GCOM-W1 AMSR2 Algorithm Software Processor (GAASP)

Critical Design Review

May 1, 2013

Presented By: Paul Chang[3], Tom King[1], Letitia Soulliard[1],
Zorana Jelenak[2], Patrick Meyers[4], Xiwu Zhan[3], Cezar Kongoli[4], and Walt Meier[5]

[1] IMSG
[2] UCAR
[3] NOAA/NESDIS/STAR
[4] CICS
[5] CIRES

Review Agenda

Section	Time	Presenter
Introduction	12:00 – 12:15	Paul Chang
PDR Report	12:15 – 12:30	Tom King
Requirements	12:30 – 12:40	Tom King
Quality Assurance	12:40 – 12:50	Tom King
Software Architecture	12:50 – 1:15	Letitia Soulliard
Algorithm Overview	1:15 – 1:25	Zorana Jelenak
Bias Correction & RFI Characterization	1:25 – 1:55	Zorana Jelenak/Fuzhong Weng
Ocean EDRs	1:55 – 2:40	Zorana Jelenak
Rain EDRs	2:40 – 3:10	Patrick Meyers
Land EDRs	3:10 – 3:30	Xiwu Zhan
Snow & Ice EDRs	3:30 – 4:10	Cezar Kongoli/Walt Meier
Risk and Actions	4:10 – 4:25	Tom King
Summary and Conclusions	4:25 – 4:30	Paul Chang

Review Outline

- Introduction
- PDR Report
- Requirements
- Quality Assurance
- Software Architecture
- AMSR2 Products and Algorithms
- Risks and Actions
- Summary and Conclusions

Introduction

Presented by

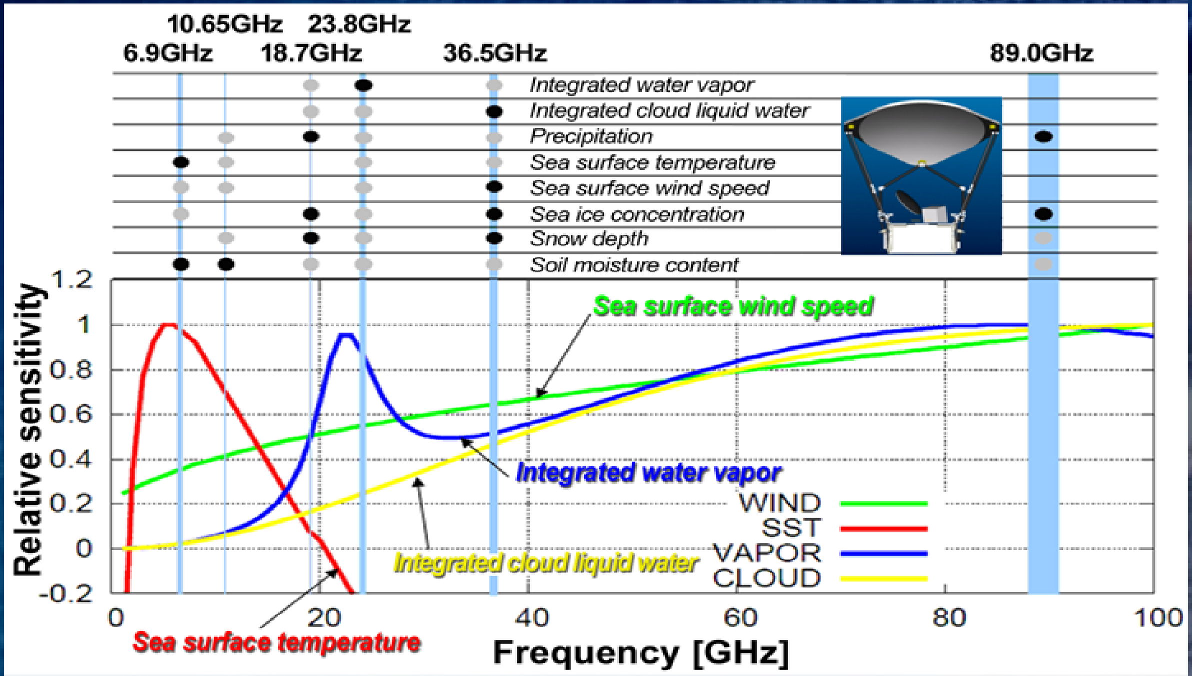
Paul Chang
NOAA/NESDIS/STAR

GCOM

- The "Global Change Observation Mission" (GCOM) is a series of JAXA Earth observation missions lasting 10-15 years.
- GCOM is part of Japan’s contribution to GEOSS (Global Earth Observation System of Systems)
- The GCOM mission is two series of satellites:
  - » GCOM-W for water observations
  - » GCOM-C for climate observations
- The GCOM-W1 launched May 18, 2012 and is the first satellite for the GCOM-W series.
- GCOM-W1 is part of the “A-Train” in a sun-synchronus orbit (~700 km altitude) with an ascending node equator crossing time of 13:30 UTC.

GCOM-W1 AMSR2

- The AMSR2 (Advanced Microwave Scanning Radiometer 2) instrument onboard the GCOM-W1 satellite will continue Aqua/AMSR-E observations of water vapor, cloud liquid water, precipitation, SST, sea surface wind speed, sea ice concentration, snow depth, and soil moisture (image below was taken from the JAXA website).



Stakeholder Roles

- The NOAA JPSS Office (NJO) is providing funding to OSD, STAR, and OSPO to operationally generate and make available AMSR2 SDR and EDR products to support NOAA's user needs.

- OSD, through their ESPDS development contract, will have their contractor (Solers) develop a system called the GCOM-W1 Processing and Distribution System (GPDS) to perform the following tasks.
  - Ingest AMSR2 RDRs and ancillary data.
  - Run the JAXA RDR-to-SDR software.
  - Run the STAR GCOM-W1 AMSR2 Algorithm Software Processor (GAASP).
  - Transfer products for distribution.
  - Interact with OSPO monitoring and control systems.

Stakeholder Roles

- STAR will:
  - » Develop a software package, called the GCOM-W1 AMSR2 Algorithm Software Processor (GAASP), to generate the AMSR2 EDRs and perform product reformatting to netCDF4.
  - » Develop operational documentation for the GAASP package and the EDR algorithms following existing SPSRB templates.
  - » Deliver the GAASP and documentation to the OSD contractor for integration into their GPDS.

- OSPO will:
  - » Receive the GPDS (with JAXA and GAASP packages integrated into it) from the OSD contractor.
  - » Operationally run and maintain the GPDS for the lifecycle of the project.

GCOM-W1 Project Organization

Customers/Users

NWS, GMAO, NRL/FNMOC
STAR, NCDC/CLASS
UK Met Office, ECMWF, DWD
Meto-France, CMC, EUMETSAT

NJO

Harry Cikanek (Director)
Ajay Mehta (Deputy Director)
Mitch Goldberg (Program Scientist)
Stephen Walters (Ground Systems)

Data Providers

JAXA, NSC/KSAT

Project Manager - Kirk Liang
Project Scientist – Paul Chang

PMO

Melissa Johnson

OSD/ESPDS

Rick Vizbulis (ESPDS PM)
Kirk Liang (GCOM PM)
Gene Legg (System Development)
Tom Schott (System Requirements)
Geoff Goodrum (System Interface - NDE)

STAR

Paul Chang (STAR Project Lead)
Ralph Ferraro (STAR Project Deputy)
Walter Wolf (Integration Lead)
Zorana Jelenak (EDR lead)
Fuzhong Weng (SDR lead)

OSPO

Paul Haggerty(OSPO GCOM-W1 Project Lead, Acting)
Limin Zhao (Product Area Lead)
Joe Mani (System Integration – ESPC Infrastructure)
Paul Haggerty (ESPC Operations Team Lead)

Solers GPDS WA#8

Dan Beall(Prog. Manager)
Ed Richard(Proj. Manager)
Robert Mann (Sys Engr)
David Chang (Soft Engr)

SDR Validation & Monitoring

Fuzhong Weng (Lead)
Hu Yang-Science Support

EDR Development and Validation

Zorana Jelenak (Lead)
Jun Park - EDR Science Support
Patrick Meyers – EDR/Precipitation Science Support
Suleiman Alsweiss – SDR/EDR Science Support
Qi Zhu – Scientific Programming Support
Micah Baker – IT support
Jeff Key – Science Lead (ice/snow)
Walt Meir – Science Support (ice)
Cezar Kongoli – Science Support (snow)
Eileen Maturi/Andy Harris – Science Support (SST)
Xiwu 'Jerry' Zhan – Science Lead (soil moisture)
Jicheng Liu – Science Support (soil moisture)

GAASP Development

Tom King (Development Lead)
Letitia Soulliard (Development)
Michael Wilson
(Algorithm Integration)
Yunhui Zhao (CM)
Larisa Koval (Documentation)

STAR GAASP Development

- GAASP development will result in 4 deliveries:

- Delivery 1 (8/29/2013):
  - » Day 1 GAASP Product Capability
    - – Microwave Brightness Temperature (MBT)
    - – Total Precipitable Water (TPW)
    - – Cloud Liquid Water (CLW)
    - – Precipitation Type/Rate (PT/R)
    - – Sea Surface Temperature (SST)
    - – Sea Surface Wind Speed (SSW)
  - » GAASP netCDF4 Reformatting Capability
  - » SPSRB documentation

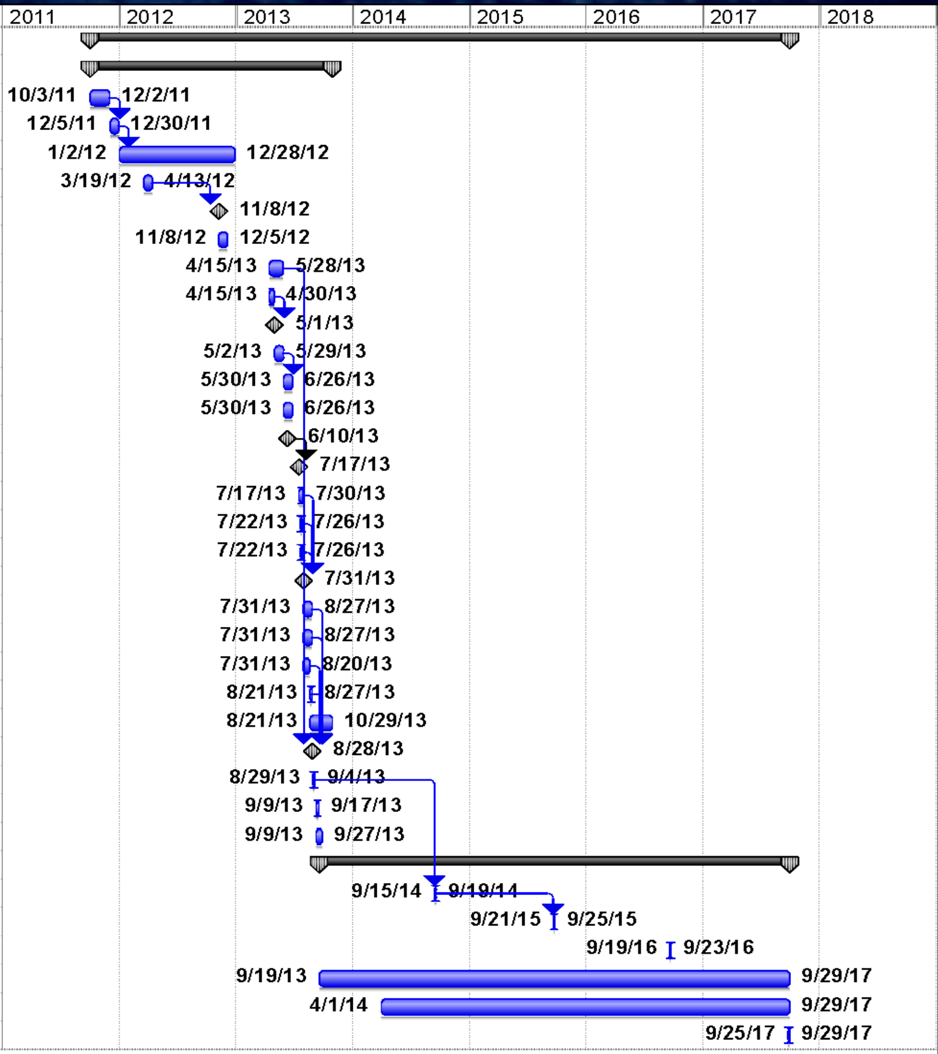
STAR GAASP Development

- Delivery 2 (9/15/2014)
  - » Day 2 GAASP Product Capability
    - – Soil Moisture (SM)
    - – Sea Ice Characterization (SIC)
    - – Snow Cover/Depth (SC/D)
    - – Snow Water Equivalent (SWE)
    - – Surface Type (ST)
  - » Updated GAASP netCDF4 Reformatting Capability
  - » Updated SPSRB Documentation

- Delivery 3 (9/21/2015) and 4 (9/19/2016)
  - » Updates and enhancements to existing EDRs

Project Timeline

ID	Task Name
1	**STAR GCOM-W1 Project**
2	**Algorithm Definition**
3	Evaluate existing algorithms
4	Define preliminary ancillary datasets
5	Preliminary algorithm evaluation
6	Preliminary system design
7	Preliminay Design Review
8	Hardware definition
10	Define/Choose algorithms
11	Prepare documents for CDR
12	Critical Design Review
14	Begin developing product NetCDF4 readers and writers
15	Initial product validation
16	Test case processed
17	Sample Algorithm Package Delivery
18	Conduct Code Test Review
19	Extensive product validation
20	Initial algorithm package delivery
21	OSPO Contractor Staff Training for GCOM L2 system
22	Software Code Review
23	Pre-operational product output evaluated & tested within the ESPC environment
24	Prepare Documentation
25	Update software
26	All SPSRB documentation is complete
27	Prepare for Transition to Operations
28	Conduct Algorithm Readiness Review
29	Algorithm update delivery_1 to operations
30	Validate Pre-Operational Products
31	Transition pre-operational system to operations
32	**Operational Phase Begins**
33	Algorithm update delivery_2 to operations
34	Algorithm update delivery_3 to operations
35	Algorithm update delivery_4 to operations
36	Operational product quality assurance and validation
37	Product enhancements and refinements
38	Final software and documentation deliver to CLASS



GAASP CDR
Entry Criteria

- Updated Requirements Allocation Document (RAD)
- Review Item Disposition (RID)
  - » This is a spreadsheet tracking all risks, actions, and mitigation throughout the life cycle of the project.
  - » This first version contains those risks and actions from the PDR.
- Updated Preliminary Design Review (PDR) slide package.

GAASP CDR
Entry Criteria

- Critical Design Review (CDR) slide package
  - » Schedule
  - » Requirements
  - » Project QA plans
  - » Software architecture
  - » Algorithm Evaluation
  - » Risks and Actions

GAASP CDR Exit Criteria

- Review Item Disposition (RID)
  - » Updated to contain CDR risks and actions.
- Updated CDR slide package

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PDR Report

Presented by

Tom King
IMSG

PDR Report

- The GAASP PDR Report is available as the Review Item Disposition (RID) spreadsheet at:
  - http://www.star.nesdis.noaa.gov/smcd/spb/iosspdt/qadocs/GCOM_CDR/GAASP_Review_Item_Disposition.xlsx
- The RID covers all open and closed risks, actions, issues, and mitigations throughout the lifecycle of the project.
- Risks closed in previous reviews are not shown here, but are located in the RID.
- Risks shown here that are marked as “closed” will be closed with the approval of this review.

PDR Risks and Actions

- **Risk #1:** External interfaces to the GAASP package and associated requirements are not yet determined. This information needs to be provided as soon as possible by the OSD contractors. There could be wasted resources and development delays if we assume the wrong interfaces to GPDS.
- **Risk Assessment:** Low (reduced from High)
- **Impact:** Low
- **Likelihood:** Low
- **Risk Mitigation:**
  - » The GAASP team will meet regularly with the GPDS developers to work out the run requirements, software interfaces, and production rules. Initial meetings have gone well and the OSD contractors have not indicated any concerns with our initial design.
  - » GAASP developers plan to make early prototype deliveries of GAASP to test production rules and interfaces to the GPDS.
- **Status:** Open

PDR Risks

- **Risk #2:** The ESPDS SOW does not say who will tailor output products to netCDF4. GAASP assumes this role. However, users will likely need other formats as well such as BUFR and GRIB2. Who does this work, how it is funded, and where that reformatting is run needs to be identified. Boxes labeled "Reformatting" are outside of the STAR box on figure 2 in the SOW. If the STAR BUFR/GRIB toolkit is funded to do this work we should know where that will run. If it runs inside of GAASP, we need to incorporate that into our design. It could also run outside of GAASP, GPDS, or in OSPO. In addition, GAASP developers would need to work with the outside tailoring project to negotiate file contents for end users.
- **Risk Assessment:** Medium
- **Impact:** High
- **Likelihood:** Low
- **Risk Mitigation:**
  - These issues have been resolved. GAASP will write all output in netCDF4. The STAR netCDF4 Reformatter Toolkit (N4RT) project is funded to tailor the GCOM EDRs to BUFR and GRIB2. The GAASP driver scripts can call the toolkit where needed to provide tailoring of output.
- **Status:** Closed

PDR Risks

- **Risk #3:** ESPDS SOW is not clear about who handles the archive Submission Agreement (SA) and metadata for archived SDRs and EDRs. The concern is that the archive process has an evaluation period that takes many months. This evaluation must happen even before the SA and metadata are developed.
- **Risk Assessment:** High
- **Impact:** High
- **Likelihood:** Low
- **Risk Mitigation:**
  - » We define our risks based on the likelihood and impact of the project failing to meet a requirement. However, there no archive requirements assigned to GAASP in any document available to us. Therefore, we are going to waive this risk for now.
- **Status:** Waive

PDR Risks

- **Risk #4:** RDR HDF5 files cannot be used by JAXA code. We currently don't know if it's possible to regenerate the original ASD files from the GCOM RDR files produced by the IDPS. In addition, in the ESPDS SOW, it is not stated as to who would have to write the code to do this work. If this is possible, STAR developers will need this very soon to conduct algorithm development with the actual AMSR2 data.
- **Risk Assessment:** Medium
- **Impact:** High
- **Likelihood:** Medium
- **Risk Mitigation:**
  - » This has been resolved. The GAASP developers have created, tested, and delivered to the OSD contractors a package capable of converting the HDF5 to ASD.
- **Status:** Closed

PDR Risks

- **Risk #5:** Routing the ASD data to IDPS, where they are converted to HDF5, and then having to convert them back to ASD (for the JAXA code) will add latency. The ESPDS SOW states that projected actual latencies will be 170-225 minutes. This is a project-level risk.
- **Risk Assessment:** High
- **Impact:** High
- **Likelihood:** Medium
- **Risk Mitigation:**
  - » At this point in the project, and based on our experience, there's no reason to believe that this should cause a latency issue and conversion times to ASD are only a few seconds for a 9 minute granule.
- **Status:** Removed

PDR Risks

- **Risk #6:** We do not have complete confirmation of who all the users are and details on exactly what they want.
- **Risk Assessment:** Low
- **Impact:** Medium
- **Likelihood:** Low
- **Risk Mitigation:**
  - » Through Ralph Ferraro, Eileen Maturi, and Limin Zhao, and their experience with the heritage users, we have list of possible users that will be updated throughout the lifecycle of the project to capture the changing needs of users.
  - » We will continue contacting these possible users to verify their needs and to update our requirements.
- **Status:** Open

PDR Risks

- **Risk #7:** The specifications of the target production hardware and compilers have not yet been determined. We need to know that the GAASP software can run on the production machine and that they will support the compilers were plan to use.
- **Risk Assessment:** Low
- **Impact:** Low
- **Likelihood:** Low
- **Risk Mitigation:**
  - » OSPO hardware has been identified and comparable GAASP development hardware is available at STAR. OSD contractors and OSPO haven't indicated any problems with our interest in using the Fortran Intel compiler.
- **Assessment:** Low
- **Status:** Closed

PDR Risks

- **Risk #8:** Brightness temperature calibration issues
- **Risk Assessment:** Medium (reduced from High)
- **Impact:** Medium
- **Likelihood:** Medium
- **Risk Mitigation:**
  - » GAASP science team has identified small biases. These have been brought to JAXA's attention over 2 telecons and are being addressed.
- **Status:** Open

PDR Risks

- **Risk #9:** RFI impacts on C and X-band brightness temperatures
- **Risk Assessment:** Medium (reduced from High)
- **Impact:** Medium
- **Likelihood:** Medium
- **Risk Mitigation:**
  - » These have been characterized. The GAASP science team has been working with JAXA on correction/flagging routines.
- **Status:** Open

PDR Risks

- **Risk #10:** Rain and Snow Flag Quality. May lead to Erroneous EDR product values because of incorrect rain and snow identification.
- **Risk Assessment:** Low
- **Impact:** Low
- **Likelihood:** Low
- **Risk Mitigation:**
  - Characterize the quality flag performance utilizing and implement changes as needed.
  - Will need to collect data over a seasonal cycle to fully characterize.
- **Status:** Open

PDR Report Summary

- 10 Risks Total:
  - 2 High Risks
  - 4 Medium
  - 4 Low
- With the approval of the CDR reviewers:
  - 3 risks can be closed
  - 1 risk can be removed
  - 1 risk can be waived
  - 5 risks will remain open
    - 2 Medium
    - 3 Low

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Requirements

Presented by

Tom King
IMSG

GAASP Requirements

- All requirements presented here are contained within the GAASP Requirements Allocation Document (RAD).

- Requirements were obtained from the following:
  - » Project Office Requirements (JPSS L1RD Supplement v2.7)
  - » ESPDS SOW (ESPDS_GCOM_WA_SOW_Draft-A1_May_8_2012_psc-www.doc)
  - » Project Plan (GCOM-W1_Project_Plan_April_30_2012.doc)
  - » Contacting potential users (identified by coordinating Limin Zhao, Ralph Ferraro, and Eileen Maturi).
  - » SPSRB process (coding/security standards and documentation requirements for OSPO).
  - » Requirements associated with running within the GPDS and in OSPO (production rules, interfaces, QC/monitoring, delivery/packaging).

- Our current understanding of the product users and their needs are identified on the next 2 slides.

AMSR2 Products and Users

Product	Format	User
Microwave Brightness Temperatures	netCDF4	EMC (NCEP) for SMOPS - Michael Ek OSPO (SAB) need 36.5 and 89 GHz channels...both H and V polarities - Sheldon Kusselson, Michael Turk NWS/NHC - Michael Brennan NAVOCEAN – Bruce McKenzie
Total Precipitable Water	netCDF4	NWS (CPC, NWSFO, NHC) - Jim Heil, Mike Johnson, Michael Brennan OSPO (SAB) - Sheldon Kusselson, Michael Turk
Cloud Liquid Water	netCDF4	NCEP/EMC - Brad Ferrier
Precipitation Type/Rate	netCDF4	NWS (CPC, NWSFO, NESDIS, NHC) - Pingping Xie, Jim Heil, Michael Brennan OSPO (SAB) - Sheldon Kusselson, Michael Turk NCEP/EMC - Brad Ferrier
Sea Surface Temperature	netCDF4	EMC (NCEP) - Bert Katz NWS/NHC - Michael Brennan CoastWatch/OceanWatch - Kent Hughes Coral Reef Watch - Mark Eakin Global High Resolution Sea Surface Temperature Group (International) - Peter Minnette NWS/NCEP/EMC/MMAB - Robert Grumbine NWS/NCEP/OPC - Joe Sienkiewicz - Ming Ji, NWS/NHC - Jiann-Gwo Jing NWS/NCEP/CPC - Pingping Xie NMFS/Pacific Marine Lab - Cara Wilson JCSDA - Eric Bayler NWS/NCEP/EMC/MMAB - Avichal Mehra Navy - Bruce McKenzie NASA/SPoRT - Gary Jedlevoc OAR/AOML - Gustavo Goni OAR/ESRL - Gary Wick

AMSR2 Products and Users

Product	Format	User
Sea Surface Winds	netCDF4	OSPO (SAB) - Sheldon Kusselson, Michael Turk NWS/NHC - Michael Brennan
Soil Moisture	netCDF4	EMC (NCEP) via SMOPS - Michael Ek
Sea Ice Characterization	netCDF4	NIC - Sean Helfrich NAVOCEAN – Bruce McKenzie (would like BUFR – see email 2/6/2013)
Snow Cover/Depth	netCDF4	NIC - Sean Helfrich
Snow Water Equivalent	netCDF4	NIC - Sean Helfrich
Surface Type	netCDF4	NWS (CPC, NWSFO) for use in blended hydro products - Jim Heil EMC – SMOPS Mike Ek

*Is SMOPS funded to ingest and use AMSR2 Soil Moisture/Surface Type EDRs?
Mike Ek has indicated via email that he would like to receive AMSR2 soil moisture from SMOPS.

GCOM-W1 AMSR2 Requirements

- More work needs to be done to identify specific user needs:
  - » Verify who needs what product
  - » Details of product contents
  - » Determine the bundling of products within files
  - » File formats (are additional formats required BUFR or GRIB2?)
  - » Update requirements accordingly

- This issue was identified as a project-level risk in the PDR.

- Some changes to requirements from the L1RD Supplement are recommended:
  - » So they are better aligned with instrument and algorithm capabilities.
  - » So they are better aligned with actual user needs.

- This issue has been identified as a new general risk (as it applies to many products).

Basic Requirement 1.0

- **Requirement 1.0:** *The STAR GCOM processing system shall produce a GCOM imagery product.*

Table 1.0 GCOM Imagery		
EDR Attribute	Threshold	Objective
Applicable conditions		1. Delivered under "all weather" conditions. 2. Each channel shall be provided at its highest native resolution. 3. All channels shall be Vertically and Horizontally polarized. 4. All channels sampled at 10 km except 89 GHz, which is at 5 km.
Horizontal sampling interval	10 km, except 89 GHz which is at 5 km	Same as threshold
Mapping uncertainty, 3 sigma	5 km	3 km
Refresh	At least 90% coverage of the globe about every 20 hours (monthly average)	Not Specified
Latency	16 minutes	
Change “Horizontal sampling interval” to “Horizontal Cell Size”. This will make it consistent with the EDR requirements that follow.		

Basic Requirement 2.0

- **Requirement 2.0:** *The STAR GCOM processing system shall produce a total precipitable water (TPW) product.*

Table 2.0 GCOM Total Precipitable Water

EDR Attribute	Threshold	Objective
Horizontal cell size	10km (21 GHz FOV sampling)	5 km
Mapping uncertainty, 3 sigma	5 km	1 km
Measurement range	1 – 75 mm	1 - 100 mm
Measurement uncertainty	2mm or 10% whichever is greater	1 mm or 4% whichever is greater
Measurement accuracy	1 mm	0.2mm
Refresh	At least 90% coverage of the globe about every 20 hours (monthly average)	Not Specified
Coverage	Ice-free global ocean	Ice-free global ocean
Latency	16 minutes	

Basic Requirement 3.0

- **Requirement 3.0:** *The STAR GCOM processing system shall produce a cloud liquid water (CLW) product.*

Table 3.0 GCOM Cloud Liquid Water		
EDR Attribute	Threshold	Objective
Applicable conditions		Delivered under "all weather" conditions
Horizontal cell size	10 km (37 GHz FOV size); 10 km sampling	5 km
Vertical reporting interval	Total Column	Total Column
Mapping uncertainty, 3 sigma	5 km	1 km
Measurement uncertainty (1 kg/m^2 = 1 mm)	0.05 mm over ocean; Best efforts over land	0.02 mm
Measurement Accuracy	0.01 mm	Not Specified
Coverage	Global Ice-free Oceans	Global
Refresh	At least 90% coverage of the globe about every 20 hours (monthly average)	Not Specified
Range (1 kg/m^2 = 1 mm)	0.005 – 1 mm	0 - 2 mm
Latency	16 minutes	
There is no known CLW product over land derived from microwave data.		

Basic Requirement 4.0

- **Requirement 4.0:** *The STAR GCOM processing system shall produce a precipitation type/rate (PT/R) product.*

Table 4.0 GCOM Precipitation Type/Rate

EDR Attribute	Threshold	Objective
Applicable conditions		Delivered under "all weather" conditions
Horizontal cell size	5 km land (89 GHz FOV); 5 km ocean (37 GHz FOV size); 5-10 km sampling	5.0 km
Mapping uncertainty, 3 sigma	< 5 km	3.0 km
Measurement range	0 – 50 mm/hr	Not Specified
Measurement precision	0.05 mm/hr	0.05 mm/hr
Measurement uncertainty	2 mm/hr over ocean; 5 mm/hr over land	2 mm/hr
Refresh	At least 90% coverage of the globe about every 20 hours (monthly average)	Not Specified
Precipitation type	Stratiform or convective	Not Specified
Latency	16 minutes	

HCS for 37GHz FOV is 10km. Change (threshold) 5km ocean to 10km ocean; (objective) 5km both ocean and land
Mapping uncertainty need to be consistent within all AMSR-2 EDRs. Currently set to 5km for other EDRs.

Basic Requirement 5.0

- **Requirement 5.0:** *The STAR GCOM processing system shall produce a snow cover/depth (SC/D) product.*

Table 5.0 GCOM Snow Cover/Depth		
EDR Attribute	Threshold	Objective
Applicable conditions		Delivered under "all weather" conditions
Sensing depth	0 – 60 cm	1 m
Horizontal cell size	10 km	5 km
Mapping uncertainty, 3 sigma	5 km	1 km
Snow depth ranges	5 – 60 cm	> 8 cm; > 15 cm; > 30 cm; > 51 cm; > 76 cm
Measurement uncertainty		
-- Clear	80% probability of correct snow/no snow classification; Snow Depth: 20 cm (30 cm if forest cover exceeds 30%)	10% for snow depth
-- Cloudy	80% probability of correct snow/no snow classification; Snow Depth: 20 cm	Not Specified
Refresh	At least 90% coverage of the globe about every 20 hours (monthly average)	Not Specified
Latency	16 minutes	

Basic Requirement 6.0

- **Requirement 6.0:** *The STAR GCOM processing system shall produce a surface type (ST) product.*

Table 6.0 - Surface Type (AMSR-2)		
EDR Attribute	Threshold (1)	Objective
Applicable conditions	Delivered under “all weather” conditions	Delivered under “all weather” conditions
Horizontal cell size	25 km	1 km
Mapping uncertainty, 3σ	5 km	1 km
Measurement Range	8 hydrological classes(2)	13 classes of land types listed in Note (3)
Measurement Precision	5%	2%
Measurement Accuracy	70% for 17 types	80%
Refresh	>90% coverage of globe every 20 hrs (4)	n/s
Latency	16 minutes	

Note:
(1) Satisfied by VIIRS under “probably clear” and “probably cloudy” conditions.
(2) 1) Standing water, 2) Dense veg (jungle), 3) Herb veg, 4) Desert, 5) Snow, 6) Urban, 7) Wetland, 8) Raining area
(3) 1) Standing water/flooded, 2) Dense veg (jungle), 3) Ag/range land, 4) Dry arable soil, 5) Moist soil, 6) Semi-arid surface, 7) Desert, 8) Dry snow, 9) Refrozen snow, 10) Wet snow, 11) Veg/water mix, 12) soil/water mix, 13) Indeterminate.
(4) Consistent with AMSR2 cross-track swath width of 1450km.

Basic Requirement 7.0

- **Requirement 7.0:** *The STAR GCOM processing system shall produce a soil moisture (SM) product.*

Table 7.0 - GCOM-W Soil Moisture

EDR Attribute	Threshold	Objective
Applicable conditions	Delivered under “all weather” conditions	Delivered under “all weather” conditions
Sensing depth	Surface to -0.1 cm (skin layer)	Surface to -80 cm
Horizontal cell size	40km (1)	20 km
Mapping uncertainty, 3 sigma	5 km	1 km
Measurement Uncertainty	6% volumetric RMSE (goal) with VWC < 1.5 kg/m^2 or GVF < 0.5 and < 2 mm/hr precip rate	Surface: 5% 80 cm column: 5%
Measurement range	0 – 50%(2)	0 – 50%
Refresh	At least 90% coverage of the globe about every 20 hours (monthly average)(3)	n/s
Latency	16 minutes	

Note:
(1) Per AMSR-E legacy and user convenience, 25km can be obtained with resampling AMSR-2 footprints to 25km.
(2) Absolution soil moisture unit (m^3/m^3 volume %) is preferred by most users of NWP community
(3) This Refresh requirement is consistent with the AMSR-2 Cross-track Swath Width design of 1450 km for a single orbit plane

Basic Requirement 8.0

- **Requirement 8.0:** *The STAR GCOM processing system shall produce a sea ice characterization (SIC) product.*

Table 8.0.1 GCOM Sea Ice Characterization

EDR Attribute	Threshold	Objective
Applicable conditions		Delivered under “all weather” conditions
Vertical coverage	Ice surface	Ice surface
Horizontal cell size	10 km	5 km
Mapping uncertainty, 3 sigma	5 km	3 km
Measurement range		
-- Ice concentration	1/10 – 10/10	0 – 100%
-- Ice age classes	Ice free, first-year, multiyear ice	Ice free, nilas, grey white, grey, white, first year medium, first year thick, second year, and multiyear; smooth and deformed ice

Basic Requirement 8.0 Cont.

Table 8.0.2 GCOM Sea Ice Characterization		
EDR Attribute	Threshold	Objective
Measurement uncertainty		
-- Ice concentration	10%	5%
Probability of correct typing of ice age classes	70%	90%
Refresh	At least 90% coverage of the globe about every 20 hours (monthly average)	Not Specified
Geographic coverage	All ice-covered regions of the global ocean	All ice-covered regions of the global ocean
Latency	16 minutes	
This should be a daily product?		

Basic Requirement 9.0

- **Requirement 9.0:** *The STAR GCOM processing system shall produce a sea surface temperature (SST) product.*

Table 9.0 GCOM Sea Surface Temperature

EDR Attribute	Threshold	Objective
Applicable conditions		Delivered under “all weather” conditions
Horizontal cell size	40 km	20 km
Mapping uncertainty, 3 sigma	5 km	3 km
Measurement range	271 – 313 K	271 – 313 K
Measurement accuracy, skin & bulk	0.5 K	0.1 K
Measurement uncertainty	1.0 K	0.5 K
Refresh	At least 90% coverage of the globe about every 20 hours (monthly average)	Not Specified
Geographic coverage	Global oceans	Global oceans
Latency	16 minutes	
MW radiometers measure skin not bulk SST		

Basic Requirement 10.0

- **Requirement 10.0:** *The STAR GCOM processing system shall produce a sea surface wind (SSW) product.*

Table 10.0.1 GCOM Sea Surface Wind – Speed

EDR Attribute	Threshold	Objective
Applicable conditions: Delivered under "all weather" conditions		
Horizontal cell size (Wind speed)	33 km (10.7 GHz FOV size); 10 km sampling	1km
Mapping uncertainty, 3 sigma	TBS-11	1 km
Measurement range (Speed)	2 – 30 m/sec	1 – 50 m/sec
Measurement uncertainty (Speed)	Greater of 2.0 m/sec or 10%	Not Specified
Measurement Accuracy	0.5 m/sec	0.2 m/sec
Refresh	At least 90% coverage of the globe about every 20 hours (monthly average)	Not Specified
Geographic Coverage	Global Ice-free Oceans	Global Ice-free Oceans
Latency	16 minutes	

Threshold requirement cannot have 2 different HCS requirements. Objective HCS not compatible with AMSR-2 capability. (Threshold) 33km (10.7GHz FOV); (Objective) 10km.
Mapping uncertainty need to be consistent within all AMSR-2 EDRs. Currently set to 5km for other EDRs.

Basic Requirement 11.0

- **Requirement 11.0:** *The STAR GCOM processing system shall produce a snow water equivalent (SWE) product.*

Table 11.0 GCOM Snow Water Equivalent

EDR Attribute	Threshold	Objective
Applicable conditions		Delivered under "all weather“ conditions
Horizontal cell size	10 km	5 km
Mapping uncertainty, 3 sigma	5 km	1 km
Measurement range	10 – 200 mm	Not Specified
Measurement uncertainty		Not Specified
-- Shallow to moderate snow packs (10 – 100 mm)	20 mm or 50%	Not Specified
-- High snow accumulation (above 100 mm)	70%	Not Specified
Refresh	At least 90% coverage of the globe about every 20 hours (monthly average)	Not Specified
Latency	16 minutes	

Basic Requirement 12.0

- **Requirement 12.0:** *The STAR GCOM-W1 AMSR2 Algorithm Software Processor (GAASP) development team shall deliver the GAASP software package to the OSD contractors for integration into their data handling and scheduling system, the GCOM-W1 Processing and Distribution System (GPDS).*

  » *It is our understanding that the OSD contractor-built system will, in turn, be delivered to OSPO where it will run operationally.*

- **Requirement 12.1:** *The GAASP package shall be delivered to the OSD contractors as a Red Hat Package Manager (RPM). The RPM shall contain all the code (programs and scripts), test data, and SPSRB-required documentation.*

  » *At this time, this project assumes that the RPM contents will follow that which has already been defined for the NDE Delivered Algorithm Package (DAP).*

Basic Requirement 12.0

- **Requirement 12.2:** *The GAASP code contained within the RPM shall adhere to SPSRB coding standards and ESPC security standards.*

- **Requirement 12.3:** *The STAR GAASP development team shall deliver to the OSD contractors the following SPSRB-required documentation as part of the RPM:*
  - » *A System Maintenance Manual (SMM)*
  - » *An External Users Manual (EUM)*
  - » *An Algorithm Theoretical Basis Document (ATBD)*
- *Note: there are sections in these documents assigned to the “System Integrators” (aka the OSD contractors).*

Basic Requirement 12.0

- **Requirement 12.4:** *The GAASP software shall consist of the STAR EDR algorithm code wrapped in Perl scripts. These scripts will be scheduled and invoked by the GPDS.*

  » *These scripts shall also drive the additional front and back end data format tailoring programs to assist the science code. This approach will minimize modification of the science code while providing users with the required format and providing a common interface to the GPDS.*

Basic Requirement 12.0

- **Requirement 12.5:** *The GAASP software shall be able to compile and run on the ESPC production platform (64-bit Linux running Red Hat).*
  - » *Details about target platform such as available memory, disk space, CPUs, and compilers are to be determined.*

- **Requirement 12.6:** *The GAASP code shall be able to compile such that it does not require access to compiler libraries at run time (compilers not allowed on OSPO production machines).*

Basic Requirement 13.0

- **Requirement 13.0:** *The GAASP software shall be able to generate all the required GCOM EDR products.*

- **Requirement 13.1:** *The GAASP software shall read and use the AMSR2 SDR (native and remapped) HDF5 files produced by the JAXA code. The data from these HDF5 files will be read in by the GAASP preprocessor code, RFI and bias corrections will be applied, and the output passed to the actual EDR programs will be HDF5.*

- **Requirement 13.2:** *The GAASP postprocessor software shall tailor the STAR EDR program output files for delivery into netCDF4.*

Basic Requirement 13.0

- **Requirement 13.3:** *The GAASP software shall perform error checking, handling, and logging.*
  - » *The GAASP software shall check the return value of all system-level and script level commands within the driver scripts. Success or failure of a given run shall be returned to the data handling and scheduling system (GPDS). All exits shall be graceful.*
  - » *The GAASP software shall generate detailed human-comprehensible error messages; these shall be directed to log files in the local working directory.*
- **Requirement 13.4:** *The GAASP software shall produce flags that indicate "degradation" and "exclusion" conditions for products as defined in section 3.3 of the JPSS L1RD Supplement V2.7.*

Basic Requirement 13.0

- **Requirement 13.5:** *All GAASP output files made available to the distribution interface shall adhere to the NDE naming convention.*

- **Requirement 13.6:** *The GAASP software shall be able to read a Production Control File (PCF) produced by the GPDS and it will produce a Production Status File (PSF) containing the names of the successfully generated output files. The contents of these files shall adhere to existing NDE standards.*
  - » *Note: Production rules associated with invocation of the algorithms (PCF generation) shall be negotiated with the OSD contractors and documented in the System Maintenance Manual.*

Basic Requirement 14.0

- **Requirement 14.0:** *The GAASP development team shall perform quality assurance on the software package and data products as well as assist with product quality monitoring activities at OSPO.*

- **Requirement 14.1:** *The GAASP developers shall conduct unit tests of the GAASP software. The unit tests shall be conducted, documented and then presented in a Code Test Review. This will validate the software functionality and the product quality.*

Basic Requirement 14.0

- **Requirement 14.2:** *The GAASP software shall produce data sets for the OSPO science quality monitoring of EDRs and stability monitoring of SDRs. This is also a requirement defined by sections 3.4 and 3.5 in the JPSS L1RD V2.7. Details are to be determined as this will require coordination with a separate joint OSPO/STAR project getting underway.*

- **Requirement 14.3:** *The GAASP software shall be submitted to OSPO for a Software Code Review to verify that the software meets SPSRB coding standards and ESPC security standards.*

GAASP Requirements Summary

- Basic and derived requirements have been identified. They are recorded in the GAASP RAD and presented here.

- There is still additional work to be done regarding derived requirements. These are identified as risks which will be summarized toward the end of this presentation.

- Changes to the requirements in the L1RD Supplement will be worked through the GAASP Science Leads and NJO.

- Updated requirements will be presented the CTR.

Review Outline

- Introduction
- PDR Report
- Requirements
- Quality Assurance
- Software Architecture
- AMSR2 Products and Algorithms
- Risks and Actions
- Summary and Conclusions

Quality Assurance

Presented by

Tom King
IMSG

Quality Assurance Background

- STAR is using the extended SPSRB standards to improve processes and practices for development and the transfer of research to operations.

- The extended SPSRB standards use the current SPSRB standards with the CMMI-like STAR Enterprise Life Cycle (EPL) standards.

- STAR has experience implementing this process methodology on several other projects (IASI, NUCAPS, N4RT, Polar Winds, GOES-R).

Quality Assurance – Project

Implemented Tailored STAR EPL Reviews

- Preliminary Design Review (November 8, 2012)
  - » Will present the initial draft of the requirements and discuss a proposed design.
  - » A Requirements Allocation Document (RAD) has been made available to Reformatting Toolkit stakeholders. It will be updated throughout the lifecycle of the project.
- Critical Design Review (May 1, 2013)
  - » To finalize requirements and to verify that the chosen design is able to meet those requirements.
- Code Test Review (July 17, 2013)
  - » Will present the unit test plan to demonstrate that the toolkit is ready to be run in the Test Environment.
- Software Code Review (July 31, 2013)
  - » Check that code meets SPSRB coding and ESPC security standards.

Configuration Management (CM)

- CM Tool (IBM Rational ClearCase, Version 7.0)
  - » Has been purchased and implemented in the Collaborative Environment.
- CM personnel have been identified.
- CM training:
  - » Administrator training completed.
  - » Developers will be trained by the CM administrator.
- We will be using a modified version CM plan developed for GOES-R framework developed at STAR.
- Software, test data, and documentation are to be configuration controlled.

Quality Assurance – Software

- All code development and testing will being conducted on a platform, and using compilers, that are as nearly identical to the integration, test, and production target platforms as possible.
- When standard libraries are used (eg. NetCDF4/HDF5, wgrib2), only the official releases will be used.
- STAR GAASP developers will adhere to SPSRB coding standards which are available at: http://projects.osd.noaa.gov/spsrb/standards_software_coding.htm
- STAR code checking tools will be used to minimize coding bugs and to ensure that GAASP code meets SPSRB coding standards.
- The Software Code Review process will check for standards and security.
- Code Test Review will present the code test plan, V&V methods, test data, and results.

Quality Assurance – RPM

- STAR GAASP developers anticipate delivering an RPM to the OSD GPDS contractors containing:
  - » Source code and scripts
  - » Static ancillary data files
  - » Code Test Document (from Code Test Review)
    - – Test plans and validation results
  - » Test data sets
  - » System Maintenance Manual
    - – Software Architecture
    - – Error messaging/handling
    - – Production rules
    - – Data flow diagrams
    - – Estimates of resource usage
  - » Algorithm Theoretical Basis Document
  - » External Users Manual

- Additional RPM details will depend on needs of the OSD GPDS contractor and are therefore yet to be determined.

Quality Assurance – Products

- STAR GAASP developers will work with the product end users to ensure that the necessary content and formats are available to them.
- Work with heritage product developers to ensure consistency with heritage products with respect to format and content.
- NetCDF files will be CF compliant and contain the NGDC standard global attribute metadata for NCDC.
- Will make test data available to users before the operational products are made available. This will allow for preliminary product content validation.

Quality Assurance – Archive and Maintenance

- Archive Plan
  - » There are no archive plans for GAASP at this time (see waived risk #3 in the PDR Report). At this time it is not clear what (if any) GAASP products will be archived and what role the GAASP development team would play in the archive process.

- Long Term Maintenance Plan
  - » The GAASP will be maintained by the OSPO staff
  - » STAR system developers will be available

Quality Assurance – Documentation

- STAR GAASP developers will produce documentation following the SPSRB document guidelines and templates at: http://projects.osd.noaa.gov/spsrb/standards_data_mtg.htm

- SPSRB Documents:
  - » System Maintenance Manual (SMM)
  - » Algorithm Theoretical Basis Document (ATBD)
  - » Users Manual (UM)

- STAR EPL Documents:
  - » Requirements Allocation Document (RAD)
  - » Review Item Disposition (RID)
  - » Critical Design Document (CDD)
  - » Code Test Document (CTD)

Quality Assurance Summary

- Quality assurance plan will consist of:
  - » Follow the extended SPSRB process lifecycle.
  - » Project reviews at which stakeholders are encouraged to participate.
  - » Ongoing interaction with customers, heritage product developers, operations, and the SPSRB.
  - » Plan to participate in the archive of process if that effort moves forward.
  - » Adhering to SPSRB standards for software and documentation.
  - » Early release of sample products and additional resources to allow for customer validation of products.

Review Outline

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Software Architecture

Presented by

Letitia Soulliard
IMSG

GAASP Processing Architecture

- Hardware Environment
  - » STAR Science/System Development and Test
  - » Integration/Test and Production
- Software Description
  - » System Level Flow
  - » Unit Level Flow

GAASP Processing Architecture

- Data Files
  - » Input Files
  - » Ancillary Files (Dynamic/Static)
  - » Output Files
  - » Log/Monitoring Files
  - » Resource Files
  - » File Formats

GAASP Production and Development Hardware

- STAR Development Hardware (rhs8142.star1.nesids.noaa.gov)
  - » Architecture: 64-bit Intel® Xeon™ X5680
  - » OS Version: Red Hat Enterprise Linux 6
  - » Diskspace: 72TB raw disk, ~30TB unallocated to logical volumes.
  - » Number of Processors: 12
    - – dual 6-core processors
  - » Total Memory: 96GB RAM, DDR3
  - » Processor Clockspeed: 3.33GHz
  - » Fortran Compiler: Intel Fortran
  - » C/C++ Compiler: gcc

GPDS/GAASP Integration Hardware

- Integration Hardware
  - » 2 Dell PowerEdge 6850 (From the MODIS project)
  - » Architecture: 64-bit Intel® Xeon™ 7100
  - » OS Version: Red Hat Enterprise Linux 6 (update 2)
  - » Diskspace: 72 GB (only)
  - » Number of CPUs: 16
    - – 2 machines with 4 dual core processors
  - » Total Memory: 16 GB
    - – 2 machines with 8 GB each
  - » Processor Clockspeed: 3.0 GHz

GPDS/GAASP Production Hardware

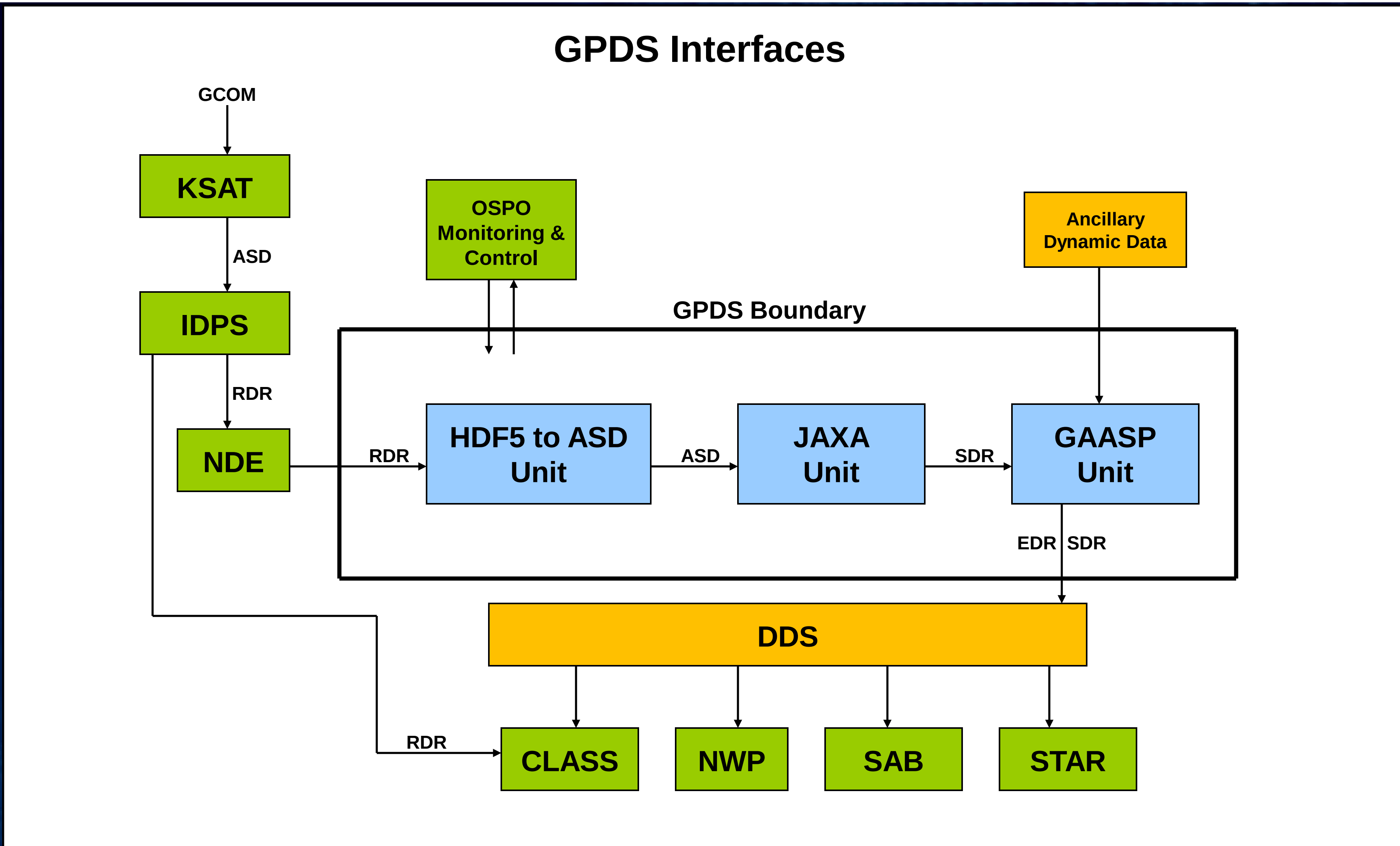
- Production Hardware
  - » 3 Dell PowerEdge 6850 (From the MODIS project)
  - » Architecture: 64-bit Intel® Xeon™ 7100
  - » OS Version: Red Hat Enterprise Linux 6 (update 2)
  - » Diskspace: Details of SAN are TBD
  - » Number of CPUs: 24
    - – 3 machines with 4 dual core processors
  - » Total Memory: 24 GB
    - – 3 machines with 8 GB each
  - » Processor Clockspeed: 3.0 GHz

GPDS Processing and Distribution System

- The following slide shows our best understanding of the full GCOM Processing and Distribution System (GPDS) and its external interfaces.

- The blue boxes in the figure represent the 3 delivered software components that need to run within the GPDS.

GPDS Interfaces



GAASP External Interfaces

- External input and output files are identified in the tables on the following 2 slides, respectively.
  - » Input files include both input data files and ancillary data.
  - » The tables indentify the file name patterns, formats, and sources (for input files).
  - » Files needed/produced for Day 1 and Day 2 products are identified.
  - » GAASP will follow the NDE output file naming convention for products.
  - » The transfers of external files to and from GAASP will be automated by the GPDS.

