S-NPP and N20
VIIRS Flood Mapping Product

Product ID #: 19-J1SPFM-N-SA-N

November 22, 2019

Presented by: Sanmei Li, Kerrie Allen
Priyanka Roy

Review Agenda

Introduction	10.00 - 10.15am	Roy
Requirements	10.15 – 10.45am	Roy
Operations Concept	10.45 – 11.00am	Roy
Algorithm Theoretical Basis	11.00 – 11.30am	Li
Software Architecture	11.30 – 12.00pm	Allen
Quality Assurance	12.00 – 12.10pm	Roy
Risks and Actions	12.10 – 12.15pm	Roy
Summary	12.15 – 12.20pm	Roy

Review Outline

- **Introduction**
- Requirements
- Operations Concept
- Algorithm Theoretical Basis
- Software Architecture
- Quality Assurance
- Risk & Actions
- Summary

Introduction

Priyanka Roy

Background

- **SPSRB requirement number, title and summary**
  - 1805-0003 VIIRS Flood Inundation
    - ➢ High resolution remotely sensed data on flood inundation and extent over large spatial domains in the CONUS and OCONUS.

- Accurate spatial information of inundated areas, especially in remote or sparsely populated regions, provides forecasters with valuable data to adjust river models in real time, improving forecasters accuracy and decision support services for flood mitigation efforts.

- VIIRS Flood Detection software is designed for global (80S to 80N in latitude) or regional automatic flood detection using Suomi-NPP and NOAA-20 VIIRS data. It consists of five modules: VIIRS Swath Projection module, VIIRS Flood Detection module, Mosaic module, Global Composite module, and Image Display module. With these modules, the software projects VIIRS Imager bands (SVI01, SVI02, SVI03, SVI05), geometric angles (stored in GITCO), VIIRS Enterprise Cloud Mask and snow cover mask into the equidistant cylindrical projection, detects flood through a series of processes to generate flood detection result in NetCDF4 format, subsets and mosaics the flood datasets in gridded granules into 136 AOIs globally, composites the NRT AOIs on daily and 5-day base, and outputs the products in netCDF4, geotiff and shapefile formats.

Project Objective – Products

VIIRS Flood detection products will be generated in using inputs from S-NPP and NOAA-20 in the following phases:

- Phase I:
  - Near Real time Granules and NWS Domain products
  - Resolution: 375m
  - Coverage:
    - Granule: Global
    - NWS Domain: CONUS and Alaska regions
  - Format: Netcdf4, geotiff and shapefile

Project Objective – Products

- Phase II:
  - Daily and Rolling 5 day Composite Flood detection Product
  - Daily and 5 day Composite Flood masks
  - Resolution: 375 m
  - Coverage: 136 AOIs covering Global land area
  - Format: Netcdf4, geotiff and shapefile

Integrated Product Team (IPT)

- **IPT Lead: Walter Wolf (STAR)**
- **IPT Backup Leads: Limin Zhao (OSPO)**
- **NESDIS team:**
  - STAR: Satya Kalluri, Ivan Csiszar
  - OSPO: Zhaohui Cheng, Antonio Irving, Donna McNamera, Chris Sisko
  - OSGS: Jonathan Doran, Ame Fox, Rick Vizbulis
  - ESPDS: Timothy Harline, David Snyder, Jonathan Hansford, Wei Yu, Krishna Tewari
  - JPSS: Lihang Zhou, Mitch Goldberg
  - Others: Sanmei Li (George Mason University), Donglian Sun (George Mason University), Kerrie Allen (IMSG), Priyanka Roy(IMSG), Claire McCaskill (IMSG)
- **User team**
  - Lead: Kevin Schrab (NWS), Brian Connelly (NWS North Central River Forecast Center), Madeline Jones (FEMA)

Project Stakeholders

- Development:
  - George Mason University
  - STAR
- Operation Implementation:
  - OSGS
  - ESPDS
  - OSPO
- Users:
  - NWS, NWS/North Central River Forecast Center
  - FEMA

Project Schedule

- Critical Design Review: 11/22/2019

Phase I:

- Unit Test Readiness Review: April 2020
- Initial DAP Delivery: May 2020
- Software Code Review: July 2020
- Algorithm Readiness Review: October 2020
- Final DAP Delivery : October 2020
- Operational Readiness Review: January 2021

Project Schedule

Phase II:

- Unit Test Readiness Review: October 2020
- Initial DAP Delivery: November 2020
- Software Code Review: November 2020
- Algorithm Readiness Review: January 2021
- Final DAP Delivery : January 2021
- Operational Readiness Review: March 2021

CDR Entry Criteria

- CDR slide package
- Requirements Document
- Review Item Disposition (RID) – risk and action tracking spreadsheet

CDR Exit Criteria

- Updated CDR slide package
- Updated Requirements Documents
- Update Review Item Disposition (RID)

Review Outline

- Introduction
- **Requirements**
- Operations Concept
- Algorithm Theoretical Basis
- Software Architecture
- Quality Assurance
- Risk & Actions
- Summary

Requirements

Priyanka Roy

Requirements Documentation

- Requirements are obtained from:
  - The Flood Mapping project plan
  - NDE DAP requirements documents
  - SPSRB process standards
  - OSPO Technical Reference Manual
  - Meetings and communications with integrators, science teams, and users
  - Archive requirements

- Requirements are documented in an associated Requirements Document kept in google drive with other project-related documents.

Requirements Organization

1. Process and Documentation
   - A high-level overview of the process-related guidelines, the document package, production plan, roles and responsibilities, and archive plan
2. System
   - Details regarding the demonstration mode, development environment testing, and the delivered algorithm package
3. Software and Hardware
   - Details of the software, security checklist, and hardware
4. Algorithm and Data Products
   - Algorithm product
5. NRT Data Products
   - Level 1 requirements, data ingest requirements, and tailored formats
6. Composite Data Products
   - Level 1 requirements, data ingest requirements, and tailored formats

Basic Requirement: 1.0

- Section 1: Process and Documentation
  - Process Guidelines
  - Delivered Algorithm Package
  - Production
  - Roles and Responsibilities
  - Archive Plan

Basic Requirement: 1.0

Process Guidelines

- **VIIRS-FMPS-R 1.0**: *The VIIRS Flood Mapping Product System (VIIRS FMPS) development project shall adopt the standard practices of the Satellite Product and Services Review Board (SPSRB).*
  - Driver: SPSRB reviews add value to product development.

Basic Requirement: 1.0

- **VIIRS-FMPS-R 1.0.1**: *The VIIRS FMPS 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

Delivered Algorithm Package

- **VIIRS-FMPS-R 1.1**: *STAR shall deliver a Delivered Algorithm Package (DAP) to OSPO.*
- **VIIRS-FMPS-R 1.1.1**: *The VIIRS FMPS DAP shall include a document package.*
- **VIIRS-FMPS-R 1.1.1.1**: *The VIIRS FMPS document package shall include a README text file*
    - The README file shall list each item in the final pre-operational system baseline, including code, test data, and documentation

Basic Requirement: 1.0

- **VIIRS-FMPS-R 1.1.1.2**: *The VIIRS FMPS document package shall include an Algorithm Theoretical Basis Document (ATBD).*
- **VIIRS-FMPS-R 1.1.1.3**: *The VIIRS FMPS document package shall include a System Maintenance Manual (SMM).*
- **VIIRS-FMPS-R 1.1.1.4**: *The VIIRS FMPS document package shall include an External Users Manual (EUM).*

Basic Requirement: 1.0

- **VIIRS-FMPS-R 1.2**: *STAR shall maintain a VIIRS FMPS document package.*
- **VIIRS-FMPS-R 1.2.2**: *The VIIRS FMPS document package shall include a Review Item Disposition (RID) document*
  - The RID shall describe the final status of all development project tasks, work products, and risks
- **VIIRS-FMPS-R 1.2.3**: *The VIIRS FMPS document package include a Requirements Allocation Document (RAD).*

Basic Requirement: 1.0

- **VIIRS-FMPS-R 1.2.4**: *The VIIRS FMPS document package shall include a Critical Design Review Report (CDRR).*
- **VIIRS-FMPS-R 1.2.5**: *The VIIRS FMPS document package shall include a Software Code Review Report (SCRR).*
- **VIIRS-FMPS-R 1.2.6**: *The VIIRS FMPS document package shall include a Unit Test Readiness Review Report (UTRRR).*

Basic Requirement: 1.0

- **VIIRS-FMPS-R 1.2.7:** *The VIIRS FMPS document package shall include a Algorithm Readiness Review Report (ARRR).*
  - The ARRR shall document the approved readiness of the VIIRS FMPS system for transition to operations.

Basic Requirement: 1.0

Production

- **VIIRS-FMPS-R 1.3**: *The VIIRS FMPS shall write product files in NetCDF4 format.*
  - SPSRB Requirement
- **VIIRS-FMPS-R 1.4**: *The VIIRS FMPS system shall generate metadata for each retrieved product.*
  - Driver: Metadata will be used by the Product Monitoring Project
- **VIIRS-FMPS-R 1.5**: *The VIIRS FMPS system shall write metadata into the NetCDF4 files associated with the retrieved products.*

Basic Requirement: 1.0

- **VIIRS-FMPS-R 1.5.1**: *The metadata shall include overall quality and summary level metadata.*
  - Coordinate with the Product Monitoring Project.
- **VIIRS-FMPS-R 1.5.2**: *The metadata shall include Granule metadata.*
- **VIIRS-FMPS-R 1.5.3:** *The metadata shall include Geographic metadata.*
- **VIIRS-FMPS-R 1.5.4**: *The metadata shall include product specific metadata as Quality Information Attributes .*
  - Coordinate with the Product Monitoring Project.

Basic Requirement: 1.0

- **VIIRS-FMPS-R 1.6**: *The VIIRS FMPS system shall have QC monitoring capability*
  - Driver: This basic requirement is traced to an OSPO need for QC monitoring.
- **VIIRS-FMPS-R 1.6.1**: *The VIIRS FMPS Product files shall include overall quality control flags and quality summary level metadata.*
  - Needed for distribution, quality control and post-processing. VIIRS FMPS code will generate metadata for this purpose.

Basic Requirement: 1.0

- **VIIRS-FMPS-R 1.6.2**: *The VIIRS FMPS 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.
- **VIIRS-FMPS-R 1.6.3**: *The VIIRS FMPS system shall be capable of monitoring product latency.*
  - Run status file will include processing time.

Basic Requirement: 1.0

- **VIIRS-FMPS-R 1.6.4**: *The VIIRS FMPS 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
- **VIIRS-FMPS-R 1.6.5**: *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: 1.0

- **VIIRS-FMPS-R 1.6.6**: *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
- **VIIRS-FMPS-R 1.6.7**: *The VIIRS FMPS system shall write a log file for each production run.*
  - Used by OSPO for QC monitoring and troubleshooting.

Basic Requirement: 1.0

Roles and Responsibilities

- **VIIRS-FMPS-R 1.7**: *Algorithm Products shall be validated and verified.*
- **VIIRS-FMPS-R 1.7.1**: *The VIIRS FMPS system shall plot datasets for verification of the Algorithm Products.*
- **VIIRS-FMPS-R 1.7.2**: *The VIIRS FMPS system shall verify that Algorithm Products files are generated correctly.*
  - Will be included in the unit tests described in the UTR and the system test described in the ARR

Basic Requirement: 1.0

- **VIIRS-FMPS-R 1.7.3**: *The VIIRS FMPS 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 ARR
- **VIIRS-FMPS-R 1.7.4**: *The VIIRS FMPS system shall perform routine data range checks to flag anomalous values in the Algorithm Products.*
  - Out-of-range values will be flagged. These checks will be included in the code. UTR will address

Basic Requirement: 1.0

- **VIIRS-FMPS-R 1.7.5**: *The VIIRS FMPS system shall generate matchup datasets between Algorithm Products retrievals and in situ measurements*

Basic Requirement: 1.0

Archive Plan

- **VIIRS-FMPS-R 1.8**: *The VIIRS Flood Detection granules, daily composite, daily flood mask, 5-day rolling composite, and 5-day flood mask products in netcdf4 format shall be archived at NCEI.*

Basic Requirement: 2.0

- Section 2: System
  - Demonstration Mode
  - Development Environment Testing
  - Delivered Algorithm Package

Basic Requirement: 2.0

Demonstration Mode

- **VIIRS-FMPS-R 2.0**: *The VIIRS FMPS shall produce a fully functional pre-operational demonstration 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: 2.0

- **VIIRS-FMPS-R 2.0.1**: *The STAR Development Environment shall be capable of hosting the conversion of VIIRS FMPS science code to VIIRS FMPS pre-operational code.*
- **VIIRS-FMPS-R 2.0.2**: *The STAR Development Environment shall include the GNU C and C++ compiler.*
  - Needed for the science code. Development Environment servers have this

Basic Requirement: 2.0

- **VIIRS-FMPS-R 2.0.3**: *The VIIRS FMPS processing code shall be able to run in the STAR Development Environment (Linux with 10 dual core 3.2 GHz CPUs) and IDL for Validation Storage: 100 TB)*
  - C code, C++ code, and Fortran code can run in this environment
- **VIIRS-FMPS-R 2.0.4**: *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 demonstration system to OSPO

Basic Requirement: 2.0

- **VIIRS-FMPS-R 2.0.5**: *The STAR Development Environment shall have access to OSPO PDA*
  - For ingest of input products for the JPSS RR products
- **VIIRS-FMPS-R 2.0.6**: *The STAR Development Environment shall have access to the GRAVITE server.*
  - For ingest of input data for VIIRS Imagery products
- **VIIRS-FMPS-R 2.0.7**: *The STAR Development Environment shall host the pre-operational demonstration system.*
  - For development and unit testing. Complete unit test of the pre-operational system is expected before delivery to NDE

Basic Requirement: 2.0

- **VIIRS-FMPS-R 2.0.8**: *The pre-operational demonstration 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
- **VIIRS-FMPS-R 2.0.9**: *The pre-operational demonstration 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

Basic Requirement: 2.0

- **VIIRS-FMPS-R 2.0.10**: *The VIIRS FMPS pre-operational demonstration system baseline shall be established and maintained with the Git CM tool.*
    - CM of the pre-operational system is expected throughout its development

Basic Requirement: 2.0

Development Environment Testing

- **VIIRS-FMPS-R 2.1**: *The VIIRS FMPS integrated pre-operational demonstration system shall be transitioned from the STAR Development Environment to the NDE.*
    - Driver: This basic requirement is traced to an NDE need for a system-tested, integrated pre-operational system delivered to its Test Environment.
- **VIIRS-FMPS-R 2.1.1**: *The STAR Development Environment shall host the VIIRS FMPS integrated pre-operational demonstration system*
    - For system testing. A complete system test of the integrated pre-operational system is expected before delivery to NDE

Basic Requirement: 2.0

- **VIIRS-FMPS-R 2.1.2**: *The integrated pre-operational demonstration 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
- **VIIRS-FMPS-R 2.1.3**: *The integrated pre-operational demonstration 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

Basic Requirement: 2.0

- **VIIRS-FMPS-R 2.1.4**: *The integrated pre-operational demonstration 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 environments will be part of the NDE system test. Specific items will be listed in the ARR
- **VIIRS-FMPS-R 2.1.5**: *The VIIRS FMPS integrated pre-operational demonstration system baseline shall be established and maintained with the Git CM tool.*
  - CM of the integrated pre-operational system is expected throughout its development

Basic Requirement: 2.0

Delivered Algorithm Package

- **VIIRS-FMPS-R 2.3**: *The integrated pre-operational demonstration system shall be delivered to NDE via google drive or FTP as a Delivered Algorithm Package (DAP).*
- **VIIRS-FMPS-R 2.3.1**: *The VIIRS FMPS development team shall ensure that the NDE integrators and OSPO PAL has the information needed to acquire the VIIRS FMPS DAP.*

Basic Requirement: 3.0

- **Section 3: Software and Hardware**
  - **Software**
  - **Security Checks**
  - **Hardware**

Basic Requirement: 3.0

Software

- **VIIRS-FMPS-R 3.0**: *The VIIRS Flood detection software will be implemented to produce the Flood detection products.*
    - Driver: This basic requirement is traced to user needs for high resolution remotely sensed data on flood inundation.

Basic Requirement: 3.0

- **VIIRS-FMPS-R 3.0.1**: *The VIIRS FMPS Algorithms shall be implemented by processing codes written in C, C++ and Python.*
- **VIIRS-FMPS-R 3.0.2**: *The VIIRS FMPS science code will be wrapped in Python scripts.*
- **VIIRS-FMPS-R 3.0.3**: *The VIIRS FMPS processing code shall be able to run in the NDE 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

Basic Requirement: 3.0

- **VIIRS-FMPS-R 3.0.4**: *The VIIRS FMPS 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: 3.0

Security Checks

- **VIIRS-FMPS-R 3.1**: *The VIIRS FMPS system shall undergo an OSPO Code Review for security compliance.*
    - Driver: OSPO Security
- **VIIRS-FMPS-R 3.1.1**: *The VIIRS FMPS system shall comply with OSPO data integrity check list.*
    - OSPO data integrity check list is part of the OSPO Code Review Security check lists
- **VIIRS-FMPS-R 3.1.2**: *The VIIRS FMPS 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: 3.0

- **VIIRS-FMPS-R 3.1.3:** *The VIIRS FMPS system shall comply with OSPO code check list.*
  - OSPO code check list is part of the OSPO Code Review Security check lists

Basic Requirement: 3.0

Hardware

- **VIIRS-FMPS-R 3.2**: *IT resource needs for operations shall be specified.*
  - Driver: OSPO IT Capacity Planning
- **VIIRS-FMPS-R 3.2.1**: *The VIIRS FMPS system shall run on Redhat Linux*
  - Servers are available

Basic Requirement: 3.0

- **VIIRS-FMPS-R 3.2.2**: *Operational server shall have 30 TB of disk space*
  - Available servers have this capability
- **VIIRS-FMPS-R 3.2.3**: *Each operational server shall have 8 GB of RAM for each core.*
  - Available servers have this capability

Basic Requirement: 4.0

- Section 4: Algorithm and Data Products
  - Algorithm Product

Basic Requirement: 4.0

- **VIIRS-FMPS-R 4.0**: *The VIIRS Flood detection algorithm shall generate the Flood detection products.*
  - Driver: SPSRB requirements: 1805-0003 VIIRS Flood Inundation - High resolution remotely sensed data on flood inundation and extent over large spatial domains in the CONUS and OCONUS.

Basic Requirement: 5.0

- Section 5: NRT Data Products
  - Level 1 Requirements
  - Data Ingest Requirements
  - Tailored Formats

Basic Requirement: 5.0

- **VIIRS-FMPS-R 5.0**: *The Flood Detection algorithm shall generate near-real time (NRT) Flood detection Products.*

Basic Requirement: 5.0

- **VIIRS-FMPS-R 5.0.1**: *The Flood Detection algorithm shall generate NRT Flood detection products at granule level.*
- **VIIRS-FMPS-R 5.0.2**: *The Flood Detection algorithm shall generate NRT Flood Detection products for 8 NWS domains.*

Basic Requirement: 5.0

Level 1 Requirements

- **VIIRS-FMPS-R 5.1**: *The NRT Flood Detection products shall have following coverage: Global coverage for granule level product and CONUS and Alaska coverage for NWS domain product.*
- **VIIRS-FMPS-R 5.2**: *The NRT Flood Detection Products shall have a latency: 40 mins for granule product and 40 mins after the arrival of the last granule covering the domain for NWS domain product*

Basic Requirement: 5.0

- **VIIRS-FMPS-R 5.3**: *The NRT Flood Detection Products shall have timeliness of ≤ 2 hours.*
- **VIIRS-FMPS-R 5.4**: *The NRT Flood Detection Products shall have Horizontal Resolution of 375m*
- **VIIRS-FMPS-R 5.5**: *The NRT Flood Detection Products shall have Measurement Range of: Water fractions between 25% and 100%.*
- **VIIRS-FMPS-R 5.6**: *The NRT Flood Detection Products shall have Mapping Accuracy: 80%*

Basic Requirement: 5.0

Data Ingest Requirements

- **VIIRS-FMPS-R 5.7**: *The VIIRS FMPS system shall use S-NPP and NOAA-20 VIIRS Imager Bands (SVI01, SVI02, SVI03, SVI05) and Geolocation (GITCO) data.*
  - Will be ingested from IDPS via PDA
- **VIIRS-FMPS-R 5.8**: *The VIIRS FMPS system shall use S-NPP and NOAA-20 Enterprise Snow Cover and Cloud Mask data.*
  - Will be ingested from ESPDS/NDE

Basic Requirement: 5.0

- **VIIRS-FMPS-R 5.9**: *The VIIRS FMPS system shall use static ancillary data.*
  - Will be included in the DAP
- **VIIRS-FMPS-R 5.9.1**: *The VIIRS FMPS system shall use global land cover data at 1km resolution.*
- **VIIRS-FMPS-R 5.9.2**: *The VIIRS FMPS system shall use global digital elevation model at 375m resolution.*
- **VIIRS-FMPS-R 5.9.3**: *The VIIRS FMPS system shall use a sun-glint look-up table.*

Basic Requirement: 5.0

- **VIIRS-FMPS-R 5.9.4**: *The VIIRS FMPS system shall use a global land/sea mask at 1km resolution.*
- **VIIRS-FMPS-R 5.9.5**: *The VIIRS FMPS system shall use global water mask resampled at 375m resolution.*
- **VIIRS-FMPS-R 5.9.6**: *The VIIRS FMPS system shall use land/sea surface temperature 16-day climatology at 5km resolution.*

Basic Requirement: 5.0

- **VIIRS-FMPS-R 5.9.7**: *The VIIRS FMPS system shall use global albedo monthly climatology at 5km resolution in visible channel.*
- **VIIRS-FMPS-R 5.9.8**: *The VIIRS FMPS system shall use pre-trained decision trees and tree attribute files.*
- **VIIRS-FMPS-R 5.9.9**: *The VIIRS FMPS system shall use user defined AOI definition files for listing the geographic information of each subset.*

Basic Requirement: 5.0

Tailored Formats

- **VIIRS-FMPS-R 5.10**: *The VIIRS FMPS system shall generate products in geotiff, and shapefile formats.*
- **VIIRS-FMPS-R 5.10.1**: *The VIIRS FMPS system shall generate tailored granule products in geotiff formats.*
- **VIIRS-FMPS-R 5.10.2**: *The VIIRS FMPS system shall generate tailored domain products in geotiff, and shapefile formats.*

Basic Requirement: 6.0

- Section 6: Composite Data Products
  - Level 1 Requirements
  - Data Ingest Requirements
  - Tailored Formats

Basic Requirement: 6.0

- **VIIRS-FMPS-R 6.0**: *The Flood Detection algorithm shall generate Flood detection composite products.*
  - Driver: Timely product for global users.

Basic Requirement: 6.0

- **VIIRS-FMPS-R 6.0.1**: *The Flood Detection algorithm shall generate 6 hr rolling 24hr Flood detection composite products.*
- **VIIRS-FMPS-R 6.0.2**: *The Flood Detection algorithm shall generate a daily composite flood mask product.*
- **VIIRS-FMPS-R 6.0.3**: *The Flood Detection algorithm shall generate rolling 5 day Flood detection composite products.*
- **VIIRS-FMPS-R 6.0.4**: *The Flood Detection Product shall generate a 5-day composite flood mask product.*

Basic Requirement: 6.0

Level 1 Requirements

- **VIIRS-FMPS-R 6.1**: *The Flood Detection composite products shall have global coverage.*
- **VIIRS-FMPS-R 6.2**: *The Flood Detection composite products shall have Horizontal Resolution of 375m.*
- **VIIRS-FMPS-R 6.3**: *The Flood Detection Product composites shall have a latency of 3 hours after the last granule is available.*
- **VIIRS-FMPS-R 6.4**: *The Flood Detection Product composites shall have timeliness of ≤ 3 hours.*

Basic Requirement: 6.0

- **VIIRS-FMPS-R 6.5**: *The Flood Detection Product composites shall have Measurement Range of: Water fractions between 25% and 100%.*
- **VIIRS-FMPS-R 6.6**: *The Flood Detection Product composites shall have Mapping Accuracy: 80%*
- **VIIRS-FMPS-R 6.7**: *The Flood Detection algorithm shall generate flood detection daily and 5 day composite products in 136 AOIs.*

Basic Requirement: 6.0

- **VIIRS-FMPS-R 6.8**: *The Flood Detection daily composite and mask products shall be generated every 6 hours.*
- **VIIRS-FMPS-R 6.9**: *The Flood Detection 5-day composites and mask products shall be generated every 24 hours.*

Basic Requirement: 6.0

Data Ingest Requirements

- **VIIRS-FMPS-R 6.10**: *The VIIRS FMPS system shall use S-NPP and NOAA-20 NRT Flood Detection reprojected granules to generate the flood detection composite products*
  - Primary Input Data, generated by the NRT processing

- **VIIRS-FMPS-R 6.10.1:** *The VIIRS FMPS system shall use S-NPP and NOAA-20 daily composite AOIs as input to generate the rolling 5 day flood detection composite products.*

Basic Requirement: 6.0

- **VIIRS-FMPS-R 6.11**: *The VIIRS FMPS system shall use static ancillary data.*
  - Will be included in the DAP

- **VIIRS-FMPS-R 6.11.1**: *The VIIRS FMPS system shall use a global land/sea mask at 1km resolution.*
- **VIIRS-FMPS-R 6.11.2**: *The VIIRS FMPS system shall use global water mask resampled at 375m resolution.*
- **VIIRS-FMPS-R 6.11.3**: *The VIIRS FMPS system shall use user defined AOI definition files for listing the geographic information of each subset.*

Basic Requirement: 6.0

Tailored Formats

- **VIIRS-FMPS-R 6.12**: *The VIIRS FMPS system shall generate Flood detection composite tailored products in geotiff and shapefile formats.*

Requirement Summary

- Product requirements have been reviewed.
- Individual product requirements have been documented in the Requirements Document (RAD).

