Recent Improvements in AMSR2 Sea Surface Temperature Products

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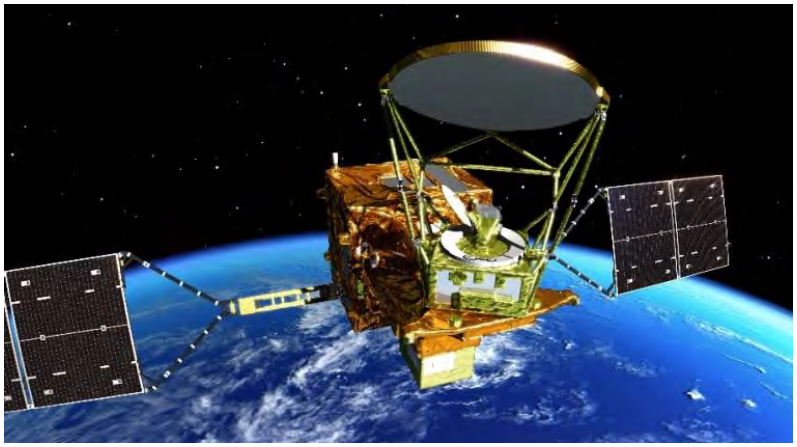
Overview of GCOM-W and AMSR2



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

Status of AMSR2 follow-on mission

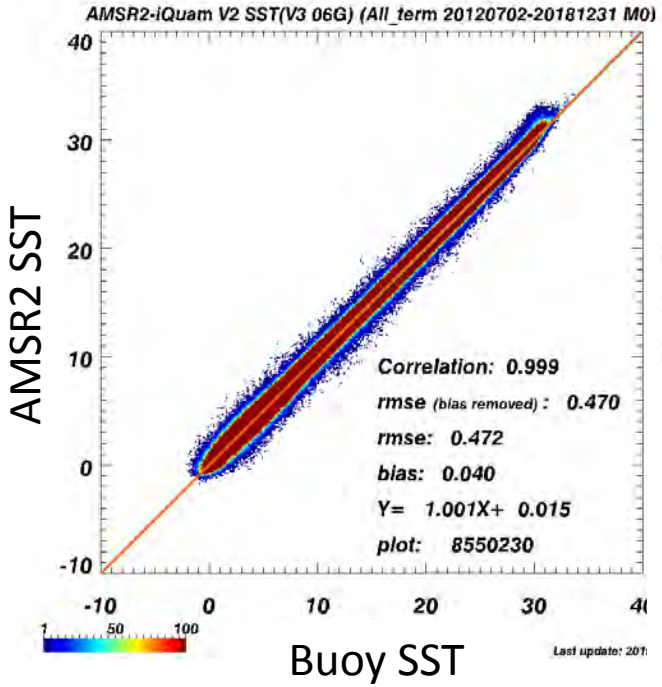
- "Development of the AMSR2's successor sensor" is mentioned on The Roadmap for the Basic Plan on Space Policy revised December, 2018.
  - Share the satellite bus with GOSAT-2/TANSO-2 follow-on mission, led by Ministry of Environment (MOE).
- JAXA proceeds with internal process to launch development project.
  - Mission Definition Review (MDR) and project readiness reviews were completed in Jun. 2018.
  - Project Preparation Phase (Phase-A) activities since Sep. 1, 2018.
  - Expect to complete System Definition Review (SDR) in mid-JFY2019 and start Phase-B in latter half of JFY2019.
- Specification of the AMSR2 follow-on instrument
  - Almost equivalent to AMSR2
  - A few high frequency channels (**166 GHz and 183 GHz**) is considered for approval (166V & 183+/-7V are baseline, 166H & 183+/3V are optional)
- Orbit will be **666 km altitude** (same as GOSAT-1) and **13:30 LT in Ascending node** (same as GCOM-W)
  - Finer FOV (5% less), narrower swath width (1535km)

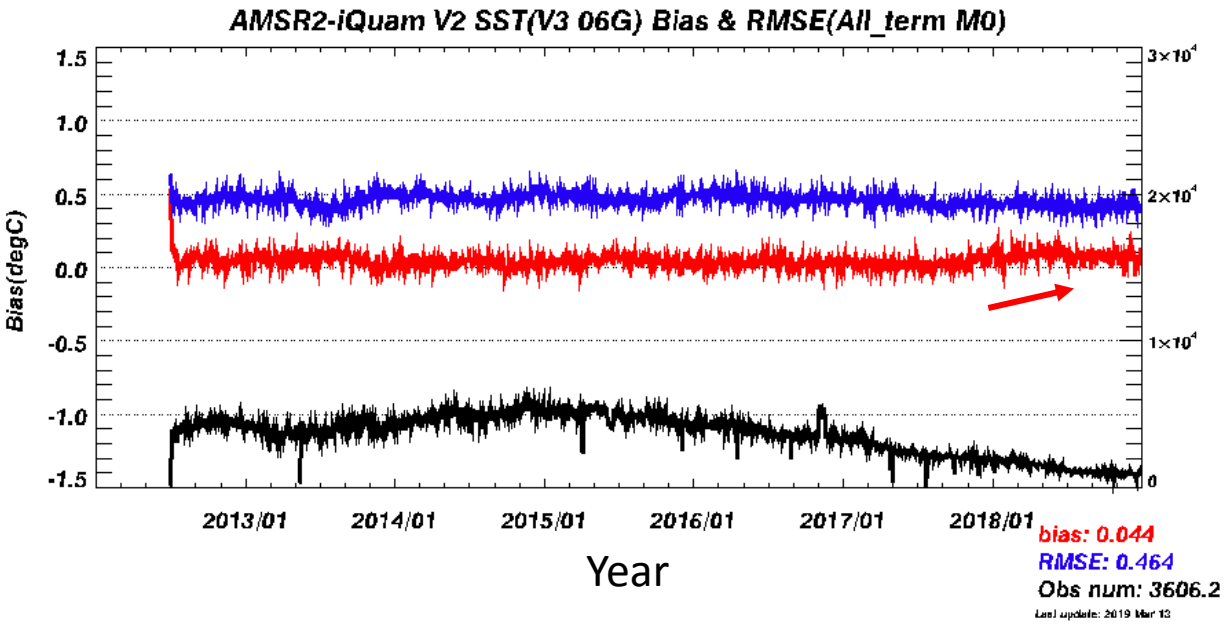
Current Issues in AMSR2 SST

- Recent increasing trends in biases
  ⇒Re-tuning of calibration table
- Users request higher spatial resolution SST (closer to coast line). 10GHz SST has finer spatial resolution than 6GHz SST, but poor sensitivity less than 10-12 degC
  ⇒SST by 3-frequency channels
- More random noises found in 10GHz SST than 6GHz SST (6GHz SST uses simple spatial filter)
  ⇒ Applying improved spatial filter to both 6 and 10GHz SSTs

AMSR2 V3 SST Validation Status

AMSR2 6GHz SST VS. iQuam V2 (currently transferring to V2.1)

