Simulating instrumentally-defined aerosol type

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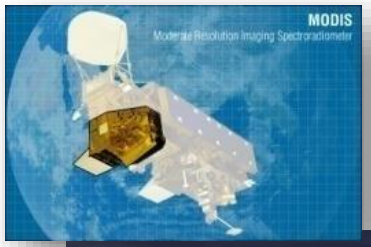
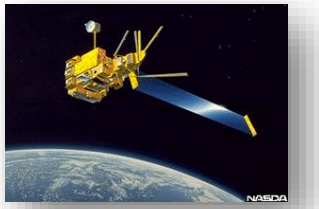
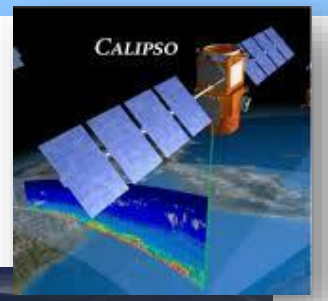
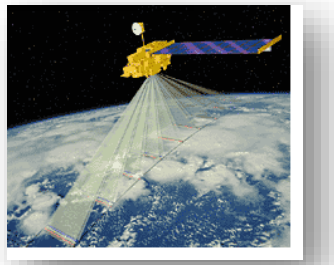
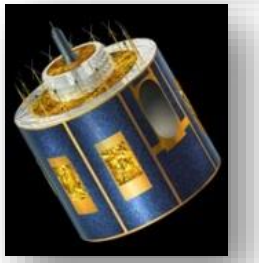
The concept


MODIS
Moderate Resolution Imaging Spectroradiometer

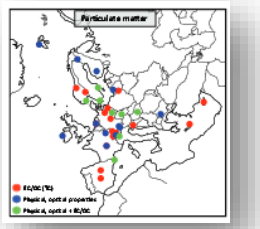

NASDA

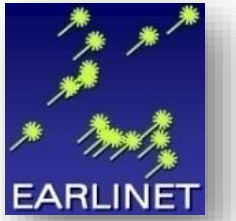

CALIPSO






Different instruments type in different ways
Translating rules needed


Particulate matter


EARLINET

The concept

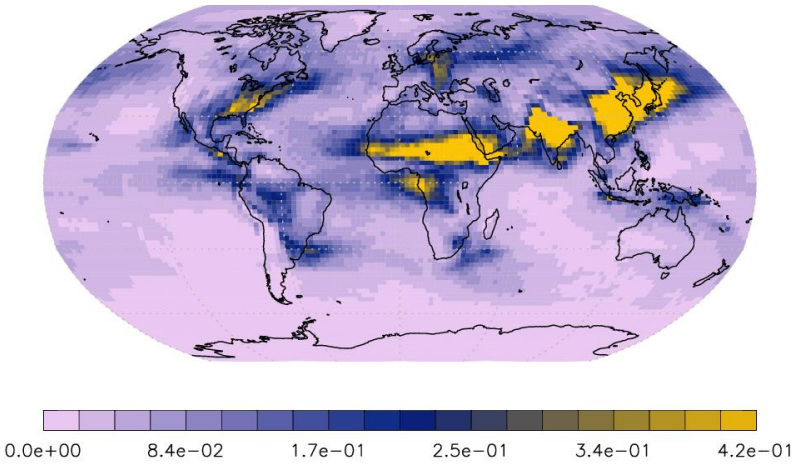
- Co-located datasets can be used for a direct comparison, but limited in number.
  - DustClim as an example.

- Models can serve the role of the common ground where typing procedures are compared against.

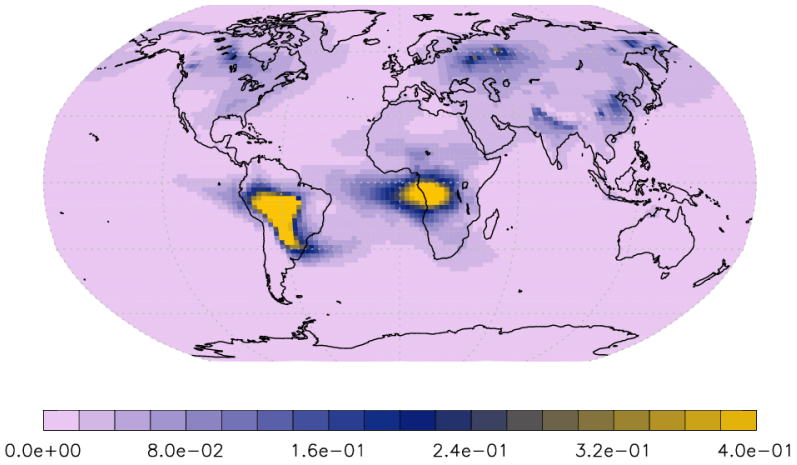
- Information collected in REDAT (Reference Database for Aerosol Typing) as base for such investigations.

What a model calculates (GISS ModelE, OMA, August 2010)

