Evaluation and Comparison of Long-term Total Precipitable Water Products by the GCOM-W/AMSR2

*Keiichi Ohara1), Takuji Kubota1), Misako Kachi1), Masahiro Kazumori2)
1)Japan Aerospace Exploration Agency, Japan, 2) Japan Meteorological Agency

Background

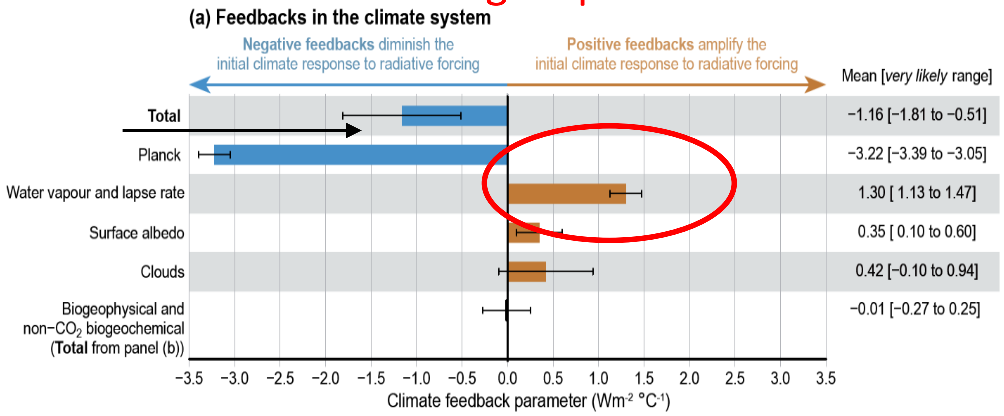
Importance of long-term analysis of water vapor

- Water vapor content is increasing with rising temperatures
- Significant positive feedback on global warming
- Relation to the global energy balance
- Relation to other climate systems (clouds and precipitation)

→Long-term and global-scale water vapor observation are important.

IPCC AR6

The largest positive feedback



https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_TS.pdf

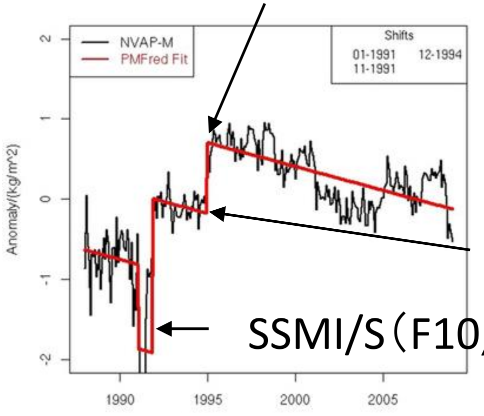
Issues identified in previous studies

IPCC AR6 WG1, GEWEX/G-VAP

> The uncertainty in the magnitude of the TPW trend due to discontinuities in the time series. This discontinuities are associated with changes in the observing systems.

➡ Accurate and consistent long-term water vapor data sets are needed

Discontinuities are created in the timing of new data assimilation



NVAP-M

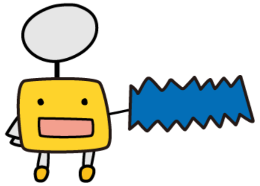
HIRS（NOAA-14）

SSMI/S（F10, F11）

[Schröder et al., 2016, 2018, 2019]

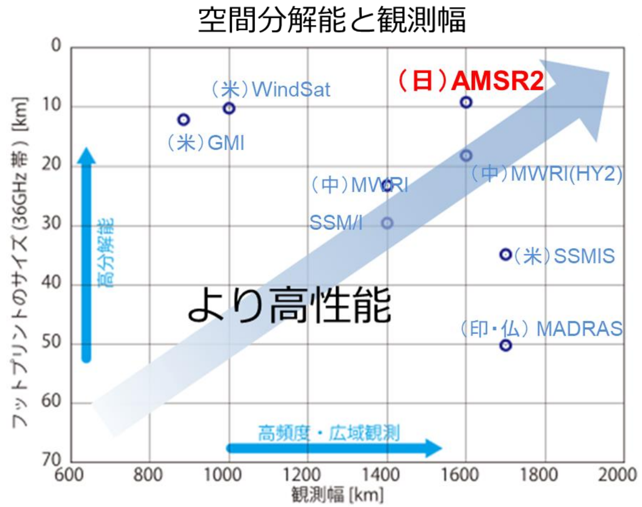
Advantages of the AMSR series observation

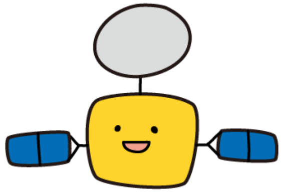
- Spatiotemporally homogeneous observation
- All weather observation (free from cloud effect)
- High spatiotemporal resolution (top-class performance)
- Continuous monitoring by Aqua/AMSR-E and GOSAT-GW/AMSR3



The Total Precipitable Water (TPW) can be retrieved from AMSR series observation data