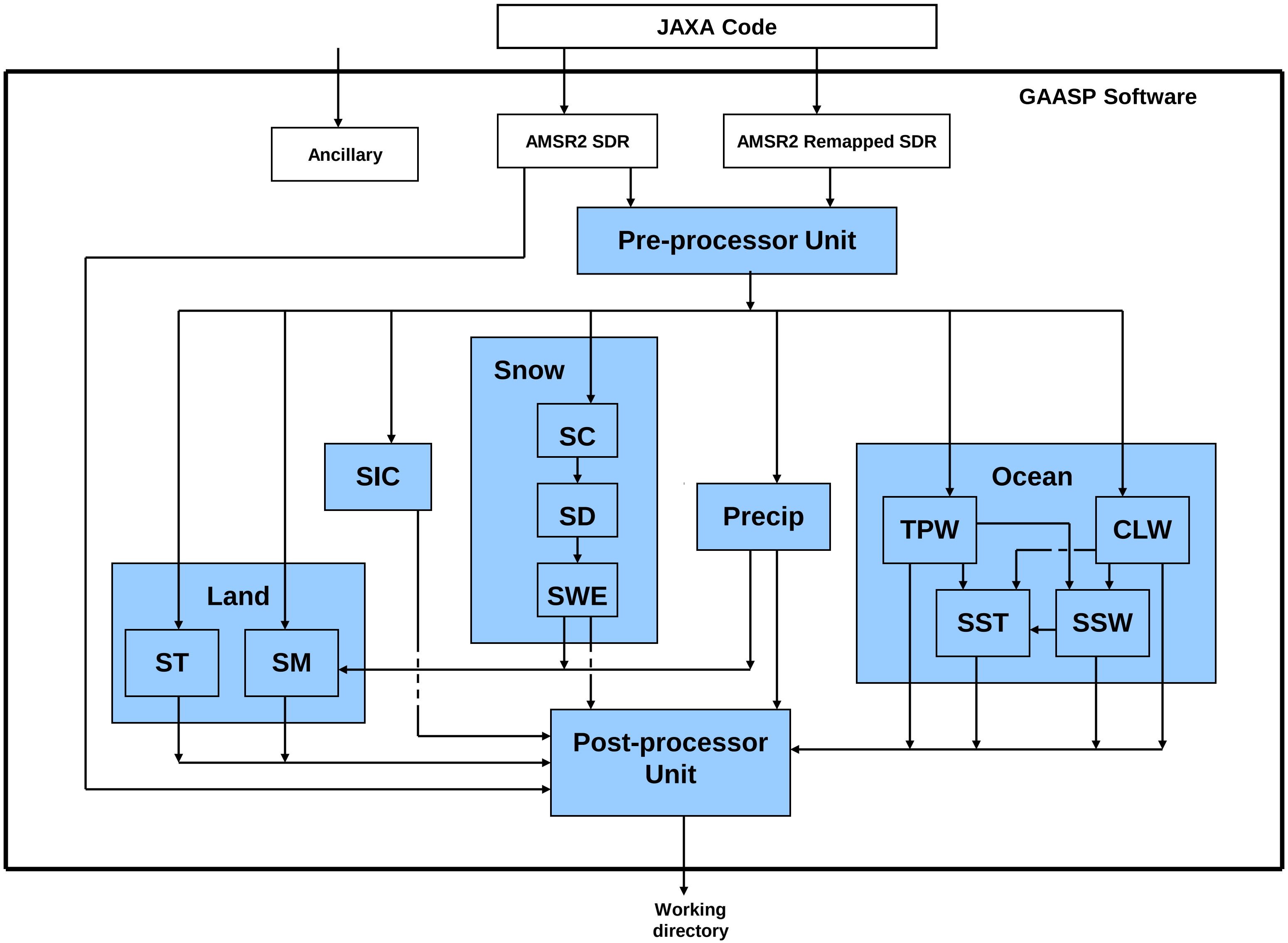
GAASP External Dynamic Input Data

External Dynamic Input Data							
Input File	**Name Pattern**	**Source**	**Update Frequency**	**When**	**EDR**	**Type**	**Format**
AMSR2 SDR Native Res	GW1AM2_????????????_????_L1SGBTBR_1110110.h5	IDPS via NDE	9 minutes	Day 1	MBT, SST, SSW, TPW, CLW, PR, SM, ST, SC, SD, SWE	Input	HDF5
AMSR2 SDR Remapped	GW1AM2_????????????_????_L1SGRTBR_1110110.h5	IDPS via NDE	9 minutes	Day 1	SST, SSW, TPW, CLW, SIC	Input	HDF5
GFS Forecast	gfs.t??z.pgrb2f??	DDS	6 hours	Day 1	SST, SSW, TPW, CLW	Ancillary	GRIB2
Daily OI SST	avhrr-only-v2.????????_preliminary	DDS	Daily	Day 1 only	PR	Ancillary	Binary
VIIRS Vegetation Index EDR	VIVIO_npp_d????????_t???????_e???????_b?????_c????????????????????_noaa_ops.h5	IDPS via NDE	~86 seconds	Day 2	SM	Ancillary	HDF5
VIIRS Quarterly Surface Type EDR	IQSTO_npp_d????????_t???????_e???????_b?????_c????????????????????_noaa_ops.h5	IDPS via NDE	4 months	Day 2	SM, ST	Ancillary	HDF5
VIIRS Surface Type EDR	VSTYO_npp_d????????_t???????_e???????_b?????_c????????????????????_noaa_ops.h5	IDPS via NDE	~86 seconds	Day 2	SM	Ancillary	HDF5

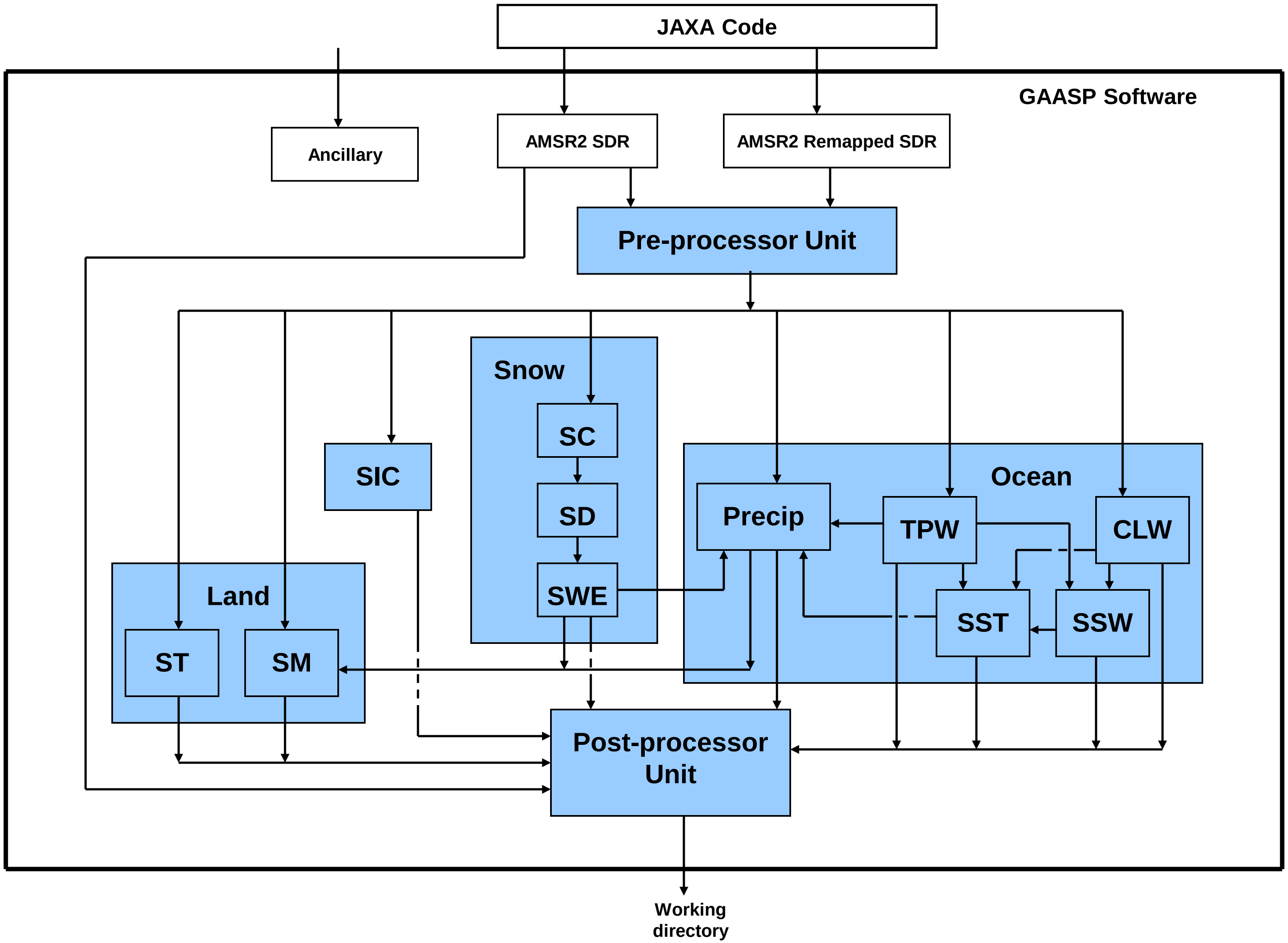
GAASP External Output Data

External Output Data					
Output File	**Name Pattern**	**Update Frequency**	**When**	**Format**	**Size**
AMSR2 SDR Native Res	GAASP-MBT_v1r0_GW1_s??????????????_e??????????????_c??????????????.nc	9 minutes	Day 1	netCDF4	12.8 MB
AMSR2 SDR Native Res	GAASP-MBT_v1r0_GW1_s??????????????_e??????????????_c??????????????.bufr	9 minutes	Day 1	BUFR	TBD
Ocean (CLW, TPW, SST, SSW, PT/R)	GAASP-OCEAN_v1r0_GW1_s??????????????_e??????????????_c??????????????.nc	9 minutes	Day 1	netCDF4	11.7 MB
Land (SM & ST)	GAASP-LAND_v1r0_GW1_s??????????????_e??????????????_c??????????????.nc	9 minutes	Day 2	netCDF4	6.4 MB
Snow (SC/D & SWE)	GAASP-SNOW_v1r0_GW1_s??????????????_e??????????????_c??????????????.nc	9 minutes	Day 2	netCDF4	3.1 MB
Sea Ice (SIC)	GAASP-SICE_v1r0_GW1_s??????????????_e??????????????_c??????????????.nc	9 minutes	Day 2	netCDF4	3.0 MB
SDR/EDR QA products	TBD	9 minutes	TBD	TBD	TBD

GAASP Software Unit Data Flow: Day 1



GAASP Software Unit Data Flow: Day 2



GAASP System Design

- Day 1 GAASP will consist of 7 Perl driver scripts that wrap the Fortran executables
  - » A given driver script may wrap one or more Fortran executables
  - » Within a driver script everything is run serially (no forking of processes)
  - » These scripts will provide a common interface to the GPDS
  - » The scripts will handle direct interfaces and arguments for individual algorithm executables (science code)
  - » Conduct file management (e.g. creating, removing, and renaming) in the local working directory (only)
  - » Perform of error handling and generate higher-level error logs for OSPO production monitoring
  - » Drive the product tailoring executables where necessary
  - » All science code will be written Fortran 90/95 (Compiled using the Intel Compiler). There will be no science code written in an interpreted or high-level language like IDL and Matlab.

- An invocation of a GAASP Perl driver script will process a single 9-minute AMSR2 granule from SDR to EDR.

GAASP System Design

- Each GAASP driver script will be invoked separately by the GPDS and may be run in parallel where applicable.
  - » Each driver will have its own set of production rules.
  - » The production rules will be documented and delivered in the System Maintenance Manual as part of the RPM
  - » Interfaces between GPDS and GAASP will consist of PCF and PSF files (like that of NDE).

- GAASP will NOT do the following as these tasks are understood to be task performed by GPDS:
  - » Schedule jobs
  - » Invoke its own driver scripts
  - » Fork processes or load manage jobs
  - » Set up manage working and system directories
  - » Ingest, distribute, or transfer files
  - » Interact directly with the OSPO monitoring

GAASP System Design

- The preprocessor must run before all other drivers.
  - » Perform brightness temperature bias correction, RFI flag, and outputs 2 HDF5 intermediate files (L1B and L1R) to be used by all downstream EDRs.

- The postprocessor will:
  - » Convert SDRs (just L1B) to netCDF4 and BUFR
  - » Convert EDRs to netCDF4, BUFR or GRIB2 where necessary
  - » Bundle EDRs where necessary
  - » Generate QA metadata or products for OSPO monitoring. Details are TBD.

- The postprocessor is shown to process the data in a serial manner in the flow charts, but it will actually be able to use different EDR inputs so it will be able to run in parallel with other instances of itself.

GAASP System Design

- The internal file format for files transferred between the science algorithms will be HDF5. The routing of files between scripts will be handled by the GPDS.

- Ancillary data will be obtained by the GPDS and made available to each GAASP driver script as a function of its production rules.

GAASP System Design: GPDS Interfaces

- The interface between the GPDS and the GAASP drivers will consist of NDE-style Production Control Files (PCF) and Production Status Files (PSF) files.
  - » PCF contains:
    - – All the required input files to process a granule, including paths if they're located outside the working directory. This includes input instrument and ancillary data, static files such as templates and lookup tables.
    - – Any run parameters or flags
  - » PSF contains All successfully generated output files

- During production, a PCF for a given driver is produced by the GPDS and made available to an instance of a GAASP driver in a local working directory.
  - » The contents of the PCF are based on the production rules negotiated by the GPDS integrators and the STAR GAASP developers.

- The GAASP driver runs and produces its output and a PSF file in the same working directory. The GPDS then reads this file, determines the output file name(s) from it, and distributes it or passes it on for additional processing.

GAASP System Design: GPDS Interfaces

- Here's an example of a PCF for an NDE algorithm:

```
job_coverage_start=201209072208471
job_coverage_end=201209072209185
PROD_TYPE=OMPS-NP
CONVERSION=NC2BUFR
NPR_INPUT=/data/scdr006/yxnOmO+1SnKACVViICnJzw/GONPO_npp_d20130124_t1200515_e1201289_b06443_c20130124185
358112670_noaa_ops.h5
NPR_INPUT=/data/scdr001/uWGmL8MGS9G7uNJ+PdqC0g/IMOPO_npp_d20130124_t1200515_e1201289_b06443_c2013012419
0055528972_noaa_ops.h5
BUFR_TABLE=OMPS-NP_BUFR_Table
OPS_BIN=/net/orbit247l/disk1/pub/ysong/gnu/code/main
H5DUMP=/net/orbit247l/disk1/pub/ysong/gnu/tool/hdf5-1.8.8/bin/h5dump
H5AUGJPSS=/net/orbit247l/disk1/pub/ysong/gnu/tool/h5augjpss-1.0.0/h5augjpss
```

- Example of the PSF produced for that same algorithm:

```
OMPS-NP_v1r0_npp_s201301241200515_e201301241201289_c201301242110080.bufr
```

GAASP System Design: Error Handling and Monitoring

- All system calls within scripts and all functions and statements in the compiled code will have their return values and/or returned content checked where applicable to allow for graceful exits.

- All standard output and standard error from scripts and programs is logged so it can be made available to the GPDS.

- Here are script and program level examples showing error trapping and logging:

```
$rc = system("$OPS_BIN/main_nucaps_preprocessor >
main_nucaps_preprocessor.log 2>&1");

  if( $rc != 0 ) {
     print "Error in ${PROGRAM}.pl: the program main_nucaps_preprocessor
returned an error. See main_nucaps_preprocessor.log. ";
     print "${PROGRAM}.pl will now exit.\n";
     $STATUS_NUCAPS_ALL_PRODUCT = "NO";
     $STATUS_BOUNDING_BOX_PRODUCT = "NO";
     &make_psf();
     exit 1;
  }
```

```
OPEN(UNIT=Unit_Number, FILE=Resample_Weight_File, &
  STATUS="OLD", ACTION = "READ", IOSTAT=Open_Status)

IF(Open_Status /= 0)THEN
    CALL error_messaging('main_nucaps_preprocessor', &
    'Failed TO OPEN '//Resample_Weight_File, &
    FATAL)
  ENDIF

  ! Read Instructions
  READ (Unit_Number, FMT='(a)',IOSTAT=Read_Status) Instructions

  IF(Read_Status /= 0)THEN
    CALL error_messaging('main_nucaps_preprocessor', &
    'Failed TO READ '//Resample_Weight_File, &
    FATAL)
  ENDIF
```

GAASP System Design: Error Handling and Monitoring

- The GAASP driver scripts will each produce a single high-level log file that the GPDS can parse in the event of an error. If there is an error:
  - Perl driver returns to the GPDS a non-zero value
  - There may be no output file(s) written in the PSF

- All errors conditions and messages written into the log files will be identified and described in the System Maintenance Manual.

- The GPDS will need to obtain these error codes and messages and pass these on to the OSPO production monitoring.

- GAASP science quality monitoring will likely be a separate effort. SDR and EDR quality monitoring data and metadata would support ongoing OSPO science quality monitoring efforts. This work is not yet funded so details are TBD.

GAASP System Design: Latency

- Table 2.2 in the JPSS L1RD states that product latency is defined as beginning at the time of receipt at ESPC (from IDPS via NDE) and ending when the product is available at the user interface.

- For a given 9-minute AMSR2 RDR granule, GAASP and GPDS have 16 minutes to generate all granule SDR and EDR products and make them available to the DDS.
  - » GPDS running the ASD converter (HDF5 RDR to ASD RDR) requires ≈ 2 seconds/9 minute granule
  - » GPDS running the JAXA code (ASD RDR to SDR) requires ≈ 2.5 minutes/9 minute granule
  - » GAASP (SDR to EDR) will have ≈ 13.5 minutes/9 minute granule
  - » This time includes any reformatting (netCDF4, BUFR, GRIB2) that would run within GAASP. This would likely require only a few seconds for granules of the projected AMSR2 product sizes (< 13MB/granule).

- Past AMSR-E Latency: all AMSR-E EDRs were run in parallel on the same hardware.
  - » The Rain product EDR took ≈ 210 seconds to be generated from a half orbit (≈ 50 minutes) SDR input file. This was the longest running EDR of those that ran (Land, Ocean, Rain, Snow/Ice).

GAASP System Design: Latency

- Projected GAASP Latency: using AMSR-E heritage regression-based algorithms, GAASP should be able to generate the Rain EDR product in about 38 seconds from a 9-minute AMSR2 SDR granule and the others should run more quickly. Therefore, GAASP should be able to easily meet product latency.

- Because we cannot truly evaluate the run times at this time, we have identified this as a new risk. This issue will be fully evaluated and tested at the upcoming Code Test Review (7/17/2013).

GAASP Unit-Level Input/Output Data

- EDR Preprocessor
  - » Input
    - – SDR native resolution (aka L1B) (HDF5)
    - – SDR remapped (aka L1R) (HDF5)
  - » Output
    - – Bias Corrected SDR native resolution data with a NOAA_RFI flag (HDF5)
    - – Bias Corrected SDR remapped data with a NOAA_RFI flag (HDF5)

GAASP Unit-Level Input/Output Data

Table 12.0 GCOM Land Unit (Soil Moisture EDR) Inputs	
Parameter	Source
TB07h, TB07v, TB0h, TB10v, TB36v	From AMSR2 SDR (L1B)
Latitude [0.01°]	From AMSR2 SDR (L1B)
Longitude [0.01°]	From AMSR2 SDR (L1B)
Surface Type from VIIRS/MODIS/AVHRR	For static algorithm parameters (static)
NDVI from VIIRS	From VIIRS Vegetation Index EDR
VIIRS QST	From VIIRS Quarterly Surface Type IP
Soil texture	From FAO soil moisture texture map (static)
RFI flag	From AMSR2 SDR (L1B)
Rain flag	From AMSR2 Precipitation EDR
Snow flag	From AMSR2 Snow EDR
Ice flag	From AMSR2 Ice EDR
L/W mask	From VIIRS Surface Type EDR
AMSR2 SDR QC flags	From AMSR2 SDR

GAASP Unit-Level Input/Output Data

- Land Unit
  - Output
    - Soil Moisture EDR
    - Surface Type EDR

Land EDR Output

Land Products						
			33km		10km	
Parameter	**Size**	**Scans**	**FOVs**	**Total**	**FOVs**	**Total**
Time	8	360	243	699840	243	699840
Lat	4	360	243	349920	243	349920
Long	4	360	243	349920	243	349920
Row_Ind	2	400	243	194400	243	194400
Colum_Ind	2	360	243	174960	243	174960
QC_Flag	4	360	243	349920	243	349920
Hetero Ind	2	360	243	174960	243	174960
Surf Type	2	360	243	174960	243	174960
Soil Mois	2	360	243	174960	243	174960
Land Sur Temp	2	360	243	174960	243	174960
Precip	2	360	243	174960	243	174960
ErrRR	2	360	243	174960	243	174960
				3168720		**3168720**
						6337440

GAASP Unit-Level Input/Output Data

Table 13.0 GCOM Snow-Ice Unit (Sea Ice Characterization EDR) Inputs	
Parameter	Source
TB18.7h, TB18.7v, TB23.8v, TB36.5h, TB36.5v, TB89v, TB89h	From AMSR2 SDR (L1B)
Landmask (land/not land)	NSIDC
Climatologically ocean mask	NSIDC
Coastal mask	NSIDC

GAASP Unit-Level Input/Output Data

Table 14.0 GCOM Snow-Ice Unit (Snow Cover/Depth EDR) Inputs	
Parameter	**Source**
TB10h, TB10v, TB18.7h, TB18.7v, TB23.8v, TB36.5h, TB36.5v, TB89v, TB89h	From AMSR2 SDR (L1B)
Snow cover climatology	From IMS historical data
Surface elevation	From USGS GTOPO30 dataset
Land surface type	From MCD12Q1
Tree cover fraction/type	From MOD44B
Global snow cover classes	From NSIDC
Snow density climatology look-up table	From NCDC

GAASP Unit-Level Input/Output Data

- Snow and Ice Unit
  - » Output
    - – Sea Ice Concentration EDR
    - – Ice Age Classes EDR
    - – Snow Depth EDR
    - – Snow Water Equivalent EDR

Snow EDR Output

Snow Products				
Parameter	**Size**	**Scans**	**FOVs**	**Total**
Time	8	360	243	699840
Latitude	4	360	243	349920
Longitude	4	360	243	349920
Scan Angle	4	360	243	349920
Earth Incidence Angle	4	360	243	349920
Compass Azimuth Angle	4	360	243	349920
Across Scan Number	2	360	243	174960
Along Scan Number	2	360	243	174960
Snow Cover	1	360	243	87480
Snow Water Equivalent	1	360	243	87480
QC Flags	1	360	243	87480
				3061800

Sea Ice EDR Output

Sea Ice Products				
Parameter	**Size**	**Scans**	**FOVs**	**Total**
Time	8	360	243	699840
Latitude	4	360	243	349920
Longitude	4	360	243	349920
Scan Angle	4	360	243	349920
Earth Incidence Angle	4	360	243	349920
Compass Azimuth Angle	4	360	243	349920
Across Scan Number	2	360	243	174960
Along Scan Number	2	360	243	174960
Sea Ice Characterization	1	360	243	87480
QC Flags	1	360	243	87480
				2974320

GAASP Unit-Level Input/Output Data

Table 15.0 GCOM Ocean Unit Inputs	
Parameter	Source
Brightness Temperatures	From AMSR2 SDR (L1B) and From AMSR2 SDR (L1R)
Land/Coastal mask	From AMSR2 SDR (L1B) and From AMSR2 SDR (L1R)
Model Wind Speed	From GFS Forecast Model
Model Wind Direction	From GFS Forecast Model
Model Salinity	TBD (used for Day 2)

GAASP Unit-Level Input/Output Data

- Ocean Unit
  - Output
    - Sea Surface Temperature EDR
    - Total Water Vapor EDR
    - Cloud Liquid Water EDR
    - Wind Speed EDR

GAASP Unit-Level Input/Output Data

Table 16.0 GCOM Precipitation Unit Inputs	
Parameter	**Source**
Day 1	
Brightness Temperatures	From AMSR2 SDR (L1B)
SST	From daily IEEE OI-SST from AVHRR-AMSR
Profile database	Compiled TRMM's Precipitation Radar by Dave Randel at Colorado State University
Caspian Sea Ice Climo	Developed from RSS Weekly AMSRE
Desert/Ice Climo	IGBP (Desert) IMS & AMSRE (Snow)
Day 2	
Land EDRs	From GCOM Land Unit
Ocean EDRs	From GCOM Ocean Unit
Snow and Ice EDRs	From GCOM Snow-Ice Unit

GAASP Unit-Level Input/Output Data

- Precipitation Unit
  - » Output
    - – Global Rain Rate EDR

Ocean/Precipitation EDR Output

Ocean/Precip Products										
			40km		33km		21km		10km	
Parameter	**Size**	**Scans**	**FOVs**	**Total**	**FOVs**	**Total**	**FOVs**	**Total**	**FOVs**	**Total**
Time	8	360	243	699840	0	0	0	0	0	0
Lat	4	360	243	349920	0	0	0	0	0	0
Long	4	360	243	349920	0	0	0	0	0	0
Scan Angle	2	360	243	174960	0	0	0	0	0	0
Earth Inc	2	360	243	174960	0	0	0	0	0	0
Compas	2	360	243	174960	0	0	0	0	0	0
Across Scan	2	360	243	174960	0	0	0	0	0	0
Along Scan	2	360	243	174960	0	0	0	0	0	0
SDR rec	2	360	243	174960	0	0	0	0	0	0
Surf Type	2	360	243	174960	0	0	0	0	0	0
SDR QC	2	360	243	174960	243	174960	243	174960	243	174960
SST	2	360	243	174960	0	0	0	0	0	0
sstErr	2	360	243	174960	0	0	0	0	0	0
wspd	2	360	243	174960	243	174960	0	0	0	0
wspdErr	2	360	243	174960	243	174960	0	0	0	0
wv	2	360	243	174960	243	174960	243	174960	0	0
wvErr	2	360	243	174960	243	174960	243	174960	0	0
clw	2	360	243	174960	243	174960	243	174960	243	174960
clwErr	2	360	243	174960	243	174960	243	174960	243	174960
Rain Rate	2	360	243	174960	243	174960	243	174960	243	174960
Rrerr	2	360	243	174960	243	174960	243	174960	243	174960
EDR QC flag	4	360	243	349920	243	349920	243	349920	243	349920

Ocean/Precipitation EDR Output Continued

Ocean/Precip Products										
			40km		33km		21km		10km	
Parameter	**Size**	**Scans**	**FOVs**	**Total**	**FOVs**	**Total**	**FOVs**	**Total**	**FOVs**	**Total**
Model wspd	2	360	243	174960	243	174960	243	174960	243	174960
Model wdir	2	360	243	174960	243	174960	243	174960	243	174960
Model salinity	2	360	243	174960	243	174960	243	174960	243	174960
				5423760		**2449440**		**2099520**		**1749600**
										11722320

GAASP Unit-Level Input/Output Data

- EDR Postprocessor
  - Input
    - AMSR2 Land EDR (HDF5)
    - AMSR2 Snow & Ice EDR (HDF5)
    - AMSR2 Ocean EDR (HDF5)
    - AMSR2 GPROF EDR (HDF5)
    - AMSR2 SDR (HDF5)
  - Output
    - AMSR2 Land EDR (netCDF4)
    - AMSR2 Snow & Ice EDR (netCDF4)
    - AMSR2 Ocean EDR (netCDF4)
    - AMSR2 GPROF EDR (netCDF4)
    - AMSR2 SDR (netCDF4 & BUFR)

Microwave Brightness Temperature Output

Microwave Brightness Temperature				
Parameter	**Size**	**Scans**	**FOVs**	**Total**
Time	8	360	243	699840
Lat 10km	4	360	243	349920
Long 10 km	4	360	243	349920
Long 5 km	4	360	486	699840
Long 5 km	4	360	486	699840
Satellite Height	4	400	243	388800
Earth Azimuth	4	360	243	349920
Earth Incidence	4	360	243	349920
Sun Azimuth	4	360	243	349920
Sun Elevation	4	360	243	349920
Brightness Temperature (10.7GHz,H)	4	360	243	349920
Brightness Temperature (10.7GHz,V)	4	360	243	349920
Brightness Temperature (18.7GHz,H)	4	360	243	349920
Brightness Temperature (18.7GHz,V)	4	360	243	349920
Brightness Temperature (23.8GHz,H)	4	360	243	349920
Brightness Temperature (23.8GHz,V)	4	360	243	349920
Brightness Temperature (36.5GHz,H)	4	360	243	349920
Brightness Temperature (36.5GHz,V)	4	360	243	349920
Brightness Temperature (6.9GHz,H)	4	360	243	349920
Brightness Temperature (6.9GHz,V)	4	360	243	349920
Brightness Temperature (7.3GHz,H)	4	360	243	349920
Brightness Temperature (7.3GHz,V)	4	360	243	349920
Brightness Temperature (89.0GHz-A,H)	4	360	486	699840
Brightness Temperature (89.0GHz-A,V)	4	360	486	699840

Microwave Brightness Temperature Output Continued

Microwave Brightness Temperature				
Parameter	**Size**	**Scans**	**FOVs**	**Total**
Brightness Temperature (89.0GHz-B,H)	4	360	486	699840
Brightness Temperature (89.0GHz-B,V)	4	360	486	699840
Pixel Data Quality 6 to 36	1	360	486	174960
Pixel Data Quality 89	1	360	486	174960
Orbit Number	2	360	486	349920
Ascending/Descending Status	1	360	486	174960
Land_Ocean Flag 6 to 36	1	360	486	174960
Land_Ocean Flag 89	1	360	486	174960
				12810960

GAASP Architecture Summary

- Hardware
  - » Development, Integration, and Production hardware are defined
- Software Architecture
  - » A high-level system and unit-level designed are defined.
  - » GAASP external interfaces will assume NDE-like interfaces.
- Data Files (Input/Outputs)
  - » Input, output, and ancillary data types are defined
  - » All dynamic ancillary data types and their sources have been identified

Review Outline

- Introduction
- PDR Report
- Requirements
- Quality Assurance
- Software Architecture
- AMSR2 Products and Algorithms
- Risks and Actions
- Summary and Conclusions

AMSR2 Algorithm Overview and Preprocessing

Presented by

Zorana Jelenak
UCAR

Algorithm Theoretical Basis Outline

- Introduction
- Observing System Overview
  - » Product Generated
  - » Instrument Characteristics
- Algorithm Description
  - » Theoretical Description
  - » Algorithm Input
  - » Algorithm Overview
  - » Processing Outline
- Test Data Sets and Outputs
  - » Simulated/Proxy Input Data Sets
  - » Output from Simulated/Proxy Data Sets
  - » Error Budget

Algorithm Theoretical Basis Outline

- Practical Considerations
  - » Numerical Computation Considerations
  - » Programming and Procedural Considerations
  - » Quality Assessment and Diagnosis
  - » Exception Handling
  - » Algorithm Validation
- Assumptions and Limitations
  - » Performance
  - » Assumed Sensor Performance
  - » Pre-Planned Improvements
- References

Algorithm Theoretical Basis Document

- Purpose: Provide a theoretical description (scientific and mathematical) of the AMSR-2 geophysical retrieval algorithms
- Will be documented in the AMSR-2 EDR ATBD

Modular Approach

- SDR Postprocessor (address any residual calibration issues)
- EDR Preprocessor (reformatting, sampling issues, data flagging)
- Notionally 4 EDR modules
  - » Ocean Scene EDRs
  - » Global Rain Rate Module (Ocean, Land and Coastal Region)
  - » Snow and Sea Ice
  - » Soil Moisture and Surface Type
- EDR Postprocessor (reformatting)

Modular Approach

EDR Postprocessor

Soil Moisture and Surface Type

Global Rain Rate EDR

Snow and Ice

TPW, CLW, SST, Wind Speed and Rain (Ocean Scene EDRs)

EDR Preprocessor

SDR Postprocessor

Ancillary Data

Level 0 (RDR) to Level 1 (SDR) Processor

Ancillary Data

- Some retrievals will require external data for the retrieval and flagging process
- EDR processor will be setup to run in the event these data are not available

SDR Post-Processor Bias Corrections

Presented by

Zorana Jelenak
UCAR

OUTLINE

- Brightness Temperature Simulation
- Sun Glint & RFI Flagging
- Double Difference Analysis
- AMSR-2 Corrections

Brightness Temperature Inter-calibration

- Inter-calibration between sensors relies on finding collocated observed Tbs between the different platforms. For sun-synchronous orbits, these points occur only at high latitudes near the poles [Yan 2008], which greatly limits the amount of available data for inter-calibration. Thus, for a sun-synchronous radiometer like AMSR2, a non-sun-synchronous, low inclination orbiter will create a larger amount of collocated observations to be used. Thus, TMI was chosen as the reference radiometer to study the calibration biases of AMSR2.

Instrument Specifications

Center Freq. (GHZ)	Band Width (MHz)	Beam Width (3dB, deg.)	Ground IFOV (km)	Sampling Interval (km)
6.925/7.3	350	1.8	35×62	10
10.65	100	1.2	24×42	
18.7	200	0.65	14×22	
23.8	400	0.75	15×26	
36.5	1000	0.35	7×12	
89.0	3000	0.15	3×5	5

AMSR2

Center Freq. (GHZ)	Band Width (MHz)	Polarization	Ground IFOV (km)
10.65	100	V/H	73×43
19.35	500	V/H	35×21
21.3	200	V	27×21
37.0	2000	V/H	19×10
85.5	3000	V/H	8×6

TMI

Methodology

- Direct comparison
  - » Simple inter-calibration method involves direct comparison between observations of two sensors
- Even if the two radiometers to be compared have the same center frequency & nominal EIA there can be differences
  - » Attitude differences cause EIA variation
- Errors associated with comparing two sensors with different frequencies & EIA are too big to ignore
  - » Up to ~ 5K

Methodology – cont.

- Sensors direct comparison discrepancies can be overcome by using radiative transfer modeling (RTM)
  - » RTM accounts for radiometer frequency, polarization & EIA
- Simulated Tbs are included through calculating the "Single Difference" (SD)
  - » SD is the difference between observed and simulated Tbs for the same sensor

SD= Tb_obs. – Tb_sim.

Methodology – cont.

- Unfortunately, the use of RTM may not exactly represent the physics
  - » Oceanic & atmospheric environmental parameters from numeric weather models are imperfect estimates of true values
- The use of "Double Difference" (DD) based on the SD mitigates the RTM errors

$$DD_{AB} = SD_A - SD_B$$

- DD is used to calculate calibration errors with respect to a reference sensor

Radiative Transfer Model

- RTM is used to simulate Tbs then calculate SD
  - » Reduce design differences between sensors
- RTM captures dynamic change of ocean scene radiance due to change in environmental parameters
  - » Sea surface temperature (SST), wind vector, water vapor (WV), and cloud liquid vapor (CLW)

Ancillary Data

- Numerical weather model data needed to run RTM
  - » Atmospheric profiles
    - – Temperature, water vapor, and cloud liquid water
      - Determine attenuation of EM radiation through atmosphere
  - » Ocean surface parameters
    - – SST, sea surface salinity (SSS), wind speed, and wind direction
      - Determine the emissivity of the observed scene
- European Center for Medium-range Weather Forecast (ECMWF) data used
  - » 91 level profiles
  - » 90 – -90 Lat, 0 – 360 Lon, 0.25° grid
  - » 4 times a day (03, 09, 15, 21z)

Brightness Temperature Data Sets

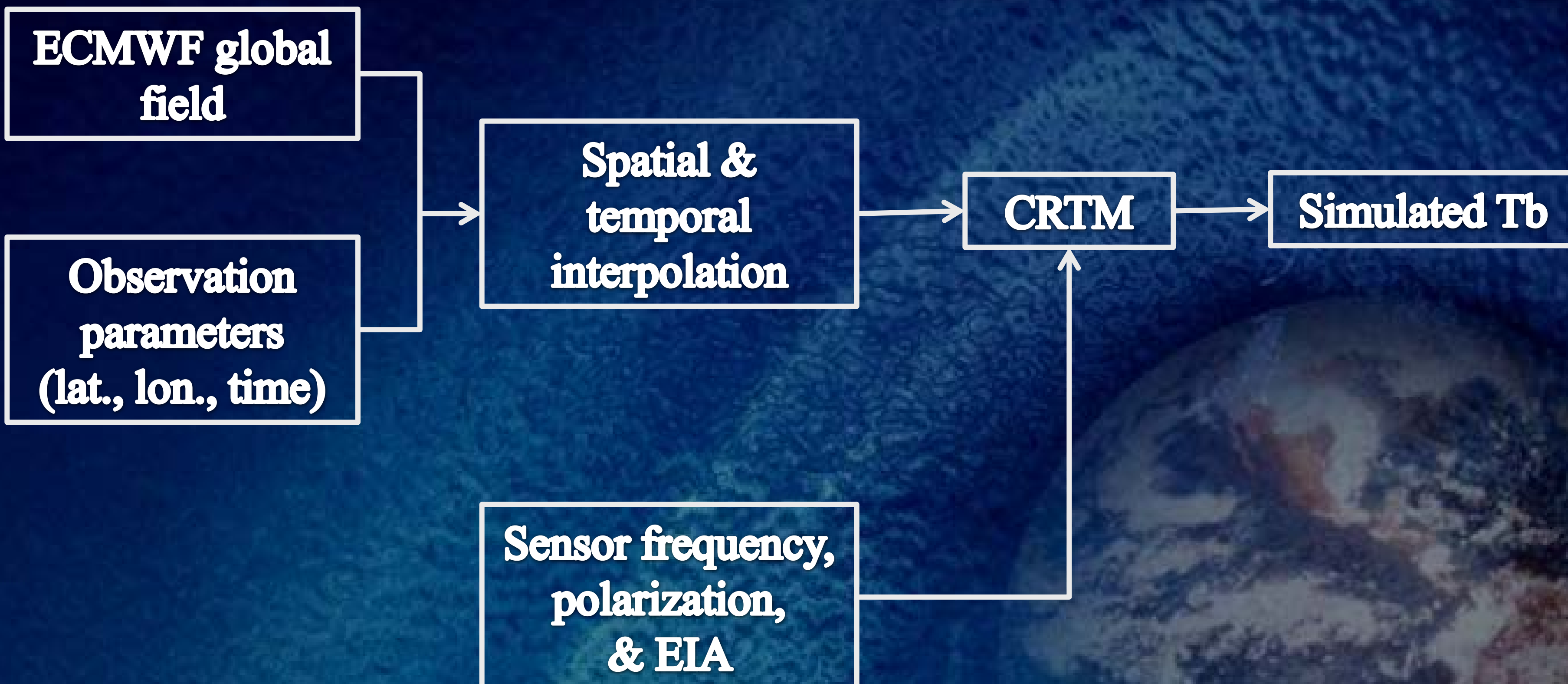
- AMSR2 data
  - JAXA Level 1B version 1.1 (GW1AM2 L1B v1.1) released on March, 1st, 2013
- TMI data

  Version 7 (v7) of the Level 1B Calibrated Tb product (TMI 1B11 v7)

Tb Simulation

- AMSR-2 & TMI radiances were simulated for all channels
  - » CRTM version 2.1
  - » Fastem5 surface model
- ECMWF global data
  - » 0.25° spatial resolution

Tb Simulation Diagram

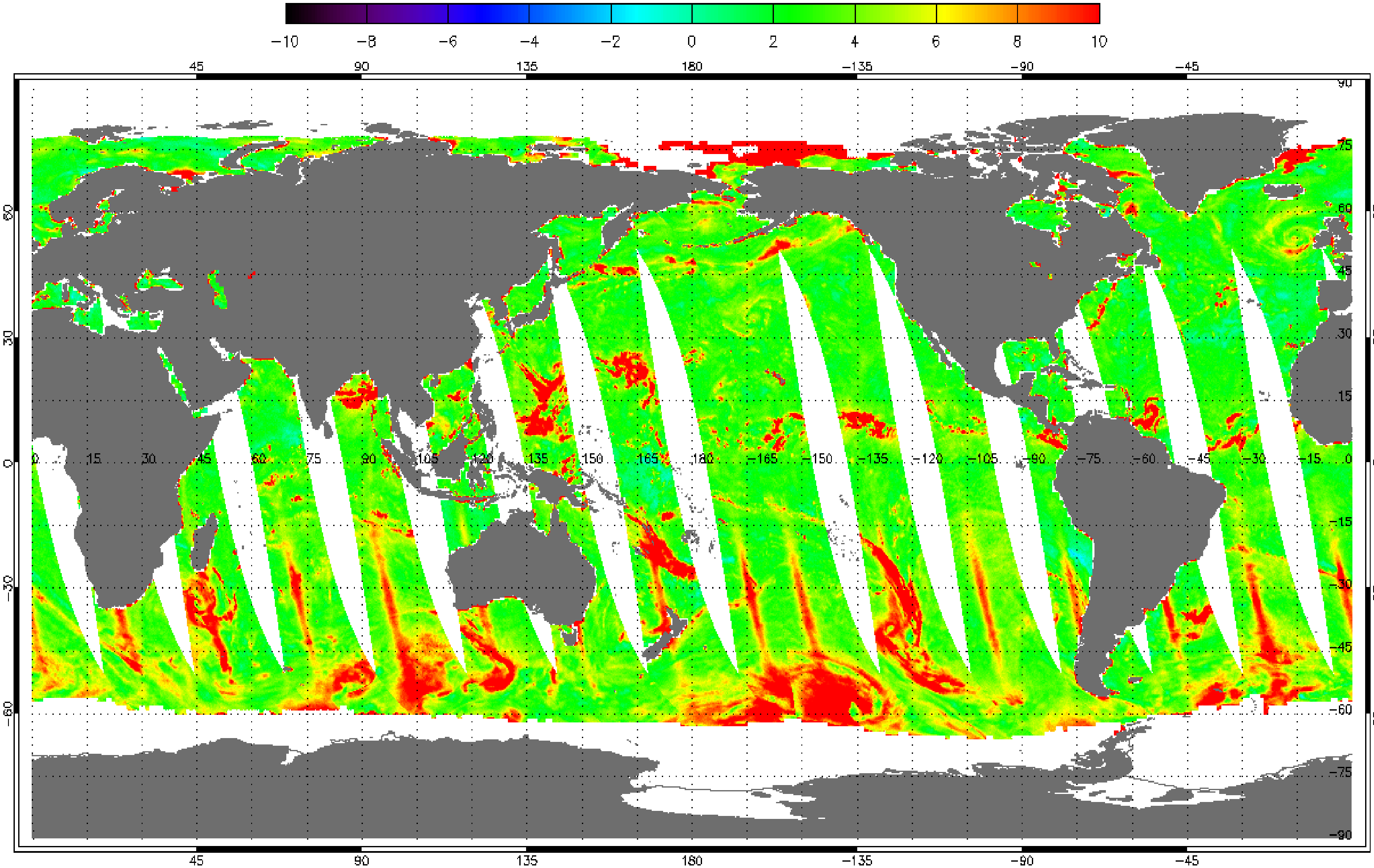


Sun Glint Impacted Channels

- Sun glint affects
  - » Lower frequencies more than higher frequencies
    - – No effect on 89 GHz
  - » H-pol more than V-pol
- Different flagging criteria need to be assigned for each frequency and polarization
  - » Tbv(6 & 7):(abs(Sun_Az) < 13) & (abs(Sun_Elev) < 20)
  - » Tbh(6 & 7):(abs(Sun_Az) < 16) & (abs(Sun_Elev) < 20)
  - » Tbv(10 & 18):(abs(Sun_Az) < 10) & (abs(Sun_Elev) < 18)
  - » Tbh(10 & 18):(abs(Sun_Az) < 12) & (abs(Sun_Elev) < 18)

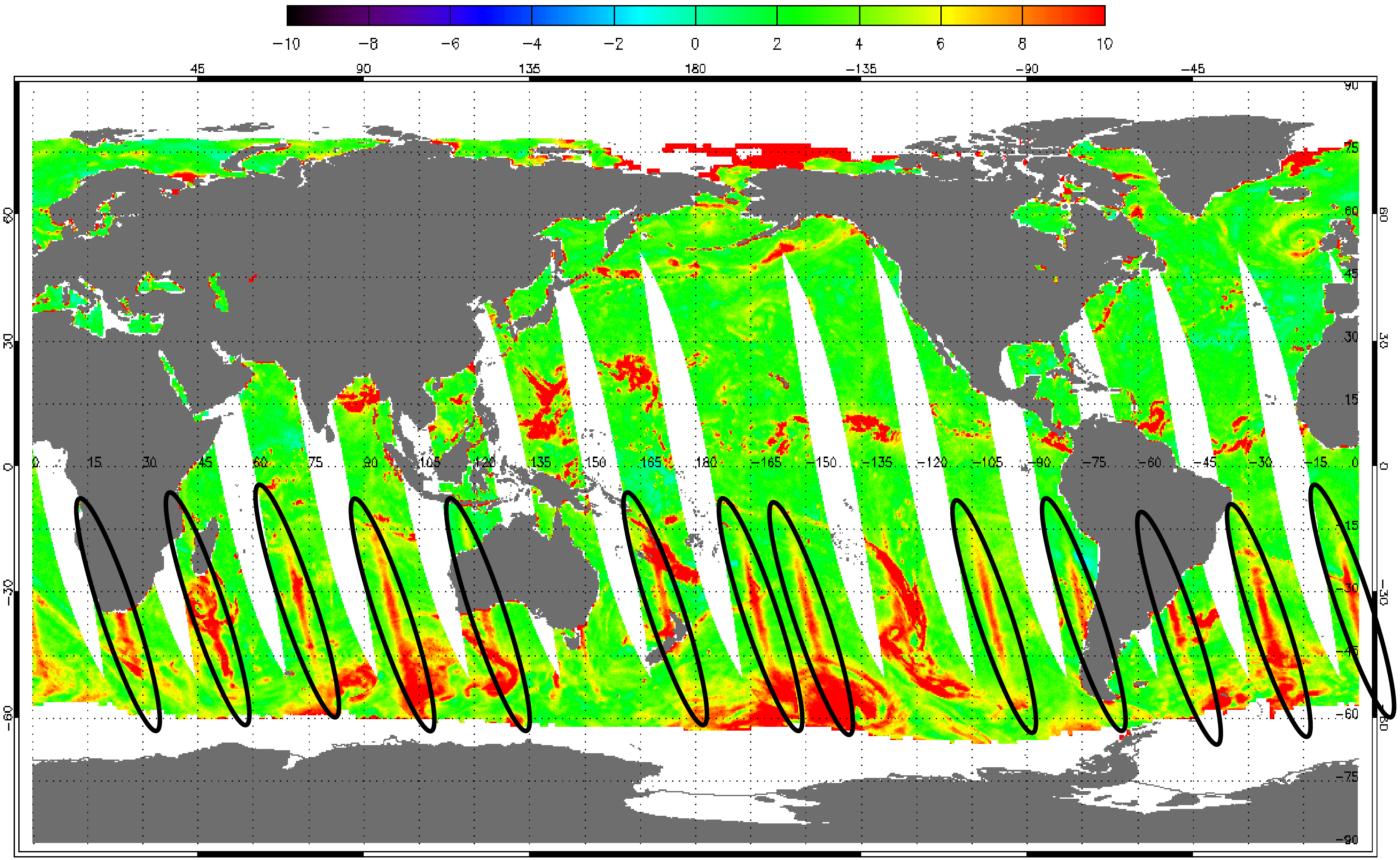
Flagging Sun Glint – cont.

[Tbh6_L1B – Tbh6_sim.], 08/02/2012



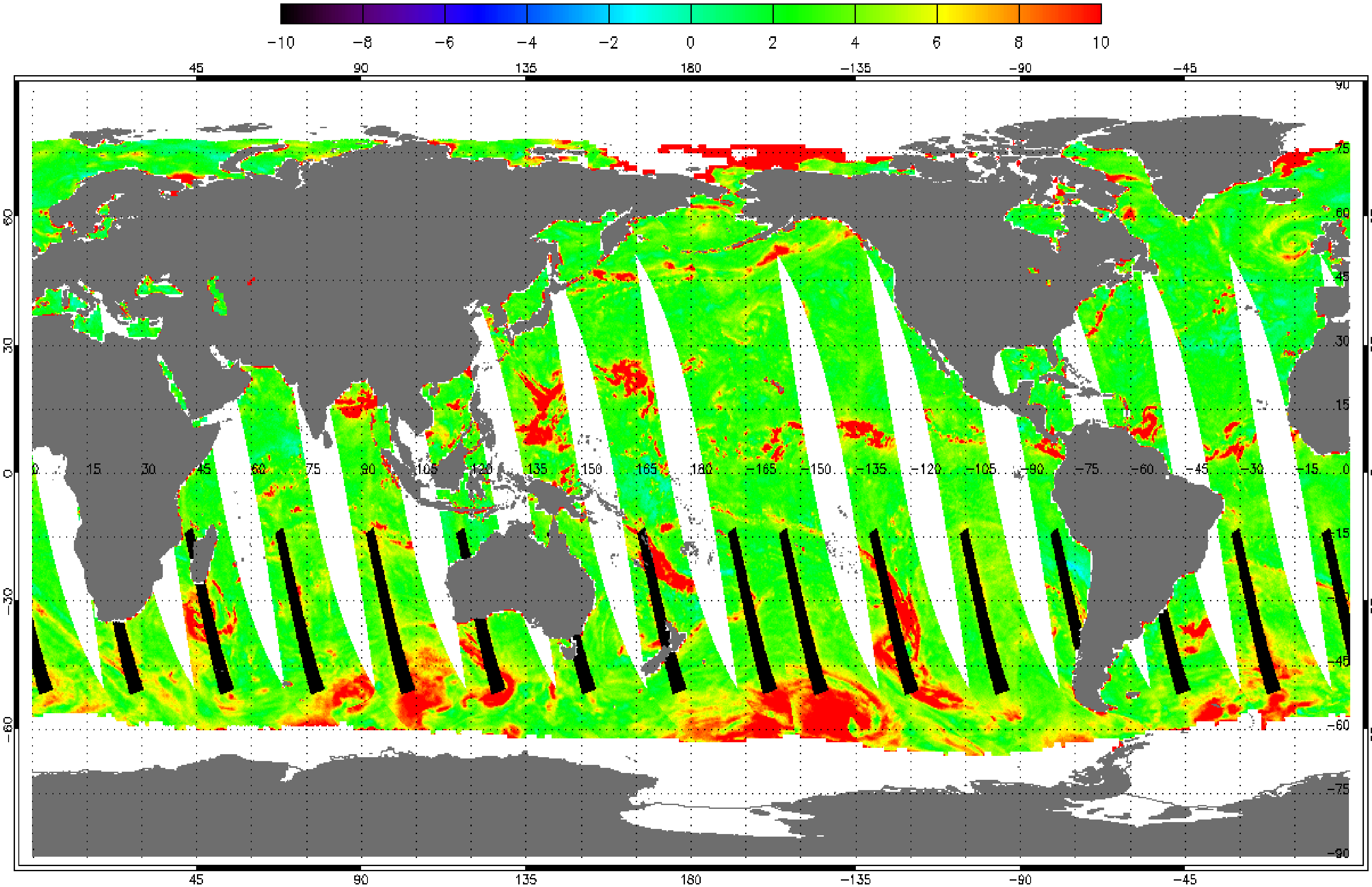
Flagging Sun Glint – cont.

[Tbh6_L1B – Tbh6_sim.], 08/02/2012



Flagging Sun Glint – cont.

[Tbh6_L1B – Tbh6_sim.], 08/02/2012



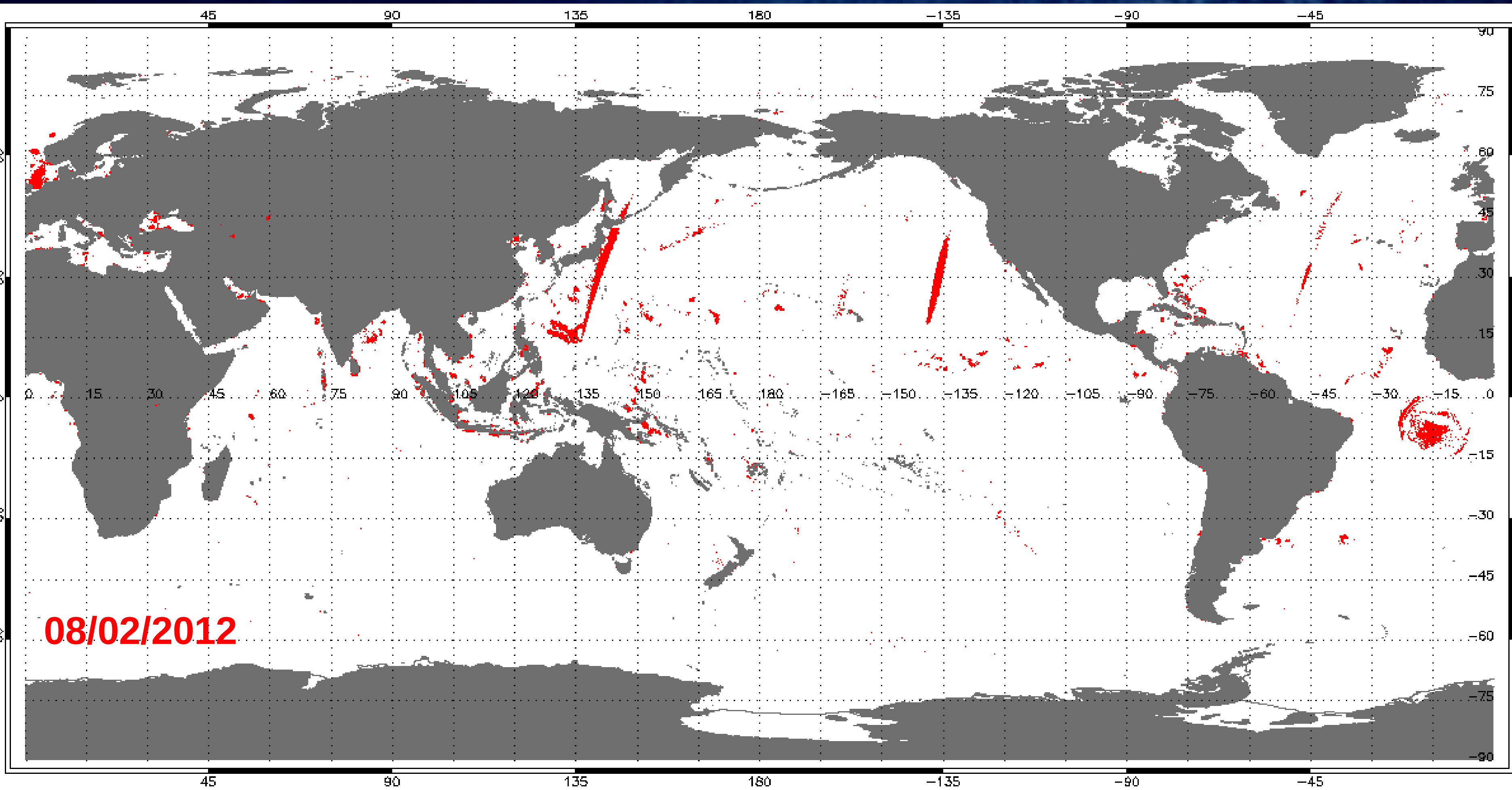
C-band RFI Detection

- For the purpose of ASMR-2 Tb calibration and correction development simple RFI identification was implemented
  - Spectral difference (ΔTbV) between 6.9 and 7.3 GHz channels

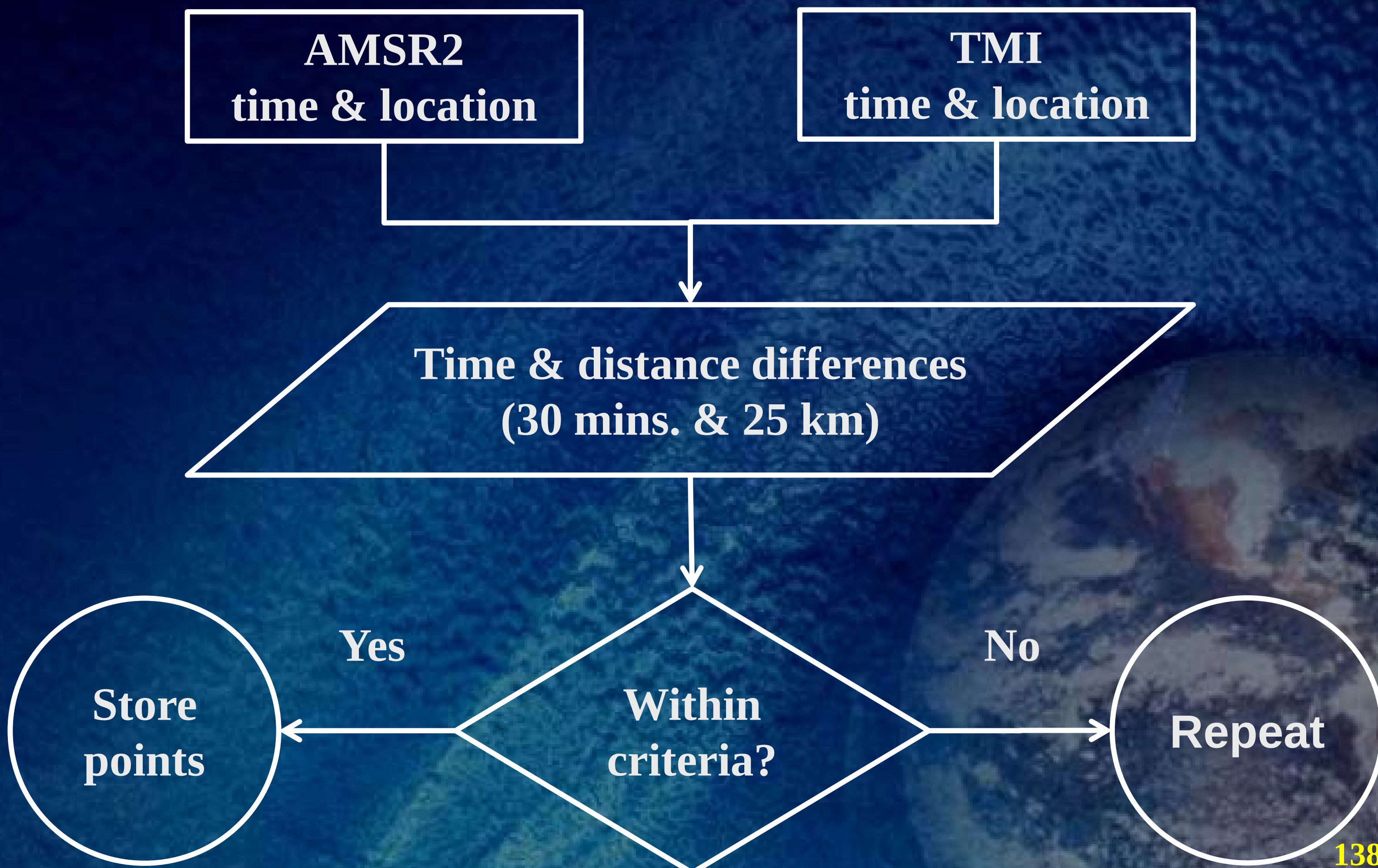
$$\Delta TbV = TbV6\_L1B - TbV7\_L1B$$

Flagging C-band RFI

- Criteria used : abs(Tbv6_L1B – Tbv7_L1B) > 3



Collocation Block Diagram



DD Analysis Criteria

- 60 days of collocated AMSR2 and TMI measurements
- 30 minutes maximum time difference
- 25 km maximum distance between observations
- The collocation dataset was filtered for rain, clouds, and minimal water vapor to assure rain-free clear-sky observations.
  - » TMI environmental daily retrieval maps (version 4) provided by Remote Sensing Systems [RSS online] were used for data filtering.
- To eliminate any intensive C-band radio frequency interference (RFI), the new 7.3 GHz channel added to AMSR2 was utilized
  - » Because RFI signals are typically narrow band, a simple RFI detection technique that utilizes the absolute Tb difference (ΔTb) between the 6.9 GHz and the 7.3 GHz channels. For this analysis we flagged and excluded all the points with ΔTb >3 k.

$$\Delta Tb = |Tb_{V\text{-}pol,6.9GHz} - Tb_{V\text{-}pol,7.3GHz}|$$

DD Analysis Criteria– cont.