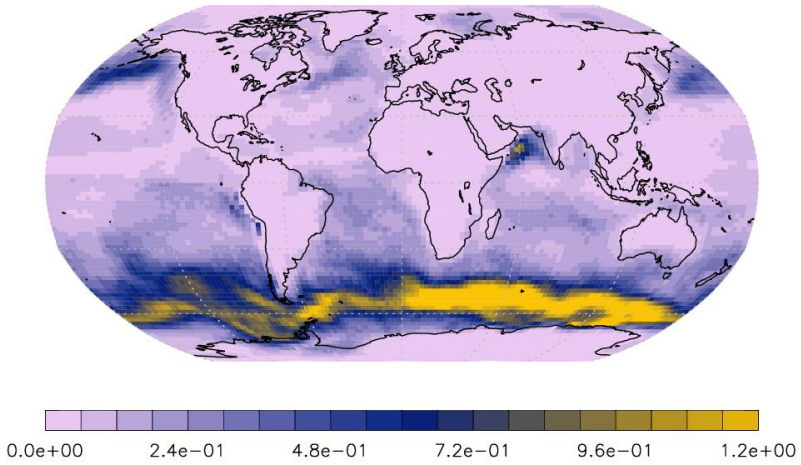
Sulfate



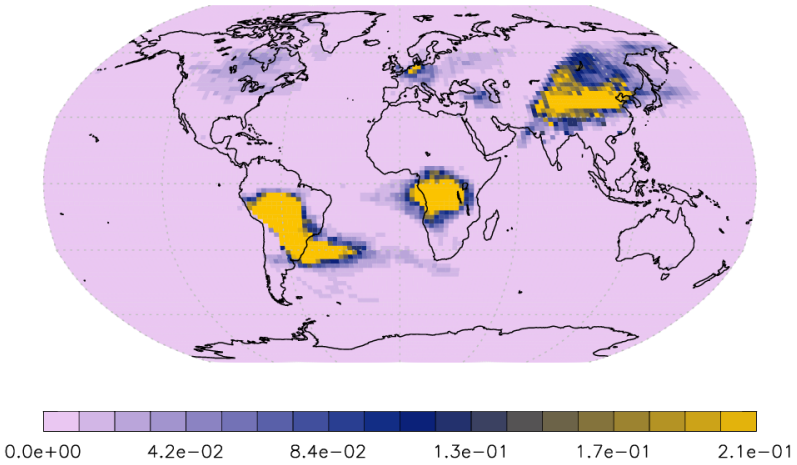
OA



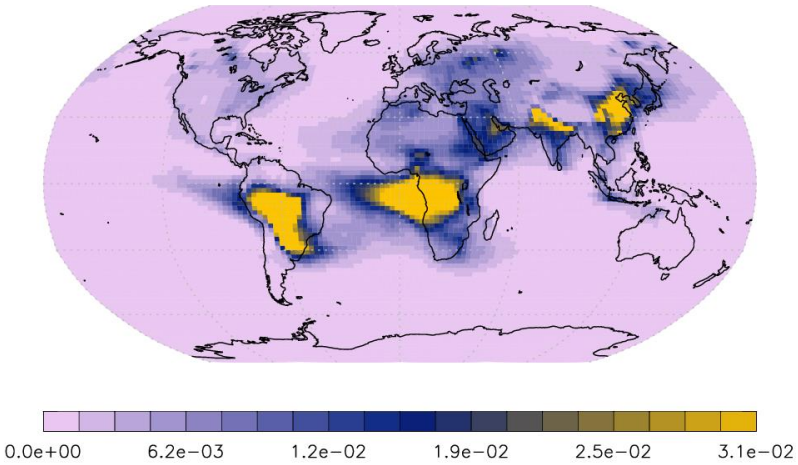
Sea salt



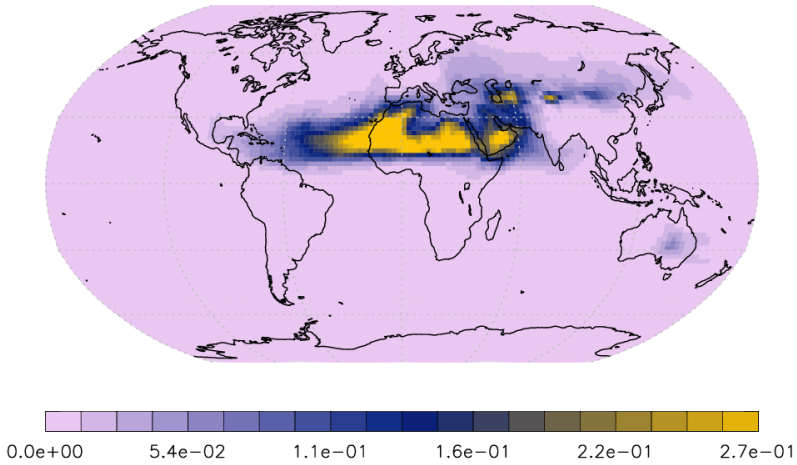
Nitrate



BC



Dust



Note different scales

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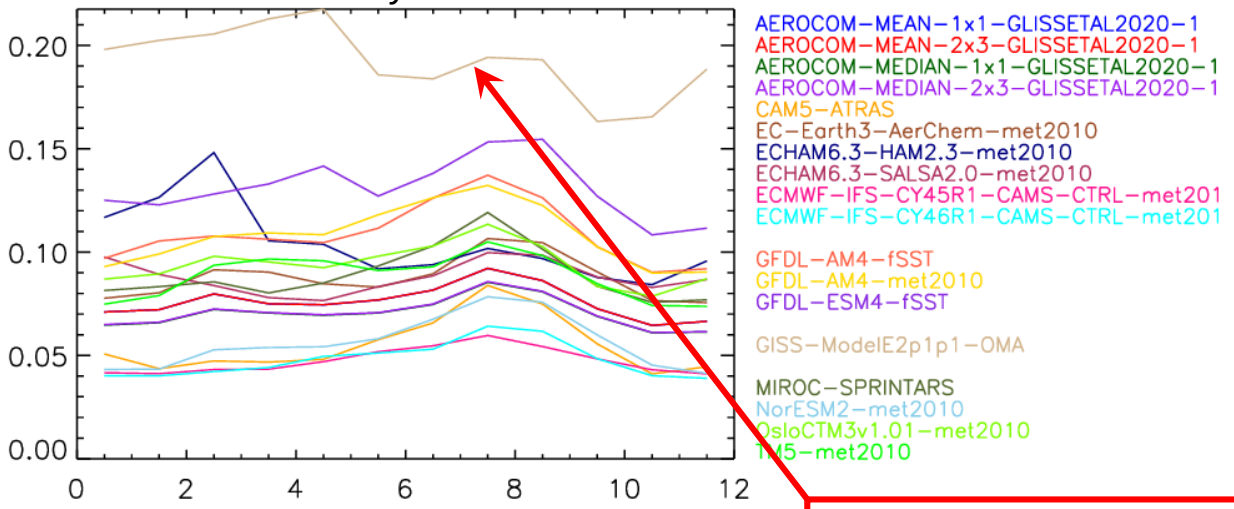
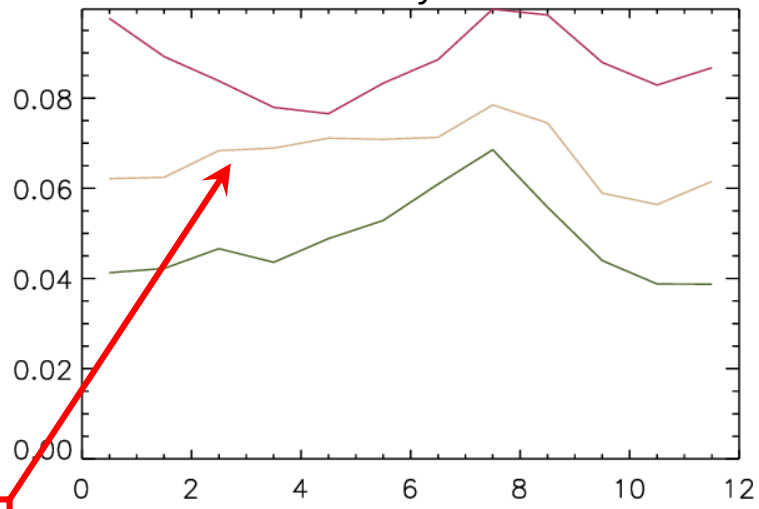
Clear-sky vs. all-sky AOD @ 550 nm

All-sky AODf



AEROCOM−MEAN−1x1−GLISSETAL2020−1
AEROCOM−MEAN−2x3−GLISSETAL2020−1
AEROCOM−MEDIAN−1x1−GLISSETAL2020−1
AEROCOM−MEDIAN−2x3−GLISSETAL2020−1
CAM5−ATRAS
EC−Earth3−AerChem−met2010
ECHAM6.3−HAM2.3−met2010
ECHAM6.3−SALSA2.0−met2010
ECMWF−IFS−CY45R1−CAMS−CTRL−met201
ECMWF−IFS−CY46R1−CAMS−CTRL−met201
GFDL−AM4−fSST
GFDL−AM4−met2010
GFDL−ESM4−fSST
GISS−ModelE2p1p1−OMA
MIROC−SPRINTARS
NorESM2−met2010
OsloCTM3v1.01−met2010
TM5−met2010

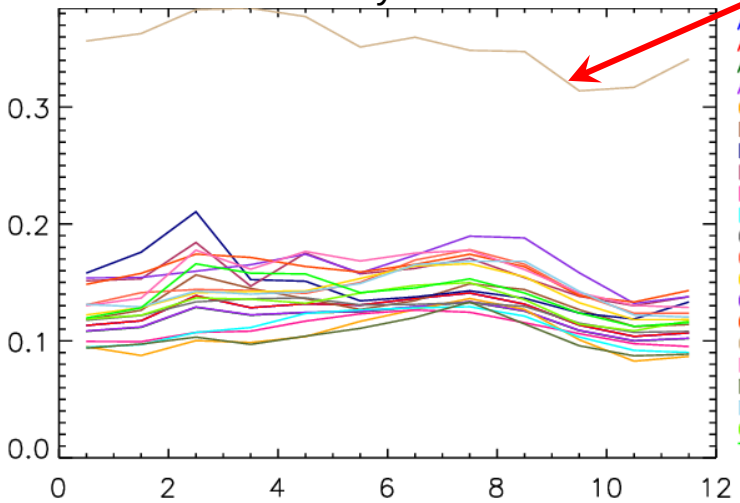
Clear-sky AODf



ECHAM6.3−SALSA2.0−met2010
GISS−ModelE2p1p1−OMA
MIROC−SPRINTARS

GISS ModelE OMA

All-sky AOD



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AEROCOM−MEAN−2x3−GLISSETAL2020−1
AEROCOM−MEDIAN−1x1−GLISSETAL2020−1
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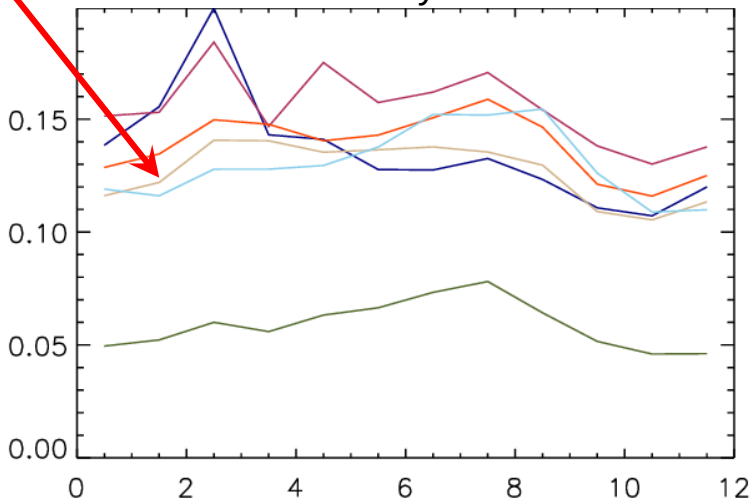
ECMWF−IFS−CY45R1−CAMS−CTRL−met201
ECMWF−IFS−CY46R1−CAMS−CTRL−met201
GEOS−i33p2−met2010
GFDL−AM4−fSST
GFDL−AM4−met2010
GFDL−ESM4−fSST
GISS−ModelE2p1p1−MATRIX
GISS−ModelE2p1p1−OMA
INCA
MIROC−SPRINTARS
NorESM2−met2010
OsloCTM3v1.01−met2010
TM5−met2010

Clear-sky AOD



ECHAM6.3−HAM2.3−met2010
ECHAM6.3−SALSA2.0−met2010
GISS−ModelE2p1p1−MATRIX
GISS−ModelE2p1p1−OMA
MIROC−SPRINTARS
NorESM2−met2010

AOD: all aerosols
AODf: fine mode only (lt1)

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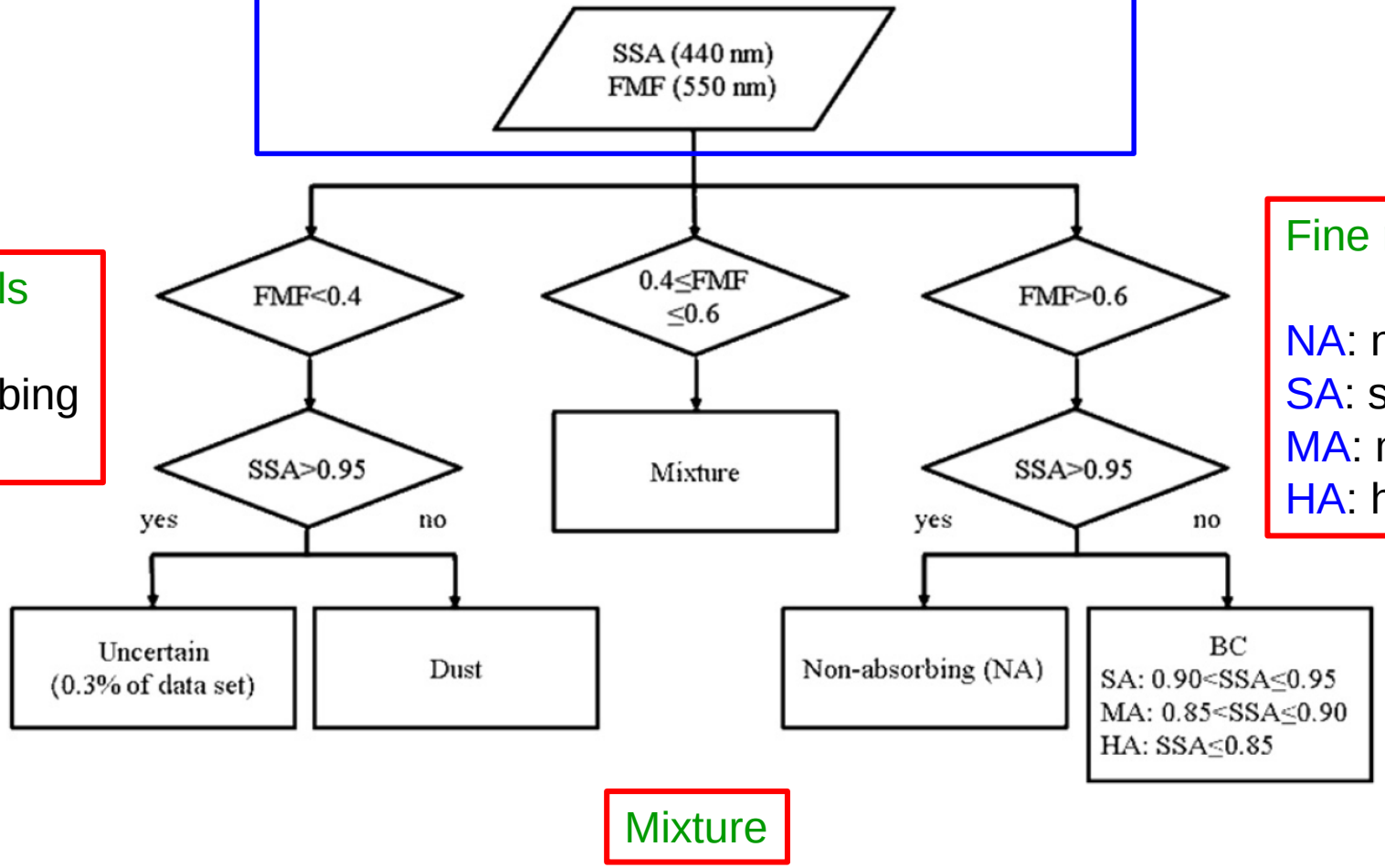
Example of an aerosol classification algorithm for AERONET