Microwave radiometer in the world



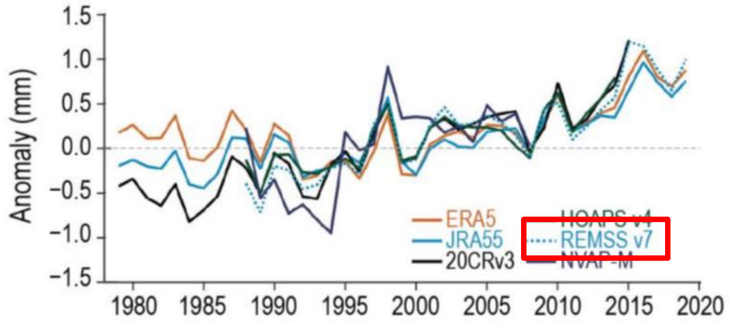


Chapter 2 IPCC AR6 WGI

Remote Sensing Systems (RSS)

- The RSS TPW was estimated using an algorithm developed independently by RSS (Wentz et al. 2007).
- The RSS TPW products was used in the IPCC report as a basis for evaluating reanalysis data and models (Wentz et al. 2007).

Changes in global mean total column water vapour



Comparison and validation of Long-term AMSR2 TPW products for JAXA and RSS

Data

Data used in this study

- JAXA＆RSS　AMSR2 TPW Daily Product:
  Period：2012-2020, Resolution：0.25°

- Radiosonde：
  Period ： 2012-2020

- GANAL：
  Global objective analysis data of JMA
  Period ： 2018, Resolution ： 0.5 °

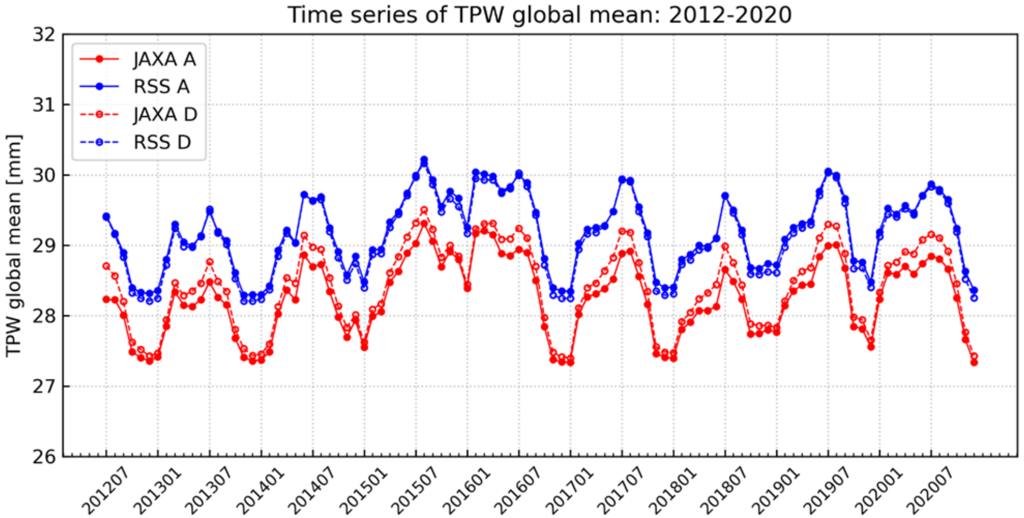
- MGDSST:
  Global daily SST product of JMA
  Period ： 2018, Resolution ： 0.25 °

- Aqua/MODIS Daily Products:
  Surface Reflectance & Cloud Properties
  Period ： 2018, Resolution ： 0.05 °

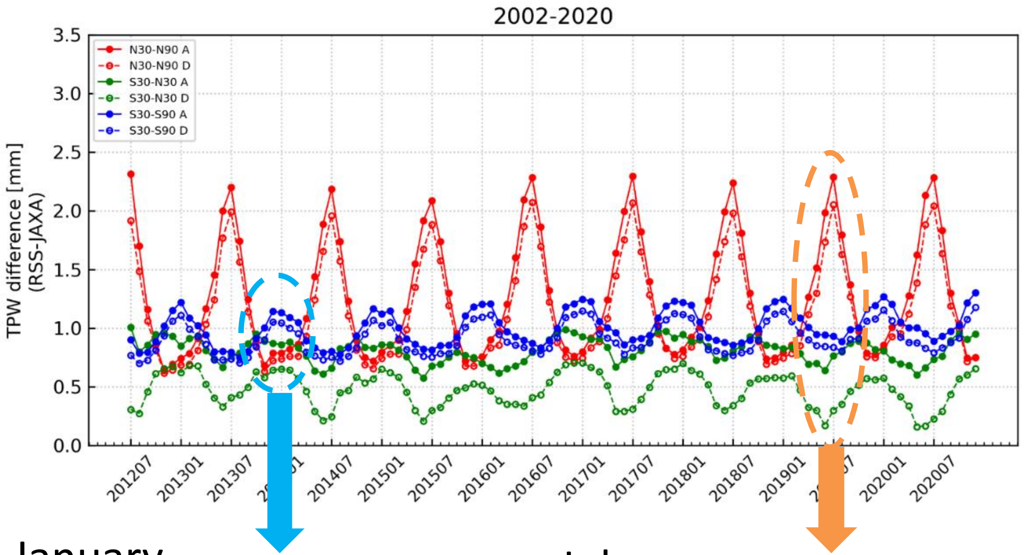
- Satellite Joint Simulator：
  Radiative Transfer model

