BC

impact on climate

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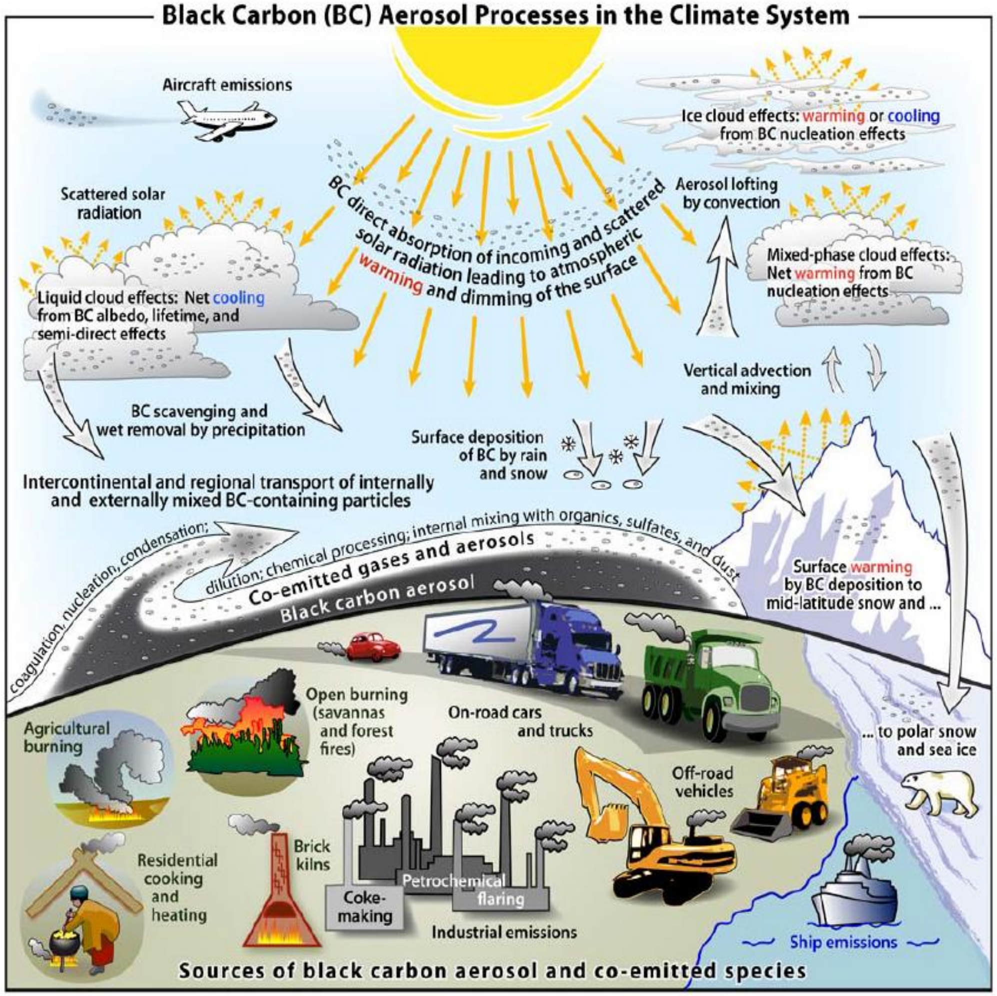
a remaining open issue

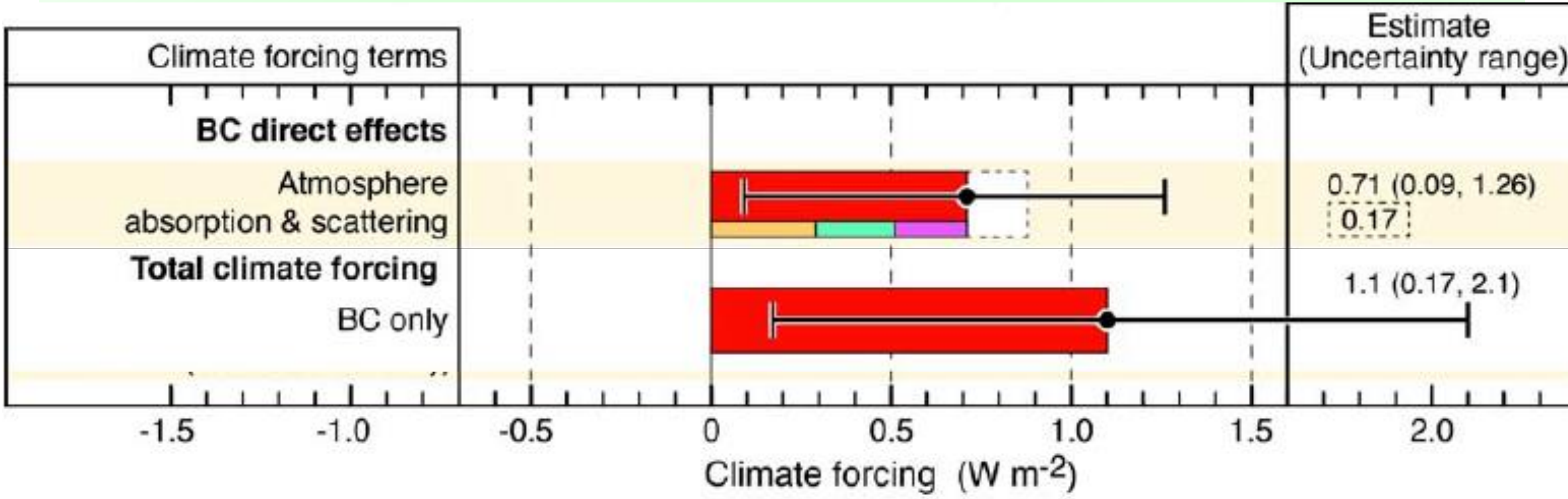
- **the comprehensive BC assessment report failed to accurately pin-point the climatic impact of BC ... mainly due to limitations in quantifying solar direct rad. forcing anthropogenic BC**



The BC assessment report
Bond et al. 2013

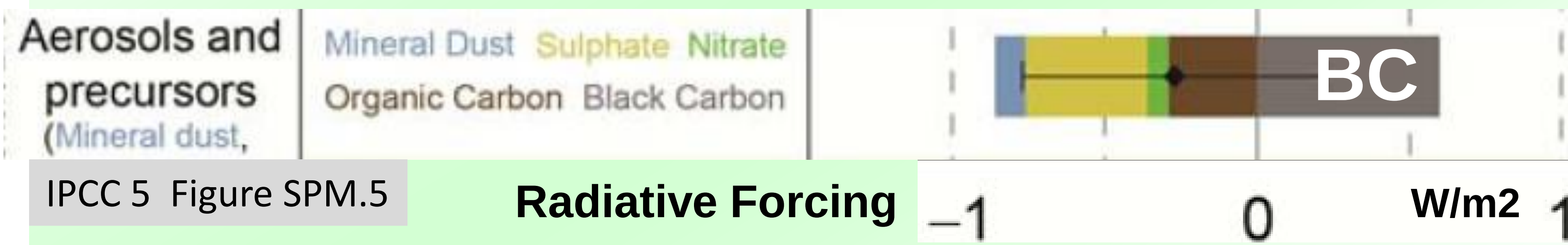
+0.09 to +1.26 W/m2 range ?

- **the direct effect range turned so large because the report wanted to be inclusive**
  - **since then very high estimates** (e.g. AERONET AAOD-Ang interpretations) **have been rejected**



+ 0.7W/m2 … or less …like ‘models’ ?

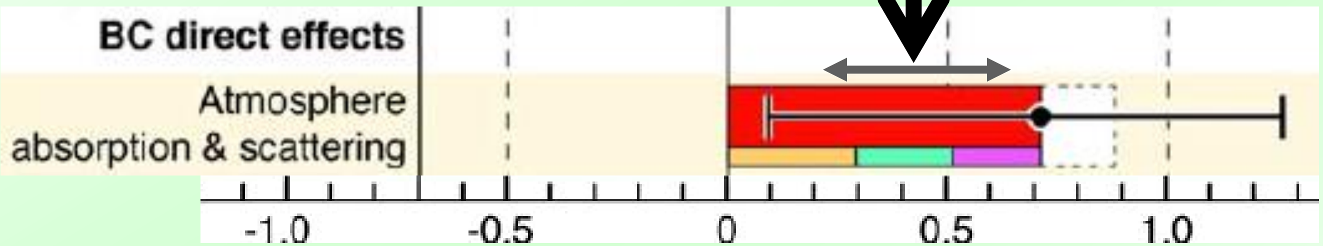
- **taking simply the central value (+0.7 W/m2) of the uncertainty range overstates the BC impact**
- **+0.7 W/m2 is ca. twice as large as estimates by global modeling** ***… can models be so wrong***
  even if emission may be at the low side in some regions ***?***



- **is the ” + 0.7 W/m2” stated estimate in IPCC AR5 a tribute to the Bond BC-assessment average?**

main points

- Q. Are there observations to constrain uncertainty?
  - try AERONET sun/-sky- photometry !
    - consistency to modeling achieved
    - NEW best estimate → ↓ smaller range



- Q. Is BC important for climate?
  - maybe not at TOA *(co-emitter cooling dominates)*
  - yes… for dynamics *(via local solar heating)*

observations ? Yes !!

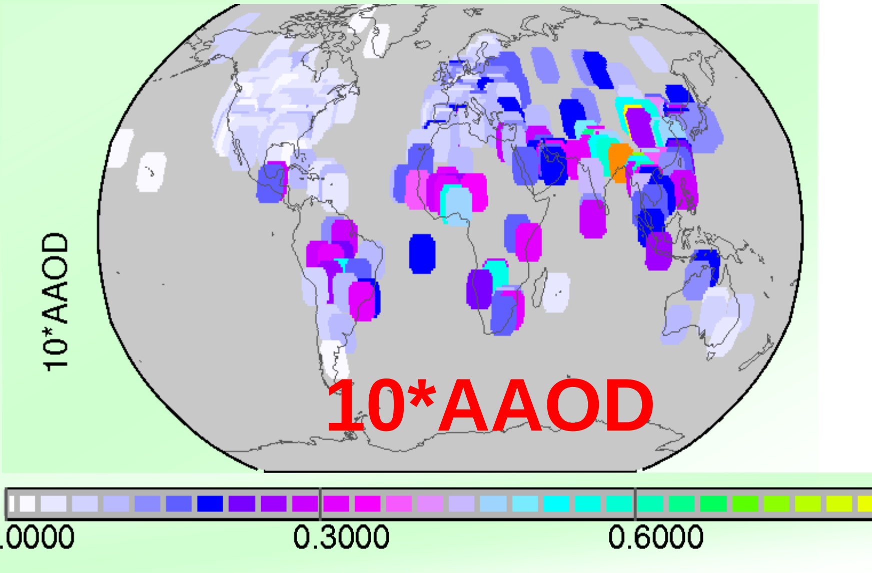
- in-situ (ground, SP2 air samples) give flavors …
  - but limited statistics and column irrelevance

“ bottom-up approach”

- AERONET column absorption more promising
  - but … how to deal with components ? and
  - inversion limitations ?
  - still … our best shot !

“top down approach”

AERONET based annual AAOD statistics at ca 400 → continental sites worldwide



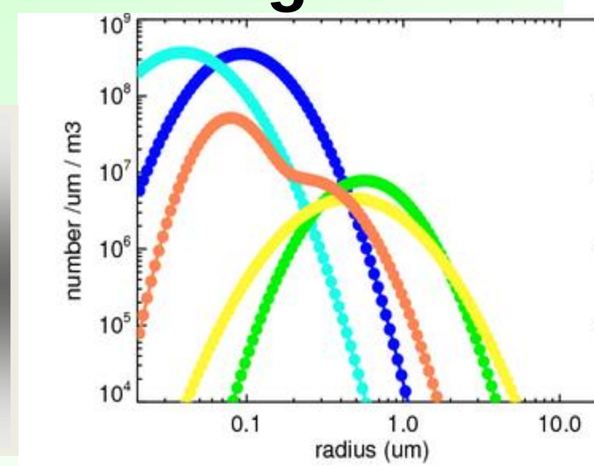
AERONET – offer & challenge

- **inversion data**
  - **using solar direct attenuation and almucantar-wise scanned sky radiance data at 4 different wavelengths (440, 670, 870 and 1020nm) yields**
    - **size distr. (22 bins-# between .05-15um radius)**
    - **refr. indices** *(real, imag)* **at all 4 wavelengths for the entire size-distribution**

      (and not by size !)

