Recent Changes in the Community Atmosphere Model, version 6.

Rich Neale, Peter Caldwell, Christiane Jablonowski and Cecile Hannay

and many, many others!

AMP/CGD

National Center for Atmospheric Research
Boulder, Colorado

New co-chair

Rich Neale

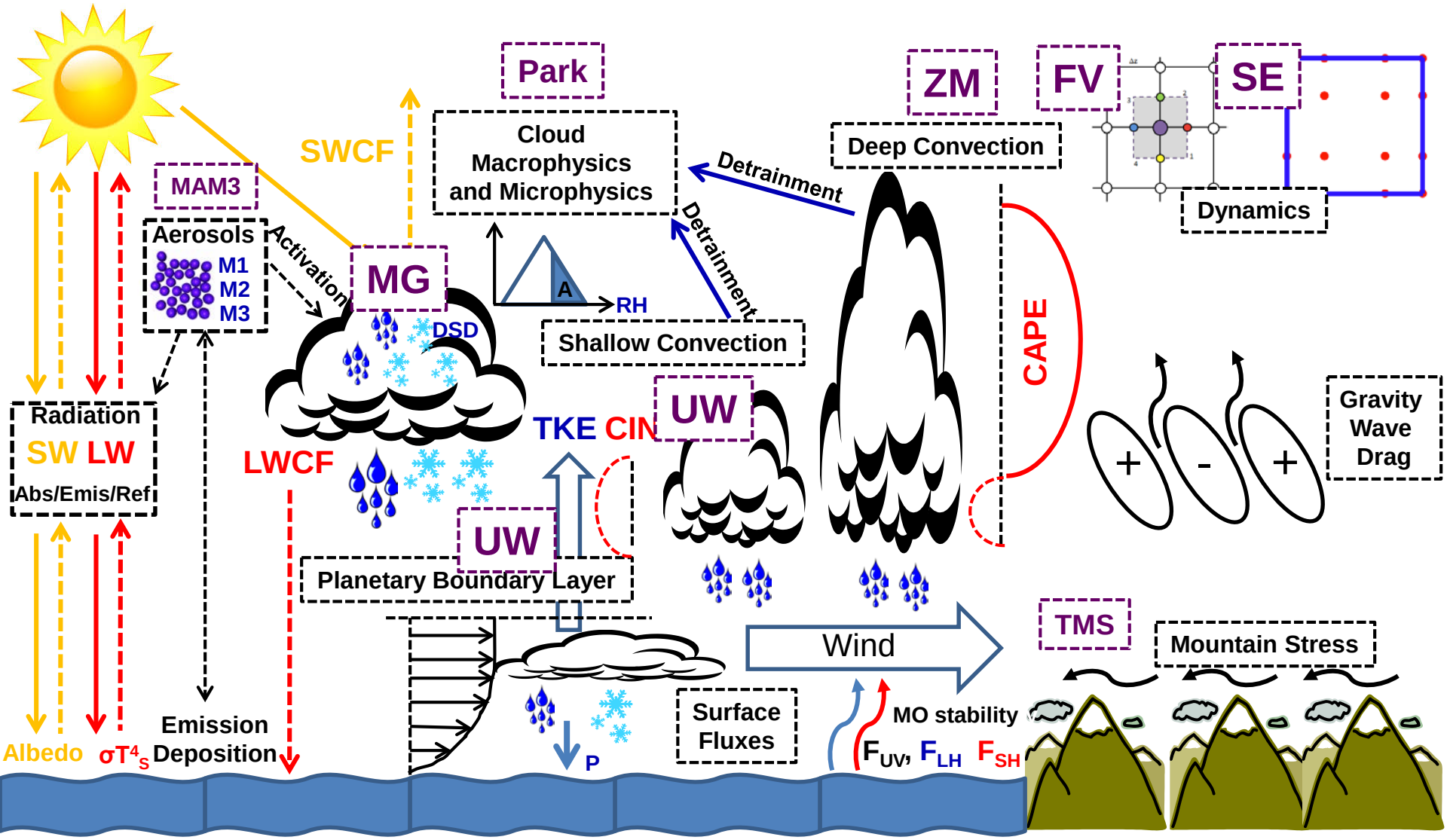
2010 2017

Julio Bacmeister

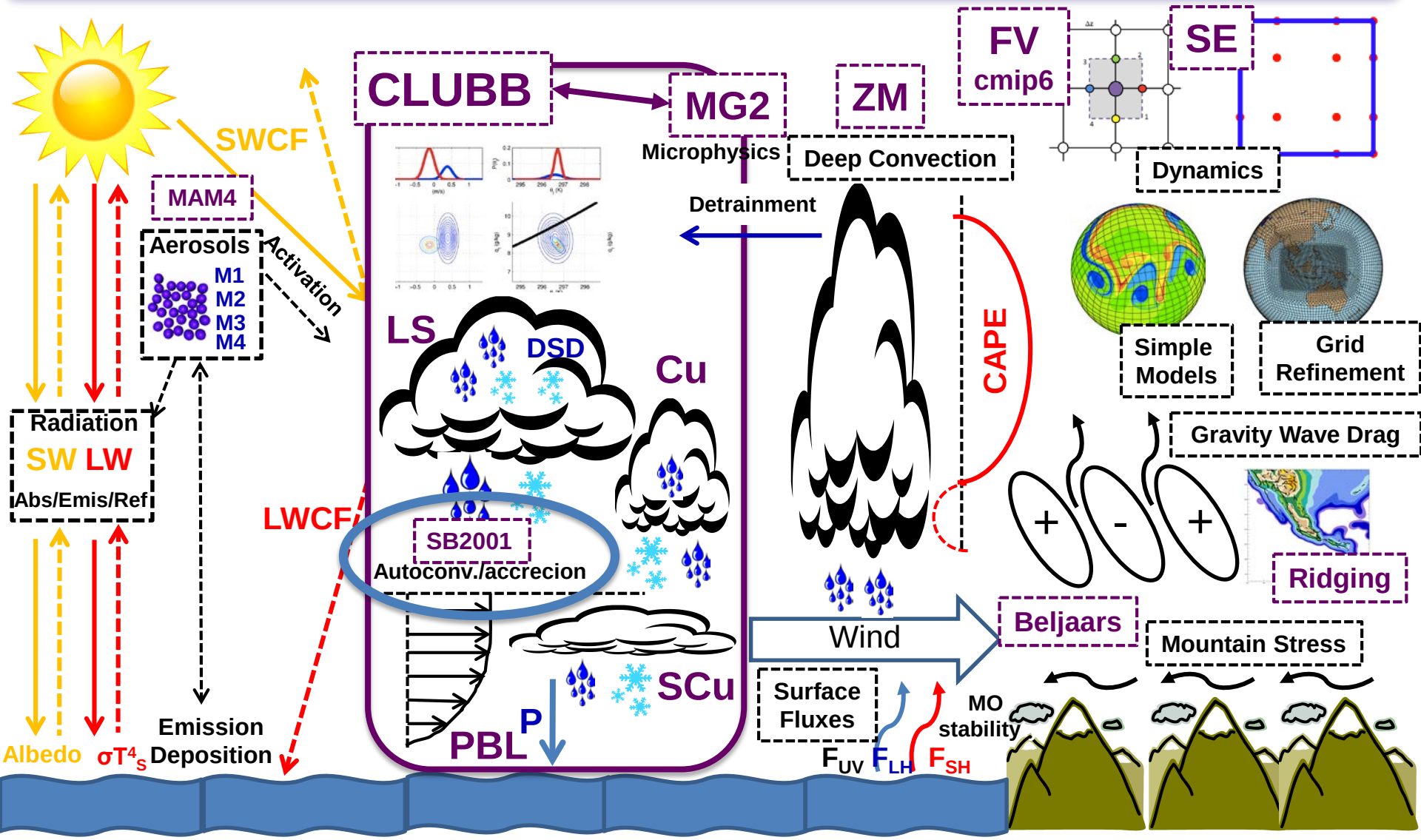
Atmosphere Model Activities Since June 2016 (CAM6)

- ***AIM*: *Fix Labrador sea-ice excess***
  - *Ocean convection*
  - *Meridional overturning circulation*
- ***AIM*: *Reduce Greenland precipitation excess***
  - Implications for ice-sheet mass balance
  - Relationship to surface drag/roughness
- ***AIM*: *Understand climate sensitivity variability***
  - *Relationship to cloud processes*
  - *Liquid supersaturation removal*
- ***AIM*: *Maintain/improve tuned climate***
  - Multiple updates of surface models
  - Updated forcing datasets (CMIP6)

Community Atmosphere Model, version 5 (CAM5)

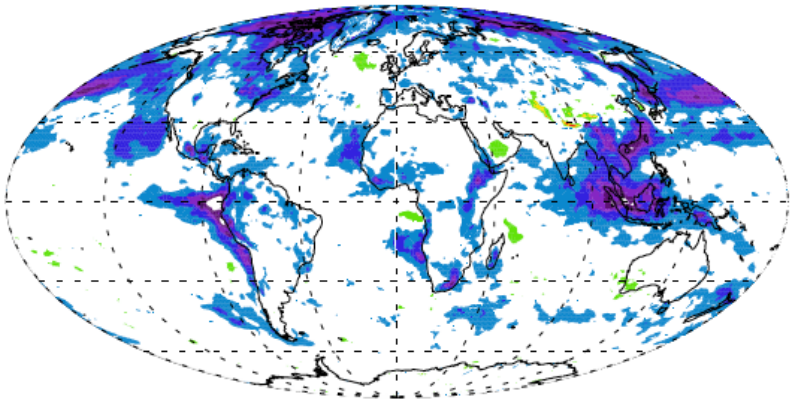


Community Atmosphere Model, version 6 (CAM6)



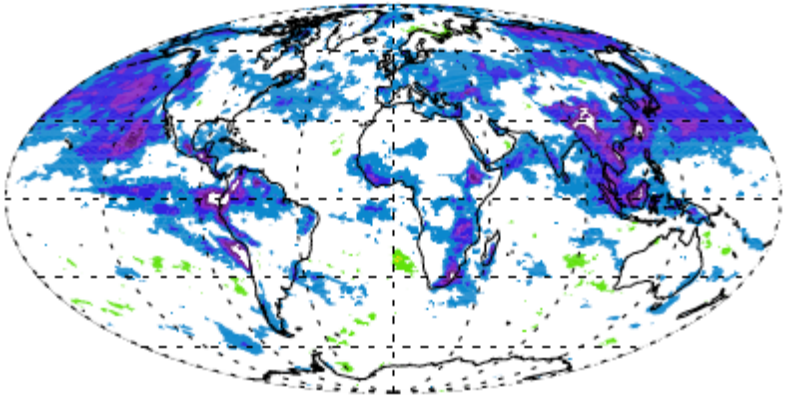
Autoconversion Changes - > Seifert and Beheng (2001)

