NOAA GCOM-W1 PROJECT

Global Change Observation Mission 1st – Water “SHIZUKU” (GCOM-W1)

STAR GCOM-W1/AMSR2 Product Development and Validation Project

Presented by Paul S. Chang

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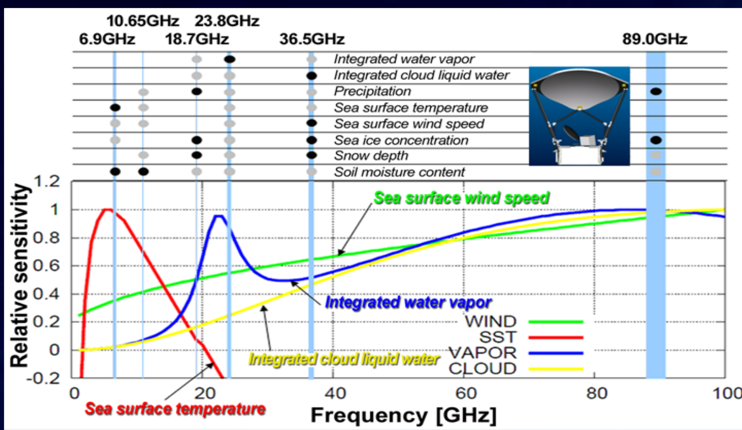
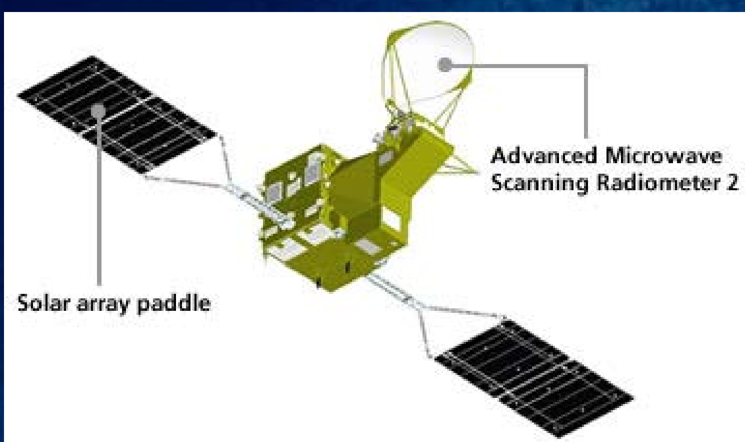
GCOM-W1 AMSR2





- The "Global Change Observation Mission" (GCOM) was envisioned as a series of JAXA Earth observation missions spanning 10-15 years.
- GCOM is part of Japan’s contribution to GEOSS (Global Earth Observation System of Systems)
- The GCOM program is comprised of two series of satellites:
  - » GCOM-W for water cycle observations
  - » GCOM-C for climate observations
- The GCOM-W1 as launched at 1:39am (JST) on May 18, 2012 and is the first satellite in the GCOM-W series.
- GCOM-W1 is part of the “A-Train” in a sun-synchronous orbit (~700 km altitude) with an ascending node equator crossing time of 13:30 UTC providing continuity of AMSRE

NOAA GCOM-W1 Project Responsibilities

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 will 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.

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.

STAR GAASP Development
(Four Planned Deliveries)

Delivery 1:

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

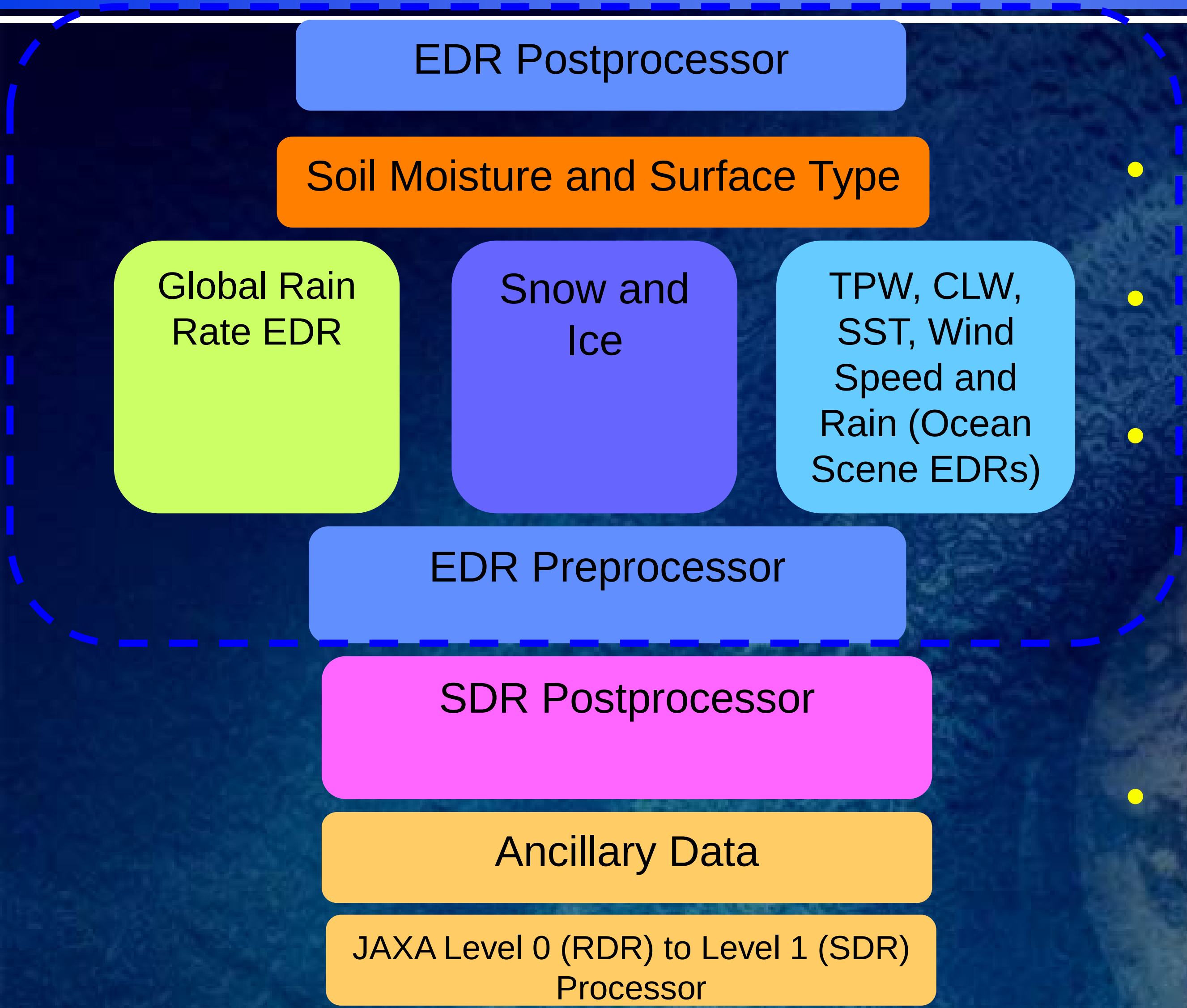
Delivery 2

- Day 2 GAASP Product Capability
  - Soil Moisture (SM)
  - Snow Cover/Depth (SC/D)
  - Sea Ice Characterization (SIC)
  - Snow Water Equivalent (SWE)
- Updated GAASP netCDF4 Reformatting Capability
- Updated SPSRB Documentation

Delivery 3 and 4

- Updates and enhancements to existing EDRs

NOAA AMSR-2 Processor Modular Approach



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

AMSR2 On Orbit Calibration

- Well calibrated AMSR2 Tbs significantly improve the performance and accuracy of geophysical retrieval algorithms
  - » Identifying and correcting residual calibration biases in AMSR2 Tbs reduce retrievals errors

Double difference analysis utilized to characterize the brightness temperature performance

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

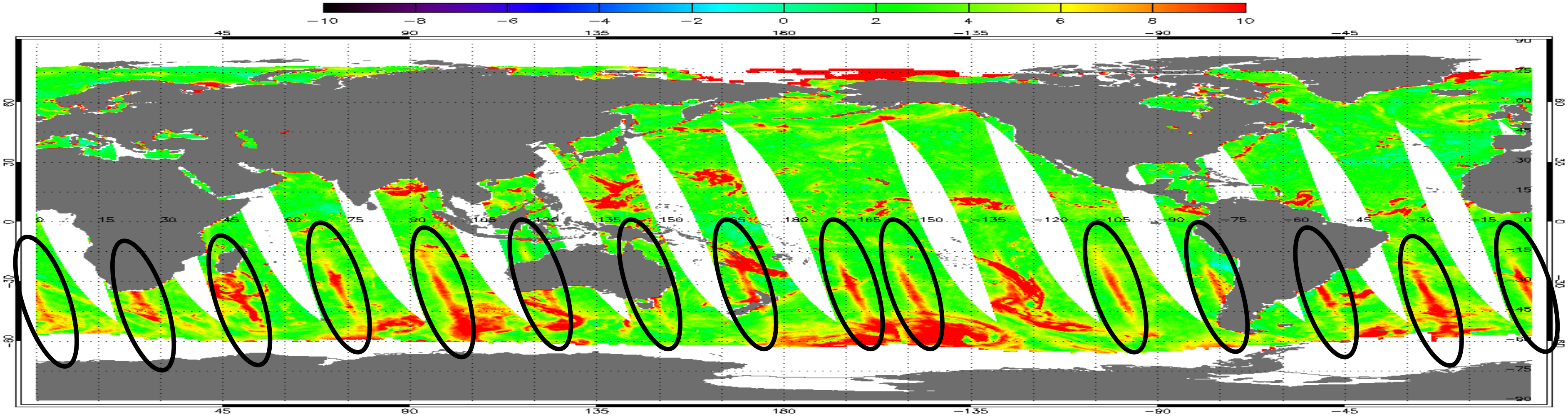
Bad pixels excluded

Rain & clouds using TMI EDR maps (Remote Sensing Sys.)

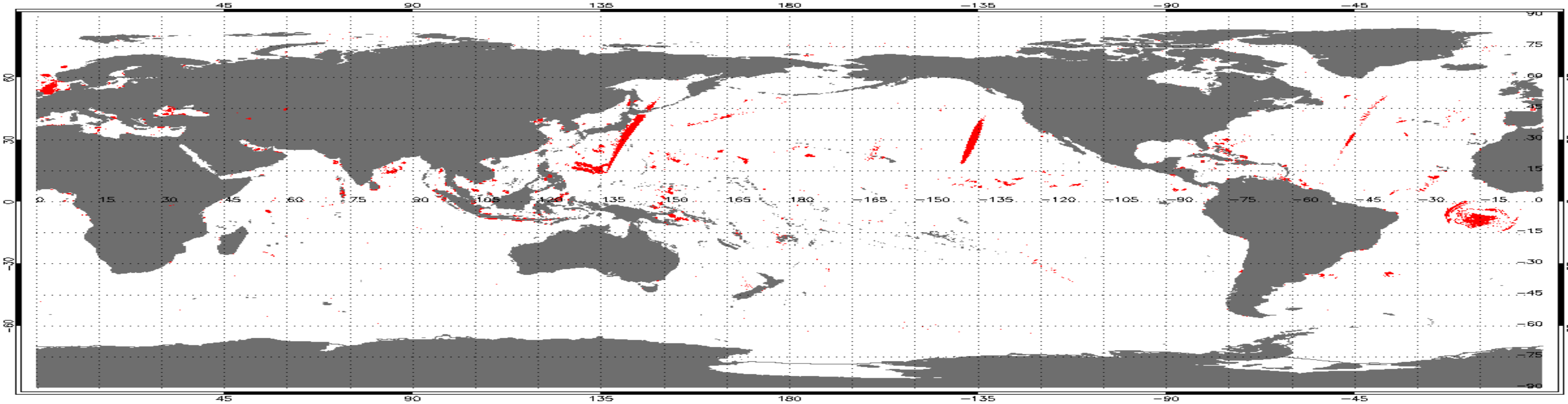
Sun glint & RFI

Sun Glint & RFI

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



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



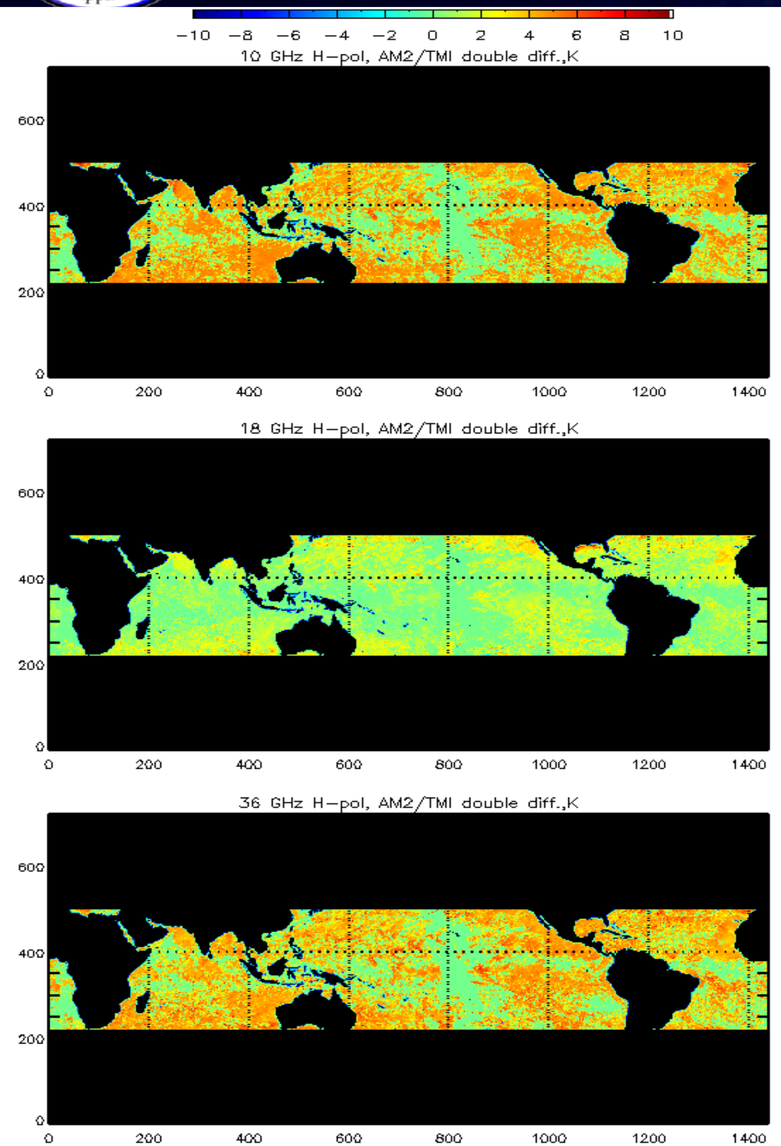
Oceanic Mean Calibration Biases

▪ → 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

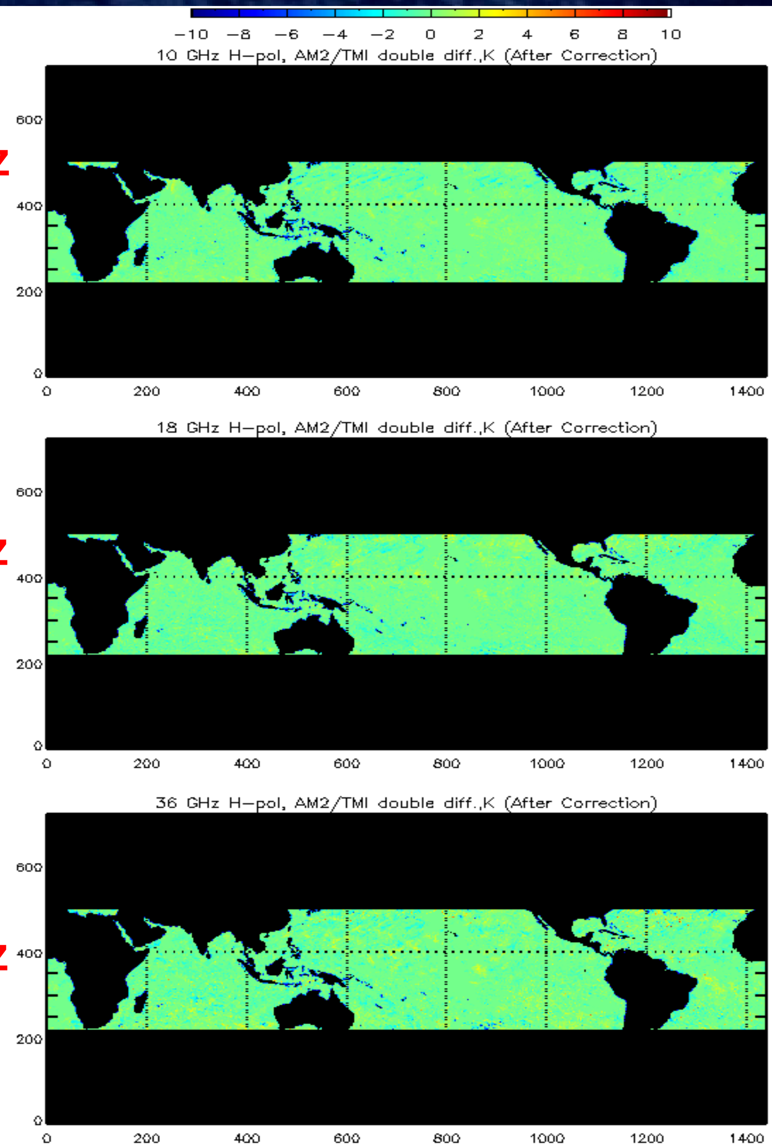
Double Difference Map Bias H-Pol



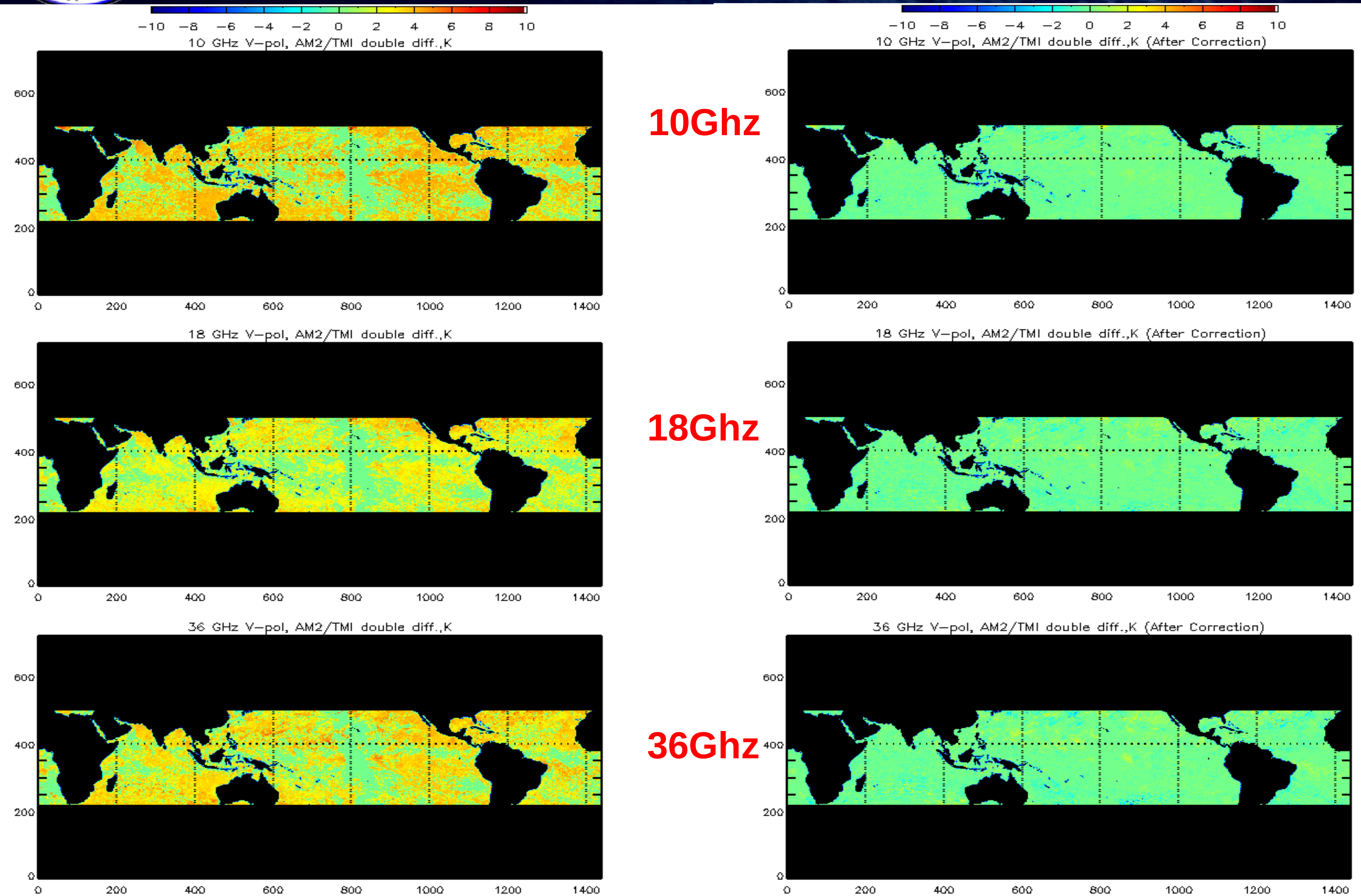
10Ghz

18Ghz

36Ghz



Double Difference Map Bias V-Pol



AMSR2 Oceanic EDR Validation

NOAA AMSR2 Ocean EDR Products

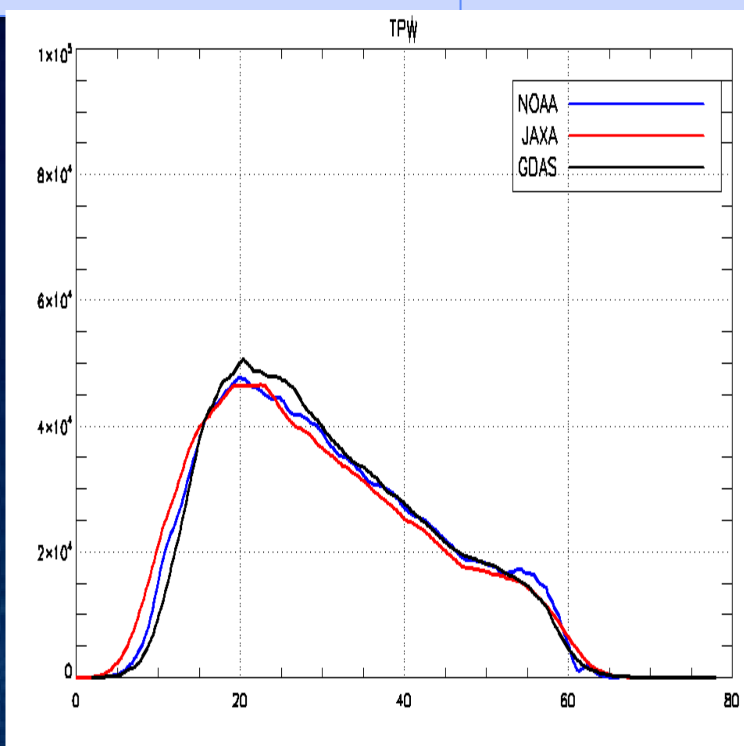
- Ocean Scene EDRs include
  - » Total Precipitable Water (TPW)
  - » Cloud Liquid Water (CLW)
  - » Sea Surface Wind Speed (SSW)
  - » Sea Surface Temperature (SST)
- **1st Delivery**
  - » **Multi stage regression ocean EDR algorithms**
- 2nd Delivery
  - » Iterative multistage regression & Bayesian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

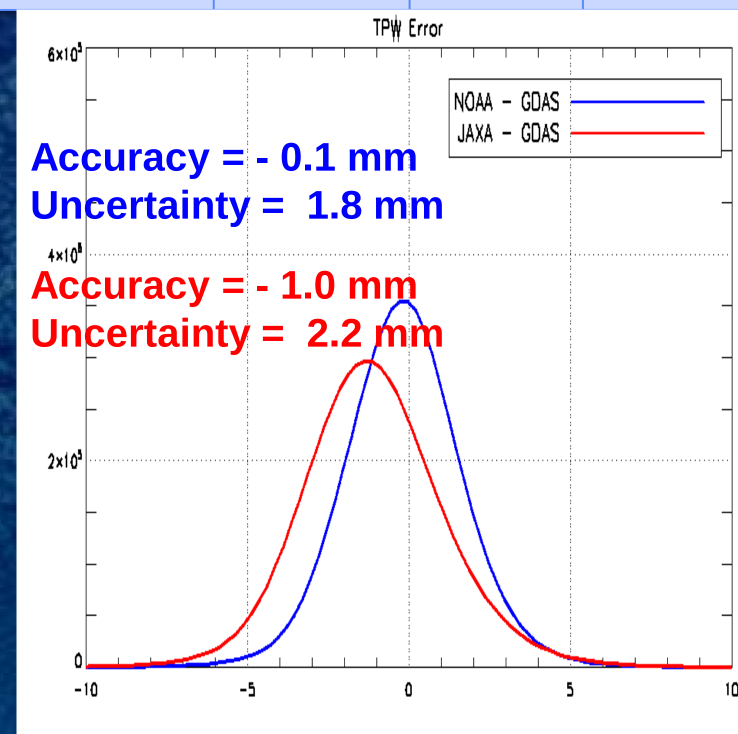
Validation Data Set

- Validation data set consists of one year worth of data
  - » Year 2013
  - » Several Data Sources
    - – Models: GDAS, Reynolds SST
      - 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 Validation

