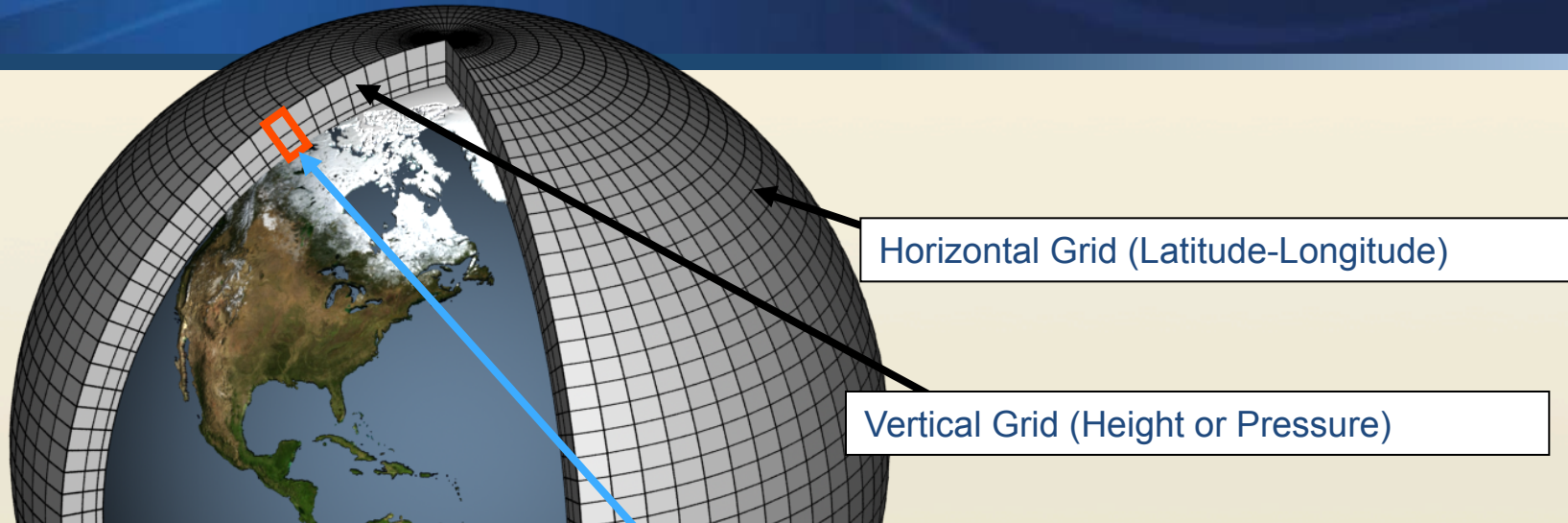
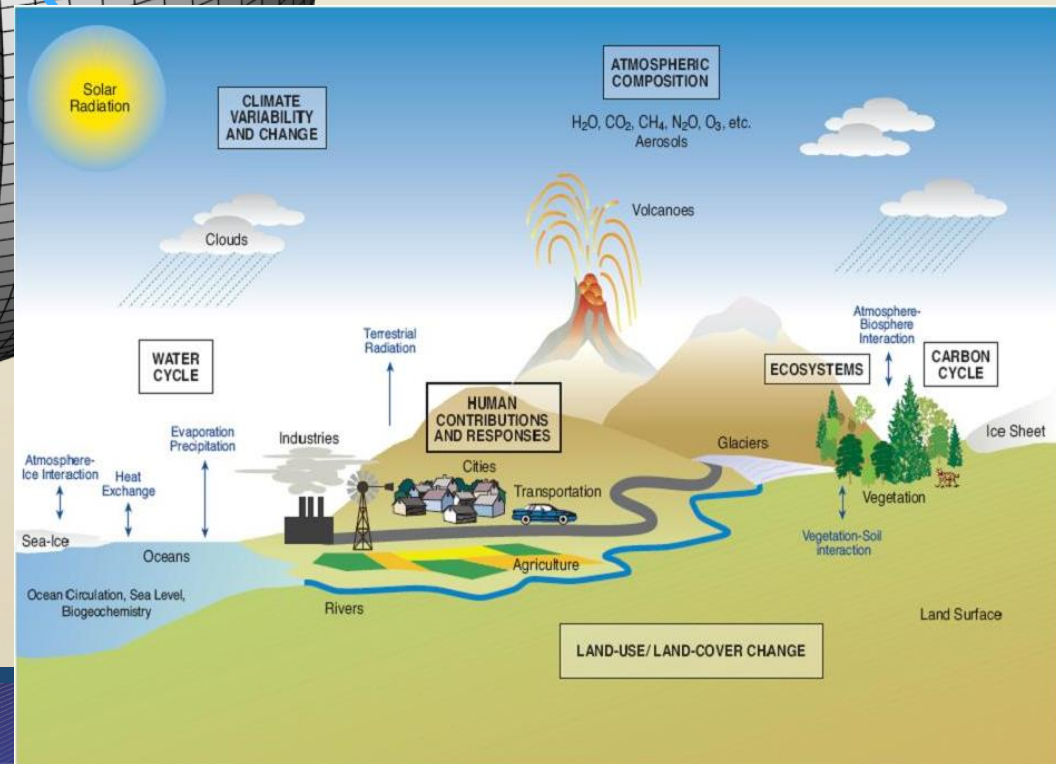


Schematic Global Climate Model



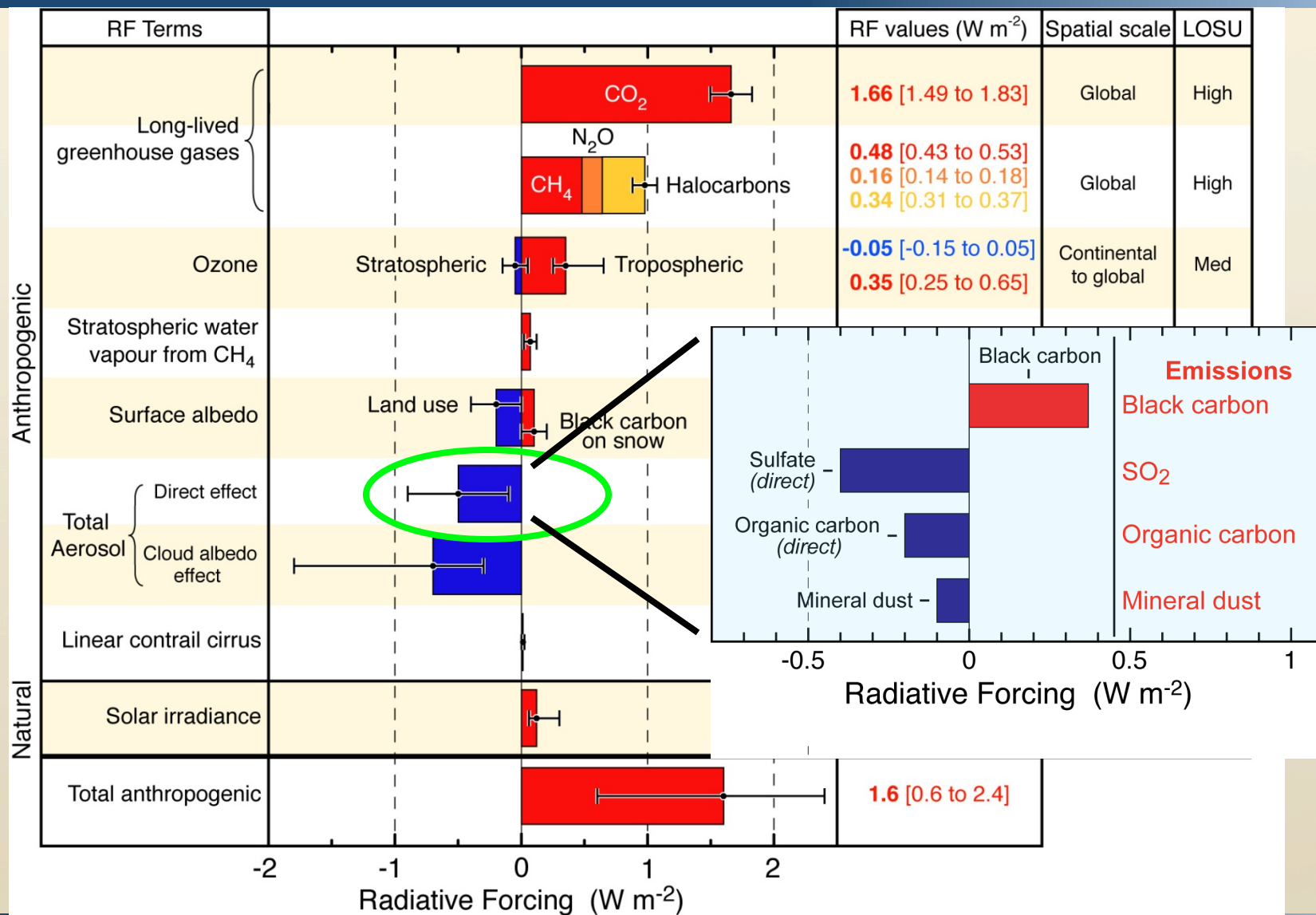
NOAA/ GFDL's CLIMATE and EARTH SYSTEM MODELING