CAM5.4

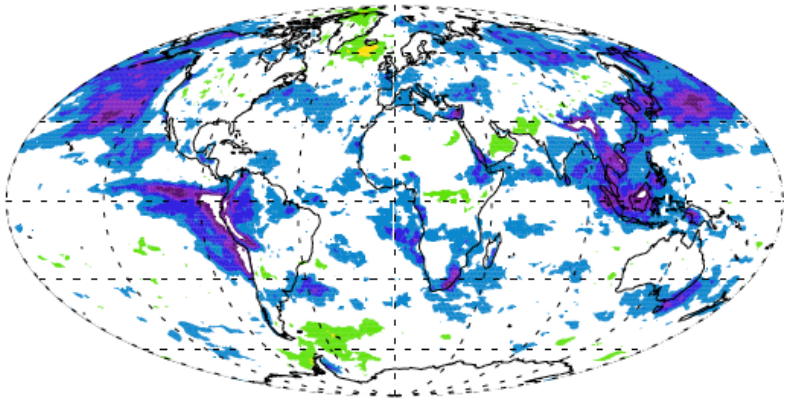


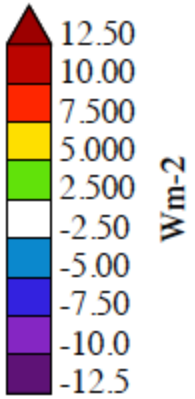
SWCF: Subtropics and Middle Latitudes:
Shallow convection Regime
Arctic effects decrease

CAM5.5



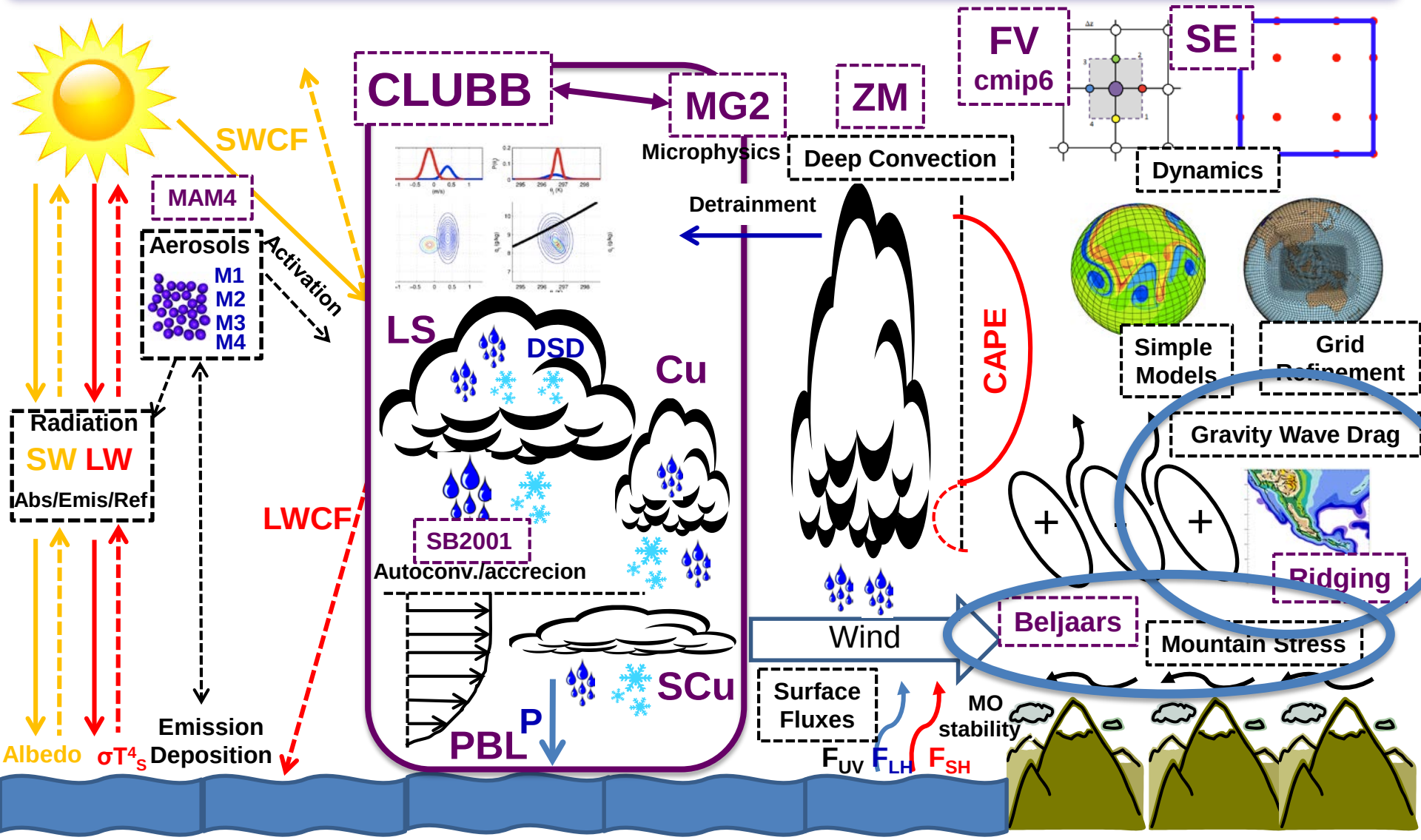
CAM6-125





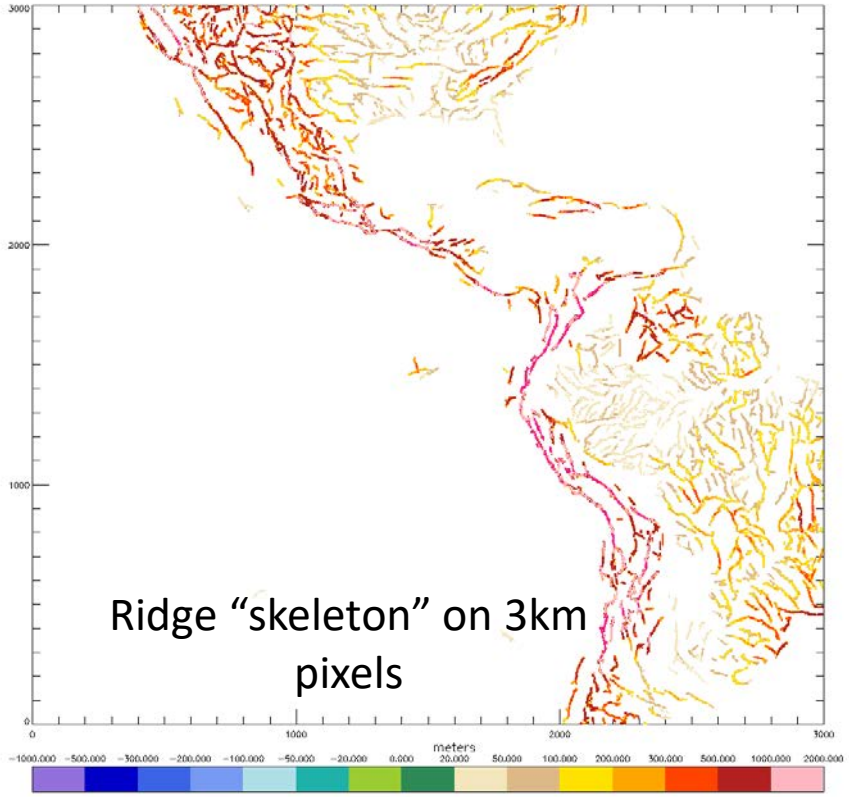
Seifert and Beheng (2001) A double-moment parameterization for simulating autoconversion, accretion and selfcollection, *Atmos Res.*

Community Atmosphere Model, version 6 (CAM6)



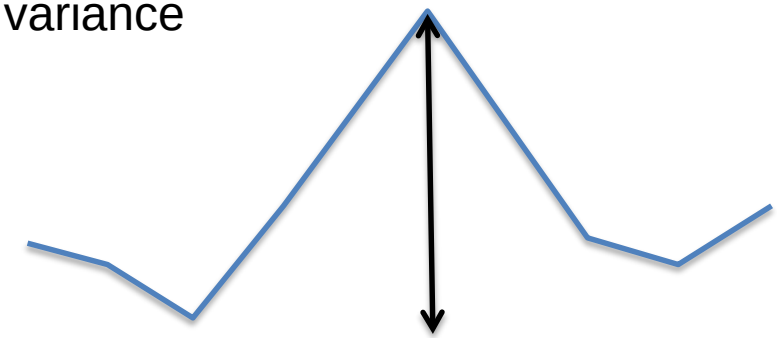
Anisotropic Orographic Gravity Wave Drag (scales~>10km)

Ridge orientation determines wave orientation and direction of drag force not low-level wind.

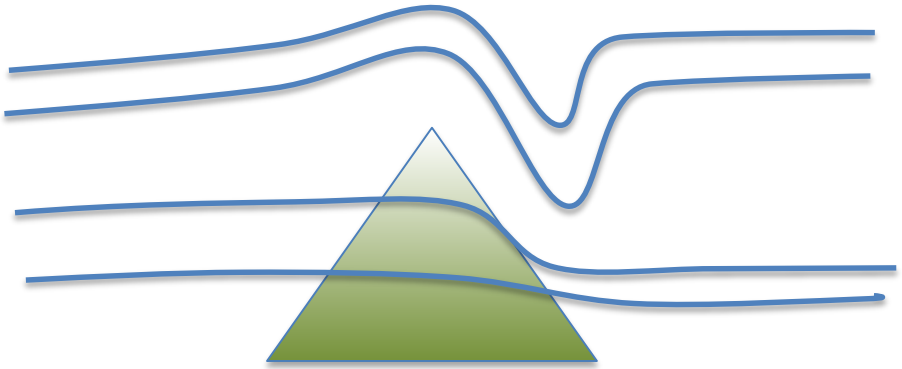


Ridge "skeleton" on 3km pixels

Ridge height estimate is based on min and max elevations of mean ridge profile not based on subgrid variance



Parameterization allows flow around obstacles – *form drag* - as well as "downslope wind" high-drag dynamics (e.g. Scinocca&McFarlane 2000)



PBL Form Drag (from smooth small obstacles)

TMS:

$$\mathbf{F}_x = C_D |\mathbf{U}| U(z_{LM}), \quad C_D = \kappa \left(\ln \left(\frac{z_{LM}}{z_0} \right) \right)^{-2}, \quad z_0 \propto \sqrt{\left\langle h'^2_\delta \right\rangle}$$

- Logarithmic in h'_δ. Only applied in lowest model layer.