Review Outline

- Introduction
- Requirements
- **Operations Concept**
- Algorithm Theoretical Basis
- Software Architecture
- Quality Assurance
- Risk & Actions
- Summary

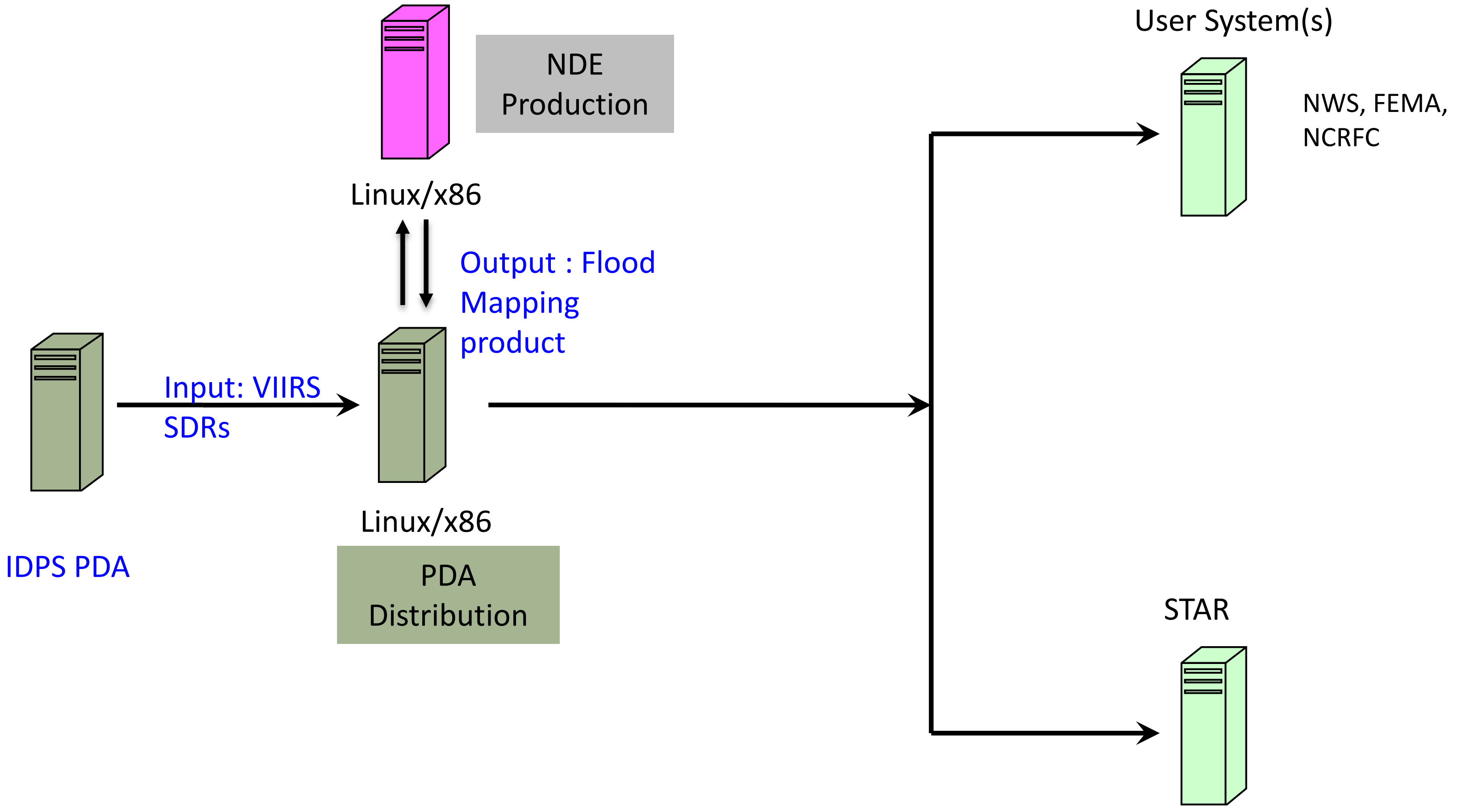
Concept of Operations

Priyanka Roy

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 in consultation with customers/users as user needs evolve.

Flood Mapping Products IT System Architecture



What are the Products?

- The following are the VIIRS Flood detection products:
  - NRT Global Flood detection granules
  - NRT mosaic Flood detection products for the 8 NWS domains covering CONUS and Alaska.
  - Daily composite product distributed as 136 Area Of Interests (AOIs) covering global land area.
  - 5 Day rolling composite distributed as 136 AOIs covering global land area.
  - Daily and 5 day rolling flood masks.

- The Flood Mapping products will be created using the following dynamic inputs:
  - VIIRS Imagery Bands (I1, I2, I3 and I5)
  - VIIRS Terrain Corrected Geolocation data
  - Enterprise Cloud mask and snow cover

Why Are the Products Being Produced?

- NWS and FEMA will use this data operationally for obtaining accurate spatial information of inundated areas, especially in remote or sparsely populated regions.
- This will provide forecasters with valuable data to adjust river models in real time, improving forecasters accuracy and decision support services for flood mitigation efforts.

How Will the Products Be Used?

Product	Format	User
NRT Flood detection reprojected Granules	Netcdf4, Geotiff	NWS, NCEI
NRT Flood detection domain products	Netcdf4, Geotiff and Shapefile	NWS, FEMA, NWS/NCRFC
Global Daily Composites in 136 AOIs	Netcdf4, Geotiff and Shapefile	NCEI
Global 5 day rolling composites in 136 AOIs	Netcdf4, Geotiff and Shapefile	NCEI
Daily Global Flood Mask	Netcdf4, Geotiff and Shapefile	NCEI
5 Day Global Flood Mask	Netcdf4, Geotiff and Shapefile	NCEI

How Should the Products Be Produced?

- There are currently 4 distinct processing environments:
  - Development Environment (STAR)
    - Development and testing of pre-operational codes
    - STAR algorithm code transition
  - ESPDS Development Environment
    - Location where NDE system developers conduct initial DAP integration and unit tests
  - ESPDS Integration & Test Environment
    - Ground system maintenance releases
    - Algorithm changes
    - Bug fixes
    - Production rule updates
    - Tailoring functions
    - Improvements to data handling and database updates/optimization
  - ESPDS Operational Environment in OSPO
    - Full production environment with a backup string

Production Scenarios – Monitoring and Maintenance

- ESPDS help desk and NDE system will monitor for production and latency issues.
- The quality of the VIIRS SDRs will be monitored by the OSPO quality monitoring, IDPS data quality technicians, and STAR VIIRS SDR cal/val team.
- The quality of the VIIRS Enterprise cloud mask and snow cover will be monitored by OSPO product quality monitoring and STAR science teams.
- The Flood detection products may be added to future phases of OSPO Product Monitoring tool.
- STAR will assist NDE and OSPO with integration and troubleshooting.
- STAR developers will be available for maintenance.

Production Scenarios – Archive Product

The following Flood mapping product will be archived following existing S-NPP and N-20 archive plans:

- Reprojected NRT granules.
- Daily Flood product as AOIs
- 5 Day flood product as AOIs
- Daily Flood mask
- 5 day flood mask

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 NDE data products to the user community
  - Resolves user issues through coordination with the associated PALs and STAR science teams if necessary
- The PALs will coordinate further with the STAR scientists for any product quality issues when identified and will communicate those to users

Summary

- OSPO will run the Flood Mapping packages within the NDE system.
- IDPS VIIRS input data will be provided to NDE through PDA and the Enterprise products from ESPDS.
- The OSPO PAL and NDE integration teams will perform system validation in association with the STAR algorithm development teams.
- OSPO will perform production monitoring.
- OSPO, IDPS and STAR will perform quality monitoring of the input data and products

Review Outline

- Introduction
- Requirements
- Operations Concept
- **Algorithm Theoretical Basis**
- Software Architecture
- Quality Assurance
- Risk & Actions
- Summary

VIIRS Flood Detection Algorithm

Sanmei Li and Donglian Sun

Background

- Since 2013, the Suomi-NPP/VIIRS flood extent product has been under development through a demonstration initialized by JPSS Proving Ground and Risk Reduction Program.
- In 2015, the first version of the VIIRS flood mapping software was released. Since then, the software has been running routinely to generate near real-time SNPP/VIIRS flood products for NWS's RFCs.
- In March 2017, the software was delivered to CSPP group. Later in 2017, CSPP released the version 1.0 VIIRS flood software for global users to generate VIIRS flood products locally.
- In 2018, the NOAA-20/VIIRS data was integrated into the software, and the second version of the VIIRS flood mapping software was released for routine process in the CONUS and Alaska, as well as for CSPP's global process.

Background

- Since 2018, FEMA has started using the VIIRS flood product routinely for emergency response.
- In 2018, NWS submitted a user request for the operational production of the VIIRS 375-m flood extent product.
- In 2019, the third version of the VIIRS flood mapping software was released to generate global near real-time, daily, 5-day composited VIIRS flood products on a routine base. The demo products are available in: https://www.ssec.wisc.edu/flood-map-demo/flood-products/
- Different to other products, the VIIRS flood product is a new product without any similar algorithms or products for comparison.

VIIRS Flood Detection Algorithms

- VIIRS flood detection algorithms are a combination of distance-based classification, decision-tree approach, change detection, thresholding, geometry-based and object-based methods, which include six parts:
  - **Water detection:** Distance-based classification, decision-tree approach and thresholding methods are applied to differentiate water surface from cloud, snow/ice, vegetation and bare land.
  - **Cloud shadow removal:** Geometry-based method is applied to remove cloud shadows from water pixels.
  - **Terrain shadow removal:** Object-based method is applied to remove terrain shadows from water pixels.
  - **Minor flood detection:** Change detection method is applied to detect water pixels with small water fractions.

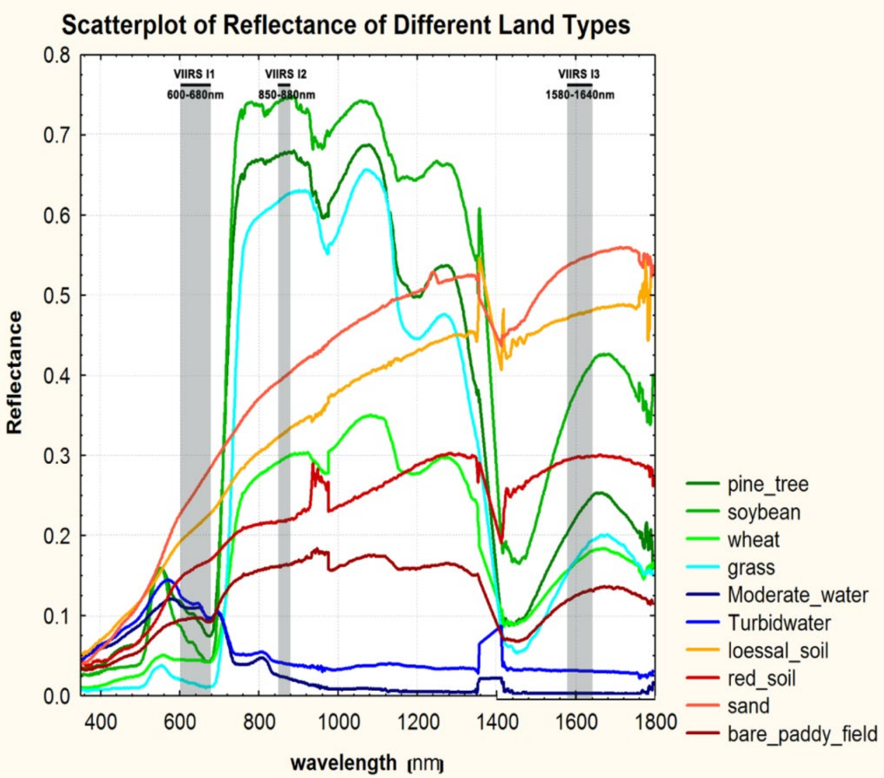
VIIRS Flood Detection Algorithms

- **Water fraction retrieval:** Dynamic nearest neighboring searching method is applied for water fraction retrieval over non sun-glint water surface and histogram method is applied to retrieve water fractions on sun-glint contaminated water surface.
- **Floodwater determination:** The retrieved water fractions and supra-snow/ice water pixels are compared with a static water reference map to determine floodwater.

Water Detection

- In VIIRS flood detection, floods are divided into two types based on the underlying conditions: supra-veg/bare land flood and supra-snow/ice flood.
  - **Supra-veg/bare land flood detection:**
    - Underlying conditions are vegetation and bare land
    - Decision-tree technique serves as the main approach for supra-veg/bare flood detection based on different land cover types under different geometry angles.
  - **Supra-snow/ice flood detection:**
    - Underlying conditions are snow/ice cover
    - The detection is a further step of snow/ice cover using thresholding and change detection methods.

Supra-veg/bare land flood detection



- Decision-tree approach using the following variables: R_{Vis}, R_{NIR}, R_{SWIR}, NDVI, NDSI and NDWI based on different land cover types under different solar zenith angles.

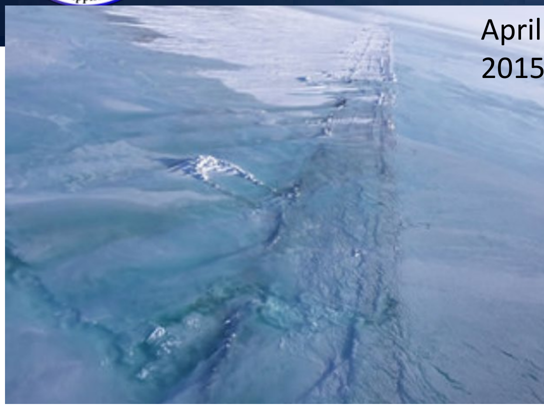
$$\mathrm{NDVI} = \frac{R_{NIR} - R_{Vis}}{R_{NIR} + R_{Vis}}$$

$$\mathrm{NDSI} = \frac{R_{Vis} - R_{SWIR}}{R_{Vis} + R_{SWIR}}$$

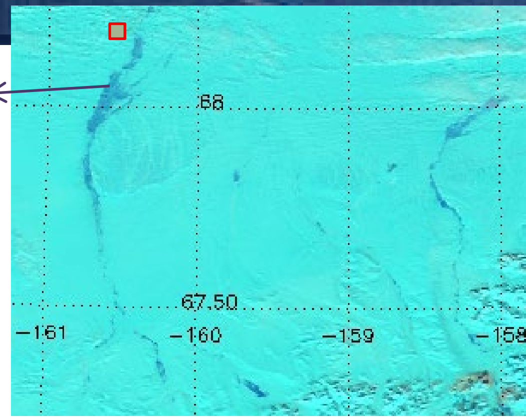
$$\mathrm{NDWI} = \frac{R_{NIR} - R_{SWIR}}{R_{NIR} + R_{SWIR}}$$

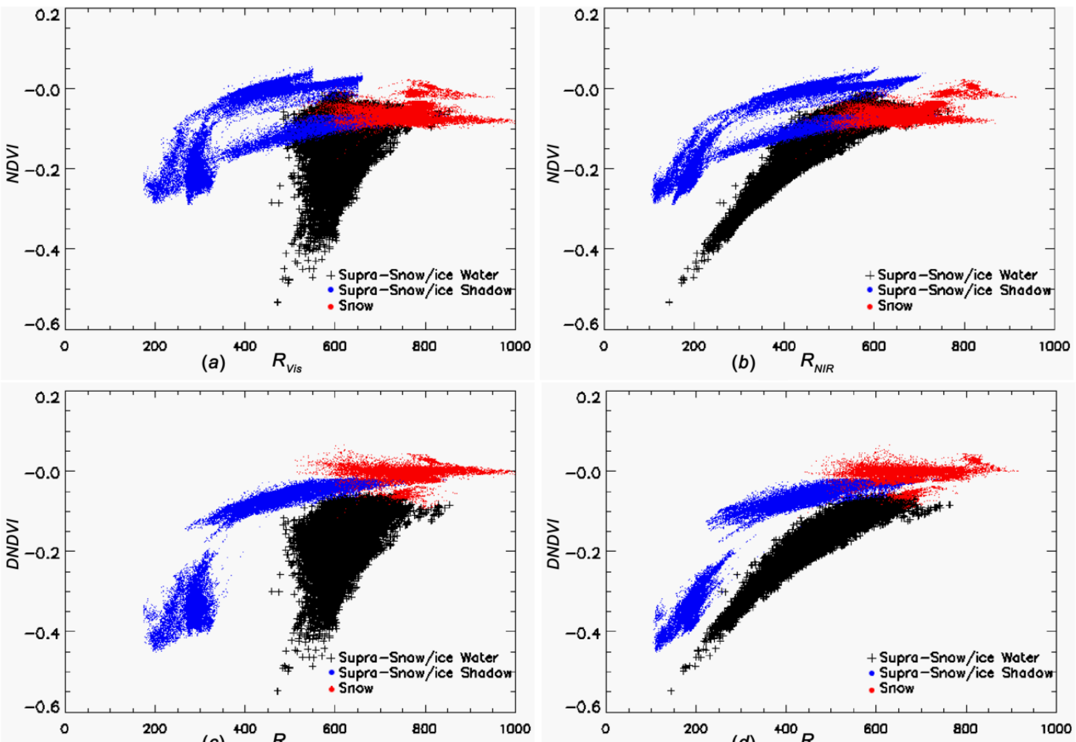
- Spectral features of water surface in visible to short-wave infrared channels:
  - ✓ Higher reflectance in VIS channel than in NIR and SWIR (short-wave infrared) channels
  - ✓ Reflectance of clean water in SWIR channel is close to 0
  - ✓ Reflectance changes with suspending matter content: clean<moderate turbid<turbid<severe turbid

Supra-Snow/Ice flood detection



April 8, 2015

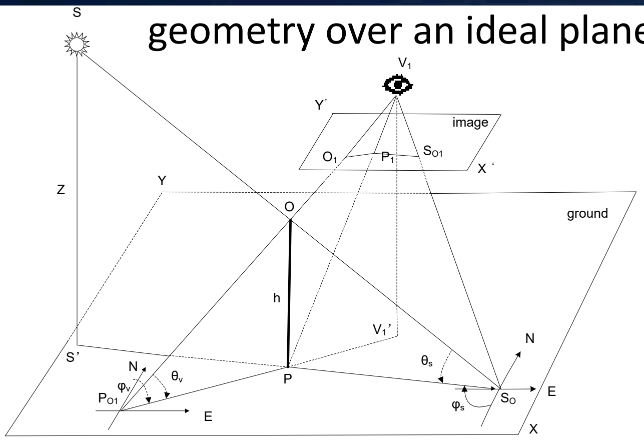




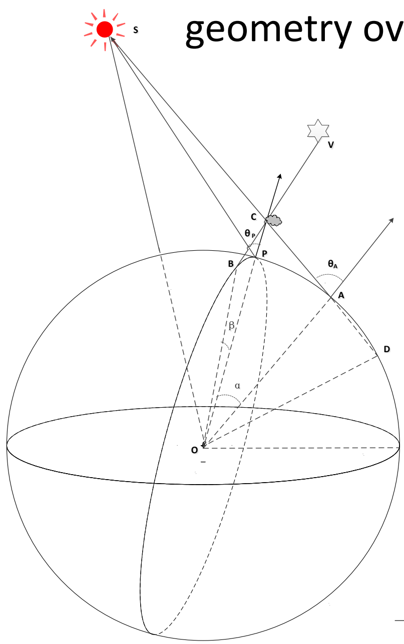
- Supra-snow/ice flood is a special flood type because the bottom layer is still covered with snow/ice.
- The detection is based on its spectral features:
  - ✓ Reflectance in visible and near-infrared channels can be as high as 70%.
  - ✓ NDVI varies from -0.6 to -0.03.
  - ✓ DNDVI, defined as the difference between a pixel’s NDVI and the average NDVI of the surrounding snow/ice surface, is proven effective to discriminate supra-snow/ice water from shadows over snow/ice surface and snow/ice surface in melting status.

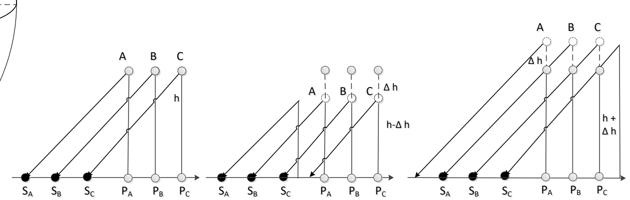
Cloud Shadow Removal

geometry over an ideal plane



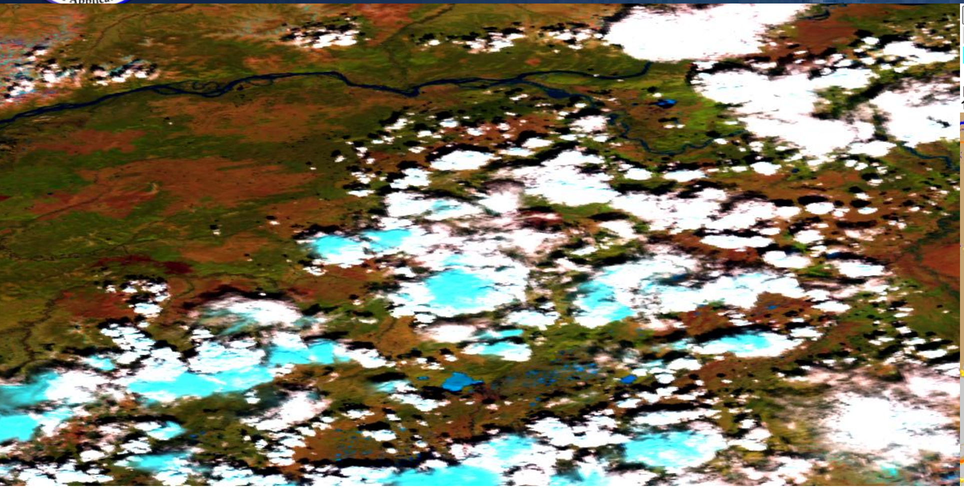
geometry over spherical surface



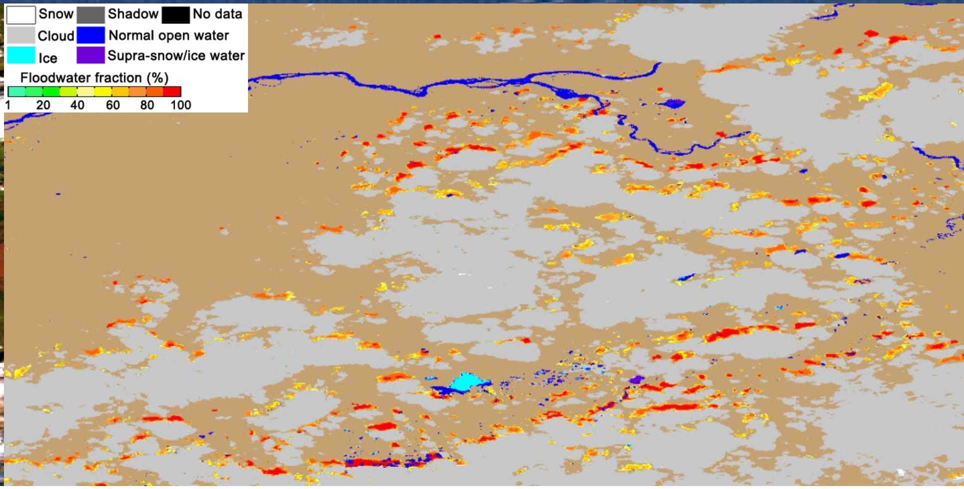


- Geometry-based method to remove cloud shadows from water pixels (Li et al., 2013).
- Assumption of geometry-based cloud shadow removal method:
  - ✓ One cloud pixel casts at most one cloud shadow pixel.
  - ✓ Neighboring cloud pixels share similar cloud heights.
- Iterate cloud heights to construct clouds and shadows relationship using the geometric models over ideal plane and spherical surface:
  - ✓ If a cloud pixel has its shadow pixel, then its neighboring cloud pixel can find a shadow pixel at the same height.

