Urban Air Pollution, Tropospheric Chemistry, and Climate Change: An Integrated Modeling Study

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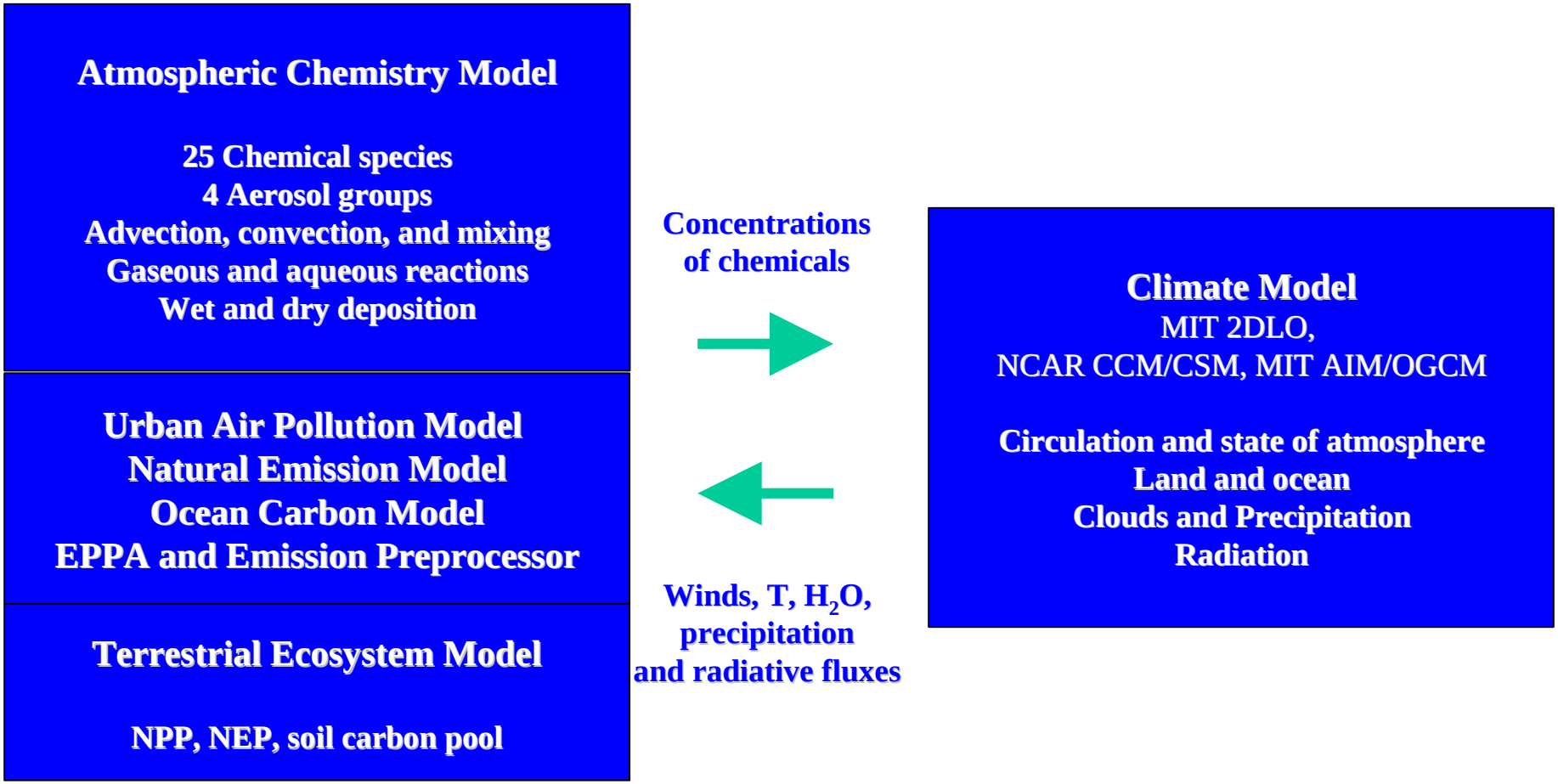
Linking Urban Pollution, Tropospheric Chemistry and Climate Change

- *Impact of urban air pollution on global tropospheric chemistry and climate (e.g., tropospheric O_3 and NO_x budgets, radiative forcing by O_3 and aerosols);*
- *Impact of future climate change on urban air pollution and tropospheric chemistry (e.g., effects of clouds, UV, precipitation, H_2O, and temperature on reaction rates);*
- *Interaction between urban/tropospheric chemistry and climate under various emissions policies;*
- *Anthropogenic aerosols' impact on human health;*
- *Impact of air pollution and climate change on natural ecosystems*