Understanding the 20th C and 21st C Projected Climate Change

Radiative Forcing Components in 2005 [IPCC AR4, 2007]

(since preindustrial times, ca. 1750)

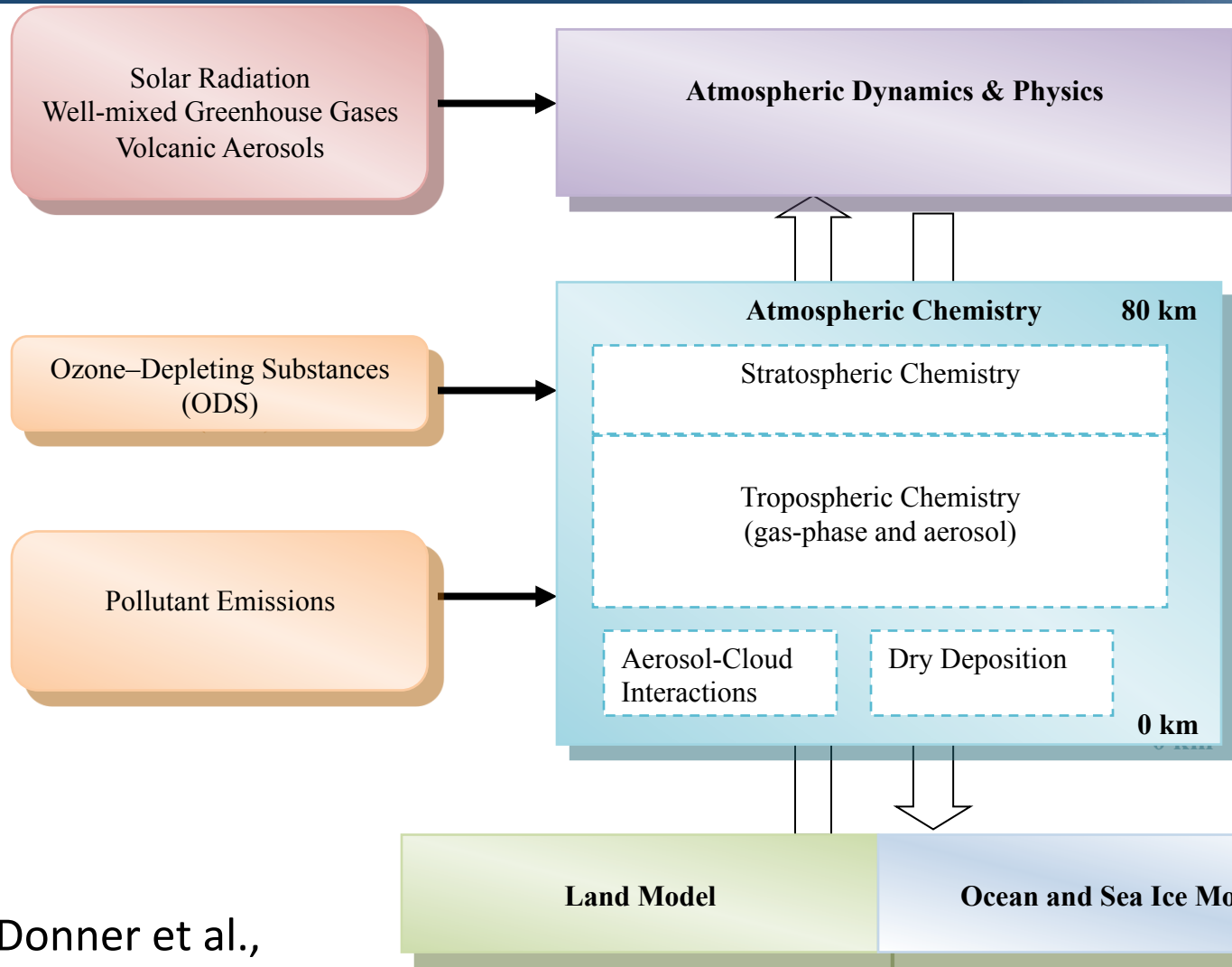


Results from

GFDL Climate Model CM3

[CMIP5; IPCC AR5 report, 2013]

CM3 Coupled Climate Model



- Cubed-sphere dynamical core
- ~200km horiz. resolution
- 48 vertical levels
- Updated moist physics

