Status of AMSR2 Level-2 Products (Algorithm Ver. 1.00)

Earth Observation Research Center
Japan Aerospace Exploration Agency
and
GCOM-W1 Algorithm Development PI

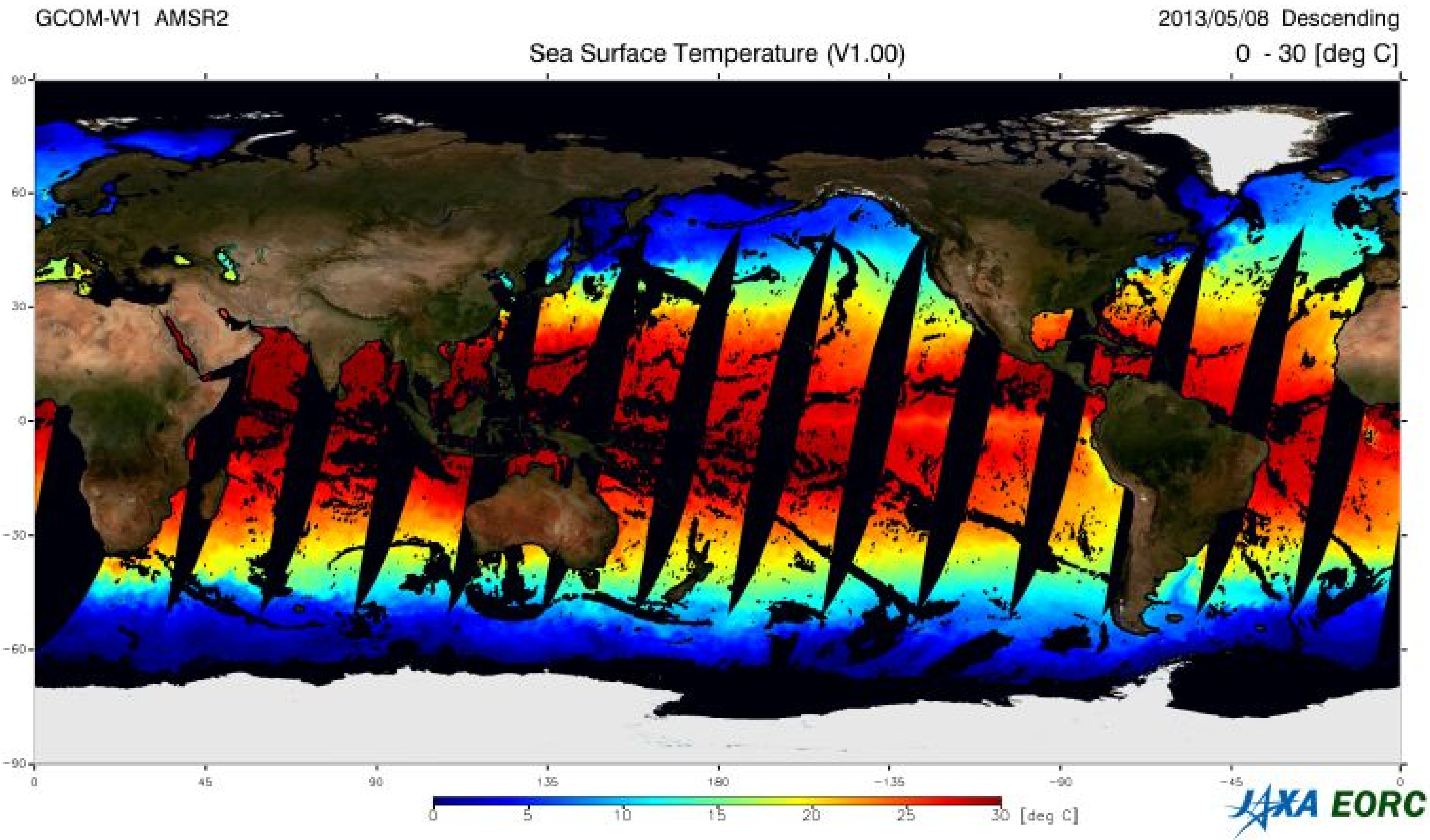
July 9, 2013

Current Status and Schedule

- 2012.05.18 GCOM-W1 (SHIZUKU) launched
- 2012.07.03 Started AMSR2 observation from A-Train orbit
- 2012.07.04 Released AMSR2 observation images
- 2012.08.10 Initial functional verification completed
- 2012.09.03- Preliminary L1 products to PI and collaborating agencies
- 2012.10.19 Preliminary L2 products to PI and collaborating agencies
  SST,SSW,TPW,CLW,SIC
- 2012.11.07 Preliminary L2 and L1R products to PI and collaborating agencies
  PRC,SMC,SND,SST (revision),SSW (revision)
- 2013.01.25 Public release of L1 products
- 2013.05.17 Public release of L2 products

** GCOM-W1 project reviewed prior to the public data release, based on the predetermined success criteria (i.e., accuracy of products).*

Sea Surface Temperature (SST)



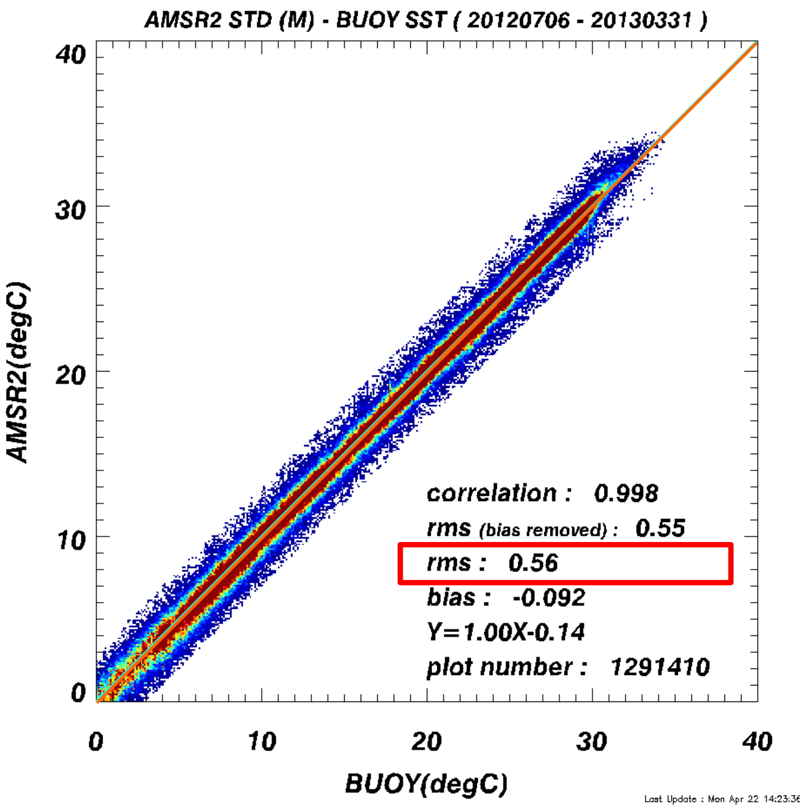
Sea Surface Temperature (SST)

- ## Algorithm PI
  - Akira Shibata, Meteorological Satellite Center, Japan Meteorological Agency
- ## Product status
  - SST algorithm Ver. 1.00, using L1B brightness temperatures Ver. 1.10 released on 1 March 2013 as inputs.
- ## Caveats
  - Potential errors in brightness temperatures should be corrected to estimate accurate SST. Currently, the correction is performed on monthly basis: last month's correction table is used for correcting the present month's brightness temperatures. This "non-realtime" correction may sometimes degrade the SST accuracy. After we will get one year observation of AMSR2 in July 2013, correction method will be re-considered.
  - Simple spatial filter (3x7 (scan x line) running mean) is applied to remove noise. After applying this filter horizontal resolution is almost same as AMSR2 FOV of 6GHz channel.
  - Currently, SST is retrieved based on the 6.925 GHz channels. Comparable SST can be retrieved by using the newly added 7.3 GHz channels. After the 1-year stability and quality monitoring of 7.3 GHz channels, utilization of both frequency channels will be considered.
- ## Validation results
  - Validation period: from 6 July 2012 to 31 March 2013.
  - Match-up condition: Select buoy SST derived from GTS within 2-hr in time and 30km in distance, 10-points average of AMSR2 SST (excluding those have differences larger than 3˚C from corresponding buoy measurement based on AMSR-E experience).
  - Resulted errors: rms error <u>0.6℃</u>, bias -0.092 (see next page for detail)
- ## References

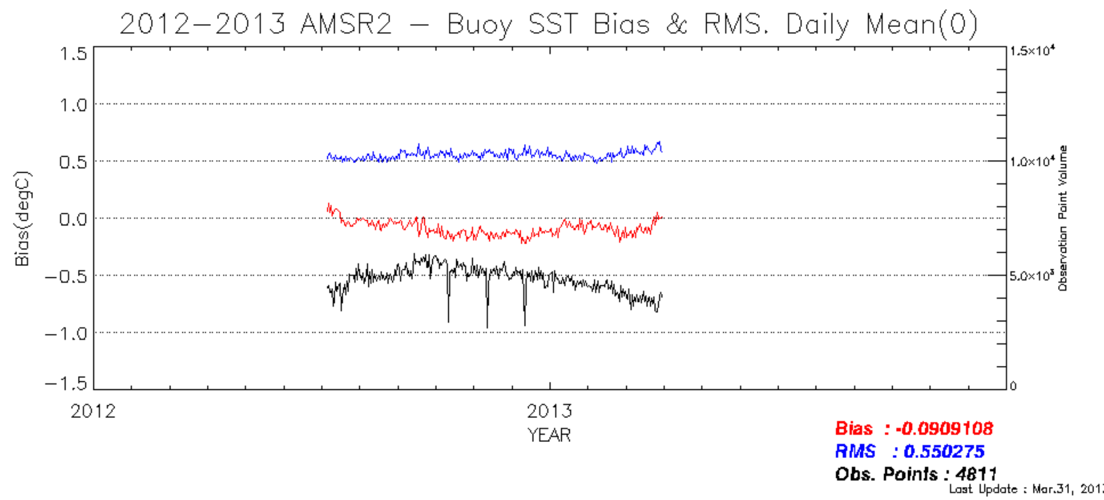
  - Algorithm description of GCOM-W1 AMSR2, JAXA Technical Report, NDX-1200015A, 2013.

Sea Surface Temperature (SST)

Comparison with buoy SST
Ascending + Descending



Time series of bias, RMSE and observation number (Ascending + Descending)

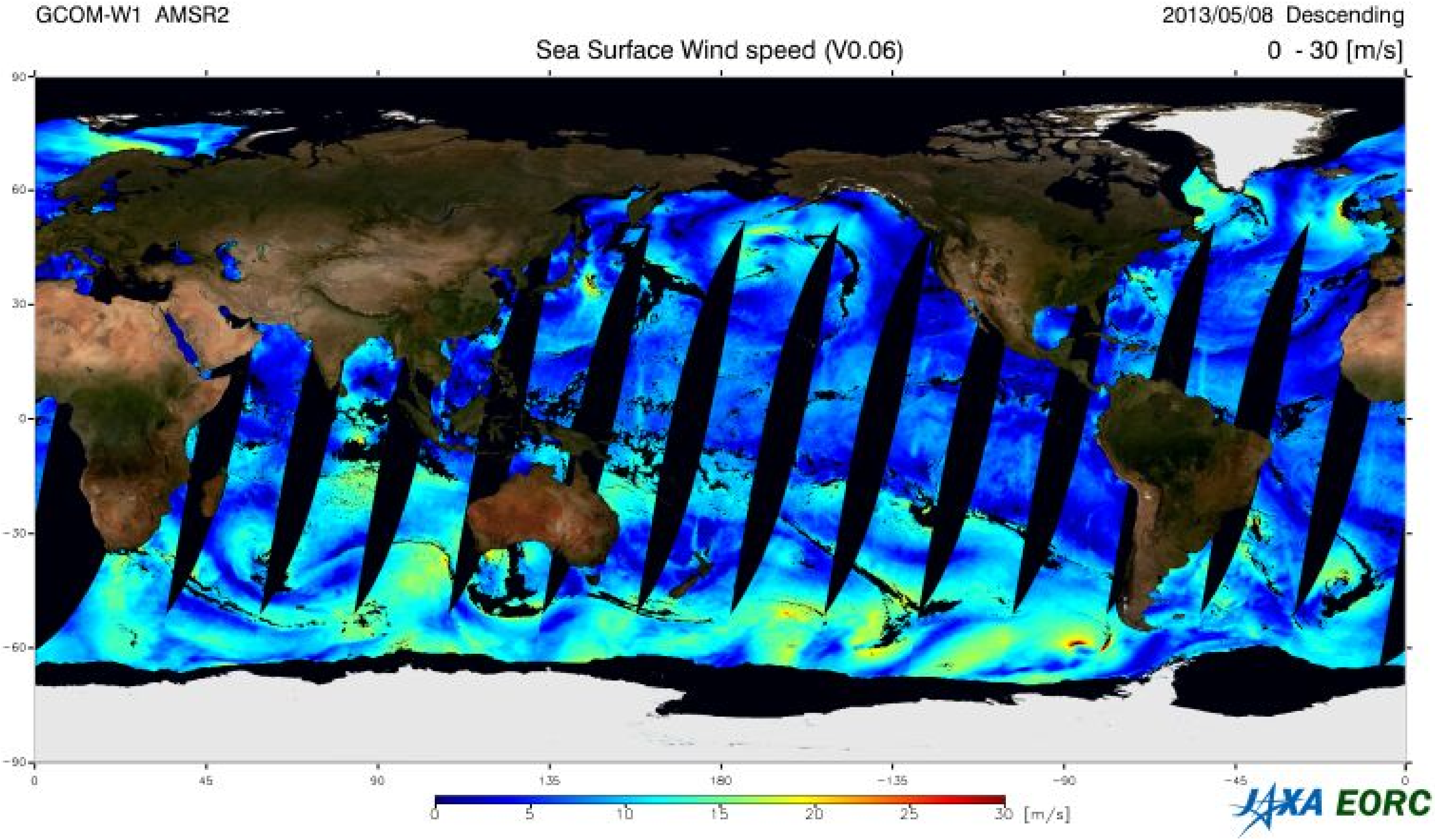


Validation period:
6 July 2012 to 31 March 2013

Validation	Required (Release)
0.6 ℃	0.8 ℃

(RMSE)

Sea Surface Wind Speed (SSW)

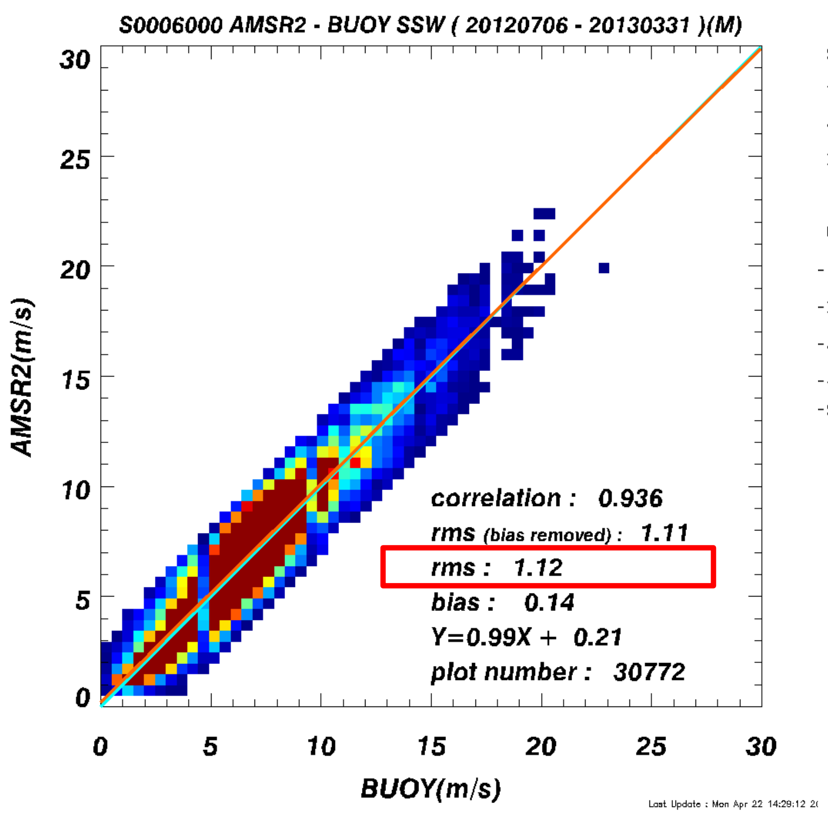


Sea Surface Wind Speed (SSW)

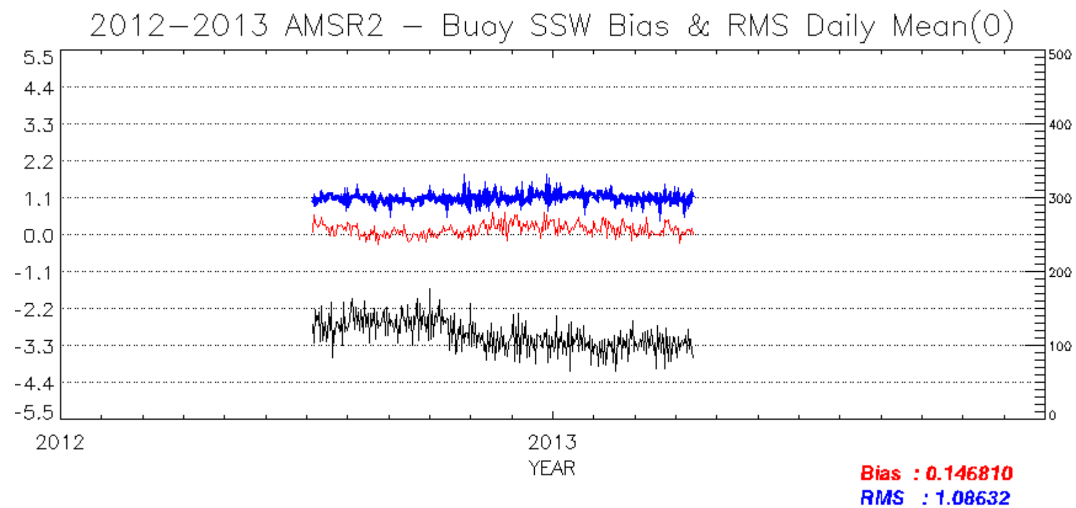
- ## Algorithm PI
  - Akira Shibata, Meteorological Satellite Center, Japan Meteorological Agency
- ## Product status
  - SSW algorithm Ver. 1.00, using L1B brightness temperatures Ver. 1.10 released on 1 March 2013 as inputs.
- ## Caveats
  - Corrections were applied to AMSR2 brightness temperatures based on the statistical comparison with 9.5-years AMSR-E brightness temperatures.
  - Potential errors in brightness temperatures should be corrected to estimate accurate SSW. Currently, the correction is performed on monthly basis: last month's correction table is used for correcting the present month's brightness temperatures. This "non-realtime" correction may sometimes degrade the SSW accuracy. After we get one year observation of AMSR2 in July 2013, correction method will be re-considered.
- ## Validation results
  - Period of comparison: 6 July 2012 – 31 March 2013.
  - Match-up condition: Select buoy SSW derived from GTS within 2h in time and 30km in distance, 10-points average of AMSR2 SSW (excluding those have differences larger than 3 m/s from corresponding buoy measurement).
  - Resulted errors: rms error 1.11 m/s, bias 0.14 m/s (see next page for detail)
- ## References
  - Algorithm description of GCOM-W1 AMSR2, JAXA Technical Report, NDX-1200015A, 2013.

