YAMAGUCHI UNIVERSITY

Investigation on comparison and integration of microwave- and infrared-based precipitable water estimates

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Online

Backgrounds

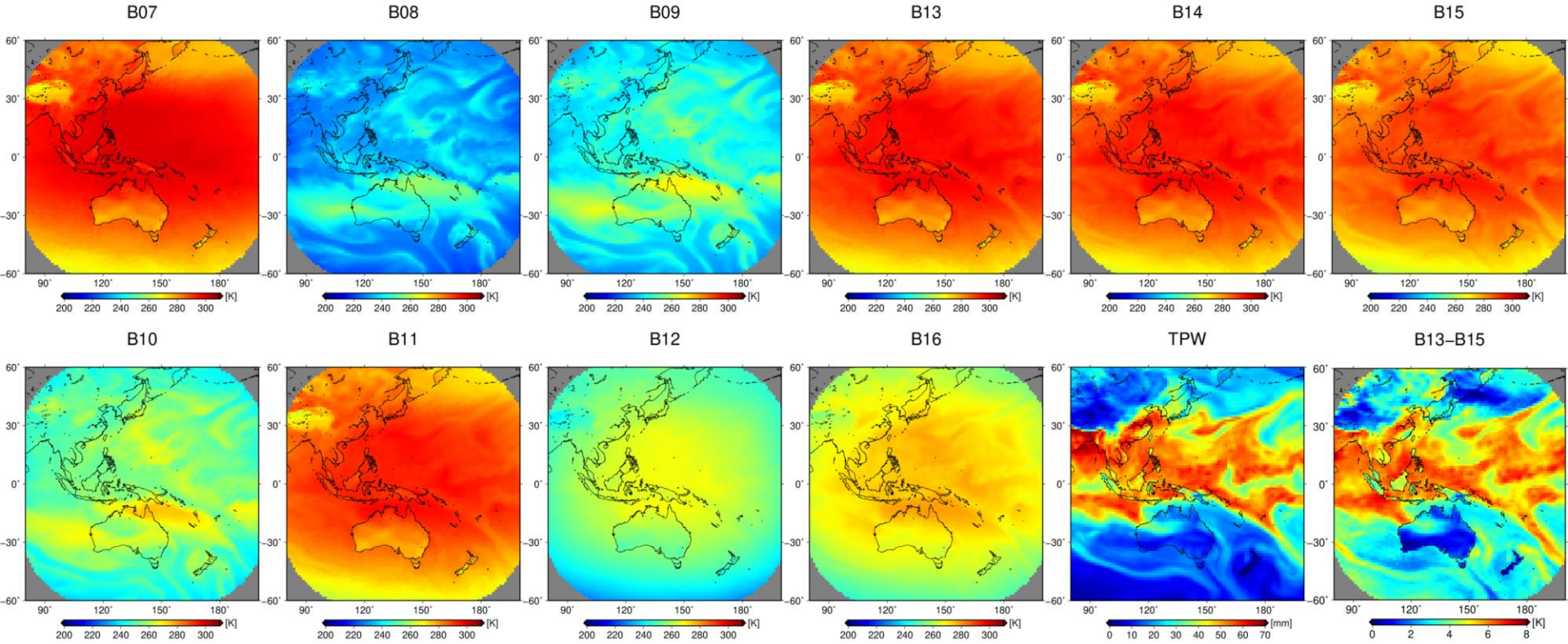
- Needs for high spatial- and temporal-resolution of total precipitable water (TPW)
  - Study of cloud-precipitation system evolution
  - Improvement of short-range forecast
  - Correction of vapor delay in InSAR processing
- Objective
  - To gain knowledges to combine two estimates, through the comparison between AMSR2 and Himawari-8 AHI TPW.
- Research Items
  - Development of TPW retrieval algorithm from AHI infrared brightness temperatures.
  - Comparison of TPW derived from AMSR2 and AHI.
  - Investigation on integration of AMSR2 and AHI TPW estimates.

TPW Retrievals

- No single method can satisfy the needs. Each method has strengths and limitations.
- Microwave radiometer (all-weather)
  - Dual polarizations at vapor bands enable retrieval over polarized land surfaces (e.g., Kazumori and Kachi, 2018).
  - Tuned with GNSS and compared with RAOB TPW.
- GNSS (all-weather)
  - Accurate and high-temporal measurement (e.g., 5 min)
  - Worldwide, limited spatial density (Japan is rare case with around 1,300 stations to achieve 20 km interval).
- Infrared radiometer (cloud-free area)
  - Near Infrared (e.g., MODIS) provides accurate estimates in daytime but no future instruments.
  - Thermal infrared by geostationary satellites provides less accurate but high-temporal ability.

Thermal Infrared TPW Algorithm

- Existing algorithms
  - Most traditional one is so called Split-Window algorithm using two atmospheric window bands in 10-12 microns (based on small difference of water vapor effect).
  - Data assimilation-type algorithm (like for ABI).



RTTOV Simulation with JRA-55

AHI TPW algorithm

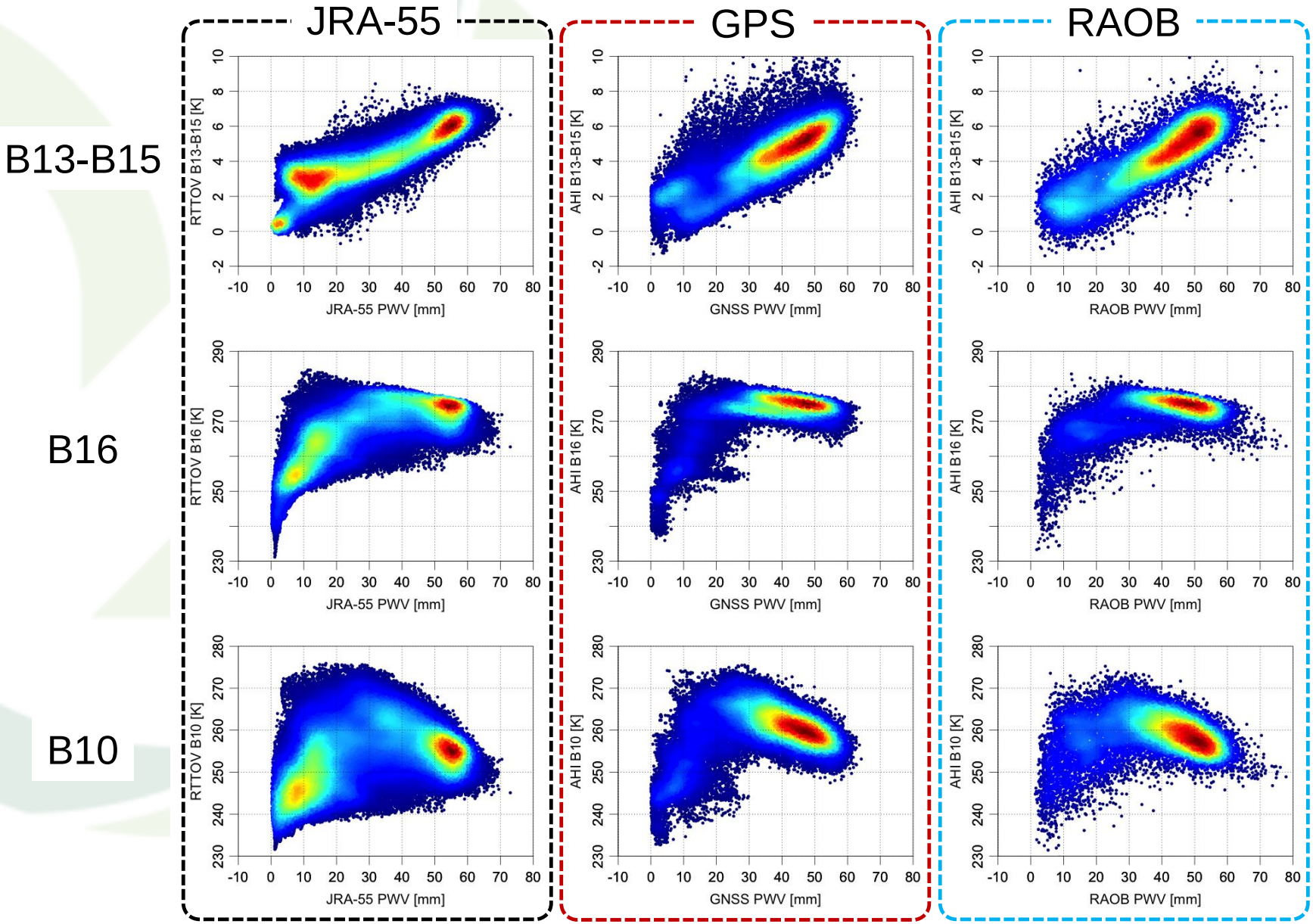
- Empirical algorithm using SVR
  - Support Vector Regression (SVR) trained with observation-based dataset.
  - Updated cloud screening with Band 13 (10.4 μm) by 3 K (12 K) depression from monthly Tb maximum values at each hour and grid for ocean (land) (Choi and Ho, 2009).
  - Explanatory variables include Band 13 Tbs, band ratios for other bands (e.g. Tb_{16}/Tb_{13}) except Band 8, and cosine of satellite zenith angle (SZA). Band 16 greatly improved the performance.
  - Hyper-parameters adopted: regularization parameter of 1.0, kernel parameter of 1.0, and insensitive loss parameter of 0.1. 10-times cross validation was used.
- Training/Validation Dataset
  - Training

    Himawari-8 AHI L1 gridded data (distributed by EORC)