Lee et al., Atm. Env., 2010

FMF: fine mode fraction @ 550 nm
SSA: single scattering albedo @ ~~440 nm~~ 550 nm



Coarse mode aerosols

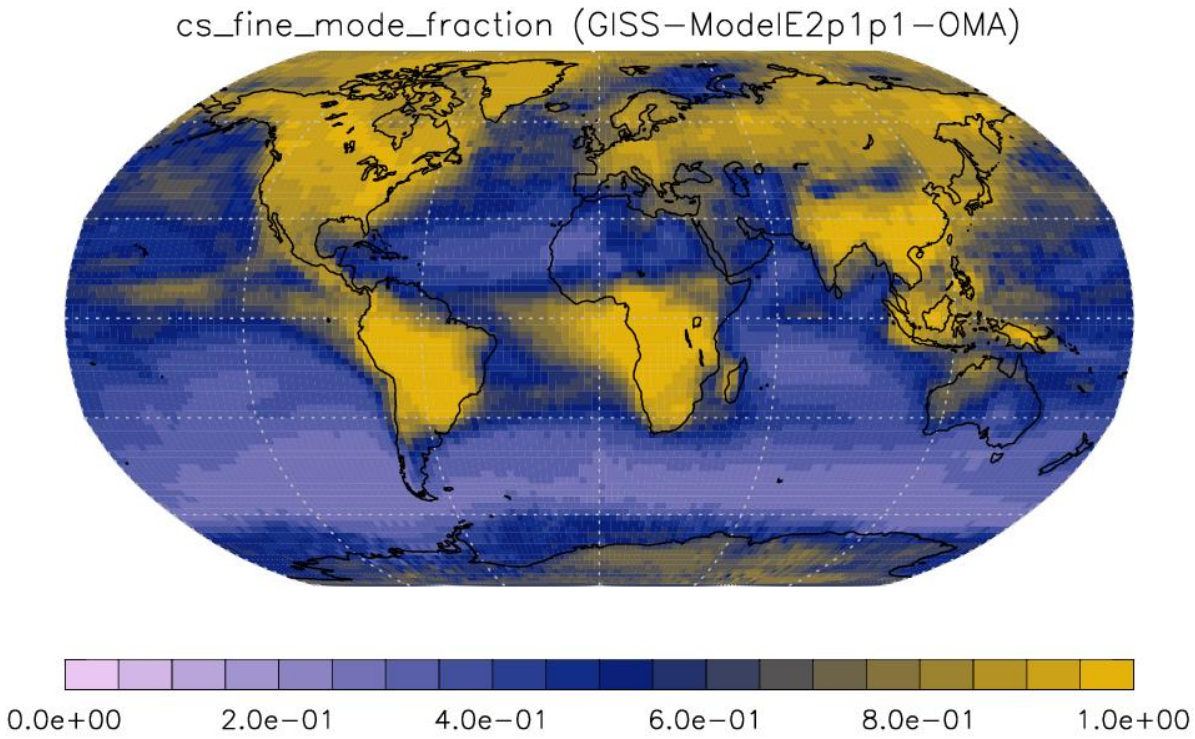
Uncertain: non-absorbing
Dust: absorbing

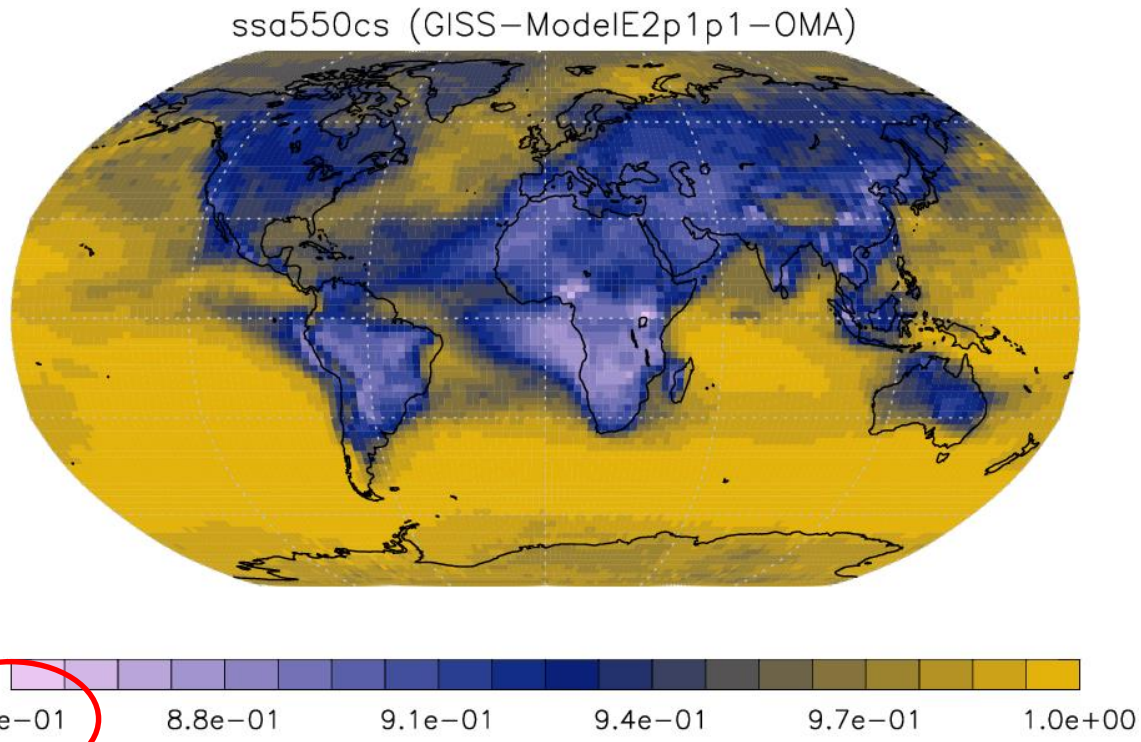
Fine mode aerosols

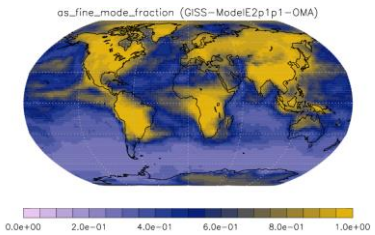
NA: non absorbing
SA: slightly absorbing
MA: moderately absorbing
HA: highly absorbing

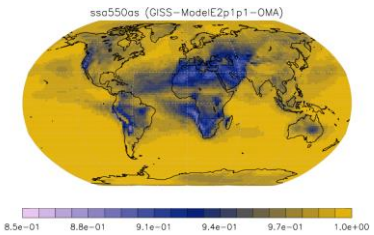
Mixture

FMF and SSA @ 550 nm (clear-sky)









