Blending Approaches for SMOPS

Presented by Xiwu Zhan (STAR) & Limin Zhao (OSPO)
Jicheng Liu, Jifu Yin, Li Fang, Mitch Schull (UMD-CICS)

Date: 2018/08/28

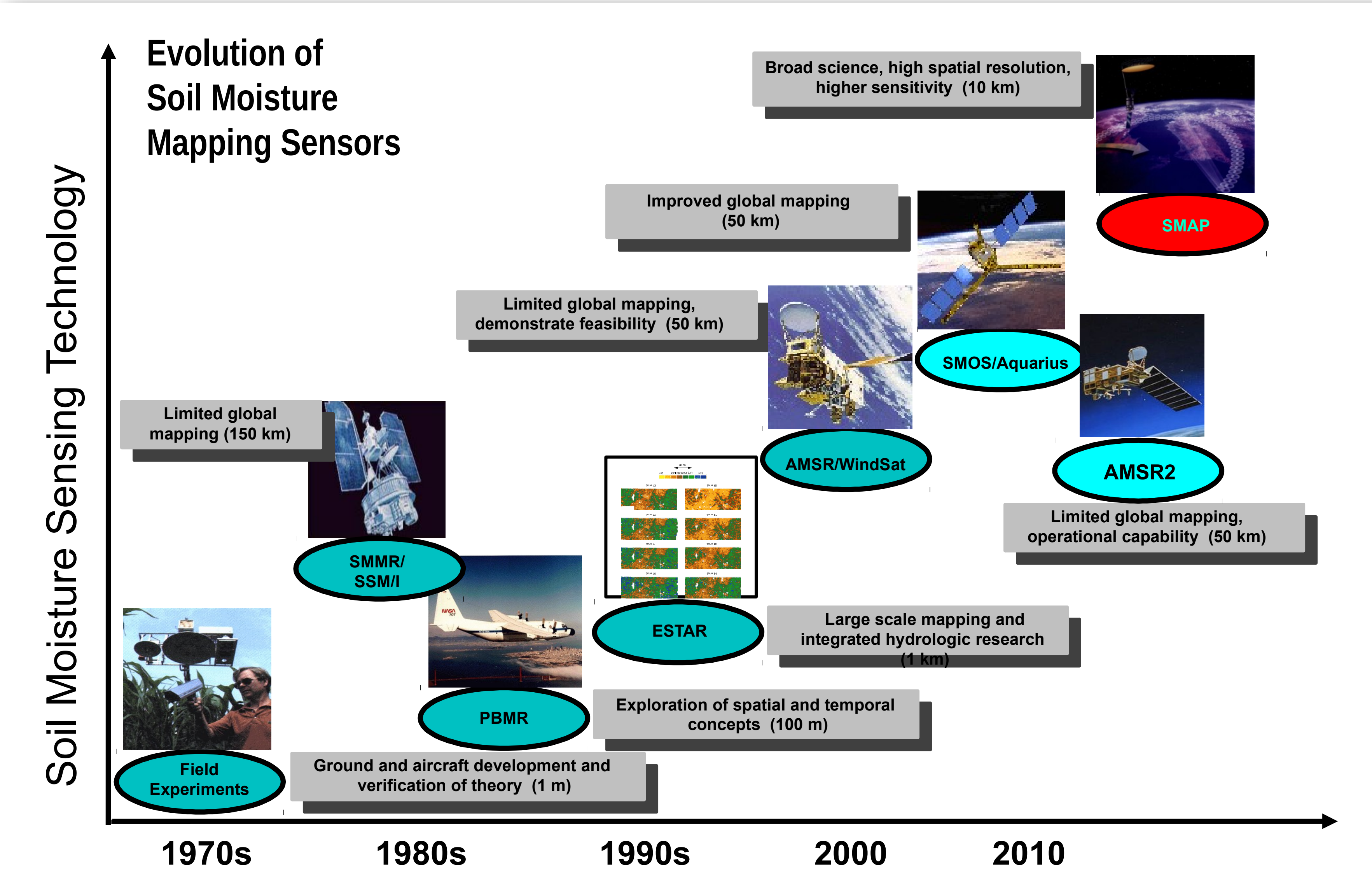
SMOPS Project Team

Name	Organization	Major Task
Xiwu Zhan	NESDIS-STAR	Government Development Lead
Limin Zhao	NESDIS-OSPO	Government Operation Lead
Jicheng Liu	UMD-CICS	Algorithm and Software Lead
Jifu Yin	UMD-CICS	Cal/Val and Application
Li Fang	UMD-CICS	Cal/Val and Application
Stephen Quinn	NESDIS-OSPO	SMOPS Operational Implementation
Nicholas ESposito	NESDIS-OSPO	SMOPS Operational Implementation
Tom Schott	NESDIS-OSGS	PSDI Program Manager (retired)
Ralph Ferraro	NESDIS-STAR	JPSS/GCOM Project Deputy Manager
Paul Chang	NESDIS-STAR	JPSS/GCOM Project Manager
Lihang Zhou	NESDIS-STAR	STAR-JPSS Program Manager

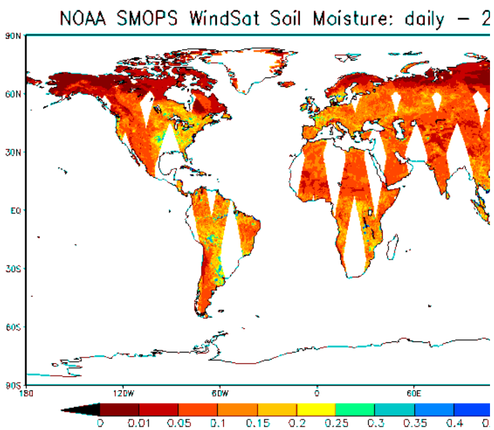
Outline

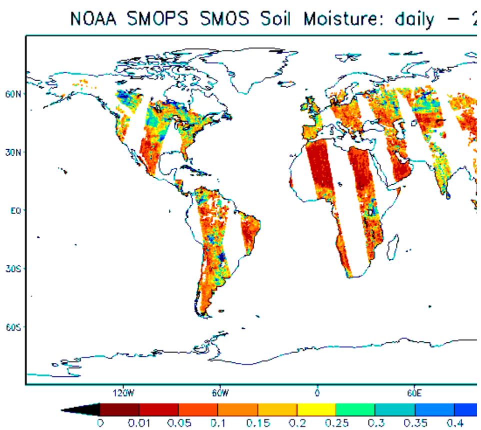
- Why SMOPS & Why Blending
- SMOPS Architecture and Blending Algorithms
  - CDF Matching to count satellite retrieval differences
  - Simple averaging for blending
  - TCEM-based weighting for blending
- Evaluation of the different blending method
- Summary and Path Forward

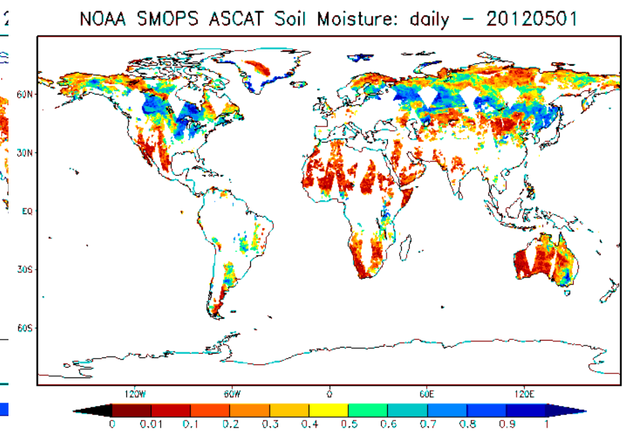
Why SMOPS & Blending



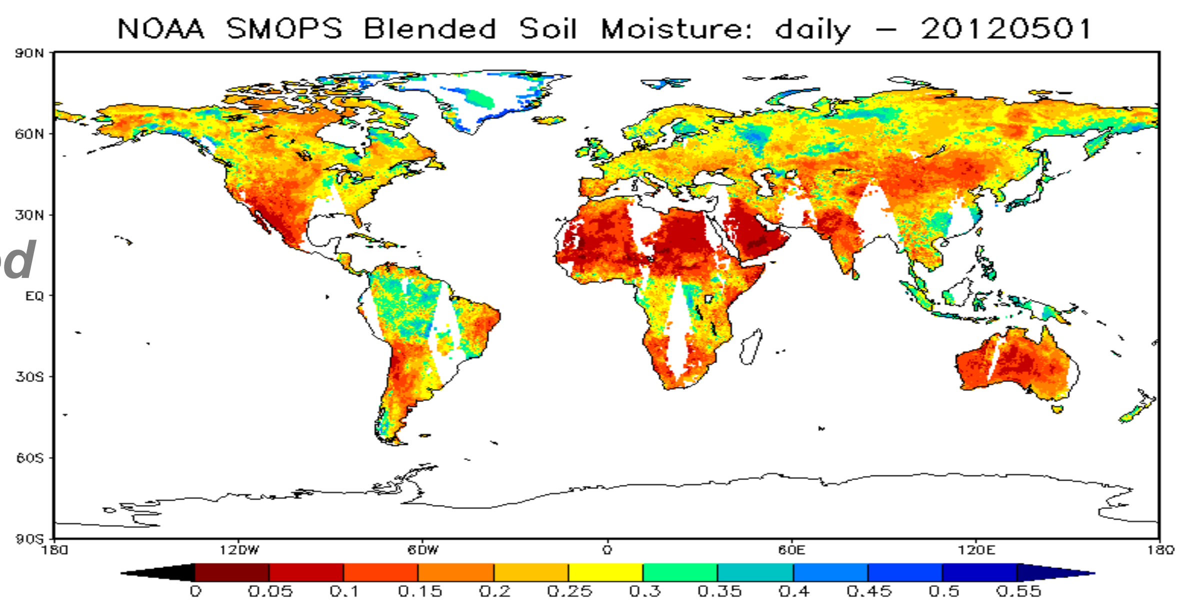
Why SMOPS & Blending



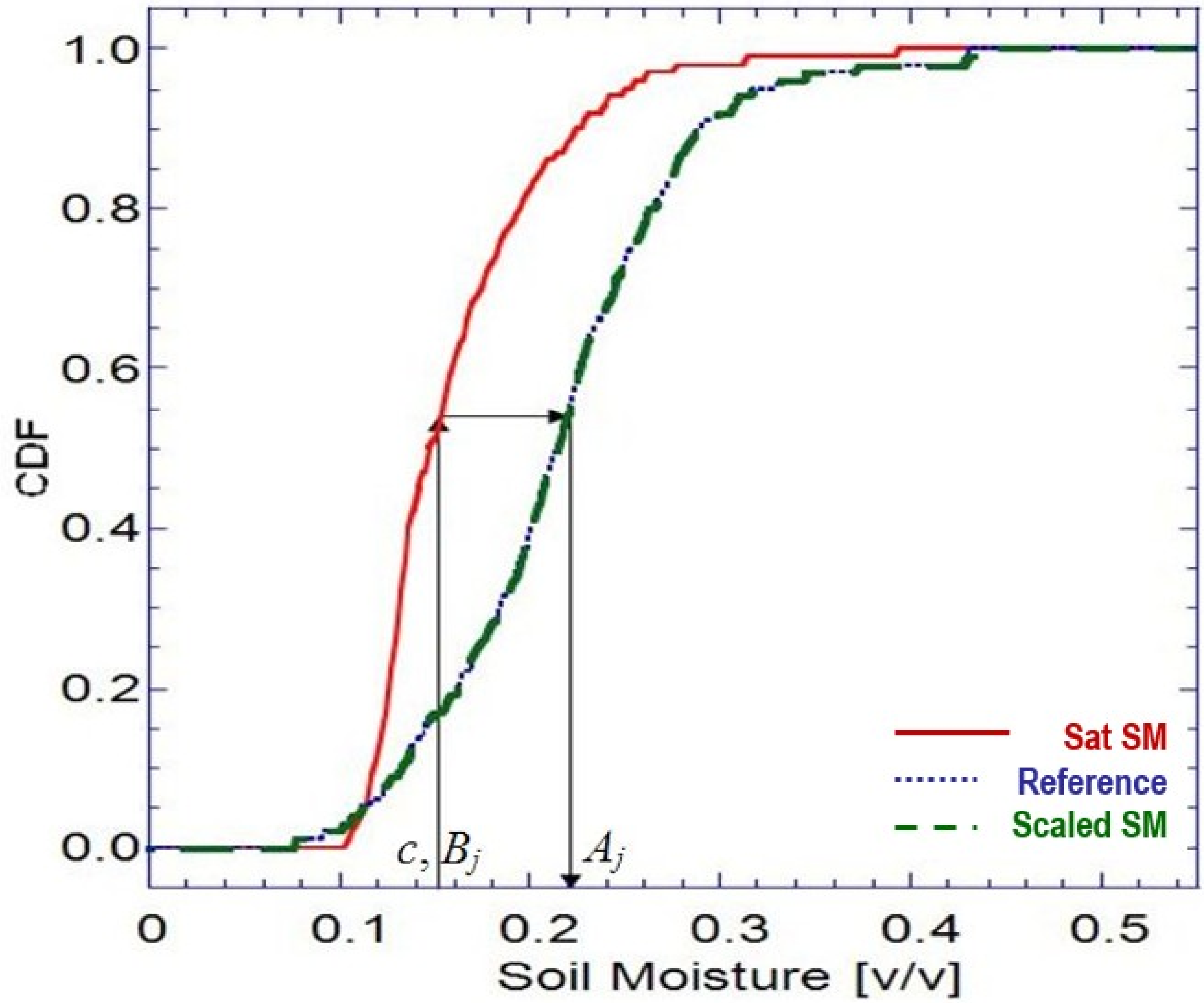




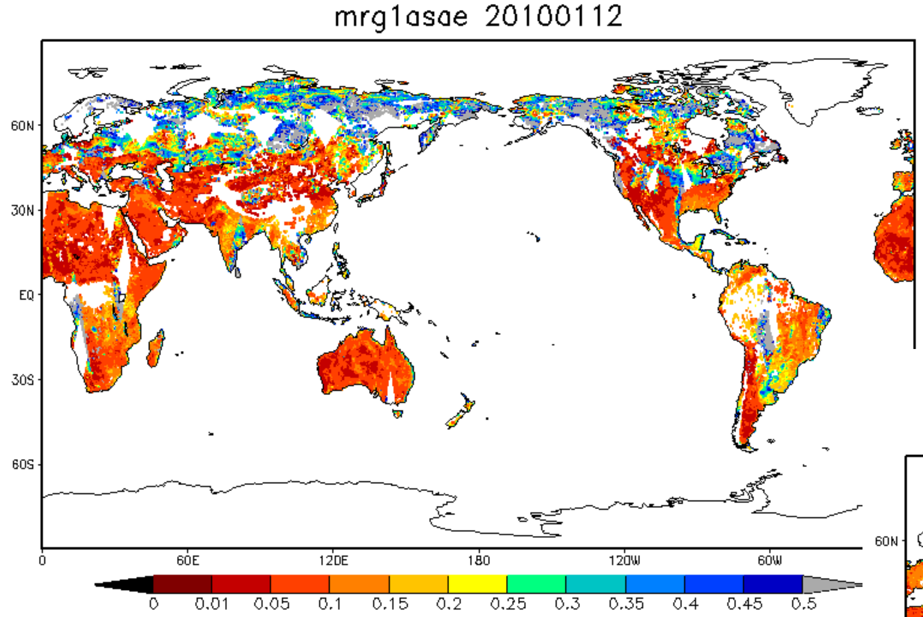
Blended

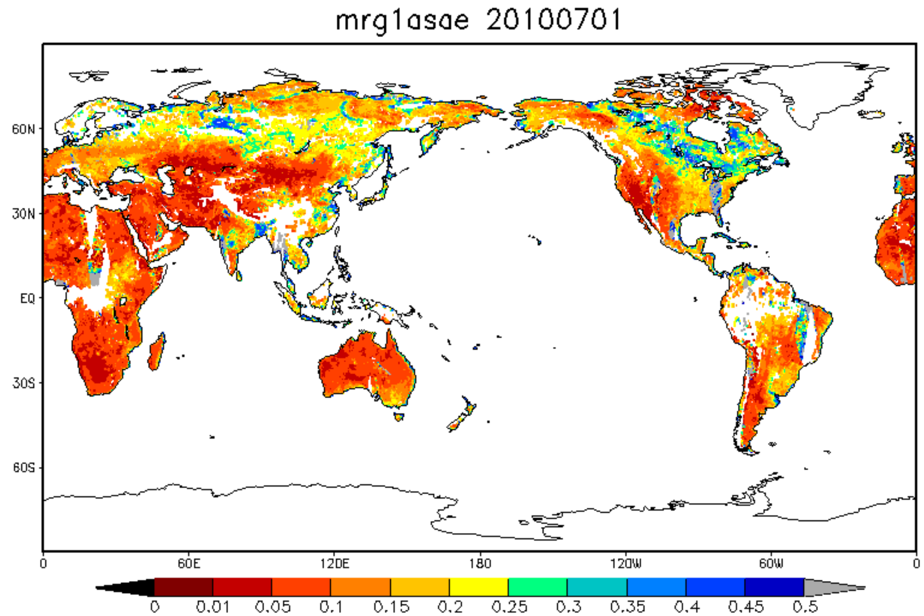


CDF Matching



Simple Average Blending





- Increased spatial coverage
- Multi retrieval variance could be used as error estimate

Weighted Average Blending

Triple Collocation Error Model (TCEM)

Individual SM:

$$\psi_A = \Pi + \mu$$
$$\psi_P = \Pi + \omega$$
$$\psi_G = \Pi + \rho$$

Assuming their error are not correlated:

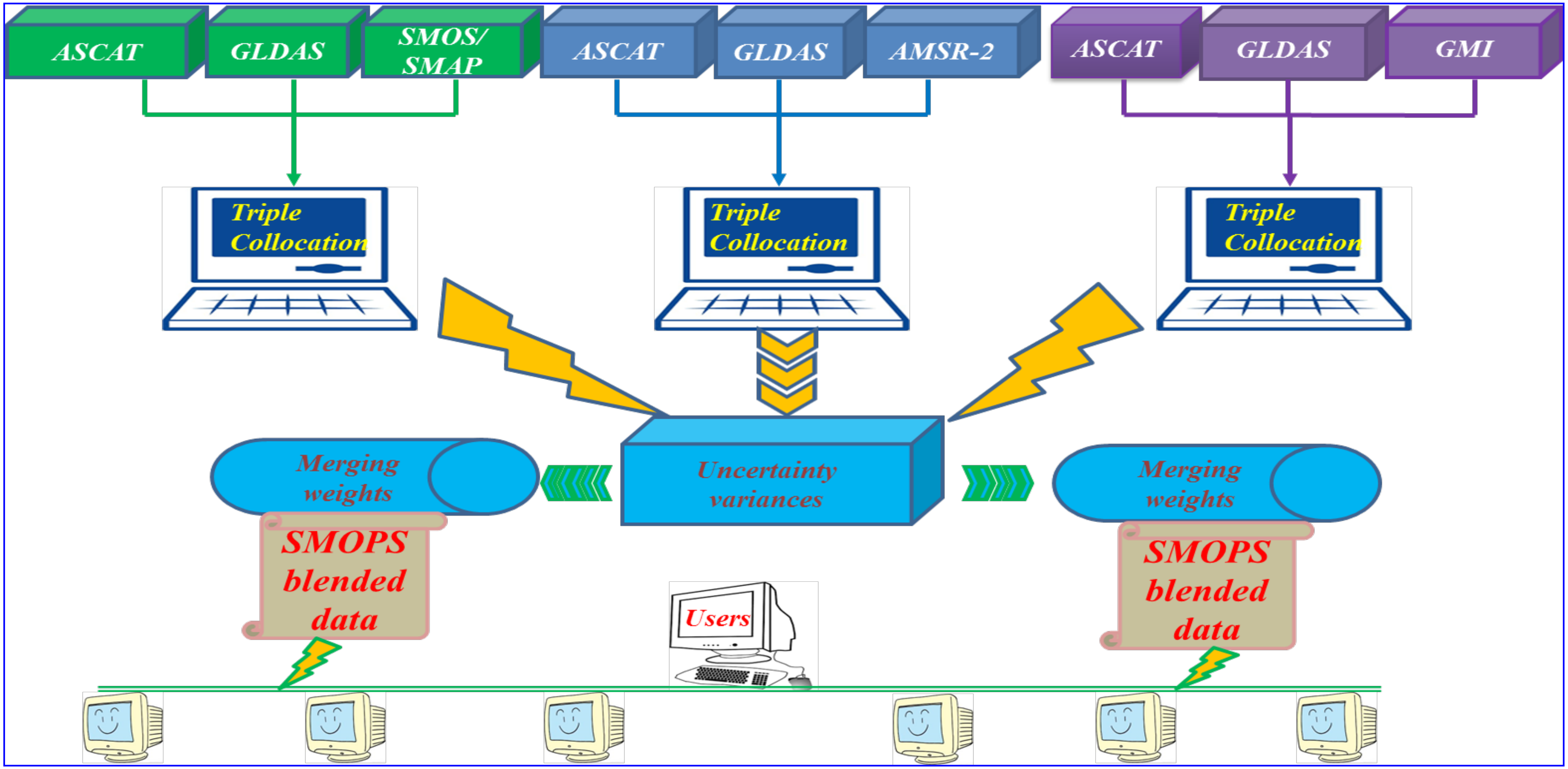
$$\mu\rho = 0, \mu\omega = 0, \omega\rho = 0$$

Then we get their relative RMSE as:

$$\xi_A = (\psi_A - \psi_P)(\psi_A - \psi_G) = \mu^2$$
$$\xi_P = (\psi_P - \psi_A)(\psi_P - \psi_G) = \omega^2$$
$$\xi_G = (\psi_G - \psi_A)(\psi_G - \psi_P) = \rho^2$$

