Report to WGNE: Selected GFDL Research Activities

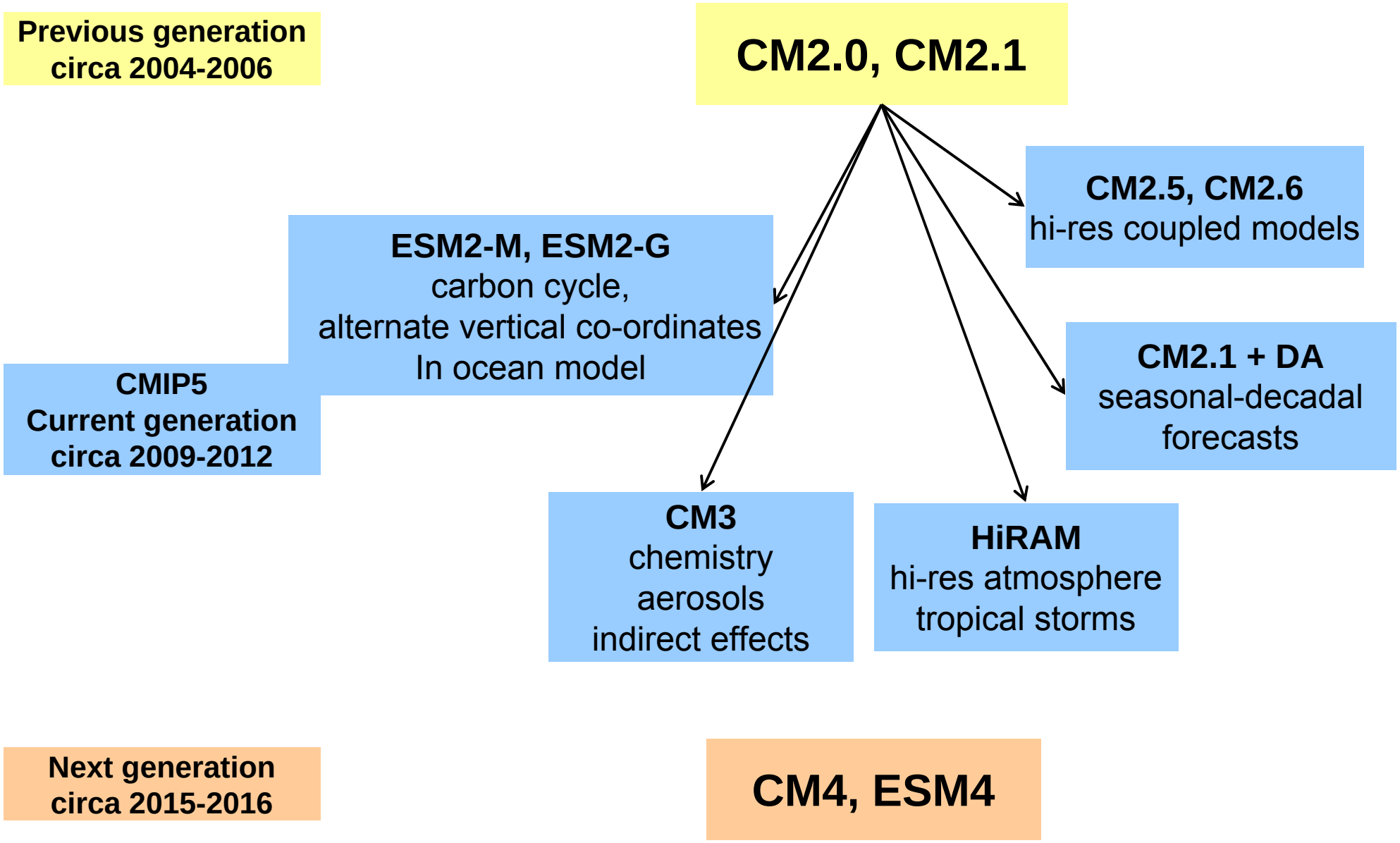
GFDL's Atmospheric Model-4 (AM4)

Excerpted from a presentation by Chris Golaz at the 2014 American Meteorological Society Annual Meeting, "Climate Processes in CMIP5: Inside the Development Process of the Next-Generation GFDL Climate Model"

FLOR Experimental Seasonal-to-Decadal Prediction

Report prepared by Gabe Vecchi.

Brief history of GFDL climate models



Next generation: organization and goals

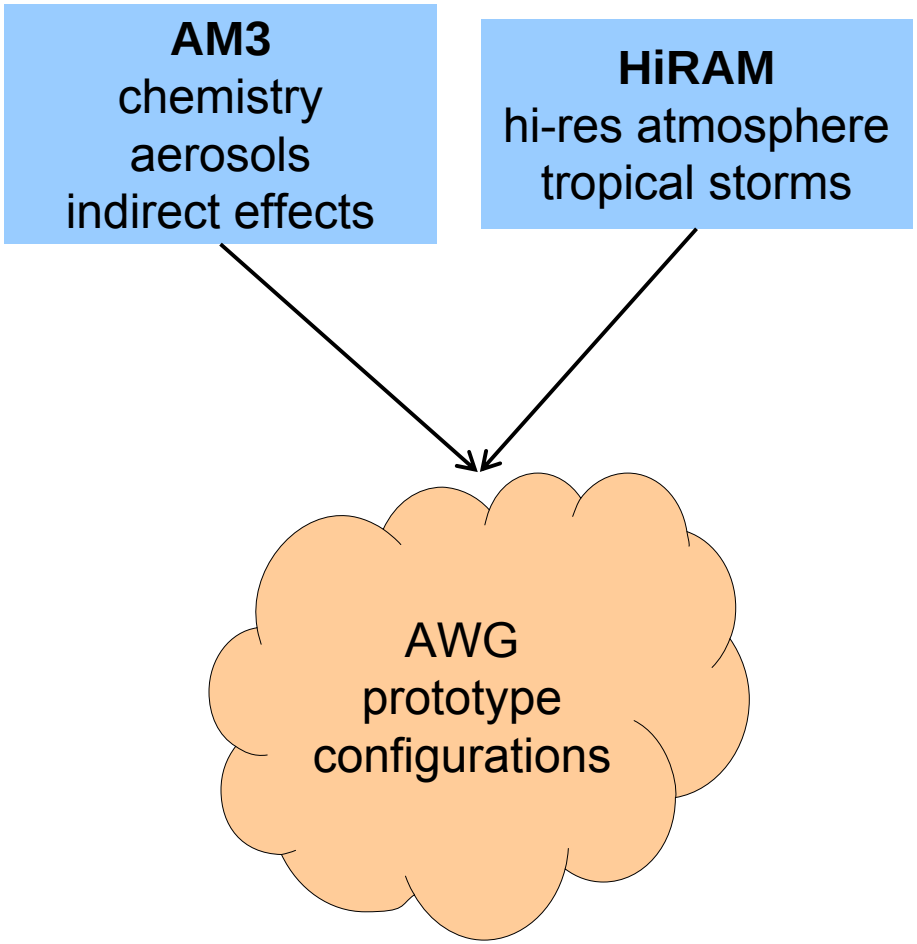
GFDL Model Development Team (MDT, Isaac Held)