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**



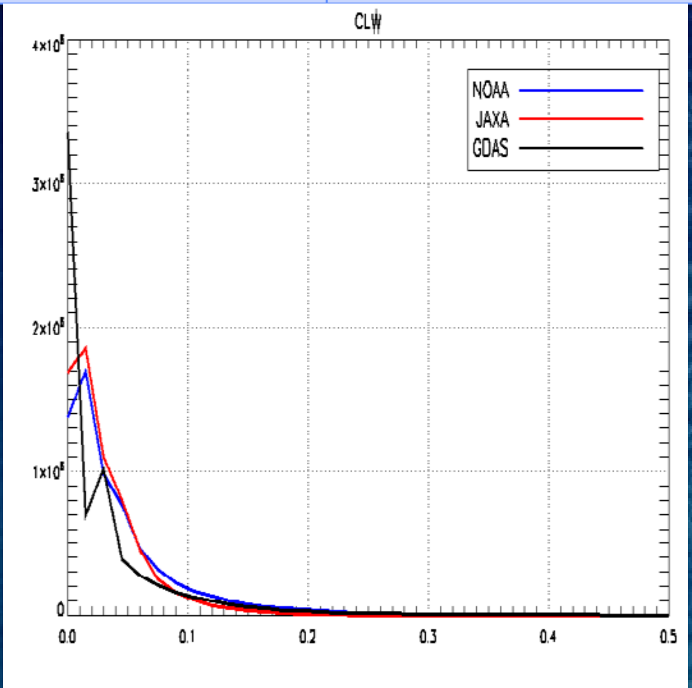


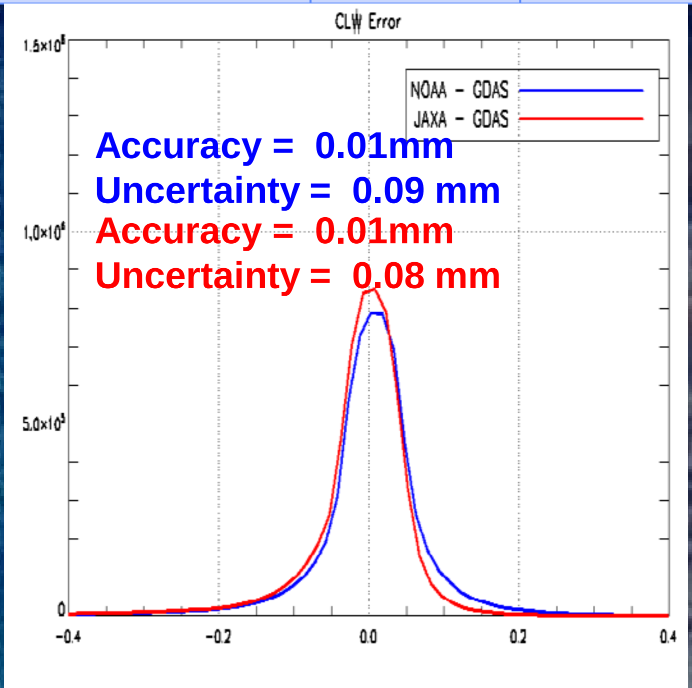
CLW Validation

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

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**

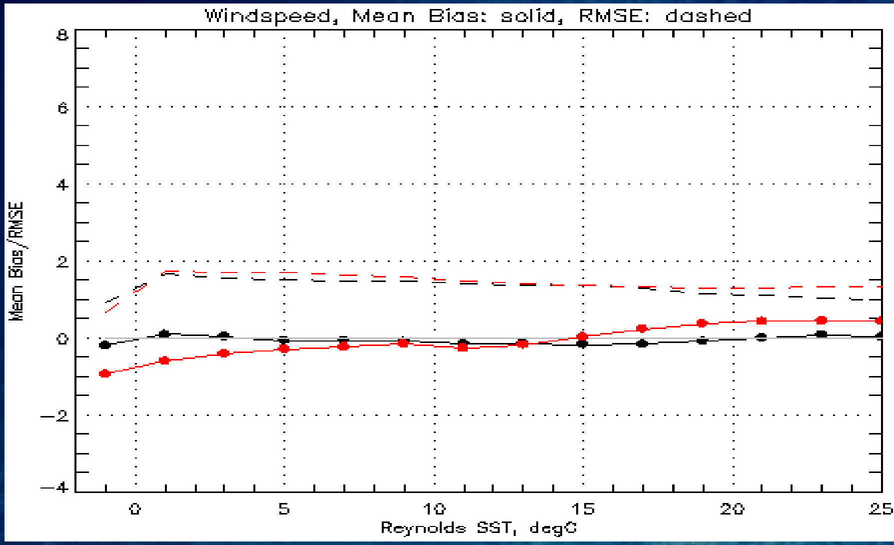


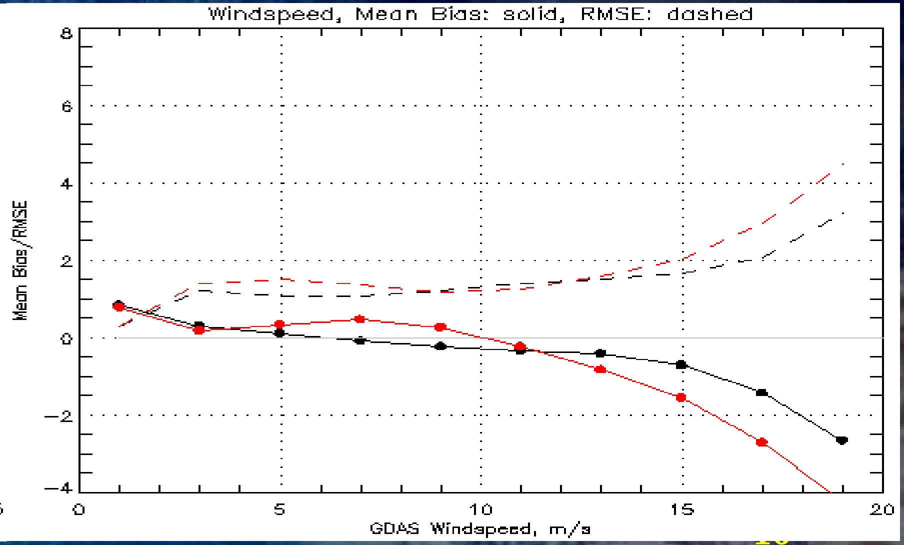


SSW Validation

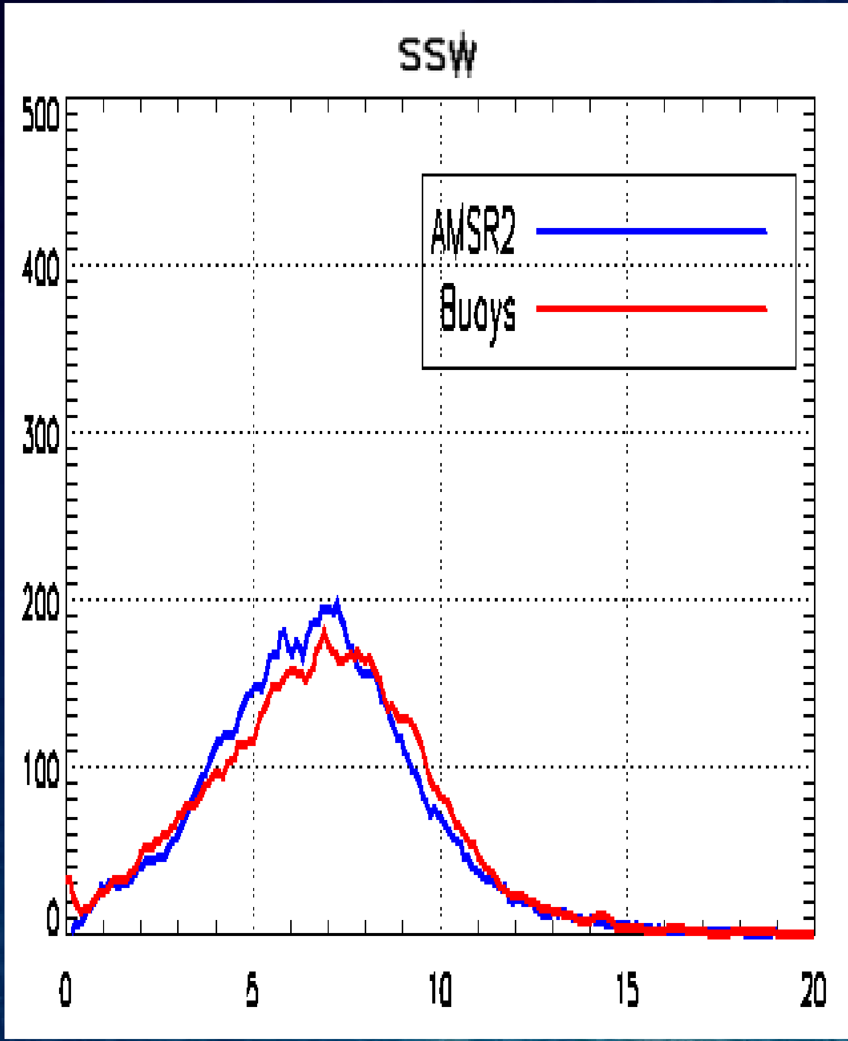
GCOM Sea Surface Wind Speed Requirements

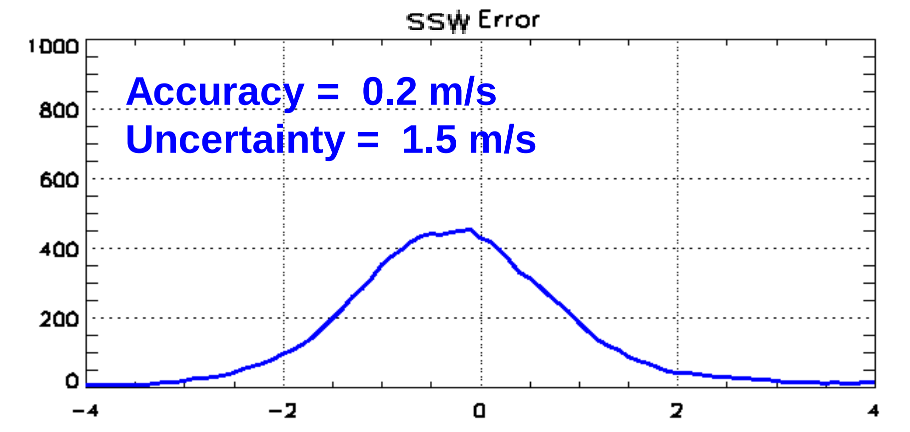
EDR Attribute	Requirement	Status		
		GDAS	TMI	Buoys
Measurement range	**2 – 30 m/s**			
Measurement uncertainty	**2 m/s or 10 % whichever is greater**	**1.3**	**0.9**	**1.5**
Measurement accuracy	**0.5 m/s**	**0.1**	**0.3**	**0.2**

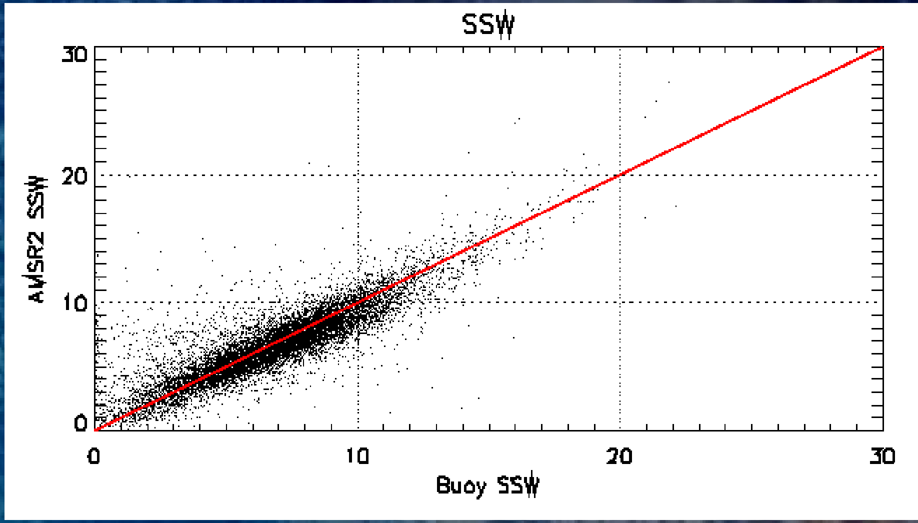




SSW Validation / GDAS

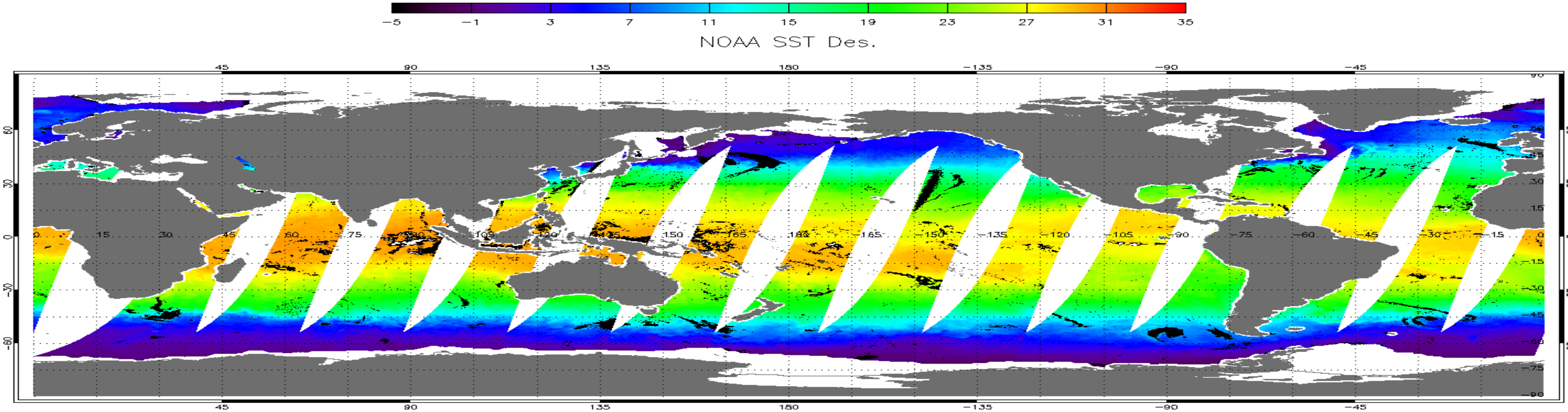


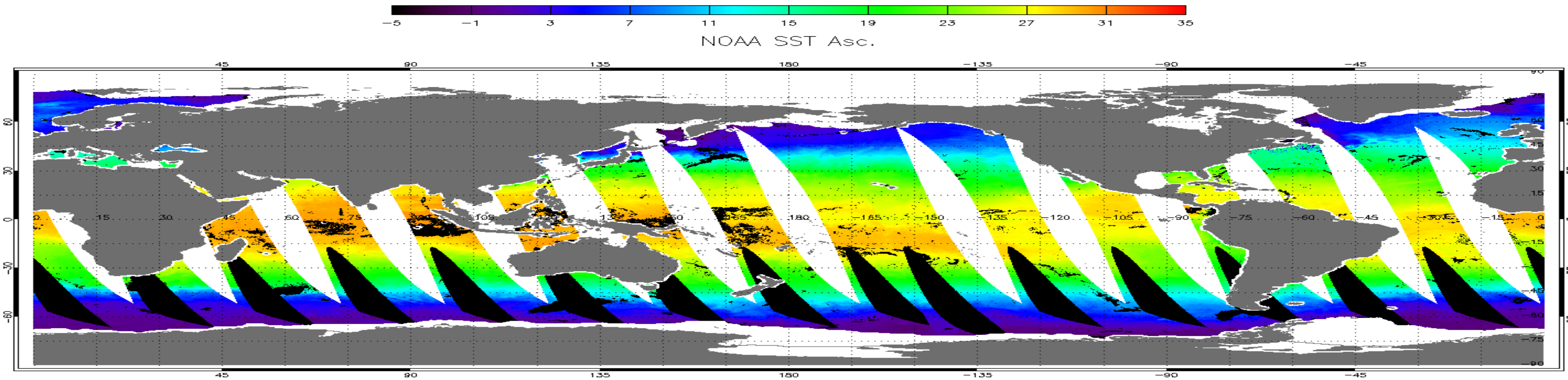




NOAA SST Example (04/01/2014)

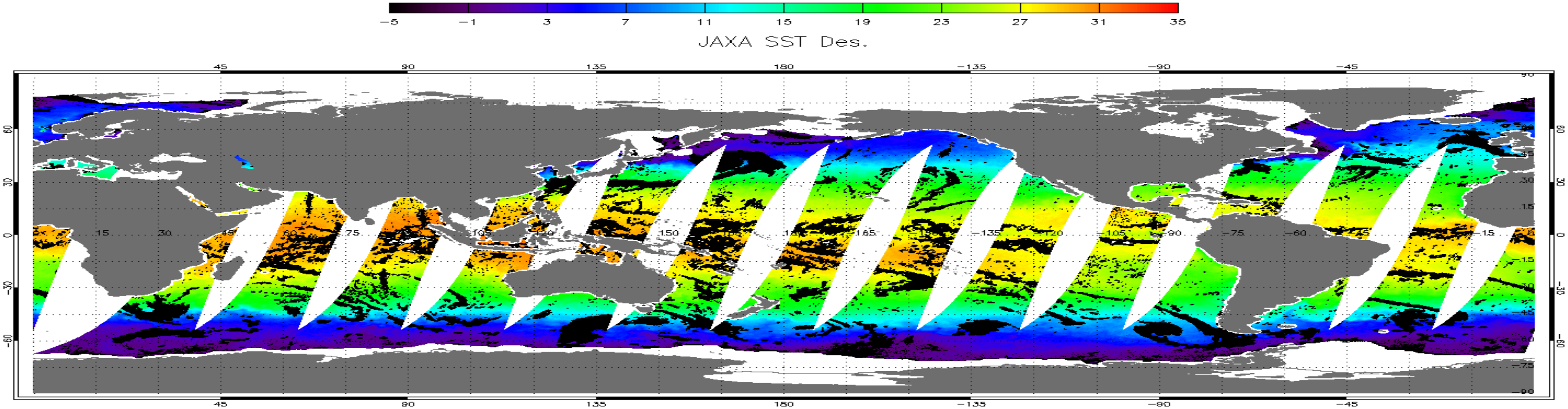
% of flagged points (NOAA): ~ 11%

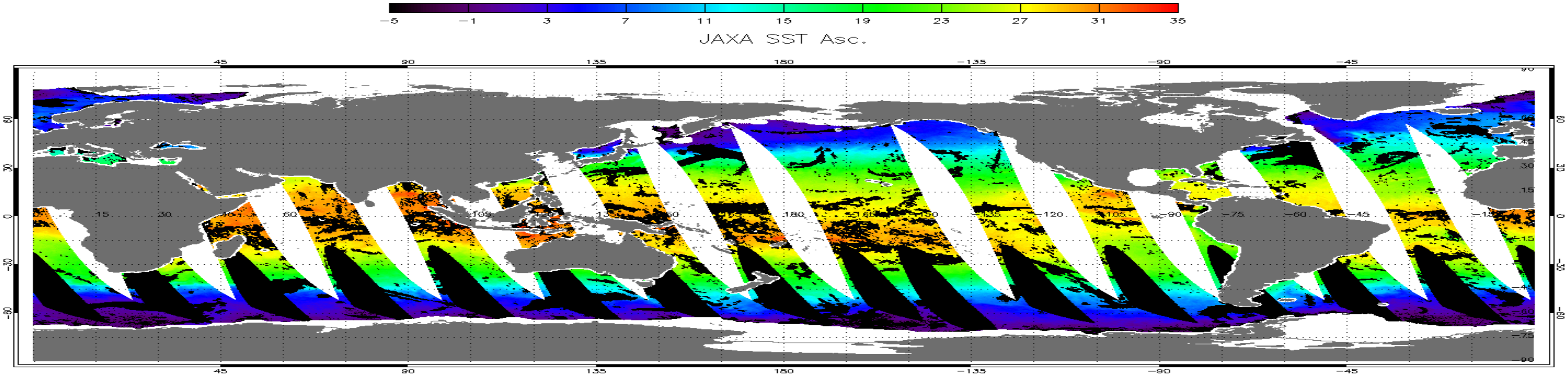




JAXA SST Example (04/01/2014)

% of flagged points (JAXA): ~ 30%





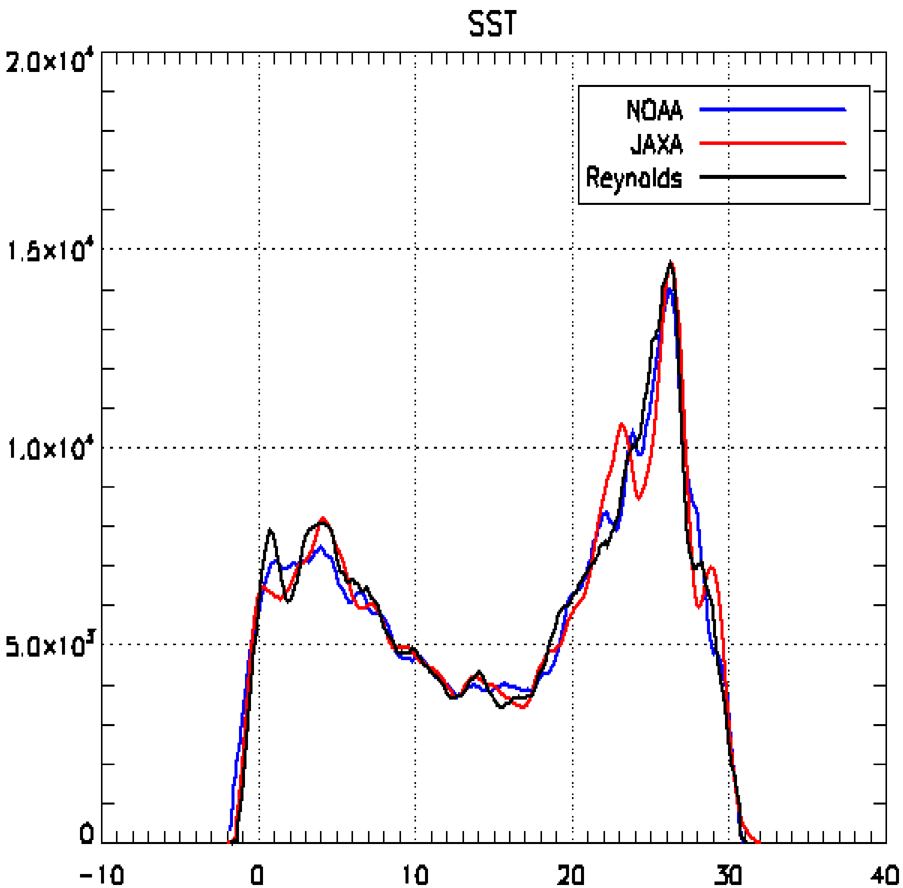
SST Validation

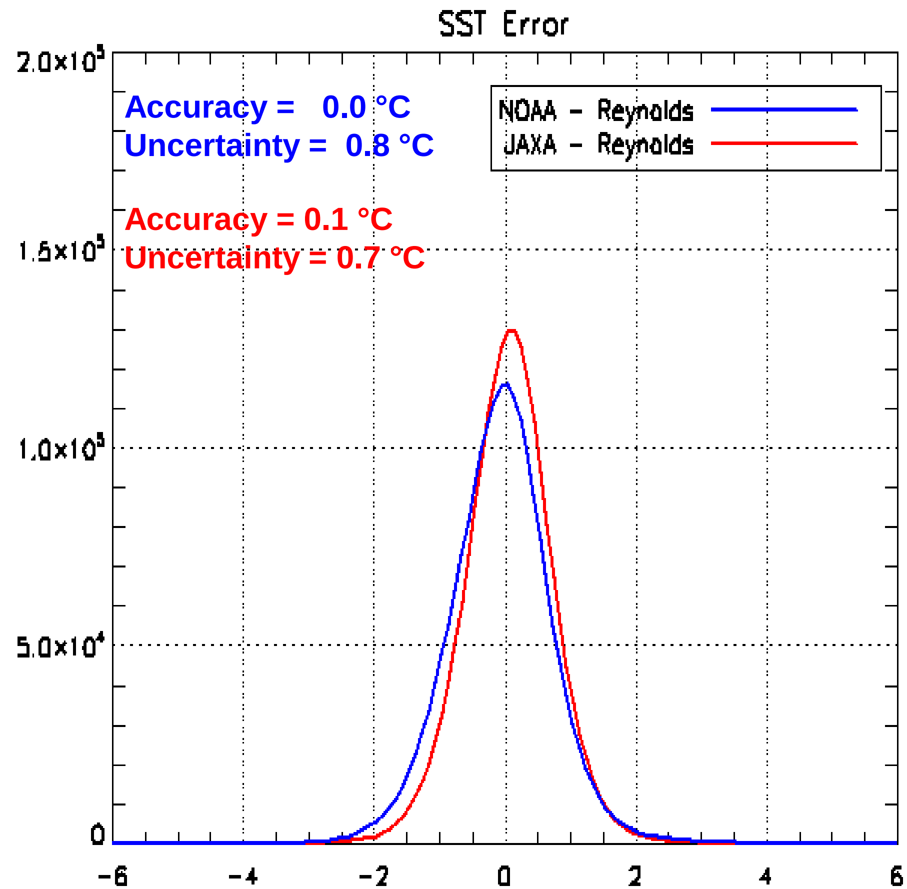
- Ancillary data for AMSR2 SST validation
  - Models : Reynolds
  - Measurements : TMI, Buoys

