Drought Prediction: The Role and Predictability of Stationary Rossby Waves

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Understanding Sources of Predictability

- SST controls
- Land impacts
- Large-scale (internal) atmospheric dynamical controls
Predictability

- Initial uncertainty
- Evolution of uncertainty
- Nature

Initial state
- 1 week
- 1 month
- 1 season
- 1 year

Noise:
- Convection
- Weather systems
- Planetary waves
- Land processes
- SST

Signal:
- Weather systems
- Planetary waves
- Land processes
- Climate Distribution
Summertime Rossby Waves

– *Determine basic structure of the leading waves*

– *Determine impacts on precipitation and surface temperature*

– *What forces the waves?*

– *How predictable are they? (case studies of extreme events)*
Leading REOFs of Monthly v250mb (JJA 1979-2010)

Impacts Eurasia

Will focus on these two leading patterns (REOFs 2 and 3)
Impacts on Surface Meteorology
Corr (RPC2, T2m)
Corr (RPC3, T2m)
Corr (RPC2, Precip)
Corr (RPC3, Precip)

JJA 1979-2010 (monthly)

Over the US

Northern Hemisphere
What forces these Waves?
Stationary Wave Model* Diagnosis of Forcing (MERRA Base State JJA 1979-2008)

Primarily Forced By Submonthly Vorticity Transients

*Ting and Yu (1998)
V (sigma=0.257) Responses to Idealized Vorticity Sources
(Stationary Wave Model: MERRA Base State JJA 1979-2008)
Focus on A Couple of Cases Where these Waves Achieve Large Amplitude
June 1998

RPC 2

June 1988

RPC 3
REOFs Versus Actual Anomalies (V250mb)

REOF 3

June 1988 Anomalies - MERRA

REOF 2

June 1998 Anomalies - MERRA
Synoptic activity precedes stationary phase.

Daily

9 day smooth

Synoptic activity precedes stationary phase
Summary so far

• Leading REOFS reflect stationary Rossby Waves (wave number 6) that tend to be confined to the mean jet which acts as a wave guide.

• These appear to be major players in monthly extremes of surface temperature and precipitation over a number of regions of the NH middle latitudes including parts of North America.

• They appear to be primarily forced by submonthly vorticity transients.

• How predictable are they?
Predictability Experiments with GEOS-5 AGCM

- June 1988
- June 1998
- *June 2012 (just recently added this case for comparison)*
- Produce an ensemble of 32 runs initialized on May 20\textsuperscript{th} for each case (small initial atmospheric perturbations)
- Forced with observed SST
Ensemble Mean v250mb

Predictability (signal) extends into late June/early July (some tendency for waves to retrograde)
Focus on 1988- Ensemble Mean
Focus on 1988

MERRA: Shaded
Forecast Ensemble Mean: Contours
Forecast retrogrades
RPC 1 amplitude for all ensemble members and MERRA (circles). Color indicates the phase of the complex REOF 1 (at left). Note the significant predictability extending well into June, but the forecast wave retrogrades (propagates to the west – blue to red color), while the observations show an eastward propagation (blue to gold color). Forecasts were initialized on May 20 (21z).
Conclusions

• Rossby waves play a pivotal role in summertime surface temperature and precipitation variability over NH middle latitudes on subseasonal time scales
• They are at times (on subseasonal time scales) the primary driver of temperature and precipitation extremes
• They have some predictability on monthly and shorter time scales, but appear to be unpredictable at seasonal and longer time scales (they are likely the largest contributors to the noise in seasonal forecasts in the summer)
• Model deficiencies (likely tied to errors in the summertime mean jets) currently limit the skill that could potentially be harvested from these waves.
• The extent to which these waves are modulated by the land surface (soil moisture anomalies), SSTs, and global warming is still unclear (focus of on-going work).