Aerosol Direct Forcing

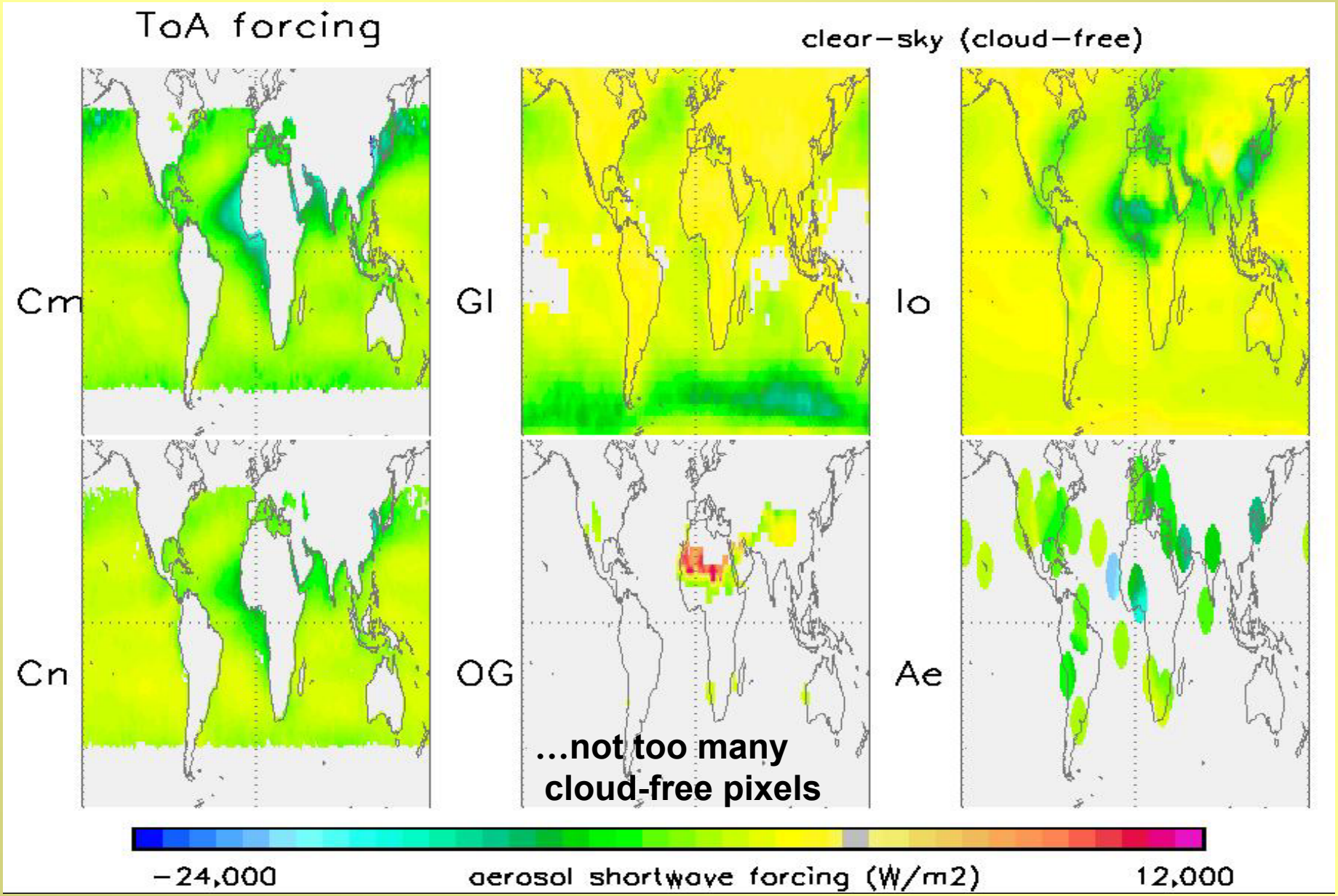
simulations in global models and measurement based approaches

overview

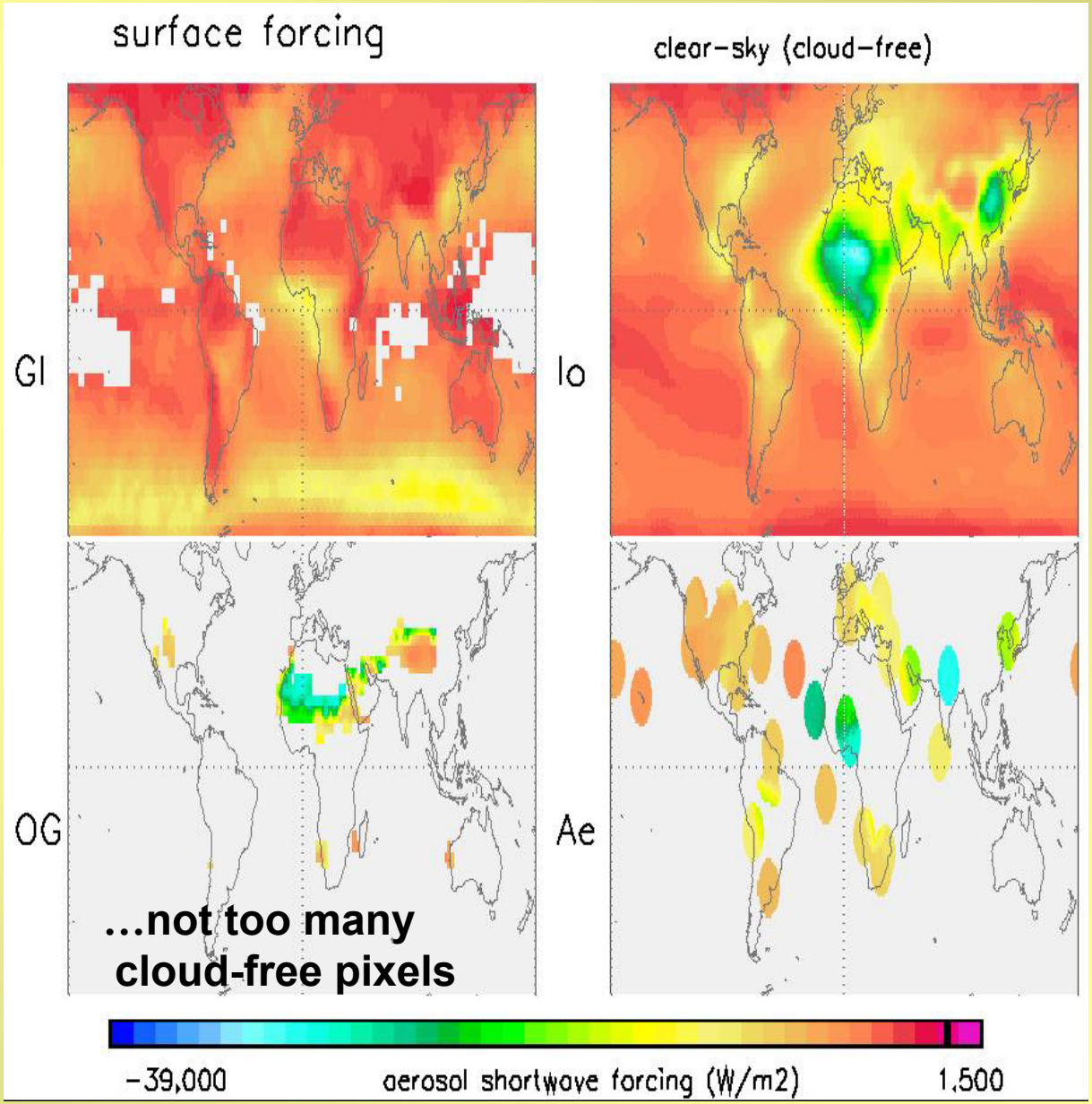
- **forcing**
  - **clear-sky forcing (ToA comp. to CERES)**
  - **all-sky forcing**
  - **anthropogenic forcing and forcing efficiencies**
- **available data-sets**
  - **GI GISS, New York Koch, Bauer, Miller …**
  - **OG Oslo-GCM, Oslo Iversen, Seland**
  - **LO LOA, Lille Boucher, Reddy**
  - **SP Kyusho Takemura**
  - **EC MPI, Hamburg Stier, Feichter**
  - **Ae AERONET Holben, … , Kinne**