Sea Surface Wind Speed (SSW)

Comparison with buoy SSW
Ascending + Descending



Time series of bias, RMSE and observation number
(Ascending + Descending)

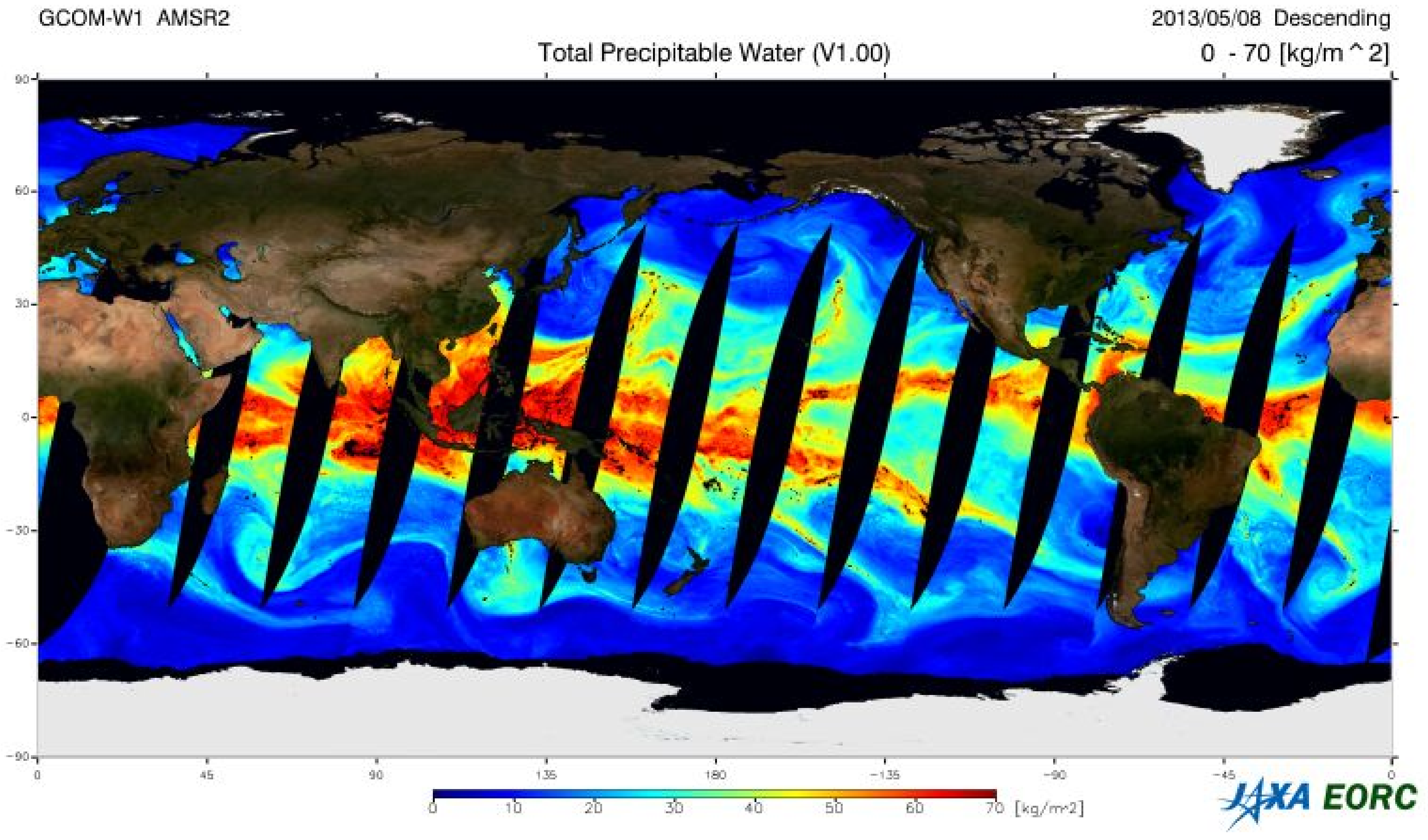


Validation period:
6 July 2012 to 31 March 2013

Validation	Required (Release)
1.1 m/s	1.5 m/s

(RMSE)

Total Precipitable Water (TPW)



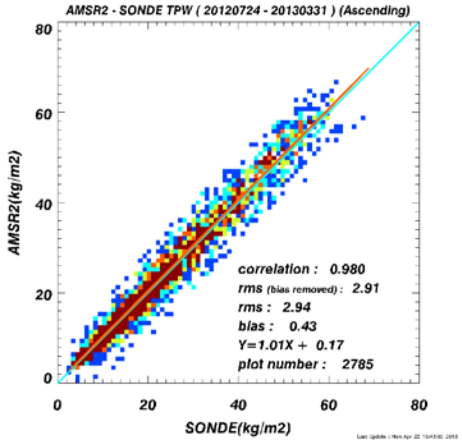
Total Precipitable Water (TPW)

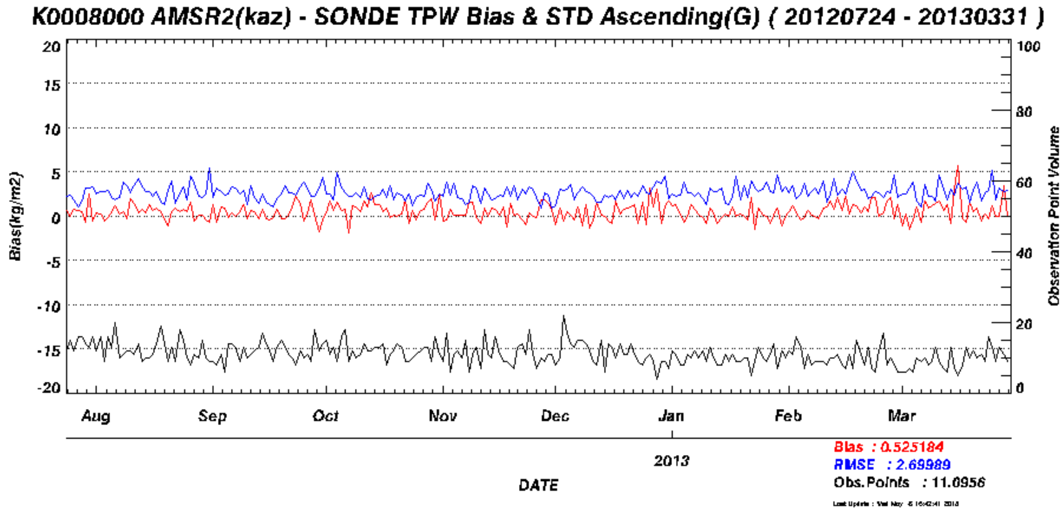
- ## Algorithm PI
  - Masahiro Kazumori, Numerical Prediction Division, Japan Meteorological Agency
- ## Product status
  - TPW algorithm Ver. 1.00, using L1R brightness temperatures Ver. 1.10 released on 1 March 2013 as inputs.
- ## Caveats
  - TPW are retrieved based on 18GHz, 23GHz and 37GHz channels' brightness temperature. TPW are sometimes not retrieved in descending orbit near coastal area of Continental United States. In this situation, observed AMSR2 brightness temperatures exceed a threshold of normal observed value in the algorithm. One possible cause is RFI contamination for 18GHz descending brightness temperature. Currently, the data are flagged as "invalid retrieval". The cause is under investigation.
- ## Validation results
  - Validation period
    - Radiosonde (RAOB): July 24, 2012 – March 31, 2013
    - GPS: July 24, 2012 – December 30, 2012

      Selected sites: bamf barh bjco brmu cnmr coco cro1 dgar dgav falk geno guug hers hert hlfx lmmf mac1 mars onsa palm qaq1 rio2 thti uclu
  - Match-up condition
    - RAOB: Distance less than 30km, Time difference within 6 hours
    - GPS: Distance less than 30km, Time difference within 3 minutes
  - Resulted errors: rms error $2.9\ kg/m^2$, bias $0.09\ kg/m^2$, based on RAOB results (see next page for detail)
- ## References
  - Algorithm description of GCOM-W1 AMSR2, JAXA Technical Report, NDX-1200015A, 2013.

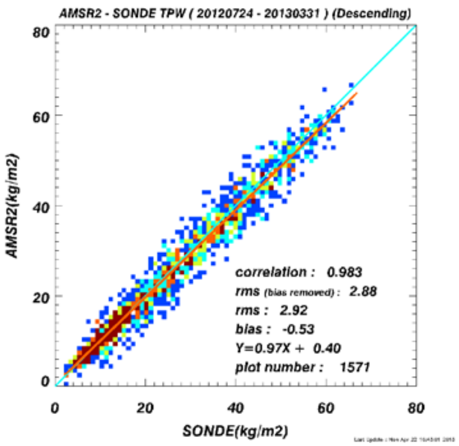
Total Precipitable Water (TPW)

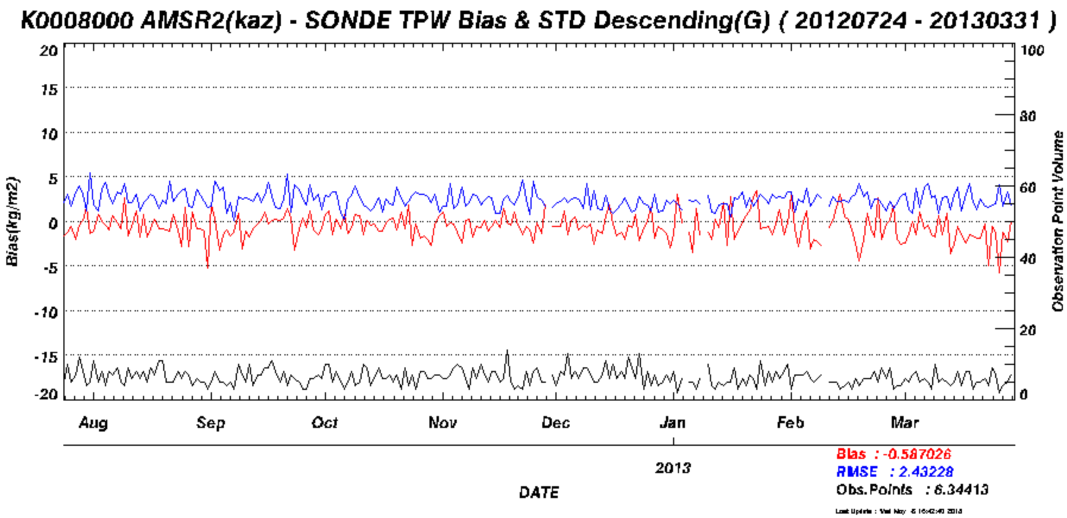
Ascending passes





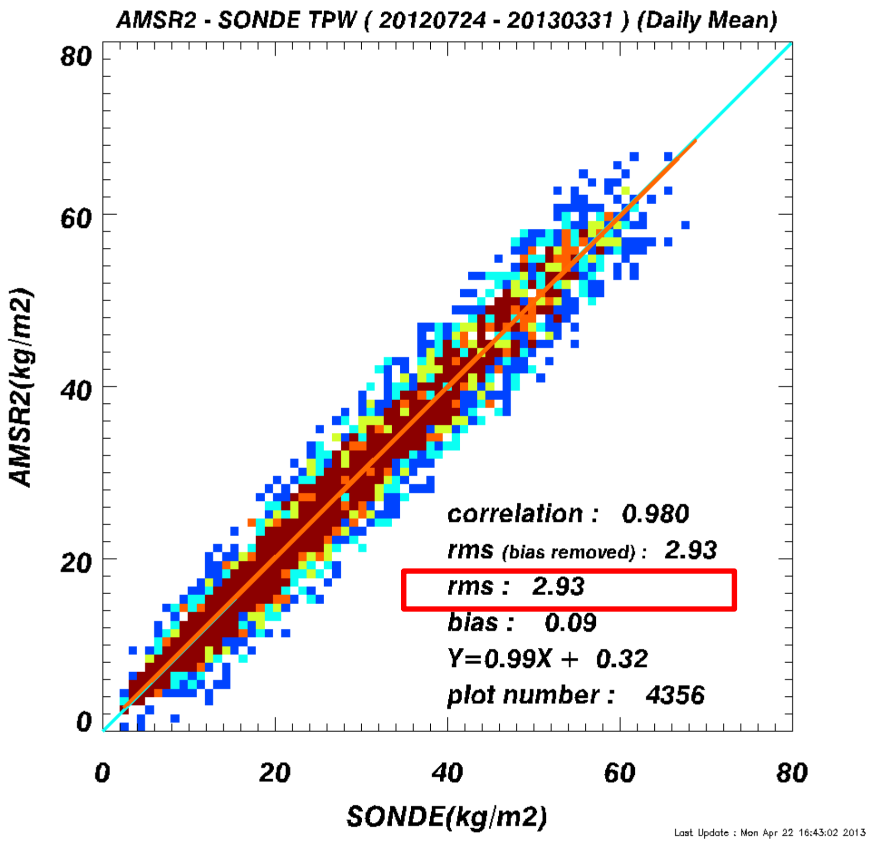
Descending passes



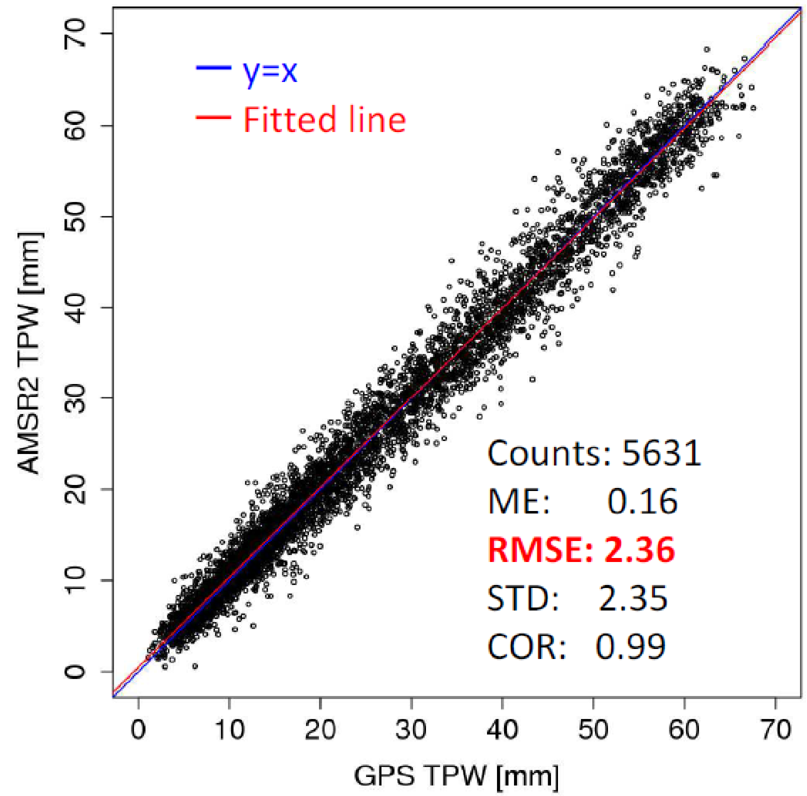


Total Precipitable Water (TPW)

Comparison with Radiosonde
Ascending + Descending



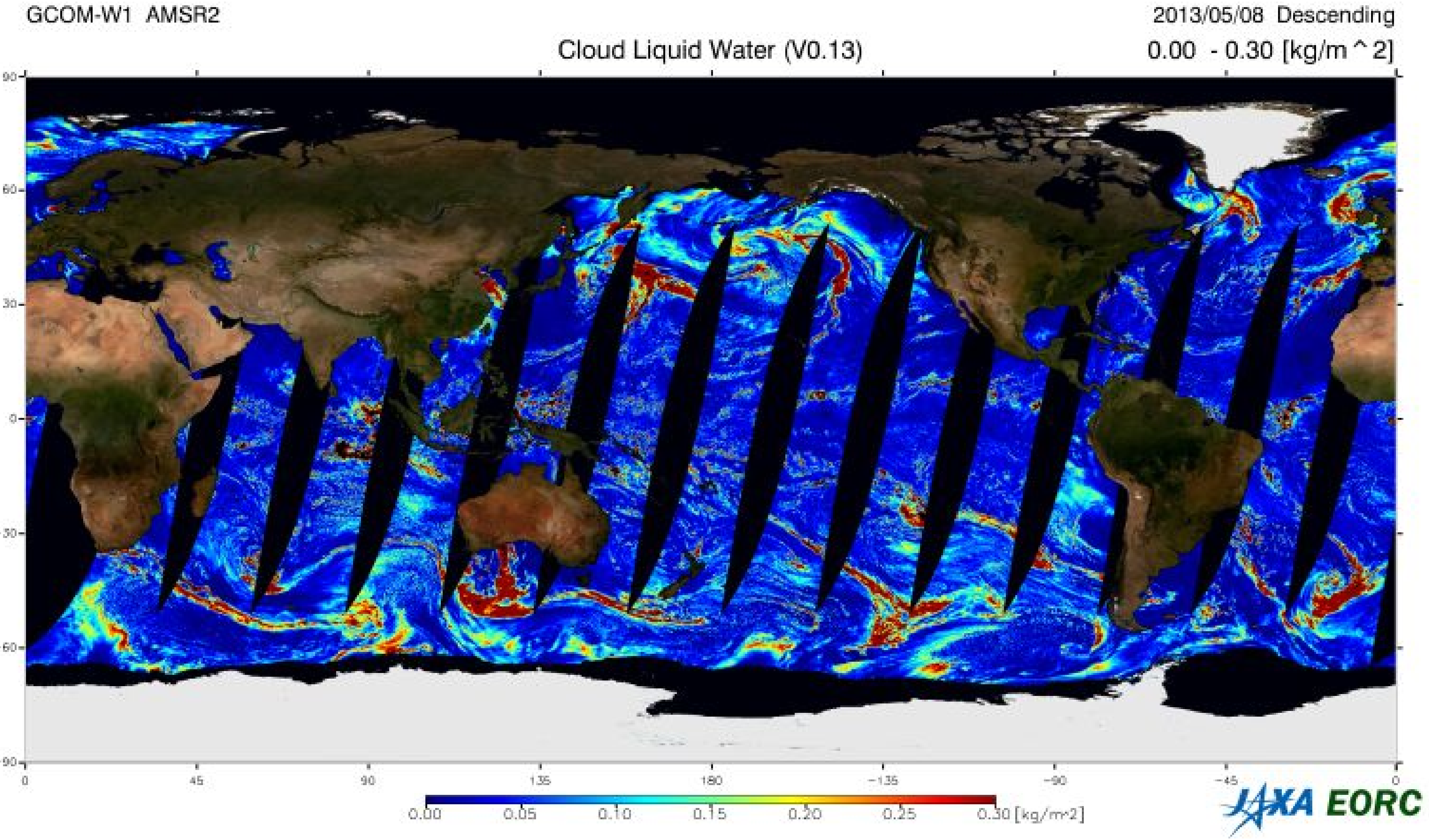
Comparison with GPS
Ascending + Descending



