# Hyperspectral model validation in cloudy radiance space from AIRS


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## Project Overview

*Cloudy infrared spectra are calculated from forecast model output and compared to AIRS (Atmospheric Infrared Radiance Sounder) observations.*

*Retrieved cloud parameters from AIRS are also compared to the equivalent forecast quantities. These parameters are the equivalent height and cloud fraction derived from the $CO_2$-slicing technique [Garand and Beaulne, 2004] . The potential ambiguity created by a different definition of forecast and observed cloud parameters is eliminated by applying the same retrieval technique using observed and calculated radiances from model output.*

## Objectives

- Validate forecast models in cloudy radiance space using AIRS observations
- Validate as well cloud top height and cloud fraction
- Evaluate sensitivity to assumed cloud optical properties used in radiance calculations
- Improve AIRS quality control for assimilation (dependence on cloud height)
- Evaluate models in polar areas as part of International Polar Year

## Methodology

### Data

AIRS 281-channel set for July 2008 reduced to center pixel in 3X3 "golf ball" (*note that in operations warmest pixel is used, not suitable for cloud validations*)

### Forecast model

EC global model, 600 X 800 grid (~35 km), forecasts 3-15-h. Model output every 45 min is available to match with observations

Calculation were made for two forecasts: 3-9 (trial 6h) and 9-12 (trial 12h)

### Radiative transfert model

Modified RTTOV 8 version

### Cloud optical properties

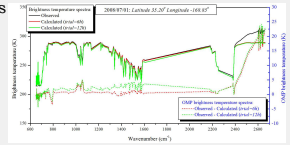
Cloud overlap scheme: [Räisänen, 1998]

Fixed liquid particle size :10 μm radius over land and 13 μm radius over ocean

Ice particle size parameterization: [McFarquhar et al. 2003]

### Output

All sky radiances/brightness temperatures (BT) from model output (one observed and two calculated using the both forecasts



Cloud top pressure(CTP)/height(HT) and cloud fraction(CF) from EC $CO_2$-slicing method using observations and calculated radiances

CTP/HT and CF using directly the model output (cloud matrix)

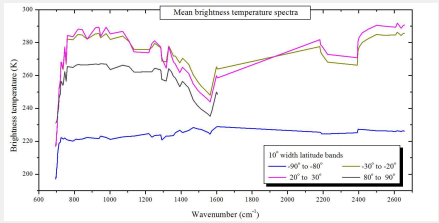
**Additional cloud parameters:**

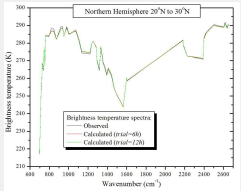
CTP/HT and CF from AIRS Science team

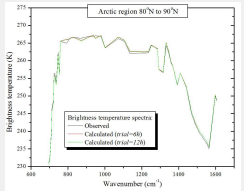
CTP/HT and CF from MODIS Science team

CTP/HT and CF from EC GOES processing

## Results: mean BT spectra



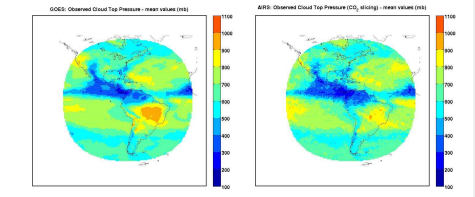




… good agreement between observed and calculated radiances

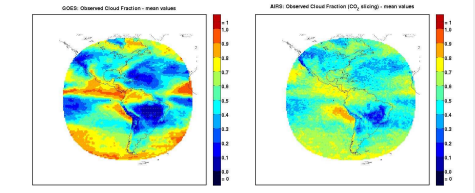
## Results: GOES/AIRS comparisons

Cloud Top Pressure

GOES: 95% coldest pixel | AIRS: coldest pixel

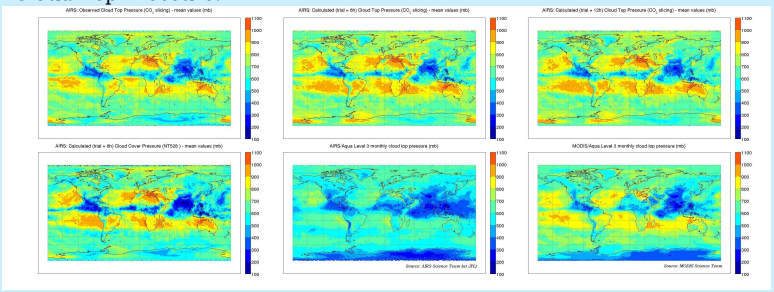


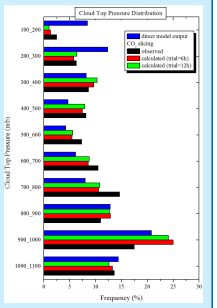
Cloud Fraction



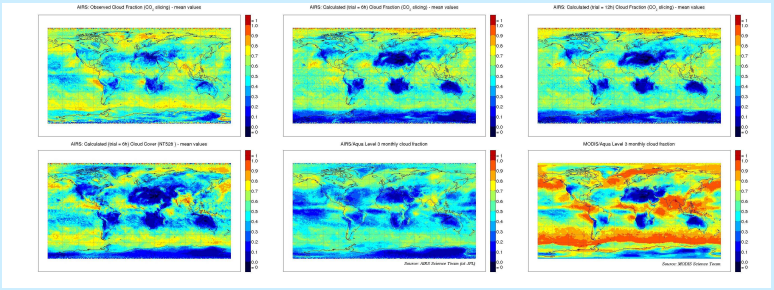
## Results: monthly mean comparisons of cloud parameters

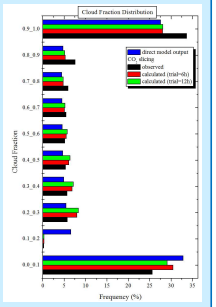
Cloud Top Pressure:






Cloud Fraction:






## Conclusions

Overall the agreement between model and calculated radiances is remarkable. Further, the quality of 3 – 6 h forecast is about the same as 9 – 15 h ones.

The use of cloudy simulated radiances allows a better understanding of the strength and limitations of the $CO_2$-slicing method used operationally for AIRS quality control .

Global maps of mean cloud parameters, along with their distribution, point out some differences between these parameters. This could be explained by the various definitions of cloud parameters and could induce significant variations in results.

According to mean BT variations, Antarctic spectrum is very flat, which leads to difficulties of atmospheric sounding in nearly isothermal atmospheres. It is interesting to note also that the sign of BT differences in 25° S and 25° N latitude bands varies with the wavenumber. This indicates a slightly warmer atmosphere at 25° N, but with more high clouds than at 25° S.

The methodologies developed here will eventually be implemented operationally; in short terms they will be used for the EC model centered on North Pole to validate cloud parameterization in the Arctic ( project in the framework of International Polar Year).

In the future we hope to test the sensitivity to cloud optical properties.


Acknowledgments:

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*Special thanks to Nicolas Wagneur for his precious help with forecast data.*



References:

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McFarquhar, G. M., S. F. Iacobellis, and R. C. J. Somerville: SCM simulations of tropical ice clouds using observationally based parameterizations of microphysics. *J. Climate*, ***16,*** 1643-1664, 2003.