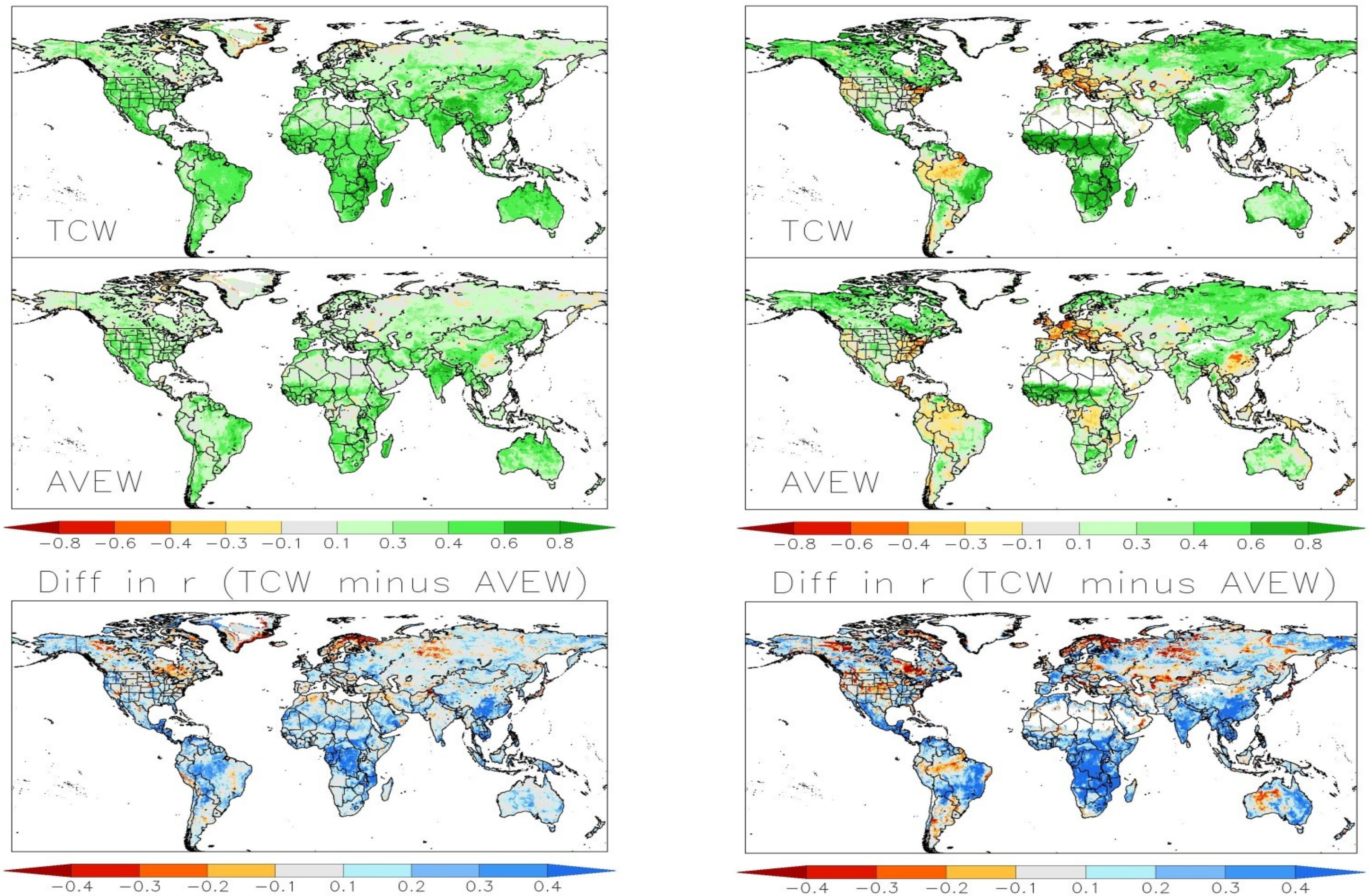
Weighted Average Blending

Triple Collocation Error Model for Blending



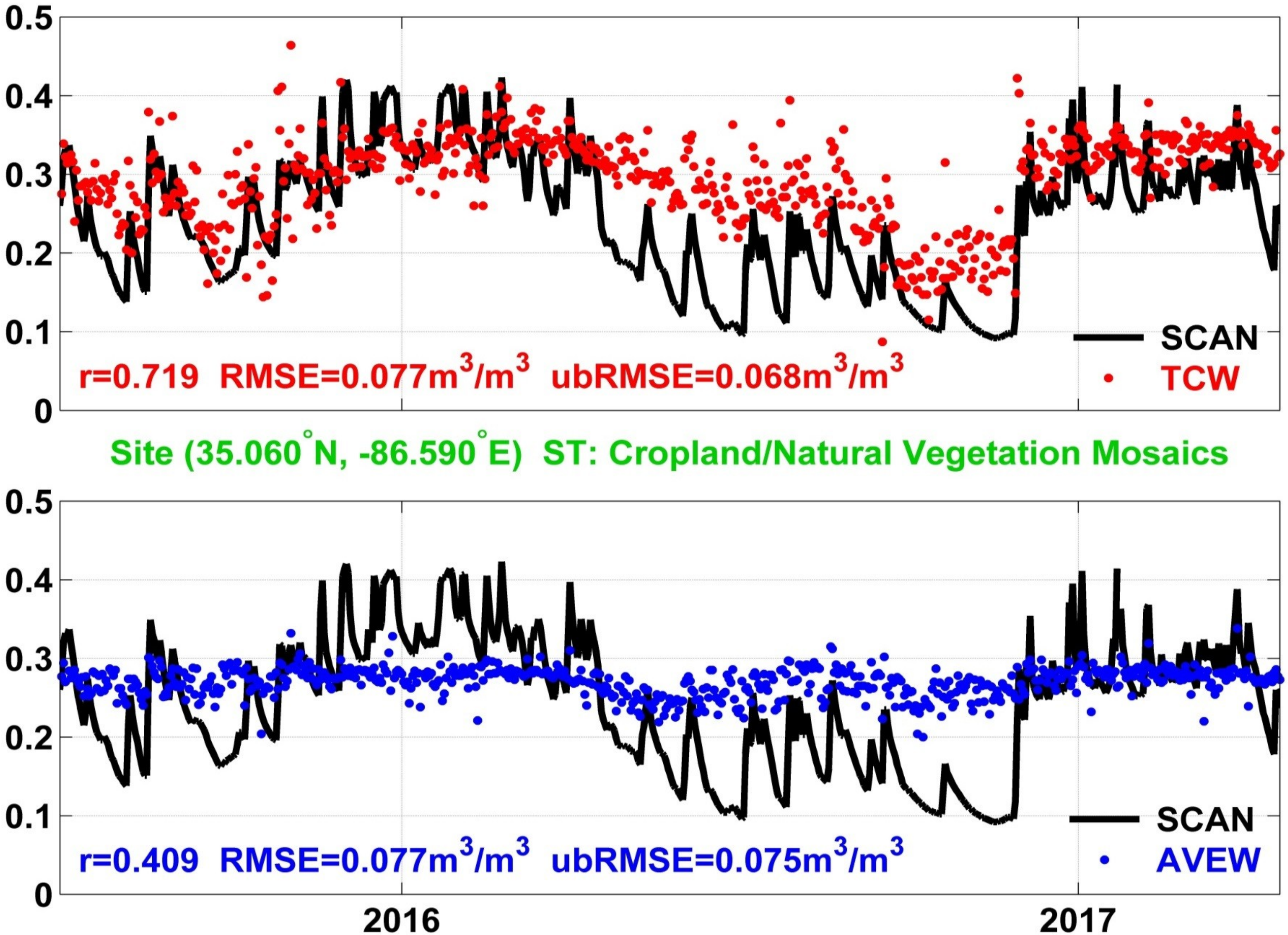
Flow chart describing the TCEM weights-based SMOPS blended SM product.

Blending Method Comparison

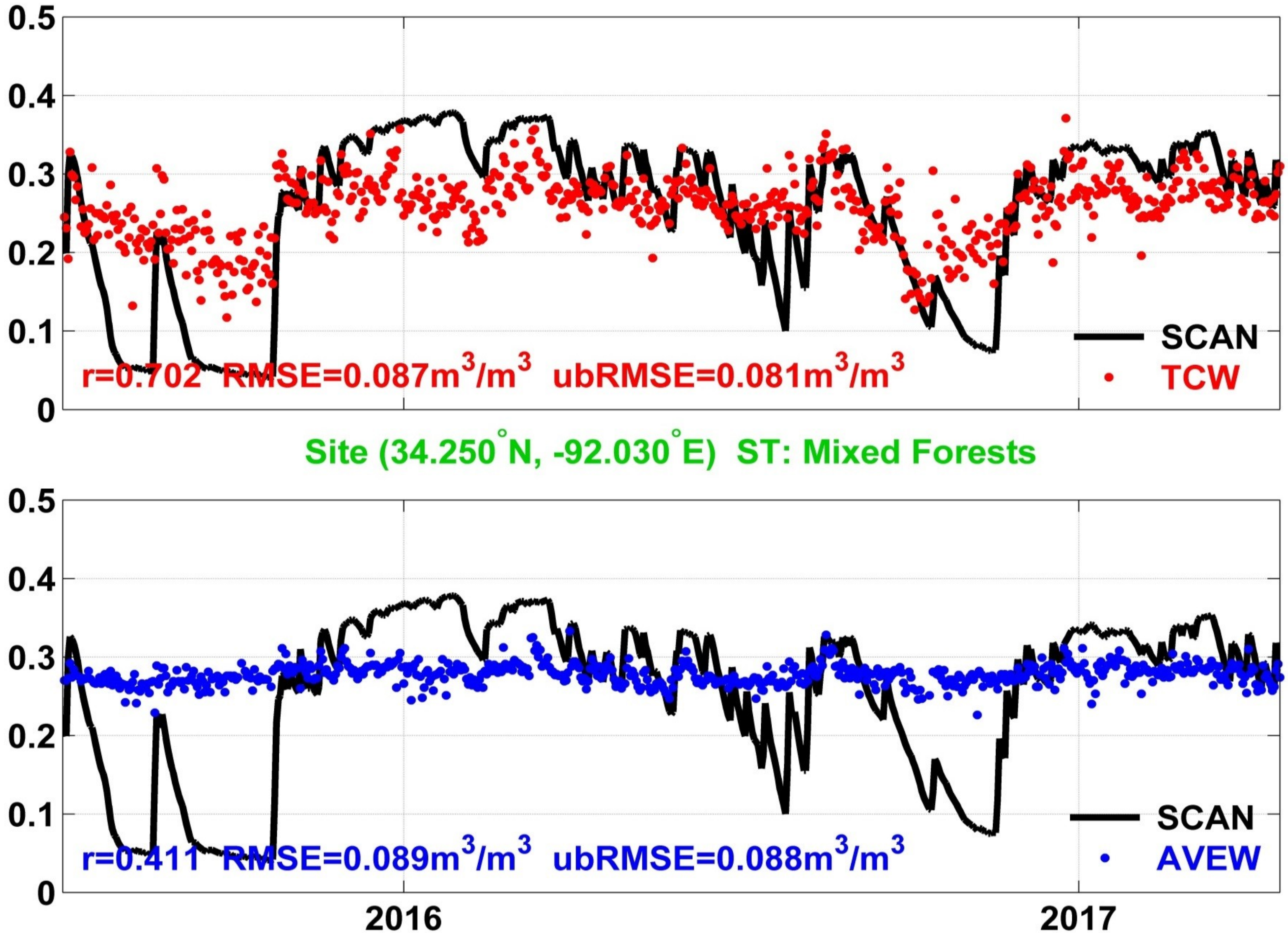


GLDAS precip-based (left) and MODIS EVI-based (right) correlations over 1 April 2015-30 June 2018 period. EVI data lags SM data by 8 days.

