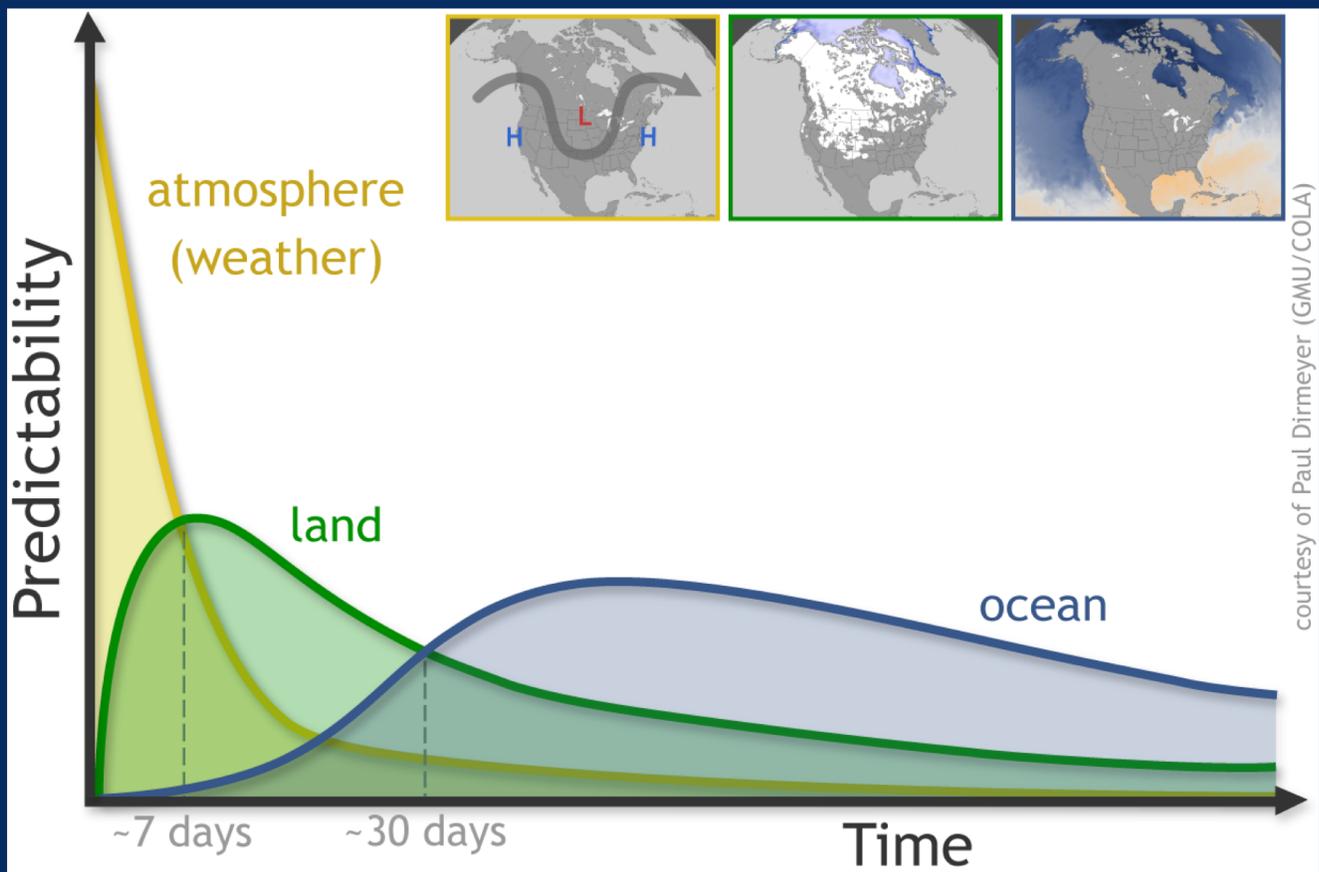


Validation of the coupled system

Laurie Trenary

George Mason University, Fairfax VA

Sources of Predictability



Quantities of interest

Mean (annual/seasonal)