Beljaars et al. (2004):

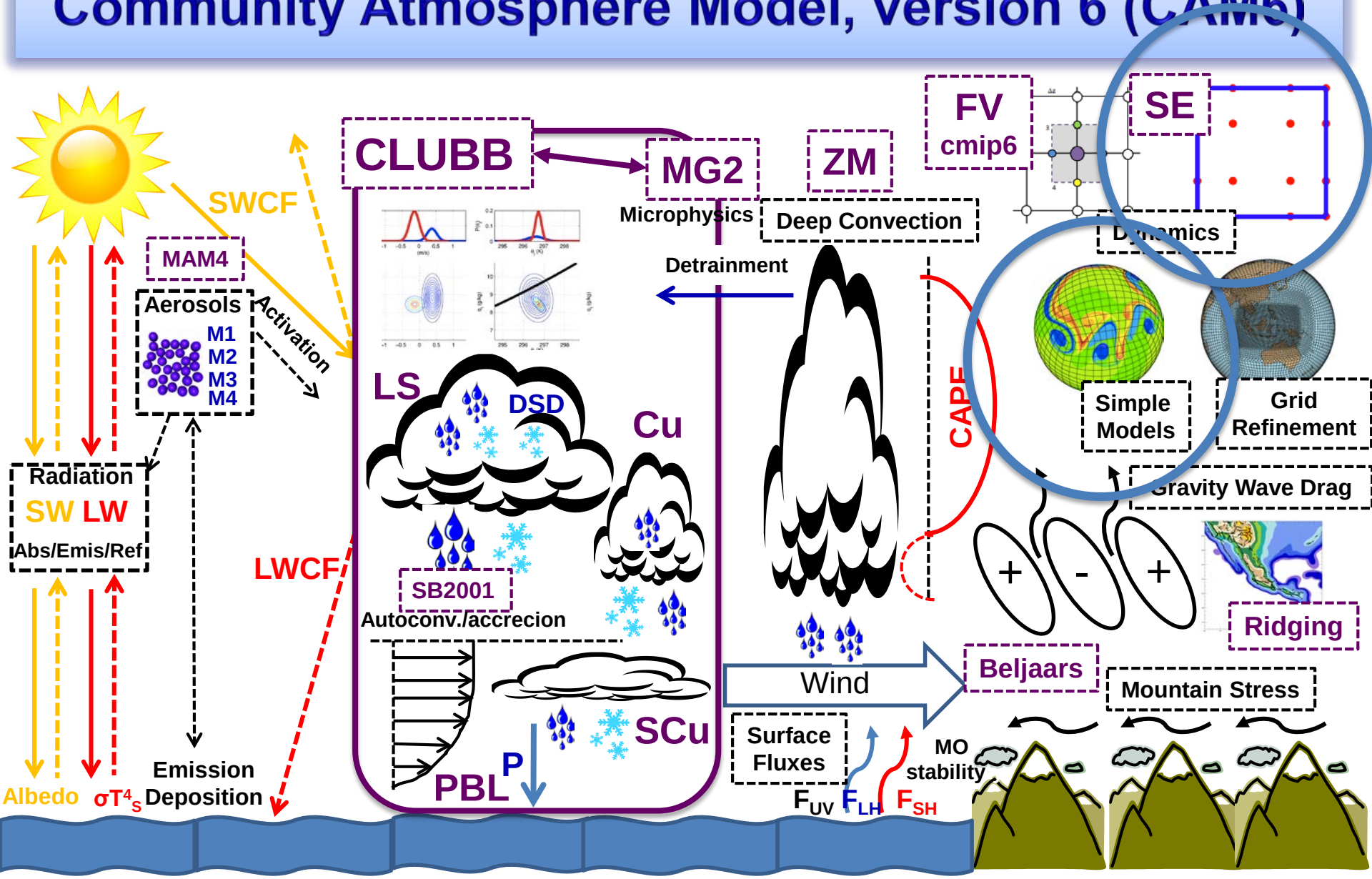
$$\mathbf{F}_x =: -\alpha \beta C_{md} C_{corr} |\vec{U}(z)| \vec{U}(z) \, 2.109 \, e^{-(z/1500)^{1.5}} a_2 z^{-1.2}, \quad a_2 \propto \left\langle h'^2_\delta \right\rangle$$

- Proportional to h'^2_δ. Applied over physically based vertical profile.

h'_δ are topographic perturbations with scales below 3km derived from GMTED data. represents averaging to model grid.

"Greenland mods" to be described later.

Community Atmosphere Model, version 6 (CAM6)



CESM2 Simple Models

"Out-of-the-box" support for:

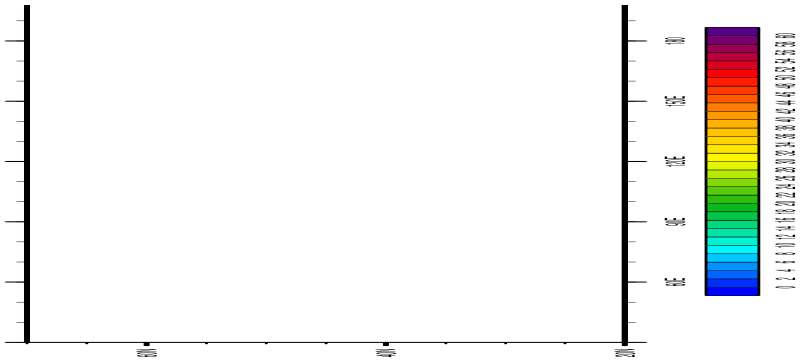
- Aquaplanet configurations (Medeiros et al., 2016; …)
- Idealized moist baroclinic wave (Ullrich et al., 2014)
- Held-Suarez forcing (Held and Suarez, 1994)
- Kessler Microphysics (Kessler, 1969)
- Toy terminator chemistry (Lauritzen et al., 2015)
- Moist Held-Suarez (Reed and Jablonowski, 2012; …)

New version of SE

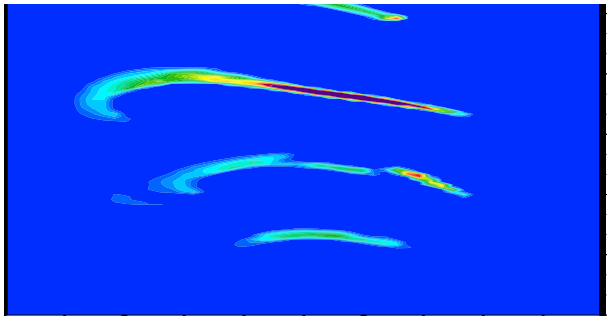
- Dry mass vertical coordinate
- Condensate loading
- "Correct" moist energy
- Optional CSLAM transport
- Separate physics grid (CSLAM grid, coarser or finer finite-volume grid in each element)
- Massive code cleanup

