EVALUATION OF 3D CLOUDS WITH COSP RADAR-LIDAR SATELLITE SIMULATOR UNDER GCM ARPEGE

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Objectives :

Use radar and lidar measures to evaluate three-dimensional representation of clouds in climate and weather prediction models.

Method :

On a global scale Observational Simulator uses model fields to calculate synthetic observations that are directly comparable with satellite measurements.

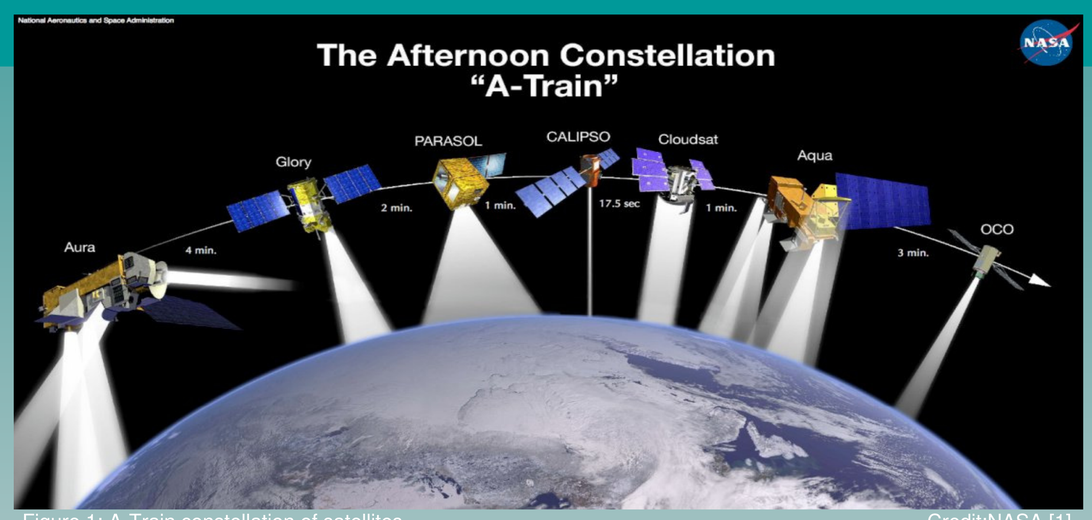


Figure 1: A-Train constellation of satellites. Credit:NASA [1]

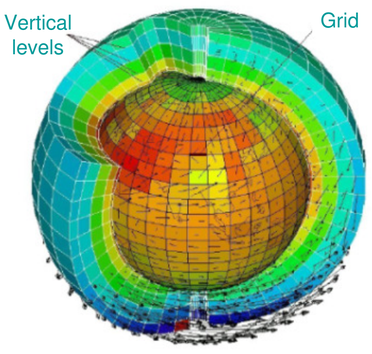
Background :

– Within the framework of EUCLIPSE project, improving representation of clouds is a key objective of climate models. Clouds feedback remains one of the largest sources of uncertainty for precipitation and climate variability.

– Active instruments (lidar and radar) aboard the CALIPSO and CloudSat satellite provide high-resolution vertical profiles of clouds from the surface to the lower stratosphere

Description :

ARPEGE



– Horizontal resolution ~ 150 km

– 31 vertical levels

– Prognostic physics: (Bougeault 1985, Bechtold 2001,Lopez 2002)

– 24h daily forecasts of 2008 starting from operational ARPEGE analysis interpolated

– Three-hourly

Implementation off-line of the simulator (*COSP*)

Radar and Lidar simulators

INPUTS

Cloudy model parameters (Cloud cover, Cloudy condensate, Precipitations flux)