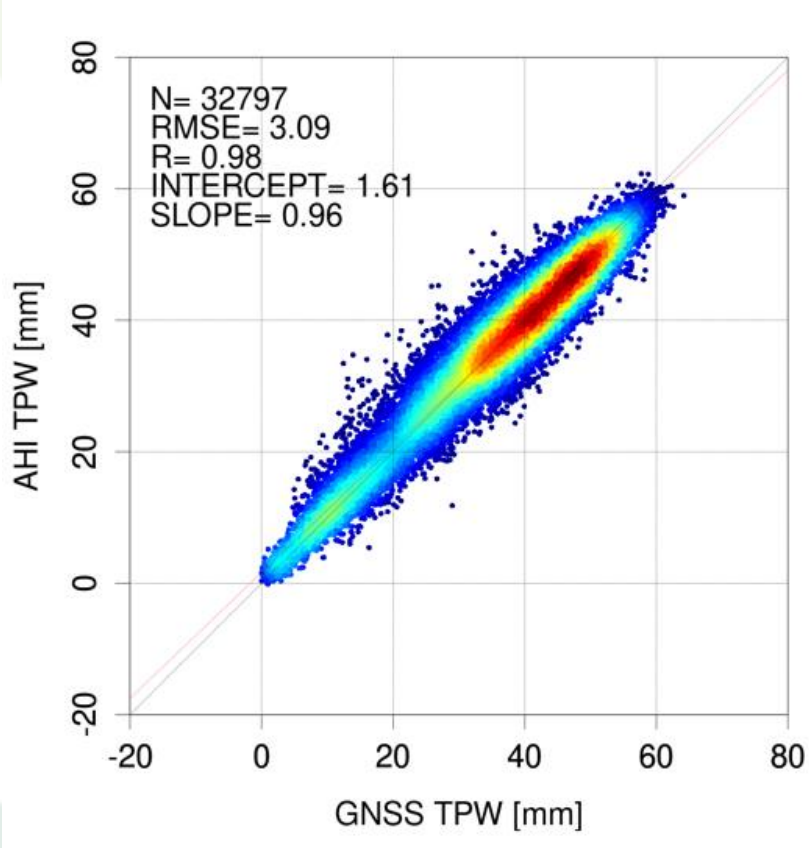
    GNSS-based TPW: Hourly (provided by EORC)
  - Validation

    RAOB-based TPW: 00/12UTC (provided by EORC)

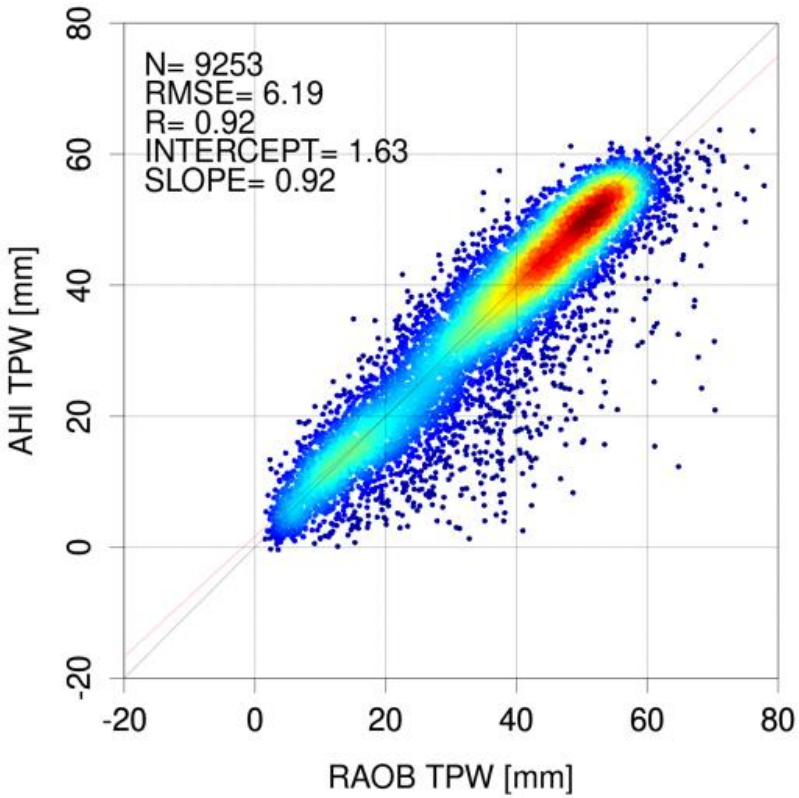
Dataset Difference



Results of Training and Validation

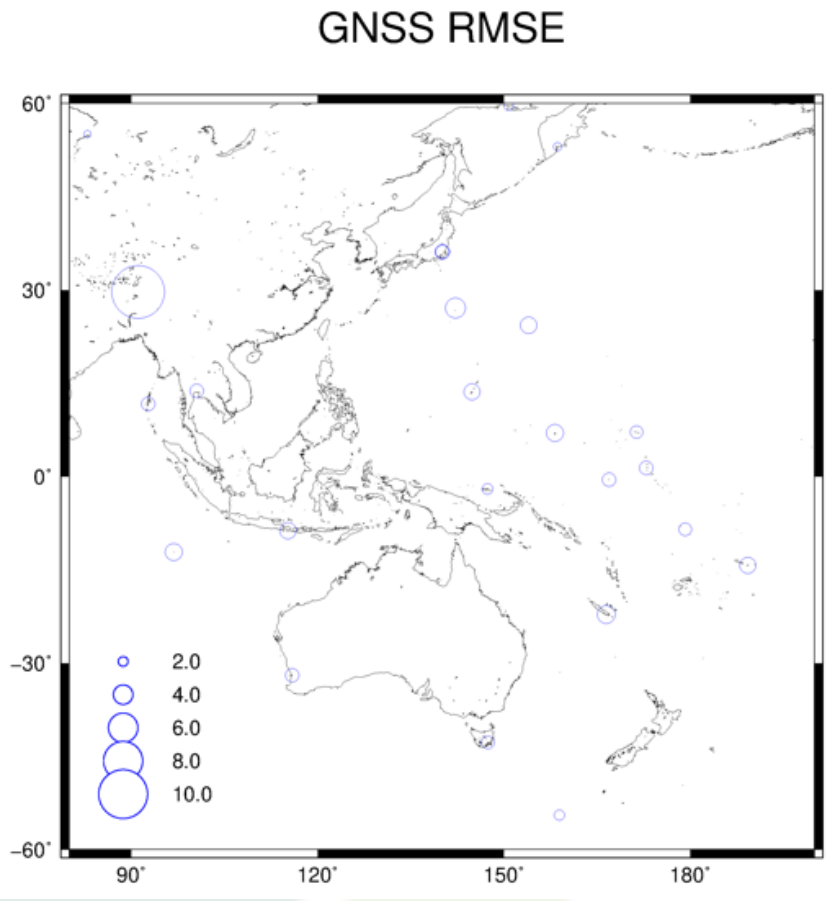


Training Dataset (GPS)



Validation Dataset (RAOB)

Results of Training and Validation



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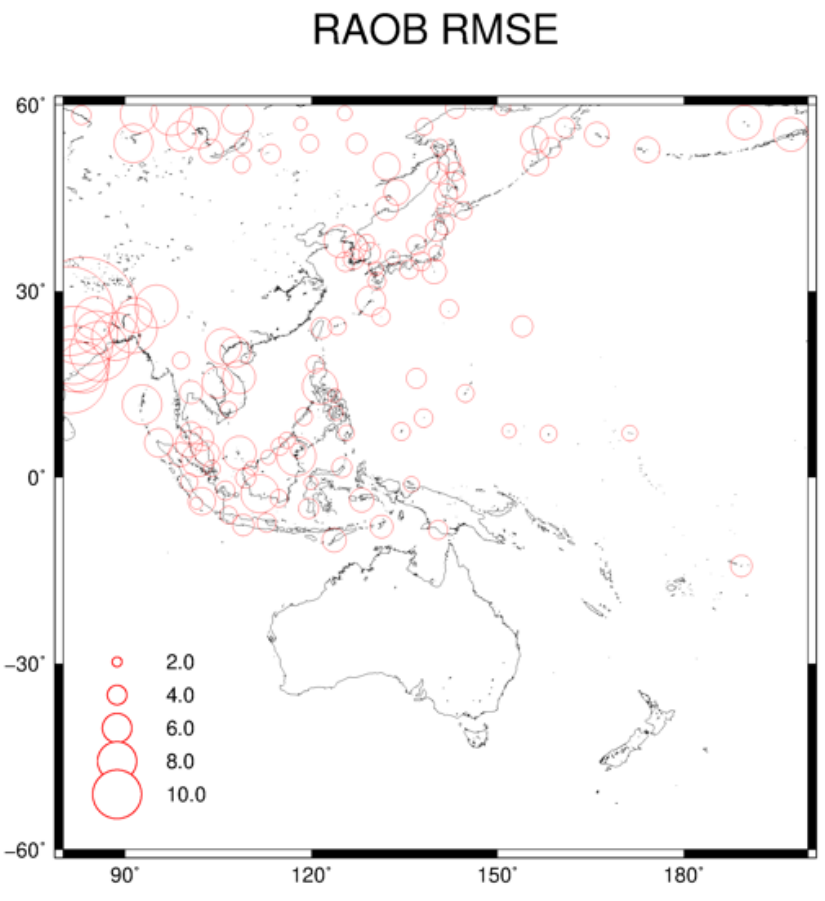
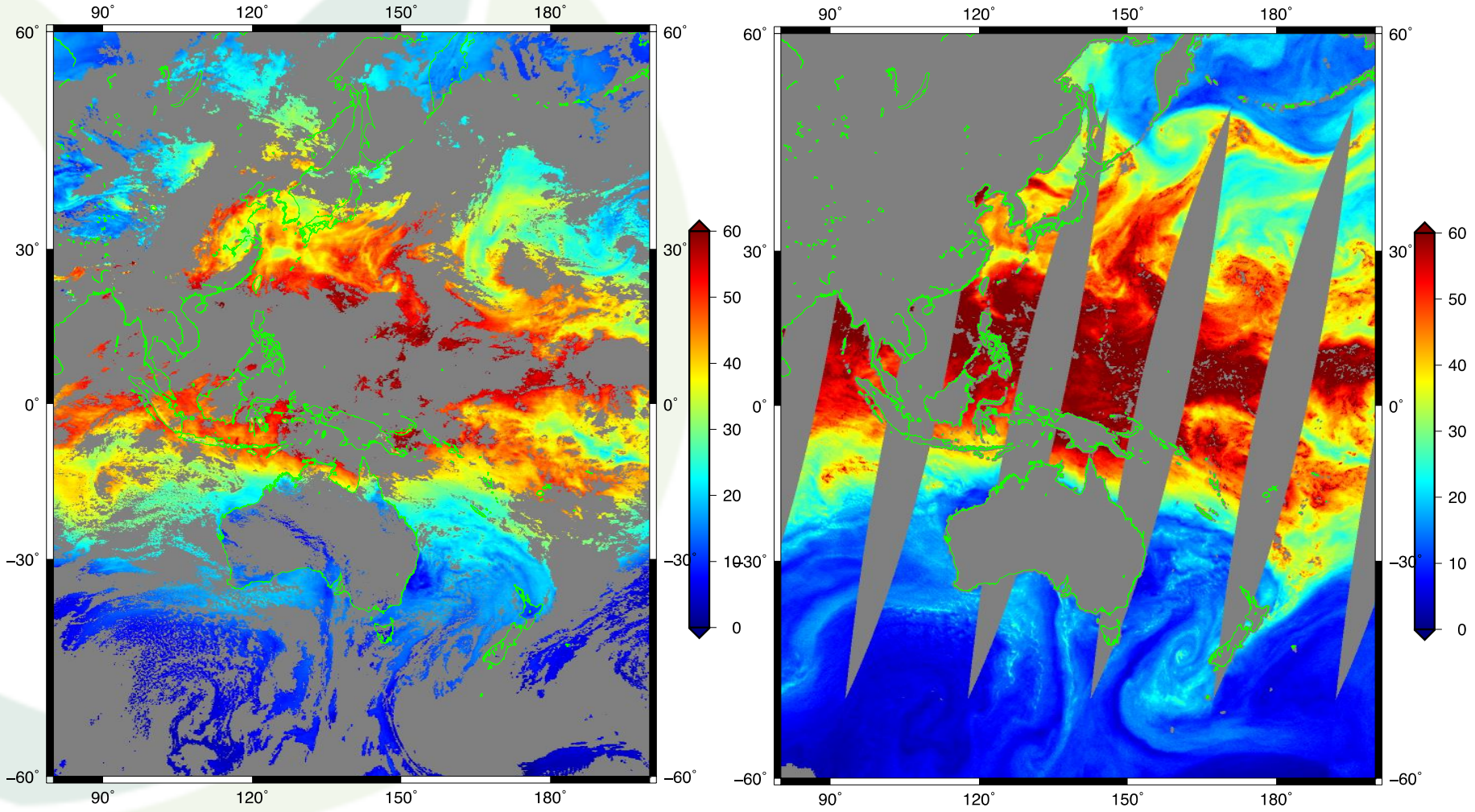


