JPSS Risk Reduction: Uniform Multi-Sensor Cryosphere Fractional Snow Cover Algorithm for Consistent Products Critical Design Review

Dec 09, 2014

Presented By: Walter Wolf[1], Jeff Key[1], Peter Romanov[2], Igor Appel[5], and Veena Jose[5]

[1] NOAA/NESDIS/STAR
[2]CREST
[3]Cooperative Institute for Meteorological Satellite Studies, UW
[4]NOAA/NESDIS/OSPO
[5]IMSG

Products Covered in this CDR

- Fractional Snow Cover

Review Agenda

• Introduction	9:00 am – 9:15 am	Wolf
• Requirements	9:15 am – 9:40 am	Wolf
• Operations Concept	9:40 am – 10:00 am	Wolf
• ATB	10:00 am – 11:00 am	Key/Appel/ Romanov
• Detailed Design	11:00 am – 11:20 am	Jose
• Quality Assurance	11:20 am – 11:30 am	Wolf
• Algorithm Package	11:30 am – 11:35 am	Wolf
• Risks & Actions	11:35 am – 11:45 am	Wolf
• Summary and Conclusions	11:45 am – 11:50 am	Wolf

Outline

- Introduction
- Requirements
- Operations Concept
- Fractional Snow Cover
- Detailed Design
- Algorithm Package
- Quality Assurance
- Risks and Actions Summary
- Summary and Conclusions

Introduction

Presented by

Walter Wolf

Contents

- Project Objectives
- Stakeholders
- Teams
- Project Plan
- Entry and Exit Criteria

Project Background

- NWS requests continuity of NOAA products between current and future NOAA operational satellites
- Demonstration of cost effective processing for NOAA JPSS products
- Demonstration of NOAA's goal of enterprise solutions by employing same algorithms for "POES" and "GOES"
- Supports NWS OS&T implementation strategy of multi-sensor algorithms and products

Project Background – NDE

- Disseminate JPSS/S-NPP Data Records to customers.
- Generate and disseminate tailored JPSS/S-NPP Data Records (versions of JPSS/S-NPP Data Records in previously agreed alternative formats and views).
- Generate and disseminate NOAA-unique products (augmented environmental products constructed from JPSS/S-NPP Data Records).
- Deliver NOAA-unique products, product processing elements, and associated metadata to CLASS for long-term archiving.
- Provide services to customers, including NDE product training, product enhancement, and implementation support across NOAA.
- Provide software for JPSS/S-NPP Data Record format translation and other data manipulations.

Project Objectives

- Modification of the NOAA Heritage Cloud, Cryosphere, Volcanic Ash, and Aerosol algorithms to work on VIIRS data
- This will bring scientific consistency between the current operational products, GOES-R products and VIIRS products
- Run the product system within NDE 2.0

Products Objectives
Cloud Products

- Cloud Mask
- Cloud Top Phase
- Cloud Type
- Cloud Top Height
- Cloud Cover Layers
- Cloud Top Temperature
- Cloud Top Pressure
- Cloud Optical Depth
- Cloud Particle Size Distribution
- Cloud Liquid Water
- Cloud Ice Water Path

Products Objectives
Aerosol Products

- Aerosol Detection
- Aerosol Optical Depth
- Aerosol Particle Size
- Volcanic Ash Mass Loading
- Volcanic Ash Height

Products Objectives
Cryosphere Products

- Snow Cover
- Fractional Snow Cover
- Ice Concentration and Cover
- Ice Surface Temperature
- Ice Thickness/Age

JPSS Risk Reduction Integrated Product Team

- IPT Lead: Walter Wolf (STAR)
- IPT Backup Lead: Shuang Qiu (OSPO)
- NESDIS team:
  - » STAR: Andy Heidinger, Jeff Key, Shobha Kondragunta, Istvan Laszlo, Mike Pavolonis
  - » OSPO: A. K. Sharma, Hanjun Ding, Zhaohui Cheng, Chris Sisko, Donna McNamera
  - » OSD: Tom Schott, Rick Vizbulis, Geof Goodrum
  - » NOAA JPSS: Mitch Goldberg, Eric Gottshall, Neal Baker
  - » NIC: Sean Helfrich, Pablo Clemente
  - » Data Center: Lei Shi (NCDC)
  - » Others: Shanna Sampson (IMSG), Peter Romanov (CREST), Veena Jose (IMSG), William Straka III (CIMSS), Ray Garcia (CIMSS), Andi Walther (CIMSS), Pat Heck (CIMSS), Igor Appel (IMSG)
- User team
  - » Lead: Kevin Schrab (NWS), Mike Johnson(NWS), John Derber (NWS/NCEP/EMC), Jeff Ator (NWS/NCEP/NCO), Sid Boukabara (JCSDA), Carven Scott (NWS), VAACs
  - » Others: International NWP users, NWP FOs, Climate Users
- POPs involved: EPOP, ICAPOP, CAL/NAVPOP, ACPOP, SURPOP

Project Stakeholders

- OSPO
- STAR
- OSD
- NOAA National Weather Service
- Department of Defense
- National Ice Center
- Global NWP

Project Plan

- Design and Development (2012 – 2014)
  - » Develop Requirements Document
  - » Product leads to identify updates to the algorithms to work with VIIRS data
  - » Identify ancillary data for the algorithms
  - » Conduct CDR
  - » Algorithm development
  - » Implement algorithms within the Framework
  - » Conduct UTRR

Project Timeline
Design and Development

ID	Task Name	Start	Finish
1	**JPSS Risk Reduction**		
2	**Development Phase**		
3	IPT Lead informed to begin product development		10/1
4	**Algorithm Evaluation/Preliminary Development**	10/1	12/31
5	Initial Archive Requirements identified	10/1	12/7
6	Quality Monitoring Concept Defined	10/1	12/7
7	Long-term Maintenance Concept Defined	10/1	12/7
8	Development processing system defined	10/1	12/7
9	Evaluate the modifications required to create VIIRS products from the GC	10/1	12/7
10	Initial Information Technology (IT) Security concept defined	10/1	12/7
11	Requirements Review		12/10
12	Preliminary development Aerosol, Cloud, Cryosphere and Volcanic Ash a	10/1	12/28
13	Identify ancillary data inputs for all the algorithms	11/1	12/28
14	Preliminary development of infrastructure to implement the NetCDF4 rea	11/1	12/28
15	Critical Design Reviews for Aerosol, Cloud, Cryosphere, and Volcanic		12/31
16	**Algorithm Development**	1/2	11/29
17	Development of Aerosol, Cloud, Cryosphere and Volcanic Ash algorithm	1/2	11/29
18	Define Aerosol, Cloud, Cryosphere and Volcanic Ash output files	1/2	10/31
19	Development of infrastructure to implement the NetCDF4 readers and w	2/1	11/29
20	**Algorithm Implement/Testing/Demonstration**	12/2	12/19
21	Begin documentation of the framework	12/2	12/2
22	Implement Cloud Mask, Height, Phase and COMP algorithms into the fra	12/2	8/8
23	Cloud Mask, Height, Phase and COMP test cases processed	12/2	4/18
24	Test Readiness Review for Cloud Mask, Height, Phase and COMP		11/12
25	Deliver preliminary Cloud DAP to NDE		10/24
26	Implement Aerosol Detection and Aerosol Optical Depth algorithms into	12/2	9/5
27	Aerosol Detection and Aerosol Optical Depth test case processed	12/2	6/27
28	Test Readiness Review for Aerosol Detection and Aerosol Optical Dep		11/14
29	Deliver preliminary Aerosol DAP to NDE		10/24
30	Implement Cryosphere algorithms into the framework	12/2	9/5
31	Cryosphere algorithm test case processed	12/2	8/8
32	Test Readiness Review for Cryosphere(Ice only) algorithms		10/7
33	Deliver preliminary Cryosphere(Ice only) DAP to NDE		10/20
34	Implement Snow Cover and Volcanic Ash algorithms into the framework	12/2	10/15
35	Snow Cover and Volcanic Ash test case processed	12/2	9/12
36	Test Readiness Review for Snow Cover and Volcanic Ash Algorithms		12/17
37	Deliver preliminary DAP for Snow Cover and Volcanic Ash Algorithms		12/19
38	**Pre-operational Phase**		
60	**Operational Phase**		

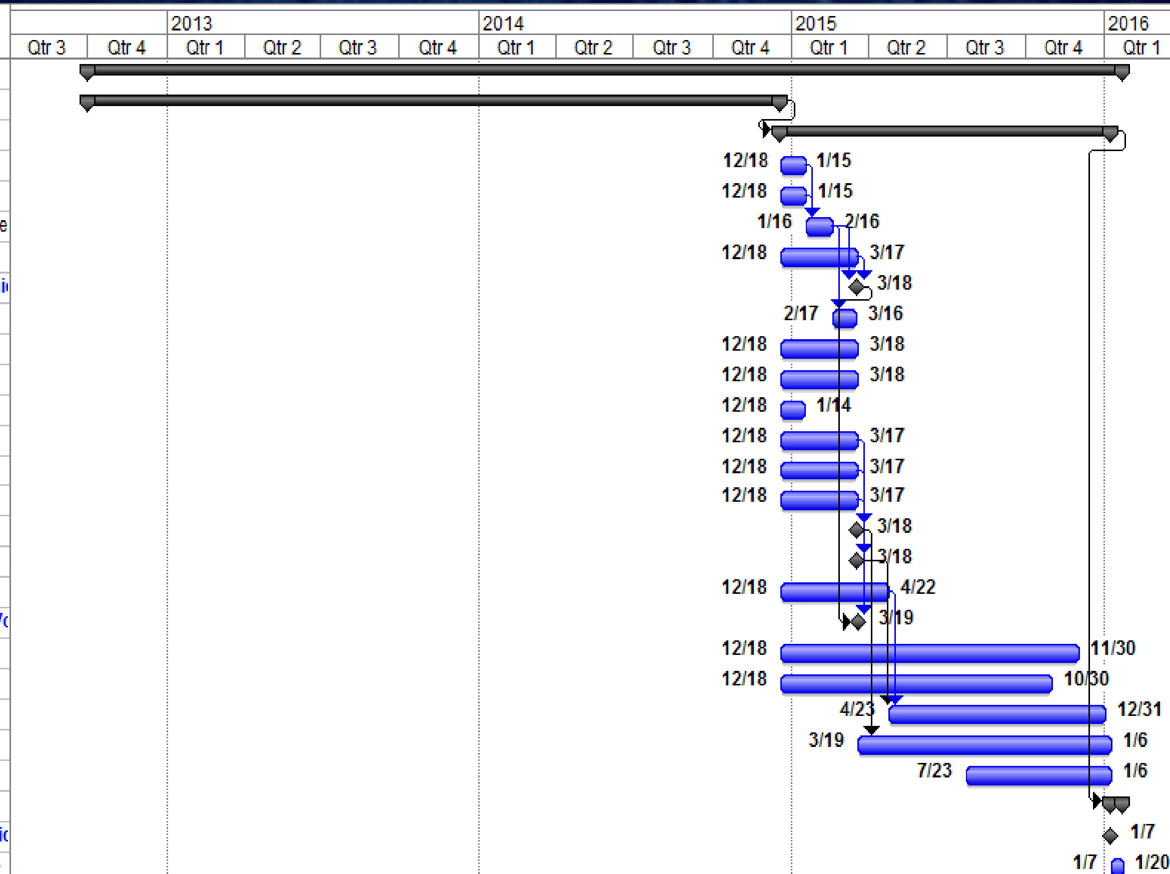
2012: Qtr 3, Qtr 4 (2011); 2012: Qtr 1, Qtr 2, Qtr 3, Qtr 4; 2013: Qtr 1, Qtr 2, Qtr 3, Qtr 4; 2014: Qtr 1, Qtr 2, Qtr 3, Qtr 4; 2015: Qtr 1, Qtr 2

Project Plan

- Transition to Pre-Operations (2014 – 2016)
  - » Deliver initial DAP (Framework with pre-operational algorithms) to NDE
  - » Conduct Software Review
  - » Update algorithms
  - » Transition and test system within the NDE 2.0 environment
  - » Perform test data flows
  - » Conduct Algorithm Readiness Review
  - » Deliver final DAP to NDE 2.0

Project Timeline
Transition to Pre-Operations

ID	Task Name
1	**JPSS Risk Reduction**
2	**Development Phase**
38	**Pre-operational Phase**
39	Transition Framework to the pre-operational system on the NDE hardware
40	NDE/OSPO Contractor Staff Training for the Framework
41	Pre-operational product output evaluated & tested within the NDE environme
42	Aerosol, Cloud, Cryosphere, and Volcanic Ash algorithms are upgraded
43	Software Review for Aerosol, Cloud, Cryosphere(Ice & Snow) and Volcani
44	Provide test products to the end users
45	Prepare Documentation
46	Developed Operational Products Implementation Plan
47	Baseline products system
48	Evaluated and Modify Operational Documentation
49	Validation and Verification of Operational Quality Assurance for Products
50	Validation and Verification of Monitoring capability for Products
51	All documentation is complete
52	Final DAP delivered to NDE
53	Prepare for Transition to Operations
54	Conduct System Readiness Review for Aerosol, Cloud, Cryosphere and Vo
55	Operational and backup processing capabilities in place
56	Final IT Security Concept Defined
57	Transition DAP to operations
58	Brief SPSRB Oversight Panel(s) on product status
59	Brief SPSRB capability is ready to operational
60	**Operational Phase**
61	SPSRB manager and secretaries notified JPSS Risk Reduction NOAA Unic
62	SPSRB Secretaries/manager update the SPSRB product metrics web page



Project Plan
Cryosphere Schedule

- **Schedule (Milestones)**
  - » Project begins – 10/05/12
  - » Requirements Review – 12/27/12 (10/31/12)
  - » Critical Design Review – 04/18/13 (12/31/12)
    - – Fractional Snow Cover – 12/09/14
    - – Ice and Snow Cover – 04/18/13
  - » Test Readiness Review – 05/06/14 (10/31/13)
    - – Ice and Snow Cover – 10/07/14
  - » Software Review – 11/15/14 (02/28/14)
  - » Algorithm Readiness Review – 03/31/15 (05/30/14)

CDR Entry Criteria

- Reviewed Requirements Document
- Review of JPSS RRPS Project:
  - » Requirements
  - » Operations Concept
  - » Algorithm Theoretical Basis
  - » Detailed Design
  - » Algorithm Package
  - » Quality Assurance
  - » Risks and Actions

CDR Exit Criteria

- Critical Design Review Report
  - » The CDR Report (CDRR), a standard artifact of the SPSRB Process Lifecycle, will be compiled before the TRR
  - » The report will contain:
    - – Actions
    - – Comments
    - – CDR presentation

Outline

- Introduction
- Requirements
- Operations Concept
- Fractional Snow Cover
- Detailed Design
- Algorithm Package
- Quality Assurance
- Risks and Actions Summary
- Summary and Conclusions

Requirements for JPSS Risk Reduction: Uniform Multi-Sensor Algorithms for Consistent Products

Presented by
Walter Wolf

JPSS Risk Reduction System Requirements

- All JPSS Risk Reduction System Project requirements are present in this section
- All JPSS Risk Reduction System Project requirements are documented in a single RAD and are part of the CDR documentation suite
- Basic requirements are shown in all yellow text on a single slide
- New/additional requirements since the CDR are listed in green

JPSS Risk Reduction Requirements Information

- The JPSS Risk Reduction Products are addressing SPSRB requirements
- The Products created from this project will at least meet the associated product requirements within the L1RD Supplement
- The RAD traces the Risk Reduction products to the L1RD Supplement requirements

Basic Requirement 0.0

- **JPSS-PS-R 0.0:** *The JPSS Risk Reduction Product System (JPSS RRPS) development project shall adopt the standard practices of the Satellite Product and Services Review Board (SPSRB).*
  - » **Driver:** *STAR Enterprise Product Lifecycle (EPL)*. The SPSRB process has been updated by incorporating aspects of the STAR EPL Process.

Basic Requirement 0.0

- **JPSS-PS-R 0.1:** *The JPSS RRPS development project practices shall be tailored from the SPSRB process.*
  - » This requirement should be met by following the SPSRB process, as long as the tailoring does not introduce an incompatibility.

Basic Requirement 1.0

- **JPSS-PS-R 1.0:** *The JPSS RRPS shall generate Global Cloud products.*

  » **<u>Driver:</u> SPSRB requirements:**
  - 1107-0011: Gridded Cloud Products for NWP Verification
  - 0909-0018: CLAVR-x and GSIP cloud product composites over Alaska

Basic Requirement 1.0

- **JPSS-PS-R 1.1:** *The Cloud products shall include Cloud Mask Product.*

  » Current operational products, with upgraded capabilities.

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.1.1:** *The Cloud Mask Product shall have JPSS 3 priority.*
- **JPSS-PS-R 1.1.2:** *The Cloud Mask Product shall have global coverage.*
- **JPSS-PS-R 1.1.3:** *The Cloud Mask Product shall have Vertical Reporting Interval of N/A.*
- **JPSS-PS-R 1.1.4:** *The Cloud Mask Product shall have Horizontal Cell Size of 0.75 km.*

  - Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.1.5:** *The Cloud Mask Product shall have Mapping Uncertainty, 3 Sigma: threshold - 4 km; objective - 1 km.*

- **JPSS-PS-R 1.1.6:** *The Cloud Mask Product shall have Measurement Range of Cloudy/Not Cloudy.*

- **JPSS-PS-R 1.1.7:** *The Cloud Mask Product shall have Measurement Accuracy of 90% correct detection.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.1.8:** *The Cloud Mask Product Refresh Rate shall be:*
  - » *Threshold - At least 90% coverage of the globe every 12 hours (monthly average)*
  - » *Objective – 4 hrs*

- **JPSS-PS-R 1.1.9:** *The Cloud Mask Product False Alarm Rate shall be:*
  - » *1. Ocean, Day, COT>1.0- 5%*
  - » *2. Land, Day, ToC NDVI < 0.2 or ToC NDVI > 0.4, or Desert, COT > 1.0 – 7%*
  - » *3. Land, Ocean, Night, COT>1.0 – 8%*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.1.10:** *The Cloud Mask Product shall have latency of 30 minutes after granule data is available.*

  » Latency is defined as the interval from the last observation to when the product is available to users. Current capability is 60 minutes.

- **JPSS-PS-R 1.1.11:** *The Cloud Mask Product shall have timeliness of ≤ 3 hours.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.1.12:** *The applicable conditions for Cloud Mask Product shall be: whenever detectable clouds are present.*

- **JPSS-PS-R 1.1.13:** *The Cloud Mask Product shall be computed and reported for the total cloud cover.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.1.14:** *The JPSS RR Cloud Mask shall use the VIIRS calibrated and navigated brightness temperature and radiances in bands M12, M13, M14, M15, M16 and reflectance in bands M5, M7, M9, M10 with solar and satellite view angles as an input data set.*

- **JPSS-PS-R 1.1.15:** *The JPSS RR Cloud Mask shall use the MODIS Collection 5 1km resolution Land Mask as an input data set.*

- **JPSS-PS-R 1.1.16:** *The JPSS RR Cloud Mask shall use Digital Surface Elevation at 1km resolution as an input data set.*

Basic Requirement 1.0

- **JPSS-PS-R 1.1.17:** *The JPSS RR Cloud Mask shall use Snow Mask by the Interactive Multi-sensor Snow and Ice Mapping System as an input data set.*

- **JPSS-PS-R 1.1.18:** *The JPSS RR Cloud Mask shall use calculated Desert Mask as an input data set.*

- **JPSS-PS-R 1.1.19:** *The JPSS RR Cloud Mask shall use calculated Coast Mask as an input data set.*

Basic Requirement 1.0

- **JPSS-PS-R 1.1.20:** *The JPSS RR Cloud Mask shall use MODIS monthly mean IR Land Surface Emissivity for channel M7 as an input data set.*
- **JPSS-PS-R 1.1.21:** *The JPSS RR Cloud Mask shall use CRTM Clear sky radiance/BT for bands M7, M14 and blackbody radiance for channel M14 and atmospheric transmittance profiles for channel M7 as an input data set.*
- **JPSS-PS-R 1.1.22:** *The JPSS RR Cloud Mask shall use Surface, Tropopause Level and Surface Temperature from GFS model as an input data set.*

Basic Requirement 1.0

- **JPSS-PS-R 1.2:** *The Cloud products shall include Cloud Top Phase Product.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.2.1:** *The Cloud Top Phase Product shall have global coverage.*

- **JPSS-PS-R 1.2.2:** *The Cloud Top Phase Product shall have Horizontal Cell Size of 0.75 km.*

- **JPSS-PS-R 1.2.3:** *The Cloud Top Phase Product shall have Measurement Accuracy of 80% Correct Classification (7 phases).*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.2.4:** *The Cloud Top Phase Product Refresh Rate shall be:*
  - » *Threshold - At least 90% coverage of the globe every 12 hours (monthly average);*
  - » *Objective – 4 hrs;*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.2.5:** *The Cloud Top Phase Product shall have latency of 30 minutes after granule data is available.*
  - » Latency is defined as the interval from the last observation to when the product is available to users. Current capability is 60 minutes.
- **JPSS-PS-R 1.2.6:** *The Cloud Top Phase Product shall have timeliness of ≤ 3 hours.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.2.7:** *The JPSS RR Cloud Top Phase shall use the VIIRS calibrated and navigated brightness temperature in bands M14, M15, M16 as an input data set.*
- **JPSS-PS-R 1.2.8:** *The JPSS RR Cloud Top Phase shall use the MODIS Collection 5 1km resolution Land Mask as an input data set.*
- **JPSS-PS-R 1.2.9:** *The JPSS RR Cloud Top Phase shall use Digital Surface Elevation at 1km resolution as an input data set.*
- **JPSS-PS-R 1.2.10:** *The JPSS RR Cloud Top Phase shall use Snow Mask by the Interactive Multisensor Snow and Ice Mapping System as an input data set.*

Basic Requirement 1.0

- **JPSS-PS-R 1.2.11:** *The JPSS RR Cloud Top Phase shall use calculated Coast Mask as an input data set.*

- **JPSS-PS-R 1.2.12:** *The JPSS RR Cloud Top Phase shall use CRTM Clear sky radiance and transmittance for bands 14, 15, 16 TOA radiance bands 14, 15, 16 as an input data set.*

- **JPSS-PS-R 1.2.13:** *The JPSS RR Cloud Top Phase shall use Temperature, Pressure, Height profiles, Surface Level, Tropopause Level, and Surface Temperature from GFS model as an input data set.*

- **JPSS-PS-R 1.2.14:** *The JPSS RR Cloud Top Phase shall use Cloud mask produced by JPSS RR cloud mask algorithm as an input data set.*

Basic Requirement 1.0

- **JPSS-PS-R 1.3:** *The Cloud products shall include Cloud Type Product.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.3.1:** *The Cloud Type Product shall have global coverage.*

- **JPSS-PS-R 1.3.2:** *The Cloud Type Product shall have Horizontal Cell Size of 0.75 km.*

- **JPSS-PS-R 1.3.3:** *The Cloud Type Product shall have Measurement Accuracy of 60%.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.3.4:** *The Cloud Type Product Refresh Rate shall be:*
  - » *Threshold - At least 90% coverage of the globe every 12 hours (monthly average)*
  - » *Objective – 4 hrs*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.3.5:** *The Cloud Type Product shall have latency of 30 minutes after granule data is available.*

   » Latency is defined as the interval from the last observation to when the product is available to users. Current capability is 60 minutes.

- **JPSS-PS-R 1.3.6:** *The Cloud Type Product shall have timeliness of ≤ 3 hours.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.3.7:** *The JPSS RR Cloud Type shall use the VIIRS calibrated and navigated brightness temperature in bands M14, M15, M16 as an input data set.*

- **JPSS-PS-R 1.3.8:** *The JPSS RR Cloud Type shall use the MODIS Collection 5 1km resolution Land Mask as an input data set.*

- **JPSS-PS-R 1.3.9:** *The JPSS RR Cloud Type shall use Digital Surface Elevation at 1km resolution as an input data set.*

- **JPSS-PS-R 1.3.10:** *The JPSS RR Cloud Type shall use Snow Mask by the Interactive Multisensor Snow and Ice Mapping System as an input data set.*

Basic Requirement 1.0

- **JPSS-PS-R 1.3.11:** *The JPSS RR Cloud Type shall use calculated Coast Mask as an input data set.*

- **JPSS-PS-R 1.3.12:** *The JPSS RR Cloud Type shall use CRTM Clear sky radiance and transmittance for bands 14, 15, 16 TOA radiance bands 14, 15, 16 as an input data set.*

- **JPSS-PS-R 1.3.13:** *The JPSS RR Cloud Type shall use Temperature, Pressure, Height profiles, Surface Level, Tropopause Level, and Surface Temperature from GFS model as an input data set.*

- **JPSS-PS-R 1.3.14:** *The JPSS RR Cloud Type shall use Cloud mask produced by JPSS RR cloud mask algorithm as an input data set.*

Basic Requirement 1.0

- **JPSS-PS-R 1.4:** *The Cloud products shall include Cloud Top Height Product.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.4.1:** *The Cloud Top Height Product shall have priority of JPSS 3.*

- **JPSS-PS-R 1.4.2:** *The Cloud Top Height Product shall have global coverage.*

- **JPSS-PS-R 1.4.3:** *The Cloud Top Height Product shall have Vertical Reporting Interval:*
  - » *Threshold - Tops of up to three cloud layers (1); applicable to single layered clouds only*
  - » *Objective - Tops of all distinct cloud layers*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.4.4:** *The Cloud Top Height Product shall have Horizontal Cell Size of 0.75 km.*

- **JPSS-PS-R 1.4.5:** *The Cloud Top Height Product shall have Mapping Uncertainty, 3 Sigma:*
  - » *Threshold - 4 km*
  - » *Objective - 1 km.*

- **JPSS-PS-R 1.4.6:** *The Cloud Top Height Product shall have Measurement Accuracy of 500m for Clouds with emissivity > 0.8.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.4.7:** *The Cloud Top Height Product Refresh Rate shall be:*
  - » *Threshold - At least 90% coverage of the globe every 12 hours (monthly average)*
  - » *Objective – 4 hrs*

- **JPSS-PS-R 1.4.8:** *The Cloud Top Height Product Measurement Precision shall be:*
  - » *Threshold – 1. COT ≥1 – 1.0 km; 2. COT < 1 – 2.0 km;*
  - » *Objective –1. COT ≥ 1 – 0.15 km; 2. COT < 1 – 0.15 km;*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.4.9:** *The Cloud Top Height Product shall have latency of 30 minutes after granule data is available.*
  - » Latency is defined as the interval from the last observation to when the product is available to users. Current capability is 60 minutes.
- **JPSS-PS-R 1.4.10:** *The Cloud Top Height Product shall have timeliness of ≤ 3 hours.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.4.11:** *The requirements for the Cloud Top Height Product shall apply whenever detectable clouds are present.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.4.12:** *The JPSS RR Cloud Top Height shall use the VIIRS calibrated and navigated brightness temperature and radiance in bands M14, M15, M16 with solar and satellite view angles as an input data set.*
- **JPSS-PS-R 1.4.13:** *The JPSS RR Cloud Top Height shall use the MODIS Collection 5 1km resolution Land Mask as an input data set.*
- **JPSS-PS-R 1.4.14:** *The JPSS RR Cloud Top Height shall use Digital Surface Elevation at 1km resolution as an input data set.*
- **JPSS-PS-R 1.4.15:** *The JPSS RR Cloud Top Height shall use Snow Mask by the Interactive Multisensor Snow and Ice Mapping System as an input data set.*

Basic Requirement 1.0

- **JPSS-PS-R 1.4.16:** *The JPSS RR Cloud Top Height shall use CRTM Clear sky radiance and transmittance for channels 14, 15, 16 and radiance profiles for channels 14, 15, 16 as an input data set.*

- **JPSS-PS-R 1.4.17:** *The JPSS RR Cloud Top Height shall use Temperature, Pressure, Height profiles, Surface Level and Tropopause Temperature from GFS model as an input data set.*

- **JPSS-PS-R 1.4.18:** *The JPSS RR Cloud Top Height shall use Cloud mask produced by JPSS RR cloud mask algorithm as an input data set.*

- **JPSS-PS-R 1.4.19:** *The JPSS RR Cloud Top Height shall use Cloud type produced by JPSS RR cloud type algorithm as an input data set.*

Basic Requirement 1.0

- **JPSS-PS-R 1.5:** *The Cloud products shall include Cloud Cover/Layers Products.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.5.1:** *The Cloud Cover/Layers Products shall have priority of JPSS 3.*

- **JPSS-PS-R 1.5.2:** *The Cloud Cover/Layers Products shall have global coverage.*

- **JPSS-PS-R 1.5.3:** *The Cloud Cover/Layers Products shall have Vertical Reporting Interval:*
  - » *Threshold -Up to three cloud layers*
  - » *Objective – 0.1 km*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.5.4:** *The Cloud Cover/Layers Products shall have Horizontal Cell Size of 0.75 km.*

- **JPSS-PS-R 1.5.5:** *The Cloud Cover/Layers Products shall have Mapping Uncertainty, 3 Sigma:*
  - » *Threshold - 4 km*
  - » *Objective - 1 km*

- **JPSS-PS-R 1.5.6:** *The Cloud Cover/Layers Products shall have Measurement Range (Applies only to total cloud cover; Not applicable to layers):*
  - » *Threshold - 0 to 1.0 HCS Area; Objective – 0 to 1.0*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.5.7:** *The Cloud Cover/Layers Products shall have Measurement Accuracy of 80% Correct Classification (Low, Mid, High).*

- **JPSS-PS-R 1.5.8:** *The Cloud Cover/Layers Products Refresh Rate shall be:*
  - » *Threshold - At least 90% coverage of the globe every 12 hours (monthly average)*
  - » *Objective – 4 hrs*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.5.9:** *The Cloud Cover/Layers Products shall have latency of 30 minutes after granule data is available.*

  - Latency is defined as the interval from the last observation to when the product is available to users. Current capability is 60 minutes.

- **JPSS-PS-R 1.5.10:** *The Cloud Cover/Layers Products shall have timeliness of ≤ 3 hours.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.5.11:** *The requirements for the Cloud Cover/Layers Products shall apply whenever detectable clouds are present.*

- **JPSS-PS-R 1.5.12** *The Cloud Cover Product shall be computed and reported at each separate, distinct layer, as well as for the total cloud cover.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.5.13:** *The JPSS RR Cloud Cover/Layers shall use the VIIRS calibrated and navigated brightness temperature and radiance in bands M14, M15, M16 with solar and satellite view angles as an input data set.*

- **JPSS-PS-R 1.5.14:** *The JPSS RR Cloud Cover/Layers shall use the MODIS Collection 5 1km resolution Land Mask as an input data set.*

- **JPSS-PS-R 1.5.15:** *The JPSS RR Cloud Cover/Layers shall use Digital Surface Elevation at 1km resolution as an input data set.*

- **JPSS-PS-R 1.5.16:** *The JPSS RR Cloud Cover/Layers shall use Snow Mask by the Interactive Multisensor Snow and Ice Mapping System as an input data set.*

Basic Requirement 1.0

- **JPSS-PS-R 1.5.17:** *The JPSS RR Cloud Cover/Layers shall use CRTM Clear sky radiance and transmittance for channels 14, 15, 16 and radiance profiles for channels 14, 15, 16 as an input data set.*

- **JPSS-PS-R 1.5.18:** *The JPSS RR Cloud Cover/Layers shall use Temperature, Pressure, Height profiles, Surface Level and Tropopause Temperature from GFS model as an input data set.*

- **JPSS-PS-R 1.5.19:** *The JPSS RR Cloud Cover/Layers shall use Cloud mask produced by JPSS RR cloud mask algorithm as an input data set.*

- **JPSS-PS-R 1.5.20:** *The JPSS RR Cloud Cover/Layers shall use Cloud type produced by JPSS RR cloud type algorithm as an input data set.*

Basic Requirement 1.0

- **JPSS-PS-R 1.6:** *The Cloud products shall include Cloud Top Temperature Product.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.6.1:** *The Cloud Top Temperature Product shall have priority of JPSS 3.*

- **JPSS-PS-R 1.6.2:** *The Cloud Top Temperature Product shall have global coverage.*

- **JPSS-PS-R 1.6.3:** *The Cloud Top Temperature Product shall have Vertical Reporting Interval:*
  - » *Threshold – Tops of up to three cloud layers; applicable to single layered clouds only*
  - » *Objective – Tops of all distinct cloud layers*

- ➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.6.4:** *The Cloud Top Temperature Product shall have Horizontal Cell Size of 0.75 km.*

- **JPSS-PS-R 1.6.5:** *The Cloud Top Temperature Product shall have Mapping Uncertainty, 3 Sigma:*
  - » *Threshold - 4 km*
  - » *Objective - 1 km.*

- **JPSS-PS-R 1.6.6:** *The Cloud Top Temperature Product shall have Measurement Accuracy of 3 K for clouds with emissivity > 0.8.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.6.7:** *The Cloud Top Temperature Product Refresh Rate shall be:*
  - » *Threshold - At least 90% coverage of the globe every 12 hours (monthly average);*
  - » *Objective – 4 hrs;*

- **JPSS-PS-R 1.6.8:** *The Cloud Top Temperature Product Measurement Precision shall be:*
  - » *Threshold –1. Optical thickness ≥ 1 – 3K;*
    2. Optical Thickness < 1 – 6K;
  - » *Objective – N/A*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.6.9:** *The Cloud Top Temperature Product shall have latency of 30 minutes after granule data is available.*

  » Latency is defined as the interval from the last observation to when the product is available to users. Current capability is 60 minutes.

- **JPSS-PS-R 1.6.10:** *The Cloud Top Temperature Product shall have timeliness of ≤ 3 hours.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.6.11:** *The requirements for the Cloud Top Temperature Product shall apply whenever detectable clouds are present.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.6.12:** *The JPSS RR Cloud Top Temperature shall use the VIIRS calibrated and navigated brightness temperature and radiance in bands M14, M15, M16 with solar and satellite view angles as an input data set.*

- **JPSS-PS-R 1.6.13:** *The JPSS RR Cloud Top Temperature shall use the MODIS Collection 5 1km resolution Land Mask as an input data set.*

- **JPSS-PS-R 1.6.14:** *The JPSS RR Cloud Top Temperature s shall use Digital Surface Elevation at 1km resolution as an input data set.*

Basic Requirement 1.0

- **JPSS-PS-R 1.6.15:** *The JPSS RR Cloud Top Temperature shall use Snow Mask by the Interactive Multisensor Snow and Ice Mapping System as an input data set.*

- **JPSS-PS-R 1.6.16:** *The JPSS RR Cloud Top Temperature shall use CRTM Clear sky radiance and transmittance for channels 14, 15, 16 and radiance profiles for channels 14, 15, 16 as an input data set.*

- **JPSS-PS-R 1.6.17:** *The JPSS RR Cloud Top Temperature shall use Temperature, Pressure, Height profiles, Surface Level and Tropopause Temperature from GFS model as an input data set.*

Basic Requirement 1.0

- **JPSS-PS-R 1.6.18:** *The JPSS RR Cloud Top Temperature shall use Cloud mask produced by JPSS RR cloud mask algorithm as an input data set.*

- **JPSS-PS-R 1.6.19:** *The JPSS RR Cloud Top Temperature shall use Cloud type produced by JPSS RR cloud type algorithm as an input data set.*

Basic Requirement 1.0

- **JPSS-PS-R 1.7:** *The Cloud products shall include Cloud Top Pressure Product.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.7.1:** *The Cloud Top Pressure Product shall have priority of JPSS 3.*

- **JPSS-PS-R 1.7.2:** *The Cloud Top Pressure Product shall have global coverage.*

- **JPSS-PS-R 1.7.3:** *The Cloud Top Pressure Product shall have Vertical Reporting Interval:*
  - » *Threshold – Tops of up to three cloud layers; applicable to single layered clouds only*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.7.4:** *The Cloud Top Pressure Product shall have Horizontal Cell Size of 0.75 km.*

- **JPSS-PS-R 1.7.5:** *The Cloud Top Pressure Product shall have Mapping Uncertainty, 3 Sigma: threshold - 4 km ; objective - 1 km.*

- **JPSS-PS-R 1.7.6:** *The Cloud Top Pressure Product shall have Measurement Range of:*
  - » Cloudy/Not Cloudy.

- **JPSS-PS-R 1.7.7:** *The Cloud Top Pressure Product shall have Measurement Accuracy of 50 mb for clouds with emissivity > 0.8.*

Basic Requirement 1.0

- **JPSS-PS-R 1.7.8:** *The Cloud Top Pressure Product Refresh Rate shall be:*
  - » *Threshold - At least 90% coverage of the globe every 12 hours (monthly average); Objective – 4 hrs*

- **JPSS-PS-R 1.7.9:** *The Cloud Top Pressure Product Measurement Precision shall be:*
  - » *Threshold – COT ≥ 1:*
    1. *Surface to 3km – 100mb*
    2. *3 to 7 – 75mb*
    3. *> 7km – 50mb*
  - » *Objective –*
    1. *Surface to 3km – 10mb*
    2. *3 to 7 – 7mb*
    3. *> 7km – 5mb*

Basic Requirement 1.0

- **JPSS-PS-R 1.7.10:** *The Cloud Top Pressure Product shall have latency of 30 minutes after granule data is available.*
  - » Latency is defined as the interval from the last observation to when the product is available to users. Current capability is 60 minutes.