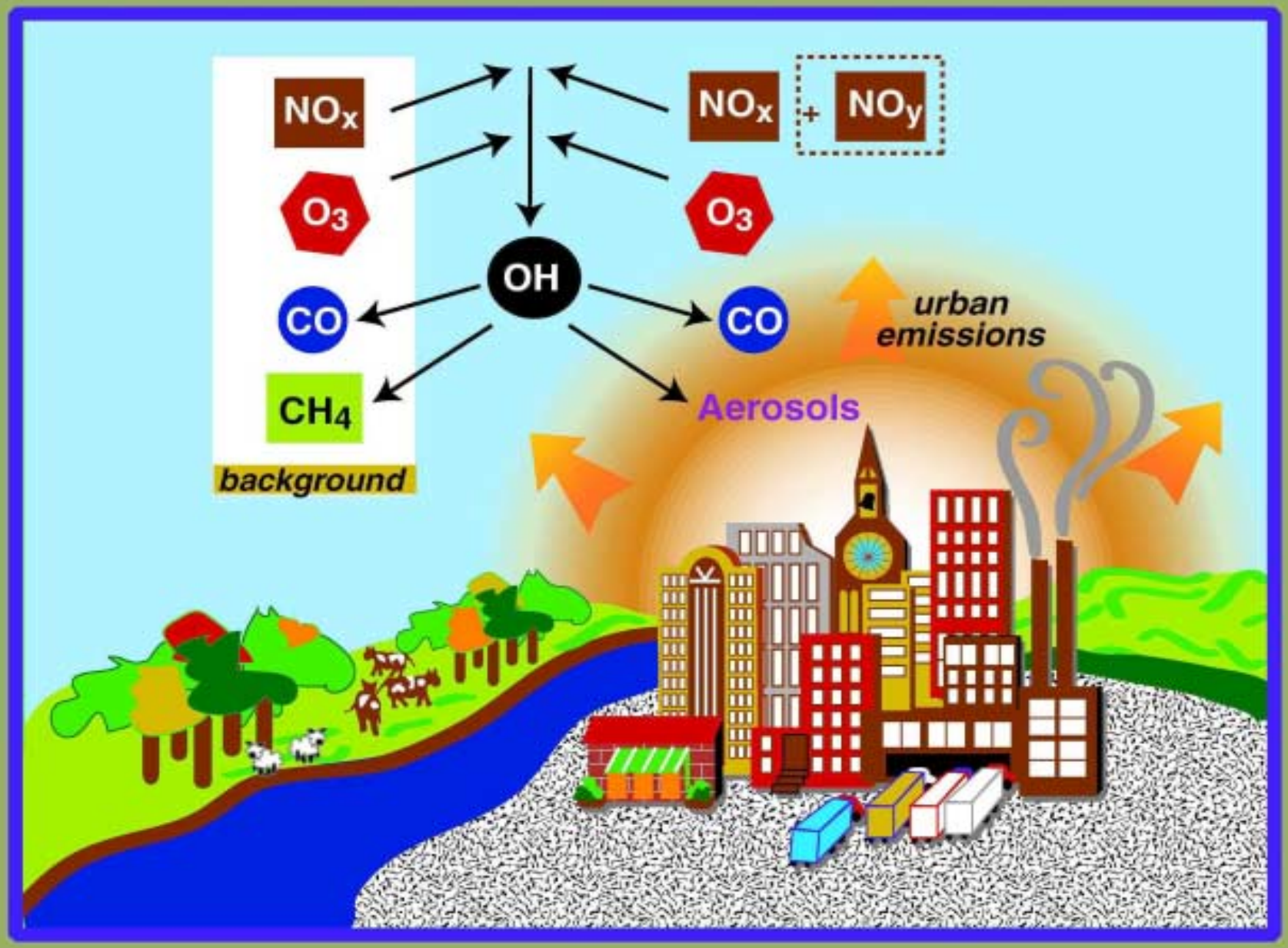
Integrated Modelling Study

- *Climate-chemistry interactions require models with integrated components of atmosphere, ocean, tropospheric chemistry, emissions (policy and non-policy), and ecosystem;*
- *Integration time: $\geq$10 years for tropospheric chemistry studies (primarily due to CH_4 and O_3 simulation as well as aerosol forcing assessment), $\geq$100 years for tropospheric chemistry and climate interaction studies;*
- *Subgrid scale nature of urban and fast tropospheric chemistry as well as lightning production of certain chemical species in current global models with resolution coarser than ~100 km requires adequate parameterizations for relevant processes;*
- *Data base (measurement and emissions);*
- *Computational efficiency (parallel, esp. distributed memory computing)*

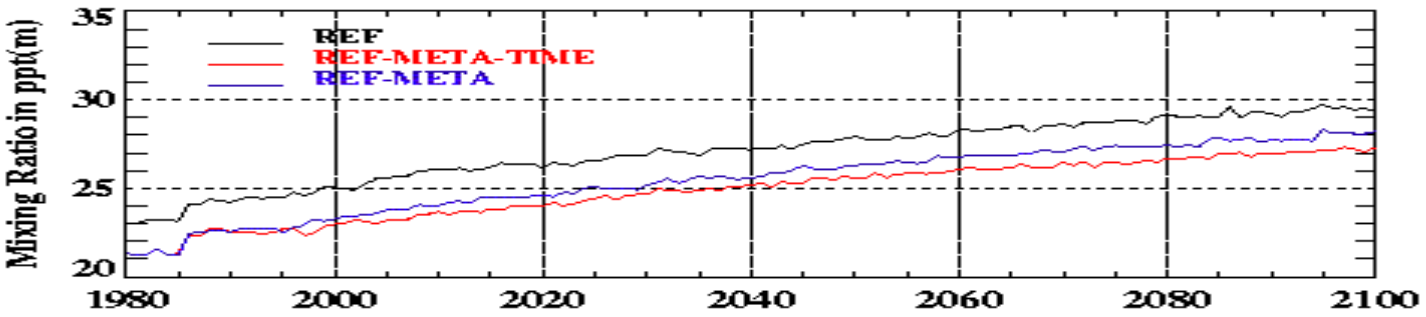
MIT Interactive Chemistry-Climate Model



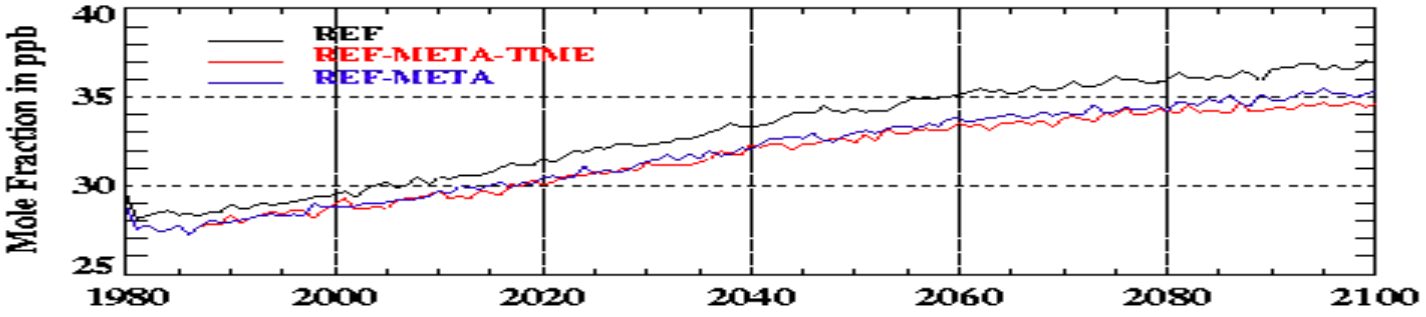
Urban Air Pollution Model and Global Chemistry Model



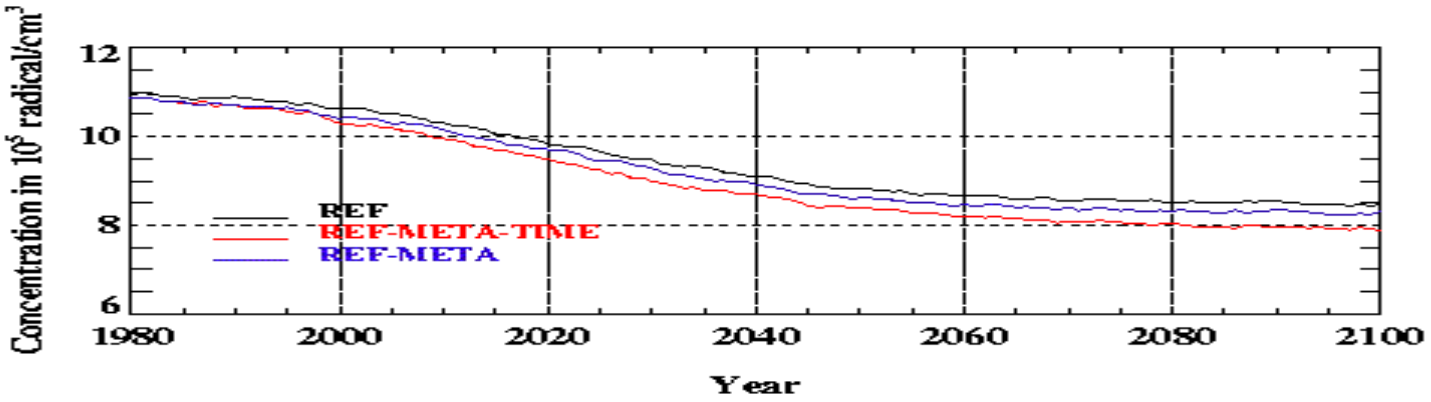
Tropospheric Averaged Mixing Ratio of NOx



