NMSC

Application of Cumulative Probability Distribution Function to Compositing Precipitable Water with LEO

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Introduction

- Precipitable water (PW) data are retrieved from various Low Earth Orbit (LEO) satellite measurements such as NOAA-18,19, MetOp-A,B, Suomi-NPP, and so on. And forecasters want to know more dense distribution of PW from many paths of multi LEO on map (Kidder and Jones, 2007).
- When compositing PW retrieved from multi satellites, there are difference among them. Generally, the difference between satellite retrievals is corrected by another reference data.
- In this study, we use Unified Model (UM) Regional Data Assimilation Prediction System (RDAPS) analysis data as the reference data. And we use direct reception LEO data of the National Meteorological Satellite Center (NMSC) as the observation data.
- The cumulative probability distribution function (CDF) matching method matches the CDF of the precipitable water (PW) retrieved from the LEO with the CDF of the reference PW to lessen their differences (Kidder and Jones, 2007).
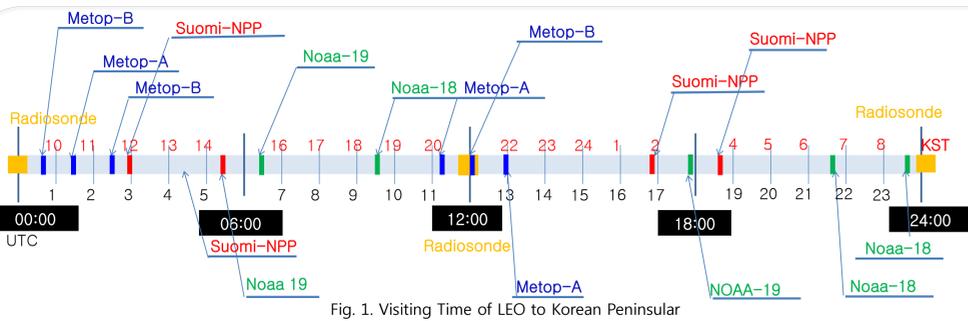
Data & Method

Fig. 1. Visiting Time of LEO to Korean Peninsular

$$PW = \int_{p_{top}}^{p_{bottom}} q \frac{dp}{g} \text{ ------ (1)}$$

TPW : surface-top of atmosphere

BL, ML, and HL : surface to 850 hPa, 850-500 hPa, and 500 hPa–top of atmosphere

LEO data

1. NOAA-18,19, MetOp-A,B(ATOVS)
   Package : IAPP
   Retrieval Res. : 126km×126km
2. Suomi-NPP(CrIS, ATMS)
   Package : NUCAPS
   Retrieval Res. : 50km×50km

Reference data

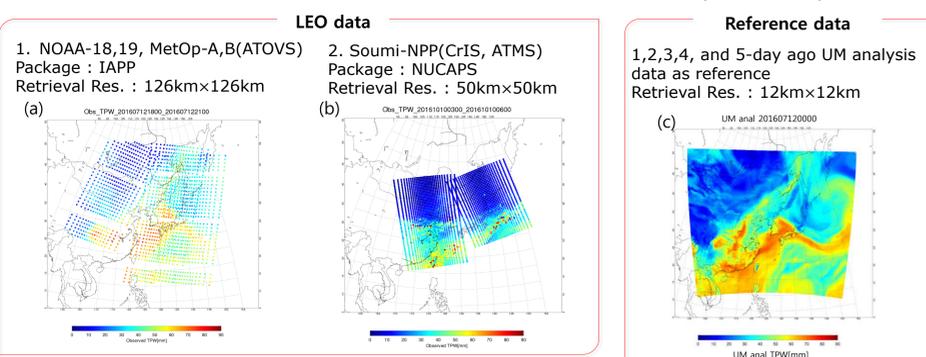1,2,3,4, and 5-day ago UM analysis data as reference
Retrieval Res. : 12km×12km

