A process oriented description of oceanic clouds derived from A-train observations, for climate model evaluation

D. Konsta, H. Chepfer, JL Dufresne, G. Cesana, S. Bony

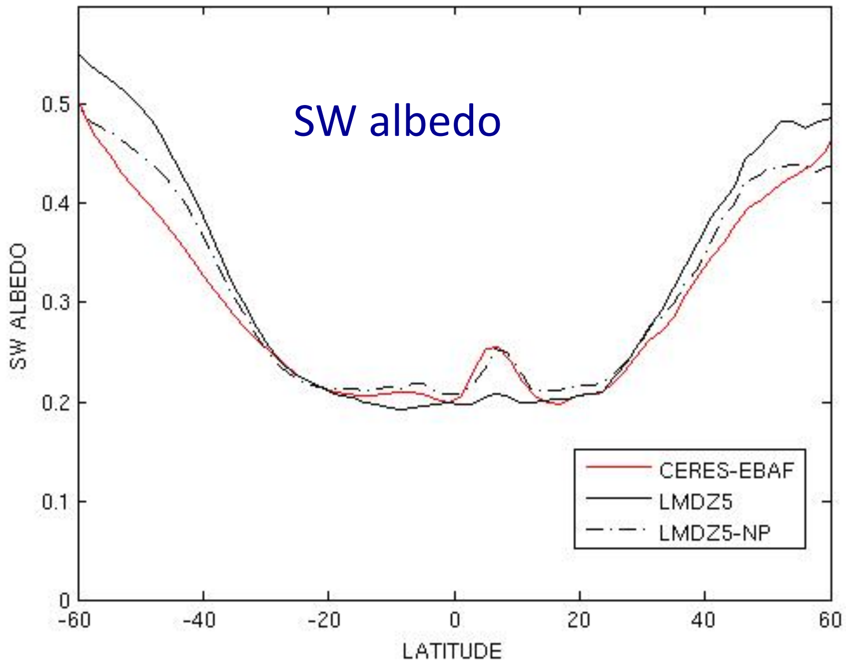
LMD/IPSL

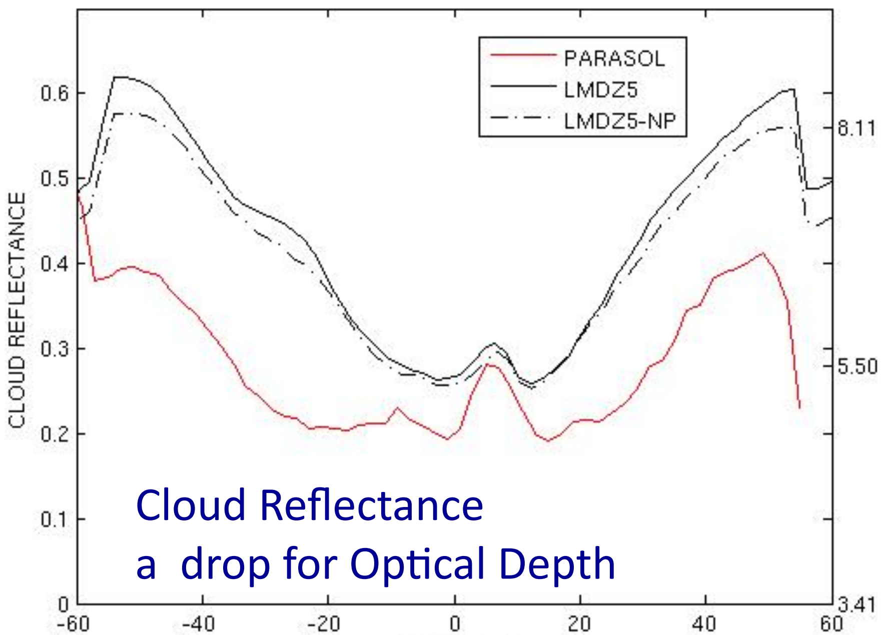
Konsta D. et al : A process oriented description of tropical oceanic clouds for climate model evaluation, based on a statistical analysis of daytime A-train high spatial resolution observations, submitted to Climate Dynamics

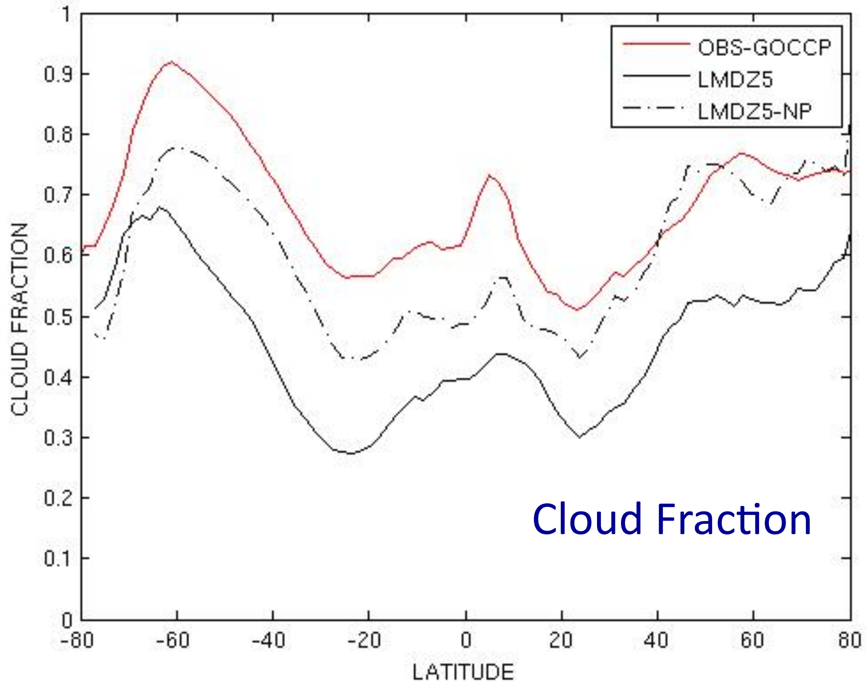
Konsta D. et al: What do we learn about clouds in climate models from A-train observations, to be submitted to Climate Dynamics

** all the model / observation comparisons presented in this talk use COSP**

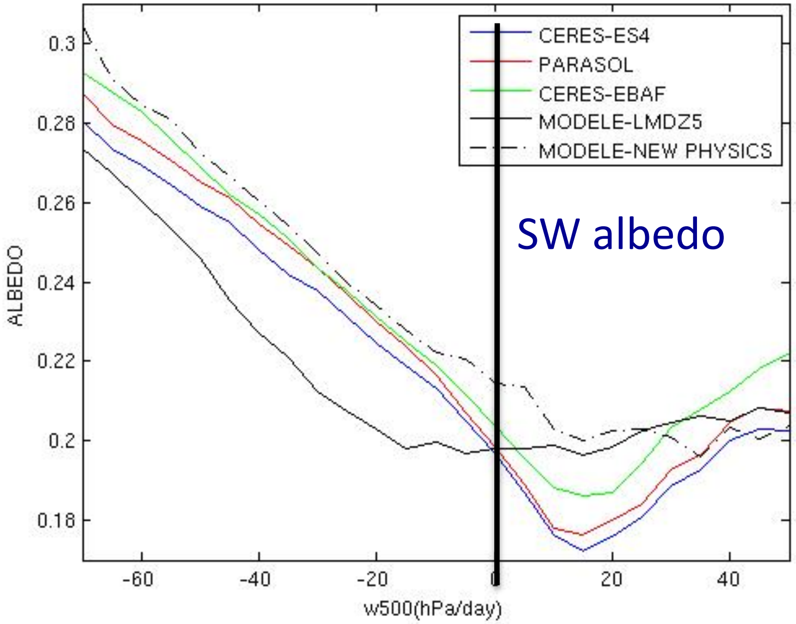
SW albedo depends on the Cloud Reflectance and the Cloud Fraction