- Bad pixels excluded
  - » Rain & clouds
    - – Using RSS TMI EDRs
  - » Sun glint
  - » RFI
- Data separated by frequency, polarization and ascending/descending
- Variations with AMSR2 Tb's and flight relative azimuth examined

Oceanic Double Difference Table

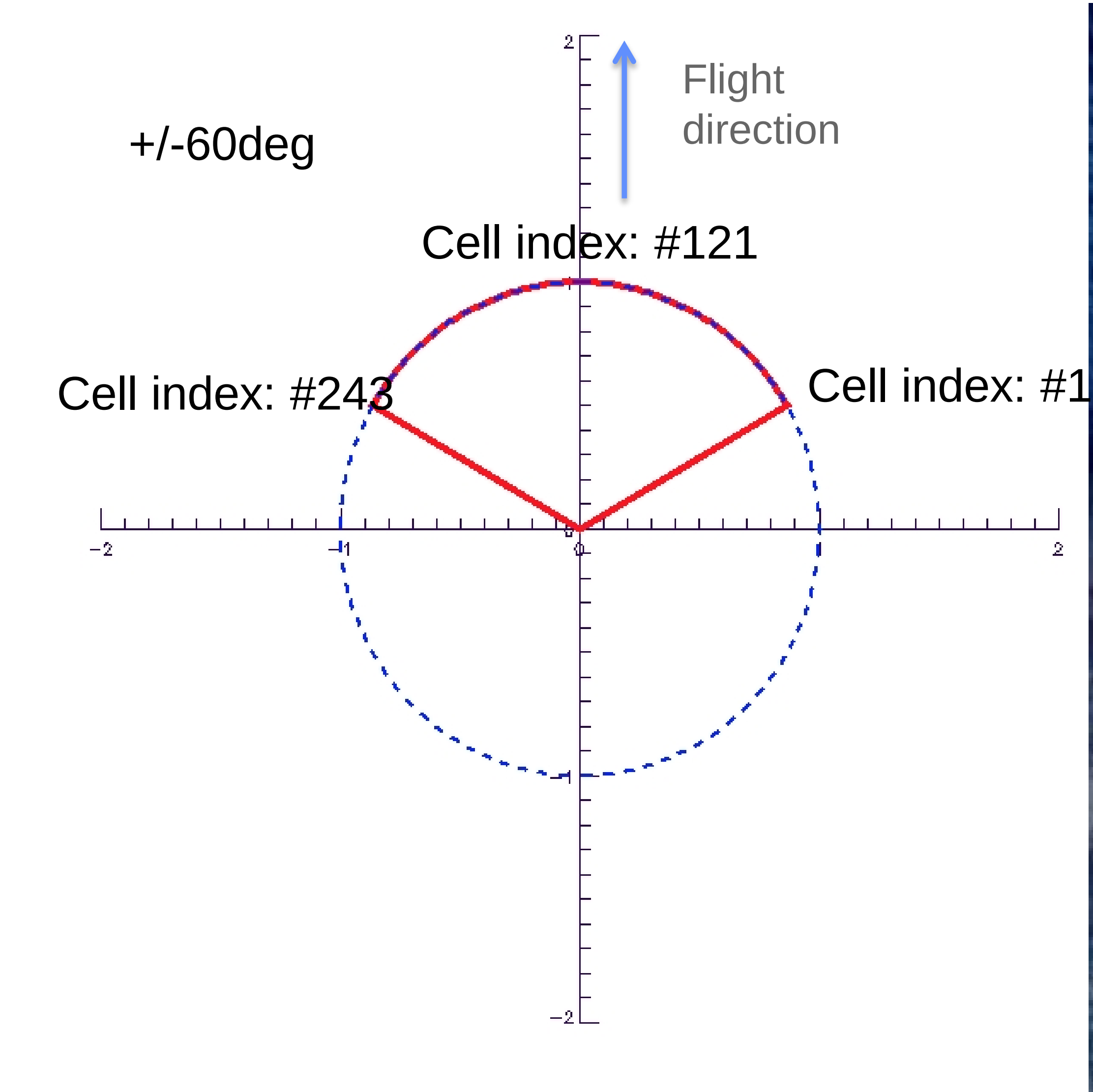
DD=[(AMSR2_L1b – AMSR2_sim) - (TMI_1b11v7 – TMI_sim)]

Channel	AMSR2 –TMI (ascending)	AMSR2 –TMI (descending)	AMSR2 –TMI (all)
10V	4.4	4.4	4.4
10H	5.1	4.9	5.0
18V	3.8	4.0	3.9
18H	2.5	2.2	2.4
23V	4.0	4.3	4.1
23H	-	-	-
36V	4.4	4.9	4.6
36H	5.2	5.7	5.4
89V	2.8	3.1	2.9
89H	3.5	4.0	3.6

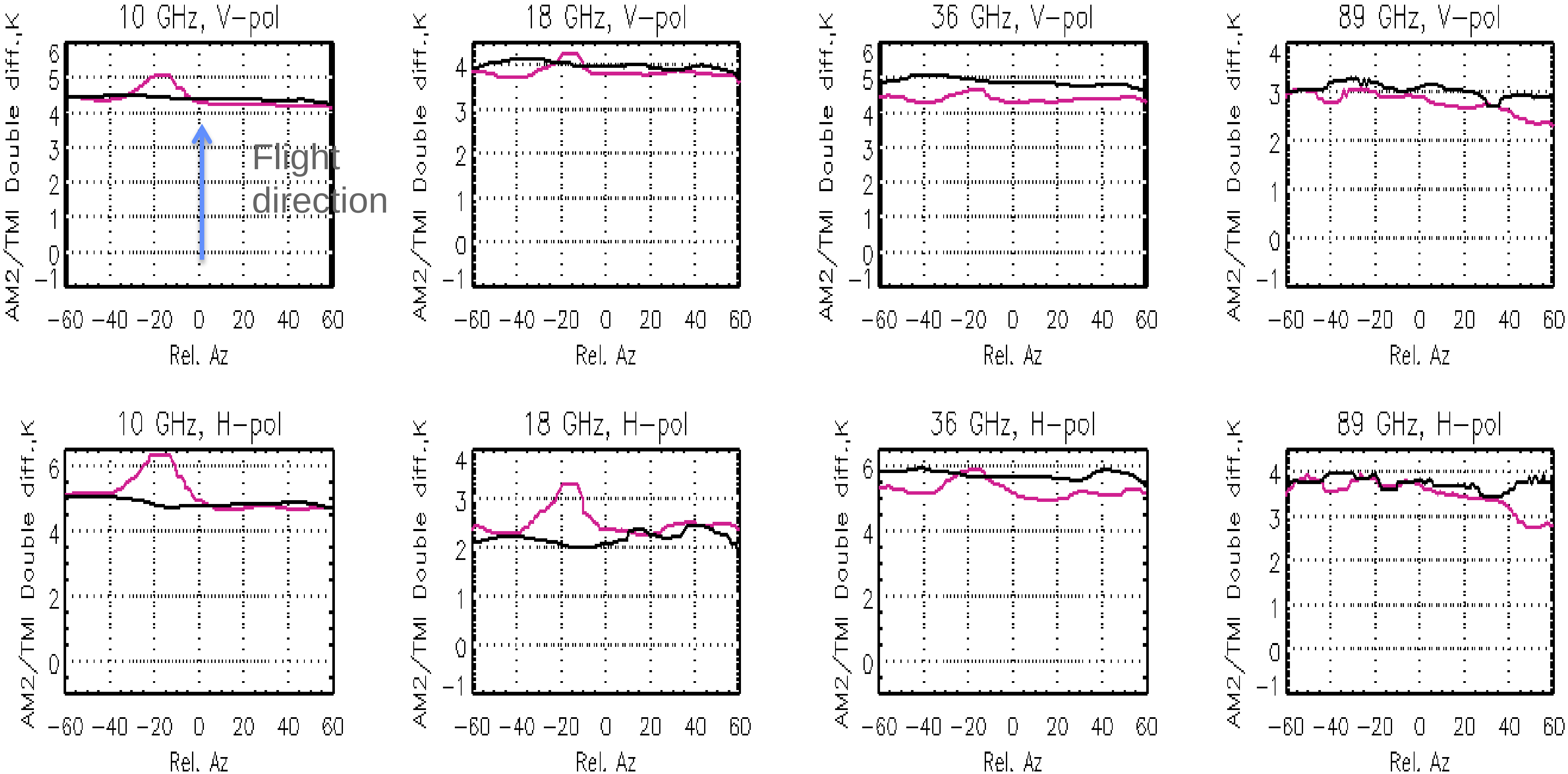
Azimuth Relative to Flight Direction

- Earth_Azimuth provided in AMSR2 L1B data ranges between: -180° and 180°
  - » Relative to North
- In order to calculate Azimuth relative to flight direction (Az_dir) we needed flight direction
  - » Az_dir = (Earth_Azimuth – Flight_Dir) mod 360°
- Flight direction was approximated using the azimuth of the great circle line connecting two consecutive satellite measurements
  - » Consecutive cells from the center of the swath were used
  - » Lat/Lon information needed to calculate flight direction
  - » IDL built in function "map_2points" used to perform calculations

Azimuth Relative to Flight Direction



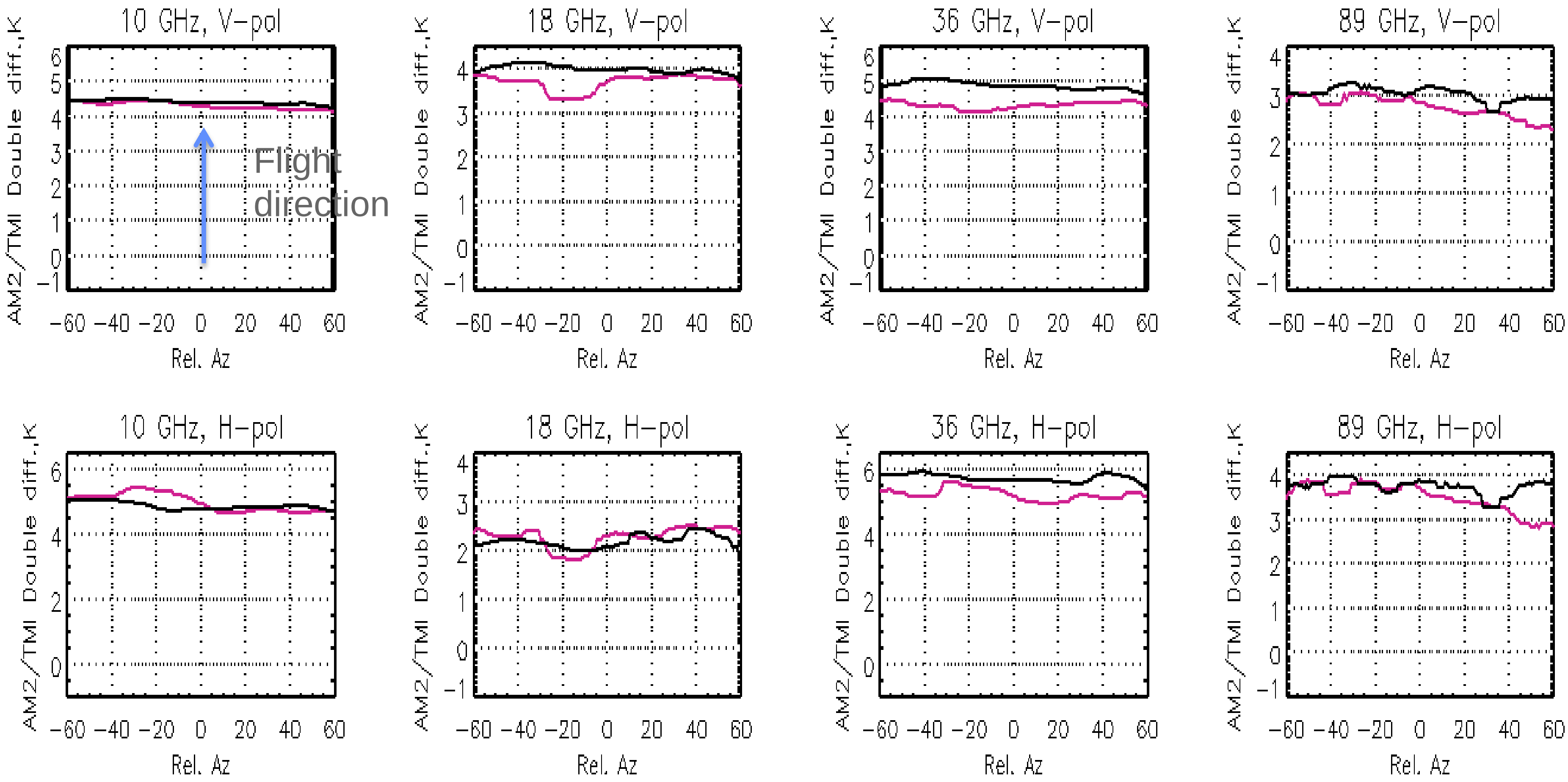
Double Difference versus Relative Azimuth



Ascending
Descending

Before removing sun glint

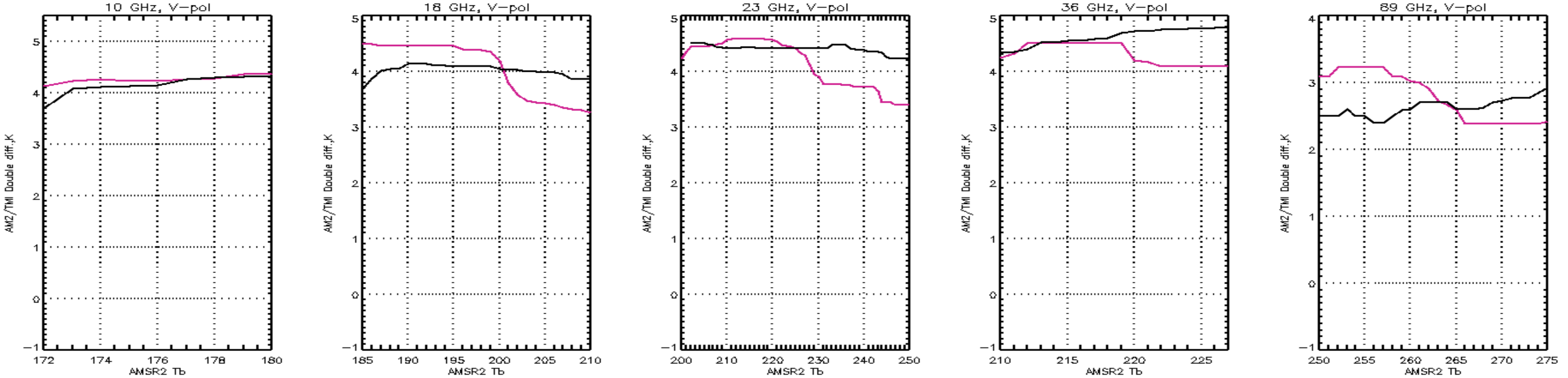
Double Difference versus Relative Azimuth

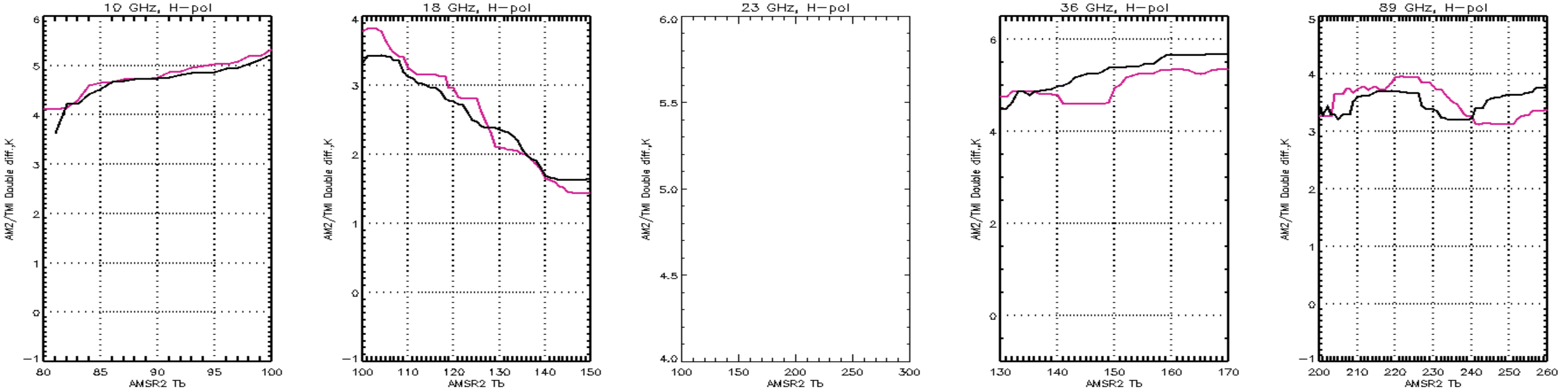


Ascending
Descending

After removing sun glint

Double Difference versus AMSR-2 Tbs



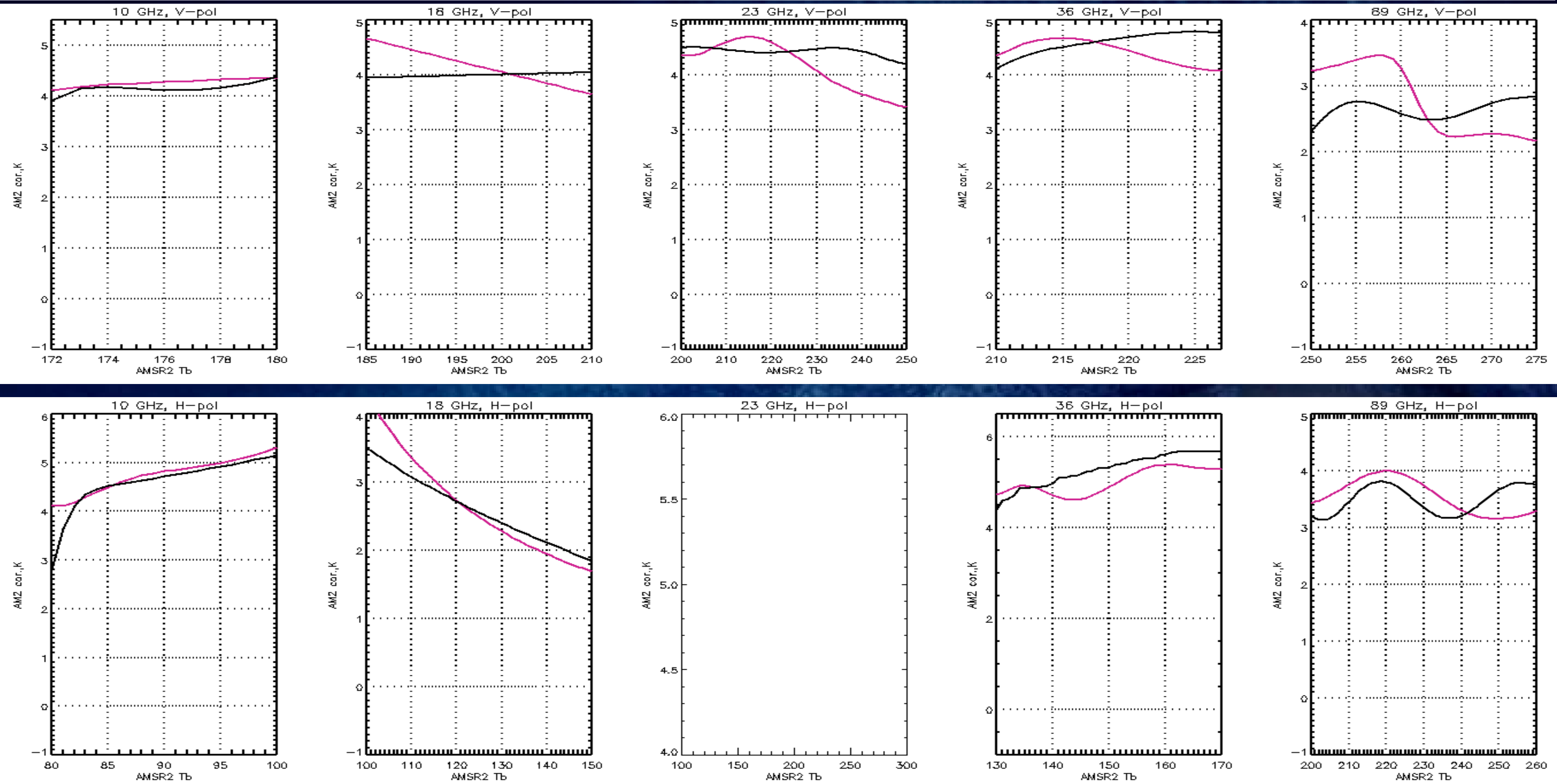


Ascending
Descending

AMSR-2 Tb Correction Development

- Correction developed based on double difference relation with AMSR2 radiances
  - » Correction = f(AMSR2_L1B Tbs)
- Different correction applied for different frequencies, polarizations, and ascending/descending

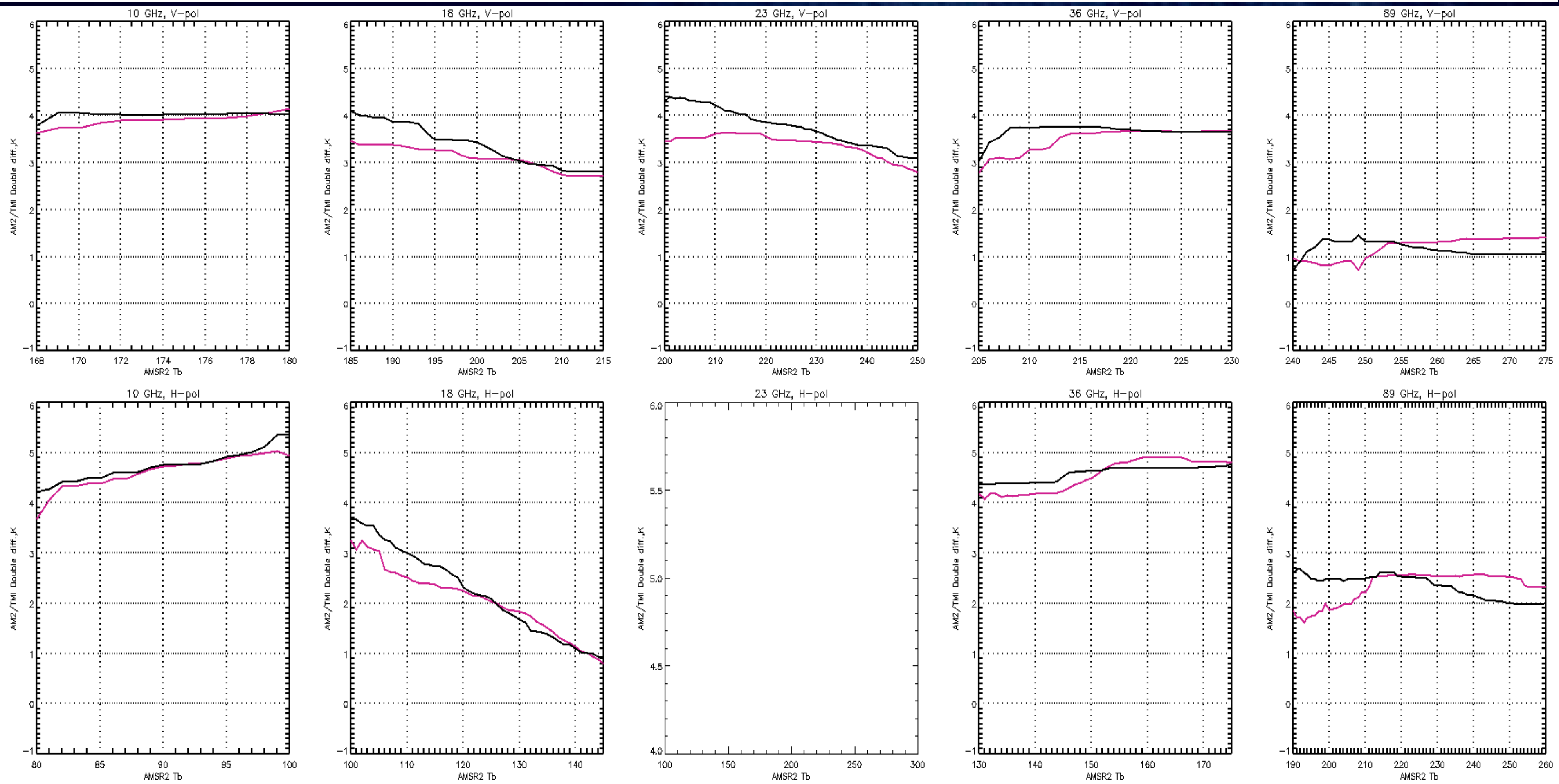
Correction Functions



Ascending
Descending

Corrected AMSR2 Tb= AMSR2_L1B – DD_mod.

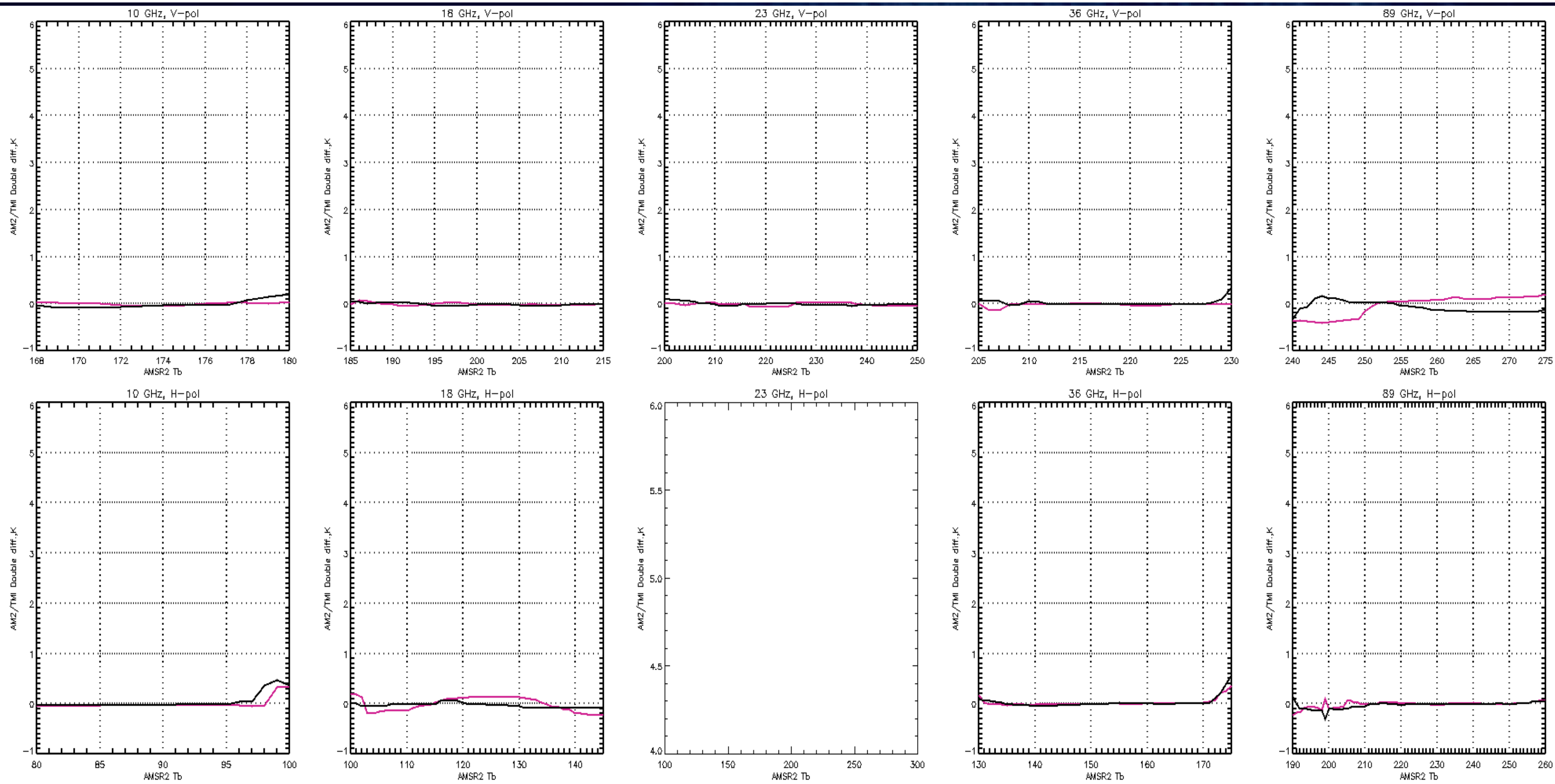
Double Difference, AMSR2 Tbs



Ascending
Descending

Before Applying Correction

Double Difference, AMSR2 Tbs



Ascending
Descending

After Applying Correction

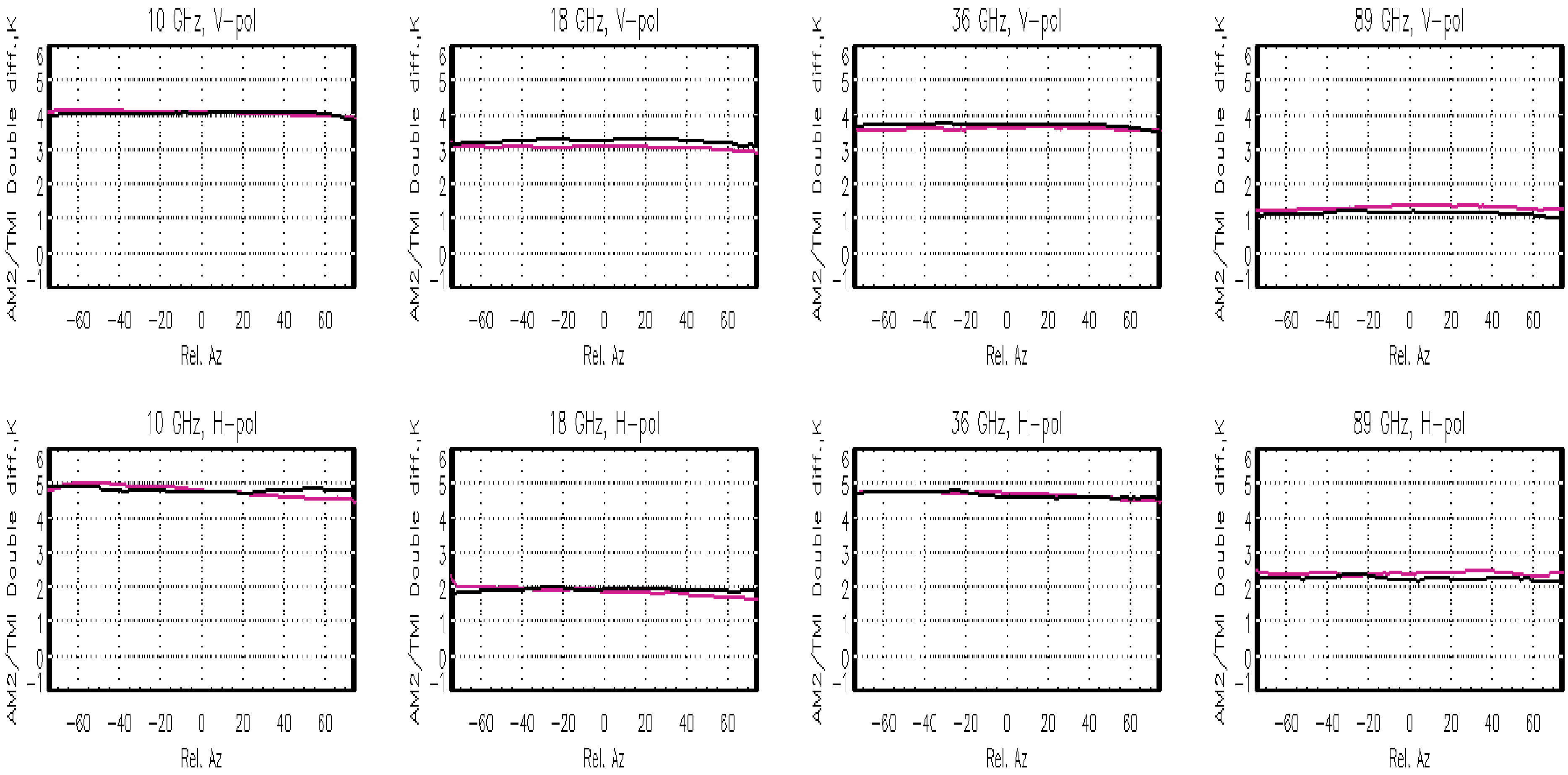
Oceanic Double Difference Table

DD=[(AMSR2_L1b – AMSR2_sim) - (TMI_1b11v7 – TMI_sim)]

Channel	AMSR2 –TMI (ascending)		AMSR2 –TMI (descending)	
10V	4.1	-0.03	4.05	-0.06
10H	4.8	-0.02	4.8	-0.03
18V	3.0	0.0	3.26	-0.02
18H	1.9	0.0	1.9	-0.01
23V	3.3	0.0	3.6	-0.01
23H	-	-	-	-
36V	3.6	-0.02	3.7	0.0
36H	4.7	0.04	4.7	0.01
89V	1.3	0.08	1.17	-0.06
89H	2.4	0.03	2.3	0.0

After applying corrections

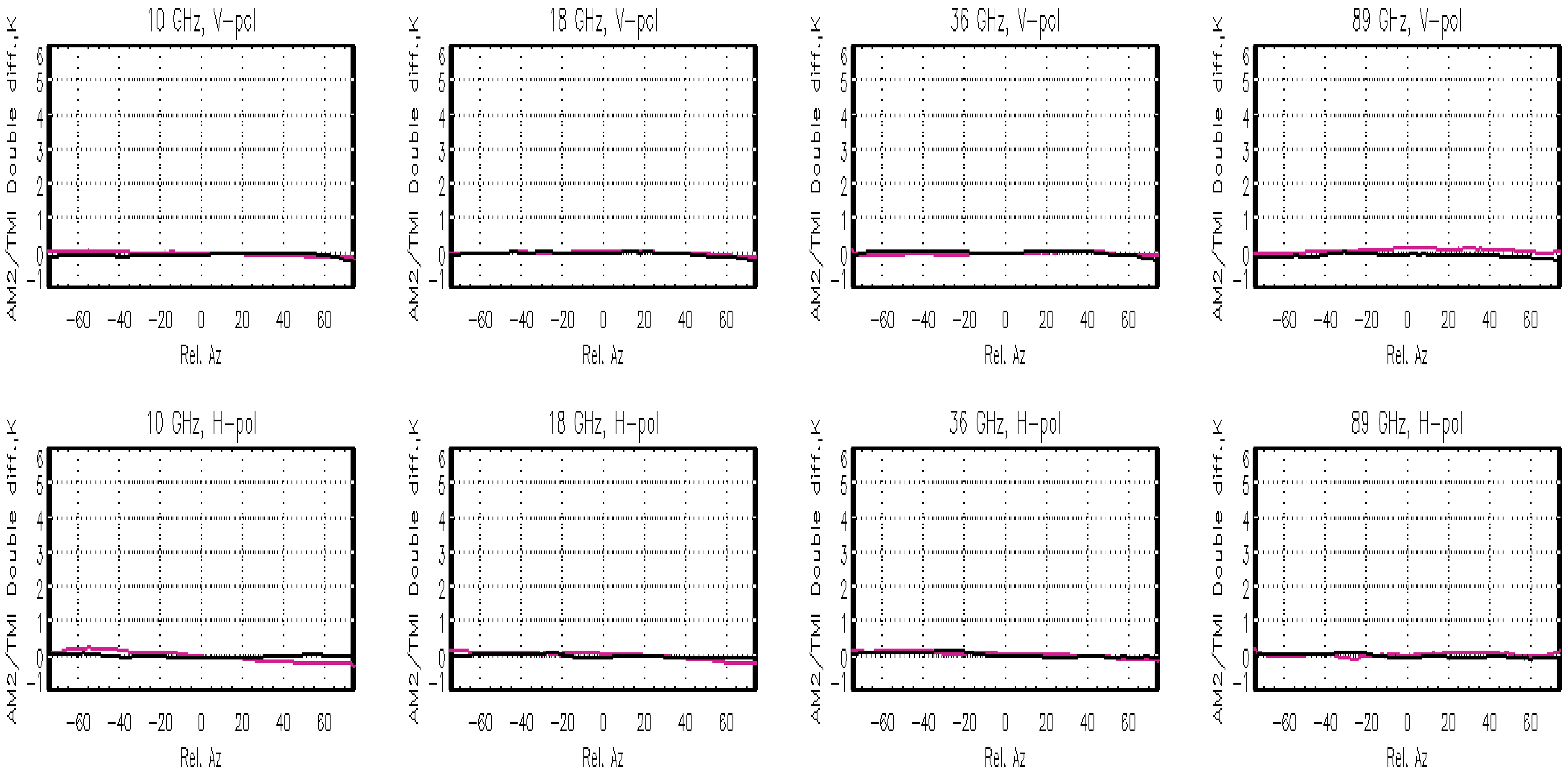
Double Difference, Rel. Az.



Ascending
Descending

Before Applying Correction

Double Difference, Rel. Az.

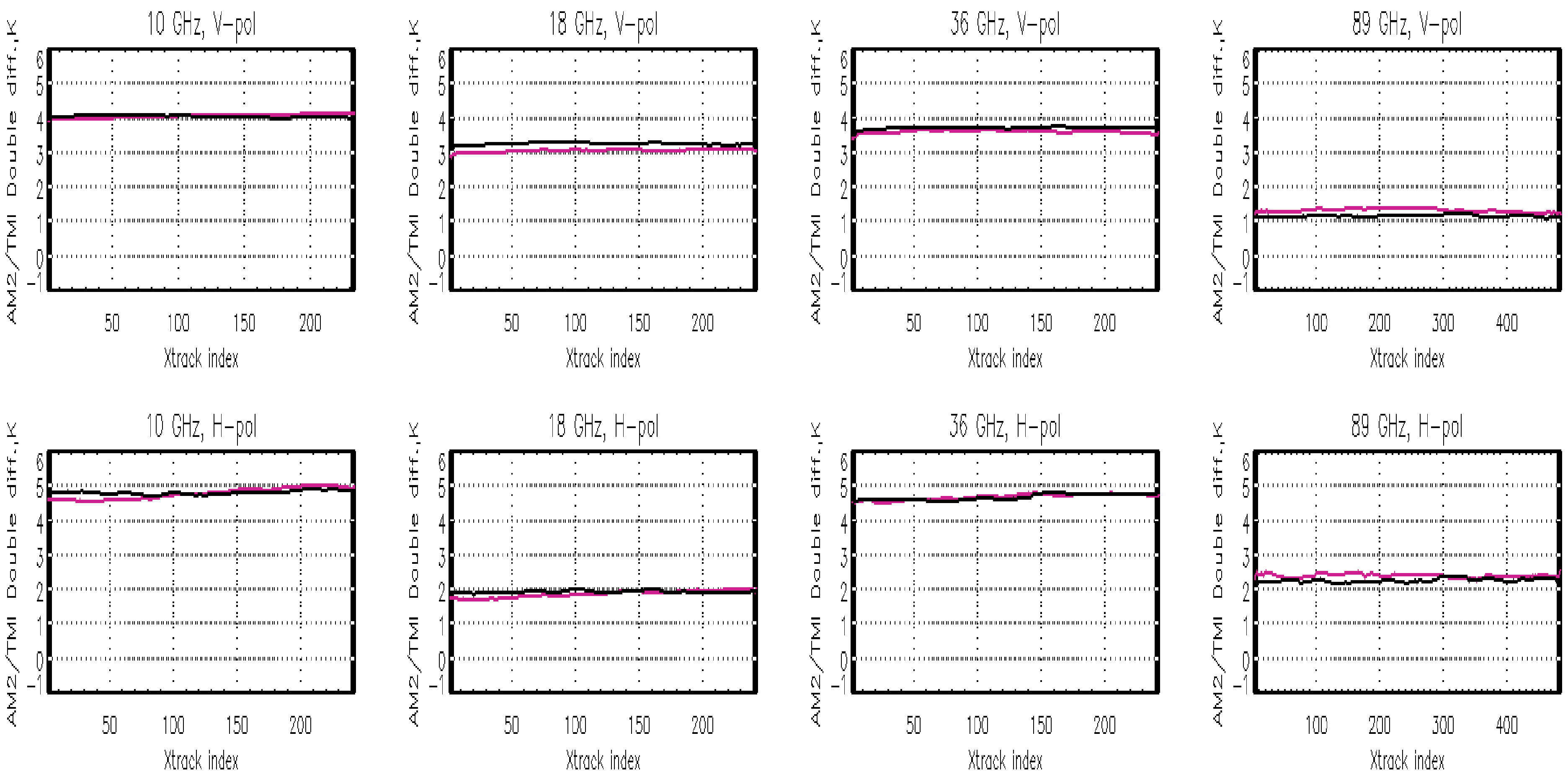


Ascending

Descending

After Applying Correction

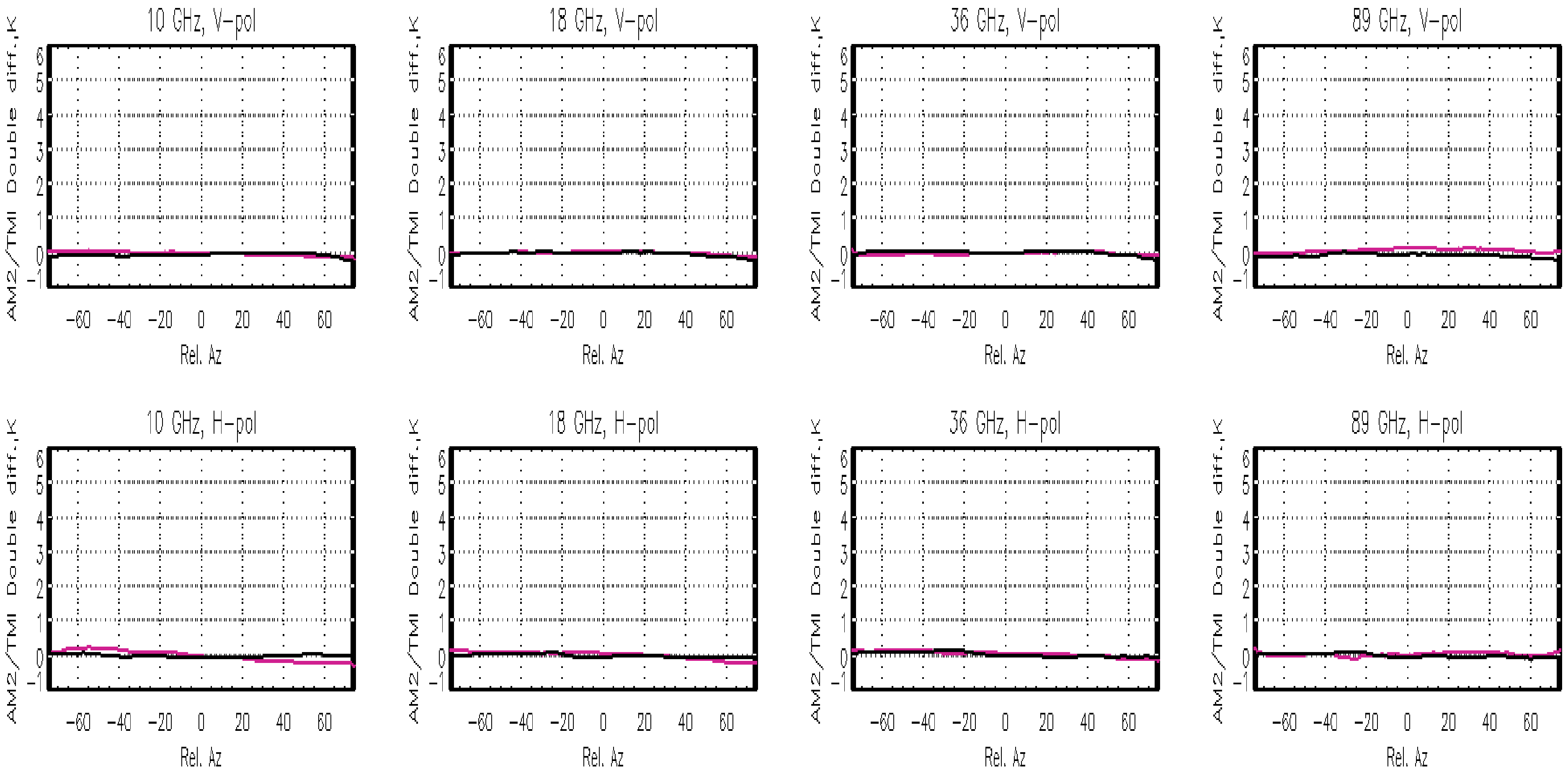
Double Difference, Cell index



Ascending
Descending

Before Applying Correction

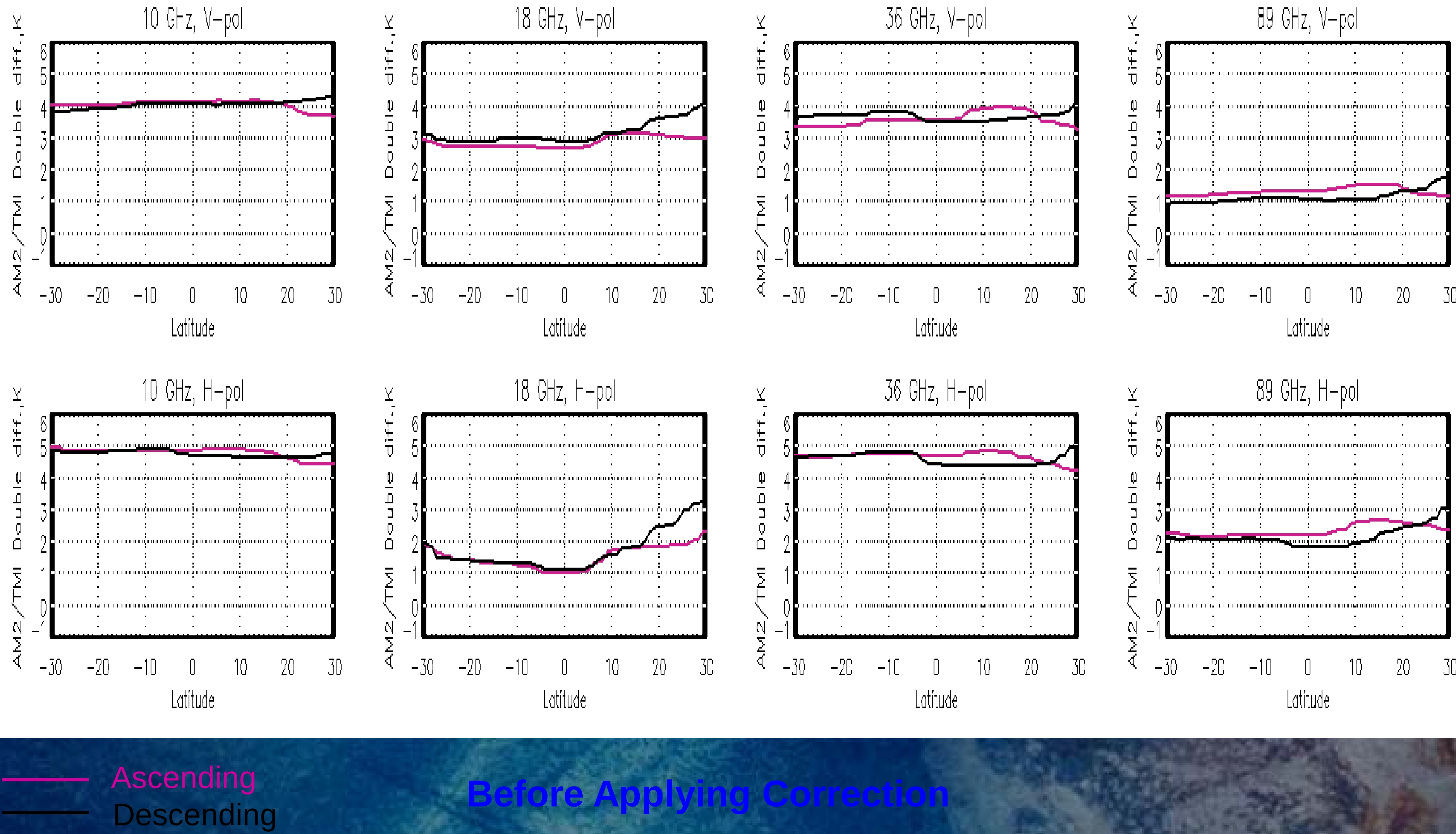
Double Difference, Cell index



Ascending
Descending

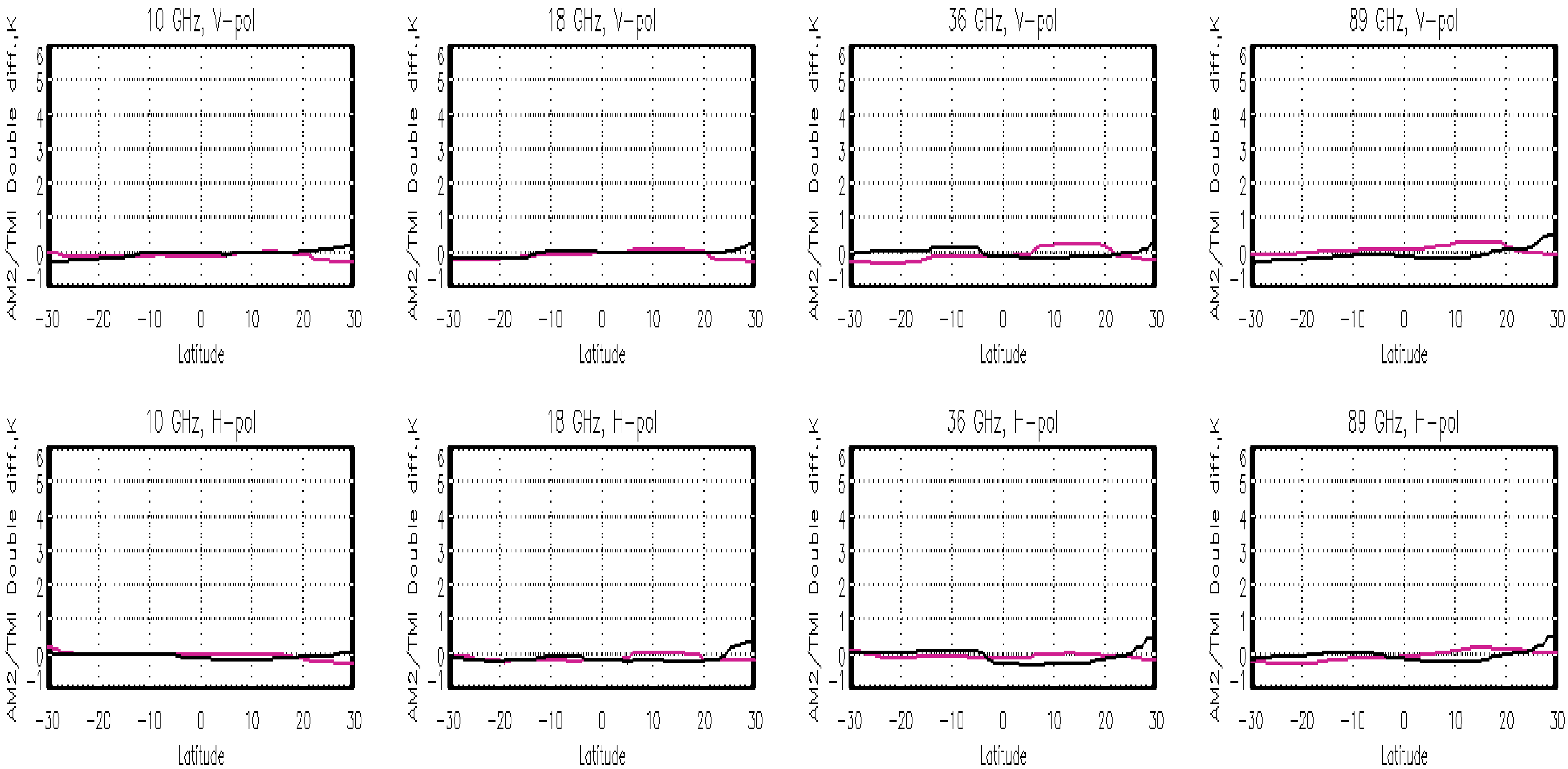
After Applying Correction

Double Difference, Latitude



Before Applying Correction

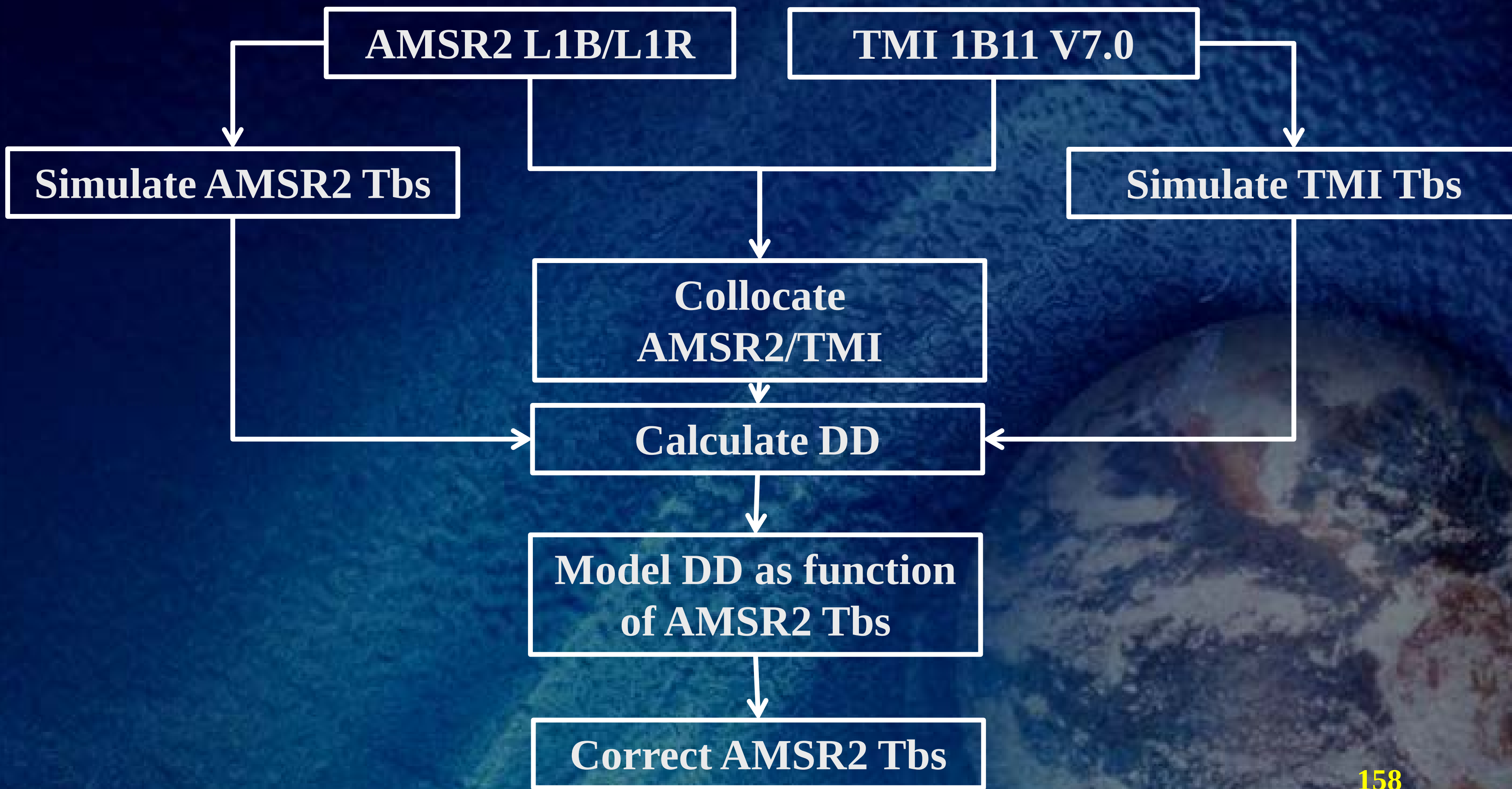
Double Difference, Latitude



Ascending
Descending

After Applying Correction

SDR Correction Block Diagram



SDR Corrections Algorithm Processing Flow

Input Data
- Brightness temperatures (TB) for 6.925V/H, 7.3V/H, 10.7V/H,18.7V/H 23.8V, 36.5H/V,89H/V

6.925h/V ghz channel correction

7.3H/V Ghz channel correction

10.7H/V Ghz channel correction

18.7H/VGhz channel correction

23.8 H/V Ghz channel correction

36.5 H/V Ghz channel correction

89a H/V Ghz channel correction

89b H/V Ghz channel correction

Correction Function

$$\Delta T_{Bi} = \frac{\sum_{n} a_{in} T_{Bi}^{n}}{\sum_{m} b_{i} T_{Bi}^{m}}$$

$$T_{Bi} = T_{Bi} - \Delta T_{Bi}$$

$$i = Channels$$

Output Data
- Corrected Ocean Brightness temperatures

AMSR2 Land Tb Calibration

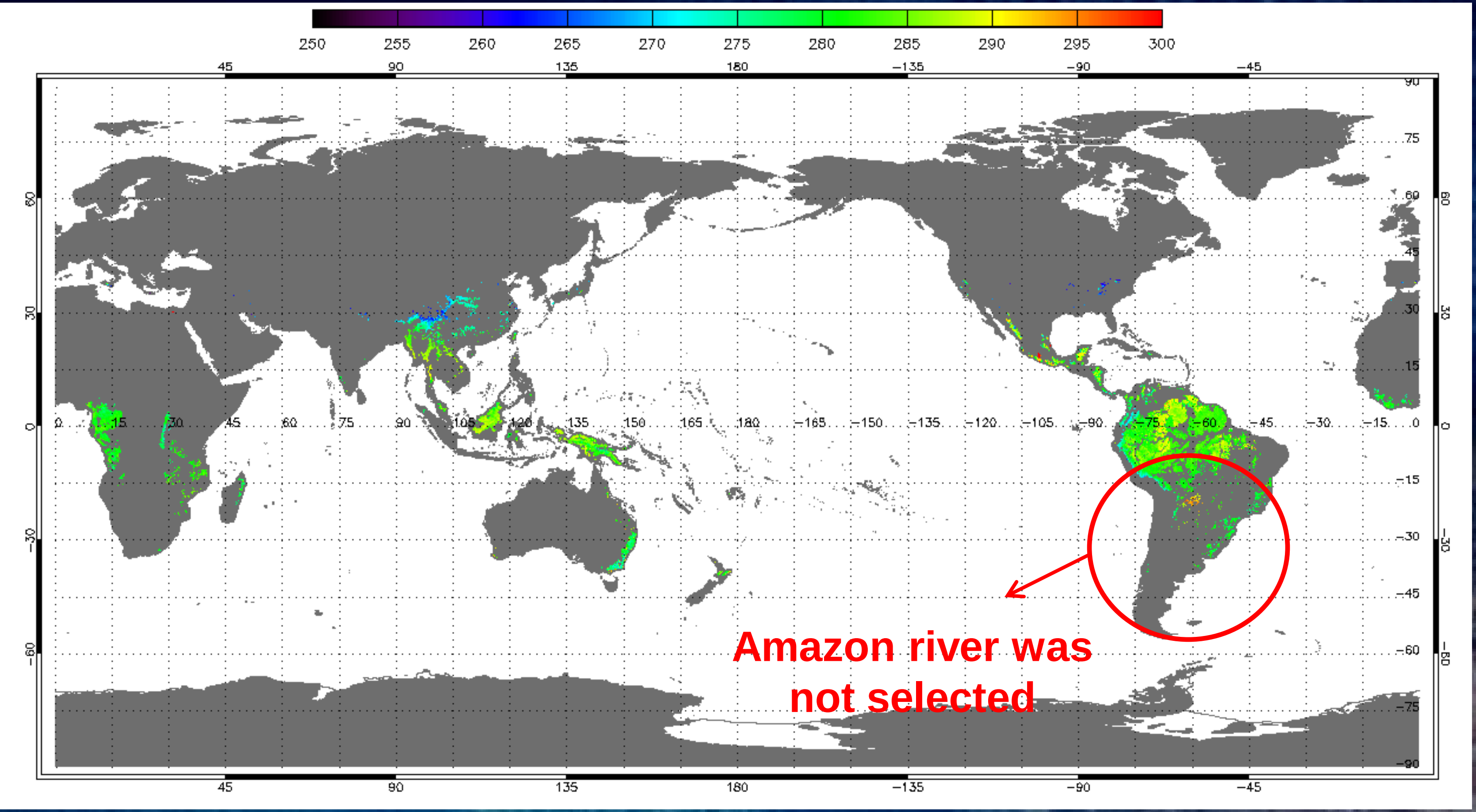
Description

- The following slides demonstrates AMSR2 hot end (land) calibration
- 75 days of AMSR2/TMI collocations were used
  - » **10 km** spatial difference & **15 mins**. Time difference
- No simulated Tbs available over land
  - » Direct comparison (AMSR2 - TMI) is used

Areas of Interest

- Thick leaf canopy vegetation were chosen for hot end calibration
  - » Close to be a black body
  - » High emissivity
  - » Non polarized
  - » Minimal dependence on differences in earth incidence angle between sensors and measurements

Areas of interest – cont.



