

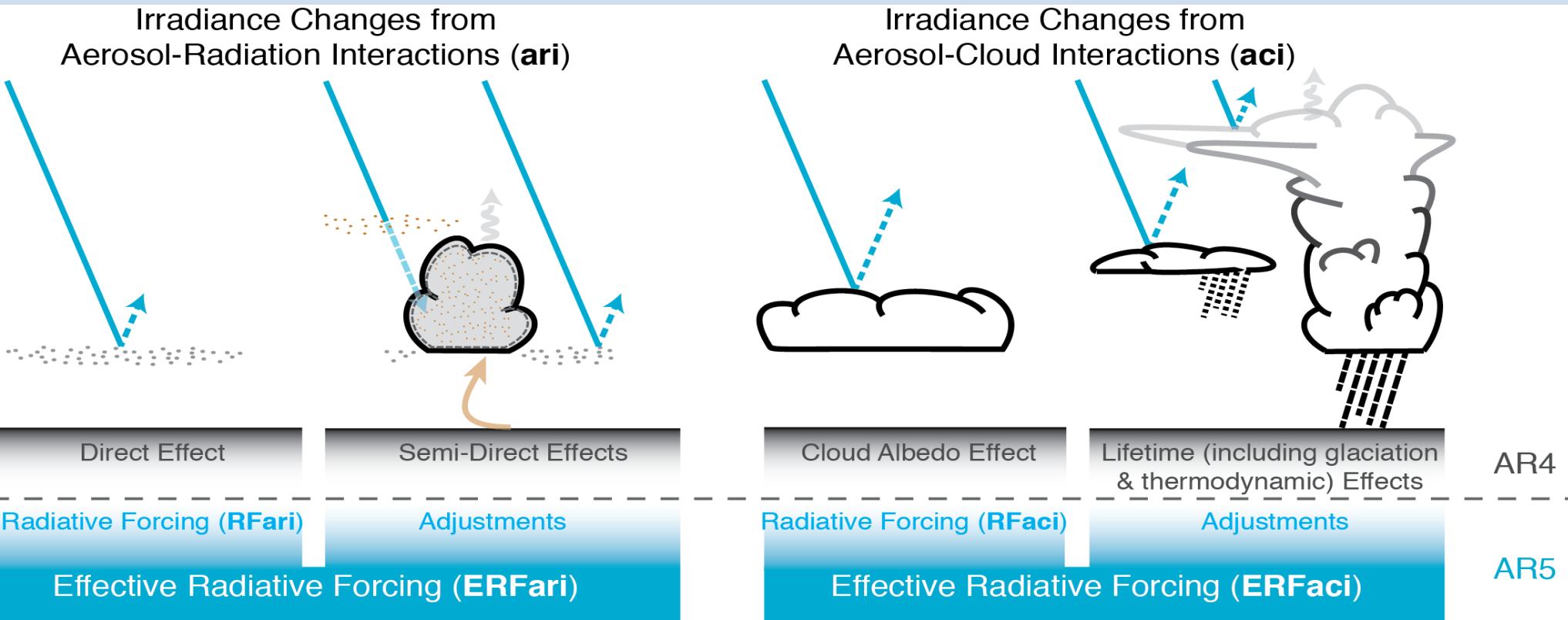
# **Aerosols in LMDZ model**

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# Categorization of aerosol effects



# Aerosols

## Online

## Offline

Anthropogenic and natural emissions

**INCA** Chemistry Model  
- Natural aerosol emissions  
- photochemistry (NMHC/NO<sub>x</sub>/O<sub>3</sub>)  
- wet and dry deposition ...

