WHY

Aerosol introduces one of the largest uncertainties in climate research. Aerosol comes from multiple sources and has short lifetimes on the order of a few days, with the result that aerosol properties vary strongly in space and time. With the necessity to include effects on (at minimum) regional and seasonal scales, global assessments on the impact of aerosol on climate are almost entirely based on simulations with global models. However, the uncertainty of the simulated aerosol climate forcing is so large, that more measurement based techniques are explored. With new and detailed aerosol data now available from remote sensing, measurement based approaches have become an option.

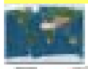
Aerosol (direct) Radiative Forcing

a measurement approach with modeling support

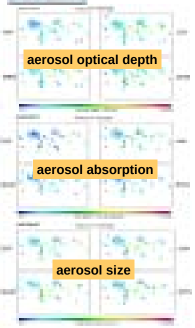
S. Kinne (1)
the AERONET-group (2)
and the AeroCom modeling community

(1) Max-Planck Institute for Meteorology, Hamburg
(2) NASA Goddard Space Flight Center, Greenbelt

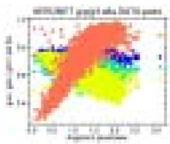
AERONET



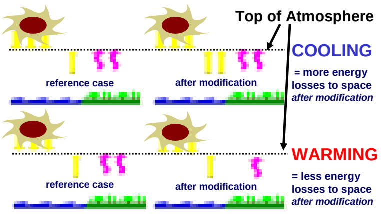
'quasi'-global seasonal properties of



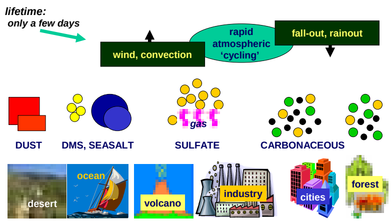
AERONET - data for size and absorption are based on inversions of sky-radiance data *(quality absorption data require larger AOT)*



'climate' forcing



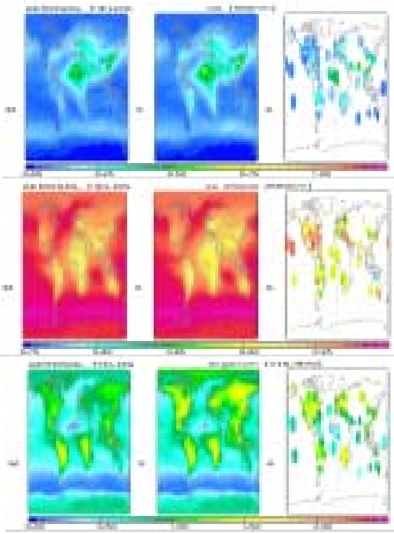
aerosol is complex !



forcing approach

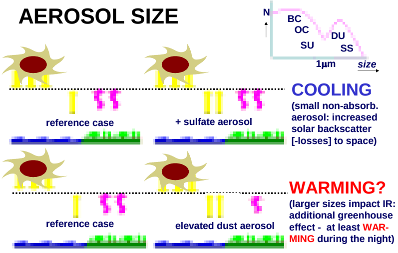
1. **establish 1°x1° monthly statistics of**
   AERONET sun/sky photometer data
   AeroCom global model median data
2. **impose local AERONET statistics on model median fields ('merging') for**
   amount ⇨ aerosol optical depth (vis)
   size ⇨ aerosol Angstrom parameter
   compos⇨ aerosol ss-albedo (vis)
3. **apply AERONET statistics to establish solar spectral dependencies (for far-IR: size and absorption is defined by dust)**
4. **use MODIS data to prescribe the solar surface albedo (visible, near-IR)**
5. **use ISCCP data to include clouds for all-sky simulations (cover [high/mid/low], ot)**
6. **use global modeling to assign altitude and to identify anthropogenic fractions**
7. **determine direct aerosol forcing (F) and aerosol forcing effciency (F/aot)**
   clear-sky and all-sky (with clouds)
   solar, infrared and solar+infrared
   total and anthropogenic

aerosol input data



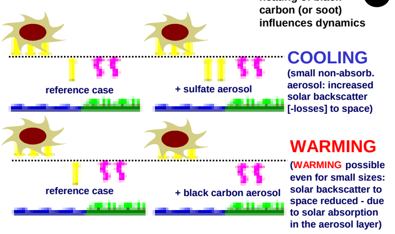
critical parameters

AEROSOL SIZE



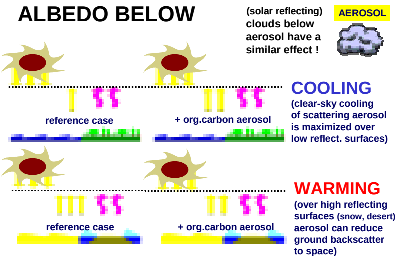
AERO. ABSORPTION

aerosol layer heating of black carbon (or soot) influences dynamics



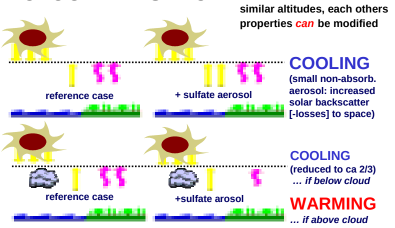
ALBEDO BELOW

(solar reflecting) clouds below aerosol have a similar effect !



