Modeling Stratospheric Aerosol with the GEOS-5 Chemistry Climate Model

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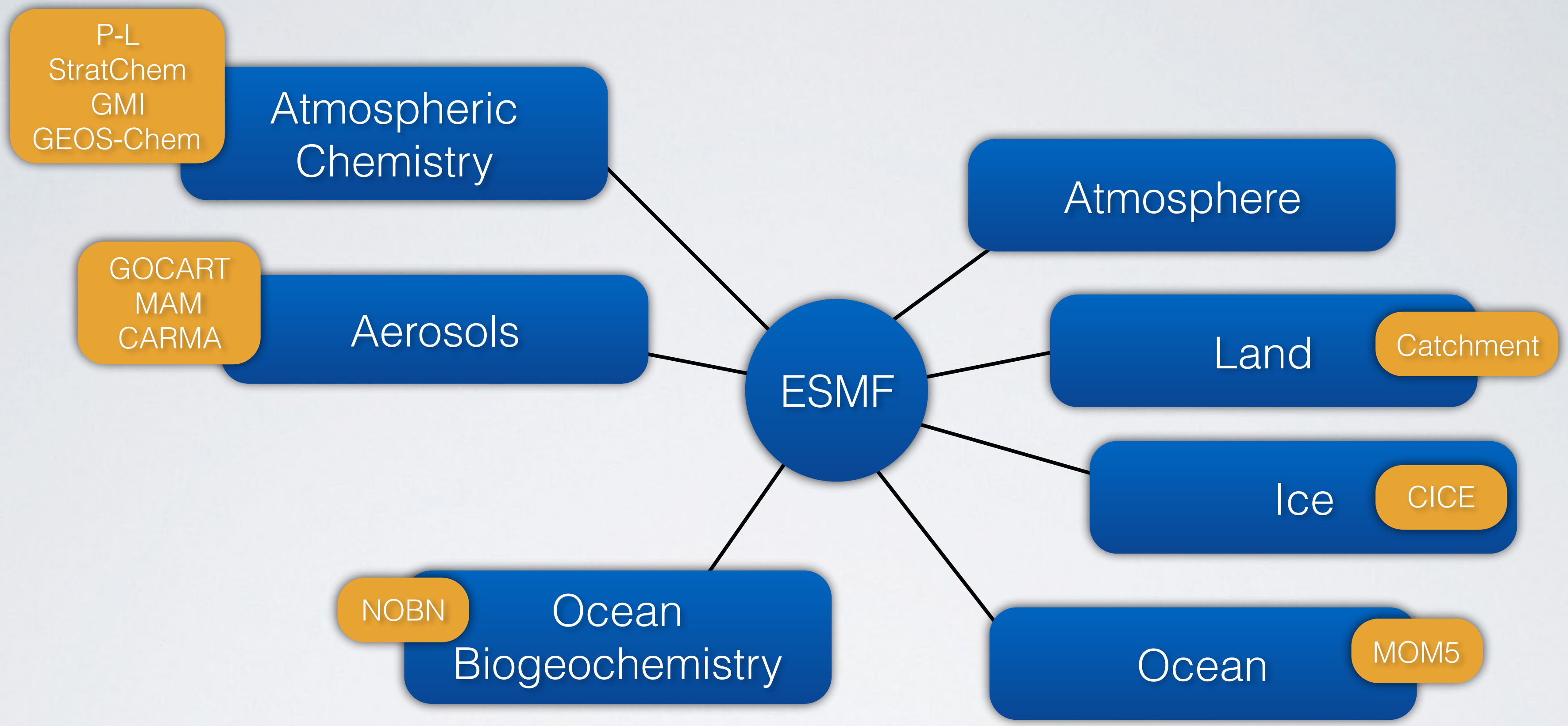
Goddard Earth Observing System, V5



GEOS-5 Aerosol Modules:

- GOCART (bulk)
- MAM (modal) ➞ Under implementation
- CARMA (sectional) ➞ For sulfate only

Main uses of GEOS-5:

- Weather forecast
- MERRA Climate reanalysis
- Mission support
- Science

Figure by P. Colarco

SOURCES OF STRATOSPHERIC AEROSOL

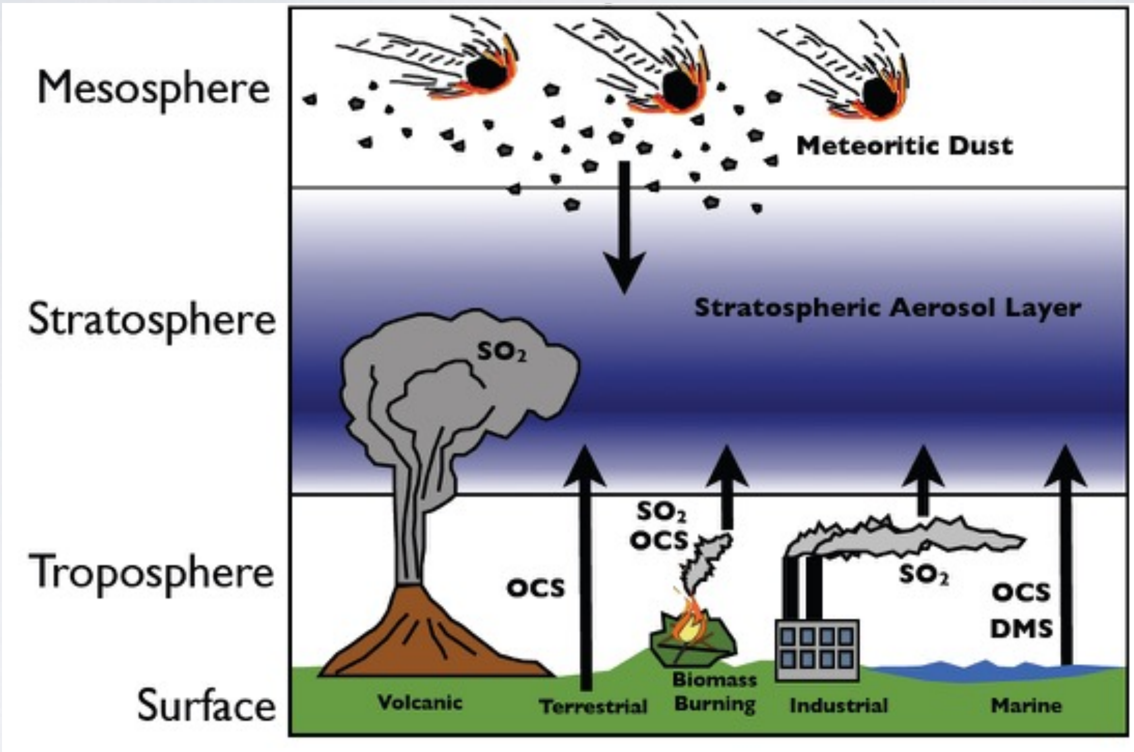


Image credit: NOAA

OCS:

- prescribed surface concentration (510 ppt, English et al. 2013);
- production of sulfur via photolysis, OCS+O, and OCS+OH;
- subsequent formation of sulfate aerosol

Volcanic eruptions:

- injection of SO2 (gas) following database of altitude and magnitude (Carn et al. 2015);
- subsequent transformation of SO2 in sulfate aerosol

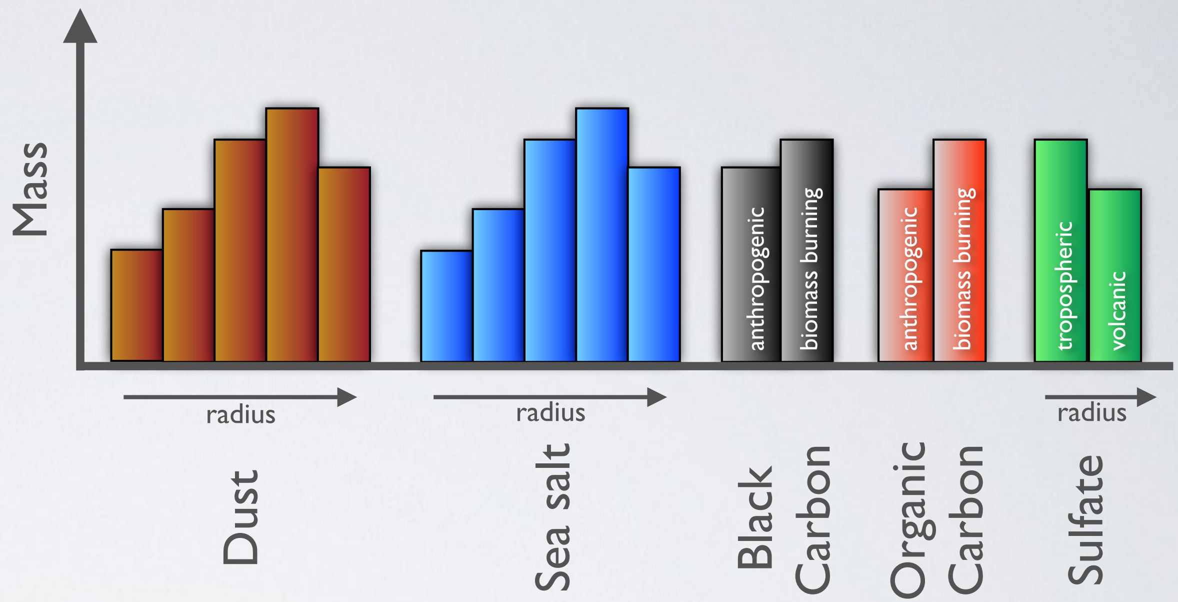
Tropospheric aerosol:

- emissions of tropospheric aerosol and aerosol precursor
- transport to the stratosphere

GEOS-5 Aerosol Schemes

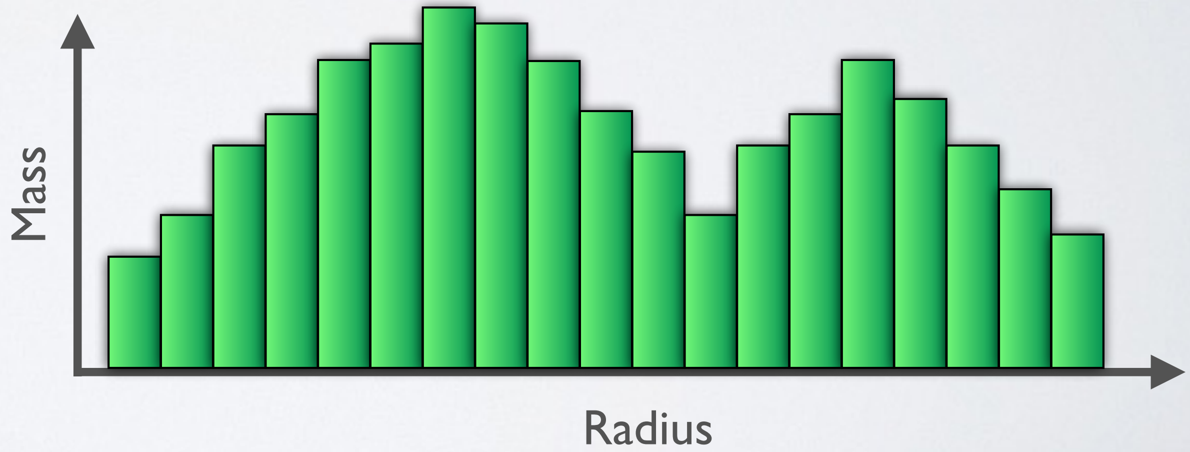
GOCART

- tracks **only** the mass of each aerosol species (bulk model)
- Sectional approach for DU and SS
- Pro: Computationally fast
- Con: The aerosol radius is prescribed



