Developments at GFDL

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GFDL CMIP5 Activities
4 “Streams”

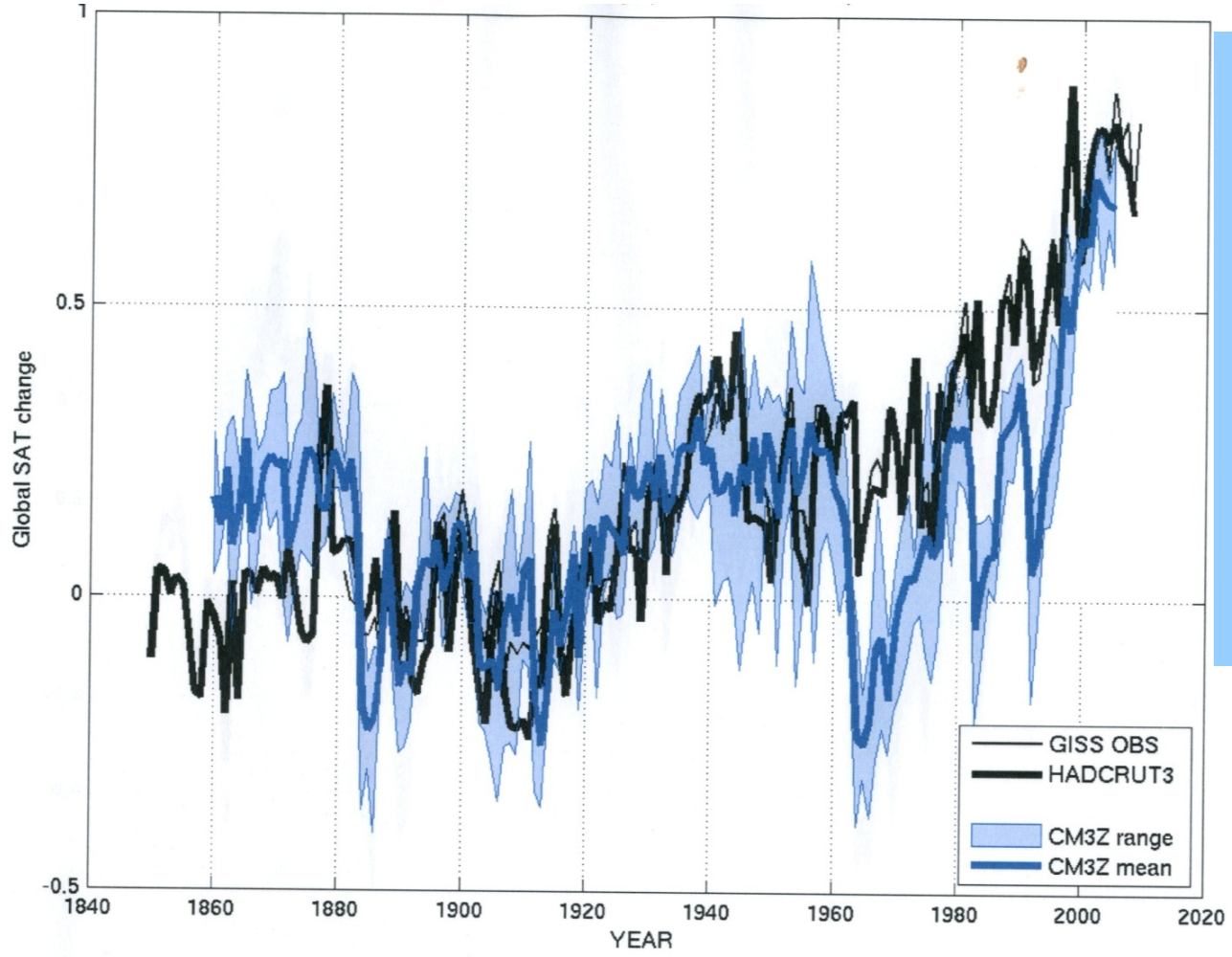
- CM3: Atmosphere-Ocean-Land-Sea Ice Model with Aerosol-Cloud Interactions
  - Atm chem (trop and strat) and aerosol-cloud interactions
- Decadal Prediction Model (DECP, CM2.1, CM2.5)
  - Unique initialization method
- Earth-System Models (ESM2M,ESM2G)
  - Close carbon cycle, 2 different oceans
- High-Resolution Atmosphere-only Models (C180 (50km), C360(25km))

GFDL CMIP5 status (13 Oct 11)

Stream/ model	Production complete	Normal Post processing	CMOR post processing	Data on server	METAFOR questionnaire
ESM2M	12/2010	12/2010	75%	50%	9/2011
ESM2G	85%	80%	1%	0%	Model done
CM3	12/2010	90%	70%	5%	Model done
DECP	9/2011	99%	0%	0%	Model done
C180	Complete	Complete	9/2011	50%	90%
C360	Complete	Complete	10/2011	0%	0%

CM3

Global SAT – CM3 vs Obs



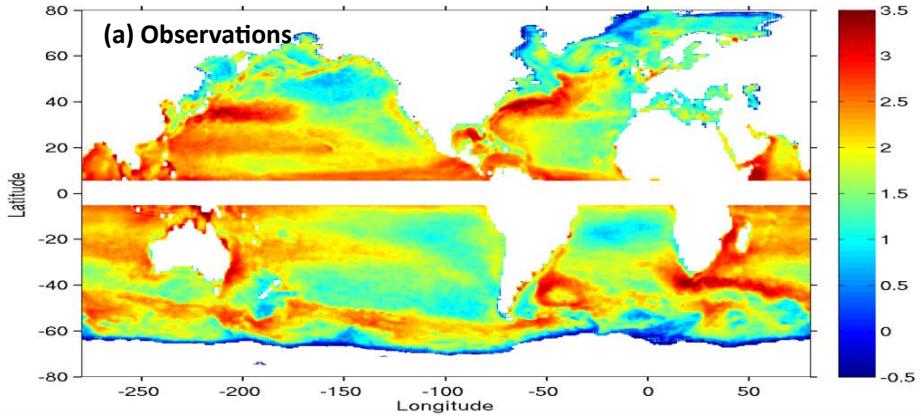
CM3:
- Relatively large climate sensitivity
  - 4.3K for 2XCO2
- Large aerosol indirect effect
  - Near 0 global direct effect