- **how to extract BC absorption ?**

sulfate +org.
black carbon
dust
sea-salt
volcanic



BC info from AERONET

- **CONCEPT**
  - **all absorption at 650nm is by BC**
  - **effective radius is 0.08um (SSA,$_{BC}$=0.24)**
    - **AAOD, BC = AAOD, $_{650nm}$**
    - **AOD, $_{BC}$ = 1- AAOD,$_{BC}$ /(1-SSA,$_{BC}$)**
    - **MASS, $_{BC}$ = AOD,$_{BC}$ /10** *(MAC = 10m2/g)*
  - **global spread with BC-AOD by global modeling**
    - **local comparisons to global modeling**
    - **regional correction with Anet/Model factors**
    - **updated modeling distribution for BC-AOD**
    - **updated modeling for BC rad.direct forcing**

AERONET

- **direct solar attenuation and sky radiance data at 4 solar wavelengths (.44, .67, .87 and 1.02 μm)**
  - **retrieval of ref. indices at all 4 wavelengths**
  - **retrieval of size-distribution *(radius: .05-15 μm)***
  - **refractive indices (and associated SSA or AAOD) are for the entire size-distribution**

… in order to convert BC AAOD into BC-AOD there is the major challenge:

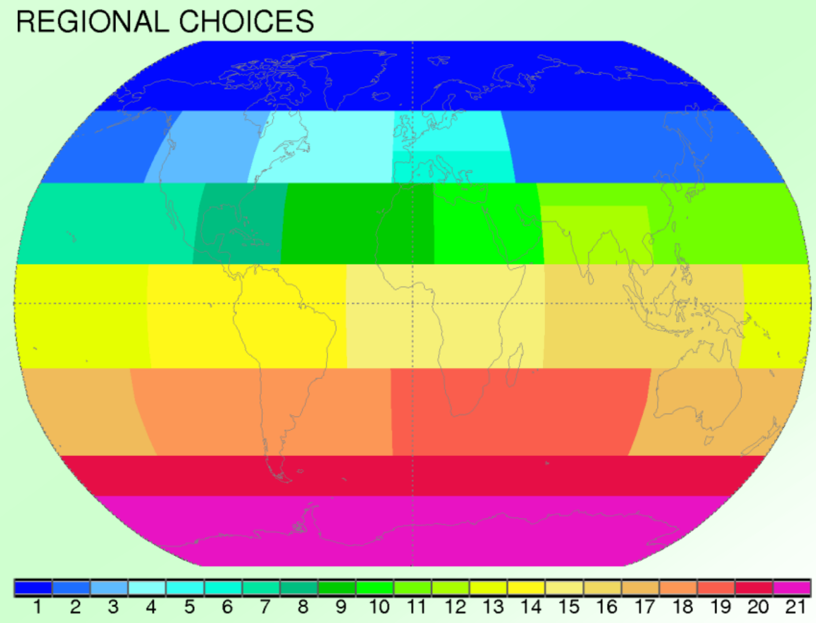
how to extract BC absorption (AAOD) ?

BC-AAOD attribution ideas

- **Path 1**
  - **all BC abs is in the fine mode [AODf*(1-SSA)]**
    - **yields underestimate** (no coarse mode BC)
- **Path 2**
  - **estimated dust absorption contribution are removed from total absorption [AOD*(1-SSA]**
    - **yields overestimate** (size eff. contaminates)
- **Path 3**
  - **total AOD is combined with SSA of fine-mode [(AODf+AODc) *(1-SSAf)]** (superior approach)

path(s) application

- compare AERONET estimates for BC-AOD on a to locally matching BC-AOD of global modeling
- for each month and region (see choices below) define corr-factors
- smooth factors
- apply to model BC-AOD
- →'new BC-AOD map

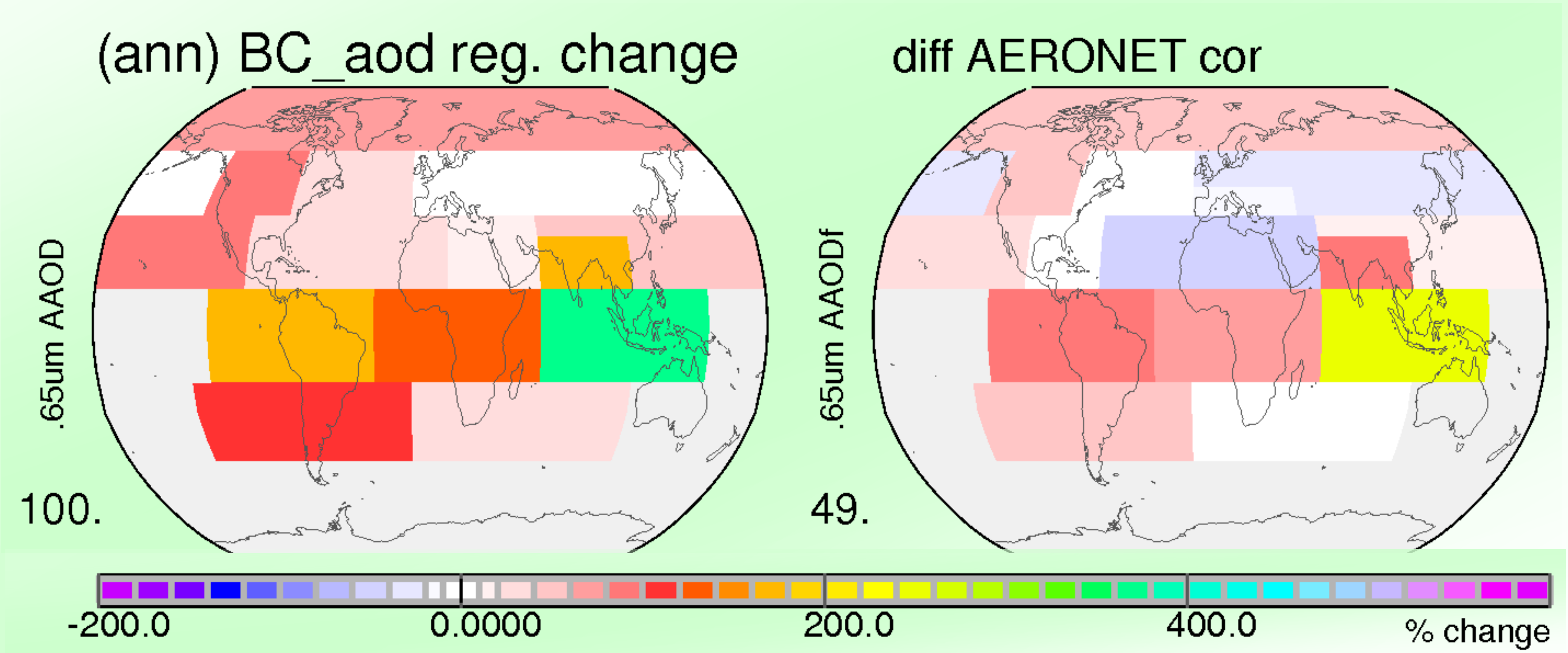


regional choices are also linked to the number of available AERONET sites

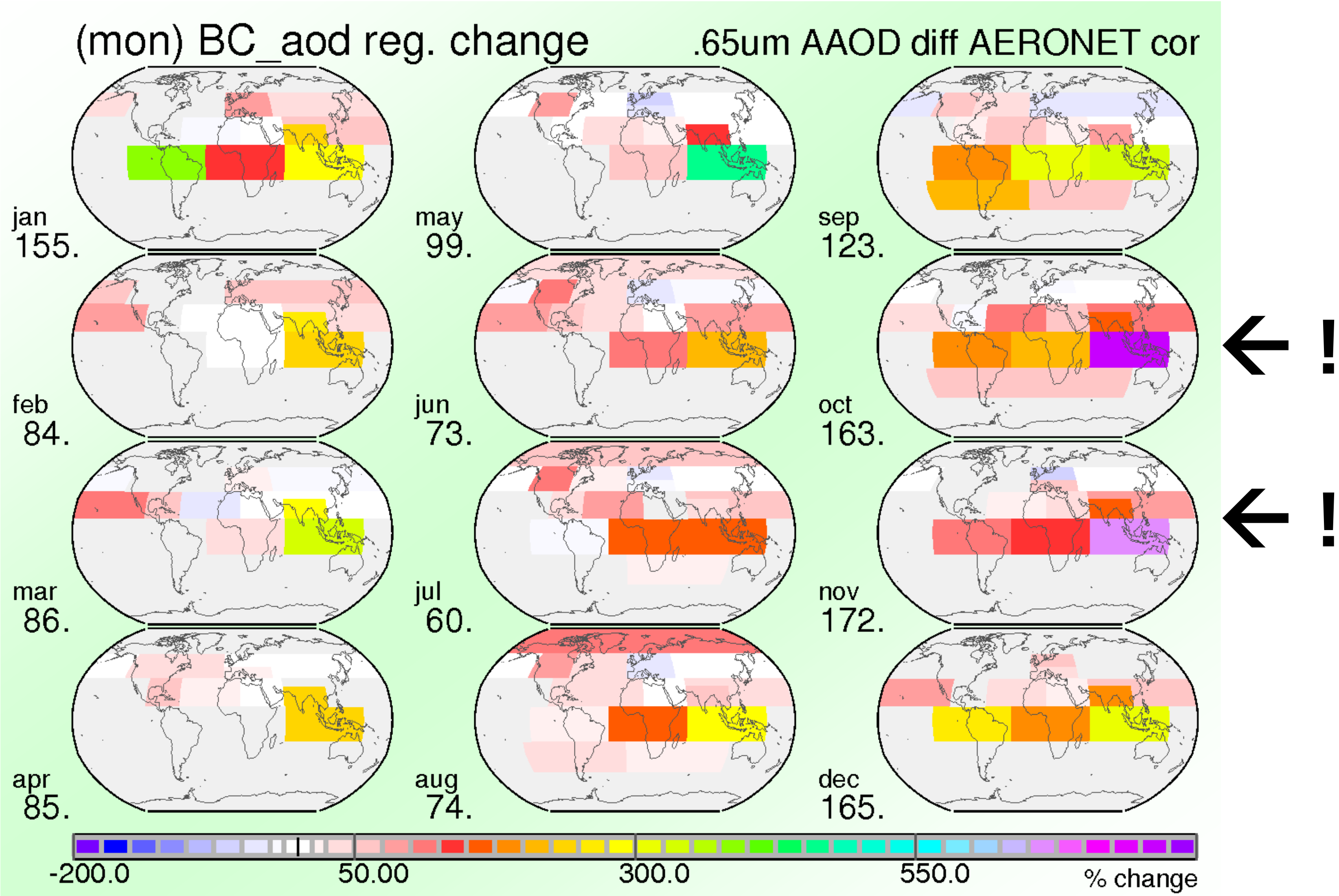
% change adjustments

- **using .65μm corr. factors are determined for …**

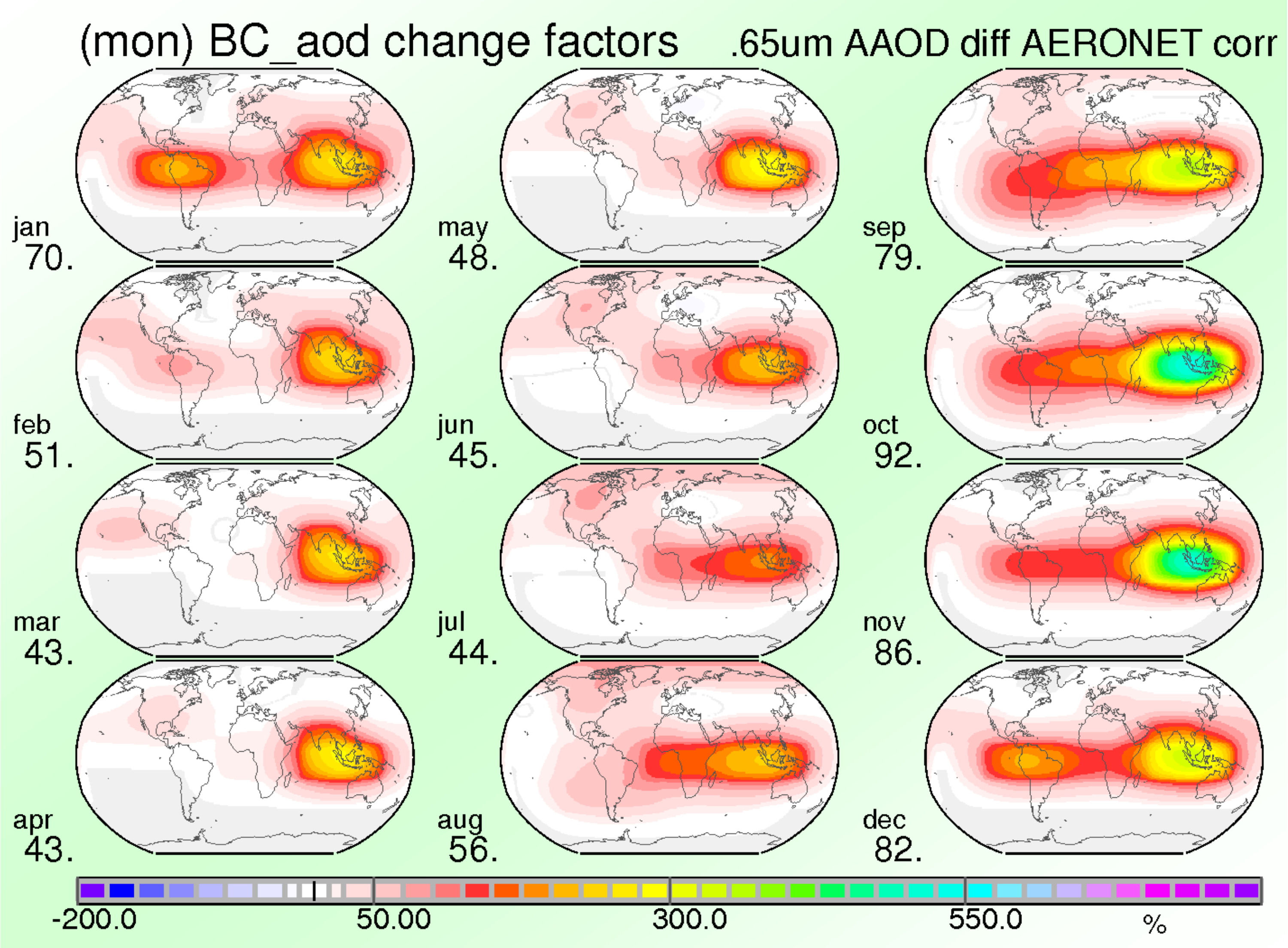
path 3 - ***recommended*** **path 1** - *underestimate*