Validation	Required (Release)
2.9 kg/m^2	3.5 kg/m^2

(RMSE)

Cloud Liquid Water (CLW)

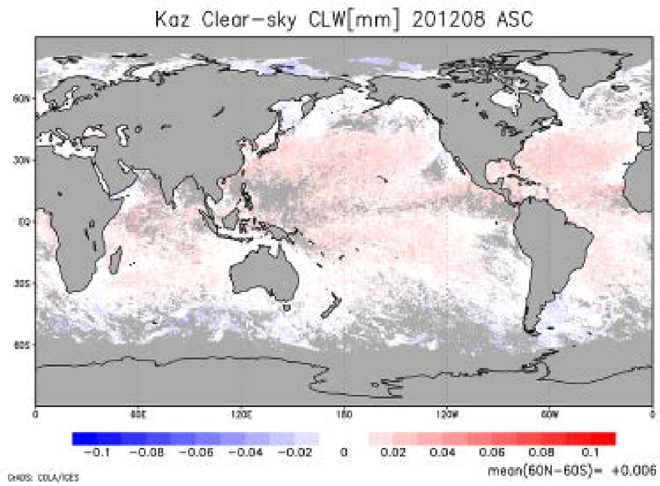


Cloud Liquid Water (CLW)

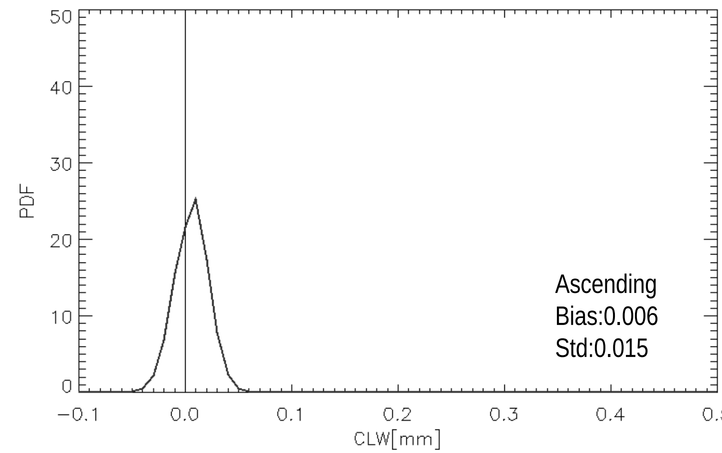
- ## Algorithm PI
  - Masahiro Kazumori, Numerical Prediction Division, Japan Meteorological Agency
- ## Product status
  - CLW algorithm Ver. 1.00, using L1R brightness temperatures Ver. 1.10 released on 1 March 2013 as inputs.
- ## Caveats
  - Because directly measured CLW amount is not available at present, absolute value of retrieved CLW are not optimized. CLW are retrieved based on 18GHz, 23GHz, and 37GHz channels' brightness temperature. CLW are sometimes not retrieved in descending orbit near coastal area of Continental United States. In this situation, observed AMSR2 brightness temperatures exceed a threshold of normal observed value in the algorithm. One possible cause is RFI contamination for 18GHz descending brightness temperature. Currently, the data are flagged as "invalid retrieval". The cause is under investigation.
- ## Validation results
  - Obtaining in-situ data of cloud liquid water is a difficult issue. Therefore, we evaluated CLW errors over clear sky areas identified by MODIS cloud flag information for the present validation. From the probability density functions (PDFs) of CLW over clear sky areas, biases and standard deviations were computed. Those errors were also evaluated for various environment conditions such as under different SST, sea surface wind speed, and total precipitable water observed by AMSR2.
  - Comparisons with ground-based microwave radiometer data are also ongoing over small island sites such as Nauru and Manus islands (maintained by US ARM program).
  - Validation period is from August 2012 to March 2013.
  - Resulted errors: 0.05 kg/m^2 (see next page for detail)
- ## References
  - Algorithm description of GCOM-W1 AMSR2, JAXA Technical Report, NDX-1200015A, 2013.

Cloud Liquid Water (CLW)

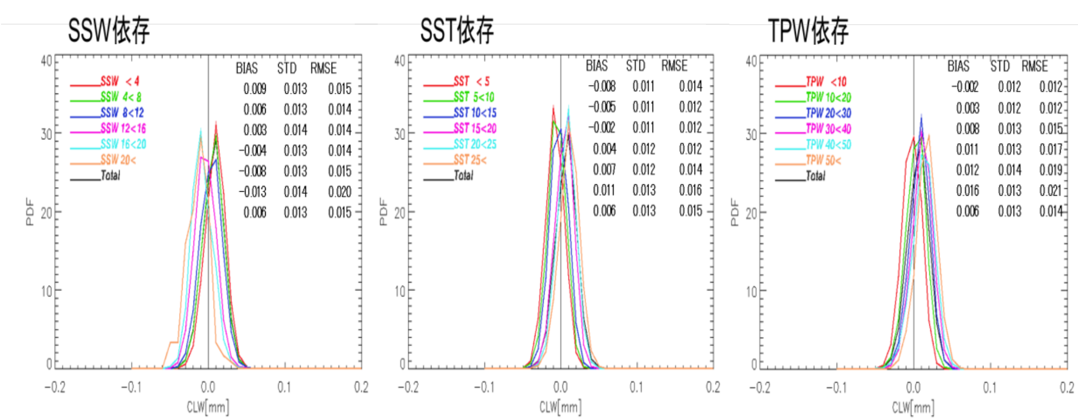
AMSR2 CLW over clear sky areas (August 2012)



CLW PDF over clear sky areas (August 2012)



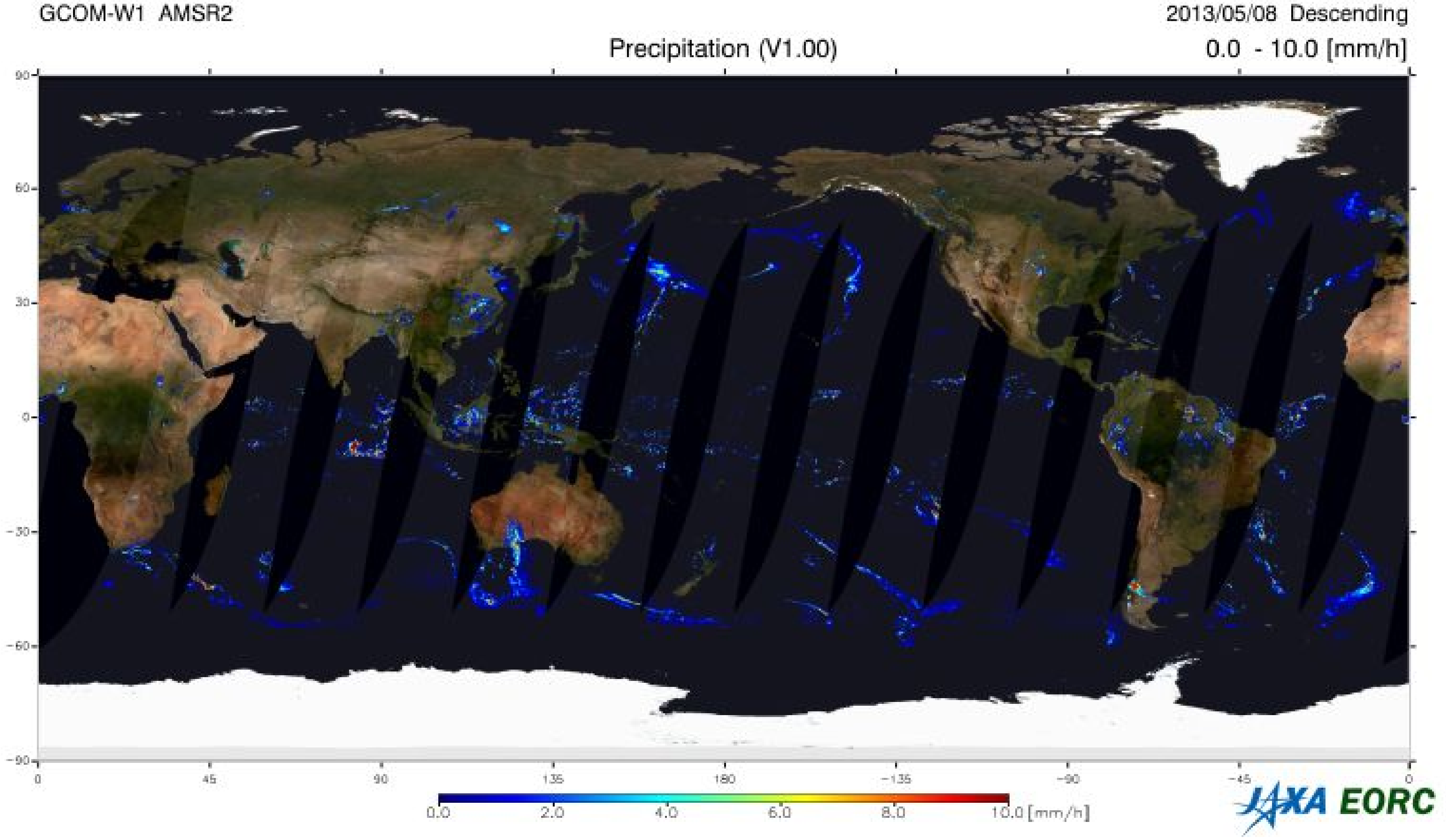
CLW PDF for various environmental conditions (August 2012)



- ✓ As the linear sum of the worst cases of bias (~0.019) and standard deviation (~0.026) in the period from August 2012 to March 2013, total error is about 0.05 kg/m^2.
- ✓ However, as mentioned before, this is just the error around zero CLW values. Ground-based microwave observations will be used for further validation activities.

Validation	Required (Release)
0.05 kg/m^2	0.1 kg/m^2

Precipitation (PRC)



Precipitation (PRC)

Algorithm PI

- Kazumasa Aonashi, Meteorological Research Institute, Japan Meteorological Agency

Product status

- PRC algorithm Ver. 1.00, using L1B brightness temperatures Ver. 1.10 released on 1 March 2013 as inputs.

Caveats

- Biases depending on input L1B are corrected to TMI using parameters provided by JAXA.

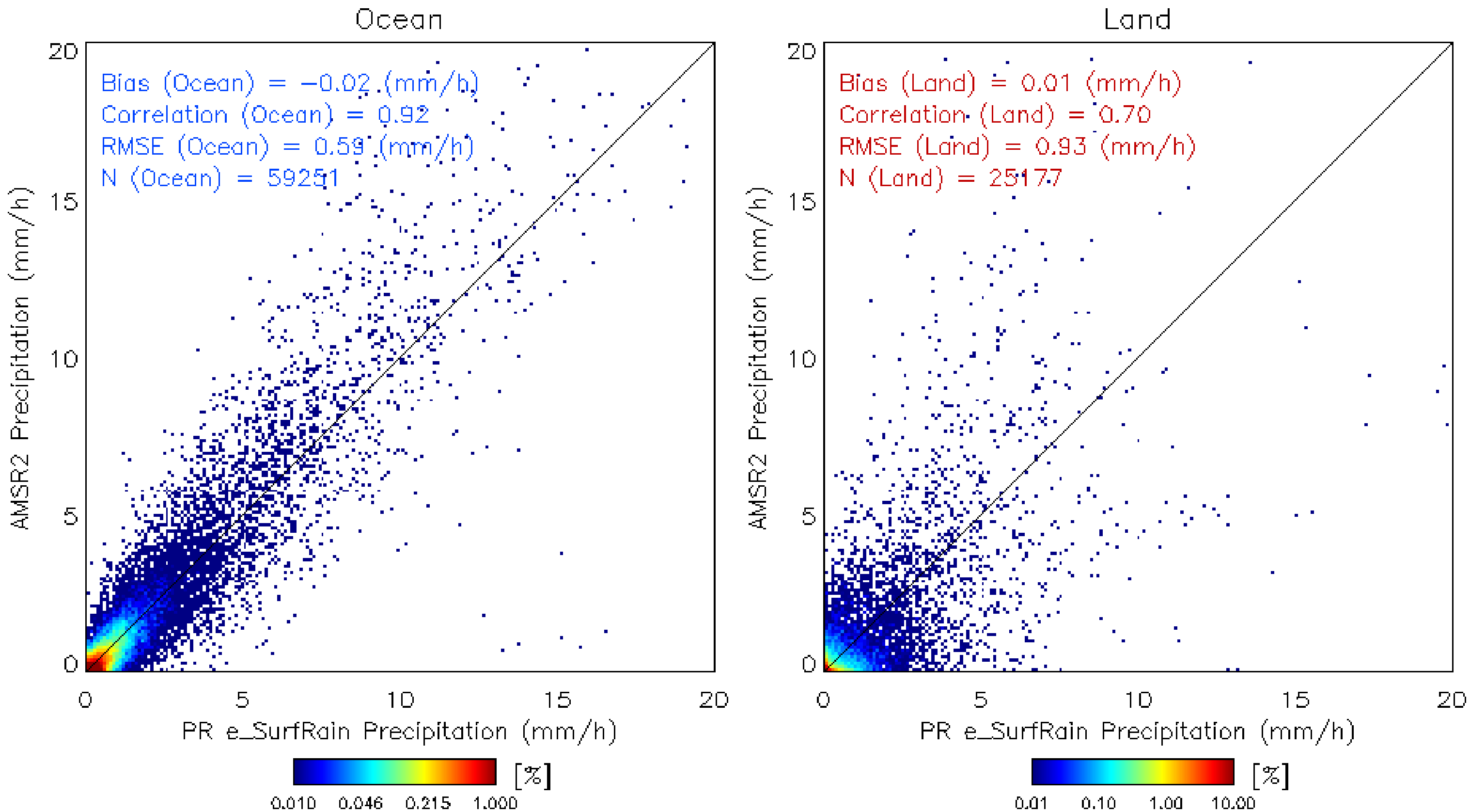
Validation results

- Validation period: July 24, 2012 – March 31, 2013
- Match-up condition: Select cross observation between AMSR2 and the TRMM Precipitation Radar (PR) within 10 minutes, averaged to about 50km (same as FOV of TMI 10 GHz (63.2x36.8 km))
- Resulted errors (see next page for detail)
  - Ocean: relative error (RMSE/Mean(%)) 47%, bias -0.02 mm/hr.
  - Land: relative error 91%, bias 0.01 mm/hr.

References

- Algorithm description of GCOM-W1 AMSR2, JAXA Technical Report, NDX-1200015A, 2013.

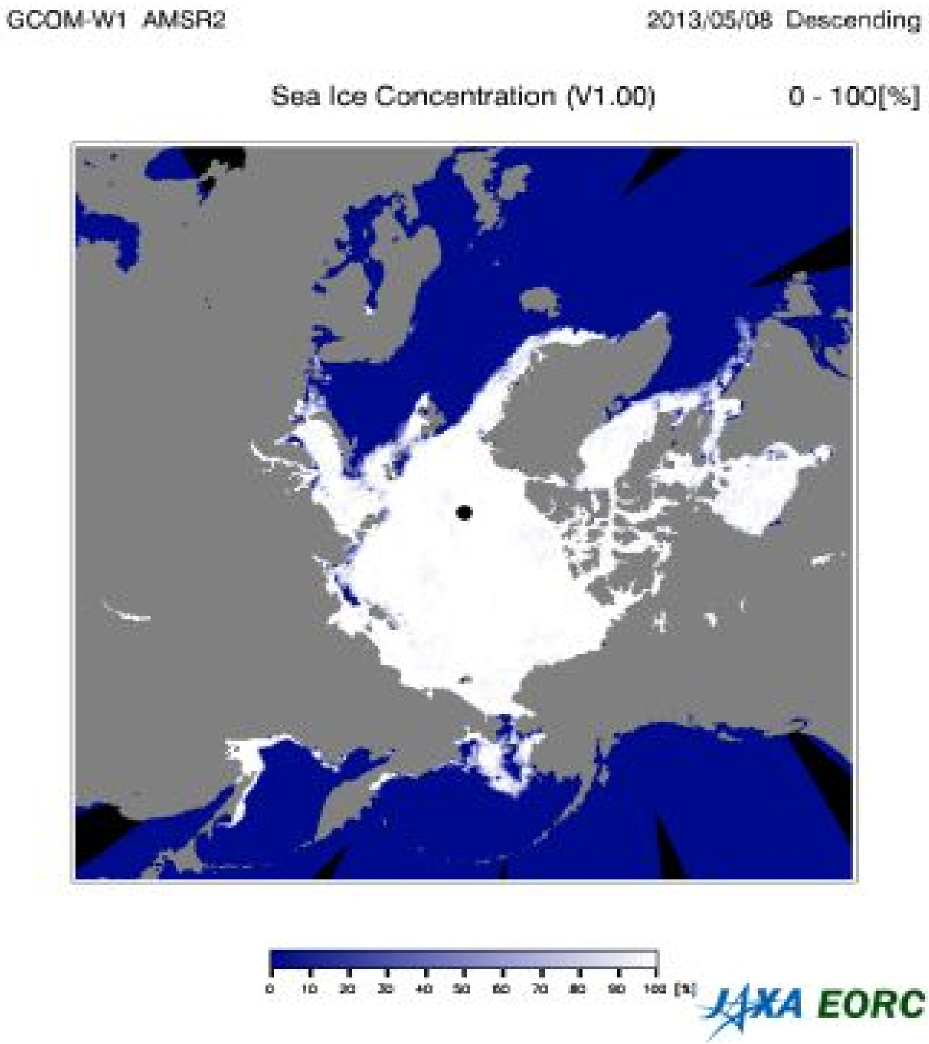
Precipitation (PRC)