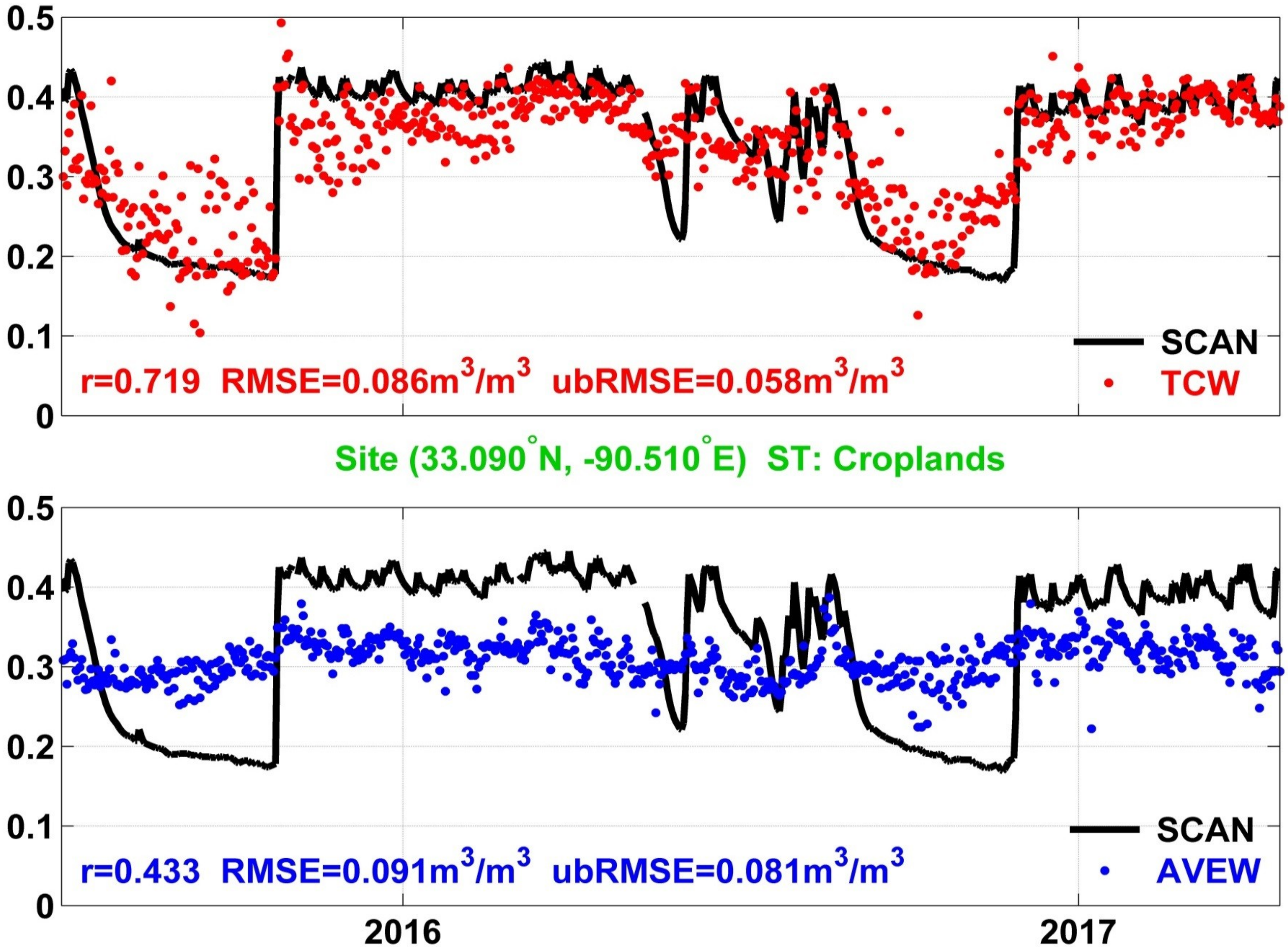
Blending Method Comparison



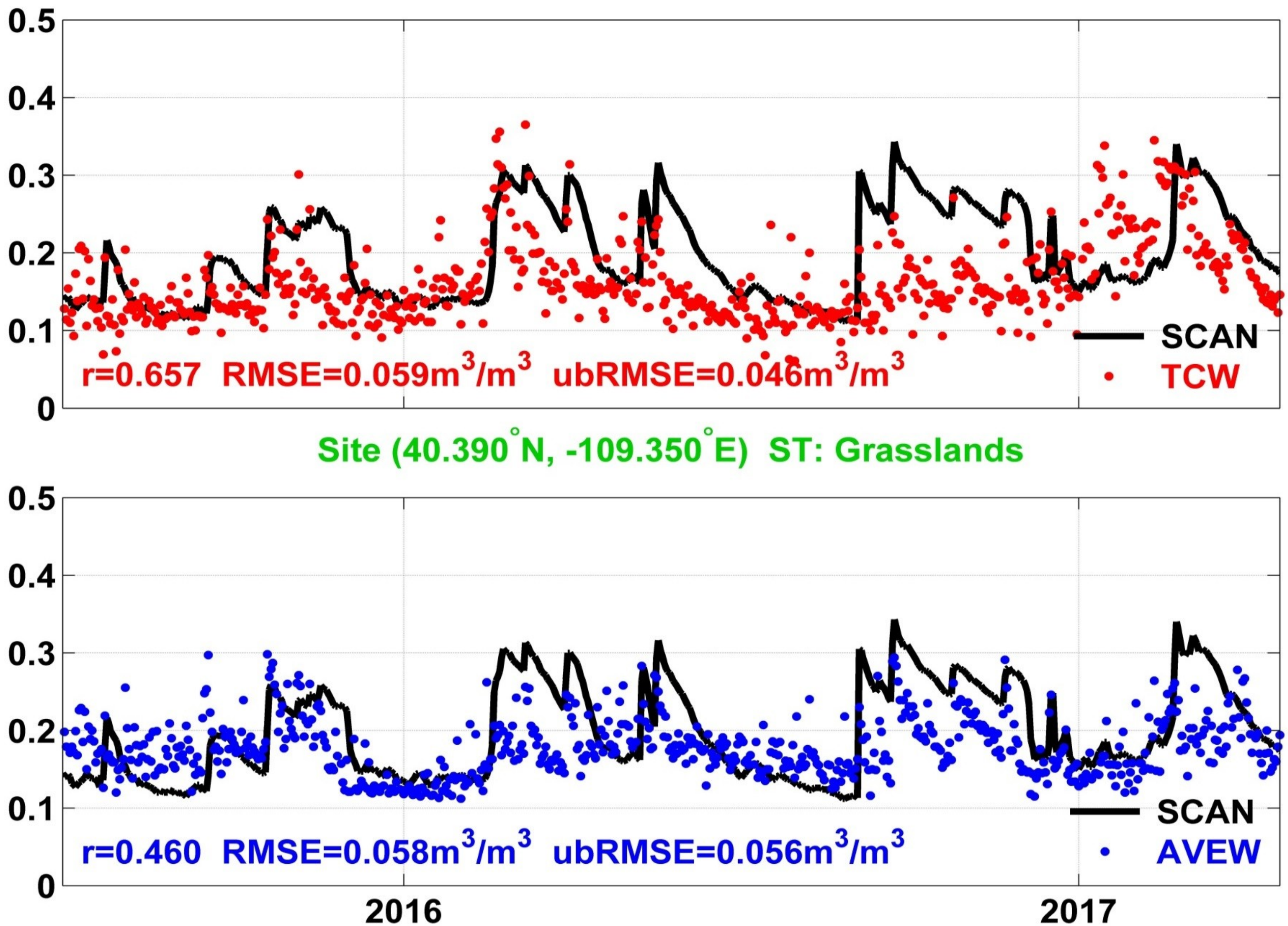
Blending Method Comparison



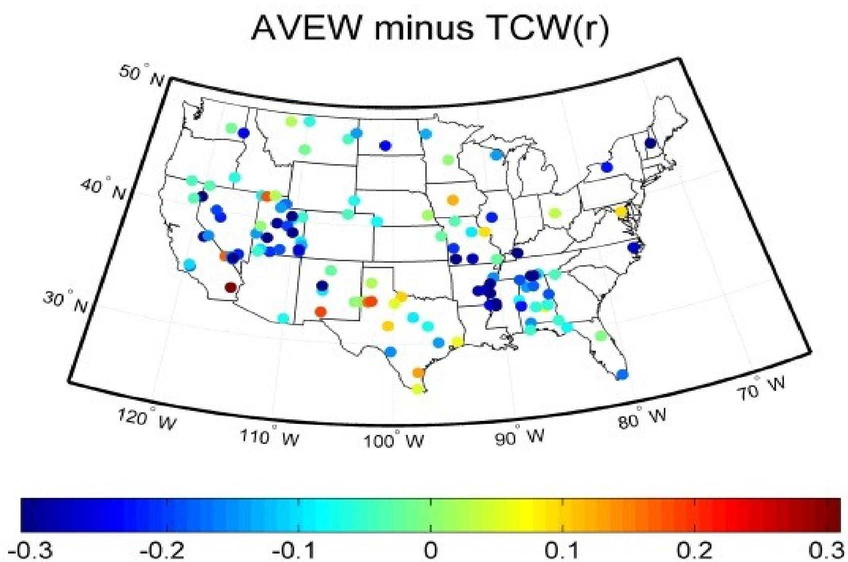
Blending Method Comparison

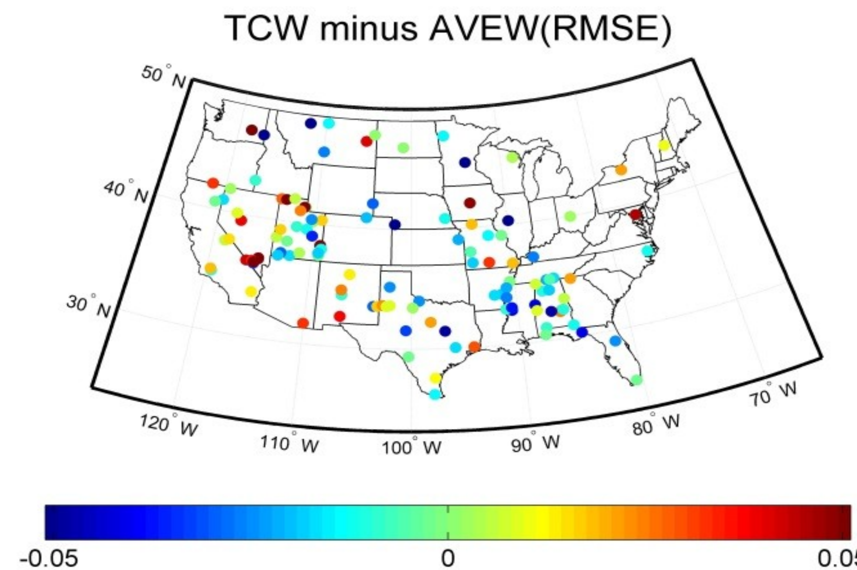


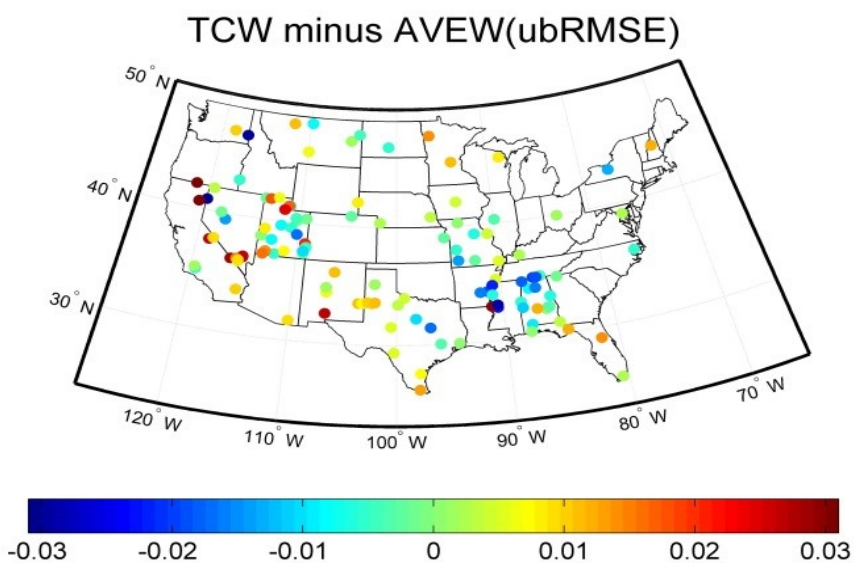
Blending Method Comparison



Blending Method Comparison

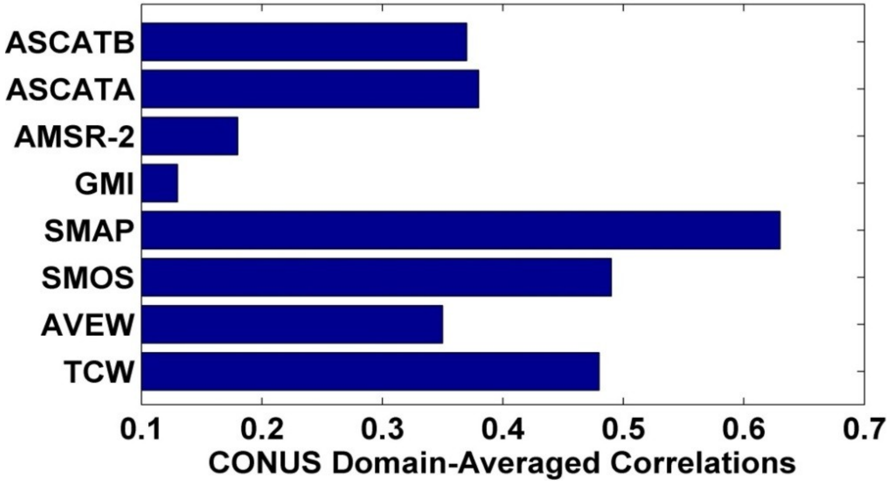


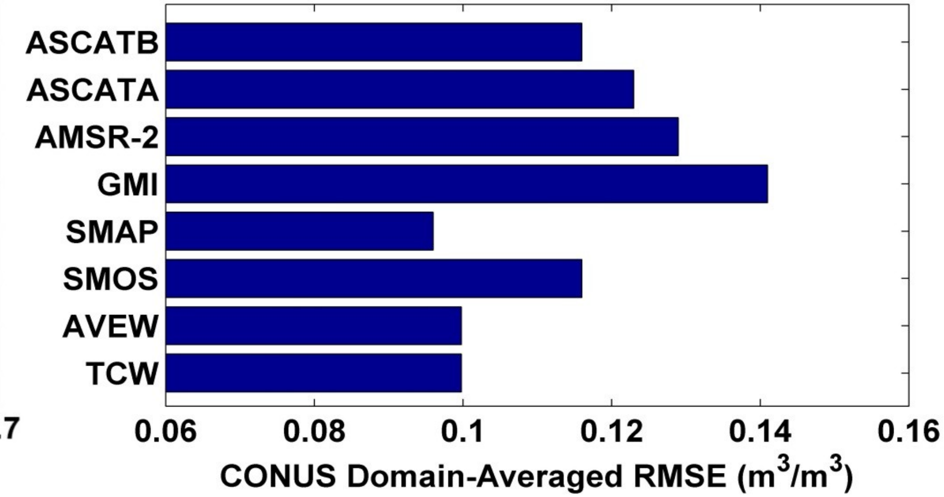


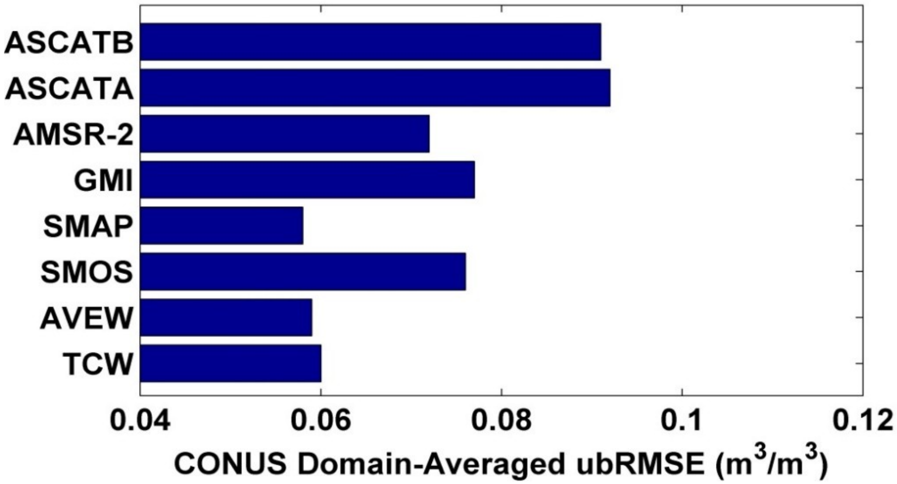


With Respect to the SCAN SM measurements for 10 cm soil layer, *differences in (a) correlations (r), (b) RMSE, and (c) ubRMSE* between AVEW and the scaled TCW SMOPS blended SM data over 1 April 2015-June 30 2017 period. **Site in blue color denotes improvement.**

Blending Method Comparison







CONUS domain-averaged (a) correlations, (b) RMSE and (c) ubRMSE for each of the 6 individual satellite SM retrievals with respect to the 5 cm SCAN SM measurements and both SMOPS blended SM datasets against to the SCAN SM measurements over 1 April 2015-June 30 2017 period.

STAR - SMCD - EMB - Soil Moisture Project - Daily Maps - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.orbit2.nesdis.noaa.gov/smcd/emb/soilmoisture/DailyMaps.php

Latest Headlines

Google Calendar | STAR - SMCD - EMB - S...

STAR Center for Satellite Applications and Research
formerly ORA — Office of Research and Applications

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

Skip Top Navigation

STAR Home | Contact STAR | Careers | STAR Intranet | Advanced Search

Enter search term(s) Search

Soil Moisture Home > Daily Maps

Soil Moisture Daily Maps

To display maps, please select a data type, region, year, month, and date, and then click 'Refresh'.

Use the '<' and '>' buttons to step ahead or backward through the images. Soil moisture is expressed in Volumetric Soil Moisture Content [m^3 water/m^3 soil] (see Documents for details).

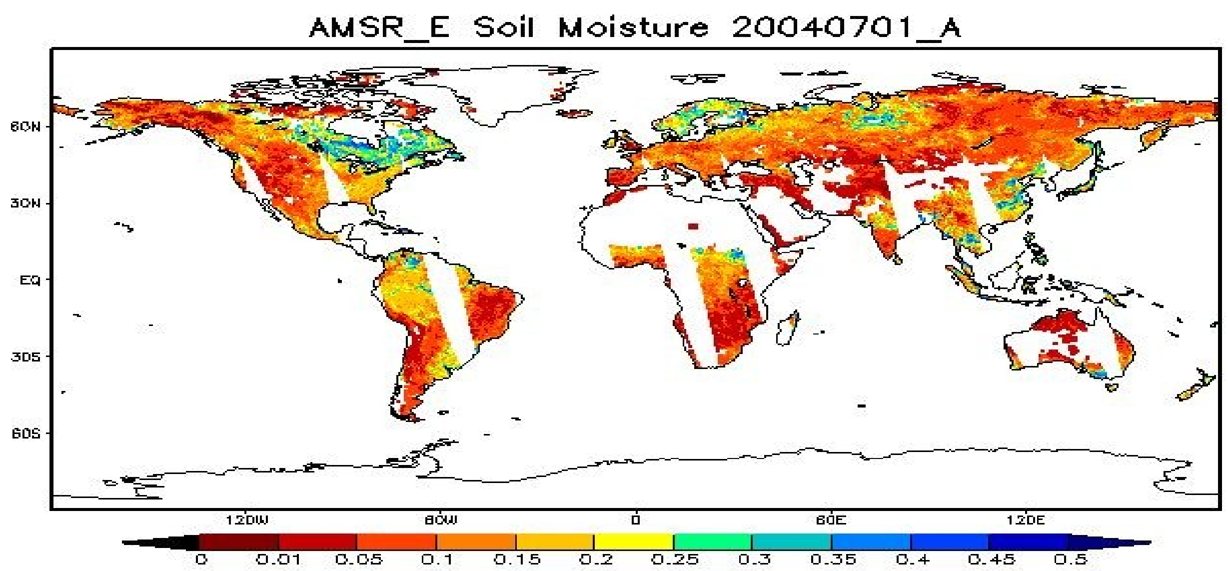
Data type	Region	Year	Month	Day	
NOAA-AMSR-E	Global	< 2004 >	< 7 >	< 1 >	Refresh Map

Regions:

- Global, North America, South America, Africa, Eurasia, Australasia, Asia, CONUS, China, India, South Africa.

Data Types:

- **NOAA-AMSR-E**
  NOAA Soil Moisture from AMSR-E: Land surface soil moisture retrieved from AMSR-E X-band brightness temperature (TB10H) observations using the Single- Channel-Retrieval (SCR) algorithm.
- **NOAA-WindSat**
  NOAA Soil Moisture from WindSat: Land surface soil moisture retrieved from Navel Research Lab's (NRL) WindSat X-band brightness temperature (TB10H) observations using the Single-Channel-Retrieval (SCR) algorithm.
- **NOAA-TMI**
  NOAA Soil Moisture from TMI: Land surface soil moisture retrieved from the X-band brightness temperature

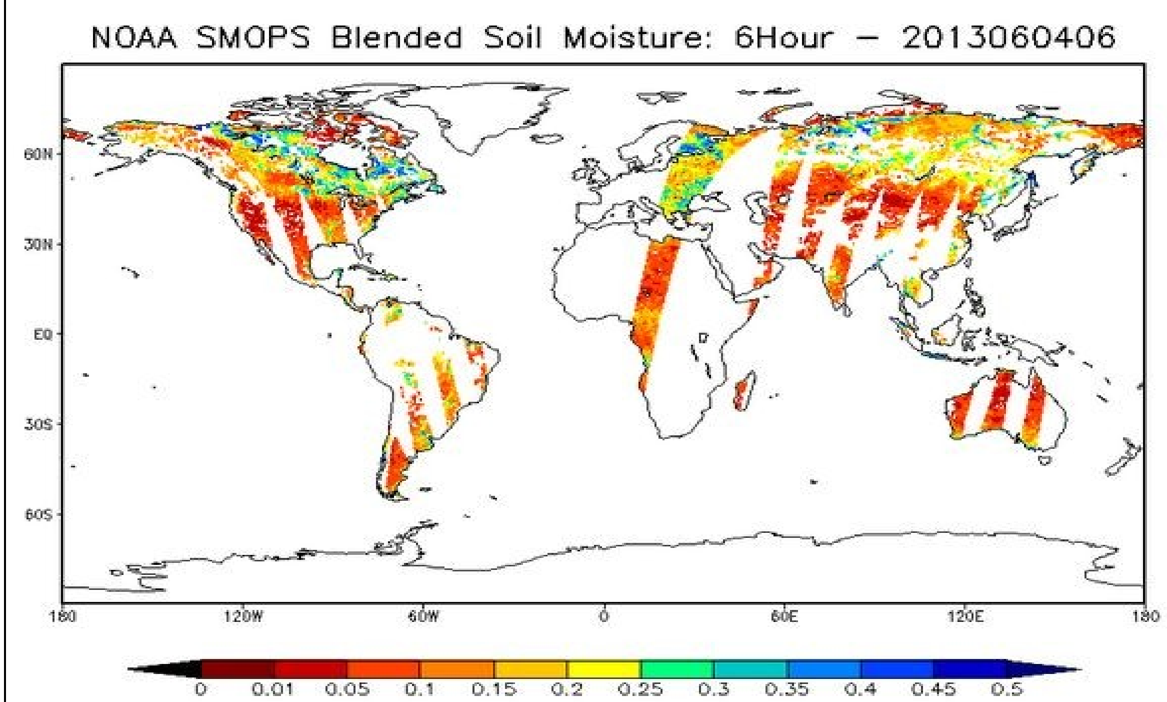


Done

Soil Moisture Products - 6 Hour

Start | Stop | << | NOAA_SMOPS_Blended_SoilMoistur | >>

Start: May 28 2013 End: Jun 4 2013 Reload



SMOPS Home

Algorithm Description

Satellites/Sensors:
ASCAT | SMOS | WindSat | AMSR-E

Product Animation:
Daily | 6-hourly

Validation:
In Situ | Time Series

Monitoring:
Product | Time Series | Processing | Timeliness

Test Data

Documents

IPT Members

Links

Summary & Path Forward

- *Many satellite soil moisture data products have been available while NWS users requested a combined data layer for their application convenience*
- *Using CDF match algorithm, SMOPS unified individual satellite retrievals to a common global satellite data climatology before blending them together*
- *Current operational SMOPS uses simple average as the blended SM data layer*
- *A testing indicates that weighted averaging using the TCEM-based relative RMSE of individual sensor retrievals may generate better blended products*
- *Upgrading SMOPS using the weighted averaging is to be explored with further evaluation and resources assessment*

Thanks!

Contacts for SMOPS:

Xiwu.Zhan@noaa.gov
Limin.Zhao@noaa.gov
Jicheng.Liu@noaa.gov

Geo-Polar Blended Sea Surface Temperature Analysis

Presented by

Eileen Maturi, NESDIS/STAR/SOCD

Andy Harris[1], Eileen Maturi[2], John Sapper[3], Jonathan Mittaz[1,4], Sasha Ignatov[2] Gary Wick[5], Mark Eakin[2]

[1]NOAA-CICS, University of Maryland, [2]NOAA/NESDIS/STAR , [3]NOAA/NESDIS/OSPO
[4]University of Reading, UK , [5]NOAA/OAR/ESRL

Date: {2018/09/30}

Geo-Polar Blended SST Analysis

- Team Members and Affiliations
- Blended Product Development
  - Inputs needed for the Blended Product Algorithm
  - Technical Approach:
  - Product Examples/Outputs
  - Product Evaluation/Validation/Tools
  - Status of Implementation/Resources
- Identified Issues/Risks/Mitigations
- Future Algorithm Improvements
- Product Outreach
  - Importance/Benefits/Users
  - Documentation/website links
- Summary and Path Forward

Algorithm Team Members

Name	Organization	Major Task
Andy Harris	NOAA-CICS/University of Maryland	Ongoing Scientific Development and Maintenance
Jon Mittaz	University of Reading, UK	C-code for Data Ingestion, F90 code for Diurnal Warming Model
Gary Wick	NOAA/OAR/ESRL	Scientific development of Diurnal Warming Model
John Sapper	NOAA/NESDIS/OSPO	Oversee Implementation into Operations
Mark Eakin	NOAA/NESDIS/STAR/SOCD	Requester for the Coral Reef Watch application
Eileen Maturi	NOAA/NESDIS/STAR	Oversee Development of Analysis
Sasha Ignatov	NOAA/NESDIS/STAR	Generate Polar L2 SSTs and GOES-16 L2 SST

Required Satellite and Ancillary Input Data Products

	Data Product Name (Inputs)	Input Data Type (Satellite/Model Forecasts/*In-situ*)	Temporal/ Spatial Resolution, Format	Source(s)
1	Blended Day/Night Analysis	Satellite L2P/Analysis	5-km Resolution	NESDIS UK Met Office
2	Blended Nighttime Analysis	Satellite L2P/ Analysis	5-km Resolution	NESDIS UK Met Office
3	Blended Diurnally Corrected	Satellite L2P/ Analysis/ Model	5-km Resolution	NESDIS UK Met Office NWS

1. Blended Product Algorithm Description

Application of a dynamic data-fusion scheme to produce a global, operational SST Analysis of polar and geostationary SST data from NOAA and non-NOAA platforms. The method employs a recursive estimator which emulates the Kalman Filter and uses data-adaptive correlation length scales to provide a reasonable balance between noise reduction and detail preservation.

2. Technical Approach

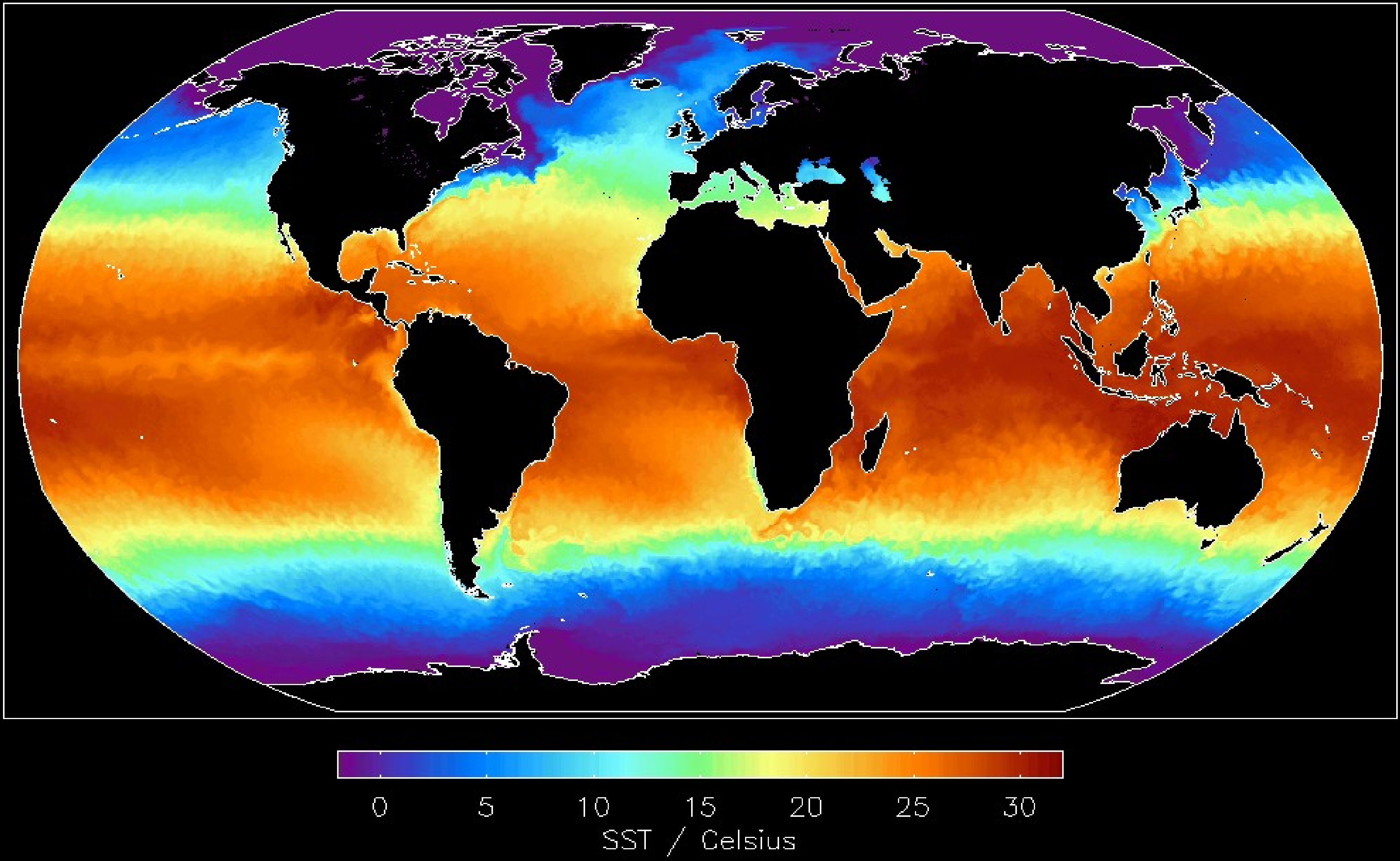
- Each input dataset is super-ob'd on separate $1/20^{o} \times 1/20^{o}$ grids (*e.g.* S-NPP VIIRS daytime SST is treated as a separate observation field from S-NPP VIIRS nighttime SST)
- Super-ob process evaluates standard deviation within grid cell and eliminates outliers, based on expected standard deviation
- Diurnally-adjusted analysis applies modeled diurnal warming estimates to every input observation during the super-ob process
- Each observation field is adjusted for ~long-scale (~$2^{o} \times 2^{o}$) biases, which are updated daily with respect to the reference field
- Analysis performed on quad-tree for efficiency, using 3 separate anomaly correlation length scales. Final result is interpolated from the coarse, medium and fine-scale analyses, based on local data density
- Separate ocean basins (*e.g.* no data cross-talk across Isthmus of Panama)
- Covariance structures are updated after every analysis step