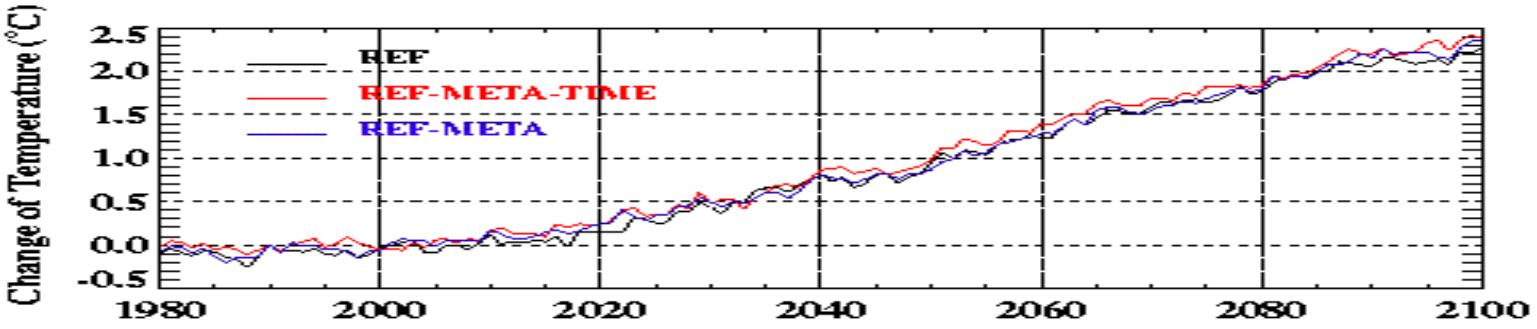
Tropospheric Averaged Mole Fraction of O_3



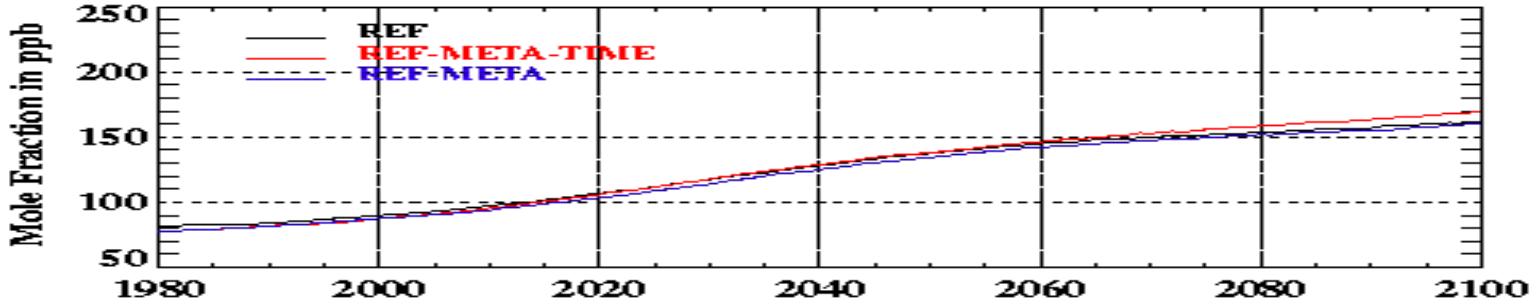
Tropospheric Averaged Concentration of OH



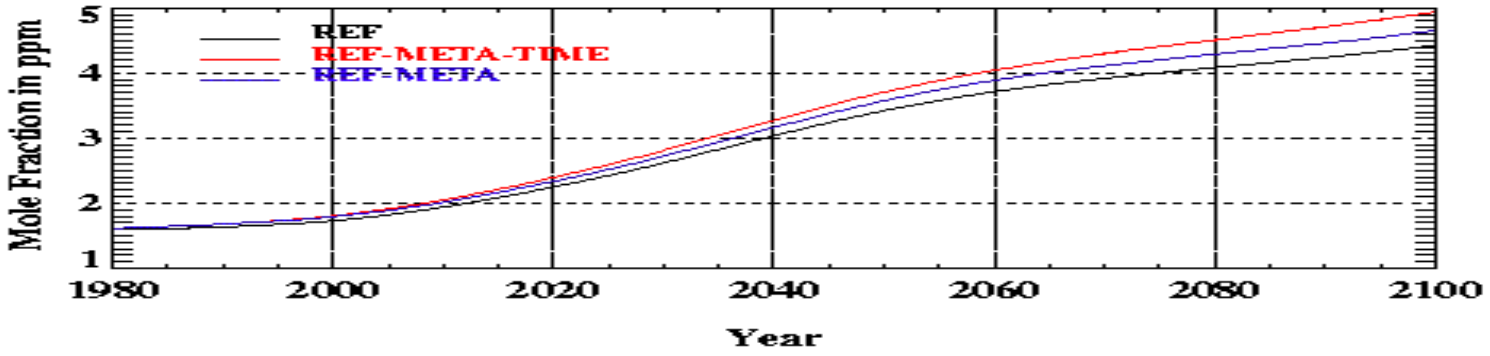
Change of Annual-Mean Global Surface Temperature