Donner et al.,
J. Climate, 2011

Aerosol-Cloud-Climate Interactions

"DIRECT" effects

"INDIRECT" effects

Clear Sky

Cloudy Sky



SW Radiation

Reflection

Reflection

Wet Particles

Droplets

Hygroscopic Growth

SW Radiation

Interstitial Aerosols

Activation

Advection

Emission

Advection

Emission

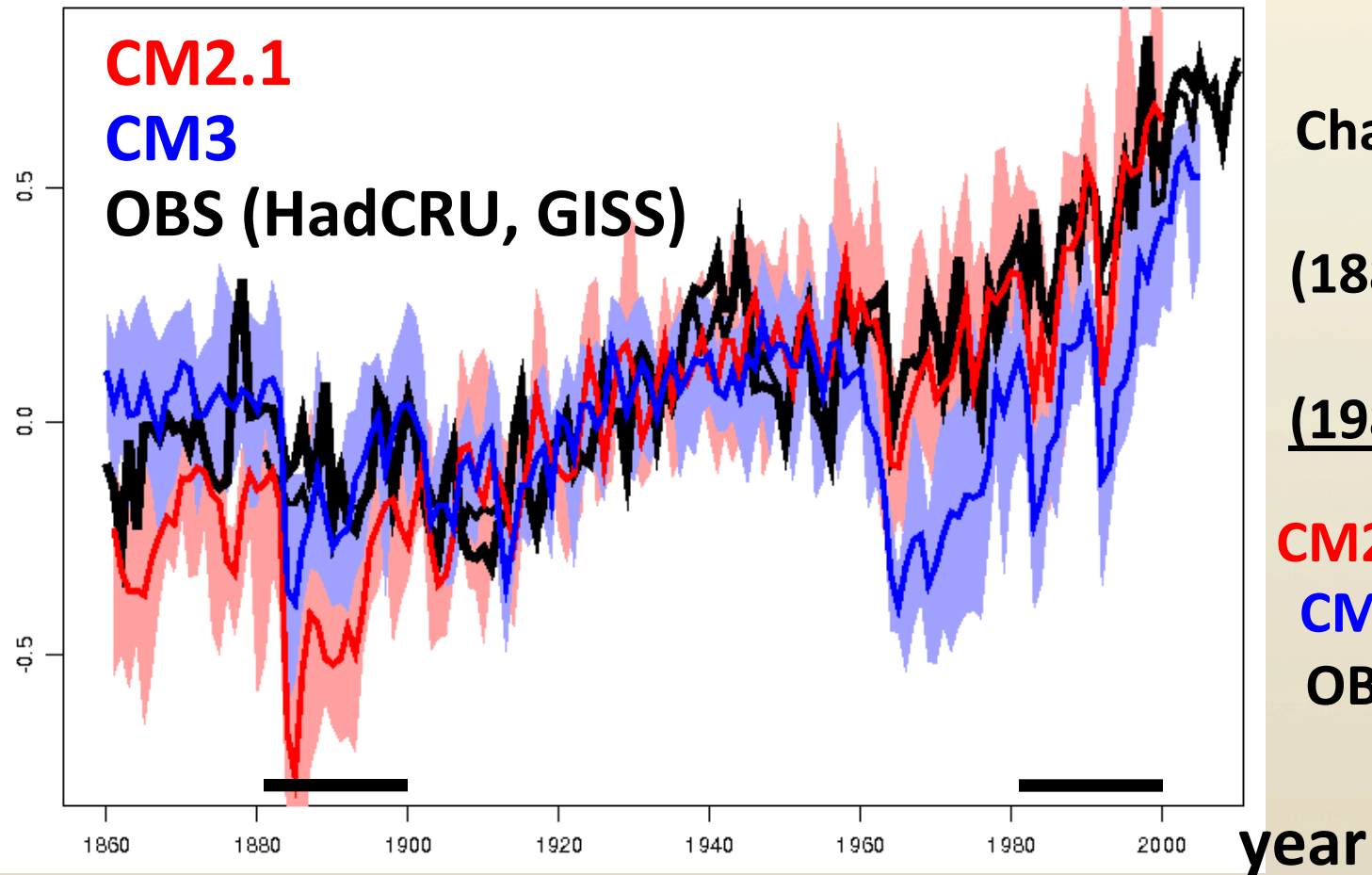
Land

Ocean

Land

Surface Air Temperature

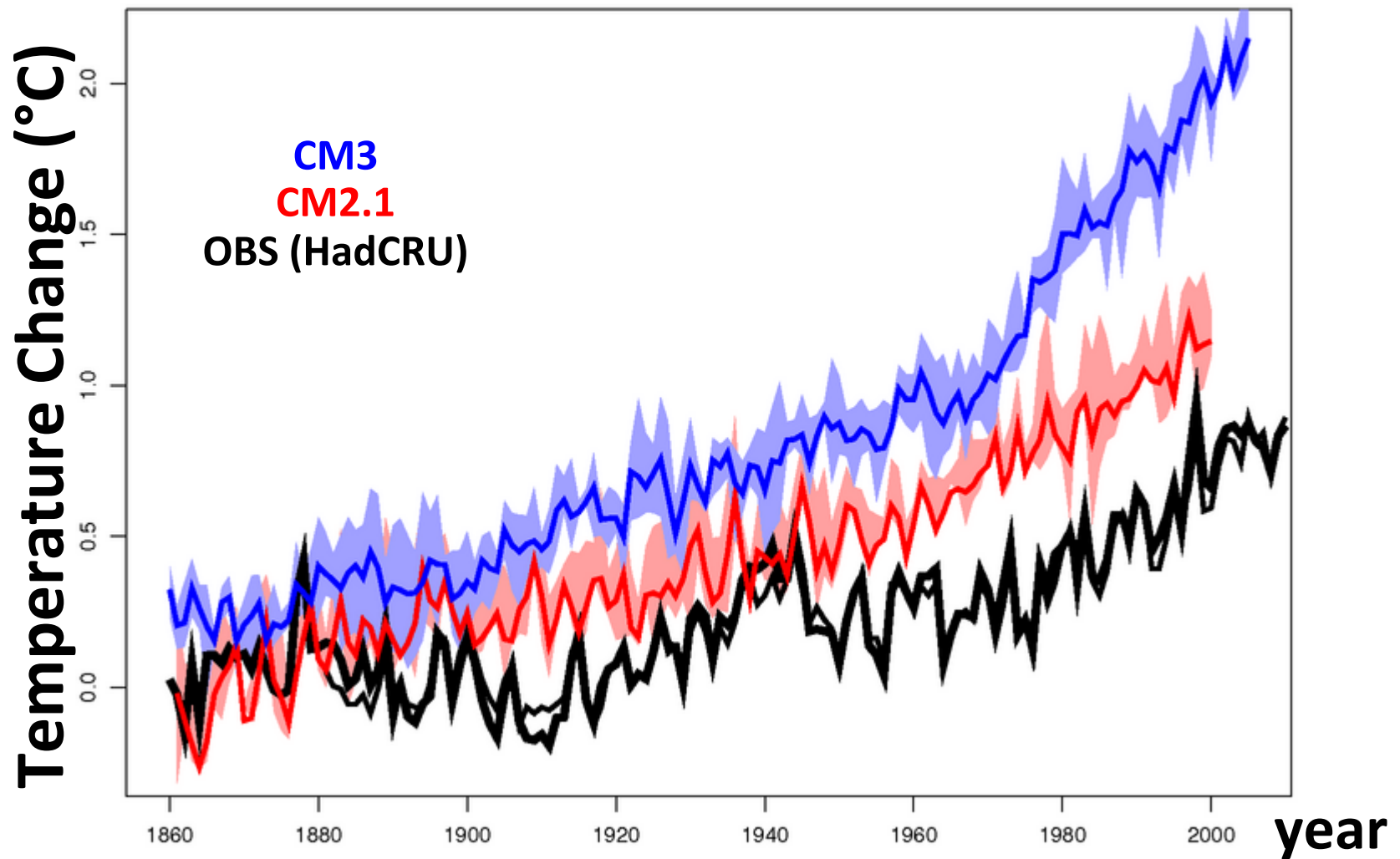
Temperature Change (°C)
versus (1901-1950)



Change (°C)
from
(1881-1900)
to
(1981-2000)

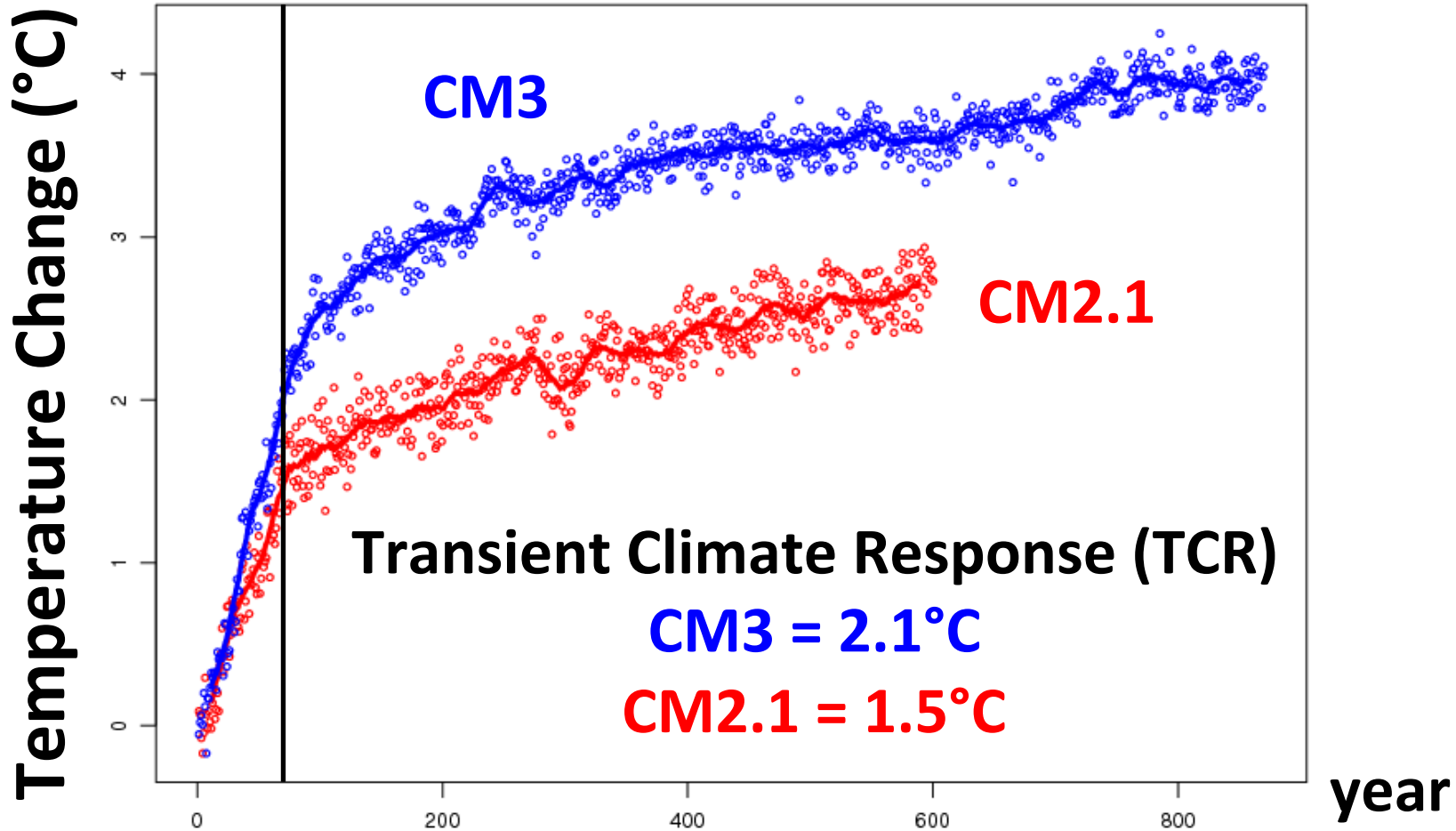
CM2.1 = 0.74
CM3 = 0.23
OBS = 0.51

Surface Air Temperature WMGG+O3 Forcings Only



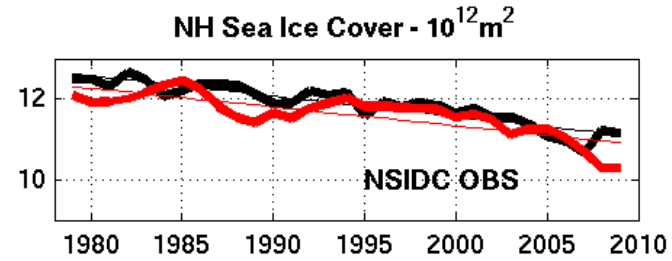
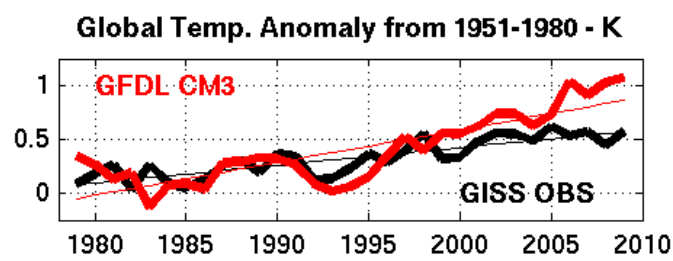
Climate Sensitivity

