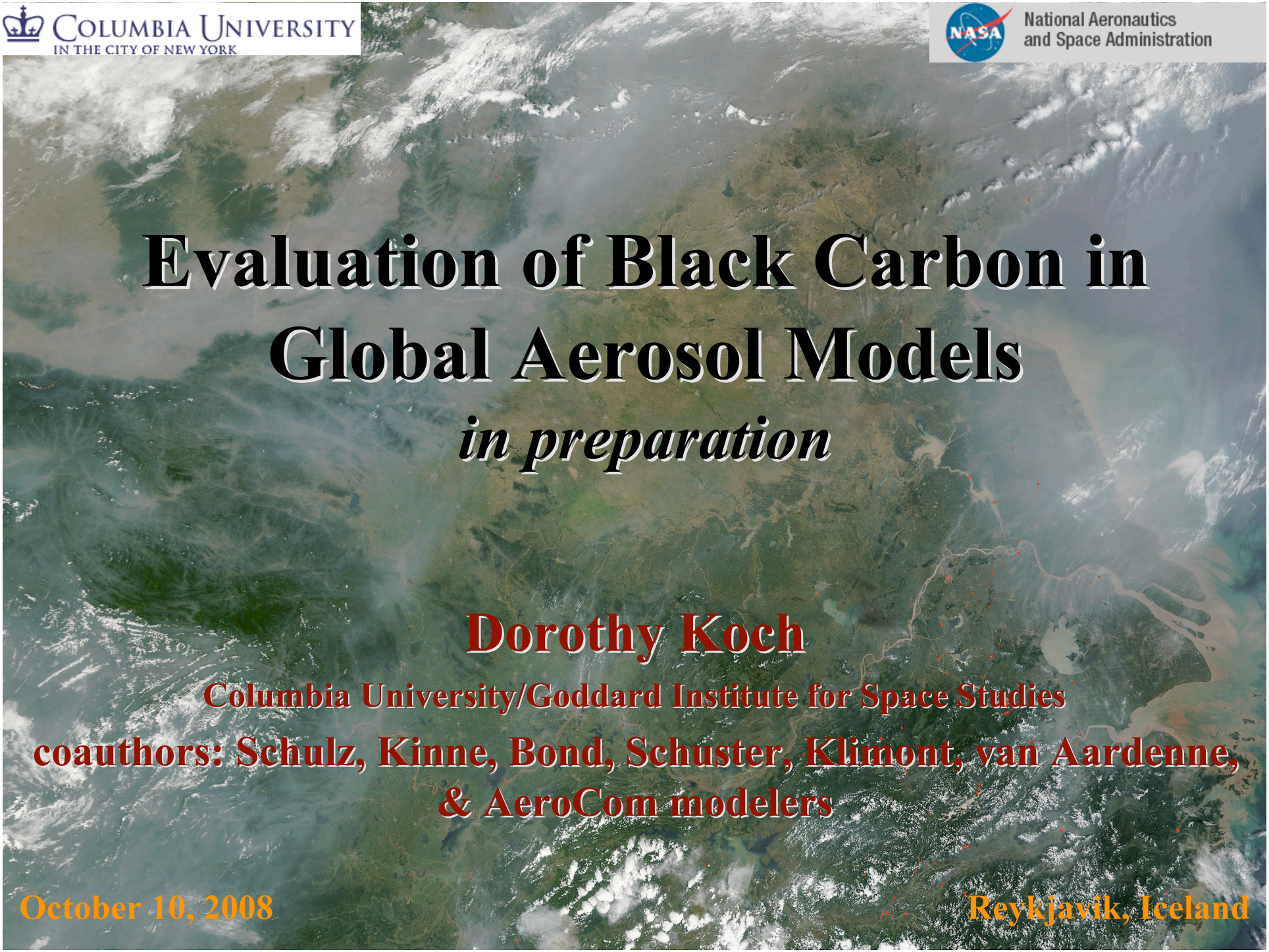


COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

National Aeronautics
and Space Administration

Evaluation of Black Carbon in Global Aerosol Models

in preparation

Dorothy Koch

Columbia University/Goddard Institute for Space Studies

coauthors: Schulz, Kinne, Bond, Schuster, Klimont, van Aardenne, & AeroCom modelers

