GCOM-W1 AMSR2 Algorithm Software Processor (GAASP)

Day 1 Products
Algorithm Readiness Review

April 10, 2014

Presented By: Paul Chang[3], Zorana Jelenak[2], Patrick Meyers[4], Suleiman Alesweiss[5], Letitia Soulliard[1], and Tom King[1]

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[5]GST

Review Agenda

Section	Time	Presenter
Introduction	9:00 – 9:10	Paul Chang
CTR Report	9:10 – 9:25	Tom King
Requirements	9:25 – 9:30	Tom King
Software Architecture	9:30 – 9:40	Letitia Soulliard
Validation	9:40 – 10:50	Suleiman Alsweiss, Patrick Meyers, and Letitia Soulliard
Risk and Actions	10:50 – 11:00	Tom King
Summary and Conclusions	11:00 – 11:05	Paul Chang

Review Outline

- Introduction
- CTR Report
- Requirements
- Software Architecture
- Validation
- 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 missions lasting 10-15 years designed to obtain observations related to water and climate.

- The GCOM-W1 platform was launched May 18, 2012 and is the first satellite of the GCOM-W series.

- GCOM-W1 is in a sun-synchronus orbit (~700 km altitude) and part of the “A-Train” with an ascending node equator crossing time of 13:30 UTC.

- 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..

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

NJO

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

Customers/Users

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

Data Providers

JAXA, NSC/KSAT

Project Manager - Kirk Liang
Project Scientist – Paul Chang

PMO

Thomas Brigham

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

Limin Zhao(OSPO GCOM-W1 Project Lead, PAL)
TBD - formerly 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)
Peter Keehn (Algorithm Integration)
Yunhui Zhao (CM)
Larisa Koval (Documentation)
Yi Song (BUFR)

STAR GAASP Development

- GAASP development will result in 4 deliveries:

- Delivery 1 (12/18/2013):
  - » 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	Start	Finish
1	**STAR GCOM-W1 Project**		
2	**Algorithm Definition**		
3	Evaluate existing algorithms	10/3/11	12/2/11
4	Define preliminary ancillary datasets	12/5/11	12/30/11
5	Preliminary algorithm evaluation	1/2/12	12/28/12
6	Preliminary system design	3/19/12	4/13/12
7	Preliminay Design Review		11/8/12
8	Hardware definition	11/8/12	12/5/12
10	Define/Choose algorithms	4/15/13	5/28/13
11	Prepare documents for CDR	4/15/13	4/30/13
12	Critical Design Review		5/1/13
14	Begin developing product NetCDF4 readers and writers	5/2/13	5/29/13
15	Initial product validation	5/30/13	6/26/13
16	Test case processed	5/30/13	6/26/13
17	Sample Algorithm Package Delivery		6/10/13
18	Conduct Code Test Review		8/1/13
19	Extensive product validation	8/1/13	8/27/13
20	Initial algorithm package delivery	8/1/13	9/11/13
21	OSPO Contractor Staff Training for GCOM L2 system	8/1/13	9/4/13
22	Software Code Review		9/18/13
23	Pre-operational product output evaluated & tested within the ESPC environment	10/30/13	3/18/14
24	Prepare Documentation	10/30/13	3/18/14
25	Update software	11/18/13	4/4/14
26	All SPSRB documentation is complete	11/18/13	4/4/14
27	Prepare for Transition to Operations	11/25/13	5/23/14
28	Conduct Algorithm Readiness Review		4/10/14
29	Algorithm update delivery_1 to operations	4/14/14	4/18/14
30	Validate Pre-Operational Products	4/18/14	4/25/14
31	Transition pre-operational system to operations	4/18/14	5/22/14
32	**Operational Phase Begins**		
33	Algorithm update delivery_2 to operations	9/15/14	9/19/14
34	Algorithm update delivery_3 to operations	9/21/15	9/25/15
35	Algorithm update delivery_4 to operations	9/19/16	9/23/16
36	Operational product quality assurance and validation	5/22/14	9/29/17
37	Product enhancements and refinements	5/26/14	9/29/17
38	Final software and documentation deliver to CLASS	9/25/17	9/29/17

Algorithm Readiness Review

- The purpose of the Algorithm Readiness Review (ARR) is to:
  - » Present the results of the product validation to show that the products are meeting the requirements.
  - » Present and verify the contents of the Delivered Algorithm Package (DAP)
  - » Review any updates to project schedule, requirements, and risks.

GAASP ARR
Entry Criteria

- Updated Requirements Allocation Document (RAD)
- Review Item Disposition (RID)
- Updated Code Test Review (CTR) slide package.
- GAASP Day 1 Delivered Algorithm Package as a Delivered Algorithm Package (DAP) containing:
- Algorithm Readiness Review (ARR) slide package

GAASP ARR
Exit Criteria

- Update RAD, if necessary
- Review Item Disposition (RID)
  - » Updated to contain ARR risks and actions.
  - » Closure date provided for any open risks.
- Updated ARR slide package

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CTR Report

Presented by

Tom King
IMSG

CTR Report

- The GAASP CTR Report is available as the Review Item Disposition (RID) shared on Google Docs (GAASP_Review_Item_Disposition).
- 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 Risk

- **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
- **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:** Closed

PDR Risk

- **Risk #3:** Development team needs to know if there is an archive requirement. This evaluation must happen even before the SA and metadata are developed.
- **Risk Assessment:** Low
- **Impact:** Low
- **Likelihood:** High
- **Risk Mitigation:**
  - » The GAASP development team has put metadata into the netCDF4 headers that they believe will meet the potential needs of CLASS and end users.
- **Status:** Open

PDR Risk

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

PDR Risk

- **Risk #9:** RFI impacts on C and X-band brightness temperatures
- **Risk Assessment:** Medium
- **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 Risk

- **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

CDR Risk

- **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.
- **Risk Assessment:** Medium
- **Impact:** Medium
- **Likelihood:** Medium
- **Risk Mitigation:**
  - » Work with NJO to update GCOM product requirements.
- **Status:** Open

CTR Risk

- **Risk #13:** GAASP error notifications are made by email. This should be optional.
- **Risk Assessment:** Low
- **Impact:** Low
- **Likelihood:** Low
- **Risk Mitigation:**
  - » Tish will make the updates.
- **Status:** Closed

CTR Risk

- **Risk #14:** If rain algorithm (GPROF) fails, the ocean EDRs should still be produced. However, currently this is not the case.
- **Risk Assessment:** Low
- **Impact:** Low
- **Likelihood:** Low
- **Risk Mitigation:**
  - » Tish will make the updates to allow ocean EDRs to still be produced if there's no GPROF output.
- **Status:** Closed

CTR Risk

- **Risk #15:** There should be checks on the age of the ancillary data provided to the GAASP code. Currently, these checks are not in place.
- **Risk Assessment:** Low
- **Impact:** Low
- **Likelihood:** Low
- **Risk Mitigation:**
  - » Tish to make modifications and work with science teams to get the meaningful thresholds.
- **Status:** Closed

CTR Risk

- **Risk #16:** The ocean EDRs should be able to run if there is no Sea Ice ancillary data. This capability is currently not present.
- **Risk Assessment:** Low
- **Impact:** Low
- **Likelihood:** Low
- **Risk Mitigation:**
  - » Tish to make modifications to allow ocean EDRs to run if there's no Sea Ice ancillary data.
- **Status:** Closed

CTR Risk

- **Risk #17:** The metadata in the GAASP netCDF4 output files should contain the ancillary input file names.
- **Risk Assessment:** Low
- **Impact:** Low
- **Likelihood:** Low
- **Risk Mitigation:**
  - » Tish to make modifications to add in this information.
- **Status:** Closed

CTR Risk

- **Risk #18:** The units for some of the ocean products need to be corrected.
- **Risk Assessment:** Low
- **Impact:** Low
- **Likelihood:** Low
- **Risk Mitigation:**
  - » Tish to make modifications.
- **Status:** Closed

CTR Risks

- **Risk #19:** Need to change output file names from GAASP to AMSR2 to avoid confusion with the existing GASP product at OSPO.
- **Risk Assessment:** Low
- **Impact:** Low
- **Likelihood:** Low
- **Risk Mitigation:**
  - » Tish to make modifications.
- **Status:** Closed

CTR Risks

- **Risk #20:** GAASP file name content and name patterns need to meet both GPDS and NDE requirements if GAASP is to run in NDE version 2.0. The risk is that we want to avoid changing file names and contents on the end users in the middle of the operational lifecycle of this project.
- **Risk Assessment:** Low
- **Impact:** Low
- **Likelihood:** Low
- **Risk Mitigation:**
  - » Tish to make modifications to files. The DARs transferring data to DDS and transferring data to STAR need to be updated.
- **Status:** Closed

CTR Report Summary

- 14 Risks Total:
  - 3 Medium
  - 11 Low
- With the approval of the ARR reviewers:
  - 9 risk can be closed
    - 9 Low
  - 5 risks will remain open
    - 3 Medium
    - 2 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) made available in Google Docs (GAASP_RAD_1.3.docx).

- 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 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).

GAASP Requirements

- The requirements have already presented in the previous reviews (PDR, CDR, CTR).

- The requirements have not changed since CTR. The slides are here for completeness, but it will not be presented again.

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) for use in blended products - 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
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.		

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 and 1km Obj.		

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.
(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 part of a Delivered Algorithm Package (DAP). The DAP shall contain all the code (programs and scripts), test data, and SPSRB-required documentation.*

Basic Requirement 12.0

- **Requirement 12.2:** *The STAR GCOM-W1 GAASP code contained within the DAP 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 DAP:*
  - » *A System Maintenance Manual (SMM)*
  - » *An External Users Manual (EUM)*
  - » *An Algorithm Theoretical Basis Document (ATBD)*

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 a slightly modified version of the NDE file naming convention.*
  - » *Note: Date/Time strings will be in YYYYMMDDhhmmss instead of YYYYMMDDhhmmsss (no tenths of second as this was an IDPS 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 for Day 2. These are identified as risks which will be summarized toward the end of this presentation.
- Updated requirements will be presented at the Day 2 ARR.

Review Outline

- Introduction
- CTR Report
- Requirements
- Software Architecture
- Validation
- Risks and Actions
- Summary and Conclusions

Software Architecture

Presented by

Letitia Soulliard
IMSG

GAASP Processing Architecture

- The GAASP Day 1 software architecture has already presented in the previous reviews (PDR, CDR, CTR).

- There have been some minor adjustments to the architecture since CTR. All of the software architecture slides are here for completeness, but only the updates made since CTR will be presented. These are highlighted in green.

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 Composer XE (Version 12.1.3)

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

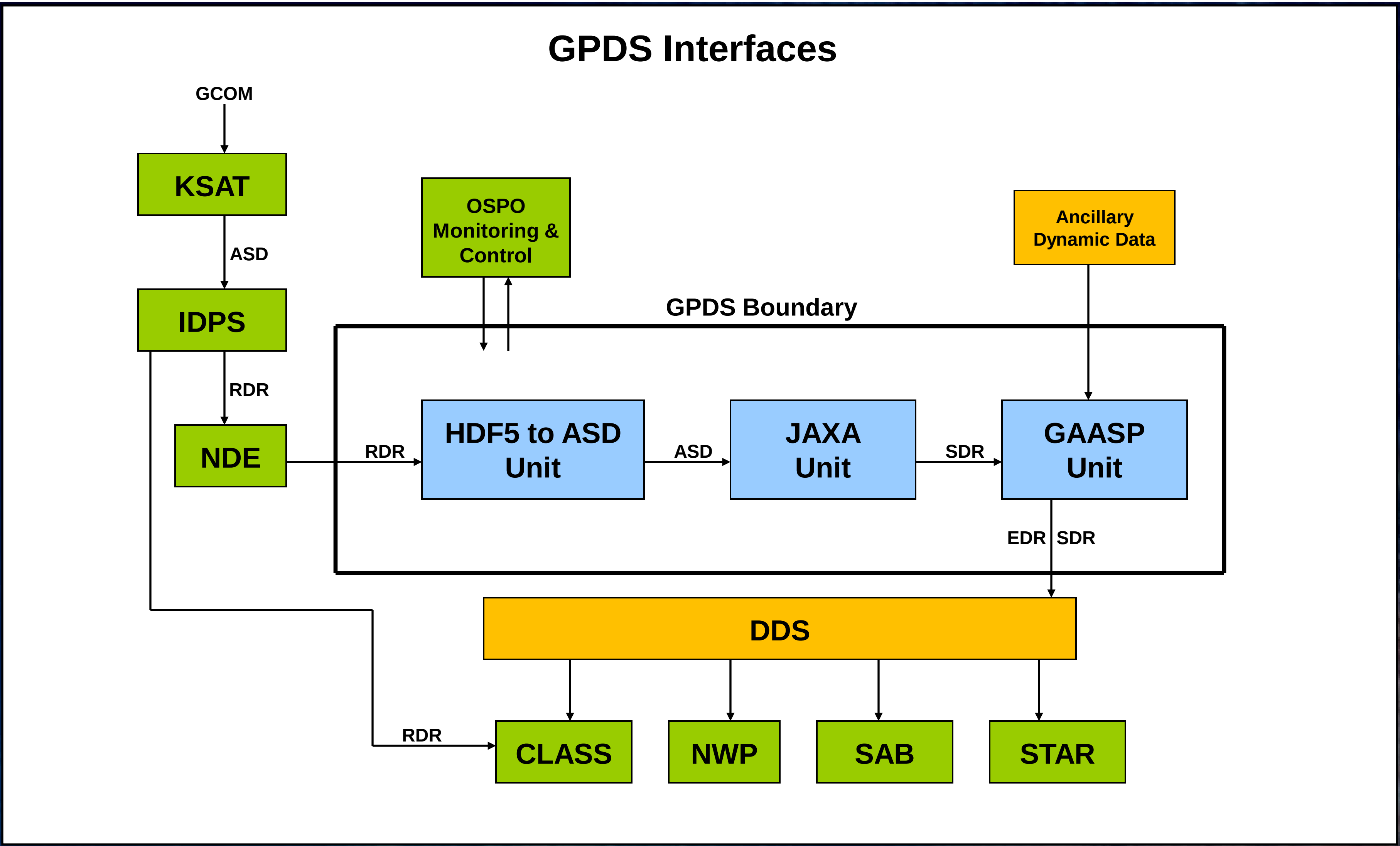
- Production Hardware
  - » 3 Dell PowerEdge 6850 (From the MODIS project)
  - » Architecture: 64-bit Intel® Xeon™ 7100
  - » OS Version: Red Hat Enterprise Linux 6 (update 2)
  - » Diskspace: Details of SAN are TBD
  - » Number of CPUs: 24
    - – 3 machines with 4 dual core processors
  - » Total Memory: 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.
  - » netCDF files will contain the NDE-compliant metadata.
  - » 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	Size
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	9.2 MB
AMSR2 SDR Remapped	GW1AM2_????????????_????_L1SGRTBR_1110110.h5	IDPS via NDE	9 minutes	Day 1	SST, SSW, TPW, CLW, SIC	Input	HDF5	12.7 MB
GFS Forecast (0.5 degree)	gfs.t??z.pgrb2f??.????????	DDS	6 hours	Day 1	SST, SSW, TPW, CLW	Ancillary	GRIB2	18.5 MB
*Daily OI SST	avhrr-only-v2.????????_preliminary	DDS	Daily	Day 1 only	PR, SST, SSW, TPW, CLW	Ancillary	Binary	1.8 MB
Sea Ice	seaice.t00z.5min.grb.grib2.????????	DDS	Daily	Day 1	RFI	Ancillary	GRIB2	0.5 MB

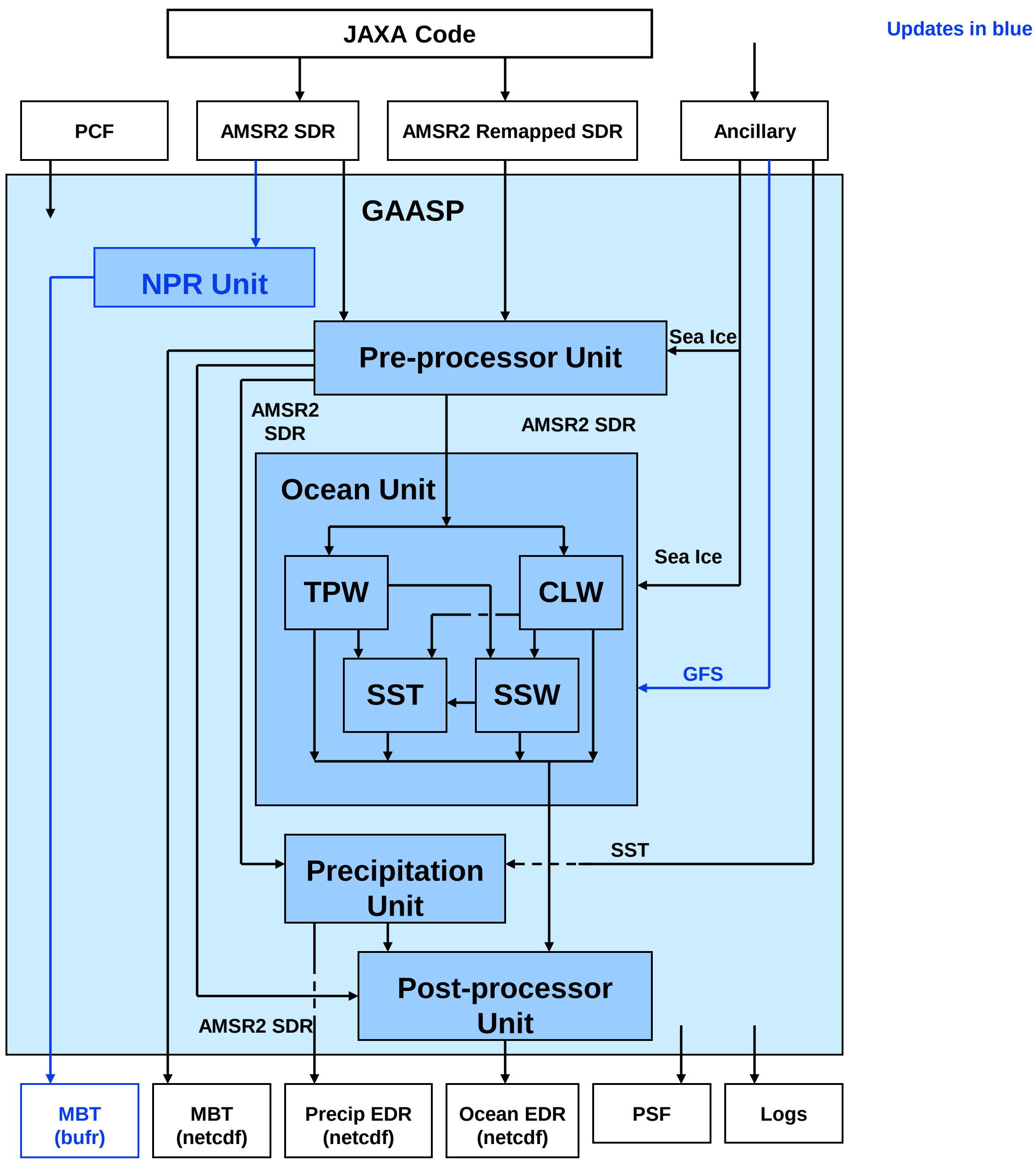
*Daily OI SST will only be needed by GPROF for the first year. After that, GPROF will use the GAASP SST produced internally.

GAASP External Output Data

External Output Data

Output File	Name Pattern	Update Frequency	When	Format	Size
AMSR2 SDR Native Res	AMSR2-MBT_v1r0_GW1_sYYYYMMDDhhmmsss_eYYYYMMDDhhmmsss_cYYYYMMDDhhmmsss.nc	9 minutes	Day 1	netCDF4	18.7 MB
AMSR2 SDR Native Res	AMSR2-MBT-LR_v1r0_GW1_sYYYYMMDDhhmmsss_eYYYYMMDDhhmmsss_cYYYYMMDDhhmmsss.bufr	9 minutes	Day 1	BUFR	3.5 MB
AMSR2 SDR Native Res	AMSR2-MBT-89A_v1r0_GW1_sYYYYMMDDhhmmsss_eYYYYMMDDhhmmsss_cYYYYMMDDhhmmsss.bufr	9 minutes	Day 1	BUFR	3.4 MB
AMSR2 SDR Native Res	AMSR2-MBT-89B_v1r0_GW1_sYYYYMMDDhhmmsss_eYYYYMMDDhhmmsss_cYYYYMMDDhhmmsss.bufr	9 minutes	Day 1	BUFR	3.4 MB
Ocean (CLW, TPW, SST, SSW)	AMSR2-OCEAN_v1r0_GW1_sYYYYMMDDhhmmsss_eYYYYMMDDhhmmsss_cYYYYMMDDhhmmsss.nc	9 minutes	Day 1	netCDF4	7.9 MB
Precip (PT/R)	AMSR2-PRECIP_v1r0_GW1_sYYYYMMDDhhmmsss_eYYYYMMDDhhmmsss_cYYYYMMDDhhmmsss.nc	9 minutes	Day 1	netCDF4	3.3 MB
Land (SM & ST)	AMSR2-LAND_v1r0_GW1_sYYYYMMDDhhmmsss_eYYYYMMDDhhmmsss_cYYYYMMDDhhmmsss.nc	9 minutes	Day 2	netCDF4	6.4 MB
Snow (SC/D & SWE)	AMSR2-SNOW_v1r0_GW1_sYYYYMMDDhhmmsss_eYYYYMMDDhhmmsss_cYYYYMMDDhhmmsss.nc	9 minutes	Day 2	netCDF4	3.1 MB
Sea Ice (SIC)	AMSR2-SICE_v1r0_GW1_sYYYYMMDDhhmmsss_eYYYYMMDDhhmmsss_cYYYYMMDDhhmmsss.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 System Design

- The Day 1 GAASP will consist of a single Perl driver script that wraps the individual units.
  - » This script will be run by the GPDS and will in turn run the entire Day 1 processing for a single input granule (i.e. SDR to EDR)
  - » Within the driver script everything is run serially (no forking of processes)
  - » The individual units are also Perl scripts that wrap the Fortran executables.
  - » These units scripts will handle direct interfaces and arguments for individual algorithm executables (science code)
  - » The driver and it’s unit scripts will:
    - – 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.

GAASP System Design

- The Day 1 GAASP driver script will be invoked by the GPDS and may be run in parallel by the GPDS.
  - » The production rules for the driver script are documented in the System Maintenance Manual and will be delivered as part of the DAP.
  - » 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 and manage system directories
  - » Ingest, distribute, or transfer files
  - » Interact directly with the OSPO monitoring

GAASP System Design

- NOAA Product Reformatter (NPR) Unit:
  - » Tailor L1B hdf5 output to BUFR
- Preprocessor unit:
  - » Perform brightness temperature bias correction
  - » Assign the RFI flag
  - » Output the HDF5 intermediate files (L1B and L1R) to be used by all downstream EDRs
  - » Output the netCDF MBT EDR file
- Ocean unit:
  - » Generate all ocean EDRs (TPW, CLW, SST, SSW)
- Precipitation unit:
  - » Generate land/ocean precipitation EDR
  - » Output the netCDF PRECIP EDR file
- Postprocessor unit:
  - » Bundle EDRs where necessary (eg. add the Precip EDR to the Ocean EDR)
  - » Generate QA metadata or products for OSPO monitoring. Details are TBD

GAASP System Design

- The internal file format for files within the driver script will be HDF5.
- Ancillary data will be obtained by the GPDS from DDS (see table) and made available to the Day 1 GAASP driver script.

GAASP System Design: GPDS Interfaces

- The interface between the GPDS and the GAASP driver script will consist of an NDE-style Production Control File (PCF) and Production Status File (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 run is produced by the GPDS and made available to an instance of the GAASP driver in a local working directory.
  - » The contents of the PCF are based on the production rules defined in the System Maintenance Manual.

- 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 to DDS.

GAASP System Design: GPDS Interfaces

- Here's an example of a GAASP PCF from the Code Test Review:

```
WORKING_DIR=/home/GAASP/SATELLITE_DATA/GCOM-W1/test/2013/03/11/201303112359_179D
GRANULE=201303112359_179D
PSF_FILE=GAASP_201303112359_179D_20130311.PSF
L1B_FILE=GW1AM2_201303112359_179D_L1DLBTBR_0000000.h5
L1R_FILE=GW1AM2_201303112359_179D_L1DLRTBR_0000000.h5
EMAIL_ERROR_FLAG=YES
OPS_MACHINE=letitias@rhs8142.star1.nesdis.noaa.gov
OPS_MAIL=letitia.soulliard@noaa.gov
LOG_FILE=/home/GAASP/SATELLITE_DATA/GCOM-W1/test/2013/03/11/201303112359_179D/GAASP.log
PERL_LOC=/usr/bin/perl
PERL_LIB=/home/GAASP/OPS/scripts/lib
SCRIPT_OPS=/home/GAASP/OPS/scripts
H5DUMP_LOC=/usr/local/bin/h5dump
WGRIB2_LOC=/usr/local/bin/wgrib2
UUID_LOC=/usr/bin/uuidgen
OPS_BIN=/home/GAASP/OPS/Common_Bin
CDL_TEMPLATES=/home/GAASP/OPS/CDLFILES
SEAICE_FILE=/home/GAASP/DATA/seaice/seaice.t00z.5min.grb.grib2.20130311.nc
SST_FILE=/home/GAASP/DATA/sst/avhrr-only-v2.20130311
GFS_FILE_DIR=/home/GAASP/DATA/gfs
NPR_ANCDIR=/home/GAASP/OPS/ancillary/npr
OCEAN_ANCDIR=/home/GAASP/OPS/ancillary/ocean
GPROF_ANCDIR=/home/GAASP/OPS/ancillary/gprof
RUN_NPR_FLAG=YES
RUN_L1R_CORRECTION_FLAG=YES
RUN_OCEAN_FLAG=YES
RUN_PRECIPITATION_FLAG=YES
```

GAASP System Design: GPDS Interfaces

- And here's the PSF produced for that same run:

```
/home/GAASP/SATELLITE_DATA/GCOM-W1/test/2013/03/11/2013031123590_179D/AMSR2-MBT-LR_v1r0_GW1_s201303112359590_e201303120008580_c201307221919120.bufr
/home/GAASP/SATELLITE_DATA/GCOM-W1/test/2013/03/11/2013031123590_179D/AMSR2-MBT-89A_v1r0_GW1_s201303112359590_e201303120008580_c201307221919150.bufr
/home/GAASP/SATELLITE_DATA/GCOM-W1/test/2013/03/11/2013031123590_179D/AMSR2-MBT-89B_v1r0_GW1_s201303112359590_e201303120008580_c201307221919180.bufr
/home/GAASP/SATELLITE_DATA/GCOM-W1/test/2013/03/11/2013031123590_179D/AMSR2-MBT_v1r0_GW1_s201303112359590_e201303120008580_c201307221919440.nc
/home/GAASP/SATELLITE_DATA/GCOM-W1/test/2013/03/11/2013031123590_179D/AMSR2-PRECIP_v1r0_GW1_s201303112359590_e201303120008580_c20130722191950.nc
/home/GAASP/SATELLITE_DATA/GCOM-W1/test/2013/03/11/2013031123590_179D/AMSR2-OCEAN_v1r0_GW1_s201303112359590_e201303120008580_c201307221920090.nc
```

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 in the event of an error.
- All standard output and standard error from scripts and programs is logged so it can be made available to the GPDS and OSPO monitoring efforts.
- Contents of logs were shown in the Code Test Review held on 8/1/2013 and the code was checked for security and coding standards in the Software Code Review held on 9/18/2013.
- The GAASP driver script produces 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 depending upon at what stage the error occurred

GAASP System Design: Error Handling and Monitoring

- All error conditions and messages written into the log files are 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.