monthly adjustments – path 3



smoothed for applications



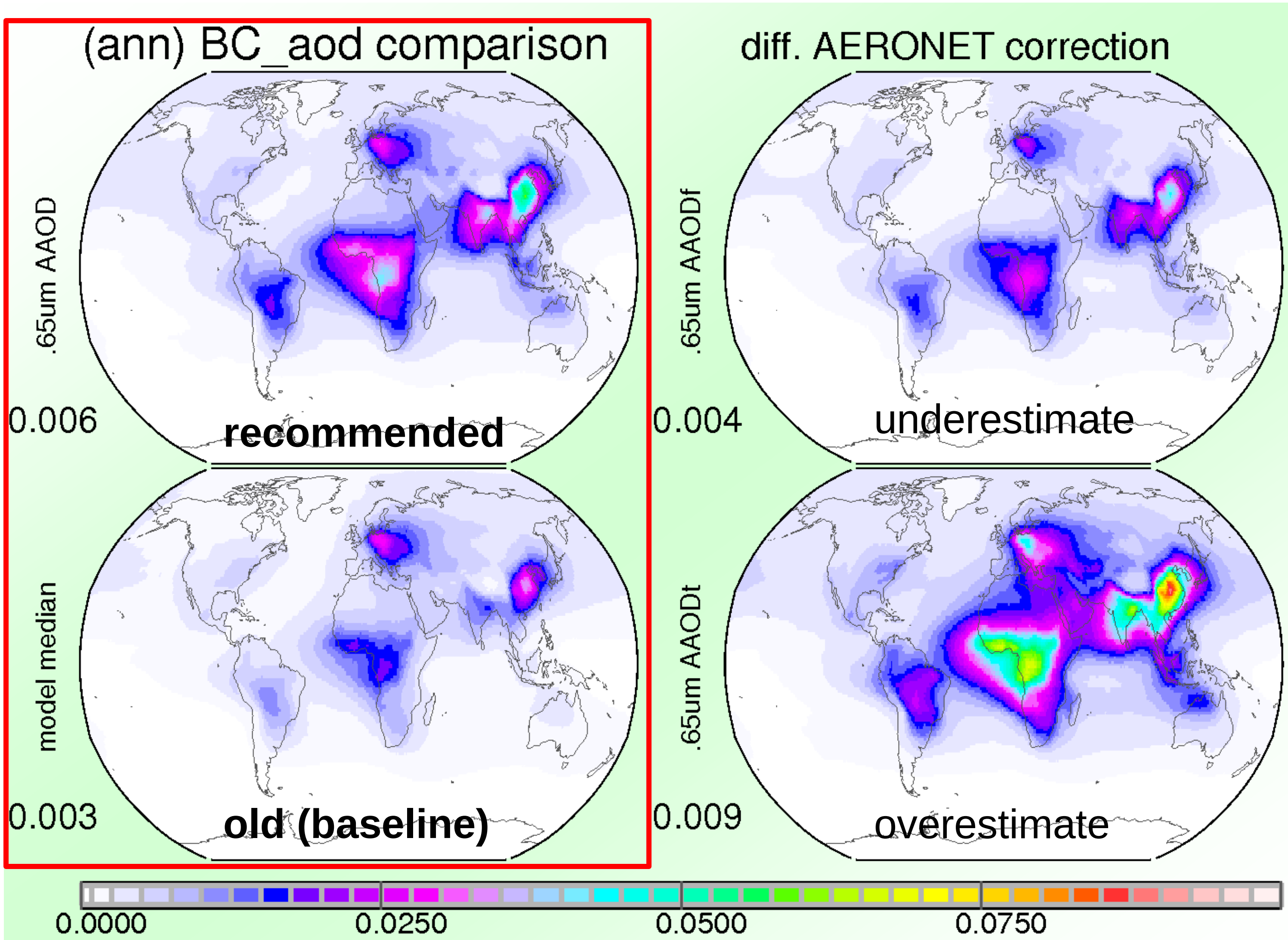
modified BC-AOD

corr
path 3

'**NEW**'

model
base
-line

'**OLD**'



corr
path 1

'low'

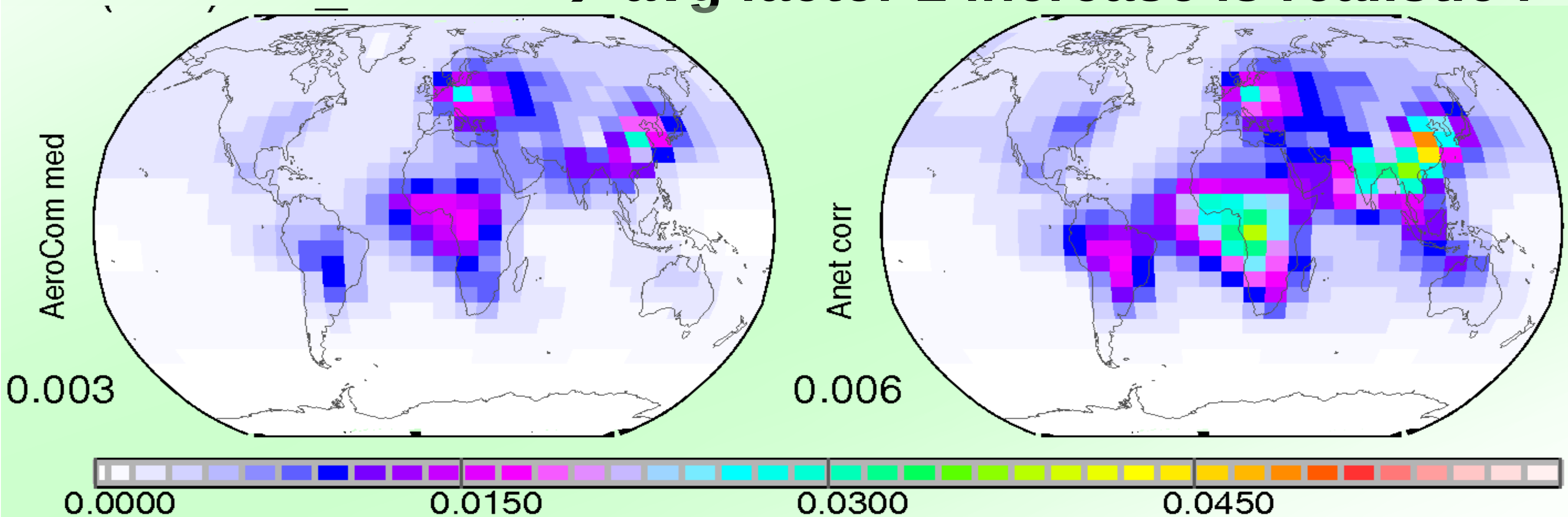
corr
path 2

'high'

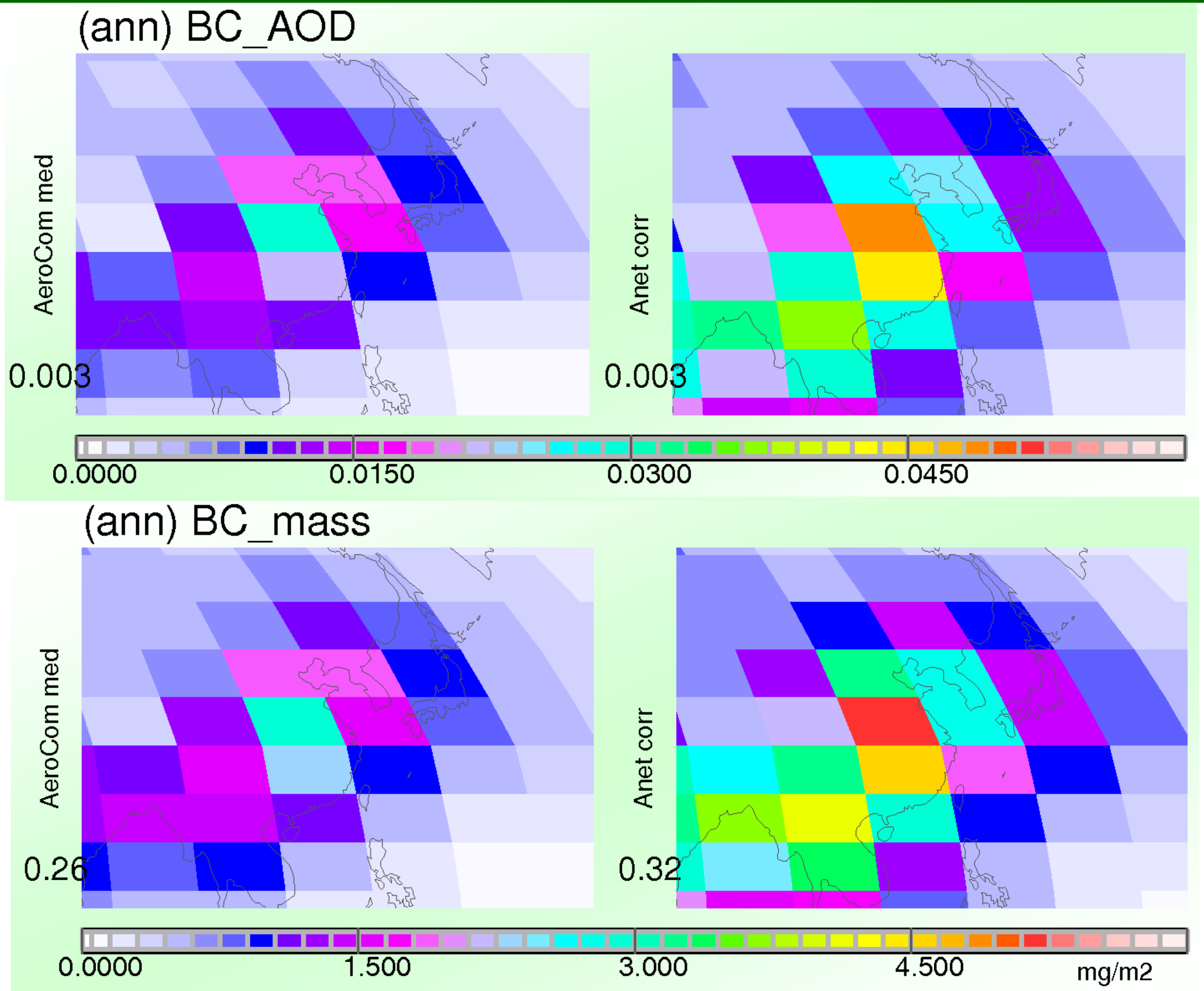
path 3 correction

- **BC(-AOD) was underestimated in the baseline**
  - **baseline (AeroCom ensemble median)**
    - **likely underestimates emission input**
    - **did not consider internal mixing**

→ avg factor 2 increase is realistic !



