



Predictability of Eastern MT Flooding Event: May 20-21, 2011

Workshop on Improving Long-Range Weather Forecasting

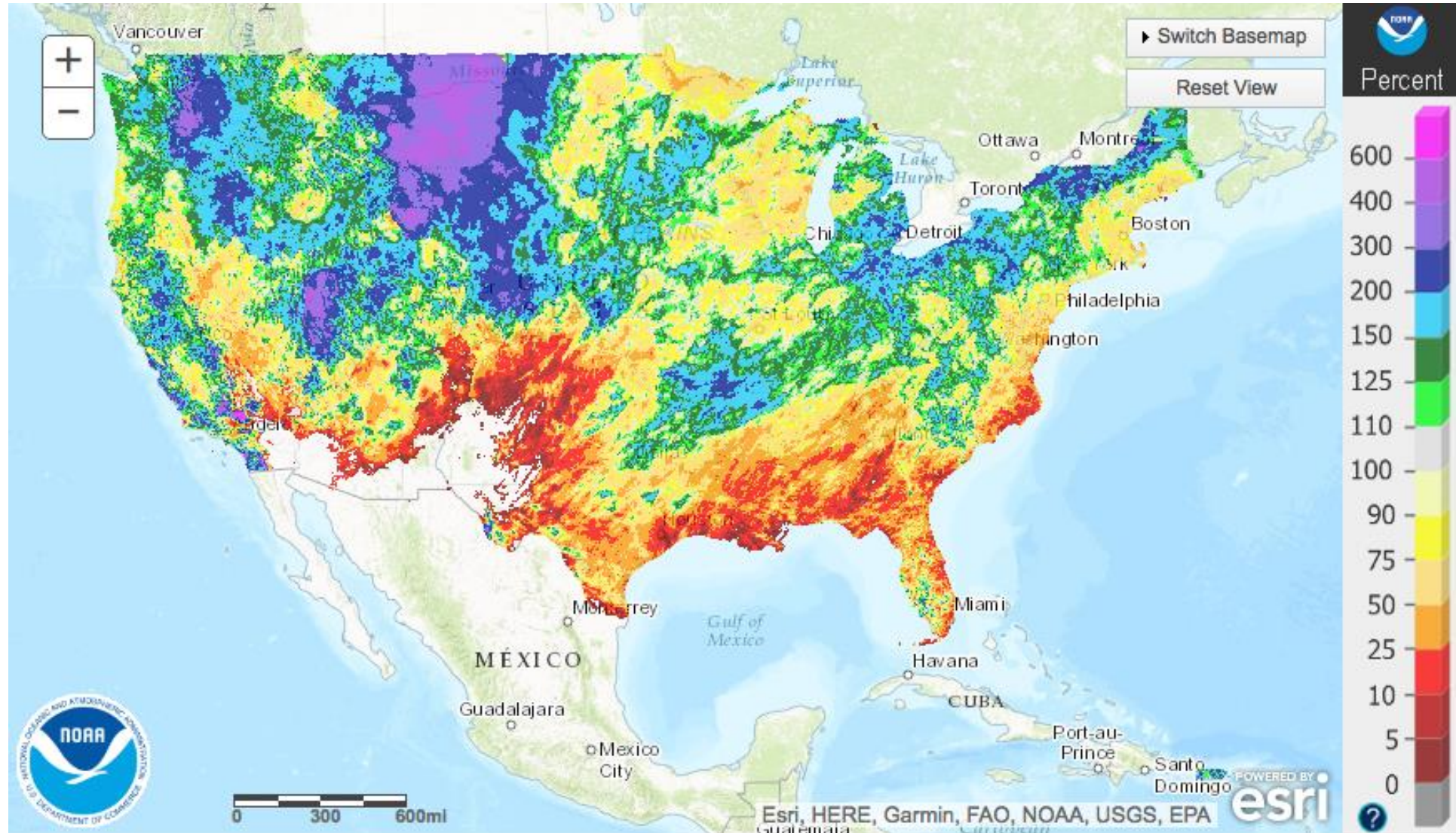
Jon Rutz