Unit Level Input/Output

- The following slides contain tables showing all the GAASP Day 1 unit level input and output.
- Required input data fields are identified for each unit.
- Output data fields are identified for the products coming out of each unit. These also show:
  - Variable names
  - Variable size (bytes)
  - Resolution
  - Dimensionality
  - Total file size

Ocean EDR Inputs

Table 15.0 GCOM Ocean Unit Inputs

Parameter	Source	Status
Brightness Temperatures	From AMSR2 SDR (L1B) and From AMSR2 SDR (L1R)	Dynamic
Geo location information	From AMSR2 SDR (L1B) and From AMSR2 SDR (L1R)	Dynamic
Land/Coastal mask	From AMSR2 SDR (L1B) and From AMSR2 SDR (L1R)	Dynamic
Model Wind Direction	From GFS Forecast Model	Dynamic
Model Sea Surface Temp	From GFS Forecast Model	Dynamic
Model Sea/Land Flag	From GFS Forecast Model	Dynamic
SST (Sea Ice data)	From daily IEEE OI-SST from AVHRR	Dynamic
CLW Coefficient files	From STAR algorithm development	Static
TPW Coefficient files	From STAR algorithm development	Static
WS and SST Coefficient files	From STAR algorithm development	Static

Ocean EDR Output

Ocean/Precip Products				
Parameter	**Size**	**scans**	**FOV**	**Total**
Time	2	360	6	4320
Lat	4	360	243	349920
Long	4	360	243	349920
Scan Angle	4	360	243	349920
Earth Inc	4	360	243	349920
Compas	4	360	243	349920
Across Scan	4	360	243	349920
Along Scan	4	360	243	349920
SDR rec	4	360	243	349920
Surf Type	4	360	243	349920
SDR QC	4	360	486	699840
SST	8	360	243	699840
wspd	8	360	243	699840
wv	8	360	243	699840
clw	8	360	243	699840
Rain Rate	4	360	486	699840
RR_Err	1	360	486	174960
EDR QC flag	4	360	243	349920
Model wdir	4	360	243	349920
Model sst	4	360	243	349920
Model mask	4	360	243	349920
				8927280

Precipitation Unit Inputs

Table 16.0 GCOM Precipitation Unit Inputs		
Parameter	Source	Status
Brightness Temperatures	From AMSR2 SDR (L1B)	Dynamic
Geo location information	From AMSR2 SDR (L1B)	Dynamic
SST	From daily IEEE OI-SST from AVHRR	Dynamic
Profile database	Compiled TRMM's Precipitation Radar by Dave Randel at Colorado State University	Static
Caspian Sea Ice Climo	Developed from RSS Weekly AMSRE	Static
Desert/Ice Climo	IGBP (Desert) IMS & AMSRE (Snow)	Static
Elevation		Static
Land Mask		Static
Forward Model coefficient file	From STAR algorithm development	Static
TMI Correction files	From STAR algorithm development	Static

Precipitation EDR Output

Precip Products				
Parameter	**Size**	**scans**	**FOV**	**Total**
Scan_Time	2	360	6	4320
Latitude	4	360	486	699840
Longitude	4	360	486	699840
surfaceType	1	360	486	174960
qualityFlag	1	360	486	174960
convectPrecipitaiton	4	360	486	699840
surfaceRain	4	360	486	699840
				3153600

Microwave Brightness Temperature SDR

Microwave Brightness Temperature				
Parameter	**Size**	**scans**	**FOV**	**Total**
Brightness_Temperature_6.9GHzV	4	360	243	349920
Brightness_Temperature_6.9GHzH	4	360	243	349920
Brightness_Temperature_7.3GHzV	4	360	243	349920
Brightness_Temperature_7.3GHzH	4	360	243	349920
Brightness_Temperature_10.7GHzV	4	360	243	349920
Brightness_Temperature_10.7GHzH	4	360	243	349920
Brightness_Temperature_18.7GHzV	4	360	243	349920
Brightness_Temperature_18.7GHzH	4	360	243	349920
Brightness_Temperature_23.8GHzV	4	360	243	349920
Brightness_Temperature_23.8GHzH	4	360	243	349920
Brightness_Temperature_36.5GHzV	4	360	243	349920
Brightness_Temperature_36.5GHzH	4	360	243	349920
Brightness_Temperature_89.0GHz-AV	4	360	486	699840
Brightness_Temperature_89.0GHz-AH	4	360	486	699840
Brightness_Temperature_89.0GHz-BV	4	360	486	699840
Brightness_Temperature_89.0GHz-BH	4	360	486	699840
Latitude_of_Observation_Point_for_6	4	360	243	349920
Longitude_of_Observation_Point_for_6	4	360	243	349920
Latitude_of_Observation_Point_for_7	4	360	243	349920
Longitude_of_Observation_Point_for_7	4	360	243	349920
Latitude_of_Observation_Point_for_10	4	360	243	349920
Longitude_of_Observation_Point_for_10	4	360	243	349920

Microwave Brightness Temperature SDR

Microwave Brightness Temperature				
Parameter	**Size**	**scans**	**FOV**	**Total**
Latitude_of_Observation_Point_for_18	4	360	243	349920
Longitude_of_Observation_Point_for_18	4	360	243	349920
Latitude_of_Observation_Point_for_23	4	360	243	349920
Longitude_of_Observation_Point_for_23	4	360	243	349920
Latitude_of_Observation_Point_for_36	4	360	243	349920
Longitude_of_Observation_Point_for_36	4	360	243	349920
Latitude_of_Observation_Point_for_89A	4	360	486	699840
Longitude_of_Observation_Point_for_89A	4	360	486	699840
Latitude_of_Observation_Point_for_89B	4	360	486	699840
Longitude_of_Observation_Point_for_89B	4	360	486	699840
Scan_Time	2	360	6	4320
Land_Ocean_Flag_6_to_36	2	360	243	174960
Land_Ocean_Flag_89	2	360	486	349920
Pixel_Data_Quality_6_to_36	2	360	486	349920
Pixel_Data_Quality_89	2	360	486	349920
RFI_NOAA_LAND_10v	4	360	243	349920
RFI_NOAA_LAND_10h	4	360	243	349920
RFI_NOAA_OCEAN_10v	4	360	243	349920
RFI_NOAA_OCEAN_10h	4	360	243	349920
RFI_NOAA_OCEAN_18v	4	360	243	349920
RFI_NOAA_OCEAN_18h	4	360	243	349920
				17325360

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
- CTR Report
- Requirements
- Software Architecture
- Validation
- Risks and Actions
- Summary and Conclusions

Ocean EDR Validation

Presented by

Suleiman Alsweiss
GST

NOAA GCOM-W1 Project Goal

- Goal of NOAA GCOM-W1 product processing system is to provide validated operational ***Level-2 products*** from AMSR2 measurements
  - » Meets scientific accuracy requirements
  - » Meets GCOM-W1 distribution to operational users requirements
  - » Easily maintainable over the life of the mission
  - » Adaptable to handle any required modifications

NOAA GCOM-W1 Processing System

- SDR Postprocessor
  - » Address any AMSR2 residual calibration issues
- EDR Preprocessor
  - » Reformatting & flagging
  - » Prepare ancillary data
- EDR Postprocessor
  - » Three EDR modules
    - – Ocean Scene EDRs (SST, SSW, TPW, CLW)
    - – Global Rain Rate (Ocean, Land and Coastal Region)
    - – Snow and Sea Ice

AMSR2 In Orbit Calibration

- AMSR2 observed brightness temperatures (Tbs) will be used to infer several geophysical parameters over land and ocean
- Calibrated AMSR2 Tbs significantly improve performance and accuracy of geophysical retrieval algorithms
  - » Identifying and correcting residual calibration biases in AMSR2 Tbs reduce retrievals errors

Inter-calibration Methodology

- Direct comparison
  - » Simple inter-calibration method involves direct comparison between observations of two sensors
- Errors associated with comparing two sensors with different frequencies & EIA are too big to ignore
  - » Up to ~ 4K
- Even if the two radiometers to be compared have same center freq. & nominal EIA there can be differences
  - » Attitude differences cause EIA variation

Inter-cal. Methodology – cont.

- Sensors direct comparison discrepancies can be mitigated using radiative transfer modeling (RTM) to simulate Tbs
  - » RTM accounts for radiometer frequency, polarization & EIA
- Simulated Tbs are needed to calculate the "*Single Difference*" (**SD**)
  - » SD is the difference between observed and simulated Tbs for the same sensor

SD= Tb_obs. – Tb_sim.

Inter-calibration Methodology – cont.

- RTM may not accurately represent the physics
  - » Oceanic & atmospheric environmental parameters from numeric weather models are imperfect estimates of true values
- The use of "*Double Difference*" (**DD**) alleviates RTM errors
  - » Two instruments are needed (A & B) with one being the reference sensor

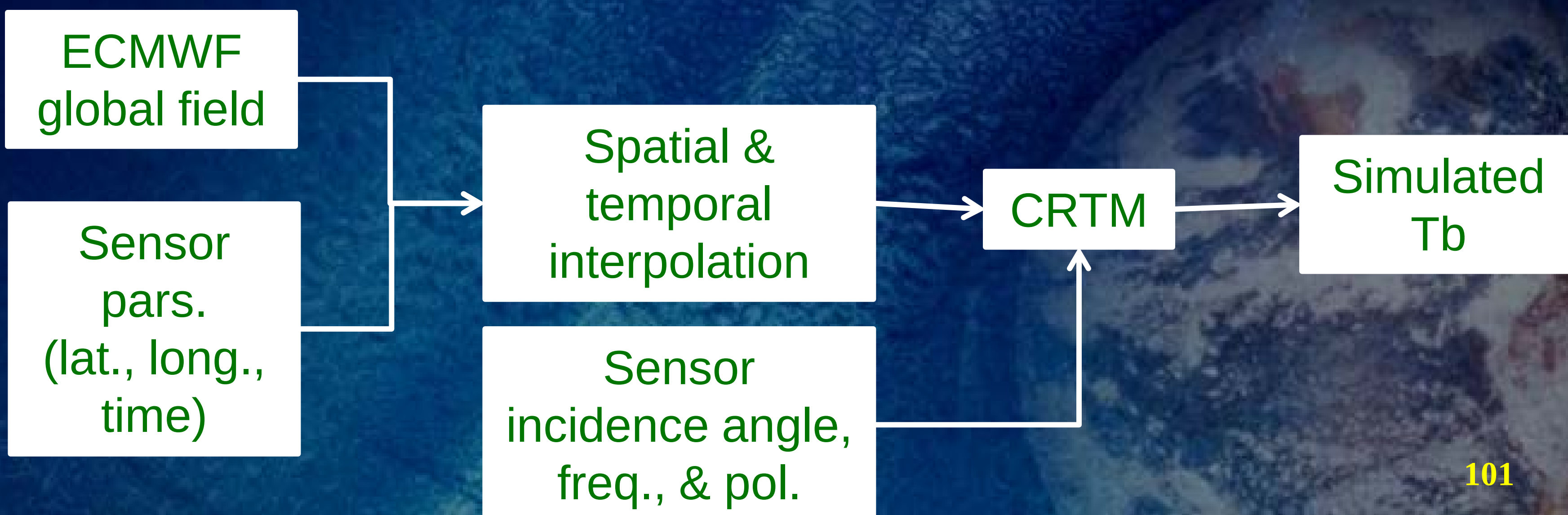
$$DD_{AB} = SD_A - SD_B$$

Reference Radiometer

- Inter-calibration between sensors relies on finding collocated observations between different platforms
- Sun-synchronous orbits collocate at high latitudes near poles
  - » Limits amount of available data for inter-calibration
- For sun-synchronous radiometer like AMSR2, TRMM microwave imager (TMI) chosen as reference radiometer
  - » Non-sun-synchronous, low inclination orbiter will result in larger number of collocated observations

Brightness Temperature Simulation

- AMSR2 & TMI radiances were simulated for all channels
  - » CRTM version 2.1
  - » *Fastem5* surface model
- ECMWF global data
  - » 0.25° spatial resolution

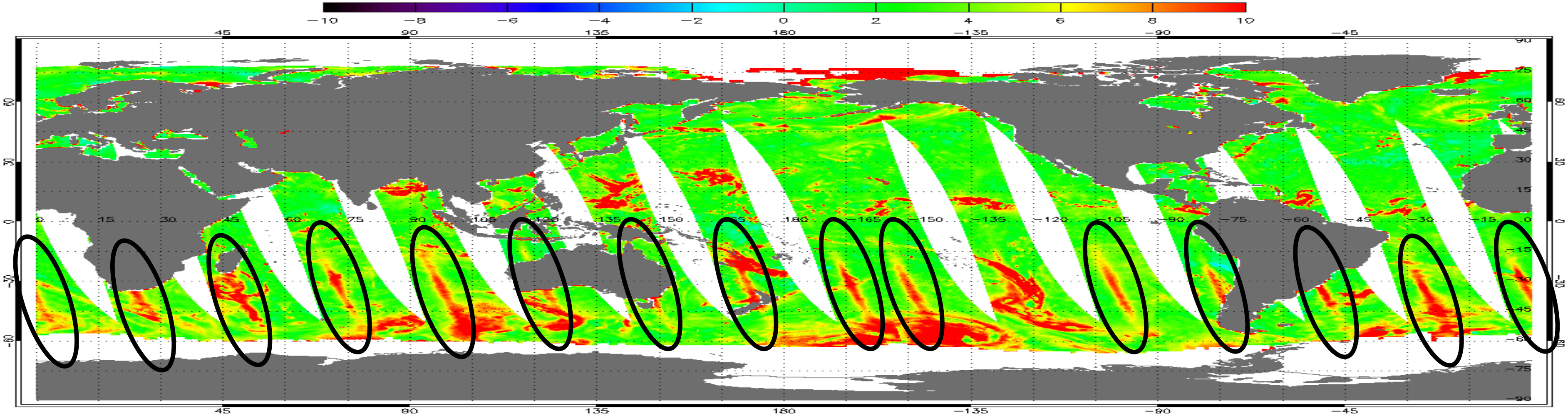


Double Difference Analysis

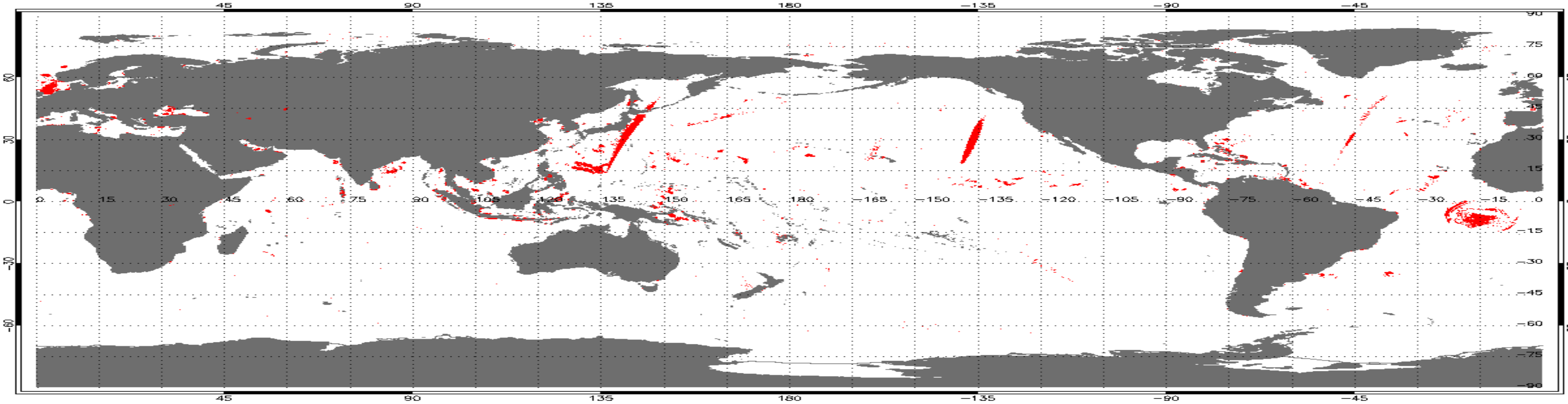
- Data
  - AMSR2: L1B 2013 release (V1.1)
  - TMI: 1B11 V7 calibrated Tbs
- AMSR2/TMI collocations
  - 30 minutes time difference & 10 km spatial difference
  - Separated by channel & ascending/descending
- Bad pixels excluded
  - Rain & clouds using TMI EDR maps (Remote Sensing Sys.)
  - Sun glint & RFI

Sun Glint & RFI

Sun Glint: [Tbh6_L1B – Tbh6_sim.], 08/02/2012



C-band RFI: Abs(Tbv6_L1B – Tbv7_L1B.) > 3, 08/02/2012



AMSR2 Tb Bias Corrections

- Corrections developed based on double difference relation with AMSR2 Tbs
  - Correction = *f(AMSR2_L1B Tbs)*
  - Different correction applied for each channel

Input Data
- **Brightness temperatures (TB) for 6.9 V/H, 7.3 V/H, 10.7 V/H,18.7 V/H 23.8 V, 36.5 H/V,89 H/V**

6.925h/V Ghz channel correction

7.3H/V Ghz channel correction

10.7H/V Ghz channel correction

18.7H/V Ghz 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

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

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

$$i = AMSR2channel$$

Output Data
- **Corrected ocean brightness temperatures**

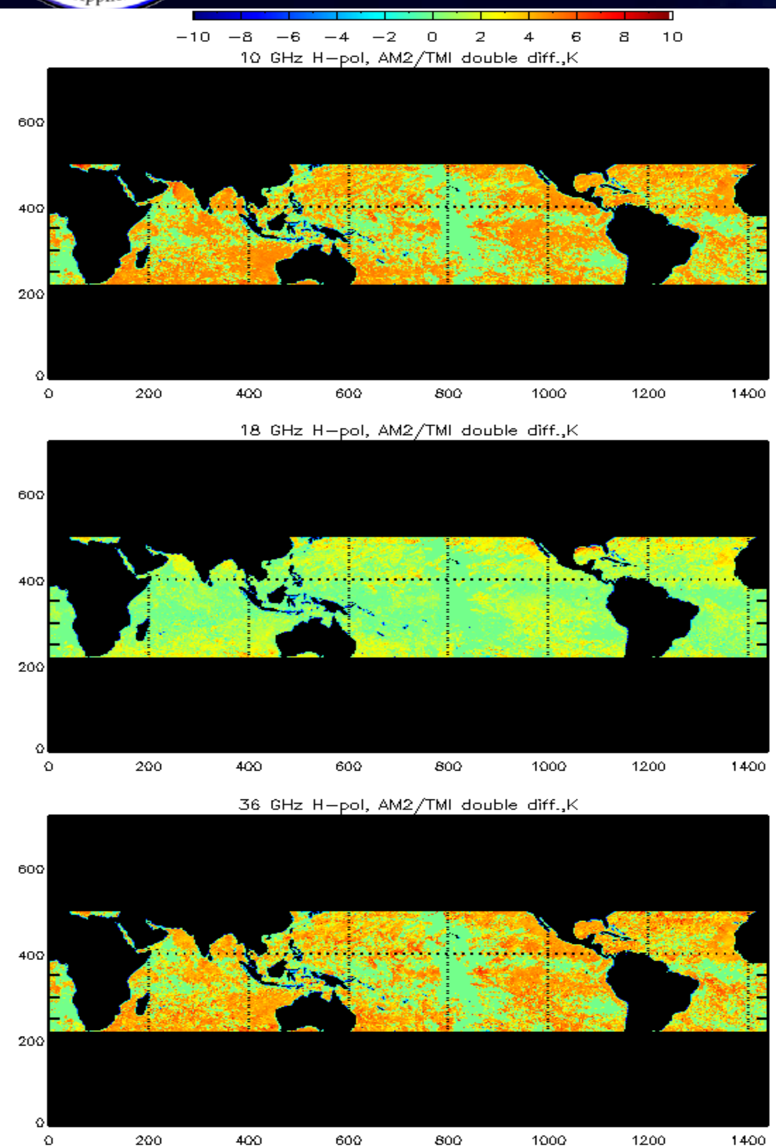
Oceanic Mean Calibration Biases

▪ → After applying corrections

Channel	AMSR2 –TMI (ascending)		AMSR2 –TMI (descending)		AMSR2 –TMI (all)	
10V	4.4	-0.3	4.4	0.05	4.4	-0.23
10H	5.1	-0.2	4.9	0.22	5.0	-0.1
18V	3.8	-0.32	4.0	0.05	3.9	-0.2
18H	2.5	-0.33	2.2	0.14	2.4	-0.17
23V	4.0	-0.2	4.3	0.14	4.1	-0.18
23H	- -	- -	- -	- -	- -	- -
36V	4.4	0	4.9	0.09	4.6	0.03
36H	5.2	0.05	5.7	0.06	5.4	0.05
89V	2.8	-0.1	3.1	-0.02	2.9	-0.08
89H	3.5	0.03	4.0	0.03	3.6	0.03

Actual biases are modeled as functions of AMSR2 Tb, so they are not just one number

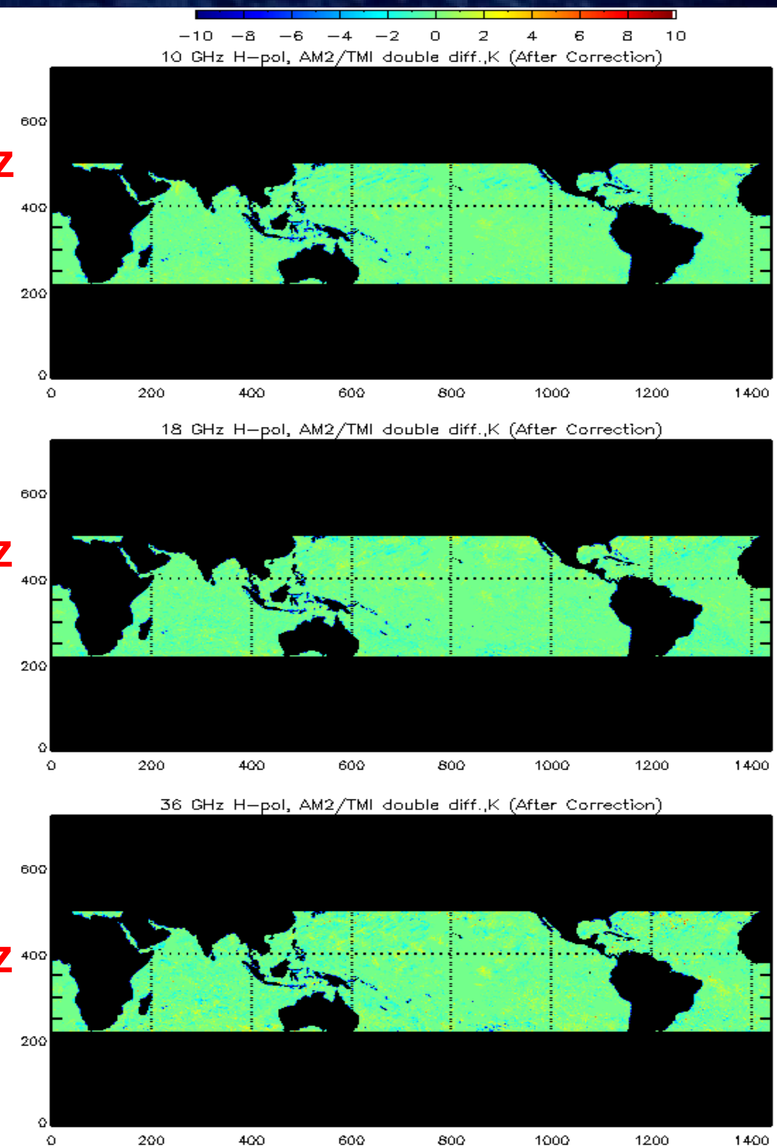
Double Difference Map Bias H-Pol



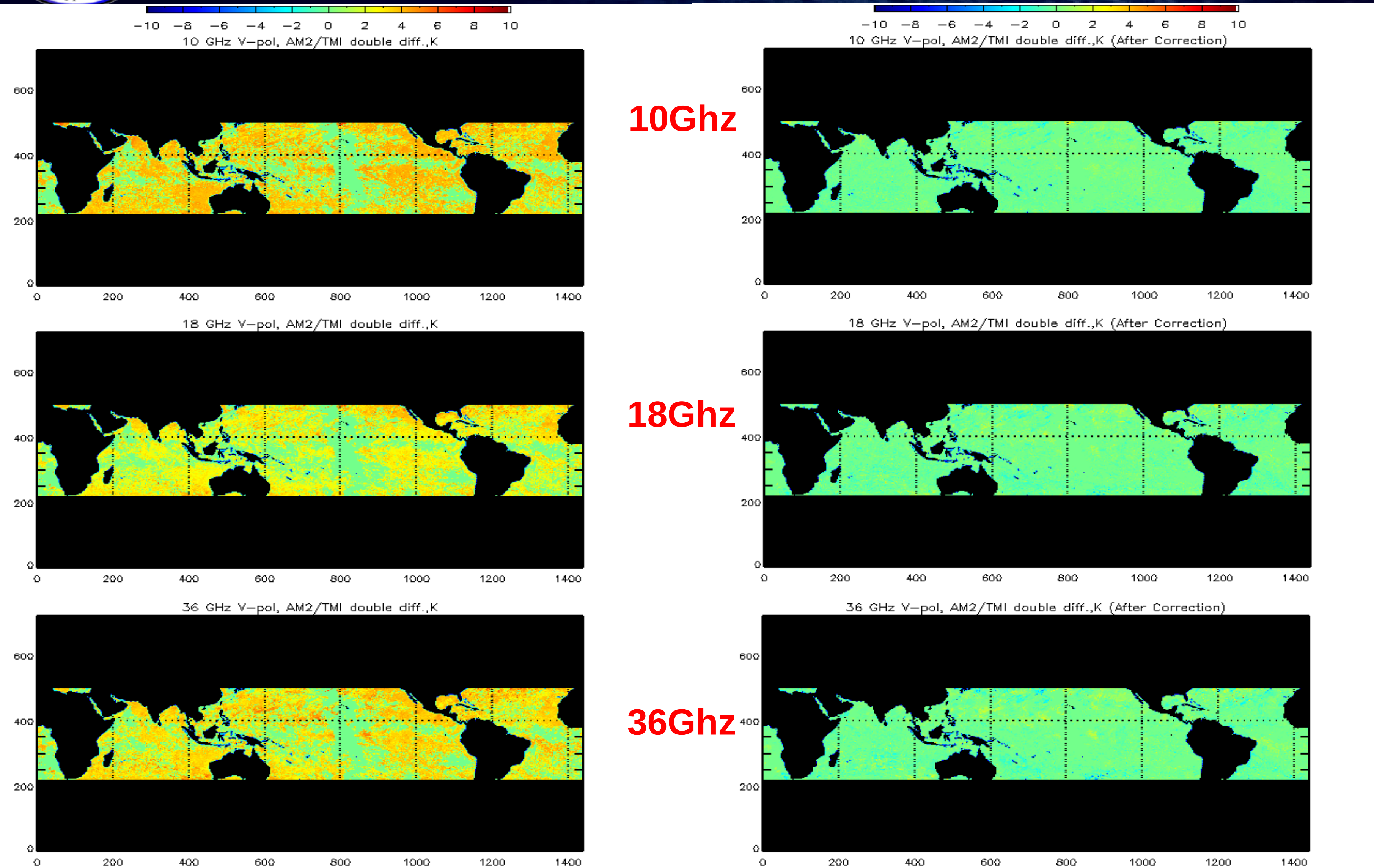
10Ghz

18Ghz

36Ghz



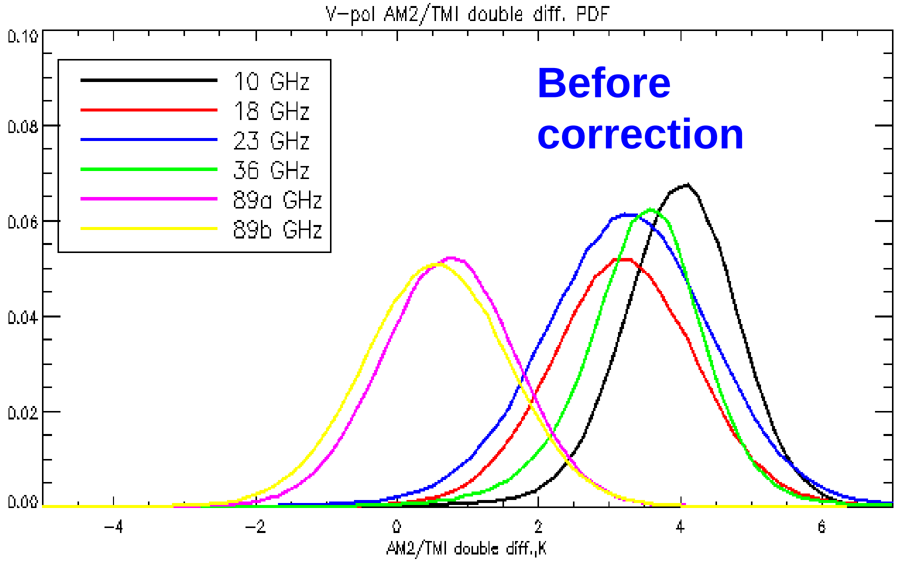
Double Difference Map Bias V-Pol

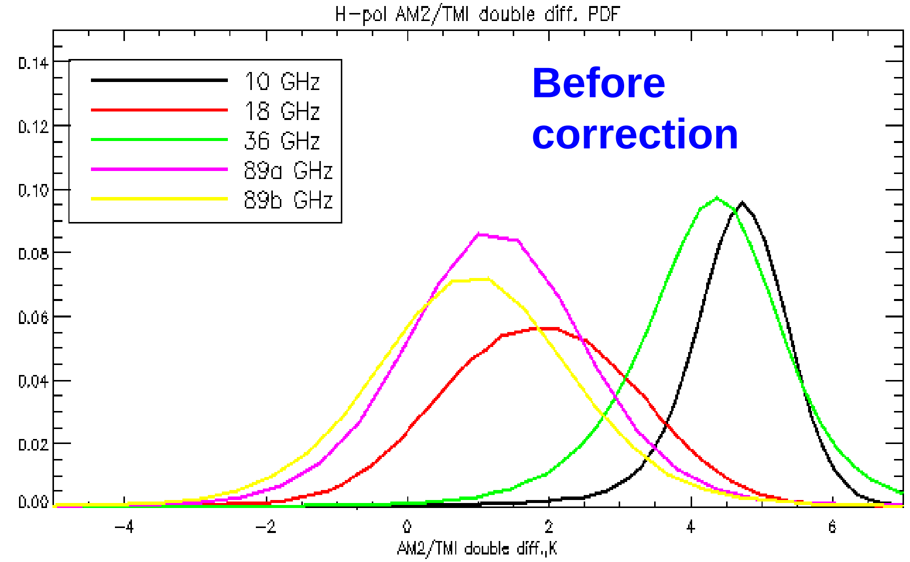


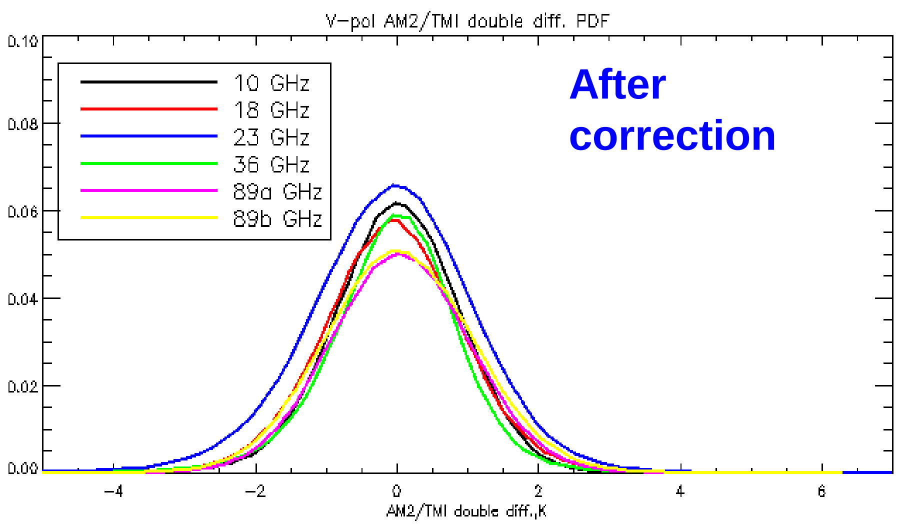
Double Difference PDFs

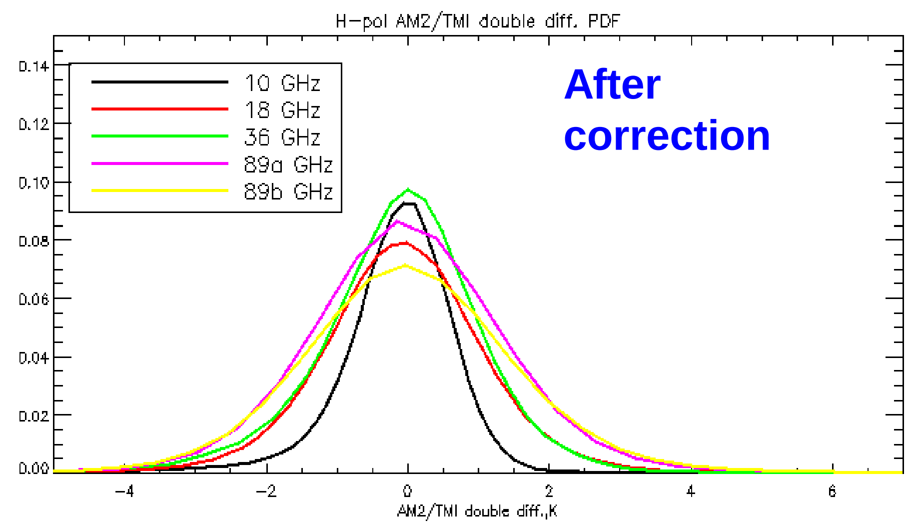
V-Pol

H-Pol









AMSR2 Oceanic EDR Validation

NOAA AMSR2 Ocean EDR Products

- Ocean Scene EDRs include
  - » Total Precipitable Water (TPW)
  - » Cloud Liquid Water (CLW)
  - » Sea Surface Wind Speed (SSW)
  - » Sea Surface Temperature (SST)
- **1st Delivery**
  - » **Multi stage regression ocean EDR algorithms**
- 2nd Delivery
  - » Iterative multistage regression & Bayesian probability

