AERCOM

and other things

Stefan Kinne, *MPI-Meteorology*

overview

- **AeroCom & AeroSAT**
- **current topics in AeroCom**
- **reference aerosol data**
- **ICAP ‘biases’**
- **ICAP variability (AOD, AODf, AODc, FMF)**
- **current topics in AeroCom**
- **next annual meeting: 9-13 Oct. 2017 Helsinki**

AeroCom & AeroSAT

- **AeroCom**
  - **constrain uncertainty of bottom up modeling**
    - **evaluation strategies**
    - **best model practices**
    - **emerging constraints**
    - **reference fields**
- **AeroSAT**
  - **the (global) remote sensing data branch**
    - **aerosol-type retrieval**
    - **retrieved AOD uncertainties**
    - **long-term data records (anomalies, trends?)**
    - **Interactions with modeling**

evaluation strategies

- detailed evaluation to trusted data / relations
  - optical properties, satellite relationships
- regular ‘standard’ submissions expected
  - to monitor model evolution
- web-site data display for self-checks
  - http://aerocom.met.no/data.html
    - maps of AeroCom & related projects
- encourge volunteers to conduct experiments
  - participation >5 models recommended

ongoing 'experiments' (1)

- **aerosol changed cloud-lifetime**
  - **Minghuai Wang (rain frequ. susceptibility)**
- **hindcast (1980-2015) simulations**
  - **Mian Chin (vs. satellite and ground records)**
- **radiative forcing**
  - **Bjorn Samset (BC)**
  - **Stephanie Fiedler (RFMIP)**
- **simulated optical property evaluations**
  - **Nick Schutgens (vs. satellite & ground)**
- **nitrate treatment**
  - **Huisheng Bian**

ongoing 'experiments' (2)

- **aerosol properties / transport at the UTLS**
  - **Mian Chin**
- **dust as function of landuse and suf. winds**
  - **Paul Ginoux**
- **biomass burning (emission corr factors ?)**
  - **Mariya Petrenko**
- **aerosol and precipitation**
  - **Bjorn Samset (PDRMIP)**
- **Aerosol in polar regions**
  - **Maria Sand**

best modeling practices

- **documentation of model and changes**
  - **… it will help all**
- **regular baseline submission**
  - hWps://**wiki.**met.no**/**aerocom/phase3-experiments
- **advise on how to model components**
  - **balancing between detail and complexity**
  - **organics**
  - **nitrate**
- **advise on needs and on overkill**
  - **chemistry, size representation, components, ..**

emerging constraints

- volcanic sulfate on aerosol (indirect) forcing
  - Island, Hawaii
    - Gettelman, Hayward
- multi-sensor satellite on hydrol. processes
  - Cloudsat & MODIS & …
    - Kentaroh Suzuki
- data of old / new field experiments
  - VOCALS, ORACLES
    - Bob Wood, Jens Redemann
- ground in-situ on (dry) aerosol properties
  - NOAA / ACTRIS sampling
    - Betsy Andrews

aerosol reference fields

– **… also potential for ICAP defaults ?**

- **AERONET & MAN**
  - **quality … but 'incomplete'**
- **MACv2** (2000-2014 average)
  - **AERONET / MAN extended with AeroCom ensemble modeling**
- **ICAP ensemble** (2 years: 2014/2015)
  - **forecast based (with model / data biases)**

– **let us compare … AODc and AODf**

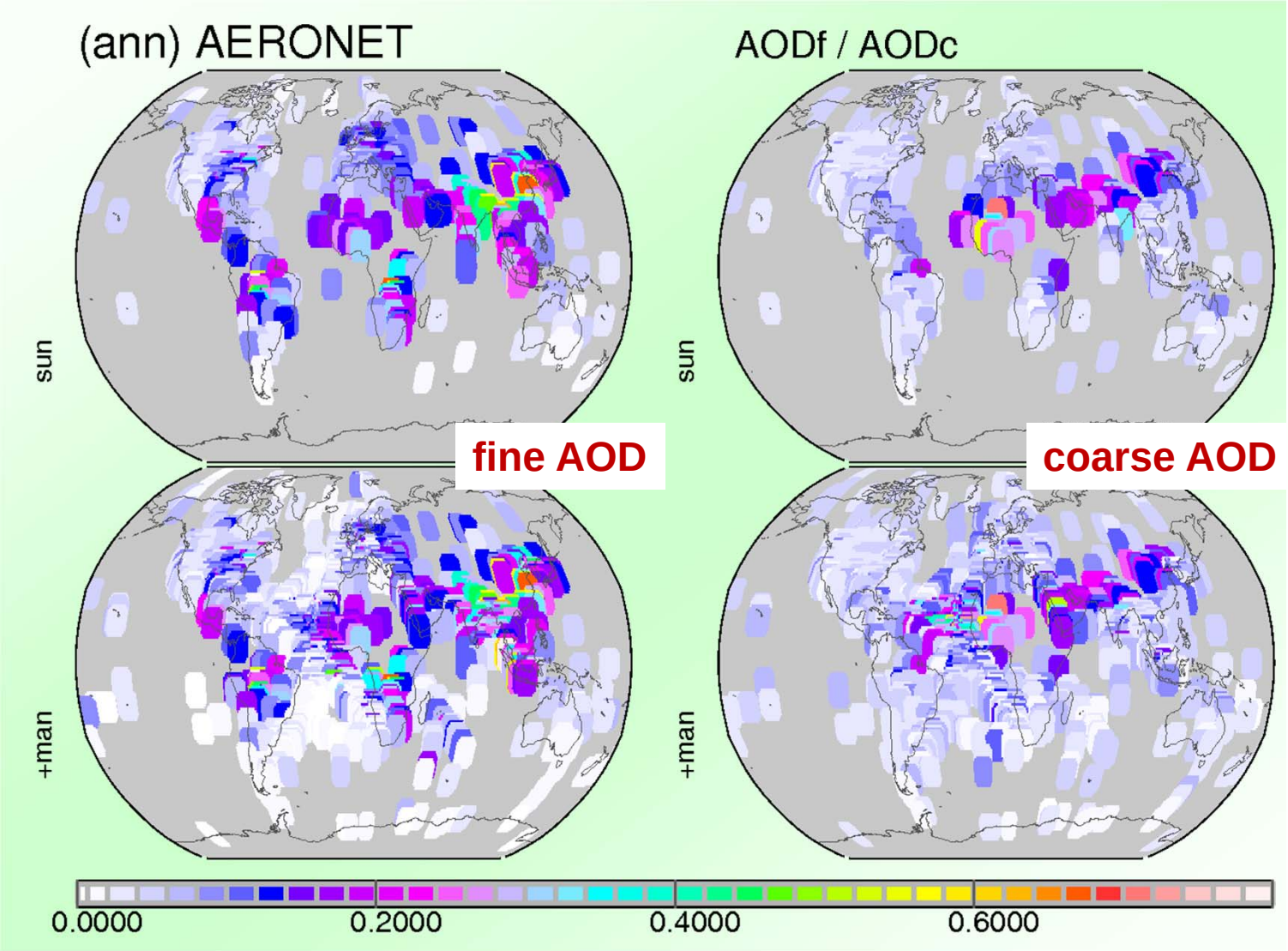
– **AODc AOD of aerosol sizes > 0.5um radius**

– **AODf AOD of aerosol sizes < 0.5um radius**

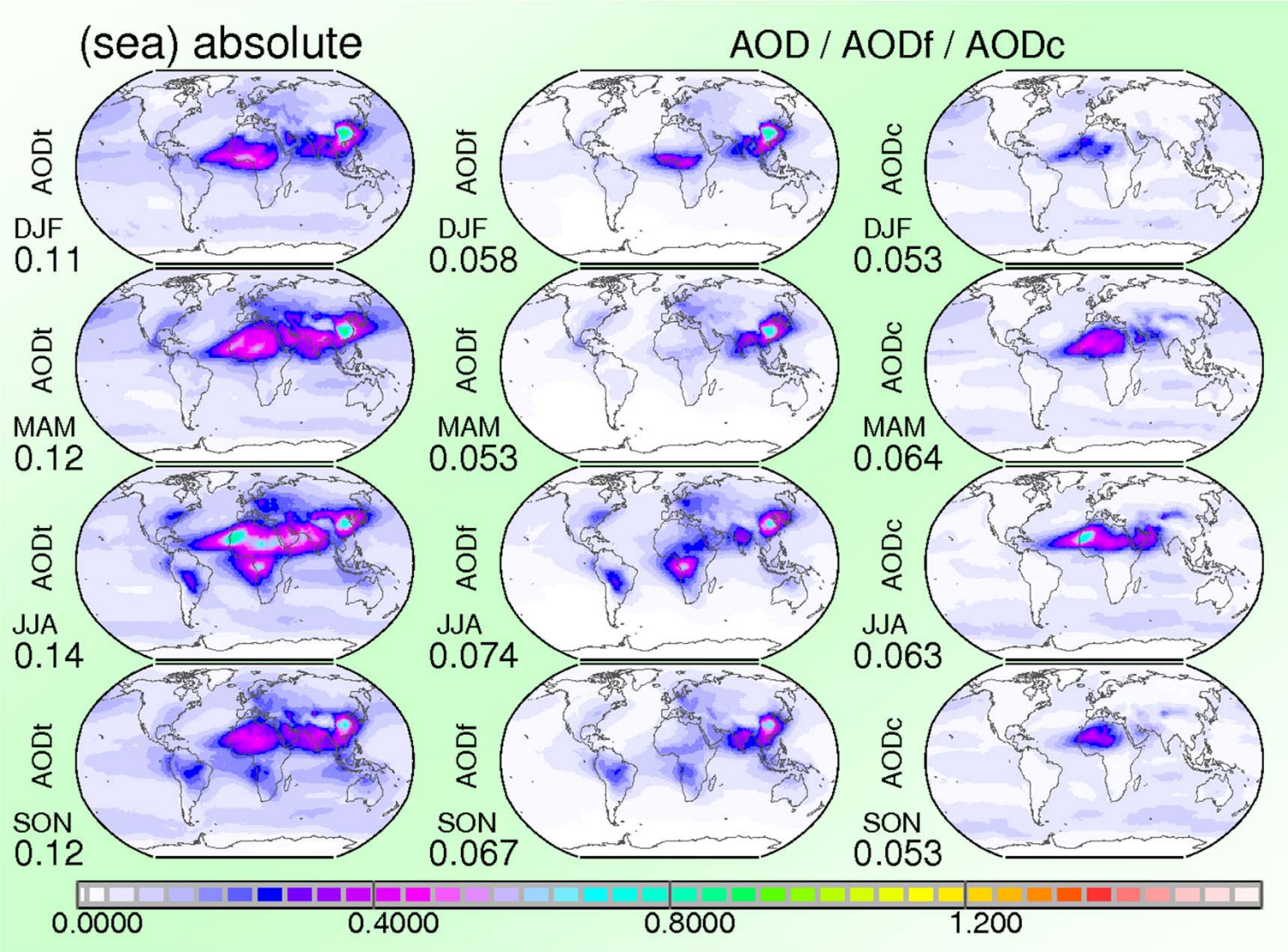
AERONET vs AERONET+MAN

AERONET

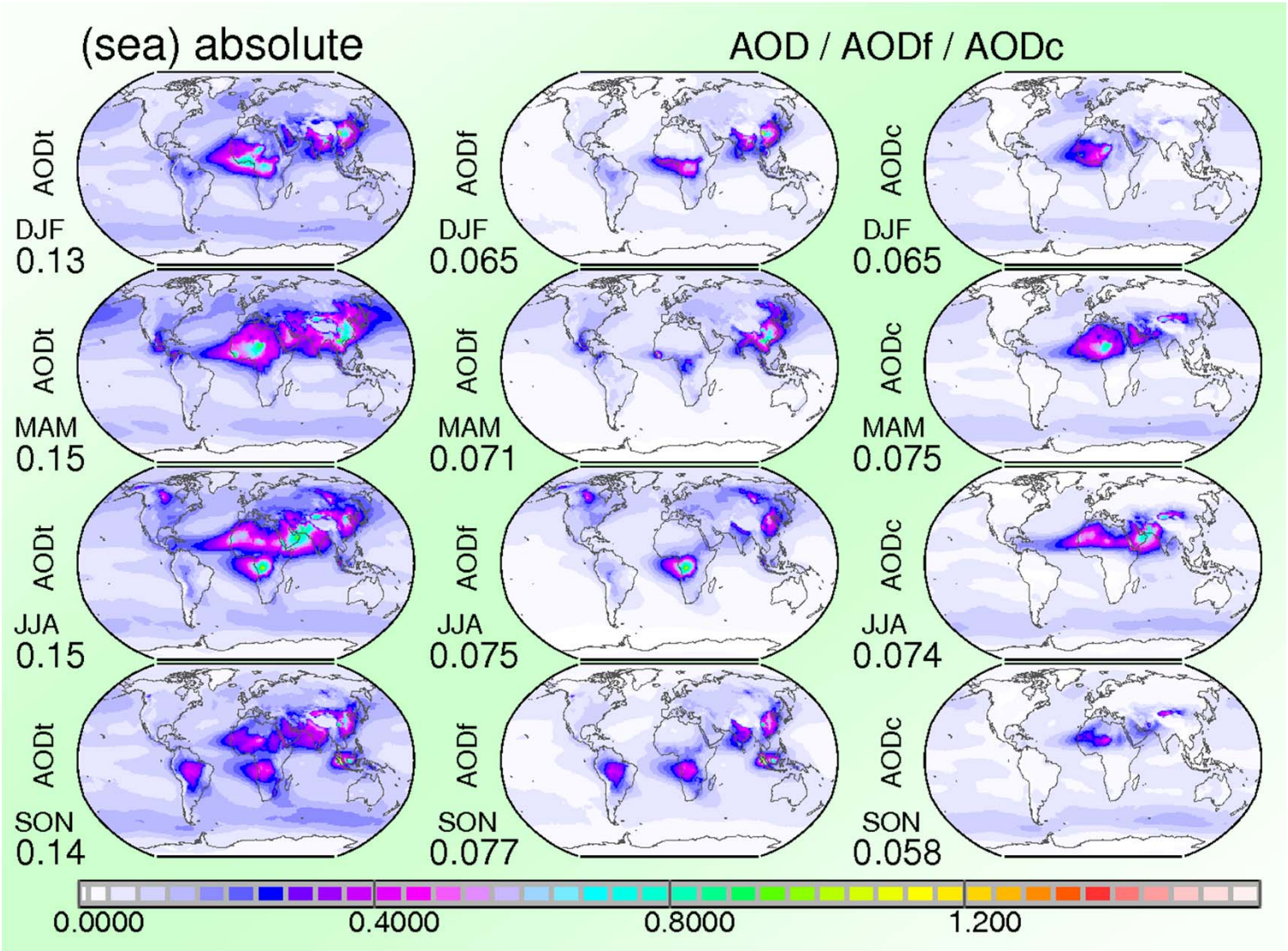
AERONET & MAN



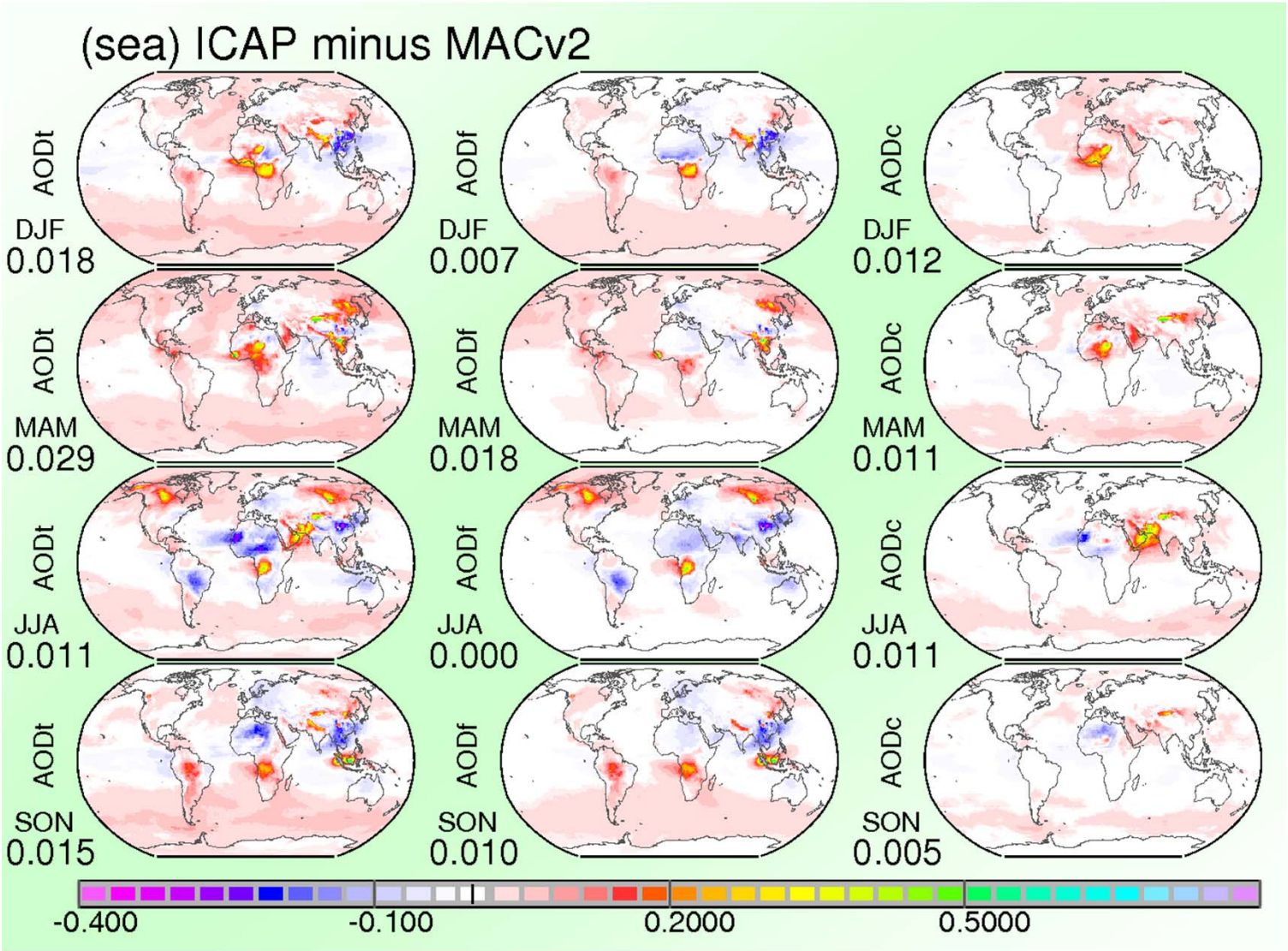
MACv2 - seasonal AOD



ICAP - seasonal AOD



ICAP *minus* MACv2 - AOD



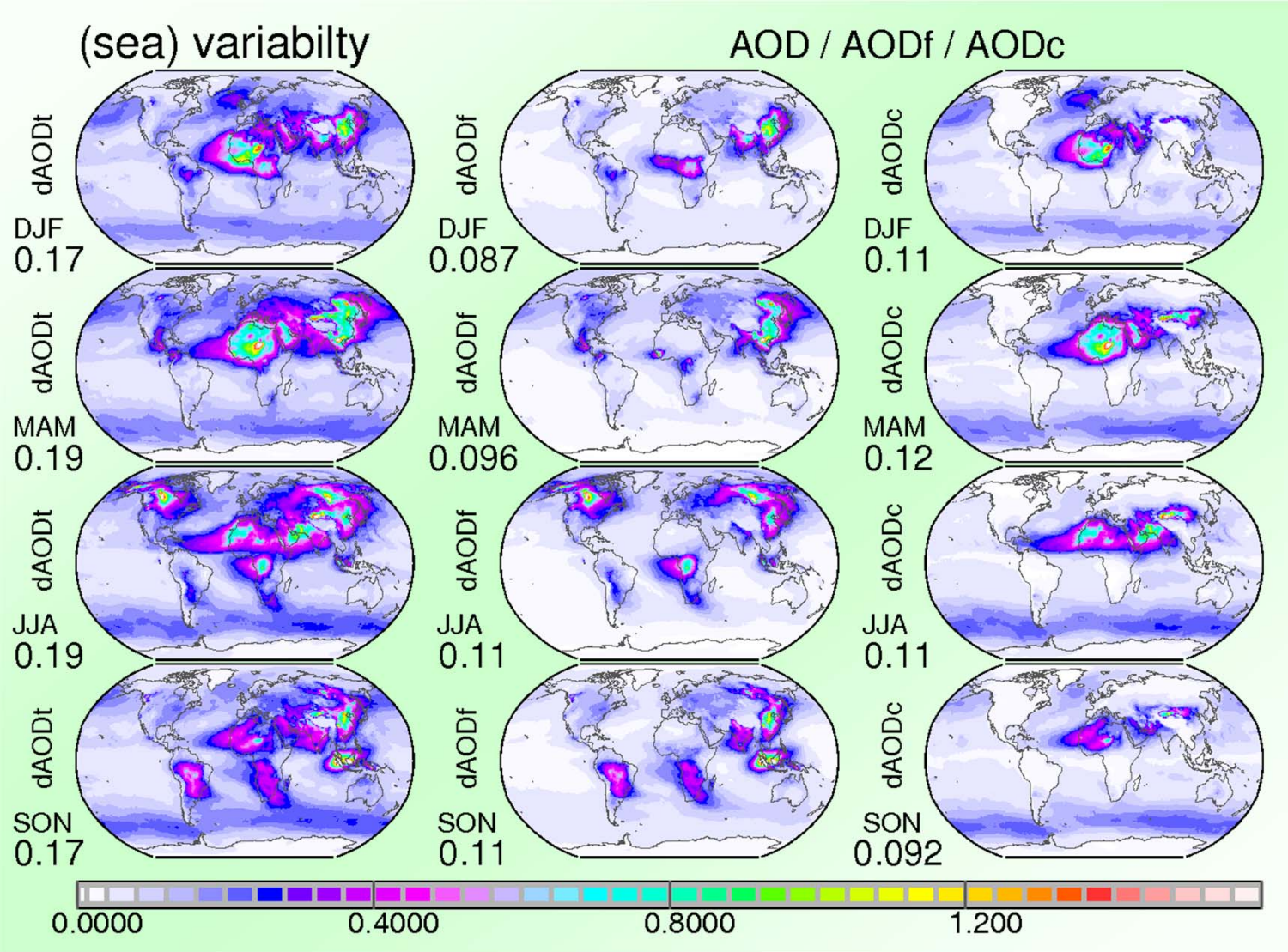
ICAP 'biases' ? ... or trends ?