yearly averages are shown ***(yearly averages data required averages from all 12 months)***

CERES / clear-sky / cloud-free



clear-sky / cloud-free



clear-sky forcing *[- W/m2]*

ToA	C,m	C,n	GI	OG	LO	AE
global	5.7	4.2	2.7	2.2	2.8	6.4*
NH coast	8.5	6.7	1.5	3.8	5.8	7.5
EQ coast	6.1	4.9	1.4	3.2	2.9	7.6

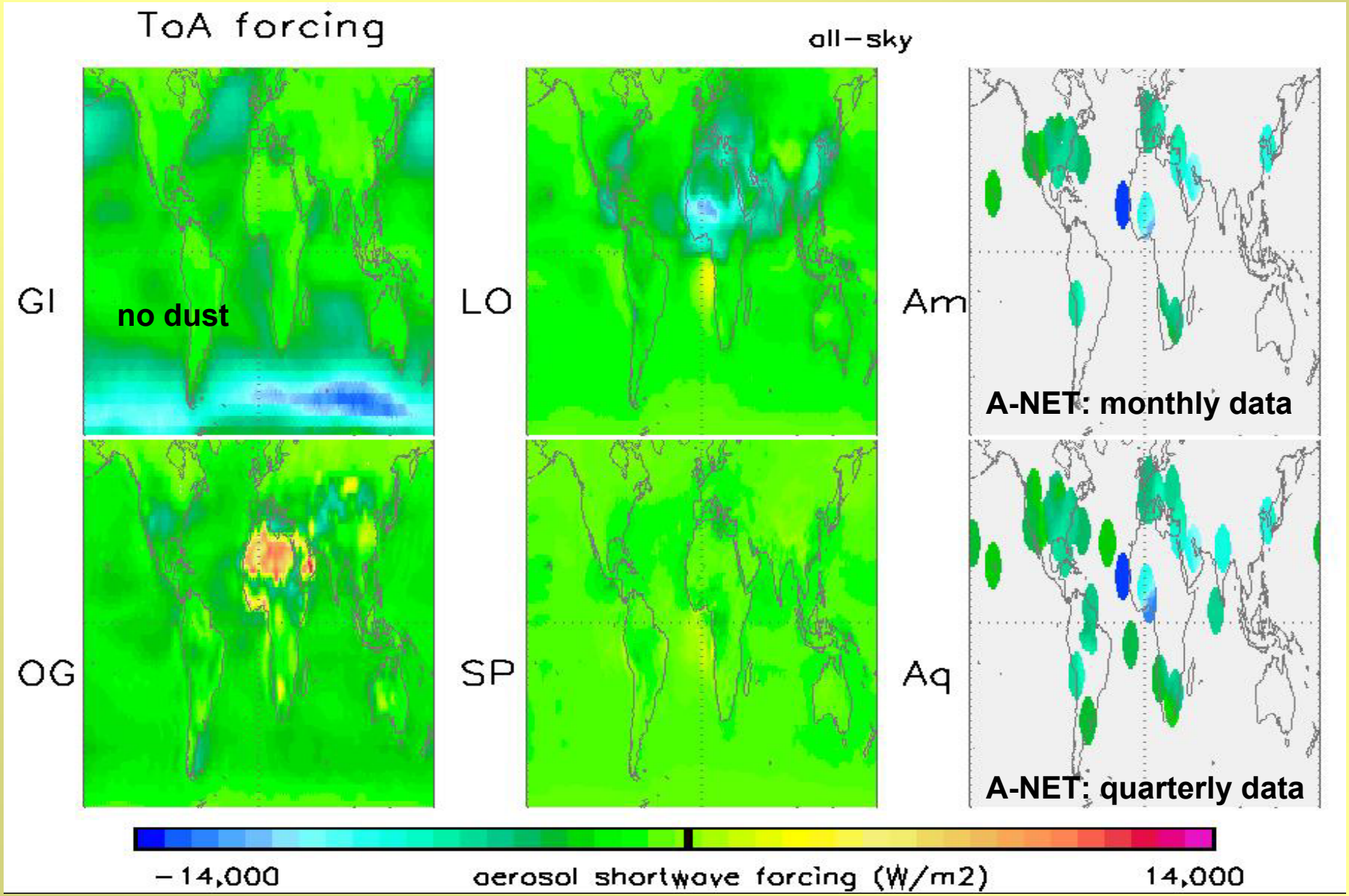
surface			GI	OG	LO	AE
global			4.0	10.8	5.6	10.7*
NH coast			3.5	10.2	10.4	10.3
EQ coast			3.1	8.7	6.7	13.1