CARMA

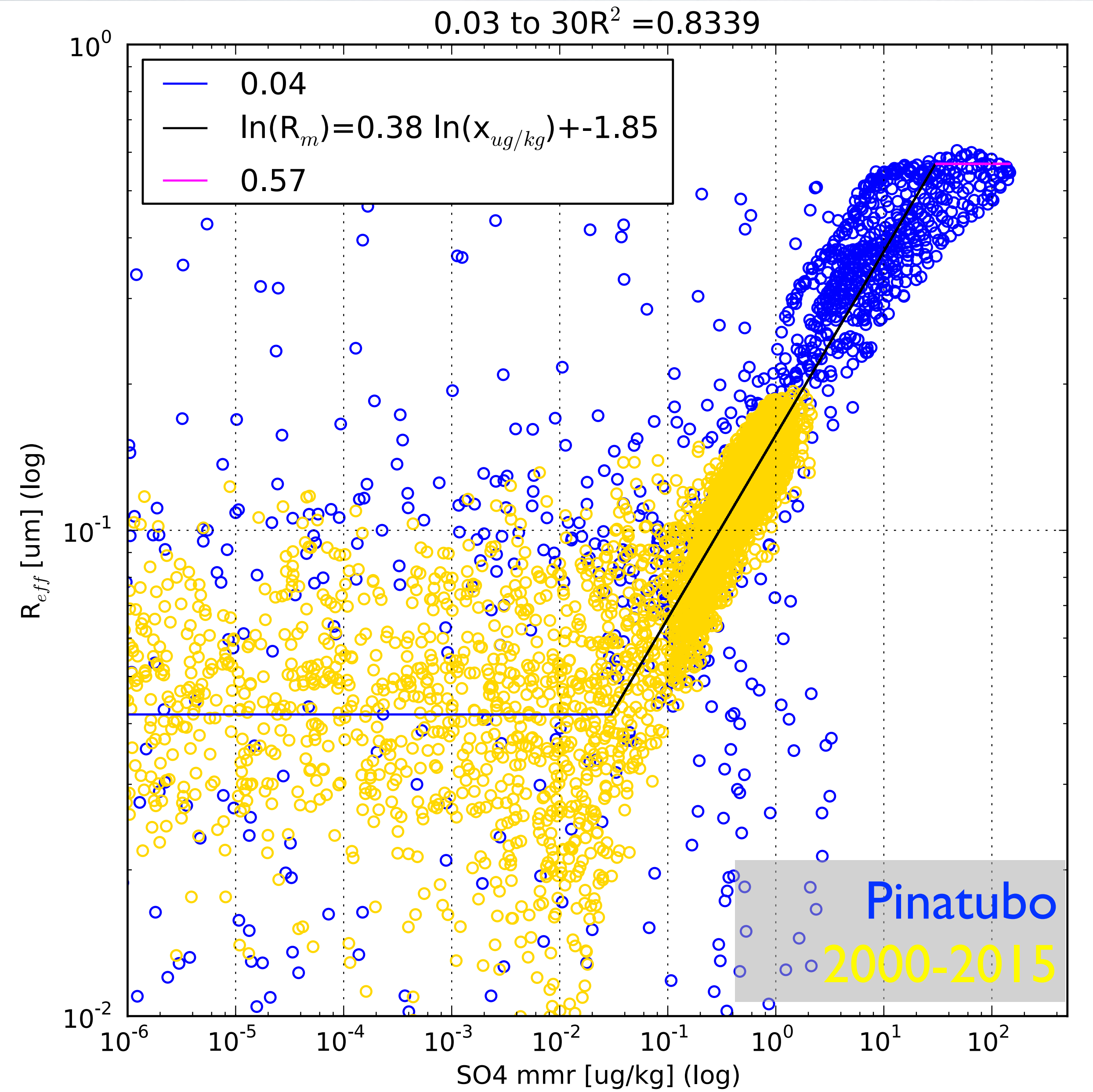
- tracks the sulfate mass in each size bin (sectional model), hence simulate the aerosol size distribution
- 21 size bins
- Pro: online calculation of size distribution
- Cons:
  - implemented only for SU
  - ~50% more computationally expensive than GOCART



MAM not yet fully implemented

Figure by P. Colarco

A New Aerosol Radius Parameterization



Relationship between aerosol effective radius and SO_4 mass mixing ratio **above the tropopause**, calculated from CARMA output.

Currently implemented only in GOCART settling routine (soon to be implemented for optical properties)

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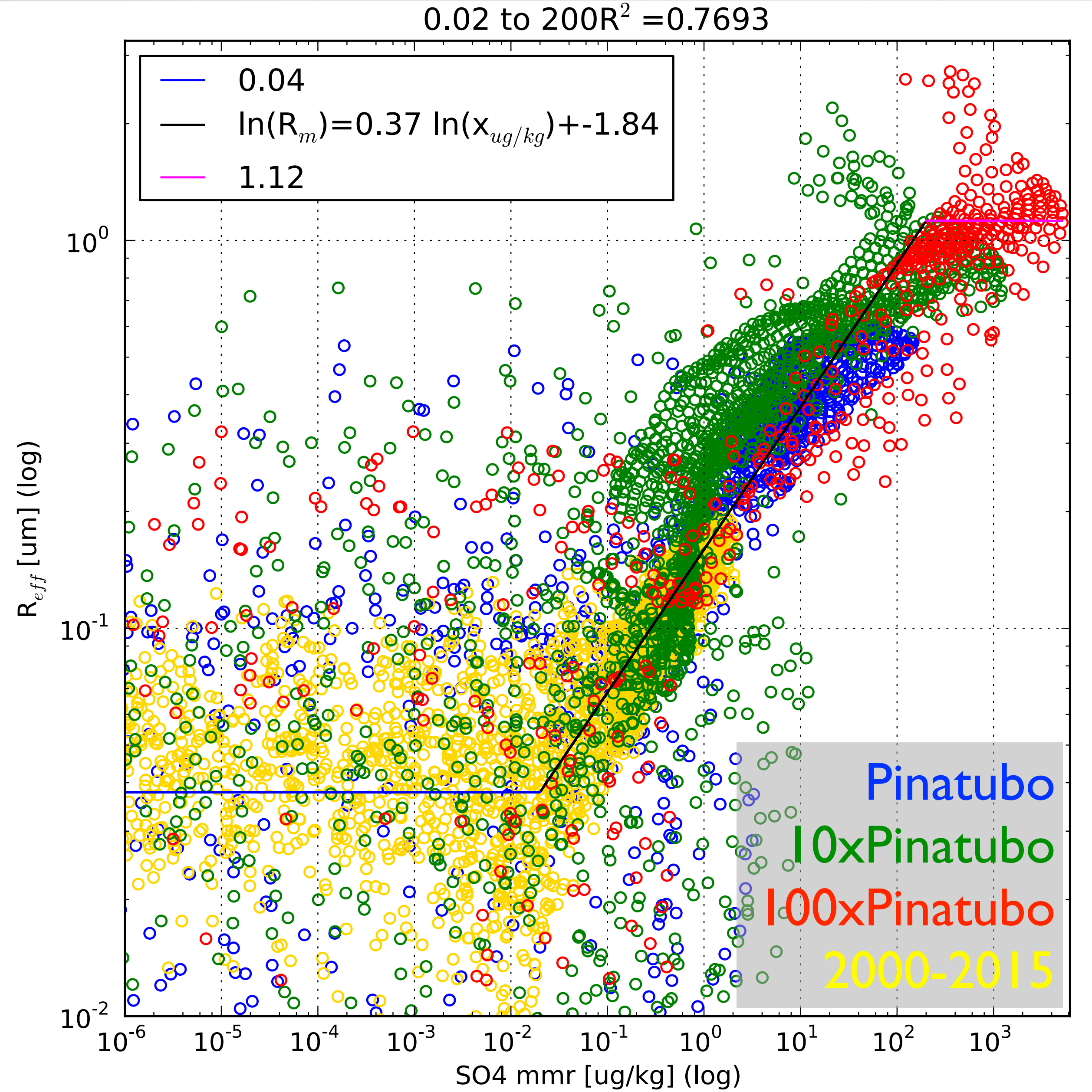