Modes of variability

- Spatial/temporal characteristics
- Teleconnections
- Feedbacks

Statistics of extremes

Validation Metrics

- RMSE error
- Mean bias
- Centered RMSE
- Ratio of standard deviations
- Correlation

Estimates for each point within verification region are treated as individual forecasts and combined to produce a single score

$$E^2 = \frac{1}{W} \sum_i \sum_j \sum_t w_{ijt} (F_{ijt} - R_{ijt})^2$$

Where:

F = simulated field

i,j = longitude and latitude

R = Reference

w = weight (cosine latitude)

See Pincus et al. 2008, *JGR* or
Glecker et al. 2008, *JGR*

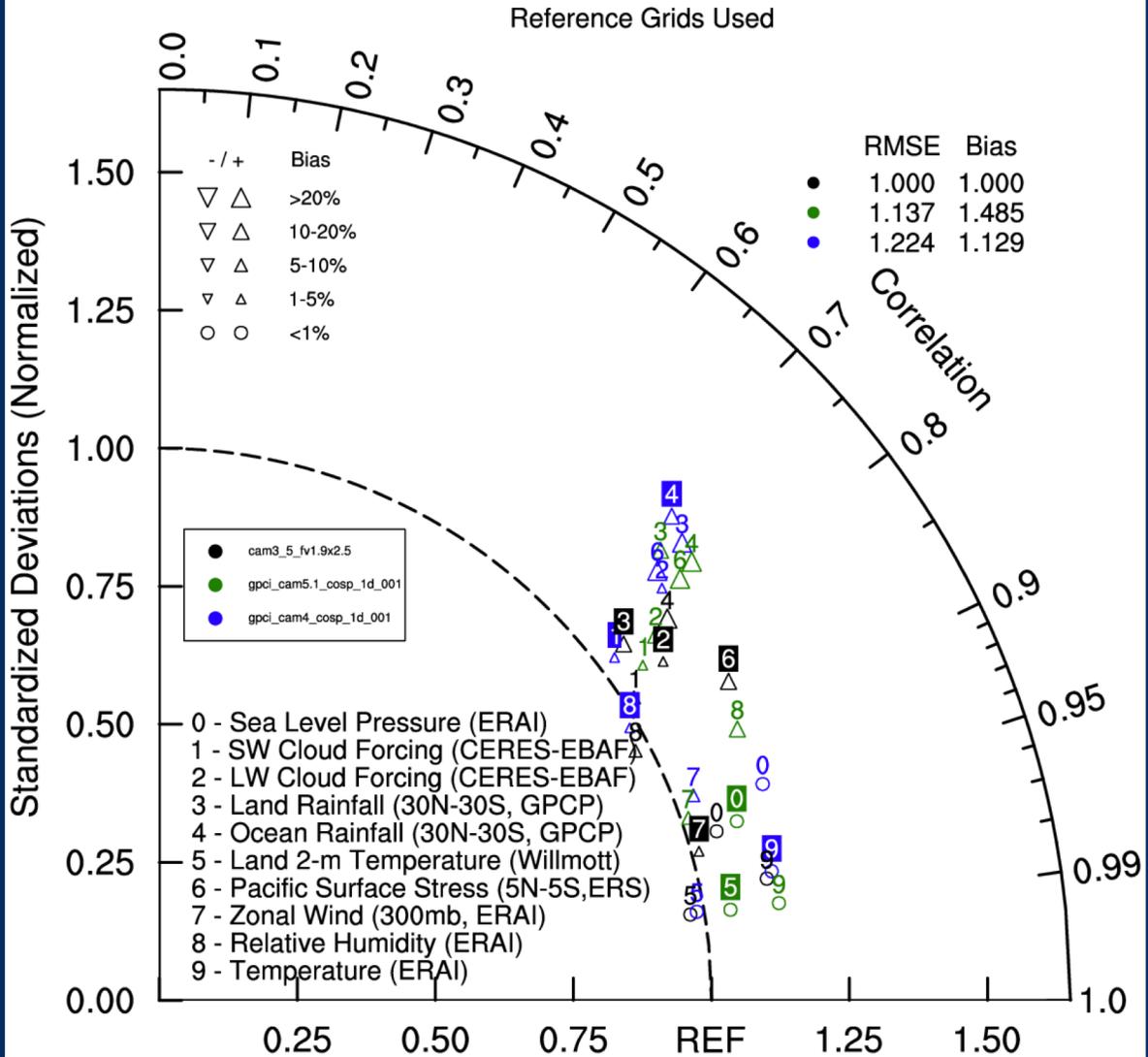
Atmospheric Component

Example of variables

- Sea level pressure
- Shortwave cloud forcing
- Longwave cloud forcing
- Tropical land rainfall (30S-30N)
- Tropical ocean rainfall (30S- 30N)
- Surface air temperature over land
- Equatorial Pacific zonal wind stress (5S-5N)
- Zonal winds at 300mb
- Relative humidity
- Temperature

See CESM AM-working group

ANN: SPACE-TIME



Oceanic Component

Example of variables

- Sea surface temperature
- Sea surface salinity
- Global and Atlantic meridional overturning circulation
- Mixed layer depth
- Antarctic Circumpolar Current transport
- Equatorial undercurrent and thermocline
- Heat budgets
- Meridional heat transport
- Other variables of interest: SSH, western boundary currents, water mass analysis

