A reduction of discontinuity due to the **orbit** boost in a TRMM Precipitation Radar product for climate studies

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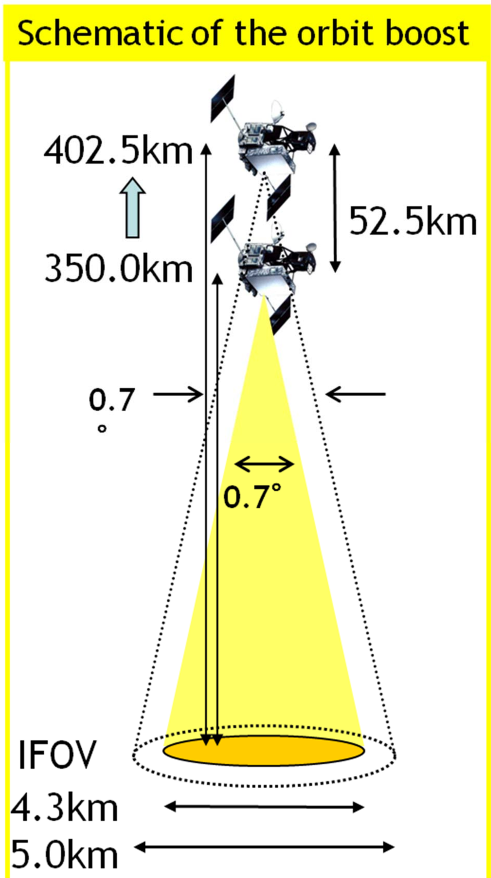
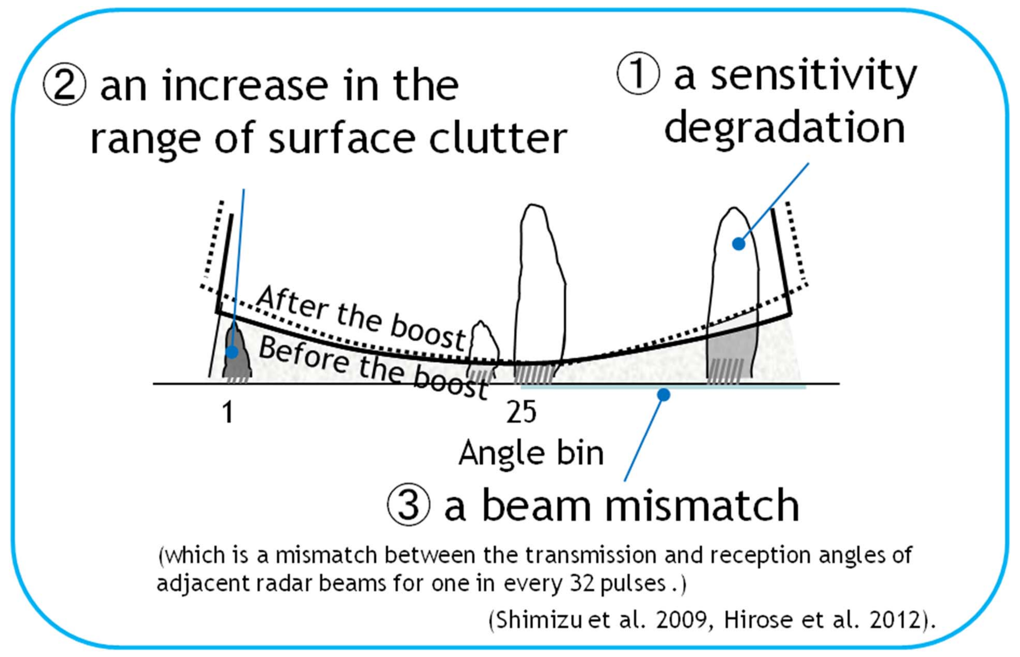
1. Introduction

- The long-term rainfall data from TRMM PR have been very useful for scientific studies.
- However, because the satellite altitude was changed from 350 km to 402.5 km in August 2001 to extend its lifetime, several studies have shown that the amount of weak convective rainfall decreased after the altitude boost
- In order to produce the long-term rainfall data for the climate studies, we produce the TRMM PR product whose discontinuity due to the orbit boost is reduced.
- The impact of the sensivity degradation on the rainfall amounts is estimated by simulating the received powers after the reduction of sensitivity by using the pre-boost data.