RADAR

Microphysical parameters

- $N(D)$
- $M_x(D)= a_x D^b$

LIDAR

Particle effective radius

Hypothesis of spherical particles

SCOPS

Samples the sub-grid distribution of clouds

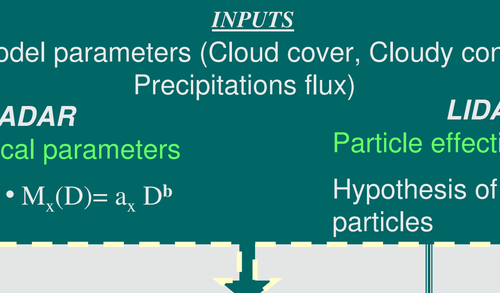
COSP SIMULATOR

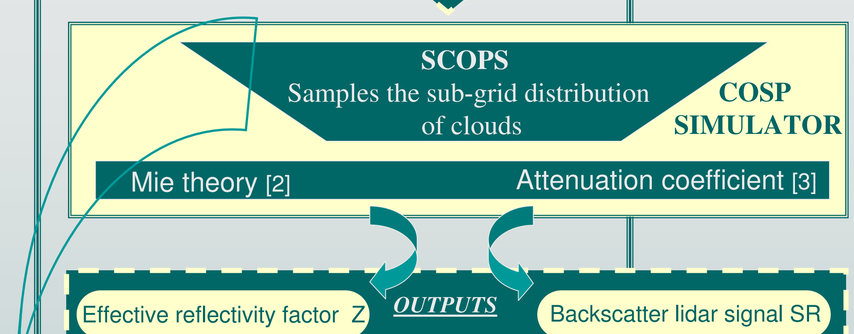
Mie theory [2] | Attenuation coefficient [3]

OUTPUTS

Effective reflectivity factor Z | Backscatter lidar signal SR

Sensitivity test of number of sub-columns





Reference RMS value of a simulation with a large number of sub-columns

Results:

2) a. **CloudSat Observations** JUNE 2008 b. **Radar Simulator** 3) c. **CALIPSO Observations** JUNE 2008 d. **Lidar Simulator**