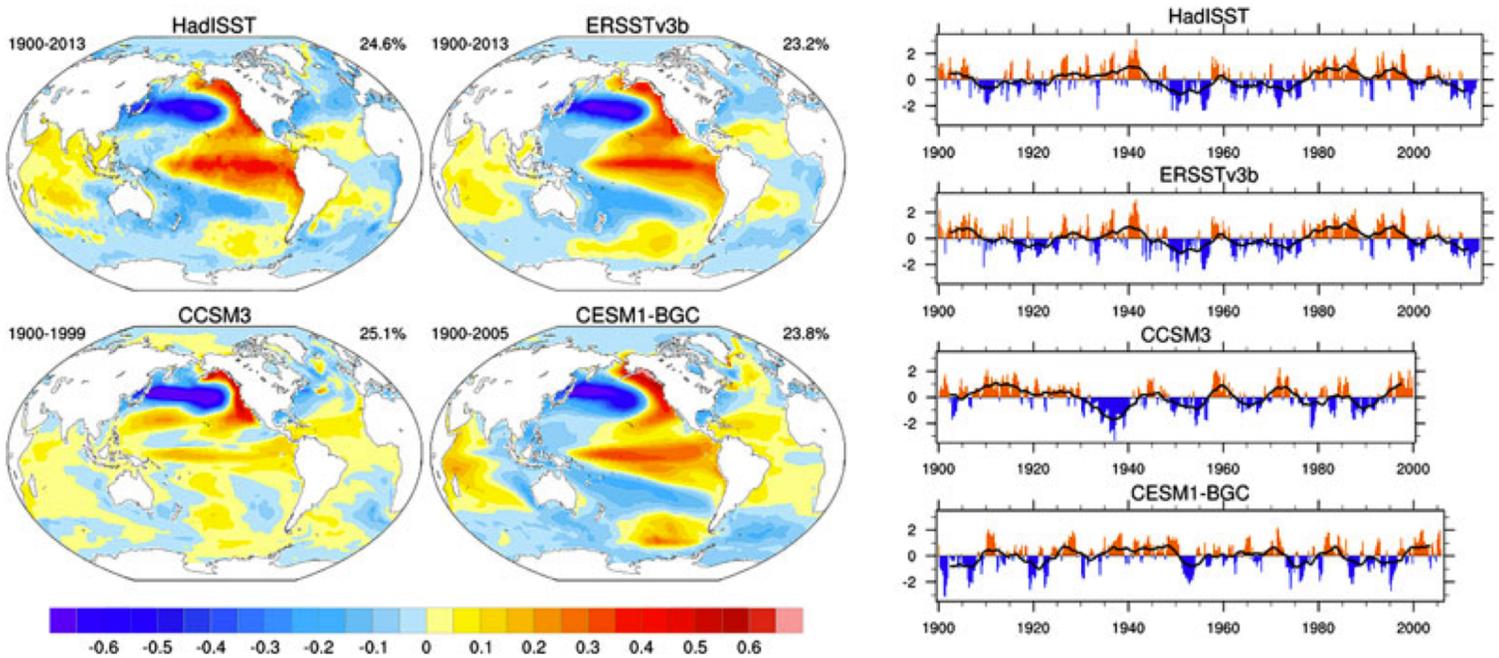
CESM OM-working group

Diagnostics of modes of variability

- Evaluate spatial structure
- Temporal variations (preferred time scale, auto-correlation, seasonal variance)
- Teleconnections
- Dynamics and feedbacks