Validation Dataset (RAOB)

AHI/AMSR2 TPW in Nighttime

July 15, 2018



AHI

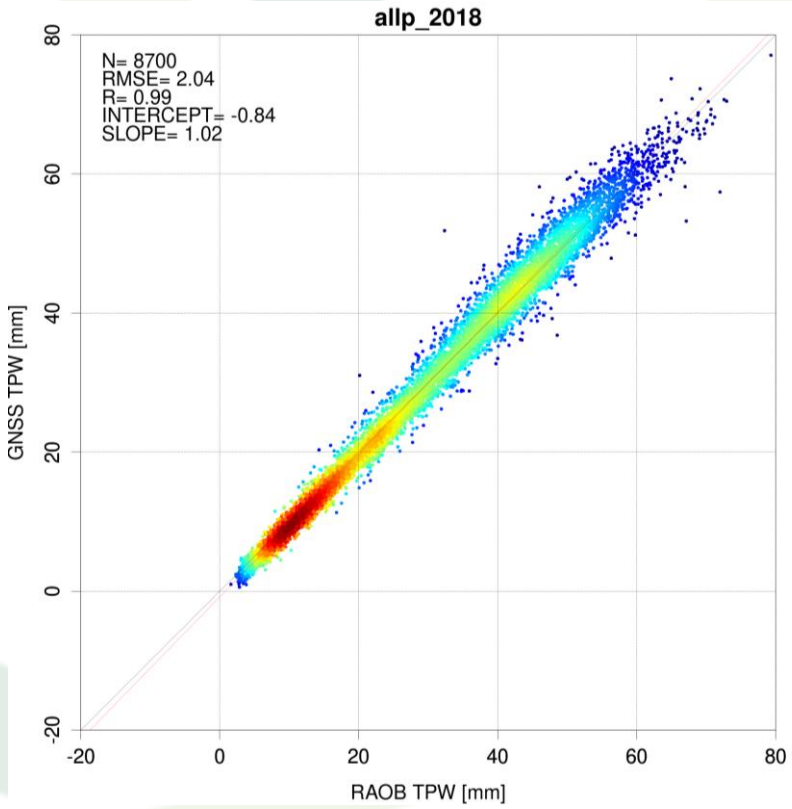
AMSR2

Comparison with Other Dataset

- GPS TPW (independent from training dataset)
  - GPS observation and navigation RINEX data of GEONET and some IGS-registered stations.
  - Post-processed into zenith tropospheric delay (ZTD) by RNX2RTKP application of RTKLIB program package.
    - ✓ Precise Point Positioning (PPP) mode.
    - ✓ Precise orbit and clock solutions by International GNSS Service (IGS).
    - ✓ PCV correction by ANTEX file by National Geodetic Survey.
  - Conversion to TPW by using surface pressure and air temperature extracted from JRA-55 surface reanalysis.
- AMSR2 Ocean/Land TPW
  - AMSR2 standard (ocean) and research (land) products

GEONET GPS/RAOB Comparison

16 RAOB stations



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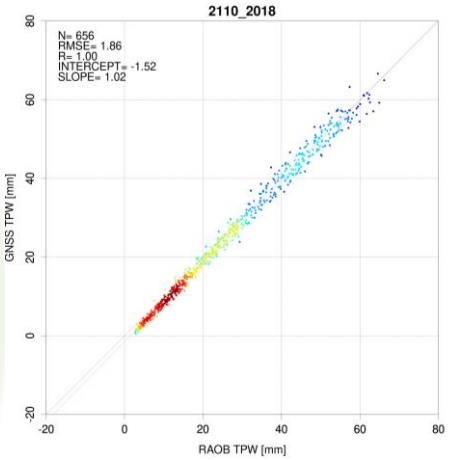
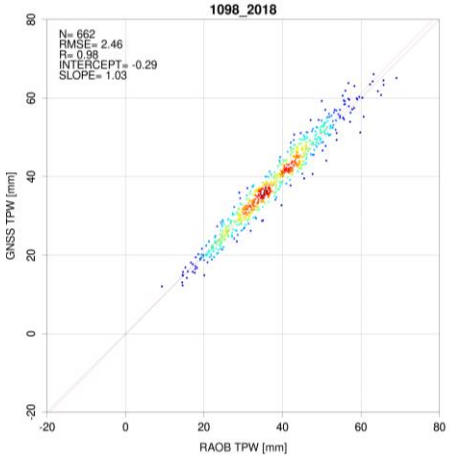
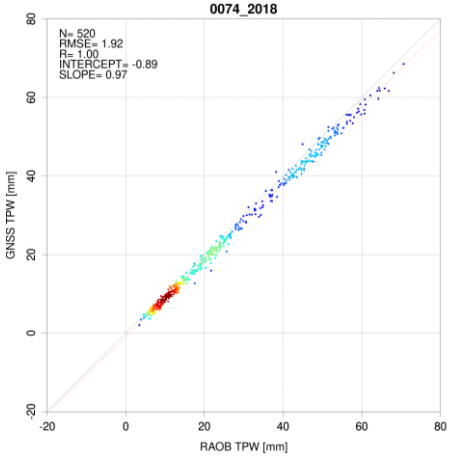


