The Role of Stationary Rossby Waves in the Subseasonal Development of Drought over North America

Hailan Wang[1,2], Siegfried Schubert[1] and Randal Koster[1]
NASA/GMAO[1]; SSAI[2]

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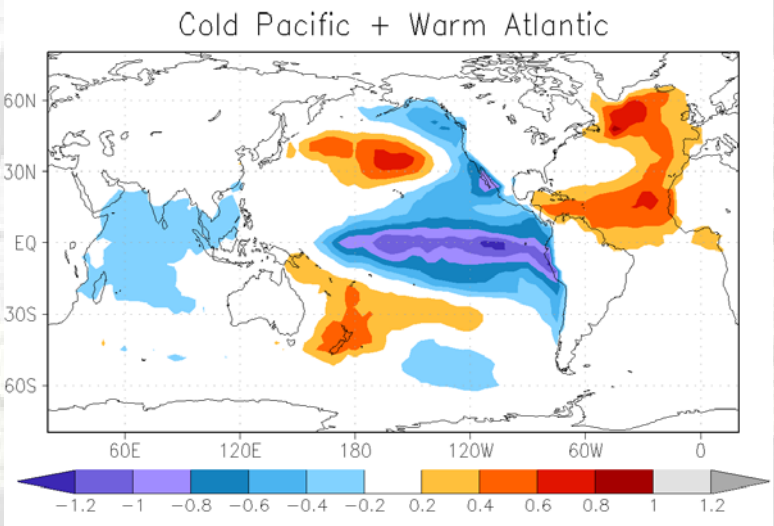
Warm Season North American Drought Drivers

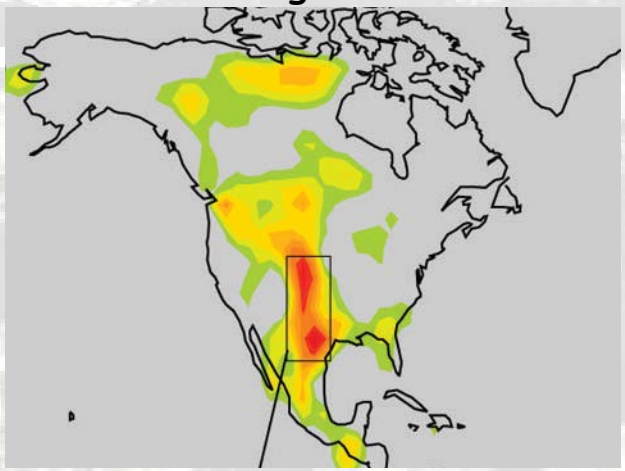
- SST controls
- Soil moisture feedback
- Large-scale atmospheric (internal) dynamical controls

SST Anomaly



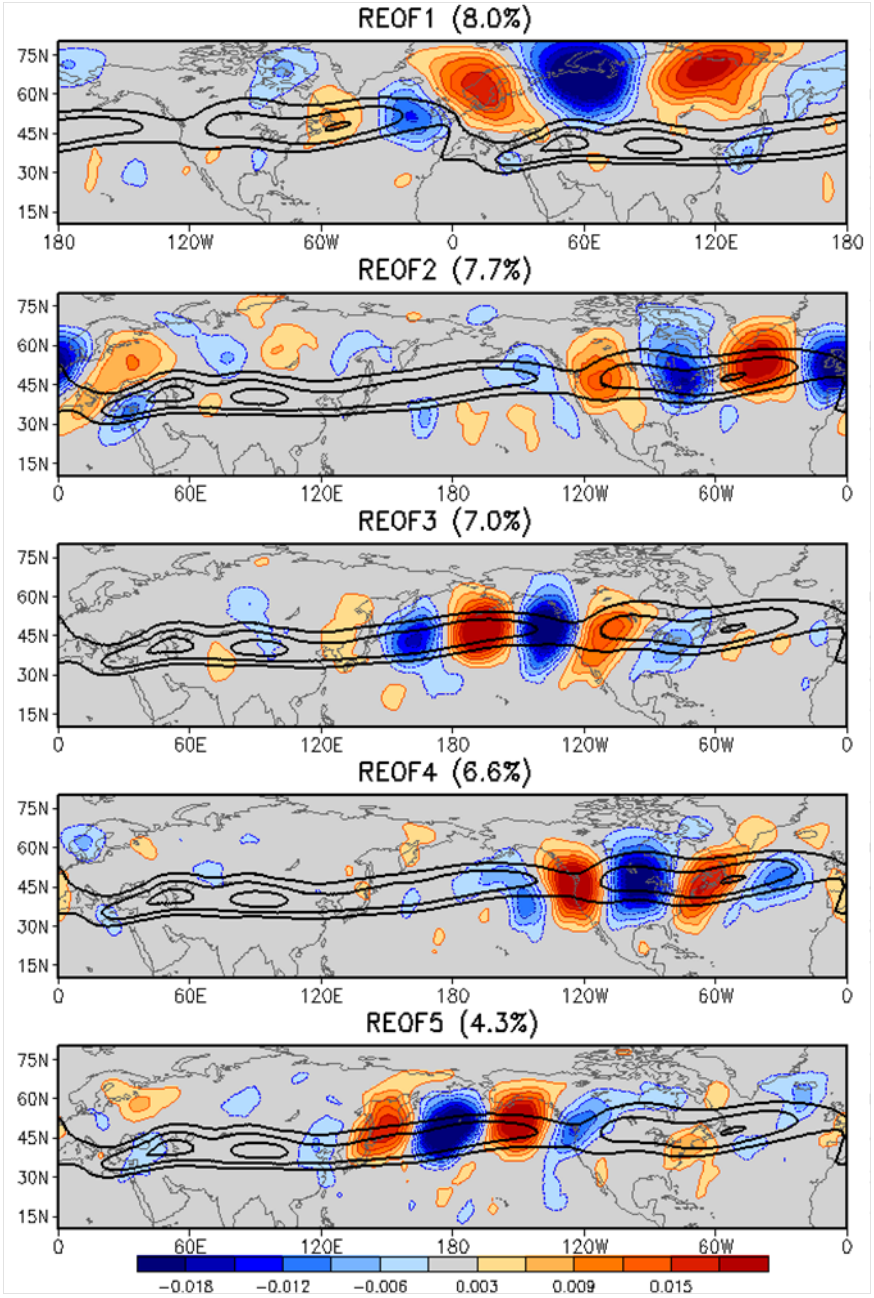
Schubert et al 2009

Land-atmos coupling strength
JJA; average of AGCMs



Koster et al 2004

Leading REOFs of J-J-A subseasonal V250mb (MERRA)