* biased high due to sampling in areas of large aot

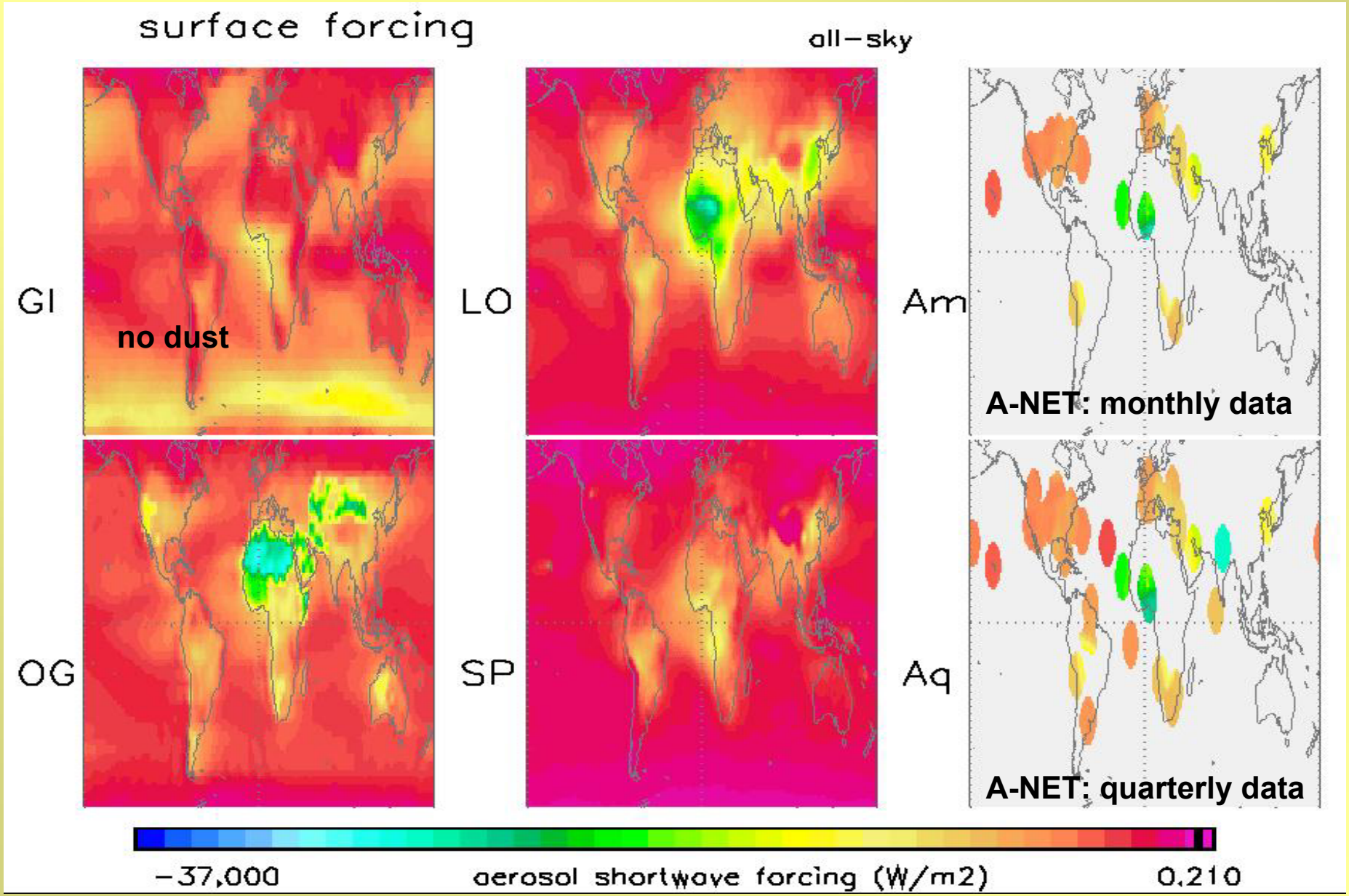
- data suggest larger (neg.) ToA forcing than models
- data suggest biomass stronger surf forcing (+ ssa)
- larger ToA model differences on a regional basis

all-sky forcing

all-sky forcing



all-sky forcing



all-sky forcing *[- W/m2]*

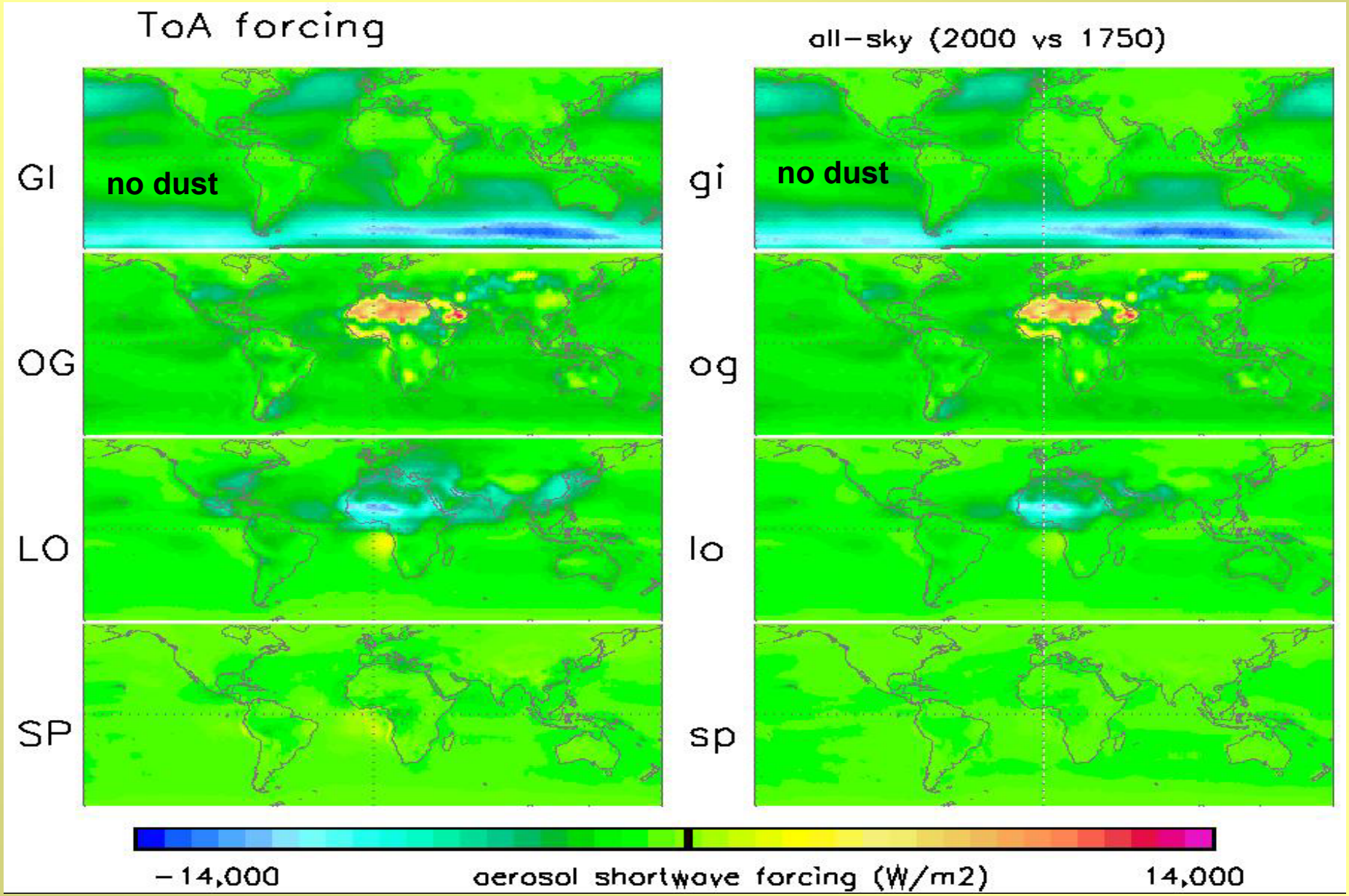
ToA	GI	OG	LO	SP	AE
global	2.6	1.5	1.7	0.5	5.2*
NH coast	1.5	1.7	4.2	1.1	6.4
EQ coast	1.3	1.4	1.9	0.6	6.2