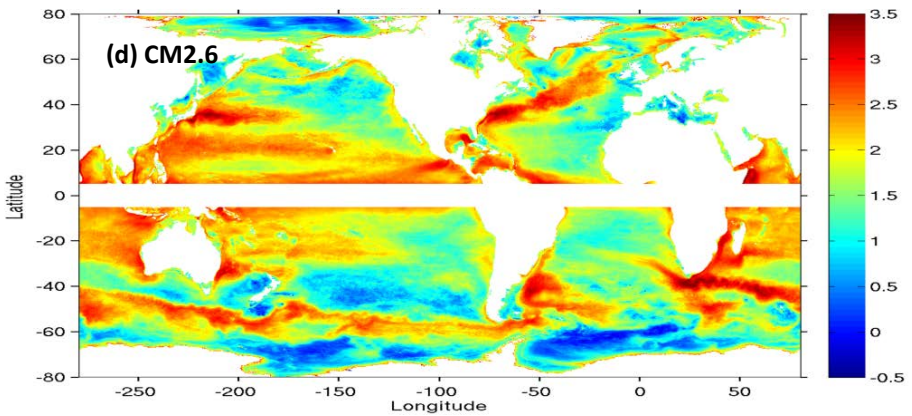
Decadal Prediction with Higher-Resolution Coupled Models using GFDL IPCC AR4 Physical Parameterizations (DECP)

Sequence of coupled models with increasing resolution

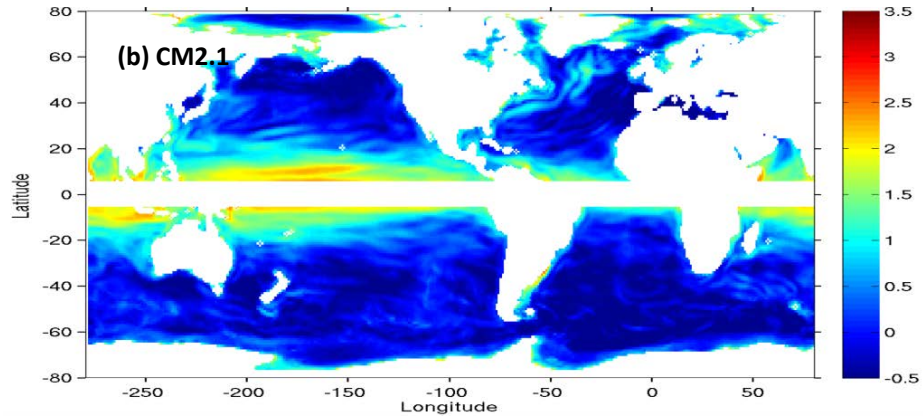
MODEL	ATMOSPHERE	OCEAN	LAND	Comments
CM2.1	2° lon x 2.5°lat 24 levels	1° lon x 1/3-1° lat	LM2	IPCC AR4 model
CM2.1.1	2° lon x 2.5°lat 24 levels	1° lon x 1/3-1° lat	LM2	Higher order advection in ocean, and low viscosity
CM2.3	1° lon x 1.25°lat 24 levels	1° lon x 1/3-1° lat	LM2	Same ocean as CM2.1, higher resolution atmosphere
CM2.4	1° lon x 1.25°lat 24 levels	25Km in Tropics to 9 Km in polar regions Square grid.	LM2-LM3	Same atmosphere as CM2.3, higher resolution ocean
CM2.5	50 Km atmosphere, 32 levels, cubed sphere grid	Similar to CM2.4, uses z* as vertical coord.	LM3	Uses icebergs in ocean Similar ocean to CM2.4, higher resolution atmosphere
CM2.6	50 Km atmosphere, 32 levels	10 Km in Tropics to 3 Km in polar regions	LM3	Same atmosphere as CM2.5, higher resolution ocean

