Status of CAM5

Releases and simulations

- CAM5.1 released in CESM1.0.3 (June 2011)
- CMIP5 version of the model -> AR5
- Multiple 1^{o} simulations (pre-industrial, 20^{th} C (3), RCPs(3) , AMIP, SOM)
- Initial RCPs recently completed
- PNNL: Multiple 2^{o} simulations
- Reproduces 20^{th} century surface temperature evolution
- CAM4 high resolution (25km) time slice experiments (1980-2005; 2075-2100)

High resolution simulations (25 km and finer)

- Time slices (CAM4-FV, CAM5-FV, CAM5-SE; global spectral)
- Global $1/8^{o}$ (12.5 km) simulations using CAM5-SE (2004-2005)
- Regionally refined simulations over US (1^{o} -> $1/8^{o}$)
- CAM5 realistic hurricane statistics (number/strength/variability)
- Summer time US orogenic propagating systems, atmospheric rivers

Status of CAM5

Model Physics

- Microphysics in convection (DOE-ASR) + next generation MG
- Unified Convection (UNICON): combined deep + shallow
- Cloud Layers Unified By Binormals (CLUBB) (CPT)
- PDF cloud schemes implementation (CPT)
- MMF/SP-CAM (EaSM)
- Conservative Semi-LAgrangian Multi-tracer (CSLAM) advection
- Diagnostic aerosol calculations, dust optics
- Resolution dependence -> scale-aware schemes (SciDAC)

Model climate diagnosis

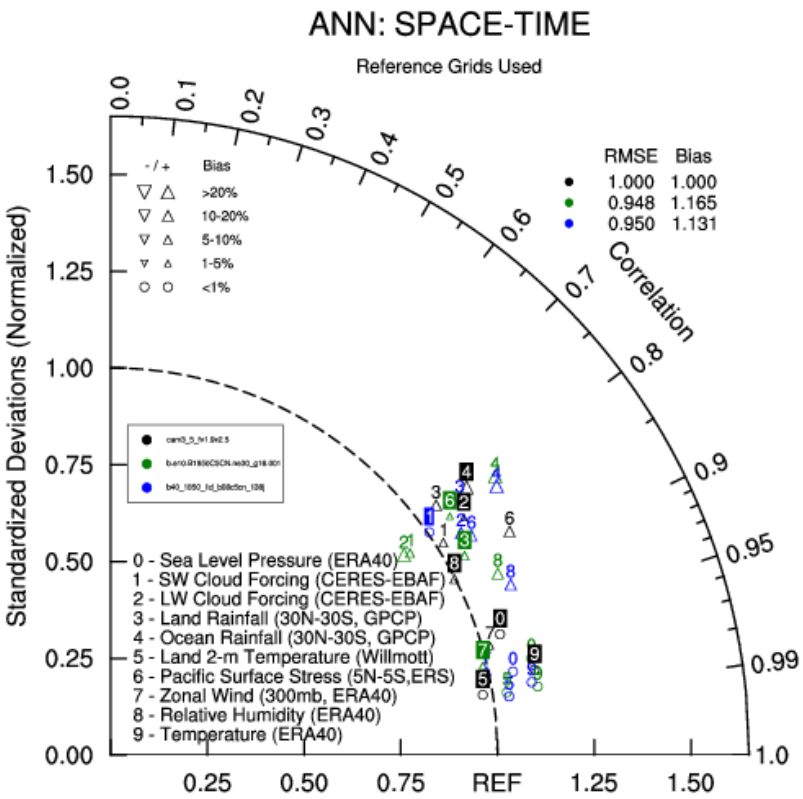
- Cloud properties via satellite simulators (COSP)
- Initialized hindcast activities (CAPT)
- Diagnose fast-physics errors
- Mean climate, variability and numerics sensitivties
- Uncertainty Quantification (UQ): CAM5 versus CAM4 sensitivities

Next CAM5 release (May 2012)

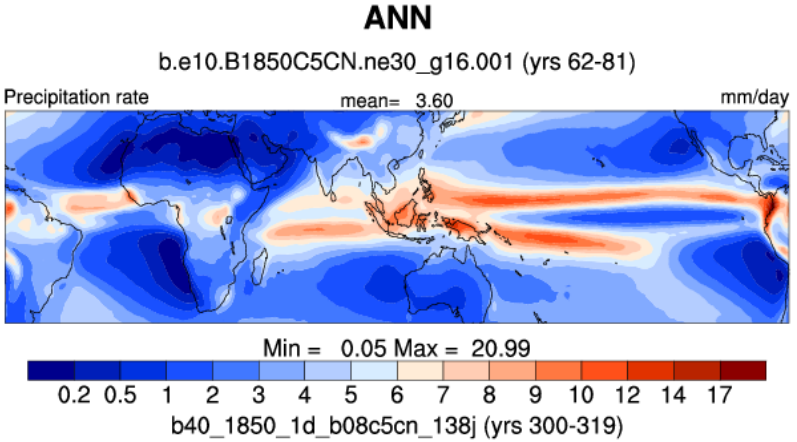
- CAM5-SE 1° coupled climate (retaining CAM5.1 physics)
  - Initial simulation similar to CAM5-FV 1°
  - Differences related to orographic smoothing (too smooth)
  - Complete revamp of orographic specification (Peter)
  - Short term: Provide orog. data -> similar climate to CAM5-FV
  - Long term: Specify rougher resolved orog., tune TMS and GWD response to sub-grid scale orog.
- CAM5-FV, MAM prescribed aerosols
  - Sampling methodology of monthly mean aerosol is in place
  - Sub-sample in-cloud and mean aerosol, proportional to liquid cloud frac.
  - Reproduces cloud liquid/radiative forcing fields well (AMIP 2°)
  - Outstanding problems: Low arctic aerosol issues/some code cleanup
  - Strategy for fixing problem and coupled testing (and 2° and 1°)
  - Short term: Adjusted aerosols datasets vs. traditional tuning?
  - Long term: MAM/transport tuning in CAM5 predicted

CESM(CAM5-SE) coupled simulations

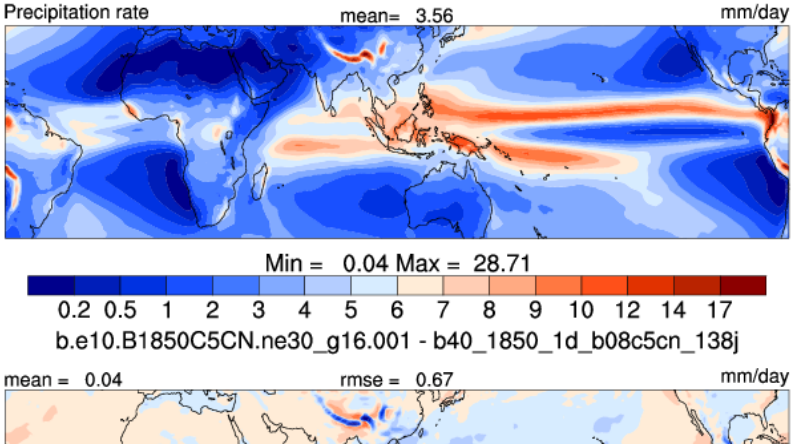
1° Pre-industrial control



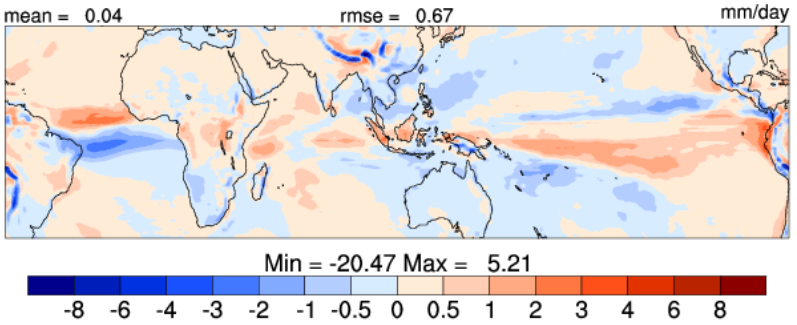
CAM5-SE



CAM5-FV



Diff.

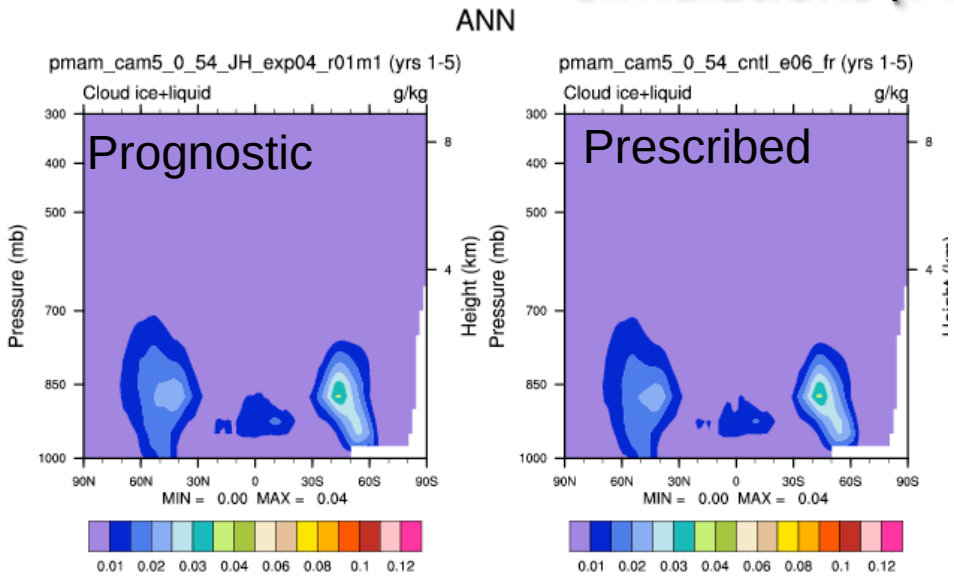


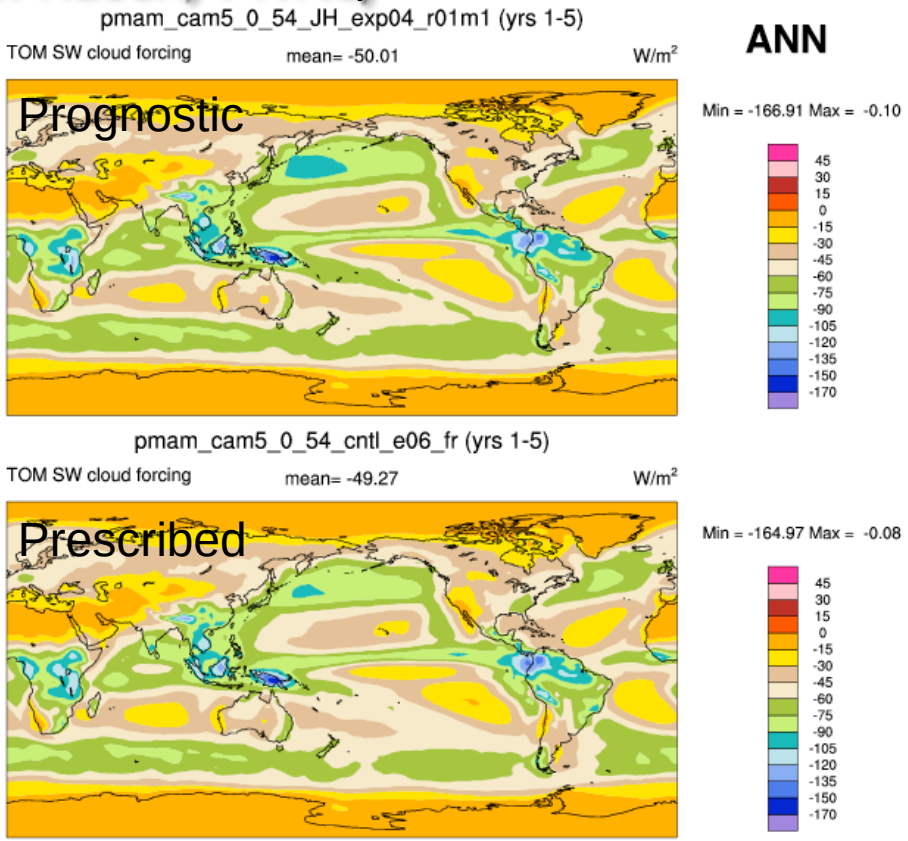
✓Major differences related to orography

Thanks: Andy Mai, NCAR

Prescribed Aerosols

Simulations (Phil Rasch, PNNL)