- **larger AOD *(by ca 20%)***
  - **similiar 50% AODf / 50% AODc split**
- **AODf**
  - **larger**
    - **central Africa, boreal sum, ocean backgrd**
  - **smaller**
    - **east Asia**
- **AODc**
  - **larger**
    - **Arabia, west Africa biomas, mid-lat oceans**
  - **smaller**
    - **dust off Africa over Atlantic**

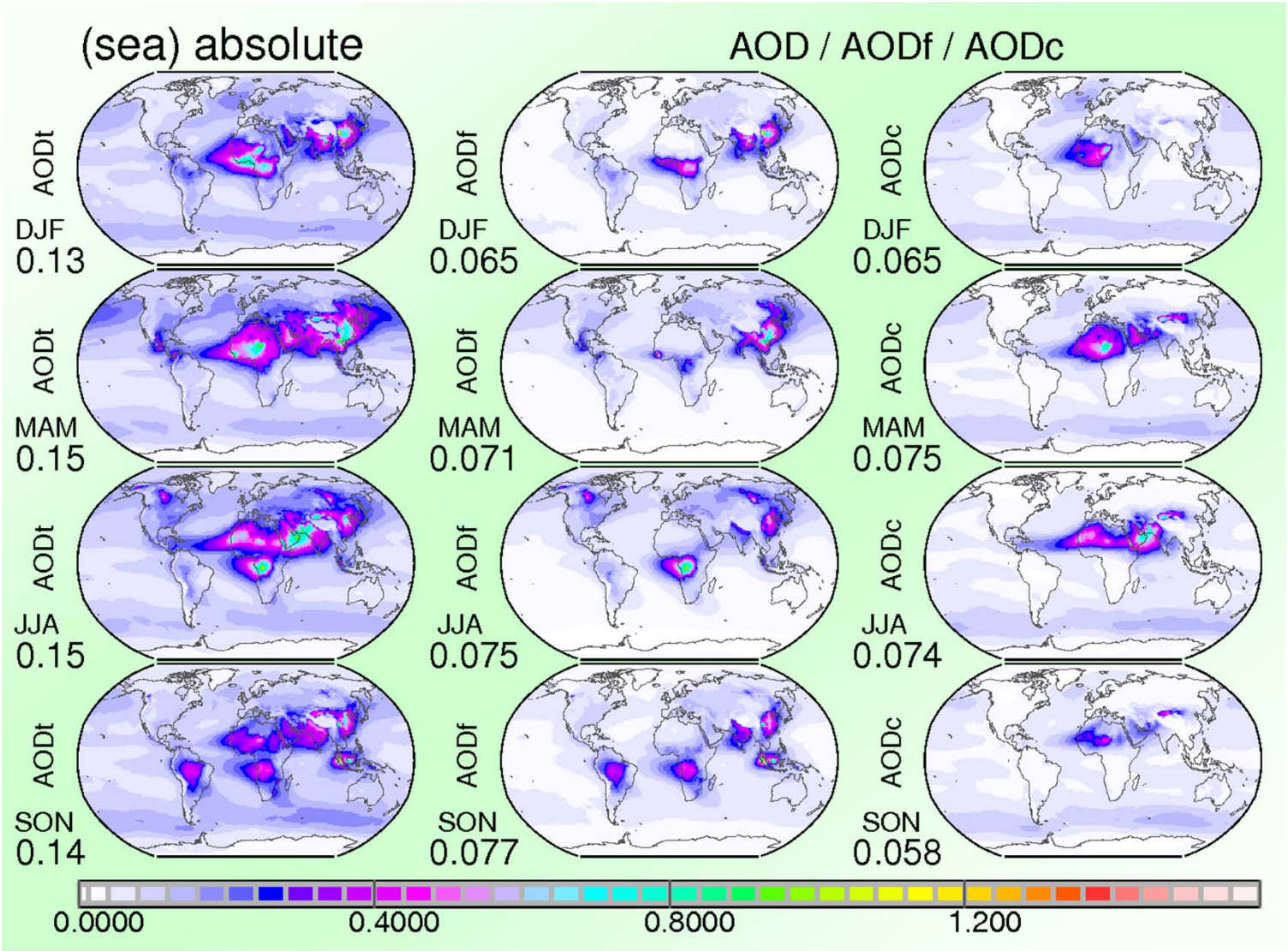
now on variability

- **ICAP variability (for AOD, AODf, AODc, FMF)**
  - **definition**
    - **create local 1x1 monthly PDF using 0, 3, 6, 9 and 12 hour ensemble data of 2 years**
    - **var = (100-80% average) – (20-0% average)**
    - **for AOD, AODf, AOD c**
  - **relative to average**
    - **identify regions of (relative) variability**
  - **FMF as function of AOD**
    - **if high AOD due to pollution ΔFMF negative**
    - **if high AOD due to dust ΔFMF positive**

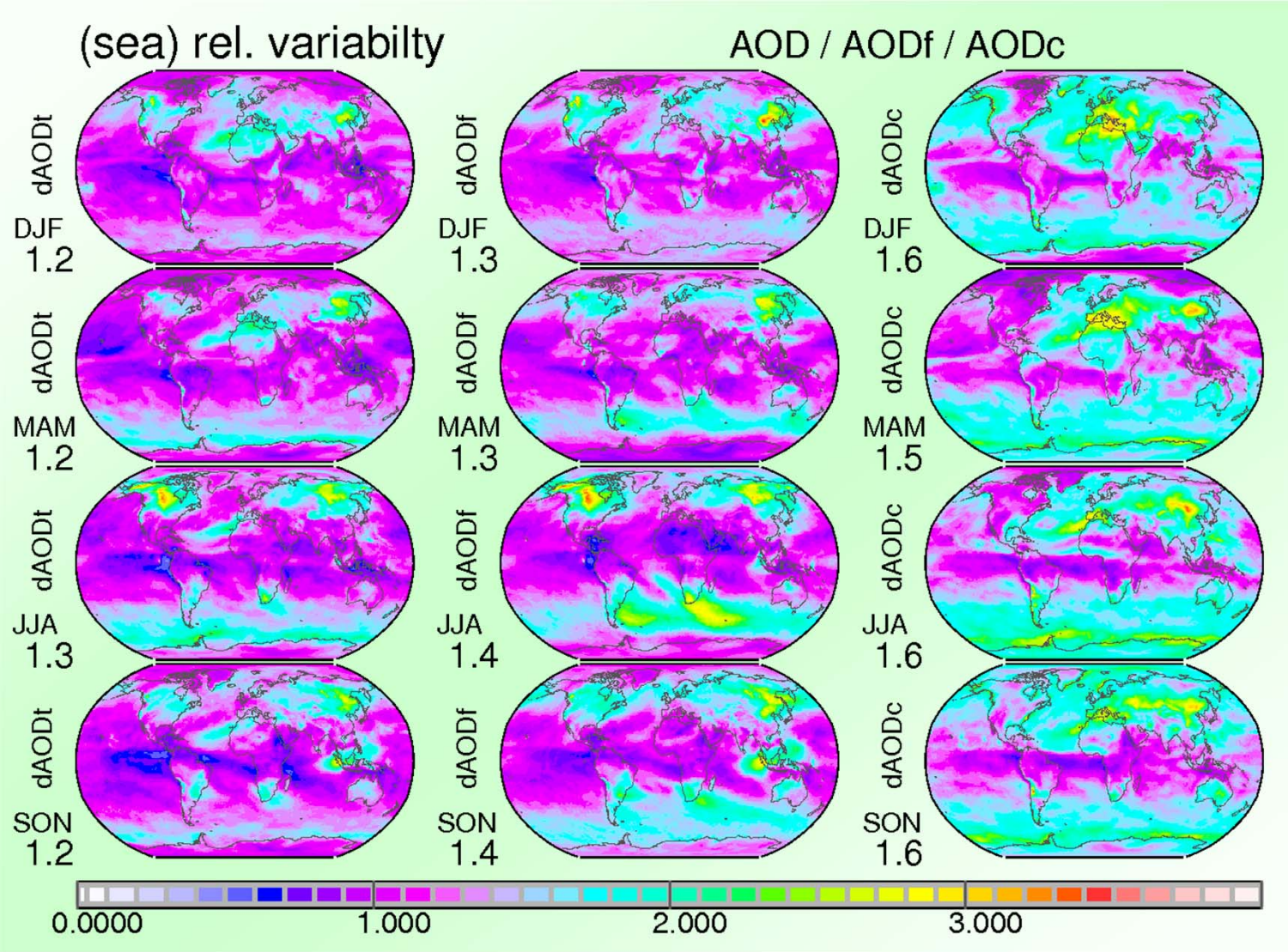
ICAP - averaged monthly variability



ICAP - seasonal AOD



var / avg ICAP - AOD

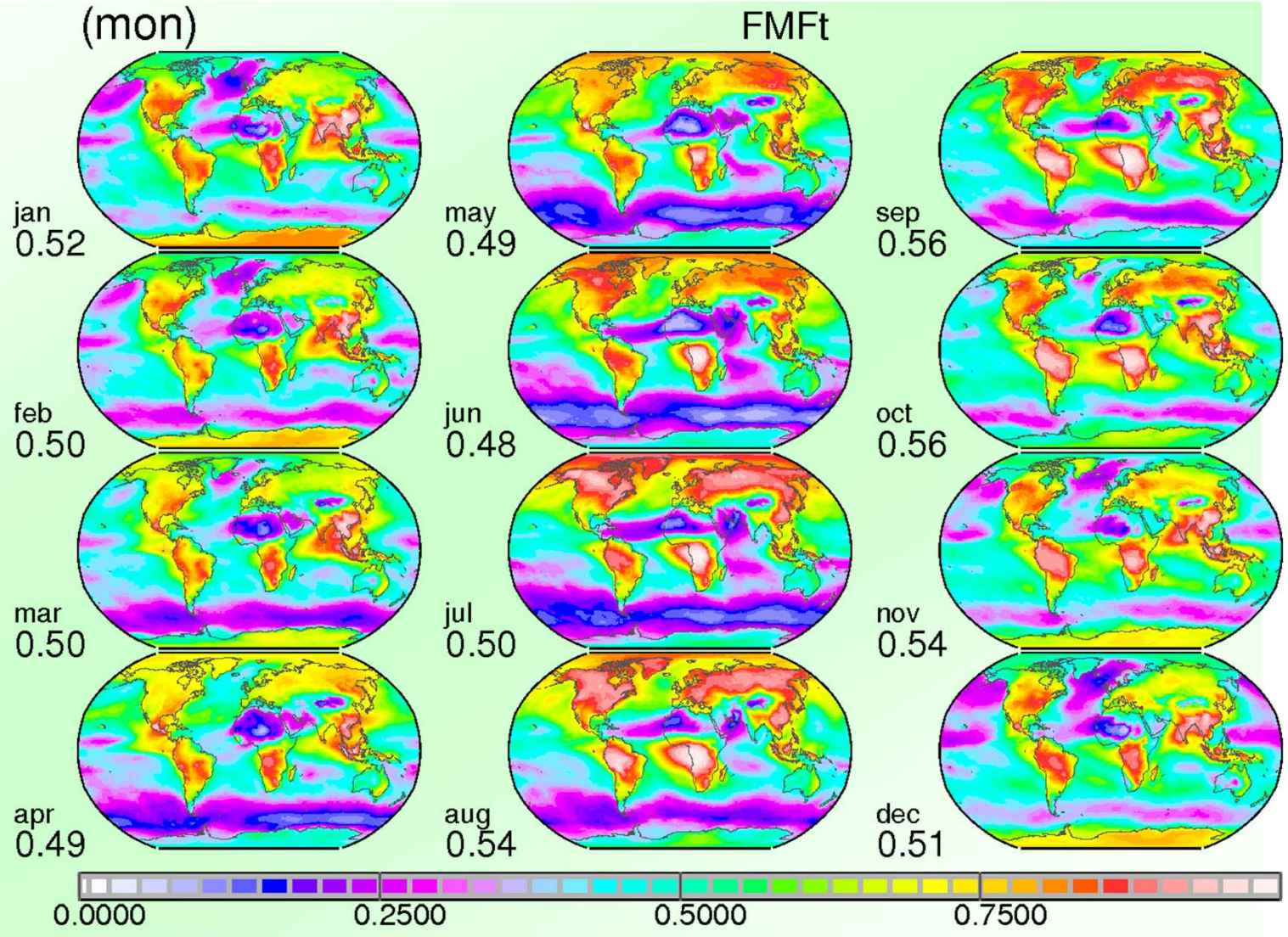


on AOD variability

- coarse-mode more variable than fine-mode
- relative fine-mode variability
  - larger
    - wildfire / pollution regions, southern oceans
  - smaller
    - tropics
- relative coarse-mode variability
  - larger
    - Mediterranean, East Asia, Southern Ocean
  - smaller
    - SH subtropics, US

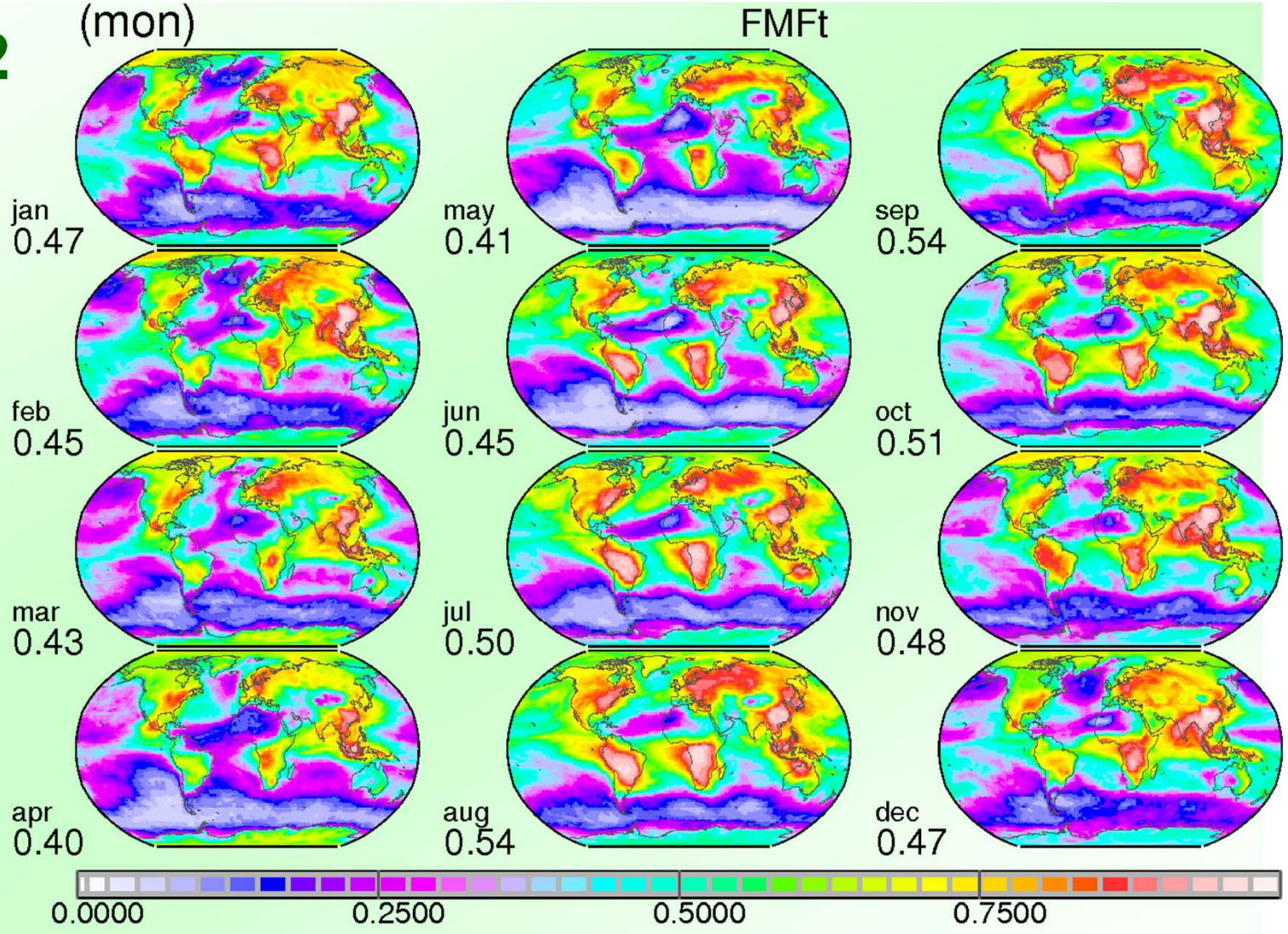
AOD fine-mode fraction

- **ICAP**

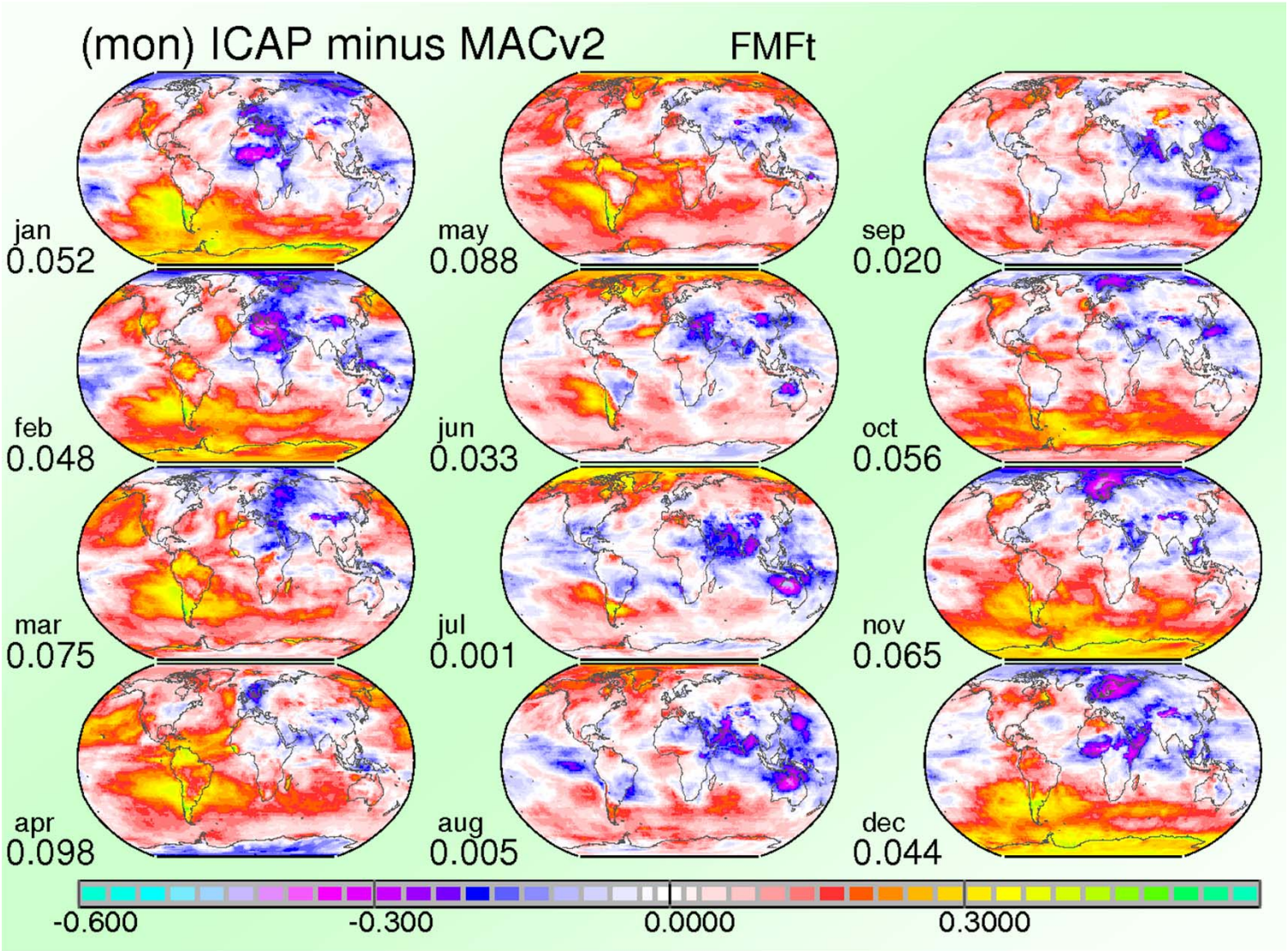


AOD fine-mode fraction

- **MACv2**



Δ FMF

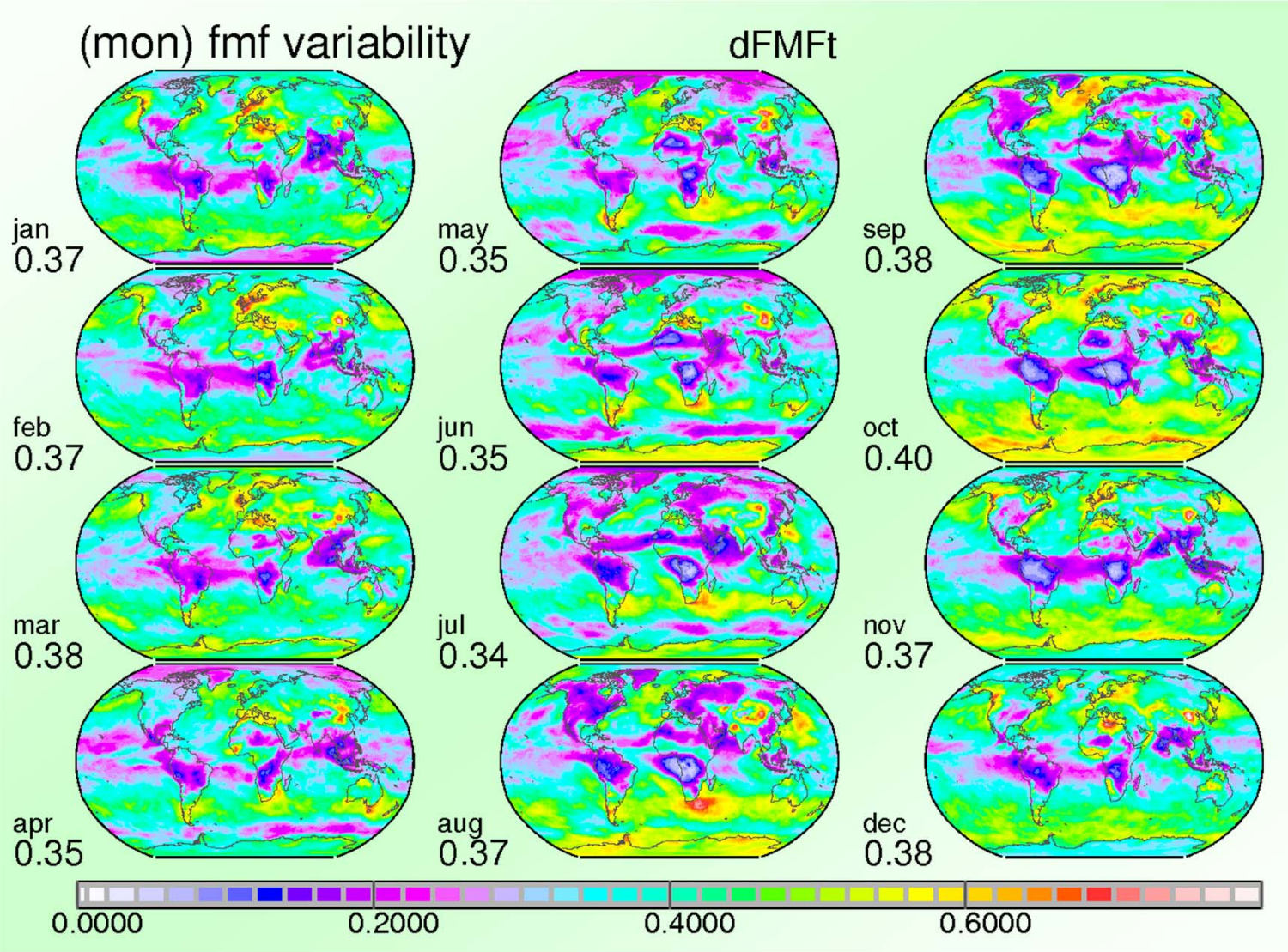

(mon) ICAP minus MACv2
FMFt
jan
0.052
feb
0.048
mar
0.075
apr
0.098
may
0.088
jun
0.033
jul
0.001
aug
0.005
sep
0.020
oct
0.056
nov
0.065
dec
0.044
-0.600
-0.300
0.0000
0.3000

on AOD fine-mode fraction

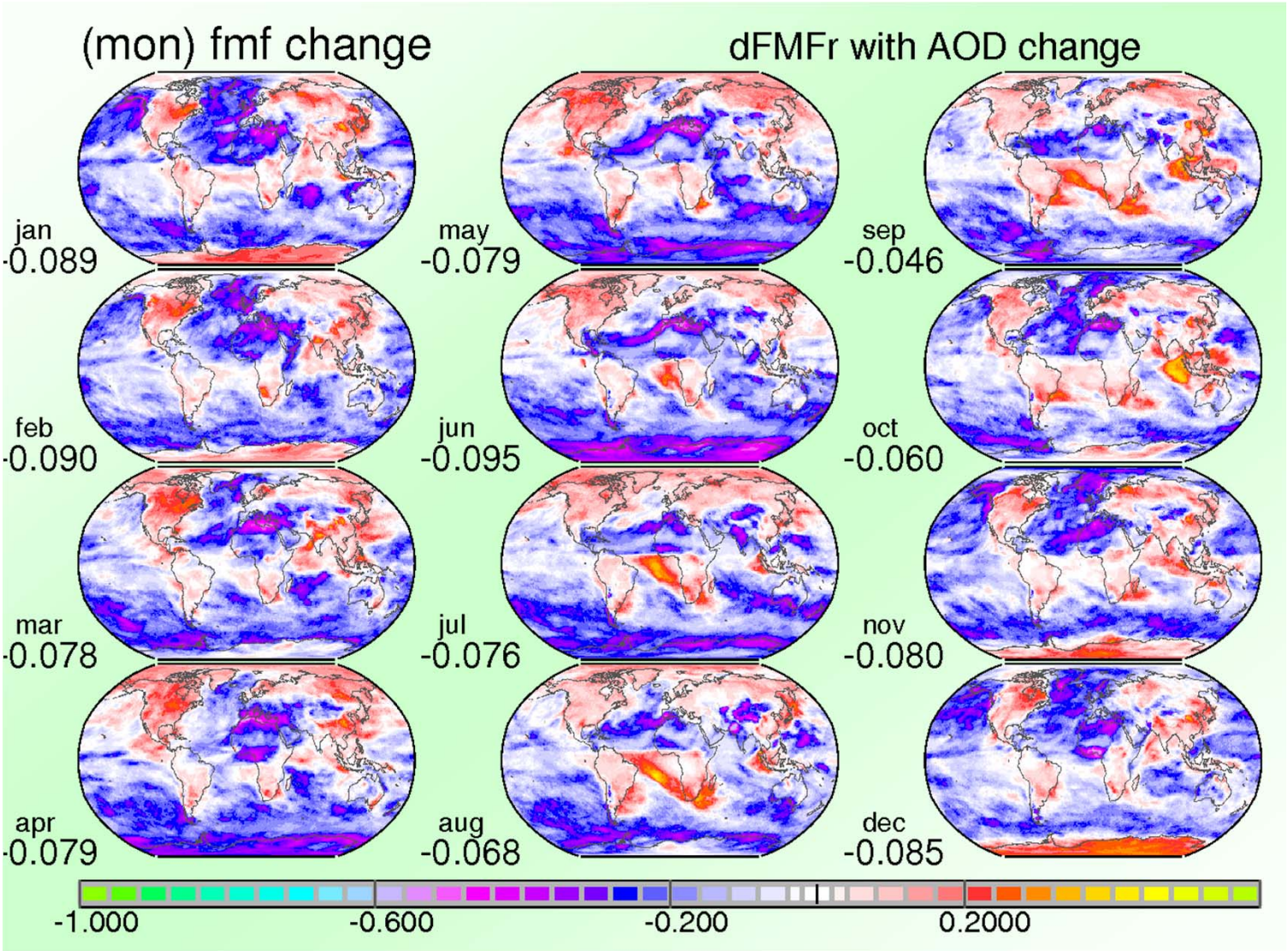
- (ca 5-10%) larger in ICAP than in MACv2
- larger in SH higher lat. during boreal winter
- smaller over trop. Asia during boreal summer
- smaller over Africa/Europe during boreal winter