Comparison of JAXA and RSS AMSR2 TPW

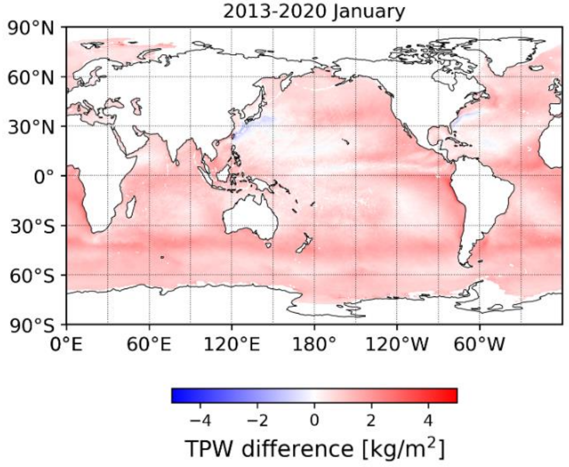
Difference of time series and horizontal distribution between JAXA and RSS products (from July 2012 to December 2020)



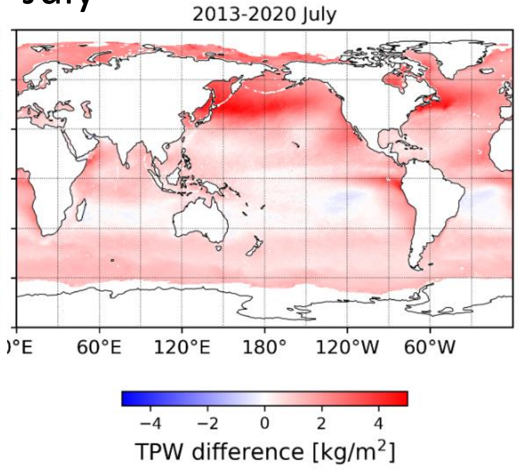
RSS - JAXA
Zonal mean



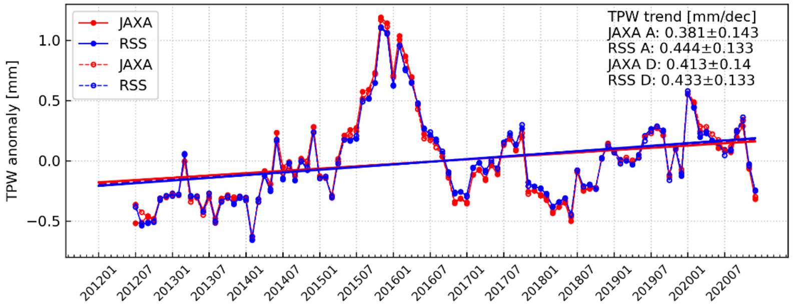
January



July



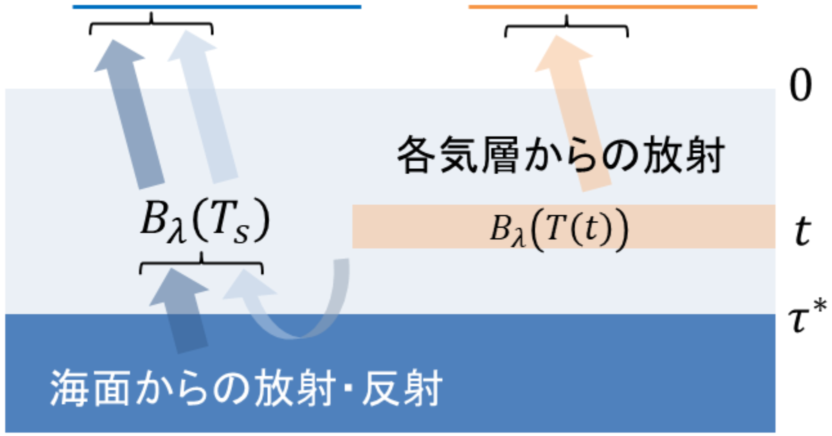
- ✓ Large TPW differences at the northwest Pacific and northwest Atlantic Ocean in every boreal summer.
- ✓ No significant difference in TPW anomaly trend



What causes the large TPW difference?