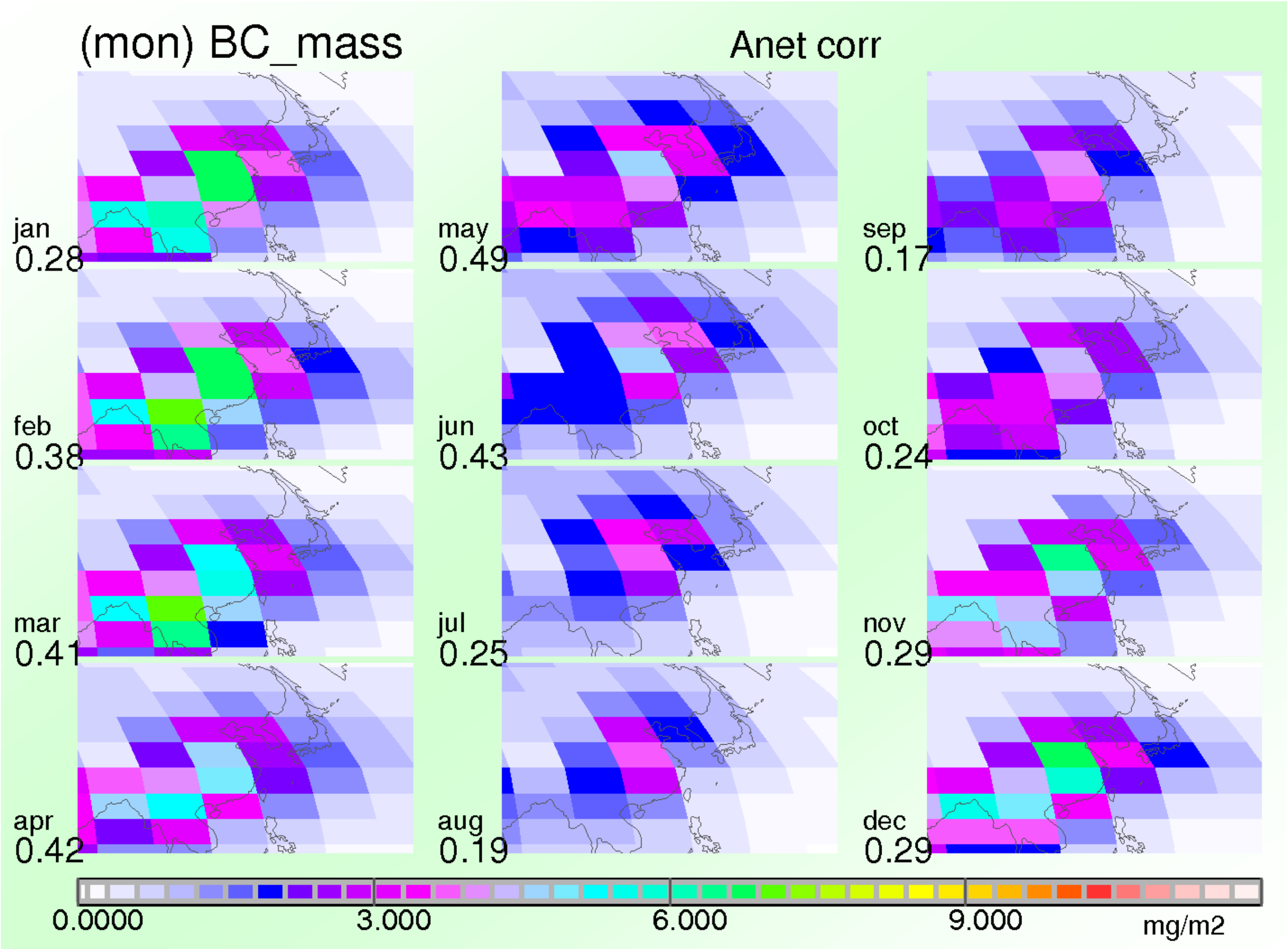
China relevance



baseline model

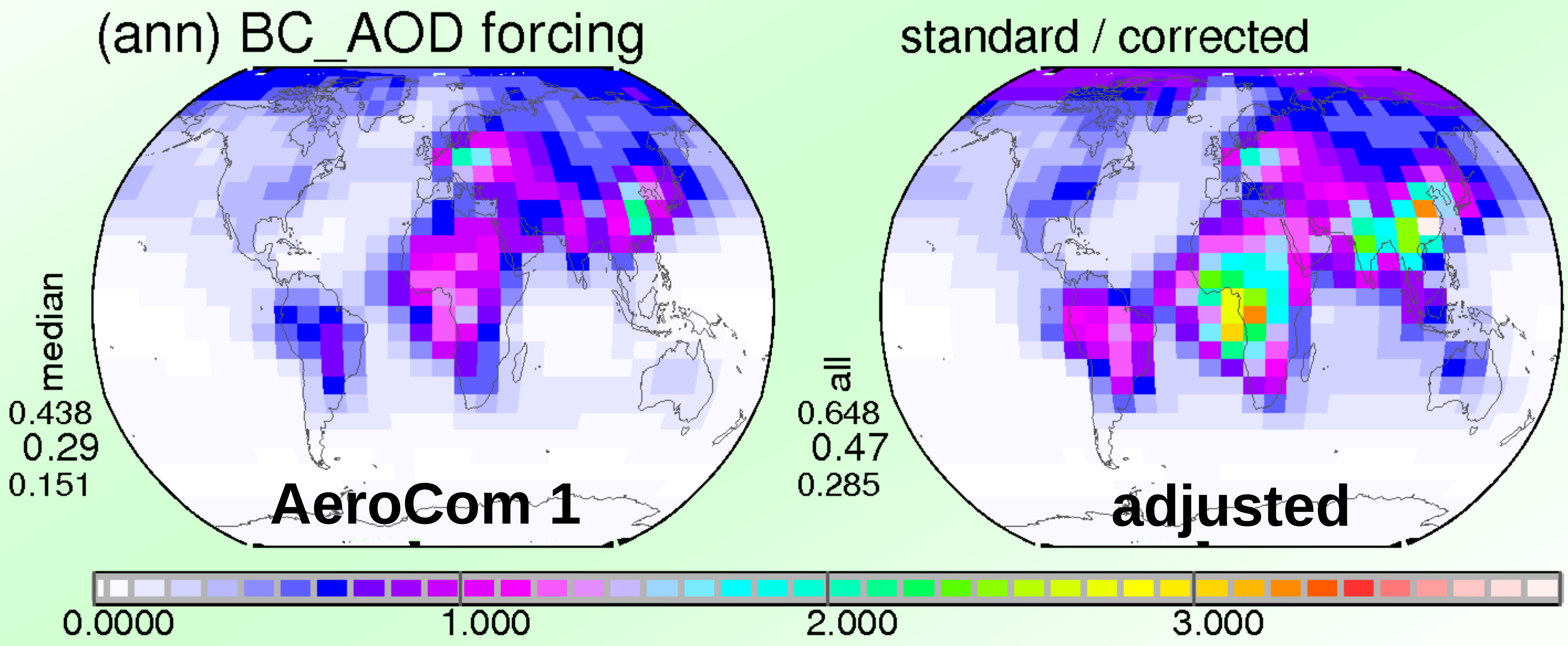
corrected model

BC mass Aeronet corrected China

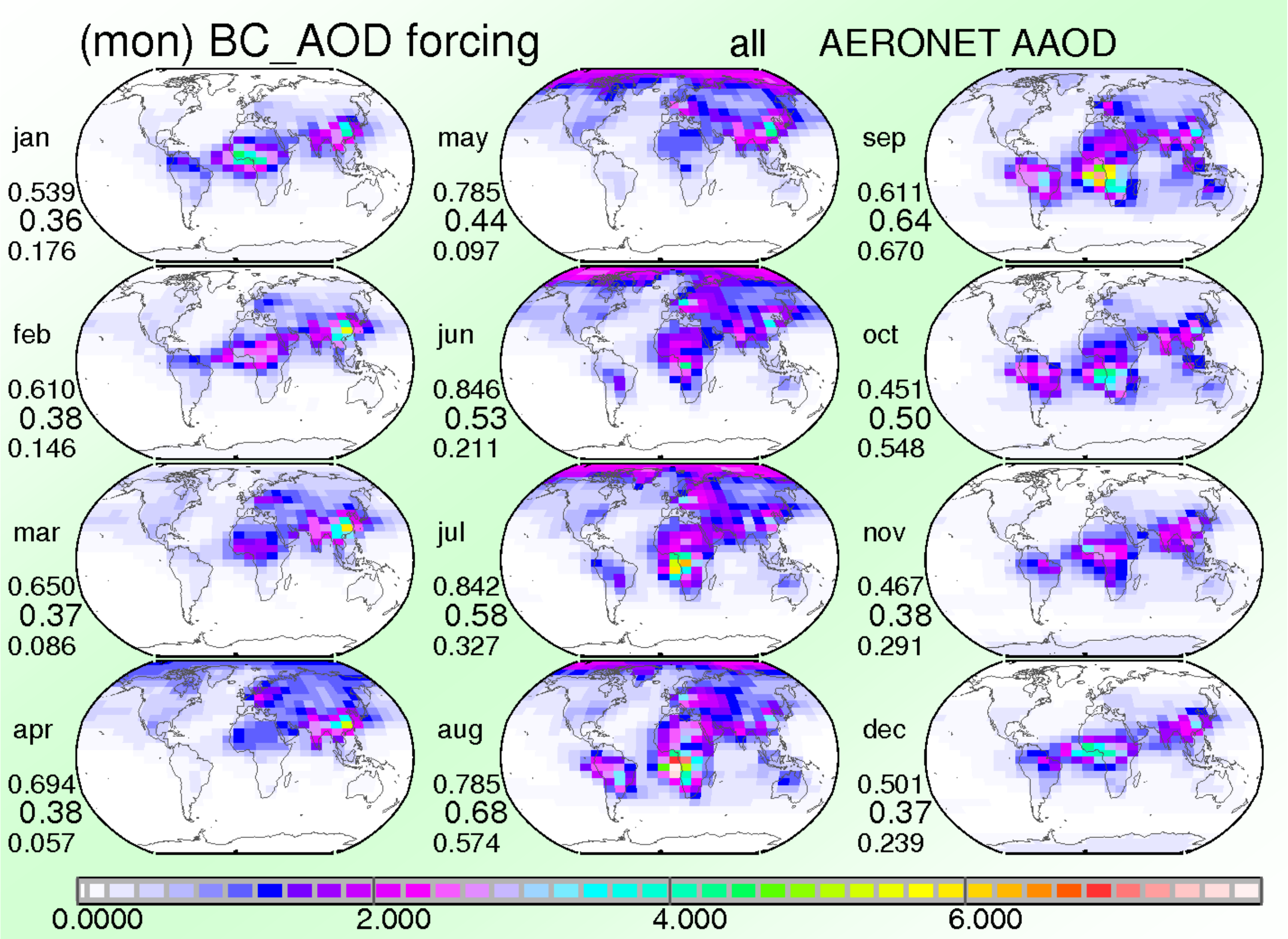


modified forcing – off-line RT

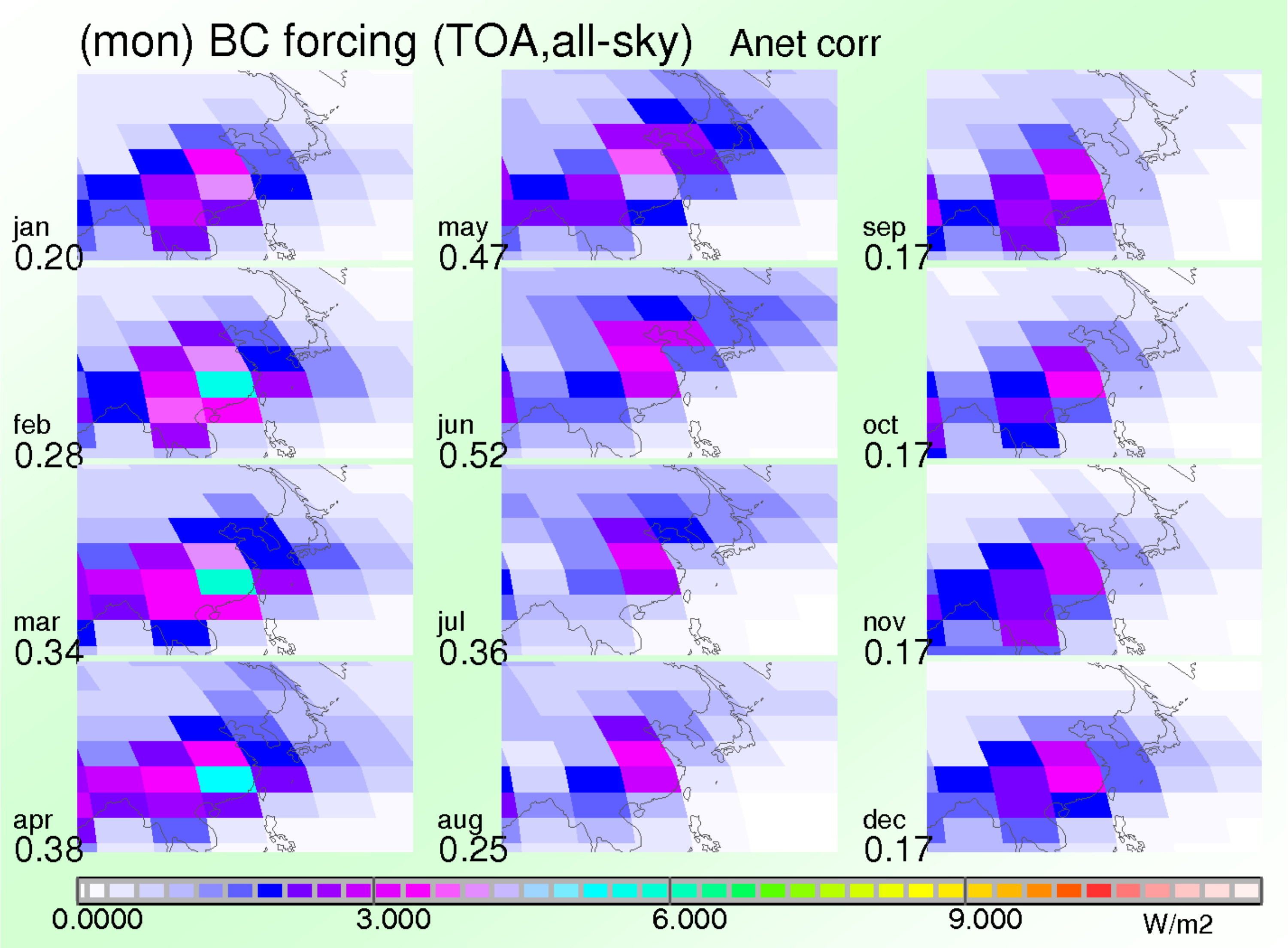
- the total BC forcing of AeroCom 1 (modeling) is raised from +0.29 W/m2 to +0.47 W/m2