Response to idealized 1%/year increase in CO₂

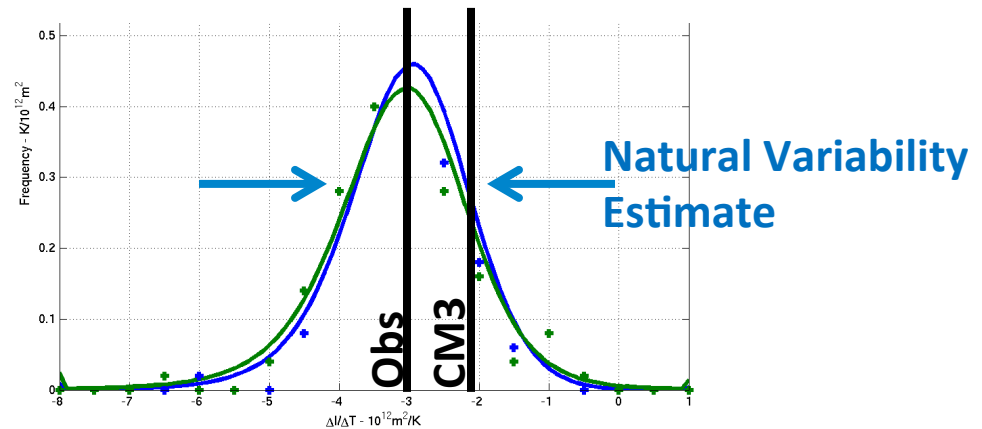


TCR in **CM3** is ~40% greater than that in **CM2.1**

CM3 has more sensitive NH sea ice cover than *any* other AOGCM (more area loss per degree global warming)



... but obs indicate even more sensitivity than in CM3, possibly due to natural variability

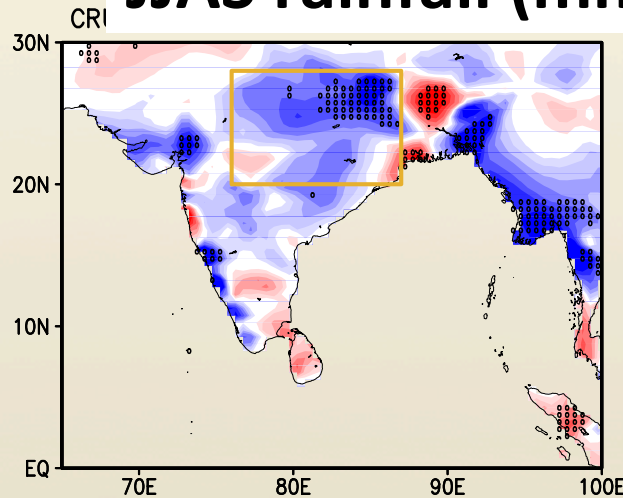


What factors influence ice sensitivity? CM3 and CM2.1 have same sea ice model but simulate sea ice sensitivities at opposite ends of the model spectrum. Atmosphere plays a large role.

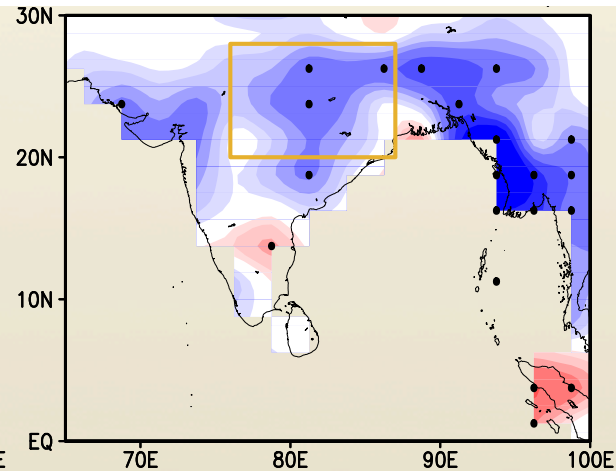
A drying trend observed over central-northern India during the second half of the 20th century

JJAS rainfall (mm day⁻¹ 50 years⁻¹)

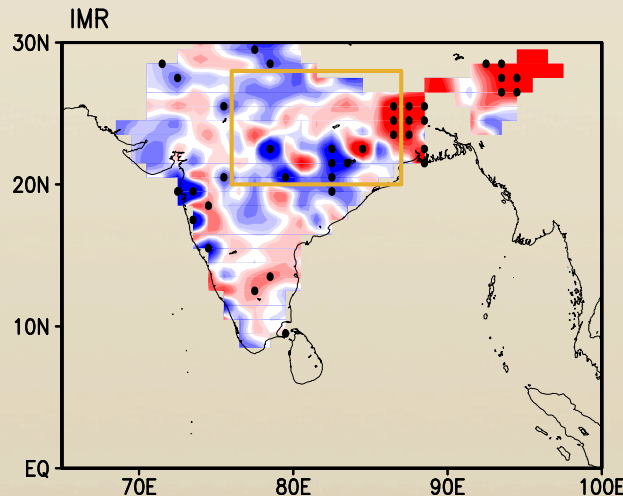
CRU



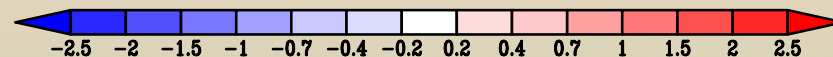
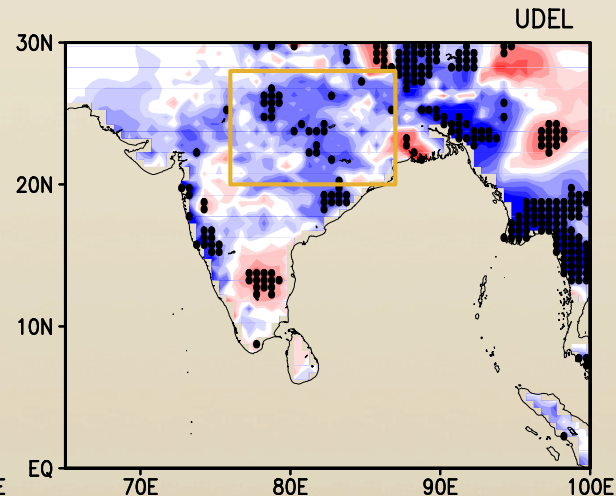
PREC/L



IMR



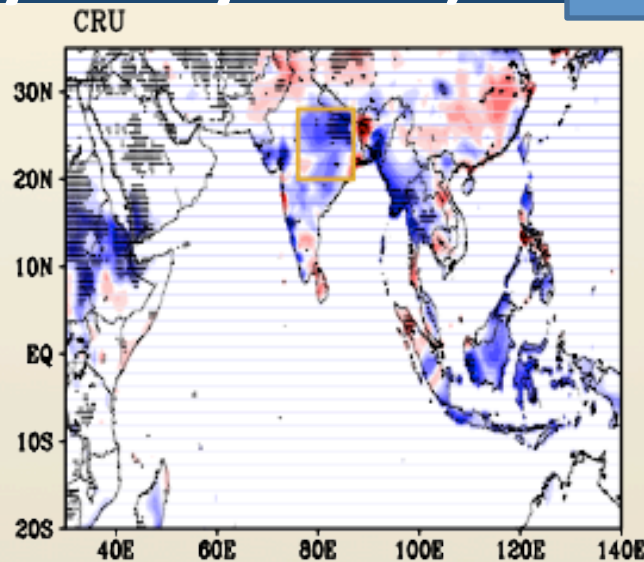
UDEL



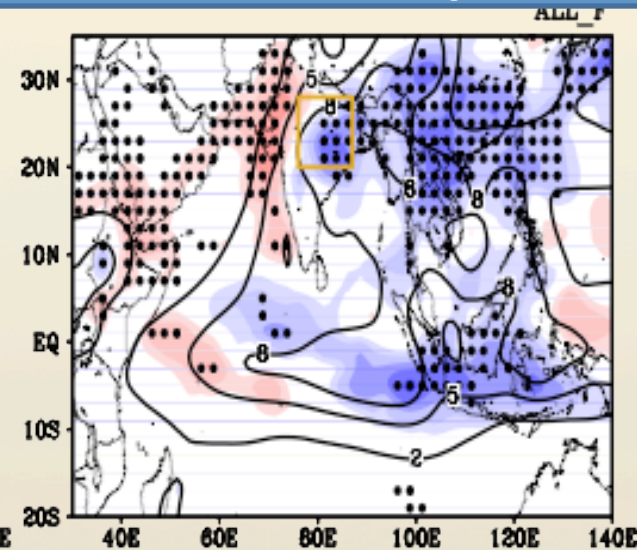
Spatial pattern of linear trends of JJAS rainfall (mm day⁻¹ 50 years⁻¹)