Cloud Shadow Removal

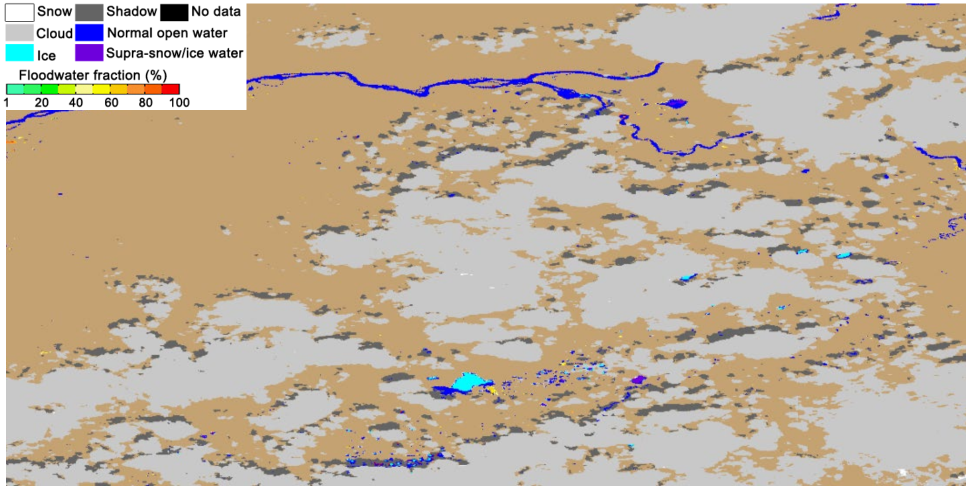


VIIRS false-color composited image, May 30, 2013 at 22:48 (UTC)



VIIRS flood map without cloud shadow removal, May 30, 2013 at 22:48 (UTC)

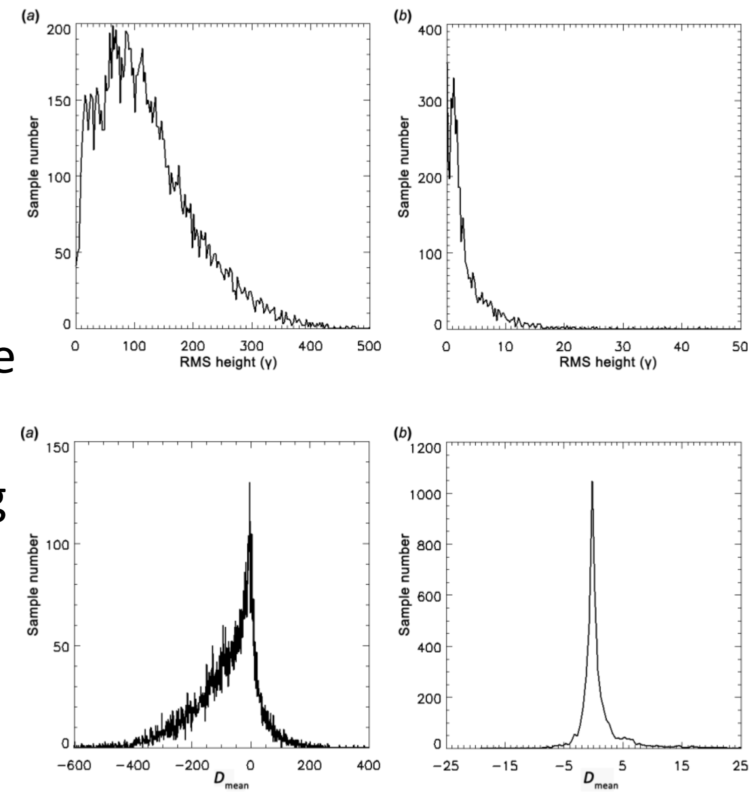
- In VIIRS false-color image (Top left), cloud shadows look very similar to open water and they are easily detected as flood water and further retrieved in large water fractions (Top right).
- After cloud shadow removal, these shadows are removed from VIIRS flood map (Bottom right).



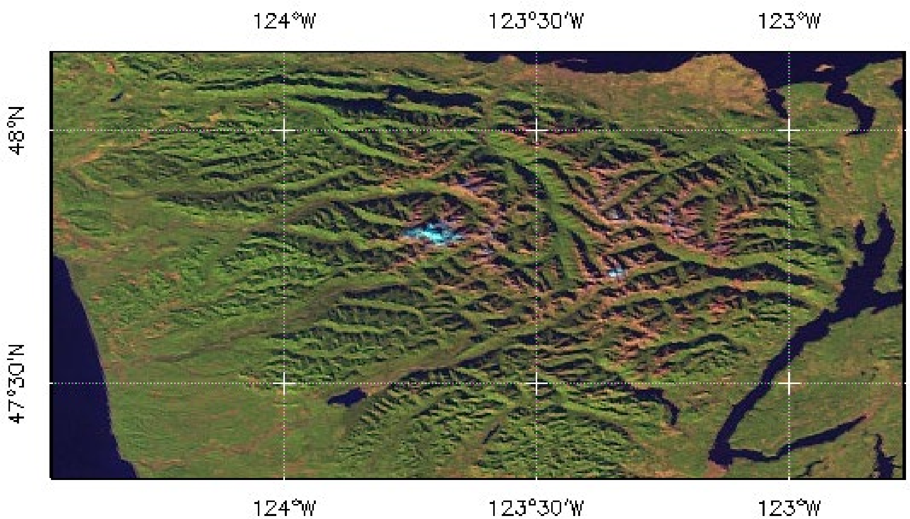
VIIRS flood map after cloud shadow removal, May 30, 2013 at 22:48 (UTC)

Terrain Shadow Removal

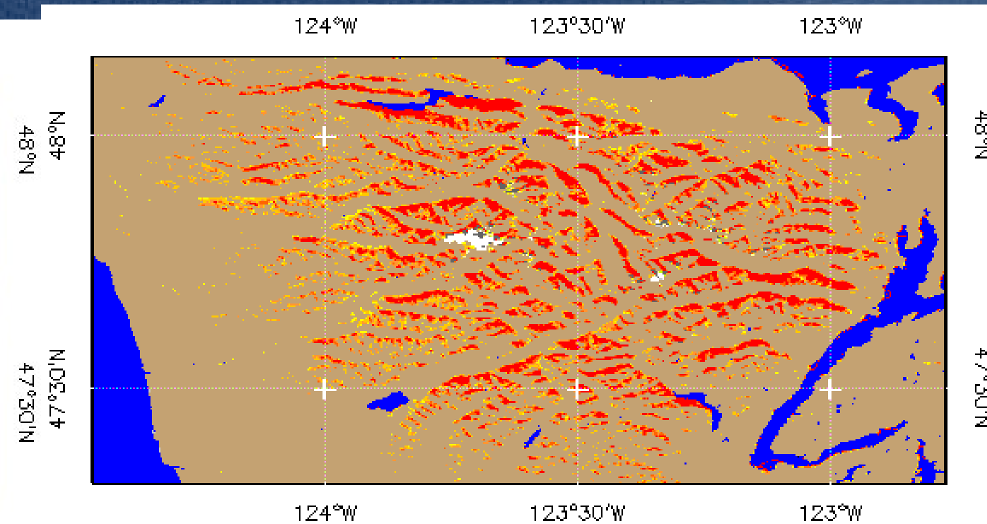
- Object-based method to remove terrain shadows from flood maps (Li. et al., 2015).
  - ✓ Full application of surface roughness analysis:
    - Terrain shadows are formed in mountainous areas with large surface roughness
    - Flood water accumulates in low-lying areas with small surface roughness
  - ✓ Object-based instead of pixel-based.



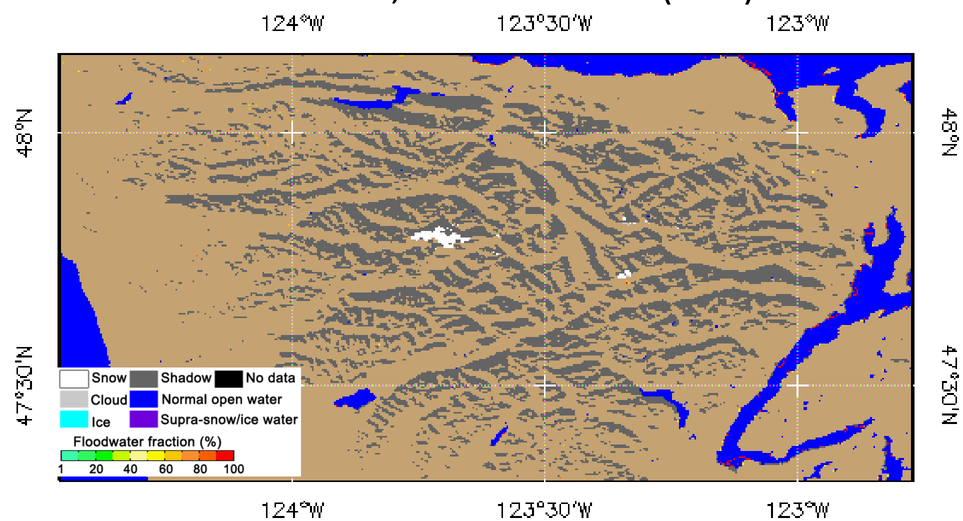
Terrain Shadow Removal



VIIRS false-color composited image, Nov. 15, 2014 at 21:02 (UTC)



VIIRS flood map without terrain shade removal, Nov. 15, 2014 at 21:02 (UTC)



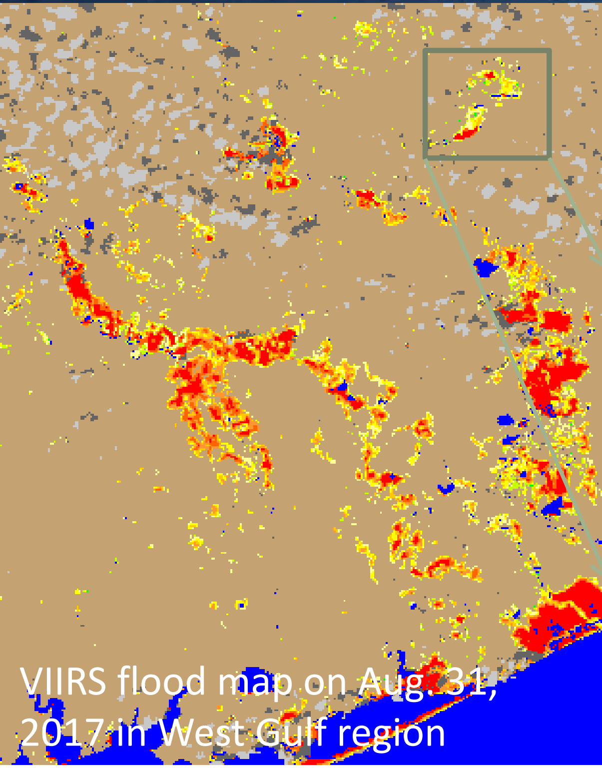
VIIRS flood map after terrain shadow removal, Nov. 15, 2014 at 21:02 (UTC)

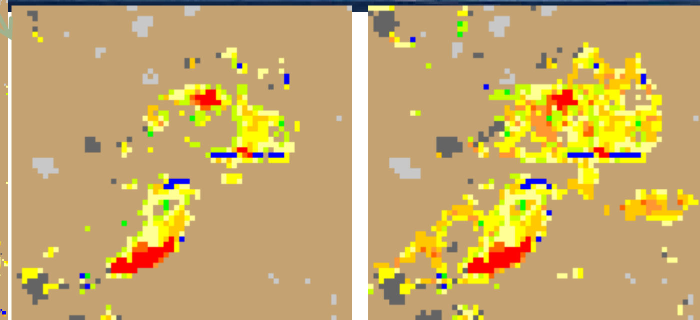
- Without terrain shadow removal, most terrain shadows are detected as flood water with large water fractions (Top right).
- After terrain shadow removal, these terrain shadows are removed from flood map (Bottom right).

Minor Flood Detection

- Change detection is applied to detect water pixels with small water fractions.
  - ✓ Along the existing water bodies (rivers, lakes, reservoirs) and detected water pixels.
  - ✓ Extract the change information by comparing the signals of a potential minor water pixel to that of the dry land nearby with the same surface type.
  - ✓ Detect more flood pixels that are partially veiled by tree cover.

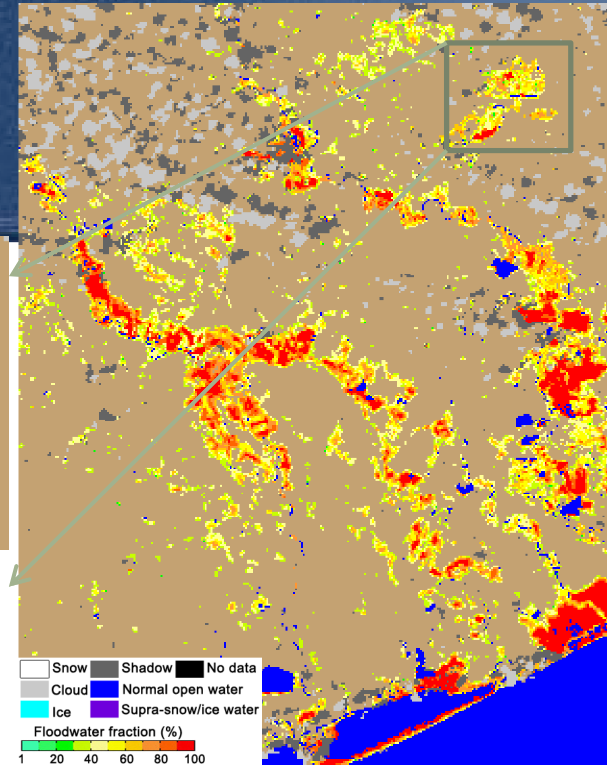
Minor Flood Detection

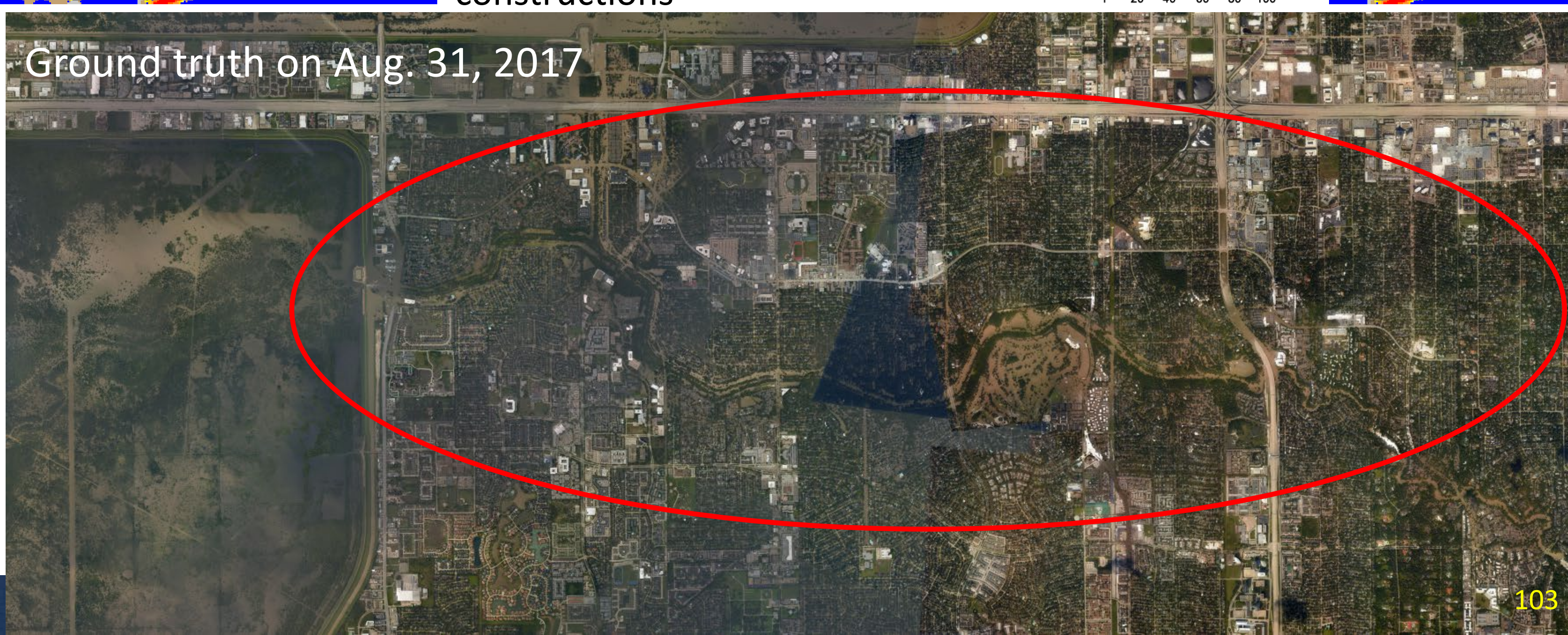




Before After

Helps detect more flooding over regions with tree cover and urban constructions





Water Fraction Retrieval

- Over water surface without sun glint contamination, the dynamic nearest neighboring searching method by considering the reflectance in the short-wave infrared channel is close to 0 (Li. et al., 2012).
  - ✓ Based on linear combination model:

$$R = \sum_{i=1}^{n} f_i * R_i \qquad f_w = \frac{R_{ch\_land} - R_{ch\_mix}}{R_{ch\_land} - R_{ch\_water}}$$

  - ✓ Considering the mixing structure of sub-pixel land portion for supra-veg/bare soil water fraction retrieval to cluster dryland pixels nearby for calculation of the reflectance of dry land:

$$\frac{R_{ch1\_mix}}{R_{ch6\_mix}} - \frac{R_{ch1\_water}}{R_{ch6\_mix}} < \frac{R_{ch1\_land}}{R_{ch6\_land}} < \frac{R_{ch1\_mix}}{R_{ch6\_mix}}$$

$$\frac{R_{ch2\_mix}}{R_{ch6\_mix}} - \frac{R_{ch2\_water}}{R_{ch6\_mix}} < \frac{R_{ch2\_land}}{R_{ch6\_land}} < \frac{R_{ch2\_mix}}{R_{ch6\_mix}}$$

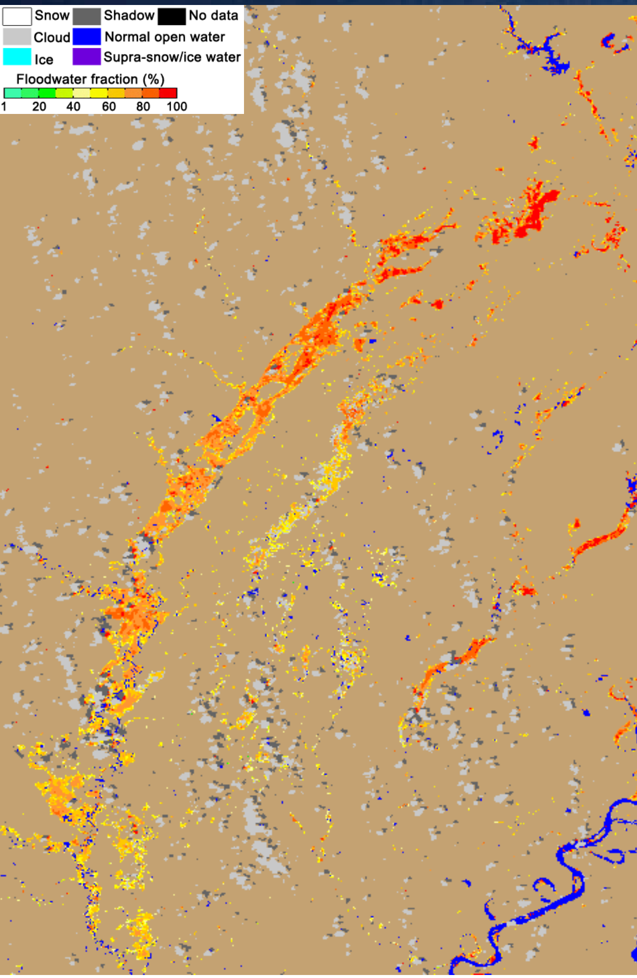
Water Fraction Retrieval

- Over water surface with minor to moderate sun-glint contamination, the histogram method is applied for water fraction retrieval because of the significantly increased reflectance in the short-wave infrared channel.
  - ✓ It is still based on linear combination model.

$$R = \sum_{i=1}^{n} f_i * R_i \qquad f_w = \frac{R_{ch\_land} - R_{ch\_mix}}{R_{ch\_land} - R_{ch\_water}}$$

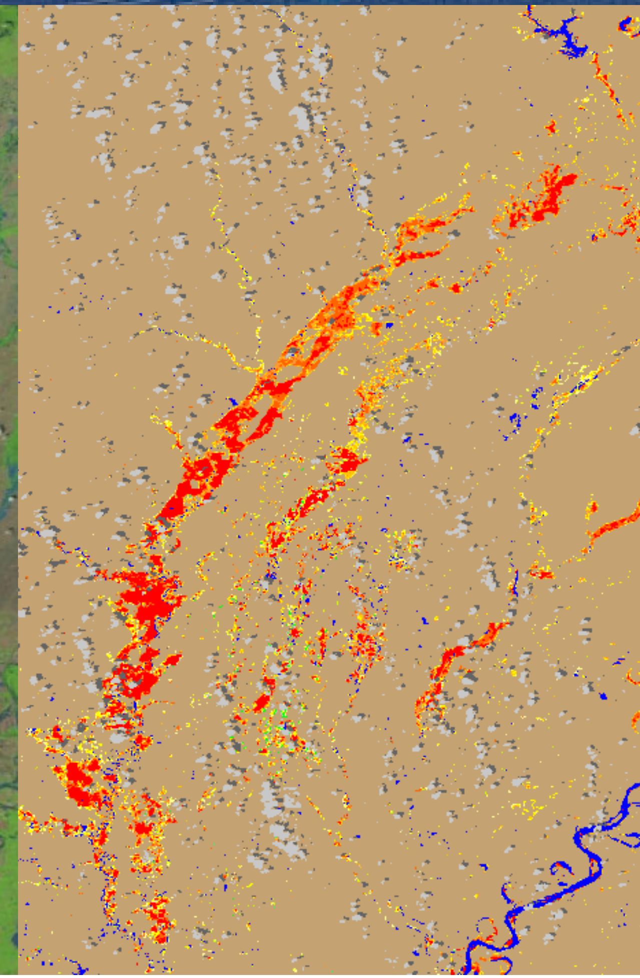
  - ✓ The reflectance of the dryland and pure water (100% water fraction) are the average of the nearby dryland and sun-glint contaminated water surface.
  - ✓ A sun-glint look-up table is used to determine sun-glint contaminated water surface.

Water Fraction Retrieval



With DNNS method

SNPP/VIIRS false-color image with moderate sun-glint contamination May 05, 2017 18:52 (UTC)



With histogram method

Floodwater Determination

- The retrieved water fractions or supra-snow/ice water are compared with a static water reference map to determine floodwater.
  - ✓ Water reference map: the current water reference map is generated from the 250-m MODIS global water mask (MOD44W), water layer in the 30-m national land cover dataset (NLCD 2006), and ESA’s 150-m global water mask. Need to be updated every one or two years.
  - ✓ Supra-veg/bare flood water is determined when retrieved water fractions are larger than 1% if it is dryland pixel or 40% more than the current water fraction if it is a narrow river or small lake (with small water fractions).

Multiple-day Composition

- Maximal water-fraction composition for flooded pixels:
  - ✓ Any pixel determined as a flood pixel in any NRT flood maps, is determined as a flooded pixel in the composited map
  - ✓ The maximal water fraction of a flooded pixel in multiple days is used as the composited result
- Maximal clear-sky land composition for non-flooded pixels
  - ✓ Any pixel without being determined a flood pixel in any NRT flood maps is taken as a non-flooded pixel in the composited map.
  - ✓ Currently, the maximal snow/ice cover composition is applied to determine snow/ice cover in the composited map.
  - ✓ If without snow/ice cover, then the maximal clear-sky land composition is applied.

Product Design

- The VIIRS flood products include:
  - ✓ Near real-time (NRT) flood products:
    - CONUS/Alaska in the eight NWS domains.
    - Global land in the gridded 89-S granules between 80° S and 80° N
  - ✓ Global composited flood product in 136 AOIs (Area of Interest).
    - Global daily composited flood product in 136 AOIs
    - Global 5-day composited flood product in 136 AOIs.