CAM-FV, day 10

CAM-SE-CSLAM, day 10

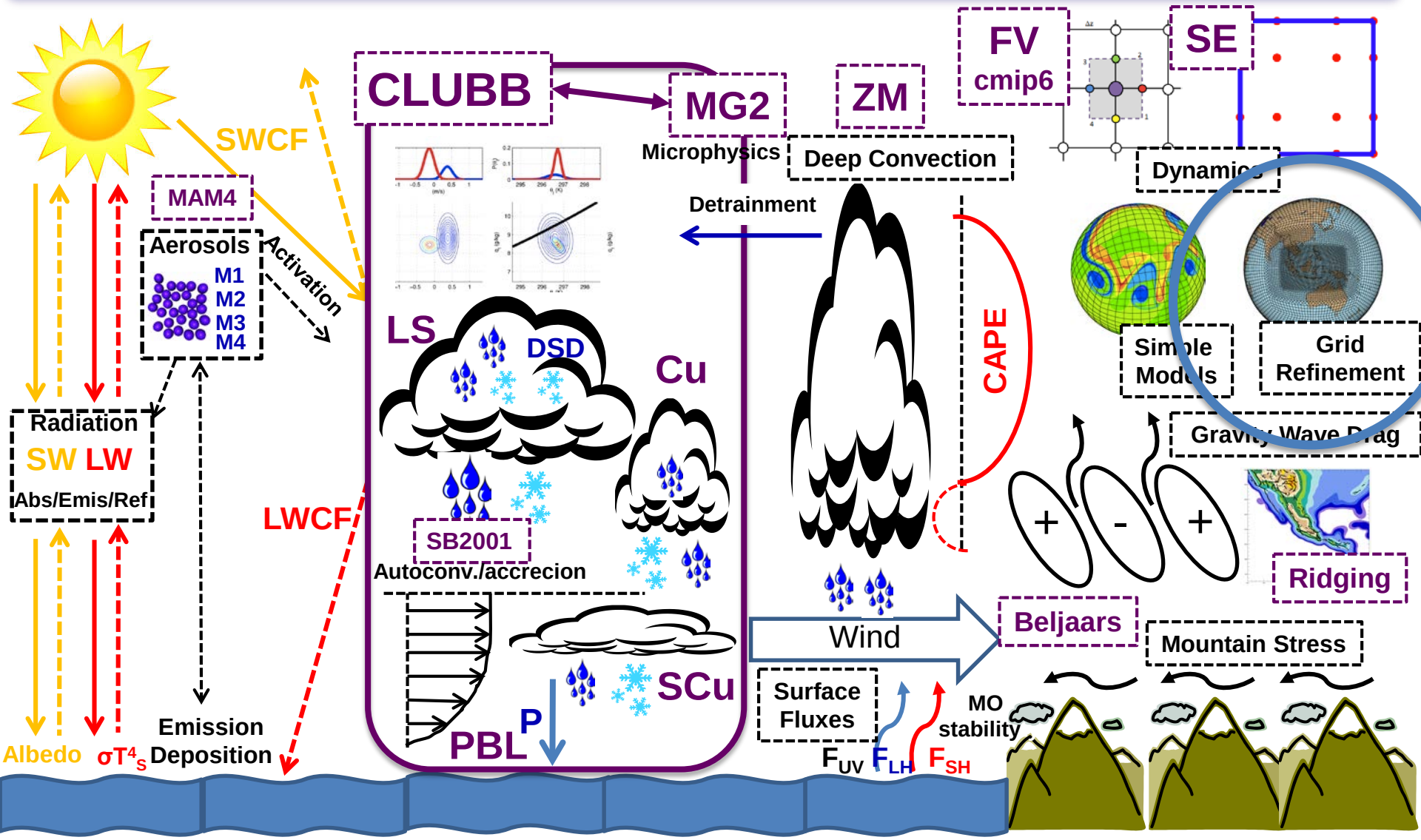


CAM-SE, day 10



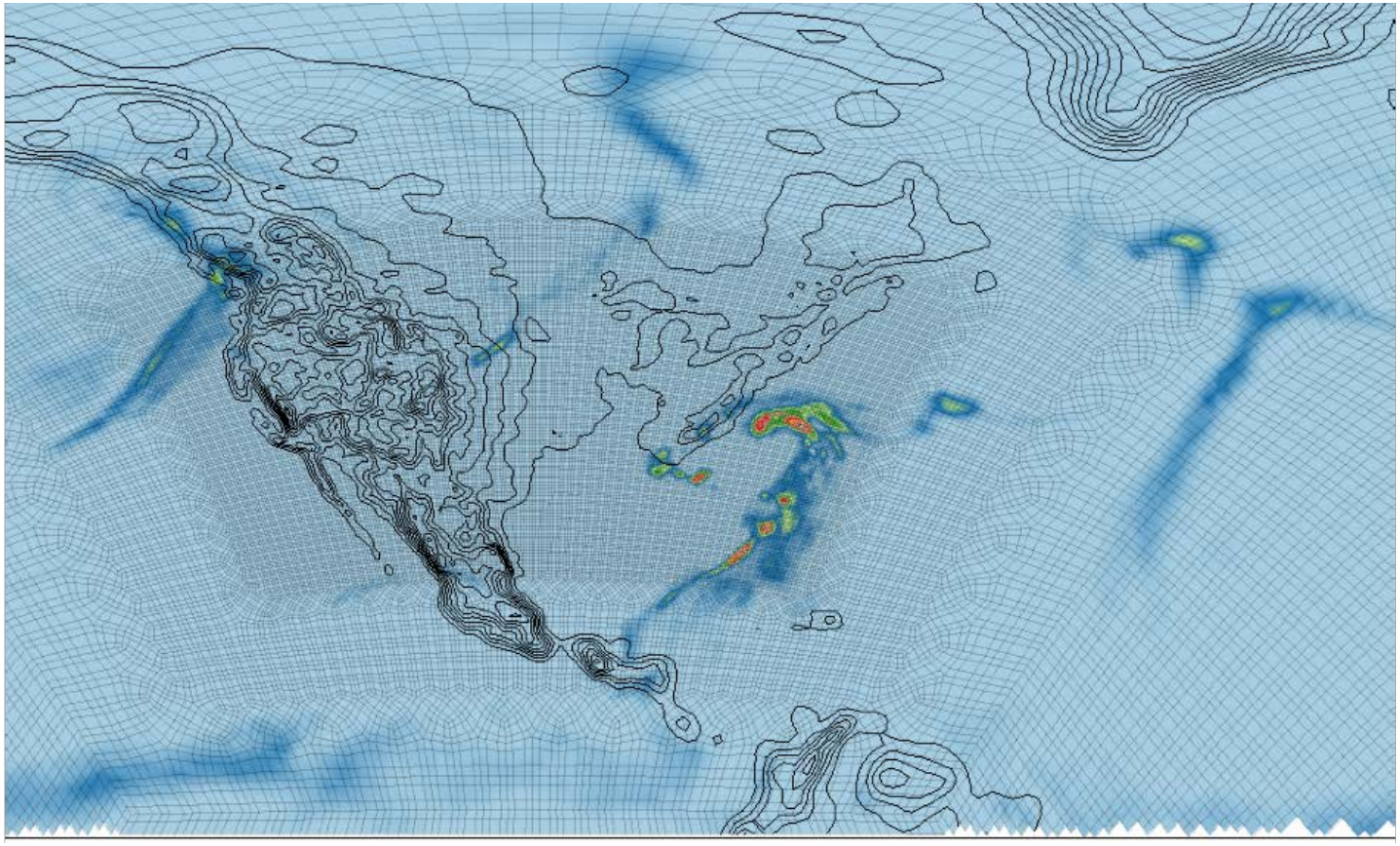
CAM-SE (dtime = 900s), day 10

Community Atmosphere Model, version 6 (CAM6)



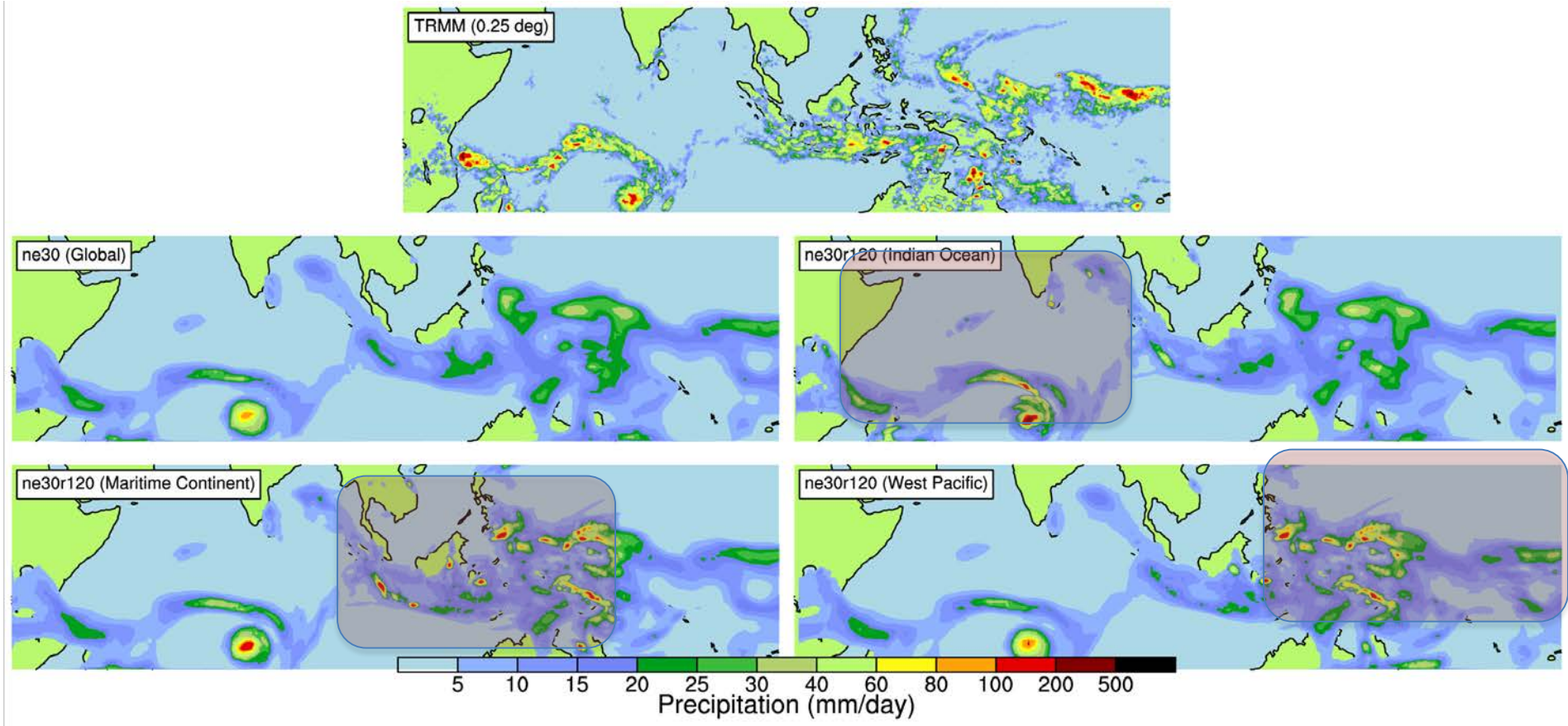
Regional Grid Refinement: US

High Resolution precipitation field. Variable resolution grid (0.25˚ fine mesh)
Low intensity in low resolution region, higher intensity in high resolution region

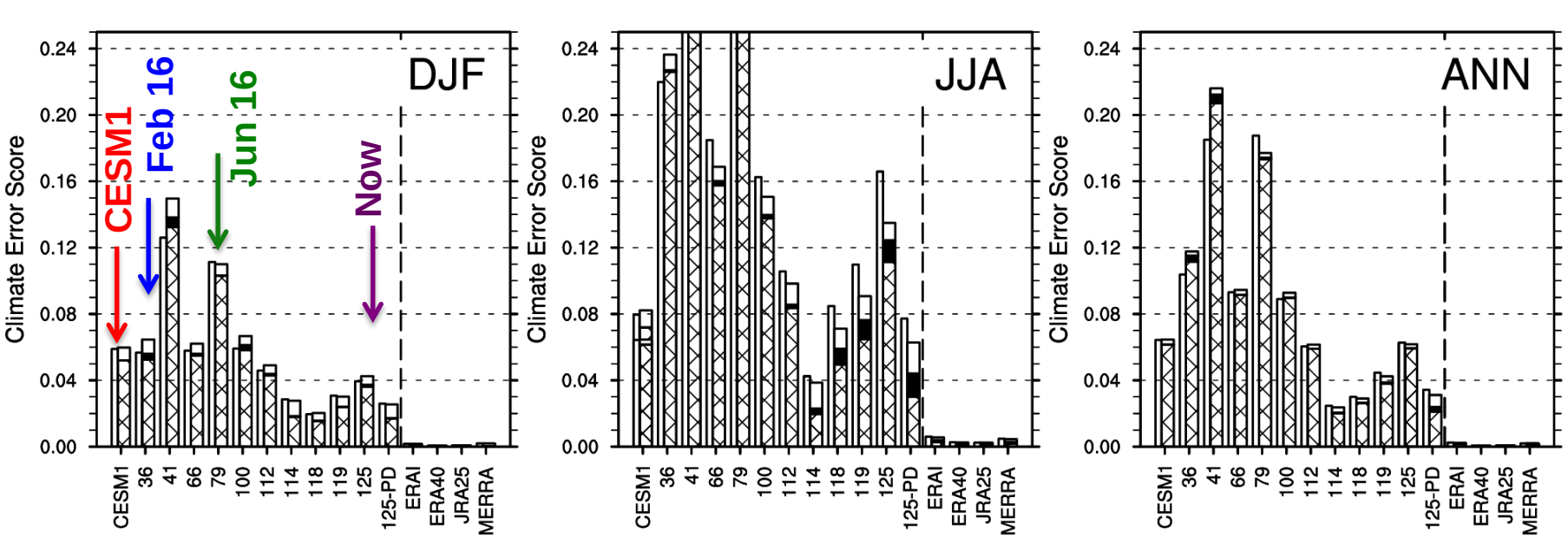


Regional Grid Refinement: Tropics

Variable resolution grid (1˚>0.5˚>0.25˚ fine mesh)
20-day hindcasts: Day-1 hindcast below (9 Jan, 2010)
Question: Which region is the most for the MJO



