Overview of Long-term Observations of the Global Water Cycle by the Advanced Microwave Scanning Radiometer (AMSR) Series

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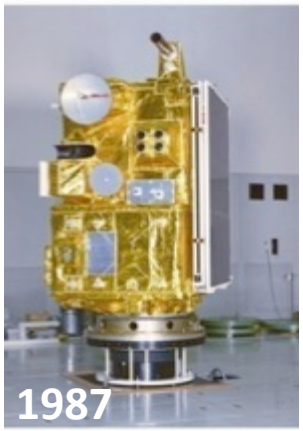
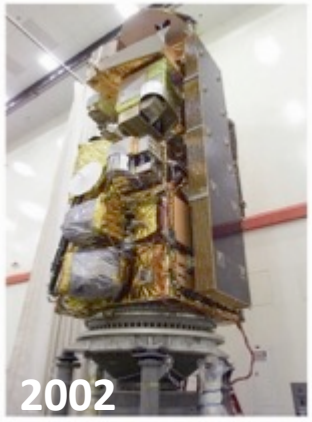
Brief History of Passive Microwave Imagers

- Spaceborne Passive Microwave Imagers
  - Started by US and USSR in 1960's: Mariner-2, Skylab, Nimbus, Cosmos, Seasat
  - Continuous Earth observation started by Nimbus-7/SMMR (1978~)
  - Series instruments: DMSP SSM/I series (1987~Current) and its successor
  - TMI on US-Japan TRMM (1997-2014) is unique due to the lower altitude (thus finer spatial resolution, non-sun synchronous orbit, and simultaneous observation with Precipitation Radar)
- Japanese Passive Microwave Imager
  - MOS-1/MSR (1987): Engineering and scientific development
  - ADEOS-II/AMSR (2002-2003): Global observation, but just 10 months
  - EOS Aqua/AMSR-E (2002-2011): Continued more than 9-years observation
  - GCOM-W/AMSR2 (2012-present): Succeed AMSR-E observation in A-train
  - AMSR2 follow-on sensor (AMSR3): Currently planning to be installed on the GOSAT-3

Development of AMSR Series

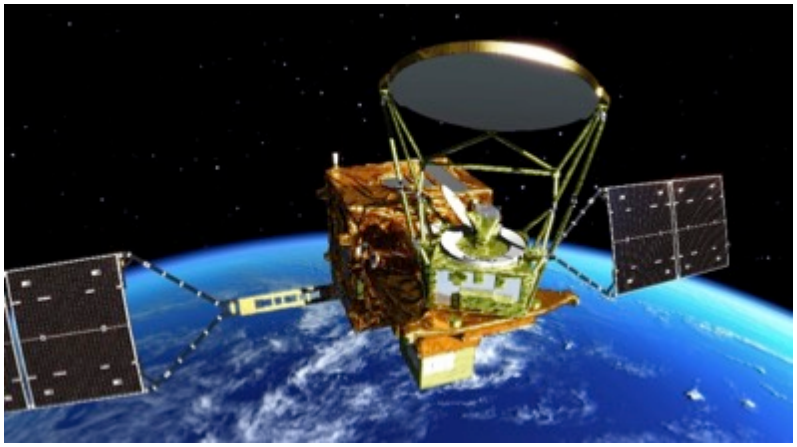
Sensor	MOS-1/MSR	ADEOS-II/AMSR	Aqua/AMSR-E	GCOM-W/AMSR2
Coverage	Direct receive only	Global	Global	Global
Swath	317km	1600km	1450km	1617km
Frequencies (GHz)	2 (23,31)	9 (6.9,10,18,23, 36,50,52,89)	6 (6.9,10,18,23, 36,89)	7 (6.9,7.3,10,18, 23,36,89)
Polarization	Mixed V and H	V and H	V and H	V and H
Antenna Size	0.5m	2.0m	1.6m	2.0m
Spatial Res.	23km @31GHz	8x14km @36GHz	8x14km @36GHz	7x12km @36GHz





AMSR3?

