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

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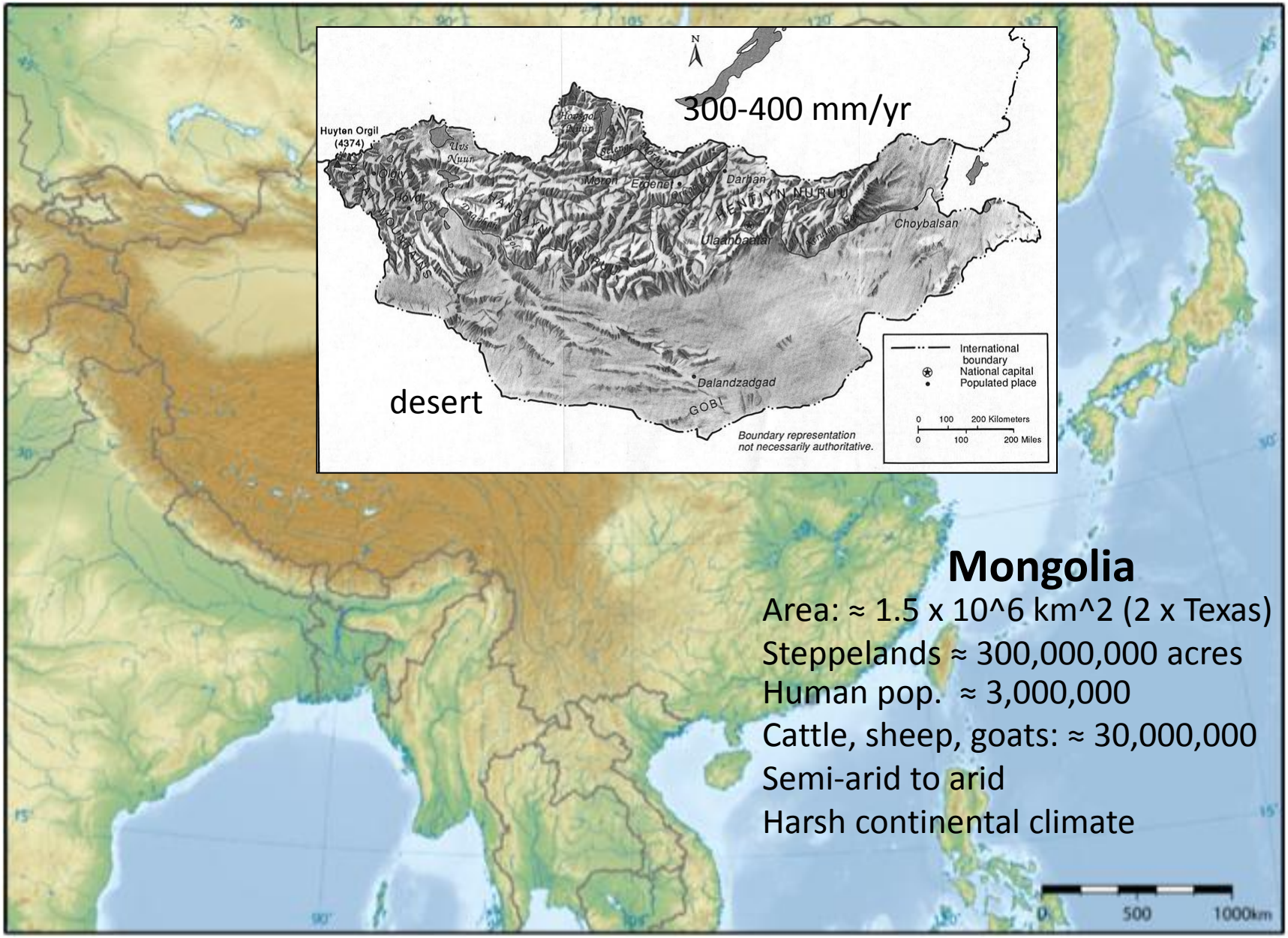


Mongolia

Area: ≈ 1.5 x 10^6 km^2 (2 x Texas)

Steppelands ≈ 300,000,000 acres

Human pop. ≈ 3,000,000

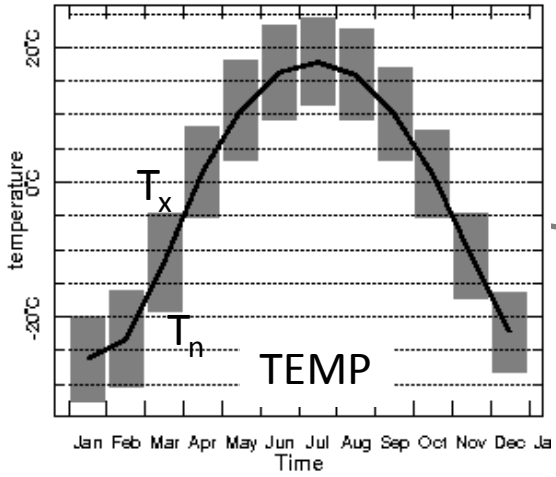
Cattle, sheep, goats: ≈ 30,000,000

Semi-arid to arid

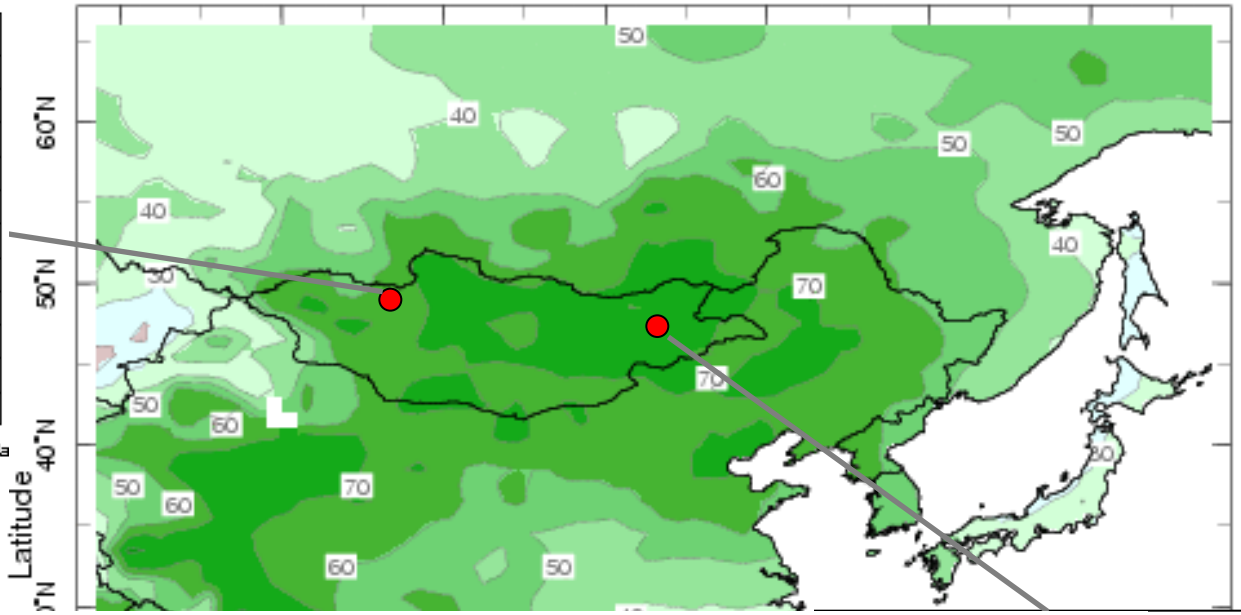
Harsh continental climate

Map: http://es.wikipedia.org/wiki/Archivo:East_Asia_topographic_map.png

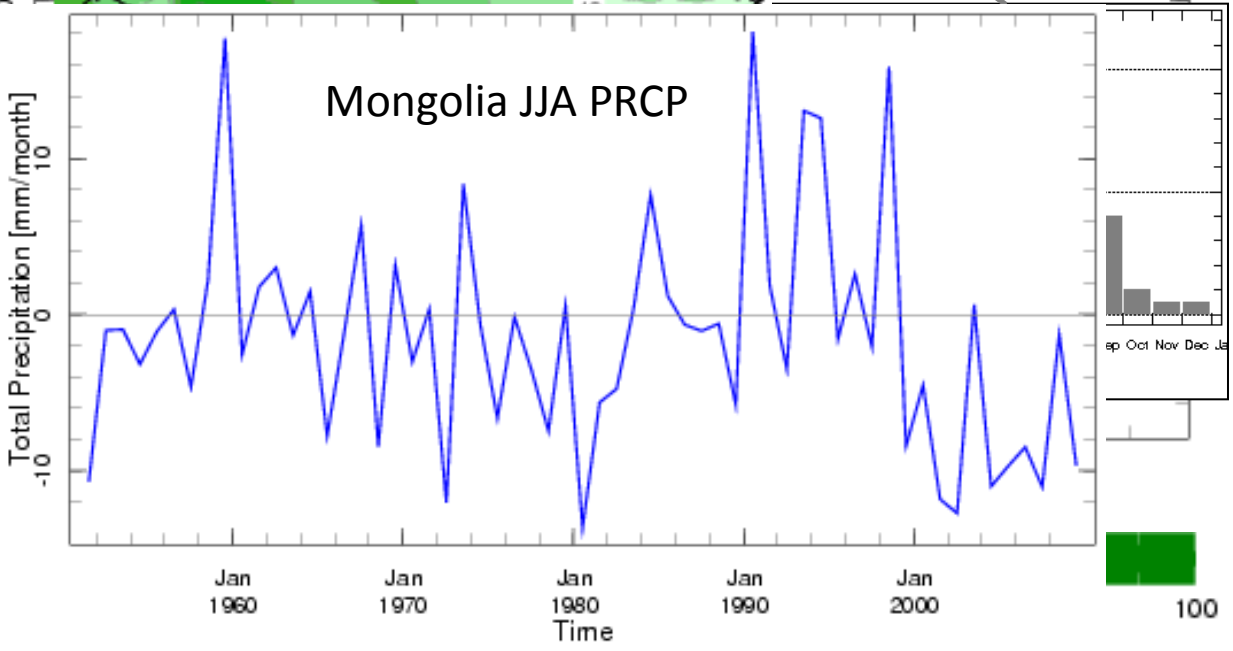
Jun-Jul-Aug (JJA) Fraction of Annual Precipitation (GPCC)