Ocean Eddy Kinetic Energy – Observed and Simulated

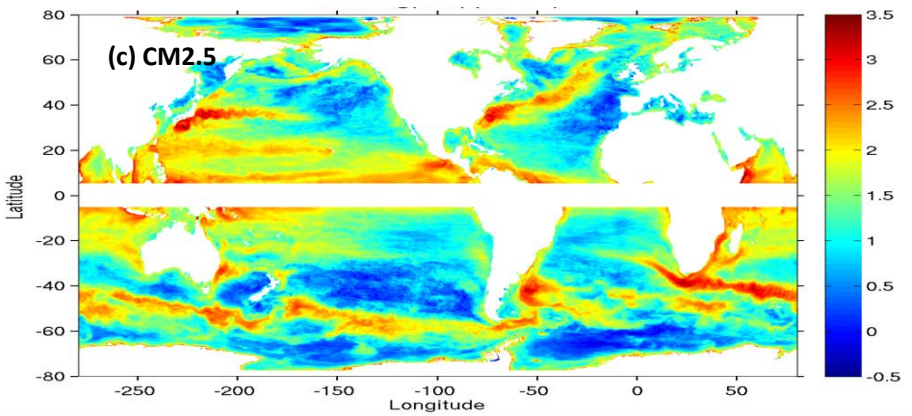




CM2.6: 50 Km atmosphere, 4-10 Km ocean

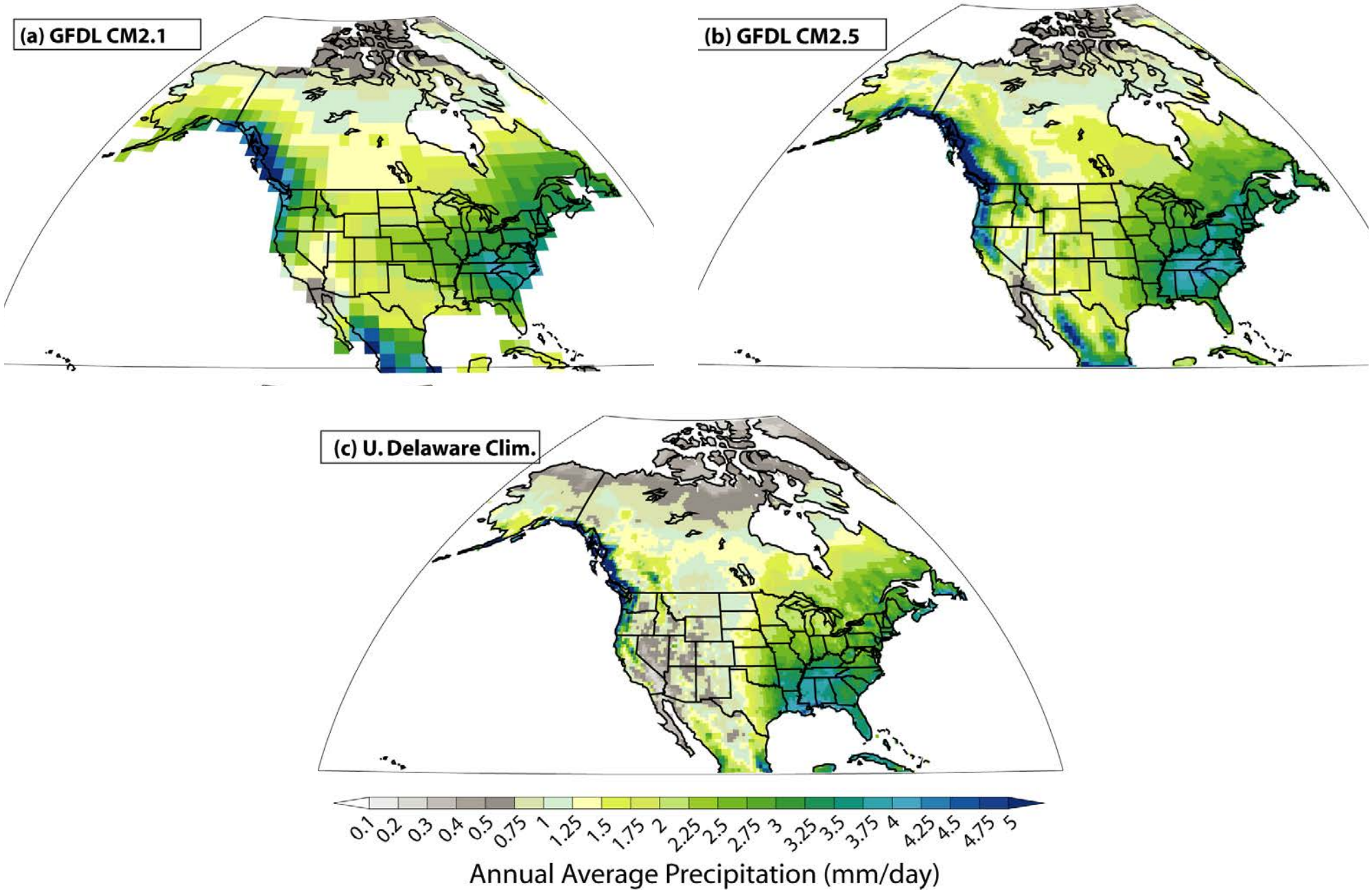


CM2.1: 200 Km atmosphere, 100 Km ocean



CM2.5: 50 Km atmosphere, 10-25 Km ocean

Delworth et al. (*J. Climate,* submitted)