Shaded: REOFs; Contour: JJAClim U250

Importance of the mean summertime NH jet streams in guiding these leading subseasonal atmospheric circulation patterns

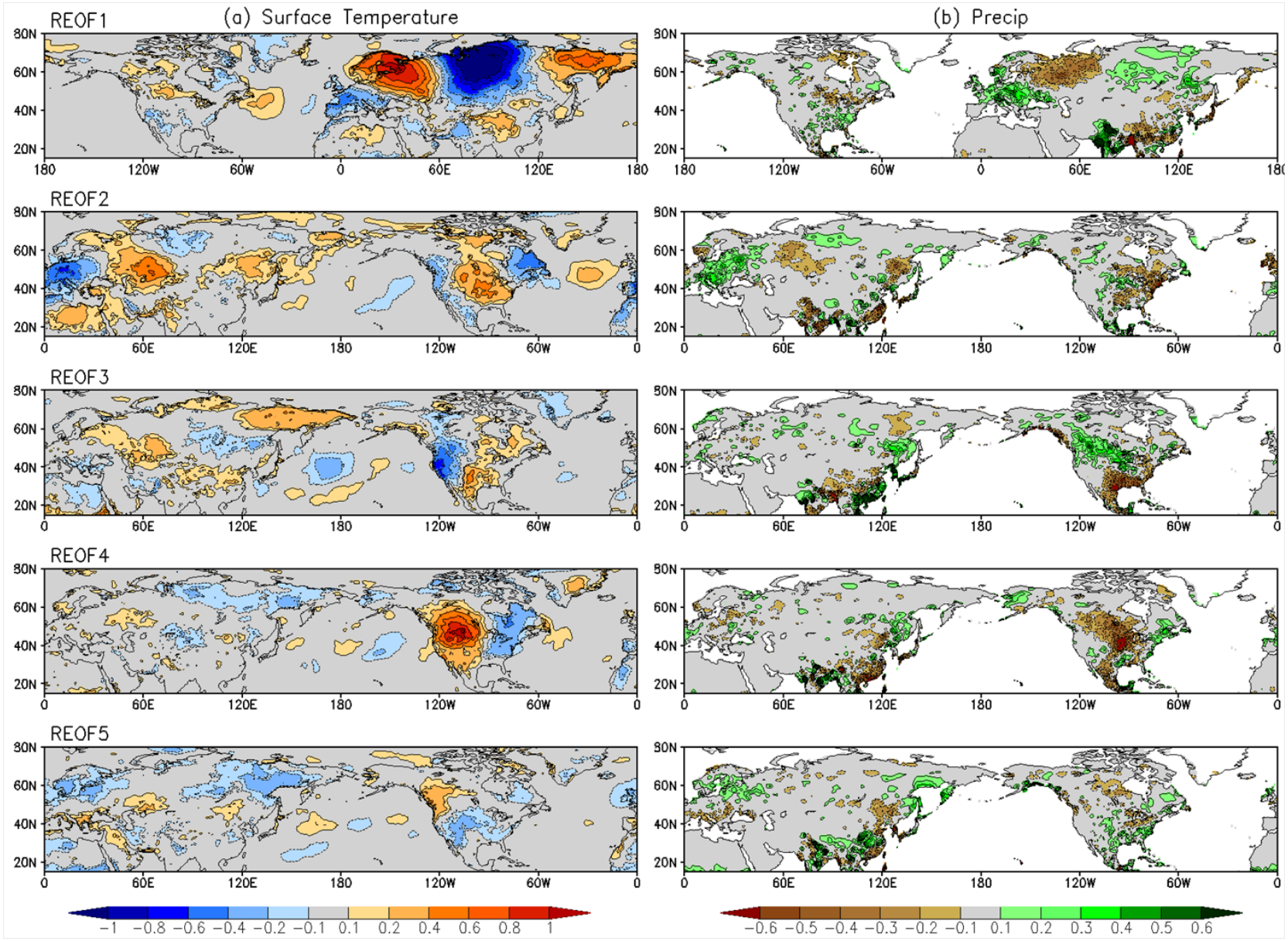
Top 10 REOFs:

50% v250 variability

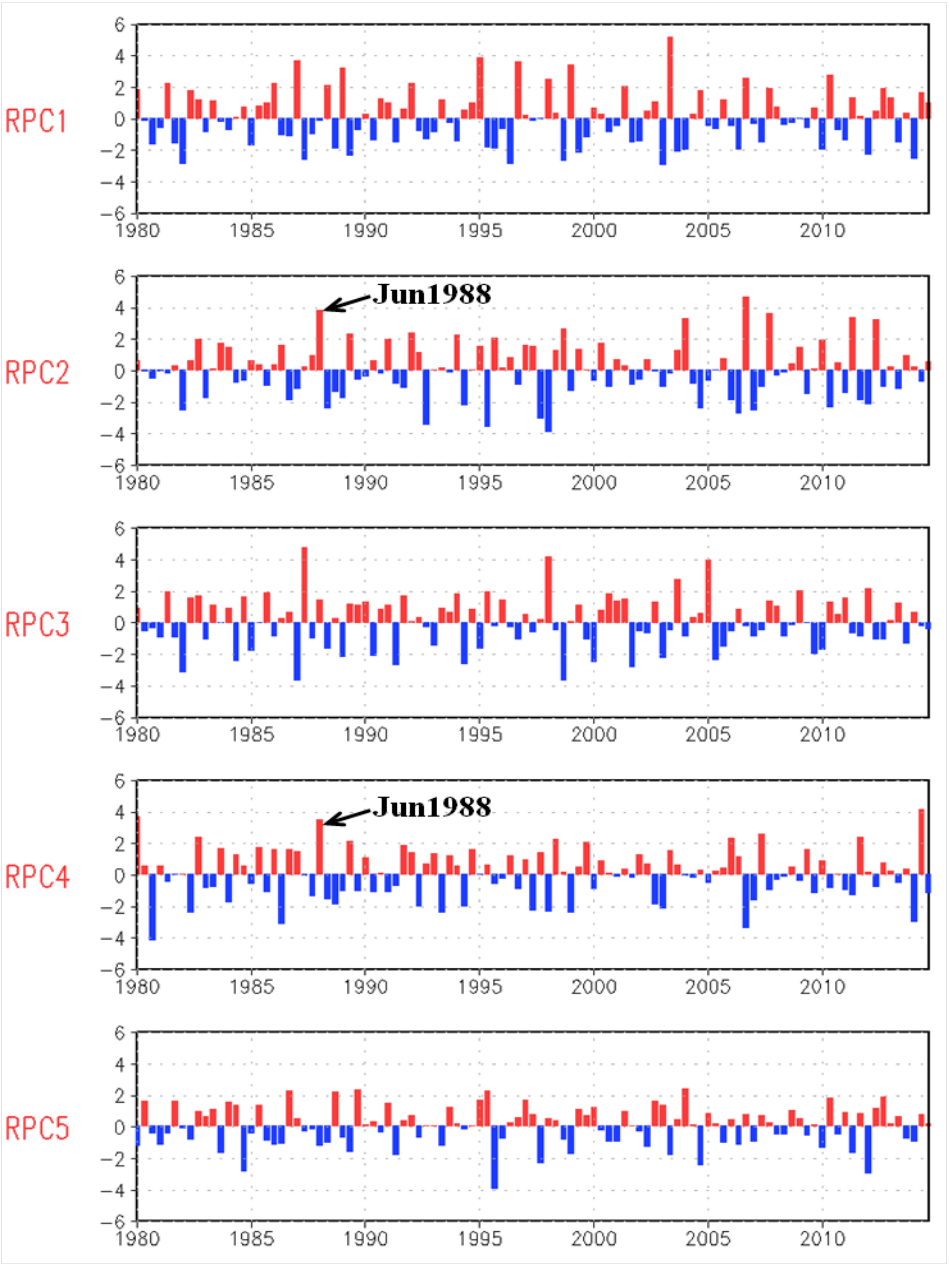
More than 60% (30%) of Ts (precip) variability over a number of regions over NH extratropical land areas

Ts (MERRA) and Precip (MERRA_Land) anomalies associated with the REOFs

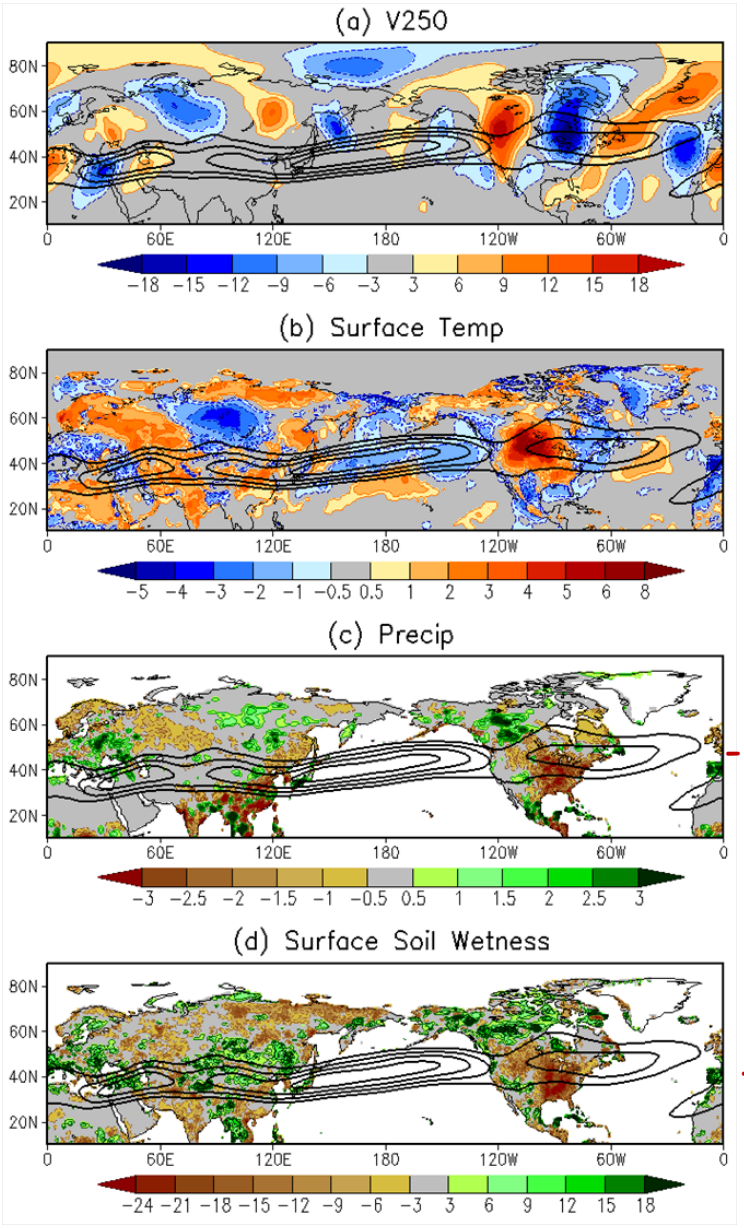
Linear regression against normalized RPCs