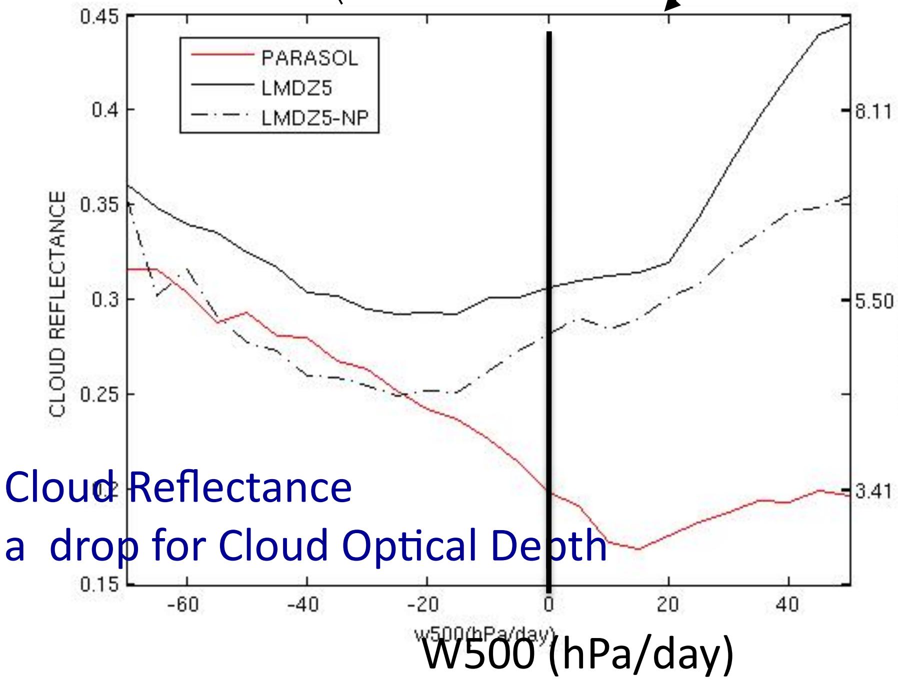


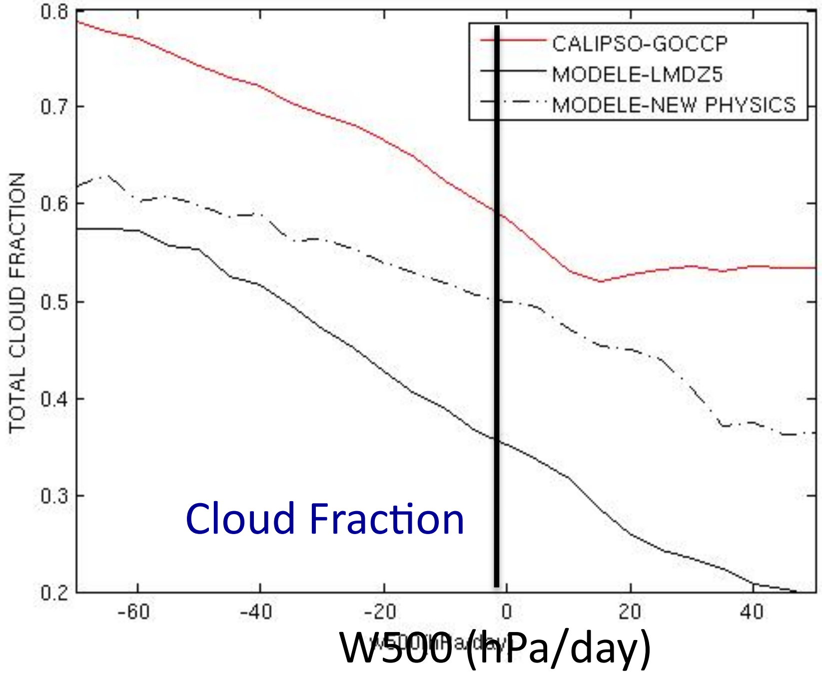




Tropics, in regimes



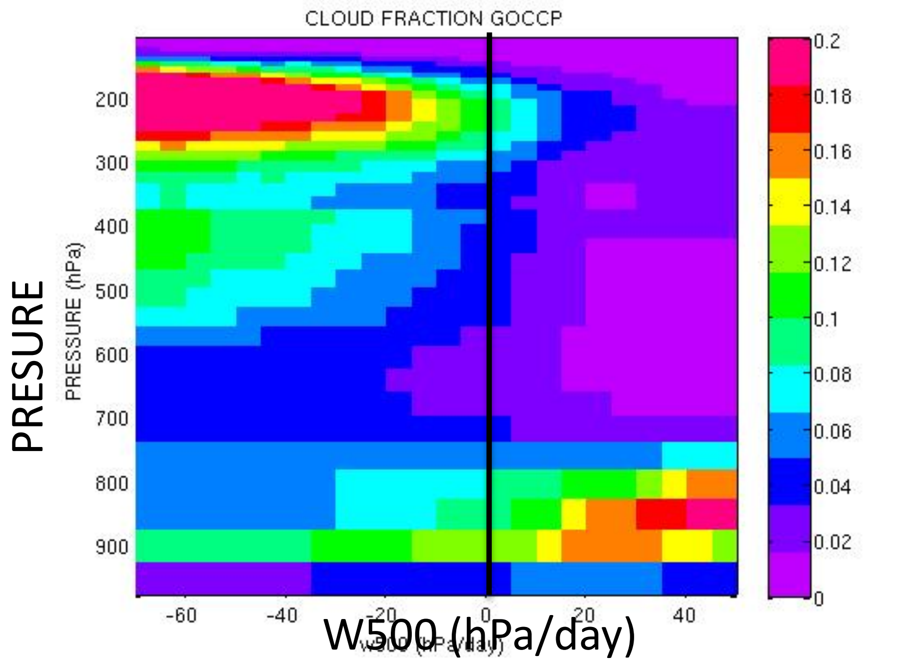




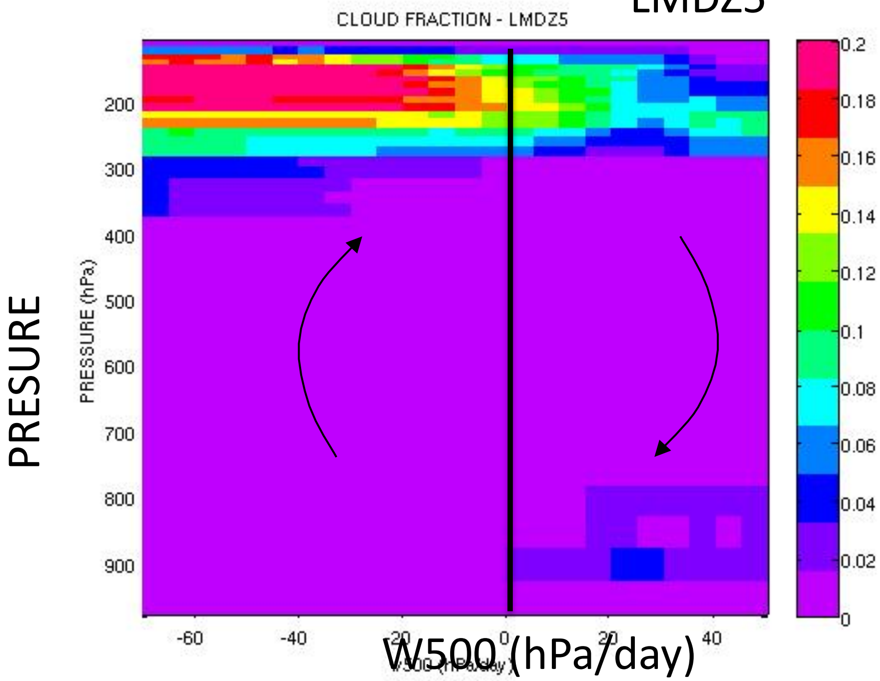
Tropics, in regimes

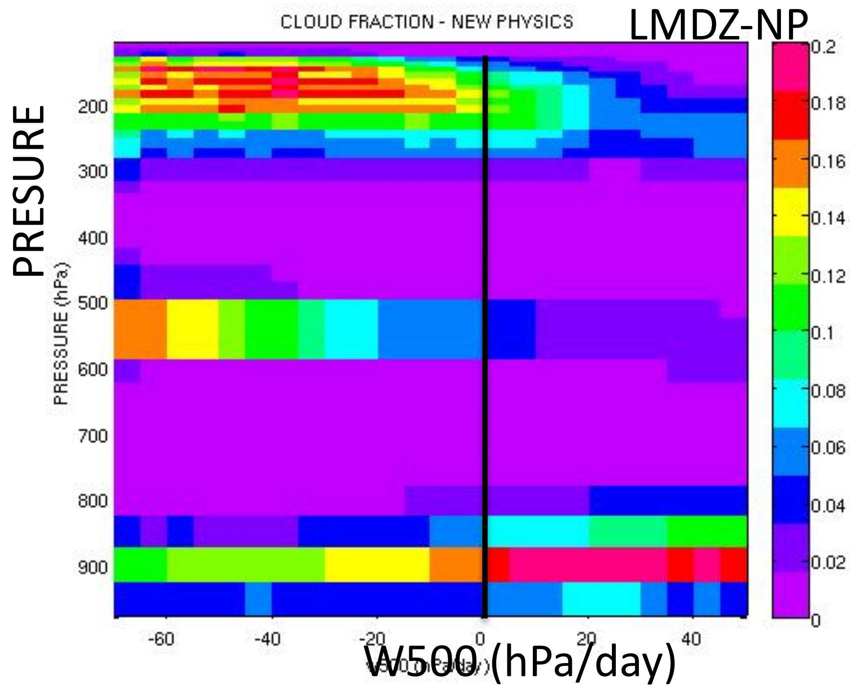
Vertical Distribution of the Cloud Fraction

Obs: Calipso-GOCCP



LMDZ5





Monthly/ Sesonal mean model-obs comparisons:

- Bias in model SW albedo at high latitudes and in subsidence tropical regions

  … significant evolution in the obs in subsidence tropical regions

- Correct SW albedo results of error compensations between cloud cover and cloud optical depth

- The cloud vertical structure is poorly reproduced by the model…

  too much high thick clouds

  lack of mid and Low level clouds

- LMDZ5-NP leads to significant improvement compared to LMDZ5, but still far from observations

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Could the « A-train » learn us more ….about clouds in climate models ?

For climate variability studies,