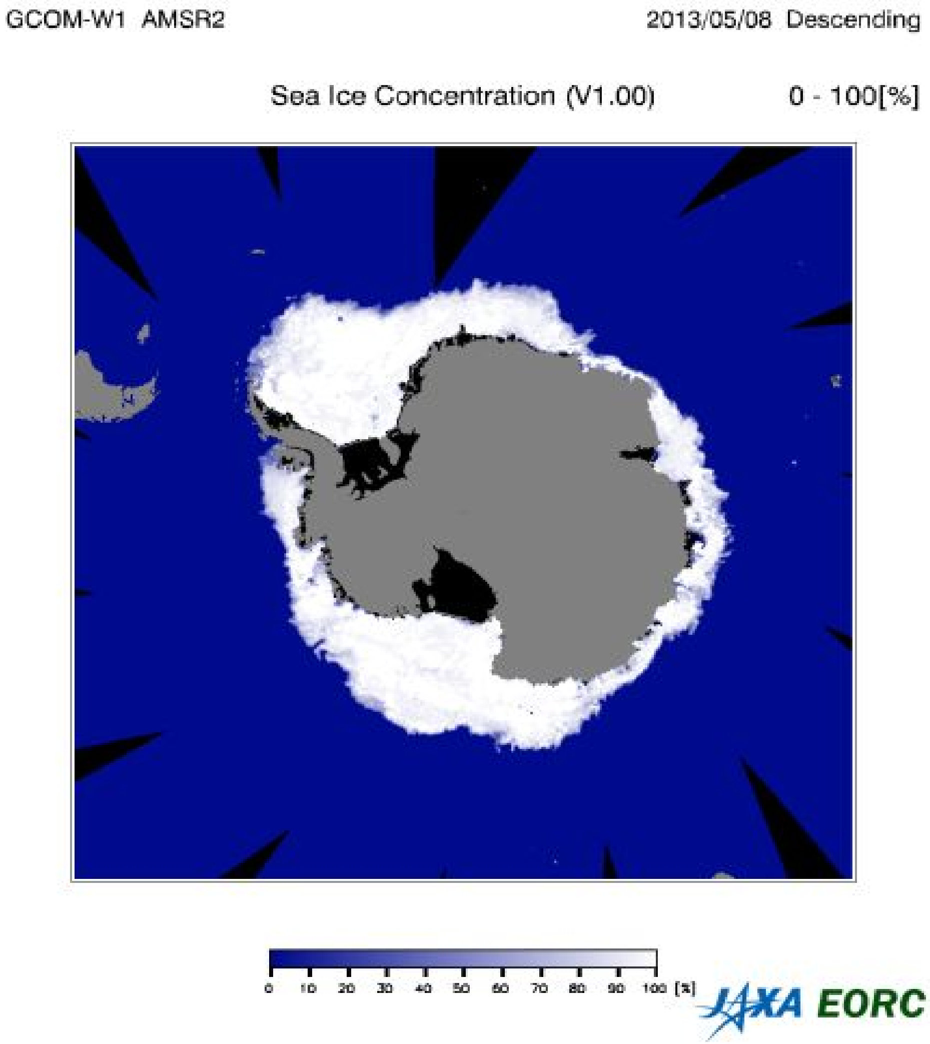


	Validation	Required (Release)
Ocean	47 %	50 %
Land	91 %	120%

RMS/Mean (%)
At TMI 10GHz footprint
(63.2x36.8 km)

Sea Ice Concentration (SIC)





Sea Ice Concentration (SIC)

- ## Algorithm PI
  - Josefino C. Comiso, NASA Goddard Space Flight Center
  - Kohei Cho, Tokai University
- ## Caveats and Limitations
  - In order to utilize sea ice parameters used for AMSR-E, AMSR2 L1R brightness temperature were converted to "AMSR-E equivalent" brightness temperature and ASMR-E sea ice concentration(SIC) algorithm is applied for estimating sea ice concentrations.
  - Some residual sea ice concentrations(false sea ice) remain in the areas of open water under excessive winds and/or stormy weather. False sea ice also appears along the coast due to the influence of land contamination. The PIs are working on optimizing filters to reduce these effects.
  - In summer, the SIC accuracy is reduced in regions where there is meltponding on the sea ice surface.
  - It should be noted that SIC less than 10% is not reliable since it is difficult to determine the difference in microwave emissivity between very low percentage sea ice covered areas and open water.
- ## Validation results
  - Verification of SIC were performed by comparing with simultaneously corrected Aqua/MODIS band2 (0.841 to 0.876μm, IFOV:250m) images. The MODIS images were collected under the cloudless conditions and were binarized to extract sea ice areas. The 250m ice grid cells were summed over each co-registered AMSR2 10km grid cell to provide a 10km resolution ice concentration.

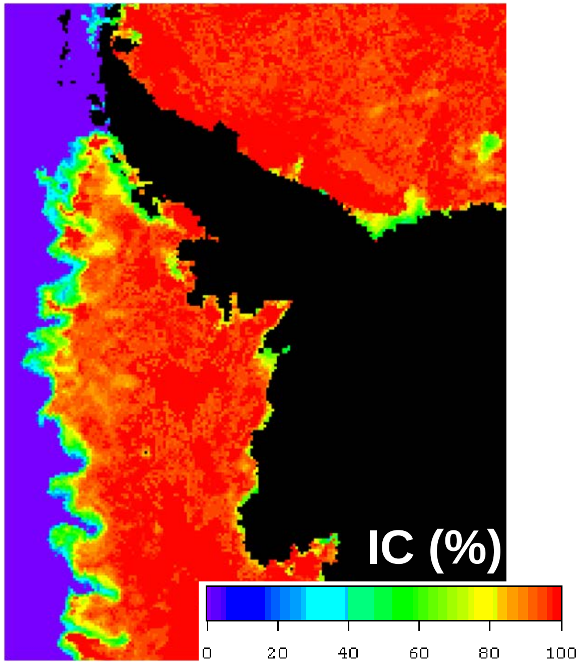
OCT 31 2012	Southern Hemisphere 1： Bellingshausen・Amundsen Sea	RMSE 9.3%
FEB 03 2013	Southern Hemisphere 2： Weddell Sea	RMSE 4.13%
JUL 28 2012	Northern Hemisphere 1： Arctic・Greenland Sea	RMSE 9.94%
MAR 01 2013	Northern Hemisphere 2： Greenland Sea	RMSE 13.65%
NOV 30 2012	Northern Hemisphere 3： Bering Sea	RMSE 9.75%
MAR 05 2013	Northern Hemisphere 4： Sea of Okhotsk	RMSE 8.69%

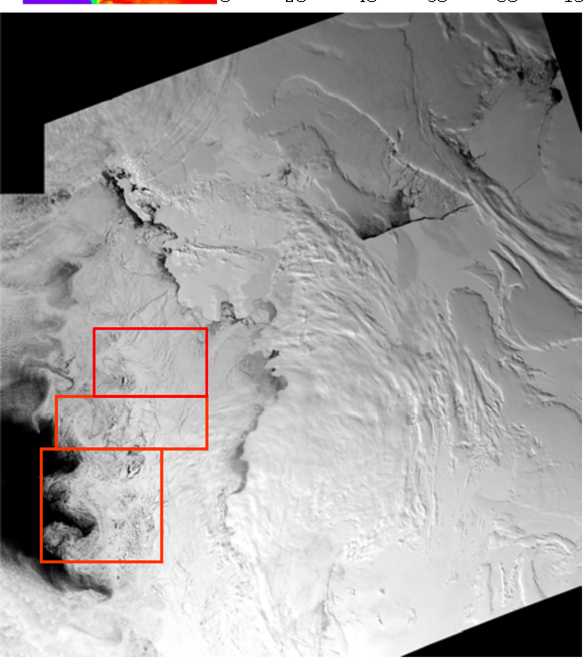
  - RMSE was almost <10%. (Average: 9.21%). Within the ice pack in winter, the SIC is near 100% and the RMSE is closer to 5%. Also, note that the SIC derived from MODIS is not 100% accurate and hence the RMSE for AMSR2 is actually lower than quoted..
- ## Reference

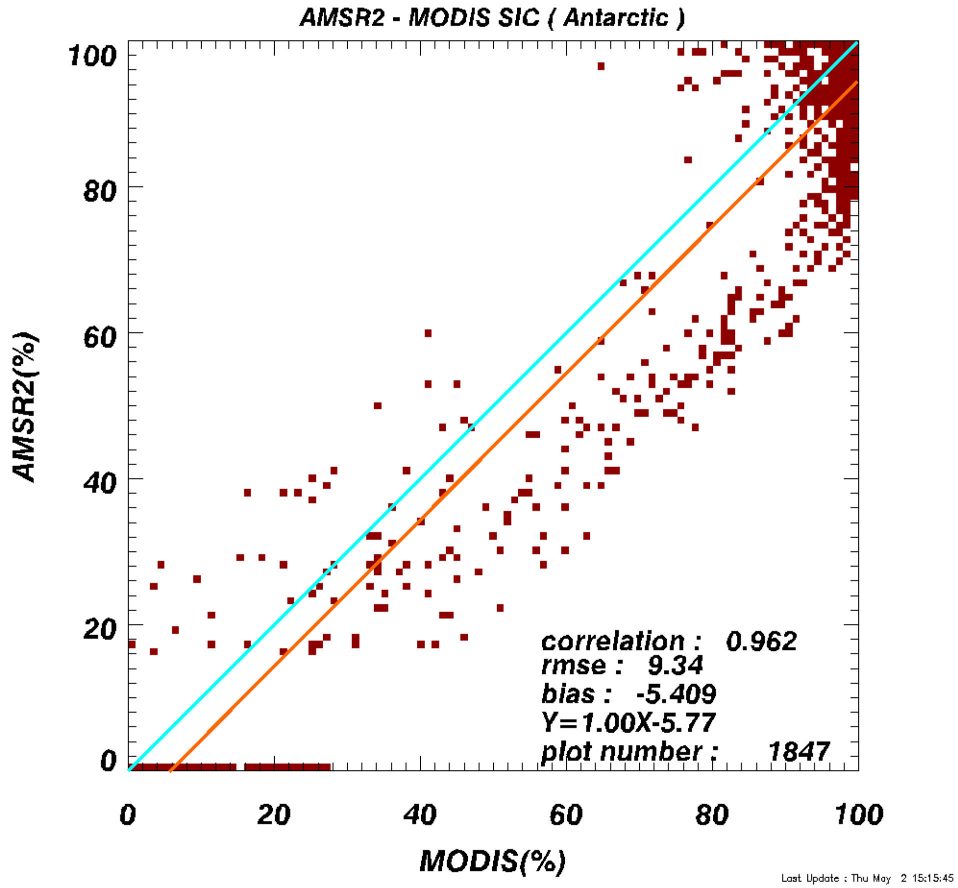
  - Comiso, J. C., 1983: Sea ice microwave emissivities from satellite passive microwave and infrared observations, *J. Geophys. Res.*, 88(C12), 7686-7704.
  - Comiso, J.C., D. Cavalieri, C. Parkinson, and P. Gloersen, 1997: Passive microwave algorithms for sea ice concentrations, *Remote Sensing of the Env.*, 60(3), 357-384.
  - Comiso, J. C. and F. Nishio, 2008: Trends in the sea ice cover using enhanced and compatible AMSR-E, SSM/I, and SMMR data, *J. Geophys. Res.,* 113, C02S07, doi:10.1029/2007JC004257.
  - Algorithm description of GCOM-W1 AMSR2, JAXA Technical Report, NDX-1200015, 2012.