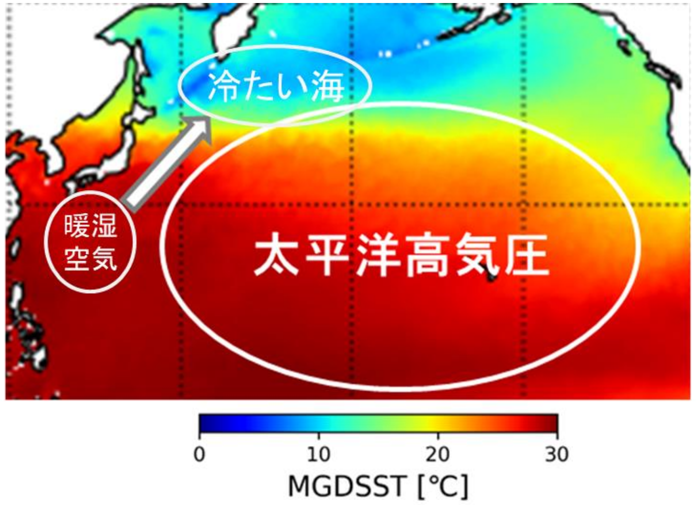
Radiative transfer equation

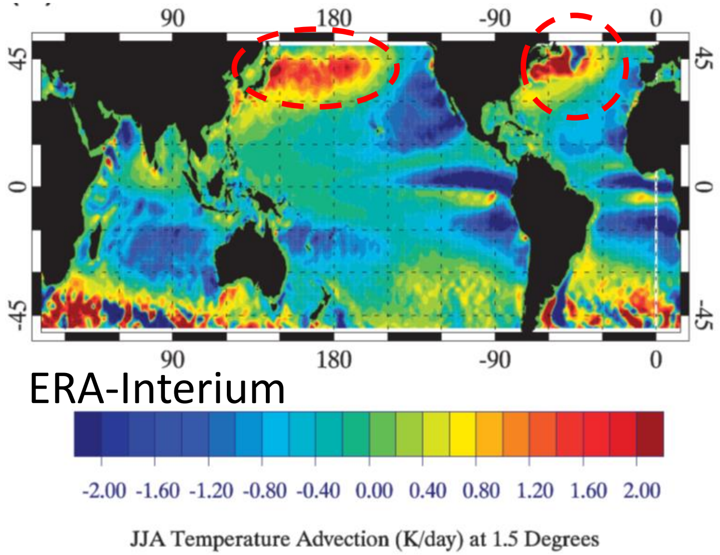
$$I_\lambda(\tau = 0; \mu) = B_\lambda(T_s)\exp\left(-\frac{\tau^*}{\mu}\right) + \int_0^{\tau^*} B_\lambda(T(t))\exp\left(-\frac{t}{\mu}\right)\frac{dt}{\mu}$$



Characteristic meteorological field

Kubar *et al.*(2012)





The significant warm air advection and fog were often observed in the northwest Pacific and northwest Atlantic Oceans during the boreal summer.

SST？ SSW?
Temperature?
RH? Cloud？

Warm air advection?
Sea fog?

Pattern correlation

◆ Pattern correlation coefficients between TPW differences and the other physical quantities

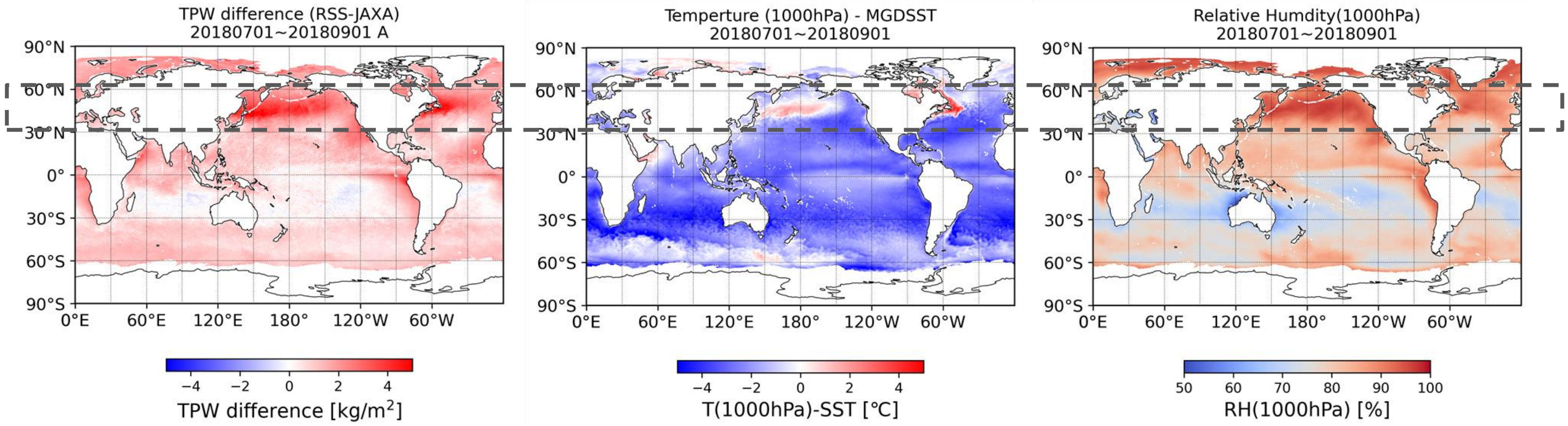
Table 2. Pattern correlation coefficient with TPW difference (RSS-JAXA) and other geophysical parameters

(for July and August 2018)