surface	GI	OG	LO	SP	AE
global	3.8	4.0	3.9	1.9	8.8*
NH coast	3.3	6.8	8.6	3.7	9.5
EQ coast	2.9	4.8	5.3	3.1	11.7

* biased high due to sampling in areas of large aot

- all-sky less negative than clear-sky forcing
- data suggest larger (neg.) ToA forcing than models
- large ToA model differences (aerosol above clouds?)

all-sky forcing (yr 2000 and yr 1750)



diff. times ToA forcing *[- W/m2]*

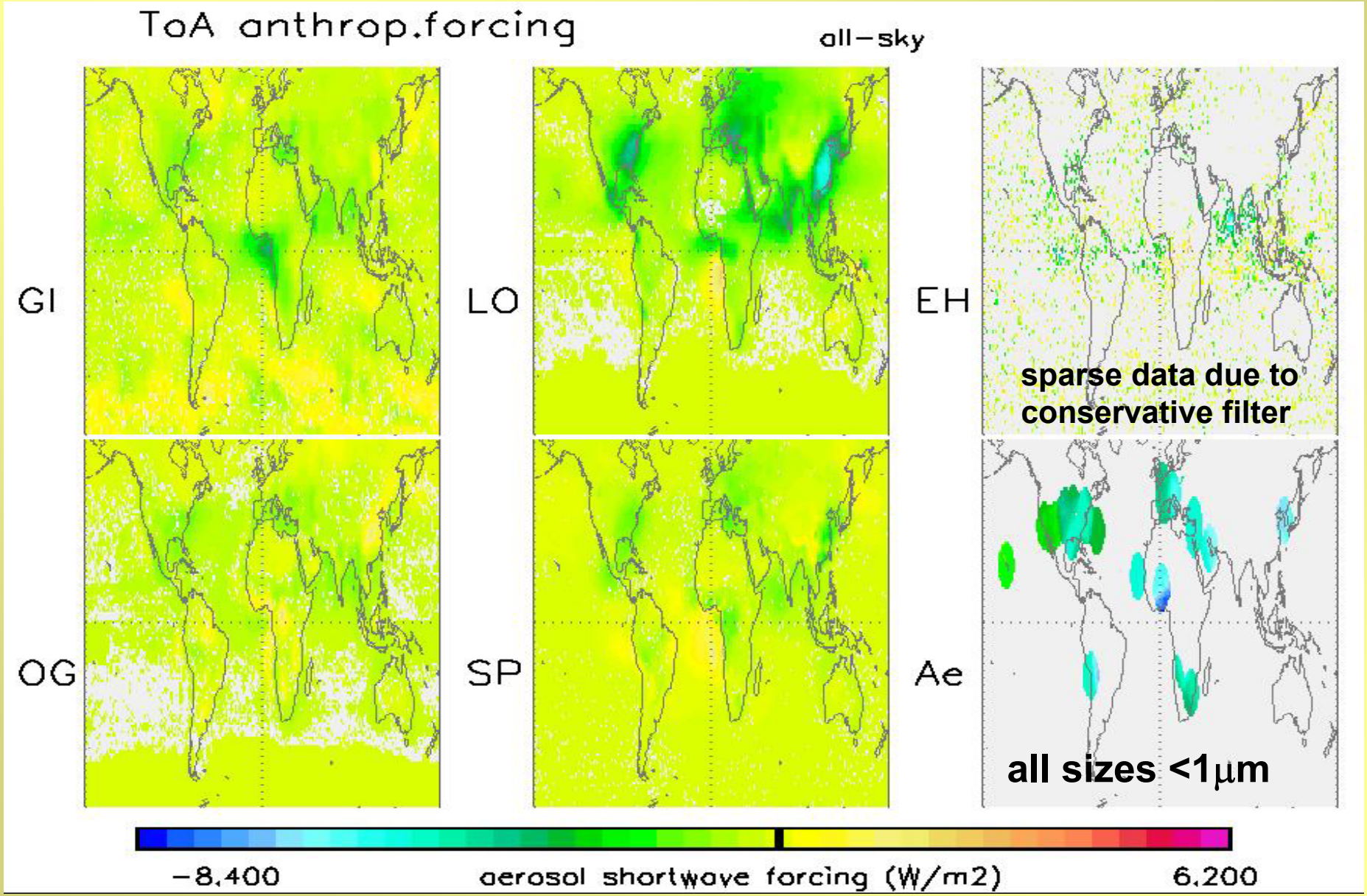
year 2000	GI	OG	LO	SP
global	2.6	1.5	1.7	0.5
NH coast	1.5	2.1	3.5	1.0
EQ coast	1.3	1.4	1.9	0.6

year 1750	GI	OG	LO	SP
global	2.6	1.5	1.3	0.6
NH coast	1.2	1.9	1.8	0.5
EQ coast	1.1	1.4	1.5	0.7