Overview of GCOM-W and AMSR2



Instrument	**Advanced Microwave Scanning Radiometer 2 (AMSR2)**
Altitude	**705 km**
Orbital inclination	**98.2 deg**
Local sun time at Ascending node	**13 :30**
Launch vehicle	**H-IIA**
Launch	**May 18, 2012**
Designed lifetime	**5 years**

- ✓Successor of Aqua/AMSR-E (launched in May 2002), providing continuous data for climate studies and operational applications
- ✓Joining A-train constellation (same as Aqua) and also GPM constellation
- ✓Carrying AMSR2, a multi-polarization and multi-frequency microwave imager
- ✓Observing various water-related ECVs at high spatial resolution
- ✓Improving on-board calibration target has resulted reduction of annual TB variation due to calibration and improvement of TB stability
- ✓Achieved designed mission life (5-year) on May 18, 2017, and continues observation
- ✓Enough fuels to keep current orbit for more than 15 years

https://gcom-w1.jaxa.jp/

AMSR2 Standard Products

Product		Coverage	Resolution	Release Accuracy	Standard Accuracy	Target Accuracy	Validation Result	Latest version
Brightness Temperature		Global	5-50km	±1.5K	±1.5K	±1.0K (bias) ±0.3K(random)	< 1.4 K	Ver.2.2
GEO	Total Precipitable Water	Global Ocean	15km	±3.5 kg/m^2	±3.5 kg/m^2	±2.0 kg/m^2	1.5 kg/m^2	Ver.2.1
	Cloud Liquid Water	Global Ocean	15km	±0.10 kg/m^2	±0.05 kg/m^2	±0.02 kg/m^2	0.04 kg/m^2	Ver.2.1
	Precipitation	Global (except high latitude)	15km	Ocean ±50 % Land ±120 %	Ocean ±50 % Land ±120 %	Ocean ±20 % Land ±80 %	Ocean 48% Land 86%	Ver.2.1
	Sea Surface Temperature	Global Ocean	50km	±0.8 ºC	±0.5 ºC	±0.2 ºC (zonal mean)	0.5 ºC < 0.2 ºC (zonal)	Ver.3.0
	Sea Surface Wind Speed	Global Ocean	15km	±1.5 m/s	±1.0 m/s	±1.0 m/s	1.0 m/s	Ver.3.0
	Sea Ice Concentration	Ocean in high latitude	15km	±10 %	±10 %	±5%	9 %	Ver.3.0
	Snow Depth	Land	30km	±20 cm	±20 cm	±10 cm	18 cm	Ver.2.1
	Soil Moisture	Land	50km	±10 %	±10 %	±5 %	4 %	Ver.3.0