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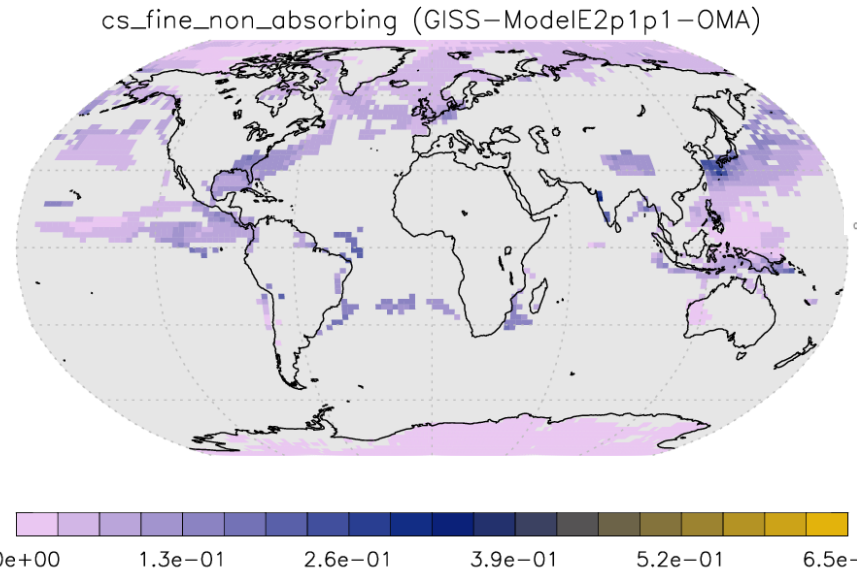
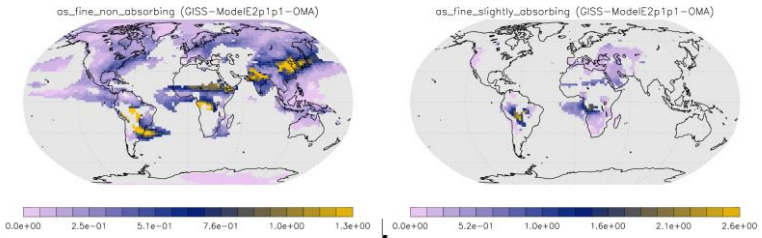
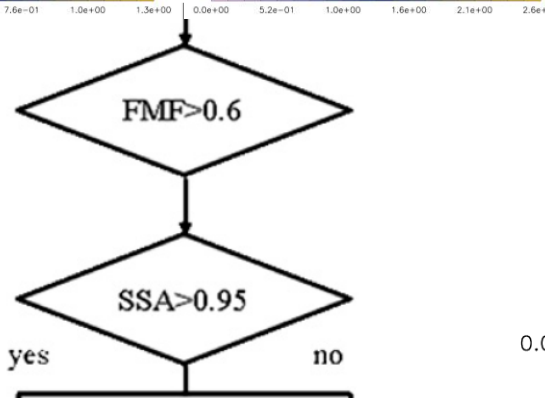
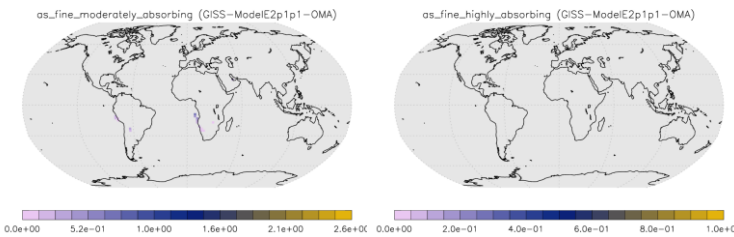
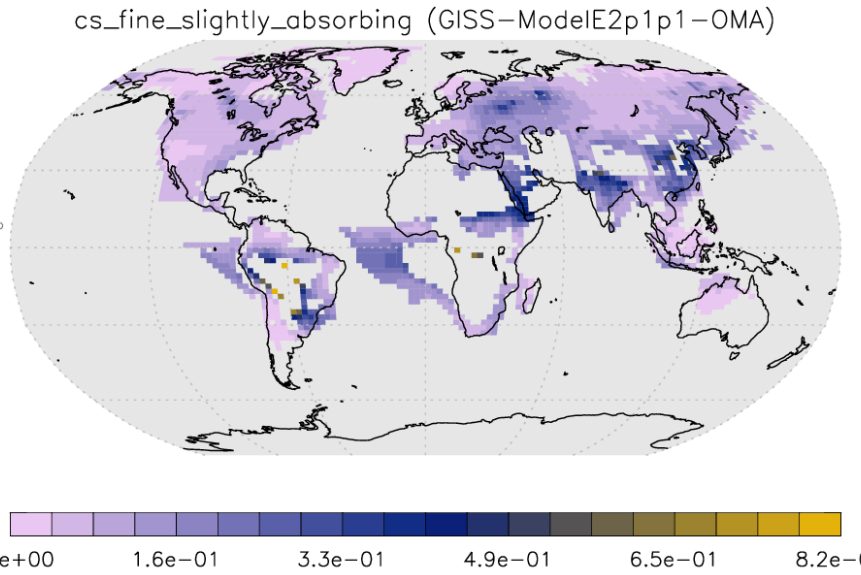
Fine mode (clear-sky)

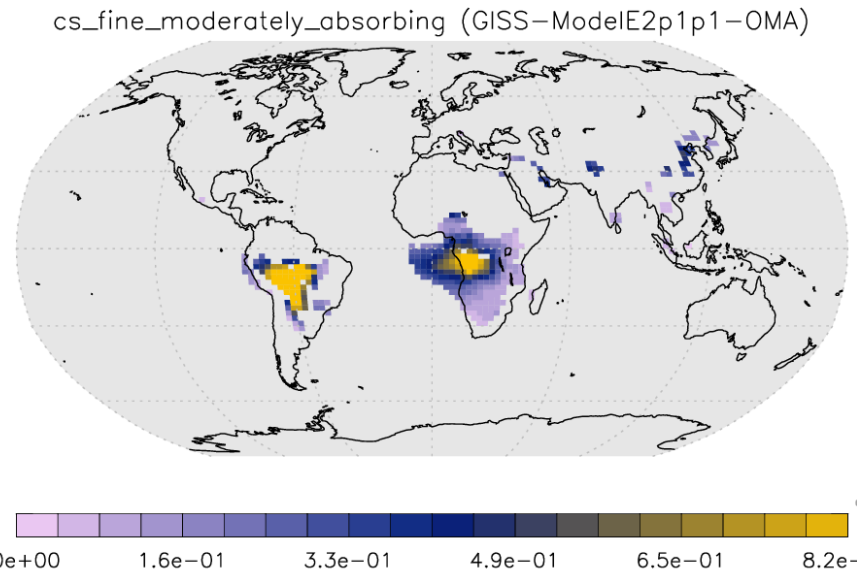


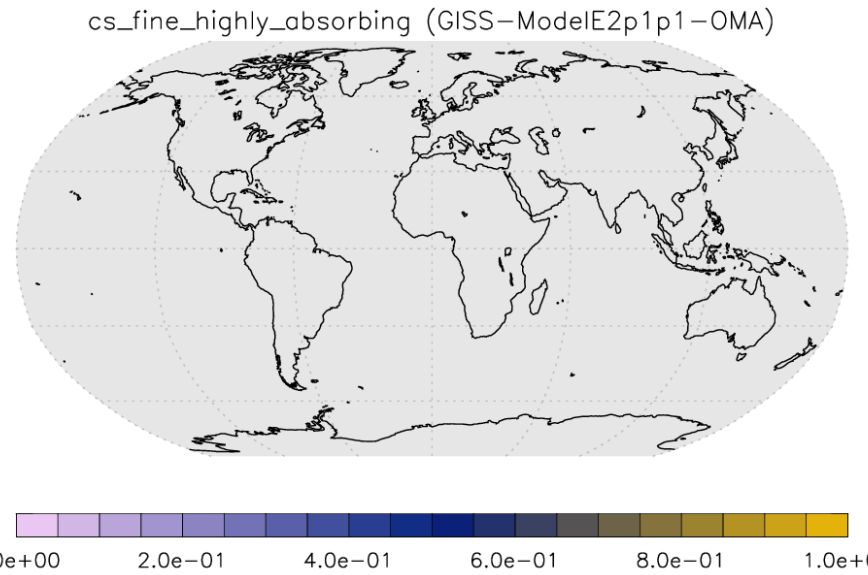












Note different scales

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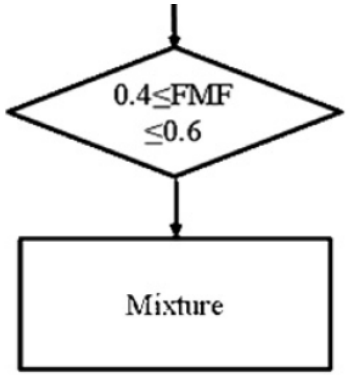
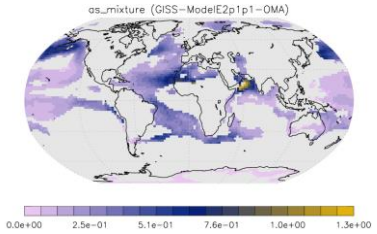
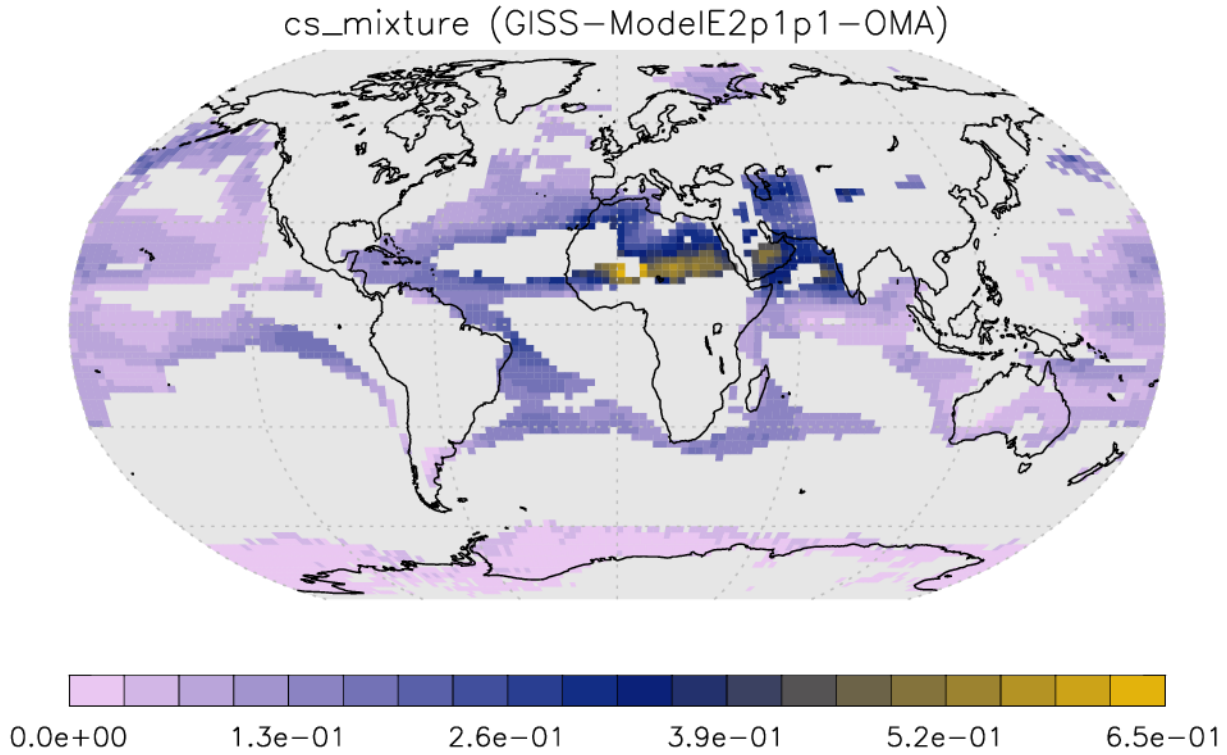
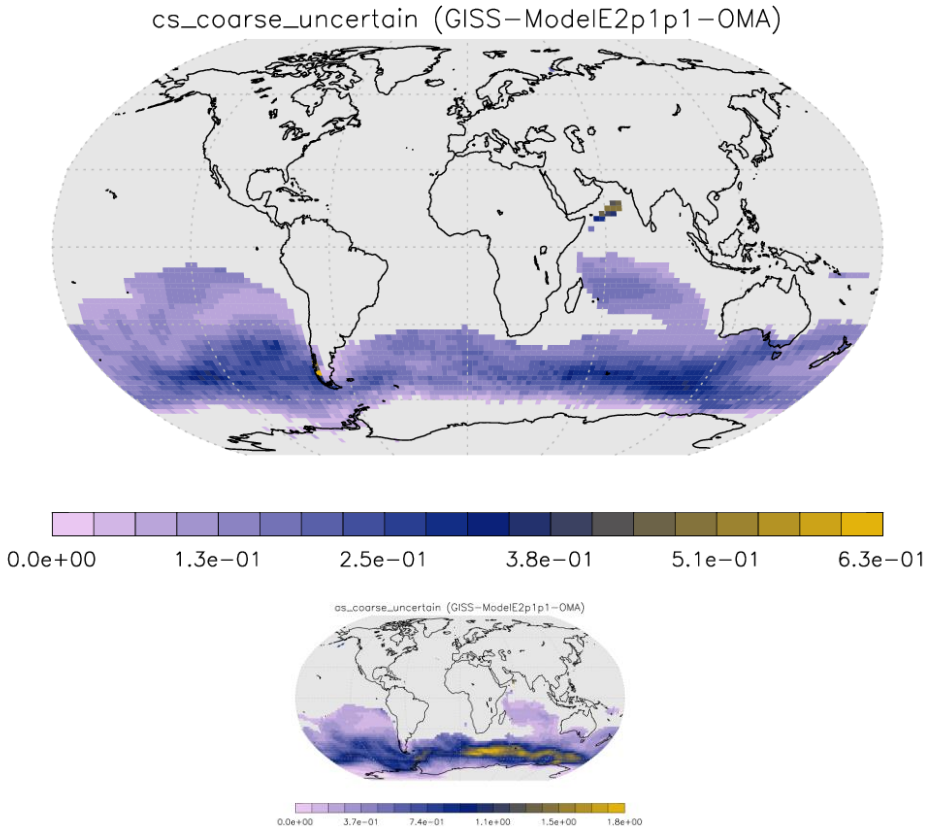
Mixed mode (clear-sky)