Tropospheric Averaged Mole Fraction of CO

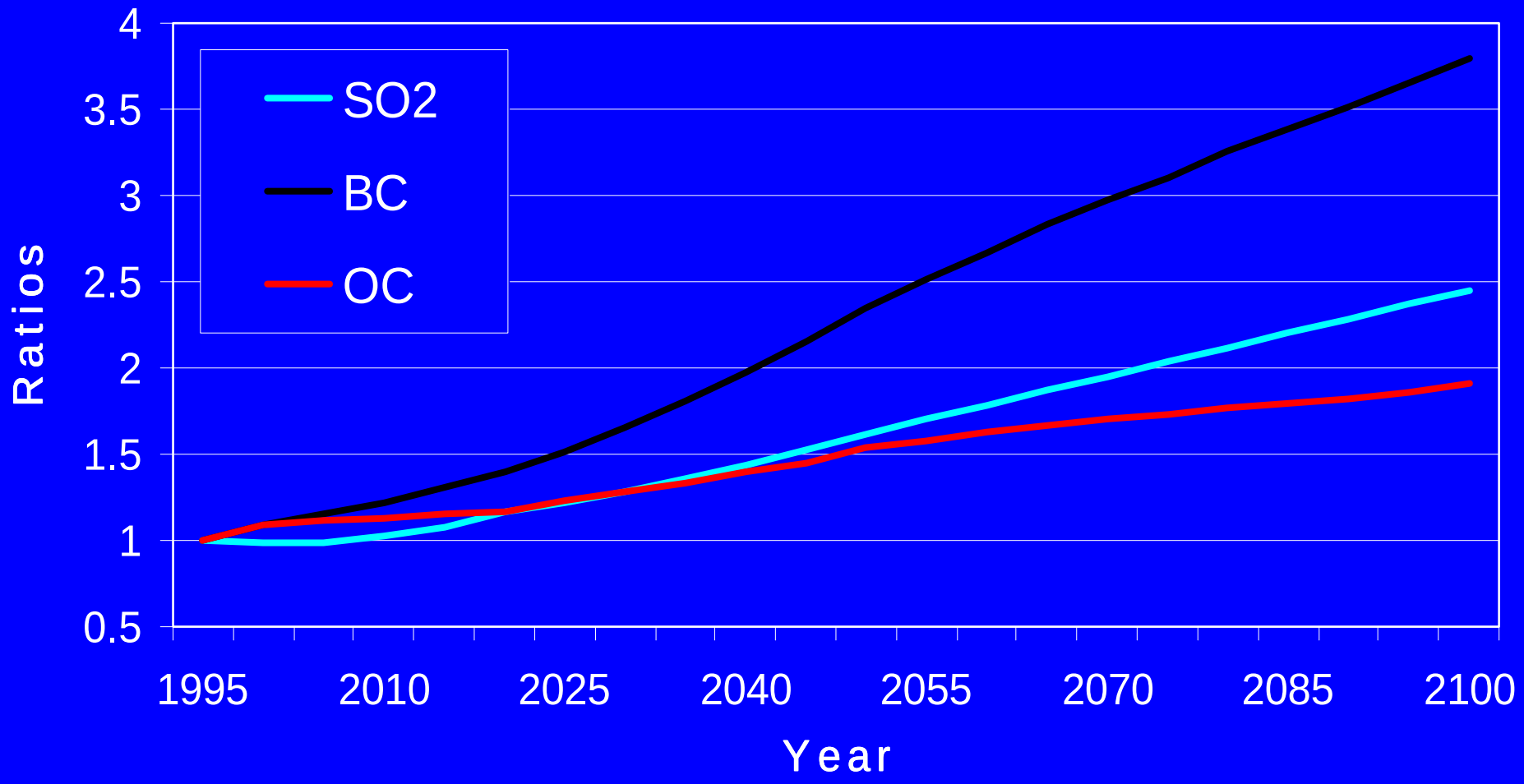


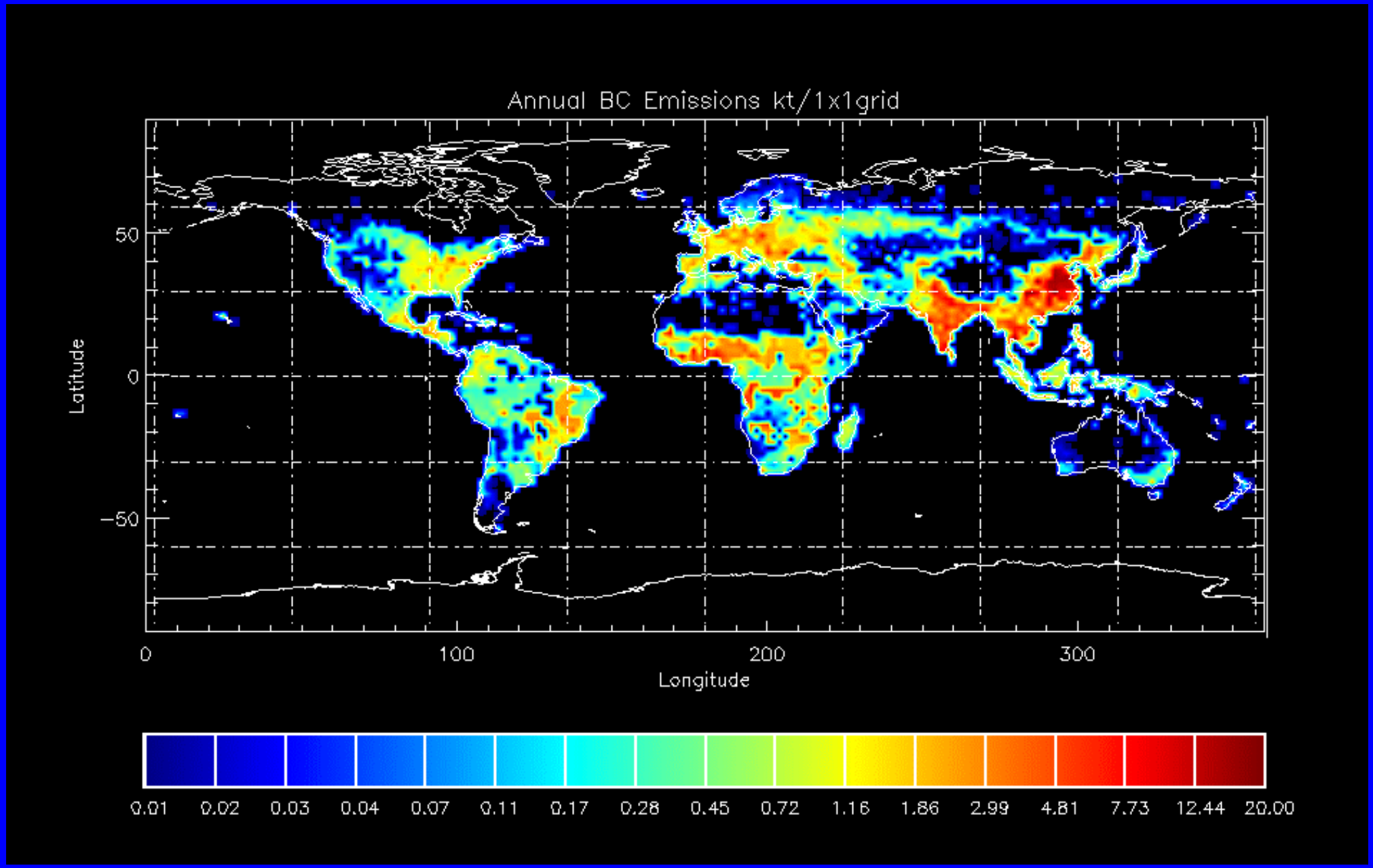
Tropospheric Averaged Mole Fraction of CH_4