Geo-Polar Blended Sea Surface Temperature Analysis

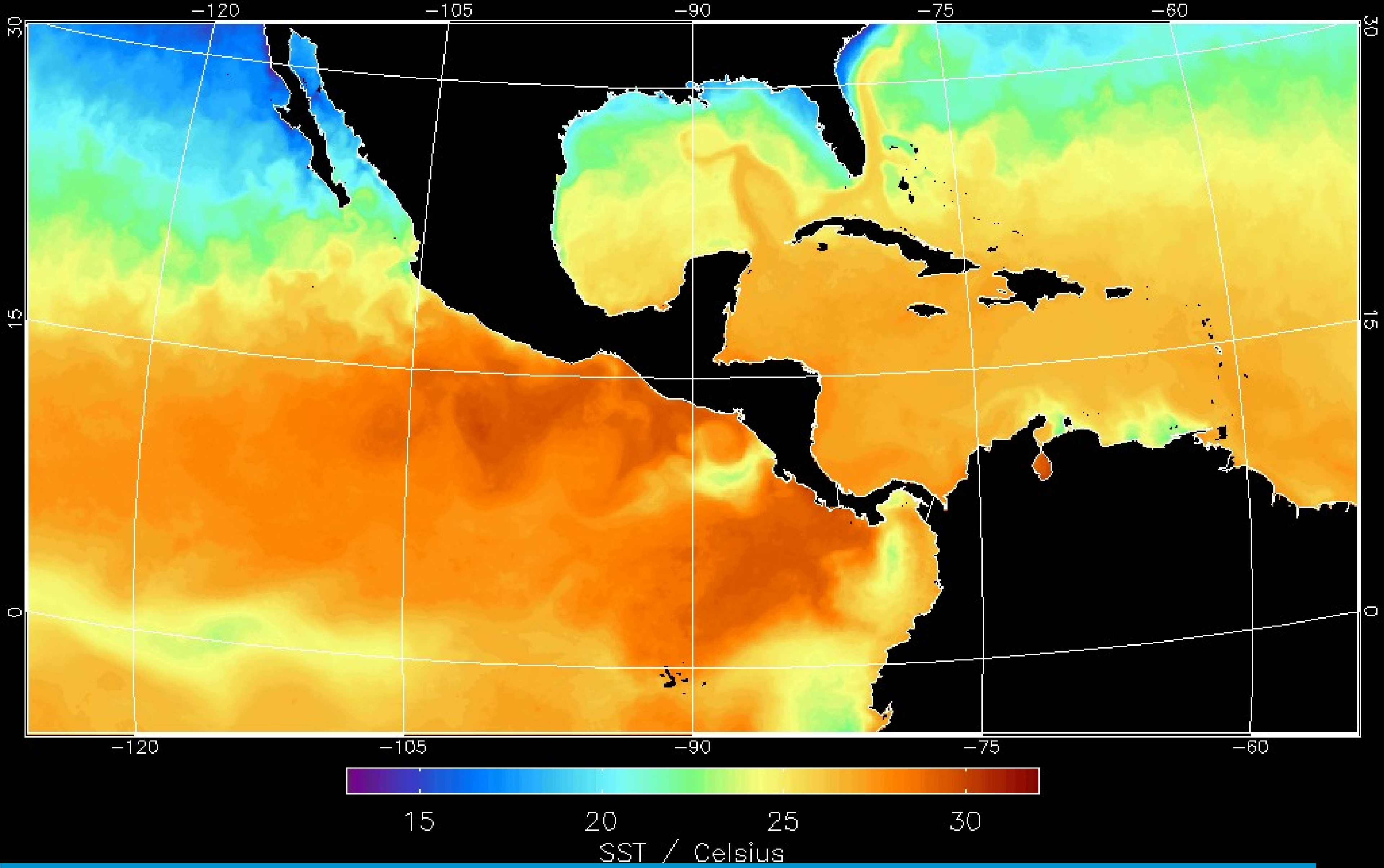
Examples/Outputs

	Blended Data Product Name (Outputs)	Output Data Type (Satellite; Model Forecasts; In-situ)	Spatial, Temporal Resolution, Format	Sources (Satellite)
1	Blended Day/Night	Multi-satellite Analysis + Error Analysis	5-km	VIIRS, AVHRR, Imager, ABI, SEVIRI, AHI
2	Blended Night time only	Multi-satellite Analysis + Error Analysis	5-km	As above
3	Blended Diurnally Corrected	Multi-satellite Analysis + Error Analysis	5-km	As above

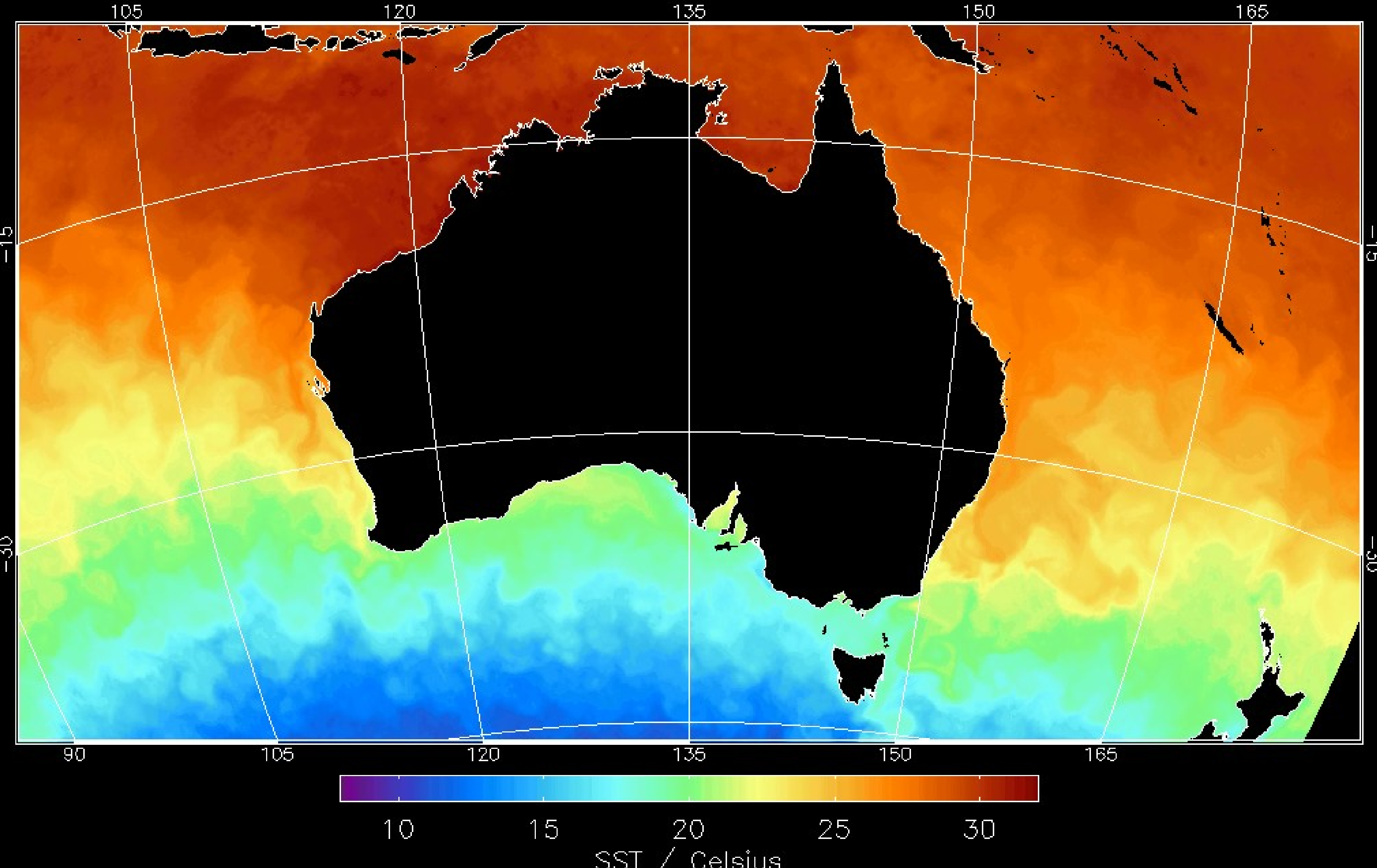
Geo-Polar Blended Sea Surface Temperature Analysis
Examples/Outputs



Geo-Polar Blended Sea Surface Temperature Analysis
Examples/Outputs

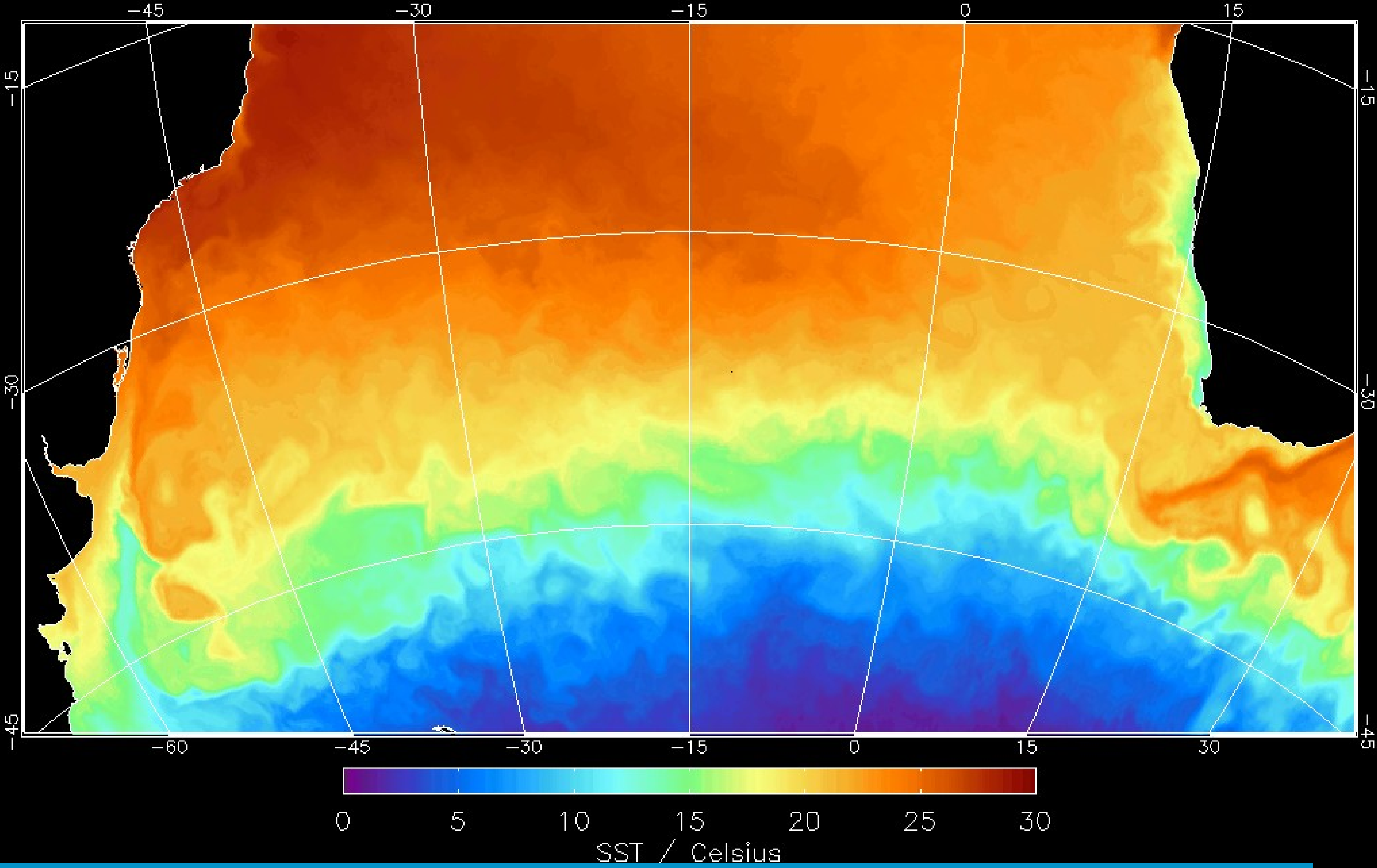


Geo-Polar Blended Sea Surface Temperature Analysis
Examples/Outputs



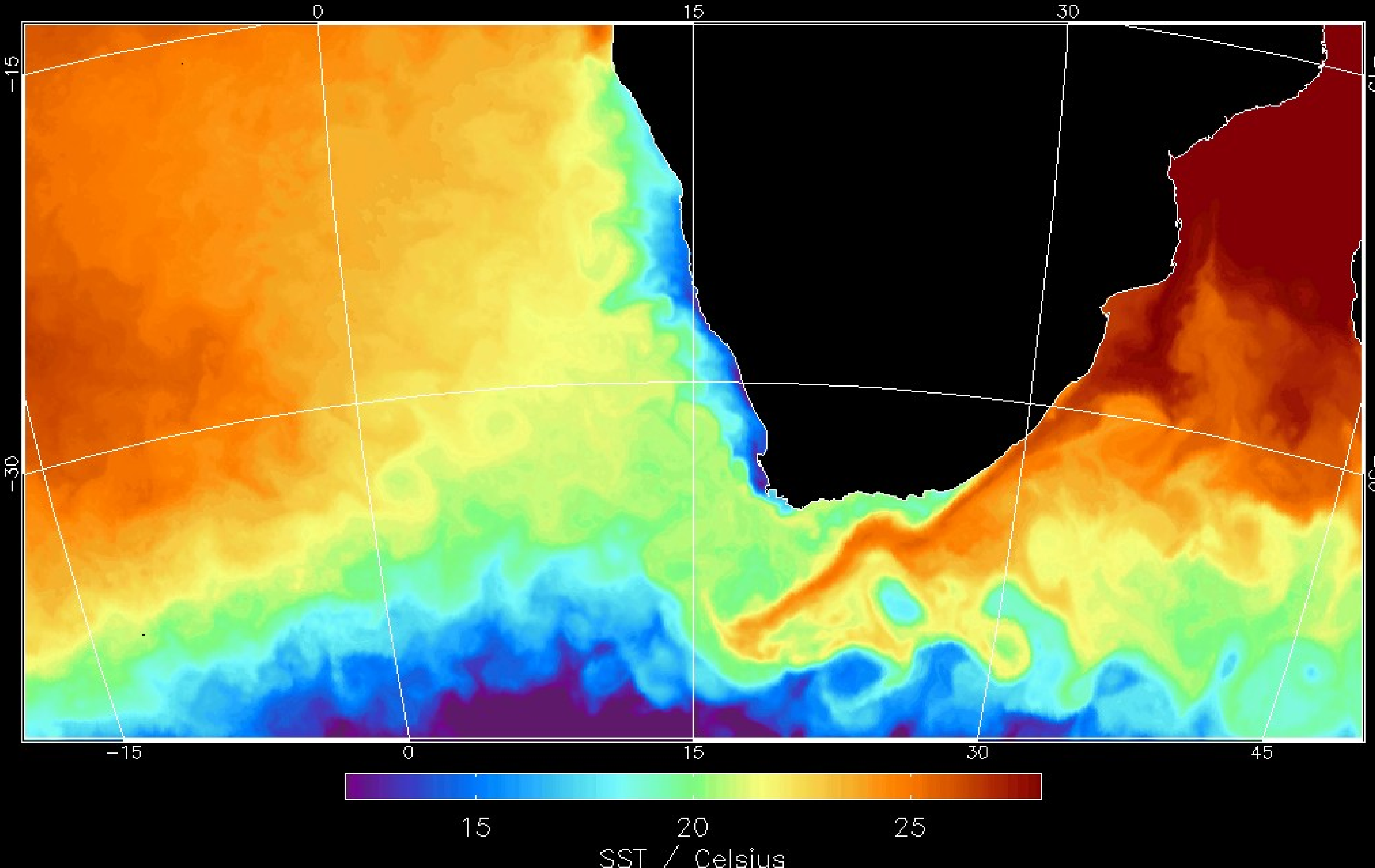
Geo-Polar Blended Sea Surface Temperature Analysis

Examples/Outputs

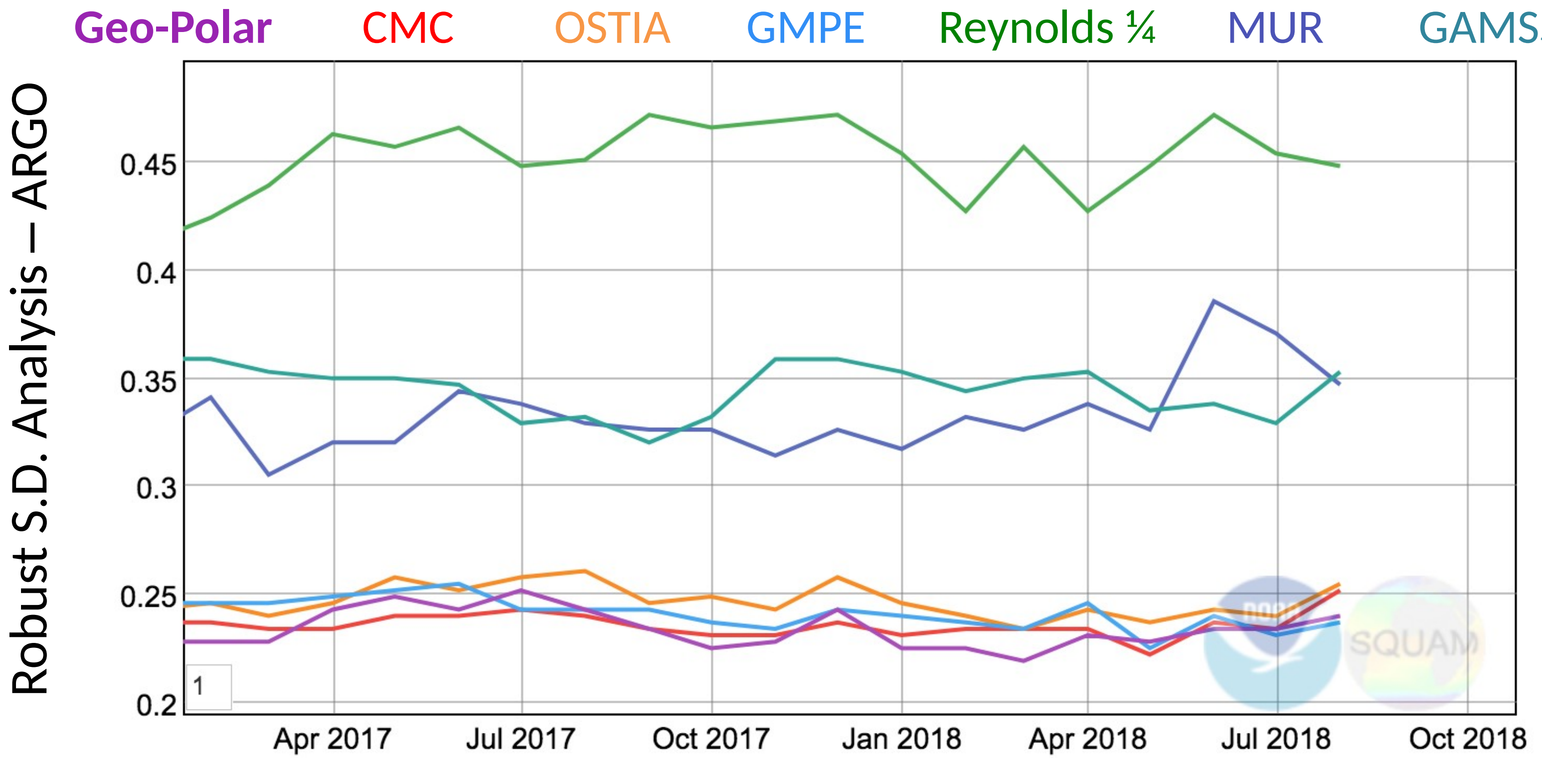


Geo-Polar Blended Sea Surface Temperature Analysis

Examples/Outputs



- Product Evaluation/Validation
  - ARGO temperatures at ~5 m depth (truly independent)
  - STAR SQUAM web page
    - ✓ https://www.star.nesdis.noaa.gov/sod/sst/squam/
  - Uncertainty information provided for every grid cell



Geo-Polar Blended Sea Surface Temperature Analysis
Implementation Status

- Operational with 24/7 support
- Available from OSPO Product Distribution and Access (PDA)
- Available in AWIPS and on CoastWatch/OceanWatch Web Site
- Runs in Linux environment
- Code is a combination of MATLAB, C, Fortran 90
- Diurnal correction to the day/night product was implemented this FY18
- Future implementation plans:
  - Regional 1km blended analyses
  - Possible addition of microwave SSTs
  - More independent bias control using Sentinel-3 SLSTR

Geo-Polar Blended Sea Surface Temperature Analysis

Identified Risk/Issues	Action/Mitigation
Dependent on OSTIA reference	Overhaul bias adjustment methodology (combination of Sentinel-3 SLSTR + VIIRS nighttime SST)
No baseline funding for scientific maintenance	Keep proposing enhancements every year and hope they get funded. Do the maintenance off the back of that.