Leading RPCs of J-J-A subseasonal V250mb

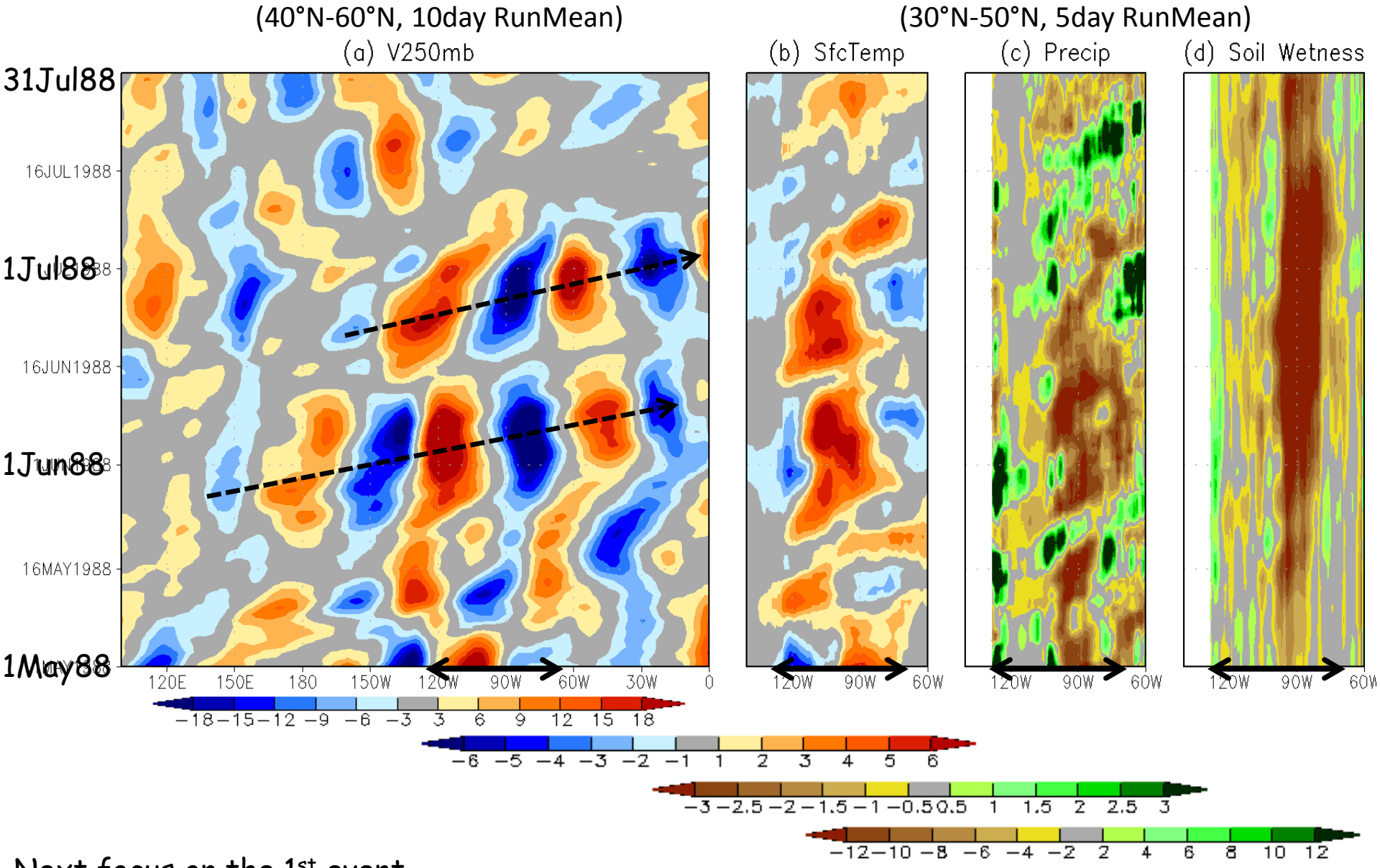


Monthly anomalies: Jun1988



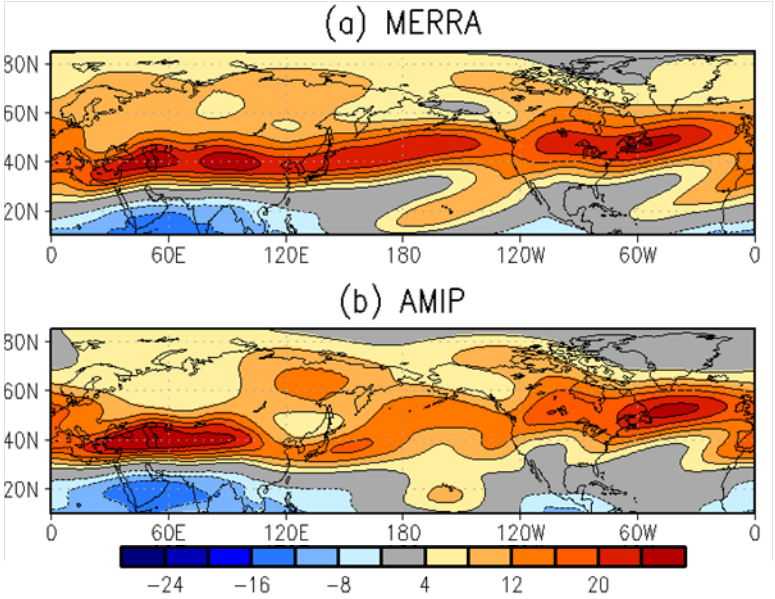
Crucial for development of some climate extremes

