

The study on the reproducibility of cold collar assuming radio occultation measurement by small satellites

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1. Introduction

◆ Cold collar

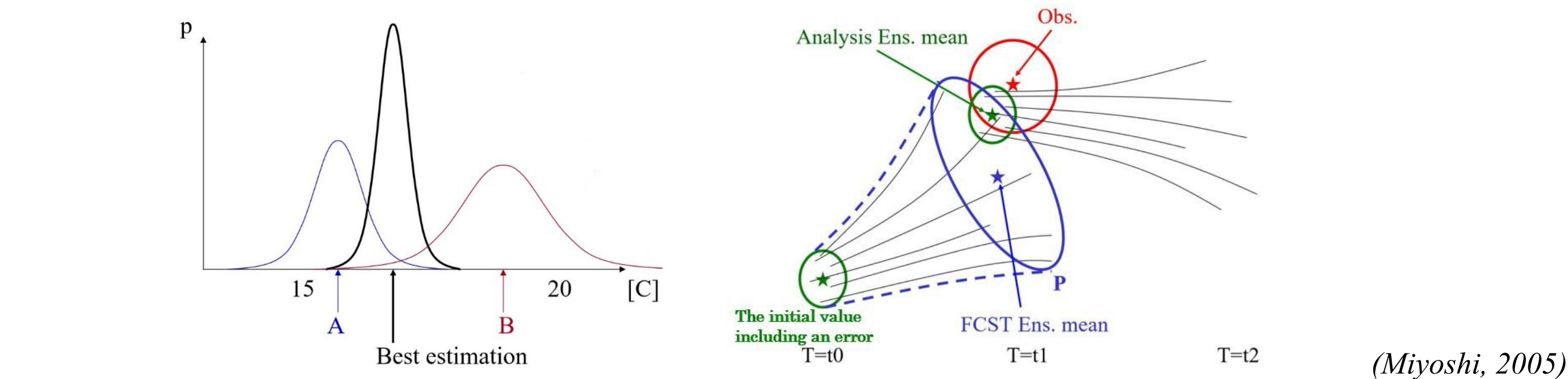
- A structure where the temperature at 60-80° latitude is lower than that of polar region at the altitude of about 65 km

◆ AFES-Venus

- Venusian atmospheric GCM based on AFES (Atmospheric GCM For the Earth simulator) (Sugimoto+2014a,b...)

◆ LETKF (Local Ensemble Transform Kalman Filter)