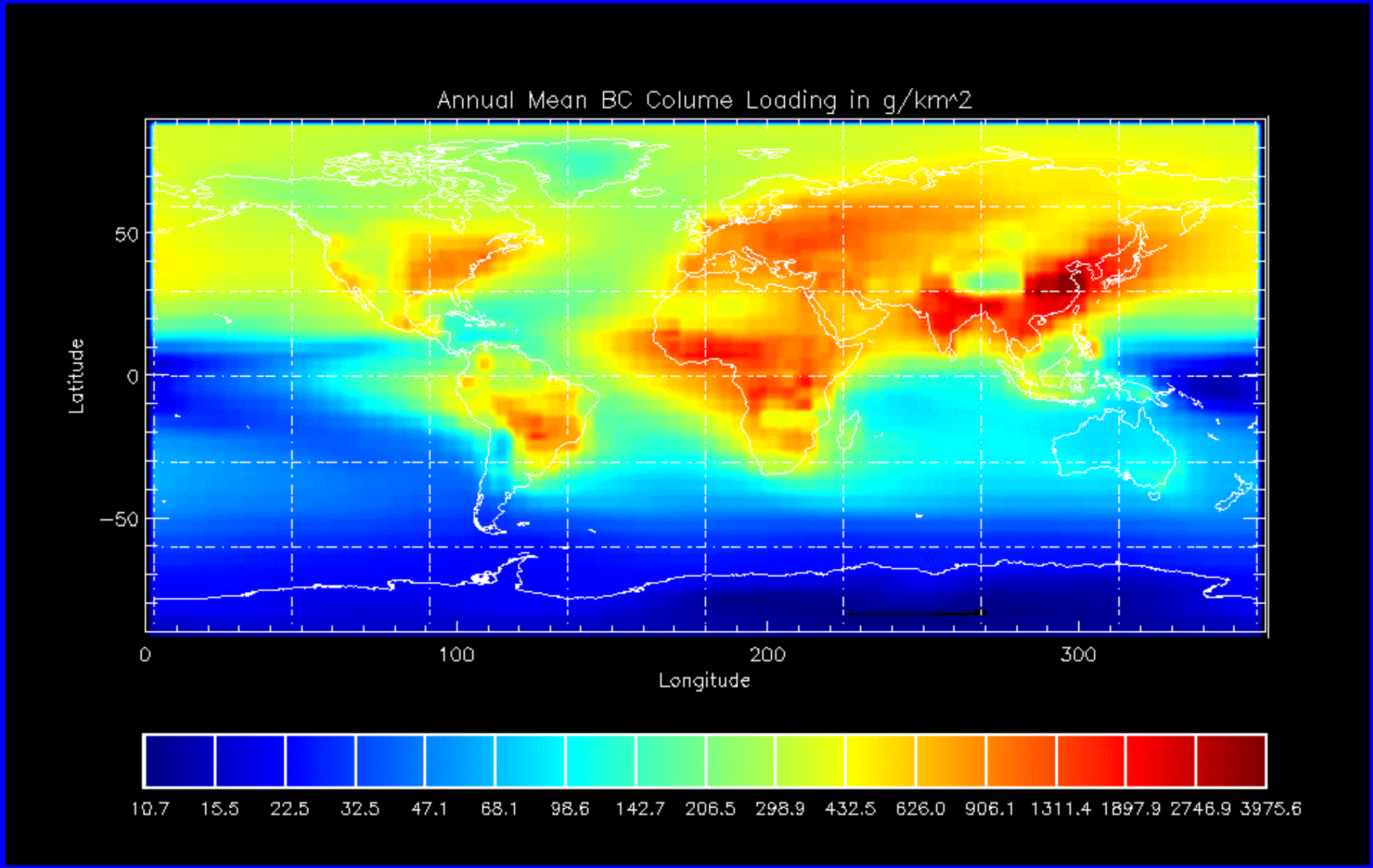


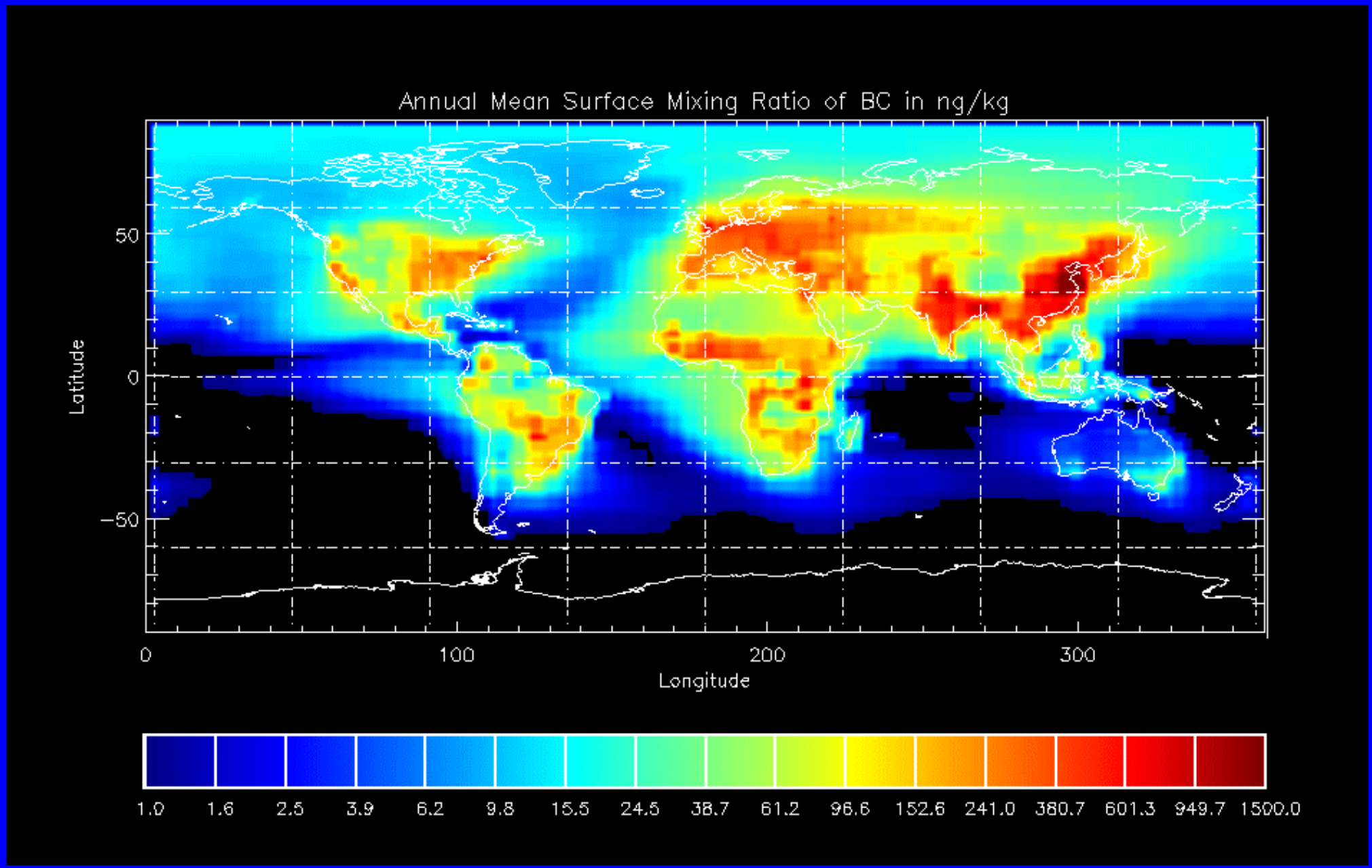
Projected Future Increases of Emissions

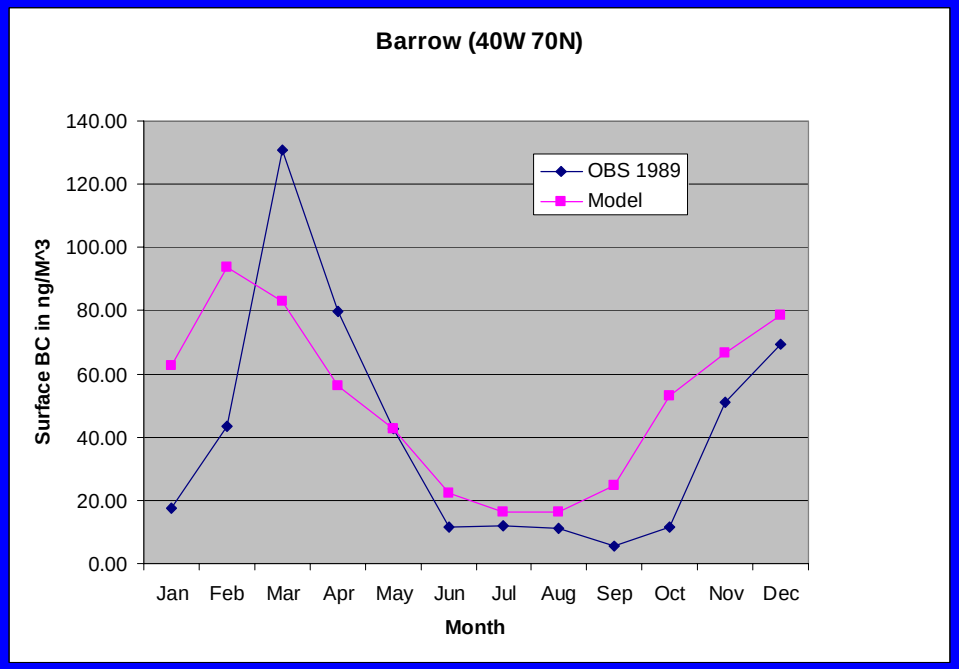
(Emissions/Emissions of 1995; MIT EPPA)