AP only: Coefficient to reconstruct a natural only aerosol field online

**LMDz - AP / NP with RRTM**  
General Circulation Model

Simple aerosol model with -dust compilation option

**LMDz - NP with RRTM**  
General Circulation Model

Sectional stratospheric aerosol model with -StratAer compilation option

**LMDz - AP / NP with RRTM**  
General Circulation Model

Climatologies of natural and anthropogenic aerosol concentrations

**LMDz - AP or NP**  
General Circulation Model

Climatologies of natural and anthropogenic aerosol concentrations

**LMDz - NP with RRTM**  
General Circulation Model

# Aerosols: running w or w/o INCA

- LMDZ with INCA: runtime parameter in config.def, **aerosol\_couple** = y

version with interactive aerosols, management of radiative transfer is different to that of LMDZ without INCA in AP but same in NP + RRTM (except for a few things)

- LMDZ without INCA: runtime parameter in config.def, **aerosol\_couple** = n

# Nature of aerosols

Runtime parameter in config.def

**flag\_aerosol** (integer):

- 0: no tropospheric aerosol
- 1: sulfate
- 2: black carbon
- 3: particulate organic matter
- 4: marine salts
- 5: dust
- 6: all tropospheric aerosols
  - including nitrate in RRTM in CMIP6 climatologies



# Aerosols: input files

- If `flag_aerosol > 0`:  
gcm.e reads aerosol data from two files **aerosols.nat.nc** and may need **another file** depending on the value of `aer_type`

# Aerosols: input files (continued)

- Runtime parameter **aer\_type** (character variable) in config.def:
  - **preind**: pre-industrial aerosols → **aerosols.nat.nc** only
  - **actuel**: when you want to use a climatology of anthropogenic aerosols → **aerosols.nat.nc** + **aerosols1980.nc** (fixed name, meaningless)
  - **annuel**: **aerosols.nat.nc** + **aerosolsYYYY.nc** where YYYY is the current year

# Aerosols: input files (continued)

- Input files should contain concentrations of aerosols of all the desired types (according to `flag_aerosol`) with nitrates being optional
- Input files should already be horizontally regrided to the LMDZ grid
- For LMDZ5 as used in AR5 runs, the input is for 19 layers and regrided online to the klev layers of the model but providing the input for klev layers is also acceptable



# Aerosols: direct and indirect effects

- Runtime parameters `ok_ade` and `ok_aie` (logical) in `config.def` to activate direct and indirect effects of anthropogenic aerosols
- If `ok_ade = n` then direct effect of natural aerosols only (but no anthropogenic aerosols)
- If `ok_aie = n` then indirect effect of natural aerosols only (but no anthropogenic aerosols)

# Aerosols: direct and indirect effects (continued)

- You can choose `ok_ade` and `ok_aie` independently
- `flag_aerosol` must be  $\geq 1$  if `ok_ade` or `ok_aie` is `y`
- If `ok_ade` or `ok_aie` is `y` then corresponding diagnostics are output (in particular instantaneous radiative forcing variables: `topswad`, `solswad`, `topswai` and `solswai`, ...)
- Note that for online aerosols in LMDZ-NP `topswai` / `solswai` diagnostics are meaningless

# Aerosols for expert users

- Runtime parameter `new_aod` (logical):  
to use the most recent parameterization of  
aerosol optical depth.  
`y` is the default value.

Note: `new_aod = n` can only be used with  
`flag_aerosol = 1` (sulfate aerosols only).  
Obsolete.

# Aerosols for expert users (continued)

Runtime parameters in config.def in case **ok\_aie = y**

**ok\_cdnc = y**

**bl95\_b0 = 1.7**

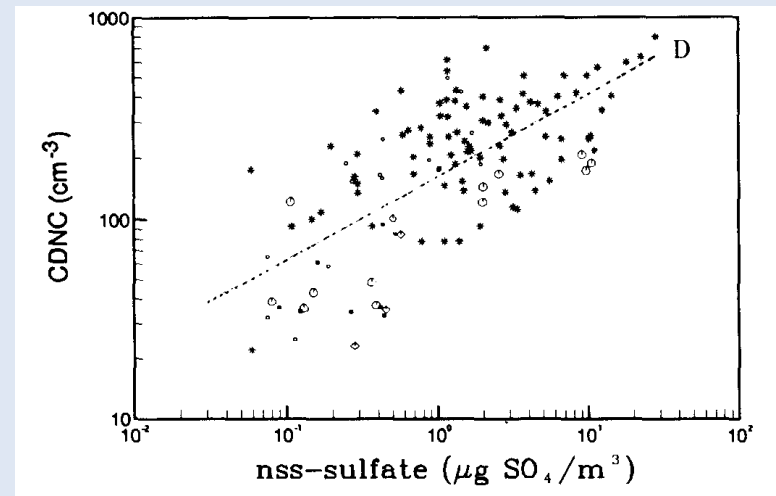
**bl95\_b1 = 0.2**

(recommended values)

$$\text{CDNC} = 10^{b_0 + b_1 \log(m \text{ SO}_4)}$$

Link cloud droplet number concentration to aerosol mass concentration (Boucher and Lohmann, Tellus, 1995)