Longitude 92.75E Latitude 49.25N



- ≈ 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

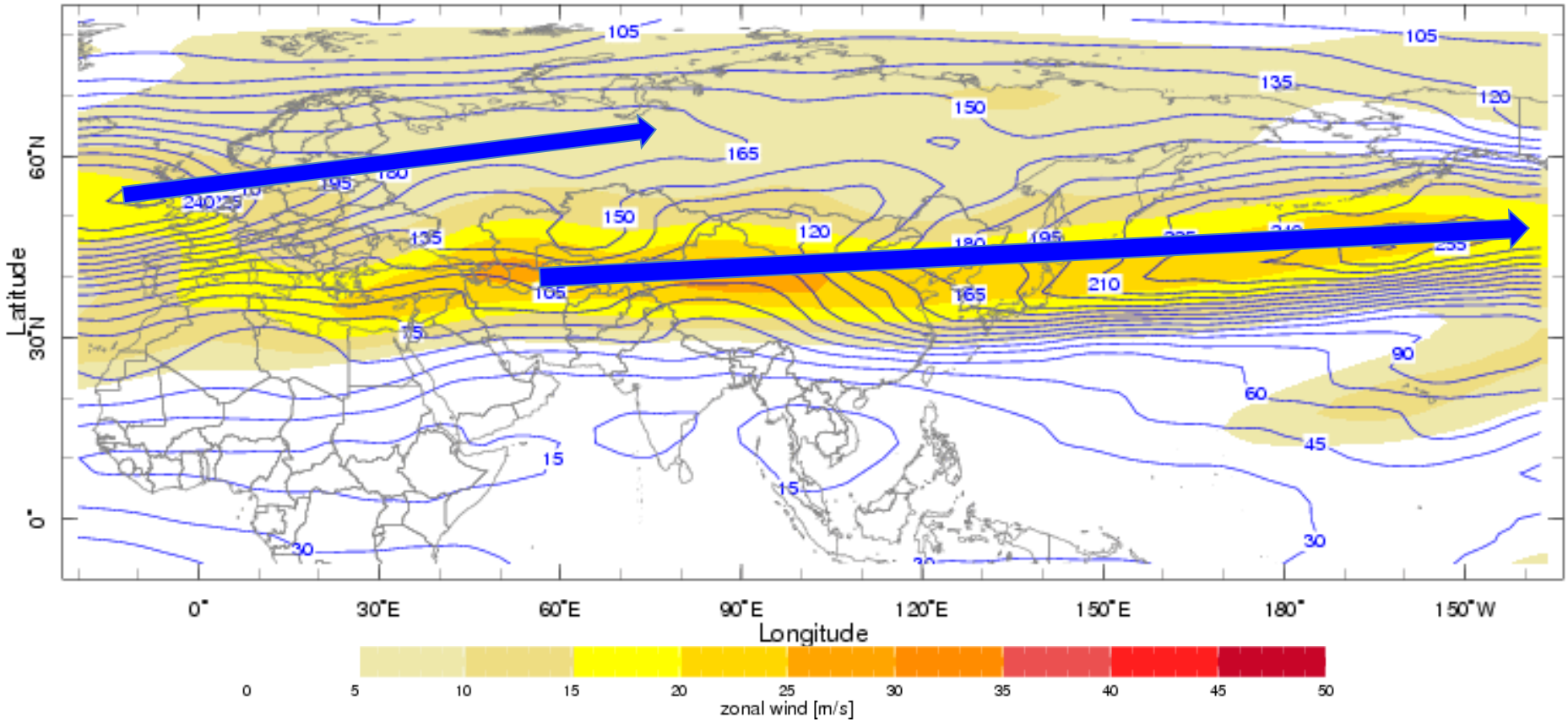


Dzud

white dzud
black dzud
iron dzud…

Images:
IFRC (top),
UNICEF (bot)

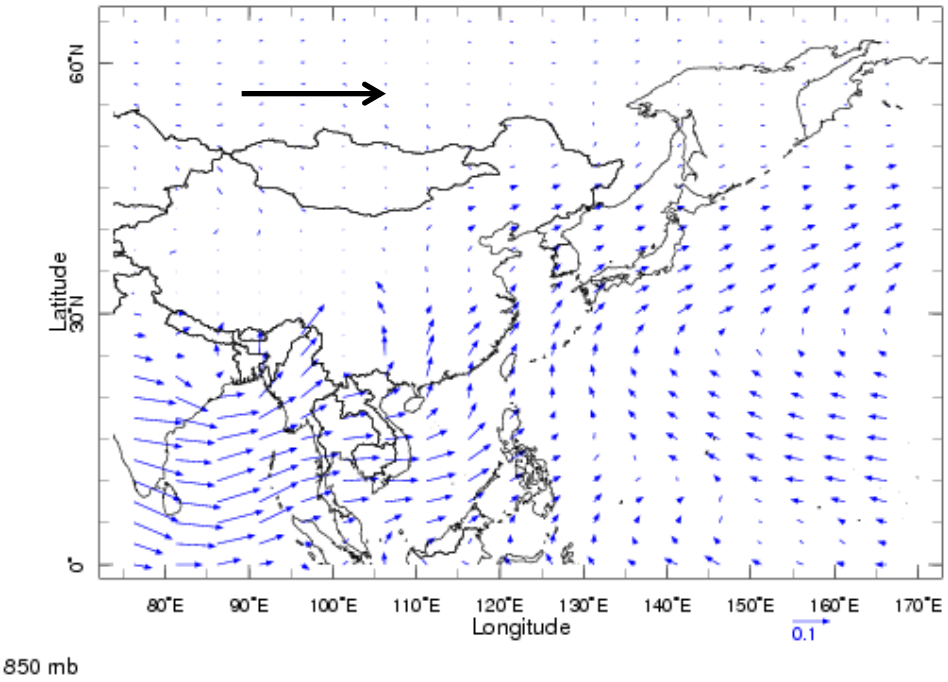
JJA 200 hPa Jet and Eddy Kinetic Energy



$$EKE = \tfrac{1}{2}\,(u'^2 + v'^2)$$

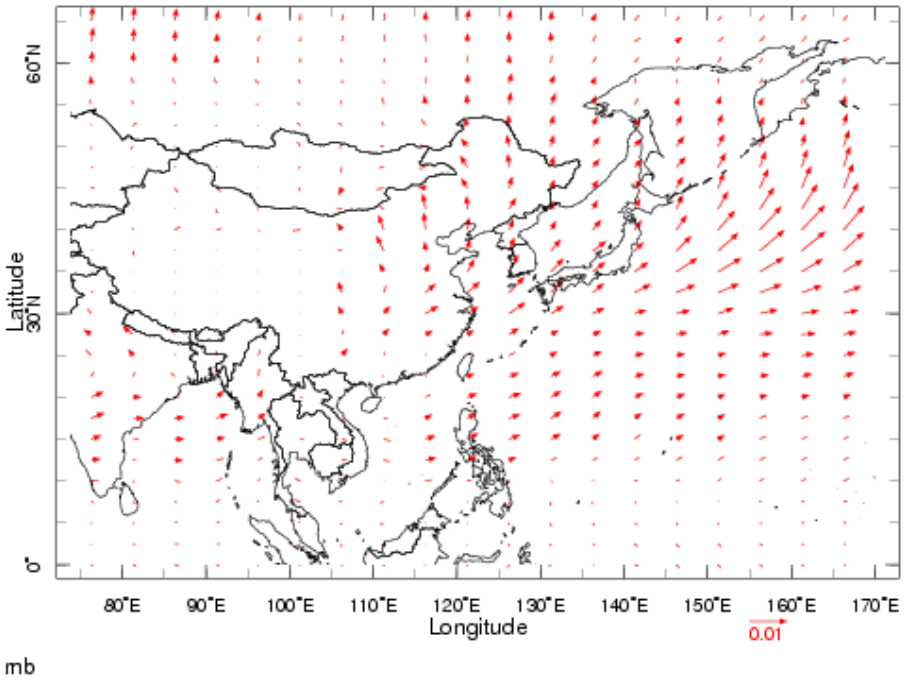
JJA Climatological Moisture Fluxes (Reanalysis)

Mean Flow



850 mb

Transient Eddies



850 mb

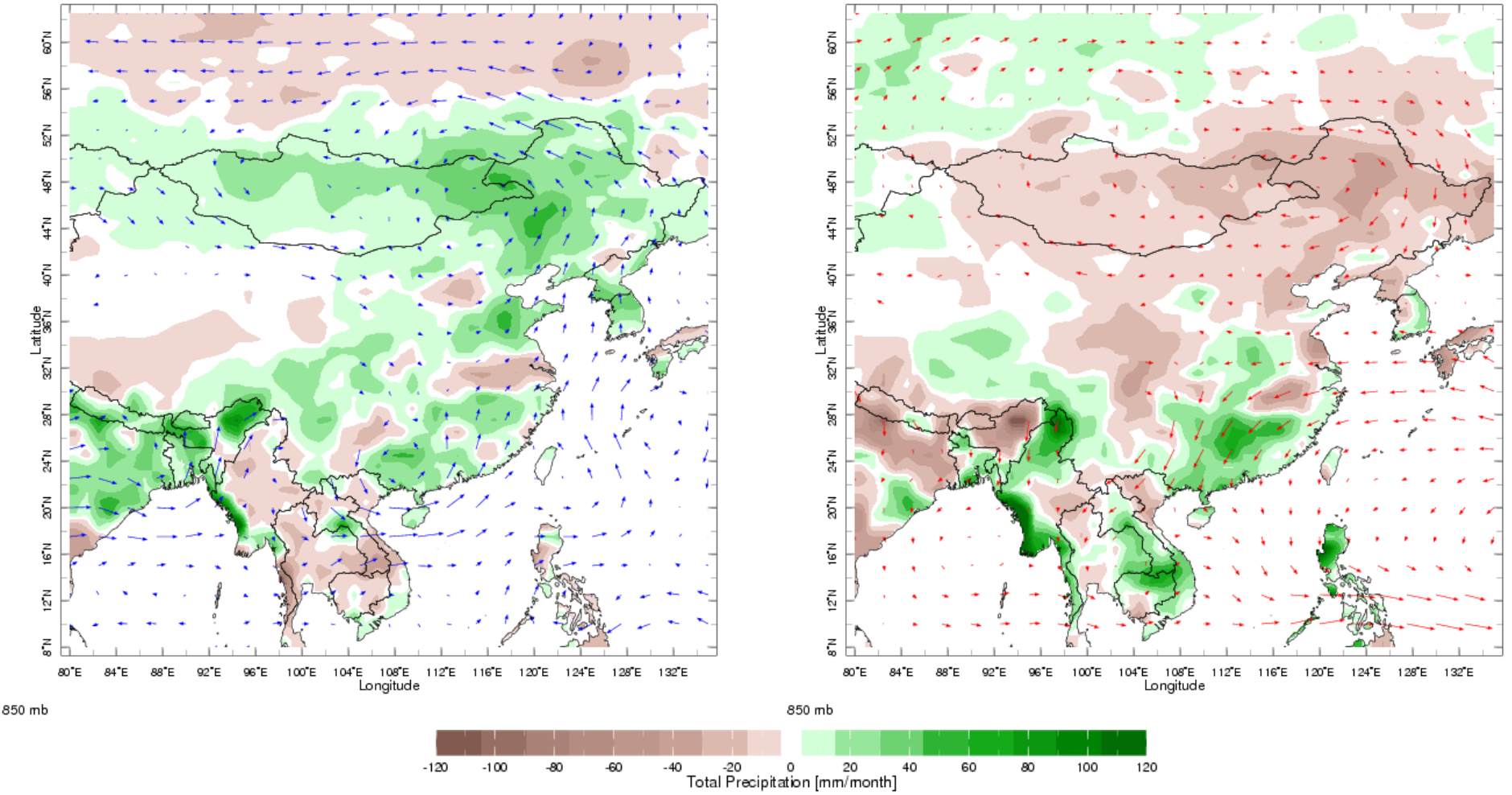
$$\langle \overline{qu} \rangle = \langle \overline{q}\,\overline{u} \rangle + \langle \overline{q'u'} \rangle$$