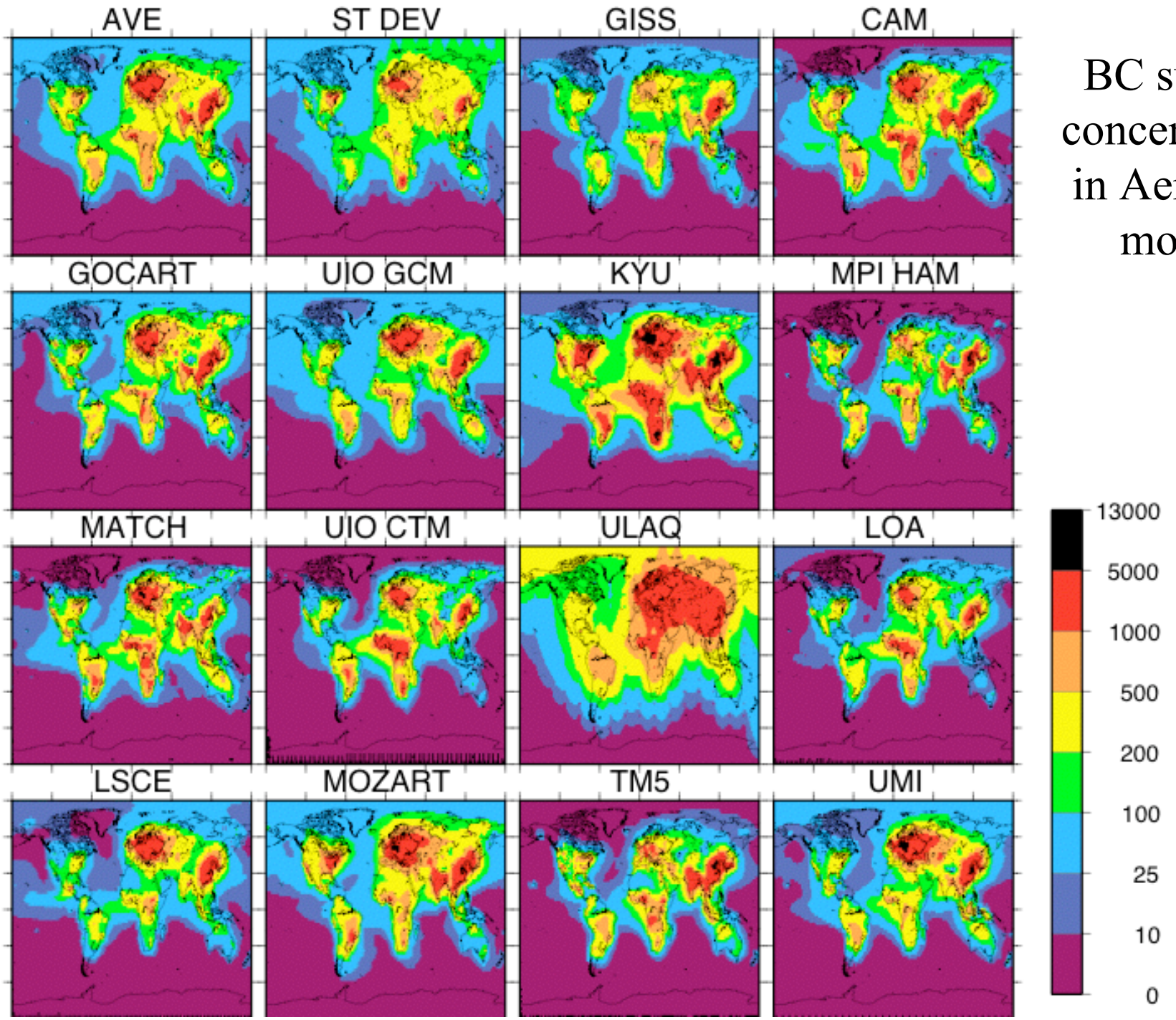
October 10, 2008

Reykjavik, Iceland

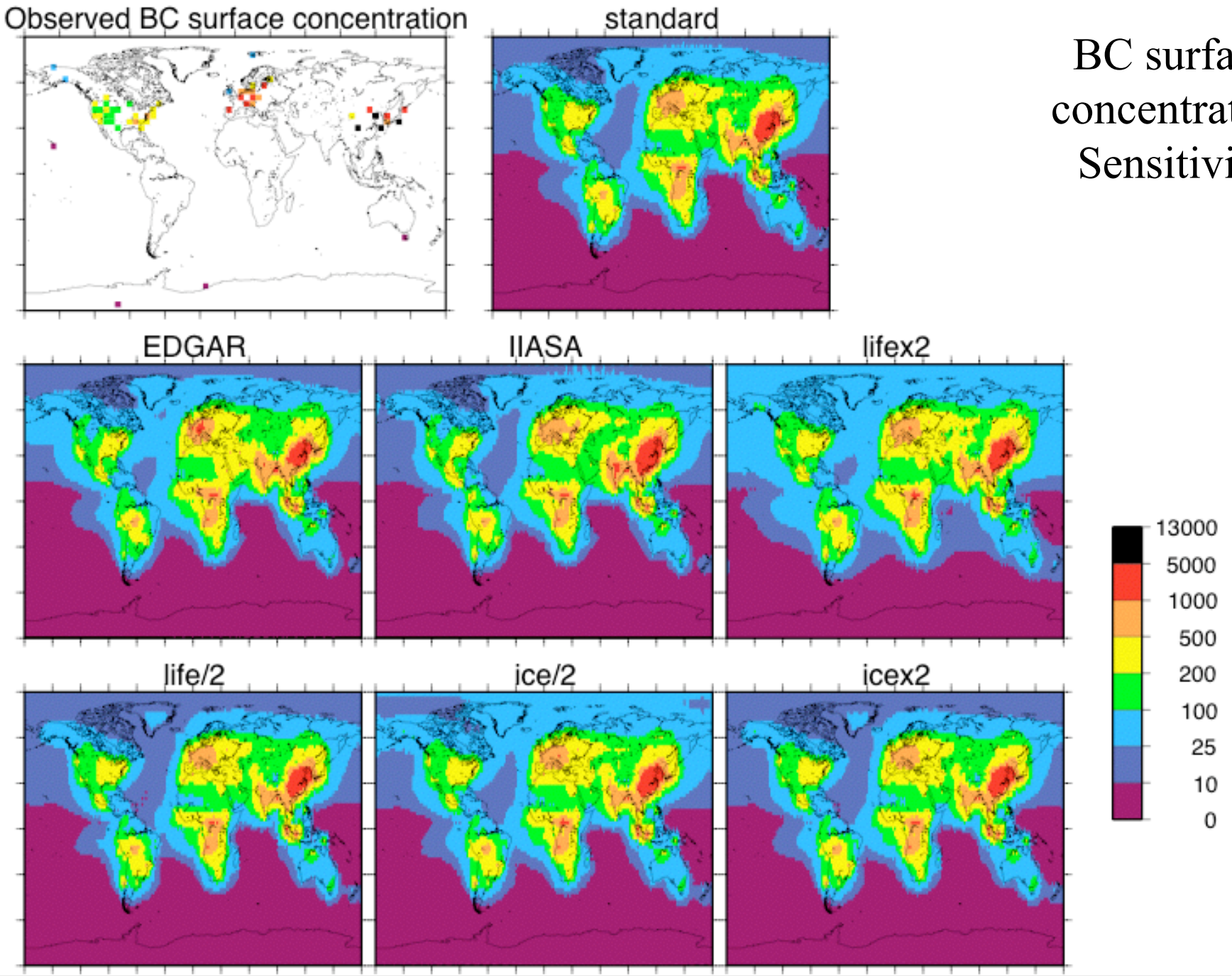
Goals

- Evaluate and consider diversity of AeroCom models':
  - BC Surface concentration (surface measurements)
  - BC column load (Schuster - from AERONET)
  - Aerosol Absorption Optical Depth (from AERONET and OMI)