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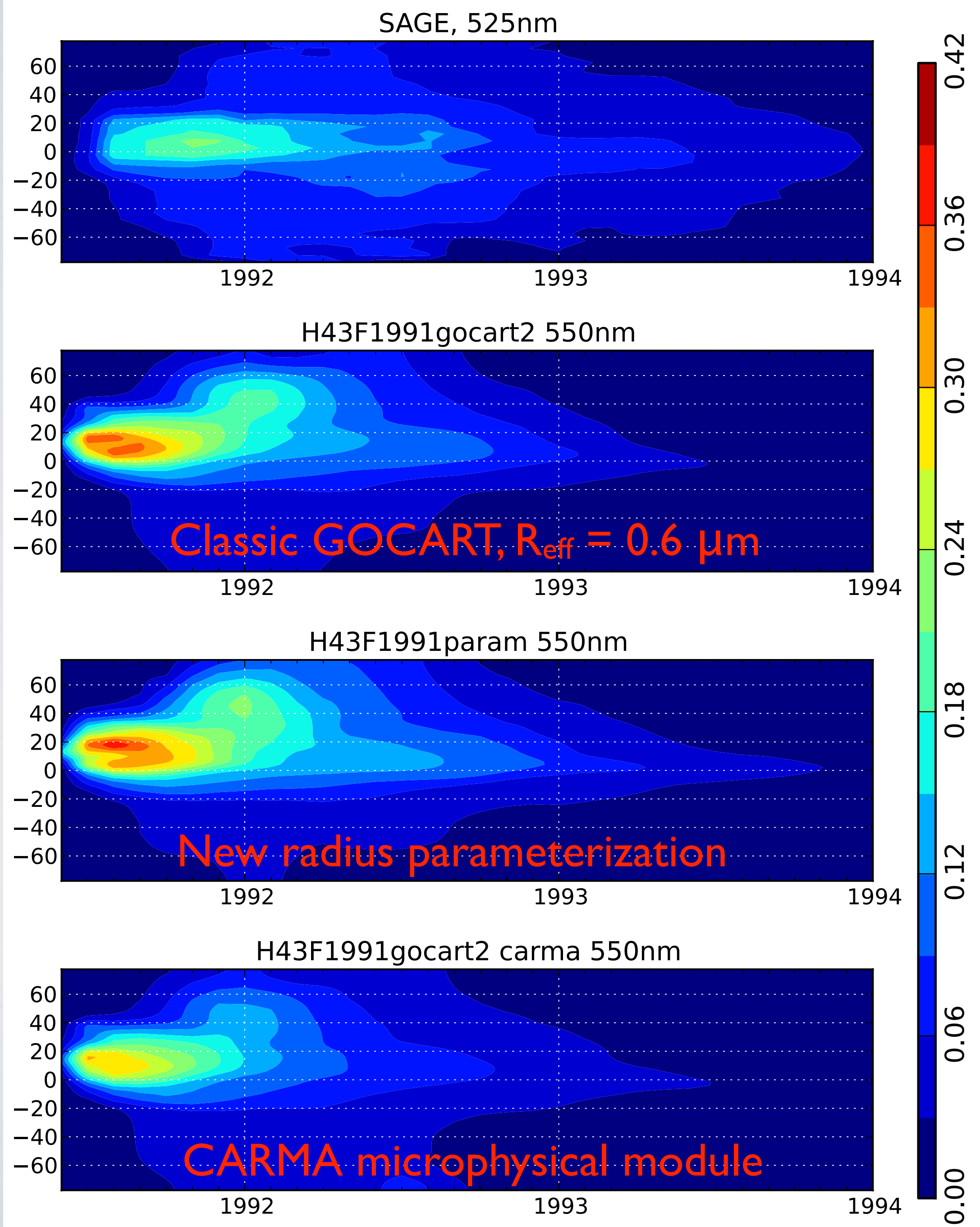
MOUNT PINATUBO



Aerosol Optical Thickness (h>16km)

Setup:
20Tg SO_2 at 18-25km
(as in database by Carn et al. 2015)