Southern Hemisphere 1: Bellingshausen･Amundsen Sea

OCT 31 2012



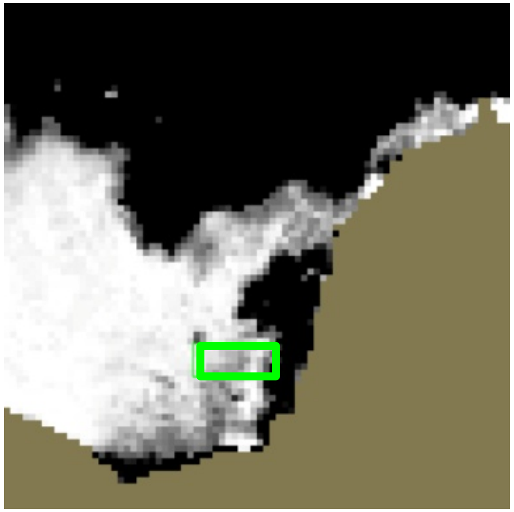


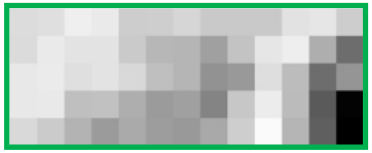


RMSE 9.3%

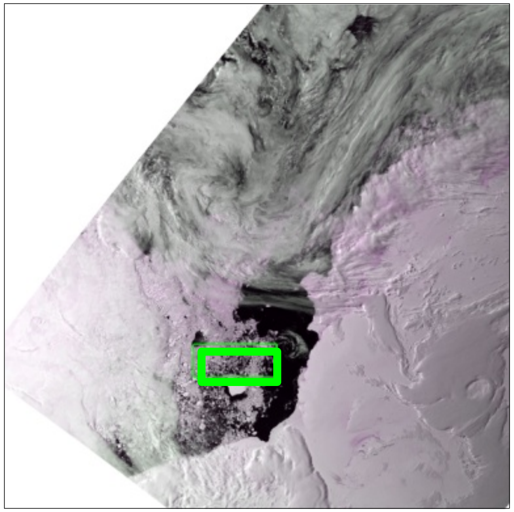
Southern Hemisphere 2: Weddell Sea

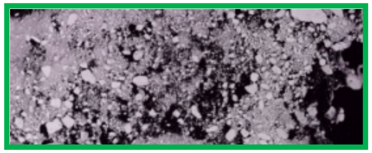
FEB 03 2013



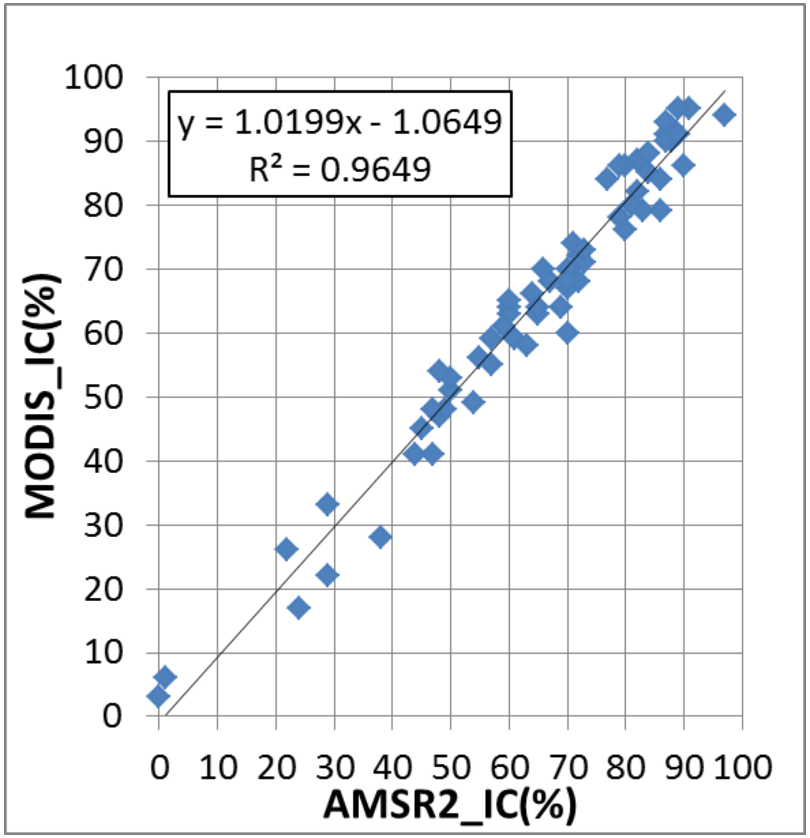


AMSR2





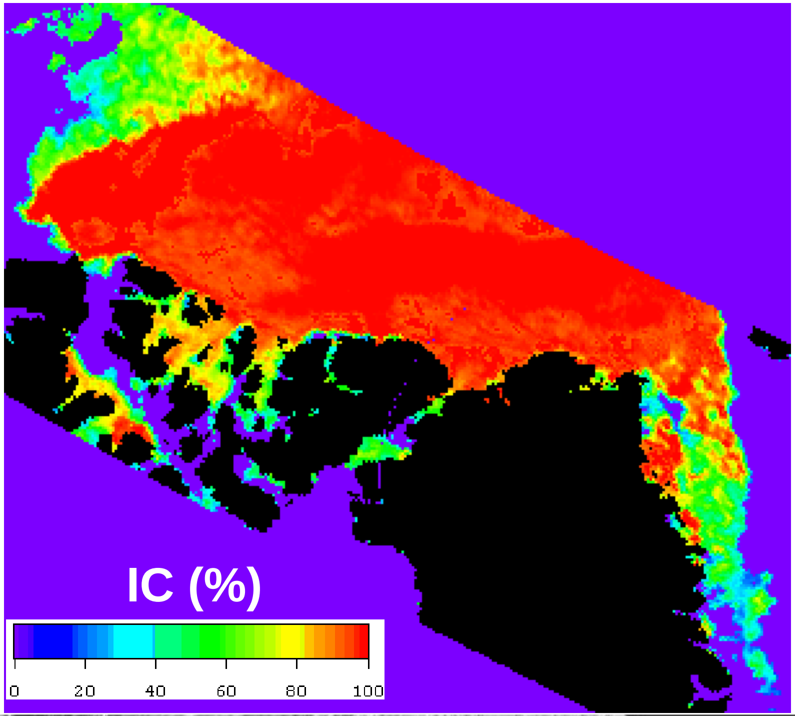
MODIS

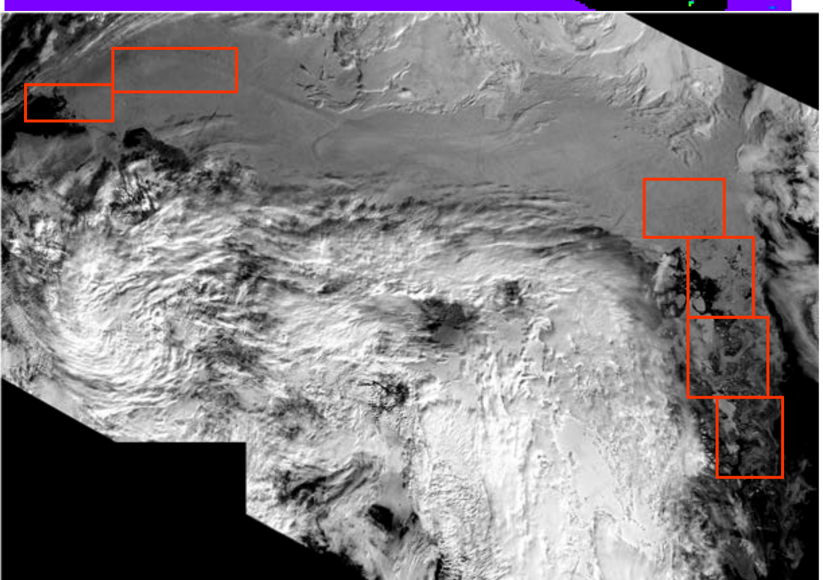


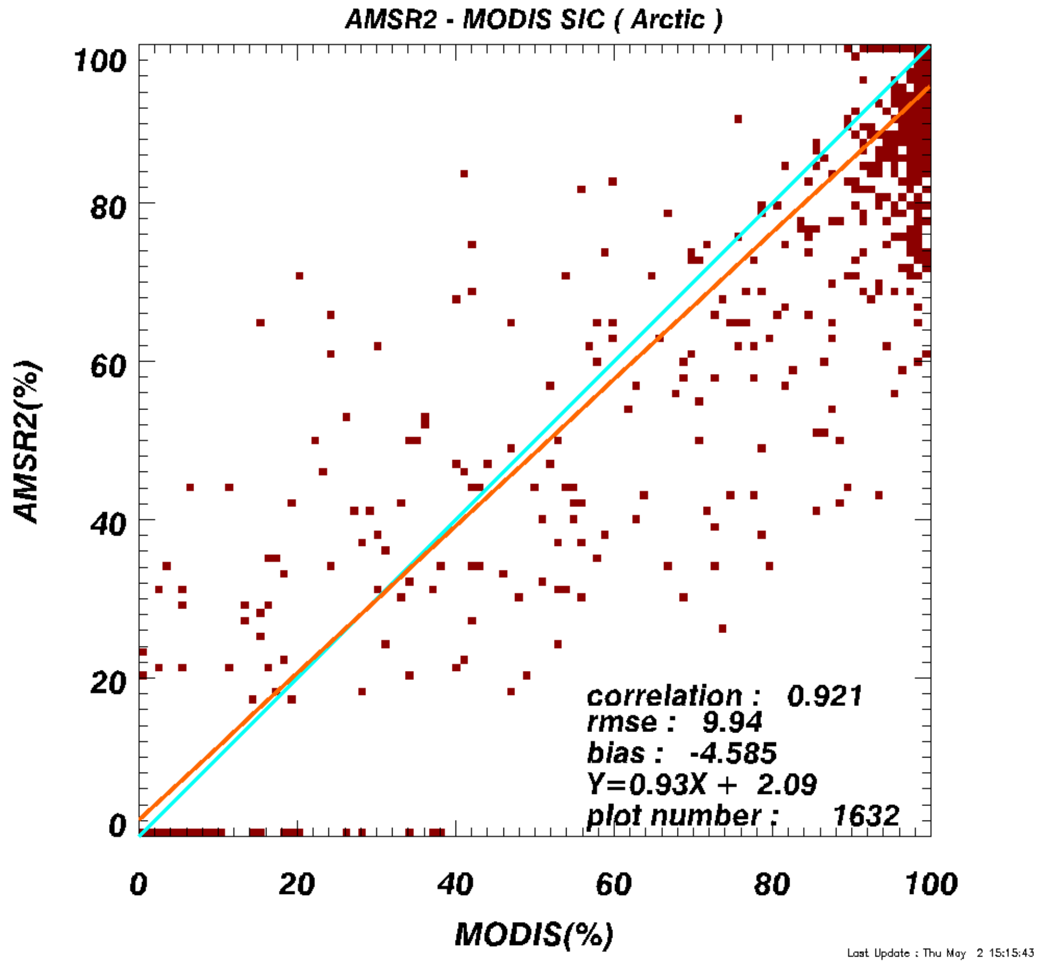
RMSE 4.13%

Northern Hemisphere 1: Arctic･Greenland Sea

JUL 28 2012



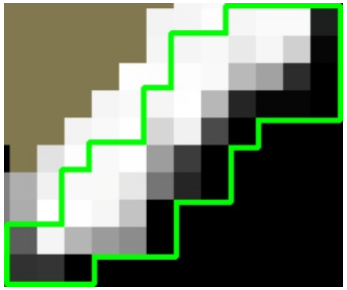




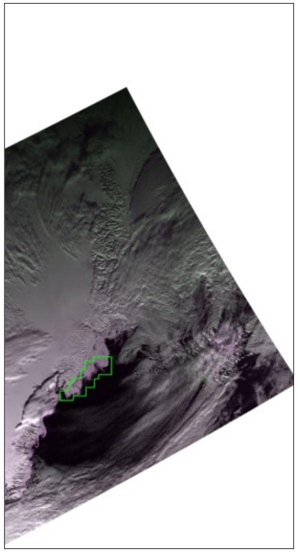
RMSE 9.94%

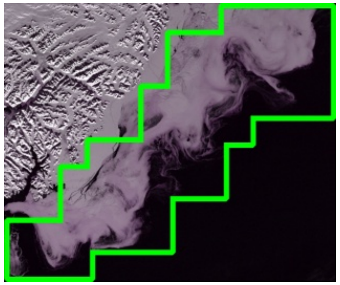
Northern Hemisphere 2：Greenland Sea

MAR 01 2013

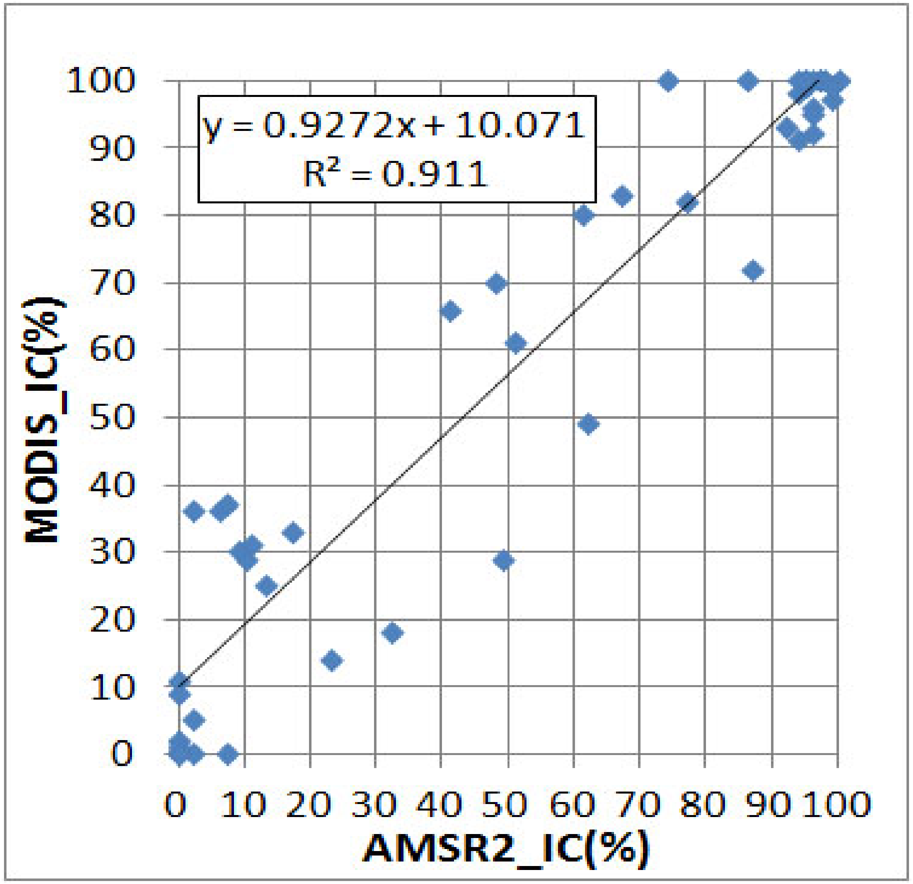


AMSR2





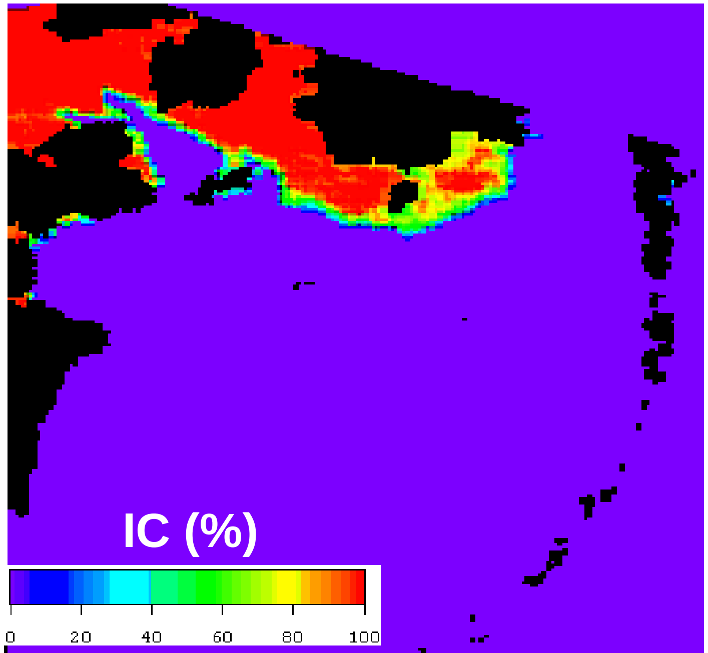
MODIS

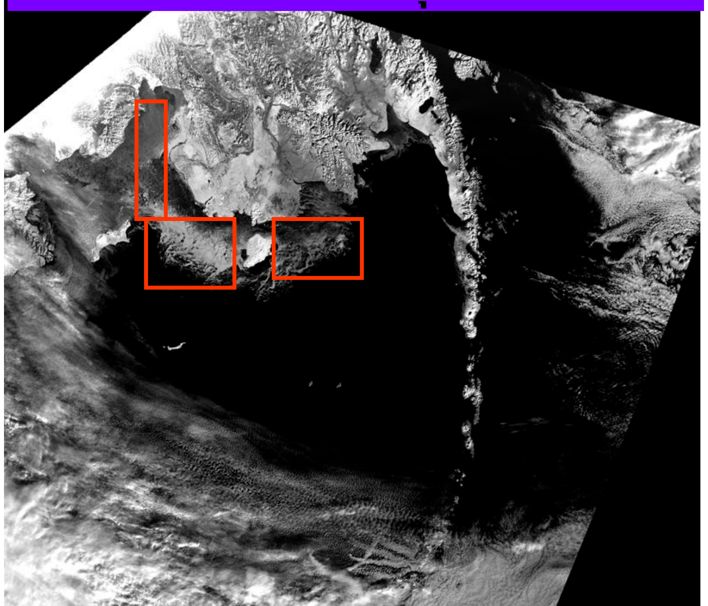


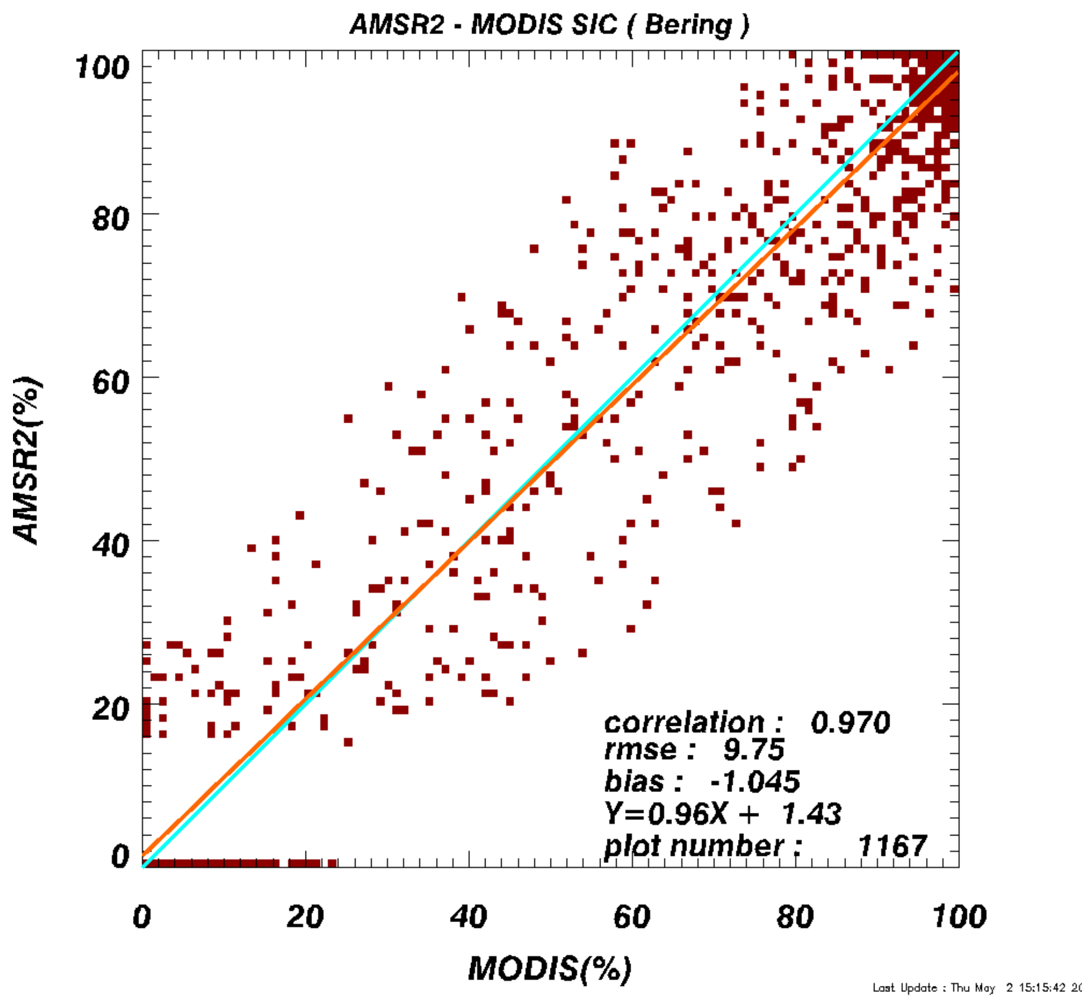
RMSE 13.65%

Northern Hemisphere 3: Bering Sea

NOV 30 2012



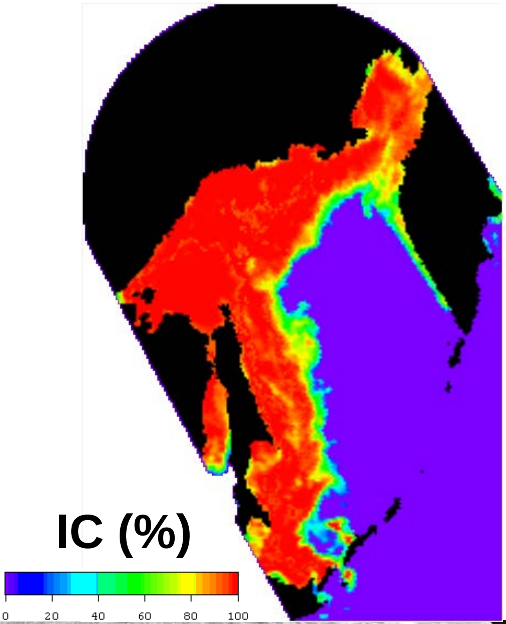


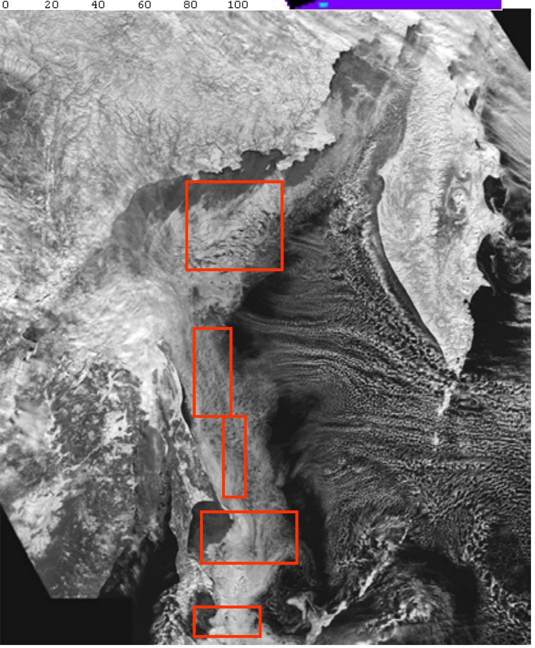


RMSE 9.75%

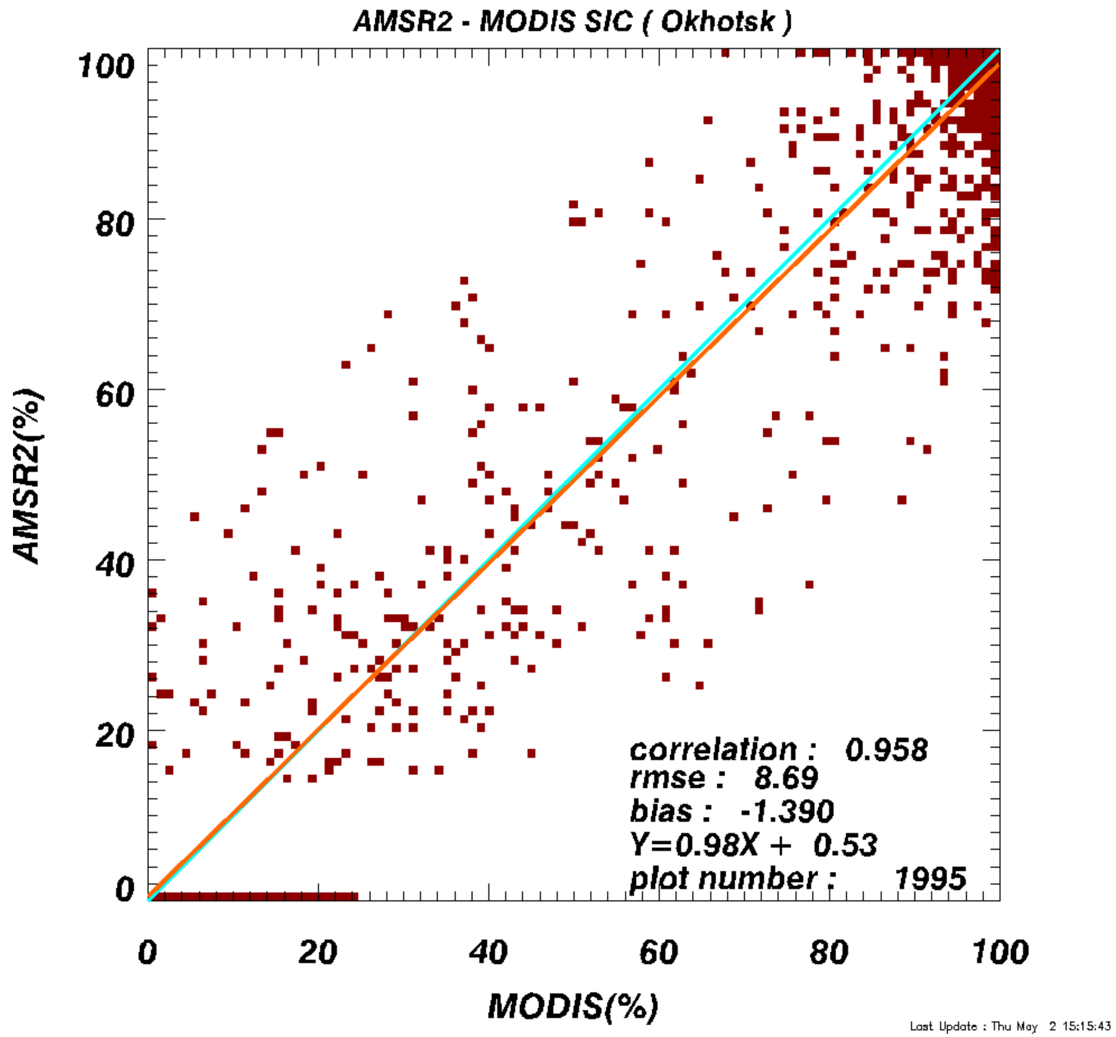
Northern Hemisphere 4: Sea of Okhotsk

MAR 05 2013



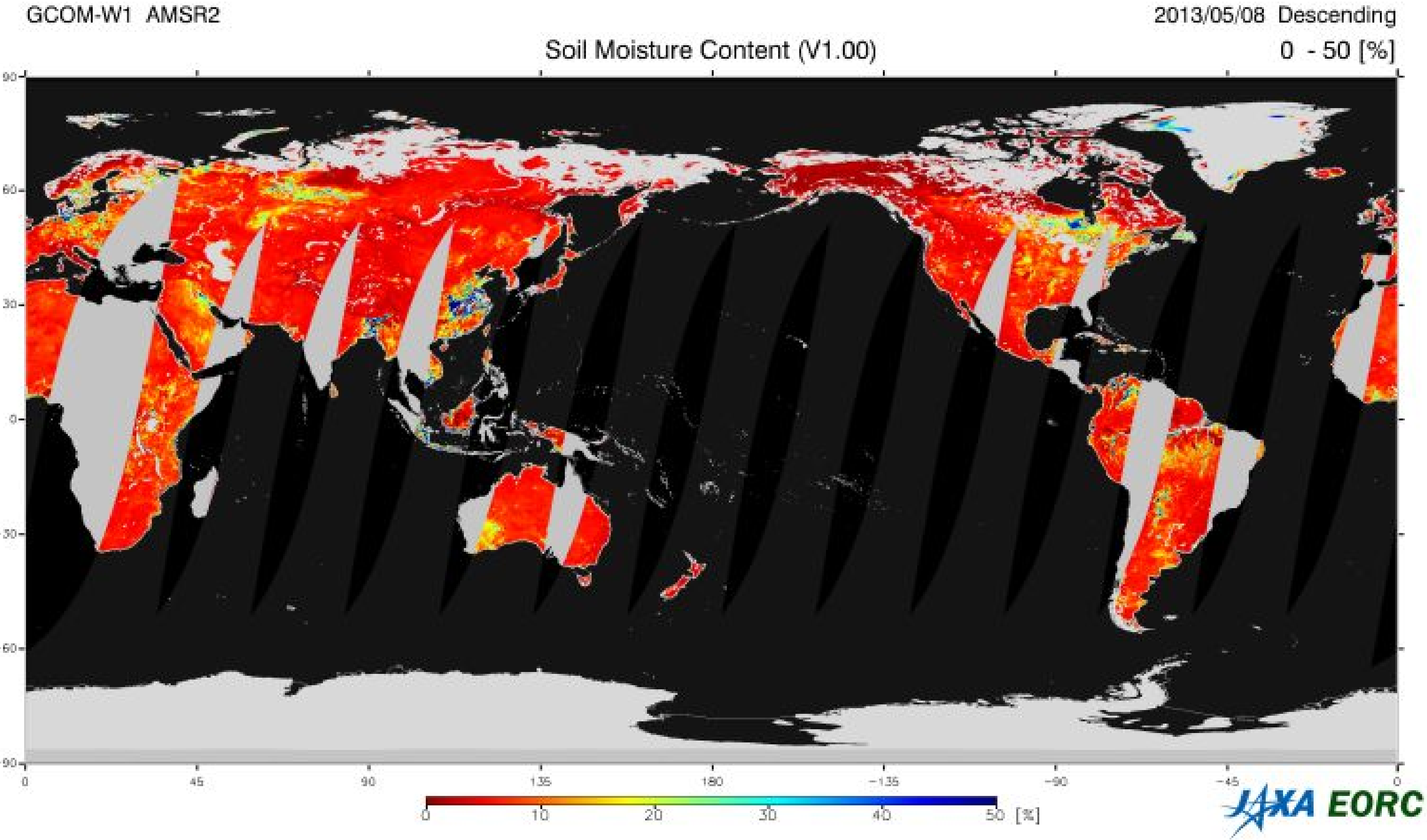


MAR 05 2013



RMSE = 8.69%

Soil Moisture Content (SMC)



Soil Moisture Content (SMC)

- ## Algorithm PI
  - Toshio Koike, The University of Tokyo
- ## Product status
  - SMC algorithm Ver. 1.00, using L1R brightness temperatures Ver. 1.10 released on 1 March 2013 as inputs. Slope/offset values were applied to L1R Tbs to compensate differences between AMSR2 and AMSR-E calibrations.
  - The algorithm is basically the same as that has been used for AMSR-E, except the update of fractional vegetation area dataset (normal value derived from MODIS NDVI during July 2002-June 2012).
- ## Caveats
  - SMC tends to be overestimated under the extreme dry condition such as over desert.
  - SMC around coastlines and large lakes often shows high value due to water surface effects.
  - Over densely vegetated areas auch as Amazon forest and Afrotropical forest, SMC shows low value because the signal from soil surface is absorbed in the vegetation layer.
  - SMC also shows low value in heavy precipitation area and mountainous area.
  - RFI in 10.65 GHz channels may affect SMC values at many locations in Europe and Japan.
  - SMC values over the Greenland ice sheet is not valid but not masked in the current product.