- **JPSS-PS-R 1.7.11:** *The Cloud Top Pressure Product shall have timeliness of ≤ 3 hours.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.7.12:** *The requirements for the Cloud Top Pressure Product shall apply whenever detectable clouds are present.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.7.13:** *The JPSS RR Cloud Top Pressure shall use the VIIRS calibrated and navigated brightness temperature and radiance in bands M14, M15, M16 with solar and satellite view angles as an input data set.*

- **JPSS-PS-R 1.7.14:** *The JPSS RR Cloud Top Pressure shall use the MODIS Collection 5 1km resolution Land Mask as an input data set.*

- **JPSS-PS-R 1.7.15:** *The JPSS RR Cloud Top Pressure shall use Digital Surface Elevation at 1km resolution as an input data set.*

Basic Requirement 1.0

- **JPSS-PS-R 1.7.16:** *The JPSS RR Cloud Top Pressure shall use Snow Mask by the Interactive Multisensor Snow and Ice Mapping System as an input data set.*
- **JPSS-PS-R 1.7.17:** *The JPSS RR Cloud Top Pressure shall use CRTM Clear sky radiance and transmittance for channels 14, 15, 16 and radiance profiles for channels 14, 15, 16 as an input data set.*
- **JPSS-PS-R 1.7.18:** *The JPSS RR Cloud Top Pressure shall use Temperature, Pressure, Height profiles, Surface Level and Tropopause Temperature from GFS model as an input data set.*

Basic Requirement 1.0

- **JPSS-PS-R 1.7.19:** *The JPSS RR Cloud Top Pressure shall use Cloud mask produced by JPSS RR cloud mask algorithm as an input data set.*

- **JPSS-PS-R 1.7.20:** *The JPSS RR Cloud Top Pressure shall use Cloud type produced by JPSS RR cloud type algorithm as an input data set.*

Basic Requirement 1.0

- **JPSS-PS-R 1.8:** *The Cloud products shall include Cloud Optical Properties Products (Daytime and Nighttime).*

- **JPSS-PS-R 1.8.1:** *The Cloud Optical Properties products shall include Cloud Optical Thickness Product.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.8.1.1:** *The Cloud Optical Thickness Product shall have priority of JPSS 3.*

- **JPSS-PS-R 1.8.1.2:** *The Cloud Optical Thickness Product shall have global coverage.*

- **JPSS-PS-R 1.8.1.3:** *The Cloud Optical Thickness Product shall have Vertical Reporting Interval:*
  - » *Threshold – up to three cloud layers;*
  - » *Objective – 3 layers;*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.8.1.4:** *The Cloud Optical Thickness Product shall have Horizontal Cell Size of 0.75 km.*

- **JPSS-PS-R 1.8.1.5:** *The Cloud Optical Thickness Product shall have Mapping Uncertainty, 3 Sigma:*
  - » *Threshold - 4km*
  - » *Objective - 1 km.*

- **JPSS-PS-R 1.8.1.6:** *The Cloud Optical Thickness Product shall have Measurement Range of:*
  - » *Cloudy/Not Cloudy.*

Basic Requirement 1.0

- **JPSS-PS-R 1.8.1.7:** *The Cloud Optical Thickness Product shall have Measurement Accuracy of:*
  - » *Liquid phase: 20% error (Day), 20% (Night);*
  - » *Ice phase: 20% Day), 30% (Night)*

- **JPSS-PS-R 1.8.1.8:** *The Cloud Optical Thickness Refresh Rate shall be:*
  - » *Threshold - At least 90% coverage of the globe every 12 hours (monthly average);*
  - » *Objective – 4 hrs;*

Basic Requirement 1.0

- **JPSS-PS-R 1.8.1.9:** *The Cloud Optical Thickness Product Measurement Precision shall be:*
  - » *Threshold – Greater of 33 % or 1 Tau*
  - » *Objective – 2%*

- **JPSS-PS-R 1.8.1.10:** *The Cloud Optical Thickness Product shall have latency of 30 minutes after granule data is available.*
  - » Latency is defined as the interval from the last observation to when the product is available to users. Current capability is 60 minutes.

- **JPSS-PS-R 1.8.1.11:** *The Cloud Optical Thickness Product shall have timeliness of ≤ 3 hours.*

Basic Requirement 1.0

- **JPSS-PS-R 1.8.1.12:** *The requirements for the Cloud Optical Thickness Product shall apply whenever detectable clouds are present.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.8.2:** *The Cloud Optical Properties products shall include Cloud Effective Particle Size Product.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.8.2.1:** *The Cloud Effective Particle Size Product shall have priority of JPSS 3.*

- **JPSS-PS-R 1.8.2.2:** *The Cloud Effective Particle Size Product shall have global coverage.*

- **JPSS-PS-R 1.8.2.3:** *The Cloud Effective Particle Size Product shall have Vertical Reporting Interval:*
  - » *Threshold – up to three cloud layers*
  - » *Objective – 0.3 km;*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.8.2.4:** *The Cloud Effective Particle Size Product shall have Horizontal Cell Size of 0.75 km.*

- **JPSS-PS-R 1.8.2.5:** *The Cloud Effective Particle Size Product shall have Mapping Uncertainty, 3 Sigma: Threshold - 4 km ; Objective - 1 km.*

- **JPSS-PS-R 1.8.2.6:** *The Cloud Effective Particle Size Product shall have Measurement Range of:*
  - » *Threshold - 0 to 50 µm;*
  - » *Objective – N/S*

Basic Requirement 1.0

- **JPSS-PS-R 1.8.2.7:** *The Cloud Effective Particle Size Product shall have Measurement Accuracy of:*
  - » *4 µm for liquid phase*
  - » *10 µm for ice phase*

- **JPSS-PS-R 1.8.2.8:** *The Cloud Effective Particle Size Refresh Rate shall be:*
  - » *Threshold - At least 90% coverage of the globe every 12 hours (monthly average);*
  - » *Objective – 4 hrs;*

Basic Requirement 1.0

- **JPSS-PS-R 1.8.2.9:** *The Cloud Effective Particle Size Product Measurement Precision shall be:*
  - » *Threshold – Greater of 22% or 1 µm for water; Greater of 28% or 1µm for ice*
  - » *Objective – 2%*

- **JPSS-PS-R 1.8.2.10:** *The Cloud Effective Particle Size Product shall have latency of 30 minutes after granule data is available.*
  - » Latency is defined as the interval from the last observation to when the product is available to users. Current capability is 60 minutes.

- **JPSS-PS-R 1.8.2.11:** *The Cloud Effective Particle Size Product shall have timeliness of ≤ 3 hours.*

Basic Requirement 1.0

- **JPSS-PS-R 1.8.2.12:** *The requirements for the Cloud Effective Particle Size Product shall apply both day and night and whenever detectable clouds are present.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.8.3:** *The Cloud Optical Properties products shall include Cloud Liquid Water Product.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.8.3.1:** *The Cloud Liquid Water Product shall be have priority of JPSS 3.*

- **JPSS-PS-R 1.8.3.2:** *The Cloud Liquid Water Product shall have global coverage.*

- **JPSS-PS-R 1.8.3.3:** *The Cloud Liquid Water Product shall have Vertical Reporting Interval:*

  N/A

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.8.3.4:** *The Cloud Liquid Water Product shall have Horizontal Cell Size of 0.75 km.*

- **JPSS-PS-R 1.8.3.5:** *The Cloud Liquid Water Product shall have Mapping Uncertainty N/A*

- **JPSS-PS-R 1.8.3.6:** *The Cloud Liquid Water Product shall have Measurement Accuracy of:*
  - » *Greater of 25 g/m2 or 15% error.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.8.3.7:** *The Cloud Liquid Water Product Refresh Rate shall be:*
  - » *Threshold - At least 90% coverage of the globe every 12 hours (monthly average)*
  - » *Objective – 4 hrs*

- **JPSS-PS-R 1.8.3.8:** *The Cloud Liquid Water Product Measurement Precision shall be:*
  - » *Threshold –Sea: 0.08 mm*
  - » *Objective – Sea: 0.06 mm;*

Basic Requirement 1.0

- **JPSS-PS-R 1.8.3.9:** *The Cloud Liquid Water Product shall have latency of 30 minutes after granule data is available.*
  - » Latency is defined as the interval from the last observation to when the product is available to users. Current capability is 60 minutes.

- **JPSS-PS-R 1.8.3.10:** *The Cloud Liquid Water Product shall have timeliness of ≤ 3 hours.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.8.4:** *The Cloud Optical Properties products shall include Cloud Ice Water Pass Product.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.8.4.1:** *The Cloud Ice Water Pass Product shall have global coverage.*

- **JPSS-PS-R 1.8.4.2:** *The Cloud Ice Water Pass Product shall have Horizontal Cell Size of 0.75 km.*

- **JPSS-PS-R 1.8.4.3:** *The Cloud Ice Water Pass Product shall have Measurement Accuracy of:*
  - » *Greater of 25g/m2 or 30% error.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.8.4.4:** *The Cloud Ice Water Pass Product Refresh Rate shall be:*
  - » *Threshold - At least 90% coverage of the globe every 12 hours (monthly average);*
  - » *Objective – 4 hrs;*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.8.4.5:** *The Cloud Ice Water Pass Product shall have latency of 30 minutes after granule data is available.*
  - » Latency is defined as the interval from the last observation to when the product is available to users. Current capability is 60 minutes.
- **JPSS-PS-R 1.8.4.6:** *The Cloud Ice Water Pass Product shall have timeliness of ≤ 3 hours.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 1.0

- **JPSS-PS-R 1.8.5:** *The JPSS RR Daytime Cloud Optical Properties shall use VIIRS calibrated and navigated brightness temperature in band 12 and reflectance in bands 5, 7, 10, and 11 with solar and satellite view angles as an input data set.*

- **JPSS-PS-R 1.8.6:** *The JPSS RR Daytime Cloud Optical Properties shall use Global 1 km land/water & coast mask used for MODIS collection 5 as an input data set.*

- **JPSS-PS-R 1.8.7:** *The JPSS RR Daytime Cloud Optical Properties shall use UW Baseline Fit Emissivity for band 7 as an input data set.*

Basic Requirement 1.0

- **JPSS-PS-R 1.8.8:** *The JPSS RR Daytime Cloud Optical Properties shall use Temperature and Water Vapor profiles from GFS model as an input data set.*

- **JPSS-PS-R 1.8.9:** *The JPSS RR Daytime Cloud Optical Properties shall use Cloud mask produced by JPSS RR cloud mask algorithm as an input data set.*

- **JPSS-PS-R 1.8.10:** *The JPSS RR Daytime Cloud Optical Properties shall use Cloud height produced by JPSS RR cloud height algorithm as an input data set.*

Basic Requirement 1.0

- **JPSS-PS-R 1.8.11:** *The JPSS RR Daytime Cloud Optical Properties shall use Cloud type produced by JPSS RR cloud type algorithm as an input data set.*

- **JPSS-PS-R 1.8.12:** *The JPSS RR Daytime Cloud Optical Properties shall be validated for Solar Zenith angle <= 70 deg and verified between 70 deg and 82 deg.*

- **JPSS-PS-R 1.8.13:** *The JPSS RR Nighttime Cloud Optical Properties shall use VIIRS calibrated and navigated brightness temperature in bands M12, M15, M16 with solar and satellite view angles as an input data set.*

Basic Requirement 1.0

- **JPSS-PS-R 1.8.14:** *The JPSS RR Nighttime Cloud Optical Properties shall use Global 1 km land/water & coast mask used for MODIS collection 5 as an input data set.*

- **JPSS-PS-R 1.8.15:** *The JPSS RR Nighttime Cloud Optical Properties shall use UW Baseline Fit Surface Emissivity for band 7 as an input data set.*

- **JPSS-PS-R 1.8.16:** *The JPSS RR Nighttime Cloud Optical Properties shall use Clear sky radiance and transmittance for bands 12, 15, 16 TOA radiance for a black cloud bands 12, 15, 16 from CRTM model as an input data set.*

Basic Requirement 1.0

- **JPSS-PS-R 1.8.17:** *The JPSS RR Nighttime Cloud Optical Properties shall use Temperature, Pressure, Height profiles from GFS model as an input data set.*

- **JPSS-PS-R 1.8.18:** *The JPSS RR Nighttime Cloud Optical Properties shall use Cloud mask produced by JPSS RR cloud mask algorithm as an input data set.*

- **JPSS-PS-R 1.8.19:** *The JPSS RR Nighttime Cloud Optical Properties shall be validated for Solar Zenith angle >= 90 deg and verified between 82 and 90 deg.*

Basic Requirement 1.0

- **JPSS-PS-R 1.9:** *The Cloud Products shall include quality information.*
  - » QC flags will be specified in the External Users Manual.

- **JPSS-PS-R 1.10:** *The JPSS RRPS shall write Cloud Products files in NetCDF4 formats.*
  - » SPSRB requirement

Basic Requirement 1.0

- **JPSS-PS-R 1.11:** *The JPSS RRPS system shall perform validation and verification of the Cloud Products.*
  - » Validation tools will be based upon the GOES-R validation tools and/or the heritage validation tools

- **JPSS-PS-R 1.11.1:** *The JPSS RRPS system shall plot datasets for verification of the Cloud Products.*

Basic Requirement 1.0

- **JPSS-PS-R 1.11.2:** *The JPSS RRPS system shall verify that Cloud Products files are generated correctly.*
  - » Will be included in the unit tests described in the UTR and the system test described in the SRR.

- **JPSS-PS-R 1.11.3:** *The JPSS RRPS system shall perform routine data range checks to flag anomalous values in the input data.*
  - » Anomalous values will be flagged. These checks will be included in the code and described in the SRR.

Basic Requirement 1.0

- **JPSS-PS-R 1.11.4:** *The JPSS RRPS system shall perform routine data range checks to flag anomalous values in the Cloud Products.*
  - » Out-of-range values will be flagged. These checks will be included in the code. UTR will address.

- **JPSS-PS-R 1.11.5:** *The JPSS RRPS system shall generate matchup datasets between Cloud Products retrievals and in situ measurements.*
  - » In situ data obtained from NCEP & ECMWF analysis, SURFRAD measurements, and CALIPSO data.

Basic Requirement 2.0

- **JPSS-PS-R 2.0:** *The JPSS RRPS shall generate Aerosol Products.*

Driver: **SPSRB requirements:**

- *1009-0016: Dust Aerosol Concentration Product*
- *0707-0014: Support satellite-based verification of the National Air Quality Forecast Capability*

Basic Requirement 2.0

- **JPSS-PS-R 2.1:** *The Aerosol Products shall include Aerosol Optical Depth.*
- **JPSS-PS-R 2.1.1:** ***The Aerosol Optical Depth Product priority shall be JPSS 4.***
- **JPSS-PS-R 2.1.2:** *The Aerosol Optical Depth Product shall have global coverage.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 2.0

- **JPSS-PS-R 2.1.3:** *The Aerosol Optical Depth Product shall have Horizontal Cell Size of 0.75 km (nadir).*

- **JPSS-PS-R 2.1.4:** *The Aerosol Optical Depth Product shall have Vertical Reporting Interval of:*
  - » *Threshold - Total column;*
  - » *Objective - Total column*

➢ Current operational products, with upgraded capabilities

Basic Requirement 2.0

- **JPSS-PS-R 2.1.5:** *The Aerosol Optical Depth Product shall have Mapping Uncertainty, 3 Sigma, of:*
  - » *Threshold – 4 km*
  - » *Objective – 1 km*

- **JPSS-PS-R 2.1.6:** *The Aerosol Optical Depth Product shall have Measurement Range of:*
  - » *Threshold – 0 to 2*
  - » *Objective – 0 to 10*

➢ Current operational products, with upgraded capabilities

Basic Requirement 2.0

- **JPSS-PS-R 2.1.7:** *The Aerosol Optical Depth Product shall have measurement accuracy based on Aerosol Optical Depth ranges:*
  - » *Over land:*
    - *< 0.04: 0.06*
    - *0.04 – 0.80: 0.04*
    - *> 0.80: 0.12*
  - » *Over water:*
    - *< 0.40: 0.02*
    - *> 0.40: 0.10*

➢ Current operational products, with upgraded capabilities

Basic Requirement 2.0

- **JPSS-PS-R 2.1.8:** *The Aerosol Optical Depth Product Refresh Rate shall be:*
  - » *Threshold - At least 90% coverage of the globe every 12 hours (monthly average)*
  - » *Objective – 4 hrs*

- **JPSS-PS-R 2.1.9:** *The Aerosol Optical Depth Products shall have latency of 30 minutes after granule data is available.*

- **JPSS-PS-R 2.1.10:** *The Aerosol Optical Depth Products shall have timeliness of ≤ 3 hours.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 2.0

- **JPSS-PS-R 2.1.11:** *The Aerosol Optical Depth Products shall have Measurement Precision of:*

  Threshold –

  » *Over Ocean -*

  0.15 (Tau < 0.3)

  0.35 (Tau ≥ 0.3) (1,2,4);

  » *Over Land –*

  0.15 (Tau < 0.1);

  0.25 (0.1 ≤ Tau ≤ 0.8);

  0.45 (Tau > 0.8) (1,2,4);

  Objective –

  » *Over Ocean –0.01;*

  » *Over Land –0.01;*

➢ Current operational products, with upgraded capabilities

Basic Requirement 2.0

- **JPSS-PS-R 2.1.12:** *Applicable Conditions for Aerosol Optical Depth shall be:*
  1. *Clear, daytime only*
  2. *Zenith angles less than or equal to 80 degrees.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 2.0

- **JPSS-PS-R 2.1.13:** *The JPSS RR Aerosol Optical Depth shall use the VIIRS calibrated and navigated reflectance in bands M1, M2, M3, M4, M5, M8 and M11 over land and M4, M5, M7, M8, M10, M11 over Water with solar and satellite view angles as an input data set.*

- **JPSS-PS-R 2.1.14:** *The JPSS RR Aerosol Optical Depth shall use the MODIS Collection 5 1km resolution Land Mask as an input data set.*

- **JPSS-PS-R 2.1.15:** *The JPSS RR Aerosol Optical Depth shall use Digital Surface Elevation at 1km resolution as an input data set.*

Basic Requirement 2.0

- **JPSS-PS-R 2.1.16:** *The JPSS RR Aerosol Optical Depth shall use Cloud mask produced by JPSS RR cloud mask algorithm as an input data set.*

- **JPSS-PS-R 2.1.17:** *The JPSS RR Aerosol Optical Depth shall use Location of areas covered by snow or ice as an input data set.*

- **JPSS-PS-R 2.1.18:** *The JPSS RR Aerosol Optical Depth shall use Fire Mask as an input data set.*

- **JPSS-PS-R 2.1.19:** *The JPSS RR Aerosol Optical Depth shall use Heavy Aerosol Mask as an input data set.*

Basic Requirement 2.0

- **JPSS-PS-R 2.1.20:** *The JPSS RR Aerosol Optical Depth shall use Lookup tables of atmospheric optical functions (reflectance, transmittance, and spherical albedo) calculated from 6S radiative transfer model as an input data set.*

- **JPSS-PS-R 2.1.21:** *The JPSS RR Aerosol Optical Depth shall use Water surface sunglint directional-hemispherical reflectance calculated from 6S radiative transfer model as an input data set.*

- **JPSS-PS-R 2.1.22:** *The JPSS RR Aerosol Optical Depth shall use Surface wind speed and direction (clockwise from local north) as an input data set.*

Basic Requirement 2.0

- **JPSS-PS-R 2.1.23:** *The JPSS RR Aerosol Optical Depth shall use NCEP model predicted surface pressure and corresponding surface height as an input data set.*

- **JPSS-PS-R 2.1.24:** *The JPSS RR Aerosol Optical Depth shall use NCEP total precipitable water grids that bracket the satellite data as an input data set.*

- **JPSS-PS-R 2.1.25:** *The JPSS RR Aerosol Optical Depth shall use NCEP surface height grids as an input data set.*

- **JPSS-PS-R 2.1.26:** *The JPSS RR Aerosol Optical Depth shall use NCEP Ozone data as an input data set.*

Basic Requirement 2.0

- **JPSS-PS-R 2.2:** *The Aerosol Products shall include Aerosol Detection.*

- **JPSS-PS-R 2.2.1:** *The Aerosol Detection Product priority shall be JPSS 3.*

- **JPSS-PS-R 2.2.2:** *The Aerosol Detection Product shall have global coverage.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 2.0

- **JPSS-PS-R 2.2.3:** *The Aerosol Detection Product shall have Horizontal Cell Size of 0.75 km.*

- **JPSS-PS-R 2.2.4:** *The Aerosol Detection Product shall have Vertical Reporting Interval of:*
  - » *Threshold: Total Column*
  - » *Objective: 0.2 km*

➢ Current operational products, with upgraded capabilities

Basic Requirement 2.0

- **JPSS-PS-R 2.2.5:** *The Aerosol Detection Product shall have Mapping Uncertainty, 3 Sigma, of:*
  - » *Threshold: 3 km*
  - » *Objective: 0.1 km*

- **JPSS-PS-R 2.2.6:** *The Aerosol Detection Product shall have Measurement Range of:*
  - » *Smoke: 0 to 200 microg/m3*

➢ Current operational products, with upgraded capabilities

Basic Requirement 2.0

- **JPSS-PS-R 2.2.7:** *The Aerosol Detection Product shall have measurement accuracy of:*
  - » *Dust: 80% correct detection over land and ocean*
  - » *Smoke: 80% Correct detection over land*
  - » *70% correct detection over ocean*

➢ Current operational products, with upgraded capabilities

Basic Requirement 2.0

- **JPSS-PS-R 2.2.8:** *The Aerosol Detection Product Refresh Rate shall be:*
  - » *Threshold - At least 90% coverage of the globe every 12 hours (monthly average);*
  - » *Objective – 4 hrs;*

- **JPSS-PS-R 2.2.9:** *The Aerosol Detection Products shall have latency of 30 minutes after granule data is available.*

- **JPSS-PS-R 2.2.10:** *The Aerosol Detection Products shall have timeliness of ≤ 3 hours.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 2.0

- **JPSS-PS-R 2.2.11:** *The JPSS RR Aerosol Detection shall use the VIIRS calibrated and navigated reflectance in bands M1, M2, M5, M6, M7, M8, M10 and M11 with solar and satellite view angles as an input data set.*

- **JPSS-PS-R 2.2.12:** *The JPSS RR Aerosol Detection shall use the MODIS Collection 5 1km resolution Land/Water Mask as an input data set.*

- **JPSS-PS-R 2.2.13:** *The JPSS RR Aerosol Detection shall use Digital Surface Elevation at 1km resolution as an input data set.*

- **JPSS-PS-R 2.2.14:** *The JPSS RR Aerosol Detection shall use Cloud mask produced by cloud mask algorithm as an input data set.*

Basic Requirement 2.0

- **JPSS-PS-R 2.2.15:** *The JPSS RR Aerosol Detection shall use Location of areas covered by snow or ice as an input data set.*

- **JPSS-PS-R 2.2.16:** *The JPSS RR Aerosol Detection shall use Location of areas covered by sun glint as an input data set.*

- **JPSS-PS-R 2.2.17:** *The JPSS RR Aerosol Detection shall use Day/Night Mask Defined by VIIRS pixel observation time as an input data set.*

Basic Requirement 2.0

- **JPSS-PS-R 2.3:** *The Aerosol Products shall include Aerosol Particle Size Parameter Product.*

- **JPSS-PS-R 2.3.1:** *The Aerosol Particle Size Parameter Product priority shall be JPSS 4.*

- **JPSS-PS-R 2.3.2:** *The Aerosol Particle Size Parameter Product shall have global coverage.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 2.0

- **JPSS-PS-R 2.3.3:** *The Aerosol Particle Size Parameter Product shall have Horizontal Cell Size of 0.75 km (nadir).*

- **JPSS-PS-R 2.3.4:** *The Aerosol Particle Size Parameter Product shall have Vertical Coverage of:*
  - » *Threshold - Surface to 30 km*
  - » *Objective - Surface to 50 km*

- **JPSS-PS-R 2.3.5:** *The Aerosol Particle Size Parameter Product shall have Vertical Cell Size of:*
  - » *Threshold – Total Column;*
  - » *Objective – 0.25 km;*

➢ Current operational products, with upgraded capabilities

Basic Requirement 2.0

- **JPSS-PS-R 2.3.6:** *The Aerosol Particle Size Parameter Product shall have Mapping Uncertainty, 3 Sigma, of:*
  - » *Threshold – 4 km*
  - » *Objective – 1 km*

- **JPSS-PS-R 2.3.7:** *The Aerosol Particle Size Parameter Product shall have Measurement Range of:*
  - » *Threshold Operational*
  - » *-1 to +3 alpha units*
  - » *Objective -2 to +4 alpha units*

➢ Current operational products, with upgraded capabilities

Basic Requirement 2.0

- **JPSS-PS-R 2.3.8:** *The Aerosol Particle Size Parameter Product shall have measurement accuracy of:*
  - » *Fine/Coarse Angstrom exponent: 0.3 over ocean and land*

➢ Current operational products, with upgraded capabilities

Basic Requirement 2.0

- **JPSS-PS-R 2.3.9:** *The Aerosol Particle Size Parameter Product Refresh Rate shall be:*
  - » *Threshold - At least 90% coverage of the globe every 12 hours (monthly average);*
  - » *Objective – 4 hrs;*

- **JPSS-PS-R 2.3.10:** *The Aerosol Particle Size Parameter Products shall have latency of 30 minutes after granule data is available.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 2.0

- **JPSS-PS-R 2.3.11:** *The Aerosol Particle Size Parameter Products shall have timeliness of ≤ 3 hours.*

- **JPSS-PS-R 2.3.12:** *The Aerosol Particle Size Parameter Products shall have Measurement Precision of:*
  - » *Operational over Ocean*
  - » *Threshold – 0.3 alpha units*
  - » *Objective – 0.1 alpha units*

➢ Current operational products, with upgraded capabilities

Basic Requirement 2.0

- **JPSS-PS-R 2.3.13:** *Applicable Conditions for Aerosol Particle Size Parameter Product shall be:*
  - » *Clear, daytime only*

➢ Current operational products, with upgraded capabilities

Basic Requirement 2.0

- **JPSS-PS-R 2.3.14:** *The JPSS RR Aerosol Particle Size Parameter shall use the VIIRS calibrated and navigated reflectance in bands M1, M2, M3, M4, M5, M8 and M11 over land and M4, M5, M7, M8, M10, M11 over Water with solar and satellite view angles as an input data set.*

- **JPSS-PS-R 2.3.15:** *The JPSS RR Aerosol Particle Size Parameter shall use the MODIS Collection 5 1km resolution Land Mask as an input data set.*

- **JPSS-PS-R 2.3.16:** *The JPSS RR Aerosol Particle Size Parameter shall use Digital Surface Elevation at 1km resolution as an input data set.*

Basic Requirement 2.0

- **JPSS-PS-R 2.3.17:** *The JPSS RR Aerosol Particle Size Parameter shall use Cloud mask produced by JPSS RR cloud mask algorithm as an input data set.*

- **JPSS-PS-R 2.3.18:** *The JPSS RR Aerosol Particle Size Parameter shall use Location of areas covered by snow or ice as an input data set.*

- **JPSS-PS-R 2.3.19:** *The JPSS RR Aerosol Particle Size Parameter shall use Fire Mask as an input data set.*

- **JPSS-PS-R 2.3.20:** *The JPSS RR Aerosol Particle Size Parameter shall use Heavy Aerosol Mask as an input data set.*

Basic Requirement 2.0

- **JPSS-PS-R 2.3.21:** *The JPSS RR Aerosol Particle Size Parameter shall use Lookup tables of atmospheric optical functions (reflectance, transmittance, and spherical albedo) calculated from 6S radiative transfer model as an input data set.*

- **JPSS-PS-R 2.3.22:** *The JPSS RR Aerosol Particle Size Parameter shall use Water surface sunglint directional-hemispherical reflectance calculated from 6S radiative transfer model as an input data set.*

- **JPSS-PS-R 2.3.23:** *The JPSS RR Aerosol Particle Size Parameter shall use Surface wind speed and direction (clockwise from local north) as an input data set.*

Basic Requirement 2.0

- **JPSS-PS-R 2.3.24:** *The JPSS RR Aerosol Particle Size Parameter shall use NCEP model predicted surface pressure and corresponding surface height as an input data set.*
- **JPSS-PS-R 2.3.25:** *The JPSS RR Aerosol Particle Size Parameter shall use NCEP total precipitable water grids that bracket the satellite data as an input data set.*
- **JPSS-PS-R 2.3.26:** *The JPSS RR Aerosol Particle Size Parameter shall use NCEP surface height grids as an input data set.*
- **JPSS-PS-R 2.3.27:** *The JPSS RR Aerosol Particle Size Parameter shall use NCEP Ozone data as an input data set.*

Basic Requirement 2.0

- **JPSS-PS-R 2.4:** *The Aerosol Products shall include quality information.*
  - » QC flags will be specified in the External Users Manual.
- **JPSS-PS-R 2.5:** *The JPSS RRPS shall write Aerosol Products files in NetCDF4 formats.*
  - » SPSRB requirement

Basic Requirement 2.0

- **JPSS-PS-R 2.6:** *Aerosol Products shall be validated and verified.*
  - » Validation tools will be based upon the GOES-R validation tools

- **JPSS-PS-R 2.6.1:** *The JPSS RRPS system shall plot datasets for verification of the Aerosol Products.*

Basic Requirement 2.0

- **JPSS-PS-R 2.6.2:** *The JPSS RRPS system shall verify that Aerosol Products files are generated correctly.*
  - » Will be included in the unit tests described in the UTR and the system test described in the SRR.

- **JPSS-PS-R 2.6.3:** *The JPSS RRPS system shall perform routine data range checks to flag anomalous values in the input data.*
  - » Anomalous values will be flagged. These checks will be included in the codeand described in the SRR.

Basic Requirement 2.0

- **JPSS-PS-R 2.6.4:** *The JPSS RRPS system shall perform routine data range checks to flag anomalous values in the Aerosol Products.*
  - » Out-of-range values will be flagged. These checks will be included in the code. UTR will address.
- **JPSS-PS-R 2.6.5:** *The JPSS RRPS system shall generate matchup datasets between Aerosol Products retrievals and in situ measurements.*
  - » In situ data obtained from AERONET Measurements

Basic Requirement 3.0

- **JPSS-PS-R 3.0:** *The JPSS RRPS shall generate Volcanic Ash Products.*

Driver*: SPSRB requirements:*

- *0507-05: Polar/Geostationary Volcanic Ash Detection and Height on CLAVR-X*

Basic Requirement 3.0

- **JPSS-PS-R 3.1:** *The Volcanic Ash Products shall include Volcanic Ash Detection (Mass Loading) and Height.*

- **JPSS-PS-R 3.1.1:** *The Volcanic Ash Detection (Mass Loading) and Height Product shall have priority of JPSS 3.*

- **JPSS-PS-R 3.1.2:** *The Volcanic Ash Detection (Mass Loading) and Height Product shall have Horizontal Cell Size of 0.75 km.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 3.0

- **JPSS-PS-R 3.1.3:** *The Volcanic Ash Detection (Mass Loading) and Height Products shall have global coverage.*

- **JPSS-PS-R 3.1.4:** *The Volcanic Ash Detection (Mass Loading) and Height Product shall have latency of 30 minutes after granule data is available.*
  - » Latency is defined as the interval from the last observation to when the product is available to users. Current capability is 60 minutes.

➢ Current operational products, with upgraded capabilities

Basic Requirement 3.0

- **JPSS-PS-R 3.1.5:** *The Volcanic Ash Detection (Mass Loading) and Height Product shall have Product Refresh Rate of at least 90% coverage of the globe every 12 hours (monthly average).*

- **JPSS-PS-R 3.1.6:** *The Volcanic Ash Detection (Mass Loading) and Height Product shall have timeliness of ≤ 3 hours.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 3.0

- **JPSS-PS-R 3.1.7:** *The Volcanic Ash Detection (Mass Loading) and Height Product shall have Mapping Uncertainty, 3 Sigma of:*
  - » *Threshold – 3 km*
  - » *Objective – 0.1 km*

- **JPSS-PS-R 3.1.8:** *The Volcanic Ash Detection (Mass Loading) and Height Product shall have Measurement Range of N/A.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 3.0

- **JPSS-PS-R 3.1.9:** *The Volcanic Ash Detection (Mass Loading) and Height Product shall have Measurement Accuracy of:*
  - » *2 tons/km2, 3 km height.*

- **JPSS-PS-R 3.1.10:** *The Applicable Conditions for Volcanic Ash Detection (Mass Loading) and Height Product shall be:*
  - » *Clear, for AOT greater than 0.15, daytime only.*

➢ Current operational products, with upgraded capabilities

Basic Requirement 3.0

- **JPSS-PS-R 3.1.11:** *The JPSS RR Volcanic Ash Detection (Mass Loading) and Height shall use the VIIRS calibrated and navigated reflectance in band M5 and brightness temperature & radiances in bands 12, 14, 15 and 16 with solar & satellite view angles as an input data set.*

- **JPSS-PS-R 3.1.12:** *The JPSS RR Volcanic Ash Detection (Mass Loading) and Height shall use the Global 1 km land/water & coast mask used for MODIS collection 5 as an input data set.*

- **JPSS-PS-R 3.1.13:** *The JPSS RR Volcanic Ash Detection (Mass Loading) and Height shall use Temperature, Pressure, Height profiles, Surface Temperature Level, Tropopause Level, and Surface Temperature as an input data sets.*

Basic Requirement 3.0

- **JPSS-PS-R 3.1.14:** *The JPSS RR Volcanic Ash Detection (Mass Loading) and Height shall use Clear sky radiance and transmittance for bands 14, 15 and 16 TOA radiance for a black cloud bands 14, 15 and 16 from CRTM model as an input data sets.*

- **JPSS-PS-R 3.1.15:** *The JPSS RR Volcanic Ash Detection (Mass Loading) and Height shall use Snow mask by the Interactive Multisensor Snow and Ice Mapping System as an input data set.*

Basic Requirement 3.0

- **JPSS-PS-R 3.2:** *The Volcanic Ash Detection (Mass Loading) and Height Product shall include quality information.*
  - » QC flags will be specified in the External Users Manual.

- **JPSS-PS-R 3.3:** *The JPSS RRPS shall write Volcanic Ash Detection (Mass Loading) and Height Product files in NetCDF4 formats.*
  - » SPSRB requirement.

Basic Requirement 3.0

- **JPSS-PS-R 3.4:** *The JPSS RRPS system shall perform validation and verification of the Volcanic Ash Detection (Mass Loading) and Height Product.*
  - » Validation tools will be based upon the GOES-R validation tools

- **JPSS-PS-R 3.4.1:** *The JPSS RRPS system shall plot datasets for verification of the Volcanic Ash Detection (Mass Loading) and Height Products.*

Basic Requirement 3.0

- **JPSS-PS-R 3.4.2:** *The JPSS RRPS system shall verify that Volcanic Ash Detection (Mass Loading) and Height Products files are generated correctly.*
  - » Will be included in the unit tests described in the UTR and the system test described in the SRR.

- **JPSS-PS-R 3.4.3:** *The JPSS RRPS system shall perform routine data range checks to flag anomalous values in the input data.*
  - » Anomalous values will be flagged. These checks will be included in the code And described in the SRR.

Basic Requirement 3.0

- **JPSS-PS-R 3.4.4:** *The JPSS RRPS system shall perform routine data range checks to flag anomalous values in the Volcanic Ash Detection (Mass Loading) and Height Products.*
  - » Out-of-range values will be flagged. These checks will be included in the code. UTR will address.

- **JPSS-PS-R 3.4.5:** *The JPSS RRPS system shall generate matchup datasets between Volcanic Ash Detection (Mass Loading) and Height Products retrievals and in situ measurements.*
  - » In situ data obtained from CALIPSO data.

Basic Requirement 4.0

- **JPSS-PS-R 4.0:** *The JPSS RRPS shall generate Cryosphere Products.*

  » **Driver: SPSRB requirements:** SPSRB 0707-0018 “Add 4 new capabilities to IMS snow cover analysis”

Basic Requirement 4.0

- **JPSS-RRPS-R 4.1:** *The Cryosphere Products shall include Snow Cover Product and a Fractional Snow Cover Product.*

- **JPSS-PS-R 4.1.1:** *The Snow Cover Product shall have priority of JPSS 3.*

- **JPSS-PS-R 4.1.2:** *The Snow Cover Product shall have Horizontal Cell Size of 0.375 km.*

➢ Continuity with GOES product, upgraded VIIRS capability

Basic Requirement 4.0

- **JPSS-PS-R 4.1.3:** *The Snow Cover Product shall have global coverage.*

- **JPSS-PS-R 4.1.4:** *The Snow Cover Product shall have latency of 30 minutes after granule data is available.*
  - » Latency is defined as the interval from the last observation to when the product is available to users. Current capability is 60 minutes.

➢ Continuity with GOES product, upgraded VIIRS capability

Basic Requirement 4.0

- **JPSS-PS-R 4.1.5:** *The Snow Cover Product shall have Product Refresh Rate of:*
  - » *Threshold - at least 90% coverage of the globe every 12 hours (monthly average).*
  - » *Objective – 3 hrs;*

- **JPSS-PS-R 4.1.6:** *The Snow Cover Product shall have timeliness of ≤ 3 hours.*

➢ Continuity with GOES product, upgraded VIIRS capability

Basic Requirement 4.0

- **JPSS-PS-R 4.1.7:** *The Snow Cover Product shall have Mapping Uncertainty, 3 Sigma of:*
  - » *Threshold*
    - *Clear – 3km;*
    - *Cloudy – N/S*
  - » *Objective*
    - *Clear – 1 km;*
    - *Cloudy – 1km;*

- **JPSS-PS-R 4.1.8:** *The Snow Cover Product shall have Measurement Range of :*
  - » *0 or 1 BSC mask*

➢ Continuity with GOES product, upgraded VIIRS capability

Basic Requirement 4.0

- **JPSS-PS-R 4.1.9:** *The Snow Cover Product shall have Measurement Accuracy of 90% correct classification.*

- **JPSS-PS-R 4.1.10:** *The Snow Cover Product shall have Sensing Depth of:*
  - » *Threshold – N/S*
  - » *Objective – 1.0 m*

- **JPSS-PS-R 4.1.11:** *The Applicable Conditions for Snow Cover Product shall be:*
  - » *Clear Daytime, only*

➢ Continuity with GOES product, upgraded VIIRS capability

Basic Requirement 4.0

- **JPSS-PS-R 4.1.12:** *The JPSS RR Snow Cover shall use the VIIRS calibrated and navigated reflectance in bands I1, I2, and I3 along with solar and satellite view angles as an input data set.*
- **JPSS-PS-R 4.1.13:** *The JPSS RR Snow Cover shall use Cloud mask produced by JPSS RR cloud mask algorithm as an input data set.*
- **JPSS-PS-R 4.1.14:** *The JPSS RR Snow Cover shall use Global 1 km land/water & coast mask used for MODIS collection 5 as an input data set.*

Basic Requirement 4.0

- **JPSS-PS-R 4.1.15:** *The JPSS RR Snow Cover shall use Digital surface elevation at 1km resolution as an input data set.*
- **JPSS-PS-R 4.1.16:** *The JPSS RR Snow Cover shall use Weekly maps of snow cover frequency of occurrence on 1/3 degree global lat/lon grid as an input data set.*
- **JPSS-PS-R 4.1.17:** *The JPSS RR Snow Cover shall use Monthly mean land surface temperature as an input data set.*

Basic Requirement 4.0

- **JPSS-RRPS-R 4.1.18:** *The Cryosphere Products shall include Fractional Snow Cover Product.*

- **JPSS-PS-R 4.1.19:** *The Fractional Snow Cover Product shall have priority of JPSS 3.*

- **JPSS-PS-R 4.1.20:** *The Fractional Snow Cover Product shall have Horizontal Cell Size of 0.375 km.*

➢ Continuity with MODIS product, upgraded VIIRS capability

Basic Requirement 4.0

- **JPSS-PS-R 4.1.21:** *The Fractional Snow Cover Product shall have global coverage.*

- **JPSS-PS-R 4.1.22:** *The Fractional Snow Cover Product shall have latency of 30 minutes after granule data is available.*
  - » Latency is defined as the interval from the last observation to when the product is available to users. Current capability is 60 minutes.