'best' total BC-forcing

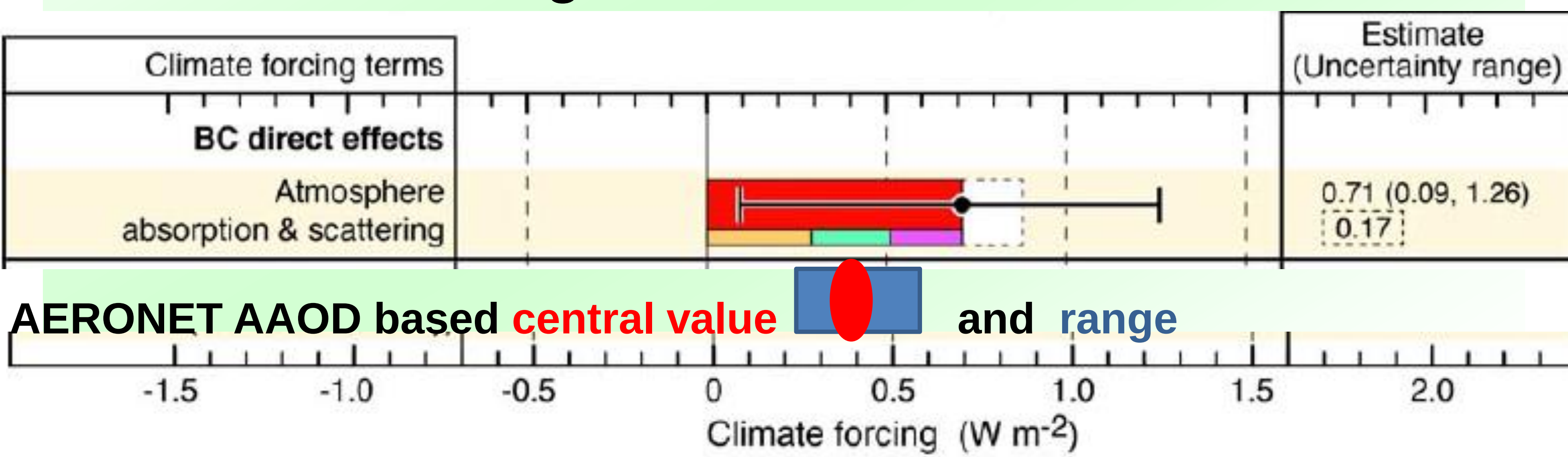


'best' total BC-forcing China



message

- AERONET AAOD estimates on BC suggest
  - ca +0.5 W/m2 for total BC-forcing (.3 - .7 W/m2)
  - ca +0.4 W/m2 for anthrop. forcing
  - 0.7 W/m2 (tot) / 0.6 W/m2 (ant) are upper limits for BC forcing



to remember

- **the anthrop. BC direct forcing is ca +0.4W/m2 and any value larger than +0.6W/m2 is unlikely**
- **there is strong spatial and temporal variability to the BC direct radiative forcing**
- **BC has ‘cooling’ co-emitters so that mitigation may only be successful in hot-spot regions.**
- **there is NO major disagreement to modeling**
- **older AeroCom modeling underestimates BC emissions, especially over south-east Asia**

extras

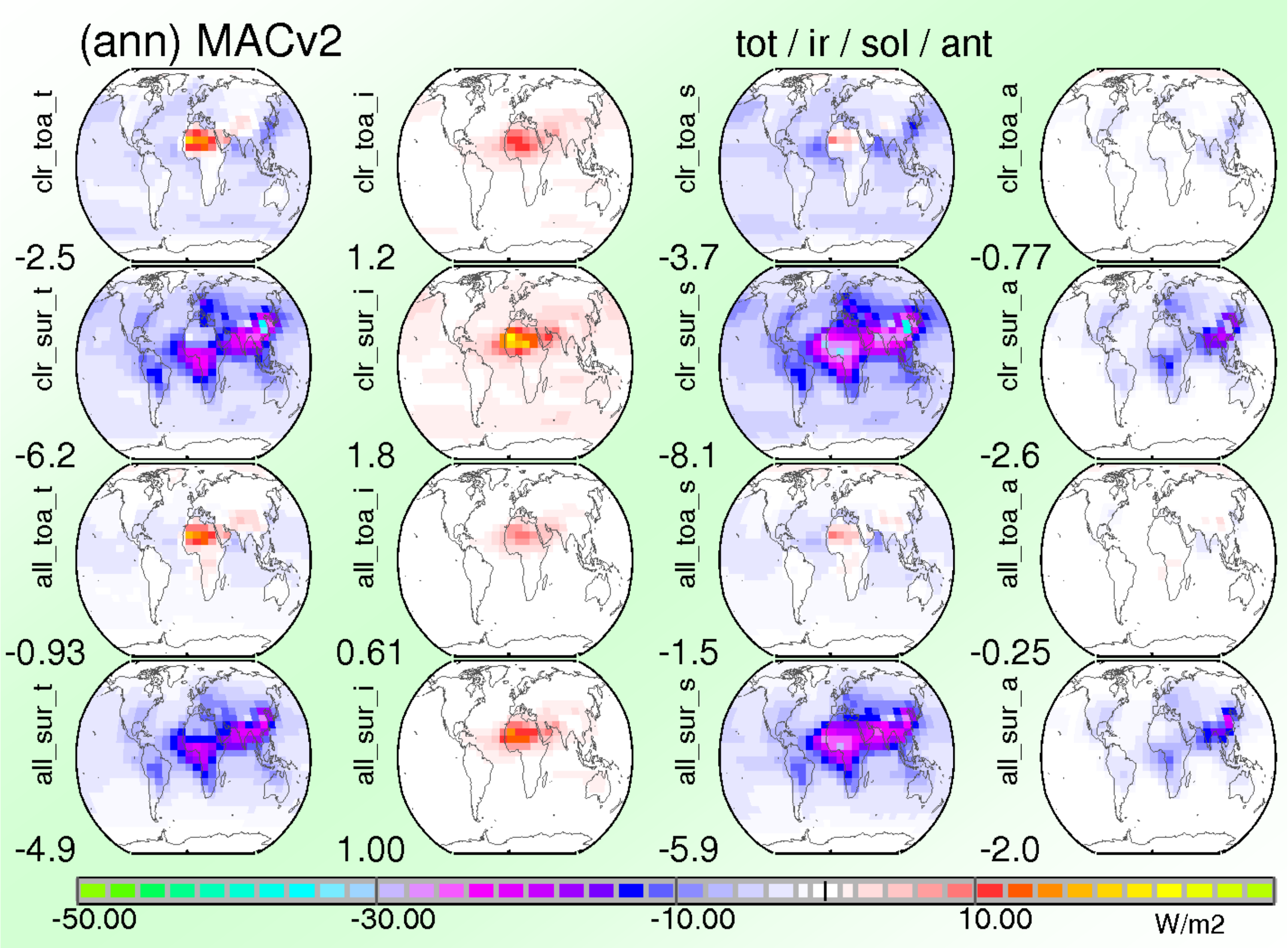
diff. to BC assessment

- **a wavelength is picked, where absorption by dust and organic aerosol does not matter**
  - **NO refr. index interpolation required**
  - **NO dust absorption sub-straction required**

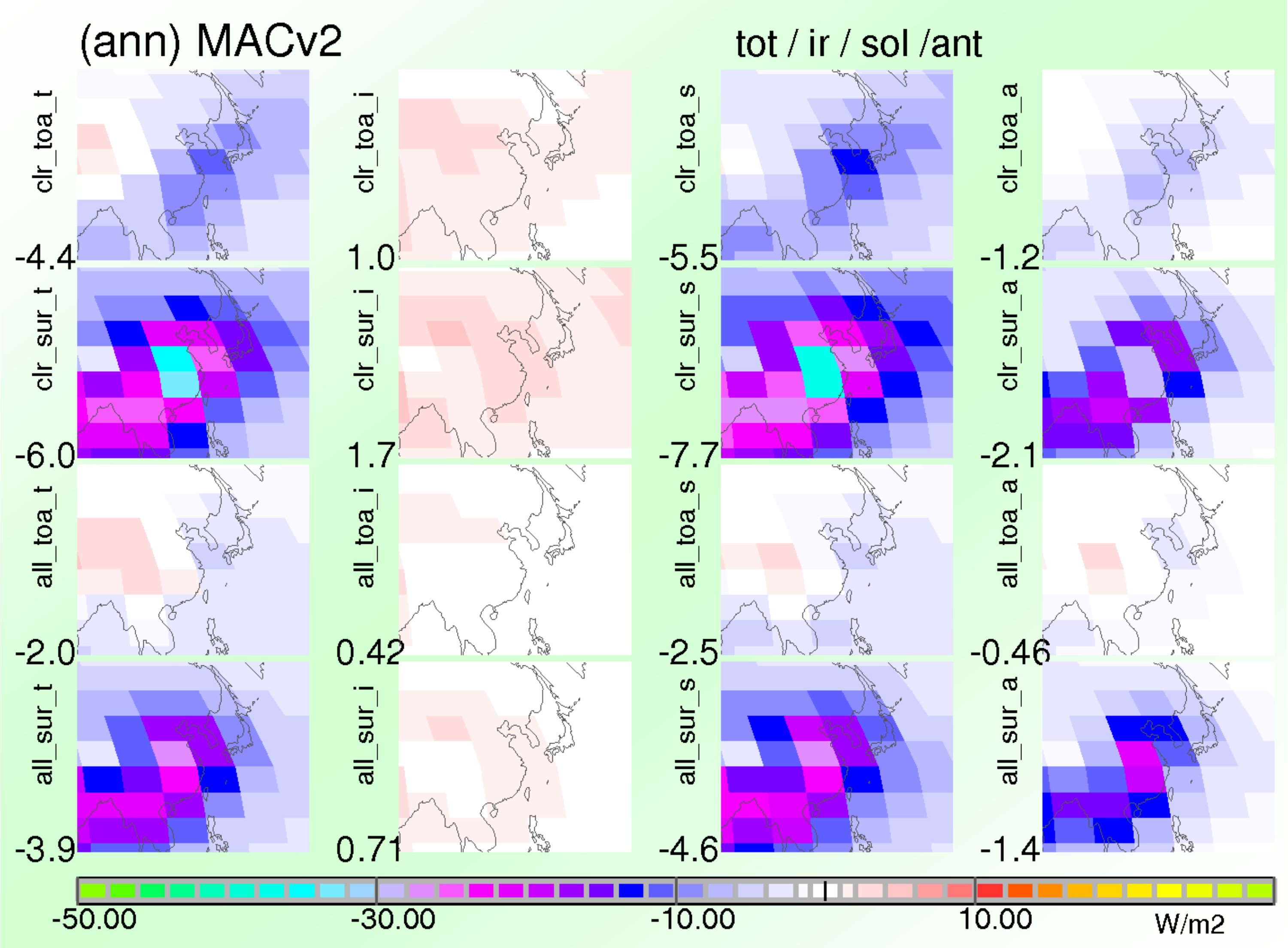
- **now the coarse mode size effect is removed from the extracted AAOD by applying the SSA,f**
  - **AAOD = AODf*(1-SSAf) + AODc*(1-SSAf)**