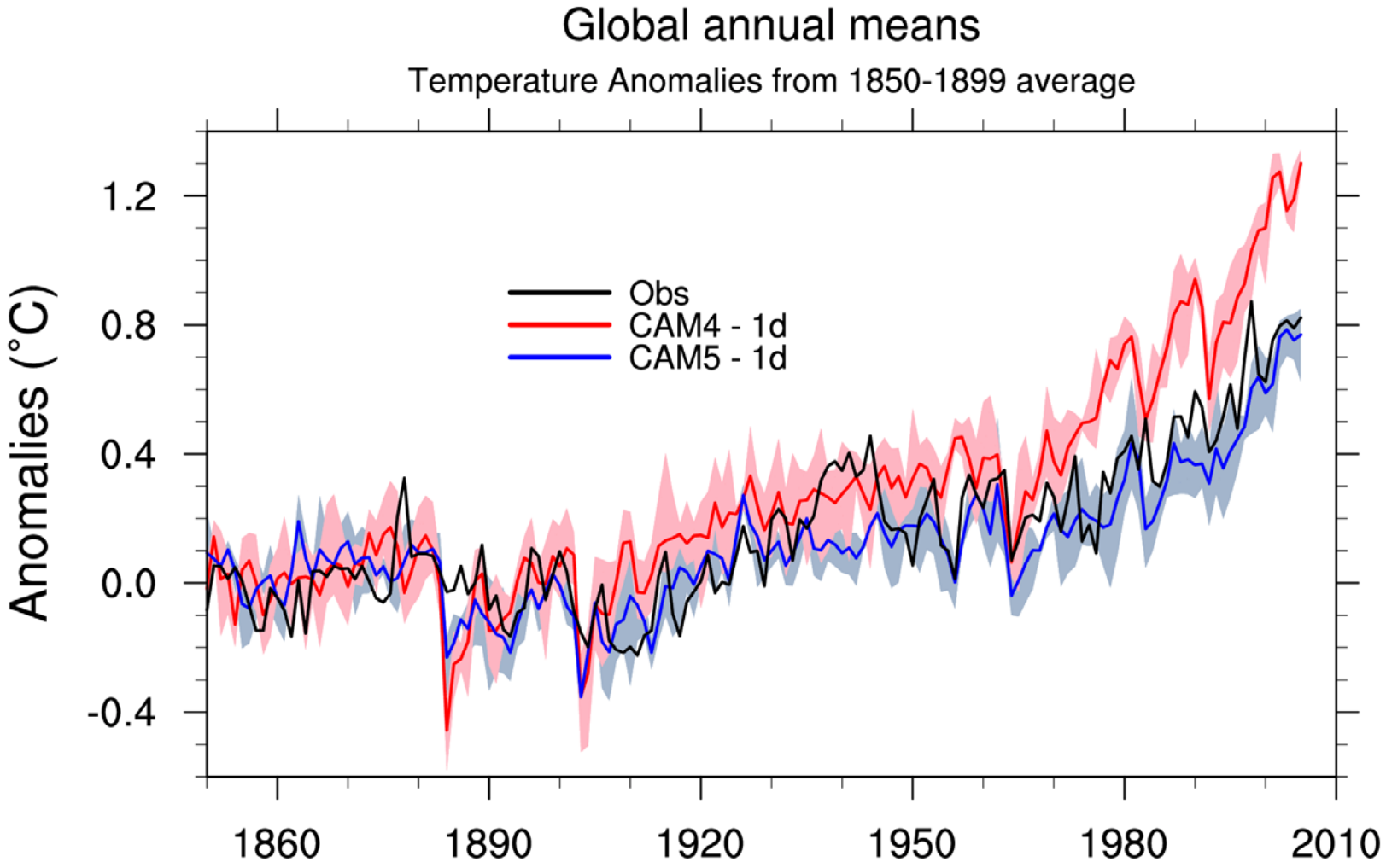


- **Cloud Water**
- Remaining tasks:
  - Remaining Differences are found in Arctic region
  - Aerosol deposition fluxes to surface need to be prescribed, too.(right now they are wrong)

- **Short-wave cloud forcing**
- $X_{prescribed} = X_{cloudy} * F_{liq} + X_{ALL} * (1 - F_{liq})$

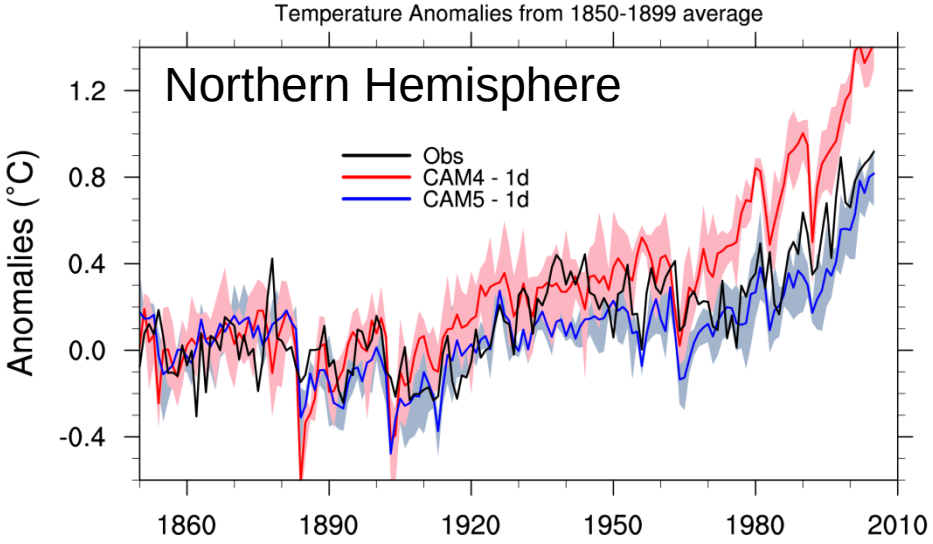
20th Century Climate Change

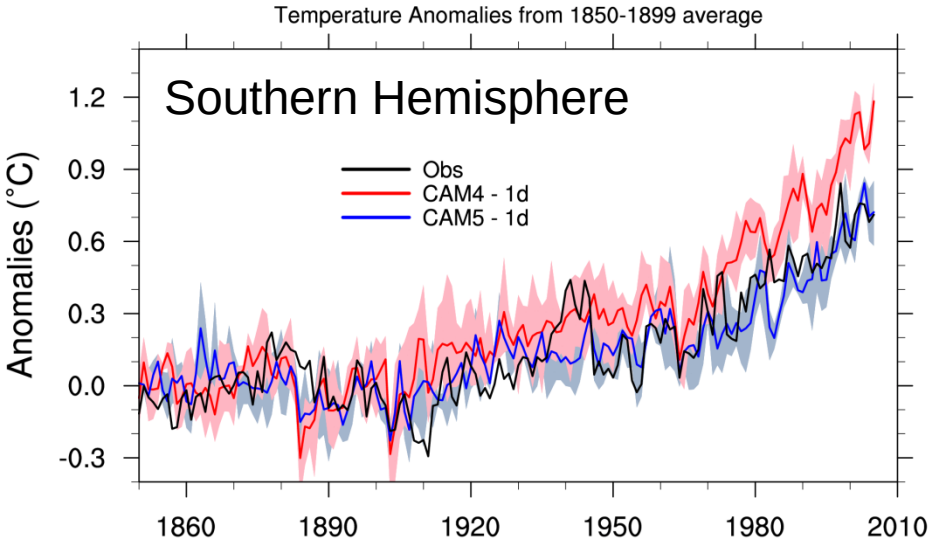
CESM1(CAM5) CMIP version vs. CCSM4(CAM4)

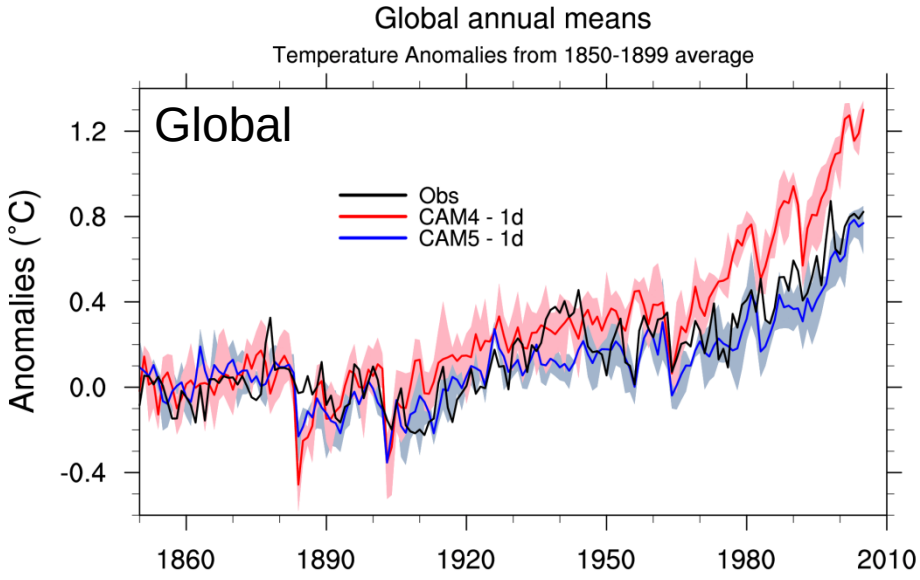


20th Century Climate Change

CESM1(CAM5) CMIP5 version vs. CCSM4(CAM4)

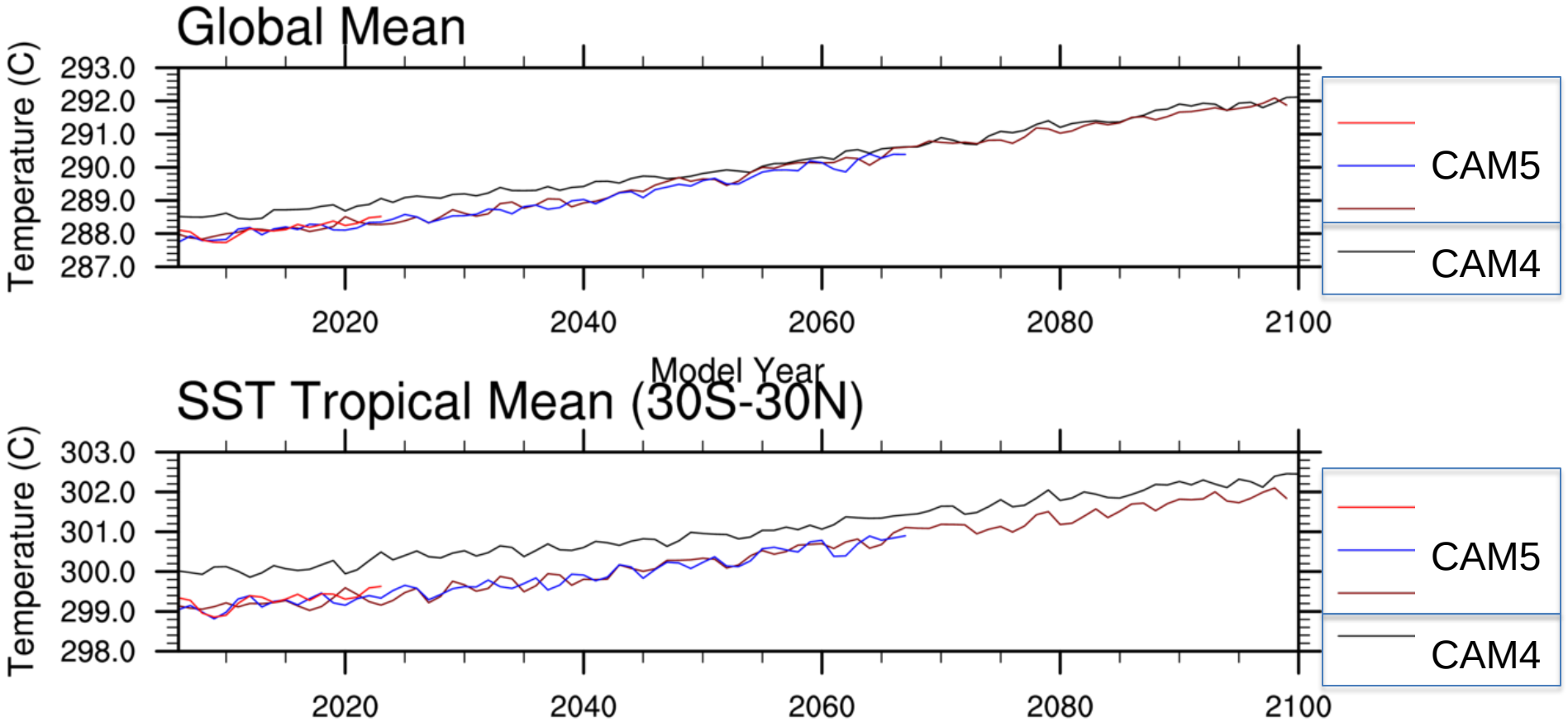






Future Climate Change (RCP8.5)