we need to characterize how cloud properties (R) vary with environment variables (E) around the cloud

$$\overline{\delta R} = \left(\int_{\delta t} \frac{\partial R}{\partial \mathbf{E}} \frac{\partial \mathbf{E}}{\partial T} dt \right) \overline{\delta T}$$

R: Cloud property
T : Surface Temperature
E : Environment

$$\frac{\overline{\delta R}}{\overline{\delta T}}$$

This sensitivity is usually estimated over inter-annual time scale (i.e. Webb et al., Bony et al. 2004) => can not be directly linked to parameterization

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$$\frac{\partial R}{\partial \mathbf{E}} = CR \frac{\partial CF}{\partial \mathbf{E}} + CF \frac{\partial CR}{\partial \mathbf{E}}$$

R: SW albedo
CF : Cloud Fraction
CR : Cloud Reflectance (drop for Cloud Optical Depth)

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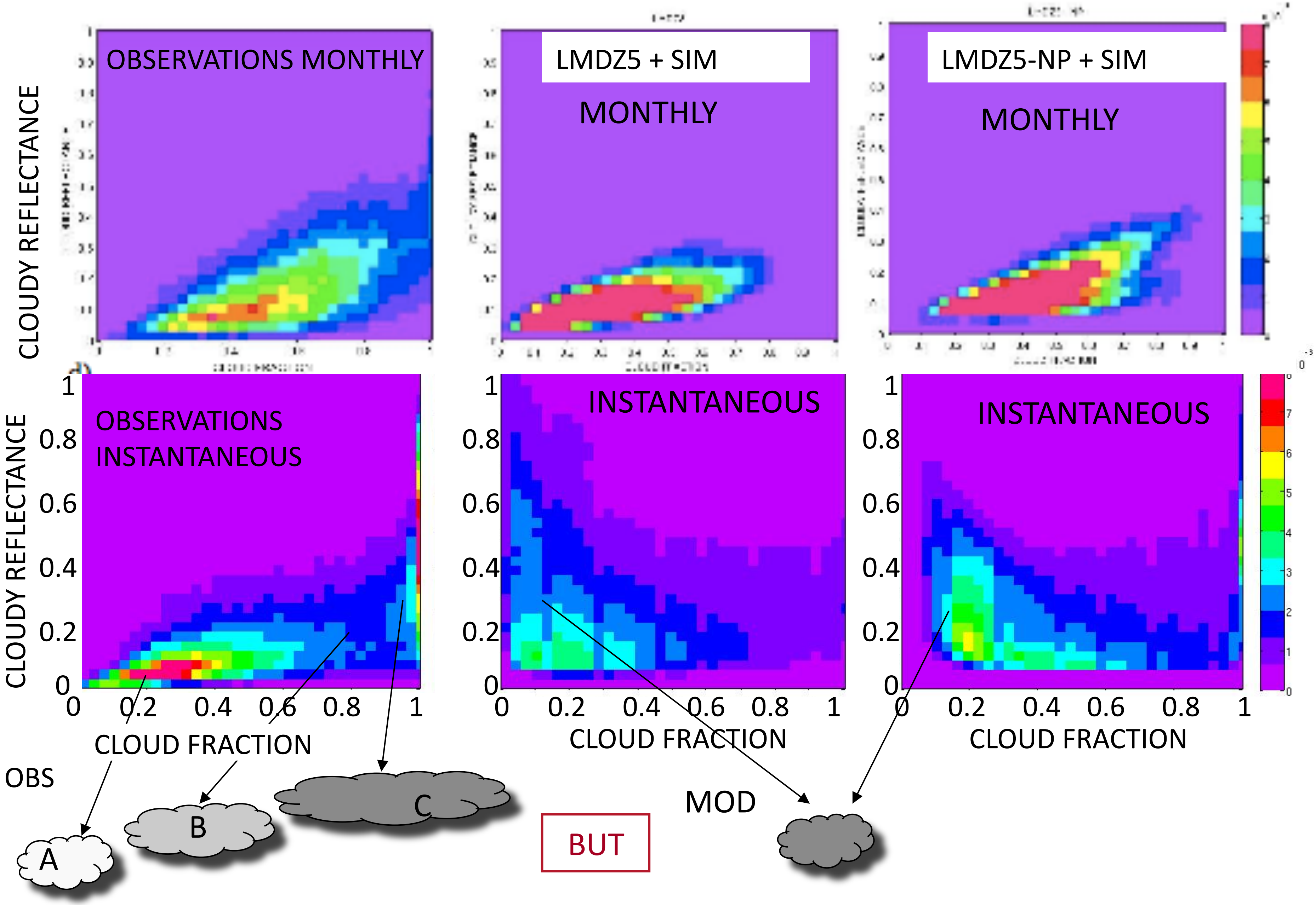
How do CF and CR vary « instantaneously » simultaneously for a same change of environment E ?