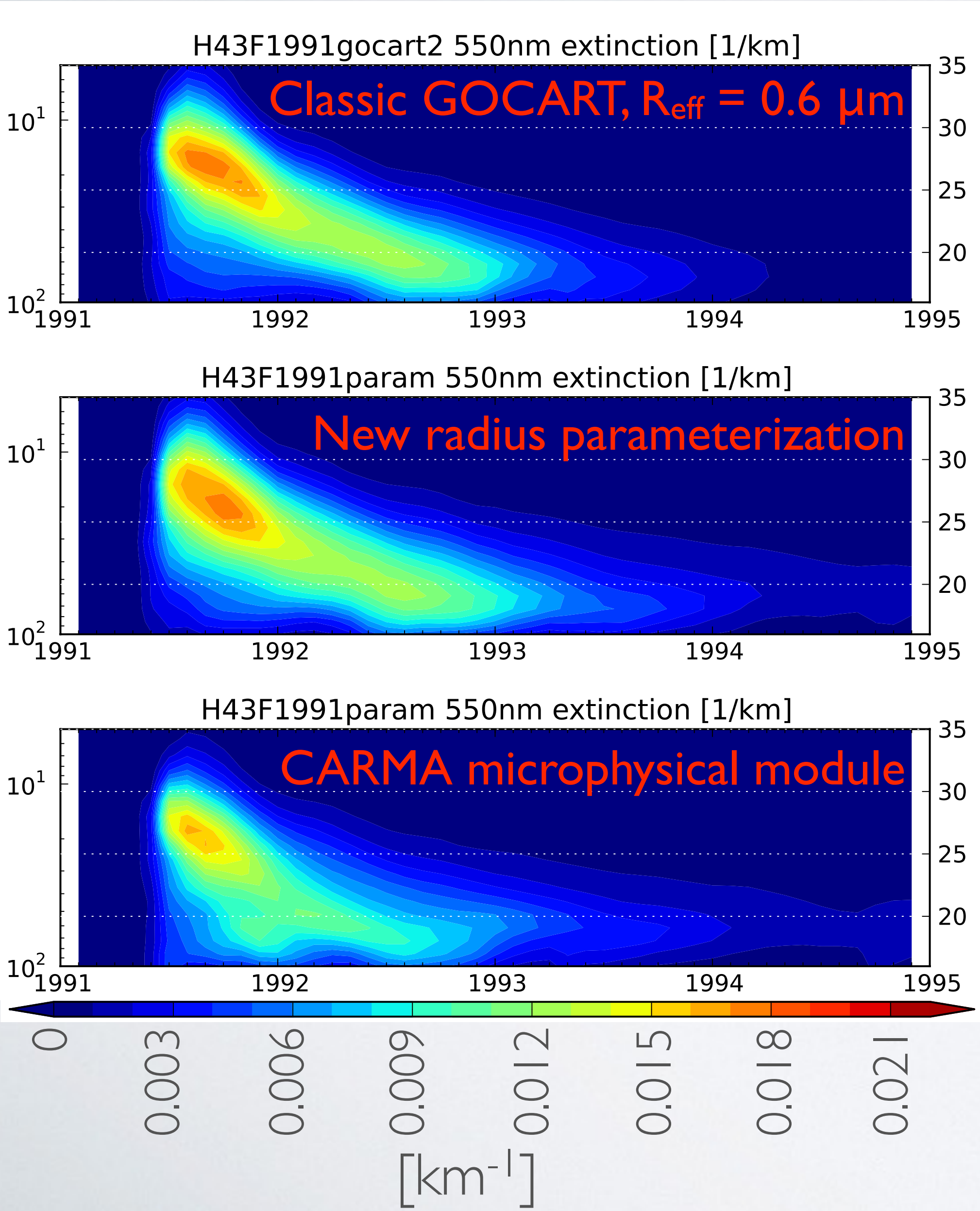
➡Simulated AOT is higher than SAGE: a 20Tg injection is probably too much

➡The new parameterization prolongs the lifetime of aerosol, in better agreement with SAGE

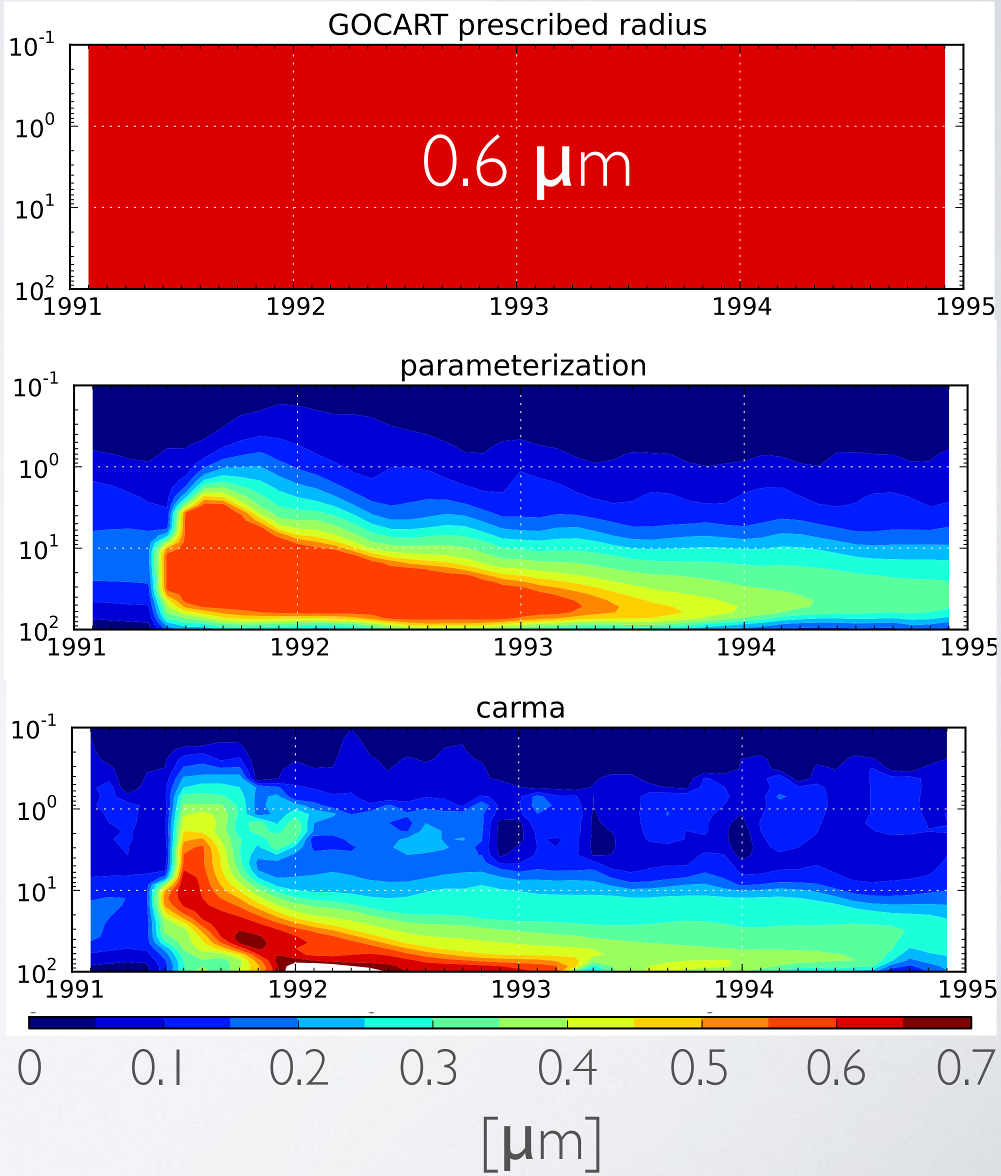
➡Not much change in max AOT between classic GOCART and the new parameterization, probably because it is not yet implemented for aerosol optical properties