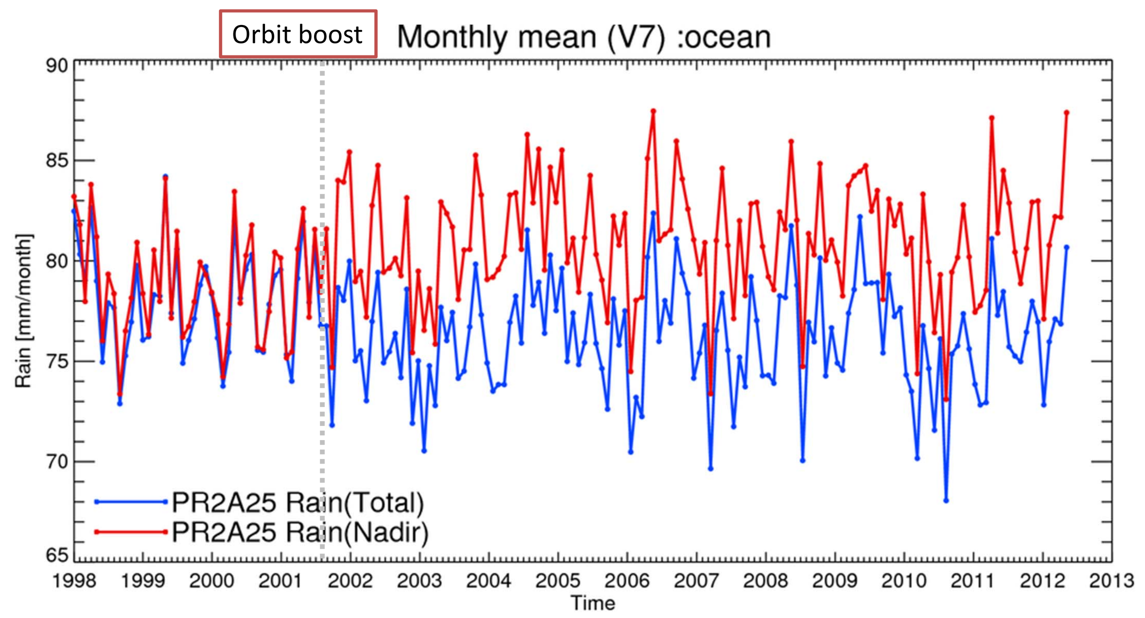
2. Causes of discontinuity due to an orbit boost

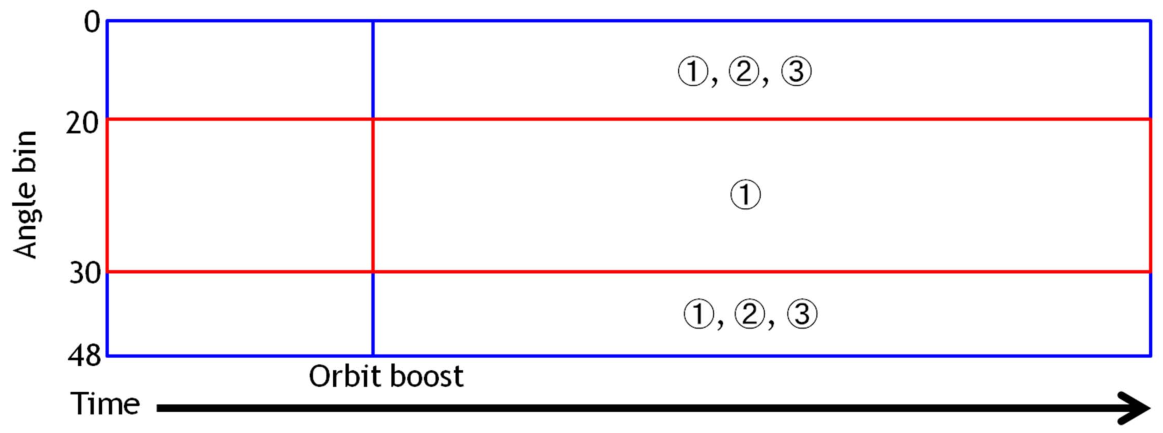




The major causes of the decreases in the rainfall amounts after the altitude boost are (1) a sensitivity degradation owing to the increase of satellite altitude, (2) an increase in the range of surface clutter owing to the increase in the footprint size, and (3) "a beam mismatch" which is a mismatch between the transmission and reception angles of adjacent radar beams for one in every 32 pulses .