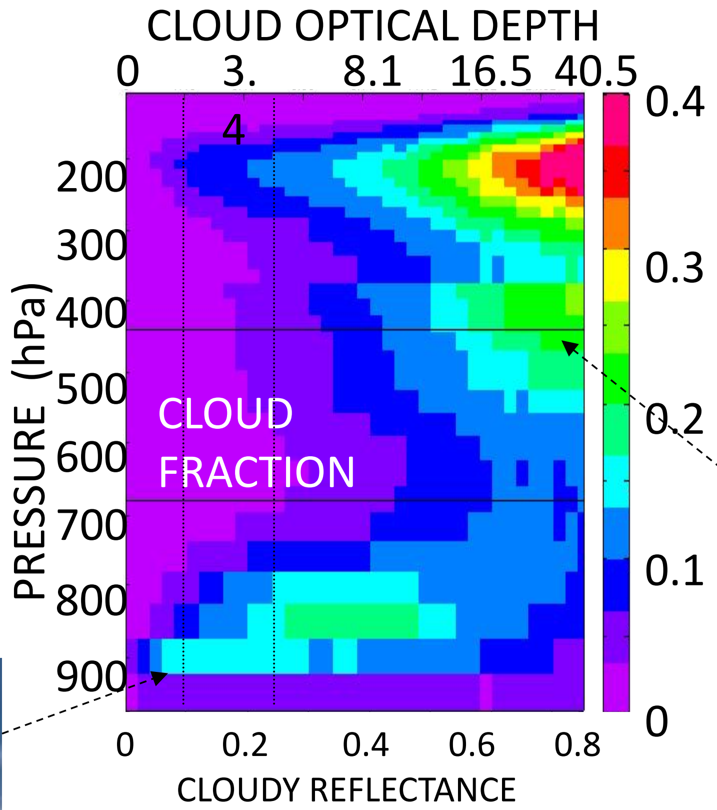
Obs. vs. Mod.

Evaluation of relation between Cloud Optical Depth and Cloud Fraction

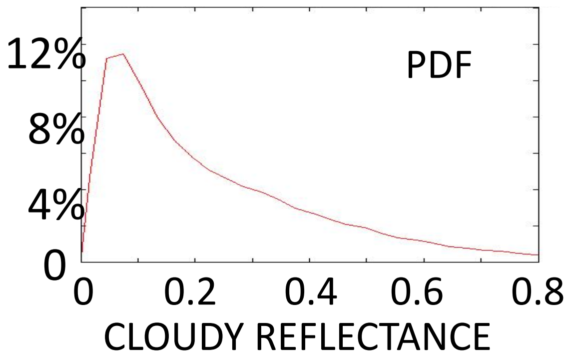


Cloud Optical Depth - Cloud Fraction - Cloud Vertical Distribution

Observations

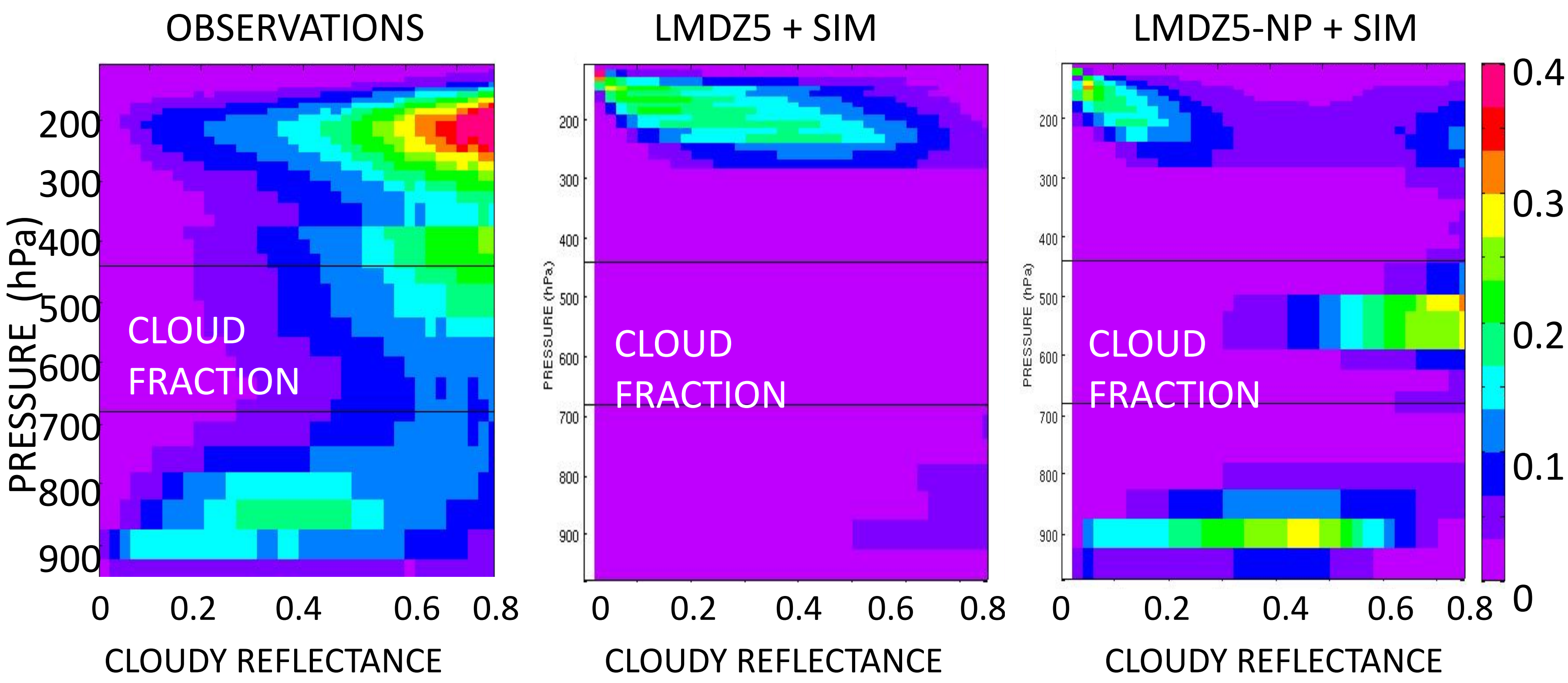


- optically thin clouds :
  low level, low CF
- optically thick clouds :
  multilayer clouds
- very thick clouds :
  abundance of high clouds



Evaluation of instantaneous relation between Cloud Optical Depth and Cloud Vertical Distribution

Obs. vs. Mod.