EDR Quality Control

- 16-bit QC flag included in AMSR2 EDR files
  - Bit0: RFI
  - Bit1: 0 < SSW < 30
  - Bit2:-2.5 < SST < 35
  - Bit3:0 < CLW < 1
  - Bit4:0 < TPW < 75
  - Bit5:0 < RR < 70
  - Bit6:SSW > 20
  - Bit7:CLW > 0.18
  - Bit8:TPW > 60
  - Bit9: RR > 1
  - Bit10: SSW quality
  - Bit11: SST quality
  - Bit12: CLW quality
  - Bit13: TPW quality
  - Bit14: RR quality
  - Bit15: Spare

0: good, 1: bad

Check if value within boundaries (Bit0–Bit5)

Check if value in upper range (Bit6–Bit9)

Cross check parameters (e.g. if SSW > 17 and CLW > 0.3 then Bit11 will be set) (Bit10–Bit14)

Validation Data Set

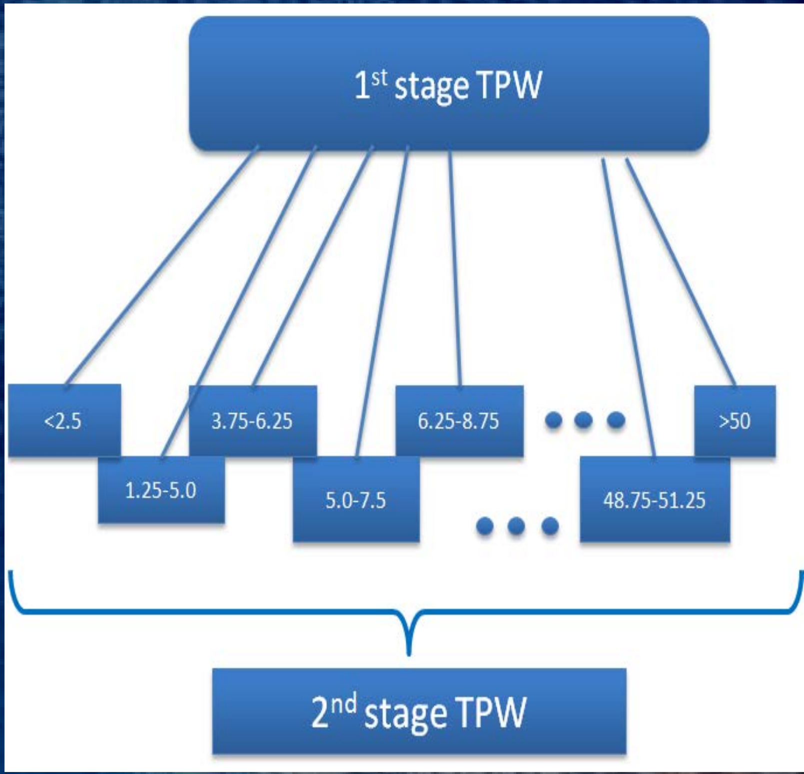
- Validation data set consists of one year worth of data
  - » Year 2013
  - » Several Data Sources
    - – Models: GDAS, Reynolds
      - Data were spatially & temporally interpolated to AMSR2 observation time & location
    - – Satellite measurements: TMI & NOAA-19
      - Collocation criteria: 10 km maximum distance & 30 minutes maximum time difference
    - – Buoys: NCDC
      - Collocation criteria: 10 km maximum distance & 30 minutes maximum time difference

TPW Algorithm

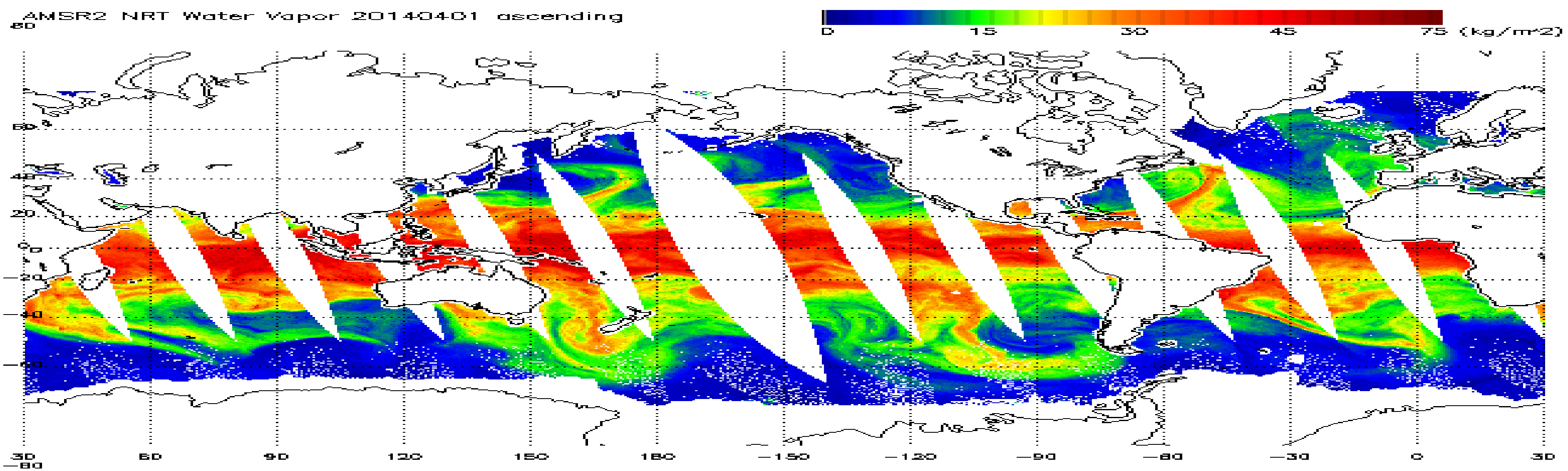
- 1^{st} stage regression:
  - » Channels used: 18, 23 and 36 GHz, H/V pol

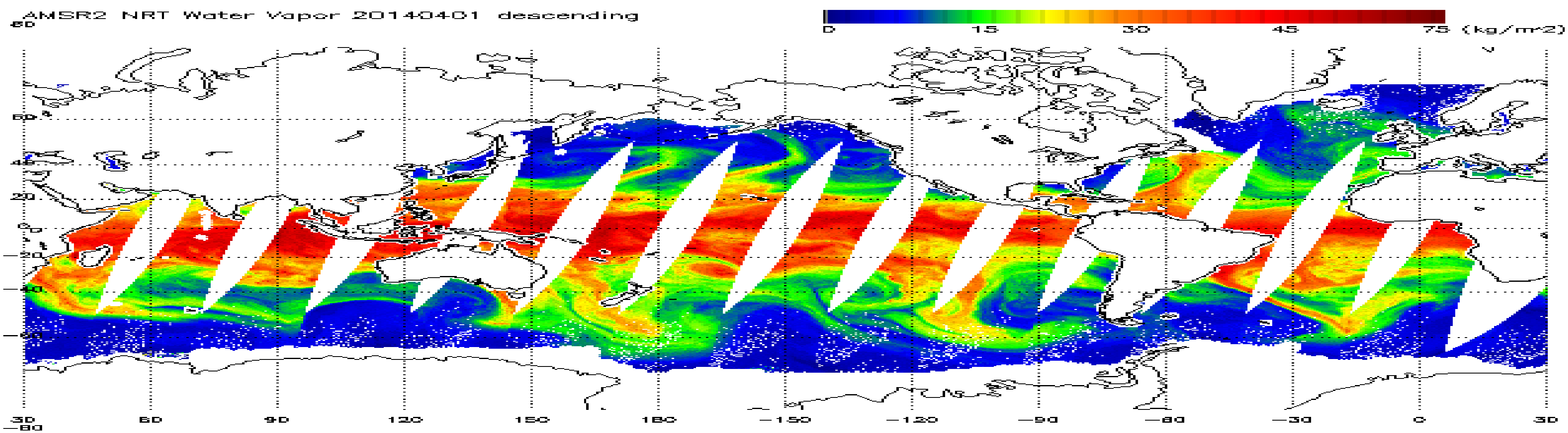
$$TPW = \sum_{i=1,6} (a_{1i} Tb_i + a_{2i} Tb_i^2)$$

- 2^{nd} stage regression:
  - » Using 1^{st} stage TPW to derive localized regressions
    - – Every 2.5mm bins
  - » In overlapping bins final TPW is average TPW from adjacent bins



AMSR2 TPW Example (04/01/2014)





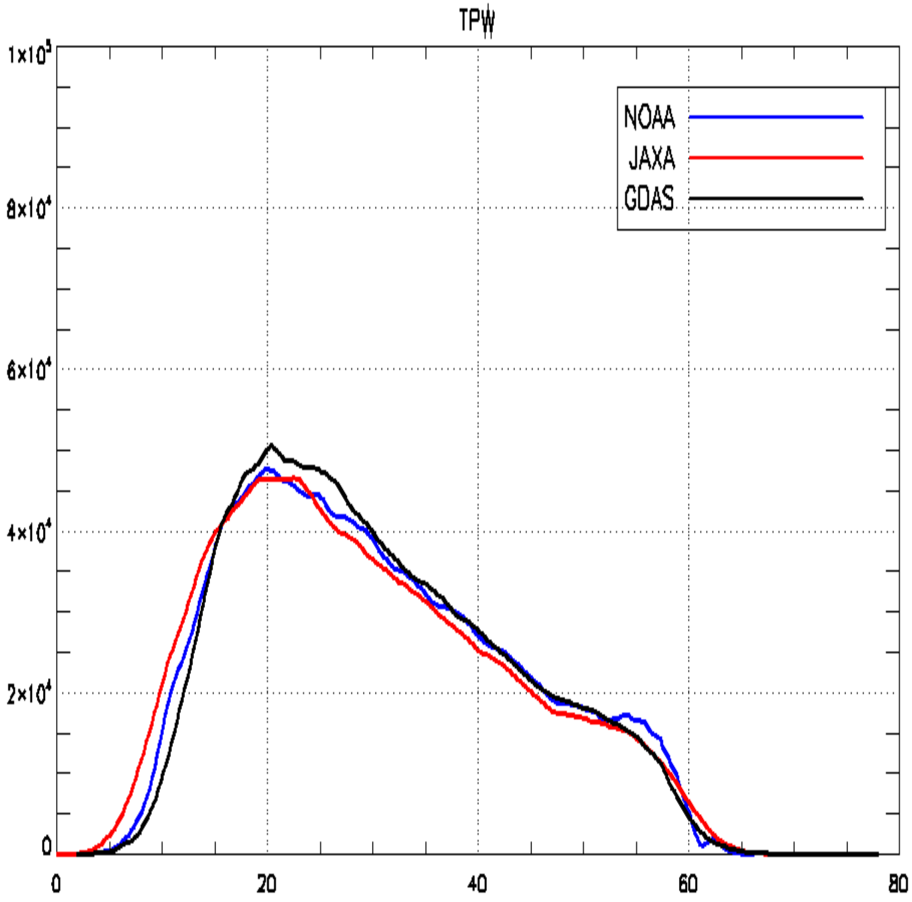
TPW Validation

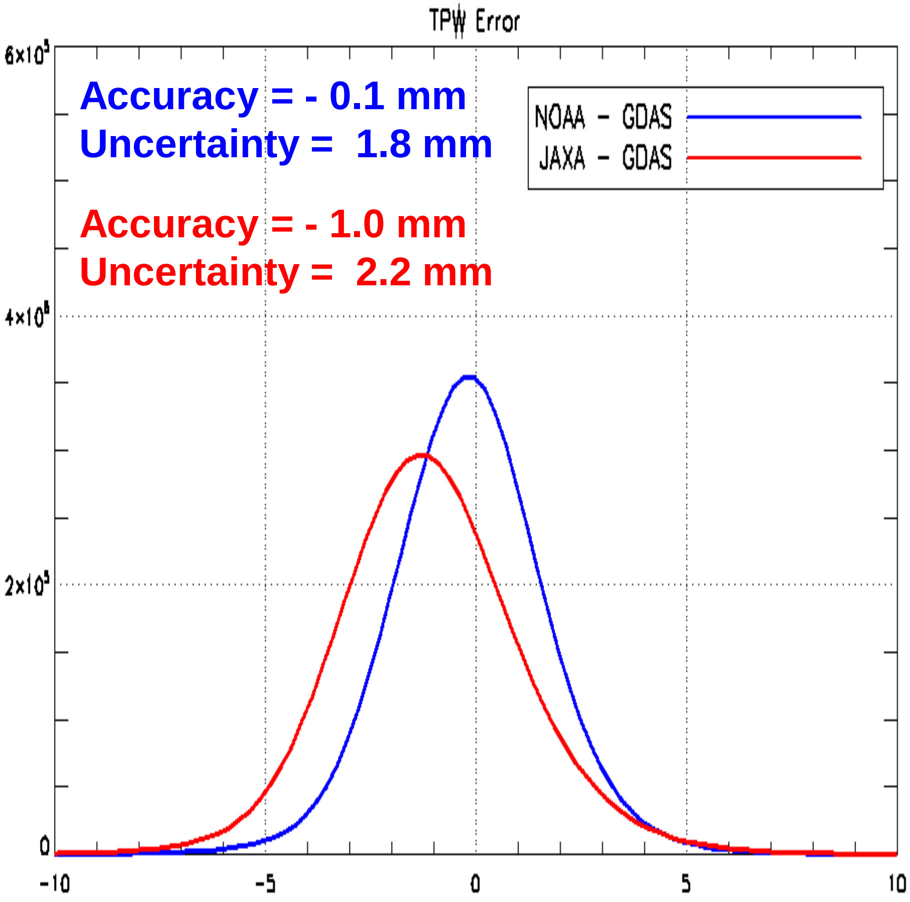
- Ancillary data for AMSR2 TPW validation
  - » Models : GDAS
  - » Measurements : TMI, NOAA-19

GCOM Total Precipitable Water Requirements

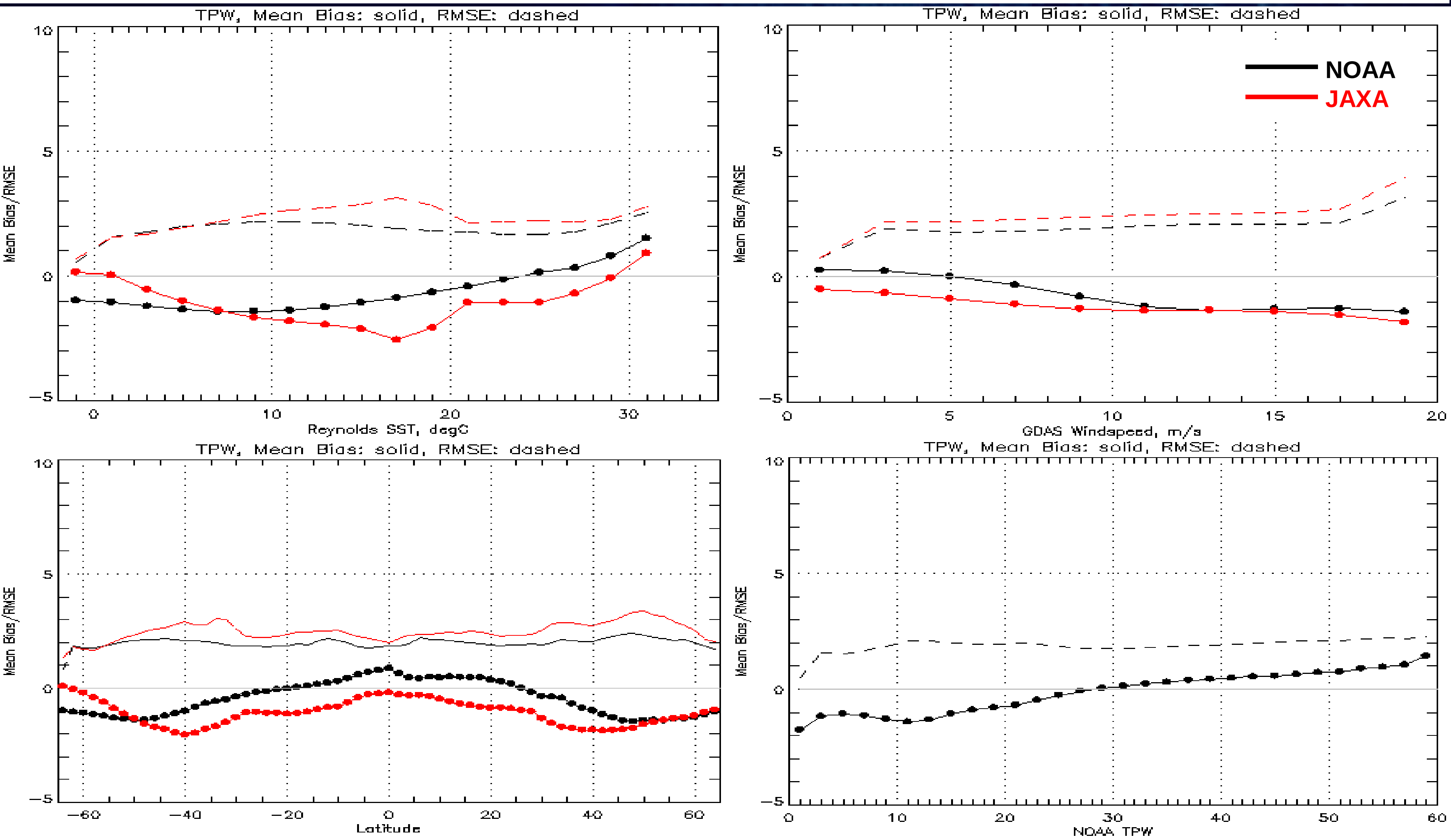
EDR Attribute	Requirement	Status		
		GDAS	TMI	NOAA-19
Measurement range	1 – 75 mm			
Measurement uncertainty	2mm or 10% whichever is greater	1.8	1.1	1.4
Measurement accuracy	1 mm	0.1	0.0	0.7

TPW Validation / GDAS

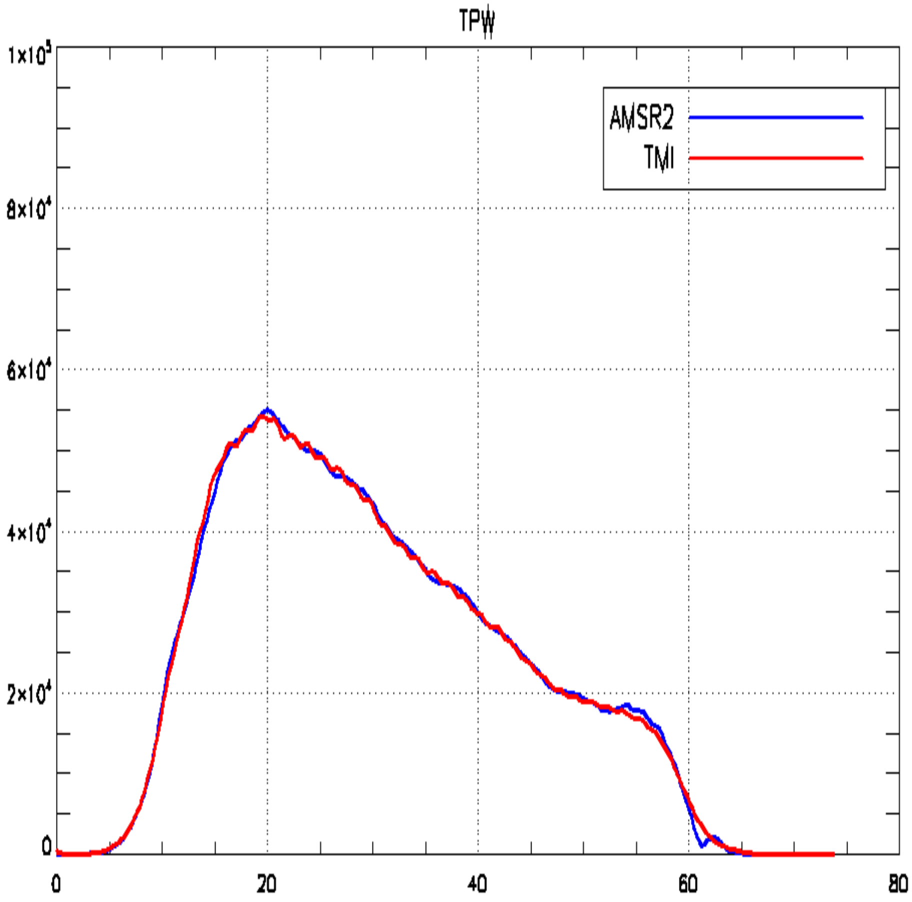


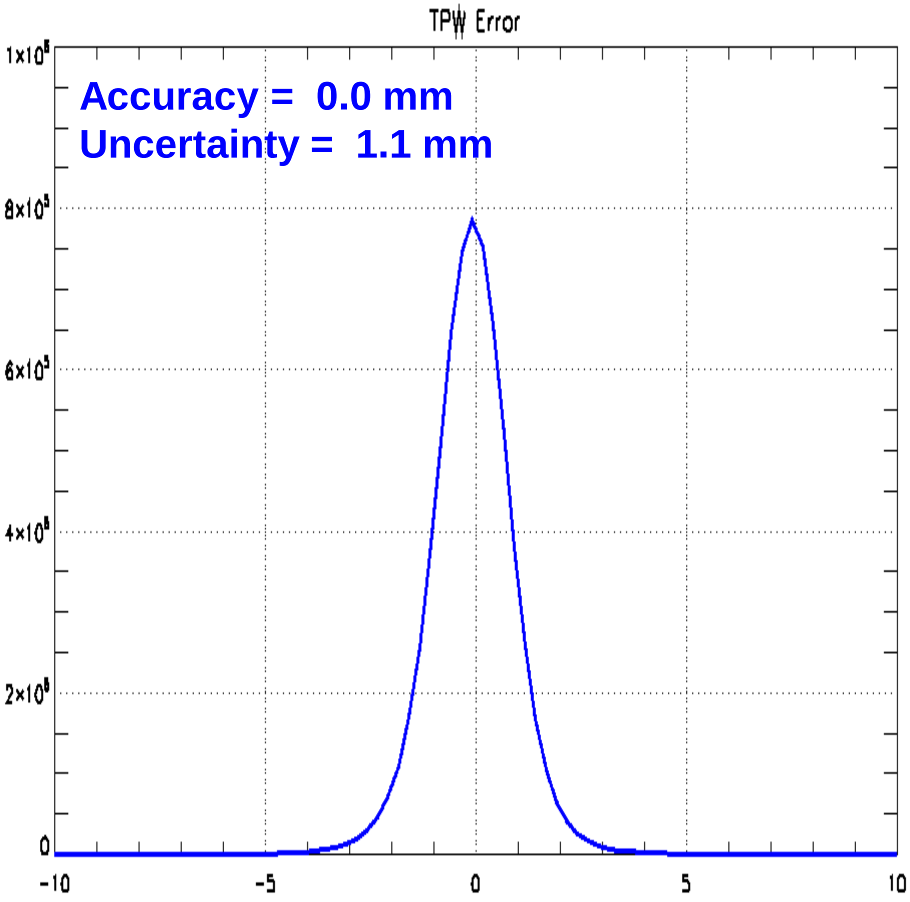


TPW Validation / GDAS – cont.