GCOM Sea Surface Temperature Requirements

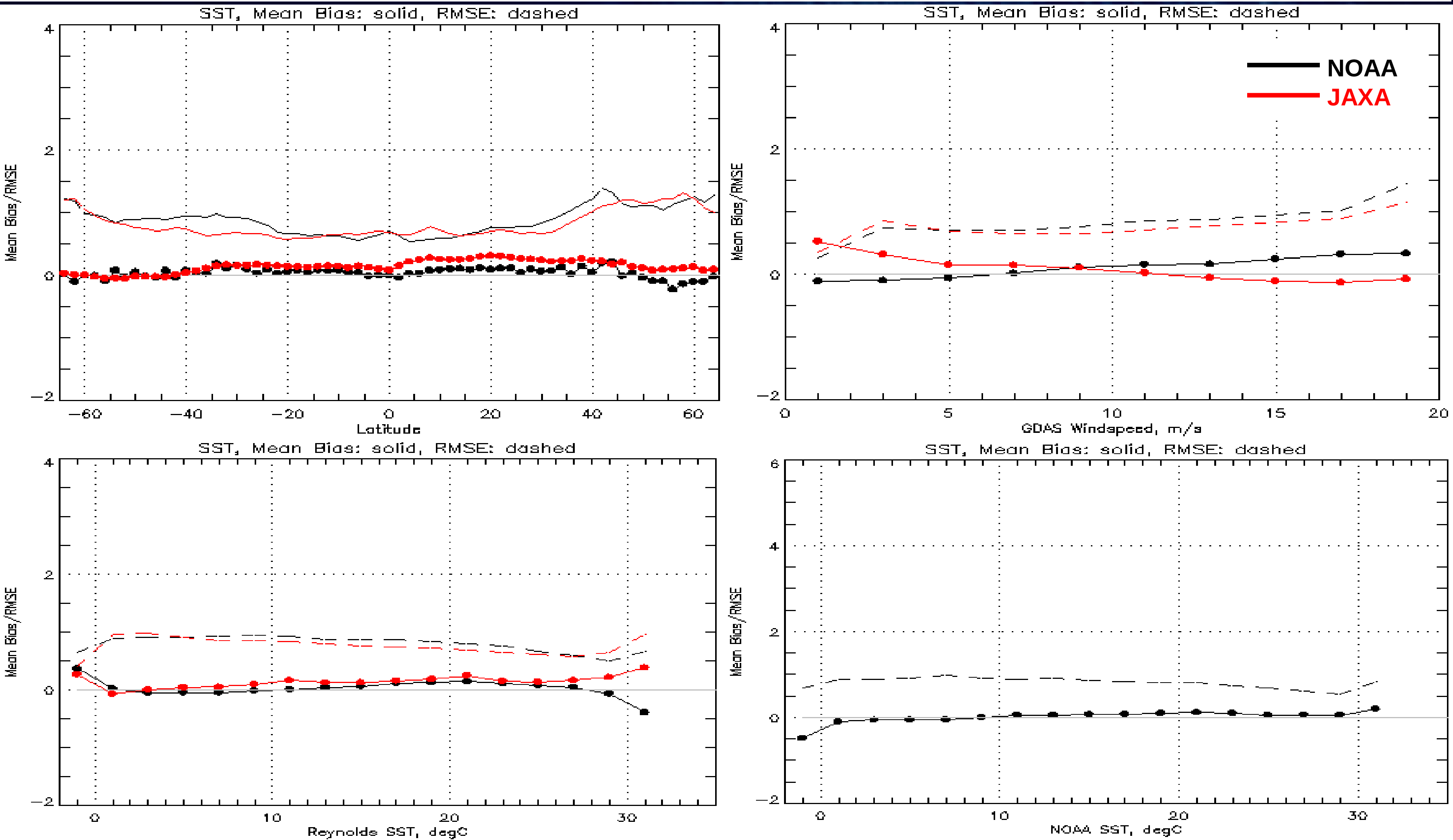
EDR Attribute	Requirement	Status		
		Reynolds	TMI	Buoys
Measurement range	271 – 313 k			
Measurement uncertainty	1.0 k	0.8	0.9	0.8
Measurement accuracy	0.5 k	0.0	0.1	0.1

SST Validation / Reynold

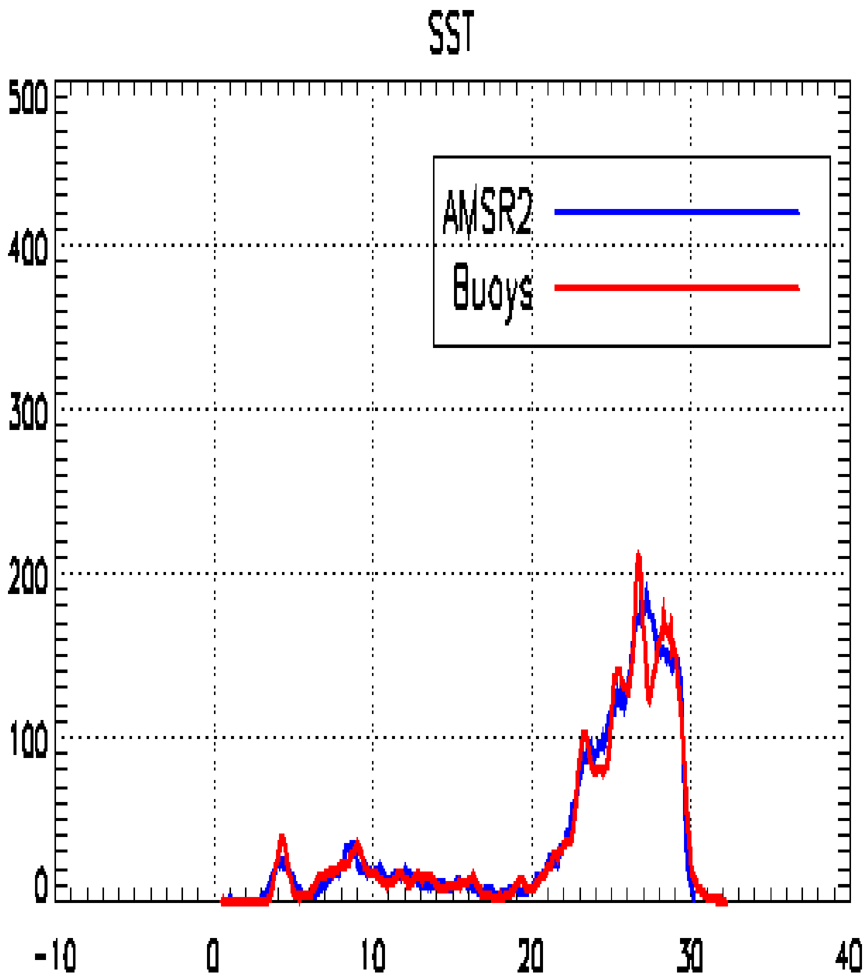


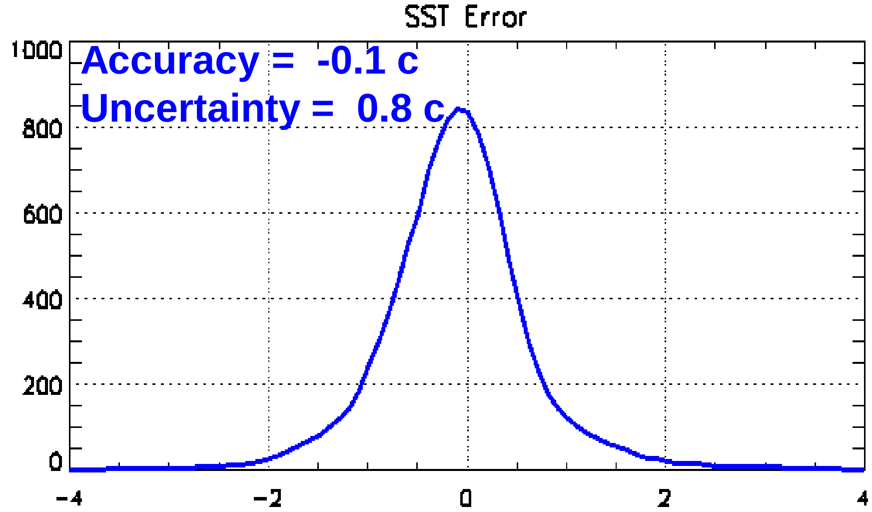


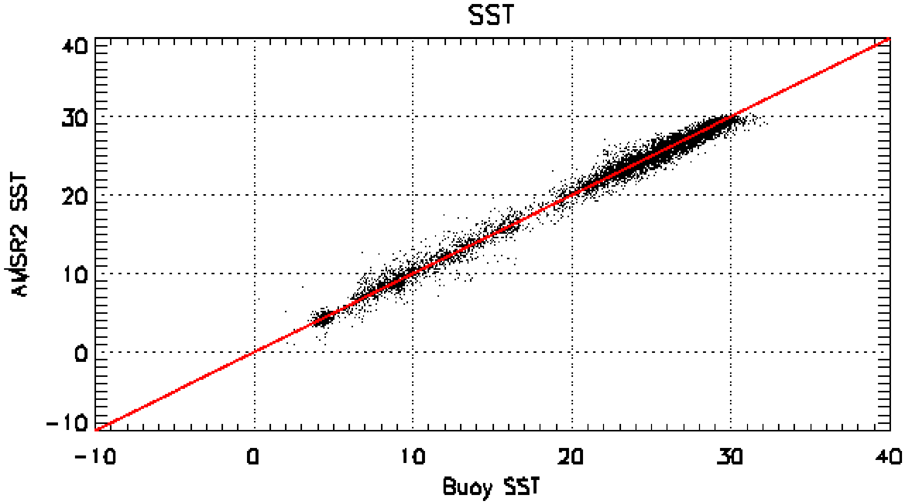
SST Validation / Reynold – cont.



SST Validation / Buoys

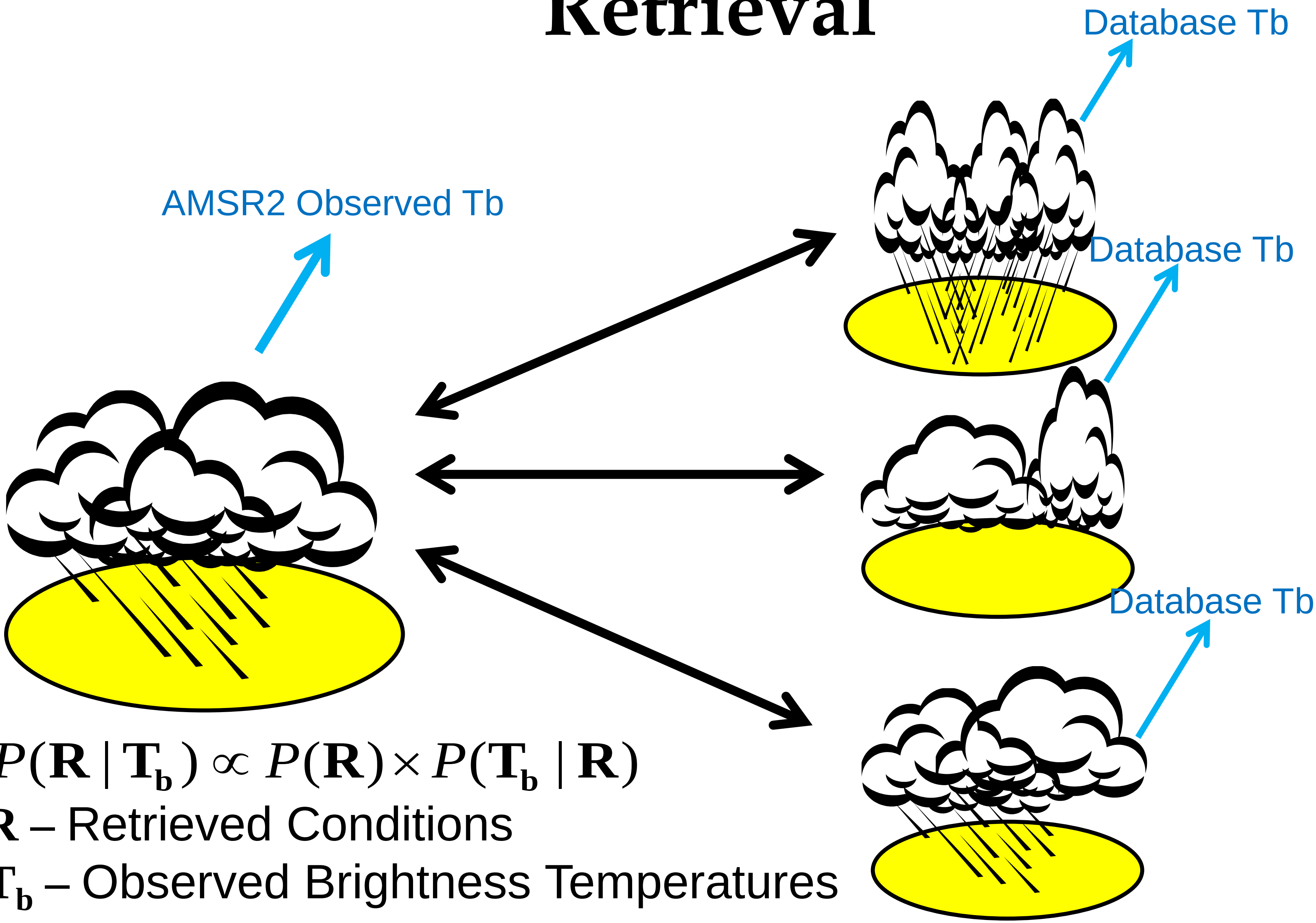






AMSR2 Precipitation EDR Validation

Ocean Segment: Bayesian Retrieval



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

$\mathbf{R}$ – Retrieved Conditions

$\mathbf{T_b}$ – Observed Brightness Temperatures

Land Segment: Semi-Empirical Calculation

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

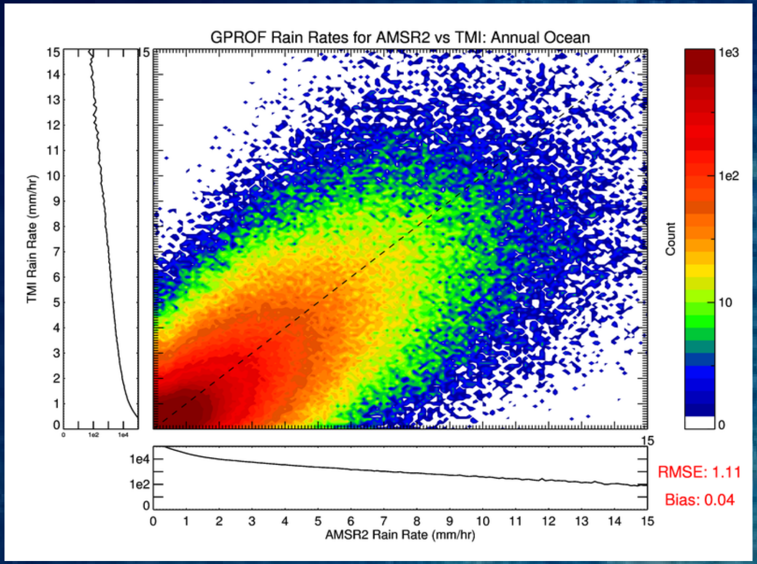
$$RR = RR_{Conv} P(C) + RR_{Strat} [1 - P(C)]$$

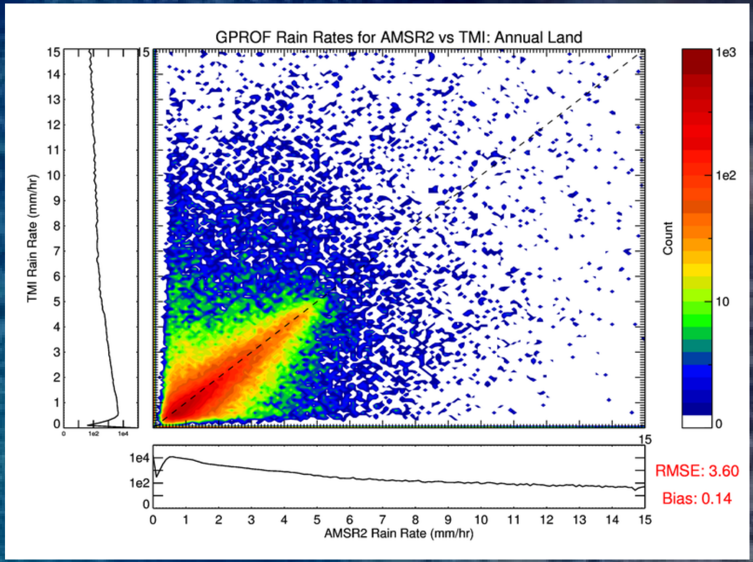
- RR_{Conv}=(O_3(T89V); RR_{Strat}=O_1(T89V)
- *P*(*C*[TbV(10, 37, 89), σ(T89V), Minima of T89V, [T89V-T89H])

AM2/TMI Validation: Precipitation Land and Ocean

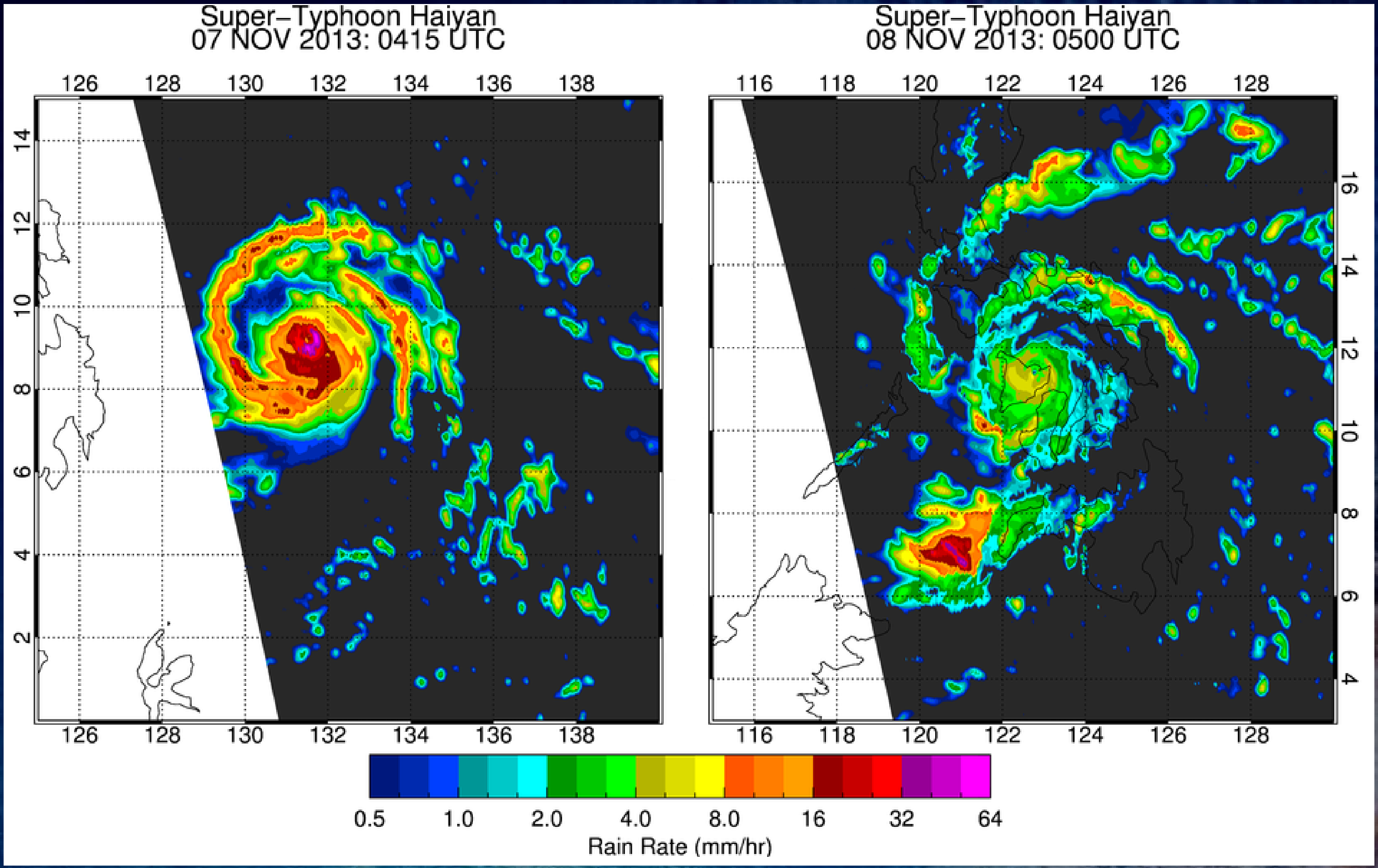
RMSD (mm/hr)	Land	Ocean	Overall
Requirements	5.0	2.0	–
TMI & TMPA	3.1	1.2	1.6
AMSR2 & TMI	3.6	1.2	1.8
AMSR2 &TMPA	3.1	1.4	1.9