➢ Continuity with MODIS product, upgraded VIIRS capability

Basic Requirement 4.0

- **JPSS-PS-R 4.1.23:** *The Fractional Snow Cover Product shall have Product Refresh Rate of:*
  - » *Threshold - at least 90% coverage of the globe every 12 hours (monthly average).*
  - » *Objective – 3 hrs*

- **JPSS-PS-R 4.1.24:** *The Fractional Snow Cover Product shall have timeliness of ≤ 3 hours.*

➢ Continuity with MODIS product, upgraded VIIRS capability

Basic Requirement 4.0

- **JPSS-PS-R 4.1.25:** *The Fractional Snow Cover Product shall have Mapping Uncertainty, 3 Sigma of:*
  - » *Threshold*

    Clear – 3km;

    Cloudy – N/S
  - » *Objective*

    Clear – 1 km;

    Cloudy – 1km;

- **JPSS-PS-R 4.1.26:** *The Fractional Snow Cover Product shall have Measurement Range of :*
  - » *0 or 100% HSC area fraction*

➢ Continuity with MODIS product, upgraded VIIRS capability

Basic Requirement 4.0

- **JPSS-PS-R 4.1.27:** *The Fractional Snow Cover Product shall have Measurement Uncertainty of 10% of FSC area.*

- **JPSS-PS-R 4.1.28:** *The Fractional Snow Cover Product shall have Sensing Depth of:*
  - *Threshold – N/S*
  - *Objective – 1.0 m*

- **JPSS-PS-R 4.1.29:** *The Applicable Conditions for Fractional Snow Cover Product shall be:*
  - *Clear Daytime, only*

- Continuity with MODIS product, upgraded VIIRS capability

Basic Requirement 4.0

- **JPSS-PS-R 4.1.30:** *The JPSS RR Fractional Snow Cover shall use the VIIRS calibrated and navigated reflectance in bands I1, I2, and I3 along with solar and satellite view angles as an input data set.*

- **JPSS-PS-R 4.1.31:** *The JPSS RR Fractional Snow Cover shall use Cloud mask produced by JPSS RR cloud mask algorithm as an input data set.*

- **JPSS-PS-R 4.1.32:** *The JPSS RR Fractional Snow Cover shall use Binary Snow mask produced by JPSS RR Snow Cover algorithm as an input data set.*

Basic Requirement 4.0

- **JPSS-PS-R 4.1.33:** *The JPSS RR Fractional Snow Cover shall use Digital surface elevation at 1km resolution as an input data set.*

- **JPSS-PS-R 4.1.34:** *The JPSS RR Fractional Snow Cover shall use Global 1 km land/water & coast mask used for MODIS collection 5 as an input data set.*

- **JPSS-PS-R 4.1.35:** *The JPSS RR Fractional Snow Cover shall use Global 250 m land/water mask used for MODIS collection 6 as an input data set.*

Basic Requirement 4.0

- **JPSS-RRPS-R 4.2:** *The Cryosphere Products shall include Sea Ice Concentration Product.*

- **JPSS-PS-R 4.2.1:** *The Sea Ice Concentration Product shall have priority of JPSS 3.*

- **JPSS-PS-R 4.2.2:** *The Sea Ice Concentration Product shall have Horizontal Cell Size of 0.75 km.*

➢ Continuity with GOES-R product, upgraded VIIRS capability

Basic Requirement 4.0

- **JPSS-PS-R 4.2.3:** *The Sea Ice Concentration Product shall have global coverage.*

- **JPSS-PS-R 4.2.4:** *The Sea Ice Concentration Product shall have latency of 30 minutes after granule data is available.*
  - » Latency is defined as the interval from the last observation to when the product is available to users. Current capability is 60 minutes.

➢ Continuity with GOES-R product, upgraded VIIRS capability

Basic Requirement 4.0

- **JPSS-PS-R 4.2.5:** *The Sea Ice Concentration Product shall have timeliness of ≤ 3 hours.*

- **JPSS-PS-R 4.2.6:** *The Sea Ice Concentration Product shall have Product Refresh Rate of:*
  - » *Threshold - at least 90% coverage of the globe every 12 hours (monthly average).*
  - » *Objective – 6 hrs*

- **JPSS-PS-R 4.2.7:** *The Sea Ice Concentration Product shall have vertical coverage of Ice Surface.*

➢ Continuity with GOES-R product, upgraded VIIRS capability

Basic Requirement 4.0

- **JPSS-PS-R 4.2.8:** *The Sea Ice Concentration Product shall have Mapping Uncertainty, 3 Sigma of:*
  - » *Threshold*
    - *Clear - 1km @ nadir*
    - *Cloudy -No capability*
  - » *Objective*
    - *Clear – 0.5 km*
    - *Cloudy - 1 km*

- **JPSS-PS-R 4.2.9:** *The Sea Ice Concentration Product shall have Measurement Range of 0/10 to 10/10.*

➢ Continuity with GOES-R product, upgraded VIIRS capability

Basic Requirement 4.0

- **JPSS-PS-R 4.2.10:** *The Sea Ice Concentration Product shall have Measurement Uncertainty of 10%.*

- **JPSS-PS-R 4.2.11:** *The Sea Ice Concentration Product shall have Cloud Leakage Rate of:*
  - » *Ocean, Day, COT>1.0, outside Sun Glint region – 1%;*
  - » *Day, Land, COT>1.0 – 3%;*
  - » *Land, Ocean, Night, COT>1.0 – 5%*

➢ Continuity with GOES-R product, upgraded VIIRS capability

Basic Requirement 4.0

- **JPSS-PS-R 4.2.12:** *The JPSS RR Sea Ice Concentration shall use VIIRS calibrated and navigated Brightness Temperature in Channel M5, M7, M10, M15 and M16 along with solar and satellite view angles as an input data set.*

- **JPSS-PS-R 4.2.13:** *The JPSS RR Sea Ice Concentration shall use global 1 km land/water & coast mask used for MODIS collection 5 as an input data set.*

- **JPSS-PS-R 4.2.13:** *The JPSS RR Sea Ice Concentration shall use Cloud mask produced by JPSS RR cloud mask algorithm as an input data set.*

Basic Requirement 4.0

- **JPSS-RRPS-R 4.3:** *The Cryosphere Products shall include Ice Age Product.*

- **JPSS-PS-R 4.3.1:** *The Ice Age Product shall have priority of JPSS 3.*

- **JPSS-PS-R 4.3.2:** *The Ice Age Product shall have Horizontal Cell Size of 0.75 km.*

➢ Continuity with GOES-R product, upgraded VIIRS capability

Basic Requirement 4.0

- **JPSS-PS-R 4.3.3:** *The Ice Age Product shall have global coverage.*

- **JPSS-PS-R 4.3.4:** *The Ice Age Product shall have latency of 30 minutes after granule data is available.*
  - » Latency is defined as the interval from the last observation to when the product is available to users. Current capability is 60 minutes.

➢ Continuity with GOES-R product, upgraded VIIRS capability

Basic Requirement 4.0

- **JPSS-PS-R 4.3.5:** *The Ice Age Product shall have timeliness of ≤ 3 hours.*

- **JPSS-PS-R 4.3.6:** *The Ice Age Product shall have Product Refresh Rate of:*
  - » *Threshold - at least 90% coverage of the globe every 12 hours (monthly average).*
  - » *Objective – 6 hrs*

- **JPSS-PS-R 4.3.7:** *The Ice Age Product shall have vertical coverage of Ice Surface.*

➢ Continuity with GOES-R product, upgraded VIIRS capability

Basic Requirement 4.0

- **JPSS-PS-R 4.3.8:** *The Ice Age Product shall have Mapping Uncertainty, 3 Sigma of:*
  - » *Threshold*
    - *Clear - 1km @ nadir*
    - *Cloudy -No capability*
  - » *Objective*
    - *Clear – 0.5 km*
    - *Cloudy - 1 km*

➢ Continuity with GOES-R product, upgraded VIIRS capability

Basic Requirement 4.0

- **JPSS-PS-R 4.3.9:** *The Ice Age Product shall have Measurement Range of:*
  - » *Threshold*

    Ice free, New/Young Ice, all other ice
  - » *Objective*

    Ice Free, Nilas, Grey White, Grey, White, First Year Medium, First Year Thick, Second Year, and Multiyear; Smooth and Deformed Ice

➢ Continuity with GOES-R product, upgraded VIIRS capability

Basic Requirement 4.0

- **JPSS-PS-R 4.3.10:** *The Ice Age Product shall have Measurement Uncertainty of :*
  - » *80% correct classification (Ice free areas, First year ice, Older ice)*

➢ Continuity with GOES-R product, upgraded VIIRS capability

Basic Requirement 4.0

- **JPSS-PS-R 4.3.11:** *The JPSS RR Ice Age shall use VIIRS solar and satellite view angles as an input data set.*
- **JPSS-PS-R 4.3.12:** *The JPSS RR Ice Age shall use Global 1 km land/water & coast mask used for MODIS collection 5 as an input data set.*
- **JPSS-PS-R 4.3.13:** *The JPSS RR Ice Age shall use NWP Derived surface air temperature, surface air pressure, surface air moisture, surface wind speed, snow cover, and snow depth as an input data set.*

Basic Requirement 4.0

- **JPSS-PS-R 4.3.14:** *The JPSS RR Ice Age shall use Ice concentration and Ice cover produced by JPSS RR ice concentration/cover algorithm as an input data set.*

- **JPSS-PS-R 4.3.15:** *The JPSS RR Ice Age shall use Ice surface skin temperature produced by JPSS RR ice surface temperature algorithm as an input data set.*

- **JPSS-PS-R 4.3.16:** *The JPSS RR Ice Age shall use Cloud mask produced by JPSS RR cloud mask algorithm as an input data set.*

Basic Requirement 4.0

- **JPSS-PS-R 4.3.17:** *The JPSS RR Ice Age shall use Parameterization File to represent the VIIRS Surface Solar Radiation as an input data set.*

- **JPSS-PS-R 4.3.18:** *The JPSS RR Ice Age shall use Parameterization File to represent the VIIRS Surface Thermal Radiation as an input data set.*

- **JPSS-PS-R 4.3.19:** *The JPSS RR Ice Age shall use Parameterization File to represent the VIIRS Surface Broadband Albedo as an input data set.*

Basic Requirement 4.0

- **JPSS-RRPS-R 4.4:** *The Cryosphere Products shall include Ice Surface Temperature Product.*

- **JPSS-PS-R 4.4.1:** *The Ice Surface Temperature Product shall have priority of JPSS 4.*

- **JPSS-PS-R 4.4.2:** *The Ice Surface Temperature Product shall have Horizontal Cell Size of 0.75 km.*

➢ Continuity with GOES-R product, upgraded VIIRS capability

Basic Requirement 4.0

- **JPSS-PS-R 4.4.3:** *The Ice Surface Temperature Product shall have global coverage.*

- **JPSS-PS-R 4.4.4:** *The Ice Surface Temperature Product shall have latency of 30 minutes after granule data is available.*
  - » Latency is defined as the interval from the last observation to when the product is available to users. Current capability is 60 minutes.

➢ Continuity with GOES-R product, upgraded VIIRS capability

Basic Requirement 4.0

- **JPSS-PS-R 4.4.5:** *The Ice Surface Temperature Product shall have timeliness of ≤ 3 hours.*

- **JPSS-PS-R 4.4.6:** *The Ice Surface Temperature Product shall have Product Refresh Rate of:*
  - » *Threshold - at least 90% coverage of the globe every 12 hours (monthly average).*
  - » *Objective – 12 hrs;*

- **JPSS-PS-R 4.4.7:** *The Ice Surface Temperature Product shall have Sensing Depth of Ice Surface.*

➢ Continuity with GOES-R product, upgraded VIIRS capability

Basic Requirement 4.0

- **JPSS-PS-R 4.4.8:** *The Ice Surface Temperature Product shall have Mapping Uncertainty, 3 Sigma of:*
  - » *Threshold*
    1. *Nadir - 1km*
    2. *Worst Case – 1.6 km*
  - » *Objective*
    1. *Nadir - 0.1km*
    2. *Worst Case – 0.1 km*

➢ Continuity with GOES-R product, upgraded VIIRS capability

Basic Requirement 4.0

- **JPSS-PS-R 4.4.9:** *The Ice Surface Temperature Product shall have Measurement Range of:*
  - » *Threshold*

    213 - 275 K
  - » *Objective-*

    213 - 293 K (2 m above ice)

- **JPSS-PS-R 4.4.10:** *The Ice Surface Temperature Product shall have Measurement Uncertainty of 1K.*

➢ Continuity with GOES-R product, upgraded VIIRS capability

Basic Requirement 4.0

- **JPSS-PS-R 4.4.11:** *The JPSS RR Ice Surface Temperature shall use VIIRS calibrated and navigated Brightness Temperature in Channels M15 and M16 with solar and satellite view angles as an input data set.*
- **JPSS-PS-R 4.4.12:** *The JPSS RR Ice Surface Temperature shall use global 1 km land/water & coast mask used for MODIS collection 5 as an input data set.*
- **JPSS-PS-R 4.4.13:** *The JPSS RR Ice Surface Temperature shall use Cloud mask produced by JPSS RR cloud mask algorithm as an input data set.*
- **JPSS-PS-R 4.4.14:** *The JPSS RR Ice Surface Temperature shall use Ice concentration and Ice cover produced by JPSS RR ice concentration/cover algorithm as an input data set.*

Basic Requirement 4.0

- **JPSS-RRPS-R 4.5:** *The Cryosphere Products shall include quality information.*
  - » QC flags will be specified in the External Users Manual.

- **JPSS-RRPS-R 4.6:** *The JPSS RRPS shall write Cryosphere Products files in NetCDF4 formats.*
  - » SPSRB requirement.

Basic Requirement 4.0

- **JPSS-RRPS-R 4.7:** *The JPSS RRPS system shall perform validation and verification of the Cryosphere Products.*
  - » Validation tools will be based upon the GOES-R validation tools

- **JPSS-RRPS-R 4.7.1:** *The JPSS RRPS system shall plot datasets for verification of the Cryosphere Products.*

Basic Requirement 4.0

- **JPSS-RRPS-R 4.7.2:** *The JPSS RRPS system shall verify that Cryosphere Products files are generated correctly.*
  - » Will be included in the unit tests described in the UTR and the system test described in the SRR
- **JPSS-RRPS-R 4.7.3:** *The JPSS RRPS system shall perform routine data range checks to flag anomalous values in the input data.*
  - » Anomalous values will be flagged. These checks will be included in the codeand described in the SRR.

Basic Requirement 4.0

- **JPSS-PS-R .4.7.4:** *The JPSS RRPS system shall perform routine data range checks to flag anomalous values in the Cryosphere Products.*
  - » Out-of-range values will be flagged. These checks will be included in the code. UTR will address

- **JPSS-RRPS-R 4.7.5:** *The JPSS PS system shall generate matchup datasets between Cryosphere Products retrievals and in situ measurements.*
  - » In situ data obtained from NCEP & ECMWF analysis, AMSR-E products, Upward Looking Sonar data, Canadian Ice Service measurements and Buoy data.

Basic Requirement 5.0

- **JPSS-RRPS-R 5.0:** *The JPSS PS system shall have a data ingest capability.*

  » **Driver:**

  – This basic requirement is traced to algorithm input needs, as documented in the Algorithm Theoretical Basis Documents (ATBDs).

Basic Requirement 5.0

- **JPSS-RRPS-R 5.1:** *The JPSS PS system shall ingest NPP VIIRS L1 data.*

    » Required algorithm input. Ingest from the IDPS. Data link for development is established by NDE.

Basic Requirement 6.0

- **JPSS-RRPS-R 6.0:** *The GOES-R algorithms to generate a retrieval of Cloud Products, Aerosol Products, Volcanic Ash Products, and Cryosphere Products shall be modified.*

  » **Driver:**

  – This basic requirement is traced to user needs for Cloud, Aerosol, Volcanic Ash, and Cryosphere products.

Basic Requirement 6.0

- **JPSS-RRPS-R 6.1:** *The JPSS RRPS Algorithms shall be implemented by processing codes written in C, C++ and Fortran 90.*
  - » *Adaptation of current algorithm/framework code.*

- **JPSS-RRPS-R 6.1.1:** *The JPSS RRPS processing code shall be able to run in the STAR Development Environment (Linux with 12 dual core 2.33 GHz CPUs.*
  - » *S/W: Intel and GNU Compilers (C/C++/Fortran) and IDL for Validation*
  - » *Storage: 100 TB)*
  - » C code, C++ code, and Fortran code can run in this environment

Basic Requirement 6.0

- **JPSS-RRPS-R 6.1.2:** *The JPSS RRPS processing code shall be able to run in the NDE 2.0 Test Environment (Linux machine with 6 quad core 3.2 GHz CPUs*
  - » *S/W: Intel and GNU Compilers (C/C++/Fortran) and IDL for Validation*
  - » *Storage: 30 TB)*
  - » *C code, C++ code, and Fortran code can run in this environment*

- **JPSS-RRPS-R 6.1.3:** *The JPSS RRPS processing code shall be able to run in the OSPO Operations Environment: (Linux machine with 6 quad core 3.2 GHz CPUs*
  - » *S/W: Intel and GNU Compilers (C/C++/Fortran) and IDL for Validation*
  - » *Storage: 30 TB)*
  - » *C code, C++ code, and Fortran code can run in this environment*

Basic Requirement 7.0

- **JPSS-RRPS-R 7.0:** *The JPSS RRPS system shall generate metadata for each retrieved product.*

  » **Driver:**
    - *Metadata will be used by the Product Monitoring Project*

Basic Requirement 7.0

- **JPSS-RRPS-R 7.1:** *The JPSS RRPS system shall write a metadata text files associated with the retrieved products.*
  - » Coordinate with the Product Monitoring Project.

- **JPSS-RRPS-R 7.1.1:** *The metadata shall include overall quality and summary level metadata.*
  - » Coordinate with the Product Monitoring Project.

Basic Requirement 7.0

- **JPSS-RRPS-R 7.1.2:** *The metadata shall include Granule metadata.*
  - » Coordinate with the Product Monitoring Project.
- **JPSS-RRPS-R 7.1.3:** *The metadata shall include product specific metadata.*
  - » Coordinate with the Product Monitoring Project.

Basic Requirement 8.0

- **JPSS-RRPS-R 8.0:** *The JPSS RRPS system shall have QC monitoring capability.*

  - **Driver:**
    - This basic requirement is traced to an OSPO need for QC monitoring.

Basic Requirement 8.0

- **JPSS-RRPS-R 8.1:** *The JPSS RRPS Product files shall include overall quality control flags and quality summary level metadata.*
  - » Needed for distribution, quality control and post-processing. JPSS PS code will generate metadata for this purpose.

- **JPSS-RRPS-R 8.2:** *The JPSS RRPS system shall be capable of monitoring input data latency and overall quality.*
  - » Need to import metadata from input file and create code for generating metadata.

Basic Requirement 8.0

- **JPSS-RRPS-R 8.3:** *The JPSS RRPS system shall be capable of monitoring product latency.*
  - » Run status file will include processing time.

- **JPSS-RRPS-R 8.4:** *The JPSS RRPS system shall produce real-time imagery for visual inspection of output files.*
  - » Will be done with IDL.

Basic Requirement 8.0

- **JPSS-RRPS-R 8.5:** *The JPSS RRPS system shall be capable of monitoring product distribution status to ensure that the data/products are successfully available for transfer to the user community.*
  - » A run status file will be produced. Work with OSPO to determine needs.

- **JPSS-RRPS-R 8.5.1:** *Each run status file shall include all runtime error messages.*
  - » Error messages will include system messages and error conditions written by the code.

Basic Requirement 8.0

- **JPSS-RRPS-R 8.5.2:** *Each run status file shall indicate whether or not the run was completed without error.*
  - » Code will write this message. This indication will be the last message in the file, so that operators can find it easily.

- **JPSS-RRPS-R 8.6:** *The JPSS PS system shall write a log file for each production run.*
  - » Used by OSPO for QC monitoring and troubleshooting.

Basic Requirement 9.0

- **JPSS-RRPS-R 9.0:** *The JPSS PS shall produce a fully functional pre-operational system in the STAR Development Environment.*

  » **Driver:**

  – This basic requirement is traced to an NDE need for a unit-tested, fully functional system delivered to its Test Environment.

Basic Requirement 9.0

- **JPSS-RRPS-R 9.1:** *The STAR Development Environment shall be capable of hosting the conversion of JPSS RRPS science code to JPSS RRPS pre-operational code.*
  - » See derived requirements 9.1.x.

- **JPSS-RRPS-R 9.1.1:** *The STAR Development Environment shall include the INTEL FORTRAN 90/95 compiler and GNU FORTRAN 90/95 compiler.*
  - » Needed for the Framework FORTRAN code. Development Environment servers have this.

Basic Requirement 9.0

- **JPSS-RRPS-R 9.1.2:** *The STAR Development Environment shall include the INTEL C compiler and the GNU C compiler.*
  - » Needed for the Framework C code. Development Environment servers have this.

- **JPSS-RRPS-R 9.1.3:** *The STAR Development Environment shall include the INTEL C++ compiler and the GNU C++ compiler.*
  - » Needed for the Framework C++ code. Development Environment servers have this.

Basic Requirement 9.0

- **JPSS-RRPS-R 9.1.4:** *The STAR Development Environment shall include Linux machine with 100TB of disk storage.*
  - » Development Environment servers have this.

- **JPSS-RRPS-R 9.2:** *The STAR Development Environment shall be capable of hosting unit tests and a system test.*
  - » Unit tests and system test required prior to delivery of pre-operational system to OSPO.

Basic Requirement 9.0

- **JPSS-RRPS-R 9.2.1:** *The STAR Development Environment shall have access to the OSPO DDS/PDA server.*
  - » For ingest of JPSS VIIRS RR products.

- **JPSS-RRPS-R 9.2.2:** *The STAR Development Environment shall have access to the GRAVITE server.*
  - » For ingest of JPSS VIIRS SDR data.

Basic Requirement 9.0

- **JPSS-RRPS-R 9.3:** *The STAR Development Environment shall host the pre-operational system.*
  - » For development and unit testing. Complete unit test of the pre-operational system is expected before delivery to NDE.

- **JPSS-RRPS-R 9.3.1:** *The pre-operational system shall include all processing code and ancillary files needed to conduct unit tests.*
  - » Complete unit test of the pre-operational system is expected before delivery to NDE. The UTRR will provide a detailed description of the source code units and ancillary files.

Basic Requirement 9.0

- **JPSS-RRPS-R 9.3.2:** *The pre-operational system shall include all input test data needed to conduct unit tests.*
  - » Complete unit test of the pre-operational system is expected before delivery to NDE. The UTRR will provide a detailed description of the unit test data.

- **JPSS-RRPS-R 9.3.3:** *The JPSS RRPS pre-operational system baseline shall be established and maintained with the Clear Case CM tool.*
  - » CM of the pre-operational system is expected throughout its development.

Basic Requirement 10.0

- **JPSS-RRPS-R 10.0:** *The JPSS RRPS integrated pre-operational system shall be transitioned from the STAR Development Environment to the NDE 2.0 Test Environment.*

  » **Driver:**
    - This basic requirement is traced to an NDE need for a system-tested, integrated pre-operational system delivered to its Test Environment.

Basic Requirement 10.0

- **JPSS-RRPS-R 10.1:** *The STAR Development Environment shall host the JPSS RRPS integrated pre-operational system.*
  - » For system testing. A complete system test of the integrated pre-operational system is expected before delivery to NDE.

- **JPSS-RRPS-R 10.1.1:** *The integrated pre-operational system shall include all processing code and ancillary files needed to conduct the system test.*
  - » Complete system test of the integrated pre-operational system is expected. The ARR will provide a description of the processing software system and ancillary files.

Basic Requirement 10.0

- **JPSS-RRPS-R 10.1.2:** *The integrated pre-operational system shall include all input data needed to conduct a system test.*
  - » Complete system test of the integrated pre-operational system is expected. The ARR will provide a description of the system test data.

- **JPSS-RRPS-R 10.1.3:** *The integrated pre-operational system shall include all output data produced by the system test.*
  - » Needed by NDE to verify the system test in its Test Environment. Comparison of outputs from system test in STAR and NDE 2.0 environments will be part of the NDE system test. Specific items will be listed in the ARR.

Basic Requirement 10.0

- **JPSS-RRPS-R 10.1.4:** *The JPSS RRPS integrated pre-operational system baseline shall be established and maintained with the Clear Case CM tool.*
  - » CM of the integrated pre-operational system is expected throughout its development.

Basic Requirement 10.0

- **JPSS-RRPS-R 10.2:** *The integrated pre-operational system shall be delivered to NDE via SADIE as a Delivered Algorithm Package (DAP).*
  - » NDE needs to reproduce the system test in its Test Environment.

- **JPSS-RRPS-R 10.2.1:** *The JPSS RRPS development team shall ensure that the NDE PAL has the information needed to acquire the JPSS RRPS DAP from SADIE.*
  - » Use of SADIE ensures this.

Basic Requirement 11.0

- **JPSS-RRPS-R 11.0:** *STAR shall deliver a JPSS RRPS document package to OSPO.*

  » **Driver:**

  – This basic requirement is traced to an OSPO need for documentation to support operations, maintenance, and distribution.

Basic Requirement 11.0

- **JPSS-RRPS-R 11.1:** *The JPSS RRPS document package shall include a README text file.*

- **JPSS-RRPS-R 11.1.1:** *The README file shall list each item in the final pre-operational system baseline, including code, test data, and documentation.*
  - » All required deliverable items must be correctly identified

Basic Requirement 11.0

- **JPSS-RRPS-R 11.2:** *The JPSS RRPS document package shall include a Review Item Disposition (RID) document.*

- **JPSS-RRPS-R 11.2.1:** *The RID shall describe the final status of all development project tasks, work products, and risks.*
  - » Supports the final Algorithm Readiness Review Report (ARRR)

Basic Requirement 11.0

- **JPSS-RRPS-R 11.3:** *The JPSS RRPS document package shall include an Algorithm Theoretical Basis Document (ATBD).*
  - » The ATBD will follow SPSRB Version 2 document standards
- **JPSS-RRPS-R 11.4:** *The JPSS RRPS document package include a Requirements Allocation Document (RAD).*
  - » The RAD will follow document standards stated in EPL v3 process asset DG-6.2

Basic Requirement 11.0

- **JPSS-RRPS-R 11.5:** *The JPSS RRPS document package shall include a System Maintenance Manual (SMM).*
  - » The SMM will follow SPSRB Version 2 document standards.

- **JPSS-RRPS-R 11.6:** *The JPSS RRPS document package shall include an External Users Manual (EUM).*
  - » The EUM will follow SPSRB Version 2 document standards.

Basic Requirement 11.0

- ~~**JPSS-RRPS-R 11.7:** *The JPSS RRPS document package shall include an Internal Users Manual (IUM).*~~
  - » ~~The IUM will follow SPSRB Version 2 document standards.~~

- **JPSS-RRPS-R 11.8:** *The JPSS RRPS document package shall include a Critical Design Document (CDD).*
  - » The CDD will follow STAR EPL document standards in DG-8.2 and DG-8.2.A.

Basic Requirement 11.0

- **JPSS-RRPS-R 11.9:** *The JPSS RRPS document package shall include a Code Test Document (CTD).*
  - » The CTD will follow STAR EPL document standards in DG-10.3 and DG-10.3.A.

- **JPSS-RRPS-R 11.10:** *The JPSS RRPS document package shall include a System Readiness Document (SRD).*
  - » The SRD will follow STAR EPL document standards in DG-11.5 and DG-11.5.A.

Basic Requirement 11.0

- **JPSS-RRPS-R 11.11:** *The JPSS RRPS document package shall include a System Readiness Review Report (SRRR).*
  - » The SRRR will follow document standards stated in EPL v3 process asset DG-11.6

- **JPSS-RRPS-R 11.11.1:** *The SRRR shall document the approved readiness of the JPSS RRPS system for transition to operations.*
  - » This is an SRR exit criteria item

Basic Requirement 12.0

- **JPSS-RRPS-R 12.0:** *The JPSS RRPS system shall undergo an OSPO Code Review Security for security compliance*

  » **Driver:**
  - OSPO Security

Basic Requirement 12.0

- **JPSS-RRPS-R 12.1:** *The JPSS RRPS system shall comply with OSPO data integrity check list.*
  - » OSPO data integrity check list is part of the OSPO Code Review Security check lists.

- **JPSS-RRPS-R 12.2:** *The JPSS RRPS system shall comply with OSPO development security check list.*
  - » OSPO development security check list is part of the OSPO Code Review Security check lists.

Basic Requirement 12.0

- **JPSS-RRPS-R 12.3:** *The JPSS RRPS system shall comply with OSPO code check list.*
  - » OSPO code check list is part of the OSPO Code Review Security check lists.

Basic Requirement 13.0

- **JPSS-RRPS-R 13.0:** *The IT resource needs for operations shall be specified.*

  - **Driver:**
    - OSPO IT Capacity Planning

Basic Requirement 13.0

- **JPSS-RRPS-R 13.1:** *The JPSS RRPS system shall run on Redhat Linux.*
  - » Servers are available.
- **JPSS-RRPS-R 13.2:** *Operational server shall have 30 TB of disk space.*
  - » Available servers have this capability.
- **JPSS-RRPS-R 13.3:** *Each operational server shall have 8 GB of RAM for each core.*
  - » Available servers have this capability.

JPSS RR Requirements shown with the JPSS L1RD Supplement Requirements

Cloud Mask

	JPSS L1RD	JPSS RRPS
Name	Cloud Mask	Cloud Mask
User & Priority	JPSS 3	JPSS 3
Geographic Coverage		Global coverage
Vertical Reporting Interval	N/A	N/A
Horizontal Cell Size	0.8 km at Nadir	0.75 km.
Mapping Uncertainty, 3 Sigma	4 km threshold; 1 km objective	4 km threshold; 1 km objective
Measurement Range	Cloudy/Not Cloudy	Cloudy/Not Cloudy
Measurement Accuracy	1. Ocean, Day, COT>1.0 – 94%; 2. Day, Land, COT>1.0 – 90%; 3. Ocean, Night, COT>1.0 – 85%; 4. Land, Night, COT>1.0- 88%;	90%
Product Refresh Rate	Threshold - At least 90% coverage of the globe every 12hours (monthly average); Objective – 4 hrs;	Threshold - At least 90% coverage of the globe every 12hours (monthly average); Objective – 4 hrs;
Cloud Leakage Rate	1. Ocean, Day, COT>1.0, outside Sun Glint region – 1%; 2. Day, Land, COT>1.0 – 3%; 3. Land, Ocean, Night, COT>1.0 – 5%	1. Ocean, Day, COT>1.0, outside Sun Glint region – 1%; 2. Day, Land, COT>1.0 – 3%; 3. Land, Ocean, Night, COT>1.0 – 5%
False Alarm Rate	1. Ocean, Day, COT>1.0- 5%; 2. Land, Day, ToC NDVI < 0.2 or ToC NDVI > 0.4, or Desert, COT > 1.0 – 7%; 3. Land, Ocean, Night, COT>1.0 – 8%;	1. Ocean, Day, COT>1.0- 5%; 2. Land, Day, ToC NDVI < 0.2 or ToC NDVI > 0.4, or Desert, COT > 1.0 – 7%; 3. Land, Ocean, Night, COT>1.0 – 8%;
Latency	96 min	30 minutes after granule data is available
Timeliness		≤ 3hours

Cloud Mask

Cloud Mask Applicable Conditions:

- 1. Requirements apply whenever detectable clouds are present.
- 2. Cloud Mask shall be computed and reported for the total cloud cover.

Cloud Top Phase

	JPSS L1RD	JPSS RRPS
Name	Cloud Phase	
User & Priority		
Geographic Coverage		Global coverage
Vertical Reporting Interval		
Horizontal Cell Size		0.75 km.
Mapping Uncertainty, 3 Sigma		
Measurement Range		
Measurement Accuracy		80% Correct Classification (7 phases)
Product Refresh Rate		Threshold - At least 90% coverage of the globe every 12 hours (monthly average); Objective – 4 hrs;
Latency		30 minutes after granule data is available
Timeliness		≤ 3hours

Cloud Type

	JPSS L1RD	JPSS RRPS
Name	Cloud Type	
User & Priority		
Geographic Coverage		Global coverage
Vertical Reporting Interval		
Horizontal Cell Size		0.75 km.
Mapping Uncertainty, 3 Sigma		
Measurement Range		
Measurement Accuracy		60%
Product Refresh Rate		Threshold - At least 90% coverage of the globe every 12 hours (monthly average); Objective – 4 hrs;
Latency		30 minutes after granule data is available
Timeliness		≤ 3hours

Cloud Top Height

	JPSS L1RD	JPSS RRPS
Name	Cloud Top Height	Cloud Top Height
User & Priority	JPSS 3	JPSS 3
Geographic Coverage		Global coverage
Vertical Reporting Interval	Threshold - Tops of up to four cloud layers (1); Objective - Tops of all distinct cloud layers	Threshold - Tops of up to three cloud layers (1); Objective - Tops of all distinct cloud layers
Horizontal Cell Size	Threshold – 7 km; Objective – 1 km;	0.75 km.
Mapping Uncertainty, 3 Sigma	Threshold 4 km; Objective 1 km;	Threshold 4 km; Objective 1 km;
Measurement Accuracy	Threshold – 1. COT ≥1 – 1.0 km; 2. COT < 1 – 2.0 km; Objective – 1. COT ≥ 1 – 0.3 km; 2. COT < 1 – 035 km;	500 m for Clouds with emissivity > 0.8
Product Refresh Rate	Threshold - At least 90% coverage of the globe every 12 hours (monthly average); Objective – 4 hrs;	Threshold - At least 90% coverage of the globe every 12hours (monthly average); Objective – 4 hrs;
Latency	96 min	30 minutes after granule data is available
Timeliness		≤ 3hours
Product Measurement Precision	Threshold – 1. COT ≥1 – 1.0 km; 2. COT < 1 – 2.0 km; Objective – 1. COT ≥ 1 – 0.15 km; 2. COT < 1 – 0.15 km;	Threshold – 1. COT ≥1 – 1.0 km; 2. COT < 1 – 2.0 km; Objective – 1. COT ≥ 1 – 0.15 km; 2. COT < 1 – 0.15 km;

Cloud Top Height (CTH)

CTH Applicable Conditions:

- 1. Requirements apply whenever detectable clouds are present.

Cloud Cover/Layers

	JPSS L1RD	JPSS RRPS
Name	Cloud Cover/Layers	Cloud Cover Layers
User & Priority	JPSS 3	JPSS 3
Geographic Coverage		Global
Vertical Reporting Interval	Threshold -Up to four cloud layers; Objective – 0.1 km;	Threshold -Up to three cloud layers; Objective – 0.1 km;
Horizontal Cell Size	Threshold – 7 km; Objective – 1 km;	0.75 km
Mapping Uncertainty, 3 Sigma	Threshold - 4 km; Objective - 1 km	Threshold - 4 km; Objective - 1 km
Measurement Range(Applies only to total cloud cover; Not applicable to layers)	Threshold - 0 to 1.0 HCS Area; Objective – 0 to 1.0;	Threshold - 0 to 1.0 HCS Area; Objective – 0 to 1.0;
Measurement Accuracy	0.1 + 0.3(TBR-7) sin (SZA) of HCS Area	80% Correct Classification (Low, Mid, High)
Product Refresh Rate	Threshold - At least 90% coverage of the globe every 12 hours (monthly average); Objective – 4 hrs;	Threshold - At least 90% coverage of the globe every 12 hours (monthly average); Objective – 4 hrs;
Latency	96 min	30 minutes after granule is available
Timeliness		≤ 3hours

Cloud Cover/Layers

CC/L Applicable Conditions:

- 1. Requirements apply whenever detectable clouds are present.
- 2. Cloud Cover shall be computed and reported at each separate, distinct layer,
- as well as for the total cloud cover.

Cloud Top Temperature

	JPSS L1RD	JPSS RRPS
Name	Cloud Top Temperature	Cloud Top Temperature
User & Priority	JPSS 4	JPSS 4
Geographic Coverage		Global coverage
Vertical Reporting Interval	Threshold – Tops of up to four cloud layers; Objective – Tops of all distinct cloud layers	Threshold – Tops of up to three cloud layers; Objective – Tops of all distinct cloud layers
Horizontal Cell Size	Threshold – 7 km; Objective – 1 km;	0.75 km.
Mapping Uncertainty, 3 Sigma	4 km threshold; 1 km objective	4 km threshold; 1 km objective
Measurement Range		
Measurement Accuracy	Threshold – 1. Optical thickness ≥ 1 – 3K; 2. Optical Thickness < 1 – 6K; Objective - 1. Optical thickness ≥ 1 – 1.5K; 2. Optical Thickness < 1 – 2K;	3 K for clouds with emissivity > 0.8
Product Refresh Rate	Threshold - At least 90% coverage of the globe every 12 hours (monthly average); Objective – 4 hrs;	Threshold - At least 90% coverage of the globe every 12 hours (monthly average); Objective – 4 hrs;
Latency	96 min	30 minutes after granule data is available
Timeliness		≤ 3hours
Product Measurement Precision	Threshold – 1. Optical thickness ≥ 1 – 3K; 2. Optical Thickness < 1 – 6K; Objective – N/A	Threshold – 1. Optical thickness ≥ 1 – 3K; 2. Optical Thickness < 1 – 6K; Objective – N/A

Cloud Top Temperature (CTT)

CTT Applicable Conditions:

- 1. Requirements apply whenever detectable clouds are present.