overbar = monthly average, ( )’ = depart. from monthly average, < > = seasonal mean

Anomalous PRCP and (total) Moisture Flux:
JJA Composite for 5 WETTEST and 5 DRIEST Seasons

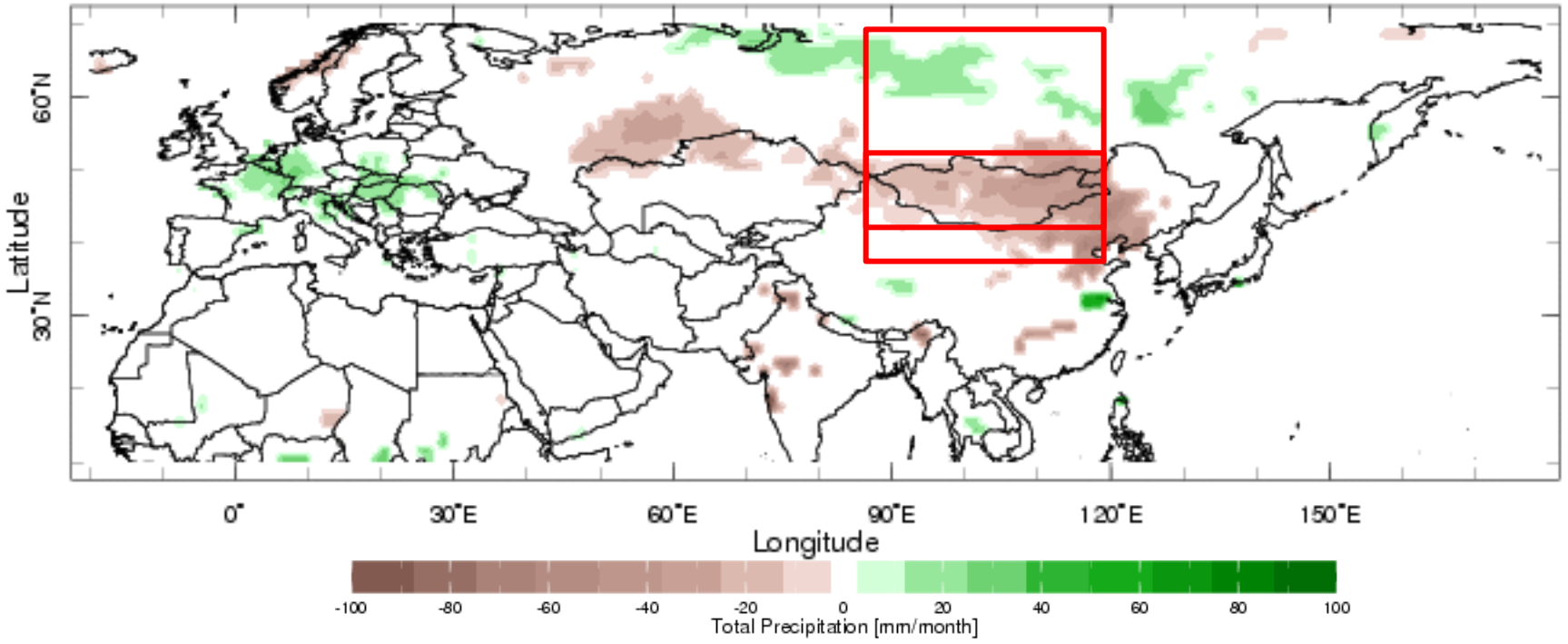
WET (5)

DRY (5)

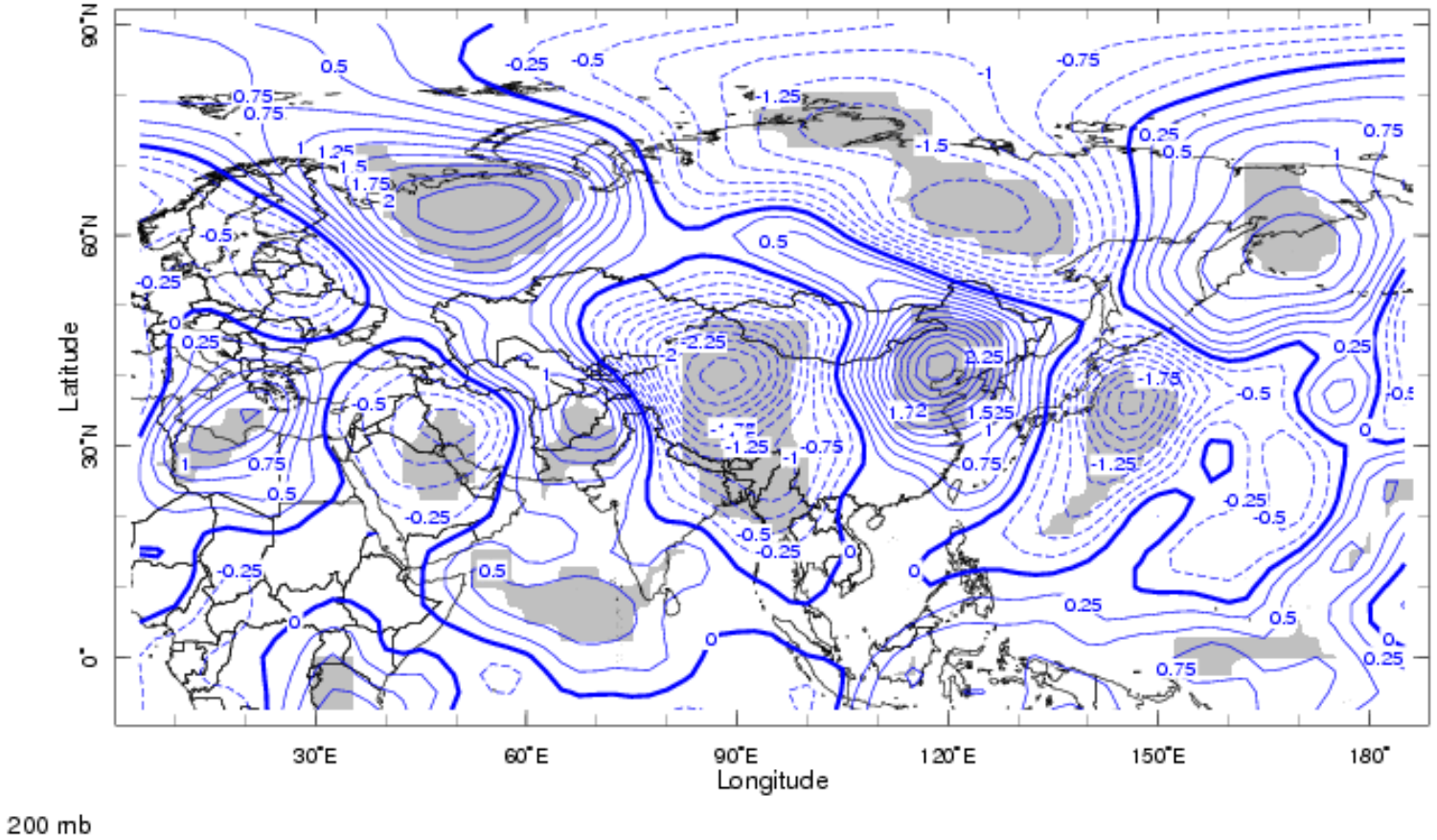


GPCC PRCP Composite Difference: DRY (10)-WET(8)

Statistically significant (95%)



Regression of 200 hPa v-comp. Wind onto Mongolia PRCP Time Series (1979-2009; GPCC & Reanalysis)