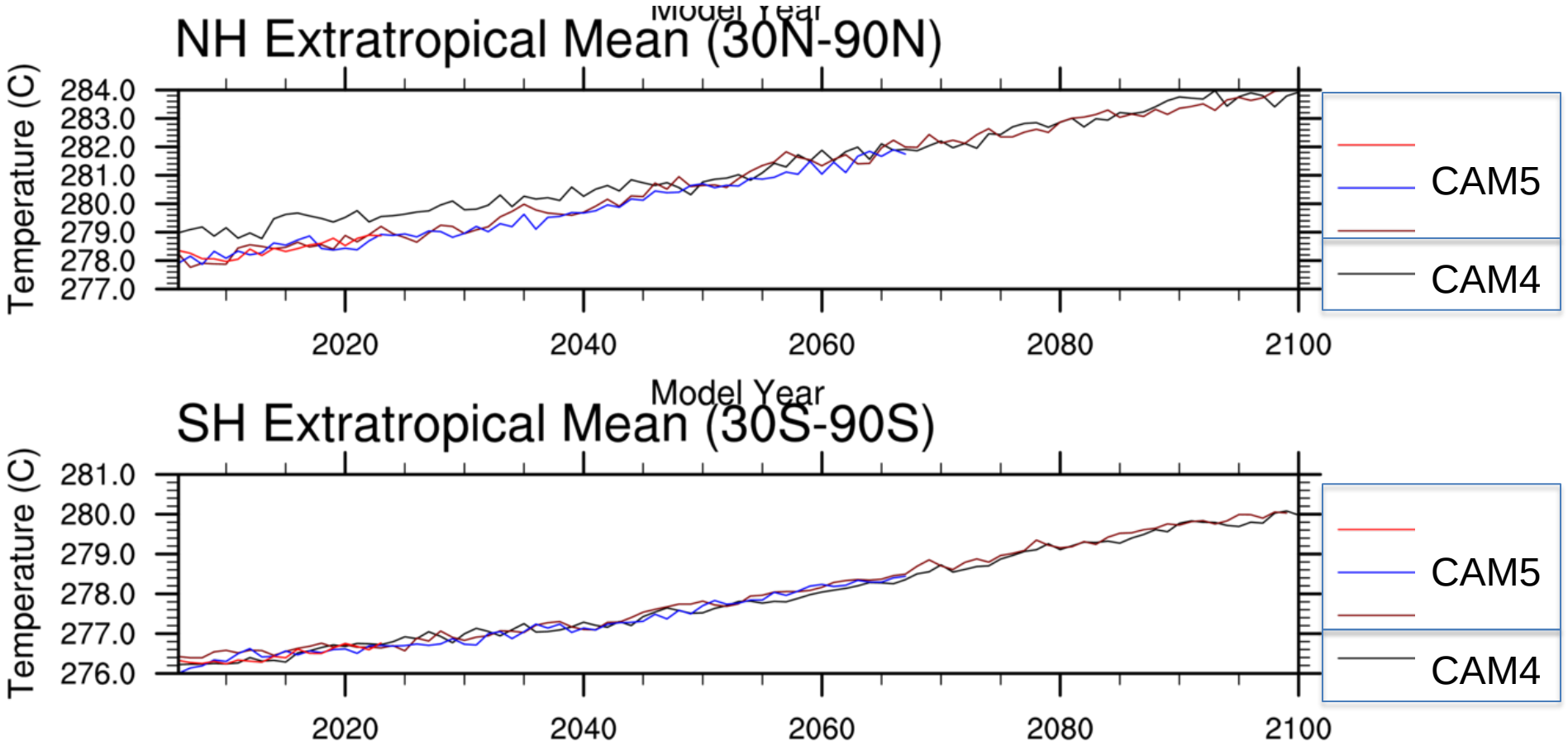
CESM1(CAM5) CMIP5 version vs. CCSM4(CAM4)



Thanks: Trey White, Adrianne Middleton, Cheryl Craig, Andrew Gettleman, and Cecile Hannay, NCAR

Future Climate Change (RCP8.5)

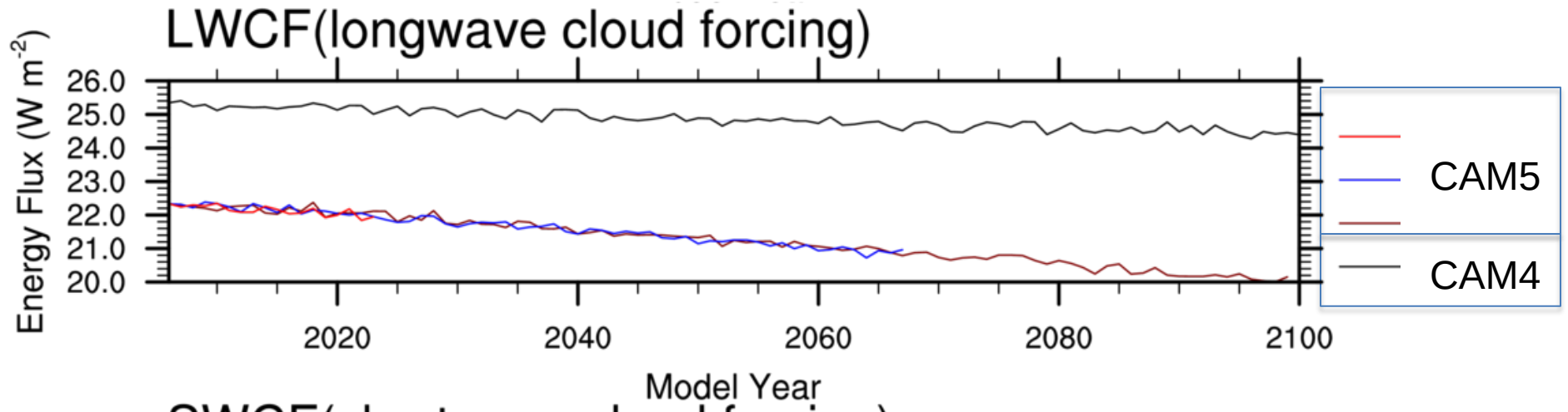
CESM1(CAM5) CMIP5 version vs. CCSM4(CAM4)

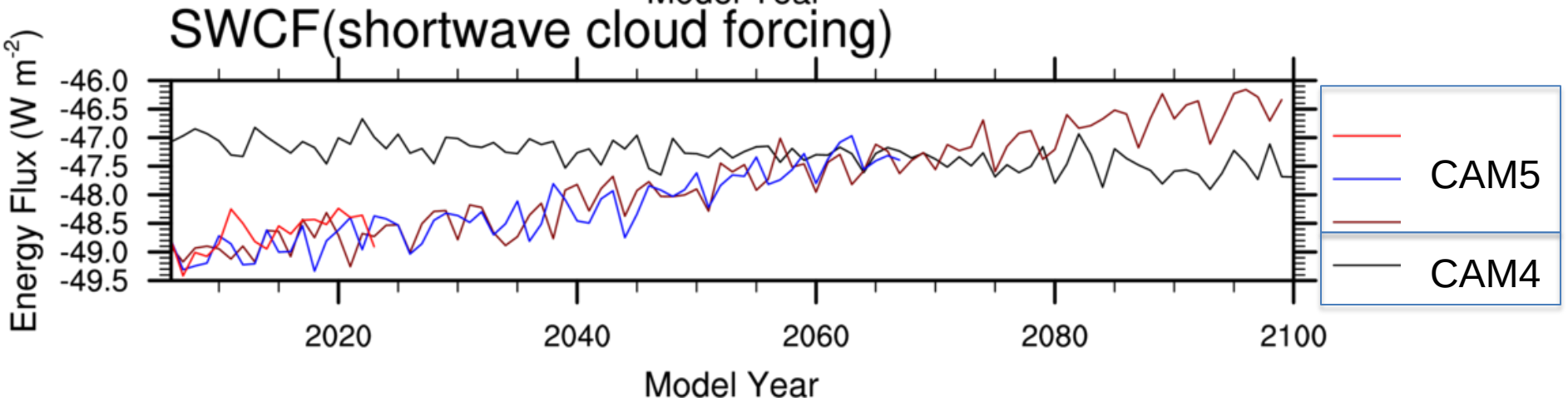


Thanks: Trey White, Adrianne Middleton, Cheryl Craig, Andrew Gettleman, and Cecile Hannay, NCAR

Future Climate Change (RCP8.5)

CESM1(CAM5) CMIP5 version vs. CCSM4(CAM4)

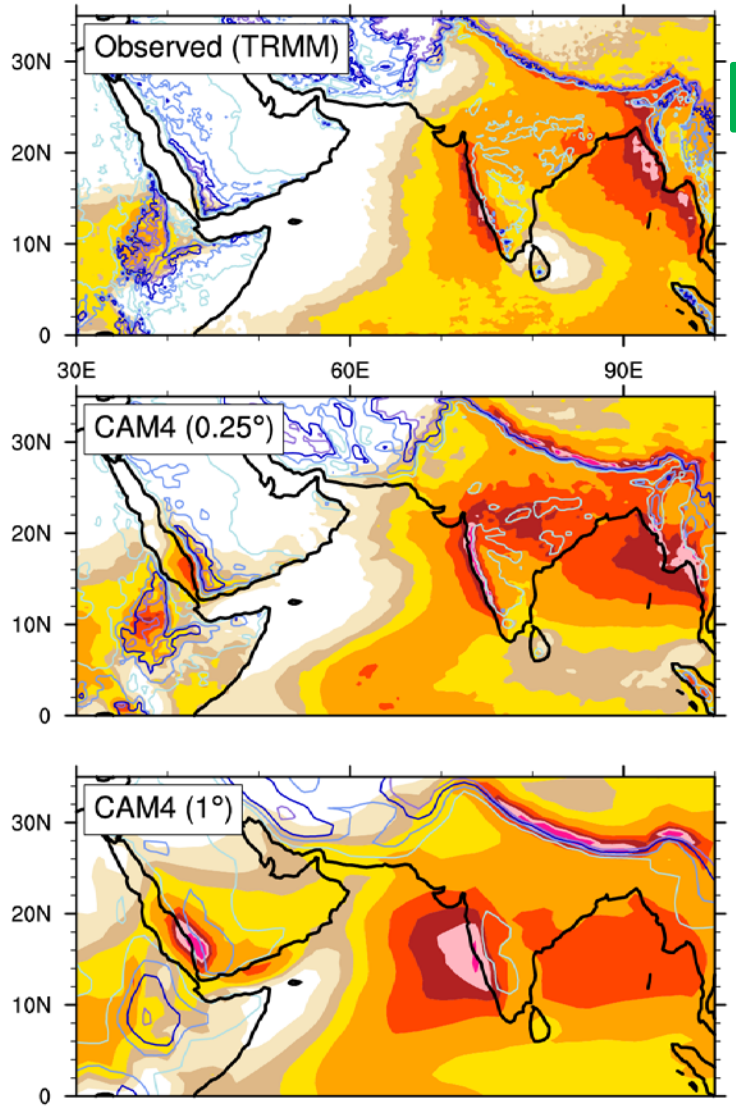




Thanks: Trey White, Adrianne Middleton, Cheryl Craig, Andrew Gettleman, and Cecile Hannay, NCAR

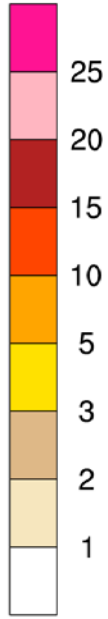
High Resolution: The role of Orography

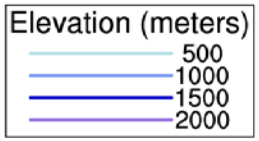
CAM4-FV 25-km AMIP runs/20-year averages



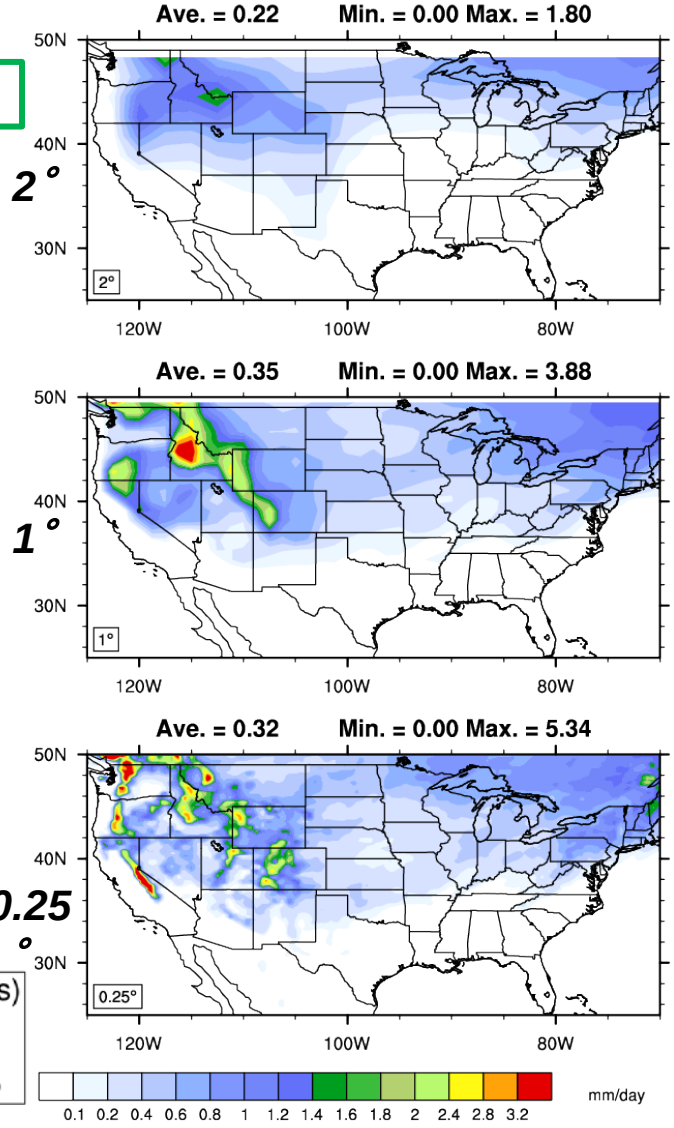
JJAS Precip.