Cloud Top Pressure

	JPSS L1RD	JPSS RRPS
Name	Cloud Top Pressure	Cloud Top Pressure
User & Priority	JPSS 4	JPSS 4
Geographic Coverage		Global coverage
Vertical Reporting Interval	Threshold – Tops of up to four cloud layers	Threshold – Tops of up to three cloud layers
Horizontal Cell Size	Threshold – 7 km; Objective – 1 km;	0.75 km.
Mapping Uncertainty, 3 Sigma	4 km threshold; 1 km objective	4 km threshold; 1 km objective
Measurement Range	Cloudy/Not Cloudy	Cloudy/Not Cloudy
Measurement Accuracy	Threshold – COT ≥ 1 1. Surface to 3 km – 100 mb; 2. 3 to 7 – 75 mb; 3. > 7 km – 50 mb; Objective – 1. Surface to 3 km – 30 mb; 2. 3 to 7 – 22 mb; 3. > 7 km – 15 mb;	50 mb for clouds with emissivity > 0.8
Product Refresh Rate	Threshold - At least 90% coverage of the globe every 12 hours (monthly average); Objective – 4 hrs;	Threshold - At least 90% coverage of the globe every 12 hours (monthly average); Objective – 4 hrs;
Latency	96 min	30 minutes after granule data is available
Timeliness		≤ 3hours
Product Measurement Precision	Threshold – COT ≥ 1 1. Surface to 3 km – 100 mb; 2. 3 to 7 – 75 mb; 3. > 7 km – 50 mb; Objective – 1. Surface to 3 km – 10 mb; 2. 3 to 7 – 7 mb; 3. > 7 km – 5mb;	Threshold – COT ≥ 1 1. Surface to 3 km – 100 mb; 2. 3 to 7 – 75 mb; 3. > 7 km – 50 mb; Objective – 1. Surface to 3 km – 10 mb; 2. 3 to 7 – 7 mb; 3. > 7 km – 5mb;

Cloud Top Pressure (CTP)

CTP Applicable Conditions:

- 1. Requirements apply whenever detectable clouds are present.

Cloud Optical Thickness

	JPSS L1RD	JPSS RRPS
Name	Cloud Optical Thickness	Cloud Optical Thickness
User & Priority	JPSS 3	JPSS 3
Geographic Coverage		Global coverage
Vertical Reporting Interval	Threshold – up to four cloud layers; Objective – 4 layers;	Threshold – up to three cloud layers; Objective – 3 layers;
Horizontal Cell Size	Threshold – 7 km; Objective – N/S;	0.75 km.
Mapping Uncertainty, 3 Sigma	Threshold - 4 km; Objective - 1 km;	Threshold - 4 km; Objective - 1 km;
Measurement Range	Cloudy/Not Cloudy	Cloudy/Not Cloudy
Measurement Accuracy	Threshold – Greater of 24 % or 1 Tau Objective – 5%;	Liquid phase: 20% error (Day), 20% (Night); Ice phase: 20% Day), 30% (Night)
Product Refresh Rate	Threshold - At least 90% coverage of the globe every 12 hours (monthly average); Objective – 4 hrs;	Threshold - At least 90% coverage of the globe every 12 hours (monthly average); Objective – 4 hrs;
Latency	96 min	30 minutes after granule data is available
Timeliness		≤ 3hours
Product Measurement Precision	Threshold – Greater of 33 % or 1 Tau Objective – 2%;	Threshold – Greater of 33 % or 1 Tau Objective – 2%;

Cloud Optical Thickness (COT)

COT Applicable Conditions:

- 1. Requirements apply whenever detectable clouds are present.

Cloud Effective Particle Size

	JPSS L1RD	JPSS RRPS
Name	Cloud Effective Particle Size	Cloud Effective Particle Size
User & Priority	JPSS 3	JPSS 3
Geographic Coverage		Global coverage
Vertical Reporting Interval	Threshold – up to four cloud layers; Objective – 0.3 km;	Threshold – up to three cloud layers; Objective – 0.3 km;
Horizontal Cell Size	Threshold – 7 km; Objective – 1 km;	0.75 km.
Mapping Uncertainty, 3 Sigma	4 km threshold; 1 km objective	4 km threshold; 1 km objective
Measurement Range	Threshold - 0 to 50 μm; Objective – N/S	Threshold - 0 to 50 μm; Objective – N/S
Measurement Accuracy	Threshold – Greater of 22% or 1 μm for water; Greater of 28% or 1 μm for ice; Objective – 5%;	4 μm for liquid phase 10 μm for ice phase
Product Refresh Rate	Threshold - At least 90% coverage of the globe every 12 hours (monthly average); Objective – 4 hrs;	Threshold - At least 90% coverage of the globe every 12 hours (monthly average); Objective – 4 hrs;
Latency	96 min	30 minutes after granule data is available
Timeliness		≤ 3hours
Product Measurement Precision	Threshold – Greater of 22% or 1 μm for water; Greater of 28% or 1 μm for ice; Objective – 2%;	Threshold – Greater of 22% or 1 μm for water; Greater of 28% or 1 μm for ice; Objective – 2%;

Cloud Effective Particle Size (CEPS)

CEPS Applicable Conditions:

- 1. Requirements apply both day and night and whenever detectable clouds are present.

Cloud Liquid Water

	JPSS L1RD	JPSS RRPS
Name	Cloud Liquid Water	Cloud Liquid Water
User & Priority	JPSS 3	JPSS 3
Geographic Coverage		Global coverage
Vertical Reporting Interval	N/S	N/S
Horizontal Cell Size	Threshold m- 15 km @ nadir;	0.75 km.
Mapping Uncertainty, 3 Sigma	N/S	N/S
Measurement Range		
Measurement Accuracy	Threshold – Sea: 0.03 mm; Objective – Sea: 0.02 mm;	Greater of 25 g/m2 or 15% error
Product Refresh Rate	Threshold - At least 90% coverage of the globe every 12 hours (monthly average); Objective – N/S;	Threshold - At least 90% coverage of the globe every 12 hours (monthly average); Objective – N/S hrs;
Latency	96/130 min	30 minutes after granule data is available
Timeliness		≤ 3hours
Product Measurement Precision	Threshold –Sea: 0.08 mm; Objective – Sea: 0.06 mm;	Threshold –Sea: 0.08 mm; Objective – Sea: 0.06 mm;

Cloud Ice Water Path

	JPSS L1RD	JPSS RRPS
Name		Cloud Ice Water Path
User & Priority		
Geographic Coverage		Global coverage
Vertical Reporting Interval		
Horizontal Cell Size		0.75 km.
Mapping Uncertainty, 3 Sigma		
Measurement Range		
Measurement Accuracy		Greater of 25g/m2 or 30% error
Product Refresh Rate		Threshold - At least 90% coverage of the globe every 12 hours (monthly average); Objective – 4 hrs;
Latency		30 minutes after granule data is available
Timeliness		≤ 3hours

Aerosol Detection

	JPSS L1RD	JPSS RRPS
Name	Suspended Matter	Aerosol Detection
User & Priority	JPSS 2	JPSS 3
Geographic Coverage		Global coverage
Vertical Reporting Interval	Threshold: Total Column Objective: 0.2 km	Threshold: Total Column Objective: 0.2 km
Horizontal Cell Size	Theshold: 3 km Objective: 1 km	0.75 km.
Mapping Uncertainty, 3 Sigma	Threshold: 3 km Objective: 0.1 km	Threshold: 3 km Objective: 0.1 km
Measurement Range	Radioactive Smoke Plumes: 0 to 150 microg/m3	Smoke: 0 to 200 microg/m3
Measurement Accuracy	Threshold: Suspended Matter: 80% Dust: 80% Smoke: 70% Volcanic Ash: 60% Objective: Suspended Matter, Dust, Smoke, Volcanic Ash: 100% Mixed Aerosol: 80%	Dust: 80% correct detection over land and ocean Smoke: 80% Correct detection over land 70% correct detection over ocean
Product Refresh Rate	Threshold - At least 90% coverage of the globe every 24 hours (monthly average); Objective – 4 hrs;	Threshold - At least 90% coverage of the globe every 12 hours (monthly average); Objective – 4 hrs;
Latency	Threshold: 96 min Objective: 30 min	30 minutes after granule data is available
Timeliness		≤ 3hours

Aerosol Optical Thickness

	JPSS L1RD	JPSS RRPS
Name	Aerosol Optical Thickness	Aerosol Optical Depth
User & Priority	JPSS 4	JPSS 4
Geographic Coverage		Global coverage
Vertical Reporting Interval	Threshold - Total column; Objective - Total column	Threshold - Total column; Objective - Total column
Horizontal Cell Size	Threshold - 6 km (nadir); 12.8 km (Edge Of Scan); Objective – 1 km;	0.75 km (nadir)
Mapping Uncertainty, 3 Sigma	Threshold – 4 km; Objective – 1 km;	Threshold – 4 km; Objective – 1 km;
Measurement Range	Threshold – 0 to 2; Objective – 0 to 10;	Threshold – 0 to 2; Objective – 0 to 10;
Measurement Accuracy	Threshold – 1. Over Ocean - 0.08 (Tau < 0.3) 0.15 (Tau ≥ 0.3) (1,2,4); 2. Over Land – 0.06 (Tau < 0.1); 0.05 (0.1 ≤ Tau ≤ 0.8); 0.2 (Tau > 0.8) (1,2,4); Objective – 1. Over Ocean – 1%; 2. Over Land – 1%;	Based on Aerosol Optical Depth ranges: Over land: < 0.04: 0.06 0.04 – 0.80: 0.04 > 0.80: 0.12 Over water: < 0.40: 0.02 > 0.40: 0.10
Product Refresh Rate	Threshold - At least 90% coverage of the globe every 24 hours (monthly average); Objective – 4 hrs;	Threshold - At least 90% coverage of the globe every 12 hours (monthly average); Objective – 4 hrs;
Latency	96 min	30 minutes after granule data is available
Timeliness		≤ 3hours

Aerosol Optical Thickness (AOT)

AOT Applicable Conditions:

- 1. Clear, daytime only
- 2. Zenith angles less than or equal to 80 degrees.

Aerosol Particle Size Parameter

	JPSS L1RD	JPSS RRPS
Name	Aerosol Particle Size Parameter	Aerosol Particle Size
User & Priority	JPSS 4	JPSS 4
Geographic Coverage		Global coverage
Vertical Coverage	Threshold - Surface to 30 km; Objective - Surface to 50 km;	Threshold - Surface to 30 km; Objective - Surface to 50 km;
Vertical Cell Size	Threshold – Total Column; Objective – 0.25 km;	Threshold – Total Column; Objective – 0.25 km;
Horizontal Cell Size	Threshold - 6 km (nadir); 12.8 km (Edge Of Scan); Objective – 1 km;	0.75 km.
Mapping Uncertainty, 3 Sigma	Threshold – 4 km; Objective – 1 km;	Threshold – 4 km; Objective – 1 km;
Measurement Range	Threshold Operational -1 to +3 alpha units; Objective -2 to +4 alpha units;	Threshold Operational -1 to +3 alpha units; Objective -2 to +4 alpha units;
Measurement Accuracy	Operational over Ocean Threshold – 0.3 alpha units; Objective – 0.1 alpha units;	Fine/Coarse Angstrom exponent: 0.3 over ocean and land
Product Refresh Rate	Threshold - At least 90% coverage of the globe every 24 hours (monthly average); Objective – 4 hrs;	Threshold - At least 90% coverage of the globe every 12 hours (monthly average); Objective – 4 hrs;
Latency	96 min	30 minutes after granule data is available
Timeliness		≤ 3hours
Product Measurement Precision	Operational over Ocean Threshold – 0.3 alpha units; Objective – 0.1 alpha units;	Operational over Ocean Threshold – 0.3 alpha units; Objective – 0.1 alpha units;

Aerosol Particle Size Parameter (APSP)

APSP Applicable Conditions:

- 1. Clear, daytime only

Volcanic Ash and Height

	JPSS L1RD	JPSS RRPS
Name	Volcanic Ash	Volcanic Ash Detection (Mass Loading) and Height
User & Priority	JPSS 3	JPSS 3
Geographic Coverage		Global coverage
Vertical Cell Size	Threshold – Total Column; Objective – 0.2 km;	Threshold – Total Column; Objective – 0.2 km;
Horizontal Cell Size	Threshold - 3 km Objective – 1 km;	0.75 km.
Mapping Uncertainty, 3 Sigma	Threshold – 3 km; Objective – 0.1 km;	Threshold – 3 km; Objective – 0.1 km;
Measurement Range	N/S	N/S
Measurement Accuracy	Threshold –50%; Objective – 100%	2 tons/km2, 3 km height
Product Refresh Rate	Threshold - At least 90% coverage (product retrieval is attempted regardless of sky condition) of the globe ovr 24 hours (monthly average).Objective – 3 hrs;	Threshold - At least 90% coverage of the globe every 12 hours (monthly average); Objective – 3 hrs;
Latency	96 min	30 minutes after granule data is available
Timeliness		≤ 3hours

Volcanic Ash

Applicable Conditions:

- 1. Clear, for AOT greater than 0.15, daytime only.

Snow Cover

	JPSS L1RD	JPSS RRPS
Name	Snow Cover	Snow Cover
User & Priority	JPSS 3	JPSS 3
Geographic Coverage		Global coverage
Sensing Depth	Threshold – N/S; Objective – 1.0 m;	Threshold – N/S; Objective – 1.0 m;
Horizontal Cell Size	Threshold 1. Clear - 1.6 km EOS; 2. Cloudy and/or nighttime – N/S Objective – 1. Clear - 1.0 km; 2. Cloudy and/or nighttime – 1.0 km	0.375 km.
Mapping Uncertainty, 3 Sigma	Threshold 1. clear – 3km; 2. Cloudy – N/S Objective 1. Clear – 1 km; 2. Cloudy – 1km;	Threshold 1. clear – 3km; 2. Cloudy – N/S Objective 1. Clear – 1 km; 2. Cloudy – 1km;
Measurement Range	0 or 1 BSC mask	0 or 1 BSC mask
Measurement Accuracy	Threshold 1. Clear: 90% probability of correct snow/no-snow classification (2,3); 2. Cloudy – N/S Objective 1. Clear: 90% probability of correct BSC snow/no snow classification (VIIRS); 2. Cloudy: N/S	90% correct classification
Product Refresh Rate	Threshold - At least 90% coverage of the globe every 24 hours (monthly average).Objective – 3 hrs;	Threshold - At least 90% coverage of the globe every 12 hours (monthly average); Objective – 3 hrs;
Latency	96/130 min	30 minutes after granule data is available
Timeliness		≤ 3hours

Fractional Snow Cover

	JPSS L1RD	JPSS RRPS
Name	Fractional Snow Cover	Fractional Snow Cover
User & Priority	JPSS 3	JPSS 3
Geographic Coverage		Global coverage
Sensing Depth	Threshold – N/S; Objective – 1.0 m;	Threshold – N/S; Objective – 1.0 m;
Horizontal Cell Size	Threshold 1. Clear - 1.6 km EOS; 2. Cloudy and/or nighttime – N/S Objective – 1. Clear - 1.0 km; 2. Cloudy and/or nighttime – 1.0 km	0.375 km.
Mapping Uncertainty, 3 Sigma	Threshold 1. clear – 3km; 2. Cloudy – N/S Objective 1. Clear – 1 km; 2. Cloudy – 1km;	Threshold 1. clear – 3km; 2. Cloudy – N/S Objective 1. Clear – 1 km; 2. Cloudy – 1km;
Measurement Range	0 - 100% HSC area fraction;	0 - 100% HSC area fraction;
Measurement Uncertainty	Threshold 1. Clear: 10% of FSC area; 2. Cloudy – N/S Objective 1. Clear: 10% for snow depth (microwave instrument) 2. Cloudy: 10% for snow depth	10% of FSC area
Product Refresh Rate	Threshold - At least 90% coverage of the globe every 24 hours (monthly average).Objective – 3 hrs;	Threshold - At least 90% coverage of the globe every 12 hours (monthly average); Objective – 3 hrs;
Latency	96/130 min	30 minutes after granule data is available
Timeliness		≤ 3hours

Snow Cover

Snow Cover Applicable Conditions:

- 1. Clear Daytime, only

Sea Ice Concentration

	JPSS L1RD	JPSS RRPS
Name	Sea Ice Concentration	Ice Concentration
User & Priority	JPSS 3	JPSS 3
Geographic Coverage	All ice-covered regions of the global ocean	Global coverage
Vertical Coverage	Ice surface	Ice Surface
Horizontal Cell Size	Threshold 1. Clear - 1km 2. All weather – No capability Objective 1. Clear – 0.5 km 2. All weather - 1 km	0.75 km.
Mapping Uncertainty, 3 Sigma	Threshold 1. Clear - 1km @ nadir 2. Cloudy -No capability Objective 1. Clear – 0.5 km 2. Cloudy - 1 km	Threshold 1. Clear - 1km @ nadir 2. Cloudy -No capability Objective 1. Clear – 0.5 km 2. Cloudy - 1 km
Measurement Range	0/10 to 10/10	0/10 to 10/10
Measurement Uncertainty	Threshold Note 1 Objective 5%	10%
Product Refresh Rate	Threshold - At least 90% coverage of the globe every 24 hours (monthly average). Objective 6 hrs	Threshold - At least 90% coverage of the globe every 12 hours (monthly average); Objective – 6 hrs;
Cloud Leakage Rate	1. Ocean, Day, COT>1.0, outside Sun Glint region – 1%; 2. Day, Land, COT>1.0 – 3%; 3. Land, Ocean, Night, COT>1.0 – 5%	1. Ocean, Day, COT>1.0, outside Sun Glint region – 1%; 2. Day, Land, COT>1.0 – 3%; 3. Land, Ocean, Night, COT>1.0 – 5%
Latency	96 / 130 min	30 minutes after granule data is available
Timeliness		≤ 3hours

Ice Age

	JPSS L1RD	JPSS RRPS
Name	Ice Age	Ice Age
User & Priority	JPSS 3	JPSS 3
Geographic Coverage	All ice-covered regions of the global ocean	Global coverage
Vertical Coverage	Ice surface	Ice Surface
Horizontal Cell Size	Threshold 1. Clear - 1km 2. All weather – No capability Objective 1. Clear – 0.5 km 2. All weather -1 km	0.75 km.
Mapping Uncertainty, 3 Sigma	Threshold 1. Clear - 1km @ nadir 2. Cloudy -No capability Objective 1. Clear – 0.5 km 2. Cloudy - 1 km	Threshold 1. Clear - 1km @ nadir 2. Cloudy -No capability Objective 1. Clear – 0.5 km 2. Cloudy - 1 km
Measurement Range	Threshold- Ice free, New/Young Ice, all other ice; Objective- Ice Free, Nilas, Grey White, Grey, White, First Year Medium, First Year Thick, Second Year, and Multiyear; Smooth and Deformed Ice	Threshold- Ice free, New/Young Ice, all other ice; Objective- Ice Free, Nilas, Grey White, Grey, White, First Year Medium, First Year Thick, Second Year, and Multiyear; Smooth and Deformed Ice
Measurement Uncertainty	Threshold -70% Objective - 90%	80% correct classification (Ice free areas, First year ice, Older ice)
Product Refresh Rate	Threshold - At least 90% coverage of the globe every 24 hours (monthly average). Objective - 6 hrs	Threshold - At least 90% coverage of the globe every 12 hours (monthly average); Objective – 6 hrs;
Latency	96/130 min	30 minutes after granule data is available
Timeliness		≤ 3hours

Ice Surface Temperature

	JPSS L1RD	JPSS RRPS
Name	Ice Surface Temperature	Ice Surface Temperature
User & Priority	JPSS 4	JPSS 4
Geographic Coverage	Threshold - Ice-covered oceans (1) Objective - All ice-covered waters.	Global coverage
Sensing Depth	Ice Surface	Ice Surface
Horizontal Cell Size	Threshold 1. Nadir - 1km 2. Worst Case –1.6 km Objective 1. Nadir - 0.1km 2. Worst Case – 0.1 km	0.75 km.
Mapping Uncertainty, 3 Sigma	Threshold 1. Nadir - 1km 2. Worst Case – 1.6 km Objective 1. Nadir - 0.1km 2. Worst Case – 0.1 km	Threshold 1. Nadir - 1km 2. Worst Case – 1.6 km Objective 1. Nadir - 0.1km 2. Worst Case – 0.1 km
Measurement Range	Threshold- 213 - 275 K Objective- 213 - 293 K (2 m above ice)	Threshold- 213 - 275 K Objective- 213 - 293 K (2 m above ice)
Measurement Uncertainty	Threshold - 1K Objective - N/S	1K
Product Refresh Rate	Threshold - At least 90% coverage of the globe every 24 hours (monthly average). Objective 12 hrs	Threshold - At least 90% coverage of the globe every 12 hours (monthly average); Objective – 12 hrs;
Latency	96 min	30 minutes after granule data is available
Timeliness		≤ 3hours

JPSS RRPS System Requirements – Summary

- The JPSS Risk Reduction System Requirements have been established.
- The Requirements have been documented in the Requirements Allocation Document (RAD).
- The Requirements are traceable to drivers (customer needs or expectations) and other requirements.

Outline

- Introduction
- Requirements
- Operations Concept
- Fractional Snow Cover
- Detailed Design
- Algorithm Package
- Quality Assurance
- Risks and Actions Summary
- Summary and Conclusions

Operations Concept

Presented by

Walter Wolf

Operations Concept - Overview

- Identify intentions of the customers/users of the products
  - Identify the SPSRB user requests
    - 1107-0011: Gridded Cloud Products for NWP Verification
    - 0909-0018: CLAVR-x and GSIP cloud product composites over Alaska
    - 0507-05: Polar/Geostationary Volcanic Ash Detection and Height on CLAVR-X
    - 1009-0016: Dust Aerosol Concentration Product
    - 0707-0014: Support satellite-based verification of the National Air Quality Forecast Capability
    - 0403-1: CrIS/ATMS Products for NWS
    - 0707-0018 "Add 4 new capabilities to IMS snow cover analysis"
  - Interact with the customers/users to produce an initial algorithm/system design that is consistent with their concept of operations

Operations Concept - Overview

- Review the answers to the following questions based on customer/user needs and expectations and production constraints
  - » What is the product?
  - » Why is this product being produced?
  - » How will this product be used?
  - » How should this product be produced (operational scenario)?
- The operations concept will be refined by the JPSS Risk Reduction Product Team (IPT), in consultation with customers/users, as the product solution and design are matured through the design development phase.

What is the Product?

- Cloud Mask
- Cloud Top Phase
- Cloud Type
- Cloud Top Height
- Cloud Cover Layers
- Cloud Top Temperature
- Cloud Top Pressure
- Cloud Optical Depth
- Cloud Particle Size Distribution
- Cloud Liquid Water
- Cloud Ice Water Path

What is the Product?

- Aerosol Detection
- Aerosol Optical Depth
- Aerosol Particle Size
- Volcanic Ash Mass Loading
- Volcanic Ash Height

What is the Product?

- Snow Cover
- Fractional Snow Cover
- Ice Concentration
- Ice Age
- Ice Surface Temperature

What is the Product - Cont.

					Product Type and Number					
Fiscal Year (FY)	Product Delivery/Tracking Name	Environmental Observational Parameters	Satellites	Sensors	N #	E #	R #	T #	O #	Tailoring Options or Comments
FY15	JPSS Risk Reduction	Cloud Mask	NPP	VIIRS	1					Formats: NetCDF4, Coverage: Granule Update Cycle: 87 seconds
FY15	JPSS Risk Reduction	Cloud Phase	NPP	VIIRS	1					Formats: NetCDF4, Coverage: Granule Update Cycle: 87 seconds
FY15	JPSS Risk Reduction	Cloud Cover Layers	NPP	VIIRS	1					Formats: NetCDF4, Coverage: Granule Update Cycle: 87 seconds
FY15	JPSS Risk Reduction	Cloud Height	NPP	VIIRS	1					Formats: NetCDF4, Coverage: Granule Update Cycle: 87 seconds
FY15	JPSS Risk Reduction	Cloud Top Pressure	NPP	VIIRS	1					Formats: NetCDF4, Coverage: Granule Update Cycle: 87 seconds
FY15	JPSS Risk Reduction	Cloud Top Temperature	NPP	VIIRS	1					Formats: NetCDF4, Coverage: Granule Update Cycle: 87 seconds
FY15	JPSS Risk Reduction	Cloud Type	NPP	VIIRS	1					Formats: NetCDF4, Coverage: Granule Update Cycle: 87 seconds

What is the Product - Cont.

					Product Type and Number					
Fiscal Year (FY)	Product Delivery/Tracking Name	Environmental Observational Parameters	Satellites	Sensors	N #	E #	R #	T #	O #	Tailoring Options or Comments
FY15	JPSS Risk Reduction	Cloud Optical Depth	NPP	VIIRS	1					Formats: NetCDF4, Coverage: Granule Update Cycle: 87 seconds
FY15	JPSS Risk Reduction	Cloud Particle Size Distribution	NPP	VIIRS	1					Formats: NetCDF4, Coverage: Granule Update Cycle: 87 seconds
FY15	JPSS Risk Reduction	Cloud Ice Water Path	NPP	VIIRS	1					Formats: NetCDF4, Coverage: Granule Update Cycle: 87 seconds
FY15	JPSS Risk Reduction	Cloud Liquid Water Path	NPP	VIIRS	1					Formats: NetCDF4, Coverage: Granule Update Cycle: 87 seconds
FY15	JPSS Risk Reduction	Aerosol Detection	NPP	VIIRS	1					Formats: NetCDF4, Coverage: Granule Update Cycle: 87 seconds
FY15	JPSS Risk Reduction	Aerosol Optical Depth	NPP	VIIRS	1					Formats: NetCDF4, Coverage: Granule Update Cycle: 87 seconds
FY15	JPSS Risk Reduction	Aerosol Particle Size	NPP	VIIRS	1					Formats: NetCDF4, Coverage: Granule Update Cycle: 87 seconds
FY15	JPSS Risk Reduction	Volcanic Ash Detection & Height	NPP	VIIRS	1					Formats: NetCDF4, Coverage: Granule Update Cycle: 87 seconds

What is the Product - Cont.

					Product Type and Number					
Fiscal Year (FY)	Product Delivery/Tracking Name	Environmental Observational Parameters	Satellites	Sensors	N #	E #	R #	T #	O #	Tailoring Options or Comments
FY15	JPSS Risk Reduction	Snow Mask	NPP	VIIRS	1					Formats: NetCDF4, Coverage: Granule Update Cycle: 87 seconds
FY15	JPSS Risk Reduction	Snow Fraction	NPP	VIIRS	1				1	Formats: NetCDF4, Coverage: Granule Update Cycle: 87 seconds
FY15	JPSS Risk Reduction	Ice Concentration	NPP	VIIRS	1					Formats: NetCDF4, Coverage: Granule Update Cycle: 87 seconds
FY15	JPSS Risk Reduction	Ice Age/Thickness	NPP	VIIRS	1					Formats: NetCDF4, Coverage: Granule Update Cycle: 87 seconds
FY15	JPSS Risk Reduction	Ice Surface Temperature	NPP	VIIRS	1					Formats: NetCDF4, Coverage: Granule Update Cycle: 87 seconds

N=New E=Enhanced R=Replacement T=Tailored O=Other

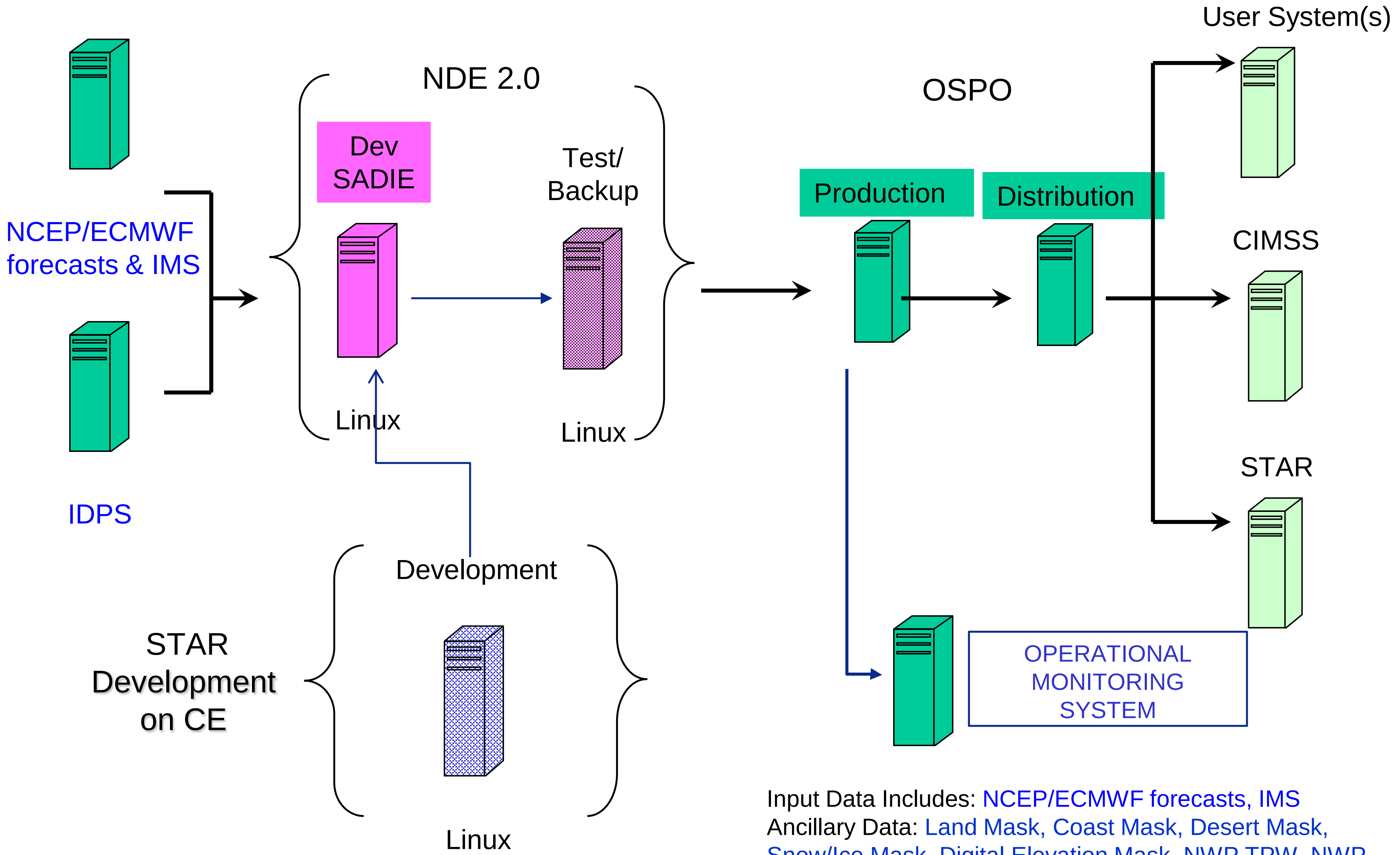
Why Are The Products Being Produced?

- NWS requests continuity of NOAA products between current and future NOAA operational satellites
- Demonstration of cost effective processing for NOAA JPSS products
- Demonstration of NOAA's goal of enterprise solutions by employing same algorithms for "POES" and "GOES"
- Supports NWS OS&T implementation strategy of multi-sensor algorithms and products

How Will The Products Be Used?

- Gridded Cloud Products for NWP Verification
- CLAVR-x and GSIP cloud product composites over Alaska
- Polar/Geostationary Volcanic Ash Detection and Height on CLAVR-X
- Dust Aerosol Concentration Product
- Support satellite-based verification of the National Air Quality Forecast Capability
- National Ice Center

How Should The Products Be Produced?



Input Data Includes: NCEP/ECMWF forecasts, IMS
Ancillary Data: Land Mask, Coast Mask, Desert Mask, Snow/Ice Mask, Digital Elevation Mask, NWP TPW, NWP Ozone, Surface pressure from NCEP forecast, Seebor Surface Emissivity, Surface Type, Surface Reflectance

How Should The Products Be Produced? Cont.

- There will be four distinct environments
  - » Development Environment (STAR)
    - – Development and testing of pre-operational codes on Redhat Linux OS
  - » SADIE Development Environment (NDE)
    - – Transition point for the Algorithm Package. Testing of Algorithm Package on Redhat Linux OS
  - » Test Environment (NDE 2.0)
    - – Pre-operational codes and documents (DAP) received from STAR will be implemented and tested on the designated Red Hat Linux machine by NDE and modified as needed before it is promoted to operation
  - » Operation Environment (OSPO)
    - – Operational DAP will be run on the designated Redhat Linux machine at ESPC and the products monitoring GUI will be posted on the intranet web server and accessed under ESPC VPN by the operators, PALS and maintenance programmers. Products will be distributed via NDE first, and then the PDA and OSPO ftp/http servers when PDA is available.

How Should The Products Be Produced? Cont.

- Production and Delivery Scenarios
  - » The ESPC Ingest Systems will handle all input satellite data and ancillary data
  - » The JPSS RR product system will collect the satellite inputs and required ancillary data to run the Fractional Snow Cover algorithms
  - » The product will be generated in NetCDF4
  - » The JPSS RR metadata will be available for the Product Monitoring Tool system to use
  - » The product users will be granted access to the ESPC distribution system (PDA, when available) through the data access request submission process.
  - » When PDA is available, ESPC will handle the distribution of JPSS RR products

Development and Operational System Environments

Project Name:	JPSS Risk Reduction	
IT Item	Research	Production
Agency	STAR	OSPO (ESPC)
Platform(s) and need dates	Linux (RHEL OS on x86-64 platform) with 12 CPUs (dual core) and 48 GB of memory. Dates: August 2013.	Linux (RHEL OS on x86-64 platform) with 6 CPUs (quad core) and 48 GB of memory. Dates: August 2013. (Purchased by NDE)
Operating Systems	Linux (RHEL OS on x86-64 platform)	Linux (RHEL OS on x86-64 platform)
Programming languages/compilers ***	Intel & GNU Compiler (C/C++/Fortran)	GNU Compiler (C/C++/Fortran) libraries
Scripting languages	Perl (version 5.8 or higher)	Perl (version 5.8 or higher)
Graphical/Imaging programs, COTS S/W, other tools, libraries, etc	IDL (version 7.0 or higher)	IDL (version 7.0 or higher)
Helpdesk Monitoring Tool (standardized tool or customized tool?)	None	NPP Product Monitorinig Tool (PSDI project)
Other platforms needed for monitoring/imaging/graphics (specify platform & operating system)	None	None
Other (tools, shareware, libraries, critical non-static ancillary data, etc)	Libraries: netCDF 4.0, HDF5, and BUFR Utilities: wgrib2	Libraries: netCDF 4.0, HDF5, and BUFR Utilities: wgrib2

Development and Operational System Environments – Cont.

Project Name:	JPSS Risk Reduction			
			Back-up Operations	
IT Item	Development	Production	On-Site	Off-Site
Agency	OSPO (ESPC)	OSPO (ESPC)	OSD (ESPC)	CIP
Platform(s) and need dates (include secondary platforms for monitoring, imagery or graphics, if necessary)	Linux with 6 CPUs (quad core, 3.2 GHz), 8 GB/CPU Dates: June 2012 – June 2017.	Linux with 6 CPUs (quad core, 3.2 GHz), 8 GB/CPU memory. Dates: August 2013. This is to be purchased by NDE.	Linux with 6 CPUs (quad core, 3.2 GHz), 8 GB/CPU memory. Dates: August 2013. This is to be purchased by NDE.	Linux with 6 CPUs (quad core, 3.2 GHz), 8 GB/CPU memory. Dates: August 2013. This is to be purchased by NDE.
Storage required on systems	30 TB	30 TB	30 TB	30 TB
How often does system run (granule time, orbital, daily); event or schedule driven?	87 seconds (Event)	87 seconds (Event)	87 seconds (Event)	87 seconds (Event)
Memory used at run time	4 GB for nominal processing	4 GB for nominal processing	4 GB for nominal processing	4 GB for nominal processing
Input data volume and input data sources	CLASS: 2 TB/day NCEP ftp server: 0.6 GB/day	IDPS: 2 TB/day TBD: 0.6 GB/day	IDPS: 2 TB/day TBD: 0.6 GB/day	IDPS: 2 TB/day TBD: 0.6 GB/day
Data volume for distribution; planned distribution server; specific push users & volumes	N/A	NDE DS: 100 GB/day	NDE DS: 100 GB/day	NDE DS: 100 GB/day
Communication Requirements/Protocol	DDS: ftp NCEP ftp server: ftp	ftp-s (managed by NDE)	ftp-s (managed by NDE)	ftp-s (managed by NDE)
Days to retain input and output data	96 hours	96 hours	96 hours	96 hours

Development and Operational System Maintenance Resources

- Walter Wolf, Andy Heidinger, Jeff Key, Shobha Kondragunta, Istvan Laszlo, Mike Pavolonis (STAR) Peter Romanov (CREST), and Igor Appel (IMSG) – Development Readiness and Quality Control support
- Shanna Sampson, Xingpin Liu (STAR), William Straka III, Ray Garcia (CIMSS) – Development support
- A. K. Sharma, Dave Donahue, Hanjun Ding, Zhaohui Cheng (OSPO), NIC – Operational Readiness and Quality control support

Distribution Environment – Capabilities and Resources

- PDA for distribution
- Personnel
  - » OSD Contractor Personnel
  - » STAR Personnel
  - » OSPO Personnel

Production Scenarios – Monitoring and Maintenance

- NDE, working with OSPO, will provide the system monitoring capability
- OSPO will provide the routine validation capability
- OSPO PAL, STAR, and NIC will perform routine validation of the JPSS Risk Reduction products

Production Scenarios – Monitoring and Maintenance (cont.)

- Production Monitoring and Maintenance Scenarios
  - » The PAL and maintenance personnel at OSPO will monitor the system's function and resolve the issues.
  - » The maintenance personnel at OSPO will maintain and back up the database
  - » STAR personnel are available for operational science issues
  - » The JPSS Risk Reduction product files will have variables available for product monitoring

JPSS Risk Reduction System Requirements

- The JPSS Risk Reduction System Requirements have been established.
- The Requirements have been documented in the Requirements Allocation Document (RAD).
- The Requirements are traceable to drivers (customer needs or expectations) and other requirements.

Production Scenarios – Archive Product

- The JPSS Risk Reduction products will not be archived to CLASS / NCDC archive

User Interaction

- The ESPC help desk will serve as the operational point of contact to provide 24/7 service support for users
  - » Provides information about the JPSS RR data products to the user community
  - » Resolves user issues through coordination with the associated PALs
- The PALs will coordinate further with the STAR scientists for any product quality issue when identified and communicate with users.