- Atmosphere Working Group (AWG)
- Land Working Group (LWG)
- Ocean Working Group (OWG)
- Diagnostics and Evaluation Team (DET)

Goals

- Target resolution of ~50 km atmosphere, 1/4 deg ocean with options for lower/higher resolution configurations.
- Model capable of running from “emissions” as well as from ”concentrations”, in regard to both the carbon cycle aerosols.

Atmosphere Working Group: Year 1



Initial steps

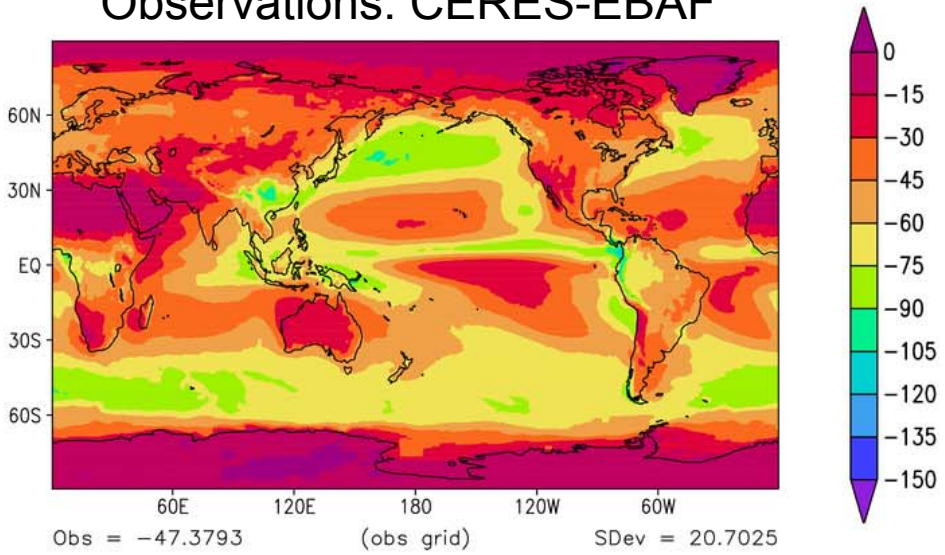
- Resolution: 50 and 100 km (HiRAM)
- Aerosol cloud interactions (AM3)
- Simplified chemistry (new)
- Multiple convection options
  - AM3; HiRAM; double-plume (new)
- AMIP and short coupled simulations
- Tests in forecast mode planned
- Evaluation with GFDL diagnostics packages

Possible future steps

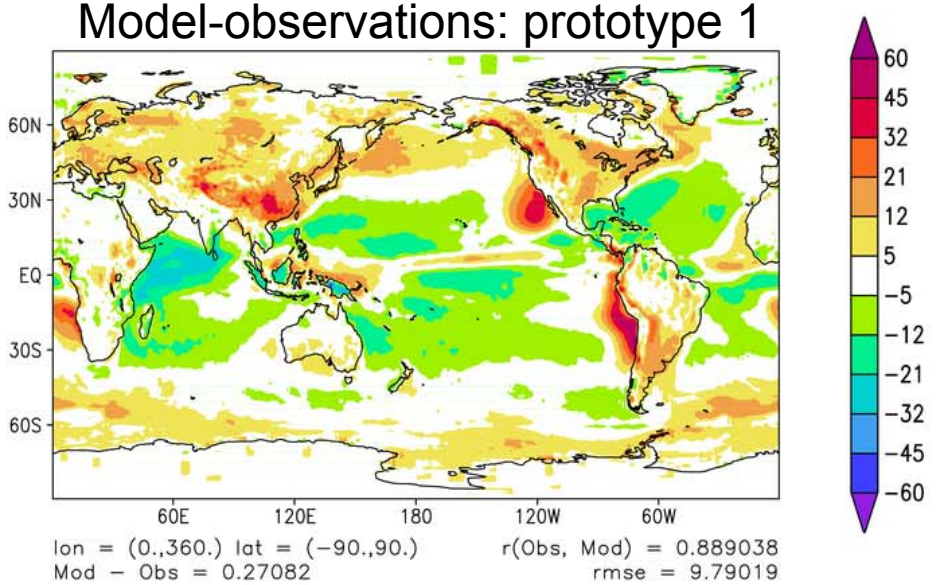
- Microphysics
- Large-scale cloud
- Turbulence