Meredith Fish

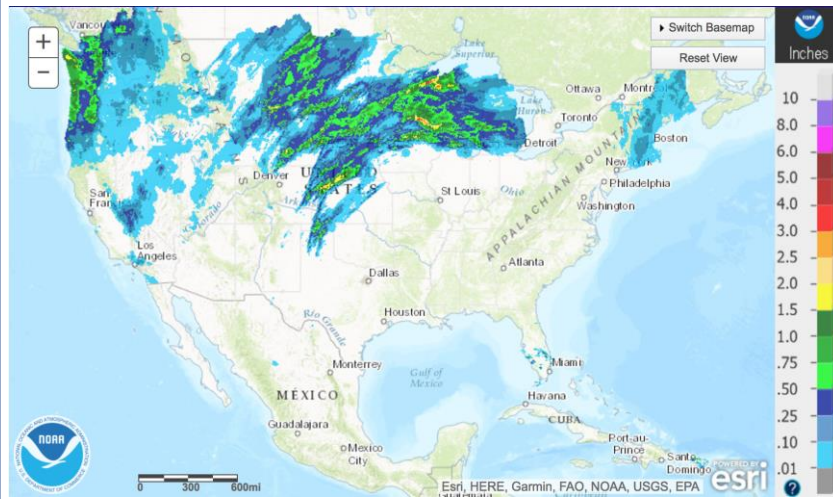
May 17-19, 2017

Precipitation as Percent of Normal

May 2011

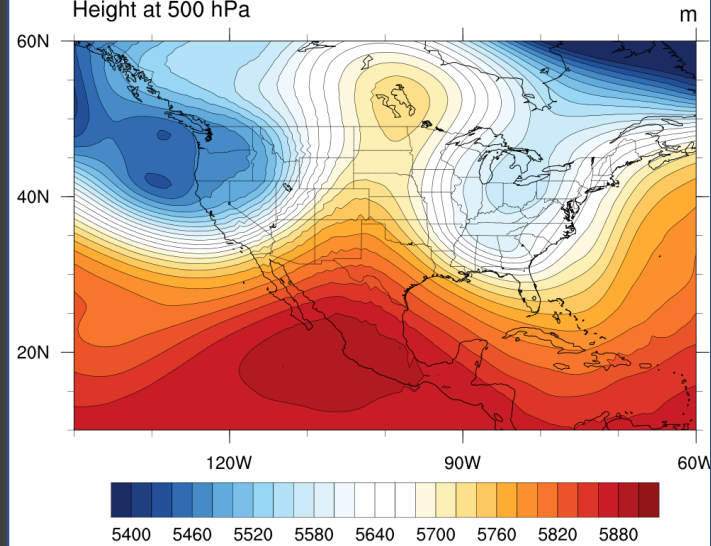


May 16, 2011