Daily Anomalies: 1May-31Jul1988

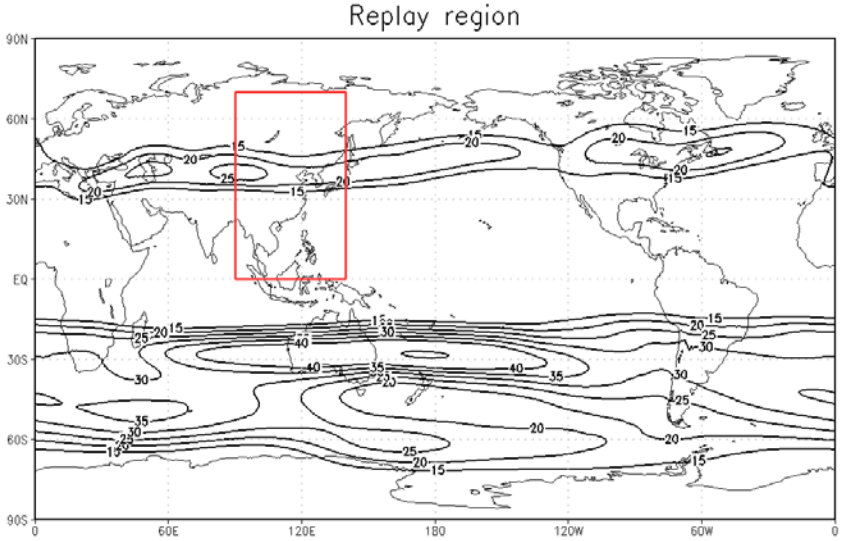


Next focus on the 1st event
Use AGM modeling approach

U250 Clim: JJA



GEOS-5 AGCM regional replay



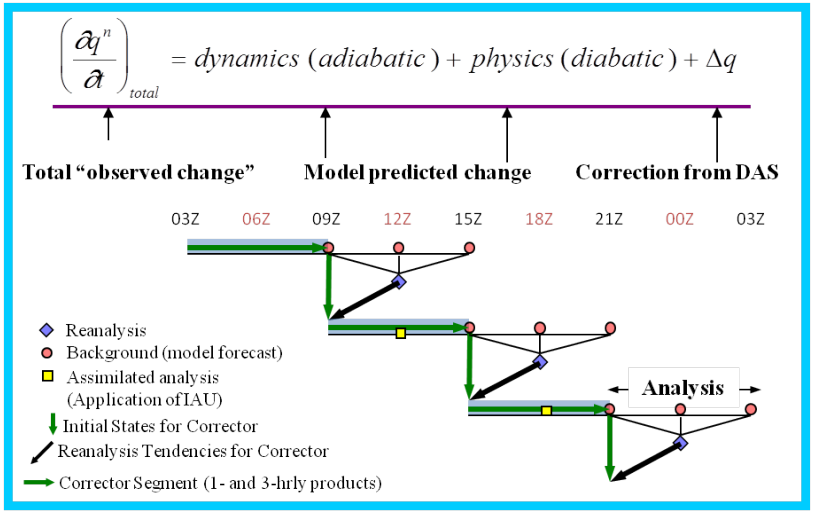


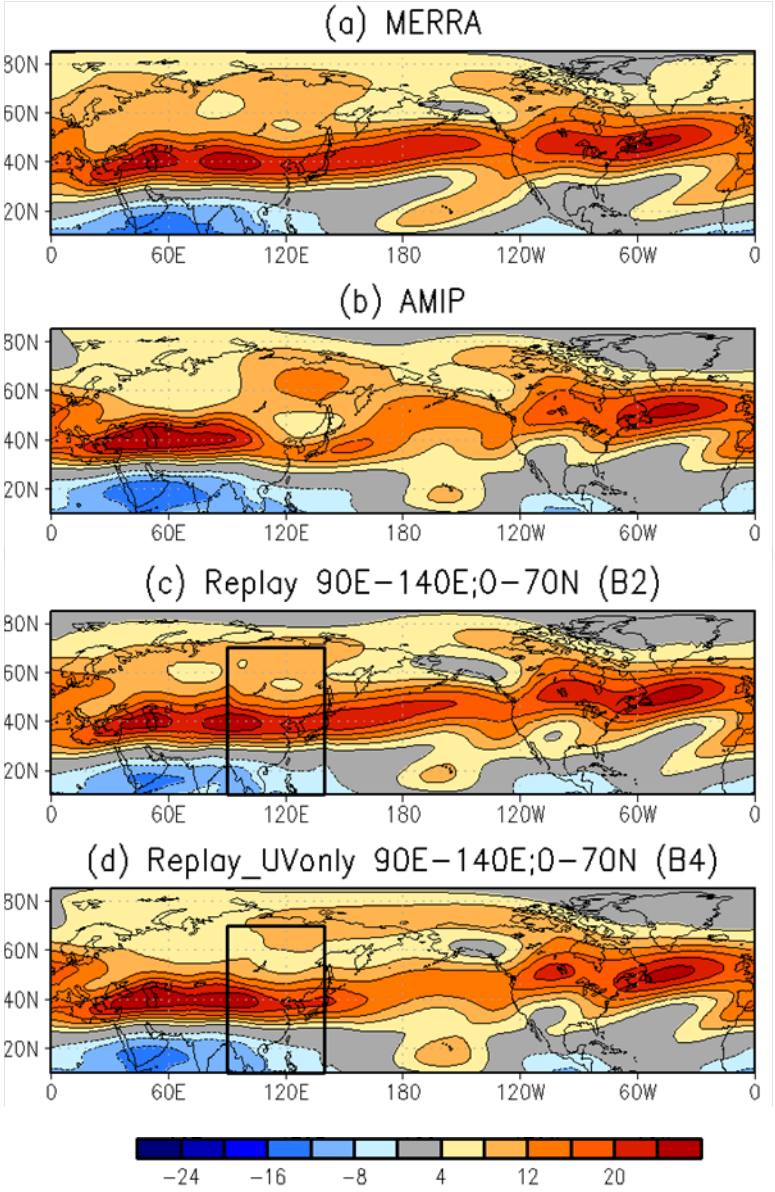
Figure 5. A schematic diagram illustrating the replay procedure.

The replay methodology:

* reads in an existing analysis field and mimics the Incremental Analysis Update approach to provide a continuous model run that is forced by analysis increments that change every 6 hours, thereby constraining the model to remain close to the original analysis.

*generalized to allow us to constrain only certain components of the atmosphere (e.g., a limited region, or a subset of model variables).