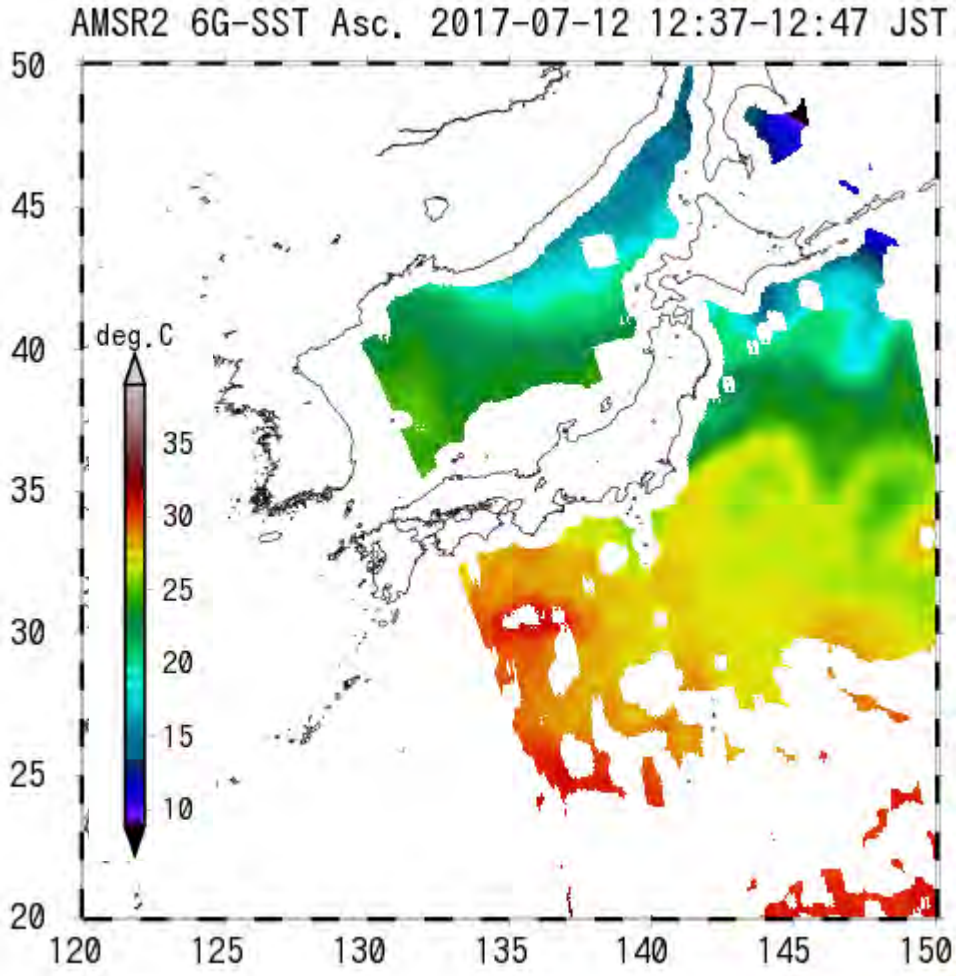




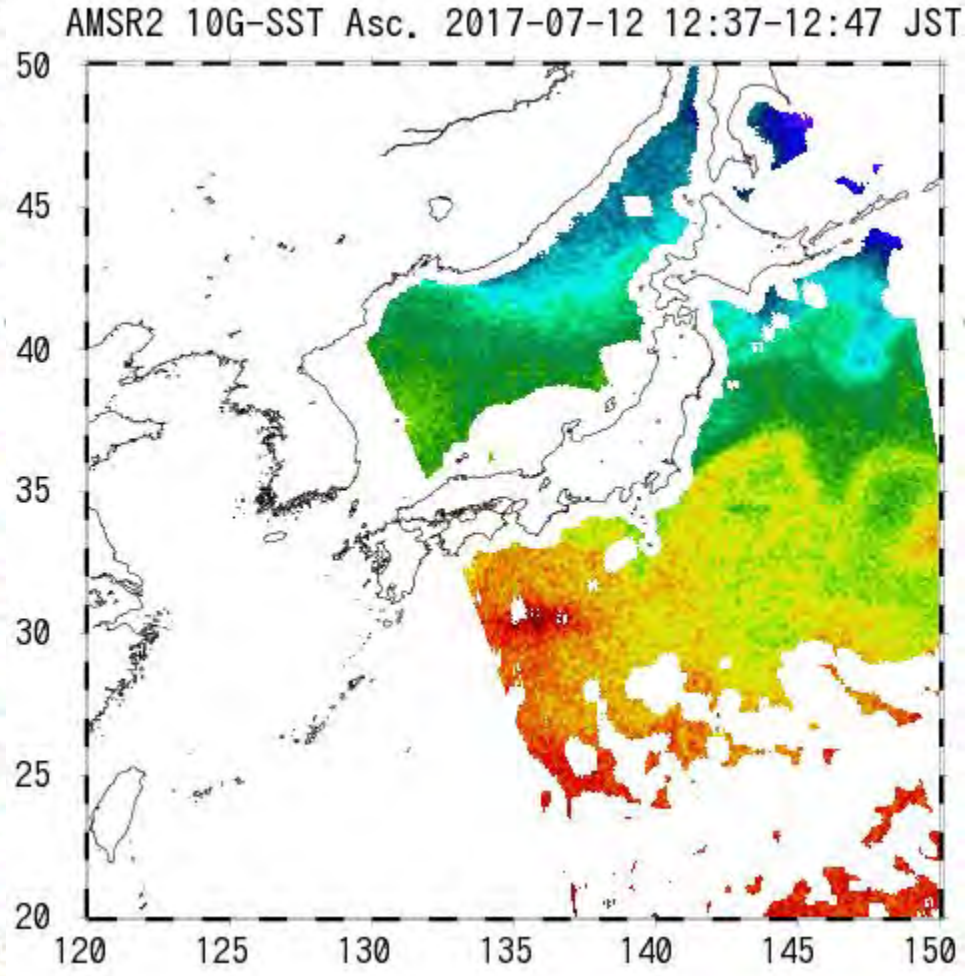
- Bias = 0.040 degC, RMSE = 0.472 degC from Jul. 2012 to Dec. 2018
- Small increasing trends in bias since 2018 due to some drifts of TB. Possible cause is aging of sensor linearity, need further check.
- Decrease of buoys in iQuam V2 is not due cause.

Random Noises in 10GHz SST

6GHz SST (3x3 filter)



10GHz SST (no filter)



Around 3UTC in Jul. 12, 2017

SST by 3-frequency channels (6, 7, and 10 GHz)

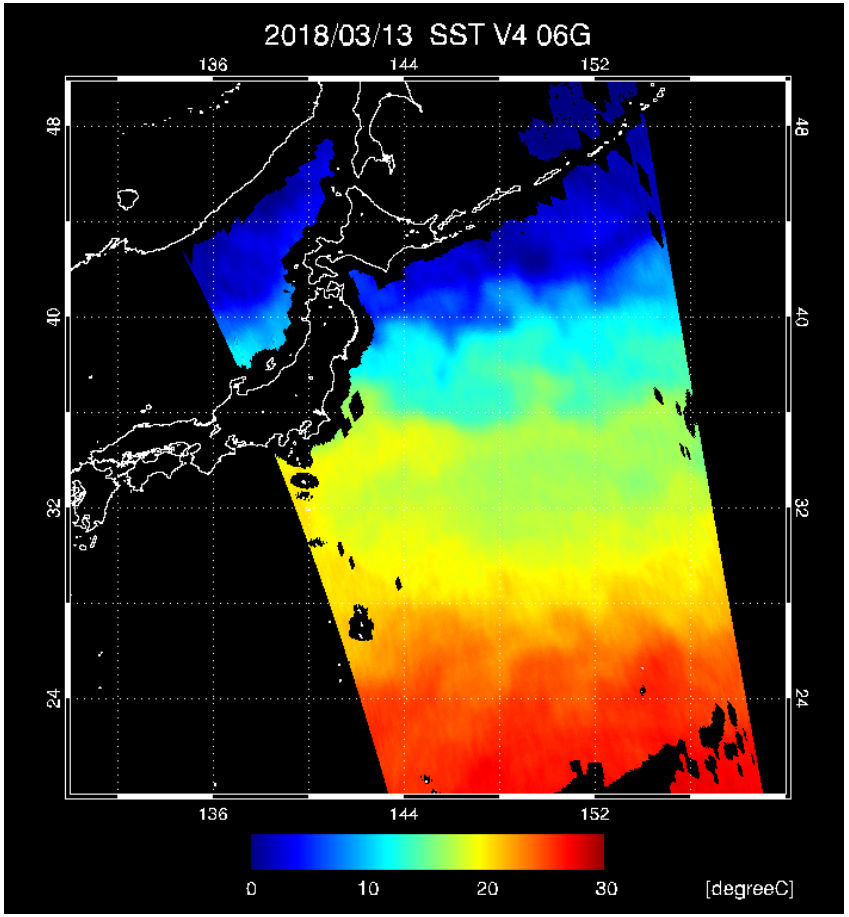
- Enable to estimate SST closer to coast line
  - In coastal area, SST where relative differences among three or two SSTs are less than 1.5C can be used.
- Enable estimate SST where missing in 6GHz SST
  - RFI signals can be removed by comparing thee SSTs.
  - Averages of two (7 and 10GHz) SSTs are used instead of missing 6GHz SST, if difference of two SSTs is less than 1.5C.
- Reduction of noise in 6GHz SST
  - Due to relatively larger noise in 6GHz SST than other two SSTs, local variability of 6GHz SST is replaced by those of two SSTs.

