Uncertainty of temperature sounding caused by the variation of CO_2 concentration

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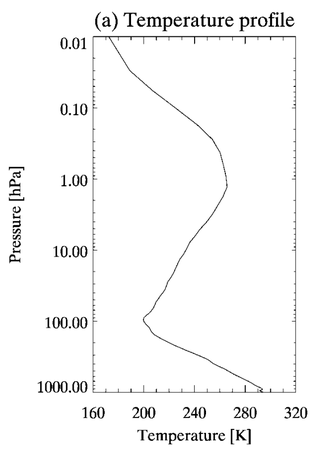
Introduction

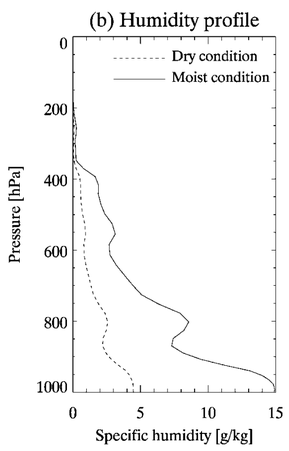
The basic assumption of temperature sounding is that absorption gas is vertically well mixed. Carbon dioxide can satisfy this assumption if infrared satellite observations are used to retrieve the temperature structure. However, CO_2 concentrations have increased steadily and regional concentration distributions are not homogenous, especially. It may cause the uncertainty of temperature sounding. In this study, we evaluated the uncertainty of temperature sounding caused by the variation of CO_2 concentration within the framework of the optimal estimation.

Datasets

- **ECMWF 91-level profile datasets**

One atmosphere profile (true profile) was randomly selected from this data to simulate observation (AIRS infrared observation) and background for the optimal estimation.

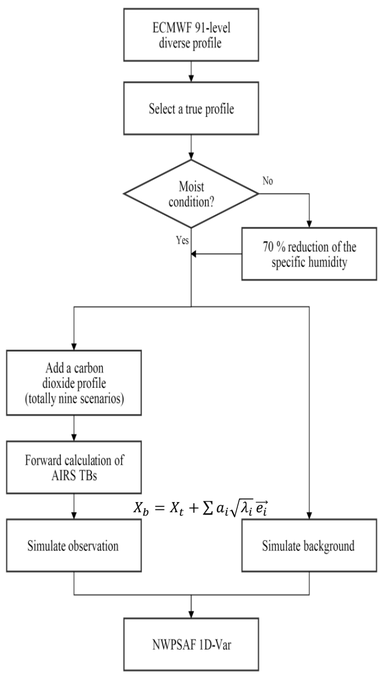




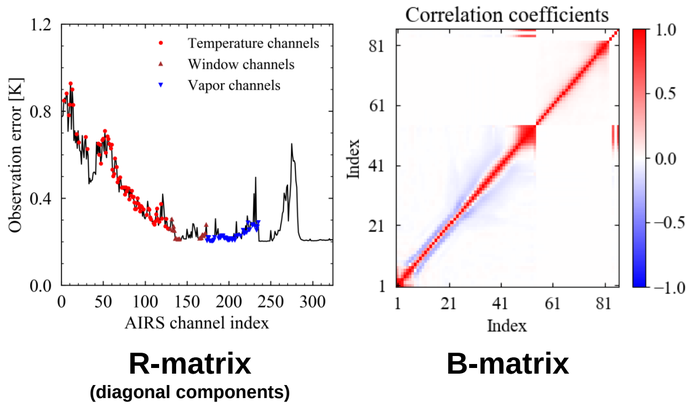
- For an additional investigation of humidity effect on the temperature sounding.
- Dry condition was obtained by a 70 % reduction of the specific humidity in the moist profile.

Methods

- We run the NWPSAF 1D-Var package to retrieve the temperature profile (sample size : 10,000).