10 GHz selected area

Frequency Dependence

- No simulated Tbs over land are available
  - » Direct comparison between AMSR2 and TMI
    - – Bias= Tb_AMSR2 – Tb_TMI
- Differences in the channels frequencies can cause some errors that are not necessarily calibration error
- WindSat was used to model Tb frequency dependence

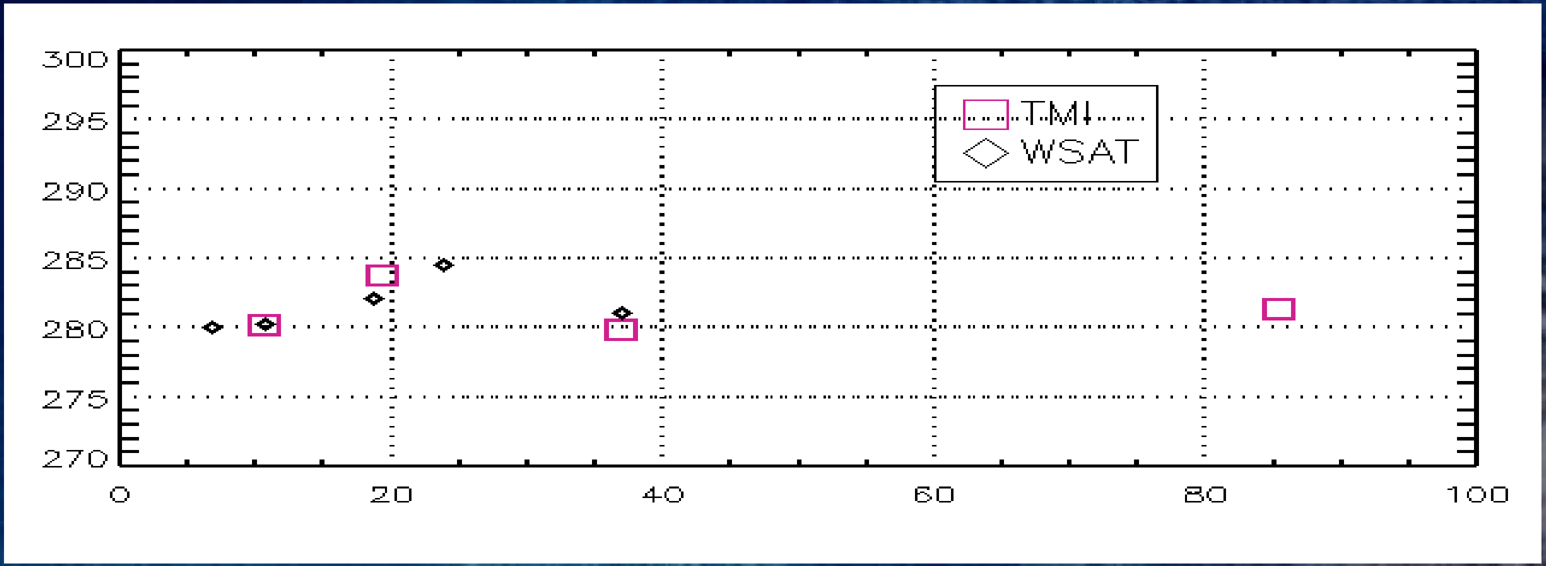
Frequency Dependence – cont.

- 500 orbits of WindSat data were used
- Same selection criterion applied
  - » |TbV –TbH| < 1K
- Selected points from 500 orbits were averaged to make one point per WindSat channel
  - » Atmospheric & surface affect on Tb will cancel out

Frequency Dependence – cont.

- Frequency dependence was modeled over land using WindSat data
  - » Transform AMSR2 Tbs @ AMSR2 frequencies to AMSR2 Tbs @ TMI frequencies

Land Tb, K



Frequency, GHz

AMSR2 Hot End Biases

- After applying ΔTb for frequency transformation, following table shows biases between AMSR2 and TMI over land

AMSR2 Freq.	Bias
10.65 V	**1.8**
10.65 H	**3.2**
18.70 V	**-1.0**
18.70 H	**-0.3**
23.8 0 V	**1.1**
36.50 V	**1.5**
36.50 H	**1.8**

SDR Correction Summary

- The current AMSR2 brightness temperatures contain significant residual calibration errors.
- These errors need to be modeled individually for each channel to appropriately correct for these residual errors (biases).
- The AMSR2 Tb's over ocean are warmer than TMI
- Corrections for AMSR2 Tb's over ocean are developed as a function of AMSR2 Tb's
- Corrections for AMSR2 Tb's over land are developed as single bias correction

SDR Corrections Algorithm Processing Flow

Input Data
- Brightness temperatures (TB) for 6.925V/H, 7.3V/H, 10.7V/H,18.7V/H 23.8V, 36.5H/V,89H/V

6.925h/V ghz channel correction

7.3H/V Ghz channel correction

10.7H/V Ghz channel correction

18.7H/VGhz channel correction

23.8 H/V Ghz channel correction

36.5 H/V Ghz channel correction

89a H/V Ghz channel correction

89b H/V Ghz channel correction

Correction Function

$$\Delta T_{Bi} = \frac{\sum_{n} a_{in} T_{Bi}^{n}}{\sum_{m} b_{i} T_{Bi}^{m}}$$

$$T_{Bi} = T_{Bi} - \Delta T_{Bi}$$

$$i = Channels$$

Output Data
- Corrected Brightness temperatures

EDR Preprocessor

- Any required formatting prior to the EDR processor
- Additional RFI flagging/information calculated and included

RFI Characterization

Presented by

Fuzhong Weng
NOAA/NESDIS/STAR

What is RFI?

Satellite microwave thermal emission mixed with the signals from the active sensors is referred to as RFI.

Active remote sensing usually uses low-frequency channels.

(C-band: 4-8 GHz, X-band: 8-12 GHz, K-band: 18-26.5 GHz)

Main Characteristics of RFI

RFI contamination increases the TB at low-frequency (C,X, and K bands) channels more significantly than at high-frequency channels of microwave measurements

Most RFIs are in or near cities or populated areas, and US and other coastal areas for every satellite overpass

US and European coastal RFI signals are increasing with time

Construct PCA Vector from Microwave Imager

NPCA vector (example)

$$\vec{V}_i = \begin{pmatrix} (\frac{TB_{10H} - TB_{18H} - \mu}{\sigma})_i \\ (\frac{TB_{18V} - TB_{23V} - \mu}{\sigma})_i \\ (\frac{TB_{18H} - TB_{23H} - \mu}{\sigma})_i \\ (\frac{TB_{23V} - TB_{37V} - \mu}{\sigma})_i \\ (\frac{TB_{23H} - TB_{37H} - \mu}{\sigma})_i \end{pmatrix} \equiv \begin{pmatrix} V_{1,i} \\ V_{2,i} \\ V_{3,i} \\ V_{4,i} \\ V_{5,i} \end{pmatrix}$$

$$(i = 1, 2, \cdots, N)$$

PCA vector from Reconstruct TB (example)

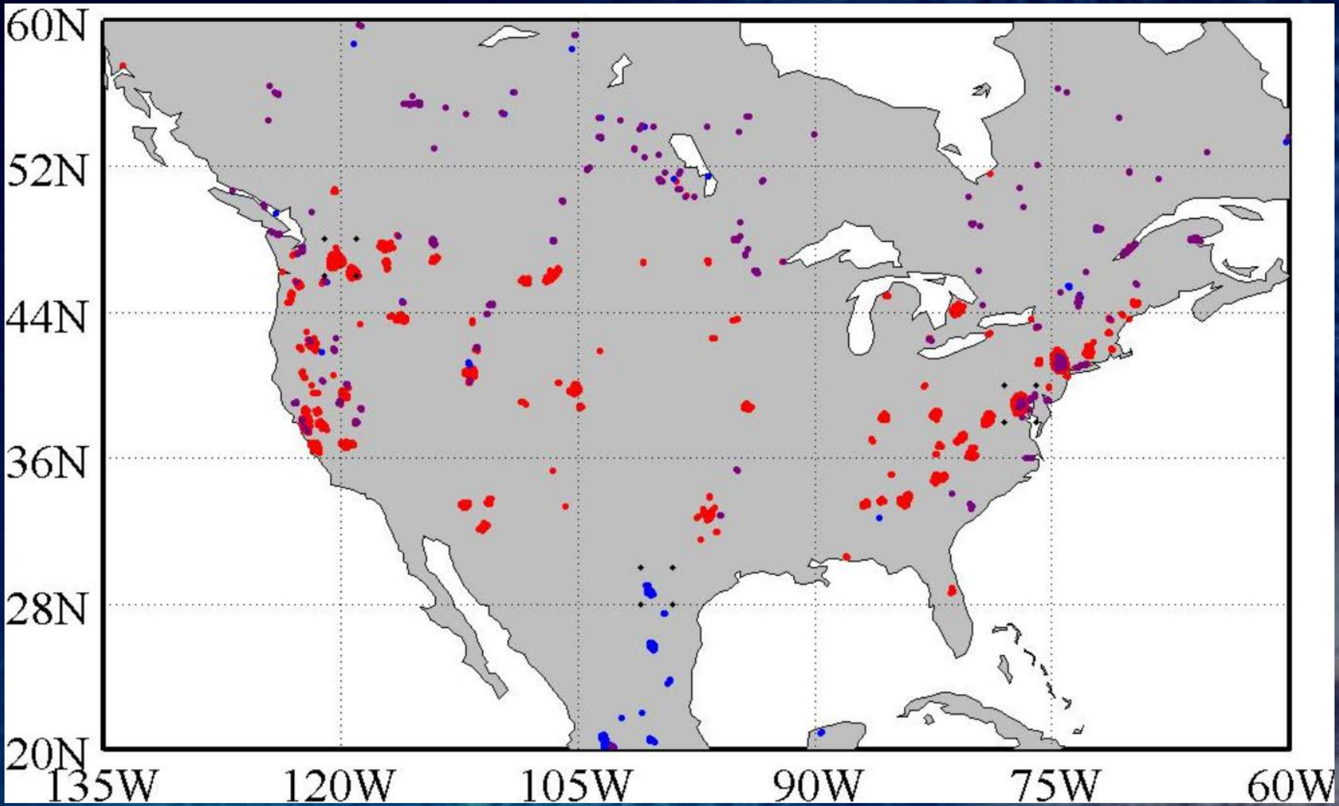
$$\vec{V}_i = \begin{pmatrix} (TB_{10H} - TB_{18H})_i \\ (TB_{18V} - TB_{23V})_i \\ (TB_{18H} - TB_{23H})_i \\ (TB_{23V} - TB_{37V})_i \\ (TB_{23H} - TB_{37H})_i \end{pmatrix}$$

N is the total number of data points

μ and σ are the mean and standard deviation of the five RFI indices

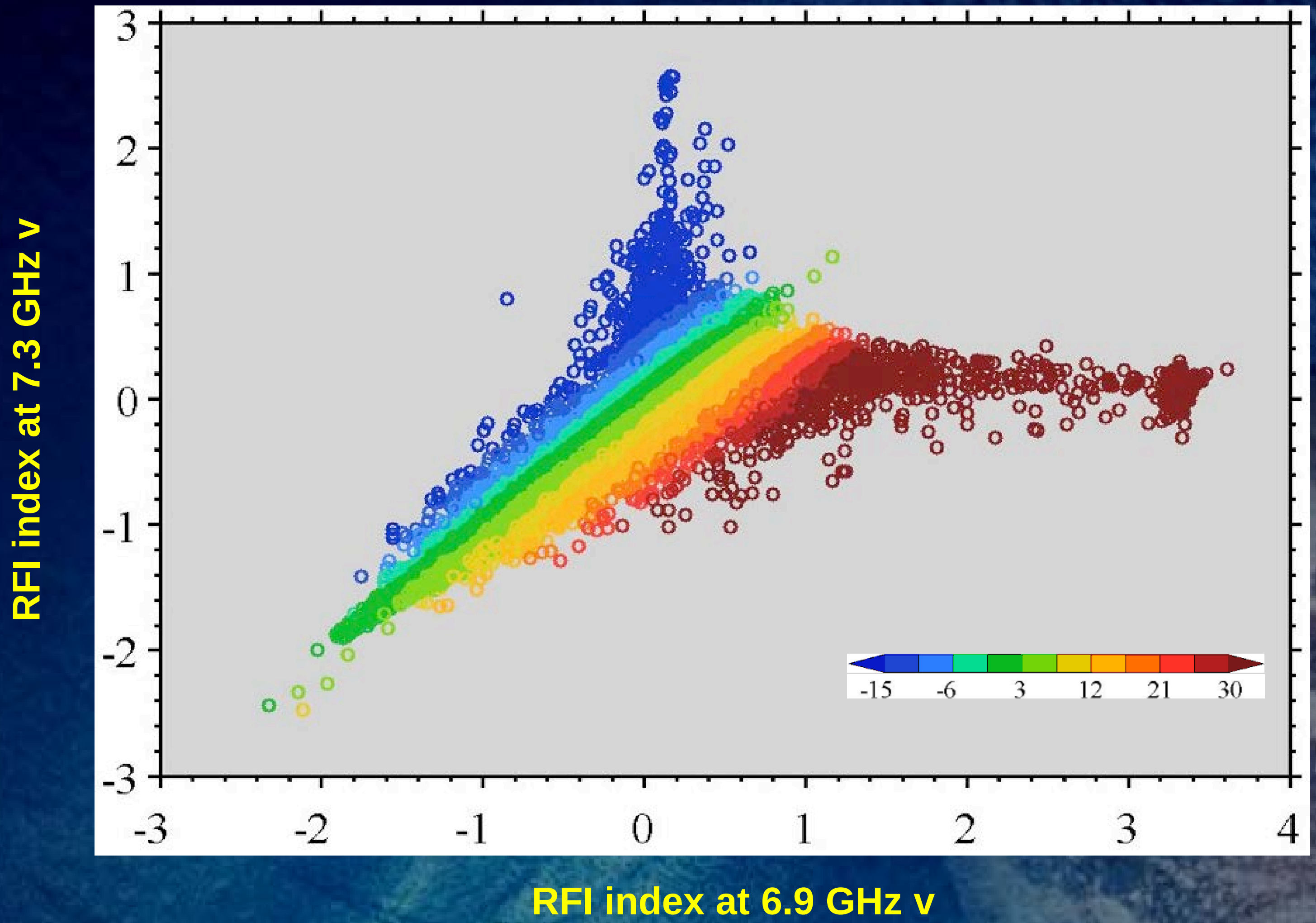
NPCA: Normalized PCA

AMSR2 RFI Signals Detected by DPCA

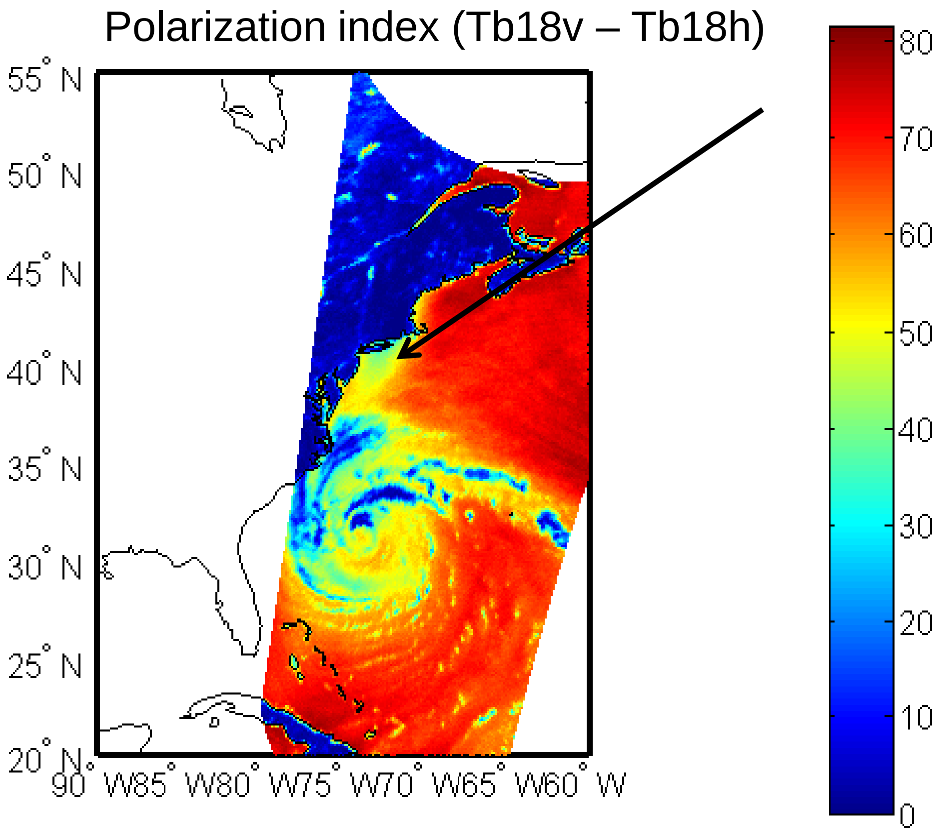


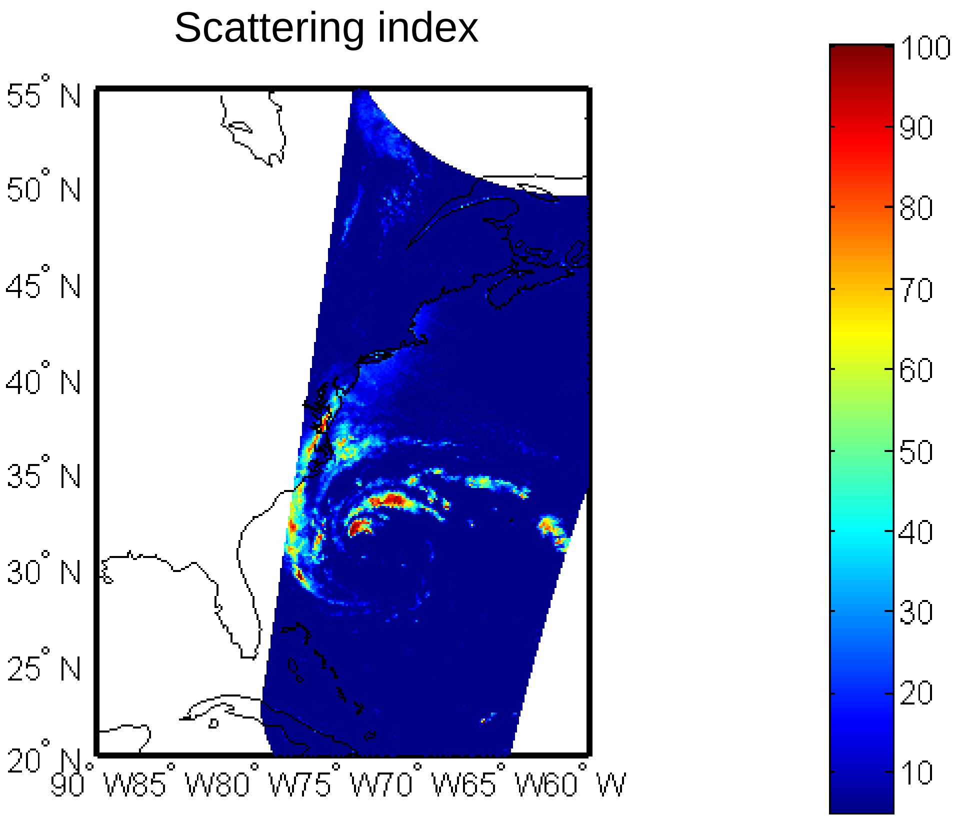
RFI at 6.9 GHz (red) and 7.3 GHz (blue), both (purple)

Differences of RFI Index at 6.9 and 7.3 GHz channels over North America using NPCA

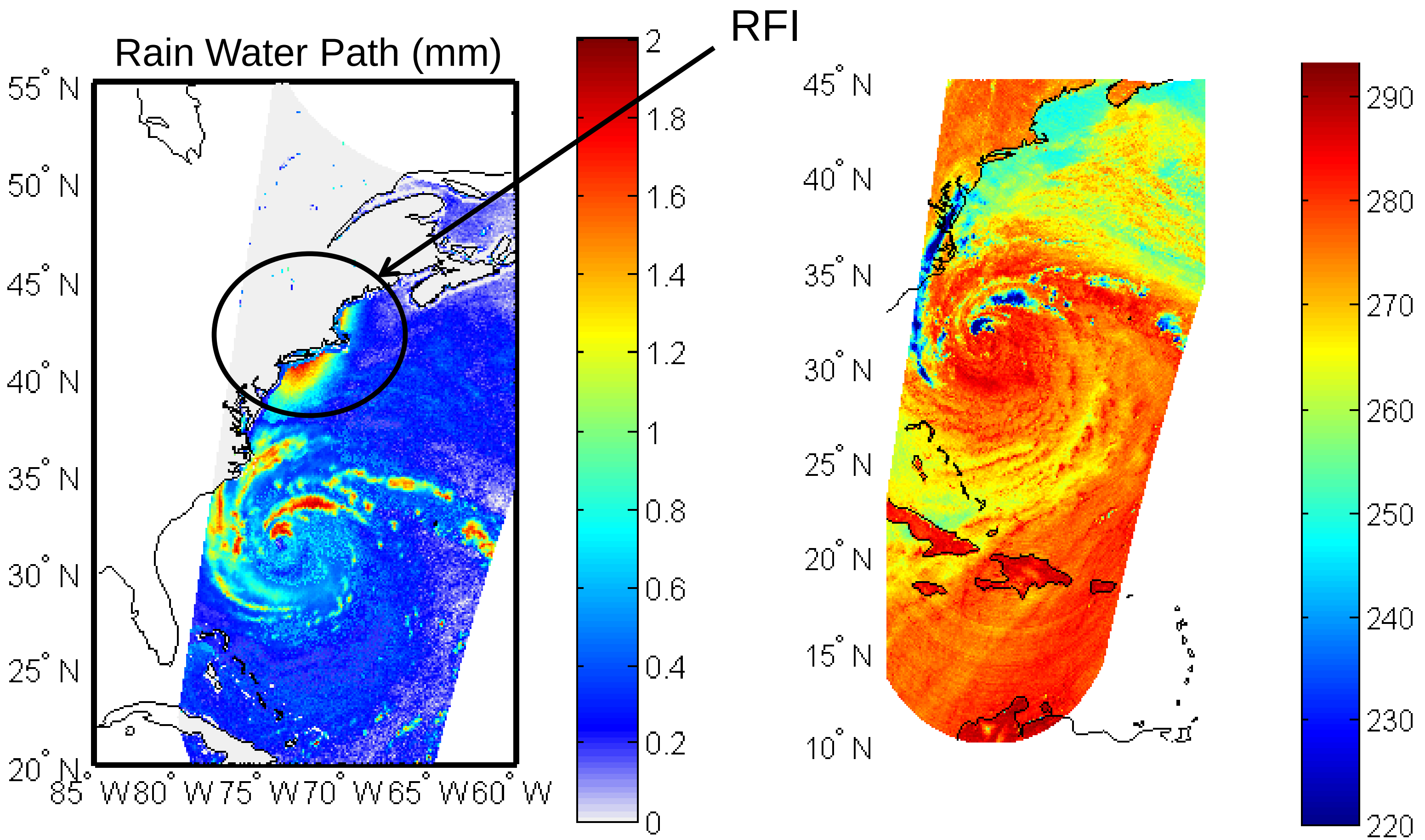


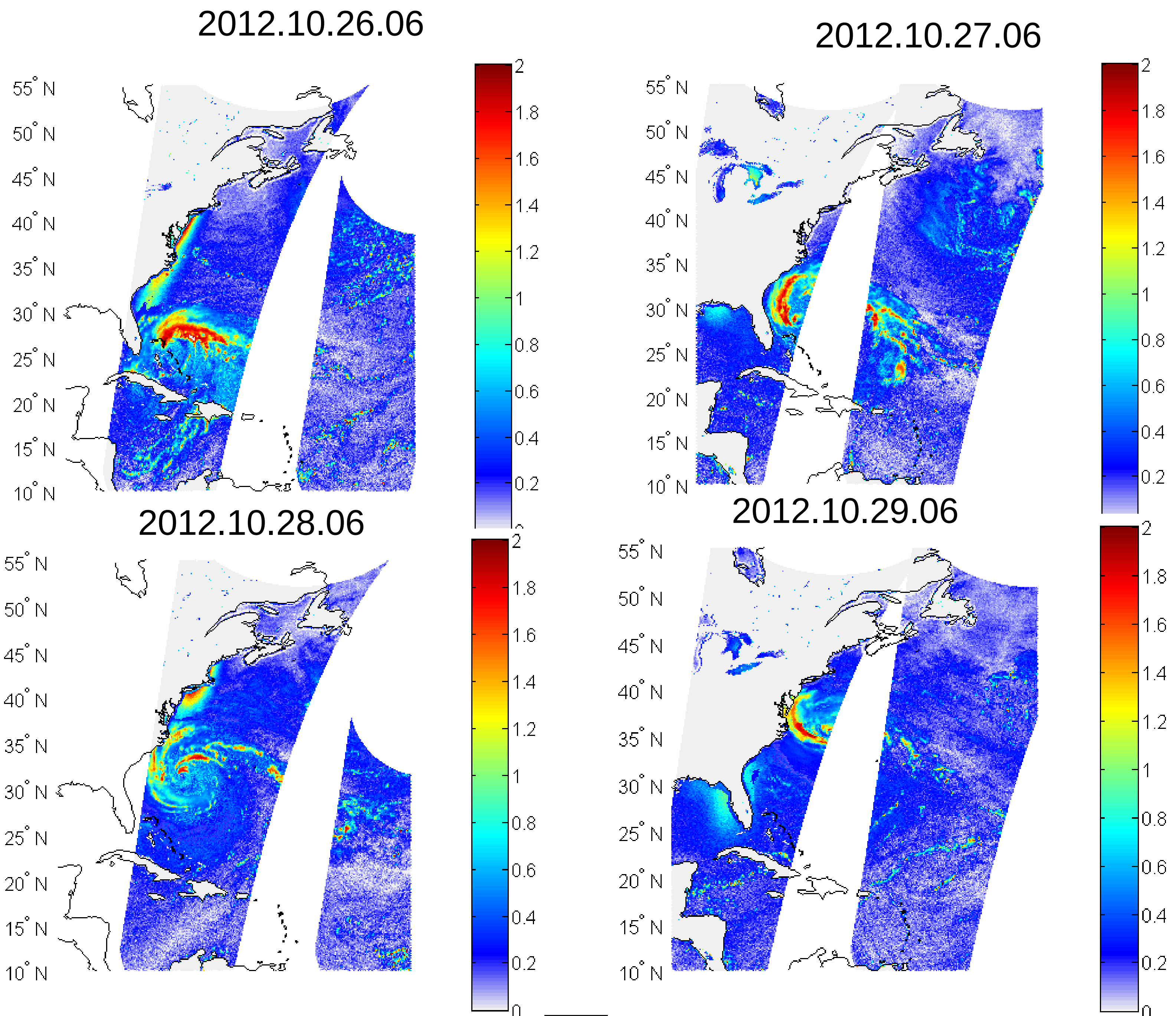
Polarization and Scattering Index from Hurricane Sandy





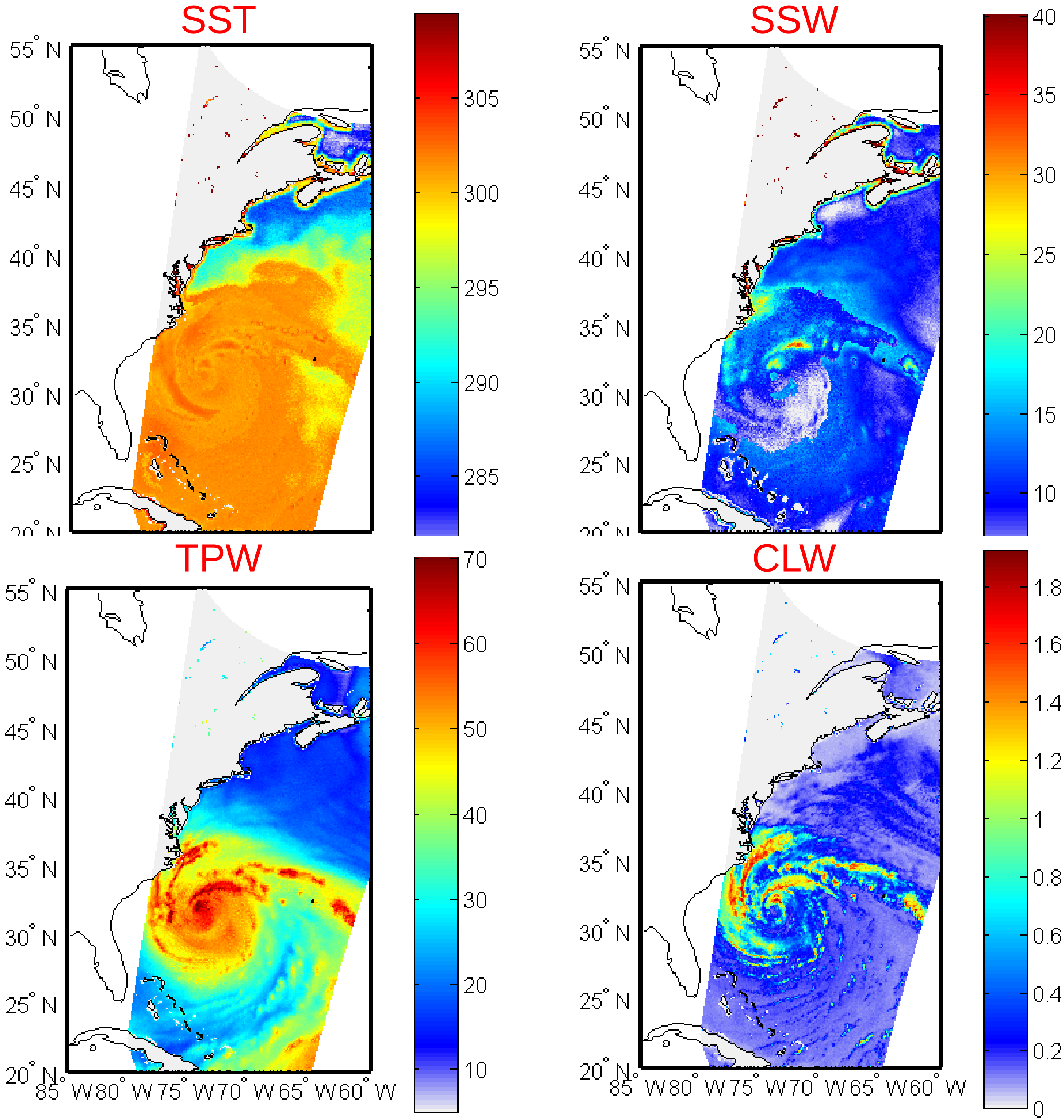
Oceanic RFI Contamination





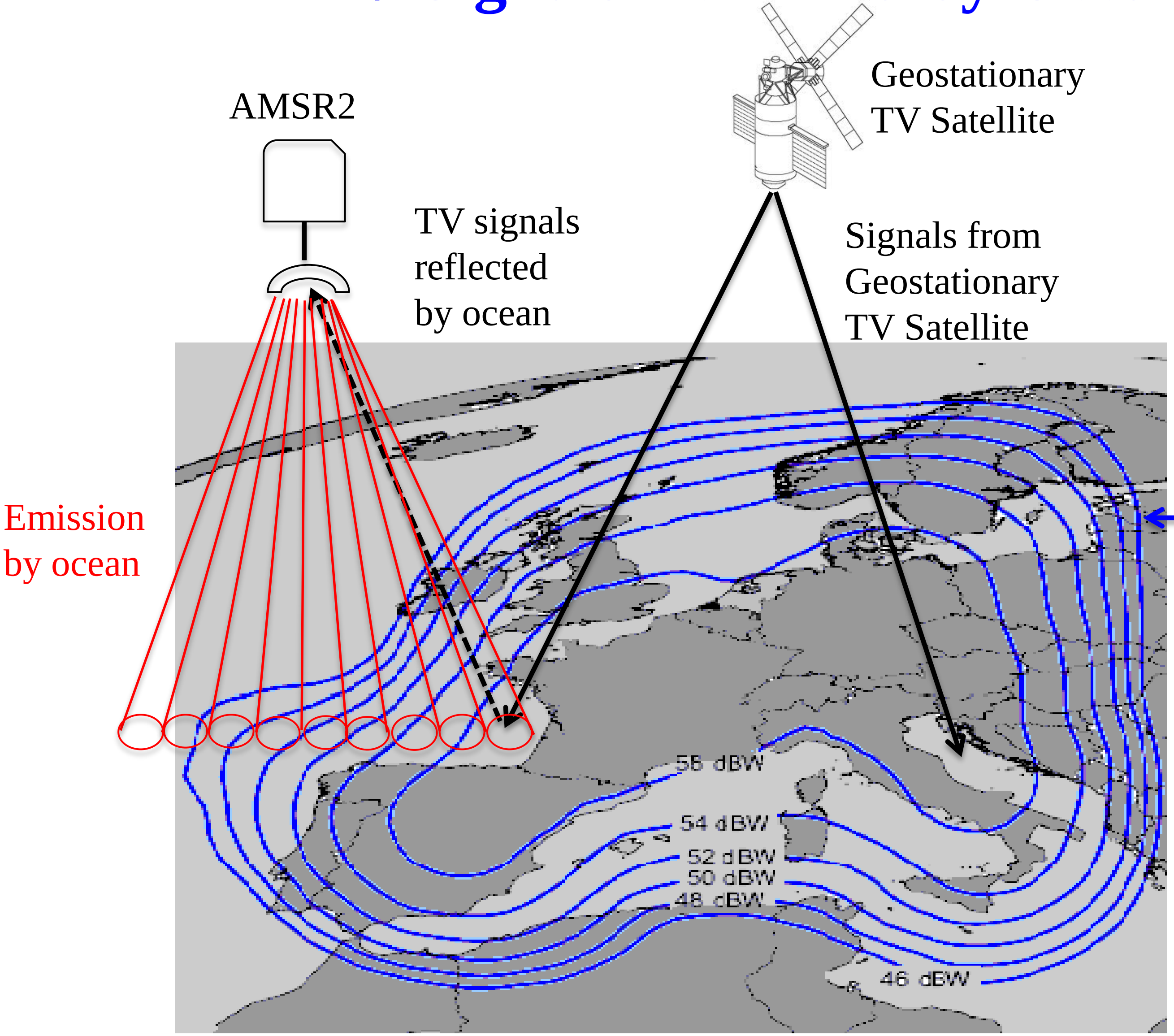
2012.10.26.06
2012.10.27.06
2012.10.28.06
2012.10.29.06
55° N
50° N
45° N
40° N
35° N
30° N
25° N
20° N
15° N
10° N
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0

Retrievals



SST
SSW
TPW
CLW
55° N
50° N
45° N
40° N
35° N
30° N
25° N
20° N
85° W 80° W 75° W 70° W 65° W 60° W
305
300
295
290
285
40
35
30
25
20
15
10
70
60
50
40
30
20
10
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0

TV Signals Reflected by Ocean – RFI

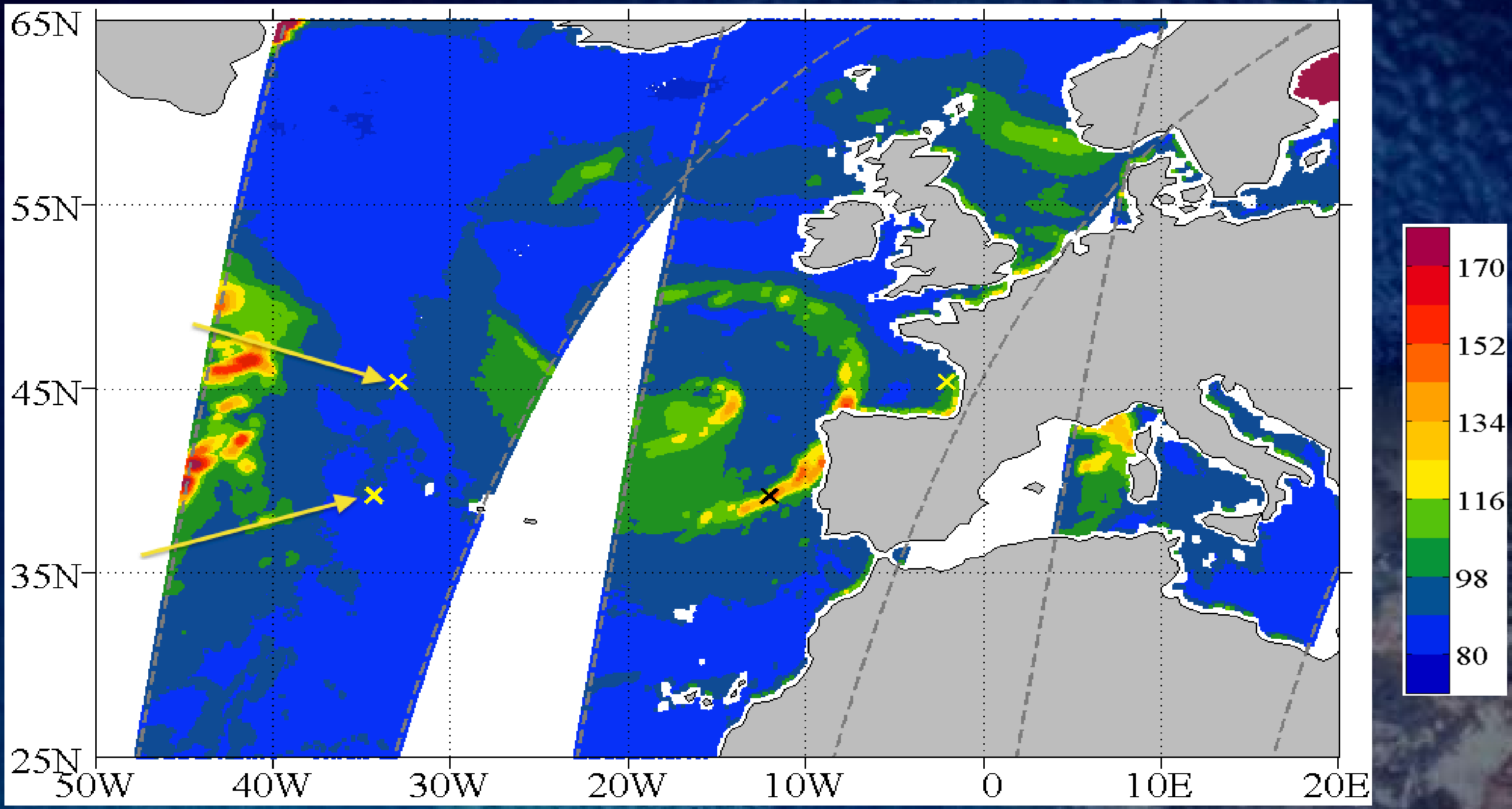


Geostationary satellite TV signals reflected by ocean surface is a major source of maritime RFI.

RFI signals are mixed with natural emission from pixels interfered by reflected TV signals.

AMSR-E Brightness Temperatures (H-Pol) at 10.7 GHz

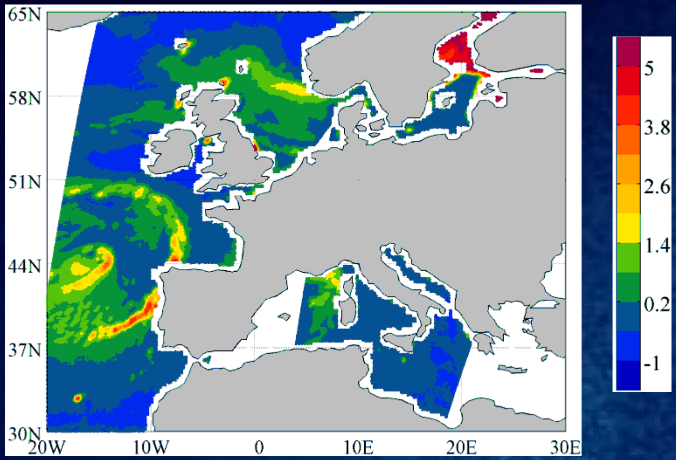
February 16, 2011



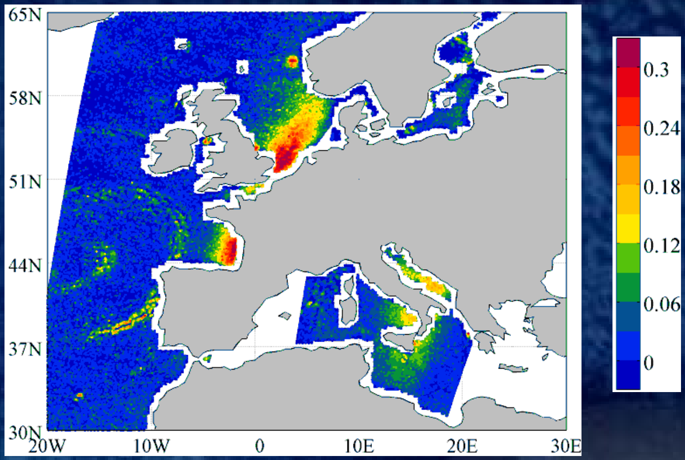
AMSR-E RFI Extraction at 10.7 GHz from DPCA

February 16, 2011

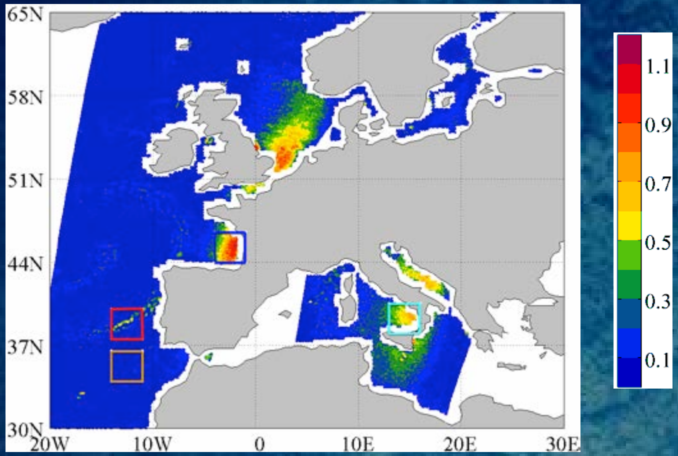
(a) Reconstructed TB from NPCA-A1



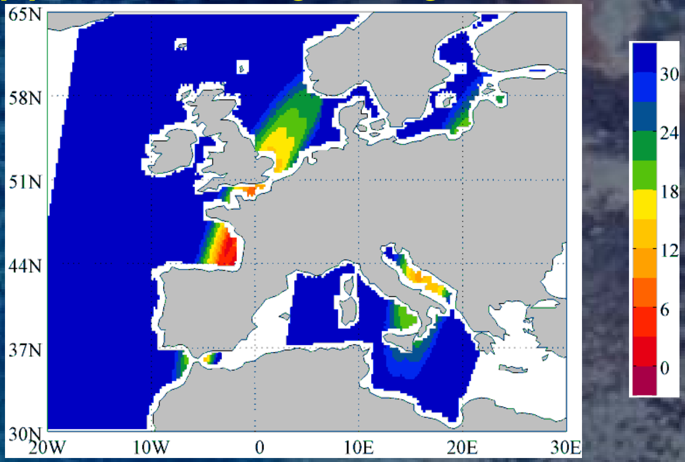
(b) Reconstructed TB from NPCA- A2



(c) Reconstruct DTB from PCA applied to (b)



(d) Geo Satellite glint angle



Summary

1. Double PCA can detect the RFI signals over all geographic locations
2. AMSR2 land RFI signals at 6.9 and 7.3 GHz are well extracted from DPCA and the channels are impacted differently.
3. Coastal RFI signals are equivalently extracted from DPCA as well as satellite glint angle

Future Work

1. Refine AMSR-E oceanic RFI algorithm for AMSR2 applications
2. Refine Windsat RFI glacial region algorithm for AMSR2 applications
3. Improve AMSR2 land RFI algorithm

Ocean Scene EDR

Presented by

Zorana Jelenak
UCAR

Ocean Scene EDRs

- The Ocean Scene EDRs (EDRs retrieved over the global oceans) include
  - » Sea Surface Temperature
  - » Total Preciptable Water
  - » Cloud Liquid Water
  - » Ocean Surface Wind Speed
  - » Rain Rate (addressed by GPROF)

AMSR-2 EDR Algorithm Approach for Day-1 ‘Ocean Scene’ EDRs

- Initial
  - Multi stage regression ocean EDR algorithms
  - 2010 GPROF Rain Rate retrieval algorithm
- Day-2
  - Iterative multistage regression + Bayesian probability matching technique algorithm capable of producing simultaneous ocean scene EDR’s and Rain Rate retrievals

Day-1 Product Requirements

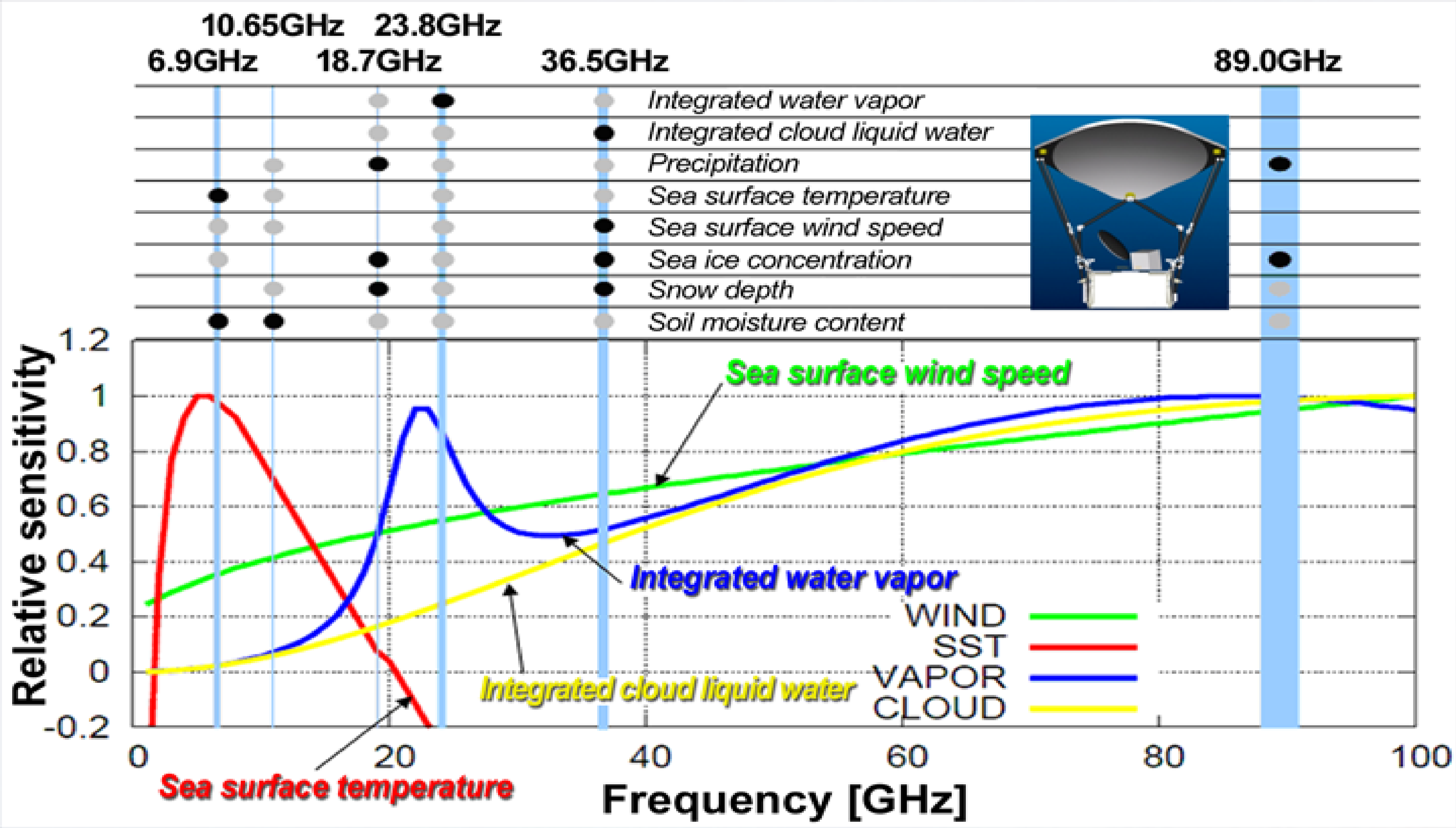
- JPSS L1RD Supplement (View Slides 37-39,45-46)

Ocean Scene EDRs

- All Ocean Scene EDR's will be reported over the global oceans
- Ocean Scene EDR's will be produced at 4 spatial resolutions defined by the lowest frequency channel in the Brightness Temperature groupings as described in Table 1

Resolution	Sampling	SST	WSPD	TPW	CLW	RR
40km (6.8GHz)	25km	X	X	X	X	X
33km (10GHz)	10km		X	X	X	X
21km (23GHz)	10km			X	X	X
10km (37GHz)	10km				X	X

Radiometric Sensitivity



Brightness Temperature (Tb) Dependence - AMSR2

- With measurements from 12 channels, 6 frequencies and 2 polarizations (vertical and horizontal), there is sufficient independent information to determine the atmospheric (rain, cloud liquid and water vapor), wind and SST contributions to the measured Tb.

Basic Matchup Data Set

- AMSR2 basic data set created to serve as the base for AMSR2 calibration and geophysical retrieval algorithm development
- It consists of AMSR2 (L1B or L1R) parameters in addition to ancillary data
  - » GDAS, ECMWF, GHRSST
- Ancillary data were spatially and temporally interpolated to AMSR2 time and location
  - » Bilinear interpolation

Basic Data Set – cont.

AMSR2	ECMWF	GDAS	GHRSST
All channels measured Tb	Wind speed & Direction	Wind speed & Direction	SST
All channels simulated Tb	SST	SST	
Lon./Lat./Time	Skin Temperature	CLDW	
Antenna Azimuth/EIA	Surface pressure		
Sun Azimuth & Elevation	TCWV		
QC flags			

Satellite Collocation Data Set

- Collocation data set consists of collocated points between AMSR2 and TMI
  - » Collocation criteria: 25 km max. distance and 30 mins. max time difference
- All parameters contained in the basic set are carried to the collocation dataset
- TMI data used
  - » 1B11 version 7.0 TMI calibrated Tb
  - » Remote Sensing Systems (RSS) TMI EDR version 4.0

Collocation Data Set – cont.