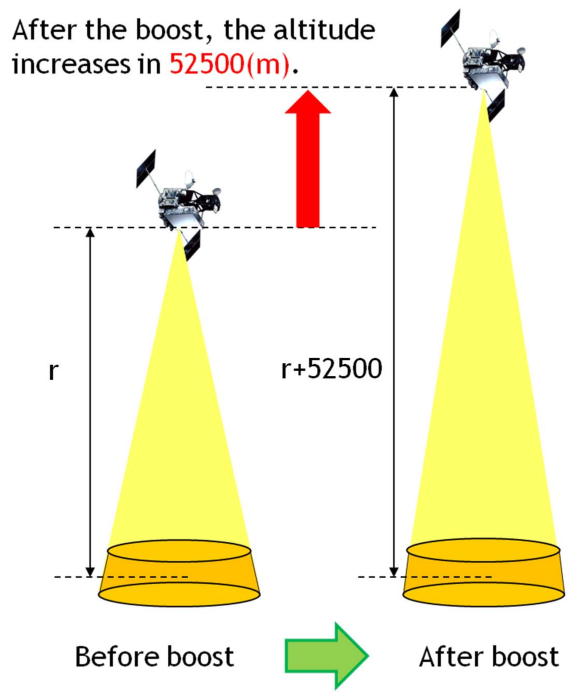
3. Reduction of discontinuity





The effects by an increase in the range of surface clutter and a beam mismatch are mitigated by use of the data at the inner swath but the effects of the sensitivity degradation remain. Therefore, it is necessary to estimate the effects of the sensitivity degradation.

4. The simulation of a degradation



Radar equation

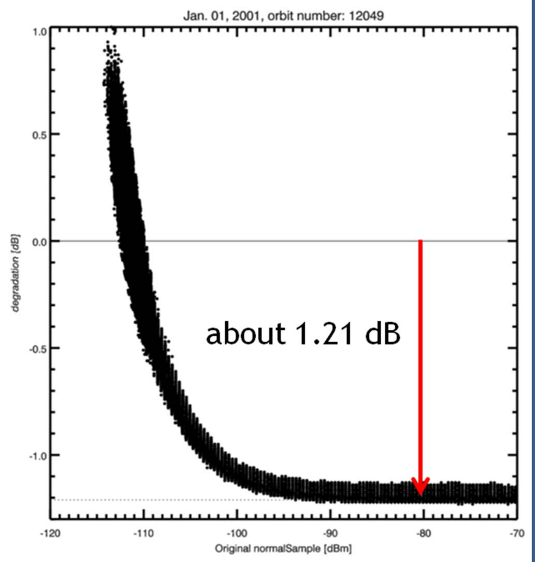
$$P_r(r) = \frac{C|K|^2}{r^2} Z_m$$

If a distance of a target is changed from r m to r+52500 m, a degradation of the radar sensitivity ΔP:

$$\Delta P = [P_r(r+52500)] - [P_r(r)]$$
$$= [r^2] - [(r+52500)^2]$$
$$= 20\log_{10}\left(\frac{r}{r+52500}\right)$$

where P_r is a received power.

(cf. if r=350000 [m], ΔP ≒-1.21 [dB])



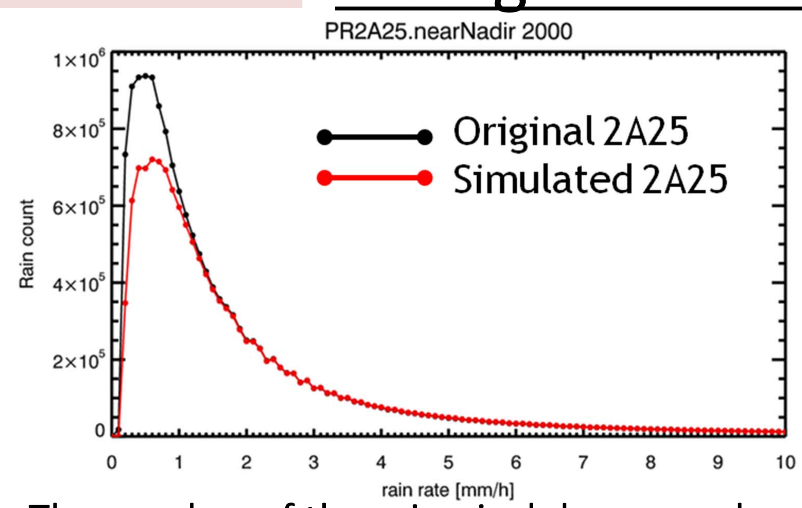
We introduced the following methodology into TRMM PR standard 1B21 algorithm.