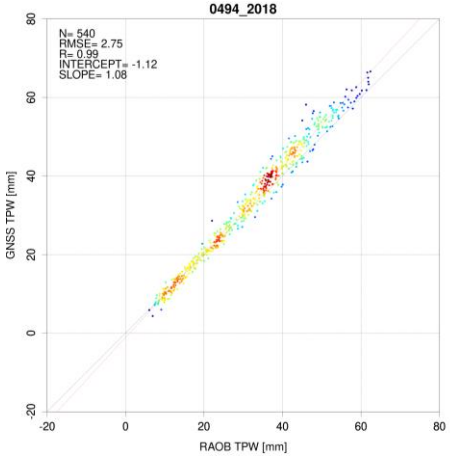
Marcus Island



Matsue



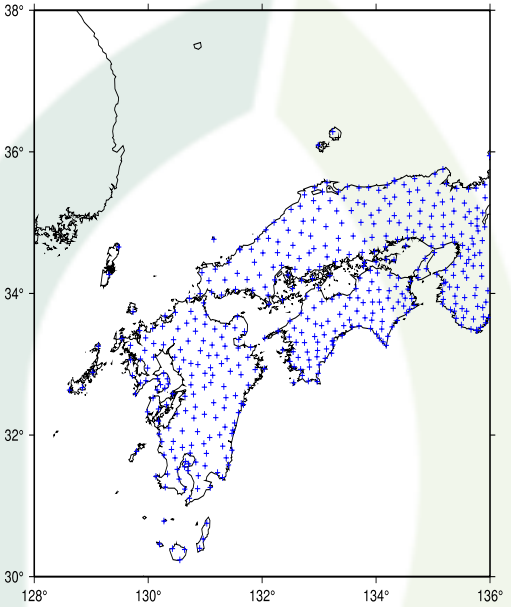
Naze

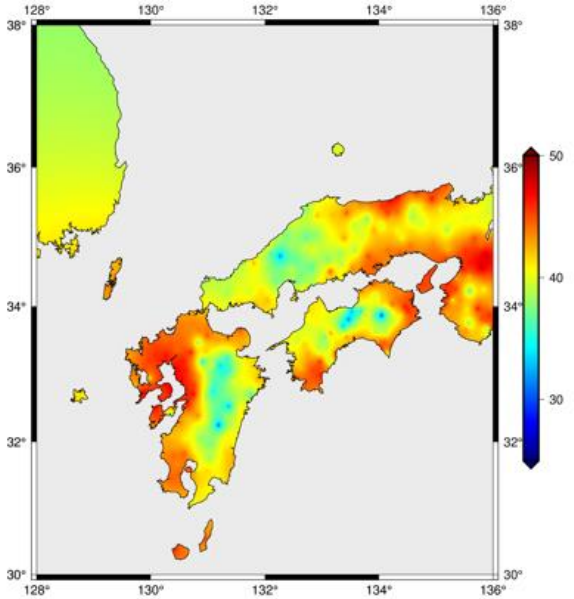


Comparison with GEONET

July 15, 2018 10JST

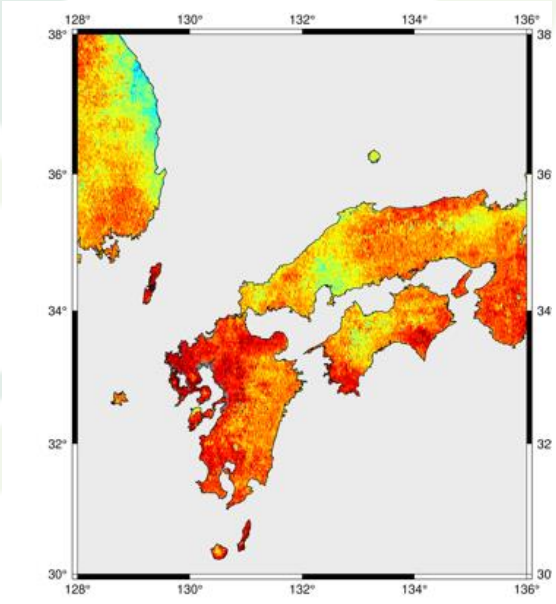
Stations

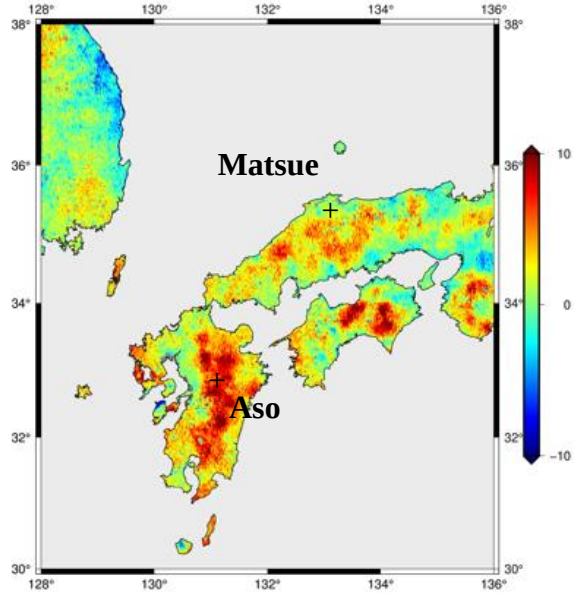




GPS

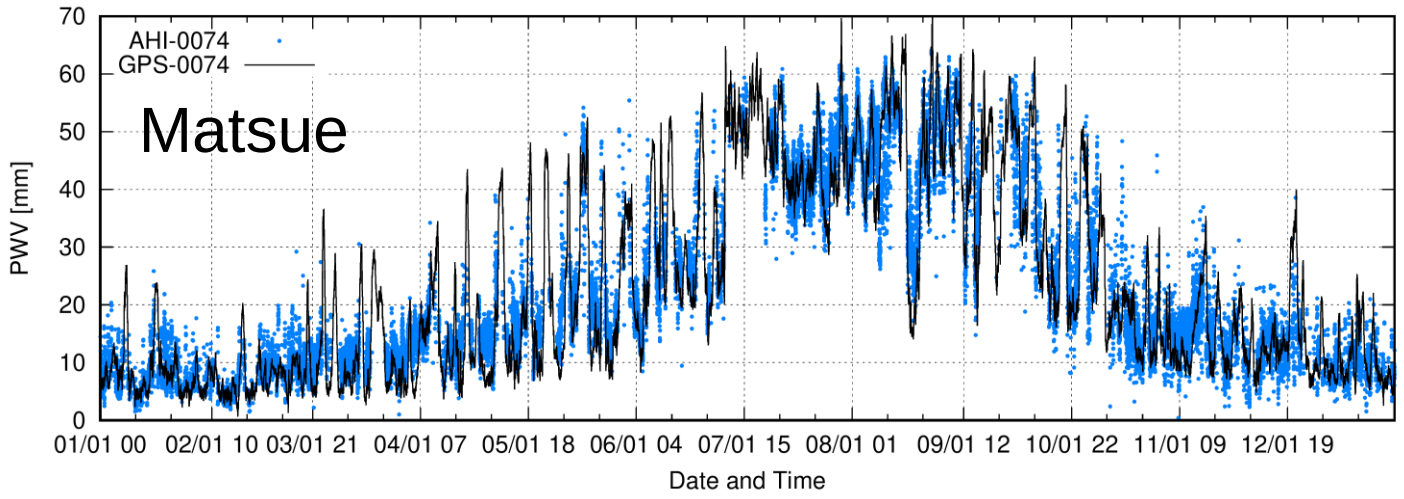
AHI

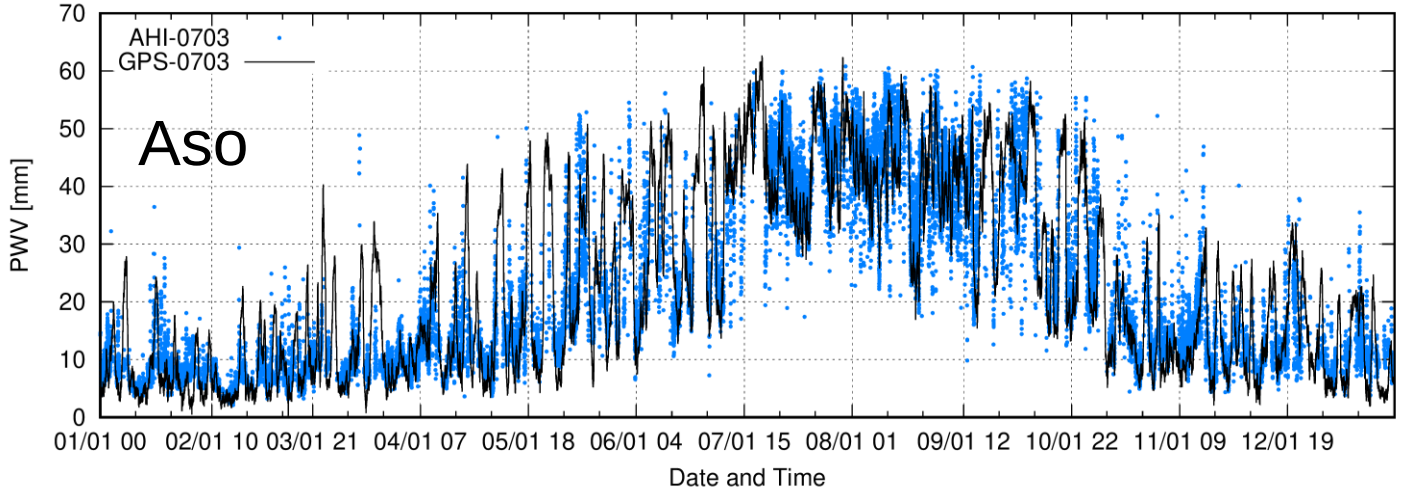




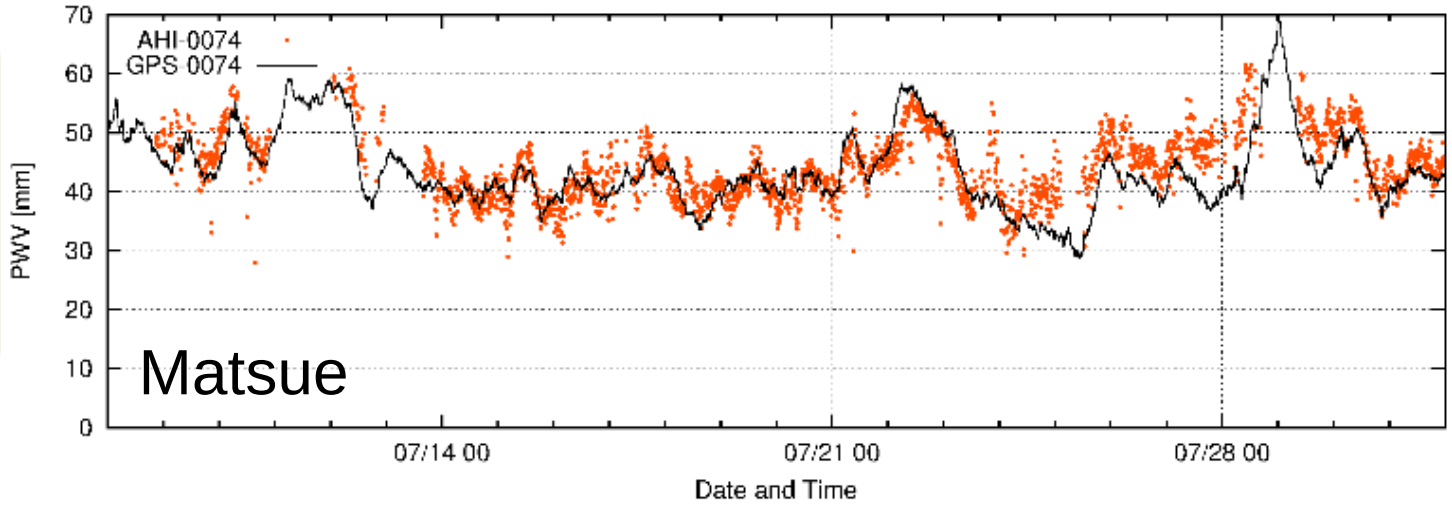
Difference

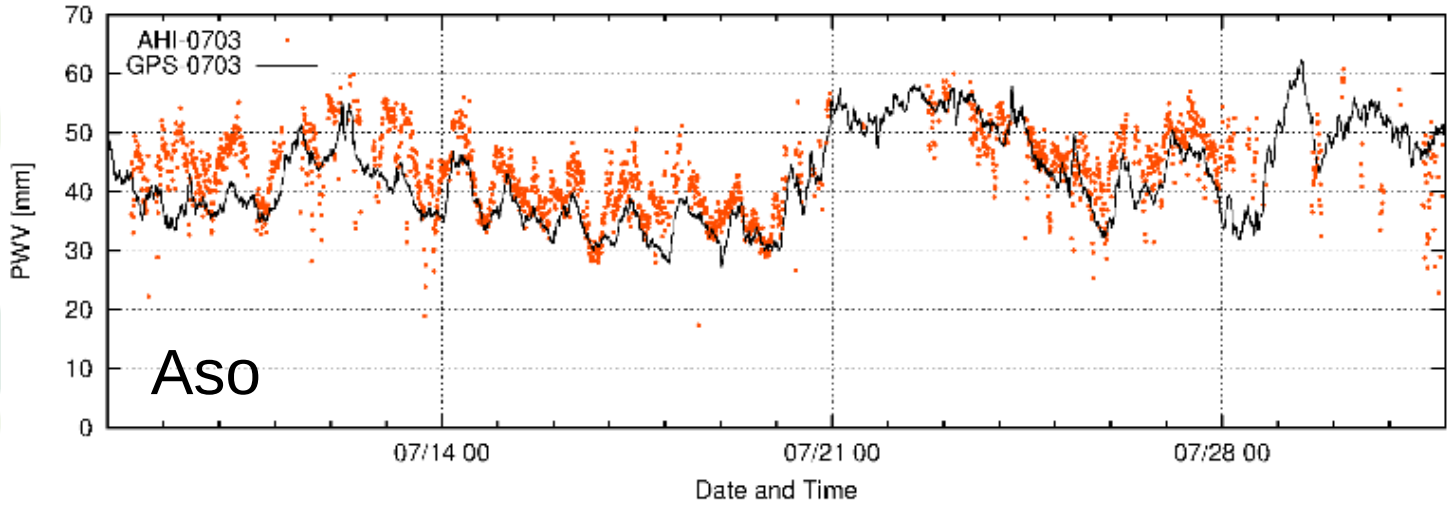
Comparison with GEONET



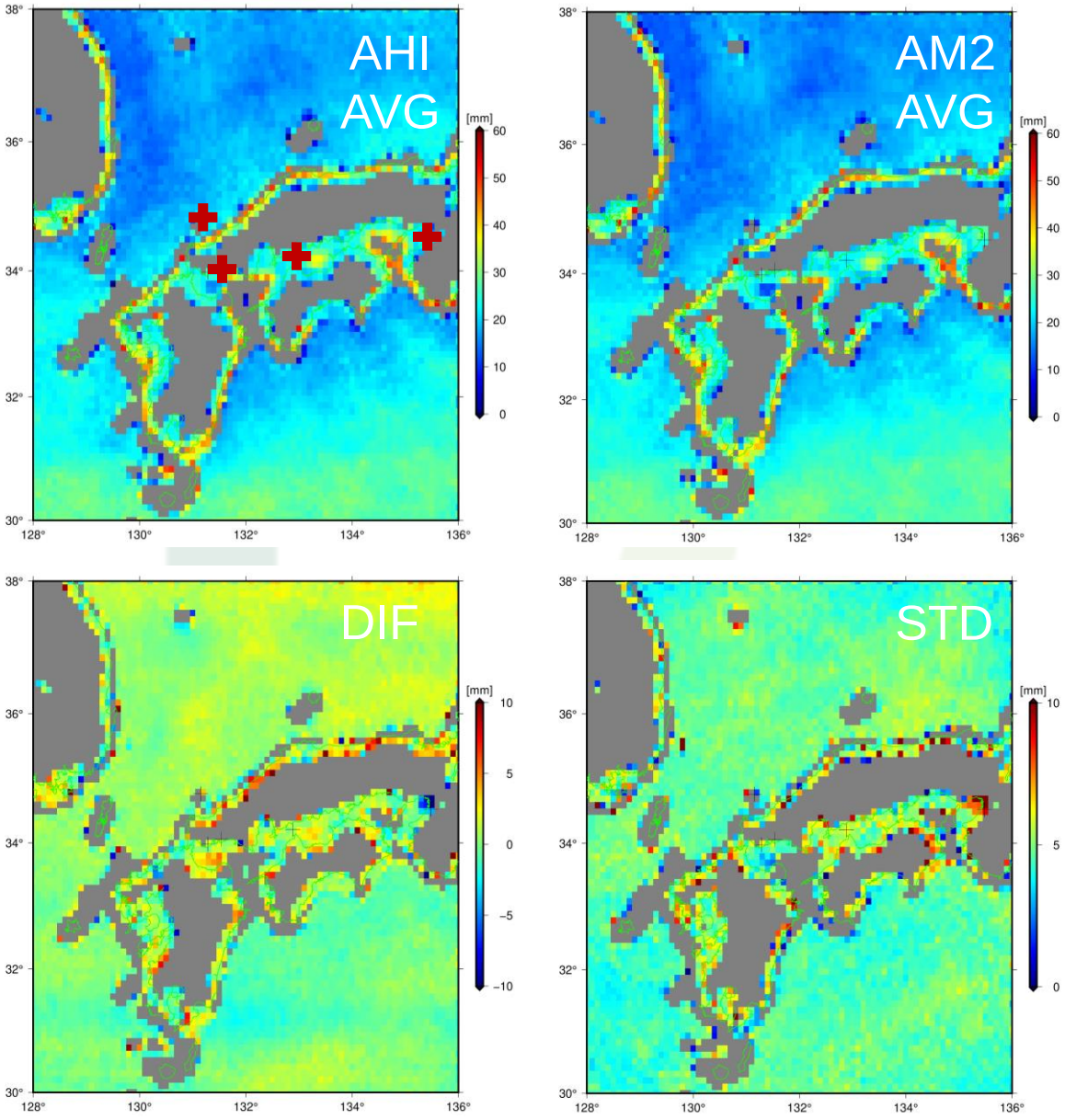