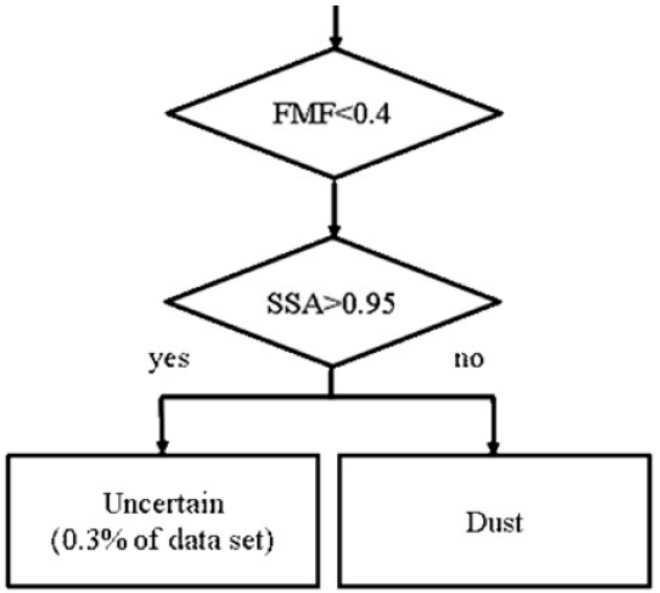


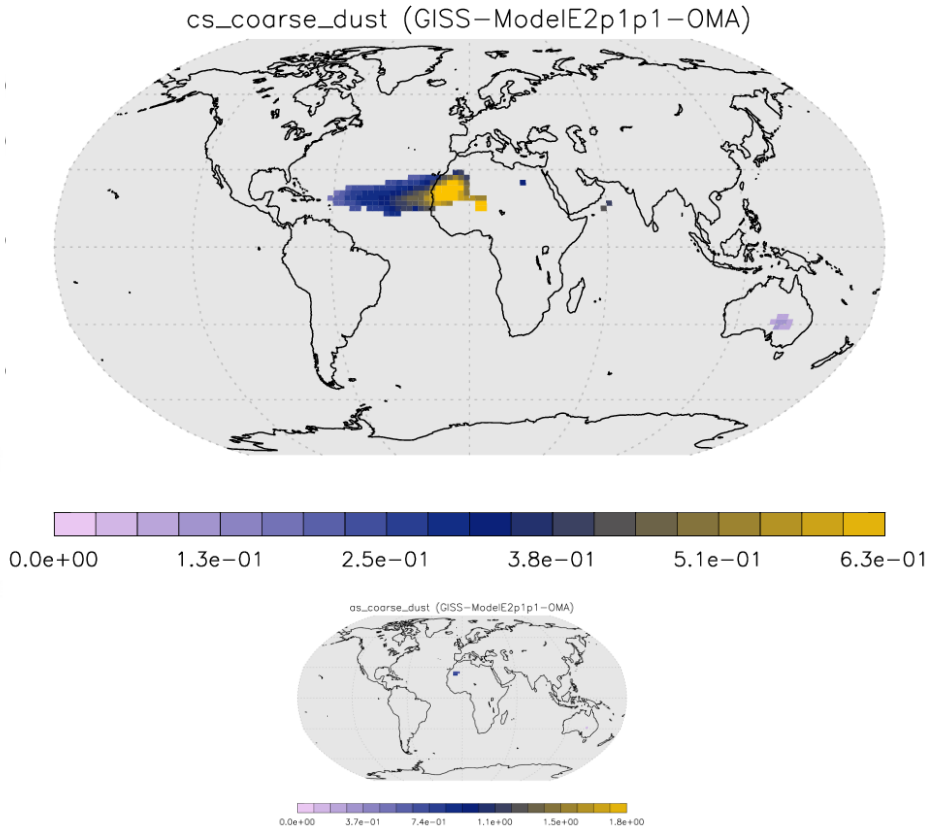




Coarse mode (clear-sky)







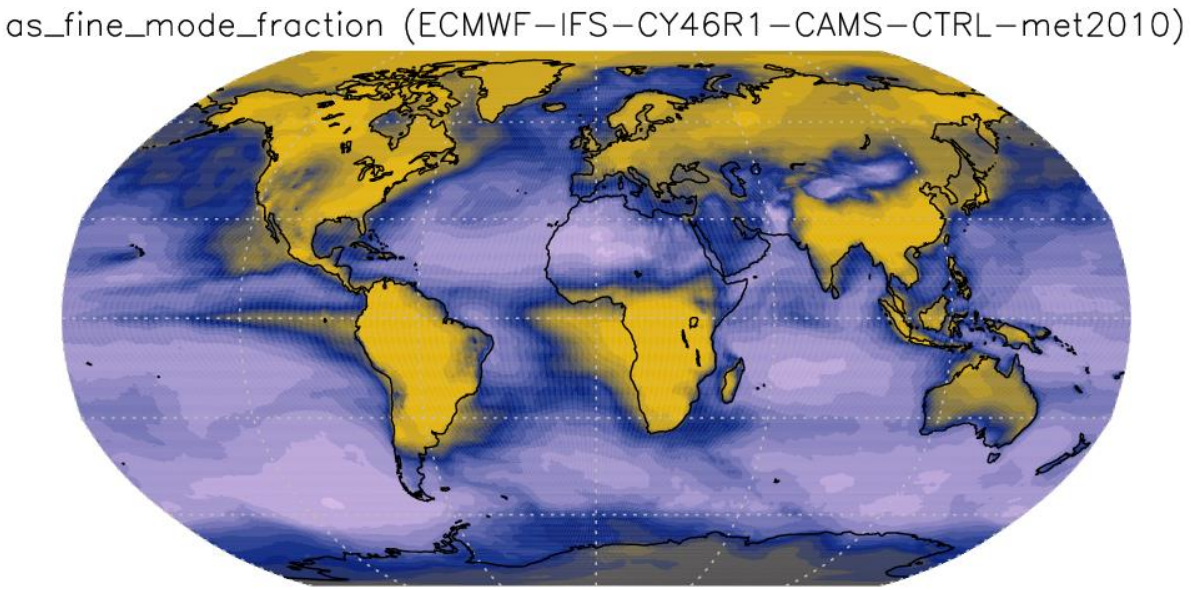
GISS: 2° x 2.5°
ECMWF: ⅓° x ⅓°

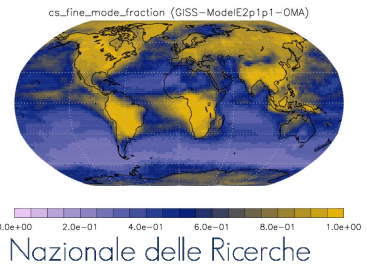
50x higher resolution!