Comparison of 6G and 3-freq. SSTs

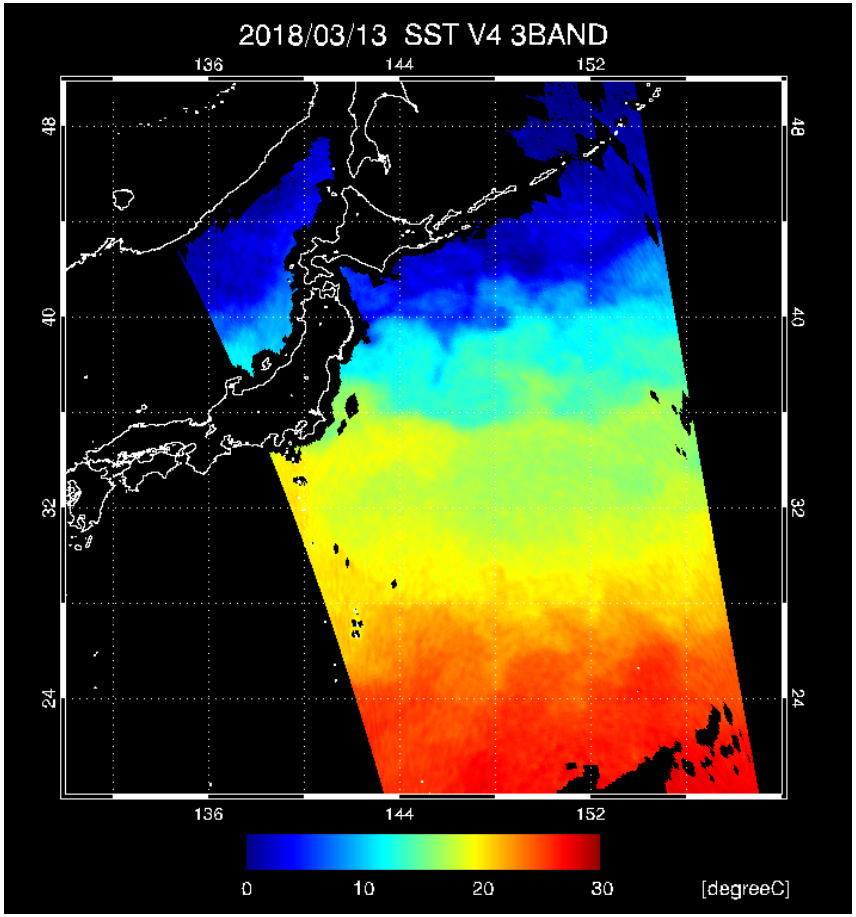
6G and 3-freq. SSTs on Mar.13, 2018

SST in coastal area and ocean eddies are sharpened in 3-freq. SST

6G SST

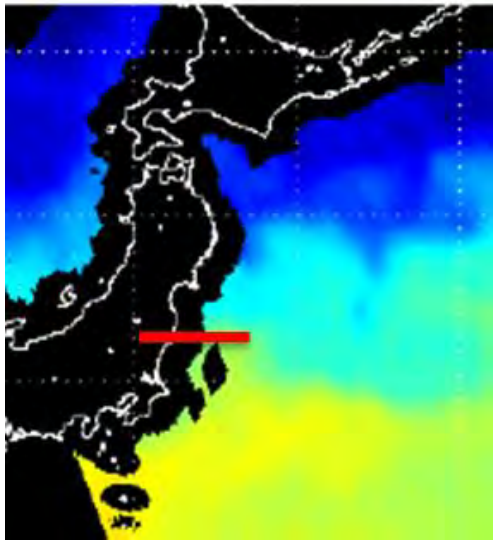


3-freq. SST

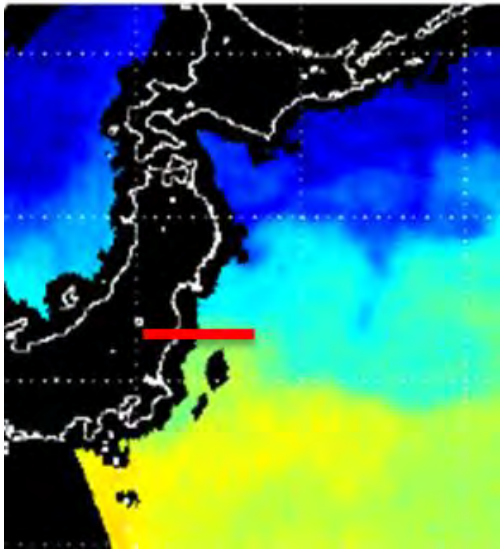


Enable to Estimate SST Closer to Coast Line

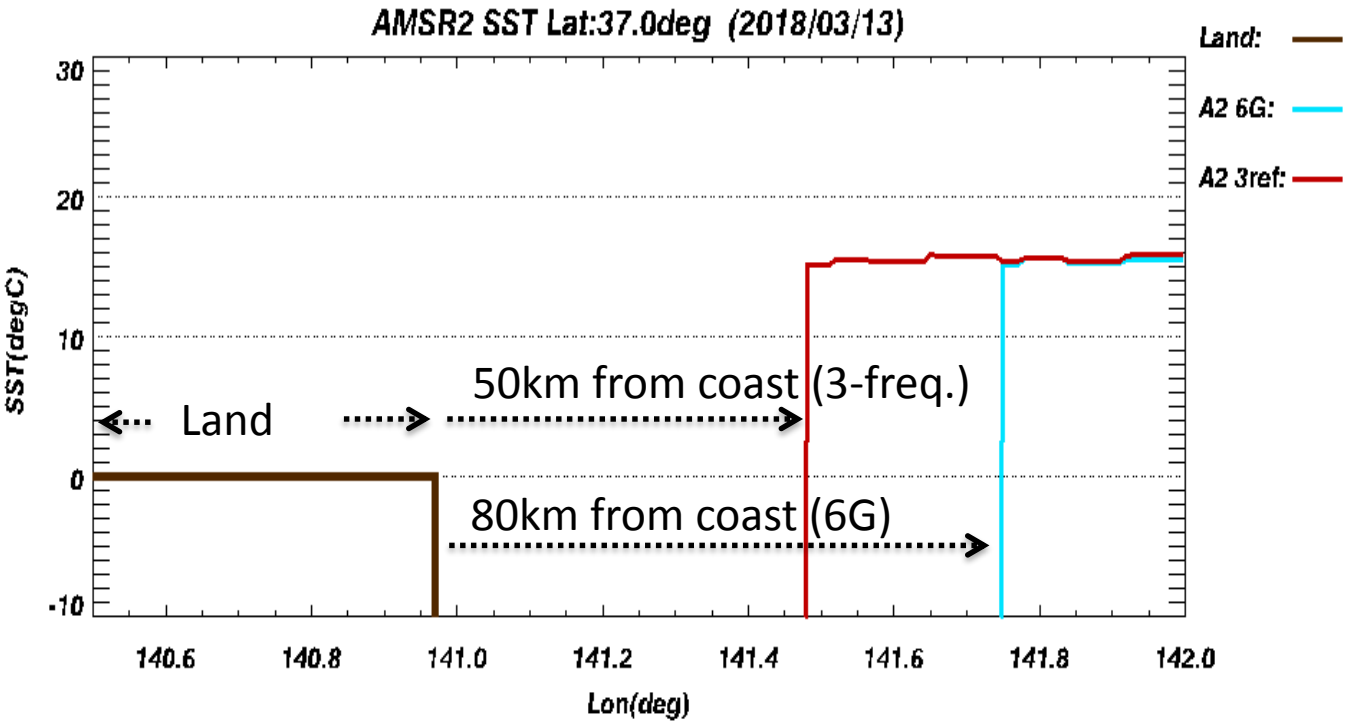
6G SST



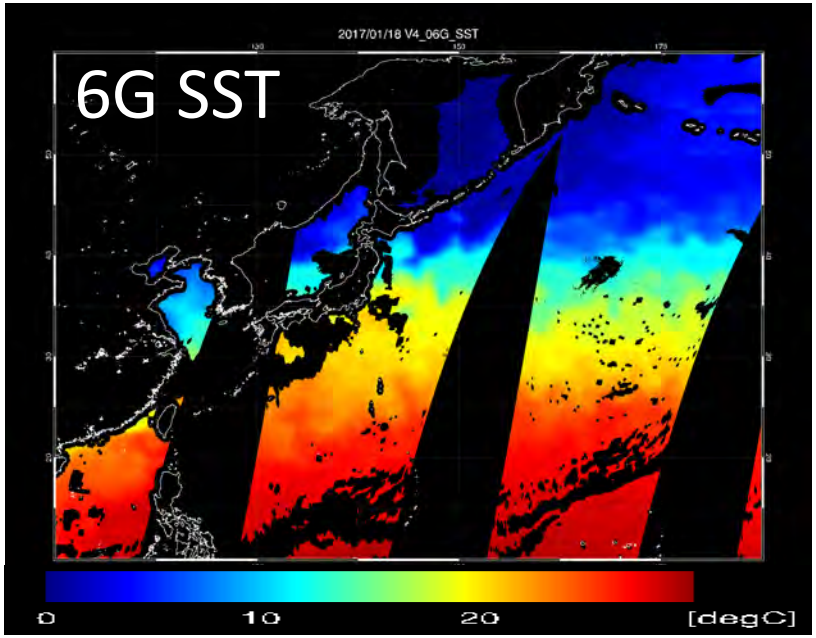
3-freq. SST

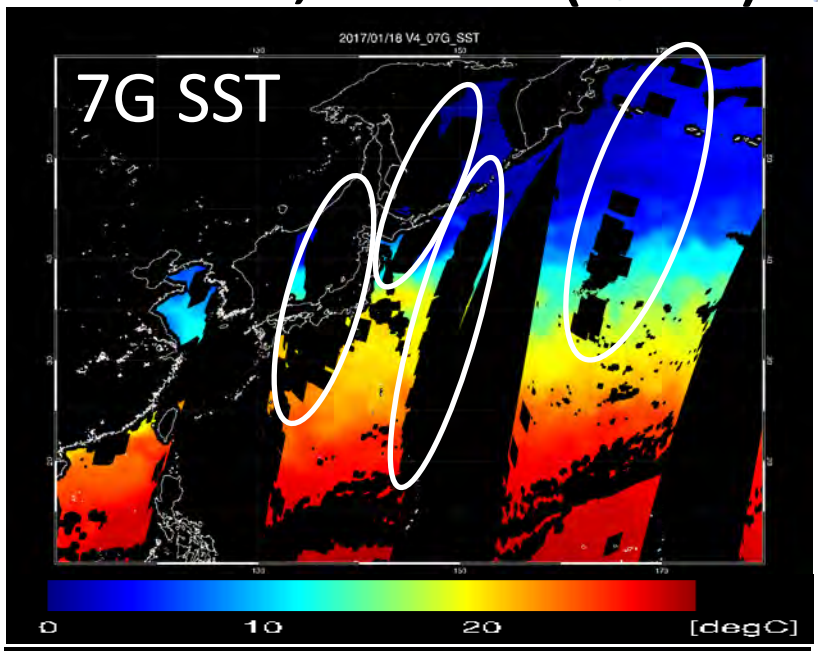


Cross section along 37N near the coast (red line) for **6G SST** and **3-freq. SST**

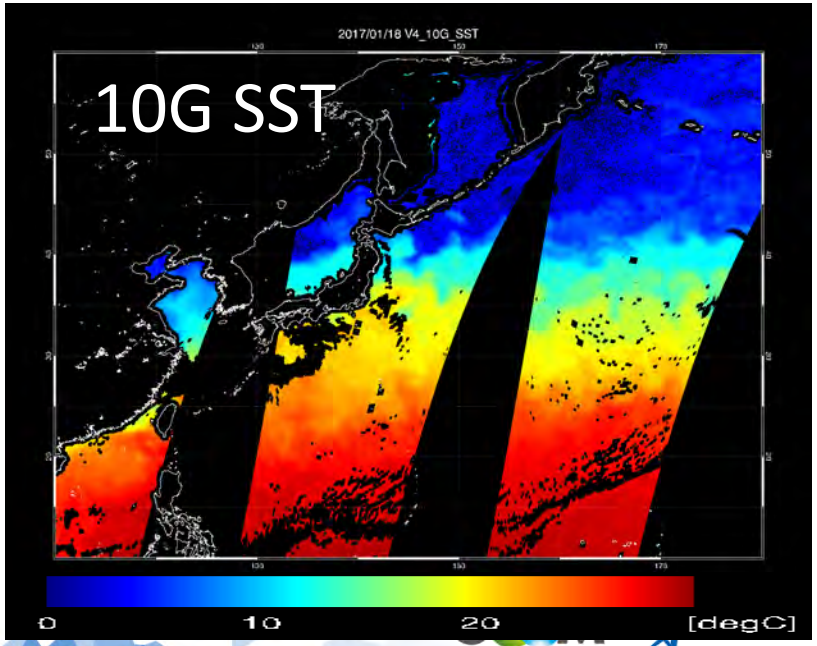


SSTs around Japan on Jan. 18, 2017 (dsc.)



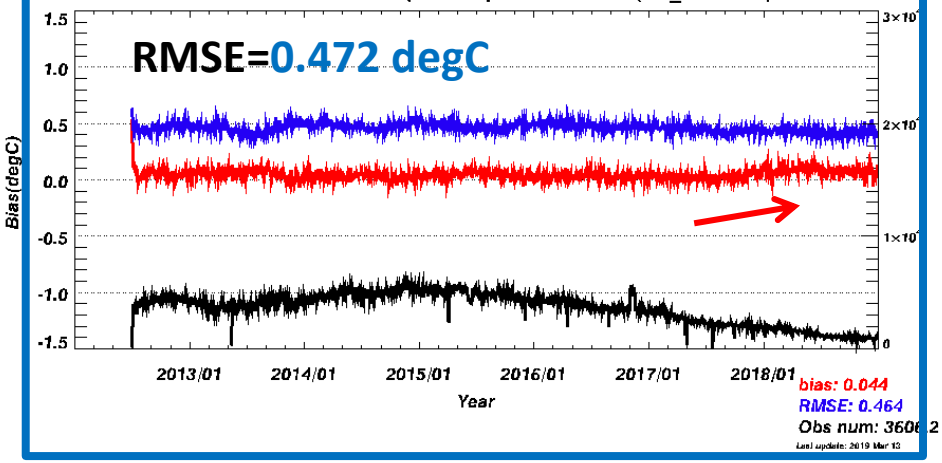


- Around Japan and US, 7G SST has more RFIs than other SSTs (white circles)
- The other area, such as Europe & Asia, 6G SST has more RFIs.
- 10G SST also has some RFIs.

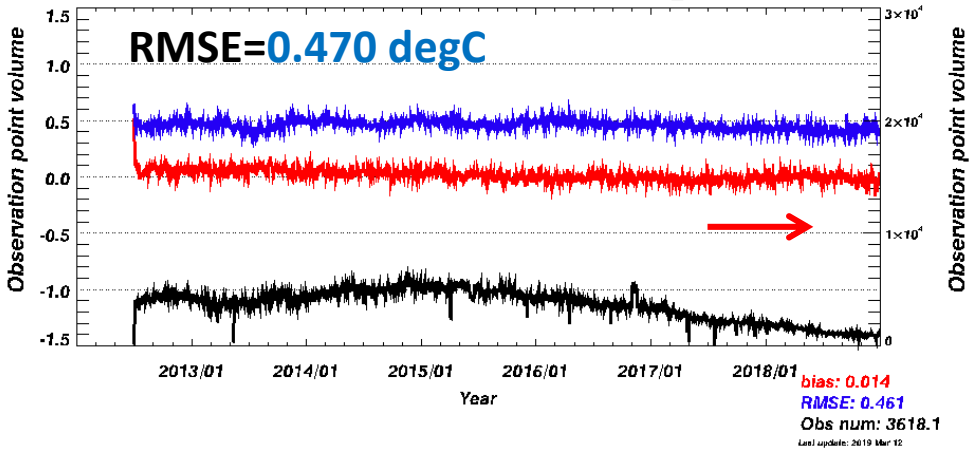


Comparison with Buoy (iQuam V2)

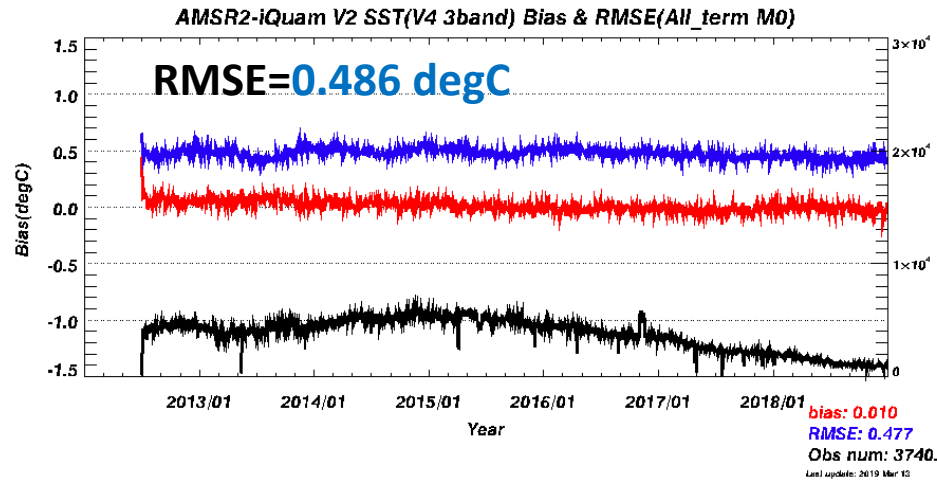
CURRENT: 6G SST V3 (A+D)



