Processes Affecting the Development of Hydroclimatic Extremes in the Canadian Prairies

Kit Szeto and Collaborators
Climate Research Division, Environment Canada

The Canadian Prairies

- Major agricultural region that is frequently affected by hydrometeorological extremes such as droughts or floods
- Because of its unique geographical location, water cycling in the Prairies is governed by the complex interplay between many physical processes
- Poorly understood and hard to predict

Objectives of Study

- Assess the mean water and energy budgets for the Canadian Prairies
- To better understand the processes that affect the flow of water and energy into and through the region and their redistribution within the region
- To better understand processes that contribute to the development of hydroclimate extremes in the region

Ensemble Mean Annual Cycles of SRB Water and Energy Budgets

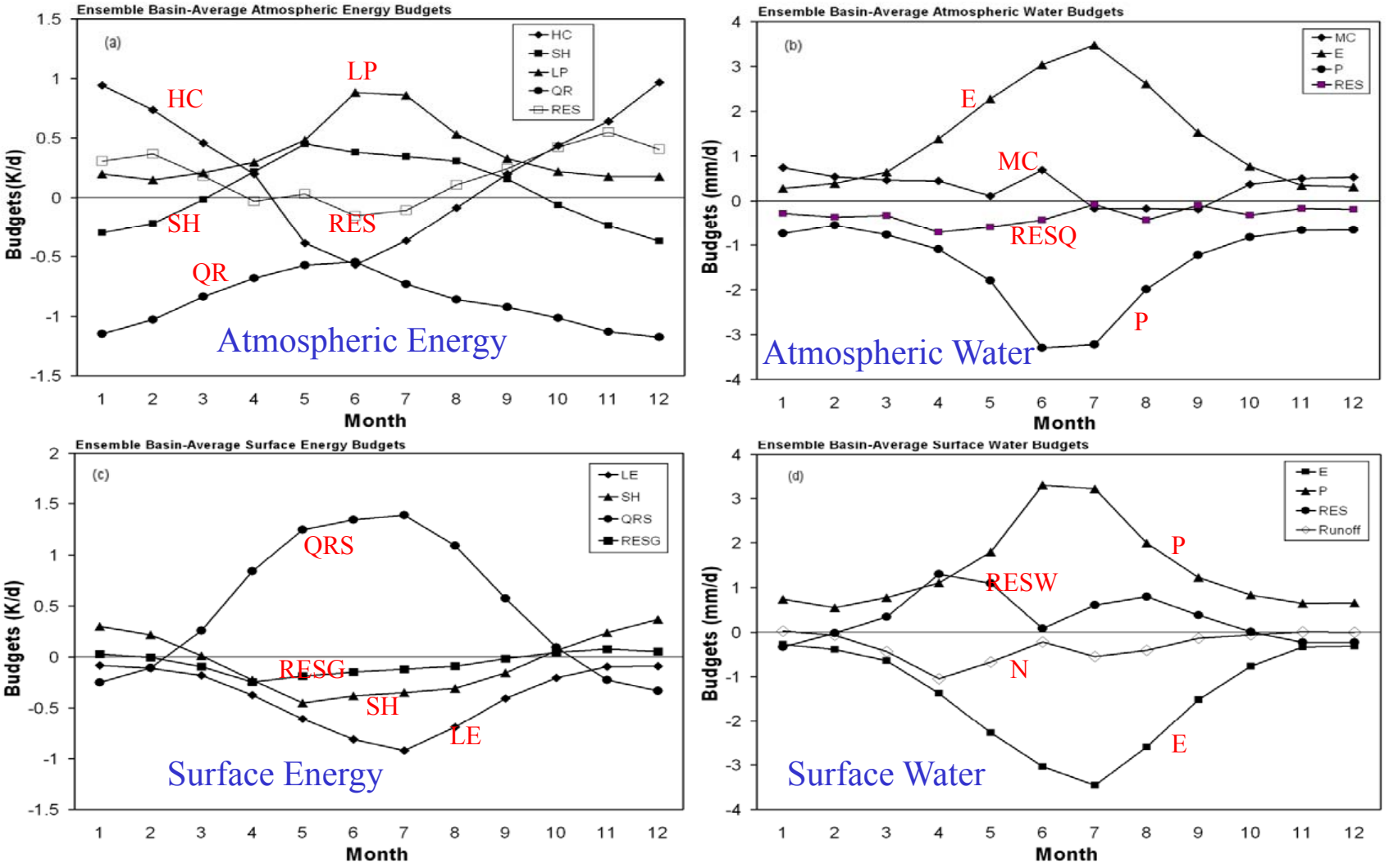
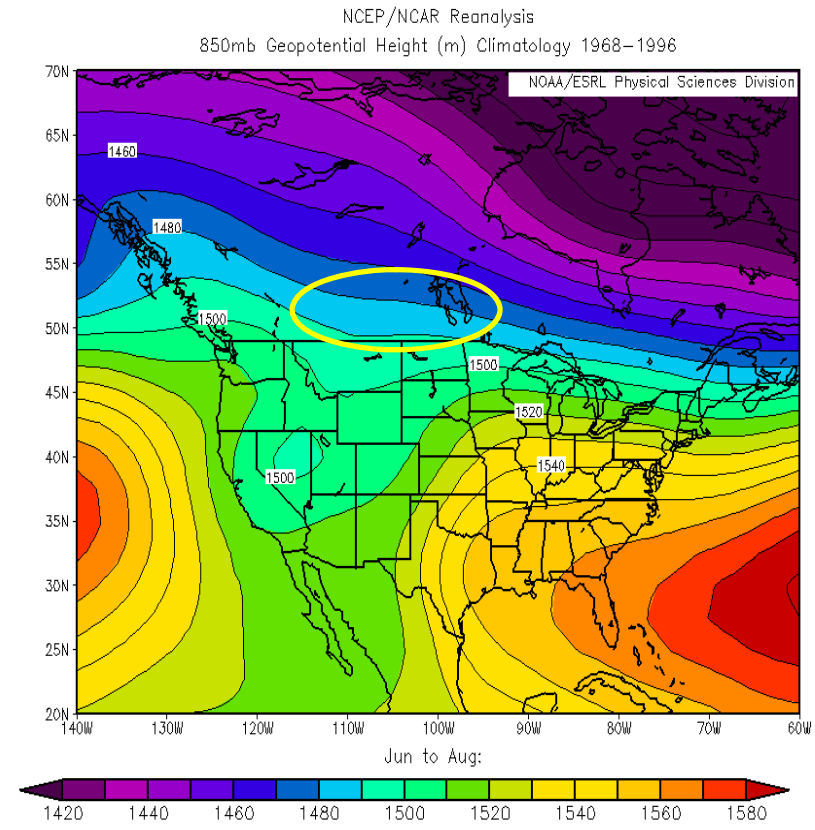