- Use the GISS model (with simple mass-based aerosol scheme) for sensitivity analysis in:
  - Emissions (Bond, IIASA, EDGAR)
  - Aging rate (E-fold = 1 day, 0.5d, 2d)
  - Removal by ice (12%, 5%, 24% wrt water)
  - Particle effective radius (0.08, 0.1, 0.06 μm)



BC surface concentration in AeroCom models



BC surface concentration Sensitivity

BC surface concentration assessment: model/observed

n	BC surf Nam 27	BC surf Eur 15	BC surf Asia 9	BC surf row 7
std	0.81	0.67	0.53	3.0
EDGAR	0.70	0.82	0.43	2.6
IIASA	0.70	0.66	0.50	2.9
Lifex2	0.87	0.74	0.55	4.7
Life/2	0.77	0.62	0.49	2.3
Ice/2	0.83	0.69	0.54	3.3
Icex2	0.78	0.67	0.51	2.7

For GISS, EDGAR is better in Europe. Longer lifetime slightly better near source regions.

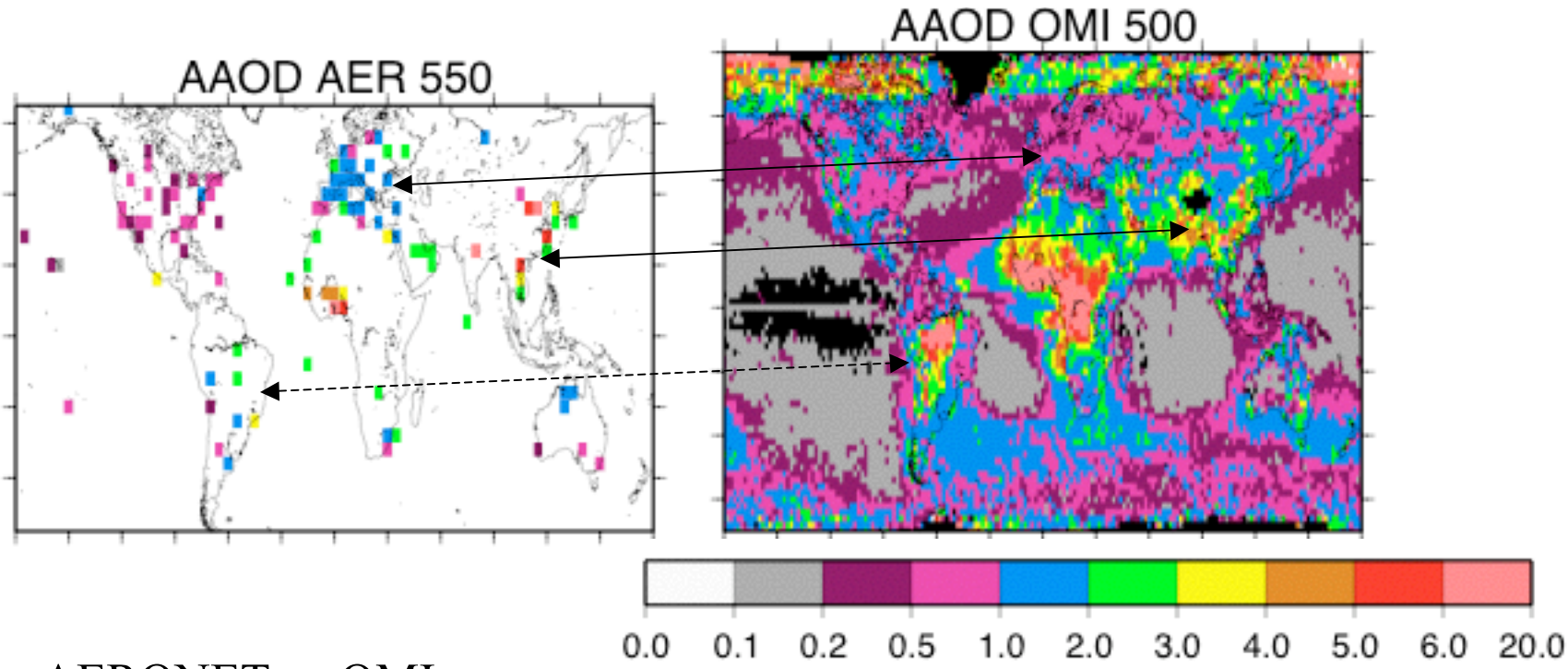
n	BC surf Nam 27	BC surf Eur 15	BC surf Asia 9	BC surf other 7
GISS	0.81	0.65	0.70	2.7
ARQM				
CAM	1.6	2.2	0.52	2.0
GOCART	1.2	2.1	0.65	1.3
KYU	7.7	9.7	1.3	5.2
LOA	0.89	1.2	0.31	0.52
LSCE	0.61	3.0	0.54	0.82
MATCH	1.3	3.0	0.32	1.1
MOZGN	2.4	3.8	1.2	2.4
MPIHAM	1.5	0.73	0.74	0.40
PNNL				
TM5	1.8	1.0	1.1	1.2
UIOCTM	0.72	1.6	0.60	0.43
UIOGCM	0.88	2.9	0.68	1.8
UMI	0.81	4.8	0.82	0.89
ULAQ	0.75	3.0	1.8	1.8
Ave	0.80	2.8	1.6	1.6

Most models are larger than observed surface concentrations, except in N. America