500 hPa Heights May 16 2011

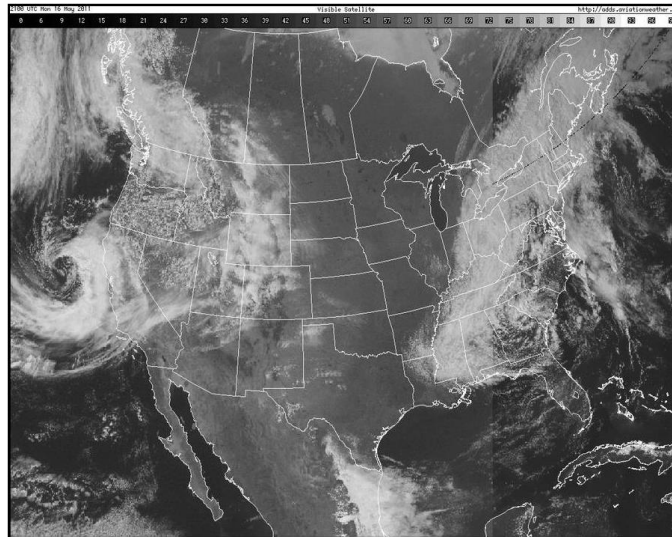
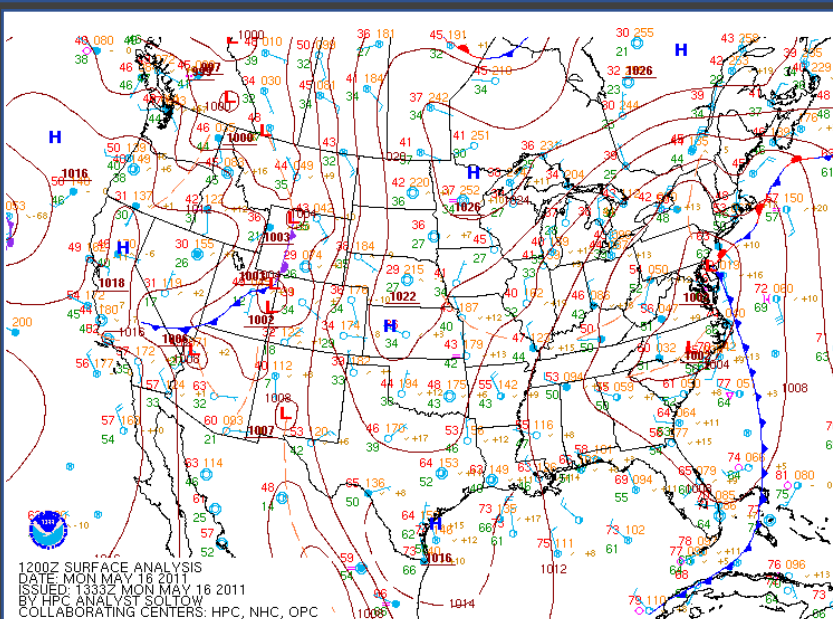
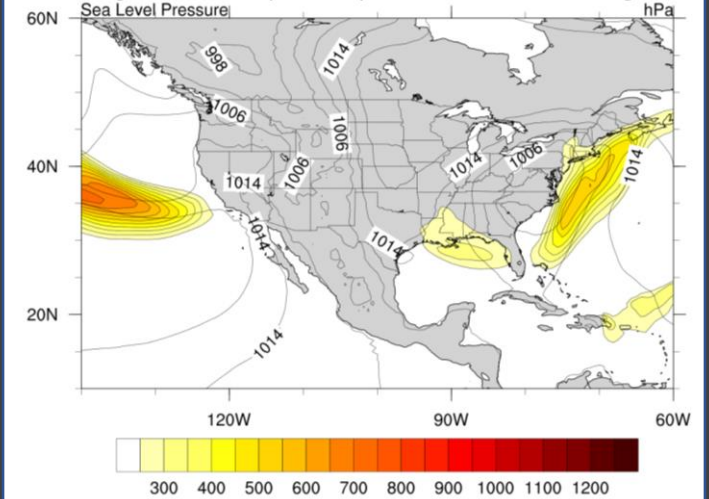
Height at 500 hPa



