All-sky Assimilation of the MWHS-2 Observations and Evaluation the Impacts on the Forecasts of Typhoons

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Introduction

- The *satellite observations* in the modern numerical weather prediction (NWP) makes a great impact on the improvement of the weather forecasts.
- Due to *cloud and rain contamination*, only a very small portion of satellite observations would really be used, and NWP centers employ the approach of *clear-sky (cloud free) radiance assimilation*.
- It is necessary to make good used of the *cloud- and precipitation- affected observations (all-sky)* because many severe weather processes are associated with clouds.

FY-3C MWHS-2

Channel Number	Central Frequency (GHz)	Peak Height (hPa)	Sensitive	Horizontal Resolution (km)
1	89 (V)	/	window channel	32
2	118.75±0.08 (H)	20	temperature	32
3	118.75±0.2 (H)	60		32
4	118.75±0.3 (H)	100		32
5	118.75±0.8 (H)	250		32
6	118.75±1.1 (H)	300		32
7	118.75±2.5 (H)	700	temperature, humidity	32
8	118.75±3.0 (H)	/	temperature, cloud and precipitation	32
9	118.75±5.0 (H)	/		32
10	150 (V)	/	window channel	16
11	183±1.0 (H)	350	humidity	16
12	183±1.8 (H)	400		16
13	183±3.0 (H)	500		16
14	183±4.5 (H)	550		16
15	183±7.0 (H)	650		16

Methodology

1. WRFDA

The *WRFDA* system and its *3D-VAR* component will be employed which aims to obtain a statistically optimal analysis through an iterative minimization of a prescribed cost function:

$$J(\mathbf{x})=\frac{1}{2}(\mathbf{x}-\mathbf{x}_b)^{\mathrm{T}}\mathbf{B}^{-1}(\mathbf{x}-\mathbf{x}_b)+\frac{1}{2}(\mathbf{y}-H(\mathbf{x}))^{\mathrm{T}}\mathbf{R}^{-1}(\mathbf{y}-H(\mathbf{x}))$$

Note:

- *H*: *RTTOV-SCATT*, requires hydrometeor profiles (obtained from the 12-hr forecast)
- B: estimated by the ***NMC*** method

2. Emissivity Retrieval

The presence of *clouds and precipitation* can affect the emissivity estimate in all-sky conditions, especially for the 183 GHz.

$$\varepsilon_{(\theta,\nu)}=\frac{T_b-(T^{\uparrow}_{(\theta,\nu)}+T^{\downarrow}_{(\theta,\nu)}\Gamma_{(\theta,\nu)})}{(T_s-T^{\downarrow}_{(\theta,\nu)})\Gamma_{(\theta,\nu)}}$$

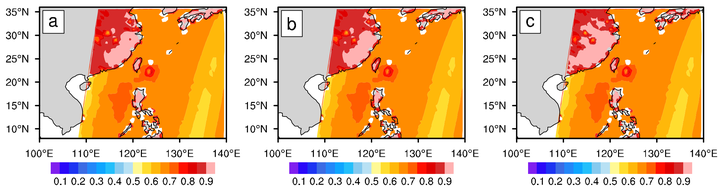


Figure 1. The emissivities from the atlas (a), clear-sky emissivities retrievals (b) and all-sky emissivities retrievals (c) for MWHS-2 channel 15.

3. Observation Errors

- ✓ The *scattering index* (SI) is used to measure cloud amount (scattering effect: $TB_{150} > TB_{90}$)
- ✓ A *symmetric error model* (Geer and Bauer 2010, 2011) will be used to estimate the observation errors of the cloud- and precipitation- affected radiance data.

$$SI_{ocean}=(TB_{90}-TB_{150})-(TB^{clr}_{90}-TB^{clr}_{150}) \qquad C_{SYM}=\frac{SI_{obs}+SI_{FG}}{2}$$

$$g(C_{SYM})=\begin{cases} g_{clr} & \in C_{SYM}\le C_{clr} \\ g_{clr}+(g_{cld}-g_{clr})\left(\dfrac{C_{SYM}-C_{clr}}{C_{cld}-C_{clr}}\right)^2 & \in C_{clr}<C_{SYM}<C_{cld} \\ g_{cld} & \in C_{SYM}\ge C_{cld} \end{cases}$$