Comparison with GEONET

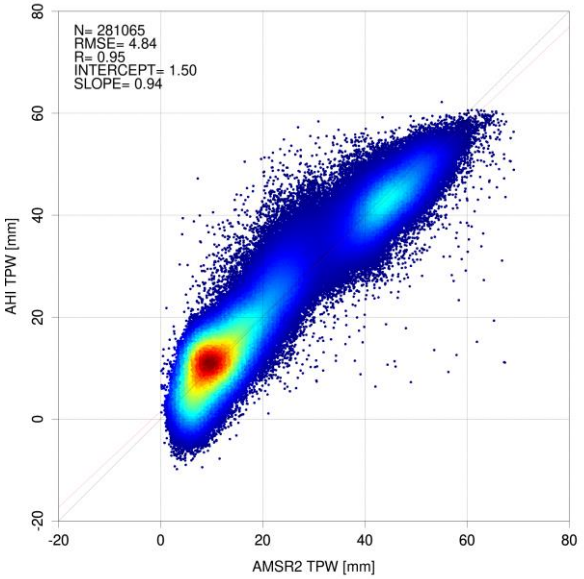




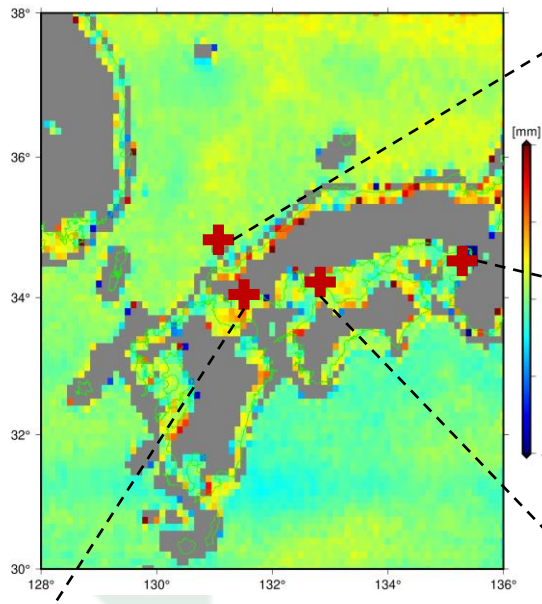
AMSR2 Comparison (Ocean + Land)



Annual Statistics in 2018

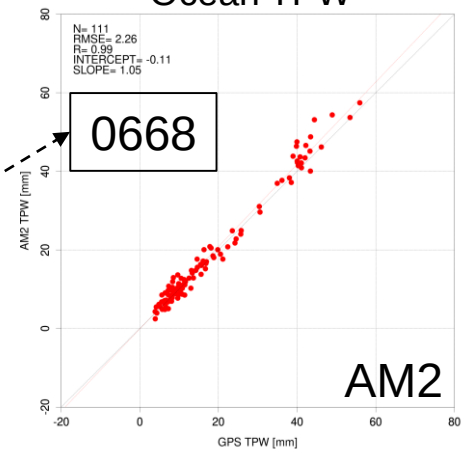


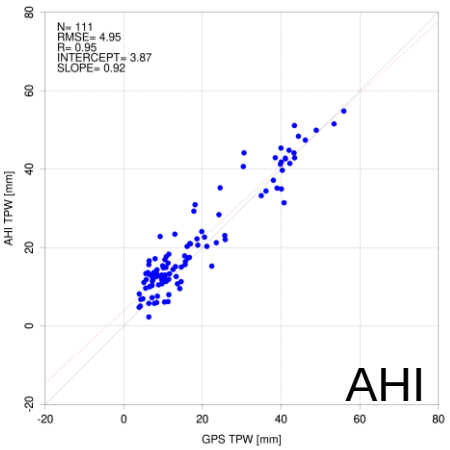
Coastal GEONET



Ocean TPW

0668





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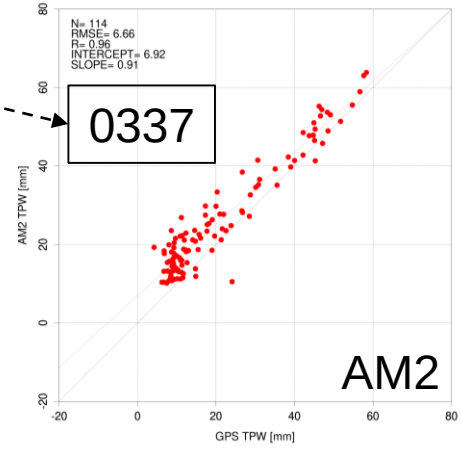

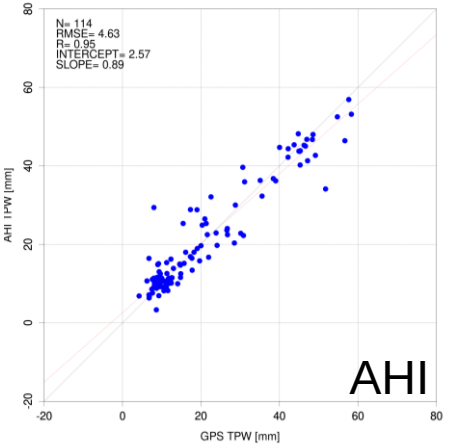

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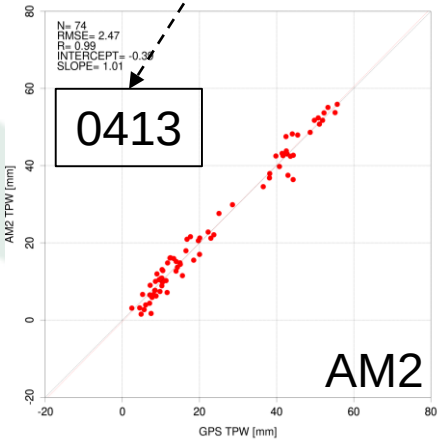