Average IVT for May 16 2011

Integrated Water Vapor Transport
Sea Level Pressure

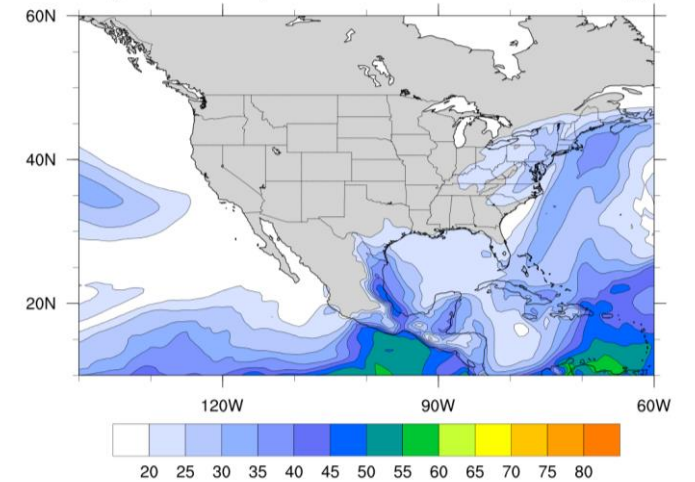
kg/m/s
hPa



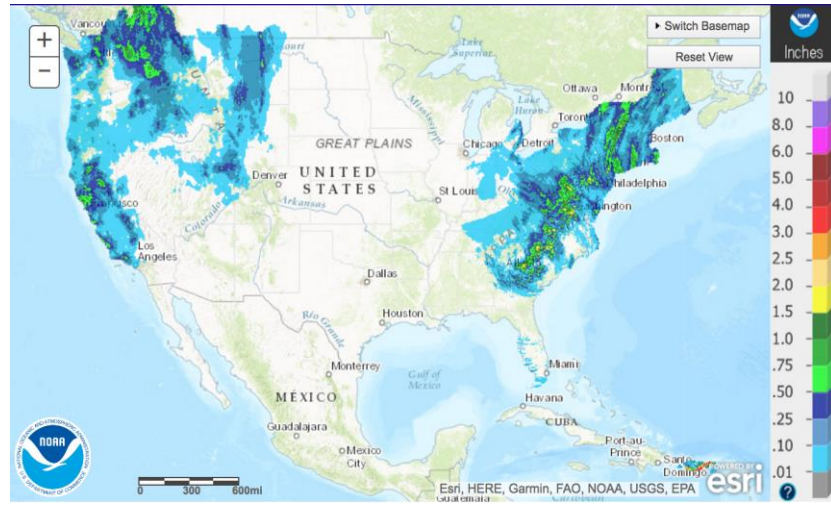
Average IWV for May 16 2011

