

Evaluation of GCM parameterizations of cloud microphysics and aerosol indirect effects using TOVS satellite data and ground-based remote sensing data of the SIRTAsite

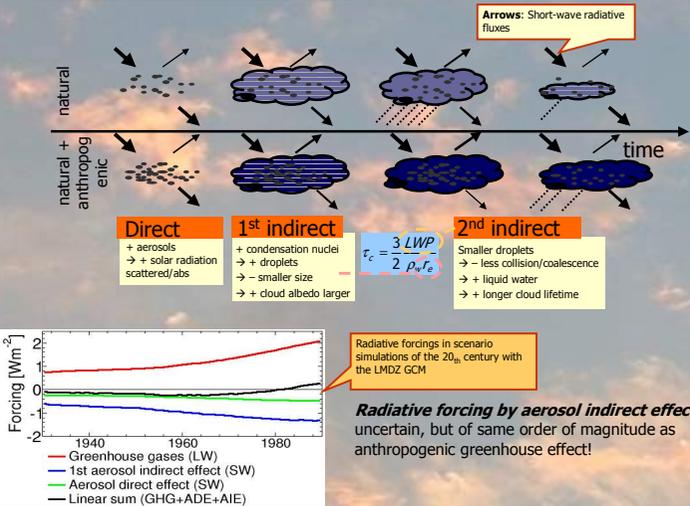
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1. Aerosol indirect effects



A large uncertainty stems in particular from the description of the ice phase / mixed phase clouds.

It is not yet clear if there is an indirect effect of aerosols on ice clouds (and if, how strong).

2. Parametrisation in the GCM

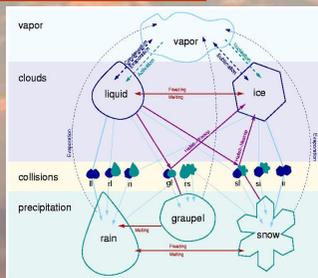
Needs for a representation of the aerosol indirect effects in a global climate model:

- 1st effect → 1. Link between droplet / ice crystal number and aerosol concentrations ("activation" / "nucleation")
- 2nd effect → 2. Description of the microphysical precipitation processes

A new GCM microphysical parametrisation including

- ice phase processes
- "physically based" aerosol activation scheme
- homogeneous nucleation of ice crystals (Lohmann & Köhler, 01)

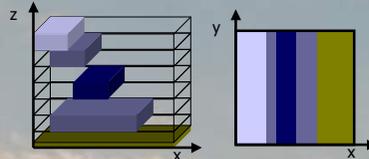
- Prognostic:**
- Mixing ratios of
 - Water vapor
 - Liquid water
 - Ice
 - Concentrations
 - Droplets
 - Crystals
- Diagnostic:**
- Mixing ratios
 - Rain
 - Snow
 - Graupel



3. Evaluation using TOVS data

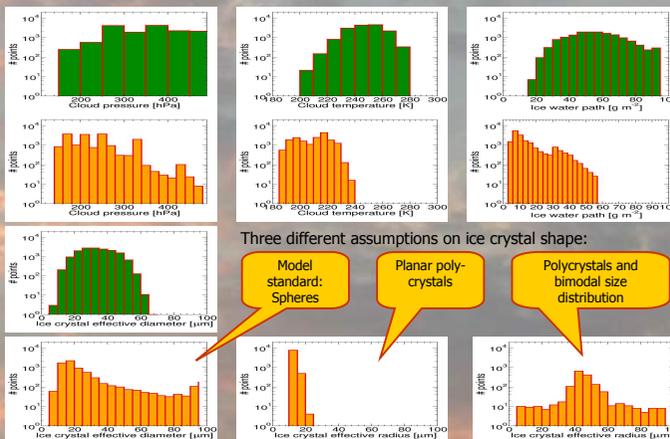
The TIROS-N Operational Vertical Sounder retrievals at the Laboratoire de Météorologie Dynamique include:

- Cloud emissivity
- Ice water path [$g m^{-2}$]
- Ice crystal effective diameter [μm]
- Cloud temperature [K]
- Cloud top pressure [hPa]