- relative larger variability
  - SH higher lat. during boreal fall
- relative smaller variability
  - tropics

ICAP – FMF variability



ICAP - FMF change with AOD increase



annual meeting

- **next meeting: Oct 9-13 at Helsinki, FI**
  - **AeroCom (Mo-Thu) AeroSAT (Thu-Fri)**
    - hosts **Gerrit** de Leeuw, **Hannele** Korhonen **FMI**
  - **info and registration**
    - **http://aerocom.mpimet.mpg.de**
    - **august 1 deadline**

aerosol-type retrieval

- **classifying aerosol by properties**
  - **AOD, depolarization, angstrom (size), altitude**
    - **different from modeled components**
  - **what is useful? what is not?**
    - **what is easy?**
  - **AODc vs AODf**
  - **dust AOD (land AODc, large AODc over sea)**
    - **what is difficult ?**
  - **separating pollution and wildfires**
  - **mixtures**

retrieved AOD uncertainties

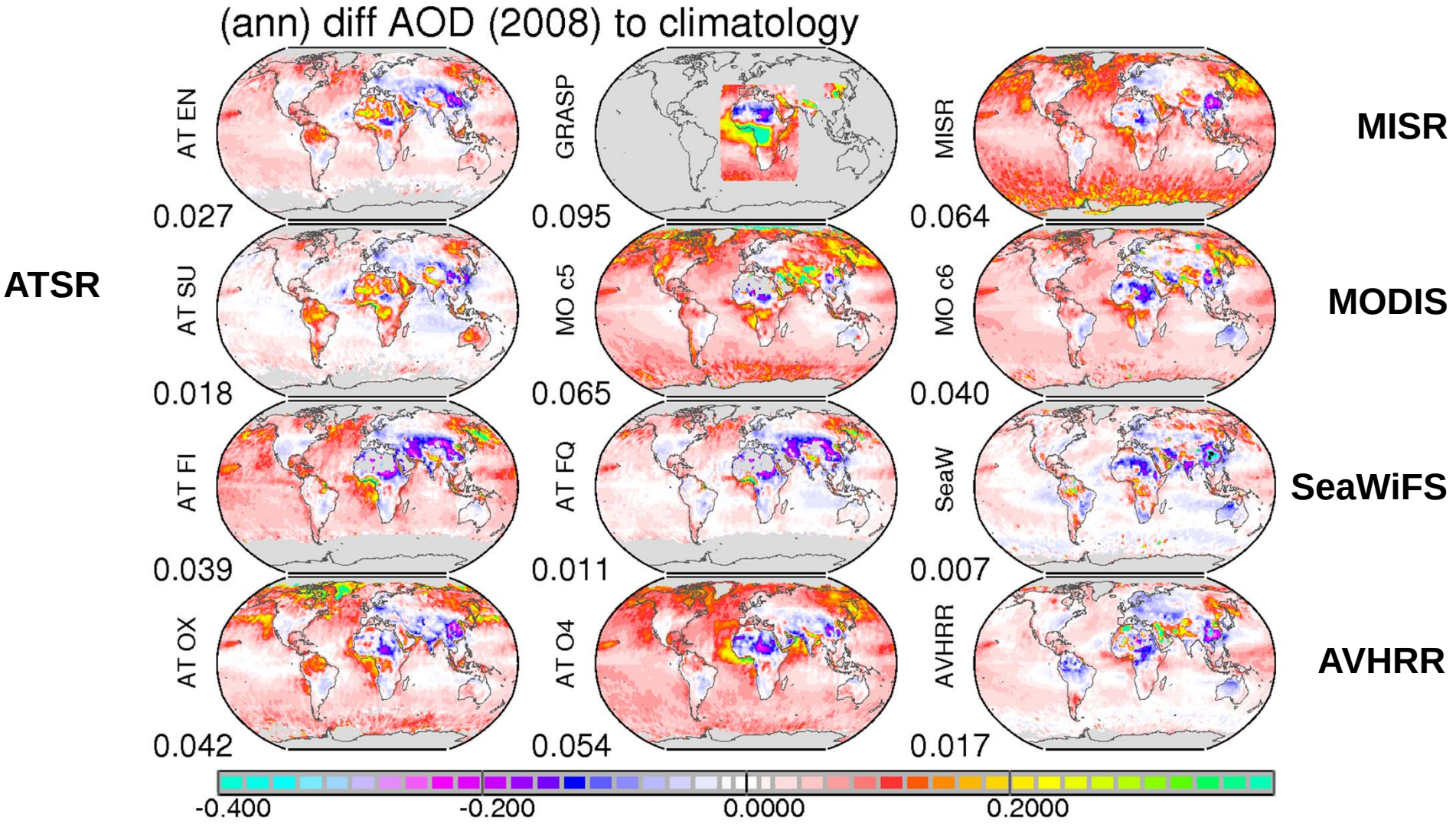
- **assimilation needs (pixel) uncertainties**
  - **NASA's general estimates not that useful**
  - **ESA's CCI started with pixel uncertainties**
    - **estimates initially differed … but are now adjusted after retrieval comparisons over AERONET sites**
    - **still only done for ATSR (no operating sensors right now and smaller coverage than MODIS … quality comparable**
  - **level 3 uncertainties remain difficult**

long-term data records

- **column aerosol amount (AOD and AODf)**
  - **AVHRR 1980-2016**
  - **TOMS/OMI 1979-2016**
  - **ATSR 1996-2012**
  - **MODIS (T/A) 2000-2016**
  - **MISR 2000-2016**
    - **no significant global trend since 1995**
    - **regional shifts from US/EU to eastern Asia**
- **column aerosol absorption**
  - **TOMS /OMI (SSA) 1979-2016**
  - **TOMI /OMI (UV AI) 1979-2016**
  - **MISR (more / less) 2000-2016**

satellite AOD biases

if we believe MACv2 *(not specific for year 2008 though)*



interactions with modeling

- how wrong are models ?
  - statistics needed
  - sampling matters (filters … daytime, clouds)
- what quantities are useful?
  - compare to what we can observe
  - try to get observations for what we need
  - simulate data with a forward model
    - is relative change sufficient ?
    - multi-sensor / multi data relationships ?
- are aerosol type retrievals useful ?
  - most types are not components in modeling

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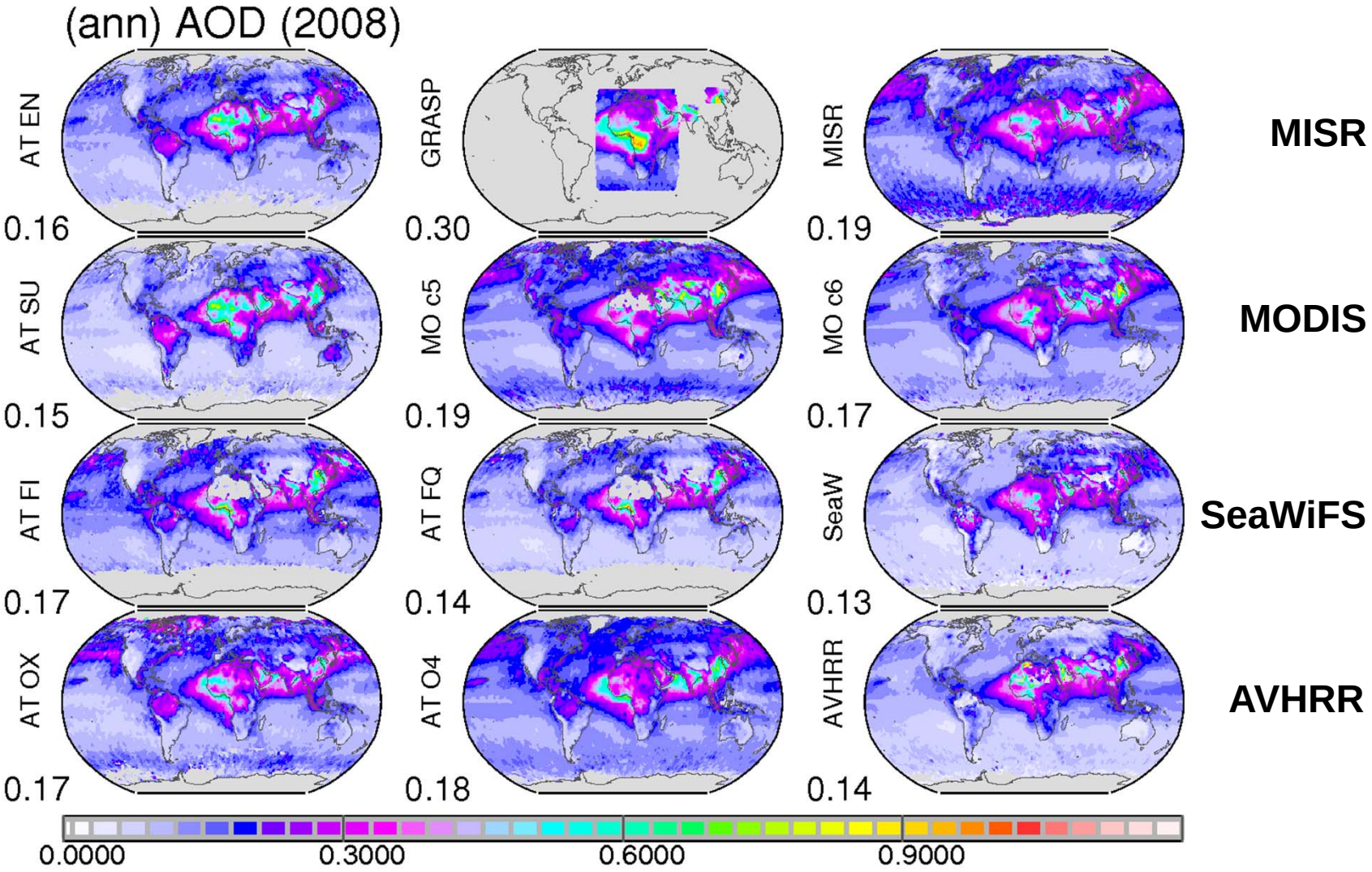
maps

- to address globally varying (atmospheric) properties I (we all) like MAPS
  - more informative than global averages
- Bill & Co has done this for clouds …
  - so this could also be done for aerosol
- Bill & Co used satellite data and smart models
  - and this also has been done for aerosol

AOD – diversity in satellite remote sensing

same year … but different answers, coverage, models



what we really want

- complete coverage
  - satellite retrievals fail at times (e.g. over snow)
- address not just aerosol amount (e.g. AOD), but also aerosol size (FMF) and absorption (AAOD)
  - satellite retrieval mainly address AOD, FMF at best over oceans, and absorption at best in a qualitative sense (e.g. UV aerosol index)
- high accuracy & property consistencies
  - satellite retrievals make different assumptions and are handicapped by a poor background
- **MAC** (now version 2) **!**

MAC v2

Max-Planck-Aerosol Climatology

- **use**
  - **for mid-visible aerosol properties**
    - **» AOD, AAOD, FMF, Angstrom**
  - **high accuracy of AERONET / MAN**
  - **spatial context from modeling**

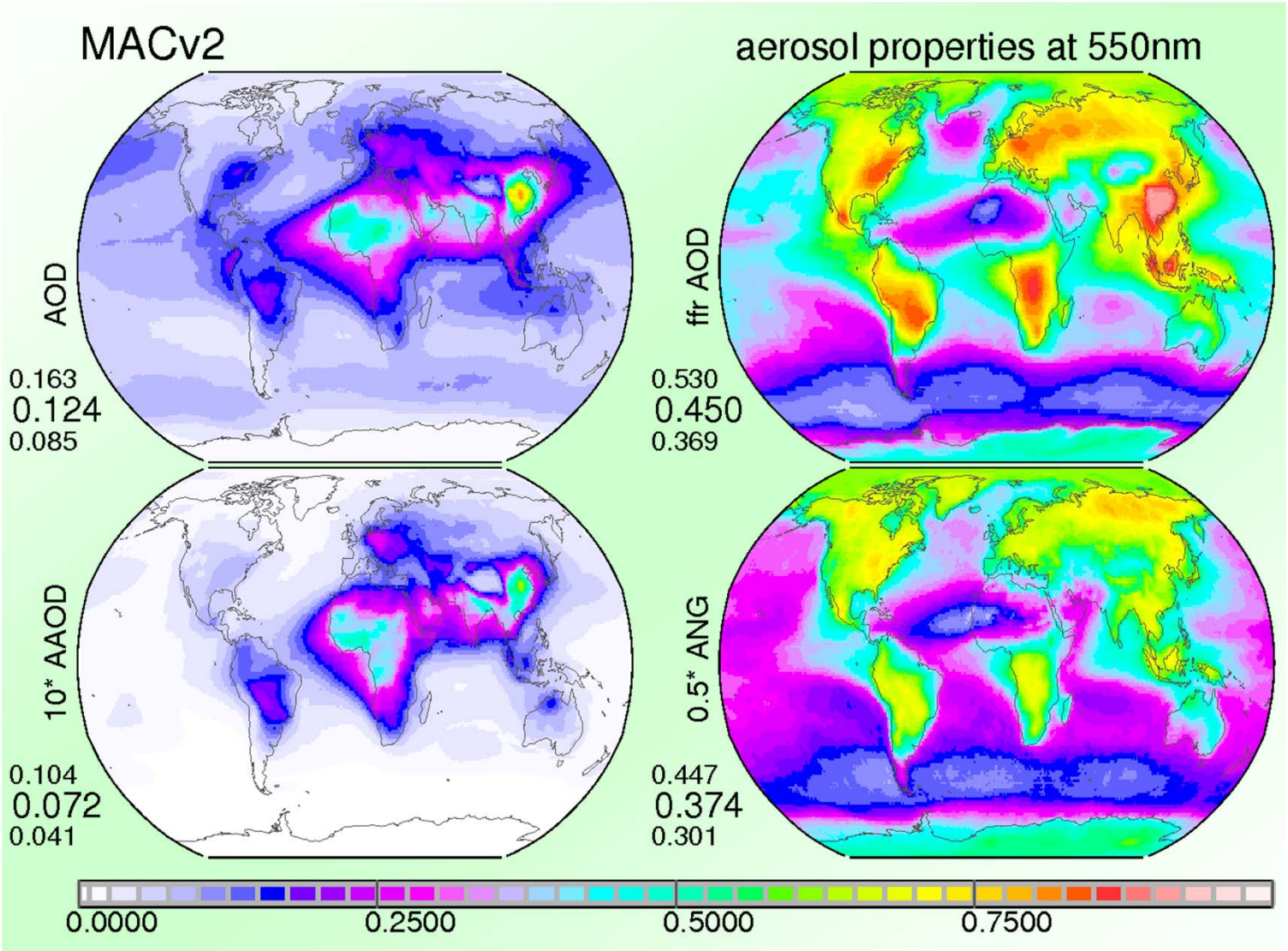
AerChemMIP AeroSAT ECMI AeroCom

- **merge multi-year monthly statistics**
  - **1x1 lat/lon, monthly maps**
    - **for spectral dep properties (fine & coarse)**
      - **» AOD, SSA, g**
    - **for vertical distribution (fine & coarse)**
    - **for anthrop. fraction of fine (function of time)**

MACv2

AOD

AAOD
(10 times)



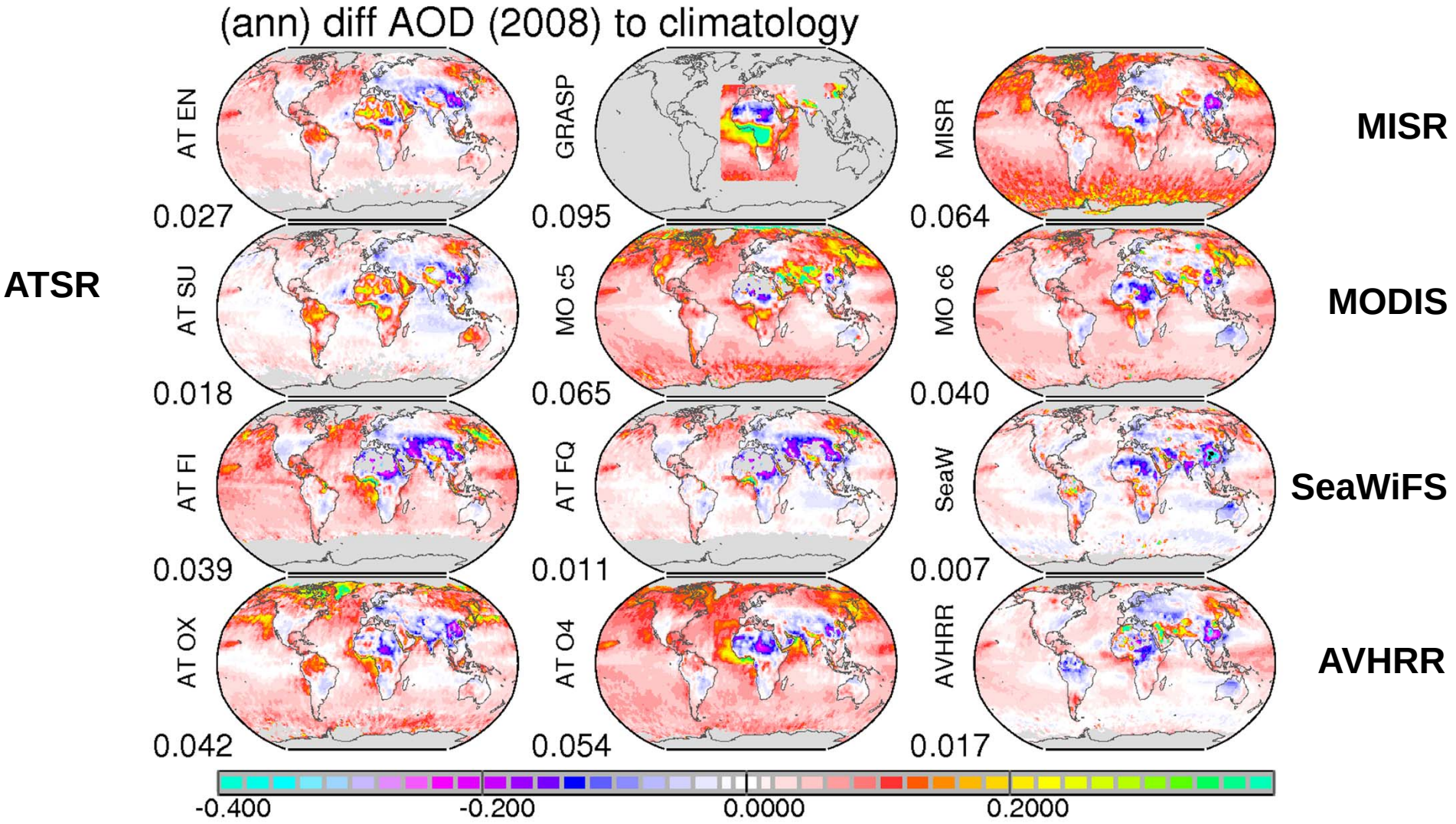
FMF

ANG
(div by 2)