Product Design- NRT flood product

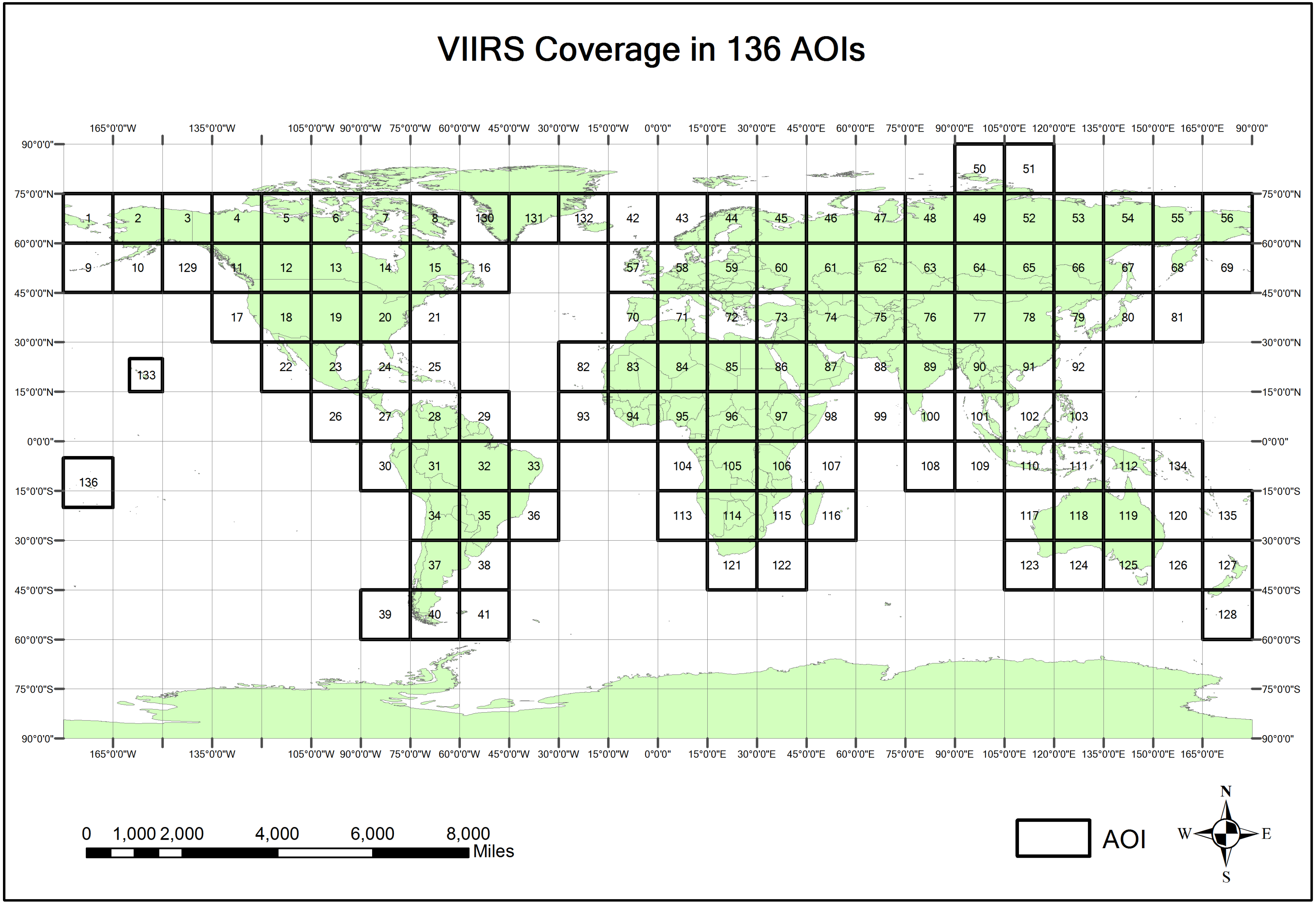
- **Composition:** maximal water-fraction composition from daily VIIRS NRT products and 5-day NRT VIIRS .
- **Daytime-only:** data with solar zenith angles less than 85 degrees (winter) or 80 degrees (spring and fall) or 76 degrees (summer) will be processed.
- **Gridded data:** the VIIRS data need to be projected into geographic lon/lat projection prior to the flood detection.
- **Coverage:**
  - ✓ CONUS and Alaska: split into 8 domains (Alaska, northeast, southeast, north central, west gulf, northwest, southwest)
  - ✓ Global: into 136 AOIs, each sizing 15° ×15°
- **Latency:** 40 minutes

Product Design- Composited flood products

- **Product level:** Level-3.
- **Daytime-only:** consistent to the NRT products.
- **Rolling composition:**
  - ✓ The daily composition is rolling run every 6 hours using the VIIRS NRT flood datasets in the latest 24 hours
  - ✓ The 5-day composition is rolling run every 24 hours using the VIIRS NRT flood datasets in the latest 120 hours
- **Coverage:** Global land in 136 AOIs, each sizing 15° ×15°
- **Latency:**
  - ✓ Daily composition :6-24 hours
  - ✓ 5-day composition: 24 hours

Eight Domains

Domain	Upper-left longitude	Down-right longitude	Upper-left latitude	Down-right latitude
Alaska	-169	-129	54	72
North East	-91	-66	35	52
North Central	-106	-81	37	54
South East	-91	-75	24	36
Missouri Basin	-115	-90	36	53
West Gulf	-115	-90	23	40
North West	-125	-113	35	52
South West	-125	-113	28	45



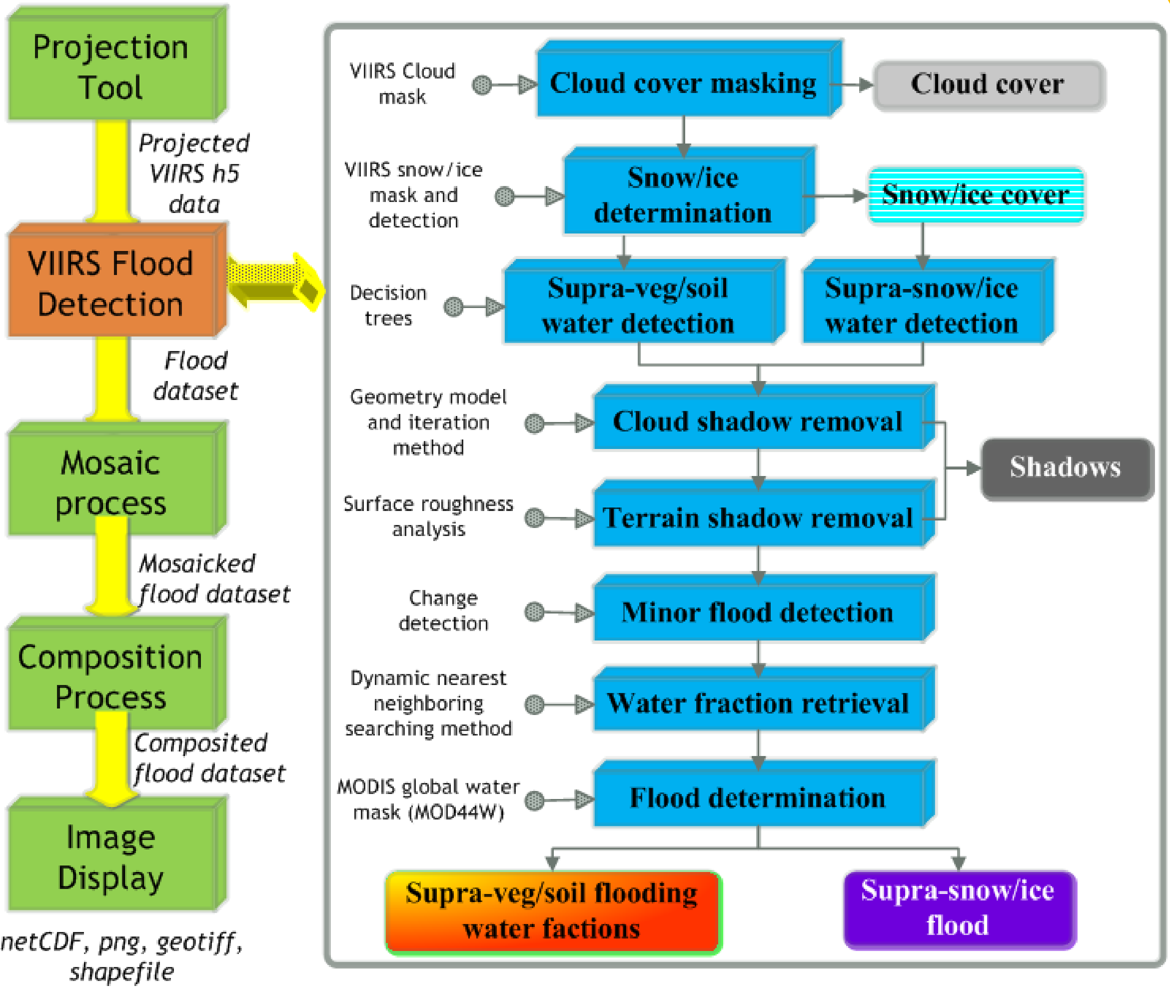
Global 136 AOIs

Product Design

The input data include:

- **Suomi-NPP and NOAA-20 VIIRS Imager Bands from :**
  - I-band 1, 2, 3, and 5
- **Suomi-NPP and NOAA-20 VIIRS Terrain-corrected Geo-location data:**
  - longitude, latitude, solar zenith angle, solar azimuth angle, sensor zenith angle, sensor azimuth angle
- **Suomi-NPP and NOAA-20 VIIRS level-2 EDR products:**
  - cloud mask (optional)
  - Snow/ice cover (optional)
- **Static ancillary datasets:**
  - Water reference map (updated every one or two years)
  - Land cover (updated every one or two years)
  - Land/sea mask
  - DEM
  - Sun glint lookup table
  - Pre-trained decision trees (updated according to the calibration performance)
  - Albedo, SST and LST climatology
  - Albedo climatology

Product Design



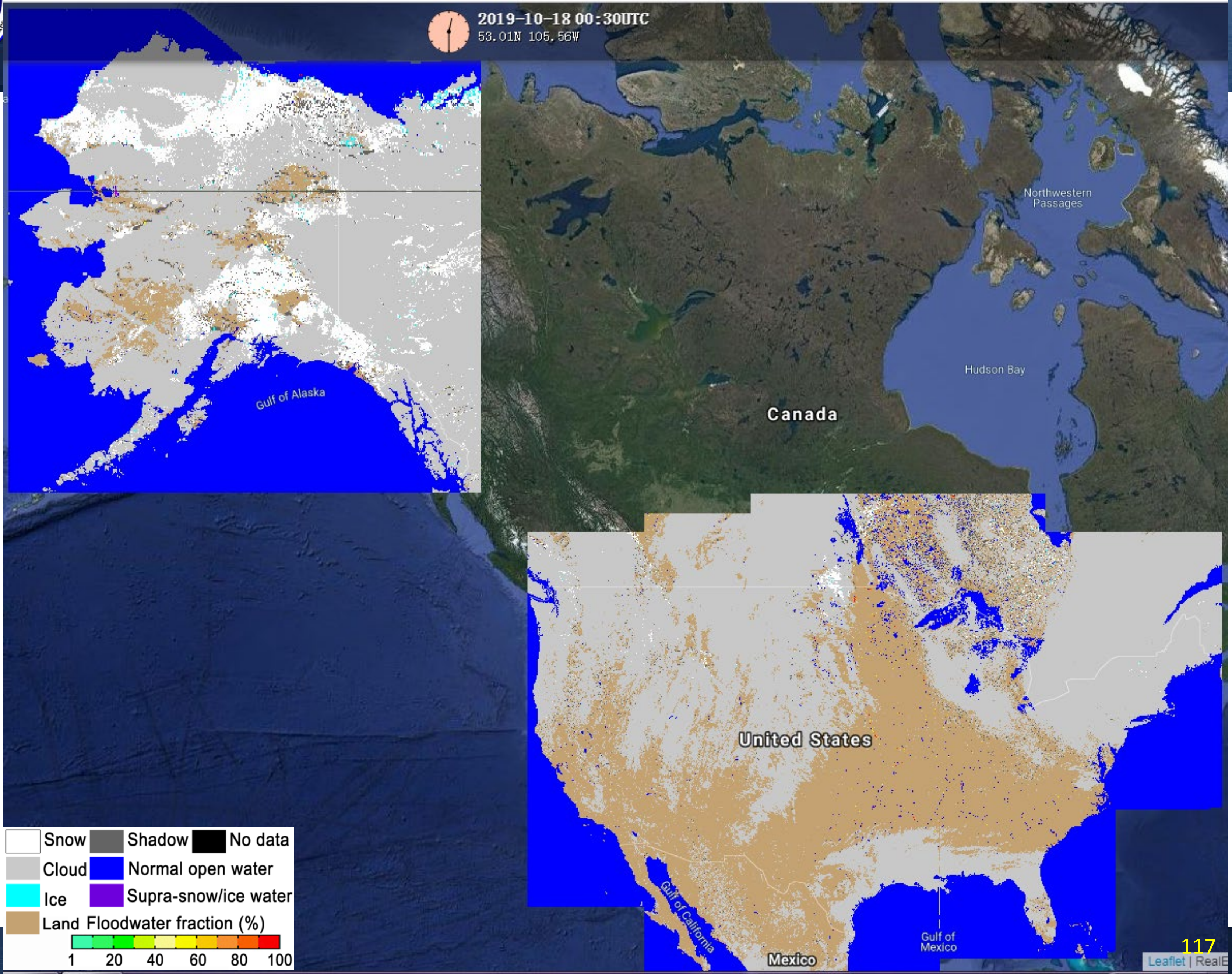
Software components and algorithm flow

- **The process includes five major steps:**
  - ✓ Projection: Project the VIIRS SDR data and products in geographic lon/lat projection
  - ✓ Flood detection: Detect floods based on the projected VIIRS data and products
  - ✓ Mosaic process: Mosaic the 89-S VIIRS flood datasets into complete flood maps in NSW domains and 136 AOIs
  - ✓ Composition process: Daily and 5-day composite VIIRS flood datasets
  - ✓ Image display: Output VIIRS flood datasets into netCDF, geotiff, shapefile and png formats

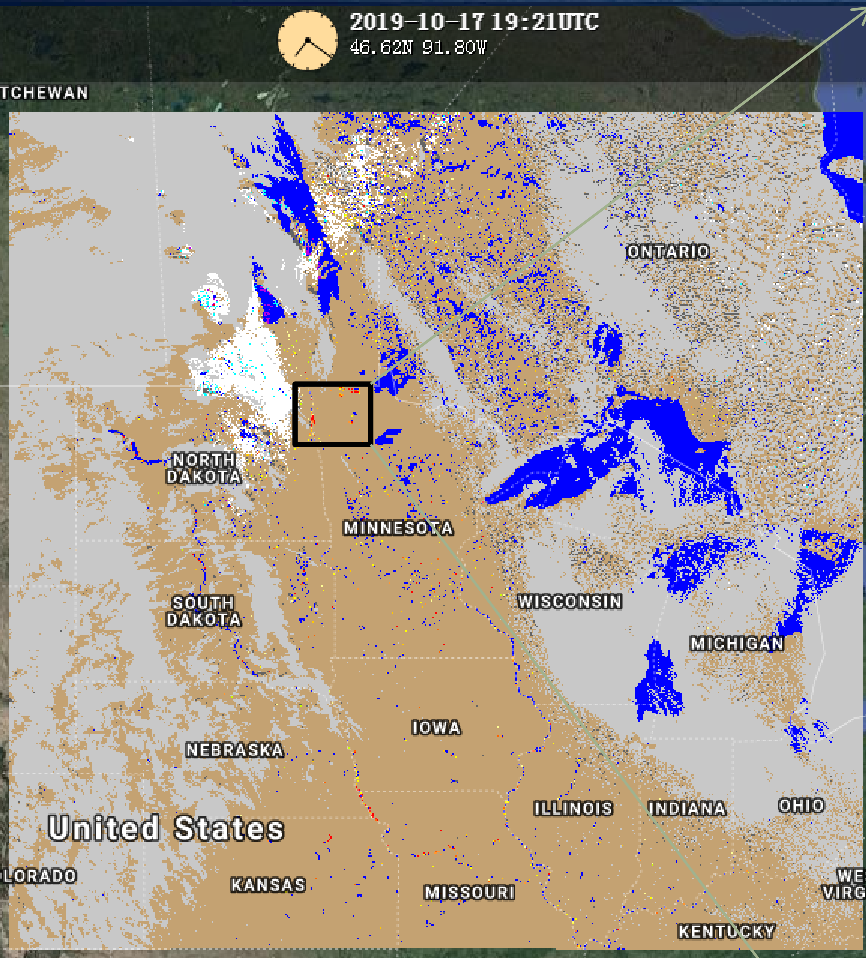
Product Design-Output Products

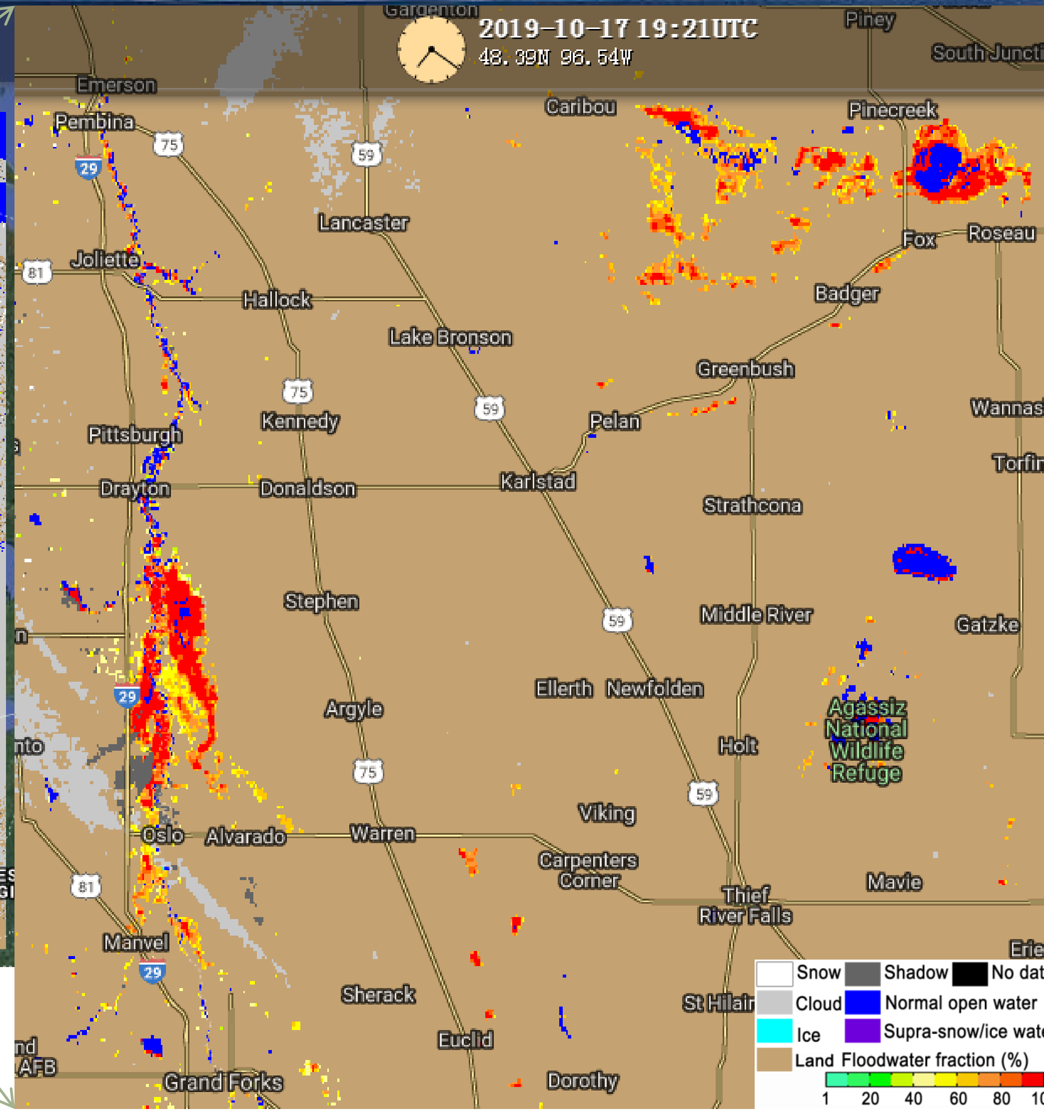
- **Coverage:**
  - ✓ Eight NWS domains
  - ✓ Global 136 AOIs
- **Datasets:**
  - ✓ Near real-time flood product
  - ✓ Daily composited flood product
  - ✓ 5-day composited flood product
- **Formats:**
  - ✓ netCDF4 (NWS)
  - ✓ Geotiff (FEMA and NWC)
  - ✓ Shapefile (FEMA and NWC)
- **Content:**
  - ✓ clear-sky land, cloud, snow cover, river/lake ice, shadow, supra-snow/ice water or mixed ice&water, normal bodies of water, floodwater fractions over supra-veg/bare land