Integrated Water Vapor

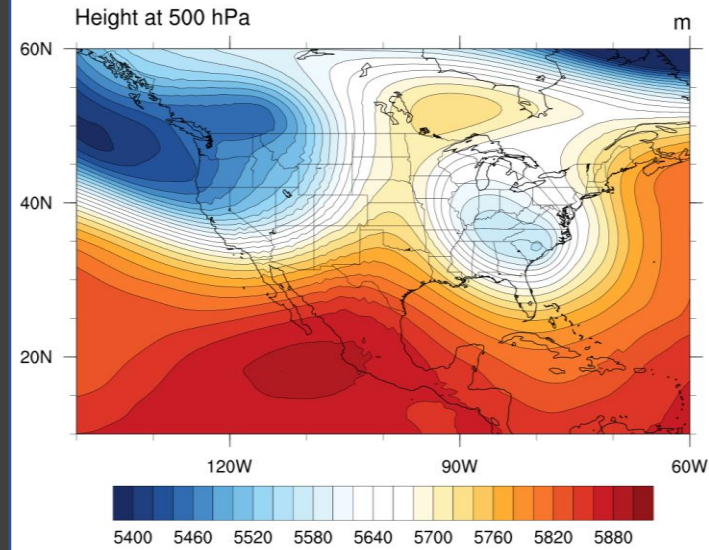
mm



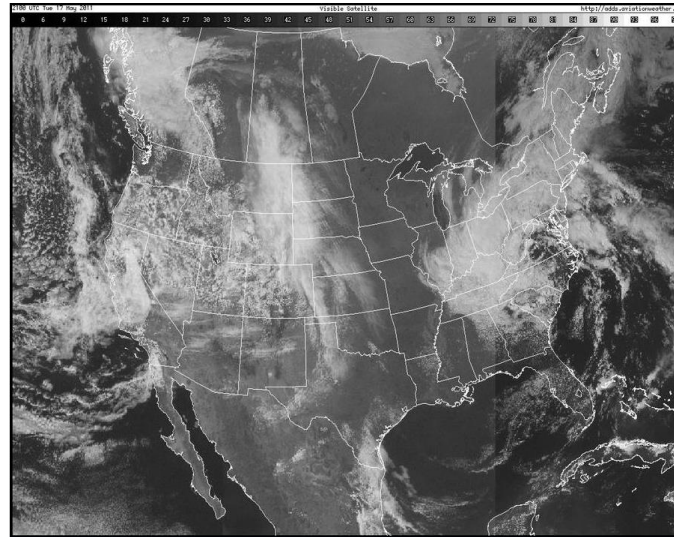
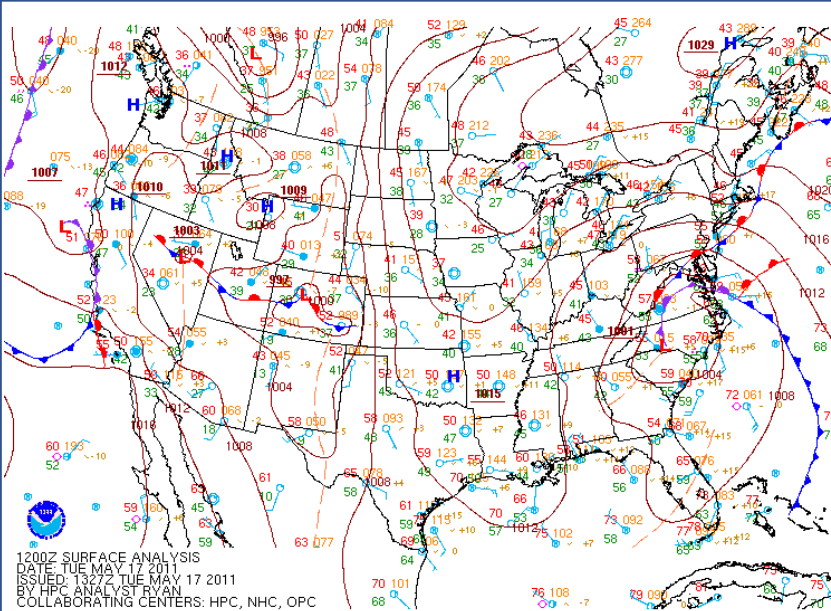
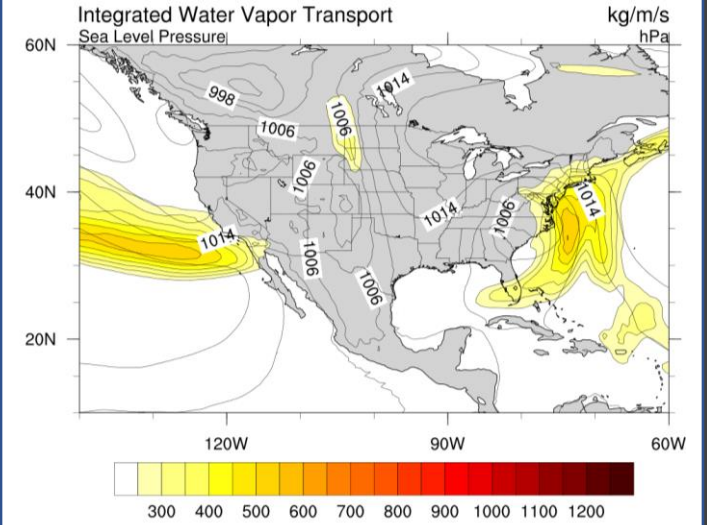
May 17, 2011