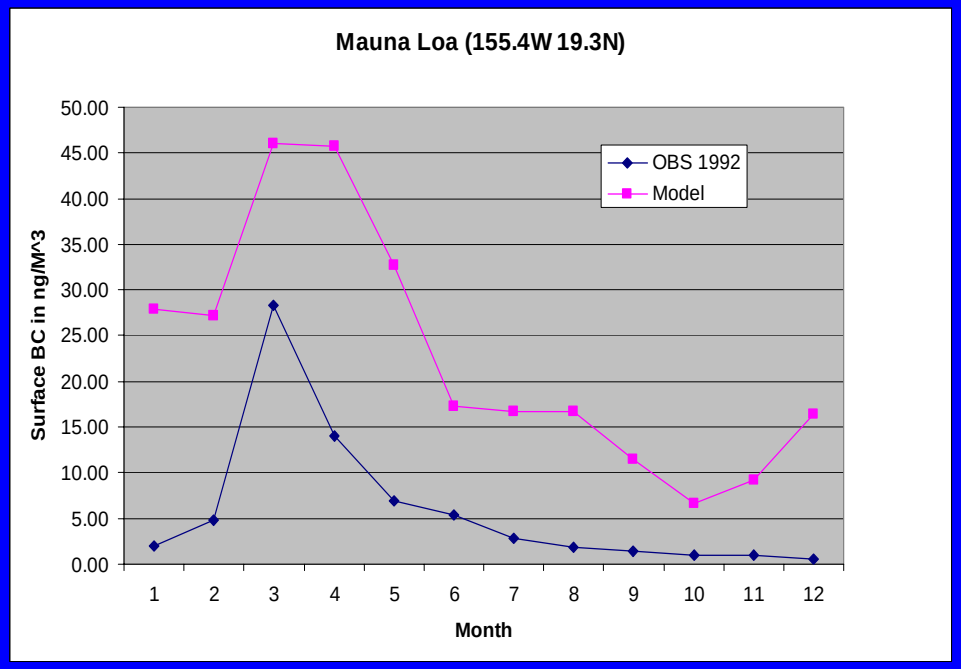


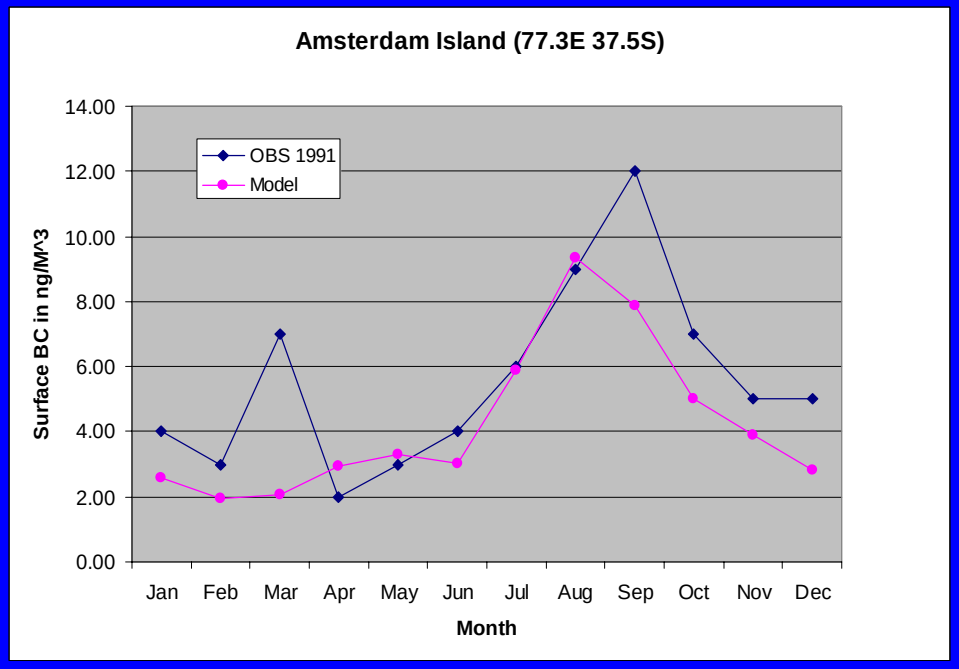

Annual BC Emissions kt/1x1grid
50
0
−50
Latitude
0
100
200
300
Longitude
0.01
0.02
0.03
0.04
0.07
0.11
0.17
0.28
0.45
0.72
1.16
1.86
2.99
4.81
7.73
12.44
20.00

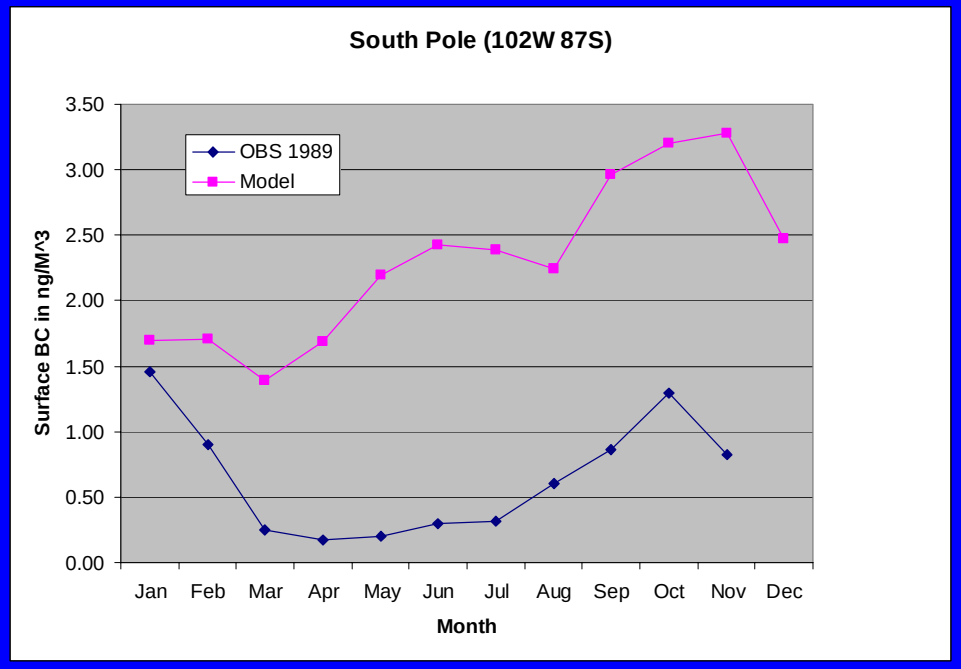

Annual Mean BC Colume Loading in g/km^2
50
0
−50
Latitude
0
100
200
300
Longitude
10.7
15.5
22.5
32.5
47.1
68.1
98.6
142.7
206.5
298.9
432.5
626.0
906.1
1311.4
1897.9
2746.9
3975.6