Now uses mass of all soluble species



# Aerosols for expert users (continued)

- If you want to compute at each time step the direct or indirect effect that aerosols would have, but not let those effects impact the simulation (eg to get the same meteorology with different RF estimates)
  - Set the variable `aerosolfeedback_active` to `.false.` in routine `sw_aeroAR4.F90` (no RRTM) or `rrtm/recmwf_aero.F90` (RRTM)
  - Recompile the program
  - Choose `flag_aerosol > 0` and `ok_ade = y` or `ok_aie = y` at runtime

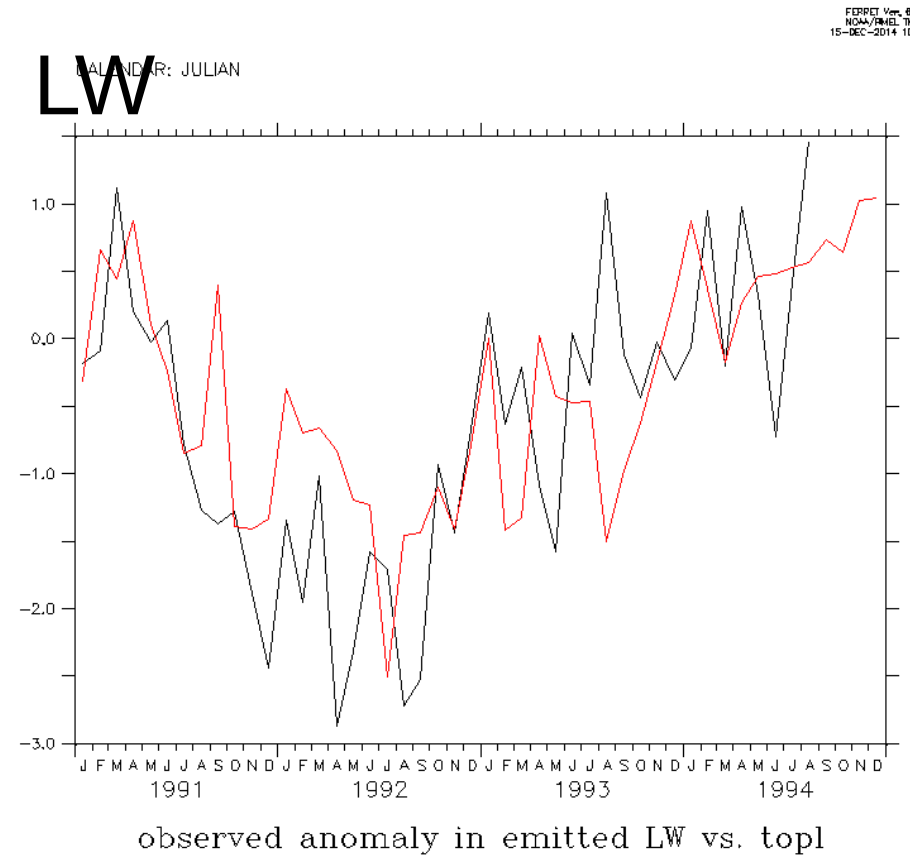
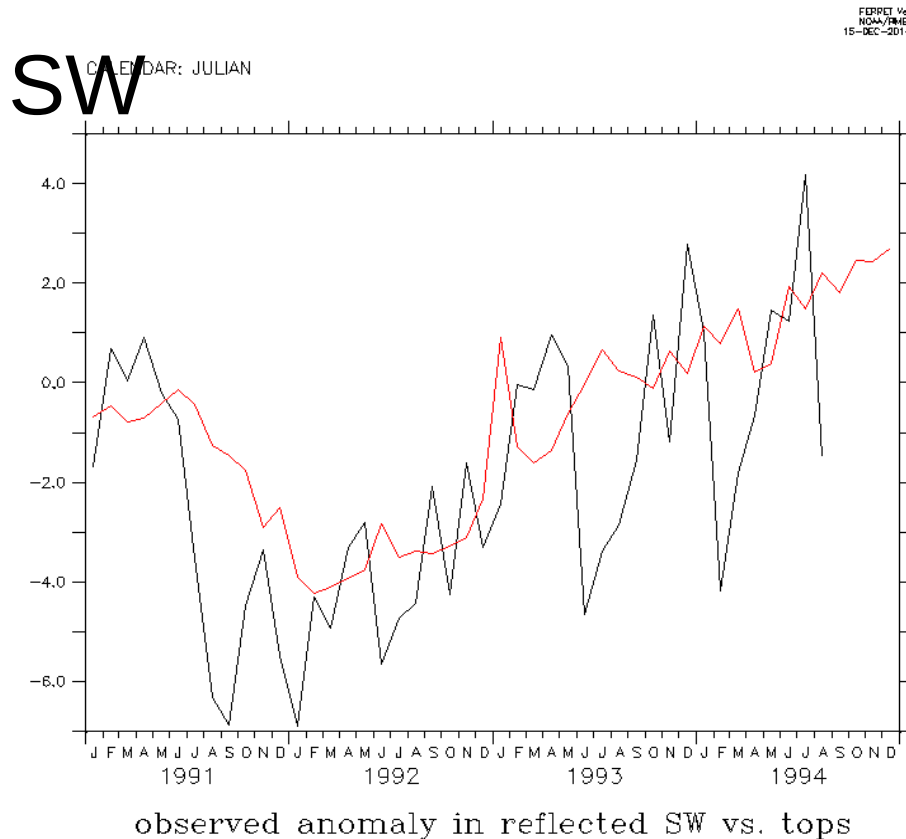