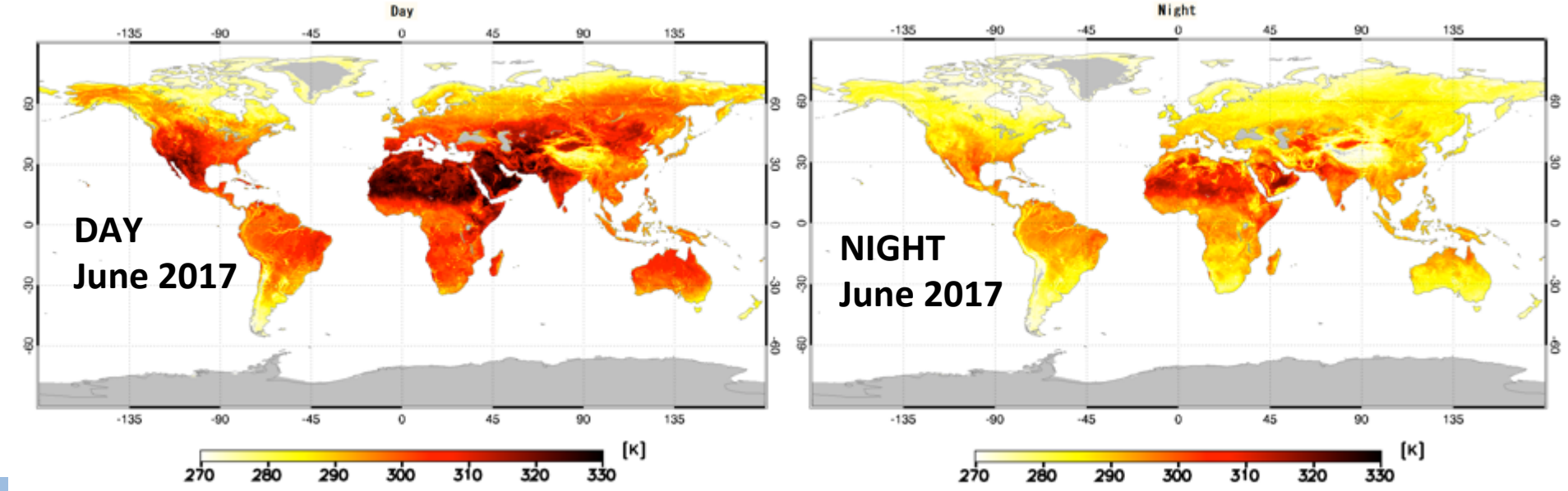
http://suzaku.eorc.jaxa.jp/GCOM_W/research/resdist_j.html

AMSR2 Research Products and Accuracy

Products	Area	Resolution	Target accuracy	Status
All-weather sea surface wind speed	Ocean	60 km	± 7 m/s for strong wind (>17m/s)	4.07 m/s (Ver.3.0)
High-resolution (10-GHz) SST	Ocean	30 km	± 0.8 ºC	0.55 ºC (Ver.3.0)
Soil moisture and vegetation water content based on the land data assimilation	Africa, Australia (at first stage)	25 km	soil moisture: ± 8% vegetation water: ± 1 kg/m^2	Under development
Land surface temperature	Land	15 km	forest area: ± 3 ºC nondense vegetation: ± 4 ºC	3 ºC (forest) 4 ºC (nondense vegetation) (Ver.1.0)
Vegetation water content	Land	10 km	± 1 kg/m^2	Under evaluation
High resolution sea ice concentration	Ocean in high latitude	5 km	± 15 %	Under evaluation
Thin ice detection	Okhotsk sea (at first stage)	15 km	± 80 %	Under evaluation
Sea ice moving vector	Ocean in high latitude	50 km	2 components: 3 cm/s	Under evaluation

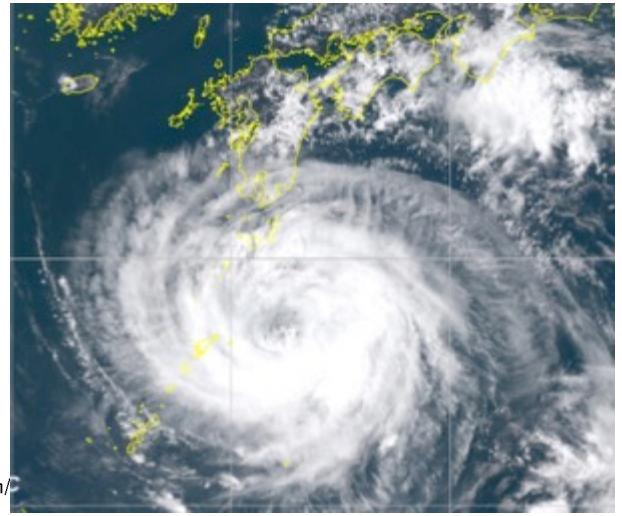
AMSR2 Land Surface Temperature Product

- Algorithm provided by Tom Jackson (USDA)
- Retrieval of LST by single equation using 36 GHz V TB
  - Equation is obtained by using linear regression between AMSR2 LST and LST at ground observation sites in Europe and US
- Observing top of forest over forest area
- Capable to obtain frequent LST for both day & night
- Available from http://suzaku.eorc.jaxa.jp/GCOM_W/research/resdist_j.html
  - Detailed validation results are also available