Geo-Polar Blended Sea Surface Temperature Analysis
Future Algorithm Improvements

- Improve diurnal warming model
  - Ongoing
- Regional analyses (~1/40° – 1/80°) for CRW and other applications
  - 18 months – dependent on funding approval
- Arctic SST analysis (new length scales, projection, treatment of sea ice)
  - 1-2 years for initial analysis
- Overhaul bias correction methodology
  - 1 year – dependent on funding approval
- Reprocessing of historical data to provide longer baseline for anomaly-based products (*e.g*. CRW)
  - Back to 1995 done by end-2018 (dependent on satellite SST inputs)
- Future Validation Plans
  - ARGO is very good for open ocean and ~monthly scale
    - Validation for sub-daily high-resolution will be harder

Summary and Path Forward

- **Summary and Conclusions**
  - Geo-Polar Blended SST Analysis is world-leading
    - Among the most accurate when validated against independent ARGO
    - Better feature resolution than competing analyses
    - All satellite inputs are NESDIS-derived
- **Path Forward**
  - Diurnal modeling is state-of-the-art turbulence closure scheme
  - Higher resolution analyses for specific ecological applications e.g. Coral Reef regions
  - Reprocessing to provide longer baselines for anomaly-based products
  - Improvements to bias adjustment to give full independence
  - Arctic analysis for an important changing region

Backup Slides

Geo-Polar Blended SST Analysis-Reprocessed

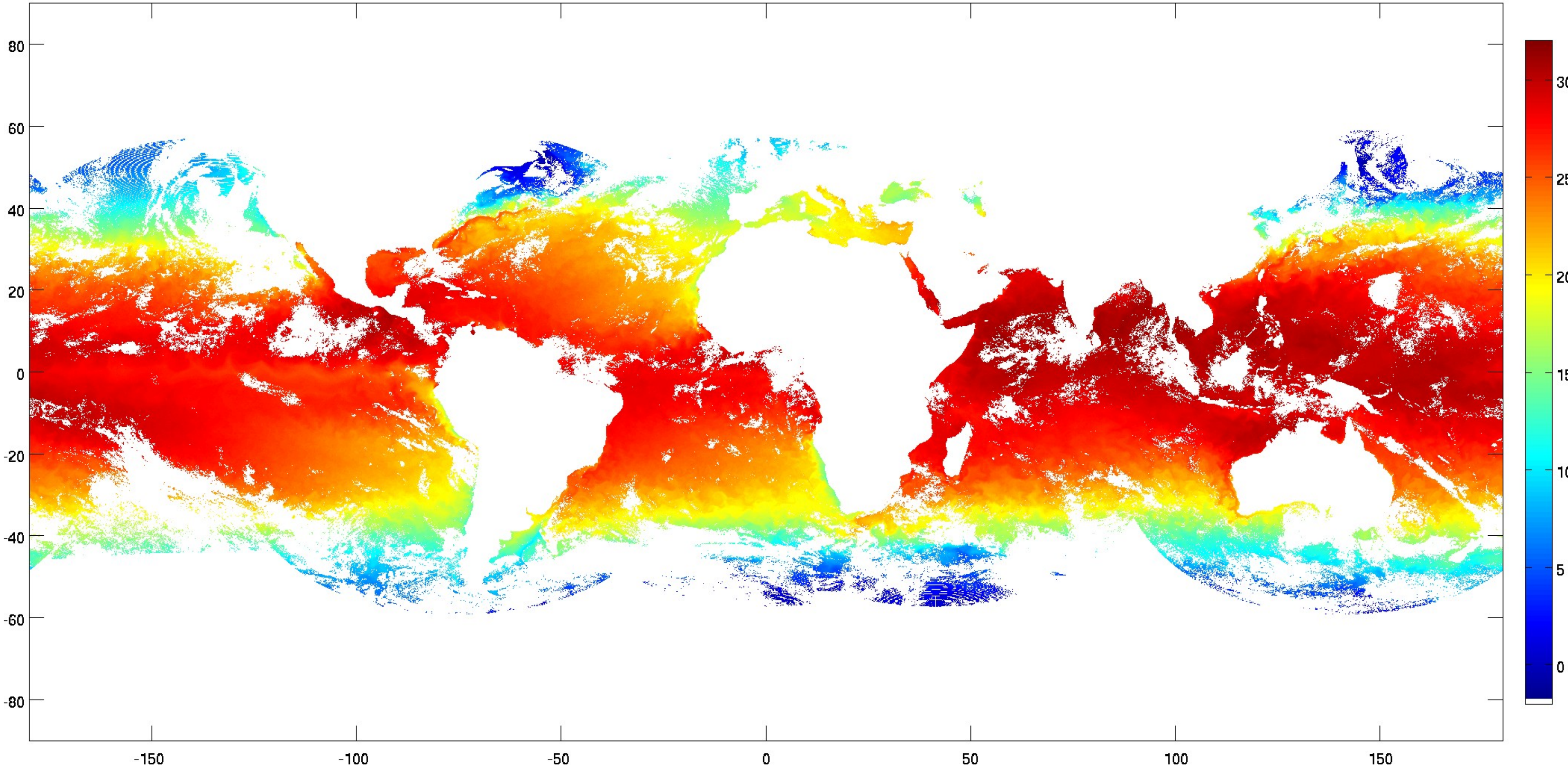
- Reprocessed Geo-Polar Blended SST Analysis 2002-2016
  - Reprocessed Geostationary Data
  - Reprocessed Polar Data (Sasha Ignatov)

- Improved Baseline for Coral Reef Watch Products

- Critical for Anomaly Based Products to use Climatology derived using the latest processing methodology Important to derive climatology from dataset with similar characteristics to current Geo-Polar Analysis
  - Take advantage of latest processing methods/products
  - Ensure anomalies are due to geophysics rather than algorithm/processing
  - Requires reprocessing of **all L2 SSTs for geostationary and polar-orbiter data sources**
  - Note, NOAA are the only operational L4 provider who also process all the L2 data in-house

GLOBAL GEO COVERAGE

GOES-15 GOES-16 Met-11 Met-8 Himawari-9



Geo-polar Blended SST Analysis - Day-Night

Input Requirements

Input Data	Resolution	Source
METOP-B	1-km global	NESDIS
GOES-16	2-km Regional	NESDIS
GOES-15	4-km Regional	NESDIS
MSG-1	3-km Regional	NESDIS
MSG-4	3-km Regional	NESDIS
OSTIA ANALYSIS	1/20° global	UK Met Office
VIIRS	0.75-km global	NESDIS
Himawari-8	2-km regional	NESDIS

Geo-polar Blended SST Analysis- Night

Input Requirements

Input Data	Resolution	Source
METOP-B	1-km global	NESDIS
GOES-16	2-km Regional	NESDIS
GOES-15	4-km Regional	NESDIS
MSG-1	3-km Regional	NESDIS
MSG-4	3-km Regional	NESDIS
OSTIA ANALYSIS	1/20° global	UK Met Office
VIIRS	0.75-km global	NESDIS
Himawari-8	2-km regional	NESDIS

Geo-Polar Blended SST Analysis -Diurnally Corrected Input Requirements

Input Data	Resolution	Source
METOP-B	1-km global	NESDIS
GOES-16	2-km Regional	NESDIS
GOES-15	4-km Regional	NESDIS
MSG-1	3-km Regional	NESDIS
MSG-4	3-km Regional	NESDIS
OSTIA ANALYSIS	1/20° global	UK Met Office
VIIRS	0.75-km global	NESDIS
Himawari-8	2-km regional	NESDIS
NCEP fluxes of heat and momentum, and wave model output	0.5°	NWS

Output Specifications

- Blended Product Name: **{Geo-Polar Blended Sea Surface Temperature Analysis- Day/Night}**
- Output Data Type(s): {Analysis/ Error Analysis}
- If your blended product algorithm produces more than one output product, use additional slides as required.

Output Product(s) Attributes	Threshold	Observed/validated
Latency	Within 12hrs of last observation	
Geographic coverage	Global	
Vertical Coverage	N/A	
Vertical Cell Size	N/A	
Horizontal Cell Size	1/20°	N/A
Mapping Uncertainty		<1/40°
Measurement Range	-2°C to +40°C	
Measurement Accuracy	<0.1 kelvin	<0.1 kelvin
Measurement Precision	0.01 kelvin	0.01 kelvin
Measurement Uncertainty	0.3 kelvin	0.3 kelvin

Output Specifications

- Blended Product Name: **{Geo-Polar Blended Sea Surface Temperature Analysis-Night}**
- Output Data Type(s): {Analysis/ Error Analysis}
- If your blended product algorithm produces more than one output product, use additional slides as required.

Output Product(s) Attributes	Threshold	Observed/validated
Latency	Within 12hrs of last observation	
Geographic coverage	Global	
Vertical Coverage	N/A	
Vertical Cell Size	N/A	
Horizontal Cell Size	1/20°	N/A
Mapping Uncertainty		<1/40°
Measurement Range	-2°C to +40°C	
Measurement Accuracy	<0.1 kelvin	<0.1 kelvin
Measurement Precision	0.01 kelvin	0.01 kelvin
Measurement Uncertainty	0.3 kelvin	0.3 kelvin

Output Specifications

- Blended Product Name: **{Geo-Polar Blended Sea Surface Temperature Analysis-Diurnally Corrected}**
- Output Data Type(s): {Analysis/ Error Analysis}
- If your blended product algorithm produces more than one output product, use additional slides as required.

Output Product(s) Attributes	Threshold	Observed/validated
Latency	Within 12hrs of last observation	
Geographic coverage	Global	
Vertical Coverage	N/A	
Vertical Cell Size	N/A	
Horizontal Cell Size	1/20°	N/A
Mapping Uncertainty		<1/40°
Measurement Range	-2°C to +40°C	
Measurement Accuracy	<0.1 kelvin	<0.1 kelvin
Measurement Precision	0.01 kelvin	0.01 kelvin
Measurement Uncertainty	0.3 kelvin	0.3 kelvin

Importance/Benefits/Users

Name	Organization	Application	User Feedback - User readiness dates for ingest of data and bringing data to operations
Paul DiGiacomo	NOAA/NESDIS STAR/SOCD	CoastWatch/OceanWatch	Product is disseminated through the CoastWatch/OceanWatch Regional Managers
Mark Eakin	NOAA/NESDIS STAR/SOCD	Coral Reef Watch: Ecosystem Monitoring and Prediction	Used to generation operational products for the coral reef bleaching forecasting/ Climate Monitoring
Cara Wilson	NOAA/NMFS	Ecosystem monitoring and prediction of fish stock	Provide good temporal resolution for location of temperature fronts for fish stock
Joe Sienkiewicz	NOAA/NWS/OPC	Commerce and Transportation	Used for High Sea Forecasts
Vijay Tallapragada	NWS	Used in the generation of Oceanic Heat Content	Ocean Heat Content Product the best forecaster for Hurricane Intensity

Documentation/website links

- Maturi E, A Harris, J Mittaz, J Sapper, G Wick, X Zhu, P Dash, P Koner, A New High Resolution Sea Surface Temperature Blended Analysis, *Bull. Am. Meteorol. Soc.*, **98**, 1015-1026, **2017**
- Khellah, F., P.W. Fieguth, M.J. Murray and M.R. Allen, "Statistical Processing of Large Image Sequences'', IEEE Transactions on Geoscience and Remote Sensing,14 (1), 80-93, **2005**
- Fieguth, P., Multiply-Rooted Multiscale Models for Large-Scale Estimation, IEEE Image Processing, 10 (11), 1676-1686, **2001**
- Fieguth P.W. et al., "Mapping Mediterranean altimeter data with a multiresolution optimal interpolation algorithm'', J. Atmos. Ocean Tech, 15 (2): 535-546, **1998.**
- Algorithm Theoretical Basis Document for Geo-Polar Blended SST Analysis

INTERACTIVE AND AUTOMATED BLENDED SNOW AND ICE PRODUCTS

Sean Helfrich, NOAA/NESDIS/STAR—5830 University Research Ct., Suite 3233
College Park, MD 20740, USA; sean.Helfrich@noaa.gov

Collaborators: Peter Romanov, John Woods, Edmond Rodriguez, Chris Jackson, Frank Monaldo

Blended and Snow and Ice Products

Blended Products = Fusion of Multi Sourced, Multisensor, and multiple time observations into a single product

Why?

The basic objective of blended remote sensing products is to leverage the strengths of multiple sensors and multiple time observations to fill gaps in time and space that are not observable or have weaknesses from a single source or time interval observation. The data synthetize allows users and forecasters to need less analysis time to apply the data for their applications.

Current / Future Blended Snow and Ice Products

Interactive Multisensor Snow and Ice Mapping System (IMS)

Automated Blended Snow and Ice Cover (GMASI)

Blended Snow Depth (IMS)

Blended Ice Concentrations: 2018/19

Blended Ice Motions: Future

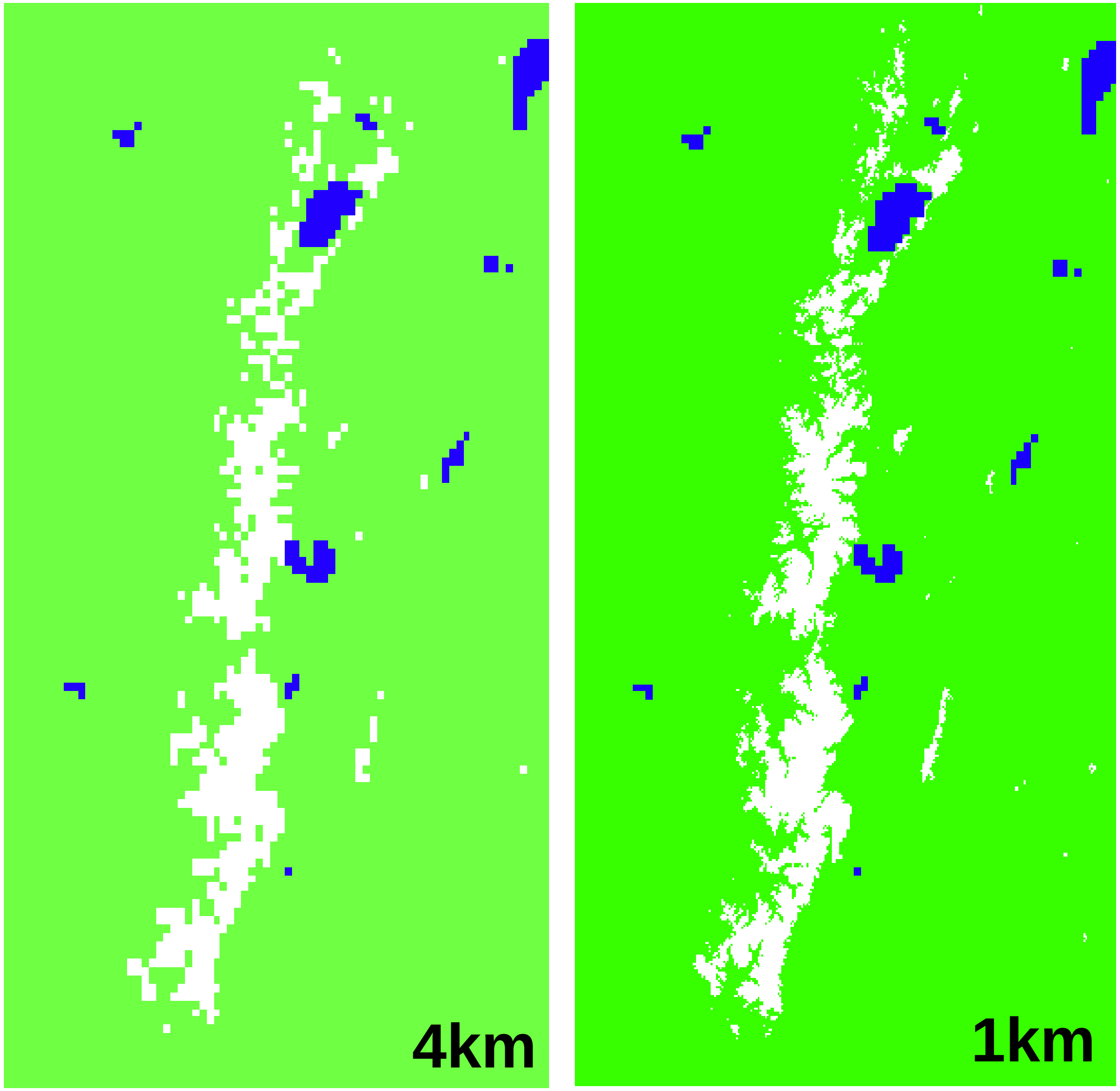
Blended Ice Thickeness: Future

Interactive Multi-Sensor Snow and Ice Mapping System (IMS)

- 1, 4, & 24km Northern Hemisphere Analysis
- Snow & Ice Cover
- ASCII, BIN, GeoTiff, Grib2
- 2x day production
- Automated 2km Southern Hemisphere Analysis
- Snow Depth (with uncertainty values)
- VIIRS, SAR, MODELS, More Surface obs,
- Ability to import derived data sources
- Same underlying Snow & Ice cover resample algorithms - *Vital to keeping consistent record*

www.natice.noaa.gov/ims/

Sierra Nevada Snow Cover – March 18, 2015



IMS Input Data Addition Timeline

1997: AVHRR (24km) NOHRSC (24km), USAF, SSMI, Joint Ice Center (NIC) Ice Edge

1998: AVHRR (4km), GOES (E) – Current Day, GOES(W) – Past Day

1999: GMS, INDOEX (MeteoSat 5), MeteoSat 7, NOHRSC (4km), AutoSnow V1, GOES W

2000: AMSU (snow, ice , rain), COOP obs

2001: Ch. 3a AVHRR (4km), INDOEX – Direct Import), NIC Ice Edge, AMSU B

2002: North American AutoSnow

2003: MSG (1km)

2004: MODIS (1km), MODIS animations, AutoSnow V2 (4km), NOHRSC (1km), MMAB Sea Ice (1km)

2005: METAR ob

2006: AMSR-E 89ghz & SIC

2008: NIC MIZ, CoCoRaHS

2009: ENVISAT GMM, NIC&Foreign Ice Charts

2010: RadarSat, WebCams

2011: AutoSnow V3, ASCAT

2014: AVHRR (Channels 1,2,3) MODIS (Channels 1,2,7,8), MeteoSat (MSG (ch 1,2,3) & 7), VIIRS (ice, snow, I1, I2, I3, I5, DNB), ATMS SWE, ACNFS Model, SYNOP obs, US Radar

2015: Himawari 8

2017: GOES ABI, Meteosat 8/10

Changes to IMS in FY18

New OSPO Product Lead : John Woods

New STAR IMS Development Lead : Sean Helfrich

Additional products available for input (SAR, SAR ice detection, Polar Composite loops) and restoration of broken links to input sources

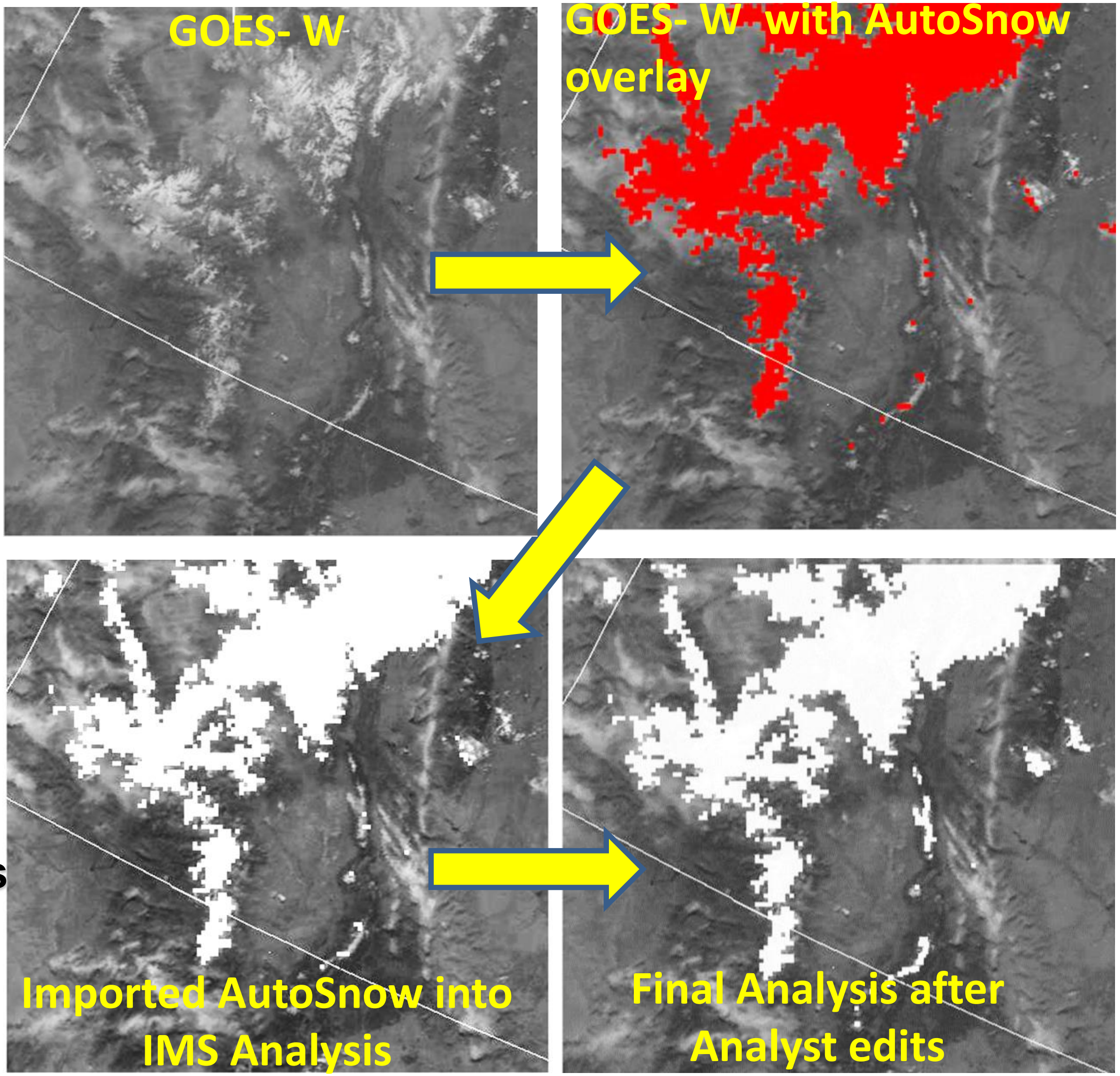
New Southern Hemisphere Snow Depth (2 km SH AutoSnow + ATMS/AMSR2)

Code adjustments for Blended Snow Depth

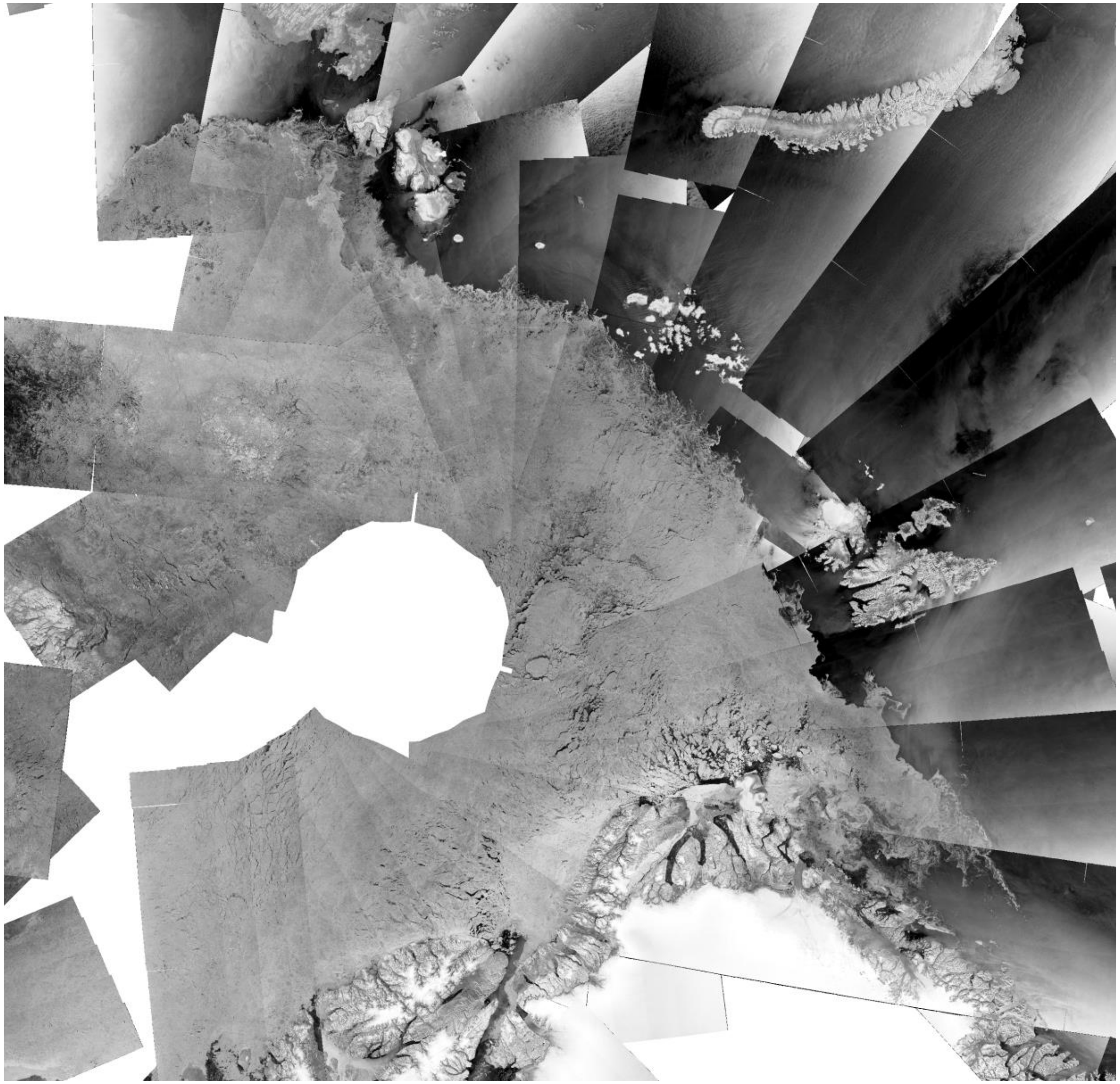
Delayed role out of the blended ice concentration