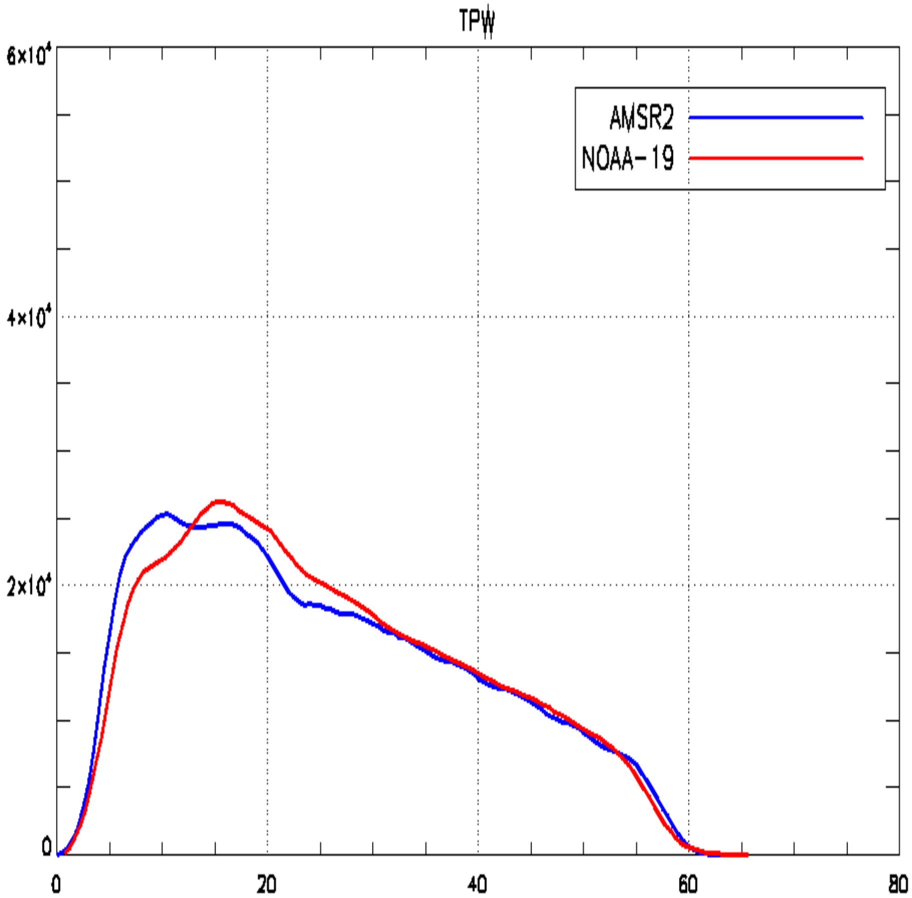


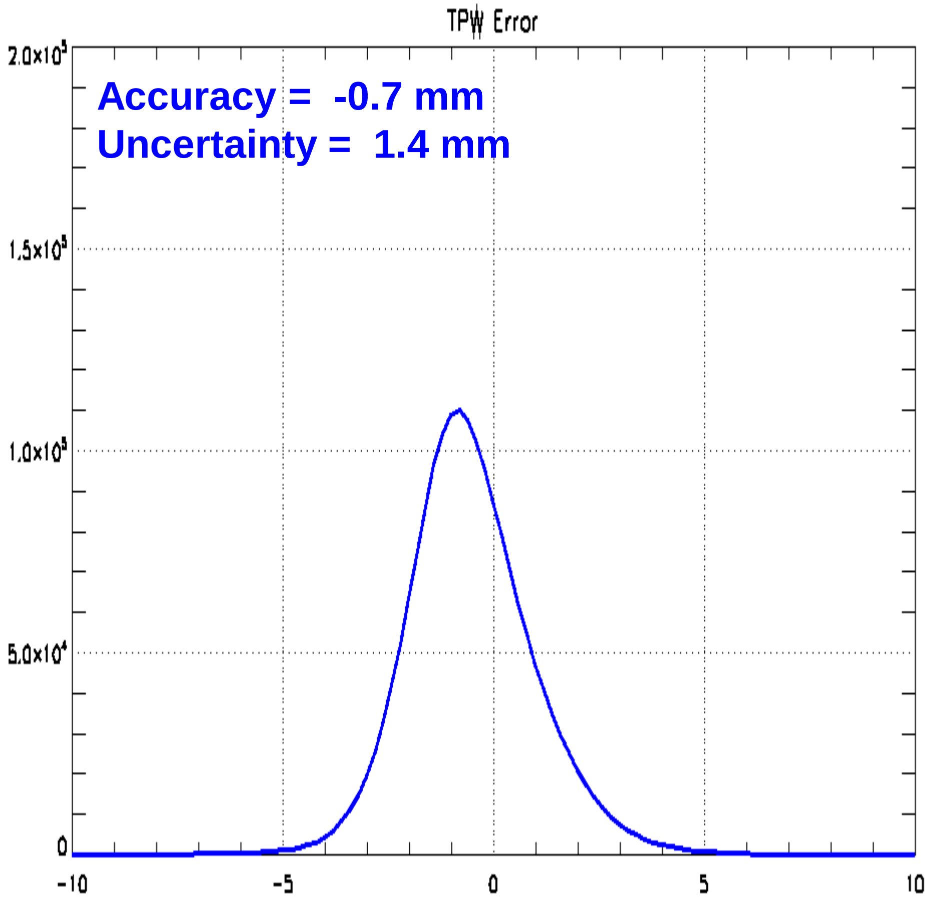
TPW Validation / TMI





TPW Validation / NOAA-19





CLW Algorithm

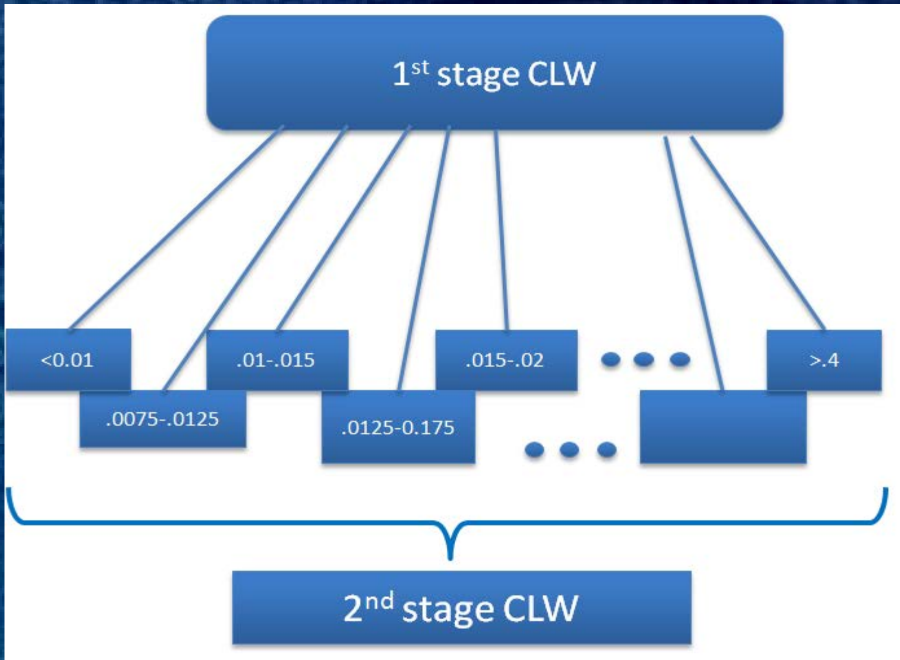
- 1^{st} stage regression:
  - » Channels used: 6,7 &10 GHz H-pol, 18, 23 & 36GHz H/V pol

$$CLW = \sum_{i=1,3}(a_i Tb_i) + \sum_{j=1,5}(b_j \ln(285 - Tb_j))$$

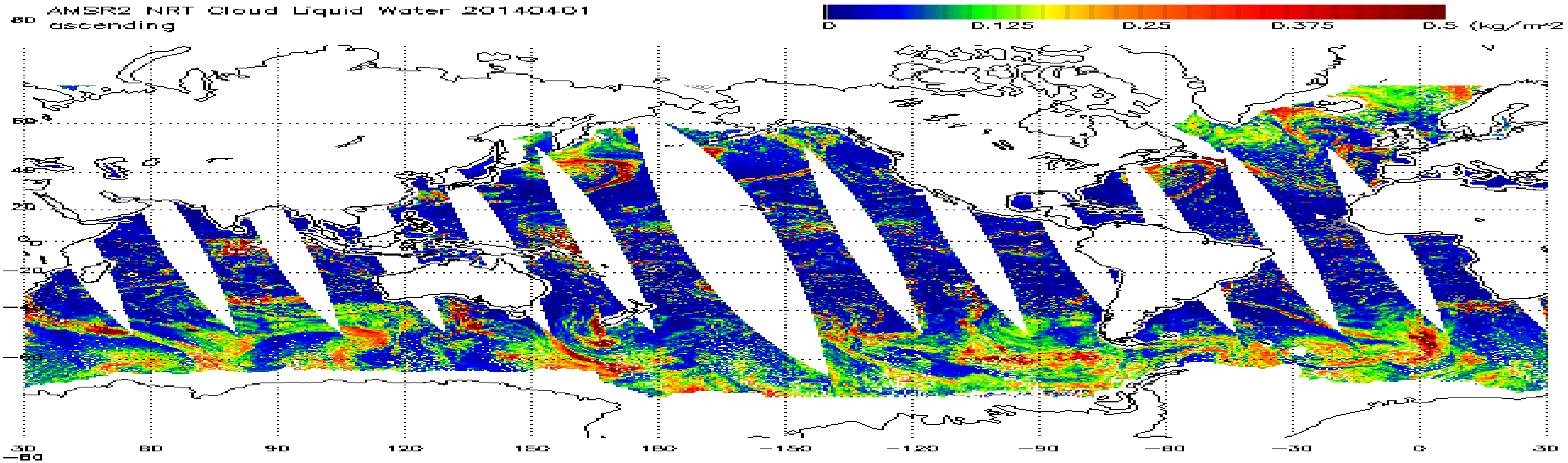
$$Tb_i = Tb^{6H}, Tb^{7H}, Tb^{10H}$$

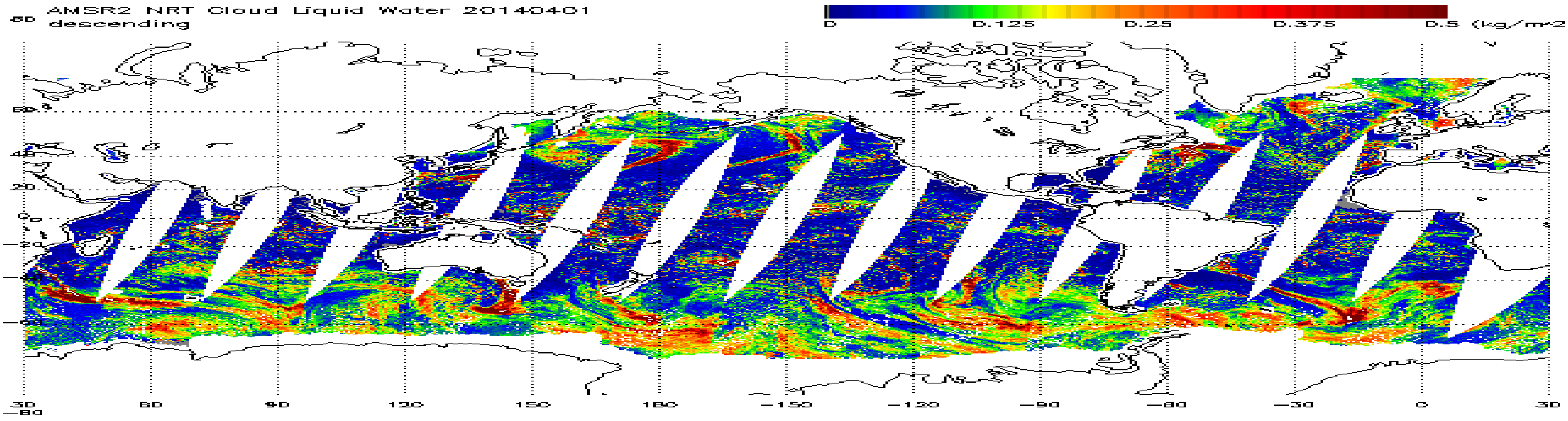
$$Tb_j = Tb^{18H/V}, Tb^{23H/V}, Tb^{36H/V}$$

- 2^{nd} stage regression:
  - » Using 1^{st} stage CLW to derive localized regressions
    - – Every 0.01mm bins
  - » In overlapping bins final CLW is average CLW from adjacent bins



AMSR2 CLW Example (04/01/2014)





CLW Validation

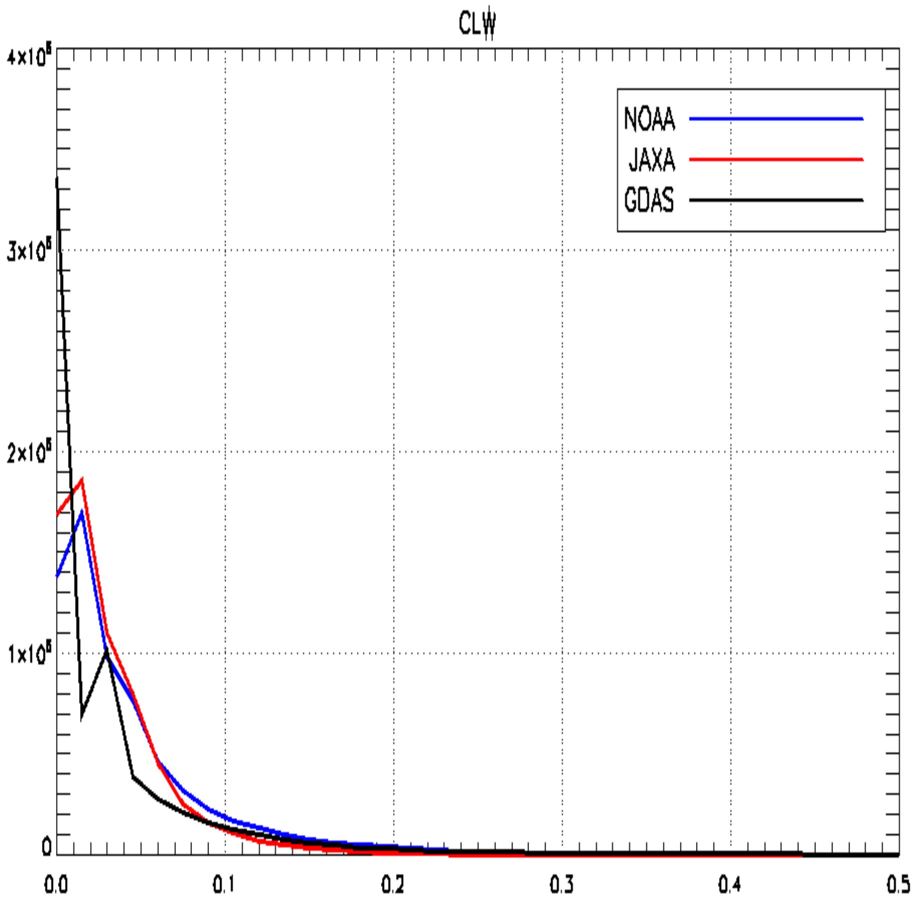
- Ancillary data for AMSR2 CLW validation
  - Models : GDAS
  - Measurements : TMI, NOAA-19

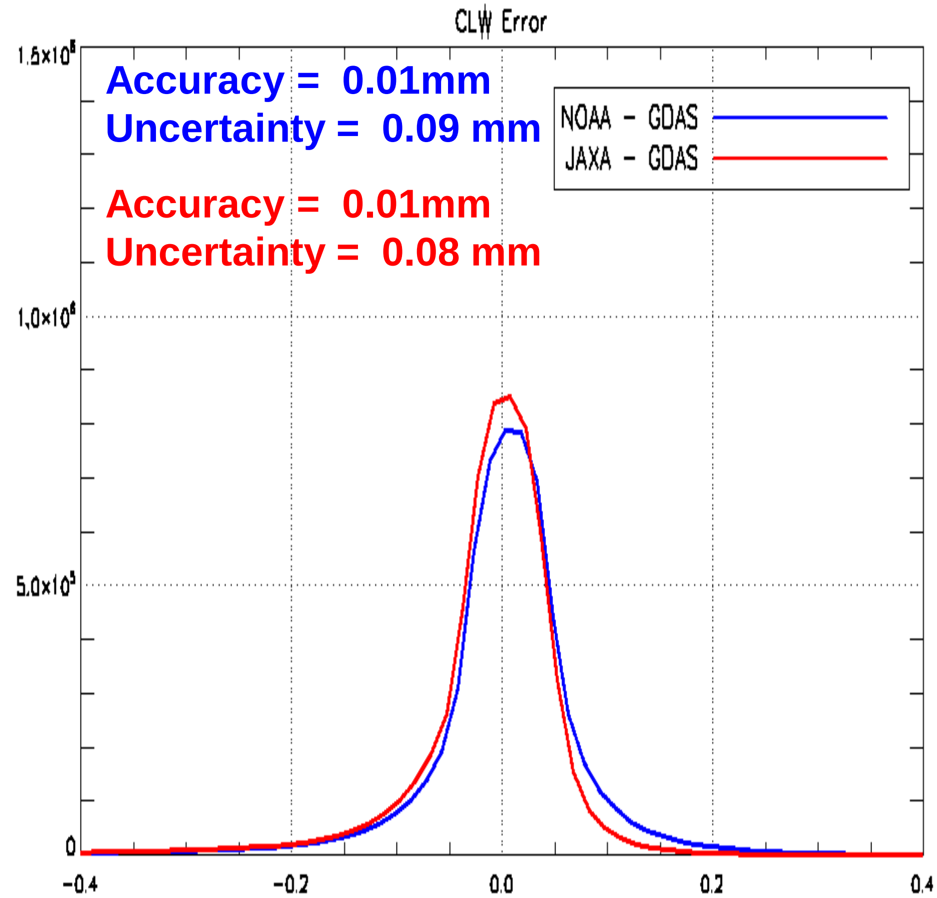
GCOM Cloud Liquid Water Requirements

EDR Attribute	Requirement	Status		
		GDAS	TMI	NOAA-19
Measurement range	0.005 – 1 mm			
Measurement uncertainty	0.05 mm over ocean	0.09*	0.04	0.03
Measurement accuracy	0.01 mm	0.01	0.01	0.01

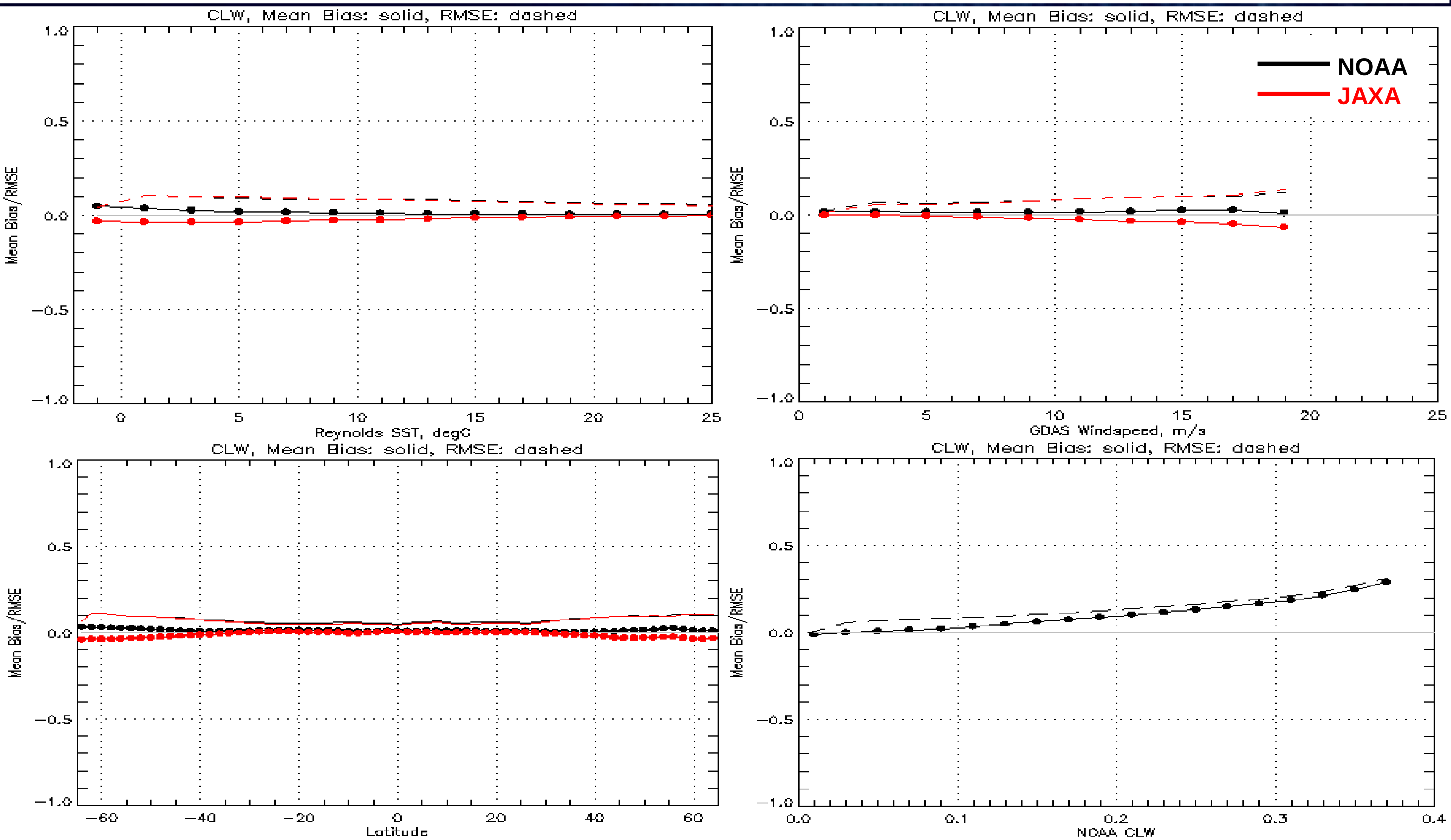
* CLW changes fastest of all other parameters. Interpolated 6H models are not expected to agree well with instantaneous measurements from AMSR2

CLW Validation / GDAS

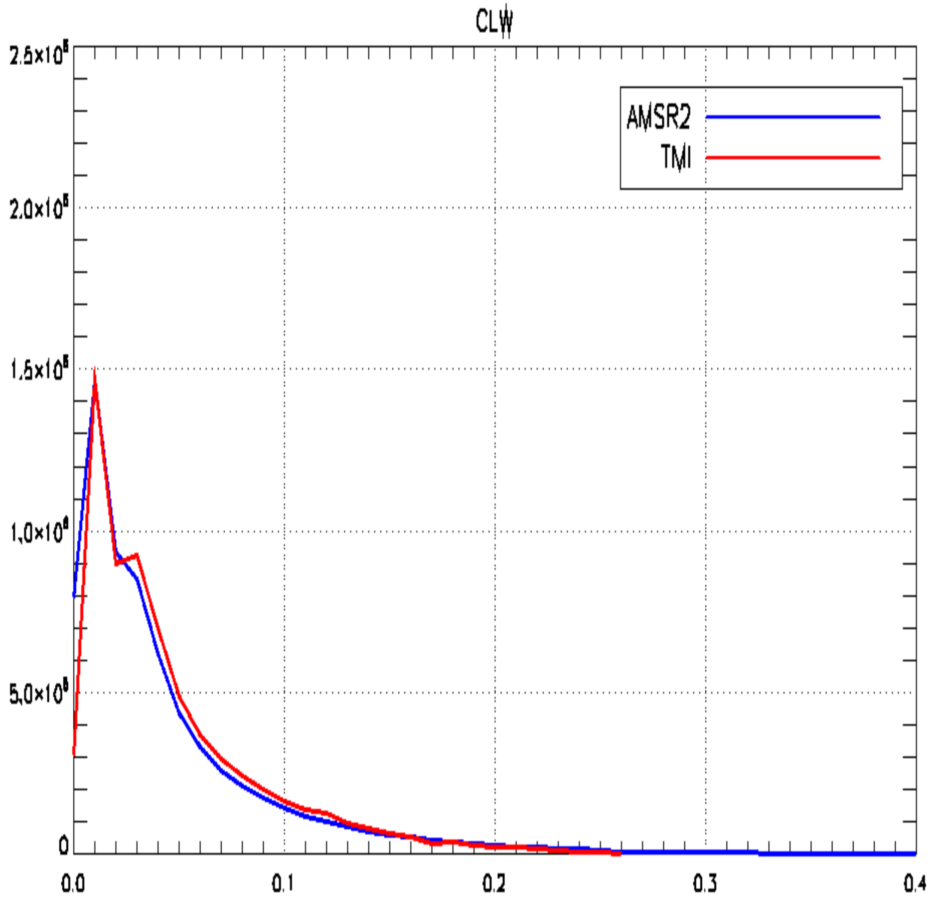


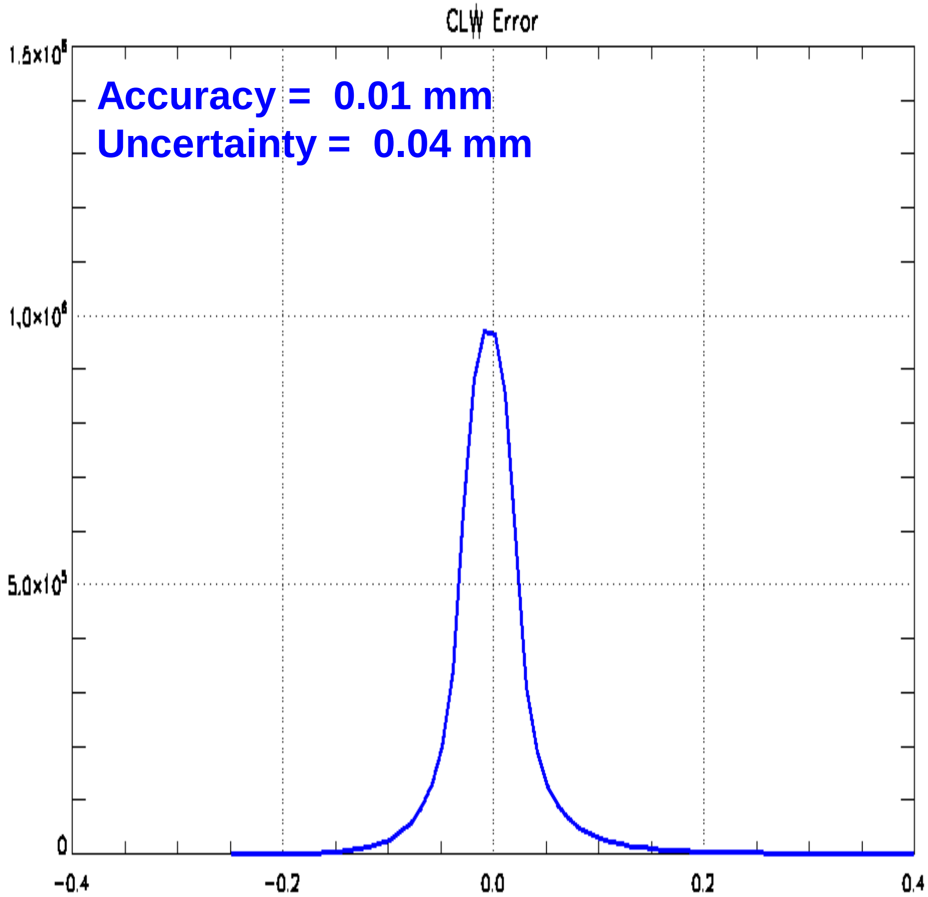


CLW Validation / GDAS – cont.

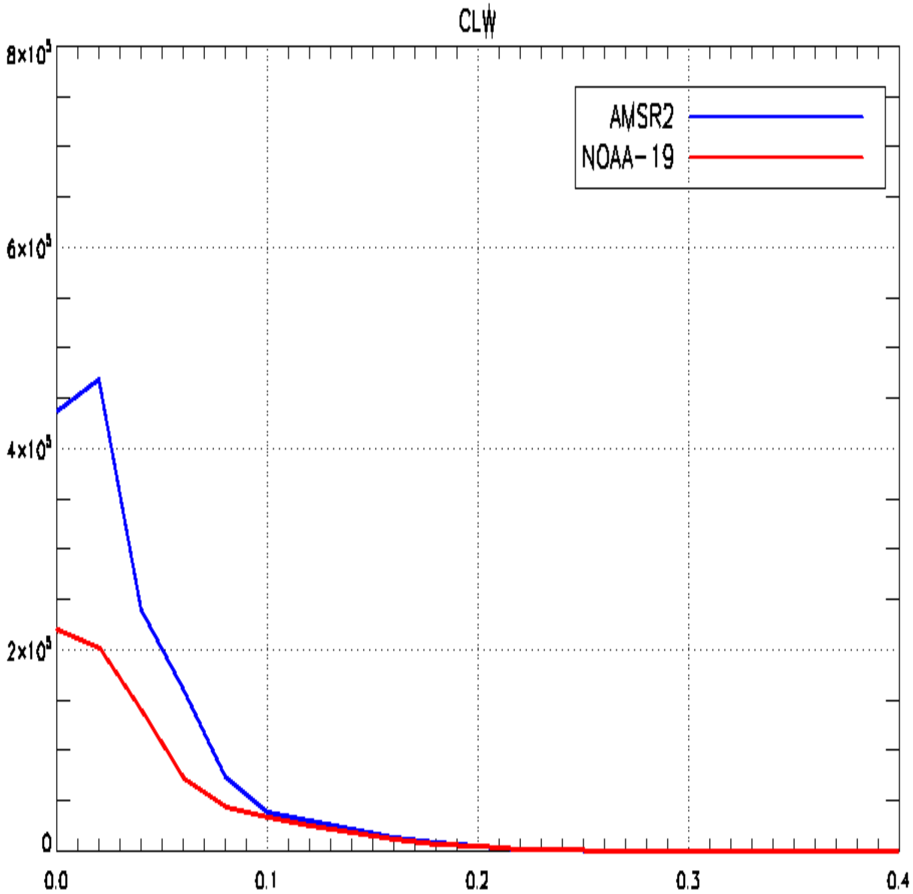


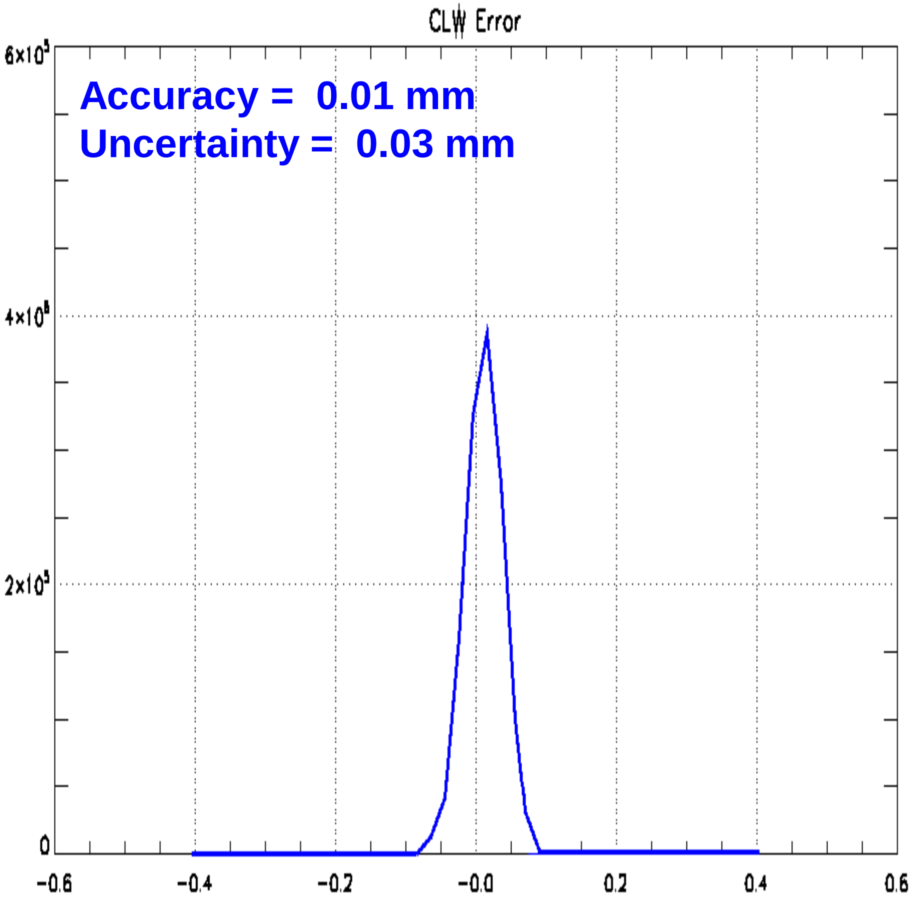
CLW Validation / TMI





CLW Validation / NOAA-19





SSW Algorithm

8 AMSR2 channels: 10-36GHz, H/V pol

CLW, TPW

3 deg. latitude bins with 1.5 deg. overlap between 60N and 60S

Wind direction correction

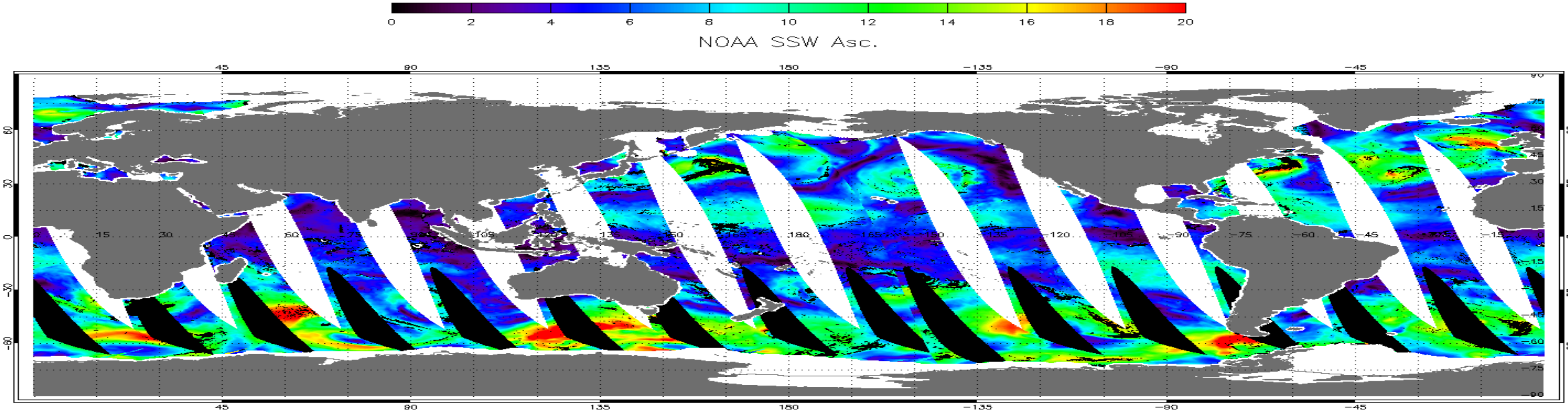
7x7 median filter

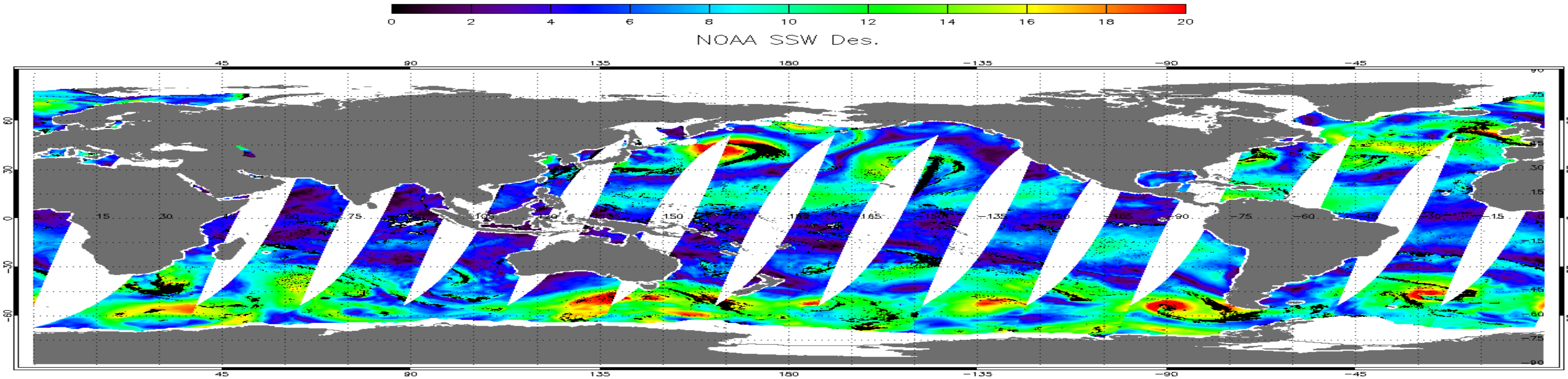
Quality control
wspd <0m/s
wspd>30m/s
CLW >0.3mm
TPW >60mm