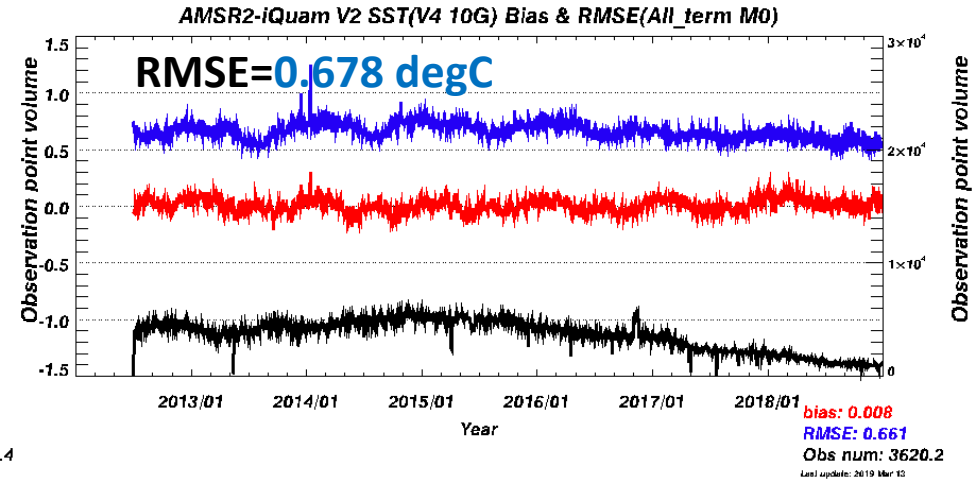
6G SST V4_beta (A+D)



3-freq. SST (far coast) (A+D)

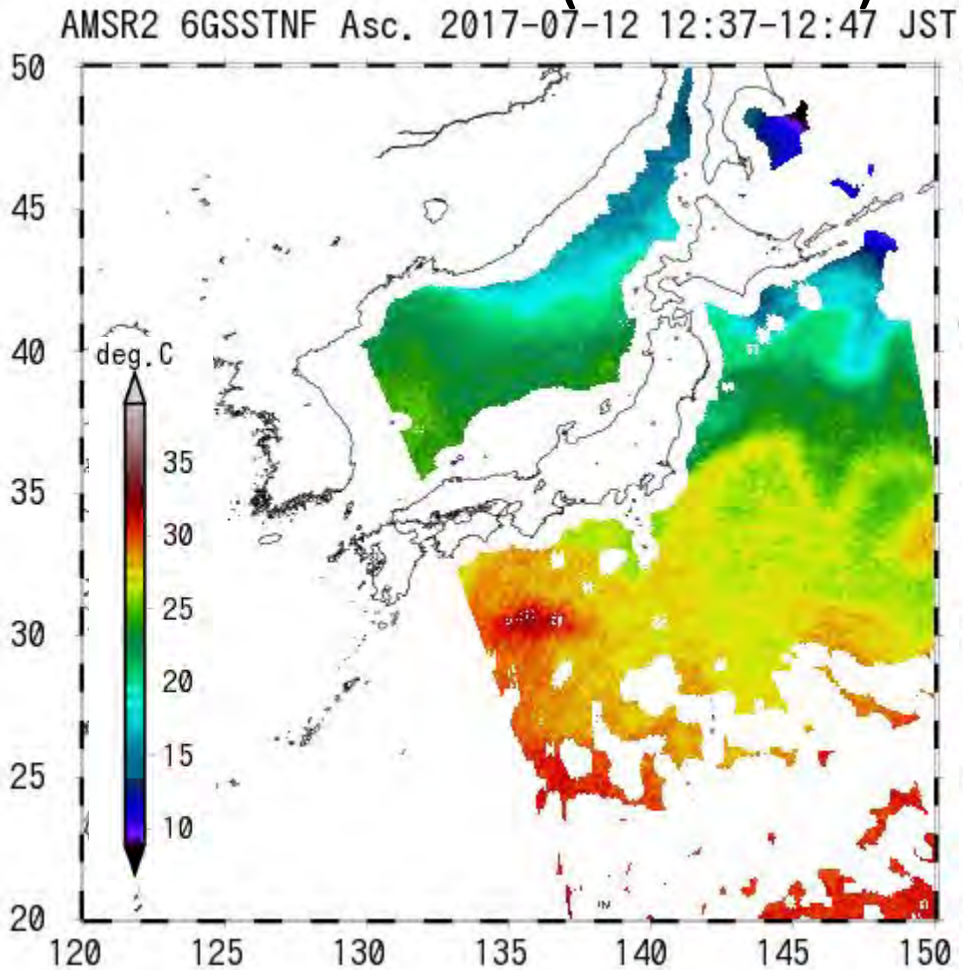


10G SST V4 all temp. (A+D)

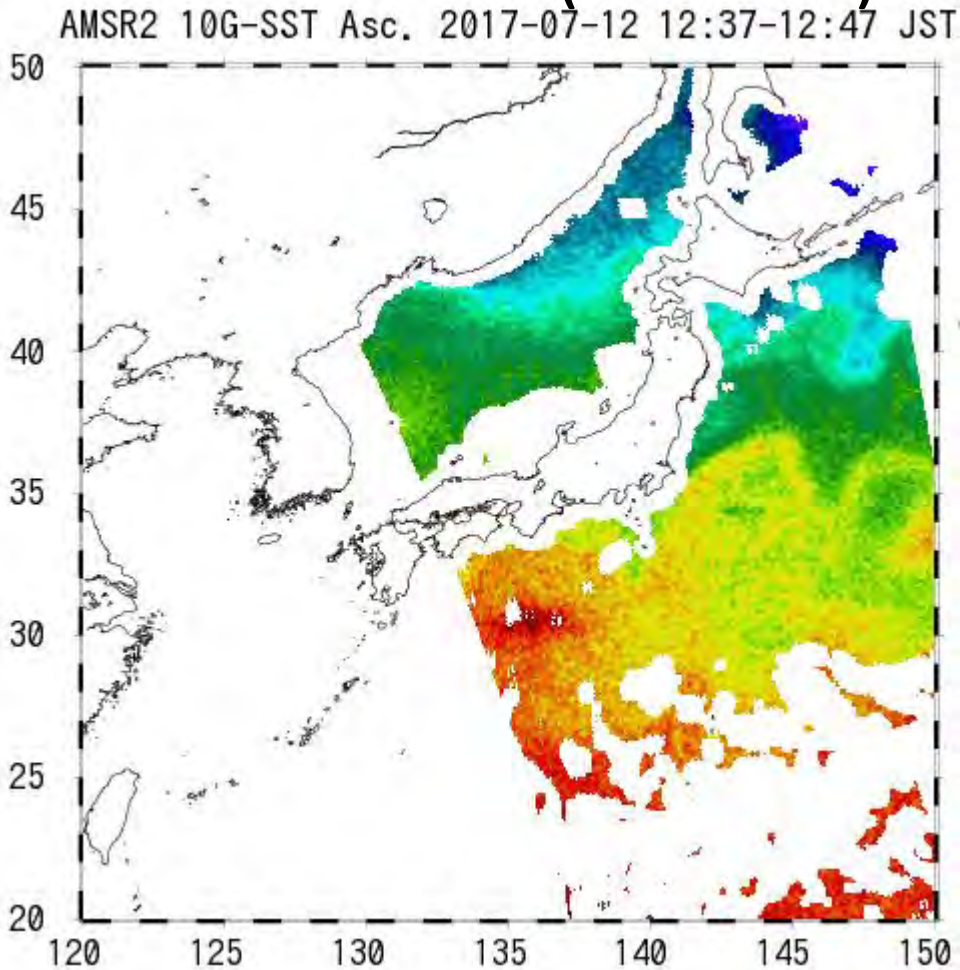


SSTs without any spatial filter

6GHz SST (no filter)



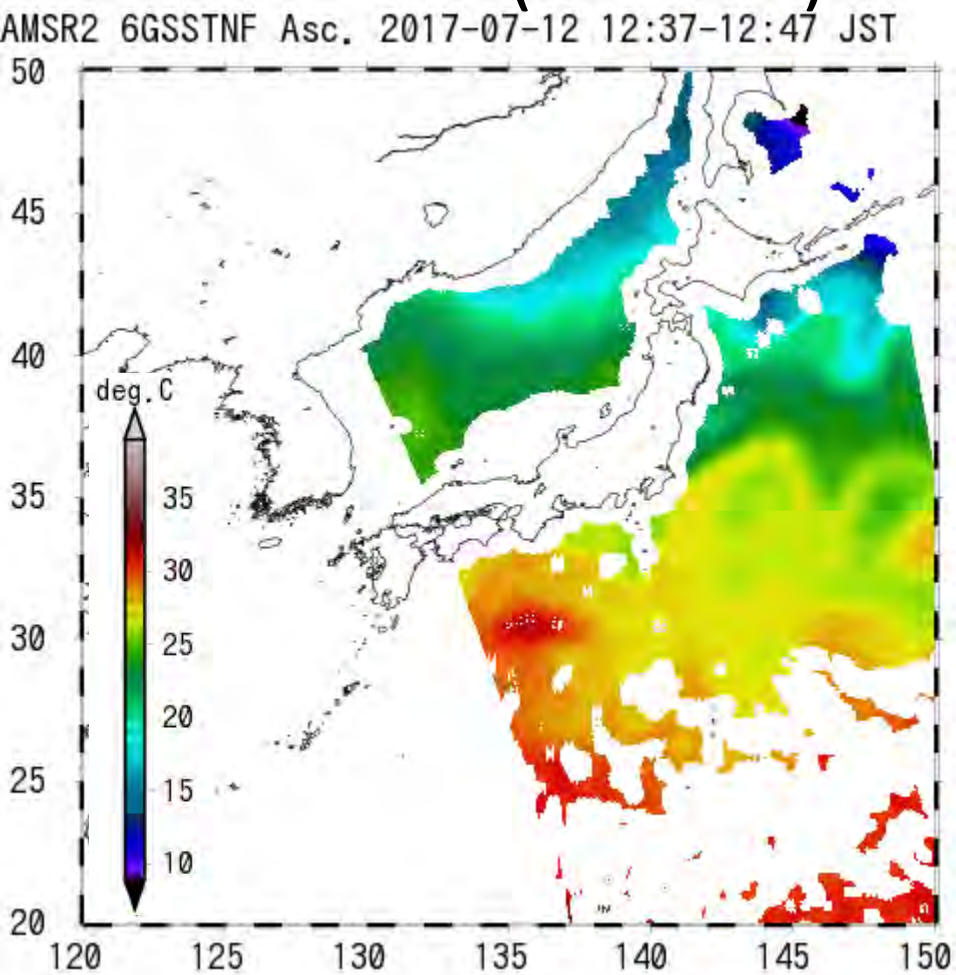
10GHz SST (no filter)