Direct Import of Automated Snow & Ice Cover

- **Analysts will be able to selectively import the data from satellite derived products directly into the IMS analysis**
- **Analysis will have selection box to select snow cover and ice cover from the VIIRS, NOHRSC (2017), and NH AutoSnowIce, Blended Ice Concentrations (2018/19), SAR ice classification (2018), and GOES 16 (2018).**
- **Human data selection to optimize product use based on expert knowledge and imagery interpretation**
- **Combines the speed and reliability of automated products with the QC and flexibility of Human Analysts**



Ice Tracking and SAR Ice Motions



SAR Program Ice Product Objectives

<u>2017-2018</u>

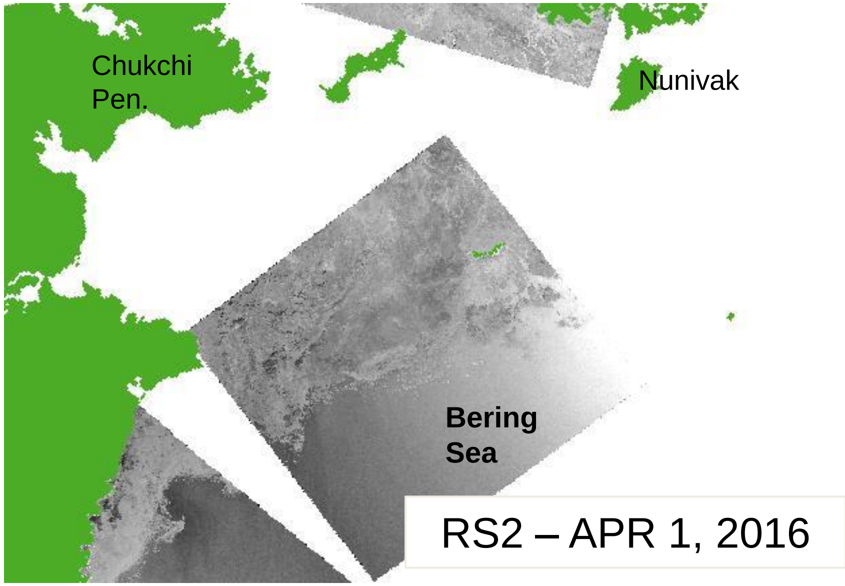
- Automated Sea-Ice Mask Using Multiple Inputs: Winds, IMS, Variance: Research mode - Evaluation phase

- Research implementation of sea-ice motion using feature tracking. Limited area with frequent coverage – Begun Test Phase

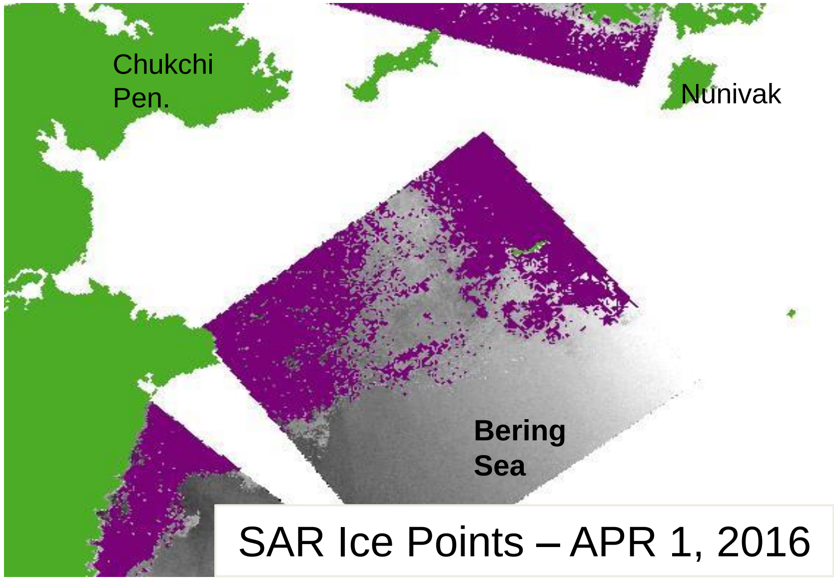
- Beta implementation of routine Great Lakes sea-ice classification - Complete

- Beta implementation of routine ship/iceberg detection – Starting Coding Phase

- SAROPS software upgrade and maintenance: improved configuration management – Complete

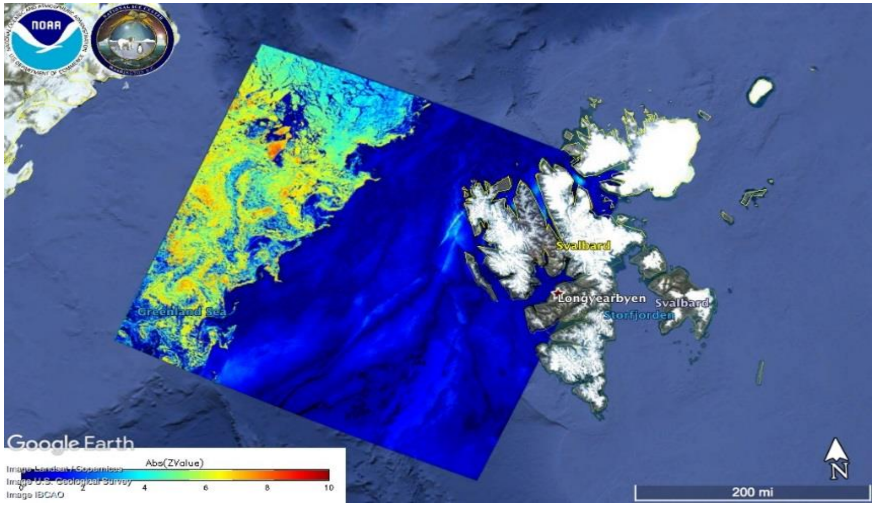


RS2 – APR 1, 2016

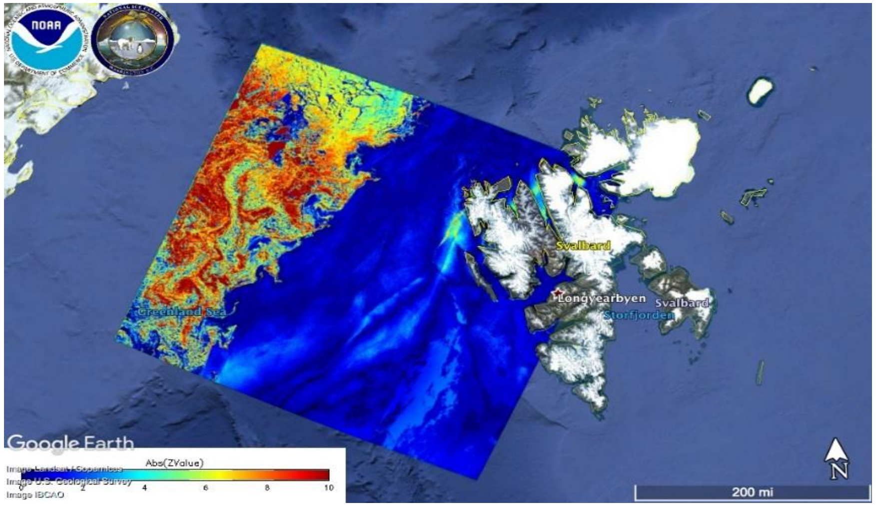


SAR Ice Points – APR 1, 2016

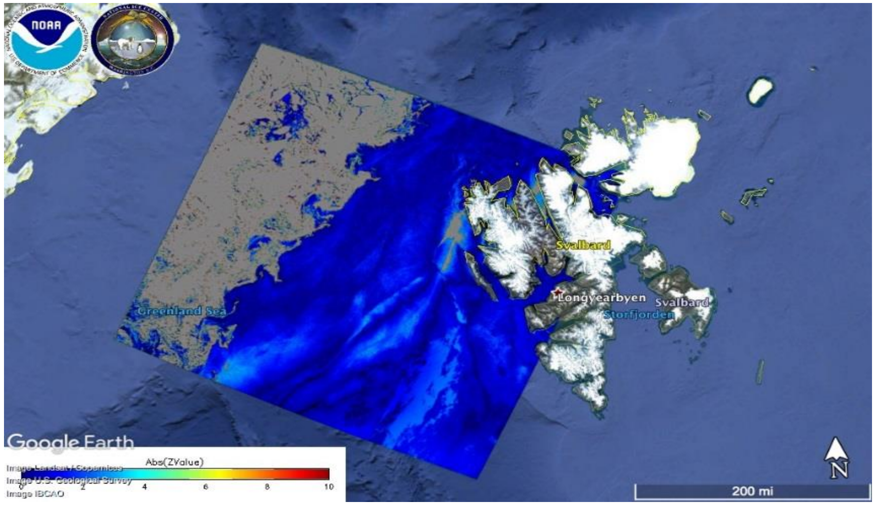
SAR Ice Mask



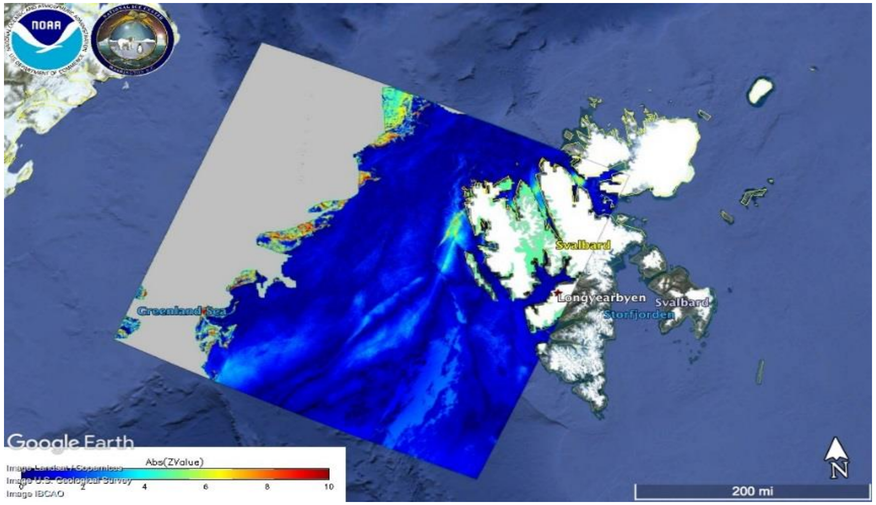
SAR-Derived Wind



SAR-Derived Wind – Model Wind



SAR-Derived Ice Mask



IMS Ice Mask

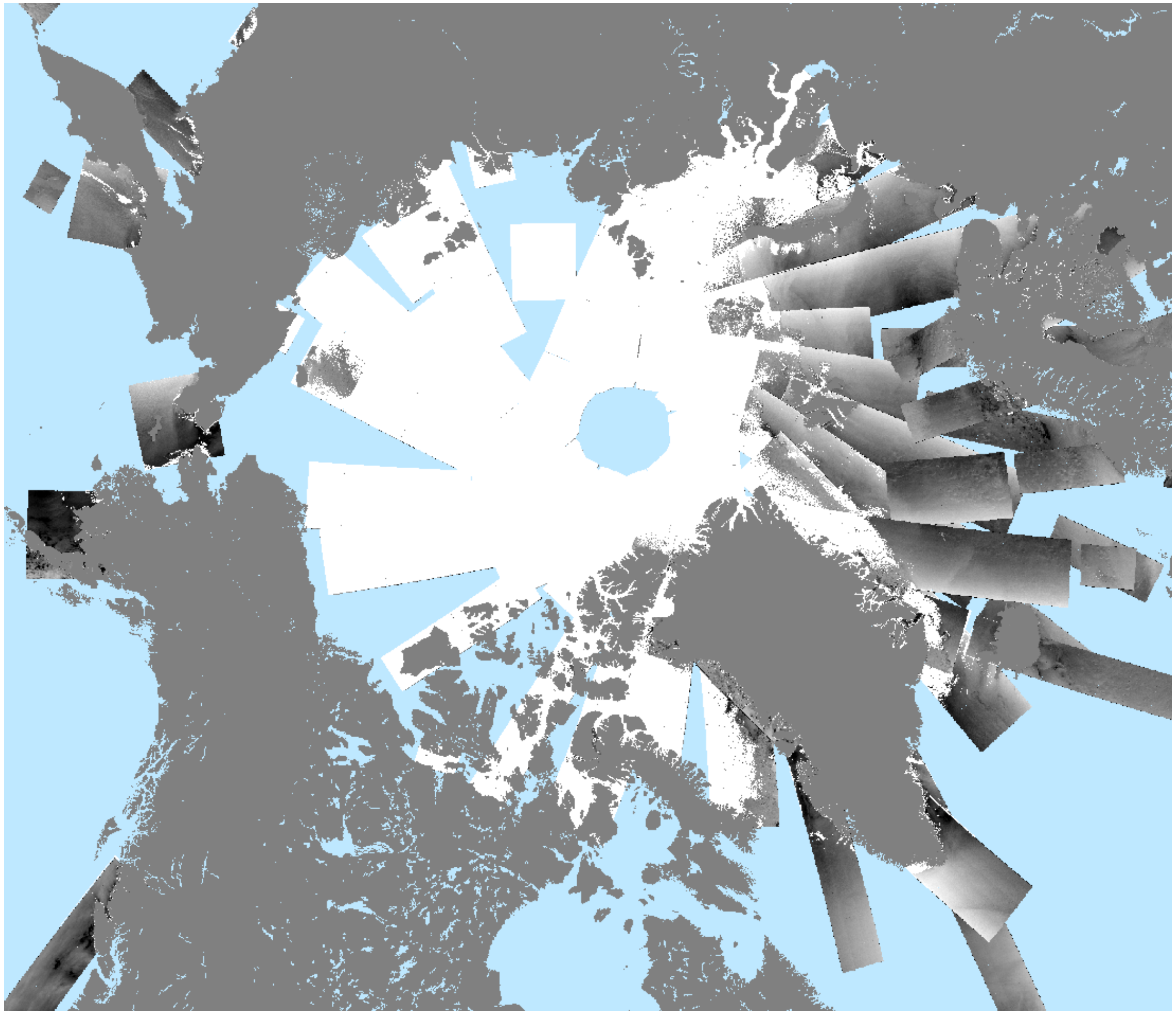
Radarsat-2 2015-09-23 07:00:58 UTC 4.81E 78.81N

Current SAR Ice Mask

Input parameters:

- Difference between SAR and GFS model wind speed,
- Wind speed variance

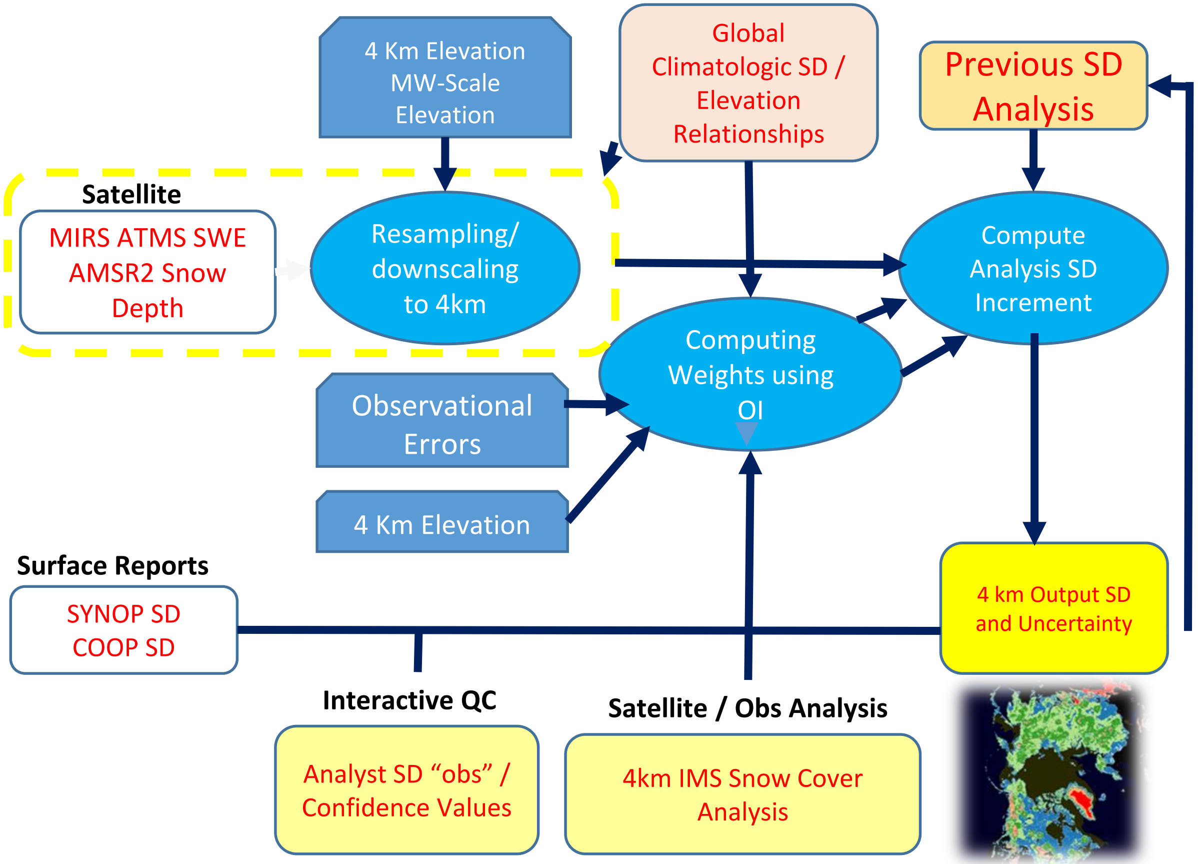
- Polar Stereographic projection sampled at 250m
- Run 2x daily using the latest 24 hours of data
- Currently input to IMS
- geotiff format



IMS Blended Snow Depth

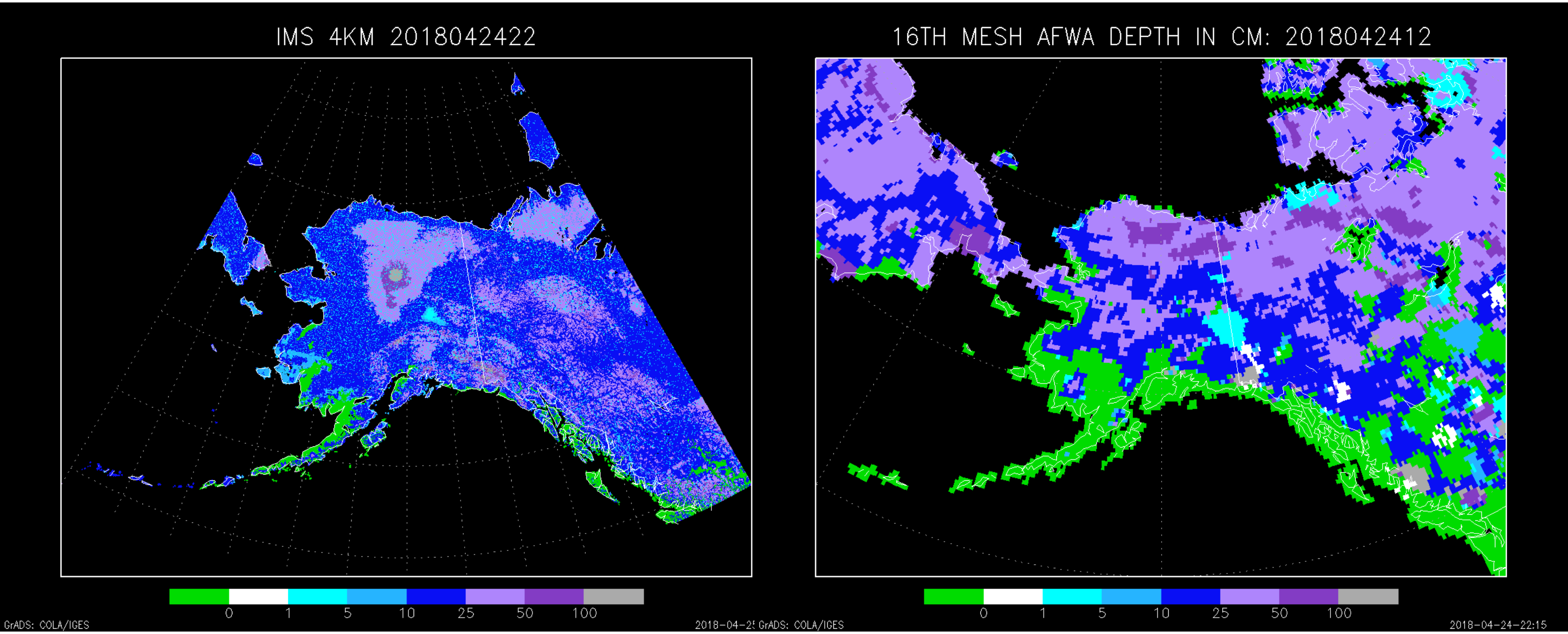
Key features:

- 2-D OI Analysis integrated into IMS V3
- Multi-Source Scheme: MW+in-situ + Climatology + Analyst Updates
- IMS Analyst SD and Uncertainty estimates are also ingested into OI as independent data stream
- MW Downscaling based on elevation
- Applies previous day as initial guess