Sampling of cloud top quantities in the model

Study of boreal summer cirrus microphysical properties:



Conditions:

- "Thin cirrus" (emissivity $0.3 < \epsilon < 0.85$)
- high clouds (cloud top pressure $p_{top} < 440$ hPa)
- « overcast conditions » at $1^\circ \times 1^\circ$ resolution

In the model:

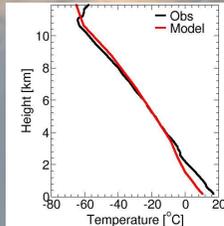
- cloud optical thickness $0.7 < \tau_c < 3.8$
- cloud top pressure $p_{top} < 440$ hPa
- cloud fraction $f > 0.5$ ($3.75^\circ \times 2.5^\circ$ resolution)

4. Evaluation using SIRTAsite data

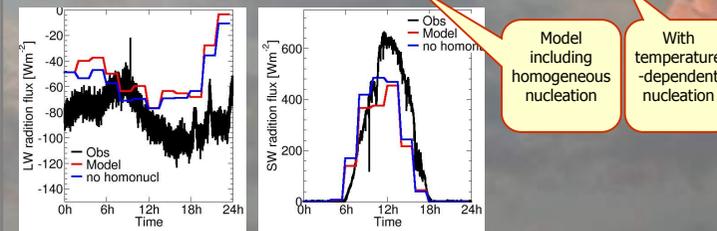
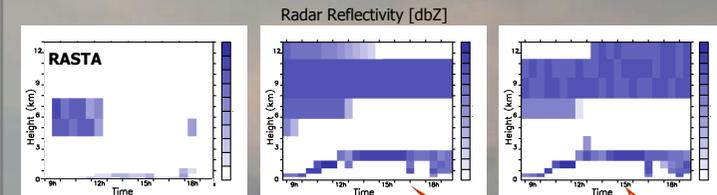
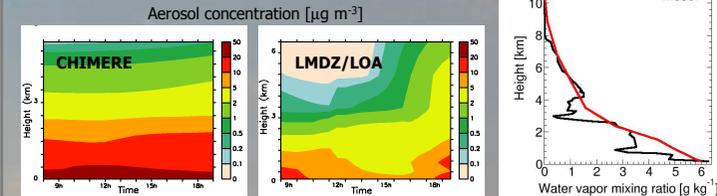
Measurements from the following instruments are used:

- RASTA (Radar Aéroporté et Sol de Télé-détection)
 - Reflectivity, Doppler velocity.
- Radiometers:
 - Surface radiation fluxes
- LNA (Lidar Nuages Aérosols):
 - To quantify the 3D aerosol distribution, the regional chemistry model CHIMERE is evaluated using LNA observations. The aerosol distribution of this model is used here to evaluate the GCM.
- Radiosondes:
 - of Météo-France at 11.28h, temperature and humidity

Simulation of the RASTA reflectivity in the model:
 $Z = \frac{IWC^2 D^{(1-2)}}{ac^{1-p}}$



The case of 27 March 2003 is chosen as an example.



Further informations

On the LMDZ GCM and the microphysical scheme: Quaas, J., The aerosol indirect effect: Parameterization in large-scale models and evaluation with satellite data. PhD Thesis, Ecole Polytechnique, Palaiseau, France, 2003, 157pp. (http://www.lmd.jussieu.fr/~quaas/quaas_these.pdf)

On the LMDZ aerosol module: Reddy et al., JGR 2004; Boucher et al., 2002, Note scientifique de l'IPSL (<http://www.ipsl.jussieu.fr/poles/Modelisation/NotesScience/notes23.htm>)

On TOVS data and applications: Stubenrauch et al., AR 2004; European project CIRAMOSA: <http://www.lmd.polytechnique.fr/CIRAMOSA/Welcome.html>

On SIRTAsite observational data: <http://sirta.lmd.polytechnique.fr>

On the CHIMERE aerosol model: <http://euler.lmd.polytechnique.fr/chimere/>