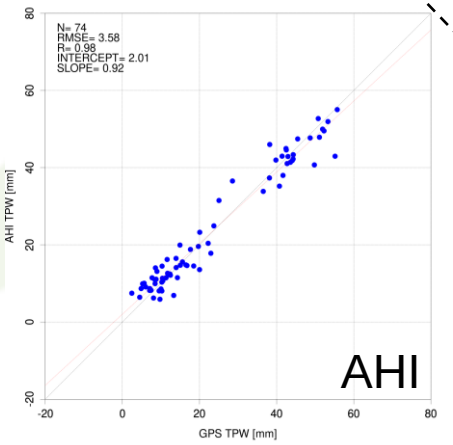

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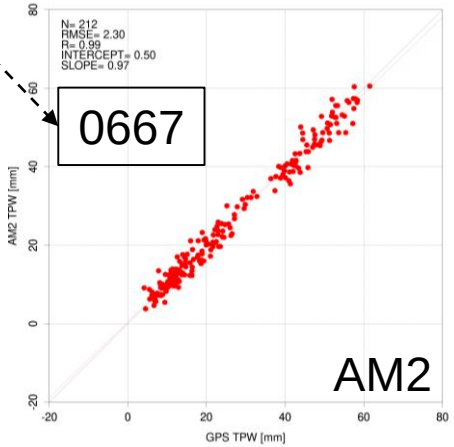
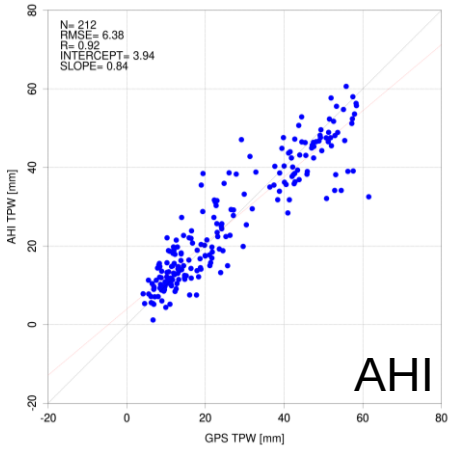
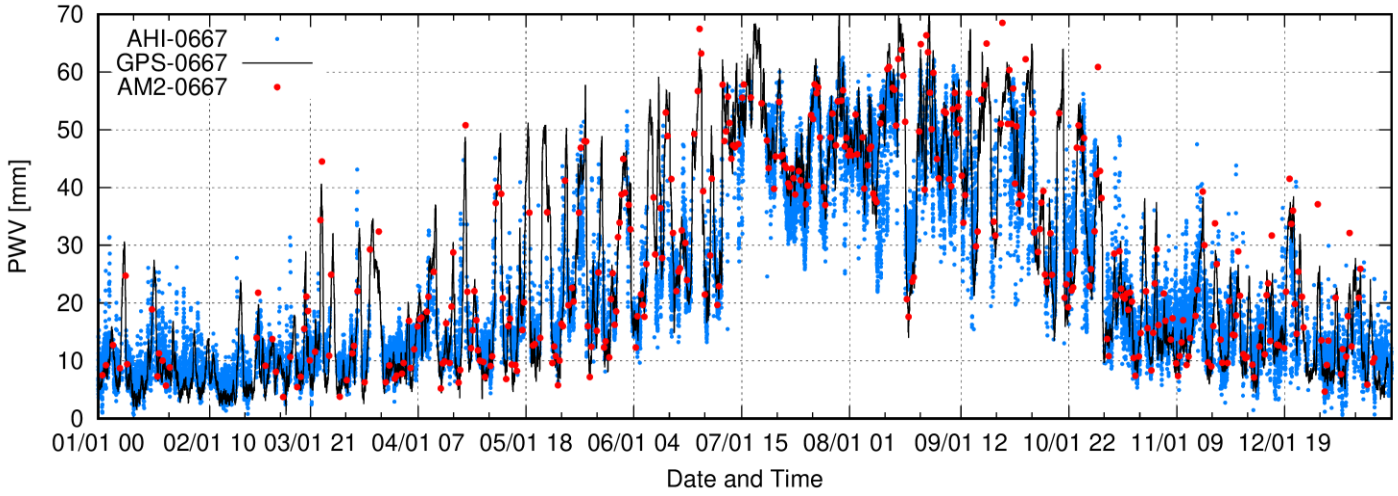
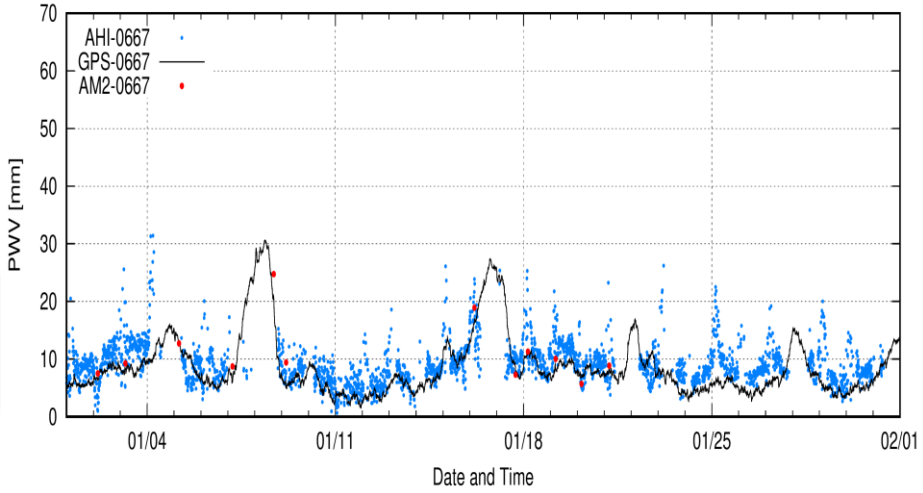
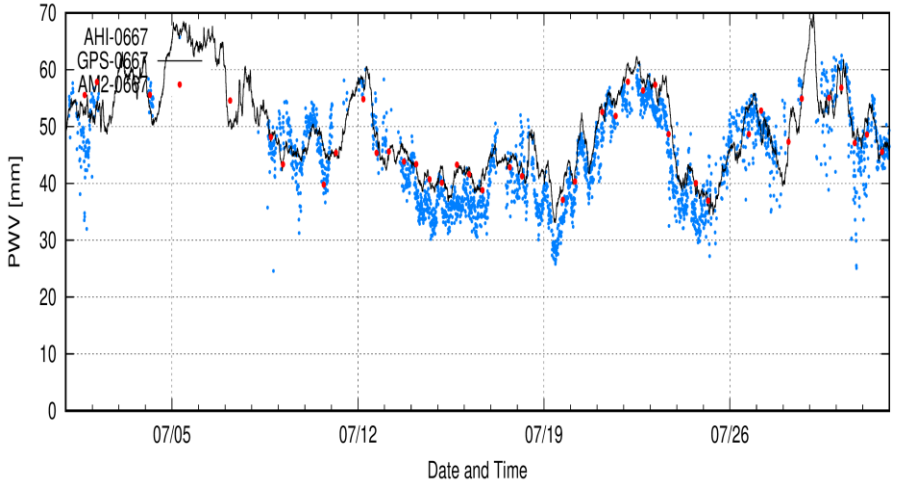