Fig. 2. Satellite retrieval TPW data and Reference data.
(a) : NOAA-18,19, MetOp-A,B(ATOVS), (b) : Suomi-NPP(CrIS and ATMS), (c) : . Reference data, UM anal TPW
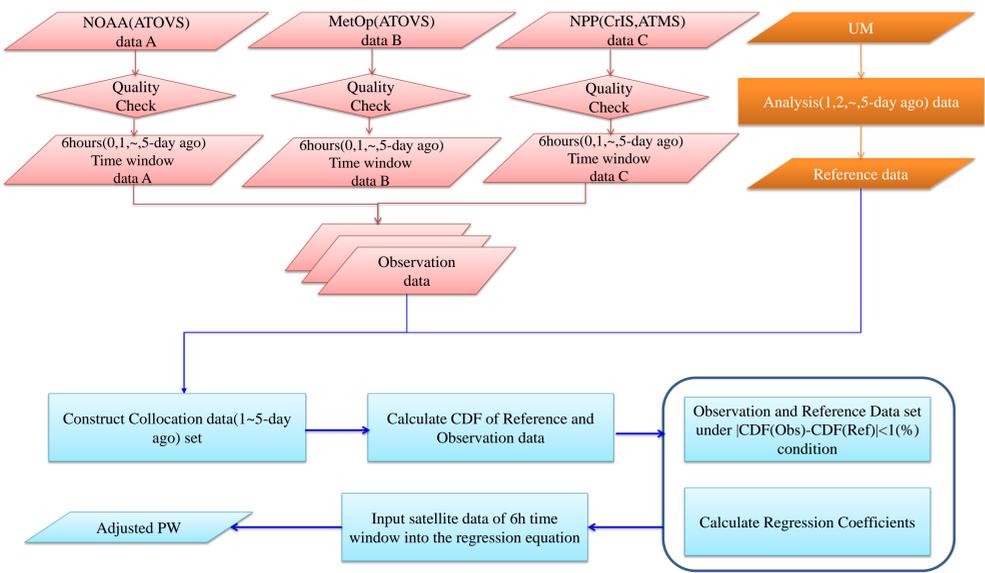

Fig. 3. CDF matching algorithm

Regression Coefficients & CDF Comparison

Data selection Condition : $|CDF(Obs) - CDF(Ref)| < 1\,(\%)$ ------ (2)

Regression equation : $Adjusted\ PW = a_0 + a_1 PW + a_2 PW^2 + a_3 PW^3$ ------ (3)
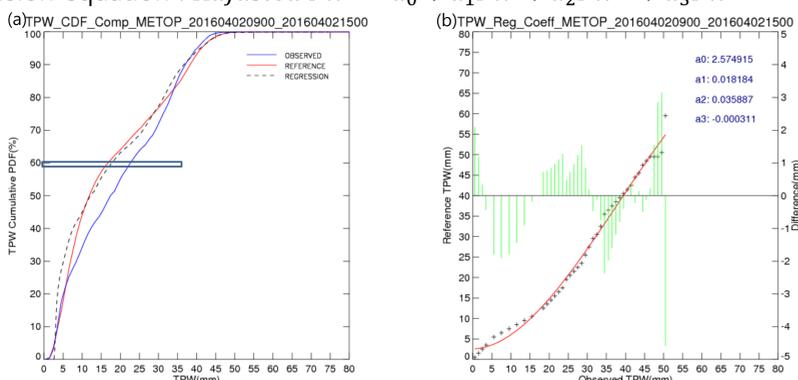

Fig 4. For MetOp case, (a): Condition to select pairs of observed and reference TPW data and CDF of observed, reference, and regression TPW, (b): Calculation of regression coefficients(2016. 4. 2.09:00~2016. 4. 2. 15:00UTC).