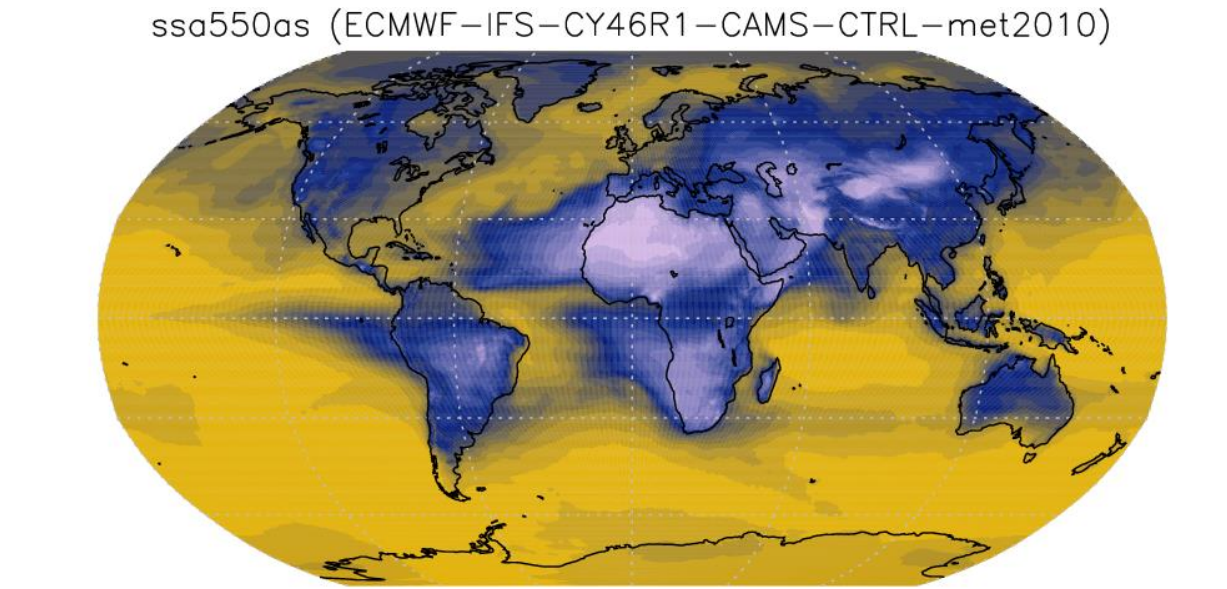
ECMWF-IFS-CY46R1-CAMS

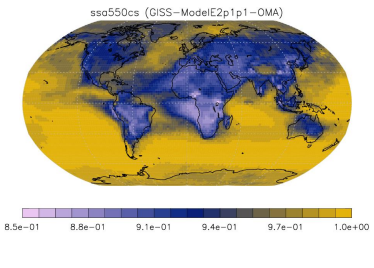
How about another model?

FMF and SSA @ 550 nm (clear-sky)









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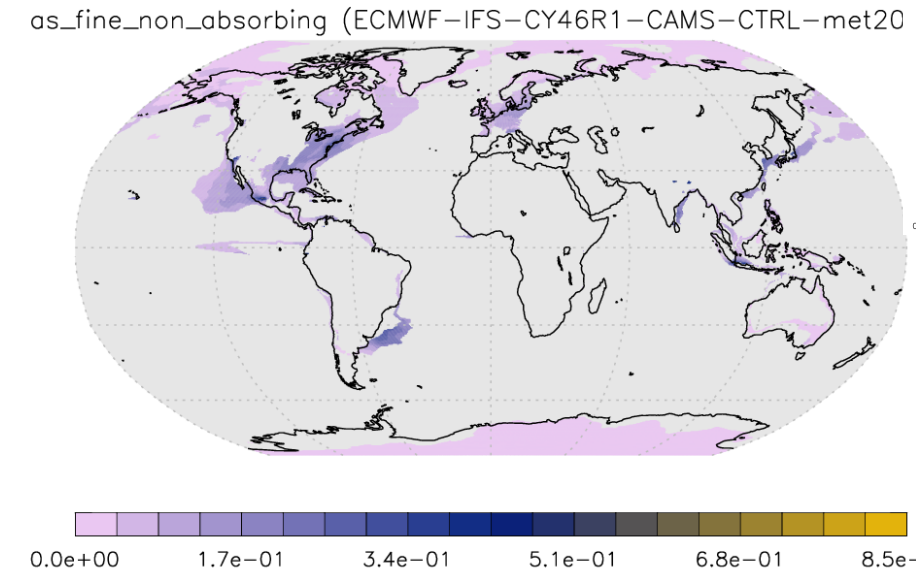
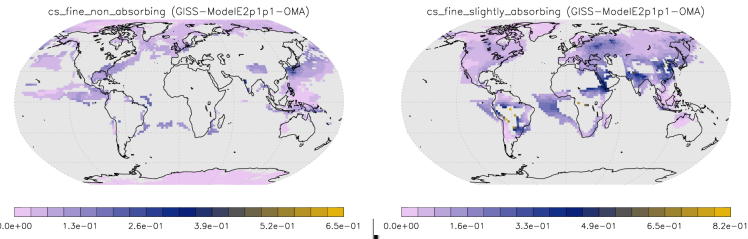
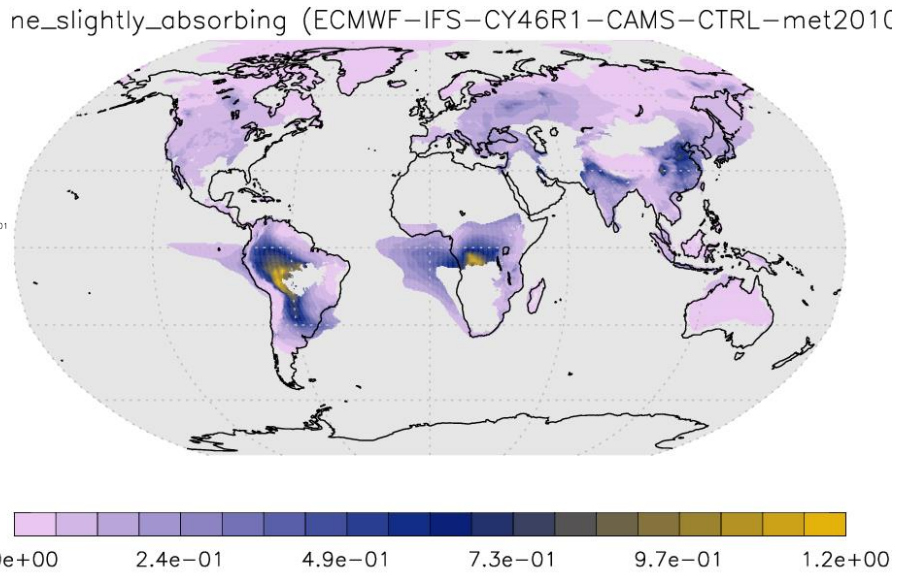
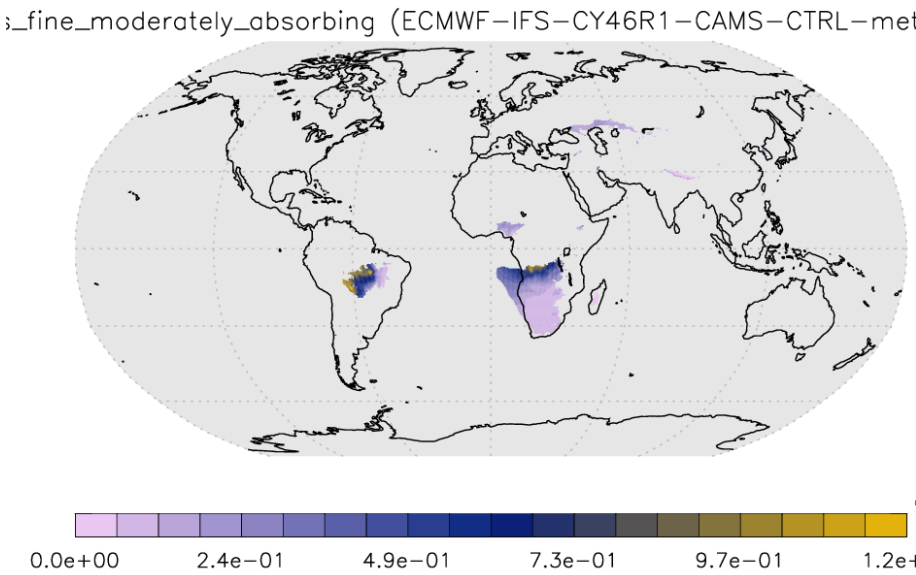
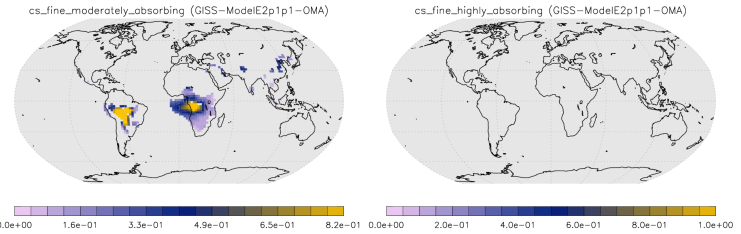
Fine mode (all-sky)