Mount Pinatubo

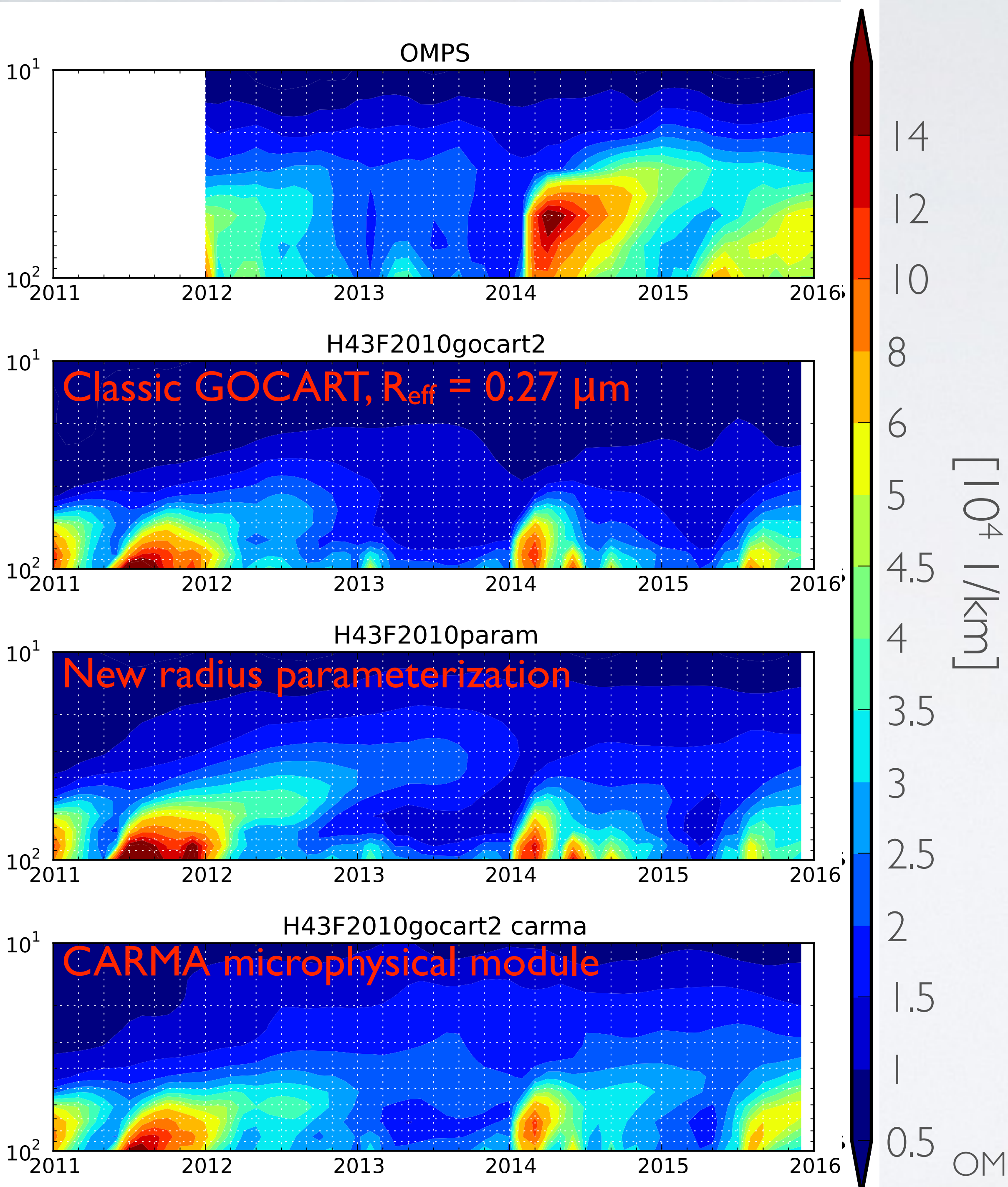
Zonal mean extinction at 30S-30N



Mean effective radius at 30S-30N



OMPS PERIOD

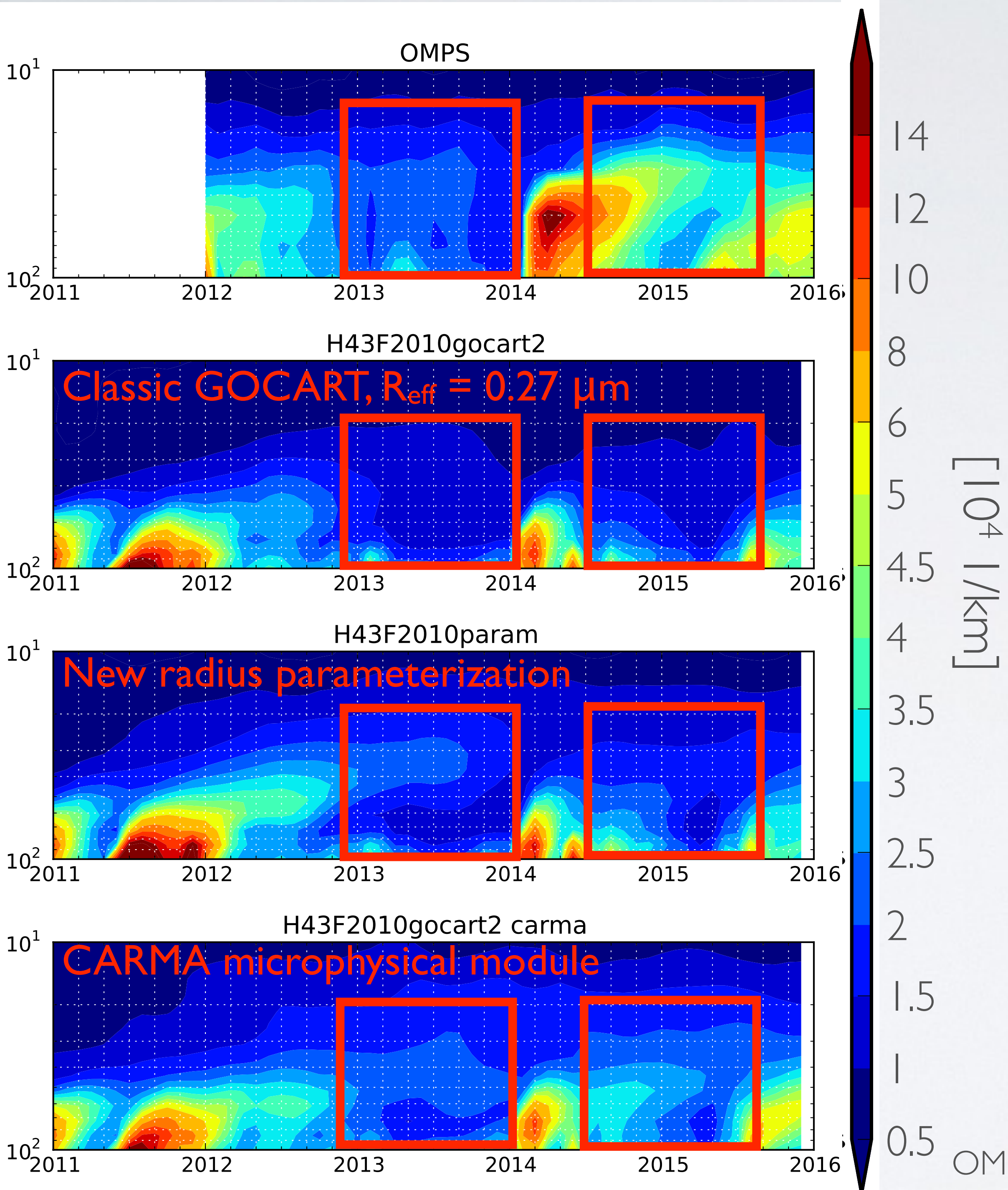


Extinction coefficient at 675 nm 10°S-EQ

- ➡ Improvement in the representation of the tail of Nabro
- ➡ Upward motion of Kelut's plume still not fully reproduced, maybe because of the misrepresented injection parameters