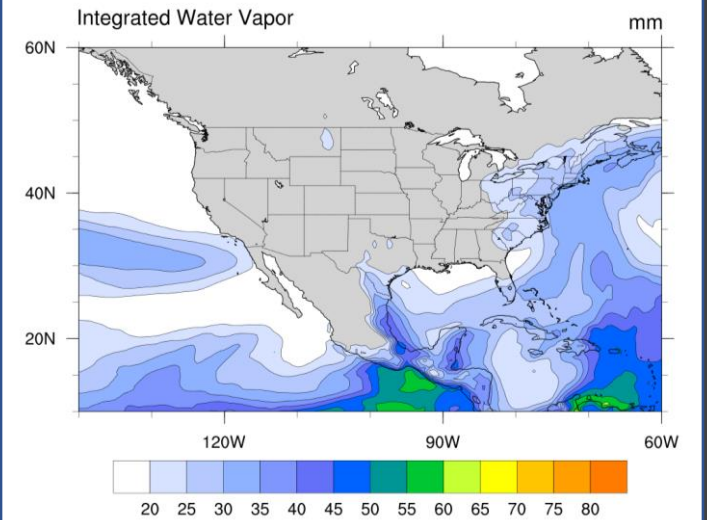
500 hPa Heights May 17 2011



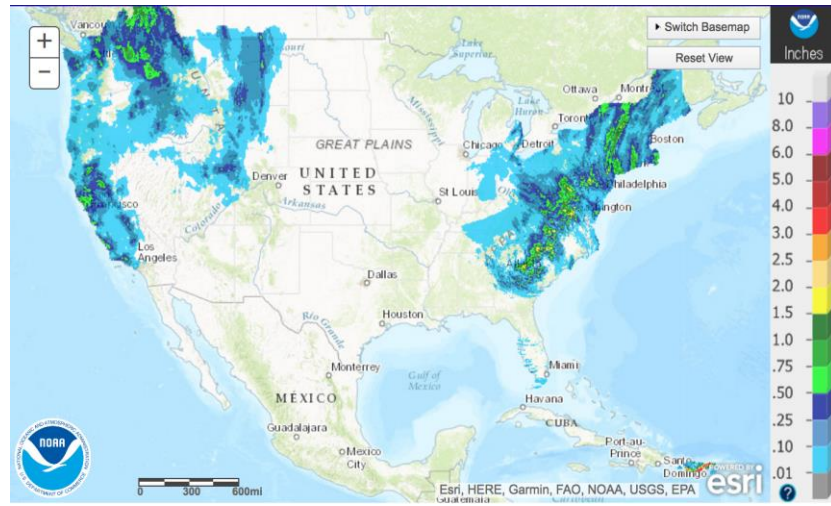
Average IVT for May 17 2011



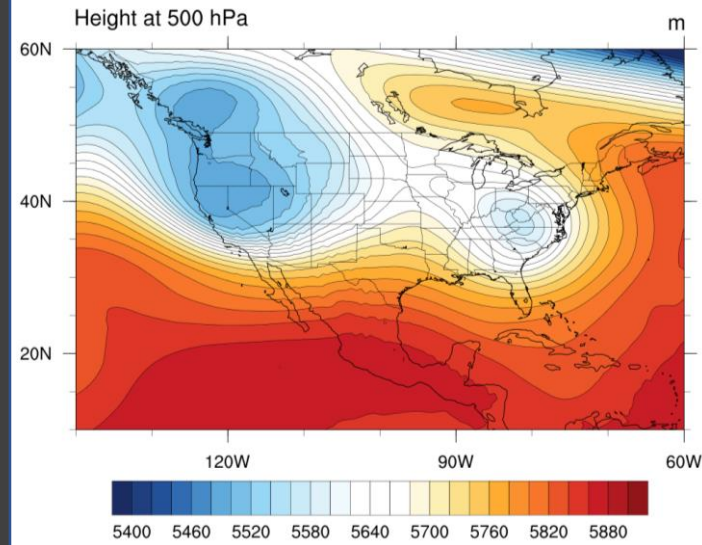