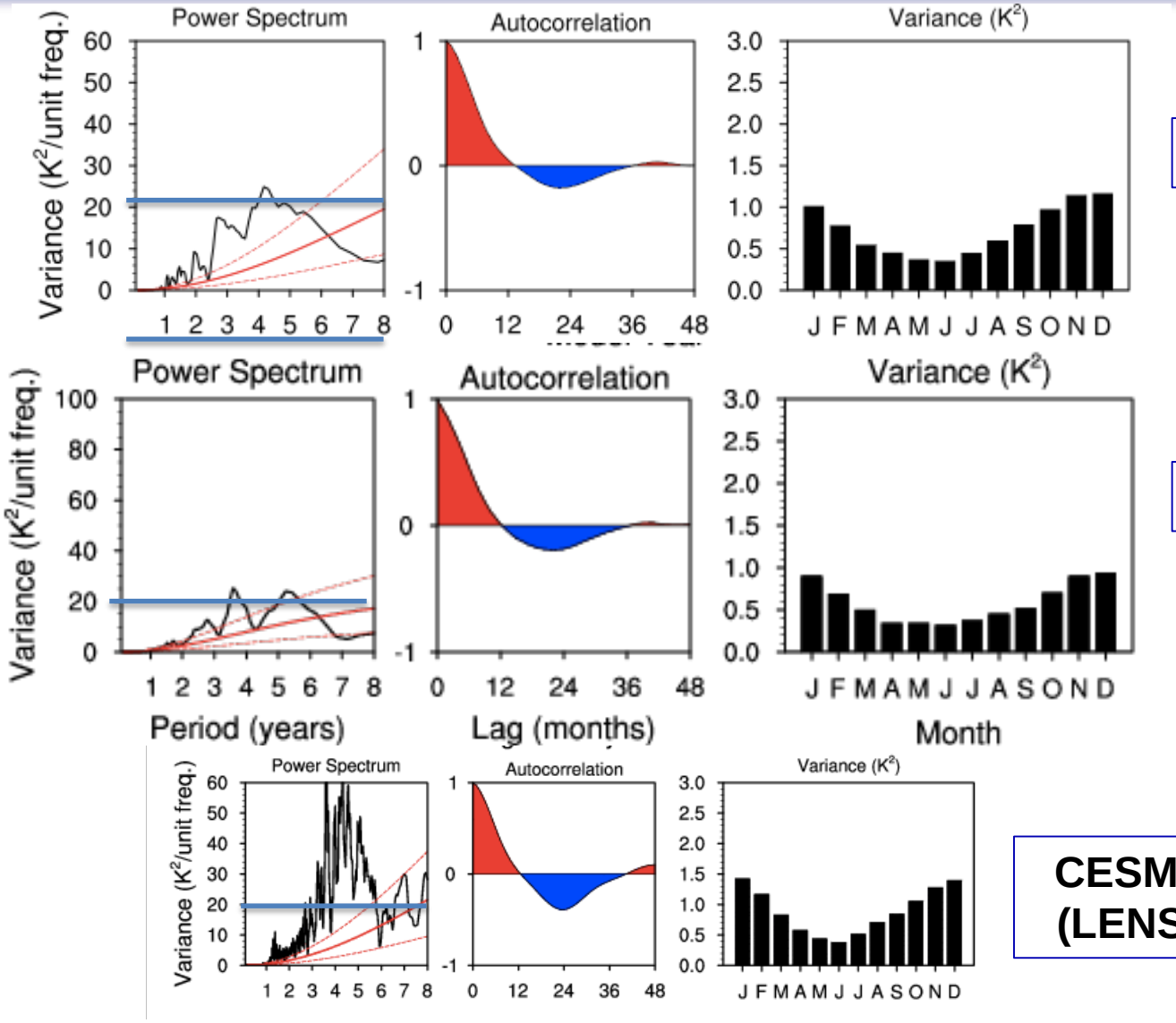
Skill Score (current simulation:#125)



NMSE = (a)+(b)+(c)

- General monotonic improvement from CESM1 (DJF/ANN)
- Large initial degradation in JJA mostly recovered
- Removing super-saturation -> improved skill, but high climate sensitivity
- Land model strongly impacts JJA score (new land at 118).

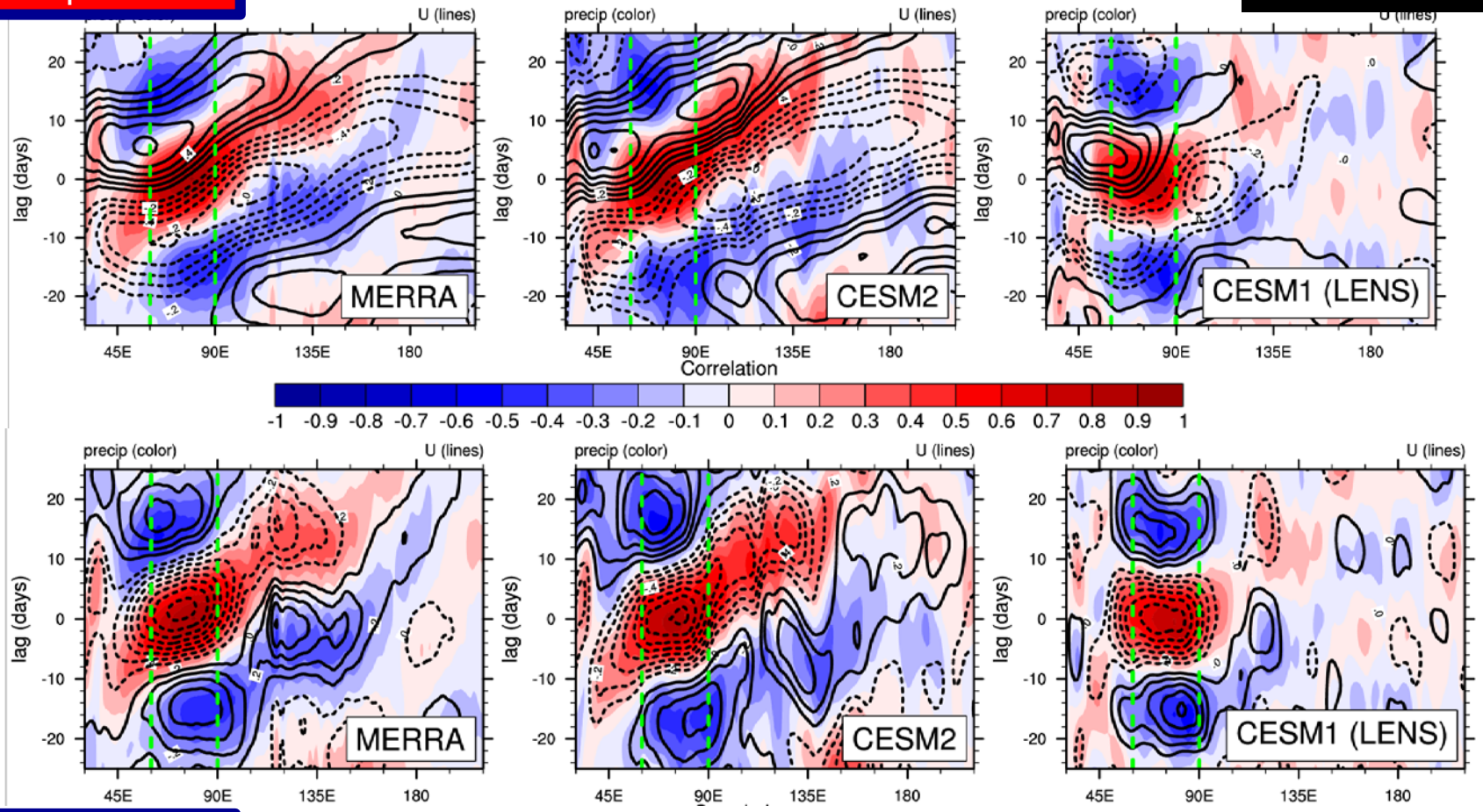
ENSO in CESM2



Madden Julian Oscillation (MJO)

Precipitation

850-mb U

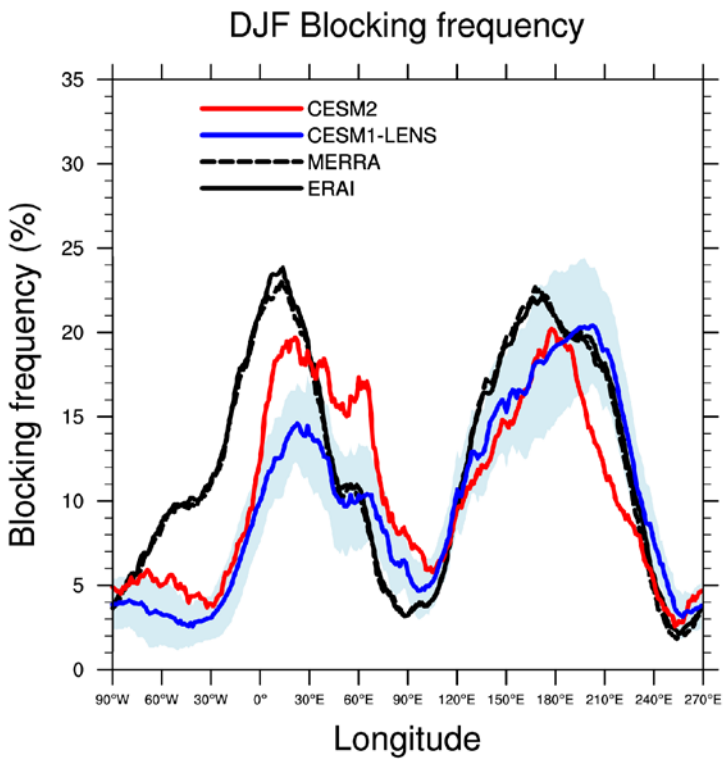


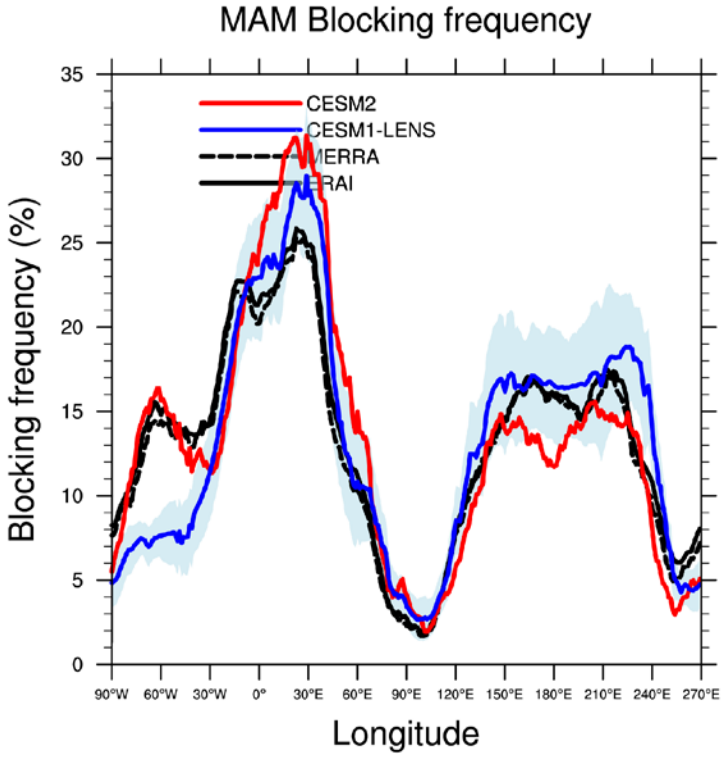
Precipitation

OLR

- Lag correlation with Indian-Ocean precip
- 20-100day band pass filter, 10S-10N
- 9 years, DJFMAM