… as almost **all absorption can be assumed in the fine-mode size.**

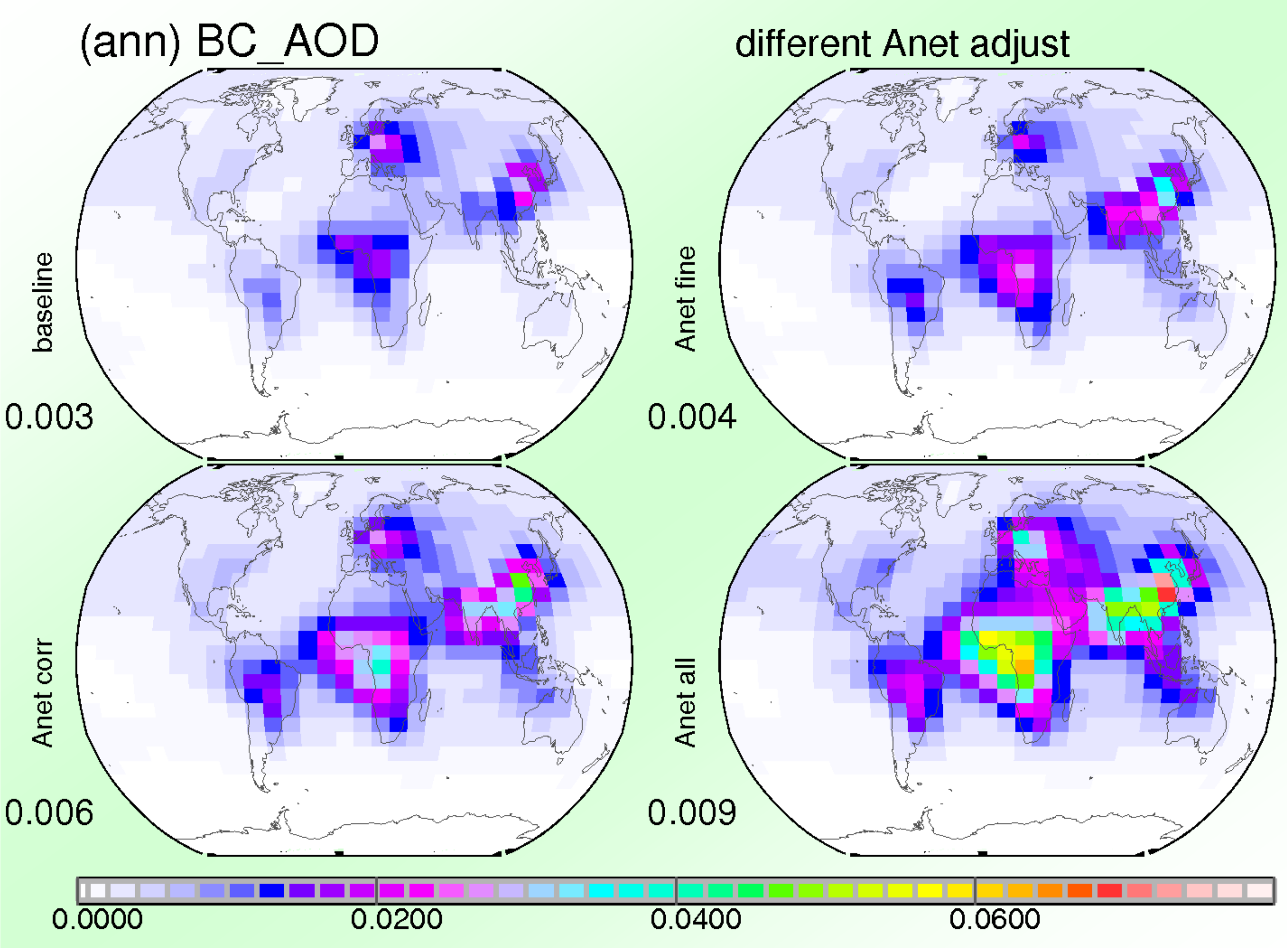
MACv2 radiative effects



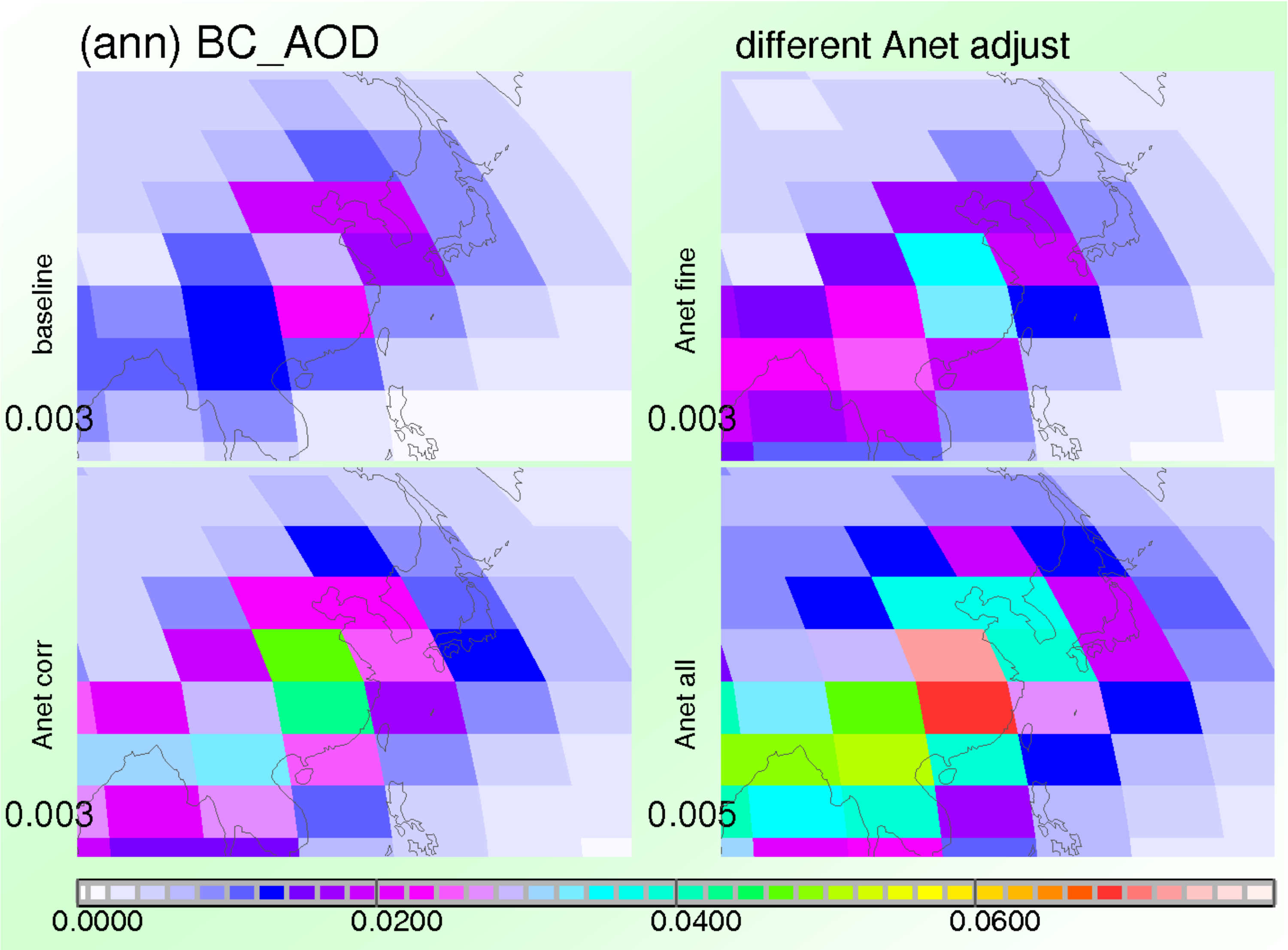
radiative effects over China



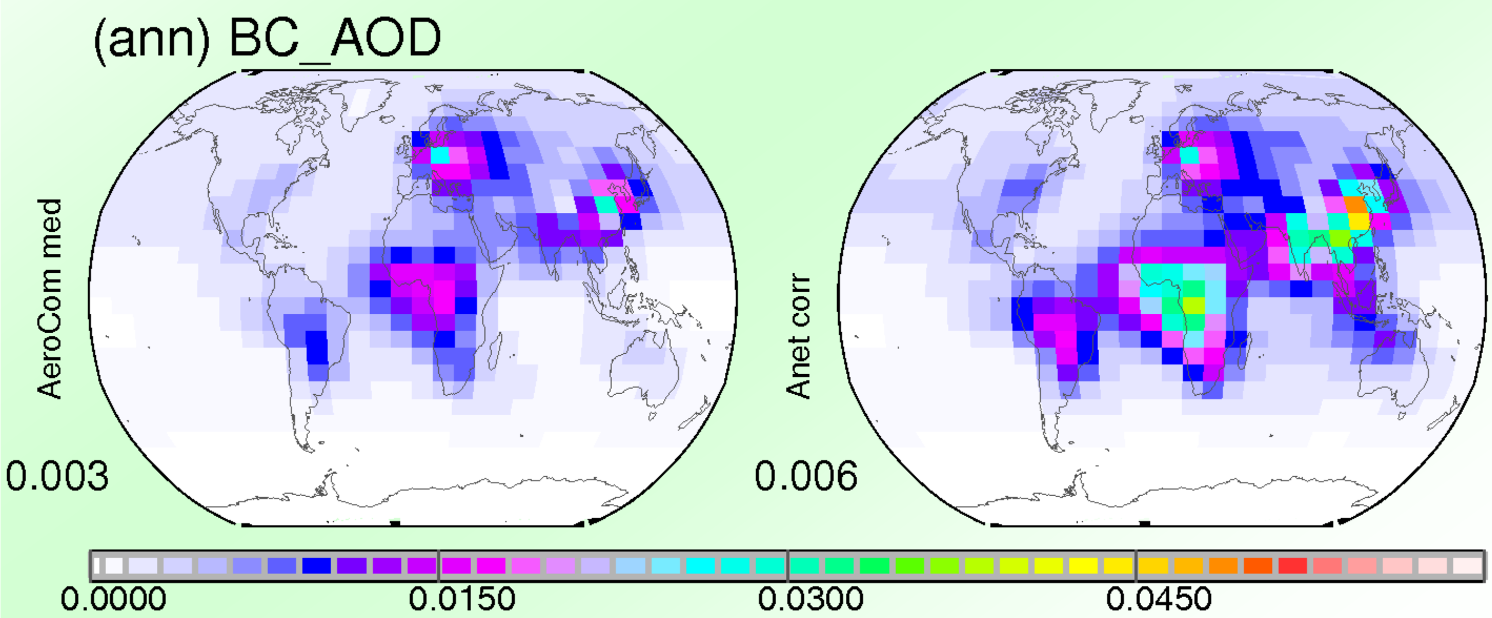
BC-AOD base + 3 corrections



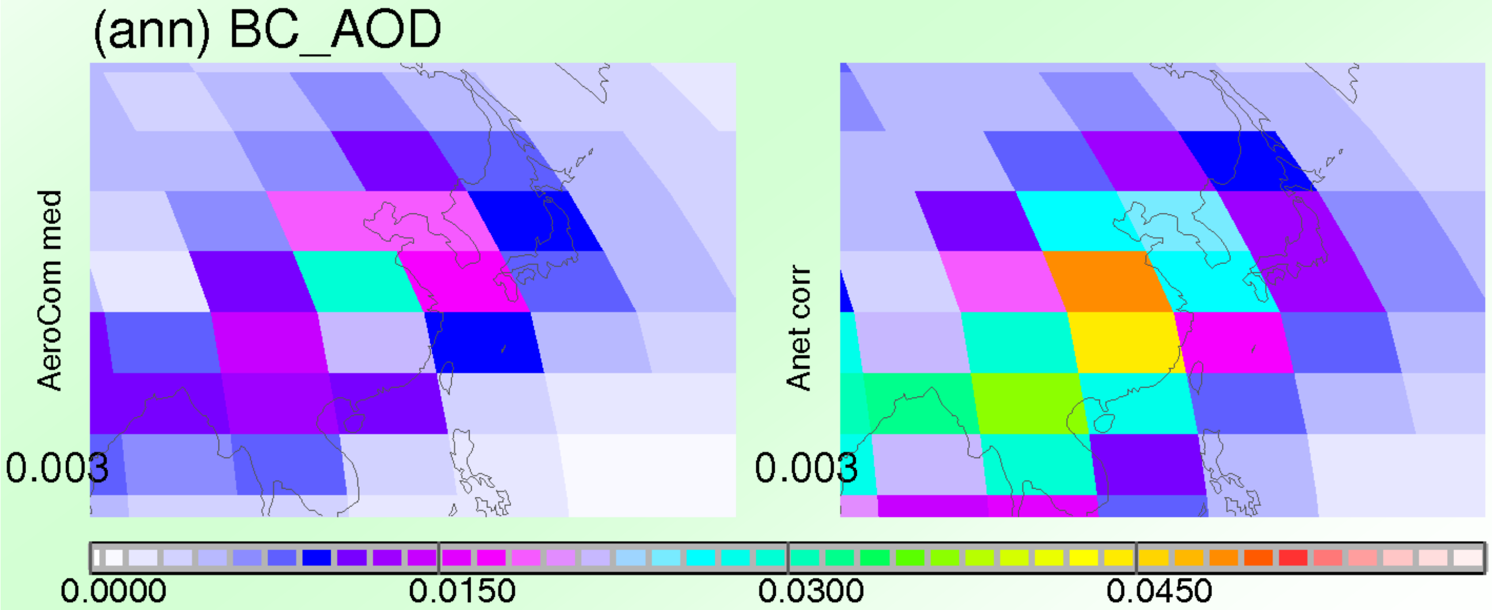
BC-AOD base + 3corr for China



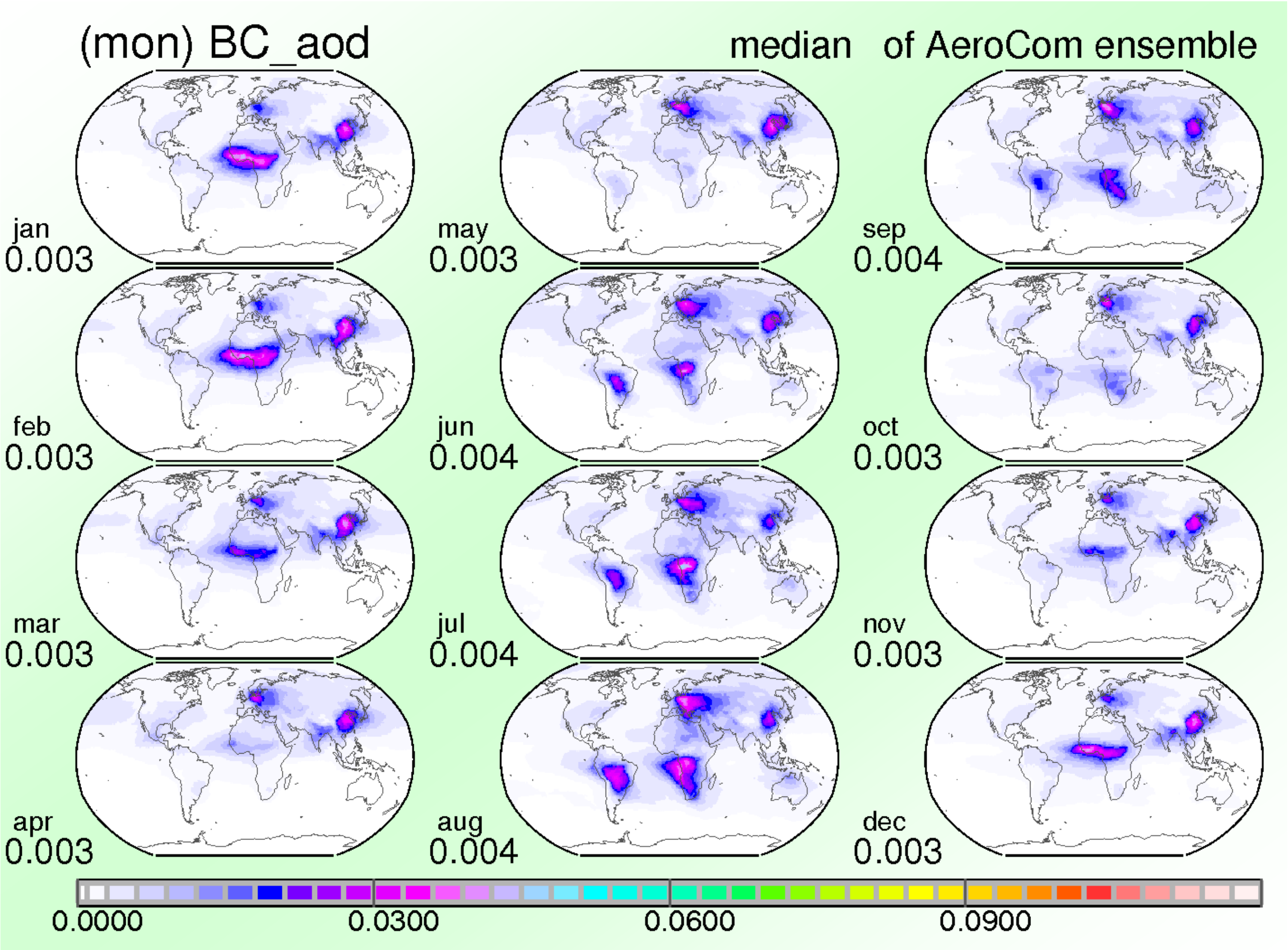