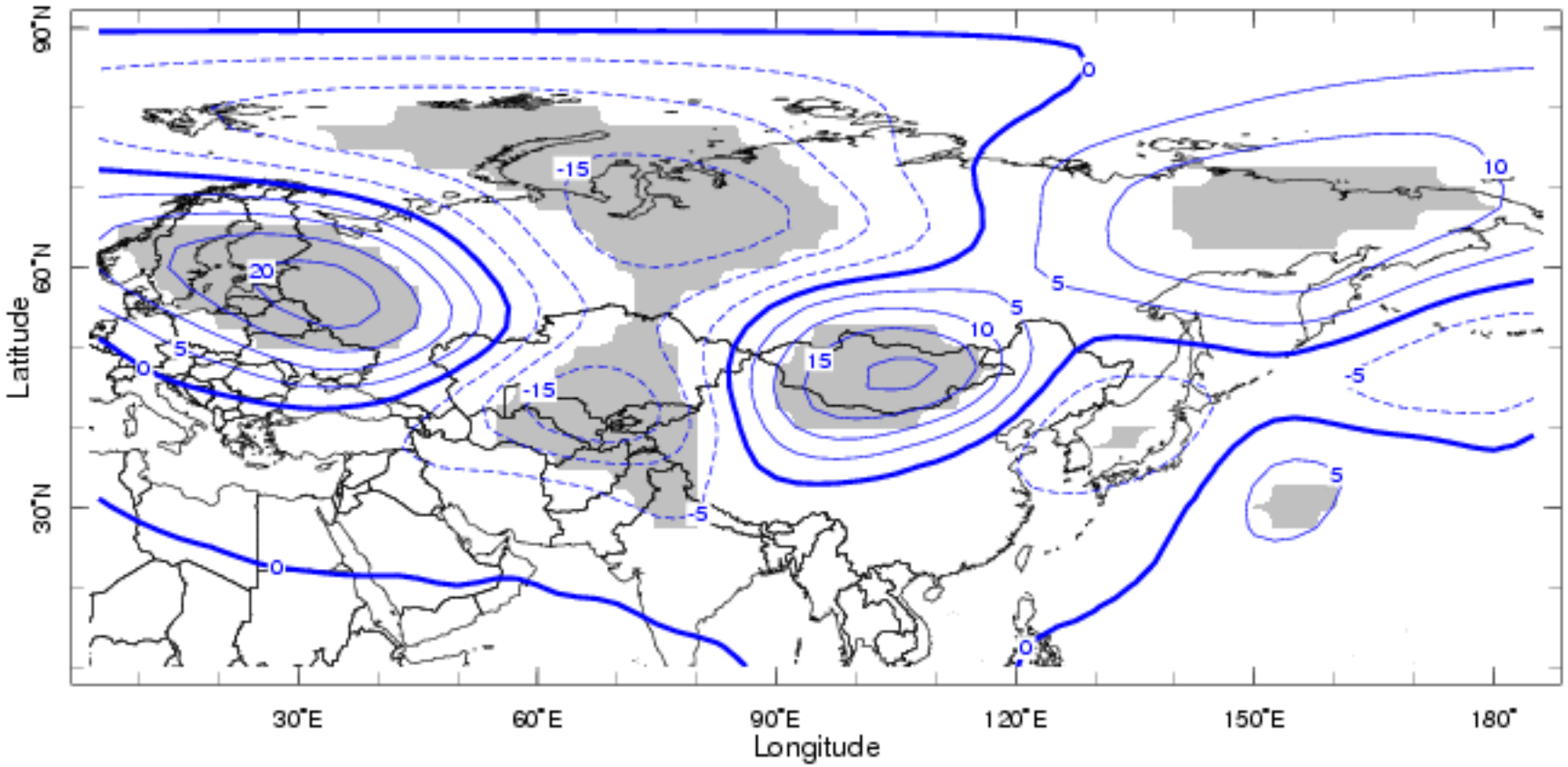


Two wave trains:

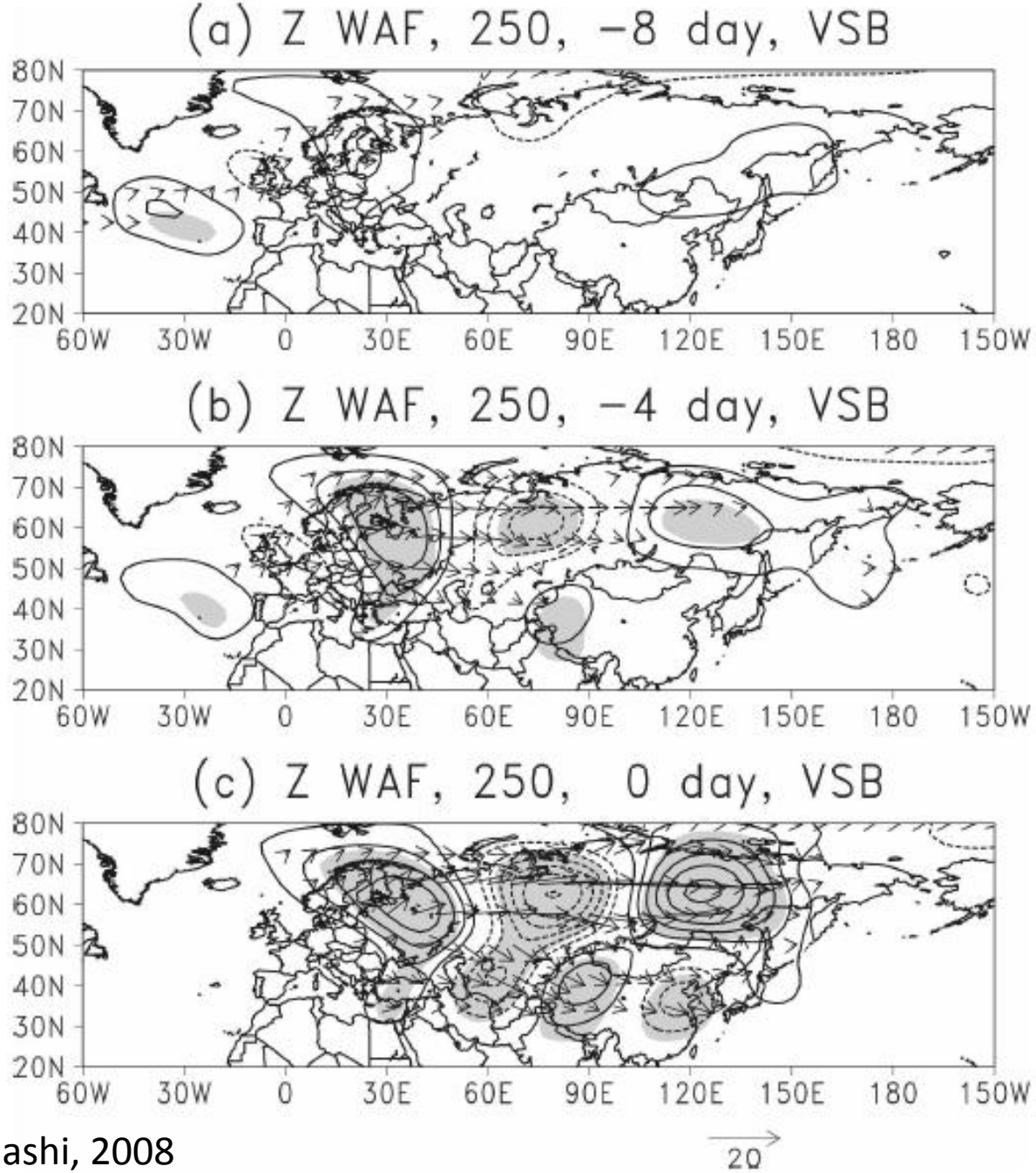
→ Subtropical jet

→ High Latitude

Regression of 200 hPa Φ onto Mongolia PRCP Time Series (1979-2009; GPCC & Reanalysis)