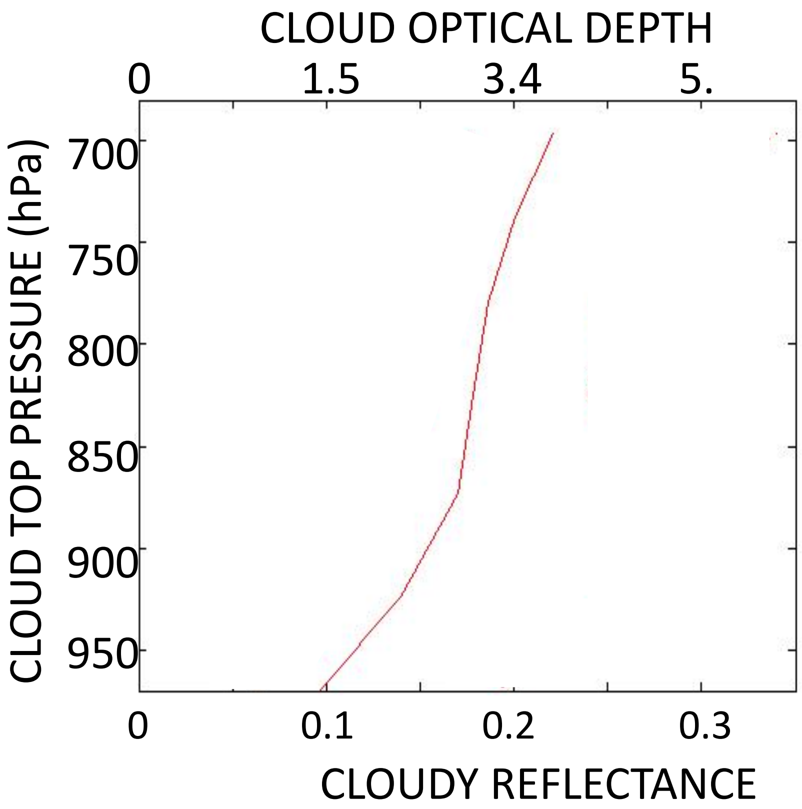


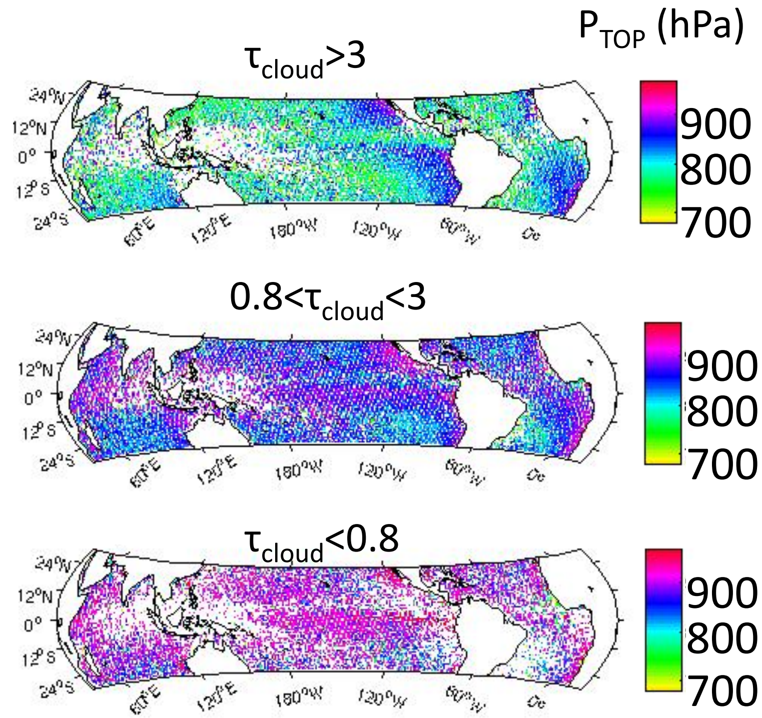
Models biases :

- more optically thin high clouds
- few optically thick high clouds
- no mid level clouds (or not well simulated)
- overestimation of optically thick low clouds