Observed Absorption Aerosol Optical Depth

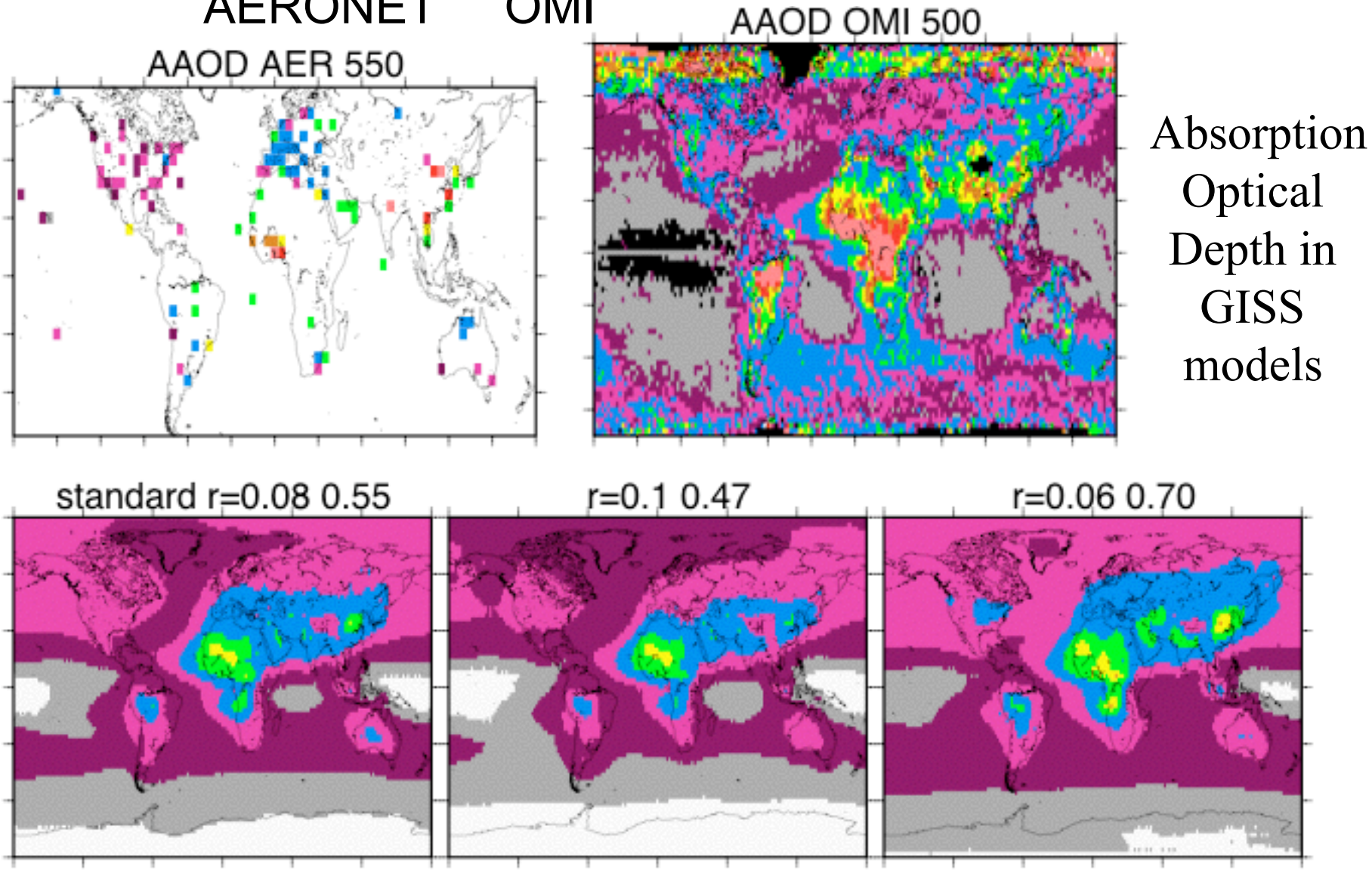
AAOD from AERONET
v2 1998-2004

OMI AAOD 2005-2007
From OMAERUVd.003 product
Processed with Giovanni



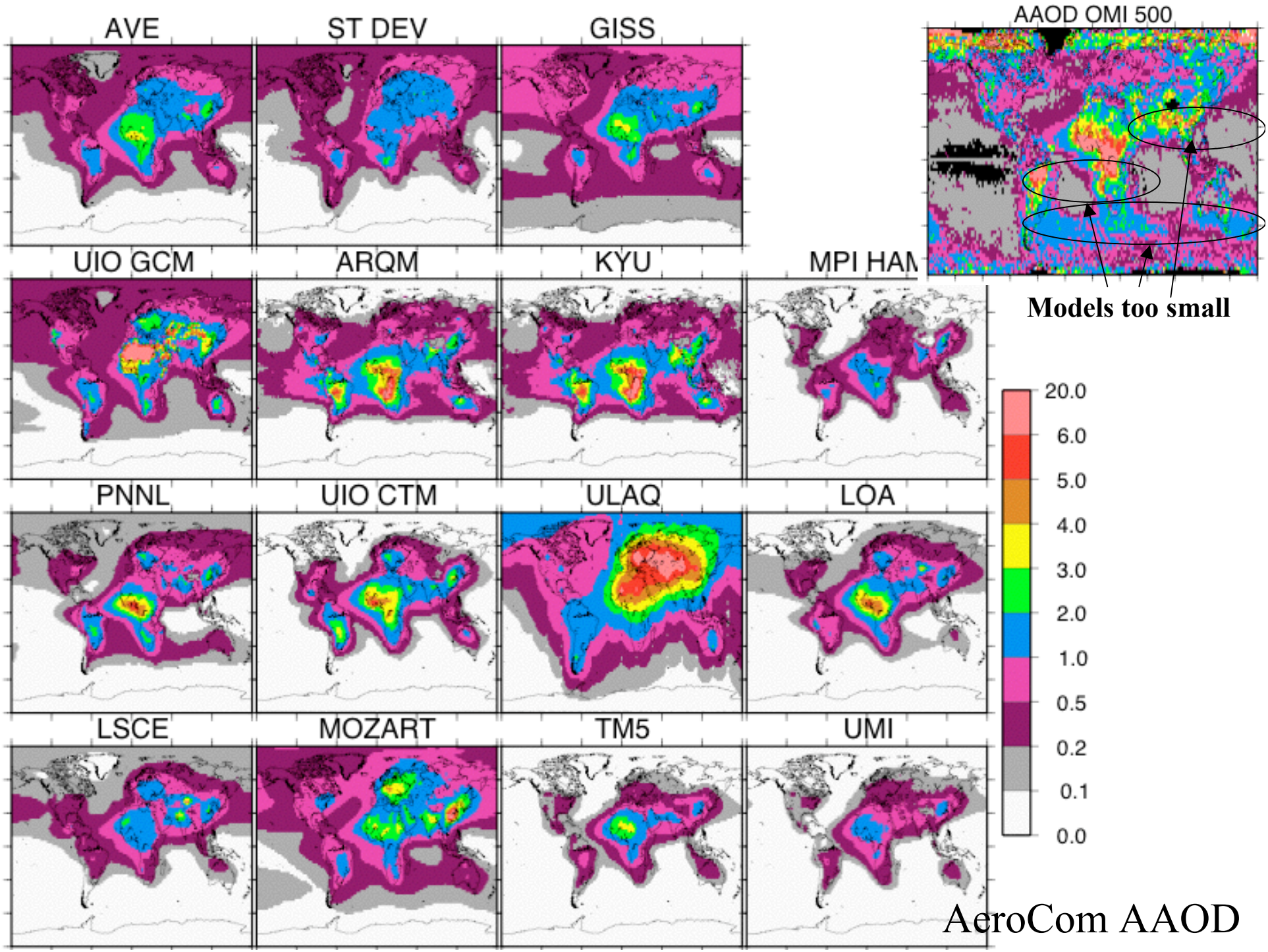
AERONET vs OMI
Smaller: South America
Larger: Europe, SE Asia