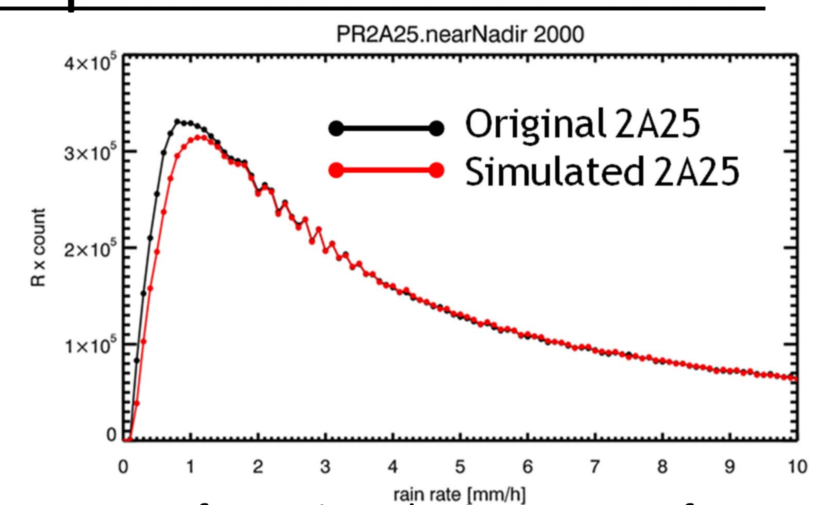
1. The echo power of precipitation, S, is calculated from the received power P. In this simulation, we assumed the noise power, N, is kept the same value.
$$S = 10\log_{10}(10^{P/10} - 10^{N/10})$$
2. The simulated echo power from precipitation, S', is calculated by subtracting the degradation from the echo power S.
$$S' = S - A, \quad A = 20\log_{10}\left(\frac{r+52500}{r}\right)$$
3. The simulated received power is calculated by adding the noise power to the simulated signal S'.
$$P' = 10\log_{10}(10^{S'/10} + 10^{N/10})$$