Focus on tropical boundary layer clouds
Cloud Optical Depth - Cloud Top Altitude

Observations

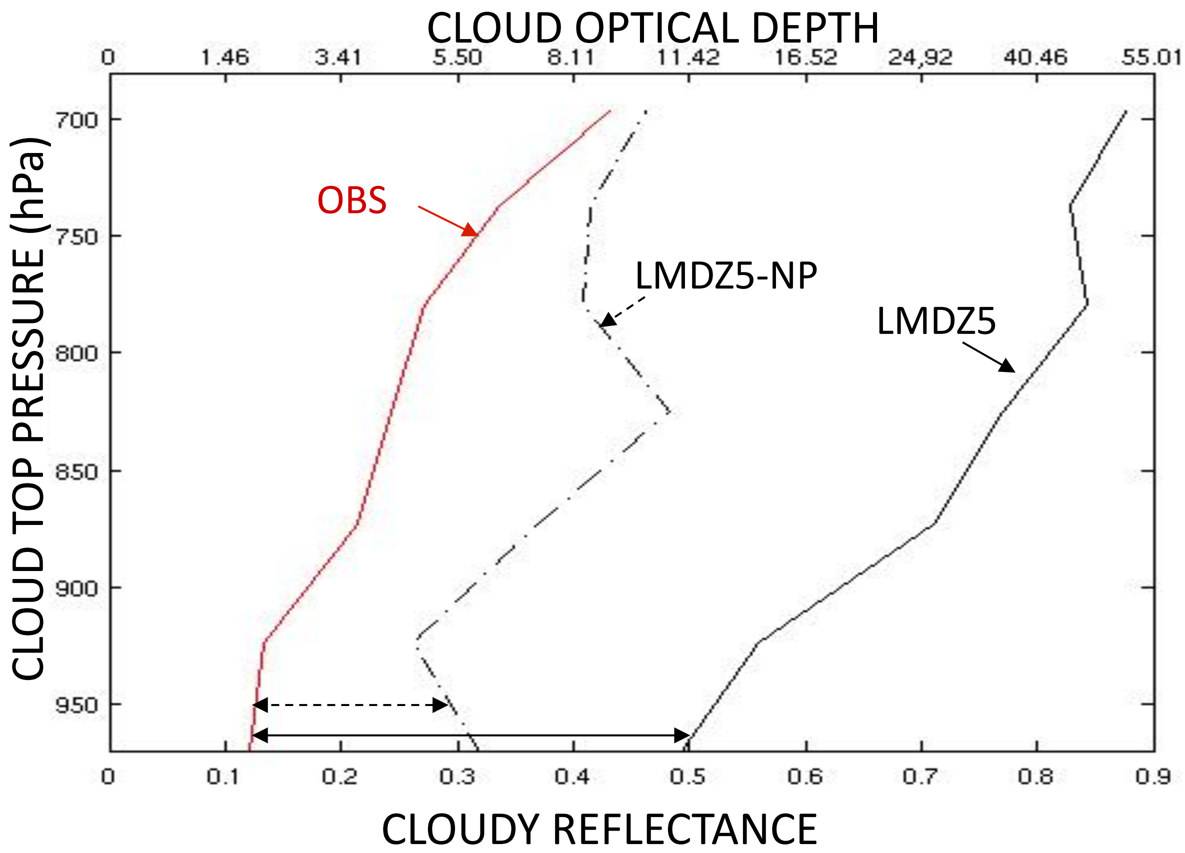




→ Cloud optical depth increases with cloud top altitude

Focus on tropical boundary layer clouds
Evaluation of Cloud Optical Depth and Cloud Top Altitude

Obs. vs. Mod.



→ Model needs more Liquid Water to form clouds

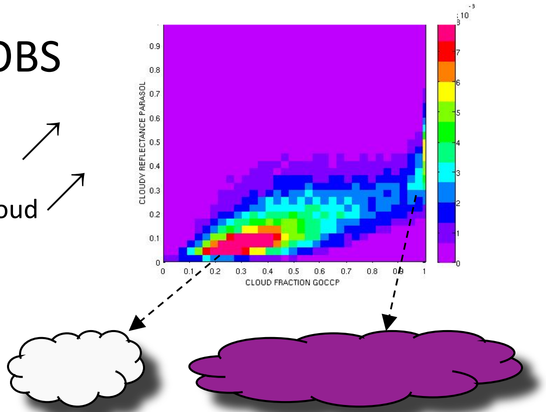
Focus on tropical boundary layer clouds
Evaluation of Cloud Optical Depth and Cloud Cover

Obs. vs. Mod.

OBS

$\delta CF \nearrow$

$\delta\tau_{cloud} \nearrow$

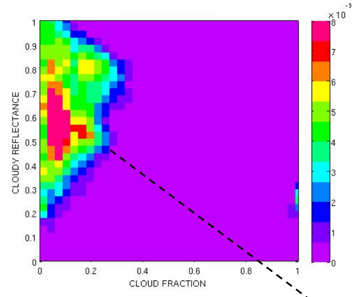


typically shallowcumulus

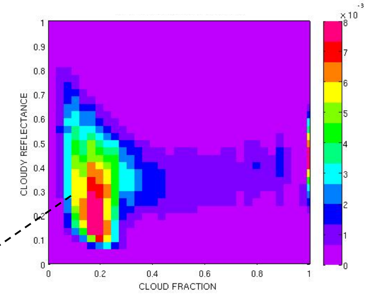
typically stratocumulus

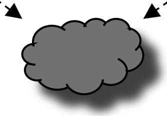
LMDZ5

$\delta\tau_{cloud}$>>



LMDZ5 NP

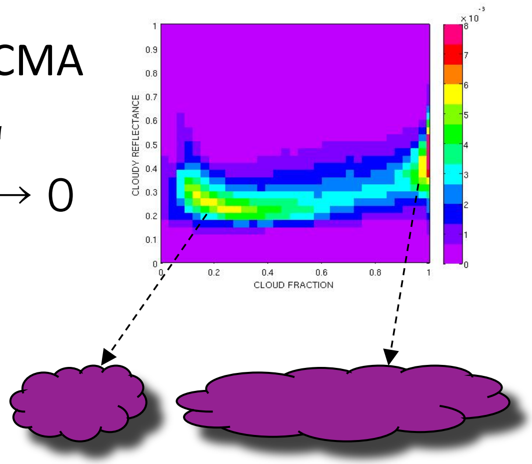




CCCMA

$\delta CF \nearrow$

$\delta\tau_{cloud} \rightarrow 0$



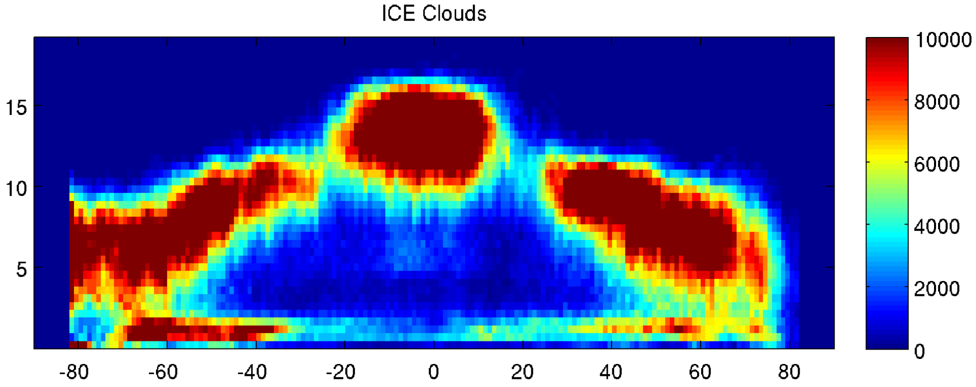
✓Assess the relation between δCF and $\delta\tau_{cloud}$ at the cloud scale

Conclusion

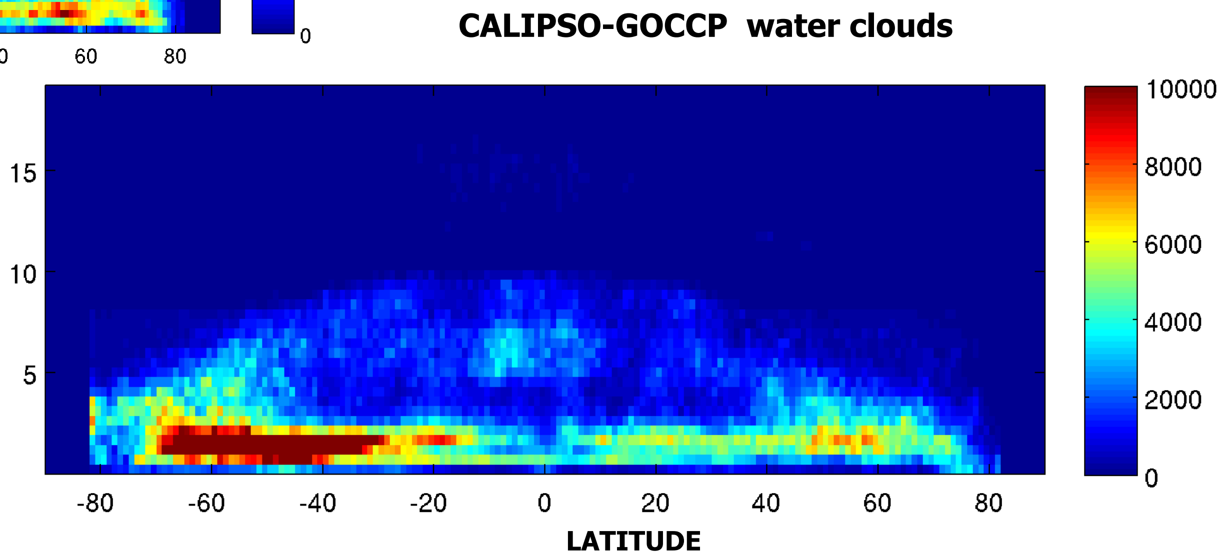
- A-train obs give access to cloud pictures at « instantaneous » time scale: it shows how the cloud properties (here CF and CR) vary together under a same change of environment around the cloud
- These pictures are statistically significant (several years of data)
- These pictures are powerful to evaluate cloud description in climate model, … a step towards a more straightforward evaluation of cloud description at the process scale in the model
- The models evaluated here are not able to reproduce instantaneous cloud pictures:

  ex; in model cloud optical depth decreases when the cloud extends horizontally (CF increases), whereas in the obs the cloud optical depth increases with the cloud horizontal extent
- The LMDZ5-NP is closer to the obs than LMDZ5

« News »:
current development in the Lidar simulator / COSP – the cloud phase



Very preliminary



Cloud Phase 3D for March 2008

« News »: recent updates of CFMIP-OBS database

Observations for model evaluation:

ARM Ground *
CALIPSO-GOCCP sat
CERES Sat
CLOUDNET Ground *
CLOUDSAT Sat
ISCCP Sat
MISR Sat
MODIS Sat *
MULTI-SENSORS Analysis Sat *
MULTI-SENSORS Sat *
PARASOL Sat
References***

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http://climserv.ipsl.polytechnique.fr/fr/cfmip-observations.html

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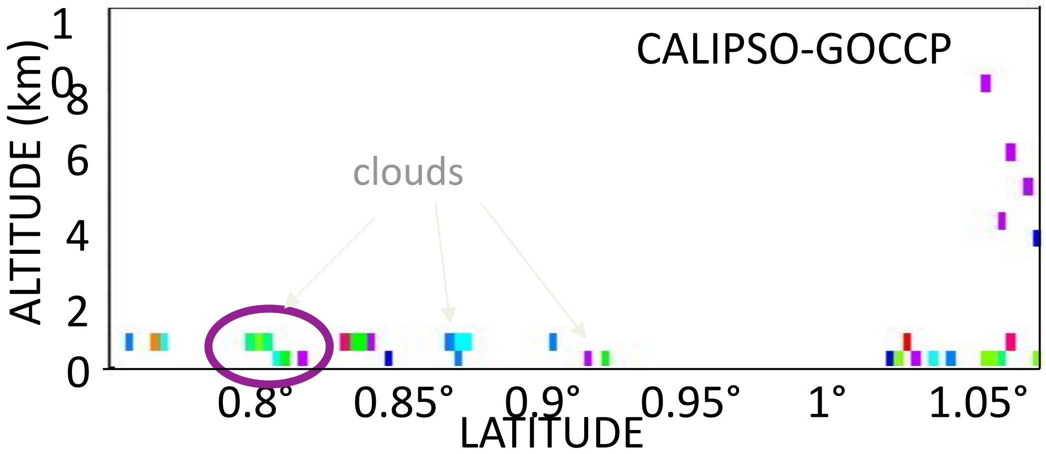
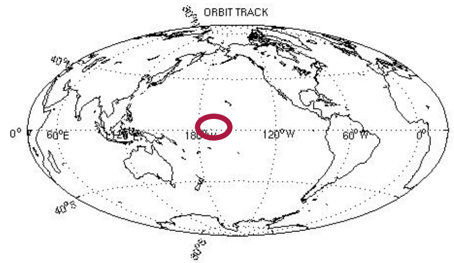
Merci !

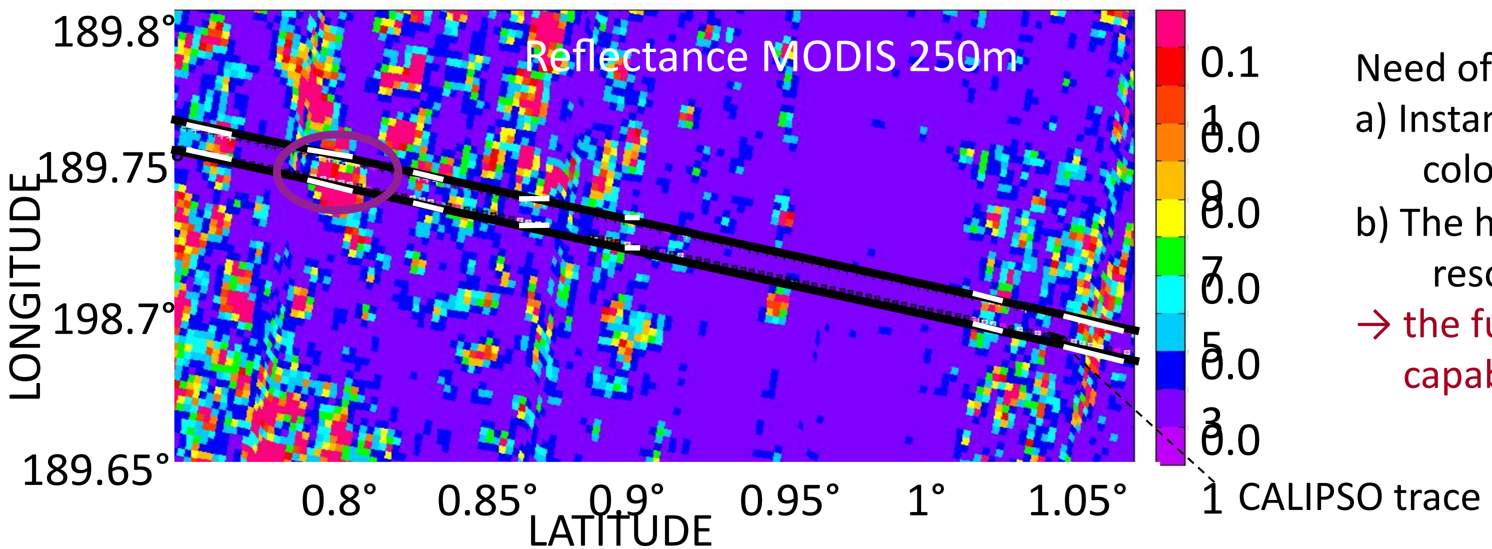
Focus on the cloud scale
Case study of low level shallow cumulus clouds