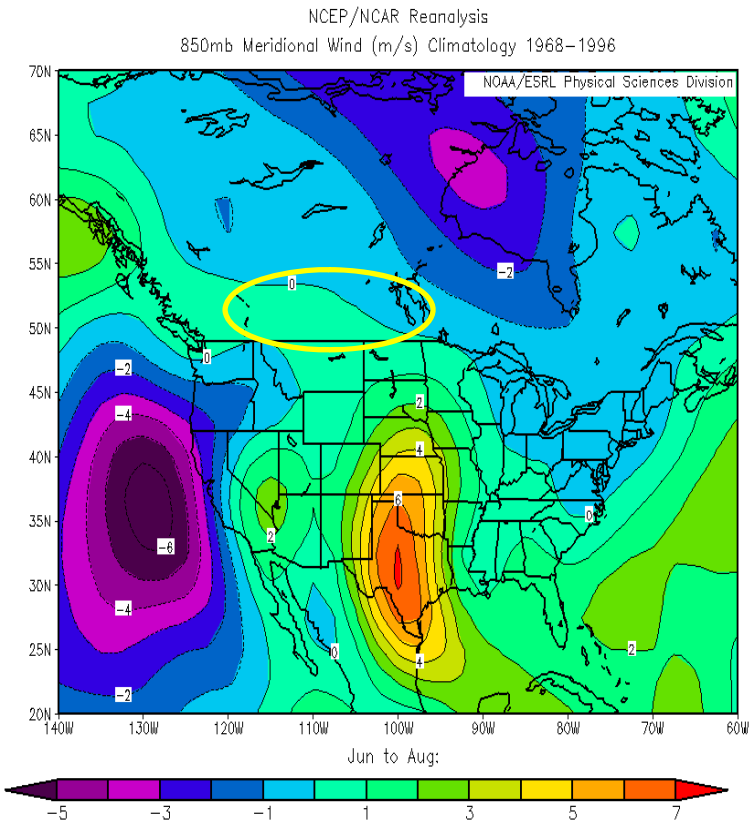
Figure 3. Mean annual cycle of ensemble (NCEP-R2, ERA-40, CMC and CRCM) basin-average budgets for (a) atmospheric energy, (b) atmospheric water, (c) surface energy and (d) surface energy.

Correlations between various July Prairie water budget terms from NARR

July	*E*	*P*	*SM*	*MC*
E	1.00			
P	0.17	1.00		
SM	0.88	0.12	1.00	
MC	-0.20	0.82	-0.20	1.00
Obs P	0.22	0.95	0.19	0.78