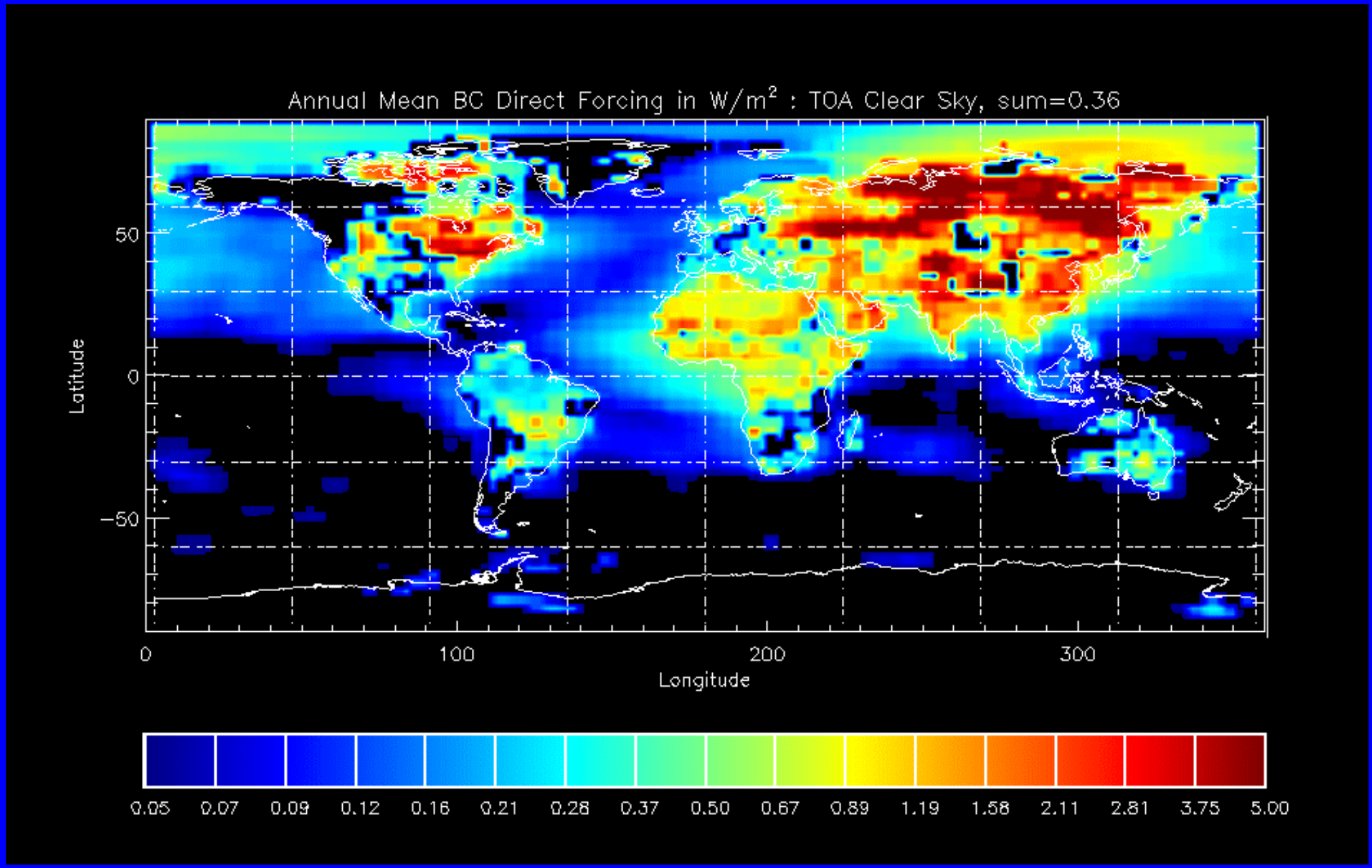

Annual Mean Surface Mixing Ratio of BC in ng/kg
50
0
−50
Latitude
0
100
200
300
Longitude
1.0
1.6
2.5
3.9
6.2
9.8
15.5
24.5
38.7
61.2
96.6
152.6
241.0
380.7
601.3
949.7
1500.0