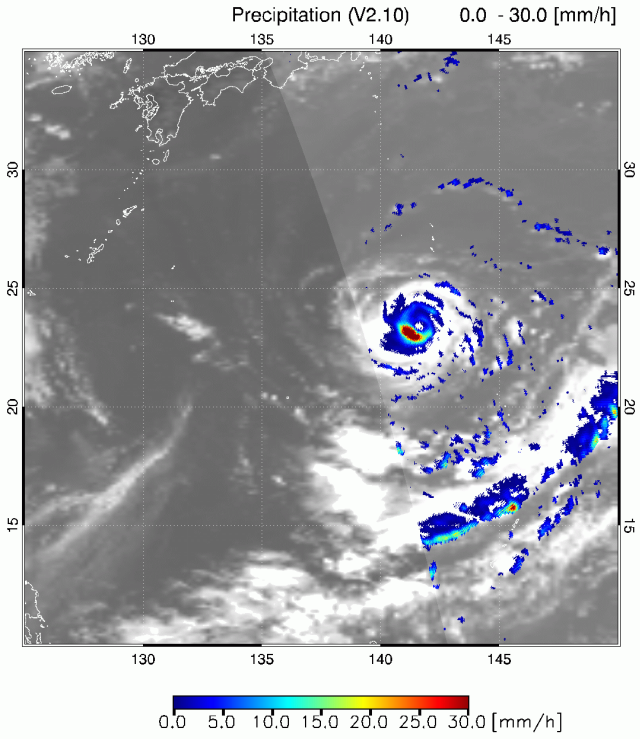
AMSR2 All-weather Sea Surface Wind Speed

- Algorithm provided by Akira Shibata (RESTEC)
- All-weather wind speed research product can observe high wind speed area under heavy rainfall
- AMSR2 observation of Super Typhoon “NORU” in 2017 (No.5)