- Emissivity dependence on wind direction can reach ~2k peak-to-peak
  - » Leads to significant error in wind speed retrievals
- Correction for wind direction requires ancillary source
  - » NWS GDAS analysis used for training purposes
  - » NWS GFS forecast fields used for NRT retrievals

NOAA SSW Example (04/01/2014)

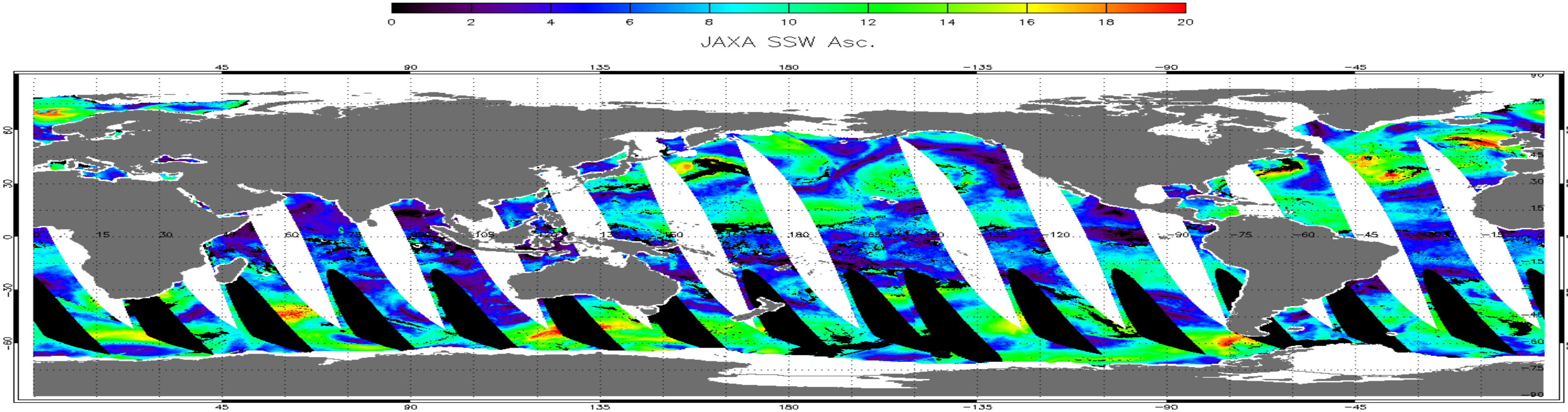
% of flagged points (NOAA): ~ 12%

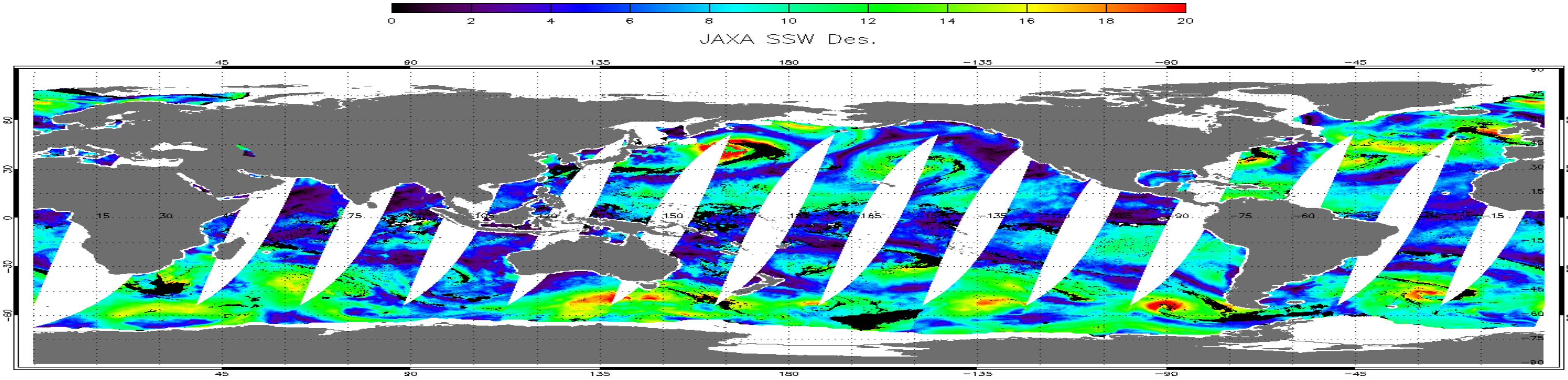




JAXA SSW Example (04/01/2014)

% of flagged points (JAXA): ~16%





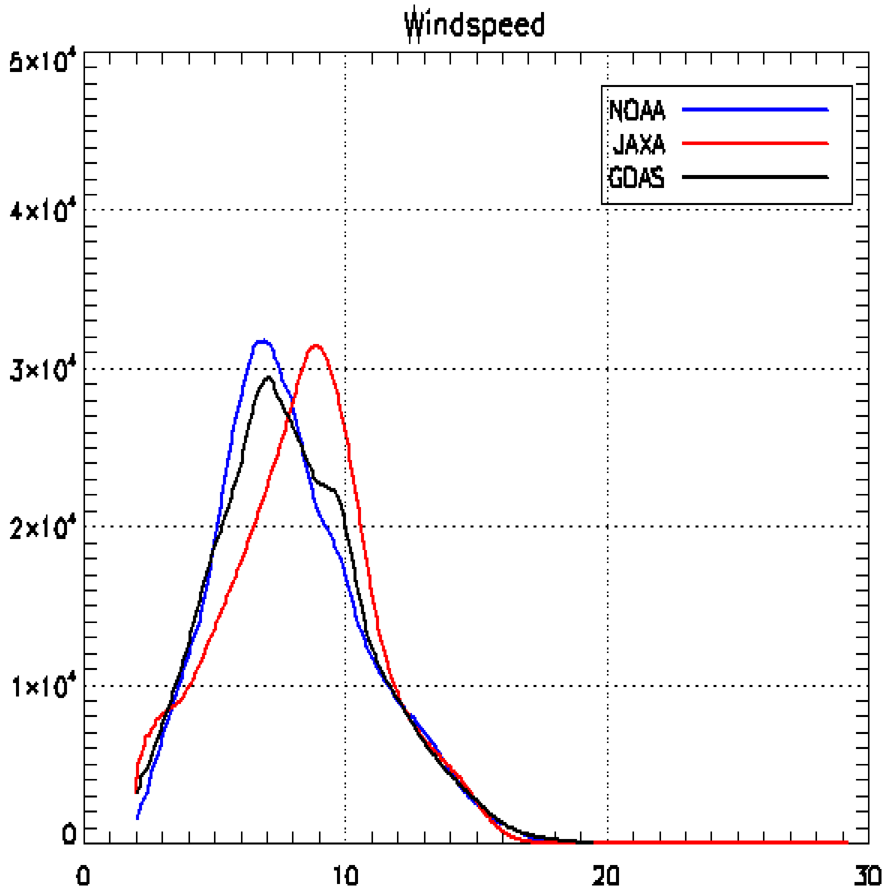
SSW Validation

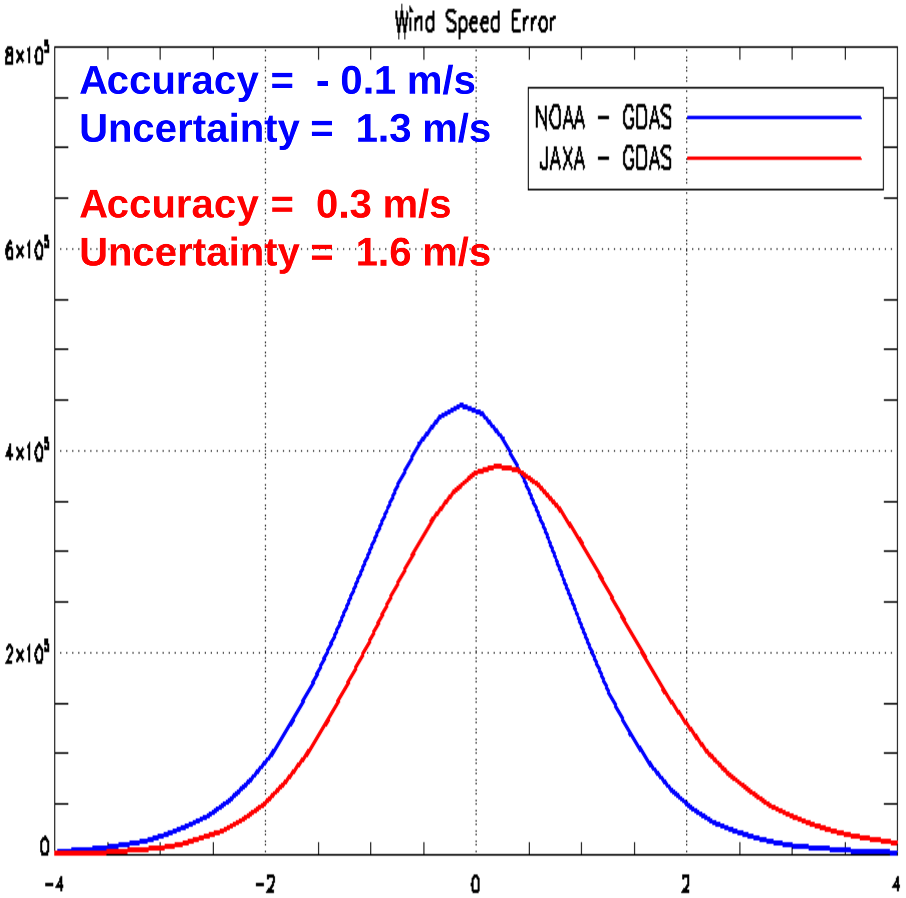
- Ancillary data for AMSR2 SSW validation
  - » Models : GDAS
  - » Measurements : TMI, Buoys

GCOM Sea Surface Wind Speed Requirements

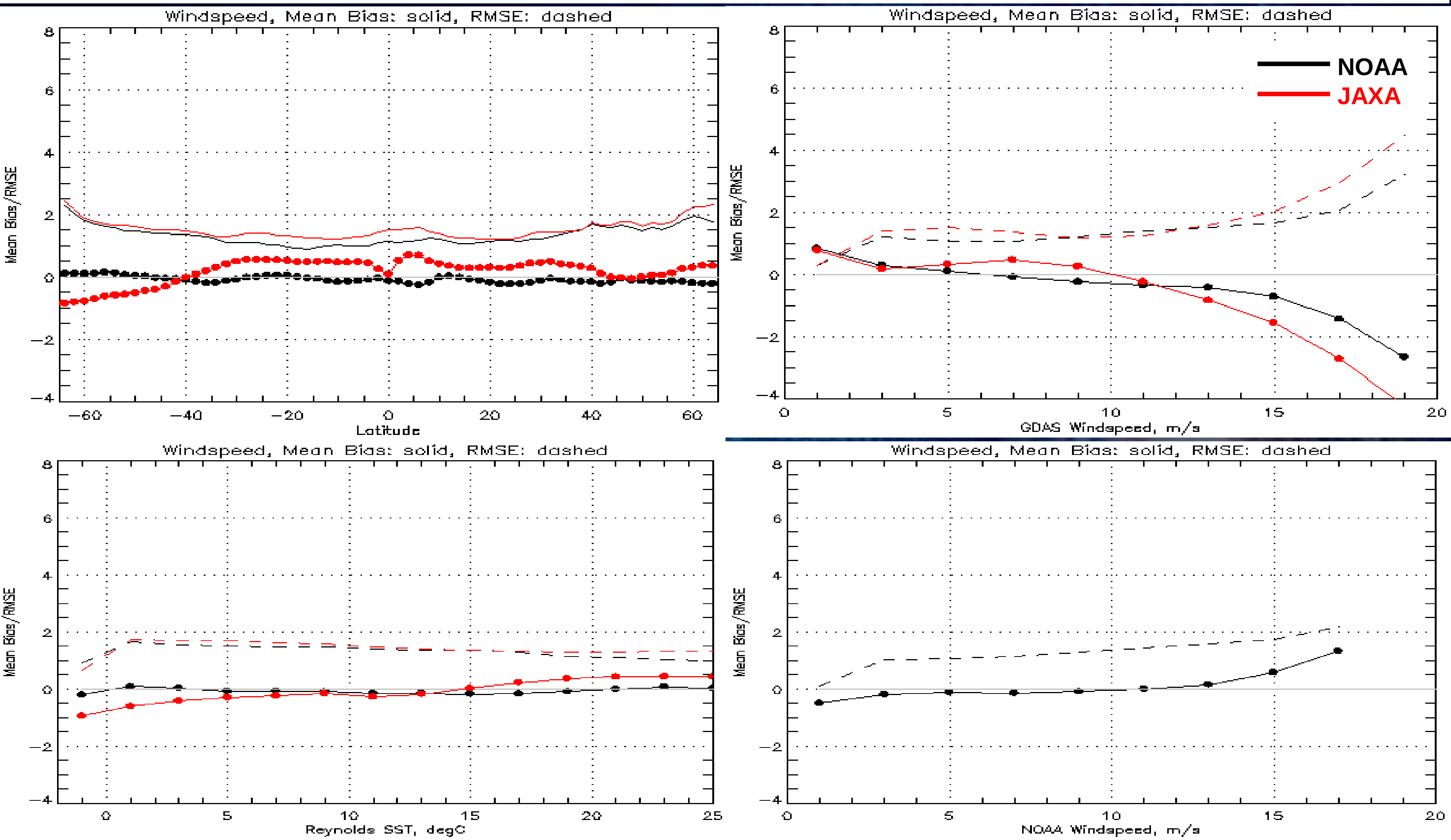
EDR Attribute	Requirement	Status		
		GDAS	TMI	Buoys
Measurement range	2 – 30 m/s			
Measurement uncertainty	2 m/s or 10 % whichever is greater	1.3	0.9	1.5
Measurement accuracy	0.5 m/s	0.1	0.3	0.2

SSW Validation / GDAS

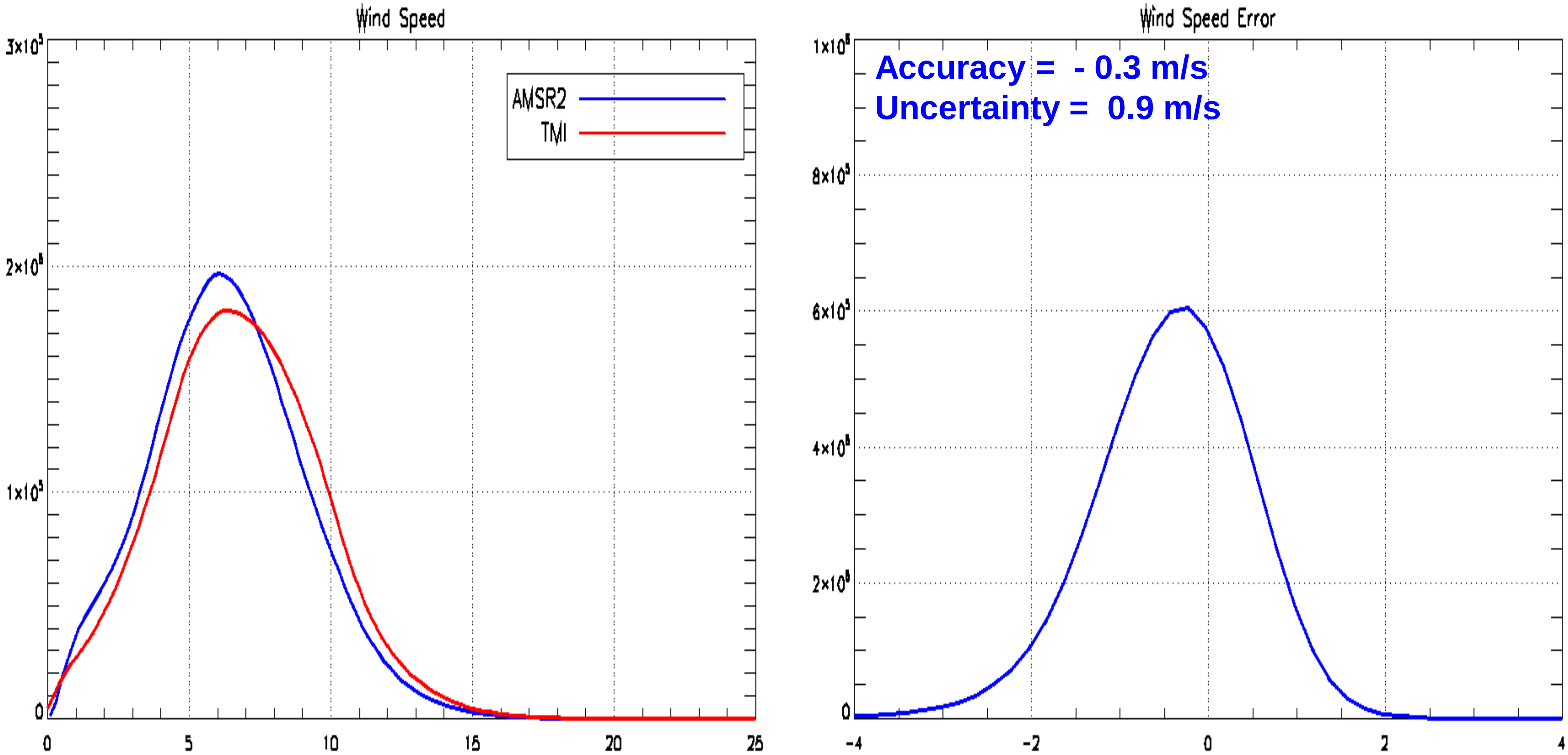




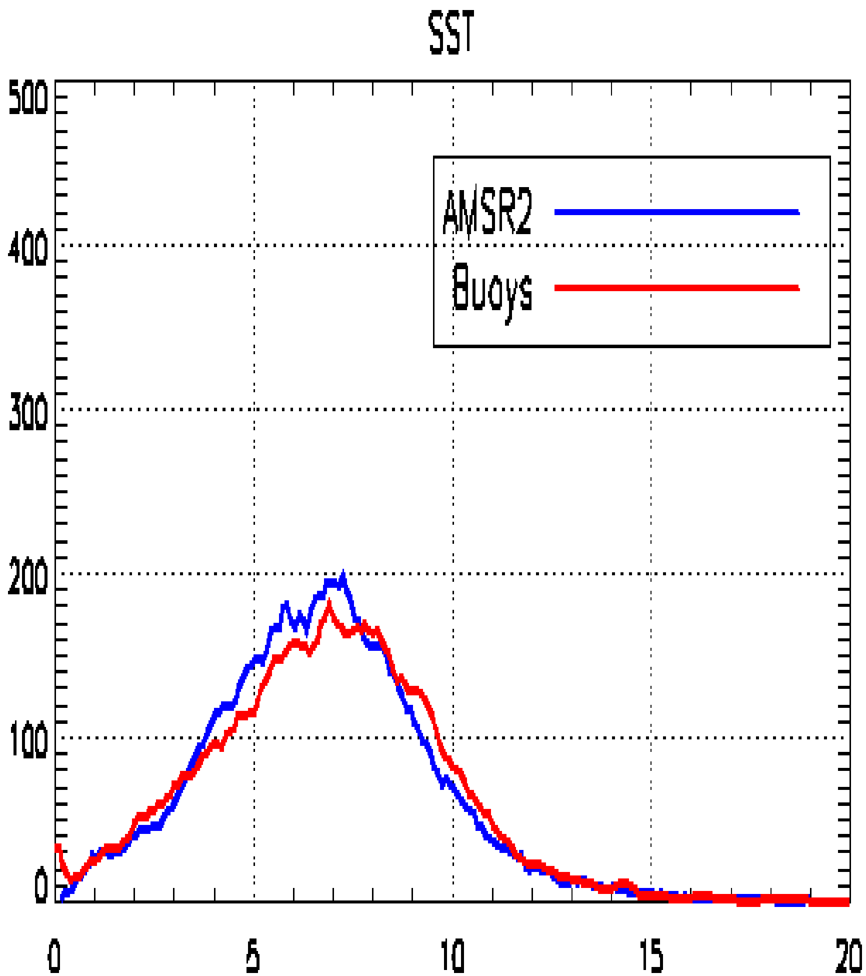
SSW Validation / GDAS – cont.

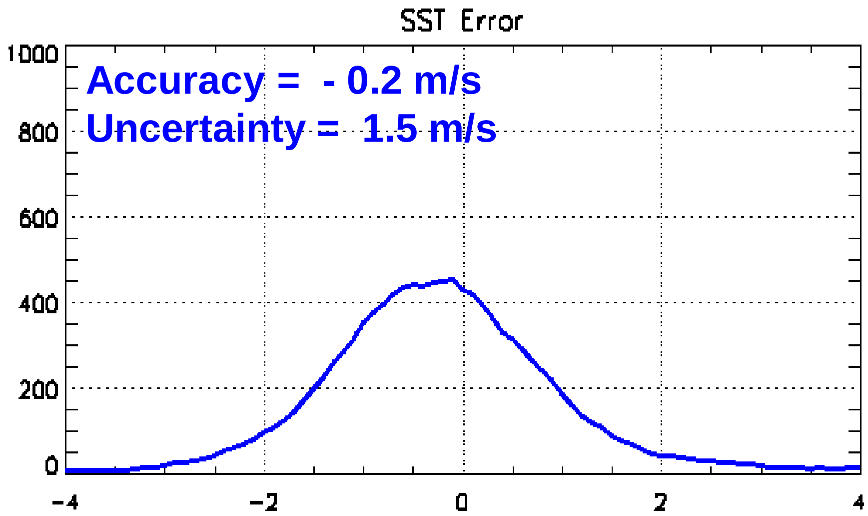


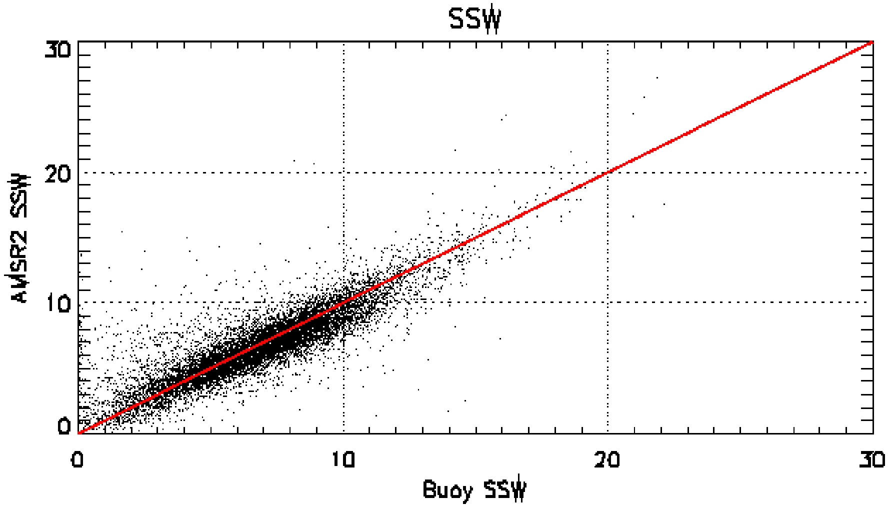
SSW Validation / TMI



SSW Validation / Buoys







SST Algorithm

12 AMSR2 channels: 6-36 GHz, H/V pol

CLW, TPW, WSPD, Wdir

3 deg. latitude bins with 1.5 deg. overlap between 60N and 60S

Wind direction signal correction

Wind Speed signal correction

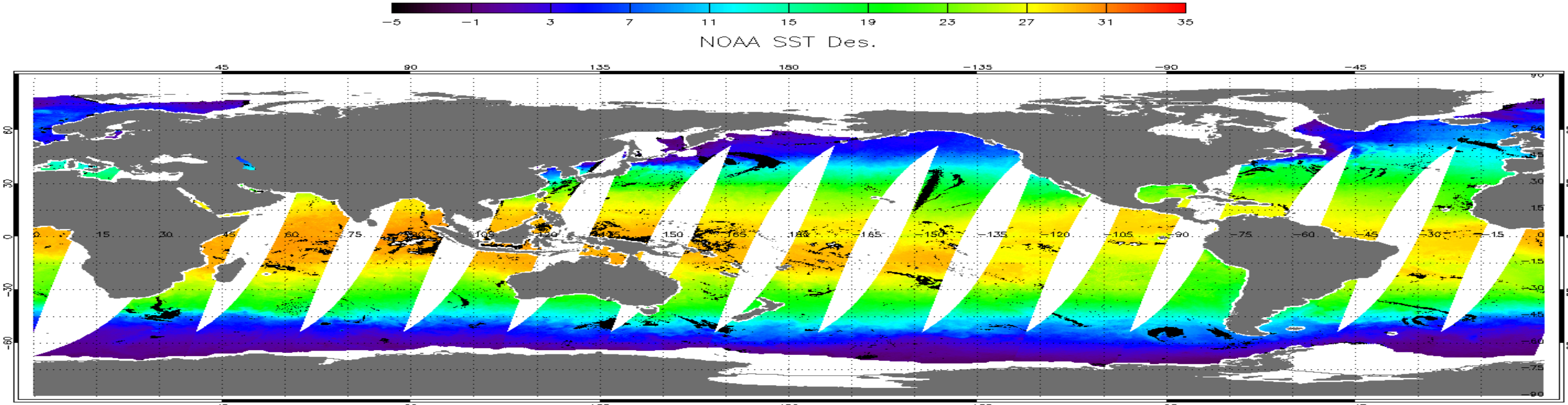
3x3 median filter

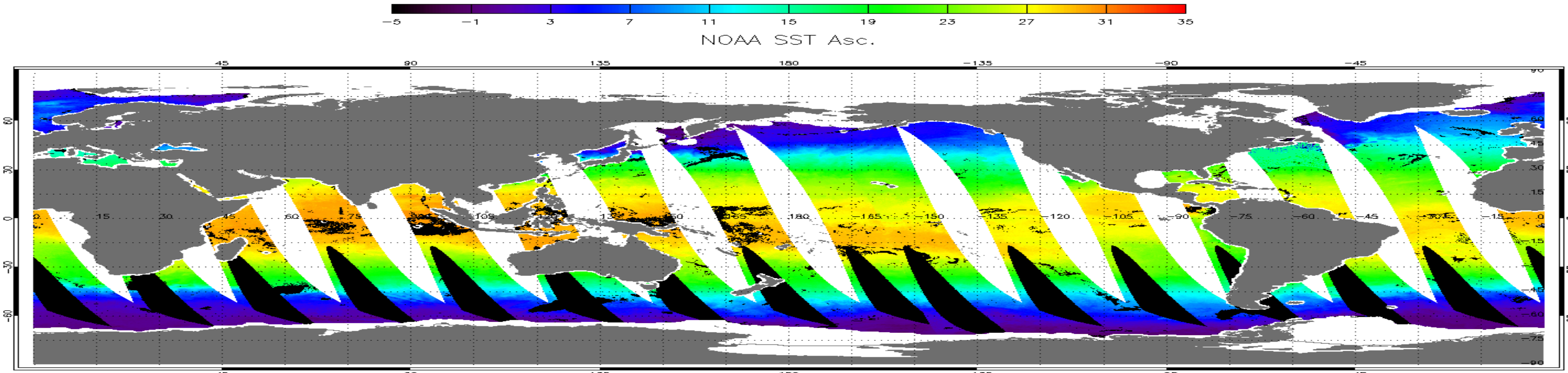
Quality control
SST < -3 c
SST > 35 c
wspd <0m/s
wspd>16m/s
CLW >0.3mm^2
TPW >60mm^2