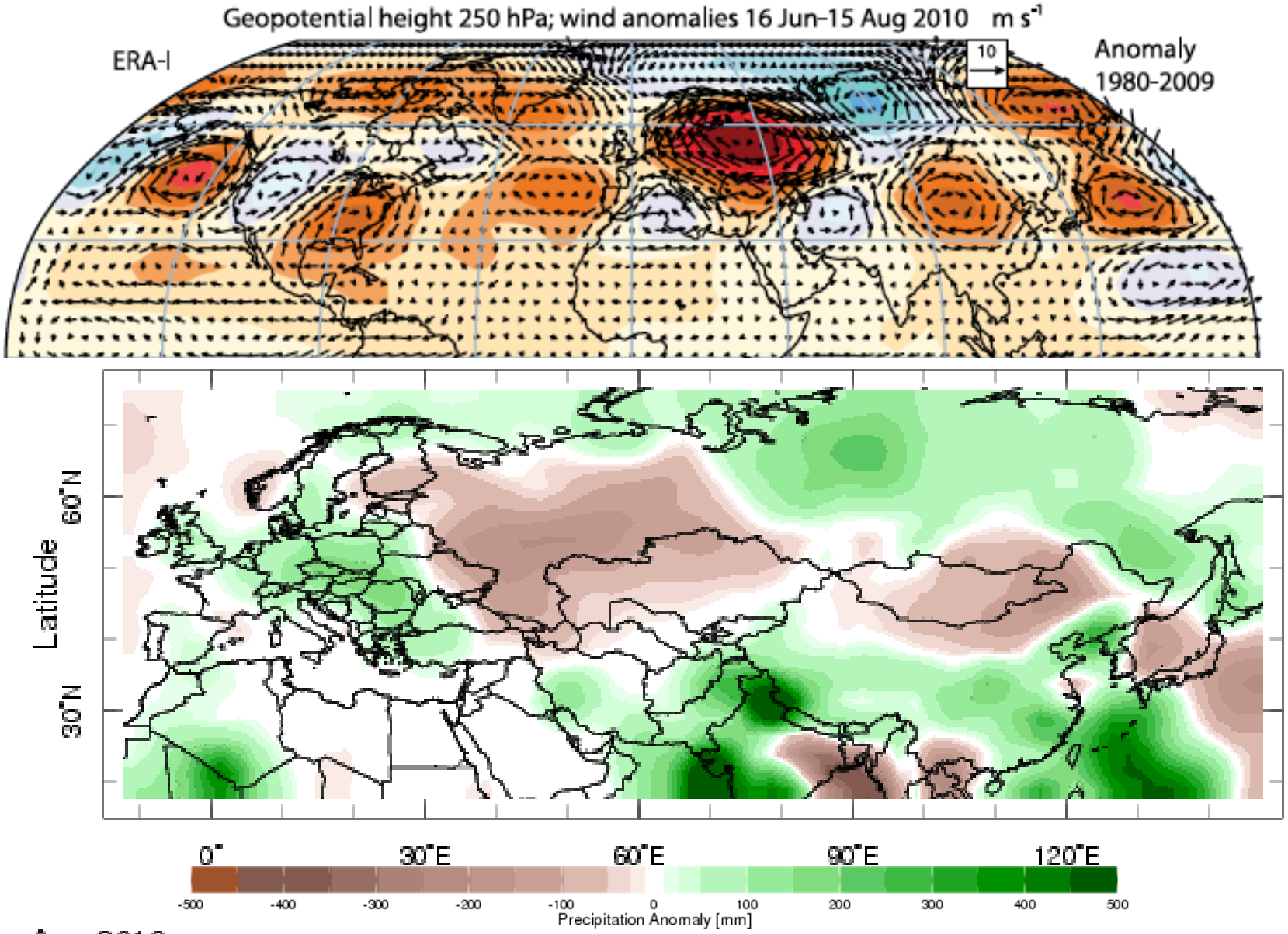


200 mb



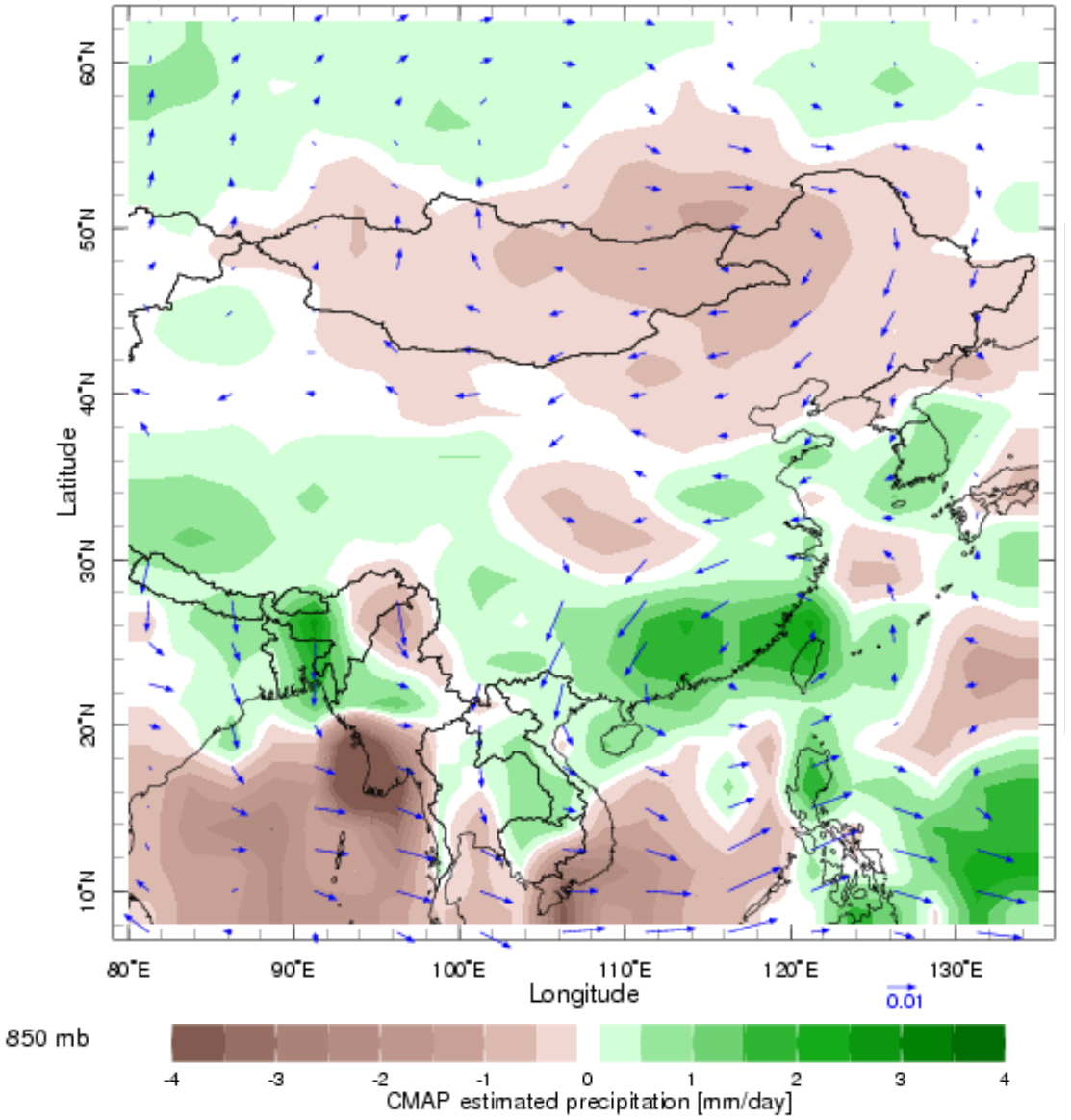
Iwao and Takahashi, 2008

Dry Summer in 2010 Associated with the Russian Heat Wave

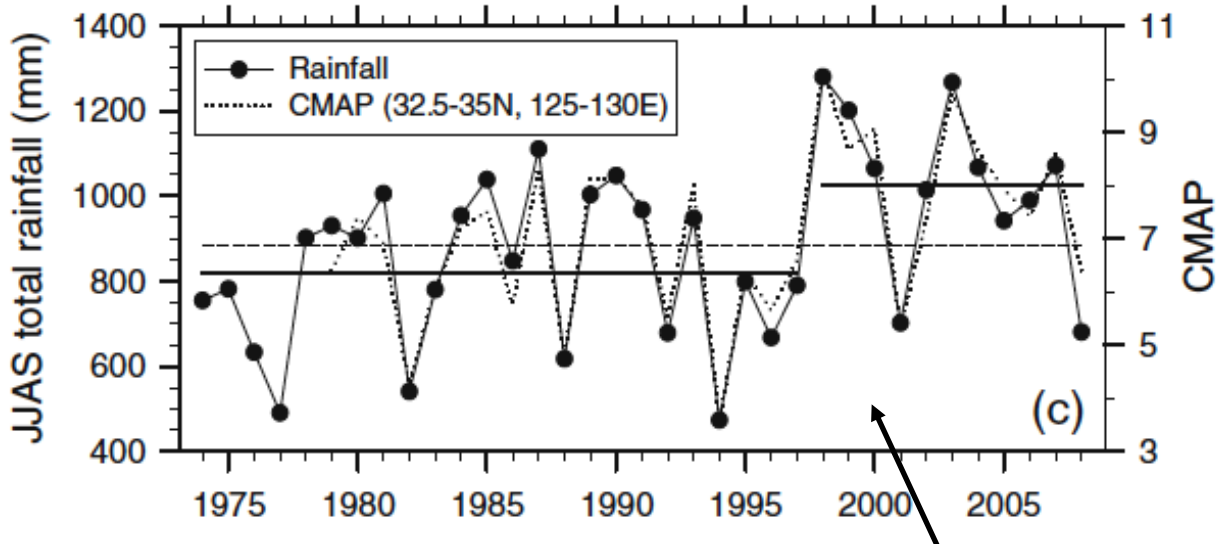


Top: Trenberth and Fasullo 2012

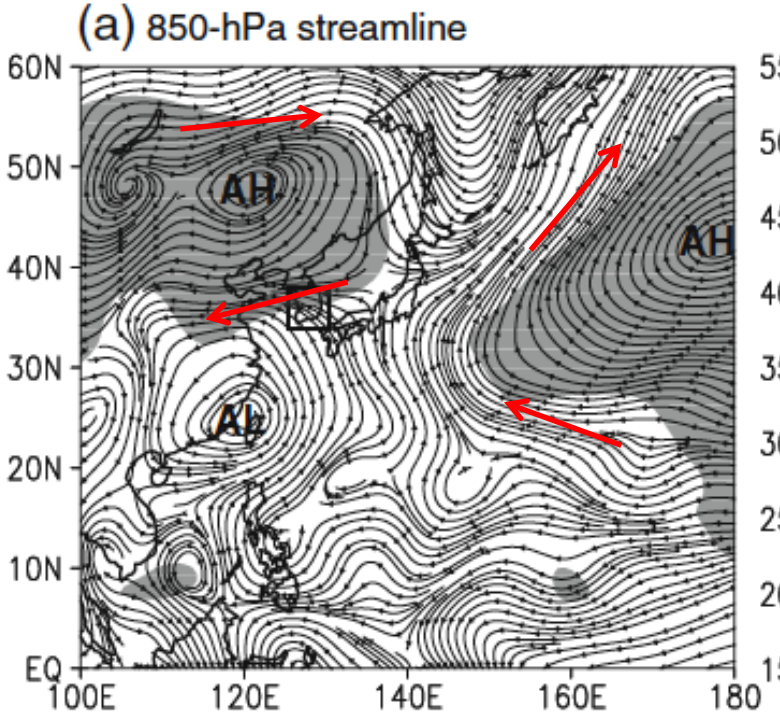
Post-1998 JJA PRCP and Moisture Flux Anomalies (CMAP, Reanalysis)

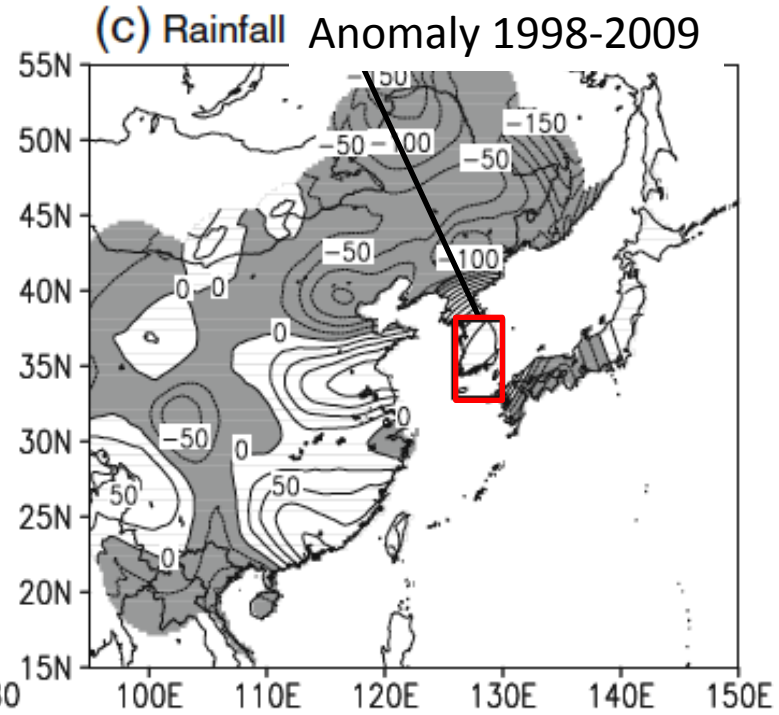


An Abrupt Increase in Summer PRCP in Korea post-1998 (Choi et al. 2010)