Diagnostics of large scales modes

Pacific Decadal Oscillation

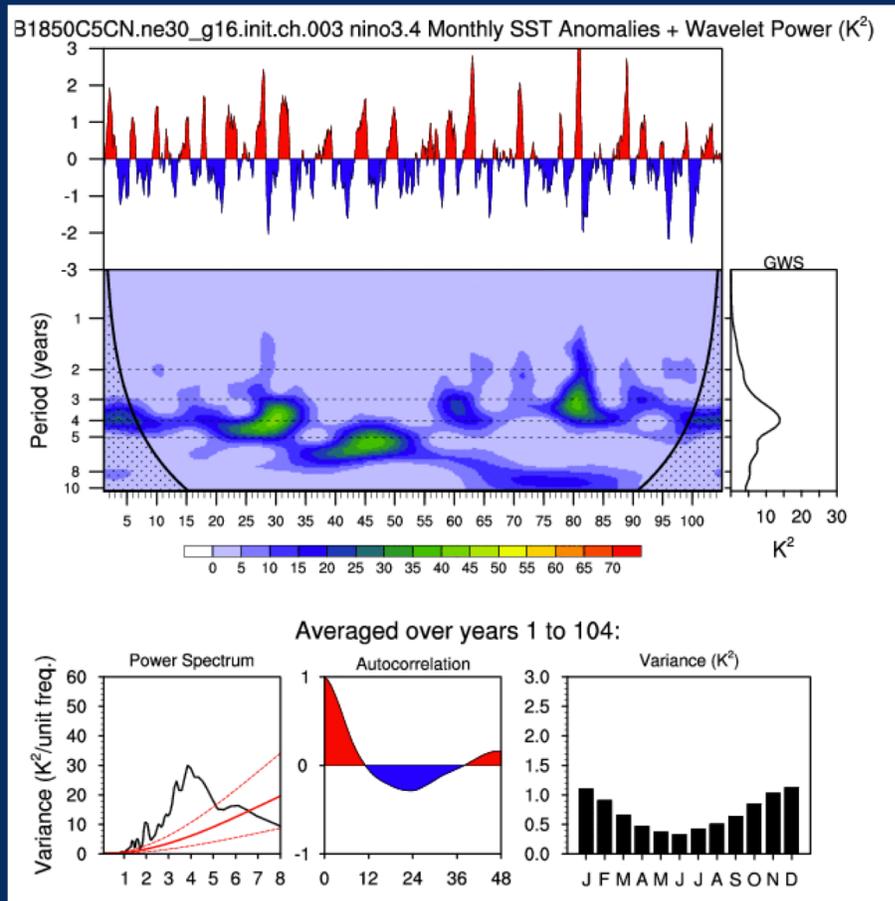


Other modes: ENSO, AMO, NAM,
SAM, PNA, PSA, IOD
Phillips et al., 2014, *EOS*

NCAR Climate variability diagnostic package

Diagnositics of large scales modes