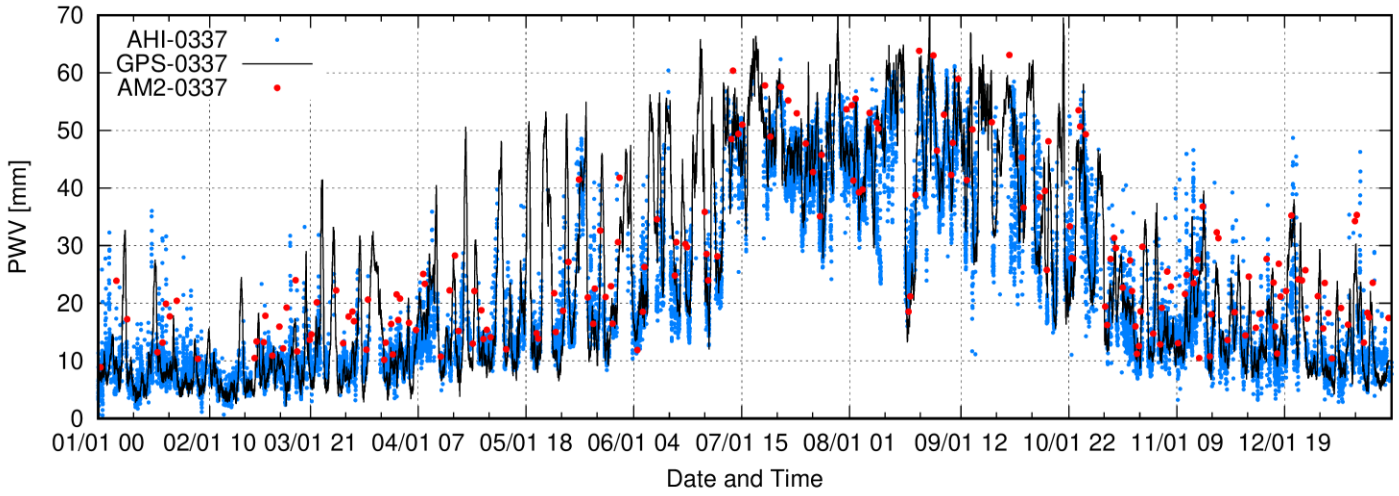
Comparison with Coastal GEONET

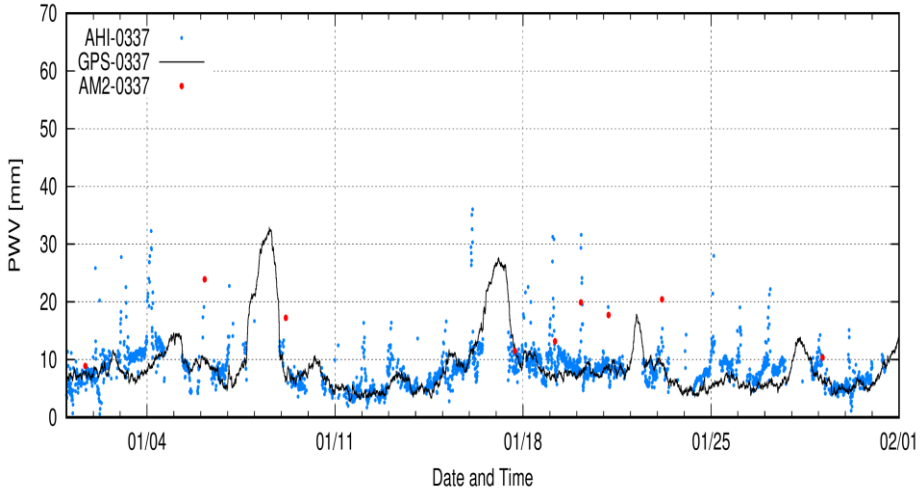


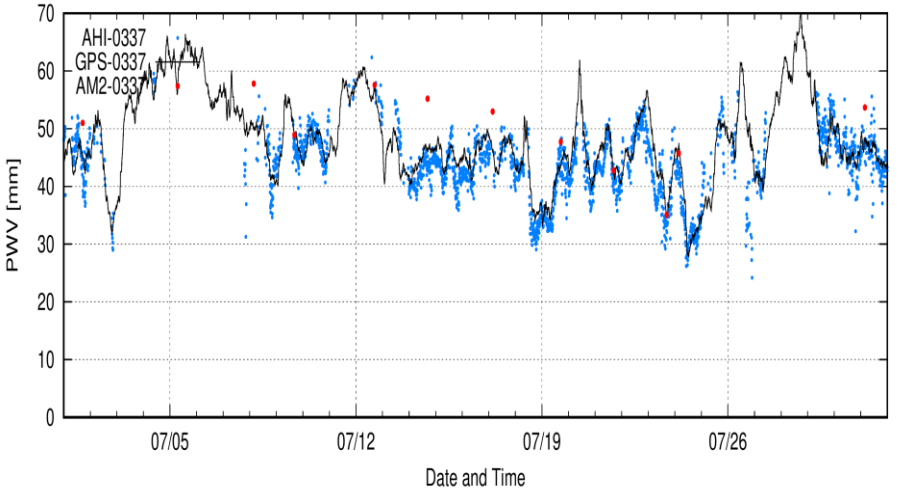




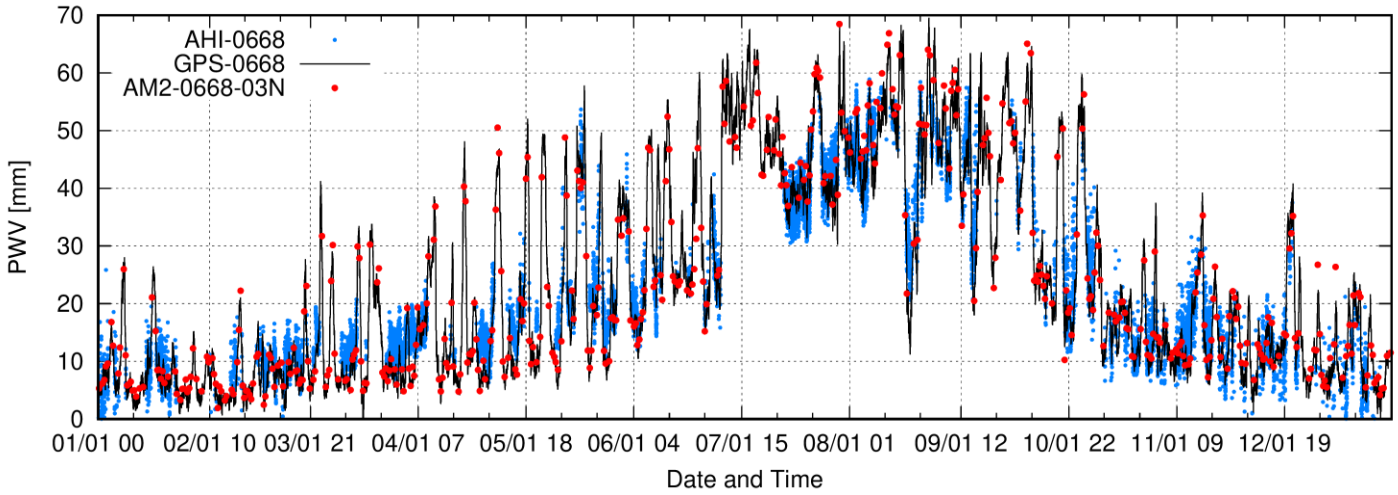
Comparison with Coastal GEONET

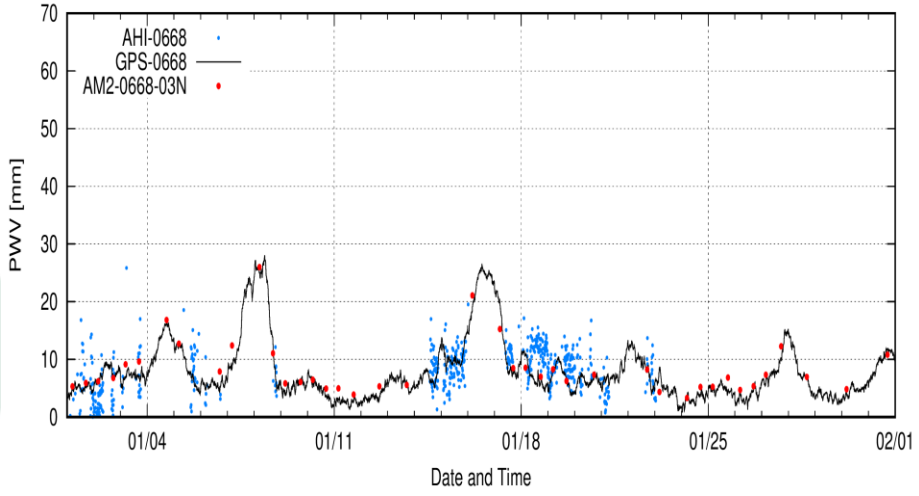


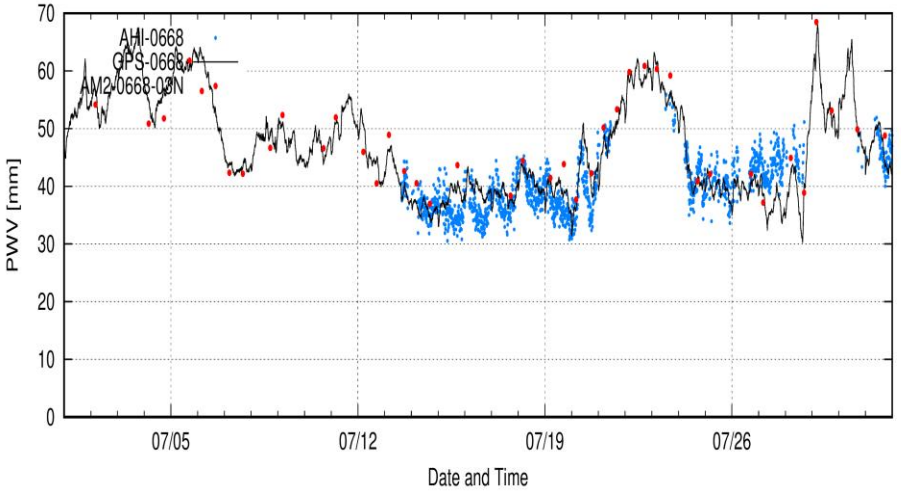




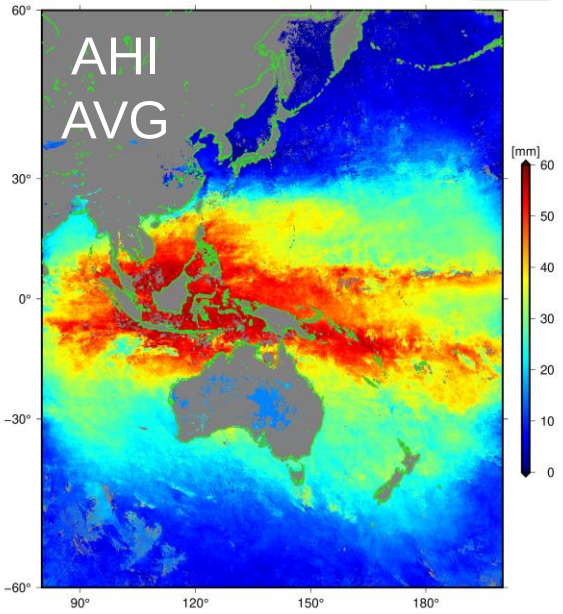
Comparison with Coastal GEONET

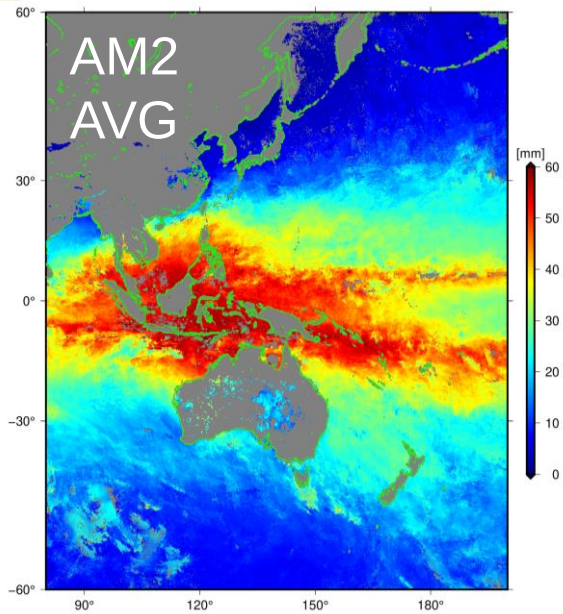


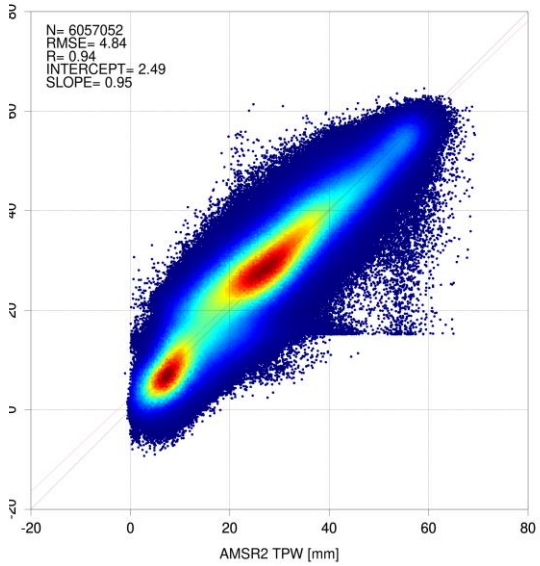


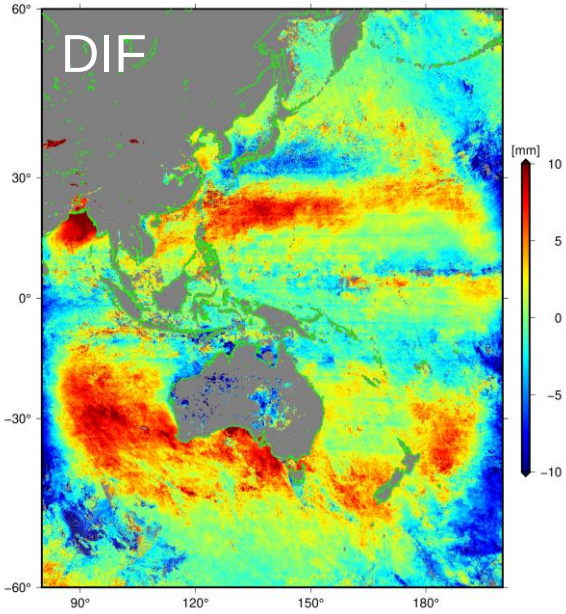


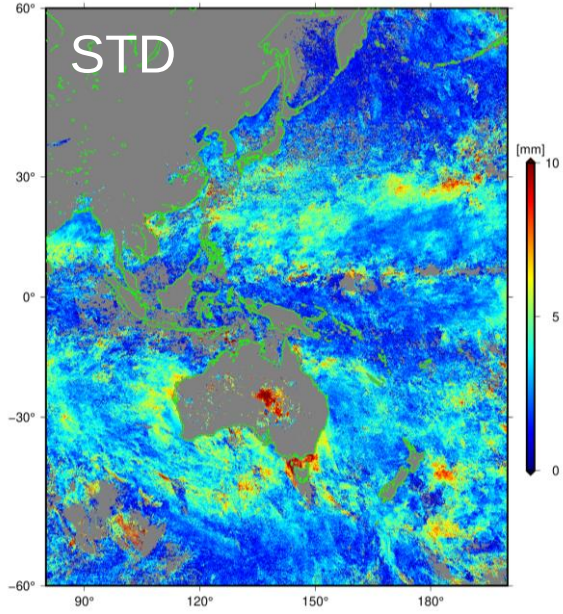
AMSR2 Comparison (Full-Disk Area)

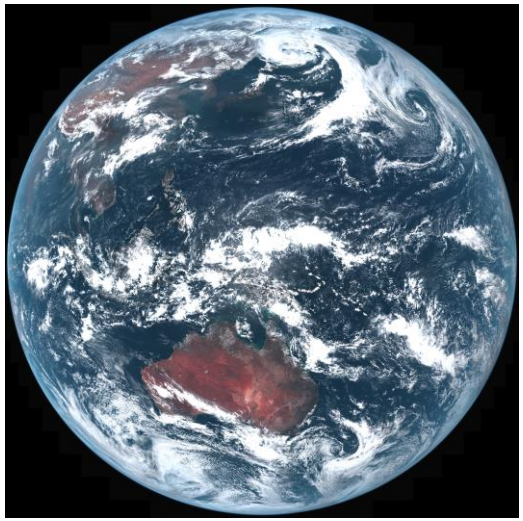




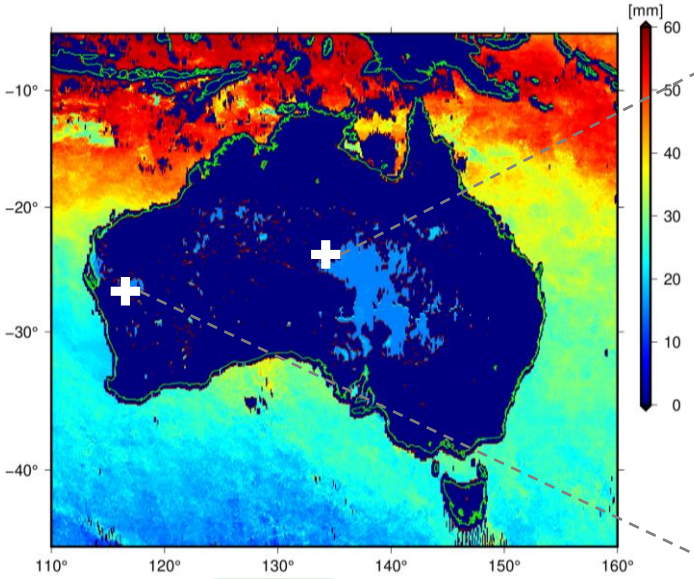




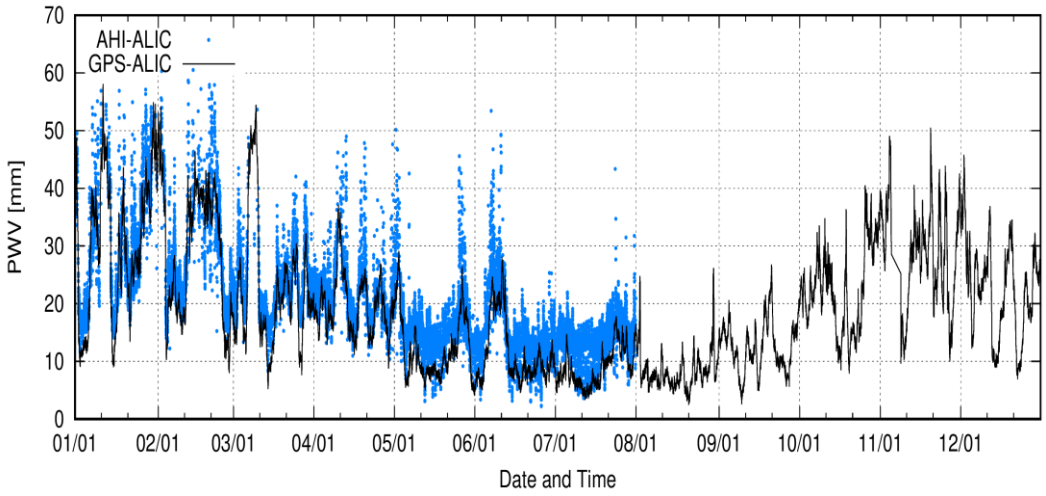