Example: shortwave cloud radiative effect

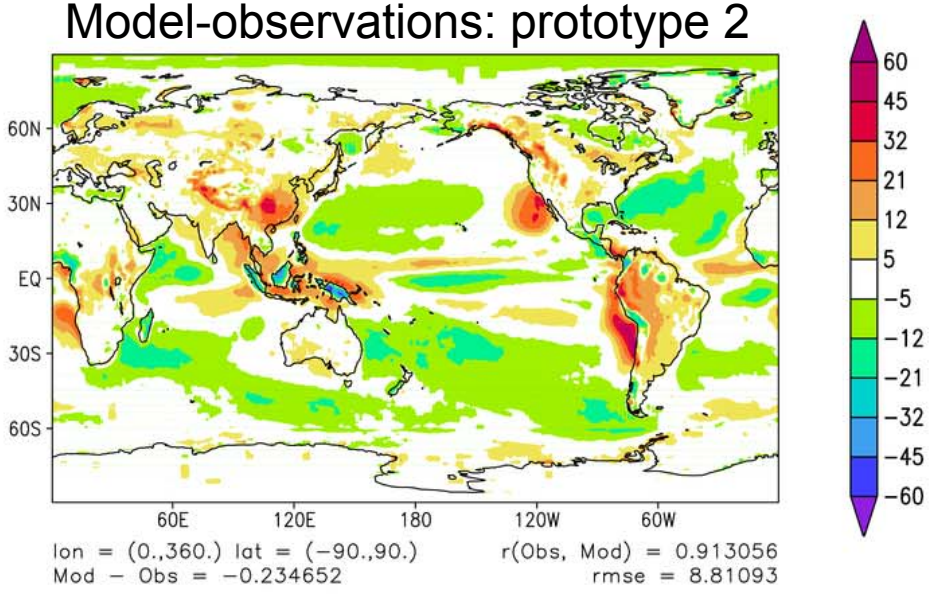
Observations: CERES-EBAF



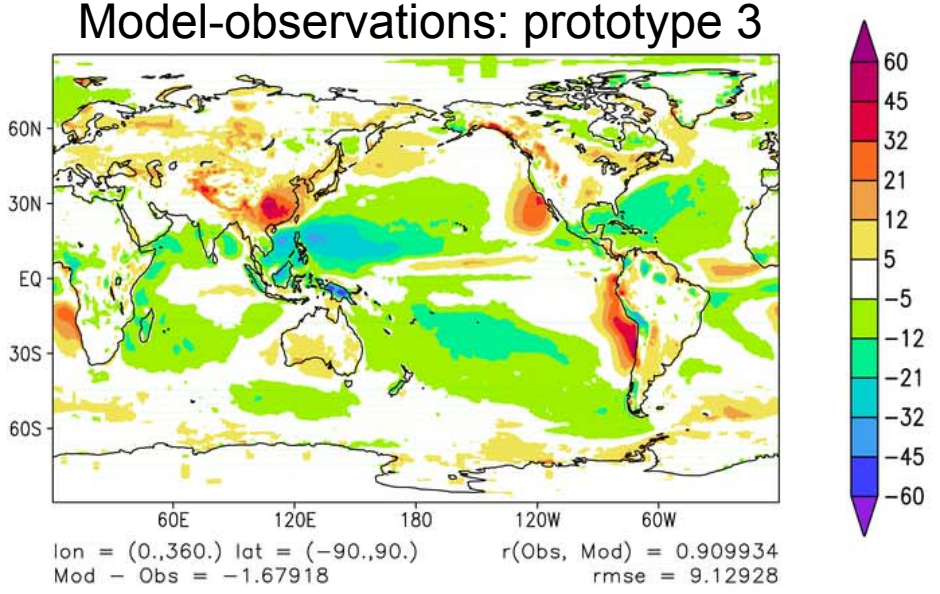
Model-observations: prototype 1



Model-observations: prototype 2



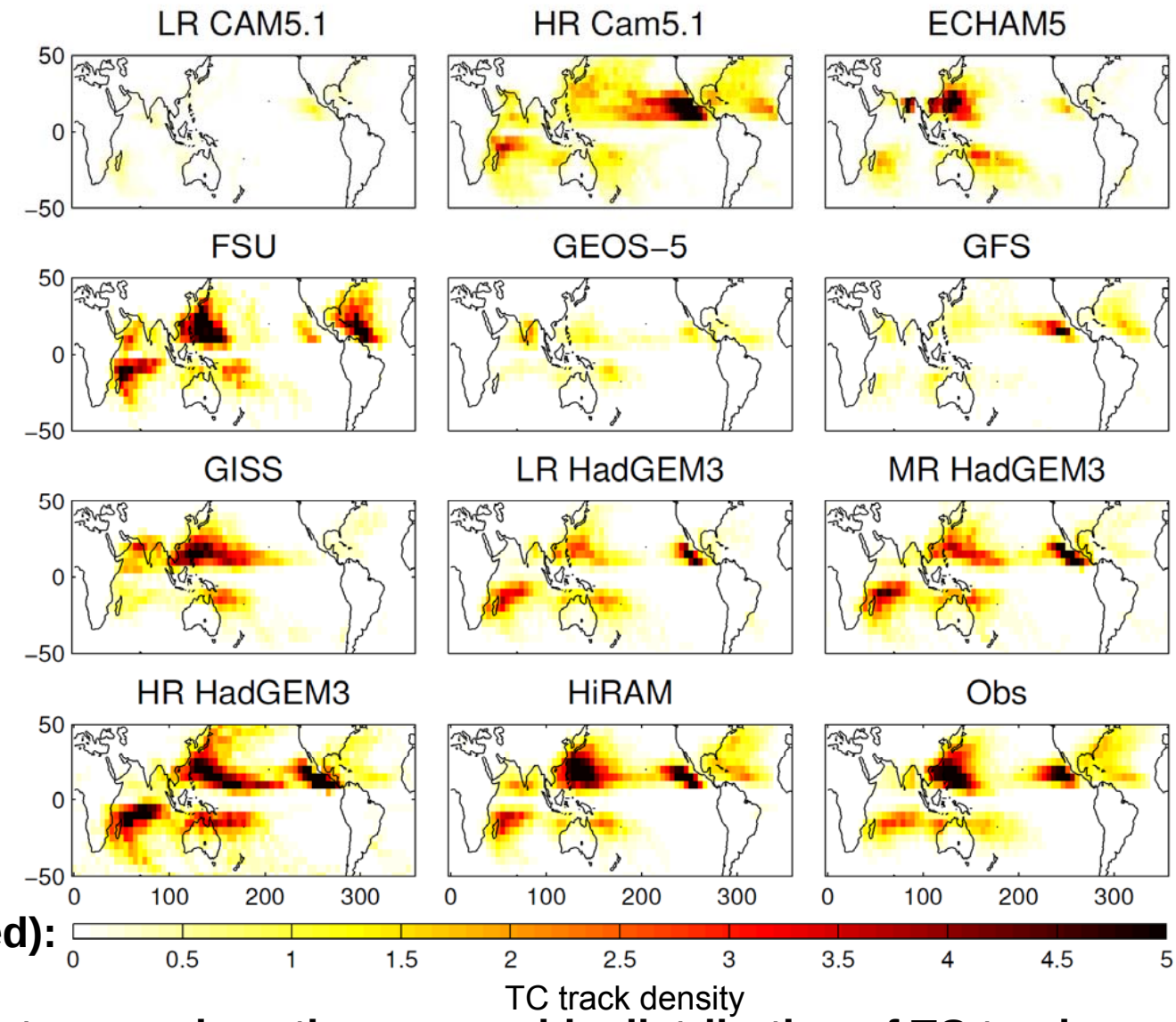
Model-observations: prototype 3



HiRAM

Excellent simulation of tropical cyclones (TC) climatology

Can we maintain this in next generation climate model?