Soil Moisture Content (SMC)

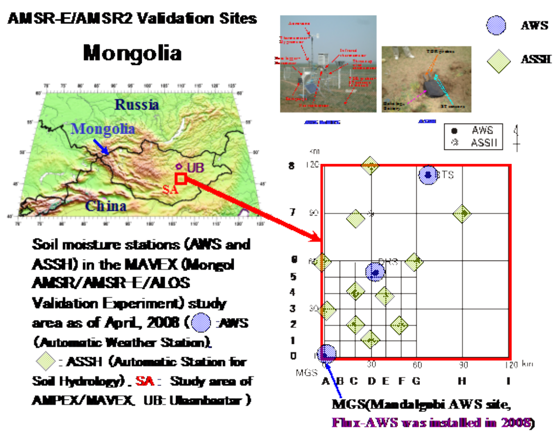
- ## Validation results
  - In-situ data over SMC validation sites (see next page) were used. To alleviate the nonuniformity issue of SMC in AMSR2 footprints, areas with several tens of kilometers on a side, monotonous geography, and good accessibility were selected and established as SMC validation sites. SMCs are measured at multiple points in each area. In addition, in-situ data from USDA/SCAN Little River site were used, although the SMC is point measurement.
  - In-situ data and AMSR2 estimates were compared under the conditions of within 7km in distance and 1 hour (2 hour for Mongolian site) in time. In-situ data measured at multiple points in a area are averaged before comparing with AMSR2 estimates, except for Little River data. SMC errors are basically evaluated by Mean Absolute Error (MAE) metric.
  - Due to the data collection timing and their calibration process, validation periods are different.
    - Mongol: July 2012 – September 2012
    - Australia: July 2012 – April 2013
    - Thailand: July 2012 – September 2012
    - Little River: July 2012 – January 2013
  - Resulted errors: 4 % in MAE (see next page for detail)
- ## Reference

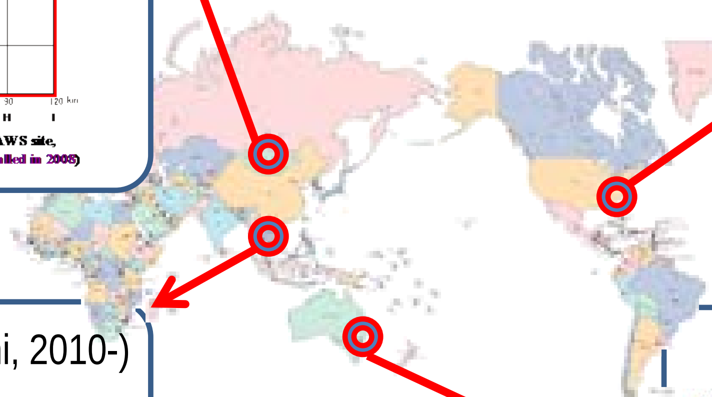
  - H.Fujii, T.Koike, and K.Imaoka : Improvement of the AMSR-E Algorithm for Soil Moisture Estimation by Introducing a Fractional Vegetation Coverage Dataset Derived from MODIS Data, *Journal of The Remote Sensing Society of Japan*, vol.29 No.1, pp.282-292, 2009.
  - Algorithm description of GCOM-W1 AMSR2, JAXA Technical Report, NDX-1200015A, 2013.

SMC Validation Sites

- ✓ All sites were established and maintained by cooperation with domestic/international agencies and universities.
- ✓ Mongolian site has been used for AMSR/AMSR-E/ALOS validation for a long time. Sites in Thailand and Australia were established recently to increase conditions of SMC and surface/vegetation types.

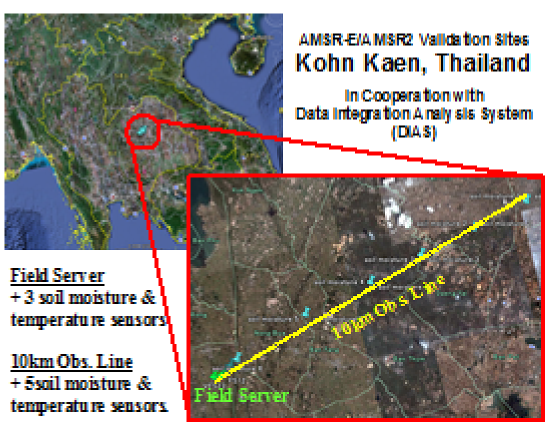
Mongolian Plateau (Kaihotsu, 2000-)



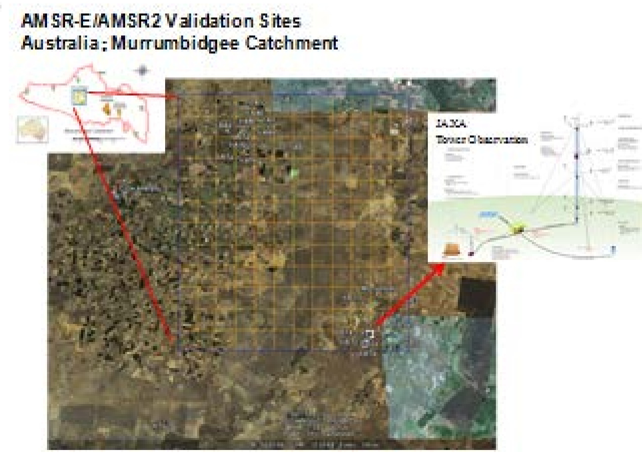


Little River (USDA SCAN)

Thailand (Kaihotsu and Mizoguchi, 2010-)

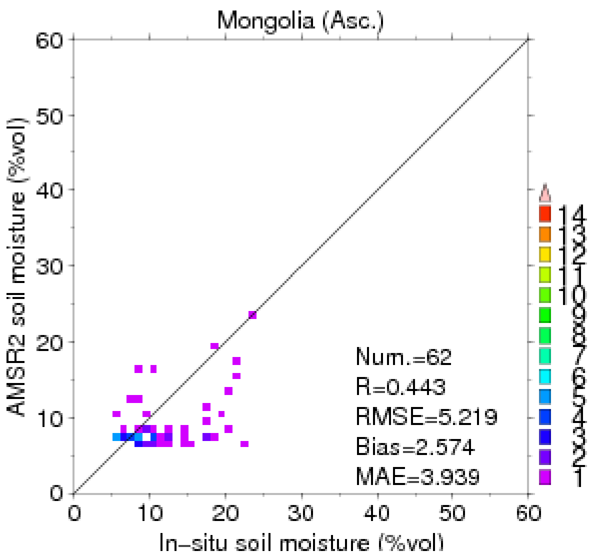


Australia (Walker, 2012-)



Validation over Mongolian Plateau

Ascending passes



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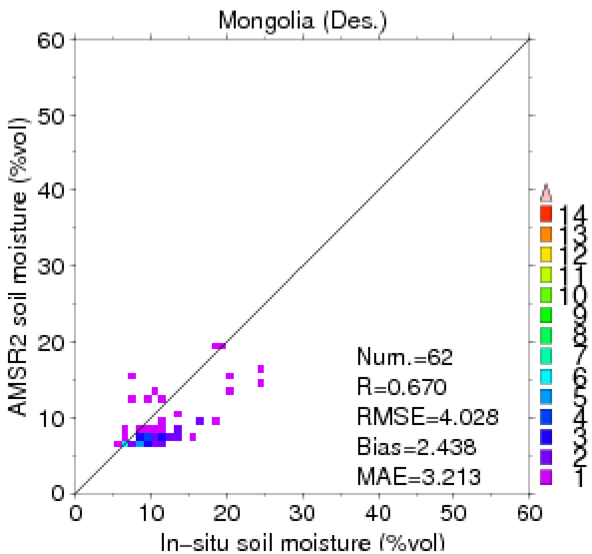
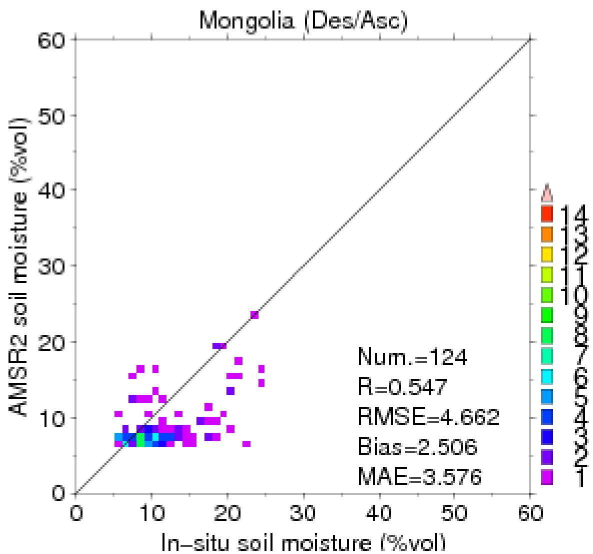
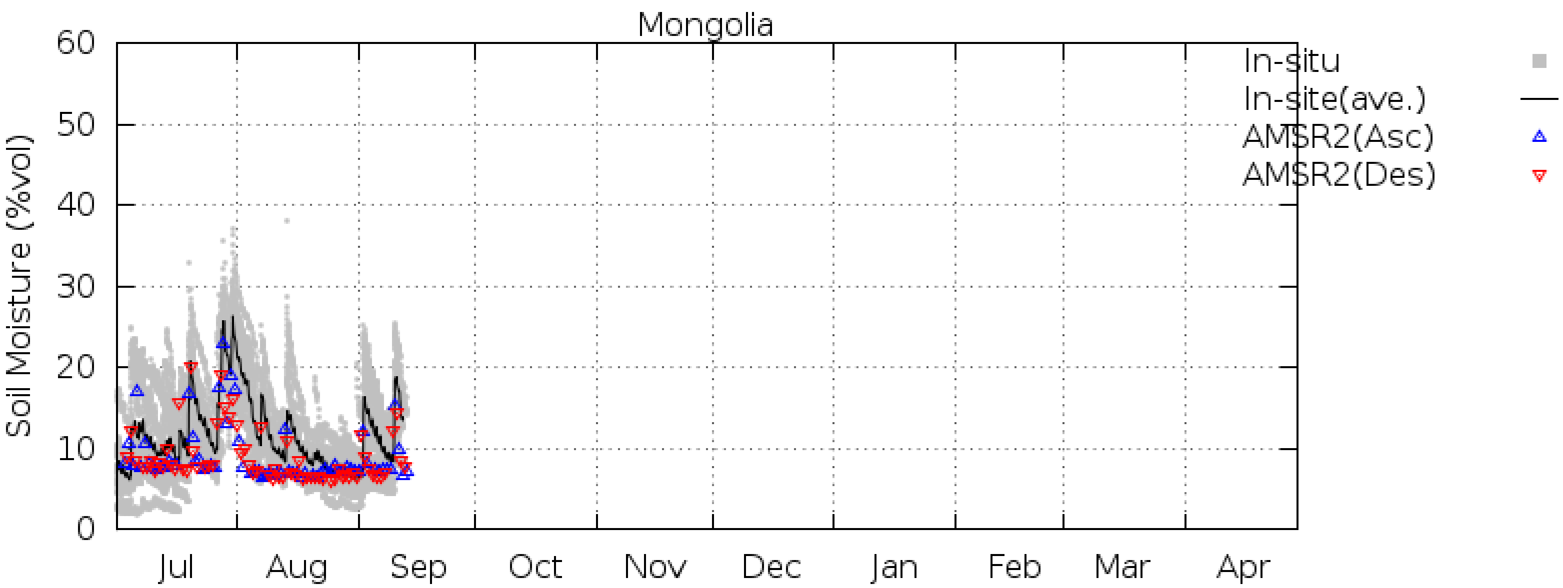