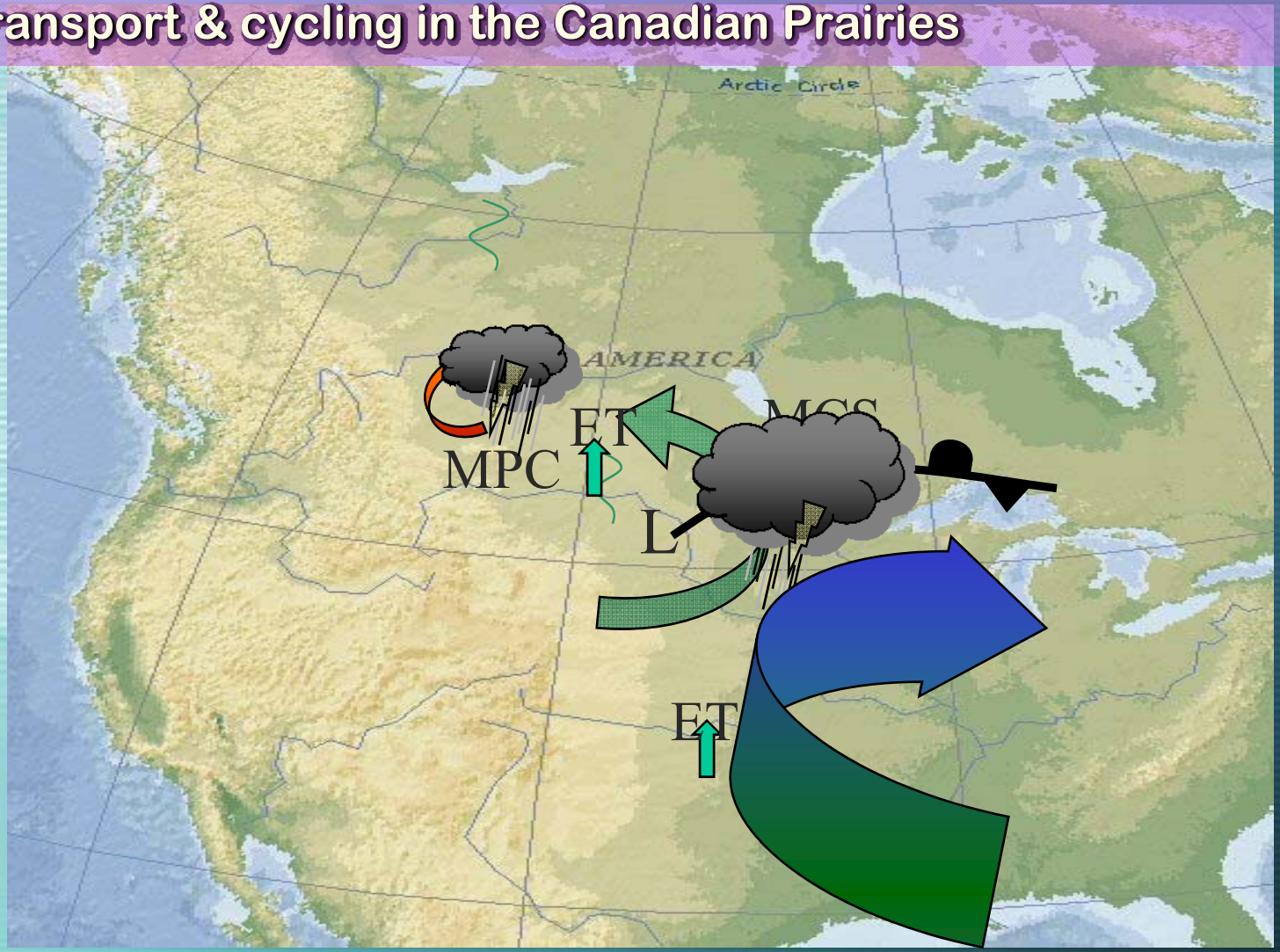
JJA mean circulation at 850 hPa





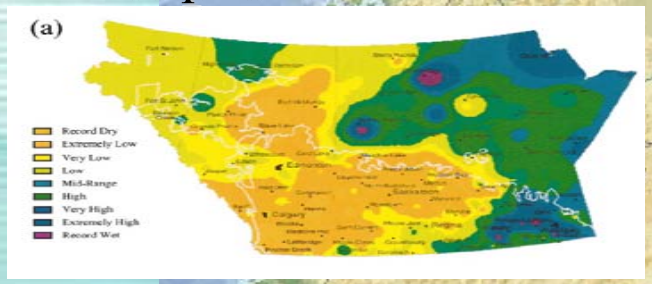
Mean subsiding and diverging lower level northwesterly flow over the Prairies and the climatological GPLLJ does not extend into the region –> moisture flux convergence and mean southerly moisture transports into the Prairies must be accounted for by eddy transports

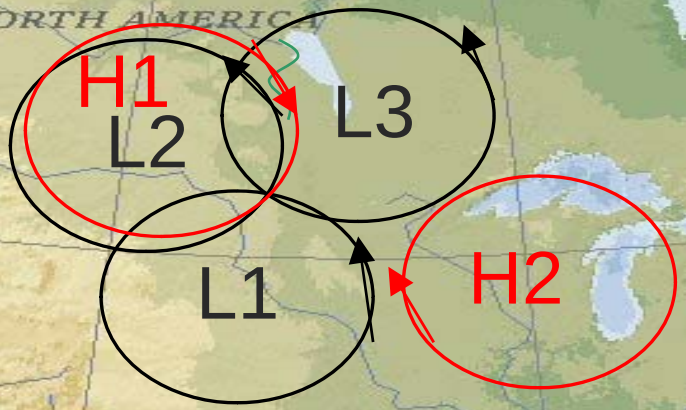
Hypothesis: Cyclonic systems over the mid-west northern U.S. play a significant role in governing the warm-season water transport & cycling in the Canadian Prairies