U250 Clim: JJA



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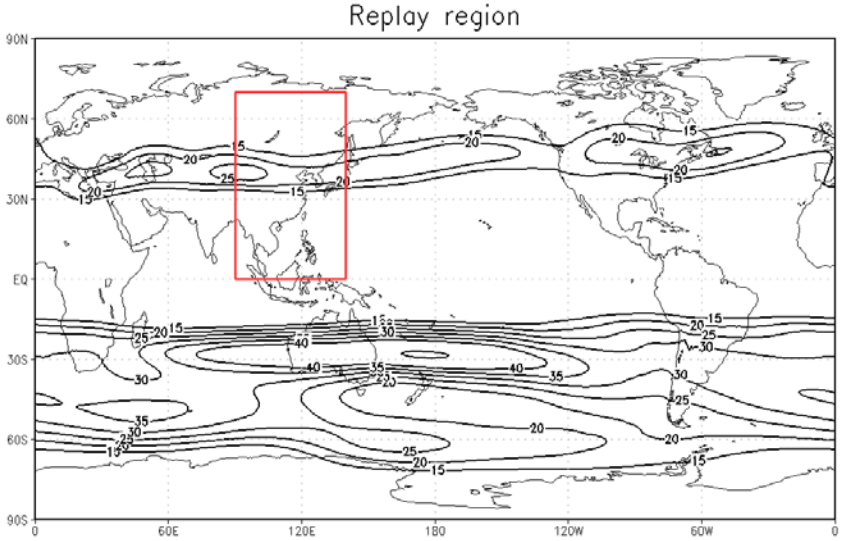


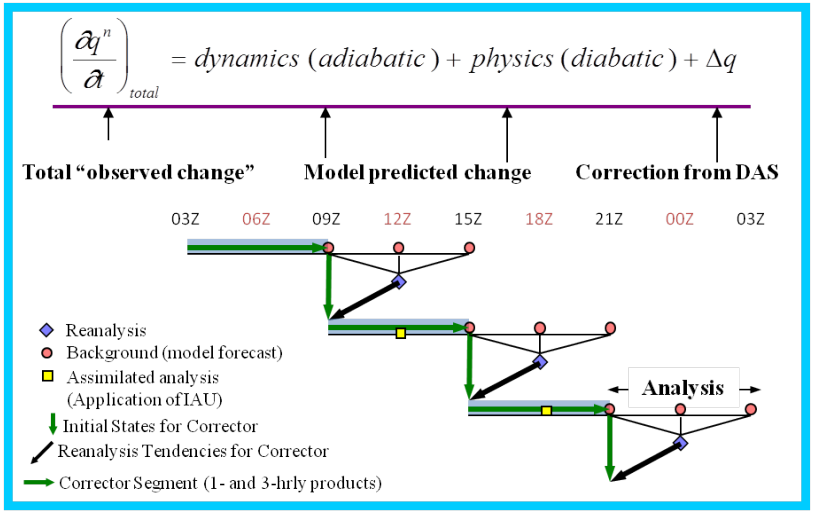


Figure 5. A schematic diagram illustrating the replay procedure.

Constraining model atmosphere to MERRA over E Asia and W Pacific: 1) removes most of model bias in north Pacific jet; 2) uses observed wave sources over E Asia and W Pacific

AGCM Experiments

Experiments	Replay region	Replay variables	Atmospheric and land initial conditions	Land feedback	Processes
A1	N/A	N/A	*Control*: 21z, 20 May of 1980-2010 *Anomaly*: 21z, 20 May 1988 plus small atmospheric perturbations	Yes	A
A2	N/A	N/A	*Control:* same as A1 *Anomaly:* 21z, 20 May of 1980-2009 for atmosphere; 21z, 20 May 1988 for land	Yes	A0
B1	90°E-140°E; 0°-70°N	U,V,T,Q,Ps	Same as A1	Yes	A, B, C, D
B2			*Control*: 21z, 2 May of 1980-2010 *Anomaly*: 21z, 2 May of 1980-2009	Yes	B, C, D
B3			Same as B2	No	B, D
B4		U,V	Same as B2	Yes	B, C

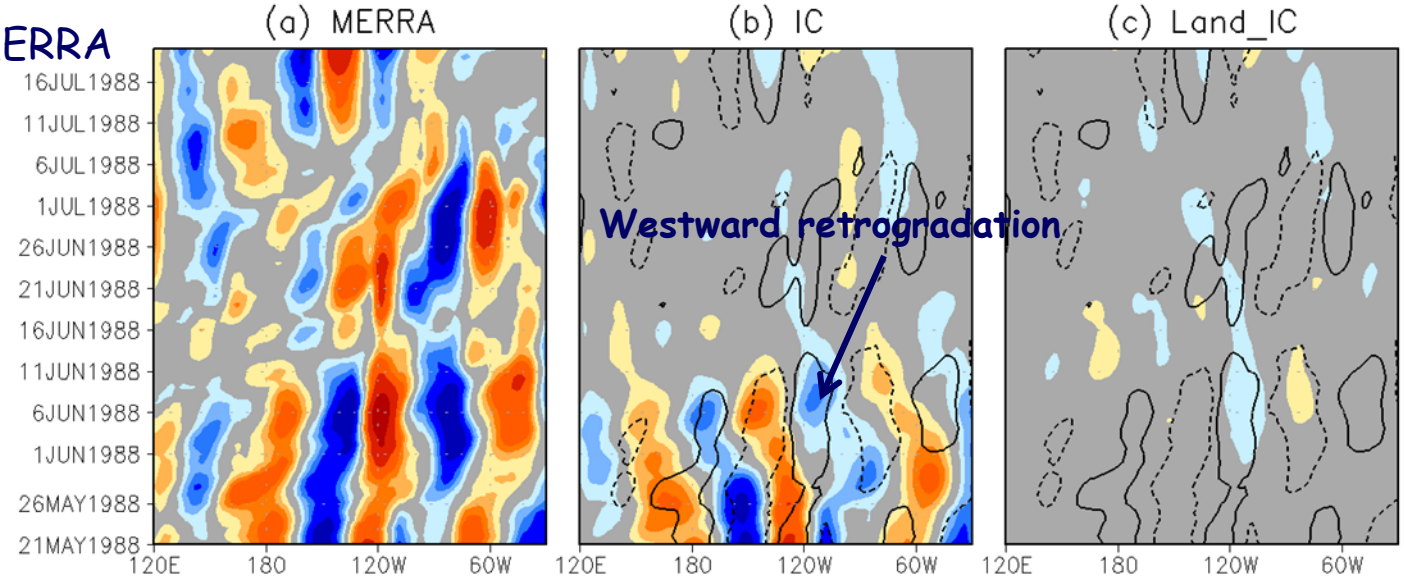
(A): 21z 20 May 1988 atmospheric and land initial conditions
(A0): 21z 20 May 1988 land initial conditions
(B): observed wave sources over western Pacific
(C): soil moisture feedback
(D): corrected model mean jet over north Pacific

GEOS-5 AGCM; 1deg; Each experiment consists of a control ensemble (31 members) and an anomaly ensemble (30 members).