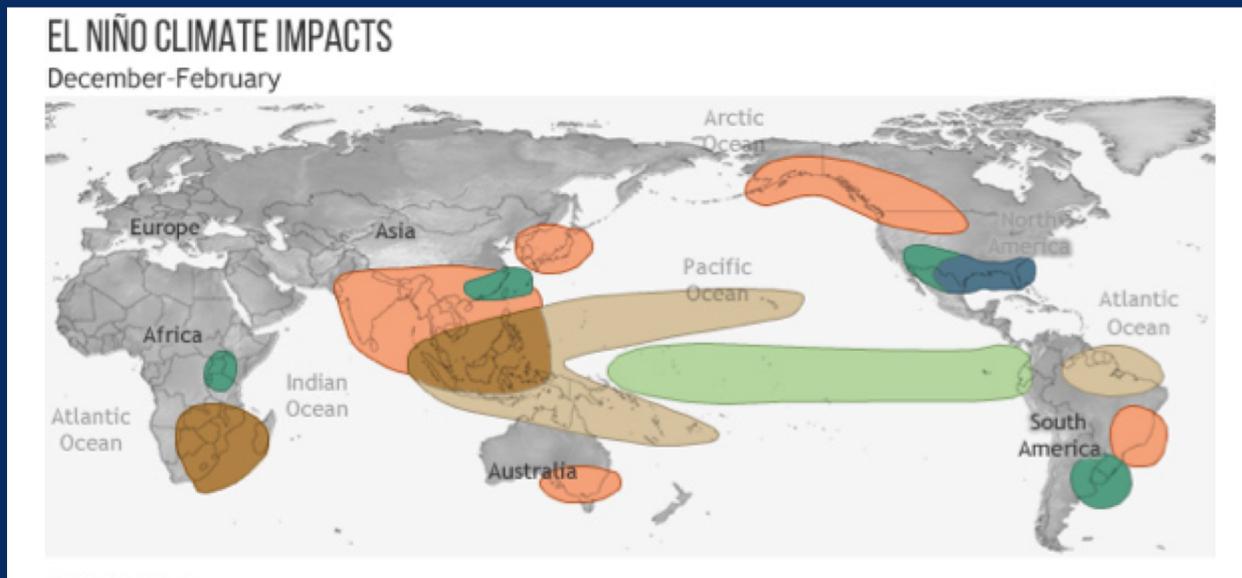
ENSO



Also see recommendations by
ENSO-CLIVAR WG

CESM AM-working group

Process evaluation: ENSO --- teleconnections



Also see recommendations by
ENSO-CLIVAR WG

NCAR Climate variability diagnostic package