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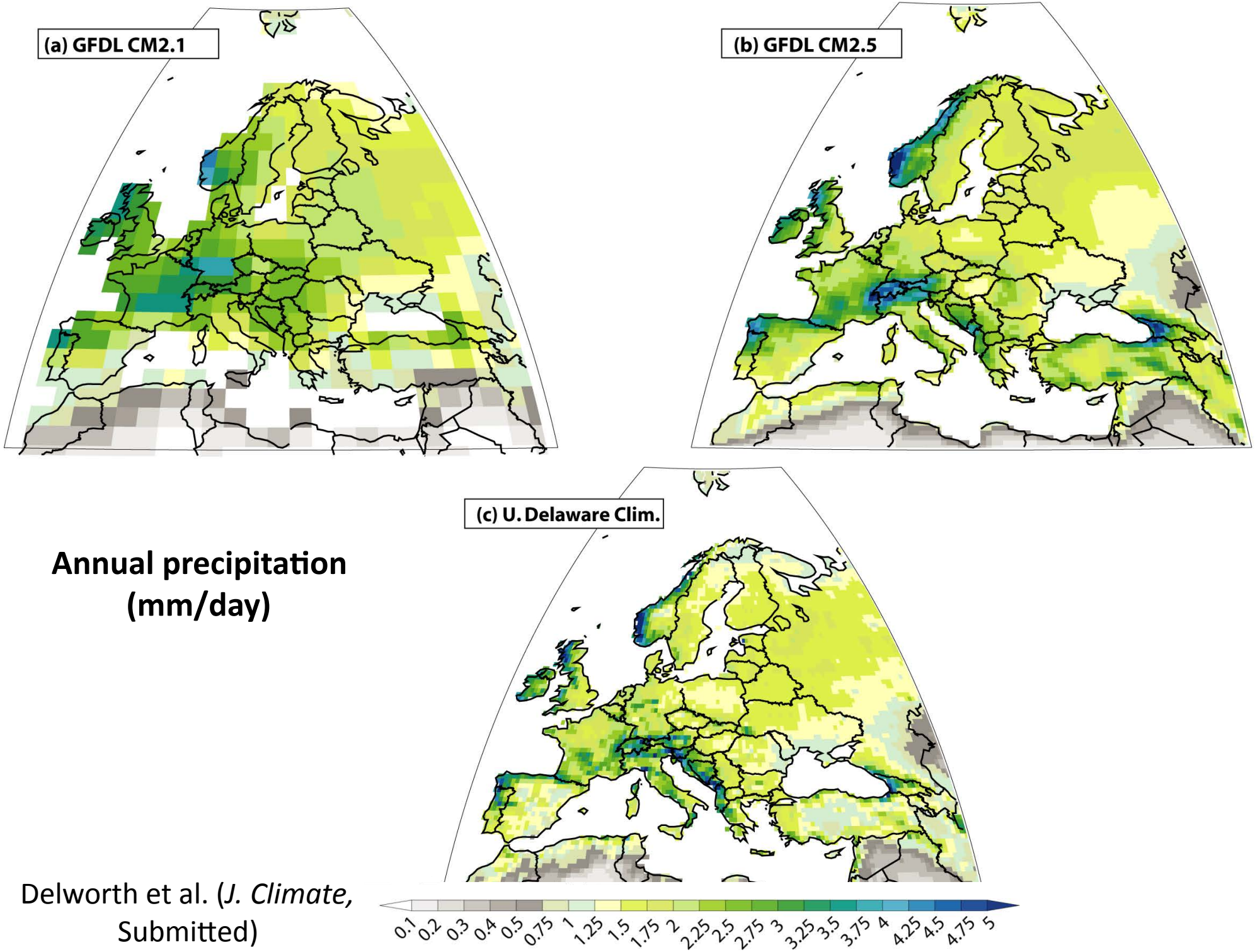
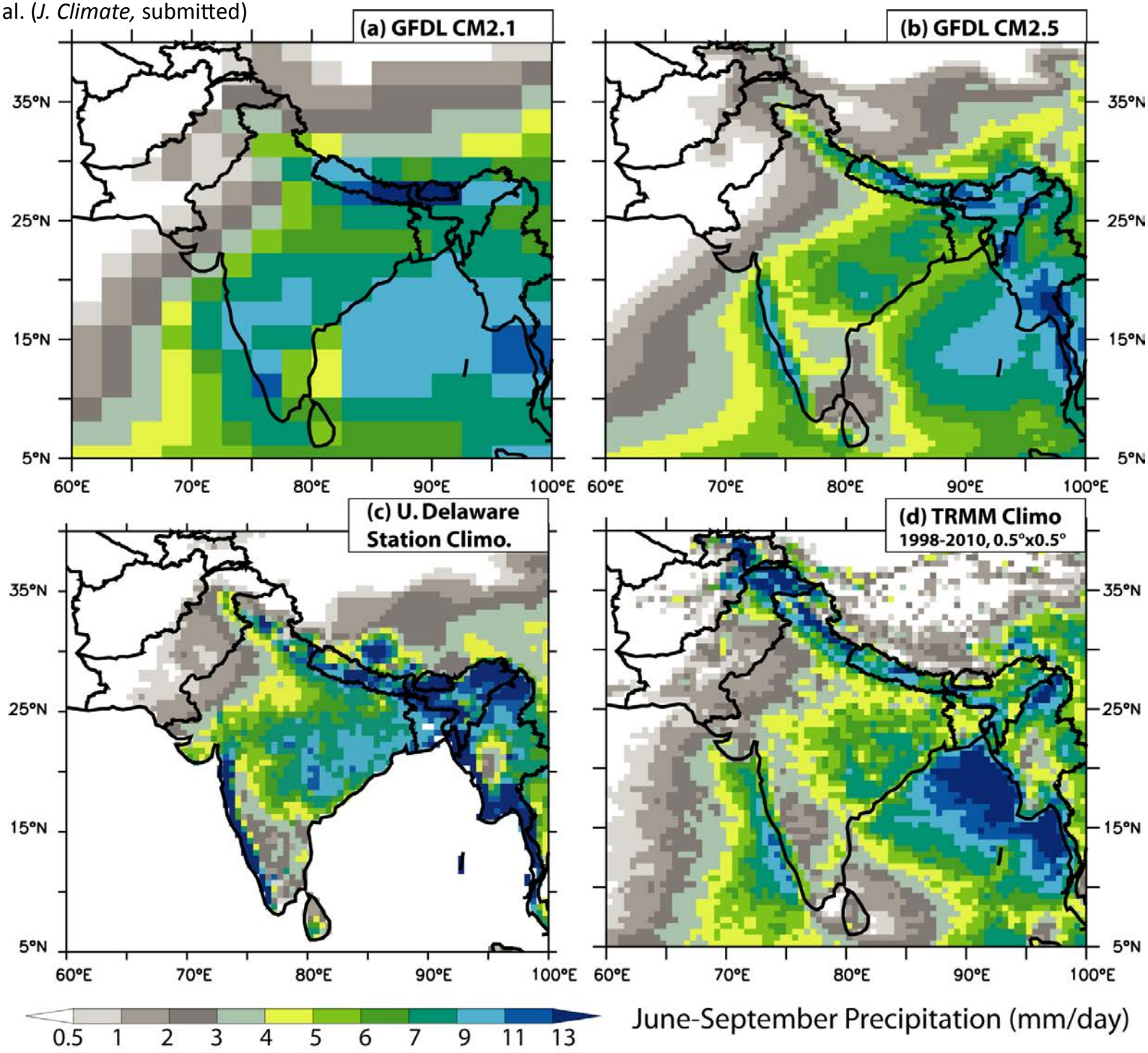


Annual precipitation (mm/day)

Delworth et al. (*J. Climate,* Submitted)

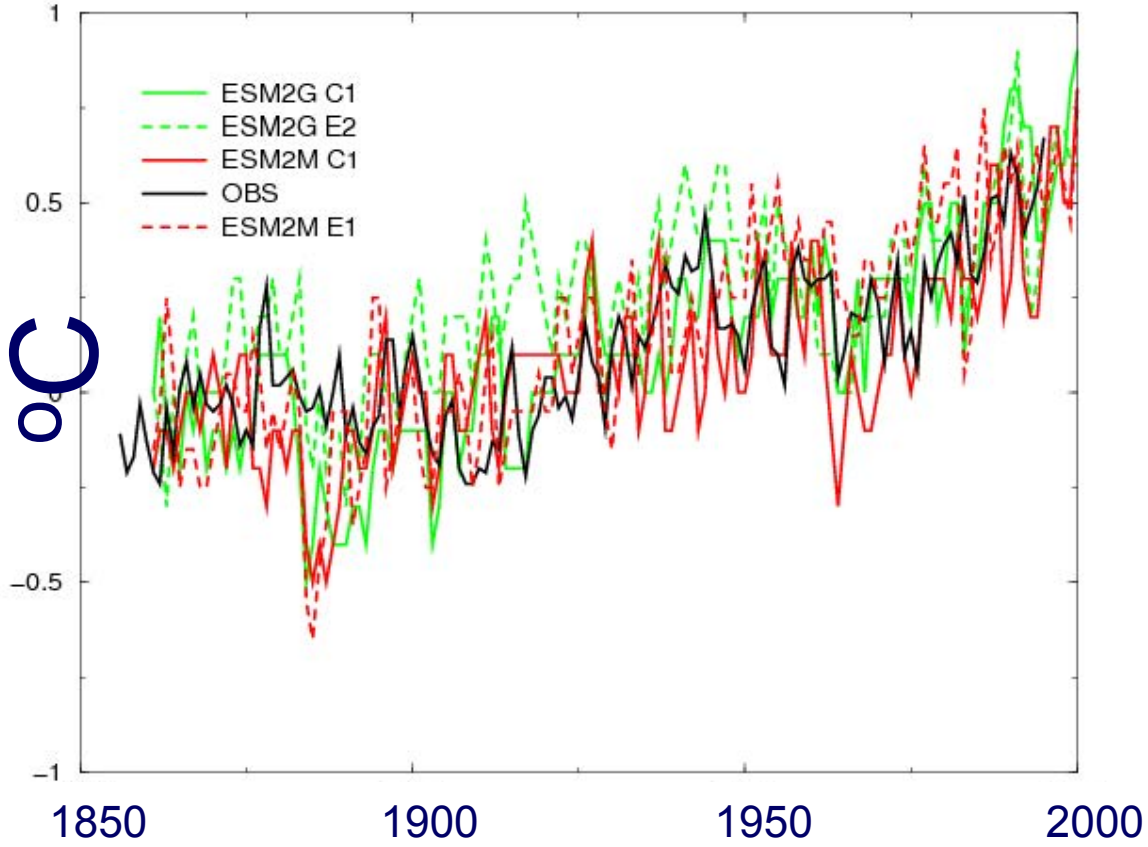
Delworth et al. (*J. Climate,* submitted)