Data	CLW (JAXA)	CLW difference (RSS-JAXA)	MGD SST	SST difference (MGDSST-RSS SST)	GANAL SSW	SSW difference (GANAL - RSS SSW)	GANAL T_{1000}-MGDSST	GANAL RH_{1000}
Pattern Correlation Coefficient (Global)	0.15	0.04	-0.25	0.18	-0.13	-0.43	0.53	0.74

Large coefficients

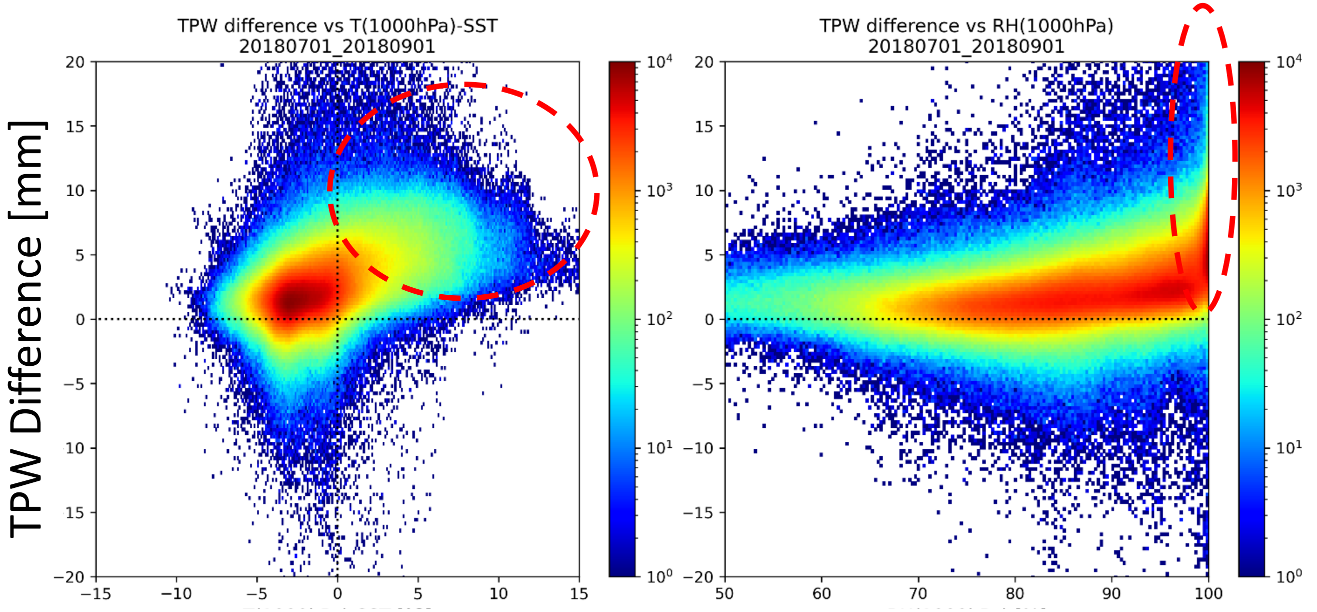
TPW difference (RSS-JAXA)　　T (1000Pa) -SST　　RH (1000Pa)



Characteristic pattern in NH mid-latitudes is common!

TPWの差が大きくなる大気下層の気象条件

Scatter plots (at 30–60N for July and August 2018)