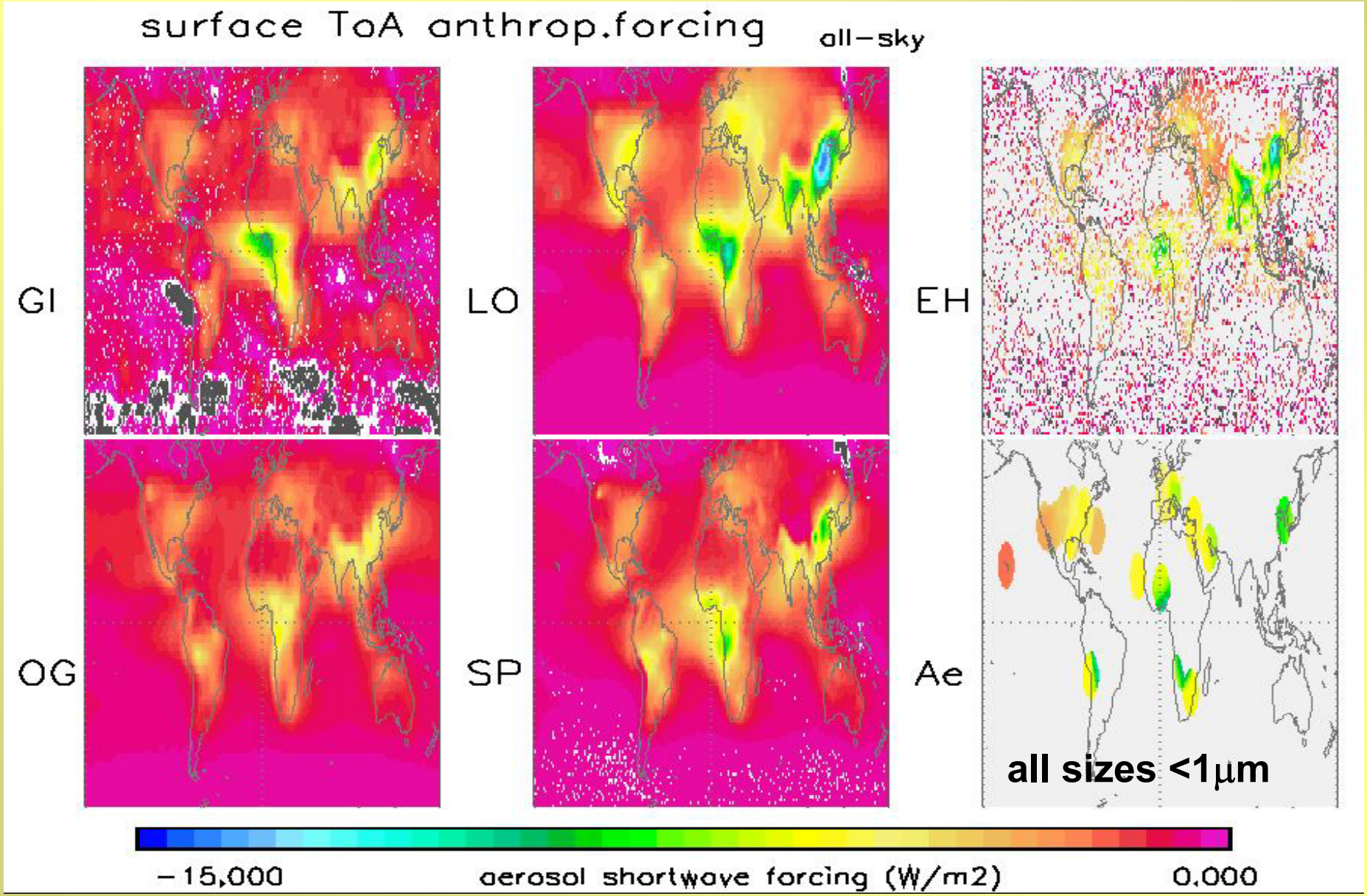
- forcing in NH urban regions has become more neg.
- globally ToA forcing has not changed much over time

anthropogenic forcing

anthr. forcing (yr 2000 – yr 1750)



anthr. forcing (yr 2000 – yr 1750)



anthropogenic forcing *[- W/m2]*

ToA	GI	OG	LO	SP	EH	AE
global	0	0	0.4	0	0.2	3.9*
NH coast	0.3	0.2	1.7	0.5	1.0	4.3*
EQ coast	0.2	0	3.7	0	0	4.7*

surface	GI	OG	LO	SP	EH	AE
global	0.9	0.9	1.5	.9	1.3	5.2*
NH coast	1.9	1.9	4.2	2.2	3.5	4.8*
EQ coast	1.4	1.4	2.3	1.7	2.3	6.4*

* aerosol sizes <1 μm to approximate anthropogenic fraction

- small to no ToA forcing changes ('warmer' possible)
- increased cooling at the surface over time (esp. NH)
- no data to compare against

forcing efficiency

- **what it is:**
  - **forcing per 'unit property'**
    - **property = aot: can be related to measurements**
    - **property = mass: interesting to less sophisticated aerosol efforts in global modeling**
    - **property = temperature: a model sensitivity**
- **how it applies to aerosol:**
  - **anthropogenic forcing efficiency (to aot)**
    - **(F,now - F,pre-industry) /(aot,now - aot,pre-industry)**