Results

CDF comparison & Mapping

- Suomi-NPP(2016. 8. 6. 03:00~ 8. 6. 09:00 UTC)

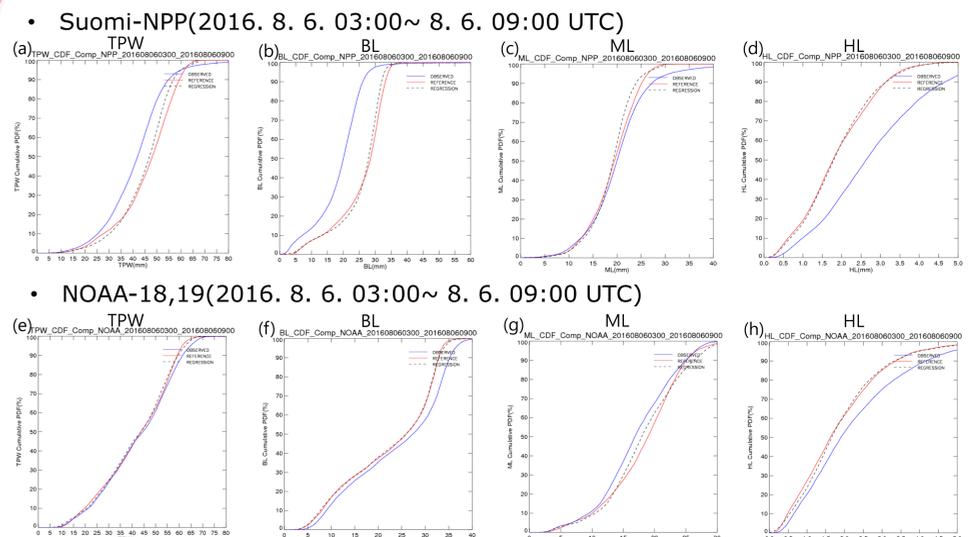- NOAA-18,19(2016. 8. 6. 03:00~ 8. 6. 09:00 UTC)

Fig. 5. PW CDF comparison(2016. 8. 5. 21:00~ 8. 6. 03:00 UTC). (a), (b), (c), (d) : TPW, BL, ML, and HL CDF Comparison for Suomi-NPP. (e), (f), (g), (h) : TPW, BL, ML, and HL CDF Comparison for NOAA-18,19.

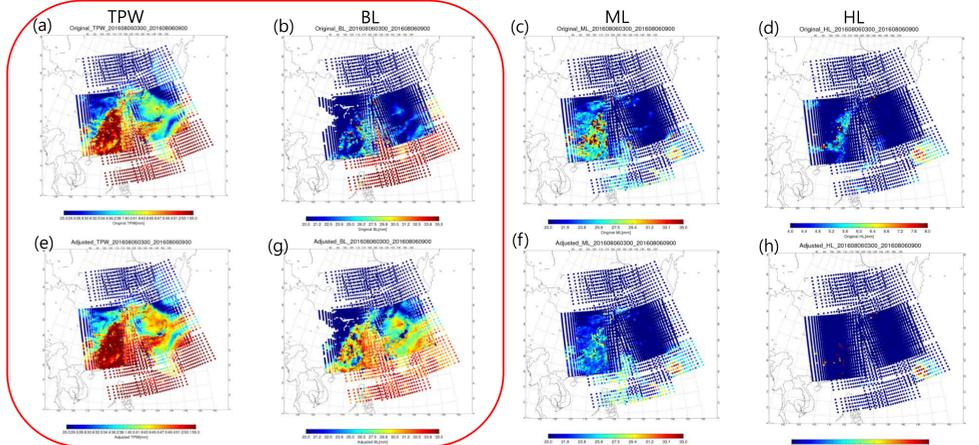- Mapping(2016. 8. 6. 03:00~ 8. 6. 09:00 UTC)

Fig. 6. For NOAA and NPP case, (a), (b), (c), (d):Original TPW, BL, ML, and HL, (e), (f), (g), (h):Adjusted TPW, BL, ML, and HL, (i), (j), (k), (l):TPW, BL, ML, and HL difference between original and adjusted TPW, BL, ML, and HL at 2016. 8. 6. 03:00 ~ 8. 6. 09:00 UTC time window.