Earth-System Model ESM2M

ESMs concentration (C1) and emission (E1) driven runs show similar Global Surface Air Temperature Response

Surface Air Temperature Response

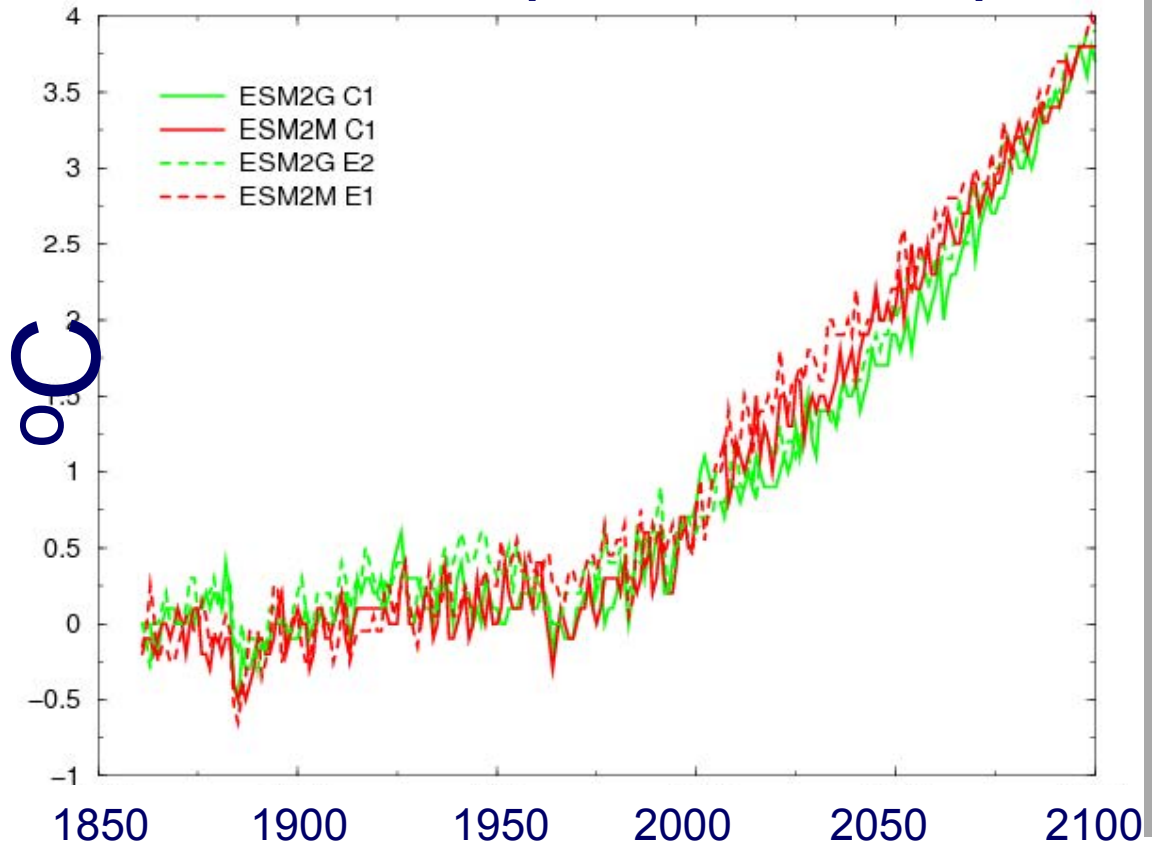


- Two different forcings (C & E) give very similar responses
- Both models (M&G) do good job of simulating observed trend using emissions and concentrations.

ESMs C1 and E1 also Similar in Future (RCP8.5)