- 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

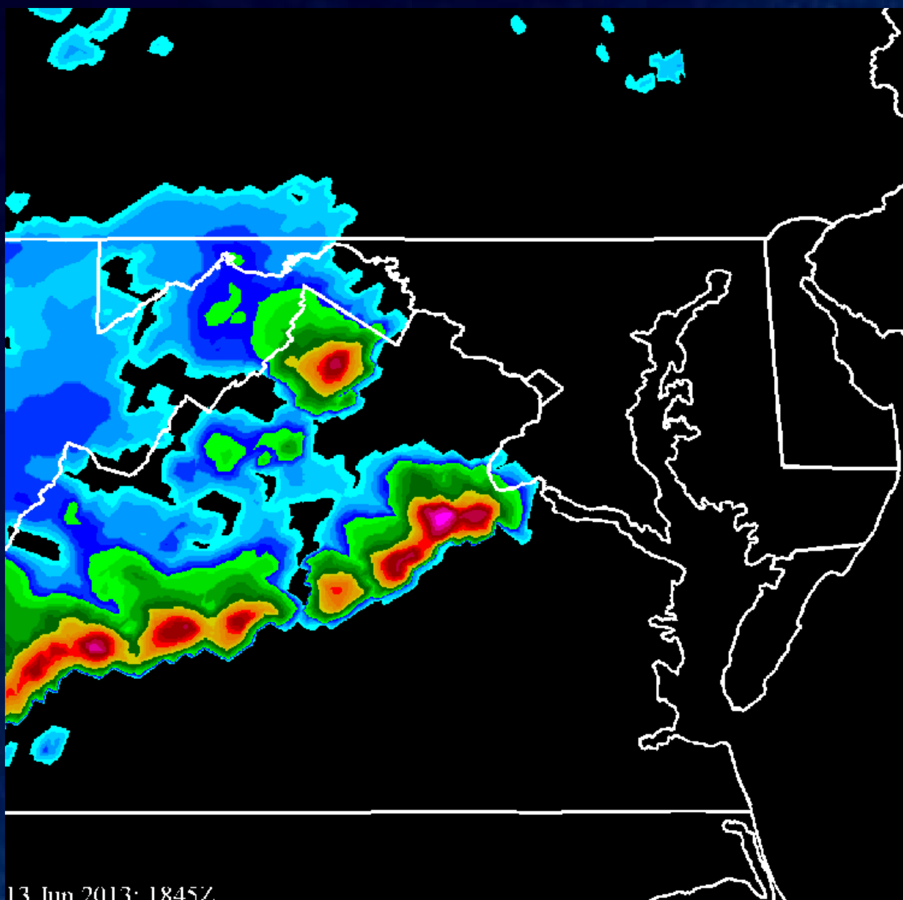


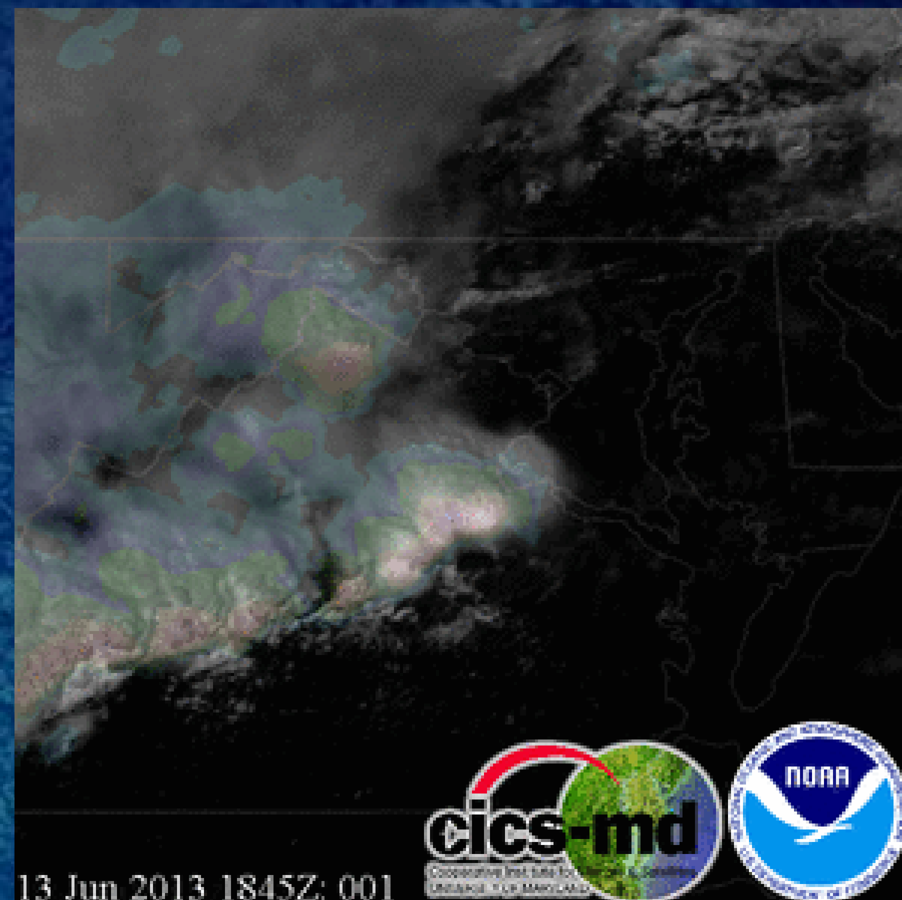


Super-Typhoon Haiyan



Tornado Outbreak
13 June 2013





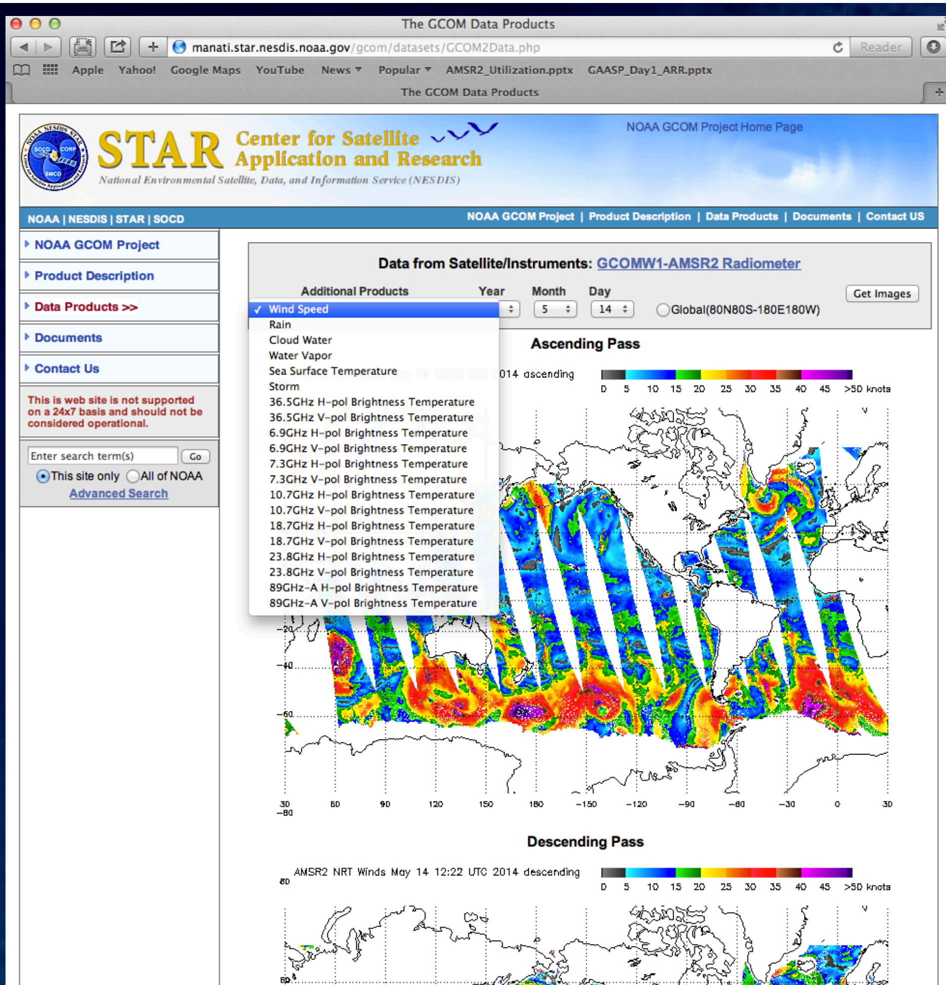
Summary

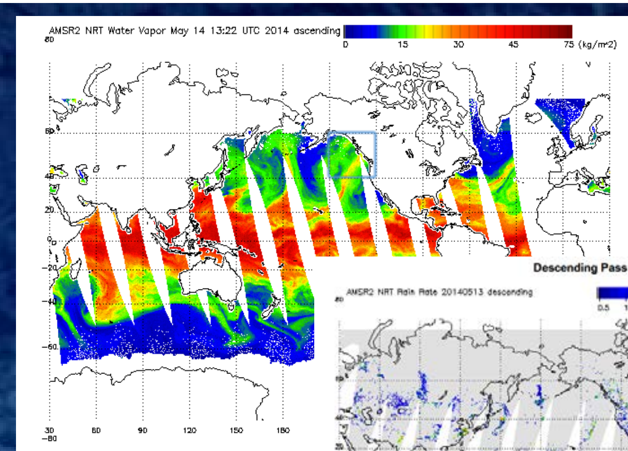
- Double difference approach used to inter-calibrate AMSR2 residual biases in observed Tbs
- AMSR2 measures warmer Tbs when compared to TMI
  - » AMSR2 L1B *V1.1*
  - » TMI 1B11 *V7*
- Corrected AMSR2 Tbs were used in EDR products
  - » TPW, CLW, SST, SSW and Precipitation

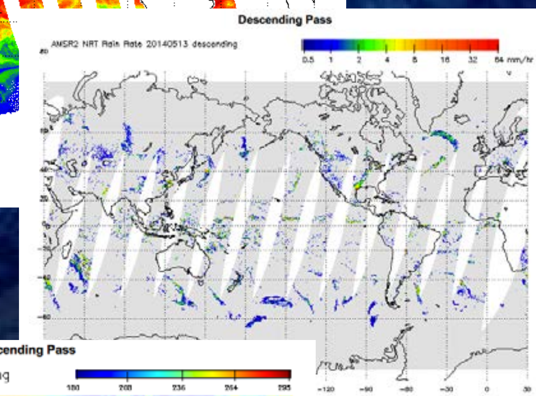
Summary – cont.

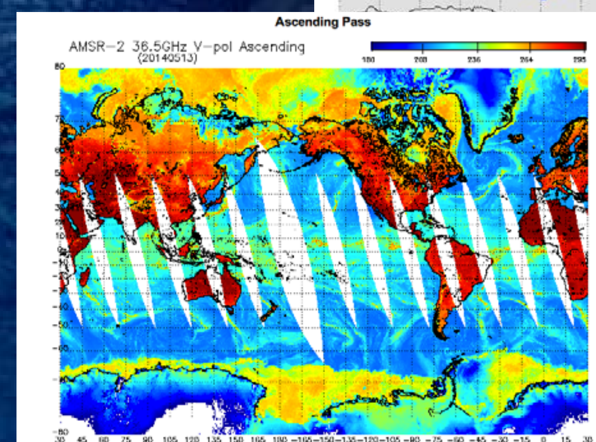
- 1st delivery EDR products were validated against several other products
  - » Models
    - – GDAS
    - – Reynolds
  - » Measurements
    - – NOAA-19
    - – TMI
- Validations results show that AMSR2 1st delivery EDRs meet accuracy requirements

STAR GCOM-W1 AMSR2 Web Page









http://manati.star.nesdis.noaa.gov/gcom

Opportunities & Challenges for leveraging the European Sentinel(-3) Missions in support of NOAA User Needs

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Chief, Satellite Oceanography and Climatology Division (SOCD)
NOAA-NESDIS Center for Satellite Applications & Research (STAR)

With contributions from Peter Regner (ESA); Kent Hughes, Frank Monaldo, Priyanka Roy, Rick Stumpf, Paul Chang (NOAA)

STAR JPSS Annual Science Team Meeting

15 May 2014
College Park, Maryland USA

NOAA Satellites and Information
National Environmental Satellite, Data, and Information Service

Opportunities & Challenges for Leveraging Non-NOAA Satellite Data

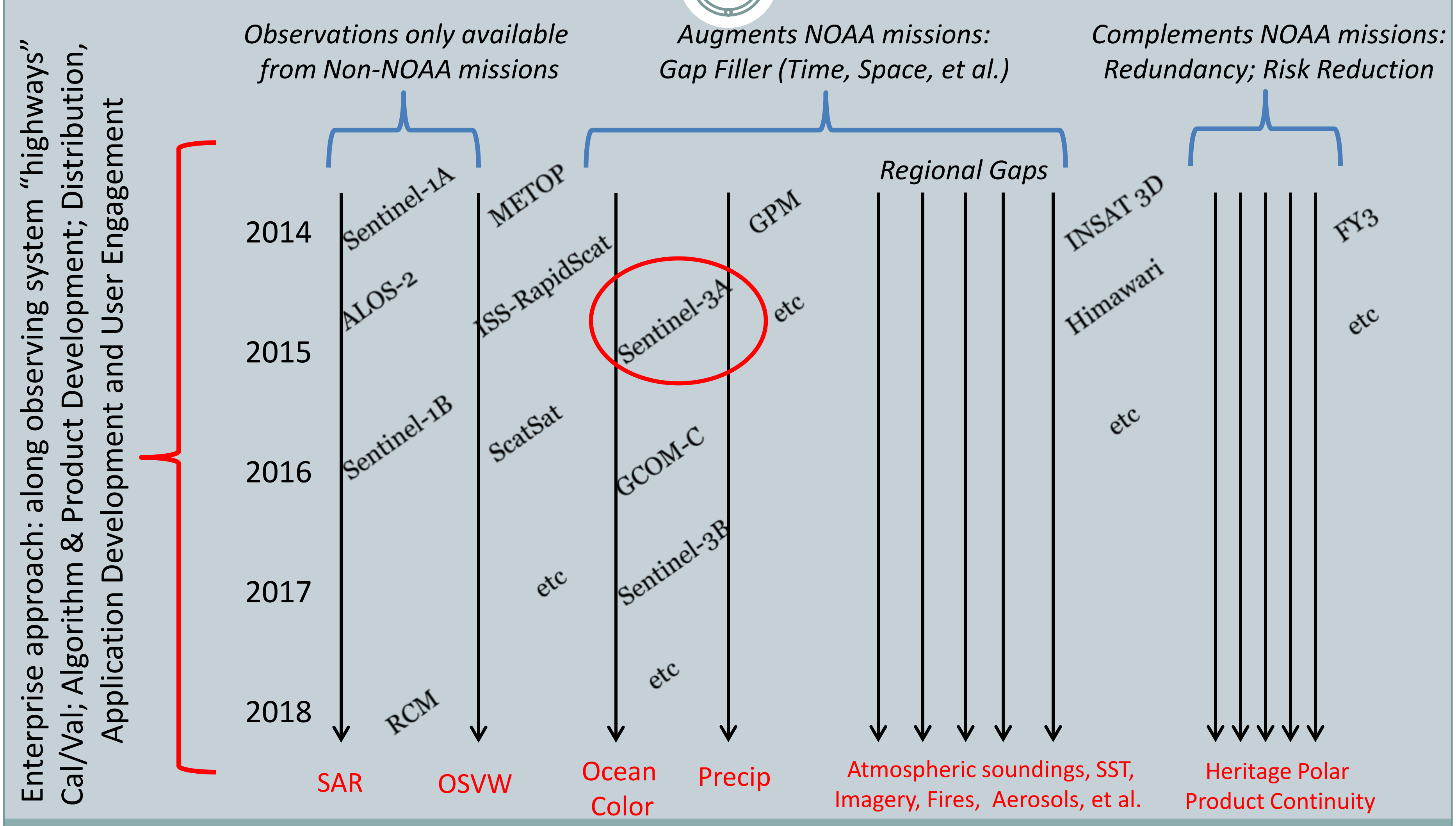
- Many key satellite data streams needed by users (e.g., ocean winds, SAR, sea-surface salinity) are only available from non-NOAA external sources, both foreign and domestic.

- Likewise, user needs for greater spatial and temporal coverage in other data sets (e.g., ocean color, SST) also require the use of non-NOAA satellite data sets to augment existing/planned NOAA assets.

- That said, there is not presently a clear path or institutional framework within NOAA for the systematic acquisition of many external satellite data sets (and their operational generation) in support of user needs; existing efforts are largely bottom-up, ad hoc and best effort endeavors.

- Other challenges include the need to redefine the "operational" paradigm – has to be more than just the near-real time provision of data. Reprocessing, blended products et al. are required to support user needs (as nicely illustrated in following presentation by M. Eakin).

Observing System Highways : "Plug & Play" data from multiple non-NOAA missions, leveraging existing science et al. infrastructure in NOAA/NESDIS



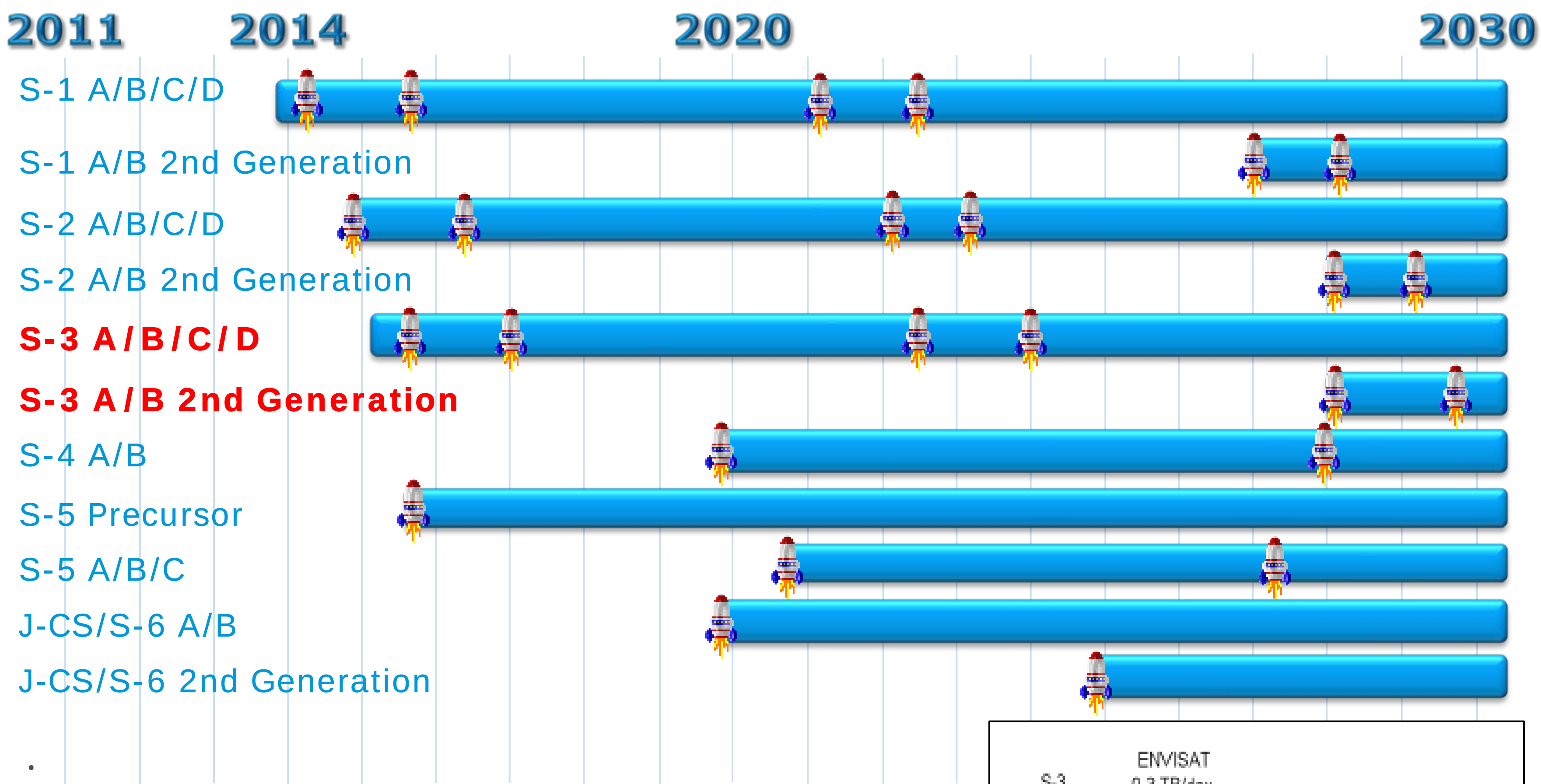
Copernicus dedicated missions: the Sentinels

- Flagship of the European Space Policy
- Led by the European Union
- Europe's contribution to GEOSS
- European capacity for global, timely and easily accessible information about climate, environment & security

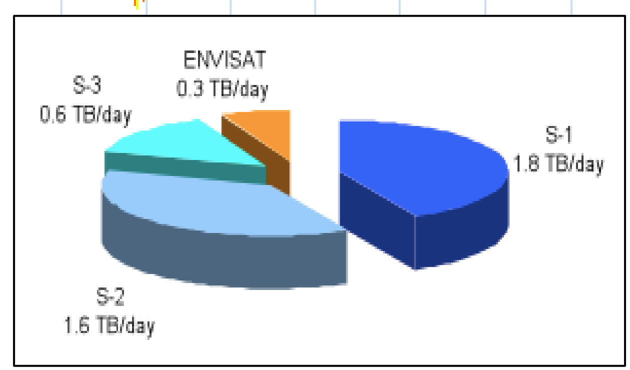
S1-A Launched 3 April 2014

- **S1A/B:** Radar Mission
- **S2A/B:** High Resolution Optical Mission
- **S3A/B:** Medium Resolution Imaging and Altimetry Mission
- **S4A/B:** Geostationary Atmospheric Chemistry Mission
- **S5P:** Low Earth Orbit Atmospheric Chemistry Precursor Mission
- **S5A/B/C:** Low Earth Orbit Atmospheric Chemistry Mission
- **Jason-CS/Sentinel-6 A/B:** Altimetry Mission

Europe's long-term operational programme



The Sentinel-1,-2,-3 A-series production
is equivalent to ˜25 ENVISAT missions



SENTINEL-3 Satellite

Operational mission in high-inclination, low earth orbit

- ❑ **Ocean and Land Colour Instrument (OLCI):**
  - 5 cameras, spectral range from 400 to 1020 nm
  - 15 (MERIS) & 6 additional bands; Swath: 1270 km
  - Camera tilt in west direction (12.20°)
  - Full res. 300m acquired systematically (land/ocean)
  - Reduced res. 1200m binned on ground (L1b)
  - Ocean coverage < 4 days, (< 2 days, 2 satellites)
  - 100% overlap with SLSTR

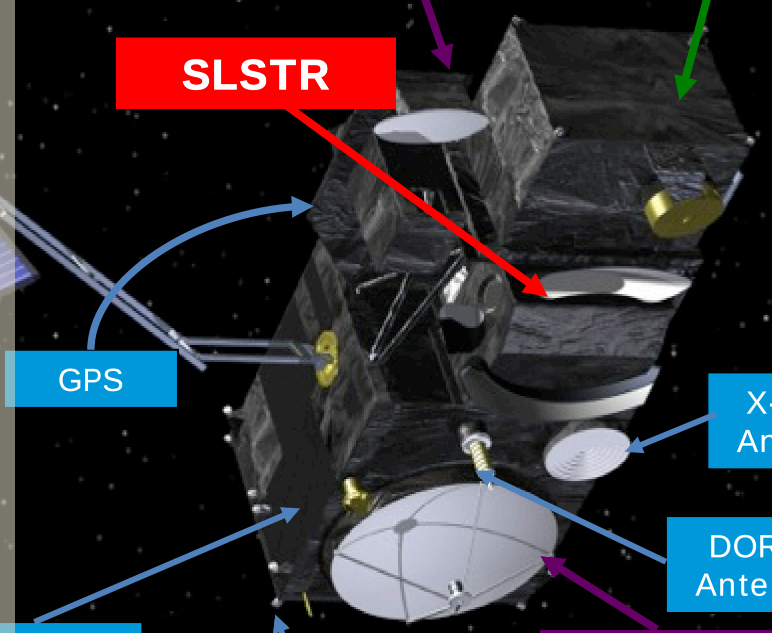
- ❑ **Sea & Land Surface Temperature Radiometer (SLSTR):**

  7 AATSR & 2 additional bands, plus 2 additional Fire channels, with 500 m (solar) and 1 km (TIR) ground res. Swath: 1420 km/750 km (single or dual view)

- ❑ **Topography package:**

  SRAL Ku-C altimeter (LRM & SAR measurement modes), MWR, POD (with Laser Retro Reflector, GPS and DORIS)

Full performance will be achieved with 2 satellites in orbit

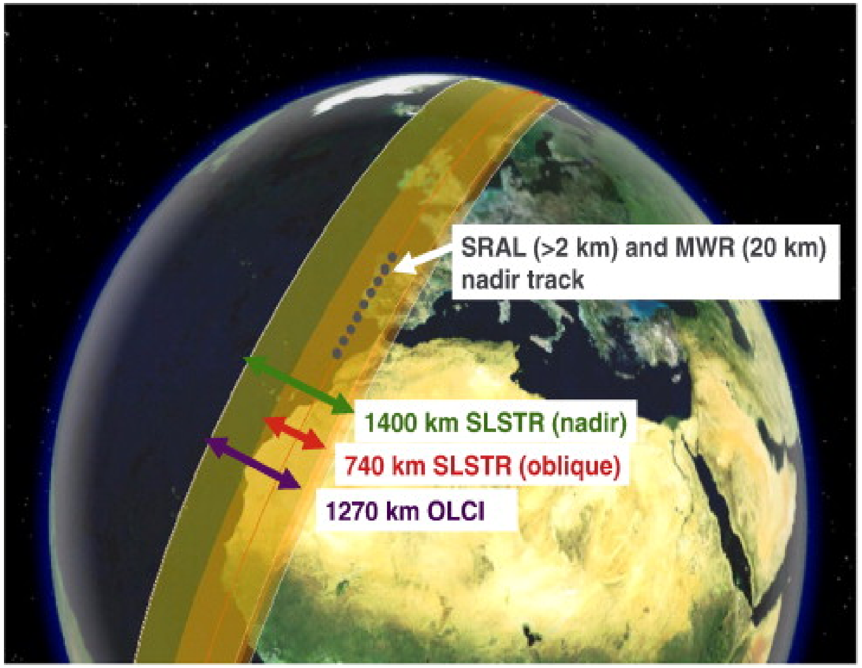


Sentinel-3 Orbit

esa
EUMETSAT

Orbit characteristics		
repeat cycle	27 days	
Equator crossing time	10:00 descending	
orbit	altitude 815 km	inclination 98.65^0
lifetime	7.5 years	