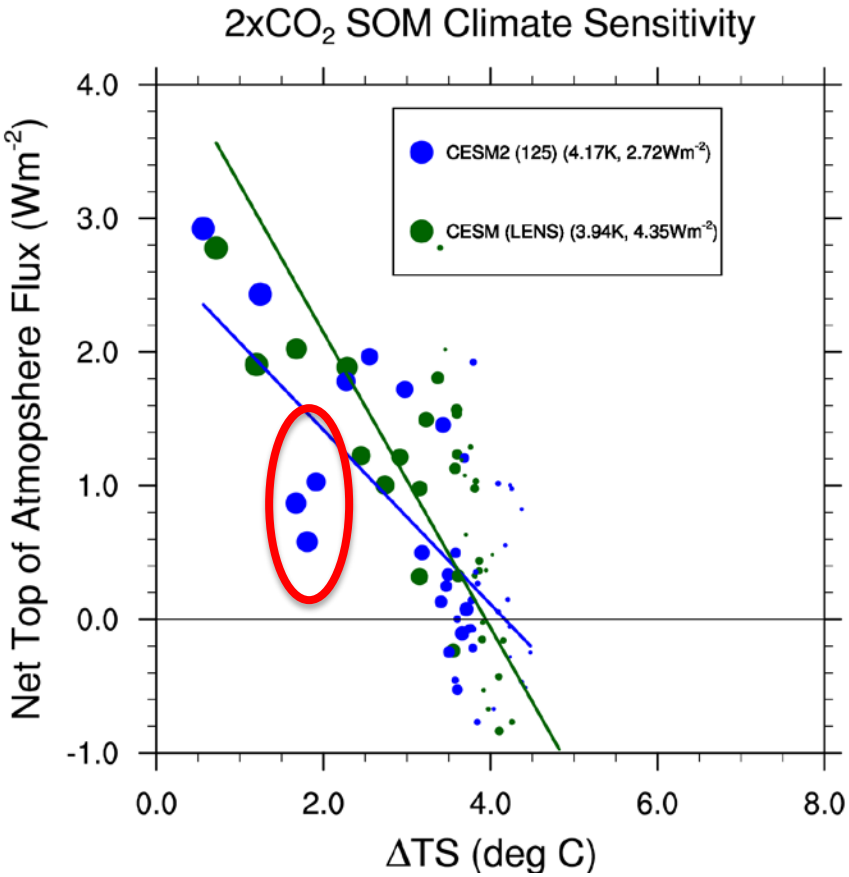
Atmospheric High Pressure Blocking





- Daily 500-mb height in the northern hemisphere mid-latitudes
- Reversal in gradient
- Lies mostly within LENS ensemble spread
- DJF W. Europe and MAM Greenland increases/improvements

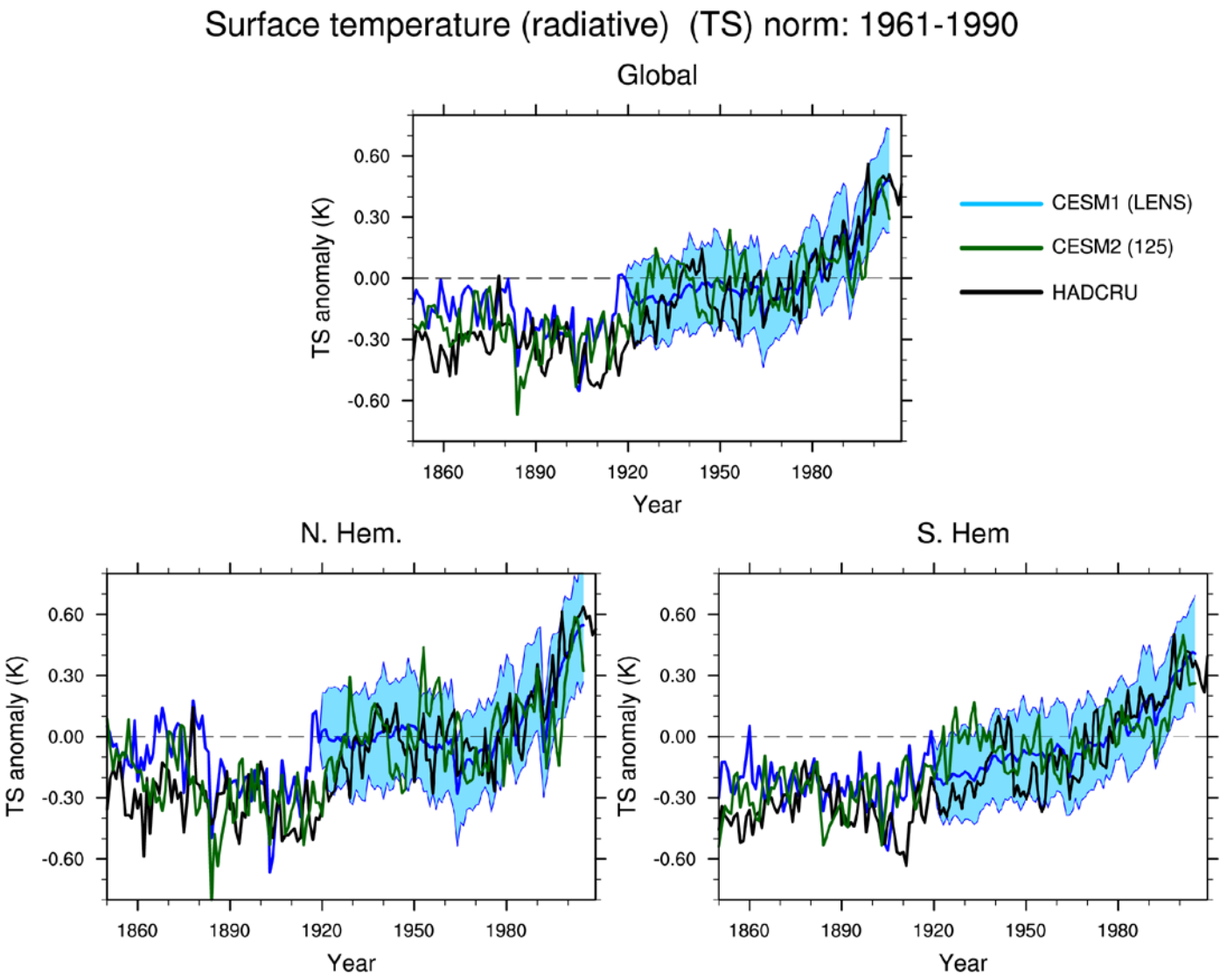
Climate Sensitivity: 2xCO2/Gregory



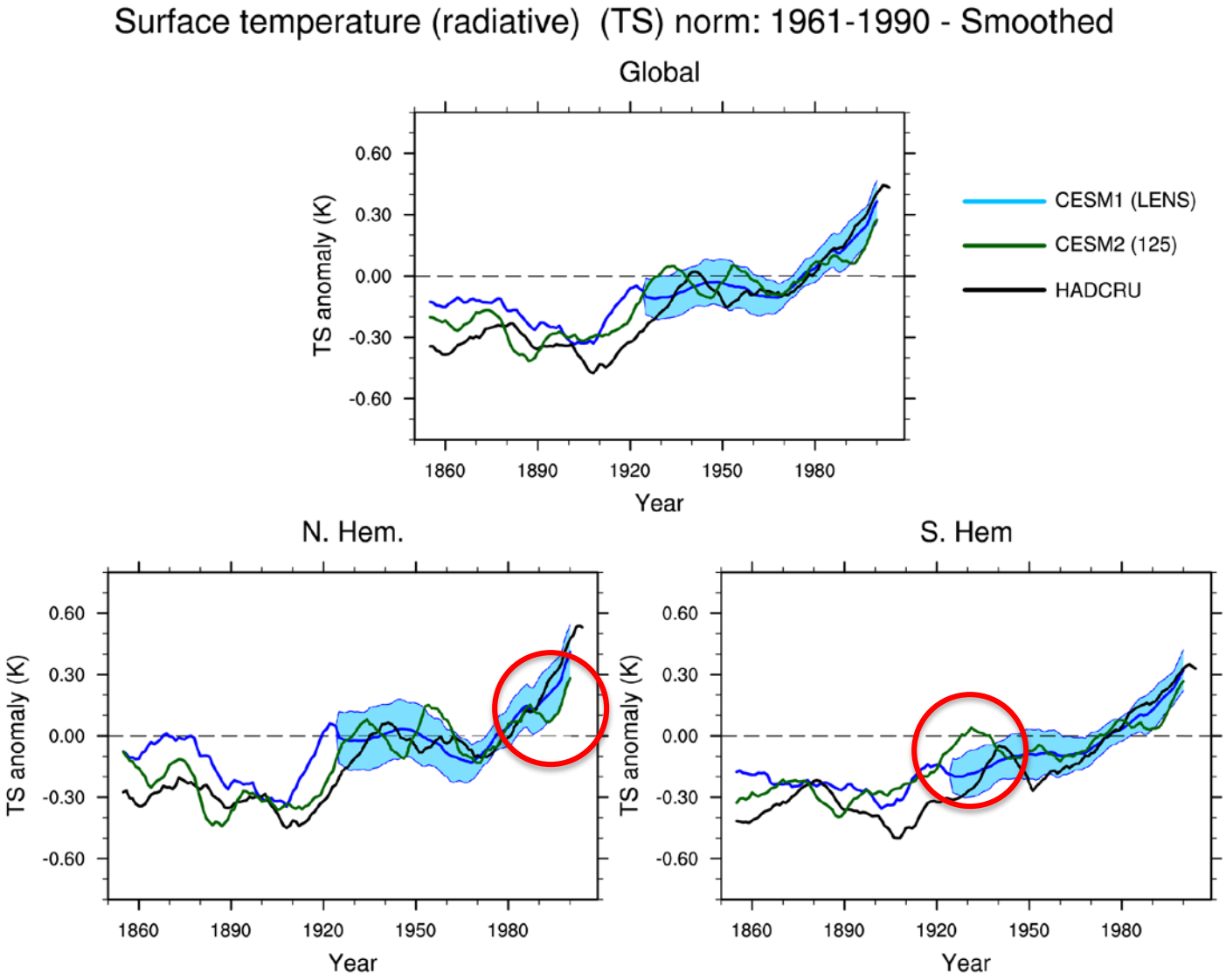
- Climate sensitivity
- **CESM1: 3.9K**
- **CESM2: 4.2K**

- Significant sensitivities
- Remove liquid supersaturation: **High**
- With in-cloud variances used in CLUBB calculations: **High**

20th Century



20th Century



To do for Release

- Low resolution; Some tuning + simulations (1850/20th/AMIP)
- High resolution: Uniform grid -> different tunings?
- High resolution: Grid refinement specific cases
- Final set of supported simple models
- Single-column model updates
- A version of SP-CAM available
- Isotopes with CAM6 to come
- Documentation

- Dust tuning
- Ocean initial conditions
- Response to final version of the land (CLM5)
- Tuning of sea-ice/snow albedos

NCAR Community Modeling:

Community Modeling Framework – Application Based

Physics Suites
CAM6
WRF (core set)
MPAS (core set)
Mix and match??