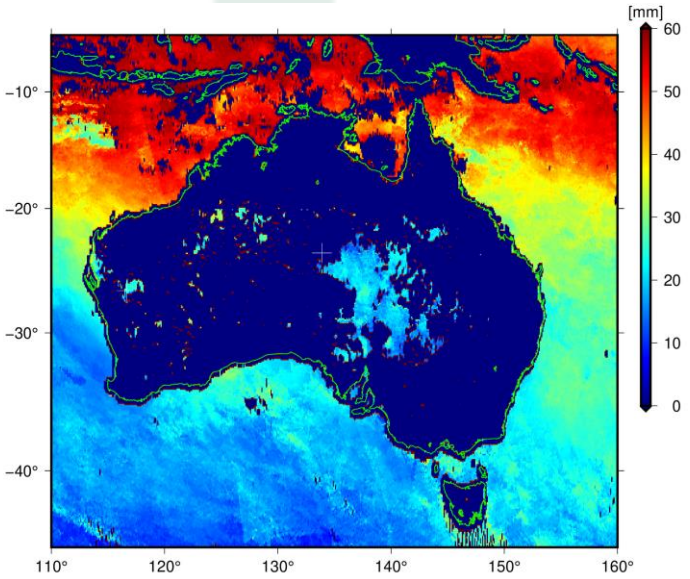


Comparison with IGS stations

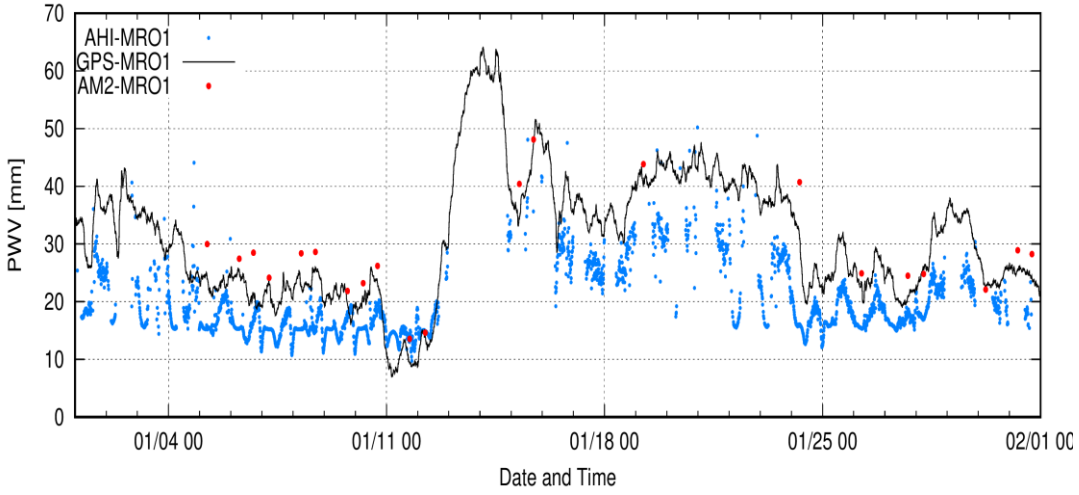


Alice Springs





Boolardy Station



Summary

Summary

- SVR-based retrieval algorithm of AHI precipitable water was constructed based on observation-based training dataset and validated (around 6 mm RMSE against RAOB).
- Comparison with GEONET and AMSR2 show that:
  - ✓ AMSR2 TPW over land shows good performance.
  - ✓ Reasonable consistency around Japan area, but indicate the need of further improvement over dry land areas.

Prospects

- Although further improvements are absolutely necessary, AHI precipitable water potentially complement the AMSR2 and GPS observations by its wide-area and high spatial and temporal resolution.