$$\Rightarrow \quad P' = 10\log_{10}[10^{P/10} + 10^{N/10}(10^{A/10} - 1)] - A$$

5. Result

Histogram of rain pixel and rain amount



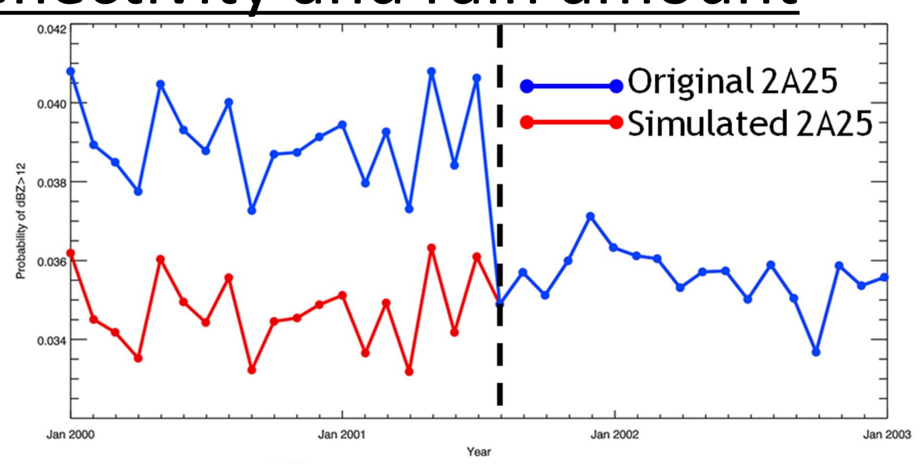


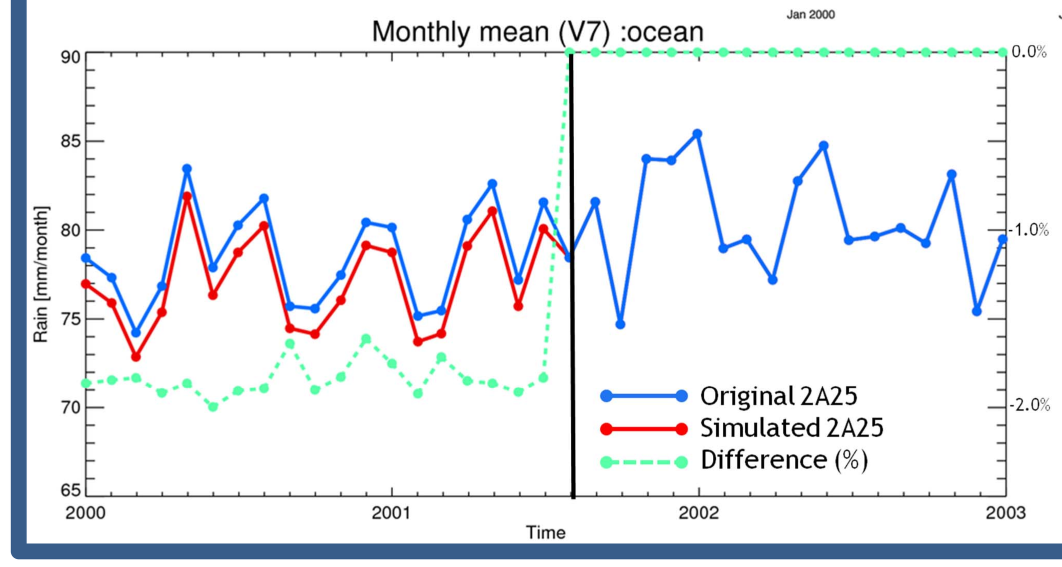
The number of the rain pixel decreases by an average of 10.8%, and rain amount of simulated data decreases by an average of 1.9 %.

Time series of radar reflectivity and rain amount

Monthly time series of the probability of path-averaged reflectivity greater than 12 dBZ.

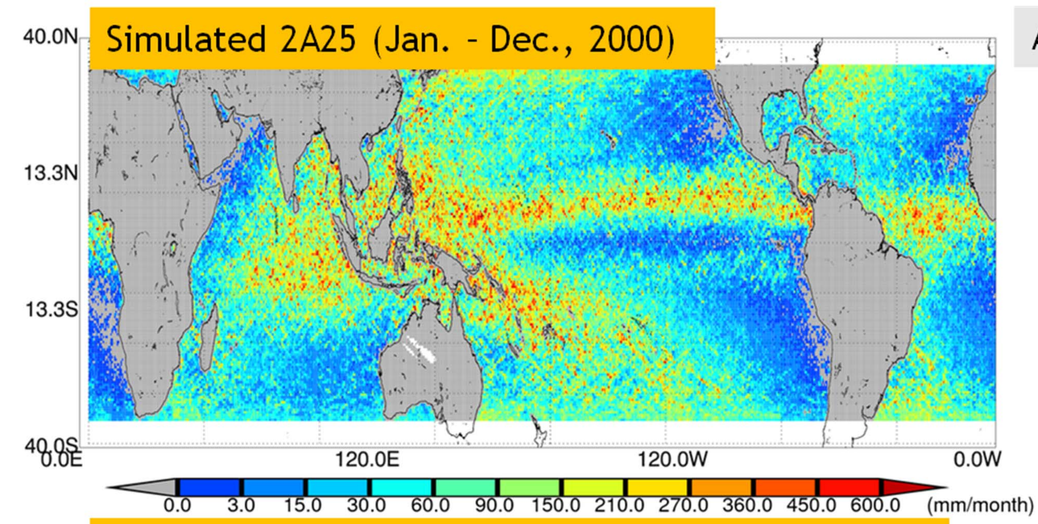
The time series of the simulated 2A25 reduce discontinuity before and after the orbit boost.