Diagnosics of large scales modes

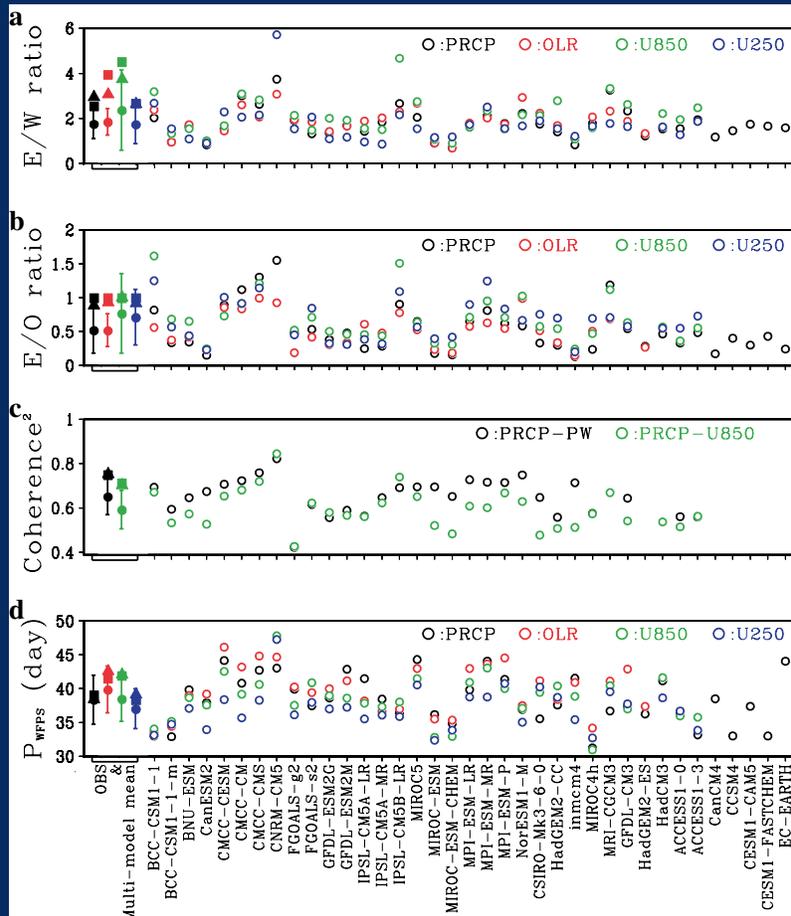
MJO

East/west power ratio

East/Obs. power ratio

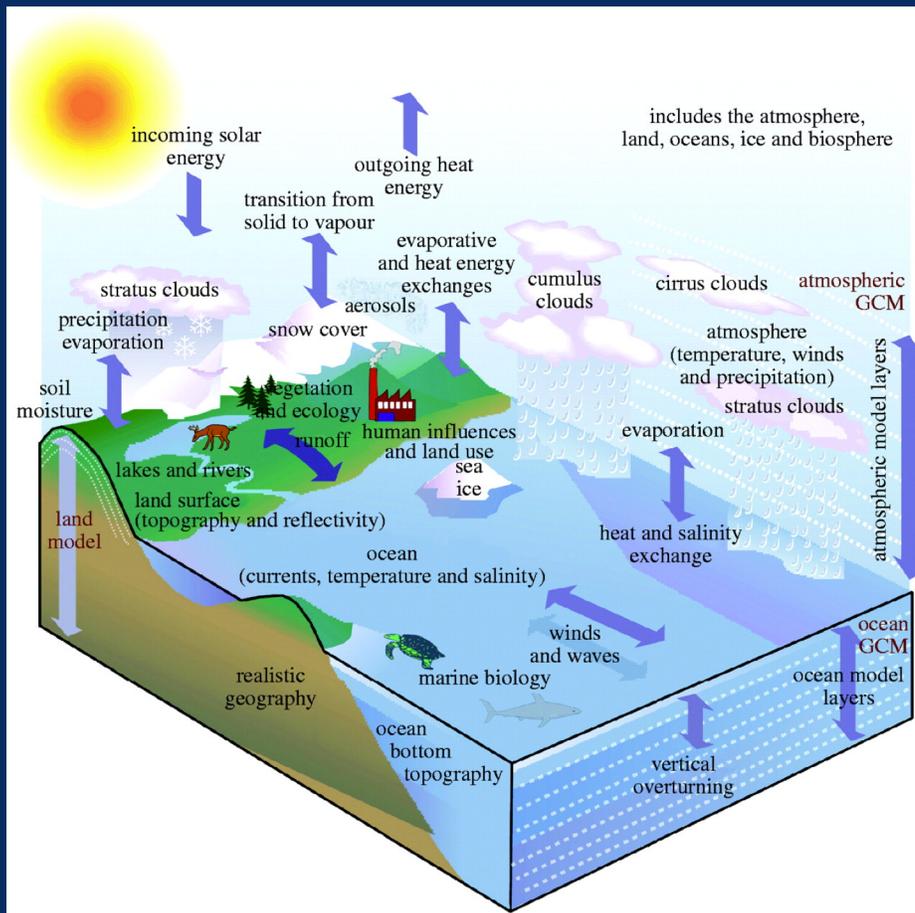
Squared coherence
Precip. and
precipitable
water/850 mb zonal
winds