AERONET OMI



Absorption Optical Depth in GISS models

Model AAOD sensitive to e.g. assumed effective radius


AVE
ST DEV
GISS
AAOD OMI 500
Models too small
UIO GCM
ARQM
KYU
MPI HAM
PNNL
UIO CTM
ULAQ
LOA
LSCE
MOZART
TM5
UMI
20.0
6.0
5.0
4.0
3.0
2.0
1.0
0.5
0.2
0.1
0.0
AeroCom AAOD

AAOD assessment: model/observed

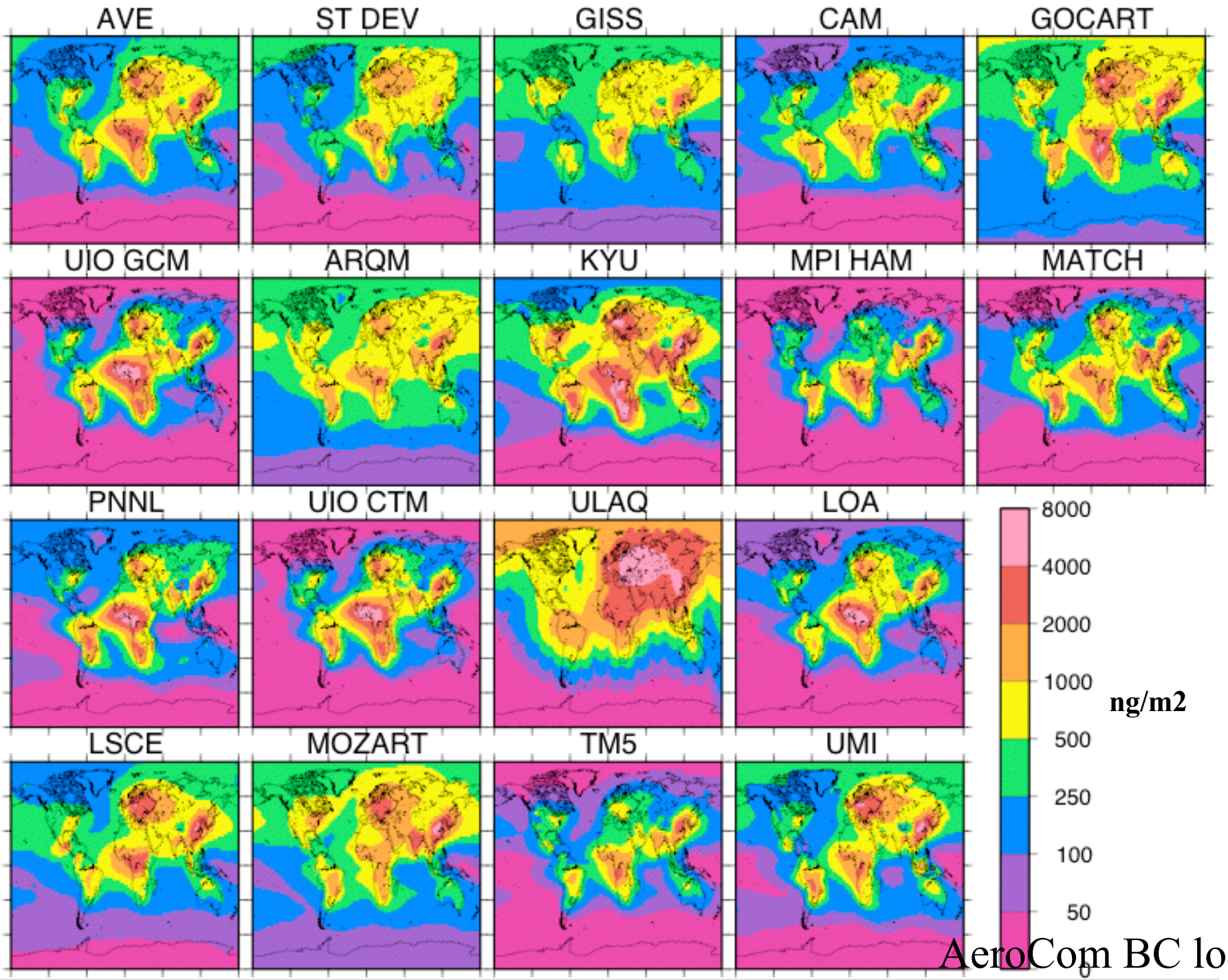
n GISS Sens.	AAOD AER N Am 44	AAOD AER Eur 41	AAOD AER Asia 11	AAOD AER S Am 7	AAOD AER Afr 5	AAOD AER row 21	AAOD OMI N Am	AAOD OMI Eur	AAOD OMI Asia	AAOD OMI S Am	AAOD OMI Afr	AAOD OMI ROW
std	1.0	0.83	0.49	0.59	0.35	0.88	0.73	1.4	0.74	0.29	0.40	0.28
r=.1	0.86	0.66	0.40	0.49	0.28	0.71	0.60	1.2	0.61	0.24	0.32	0.22
r=.06	1.4	1.1	0.68	0.77	0.47	1.8	1.0	1.8	1.0	0.38	0.53	0.38