BC-AOD base + correction



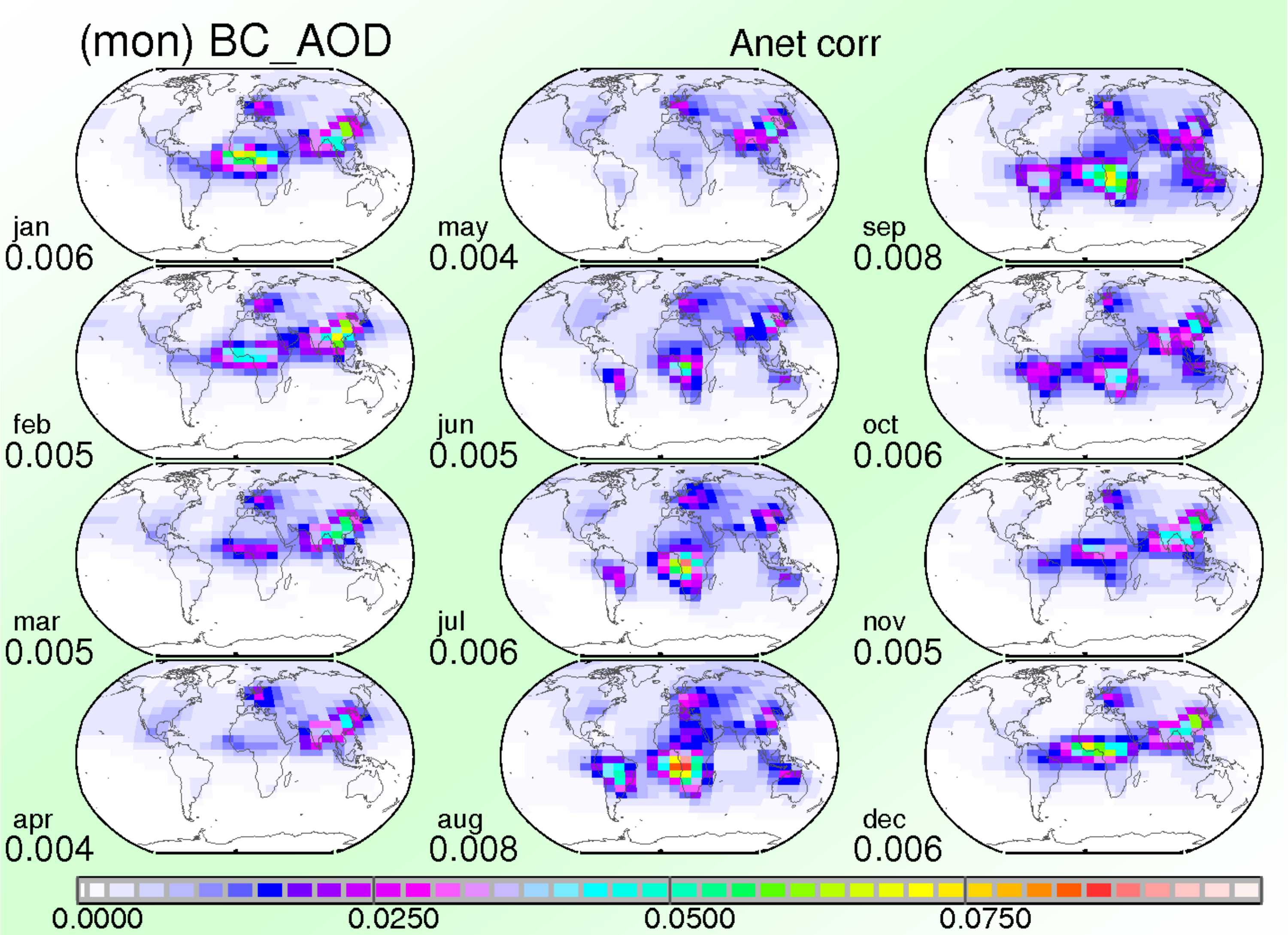
BC-AOD base + correction China



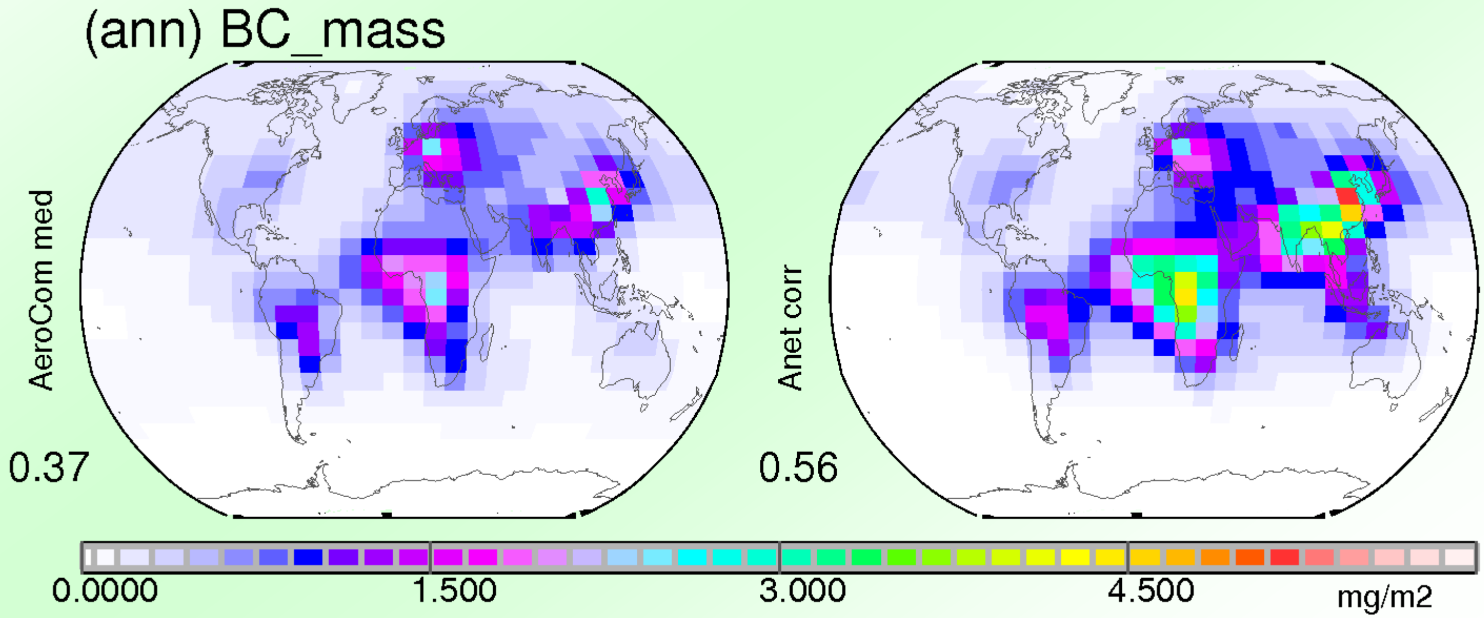
BC-AOD model baseline global



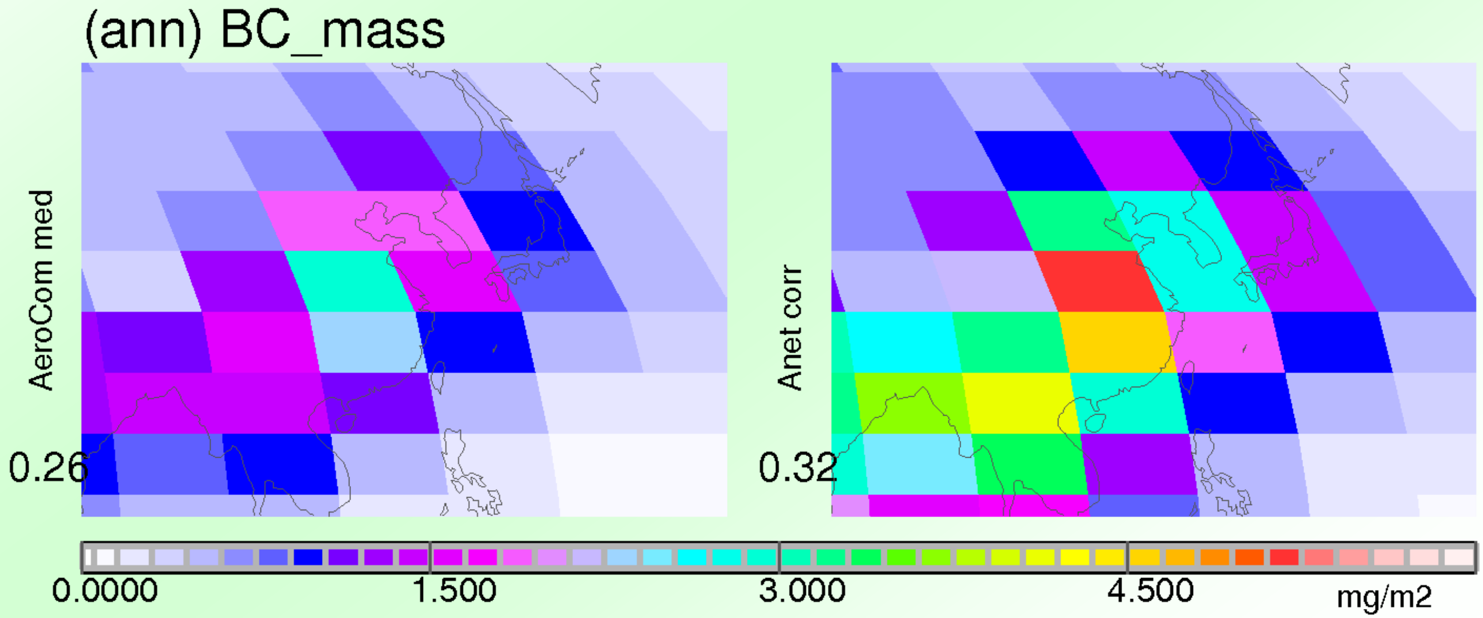
BC-AOD ANET corrected global



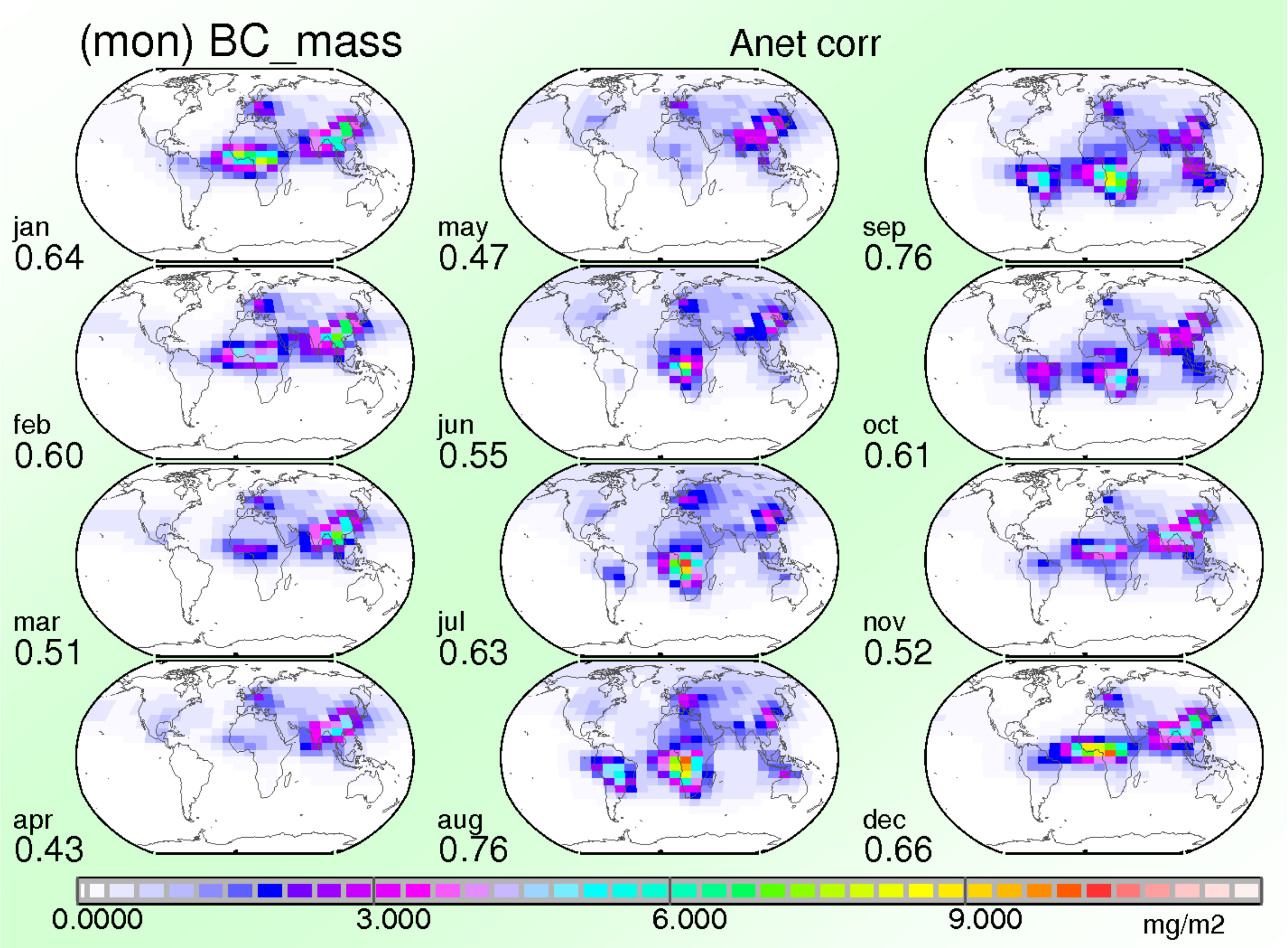
BC-mass base + correction



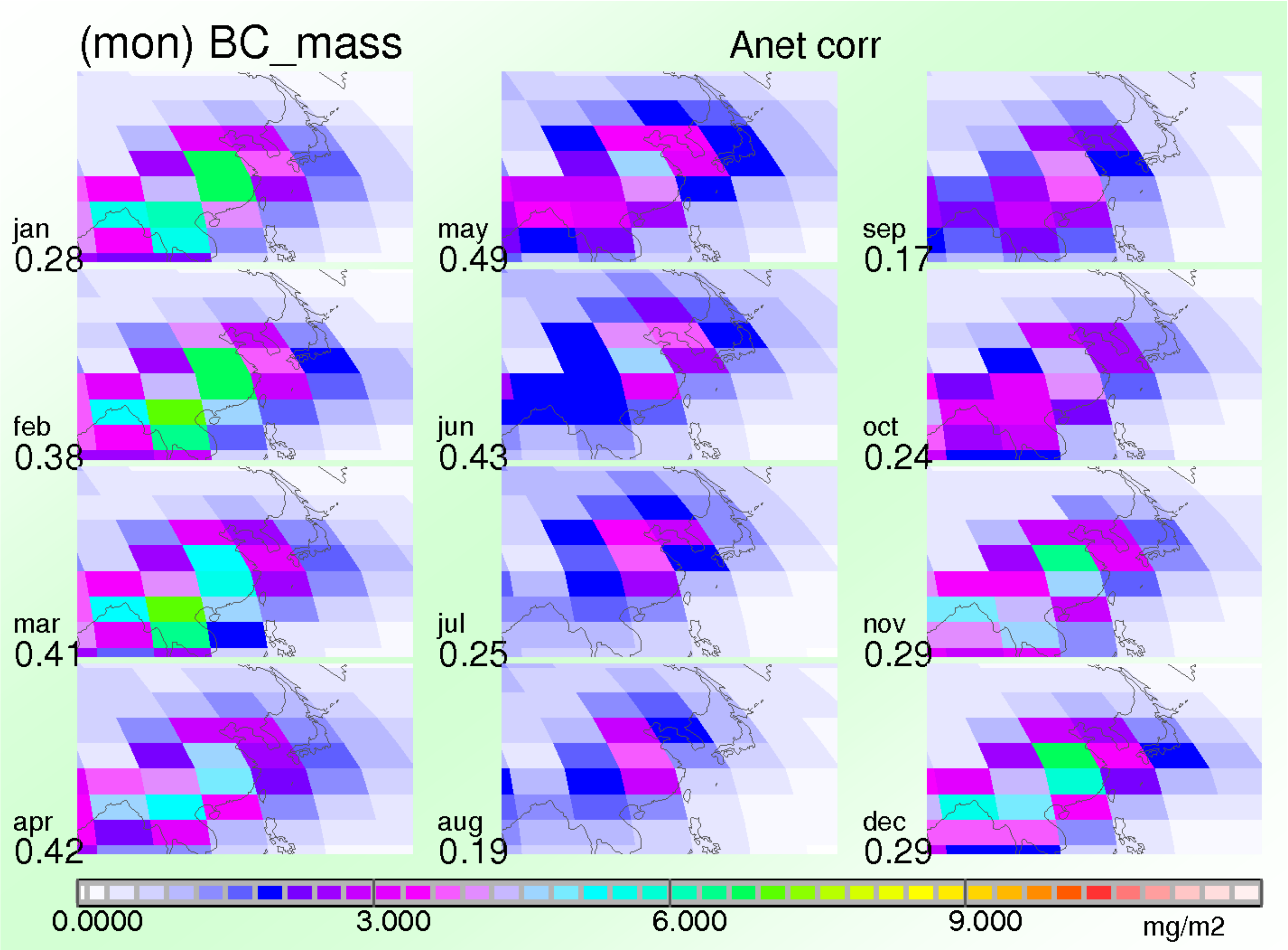