Summary

- The OSPO Ingest Systems will handle all input satellite data and ancillary data
- OSPO will run the JPSS RR system
- OPSO PAL, STAR team and NIC team will perform product validation
- NCEP will use the associated products within their models and will provide the support for products testing and validation
- JPSS RR products will be available to be sent the to Gridded and Composite Cloud Products Project, the Product Monitoring Project and CLASS

Outline

- Introduction
- Requirements
- Operations Concept
- Fractional Snow Cover
- Detailed Design
- Algorithm Package
- Quality Assurance
- Risks and Actions Summary
- Summary and Conclusions

Algorithm Theoretical Basis

VIIRS Fractional Snow Cover

Presented by

Jeff Key, Igor Appel and Peter Romanov

Fraction Snow Cover Algorithm Theoretical Basis

- Purpose: Provide product developers, reviewers and users with a theoretical description (scientific and mathematical) of the VIIRS Fractional Snow Cover algorithm

- Will be documented in the S-NPP VIIRS Fractional Snow Cover ATBD

Current Requirements: Snow Fraction

Name	User	Geographic Coverage	Horiz. Res.	Mapping Accuracy	Msmnt. Range	Msmnt. Uncertainty	Refresh Rate	Data Latency	Product Measurement Precision
Snow Fraction	JPSS	Global	0.375 km	3km	0-100% Horizontal snow cover	10% of snow-covered area	90% coverage of the globe every 12 hours	30 min after granule data is available	N/A

Fractional snow is understood as the viewable snow fraction, not the true fraction of snow on the ground. The viewable snow fraction does not include the snow cover masked by the tree canopy

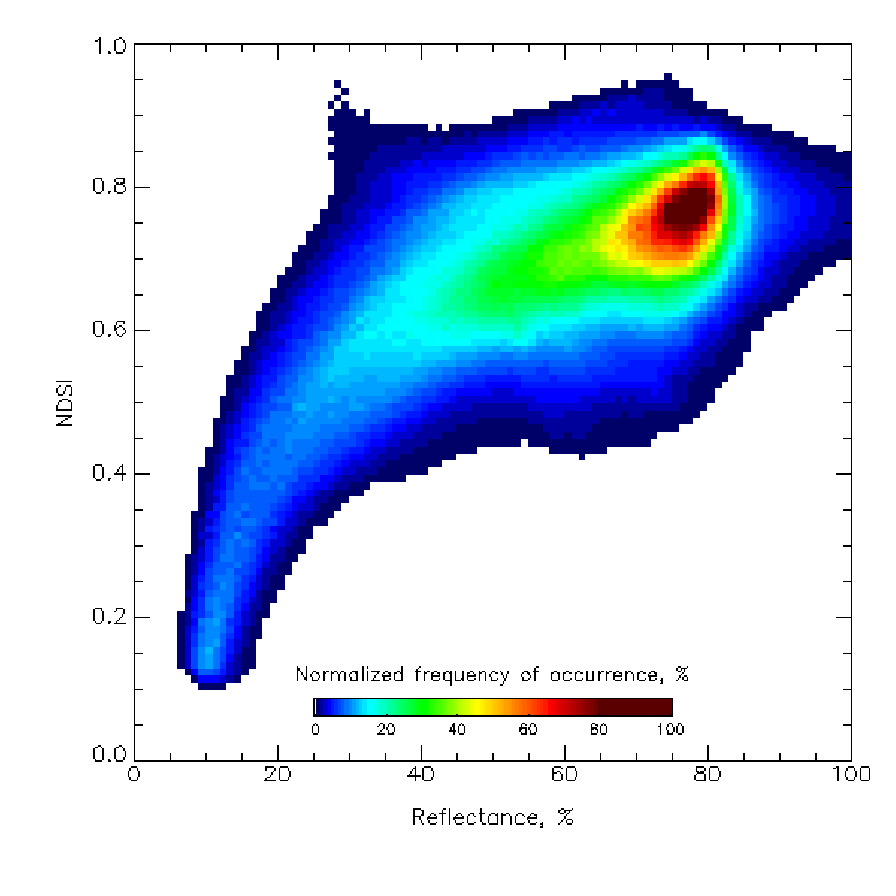
CDR Snow Fraction Algorithms

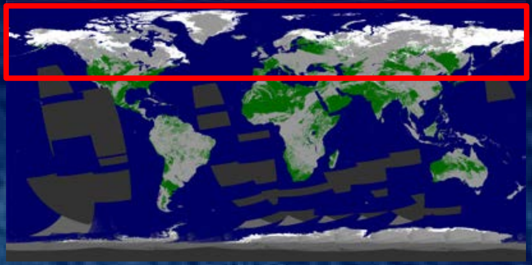
Two algorithms and two snow fraction products

- NDSI-based algorithm (Primary Product)
  - » MODIS heritage
  - » Widely utilized by MODIS data users
  - » Recommended by JPSS Validation Maturity Review Board
- Reflectance-based algorithm (Risk Reduction Product)
  - » GOES, AVHRR heritage (single-band version)
  - » Applied to MODIS regionally (multiband version) (Painter, 2009)
  - » Approved for and implemented with GOES-R ABI (multi-band version)
- The two approaches are different and may result in different estimates of the snow fraction.

Reflectance vs. NDSI

Scatter plot of VIIRS visible (band 1) reflectance and NDSI for snow-covered pixels





VIIRS snow map , April 9, 2014

Both algorithms (NDSI-based and Reflectance-based) assume a linear relationship between the corresponding predicands and the snow fraction

However there is a substantial difference between NDSI and Reflectance over snow-covered land which results in different snow fraction values estimated with these two approaches

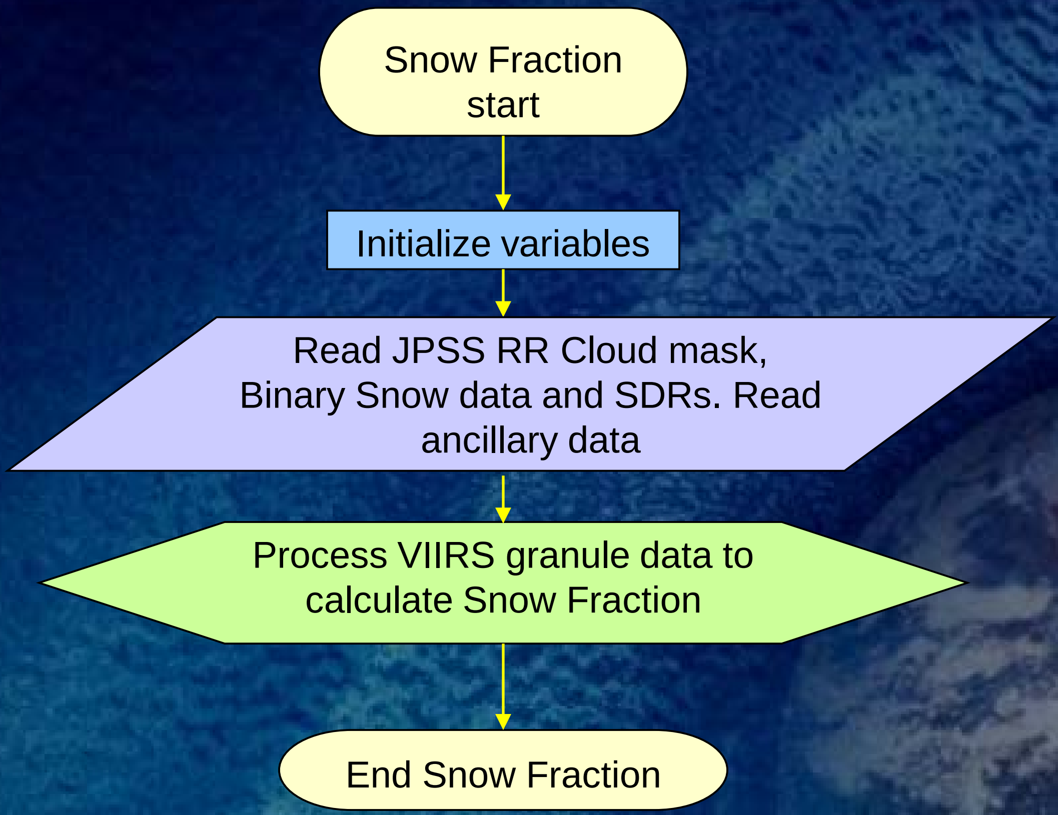
Why Implement Two Algorithms

- Both snow fraction approaches/algorithms/products are widely used
  - » NDSI-based: MODIS, Snow extent in the mountains
  - » Reflectance-based: AVHRR, GOES, MTSAT, GOES-R, land surface/climate models
- Snow fraction derived with the two algorithms is different
- There is no ground-truth data to conclusively establish the validity/accuracy of one algorithm over the other
- Implementing both approaches with VIIRS answers the interests of both MODIS and GOES/GOES-R user communities as well as the land surface/climate modeling community.

Snow Fraction Algorithm Objectives

- Meet the requirements for the snow fraction product
- Provide quality control flags.
- Applications of the product include numerical weather prediction, hydrology, climate modeling

Snow Fraction Processing Outline



High Level Flow Chart of Both Snow Fraction Algorithms

Snow Fraction Sensor Inputs

- **NDSI-based algorithm**

VIIRS Band	Nominal Wavelength Range (µm)	Nominal Central Wavelength (µm)	Nominal Central Wavenumber (cm-1)	Nominal sub-satellite IGFOV (km)	Sample Use
I1	0.60-0.68	0.64	15625	0.375	
I2	0.85-0.88	0.865	11561	0.375	
i3	1.58-1.64	1.61	6211	0.375	
I4	3.55-3.93	3.74	2674	0.375	
i5	10.5-12.4	11.45	873	0.375	

- **Reflectance-based algorithm**

VIIRS Band	Nominal Wavelength Range (µm)	Nominal Central Wavelength (µm)	Nominal Central Wavenumber (cm-1)	Nominal sub-satellite IGFOV (km)	Sample Use
I1	0.60-0.68	0.64	15625	0.375	
I2	0.85-0.88	0.865	11561	0.375	
i3	1.58-1.64	1.61	6211	0.375	
I4	3.55-3.93	3.74	2674	0.375	
i5	10.5-12.4	11.45	873	0.375	

Current Input for Snow Fraction

Expected Added Input

Snow Fraction
Sensor Input Details

Name	Type	Description	Dimension
Latitude	Input	VIIRS Latitude	Granule (xsize, ysize)
Longitude	Input	VIIRS Longitude	Granule (xsize, ysize)
Solar zenith angle	Input	Solar zenith angle	Granule (xsize, ysize)
Satellite view angle	Input	VIIRS view zenith angle	Granule (xsize, ysize)
Relative azimuth	Input	VIIRS relative azimuth angle	Granule (xsize, ysize)
QC flags	Input	VIIRS SDR quality control flags	Granule (xsize, ysize)

Snow Fraction Ancillary Input Data

- Two types of ancillary data needed:
  - » JPSS RR VIIRS Products:
    - – Cloud mask
    - – Snow Cover
  - » Non-VIIRS Static Data:
    - – Land/water mask
    - – Surface elevation

Snow Fraction Ancillary Input Data Details (1/2)

Algorithm Precedence Data

Name	Type	Description	Dimension
Cloud Mask	Input	Derived JPSS RR VIIRS Cloud Mask & Cloud Shadow Mask	Granule(xsize, ysize)
Snow Cover	Input	Calculated JPSS RR VIIRS Snow Cover Product	Granule(xsize, ysize)

Snow Fraction
Ancillary Input Data Details (2/2)

Non-VIIRS Static Data

Name	Type	Description	Dimension
Land/Water Mask	Input	Binary file discriminating land and water-covered pixels	Granule(xsize, ysize)
Surface elevation	Input	Binary file specifying surface elevation for every pixel of the granule	Granule(xsize, ysize)

Snow Fraction Algorithm Output

- NDSI-based algorithm

Name	Type	Description	Dimension
Snow Fraction	Output	Pixel level output: Snow Fraction product	granule (xsize, ysize)
Quality flags	Output	Pixel level output: quality flag for Snow Fraction retrieval	granule (xsize, ysize)
Quality Control Information/Metadata	Output	granule level output: snow retrievals statistics	Text

- Reflectance-based algorithm

Name	Type	Description	Dimension
Snow Fraction	Output	Pixel level output: Snow Fraction product	granule (xsize, ysize)
Quality flags	Output	Pixel level output: quality flag for Snow Fraction retrieval	granule (xsize, ysize)
Quality Control Information/Metadata	Output	granule level output: snow retrievals statistics	Text

Snow Fraction Retrieval Strategy

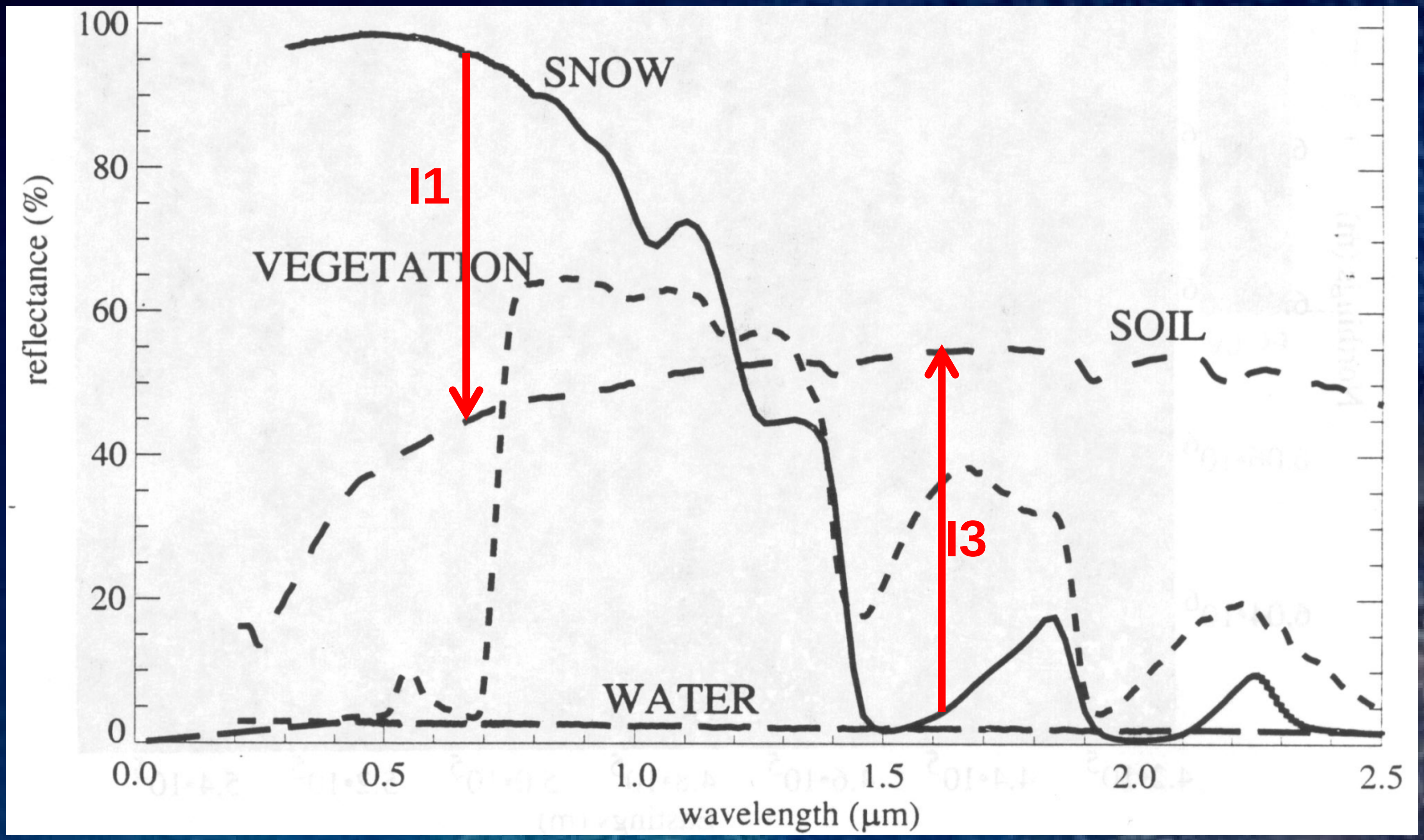
- Acquire JPSS RR VIIRS binary snow map granule
- Acquire ancillary data for the granule
- Estimate snow fraction for pixels labeled as “snow” in the binary snow map
- Restrict the derived snow fraction to 0.01-1.0 range
- Save the derived snow fraction granule

Snow Fraction Retrieval Assumptions and Limitations

- Fractional Snow Cover is produced when:
  - » Solar Zenith Angle is less than 85 degrees
  - » Cloud Mask is confidently clear
  - » Pixel is not covered by forrest

NDSI-based Snow Fraction Algorithm

NDSI-Based Snow Fraction: Physical Basis (1)



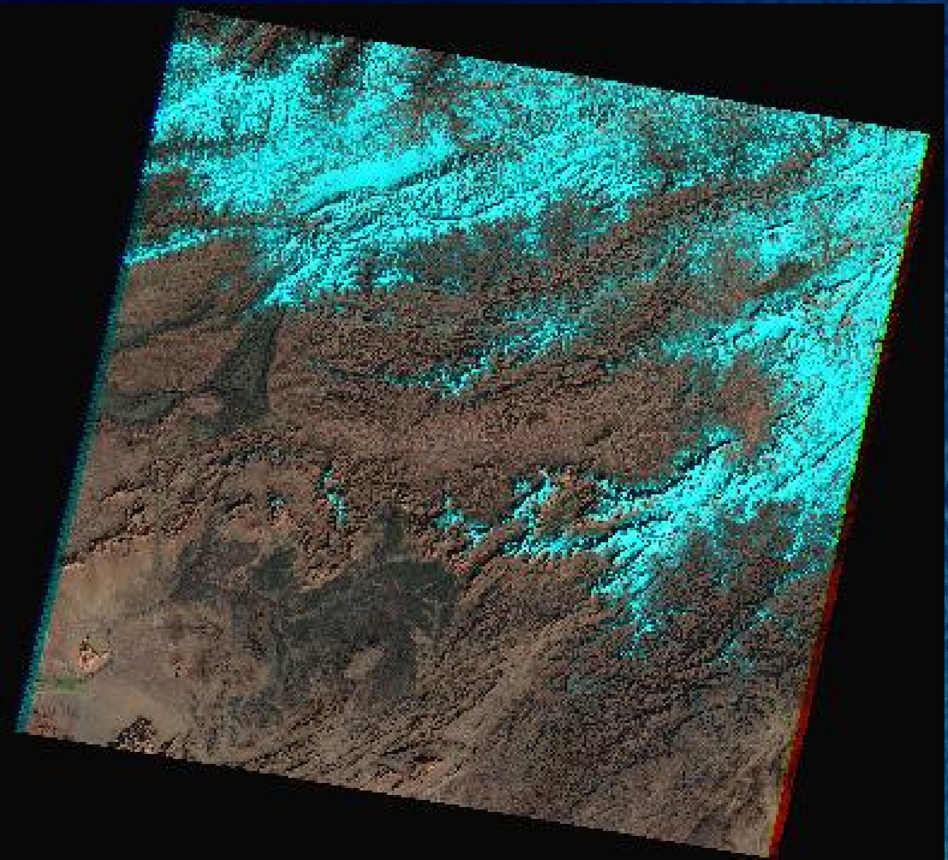
The information from bands I1 and I3 is very useful to distinguish snow from non-snow

NDSI-Based Snow Fraction: Physical Basis (2)

- The reflectance of snow is unique among land cover types. It is among the brightest of natural substances in the visible part of the spectrum, but it is also often the darkest in the short wave infrared
- High visible and low short-wave reflectances correspond to snow; low visible and high short-wave reflectances correspond to non-snow
- The reflectance spectra shown in the previous figure are representative of one specific case.
- Any given surface type and individual scene will exhibit spectral variability

NDSI-Based Snow Fraction: Physical Basis (3)

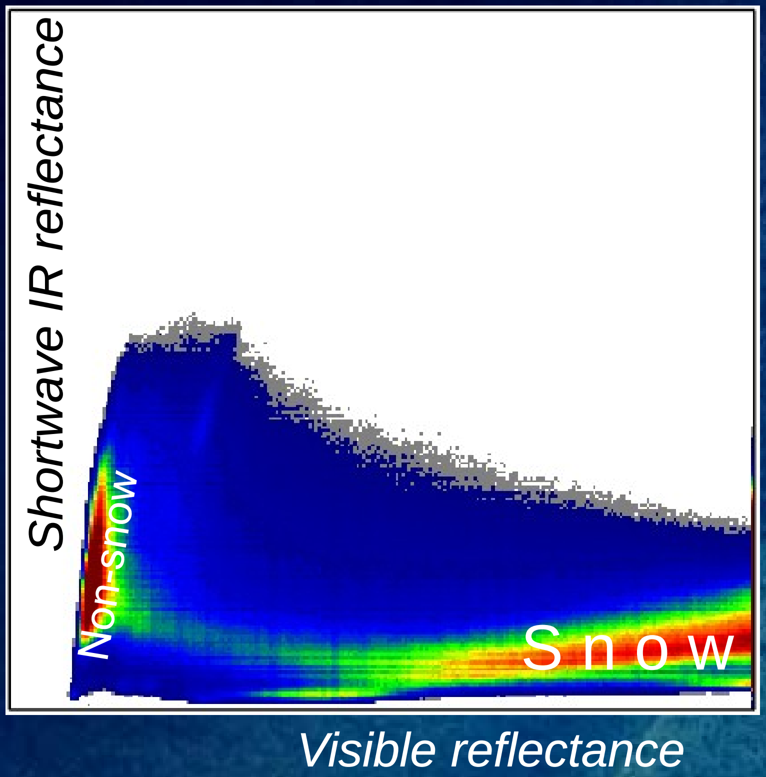
False color images clearly identify snow (cyan), vegetation (green) and bare ground (brown-reddish)



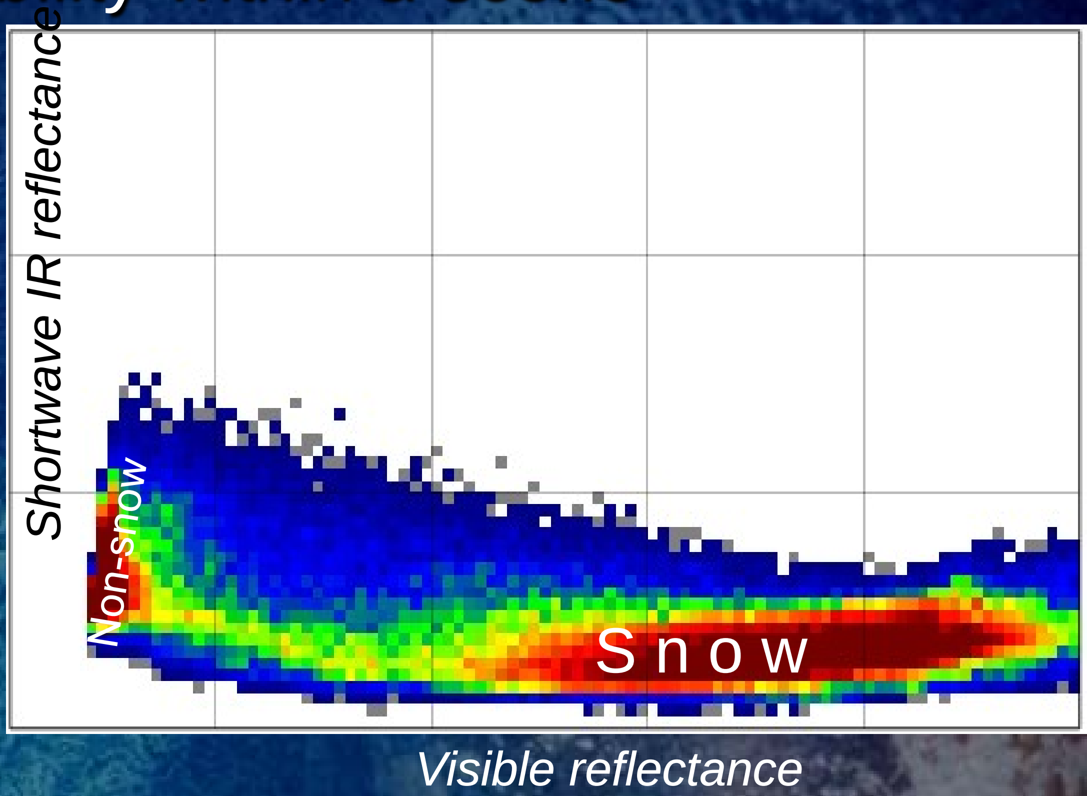
The same false color pixels are presented in the spectral space defined by visible (X axis) and short-wave infrared (Y axis) reflectances

NDSI-Based Snow Fraction: Physical Basis (4)

Snow & non-snow reflectances are characterized by high variability within a scene



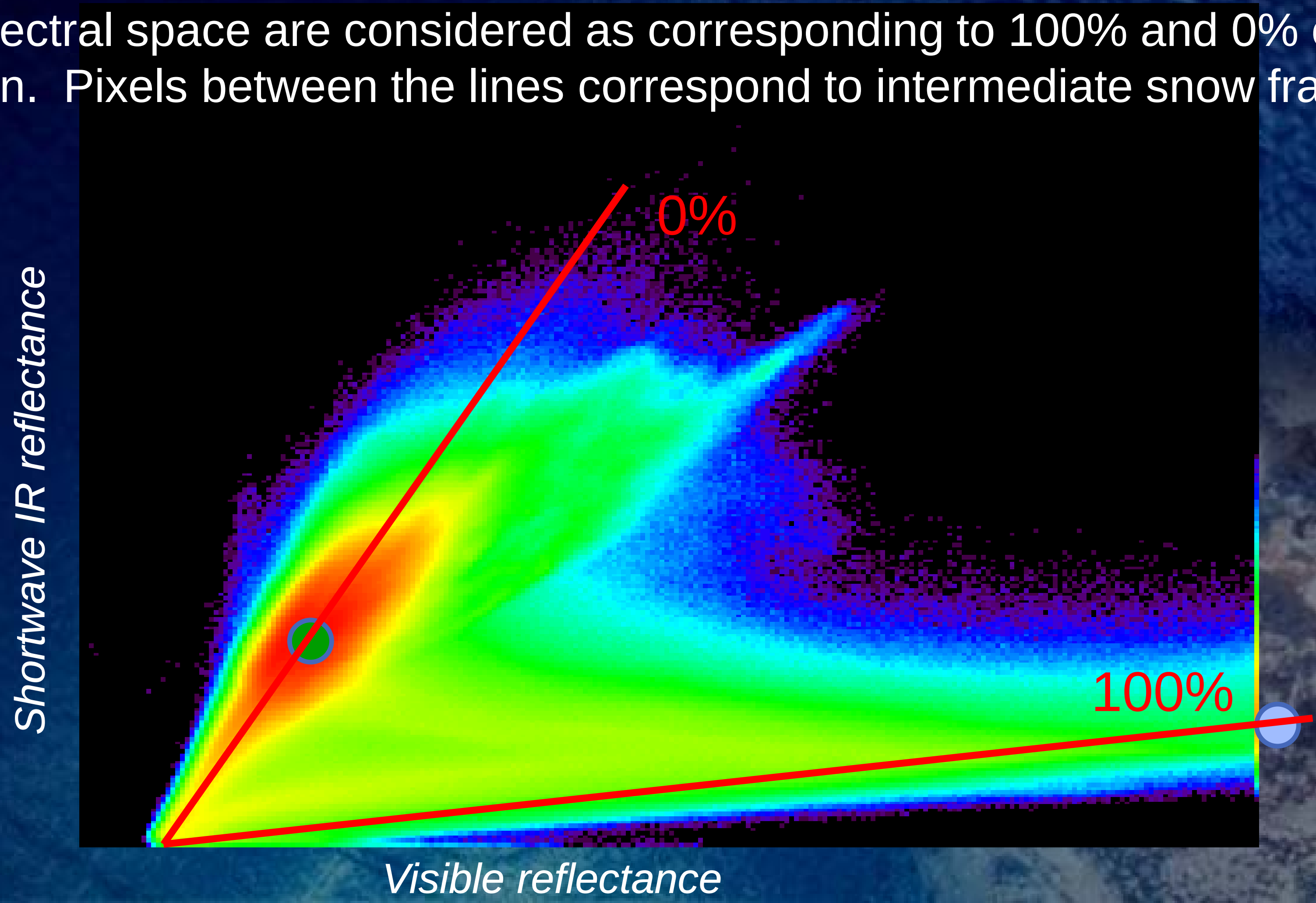
High resolution observations



Moderate resolution

NDSI-Based Snow Fraction: Physical Basis (5)

The lines going through the most probable locations of snow and non-snow in the spectral space are considered as corresponding to 100% and 0% of snow fraction. Pixels between the lines correspond to intermediate snow fraction

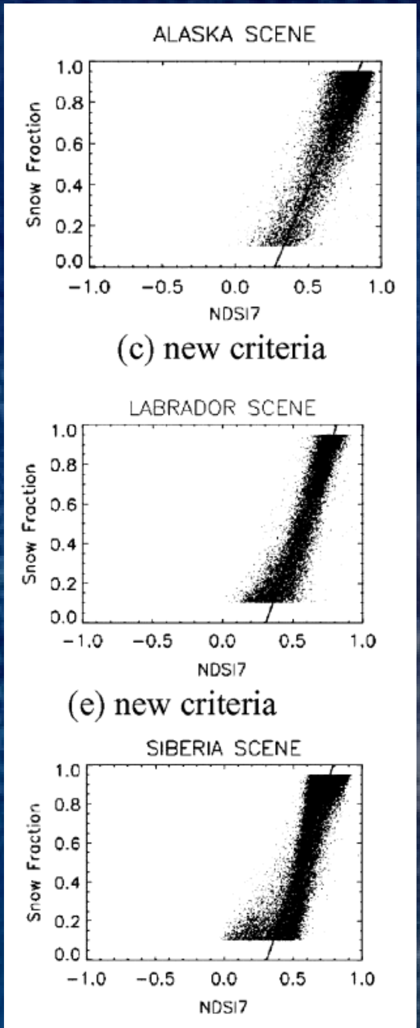


NDSI-Based Snow Fraction: Mathematical Description(1)

- The Normalized Snow Difference Index (NDSI) characterizes snow reflective properties: high snow reflectance in the visible wavelengths and low reflectance in the near infrared wavelengths
- NDSI is widely considered as an indicator of the presence of snow on the ground
- NDSI is sensitive enough to provide the snow fraction within a pixel of moderate resolution observations
- NDSI presenting relative ratio of reflectances to a large degree suppresses the influence of varying illumination conditions

NDSI-Based Snow Fraction: Mathematical Description(2)

- NDSI = $(R_1 – R_3)/ (R_1 + R_3)$, where R_1 and R_3 are reflectances in VIIRS bands I1 and I3
- Salomonson and Appel (2004, 2006) established that snow fraction is linearly related to NDSI
- The snow fraction – NDSI relationship was derived using the analysis of snow fraction in matched MODIS and Landsat scenes



Snow fraction and NDSI scatter plots for different scenes from Salomonson and Appel (2006)

NDSI-Based Snow Fraction: Mathematical Description(3)

"Universal" approach to NDSI-based snow fraction retrieval

- The Salomonson-Appel (2004) algorithm linearly relates snow fraction to the observed NDSI

$$SF_{NDSI} = a + b * NDSI$$

- Parameters a =-0.01 and b=1.45 characterize the optimal "universal" linear function for MODIS data

- NASA team (D.Hall, G.Riggs) has found that the optimal values of a and b for VIIRS are the same as for MODIS (a = - 0.01; b = 1.45)

NDSI-Based Snow Fraction: Mathematical Description(4)

Role of changes in endmembers

- The quality of snow cover information provided by remote sensing varies depending on
  - » snow and background surface types
  - » the geometry of satellite observations
  - » the state of the atmosphere
- Changes in pixel reflectances should not be ascribed exclusively to variable fraction, because they depend also on the variability in spectral signatures of the endmembers
- Allowing for the variability in spectral signatures of endmembers is a key requirement to snow algorithms

NDSI-Based Snow Fraction: Mathematical Description(5)

Scene-specific approach to NDSI-based snow fraction retrieval

- The NDSI snow fraction formula is equivalent to

  $SF_{NDSI} = (NDSI - NDSI_{non\text{-}snow}) / (NDSI_{snow} - NDSI_{non\text{-}snow})$

- The quality of snow retrieval could be improved if the variability of reflective properties characterizing snow and underlying non-snow states is taken into account

- The adjustment of the parameters in snow algorithms to specific local conditions is a promising improvement leading to better quality of the VIIRS snow products

NDSI-Based Snow Fraction: Algorithm Validation (1)

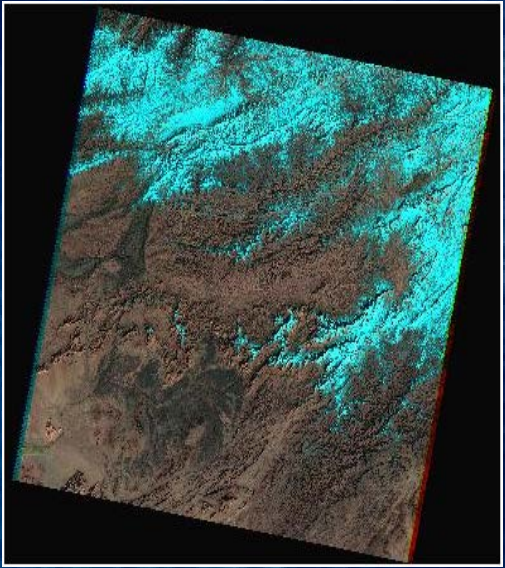
General approach

- Use matched in time VIIRS and Landsat scenes
- Binary classify Landsat pixels as snow / non-snow
- Exactly co-register data sets to make Landsat and VIIRS information completely comparable
- Aggregate estimates within larger grid cells (5km) to reduce the effect of data spatial mismatch
- Compare snow fraction derived from Landsat classifications with VIIRS snow fraction estimates

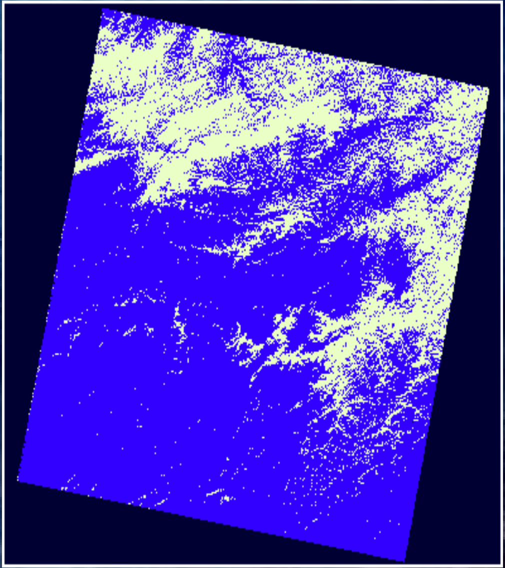
NDSI-Based Snow Fraction: Algorithm Validation (2)

Landsat binary snow cover classification

Location of Landsat scene



false color image

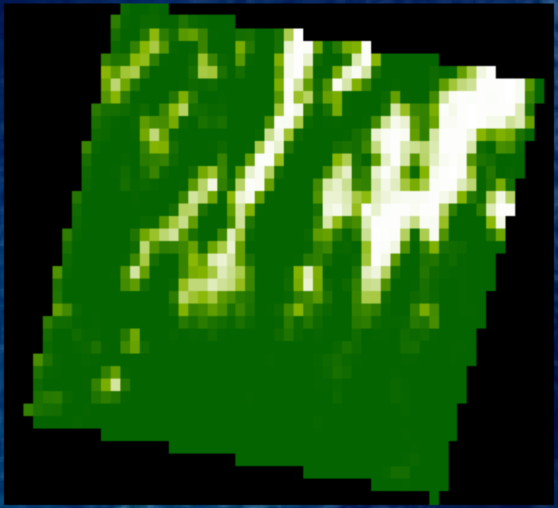


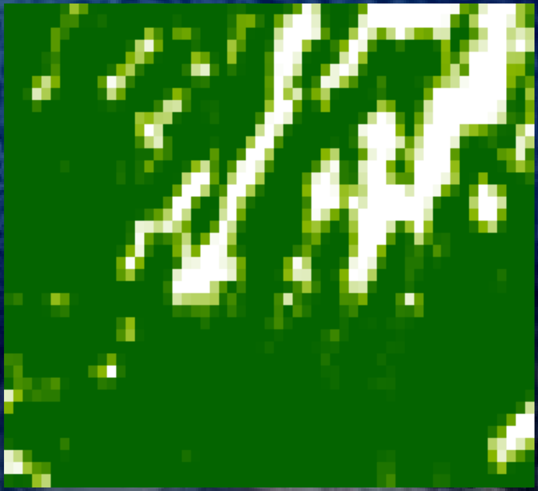
pixel classification

on 02/09 (path - 156, row – 37)

NDSI-Based Snow Fraction: Algorithm Validation (3)

Aggregation and coregistration of fraction data





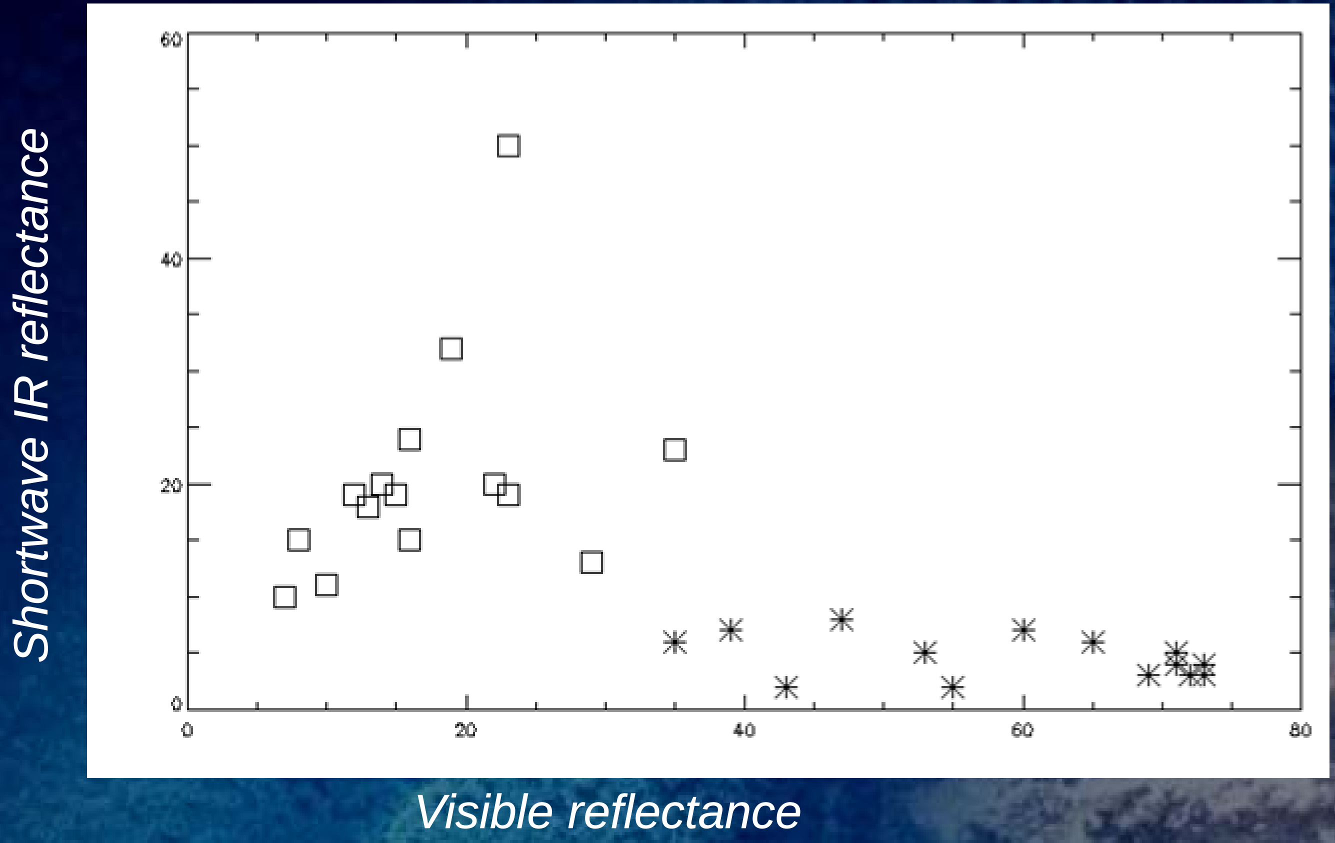
Location of Landsat scene on 02/03 (path - 41, row – 33)