- One of the ways of the data assimilation for the Earth and Mars

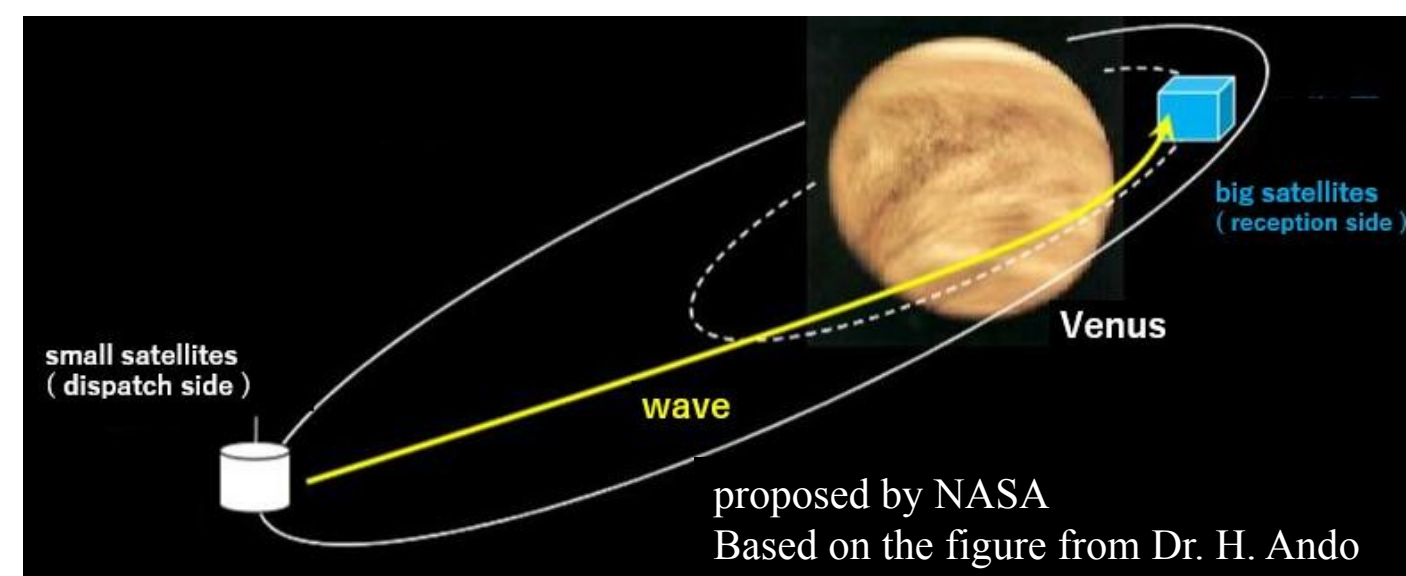


◆ Venus AFES LETKF Data Assimilation System (VALEDAS)

- The first data assimilation system for the Venusian atmosphere (Sugimoto+2017, 2019)

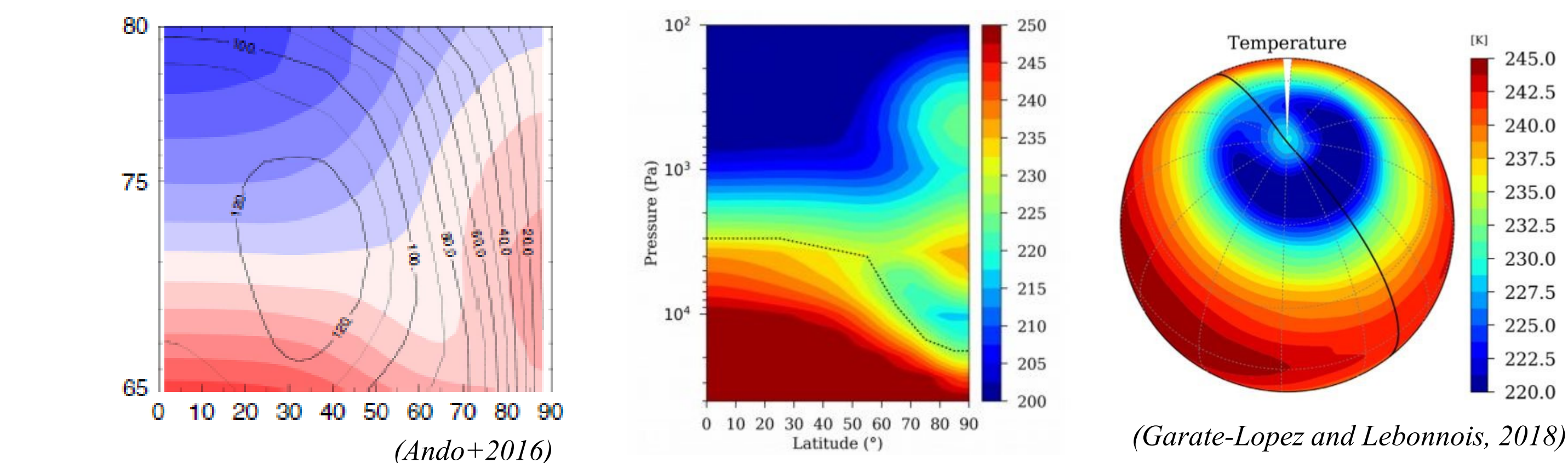
◆ Radio occultation (RO) measurement by small satellites

- High resolution vertical temperature profiles can be obtained
- Frequency is much more than previous observations between the Earth and a satellite



◆ French Venusian GCM (LMD/IPSL VGCM)

- French Venus atmospheric GCM in which cold collar is realistically reproduced



Preparing idealized observation data from LMD VGCM

(Garate-Lopez and Lebonnois, 2018)

Investigating the effectiveness of RO by satellites with OSSE (observing system simulation experiments) using VALEDAS

“How many observations, satellites are needed?”