annual means

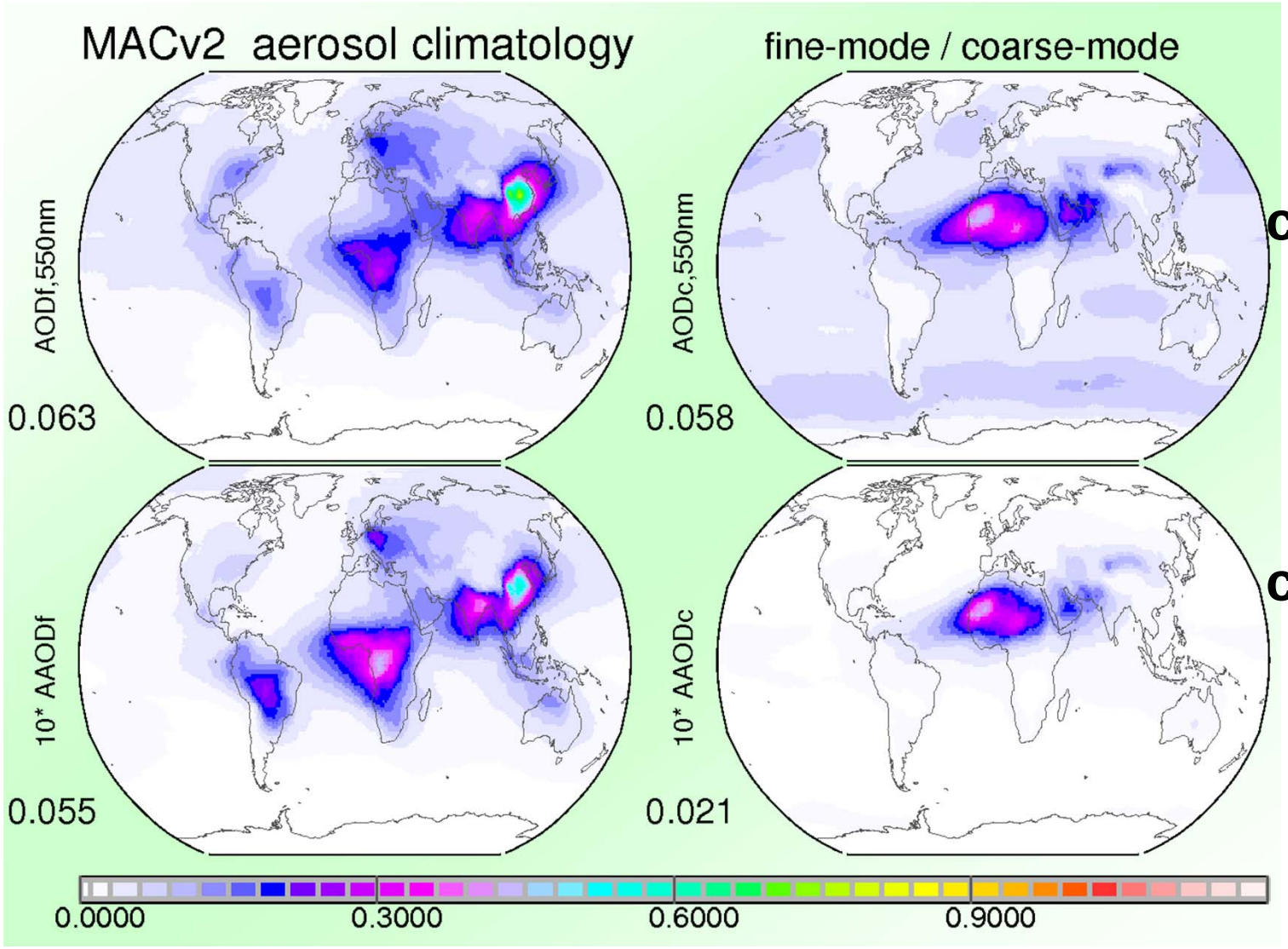
satellite AOD biases

if we believe MACv2 *(not specific for year 2008 though)*



MACv2 - AOD and AAOD by size-mode

fine-mode **coarse mode**



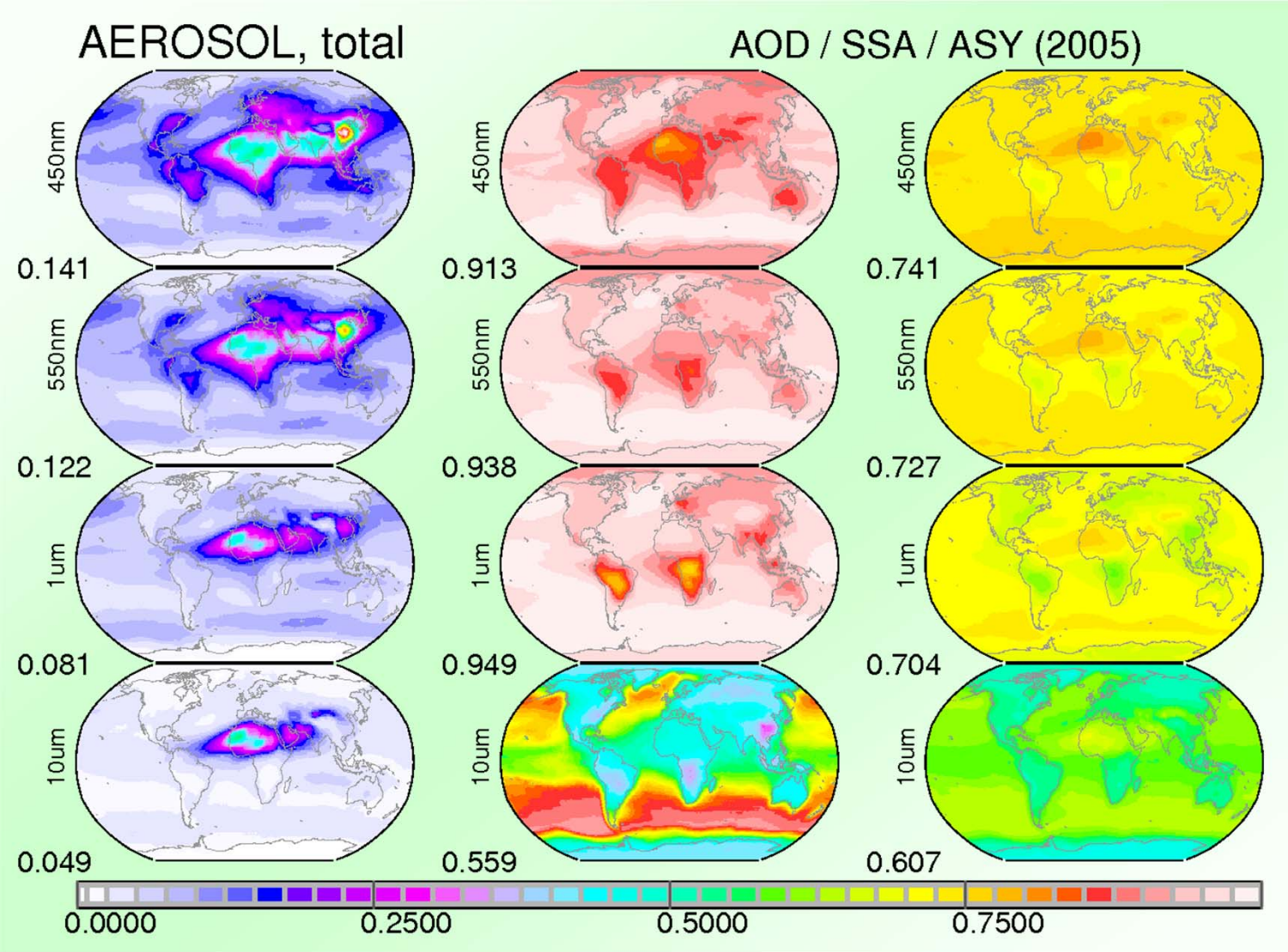
fine AOD **50%**

coarse AOD **50%**

fine AAOD **(10 times)** **70%**

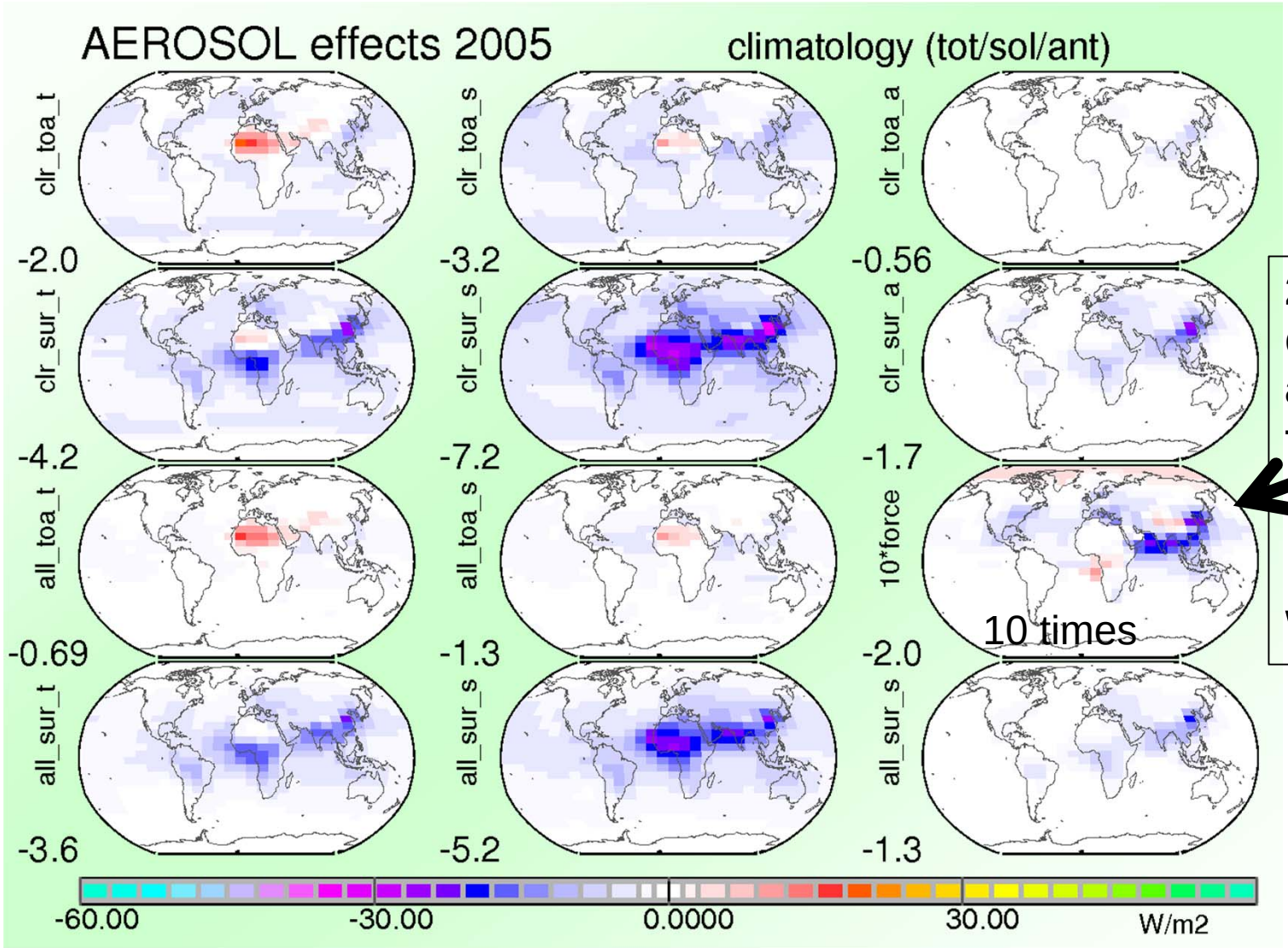
coarse AAOD **(10 times)** **30%**

Radiative impacts – here we are



direct radiative effects - 2005

solar +IR **solar only** **anthropogenic**



clr-sky TOA

clr-sky surf

all-sky TOA

all-sky surf

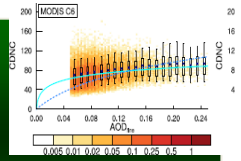
10 times

2005 direct anthrop forcing

-0.2 W/m2

indirect forcing ?

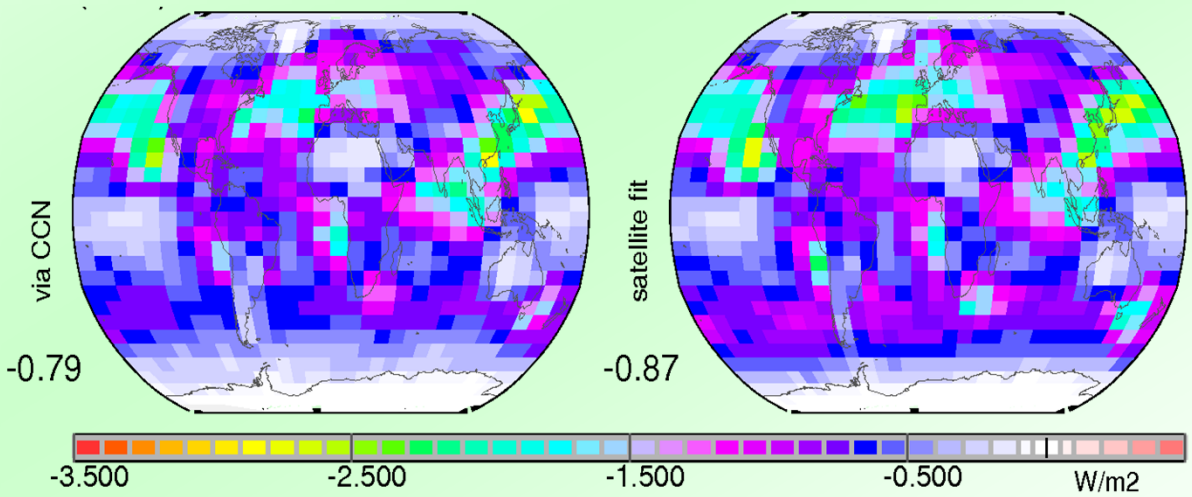
we tried it 2 ways … almost identical result



- **assuming that the Twomey effect only matters**
  - **more CCN from anthr. aerosol → more CDNC in water clouds → more cloud solar reflection**
  - **existing CDNC (natural) background matters**

complex: use a vertical distribution, assume SS (.1%), determine CCN

simple: use AODf CDNC relations of MODIS and ATSR retrievals

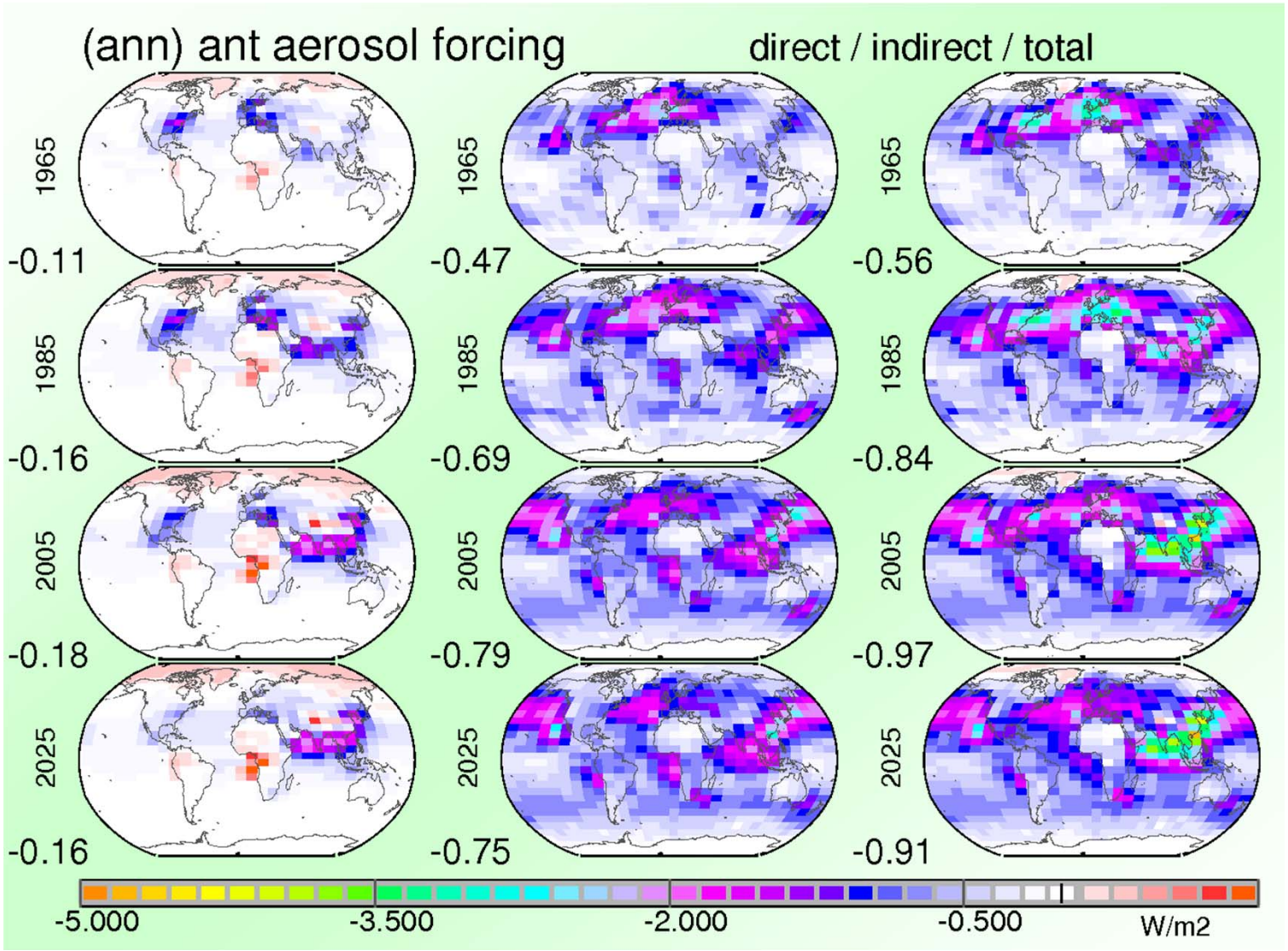


2005 indirect anthrop forcing

-0.8 W/m2

aerosol forcing – 1965 to 2025

direct **indirect** **total**



aerosol forcing highlights

- aero forcing has not changed much since 1985
  - regional shift though: US/EU → SE-Asia
- indirect (cloud effects) dominate TOA response

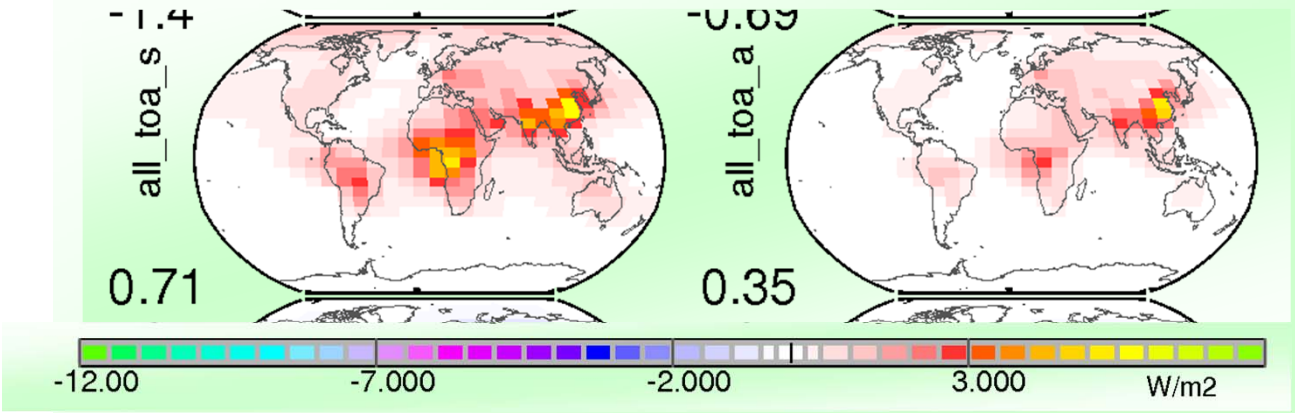
  -0.8 W/m2 (indirect) -0.2 W/m2 (direct)
- aerosol absorption dominate the atm heating

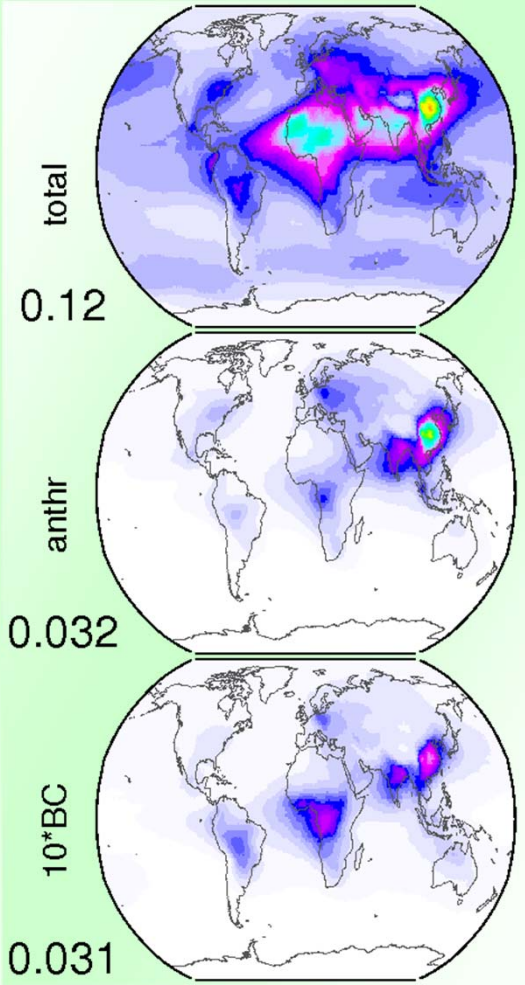
  -1.1 W/m2 (direct)
- AOD dominate the response at the surface

  -1.3 W/m2 (direct)
- strong spatial (and also seasonal) variability

BC forcing – 2005

total BC **anthrop BC** **AOD-fields**





- **what is the natural background ?**
- **anthrop BC effects**
  - **TOA forcing +0.35 W/m2**
  - **atm forcing +0.95 W/m2**

summary

- all aerosol properties are highly variable
  - different sources, short lifetime, transport
- although global averages are given …
  - maps display diversity (e.g. source regions)
- regional impacts are often an order of magnitude larger than global averages
  - the indirect global aerosol forcing is -.2 W/m2 regional responses range from -6 to +6 W/m2

finally Bill

- didn't we all hate to get interrupted during presentations by Bill …
  - sometimes valid, sometimes for his pleasure
- but there is also a gentler & constructive side
  - … once you get to know him
- in that way his resembles his 'German twin'
  - unfortunately also in terms of recent health issues
- so *…with wishes from Ehrhard*
  - get well ! … and
  - keep challenging us !

Max-Planck Aerosol Climatology

ftp ftp-projects.zmaw.de/aerocom/climatology/MACv2_2017

- **1x1 deg global, monthly, aerosol opt. properties**
- **capturing today's average properties for**
  - **column amount ('attenuation') AOD**
  - **column absorption ('composition') AAOD**
  - **particle 'size' information FMF, Angstrom**
  - **– how? …. combine!**
    - **quality statistics from sun-photometer data**
    - **completeness from bottom-up modeling**

relying on OBSERVATIONS of AERONET and MAN plus background from modeling
(no direct use of satellite data)

AerChemMIP AeroSAT ECMI AeroCom

why MAC ?

… climate studies require aerosol rad. properties

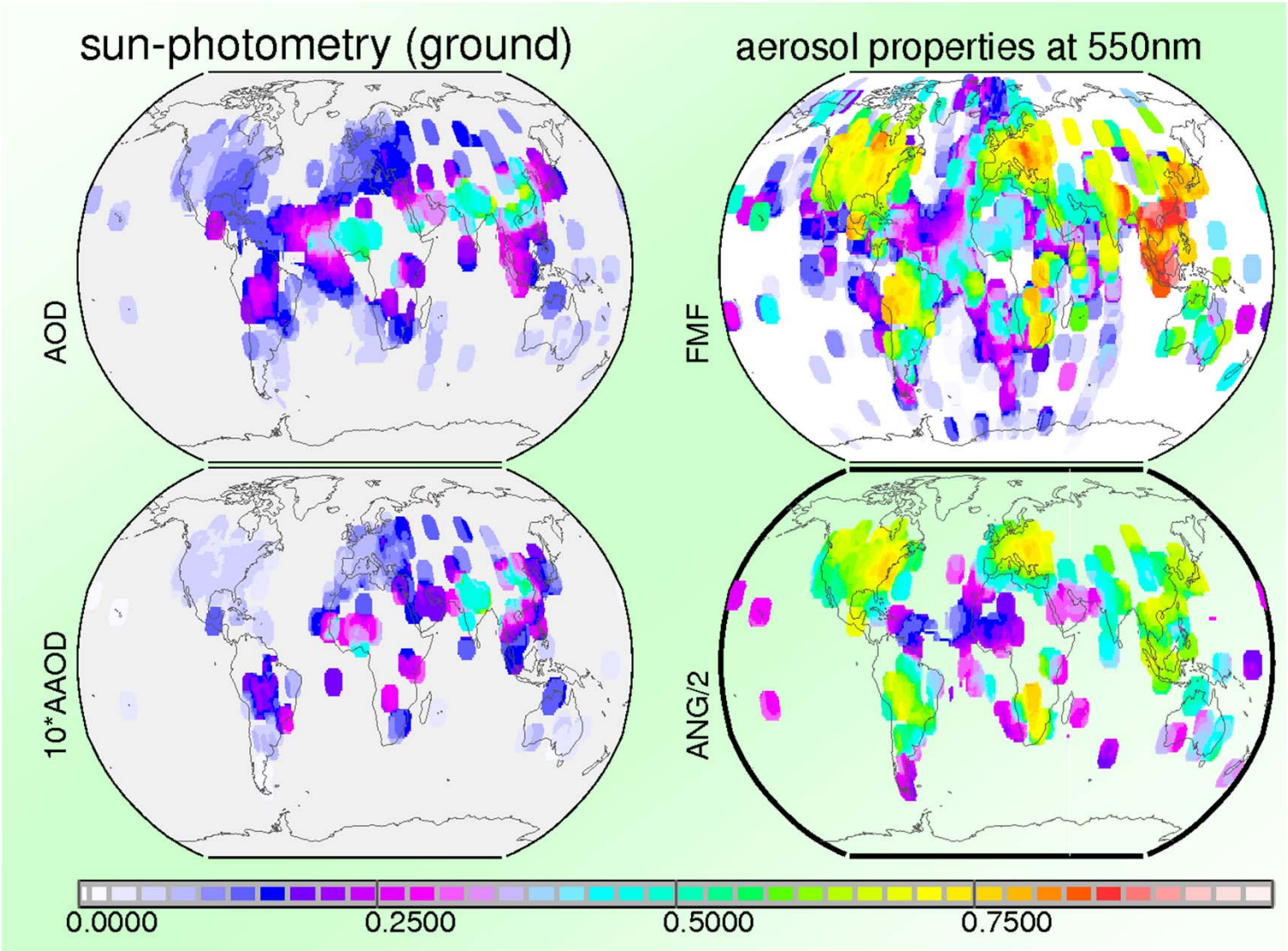
- simulations from global modeling
  - accuracy suffers from input and complexity
  - time-consuming
- prescription by a climatology (e.g. MAC)
  - direct link to observations
  - fast (and simple to implement)

while the climatology can be a nice option in many applications … the reliance on context from global modeling underlines to importance on advancements in detailed aerosol modeling

use **observations** if you can

AOD

AAOD
(10 times)