Collocation Set

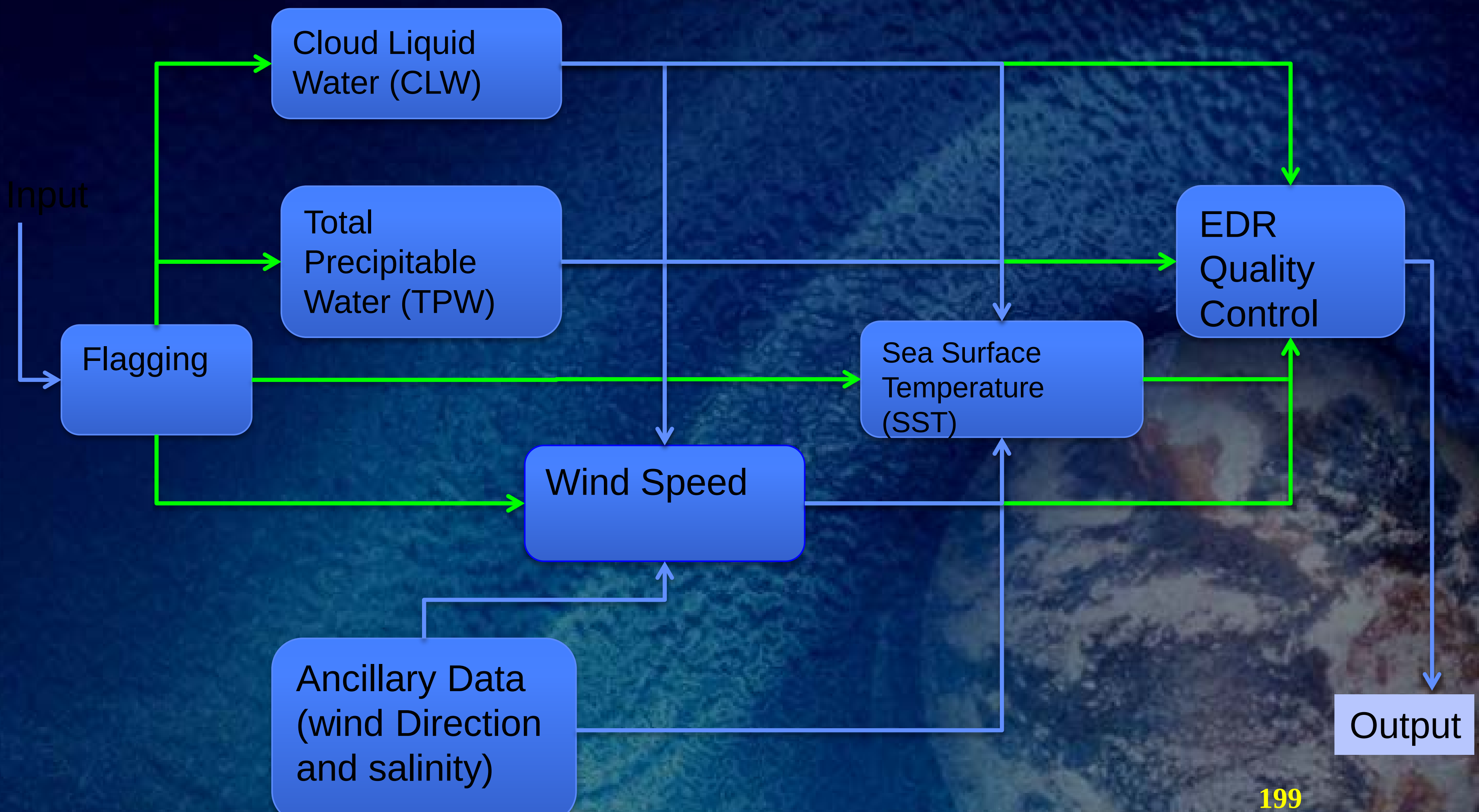
AMSR2 Basic Set

AMSR2	ECMWF	GDAS	GHRSST	TMI	RSS
All channels measured Tb	Wind speed & Direction	Wind speed & Direction	SST	All channels measured Tb	Wind speed
All channels simulated Tb	SST	SST		All channels simulated Tb	SST
Lon/Lat/Time	Skin Temperature	CLDW		Lon/Lat/Time	Lon/Lat/Time
Antenna Azimuth/EIA	Surface pressure				Rain
Sun Azimuth & Elevation	TCWV				Vapor
QC flags					

Ocean Scene EDR Algorithm

- Multiple stage non linear multi channel regression
- Next step will be a semi-physical (or semi-empirical) based approach combining multiple regression and Bayesian search algorithms

Ocean Scene EDR Processing Flow



Ocean Scene EDR Flagging

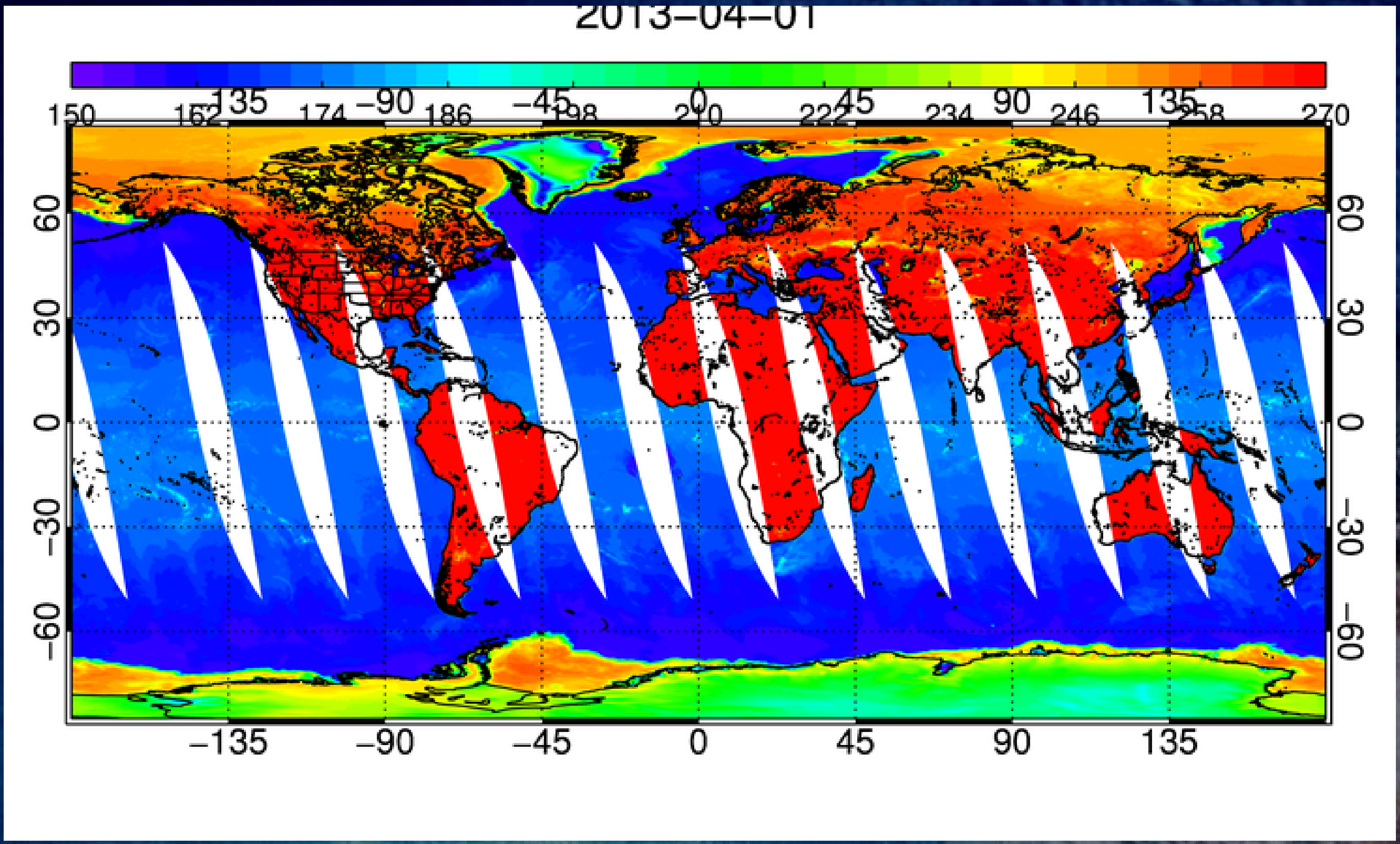
- RFI
  - » The 6 and 7 GHz channels are checked for RFI contamination
  - » Flag is set for |T6V-T7V|>3
- Sun Glint
  - » Flag set when Azimuth < 15 ° and Elevation < 20° for channels 6-18Ghz

Ocean Scene EDR Flagging

- Sea Ice Flagging
  - » Read in GRHSST Ice data file
    - – Utilize most recent file going back 5 days
  - » Check nearest ¼ degree and flag if sea ice detected
  - » Additional Tb check implemented for case when GHRSST file unavailable
    - – Checks 6 GHz v-pol followed by 18 GHz v-pol – 18 GHz h-pol

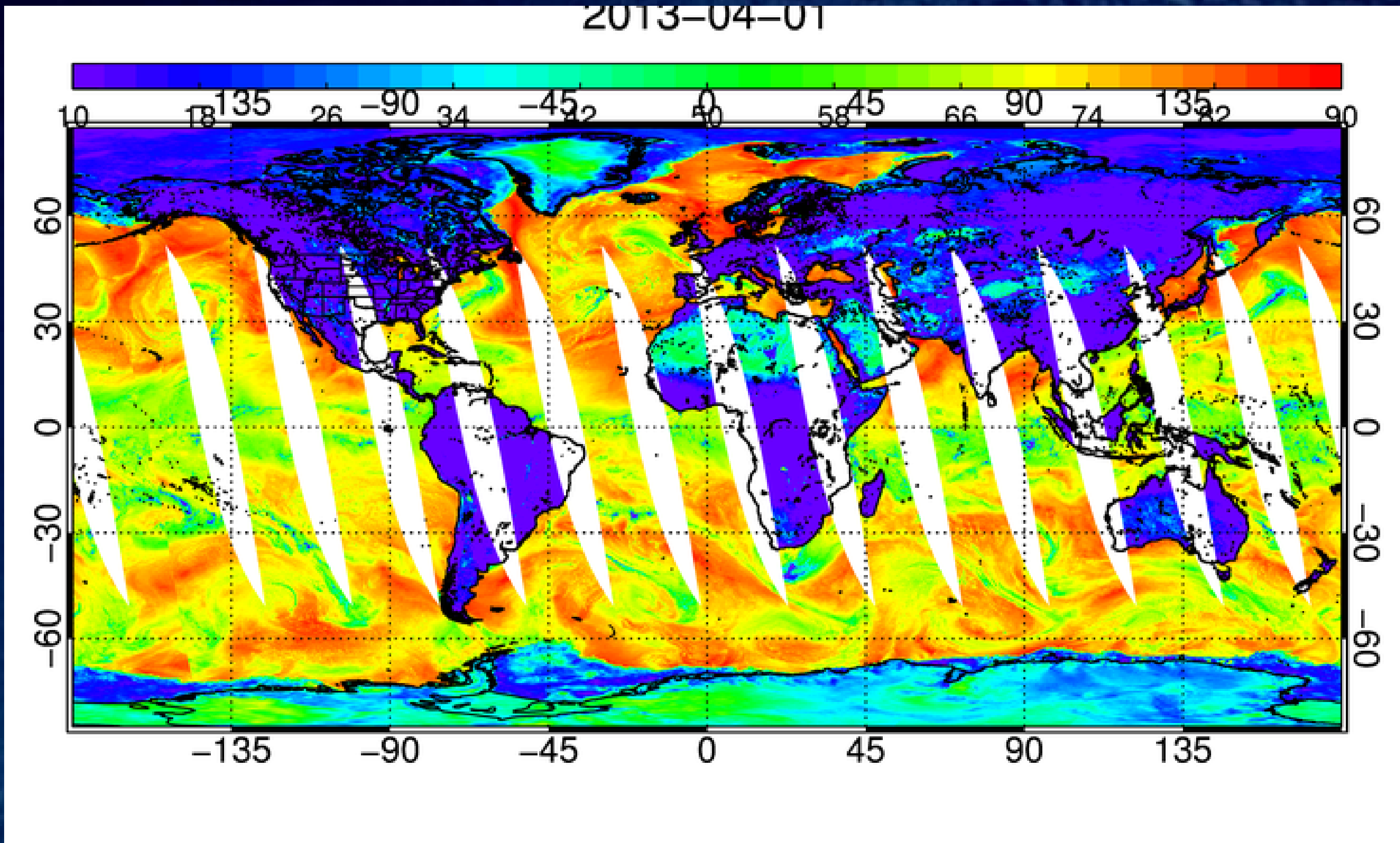
Ocean Scene EDR Flagging

For latitudes higher than 50 degrees check if 6 GHz V-pol > 190



Ocean Scene EDR Flagging

Secondary check if 18 GHz V-pol – 18 GHz H-pol < 35



Ocean Scene EDR Flagging

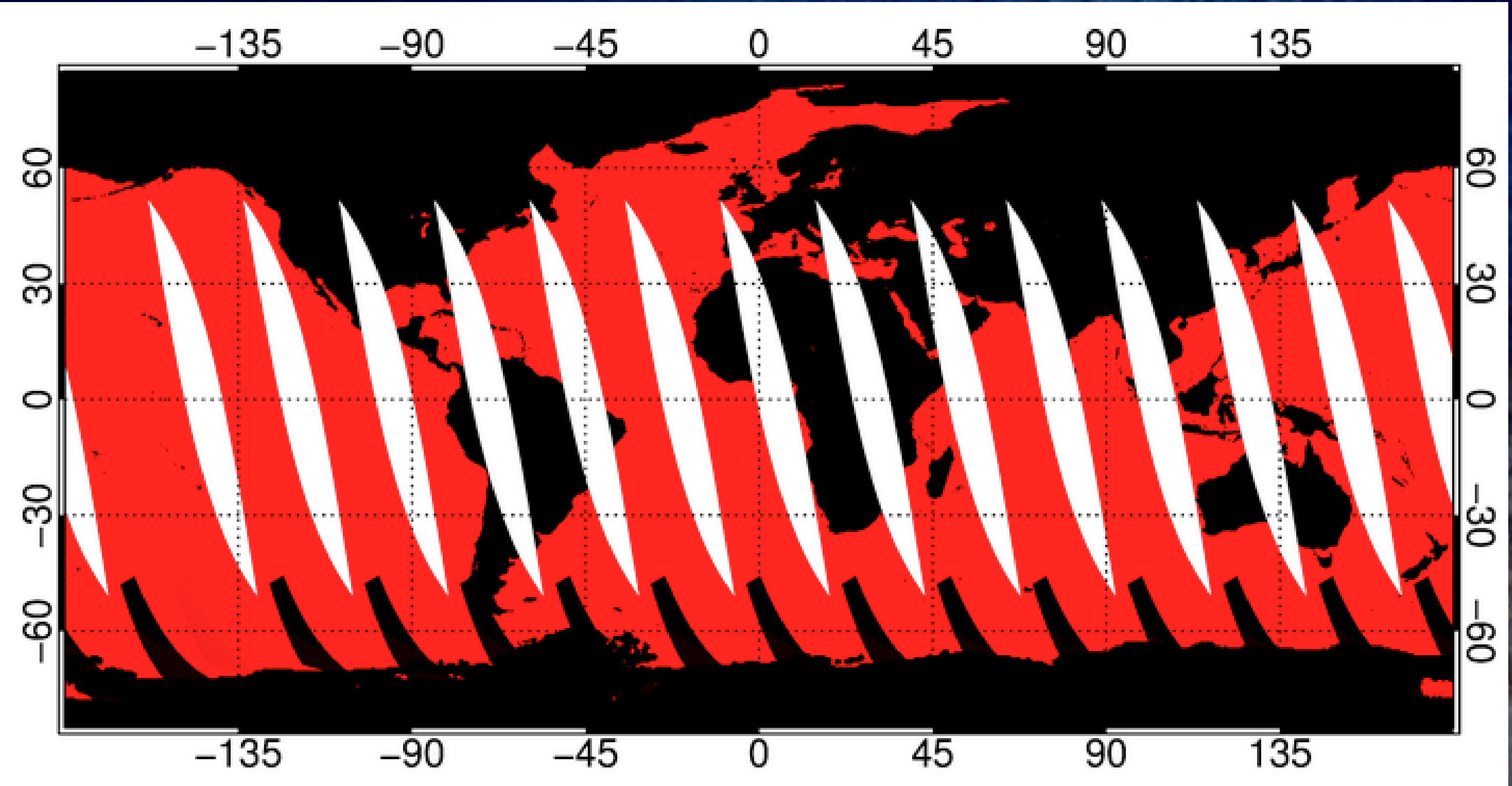
- Utilize included Land Percentage Flag
  - » < 5% indicates ocean
  - » > 90% indicates land
  - » > 90% and > 5% indicates coast

Ocean Scene EDR Flagging

- Internal Flags passed from SDR files
  - » Scan Quality
    - – Continue retrieval but flag as unreliable
  - » Pixel Quality
    - – Currently empty but will propagate for future use

Ocean Scene EDR Flagging

Example of all flags plotted



EDR Flagging Algorithm Processing Flow

- Ocean EDR flagging algorithm processing flow shown on slide #259

Ocean Cloud Liquid Water (CLW) - Algorithm

CLW Algorithm Development

Simulated Tb

AMSR-2 L1B
TIM matchup
data set

Tb Correction

Data flag
(Sun glint, RFI, Rain,
Cloud, ΔTb<Std(ΔTb)

1st stage regression

2st stage localized regressions

1st Stage Regression

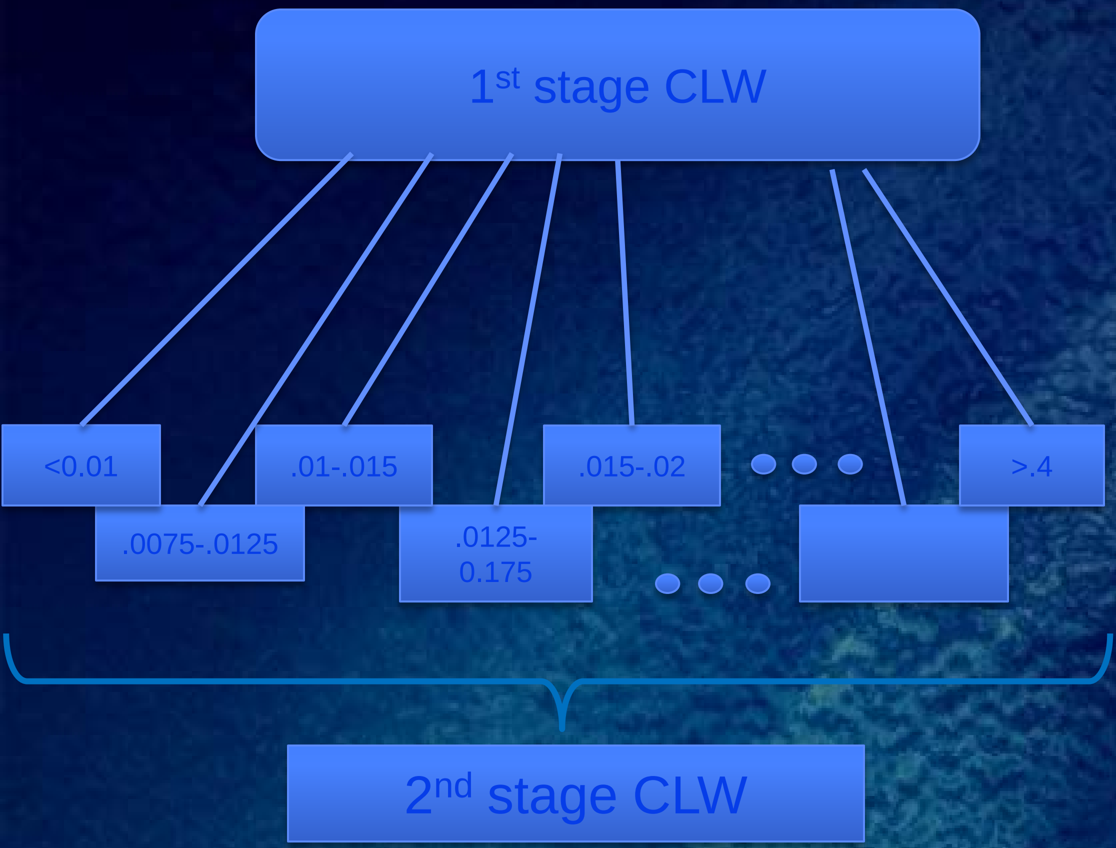
- Using AMSR-2/TMI matchups
  - » 5min time separation
  - » 10km spatial separation
  - » CRTM simulated Tb's using ECMWF input fields
- 9 channels used: 6,7 and 10Ghz H-pol, 18, 23 and 36Ghz, H/V pol

$$tpw = \sum_{i=1,3} (a_i T_{Bi}) + \sum_{j=1,5} (b_{j,} \ln(285 - T_{Bj}))$$

$$T_{Bi} = T_B^{6H}, T_B^{7H}, T_B^{10H}$$

$$T_{Bj} = T_B^{18H/V}, T_B^{23H/V}, T_B^{36H/V}$$

2^{nd} Stage Regression



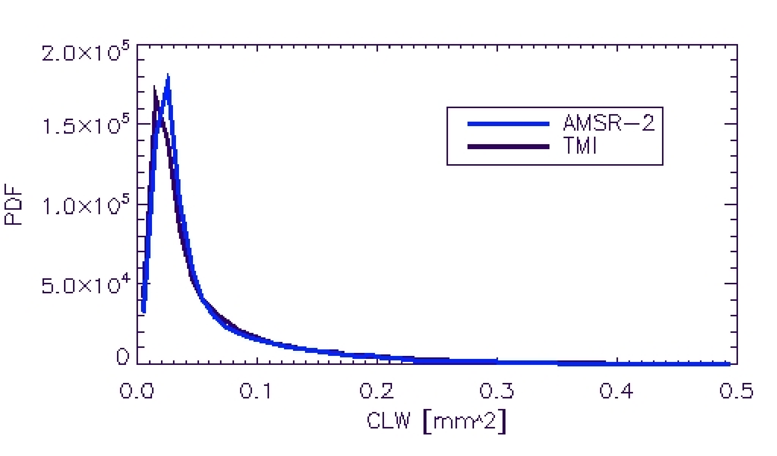
- Using first stage regressed TPW derive localized regressions within every 0.01mm^2 bins
  - » 40 localized regressions
- 9 Channels used: 6,7,10 Hpol and 18, 23 and 36Ghz, H/V pol
- In overlapping bin regions final clw is average of clw from two adjacent algorithms

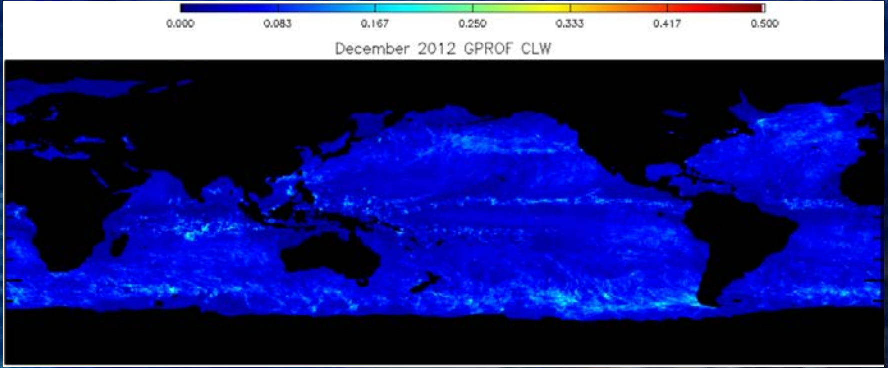
CLW Validation

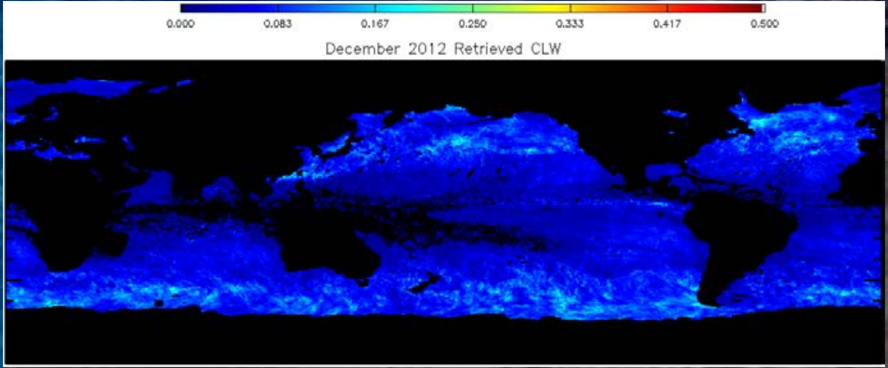
- TMI/AMSR-2 CPW matchups
- AMSR-2 GPROF CLW, Precipitation EDR
- CPW performance
  - Mean and Standard Deviation
    - Across measurement swath
    - As a function of other ocean EDR's
  - PDF comparisons
  - Global anomalies

CLW Initial Algorithm Performance

	Accuracy	Uncertainty
AMSR-2	0.038	-0.002
L1RD	0.05	0.01





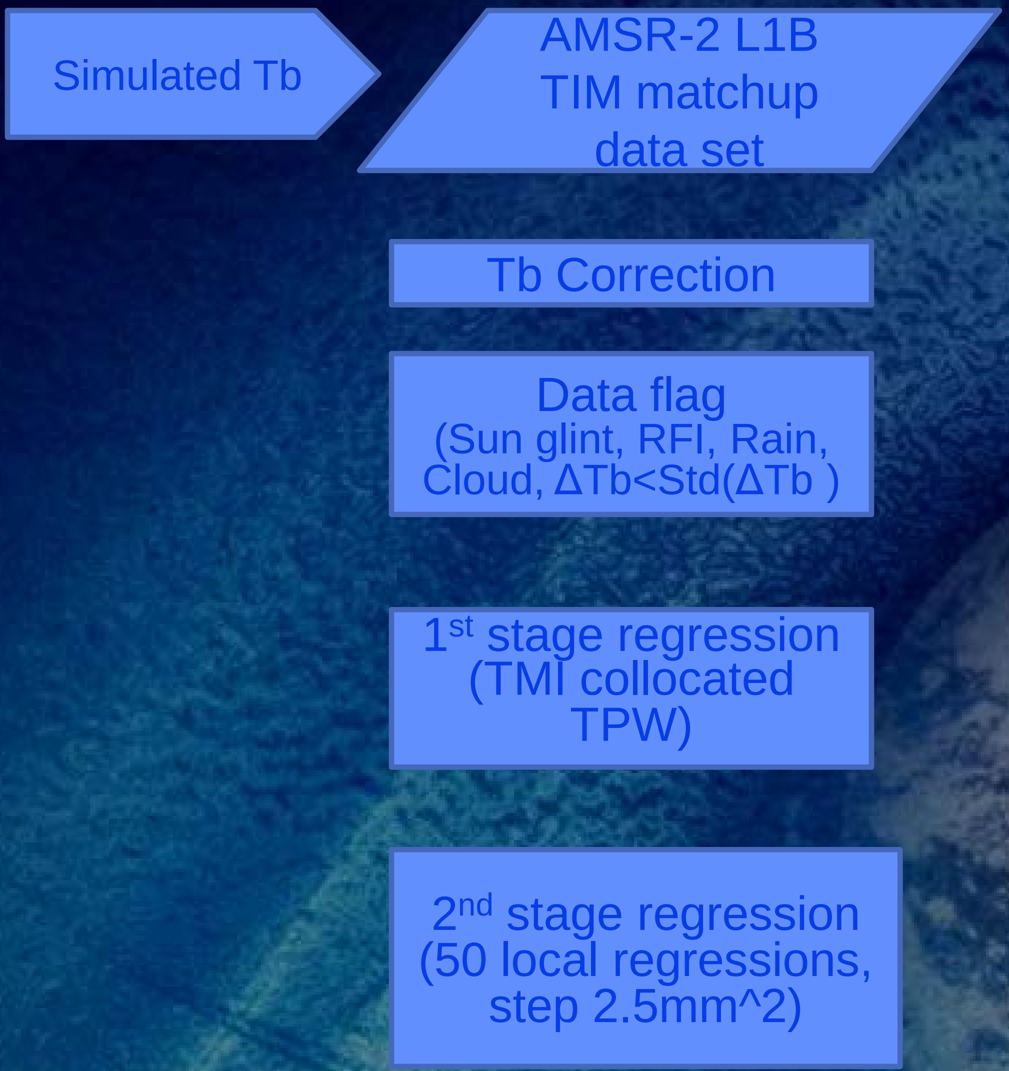


CLW Algorithm Processing Flow

- Ocean CLW algorithm processing flow shown on slide #260

Ocean Total Precipitable Water (TPW) - Algorithm

TPW Algorithm Development

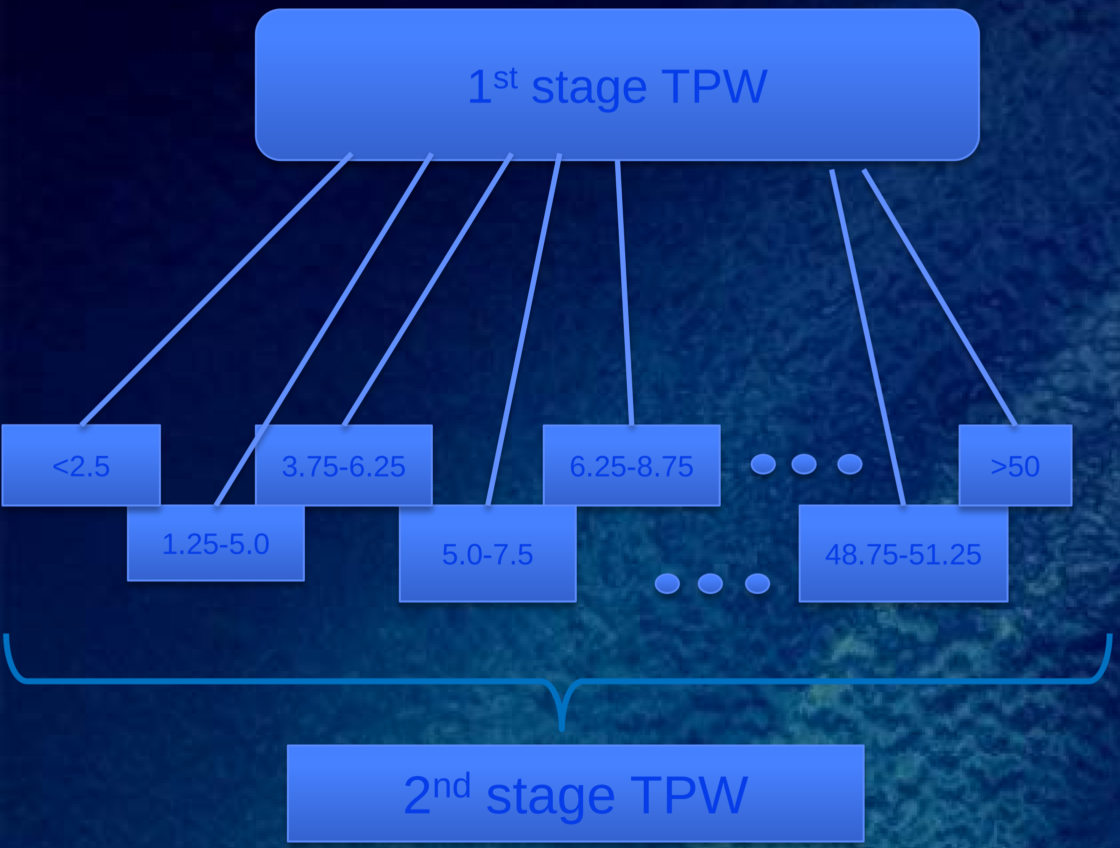


1^{st} Stage Regression

- Using AMSR-2/TMI matchups
  - » 5min time separation
  - » 10km spatial separation
  - » CRTM simulated Tb's using ECMWF input fields
- 6 channels used: 18, 23 and 36Ghz, H/V pol

$$tpw = \sum_{i=1,3} (a_{i1} T_{Bi} + a_{a2} T_{Bi}^2)$$

2nd Stage Regression



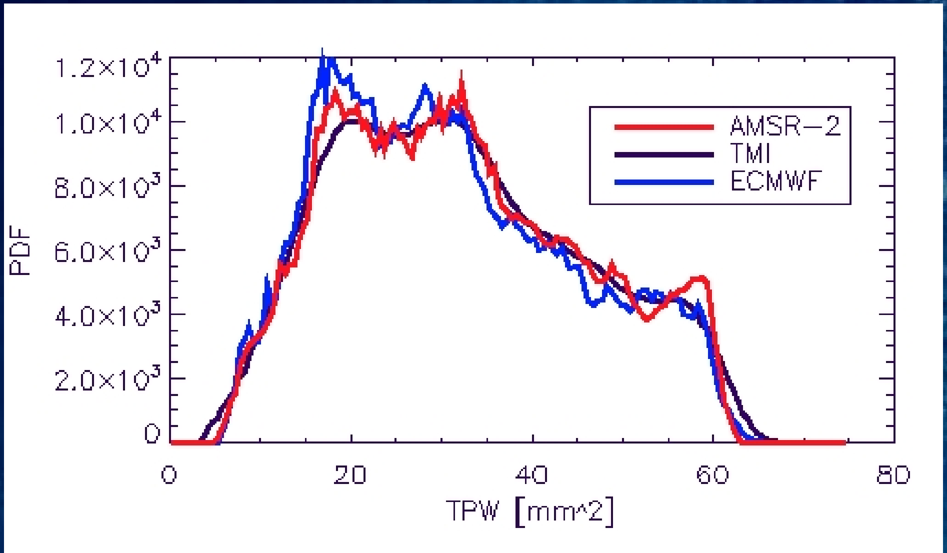
- Using first stage regressed TPW derive localized regressions within every 2.5mm^2 bins
- Channels used: 18, 23 and 36Ghz, H/V pol
- In overlapping bin regions final tpw is average of tpw from two adjacent algorithms

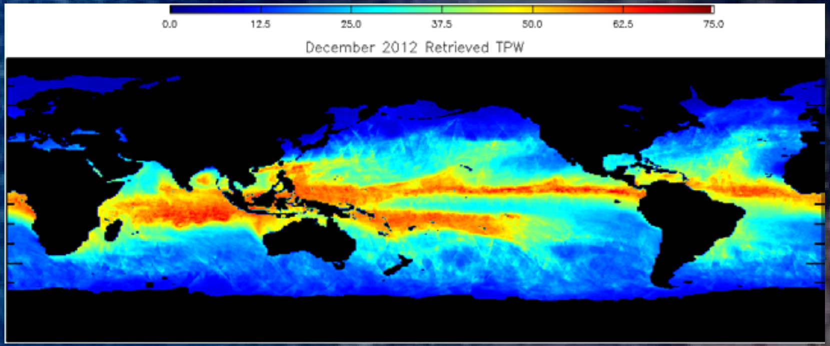
TPW Validation

- TMI/AMSR-2 TPW matchups
- AMSR2 GPS-Met data from Bermuda
- AMSR-2/ECMWF TPW comparison
- TPW performance
  - Mean and Standard Deviation
    - Across measurement swath
    - As a function of other ocean EDR's
  - PDF comparisons
  - Global anomalies

TPW Initial Algorithm Performance

	Accuracy	Uncertainty
AMSR2-TMI	0.16	0.92
AMSR2-ECMWF	-1.03	2.24
TMI-ECMWF	-1.04	2.23
L1RD	1mm	2mm or 10%





TPW Algorithm Processing Flow

- Ocean TPW algorithm processing flow shown on slide #261

Ocean Surface Wind Speed - Algorithm

Brightness Temperature (Tb) Dependence - AMSR2

- The sea surface roughness is typically parameterized in terms of the near-surface wind speed and wind direction, where the sea surface roughness is closely correlated with the local wind field.
- The spectral and polarization signatures of the surface roughness and intervening atmosphere are quite different from the SST signature, which permits the contribution of these effects to separated or determined through use of multiple frequencies and polarizations.

Algorithm Input: Ancillary Data

- Ancillary Data Needed:
  - » Global NWP forecast fields

Wind Speed Algorithm Development

CLW,TPW

Flaggin
g

1st stage regression

Global wind speed

> 50 degrees latitude

5 degree bin

5 degree bin

5 degree bin

2nd stage regression

< -50 degrees latitude

Wind direction correction

EAI correction

Quality control

5 degree latitude bins with 1 degree overlap between 50N and 50S

Initial Data Flagging

- Data flagged for
  - » CLW > $0.2mm^2$ data discarded
  - » Sun glint – threshold flagging (slides 176-181)
  - » RFI – threshold flagging (slides 176-181)
  - » Out of bound Tb's based on simulated Tb
    - – $\Delta Tb < Std(\Delta Tb)$ (slides 176-181)

1st Stage Regression

- Using Basic collocation data set
  - » CRTM simulated Tb's using ECMWF input fields
  - » GHRSST as ground truth
  - » GDAS and AMSR2 retrieved wind speed
  - » CLW and TPW from AMSR2
- 22 channels used; all except 23Ghz

$$wspd = \sum_{i=1,3} (a_{i1} T_{Bi} + a_{a2} T_{Bi}^2)$$

2^{nd} Stage Regression

- Using 1^{st} regressed SST and 4 month global base matchup dataset localized 2^{nd} stage regression developed for each 5deg latitudinal bins

Correction for Wind Direction

- The surface emissivity depends upon the wind direction relative to the look azimuth direction
  - » The wind direction signal varies with wind speed reaching values around 3K peak-to-peak amplitude.
  - » Will lead to a significant error in wind speed
  - » Result in crosstalk in the accuracy error between SST, wind speed retrievals and relative wind direction

Correction for Wind Direction

- Correction for the wind direction signal requires binning data into wind direction bins for retrieval algorithm training
- Actual retrievals require wind direction input from an ancillary source
  - » NWS GFS forecast fields used for NRT retrievals
  - » NWS GDAS analysis used for training purposes

Earth Incidence Angle Variations

- Surface emissivity is also a function of the Earth Incidence Angle (EIA)
  - » Earth is an oblate sphere and thus the EIA can deviate +- XX from the nominal EIA of XX deg.

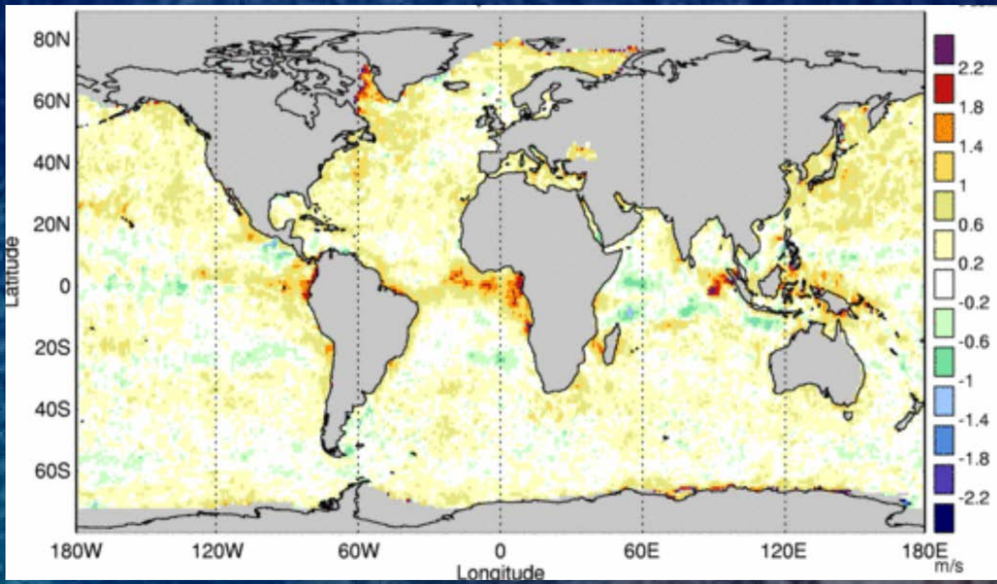
Wind Speed EDR Quality Control

- WSPD retrievals flagged if:
  - » Retrieved wspd <3m/s
  - » Retrieved wspd>25m/s
  - » High clw values >0.2mm^2
  - » High tpw values >55mm^2
  - » No GFS direction was available
  - » Not all 22 channels input Tb’s were used for retrievals

Wind Speed EDR Validation Plan

- Bias detection
  - » Biases come from
    - – From radiometer
      - Ocean currents
      - Calibration errors
      - Atmospheric stability
      - Sea state
    - – From model
      - Incorrect model physics
    - – Or from other causes
      - Sampling artifacts

O-B Speed bias



Bias Detection

Method	Advantage	Disadvantage
1. **O-B regression**	Quick and easy	Not exact (but in many cases good enough)
2. **Triple collocation**	Simultaneous (linear) calibration coefficients and errors	Requires collocated sparse buoy data More elaborate

Triple Collocations

$$w_{buoy} = t + \delta_{buoy}$$

w = wind component

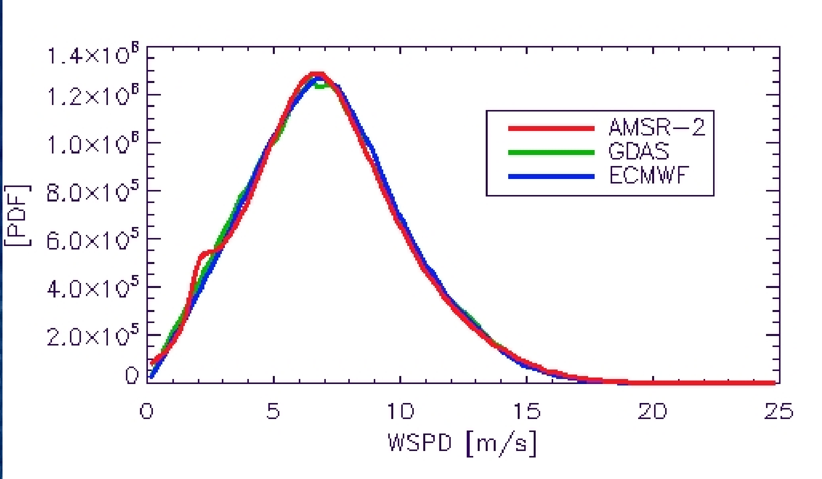
$$w_{scat} = a_{scat}t + b_{scat} + \delta_{scat}$$

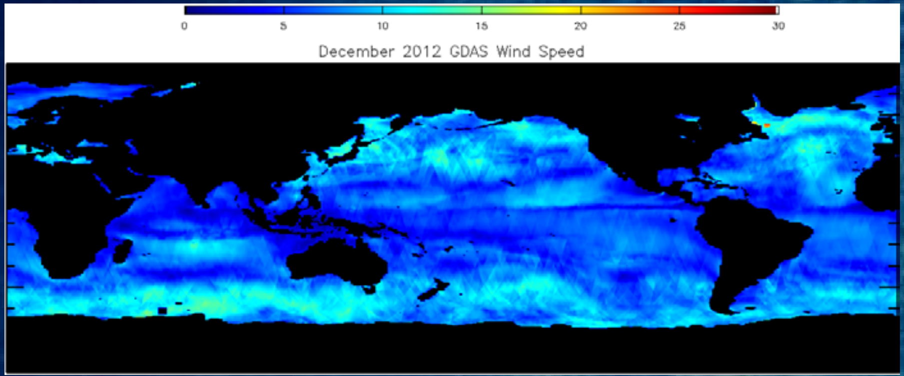
$$w_{back} = a_{back}t + b_{back} + \delta_{back}$$

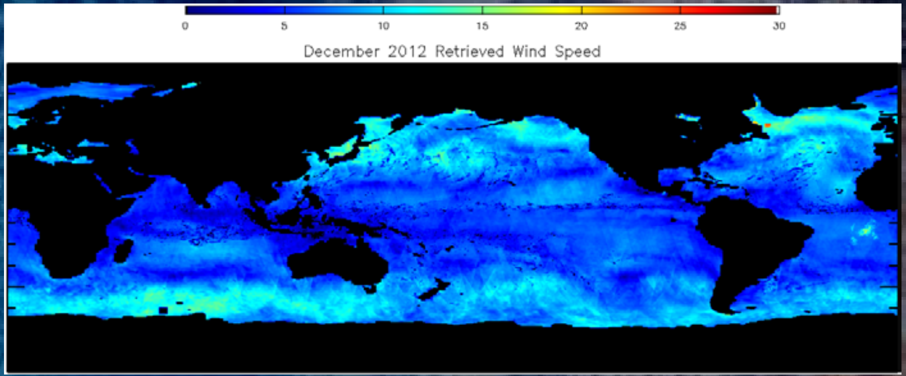
- Calculate first and second (mixed) moments
- Apply assumptions on errors and representation error
- Eliminate $<t>$ and $<t^2>$ (get rid of the truth)
- Solve for calibration coefficients and error variances $<\delta^2>$
- Apply CDF matching for higher order calibration (beyond linear)

WSPD Initial Algorithm Performance

	Accuracy	Uncertainty
AMSR2/GDAS	0.05	1.44
AMSR2/ECMWF	0.103	1.48
GDAS/ECMWF	-0.06	1.05
L1RD	0.5m/s	2m/s or 10%







Wind Speed Algorithm Processing Flow

- Ocean Wind Speed algorithm processing flow shown on slide #262

Ocean Sea Surface Temperature
SST - Algorithm

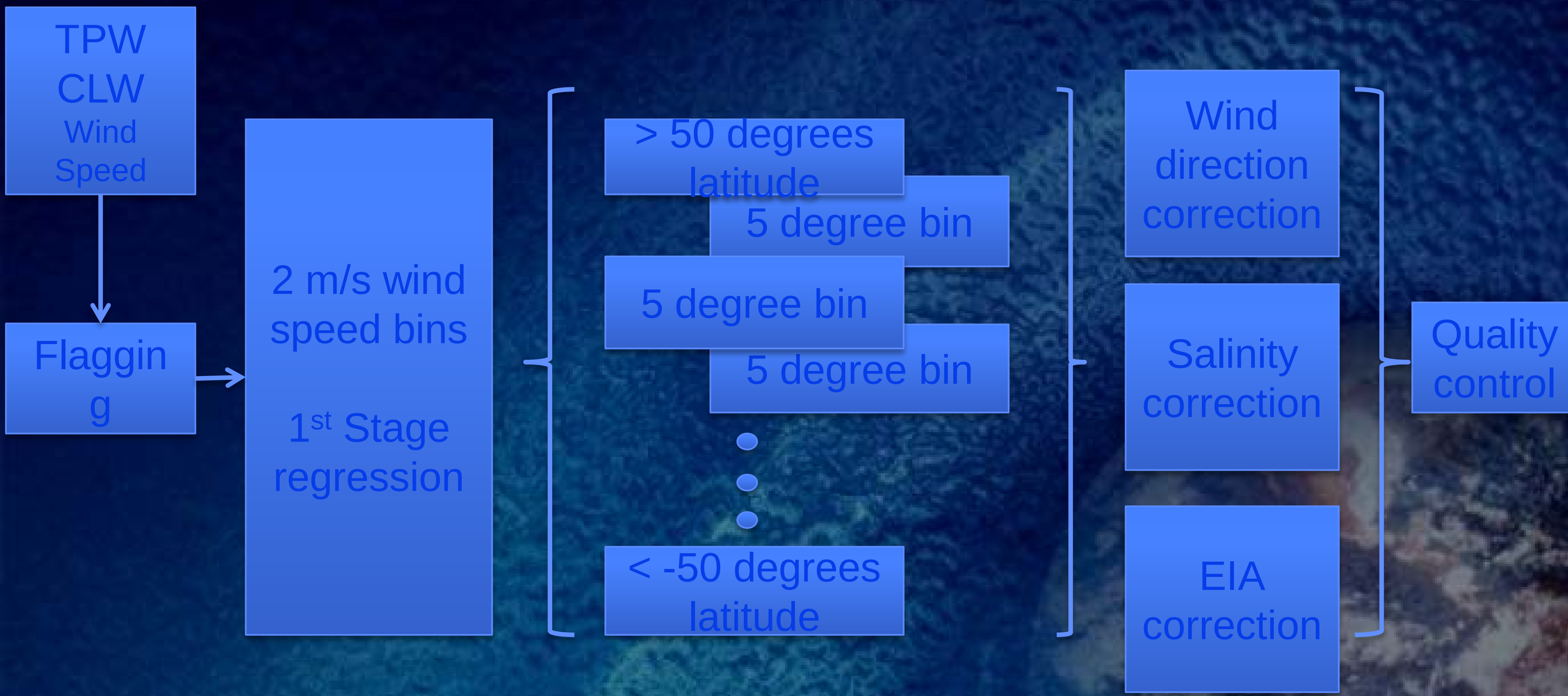
Brightness Temperature (Tb) Dependence - AMSR2

- Over the ocean Tb depends primarily upon SST, sea-surface roughness(local winds), and the atmospheric moisture and temperature profile.
  - » The 6.9(7.3) and 10.65 GHz channels have the highest sensitivity to SST changes
  - » SST also sensitive to the small scale surface roughness and the atmospheric temperature and moisture profile

Algorithm Input: Ancillary Data

- Ancillary Data Needed:
  - » Global NWP forecast fields
  - » Salinity climatology

Training of the Algorithm



5 degree latitude bins
with 1 degree overlap
between 50N and 50S

Initial Data Flagging

- Data flagged for
  - » CLW > $0.2mm^2$ data discarded
  - » Sun glint – threshold flagging (slide #)
  - » RFI – threshold flagging (slide #)
  - » Out of bound Tb's based on simulated Tb
    - – $\Delta Tb < Std(\Delta Tb)$
  - » Wind Speed > 30m/s

1st Stage Regression

- Using Basic collocation data set
  - » CRTM simulated Tb's using ECMWF input fields
  - » GDAS wind speed and direction as ground truth
  - » GHRSST as ground truth
  - » CLW and TPW from AMSR2

- 22 channels used; all except 23Ghz

$$SST = \sum_{i=1,3} (a_{i1} T_{Bi} + a_{a2} T_{Bi}^2)$$

2nd Stage Regression

- Using 1st regressed wspd and 4 month global base matchup data set localized 2nd stage regression developed for each 2m/s bins from 4-14m/s and 5deg latitudinal bins

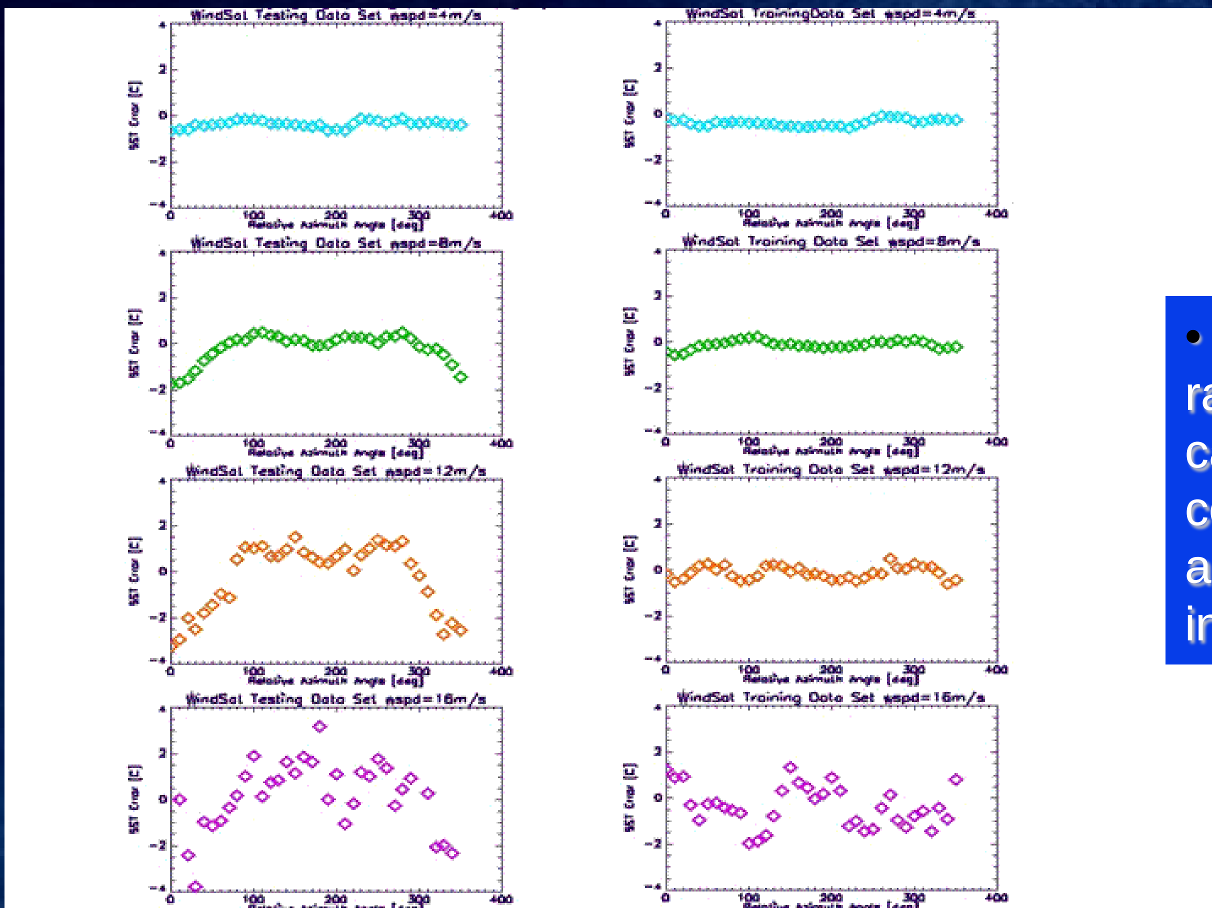
Correction for Wind Direction

- The surface emissivity depends upon the wind direction relative to the look azimuth direction
  - » The wind direction signal varies with wind speed reaching values around 3K peak-to-peak amplitude.
  - » Will lead to a significant error in SST and wind speed
  - » Result in crosstalk in the accuracy error between SST, wind speed retrievals and relative wind direciton

SST Error vs Relative Wind Direction

Without direction information

With direction information



- The accuracy of radiometer SST retrievals can be significantly compromised in the absence of wind direction information.

Correction for Wind Direction

- Correction for the wind direction signal requires binning data into wind direction bins for retrieval algorithm training
- Actual retrievals require wind direction input from an ancillary source
  - » NWS GFS forecast fields used for NRT retrievals
  - » NWS GDAS analysis used for training purposes

Earth Incidence Angle Variations

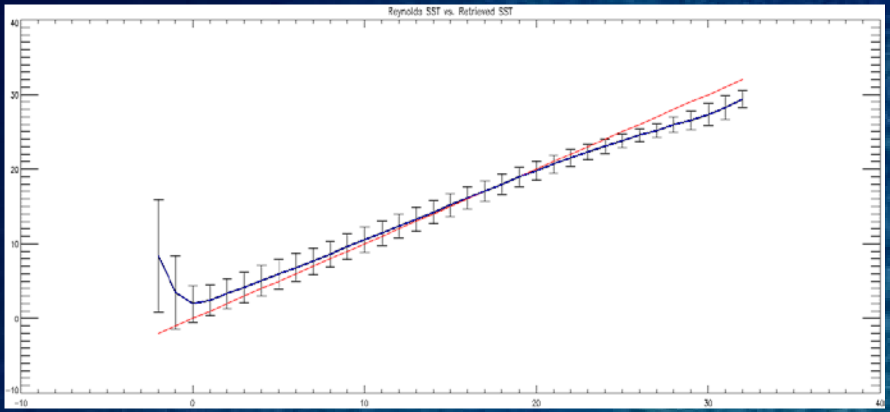
- Surface emissivity is also a function of the Earth Incidence Angle (EIA)
  - » Earth is an oblate sphere and thus the EIA can deviate +- XX from the nominal EIA of XX deg.