Evaluating by the cold collar reproducibility

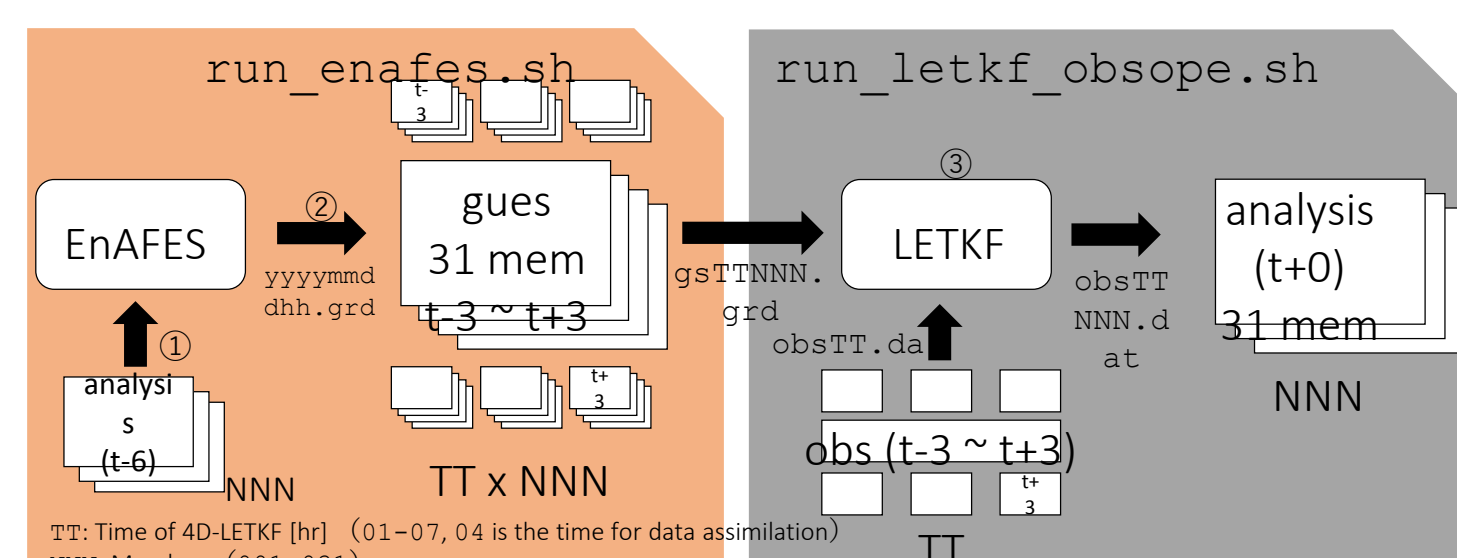
2. Experimental setting

• Venusian atmospheric GCM (AFES-Venus)

- 3-D Primitive equation on sphere (hydro static balance) without moist processes
- Resolution: T42L60 (128 × 64 × 60)
- Initial value: zonal wind assuming super rotation
→ Spin up for 4 Earth years
(obtained wind value is good agreement with observed value)
- Specific heat: C_p is constant (1000 Jkg⁻¹K⁻¹)
- No topography and planetary boundary layer
- Solar heating: based on Tomasko, (1980) and Crisp, (1989)
- Simplified by Newtonian cooling: $dT/dt = -\kappa(T - T_{ref}(z))$ (Crisp, 1986)

• Data Assimilation (VALEDAS)

- Ensemble member number: 31
- Cycle of data assimilation: 6 h
- Observation window: 1h
- Inflation: 10 %
- 9-hour forecast from $t=0$ and use from $t=3$ to $t=9$ for the assimilation
- Input observations from $t=3$ to $t=9$ and output reanalysis at $t=6$ (=4D LETKF)