Shaevitz et al. (2014, submitted):

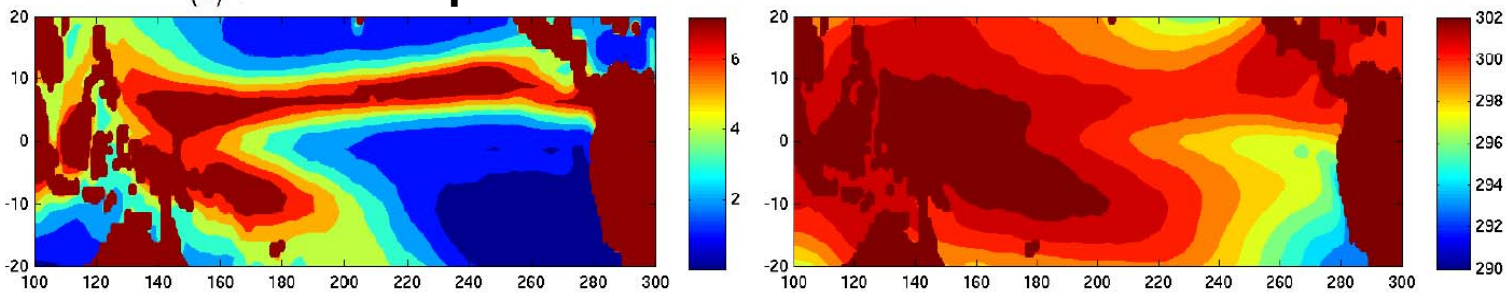
“Overall the models were able to reproduce the geographic distribution of TC track density in the observations, with the HiRAM model, in particular, demonstrating the most similarity to observations”

“Some of the models (especially HiRAM) are able to simulate the TC climatology remarkably well and demonstrate the usefulness of GCM modeling studies of TC characteristics.”