OLCI data distribution timeliness	NRT 3 hours	NTC 1 month



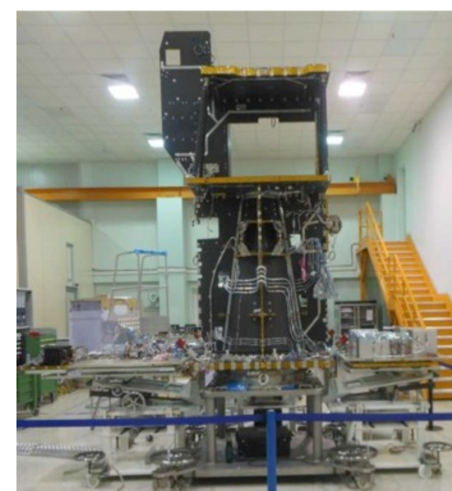
OLCI	coverage at Equator	coverage at lat > 30^0	requirement
1 satellite	< 3.8 days	< 2.8 days	< 2 days
2 satellites	< 1.9 days	< 1.4 days	< 2 days

OLCI	GB/day	TB/year
Level-0	134.98	48.11
Level-1	422.07	150.45
Level-2 marine	506.20	180.43

Sentinel-3 Satellite Status

- **Quite advanced development status for both S-3A & S-3B satellites**
  - S-3A Platform AIT completed;
  - Instrument integration and testing at satellite level started
  - Topography Payload (GPS, LRR, DORIS, SRAL and MWR) mechanically and electrically integrated in the S-3A Platform
  - S-3B Platform integration at TAS-I, Rome, almost completed, delivery to Prime for Satellite AIT planned in Q1 2014
- **S-3A readiness for launch driven by SLSTR**
  - issues with Flip Mirror, Cryocooler, Blackbodies
- **S-3A FAR expected in April 2015**
- **S-3A Launch date: end of June 2015**
  consistent with the launch period agreed with Eurockot
- **S-3B FAR 1 year later**

S3A Satellite at TAS-F, Cannes with Topo P/L installed



S3B Platform electrical integration at TAS-I, Rome

OLCI Core User Products

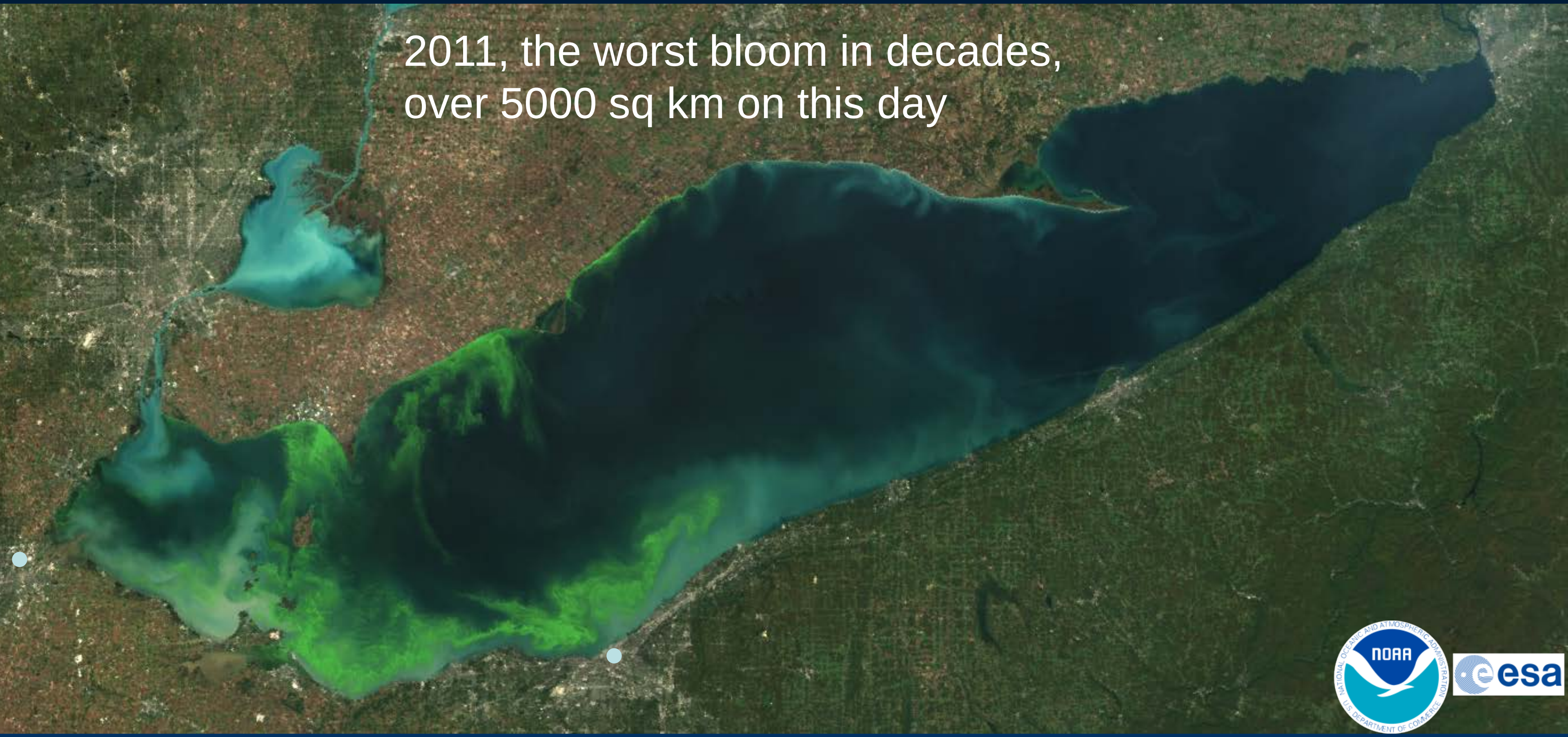
	Product Type	Resol.	GB/orbit	Comparison with MERIS
Level 1	Ortho-geolocated TOA Radiance at 21 bands	FR	27.9	MERIS FR+RR 10 GB/orbit
		RR	1.7	
Level 2 **Water**	Water Leaving Reflectance (16 bands) Chlorophyll (OC4Me & NN) TSM_NN KD490 (Morel et al.) CDM Absorption PAR AOT at 865 nm & Angstrom Integrated Water Vapour	FR	25.8	
		RR	1.6	
Level 2 **Land**	FAPAR Terrestrial Chlorophyll Index Integrated Water Vapour	FR	7.32	
		RR	0.50	

- Similar product suite as for MERIS
- Product portfolio corresponds to Copernicus service projects needs of well identified operational communities
- Systematic processing of all OLCI data in 300m/1200 m
- Data format: netCDF with CF compliant metadata
- Algorithm development follows very closely the MERIS concept
- Uncertainty per pixels

Conclusion

- Sentinel-3 is an operational mission
- will secure the continuity of ocean and land colour observations for the next decade
- OLCI design is inherited from that of MERIS, with many improvements
- Similar or improved performance than MERIS
- Free, full and open data access
- Missions Performance Framework being established
- Launch end of June 2015 on Rockot from Plesetsk
- OLCI Prototype Processors delivered & first PDGS successfully accepted
- User support tools under development

2011 Lake Erie cyanobacteria bloom



09 October : Data from MERIS
(European Space Agency

Weekly Lake Erie Bulletin,MERIS 2009-2011

Experimental
Lake Erie Harmful Algal Bloom Bulletin
2011-008
08 September 2011
National Ocean Service
Great Lakes Environmental Research Laboratory
Last bulletin: 22 July 2011

Bloom from MERIS

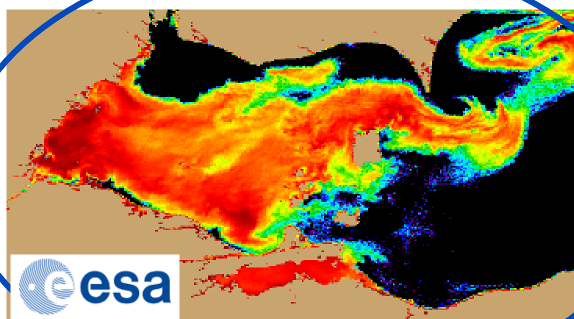


Figure 1. MERIS image from the European Space Agency. Imagery shows the spectral shape at 681 nm from September 03, where colored pixels indicate the likelihood of the last known position of the *Microcystis* spp. bloom (with red being the highest concentration). *Microcystis* spp. abundance data from shown as white squares (very high), circles (high), diamonds (medium), triangles (low) , + (very low) and X (not present).

Forecast (with Great Lakes CFS)

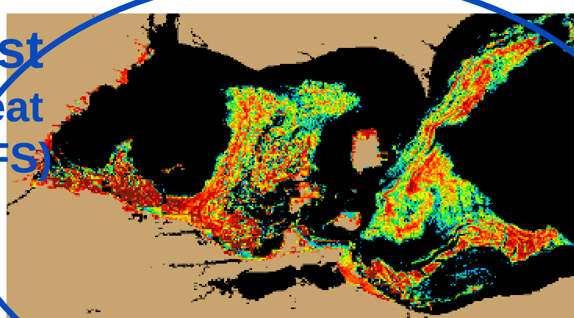


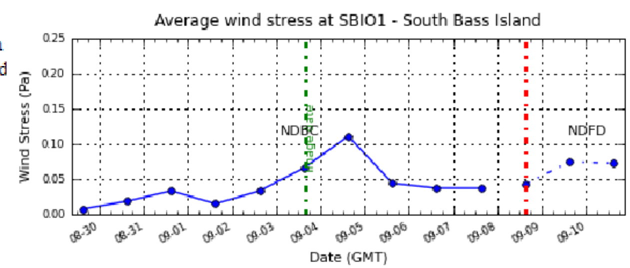
Figure 2. Nowcast position of *Microcystis* spp. bloom for September 08 using GLCFS modeled currents t move the bloom from the September 03 image.

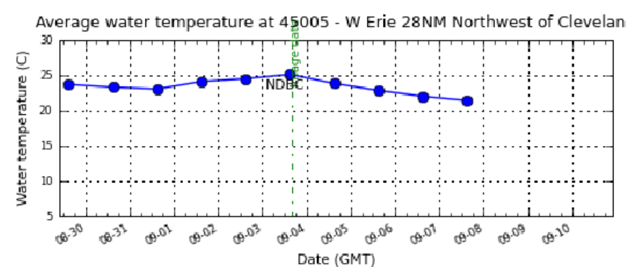
Conditions: A massive *Microcystis* bloom persists throughout most of Lake Erie's Western Basin.

Analysis: As indicated in satellite imagery from Saturday (9/3/2011), an enormous *Microcystis* bloom was present in western Lake Erie. The southern extent of the bloom was remotely observed along the coast of Ohio from Maumee Bay to Catawba Island. The northern extent of the bloom was observed to be consistent along the Michigan coast from Northern Maumee Bay to the mouth of the Detroit River. The eastern-most portion of the bloom was observed past Point Pelee and to the northeast up in to Rondeau Provincial Park.

At the mouth of the Detroit River, a five day nowcast shows a southward suppression of the western-most portions of the bloom. However, the bloom is likely to still persist in much of the Western Basin. The nowcast also suggest the bloom has spread to the east of Sandusky and into the Cleveland area. (**Note: Due to a lack of clear imagery the bloom has not been remotely observed in the Cleveland area.**) A three day forecast also suggests that the bloom will persist to the north of Cleveland through the weekend. Water temperatures remain above 20 degrees Celsius and are forecast to decrease into the weekend; however, conditions remain favorable for bloom growth.

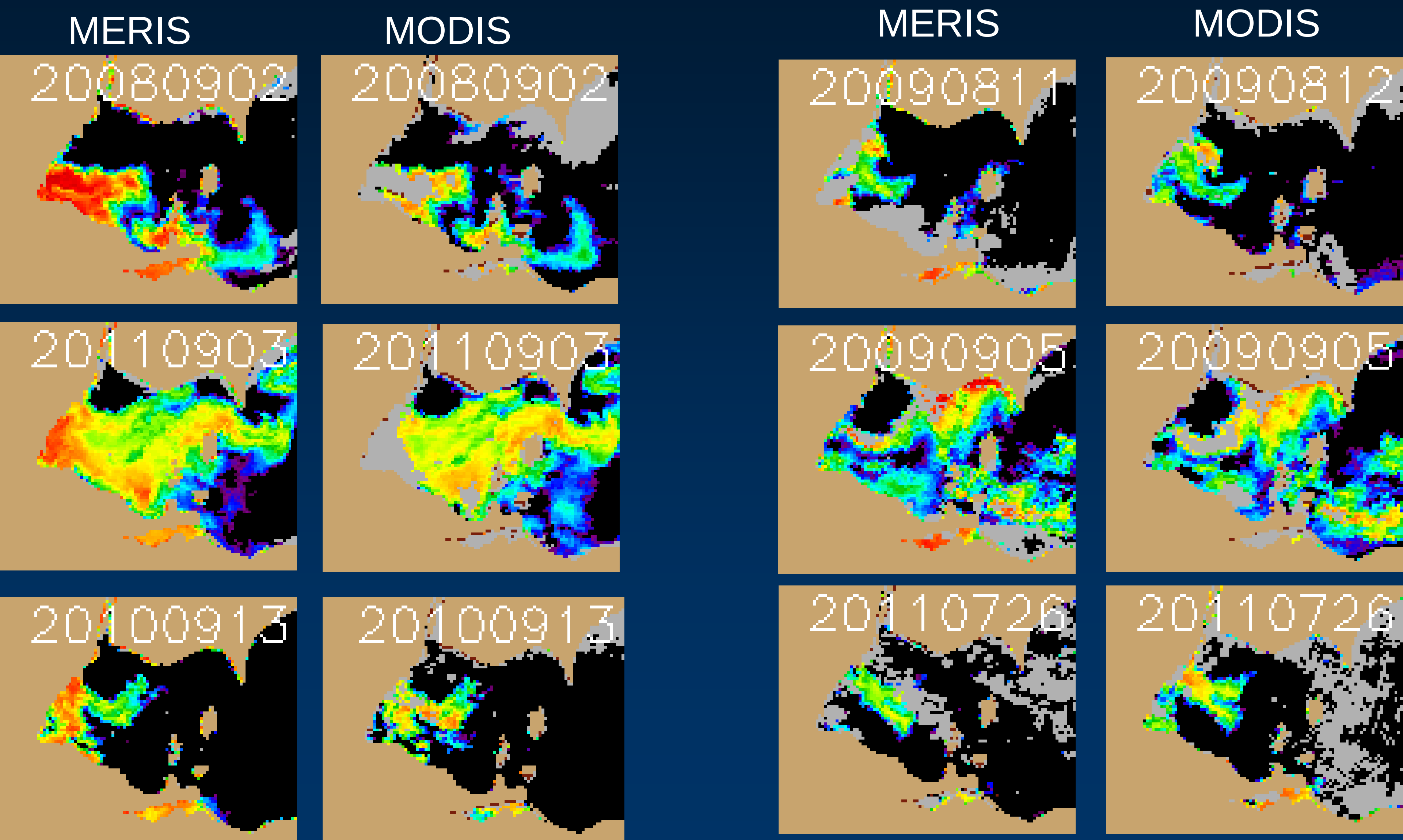
Briggs, Wynne





Loss of MERIS: MODIS comparable but less sensitive)

(Wynne, Stumpf & Briggs., 2013 Intl J. Remote Sensing)



Weekly Bulletin Switch to MODIS for 2012-2013

2012 (and 2013) Bulletins: MERIS data stopped, shifted to MODIS.

Impact: Loss of resolution, MODIS is noisier and less sensitive. But MODIS algorithm is equivalent to MERIS.

Transports with the NOAA Great Lakes Coastal Forecast System

Experimental Lake Erie Harmful Algal Bloom Bulletin

National Centers for Coastal Ocean Science and Great Lakes Environmental Research Laboratory

23 August 2013; Bulletin 15

Microcystin concentrations in some areas of the bloom near Maumee Bay may reach 56 ug/L. Dense cyanobacteria is present along some of the western shore. There may be small patches of scum from the Bass Islands west to Maumee Bay.

Slight eastward transport is forecasted for the next few days. Winds today >15 knots could possibly cause mixing of the bloom. Low winds (<8 knots) are expected over the weekend which could cause the bloom to intensify at the surface and produce patchy areas of scum.

- Dupuy, Stumpf, Tomlinson

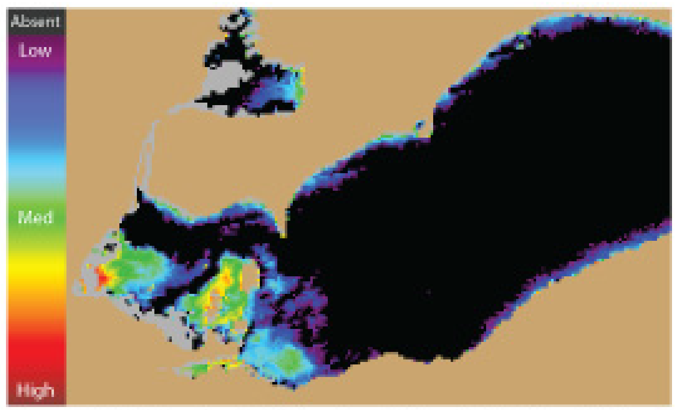


Figure 1. MODIS Cyanobacterial Index from 20 August 2013. Grey indicates clouds or missing data. Black represents no cyanobacteria detected. Colored pixels indicate the presence of cyanobacteria. Cooler colors (blue and purple) indicate low concentrations and warmer colors (red, orange, and yellow) indicate high concentrations. The estimated threshold for cyanobacteria detection is 35,000

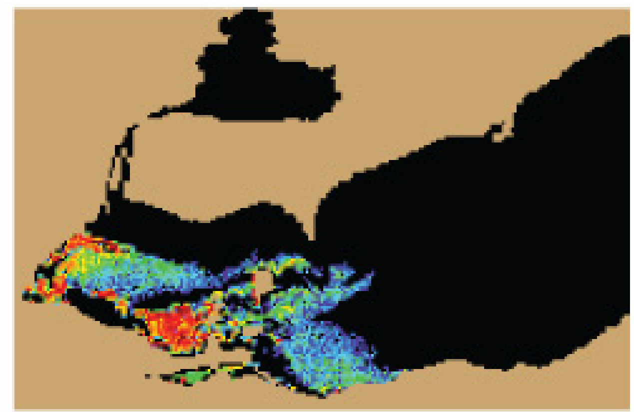


Figure 2. Nowcast position of bloom for 23 August 2013 using GLCFS modeled currents to move the bloom from the 20 August 2013 image.

Over 700 subscribers to bulletin

Copernicus: ESA Earth Observation Program
Sentinel Missions are the lead for the Space Segment

Sentinel-1A/B
(3 Apr 2014, 2016)

C-band synthetic aperture radar (SAR)

Applications:
- Sea Ice/Cryosphere
- Marine winds and waves
- Oil spills
- Ship detection
- Coastal monitoring, etc.

Sentinel-2A/B
(2015, 2017)

Optical imagery -13 bands for land observation (MSI)

Applications:
- Land management
- Biomass
- Water management
- Urban Mapping

Sentinel-3A/B
(2015, 2017)

Sea and Land Surface Temperature Radiometer (SLSTR), Ocean and Land Color Instrument (OLCI), Synthetic aperture radar altimeter (SRAL)

Applications:
- Ocean color and land reflectance
- Sea, land, and ice surface temperature
- Fire monitoring
- Sea surface topography, winds, significant wave height

Sentinel: Experimental Readiness at NOAA

Focus Areas: Sentinel-3 data

- Why is Sentinel-3 data needed?
  - Extensive user needs/requirements, including as documented as part of the NOAA Sentinel Interest Workshop, held August 2011 in Silver Spring, MD
  - Also, “2+1” operational framework: Requirement for ocean color and other data sets to maintain at least two operational sources, with one (experimental) back-up ready to be promoted to operations upon loss of existing data stream
- In this context, Sentinel-3 a/b will provide another source of operational satellite data, *complementing* as well as *augmenting* what VIIRS provides, especially given it has:
  - Global 300 m resolution
  - Mid-morning acquisition
  - Additional spectral bands
- NOAA will in turn contribute to the partnership in numerous ways, including:
  - Provision of VIIRS data to address existing operational gaps following the loss of the Envisat platform in 2012
  - Serving as members of the Sentinel-3 Validation Team (S3VT), with several approved projects (PIs: DiGiacomo; Leuliette); will also provide critical cal/val data sets, e.g., MOBY data to support OLCI vicarious calibration

Sentinel: Experimental Readiness at NOAA

Focus Areas

- Access
- Communications
- Landing Zone
- Dissemination / Distribution
- Algorithm and Data Product Development, Assessment and Science Maintenance, including:
  - Native EUMETSAT core user/mission products
  - NOAA heritage/unique generated products
- Cal/Val
- Applications Development & Collaboration

Sentinel: Experimental Readiness at NOAA

May 2014 Status

- Frank Monaldo: New lead of STAR Data Management Group (DMWG); DMWG facilitating the Sentinel readiness activities.
- Sentinel-1a: Successful launch April 2014. Data flow not yet established – but sample data sets received and processed…
- Telecommunications (EUMETSAT) : Boulder test to occur (June?) to test connectivity between Europe and U.S. via Internet-2; but ultimately link will be via Silver Spring, then…
- Local telecommunications (10Gbit connection; Silver Spring <-> NCWCP): Appear to be installed and ready; not yet tested.
- Landing zone: Storage and server installed and ready.
- Test data sets: Coordination by Phil Keegstra (CoastWatch).
- To do items: Landing zone tests, processing and distribution strategy/tests, requirements summary (all agencies), scope and complete user request(s), level 0 access (e.g., ocean color) still TBD .

Sentinel: Experimental Readiness at NOAA

Overall Project Summary (May 2014)

- Potentially all Sentinel platforms. But S-1 and S-3 emphasis at present.
- S-3 ocean color: Important aspect of the (NOAA) Ocean Color Radiometry Virtual Constellation. JPSS and GCOM-C other elements.
- NOAA STAR Data Management Group. Foci for collaboration.
- Biweekly telecons between US agencies and EUMETSAT & ESA.
- NOAA best effort: Experimental/Pre-operational access, availability and utilization of Sentinel data and products with cal/val support; operational capacity and plans still to be determined.
- Collaborative and opportunistic. Largely bottom up, best effort basis.
- Free and open availability of data / products.
- Expect at least MERIS heritage products for ocean color; but also can /will generate NOAA heritage and unique products via the NOAA MSL12 system.

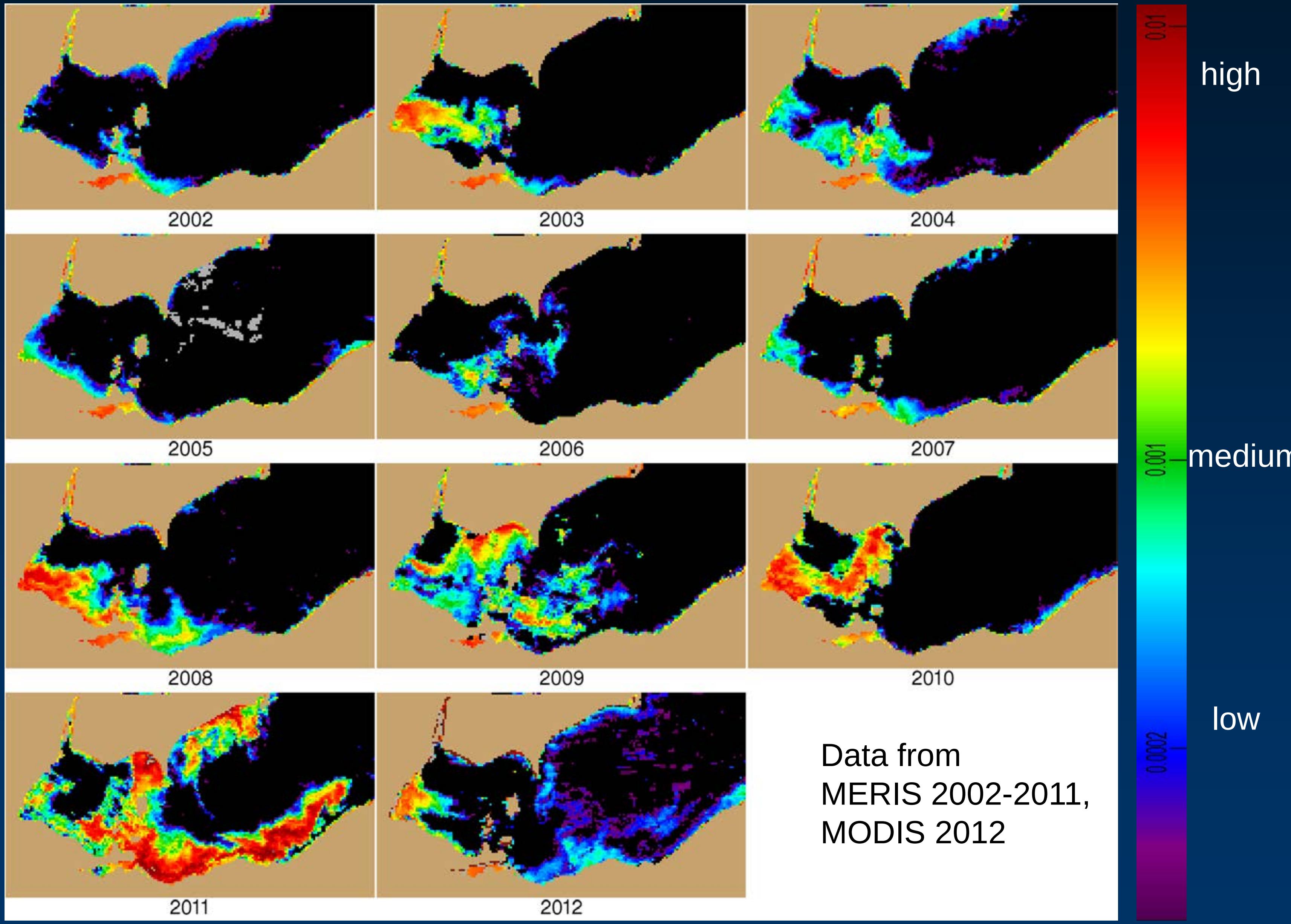
So, the question is…….