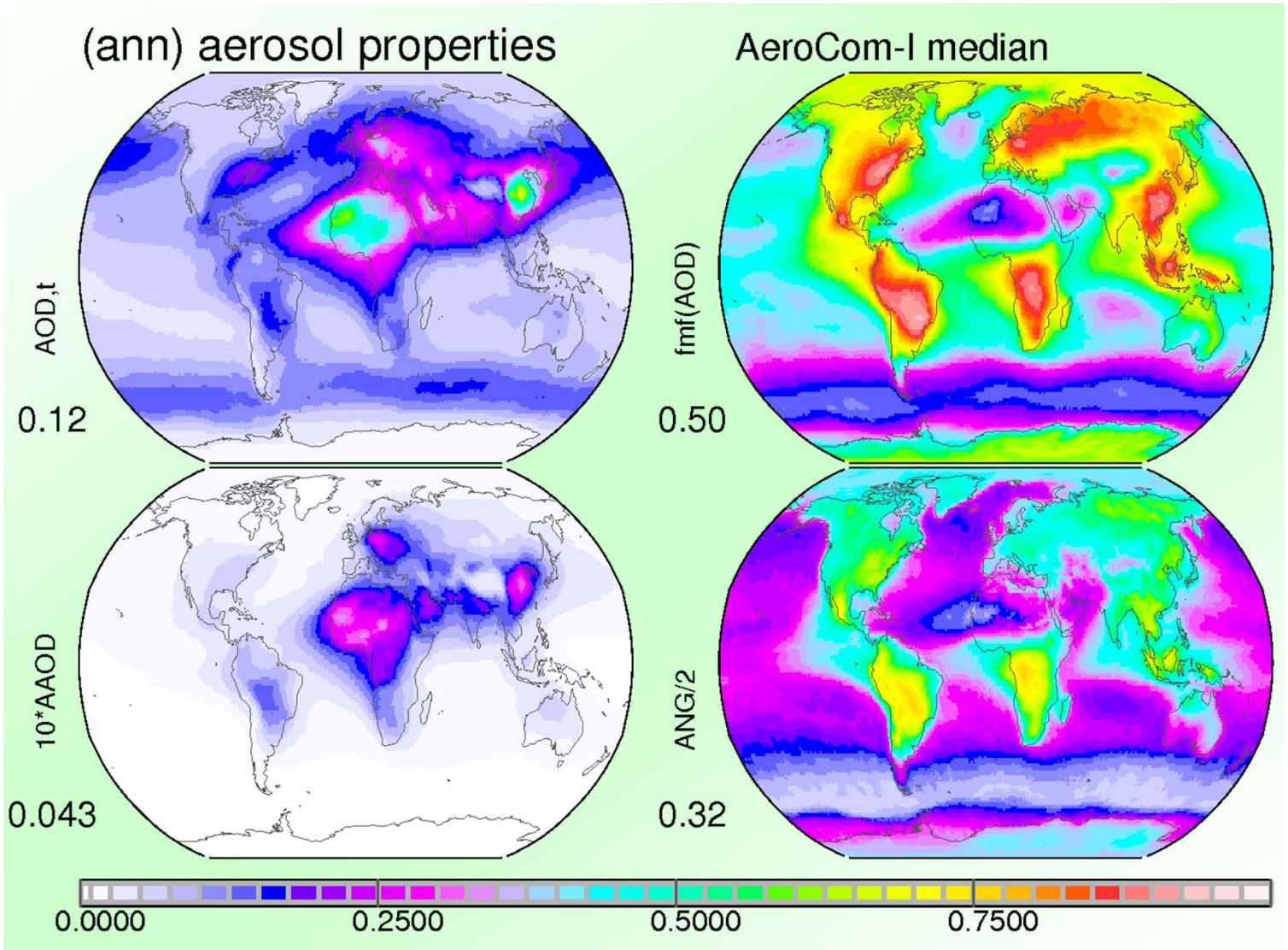


FMF

ANG
(div by 2)

annual
means

complete modeling



AOD

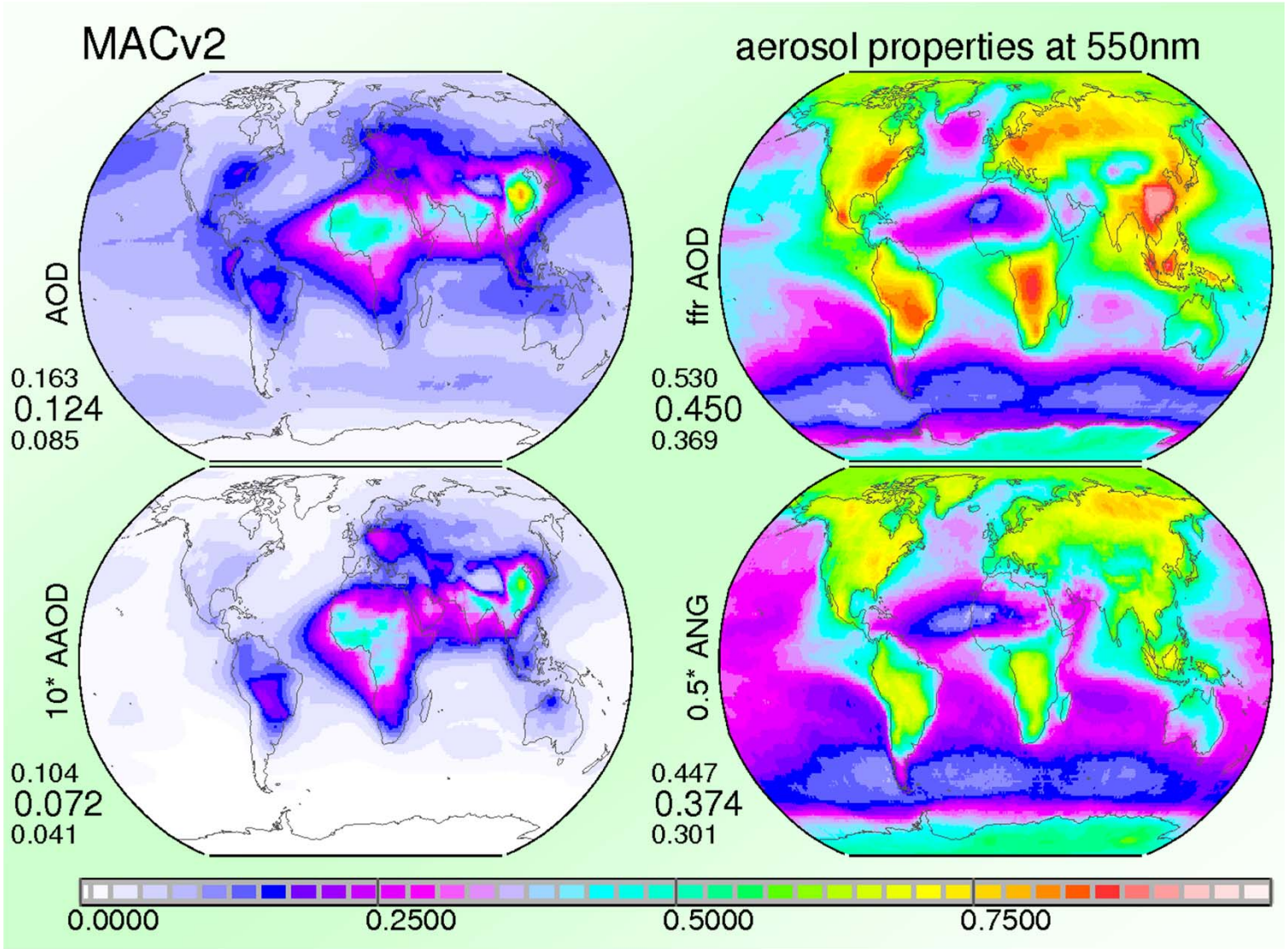
AAOD
(10 times)

FMF

ANG
(div by 2)

annual means

extended with model context → MACv2



AOD

AAOD
(10 times)

FMF

ANG
(div by 2)

annual means

particularly useful with extra help

- to make it useful for climate applications
  - anthropogenic fraction
    - fine-mode only (no anthrop dust)
  - temporal variability (seasonality)
  - temporal variability (inter-annual)
    - only anthrop AOD change (const coarse-m.)
  - spectral variability
  - vertical distribution
  - microphysics (fine-mode size → CCN conc.)
    - changes to low cloud properties

ver.2 vs ver.1 (what changed?)

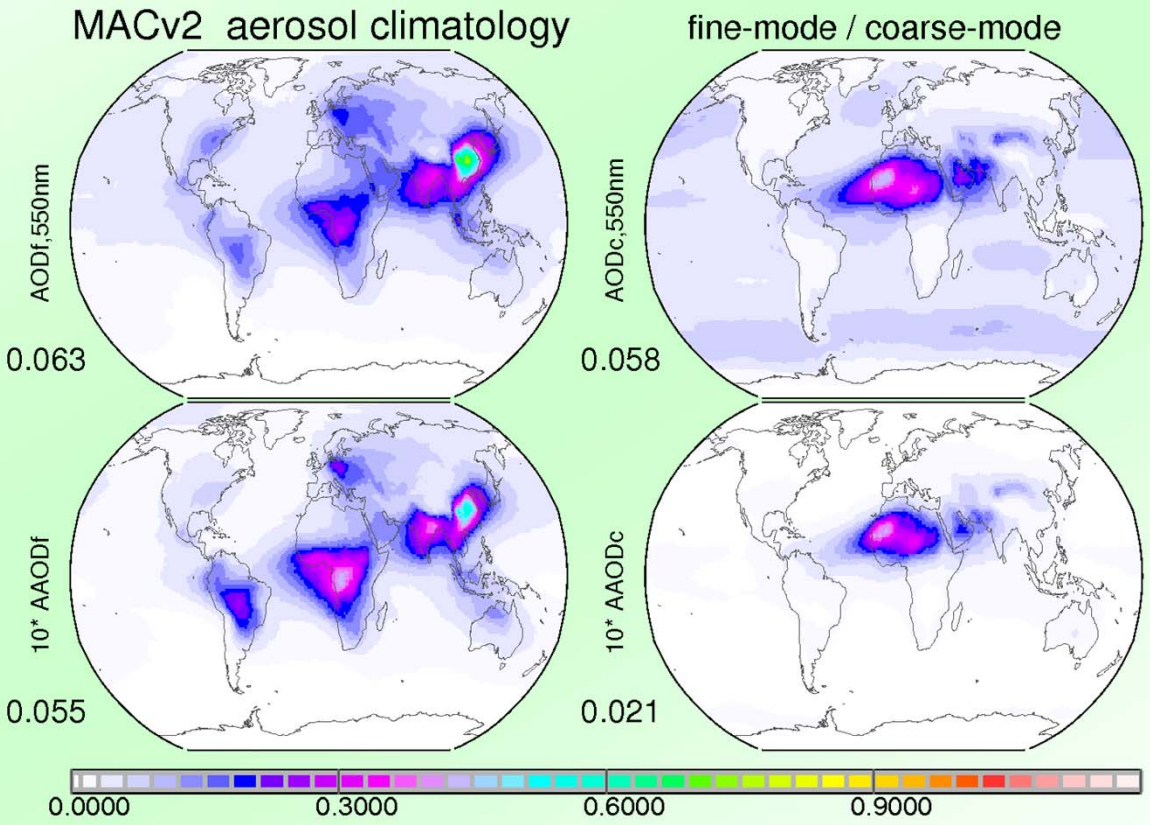
- merge absolute quantities, now in two steps
  - not relative properties (SSA, FMF, …)
- use MAN data over oceans
  - reduced dep. on modeling
- use a different (higher) PI fine-mode state
  - anthropogenic AOD dropped by 30%
- outcome
  - AOD remains similar, but anthrop AOD smaller
  - AAOD is much stronger
    - less direct forcing (-0.5W/m2 to -0.2Wm2)

recent ver.2 update (what changed?)

- **better absorption attribution to size-modes**
  - **allows now to quantify aerosol components**