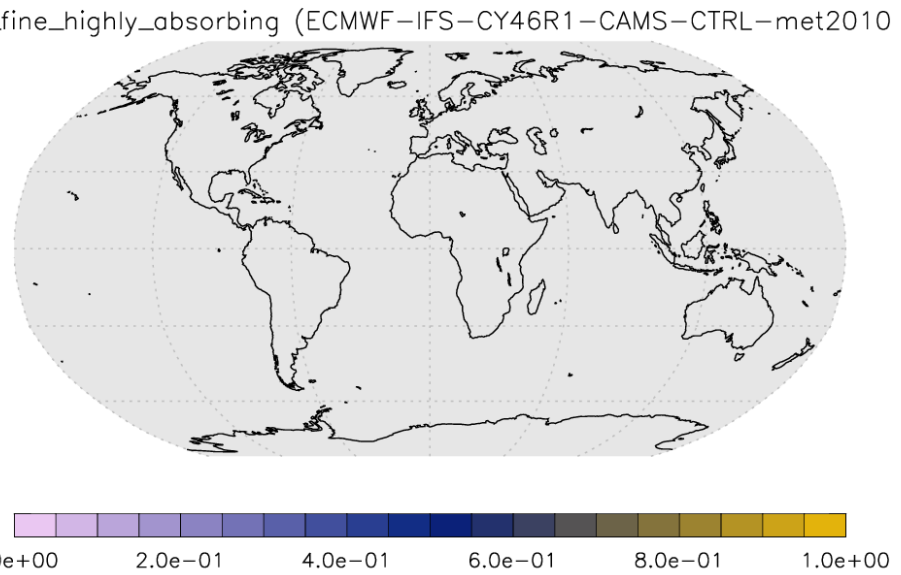


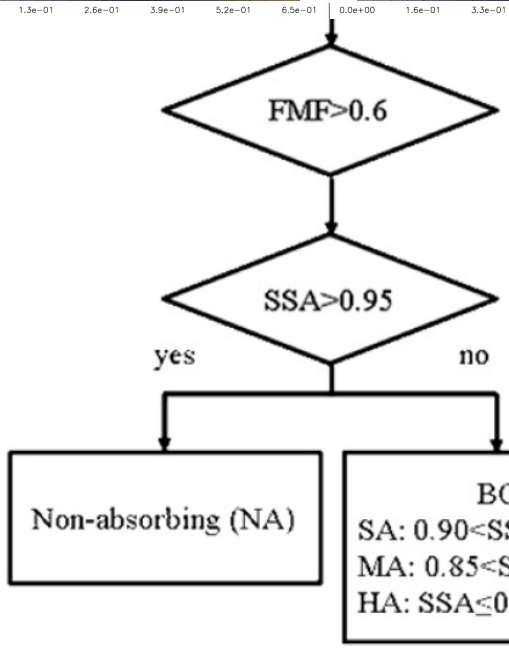












Note different scales

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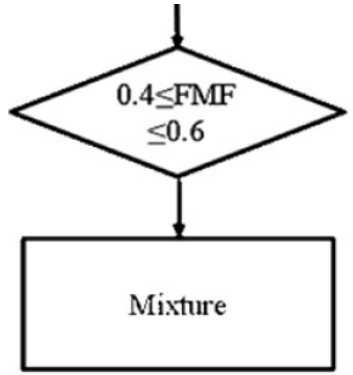
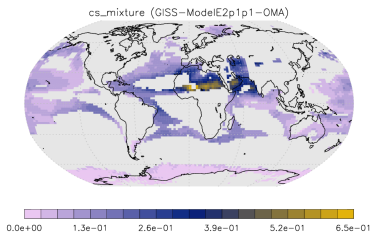
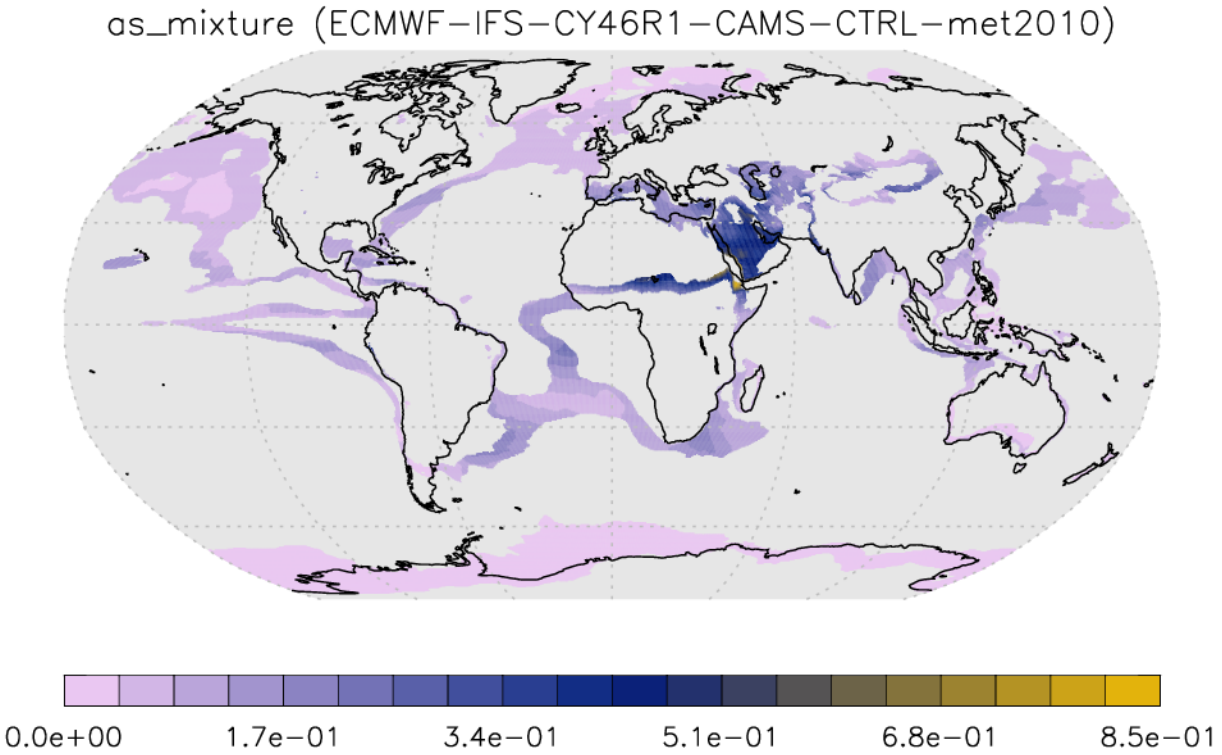
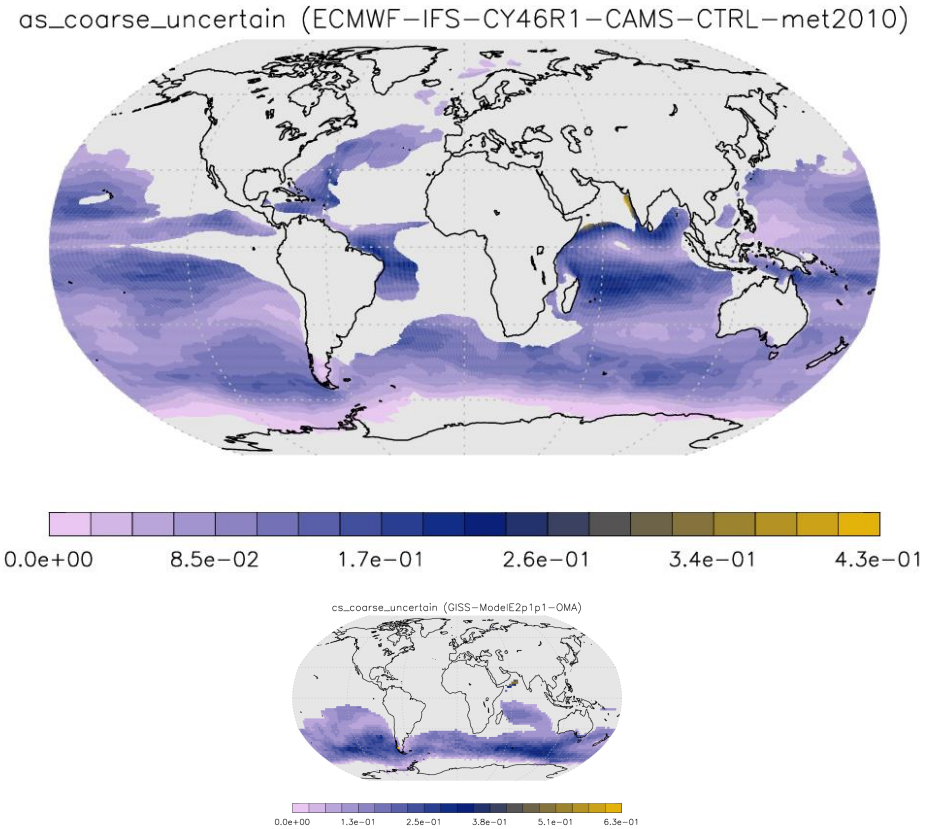
Mixed mode (all-sky)

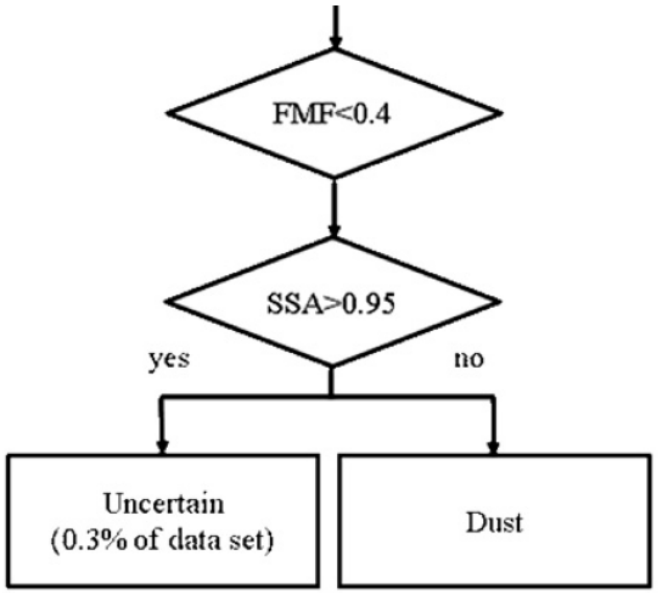


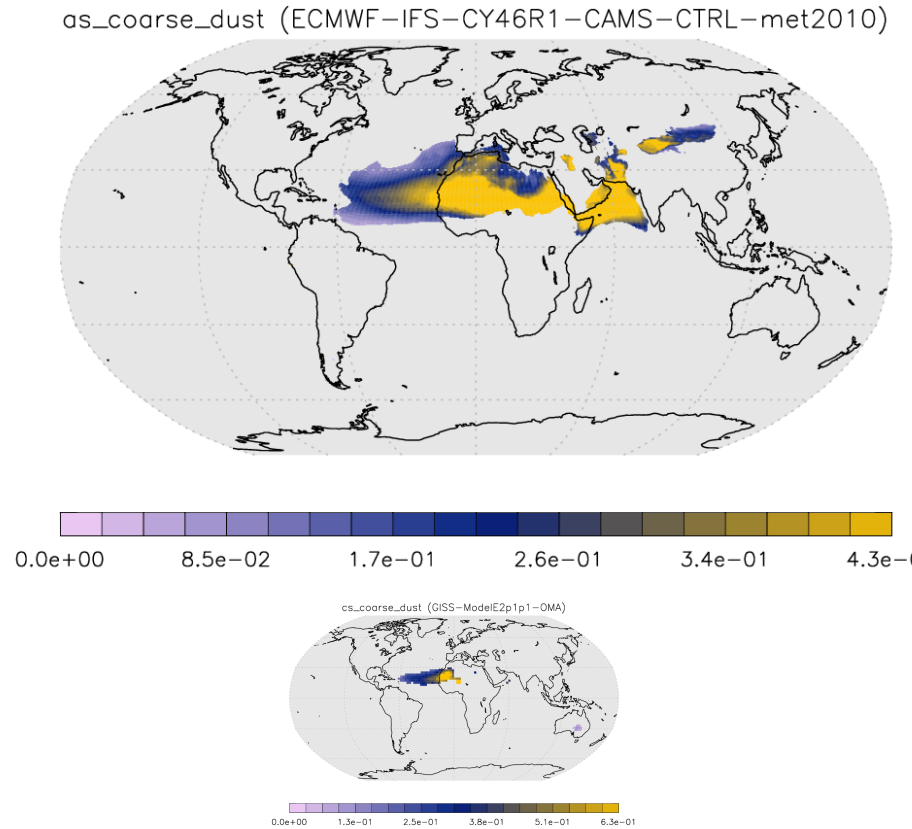




Coarse mode (all-sky)