Average IWV for May 17 2011



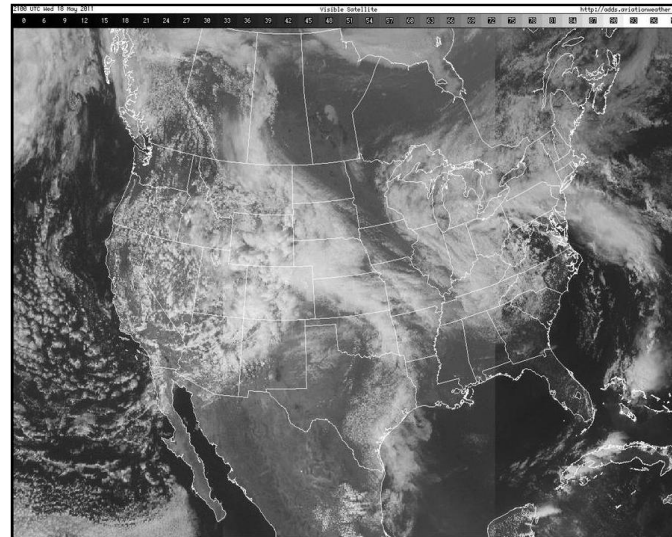
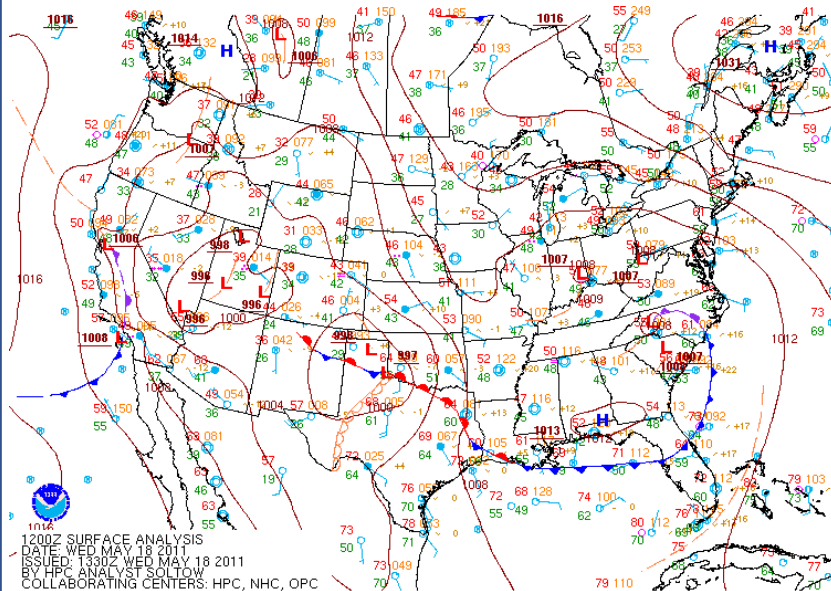
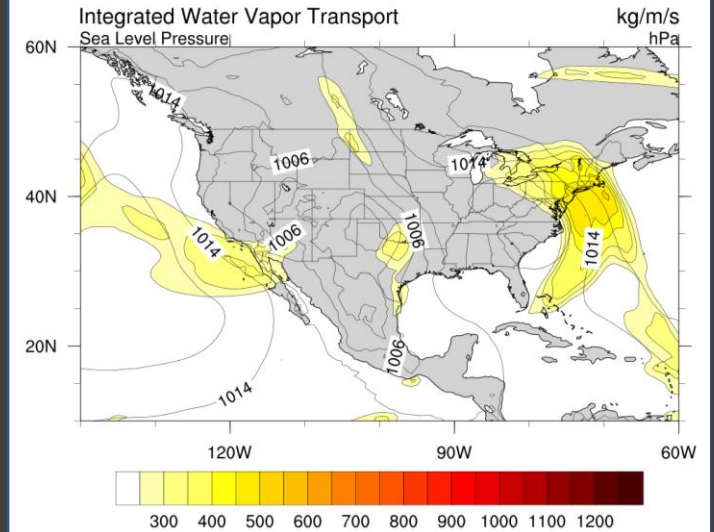
May 18, 2011