BC-mass base + correction China



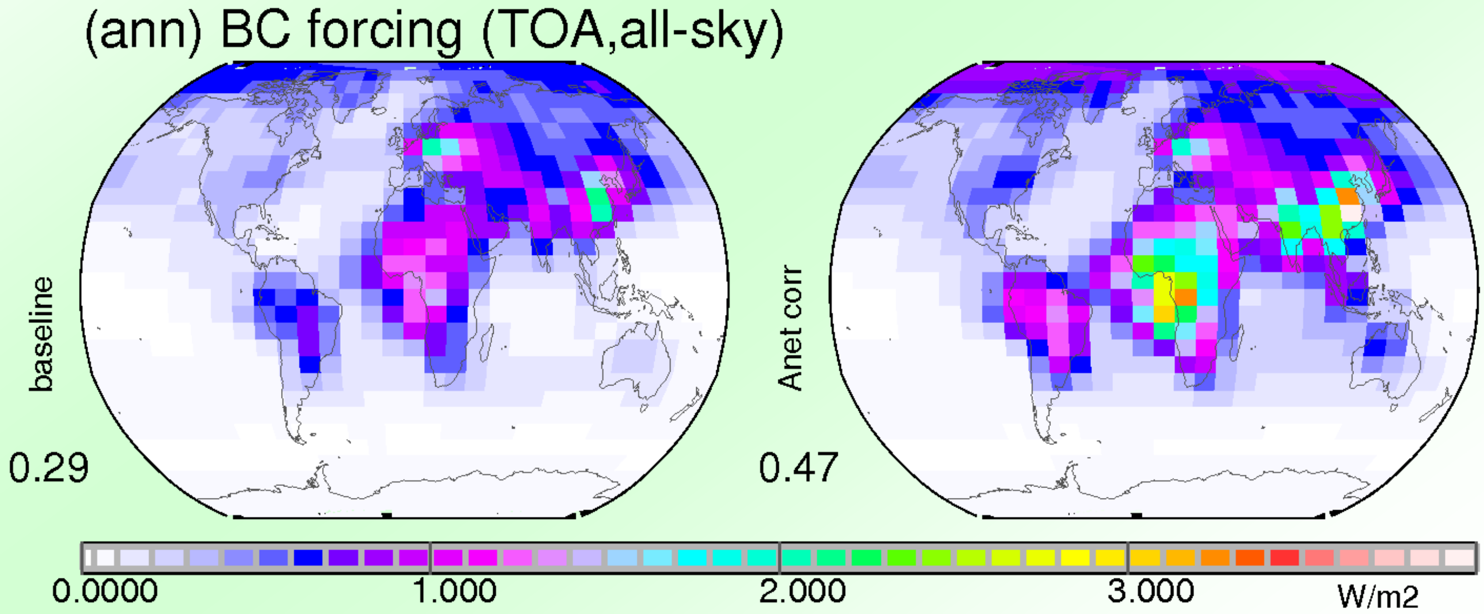
BC AOD ANET corrected global



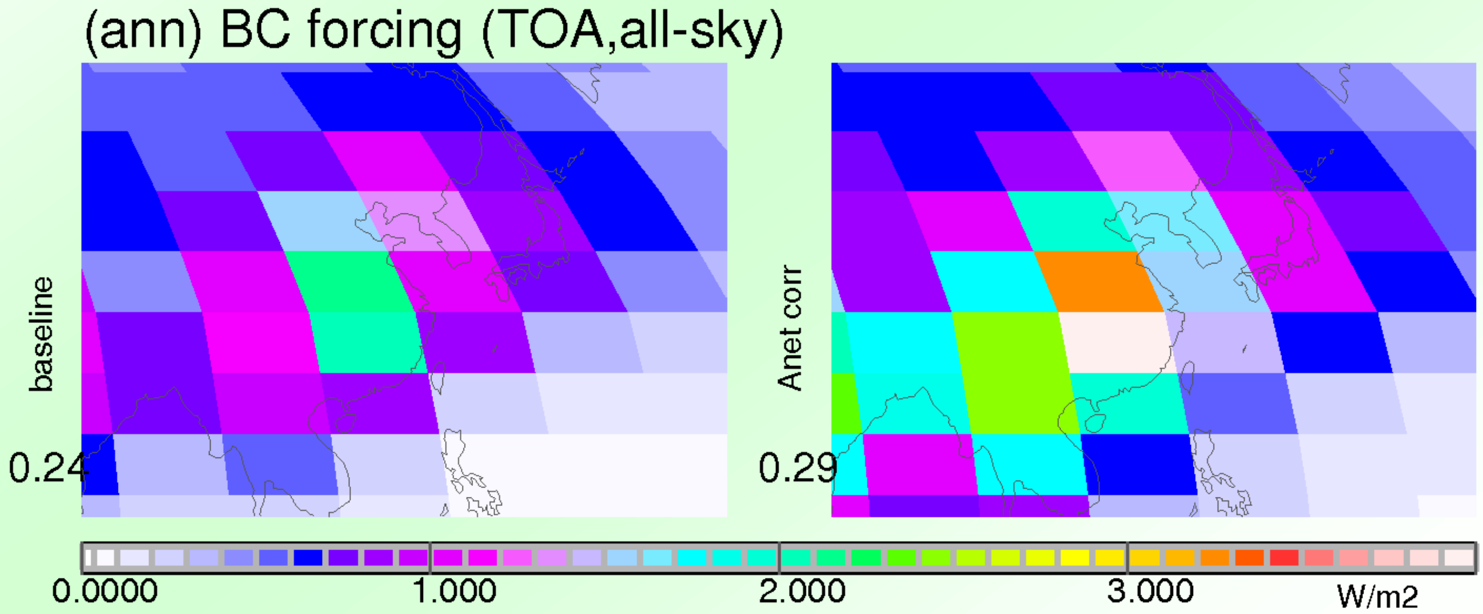
BC mass Aeronet corrected China



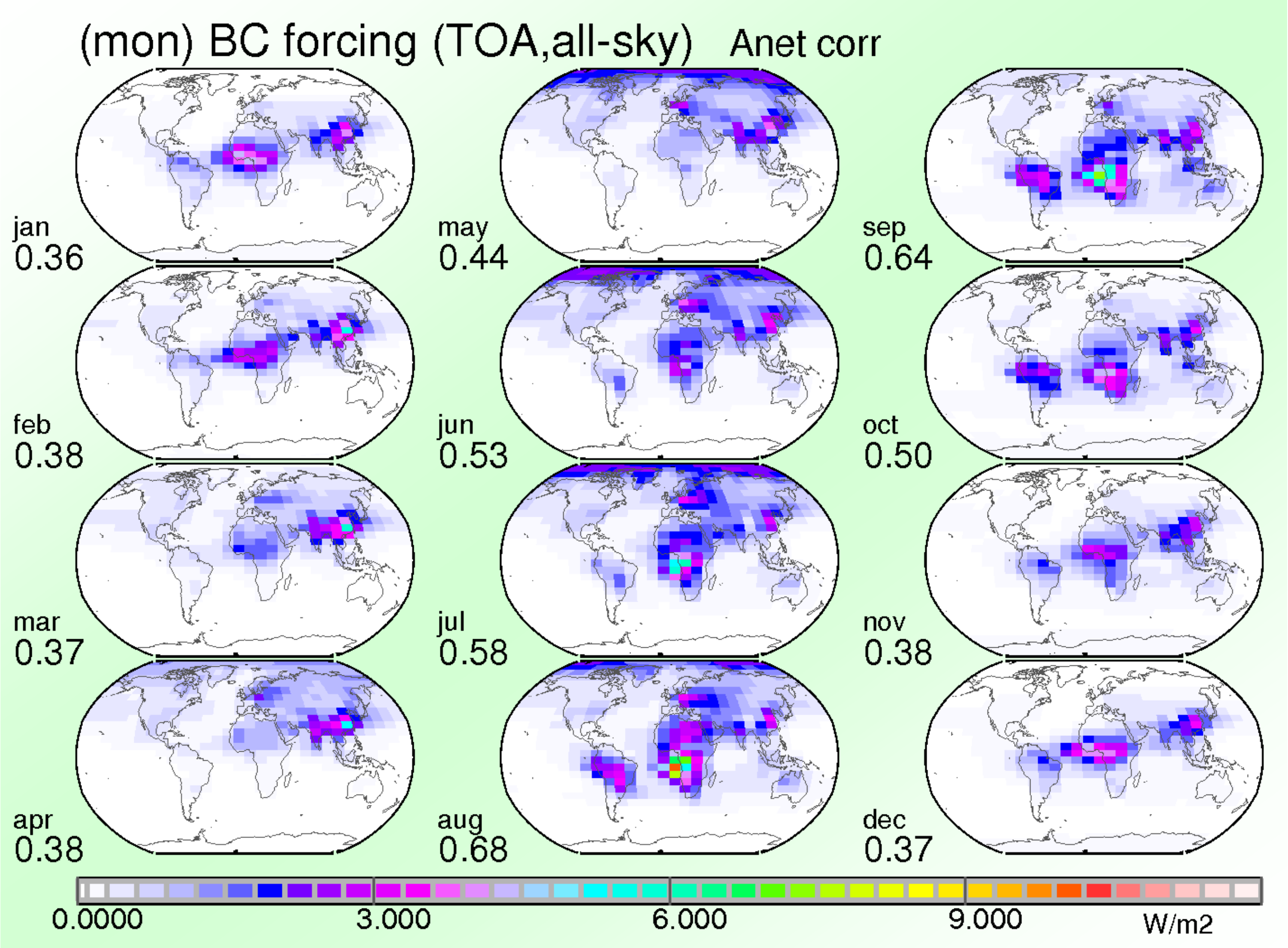
modified forcing – off-line RT global



modified forcing – off-line RT China



modified forcing – off-line RT global



modified forcing – off-line RT China