The details of VALEDAS are shown in P28

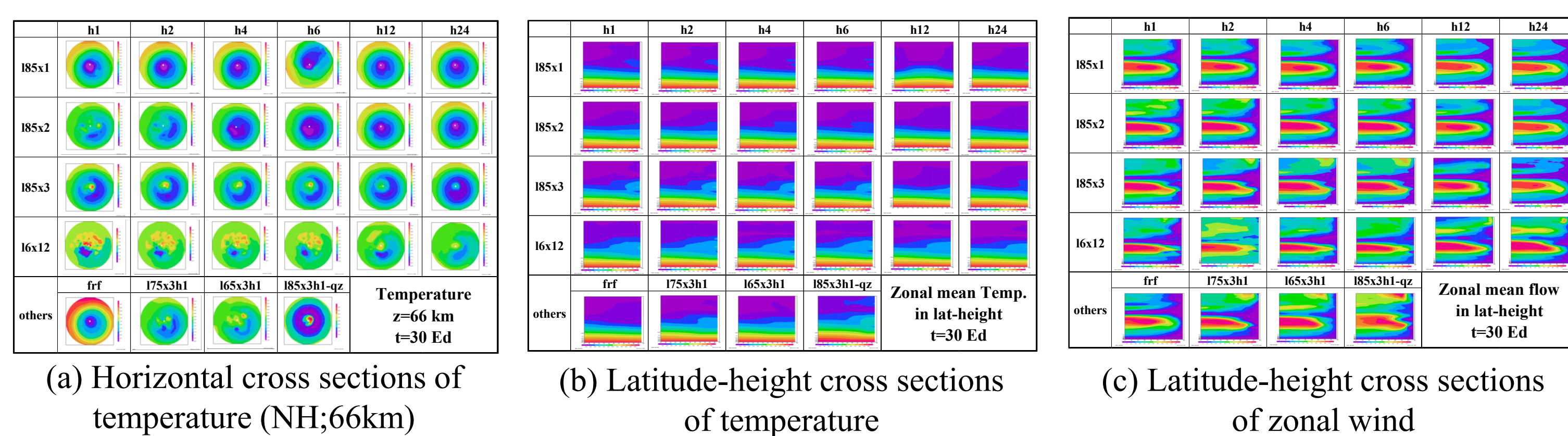
• Idealized observation(LMD/ISPL VGCM)

- Vertical (40-90km) temperature distribution of a fixed point on the Northern Hemisphere (NH) assuming RO
- Observation period and error: 1 month and 3K
- Observation changed its condition number: 28

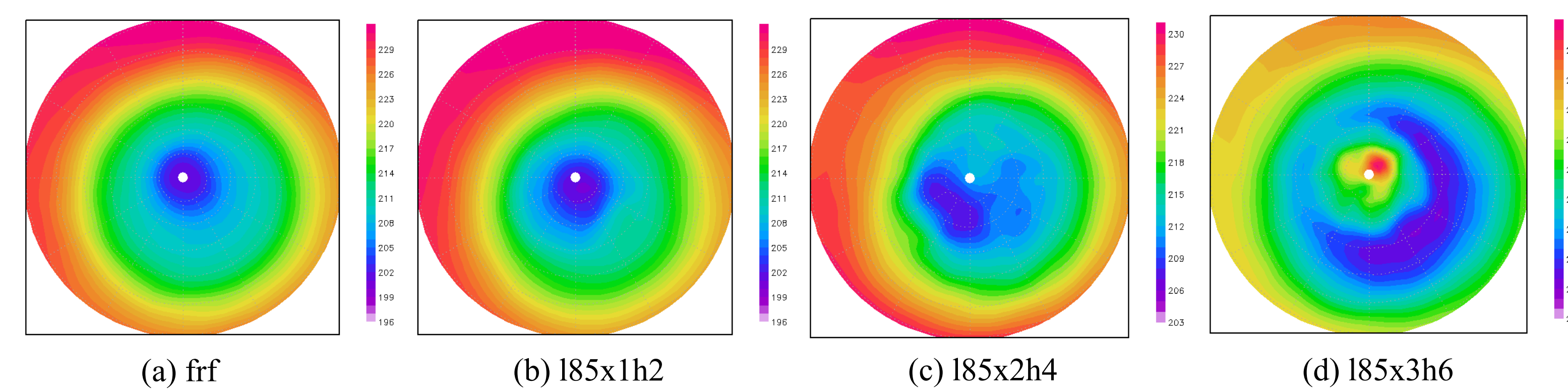
185x1	h1	h2	h4	h6	h12	h24
185x2	h1	h2	h4	h6	h12	h24
185x3	h1	h2	h4	h6	h12	h24
16x12	h1	h2	h4	h6	h12	h24
Others	Frfr	175x3h1	165x3h1	185x3h1-qz		