Short coupled simulations with prototype configurations

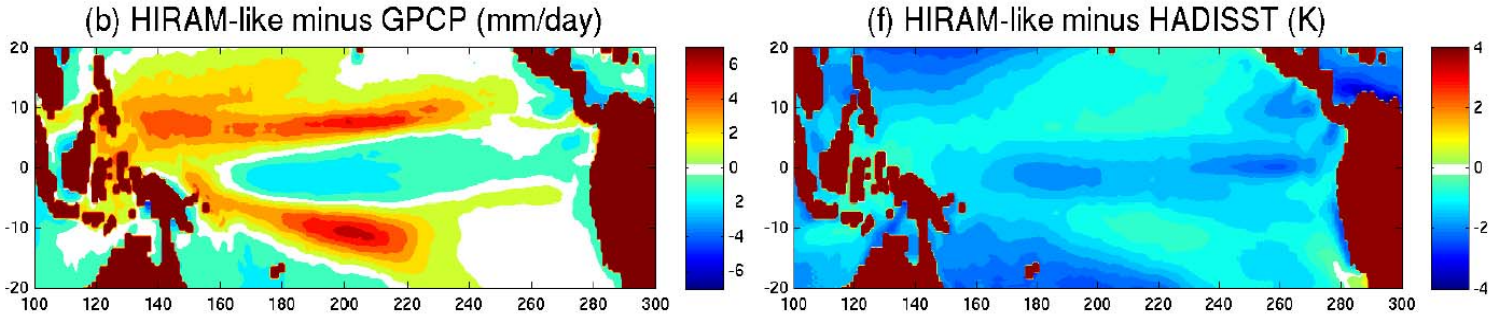
Precipitation **SST**

Observations

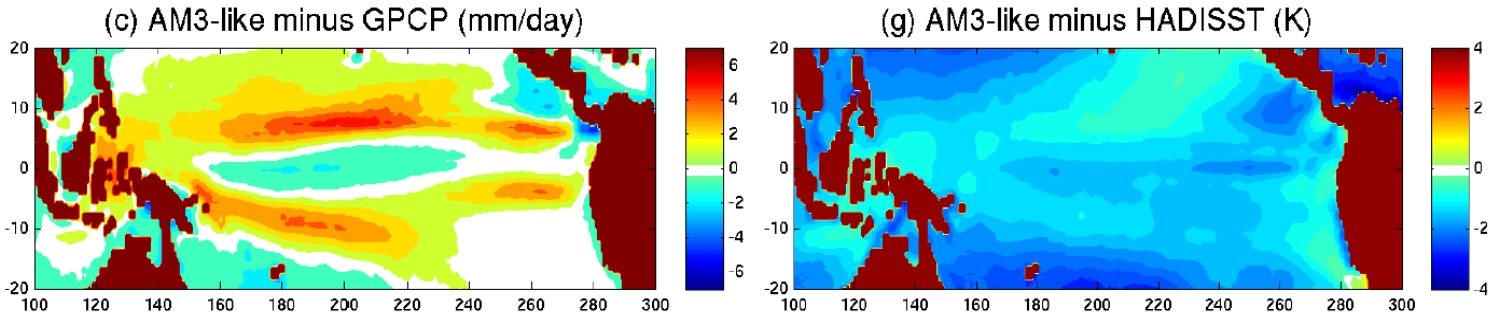


Model - Observations

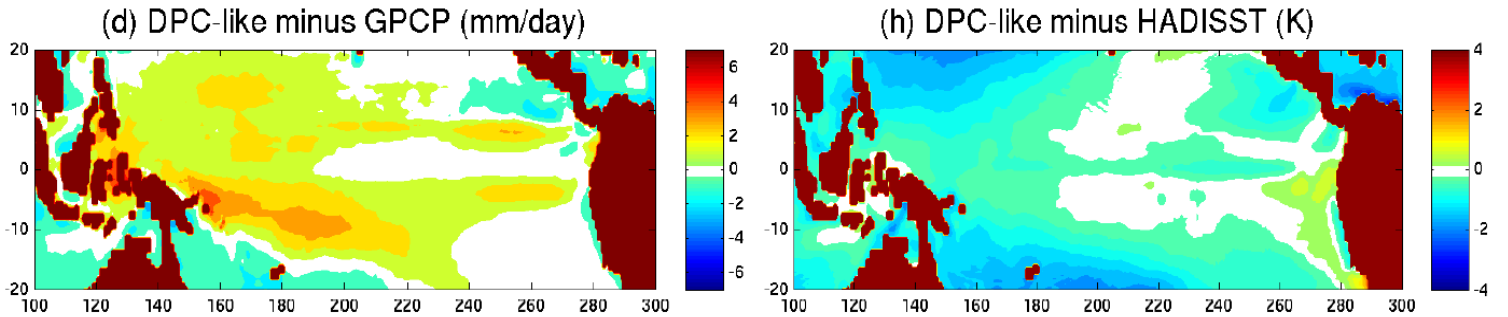
HiRAM-like convection



AM3-like convection



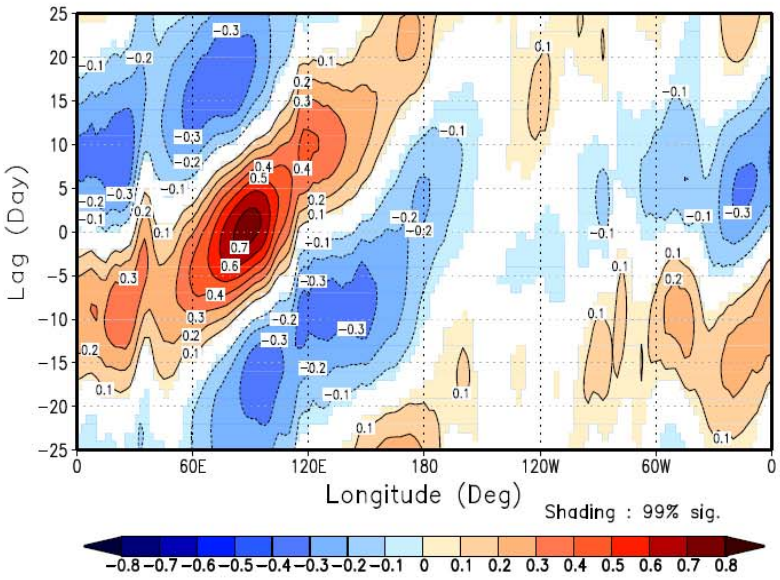
New double-plume convection



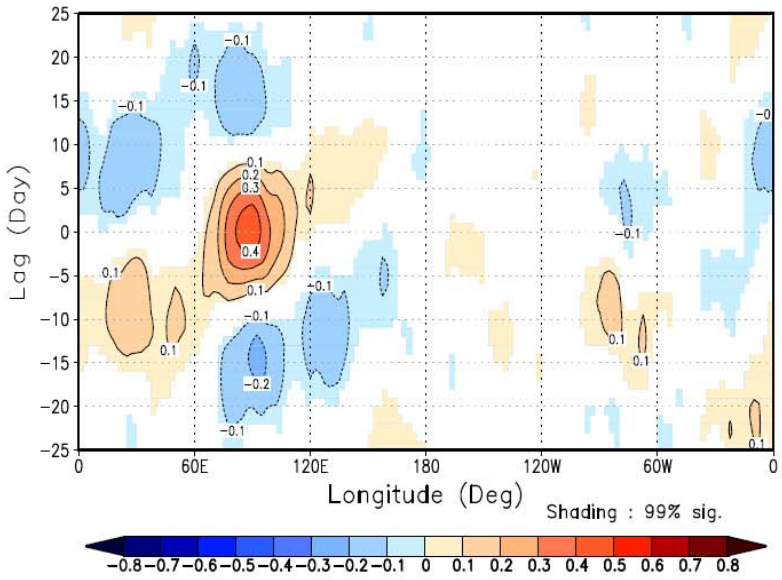
Zhao et al. (in prep.)