Landsat Snow Fraction

VIIRS fraction

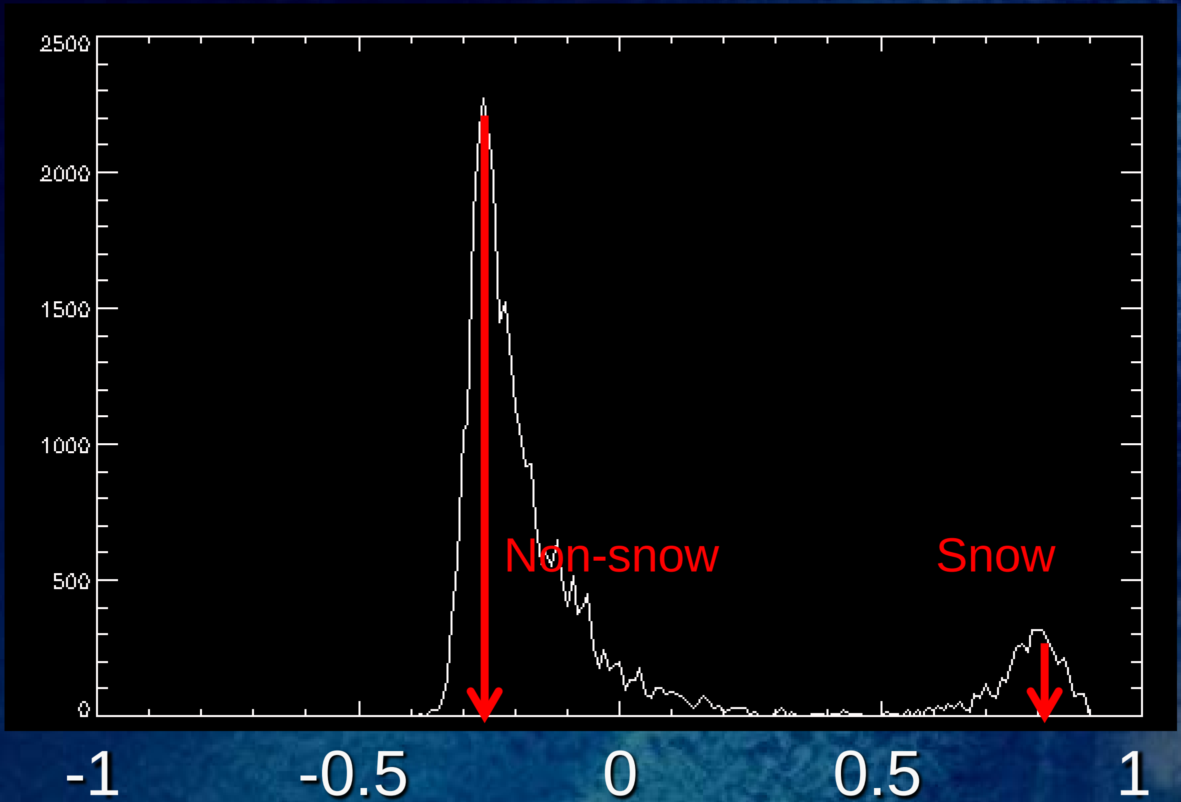
0% 100%

Variability of snow & non-snow reflectances (between scenes)



The most probable snow (asterisks) and non-snow (squares) VIIRS reflectances for 16 scenes under detailed analysis

Scene-specific Estimate of Snow and Non-snow NDSI



NDSI probability density function identifies predominant magnitudes of snow and non-snow NDSI

Local snow and non-snow endmembers are estimated from the analysis of NDSI frequency (probability density function)

Statistics of VIIRS Snow Fraction Validation (Average Endmembers)

Results demonstrate high accuracy of VIIRS snow fraction estimates

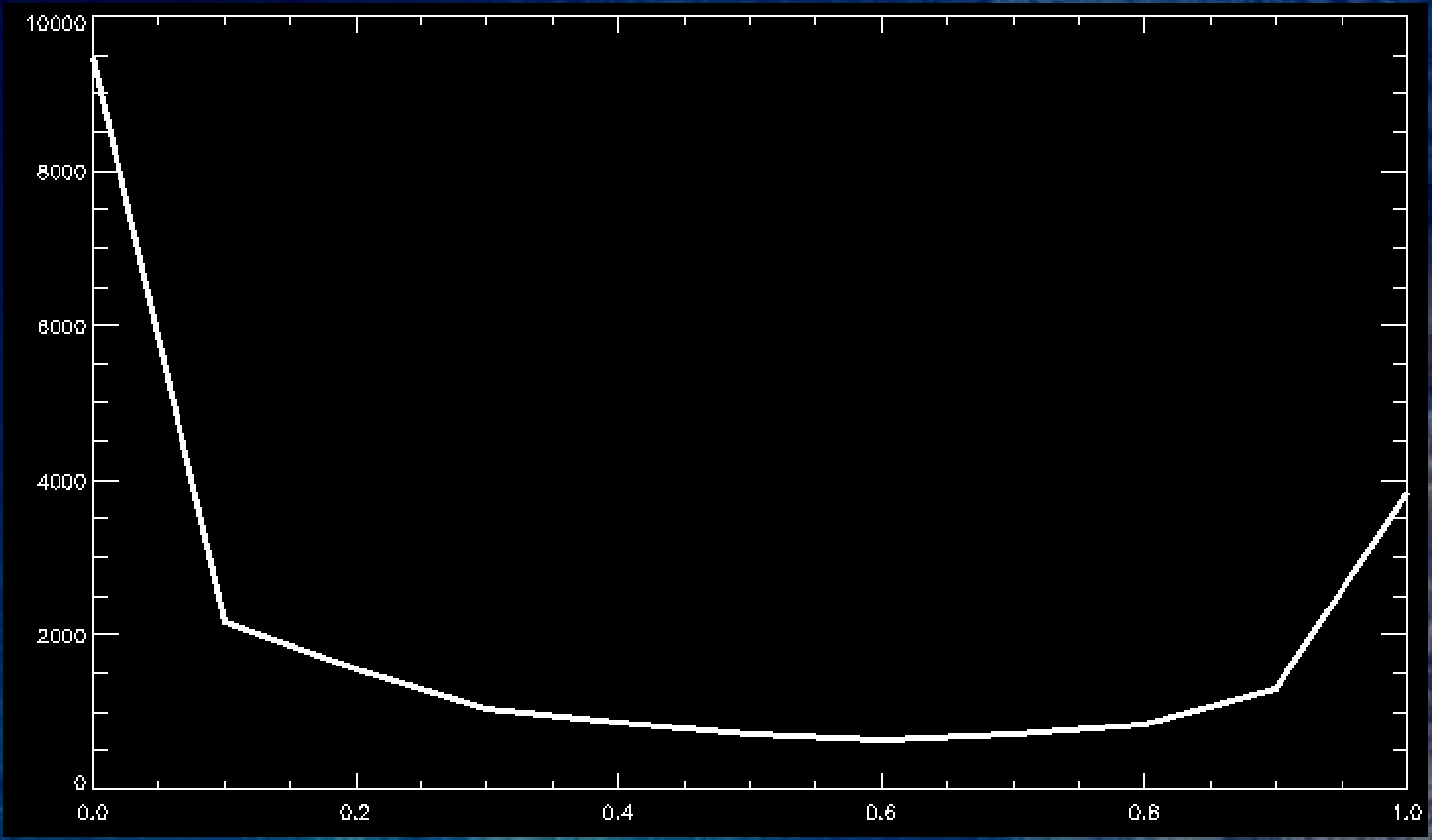
Date	Path	Row	Corr. Coeff	Inter-cept	Slope	Mean true	Mean VIIRS	Location
33	123	32	0.87	-0.04	0.88	0.2	0.13	Beijing
33	139	29	0.94	0.01	0.91	0.4	0.37	Altay
33	139	30	0.95	-0.05	1.01	0.61	0.57	Xinjiang 1
33	139	31	0.97	0.01	0.97	0.2	0.2	Xinjiang 2
34	41	33	0.98	0	0.8	0.2	0.16	Nevada
34	41	34	0.97	-0.01	0.91	0.07	0.06	Sierra
34	146	29	0.94	-0.01	0.99	0.68	0.65	Tian Shan
35	137	29	0.94	0.01	0.93	0.52	0.49	W Mongolia
35	137	30	0.95	0.05	0.87	0.35	0.36	Gobi
35	153	39	0.81	-0.01	0.63	0.05	0.02	Pakistan
36	128	30	0.92	0.07	0.93	0.92	0.92	S Mongolia
37	30	28	0.94	0.23	0.71	0.8	0.79	Dakotas
39	44	27	0.96	0	0.96	0.19	0.18	Spokane
39	44	31	0.94	0.03	0.89	0.22	0.22	Oregon
40	156	35	0.96	0	0.98	0.09	0.08	N Afghanistan
40	156	37	0.95	-0.04	1.1	0.27	0.25	C Afghanistan

Summary of Quantitative Assessment of NDSI-Based Algorithm Performance

- Average correlation coefficient is 94% despite a couple of low magnitudes
- Typical intercept of linear regression line is on the order of 1%
- Average slope of linear regression line is more than 0.9
- Average bias of data is 2 %
- Average standard deviation is 10%

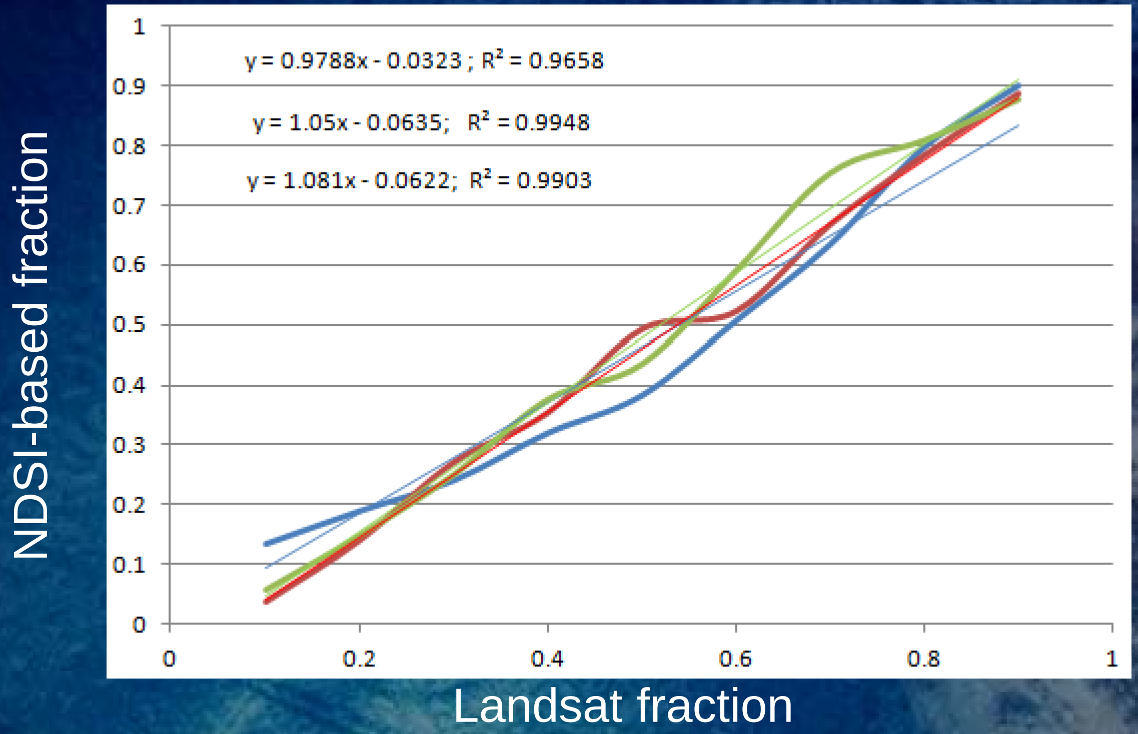
Stratified Quantitative Assessment of NDSI-Based Algorithm Performance (1)

Frequency of snow fraction shows large probability of extreme magnitudes

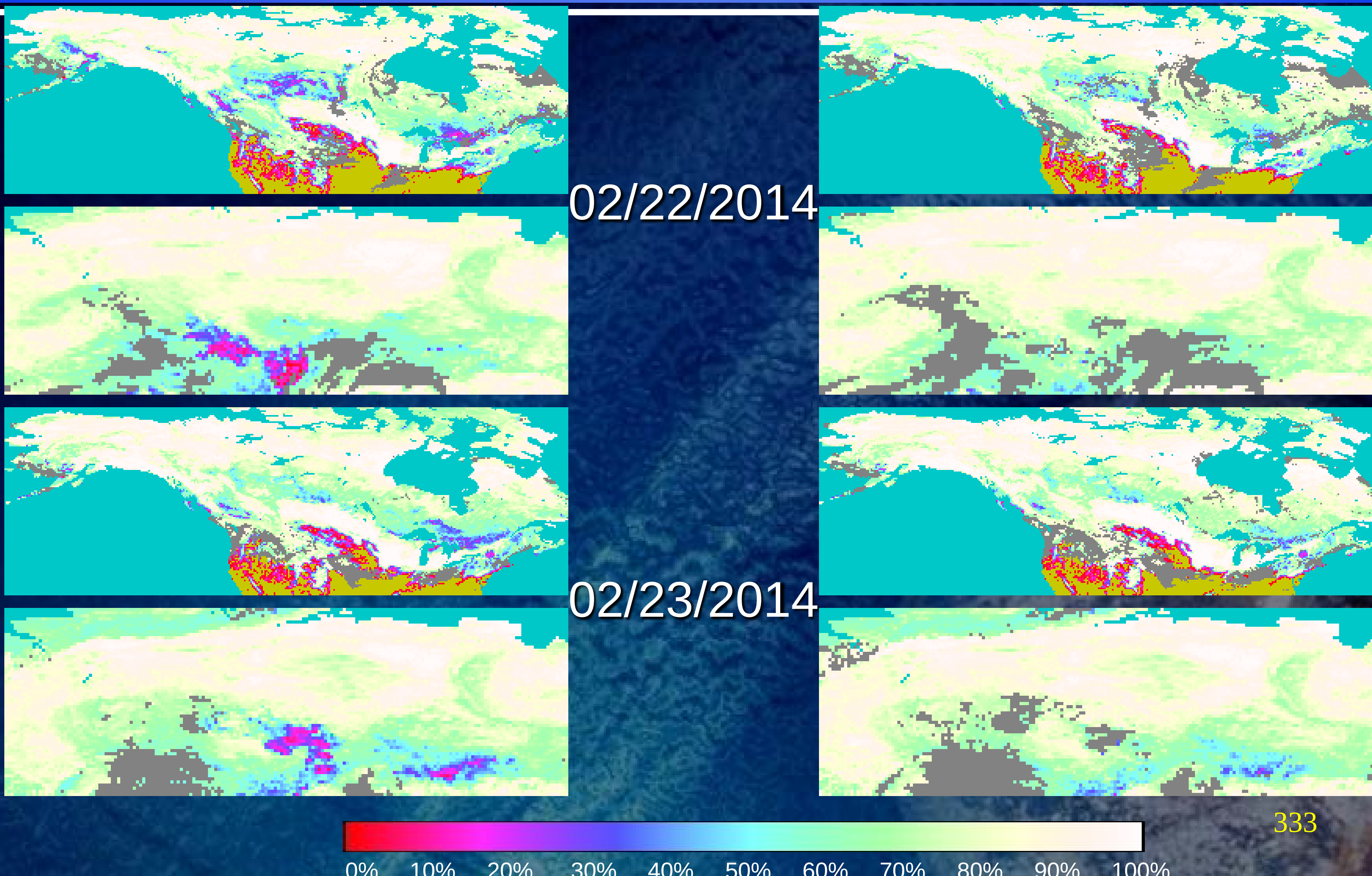


Stratified Quantitative Assessment of NDSI-Based Algorithm Performance (2)

Comparison of ground truth with NDSI algorithm results (thick lines) and trends (thin lines) for intermediate fractions demonstrates stratified performance for individual scenes

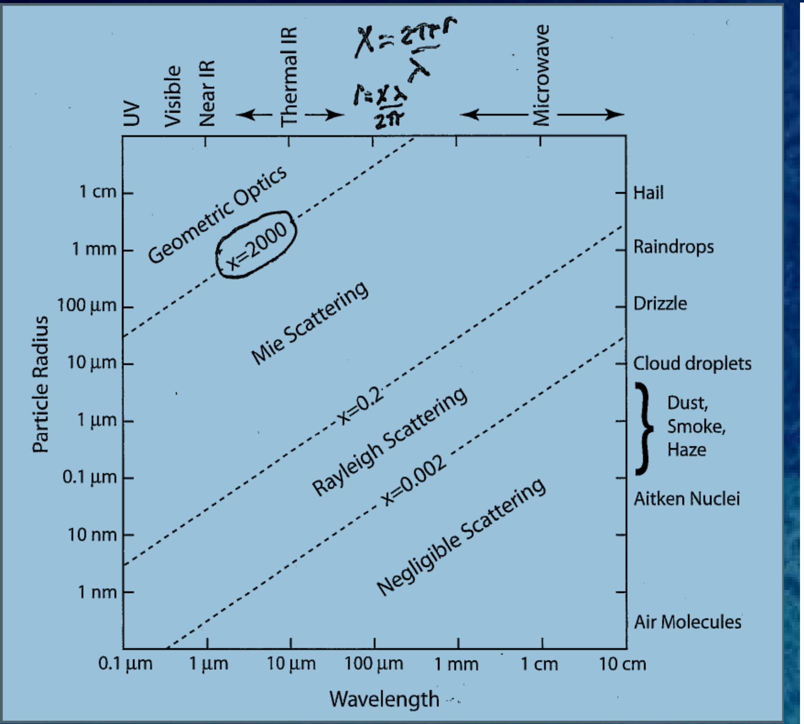


Snow retrieval with liberal (left) and conservative (right) cloud mask on February 22, 23 2014



Path Forward (1/3)
NDSI-Based Snow Fraction: BRDF Model

Validation Maturity Review Board recommended that Inter-comparisons with MODSCAG (MODIS snow covered area and grain size) should be explored by a coordinated GOES-R JPSS effort



Resulting Equation for Reflectance

$$R(\mu, v, \varphi) = R_0(\mu, v, \varphi) - \lambda K_0(\mu) K_0(\eta)$$

$R_0 = F(P(\theta))$

$P(\theta)$ – phase function (very important)

Where K_0 – the escape function approximated as

$$K_0(\xi) = (3/7)(1 + 2\cos(\xi))$$

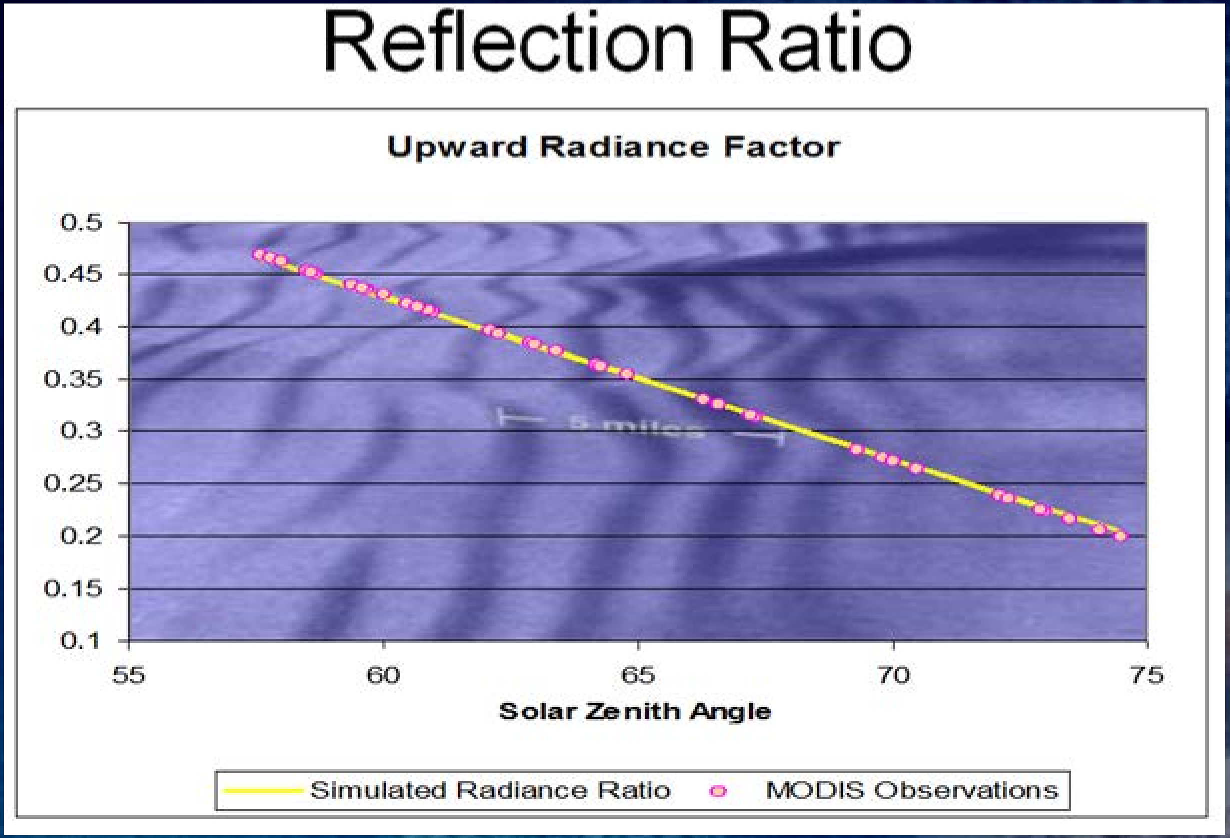
And fraction of absorbed energy (λ)

$$\lambda = 4\sqrt{(1-w)/3(1-g)}$$

Reflectance = Φ (ω, g, $P(\theta)$)

Analytical description of Snow BRDF could be used to estimate grain size

Path Forward (2/3)
NDSI-Based Snow Fraction: BRDF Model Validation



Analytical asymptotic description of radiative transfer in snow provides simple and highly accurate solution allowing clear physical explanations applicable to numerous issues

Path Forward (3/3)

- It is necessary to explore and improve the quality of the following Look Up Tables
  - » NDSI LUT used to estimate scene-specific snow and non-snow NDSI (parameters of processed histograms)
  - » Cloud conditions LUT (cloud shadow, cloud confidence used for snow retrieval)
  - » Exclusion LUT defining conditions when snow fraction is not retrieved (dark pixels, climatic limitations)
- Investigate non-linear NDSI / snow fraction relationship
- Improve validation of the NDSI-based snow fraction for different scales, seasons, and conditions of observations
- Implement 250 m Land/Water mask
- Consider using of cloud mask at imagery resolution

References

- Appel, I. (2014) *Retrieval and Validation of VIIRS Snow Cover Information for Terrestrial Water Cycle Applications*, in Remote Sensing of the Terrestrial Water Cycle (ed. V. Lakshmi et al.), John Wiley & Sons, Inc, Hoboken, NJ. doi: 10.1002/9781118872086.ch11.

Reflectance-Based Snow Fraction Algorithm

Reflectance-Based Snow Fraction: Physical Basis

- Reflectance in the visible spectral band is sensitive to the presence of snow on the ground
- Visible reflectance is assumed linearly related to the fractional snow cover . This assumption is natural and has never been challenged. It is based on the assumption of independent reflection from different surface classes.
- Linear relationship between visible reflectance and snow fraction is inherently used to estimate the snow fraction in situ when performing snow course observations. These observations are rare and their results typically are not reported through GTS.
- Linear relationship between the surface reflectance/albedo and the snow fraction is incorporated in most climate/land surface models (Noah, BATS, UKMO, ECMWF, etc.)

Reflectance-Based Snow Fraction: Mathematical Description

- Linear unmixing technique is applied to estimate the snow fraction within the image pixel
- Single-band dual-end member algorithm (Romanov et al, 2003)

  $SF_R = (R_1 - R_{1land})/(R_{1snow} - R_{1land})$,

  where, R_1 is VIIRS-observed reflectance in band I1,

  R_{1land} is reflectance of snow-free land in VIIRS band I1

  R_{1snow} is reflectance of snow in VIIRS band 1

- Both endmemebrs R_{1land} and R_{1snow} vary with the observation geometry but are assumed independent of location and time of the year. To perform retrievals end member reflectance and reflectance anisotropy has to be established and parameterized.

Reflectance-Based Snow Fraction: BRDF Model Development

End member values and angular anisotropy were established empirically from VIIRS observations over two regions

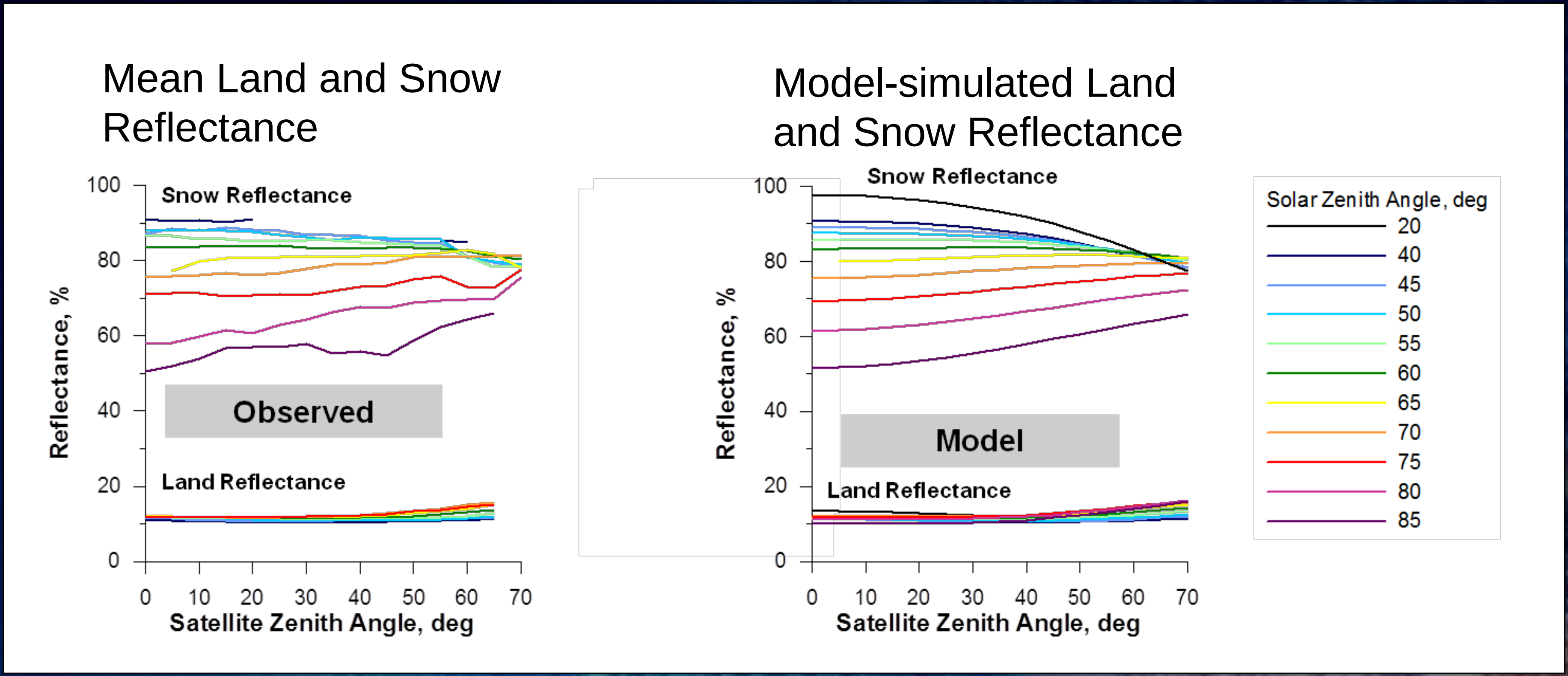
Proposed BRDF model:

$$R_{snow,\ land} = C_0 + \Sigma_{i=1,7}\ C_i\ F_{i,}$$

Kernel functions (F_i) and kernel loads (C_i)

Kernel Functions	Kernel Loads	Kernel Load Values	
		Snow-free land	Snow
1.	C_0	19.02	63.45
Cos (θ_{sol})	C_1	9.699	89.90
Cos (θ_{sat})	C_2	-9.944	-16.33
Cos (θ_{sol}) Cos (θ_{sat})	C_3	13.16	61.81
Cos^2 (θ_{sol})	C_4	-36.30	-140.9
Cos^2 (θ_{sat})	C_5	-6.289	-5.114
Cos^4 (θ_{sol})	C_6	20.18	51.62
Cos^4 (θ_{sat})	C_7	5.419	-2.623

Reflectance-Based Snow Fraction: BRDF Models



Accuracy of the model parameterization of reflectance angular change

- 3% for snow reflectance
- <1% for snow-free land reflectance

Theoretical Estimate of the Algorithm Accuracy

- Factors contributing to the retrieval uncertainty and their assumed magnitude
  - » Measurement noise: 0.1% (observed reflectance)
  - » Aerosol variability: 5% (observed reflectance)
  - » Snow-free land reflectance variation: 6%
  - » Snow reflectance natural variation: 5%
  - » Inaccuracy of BRDF models: 2-3%
- Overall estimated uncertainty: from ~10% at small snow fraction (0.3 and below) to ~13% at large snow fraction of over 0.9

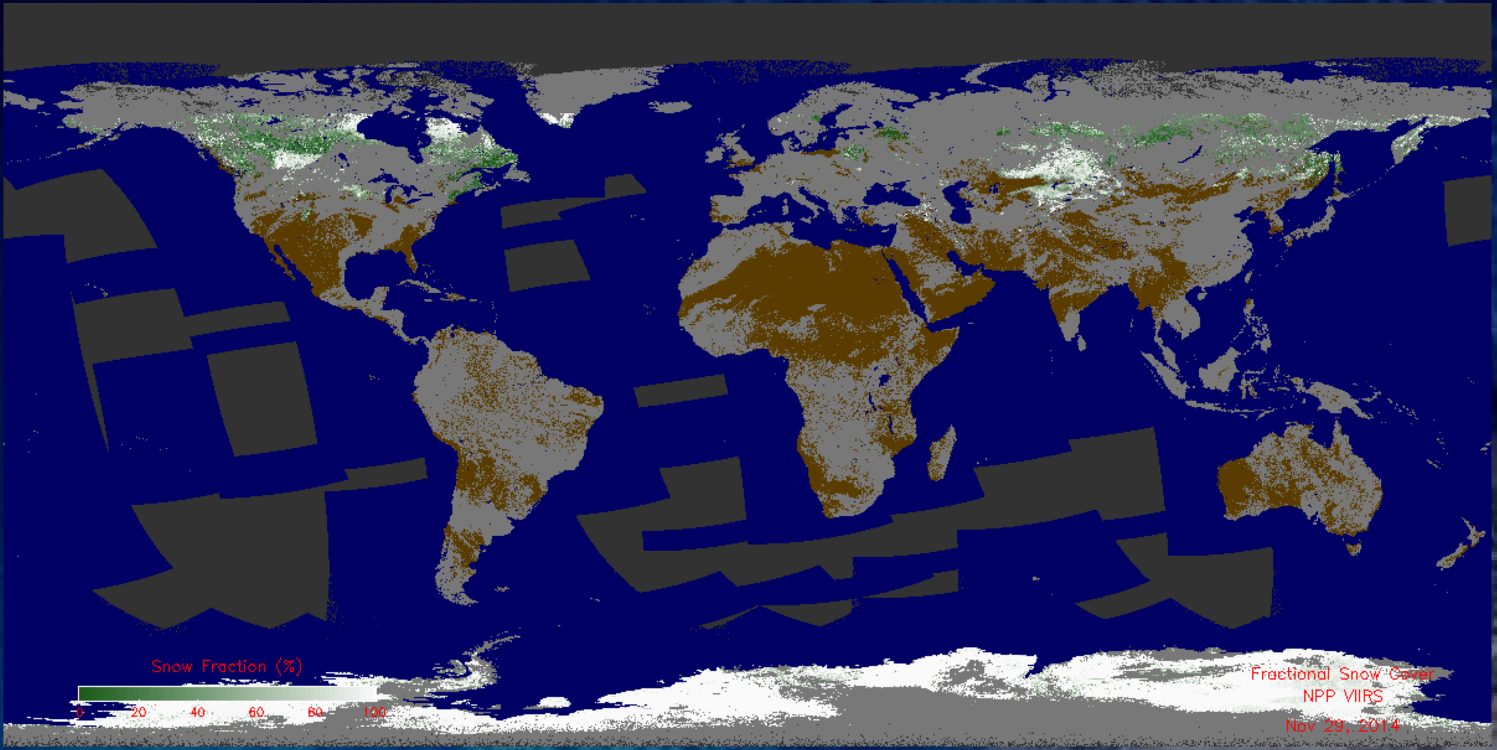
Reflectance-Based Snow Fraction Algorithm Verification

- General approach
  - » Overall qualitative assessment of the product
  - » Consistency testing
    - – Self-consistency:
      - Flat areas
      - Lack of abnormal spatial patterns
      - Day-to-day repeatability of spatial patterns
    - – Consistency (spatial correlation) with the forest cover distribution
    - – Consistency (correlation) with in situ snow depth data over open
  - » Comparison with higher spatial resolution data

Reflectance-Based Snow Fraction Algorithm Verification

- Reflectance-based algorithm has been evaluated, tested and verified over VIIRS global daily data at imagery spatial resolution collected daily since January 2014
- All daily snow fraction maps since Jan 1, 2014 are available at http://www.star.nesdis.noaa.gov/smcd/emb/snow/viirs/viirs-snow-fraction.html
- Detailed algorithm evaluation report is available at http://www.star.nesdis.noaa.gov/smcd/emb/snow/documents/snow_fraction_algorithm_for_VIIRS.pdf

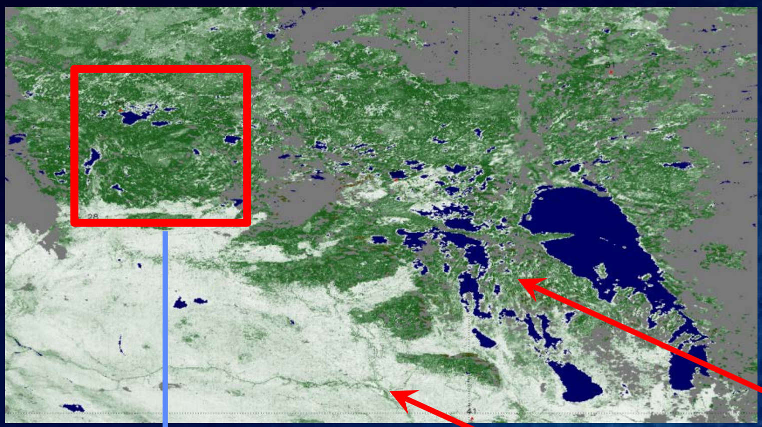
Reflectance-Based Snow Fraction Recent Example

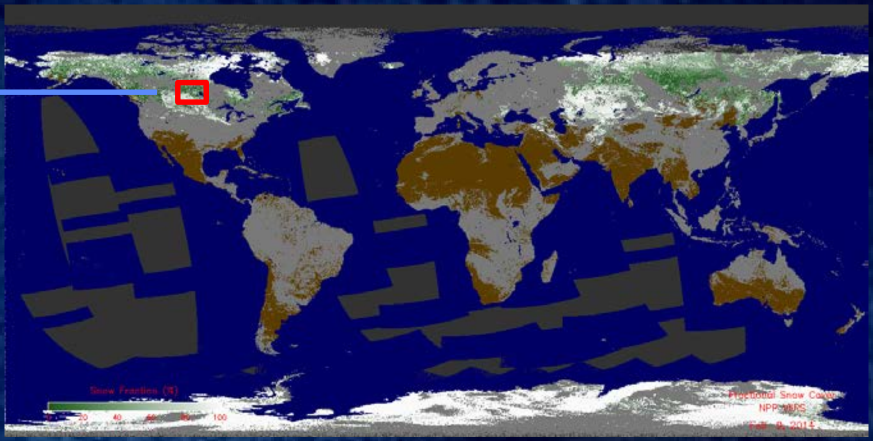


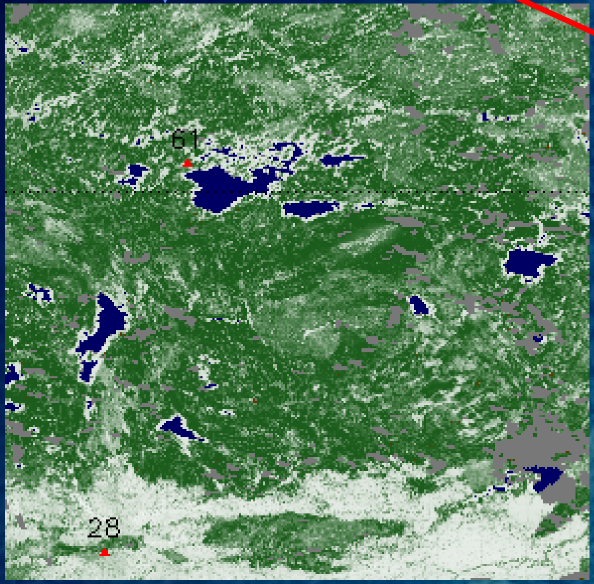
Daily VIIRS Reflectance-based snow fraction map gridded at 1 km, Nov 29, 2014

Global reflectance-based snow fraction maps have been generated daily and examined since January 2014.