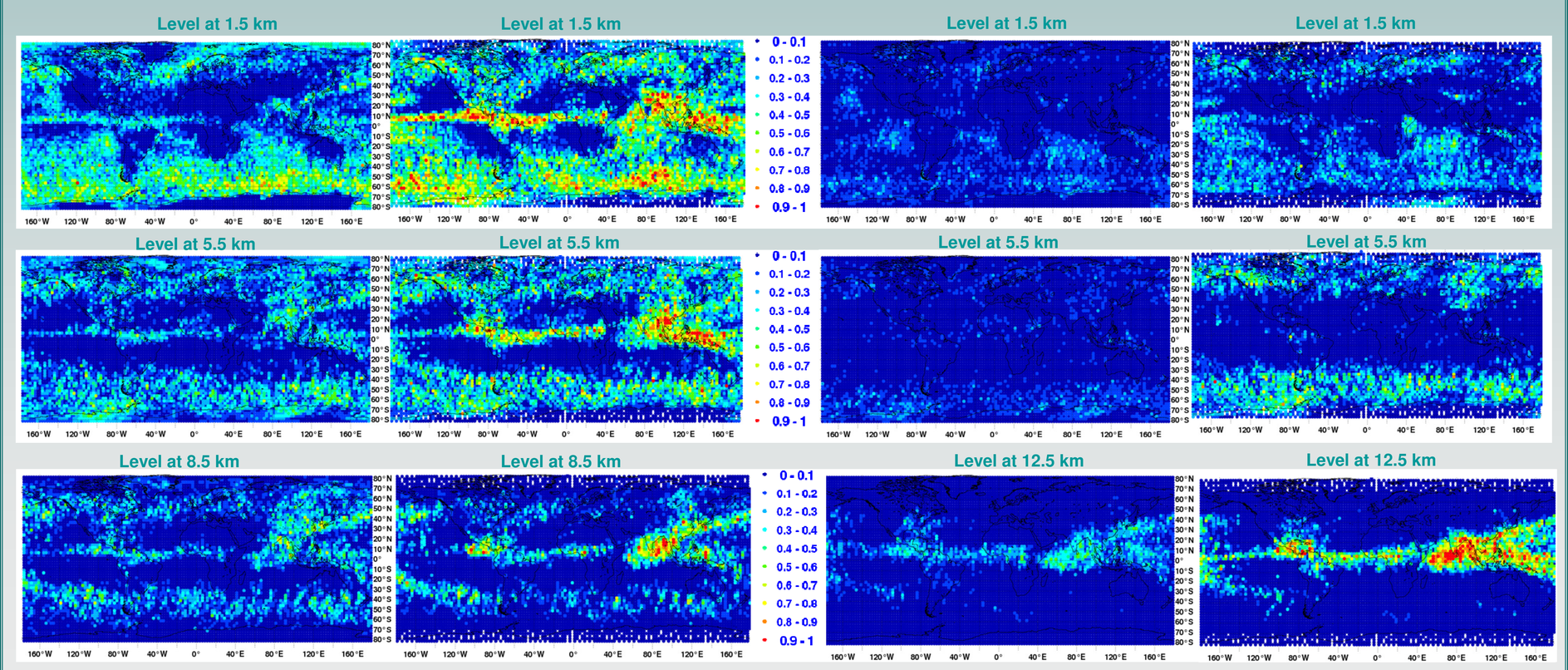


Figure 2 : Global distribution of Hydrometeor fraction of June 2008 for a 1 km height layer as observed by CloudSat (a) and simulated by radar simulator (b)
Figure 3: As observed by CALIPSO (c) and simulated by lidar simulator (d). The altitude of the center of the layer is shown in the title of each plot.

Comparing observations/simulations

- Time (1 month) and spatial average (2.5°x 2.5° horizontal and 1km vertical)
- Method for determining presence of clouds = Radar Reflectivity > -27 dBz; SR Lidar > 5

$$\text{Hydrometeor fraction} = \frac{\text{Number of observed cloud}}{\text{Total number of observations}}$$

Comparing « global » versus « path »

4)

Global — Average over all points in the grid

Path — Average only the orbital path of the satellite.