Synoptic Patterns Affecting Summer Moisture Flux and P over the Prairies

2000-01WY
Precipitation Anomalies

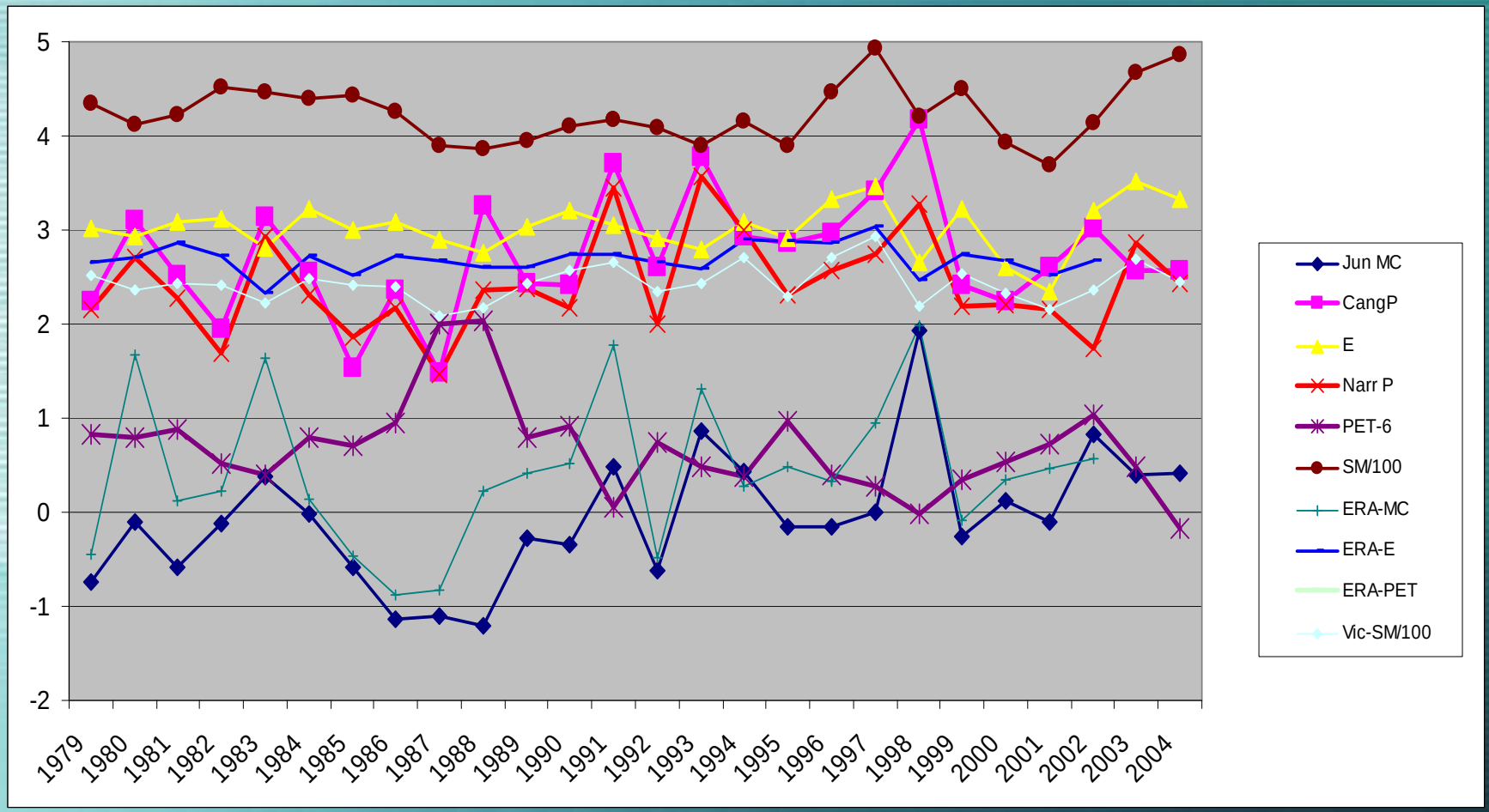




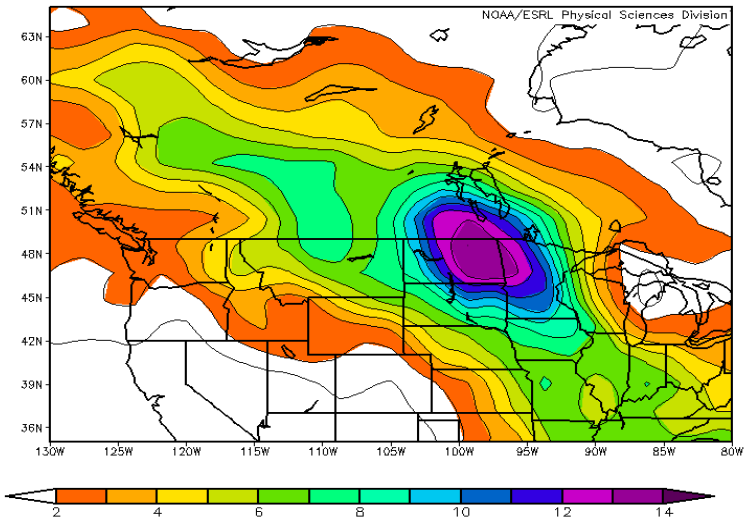
Q: What largescale process control the variability of summer synoptic activities and how?

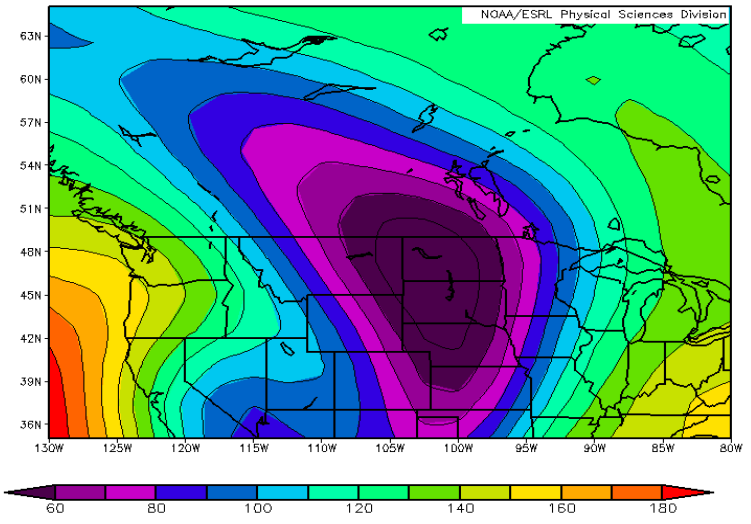
JJA Freq (days)	L1	L2	L3	H1	H2
2001- Dry	5	18	27	24	15
1961- Dry	8	16	19	15	25
1988 - Dry	14	17	21	19	17
1993 -Wet	14	17	22	21	27

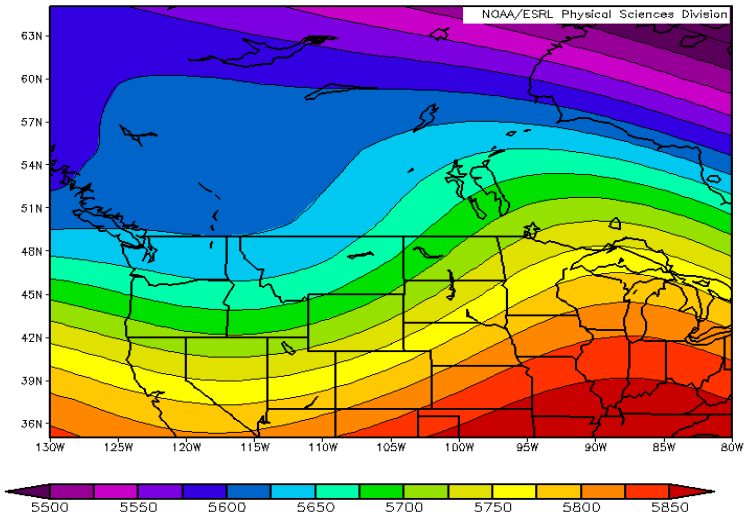
Timeseries of June water Budgets from NARR and ERA40



Composites of atmospheric conditions associated with June days with precip in the highest 2 percentiles over the eastern Prairies (1950-2005)