mm/day





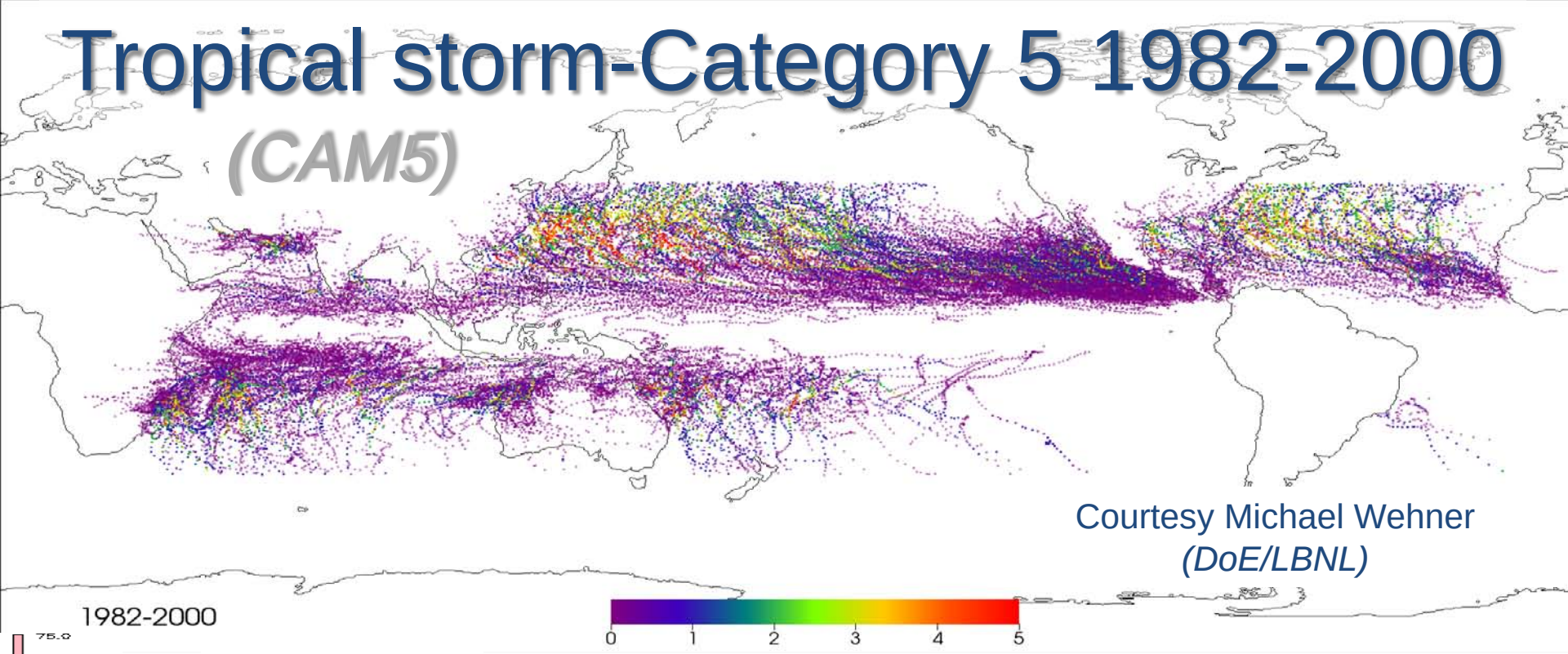
March Snowfall



Community Earth System Model

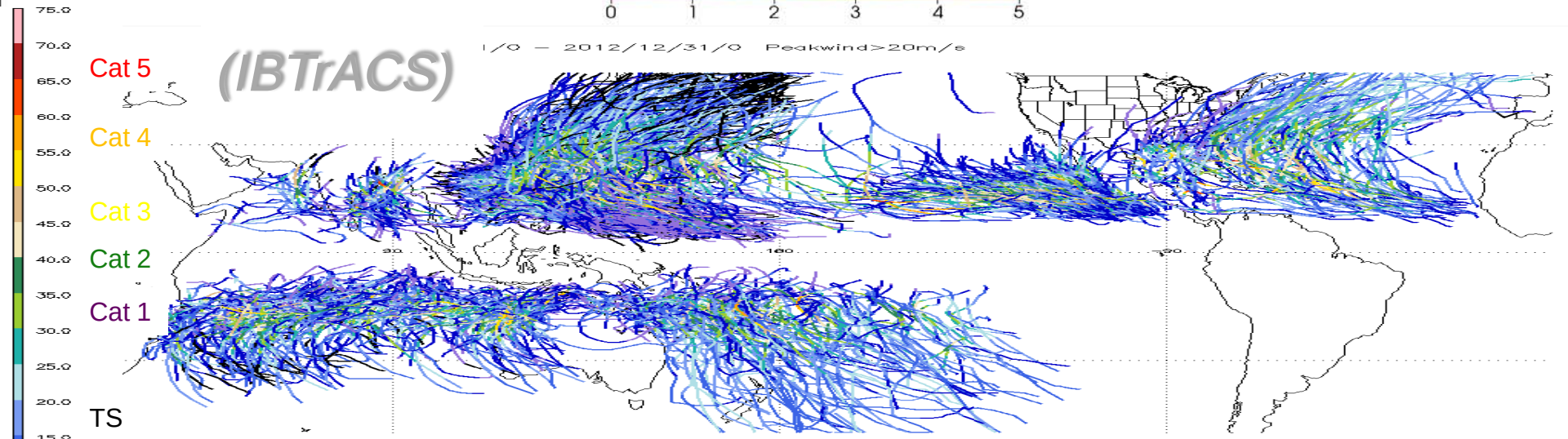
Tropical storm-Category 5 1982-2000

(CAM5)



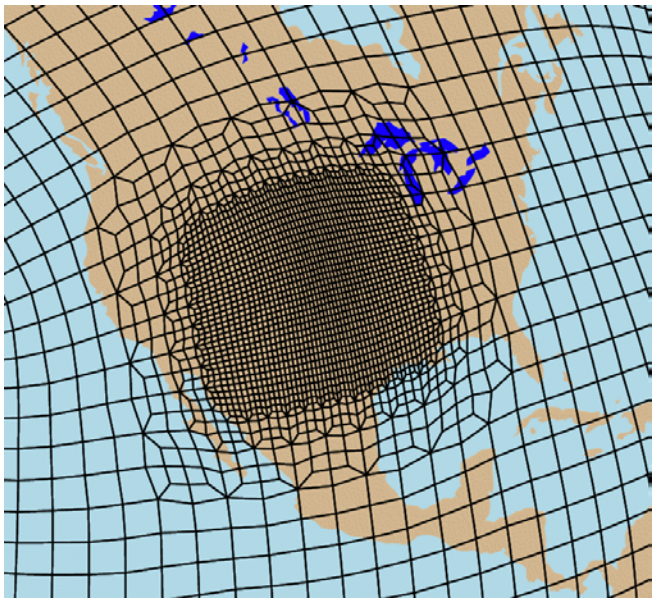
Courtesy Michael Wehner
(DoE/LBNL)

(IBTrACS)

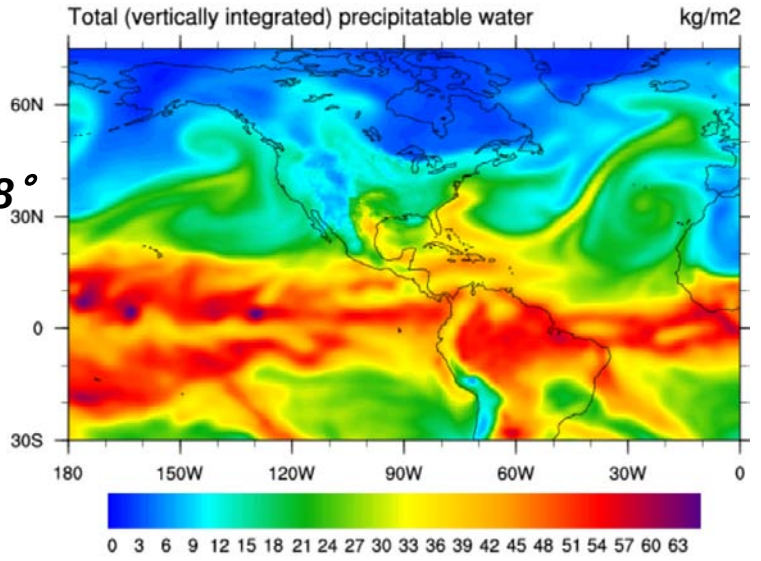


CESM1(CAM5-SE): Regional Refinement

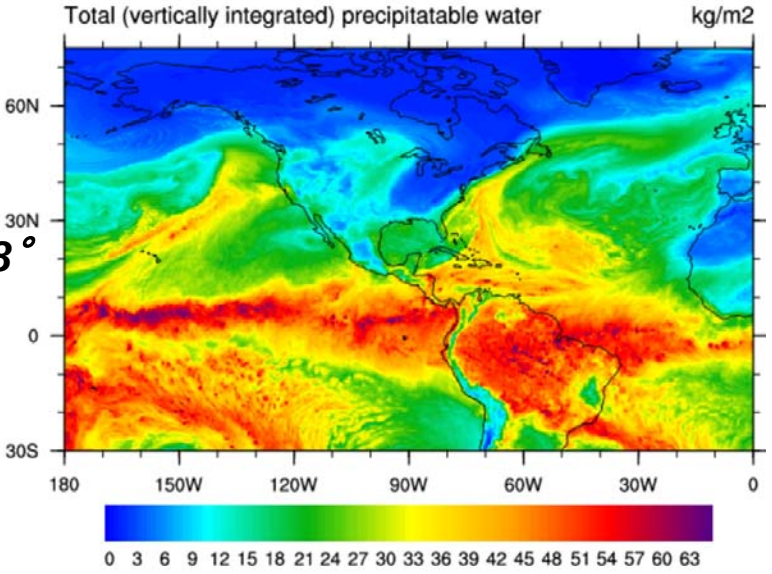
Avoiding Downscaling BUT Implications for resolution dependence



1˚ to 1/8˚



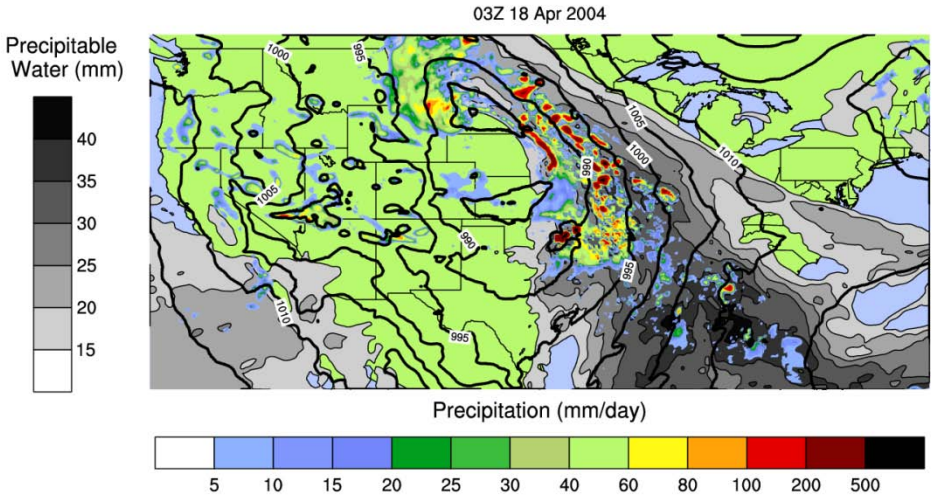
Global 1/8˚



- ✓ 3 levels (steps) of refinement
- ✓ CAM5-SE AMIP simulations
- ✓ Regional refinement should reproduce statistics of global high-res equivalent
- ✓ Land can run on same grid
- ✓ Calibration testbed