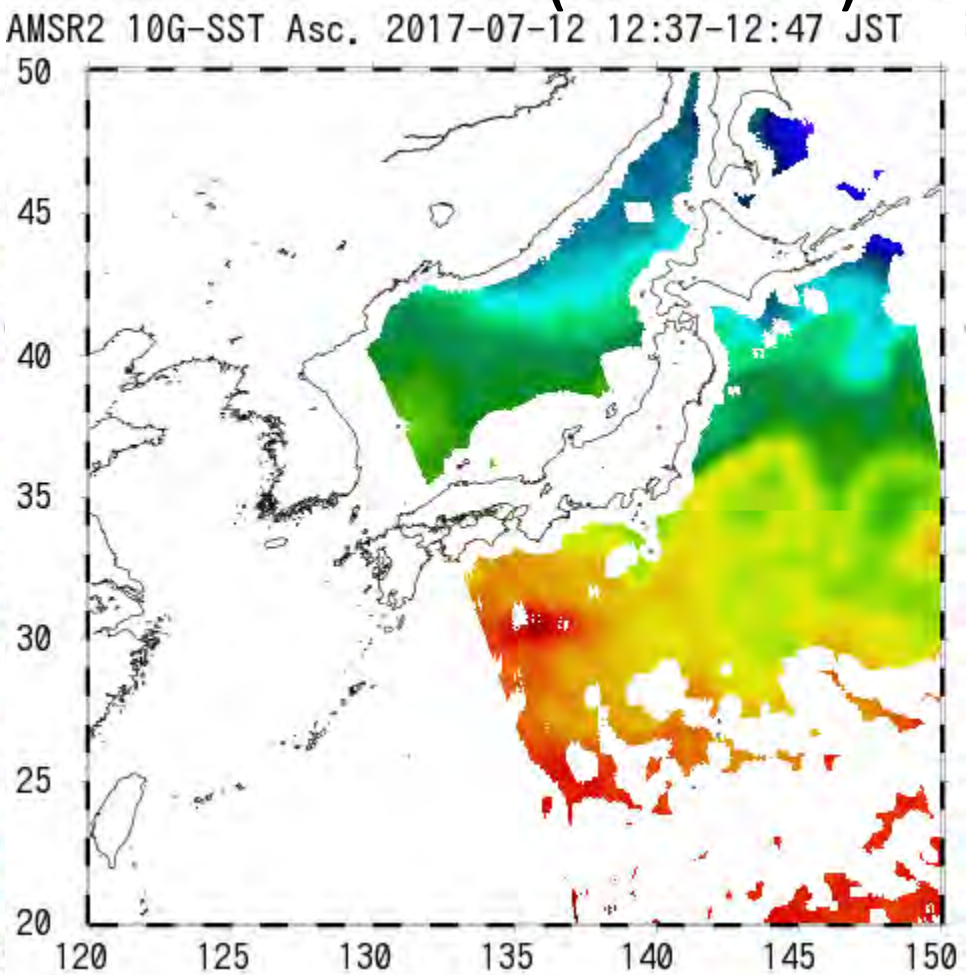
Around 3UTC in Jul. 12, 2017

SSTs with Improved Spatial Filter

6GHz SST (KZ filter)



10GHz SST (KZ filter)

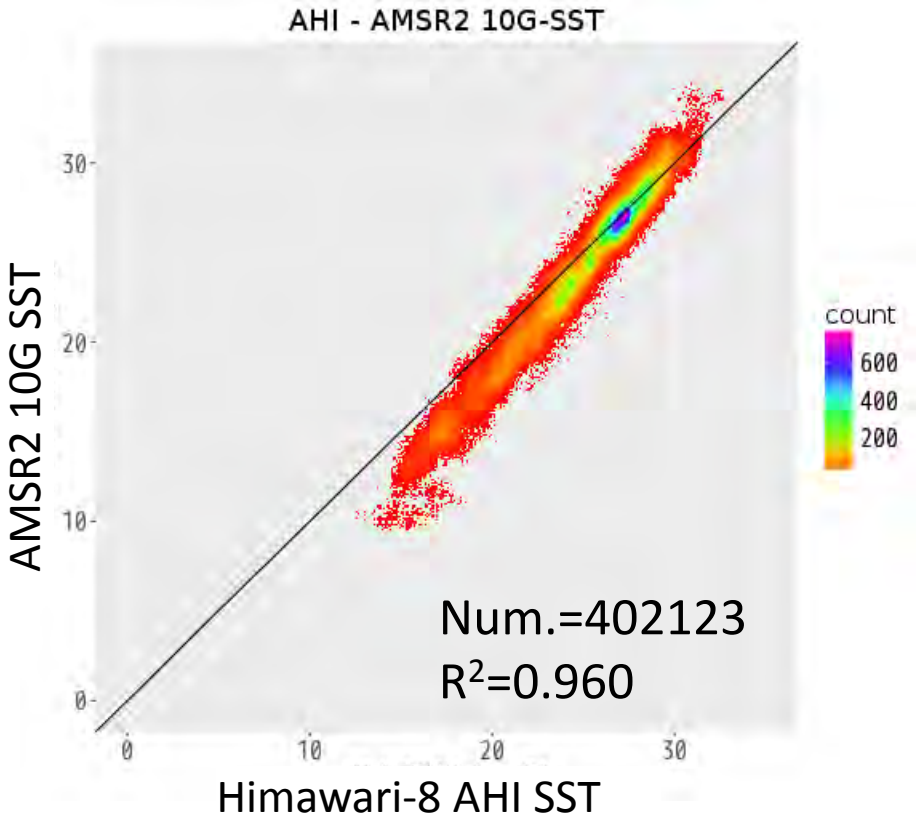


Around 3UTC in Jul. 12, 2017

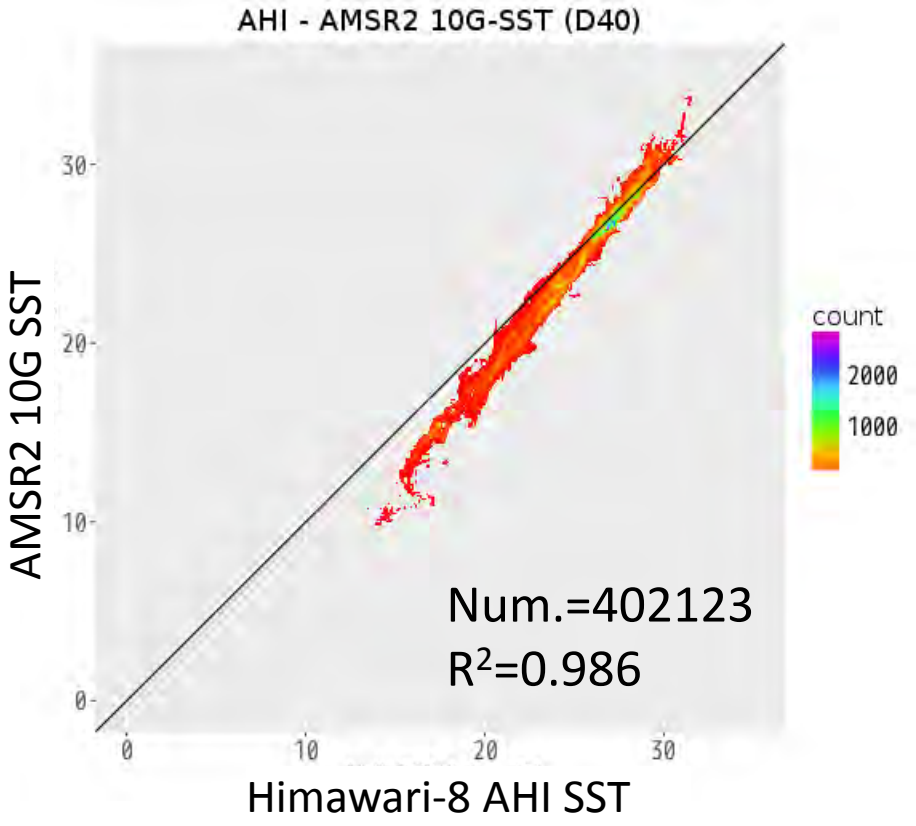
Comparison with Himawari/AHI SST

AMSR2 10G SST : 03:37-03:47 UTC on Jul. 12, 2017
Himawari-8 AHI SST : 03:00-03:59 UTC on Jul. 12, 2017