Chemistry
WACCM

Dynamical Cores
MPAS
Spectral Element
FV cubed
++
-- Old cores (SLD)

Simple Models

Data Assimilation
Atmos
Land
Ocean
Ice
Coupled

Initialization
Decadal
Forecast
Hindcast

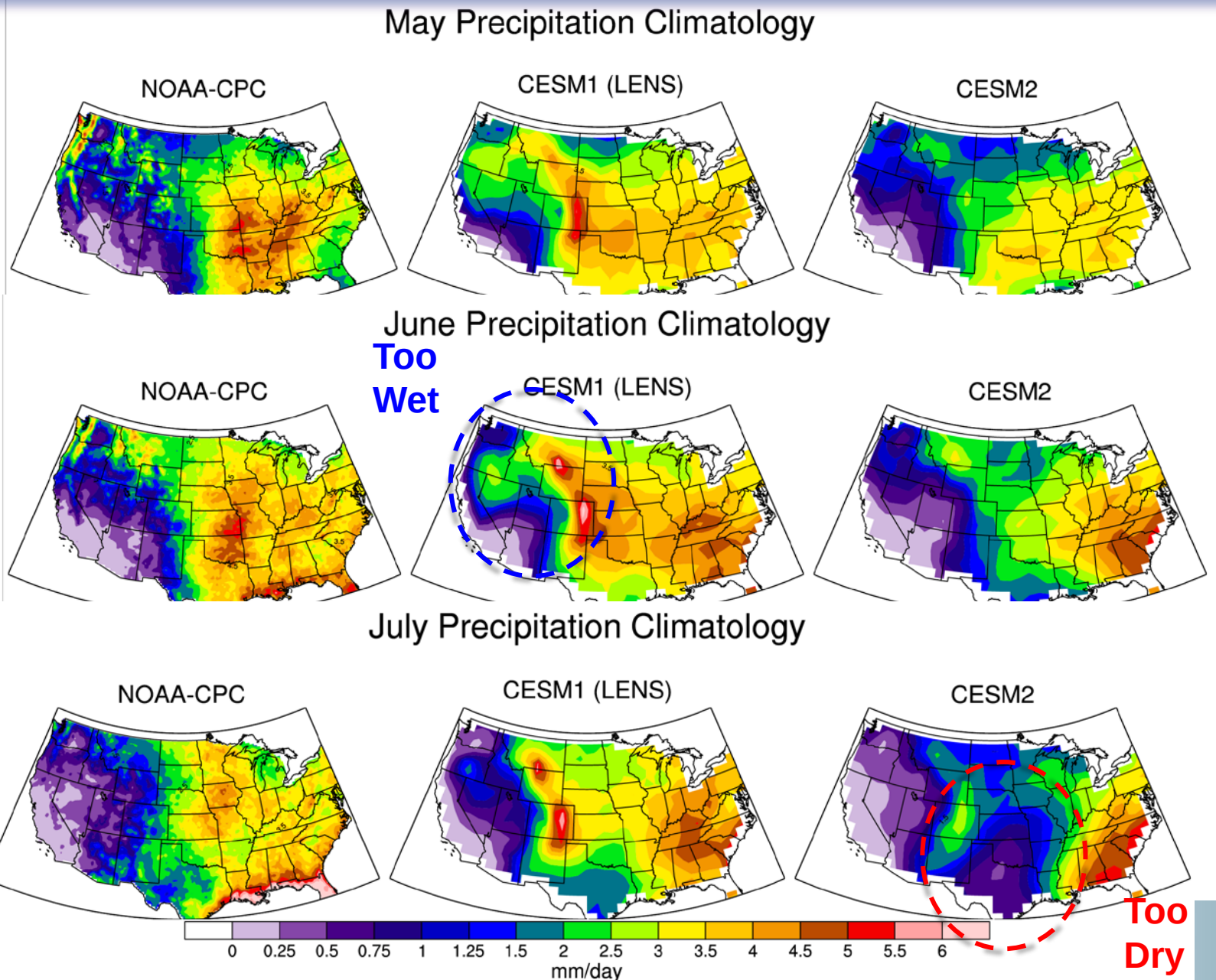
Coupler

Ocean
MOM
Regional Model (ROMS?)