- Correcting SST for wind speed signal utilizes PDF matching technique
  - » GFS model SST binned at every 10 deg. latitude and every 5 m/s wind speed bins
    - – Retrieved wind speed

NOAA SST Example (04/01/2014)

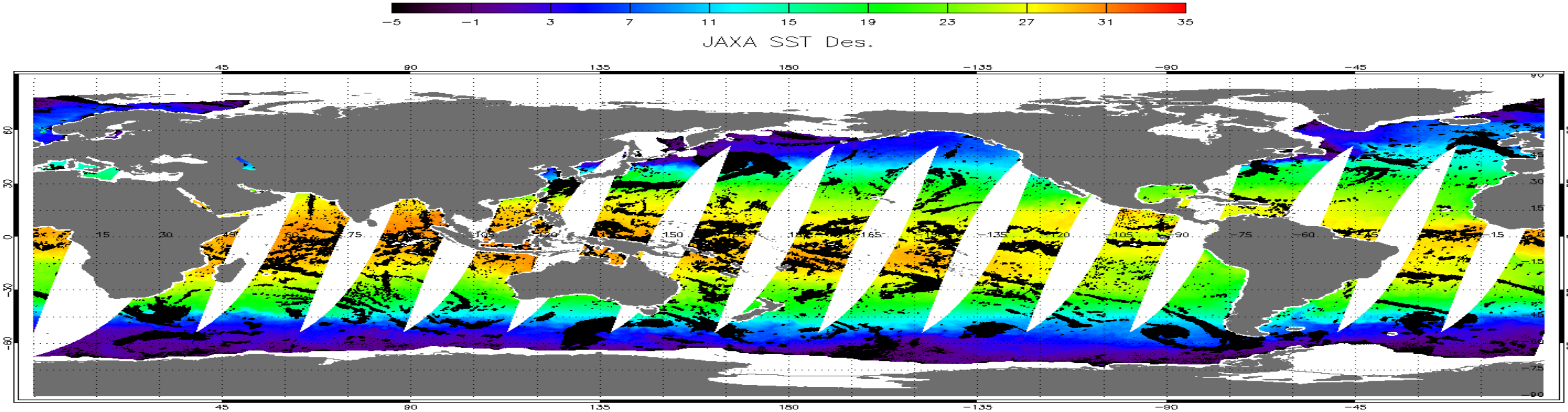
% of flagged points (NOAA): ~ 11%

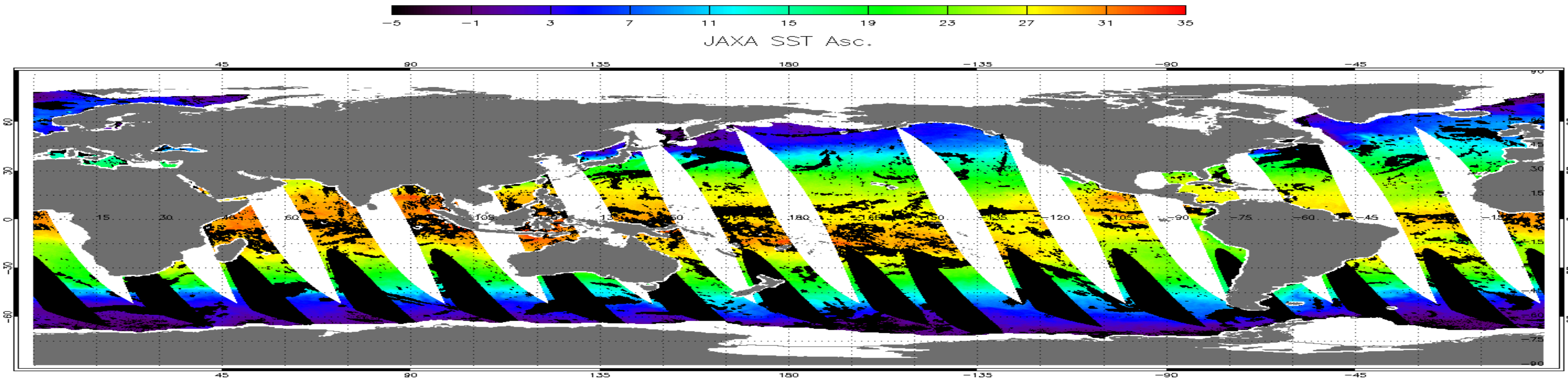




JAXA SST Example (04/01/2014)

% of flagged points (JAXA): ~ 30%



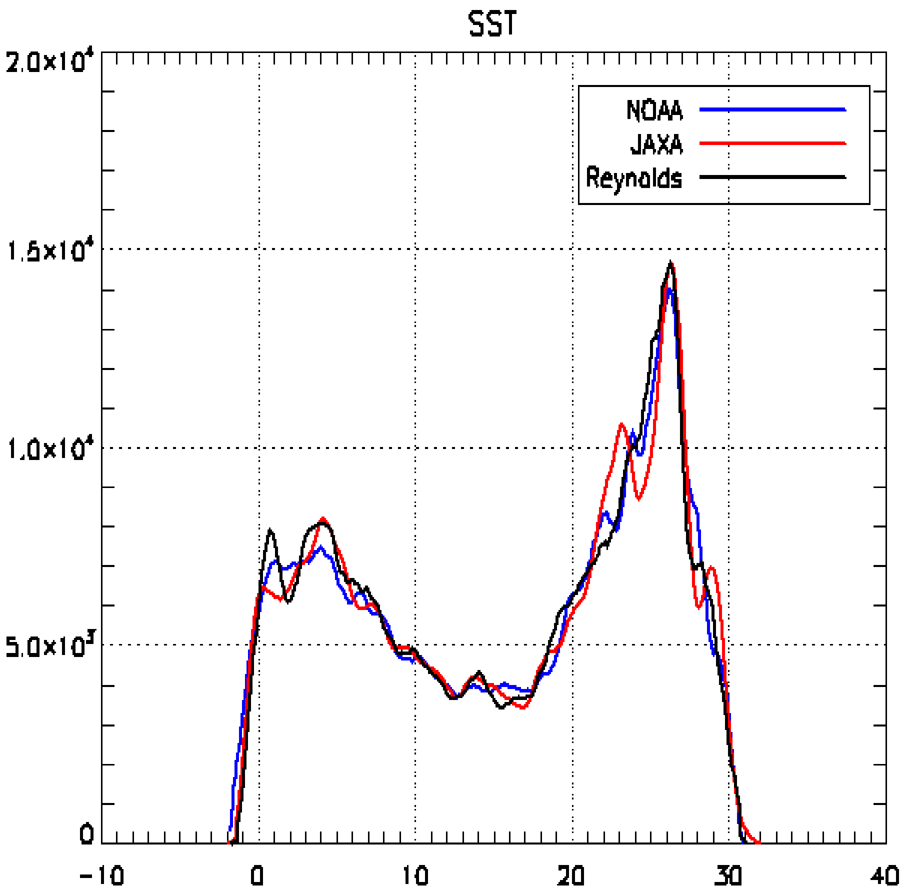


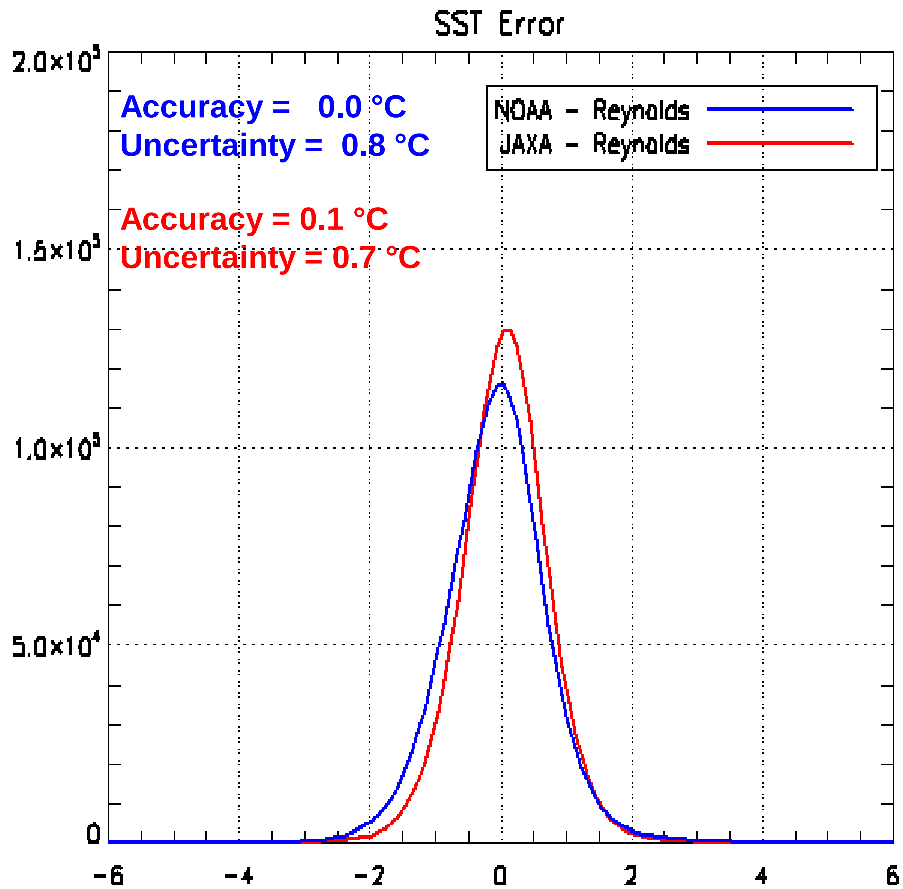
SST Validation

- Ancillary data for AMSR2 SST validation
  - » Models : Reynolds
  - » Measurements : TMI, Buoys

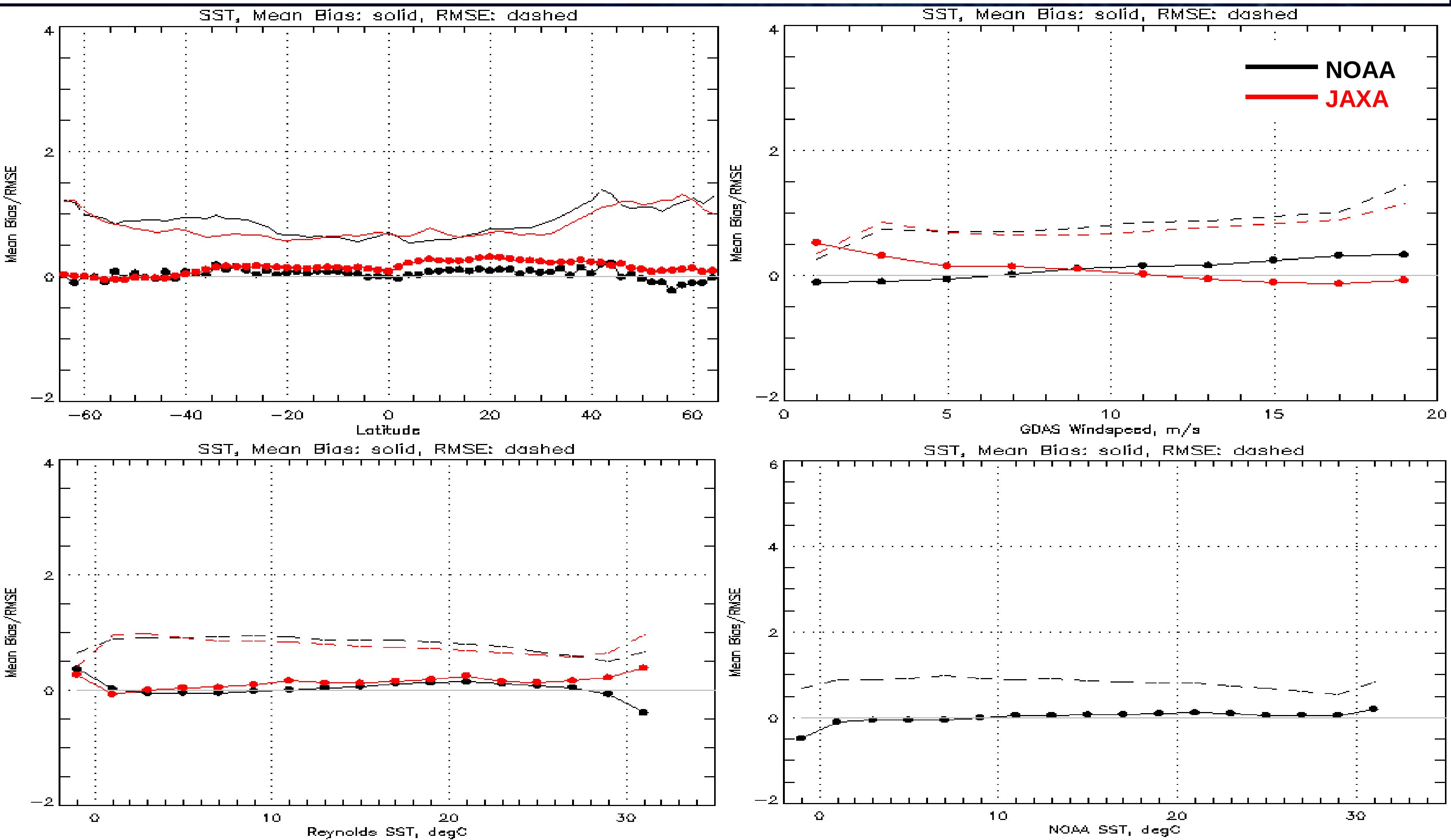
GCOM Sea Surface Temperature Requirements				
EDR Attribute	**Requirement**	**Status**		
		Reynolds	**TMI**	**Buoys**
Measurement range	271 – 313 k			
Measurement uncertainty	1.0 k	0.8	0.9	0.8
Measurement accuracy	0.5 k	0.0	0.1	0.1

SST Validation / Reynold

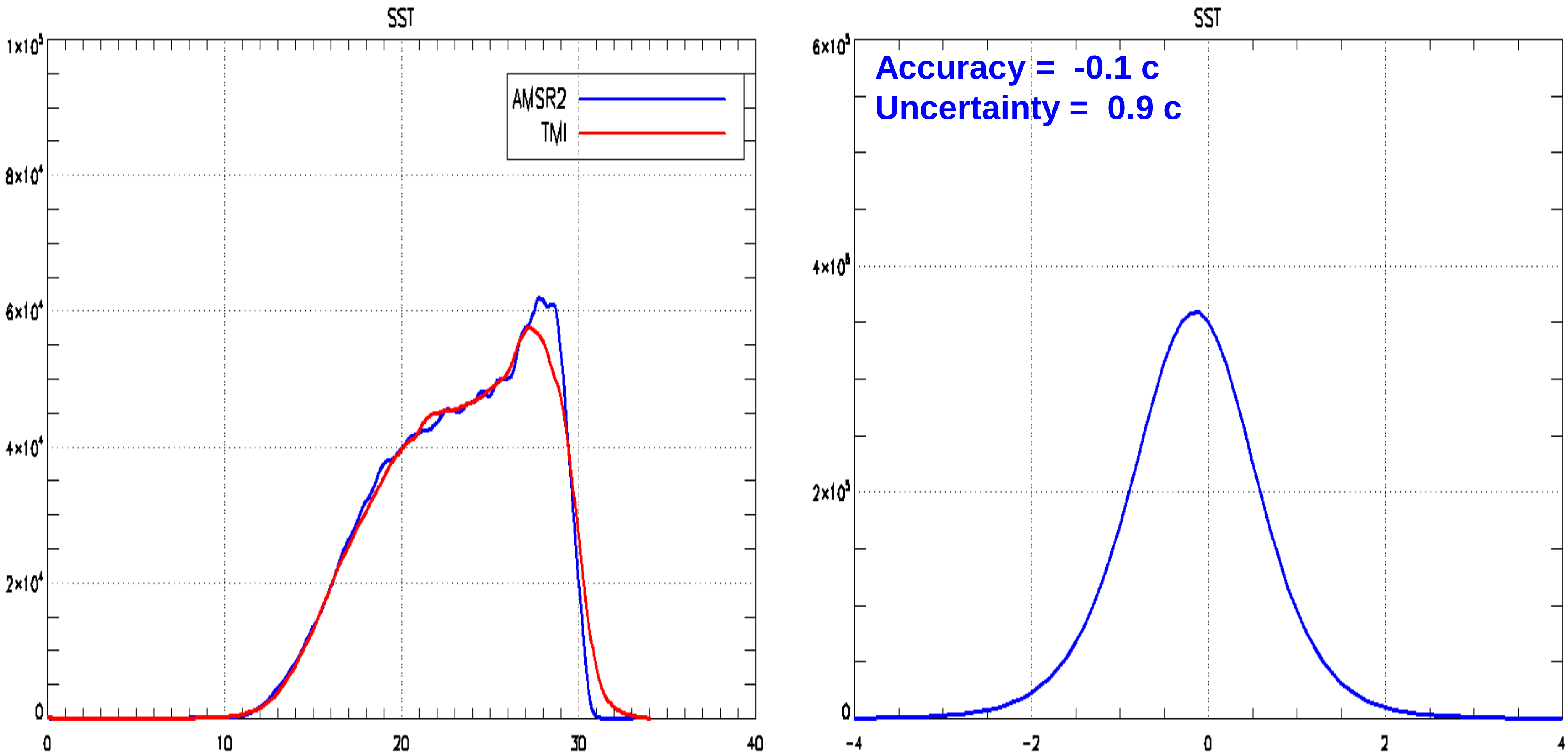




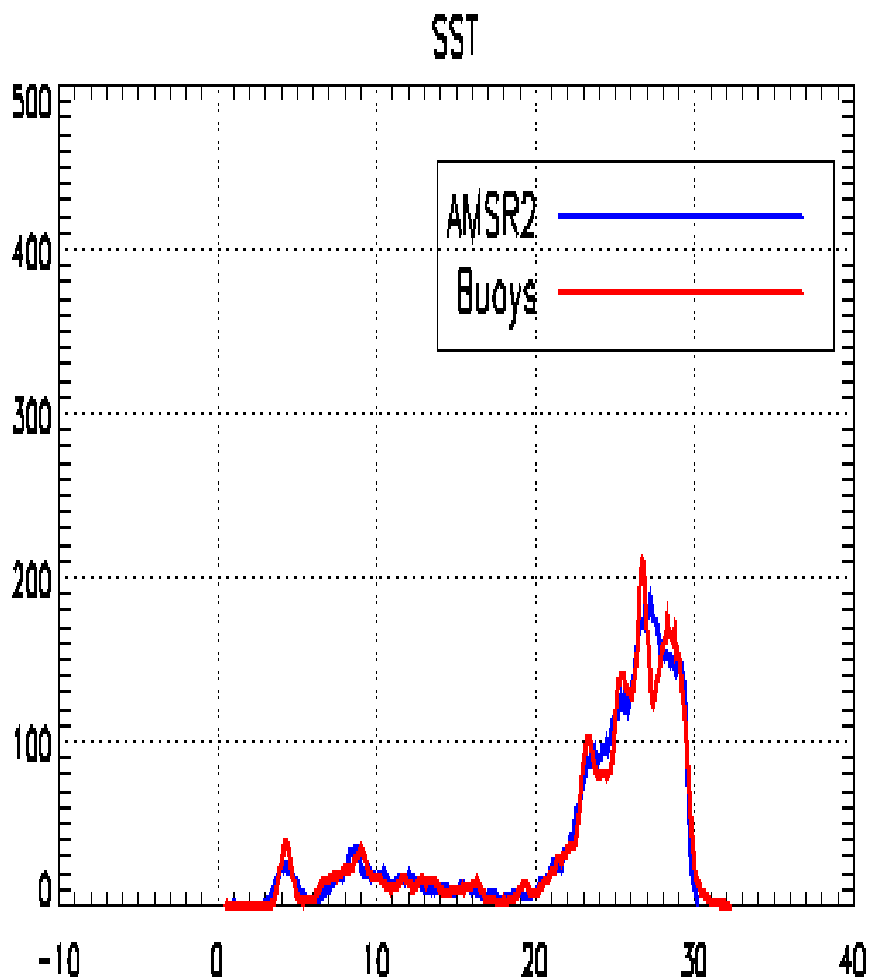
SST Validation / Reynold – cont.

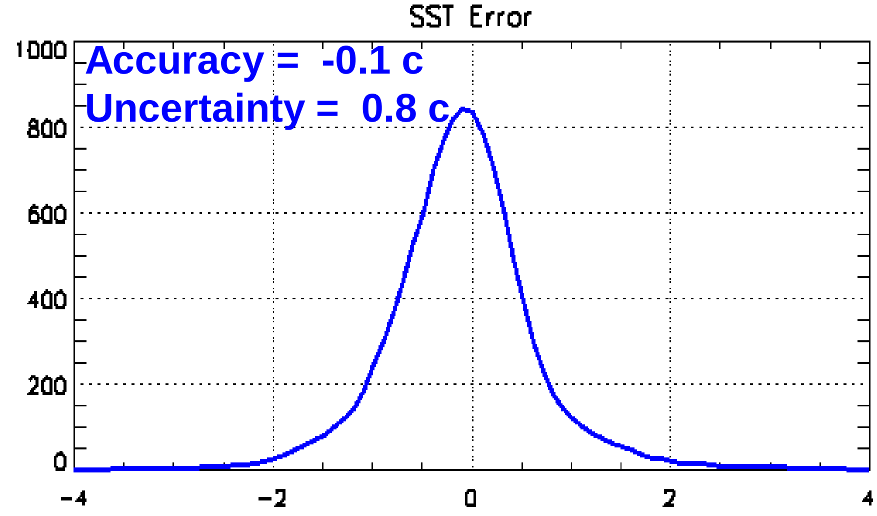


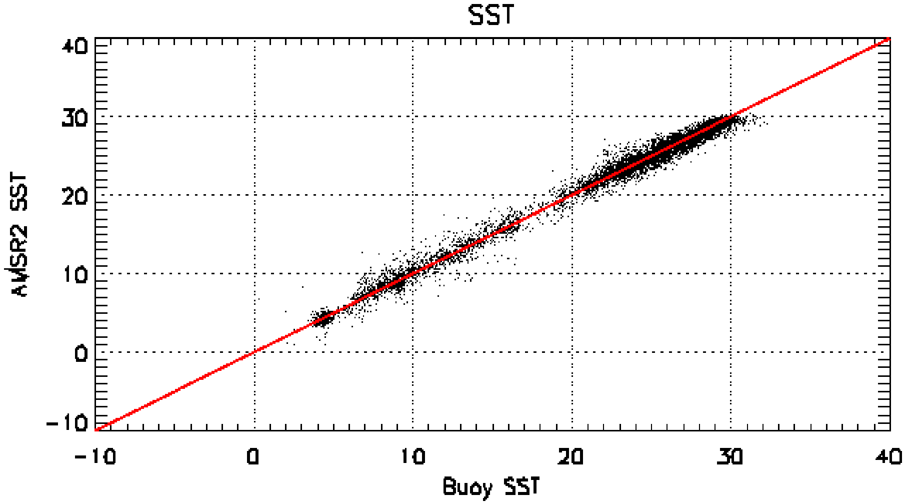
SST Validation / TMI



SST Validation / Buoys







Summary

- Double difference approach used to inter-calibrate AMSR2 residual biases in observed Tbs
- AMSR2 measures warmer Tbs when compared to TMI
  - » AMSR2 L1B *V1.1*
  - » TMI 1B11 *V7*
- Corrected AMSR2 Tbs were used in ocean EDR products
  - » TPW, CLW, SST, and SSW

Summary – cont.

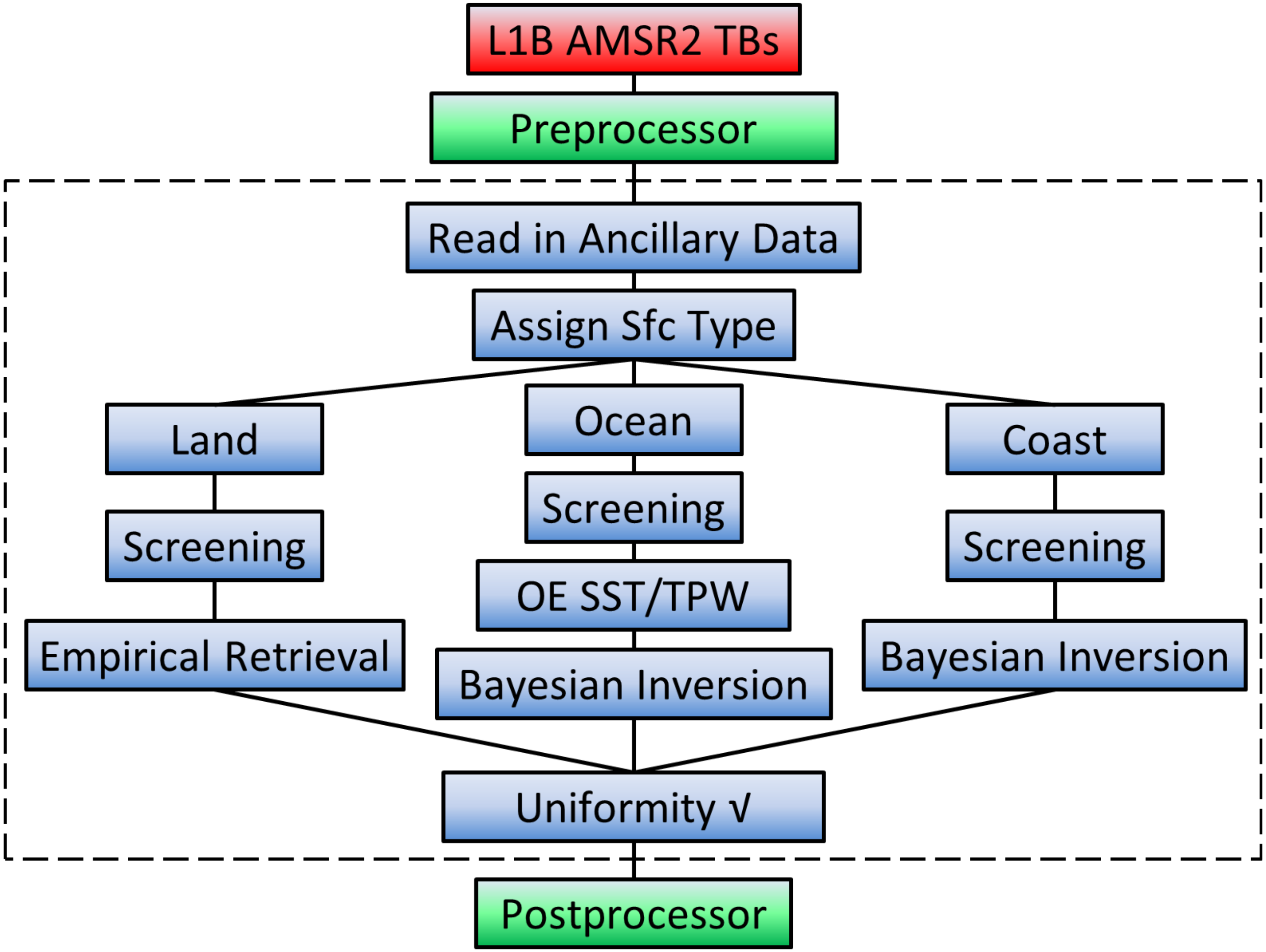
- 1st delivery ocean EDR products were validated against several other products
  - » Models
    - – GDAS
    - – Reynolds
  - » Measurements
    - – NOAA-19
    - – TMI
- Validations results show that AMSR2 1st delivery ocean EDRs meet accuracy requirements