185 = latitude 85 degree north
x3 = 3 points in the longitudinal direction
h1 = hourly observations
16 = latitude 60, 65, 70, 75, 80, 85 degree north
Frfr = free run forecast
qz = Qz forcing (without thermal tides)

3. Result



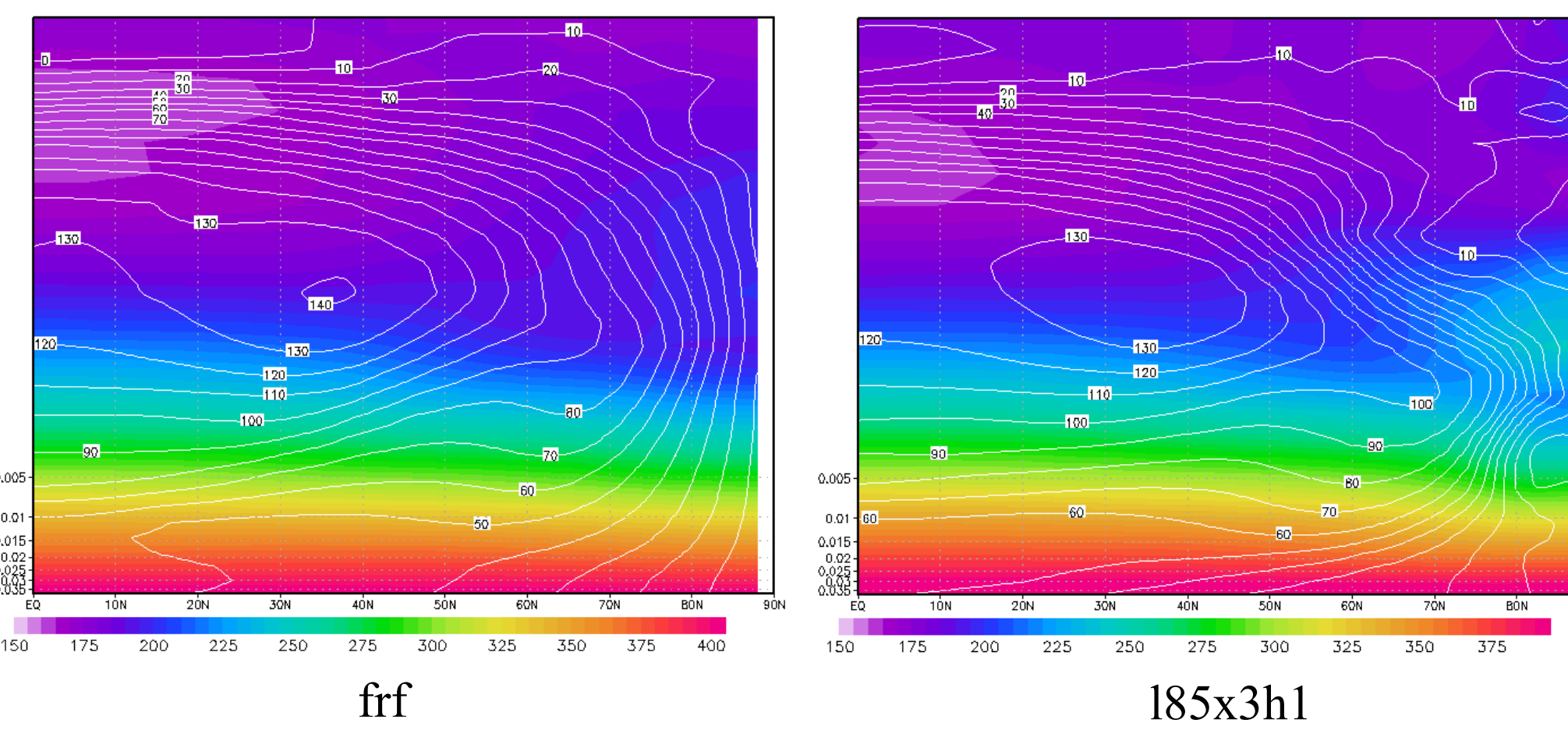
◆ Temperature for the cases with 12 observations per a day (NH, 66 km)