Bollasina et al. (Science , 2011)

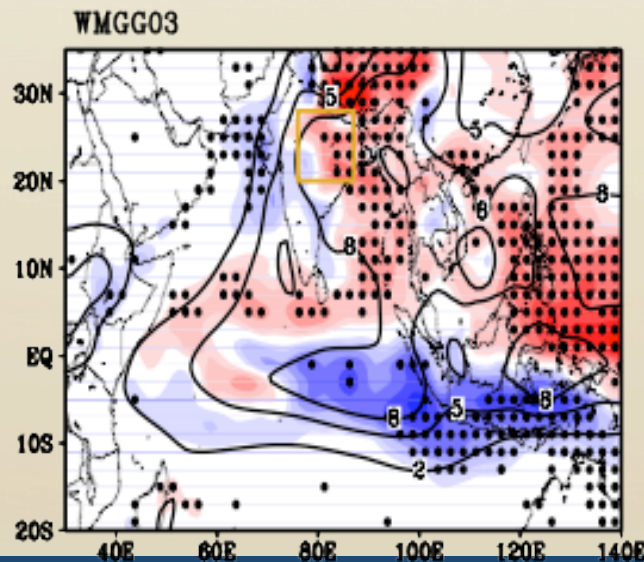
CRU



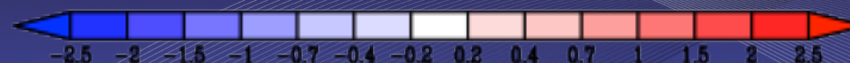
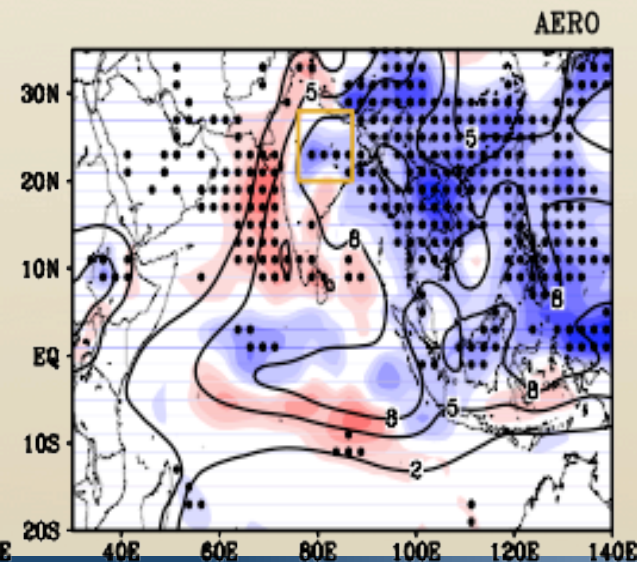
All
forcing



GG



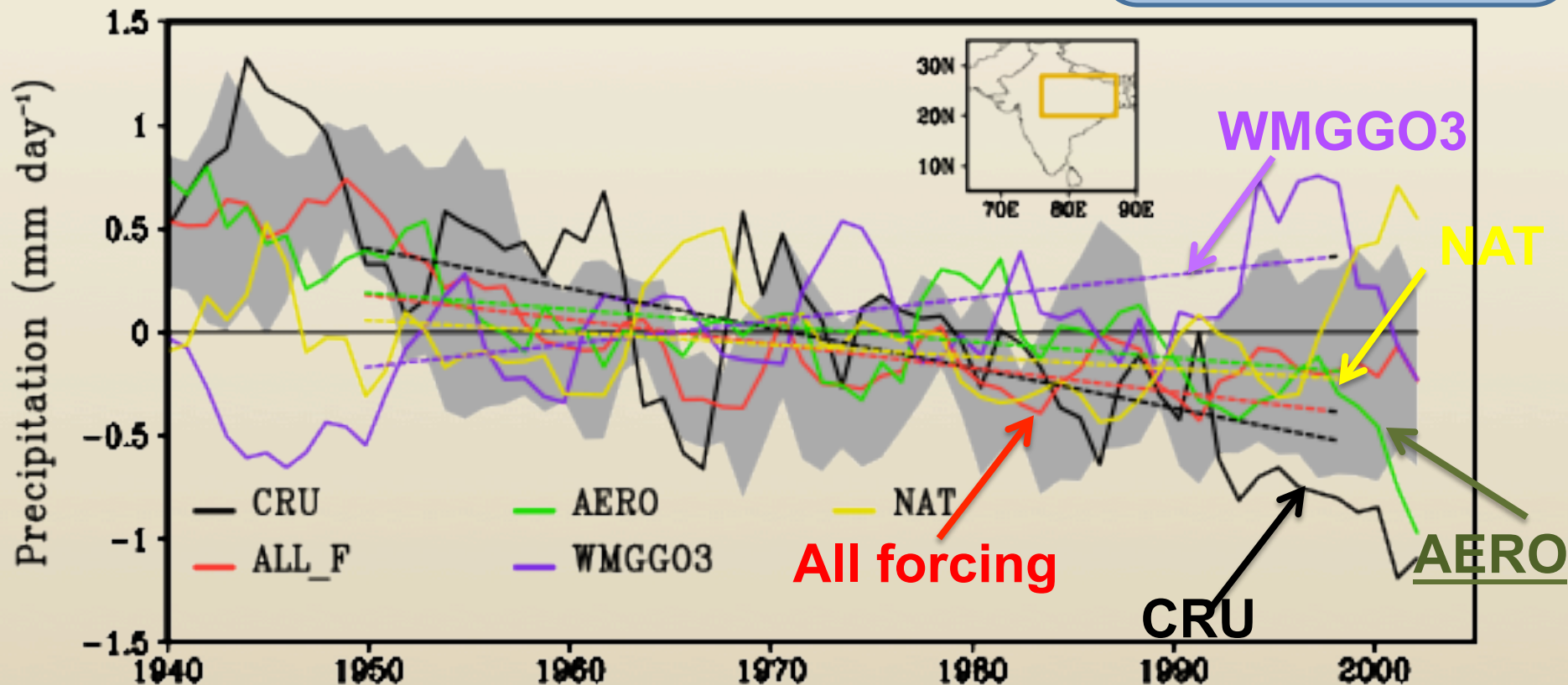
AERO



Attribution of the recent trend of the S. Asian summer monsoon using CM3 historical simulations

Linear trends of average JJAS rainfall over central-northern Indian (mm day^{-1})