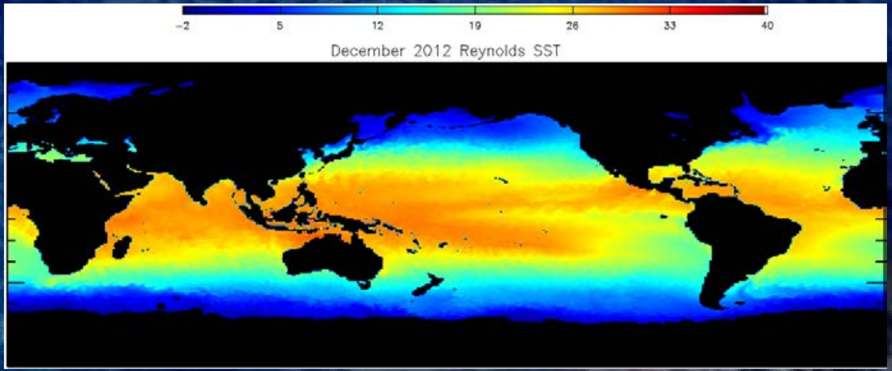
Salinity Correction

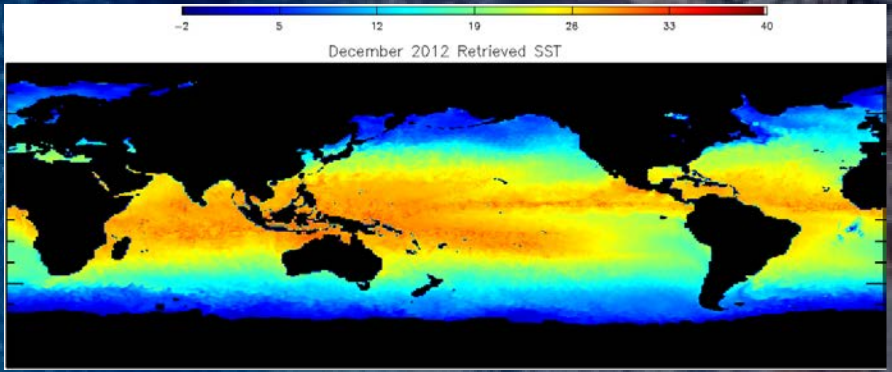
- SST retrieval error bias is modeled as a function of salinity
- Utilizing a salinity climatology the measured AMSR2 brightness temperatures are corrected to the reference salinity

SST Initial Algorithm Performance

	Accuracy	Uncertainty
AMSR-2/GHRSST	0.02K	1.03K
L1RD	0.5K	1K







TPW Algorithm Processing Flow

- Ocean TPW algorithm processing flow shown on slide #263

SST Validation Slides for AMSR-2 Critical Design Review May 1, 2013

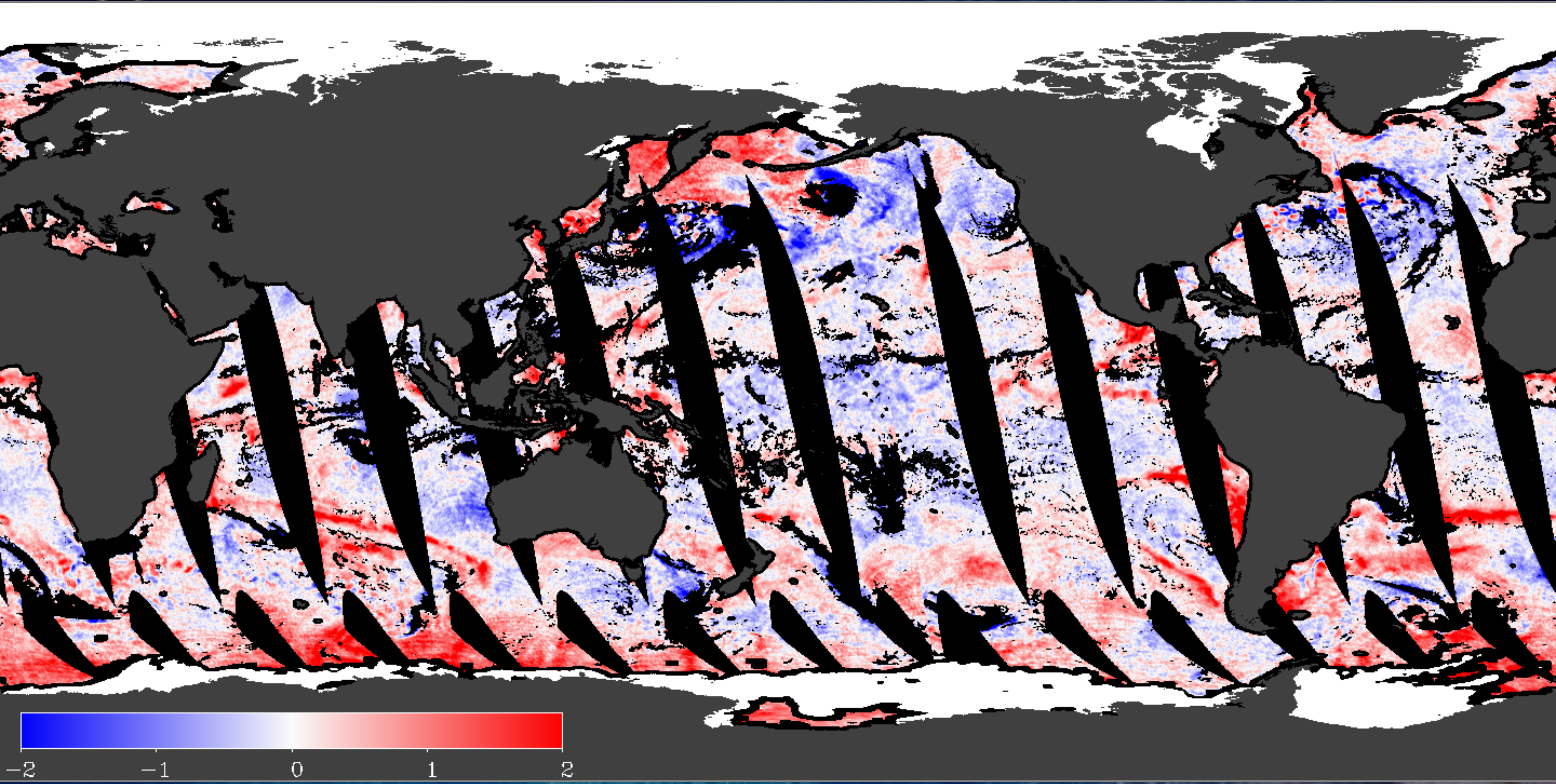
Andy Harris

Eileen Maturi

Validation Process

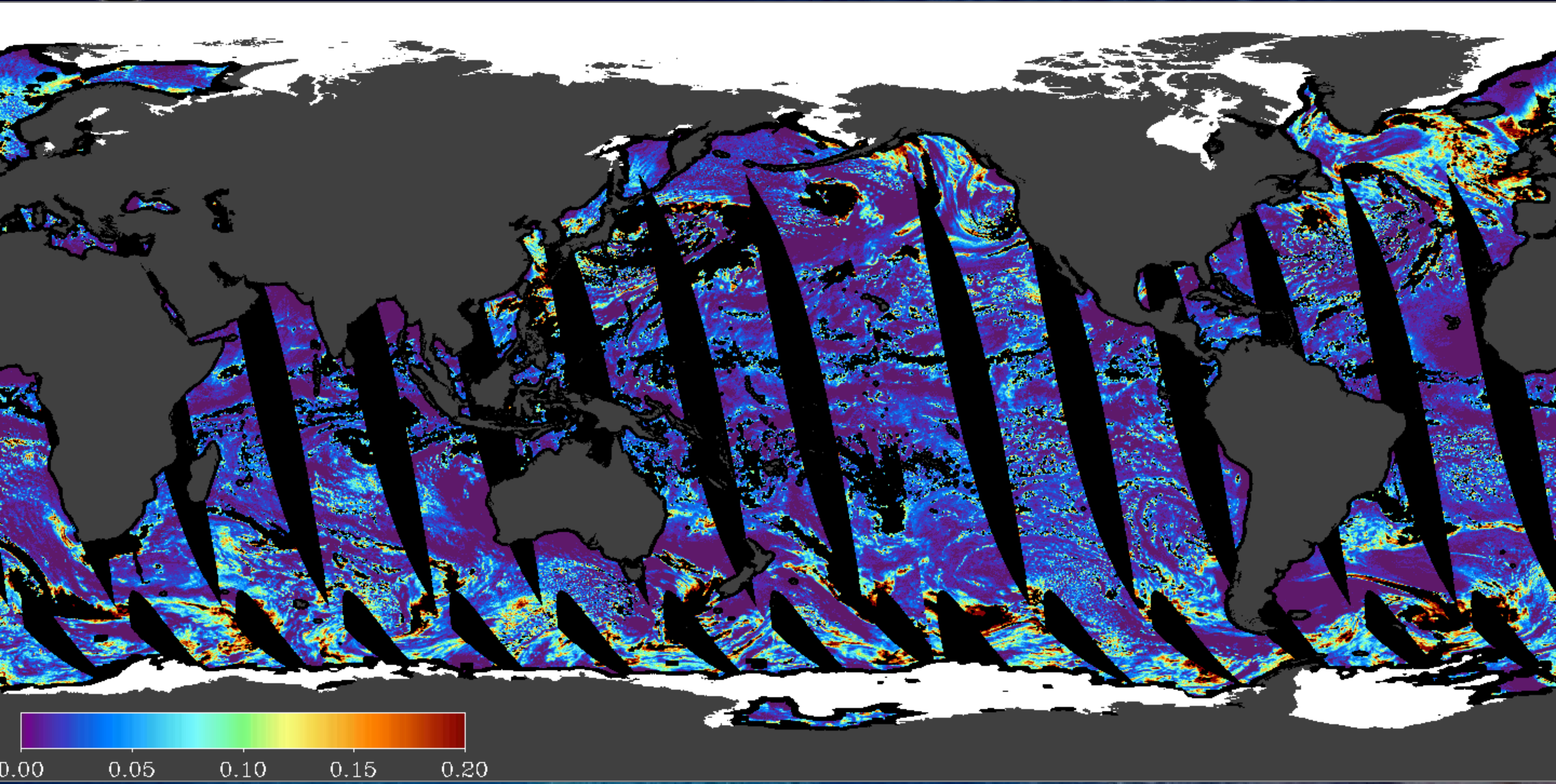
- The Validation and Quality Monitoring System for AMSR-2 SST will be set up on a STAR Server
  - » We will generate comparisons with moored buoys, ocean drifters, and other satellite SST products
- The accuracy goal is about 0.5˚C for instantaneous observations and 0.2˚C for monthly averages which satisfies the JPSS Level-1 Requirements
- Validate AMSR-2 SST products against *in situ* data and level-4 analyses
  - » Intercomparison of WindSat and AMSR-2 SSTs
  - » Moored and drifting buoys, Argo Floats
  - » OSTIA SST Analysis
- Report findings to JPSS AMSR-2 project
  - » Potential areas for improvement in Level 2 products
    - – See example on following slides
  - » Iteration on validation of Level 2 product accuracies
- Incorporated into the STAR validation web sites
  - » Operational SST websites
  - » Squam Web site

AMSR-E – OSTIA SST Analysis



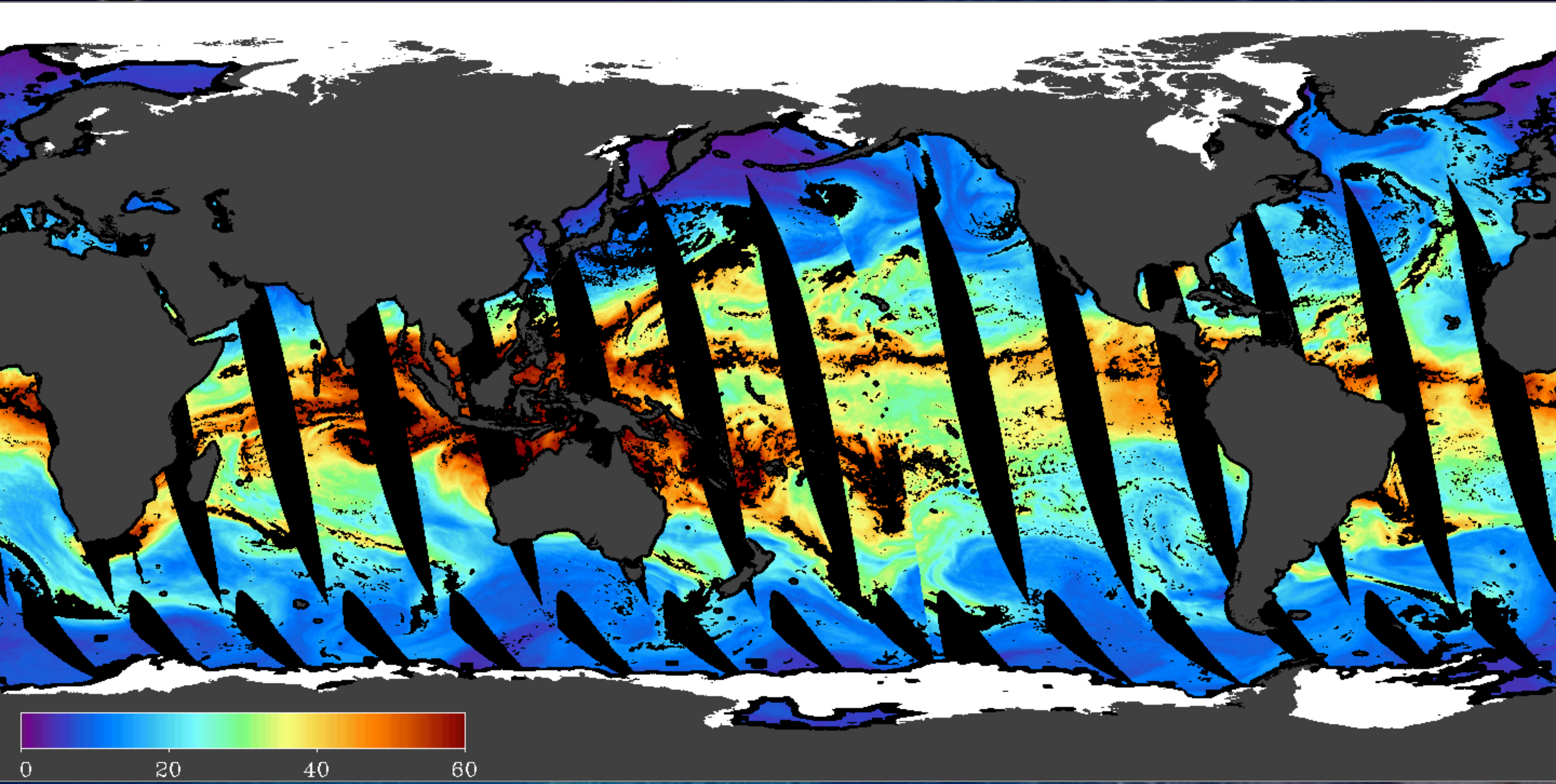
OSTIA-Operational Sea Surface Temperature and Sea Ice Analysis (generated by the UK Met Office)

AMSR-E Cloud Liquid Water



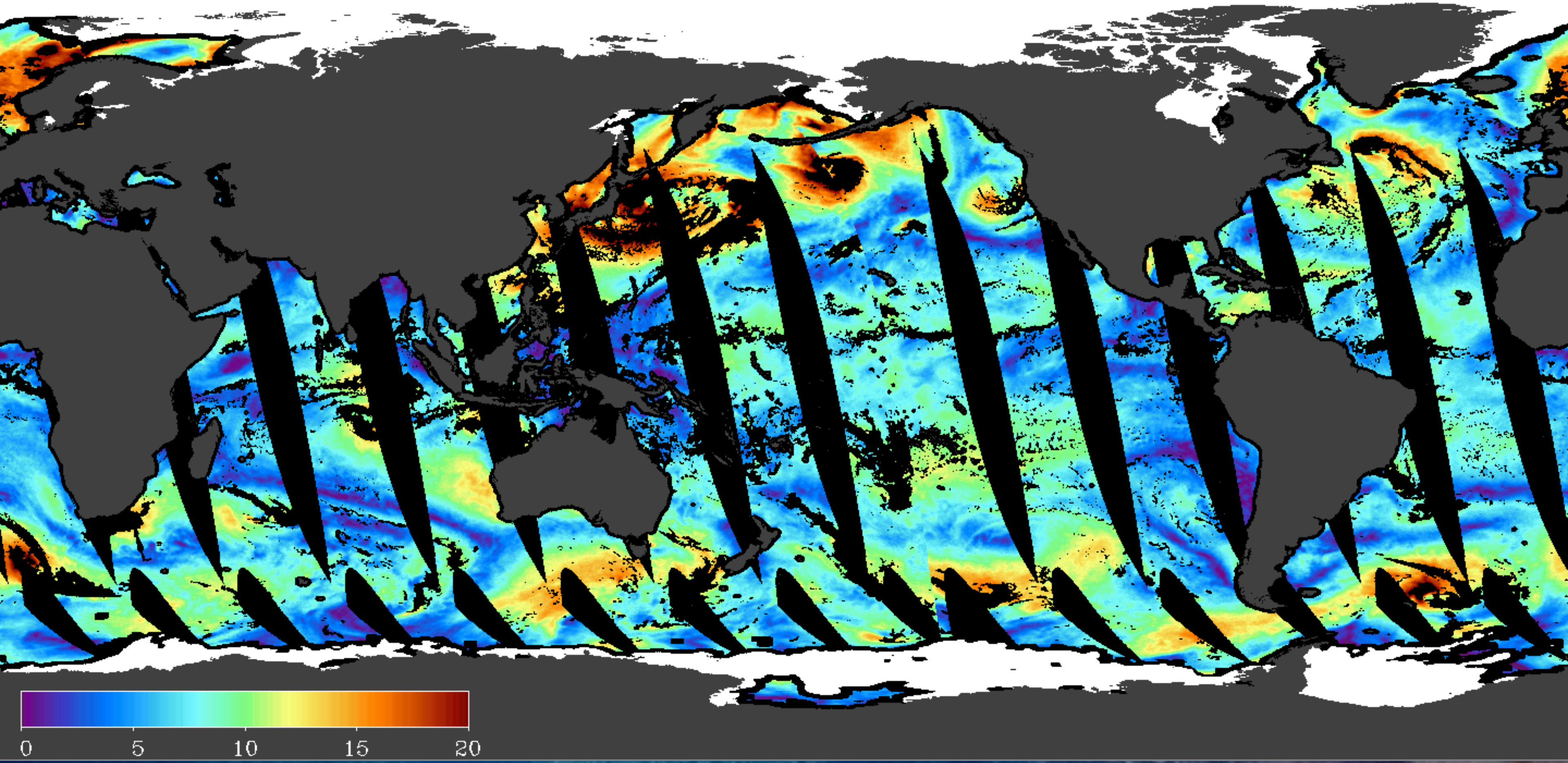
Correlation with AMSR-E - OSTIA?

AMSR-E Total Column Water Vapor



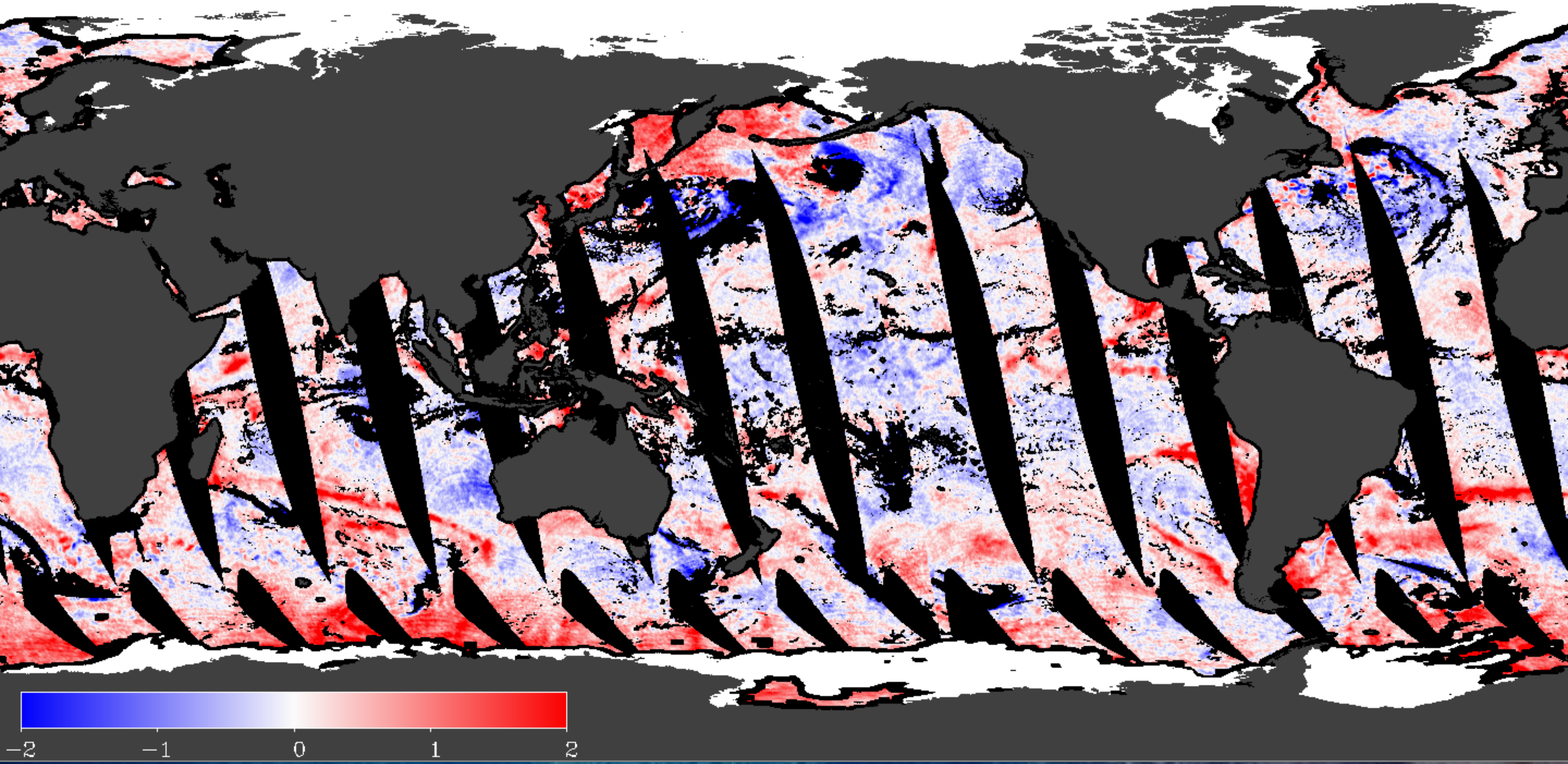
Correlation with AMSR-E - OSTIA?

AMSR-E Wind Speed (Low Frequency)



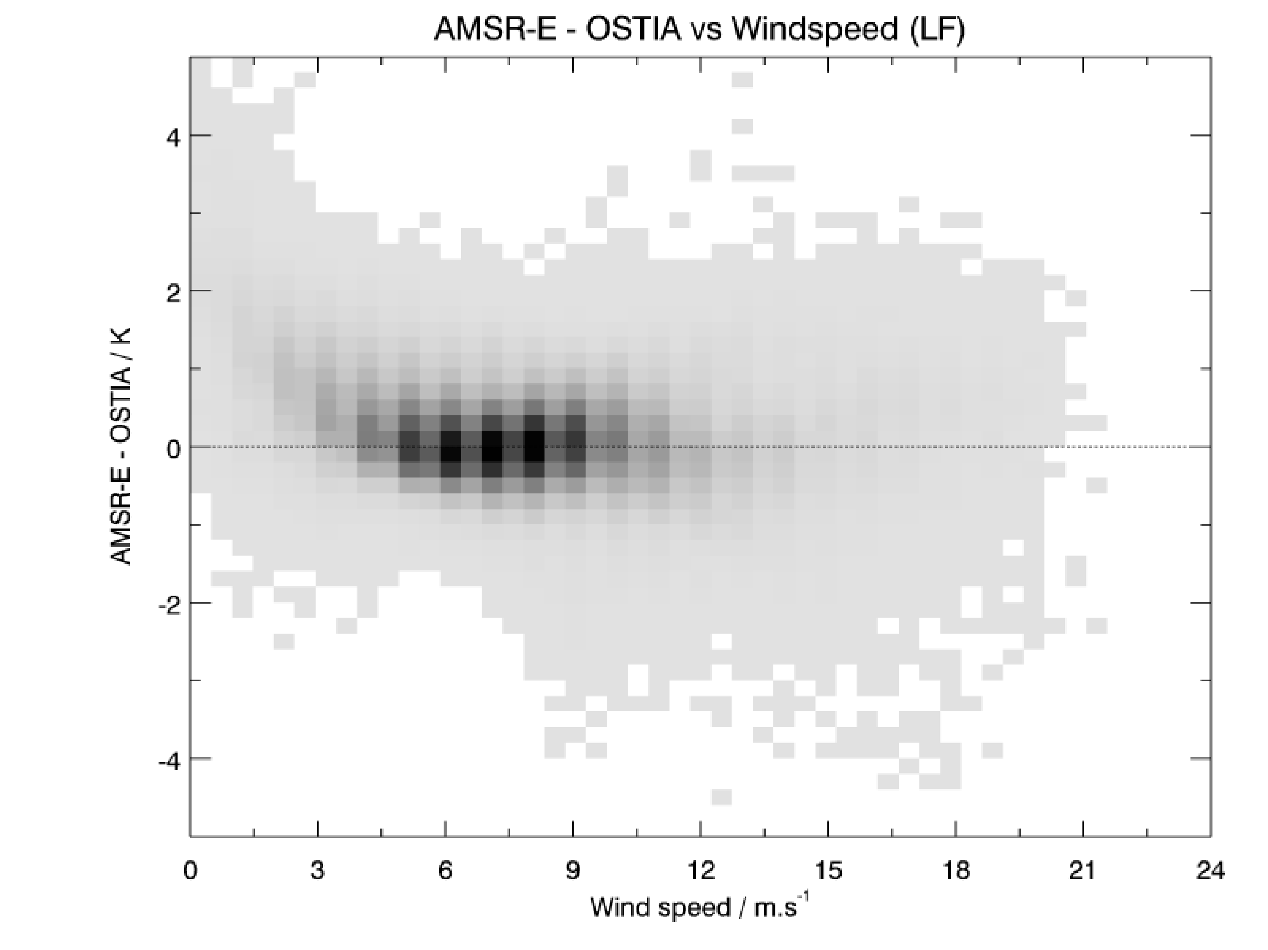
Correlation with AMSR-E - OSTIA?

AMSR-E – OSTIA SST Analysis



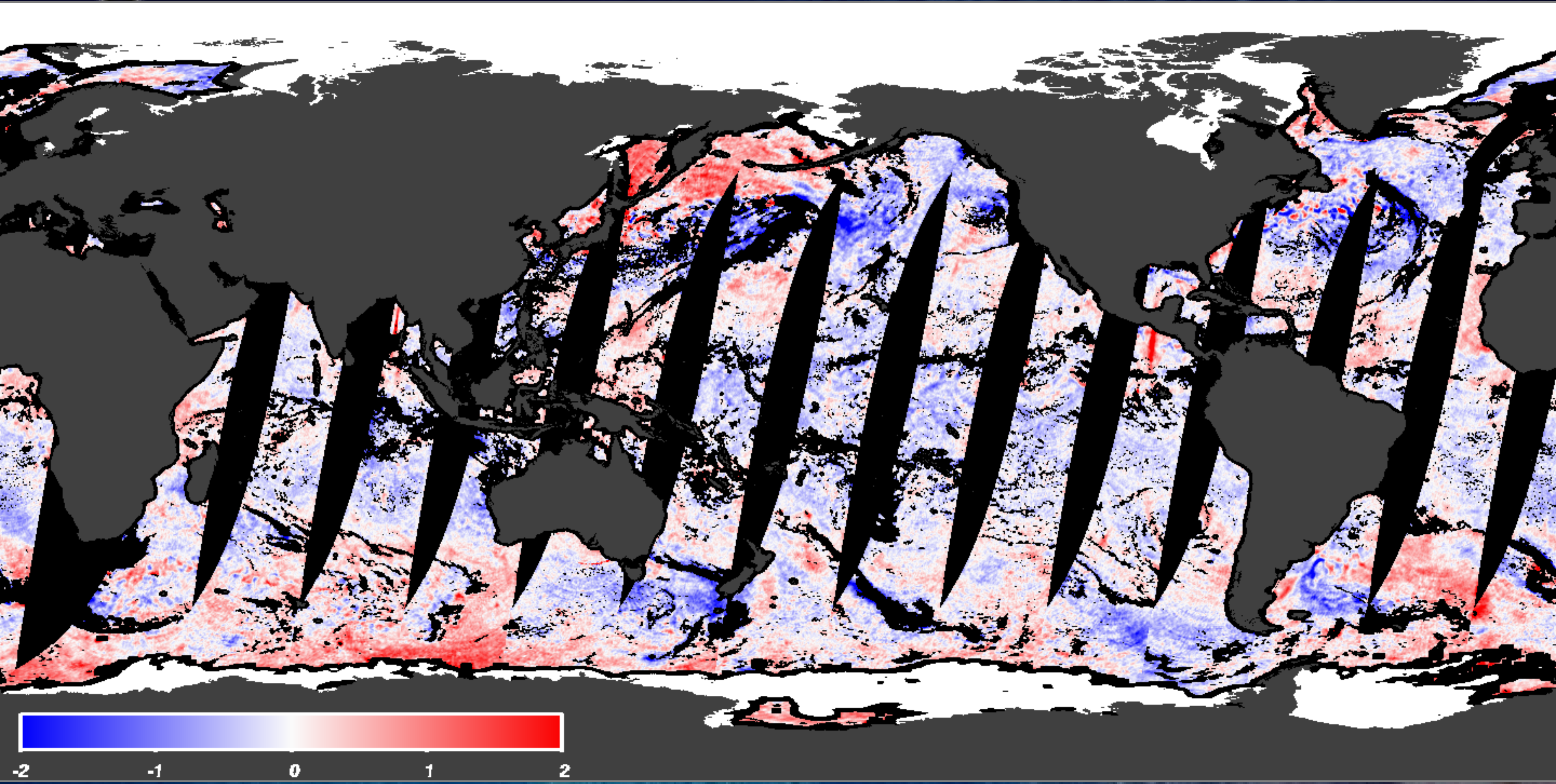
- Differences seem to be correlated with low frequency wind speed retrievals

Quantifying Bias vs Wind Speed



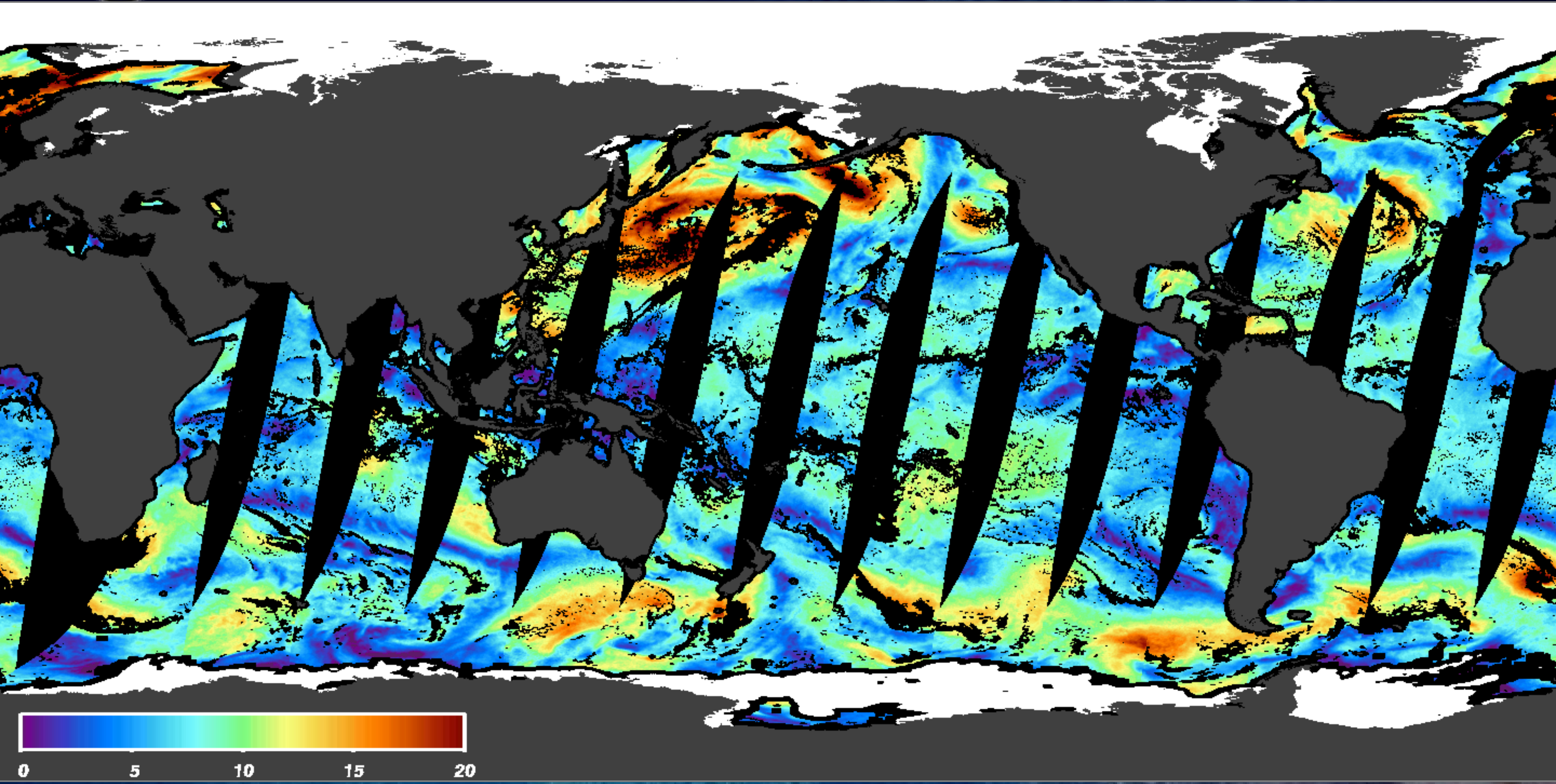
- Qualitative dependence of AMSR-E – OSTIA on wind speed observed in geographical plots
- Next step is more quantitative assessment of bias dependence
- Results like this will be fed back into SST algorithm refinement

AMSR-E – OSTIA SST Analysis



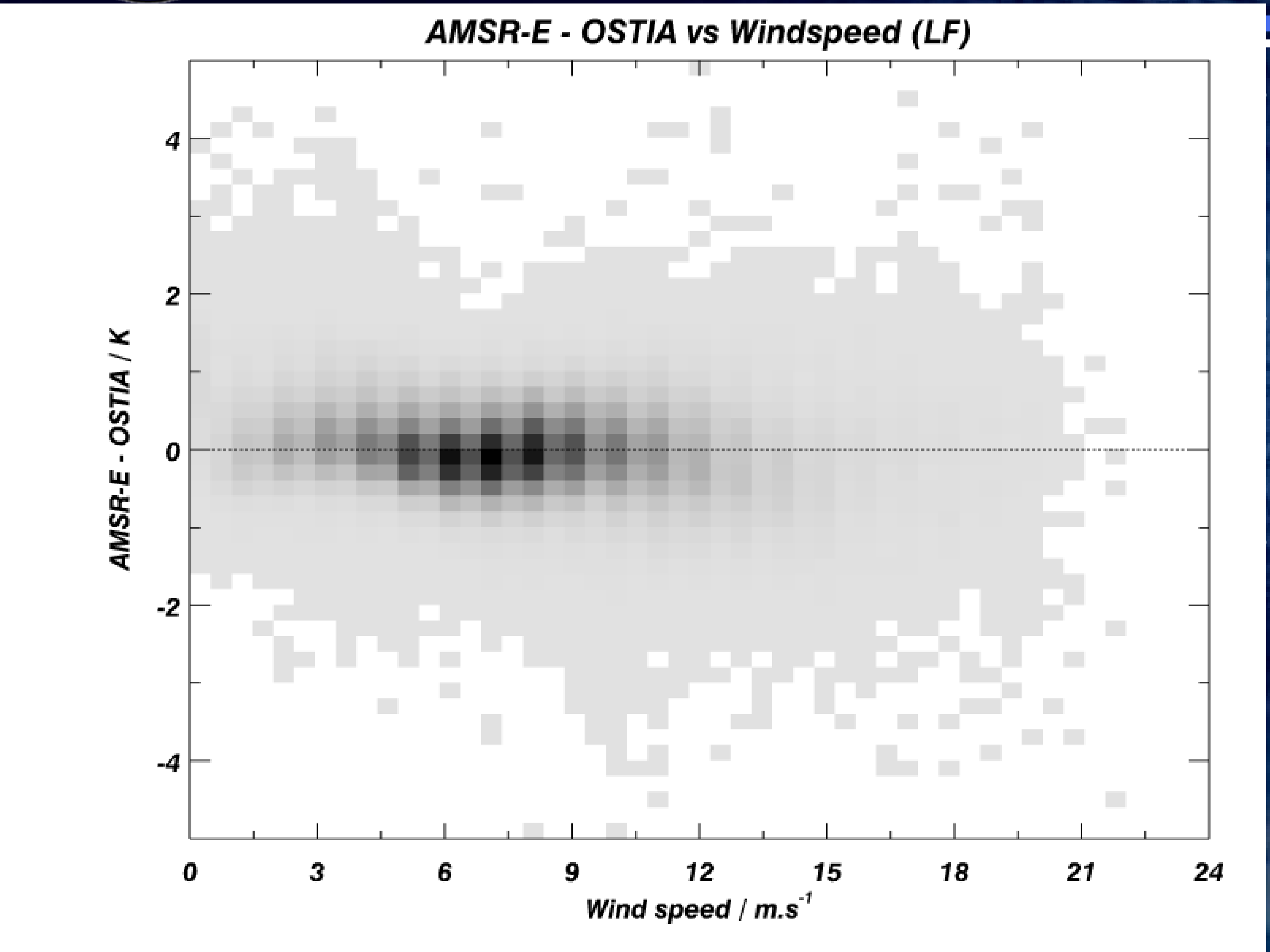
- Descending pass

AMSR-E Wind Speed (Low Frequency)



- Correlations not as prominent as for daytime

Quantifying Bias vs Wind Speed



- Warm bias at low wind speed much less prominent
- Ascending pass is subject to diurnal warming
- We are developing a global diurnal warming model to account for such effects

Ocean EDR Algorithm Processing Flow

Ocean EDR's Algorithm Input

Name	Type	Description	Dimension
6.925 Ghz brightness temperature	Input	Navigated and Calibrated 6.925 GHz level 1b/1r brightness temperatures for V & H polarized	Scan grid (xsize, ysize)
7.3 Ghz brightness temperature	Input	Navigated and Calibrated 7.3 GHz level 1b/1r brightness temperatures for V & H polarized	Scan grid (xsize, ysize)
10.65 GHz brightness temperature	Input	Navigated and Calibrated 10.65 GHz level 1b brightness temperatures for V & H polarized	Scan grid (xsize, ysize)
18.7 GHz brightness temperature	Input	Navigated and Calibrated 18.7 GHz level 1b brightness temperatures for V & H. polarized	Scan grid (xsize, ysize)
23.8 GHz brightness temperature	Input	Navigated and Calibrated 23.8 GHz level 1b brightness temperatures for V. & H. polarized	Scan grid (xsize, ysize)
36.5 GHz brightness temperature	Input	Navigated and Calibrated 36.5 GHz level 1b brightness temperatures for V. & H. polarized	Scan grid (xsize, ysize)
Latitude	Input	Pixel Latitude	Scan grid (xsize,ysize)
Longitude	Input	Pixel Longitude	Scan grid (xsize,ysize)
SDR quality control flag	Input		Scan grid (xsize,ysize)

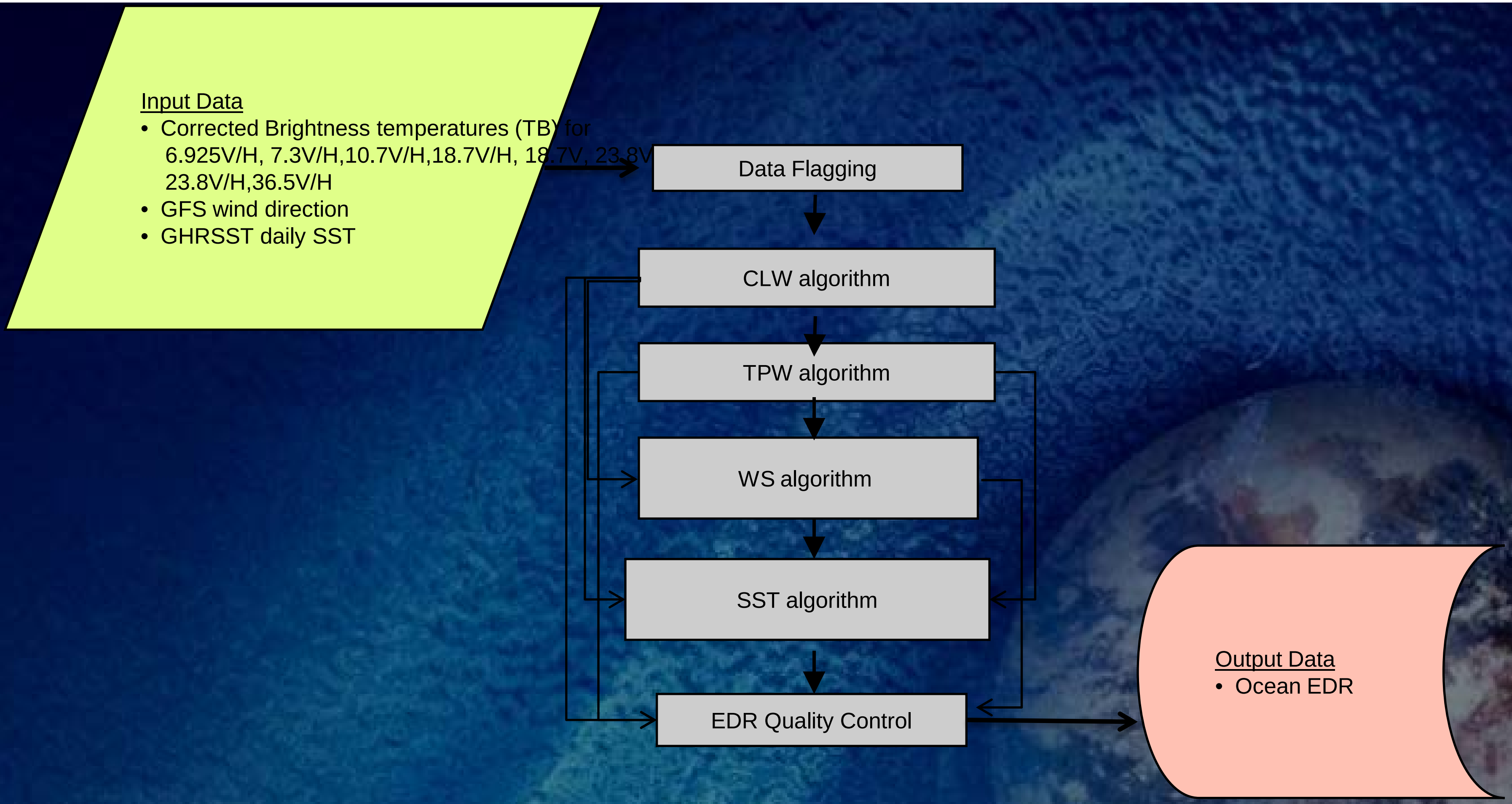
Ocean EDR
Algorithm Input: Ancillary Data

- Two types of ancillary data needed:
  - » GFS: 6-hourly Global Wind direction product
  - » GHRSST: $1/4^0$ Daily Sea Surface Temperature
  - » SSS: TBD

Name	Type	Description	Dimension
GFS Global	Input	Global wind direction	Interpolated to Scan grid (xsize, ysize)

Name	Type	Description	Dimension
GHRSST	Input	$1/4^0$ Daily sea surface temperature	Interpolated to Scan grid (xsize, ysize)

Ocean EDR Algorithm Processing Outline



SDR Corrections Algorithm Processing Flow

Input Data
- Brightness temperatures (TB) for 6.925V/H, 7.3V/H, 10.7V/H,18.7V/H 23.8V, 36.5H/V,89H/V

6.925h/V ghz channel correction

7.3H/V Ghz channel correction

10.7H/V Ghz channel correction

18.7H/VGhz channel correction

23.8 H/V Ghz channel correction

36.5 H/V Ghz channel correction

89a H/V Ghz channel correction

89b H/V Ghz channel correction

Correction Function

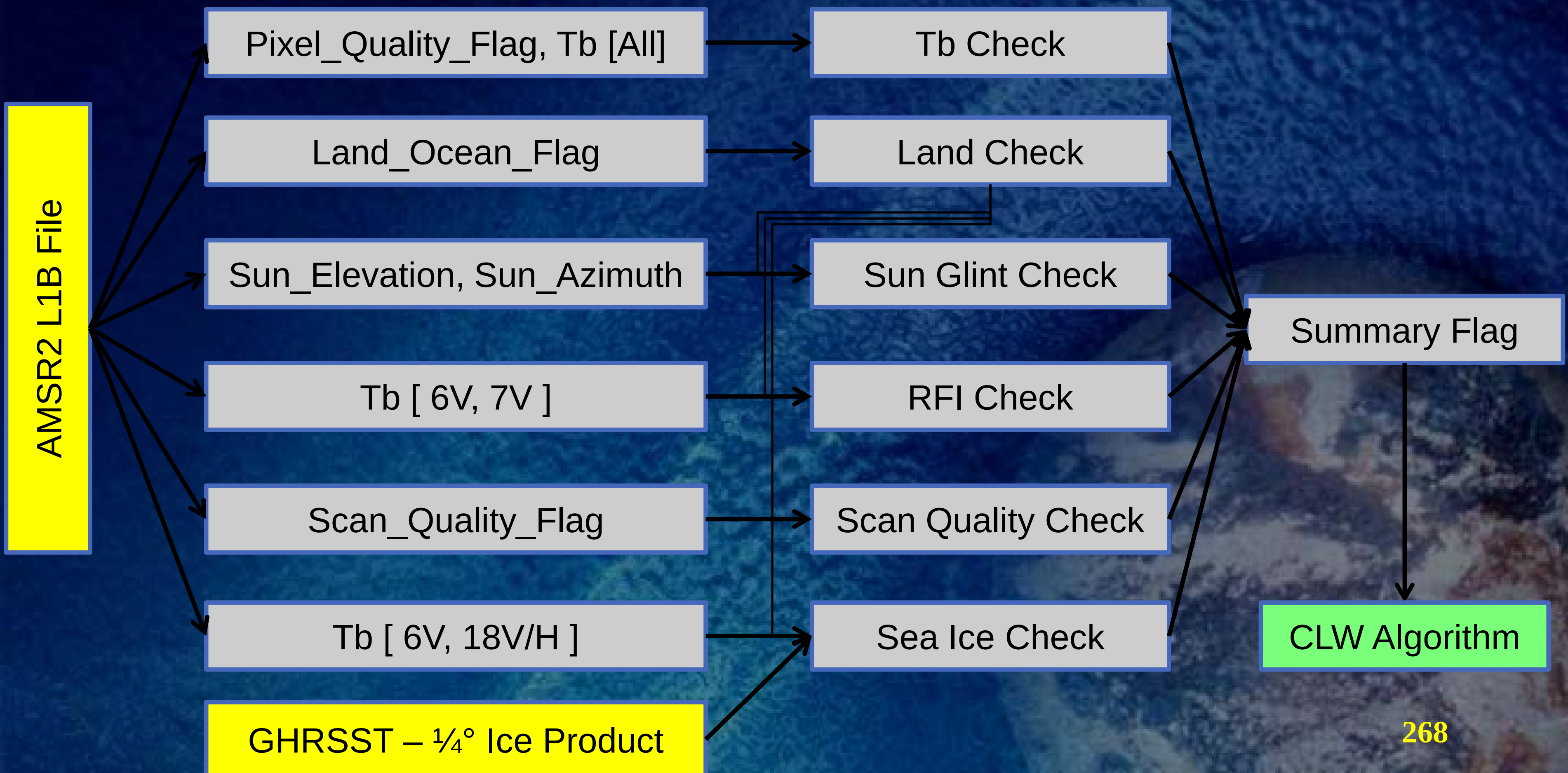
$$\Delta T_{Bi} = \frac{\sum_{n} a_{in} T_{Bi}^{n}}{\sum_{m} b_{i} T_{Bi}^{m}}$$

$$T_{Bi} = T_{Bi} - \Delta T_{Bi}$$

$$i = Channels$$

Output Data
- Corrected Ocean Brightness temperatures

Flagging Procedures



Ocean CLW Algorithm Processing Outline

Input Data
- Corrected Brightness temperatures for 6.925H, 7.3H,10.7H,18.7V/H, 18.7V/H, 23.8V/H, 36.5V/H

1st stage regression

$$clw = a_0 + \sum_{i=1,9} a_i t_i$$

$$t_i = T_{Bi}$$

$$i = 6.925H, 7.3H, 10.7H$$

$$t_j = \ln(295 - T_{Bj})$$

$$j = 18.7V/H, 23.8V/H, 36.5V/H$$

2st stage regression

$$clw_{jk} = a_0 + \sum_{i=1,9} a_i t_{ijk}$$

$$clw_j = \sum_{k=0,2} w_{jk} clw_{jk}$$

$$t_i = T_{Bi}$$

$$i = 6.925H, 7.3H, 10.7H$$

$$t_j = \ln(295 - T_{Bj})$$

$$j = 18.7V/H, 23.8V/H, 36.5V/H$$

CLW Quality Control

Output Data
- Ocean EDR

Ocean TPW Algorithm Processing Outline

Input Data
- Corrected Brightness temperatures for 18.7V/H, 23.8V/H, 36.5V/H

1st stage regression

$$tpw = a_0 + \sum_{i=1,9} a_{1i} t_i + a_{2i} t_i^2$$

$$t_i = T_{Bi}$$

$$i = 18.7V/H, 23.8V/H, 36.5V/H$$

2st stage regression

$$tpw_j = a_0 + \sum_{i=1,9} a_{1i} t_{ij} + a_{2i} t_{ij}^2$$

$$tpw = \sum_{k=0,2} w_{jk} tpw_{jk}$$

$$t_i = T_{Bi}$$

$$i = 18.7V/H, 23.8V/H, 36.5V/H$$

TPW Quality Control

Output Data
- Ocean EDR

Ocean Wind Speed Algorithm Processing Outline

Input Data

- Corrected Brightness temperatures for 6.925H, 7.3H,10.7H,18.7V/H, 18.7V/H, 23.8V/H, 36.5V/H

1st stage regression

$$ws = a_0 + \sum_{i=1,9} a_{1i} t_i + a_{2i} t_i^2$$

$$t_i = T_{Bi}$$

$$i = 6.925V/H, 7.3V/H, 10.7V/H 18.7V/H, 23.8V/H, 36.5V/H$$

2st stage regression

$$ws_j = a_0 + \sum_{i=1,9} a_{1i} t_{ij} + a_{2i} t_{ij}^2$$

$$ws = \sum_{l=l_0-1,l_0+1} \sum_{k=k_0-1,k_0+1} w_{k-k_0,l-l_0} ws_{jkl}$$

$$ws_{corr} = ws_{oi} + \frac{\Delta ws_{oi}}{ws_i} ws_{oi}$$

$$\Delta ws_{oi} = a_1(ws_{oi}) + a_2(ws_{oi})\cos(\varphi) + a_3(ws_{oi})\cos(2\varphi)$$

$$\varphi = GFS_{wdir} - \phi$$

$$\Delta ws_{oi\theta} = f(EAI)$$

WS Quality Control

Output Data

- Ocean surface Wind speed

Ocean Sea Surface Temperature Algorithm Processing Outline

<u>Input Data</u>

- Corrected Brightness temperatures for 6.925H, 7.3H,10.7H,18.7V/H, 18.7V/H, 23.8V/H, 36.5V/H

1st stage regression

$$sst = a_0 + \sum_{i=1,9} a_{1i} t_i + a_{2i} t_i^2$$

$$t_i = T_{Bi}$$

$$i = 6.925V/H, 7.3V/H, 10.7V/H 18.7V/H, 23.8V/H, 36.5V/H$$

2st stage regression

$$sst_j = a_0 + \sum_{i=1,9} a_{1i} t_{ij} + a_{2i} t_{ij}^2$$

$$sst = \sum_{l=l_0-1,l_0+1} \sum_{k=k_0-1,k_0+1} w_{k-k_0,l-l_0} sst_{jkl}$$

k = wind speed bins

l = latitude bins

$$sst_{corr} = sst_{oi} + \frac{\Delta sst_{oi}}{sst_i} sst_{oi}$$

$$\Delta sst_{oi} = a_1(ws_{oi}) + a_2(ws_{oi})\cos(\varphi) + a_3(ws_{oi})\cos(2\varphi)$$

$$\varphi = GFS_{wdir} - \phi$$

$$\Delta sst_{oi\theta} = f(EAI)$$

$$\Delta sst_{oisss} = f(sss)$$

SST Quality Control

<u>Output Data</u>

- Ocean surface temterature

Ocean EDR Algorithm Output

- Output Data:
  - Ocean surface wind speed by this algorithm
  - Ocean surface temperature by this algorithm
  - Total precipitable water by this algorithm
  - Cloud liquid water

Name	Type	Description	Dimension
Ocean Surface Wind Speed	output	Output contains ocean surface wind speed for each pixel	Scan grid (xsize, ysize)
Ocean Surface Temperature	output	Output contains ocean surface temperature for each pixel	Scan grid (xsize, ysize)
Total Precipitable Water	output	Output contains total precipitable water for each pixel	Scan grid (xsize, ysize)
Cloud Liquid Water	output	Output contains cloud liquid water for each pixel	Scan grid (xsize, ysize)

Ocean EDR Output File Structure

Parameter	Data Type	Description	Scaling Value
Time	Float64		
Latitude	Float32	Latitude (-90 to 90)	
Longitude	Float32	Longitude (-180 to 180)	
Scan Angle	Int16		
Earth Incidence Angle	Int16		
Compass Azimuth Angle	Int16		
Across Scan number	Int16		
Along scan number	Int16		
SDR record number	Int16	Number that maps SDR's to EDR swath position for easy matchups	
Surface type	Int16	land/coast/ocean/ice/possible ice	
SDR QC flag	Int16	Copied from SDR file should contain ascending/descending flag	
SST	Int16		
sstErr	Int16	Estimated SST error	
wspd	Int16		
wspdErr	Int16	Estimated Wind Speed error	
wv	Int16		
wvErr	Int16	Estimated Water Vapor error	
clw	Int16		
clwErr	Int16	Estimated Cloud Liquid Watre error	
Rain Rate (RR)	Int16		
RRErr	Int16	Estimated Rain Rate Error	
EDR QC flag	Int32	Description in Table 1.3	
Model wspd	Int16	Place holders for input external parameters that might be needed for successful retrieval output for one or all ocean EDR's	
Model wdir	Int16		
Model salinity			

Ocean EDR QC Flag
32-bit integer

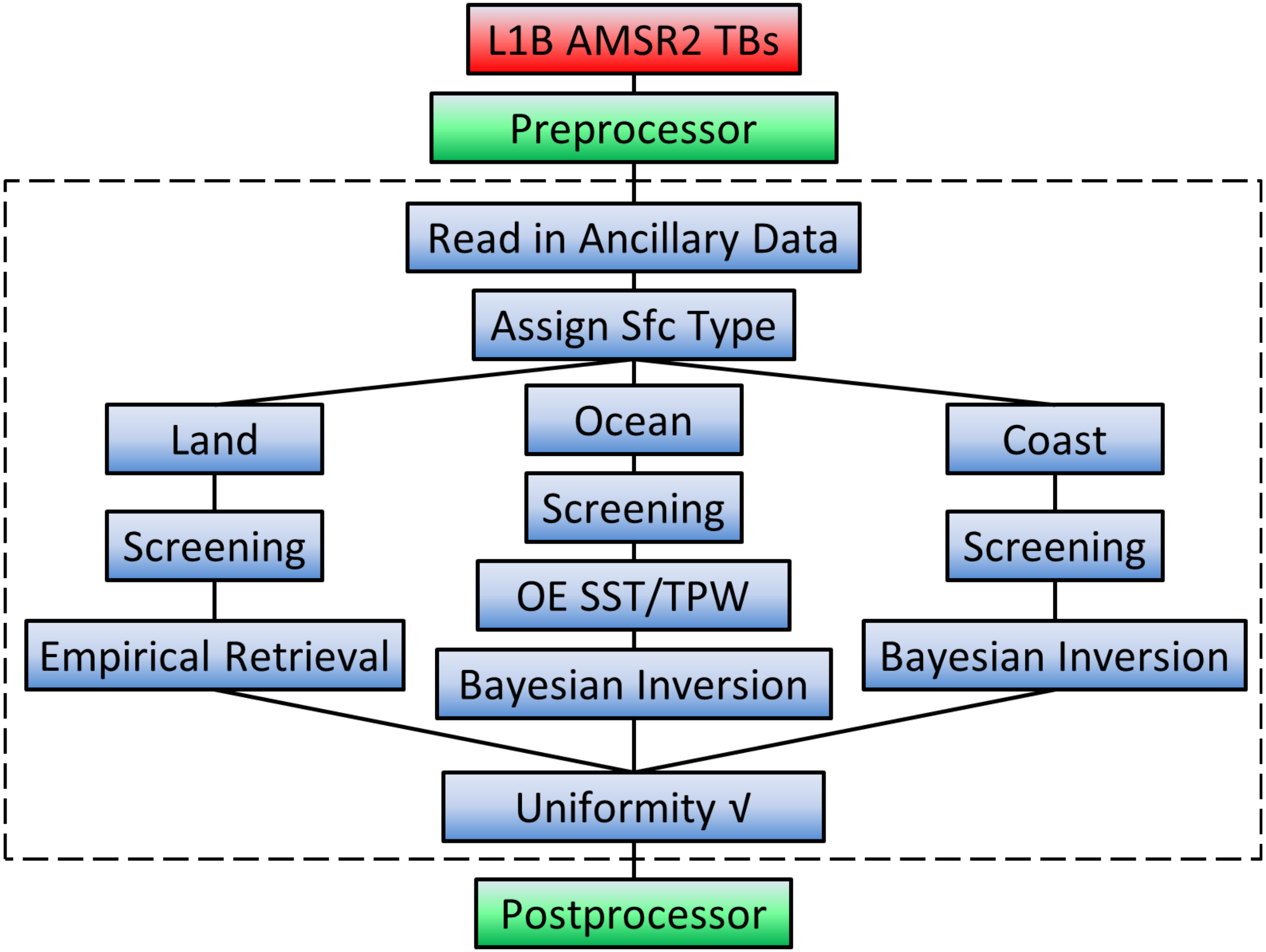
Bit Number	Contents	Values
0	Retrieval Status	0=OK, 1=Retrieval not performed or retrieval failure for all EDR's
1	Low Confidence	Union of bits 2-11
2	6-7GHZ RFI flag	SST retrievals are less accurate particularly for SST <15C
3	10GHz RFI flag	
4	EDR rain flag	Based on clw and/or RR
5	SDR rain flag	Rain flag based on Tb's (copied from SDR QC flag)
6	Ice flag	0=ice contamination based on climatology 1=ice contamination based on Tb's
7	Land contamination	Tb threshold for land contamination exceeded
8	Coastal flag	
9	Salinity flag	Salinity out of bounds 0=based on climatology, 1=based on model input data
10	Sun glint	Threshold exceeded for sun glint
11	Beam averaging Threshold	Insufficient data available for reliable beam averaging to be performed
12	SST Quality	Low confidence SST retrieval
13	SST retrieval status	No SST retrievals
14	Winds speed too high for accurate SST retrievals	Wspd >20m/s
15	Wspd Quality	Low confidence wind speed retrieval
16	Wspd retrieval status	No wind speed retrievals
17	Water Vapor Quality	Low confidence Water vapor retrieval
18	Water Vapor retrieval status	No Water Vapor retrievals
19	Cloud Liquid Water Quality	Low confidence Clopud Liquid Water retrieval
20	CLW retrieval status	No CLW retrieval
21	Rain Rate Quality	Low confidence Rain rate retrieval
22	Rain Rate retrieval status	No Rain Rate retrieval
23-32	Reserved	