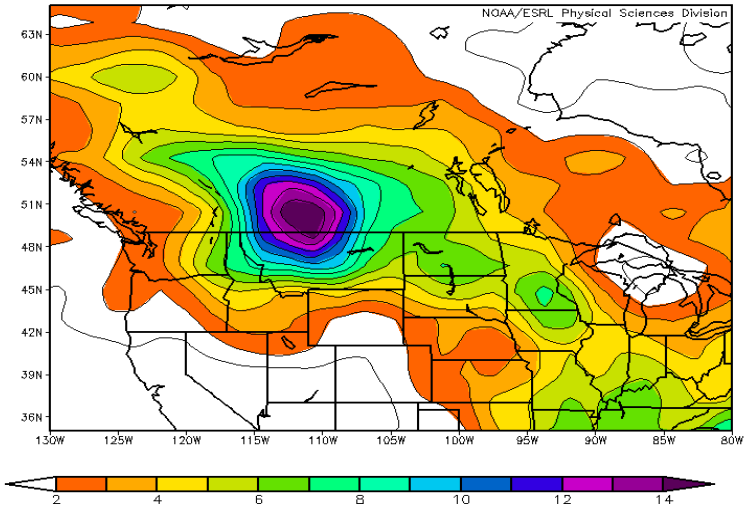


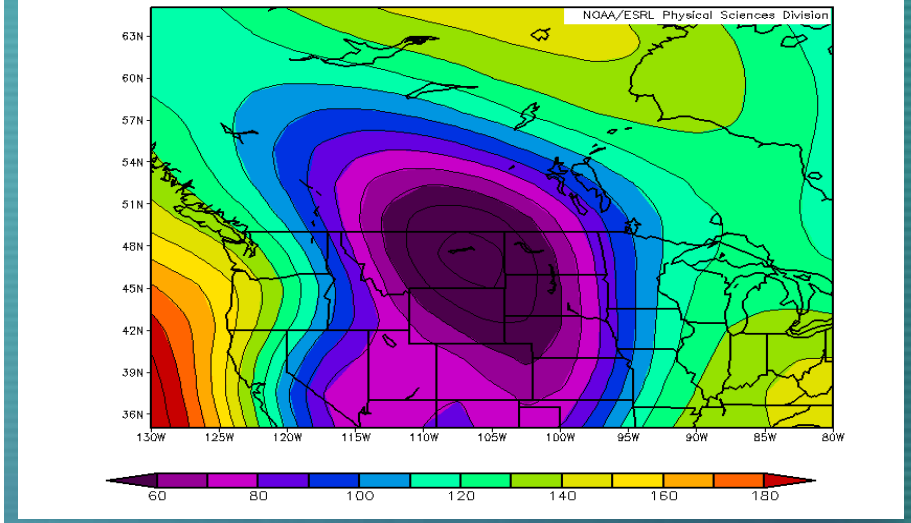


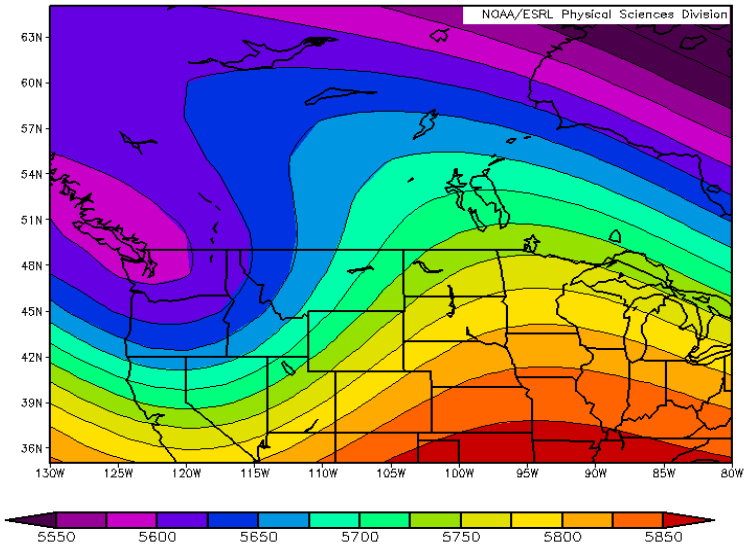


NCEP-reanalysis
Precipitation (top left)
1000 hPa Geopotential Height (top right)
500 hPa Geopotential Height(bottom left)

Composites of atmospheric conditions associated with June days with precip in the highest 2 percentiles over the western Prairies





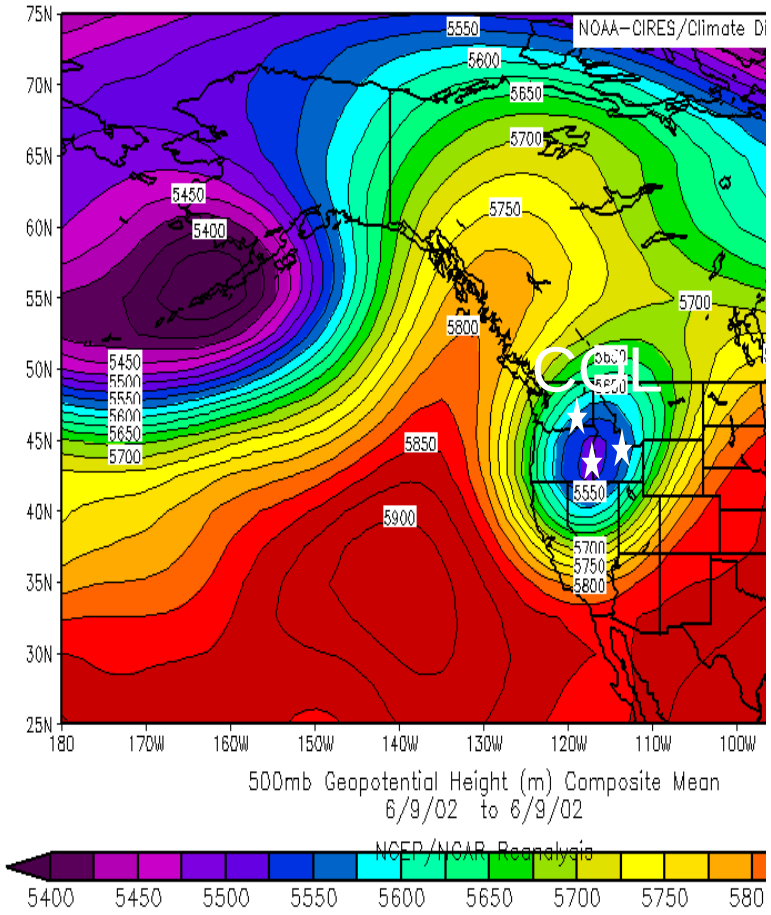


NCEP-reanalysis
Precipitation (top left)
1000 hPa Geopotential Height (top right)
500 hPa Geopotential Height(bottom left)