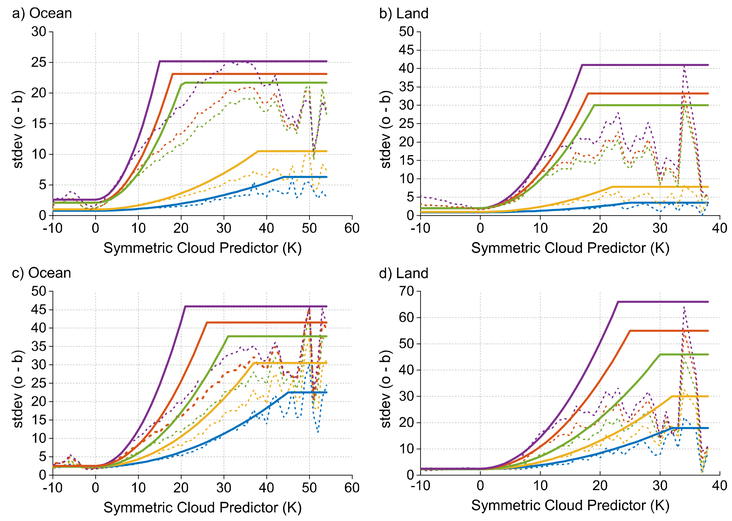
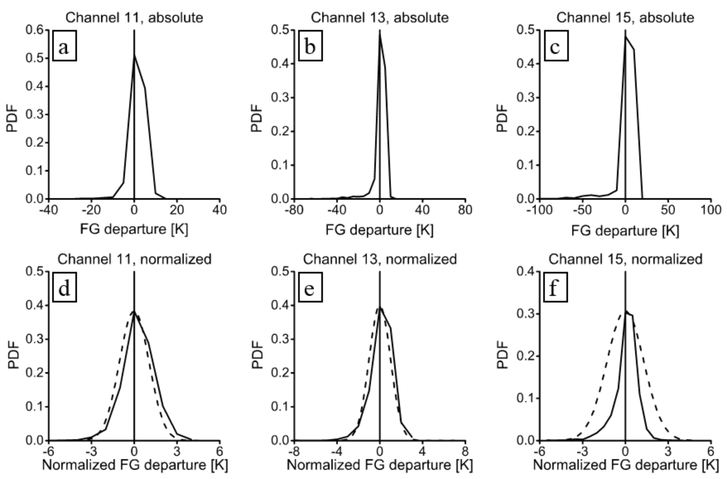


Figure 2. Standard deviation of MWHS-2 first guess departures (dash line) as a function of symmetric cloud predictor for channels 5-9 (top) and 11-15 (bottom) over ocean (left) and land (right), along with the applied observation errors (solid line).

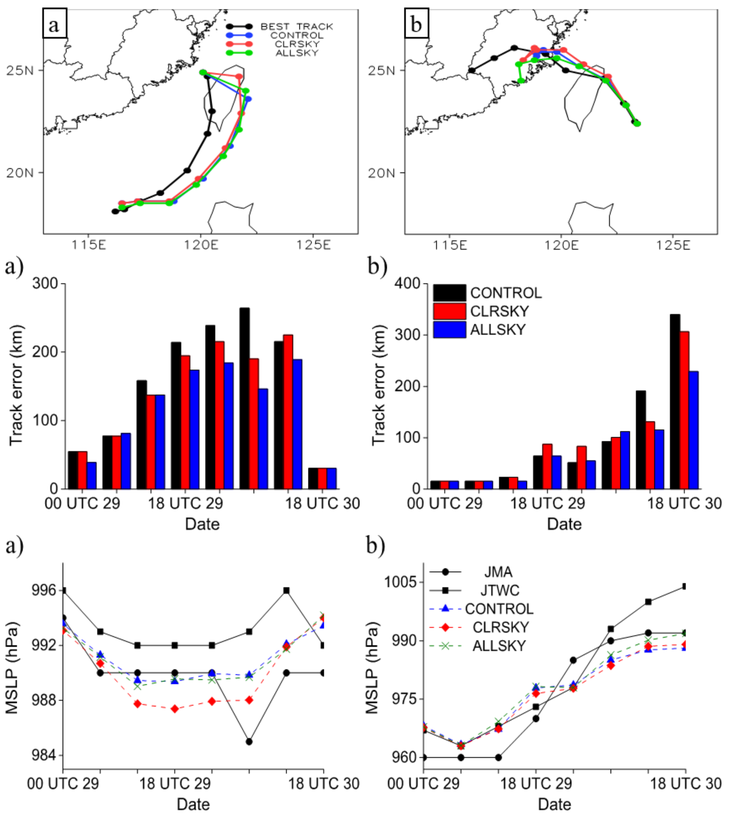
Results

Binary Typhoons Haitang and Nesat occurred in 2017 are selected to access the impacts of assimilating MWHS-2 radiances on the forecasts of typhoons, three experiments (*CONTROL*: without data assimilation; *CLRSKY* and *ALLSKY*) are carried out.

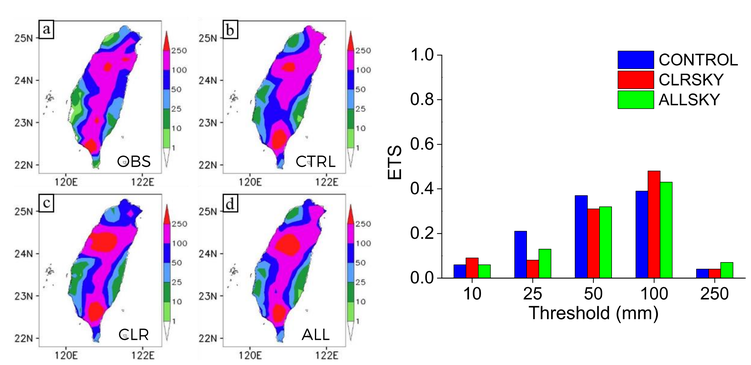
1. The symmetric observation error model can transform a highly non-Gaussian PDF into a more Gaussian.



2. All-sky assimilation makes better performances in the forecasts of tracks and intensities of binary typhoons.



3. All-sky assimilation has an ability to predict heavy rainfall caused by typhoons.



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- Xian, Z., Chen, K., & Zhu, J. (2019). All-sky assimilation of the MWHS-2 observations and evaluation the impacts on the analyses and forecasts of binary typhoons. *Journal of Geophysical Research: Atmospheres*.