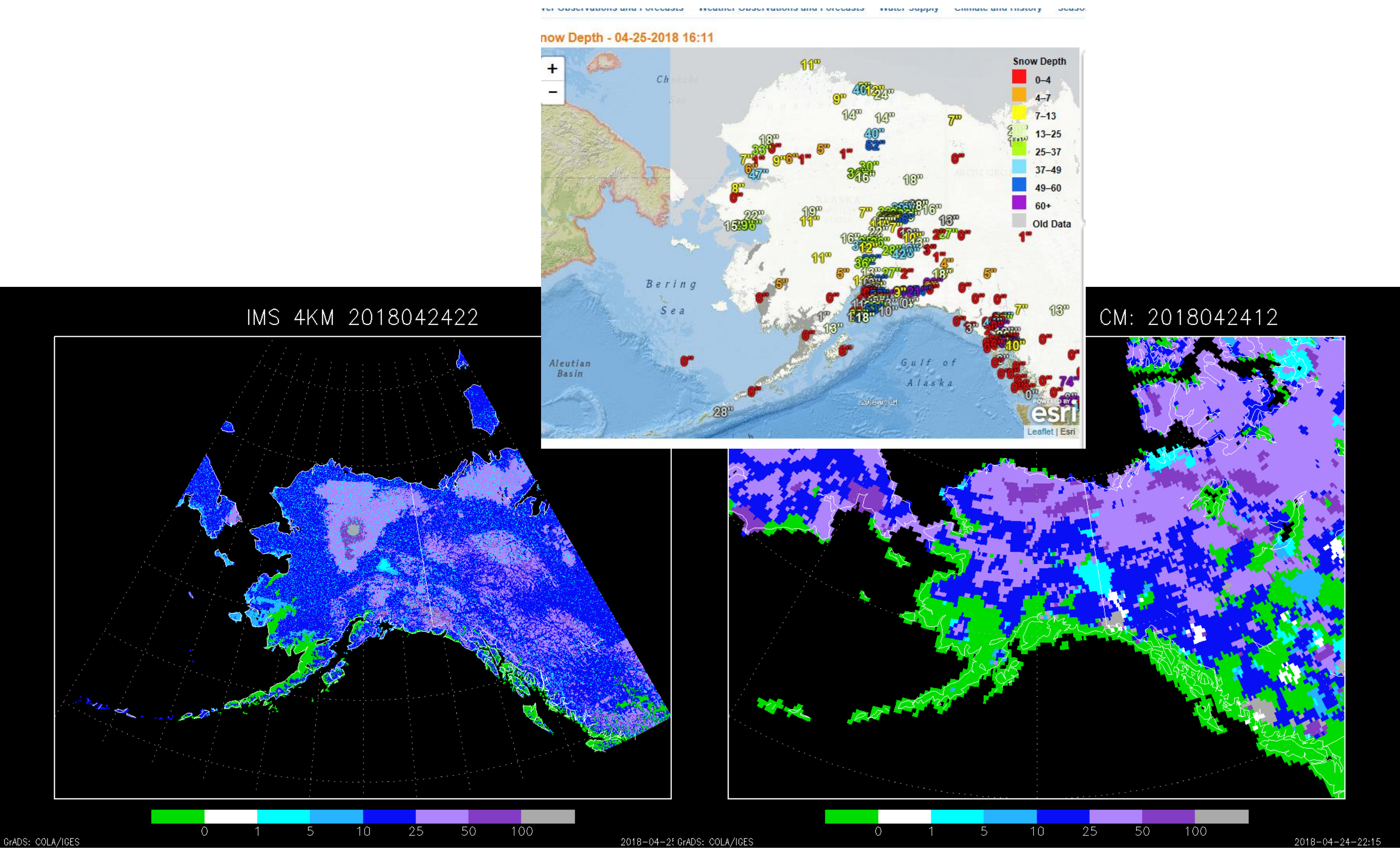


***** JAXA's Global Change Observation Mission (GCOM) AMSR2 data is used to generate Snow Depth via NOAA Algorithm, ATMS data uses the NOAA MIRS SWE to convert to SD. Both are applied in the algorithm***

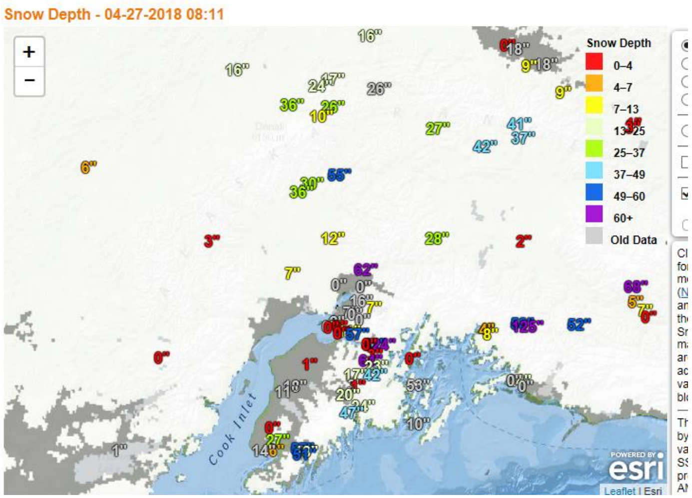
IMS Blended Snow Depth

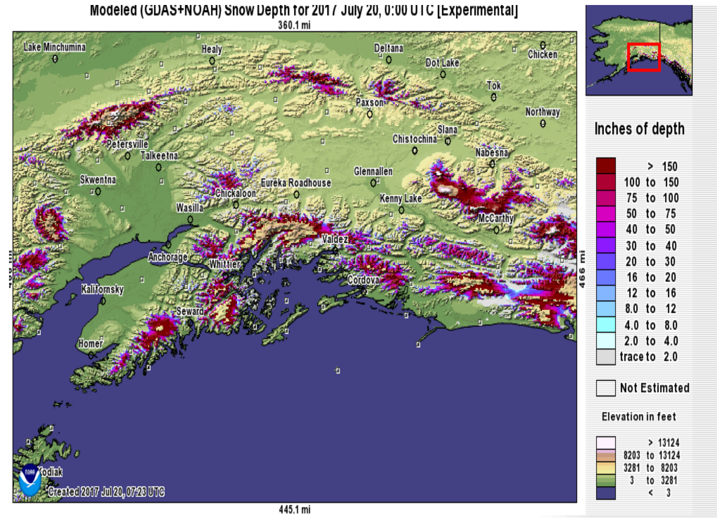


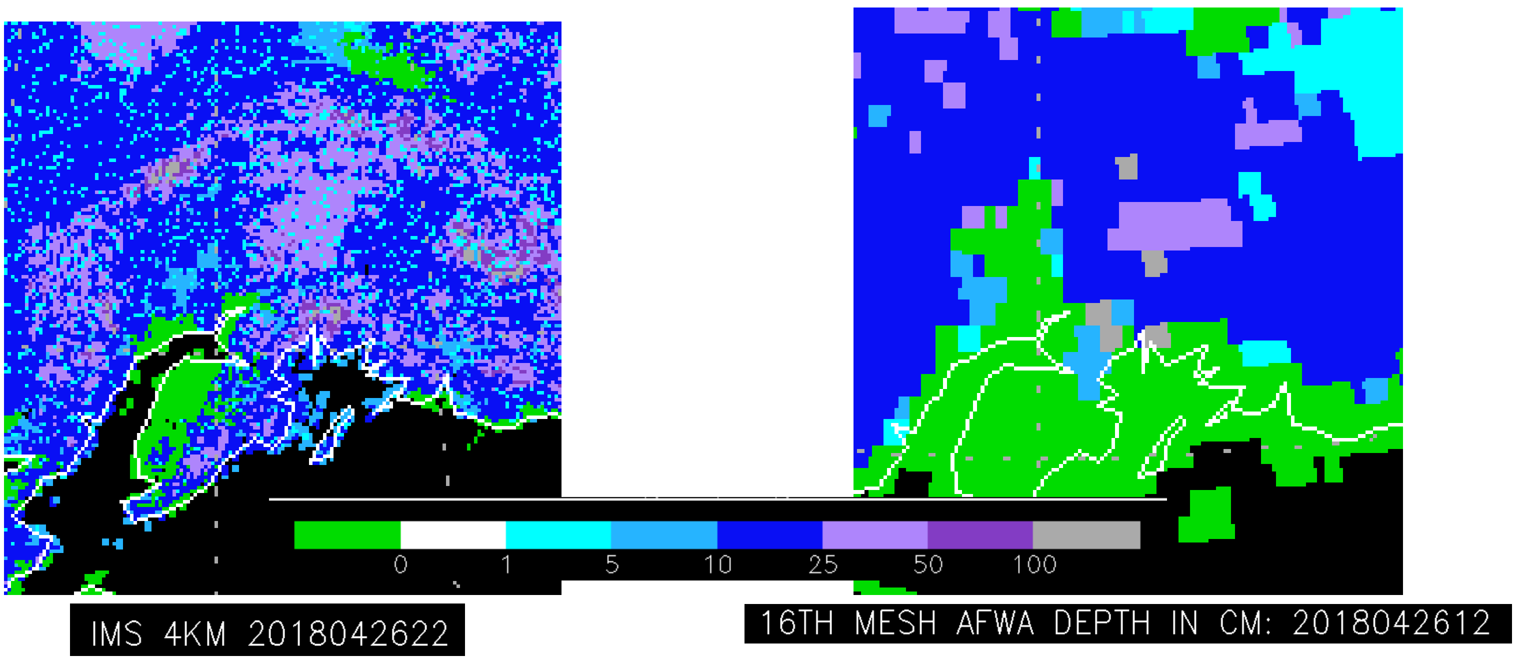
IMS Blended Snow Depth



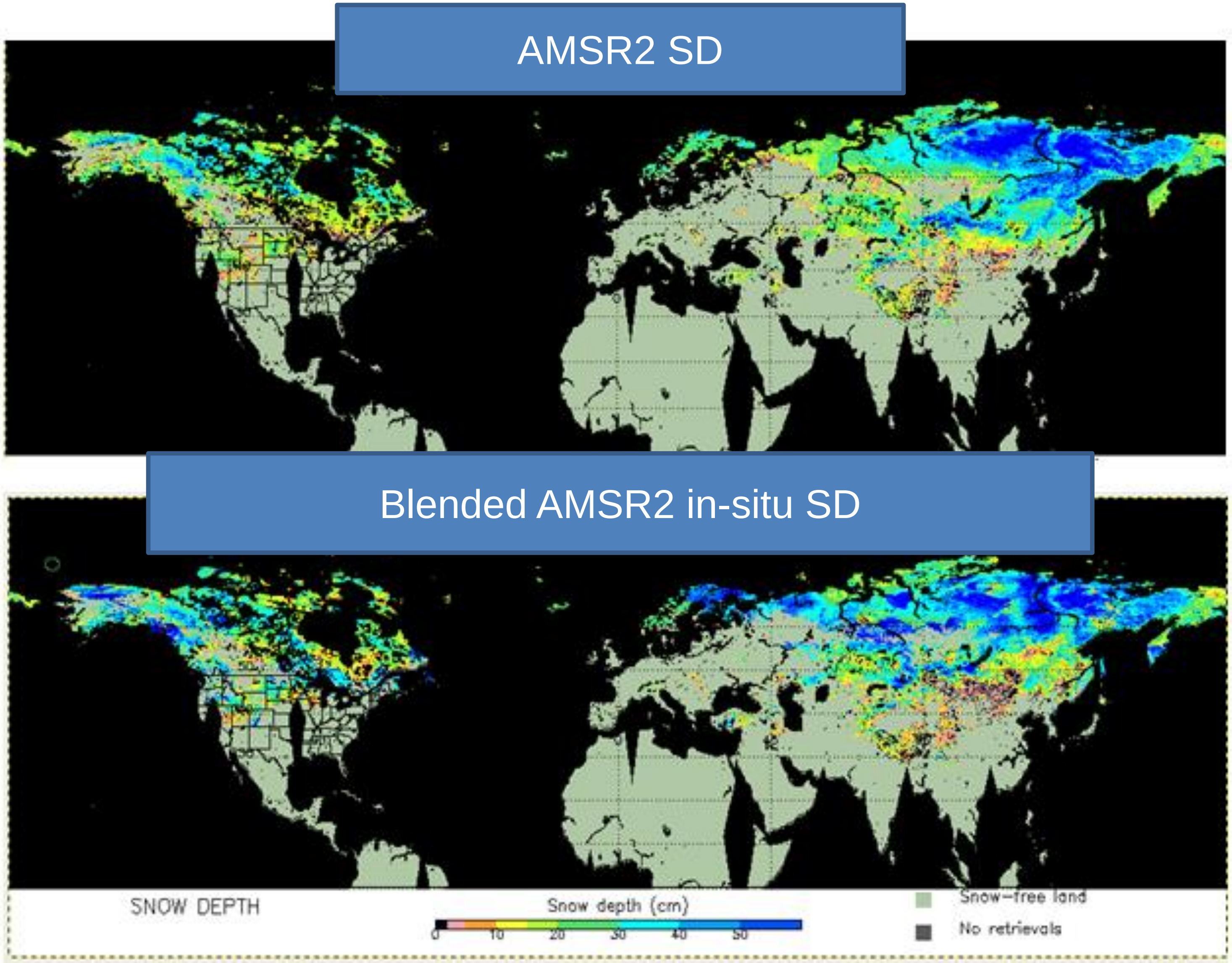
IMS Blended Snow Depth



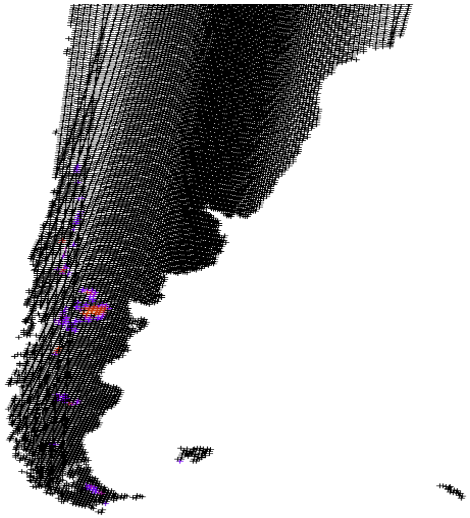




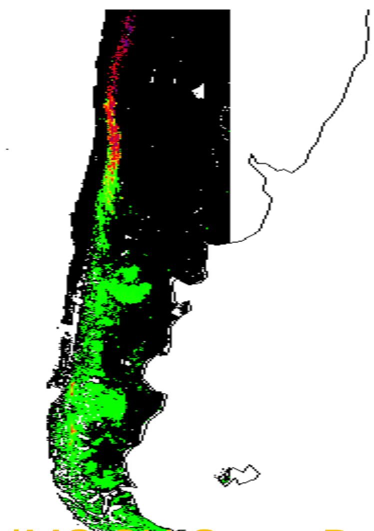
IMS Blended Snow Depth



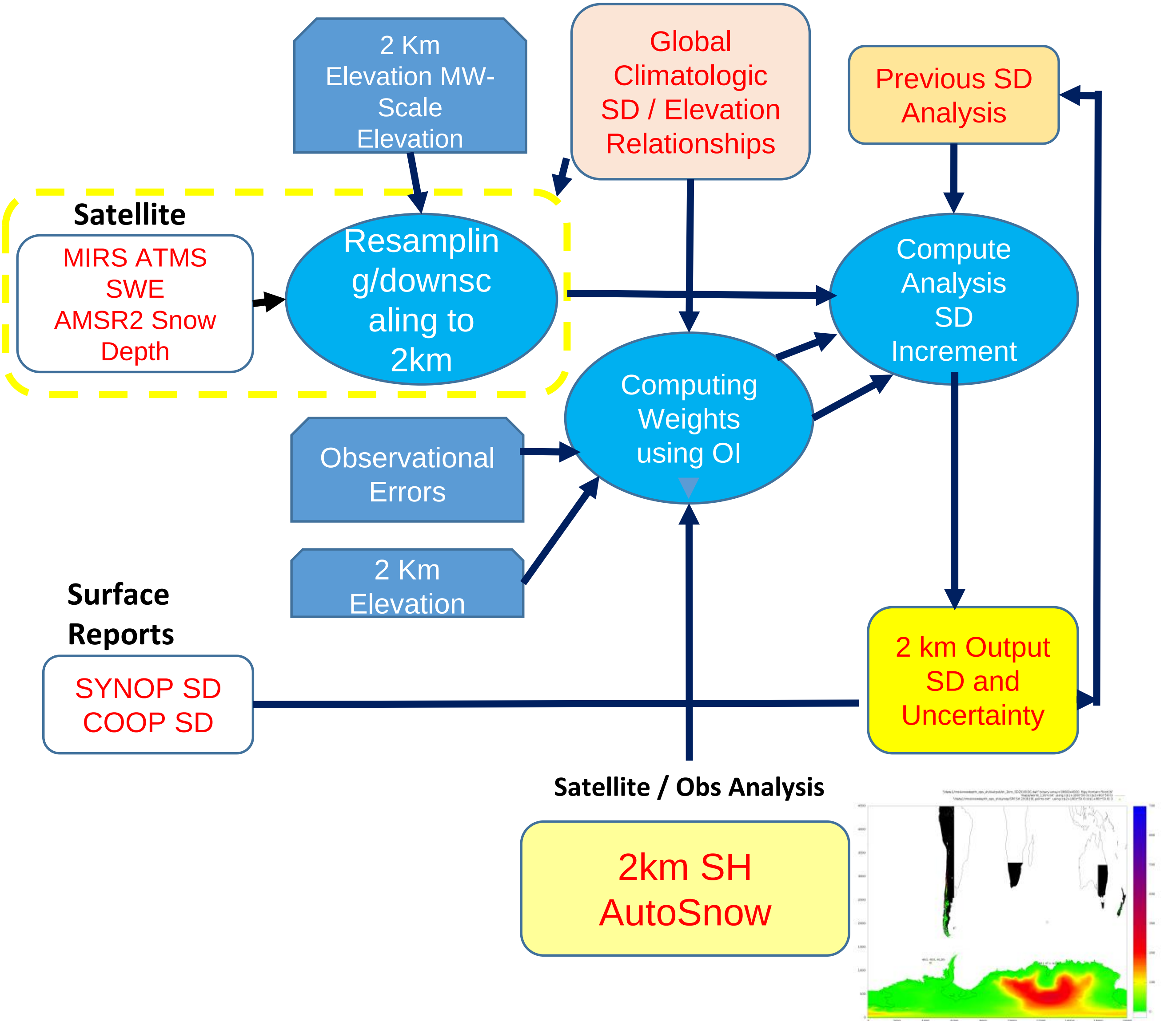
Southern Hemisphere Blended Snow Depth



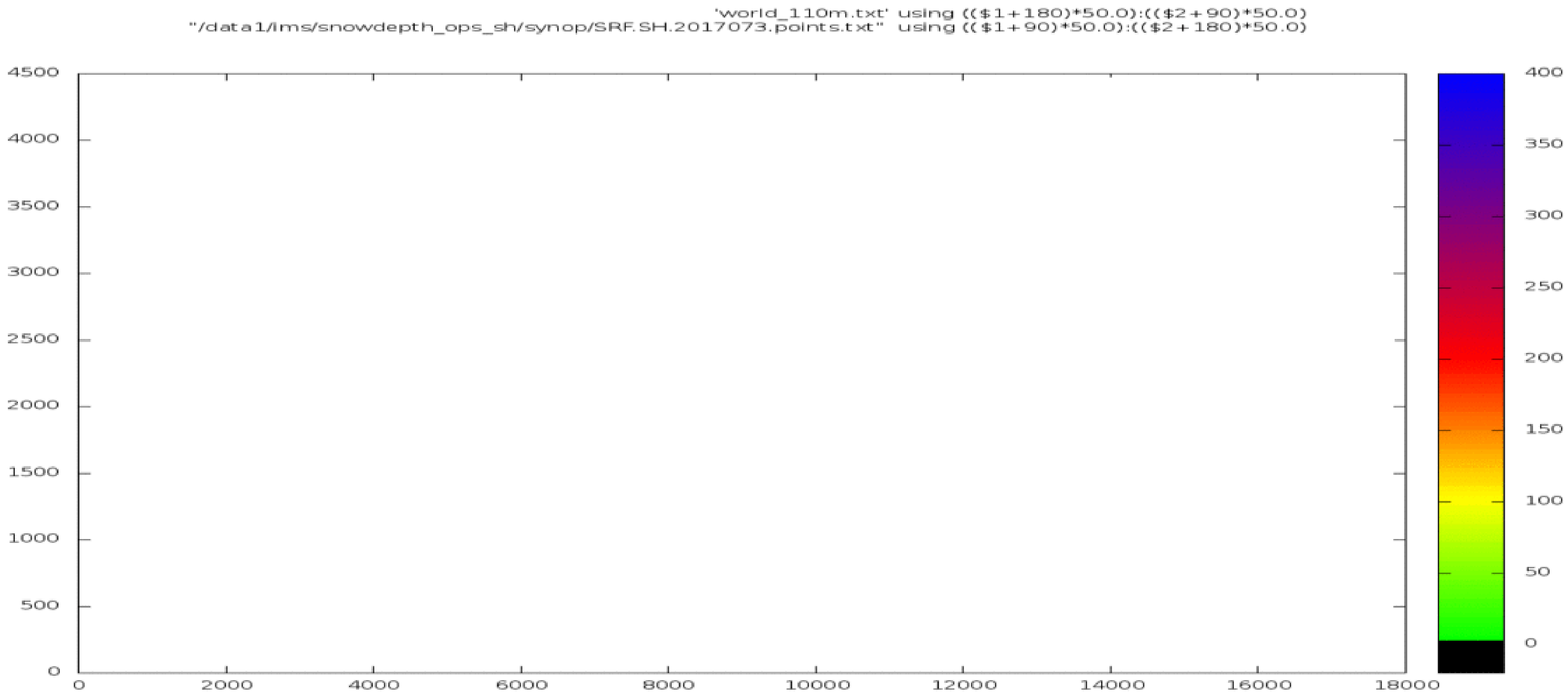
ATMS SWE



IMS SH Snow Depth

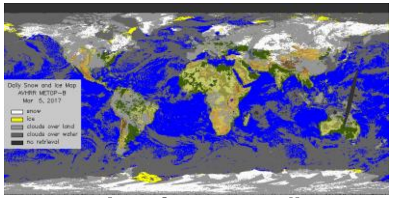


Southern Hemisphere Blended Snow Depth

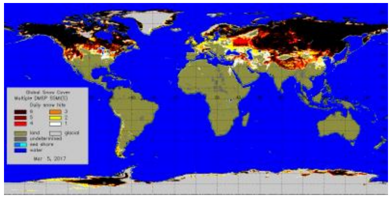


Approach

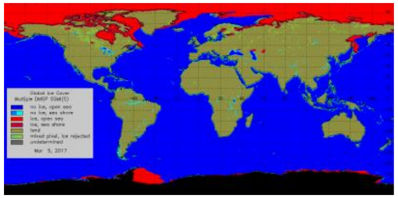
: - Snow/ice maps are derived for each sensor data individually and then combined
- Blending algorithm accounts for snow/ice and temperature climo, surface topography and surface type
- Previous day product is used to fill in remaining gaps in the current day snow/ice map