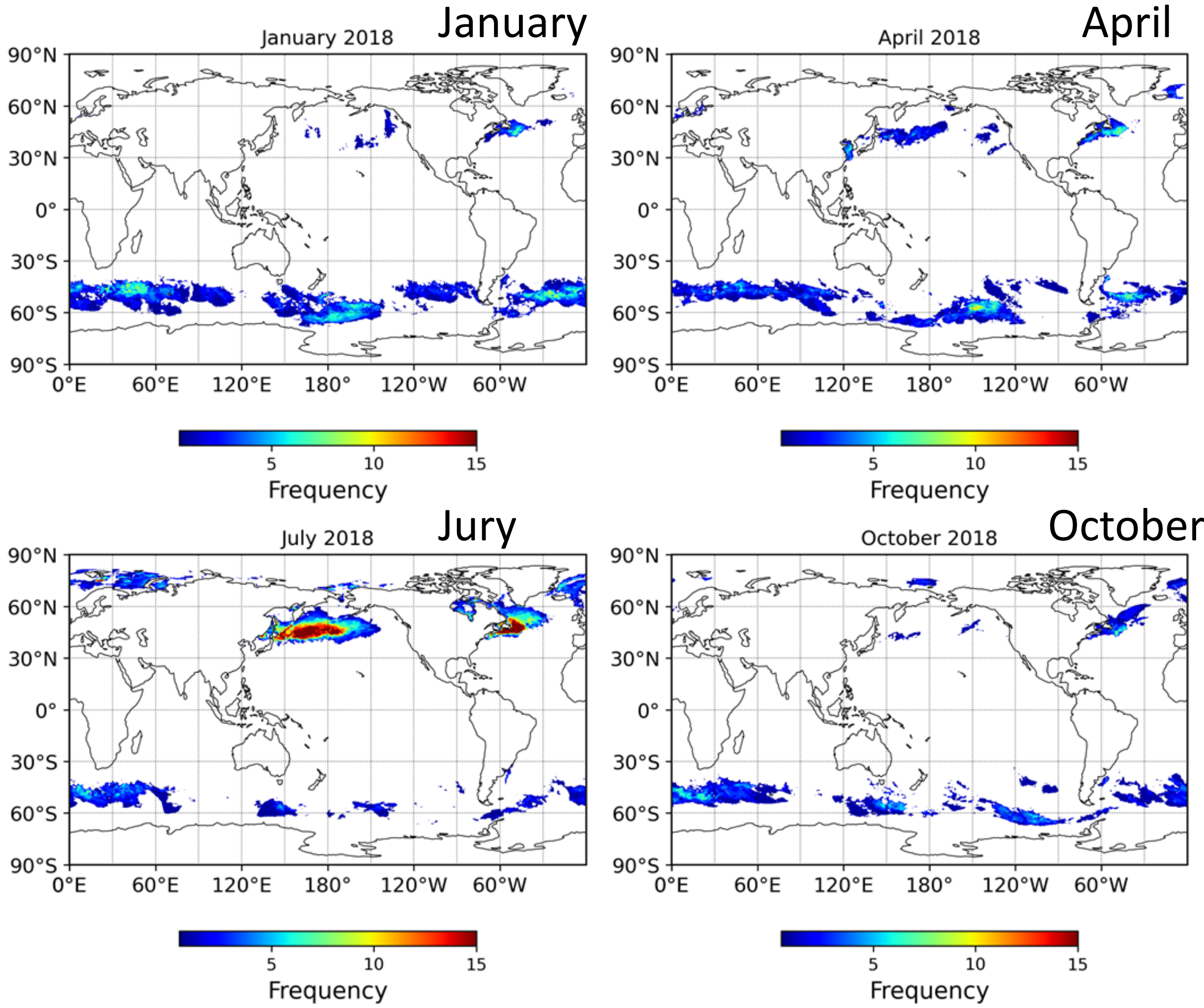
T (1000hPa) - SST

Relative Humidity (1000hPa)

TPW difference tends to be large where…
- ✓ T_{1000} is warmer than SST
- ✓ RH_{1000} is close to 100%

These meteorological conditions are consistent with the characteristic warm air advection and sea fog reported previous research.

The frequency of the characteristic cases (T_{1000}-SST > 2deg and RH_{1000}>95% for July and August 2018)