Without KZ filter



With KZ filter

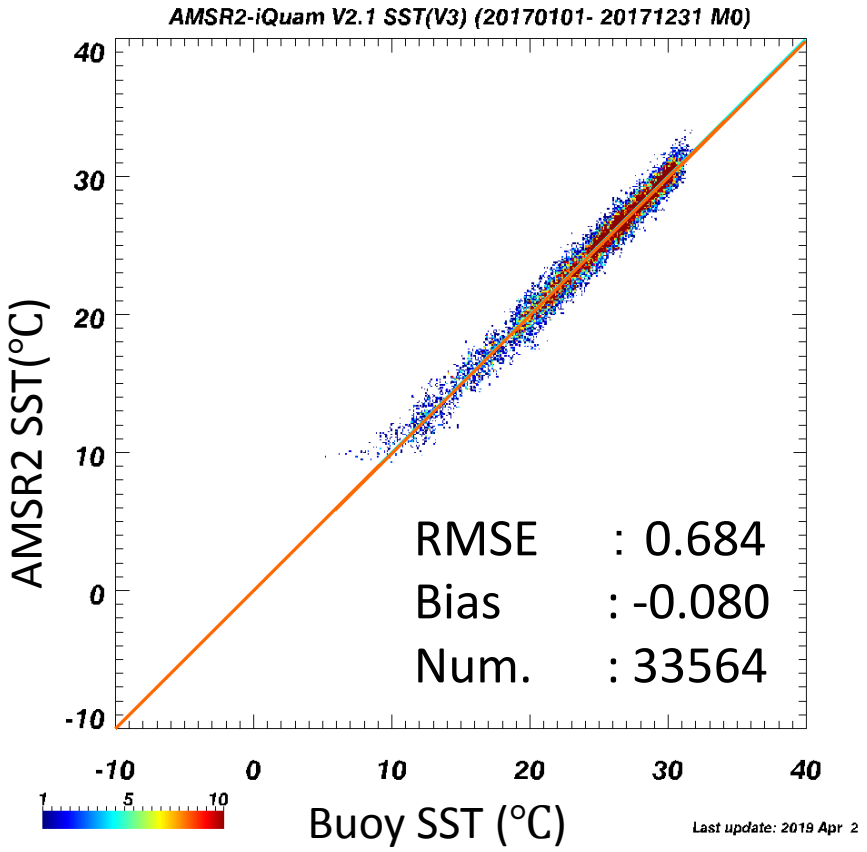


Comparison with Buoy SST

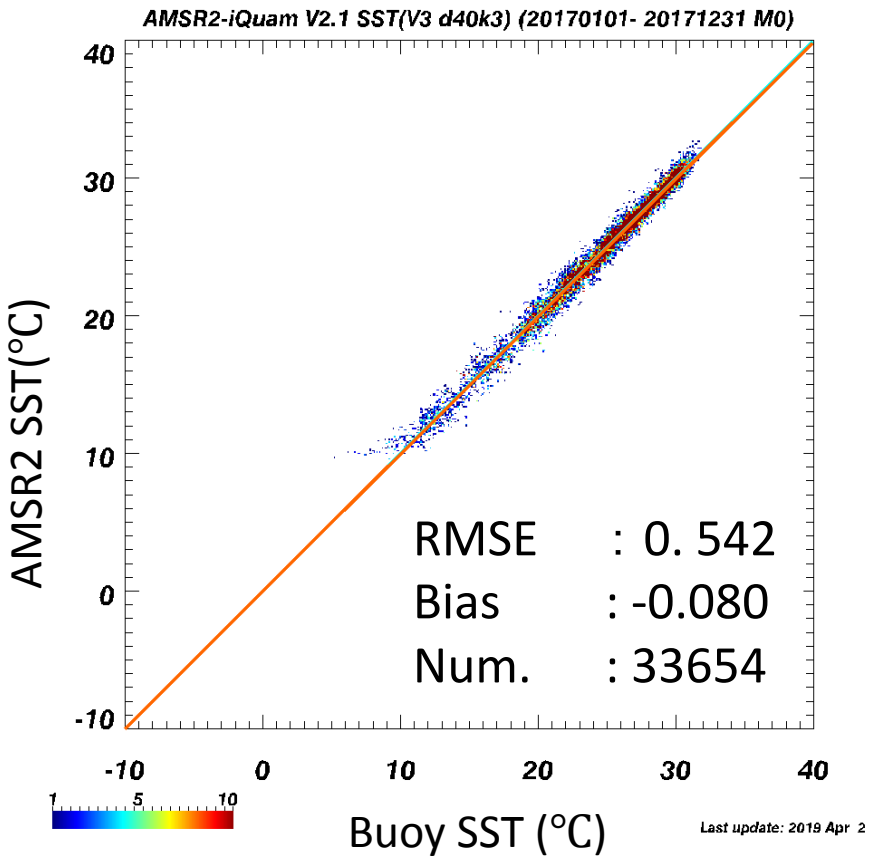
Period: Jan. 1, 2017 – Dec. 31, 2017

Buoy SST: iQuam v2.1

Without KZ filter



With KZ filter

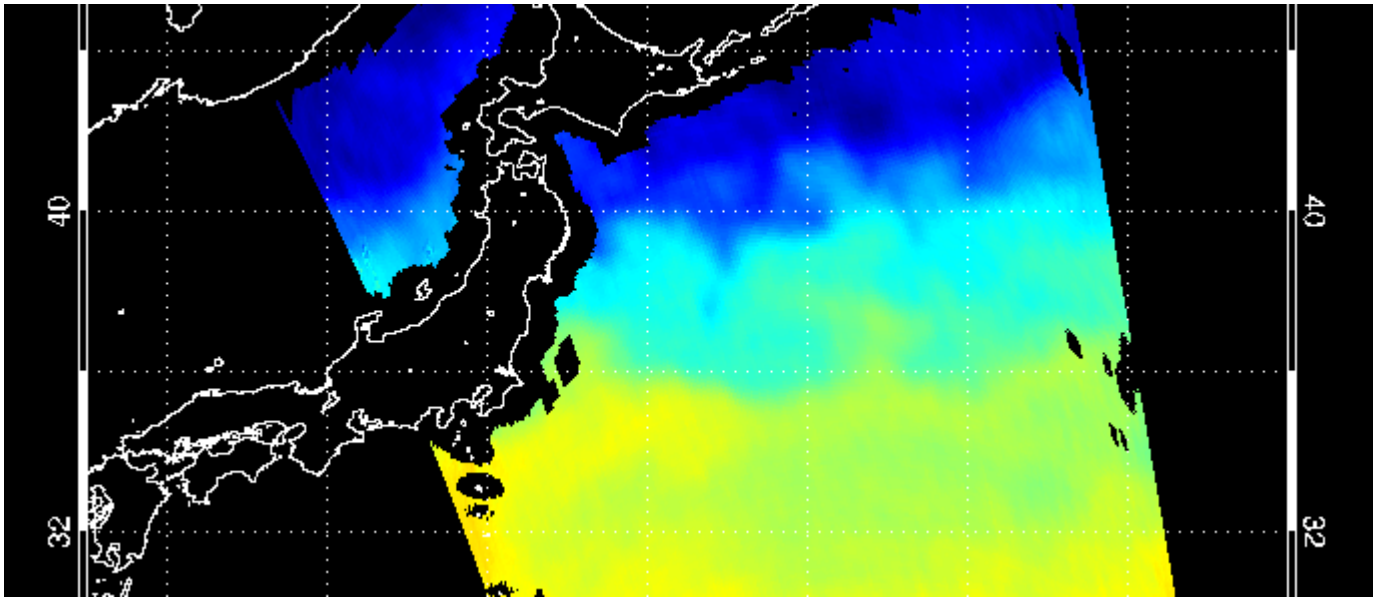


Summary

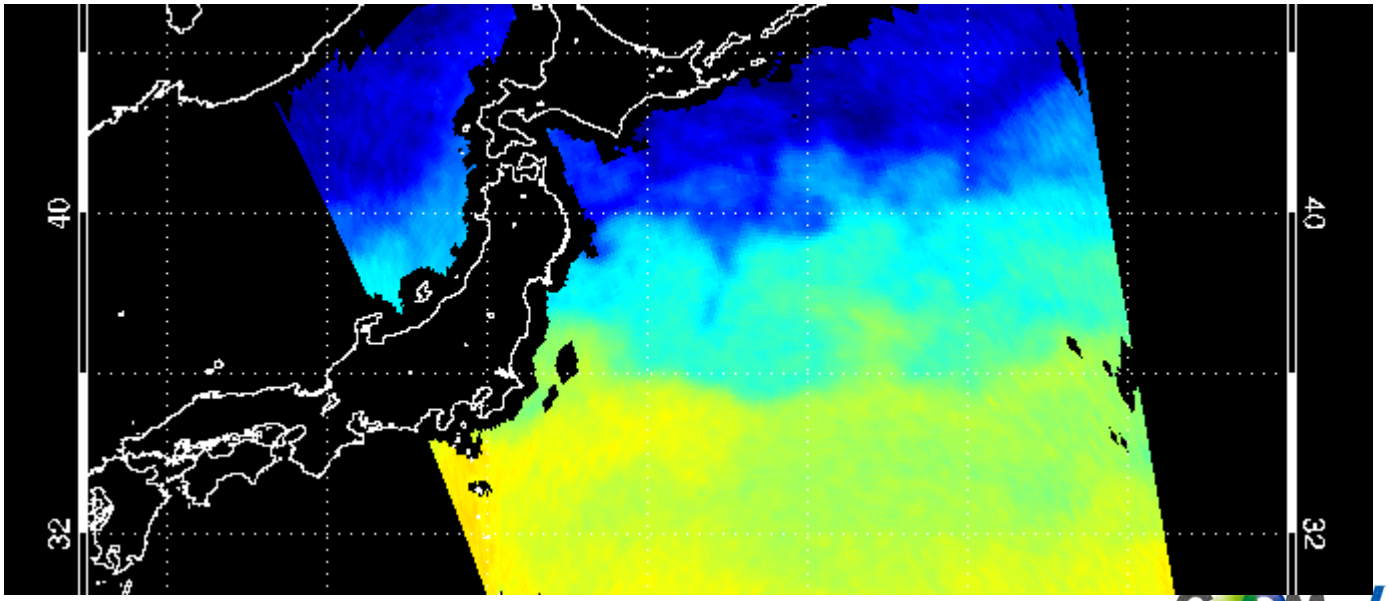
- AMSR2 is working in healthy condition. AMSR2 f/o (AMSR3) is now in pre-project phase and expected to become project in winter 2019.
- For new AMSR2 V4 SST, several improvements are planning.
  - In V4, recent positive bias trend due to sensor aging will be corrected.
  - New SST product using 3-frequency channels (6, 7, 10G) is developed.
    - Available coastal SST around 50km distance while 6GHz SST is around 80km from the coast.
    - RMSE is almost equivalent to AMSR2 6GHz SST V3.
    - Spatial Filter should be improved by using KZ filter below.
  - KZ filter is applied to both AMSR2 6GHz and 10GHz SSTs. Validation by buoy (iQuam2.1) shows that;
    - Improvement of RMSE from 0.684 to 0.582; and
    - No bias change before/after filter (-0.08) and no changes in averaged field.
  - SST dependencies to water vapor and wind direction found in V3 will be improved in V4. Currently under investigation.

backup

Enable to estimate SST where missing



6G



3-freq.

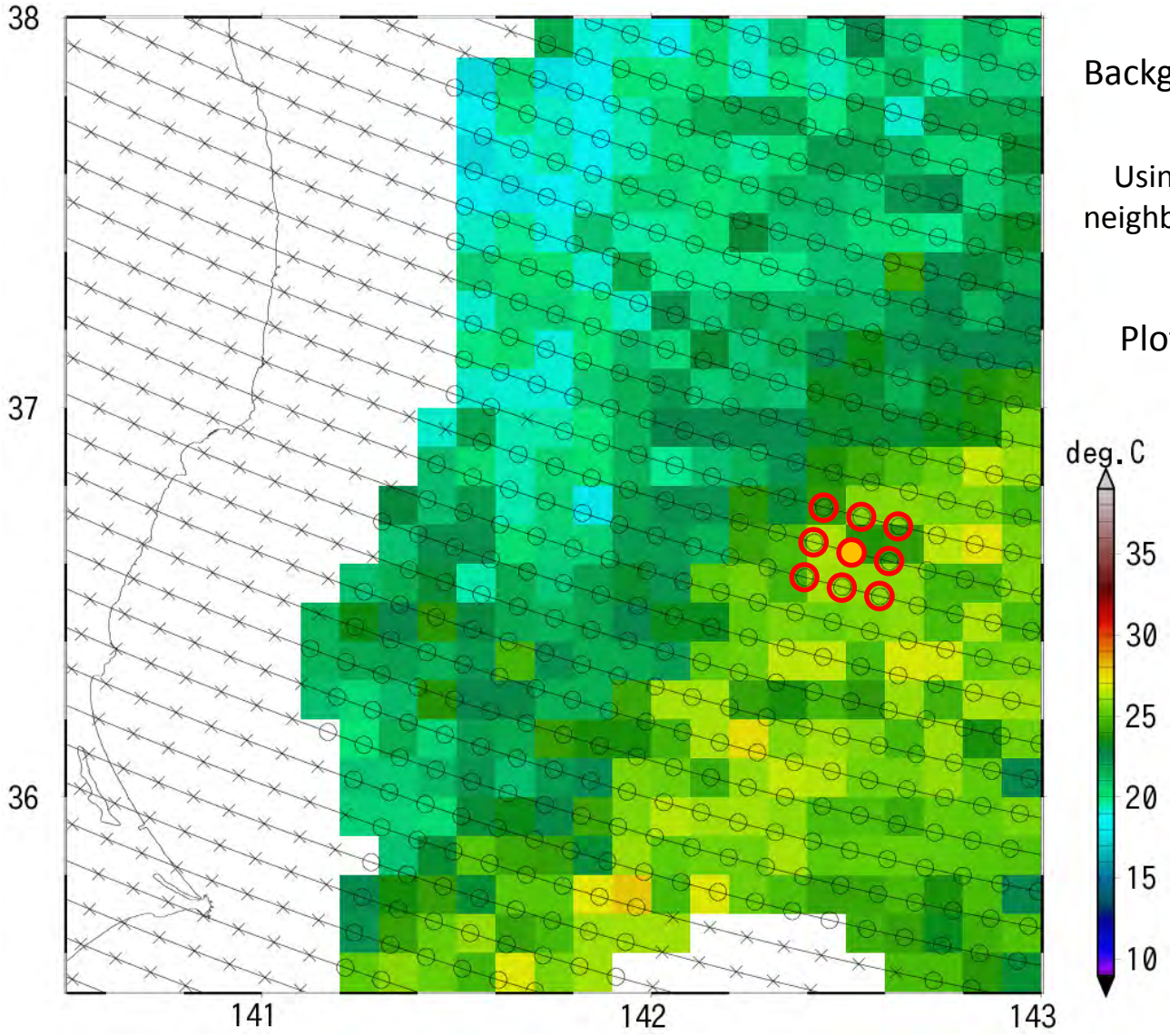
SST processing with KZ filter

1. Pre-processing (interpolation/gridded)
   - Resampling swath SST to 0.02 degC grid to make gridded data
   - Pixel value of each grid are distance-weighted average of neighborhood pixels. Since observing points of PMW become more thicker at scan edges than at nadir, avoid to be affected by nonuniformity by spatial distribution of observing points.