V250mb averaged over 30N-60N

Little role from land IC

Contour: MERRA
±6m/s

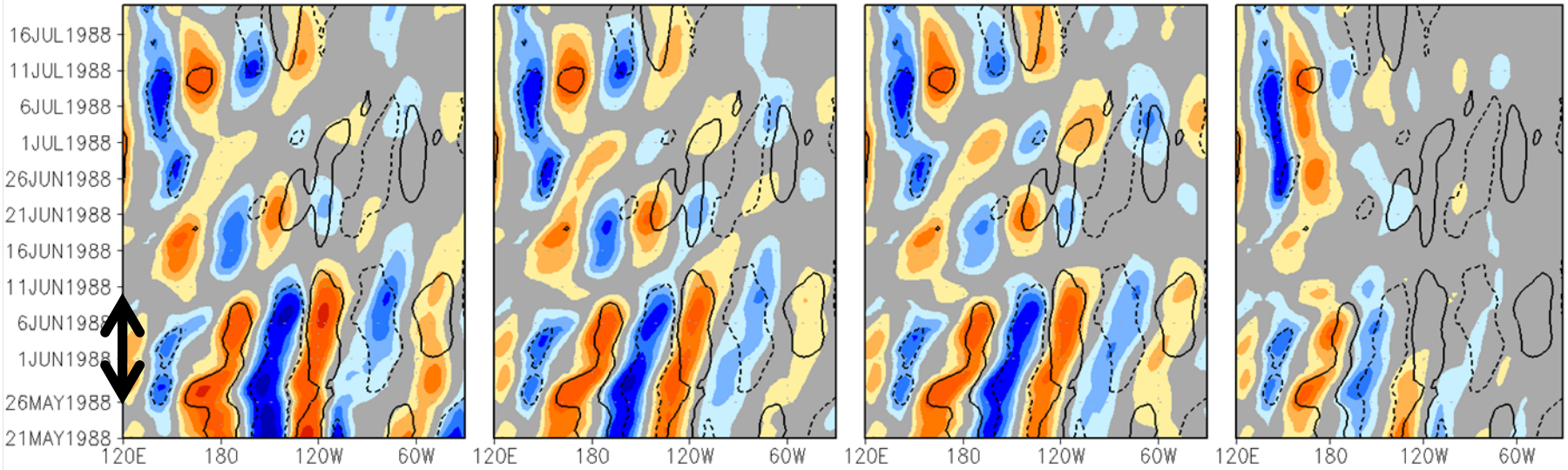


Best agreement

Good agreement

Little role from land

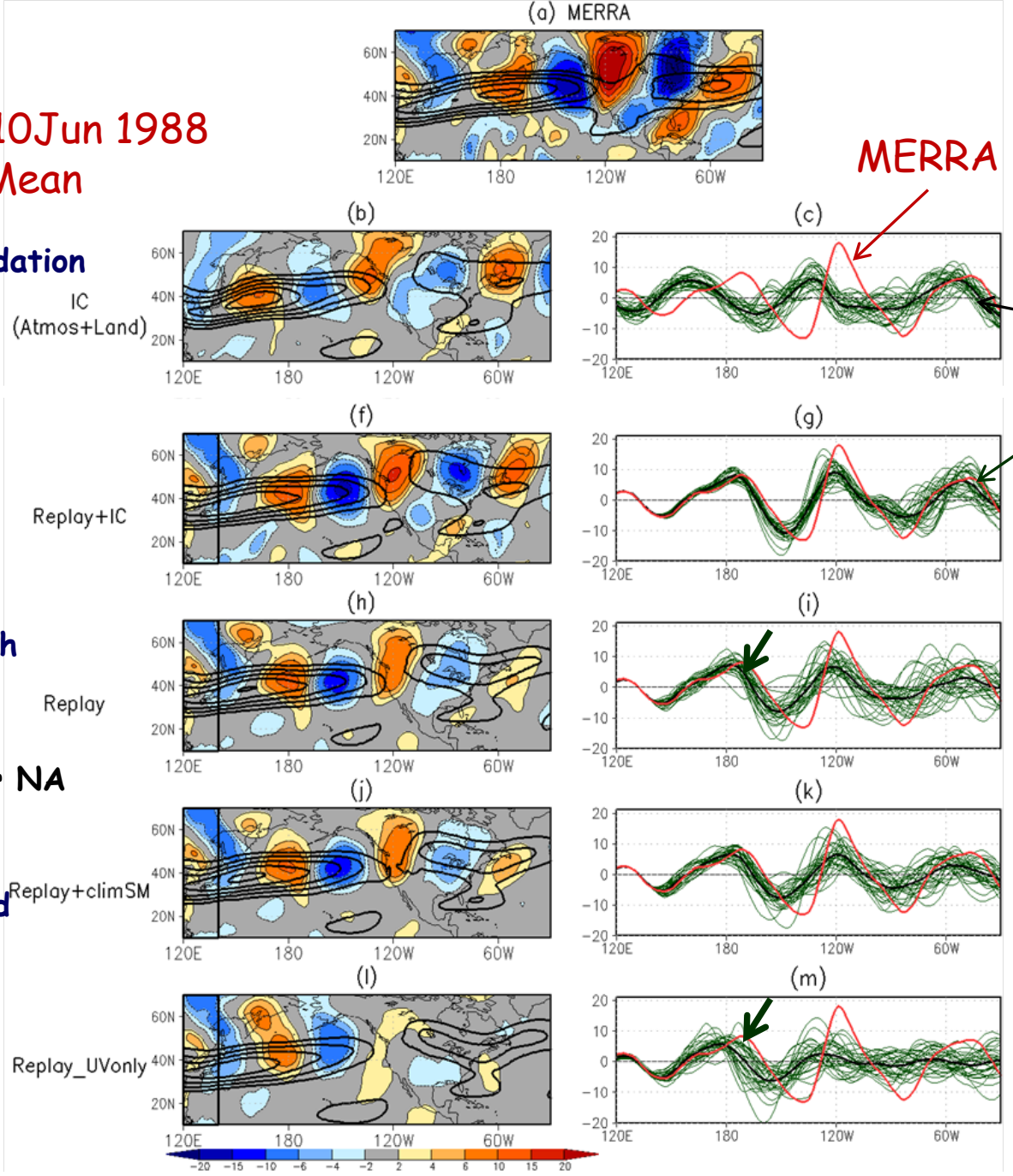
Importance of jet



26May-10Jun 1988 Mean

30N-60N Mean

MERRA



anom ensmean

30 anom ens

Westward retrogradation

Best agreement

Good agreement with weaker magnitude

WPac Conv anom => persistent high over NA

Little role from land feedback

Importance of jet

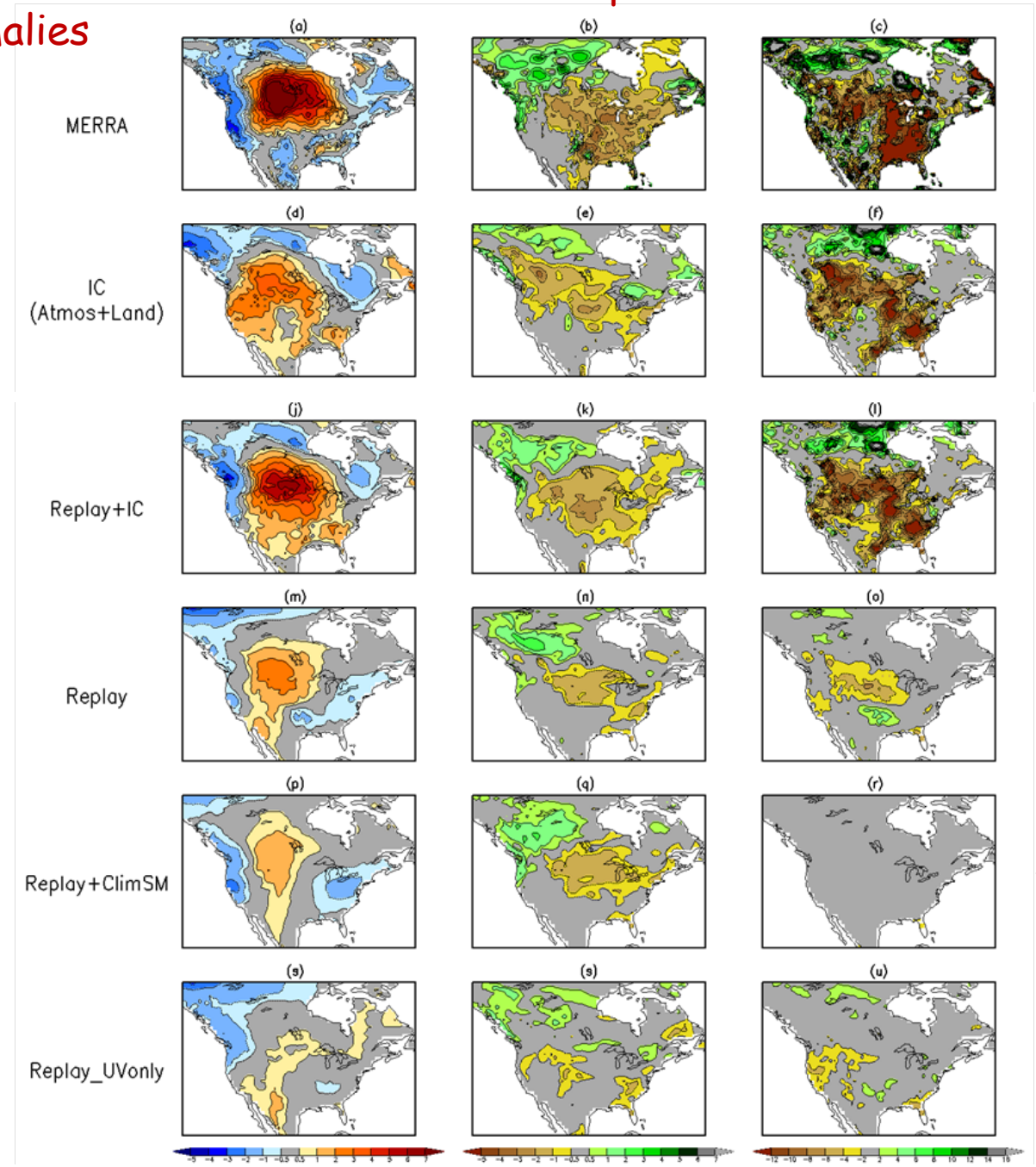
Jet guides and constrains wave energy propagation path and speed

26May-10Jun 1988 mean anomalies

Ts

Precip

Soil wetness



Still benefit from atmos and land ICs

Best agreement

WPac Conv anom=>persistent high over NA=>NA drought

Land feedback amplifies Ts, but not v250 and P

Critical importance to have correct NPac mean jet

Conclusions

- The leading modes of subseasonal atmospheric circulation variability have been crucial in the subseasonal development of a number of North American droughts

- A case study of a stationary Rossby wave event during 20May-15Jun1988:
  - Critical importance of north Pacific mean jet stream in guiding and constraining wave energy propagation path and speed
  - Convective anomalies over western Pacific in late May produce a predilection for persistent upper-level high anomalies over central North America about ten days later, leading to the rapid development of severe dry conditions there
  - Local soil moisture anomalies induced by the waves amplify surface temperature anomalies but not waves and precipitation.

- Stationary Rossby waves can serve as a source of predictability for subseasonal development of droughts over North America
  - Critical importance for GCMs to have correct NH jet streams (location, shape, magnitude)
  - Future work: Predictability of stationary Rossby waves, incl. their origins