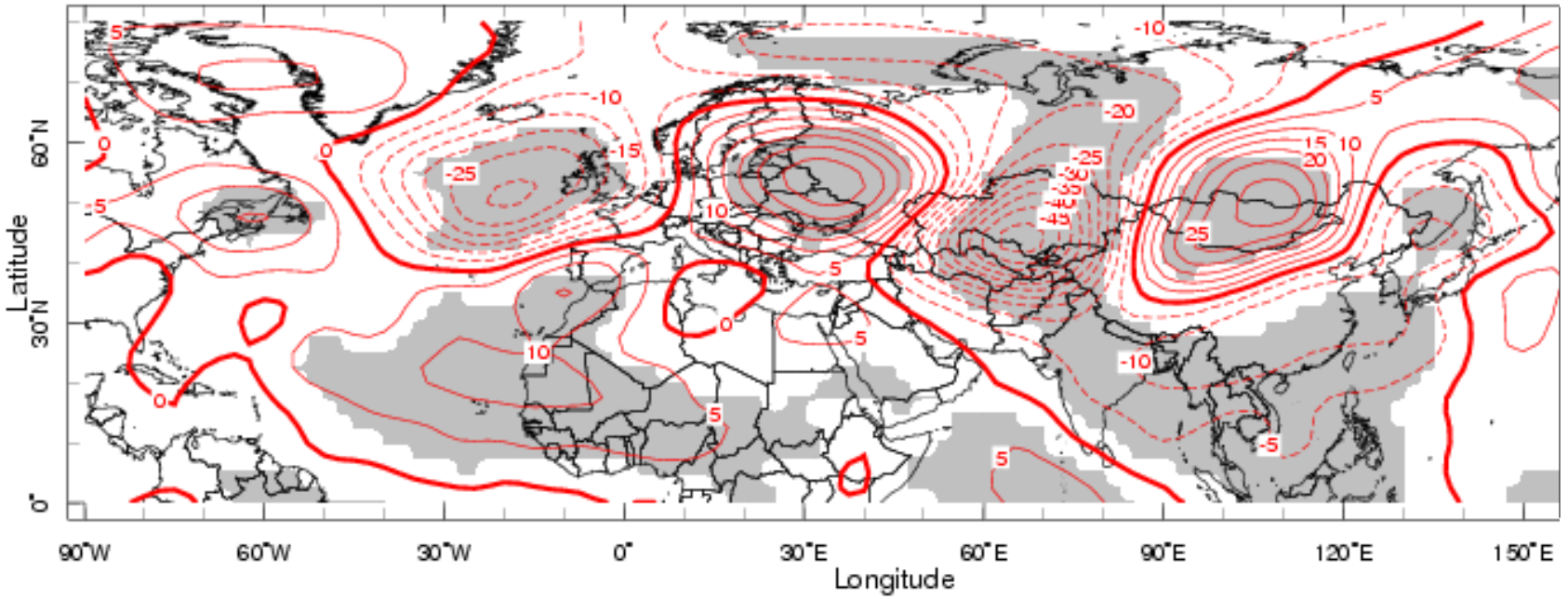


Anomaly 1998-2009





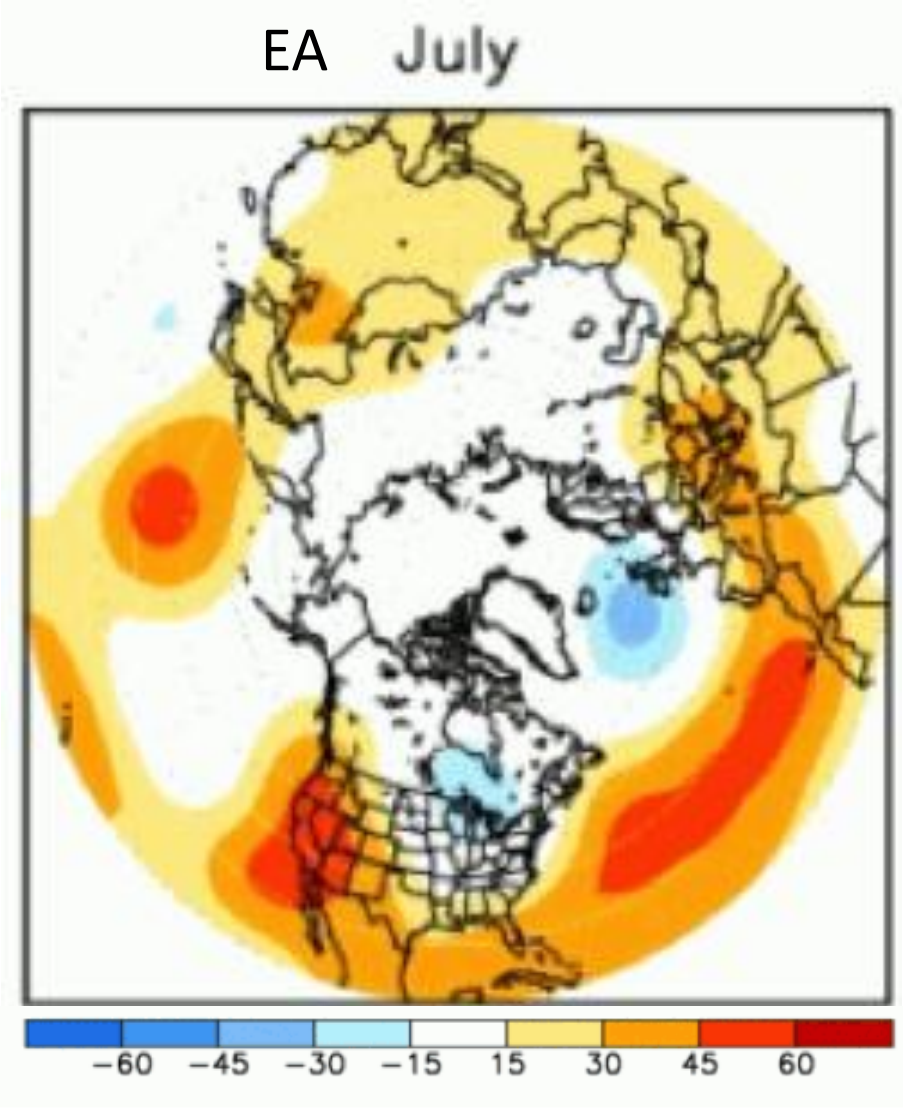
Composite 200 hPa Phi Anomaly Post-1998 (Reanalysis)



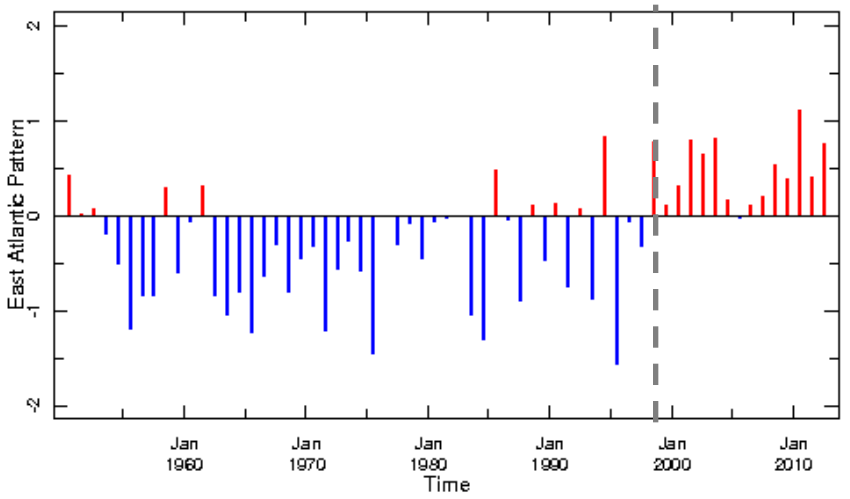
- Why is this pattern a recurrent feature post-1998?

An Atlantic Connection

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



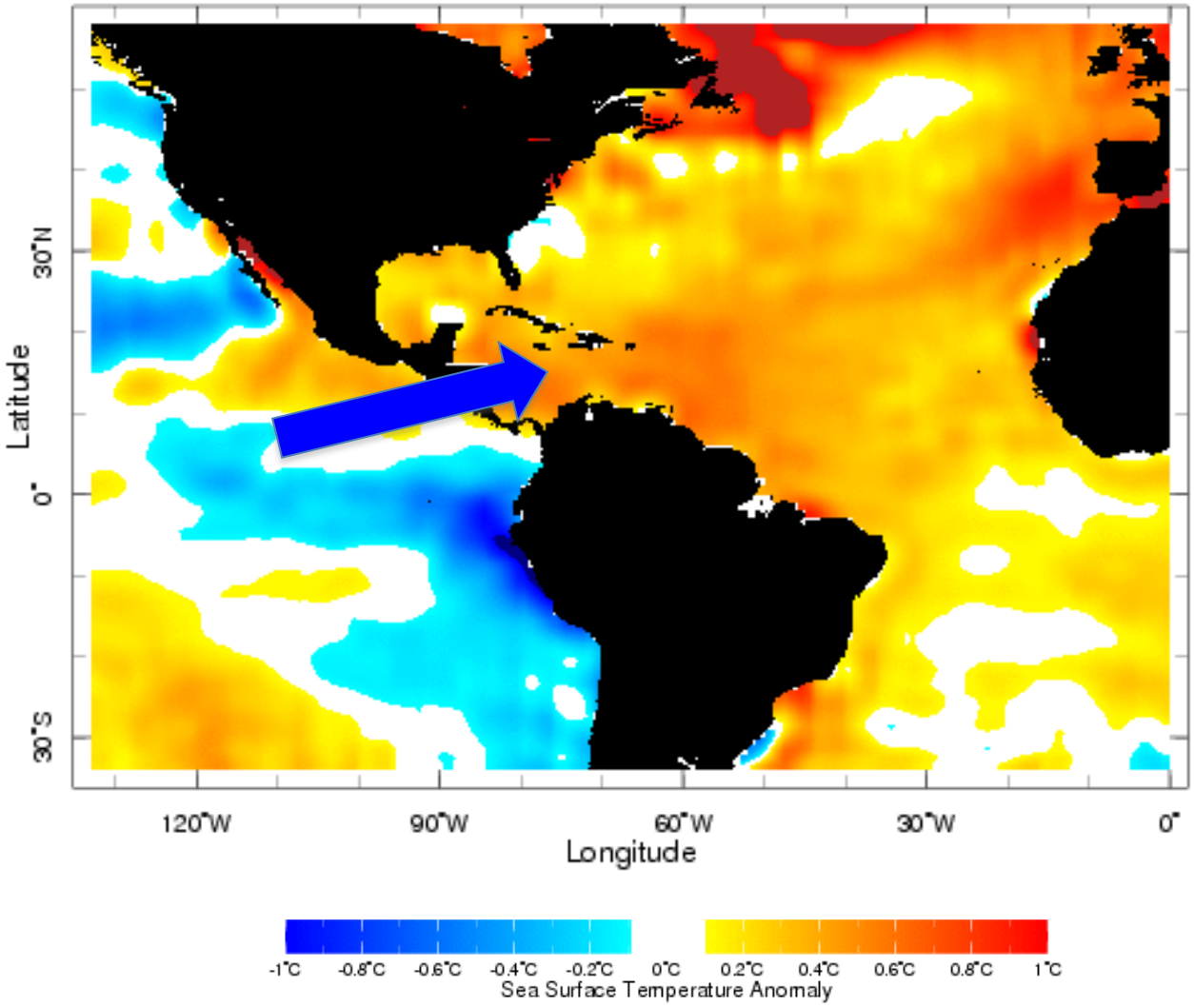
EA Pattern Time Series



- 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)