MJO: Lag correlation (OLR)

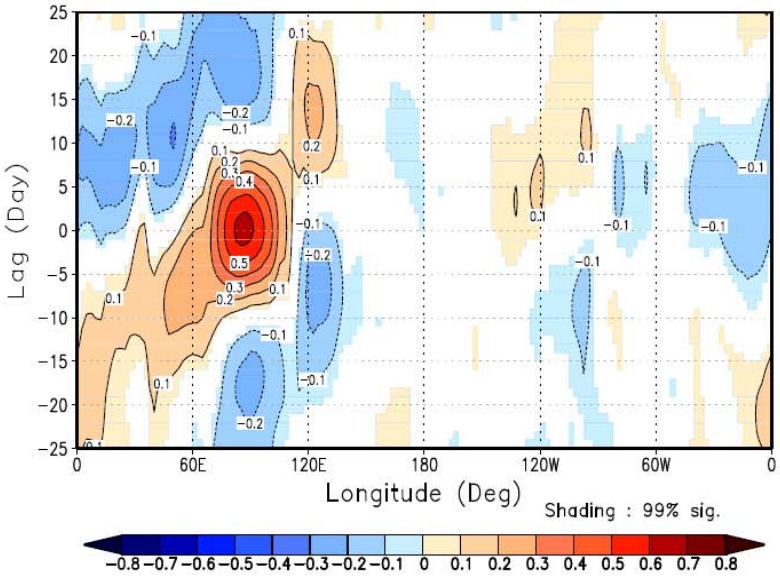
Observations



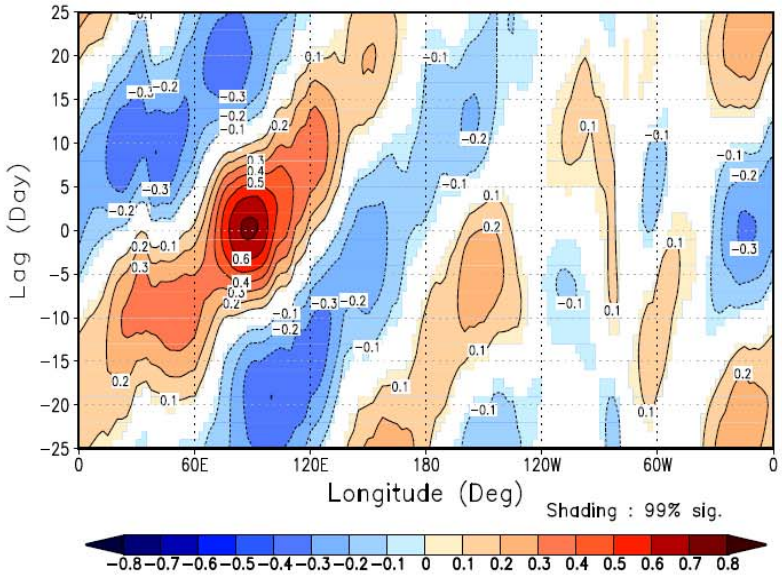
HiRAM-like convection



AM3-like convection

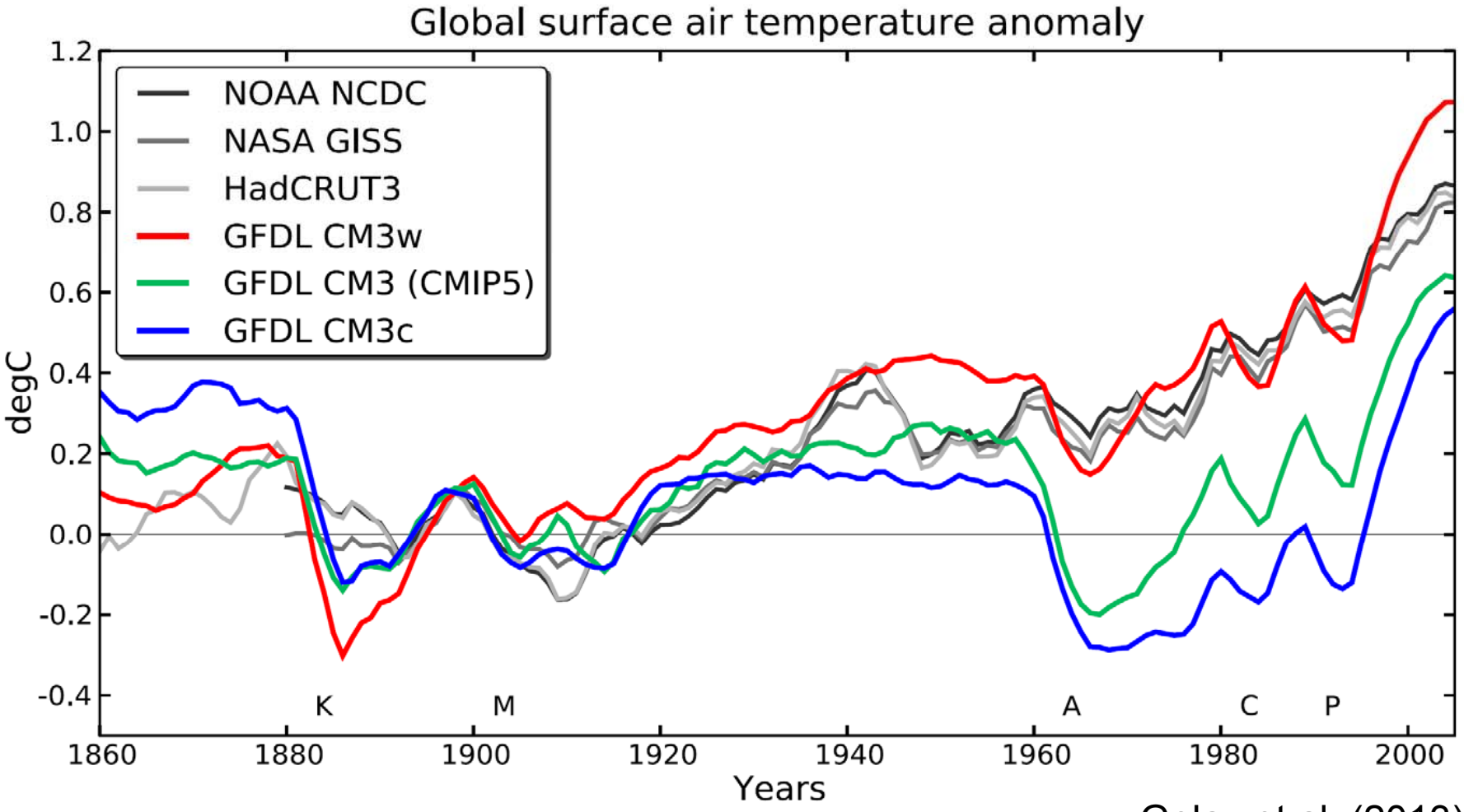


Double-plume convection



Zhao et al. (in prep.)