Precipitation EDR Validation

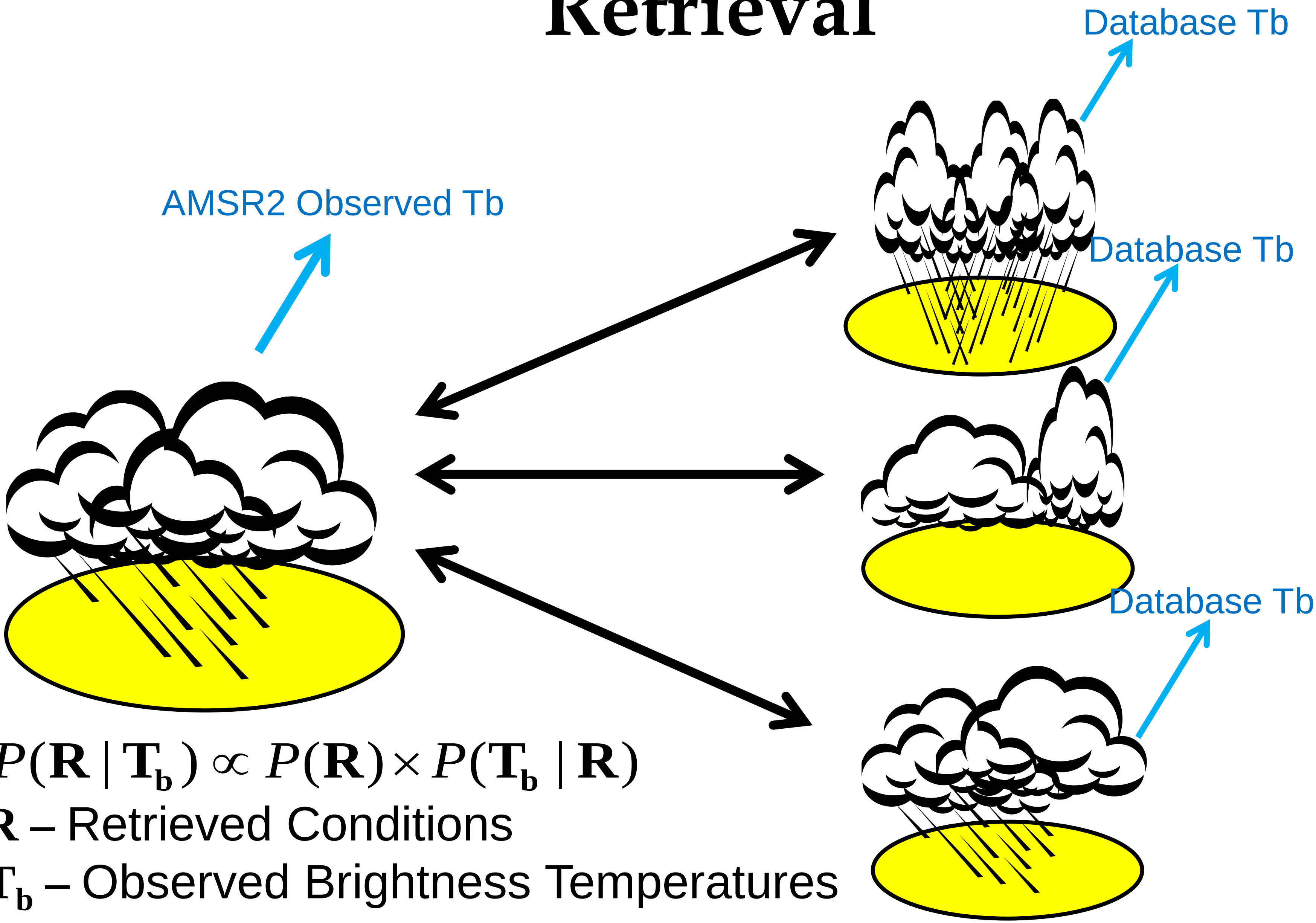
Presented by

Patrick Meyers
CICS

GPROF Structure



Ocean Segment: Bayesian Retrieval



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

$\mathbf{R}$ – Retrieved Conditions

$\mathbf{T_b}$ – Observed Brightness Temperatures

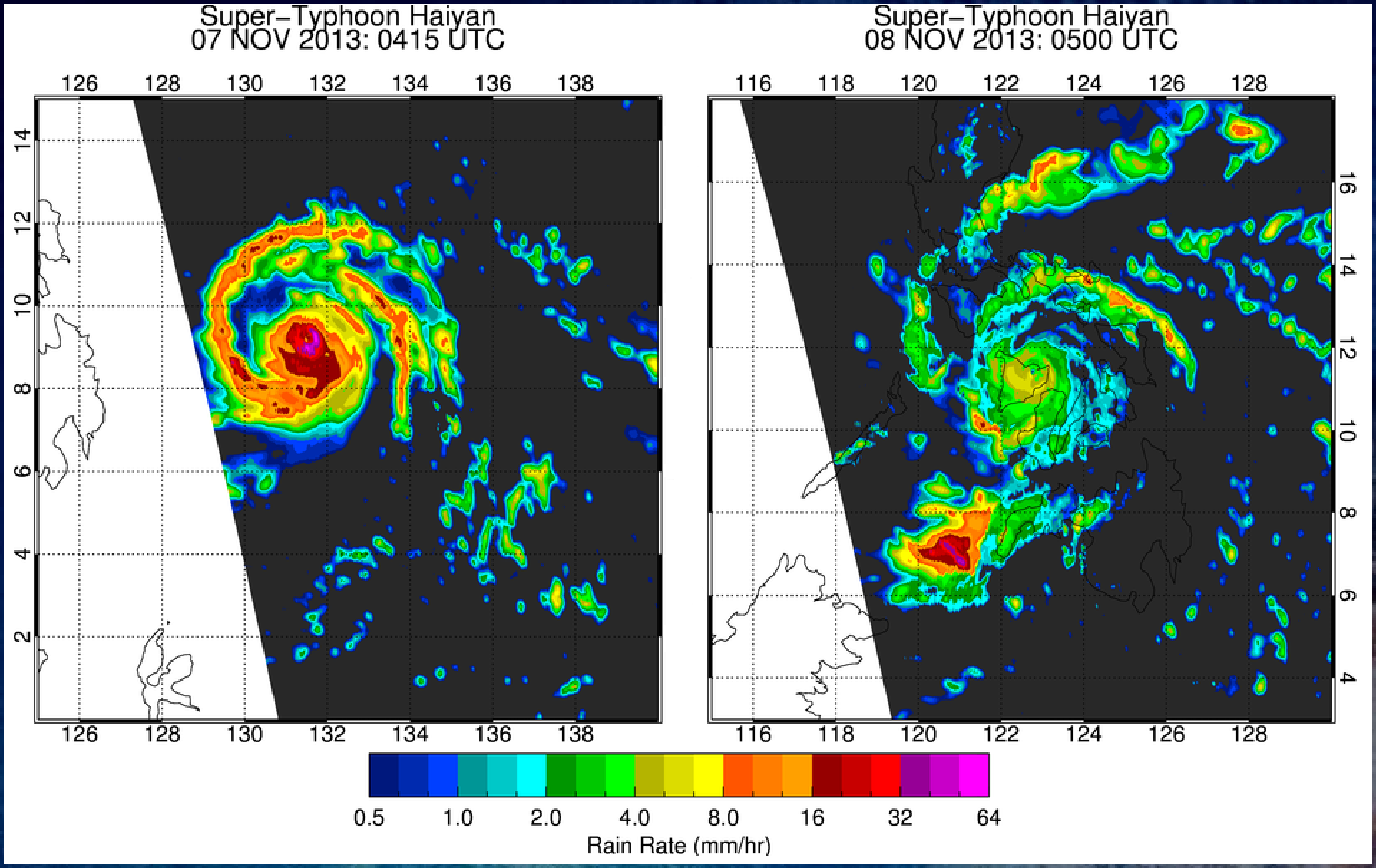
A-Priori Database

- 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.

Super-Typhoon Haiyan



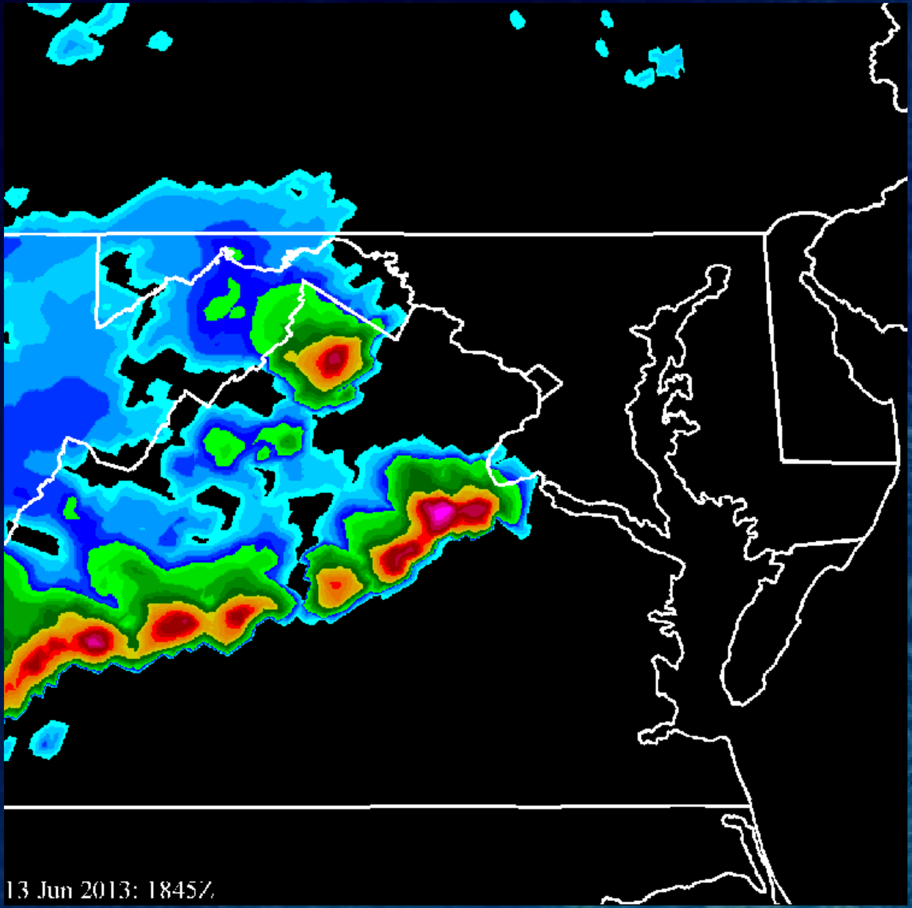
Land Segment: Semi-Empirical Calculation

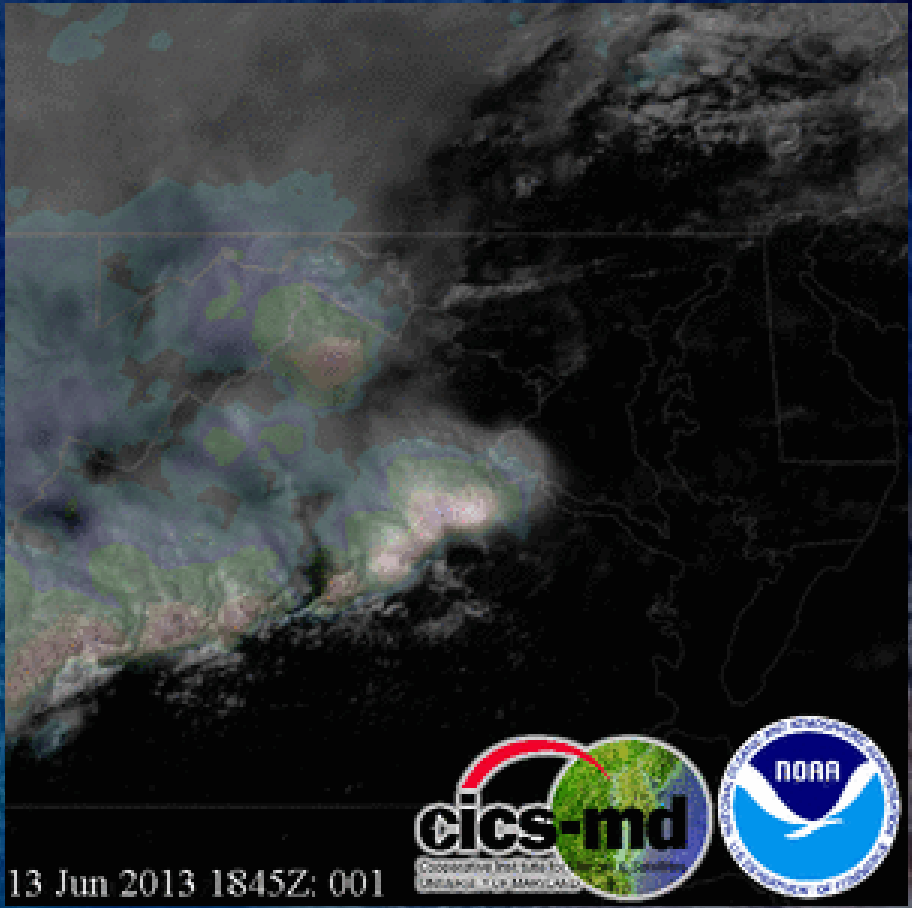
- Developed for TRMM with training dataset from PR & TMI
  - » Requires adjustment from TMI to AMSR2 frequencies
- Separated into Convective/Stratiform rain rates

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

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

Tornado Outbreak
13 June 2013



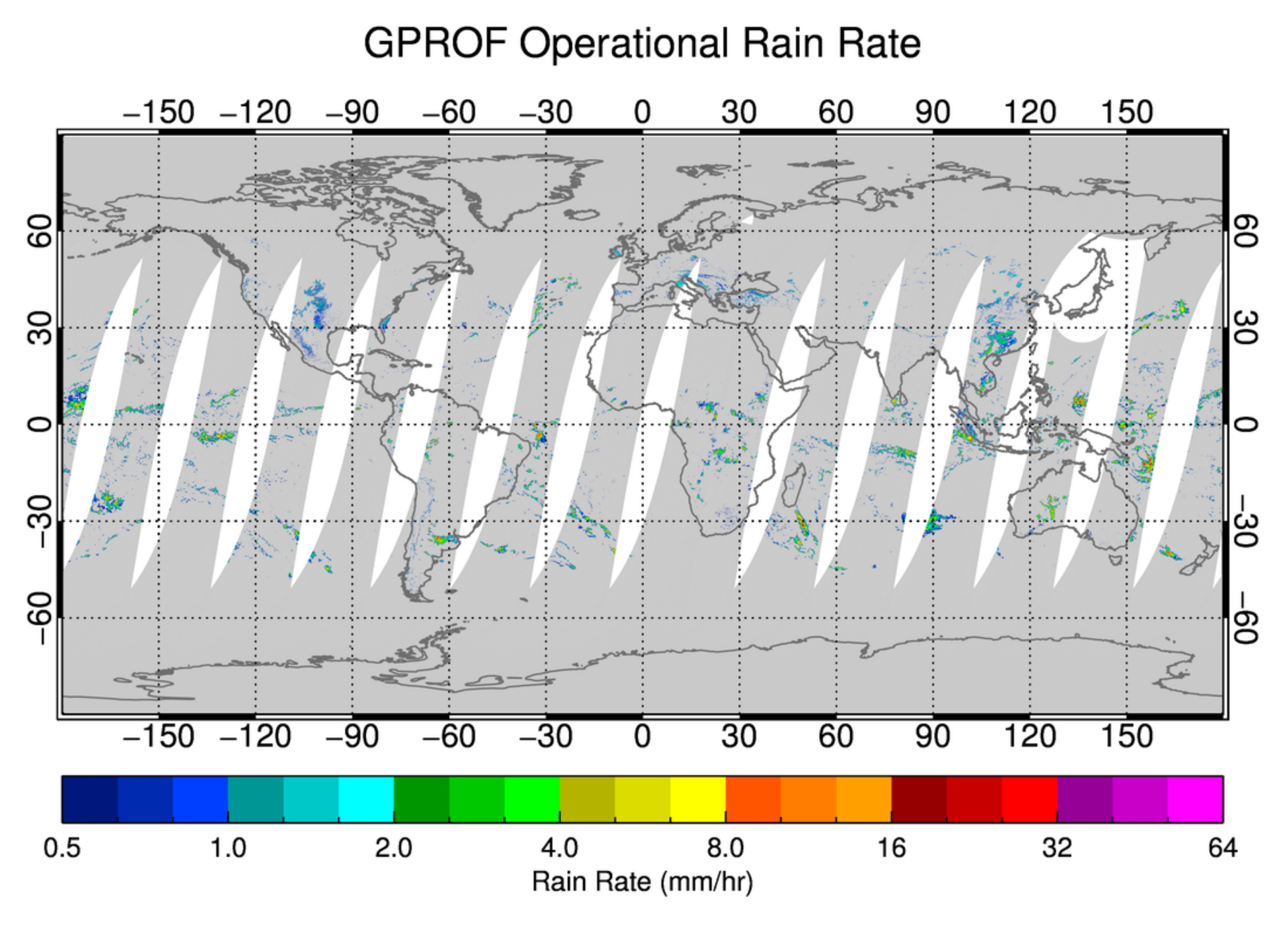


Precipitation Requirements

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
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

- 5 km sampling
  - » Land – 89 GHz FOV
  - » Ocean – 37 GHz FOV
- Precision: 0.01 mm/hr
- Measurements cover range
- Meets latency requirement
- Outputs total surface rain and convective rain rates

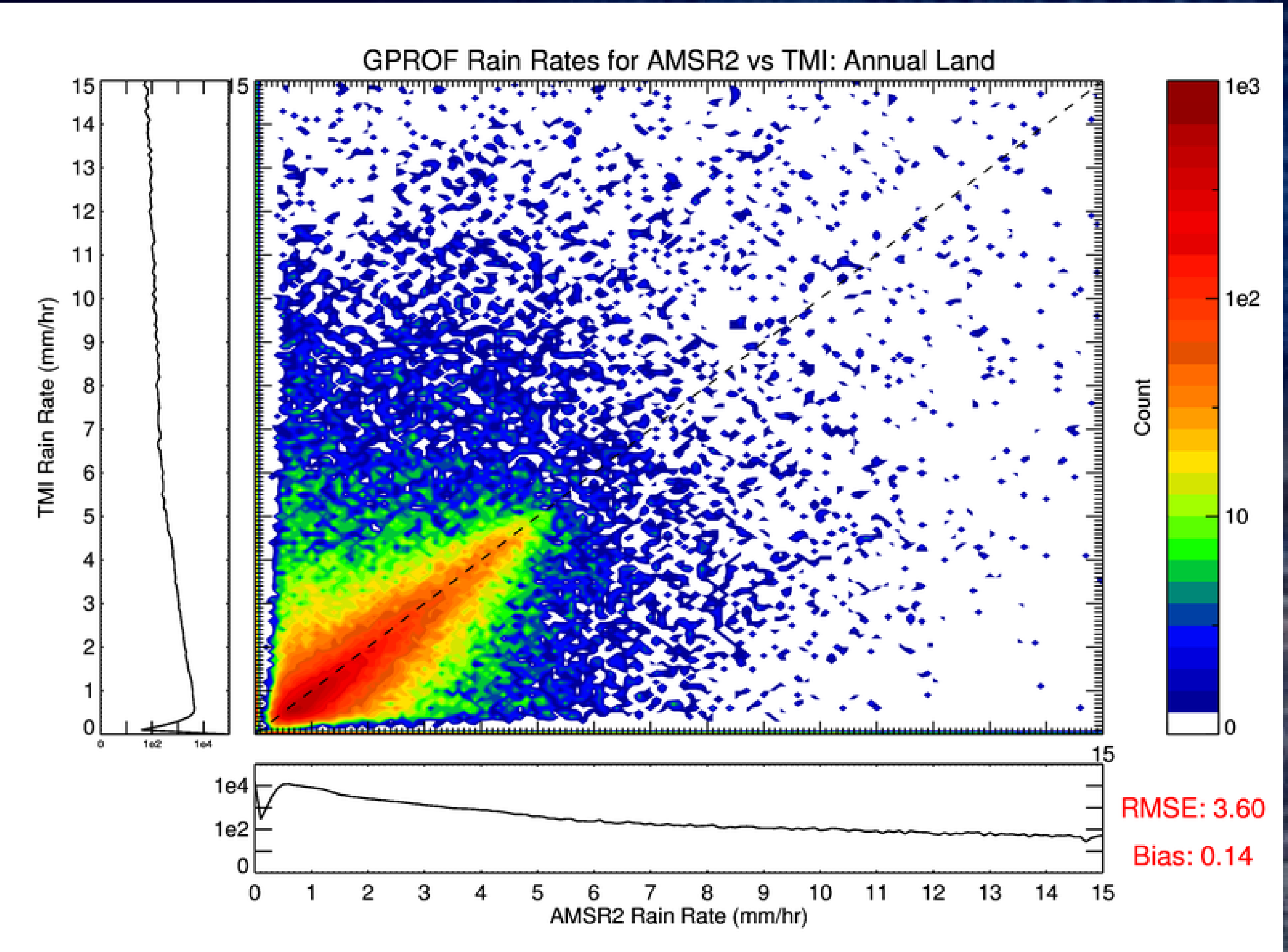
Daily Rain Rates
6 April 2014



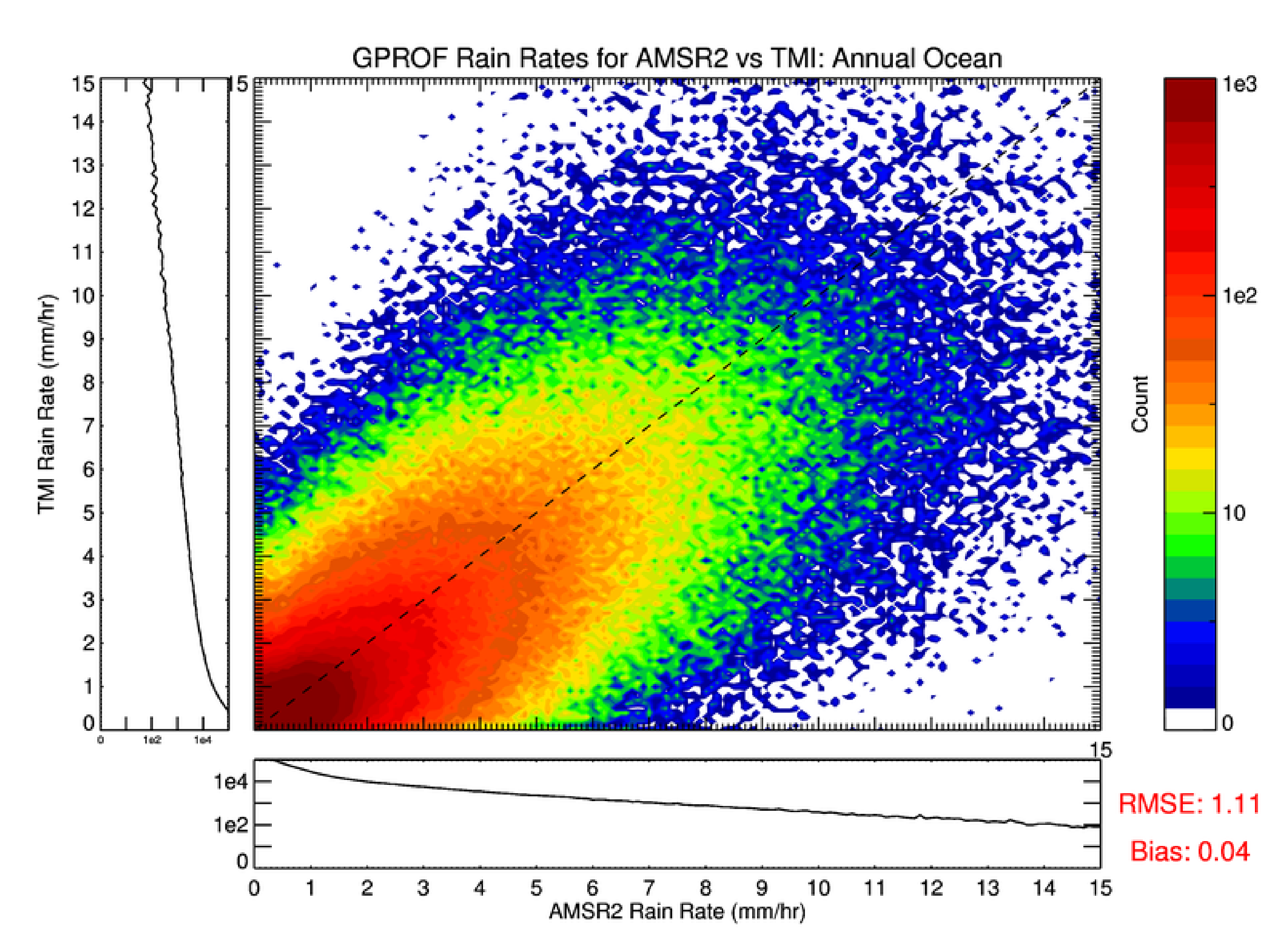
GPROF Validation with TMI

- TMI: Similar sensor; Similar algorithm
- Collocation within 30 minutes and 10 km
- High quality retrieval for both instruments
  - » Land Flags: Snow/semi-arid/arid land
  - » Ocean Flags: Non-convergence of Bayesian retrieval, low-quality SST/TPW
- Validation for Jan-Dec 2013

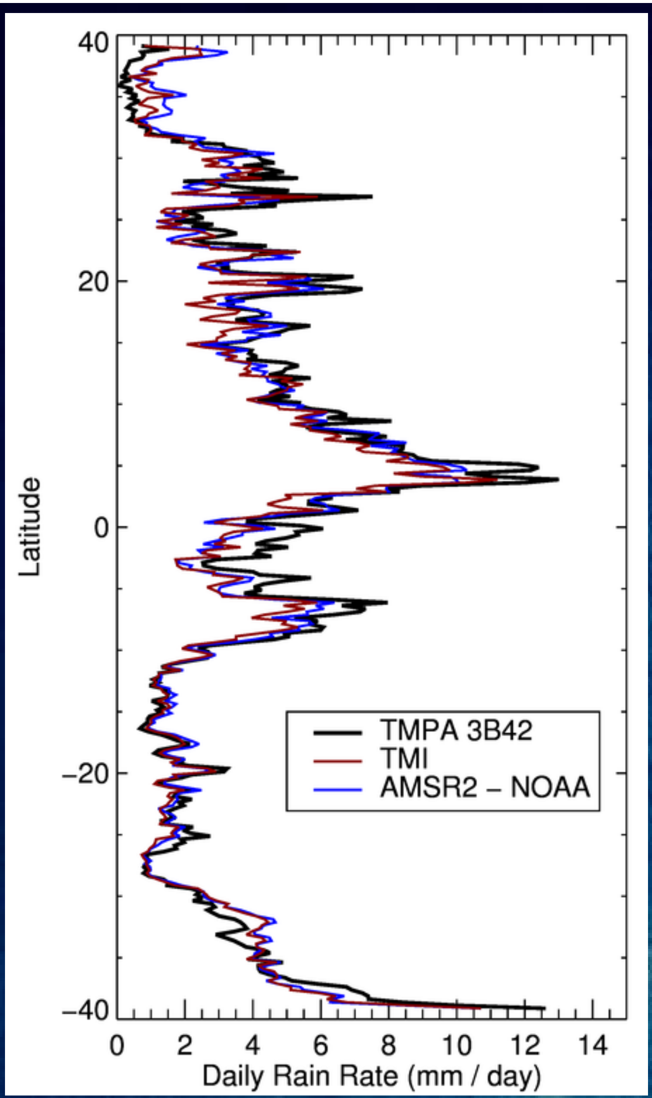
AM2/TMI Validation: Precipitation over Land



AM2/TMI Validation: Precipitation over Ocean



AMSR2 Validation with TRMM



- AMSR2 Level 2 swath retrievals
- 2A12: Level 2 TMI rain retrievals
- 3B42: Level 3 3-hr estimate from multiple satellites

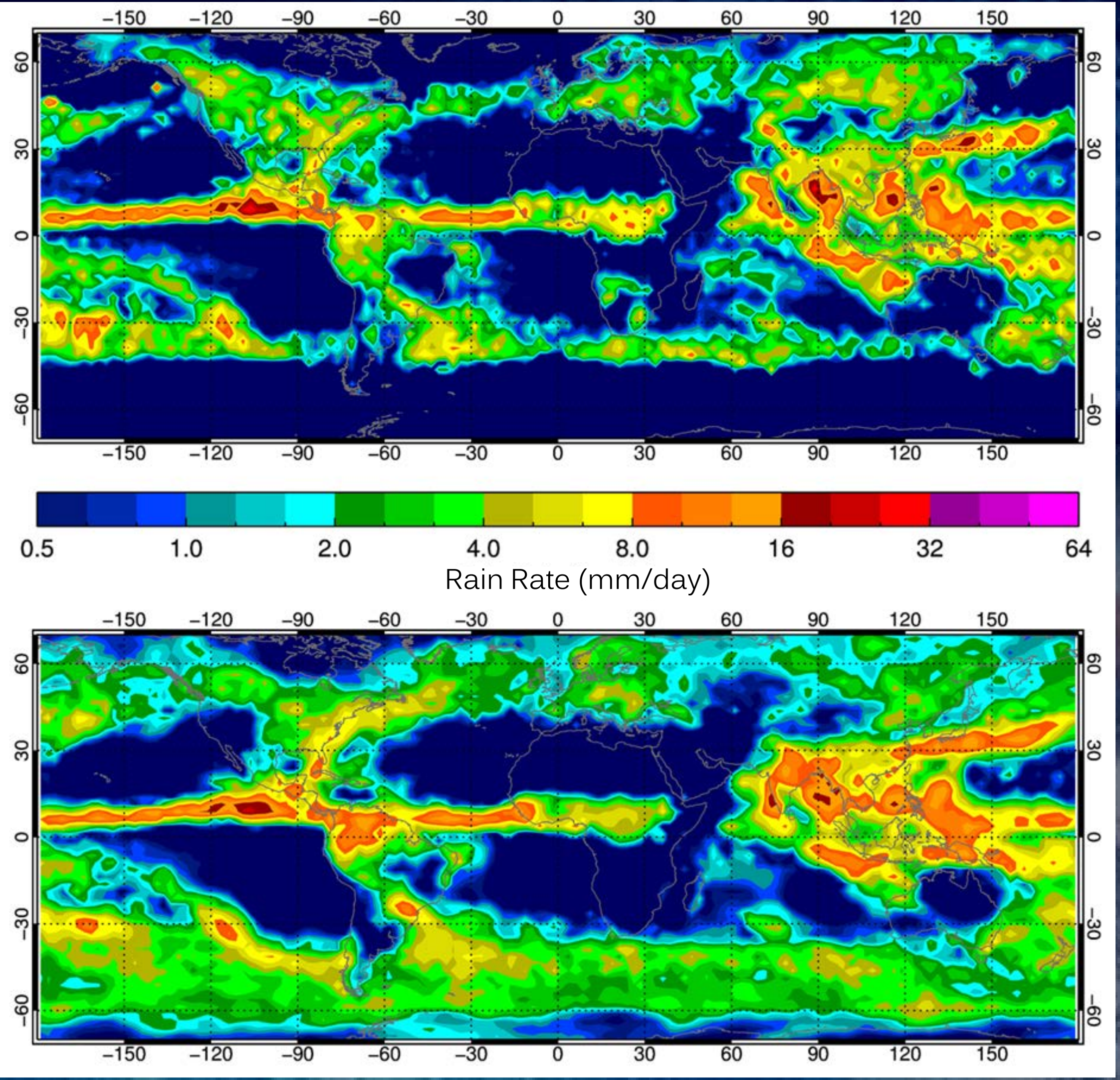
RMSD (mm/hr)	Land	Ocean	Overall
Requirements	5.0	2.0	–
TMI & TMPA	3.1	1.2	1.6
AMSR2 & TMI	3.6	1.2	1.8
AMSR2 &TMPA	3.1	1.4	1.9