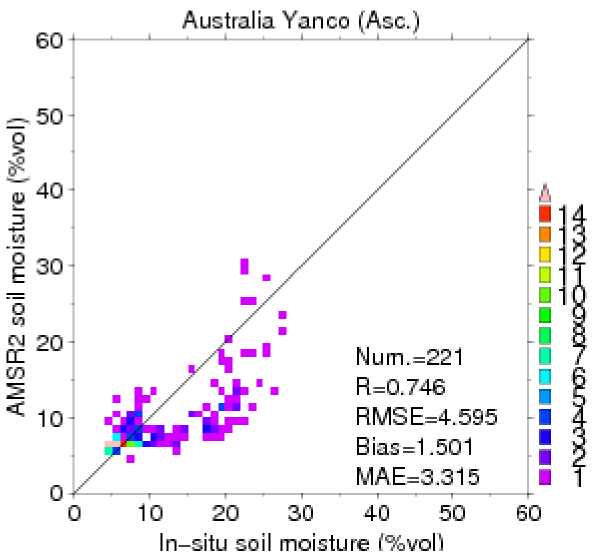
Ascending/Descending passes



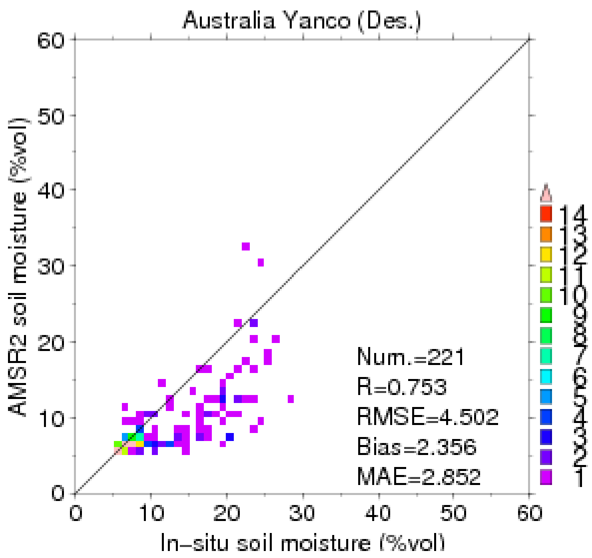


Validation over Australia Yanco

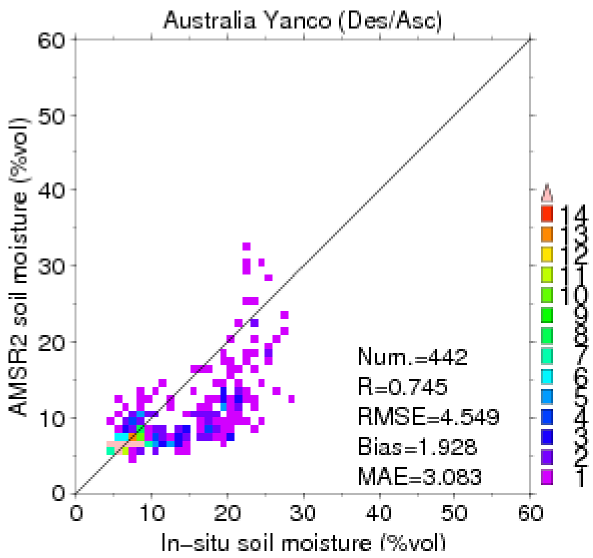
Ascending passes

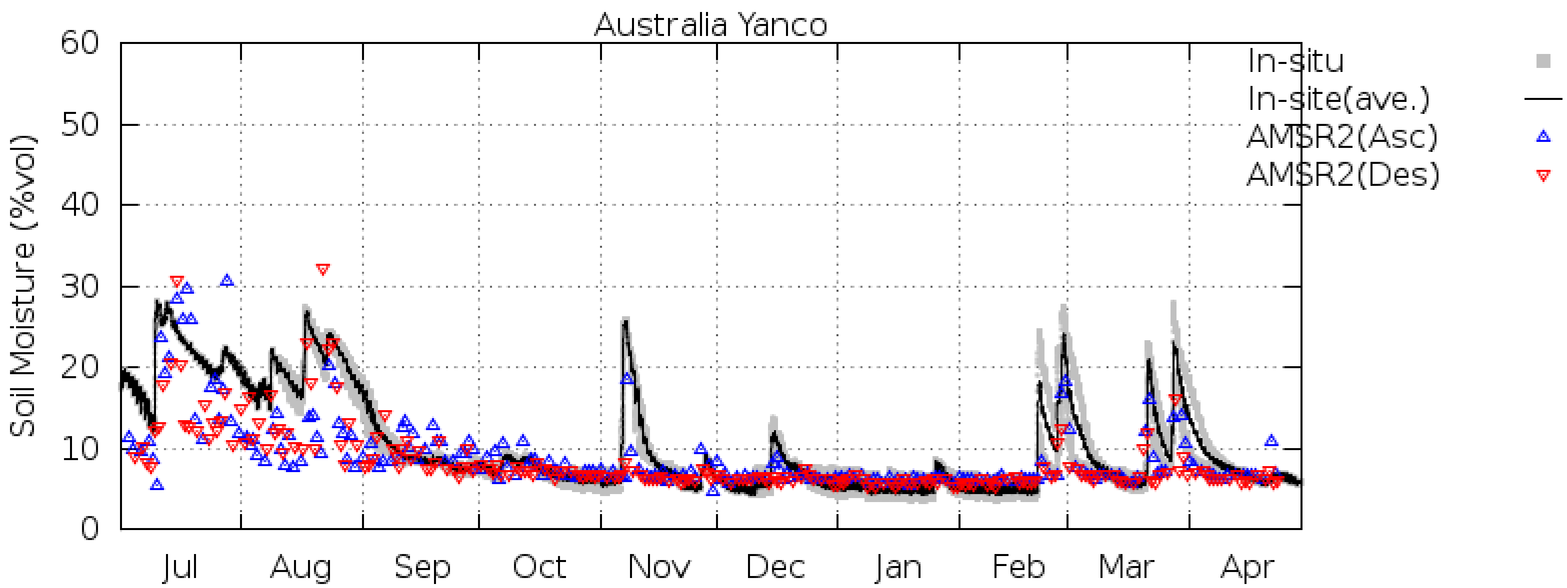


Descending passes



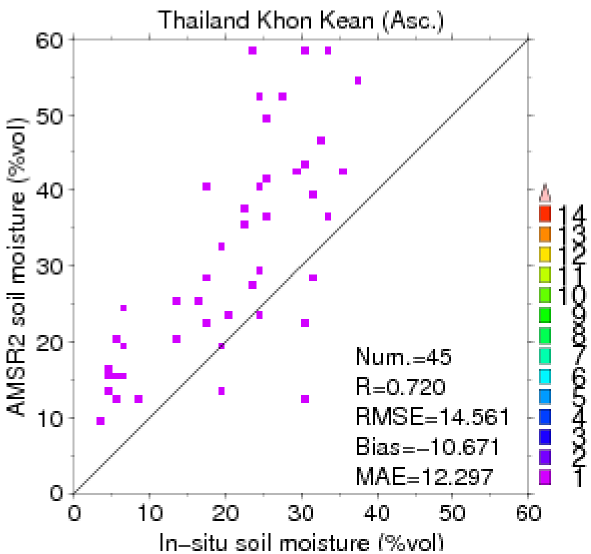
Ascending/Descending passes





Validation over Thailand

Ascending passes



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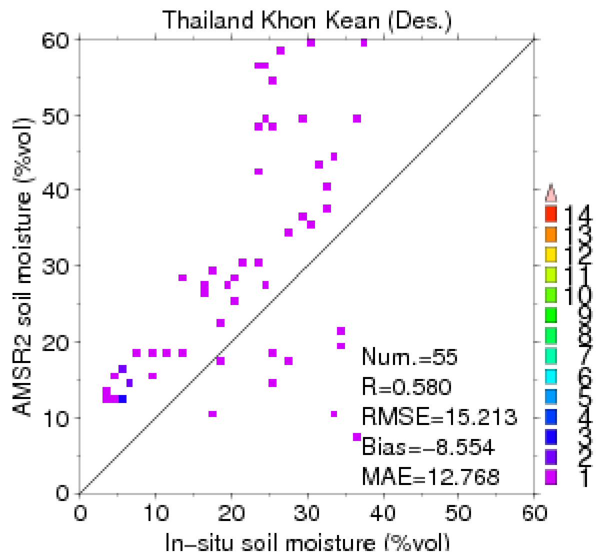
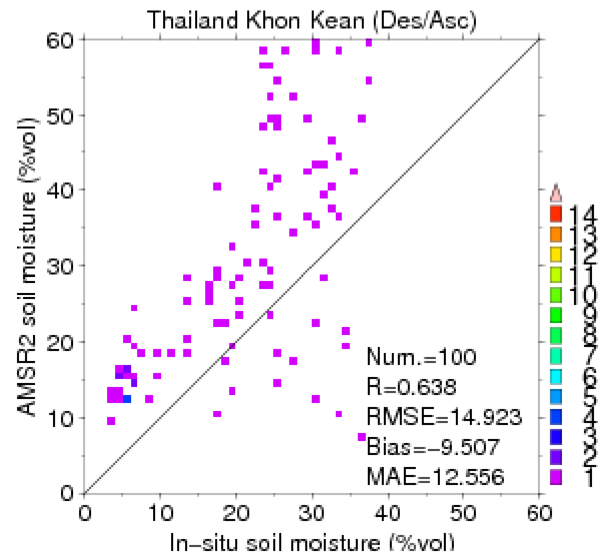
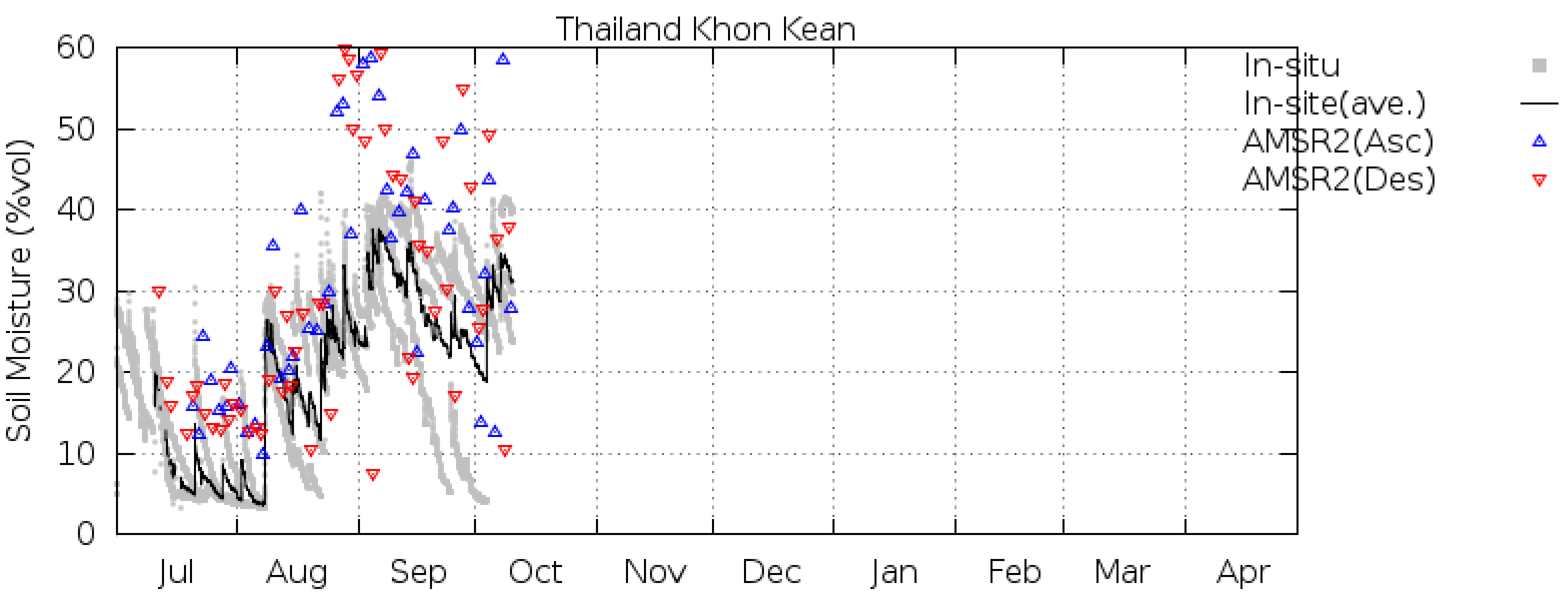


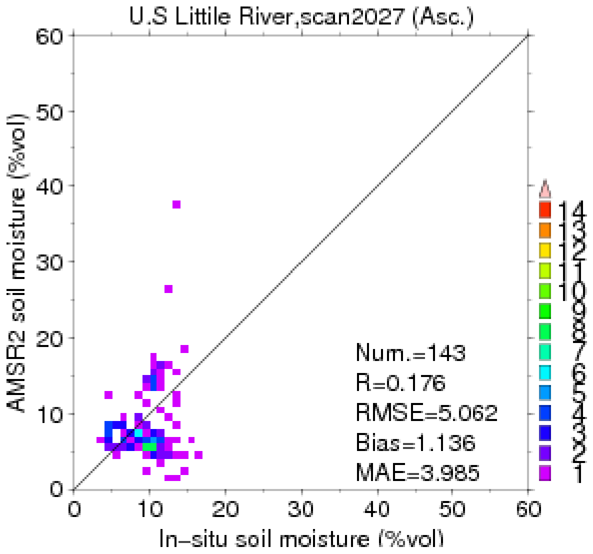
Ascending/Descending passes





Validation over U.S. Little River (SCAN 2027)

Ascending passes



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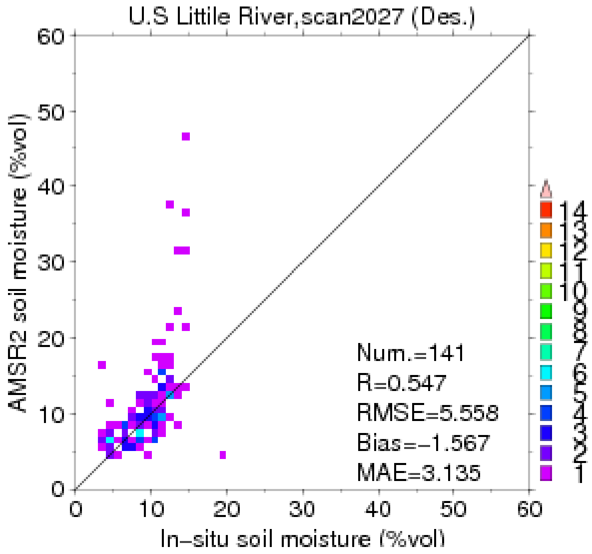
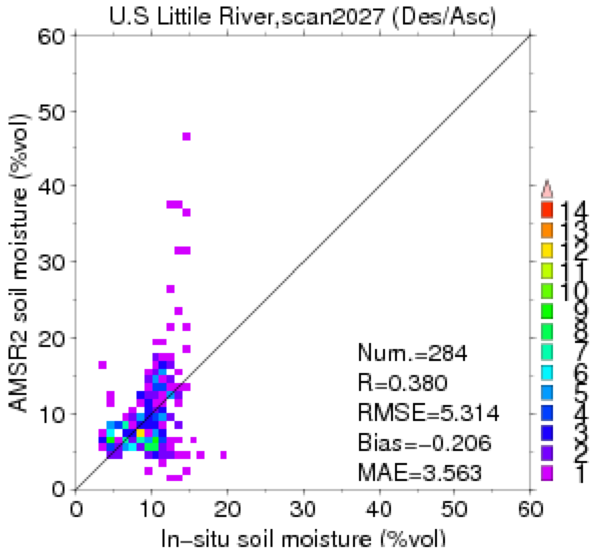
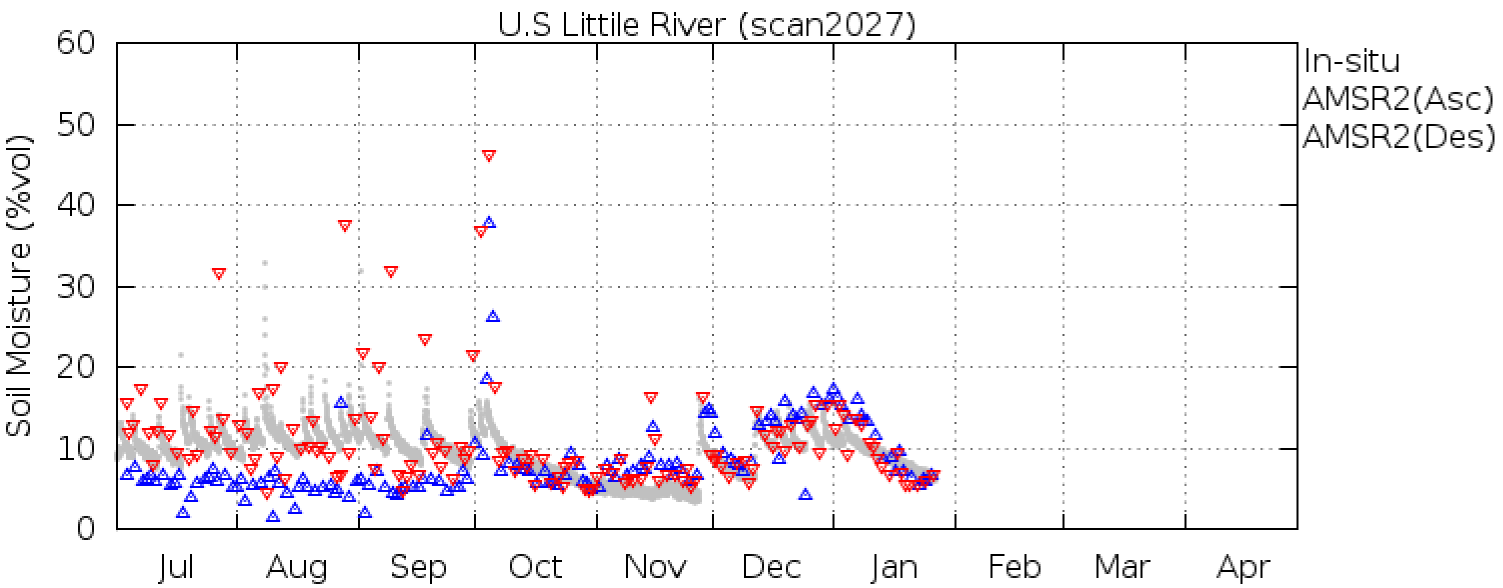