VERTICAL DISTRIBUTION





HORIZONTAL DISTRIBUTION



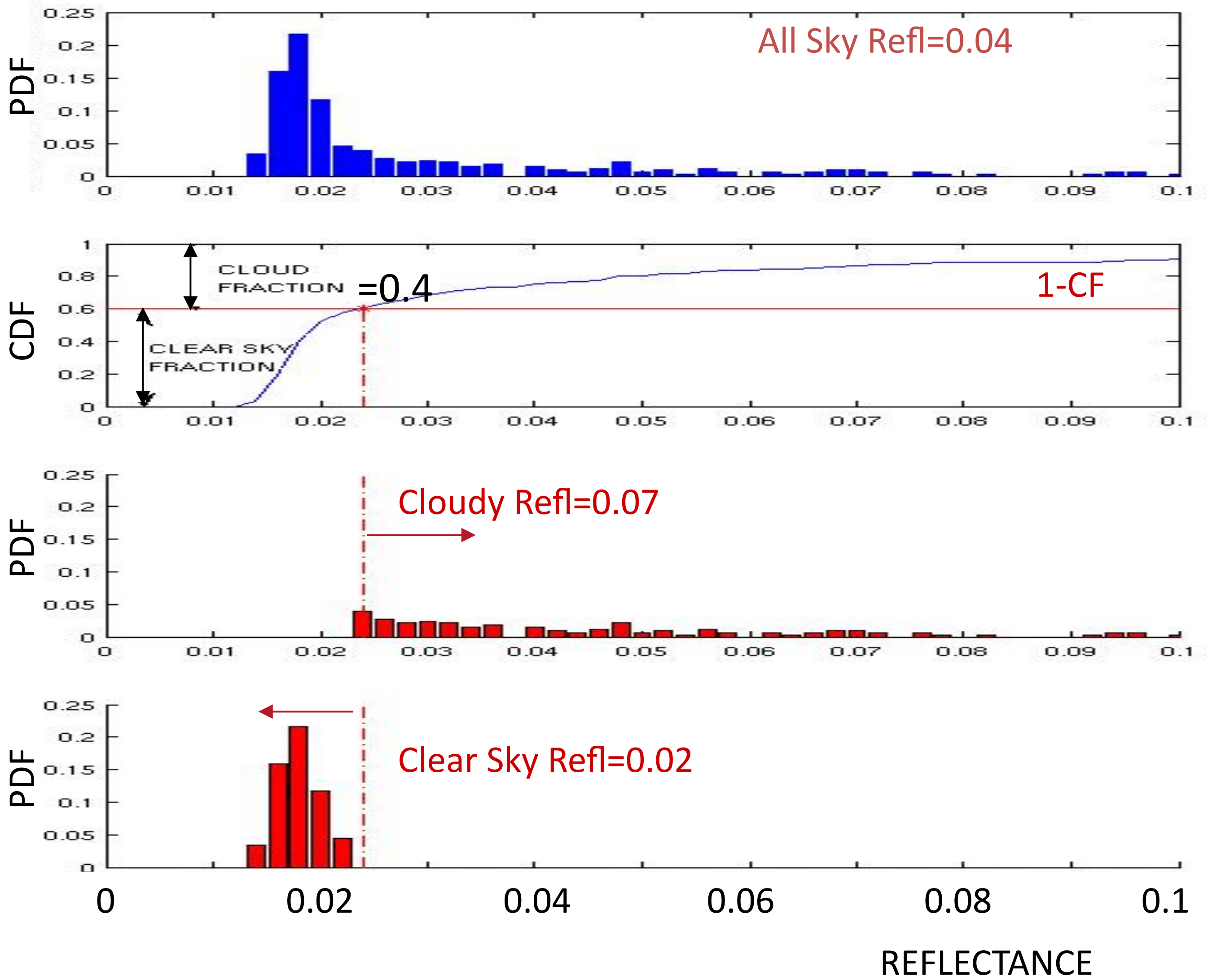
Need of:

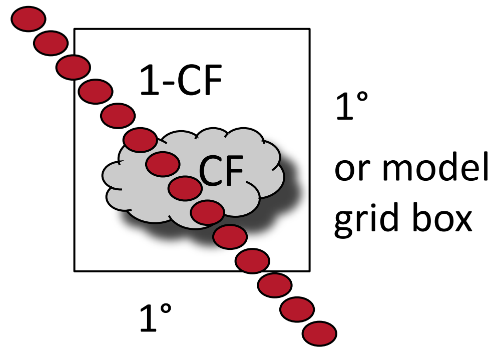
a) Instantaneous and colocated obs

b) The highest possible resolution

→ the full A-Train capabilities are required

Use of high resolution data - Methodology

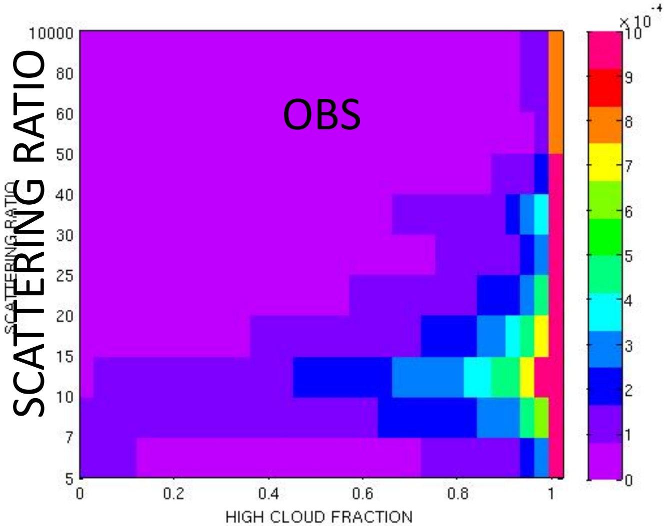




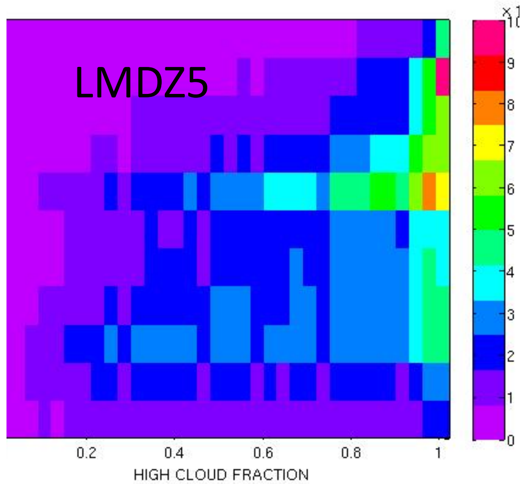
CALIPSO trace

From case study to statistical study conserving the information contained in high resolution obs

High clouds



HighCloud Fraction



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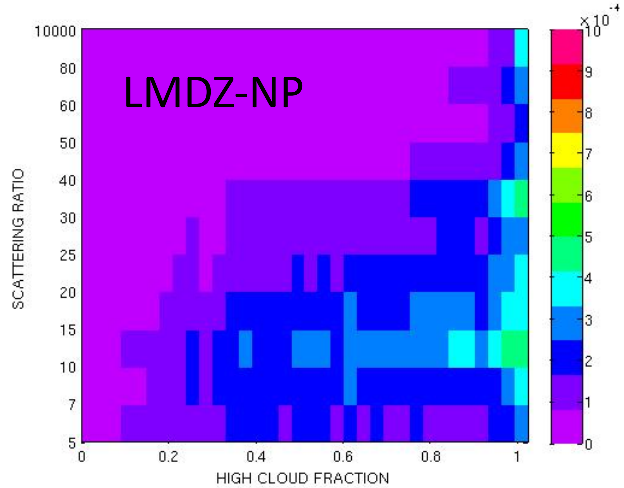

HighCloud Fraction