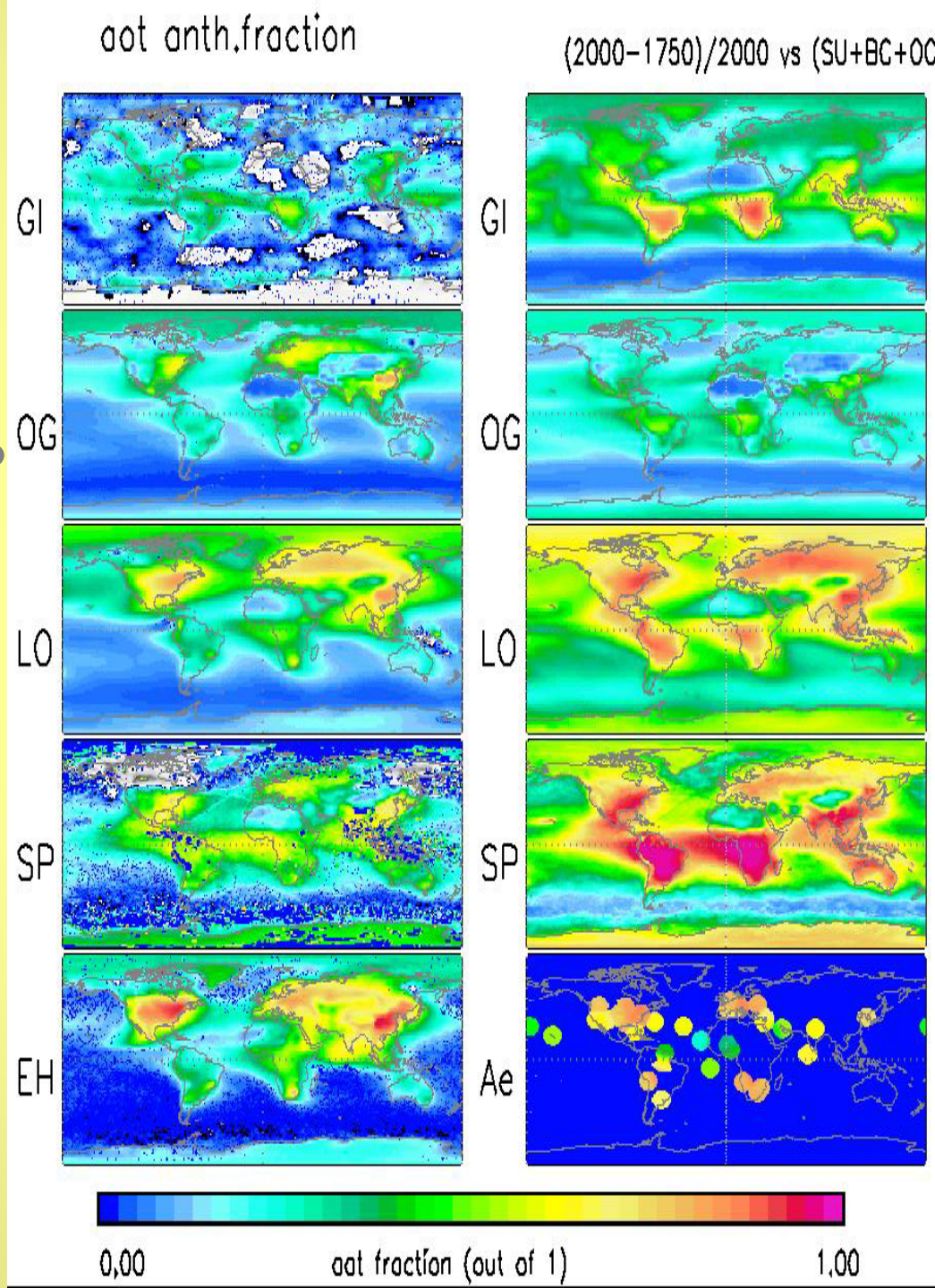
    Q: as little is known about pre-industrial conditions: anthropogenic ←=→ sulfate+carbon?

aot - *anthropogenic*

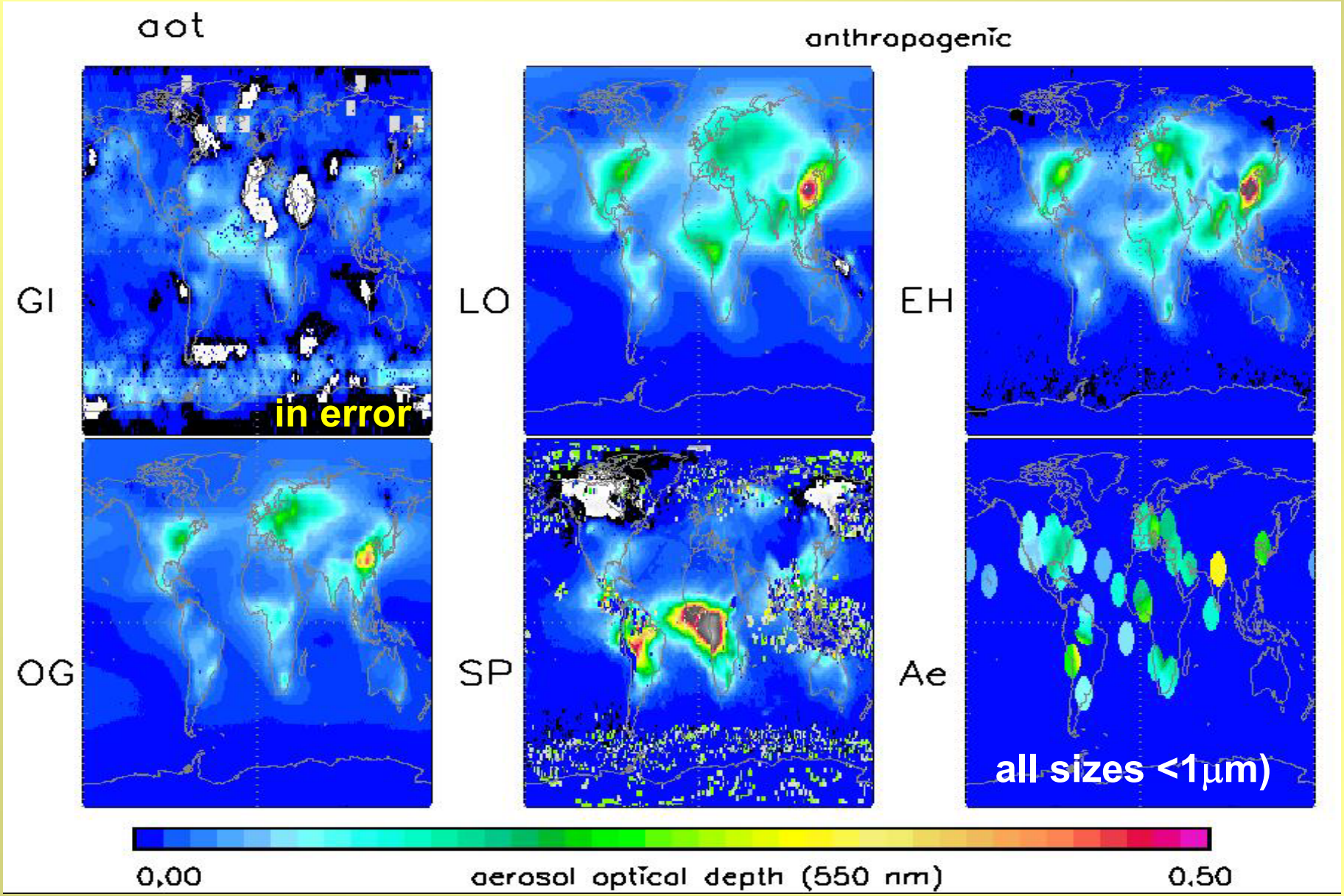
how well approximate contributions of sulfate (SU) and carbon (OC, BC) anthropogenic fraction?