fine AOD 50%

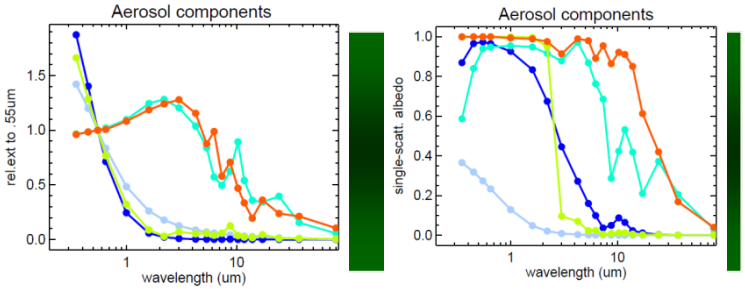
fine AAOD (10 times) 70%



coarse AOD 50%

coarse AAOD (10 times) 30%

AOD by components



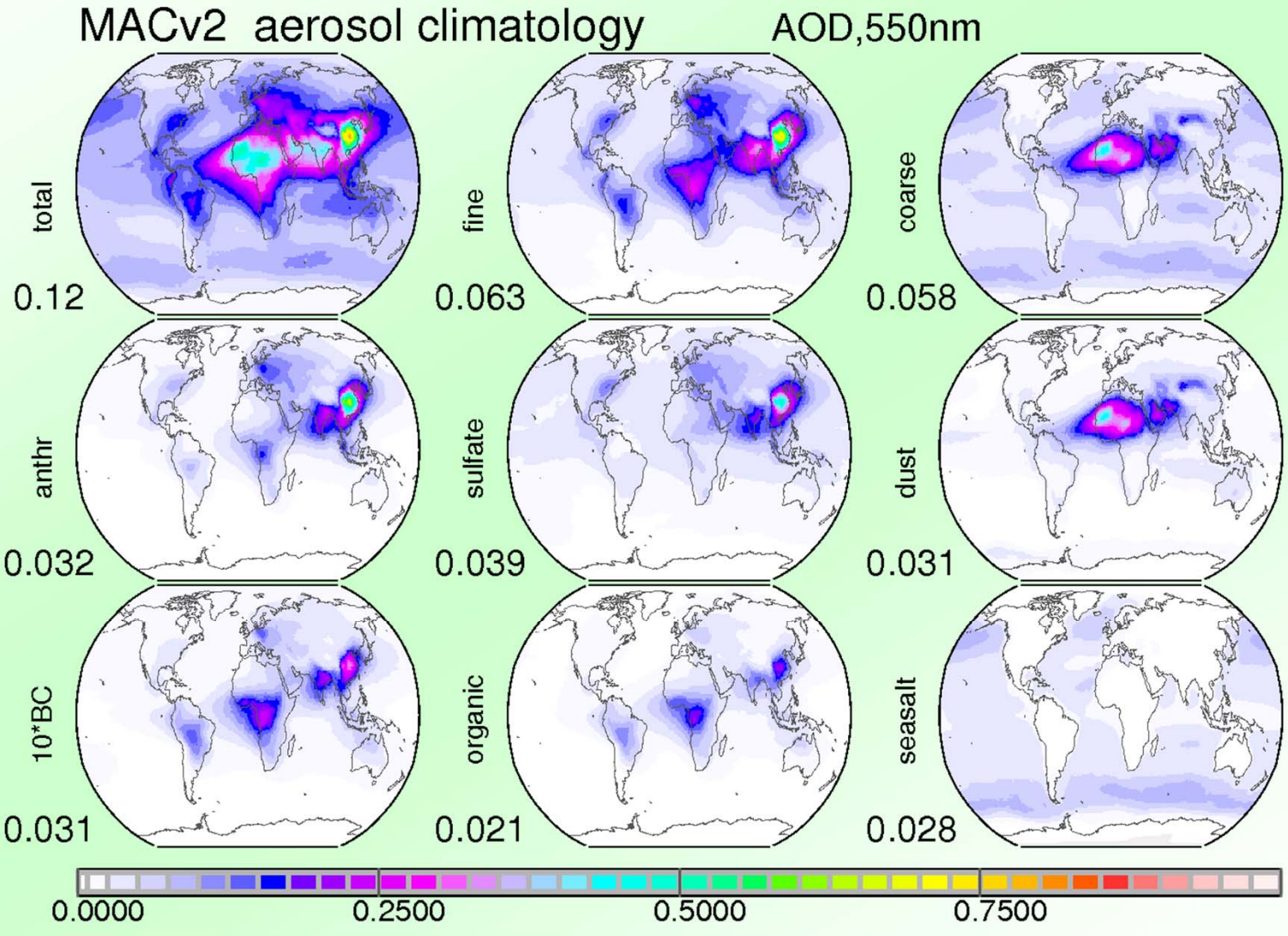
BC
black carb

OC
org. carb

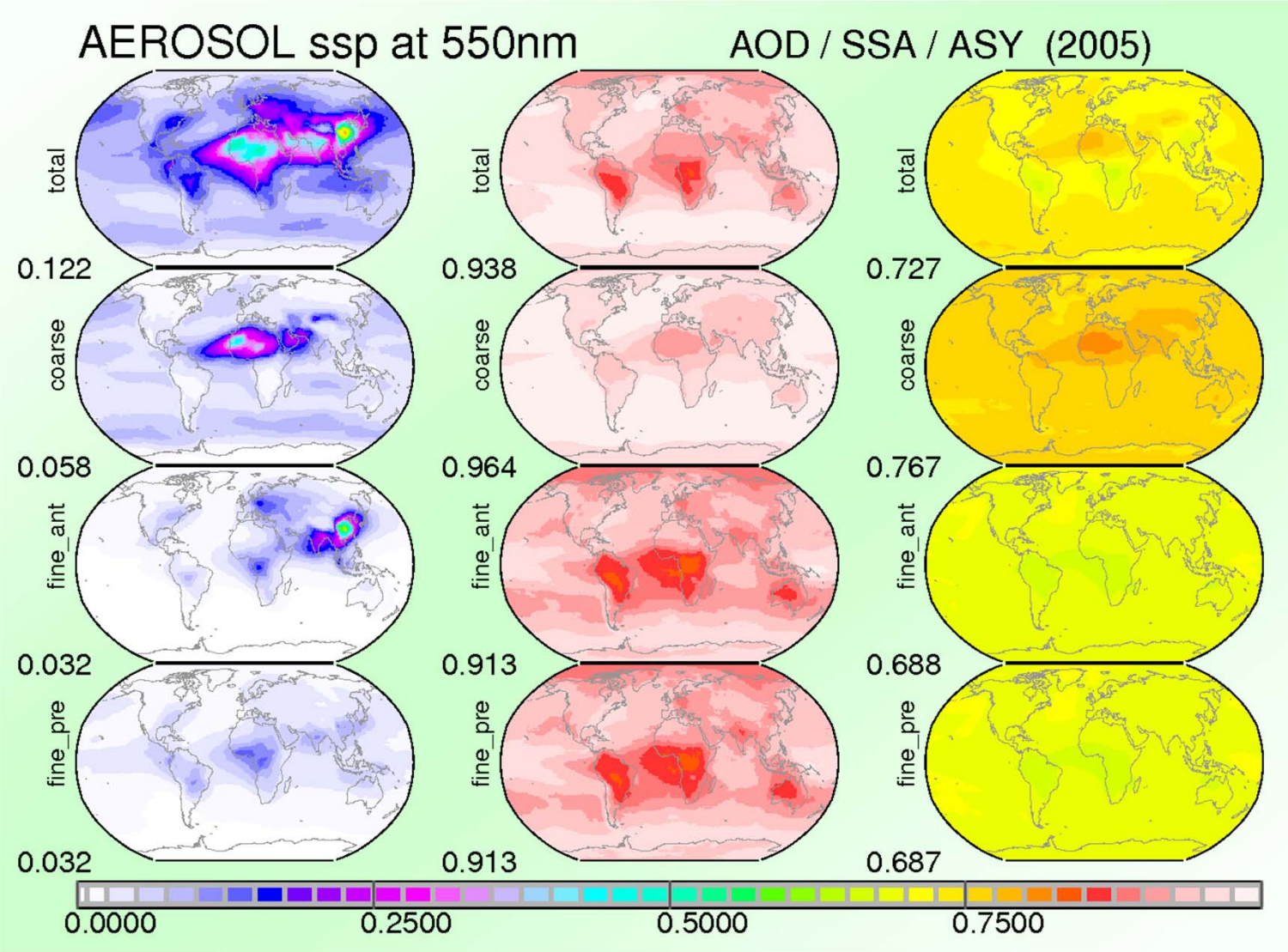
SU
sulfate

DU
dust

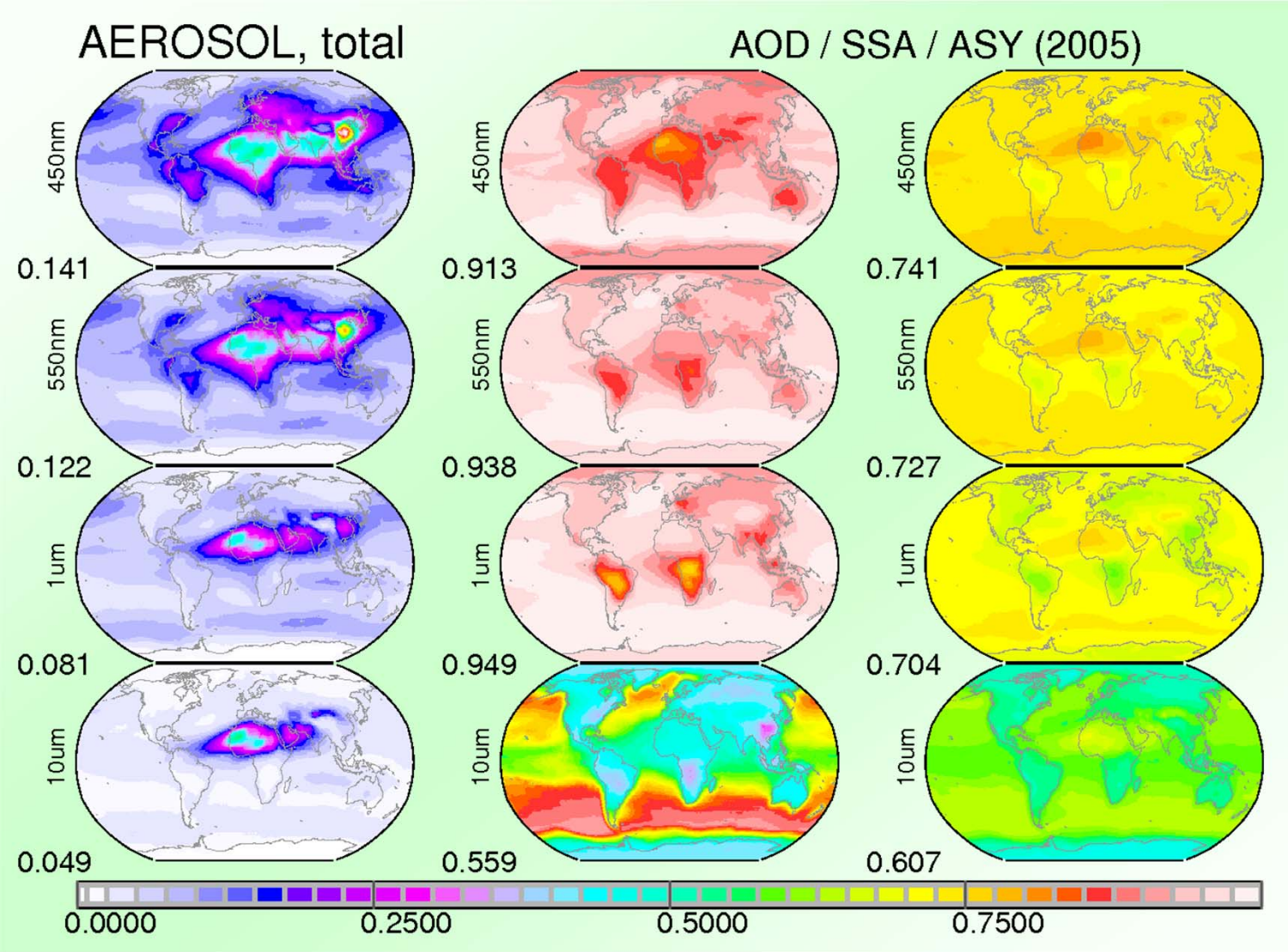
SS
seasalt



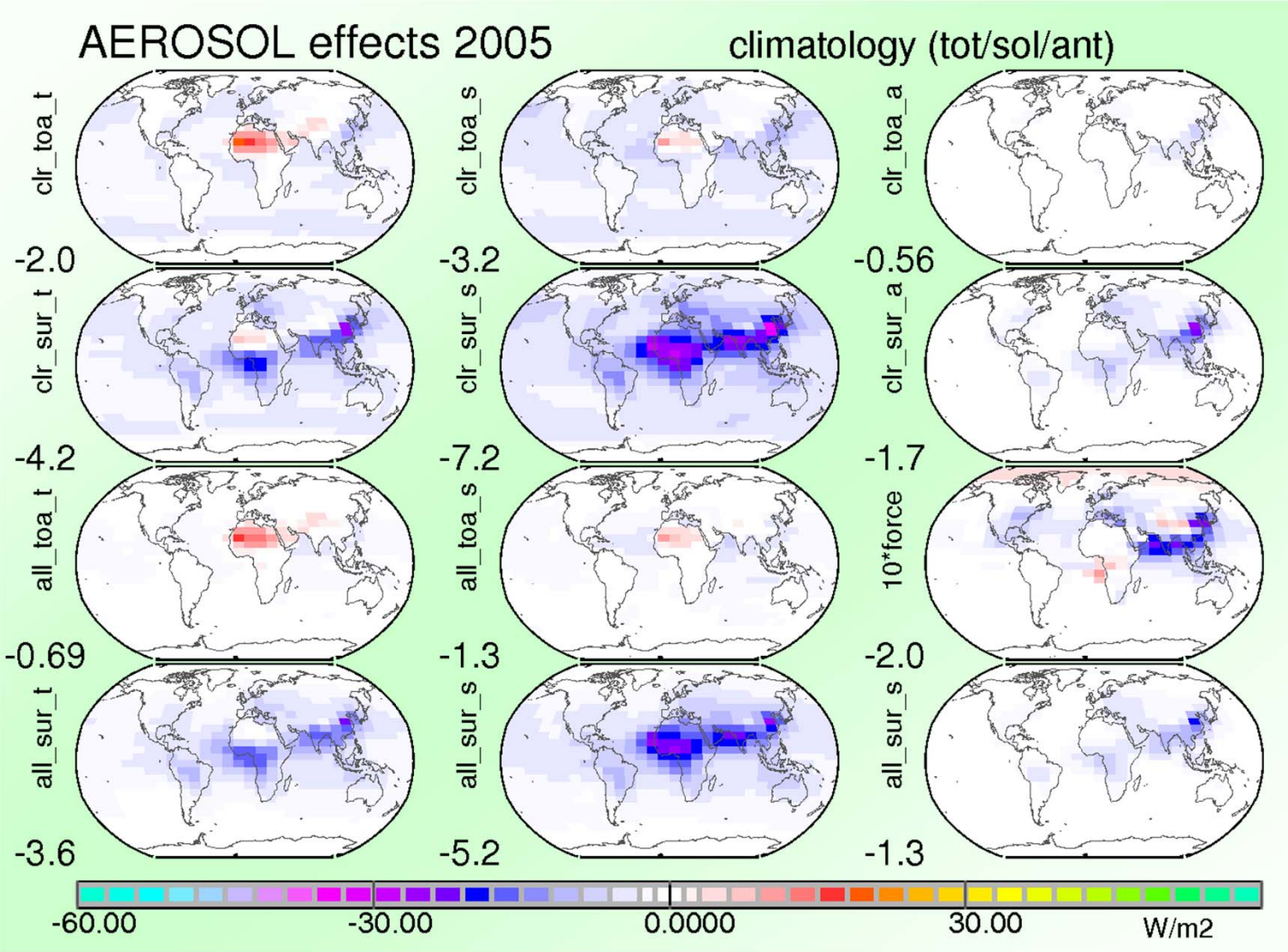
AOD SSA ASY rad. transfer needs



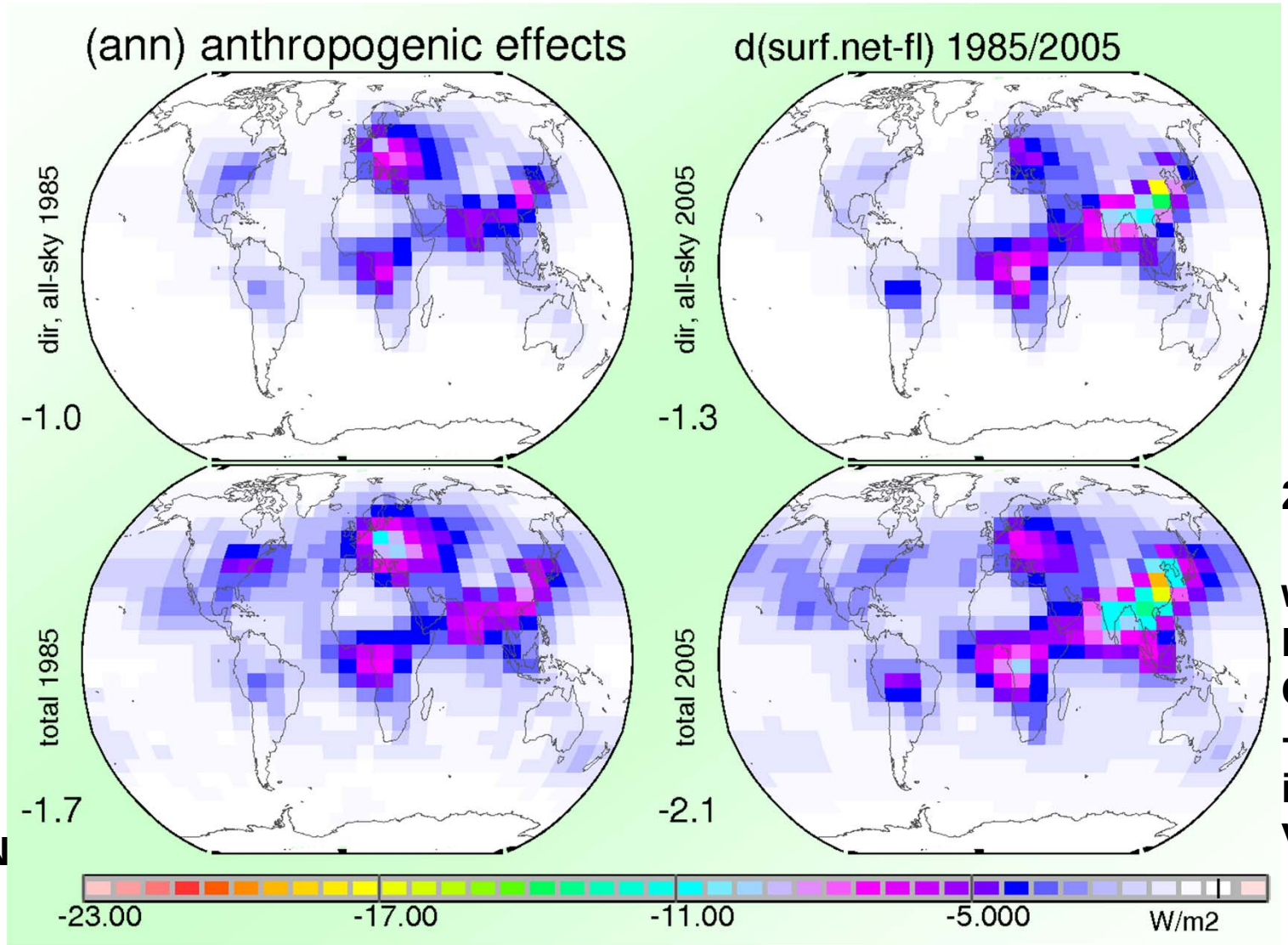
AOD SSA ASY rad. transfer needs



dir rad. impacts



changing impact on surf net fluxes



1985 clr-sky

2005 clr-sky

1985

with ISCCP Clouds + indirect Via CCN

2005

with ISCCP Clouds + indirect Via CCN

final slide

- **update for MACv2 is available**

ftp ftp-projects.zmaw.de/aerocom/climatology/MACv2_2017

  - **next monthly pdf in place of single value**
  - **considering changes in fine-absorption**
  - **for specific spectral data needs: contact me**

- **forcing (and rad.effects)**
  - **indirect (via clouds) eff.s most import at TOA**
  - **direct effects most imp. in atm and at surface**
  - **over the last decades the aerosol induced reductions to on surface net-fluxes increased**