AERONET ◄——► OMI ◄——►

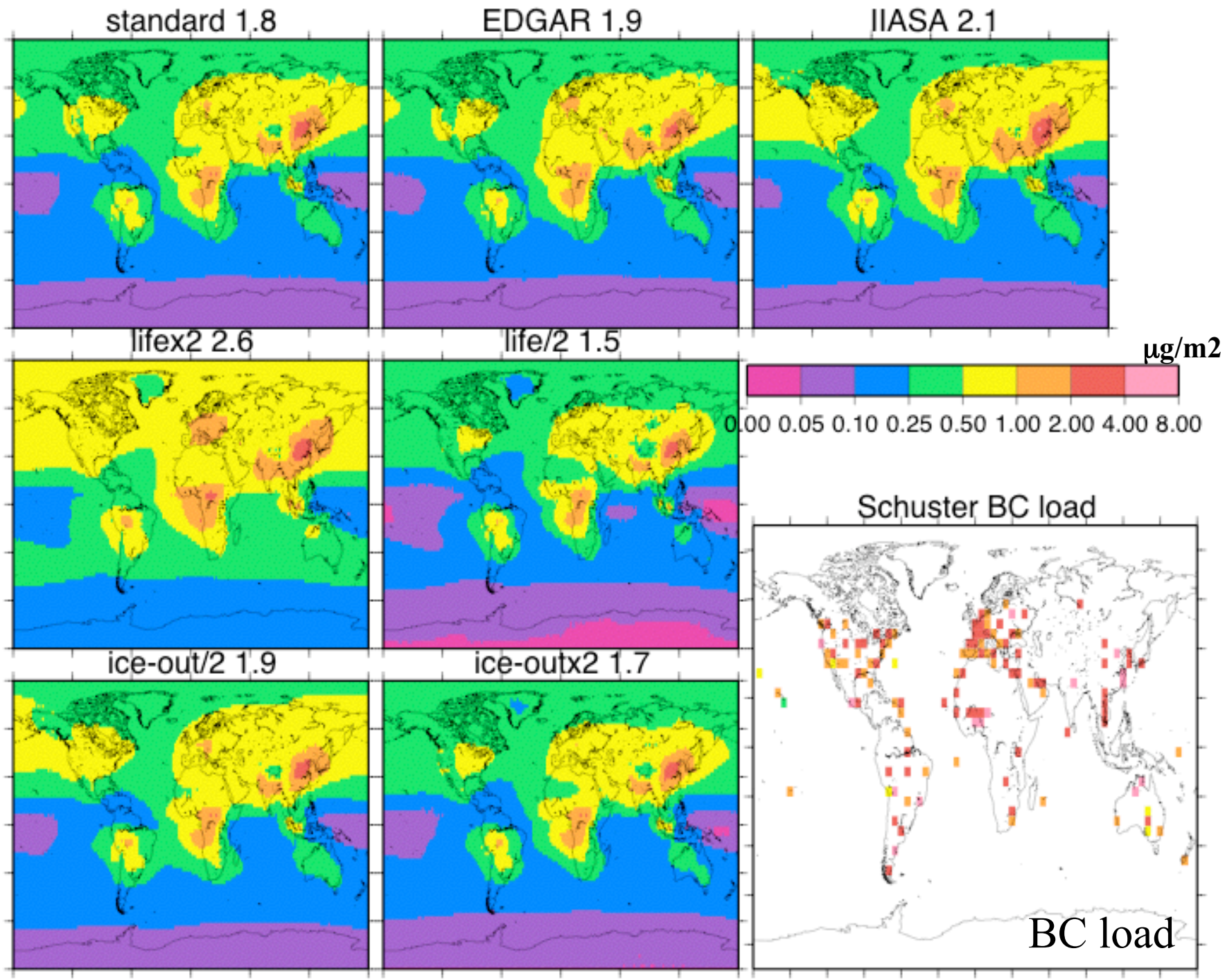
n AERO COM.	AAOD AER N Am 44	AAOD AER Eur 41	AAOD AER Asia 11	AAOD AER S Am 7	AAOD AER Afr 5	AAOD AER other 40	AAOD OMI N Am	AAOD OMI Eur	AAOD OMI Asia	AAOD OMI S Am	AAOD OMI Afr	AAOD OMI ROW
GISS	1.0	0.83	0.49	0.59	0.35	0.88	0.73	1.4	0.74	0.29	0.40	0.28
ARQM	0.79	0.36	0.30	0.42	0.25	0.44	0.50	0.61	0.40	0.22	0.23	0.19
CAM												
GOCART												
KYU	1.4	0.48	0.44	1.8	1.2	0.64	0.76	0.69	0.59	0.83	1.3	0.28
LOA	0.57	0.56	0.42	0.44	0.70	0.44	0.32	0.95	0.44	0.25	0.48	0.18
LSCE	0.42	0.55	0.48	0.20	0.18	0.34	0.29	1.1	0.51	0.11	0.21	0.16
MATCH												
MOZGN	1.5	1.3	0.99	0.60	0.60	0.77	0.82	2.6	1.4	0.32	0.40	0.35
MPIHAM	0.39	0.21	0.29	0.43	0.35	0.21	0.21	0.29	0.32	0.22	0.35	.082
PNNL	0.73	0.55	0.49	0.76	0.78	0.42	0.35	0.91	0.48	0.41	0.58	0.20
TM5	0.41	0.32	0.29	0.24	0.20	0.31	0.21	0.48	0.31	0.12	0.22	0.11
UIOCTM	0.62	0.67	0.46	1.1	0.61	0.57	0.37	1.1	0.53	0.57	0.54	0.19
UIOGCM	1.3	1.1	0.75	0.82	0.54	0.80	0.82	1.8	1.0	0.46	0.42	0.36
UMI	0.32	0.29	0.29	0.21	0.21	0.22	0.17	0.44	0.28	0.095	0.19	0.086
ULAQ	1.4	2.6	2.1	1.1	0.52	1.1	1.1	6.7	1.5	0.62	0.48	0.71
Ave	0.82	0.75	0.60	0.67	0.51	0.52	0.50	1.5	0.64	0.35	0.45	0.24