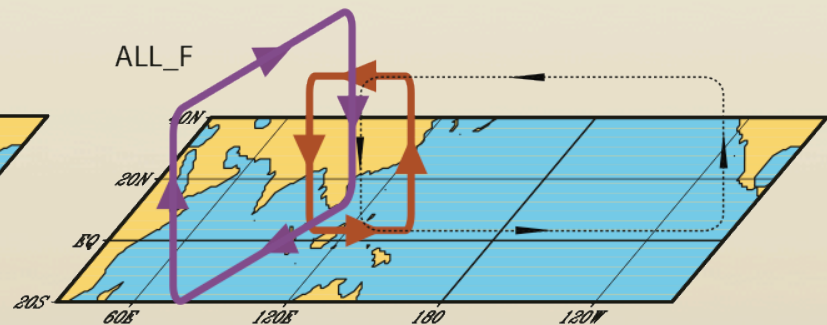
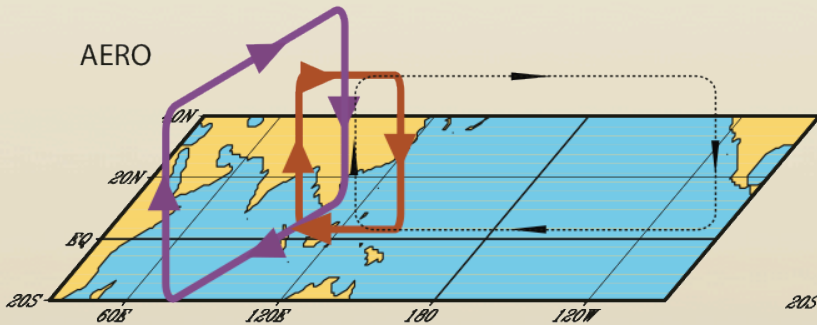
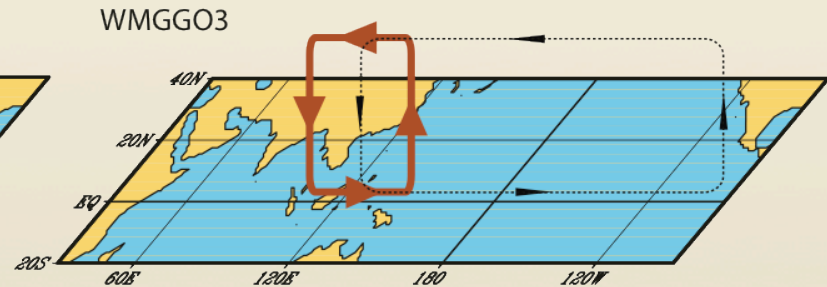
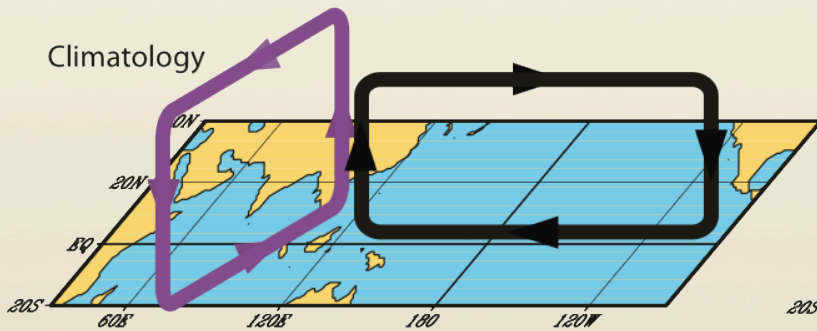
- *AERO trend opposite in sign to WMGG03*
- *AllForc trend compares well with CRU (Obs)*



How Hadley and Walker circulations respond to greenhouse gases and aerosols?