2. Application of KZ filter to gridded data
   - Shape of filter is circle with 20-km radius centering target pixel, and simple running mean is applied 3-times.

3. Post-processing (handling missing value)
   - Pixel that was missing before applying KZ filter is set as missing after applying KZ filter

L3 (0.1-grid) and Scan Intervals

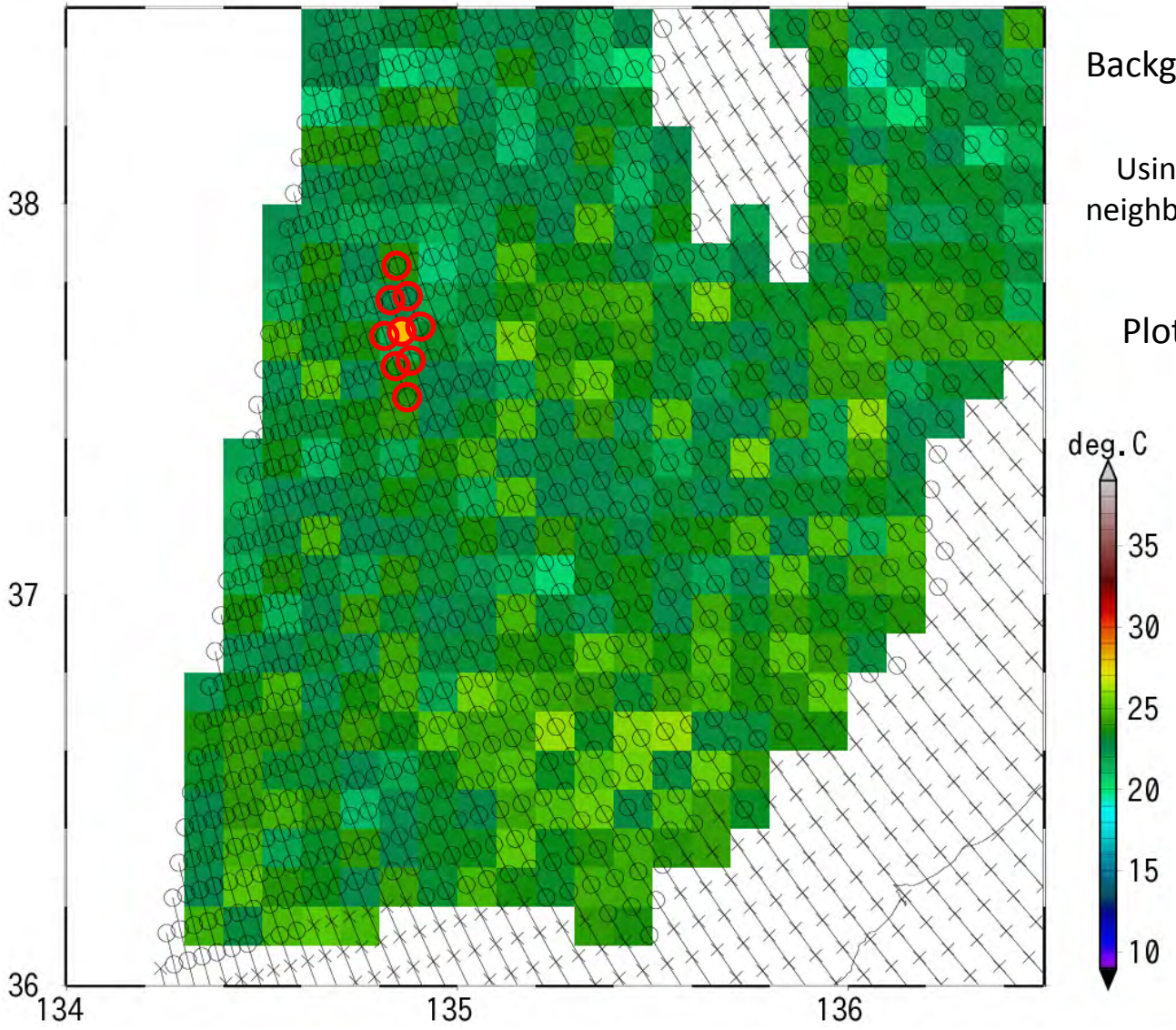


Background: AMSR2 SST
0.1-deg grid with NN method

Using L2 and select SST of the nearest neighbor footprint

Plot: Center of footprint
○ SST estimated pixel
× SST missing pixel

Footprint distribution near scan edge

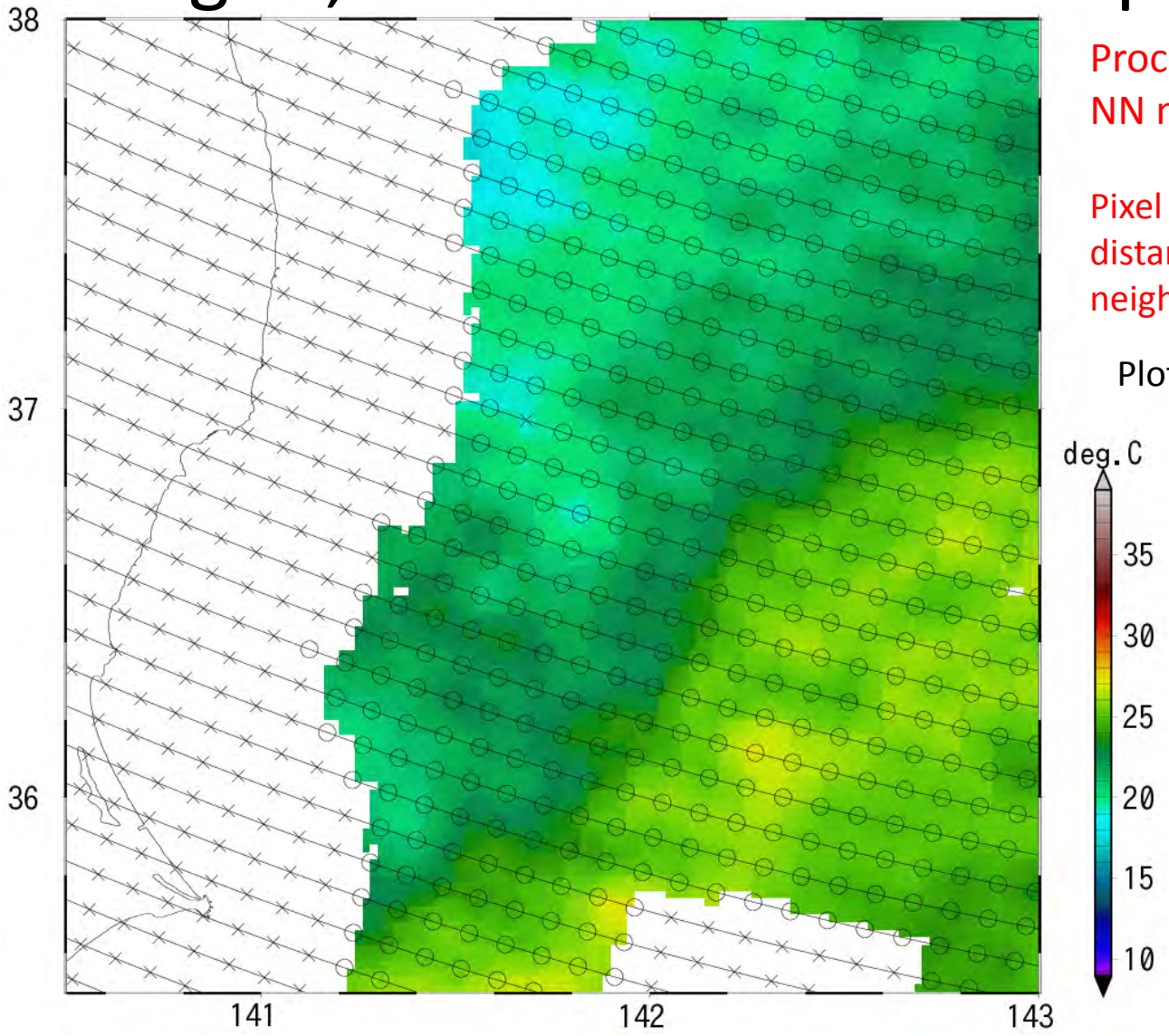


Background: AMSR2 SST
0.1-deg grid with NN method

Using L2 and select SST of the nearest neighbor footprint

Plot: Center of footprint
○ SST estimated pixel
× SST missing pixel

Process 1: Resampling with high-resolution grid, NN method and interpolation

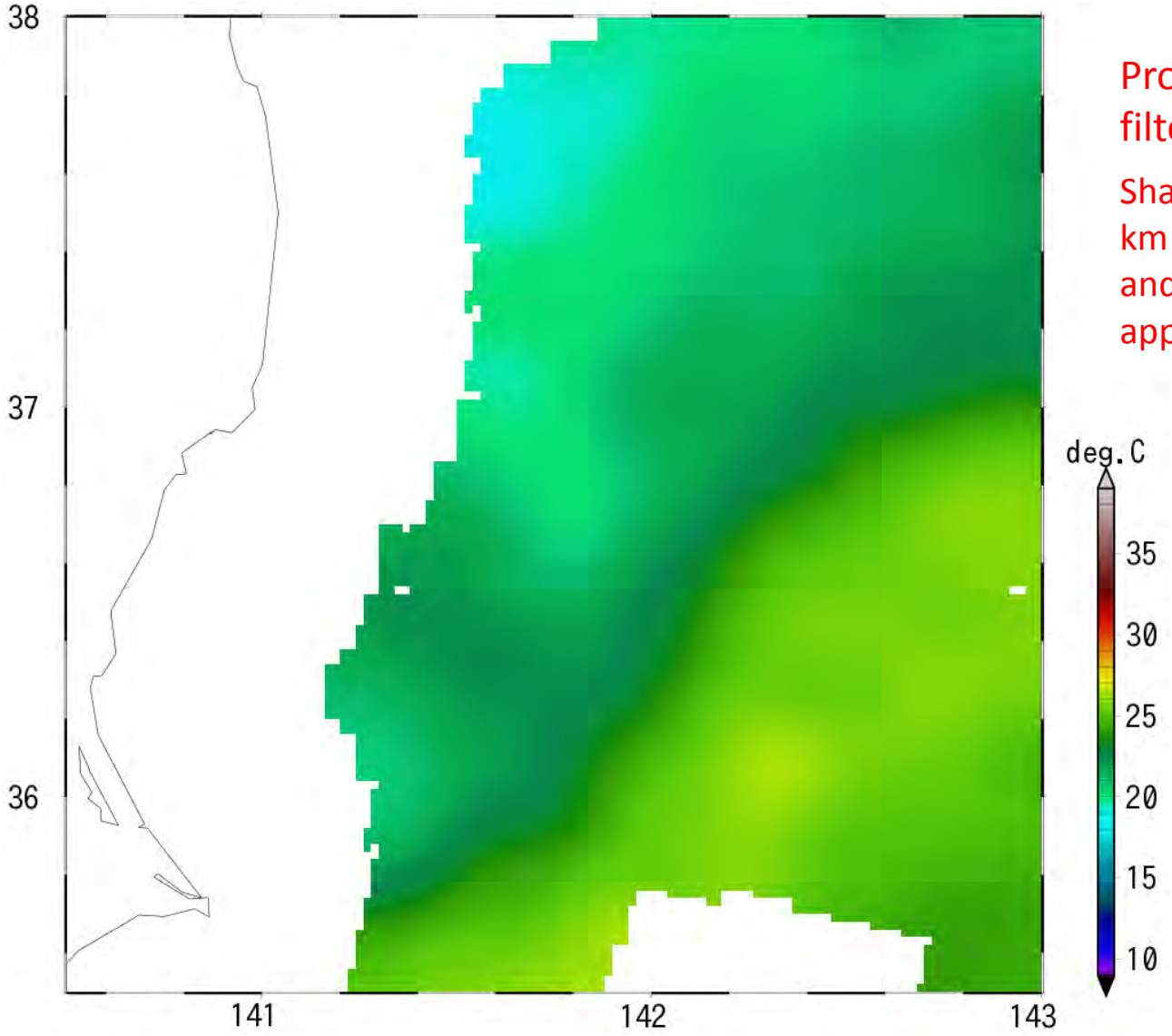


Process 1: 0.02 degC grid with NN method & interpolation

Pixel value of each grid are distance-weighted average of neighborhood pixels

Plot: Center of footprint
- ○ SST estimated pixel