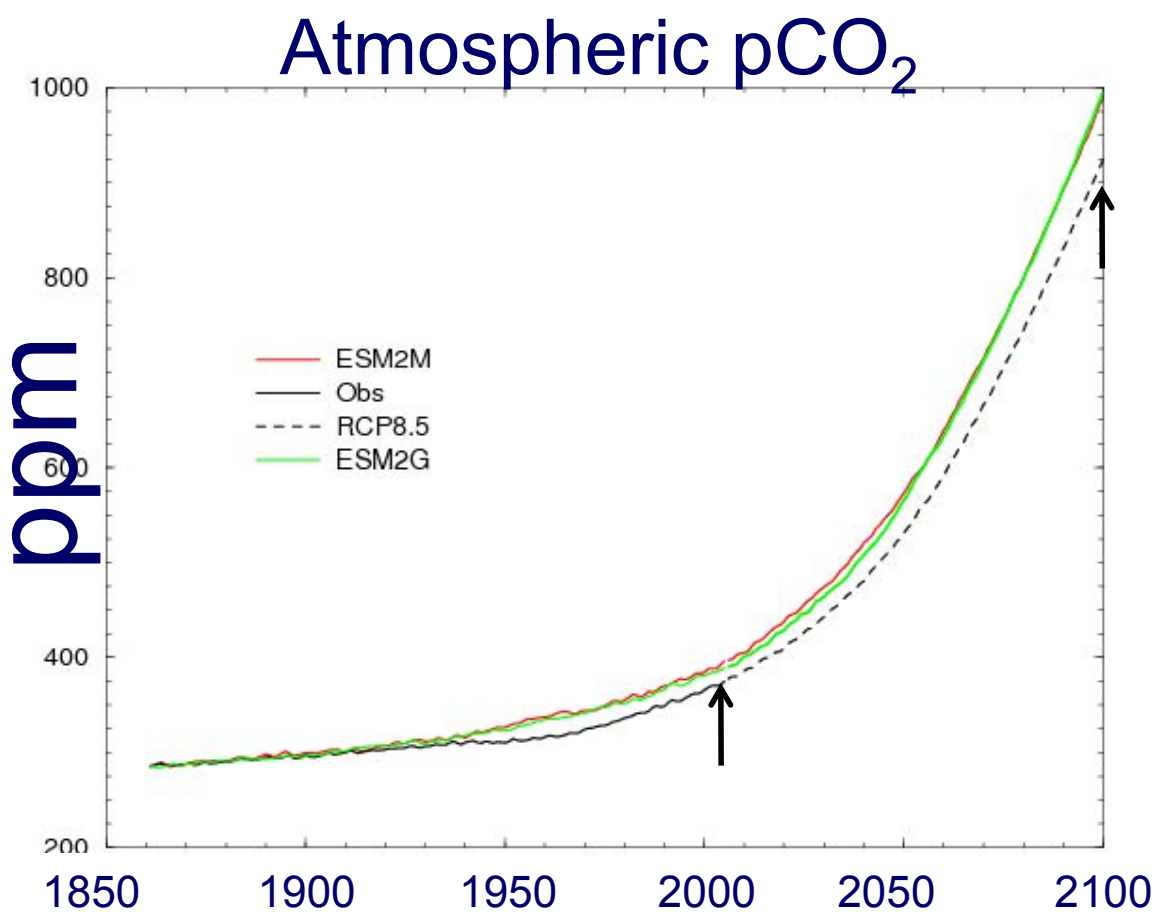
C1=concentration; E1=emission

Surface Air Temperature Respons



- Two different forcings give very similar responses
- ESM2M: Emission driven run slightly warmer than concentration run
- ESM2G: Slightly cooler than 2M in middle of this century

ESM emissions driven runs show similar atmospheric pCO_2 response to each other and observations



- Emission driven runs have concentrations similar to observed
- ESMs about 20ppm high in 2005 versus observations
- ESMs about 70ppm higher than RCP8.5 by 2100

Summary

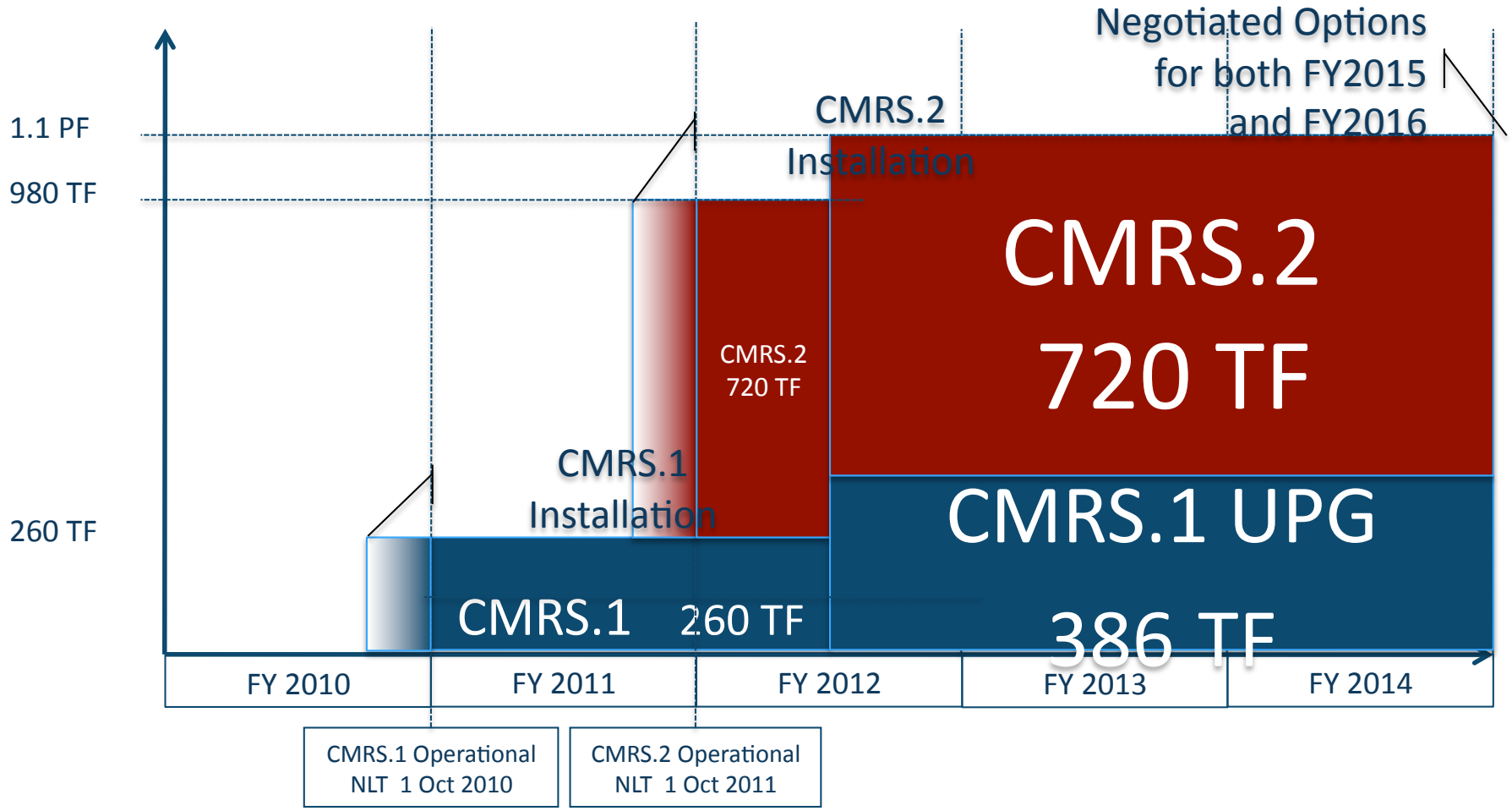
- GFDL, in support of IPCC AR5, has developed a new generation of coupled physical and earth-system models.
- Integrations for AR5 are mostly completed with results becoming available to community.
- New models have been applied to regional climate change, chemistry, and carbon cycle.