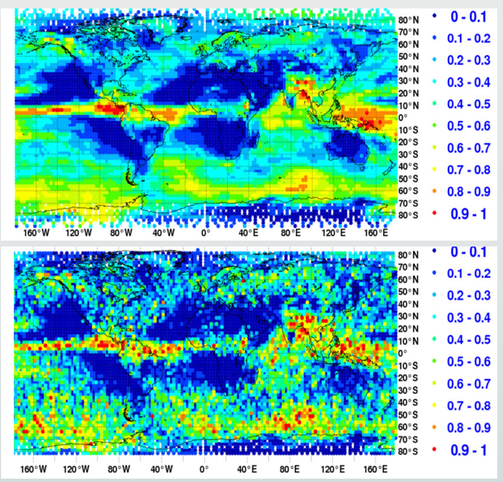


Figure 4: Radar simulator: Hydrometeor fraction à 1.5 km June 2008

5) e. **CloudSat Observations** — **CALIPSO Observations**

f. **Radar Simulator** — **Lidar Simulator**

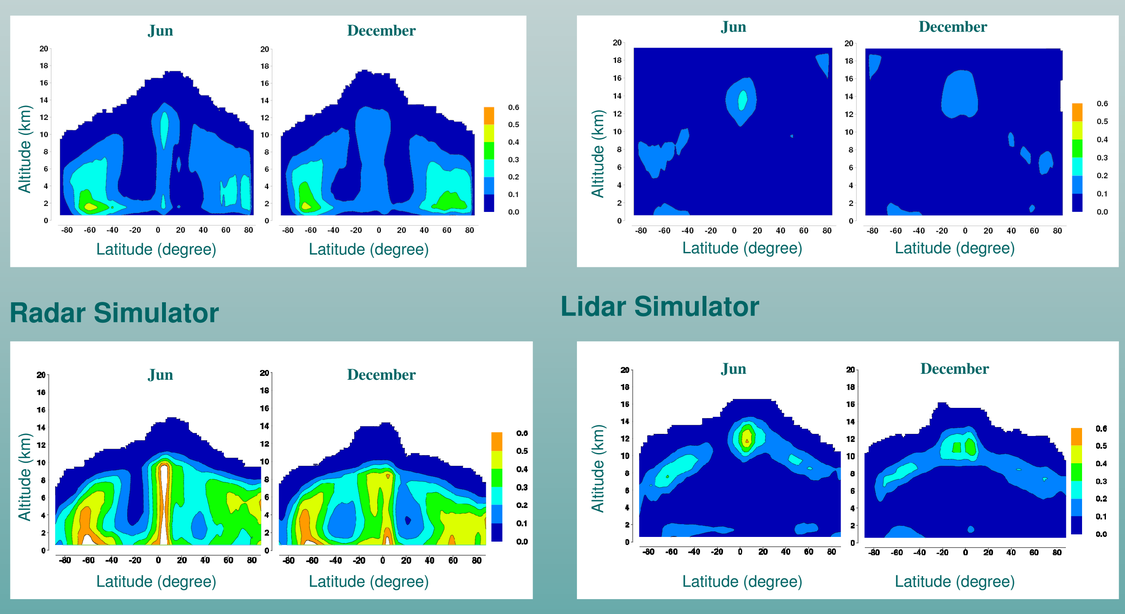


Figure 5: Zonal mean cross section of hydrometeor as observed (e) and simulated (f).

6)

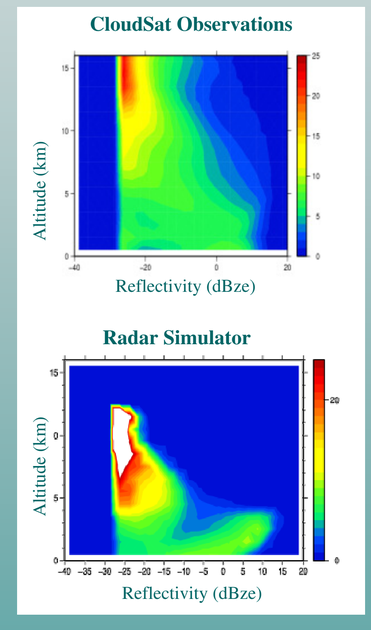


Figure 6: A levels histogram normalized by the number of cloudy values

Conclusions :

To obtain a stable result a greater number of sub-columns is needed for radar and Low-level clouds; we have a decreasing number of sub-columns with increasing of period average.
After that 150 sub-columns was chosen to use both simulators with simultaneity in daily and monthly scales.
The comparison of outputs of COSP simulator with radar and lidar observations shows: the importance of doing these monthly diagnostics over orbital path of the satellite CALIPSO and Cloudsat; the underestimation of deep convective cloud top and of marine stratocumulus in the east part of subtropical anticyclonical areas; instead an overestimation of Cloudy fraction in the ITCZ.
Complementarity between the radar and the lidar observations : Thin higher clouds (cirrus) detected by lidar and Medium-low clouds detected by radar.

REFERENCES :

[1] NASA, http://www.nasa.gov/mission_pages/cloudsat/multimedia/a-train.html
[2] Bodas-Salcedo, A., M. J. Webb, M. E. Brooks, M. A. Ringer, K. D. Williams, S. F. Milton, and D. R. Wilson, Evaluating cloud systems in the met office global forecast model using simulated cloudsat radar reflectivities, *J. Geophys. Res.,* **113**, D00A13, 2008.
[3] Chiriaco, M., R. Vautard, H. Chepfer, M. Haeffelin, Y. Wanherdrick, Y. Morille, A. Protat, J. Dudhia, and C. F. Mass (2006), The ability of MM5 to simulate thin ice clouds: Systematic comparisons with lidar/radar and fluxes measurements, Mon. eather Rev., 134, 897–918.

Internship "MASTER2nd year Ocean Atmosphere and Land surfaces" at Paul Sabatier University in the Research Group "CNRM/GAME" of Météo-France/ CNRS under the supervision of François Bouyssel, Isabelle Beau and Dominique Bouniol :
http://www.cnrm.meteo.fr/aladin/IMG/pdf/M2OASC-0910-rapport2-DERRICO-Miriam.pdf