Dominant eastward
period



Ahn et al., 2017, *Clim Dyn*

Climate Feedbacks



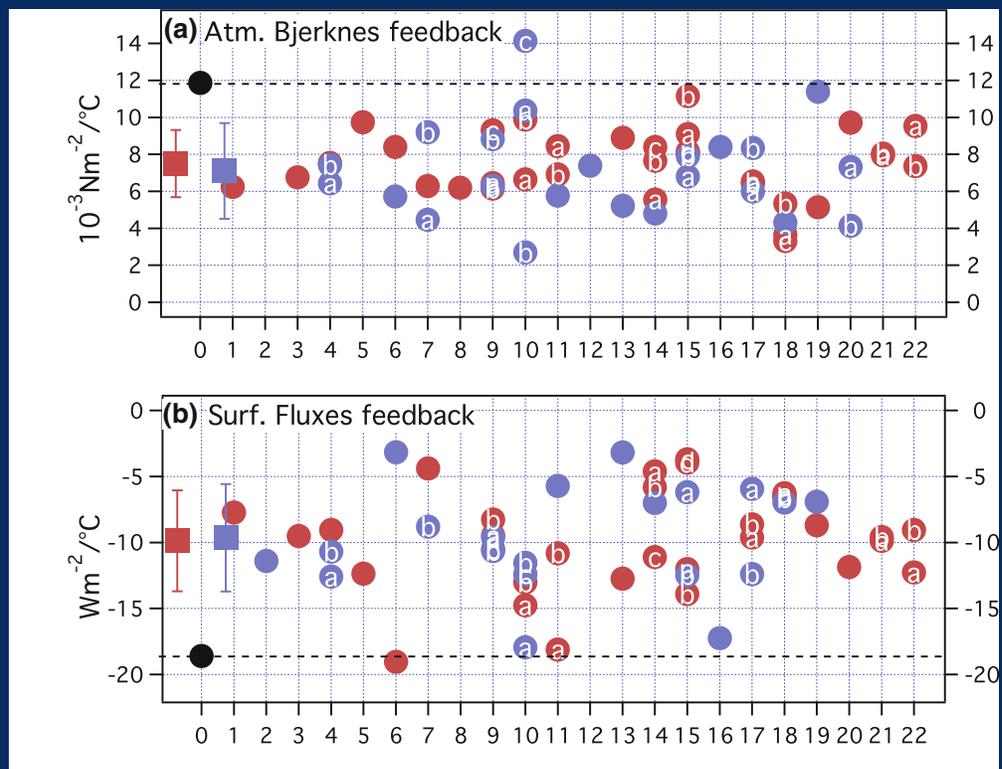
Washington et al., 2009, *Philos. Trans. Royal Soc. A*

Climate Feedbacks

ENSO

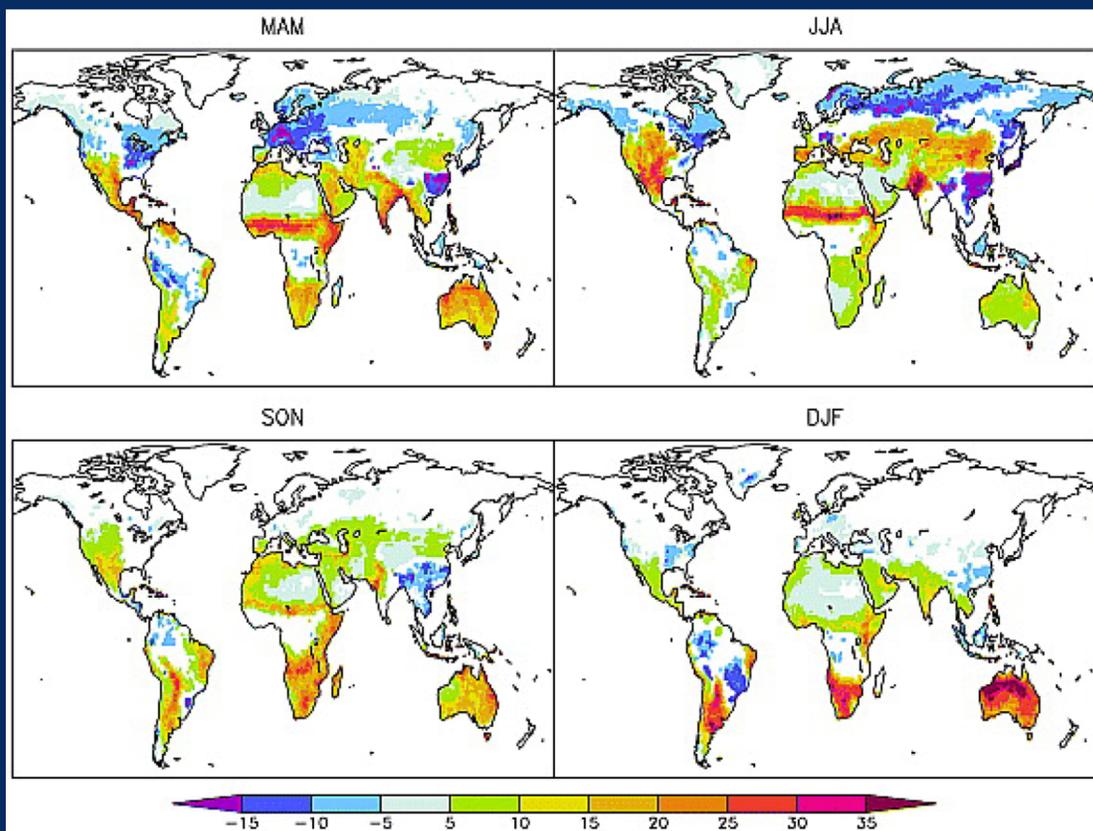
Bjerknes feedback:
Regression of Nino4
wind-stress and
Nino3 SST