NOAA Climate Modeling and Research System (CMRS)

OAK RIDGE NATIONAL LABORATORY

MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

NOAA Climate Modeling and Research System (CMRS)
Computing Capability Timeline at Oak Ridge National Lab



Climate Modeling and Research System: Initial Capability (CMRS.1)

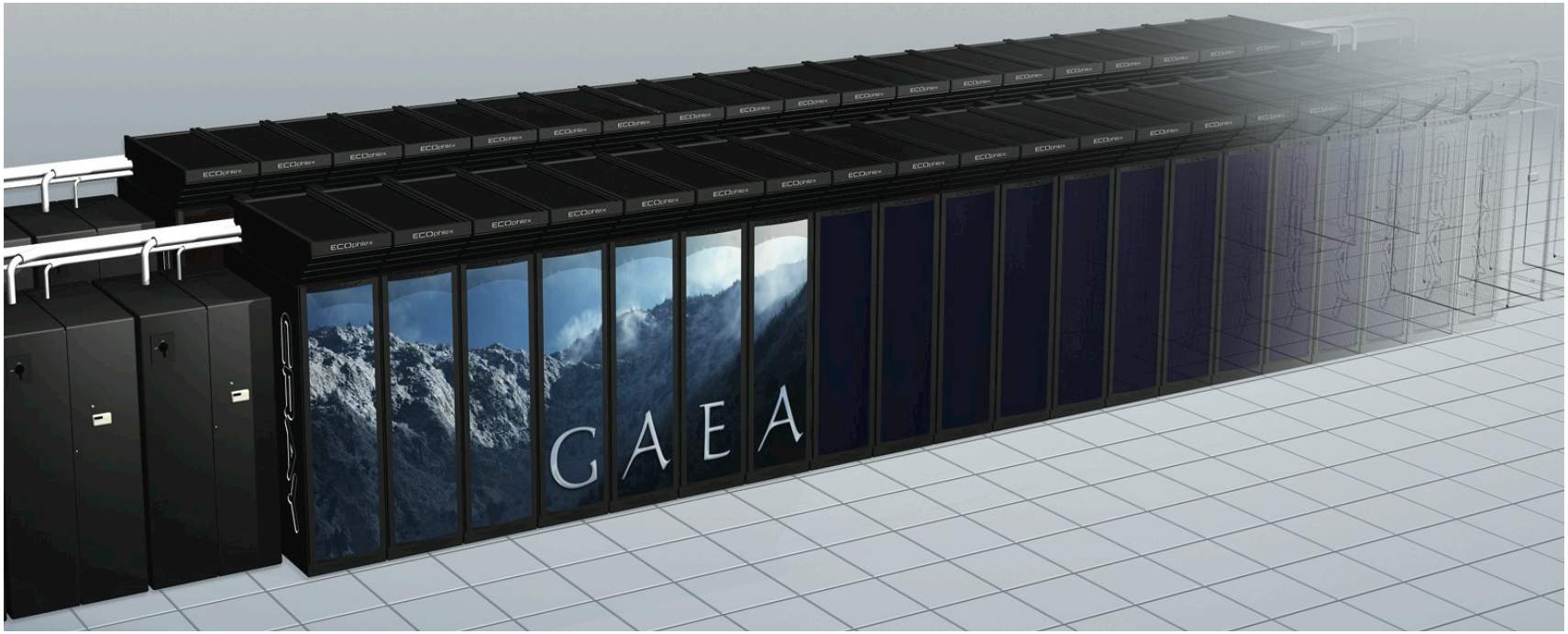
Cray XT6 LC

- 2,576 Socket G34 AMD 2.1 GHz 12-core Magny-Cours processors
- 30,912 compute cores, 1,288 24-core nodes
- 82.4 TB DDR3 memory, 64 GB/node, 2.67 GB/core
- Peak performance: 260 TF
- 14 cabinets in a 2x7 cabinet configuration
- Liquid cooled using Cray ECOphlex cooling technology
- Peak Electrical Consumption: 792 kVA
  - Peak demand to date: 512 kVA (64.6%)
- Cooling Requirement: 225 tons
  - Peak demand to date: 145 tons (64.4%)
- Connectivity to the external Lustre-based Fast Scratch and Long Term File Systems

CMRS Year Two System (CMRS.2)

Cray XE6 LC (Separate System Partition)

- *Scheduled Delivery in 2011*
- 4,896 AMD Interlagos processors
  - 2,448 nodes
- 156.7 TB DDR3 memory, 64 GB/node
- Gemini High Speed Interconnect
- Infrastructure
  - 26 cabinets (total of 40 compute cabinets among CMRS.1 and CMRS.2)
  - Cray ECOphlex liquid cooling
  - Peak Electrical Consumption: 1,455 kVA
  - Cooling Requirement: 413 tons



CMRS.1 Upgrade

Cray XE6 LC

- Original Configuration
  - 2,576 Socket G34 AMD 2.1 GHz 12-core Magny-Cours processors
  - 30,912 compute cores, 1,288 24-core nodes
  - 82.4 TB DDR3 memory, 64 GB/node, 2.67 GB/core
  - Peak performance: 260 TF
- Upgraded Configuration
  - 2,624 AMD Interlagos processors
    - 1,312 32-core nodes
  - 84 TB DDR3 memory, 64 GB/node
  - Scheduled Delivery in Q2 CY2012

After the successful introduction to operation of the CMRS.2 Interlagos-based system, the initial CMRS.1 system will receive an architecturally identical upgrade

AM3/LM3: Atmosphere and Land in CM3

What is NEW in AM3?