So, the question is…….

- How do we (NOAA) proceed with the acquisition, development and (operational) distribution et al. of non-NOAA data (foreign & domestic) in the JPSS (polar)/GOES-R (geo) era in support of user needs?

Backup slides

11 years of satellite data provide bloom extent

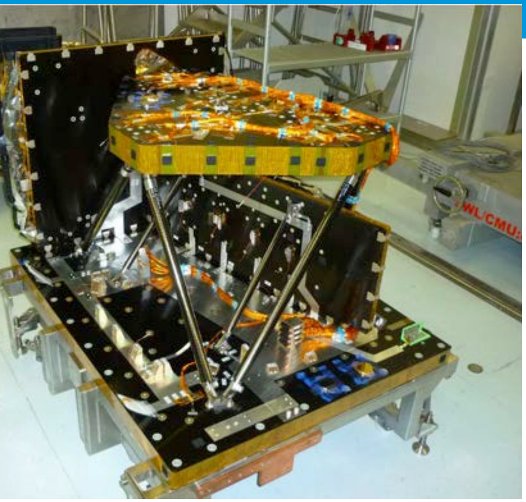


S-3 Payload Data Ground Segment

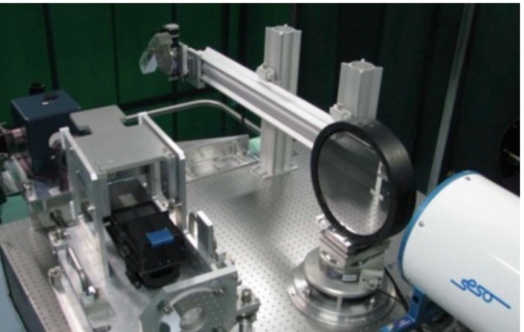
- ❑ **Flight Operations Segment** (Satellite commanding & control)
  - ESA (ESOC) to operate until end of commissioning phase
  - EUMETSAT to operate in routine operations phase
- ❑ **X-band Core Ground Station at Svalbard (Norway)**
- ❑ **Marine Centre at EUMETSAT:** L0 ,L1 ,L2 marine products
- ❑ **Land Processing and Archiving Centres (PAC):**

  DLR (OLCI L2 land), **CLS** (SRAL L2 land), **ACRI** (SLSTR & S-3 SYN)
- ❑ **Topographic & Optical Prototype Processors delivered**
- ❑ **First payload data GS version successfully accepted**
- ❑ **Missions Performance Framework:**
  - Cal/val, quality control, end-to-end system performance
  - Includes MPC (ITT issued), QWG, Expert Support Labs
  - S3 Val Team formed as output of a ESA/EUMETSAT AO for collaborative Validation Proposals ➔ 37 Ocean proposals accepted
  - 1st S3VT meeting in Nov 2013, ESRIN ➔ Consolidate S3VT activities ➔ Draft S3VT Implementation Plan

S-3A OLCI development status



OLCI structure: Camera bench (top), baseplate (bottom) and VAM bench (vertical)

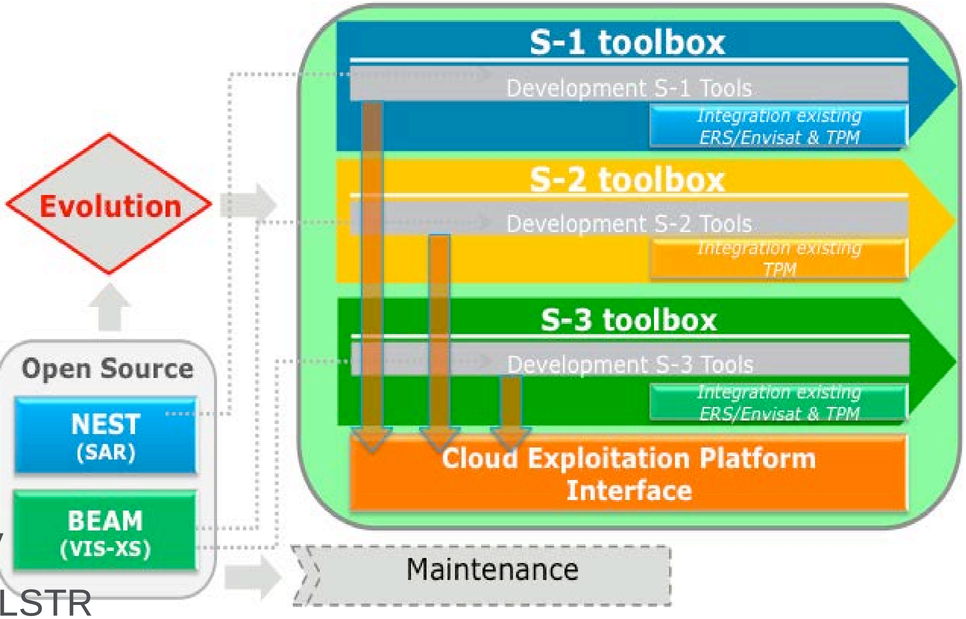


FM3 camera during contrast test on CAAV2 bench

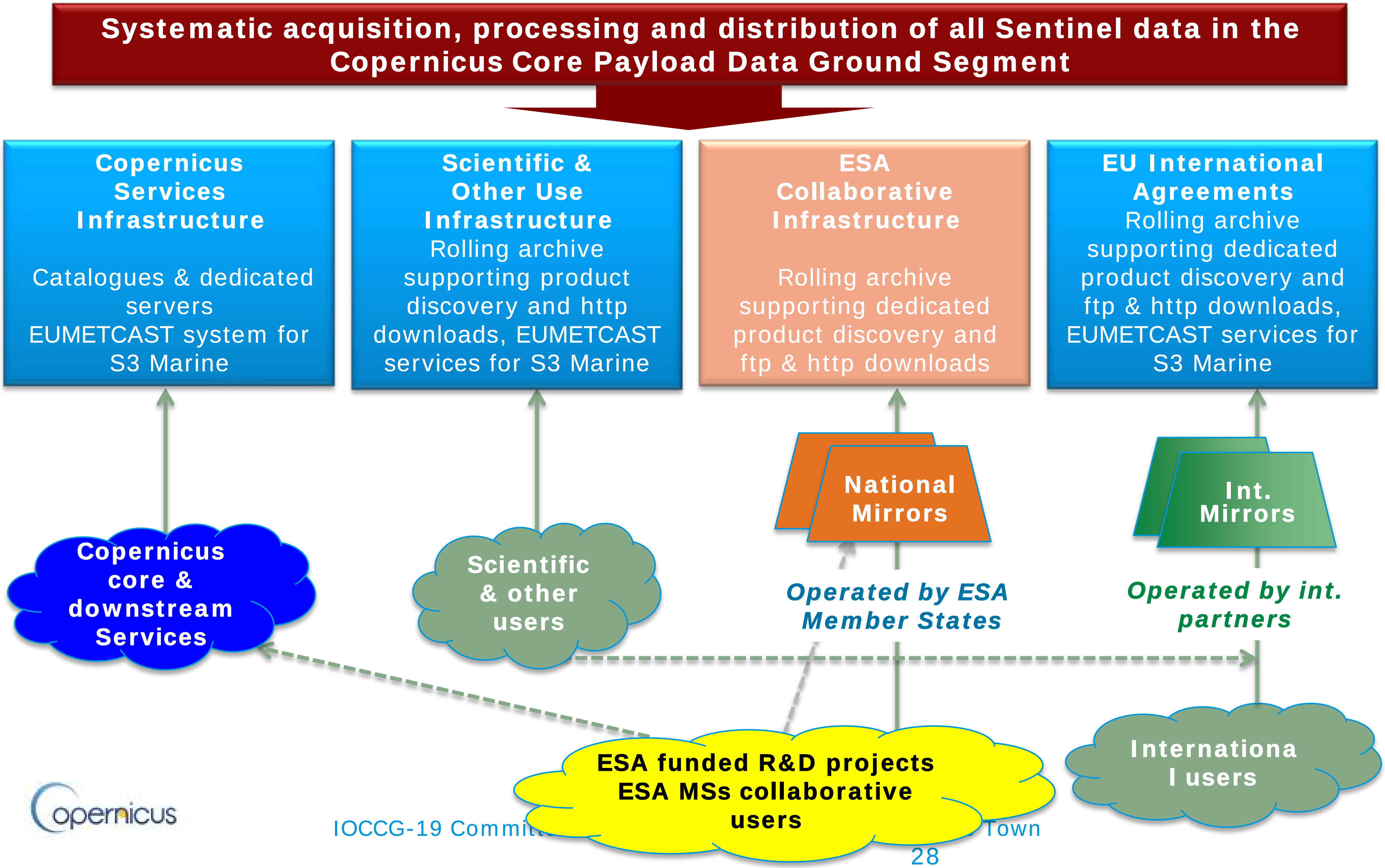
- **Pushbroom Imaging Spectrometer (VIS-NIR) – similar to MERIS, but with improvements:**
  - more spectral bands (from 15 to 21): 400-1020 nm
  - broader swath: 1270 km
  - camera tilt in west direction (12.20°)
  - absolute accuracy 2% (relative 0.5%)
  - polarisation sensitivity < 1%
- **Assembly, Integration & Testing (AIT) for the five cameras completed**
- **Integration of 5 cameras at instrument level on-going**
- **Camera test results reveal overall good level of compliance to the performance requirements → similar/better performances than MERIS:**
  - better spectral dispersion
  - better straylight characterization
  - better inter-channel spatial co-registration

Sentinel Toolbox Development

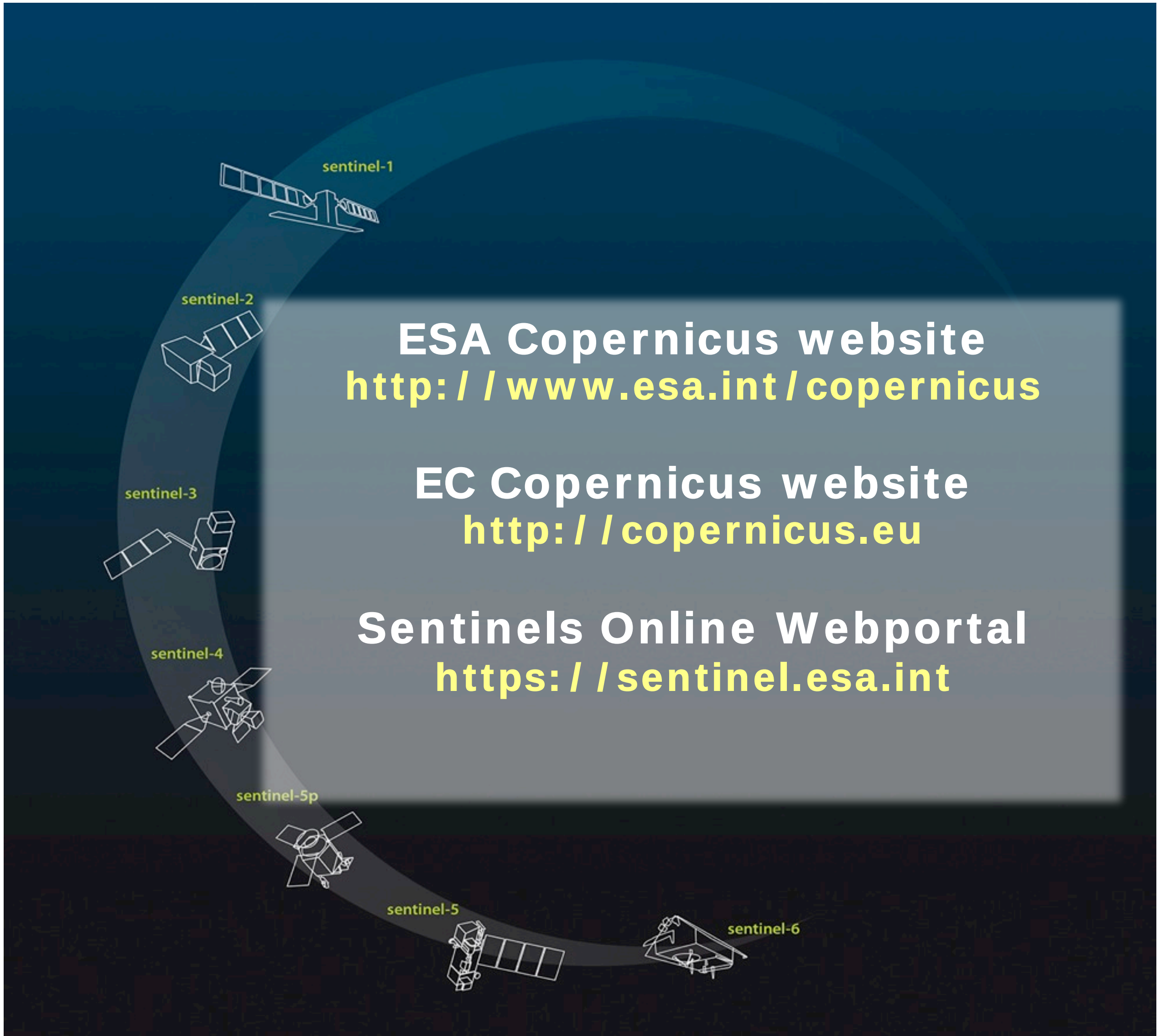
- **BEAM 4.11 (current version)**
- **BEAM 5 release end of March 2014**
  - CoastColour Processor
  - IdePix Processor
  - Optical Water Types Processor
  - LST Processor
  - Python API
- **BEAM maintenance ensured until 1st S3 Toolbox release**
  - Based on BEAM architecture & functionality
  - Dedicated tools and processors for OLCI, SLSTR
  - Direct access to in-situ databases via Data Web Services (e.g. MERMAID, GHRSST)
  - Extension to Cloud Exploitation Platforms for large-scale data processing
  - Interoperability of S-1, S-2 and S-3 Toolboxes
  - Support of VIIRS L1, OCM L1 products by compatible SeaDAS modules
- **TBX development coordination through Developer Forum**
- **First S3TBX release in Sep. 2014**



Data access per user type



More information



ESA Copernicus website
http://www.esa.int/copernicus

EC Copernicus website
http://copernicus.eu

Sentinels Online Webportal
https://sentinel.esa.int

The Importance of Reprocessing and Blending in Coral Bleaching Products:
No satellite is an island, and history is key to understanding the present

C. Mark Eakin
the NOAA Coral Reef Watch Team
and extended partners

Acknowledgements

- Funding provided by:
  - NASA Applied Sciences Program
  - NOAA
    - Coral Reef Conservation Program
    - JPSS Proving Ground Program

Coral Bleaching:
Impact of Climate Change

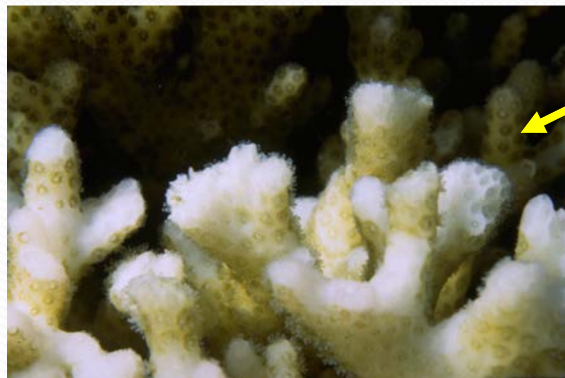
- Most of corals' food comes from photosynthesis

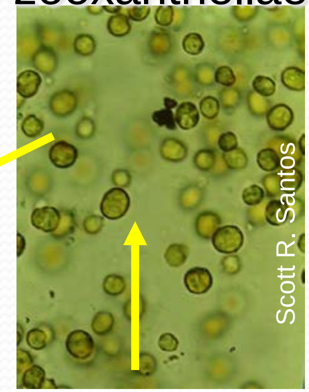
- Corals exposed to high temperatures and/or high light become stressed

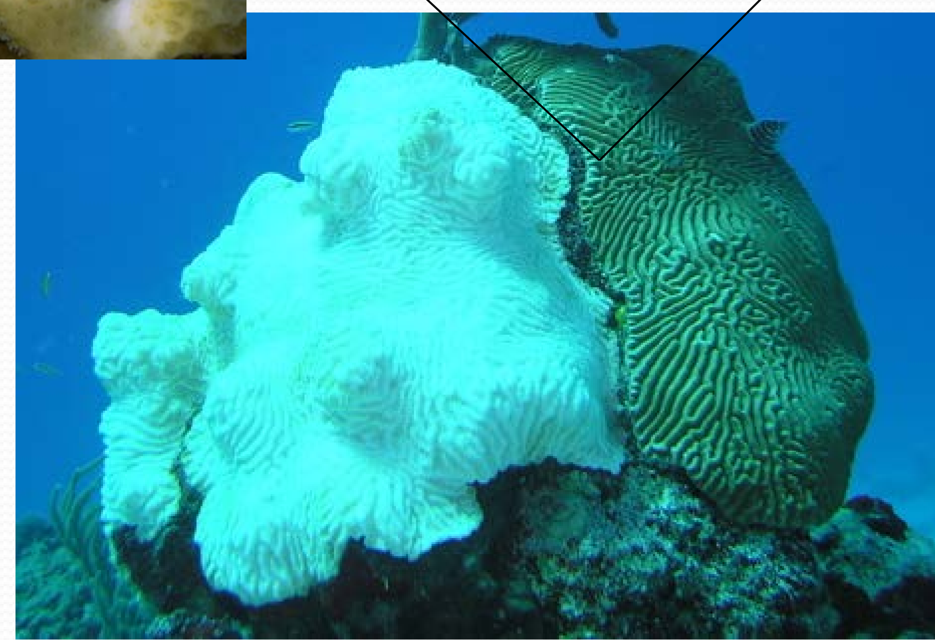
- Corals eject their algae; coral appears "bleached

- If stress is mild or brief, corals recover, otherwise they die

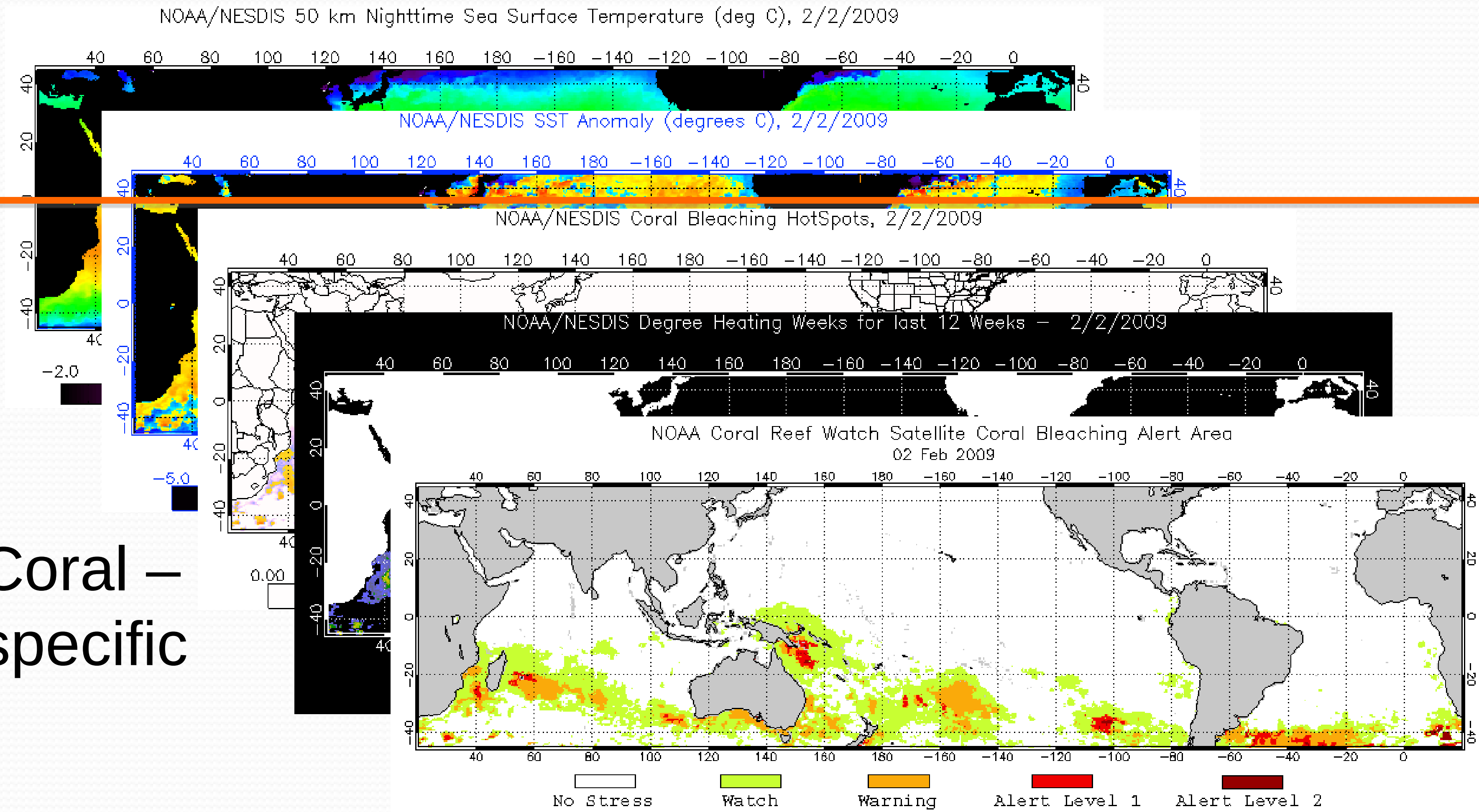
- Mass bleaching covers 100-1000 kms







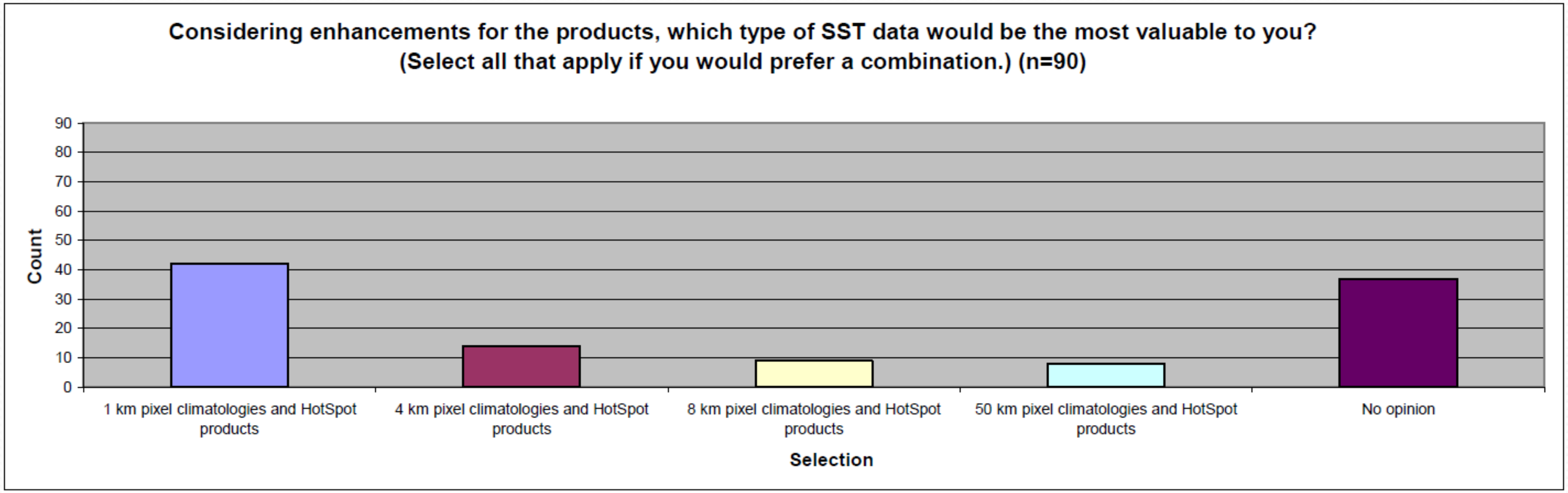
Coral Reef Watch Satellite-Based Products