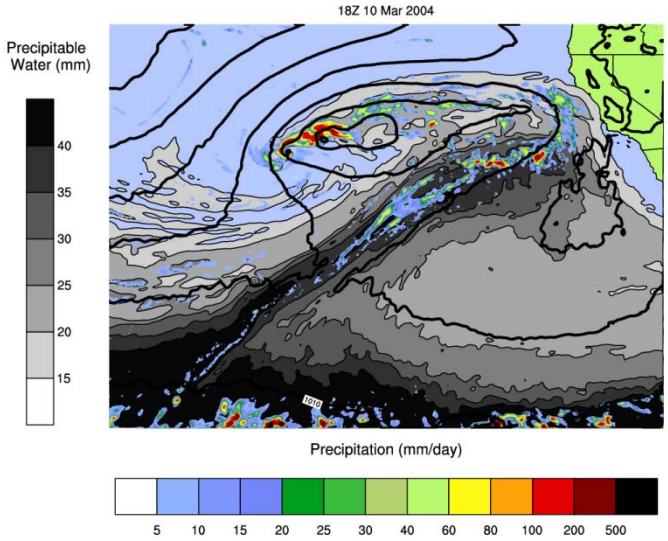
High Resolution: High Impact Phenomena

12-km CAM5-SE AMIP Simulation Snapshots

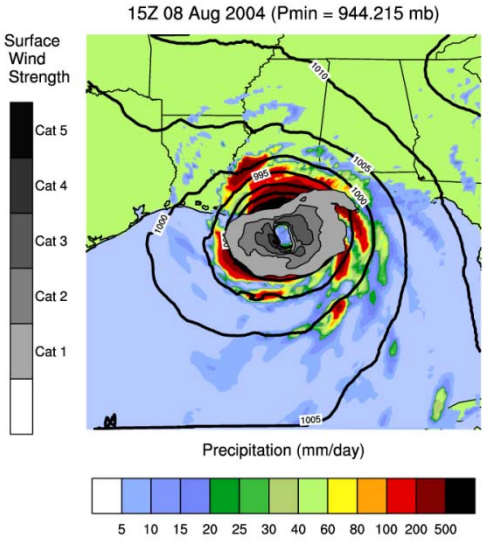


Mid-west Spring time systems

Atmospheric Rive

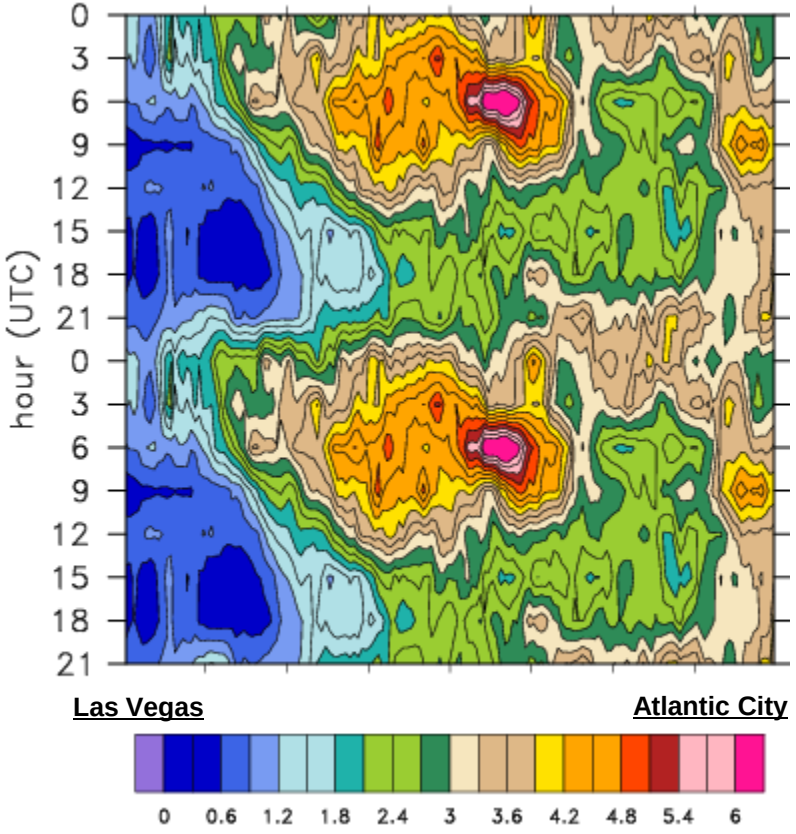


Tropical Cyclones



US Orogenic Systems

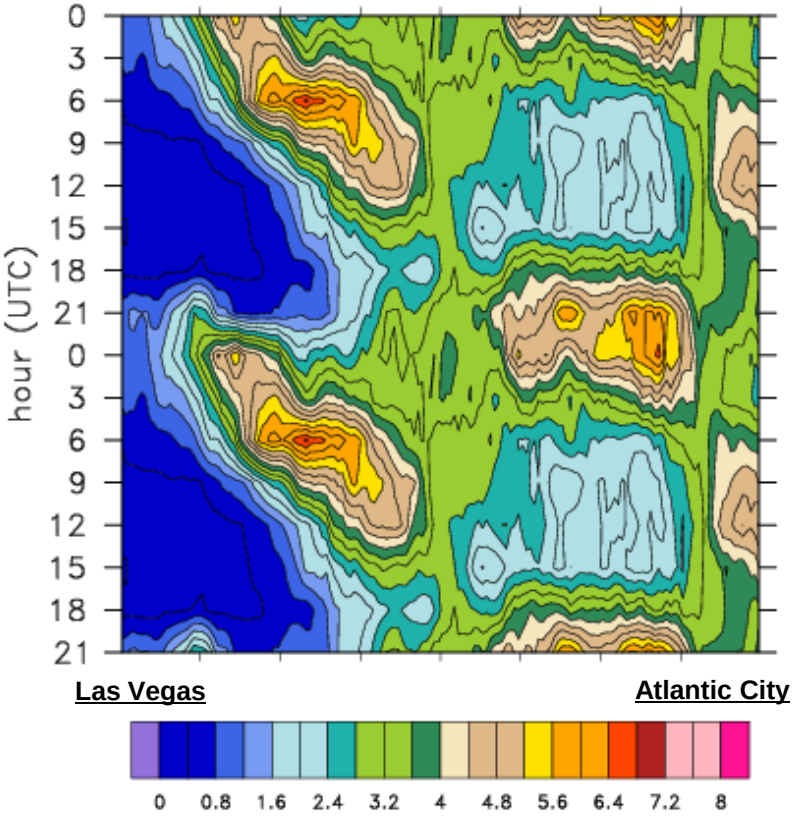
TRMM
(April/May)



5pm
11pm
5am
11am
5pm
11pm
5am
11am
5pm

CO Local Time

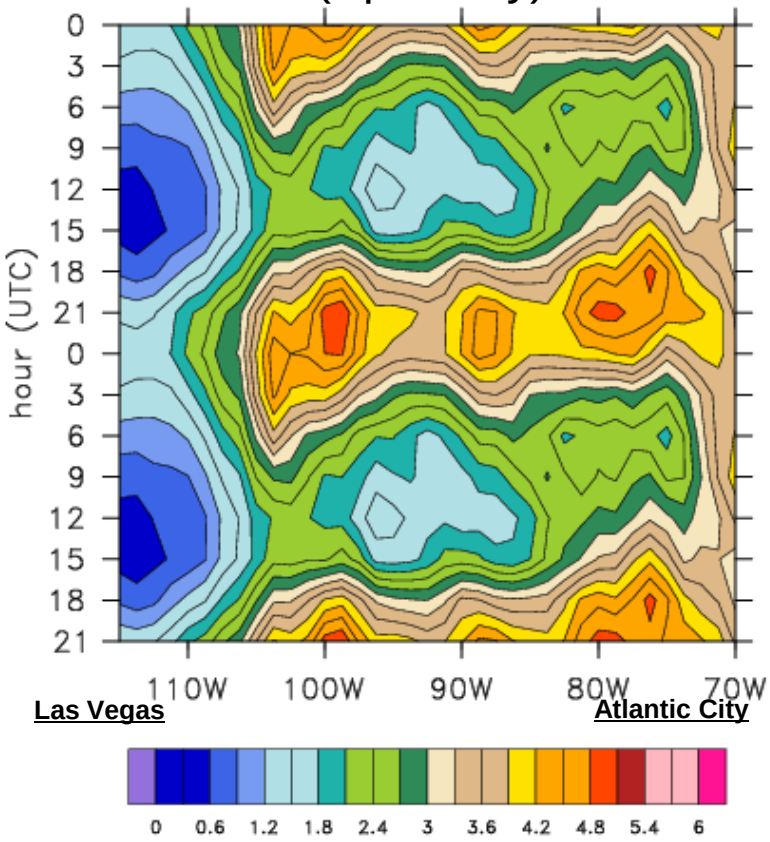
TRMM
(June/July)



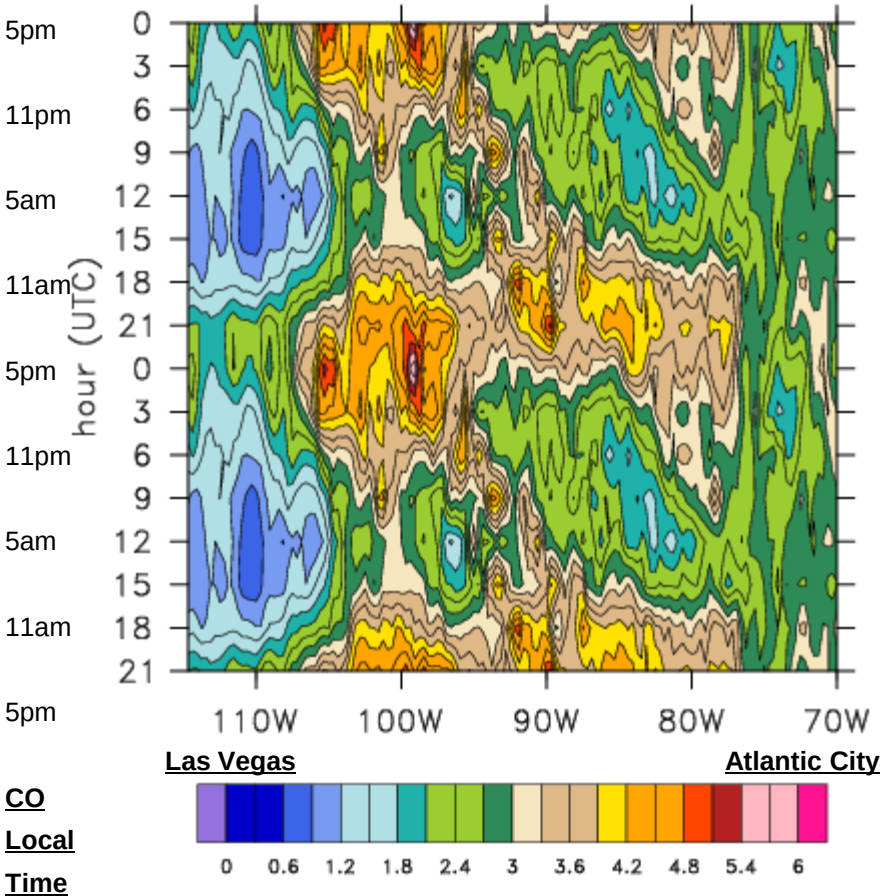
Community Earth System Model

US Orogenic Systems

CAM5-FV 1˚
(April/May)

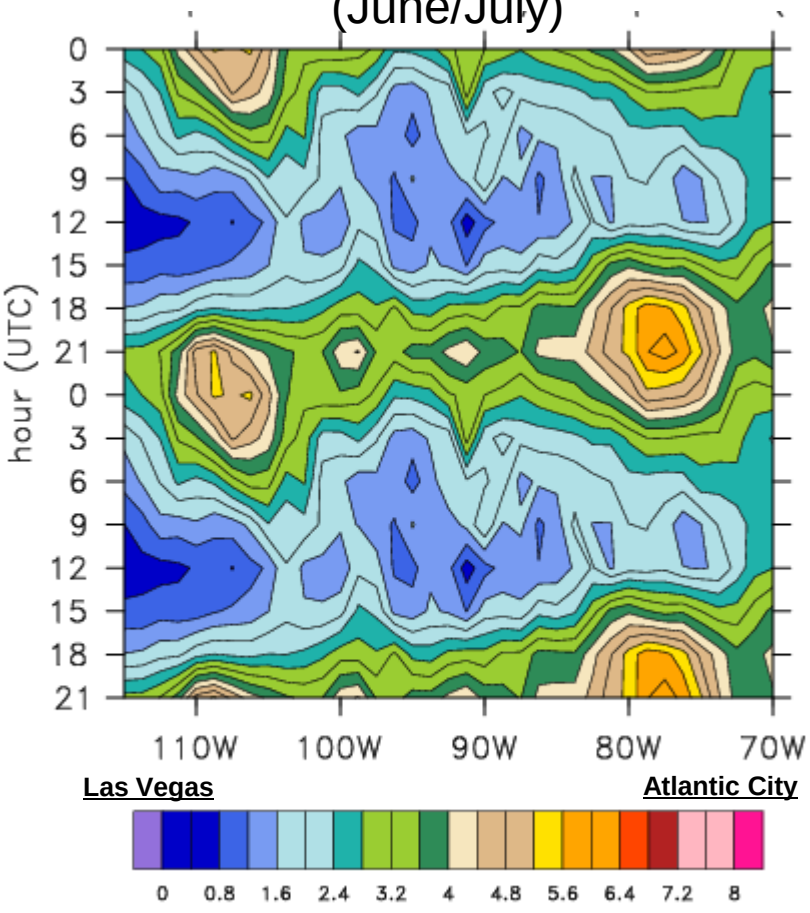


CAM5-SE 1/8˚
(April/May)



US Orogenic Systems

CAM5-SE refined 1˚ -> 1/8˚
(June/July)



5pm
11pm
5am
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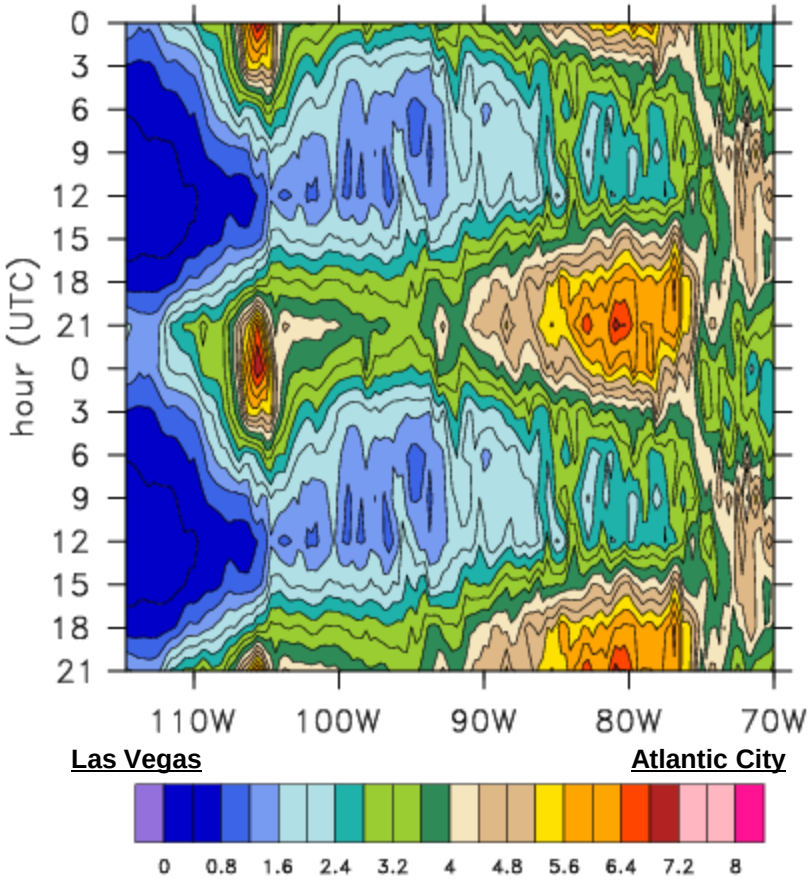
11am
5pm