Precipitation EDR

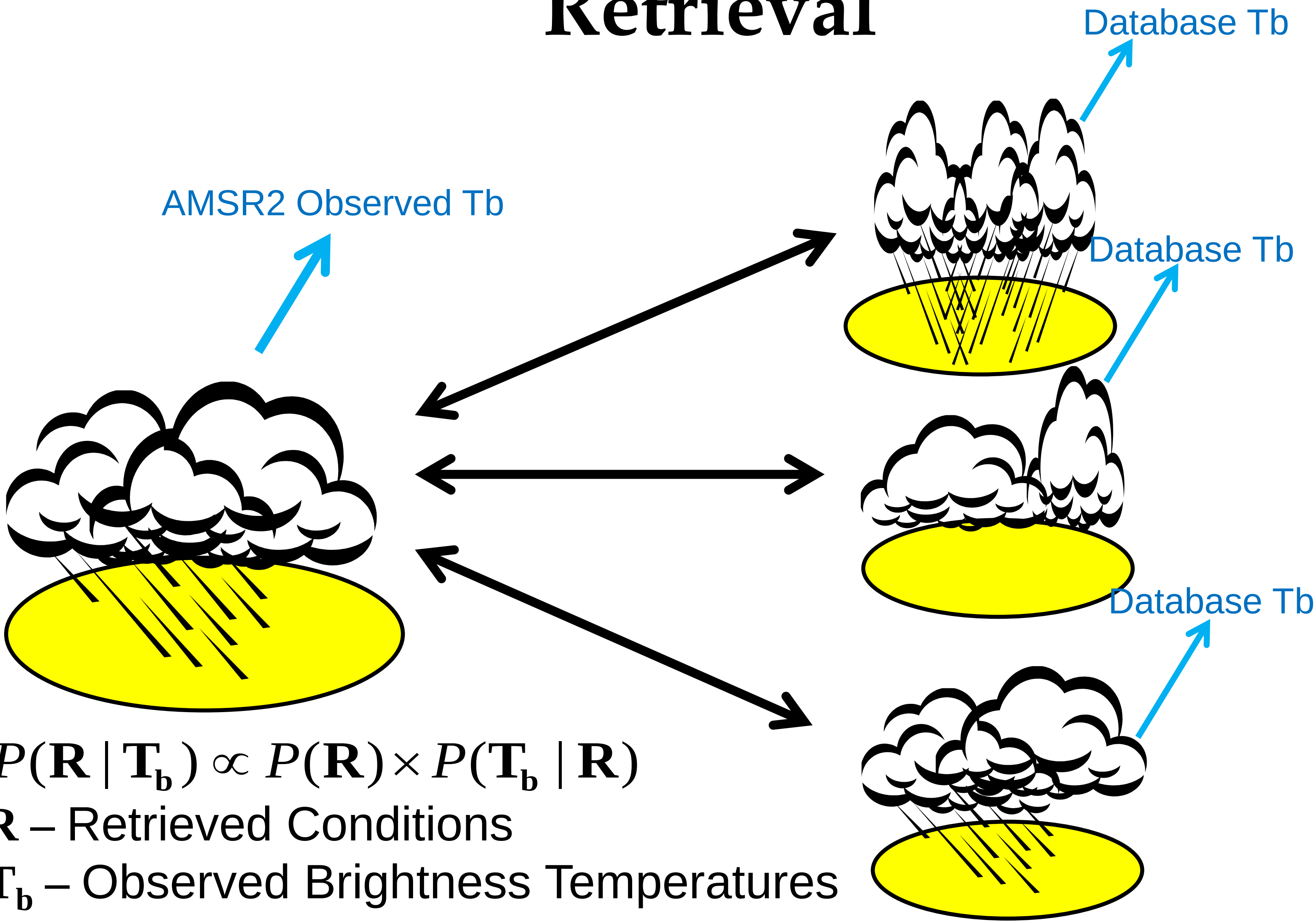
Presented by

Patrick Meyers
CICS

GPROF Structure



Ocean Segment: Bayesian Retrieval



$$P(\mathbf{R} \mid \mathbf{T_b}) \propto P(\mathbf{R}) \times P(\mathbf{T_b} \mid \mathbf{R})$$

R – Retrieved Conditions

$\mathbf{T_b}$ – Observed Brightness Temperatures

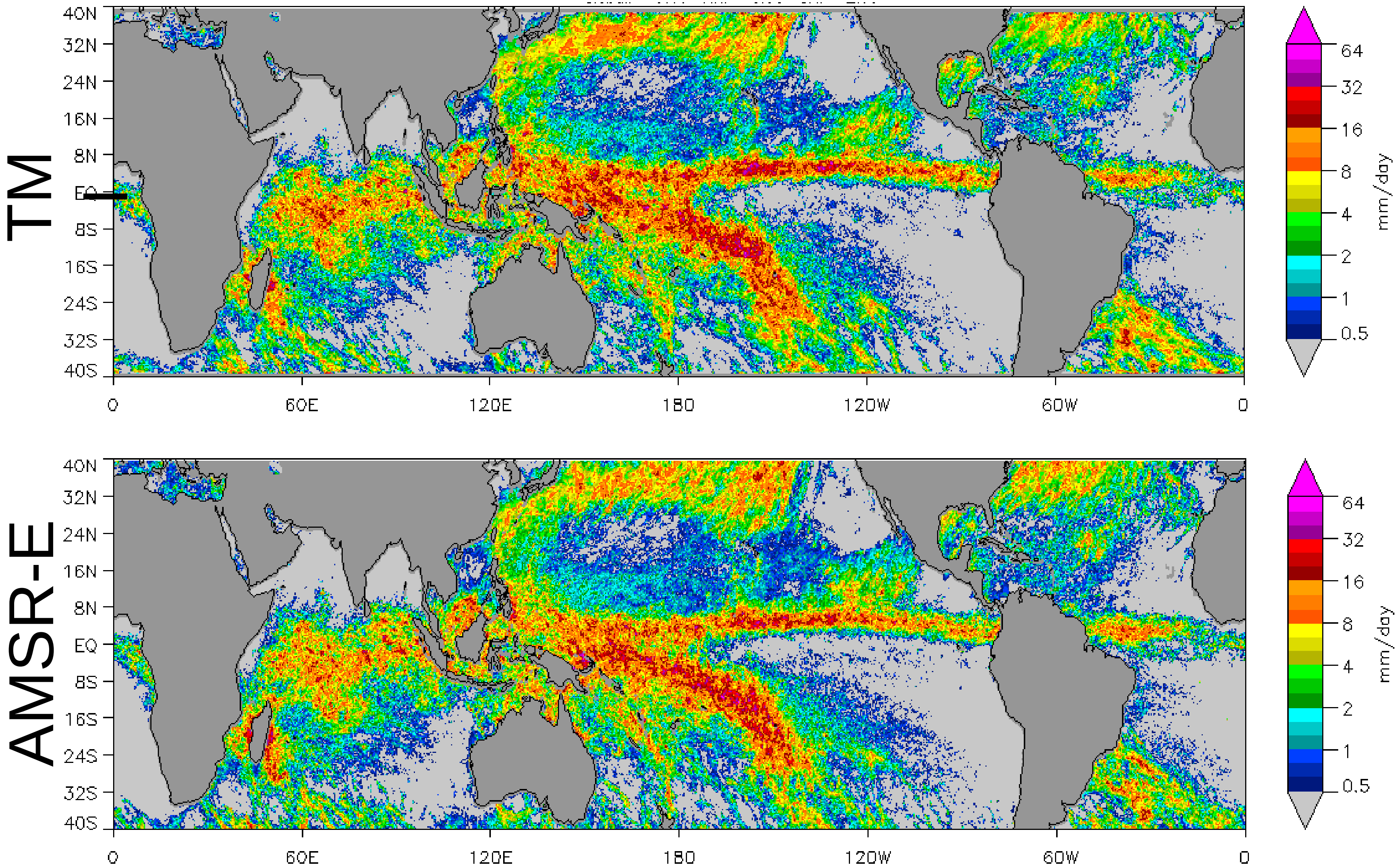
A-Priori Database

- Compare observed Tbs to database of known atmospheric profiles with corresponding Tbs
  - » Collocated TRMM Precipitation Radar/TMI
    - – Removes reliability on CRM in previous versions
  - » Database of raining/non-raining pixels
  - » Binned into 2 mm TPW and 1K SST bins
  - » Clustered each bin to 2400 profiles for efficiency
  - » Weight profiles based on uncertainty and absolute difference between observed and database Tbs
  - » Utilizes 10-89GHz

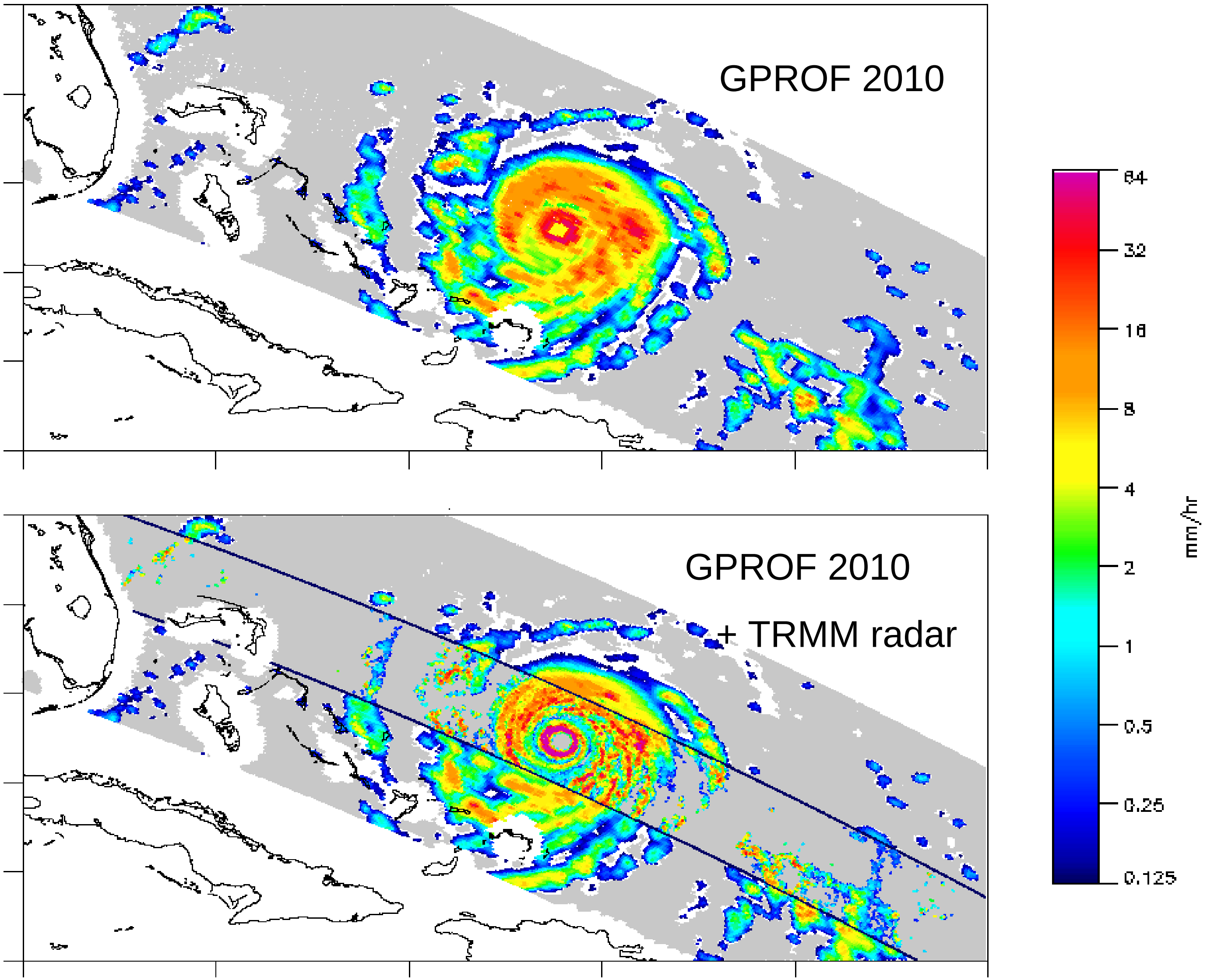
$$\hat{E}(\mathrm{R}) = \sum_j \mathrm{R}_j \frac{\exp\left\{-\frac{1}{2}(Tb_O - Tb_S(\mathrm{R}_j))^T (O+S)^{-1} (Tb_O - Tb_S(\mathrm{R}_j))\right\}}{\hat{A}}$$

Kummerow, Christian D., S. Ringerud, J. Crook, D. Randel, W. Berg, 2011: An Observationally Generated A Priori Database for Microwave Rainfall Retrievals. *J. Atmos. Oceanic Technol.*, **28**, 113–130.

Consistency Between Imagers – Jan 2007



GPROF2010 Example – Hurricane Floyd



AMSR2 Ocean Retrieval

- Tbs that are not resampled (native resolution)
- Retrievals made at 89GHz-A locations
- Indexes SST from latest Level 4 GHRSST 1/4 degree Reynolds Product
  - » TPW Index internally estimated by OE

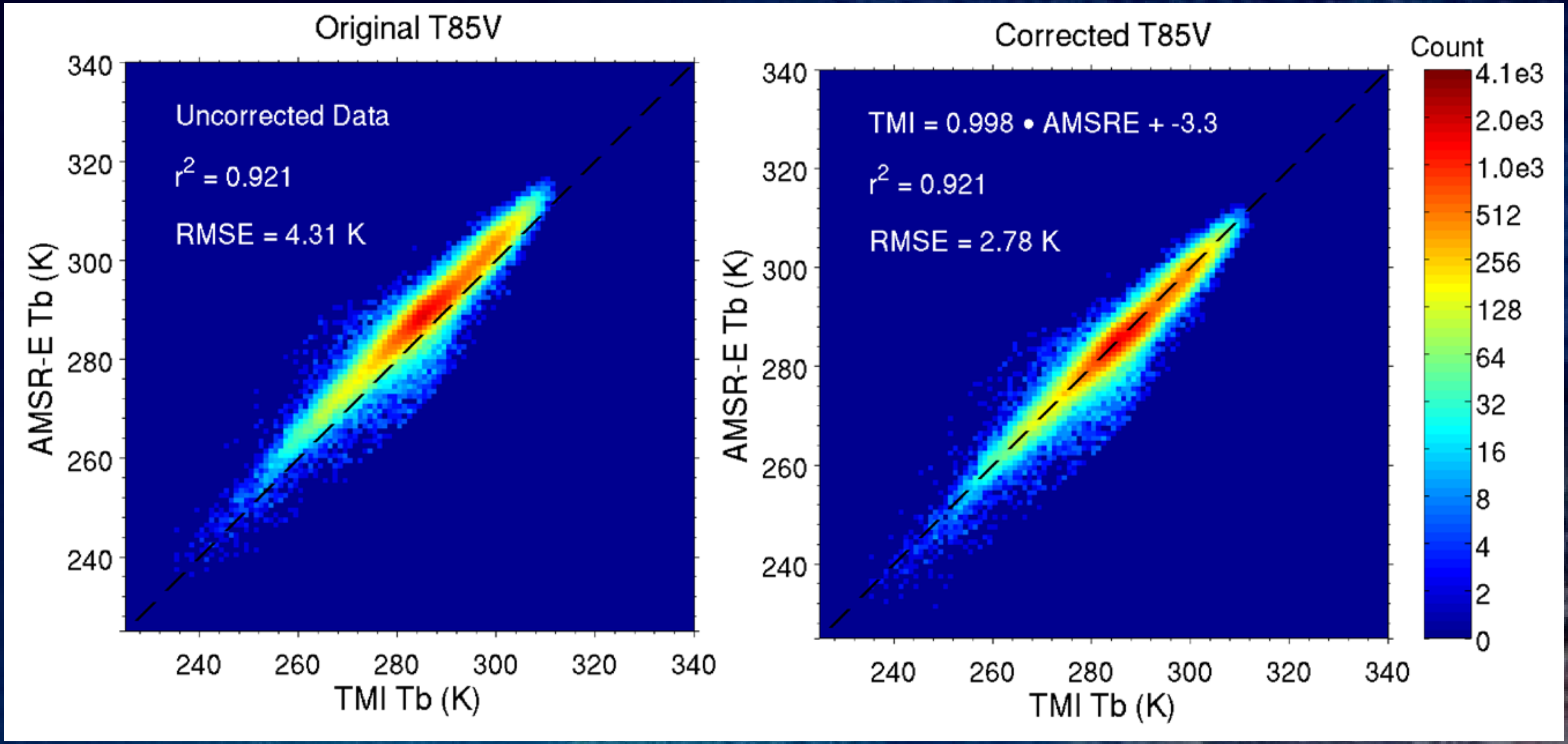
Land Segment: Semi-Empirical Calculation

- Developed for TRMM with training dataset from PR & TMI
  - » Requires adjustment from TMI to AMSR2 frequencies
- Separated into Convective/Stratiform rain rates

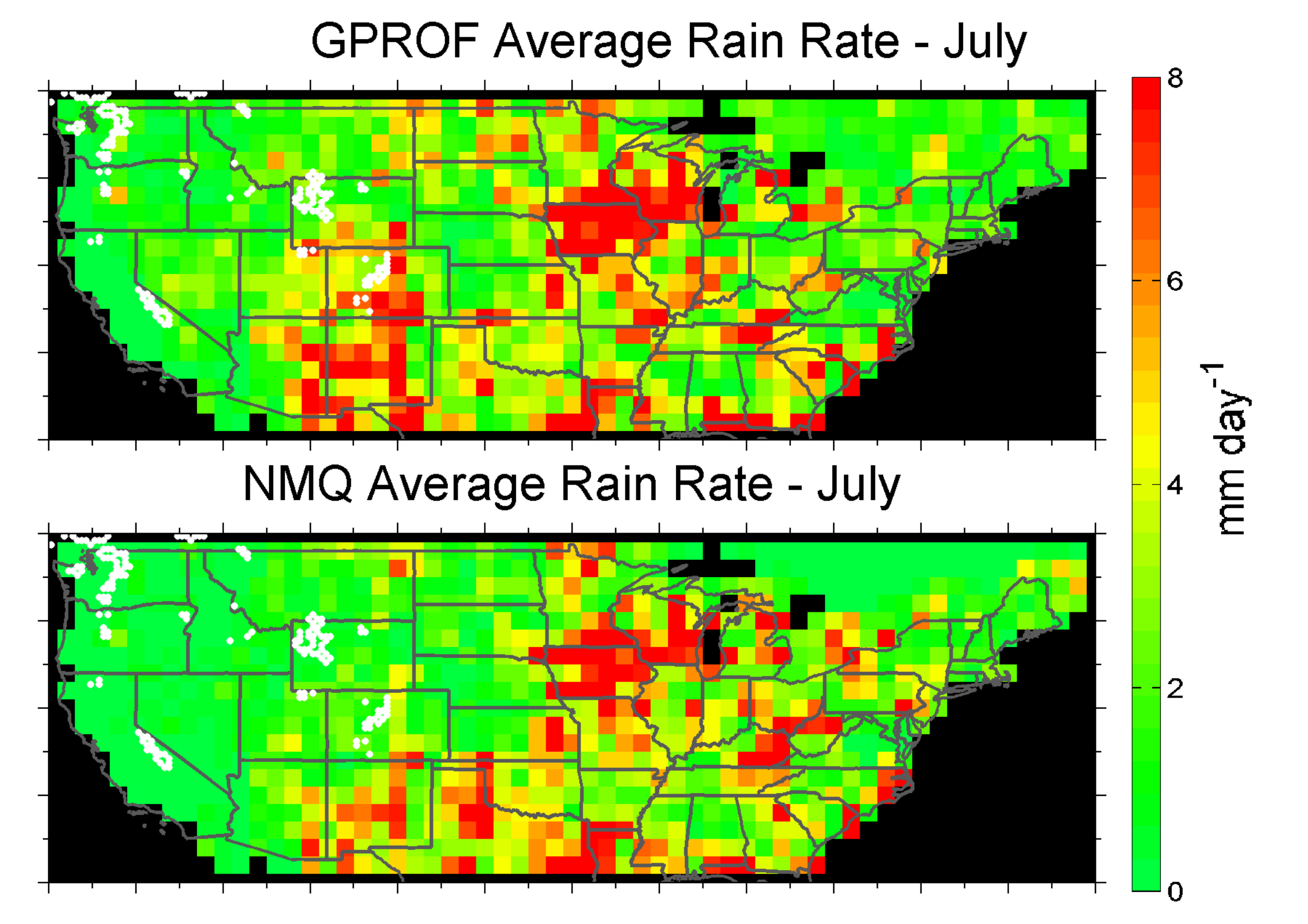
$$RR = RR_{Conv} P(C) + RR_{Strat} [1 - P(C)]$$

- RR_{Conv}=(O_3(T89V); RR_{Strat}=O_1(T89V)
- *P*(*C*[TbV(10, 37, 89), σ(T89V), Minima of T89V, [T89V-T89H])

Tbs Corrected to AMSR2

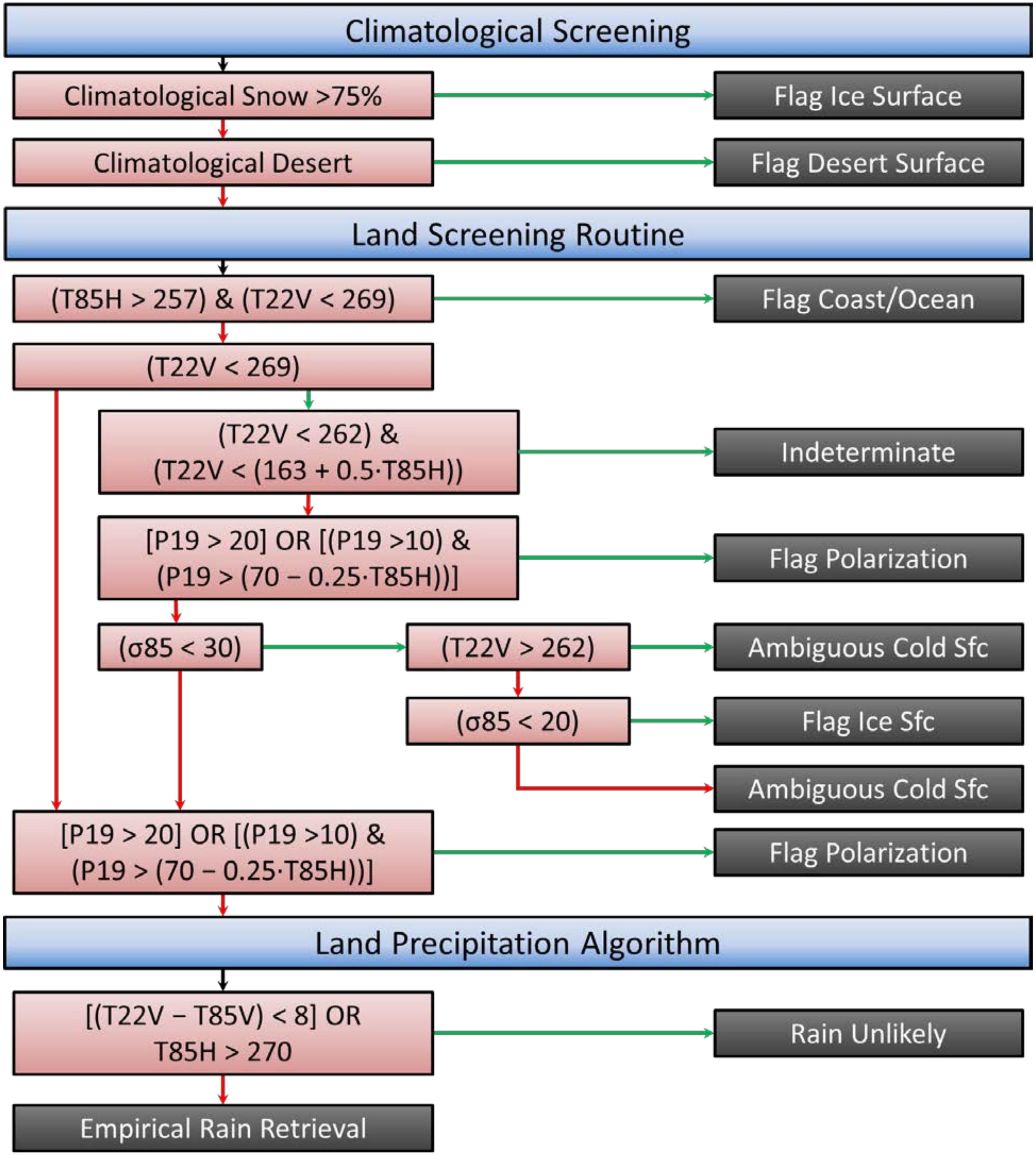


Monthly Average Rain Rate

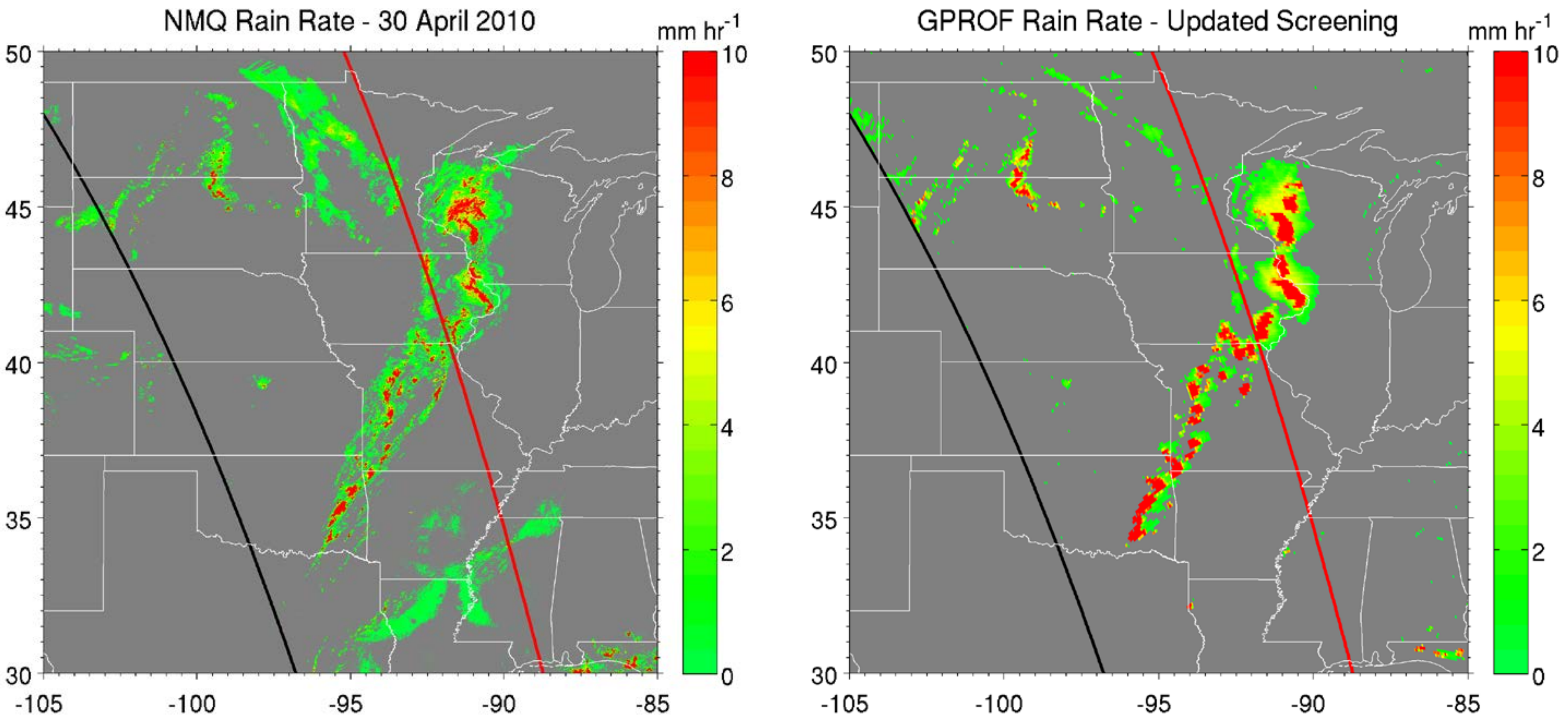


Surface Screening

- Universal algorithm over all surface types
  - » Flags snow/ice/sand as unreliable
- Heritage code to flag uncertain pixels
- Latest version incorporates annual desert climatology and monthly snow climatology


Climatological Screening
Climatological Snow >75%
Flag Ice Surface
Climatological Desert
Flag Desert Surface
Land Screening Routine
(T85H > 257) & (T22V < 269)
Flag Coast/Ocean
(T22V < 269)
(T22V < 262) &
(T22V < (163 + 0.5·T85H))
Indeterminate
[P19 > 20] OR [(P19 >10) &
(P19 > (70 – 0.25·T85H))]
Flag Polarization
(σ85 < 30)
(T22V > 262)
Ambiguous Cold Sfc
(σ85 < 20)
Flag Ice Sfc
Ambiguous Cold Sfc
[P19 > 20] OR [(P19 >10) &
(P19 > (70 – 0.25·T85H))]
Flag Polarization
Land Precipitation Algorithm
[(T22V – T85V) < 8] OR
T85H > 270
Rain Unlikely
Empirical Rain Retrieval

Improved Screening



Known Caveats

- TRMM doesn’t sample low SST regions
  - » Exteneded to upper latitudes by lowering SSTs and removing lower atmosphere from profile
- Rain added below threshold of PR and DSD modified to increase lower atmosphere precipitation
- Warm rain over land underestimated due to lack of ice-scattering signal
- Misses orographically enhanced precipitation
- Heritage screening code can be unreliable globally

Land Products

Presented by

Xiwu Zhan
NOAA/NESDIS/STAR

JPSS Requirements for AMSR-2 Soil Moisture EDR

(L1RD Supplement 2.7)

Requirement 6.1.10: *Soil Moisture is moisture within the surface soil layer to the depth where microwave emission or reflection signals can be sensed by satellite sensors*

Table 6.1.10 - Soil Moisture (AMSR-2)		
EDR Attribute	**Threshold**	**Objective**
SM Applicable Conditions: 1. Delivered under "all weather"		
a. Sensing Depth	Surface to -0.1 cm (Skin Layer)	Surface to - 80 cm
b. Horizontal Cell Size	40 km	20 km
c. Mapping Uncertainty, 3 Sigma	5 km	1 km
d. Measurement Uncertainty	6% volumetric RMSE (goal), with VWC < 1.5 kg/m^2 or GVF < 0.5 and < 2 mm/hr. Precip. Rate	Surface: 5 % 80 cm column: 5 %
e. Measurement Range	0 - 50 % (1)	0 - 100 %
f. Refresh	At least 90% coverage of the globe about every 20 hours (monthly average) (2)	NS
		v2.5, 1/23/13

Notes:

1. Under Attribute (e), the threshold measurement range is given as 0-50% which is appropriate. However, the objective is given as 0-100%. A 0-100% range in absolute soil moisture only makes sense if you are including some fraction of standing water in the total of what you are calling "soil moisture" since soils will saturate at an absolute soil moisture level of 40-50%. The community often converts % soil moisture into absolute units (for ex., 50% = 0.50 cm^3/cm^3) to avoid confusion. The later approach would not include standing water in the units of soil moisture since the "per cm^3" volume referred to is the soil volume at and below the soil surface and would not include anything sitting on top of the surface like puddles of water.
2. This Refresh requirement is consistent with the AMSR-2 Cross-track Swath Width design of 1450 km for a single orbit plane.

JPSS Requirements for AMSR-2 Soil Moisture EDR

(Recommended by GCOM-W Land Team)

Table 6.1.10 - GCOM-W Soil Moisture

EDR Attribute	Threshold	Objective
Applicable conditions	Delivered under "all weather" conditions	Delivered under "all weather" conditions
Sensing depth	Surface to -0.1 cm (skin layer)	Surface to -80 cm
Horizontal cell size	25 km (1)	20 km
Mapping uncertainty, 3 sigma	5 km	1 km
Measurement Uncertainty	6% volumetric RMSE (goal) with VWC < 1.5 kg/m^2 or GVF < 0.5 and < 2 mm/hr precip rate	Surface: 5% 80 cm column: 5%
Measurement range	0 – 50%(2)	0 – 50%
Refresh	At least 90% coverage of the globe about every 20 hours (monthly average)(3)	n/s

Note:
(1) Per AMSR-E legacy and user convenience, 25km can be obtained with resampling AMSR-2 footprints to 25km.
(2) Absolution soil moisture unit (m^3/m^3 volume %) is preferred by most users of NWP community
(3) This Refresh requirement is consistent with the AMSR-2 Cross-track Swath Width design of 1450 km for a single orbit plane

JPSS Requirements for AMSR-2 Surface Type EDR

(L1RD Supplement 2.7)

Requirement 6.1.11: ***The Surface Type EDR from AMSR-2 will provide land surface type information for AMSR-2 footprints or pixels***

Table 6.1.11 - Surface Type (AMSR-2)		
EDR Attribute	**Threshold (1)**	**Objective**
ST Applicable Conditions: 1. Delivered under "all weather"		
a. Horizontal Cell Size	40 km	20 km
b. Mapping Uncertainty, 3 Sigma	5 km	1 km
c. Measurement Range	13 classes of land types specified in Note (2) with no precipitation.	17 IGBP Classes
d. Measurement Precision	NS	NS
e. Measurement Accuracy: Probability of Correct Typing	50% correct for 13 types listed in Note (2)	80 % correct
f. Refresh	At least 90% coverage of the globe about every 20 hours (monthly average) (3)	NS
		v2.5, 1/23/13

Notes:

1. The primary Surface Type measurement Thresholds are satisfied by the JPSS VIIRS under "probably clear" and "Probably cloudy" conditions.
2. 1) Standing water or flooded, 2) Dense vegetation (jungle), 3) Agricultural/range land, 4) Dry arable soil, 5) Moist soil, 6) Semi-arid surface, 7) Desert, 8) Dry snow, 9) Refrozen snow, 10) Wet snow, 11) Composite vegetation and water, 12) Composite soil and water, 13) Indeterminate.
3. This Refresh requirement is consistent with the AMSR-2 Cross-track Swath Width design of 1450 km for a single orbit plane.

JPSS Requirements for AMSR-2 Surface Type EDR

(Recommended by GCOM-W Land Team)

Table 6.1.11 - Surface Type (AMSR-2)		
EDR Attribute	Threshold (1)	Objective
Applicable conditions	Delivered under "all weather" conditions	Delivered under "all weather" conditions
a. Horizontal cell size	25 km	1 km
b. Mapping uncertainty, 3σ	5 km	1 km
c. Measurement Range	8 hydrological classes(2)	13 classes of land types listed in Note (3)
d. Measurement Precision	5%	2%
e. Measurement Accuracy	70% for 17 types	80%
f. Refresh	>90% coverage of globe every 20 hrs (4)	n/s

Note:

(1) Satisfied by VIIRS under "probably clear" and "probably cloudy" conditions.

(2) 1) Standing water, 2) Dense veg (jungle), 3) Herb veg, 4) Desert, 5) Snow, 6) Urban, 7) Wetland, 8) Raining area

(3) 1) Standing water/flooded, 2) Dense veg (jungle), 3) Ag/range land, 4) Dry arable soil, 5) Moist soil, 6) Semi-arid surface, 7) Desert, 8) Dry snow, 9) Refrozen snow, 10) Wet snow, 11) Veg/water mix, 12) soil/water mix, 13) Indeterminate.

(4) Consistent with AMSR2 cross-track swath width of 1450km.

AMSR-2 Soil Moisture EDR Algorithm

Hybrid of the SCR and LPRM algorithms:

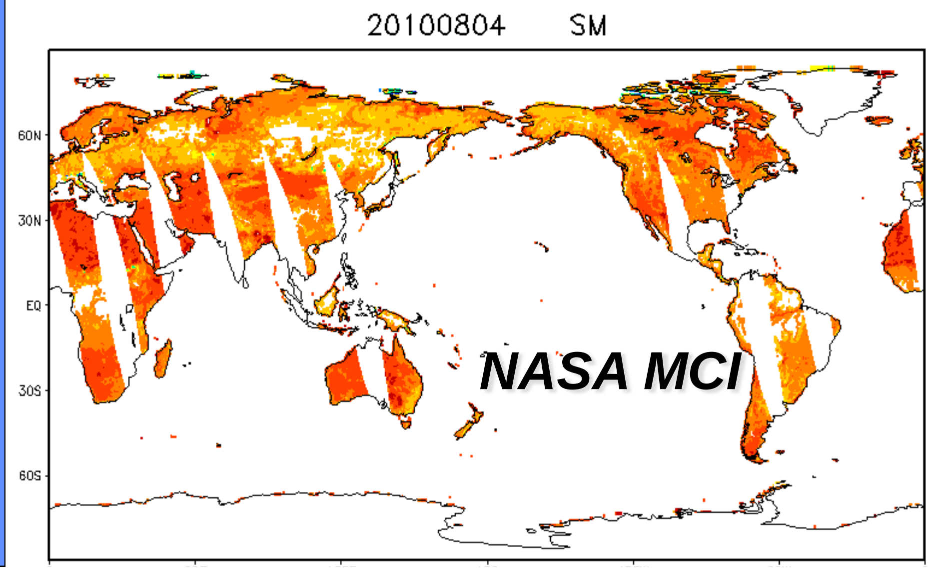
SCR: Inverse tau-omega equation of a TB_h (C/X-band) for *SM* with *tau* from *NDVI* and T_s from TB_{36v}. Used in SMOPS

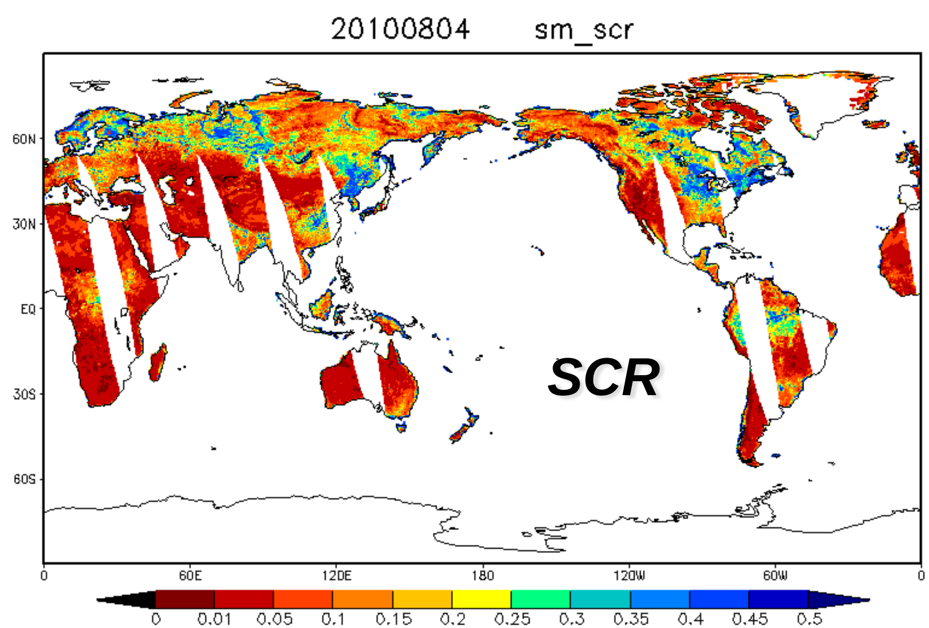
LPRM: Inverse tau-omega equations of TB_h and TB_v (C/X-band) for *tau* and *SM* with T_s from TB_{36v}

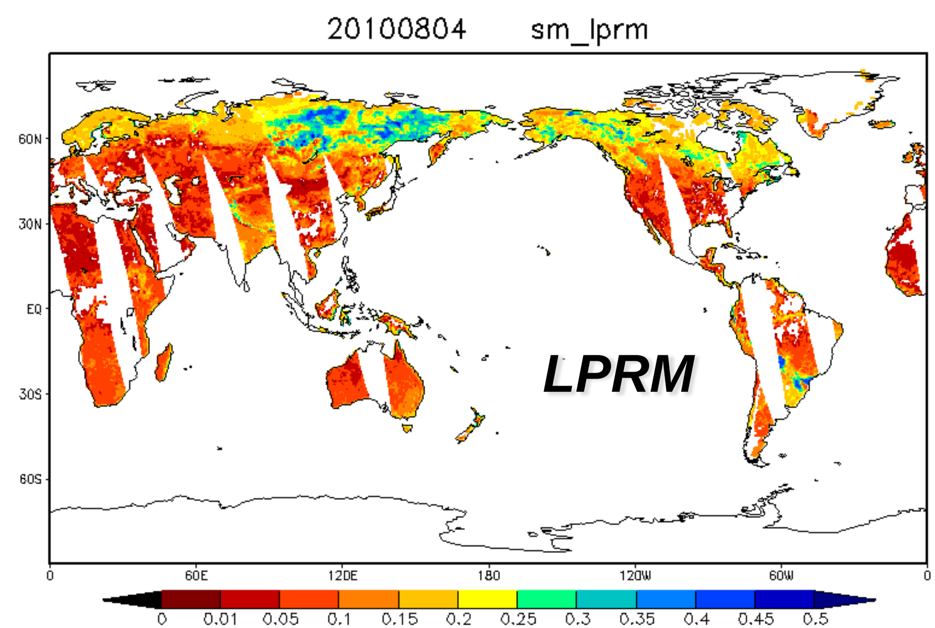
Hybrid: Use LPRM inversed *tau* in SCR

Results from different SM retrieval algorithms are very different:

- *NASA retrievals too flat*
- *LPRM retrievals too large*
- *SCA retrieval range more reasonable*







Theoretical Basis of the SCR Algorithm

- Introduced by Jackson (1993).
- *TB_h* (C/X-band) is the most sensitive to SM
- *Simplified* τ-ω equation is used to inverse *e* while τ & T_s are estimated from *NDVI* and TB_{36v}

$$T_{Bp} = T_s e_{r,p} \exp(-\tau_p / \cos\theta) + T_s [1 - \exp(-\tau_p / \cos\theta)][1 + R_{r,p} \exp(-\tau_p / \cos\theta)]$$

- The Fresnel equation is then used to determine the dielectric constant from *e* and a dielectric mixing model is used to inverse *SM*
- Results were too sensitive to *NDVI* errors

Theoretical Basis of the LPRM Algorithm

- Introduced by Owe et al (2001).
- Relate τ to $MPDI = (T_{Bv} - T_{Bh})/(T_{Bv} + T_{Bh})$
- The τ-ω equation is used to inverse *e* while T_s is estimated from TB_{36v}

$$T_{Bp} = T_s e_{r,p} \exp(-\tau_p / \cos\theta) + T_s (1 - \omega_p) [1 - \exp(-\tau_p / \cos\theta)][1 + R_{r,p} \exp(-\tau_p / \cos\theta)]$$

- The Fresnel equation is then used to determine the dielectric constant from *e* and a dielectric mixing model is used to inverse *SM*
- Results were too high for some areas

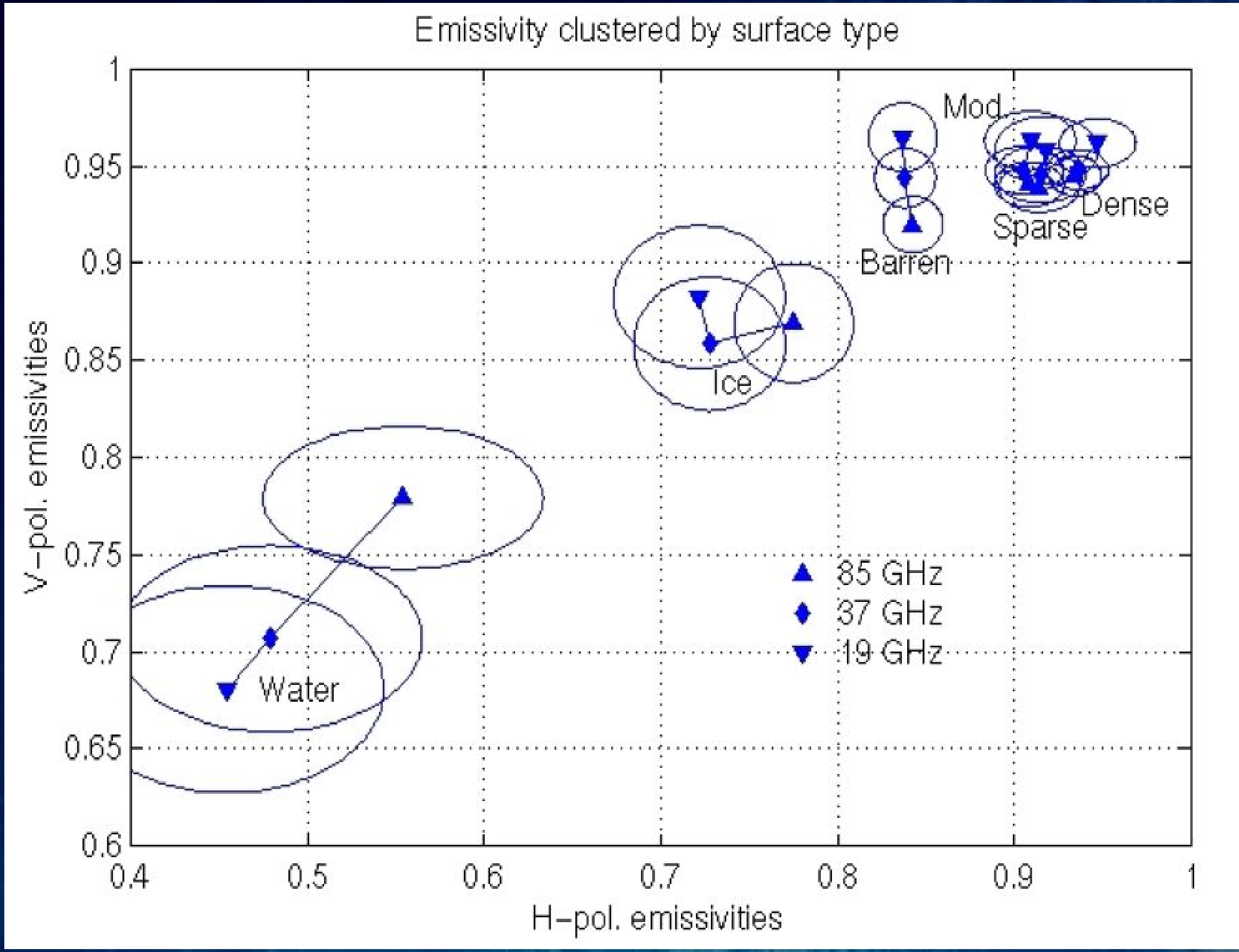
Approach to Combining the SCR and LPRM Algorithms

- Introduced by Owe et al (2001).
- Relate τ to $MPDI = (T_{Bv} - T_{Bh})/(T_{Bv} + T_{Bh})$
- *Simplified* τ-ω equation is used to inverse *e* while T_s is estimated from TB_{36v}

$$T_{Bp} = T_s e_{r,p} \exp(-\tau_p / \cos\theta) + T_s [1 - \exp(-\tau_p / \cos\theta)][1 + R_{r,p} \exp(-\tau_p / \cos\theta)]$$

- The Fresnel equation is then used to determine the dielectric constant from *e* and a dielectric mixing model is used to inverse *SM*
- Result is expected to meet the requirements

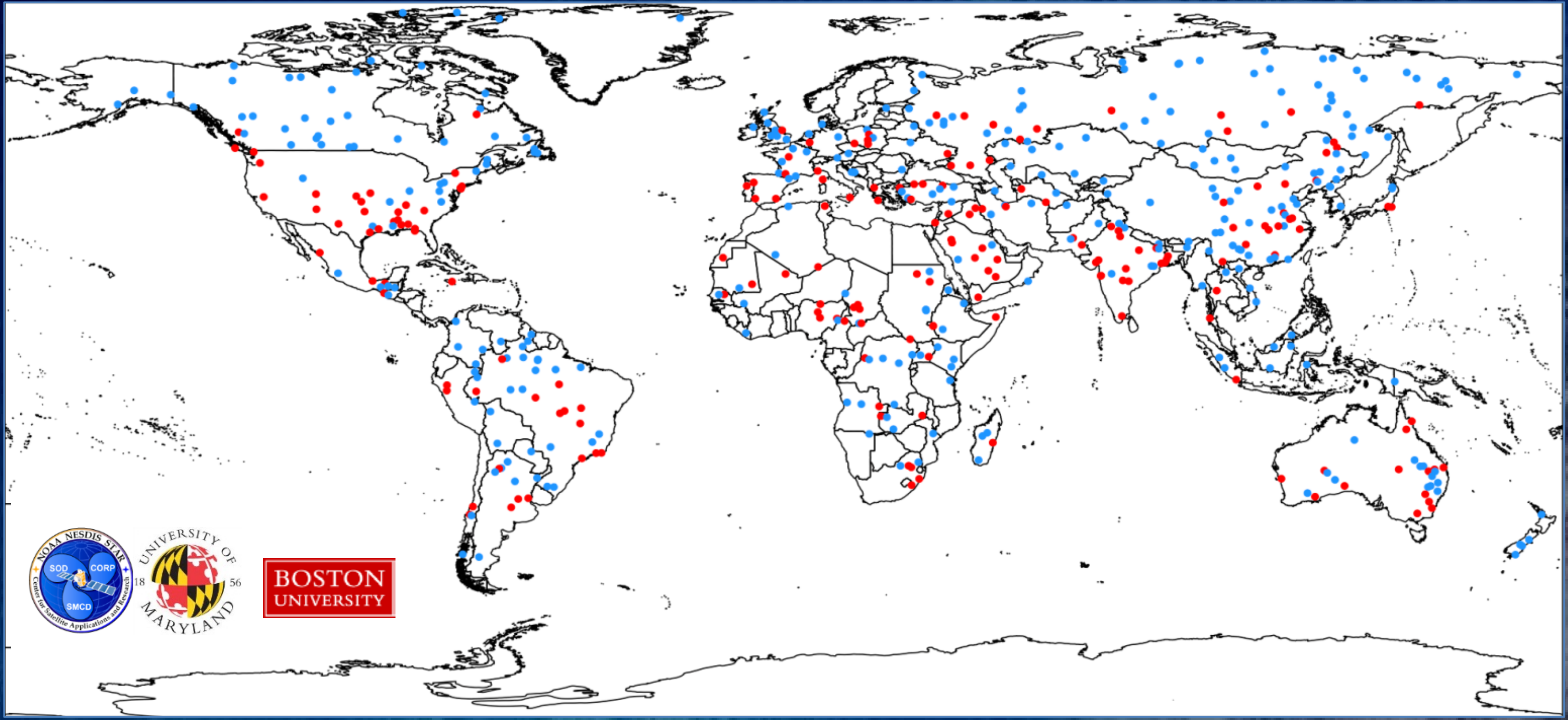
Theoretical Basis of Surface Type Classification



- Certain surface type spectral signatures are distinguishable
- A Decision Tree algorithm classifies the types with the signature
- Most types are static and available from VIIRS QST IP

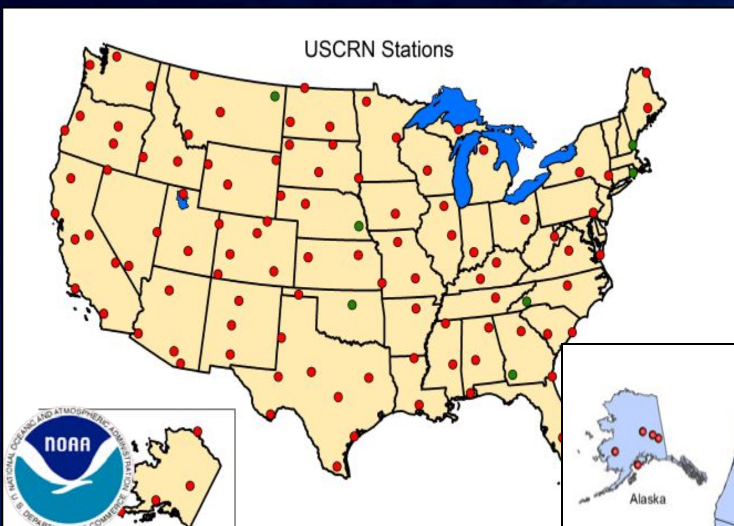
Validation of ST EDR

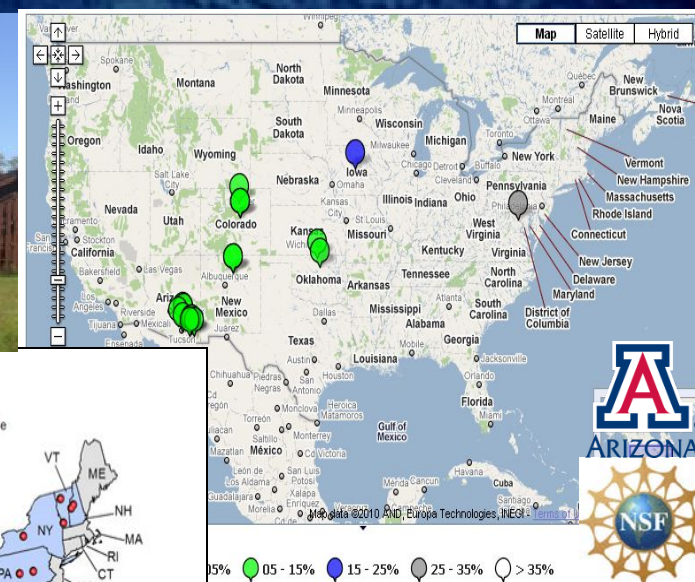
- VIIRS Surface Type EDR Team are developing ground surface type truth data for 500 sites around the world that with be used to validate AMSR-2 ST EDR too