- × SST missing pixel

Process 2: Application of KZ filter



Process 2: Application of KZ filter

Shape of filter is circle with 20-km radius centering target pixel, and simple running mean is applied 3-times.

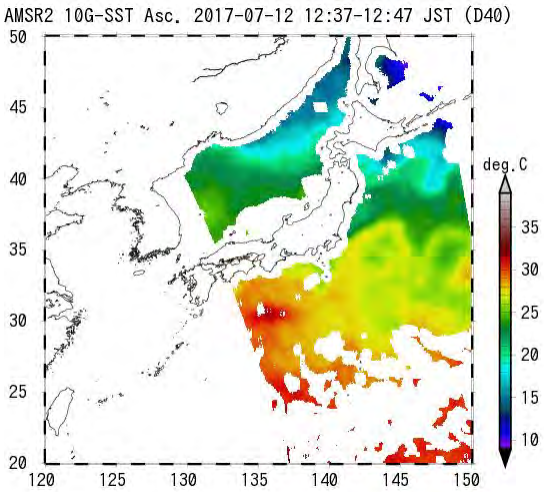
Comparison with Himawari/AHI SST

AMSR2 10G SST : 03:37-03:47 UTC on Jul. 12, 2017

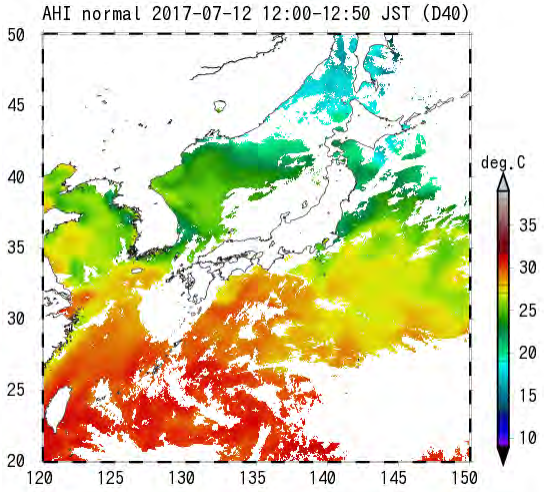
Himawari-8 AHI SST : 03:00-03:59 UTC on Jul. 12, 2017

With KZ filter

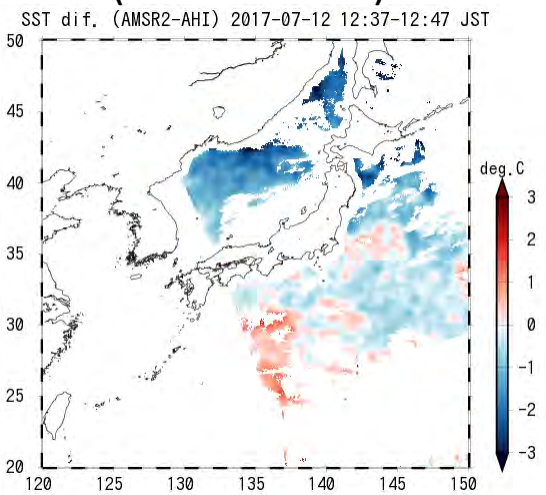
AMSR2 10G SST



Himawari-8 AHI SST

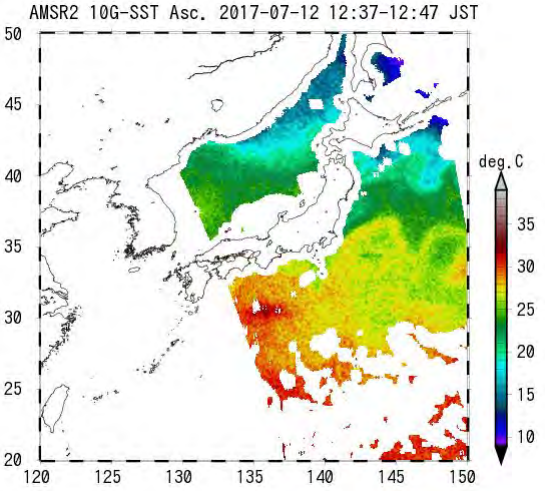


Diff (AMSR2 - AHI)

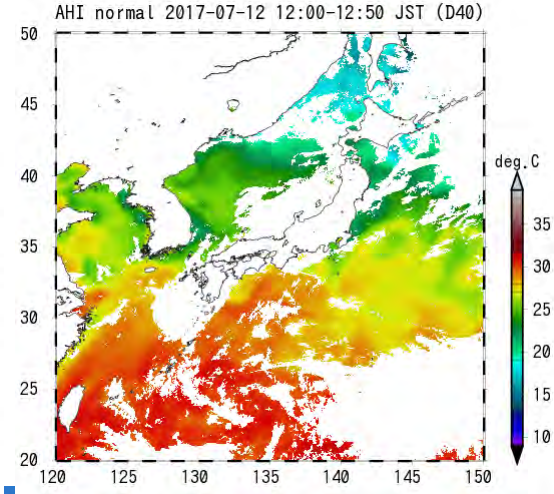


Without KZ fiter

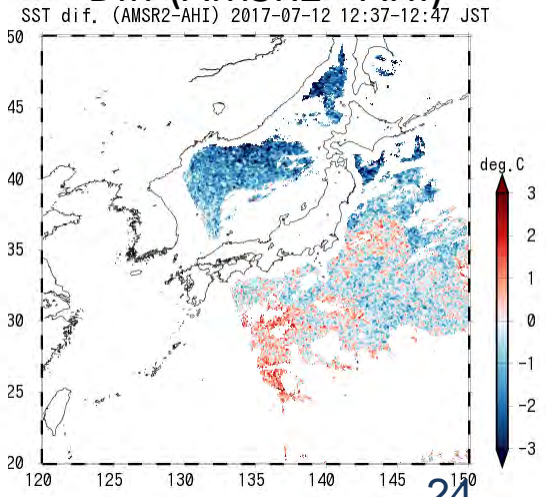
AMSR2 10G SST



Himawari-8 AHI SST

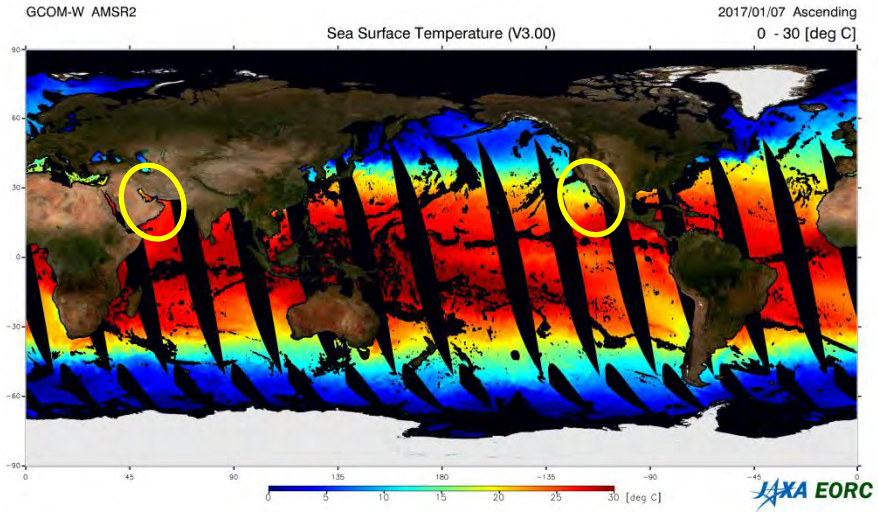


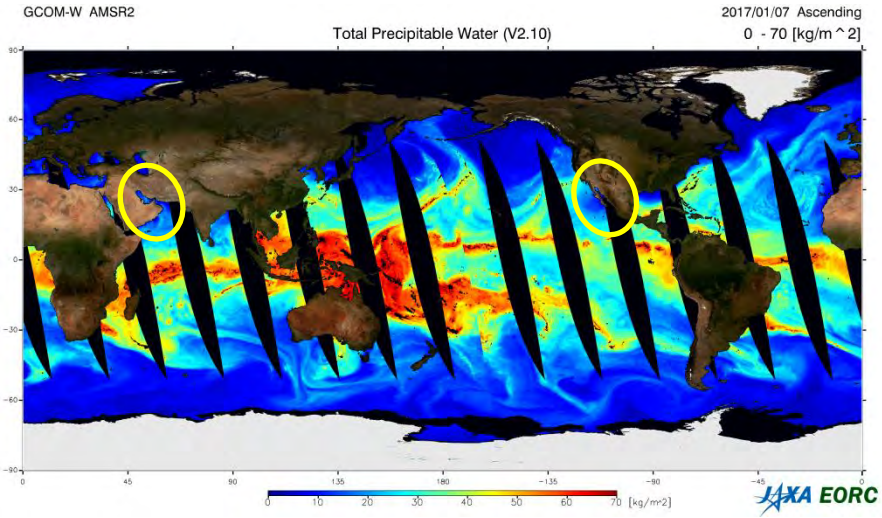
Diff (AMSR2 - AHI)



SST dependency to water vapor

- When higher SST (20-25 degC) and dryer TPW (0-5 kg/m2), lower bias in SST is found (c.f., Middle-East and coast of California bay).
- When SST is 10-15 degC and wet TPW (> 45 kg/m2), lower bias in SST is also found.





Diff. to OISST

Diff to MGDSST