Cold collar is reproduced only in 185x3h6.

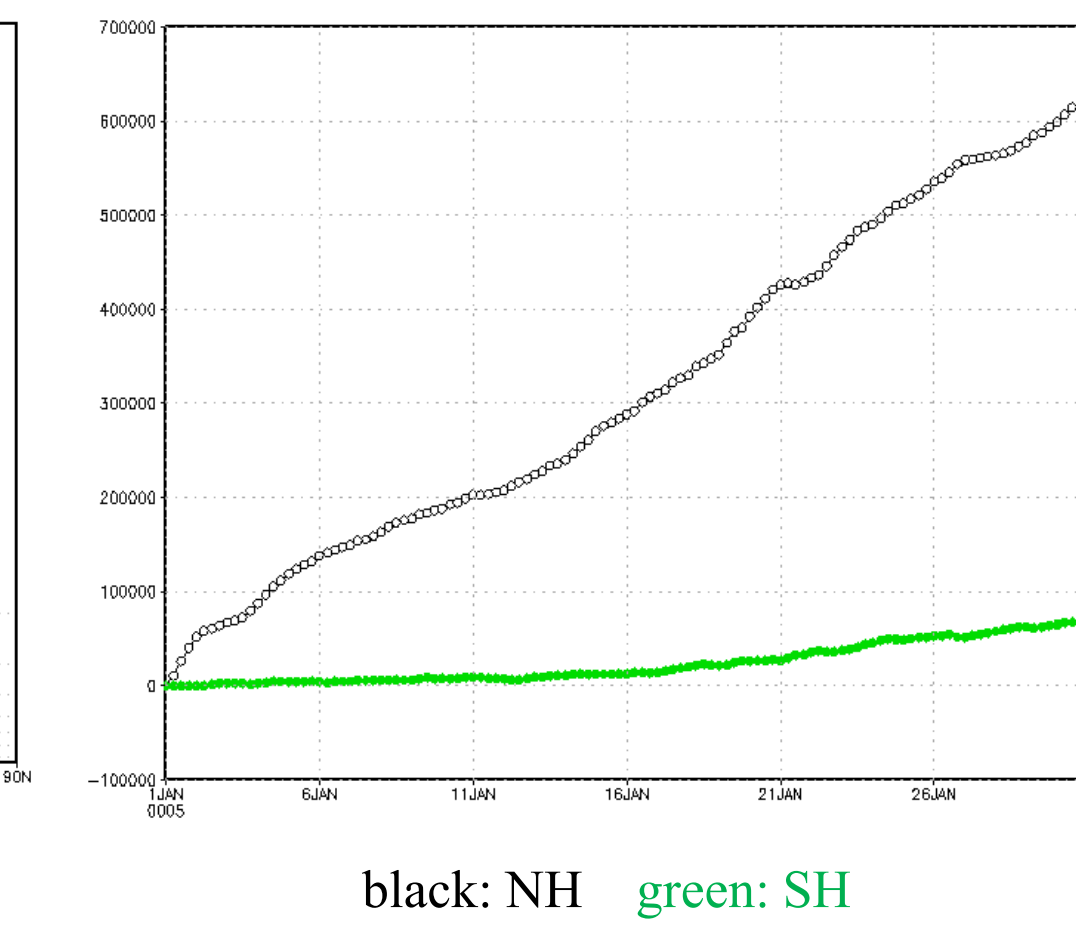
The number of the observation points are more important than the frequencies.