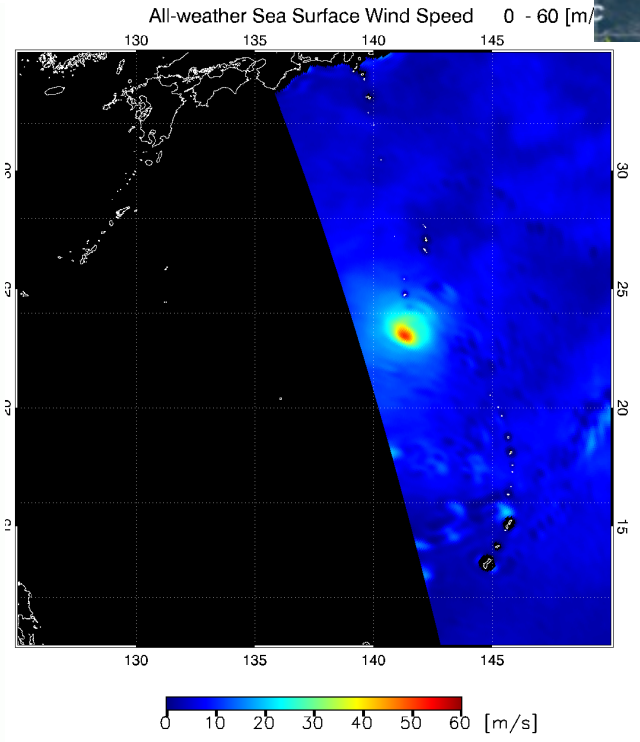


Himawari-8/AHI RGB composite at 5Z on Aug. 4, 2017

AMSR2 Rainfall

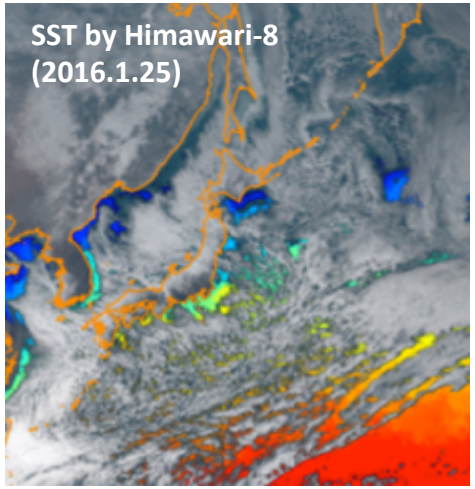


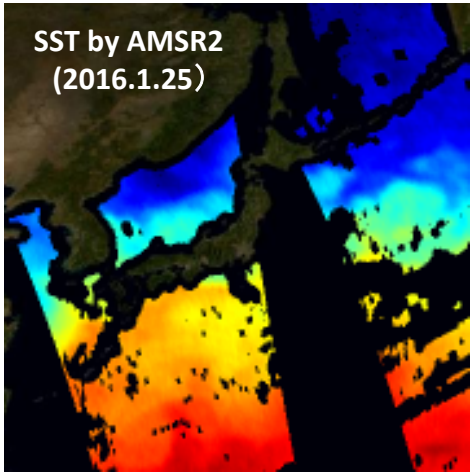
All-weather wind speed



Animation from Jul. 30 to Aug. 4, 2017

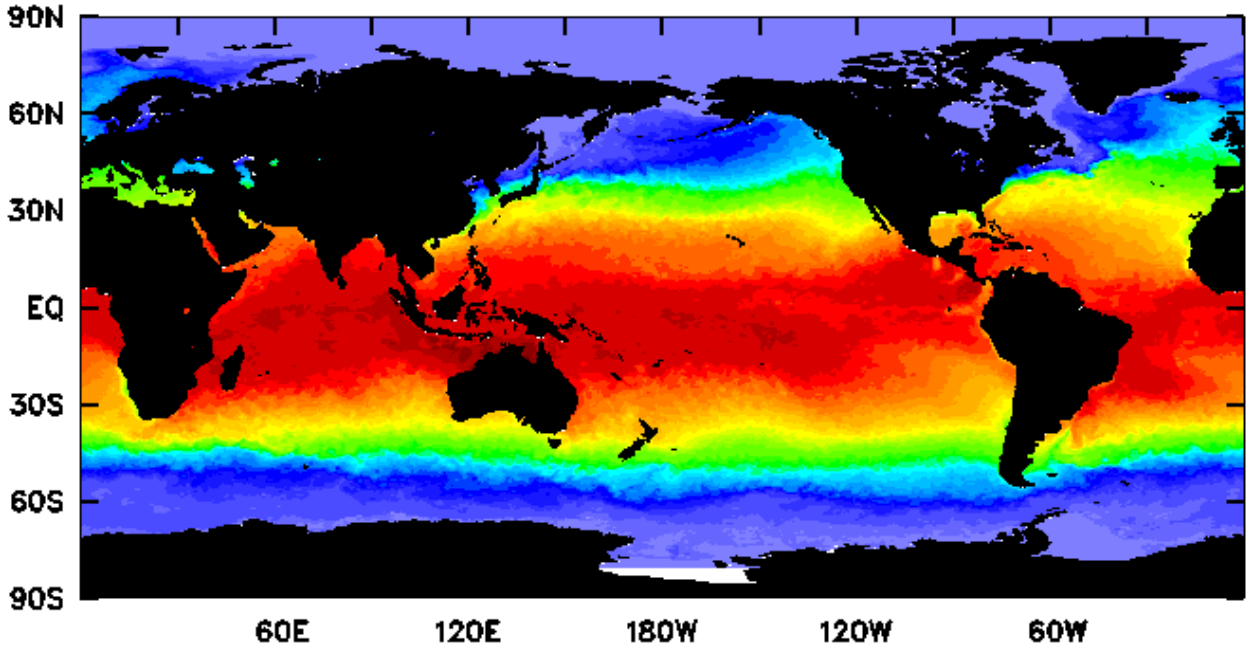
Application in Merged Global SST





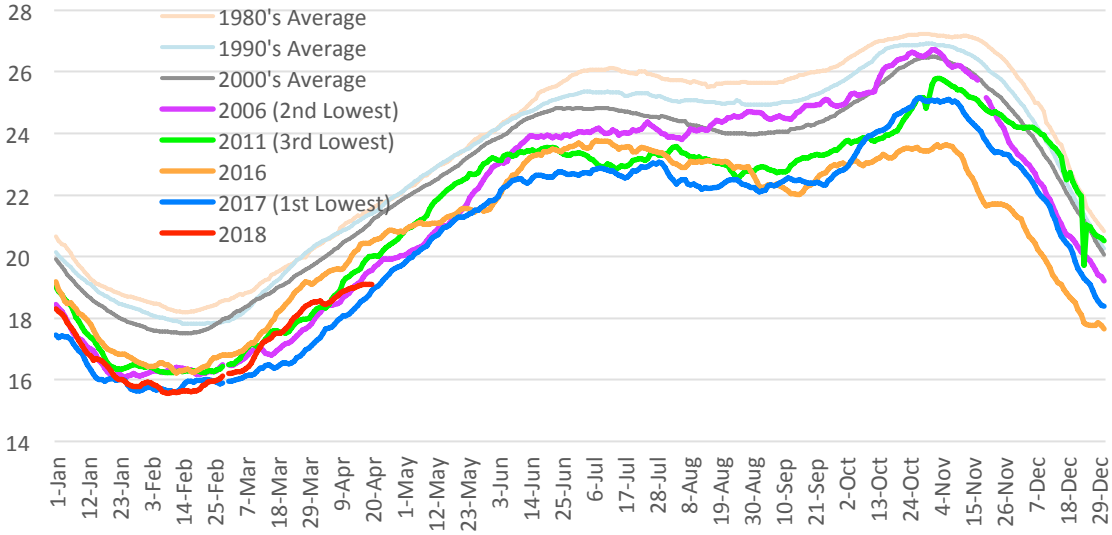
IR imager (upper) cannot observe SST under clouds, but AMSR2 (lower) can observe.

- Many meteorological agencies, such as JMA, UK MetOffice, ABoM, and NOAA, produce daily global SST by merging satellite and in-situ data for inputs to numerical models and monitor sea status.
- All-weather SST by AMSR2 plays significant role in merged SST when IR imagers on board geostationary and polar-orbital satellites cannot observe SST because of clouds.