CLOUD PRESENCE

if aerosol and cloud are at similar altitudes, each others properties *can* be modified



not only magnitude but ... **even the sign of forcing is affected!**

Results

- **calculated properties**
  - **FORCING** *(W/m2)*
  - **FORCING EFFICIENCY** *(W/m2 /aot)*
    - clear-sky at ToA total
    - clear-sky at surface total
    - all-sky at ToA total
    - all-sky at surface total
    - clear-sky at ToA anthropogenic
    - clear-sky at surface anthropogenic
    - all-sky at ToA anthropogenic
    - all-sky at surface anthropogenic
      - separately for solar and IR spectral region

- **aerosol direct forcing by numbers**
  (there are certainly deviations on a regional basis)
  - ca. 70% of ToA cooling is anthropogenic
  - ca. 70% of clear-sky forcing is all-sky forc.
  - ⇨ the anthropogenic ToA all-sky forcing is about half or the ToA clear-sky forcing
  - atmospheric forcing amounts to ca 30% of the ToA cooling (aerosol cools globally)
  - ca 35% of the solar forcing is anthropog.
  - solar surf. forcing is ca 60% over ToA forc.
  - globally averaged clear-sky ToA cooling is ca -2 *W/m2 - this is significant lower than the CERES based estimate ... and much more in line with estimates from global modeling*

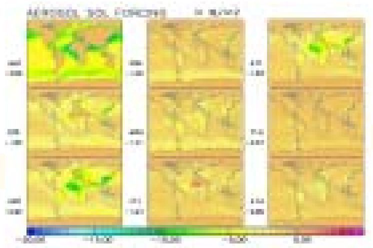
- **there are forcing difference by type**
  - BIOMASS: weak cooling, strong atm heating
  - DUST: strong cooling, weak atmos. heating
  - URBAN: mod. cooling, atm. heating ~ pollu.

annual solar AEROSOL FORCING

FORCING	NO clouds		ISCCP clouds	
(W/m²)	SOLAR	SOL+IR	SOLAR	SOL+IR
ToA	-1.85	-1.68	-1.03	-1.51
surface	-2.67	-2.07	-1.83	-2.37
ToA anthr	-1.02	-0.95	-0.58	-1.11
surf anthr	-1.35	-1.06	-0.90	-1.60

annual sol. AEROSOL F. EFFICIENCY

FOR.EFF	NO clouds		ISCCP clouds	
(W/m² /aot)	SOLAR	SOL+IR	SOLAR	SOL+IR
ToA	-15.2	-14.0	-8.7	-30.5
surface	-19.3	-14.7	-12.7	-47.7
ToA anthr	-10.0	-9.4	-5.8	-28.1
surf anthr	-12.0	-9.4	-7.8	-44.0



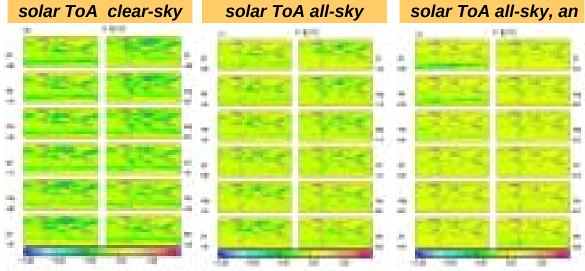
solar forcing

label – explanation

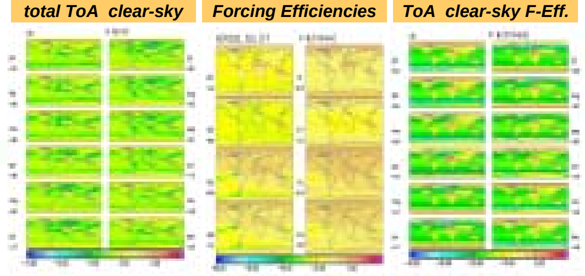
sat	– CERES
t0t	– ToA / cloud-free / total
s0t	– surf / cloud-free / total
t0a	– ToA / cloud-free / anthr
s0a	– surf / cloud-free / anthr
t1t	– ToA / all-sky / total
s1t	– surf / all-sky / total
t1a	– ToA / all-sky / anthrop.
s1a	– surf / all-sky / anthrop.

solar ToA - CERES · *solar ToA – simul.* · *solar surface - simul.*

solar ToA clear-sky · *solar ToA all-sky* · *solar ToA all-sky, an*



total ToA clear-sky · *Forcing Efficiencies* · *ToA clear-sky F-Eff.*



NEXT

- **'A-train' profiling data** will provide needed information on relative altitude of clouds and aerosol