◆ Latitude-height cross sections of zonally averaged zonal wind (contour) and temperature (color)



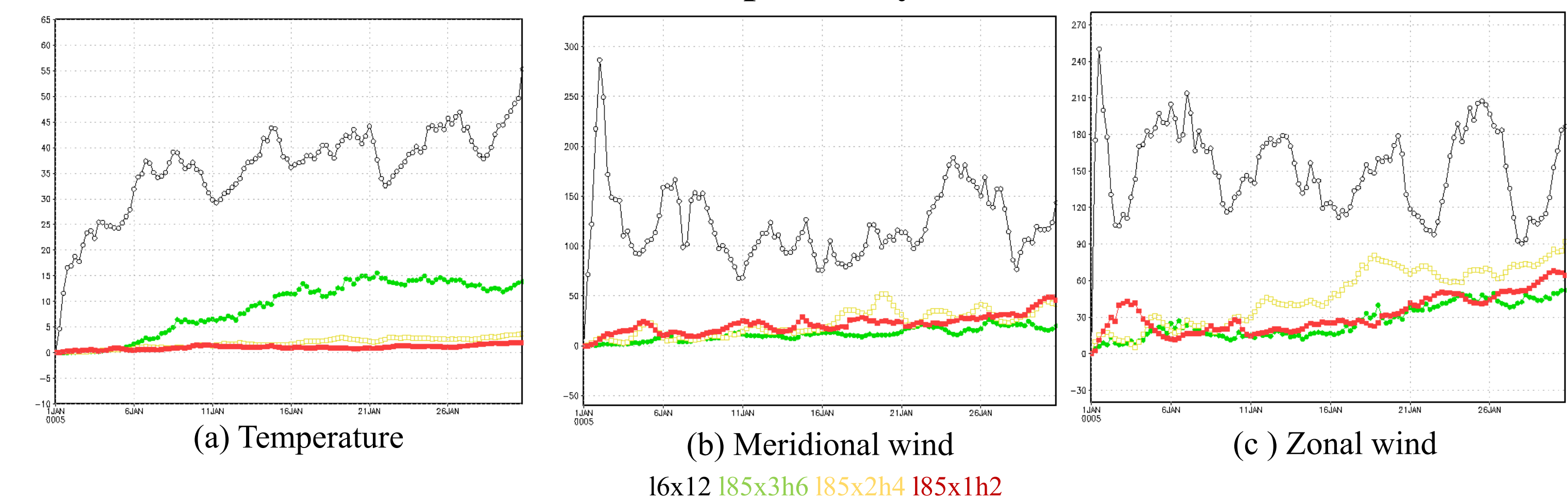
Although only temperature is observed, zonal wind also changes

◆ Root-mean-square-deviation of the global temperature (185x3h1)



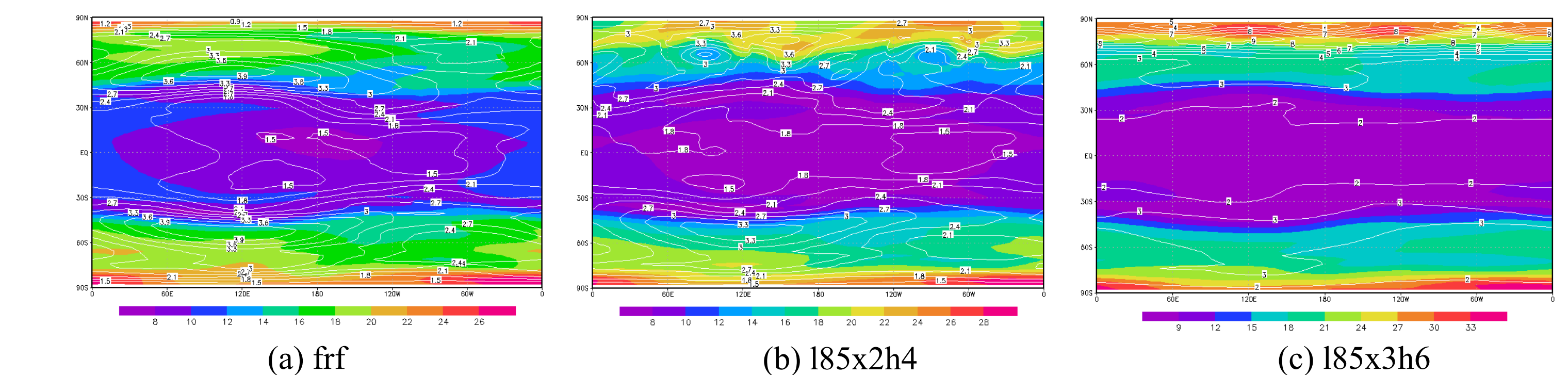
Although only temperature on the NH are assimilated, those on the SH also change

