Recurrent, Anomalous Circulation Patterns Associated with Mongolian Summertime Rainfall Variability and “Dzud” Events

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Mongolia

Area: $\approx 1.5 \times 10^6 \text{ km}^2$ (2 x Texas)
Steppelands $\approx 300,000,000$ acres
Human pop. $\approx 3,000,000$
Cattle, sheep, goats: $\approx 30,000,000$
Semi-arid to arid
Harsh continental climate
Jun-Jul-Aug (JJA) Fraction of Annual Precipitation (GPCC)

- ≈ 85% of annual precipitation between April & September
- Annual temp. range > 45°C
- Very few studies on climate variability in Mongolia
- Regionally, weak statistical associations between PRCP & NAO, SNAO, PDO, ENSO, IMR
Dzud

white dzud
black dzud
iron dzud...

Images:
IFRC (top),
UNICEF (bot)
JJA 200 hPa Jet and Eddy Kinetic Energy

\[ \text{EKE} = \frac{1}{2} (u'^2 + v'^2) \]
\[ \langle qu \rangle = \langle qu \rangle + \langle q'u' \rangle \]

overbar = monthly average, ( )’ = depart. from monthly average, < > = seasonal mean
Anomalous PRCP and (total) Moisture Flux: JJA Composite for 5 WETTEST and 5 DRIEST Seasons
GPCC PRCP Composite Difference: DRY (10) - WET (8)

Statistically significant (95%)

Two wave trains:
→ Subtropical jet
→ High Latitude
Regression of 200 hPa Φ onto Mongolia PRCP Time Series
(1979-2009; GPCC & Reanalysis)
Dry Summer in 2010 Associated with the Russian Heat Wave

Top: Trenberth and Fasullo 2012
Post-1998 JJA PRCP and Moisture Flux Anomalies (CMAP, Reanalysis)
An Abrupt Increase in Summer PRCP in Korea post-1998 (Choi et al. 2010)
Composite 200 hPa Phi Anomaly Post-1998 (Reanalysis)

• Why is this pattern a recurrent feature post-1998?
An Atlantic Connection

Correlation EA Pattern PC and 500 hPa height anomalies for JJA (CPC)

- Caribbean, tropical North ATL as a forcing region for European heat waves, 2010 blocking over Russia:
  - Schneidereit et al. 2012;
  - Cassou et al. 2005
Cold Pacific, Warm Atlantic on Multi-year Timescales

JJA Average SST Anomalies post-1998
Conclusions

• Summer precipitation dominates the annual cycle in Mongolia, with summer drought a key aspect of “dzud” events (and livestock losses)

• Interannual variations in summer precipitation associated with a recurrent, large-scale, atmospheric circulation anomaly pattern that spans across Eurasia that is frequently associated with upstream “blocking” (2010 Russian Heat Wave)

• An abrupt decline in Mongolia summertime precipitation after 1998 is seen in multiple datasets (and dendrochronologies)

• The above decline is again associated with a persistent large-scale atmospheric anomaly pattern. The role of Atlantic and Pacific SST forcing of this pattern is currently being investigated.
Additional Slides
Composite PRCP Anomaly (GPCC) Statistically Significant >90%

51, 65, 68, 72, 78, 80

59, 73, 84, 90, 93, 94, 98
Post-1998: JJA Composite PRCP Anomaly
(Statistically Significant P < 0.10; GPCC)
Cold Pacific, Warm Atlantic on Multi-year Timescales

JJA Average SST and PRCP Anomalies post-1998
Vulnerability Base Map (MARCC 2009) and drought sensitive tree-ring network (circles)