GPCP Comparisons

Monthly Precipitation
June 2013

AMSR2/GPROF

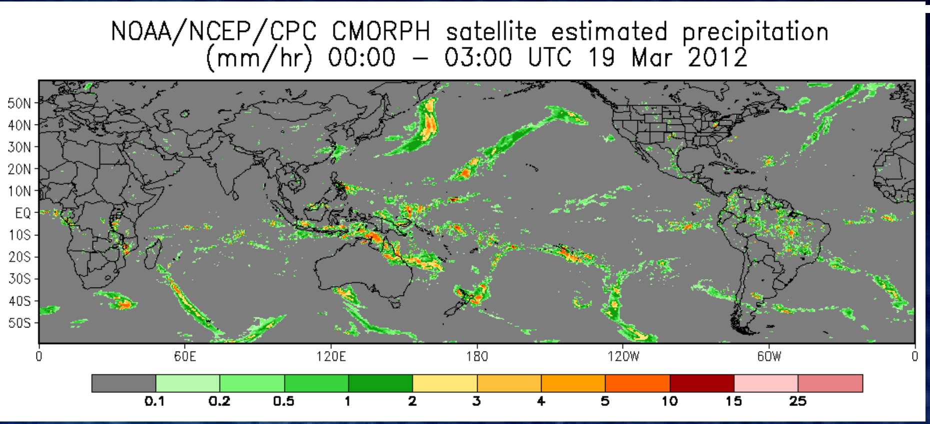
GPCP

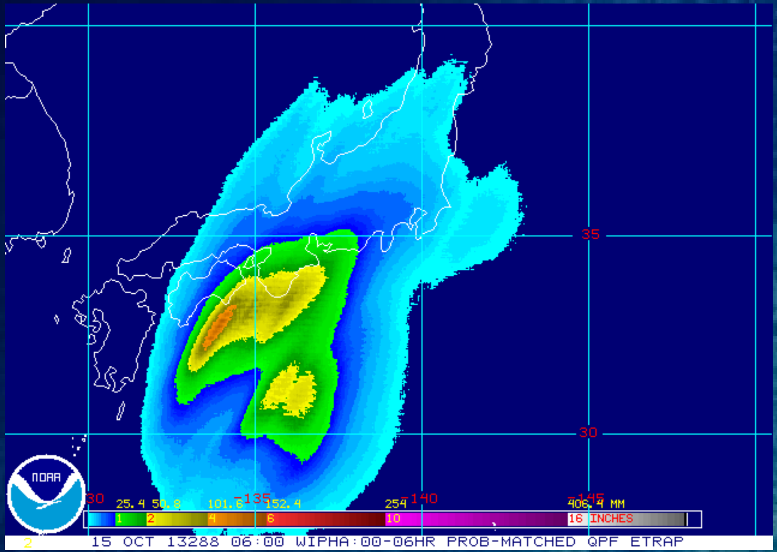


Precipitation Applications

CPC Morphing Technique (CMORPH)

- Global precipitation analysis at high spatial/temporal resolution
- Precipitation estimates from PMW propagated by geostationary IR motion vectors





Ensemble Tropical Rainfall Potential (eTRaP)

- Cumulative 6-hr rainfall estimate from an ensemble of PWM radiometers
- Produces probabilistic and deterministic forecasts of precipitation for tropical cyclones
- Typhoon Wipha – 15 Oct 2013 (left)

Unit Tests

Presented by

Letitia Soulliard
IMSG

Unit Tests

- This second section will show the remaining unit test results for those few code updates made since the CTR (8/1/2013). These cover:
  - » Email notification option
  - » Checks for age of ancillary data
  - » Metadata identifies ancillary input
  - » Units in the ocean netCDF4 were corrected
  - » Updated output file names (GAASP to AMSR2)
  - » Tests for the addition on the AMSR2 MBT BUFR generation

GAASP CTR Updates

- GAASP error e-mail notifications should be optional
  - » New entry in PCF file.
  - » EMAIL_ERROR_FLAG=YES
- Ocean netCDF EDR is still created even if Precip EDR fails.
  - » GAASP_Postprocessor.pl checks only if GAASP_Ocean.pl ran correctly, doesn't check for if GAASP_Precipitation.pl ran correctly.
  - » If gprof.h5 doesn't exist, it will skip trying to add it to the Ocean netCDF file.

```
if ( !-e $gprof_h5 ) {
   $error->error_check("", "GPROF output does not exist, so it won't be added".
      " to the OCEAN netCDF file.","WARNING");
    last;
}
```

GAASP CTR Updates

- Provide checks that the ancillary data is not too old.
  - » Ocean code will still run, just with out using the file.

```
my $file_age =  file_age($seaice_filename,"seaice.t00z.5min.grb.grib2.YYYYMMDD.nc",
   @processing_date);
if ( $file_age eq "" || $file_age > 14 ) {
   my $seaice_file = "NONE";
}
```

  - » Precipitation code will return a fatal error message.

```
my $file_age = file_age($sst_filename,"avhrr-only-v2.YYYYMMDD", @processing_date);
if ( $file_age eq "" || $file_age > 14 ) {
   $error->error_check("","SST file is too old, not running precip algorithm.",
      "FATAL",1);
}
```

- Metadata contains ancillary file information

```
:source = "GW1AM2_201403091806_128D_L1DLBTBR_0000000.h5, seaice.t00z.5min.grb.grib2.20140309.nc,
gfs.t18z.pgrb2f00.20140309, avhrr-only-v2.20140309" ;
```

GAASP CTR Updates

- Units in Ocean netCDF file have been updated

```
Time:units = "GMT" ;
Lat:units = "deg" ;
Long:units = "deg" ;
Scan_Angle:units = "deg" ;
Earth_Inc:units = "deg" ;
Compas:units = "deg" ;
Across_Scan:units = "" ;
Along_Scan:units = "" ;
SDR_QC:units = "" ;
SST:units = "Celsius" ;
wspd:units = "m/s" ;
wv:units = "mm" ;
clw:units = "mm" ;
Rain_Rate:units = "mm/hr" ;
RR_Err:units = "" ;
EDR_QC_Flag:units = "" ;
Model_wdir:units = "Degrees" ;
Model_sst:units = "Kelvin" ;
Model_mask:units = "" ;
```

GAASP CTR Updates

- Output filenames changed from GAASP to AMSR2
  - » Also updated the seconds place to include tenths of seconds

```
AMSR2-MBT-LR_v1r0_GW1_s201303112359590_e201303120008580_c201307221919120.bufr
AMSR2-MBT-89A_v1r0_GW1_s201303112359590_e201303120008580_c201307221919150.bufr
AMSR2-MBT-89B_v1r0_GW1_s201303112359590_e201303120008580_c201307221919180.bufr
AMSR2-MBT_v1r0_GW1_s201303112359590_e201303120008580_c201307221919440.nc
AMSR2-PRECIP_v1r0_GW1_s201303112359590_e201303120008580_c20130722191950.nc
AMSR2-OCEAN_v1r0_GW1_s201303112359590_e201303120008580_c201307221920090.nc
```

Test Sequence/Results

- AMSR2 Microwave Brightness Temperature BUFR file can be produced successfully. Here is output of the toolkit run at 10:01 on March 14 2014:

```
rhs8142(ysong):/net/orbit247l/disk1/pub/ysong/intel/AMSR2/run>ls -lrt
total 9048
-rw-r--r--. 1 ysong orbit    7291 Dec  6 12:25 AMSR2_1B_BUFR_Table
-rw-r--r--. 1 ysong orbit 9234984 Dec  6 12:26 GW1AM2_201303112359_179D_L1DLBTBR_0000000.h5
-rw-r--r--. 1 ysong orbit     221 Dec 16 22:08 NPR.pl.PCF
rhs8142(ysong):/net/orbit247l/disk1/pub/ysong/intel/AMSR2/run>perl ../NPR.pl
rhs8142(ysong):/net/orbit247l/disk1/pub/ysong/intel/AMSR2/run>ls -lrt
total 19132
-rw-r--r--. 1 ysong orbit    7291 Dec  6 12:25 AMSR2_1B_BUFR_Table
-rw-r--r--. 1 ysong orbit 9234984 Dec  6 12:26 GW1AM2_201303112359_179D_L1DLBTBR_0000000.h5
-rw-r--r--. 1 ysong orbit     221 Dec 16 22:08 NPR.pl.PCF
-rw-r--r--. 1 ysong orbit     341 Mar 14 10:01 npr.filenames
-rw-r--r--. 1 ysong orbit 3547400 Mar 14 10:01 AMSR2-MBT-LR_v1r0_GW1_s201303112359597_e201303120008581_c201403141401310.bufr
-rw-r--r--. 1 ysong orbit 3364272 Mar 14 10:01 AMSR2-MBT-
89A_v1r0_GW1_s201303112359597_e201303120008581_c201403141401310.bufr
-rw-r--r--. 1 ysong orbit     236 Mar 14 10:01 NPR.pl.PSF
-rw-r--r--. 1 ysong orbit    3572 Mar 14 10:01 NPR.pl.log
-rw-r--r--. 1 ysong orbit 3381672 Mar 14 10:01 AMSR2-MBT-
89B_v1r0_GW1_s201303112359597_e201303120008581_c201403141401310.bufr
rhs8142(ysong):/net/orbit247l/disk1/pub/ysong/intel/AMSR2/run>cat NPR.pl.PSF
AMSR2-MBT-LR_v1r0_GW1_s201303112359597_e201303120008581_c201403141401310.bufr
AMSR2-MBT-89A_v1r0_GW1_s201303112359597_e201303120008581_c201403141401310.bufr
AMSR2-MBT-89B_v1r0_GW1_s201303112359597_e201303120008581_c201403141401310.bufr
rhs8142(ysong):/net/orbit247l/disk1/pub/ysong/intel/AMSR2/run>
```

Test Sequence/Results

- Dumped the contents of the log file (NPR.pl.log) to show that everything ran correctly. There were no errors in the script itself, any of the system calls, the main program, its subroutines and BUFR library calls. This log file contains the starting and ending times indicating that everything completed within 9 second of clock time. The CPU time for the main program is 7.38 seconds for one 9-minute granule of AMSR2 Microwave Brightness Temperature data.

```
 Starting at Fri Mar 14 10:01:31 EDT 2014
 main_npr is now starting.
 Starting AMSR2_1B_hdf5_to_bufr
ORBN=        4345
 ++++++++++++++BUFR ARCHIVE LIBRARY+++++++++++++++++
 BUFRLIB: MAXOUT - THE RECORD LENGTH OF ALL BUFR MESSAGES CREATED FROM THIS POINT ON IS BEING
CHANGED FROM   10000 TO   50000
 ++++++++++++++BUFR ARCHIVE LIBRARY+++++++++++++++++
 LEAPSECONDS=           8  Seconds
Finishing AMSR2_1b_write_bufr
 Finishing AMSR2_89A_write_bufr
 Finishing AMSR2_89B_write_bufr
 Finishing AMSR2_1B_hdf5_to_bufr
 main_npr is now finished.
 CPU time for the whole program is:   7.37587900000000 Seconds
Ending at Fri Mar 14 10:01:40 EDT 2014
```

Test Sequence/Results

- The AMSR2 Microwave Brightness Temperature BUFR file can be decoded to verify the original encoding.
  - » This shows selected parts of the AMSR2 MBT BUFR file that are decoded with NCEP BUFR library.

005041	SLNM	1.0 NUMERIC	Scan line number
005043	FOVN	1.0 NUMERIC	Field of view number
005001	CLATH	33.77758 DEGREE	Latitude (high accuracy)
006001	CLONH	19.62402 DEGREE	Longitude (high accuracy)
005022	SOLAZI	229.27 DEGREE TRUE	Solar azimuth
007022	SOEL	90.64 DEGREE	Solar elevation
025081	IANG	54.960 DEGREE	Incidence angle
025082	AANG	80.490 DEGREE	Azimuth angle
033032	ACQF	131072.0 FLAG TABLE(7)	Channel quality flags for ATOVS
002141	MTYP	NORMAL (6)CCITT IA5	Measurement type
++++++ AMSRCH REPLICATION # 7 ++++++			
002153	SCCF	18700000000.0 HZ	Satellite channel center frequency
021166	ALFR	1.000 NUMERIC	Land fraction
033083	VIIRSQ	0.0 FLAG TABLE	Radiance data quality flags
002104	ANPO	0.0 CODE TABLE	Antenna polarization
012163	TMBR	112.19 K	Brightness temperature (high accuracy)
++++++ AMSRCH REPLICATION # 8 ++++++			
002153	SCCF	18700000000.0 HZ	Satellite channel center frequency
021166	ALFR	1.000 NUMERIC	Land fraction
033083	VIIRSQ	0.0 FLAG TABLE	Radiance data quality flags
002104	ANPO	1.0 CODE TABLE	Antenna polarization
012163	TMBR	191.35 K	Brightness temperature (high accuracy)

Test Sequence/Results

» Part of AMSR2 Microwave Brightness Temperature in the original HDF5 file.

```
DATASET "Latitude of Observation Point for 89A" {
    DATATYPE  H5T_IEEE_F32LE
    DATASPACE  SIMPLE { ( 360, 486 ) / ( 360, 486 ) }
    DATA {
    (0,0): 33.7776, 33.738, 33.6978, 33.6577, 33.6176, 33.5775, 33.5375,
DATASET "Longitude of Observation Point for 89A" {
    DATATYPE  H5T_IEEE_F32LE
    DATASPACE  SIMPLE { ( 360, 486 ) / ( 360, 486 ) }
    DATA {
    (0,0): 19.624, 19.6324, 19.6411, 19.6501, 19.6594, 19.6689, 19.6786,
DATASET "Sun Elevation" {
    DATATYPE  H5T_STD_I16LE
    DATASPACE  SIMPLE { ( 360, 243 ) / ( 360, 243 ) }
    DATA {
    (0,0): 9064, 9070, 9077, 9083, 9089, 9095, 9101, 9107, 9113, 9119,
DATASET "Brightness Temperature (18.7GHz,H)" {
    DATATYPE  H5T_STD_U16LE
    DATASPACE  SIMPLE { ( 360, 243 ) / ( 360, 243 ) }
    DATA {
    (0,0): 11219, 11177, 11145, 11230, 11261, 11272, 11335, 11272, 11325,
DATASET "Brightness Temperature (18.7GHz,V)" {
    DATATYPE  H5T_STD_U16LE
    DATASPACE  SIMPLE { ( 360, 243 ) / ( 360, 243 ) }
    DATA {
    (0,0): 19135, 19156, 19196, 19094, 19176, 19135, 19206, 19176, 19237,
```

Test Sequence/Results

- The AMSR2 MBT BUFR file can also be read with the ECMWF BUFR library and is therefore readable among other user communities.
  - » This output shows the same message as before, but read from the using the ECMWF BUFR library.

```
    13 SCAN LINE NUMBER                 0.10000000000000E+001 NUMERIC
    14 FIELD OF VIEW NUMBER             0.10000000000000E+001 NUMERIC
    15 LATITUDE (HIGH ACCURACY)         0.33777580000000E+002 DEGREE
    16 LONGITUDE (HIGH ACCURACY)        0.19624020000000E+002 DEGREE
    17 SOLAR AZIMUTH                    0.22927000000000E+003 DEGREE TRUE
    18 SOLAR ELEVATION                  0.90640000000000E+002 DEGREE
    19 INCIDENCE ANGLE                  0.54960000000000E+002 DEGREE
    20 AZIMUTH ANGLE                    0.80490000000000E+002 DEGREE
    54 SATELLITE CHANNEL CENTRE FREQUEN  0.18700000000000E+011 Hz
    55 LAND FRACTION                    0.10000000000000E+001 NUMERIC
 Could not find  33083
    56 RADIANCE DATA QUALITY FLAGS      0.00000000000000E+000 FLAG TABLE 33083
    57 ANTENNA POLARISATION             0.00000000000000E+000 CODE TABLE 2104
CODE ENTRY NOT KNOWN
    58 BRIGHTNESS TEMPERATURE           0.11219000000000E+003 K
    59 SATELLITE CHANNEL CENTRE FREQUEN  0.18700000000000E+011 Hz
    60 LAND FRACTION                    0.10000000000000E+001 NUMERIC
 Could not find  33083
    61 RADIANCE DATA QUALITY FLAGS      0.00000000000000E+000 FLAG TABLE 33083
    62 ANTENNA POLARISATION             0.10000000000000E+001 CODE TABLE 2104
CODE ENTRY NOT KNOWN
    63 BRIGHTNESS TEMPERATURE           0.19135000000000E+003 K
```

Final GAASP DAP Checklist

- The final Day 1 DAP will be:
  ftp://ftp2.star.nesdis.noaa.gov/smcd/letitias/GCOM/GAASP_v1-0-20140410.tar.gz

- The package contains:
  - » Code
    - – GAASP code
    - – BUFR Toolkit
  - » Documentation:
    - – README
    - – SMM, EUM, ATBD documents
    - – PDR, CDR, CTR, and ARR slide packages
  - » Data
    - – Sample data
    - – Static ancillary data

GAASP Code Details

Language	GCOM	N4RT	Total
Fortran 90	66487	6927	73414
Fortran 77	0	30792	30792
C	0	1509	1509
Perl	2228	785	3013

Review Outline

- Introduction
- CTR Report
- Requirements
- Software Architecture
- Validation
- Risks and Actions
- Summary and Conclusions

Risks and Actions

Presented by

Tom King
IMSG

Open Risks

- **Risk #3:** ESPDS SOW is not clear about who handles the NCDC/CLASS 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:**
    - – There are currently no archive requirements assigned to GAASP. If this changes the project will have to evaluate the work load and may need to ask for additional resources. It's worth noting that Eileen Maturi already has an agreement to archive AMSR2 SST to NODC (in netCDF4) and the JPL DAAC in GHRSST netCDF4.
- **Status:** Open

Open Risks

- **Risk #8:** Brightness temperature calibration issues. This will hinder development of high quality EDRs.
  - » **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

- **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

Open Risks

- **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

- **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.
  - » **Risk Mitigation:**
    - – Work with NJO to update GCOM product requirements.
- **Status:** Open

New Risk

- **Risk #21:** FY14 funding is not yet available from NJO. This may cause schedule delays, particularly for Day 2 product development and delivery.
  - » **Assessment:** Medium
  - » **Risk Mitigation:**
    - – Work with NJO, STAR management, and the contracting office to expedite the transfer of money to the contract.
- **Status:** Open

Risk Summary

- 6 Risks Total
  - » 5 Old Risks
  - » 1 New Risks

- Old Risks:
  - » 3 Medium
  - » 2 Low

- New Risk:
  - » 1 medium

Review Outline

- Introduction
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Summary and Conclusions

Presented by

Paul Chang
NOAA/NESDIS/STAR

Review Objectives Have Been Addressed

- The following have been reviewed
  - » Project Requirements
  - » Software Architecture
  - » Validation
  - » Risks and Actions

Next Steps for GAASP

- Gather reviewer feedback, make necessary updates to the ARR and the Review Item Disposition, and make these updates available to the review team.
- Assist OSPO with any transition to operations issues.
- Continue working to identify stakeholder needs to finalize Day 2 product requirements.
- Continue risk mitigation activities.

Next Steps for GAASP

- Continue Day 2 product development.
- Update bias corrections associated with JAXA code updates.

Open Discussion

- The review is now open for free discussion

Acronyms

AFWA	Air Force Weather Agency
AMSR2	Advanced Microwave Scanning Radiometer 2
AMSR-E	Advanced Microwave Scanning Radiometer – Earth Observing System
AMSU	Advanced Microwave Sounder Unit
APID	Application Package IDentifier
ARR	Algorithm Readiness Review
ASCII	American Standard Code for Information Interchange
ASD	APID Sorted Data
ASI	Arctic Sea Ice
ATBD	Algorithm Theoretical Basis Document
BT	Bootstrap
BUFR	Binary Universal Form for the Representation of meteorological data
CDR	Critical Design Review
CICS	Cooperative Institute for Climate and Satellites
CIRES	Cooperative Institute for Research in Environmental Sciences
CLASS	Comprehensive Large Array-data Stewardship System
CLW	Cloud Liquid Water

Acronyms

CM	Configuration Management
CMC	Canadian Meteorological Center
COSMOS	COsmic-ray Soil Moisture Observing System
CPC	Climate Prediction Center
CPU	Central Processing Unit
CRTM	Community Radiative Transfer Model
CTR	Code Test Review
DAP	Delivered Algorithm Package
DDS	Data Distribution Server
DPCA	Double Principal Components Analysis
ECMWF	European Center for Medium-Range Weather Forecasts
EDR	Environmental Data Record
EIA	Earth Incidence Angle
EMC	Environmental Modeling Center
EPL	Enterprise Product Lifecycle
ESPC	Environmental Satellite Processing Center
ESPDS	Environmental Satellite Processing and Distribution Services
ESRL	Earth System Research Laboratory

Acronyms

EUM	External Users Manual
EUMETSAT	European Organization for the Exploitation Meteorological Satellites
FNMOC	Fleet Numerical Meteorology and Oceanography Center
FOV	Field of View
GAASP	GCOM-W1 AMSR2 Algorithm Software Processor
GB	Gigabyte
GCOM	Global Change Observation Mission
GDAS	Global Data Assimilation System
GEOSS	Global Earth Observation System of Systems
GFS	Global Forecast System
GHRSST	Group for High Resolution Sea Surface Temperature
GMAO	Global Modeling and Assimilation Office
GMT	Greenwich Mean Time
GPDS	GCOM-W1 Processing and Distribution System
GPROF	Goddard Profiling algorithm
GRIB	Gridded Binary format
GRIB2	Gridded Binary format (version 2)

Acronyms

HCS	Horizontal Cell Size
IASI	Infrared Atmospheric Sounding Interferometer
IDPS	Interface Data Processing Segment
IGBP	International Geosphere-Biosphere Programme
IMS	Interactive Multisensor Snow and Ice Mapping System
IPT	Integrated Product Team
JAXA	Japan Aerospace Exploration Agency
JCSDA	Joint Center for Satellite Data Assimilation
JPSS	Joint Polar Satellite System
KSAT	Kongsberg Satellite Services
MBT	Microwave Brightness Temperature
MIRS	Microwave Integrated Retrieval System
MMAB	Marine Modeling and Analysis Branch
MODIS	Moderate-resolution Imaging Spectroradiometer
N4RT	NetCDF4 Reformatting Toolkit
NDE	NPOESS Data Exploitation

Acronyms

NDVI	Normalized Difference Vegetation Index
NGDC	National Geophysical Data Center
NCDC	National Climate Data Center
NCEP	National Center for Environmental Prediction
NESDIS	National Environmental Satellite, Data, and Information Service
netCDF4	network Common Data Format version 4
NHC	National Hurricane Center
NIC	National Ice Center
NJO	NOAA JPSS Office
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NRL	Naval Research Lab
NRT	Near Real-Time
NSIDC	National Snow and Ice Data Center
NSOF	NOAA Satellite Operations Facility
NT2	NASA Team 2

Acronyms

NUCAPS	NOAA Unique CrIS/ATMS Product System
NWP	Numerical Weather Prediction
NWS	National Weather Service
NWSFO	National Weather Service Forecast Office
OAR	Office of Oceanic and Atmospheric Research
OSD	Office of Systems Development
OSPO	Office of Satellite and Product Operations
OSTIA	Operational Sea Surface Temperature and Sea Ice Analysis
PCF	Production Control File
PDF	Probability Density Function
PDR	Preliminary Design Review
PSF	Production Status File
PT/R	Precipitation Type/Rate
QA	Quality Assurance
QC	Quality Control
RAD	Requirements Allocation Document

Acronyms

RDR	Raw Data Record
RFI	Radio Frequency Interference
RID	Review Item Disposition
RSS	Remote Sensing Systems
RTM	Radiative Transfer Model
SA	Submission Agreement
SAB	Satellite Analysis Branch
SAN	Storage Area Network
SAR	Synthetic Aperture Radar
SCAN	Soil Climate Analysis Network
SC/D	Snow Cover/Depth
SCR	Software Code Review
SDR	Sensor Data Record
SIC	Sea Ice Characterization
SM	Soil Moisture

Acronyms

SMCD	Satellite Meteorology and Climate Division
SMM	System Maintenance Manual
SMOPS	Soil Moisture Operational Products System
SOW	Statement of Work
SPSRB	Satellite Products and Services Review Board
SSMI	Special Sensor Microwave/Imager
SSMI/S	Special Sensor Microwave Imager/Sounder
SSS	Sea Surface Salinity
SST	Sea Surface Temperature
SSW	Sea Surface Winds
STAR	Center for Satellite Applications and Research
SWE	Snow Water Equivalent
Tb	Temperature brightness
TB	Terabyte
TBD	To Be Determined
TMI	TRMM Microwave Imager
TPW	Total Precipitable Water

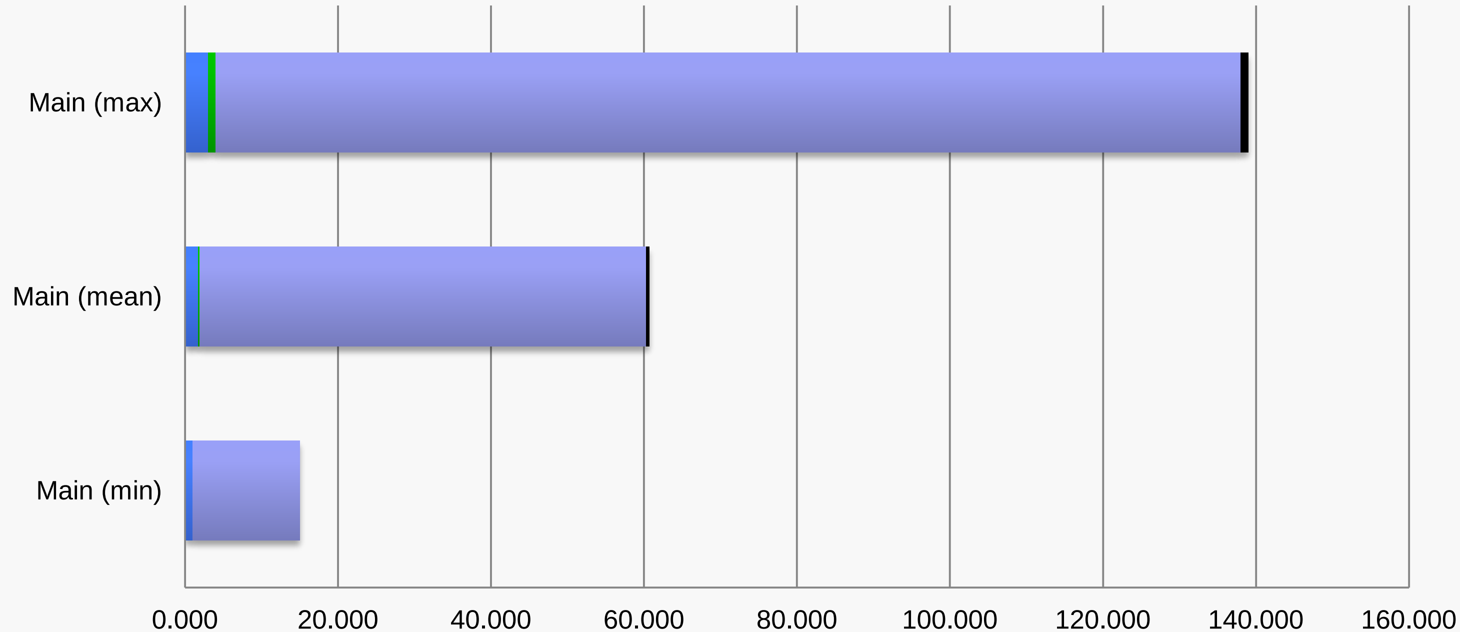
Acronyms

TRMM	Tropical Rainfall Measuring Mission
UCAR	University Corporation for Atmospheric Research
USCRN	U.S. Climate Reference Network
UTC	Universal Time Coordinated
VIIRS	Visible Infrared Imager Radiometer Suite
V & V	Validation and Verification
WMO	World Meteorological Organization
WSPD	Wind Speed

Backup Slides

Latency - Test Sequence/Results

GAASP_Main.pl



	Main (min)	Main (mean)	Main (max)
Preprocessor	1.000	1.727	3.000
Ocean	0.000	0.174	1.000
Precipitation	14.000	58.416	134.000
Postprocessor	0.000	0.373	1.000