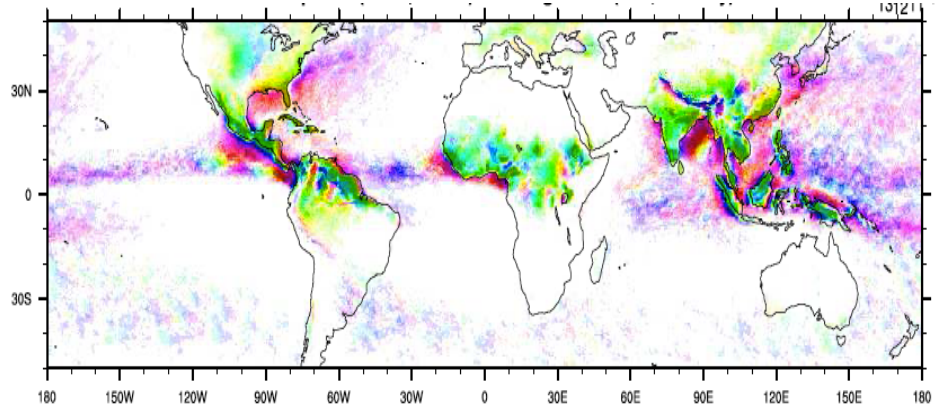
CO Local Time

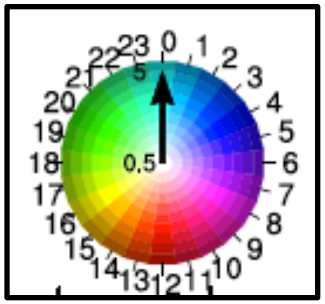
CAM5-SE 1/8˚
(June/July)



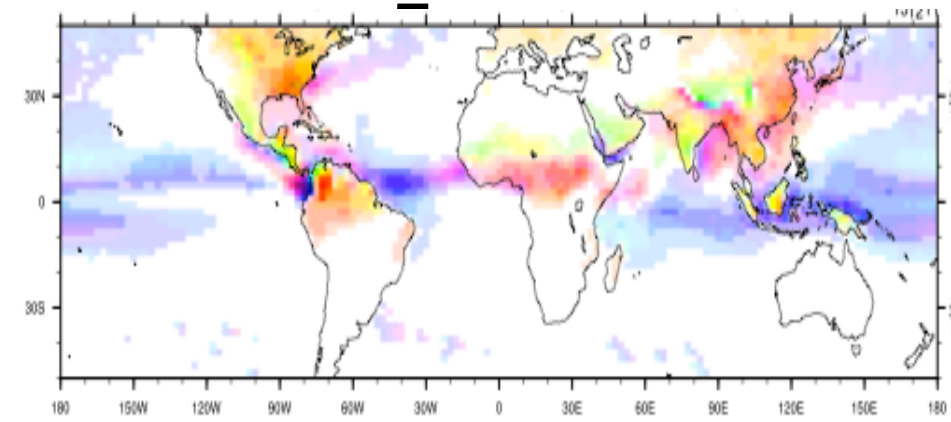
Diurnal Cycle of Precipitation. JJA.

OBS

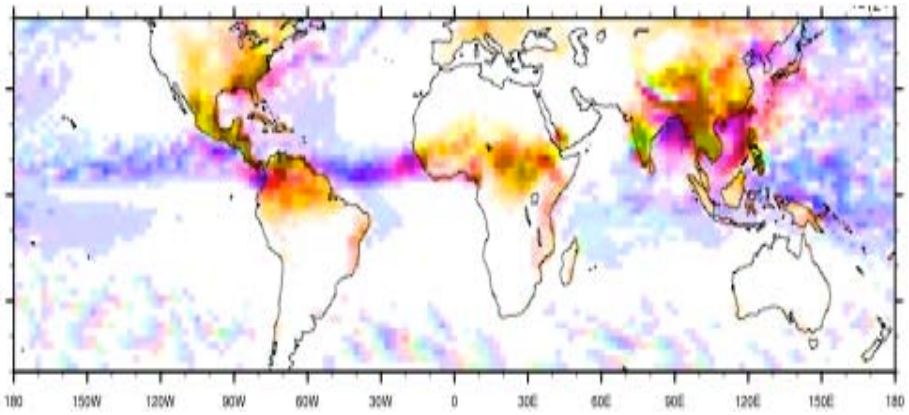




CAM



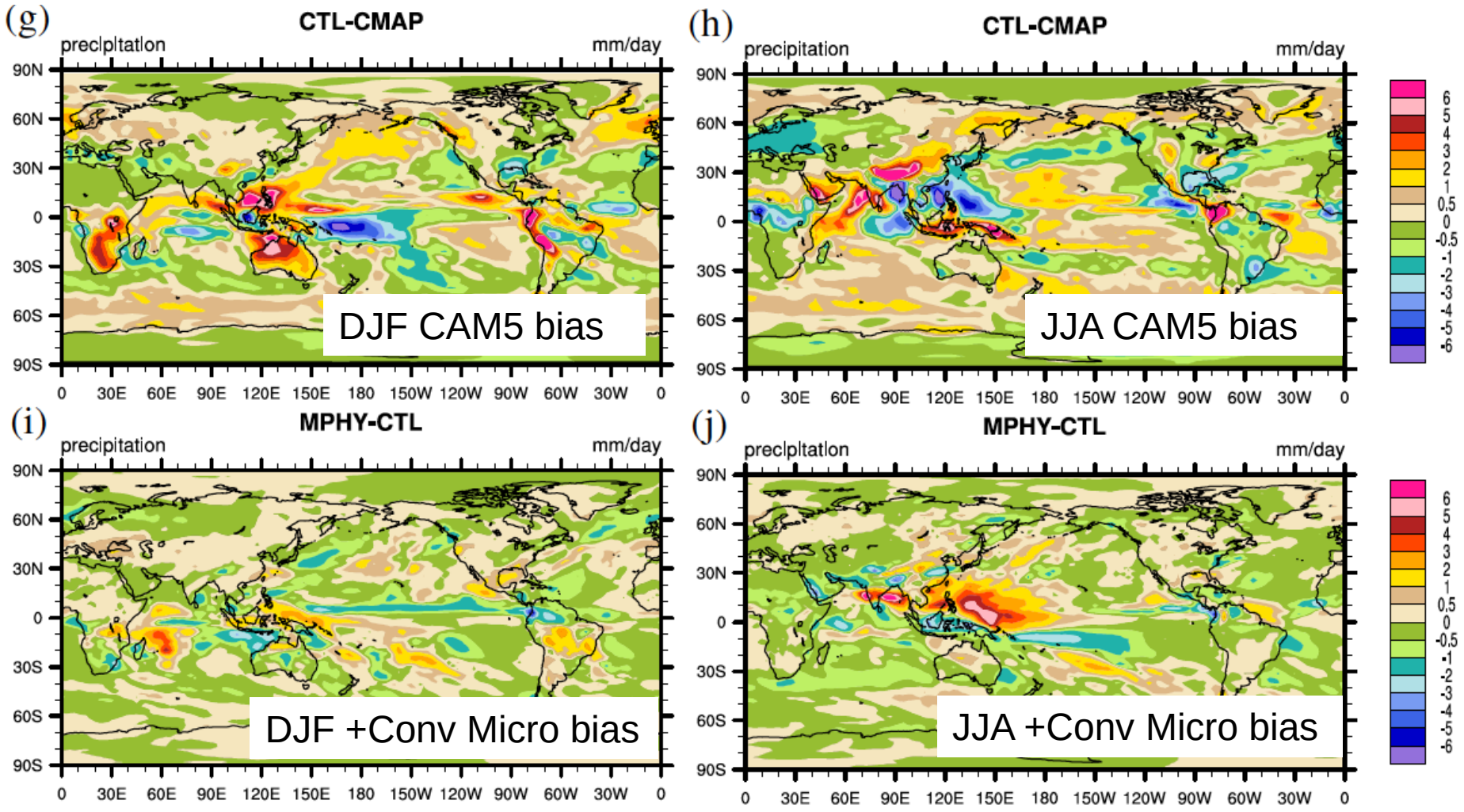
UNICON



Thanks: Sungsu Park, NCAR

Convective Microphys: Bias Reduction

Adding microphysics to convection improves precip patterns



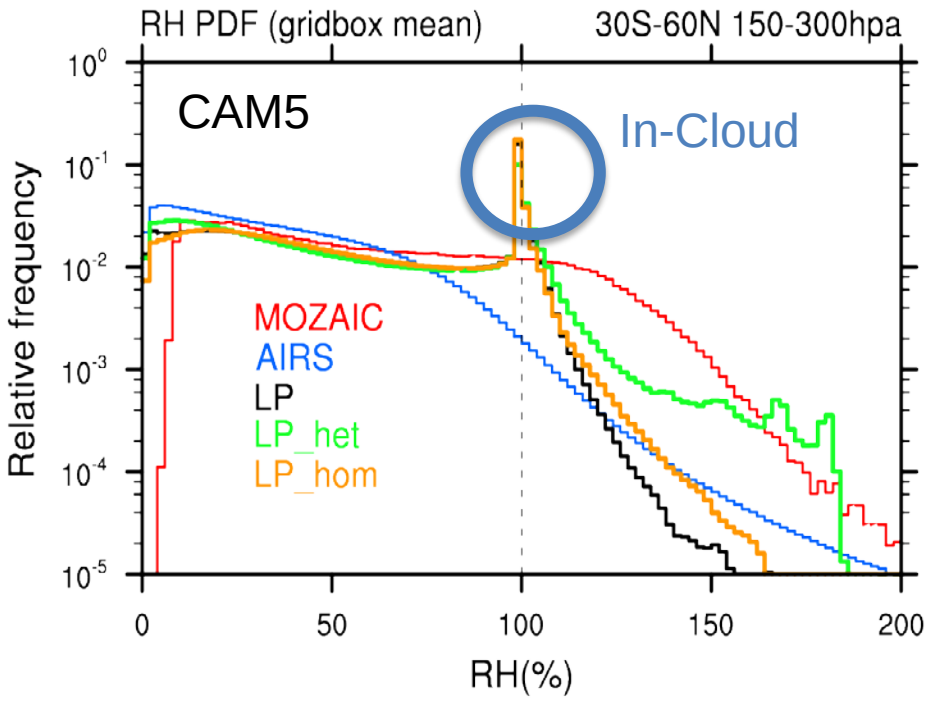
Community Earth System Model

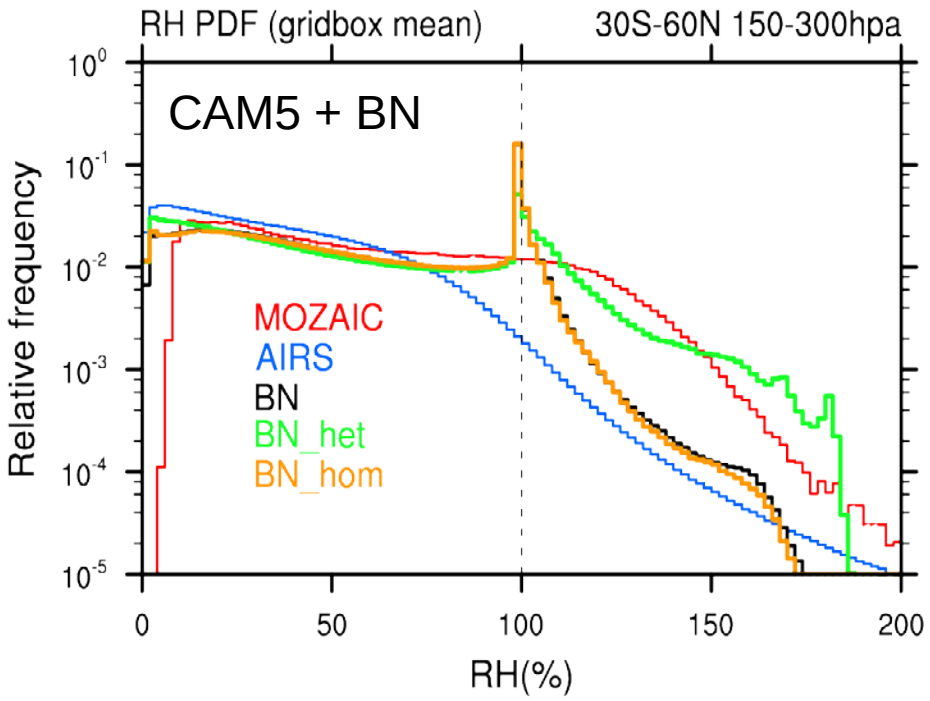
CESM

Song & Zhang 2012, submitted to J. Climate

CAM5 Ice Supersaturation v. Obs

New ice nucleation scheme (allows greater supersaturation freq.)