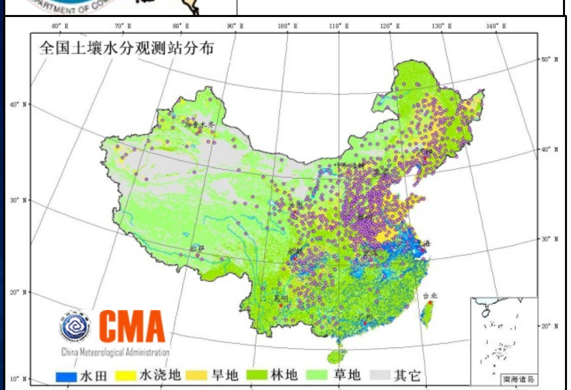


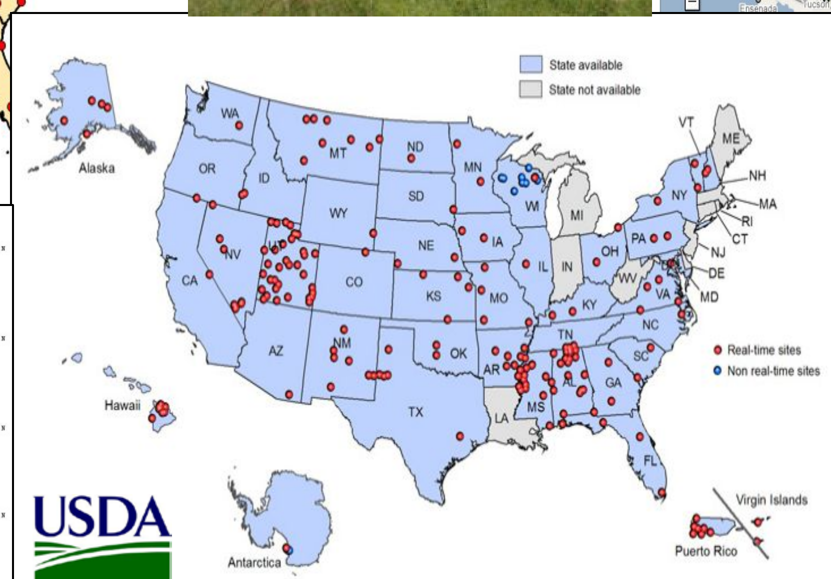
Validation of SM EDR

- *In situ* soil moisture measurements from several network stations are available from USCRN, SCAN, COSMOS, etc









etc

Operation Concepts for ST& SM EDRs

- GCOM-W land EDRs (ST & SM) will be down stream from rainfall, snow/ice EDRs so that rain and snow/ice flags will be used for ST EDR and in turn for SM EDR
- The Land EDRs will be generated in 9-minutes granules for users that needs near real time (NRT) products. For NWP users, 6-hour and daily global gridded products will be available from NESDIS Soil Moisture Operational Product System (SMOPS) which will be fed with NRT AMSR-2 soil moisture granules.
- Product files will be in NetCDF4

SUMMARY

- AMSR-2 ST & SM EDR will be down stream products from AMSR-2 Rain and Snow/Ice EDRs
- A hybrid of the SCR and LPRM algorithms is used for AMSR-2 SM EDR
- A decision tree, VIIRS QST IP & AMSR-2 rain and snow/ice EDRs will be used for AMSR-2 ST EDR
- Validation of ST and SM EDRs will be based on comparison of products with in situ measurements
- Data formats of the land EDRs will meet user requirements (NetCDF4 and GRIB2)

Snow Products

Presented by

Cezar Kongoli
CICS

AMSR-2 Snow and Ice Algorithms

- Delivery 2
  - Day 2 GAASP Product Capability
  - Sea Ice Characterization (SIC)
  - Snow Cover/Depth (SC/D)
  - Snow Water Equivalent (SWE)
- Pre-operational – September 2013
- Operational – September 2014

Snow/Ice Team

- **Jeff Key** (lead), NOAA/NESDIS
- **Yong-Keun Lee**, University of Wisconsin: snow
- **Walt Meier**, University of Colorado: sea ice
- **Cezar Kongoli**, CICS/University of Maryland: snow

Basic Requirement 5.0

- **Requirement 5.0:** *The STAR GCOM processing system shall produce a snow cover/depth (SC/D) product.*

Table 5.0 GCOM Snow Cover/Depth

EDR Attribute	Threshold	Objective
Applicable conditions		Delivered under "all weather" conditions
Sensing depth	0 – 60 cm	1 m
Horizontal cell size	10 km	5 km
Mapping uncertainty, 3 sigma	5 km	1 km
Snow depth ranges	5 – 60 cm	> 8 cm; > 15 cm; > 30 cm; > 51 cm; > 76 cm
Measurement uncertainty		
-- Clear	80% probability of correct snow/no snow classification; Snow Depth: 20 cm (30 cm if forest cover exceeds 30%)	10% for snow depth
-- Cloudy	80% probability of correct snow/no snow classification; Snow Depth: 20 cm	Not Specified
Refresh	At least 90% coverage of the globe about every 20 hours (monthly average)	Not Specified
Latency	16 minutes	

Basic Requirement 11.0

- **Requirement 11.0:** *The STAR GCOM processing system shall produce a snow water equivalent (SWE) product.*

Table 11.0 GCOM Snow Water Equivalent		
EDR Attribute	Threshold	Objective
Applicable conditions		Delivered under "all weather“ conditions
Horizontal cell size	10 km	5 km
Mapping uncertainty, 3 sigma	5 km	1 km
Measurement range	10 – 200 mm	Not Specified
Measurement uncertainty		Not Specified
-- Shallow to moderate snow packs (10 – 100 mm)	20 mm or 50%	Not Specified
-- High snow accumulation (above 100 mm)	70%	Not Specified
Refresh	At least 90% coverage of the globe about every 20 hours (monthly average)	Not Specified
Latency	16 minutes	

Snow Cover Detection

Brightness temperature (TB)-based Decision-Tree Approach

- Most operational algorithms have applied this methodology: Identify snow from non-snow surfaces by its brightness temperature scattering signal and filter out known confounding factors such as cold deserts, frozen soil and precipitation

- Pros: Straightforward and effective method of mapping snow in all weather conditions

- Cons: coarser resolution compared to VIS/IR, underestimation of early/wet snow, snow under heavy forest (omission errors), overestimation over cold deserts, confusion with convective rain (comission errors)

Snow Cover Algorithms Considered

- **Grody's 1991 SSMI Algorithm**
  - The most cited microwave snow cover algorithm
  - Continues to be a baseline algorithm
  - Applied to SSMIS and AMSU instruments at similar AMSR-E channels
  - Matured through 30 years of improvements at NOAA/NESDIS Hydrology-Remote Sensing Group
  - NOAA's AUTOSNOW (input to IMS) uses Grody's SSMI algorithm

- **Current NASA AMSR-E snow detection algorithm**
  - Similar method (TB-based screening criteria)
  - Differs in technical details from Grody's algorithm
  - Uses 10 GHz channel not available in AMSU and SSMI
  - Climatology test to rule out unlikely snow occurrence

Snow Cover Detection – Selection

- Enhanced Grody SSMI algorithm
  - Two climatology tests: probability of snowfall occurrence derived from IMS snow cover data, and monthly climatology temperature tests to rule out unlikely snow occurrence
  - Adapt the algorithm to AMSR2 configuration
  - Investigate the utility of the lower frequency channels (10 GHz and below)
  - Investigate the utility of TB atmospheric corrections

Snow Cover Detection Algorithm Input

- AMSR2 snow cover detection algorithm requires for each pixel:
  - » Calibrated/Navigated AMSR2 brightness temperatures
  - » Longitude and Latitude
  - » Land/Water mask
  - » Snow climatology

Snow Cover Detection Algorithm Input

Name	Type	Description	Dimension
18.7 GHz brightness temperature	Input	Navigated and Calibrated 18.7 GHz level 1b brightness temperatures for V. & H. polarized	Scan grid (xsize, ysize)
23.8 GHz brightness temperature	Input	Navigated and Calibrated 23.8 GHz level 1b brightness temperatures for V. polarized	Scan grid (xsize, ysize)
36.5 GHz brightness temperature	Input	Navigated and Calibrated 36.5 GHz level 1b brightness temperatures for V. & H. polarized	Scan grid (xsize, ysize)
89.0 GHz brightness temperature	Input	Navigated and Calibrated 89.0 GHz level 1b brightness temperatures for V. & H. polarized	Scan grid (xsize, ysize)
Latitude	Input	Pixel Latitude	Scan grid (xsize,ysize)
Longitude	Input	Pixel Longitude	Scan grid (xsize,ysize)

Snow Cover Detection Algorithm Input: Ancillary Data

- Three types of ancillary data needed:
  - » AMSR2 Product: Land/Water mask
  - » Non-AMSR2 Dynamic Data: N/A
  - » Non-AMSR2 Static Data: Snow Climatology

Name	Type	Description	Dimension
Land/Water mask	Input	land and water fraction	Scan grid (xsize, ysize)

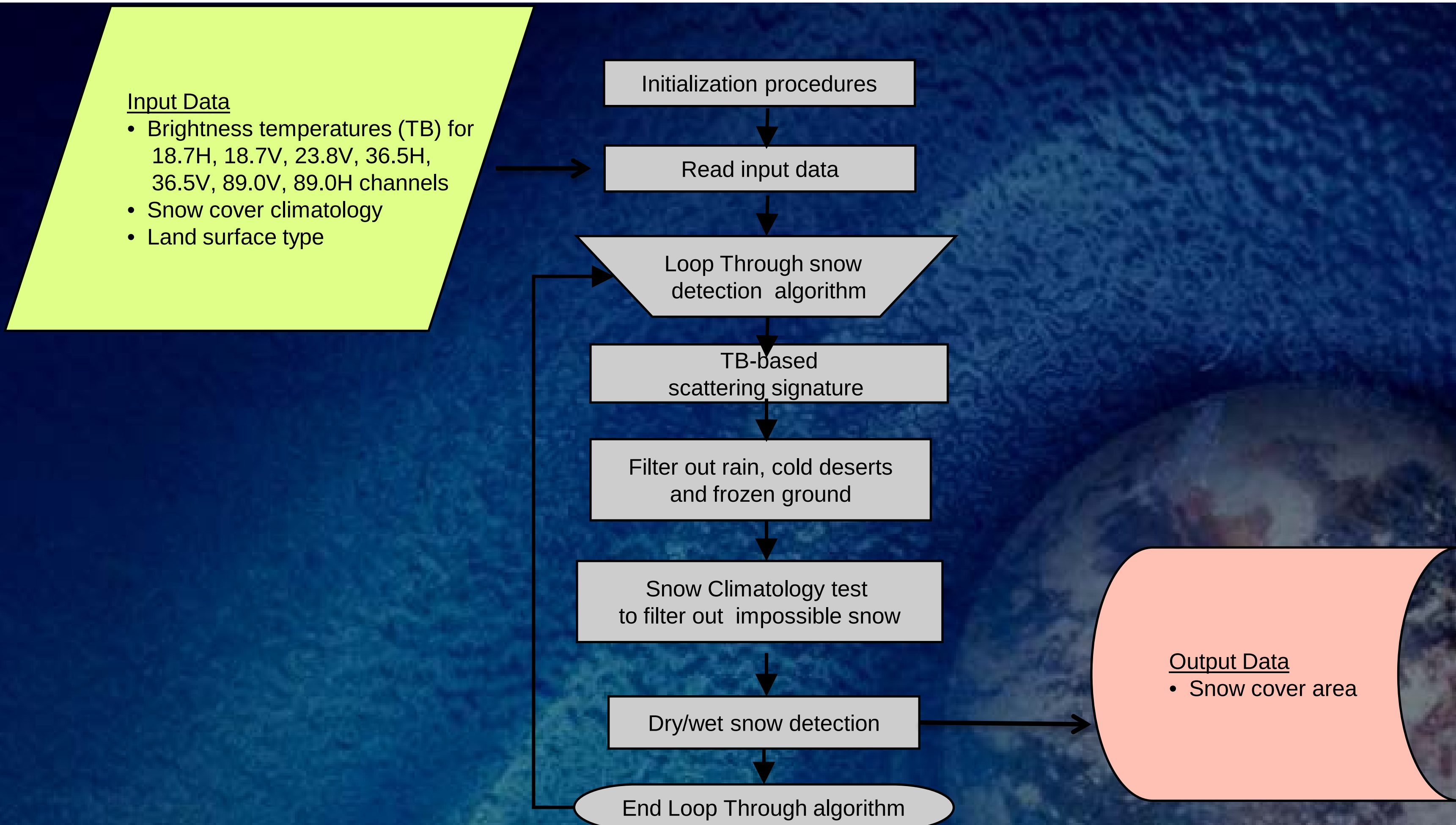
Name	Type	Description	Dimension
Snow climatology	Input	Snow frequency (probability of snow)	Scan grid (xsize, ysize)

Snow Cover Detection Algorithm Output

- Output Data:
  - Snow cover detected by this algorithm

Name	Type	Description	Dimension
Snow cover	output	Output contains snow cover information (1: snow, 0: no snow) for each pixel	Scan grid (xsize, ysize)

Snow Cover Algorithm Processing Outline



Snow Cover Detection – Algorithm Details

- Applied the Grody's 1991 SSM/I version to AMSR-E data
- Will be adjusted/optimized for AMSR2
- Dry/wet snow differentiation will be applied based on BT criteria from Northrop Grumman Corporation's report (2002).

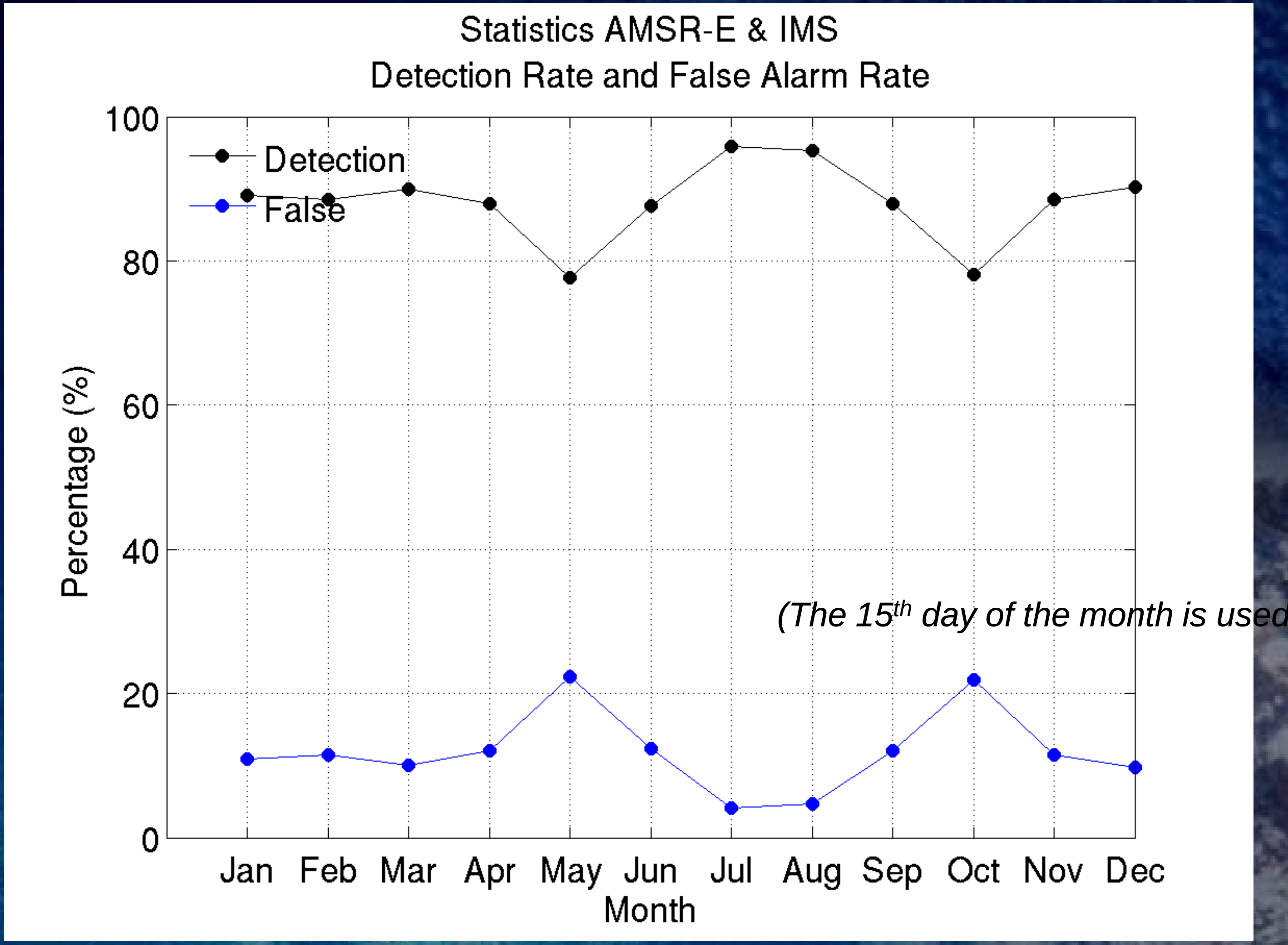
- Scattering materials test
  (T22V-T85V > 0 or T19V-T37V > 0)

- Precipitation test
  (T22V ≥ 258 or T22V ≥ 165+0.49*T85V)
  (T22V ≥ 254 and T22V-T85V ≤ 2)

- Cold desert test
  (T19V-T19H ≥18 and T19V-T37V ≤ 10 and T37V-T85V ≤10)

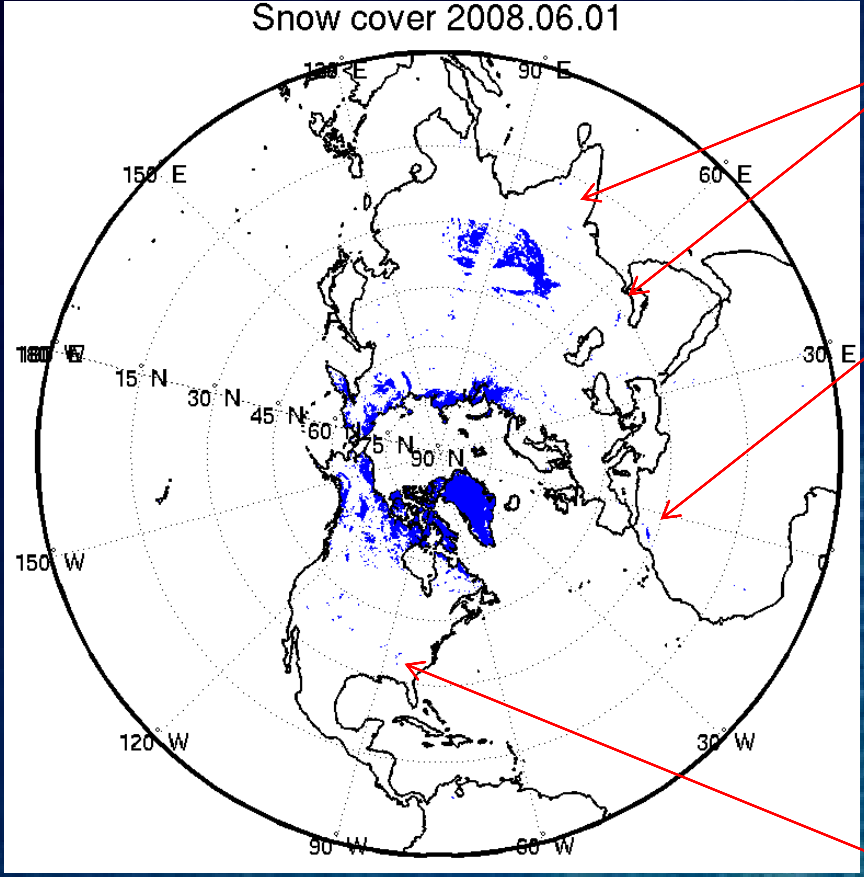
- Frozen ground test
  (T19V-T19H ≥ 8 and T22V-T85V ≤ 6)

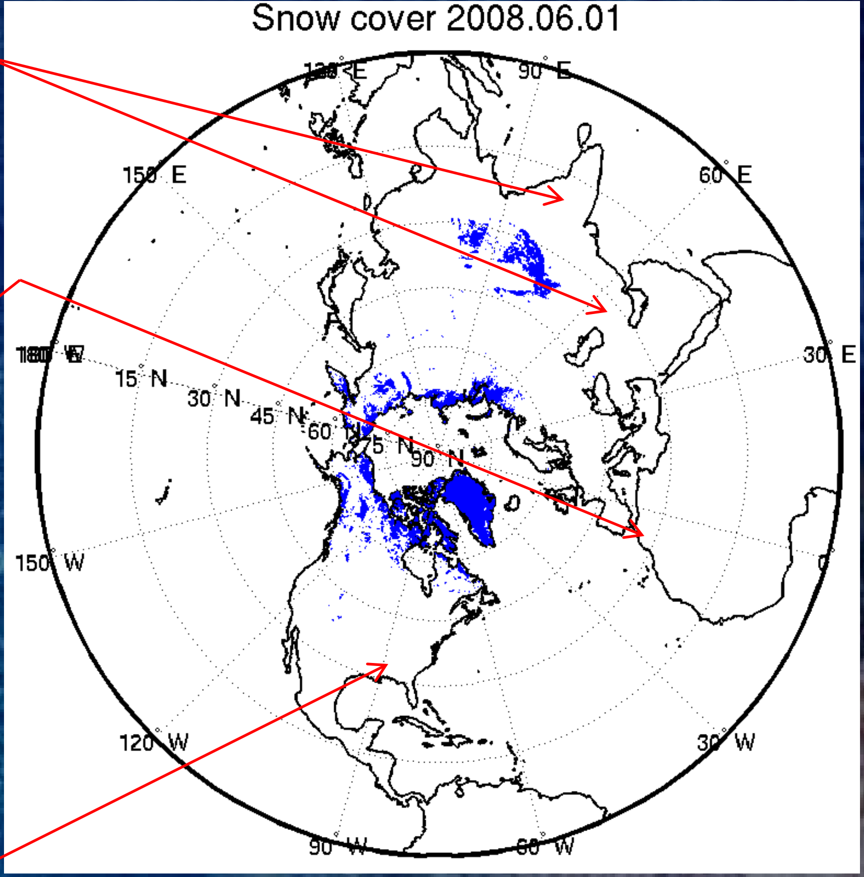
Enhanced Grody Algorithm Validation



Before snow climatology test

After snow climatology test





Snow Depth/SWE Algorithm Choices considered

- **Most recent NASA AMSR-E SWE approach (Kelly, 2009)**
    - Brightness temperature differences at 10, 18 and 37 GHz (the Chang et al. approach) but with non-linear spatially and varying coefficients computed from brightness temperatures at horizontal and vertical polarizations
    - Use of 10 & 18 GHz channels over non-forest fraction of the AMSR-E pixel for deeper snow retrievals
    - Retrievals of pixel SD are weighted between forest and non-forest fractions
    - Algorithm coefficients are tuned to SD, and SWE is estimated using a spatially and seasonally varying snow density climatology.

- **GlobSnow approach**
    - Iterative scheme that matches observed with simulated brightness temperature difference at 19 and 37 GHz vertical polarization
    - One-layer semi-empirical snow emission model for TB simulations
    - Near real time *in-situ* snow depth to estimate grain size parameter
    - The GlobSnow emission model-based iterative approach is physically-based, but a major disadvantage is the need for station snow depth data to adjust critical model parameters. This is circular logic, i.e., retrieve SD/SWE based on measured SD. Another disadvantage is the use of only vertical polarization brightness temperature difference at 19 and 37 GHz, which restricts the full utilization of AMSR-E capabilities. This approach would therefore be high risk.

Snow Depth/SWE Algorithms choices considered (cont)

- **MIRS**
  - Uses AMSU operationally
  - There is no AMSR-E version of the MIRS algorithm running operationally.
  - There is a place for MIRS algorithms as a back-up in the upcoming IMS Version 3 blended snow depth analysis product, with the NASA AMSR-E being the first choice for now,
  - MIRS will be the working algorithm until NASA AMSR2 is up and running.
  - The MIRS operational products are coarse resolution right now, they plan on being delivered in high-resolution model for AMSU, but it will take some time to have them released and validated properly. This approach would therefore be high risk.

Snow Depth/SWE Algorithm – Selection

- **Most recent NASA AMSR-E SWE approach**
  - Dynamic algorithm for regional to global applications
  - Has evolved over the course of 40-some years
  - This is a NASA signature product regarded as an international industry standard
  - Utilizes lower frequency channels (10 GHz) not available in SSMI
  - <u>Explicit sub-pixel forest cover and forest-free SWE estimates, potentially beneficial for downscaling applications</u>

Snow Depth/SWE Algorithm Input

- AMSR2 snow depth/SWE algorithm requires for each pixel:
  - » Calibrated/Navigated AMSR2 brightness temperatures
  - » Longitude and Latitude
  - » Snow cover
  - » Forest fraction and Vegetation continuous field
  - » Snow density climatology look-up table
  - » Global snow classification

Snow Depth/SWE Algorithm Input

Name	Type	Description	Dimension
10.7 GHz brightness temperature	Input	Navigated and Calibrated 10.7 GHz level 1b brightness temperatures for V. polarized	Scan grid (xsize, ysize)
18.7 GHz brightness temperature	Input	Navigated and Calibrated 18.7 GHz level 1b brightness temperatures for V. & H. polarized	Scan grid (xsize, ysize)
36.5 GHz brightness temperature	Input	Navigated and Calibrated 36.5 GHz level 1b brightness temperatures for V. & H. polarized	Scan grid (xsize, ysize)
Latitude	Input	Pixel Latitude	Scan grid (xsize,ysize)
Longitude	Input	Pixel Longitude	Scan grid (xsize,ysize)

Snow Depth/SWE Algorithm Input: Ancillary Data

- Types of ancillary data needed:
  - » AMSR2 Product: Snow cover
  - » Non-AMSR2 Dynamic Data: N/A
  - » Non-AMSR2 Static Data: Forest fraction, Vegetation continuous field Snow density climatology look-up table, Global snow classification

Name	Type	Description	Dimension
Snow cover	Input	Snow cover detected using AMSR2 measurements	Scan grid (xsize, ysize)

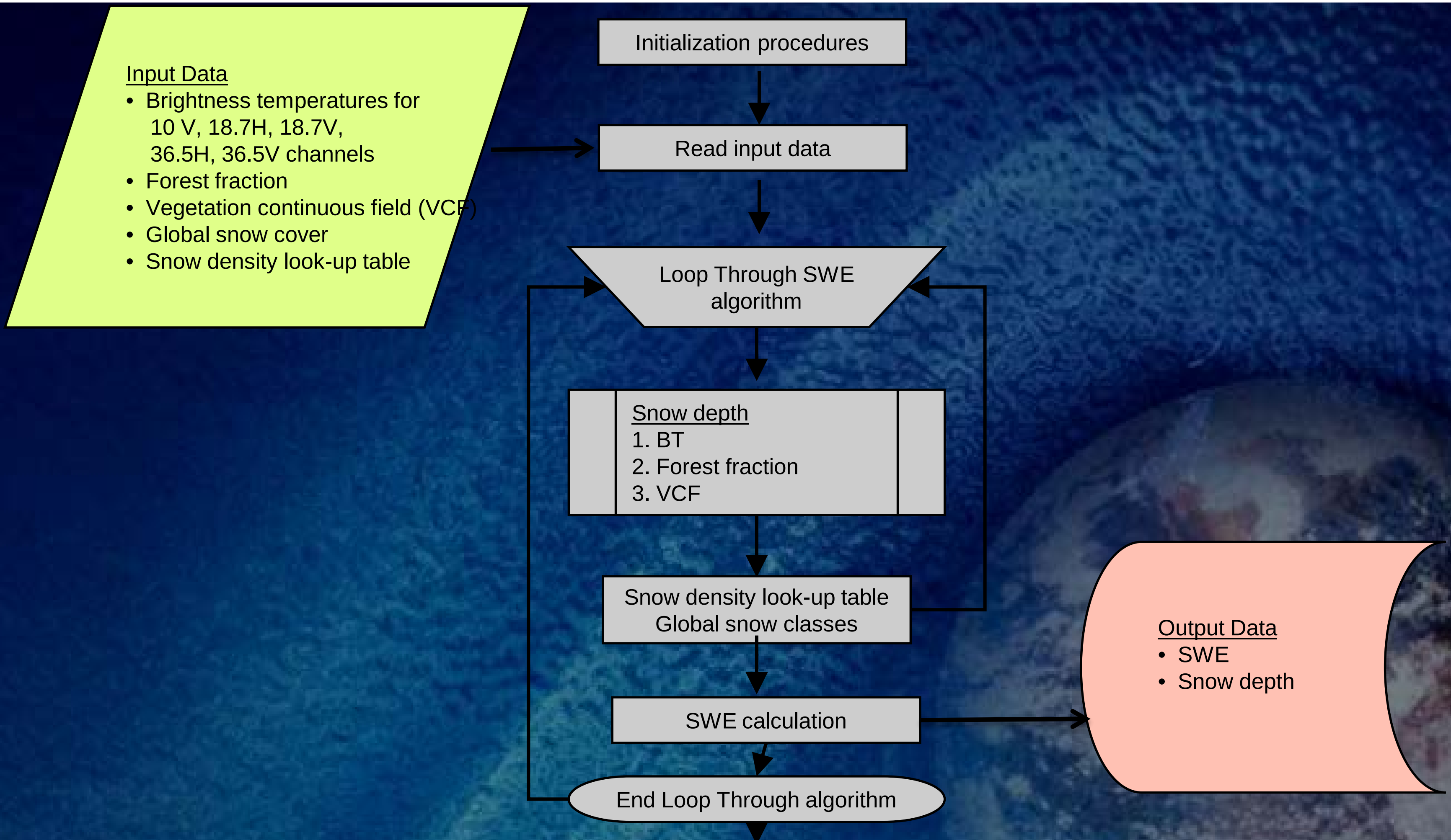
Name	Type	Description	Dimension
Forest fraction	Input	Generated from MCD12Q1 IGBP land type	Scan grid (xsize, ysize)
Vegetation continuous field	input	Generated from MOD44B tree cover fraction	Scan grid (xsize, ysize)
Snow density look-up table	Input	Available for each month and global snow class	Scan grid (xsize, ysize)
Global snow cover classes	Input	Available in EASE GRID format	Scan grid (xsize, ysize)

Snow Depth/SWE Algorithm Output

- Output Data:
  - Snow depth
  - Snow water equivalent (SWE)

Name	Type	Description	Dimension
Snow depth	Output	Output contains snow depth for each pixel where the snow cover is detected	Scan grid (xsize, ysize)
SWE	Output	Output contains SWE for each pixel where snow depth and snow density are available	Scan grid (xsize, ysize)

Snow Depth & SWE Algorithm Processing Outline



Snow Depth/SWE Algorithm Details

Adopted the current version of the Advanced Microwave Scanning Radiometer for the Earth Observing System (AMSR-E) algorithm based on Kelly (2009).

$$SD = ff * [p1 * (T18V - T36V)/(1-b*fd)] * (1-ff) * [p1 * (T10V-T36V) + p2 * (T10V-T18V)]$$

where,

ff: forest fraction product from MCD12Q1 (7km radius averaged)
fd: Vegetation continuous field product from MOD44B (7km radius averaged)
b = 0.6 from the SD comparison with 80 WMO snow measuring stations
TnnV: Brightness temperature at nn GHz, vertically polarized.
TnnH: Brightness temperature at nn GHz, horizontally polarized.

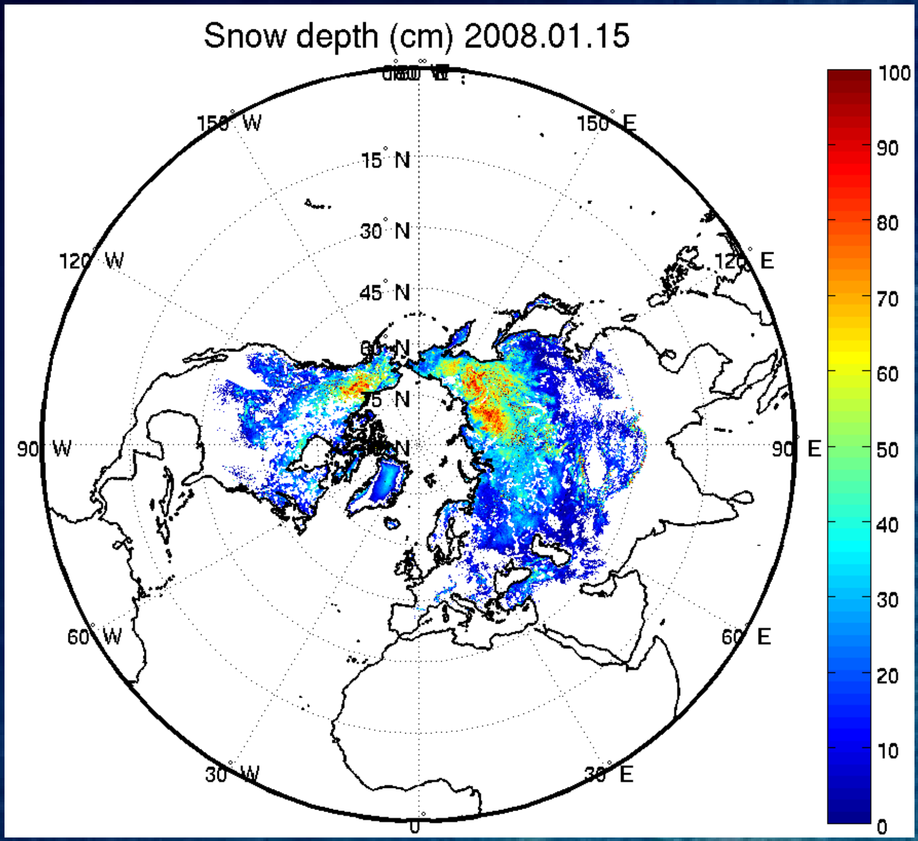
Then,

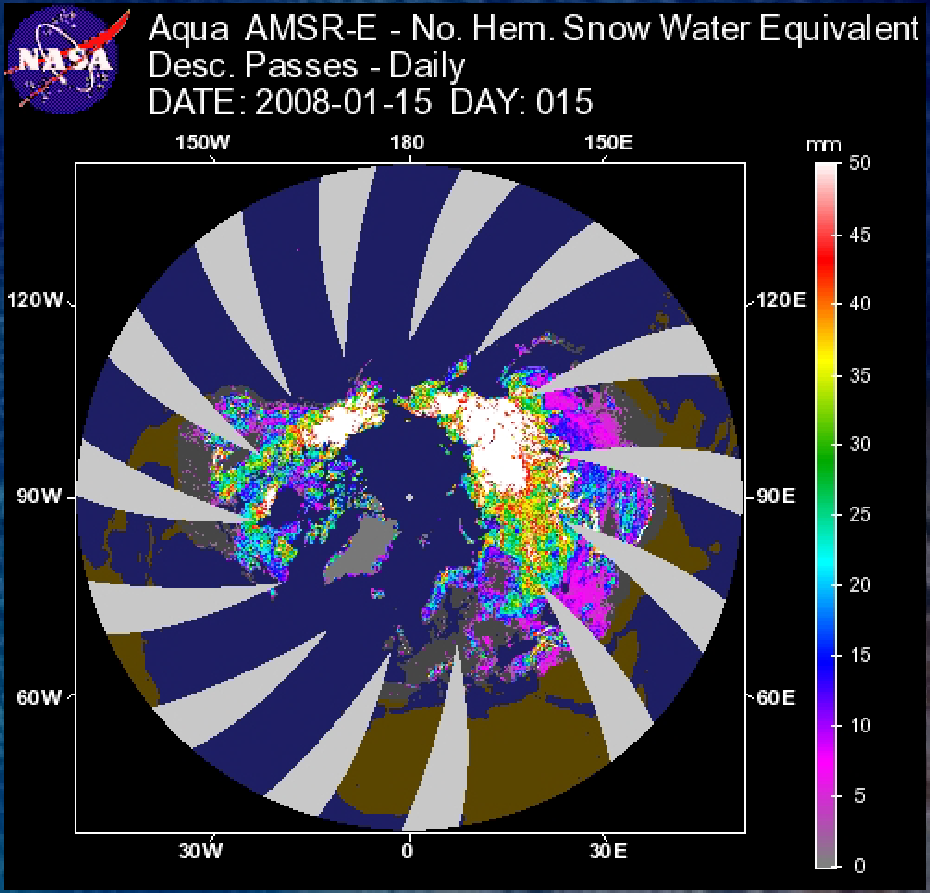
$$SWE = SD * snow\ density$$

where snow density is from a look-up table based on global snow classes)

Snow Depth/SWE – Validation

Snow depth from AMSR-E (our algorithm; left) and snow water equivalent product (right) on 15 January 2008. The two products show similar spatial patterns and variability. A quantitative analysis is underway.





Ice Products

Presented by

Walt Meier
CIRES

Basic Requirement 8.0

- **Requirement 8.0:** *The STAR GCOM processing system shall produce a sea ice characterization (SIC) product.*

Table 8.0.1 GCOM Sea Ice Characterization

EDR Attribute	Threshold	Objective
Applicable conditions		Delivered under “all weather” conditions
Vertical coverage	Ice surface	Ice surface
Horizontal cell size	10 km	5 km
Mapping uncertainty, 3 sigma	5 km	3 km
Measurement range		
-- Ice concentration	1/10 – 10/10	0 – 100%
-- Ice age classes	Ice free, first-year, multiyear ice	Ice free, nilas, grey white, grey, white, first year medium, first year thick, second year, and multiyear; smooth and deformed ice

Basic Requirement 8.0 Cont.

Table 8.0.2 GCOM Sea Ice Characterization		
EDR Attribute	Threshold	Objective
Measurement uncertainty		
-- Ice concentration	10%	5%
Probability of correct typing of ice age classes	70%	90%
Refresh	At least 90% coverage of the globe about every 20 hours (monthly average)	Not Specified
Geographic coverage	All ice-covered regions of the global ocean	All ice-covered regions of the global ocean
Latency	16 minutes	

Sea Ice Algorithms Considered

- NASA Team and Bootstrap
  - » Long-heritage, one of primary algorithms for SMMR-SSM/I-SSMIS timeseries
  - » Processing has been implemented at NSIDC
  - » Component of NOAA sea ice concentration CDR
  - » Bootstrap used for JAXA standard product
- NASA Team 2
  - » Standard algorithm for AMSR-E products
  - » Secondary JAXA product
  - » Provides enhanced spatial resolution by using high frequency channels
  - » Iterative approach using radiative transfer model to do atmospheric correction
- ASI
  - » Research algorithm product, developed at Univ. Hamburg, implemented at Univ. Bremen
  - » Higher-spatial resolution by using high frequency channels, no atmospheric correction

Sea Ice Algorithm - Selection

Combined NASA Team 2 (NT2) and Bootstrap (BT)

- Characteristics
  - NT2 includes use of high frequency channels (89 GHz) for better sensitivity to surface variability, with an atmospheric correction to mitigate weather effects
  - BT uses heritage approach from SMMR through AMSR-E, with daily varying tiepoints to account for seasonal changes in surface properties
- Average of the concentrations from each
  - Allows known errors to be mitigated:
    - NASA Team 2: atmospheric emission
    - Bootstrap: low (cold) temperatures and melt
- Similar to NOAA SSM/I Climate Data Records (CDR) approach
- Difference in concentrations between algorithms provides a confidence indicator
- Iteration for NASA Team 2 atmospheric correction provides a quantitative error estimate
- Takes advantage of higher frequency channels for better spatial resolution, up to 6.25 km – initial implementation will be at 12.5 km resolution

Sea Ice Concentration Algorithm Input

Name	Type	Description	Dimension
18.7 H, V Brightness Temperatures	Input	Level 1B or 1R Swath fields	Scan grid (xsize, ysize)
23.8 V Brightness Temperatures	Input	Level 1B or 1R Swath fields	Scan grid (xsize, ysize)
36.5 H, V Brightness Temperatures	Input	Level 1B or 1R Swath fields	Scan grid (xsize, ysize)
89.0 H, V Brightness Temperatures	Input	Level 1B or 1R Swath fields	Scan grid (xsize, ysize)
Latitude	Input	Pixel Latitude	Scan grid (xsize,ysize)
Longitude	Input	Pixel Longitude	Scan grid (xsize,ysize)

Sea Ice Concentration Algorithm Input: Ancillary Data

- Types of ancillary data needed:
  - » Land Mask: Land, coastal land, water
  - » Ocean Mask: SST-based ocean mask to define regions where sea ice not allowed
  - » Coast Mask: Grid cells adjacent to and near land for land-spillover correction

Name	Type	Description	Dimension
Land/Water mask	Input	Map of land and water flags	Scan grid (xsize, ysize)

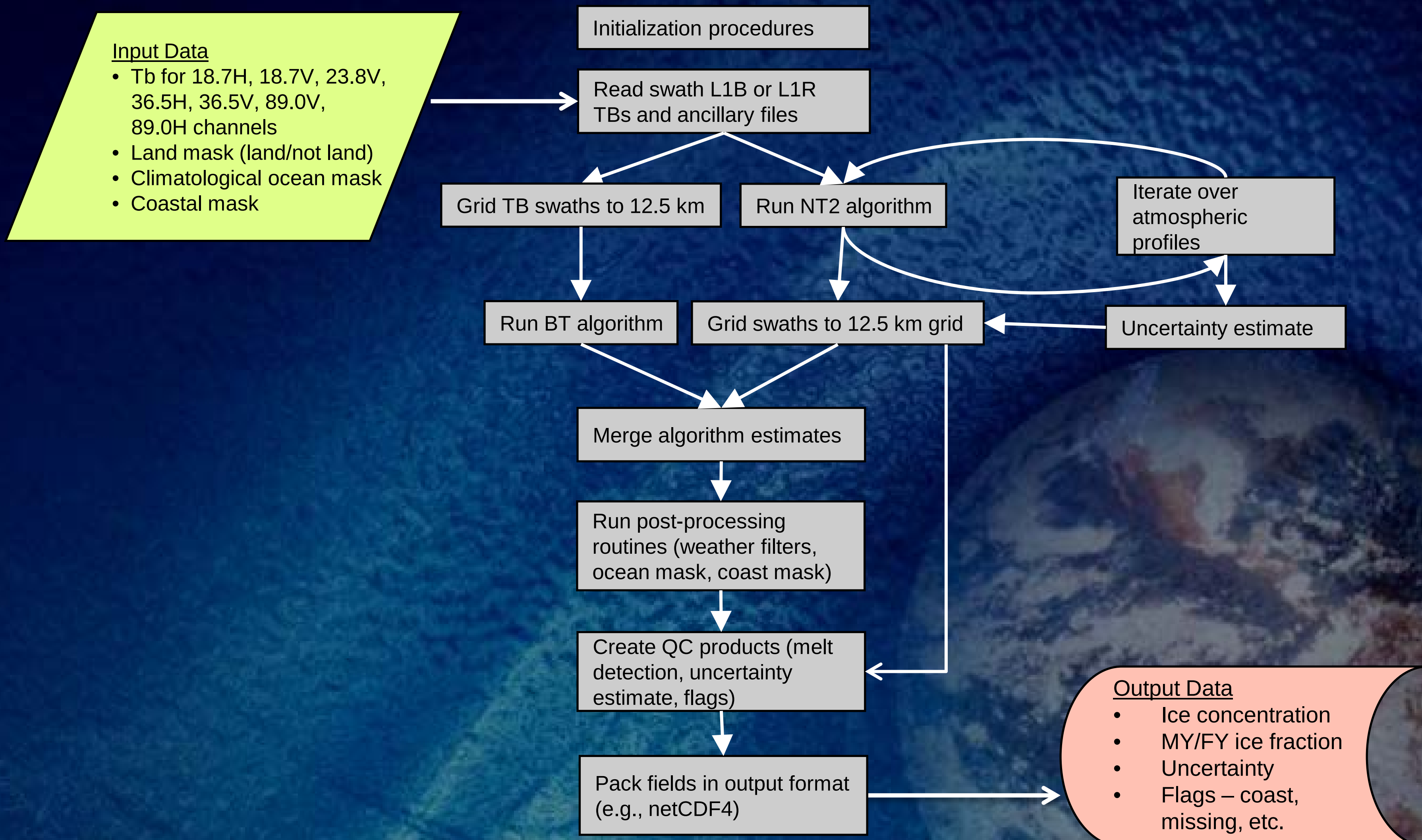
Name	Type	Description	Dimension
Ocean Mask	Input	SST-based ocean mask	Scan grid (xsize, ysize)

Name	Type	Description	Dimension
Coast Mask	Input	Adjacent and near coast grid cell flags	Scan grid (xsize, ysize)

Sea Ice Concentration Algorithm Output

Name	Type	Description	Dimension
Ice concentration	output	Output contains ice concentration for each pixel identified as ice	Scan grid (xsize, ysize)
Ice age	Output	Multiyear and first-year ice fraction	Scan grid (xsize, ysize)
Concentration uncertainty	output	Concentration uncertainty for each pixel from NASA Team 2 iteration	Scan grid (xsize, ysize)
QC flags for Ice Concentration/cover	output	Quality Control Flags for every pixel	Scan grid (xsize, ysize)

Sea Ice Algorithm Processing Outline



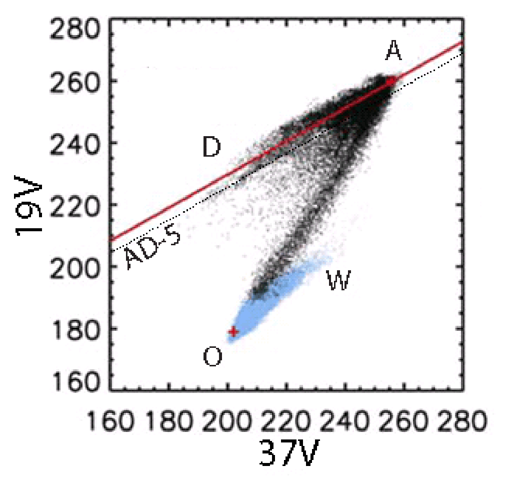
Sea Ice Algorithm Details

- NASA Team 2
  - » Gradient ratios of 89H/19H and 89V/19V TBs, and polarization ratio of 89 GHz, e.g.:
    - – $GR_{8919V} = (TB_{89V} - TB_{19V})/(TB_{89V} + TB_{19V})$
    - – $PR_{89} = (TB_{89V} - TB_{89H})/(TB_{89V} + TB_{89H})$
  - » Three ratios yield three unique surface types (open water and two ice types)
  - » Iterate over 12 atmospheric profiles to find concentration combination that minimizes different with observed TBs via a cost function
    - – Value of cost function yields an uncertainty estimate
  - » Apply GR_{3719V} and GR_{2219V} threshold to remove weather contamination
  - » Remove spurious ice far from coast with ocean mask
  - » Apply land-spillover correction using coast mask

Sea Ice Algorithm Details

- Bootstrap
  - » Linear interpolation between ice and water signatures in TB19V vs. TB37V and TB37H vs. TB37V relationship
    - – Ice values along a line
    - – Water values cluster at a point
    - – Concentration is derived from relative linear distance from water point along a line perpendicular to the ice line
    - – 5K TB Threshold applied for 100% ice to account for scatter
  - » Apply GR_{3719V} and GR_{2219V} threshold to remove weather contamination
  - » Apply land-spillover correction using coast mask
  - » Remove spurious ice far from coast with ocean mask

TB_{19V} vs. TB_{37V} (in K)

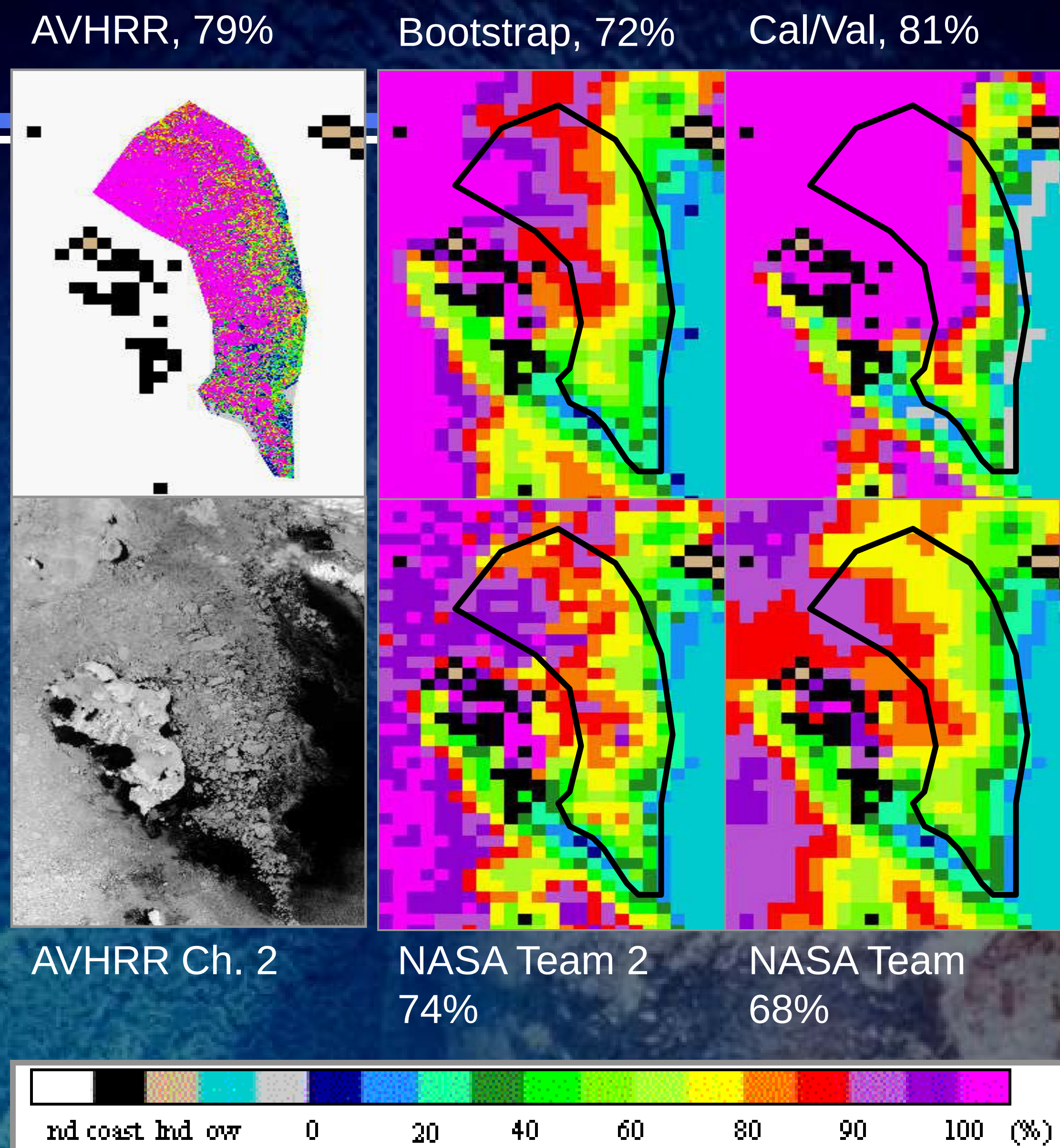


Sea Ice - Validation

- Numerous validation studies have been done on BT and NT2 algorithms via comparisons with aircraft and other satellite (vis/IR, SAR) imagery
  - » e.g., Cavalieri et al., 2006; Meier, 2005; Comiso et al., 1997
  - » Concentration errors for the central ice pack during cold, winter periods are <5%
  - » Errors for melting ice, thin ice, and near the ice edge may be higher
  - » Precision of the ice edge limited by spatial resolution of the channel with the largest footprint (IFOV), ~25 km for AMSR2
- Plan to validate AMSR2 products vs. other ice concentration and extent sources
  - » SSMIS passive microwave
  - » Operational ice analyses (produced from multiple imagery source – vis/IR, SAR)
  - » Other imagery (satellite, aircraft, ship obs.) if available

Sea Ice Algorithm Validation Example

- Comparison of SSM/I with visible AVHRR imagery (considered “truth”)
- Barents Sea, June 2001
- NASA Team concentration biased low due to melt
- Cal/Val biased high – algorithm easily saturates
- NASA Team 2 and Bootstrap provide balance of accuracy and capturing spatial details
- Similar results for AMSR-E (Comiso et al., 2003)
- AMSR2 will provide higher spatial resolution



Summary: Snow and Ice

- Snow and Ice algorithms are built around heritage products with important, but low-risk, improvements. The method for sea ice is an average of two heritage algorithms.
- Snow and Ice EDRs are independent of each other. Snow must be processed in order (snow cover, snow depth, SWE).
- All algorithms have a low computational burden.
- Validation of snow products is performed using other satellite products and in situ snow measurements. The sea ice EDR is compared to other satellite products due to the lack of in situ data.
- Validation results to date indicate that the EDRs should meet requirements.

Review Outline

- Introduction
- PDR Report
- Requirements
- Quality Assurance
- Software Architecture
- AMSR2 Products and Algorithms
- Risk and Actions
- Summary and Conclusions

Risks and Actions

Presented by

Tom King
IMSG

Open Risks

- **Risk #1:** External interfaces to the GAASP package and associated requirements are not yet determined. This information needs to be provided as soon as possible by the OSD contractors. Wasted resources and development delays if we assume the wrong interfaces to GPDS.
  - **Risk Mitigation:**
    - The GAASP team will meet regularly with the GPDS developers to work out the run requirements, software interfaces, and production rules.
- **Status:** Open

Open Risks

- **Risk #6:** We do not have complete confirmation of who all the users are and details on exactly what they want.
  - » **Risk Mitigation:**
    - – Through Ralph Ferraro, Eileen Maturi, and Limin Zhao, and their experience with the heritage users, we have list of possible users that will be updated throughout the lifecycle of the project to capture the changing needs of users. We will continue contacting these possible users to verify their needs and to update our requirements.
- **Status:** Open

- **Risk #8:** Brightness temperature calibration issues
  - » **Risk Mitigation:**
    - – GAASP science team has identified small biases. These have been brought to JAXA's attention over 2 telecons and are being addressed.
- **Status:** Open

Open Risks

- **Risk #9:** RFI impacts on C and X-band brightness temperatures
  - » **Risk Mitigation:**
    - – These have been characterized. The GAASP science team has been working with JAXA on correction/flagging routines.
- **Status:** Open

- **Risk #10:** Rain and Snow Flag Quality. May lead to Erroneous EDR product values because of incorrect rain and snow identification.
  - » **Risk Mitigation:**
    - – Characterize the quality flag performance utilizing and implement changes as needed.
    - – Will need to collect data over a seasonal cycle to fully characterize.
- **Status:** Open

New Risks

- **Risk #11:** Design might not meet latency requirements. At this time, we assume we can meet latency based on what we currently know from AMSR-E.
  - » **Assessment:** Low
  - » **Risk Mitigation:**
    - – Develop the GAASP code, test it, and demonstrate run times will meet latency requirements at the Code Test Review (7/17/2013).
- **Status:** Open

- **Risk #12:** There is a general risk for changes that need to be made to the JPSS L1RD Supplement section 6 to align product requirements with the capabilities of the instruments and the algorithms as well as with actual user needs.
  - » **Assessment:** Medium
  - » **Risk Mitigation:**
    - – Work with NJO to update GCOM product requirements.
- **Status:** Open

Risk Summary

- 7 Open Risks Total:
  - » 5 PDR:
    - – 2 Medium
    - – 3 Low
  - » 2 CDR:
    - – 1 Medium
    - – 1 Low

Review Outline

- Introduction
- PDR Report
- Requirements
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- Software Architecture
- AMSR2 Products and Algorithms
- Risks and Actions
- Summary and Conclusions

Summary and Conclusions

Presented by

Paul Chang
NOAA/NESDIS/STAR

Review Objectives Have Been Addressed

- The following have been reviewed
  - » Project Requirements
  - » Quality Assurance
  - » Software Architecture
  - » Algorithm Theoretical Basis
  - » Risks and Actions

Next Steps for GAASP

- Gather reviewer feedback, make necessary updates to the CDR and the Review Item Disposition, and make these updates available to the review team.

- Continue working to identify stakeholder needs to finalize requirements.

- Continue risk mitigation activities.

Next Steps for GAASP

- Officially begin algorithm development and preliminary testing.
- Work with OSD contractors to negotiate production rules and make early deliveries of code available for testing in the GPDS.
- Make adjustments to GAASP design, develop test plan, conducts unit tests, prepare and present the Code Test Review.

Open Discussion

- The review is now open for free discussion