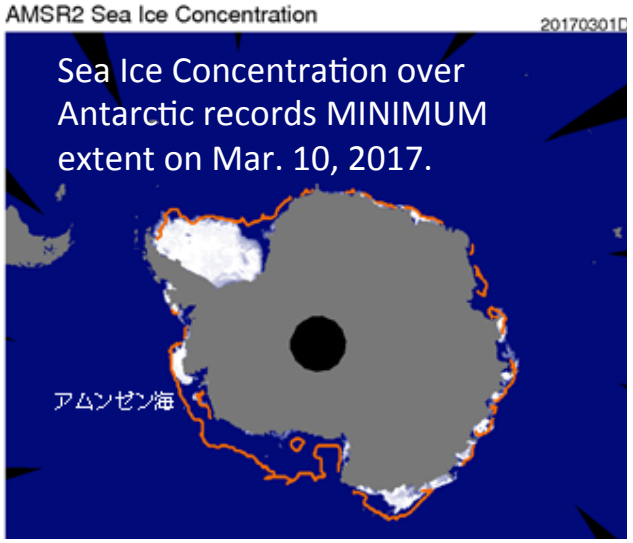


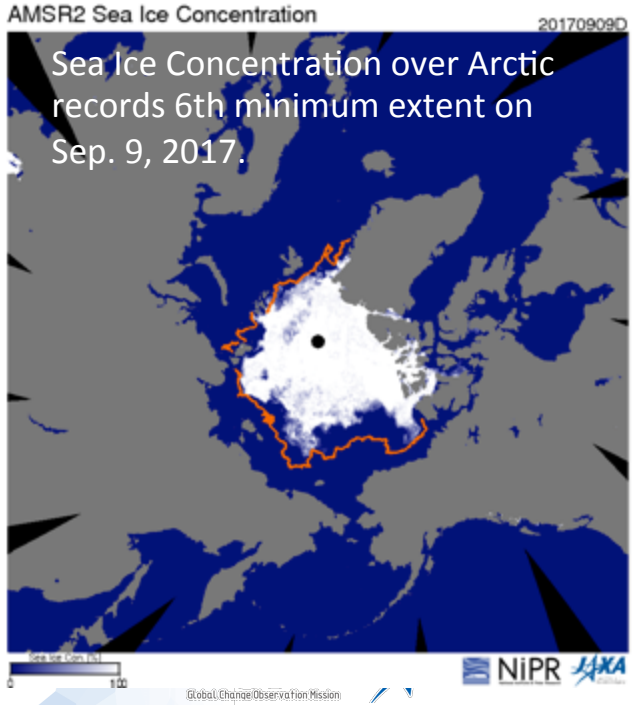
(Image provided by BoM)

Application in Sea Ice Monitoring



Seasonal variation of Sea Ice Extent over Arctic and Antarctic. Each line indicates each year (thick) or 10-year average (thin). Blue: 2017, Red: 2018.