Sample Product-CONUS/Alaska NRT product



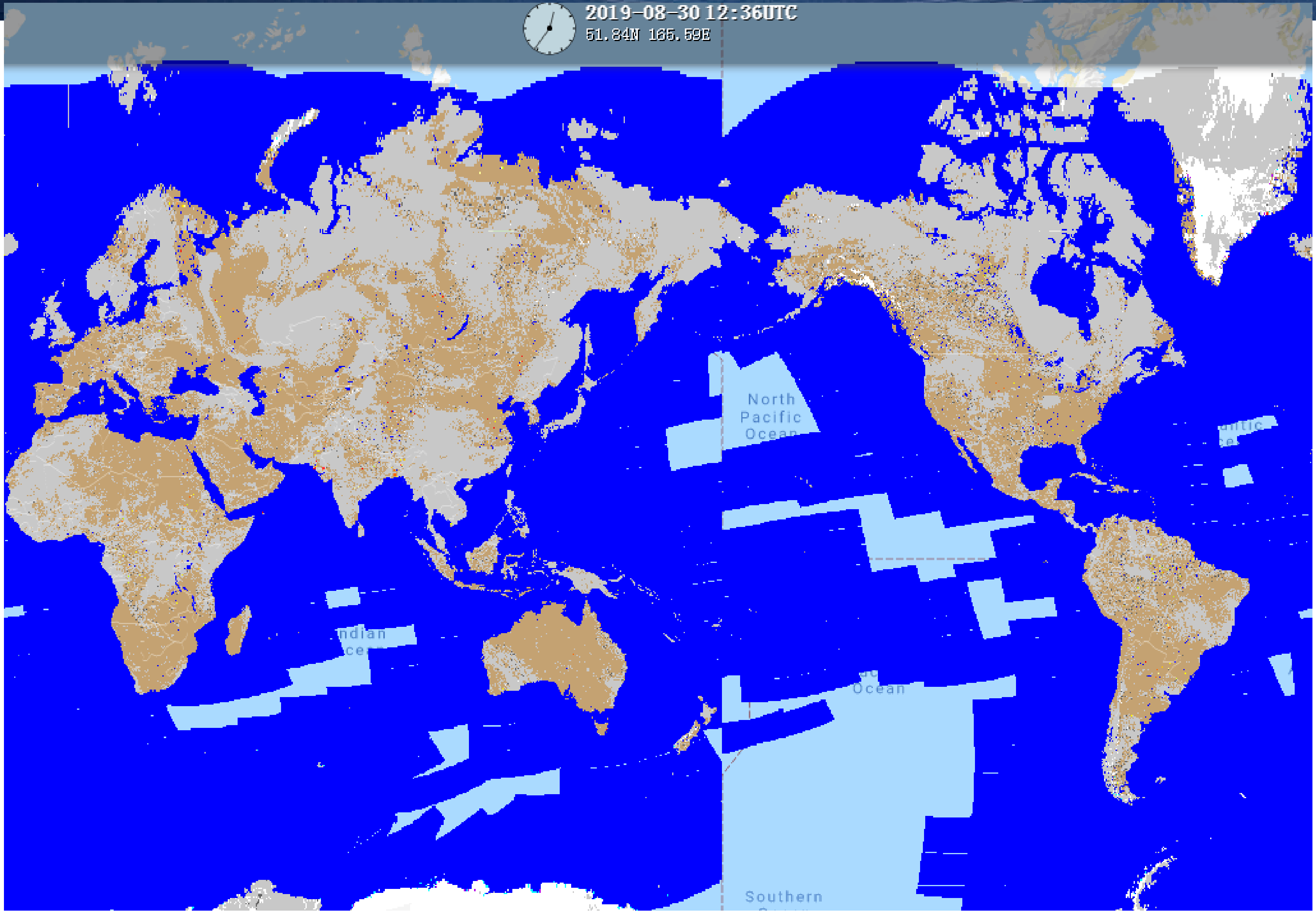
Sample Product- North Central Domain



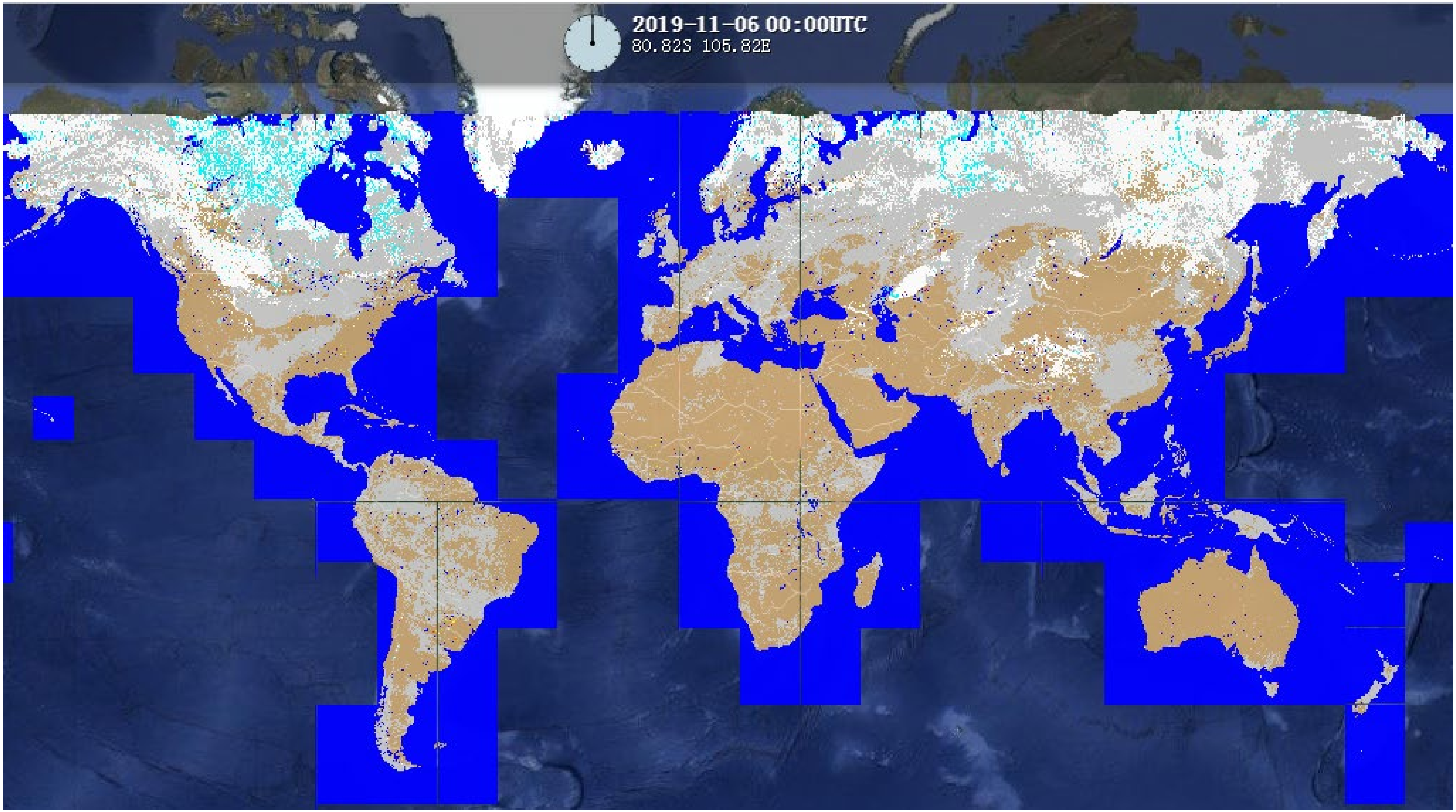


VIIRS flood map in the north central region

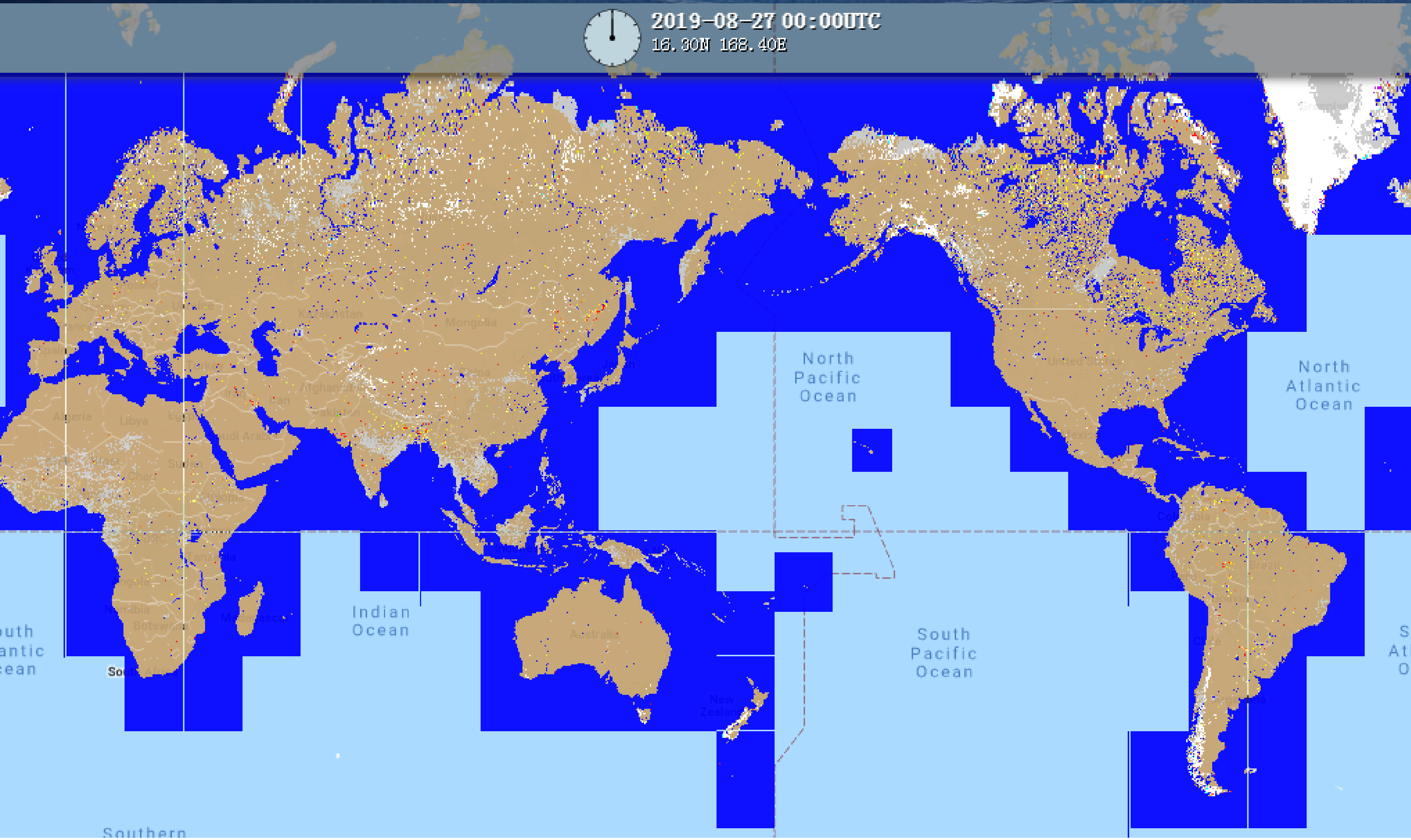
Sample product-Global NRT Product



Sample product-Global Daily Composited Product



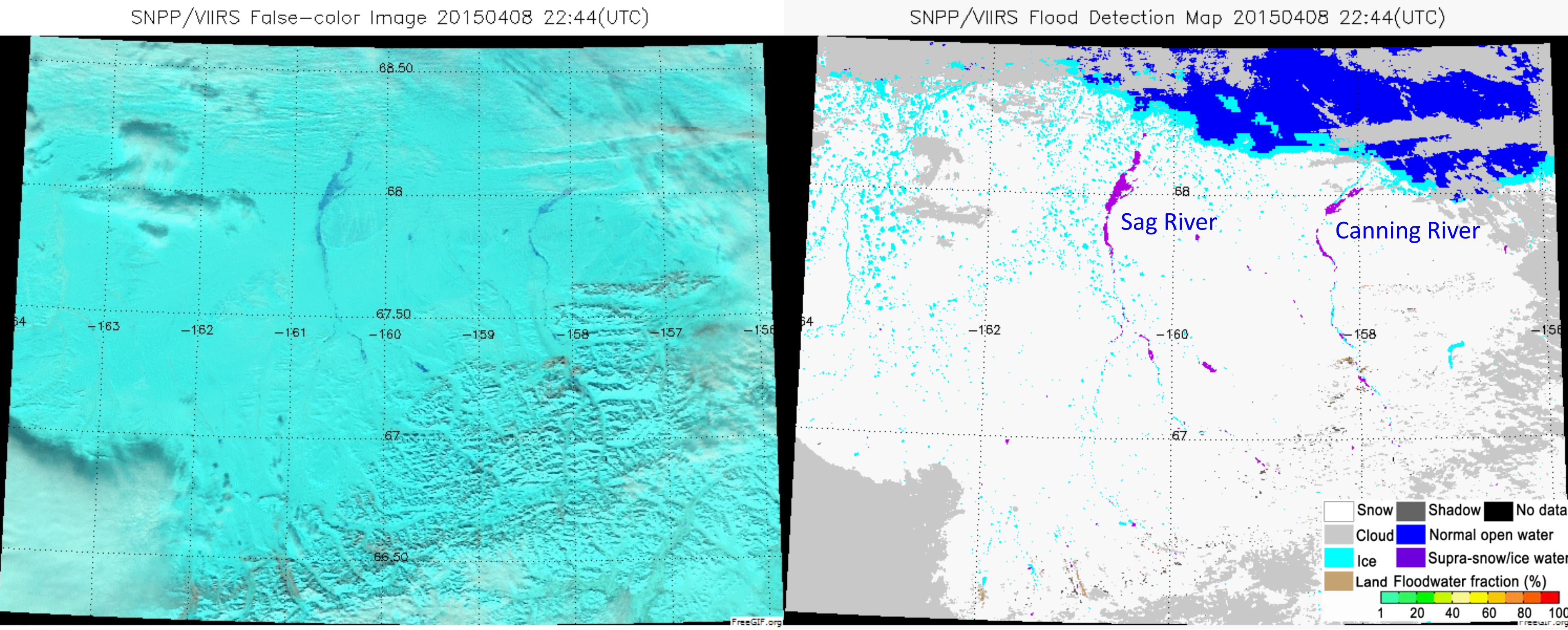
Sample product-Global 5-day Composited Product



Validation Approach and Procedure

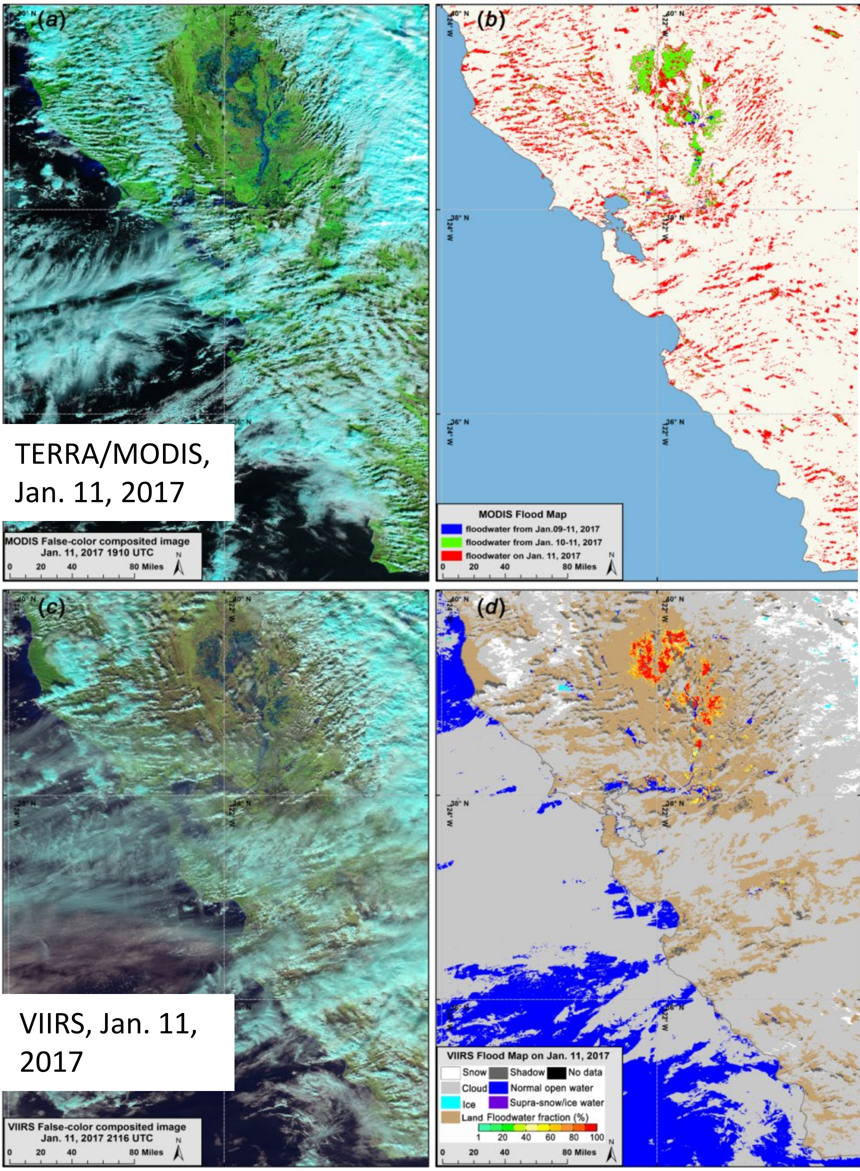
- Visual inspection with VIIRS natural-color images in the CONUS, Alaska and other areas outside of USA
- Qualitative evaluation with aerial photos provided by RFCs and NGS during most major floods
- Qualitative evaluation with river gauge observations
- Cross-comparison with MODIS, Sentinel-1 and Radarsat products
- Quantitative evaluation with Landsat-8 imagery

Supra-snow/ice flood along Sag River, AK



- Dynamic feature: Overflow can be slowed down under frozen weather, temporarily covered by new snow fall, sped up in warm weather, or refrozen into ice in hours if weather permitted.
- A hazard for local transportation and for people traveling or recreating.

Comparison with MODIS flood product



	Dates	Composition	N_{total}	N_t	N_u	P_f (%)	P_t (%)	P_O (%)
MODIS	11 Jan. 2017	near real-time	135,797	28,602	8,286	78.94	19.85	22.46
		2-day composite	22,384	16,732	20,156	25.25	39.33	54.64
		3-day composite	1,435	1,129	35,759	21.32	3.04	96.94
	13 Jan. 2017	2-day composite	34,387	24,362	16,982	29.15	47.43	41.07
		3-day composite	29,572	24,298	17,571	17.83	51.54	41.97
VIIRS	11 Jan. 2017	near real-time	25,258	23,773	4,257	5.88	80.55	15.19
	13 Jan. 2017	near real-time	42,499	41,290	23	2.84	97.10	0.06

N_{total}: the total number of detected flood pixels

N_t : the total number of true flood pixels

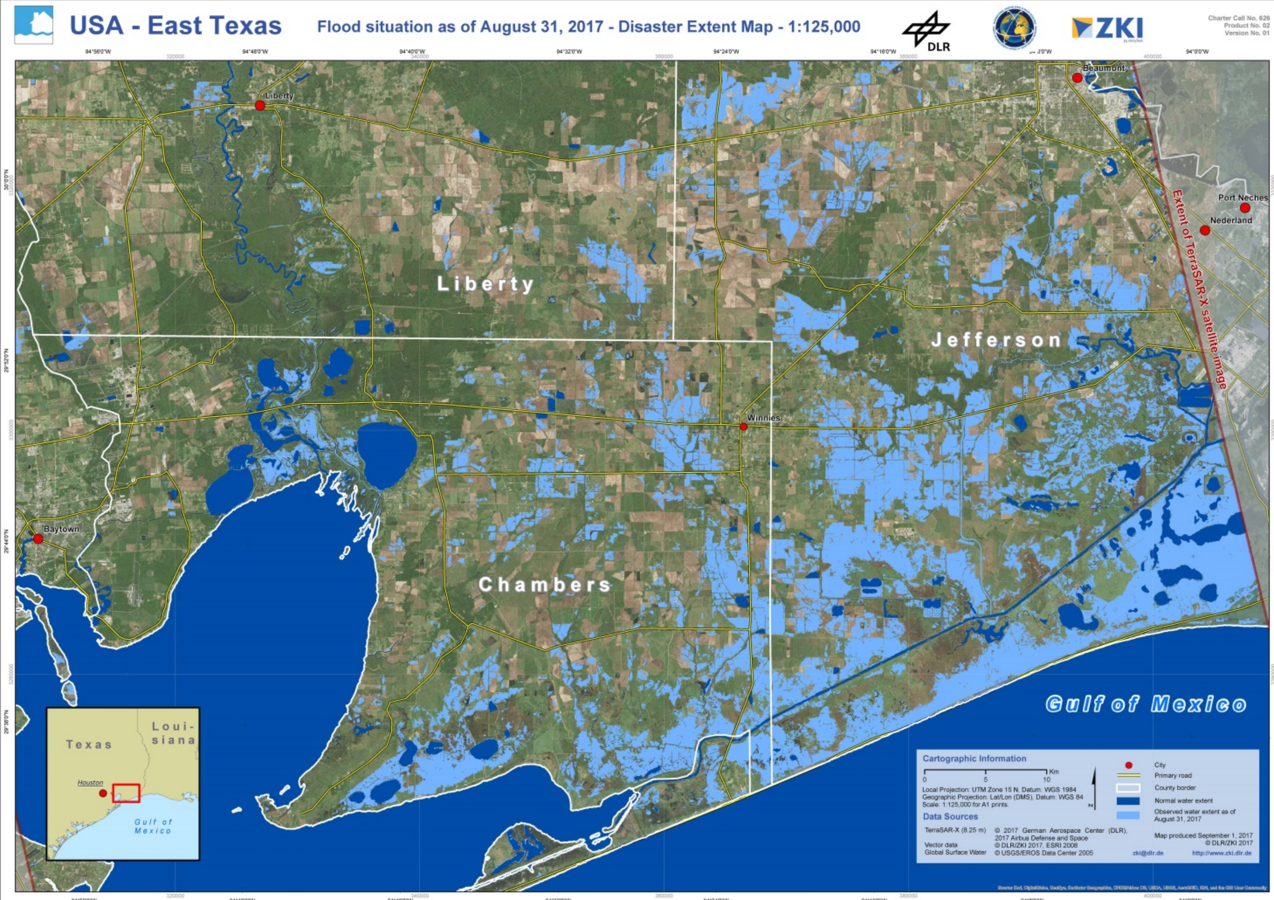
N_u: the total number of undetected flood pixels

False detection ratio: $$P_f = \frac{N_{total} - N_t}{N_{total}} \times 100\%$$

Commission ratio: $$P_t = \frac{N_t}{N_{total} + N_u} \times 100\%$$

Omission ratio: $$P_O = \frac{N_u}{N_t + N_u} \times 100\%$$

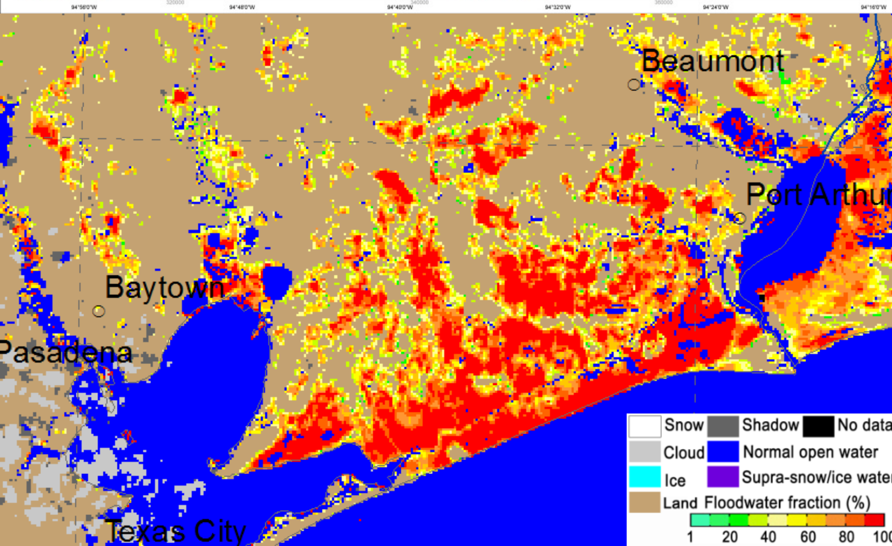
MODIS flood product data source: http://oas.gsfc.nasa.gov/floodmap



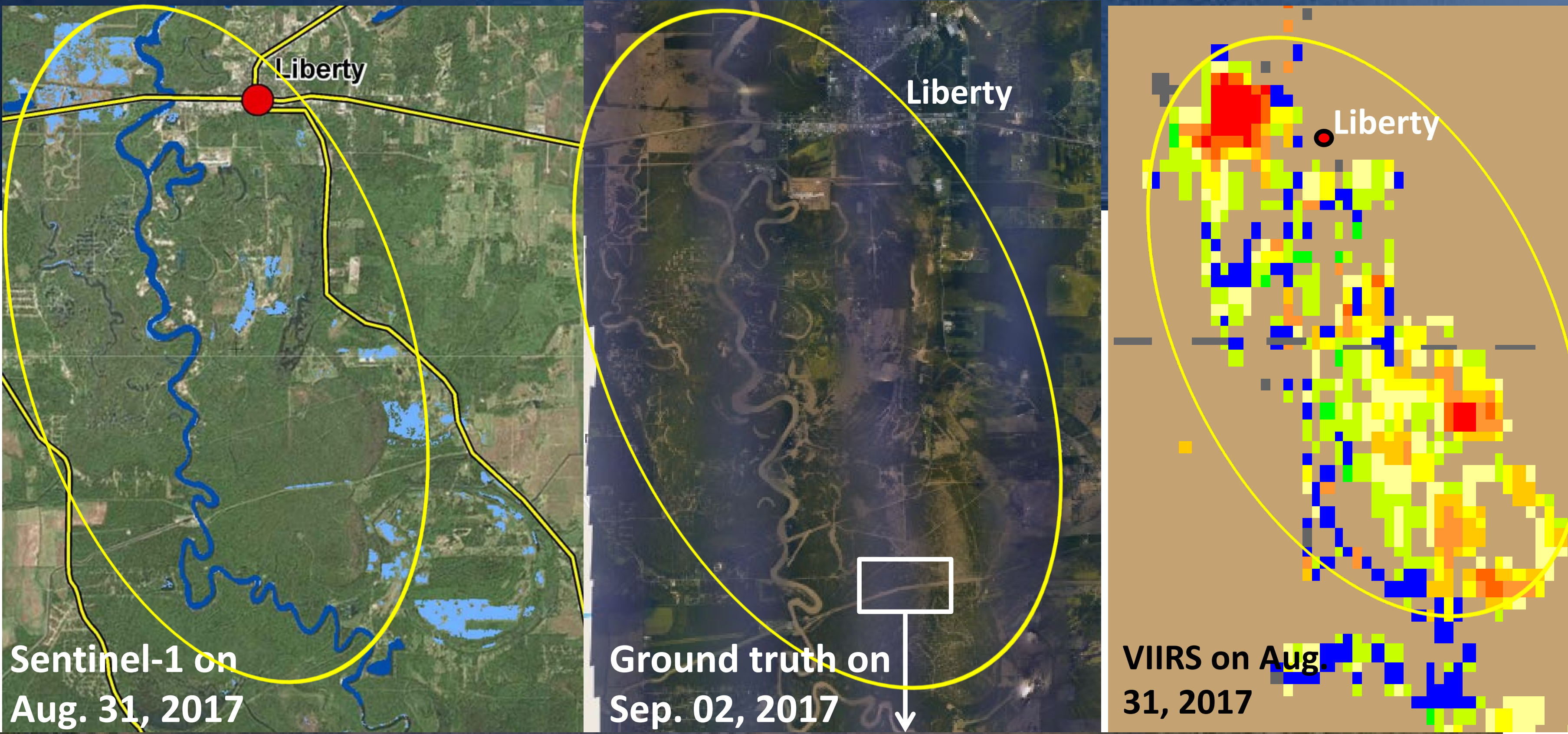
Comparison with Sentinel-1 flood product

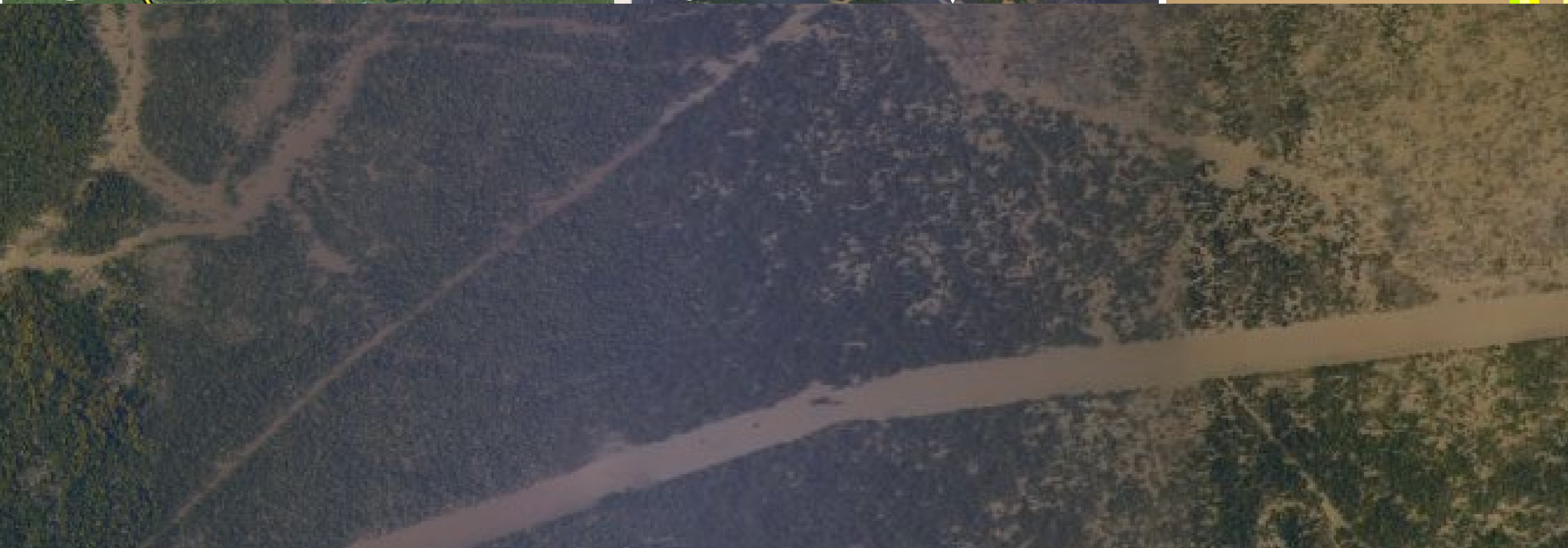
Sentinel-1 flood map on Aug. 31, 2017 in West Gulf region, USA

- Overall, VIIRS shows consistent flood detection results with Sentinel-1.
- Over vegetation cover region, VIIRS might show larger flood extent than Sentinel-1.