Heatflux feedback:
Regression between
net surface heatflux
and SST in Nino3.



Climate Feedbacks

Land



Dirmeyer, P. 2011, *GRL*

Index of surface flux sensitivity:

$$I_{LH} = s_w B_{LH,w}$$

Climate Feedbacks

Land

Pg	Name	Land State	Surf. Fluxes	Atm. State	Local Space	Local Time	Obs' ble	Type
1	Two-Legged Metrics	Y	Y	Y	Y	Y	Y	Stat
2	Mixing Diagrams	N	Y	Y	N	Y	Y	Phys
3	LCL Deficit	N	N	Y	Y	Y	Y	Phys
4	Betts Relationships	Y	Y	Y	Y	N	Y	Stat
5	Priestley-Taylor Ratio	N	Y	Y	Y	Y	Y	Phys
6	Heated Condensation Framework	N	Y	Y	Y	Y	Y	Phys
7	RH Tendency	N	Y	Y	Y	Y	Y	Phys
8	CTP-HI _{Low}	N	N	Y	Y	Y	Y	Phys
9	GLACE Coupling Strength	Y	Y	Y	Y	Y	N	Stat
10	Feedback parameter	Y	Y	Y	Y	N	Y	Stat
11	Conditional Correlation	Y	Y	Y	Y	N	Y	Stat
12	Associated Predictability Ratio	Y	Y	Y	Y	Y	N	Stat
13	Soil Moisture Memory	Y	N	N	Y	N	Y	Stat
14	Granger Causality	Y	Y	Y	N	N	Y	Stat
15	P-T metrics	N	N	Y	N	N	Y	Stat
16	Zeng's Gamma	Y	Y	Y	Y	Y	Y	Stat
17	Coupling Drought Index	Y	N	Y	Y	N	Y	Phys
18	Bulk Recycling Ratio	N	Y	Y	N	N	Y	Phys
19	Vegetated Coupling (Little Omega)	N	Y	Y	Y	Y	N	Phys
20	Latent Heating Tendency	Y	Y	Y	Y	Y	N	Phys
21	Correlations	Y	Y	Y	Y	Y	Y	Stat
22	SM-T Metric	N	Y	Y	Y	Y	Y	Phys
23	Probit SM-P Causality	Y	N	Y	Y	N	Y	Stat
24	TFS/AFS	N	Y	Y	Y	Y	Y	Stat

Summary

- Community effort to establish performance metrics for climate models
 - focus on large aspects of climate and represented by a statistical measures (Bias, RMSE, correlation)
 - Climate modes and process based evaluation
- Adopting standardized metrics used routinely by the climate community
 - Ability to monitor model performance
 - Objective comparison across models
 - Aid in model development and tuning

Currently Available resources

- WGNE/WGCM Climate Model Metrics Panel
 - Earth System Model Evaluation Tool (ESMValTool)
 - Climate Variability Diagnostics Package (CVDP)
 - PCMDI's Metrics Package (PMP)
- MJO and ENSO CLIVAR working groups
- GEWX --- land based metrics