Indirect effect and 20th century warming



Golaz et al. (2013)

→ Details of warm rain formation have large impact on magnitude of aerosol cloud indirect effect.

→ 20th century warming strongly impacted by indirect effect.

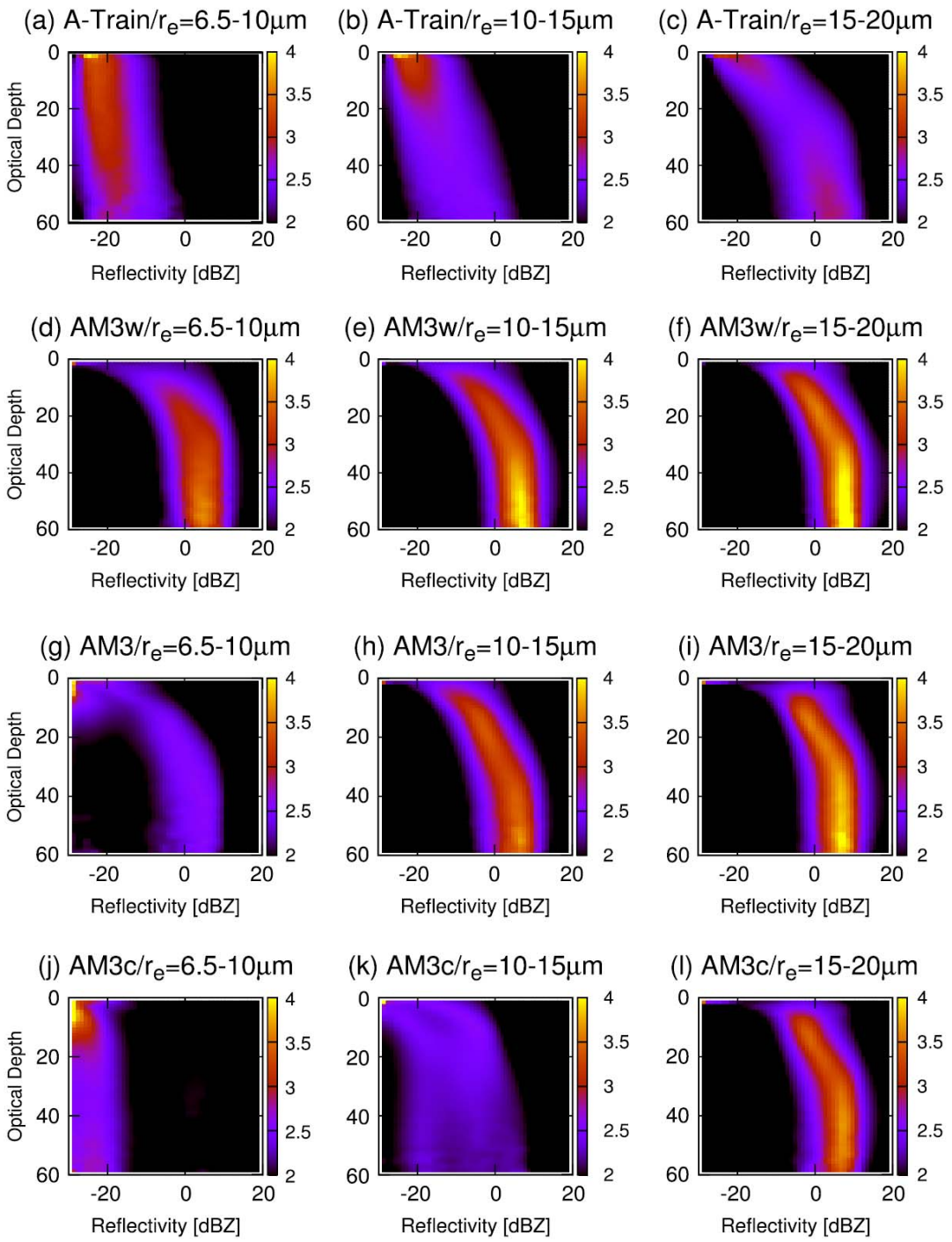
Constraining warm rain formation with satellites
Suzuki et al. (2013)

Observations

CM3w
rain formation is unrealistic (too fast),
but 20th century is realistic

CM3 (CMIP5)

CM3c
rain formation is more realistic,
but 20th century is unrealistic (too cold)



GFDL FLOR: Experimental high-resolution coupled seasonal to decadal prediction system (Vecchi et al. 2014, Jia et al. 2014)