Reflectance-based Snow Fraction: Qualitative Assessment

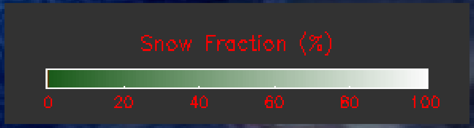






Forest

Prairies

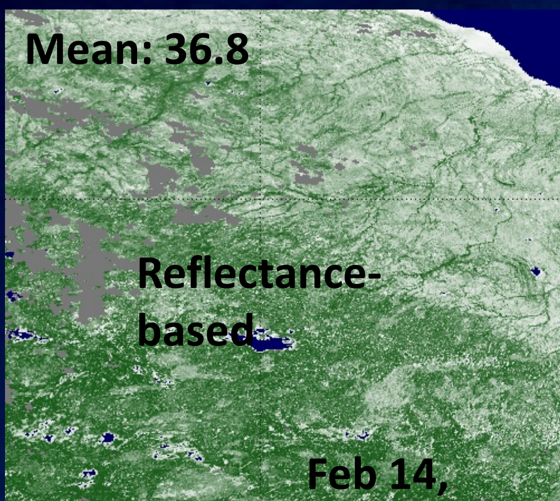


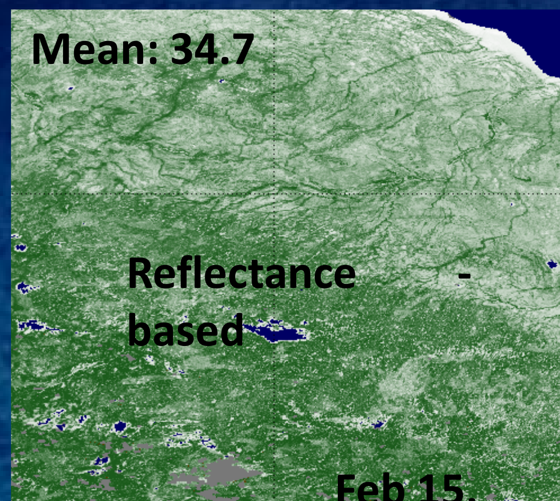
Clouds are shown in gray

<u>VIIRS Global Reflectance-Based Snow Fraction</u>: The spatial pattern of the derived snow fraction is consistent with the pattern of forest cover distribution in Northern Hemisphere

Reflectance-based Snow Fraction: Temporal Stability

VIIRS-derived snow fraction is compared on two consecutive days
No snow fall and no snow melt: the derived snow fraction should not change much



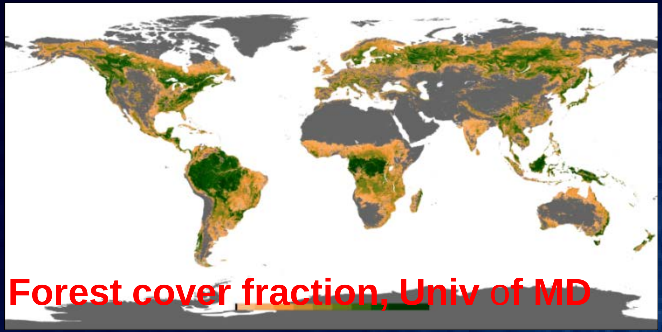


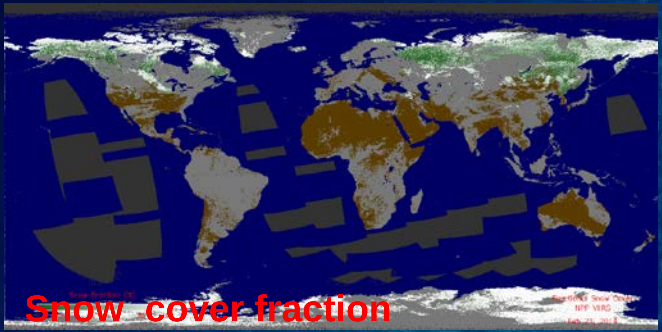
Map Type	Feb 14 to Feb 15, 2014	
	Mean Diff.	Correlation
Refl.-based	**1.9%**	**0.80**

Reflectance-based snow fraction retrievals demonstrate robust performance over space and time

- 2% day-to day variations
- 0.80 spatial correlation

Reflectance-based Snow Fraction vs Tree Cover

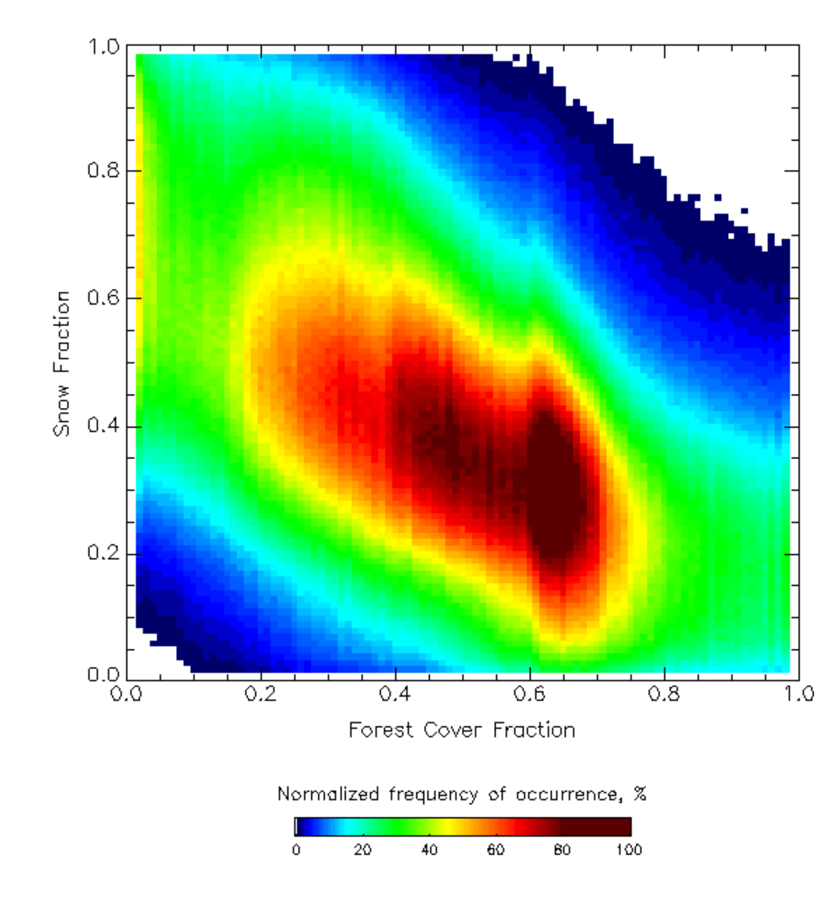




Forest Cover vs Snow Fraction daily map correlation: -0.5: -0.8

Strong correlation indicates consistency of snow fraction retrievals with the land surface cover properties

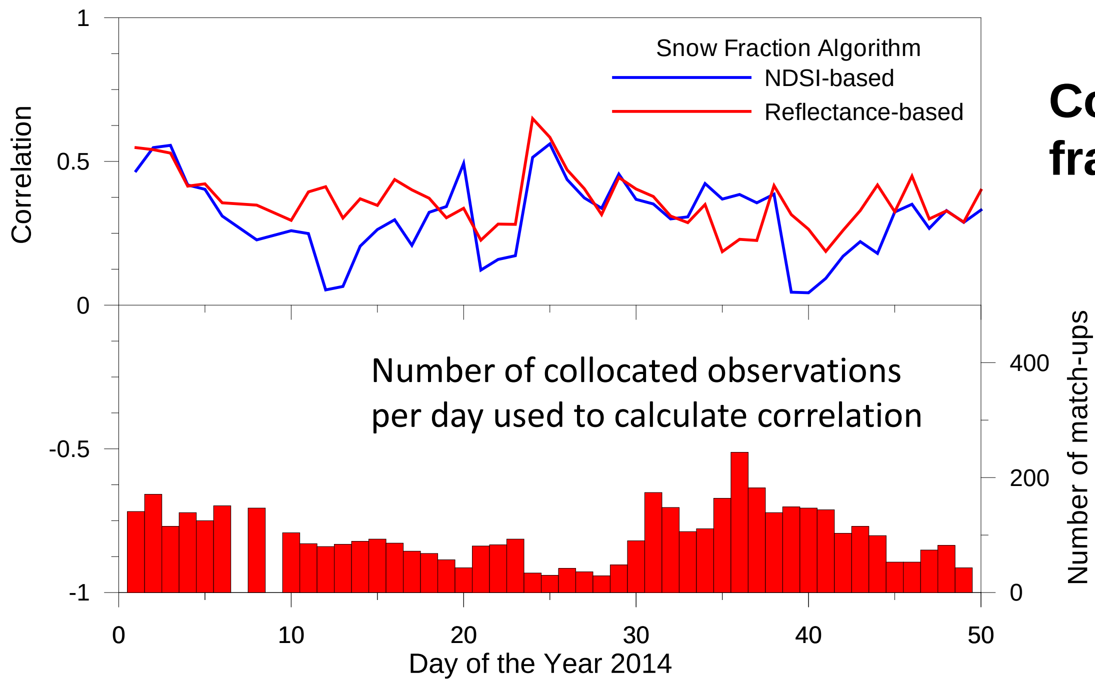
Snow fraction vs forest fraction scatter plot



Reflectance-based Snow Fraction vs In Situ Snow Depth

Over non-forested areas the snow cover fraction is determined primarily by the depth of the snow pack

VIIRS-derived snow fraction demonstrates is positively correlated (0.3 – 0.5) and hence is consistent with the observed snow depth



Correlation between VIIRS snow fraction and in situ snow depth

- Statistics collected over Great Plains
- Jan-Feb 2014
- Pixel-to-point match-ups
- 20 to 200 match-ups per day

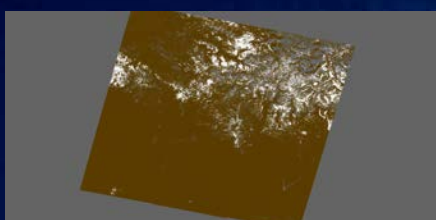
Algorithm Verification with Landsat Data

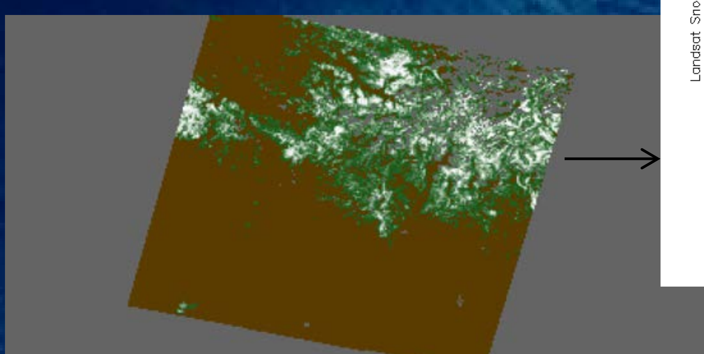
<u>Approach</u>

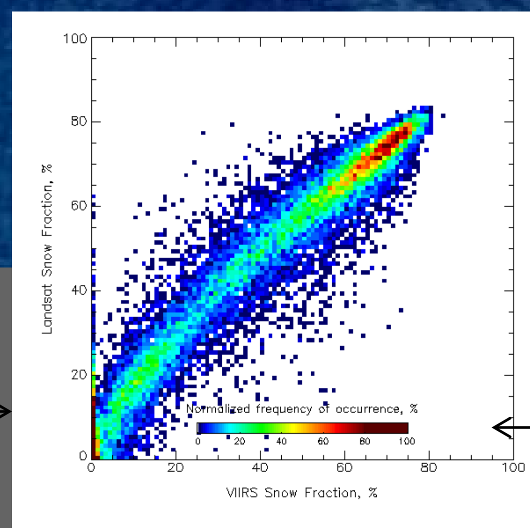
(1) Generate binary snow mask for a Landsat scene at 30 m resolution

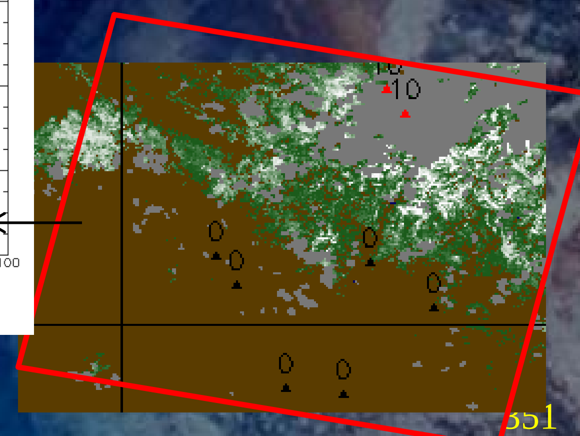
(2) Use Landsat binary snow to derive snow fraction within VIIRS pixels

(3) Compare with VIIRS snow fraction estimate



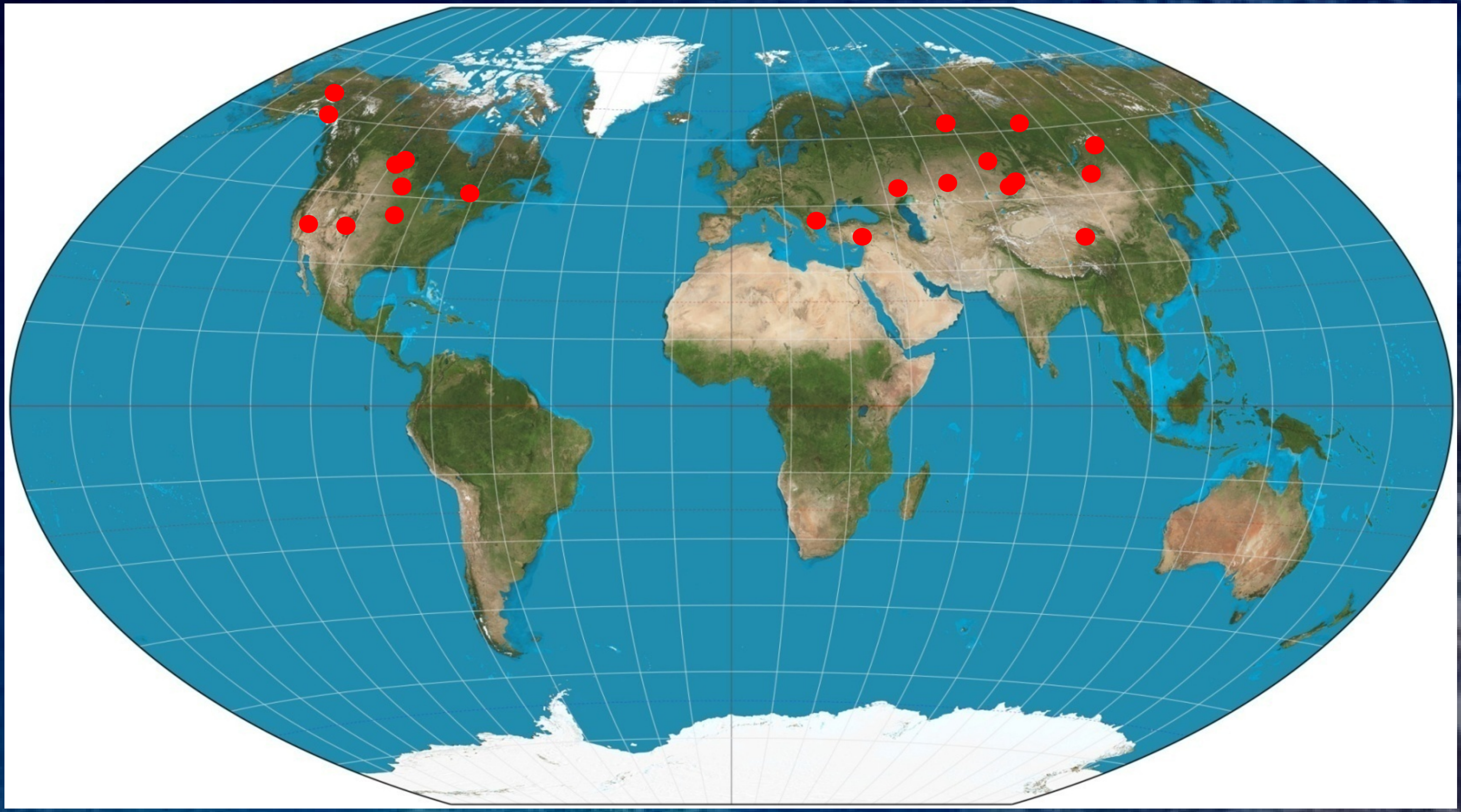






Algorithm Verification with Landsat Data

Location of VIIRS and Landsat Comaprison (Jan-May 2014)



Reflectance-based Snow Fraction Algorithm Verification

Comparison Statistics of VIIRS and Landsat snow fraction

Date of year 2014	Path	Row	Sol Elev	Lat	Lon	Mean Fraction VIIRS	Mean Fraction Landsat	1 km		5 km	
								Correl	RMSE	Correl	RMSE
01/09	16	27	18	47.4	-75.5	0.21	0.23	0.71	0.173	0.87	0.112
01/09	32	28	20	46.0	-100.8	0.77	0.83	0.40	0.17	0.41	0.157
01/13	28	33	26	38.8	-96.9	0.19	0.06	0.67	0.106	0.92	0.078
01/14	35	24	14	51.7	-103.0	0.74	0.74	0.89	0.131	0.97	0.072
01/14	35	25	17	50.2	-103.6	0.89	0.90	0.72	0.098	0.84	0.054
01/14	35	34	28	37.5	-108.2	0.26	0.27	0.84	0.140	0.94	0.069
01/15	42	34	28	37.4	-119.0	0.11	0.10	0.82	0.112	0.92	0.061
01/15	131	26	18	48.8	107.4	0.42	0.47	0.84	0.157	0.83	0.142
01/15	147	26	18	48.8	82.7	0.67	0.70	0.89	0.101	0.95	0.069
01/15	147	27	19	47.4	82.1	0.66	0.68	0.91	0.051	0.96	0.031
03/14	169	26	36	48.4	48.6	0.42	0.47	0.95	0.094	0.99	0.068
03/14	185	31	41	41.7	21.3	0.34	0.31	0.91	0.145	0.97	0.094
03/15	160	26	36	48.8	62.5	0.86	0.90	0.72	0.070	0.80	0.055
03/15	128	20	29	57.3	116.0	0.59	0.53	0.69	0.203	0.80	0.125
03/24	159	15	27	64.1	72.9	0.74	0.77	0.89	0.111	0.98	0.049
03/24	175	34	48	36.5	35.49	0.72	0.70	0.79	0.146	0.94	0.114
03/25	134	35	50	36.0	98.4	0.56	0.56	0.90	0.132	0.97	0.070
03/25	150	23	37	53.1	79.8	0.43	0.44	0.90	0.078	0.98	0.040
04/23	72	14	37	65.5	-151.5	0.32	0.34	0.90	0.103	0.97	0.054
04/27	141	16	40	62.6	99.7	0.35	0.36	0.81	0.098	0.90	0.055
05/15	66	17	47	61.5	-145.2	0.67	0.65	0.80	0.131	0.94	0.069
Mean								0.80	0.121	0.90	0.078

Statistics is provided for observations aggregated within 1 km and 5 km grid boxes. Each Landsat-VIIRS matched scene includes from about 400 to several thousand matched snow fraction estimates.

The overall agreement of VIIRS and Landsat snow fraction is 12.1% for 1 km grid cells and about 8% for 5 km aggregation

Reflectance-Based Snow Fraction Algorithm: Summary

- Reflectance-based snow fraction algorithm:
  - » Has strong physical background
  - » Has long history of application and use
  - » Has been tested with VIIRS data for 1 year-long time period, daily
  - » Provides snow fraction retrievals consistent with other existing environmental datasets (forest cover, snow depth)
  - » Provides snow fraction retrievals at an estimated accuracy of 10-13%

Path Forward: Reflectance-Based Snow Fraction

Current product presents the viewable snow fraction, which is different from the true fractional snow cover on the ground surface.

As the next step we will develop an algorithm to estimate the true snow fraction on the ground. This can be done by correcting the viewable snow fraction for the snow masking effects of forests. The intrinsic assumption of this approach is that the snow fraction is the same in the open areas and beneath the tree canopy.

$$SF_{R\text{-}TRUE} = SF_{R\text{-}VIEW} /(1- FF),$$

where FF is the forest cover fraction

The primary application of the true snow fraction is in hydrology. It helps to better estimate the snow extent on the ground and hence to get a better estimate of the snow water storage within river watersheds

Snow Fraction References

- Salomonson, Appel (2004) Estimating Fractional Snow Cover From MODIS Using the Normalized Difference Snow Index (NDSI). Remote Sensing of the Environment 89:351-360.

- Painter T.H. et al. (2009) Retrieval of subpixel snow covered area, grain size, and albedo from MODIS. Remote Sensing of Environment 113: 868-879.

- Romanov P., D. Tarpley, G. Gutman and T. Carroll (2003) Mapping and monitoring of the snow cover fraction over North America. Journal of Geophysical Research, D108, 8619, doi:10.1029/2002JD003142, 2003

Outline

- Introduction
- Requirements
- Operations Concept
- Fractional Snow Cover
- Detailed Design
- Algorithm Package
- Quality Assurance
- Risks and Actions Summary
- Summary and Conclusions

Detailed Design

Presented by

Veena Jose

Two Sub-sections:

1. Software Architecture and Interfaces
2. Design Overview and System Description

Detailed Design

1. Software Architecture and Interfaces

Software Architecture

- **Purpose:** Demonstrate that the algorithm process flow provides an implementation that is consistent with the theoretical basis and meets requirements.

CDR Software Architecture

- A preferred solution has been selected for the Aerosol, Cloud and Cryosphere Products
- The software system is an integrated collection of software elements, or code, that implements the preferred solution, producing well-defined output products from a well-defined set of input data.
- The software architecture describes the structure of the system software elements and the external and internal data flows between software elements.

Software Architecture Levels

Context Level - 0	External Interfaces
System Level - 1	Flows Between Units
Unit Level - 2	Flows Within Units
Sub-Unit Level - 3	Flows Within Sub-Units

Software Architecture Levels

Context Level - 0	External Interfaces
System Level - 1	Flows Between Units
Unit Level - 2	Flows Within Units
Sub-Unit Level - 3	Flows Within Sub-Units

External Interfaces - Definition

- An external input is defined as a data source needed by the system that is produced or made available by a process external to the system
- An external output is defined as a product that is created by the system for a user

External Interfaces - Criteria

- The external inputs are handled by a Perl wrapper script that ensures Production Control setup for the system
- The data passed to the units and sub-units will be stored in arrays.
- Most input/output data files for the Aerosol, Cloud and Cryosphere algorithms will be in NetCDF4 format.
  - Exceptions:
    - NCEP model forecast data
    - CRTM coefficients
    - PCF file
    - Log file

External Interface Design at CDR

AIT Framework

Purpose

- **Purpose:** Demonstrate that the AIT Framework provides an infrastructure that will enable the implementation of the Aerosol, Cloud and Cryosphere algorithms that meet the requirements.

STAR AIT Framework Overview

- The STAR AIT Framework is a main program designed to run any scientific algorithm
- The Framwork is a C++ program that interfaces with C++/C/Fortran 90/95 algorithms
- The Framework is run by perl scripts
- Production Control Files (PCF) determine what algorithms are run when the framework is executed

STAR AIT Framework Details

- Common ancillary data is used across algorithms (where possible)
- Forward model is run once for all algorithms
- Satellite data and ancillary data is stored in memory for use by the algorithms
- Algorithms may be run in any order – determined by the PCF file

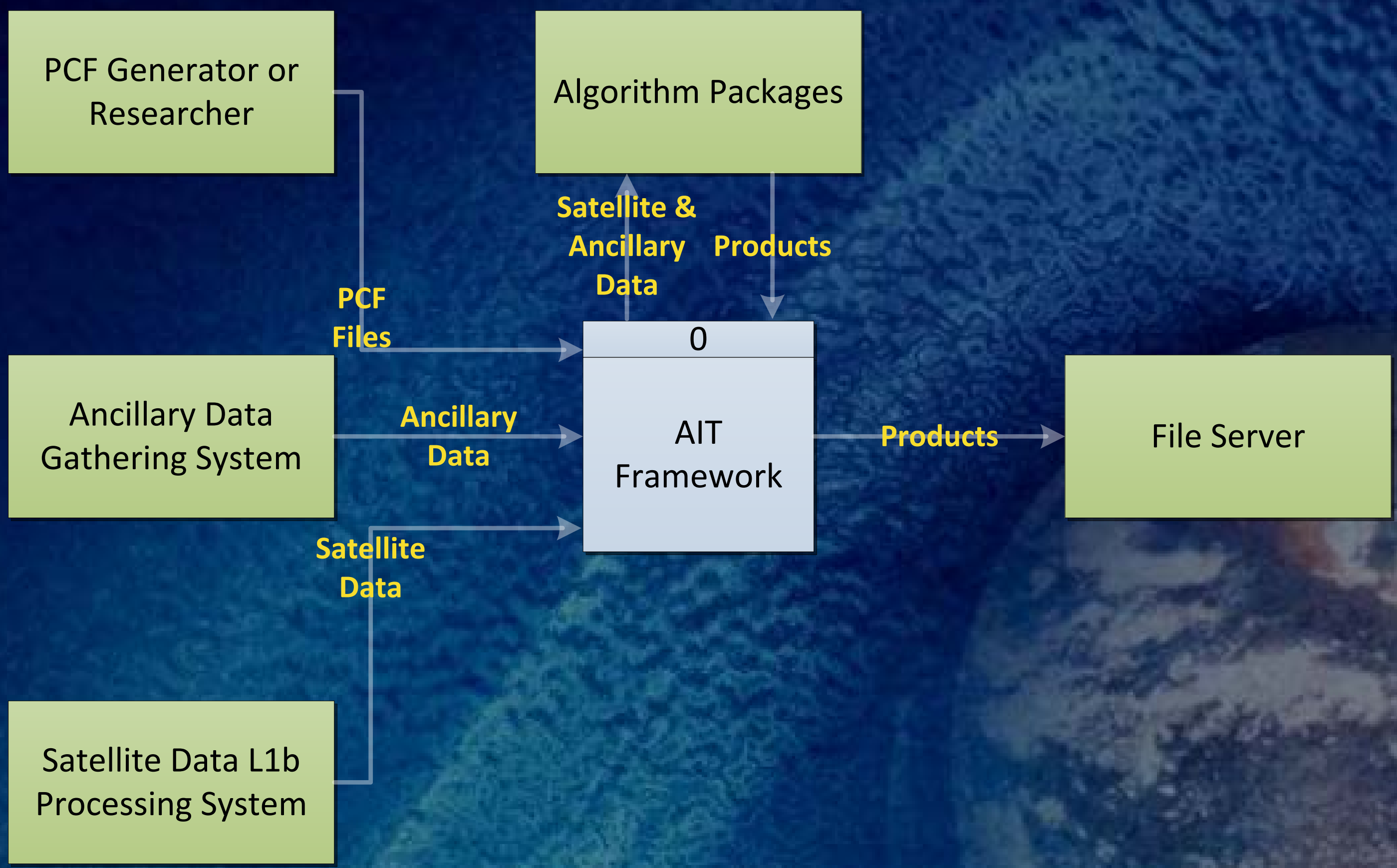
STAR AIT Framework Algorithms

- Algorithms plugged into the framework are subroutine calls
- Data is not read within the algorithm, all input data is either passed into the algorithm or is read via a function call
- Readers and writers of all types of input and output data are treated as algorithms

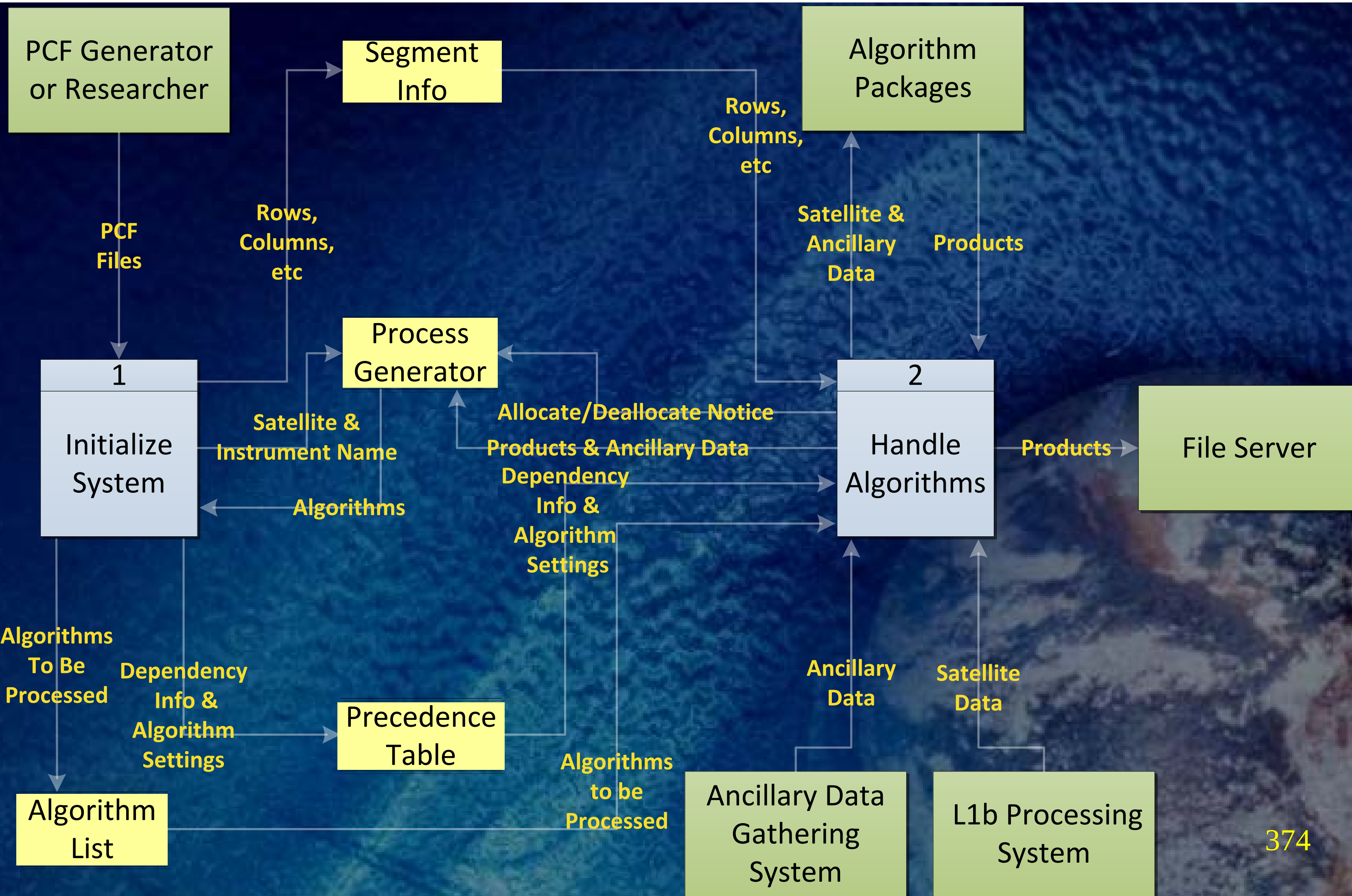
Framework Data Flow and Interfaces

- The following slides show the data flow and interfaces in the framework.

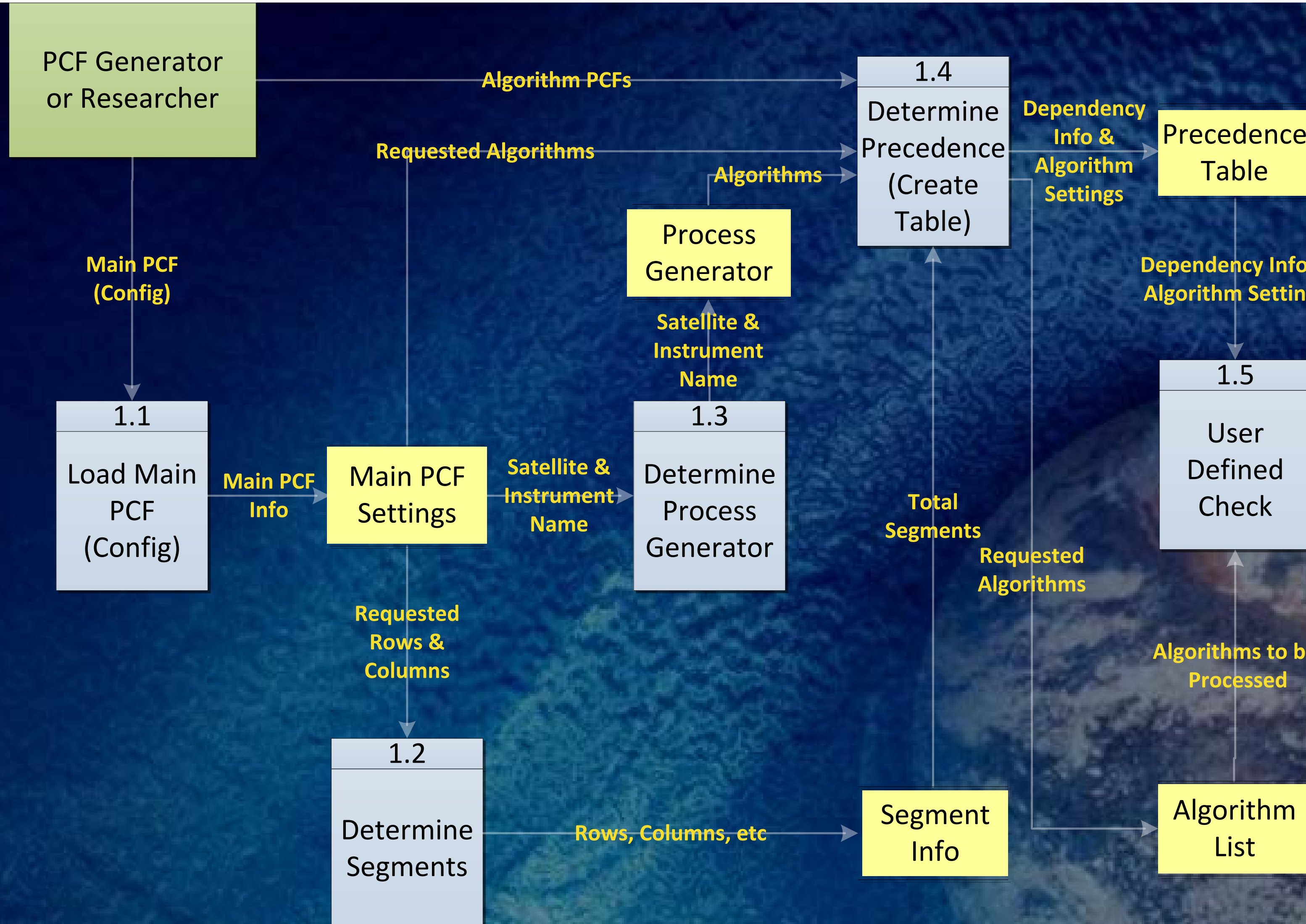
Framework Context Diagram



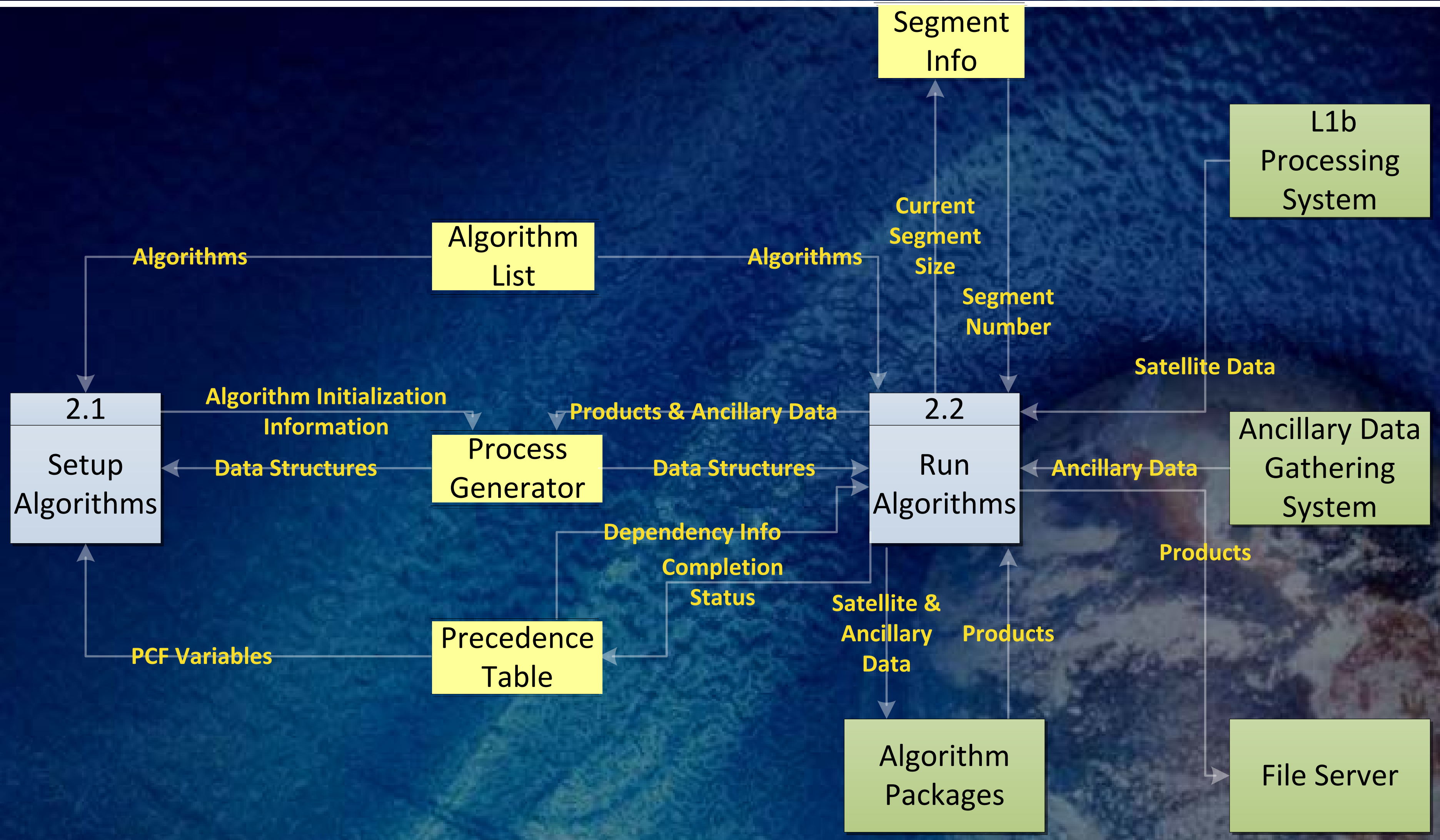
Framework
System Level



Framework Unit Level 1 Initialize System



Framework Unit Level 2 Handle Algorithms



Inputs

- PCF files
- Data
  - » Common ancillary data
  - » Radiance data
  - » Specific algorithm data

PCF Files

- Production Control Files (PCF) contain the information required to run an algorithm
  - » Algorithm dependencies to determine product precedence
  - » Algorithm specific variables such as flags and thresholds
  - » Framework loads the contents of the PCF file when the algorithm has been flagged to run in the configuration file or if it is needed by something that has been flagged to run in the configuration file.