fit properties to pre-defined components

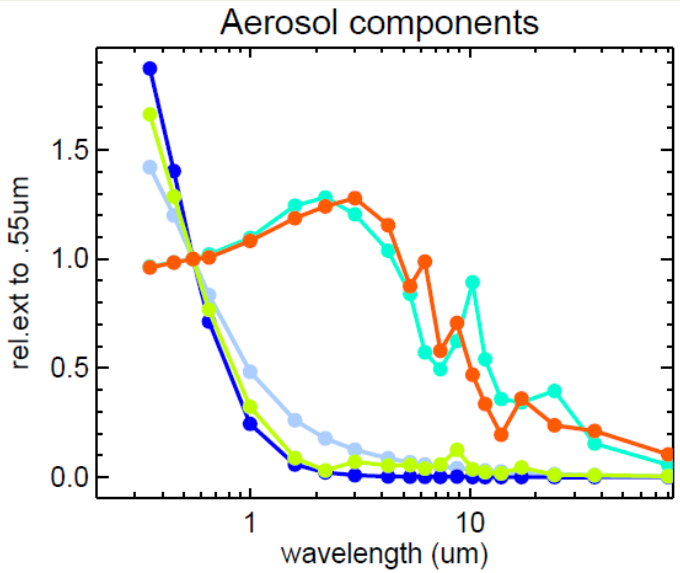
BC
black carb

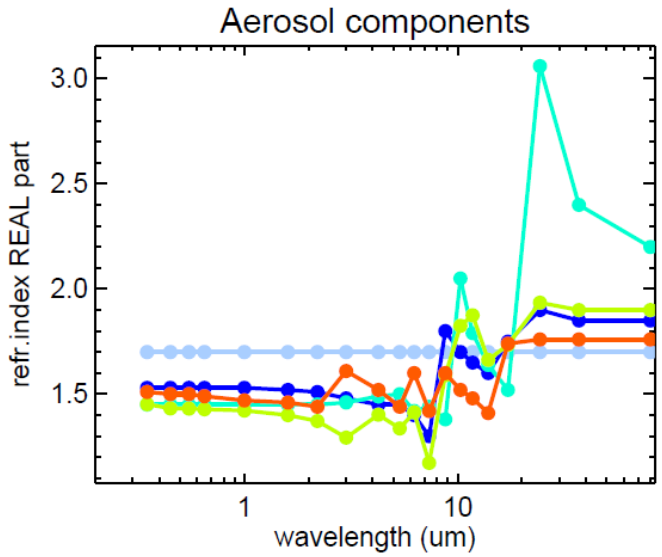
OC
org. carb

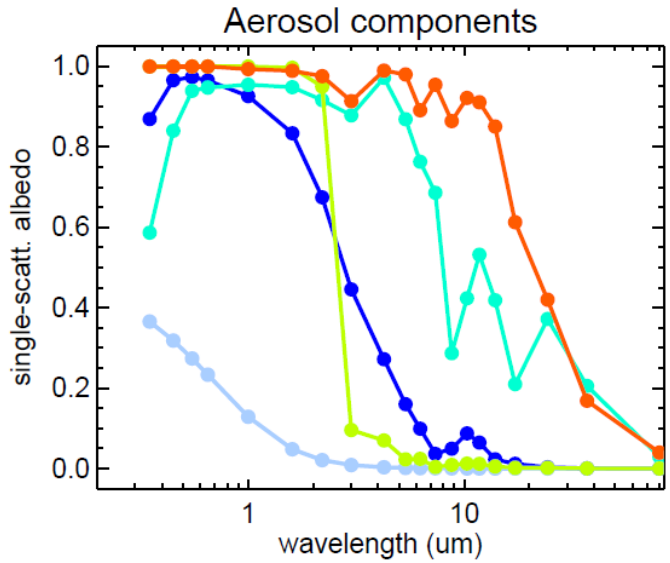
SU
sulfate

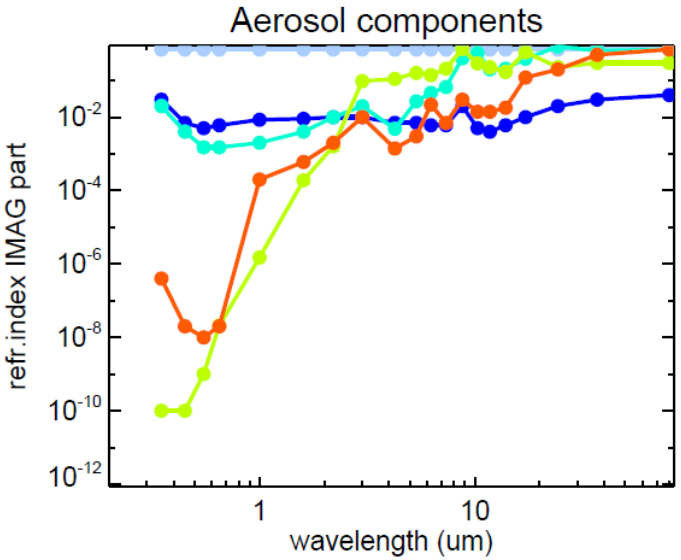
DU
dust

SS
seasalt

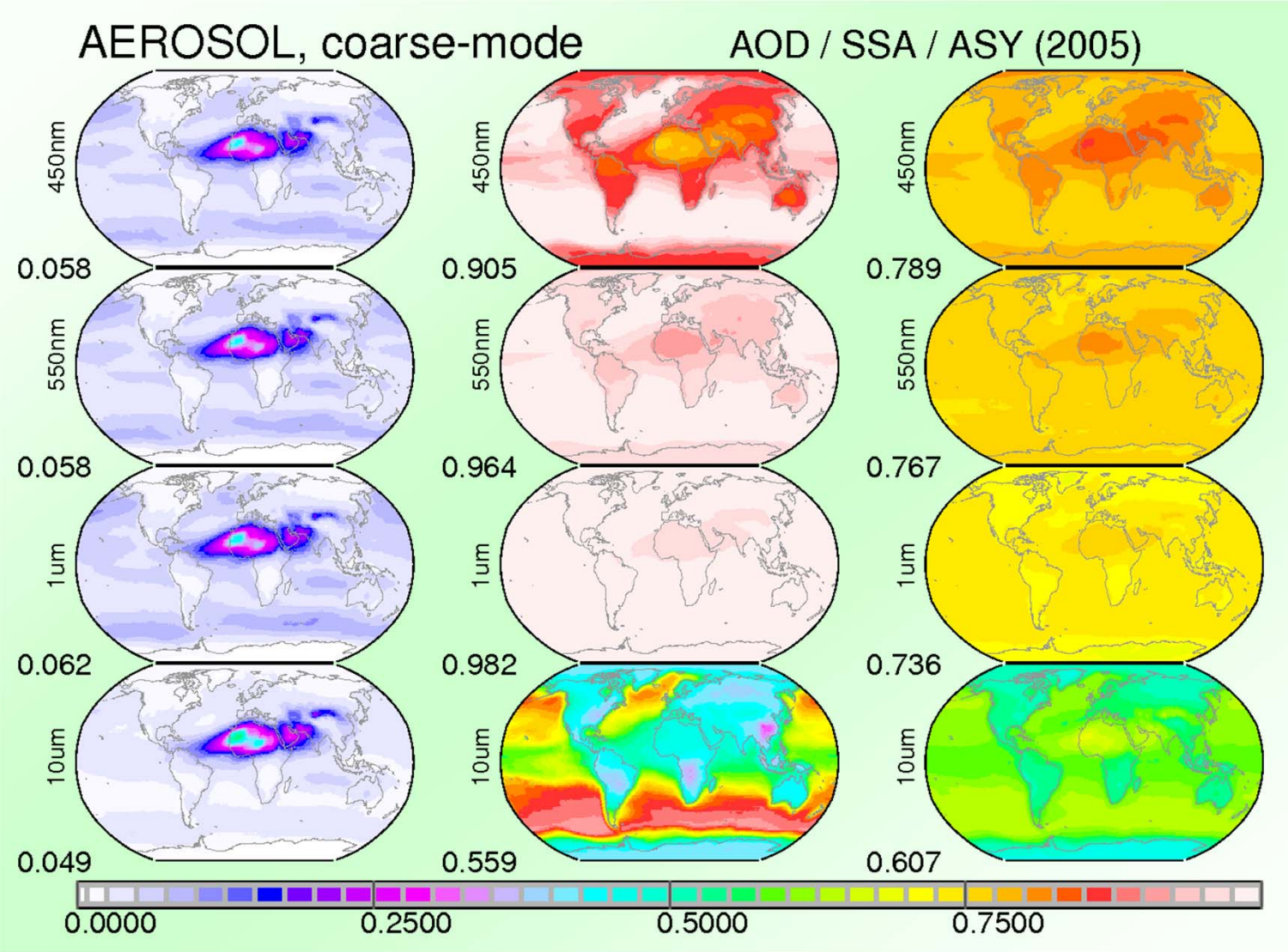




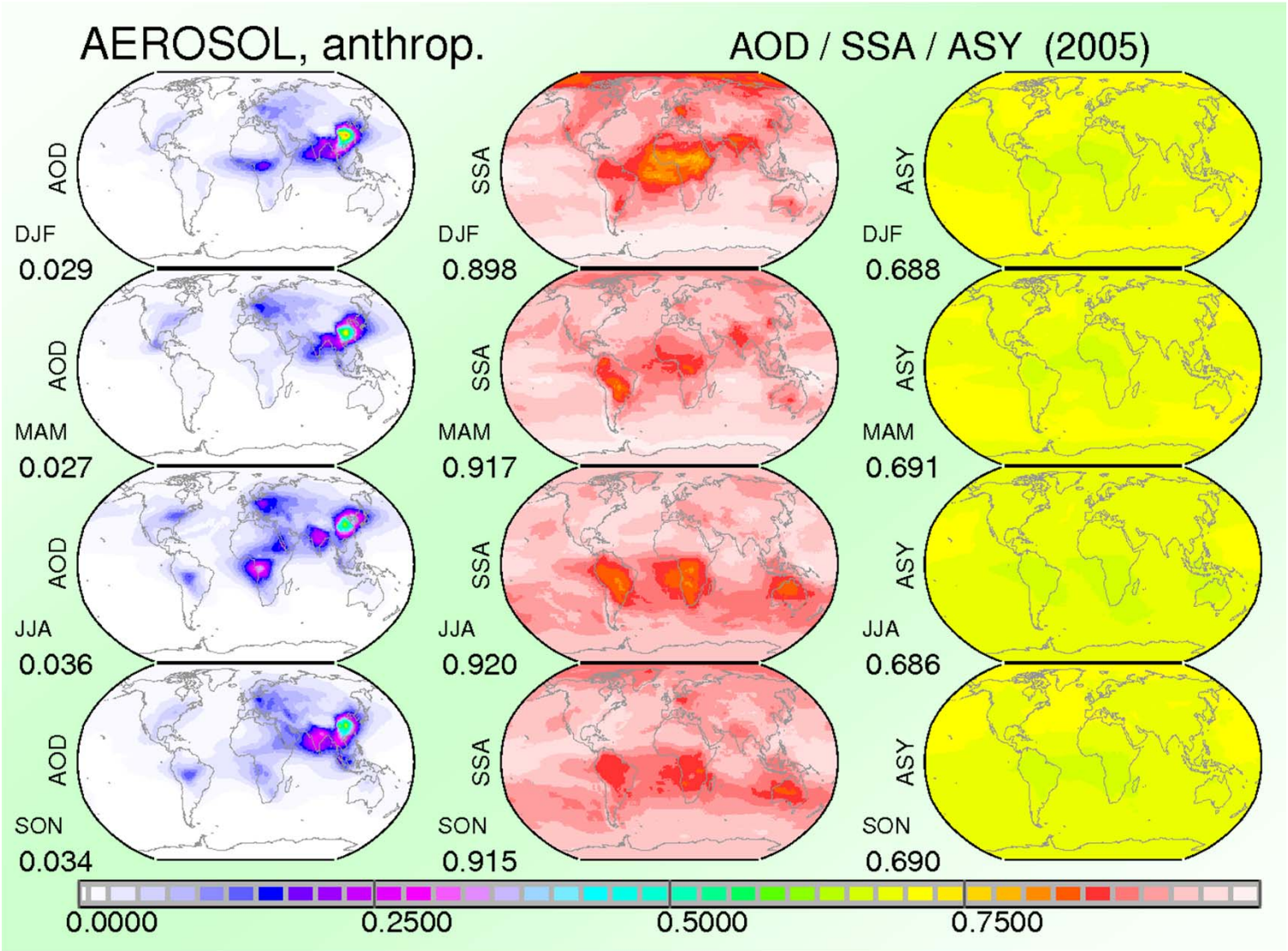




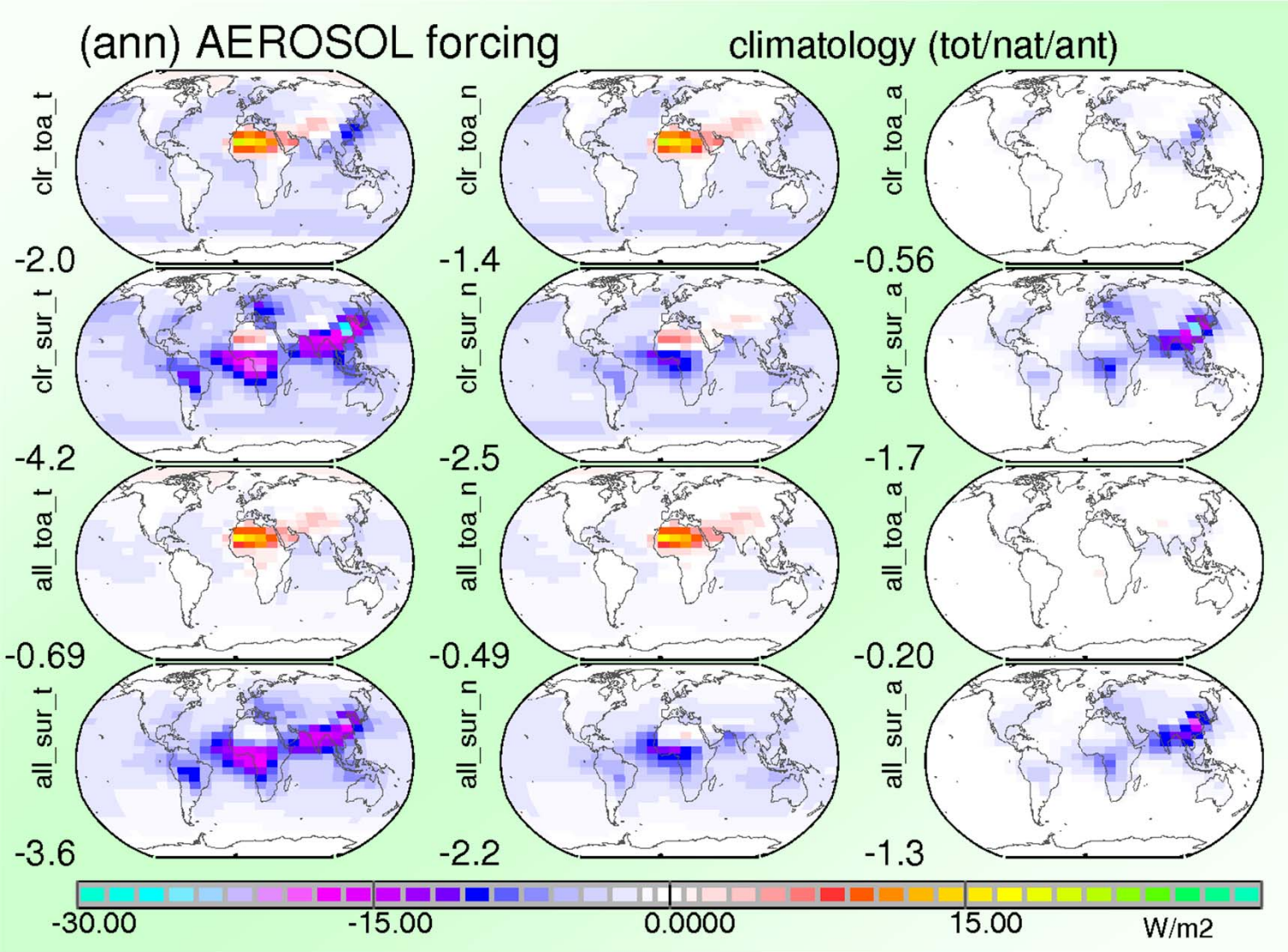
coarse mode spectral



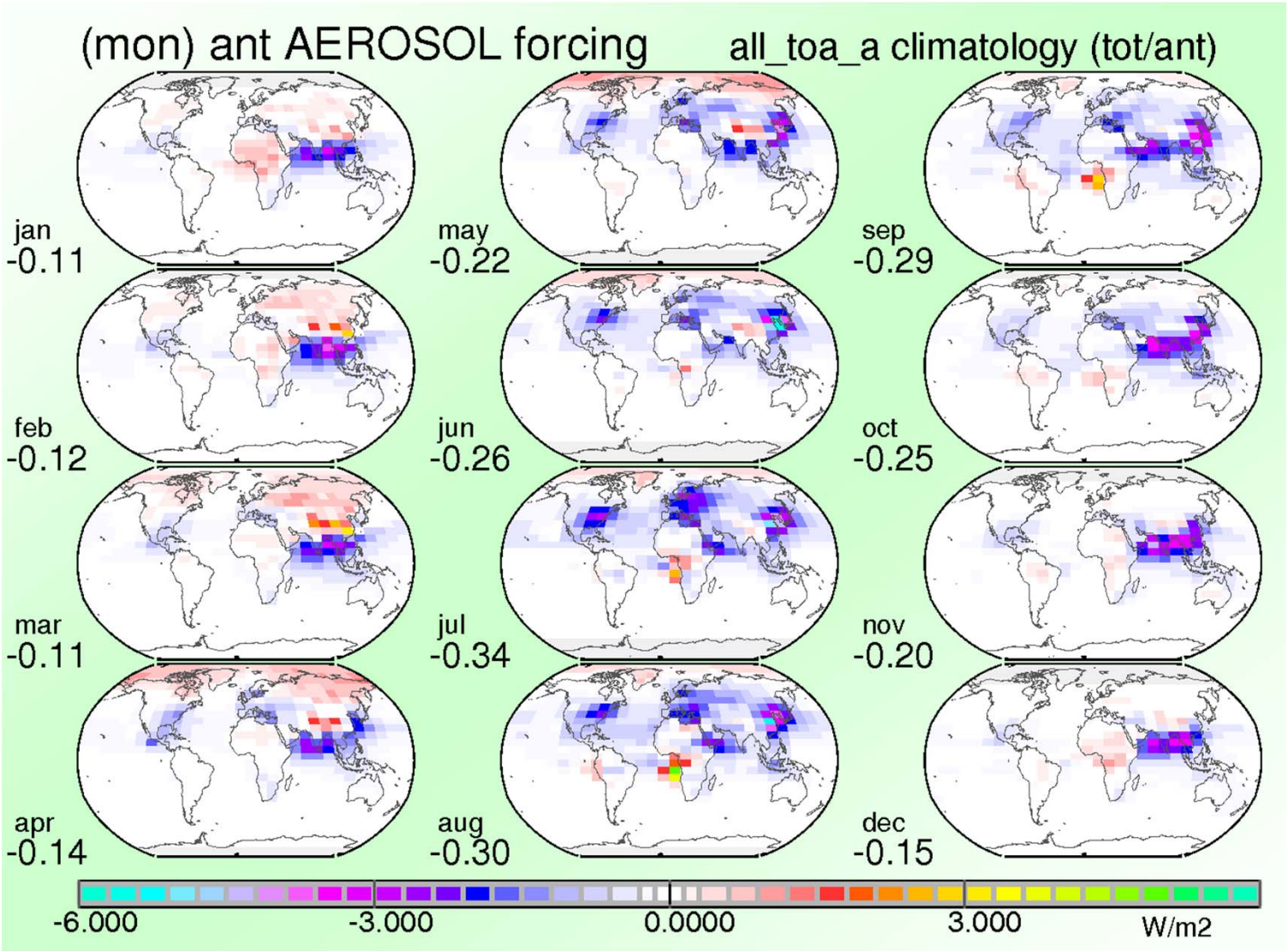
anthr. / fine mode spectral



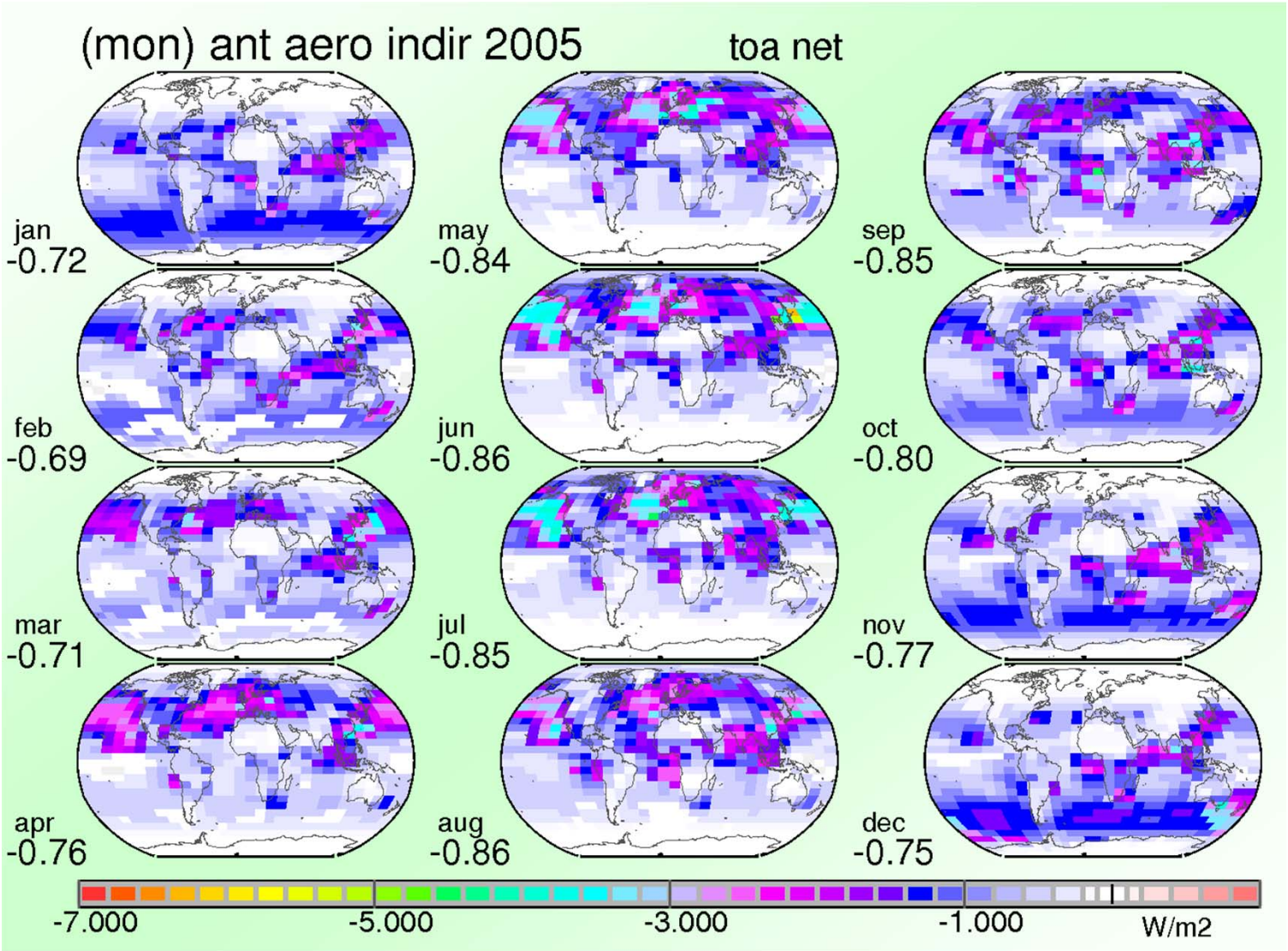
direct rad.effects overview 2005



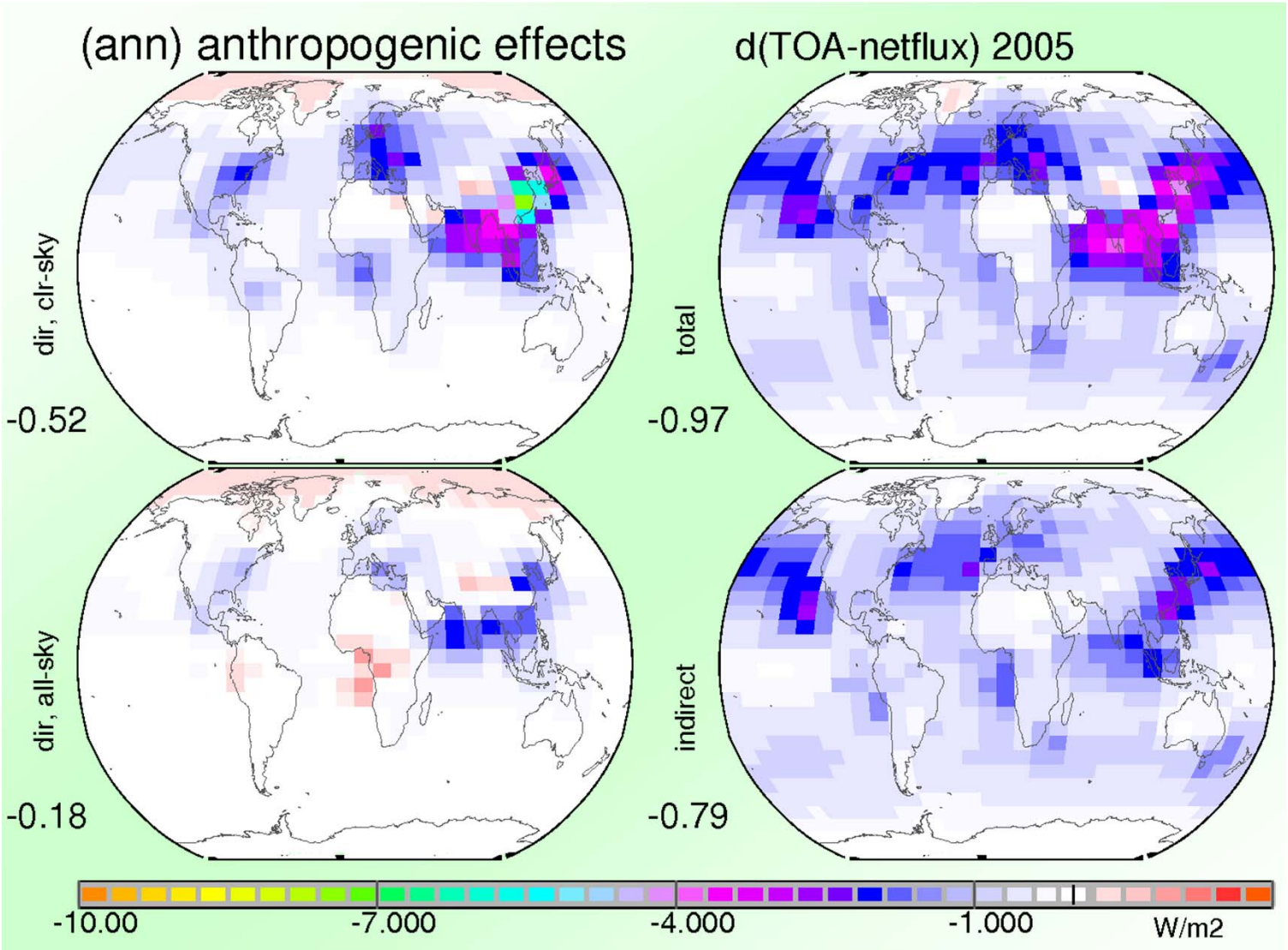
direct anthrop TOA effect



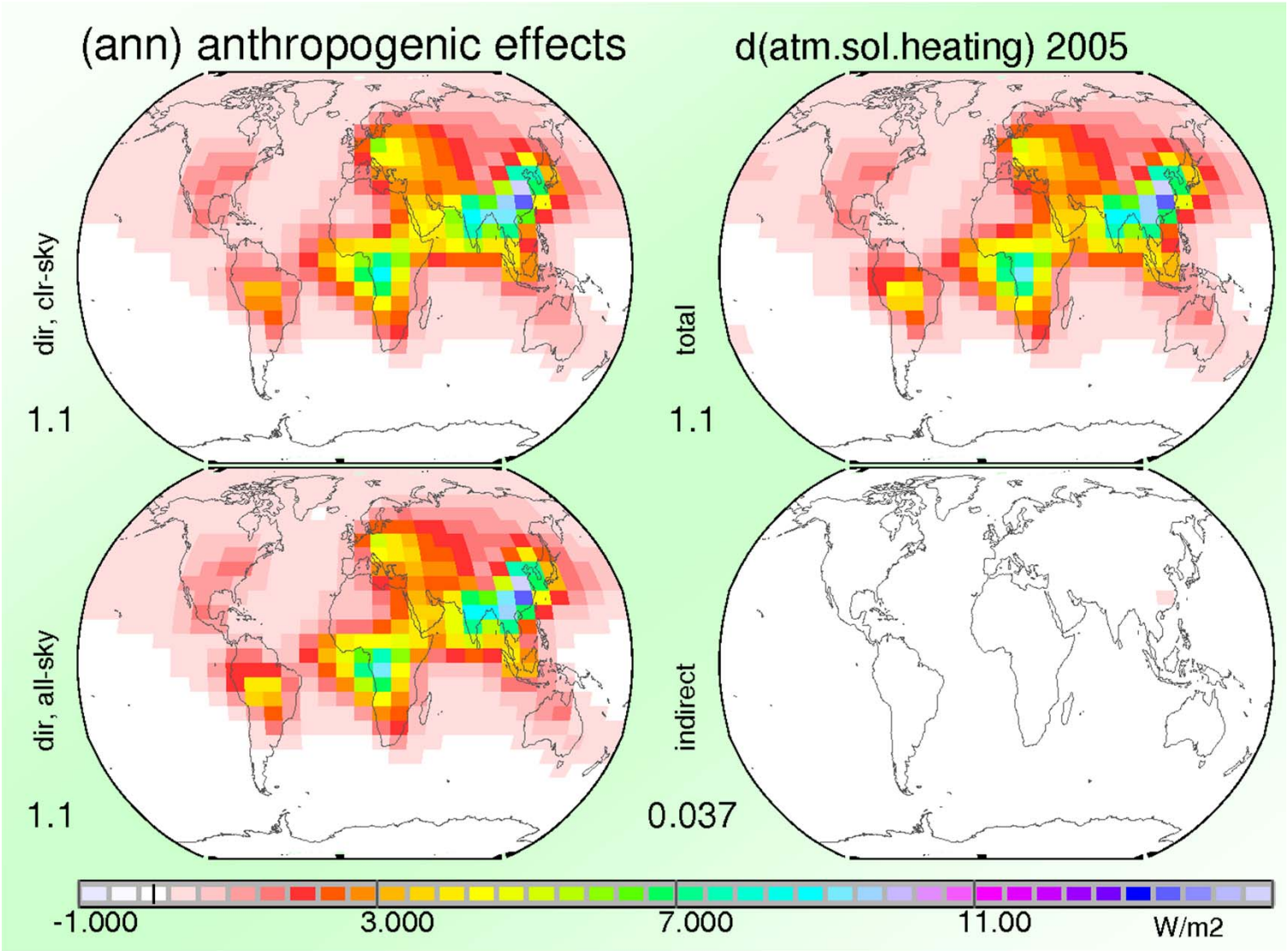
indirect anthrop TOA effect



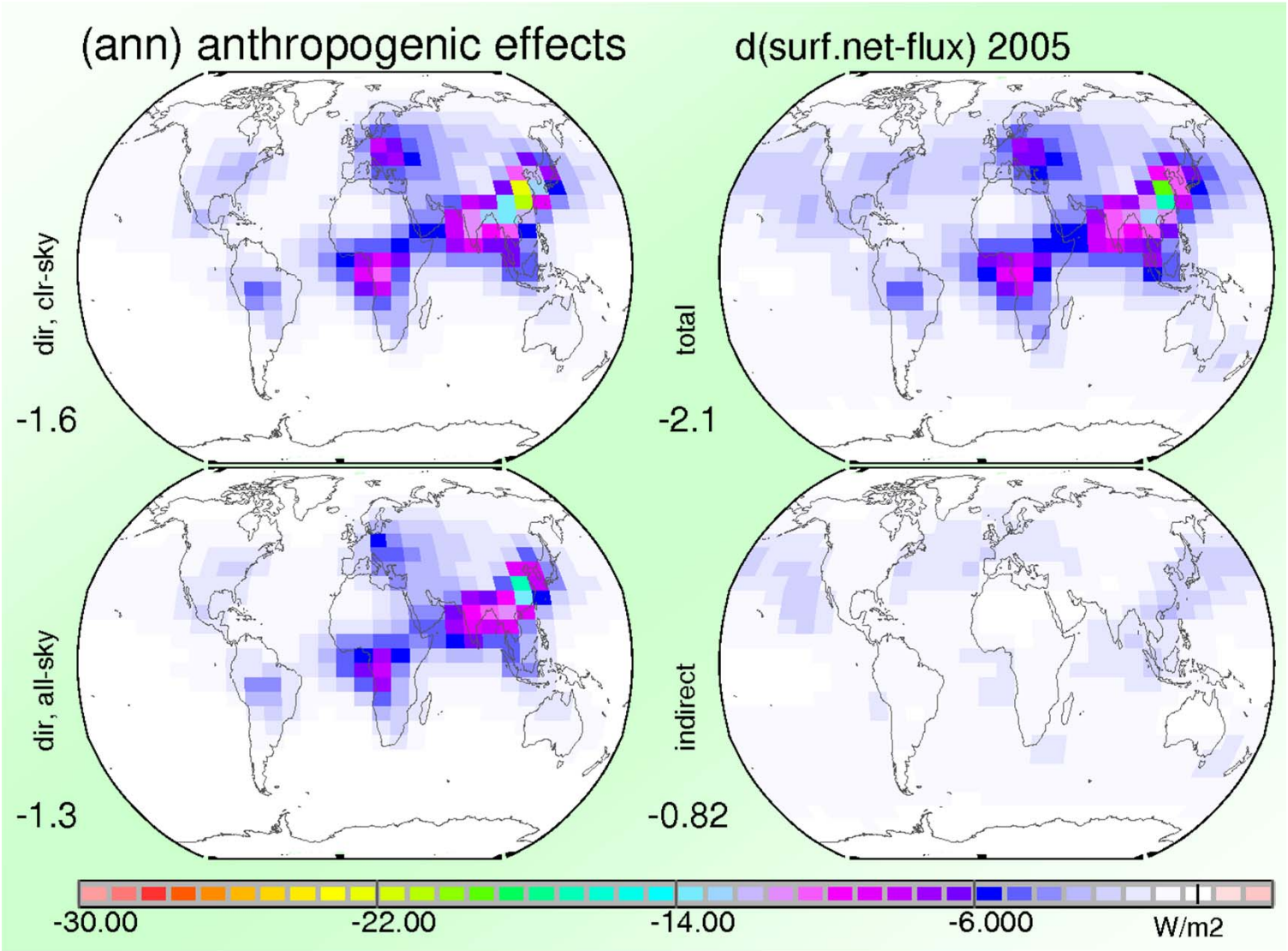
TOA components 2005



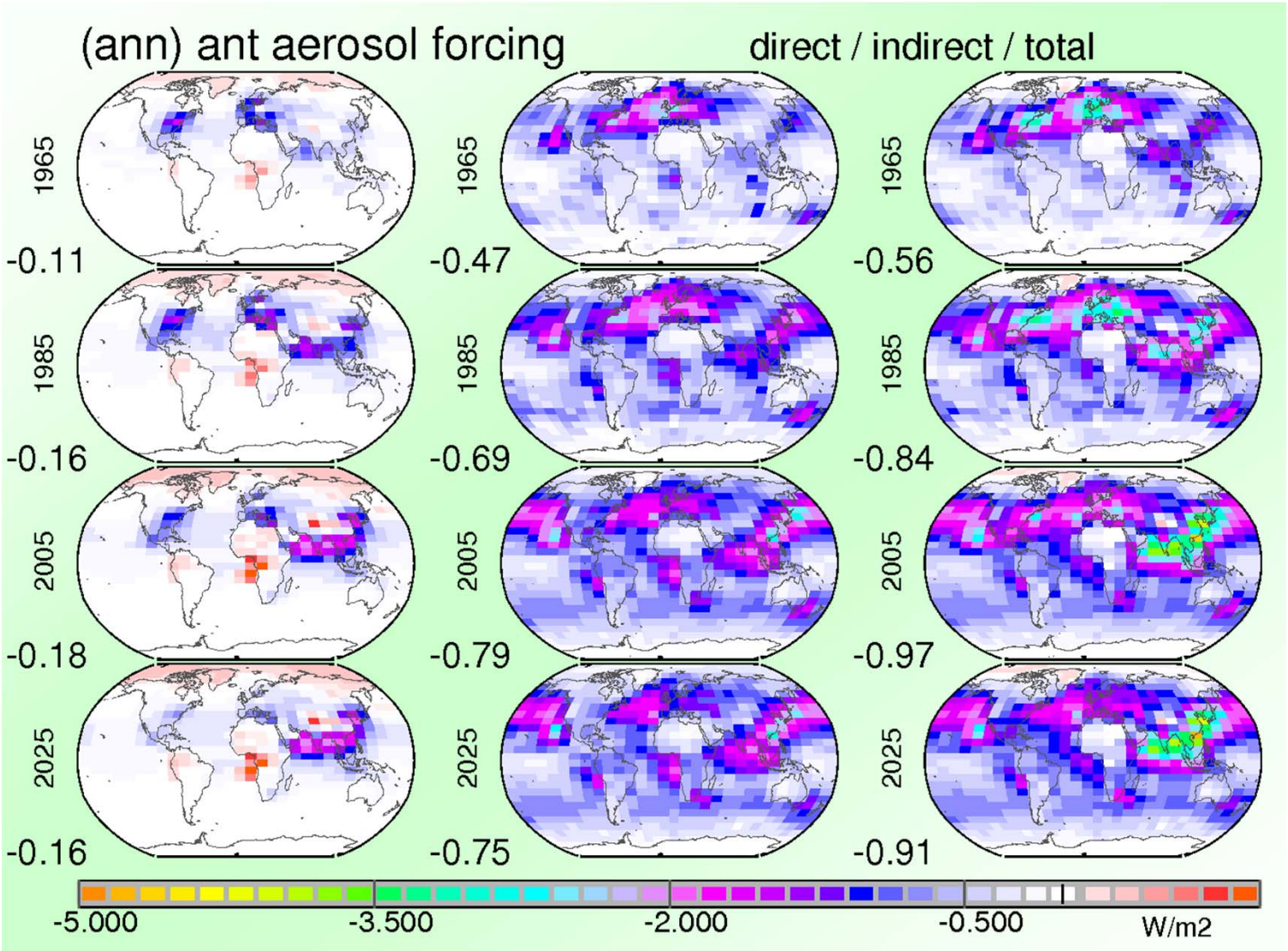
atm components 2005



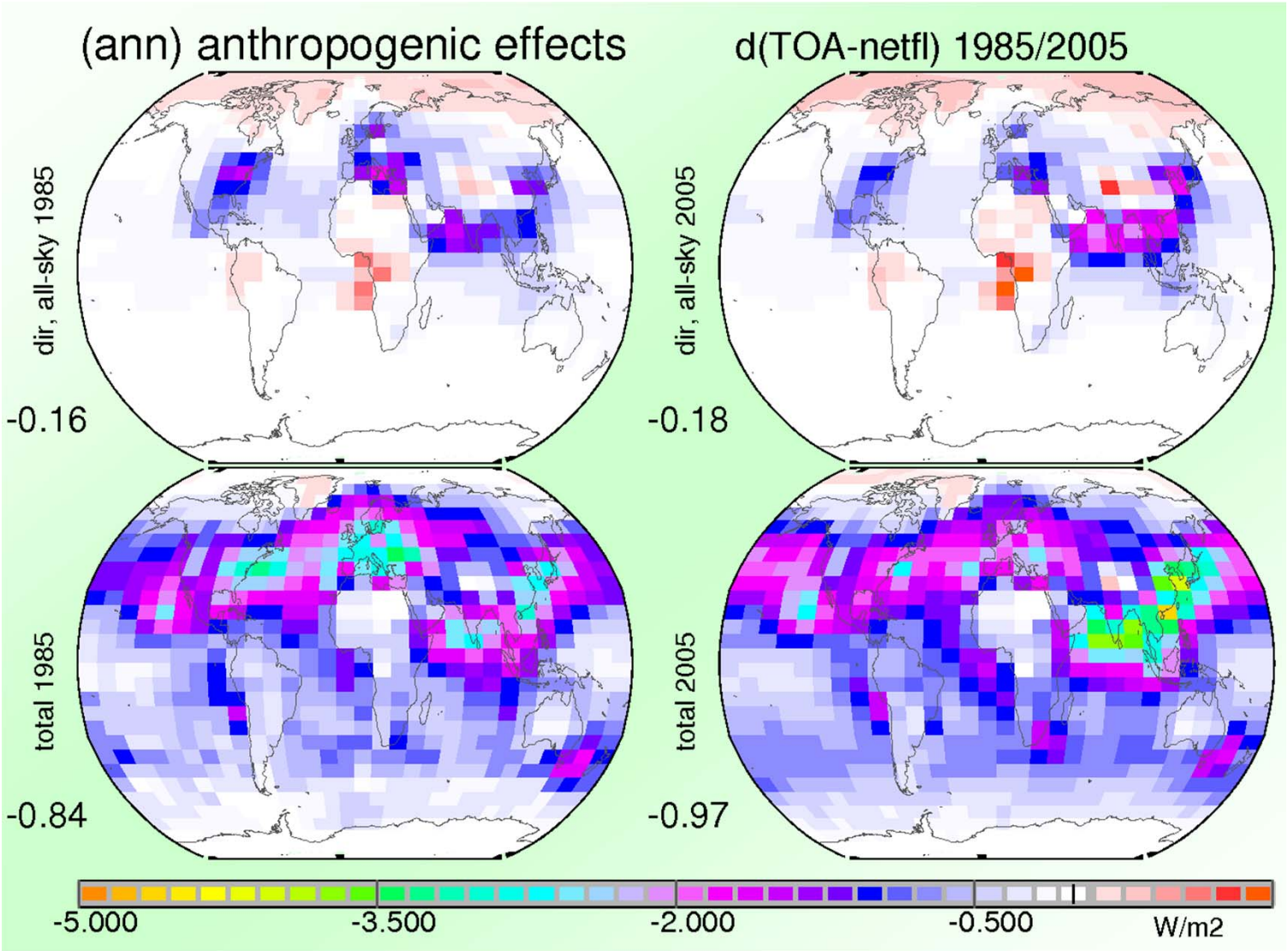
surface components 2005



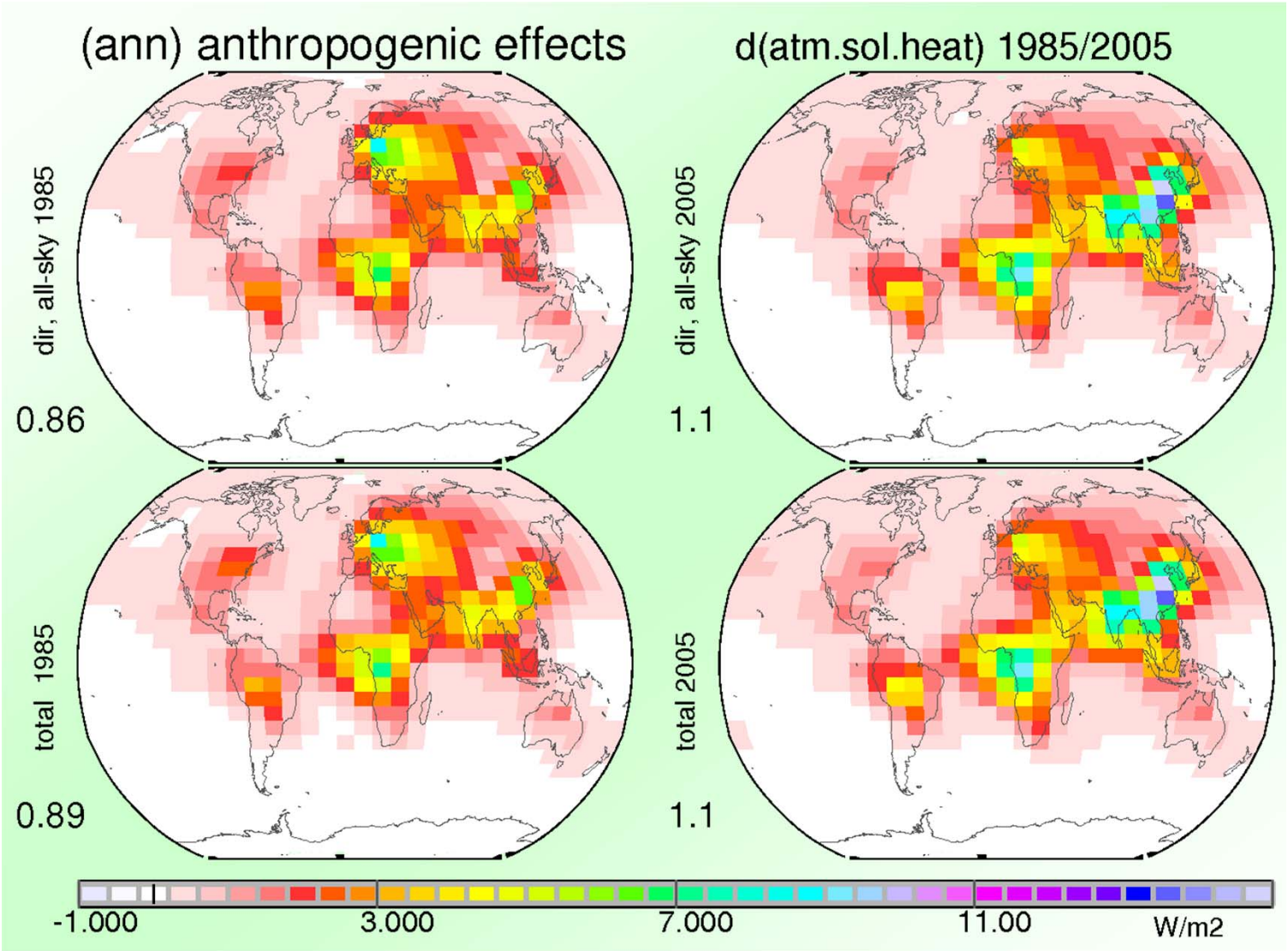
forcing over time