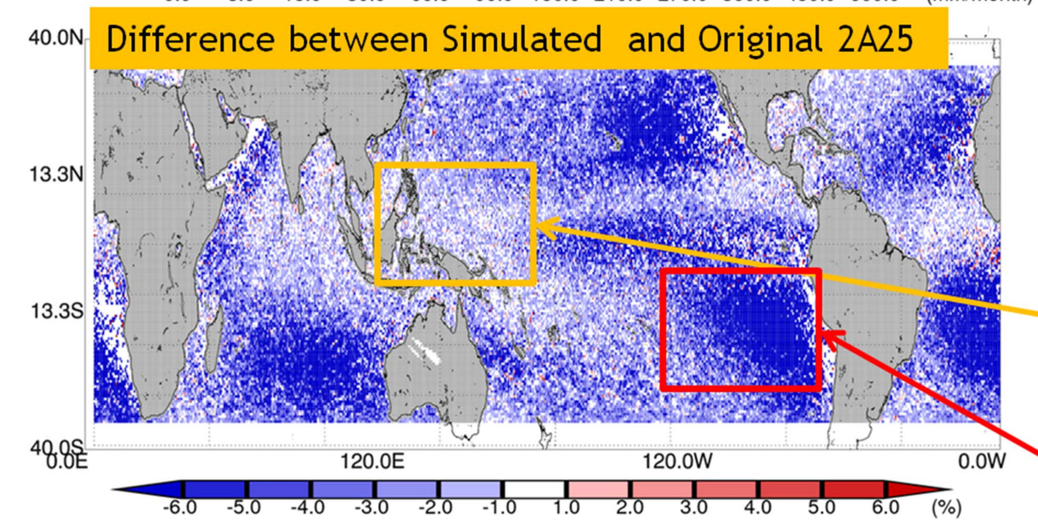
Differences of the monthly rainfall amounts between original and simulated 2A25 are from -1.64% to -1.92%.

Global pattern of rain amount and the difference



Average rainfall amount over ocean

Original 2A25	78.64 [mm/month]
Simulated 2A25	77.14 [mm/month]
Difference	-1.90 [%]