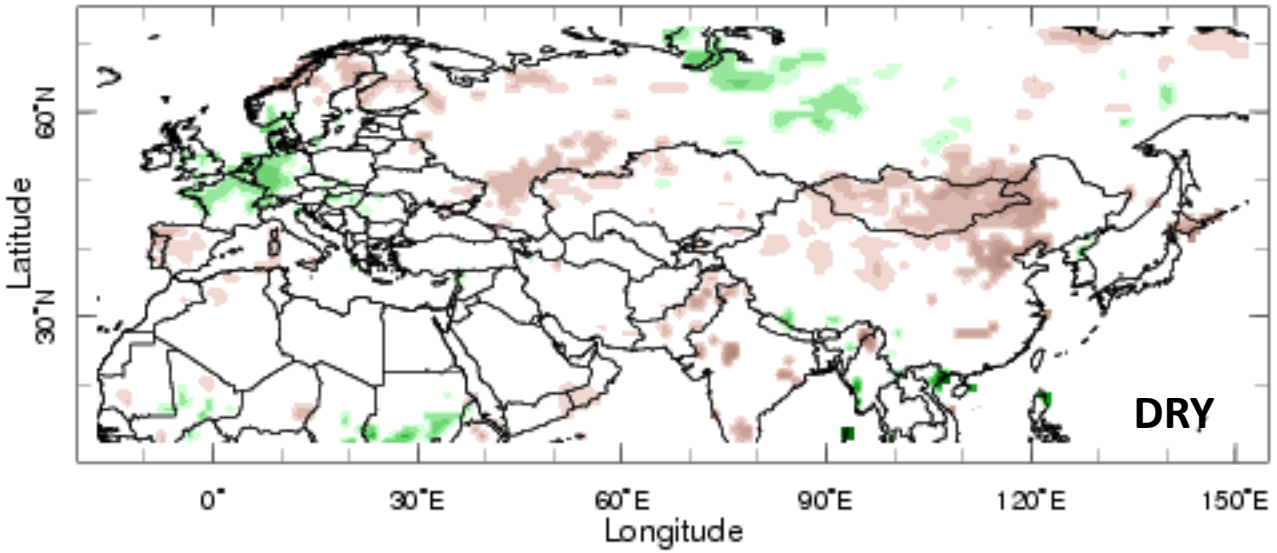
- An abrupt decline in Mongolia summertime precipitation after 1998 is seen in multiple datasets (and dendrochronologies)

- 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.

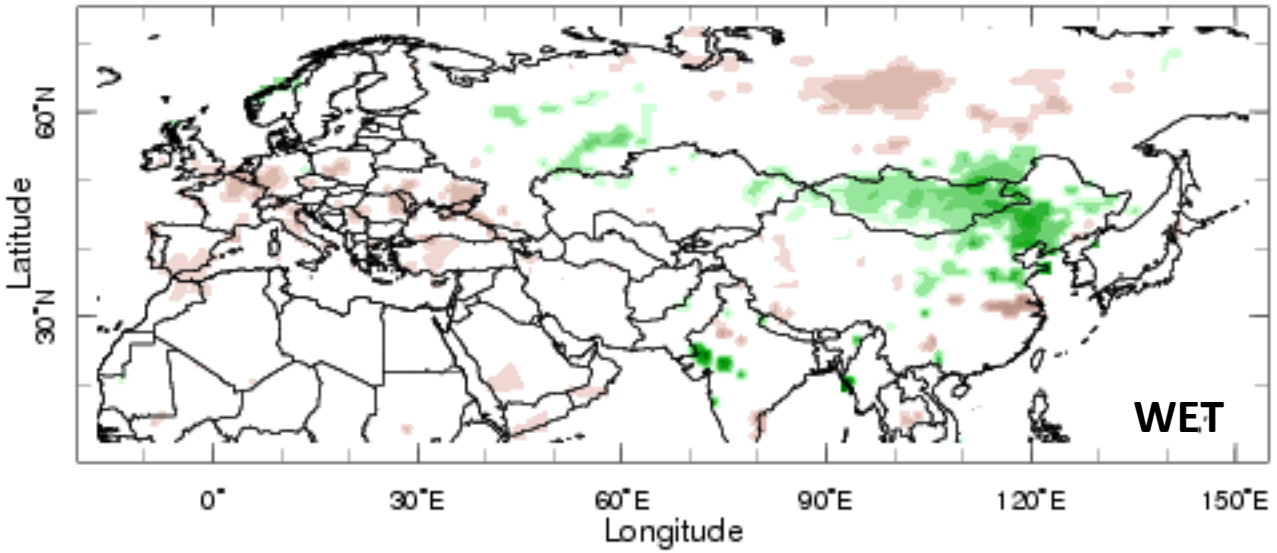
Additional Slides

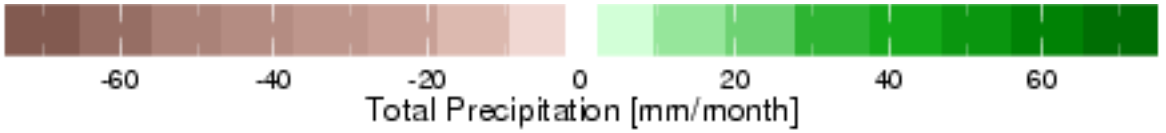
Composite PRCP Anomaly (GPCC) Statistically Significant >90%