Interactive chemistry to link emissions to aerosol composition

Sub-grid vertical velocity PDFs for convective and stratiform clouds => Supersaturation at cloud scale for aerosol activation on sulfate/black carbon, organic carbon, and sea salt

Stratospheric model for chemistry and possible links to troposphere on multi-year time scales (e.g., Southern Hemisphere Annular Mode)

More realistic land precipitation for land carbon and nitrogen models

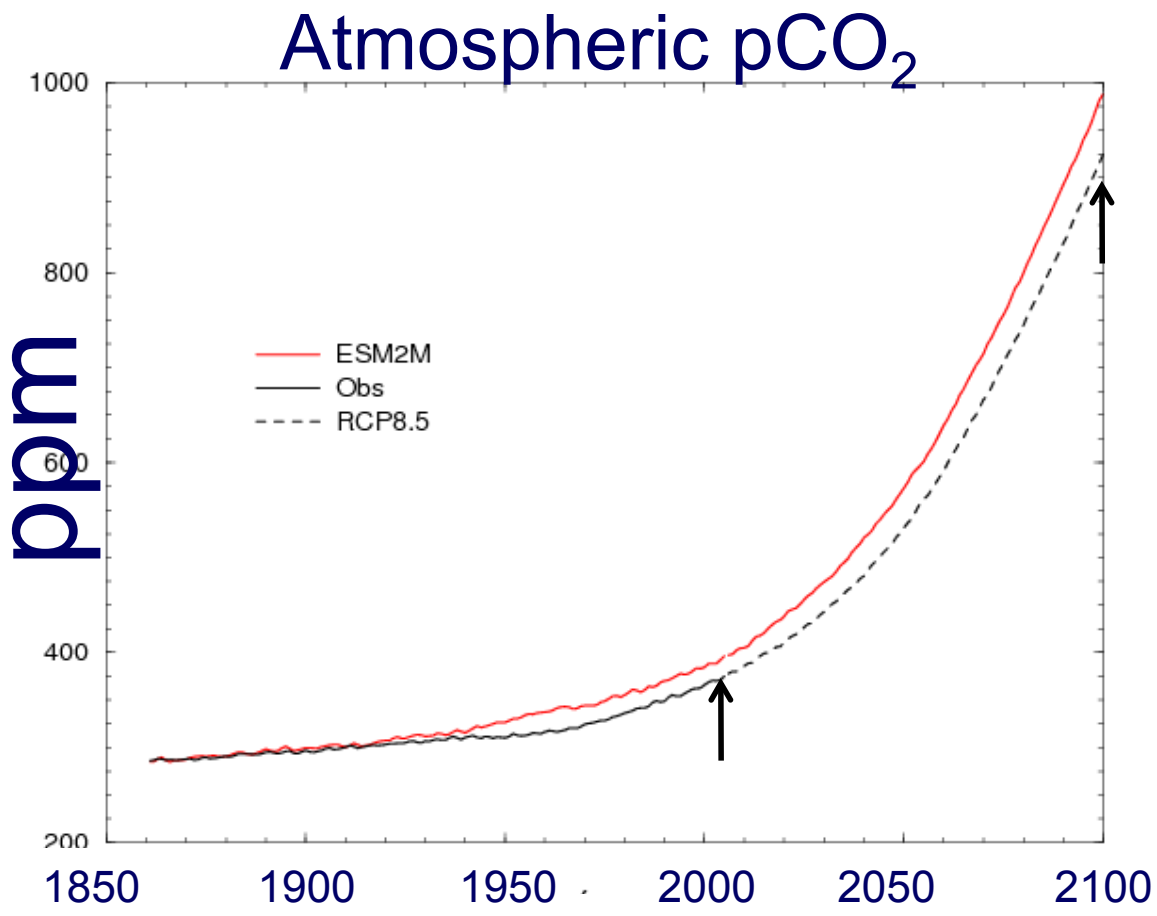
Cubed-sphere finite-volume dy-core

Dynamic vegetation model with hydrology and land use

Parameterizations based on sub-grid PDFs of vertical velocity have been implemented in AM3

- **Deep convection**: Donner *et al.* (2001, *J. Climate*), Wilcox and Donner (2007, *J. Climate*)
- **Shallow convection:** Bretherton *et al.* (2004, *Mon. Wea. Rev.*) implemented by Ming Zhao
- **Stratiform:** modfication of Tiedtke (1993, *Mon. Wea. Rev.*) by Chris Golaz, to include *w* PDF for activation only

ADD ESM2G in green



- Emission driven run has concentrations very similar to observed

- ESM2M about 23ppm high in 2005 versus observations

- ESM2M about 70ppm higher than RCP8.5 by

CM3

- Atm chemistry and higher top (lower Mesosphere)
  - Focus: atm chem and aerosol-cloud
- 2 deg atm, 48 levels
- New land module – LM3
- Old ocean and sea ice components
  - 1 deg ocean (1/3 in tropics), 50 levels

DecP

- Uses unique initialization method
  - Runs multiple oceans under data atm while ingesting ocean observations
- Uses CMIP3 model – CM2.1
- 2 deg atm, 24 levels
- 1 deg ocean, 50 levels (MOM4p0)
- Old sea ice and land components
- Much higher resolution model version coming next spring

High Res Atm-only

- ½ and ¼ deg versions
- FV cubed sphere atm dy core
- LM3 with static vegetation
- Minimal subgrid physics
  - Convection mainly explicitly resolved
- Run with different SST data sets
  - Obs, CM3, ESM2M

ESM

- Two models developed using diff oceans
- 2 deg atm, 24 levels – same as CM2.1
- LM3 – new hydro and veg/carbon components
- CM2.1 Sea ice with slight albedo change
- Only can handle carbon emissions
  - Lamarque et al. aerosol concentrations, etc

ESM Oceans

- MOM4p1 – ESM2M
  - 1 deg (1/3/ in tropics) 50 levels
  - Z* based vertical coor
  - Lots of changes from CM2.1 ocean
- GOLD – ESM2G
  - 1 deg (1/3/ in tropics) 63 layers
  - Isopycnal based vertical coor + bulk mixed layer
- TOPAZ – ocean bio-geochemistry