Validation

- Truth : Radio Sonde data
- Region : East Asia
- Target : LEO retrieval and Regressed PW data
- Time window : 03:00-09:00, 09:00-15:00, 15:00-21:00, and 21:00-03:00
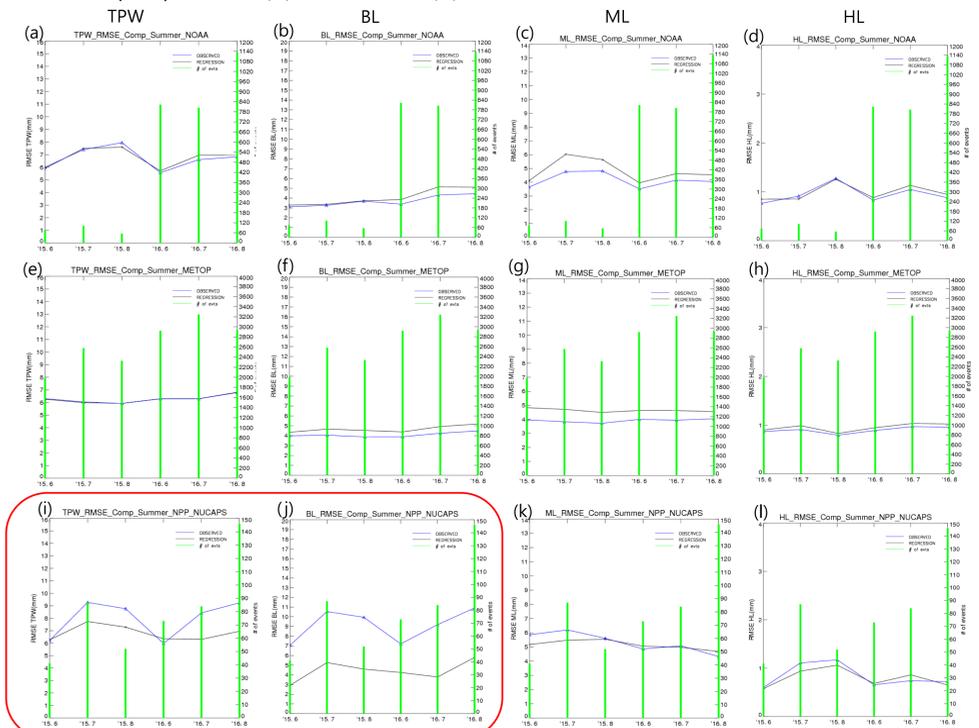- Period(UTC) : 2015. 6,7,8 and 2016. 6,7,8 months

Fig 7. Validation results of regression and observed TPW, BL, ML, and HL for Suomi-NPP. (a), (b), (c), (d) : NOAA RMSE, (e), (f), (g), (h) : MetOp RMSE, and (i), (j), (k), (l) : Soumi-NPP RMSE for summer season in 2015 and 2016.

- The validation results of composited TPW and BL from Suomi-NPP are improved about 15% and 40% in RMSE.

Summary and Conclusion

- Using 5-day UM analysis PW data as reference data and PW data retrieved from direct reception LEO data of NMSC as observation data, the CDF matching method is operated.
- The reference data that match with observation data are time and spatial–dependent. The time windows are 03:00-09:00, 09:00-15:00, 15:00-21:00, 21:00-03:00 UTC.
- After the method, the accuracy of TPW and BL retrieved from Suomi-NPP using NUCAPS is approved in RMSE. Especially, the ratios of improvement of Suomi-NPP BL is much better than the other PW retrieved from the LEO of NMSC.