Coral – specific

Bleaching Alert Areas

User surveys (S. Lynds / CIRES)



Users are interested in higher spatial resolution products

50-km Resolution Operational Global CRW Products based on:

- Climatology: legacy RSMAS AVHRR climatology 1985-1993, omitting 1991-2
- Data: 50-km Operational Nighttime AVHRR (gap-filled)
  - Polar-orbiter
  - 1 scene/day

http://coralreefwatch.noaa.gov/

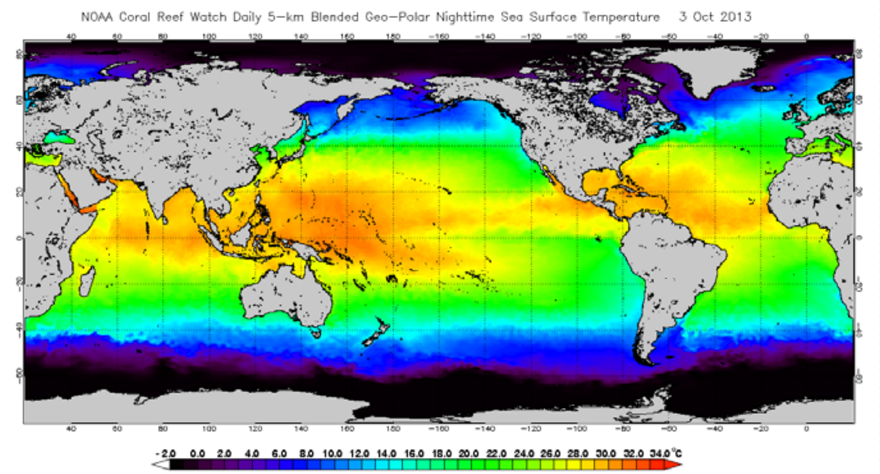
5-km Resolution Global CRW Products based on:

- Climatology: 4-km AVHRR Global Pathfinder – completed April 2014
- Data: 5-km Operational Blended
  - Polar-orbiters + Geostationary (4)
  - Up to 28-100 scenes/day
  - 5th geostationary coming

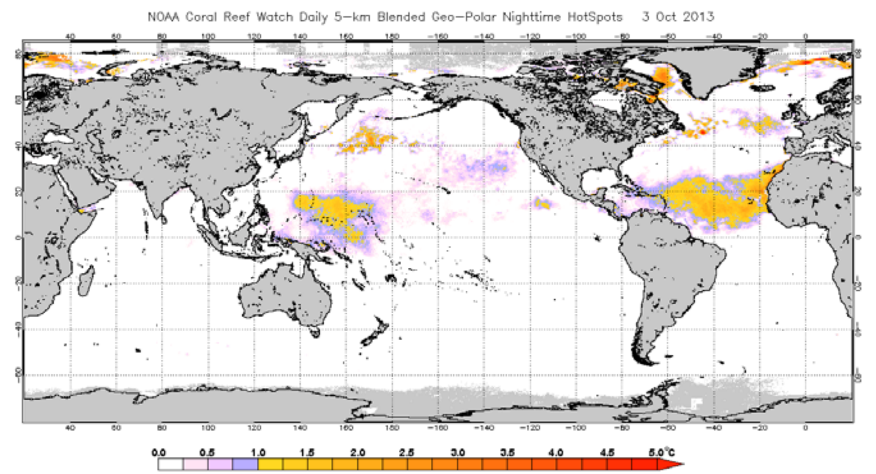
http://coralreefwatch.noaa.gov/satellite/bleaching5km/index.php

5 km – Resolution, Global Coral Thermal Stress Products – Now Live

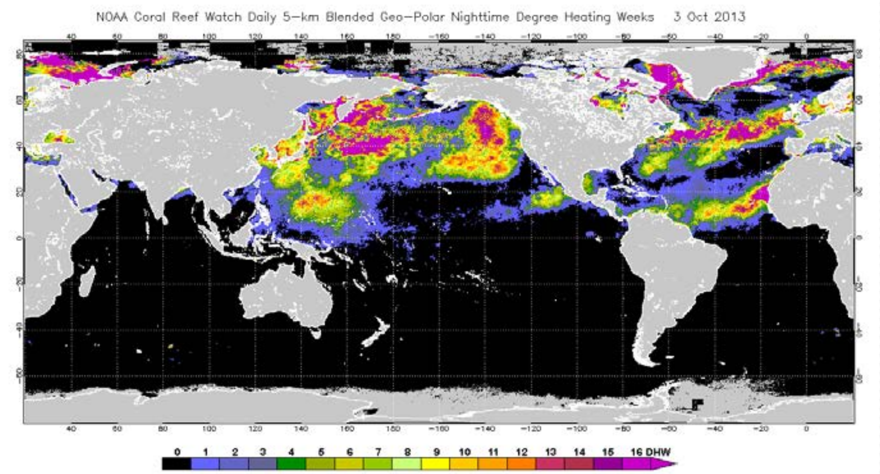
Based on NOAA Operational GOES-POES SST, 10/03/13



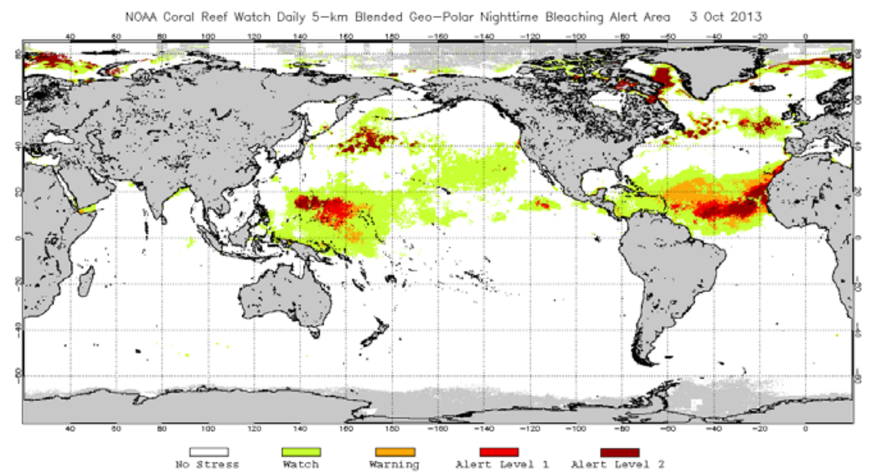
SST



HotSpot



DHW

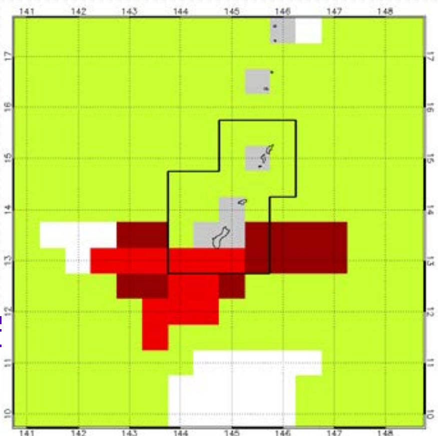


Bleaching Alert Areas

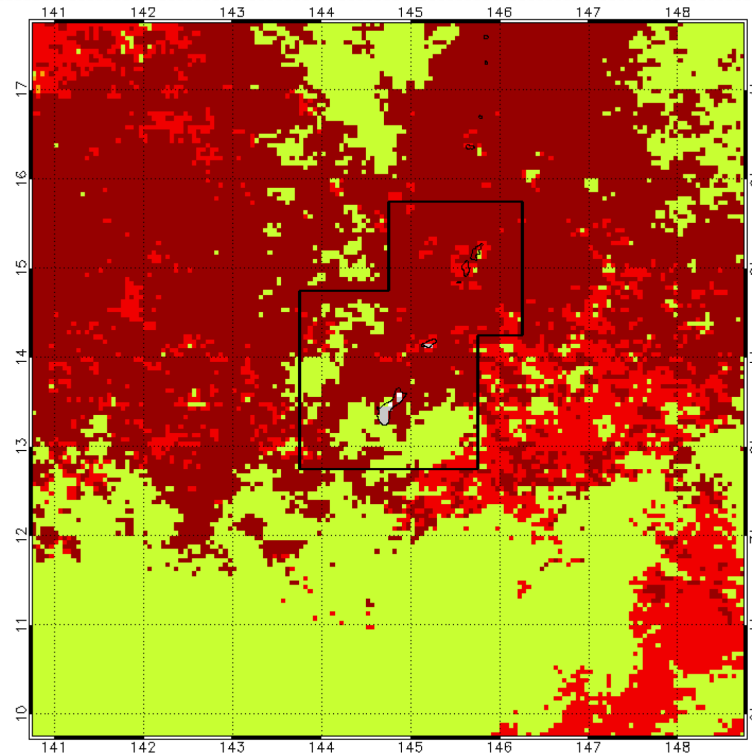
http://coralreefwatch.noaa.gov/satellite/bleaching5km/index.php

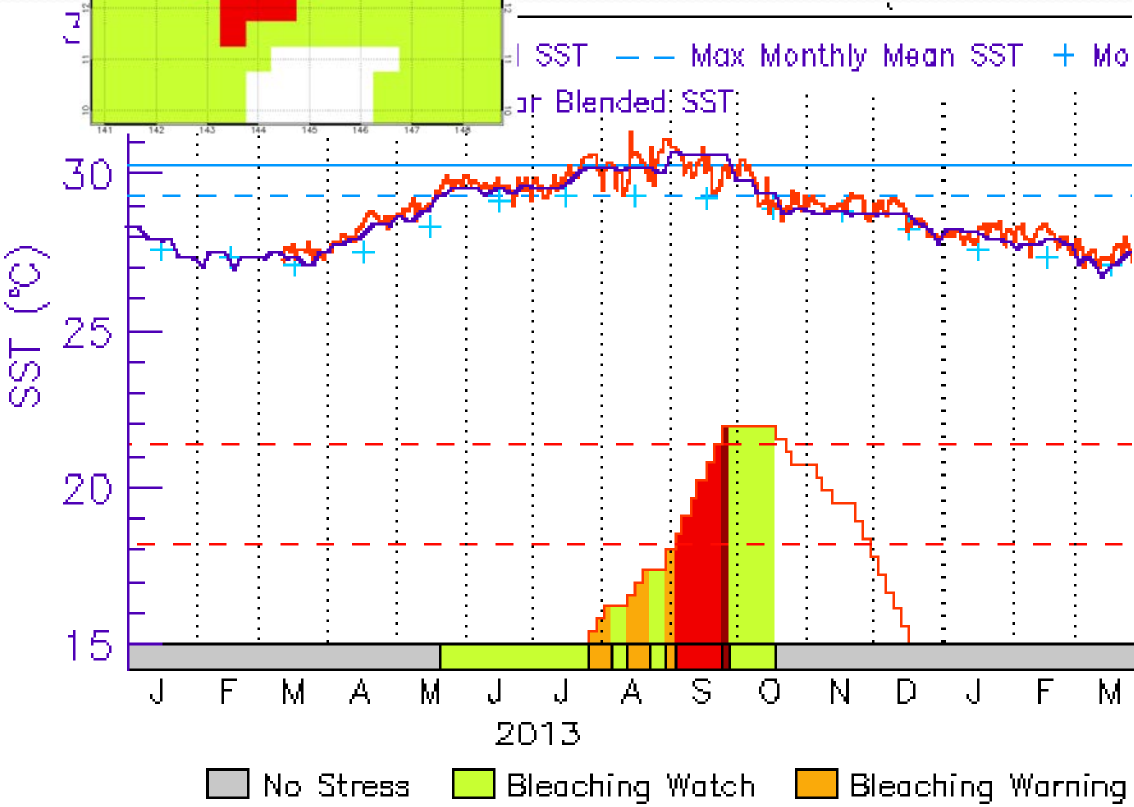
Prototype Regional Alert Products for Guam and Marianas Islands

50-km, 3 Oct 2013

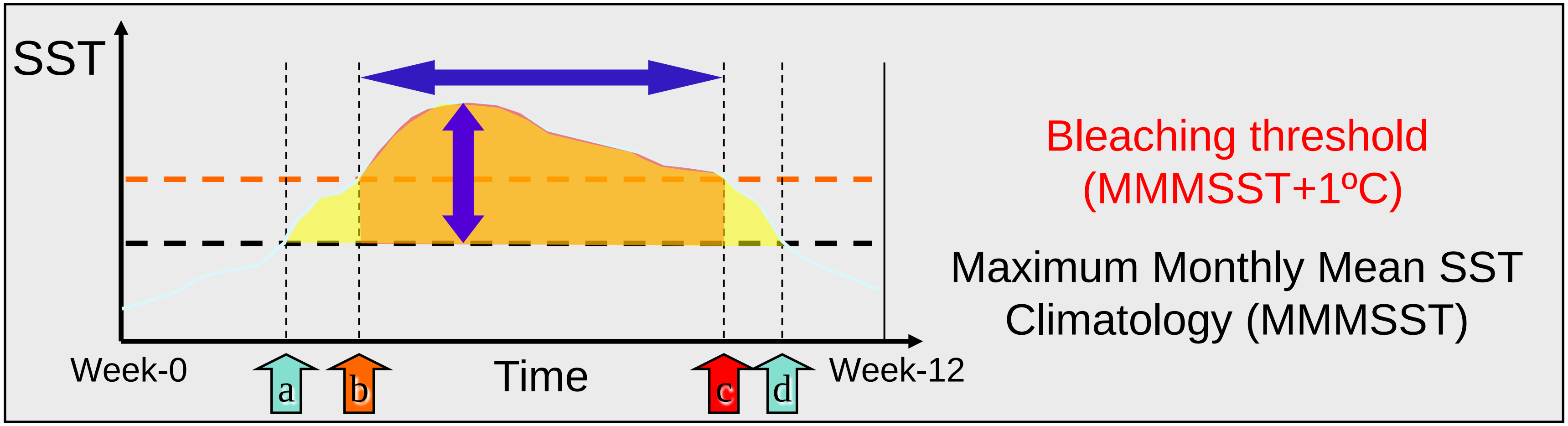


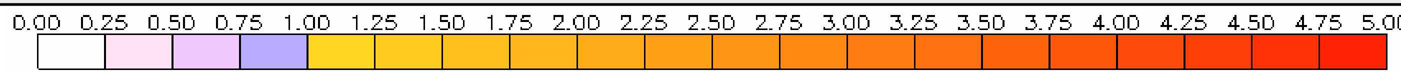
5-km Bleaching Alert 3 Oct 2013

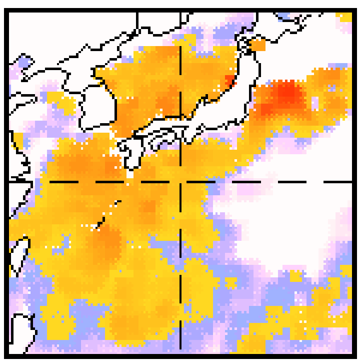




Degree Heating Week Product Algorithm







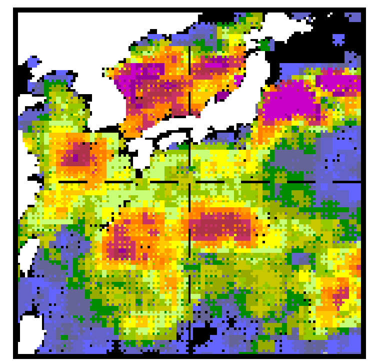
HotSpots

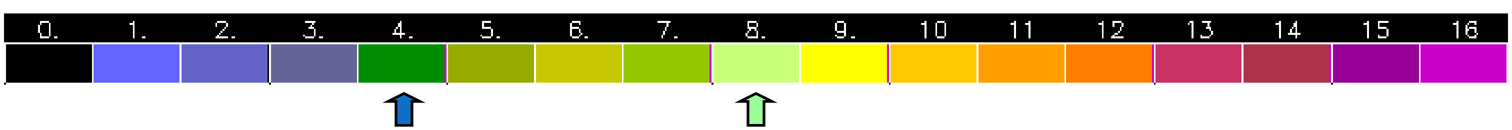
12 weeks

Σ(HotSpot value × duration)

≥ 1°C

Degree Heating Weeks





≥ 4 DHWs coral bleaching is expected

≥ 8 DHWs mass bleaching and mortality are expected

Need for Reprocessing: Lack of Overlap

- Climatology: 4-km nighttime AVHRR Global Pathfinder v5.2
  - January 1981 - December 2012
- Data: 5-km Operational Blended, Nighttime-only
  - available since 12 March 2013
  - day-night available since 27 March 2012
  - 11-km day-night February 2009 – October 2013

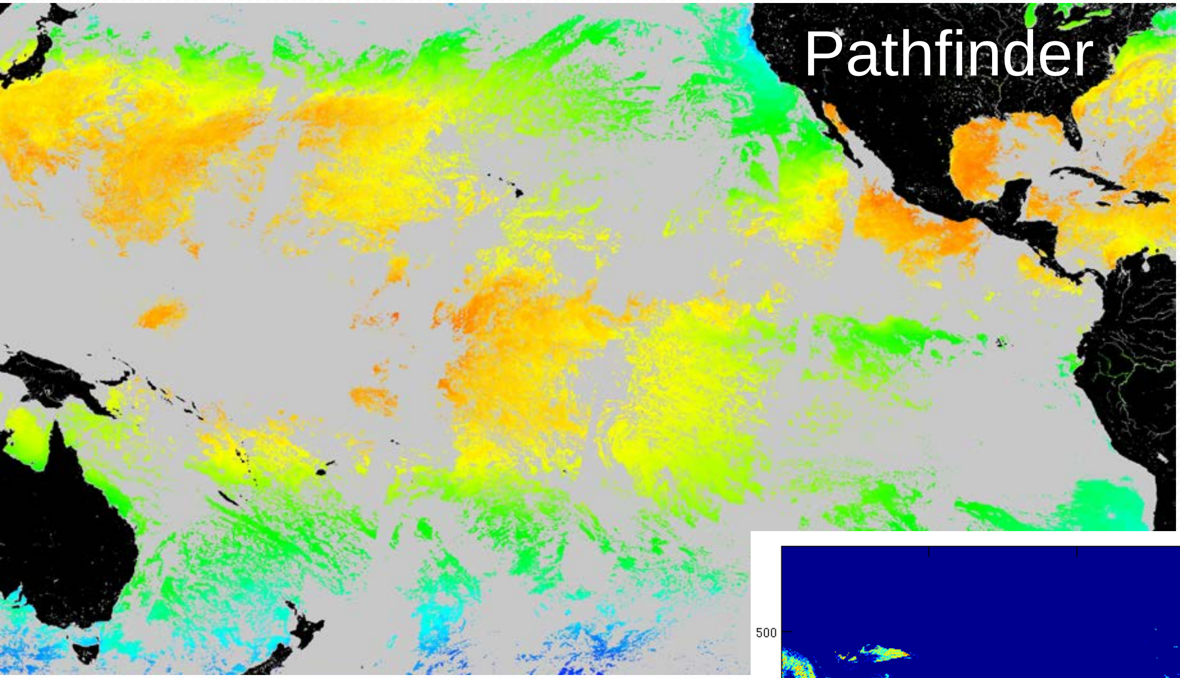
5-km Resolution Global Blended SST Reprocessing:

- 1st funding: 2005 – today
  - Polar satellites
  - Geo satellites & Geo-Polar Blending
  - Purpose: bias-adjust vs Pathfinder
- 2nd funding:
  - Polar satellites 1985 – today
- Seeking funding:
  - Geo satellites & Geo-Polar Blending 1994 – today
  - Purpose: provide consistent climatology and record

Why Blended?

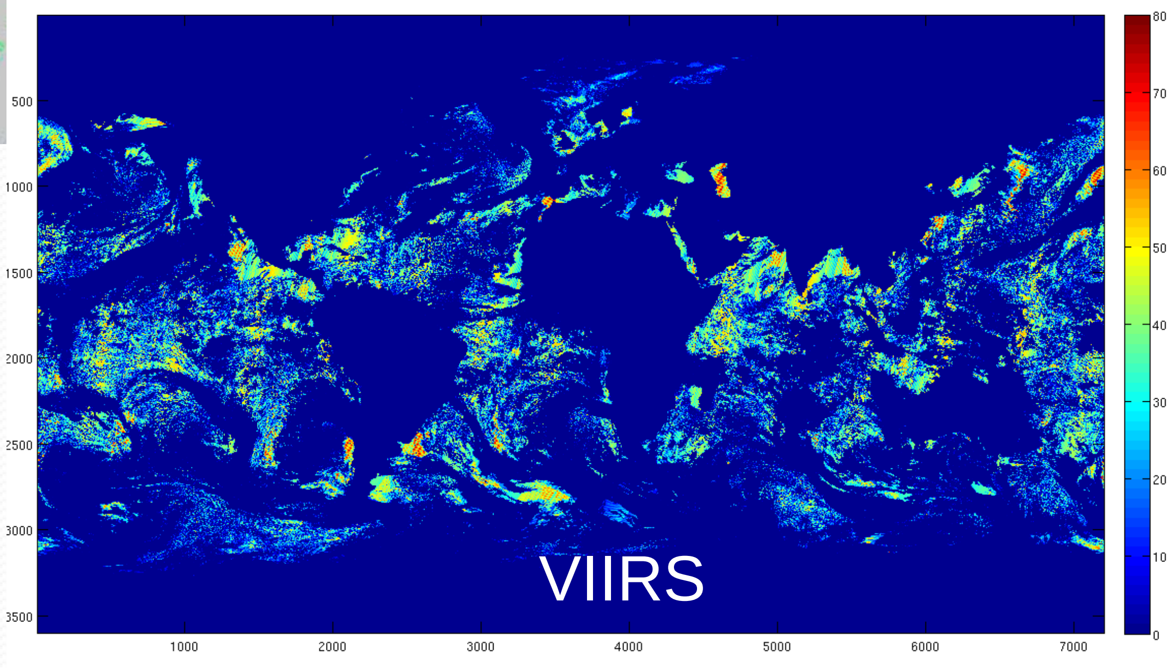
- Data: 5-km Operational Blended
  - Polar-orbiters + Geostationary (4)
  - Up to 28-100 scenes/day
  - 5th geostationary coming
- Polar only: handful of scenes/day
  - Frequent gaps due to cloud cover and other quality issues

Why Blended?



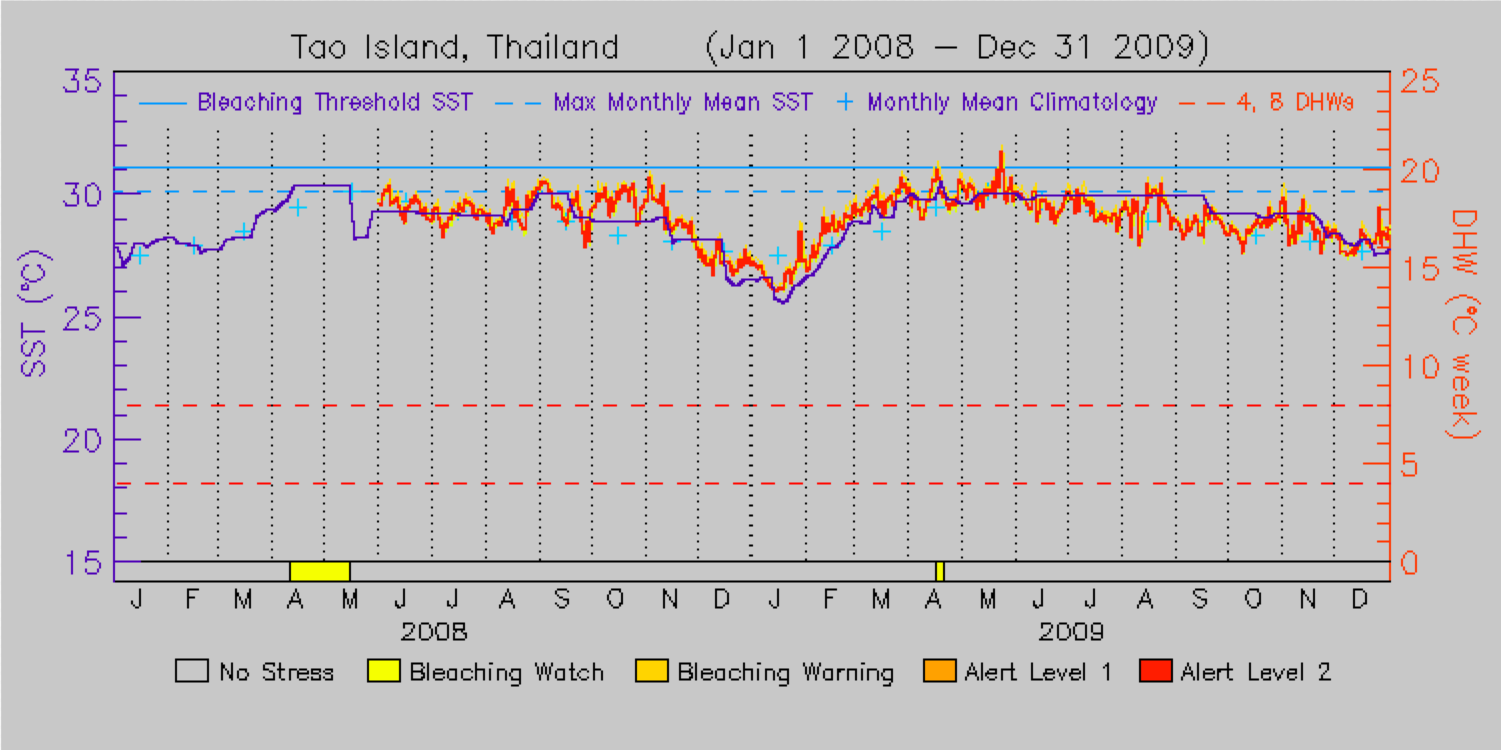
Pathfinder
35°S – 35°N:
12.6% with quality ≥ 4

90°S – 90°N:
7.8% with quality ≥ 4



Why Blended?