Climatology

GG

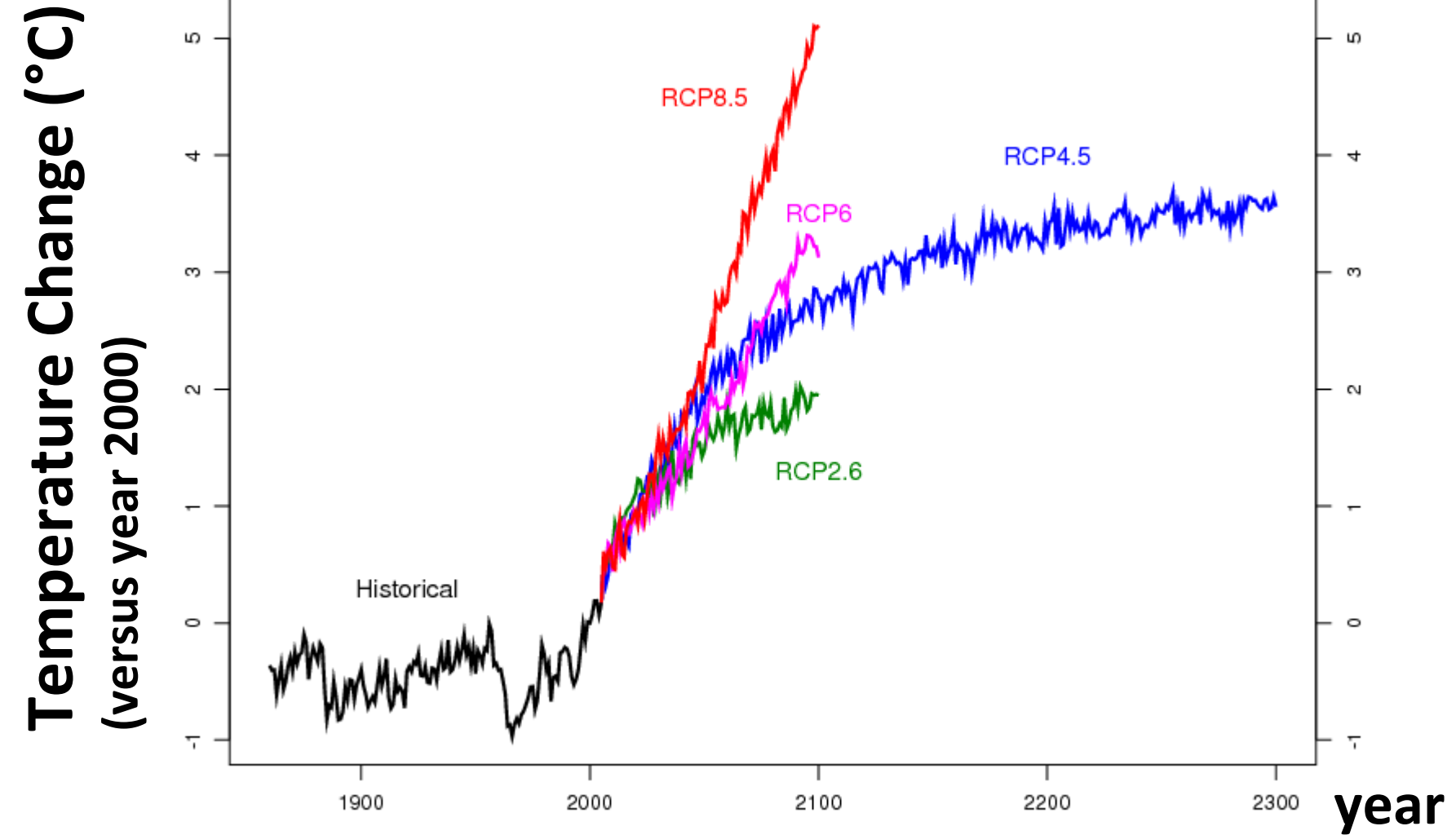


AERO

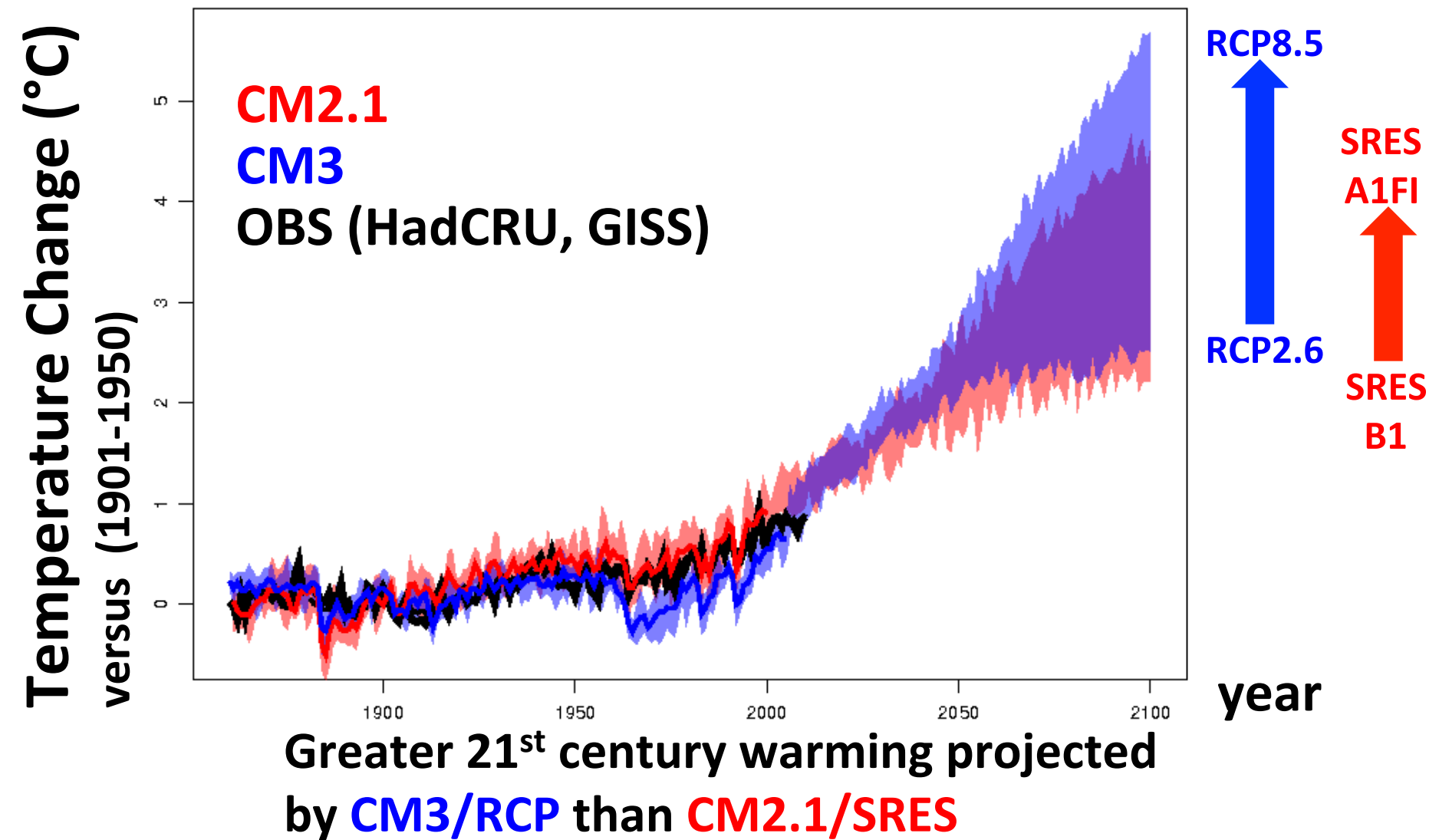
All forcing

*North-South pattern of basic mechanism evident in earlier simulations
Chen and Ramaswamy (1996); Ramaswamy and Chen (1997)*

Surface Air Temperature



Surface Air Temperature



Results from

GFDL High-spatial Resolution

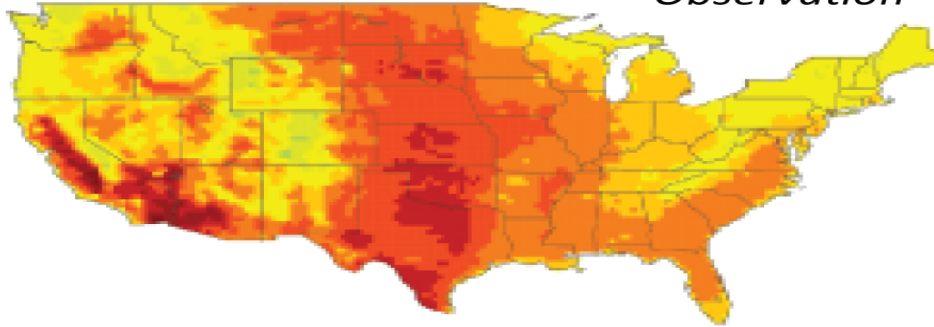
Global Atmospheric Models

[CMIP5; IPCC AR5 report, 2013]

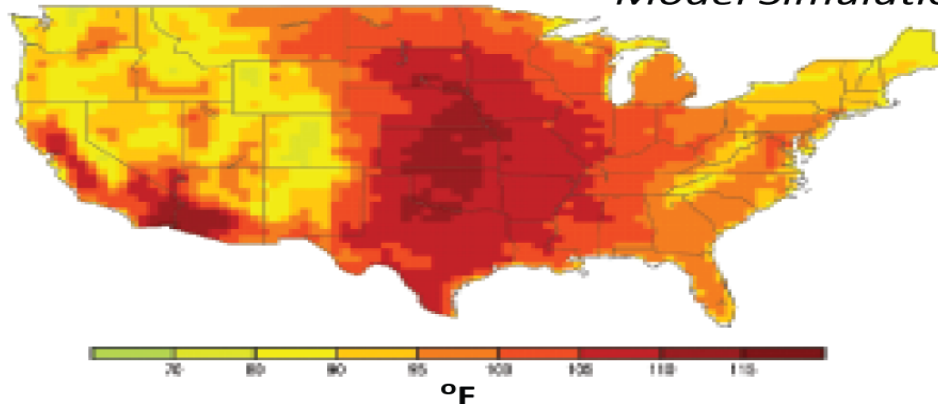
Heat Waves

Severity of Summer Heat Waves

Observation



Model Simulation



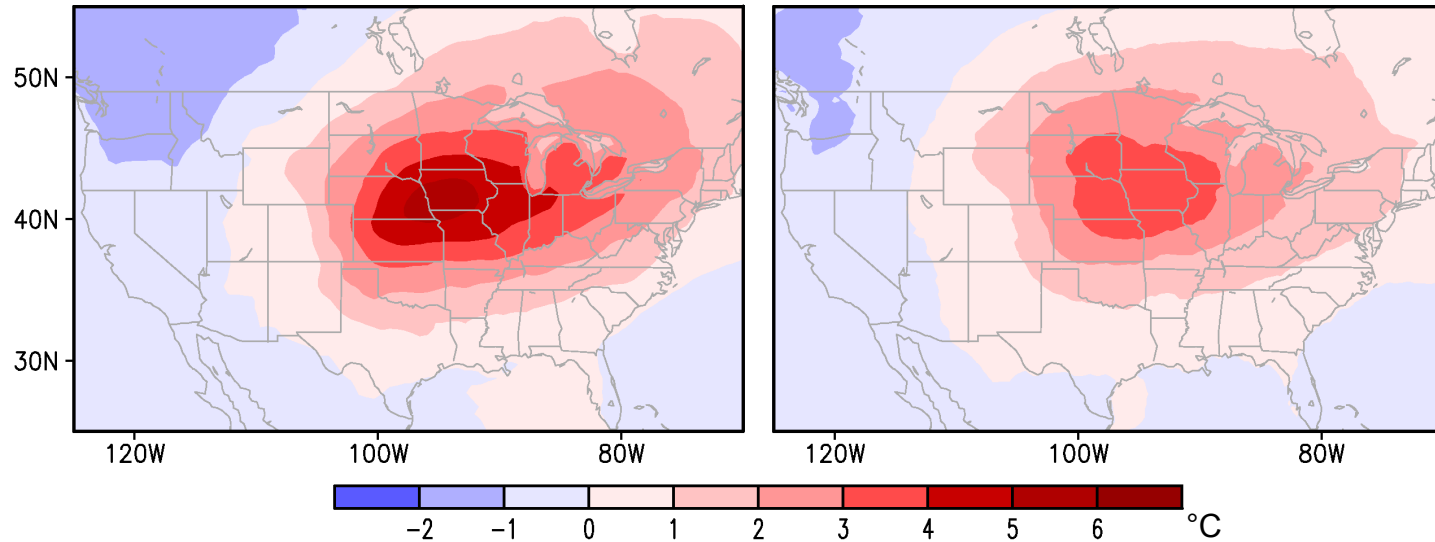
NOAA/ GFDL high-resolution global model (~50 km) used to simulate the severity and duration of summer heat waves. This model was used to produce the bottom figure, from a 30-year simulation of present-day climate. Top figure is based on observational data for a 24-year period.