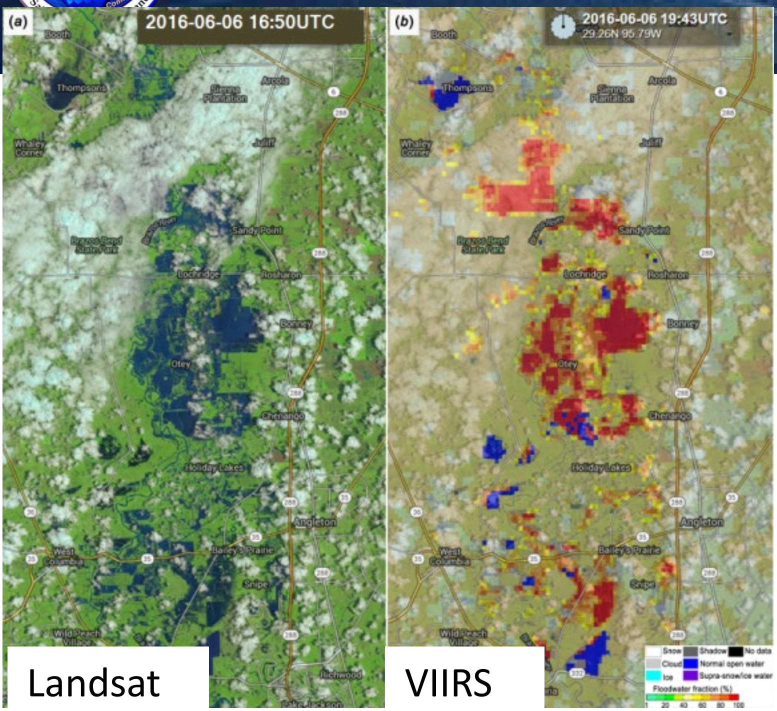


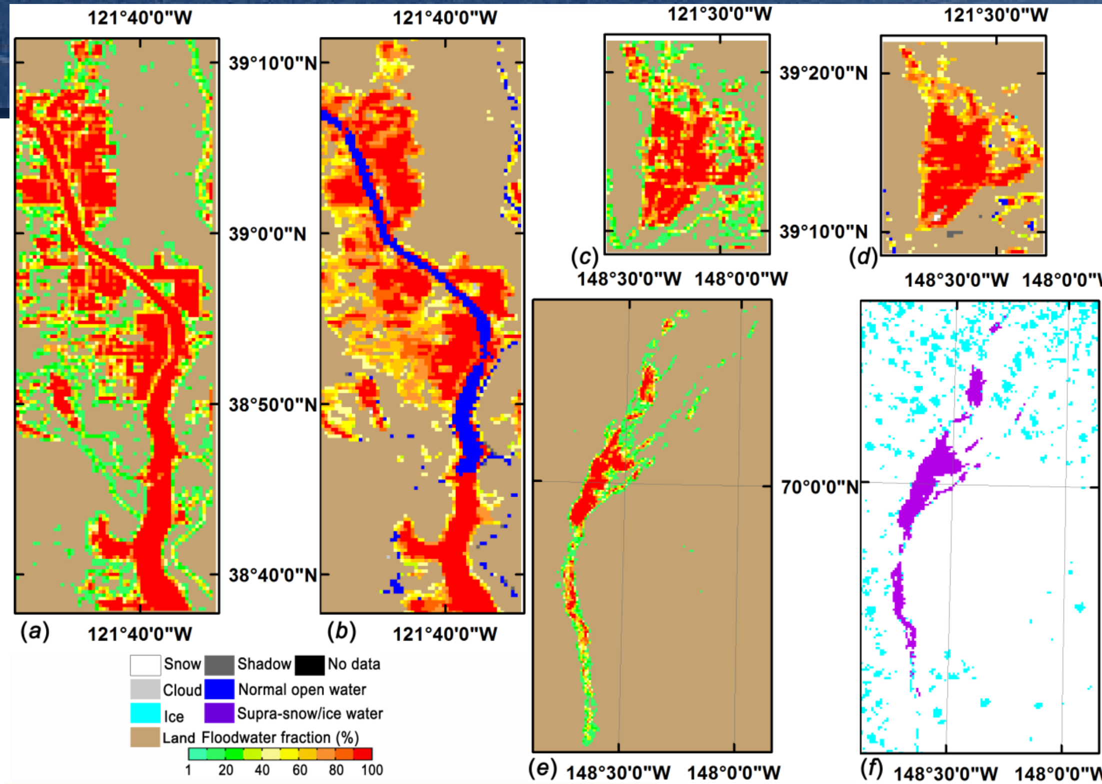
VIIRS 375-m flood map in the similar region with Sentinel-1 on Aug. 31, 2017

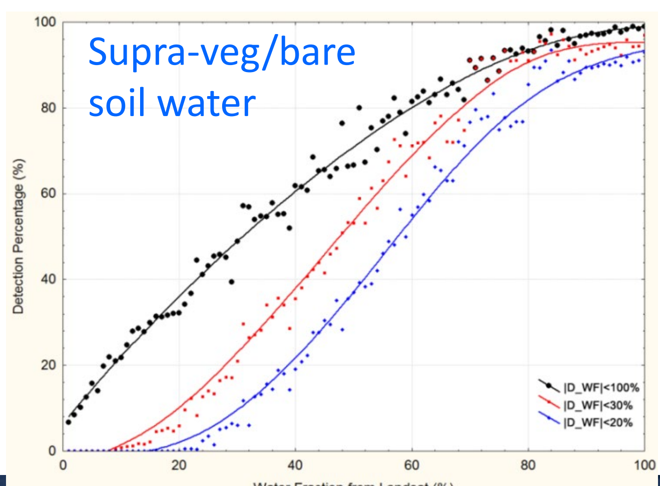

Liberty
Sentinel-1 on
Aug. 31, 2017
Liberty
Ground truth on
Sep. 02, 2017
Liberty
VIIRS on Aug.
31, 2017

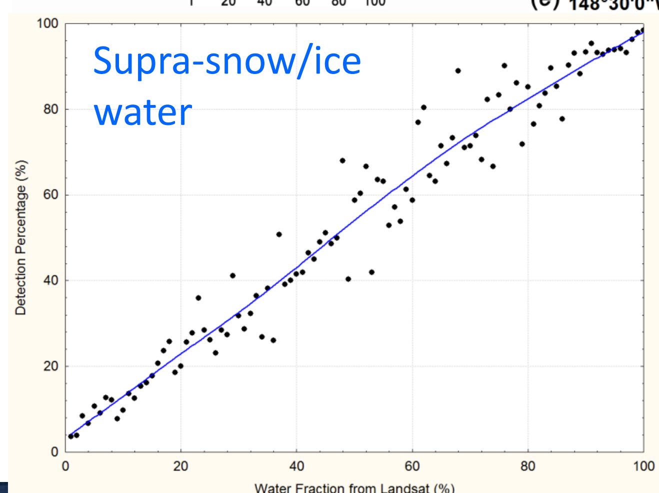


Evaluation with Landsat imagery









Summary

- The VIIRS flood product has mature algorithms including water detection, cloud shadow removal, terrain shadow removal, minor flood detection, water fraction retrieval and floodwater determination.
- The VIIRS flood mapping software developed under the JPSS proving ground risk reduction program has already been applied in producing routine flood products for NWS, FEMA and other user group since 2015.
- Since Sep. 2019, the software has been applied globally to produce global near real-time, daily composited and 5-day composited flood products routinely.
- Extensive evaluation and validation has being done by RFCs and GMU science team using river gauge observations, ground images MODIS flood product, high-resolution satellite imagery and products from Sentinel-1, Landsat and Radarsat images since 2015.
- The algorithms and software are expected to deliver reliable VIIRS 375-m flood extent in near real-time and multiple-day composition from Suomi-NPP and NOAA-20.

Reference

- Sanmei Li, Donglian Sun, Mitchell Goldberg, Bill Sjoberg, David Santek, Jay P. Hoffman, Mike DeWeese, Pedro Restrepo, Scott Lindsey, Eric Holloway (2017). Automatic near real-time flood detection using Suomi-NPP/VIIRS data, *Remote Sensing of Environment,* 204 (2018) 672–689
- Sanmei Li, Donglian Sun, Mitchell Goldberg & Bill Sjoberg (2015). Object-based automatic terrain shadow removal from SNPP/VIIRS flood maps, *International Journal of Remote Sensing*, Vol. 36, No. 21, 5504–5522
- Sanmei Li, Donglian Sun, Mitchell Goldberg & Antony Stefanidis (2013). Derivation of 30-m-resolution Water Maps from TERRA/MODIS and SRTM. *Remote Sensing of Environment* , 134 (2013) 417–430
- Sanmei Li, Donglian Sun, YunyueYu, Ivan Csiszar, Antony Stefanidis, & Mitch D. Goldberg (2012). A New Shortwave Infrared (SWIR) Method for Quantitative Water Fraction Derivation and Evaluation with EOS/MODIS and Landsat/TM data. *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 51, Issue 3
- Sanmei Li, Donglian Sun & Yunyue Yu (2013). Automatic cloud-shadow removal from flood/standing water maps using MSG/SEVIRI imagery, *International Journal of Remote Sensing*, 34:15, 5487-5502
- DonglianSun, YunyueYu, RuiZhang, SanmeiLi, and Mitchel D. Goldberg (2012). Towards Operational Automatic Flood Detection Using EOS/MODIS data. *Photogrammetric Engineering & Remote Sensing*, 78 (6).

Review Outline

- Introduction
- Requirements
- Operations Concept
- Algorithm Theoretical Basis
- **Software Architecture**
- Quality Assurance
- Risk & Actions
- Summary

Software Architecture

Kerrie Allen

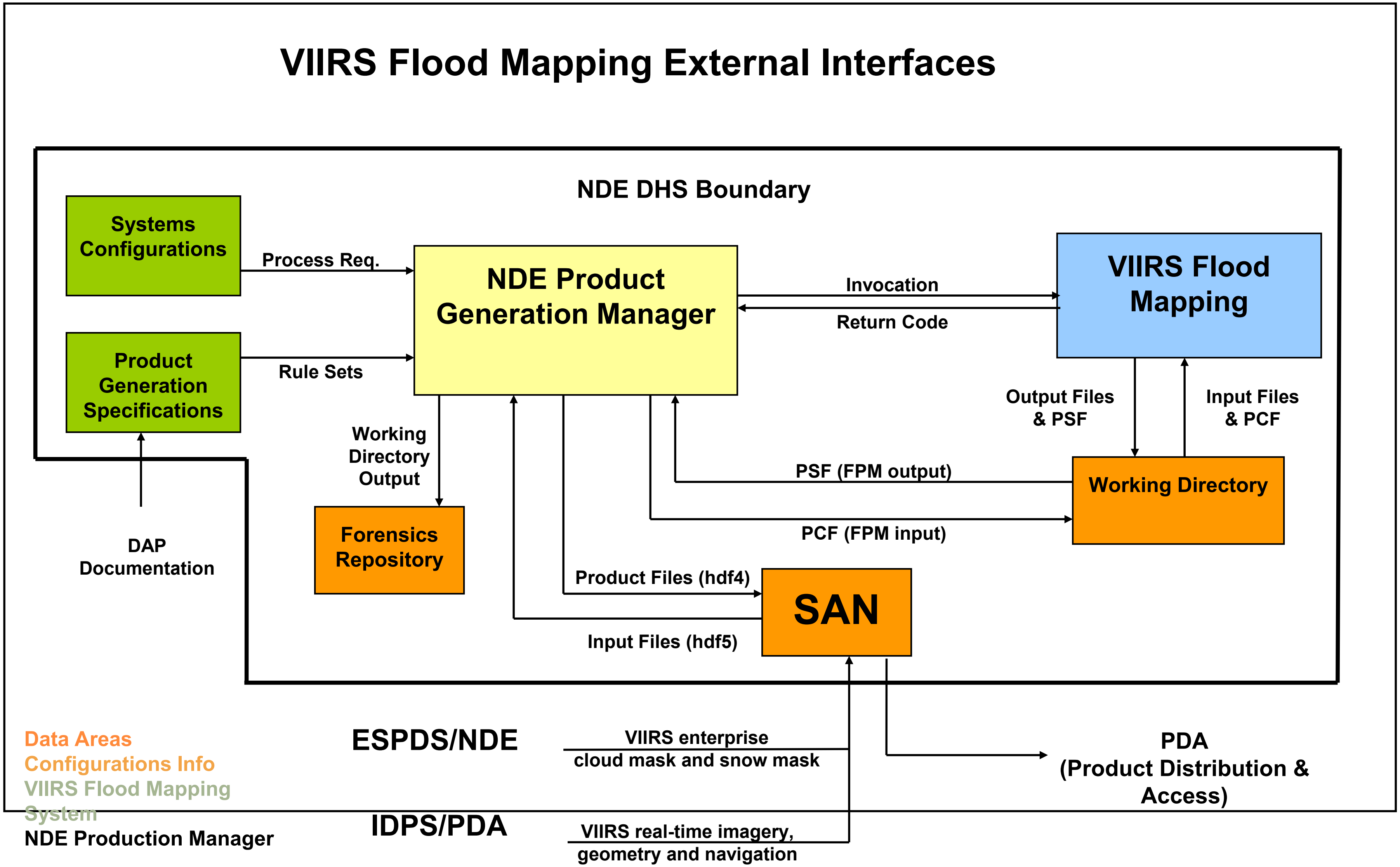
Hardware

- STAR Development Environment:
  – Redhat Linux 10 Core CPU with 3GB/Core
  – Memory: 3 GB
  – Disk Space: 24 TB
- Operational Environments:
  – Linux with 4 cores, 3 GB/core memory.
  – Memory: 3 GB for nominal processing
  – Disk Space: 24 TB

Software/Compilers

- Languages
  - C/C++
  - Python
- Compilers
  - g++ (4.8+)
- Libraries
  - HDF4
  - HDF5
  - NetCDF4
  - GDAL
  - MS2GT 0.23 or newer

VIIRS Flood Mapping External Interfaces



External Input Files

External Dynamic Input Data						
Input File	**Spatial Res.**	**Name Pattern**	**Content**	**Source**	**Update Frequency**	**Format**
VIIRS Imagery Data for bands 1, 2, 3 and 5	375m	SVI{band}_{sat ID}_d{date}_t{start time}_e{end time}_b{orbit #}_c{creation time}_{origin}_{domain}.h5 in the format SVIXX_XXX_dYYYYMMDD_tHHMMSSS_eHHMMSSS_b#####_cYYYYMMDDHHMMSSSSSSS_XXXX_XXX.h5	Channel Radiance	IDPS/PDA	1012 times per day (each granule is 89s of data)	HDF5
VIIRS Navigation at (parallax corrected)	375m	GITCO_{sat ID}_d{date}_t{start time}_e{end time}_b{orbit #}_c{creation time}_{origin}_{domain}.h5 in the format GITCO_XXX_dYYYYMMDD_tHHMMSSS_eHHMMSSS_b#####_cYYYYMMDDHHMMSSSSSSS_XXXX_XXX.h5	Geometric angles, Geolocations	IDPS/PDA	1012 times per day (each granule is 89s of data)	HDF5
VIIRS Enterprise Cloud Mask	750m	JRR-CloudMask_{version}_{sat ID}_s{start time}_e{end time}_c{creation time}.nc in the format JRR-CloudMask_v#r#_XXX_sYYYYMMDDHHMMSSS_eYYYYMMDDHHMMSSS_cYYYYMMDDHHMMSSS.nc	Cloud Mask, geolocations for Cloud Mask	NDE	1012 times per day (each granule is 89s of data)	NetCDF4
VIIRS Enterprise Snow Cover	375m	JRR-SnowCover_{version}_{sat ID}_s{start time}_e{end time}_c{creation time}.nc in the format JRR-SnowCover_v#r#_XXX_sYYYYMMDDHHMMSSS_eYYYYMMDDHHMMSSS_cYYYYMMDDHHMMSSS.nc	Snow Cover Mask	NDE	1012 times per day (each granule is 89s of data)	NetCDF4

External Outputs – Level 2

System Level Output Data					
Output File	**Name Pattern (all times are in YYYYMMDDHHMMSSS)**	**Archived/ Distributed**	**Update Freq.**	**Format**	**File Size**
VIIRS NRT Flood Detection Data	VIIRS-Flood_v?r?_{sat ID}_s{start time}_e{end time}_c{creation time}.nc (file is uniquely identified by timestamp)	Distributed and archived	Every granule	netCDF	40mb to 150mb
VIIRS NRT Flood detection data in NWS domains	VIIRS-Flood-NWS{domain ID}_v?r?_ {sat ID}_s{start time}_e{end time}_c{creation time}.nc	Distributed and archived	Within 40 minutes	netCDF	40mb to 90mb
VIIRS NRT Flood detection data in NWS domains	VIIRS-Flood-NWS{domain ID}_v?r?_ {sat ID}_s{start time}_e{end time}_c{creation time}.tif	Distributed	Within 40 minutes	geotiff	40mb to 90mb
VIIRS NRT Flood water vector data in NWS domains	VIIRS-Flood-NWS{domain ID}_v?r?_ {sat ID}_s{start time}_e{end time}_c{creation time}.shp	Distributed	Within 40 minutes	shapefile	~10mb
NRT Log files	VIIRS-Swath-Proj-Log_v?r?_{satID}_s{start time}_e{end time}_c{creation time}.txt VIIRS-Flood-Detect-Log_v?r?_{satID}_s{start time}_e{end time}_c{creation time}.txt VIIRS-Mosaic-Log_v?r?_{satID}_s{start time}_e{end time}_c{creation time}.txt	Distributed	Every process	Text	~kb

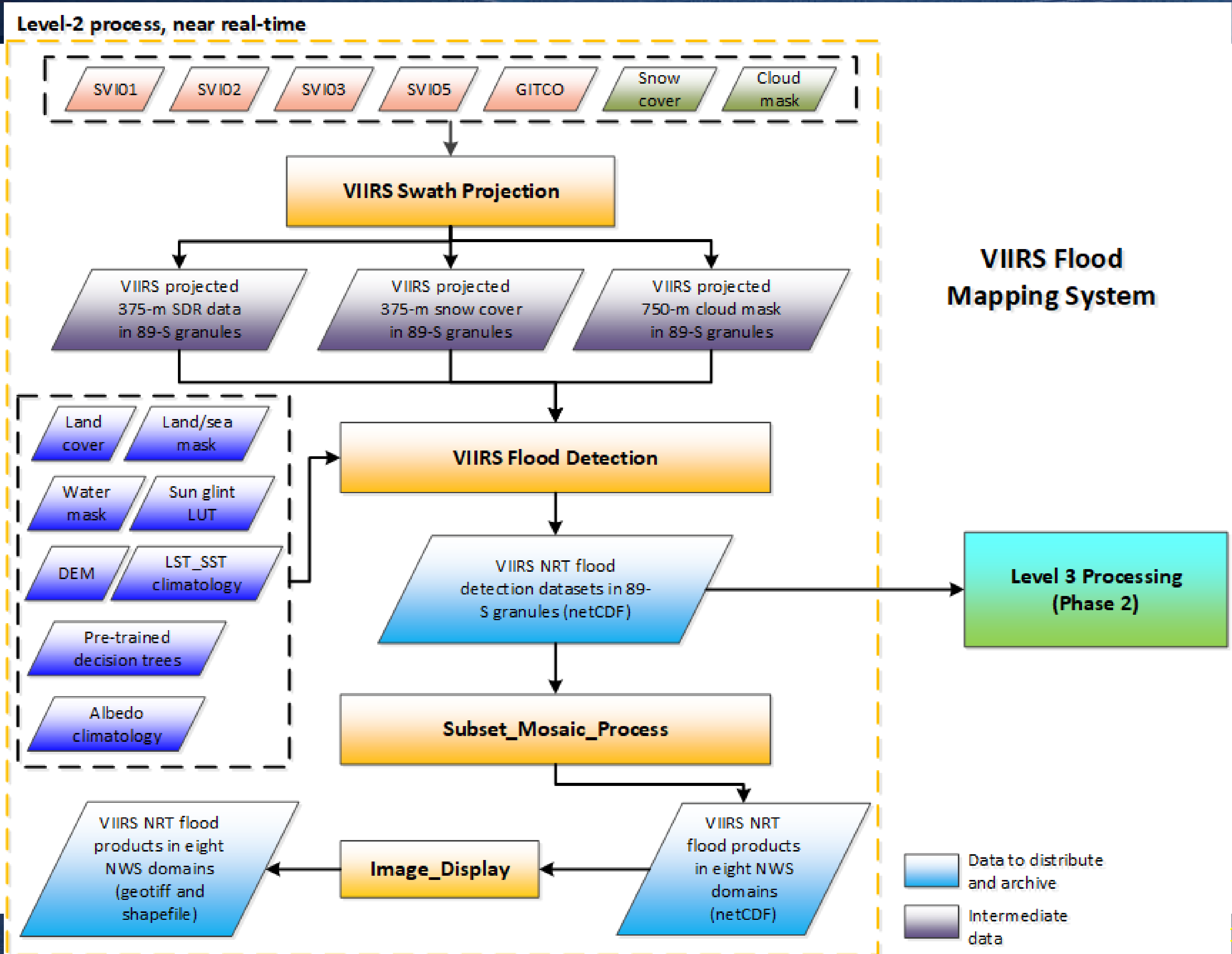
External Outputs – Level 3

System Level Output Data					
Output File	**Name Pattern (all times are in YYYYMMDDHHMMSSS)**	**Archived/ Distributed**	**Update Freq.**	**Format**	**File Size**
VIIRS daily composited data	VIIRS-Flood-1day-AOI{region ID}_v?r?_blend_s{start time}_e{end time}_c{creation time}.nc	Distributed and archived	6 hours	netCDF	40mb
VIIRS daily composited raster image	VIIRS-Flood-1day-AOI{region ID}_v?r?_blend_s{start time}_e{end time}_c{creation time}.tif	Distributed	6 hours	geotiff	40mb
VIIRS daily composited vector data	VIIRS-Flood-1day-AOI{region ID}_v?r?_blend_s{start time}_e{end time}_c{creation time}.shp	Distributed	6 hours	Shapefile	~10mb
VIIRS 5-day composited data	VIIRS-Flood-5day-AOI{region ID}_v?r?_blend_s{start time}_e{end time}_c{creation time}.nc	Distributed and archived	24 hours	netCDF	40mb
VIIRS 5-day composited raster image	VIIRS-Flood-5day-AOI{region ID}_v?r?_blend_s{start time}_e{end time}_c{creation time}.tif	Distributed	24 hours	geotiff	40mb
VIIRS 5-day composited vector data	VIIRS-Flood-5day-AOI{region ID}_v?r?_blend_s{start time}_e{end time}_c{creation time}.shp	Distributed	24 hours	shapefile	~10mb

External Outputs – Level 3 (cont)

System Level Output Data					
Output File	**Name Pattern (all times are in YYYYMMDDHHMMSSS)**	**Archived/ Distributed**	**Update Freq.**	**Format**	**File Size**
Daily flood mask	VIIRS-FloodMask-1day_v?r?_blend_s{start time}_e{end time}_c{creation time}.nc	Distributed and archived	6 hours	netCDF	TBD
Daily flood mask raster image	VIIRS-FloodMask-1day_v?r?_blend_s{start time}_e{end time}_c{creation time}.tif	Distributed	6 hours	geotiff	TBD
Daily flood mask vector data	VIIRS-FloodMask-1day_v?r?_blend_s{start time}_e{end time}_c{creation time}.shp	Distributed	6 hours	Shapefile	TBD
5-day flood mask	VIIRS-FloodMask-5day_v?r?_blend_s{start time}_e{end time}_c{creation time}.nc	Distributed and archived	24 hours	netCDF	TBD
5-day flood mask raster image	VIIRS-FloodMask-5day_v?r?_blend_s{start time}_e{end time}_c{creation time}.tif	Distributed	24 hours	geotiff	TBD
5-day flood mask vector data	VIIRS-FloodMask-5day_v?r?_blend_s{start time}_e{end time}_c{creation time}.shp	Distributed	24 hours	shapefile	TBD
Composite processing Log files	VIIRS-Mosaic-Log_v?r?_blend_s{start time}_e{end time}_c{creation time}.txt VIIRS-Composit-Log_v?r?_blend_s{start time}_e{end time}_c{creation time}.txt	Distributed	Every process	Text	~kb