NWPSAF error covariance matrix

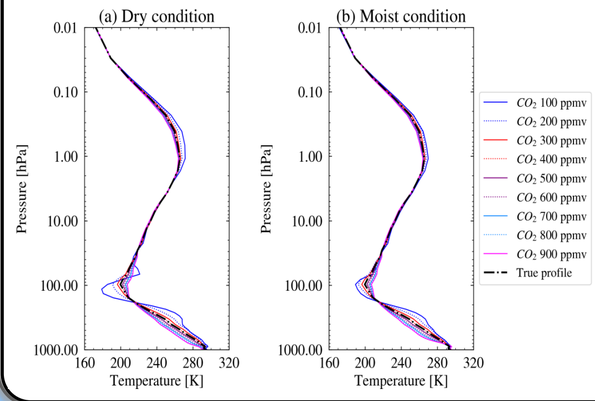


R-matrix (diagonal components) **B-matrix**

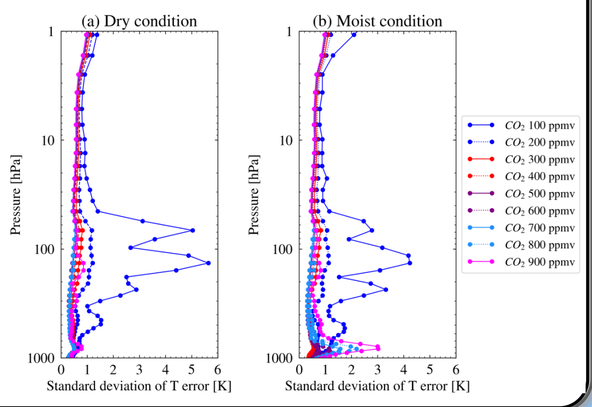
- Totally **9 CO_2 concentration scenarios** (100, 200 … 900 ppmv).

Results 1: Temperature profile retrieval

Mean temperature profiles

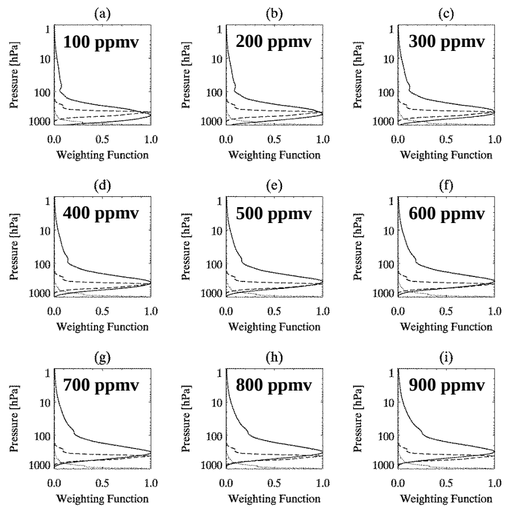


Standard deviation profiles of retrieval error

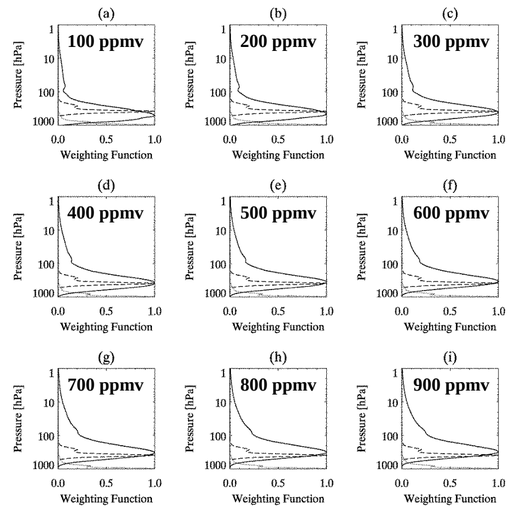


Results 2: Calculation of weighting function

Variation of the weighting function depending on the CO_2 concentration

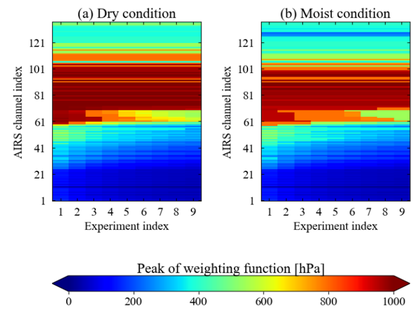


Dry condition



Moist condition

Variation of the peak of weighting function



- Calculation of weighting function (W)

$$W = \frac{\partial T}{\partial lnp} \approx \frac{T_i - T_{i+1}}{\ln(\frac{p_{i+1}}{p_i})}$$

T_i : transmittance from atmospheric level i to TOA. (calculated by RTTOV v11.1)

Conclusions

- The relatively large uncertainties of the temperature sounding were found in lower and upper atmosphere, for extremely high and low CO_2 concentration, respectively.
- For high CO_2 situations, the peaks of the weighting function for temperature sounding channels increased and these were resulted in the lack of information used to describe the temperature in the lower atmosphere. The same explanation can be applied for low CO_2 situations.
- Although it is based on the simple and simulation experiment, this study suggests that a significant consideration is required for the temperature sounding under extreme CO_2 conditions.