left: yr 2000 – yr 1750
right: (SU+BC+OC) /total

GI – GISS
OG – OSLO
LO – LOA
SP – Kyusho
EH – MPI-HAM
Ae - AERONET



anthropogenic aot (yr 2000-yr 1750)



anthr. forcing *per unit aot*

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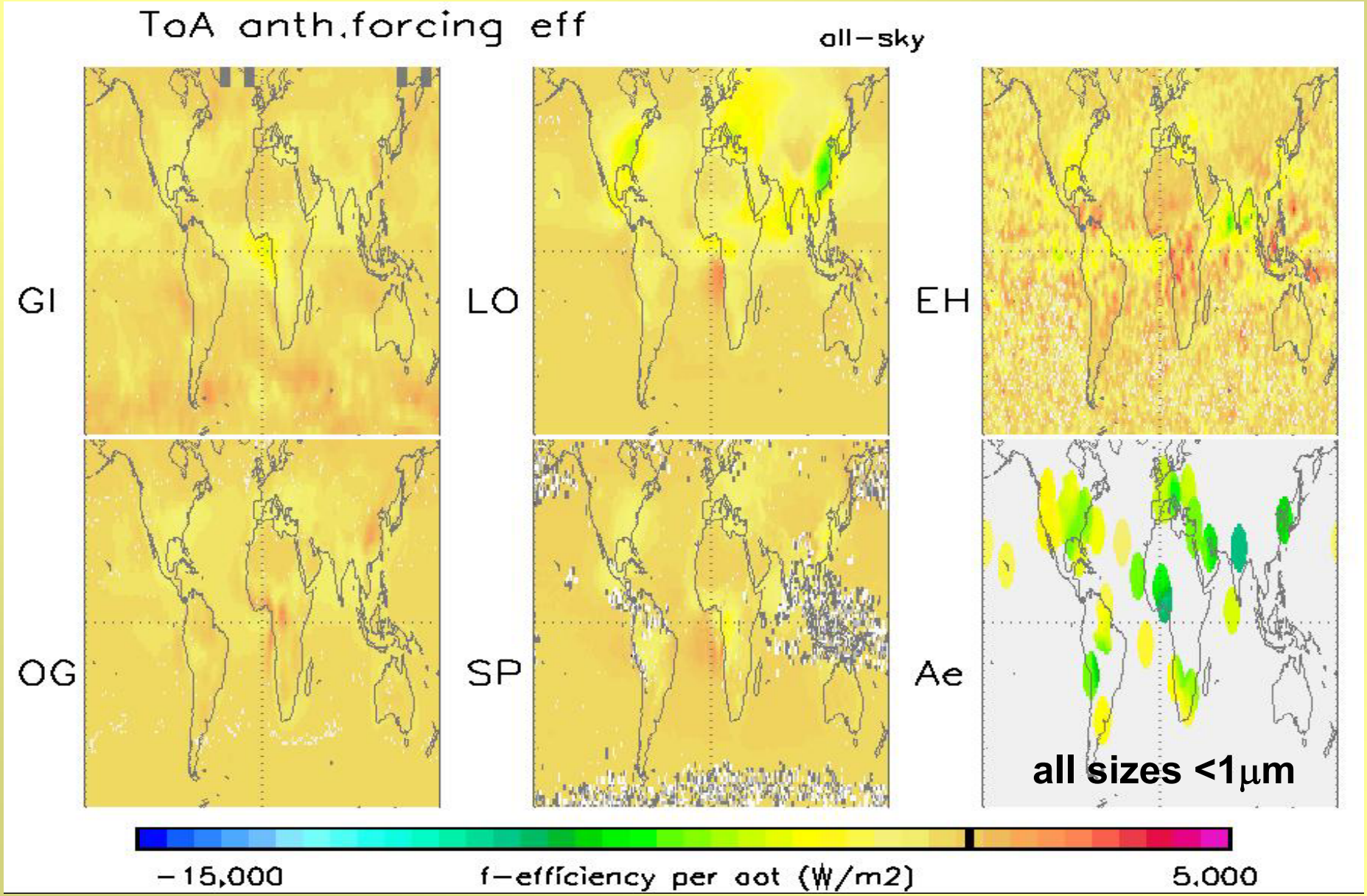
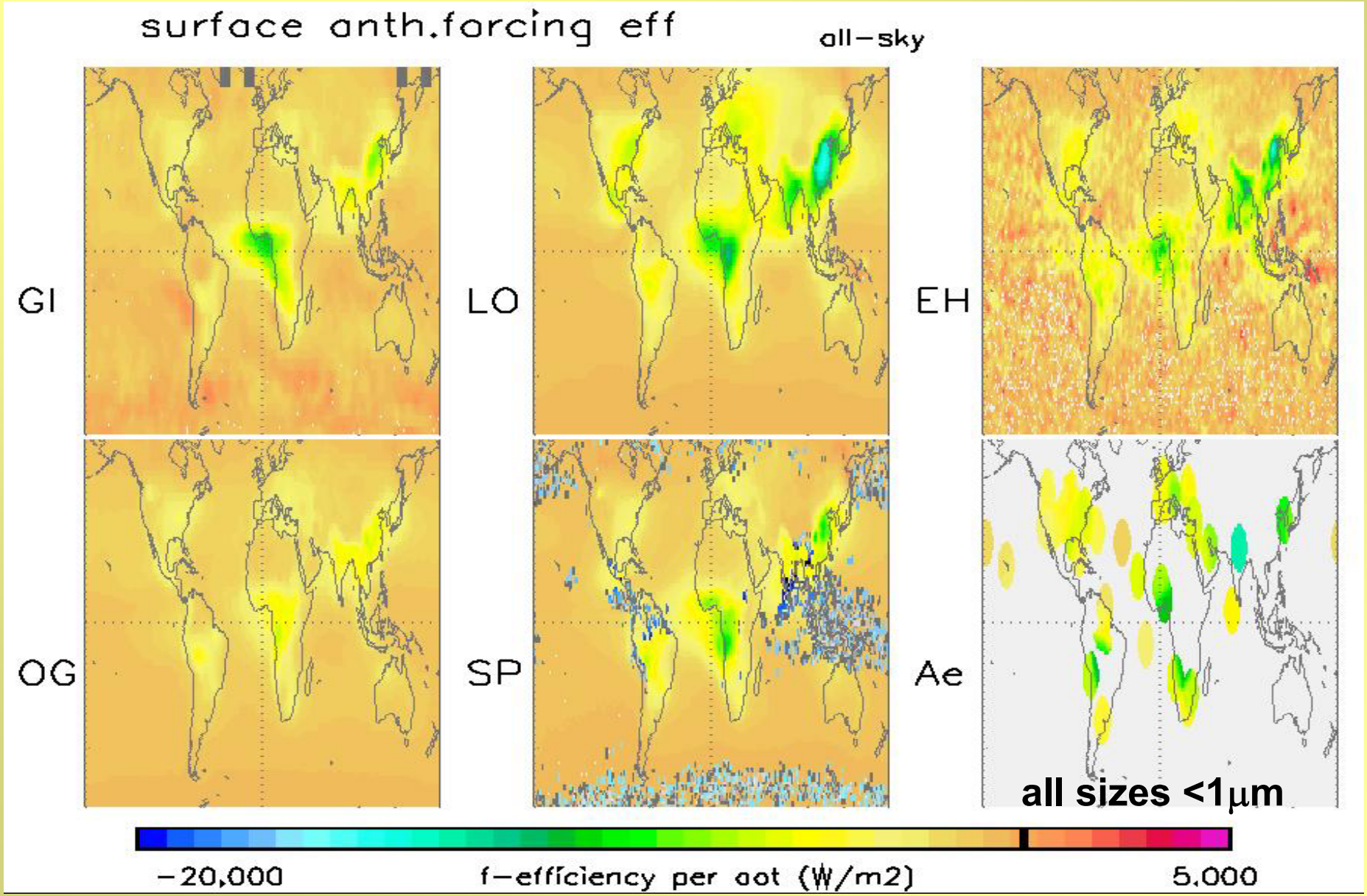