51, 65, 68, 72, 78, 80



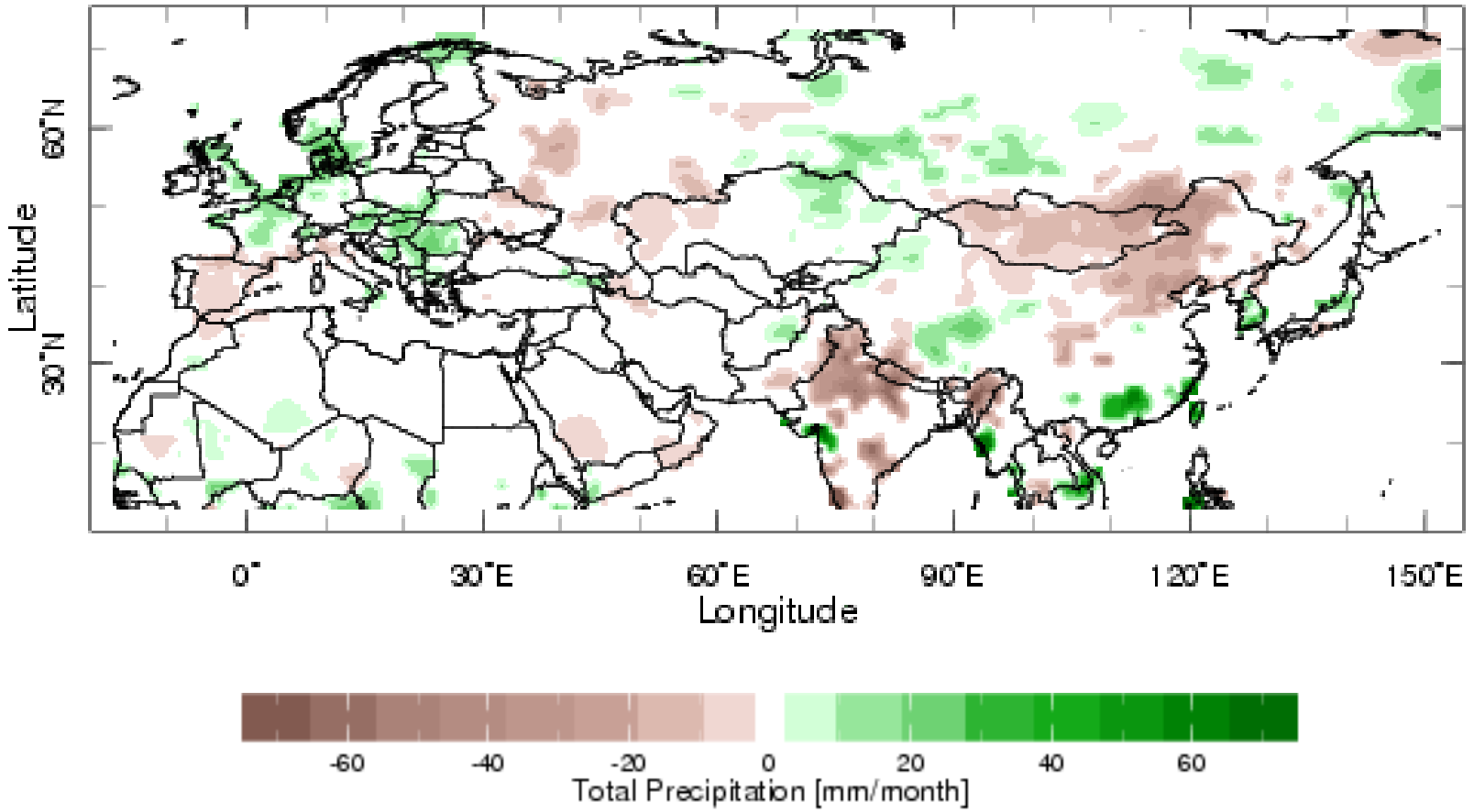
59, 73, 84, 90, 93, 94, 98





Post-1998: JJA Composite PRCP Anomaly

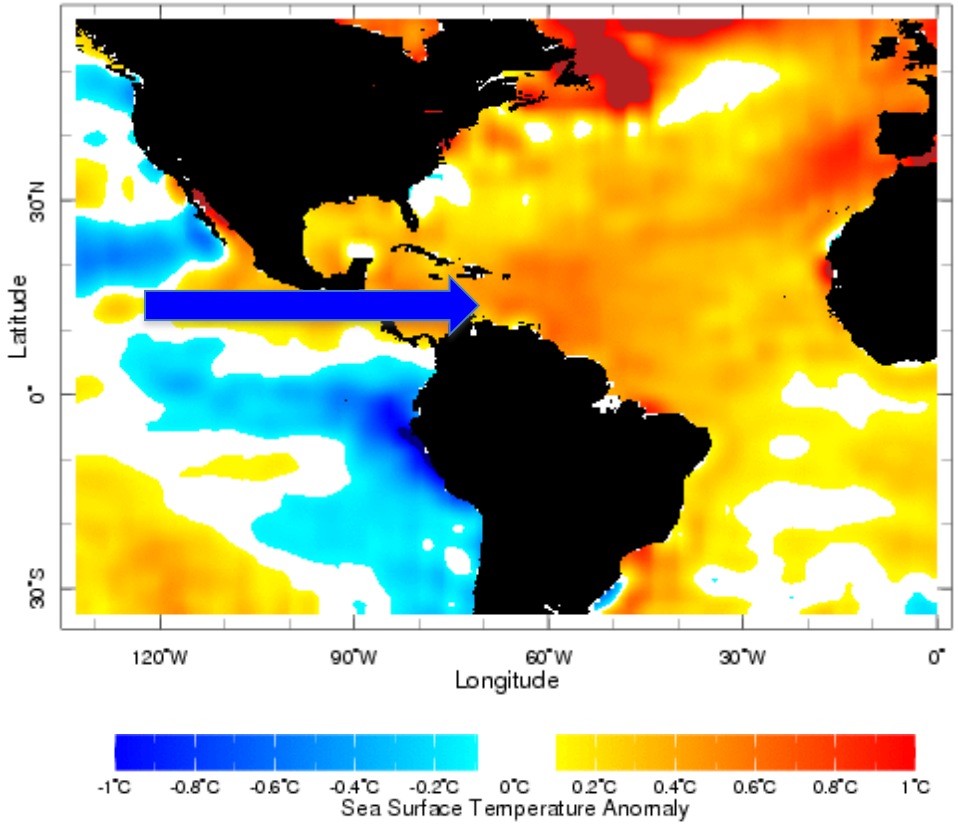
(Statistically Significant P < 0.10; GPCC)

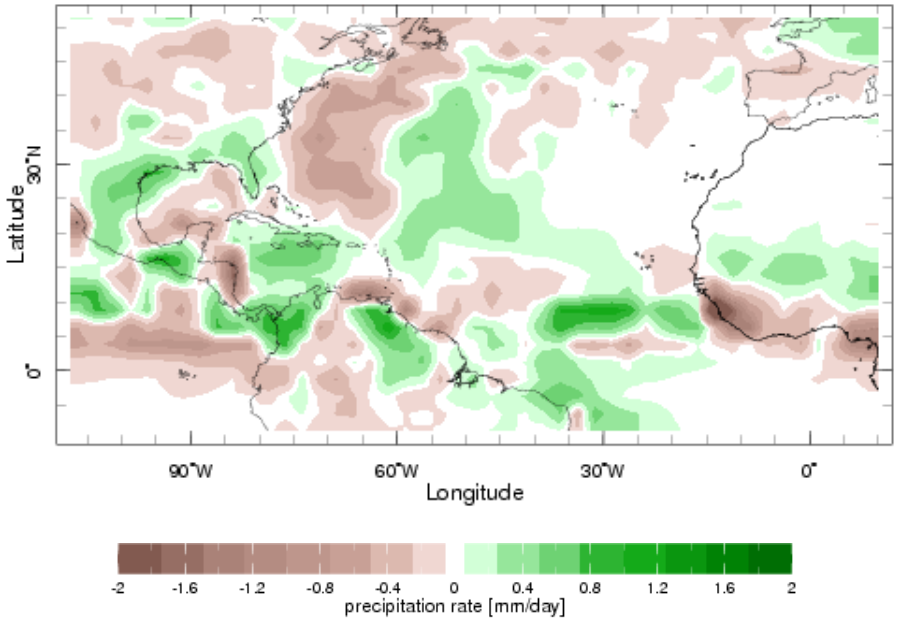


99, 01, 02, 04, 05, 06, 07, 09

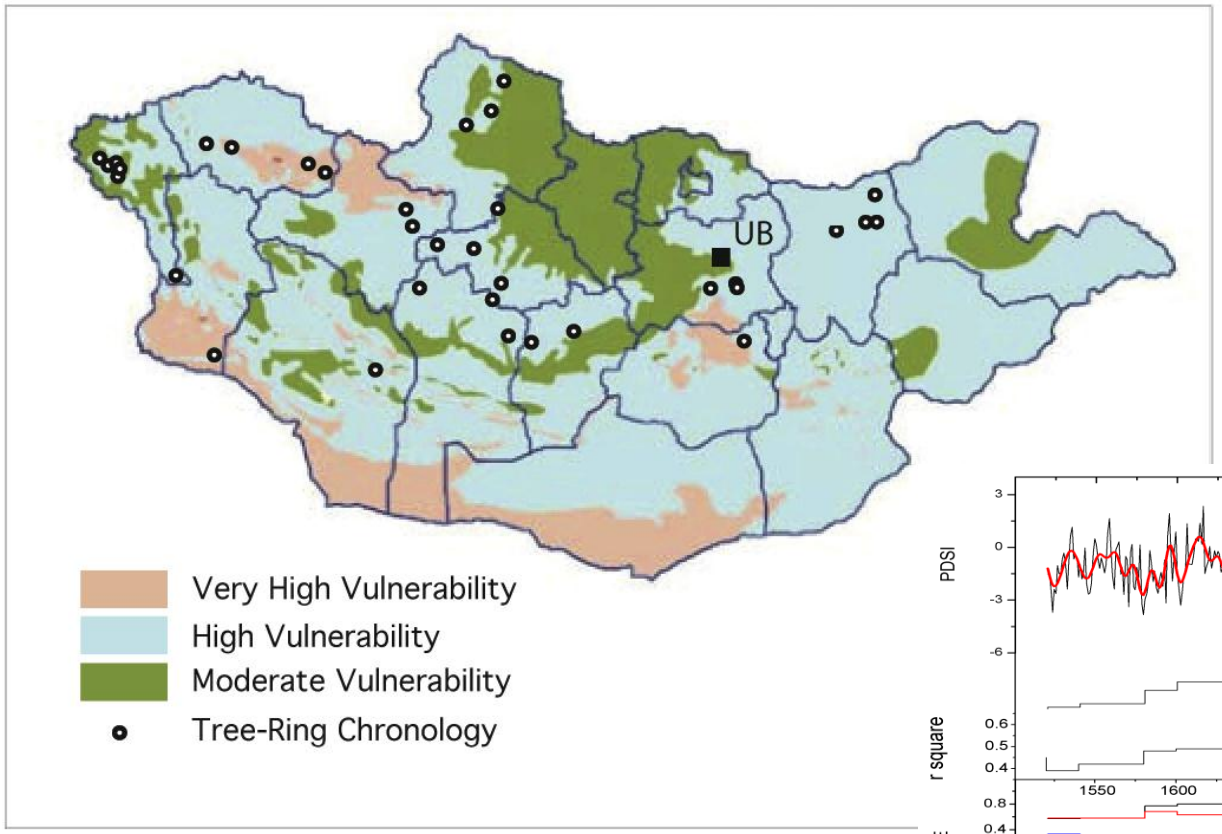
Cold Pacific, Warm Atlantic on Multi-year Timescales

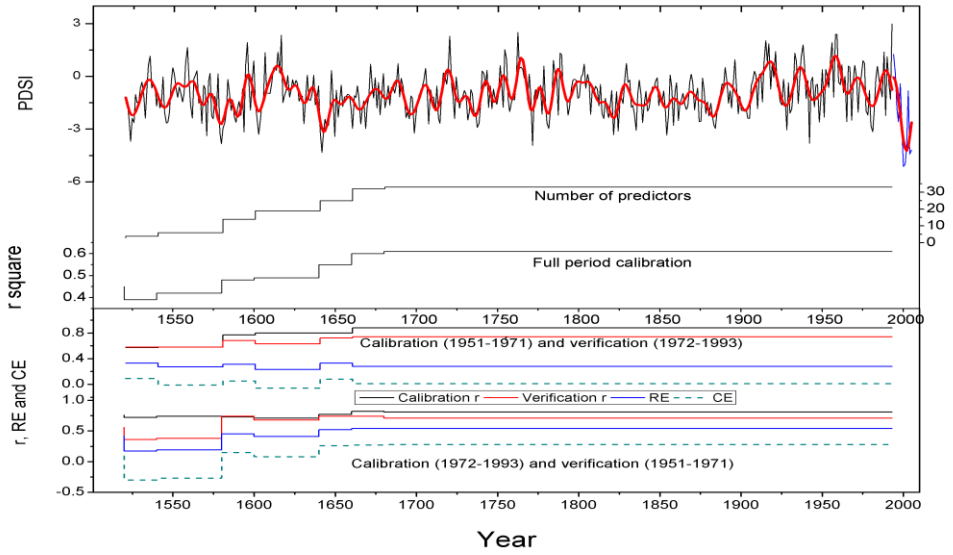
JJA Average SST and PRCP Anomalies post-1998





Vulnerability Base Map (MARCC 2009) and drought sensitive tree-ring network (circles)





Vulnerability map from: Mongolia: Assessment Report on Climate Change 2009 (MARCC 2009). UNDP, UNEP, The Ministry of Nature, Environment and Tourism.