BN= Barahona and Nenes 2009

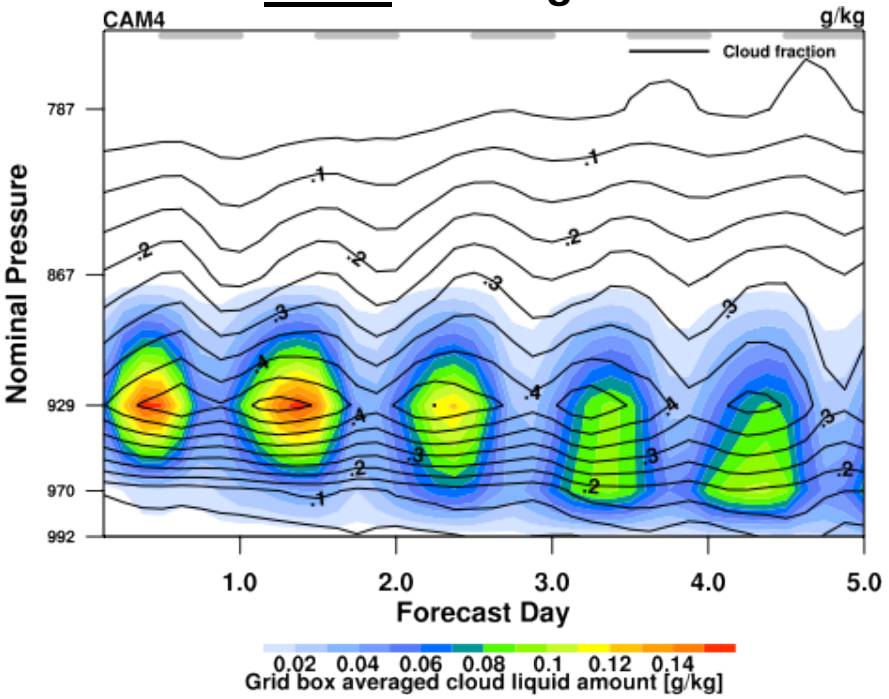
LP=Liu & Penner 2007 (Current CAM5 code)

Liu et al 2012 (in prep)

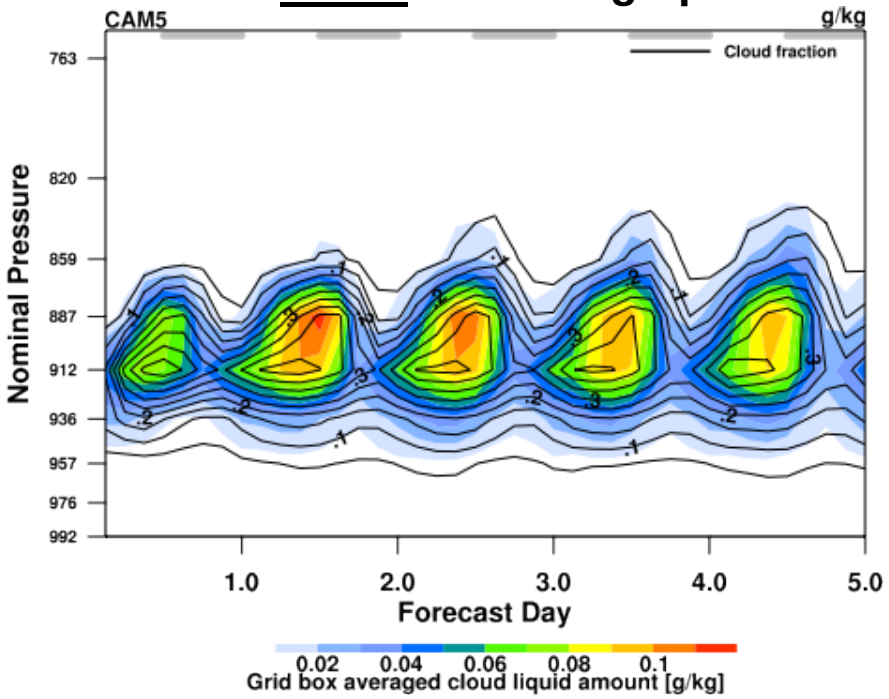
Diagnosing CAM5 climate

CAPT Forecasts and cloud stability

CAM4 "Falling down"



CAM5 "Breaking up"



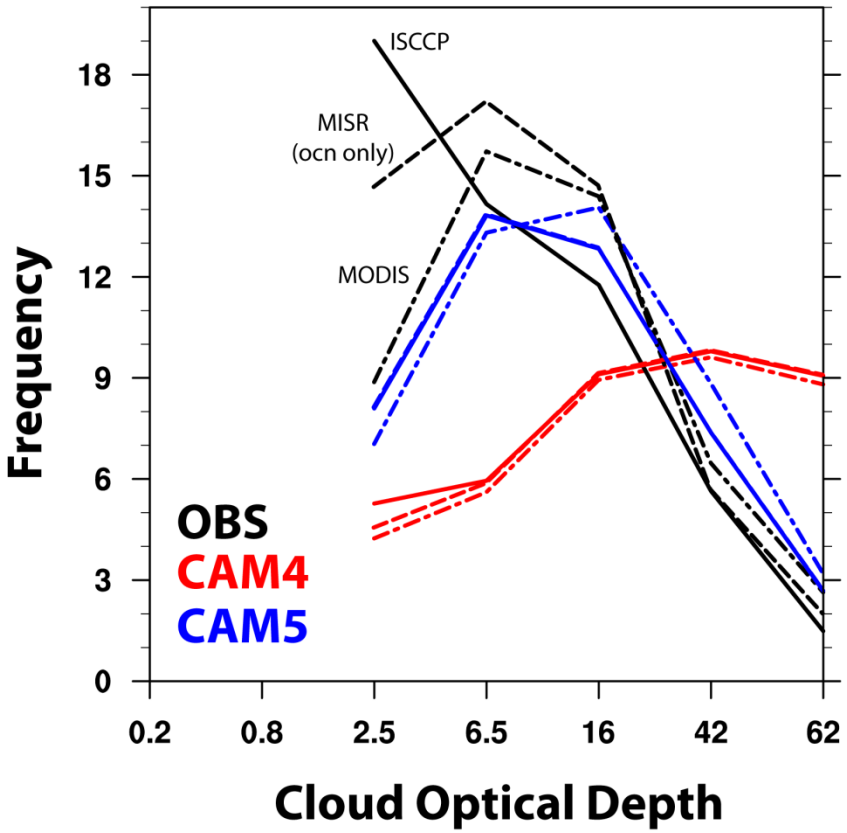
- ✓Composite 5-day forecasts of southeast Pacific stratocumulus.
- ✓Colors: cloud liquid water amount: Contours: diagnostic cloud fraction
- ✓Consistent treatment of cloud fraction and condensate
- ✓Clear sub-cloud layer (no more "stratofogulus")
- ✓Perhaps too "cumulus-like" during daytime.

Thanks: Brian Medeiros, NCAR

Diagnosing CAM5 climate

CFMIP Observation Simulator Package (COSP): in CAM5.1 release

Global cloud optical depth distributions from ISCCP, MODIS and MISR using COSP



✓COSP:

•Allows a more direct comparison between the satellite retrievals

✓CAM4:

•Too many optically thick clouds

✓CAM5:

• Improved frequency of clouds at all optical depths

Thanks: Jen Kay, NCAR

Diagnostic Radiation

Brian Eaton, Jin-Ho Yoon, Steve Ghan

- Namelist specification of up to 10 different sets of predicted or prescribed CAM5 radiative constituents (water vapor, greenhouse gases, aerosol)
- Dry and wet size of MAM modes recalculated
- Radiative fluxes, heating rates, aerosol optical depths written for each diagnostic set of constituents

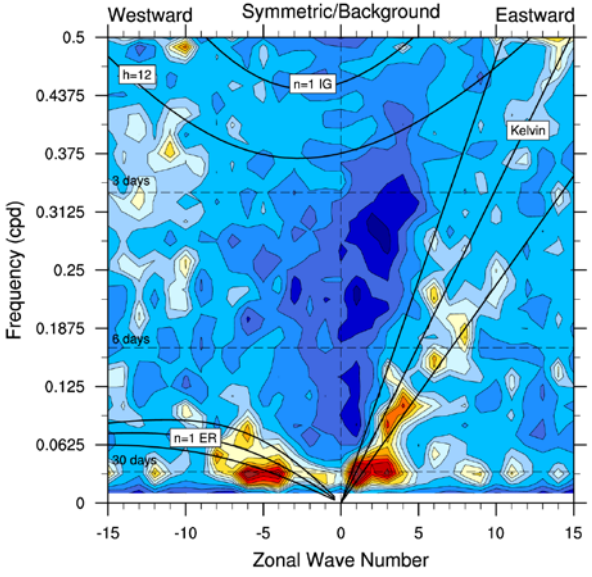
Direct Forcing (W/m2)