TOA - 1985 vs 2005

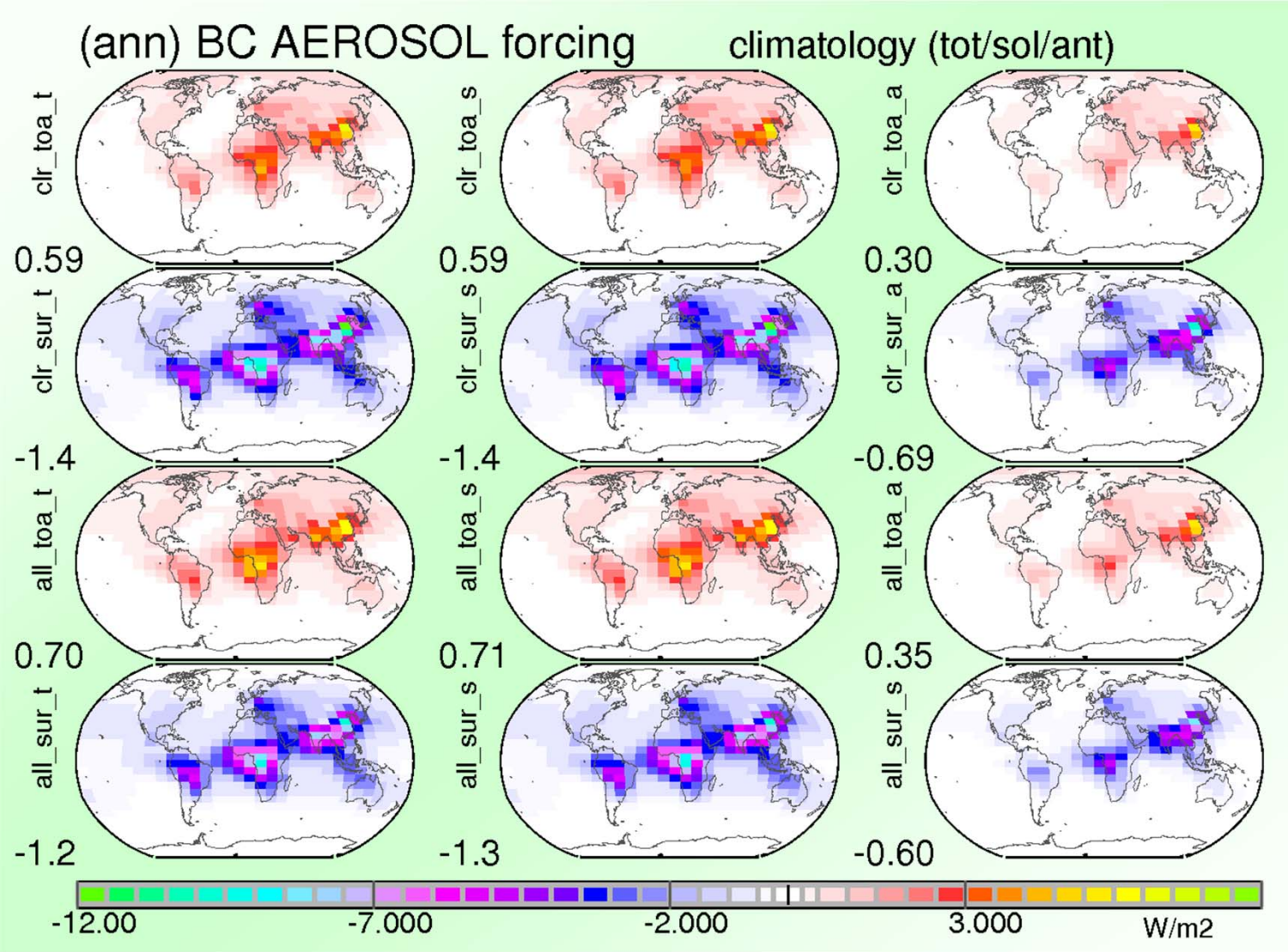


atm - 1985-2005

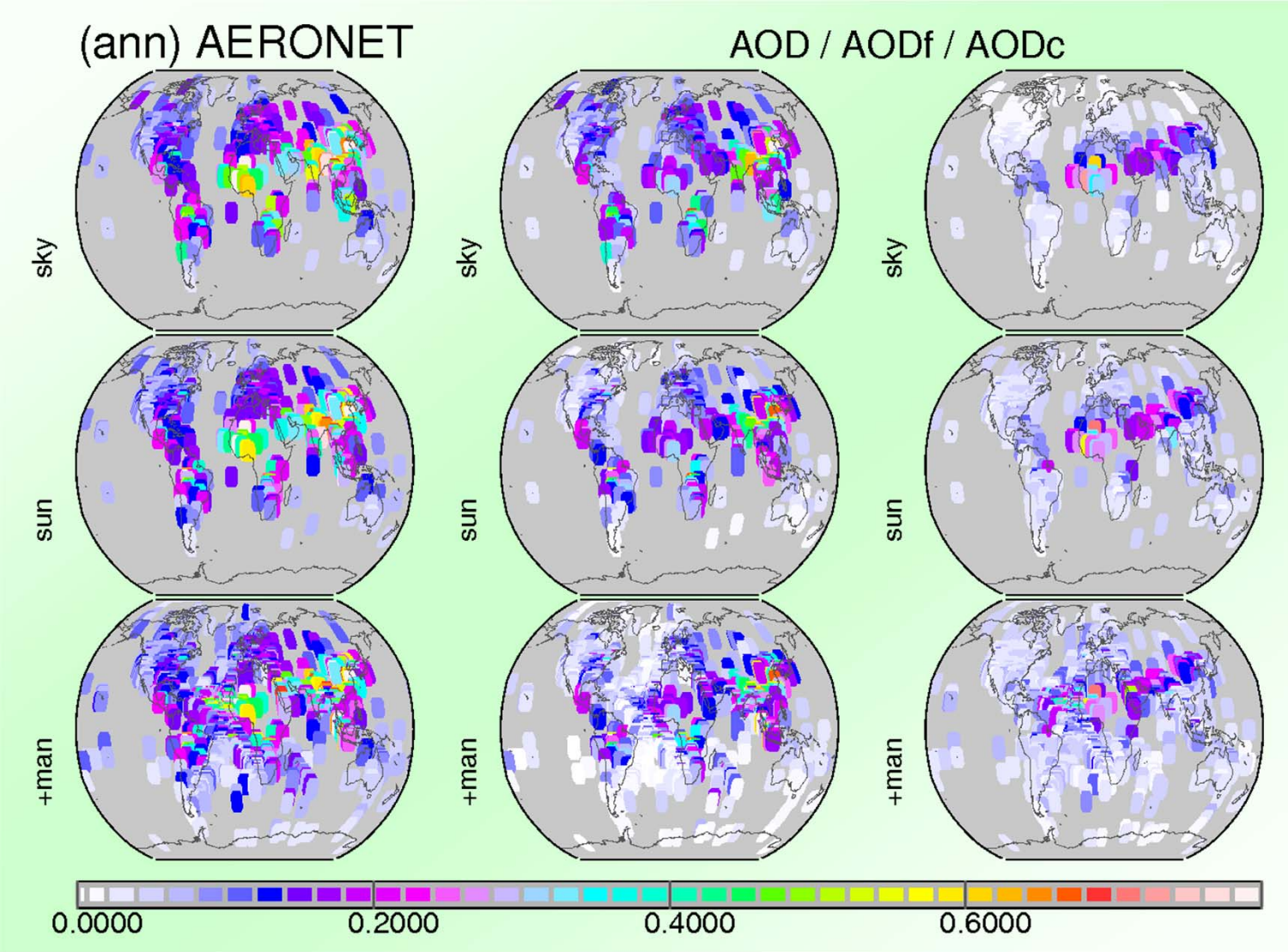


rad transfer simulations

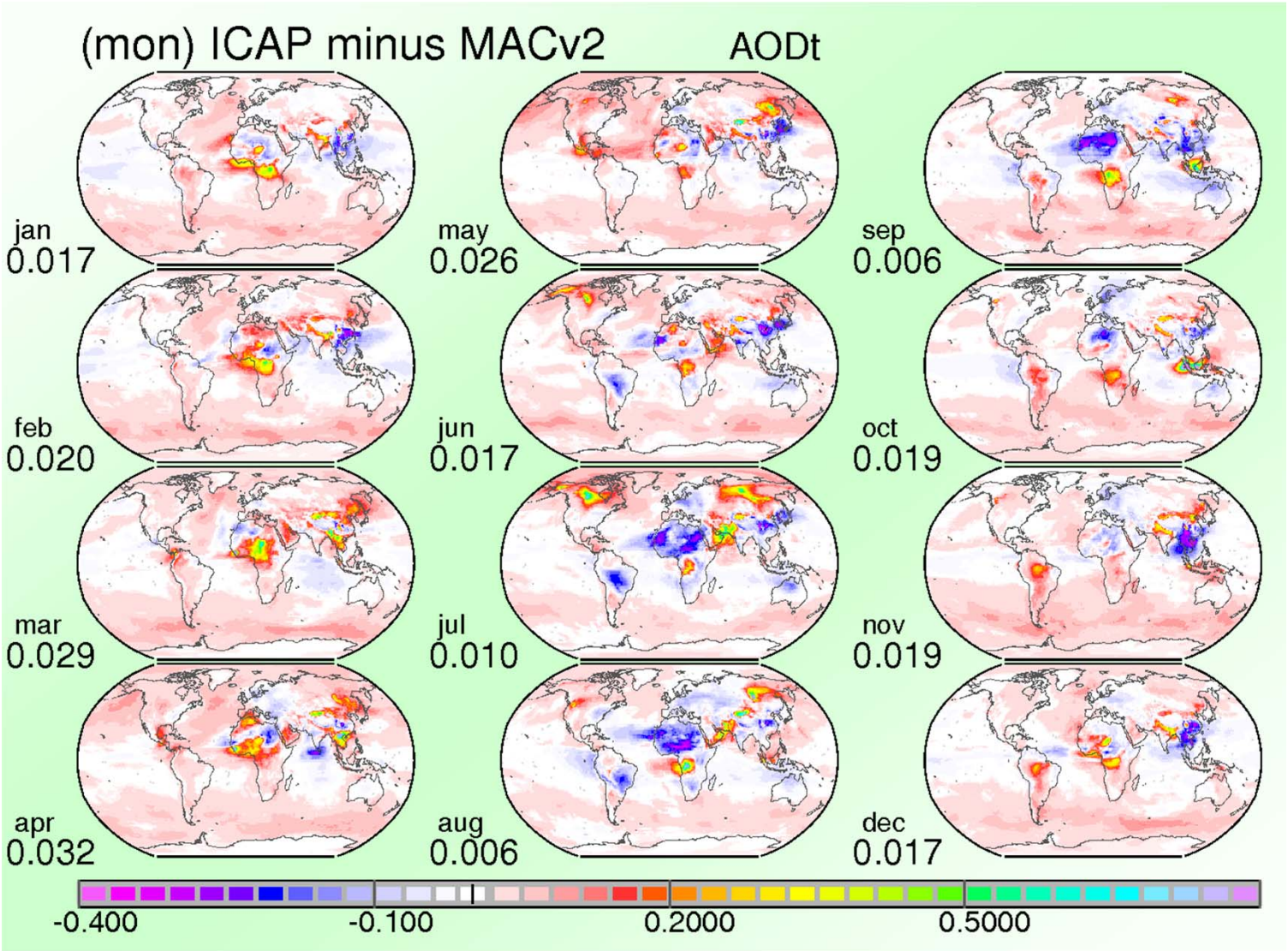
'all components' minus 'all without BC'



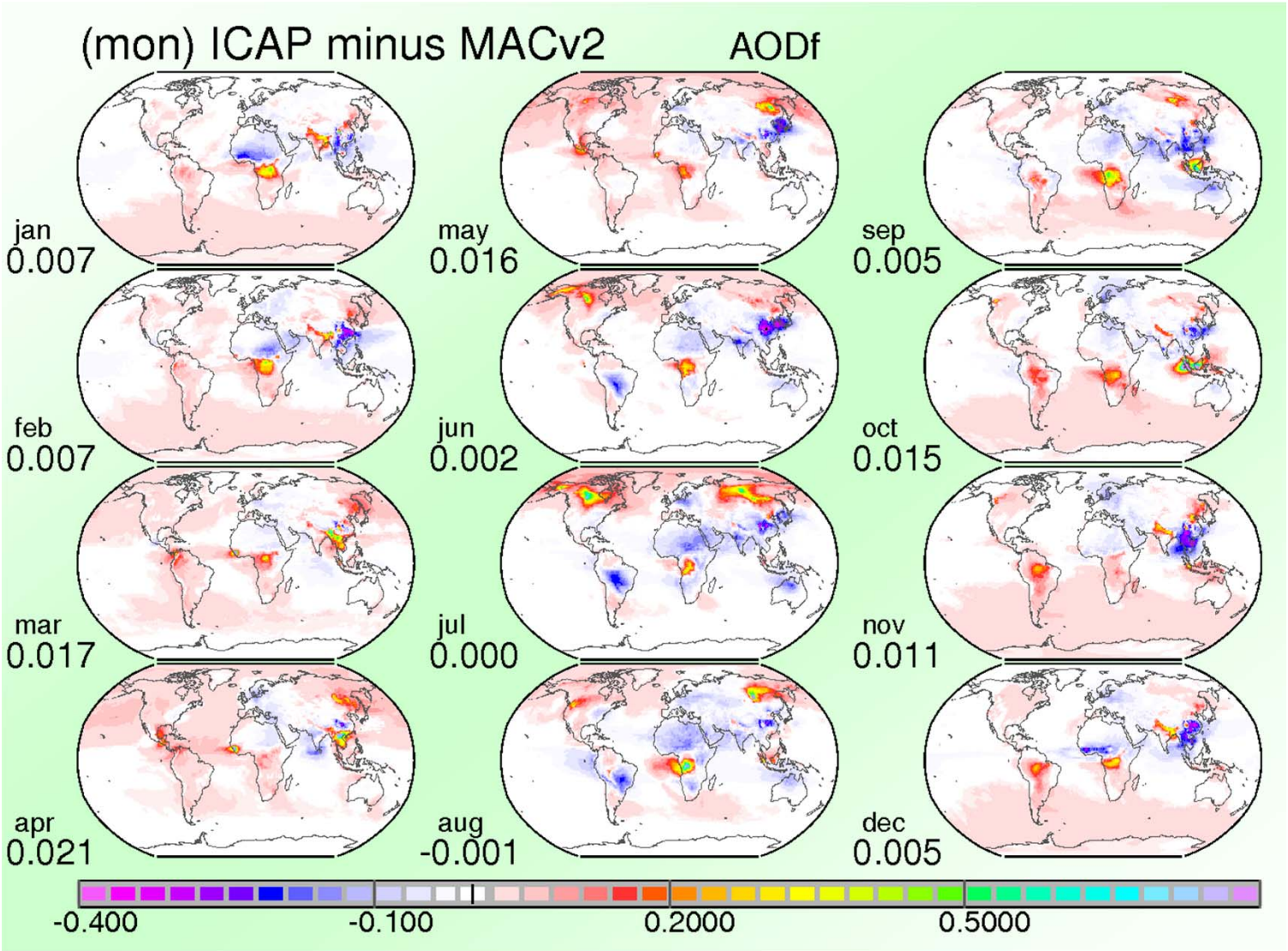
AERONET - AOD


(ann) AERONET
AOD / AODf / AODc
sky
sun
+man
sky
sun
+man
sky
sun
+man
0.0000
0.2000
0.4000
0.6000

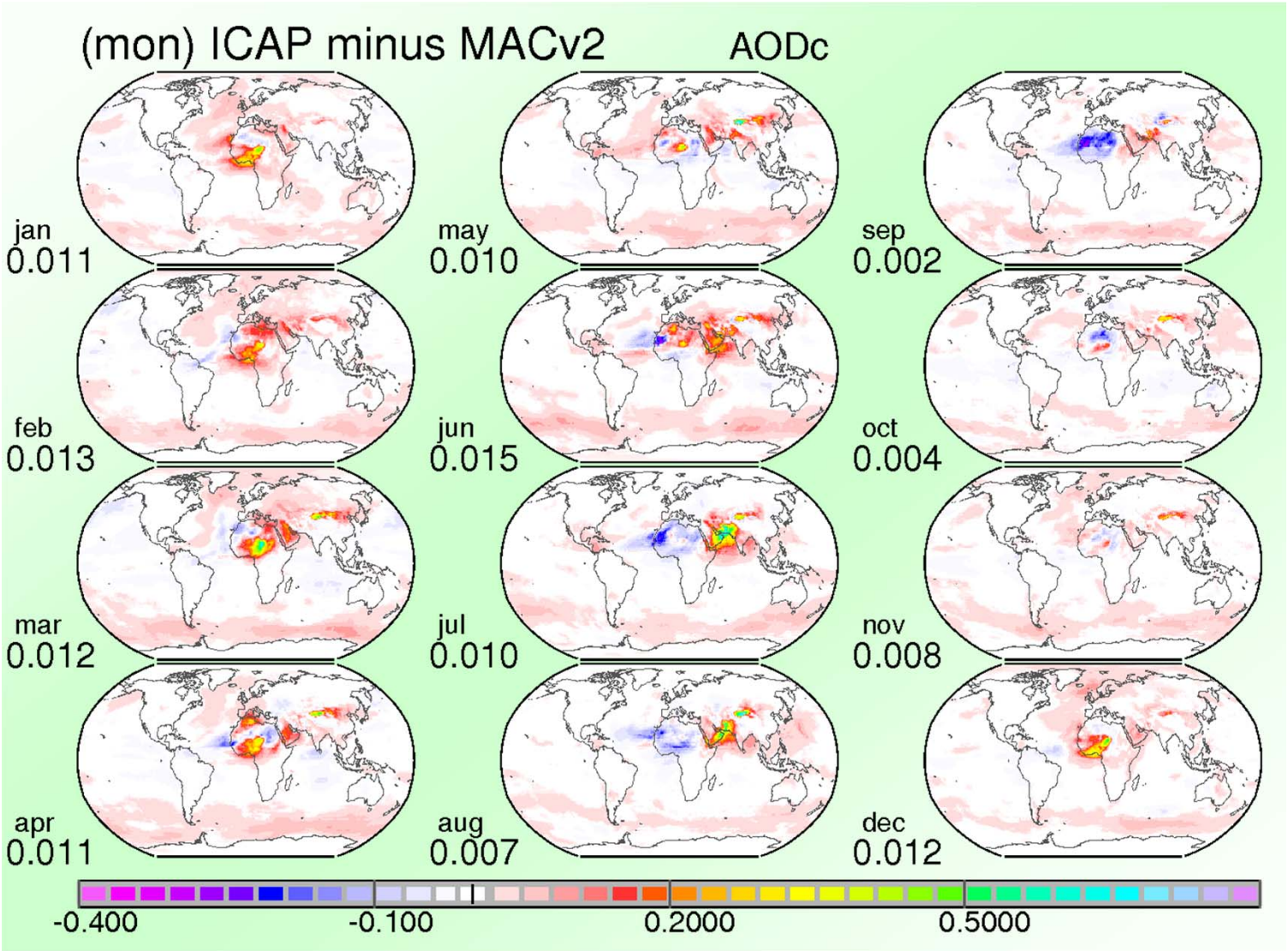
Δ AODt


(mon) ICAP minus MACv2
AODt
jan
0.017
feb
0.020
mar
0.029
apr
0.032
may
0.026
jun
0.017
jul
0.010
aug
0.006
sep
0.006
oct
0.019
nov
0.019
dec
0.017
-0.400
-0.100
0.2000
0.5000

Δ AODf


(mon) ICAP minus MACv2
AODf
jan
0.007
feb
0.007
mar
0.017
apr
0.021
may
0.016
jun
0.002
jul
0.000
aug
-0.001
sep
0.005
oct
0.015
nov
0.011
dec
0.005
-0.400
-0.100
0.2000
0.5000

Δ AODc


(mon) ICAP minus MACv2
AODc
jan
0.011
feb
0.013
mar
0.012
apr
0.011
may
0.010
jun
0.015
jul
0.010
aug
0.007
sep
0.002
oct
0.004
nov
0.008
dec
0.012
-0.400
-0.100
0.2000
0.5000