PCF File: 3 Main Sections

- DEPENDENCIES
  - » List the Type and PCF ID for each dependency the algorithm requires
- OTHER
  - » This section contains algorithm specific variables such as thresholds, flags, etc that are flexible and can be changed at run time.
- TEMPORAL
  - » This section dictates temporal needs for the algorithm if requested.

PCF Layout Example

(Default_PCF/NPP/VIIRS/NPP_BAYES_Cloud_Mask.pcf)

```
#
# NPP_BAYES_CLOUD_MASK
#
NPP_BAYES_CLOUD_MASK
```

PCF ID indicates beginning of entry.

```
PRODUCT
```

PRODUCT or ANCILLARY

```
#
# Set flag for output
#
OUTPUT_TO_FILE: Y
```

Output result to file (Y/N)

```
#
# Dependencies
#
DEPENDENCIES:
```

"DEPENDENCIES" keyword indicates dependency section of the PCF.

```
SATELLITE_DATA:
```

SATELLITE_DATA dependency type doesn't have a dependency below. The framework will look for what satellite data to use in the config file. This avoids tedious modification to each PCF.

```
LAND_MASK:
```

Dependency Type

```
LAND_MASK_NASA_1KM
```

Dependency PCF ID

PCF Layout (cont 1)

```
COAST_MASK:
COAST_MASK_NASA_1KM

DESERT_MASK:
DESERT_MASK_CALCLTED

SNOW_MASK:

SNOW_MASK_IMS_SSMI

SNOW_MASK_NWP


SURFACE_TYPE:
SFC_TYPE_AVHRR_1KM

PSEUDO_EMISSIVITY:
GOESR_ABI_CHN7_EMISS

SURFACE_ELEVATION:
SFC_ELEV_GLOBE_1KM

SST:
OISST_DAILY_QTRDEG

SURFACE_EMISSIVITY:
SFC_EMISS_SEEBOR
```

1st Dependency

Backup Dependency

PCF Layout (cont 2)

```
SURFACE_ALBEDO:
SFC_ALBEDO

NWP_DATA:
NWP_GFS

RTM:
CRTM

TEMPORAL_DATA:
NO_TEMPORAL

#
# Settings
#
OTHER:

CldMask_Packed_Constant: 8
Flag_Constant: 33
Meta10: 10
Meta20: 20
Ancillary_Path: algorithm_ancillary/NPP_BAYES_CldMask/viirs_default_bayes_mask.txt

END NPP_BAYES_CLOUD_MASK
```

Temporal data is special – has it's own section that needs to be filled out if it is specified to run.

"TEMPORAL" keyword indicates temporal section. Only required for algorithms needing temporal data.

Keyword "OTHER" indicates algorithm variables/settings section.

NPP_BAYES_CLOUD_MASK specific variables

End of algorithm entry

Specific Algorithm Data

- Each algorithm currently reads its own specific ancillary data (such as coefficient files, look up tables, etc)

- See algorithm section for details

Product Precedence

- The following 6 slides show the ancillary data product precedence information:
  » VIIRS SDR data
  » Static Ancillary data
  » Dynamic Ancillary data
  » Radiative Transfer Model (RTM)
- The full product precedence chart for the Fractional Snow Cover algorithm is shown later in this section.

Ancillary Product Precedence S-NPP VIIRS

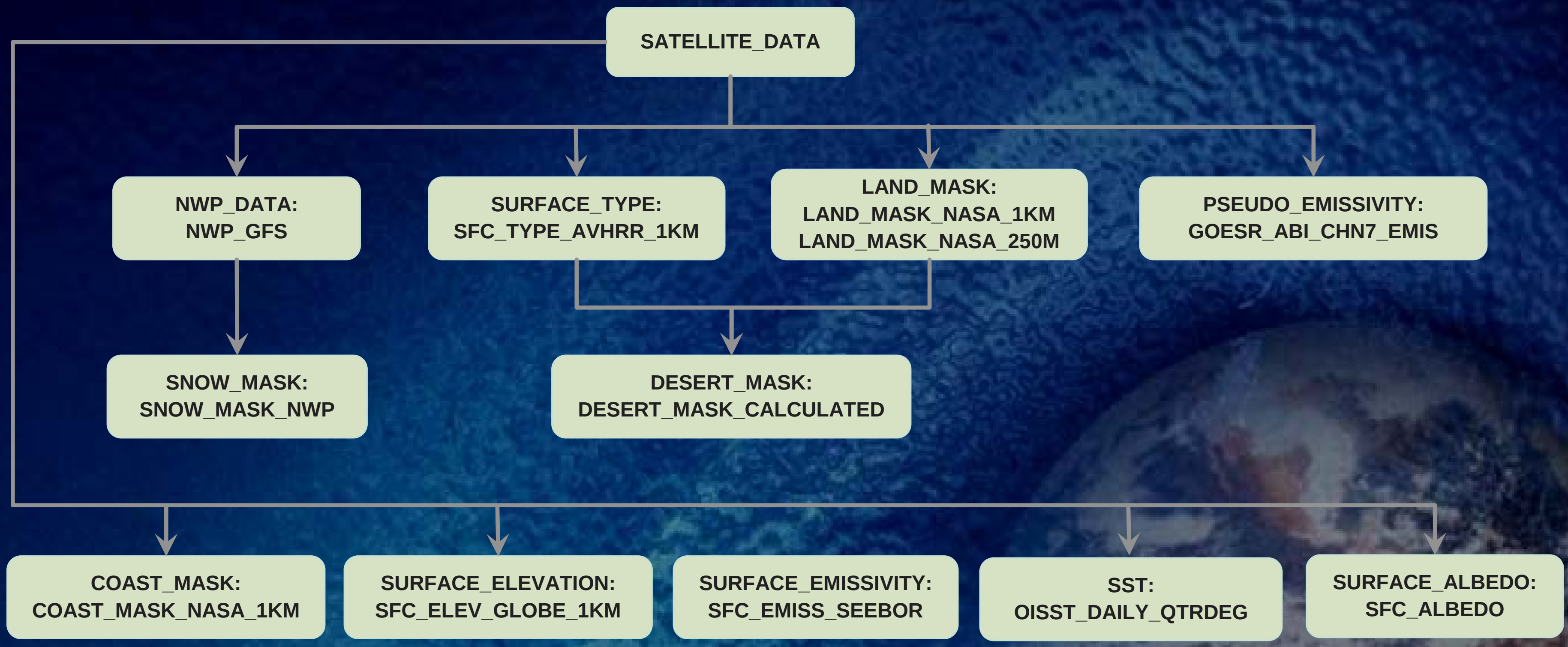


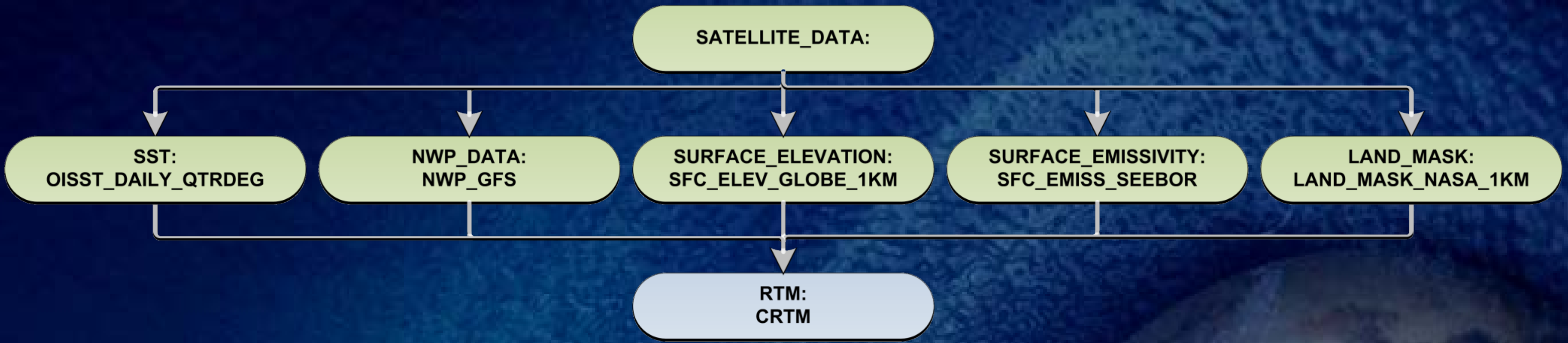
Table of DynamicAncillary Data

Ancillary Data	Description	Filename	Size
CRTM	Community Radiative Transfer Model	N/A	N/A
NWP_GFS	NCEP GFS model data in grib2 format – 0.5x0.5 degree (720x361), 26 levels	gfs.tHHz.pgrbfhh	55 – 56MB
OISST_DAILY_QTRDEG	NCEP EMC Reynolds OISST daily analysis, 0.25 degree resolution	avhrr-only-v2.YYYYMMDD.nc	8MB
SNOW_MASK_NWP	Snow/Ice mask, calculated from snow surface variable in the GFS Grib2 file	N/A	N/A

Table of Static Ancillary Data

Ancillary Data	Description	Filename	Size
COAST_MASK_NASA_1KM	Global 1km land/water used for MODIS collection 5	coast_mask_1km.nc	890 MB
DESERT_MASK_CALCLTED	Desert mask calculated using LAND_MASK_NASA_1KM and SFC_TYPE_AVHRR_1KM	N/A	N/A
LAND_MASK_NASA_1KM	Global 1km land/water used for MODIS collection 5	lw_geo_2001001_v03m.nc	890 MB
LAND_MASK_NASA_250M	Global 250 m land/water used for MODIS collection 6	TBD	TBD
SFC_ELEV_GLOBE_1KM	Digital surface elevation at 1km resolution	GLOBE_1km_digelev.nc	1843 MB
SFC_TYPE_AVHRR_1KM	Surface type mask based on AVHRR at 1km resolution	gl-latlong-1km-landcover.nc	890 MB
SFC_EMISS_SEEBOR	Surface emissivity at 5km resolution, climatology monthly	global_emiss_intABI_2005DDD.nc	693 MB x 12
GOESR_ABI_CHN7_EMISS	Pseudo channel 7 emissivity	N/A	N/A
SFC_ALBEDO	White Sky Surface albedo- 4 year composites for 0.659um, 1.64um and 2.13um	AlbMap.WS.c004.v2.0.YYYY.DDD.0.659_x4.nc AlbMap.WS.c004.v2.0.YYYY.DDD.1.64_x4.nc	28MB x 23 x3

Product Precedence RTM



Key:

Required Precedence

Algorithm

CRTM Inputs

Filename	Description	Size
CloudCoeff.bin	Cloud coefficient data for CRTM	1.6MB
AerosolCoeff.bin	Aerosol coefficient data for CRTM	5.5MB
EmisCoeff.bin	Emissivity coefficient data for CRTM	1.9MB
viirs_npp.SpcCoeff.bin	Space coefficient data of NPP VIIRS-M for CRTM	472B
viirs_npp.TauCoeff.bin	Tau coefficient data of NPP VIIRS-M for CRTM	104KB

Output Files

- Output files are in NetCDF format

STAR Hardware

- Rack of Linux Dell Processors (72 CPUS) for product development.
- 20 TB of disk space on the SAN for all simulated data, proxy data and products.

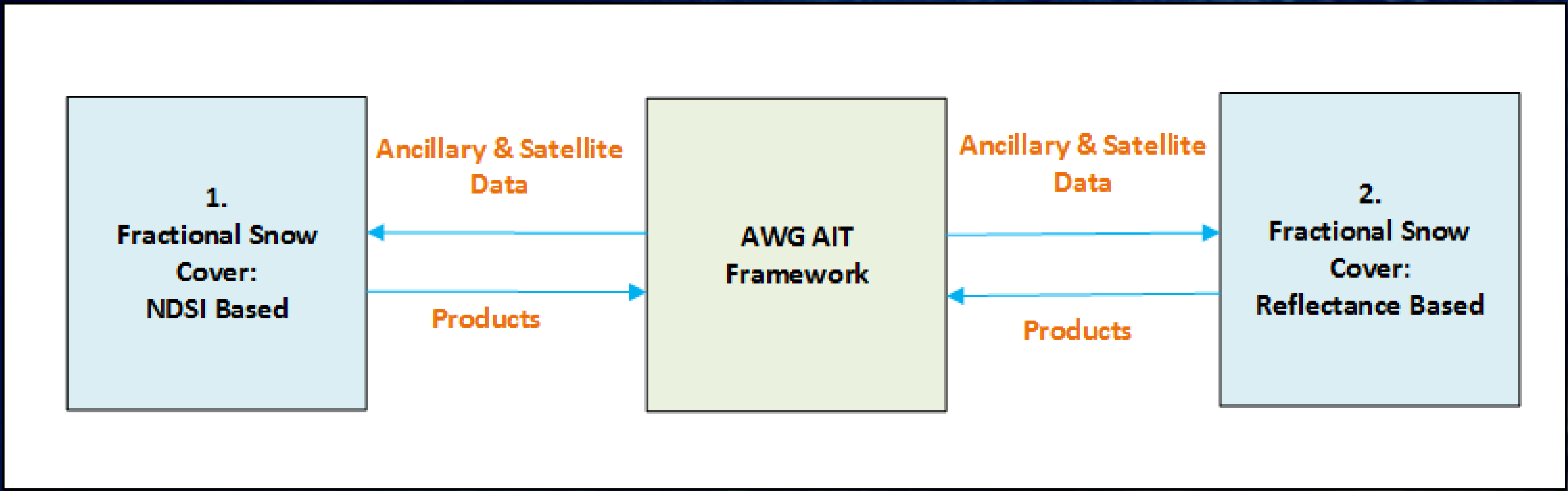
Software/Compilers

- Framework uses netCDF libraries
  - » NetCDF 4
  - » HDF 5 (required by NetCDF 4)
- Framework uses wgrib commands
- Perl scripts
  - » Code generation
  - » Standards checking
- Currently runs on Intel and GNU compilers
- ClearCase and ClearQuest used for version control
- Valgrind used to check for memory leaks

External Interface Design at CDR

System Level

Fractional Snow Cover System Level Data Flow - Diagram

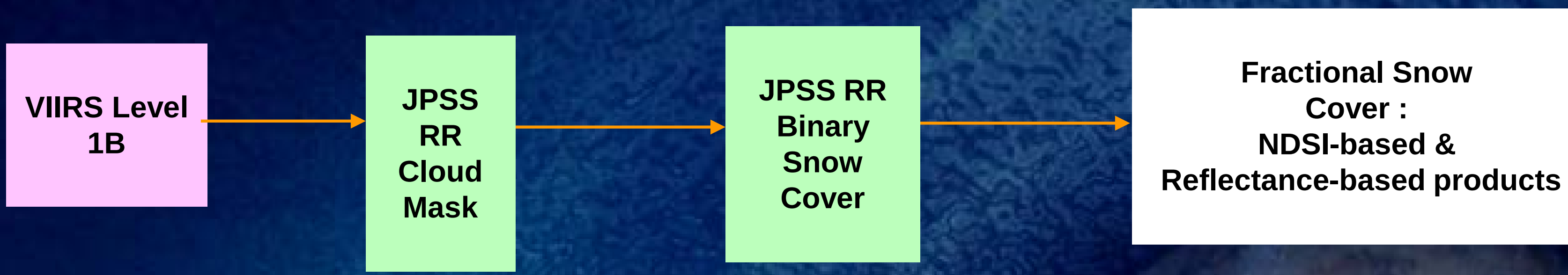


System Level Data Flow – Table

Fractional Snow Cover
Input, Internal, and Output Data Flows at the System Level

Interface Item	Interface Type	Source	Description
VIIRS SDR	Input	VIIRS	VIIRS calibrated and navigated reflectance for channels I1, I2, and I3 along with solar and satellite view angles
Land & Water Mask	Input/Static	NASA	Global 1 km land/water & coast mask used for MODIS collection 5 Global 250 m land/water & coast mask used for MODIS collection 6
Surface Elevation	Input/Static	NGDC	Digital surface elevation at 1km resolution
VIIRS Cloud Mask	Input	VIIRS Cloud Mask	Cloud mask produced by VIIRS cloud mask algorithm
VIIRS Snow Mask	Input	VIIRS Snow Mask	Snow Mask produced by VIIRS snow cover algorithm
VIIRS NDSI Snow Cover Fraction	Output	VIIRS Fractional Snow Cover	Fractional Snow Cover produced by VIIRS NDSI Snow Cover algorithm
VIIRS Reflectance Based Snow Cover Fraction	Output	VIIRS Fractional Snow Cover	Fractional Snow Cover produced by VIIRS Reflectance based Snow Cover algorithm

System Level Data Flow – Product Precedence



All VIIRS products listed within the Detailed Design section that are used as product precedence are products created within the NDE JPSS Risk Reduction project

System Level Data Flow – Sequence(1)

- The framework reads in common datasets such as VIIRS SDR and ancillary data for all products including those in precedence. The following apply to Fractional Snow Cover products:
  - » VIIRS SDR
  - » Land/Water Mask
  - » Surface Elevation

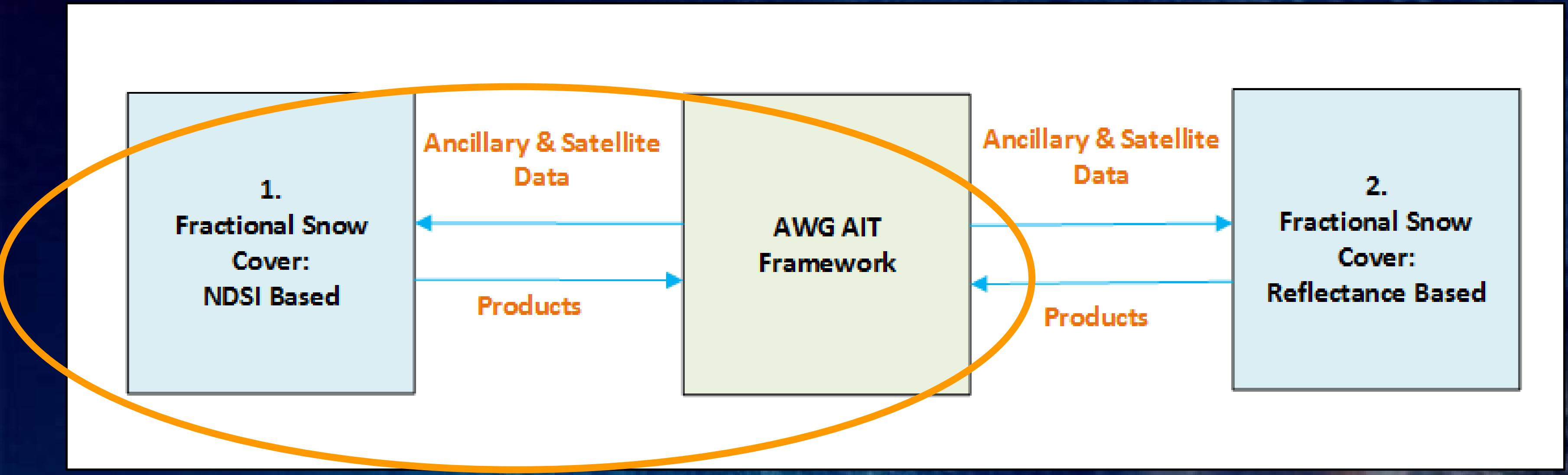
Yellow - Static

System Level Data Flow – Sequence(2)

- The framework checks the precedence to produce Fractional Snow Cover products. It will run the following products upstream:
  - » JPSS RR Cloud mask
  - » JPSS RR Binary Snow Cover
- All the ancillary data including VIIRS SDR will be passed to the Fractional Snow Cover algorithms through data structures.
- The Fractional Snow Cover algorithms read in any product specific inputs such as look up table and coefficient files.
- Fractional Snow Cover product outputs will be sent back to the framework through data structures.

Unit Level

Fractional Snow Cover Unit Level Data Flow-Diagram



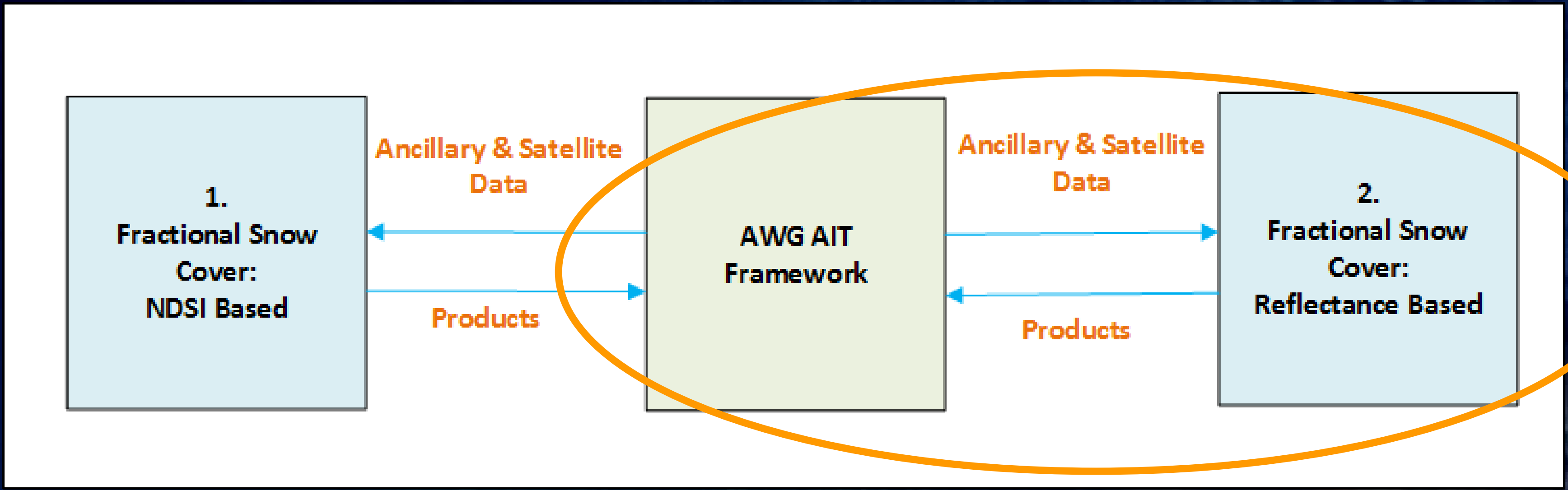
Fractional Snow Cover Unit Level Data Flow-Table

Fractional Snow Cover - NDSI Based

Input, Internal, and Output Data Flows at the Unit Level

Interface Item	Interface Type	Source	Description
VIIRS SDR	Input	VIIRS	VIIRS calibrated and navigated reflectance for channels I1, I2, and I3 along with solar and satellite view angles
Land & Water Mask	Input/Static	NASA	Global 250 m land/water & coast mask used for MODIS collection 6
JPSS RR Cloud Mask	Input	JPSS RR Cloud Mask	Cloud mask produced by JPSS RR cloud mask algorithm
JPSS RR Snow Mask	Input	JPSS RR Snow Mask	Snow Mask produced by JPSS RR snow cover algorithm
JPSS RR NDSI Based Snow Cover Fraction	Output	JPSS RR Snow Cover	Fractional Snow Cover produced by JPSS RR NDSI Snow Cover algorithm

Fractional Snow Cover Unit Level Data Flow-Diagram



Fractional Snow Cover Unit Level Data Flow-Table

Fractional Snow Cover – Reflectance Based

Input, Internal, and Output Data Flows at the Unit Level

Interface Item	Interface Type	Source	Description
VIIRS SDR	Input	VIIRS	VIIRS calibrated and navigated reflectance for channels I1, I2, and I3 along with solar and satellite view angles
Land & Water Mask	Input/Static	NASA	Global 1 km land/water & coast mask used for MODIS collection 5
Surface Elevation	Input/Static	NGDC	Digital surface elevation at 1km resolution
JPSS RR Cloud Mask	Input	JPSS RR Cloud Mask	Cloud mask produced by JPSS RR cloud mask algorithm
JPSS RR Snow Mask	Input	JPSS RR Snow Mask	Snow Mask produced by JPSS RR snow cover algorithm
JPSS RR Reflectance Based Snow Cover Fraction	Output	JPSS RR Snow Cover	Fractional Snow Cover produced by JPSS RR Reflectance based Snow Cover algorithm

Detailed Design

2. Design Overview and System Description

Design Overview Description

- The design overview builds on the software architecture by providing a high level description of each system element that is defined in the software architecture.
- The design overview describes the project system's functionality and design characteristics at a high level that covers, for each system elements:
  - » Its purpose
  - » External interfaces
  - » Decomposition into sub-elements
  - » Functional sequence
  - » Design Language
  - » Input and Output File Descriptions

Design Overview

- Fully defines the structure and capabilities of the software product components.
  » Software architecture details are finalized
  » Software components are completely defined
  » Interfaces to software components are fully characterized
  » Connects the design to the allocated product-component requirements, architecture, and higher level designs

Metadata Design

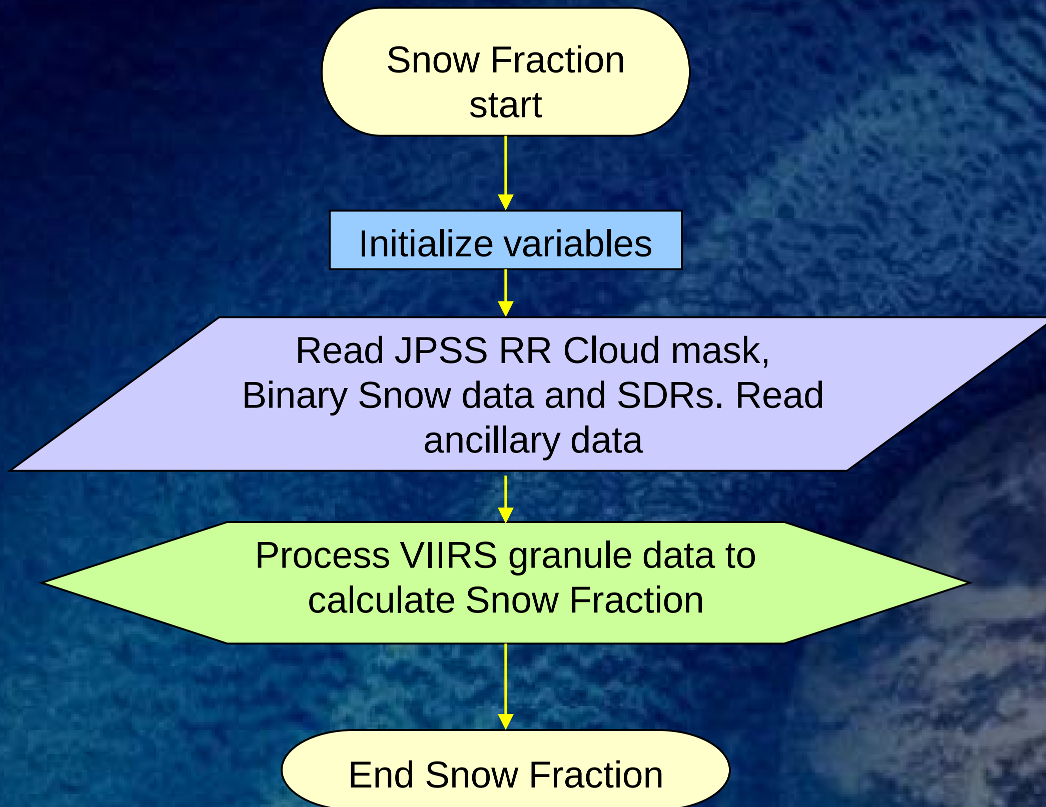
- Metadata design should respond to metadata requirements
- There is no archive requirement for this project, so the only metadata will be product level metadata for OSPO trending
- From our experience, the Cryosphere Team can populate the metadata from Fractional Snow Cover

Fractional Snow Cover Combined Unit Description

- Produce fractional snow cover with associated quality flags.
- Interfaces
  - » VIIRS calibrated and navigated reflectance in bands I1, I2, and I3 along with solar and satellite view angles
  - » JPSS RR Cloud Mask
  - » JPSS RR Snow Cover
  - » Land/water mask
  - » Surface elevation

Yellow - Static

Snow Fraction Processing Outline



High Level Flow Chart of both Snow Fraction Algorithms

Fractional Snow Cover Combined Unit Description

- Design Language – F90/95
- Assumptions applied to the unit design:
  - » VIIRS observation data are within specifications
  - » Cloud mask accuracy is the same as the accuracy of the current VIIRS operational cloud mask
  - » Snow Cover is within accuracy
- Limitations applied to the unit design:
  - » No retrievals in cloudy conditions and at night

System Description

Output

Input

Unit/Sub-Unit	NDSI Based Snow Fraction	Reflectance Based Snow Fraction
VIIRS SDR	√	√
1 km Land & Coast Mask		√
250 m Land & Water Mask	√	
Surface Elevation		√
JPSS RR Cloud Mask	√	√
JPSS RR Snow Cover	√	√

Outline

- Introduction
- Requirements
- Operations Concept
- Fractional Snow Cover
- Detailed Design
- Algorithm Package
- Quality Assurance
- Risks and Actions Summary
- Summary and Conclusions

Algorithm Package

Presented by

Walter Wolf

JPSS RR DAP

- The DAP shall contain:
  - Science algorithm source code, including make files and scripts.
  - Test plans, test description, test procedures, and detailed performance testing results.
  - Test input data, temporary files, and expected output data.
  - Coefficient files and/or look-up tables.
  - Quality monitoring information (quality flags, quality flag values).
  - Production rule-set definitions.
  - Product file specifications – layout, content, and size.
  - Data flow diagrams.
  - List of exit codes and their associated messages.
  - List of expected compiler warnings (see bullet 5 below).
  - Estimates of resources required for execution.
  - Algorithm Theoretical Basis Documents (ATBDs) or reference to where the ATBDs can be obtained.
  - Delivery Memo.
  - README text file.

JPSS RR DAP

- Delivery memo will contain:
  - » Point(s) of contact for questions specific to the algorithm (include name, telephone, e-mail address).
  - » List of delivery contents.
  - » Purpose of the delivery, e.g. an initial release, modification, etc.
  - » Description of problem(s) resolved, if any, and method of resolution.
  - » Description of significant changes from previous version, if any.
  - » List of documents updated/added/superseded, if any.
  - » List of known remaining defects.
- The README text file in the DAP must contain:
  - » Location of all required DAP contents.
  - » DAP version number.
  - » Supporting COTS/Open Source software package requirements.
  - » Target configuration for setup (directories and files after setup scripts have been executed). This is understood to be a list of where everything is located once the DAP has been unpacked.
  - » Other pertinent information as judged by the algorithm developer(s) (e.g. compiler settings, etc.).

Outline

- Introduction
- Requirements
- Operations Concept
- Fractional Snow Cover
- Detailed Design
- Algorithm Package
- Quality Assurance
- Risks and Actions Summary
- Summary and Conclusions

Quality Assurance

Presented by

Walter Wolf

Quality Assurance Background

- STAR has used the Capability Maturity Model Integrated (CMMI) to improve processes and practices for development and the transfer of research to operations.

- The Product Monitoring Project will follow the updated SPSRB process that has been influenced by the STAR EPL process.

Quality Assurance – Project

- The Requirements Review (December 2012)
  - Will present the initial draft of the requirements and a Requirements Allocation Document (RAD) has been made available to the project stakeholders. It will be updated throughout the lifecycle of the project.
- The Critical Design Review (April 2013, Dec 2014)
  - To finalize requirements and to verify that the chosen design is able to meet those requirements.
- A Unit Test Readiness Review (2014)
  - Will present the unit tests to demonstrate that the system is ready to be run in the Test Environment.
- A Software Review (2014)
  - Will be conducted to ensure that the Product Monitoring software is able to fulfill the functional software requirements.
- The Algorithm Readiness Review (Mar 2015)
  - Will show that the Product Monitoring System is ready to be transitioned to operations.

Configuration Management (CM)

- STAR CM Tool (IBM Rational ClearCase, Version 7.0)
  - » Has been purchased and implemented in the Collaborative Environment.
- OSPO CM Tool – Subversion
  - » Open source
- NDE CM Tool – Synergy
- CM personnel have been identified.
- CM training:
  - » Administrator training completed.
  - » If required, developers will be trained by the CM administrator.

SPSRB Coding Standards

- Coding standards guidelines and quick references are available.
- Provide a common list of abbreviations.
- Adhere to the standards throughout the development life cycle.
- Have checklists available for developers to keep track of the delivery status of the code.
- Code is checked for compiance during the software review.

Quality Assurance – Software

- The JPSS Risk Reduction software will be delivered incrementally as part of the series of algorithm package deliveries.
- This will allow system testing of the code within NDE 2.0.

Quality Assurance – Software

- All code development is being conducted on a platform that is nearly identical to the test and production target platforms using the same compilers and operating system.
- STAR code checking tools will be used to minimize coding bugs and to ensure that software meets the coding standards.
- The status of all system calls and intrinsic functions are checked.
- Unit tests will be conducted for each product individually.
  - » The PALs will have access to test data products to verify that values appear reasonable.

Quality Assurance – Software

- An official algorithm package will be delivered:
  - » All Product Monitoring code and system files
  - » Test plans
  - » Test data sets
  - » Error messaging/handling
  - » Configuration files
  - » Production rules
  - » Database specifications
  - » Data flow diagrams
  - » Estimates of resource usage
  - » Delivery memo

Quality Assurance – Products

- JPSS Risk Reduction developers will work with:
  - » The algorithm developers to ensure that the implemented algorithms are producing the correct results
  - » The PALs to ensure that the system has been implemented correctly
  - » The users to ensure that the products are what the users require

Quality Assurance – Archive and Maintenance

- Archive Plan
  - » Currently no plan to archive any of the products
- Long Term Maintenance Plan
  - » The Product Monitoring System will be maintained by the OSPO staff
  - » STAR system developers will be available

Quality Assurance – Documentation and Metadata

- Documentation/Metadata Plan
  - » The Documentation will include the SPRSB documents with the RAD and RID
  - » Metadata associated with these products are the variables that may be used for product monitoring

Quality Assurance Summary

- Quality assurance plan will consist of:
  - » Project reviews at which stakeholders are encouraged to participate.
  - » Ongoing interaction with algorithm developers, NDE and OSPO PALs.
  - » Adhering to SPSRB software standards and use of standard libraries only.
  - » Software unit tests shall be presented in the UTRR.
  - » Documentation of the code operation, production rules, and software tests will be in the algorithm package.
  - » Documentation of requirements will be in the JPSS RR RAD.
  - » Early release of software will allow for early system implementation.

Outline

- Introduction
- Requirements
- Operations Concept
- Fractional Snow Cover
- Detailed Design
- Algorithm Package
- Quality Assurance
- Risks and Actions Summary
- Summary and Conclusions

Risks and Actions

Presented by

Walter Wolf

Snow Fraction CDR Risks and Actions

- **CDR Risk 10:** UTRR will be skipped for Snow Fraction
- **Risk Assessment:** Medium
- **Impact:**
  - » Algorithm tests will not be reviewed. Possibility of algorithm not meeting requirements
- **Likelihood:** High
- **Mitigation:**
  - » Add algorithm to framework before Jan 2015 so extensive algorithm testing can be done.
  - » Will provide algorithm timing and accuracy information at the ARR
- **Status:** Open

Snow Fraction CDR Risks and Actions

- **CDR Risk 11:** Work toward the implementation of an Enterprise Fractional Snow Cover Algorithm
- **Risk Assessment:** High
- **Impact:**
  - » Will yield more optimized algorithm implementation
- **Likelihood:** High
- **Mitigation:**
  - » Evaluate the three Fractional Snow Cover Algorithms(NDSI, Reflectance based, and MODSCAG) to determine an enterprise Fractional Snow Cover algorithm.
  - » Work may have to wait until GOES-R is launched.
  - » Resulting enterprise algorithm maybe one of the three algorithms or a combination of the three.
- **Status:** Open

Snow Fraction CDR Risks and Actions

- **CDR Risk 12:** Evaluate Fractional Snow Cover Requirement to maybe have requirement for a product under partially clear and partially cloudy conditions
- **Risk Assessment:** Medium
- **Impact:**
  - » This will contribute to additional user interests
- **Likelihood:** High
- **Mitigation:**
  - » Will readdress the requirements when both algorithms are running
- **Status:** Open

System CDR
Risks and Actions

- **CDR Risk 7:** Are the SDRs terrain-corrected? Identify the team responsible for terrain-corrected SDRs.
- **Risk Assessment:** High
- **Impact:**
  - » Use of terrain-corrected SDRs account for the parallax correction in Clouds and hence make sure that no ambiguity is carried forth to other Cloud dependant products.
- **Likelihood:** Low
- **Mitigation:**
  - » Will ensure that the SDRs used are terrain-corrected
  - » Will identify the team responsible for terrain-correction
- **Status:** Open

System CDR
Risks and Actions

- **Review Item 8:** *Latency* is defined as the interval from the last observation to when the product is available to users. The definition of latency is challenging in the scope of this review. Latency is measured at system level and includes contributors outside of STAR control.
- **Mitigation:**
  - » Redefine latency requirement as processing time allocated to product generation.
  - » This plus NDE DHS and PDA system latency must not exceed required latency allocated to ESPC.
- **Status:** Open

System CDR
Risks and Actions

- **Review Item 9:** Source of Ground Trim data
- **Mitigation:**
  - » Identify the source of Ground trim data
- **Status:** Open

Risk and Actions Summary

- There are currently 4 risks and 2 review items identified from the CDR
- All six remain open

Outline

- Introduction
- Requirements
- Operations Concept
- Fractional Snow Cover
- Detailed Design
- Algorithm Package
- Quality Assurance
- Risks and Actions Summary
- Summary and Conclusions

Summary and Conclusions

Presented by

Walter Wolf

Review Objectives Have Been Addressed

- The following have been reviewed
  - » Requirements
  - » Operations Concept
  - » Algorithm Theoretical Basis
    - – Fractional Snow Cover
  - » The Detailed Design
  - » The Quality Assurance Plan
  - » Risks and Actions

Next Steps

- Begin preparing the documentation
- Code Implementation phase
  - » Begin software deliveries to the AIT
  - » Implement algorithms into the framework
- Software Review and the Algorithm Readiness Review are the next major reviews for the Snow Fraction product.

Open Discussion

- The review is now open for free discussion