Midwest Heat Waves

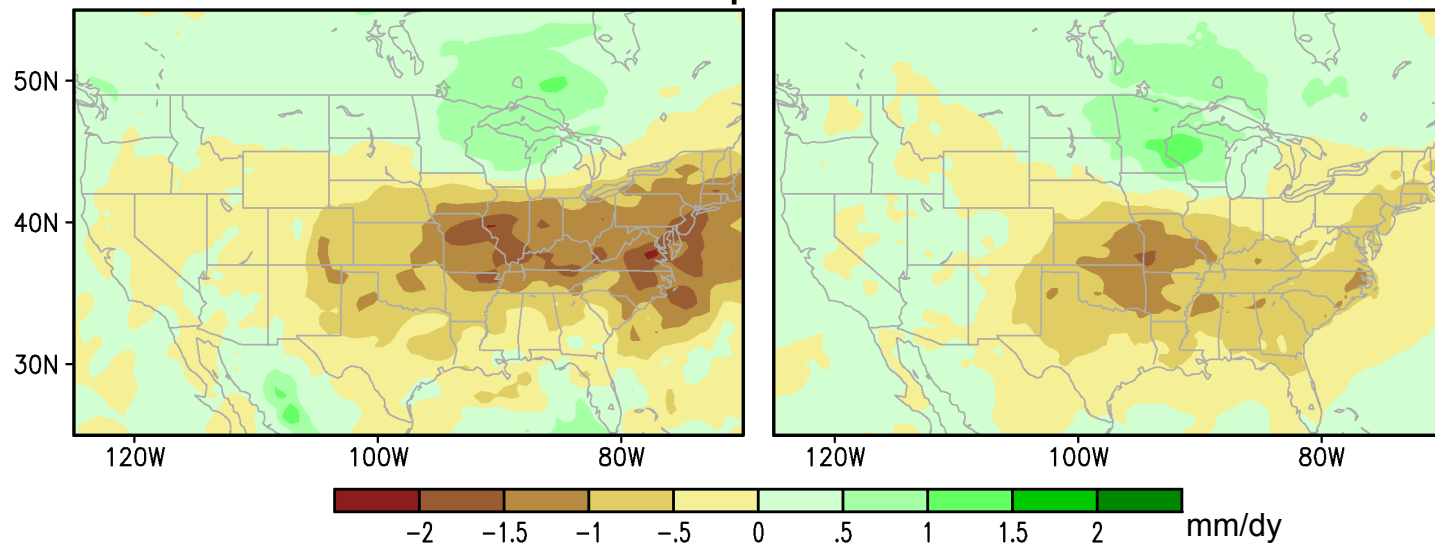
Model

Observations

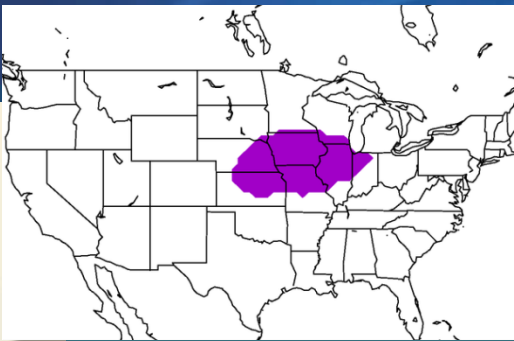
Surface Temperature



Precipitation



Midwest Heat Waves



Observation

**Model
1971-2000**

**Model
2041-2070**

**Model Ratio:
2041-2070 vs
1971-2000**

Severity (°C)

35.2

39.4

40.1

1.0

Duration (days)

9.7

8.6

12.6

1.5

**Number of Events
per year**

1.1

1.0

2.7

2.7

**Number of
Heat Wave
days per year**

10.5

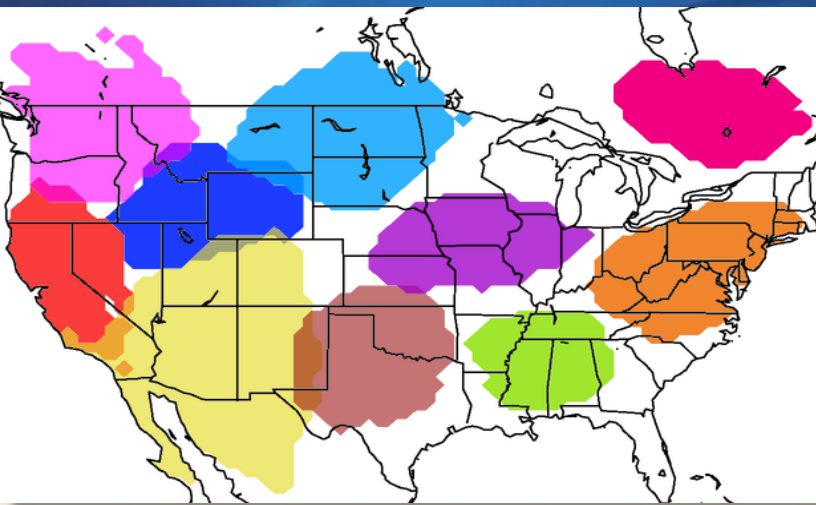
8.6

34.4

4.0

Model Projections

Ratio: 2041-2070 vs 1971-2000

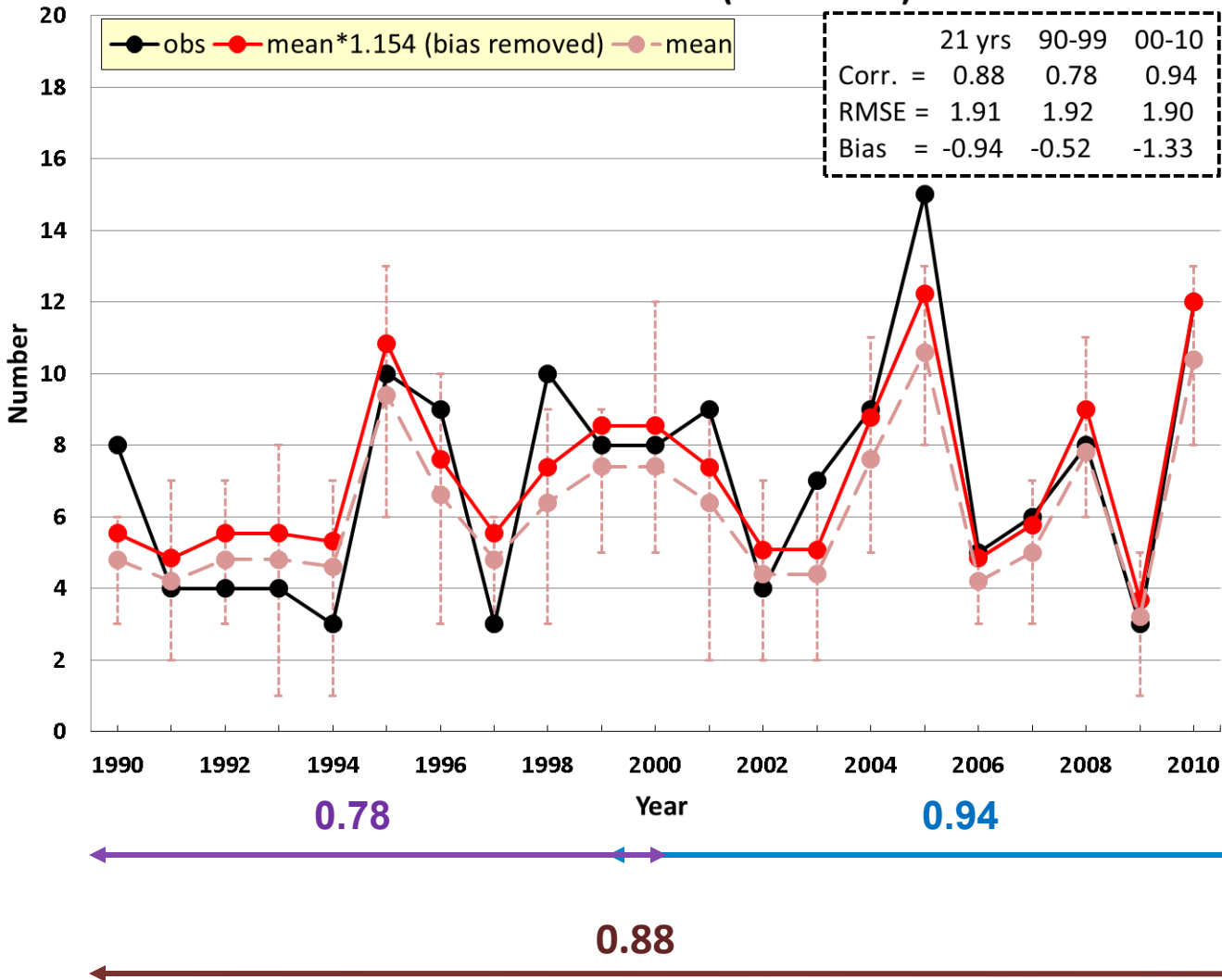


	Duration	# Events/yr	# Heat wave days/yr
Midwest	1.5	2.7	4.0
Northern Plains	1.3	3.8	4.8
Pacific Northwest	1.3	2.4	3.0
SE Canada	1.2	2.5	2.9
Texas-Oklahoma	1.8	2.6	4.5
Mid-Atlantic	1.4	2.7	3.8
California	1.9	2.3	4.3
Gulf Coast	1.2	3.2	4.0
Southwest	2.2	2.9	6.4
Wyoming/Montana/ Idaho	2.2	2.6	5.7

Seasonal hurricane predictions

1990-2010 (Jul-Nov)

North Atlantic Basin (Hurricanes)



- Resolution: 25 km, 32 levels
- 5-members initialized on July 1 with NCEP analysis
- SST anomaly is held constant during the 5-month predictions
- Climatology O3 & greenhouse gases are used

1. Chen and Lin 2011, GRL
2. Chen *et al.*, to be submitted

The END

Thank you for your attention !