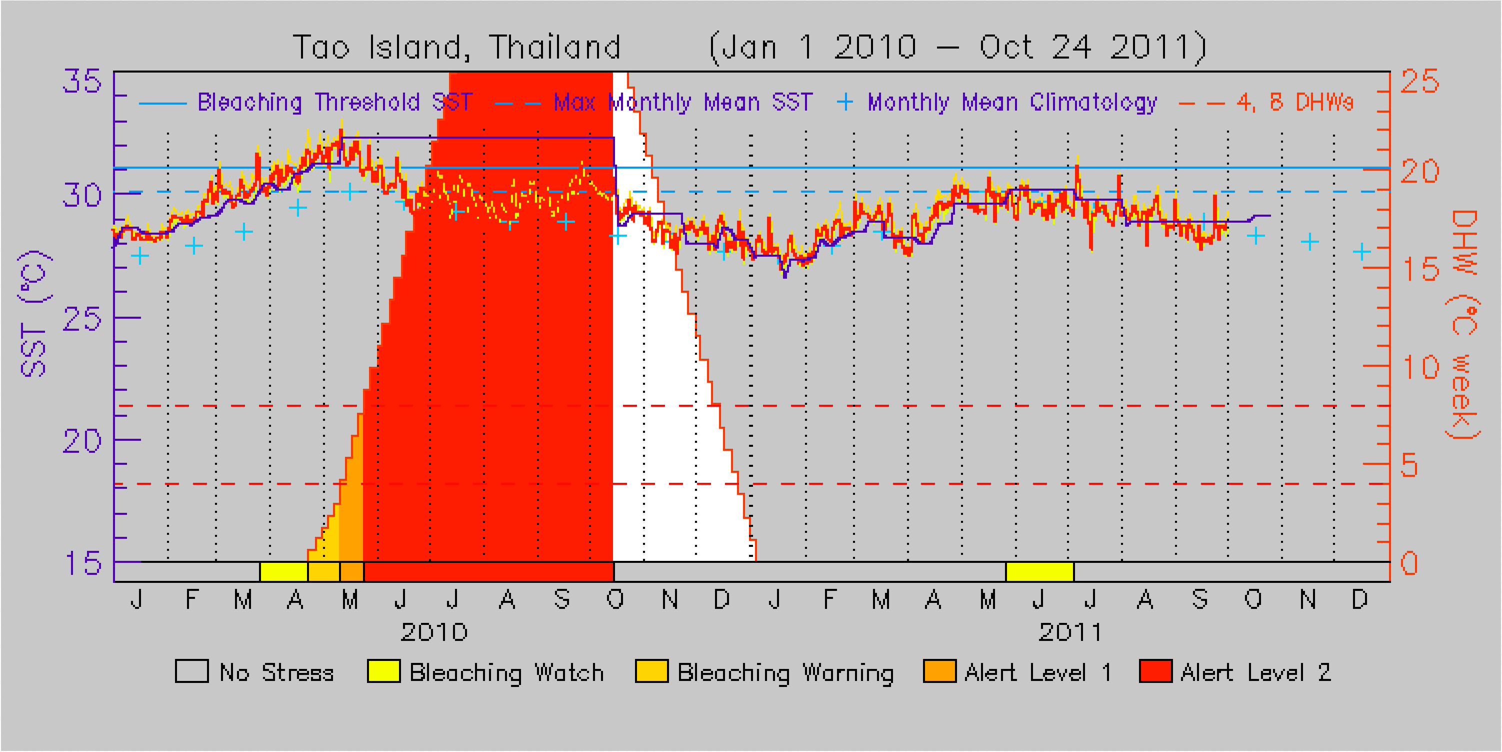
- Particular problems in cloudy regions



- Average years in Coral Triangle: frequent persistent cloud cover

Why Blended?

- Particular problems in cloudy regions



- 2010 in Coral Triangle:

  6-month persistent cloud cover

Why Blended?

- Next Step:

  Develop 1-km Geo-Polar blended SST analysis products for select regions

  VIIRS: 750 m

  GOES-R: 2 km

Linking science and management

- Goal: To improve our ability to alert reef managers around the world of bleaching-level stress, so they can take appropriate actions.

- In the Florida Keys, the CRW products have helped:
  - Guide Rapid Response efforts to assess reef conditions (BleachWatch)
  - Inform the public about what may be happening on the reef when corals are visibly stressed
  - Restrict access to a reef during thermal stress and disease
  - Increase confidence in management decisions

Linking science and management

Florida Department of Environmental Pr
Coral Reef Conservation Progran

SEAFAN BleachWatch Pro

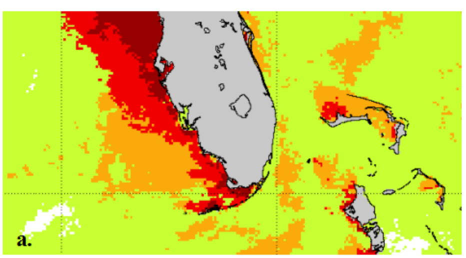
Current Conditions Report #201

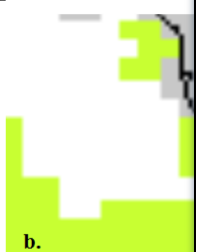
September 4, 2013

Summary: Based on climate predictions and field observations, the threat for
Florida, between Miami-Dade and Martin County, remains **LOW**.

Environmental Monitoring

According to NOAA's Coral Reef Watch (CRW) satellite imagery products; there
southeast Florida, indicating that the region is experiencing a low level of thermal s





No Stress Watch Warning Alert Level 1 Al

Figure 1. NOAA CRW Experimental 5 km Daily Geo-Polar Day-Night Blended Bleaching Alert
Satellite Coral Bleaching Area (b); September 2, 2013.
(a) http://coralreefwatch.noaa.gov/satellite/bleaching5km/index.html, (b) http://coralreefwatch.noaa.gov/satellite/index.php

Mote Marine Laboratory / Florida Keys National Marine Sanctuary

Coral Bleaching Early Warning Network

Current Conditions Report #20130903

Updated September 3, 2013

Summary: Based on climate predictions, current conditions, and field observations, the threat for mass coral bleaching within the FKNMS remains **LOW**.

NOAA Coral Reef Watch Coral Bleaching Alert Area
September 1, 2013 (experimental)

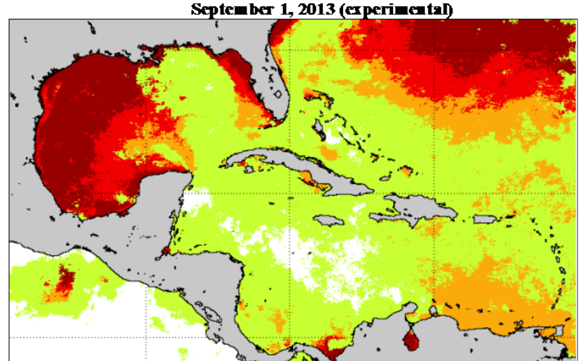


Figure 1. NOAA's 5 km Experimental Coral Bleaching Alert Areas for September 1, 2013.
http://coralreefwatch.noaa.gov/satellite/bleaching5km

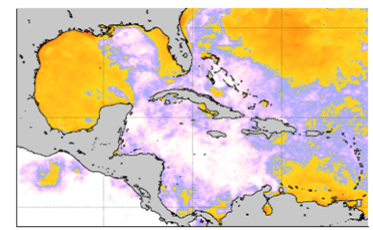


Figure 2. NOAA's Experimental 5km Coral Bleaching HotSpot Map for September 1, 2013.
http://coralreefwatch.noaa.gov/satellite/bleaching5km

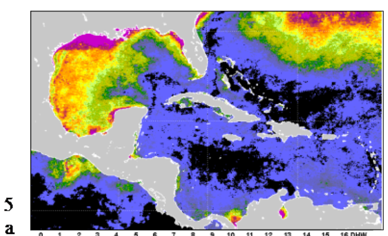


Figure 3. NOAA's Experimental 5km Degree Heating Weeks Map for September 1, 2013.
http://coralreefwatch.noaa.gov/satellite/bleaching5km

Weather and Sea Temperatures

According to the latest NOAA Coral Reef Watch (CRW) experimental 5 kilometer (km) Satellite Coral Bleaching Alert Area, there is currently a bleaching watch for the Atlantic side of the Florida Keys, with the potential for bleaching warnings and alerts if temperatures in the Gulf continue to increase (Fig. 1).

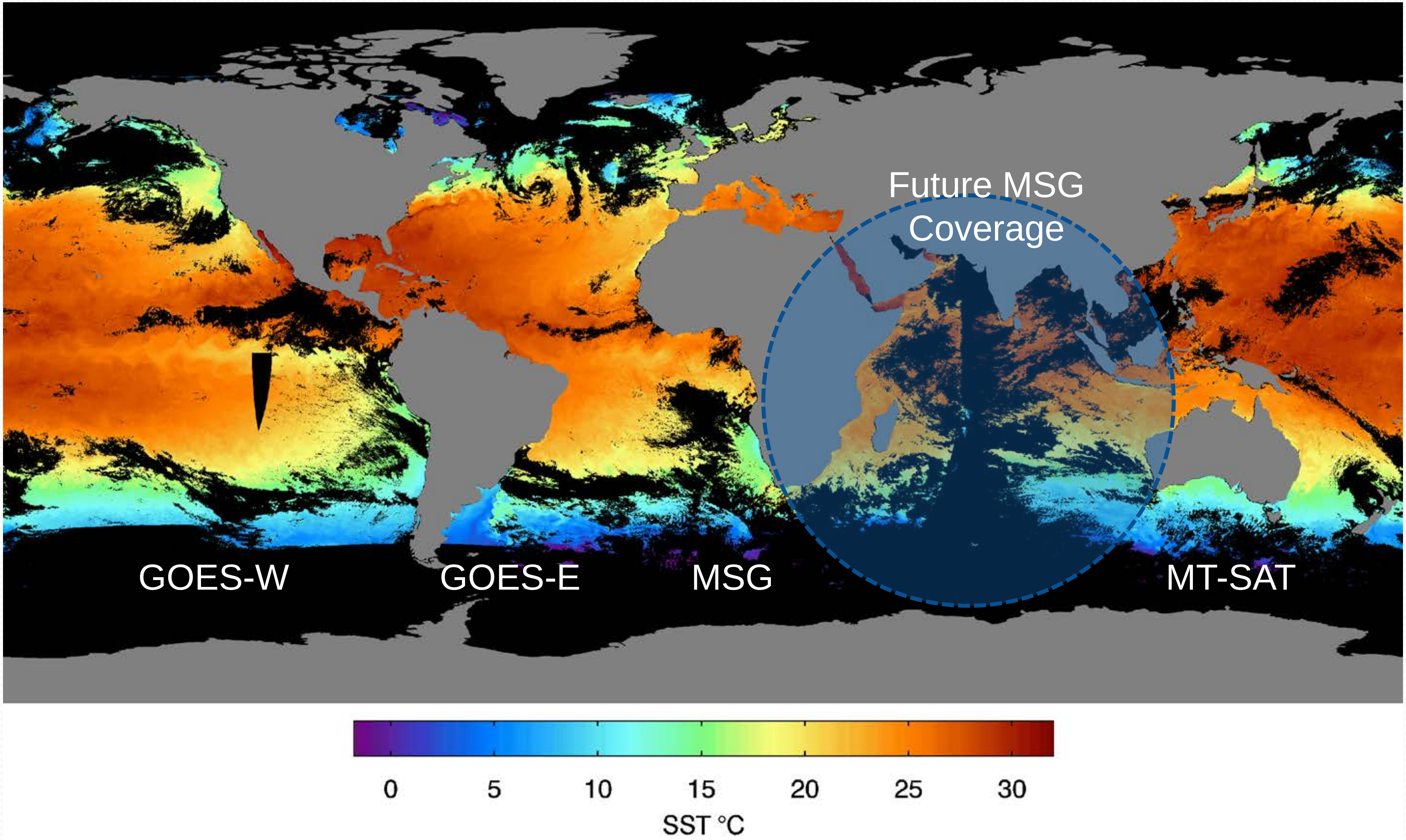
Thank You

The Importance of Reprocessing and Blending in Coral Bleaching Products:

No satellite is an island, and history is key to understanding the present

C. Mark Eakin
the NOAA Coral Reef Watch Team
and extended partners

Geostationary Sea Surface Temperature Coverage

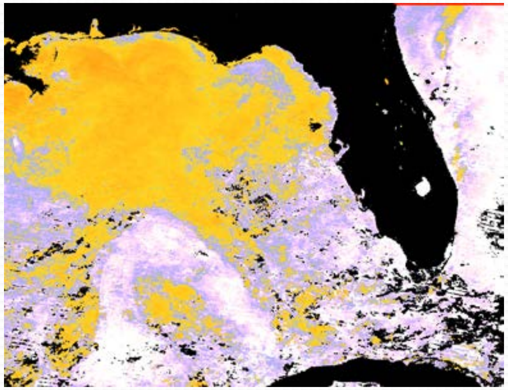


Meteosat Second Generation (**MSG**)-European   Multi-Functional Transport Satellite (**MT-SAT**)-Japanese

1-km Prototype Products based on:

- 4 km AVHRR Global Pathfinder v5.2 climatology
- 1 km MODIS and AVHRR
- Note mismatch in resolution

NASA MODIS HotSpot
Climatology from Pathfinder 4km MMM



http://imars.marine.usf.edu/crw-dss/crw-dss-description

Improving User Utilization of JPSS products

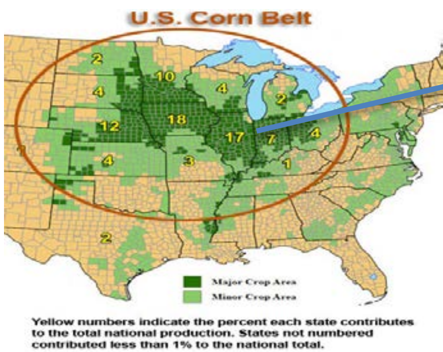
Mitch Goldberg

Higher level products are often needed by users

- Blended product - data fusion – multiple satellites, insitu, etc
- Climatology for anomalies with respect to real-time products
  - Reprocessing - episodic – can be done at STAR, CI, etc
- Non – NOAA data for robustness and for added value - Sentinel 3 for ocean color and SST
- Develop enterprise algorithms and processing systems from multiple data streams
- Research testbed - to demonstrate concepts with user community before operational investments. However initial operational investments are needed to get the data
- Even if a blended product may be the end step, the initial step with a single data type. For example land data assimilation ideally would like a blend geo/leo albedo with high temporal refresh (to account for events such as burn scars) but it may be easier to begin with VIIRS especially if climatology is currently being used.

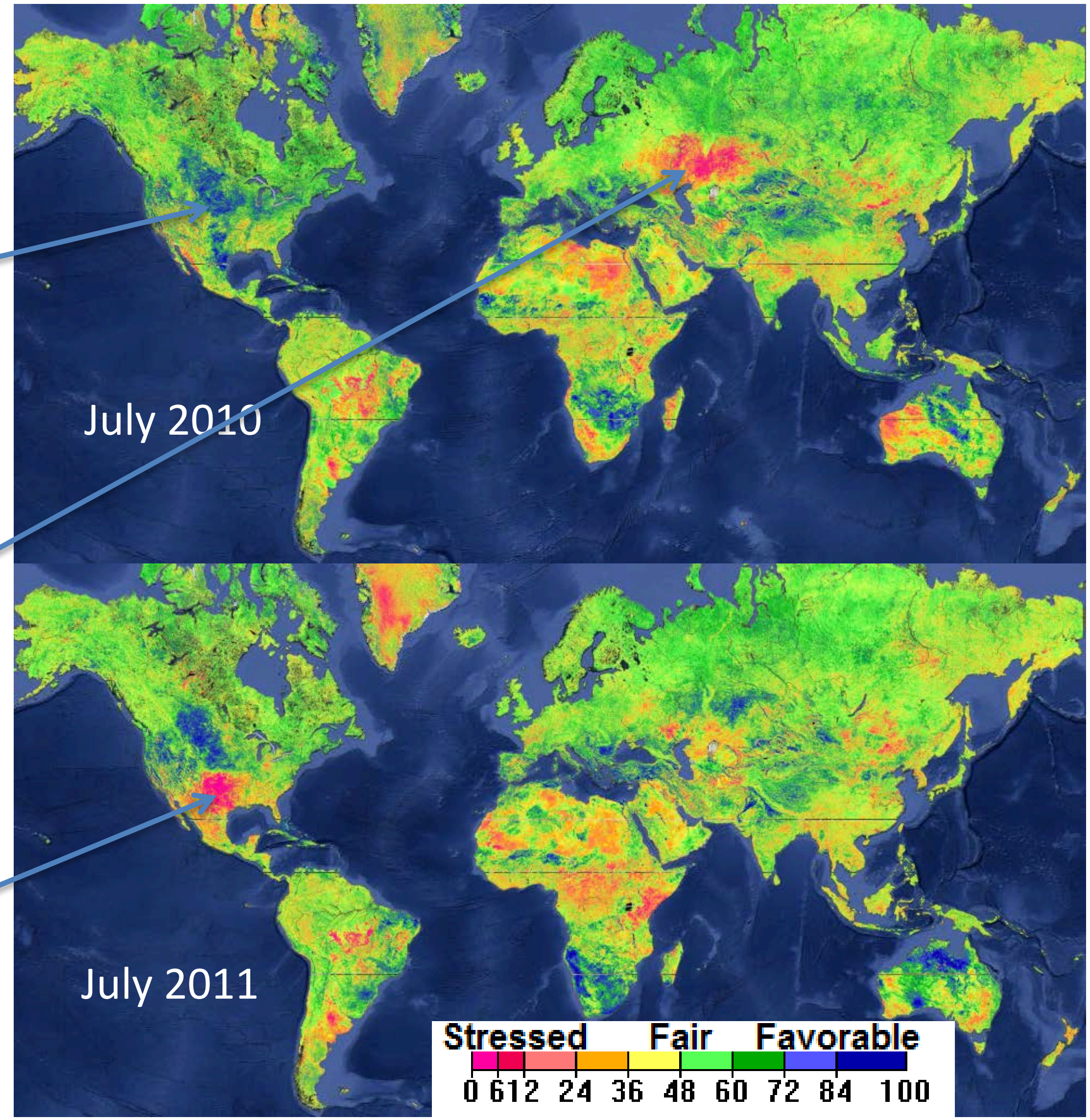
Vegetation Health from AVHRR

IMPACTS:
U.S. corn production in 2010 Hit a record high.



Wheat was down 27% in **Russia**, 32% in **Kazakhstan**, and 19% in the **Ukraine**.

Texas cotton production fell by more than half, from 7.84 million bales in 2010 to 3.5 million in 2011.



Overarching goal

- We want SNPP/JPSS data , combined with other data if needed, to improve NOAA /Partner services.

- We need you the user of SNPP/JPSS data to demonstrate the value of SNPP/JPSS data and if there are issues we want to know and we want to help.

JPSS EDRs

VIIRS (25)

ACTIVE FIRES
AEROSOL OPTICAL THICKNESS
AEROSOL PARTICLE SIZE
ALBEDO (SURFACE)
CLOUD BASE HEIGHT
CLOUD COVER/LAYERS
CLOUD EFFECTIVE PART SIZE
CLOUD OPTICAL THICKNESS
CLOUD TOP HEIGHT
CLOUD TOP PRESSURE
CLOUD TOP TEMPERATURE
GREEN VEGETATION FRACTION
ICE SURFACE TEMPERATURE
IMAGERY
LAND SURFACE TEMPERATURE
OCEAN COLOR/CHLOROPHYLL
POLAR WINDS
QUARTERLY SURFACE TYPE
SEA ICE CHARACTERIZATION
(AGE &CONCENTRATION, proposed)
SEA SURFACE TEMPERATURE
SNOW COVER
SURFACE REFLECTANCE (proposed)
SURFACE TYPE
SUSPENDED MATTER
VEGETATION HEALTH PRODUCT SUITE
VEGETATION INDICES

GCOM AMSR-2 (11)

CLOUD LIQUID WATER
IMAGERY
PRECIPITATION TYPE/RATE
SEA ICE CHARACTERIZATION
SEA SURFACE TEMPERATURE
SEA SURFACE WIND SPEED
SNOW COVER/DEPTH
SNOW WATER EQUIVALENT
SOIL MOISTURE
SURFACE TYPE
TOTAL PRECIPITABLE WATER

OMPS (2)

OZONE TOTAL COLUMN
NADIR PROFILE OZONE
AEROSOLS (proposed)
SO2 (proposed)

ATMS (11)

CLOUD LIQUID WATER
IMAGERY
LAND SURFACE EMISSIVITY
LAND SURFACE TEMPERATURE
MOISTURE PROFILE
RAINFALL RATE
SEA ICE CONCENTRATION
SNOW COVER
SNOW WATER EQUIVALENT
TEMPERATURE PROFILE
TOTAL PRECIPITABLE WATER

CrIS (5)

INFRARED OZONE PROFILE
OUTGOING LW RADIATION
TRACE GASES (CO2, CH4, CO)

CrIS/ATMS (2)

ATMOSPHERIC VERT MOISTURE PROFILE
ATMOSPHERIC VERT TEMPERATURE PROFILE

(GREEN - NOAA-LEGACY PRODUCTS)

Thread Analysis

- **All JPSS products have operational user requirements**

- **Thread analysis provides a description of the use of a given product and the weight of the thread (light, medium, heavy) provides insight on how robust the ground segment must be.**

- **Examples:**

  - 1) NCEP uses CrIS and ATMS SDRs in forecast models, low latency is needed, and its critical that the data flow is continuous, no interruptions -- THICK THREAD - the thread cannot break.

  - 2) NCEP cloud modelers use VIIRS cloud products to validate their cloud models periodically. Latency is not a concern - THIN THREAD - if it breaks, you can fix it later. However if a down stream product requires a thick thread and depends on cloud parameters then clouds become a defacto thick thread.

Basic questions

- Describe how SNPP/JPSS products provide continuity from legacy POES, METOP, DMSP, EOS?
  - Or is SNPP/JPSS a new capability for our application?
- What benefits or improvements do you expect from SNPP/JPSS?
  - Expected impact (low, medium, high) and why?
- Provide Details on:
  - when do you plan to use the SNPP/JPSS Product?
    - Is there an actionable plan?
    - Is it funded?
    - What is the priority?
    - Have you thought about how you will get the data and have you identified the issues with your operational use of SNPP/JPSS ?
  - Are the current legacy products well utilized?
  - Is the SNPP/JPSS product part of a blended product?
  - What additional work needs to be done to ensure that the SNPP/JPSS product is/will be well utilized?

Are enhancements needed for:

- Accessibility (data flow, latency, format)
- Product performance (accuracy, precision)
- User applications (modifications to modeling , decision tools, visualization to use the new products)

For breakout meetings

- Answer the questions on slides 3 and 4
- Report back at 1:30

Breakout groups

- Land data assimilation (Mike Ek, Ivan Csiszar) – Gary McWilliams
- Cryosphere (Sean Helfrich, Jeff Key) – Ray Godin
- Imagery /cloud applications (Michael Folmer, Don Hillger, Heidinger, Bill Ward) – Victoria Ozokwelu and Bill Sjoberg
- CrIS atmospheric chemistry (CO, CH4…) (Monika Kopacz, Chris Barnet) – Laura Ellen Dafoe
- CriS OLR (Pingping Xie, Mark Liu) – Murty Divakarla
- Microwave precipitation (Ralph Ferraro, Limin Zhao Dave Kitzmiller) – Lance Williams
- Ozone monitoring (Craig Long, Larry Flynn) - Wayne
- VIIRS aerosol assimilation (Shobha Kondragunta, Sarah Lu) Julie Price
- Ocean color (Menghua Wang, Rick Stumpf, Cara Wilson, EMC?) – Arron Layns
- SST (Alexander Ignatov, Ken Casey, Bob Grumbine) – John Furgerson