System Level Architecture – Phase 1



Static Files

External Static Input Data

Input File	Name Pattern	Source	Format	Used by
Global land cover at 1km resolution	Global_land_cover_IGBP_2017_USGS_types.raw	VIIRS surface type and AVHRR land cover 2000	raw	Flood Detection
Global Digital Elevation Model at 375-m resolution	Global_DEM375m_W180_W090_N90_S90.raw,… Global_DEM375m_E090_E180_N90_S90.raw	SRTM/DEM ASTER DEM	raw	Flood Detection
Sun-glint mask	Sun_Gliter_mask_005.dat		raw	Flood Detection
Global land/sea mask at 1km resolution	Lw_geo_2001001_v03m_1km.raw		raw	Flood Detection, Composition
Global water mask	VIIRS_Global_MOD44W_Water_Mask.raw	MOD44W, ESA's global water mask, NLCD 2006	raw	Flood Detection, Composition
Land/sea surface temperature 16-day climatology at 5km resolution	AQUA_Daytime_LST_SST_Climatology_NNN.raw		raw	Flood Detection
Global Albedo monthly climatology at 5km resolution in visible channel	CMG-SMT-P0B1_ch1_{Channel number}.raw		raw	Flood Detection
Pre-trained decision trees and tree attribute files	Tree_{tree number}_attr.txt Tree{tree number}_J48graft_{description}.txt		txt	Flood Detection
User AOI definition file: to list the geographic information of each subset	User_AOI_Definition.txt	User defined	txt	Swath Projection, Subset & Mosaic

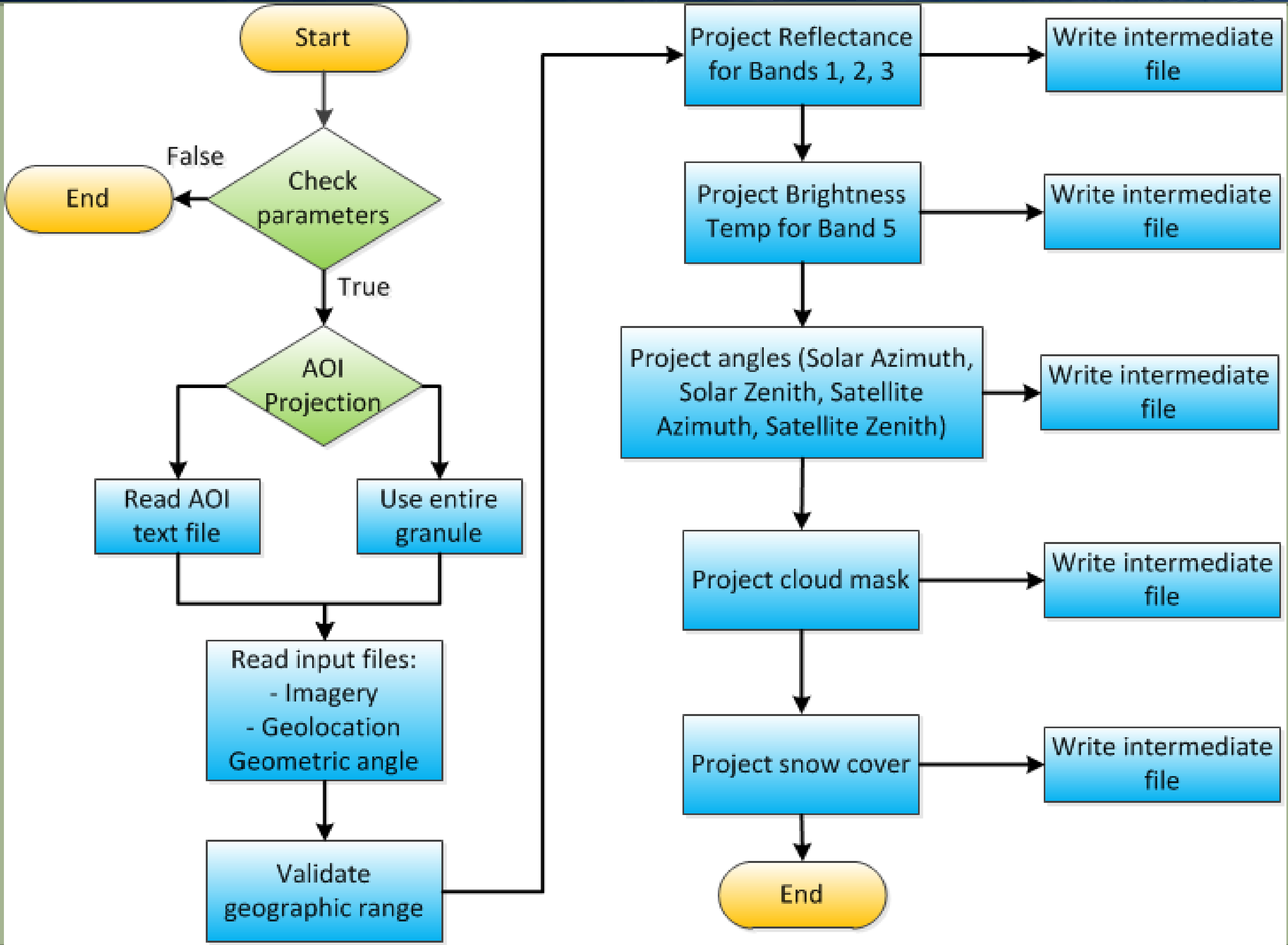
VIIRS Swath Projection Unit Inputs

File	Input/ Output	Data Description	Format
VIIRS Imagery Data	Input	Imagery data for I-Bands 1, 2, 3, and 5 SVI{band}_{sat ID}_d{start time}_e{end time}_b{orbit number}_c{creation time}_{data source}.h5 SVIXX_XXX_dYYYYMMDD_tHHMMSSS_eHHMMSSS_b#####_cYYYYMMDDHHMMSSSSSSSS_XXXX_XXX.h5	hdf5
Geometric angles and geolocations	Input	Solar zenith angle, solar azimuth angle, sensor zenith angle and sensor azimuth angle, latitude, longitude (parallax-corrected) GITCO_{sat ID}_d{start time}_e{end time}_b{orbit number}_c{creation time}_{data source}.h5 GITCO_XXX_dYYYYMMDD_tHHMMSSS_eHHMMSSS_b#####_cYYYYMMDDHHMMSSSSSSSS_XXXX_XXX.h5	hdf5
VIIRS Risk Reduction Cloud Mask	Input	Cloud Mask at 750m resolution, and its corresponding navigation JRR-CloudMask_{version}_{sat ID}_s{start time}_e{end time}_c{creation time}.nc JRR-CloudMask_v#r#_XXX_sYYYYMMDDHHMMSSS_ eYYYYMMDDHHMMSSS_cYYYYMMDDHHMMSSS.nc	netcdf4
VIIRS Risk Reduction Snow Mask	Input	Snow Mask at 375m resolution JRR-SnowCover_{version}_{sat ID}_s{start time}_e{end time}_c{creation time}.nc JRR-SnowCover_v#r#_XXX_sYYYYMMDDHHMMSSS_ eYYYYMMDDHHMMSSS_cYYYYMMDDHHMMSSS.nc	netcdf4
User AOI Definition	Static Input	List of points that define the geographic subset User_AOI_Definition.txt	ASCII

VIIRS Swath Projection Unit Outputs

File	Input/ Output	Data Description	Format
Projected Imagery and angles	Intermediate Output	Imagery and geometric angles projected into equidistant cylindrical coordinates GITCO-Prj-SVI{band}_{sat ID}_d{start time}_e{end time}_b{orbit number}_c{creation time}_{data source}.h5 GITCO-Prj-SVIXX_XXX_dYYYYMMDD_tHHMMSSS_eHHMMSSS_b#####_cYYYYMMDDHHMMSSSSSSSS_XXXX_XXX.h5	hdf5
Projected Cloud Mask	Interme Output	Cloud mask projected into equidistant cylindrical coordinates JRR-CloudMask-Prj_{version}_{sat ID}_s{start time}_e{end time}_c{creation time}.nc JRR-CloudMask-Prj_v#r#_XXX_sYYYYMMDDHHMMSSS_ eYYYYMMDDHHMMSSS_cYYYYMMDDHHMMSSS.nc	hdf5
Projected Snow Cover Mask	Intermed Output	Snow cover mask projected into equidistant cylindrical coordinates JRR-SnowCover-Prj_{version}_{sat ID}_s{start time}_e{end time}_c{creation time}.nc JRR-SnowCover-Prj_v#r#_XXX_sYYYYMMDDHHMMSSS_ eYYYYMMDDHHMMSSS_cYYYYMMDDHHMMSSS.nc	hdf5
Sub-unit log file	Output	Contains log for Swath Projection sub-unit VIIRS-Swath-Proj-Log_v?r?_{satID}_s{start time}_e{end time}_c{creation time}.txt VIIRSSwath-Proj-Log_v?r?_snpp_sYYYYMMDDHHMMSSS_eYYYYMMDDHHMMSSS_cYYYYMMDDHHMMSSS.txt	ASCII

VIIRS Swath Projection Unit



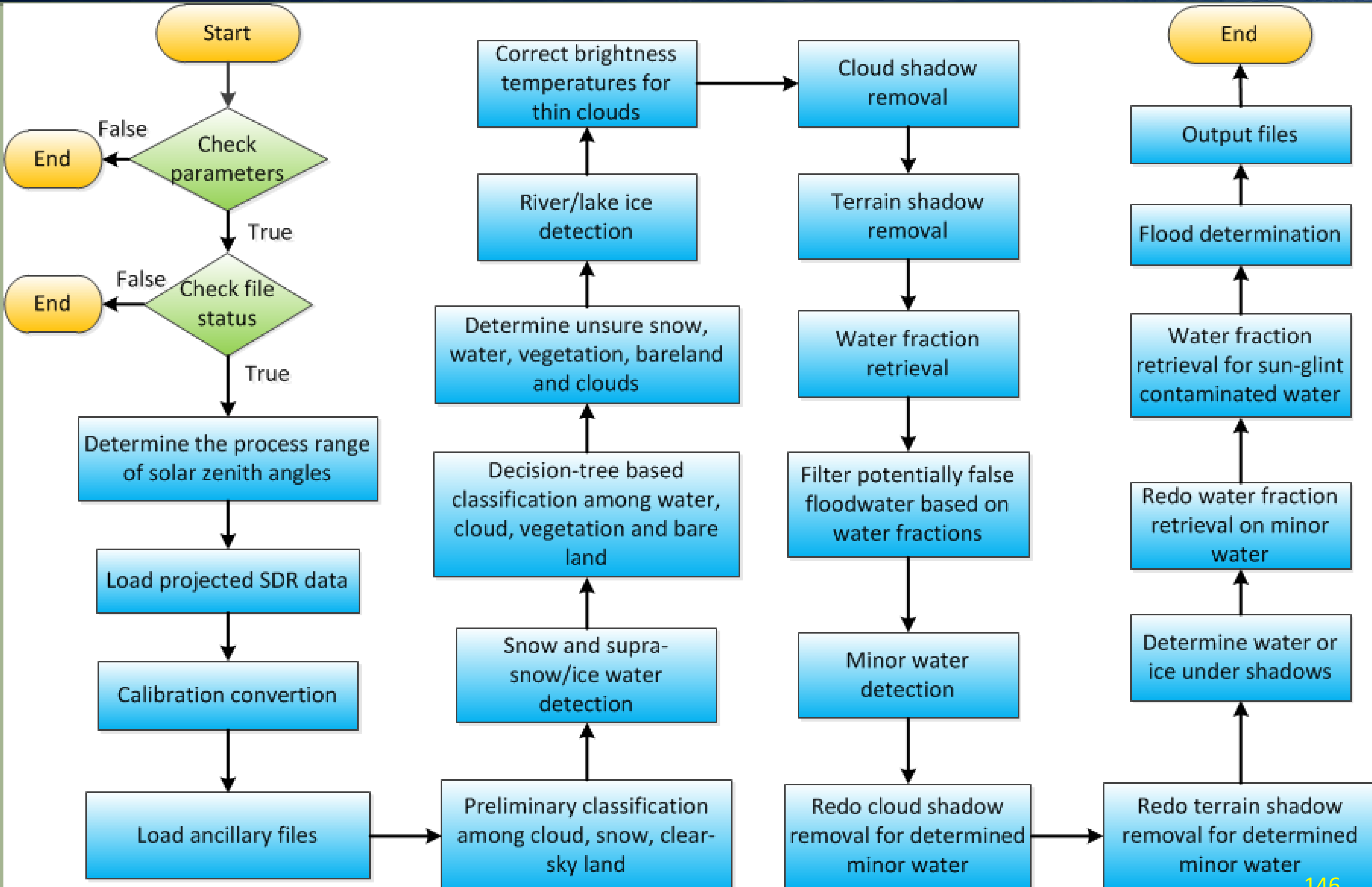
VIIRS Flood Detection Unit

File	Input/ Output	Data Description	Format
Projected Imagery and angles	Input	Imagery and geometric angles projected into equidistant cylindrical coordinates GITCO_Prj_SVI{band}_{sat ID}_d{start time}_e{end time}_b{orbit number}_c{creation time}_{data source}.h5 GITCO-Prj-SVIXX_XXX_dYYYYMMDD_tHHMMSSS_eHHMMSSS_b#####_cYYYYMMDDHHMMSSSSSSS_XXXX_XXX.h5	netcf4
Land cover	Static Input	Global land cover at 1km resolution Global_land_cover_IGBP_2017_USGS_types.raw	raw
DEM	Static Input	Global Digital Elevation Model at 375-m resolution Global_DEM375m_{geographic extent}.raw	raw
Sun-glint mask	Static Input	Mask for areas affected by sun glint Sun_Gliter_mask_005.dat	raw
Land/sea mask	Static Input	Global land/sea mask at 1km resolution Lw_geo_2001001_v03m_1km.raw	raw
Water mask	Static Input	Global water mask VIIRS_Global_MOD44W_Water_Mask.raw	raw
Land/sea temperature Climatology	Static Input	Land/sea surface temperature 16-day climatology at 5km resolution AQUA_Daytime_LST_SST_Climatology_NNN.raw	raw
Albedo Climatology	Static Input	Global Albedo monthly climatology at 5km resolution in visible channel CMG-SMT-P0B1_ch1_{Channel number}.raw	raw
Decision Trees	Static Input	Pre-trained decision trees and tree attribute files Tree_{tree number}_attr.txt, Tree{tree number}_J48graft_{description}.txt	ASCII

VIIRS Flood Detection Unit

File	Input/ Output	Data Description	Format
VIIRS NRT Flood Detection Data	Intermediate Output	16-bit short data type indicating detection of water, granule level. VIIRS-Flood_{sat ID}_s{start time}_e{end time}_c{creation time}.nc VIIRS-Flood_XXX_sYYYYMMDDHHMMSSS_eYYYYMMDDHHMMSSS_cYYYYMMDDHHMMSSS.nc	netcdf4
Sub-unit log file	Output	Contains log for Flood Detection sub-unit VIIRS-Flood-Detect-Log_v?r?_{satID}_s{start time}_e{end time}_c{creation time}.txt VIIRS-Flood-Detect-Log_v?r?_snpp_sYYYYMMDDHHMMSSS_eYYYYMMDDHHMMSSS_cYYYYMMDDHHMMSSS.txt	ASCII

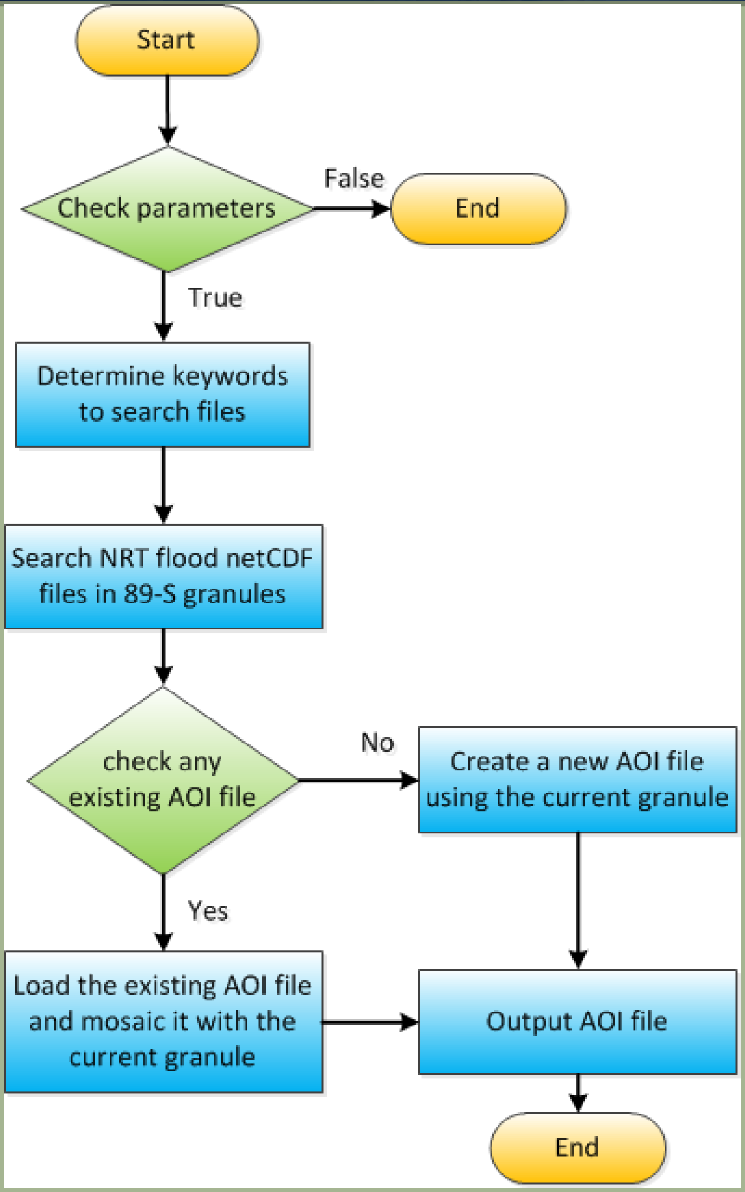
VIIRS Flood Detection Unit



VIIRS Subset and Mosaic Unit

File	Input/ Output	Data Description	Format
VIIRS NRT Flood Detection Data	Input	16-bit short data type indicating detection of water, granule level. VIIRS-Flood_v?r?_{sat ID}_s{start time}_e{end time}_c{creation time}.nc VIIRS-Flood_v?r?_XXX_sYYYYMMDDHHMMSSS_eYYYYMMDDHHMMSSS_cYYYYMMDDHHMMSSS.nc	netcdf4
User AOI Definition	Static Input	List of points that define the geographic subset User_AOI_Definition.txt	ASCII
VIIRS Flood Detection Data	Output	VIIRS NRT flood products in eight NWS domains OR 136 areas of interest VIIRS-Flood-NWS{domain ID}_v?r?_{sat ID}_s{start time}_e{end time}_c{creation time}.nc Or VIIRS-Flood-AOI{region ID}_v?r?_{sat ID}_s{start time}_e{end time}_c{creation time}.nc (all times in YYYYMMDDHHMMSSS)	netcdf4
Sub-unit log file	Output	Contains log for the Mosaick and Subset sub-unit VIIRS-Mosaic-Log_v?r?_s{start time}_e{end time}_c{creation time}.txt (all times in YYYYMMDDHHMMSSS)	ASCII

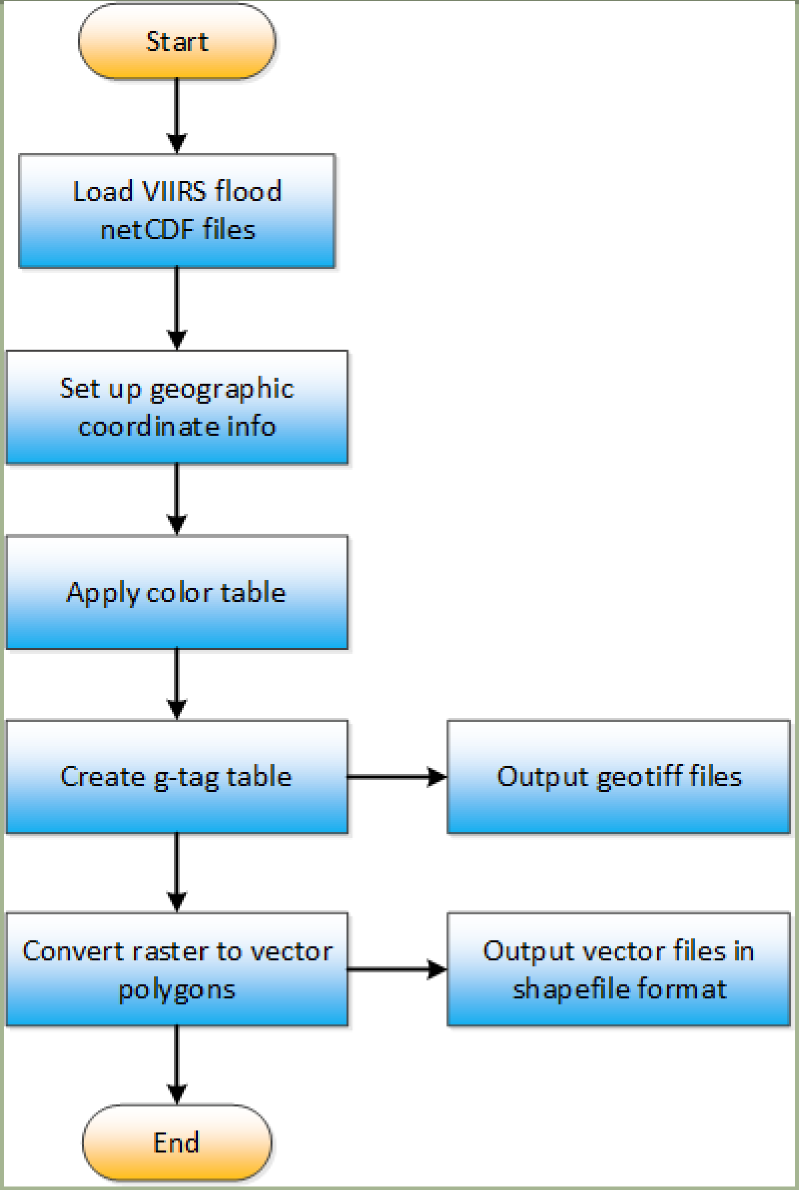
VIIRS Subset and Mosaic Unit



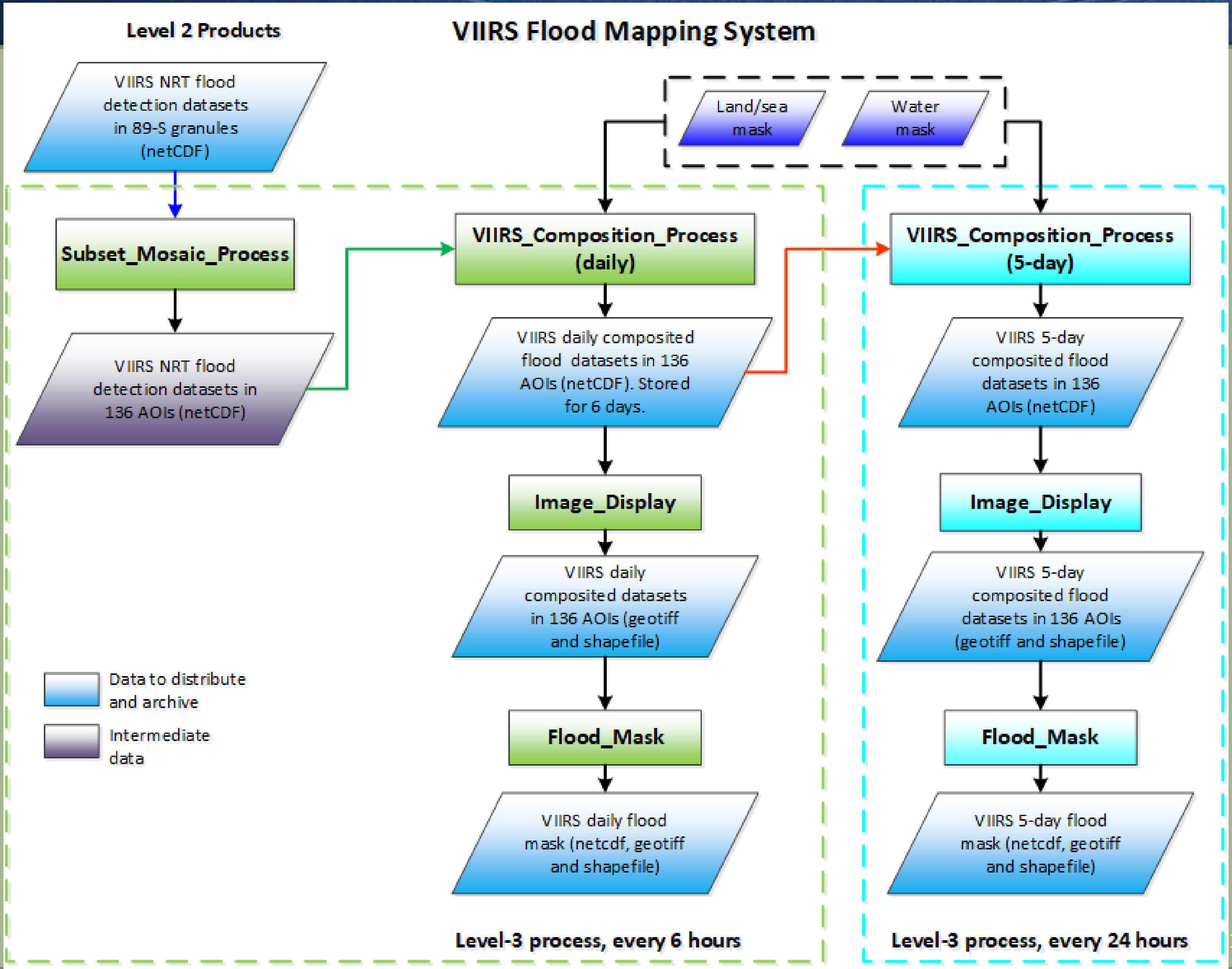
VIIRS Image Display Unit

File	Input/ Output	Data Description (all times in YYYYMMDDHHMMSSS)	Format
VIIRS Flood data	Input	VIIRS NRT flood products in eight NWS domains (NRT) OR 136 areas of interest (daily or 5-day composite) VIIRS-Flood-NWS{domain ID}_v?r?_blend_s{start time}_e{end time}_c{creation time}.nc or VIIRS-Flood-1day-AOI{region ID}_v?r?_blend_s{start time}_e{end time}_c{creation time}.nc or VIIRS-Flood-5day-AOI{region ID}_v?r?_blend_s{start time}_e{end time}_c{creation time}.nc	netcdf4
VIIRS NRT Flood raster image	Output	VIIRS-Flood-NWS{domain ID}_v?r?_blend_s{start time}_e{end time}_c{creation time}.tif or VIIRS-Flood-1day-AOI{region ID}_v?r?_blend_s{start time}_e{end time}_c{creation time}.tif or VIIRS-Flood-5day-AOI{region ID}_v?r?_blend_s{start time}_e{end time}_c{creation time}.tif	geotiff
VIIRS Flood vector data	Output	VIIRS-Flood-NWS{domain ID}_v?r?_blend_s{start time}_e{end time}_c{creation time}.shp or VIIRS-Flood-1day-AOI{region ID}_v?r?_blend_s{start time}_e{end time}_c{creation time}.shp or VIIRS-Flood-5day-AOI{region ID}_v?r?_blend_s{start time}_e{end time}_c{creation time}.shp	shapefile