Most models are smaller than retrieved, except in Europe (> OMI)

Models too small in Asia and biomass burning regions



AeroCom BC load


standard 1.8
EDGAR 1.9
IIASA 2.1
lifex2 2.6
life/2 1.5
µg/m2
0.00 0.05 0.10 0.25 0.50 1.00 2.00 4.00 8.00
Schuster BC load
ice-out/2 1.9
ice-outx2 1.7
BC load

	BC Load Nam 43	BC Load Eur 49	BC Load Asia 10	BC Load S Am 9	BC Load Afr 5	BC Load ROW 54
Std	0.29	0.35	0.49	0.22	0.22	0.17
EDGAR	0.30	0.37	0.45	0.21	0.22	0.20
IIASA	0.33	0.38	0.60	0.21	0.23	0.21
Lifex2	0.38	0.43	0.56	0.27	0.29	0.24
Life/2	0.25	0.30	0.43	0.21	0.20	0.14
Ice/2	0.31	0.36	0.50	0.23	0.23	0.18
Ice x 2	0.27	0.32	0.46	0.22	0.21	0.16

BC load assessment: model/observed

	BC Load N Am 42	BC Load Eur 49	BC Load Asia 10	BC Load S Am 9	BC Load Afr 4	BC Load ROW 56
GISS	0.31	0.25	0.52	0.30	0.76	0.42
ARQM	0.40	0.39	0.49	0.38	0.38	0.34
CAM	0.28	0.32	0.42	0.42	0.37	0.26
GOCART	0.47	0.63	0.72	0.42	0.71	0.32
KYU	1.1	1.1	0.81	0.53	2.1	0.56
LOA	0.25	0.33	0.37	0.26	0.63	0.35
LSCE	0.29	0.52	0.72	0.28	0.29	0.30
MATCH	0.30	0.38	0.35	0.49	0.47	0.29
MOZGN	0.58	0.70	0.86	0.35	0.50	0.37
MPIHAM	0.19	0.17	0.41	0.30	0.36	0.17
PNNL	0.26	0.31	0.37	0.44	0.63	0.30
TM5	0.27	0.23	0.42	0.24	0.31	0.19
UIOCTM	0.25	0.37	0.43	0.38	0.78	0.42
UIOGCM						
UMI	0.25	0.56	0.71	0.43	0.36	0.23
ULAQ	0.33	1.5	1.5	0.41	0.30	0.69
Ave	0.37	0.52	0.60	0.37	0.60	0.35

Model bias is generally worst in N. Am., S. Am., and ROW

Survey

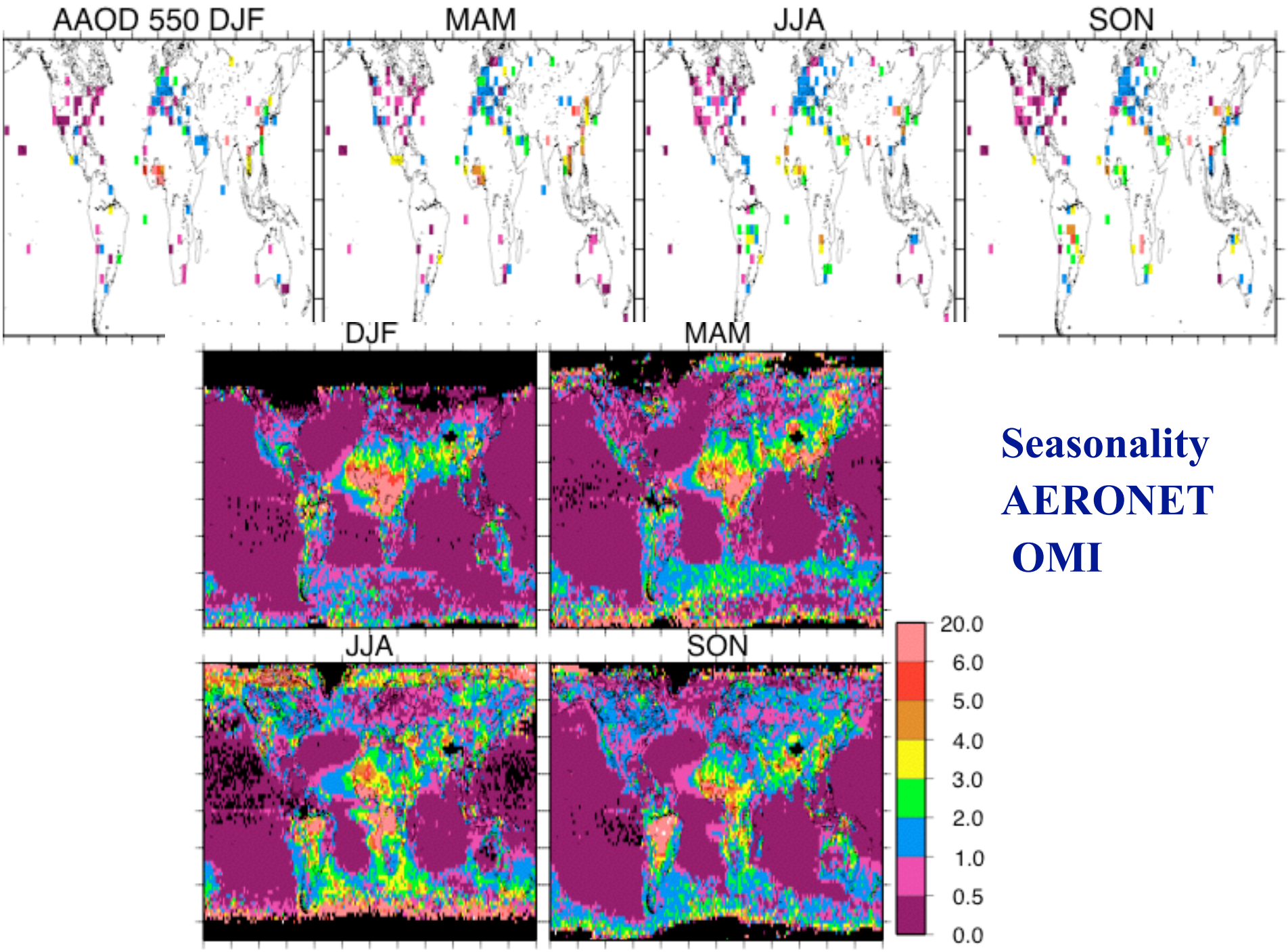
- Emissions
  - Energy
  - Biomass burning
- Treatment of aging
  - Explicit aging rate, fixed solubility or chemical microphysics?
  - Any aging effects on optics (e.g. RH effect or chemical/microphysical effect)?
- Treatment of ice/snow removal
- BC density
- (Initial) particle size
- Refractive index