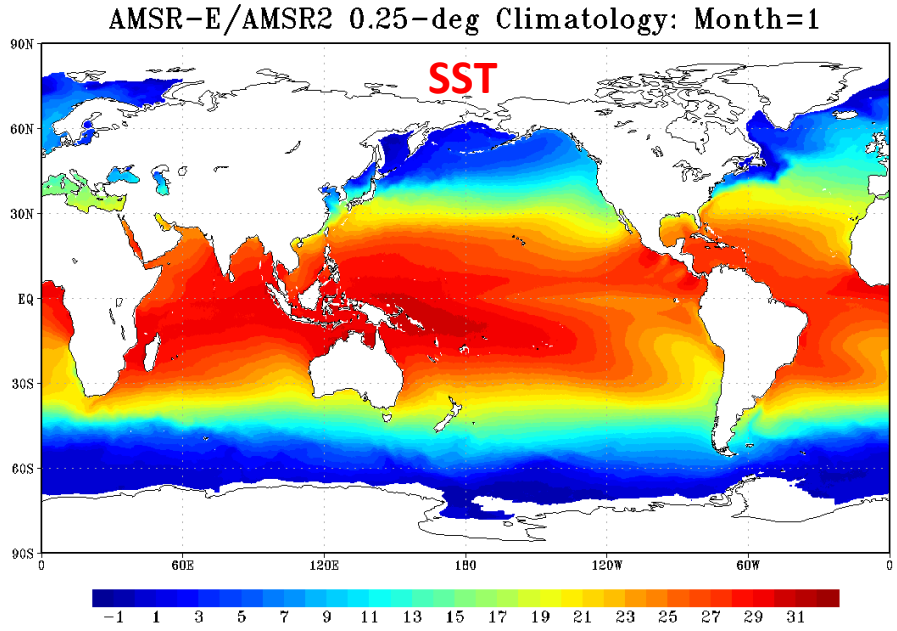


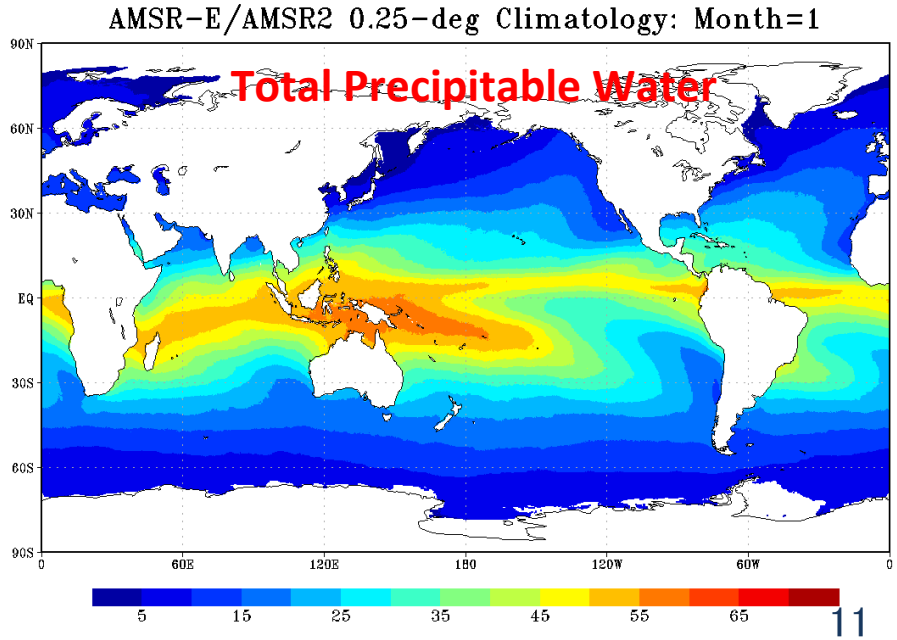
- Global: Records the minimum in Feb. 2018
- Arctic: Records the minimum in Sep. 2012
- Antarctic: Records the minimum in Mar. 2017

JASMES (JAXA): http://kuroshio.eorc.jaxa.jp/JASMES/climate/
ADS (NIPR): https://ads.nipr.ac.jp/vishop/#/monitor

AMSR-E Reprocess Product Status

- To provide consistent dataset between AMSR2 and AMSR-E for long-term analysis, JAXA has reprocessed AMSR-E product applying the latest AMSR2 algorithms.
  - Level 1 & 3 (brightness temperature): Public release from G-Portal (May-June 2018)
    - Level 1B & 1R in AMSR2 format (HDF5)
  - Level 2 & 3 (geophysical parameters): Planning public release
    - Applying the current (latest) AMSR2 L2 algorithms and format (HDF5)





Status of AMSR2 follow-on Mission

- The Roadmap for the Basic Plan on Space Policy was revised in Dec. 2017: "The government should conduct development research on AMSR2's successor sensor (AMSR3) on condition that hosted payload with GOSAT-3 (Green-house gases Observation SATellite-3) in JFY2018."
- The government approved the budget for JFY 2018 to built and test prototypes of AMSR3's components.

- Currently in Mission Definition Phase (Candidates of Pre-Project)
  - Collaborating with GOSAT-2 project team on the feasibility study on the hosted payload capability along with mission concept study.
  - Scientific synergies between AMSR2 f/o and GOSAT-3 are discussed among science communities.
  - Mission requirements for operational utilizations and science are also discussed under the GCOM user committee.
  - **Mission Definition Review (MDR)** is currently on going

Summary

- JAXA has developed series of PMW instruments, MSR, AMSR, AMSR-E, and AMSR2, resulted ~15-year archive of PMW data with wide-swath and high-resolution by C-to-W band channels
  - AMSR, AMSR-E, and AMSR2 products are distributed to public via internet. Transfer to G-Portal (https://www.gportal.jaxa.jp/gp/)
  - 8 standard geophysical parameters and 3 research products are available
  - AMSR-E reprocessing products applying AMSR2 format and algorithms are in preparation, expected to develop CDRs
- AMSR2 follow-on sensor (AMSR3) is currently proposed to be installed on GOSAT-3 and receive JFY2018 budget to built and test prototypes of the sensor's components
  - Feasibility study on the hosted payload capability along with mission concept study with GOSAT-2 project team
  - The optimum orbit for both missions has to be discussed
  - Mission Definition Review (MDR) of AMSR2 follow-on sensor will be the next step to move forward
  - Still has a risk of gaps between AMSR2 and follow-on even if development starts in JFY2018