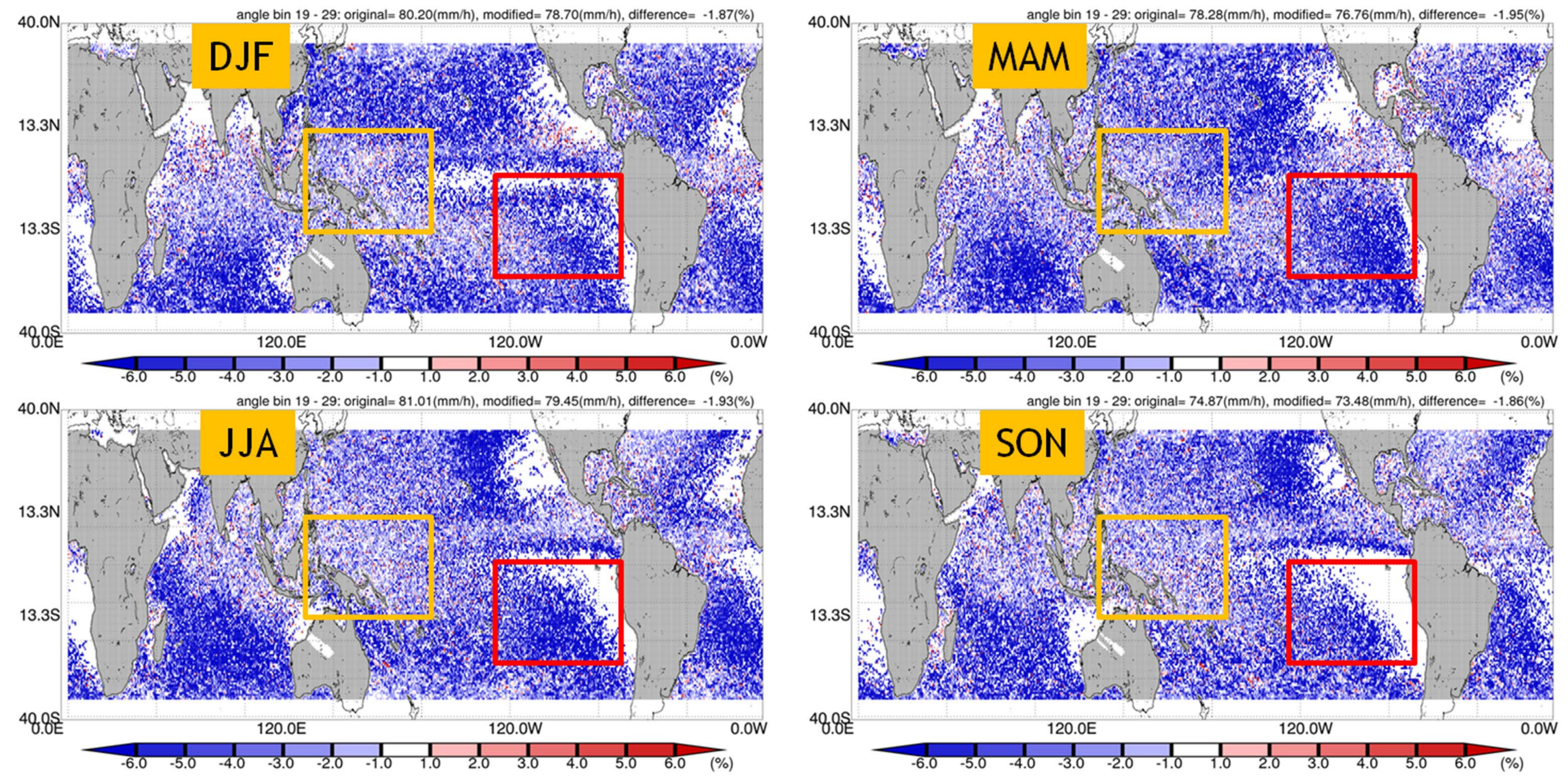


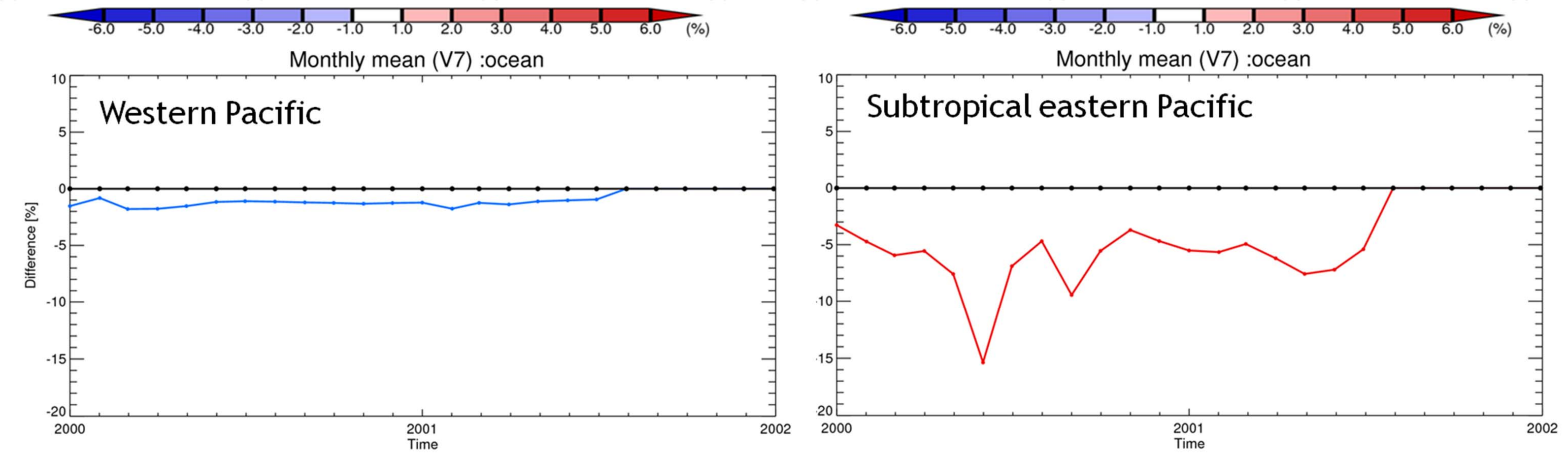
The decrease of rainfall amount varies temporally and spatially.

Western Pacific -1.30%

Subtropical eastern Pacific -5.27%

Seasonal variation of the differences





6. Summary and future work

- We made a reduction of discontinuity in PR rainfall product due to the orbit boost.
  - We simulate the degradation of the radar sensitivity in the dataset.
- We investigate the impact of the simulated PR rainfall products.
  - The discontinuity of a time series of the area-weighted probability of path-averaged dBZ > 12 was mitigated.
  - The number of rain pixels decreases by an average of about 10%. And most of the missing pixels have the light rain rate (< about 1 mm/h).
  - The total rainfall amount of the simulated products is about 1.9% lower than the original products.
  - The decrease of rainfall amount varies temporally and spatially.
- Future work
  - We will simulate the degradation of the radar sensitivity over land. The products will be investigated.