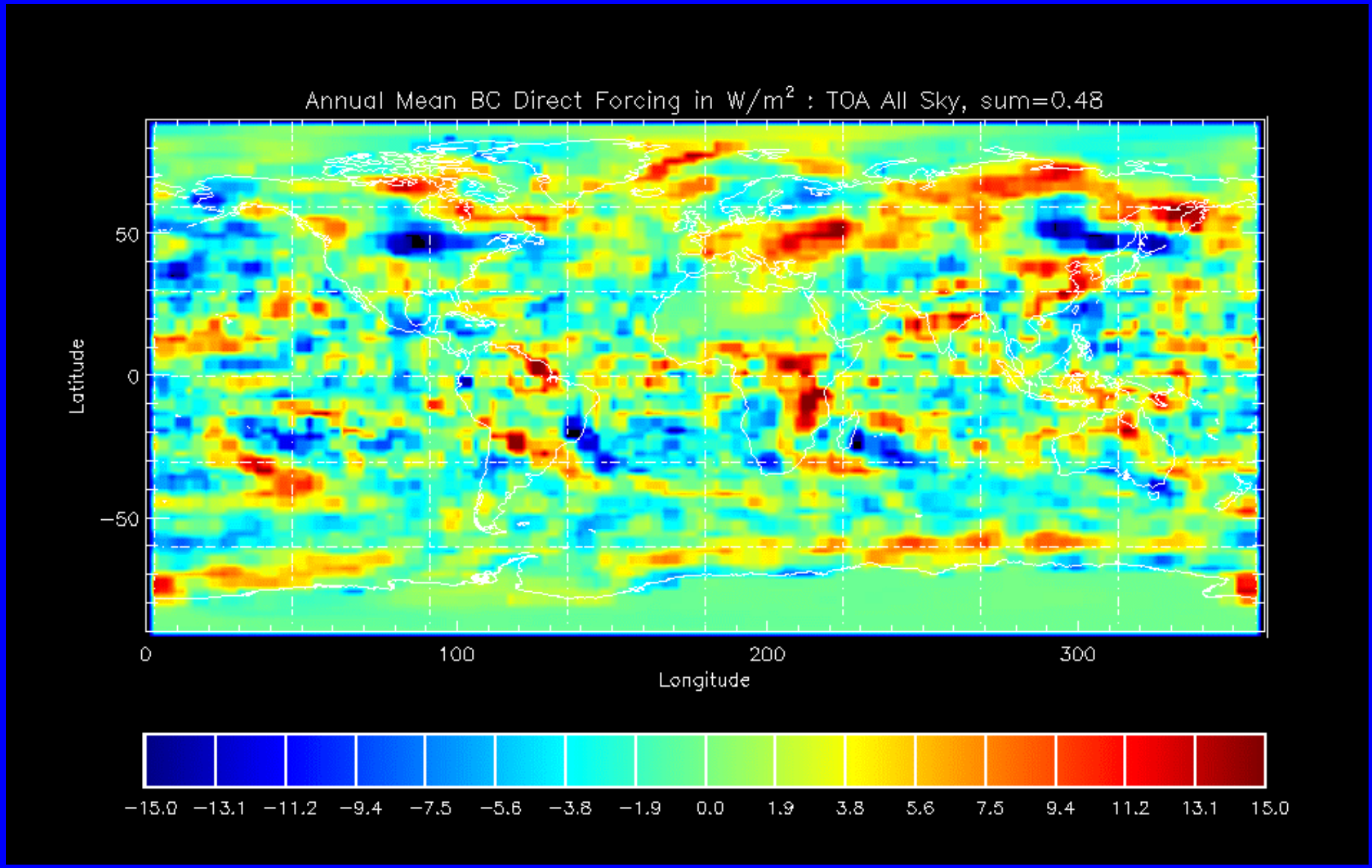

Barrow (40W 70N)
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Surface BC in ng/M^3
OBS 1989
Model
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

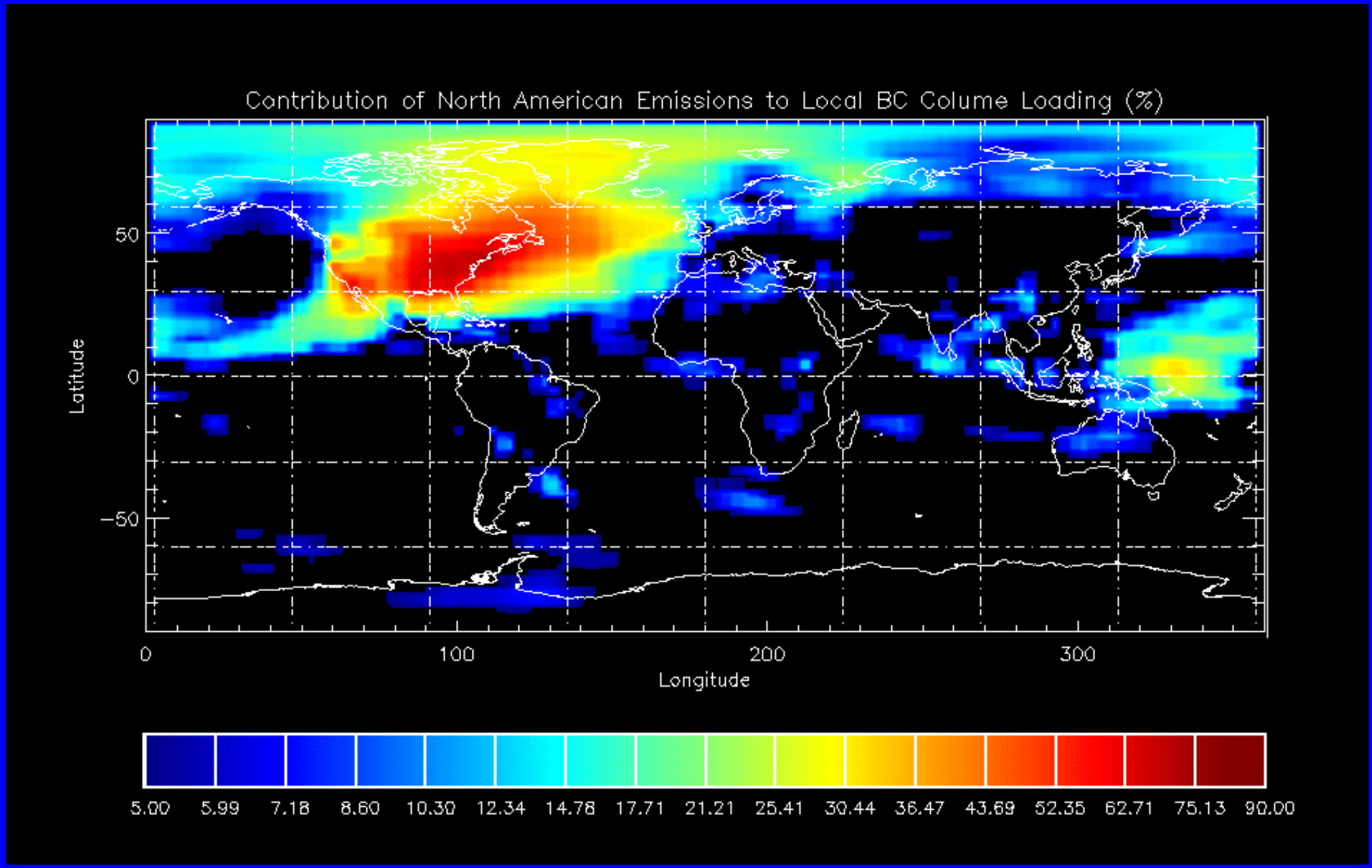

Mauna Loa (155.4W 19.3N)
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Surface BC in ng/M^3
OBS 1992
Model
1
2
3
4
5
6
7
8
9
10
11
12
Month


Amsterdam Island (77.3E 37.5S)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Surface BC in ng/M^3
OBS 1991
Model
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month


South Pole (102W 87S)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Surface BC in ng/M^3
OBS 1989
Model
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month


Annual Mean BC Direct Forcing in W/m^2 : TOA Clear Sky, sum=0.36
50
0
−50
Latitude
0
100
200
300
Longitude
0.05
0.07
0.09
0.12
0.16
0.21
0.28
0.37
0.50
0.67
0.89
1.19
1.58
2.11
2.81
3.75
5.00


Annual Mean BC Direct Forcing in W/m² : TOA All Sky, sum=0.48
Latitude
50
0
−50
0
100
200
300
Longitude
−15.0 −13.1 −11.2 −9.4 −7.5 −5.6 −3.8 −1.9 0.0 1.9 3.8 5.6 7.5 9.4 11.2 13.1 15.0


Contribution of North American Emissions to Local BC Colume Loading (%)
50
0
−50
Latitude
0
100
200
300
Longitude
5.00
5.99
7.18
8.60
10.30
12.34
14.78
17.71
21.21
25.41
30.44
36.47
43.69
52.35
62.71
75.13
90.00

Summary

- ***Integrated models are needed for linking urban air pollution, tropospheric chemistry, and climate; required integration time varies from 10 - 100 years depending on the given topics;***
- ***Adequate parameterizations of urban scale air chemistry and other subgrid scale chemical processes in global models are critical to modeling results;***
- ***Future black carbon emissions may increase according to the MIT EPPA Model;***
- ***Modeled radiative forcing of aerosols is highly uncertain, multiple year integrations with uncertainty analyses are needed for assessment;***
- ***Policy and health issues related to urban air pollution and anthropogenic emissions of aerosols need to be explored and inclusion of interaction between tropospheric chemistry and climate change is important.***