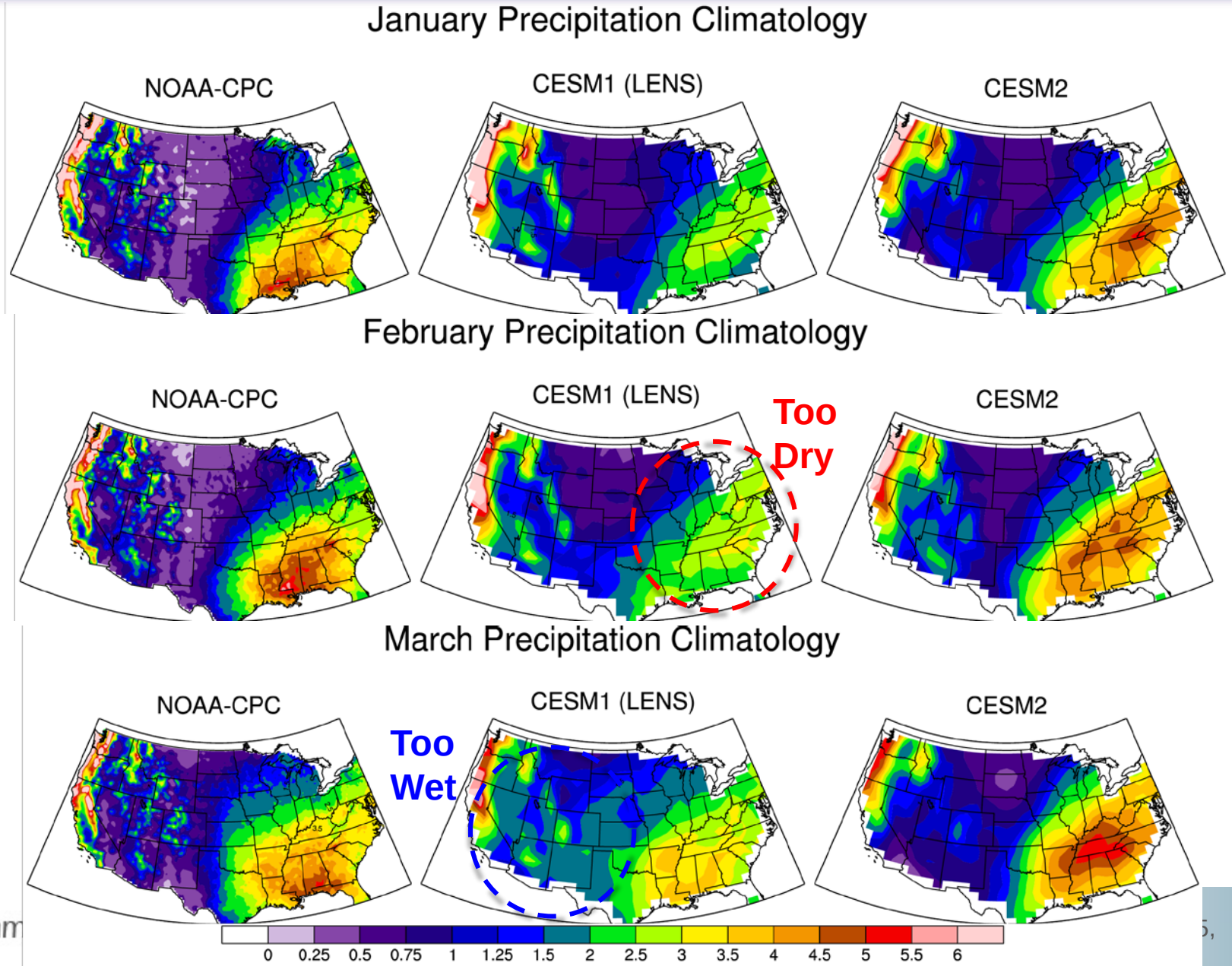
Land (SUMMA)
CLM
Noah

Sea Ice
CICE

US Precipitation: Summer



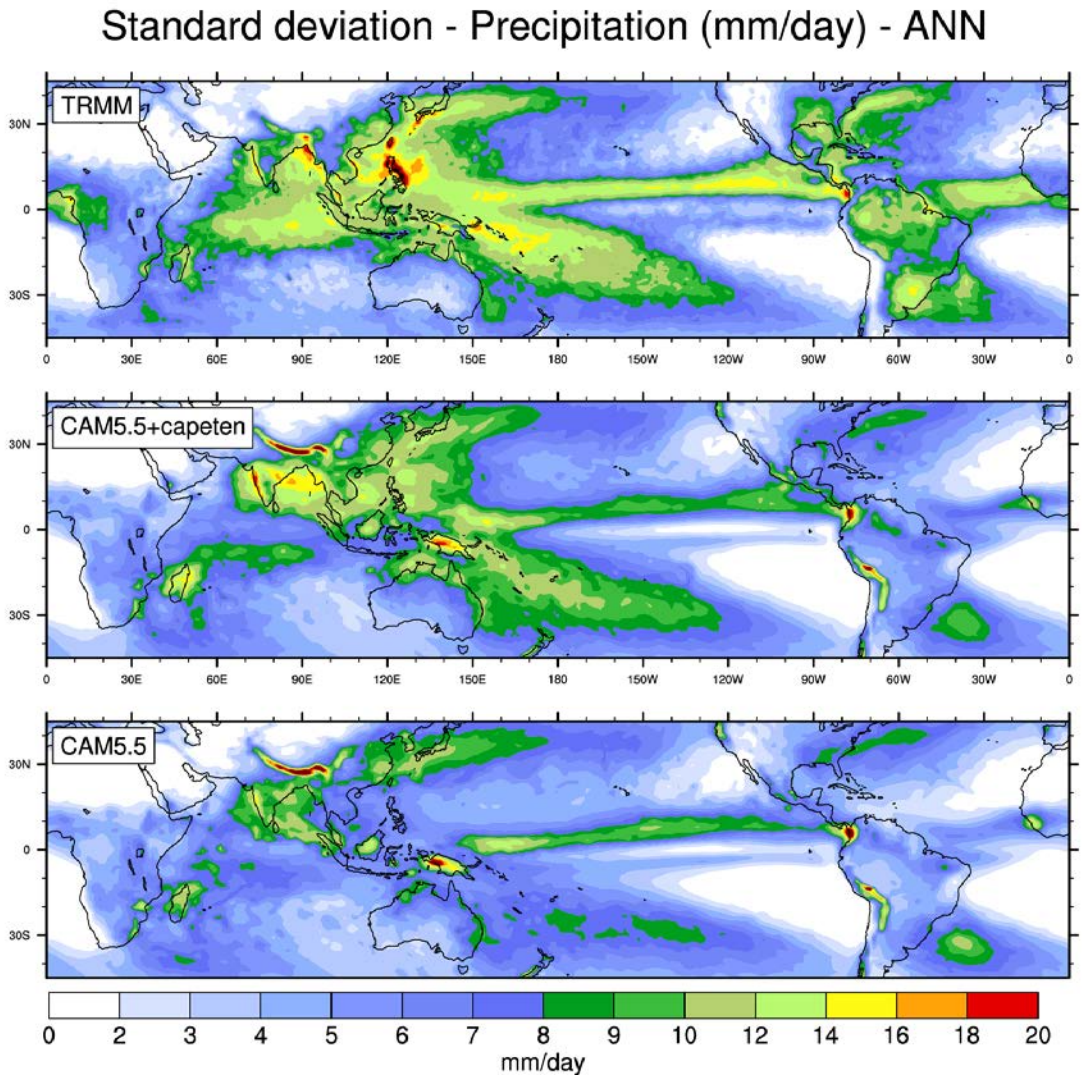
US Precipitation: Winter



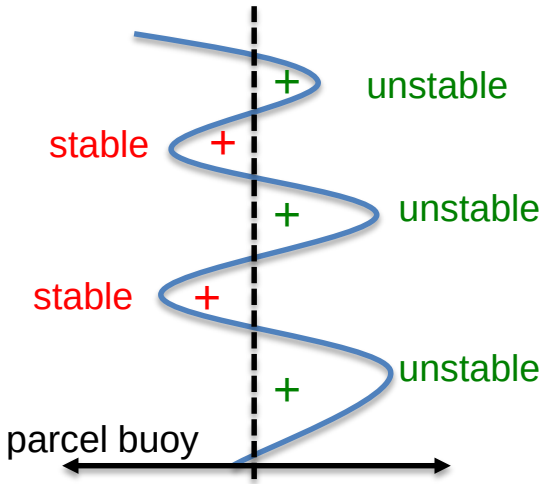
- Skill scores
- Surface stress + Greenland mods
- SB2001
- Super-saturation (past plots?)
- CLUBB tunings (gamma coeff, ck_10, C_14 and PS/PRECT plots)
- Ck_10 higher 0.5->1.0 in stable PBLs
- CLUBB MG2 subcycling
- Restriction of CLUBB in the vertical
- No angular momentum conservation fixes
- Ocean coupling frequency (24 -> 2 -> 1hrly)
- Sea-salt emission?
- Estuary model
- New solar file
- Capeten/MJO plots
- Background volcanoes
- Oxidation ozone files
- Tropopause definitions
- ENSO plots
- Simple models

- SLD core removal
- New topography
- Climate sensitivity SOM plots
- Lifetime effect changes?
- 20th plots
- Will be using new CMIP6 emissions
- Low resolution
- High resolution
- Regional refinement
- Merging of NCAR modeling?

Improved Variance with CAPETEN



Cape sum(+)
def: max of 5+
new: max of 1+



Between now and release (Breckenridge?)

- Start documentation and overview papers
- Finalize simple model options in CESM
- A 2 degree CAM6: AMIP and pre-ind. coupled (20th C?)
- Isotopes available (CAM5.4 – no CLUBB)
- SPCAM available in newer code base
- Retain CAM3/4/?5 physics packages (not climate)

Questions?

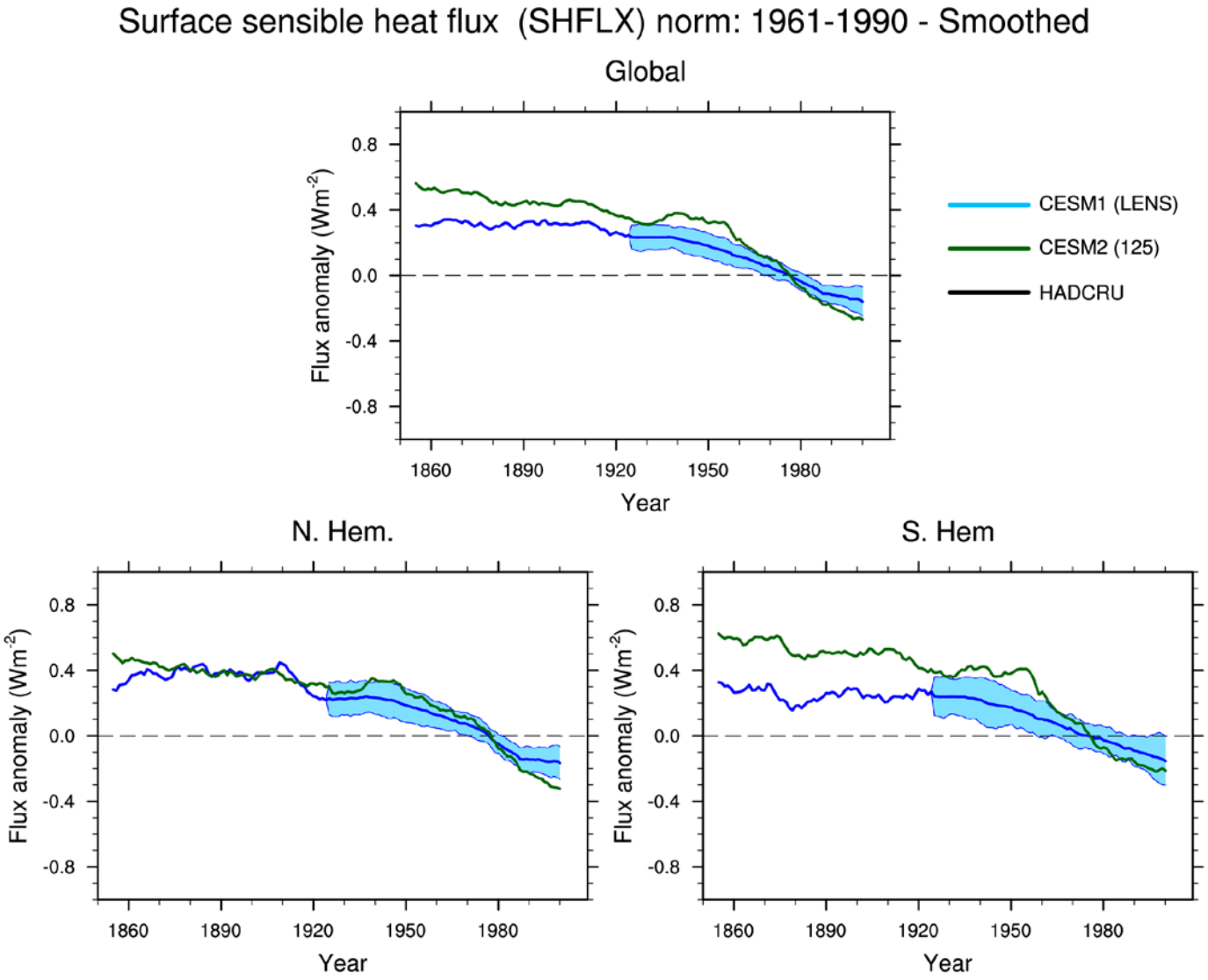
Discussion

- Comments on the final version of CAM6 (freeze July 1)
  - Simulations/configurations

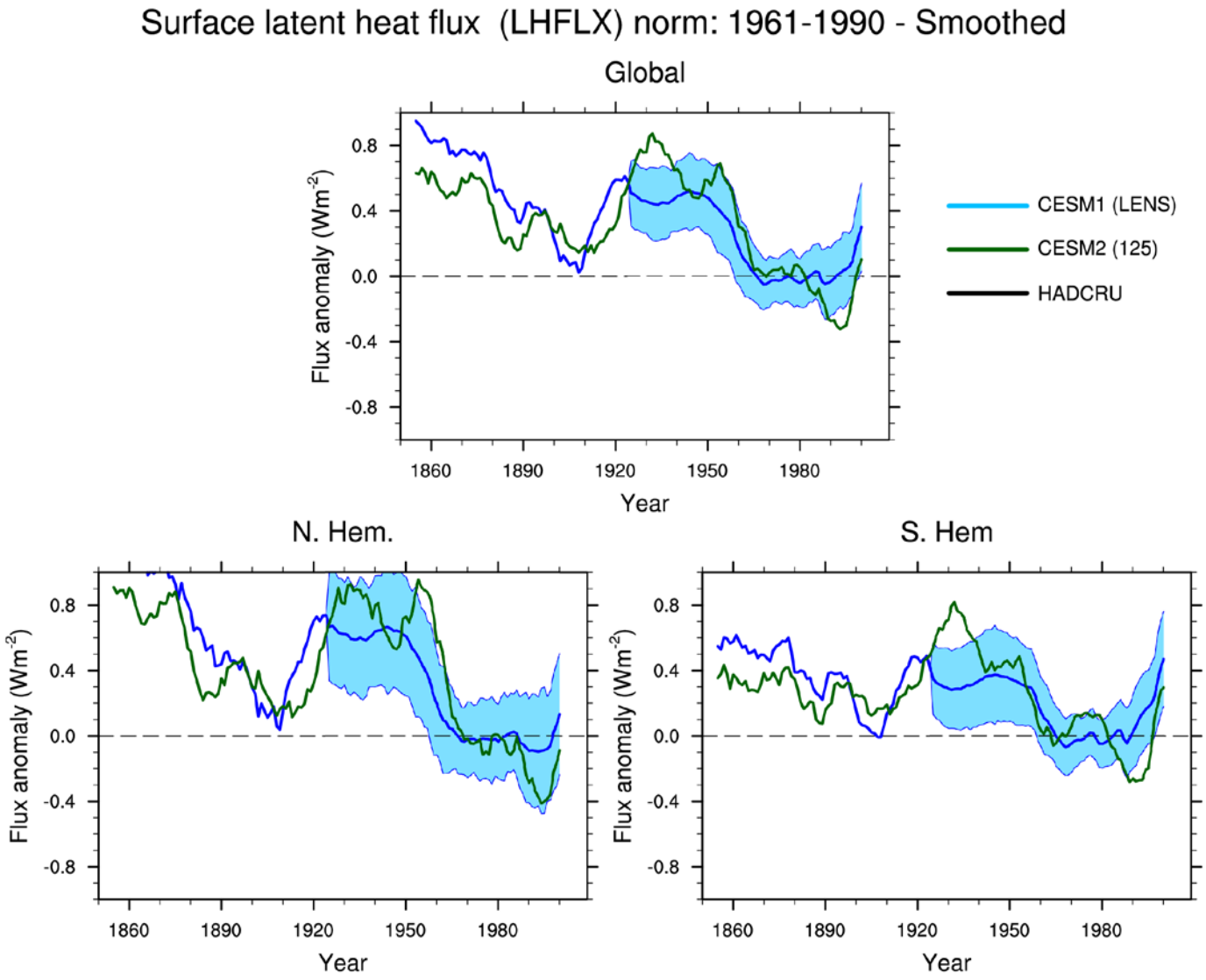
- Next steps for physics development – convection/scale-aware
  - CLUBB deep (w/ or w/o SILHS)
  - UNICON – unified convection scheme
  - Other options (A-Schubert, Kain-Fritsch)

- Dy-core (MPAS, Spectral Element, FV not developed)
  - What science problems can we address with each core?
  - What tests do we need to inform our decisions?
  - Accuracy, coupling, support, performance, refinement?
  - NCAR discussion in the Fall
  - Dry mass coordinate

20th Century



20th Century



20th Century