OMPS data by G. Taha

OMPS Period



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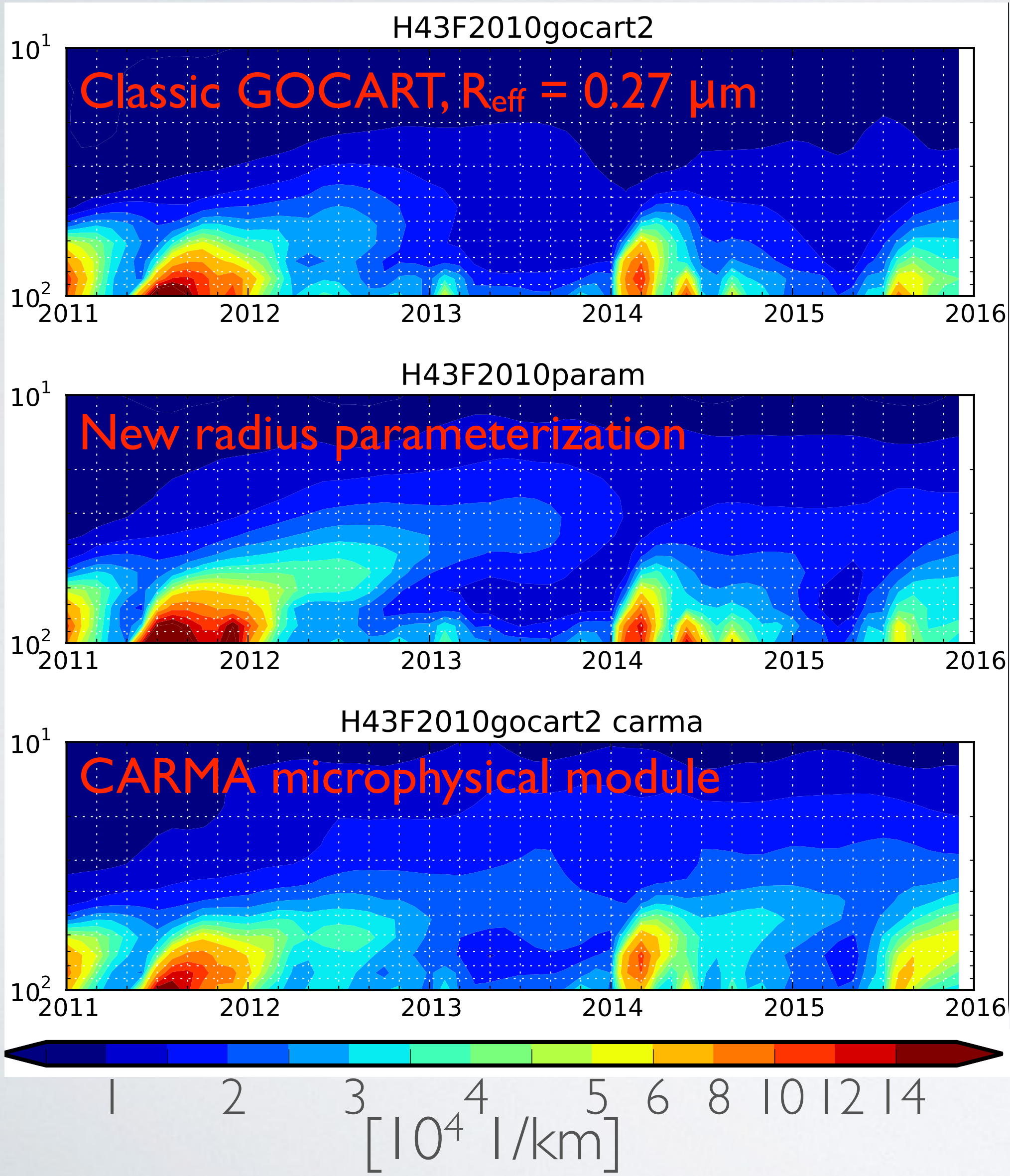
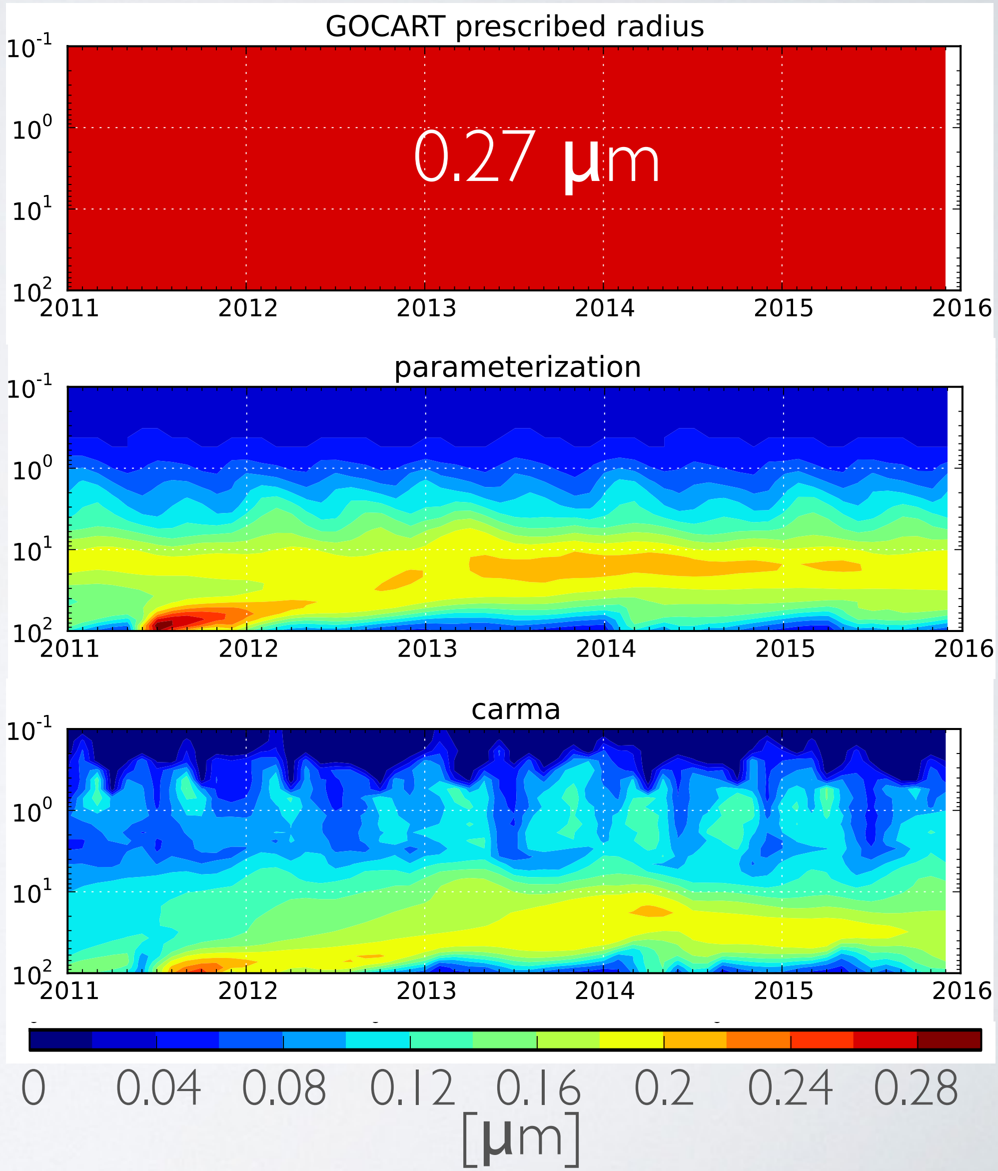
Recent Period

Extinction at 10°S-EQ



Mean effective radius at 10S-EQ



V. Aquila - SSiRC - 26/04/2016

CONCLUSIONS

- GEOS-5 model capabilities
  - ➡Major sources of stratospheric aerosol included: OCS, volcanic eruptions, and transport from the troposphere.
  - ➡Two modules for stratospheric aerosol: GOCART (bulk) and CARMA (sectional microphysics).
- New radius parameterization:
  - ➡Simple relationship between stratospheric aerosol radius and aerosol mass mixing ratio: it represents the evolution of the stratospheric aerosol size while maintaining computational efficiency.
  - ➡Improvements in the comparison with observations especially in the tail of volcanic plumes.
  - ➡Work in progress: Currently only for settling, but soon to be implemented for optical properties.