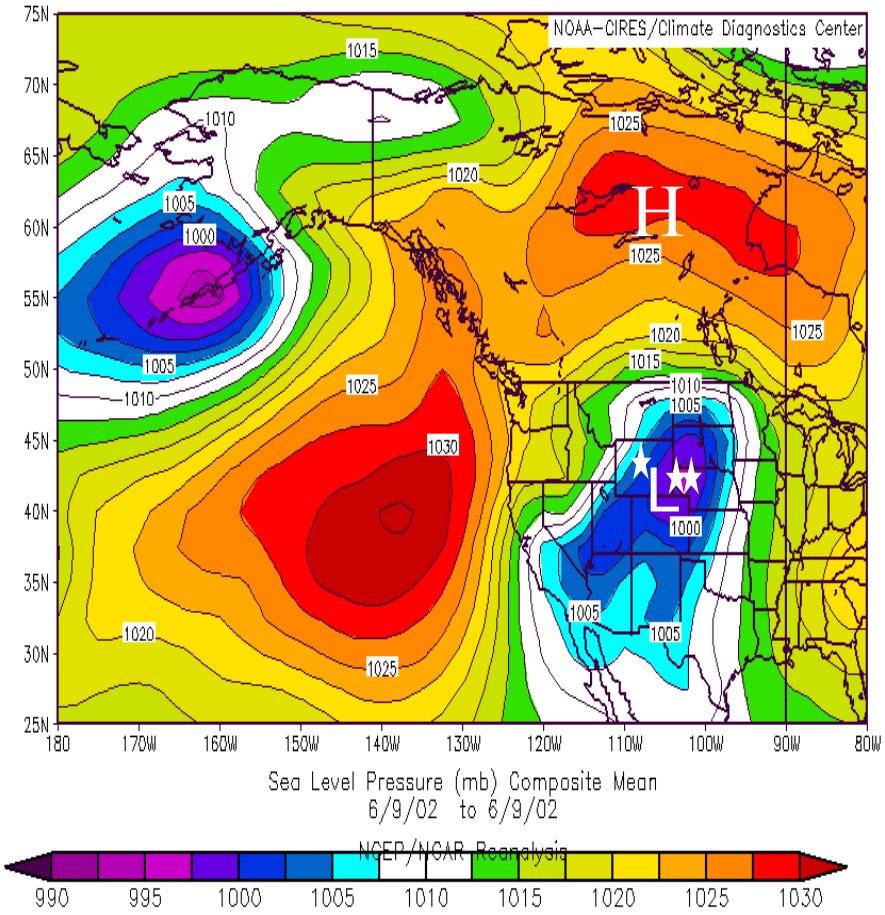
The June 2002 Extreme Rain Event – A flood within an extreme drought: Synoptic Settings