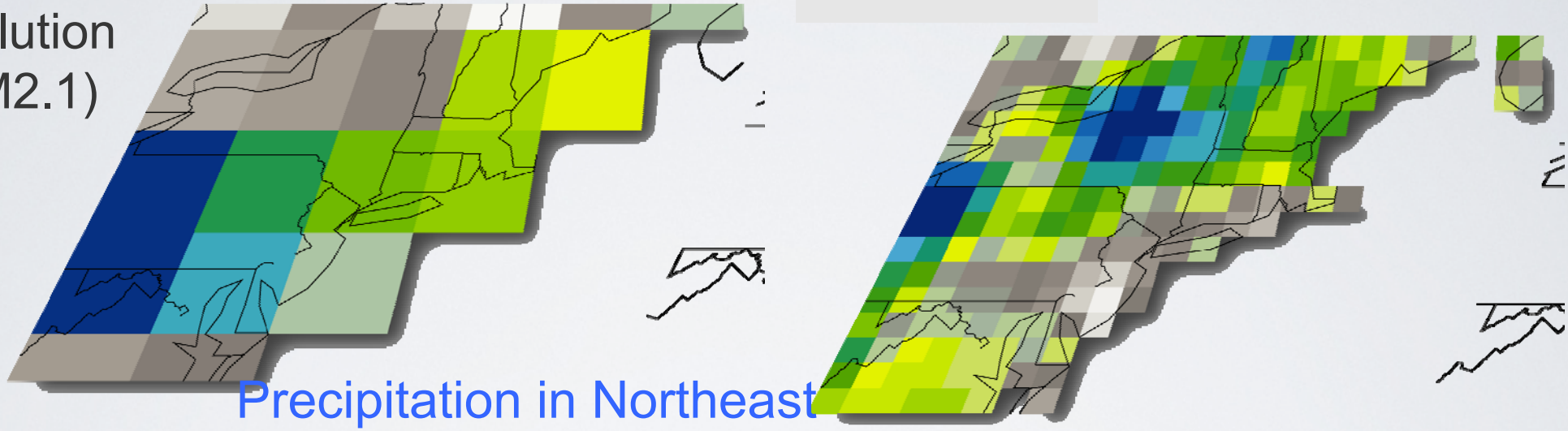
Goal: Build a seasonal to decadal forecasting system to:

Yield improved forecasts of large-scale climate

Enable forecasts of regional climate and extremes

Medium resolution (CM2.1)

High resolution (CM2.5-FLOR)



Precipitation in Northeast USA

Delworth et al. (2012), Vecchi et al. (2014.)

Modified version of CM2.5 (Delworth et al. 2012):

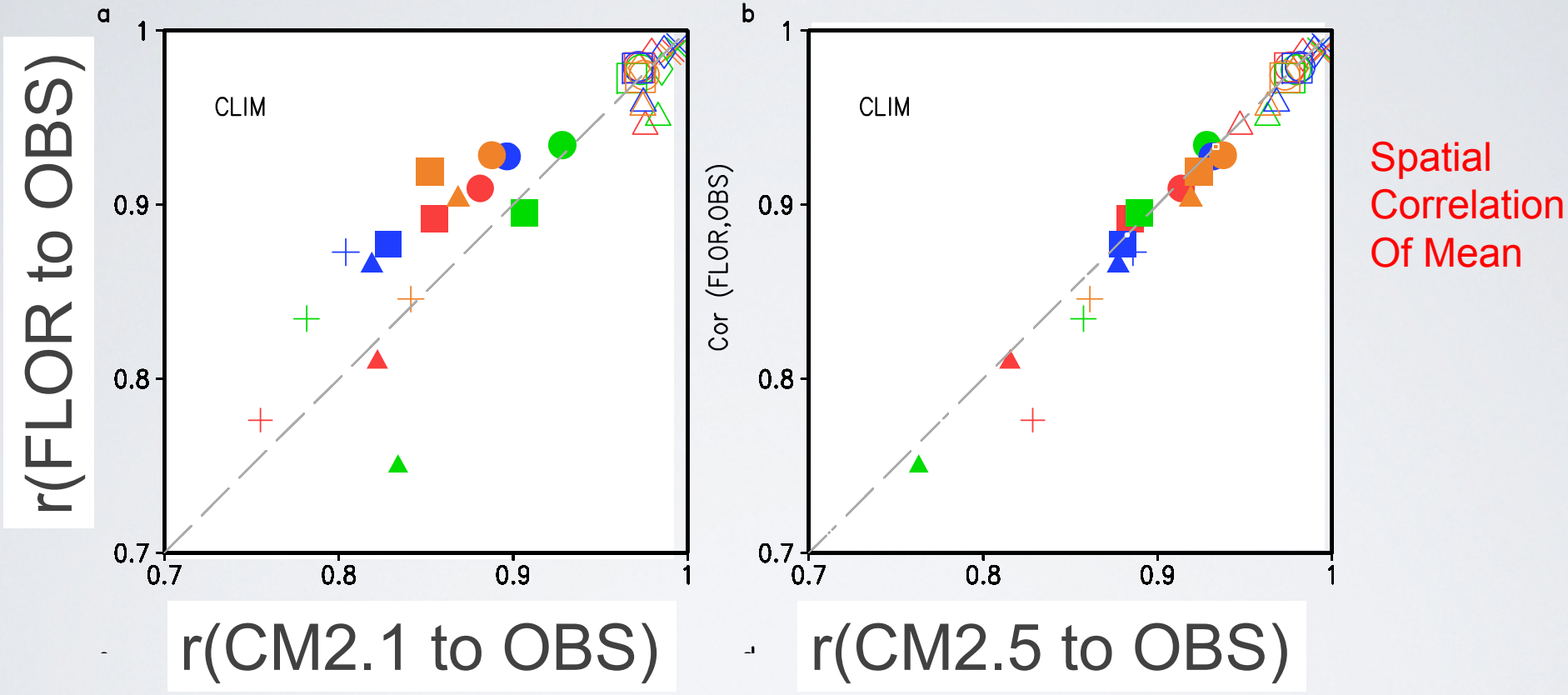
- 50km cubed-sphere atmosphere & land (latest GFDL land model: LM3)
- 1° ocean/sea ice (low res enables prediction work)

~15-18 years per day. Multi-century integrations. 9000+ model-years of experimental seasonal-decadal predictions completed and being analyzed.

Hypothesis: Enhanced atmos./land resolution improves climate

~5xAtmos Res.

4xOcean Res.



Spatial Correlation Of Mean

Figure: Lakshmi Krishnamurthy

Jia et al. (2014, J. Clim.