Thanks: Steve Ghan, PNNL

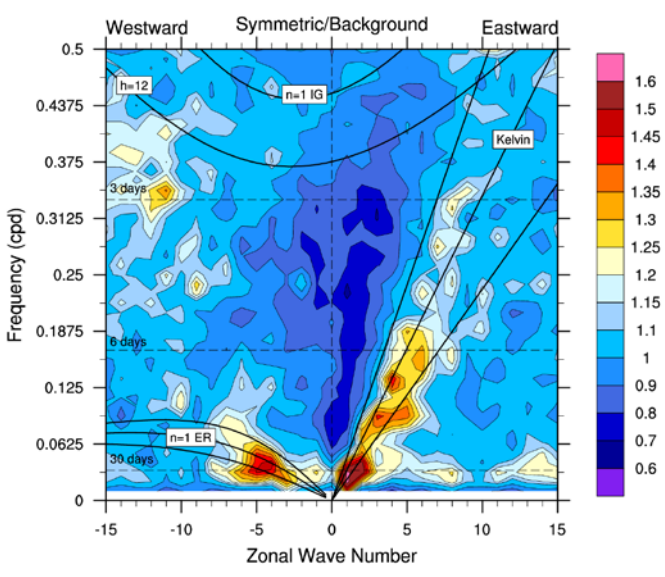
“Numerics” Sensitivity

Physics time-step: Tropical waves @ 2˚

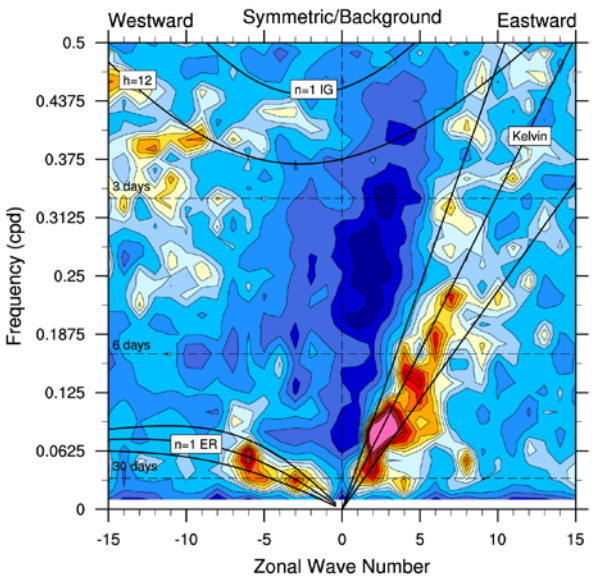
DT = 15min



DT = 30min

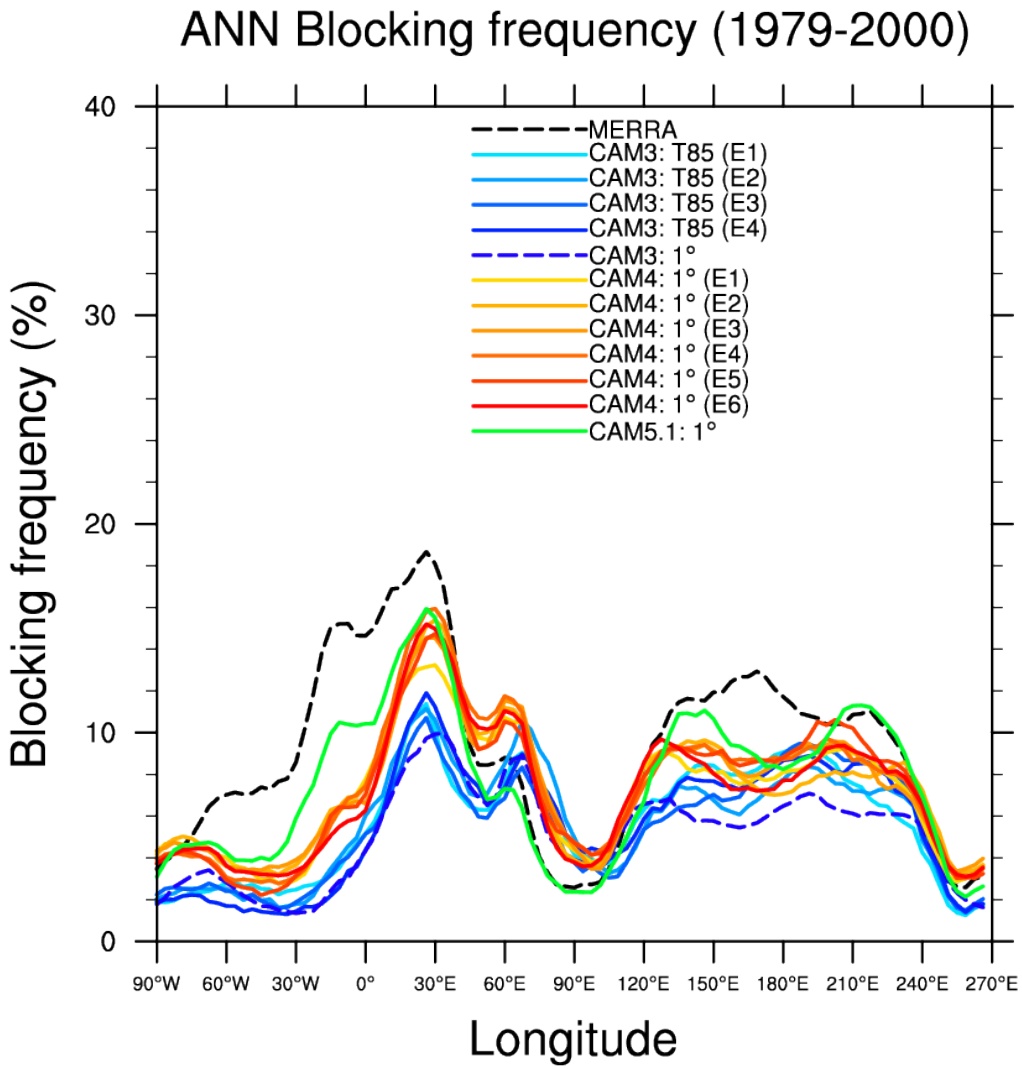


DT = 60min



Blocking in CESM

CAM (AMIP) and Reanalysis

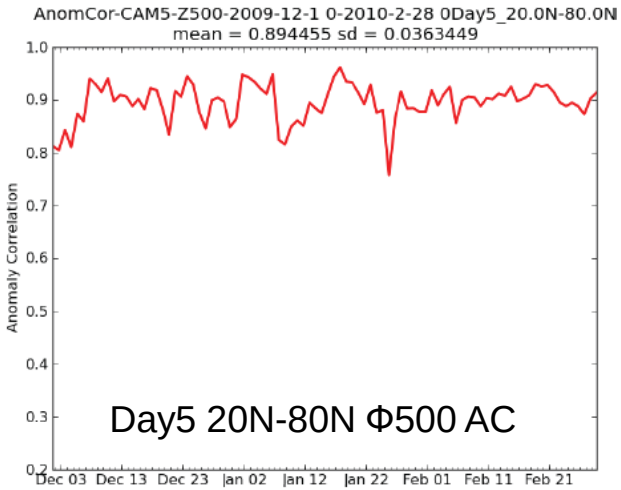


Model Skill for Hindcast Experiments

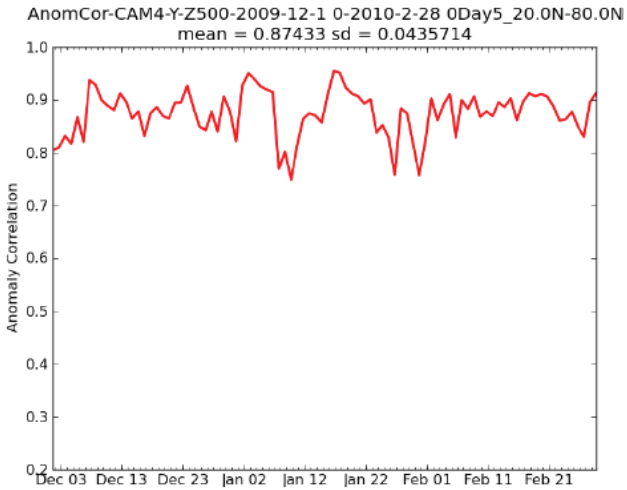
The values are comparable to those achieved by the major forecast centers.

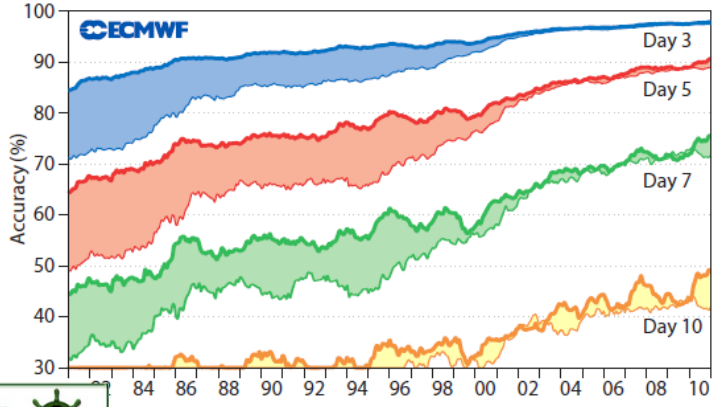
Anomaly Correlation

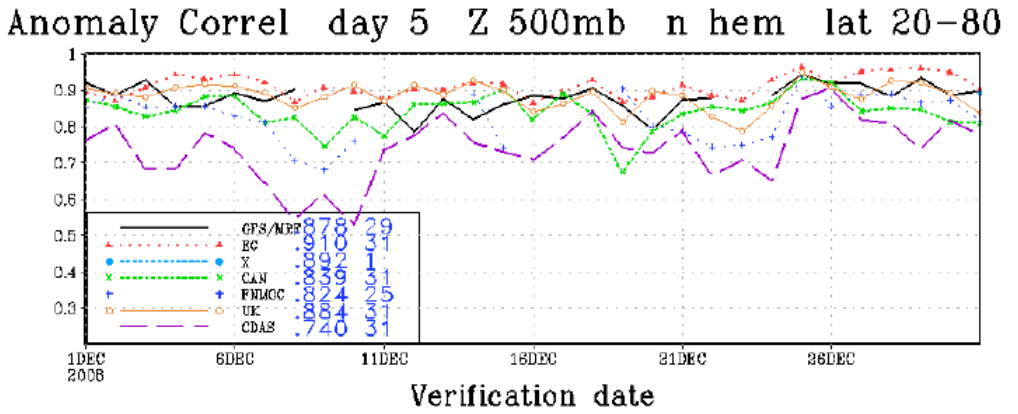
(a) CAM5 DJF NH



(b) CAM4 DJF NH







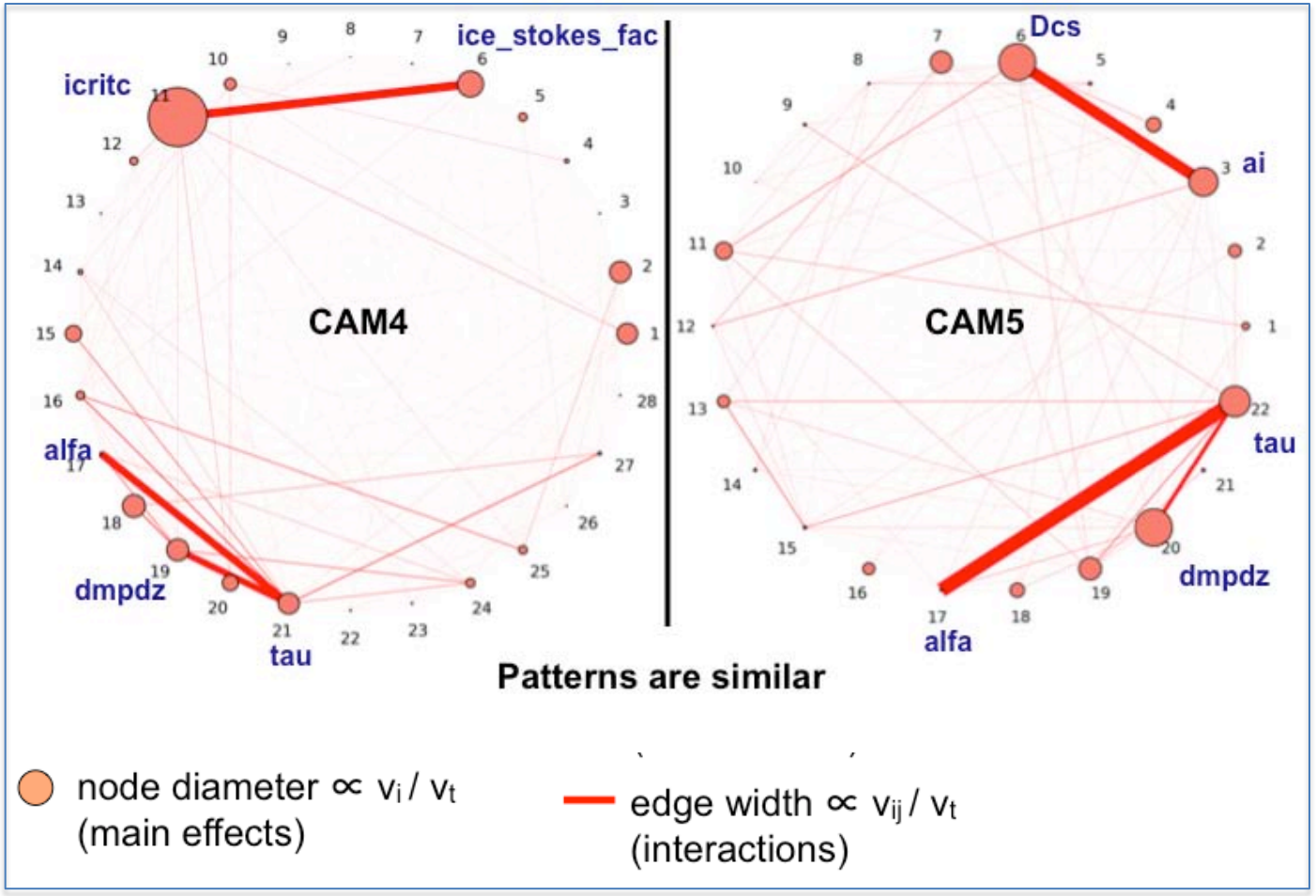
CAPT Cloud-Associated Parameterizations Testbed

Thanks: Steve Klein and Jim Boyle, LLNL

Comparison of CAM4 and CAM5 Sensitivity Analysis

Example: **Sensitivity analysis** of **outgoing longwave radiation** with respect to uncertain parameters using **Sobol's Indices** (variance decomposition).

Initial Conclusion:
Although the physics packages in CAM5 are tightly coupled, the parameter interactions in CAM5 do not appear to be more extensive than those in CAM4.



Thanks: Don Lucas, LLNL
Bill Collins, LBNL/UCB

Agenda

CAM updates and parameterization development in models

8:00 Coffee

8:30 Rich Neale – Status of CAM development and simulation activities

8:50 Cecile Hannay – CESM CMIP5 coupled and time-slice experiments

9:10 Phil Rasch – A description of progress on the "prescribed aerosol" CAM5 configuration

9:25 Xiaohong Liu – Evaluating and constraining ice cloud parameterizations in CAM5 with observations

9:40 Pete Bogenschutz – Preliminary Results of the Coupling of CAM with CLUBB

9:55 Steve Ghan – Constraining aerosol indirect effects in CAM5 and CAM5-MMF

10:10 Peter Caldwell – Macrophysics/microphysics numerical coupling errors

10:25 *Break*

10:45 Andrew Gettelman – Evaluation of CAM cloud microphysics and its impacts on radiative forcing and climate sensitivity

11:00 David Mitchell – Measurements for Guiding Ice Nucleation, PSD and Morphology Parameterizations in CAM5

11:15 Sungsu Park – CAM simulations using a unified convection scheme (UNICON)

11:30 Chris Bretherton – Single-column study of low cloud feedback processes in CAM5 vs. LES

11:45 Yong Hu – Impact of a Cloud Thermodynamic Phase Parameterization Based on CALIPSO Observations on Climate Simulation

12:00 *Lunch*

Agenda

CAM, high-resolution and resolution dependence

1:00 Phil Rasch – CAM behavior with very high vertical resolution (as low as 10 m at the surface)

1:15 Po-Lun Ma – Resolution dependency of CAM5 physics and its ramification on aerosol transport into the Arctic

1:30 Kate Evans – CAM4 high resolution study comparison of T341 with T85

1:45 Andrea Molod – The Impact of resolution based changes in GCM Total Water PDF on simulations at different horizontal resolutions

2:00 Julio Bacmeister – High resolution CAM: Phenomena and issues

2:15 Kevin Raeder – Multi-instance CESM plus DART for Fully Coupled Assimilation

2:30 Discussion

3:00 *Break*

Dynamical core development and regional climate modeling

3:20 Bill Skamarock – An update on MPAS atmospheric dy-cores in CAM/CESM

3:35 Shian-Jiann Lin – GFDL's finite-volume Cubed-Sphere Dynamical Core: Basic formulation, performance, and its applications in weather and climate modeling

3:50 Mark Taylor – Regional resolution refinement in CAM-SE

4:05 Minghua Zhang – Progress on coupling WRF within CCSM for regional climate change studies

4:20 *Discussion*

Agenda

CAM initialized simulations

8:30 Hsi-Yen Ma – Correspondence between short and long timescale systematic errors in CAM4/CAM5 explored by YOTC data

8:45 Steve Klein – Perturbed-parameter hindcasts of the MJO with CAM5

9:00 Dave Williamson – Quarter degree CAM5 precipitation characteristics in the eastern tropical Pacific in short forecasts

CMIP5 and CESM analysis studies

9:15 Huang-Hsiung Hsu – Preliminary diagnostics of CESM simulation and an introduction to a new climate modeling initiative in Taiwan

9:30 Trond Iverson – CMIP5 simulations using NorESM

9:45 Tao Zhang – An evaluation of ENSO asymmetry in CCSM4

10:00 Rich Neale – An evaluation of atmospheric blocking in CESM and CAM

10:15 Jen Kay – CAM and the COSP cloud-simulator package

10:30 Break

Meeting summary, discussion, and plans

11:00 Potential discussion topics:

- Current parameterization development
- Path towards high-resolution and regional climate simulation
- Scale aware physical parameterization strategies
- Supporting CAM configurations
- Re-thinking a low-resolution version of CAM
- Model development funding opportunities

12:30 Adjourn