NCEP reanalysis – NOAA CDC

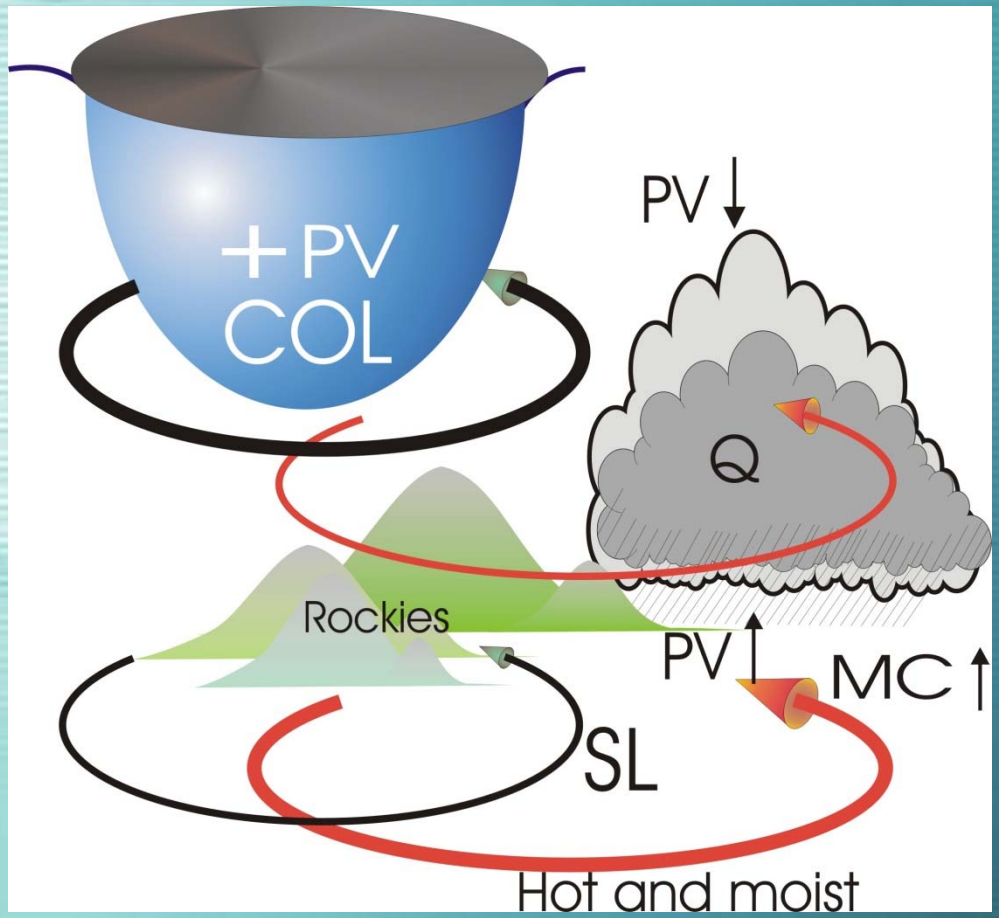
500 hPa Z Jun 9 2002



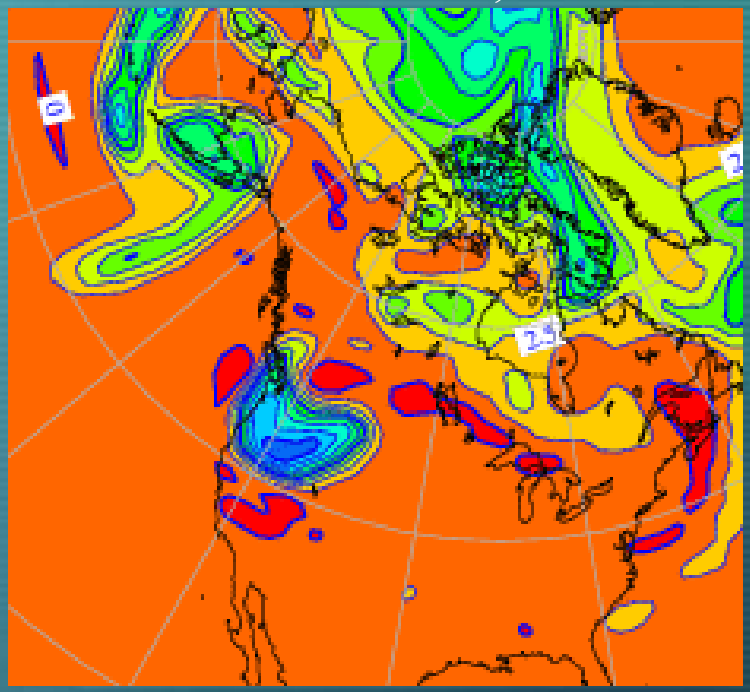
MSLP Jun 9 2002



June 2002 event : Synoptic scale feedbacks that affected storm growth and propagation



ERA40 PV at 300 hPa, Jun 09 12Z

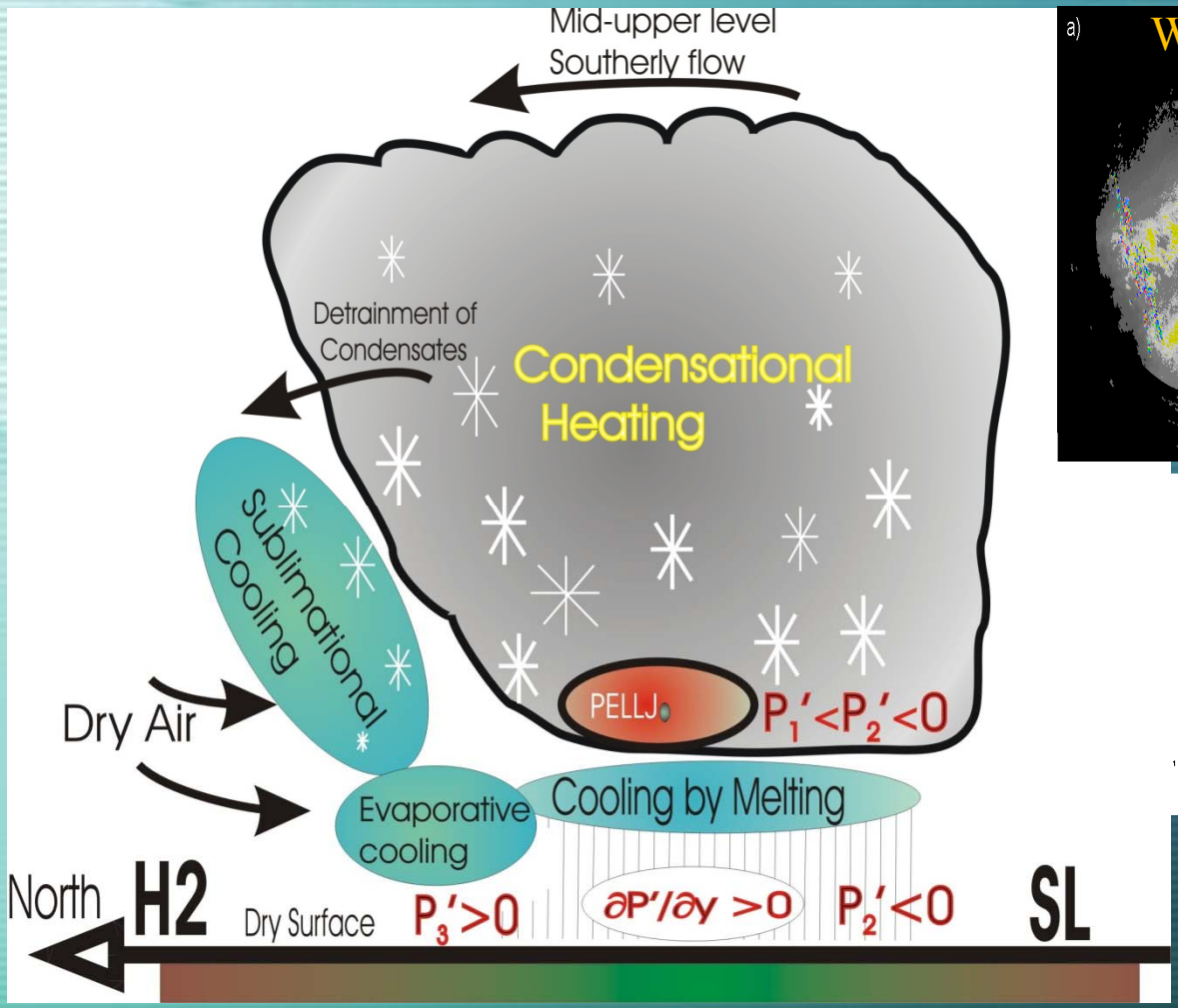


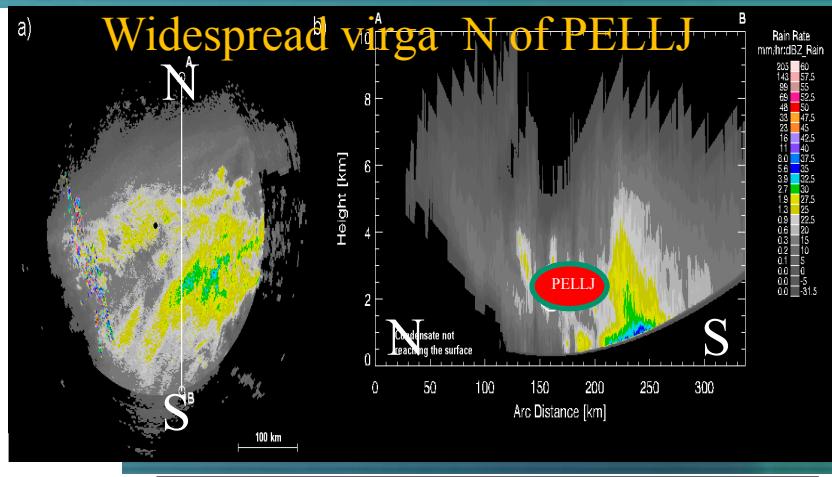
$$PV = g(\zeta + f)\{-\partial\theta/\partial p\}$$