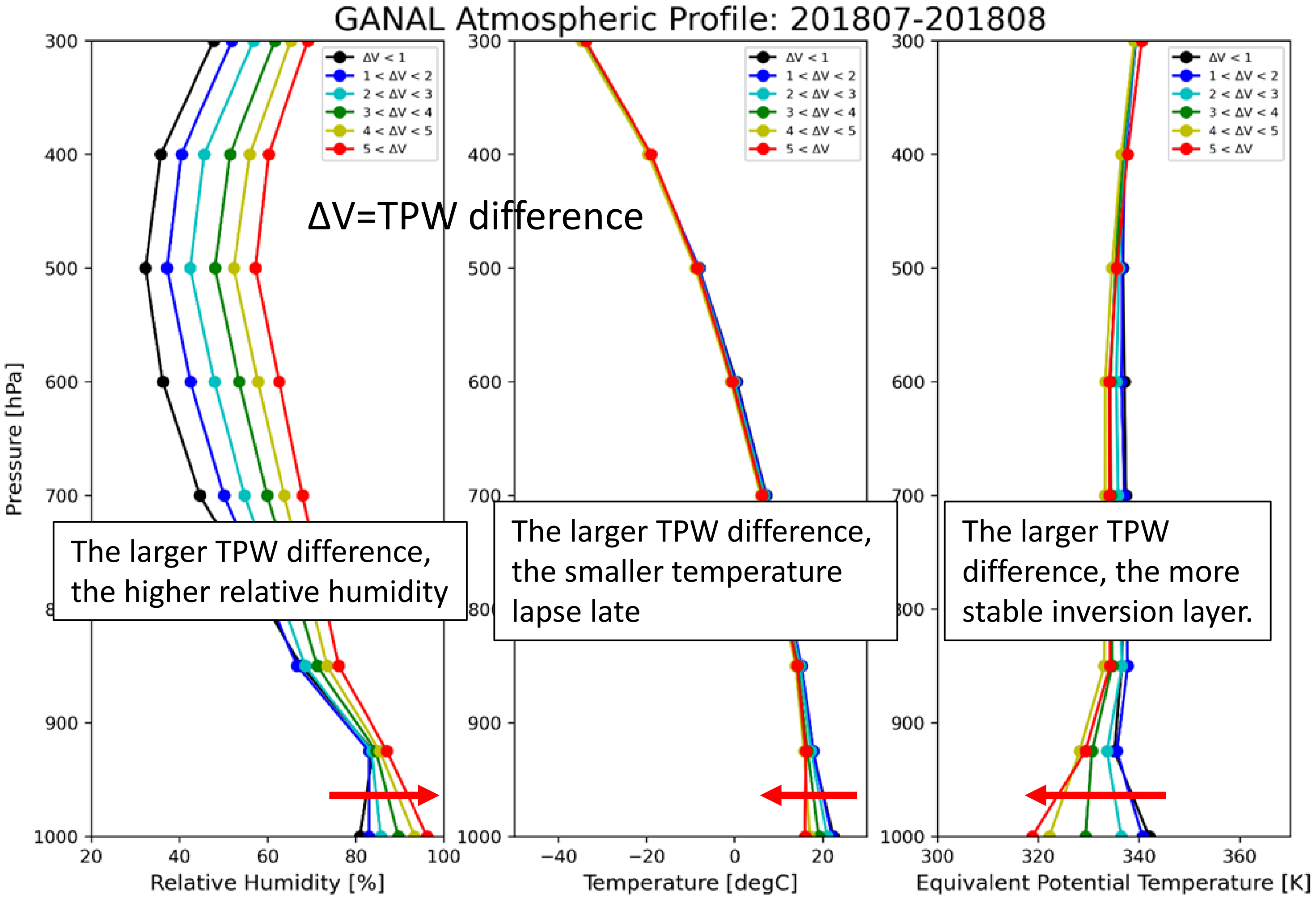


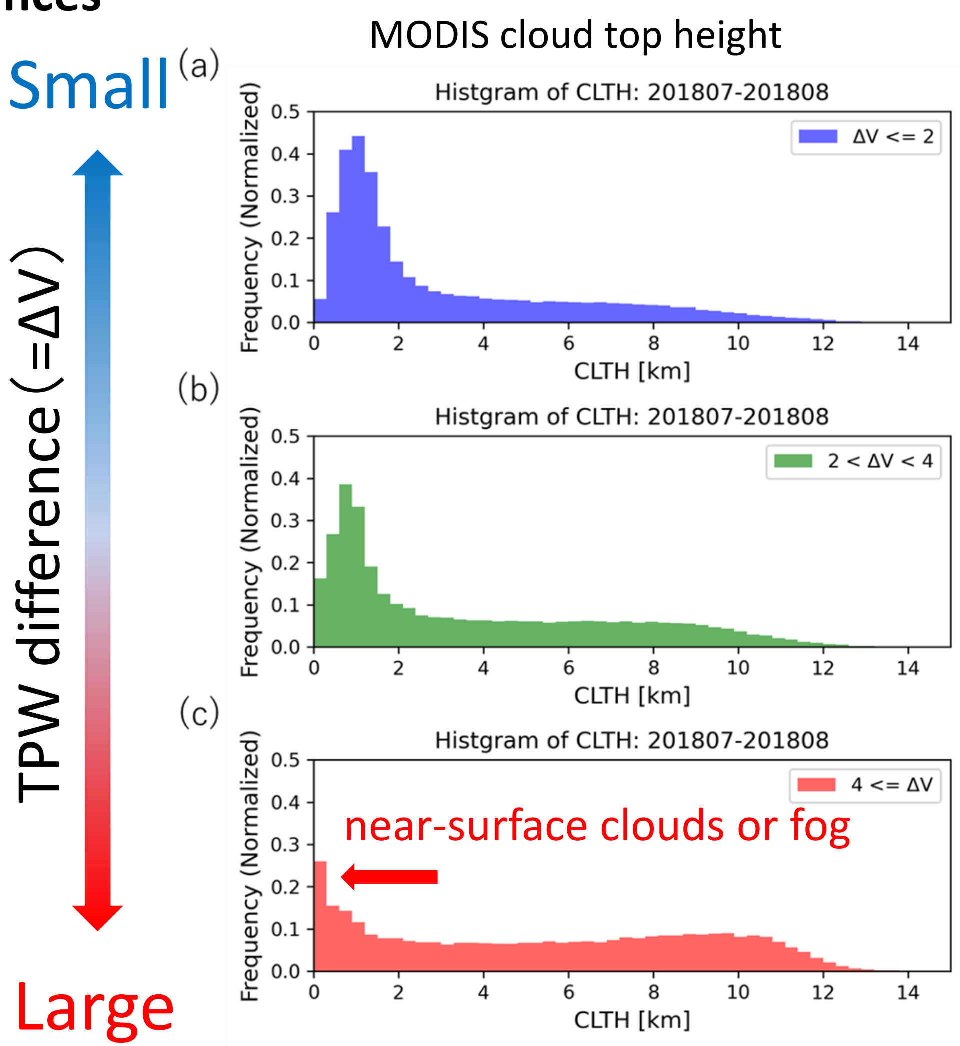
Most frequently in boreal summer in the northwest Pacific and northwest Atlantic

Moist inversion layer and sea fog

※July and August, 2018、30-60N

◆ The meteorological conditions in the areas with large TPW differences





✓ High relative humidity close to 100%, temperature inversion layer and sea fog

Validation with radiosonde observation

◆**Global and all season (2012-2020)**

✓ The absolute values of Bias and RMSE are comparable.