anthr. forcing *per unit aot*



anthr. forcing *per unit mass*

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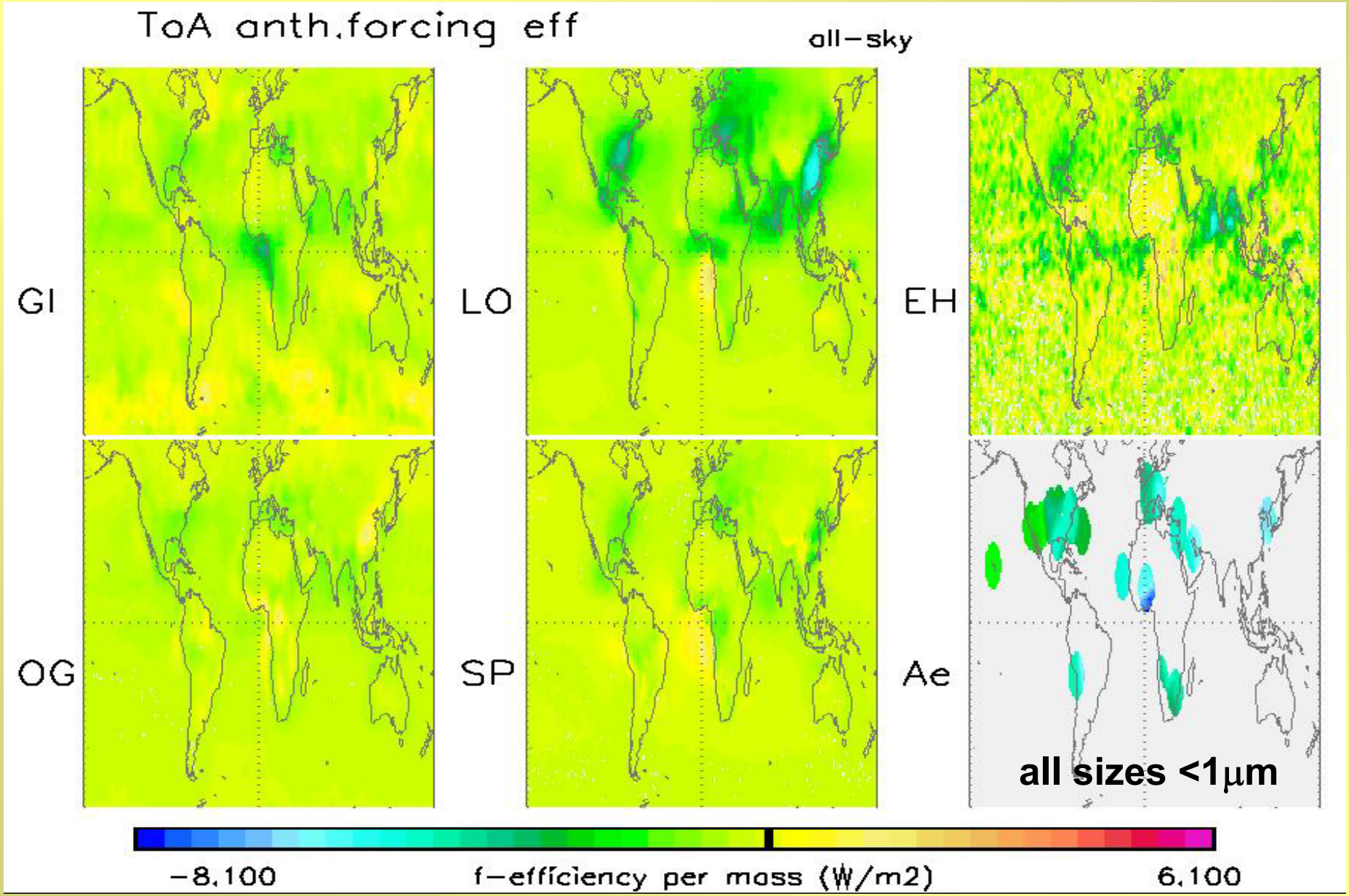

anthr. forcing *per unit mass*