VIIRS Image Display Unit



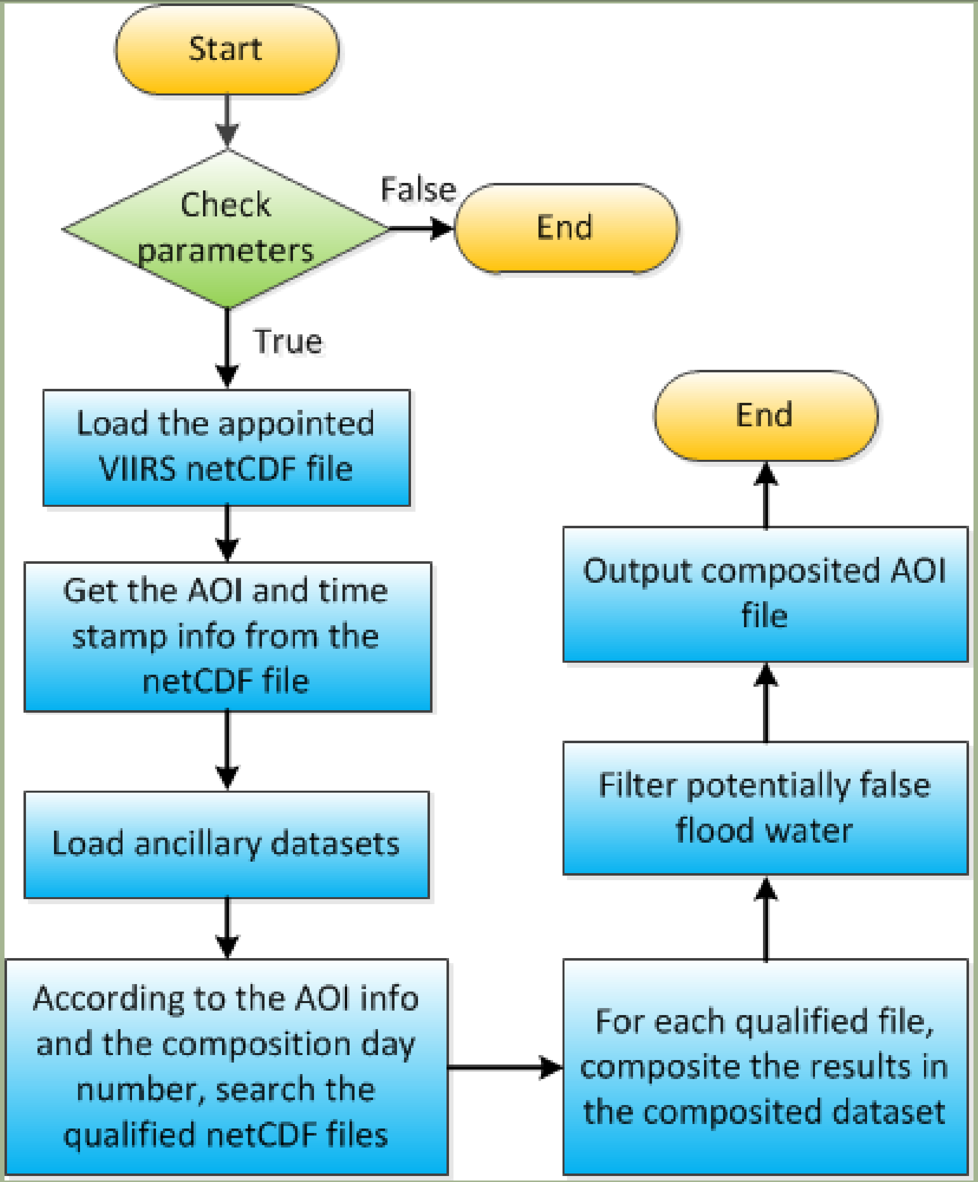
System Level Architecture – Phase 2



VIIRS Compositing Unit

File	Input/ Output	Data Description (all times in YYYYMMDDHHMMSSS)	Format
VIIRS Flood Detection Data	Input	VIIRS NRT flood products in eight NWS domains OR 136 areas of interest VIIRS-Flood-NWS{domain ID}_v?r?_{sat ID}_s{start time}_e{end time}_c{creation time}.nc Or VIIRS-Flood-AOI{region ID}_v?r?_{sat ID}_s{start time}_e{end time}_c{creation time}.nc	netcdf4
Global land/sea mask at 1km resolution	Static input	Global land/sea mask at 1km resolution Lw_geo_2001001_v03m_1km.raw	raw
Global water mask	Static input	Global water mask VIIRS_Global_MOD44W_Water_Mask.raw	raw
VIIRS daily OR 5-day composited data	Output	VIIRS-Flood-1day-AOI{region ID}_blend_s{start time}_e{end time}_c{creation time}.nc or VIIRS-Flood-5day-AOI{region ID}_v?r?_blend_s{start time}_e{end time}_c{creation time}.nc	netcdf4
Sub-unit log file	Output	Contains log for the Compositing sub-unit VIIRS-Composit-Log_v?r?_s{start time}_e{end time}_c{creation time} .txt	ASCII

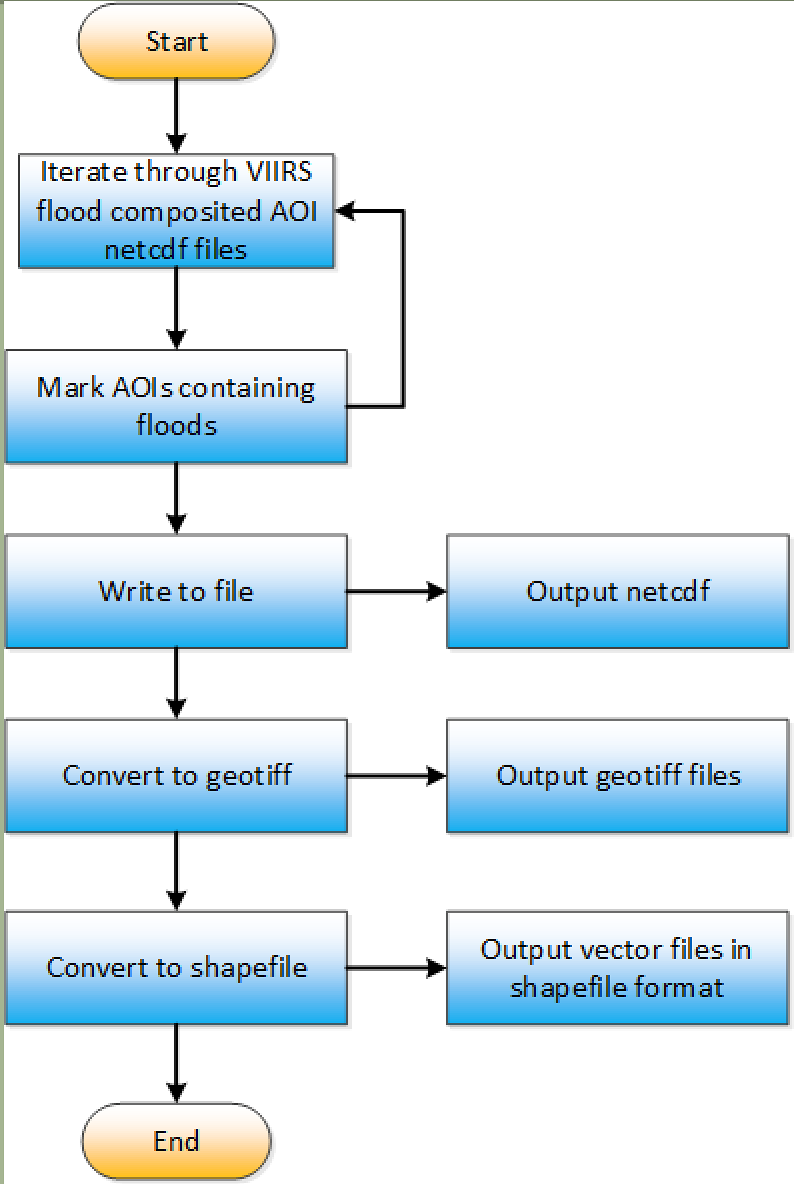
VIIRS Composition Unit



VIIRS Flood Mask Unit

File	Input/ Output	Data Description (all times in YYYYMMDDHHMMSSS)	Format
VIIRS Flood data	Input	VIIRS NRT flood products in 136 areas of interest (daily or 5-day composite) VIIRS-Flood-1day-AOI{region ID}_v?r?_blend_s{start time}_e{end time}_c{creation time}.nc or VIIRS-Flood-5day-AOI{region ID}_v?r?_blend_s{start time}_e{end time}_c{creation time}.nc	netcdf4
Daily flood mask	Output	VIIRS-FloodMask-1day_v?r?_blend_s{start time}_e{end time}_c{creation time}.nc or VIIRS-FloodMask-5day_v?r?_blend_s{start time}_e{end time}_c{creation time}.nc	netcdf4
Daily flood mask	Output	VIIRS-FloodMask-1day_v?r?_blend_s{start time}_e{end time}_c{creation time}.tif or VIIRS-FloodMask-5day_v?r?_blend_s{start time}_e{end time}_c{creation time}.tif	geotiff
VIIRS Flood vector data	Output	VIIRS-FloodMask-1day_v?r?_blend_s{start time}_e{end time}_c{creation time}.shp or VIIRS-FloodMask-5day_v?r?_blend_s{start time}_e{end time}_c{creation time}.shp	shapefile

VIIRS Flood Mask Unit



Metadata Design

- VIIRS Flood Mapping product output files contain information on NDE required metadata.
  - Collection Level Metadata
    - Static with respect to each NOAA Unique Product (NUP)
  - Granule Level Metadata
    - Granule dependent and thus are dynamic with respect to the observation
  - Gridded Geographic Metadata
  - Quality Information Attributes

Collection Level Metadata

Attribute Name	Data Type	Value/Description
Conventions	string	“CF-1.6, ACDD-1.3”
standard_name_vocabulary	string	“CF Standard Name Table (version 69, 15 October 2019)”
project	string	“ESPDS”
institution	string	“DOC/NOAA/NESDIS/OSPO > Office of Satellite and Product Operations, NESDIS, NOAA, U.S. Department of Commerce”
naming_authority	string	“gov.noaa.nesdis.ncei”
platform	string	“NPP”, “N20” or “blend”
instrument	string	“VIIRS”
title	string	Set to the NUP product short name
summary	string	Brief description of the product
history	string	Provides the algorithm name and version used to produce the NUP
processing_level	string	“NOAA Level 2”
source	string	This attribute should list all major input files as a comma delimited list.
production_site	string	This attribute is passed through the PCF and describes the processing site for the product.
production_environment	String	This attribute is passed through the PCF and describes the processing string generating the product (“DE”, “ITE” or “OE”)
references	string	Published or web-based references describing the data or methods used to produce the product

Granule Level Metadata

Attribute Name	Data Type	Description
id	string	Each product team can implement a unique identifier, approved by NEDSIS data center representative.
metadata_link	string	This attribute lists the unique NUP product file name
start_orbit_number	int	This attribute is a sequential whole number set by the S-NPP/JPSS Ground System in the xDR metadata. Orbits are incremented on the northward equatorial node
end_orbit_number	int	This attribute is a sequential whole number set by the S-NPP/JPSS Ground System in the xDR metadata. Orbits are incremented on the northward equatorial node
day_night_data_flag	string	This attribute should be set to "0" for night, "1" for day, and "2" for both depending on sunlight conditions for observation.
ascent_descend_data_flag	string	This attribute indicates whether the satellite is moving northward or southward. The center time of an observation is used. This attribute should be set to "0" for descending/southward, "1" for ascending/northward, and "2" if transitioning.
time_coverage_start	string	This attribute is set to the UTC start time of an observation as "YYYY-MM-DDThh:mm:ssZ", where YYYY is the four digit year, MM is the two digit month, DD is the two digit day, hh is the UTC hour, mm is the UTC minute, and ss is the UTC second
time_coverage_end	string	This attribute is set to the UTC end time of an observation as "YYYY-MM-DDThh:mm:ssZ", where YYYY is the four digit year, MM is the two digit month, DD is the two digit day, hh is the UTC hour, mm is the UTC minute, and ss is the UTC second
date_created	string	This attribute is set to the UTC time the NUP file was created by NDE as "YYYY-MM-DDThh:mm:ssZ", where YYYY is the four digit year, MM is the two digit month, DD is the two digit day, hh is the UTC hour, mm is the UTC minute, and ss is the UTC second

Gridded Geographic Metadata

Attribute Name	Data Type	Description
cdm_data_type	string	This attribute should be “Grid”
geospatial_lat_min	float	These attributes describe the bounding latitudes and longitudes of the geospatial coverage of the grid. Latitude values include -90 (south) to 90 (north) degrees and longitude values include -180 (west) to 180 (east).
geospatial_lat_max	float	
geospatial_lon_min	float	
geospatial_lon_max	float	
geospatial_lat_units	string	This attribute should be “degrees_north”
geospatial_lon_units	string	This attribute should be “degrees_east”

Quality Information Attribute Metadata

Attribute Name	Data Type	Description
long_name	string	This attribute should list all quality information contained within the NUP as a comma delimited string (e.g., "total number of retrievals, percentage of optimal retrievals, percentage of bad retrievals").
total_number_retrievals	int	This attribute should be a whole number representing the summation of the total number of retrievals contained within the NUP file.
percentage_optimal_retrievals	float	Percentage of the total number of retrievals that satisfy an algorithm team defined threshold for high-quality retrievals.
percentage_bad_retrievals	float	Percentage of the total number of retrievals that satisfy an algorithm team defined threshold for poor or failed retrievals.
Number of pixels in each floodwater category	int	Number of pixels designated as each of possible water detection types
Fractions of pixels in each floodwater category	float	Percentage of pixels designated as each of possible water detection types, divided by total number of valid pixels (for product monitoring)

Error Handling

- All return values and exit status from executables, script functions, unit driver scripts, and system calls from scripts are checked
- All errors or noteworthy conditions are trapped. Error codes will be used to categorize the severity levels.
- Messages are labeled and produced based on the error codes and are directed to log files.

Product Process Monitoring

- The PSF file will provide information about the successfully generated product files from each run. The files can be made available to NDE monitoring system for tracking the processing steps and checking the availability of the product files.

- The product files contain algorithm specified metadata. Depending on the requirements, detailed product attributes, such as categorized QA flags and product statistic reports, are provided in the output files. The metadata can be extracted and used as input to the product quality monitoring tool at NDE.

Current Status

- A near real time demonstration system has been running in CIMSS routinely since 2015 in the CONUS and Alaska.
- CSPP released the software for global NRT flood mapping in 2017.
- The global VIIRS demonstration system has been running in CIMSS routinely since Sep. 2019 to produce VIIRS NRT, daily and 5-day composited products.
- FEMA, NWS and WMO's International Charter are the current users
- A preliminary version of the code has been delivered to ASSISTT
- IDL calls will be replaced with Python and GDAL

Summary

- The system includes level-2 and level-3 process:
  - The level-2 process is the near real-time process to produce flood products in the gridded 89-S granules and the eight NWS domains in netCDF format
  - The level-3 process include the daily composition with the VIIRS granules within the latest 24 hours, and the 5-day composition with the VIIRS granules within the latest 120 hours from SNPP and NOAA-20
- Processing will run in NDE at different modes:
  - NRT process will run once a VIIRS granule and the corresponding cloud mask, snow cover products arrive, and distribute NRT products to NWS and FEMA in the eight NWS domains.
  - Daily composition will run every 6 hours.
  - 5-day composition will run every 24 hours.
- Output data will be in netCDF4, geotiff and shapefile formats.

Review Outline

- Introduction
- Requirements
- Operations Concept
- Algorithm Theoretical Basis
- Software Architecture
- **Quality Assurance**
- Risk & Actions
- Summary

Quality Assurance

Priyanka Roy

Quality Assurance - Overview

- STAR Quality Assurance for Flood Mapping products will utilize the SPSRB process and follow recommendations of the OSPO Technical Reference Model.
  - NDE Delivered Algorithm Package (DAP) standards will be followed.

- SPSRB process:
  - Standard project and operations documentation
  - Common review process
  - Common coding standards

- NDE standards:
  - Common DAP format
  - Common metadata
  - Common naming convention
  - Common interfaces to NDE DHS

- Common Validation and monitoring tools and methodologies

SPSRB Reviews

- Preliminary Design Review (PDR)
  - Waived.
- Critical Design Review (CDR)
  - A review to identify updates to requirements, algorithms, and validation for the migration effort.
- Software Code Review (SCR)
  - A review of the algorithm code to verify that it meets SPSRB coding and ESPC security standards.
- Unit Test Readiness Review (UTRR)
  - A review of the is to determine whether the system units have been implemented and adequately tested within the development environment.
- Algorithm Readiness Review (ARR)
  - A review demonstrating validation of the algorithm package.
- Operational Readiness Review (ORR)
  - An OSPO review to declare that the production environment is ready to generate the products.
- SPSRB Briefing
  - A presentation to the board demonstrating that the products are ready to be declared operational and that users are ready to receive and use the product.

Configuration Management

- STAR ASSISTT CM Tool - Git
- ASSISTT has a dedicated CM administrator
- CM training:
  - All developers will be trained by the CM administrator.
- NDE CM Tool – Subversion
- OSPO CM Tool – Subversion

SPSRB Coding Standards

- All development will adhere to SPSRB coding standards and guidelines: http://projects.osd.noaa.gov/SPSRB/standards_software_coding.htm
- STAR Developers will adhere to the standards throughout the development life cycle.
- The ASSISTT personnel will work with GMU algorithm team get their delivered operational code up to standards.
- Code will be checked for compliance by OSPO during the Software Code Review and then, based on recommendations, subsequently updated and redelivered to the review team.

Quality Assurance – Software

- STAR will lead code QA efforts.
- STAR will deliver the following DAPs to NDE:

1. Initial and Final NRT-Phase1 Flood Mapping DAP
2. Intial and Final Composite –Phase 2 Flood Mapping DAP

- At STAR all code is developed and tested on a platform that is as similar as possible to the integration and production environments.
  - We try to use the same types and versions of compilers and operating systems as NDE and OSPO.
  - Most development is done on Linux X86 hardware running RedHat 6 and 7 or the latest CentOS equivalent using GNU or Intel compilers.
  - Implementing Docker and Jenkins in our NRT testing environment.
- STAR code checking/profiling tools and Valgrind will be used to minimize coding bugs and to ensure that software meets the coding standards.
- Use OSPO software checking tools to clean up issues before the Software Code Review.
- Common checks are:
  - The status of all system calls and intrinsic functions are checked for error trapping
  - Memory leaks
  - No hardcoding of paths
  - No goto statements
  - Proper use of headers, indentation, and use of comments

Quality Assurance – Software

- The algorithm software and its output products will be unit tested and validated at STAR.
- The software in the DAPs will be compiled and run on a test platform to ensure compatibility with NDE. DAPs will be delivered via Google Docs.
- Preoperational sample data will be made available to end users to assist with product validation and user readiness.
- System testing of the code will be performed within the NDE I&T string.
- STAR developers will work with NDE to assist with integration and system validation.

Delivered Algorithm Packages

- NDE-compliant DAPs adhering to the standards of the V1.5 NDE DAP Standards Document will be delivered:
  - Test plans and test data
  - SPSRB documentation (SMM, EUM, ATBD) as applicable
  - Source Code
  - All scripts, static data files, and configuration files
  - Production rules
  - Description of PCF and PSF specifications
  - Delivery memo and README

- STAR will check DAP compliance and will work with the algorithm development teams to lead the delivery process

Quality Assurance – Archive and Maintenance

- Flood Mapping products will be archived following existing archive plans of S-NPP and N-20 products.

- Long Term Maintenance Plan
  – OSPO will operate and maintain the NDE system and the DAPs running within it.
  – STAR teams will be available for troubleshooting, bug fixes, and planned enhancements. The STAR team will aim to leverage JPSS STAR maintenance money for any future updates.

Quality Assurance – Documentation

- Documentation Plan
  - The Documentation will include the SPRSB documents:
    - Algorithm Theoretical Basis Document (ATBD)
    - System Maintenance Manual (SMM)
    - External Users Manual (EUM)
  - Additional project documentation will consist of:
    - Additional DAP contents (README, Delivery memo)
    - Requirements Documents
    - Review Item Disposition (RID) - risk tracking spreadsheet
    - Project Reviews slide packages (e.g. CDR, ARR)

Quality Assurance Summary

- STAR Quality Assurance for the products will utilize the SPSRB process and will follow the NDE Delivered Algorithm Package (DAP) standards.
- STAR will work with NDE and OSPO to ensure that delivered code packages are version controlled and meet the required standards.
- Existing validation and monitoring tools and methodologies will continued to be used for the products.

Review Outline

- Introduction
- Requirements
- Operations Concept
- Algorithm Theoretical Basis
- Software Architecture
- Quality Assurance
- **Risk & Actions**
- Summary

Risks and Actions

Priyanka Roy

Risks and Actions

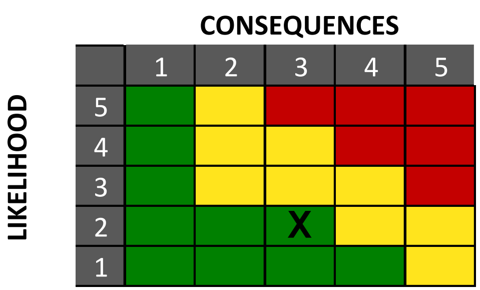
- Risk #1: This product has not been identified for operational monitoring using OSPO's Product Monitoring Tool.
- Impact: OSPO cannot ensure the quality of the product distributed.
- Risk Assessment: Low
- Risk Mitigation:
  – PAL will need to work with Product Monitoring team to have this added for being funded.
  – Science team will need to work with ASSISTT integrators to identify metadata for monitoring.
- Status: Open

CONSEQUENCES

LIKELIHOOD	1	2	3	4	5
5					
4					
3					
2			X		
1					

Risks and Actions

- Risk #2: Prior to implementation of the Enterprise Cloud Mask and Snow mask, science team should investigate the impact on product quality.
- Impact: Product quality.
- Risk Assessment: Low
- Risk Mitigation:
  - If the Enterprise Cloud mask and Snow cover negatively impact the product quality, the algorithm will not use any external cloud mask or snow cover.
- Status: Open



Risks and Actions

- Review item #3 : When the DAP is delivered to NDE for operational implementation, ASSISTT should also deliver to CSPP. This will ensure that the Flood mapping algorithm running on CSPP is in sync with the ops version.
- Review item #4 : OSPO should investigate the process for archiving DAPs at NCEI. This product uses non-enterprise versions of static data that is delivered with the DAP.
- Review item #5 : NDE should make a note that 6 days worth of data will need to be retained for producing the composite product.

Risks and Action Summary

- 2 CDR Risk with Low assessment.
- 3 Review items.

Review Outline

- Introduction
- Requirements
- Operations Concept
- Algorithm Theoretical Basis
- Software Architecture
- Quality Assurance
- Risk & Actions
- **Summary**

Summary

Priyanka Roy

Review Objectives Addressed

- The following have been reviewed
  - Project Overview and Schedule
  - Requirements
  - Concept of Operations
  - Software Architecture Updates
  - Algorithm and Product Validation Plans
  - Quality Assurance Plan
  - Risks and Actions

Next Steps

- The CDR project materials will be updated and reposted for the reviewers
- Continue product development and providing near real time data to product end users.
- Perform Unit Tests and prepare for the Unit Test Readiness Review for Phase -1.

Open Discussion

- **The Review is now open for discussion.**