# Stratospheric aerosols


- `flag_aerosol_strat` = 0, 1 (Sato) or 2 (CMIP6)
- `gcm.e` reads 3D aerosol data with monthly timestep
- Input data are available over period 1750 to 2010 (Sato) or 2014 (CMIP6)
- A routine exists to prepare input files to various resolutions [http://forge.ipsl.jussieu.fr/igcmg/svn/TOOLS/CMIP6\\_FORCING/AER\\_STRAT/](http://forge.ipsl.jussieu.fr/igcmg/svn/TOOLS/CMIP6_FORCING/AER_STRAT/)
- Direct effect in SW (old radiation + RRTM) and in the LW (RRTM only, dependent on aerosol size)

# Stratospheric aerosols: Pinatubo

Observations **Model**

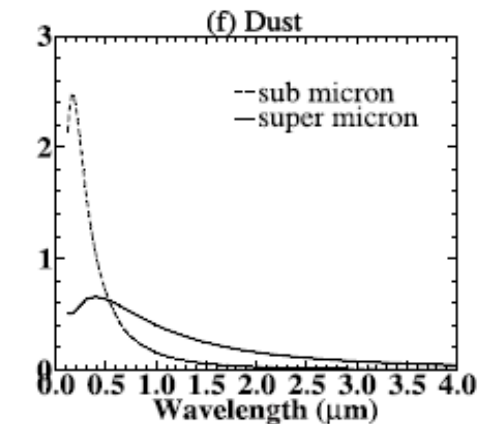
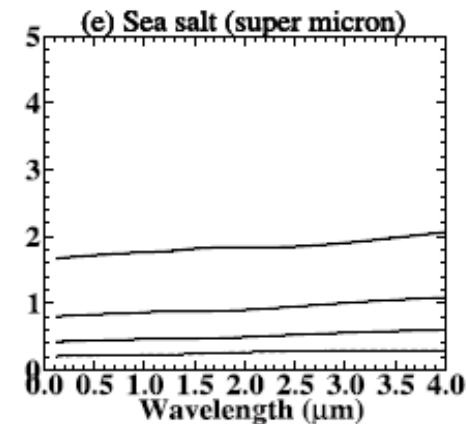
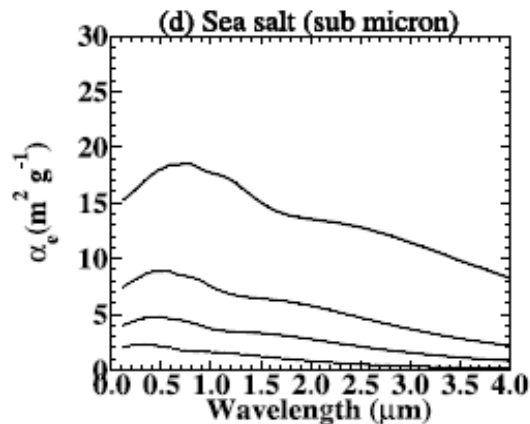
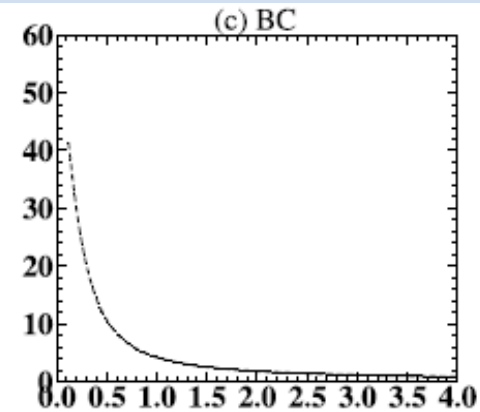
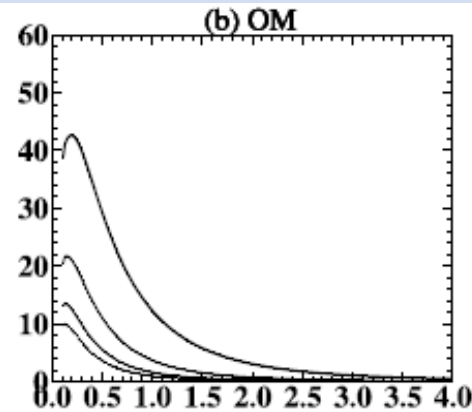
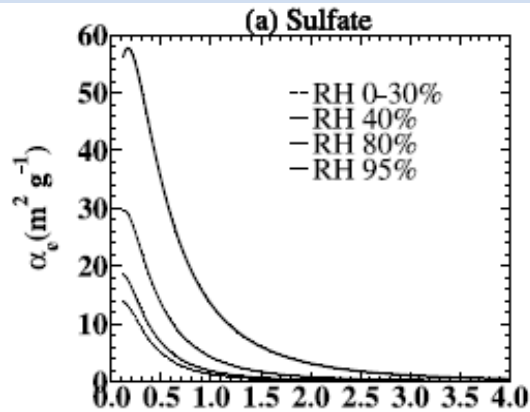


# RRTM ( -rrtm true )

- Tropospheric and stratospheric aerosols are available in RRTM, but only for the 2 and 6 SW wavebands case (NSW=2 or 6)
- Revised optical properties with routines available  
[http://forge.ipsl.jussieu.fr/igcmg/svn/TOOLS/CMIP6\\_FORCING/AER\\_OPTICS/](http://forge.ipsl.jussieu.fr/igcmg/svn/TOOLS/CMIP6_FORCING/AER_OPTICS/) 
- Reunified routine for offline (LMDZ) and online (INCA) aerosols
- LW properties for dust, forthcoming for the rest



# Aerosol optical properties



Example  
only  
 $f(\text{RH}, \lambda)$



# INCA aerosol in LMDZ-NP

- Reunified aerosol optical properties routine for offline (LMDZ) and online (INCA) aerosols
- Takes into account mixing by boundary layer, thermals and convection (with or without simultaneous scavenging)
- Requires interactive natural sources of aerosols
- Still being improved for AerChemMIP but have been used to prepare CMIP6 aerosol climatologies