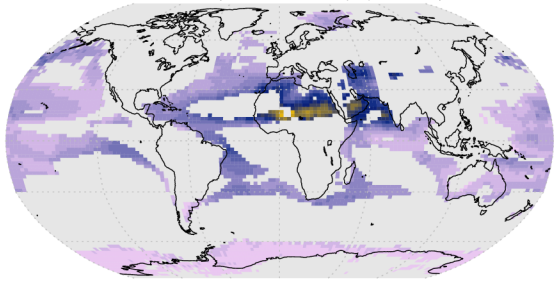




Model (Aug 2010) against Lee et al., 2010 (JJA 2005-2007)

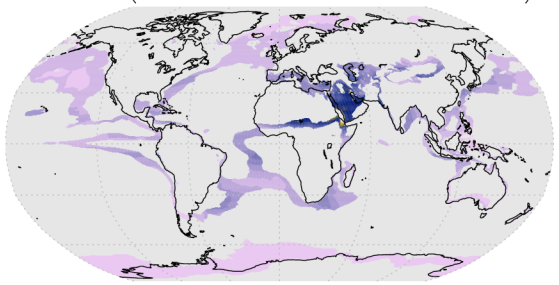
Mixture

cs_mixture (GISS-ModelE2p1p1-OMA)



0.0e+00 1.3e-01 2.6e-01 3.9e-01 5.2e-01 6.5e-01

as_mixture (ECMWF-IFS-CY46R1-CAMS-CTRL-met2010)



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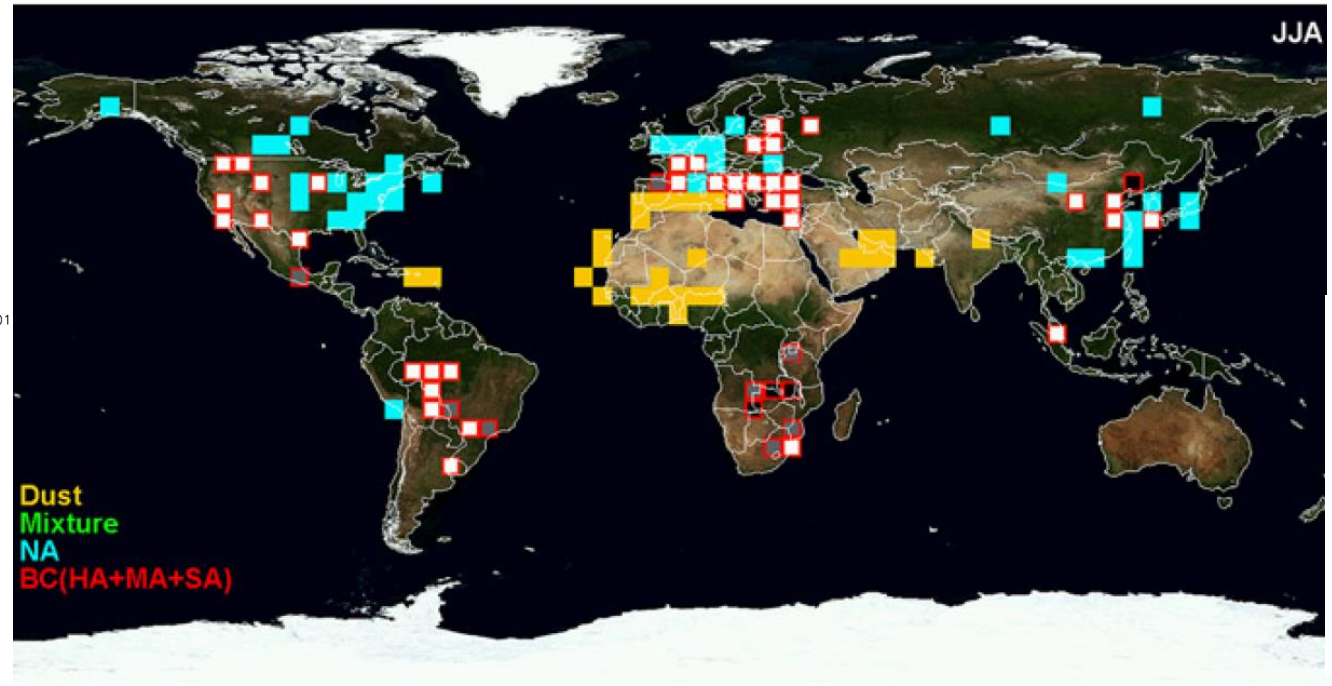
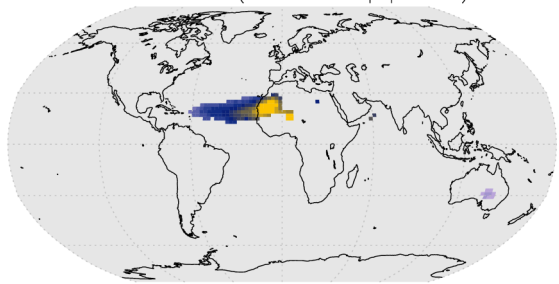


Dust

cs_coarse_dust (GISS-ModelE2p1p1-OMA)



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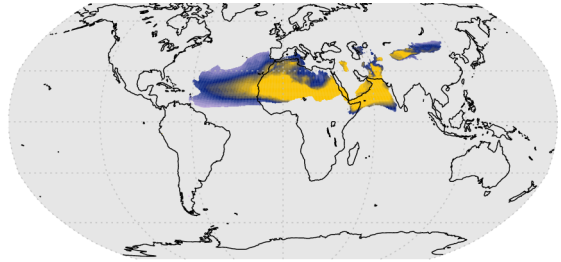
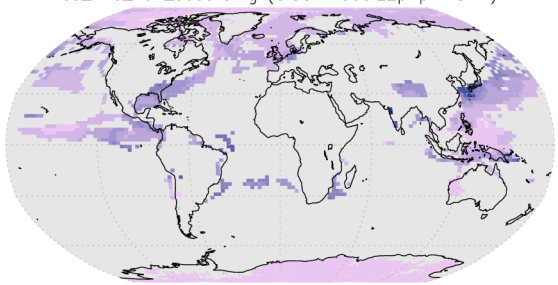


0.0e+00 8.5e-02 1.7e-01 2.6e-01 3.4e-01 4.3e-01

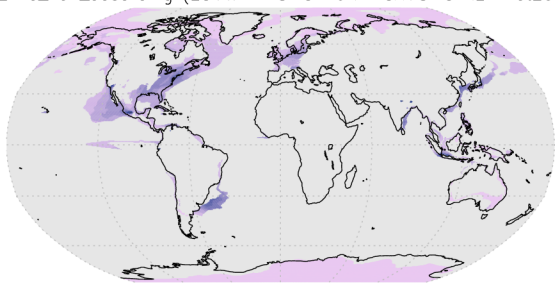
Non-absorbing

cs_fine_non_absorbing (GISS-ModelE2p1p1-OMA)



0.0e+00 1.3e-01 2.6e-01 3.9e-01 5.2e-01 6.5e-01

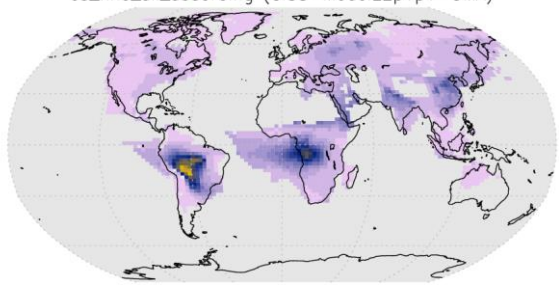
as_fine_non_absorbing (ECMWF-IFS-CY46R1-CAMS-CTRL-met2010)



0.0e+00 1.7e-01 3.4e-01 5.1e-01 6.8e-01 8.5e-01

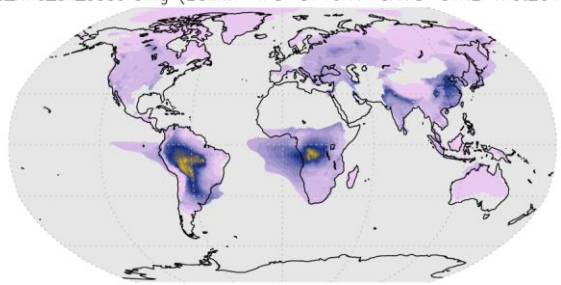
Absorbing

cs_fine_all_absorbing (GISS-ModelE2p1p1-OMA)



0.0e+00 3.0e-01 6.0e-01 9.0e-01 1.2e+00 1.5e+00

as_fine_all_absorbing (ECMWF-IFS-CY46R1-CAMS-CTRL-met2010)



0.0e+00 2.5e-01 5.0e-01 7.5e-01 1.0e+00 1.3e+00

Final thoughts

- GISS ModelE (2x2.5) likely has:
  - Too high all-sky AOD, mostly due to coarse sea salt. MIROC-SPRINTARS looks similar but with lower values.
  - High SSA, which means few strongly absorbing aerosols. Dust not so absorbing (or too little).
  - Clear-sky should always be used for remote sensing comparisons!
- When applying the Lee et al. (2010) criteria to GISS ModelE:
  - Most “uncertain coarse mode” is sea salt.
  - There is very little coarse dust.
- A much finer resolution model (ECMWF-IFS-CY46R1-CAMS) is shockingly similar.

- Probably finer temporal resolutions contain more structure.
- How can we deal with quantities that we don’t model, e.g. backscatter, depolarization?
- Can we hack in some non-sphericity assumptions?