JAXA	RSS
Bias=-0.369 [kg/m²] RMSE= 2.907 [kg/m²]	Bias = 0.448 [kg/m²] RMSE= 2.770 [kg/m²]

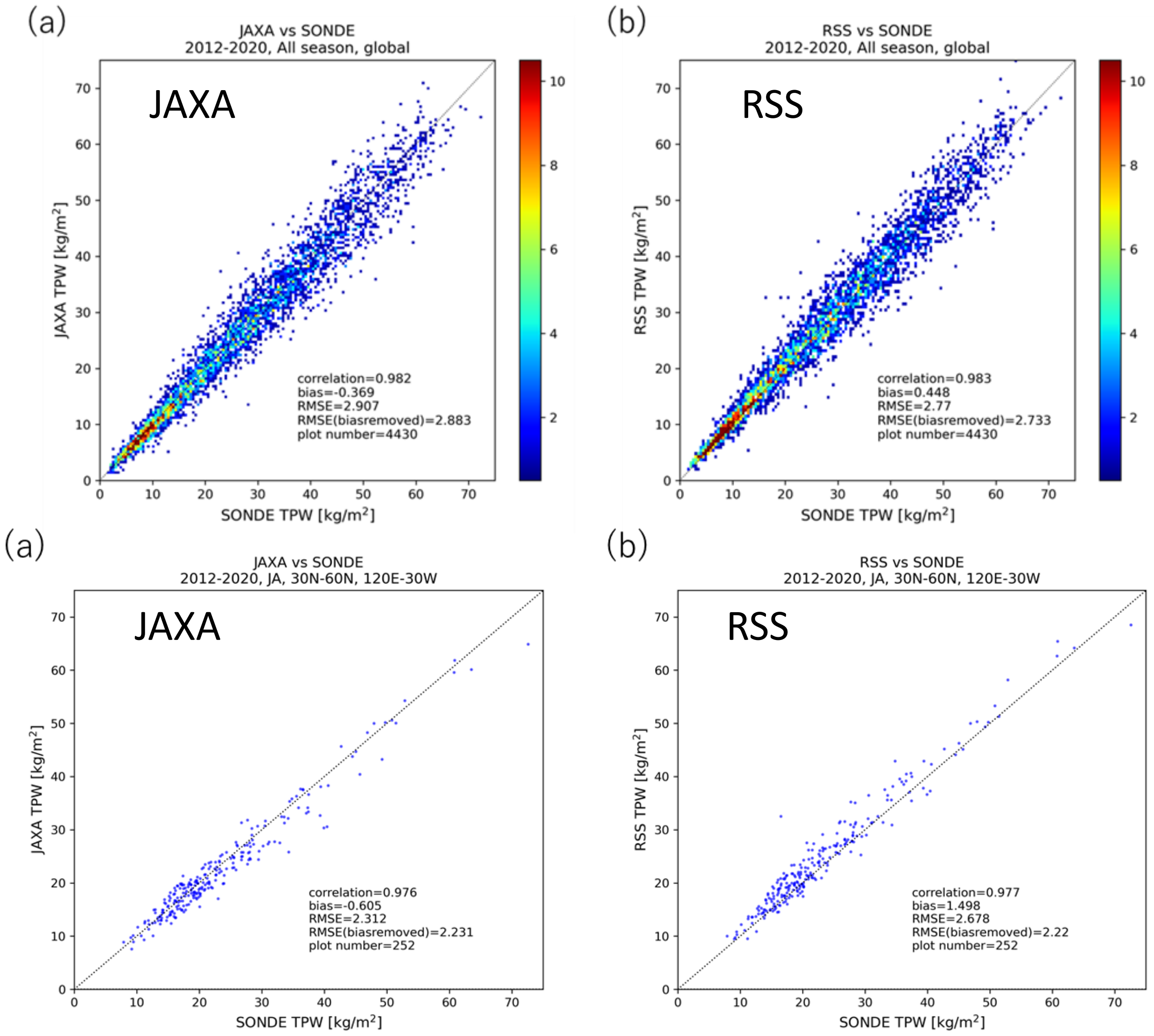
◆ **The northwest Pacific and northwest Atlantic Oceans during the boreal summer (2012-2020)**

✓ RSS is a little less accurate

✓ JAXA has a larger negative bias.

✓ RSS has a larger positive bias.

JAXA	RSS
Bias=-0.605 [kg/m²] RMSE=2.312 [kg/m²]	Bias =1.498 [kg/m²] RMSE=2.678 [kg/m²]



Summary & Future plan

Summary

- ✓ Large TPW differences in the boreal summer of the northwestern Pacific and northwestern Atlantic.
- ✓ The TPW differences are tend to be large where…
  - ✓ Relative humidity in the lower atmosphere was close to 100%
  - ✓ T(1000hPa) is higher than SST
  - ✓ Surface inversion layer occurred in the lower atmosphere.
  - ✓ Sea fog occur.
- ✓ The JAXA and RSS TPW products had the opposite sign biases for radiosonde observations, respectively.
- ✓ Simple experiments using RTM show that the main source of opposite sign bias in TPW is the inversion layer

Future plan

- ✓ More detailed paper is currently under submission...
- ✓ Long-term dataset including AMSR-E and AMSR3 data