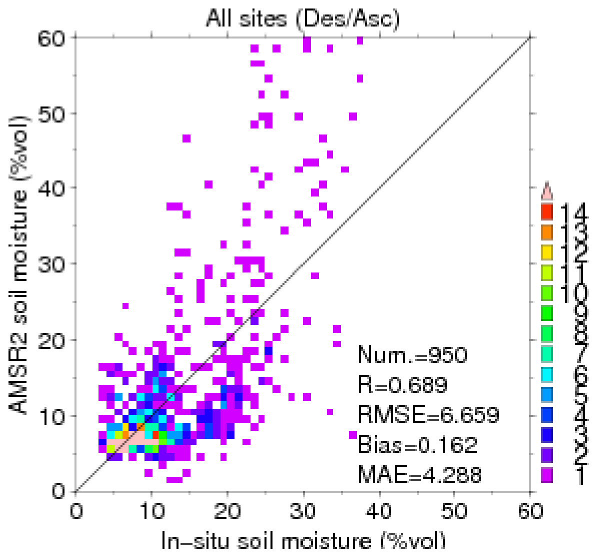
Ascending/Descending passes



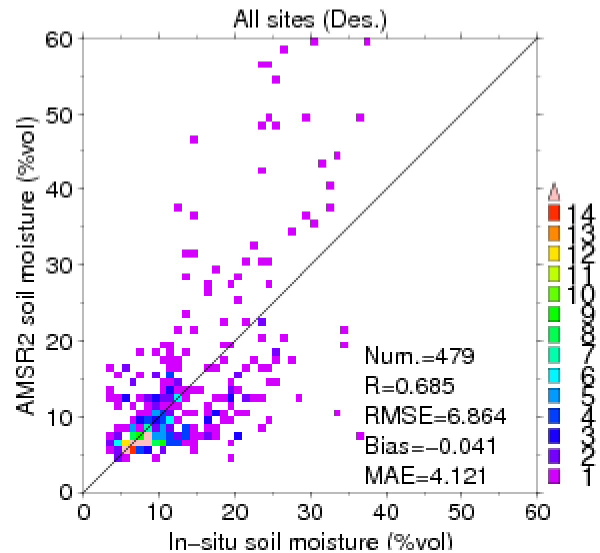


All Sites

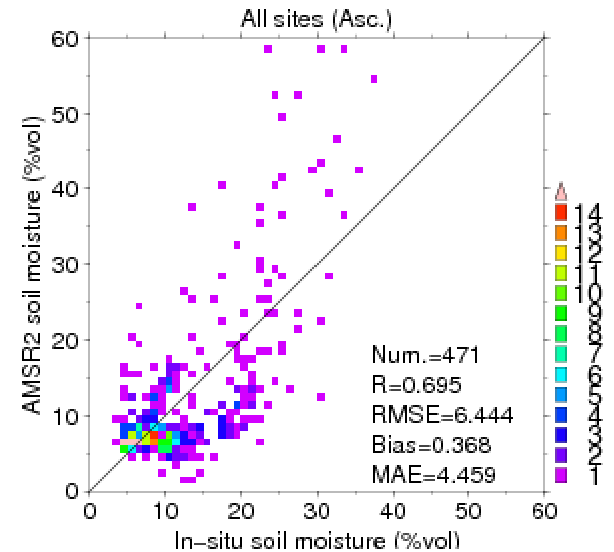
Ascending passes



Descending passes



Ascending/Descending passes

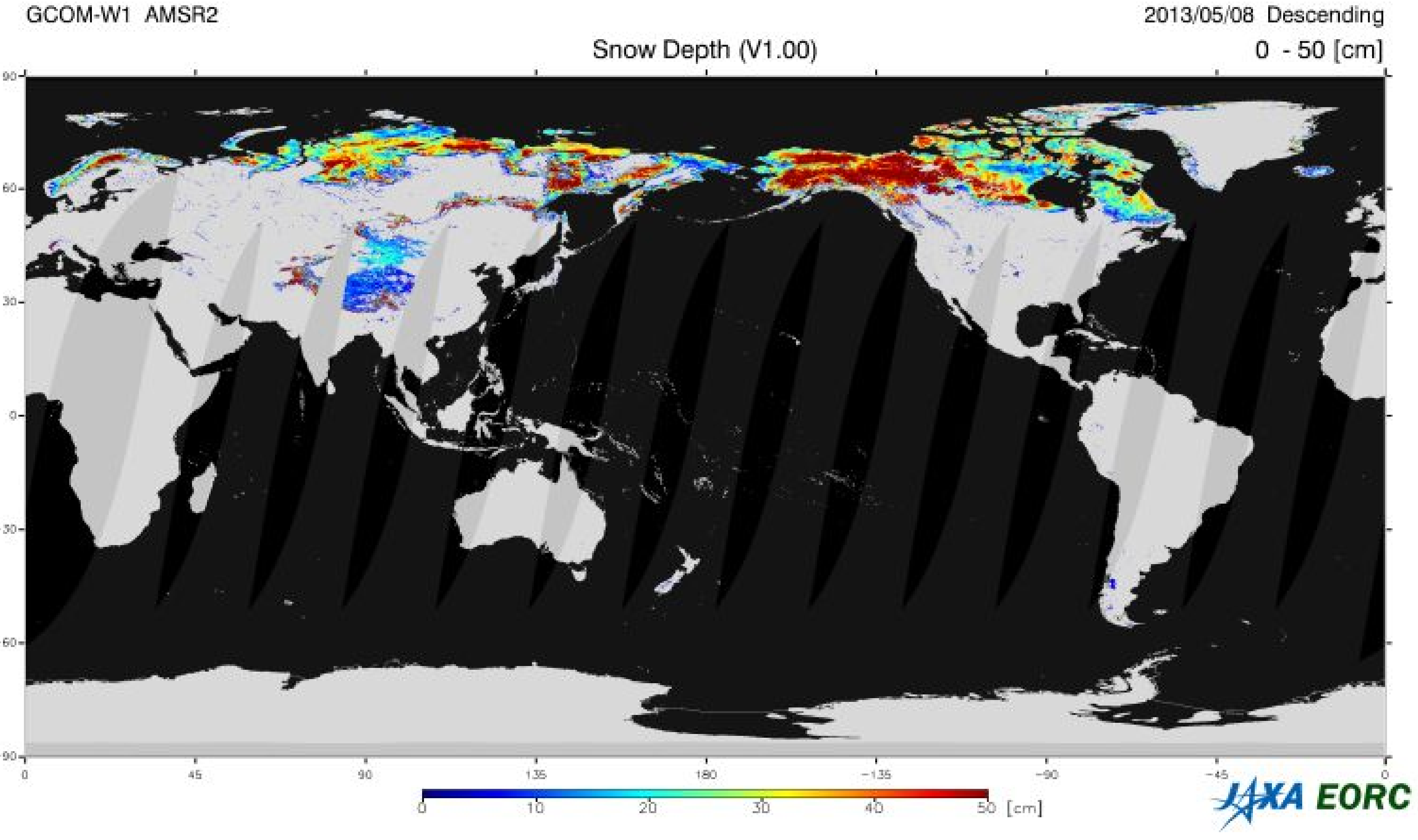


Validation	Required (Release)
4%	10%

(MAE)

- ✓ In the evaluation of all sites together (above), the SMC error in MAE meets the required “release accuracy”. However, characteristics and sizes of errors depend on the validation sites and their condition. Further in-situ data collection and validation are necessary to assess the errors of SMC product.

Snow Depth (SND)



Snow Depth (SND)

- ## Algorithm PI
  - Richard Kelly, University of Waterloo
- ## Product status
  - SND algorithm Ver. 1.00, using L1R brightness temperatures Ver. 1.10 released on 1 March 2013 as inputs. Slope/offset values were applied to L1R Tbs to compensate differences between AMSR2 and AMSR-E calibrations.
  - At present, snow depths are calculated using the AMSR-E snow depth algorithm with parameters of AMSR-E.
  - The land-water mask has been improved and the team is working on improvements to other flag areas (mountains, ocean, swath gaps).
- ## Caveats
  - There is a tendency to overestimate snow extent over the Tibetan Plateau and other high elevation plateau areas.
  - Algorithm development and validation is ongoing. Improved lake fraction, atmospheric and forest cover effects are being ameliorated. Improved retrieval scheme is being developed.

Snow Depth (SND)

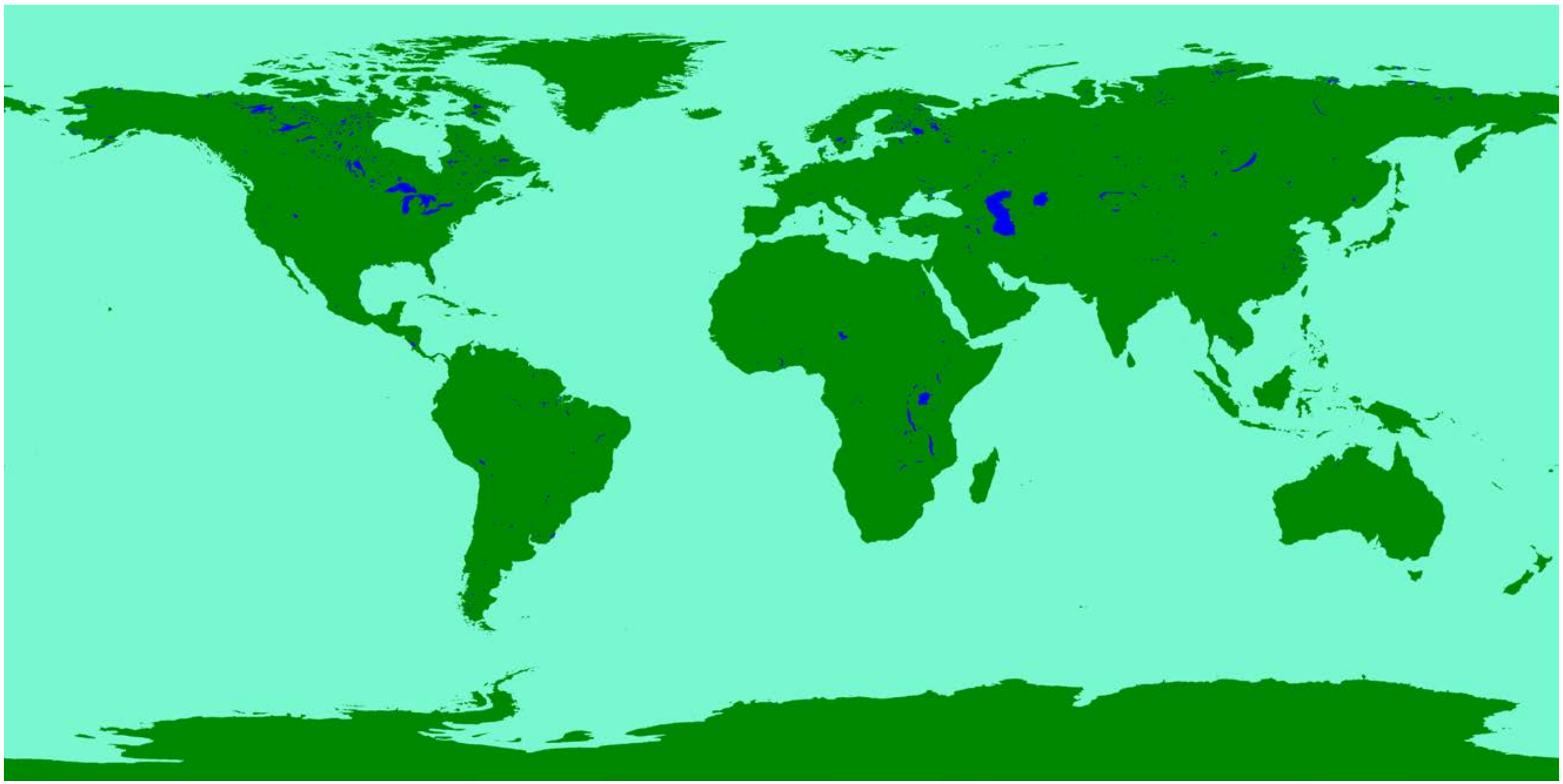
- ## Validation results
  - Global Summary of the Day (GSOD) distributed by NOAA National Climate Data Center were used for validation. By prescreening the data, 1007 locations were selected through several conditions (e.g., 10% areas of water body within 40km distance, less data deficiency).
  - Match-up conditions: within 1-day of observing time difference and 7 km of distance.
  - SND errors are evaluated using the Mean Absolute Error (MAE) metric. *In-situ* data indicating more than 100 cm snow depth were excluded from evaluation.
  - Validation period: October 1, 2012 – March 31, 2013

- ## References

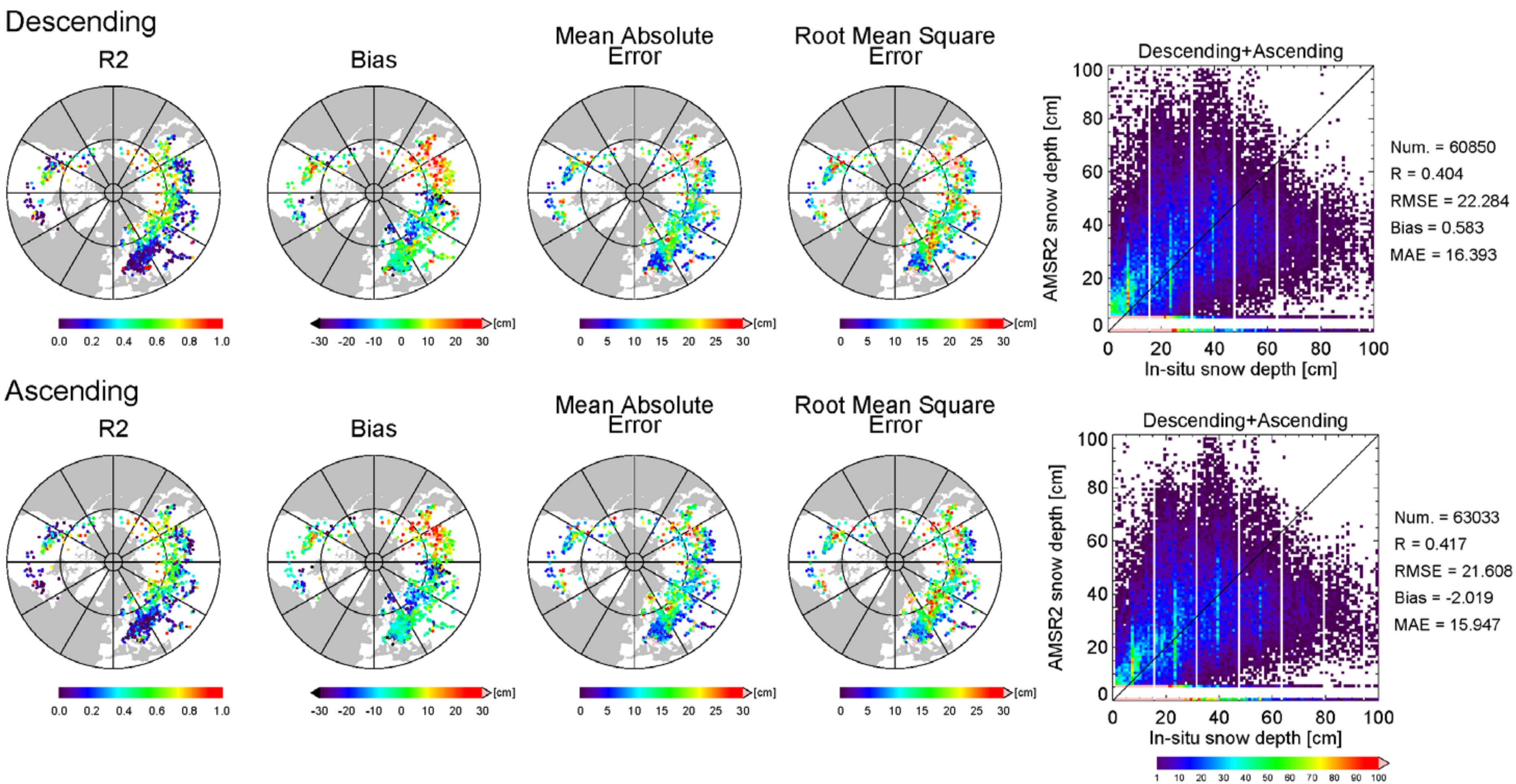
  - Algorithm description of GCOM-W1 AMSR2, JAXA Technical Report, NDX-1200015A, 2013.
  - Kelly, R.E.J. (2009) The AMSR-E Snow Depth Algorithm: Description and Initial Results, *Journal of The Remote Sensing Society of Japan.* 29(1): 307-317. (GLI/AMSR Special Issue).

Snow Depth: New Water Bodies Mask

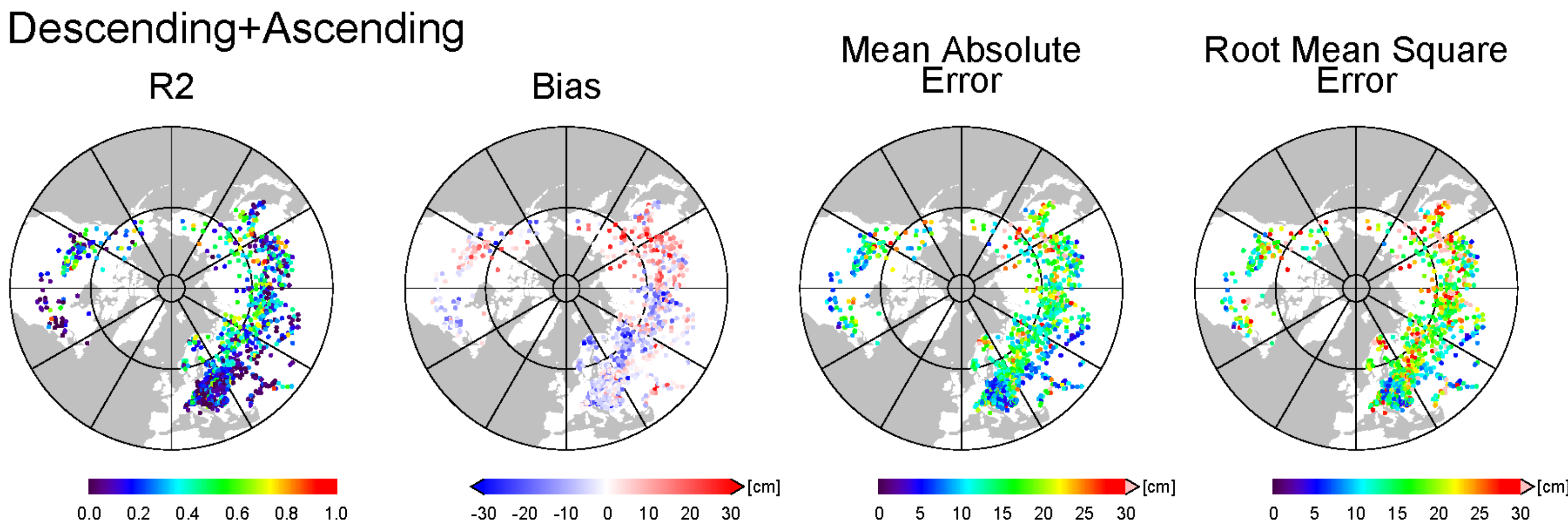
Improved parameterization of water bodies using a high resolution lakes outline vector data set.

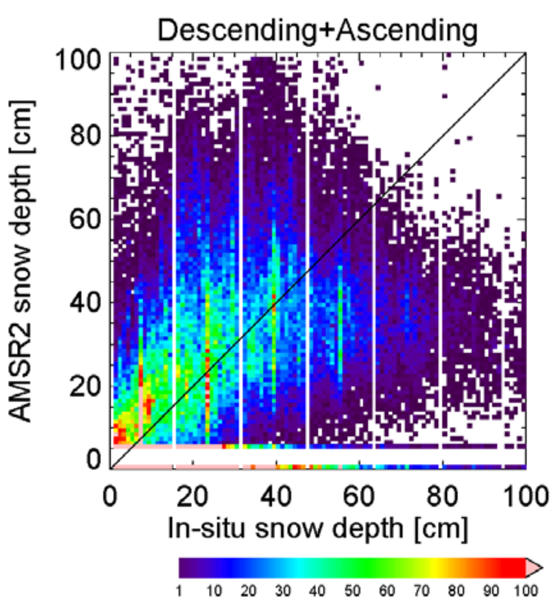


Error Statistics (Ascending or Descending)



Error Statistics (Ascending+Descending)





Num. = 123883
R = 0.408
RMSE = 21.897
Bias = -1.080
MAE = 16.106

- ✓ From the validation with GSOD/SND values in the northern hemisphere, overall SND error in MAE meets the required "release accuracy."
- ✓ However, characteristics and sizes of errors differ for different surface types and seasons. Also, as described in "caveates" section, there are some areas with problems (e.g., Tibetian plateau), and algorithm improvement is ongoing.

Validation	Required (Release)
16 cm	20 cm

(MAE)