◆ Root-mean-square deviation at 66km for the cases with 12 observations per a day and 16x12

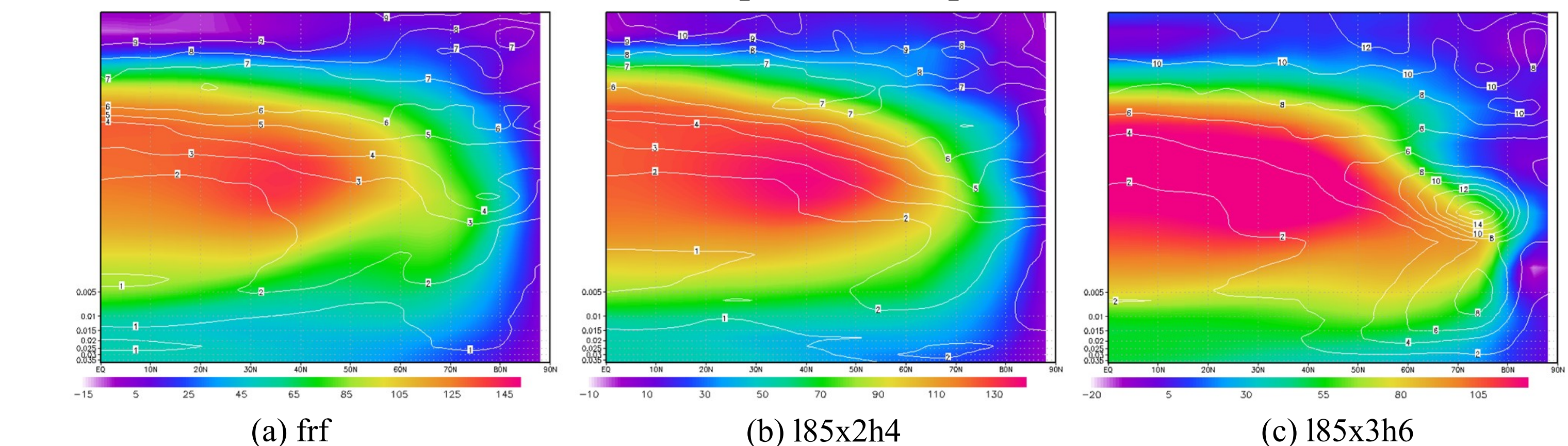


Increasing the number of observation points improves temperature fields

◆ Horizontal cross sections of spread (66km) spreads of zonal wind (color) and temperature (contour)



◆ Latitude-height cross sections of spread (40-90km) zonal mean zonal wind (color) and spread of temperature (contour)



Improvements of zonal wind and temperature fields have an impact on disturbance fields

4. Conclusion

In this study, test data assimilation was conducted assuming radio occultation measurement by small satellites

Idealized observation was evaluated by reproducibility of cold collar

- ✓ The number of **observation points** is more important than the frequencies
- ✓ Cold collar is reproduced if the observation are **3 vertical profiles** 6-hourly
- ✓ Even **the observation of temperature** influenced the wind fields

➤ It is possible to observe 3 vertical points with 2 or 4 hourly for the radio occultation measurements by 3 satellites

➤ Cold collar and wind fields would be improved by such observations



It is expected that radio occultation measurement by small satellites will be promising (at least) to reproduce of cold collar

Acknowledgements

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