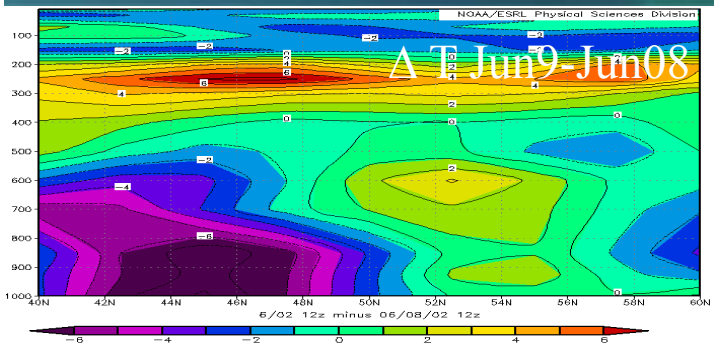
Interactions of storm circulations with the mountains to produce orographic precip and associated latent heating -> enhancement of +ve PV anomaly of the COL
-> Phase locking of the SL, COL and cloud + precip features to the Rockies
-> mutual-amplification and quasi-stationary storm features and longevity of precip

June 2002 event: Storm- and cloud-scale feedbacks

Differential net mid-to-upper level diabatic heating and associated lower-level P' focused and enhanced the synoptic scale N-S pressure gradients near the national border and thus the PELLJ and the enhanced orographic precip

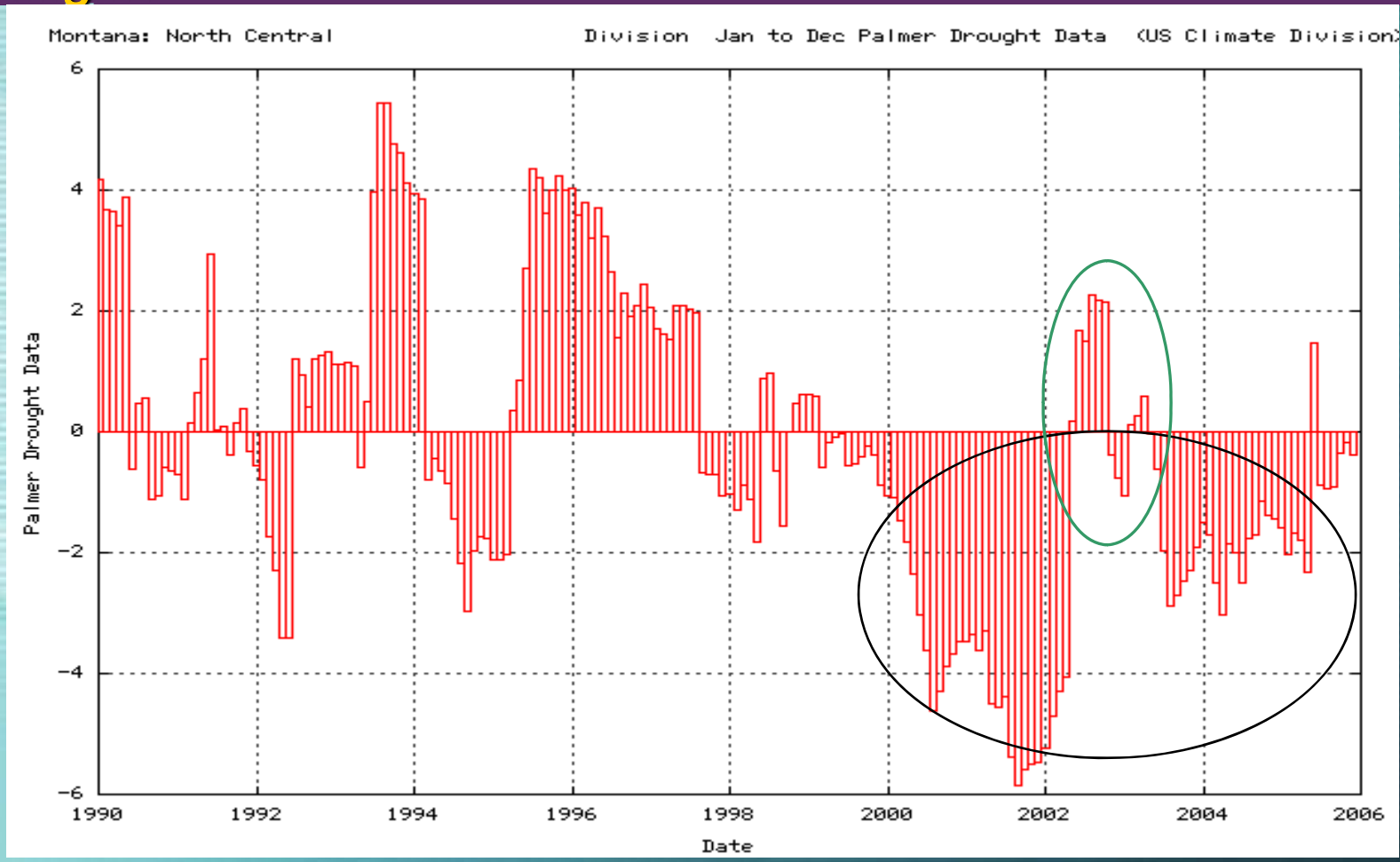






In a hydrostatic atmospheric column, pressure fall (rise) at the lower levels is a result of net warming (cooling) above the level

The extreme rain event brought an extended break to the drought over the SW Prairies – A "break point" in the evolution of the drought?



Timeseries of Monthly PDSI averaged over northern Montana

Source: *NOAA/OAR/ESRL PSD*