Conclusions: Average model compared to observations in regions

- Europe:
  - 2.8 surface concentration
  - 1.5 OMI AAOD
  - 0.75 AERONET AAOD
  - 0.5 Load - Schuster
- North America:
  - 0.8 surface concentration and AERONET AAOD
  - 0.5 OMI AAOD
  - 0.4 Load Schuster
- Asia:
  - 1.6 surface concentration
  - 0.6 AAOD OMI, AAOD AERONET, Schuster BC load
- South America (no surface concentration data)
  - 0.7 AERONET AAOD
  - 0.4 OMI AAOD, Schuster BC load
- Africa (no surface concentration data)
  - 0.5 to 0.6

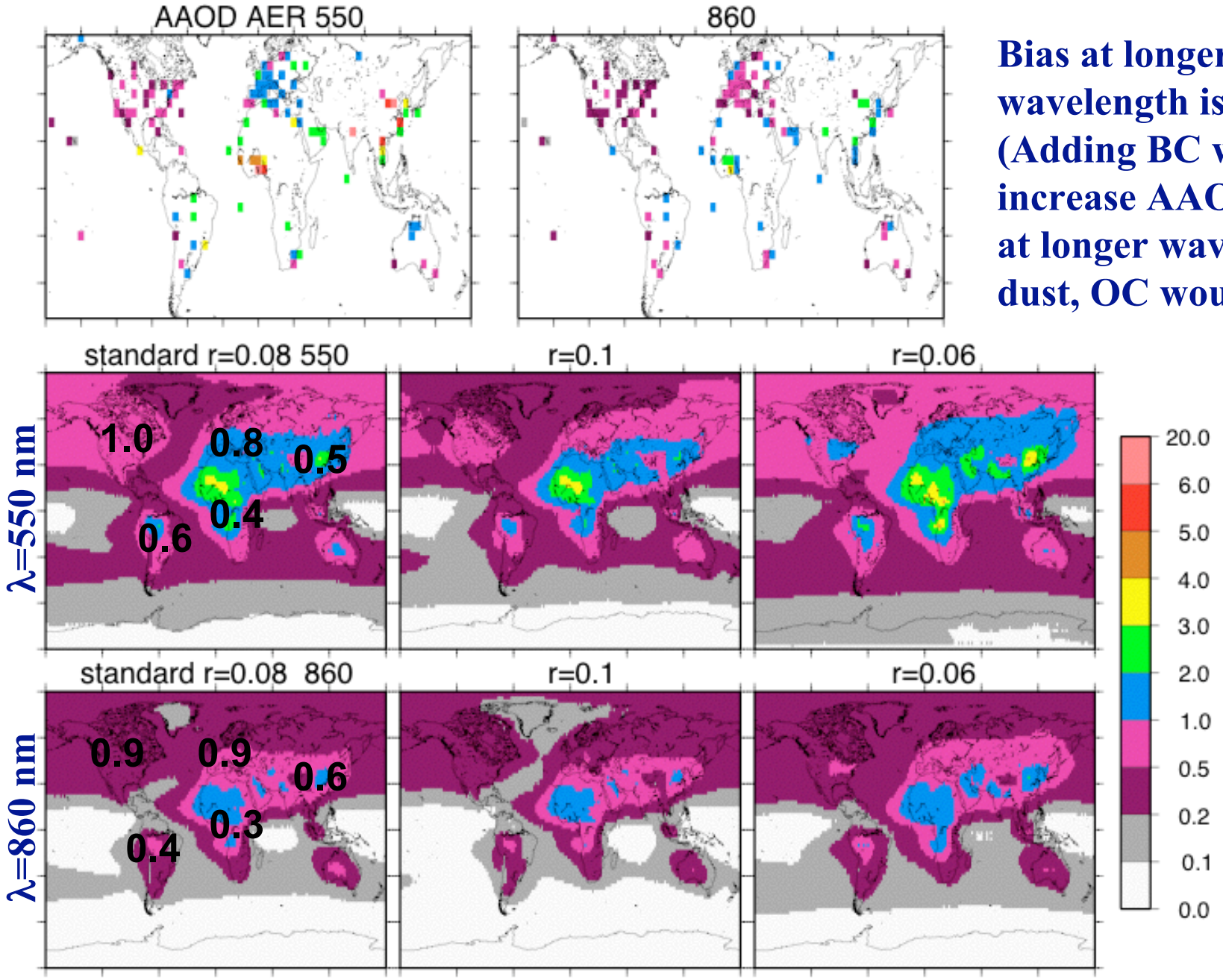
Conclusions

- **To some extent bias differences to the datasets (OMI, AERONET, surface concentrations) may be from different observational periods. I will check for observational trends.**
- **Models tend to have surface amount too large but column amount too small. Problem with removal or vertical transport…?**
- **OMI AAOD indicates larger AAOD over southern oceans, Southern Asia, biomass burning regions than in models**
- **Standard deviation among models is larger than the mean in northern Eurasia and parts of the Arctic**
- **The GISS sensitivity studies do not span the range of AeroCom model results. Suggests major differences in transport/removal, as well as effects of aerosol microphysics in some of the models.**



Seasonality
AERONET
OMI

Wavelength dependence, AAOD



Bias at longer wavelength is similar. (Adding BC would increase AAOD more at longer wavelengths; dust, OC would not)