Optical snow/ice



Microwave snow



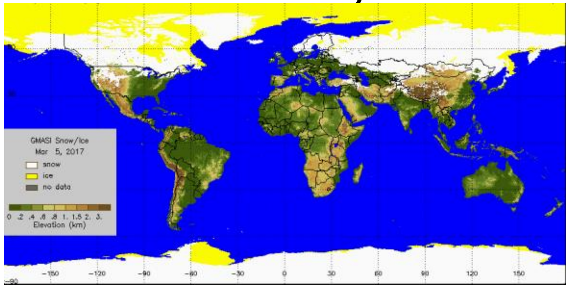
Microwave ice

Blending

Climate datasets (snow, ice, LST, SST), elevation, surface type

Final gap-filling

First guess (previous day blended snow/ice map)



Blended daily snow/ice map

Generates daily continuous (gap-free) maps of snow and ice from combined satellite observations in the visible/infrared and in the microwave

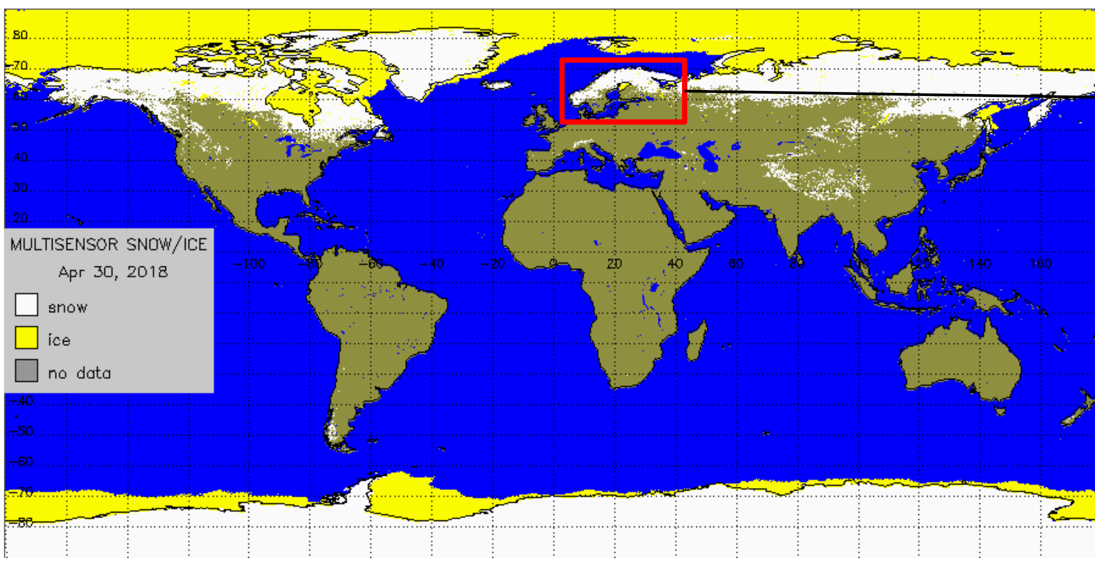
Current GMASI Input and Product Features

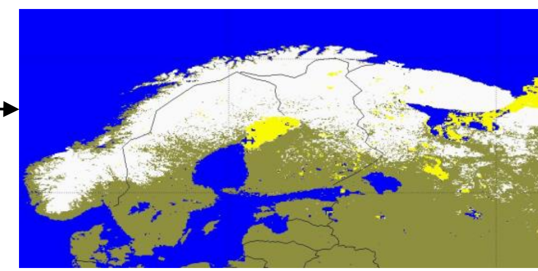
Input:

- AVHRR METOP-B
- DMSP SSMI/SSMIS F-15, -16, -17, -18

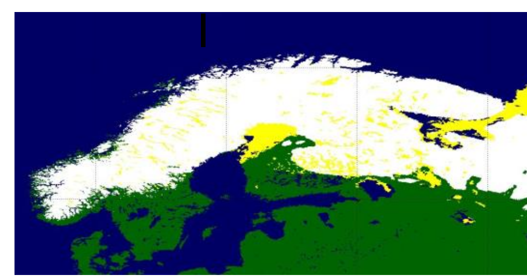
Output:

- Global daily gap-free map of snow and ice cover
- 0.04^0 (~4 km) resolution, global geographical projection, 0.02^0 (~2 km SH) Operational at OSPO since 2006, reprocessed daily data available since 1988
- > 92% agreement to IMS, over 88% agreement to in situ station data in





GMAS



IMS

In Near Term (2019)

Blended Ice Concentration

Blended Snow Depth improvements

SAR Ice Mask – Algorithm Improvement

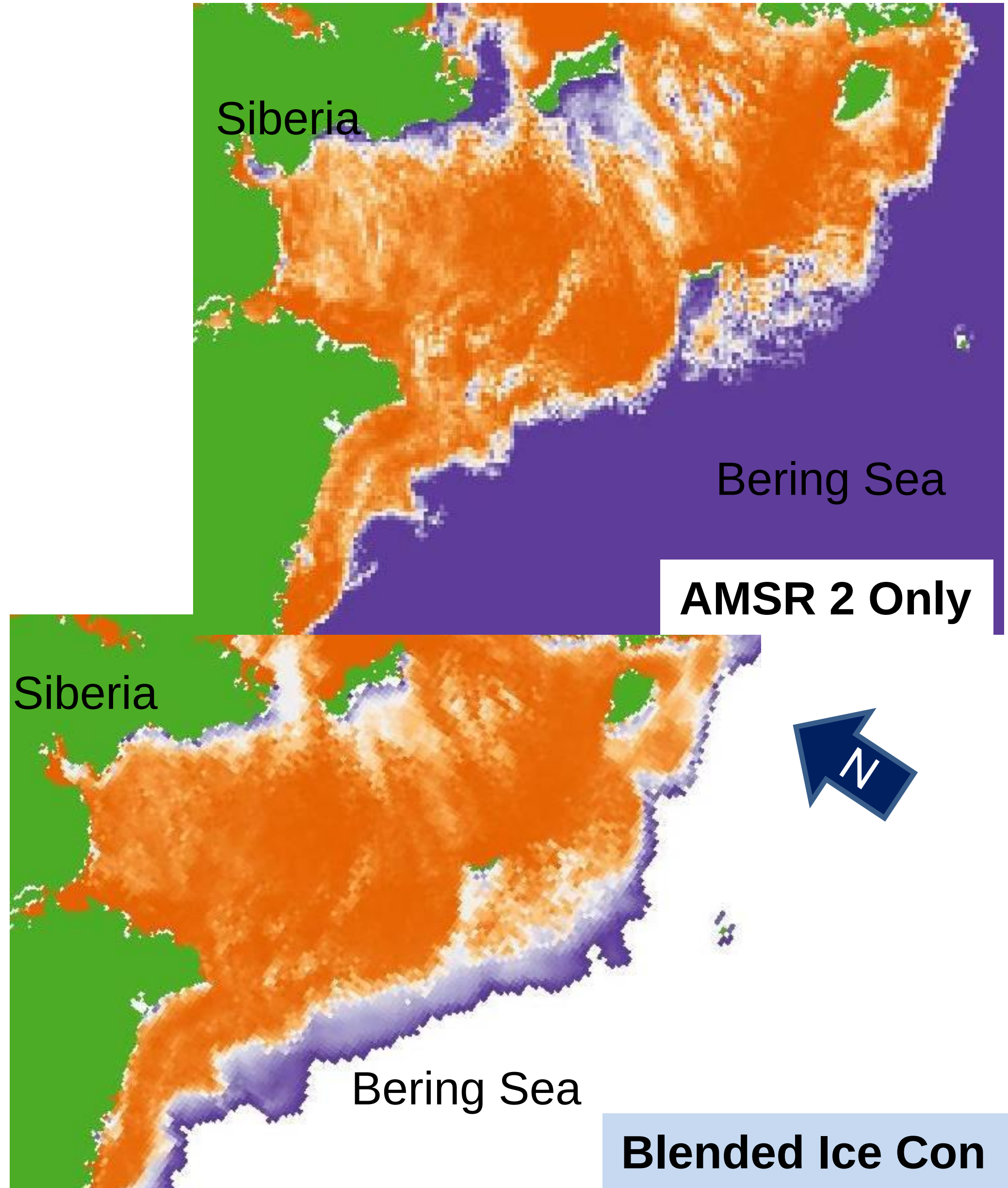
SAR Ice Motions

Improvements in IMS production environment

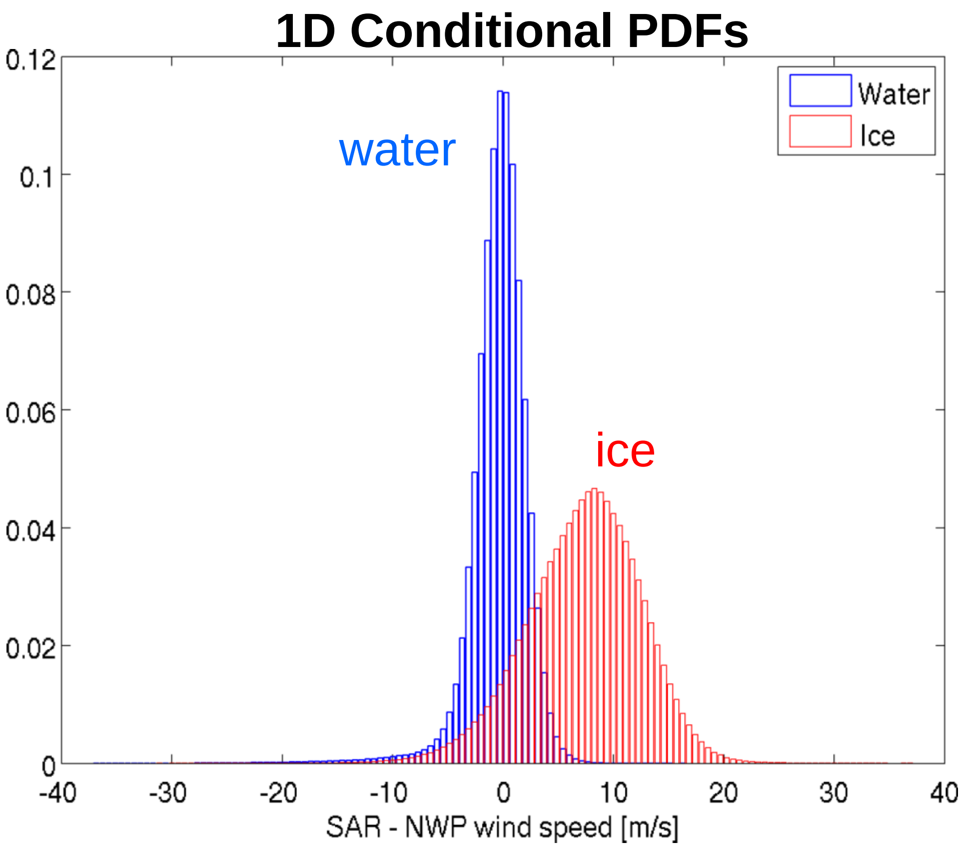
Blended Ice Conc. AMSR2+VIIRS+SAR+Model+Charts

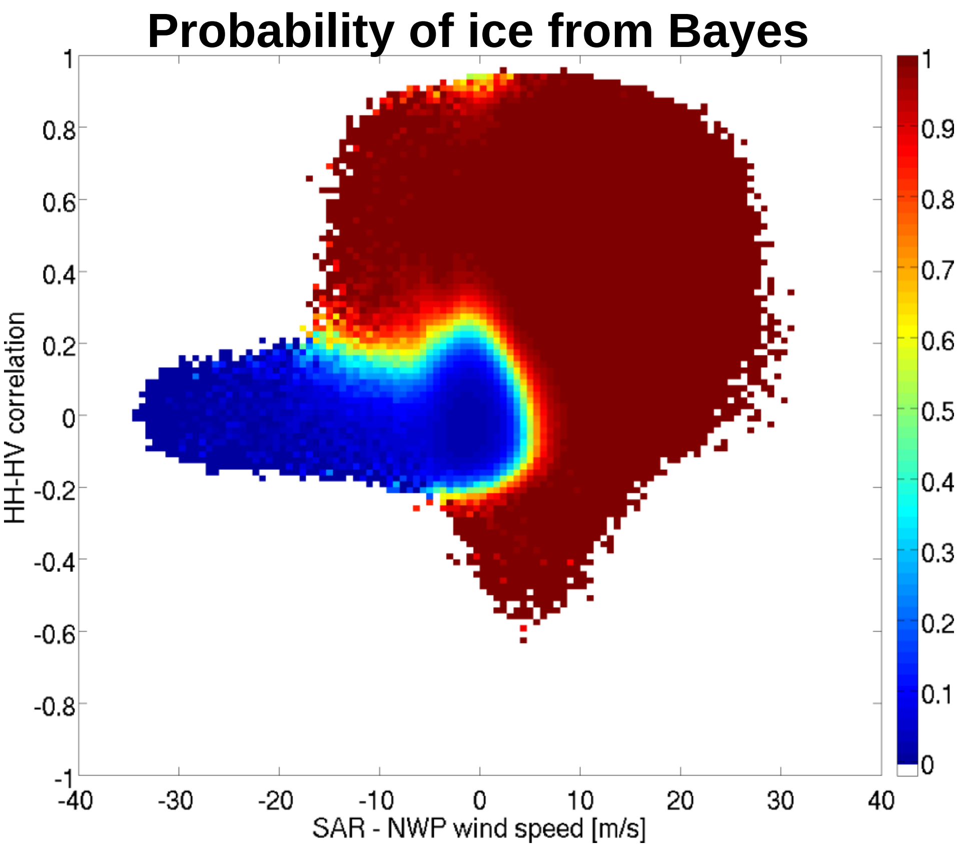
<u>BLENDED ICE CONCENTRATIONS</u>:
STAR and NIC are developing a Blended Ice Concentration primarily for modeling

- **Using Differential Weighting and Interpolation to blend ice concentrations**
- **Ice Concentrations determined from:**
  - ***IMS Ice Cover***
  - ***AMSR 2***
  - ***SAR Ice Points***
  - ***VIIRS Ice Con***
  - ***Ice Charts (NIC and NWS Alaska** with CIS, DMI, MetNo under consideration)*
  - ***NWP model SST***
- **Late 2018/Early 2019 Release**



Adding probabilistic threshold for SAR Auto Ice Extent



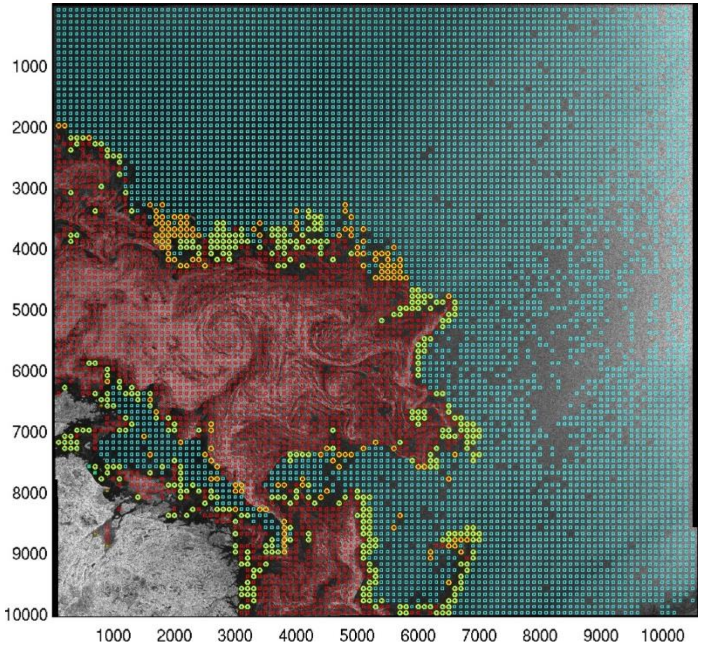


Presence of ice and open water is obtained from CIS image analyses

ECCC Verification against IMS

7411 RADARSAT-2 images in 2013

	Number of samples	Classified [%]	Misclassified [%]	Unknown [%]	Accuracy [%] Nc / (Nc + Nm)
Ice	24,719,977	75.81	2.58	21.61	96.71
Water	12,813,635	55.53	2.90	41.57	95.04
Ice & Water	37,533,612	68.89	2.69	28.43	96.24



Labrador Sea, May 3, 2013

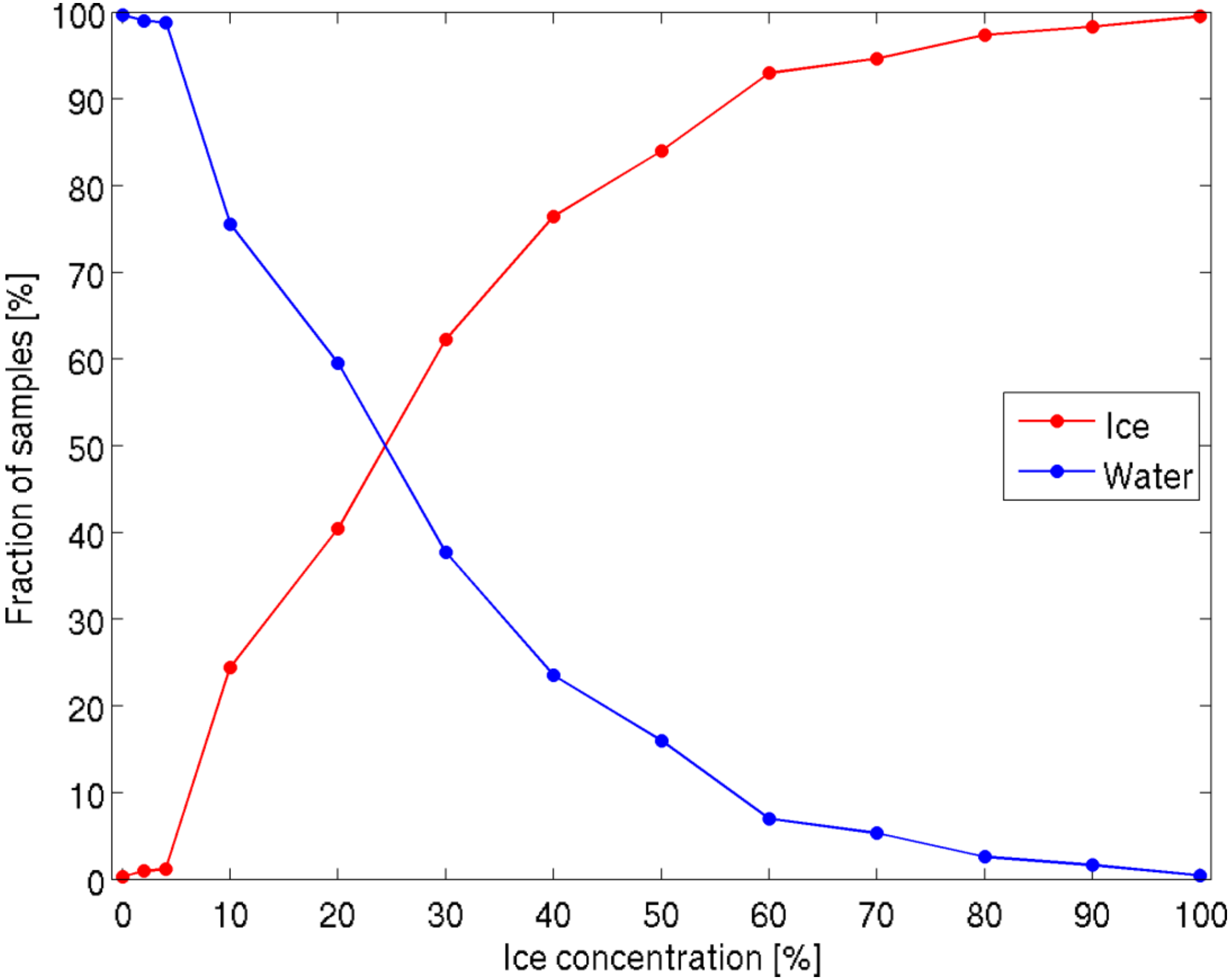
Ice/water retrievals at 5 km spacing

- Ice agrees with IMS
- Water agrees with IMS
- Ice disagrees with IMS
- Water disagrees with IMS

Many disagreements likely due to low temporal resolution of IMS

Acknowledgement: Mark Buehner, Alex Komarov, and Alain Caya (ECCC)

Potentiel SAR Ice Concentration



Fraction of ice/water samples

$F_i = N_i / (N_i + N_w)$

$F_w = 1 - F_i$

Based on estimation of different scales of CIS image analysis and 2x2 km composites of ice points

Same examination is planned by STAR to examine the

Acknowledgement: Mark Buehner, Alex Komarov, and Alain Caya (ECCC)

Outlook for 2020

NIC formally moved to Ocean Prediction Center (OPC), so NIC is no longer a JPSS Blended Products provider but a customer of the products

IMS not part of the enterprise migration since it will be a part of the NWS environment, not NESDIS'. It appears that GMASI (AutoSnowIce) products will remain in the OSPO enterprise environment

GMASI improvements (add SNPP/NOAA-20 VIIRS and GCOM-W1 snow and ice products, 1km resolution, and new formats (netCDF, HDF, geotiff) will be implemented during FY 2019-2020

Greater integration of Passive Microwave (ATMS, AMSR) + VIIRS + SAR + Scatterometry + GEO + Altimetry products to improve accuracy and customer support.

IMS moving more towards a semi-automated analysis due to the improved input data sources and allowing more time for analysts to forecast ice.

Thank you for your attention

For more information contact
NOAA/NESDIS/STAR/SOCD/MECB
Email: sean.helfrich@noaa.gov