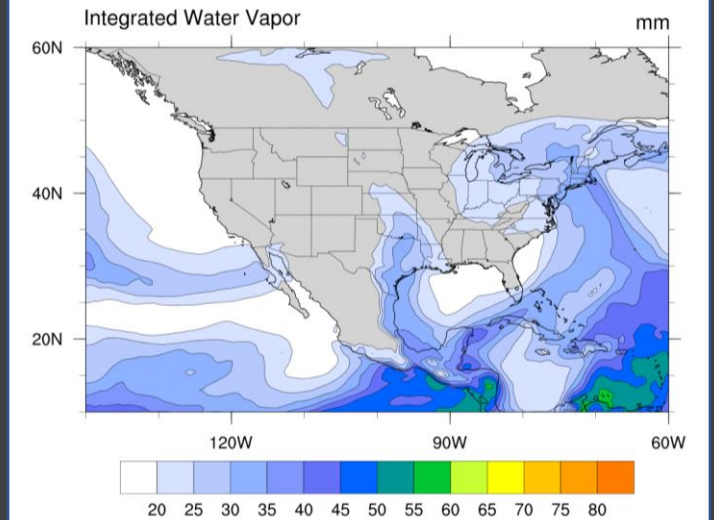
500 hPa Heights May 18 2011



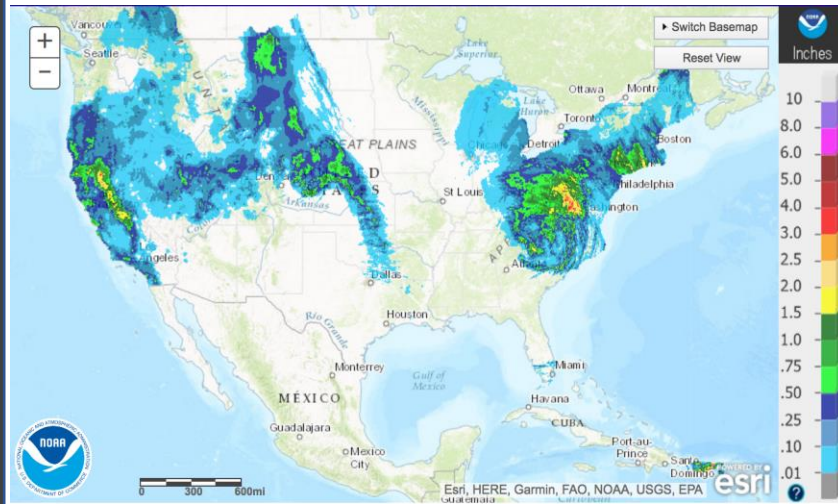
Average IVT for May 18 2011



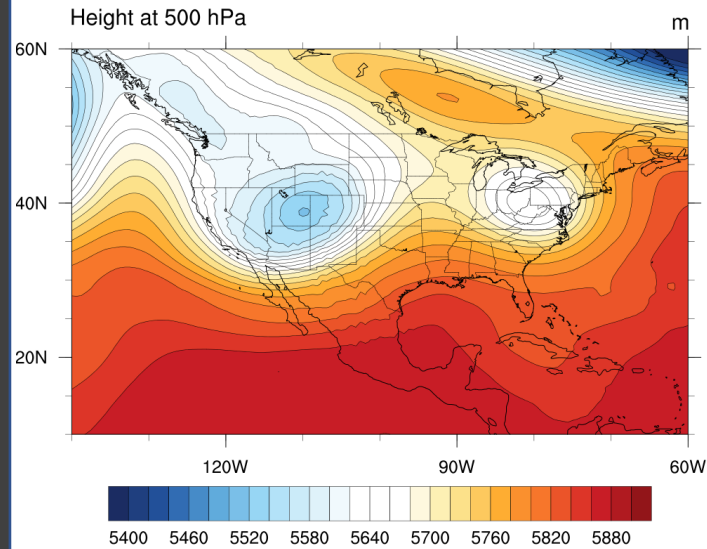
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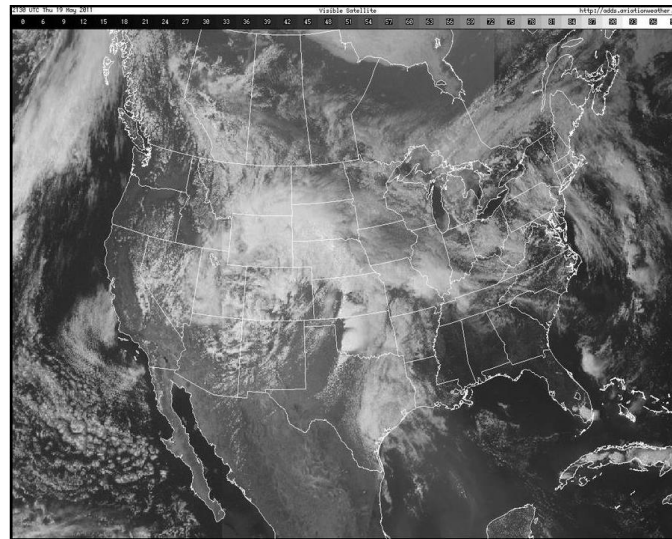
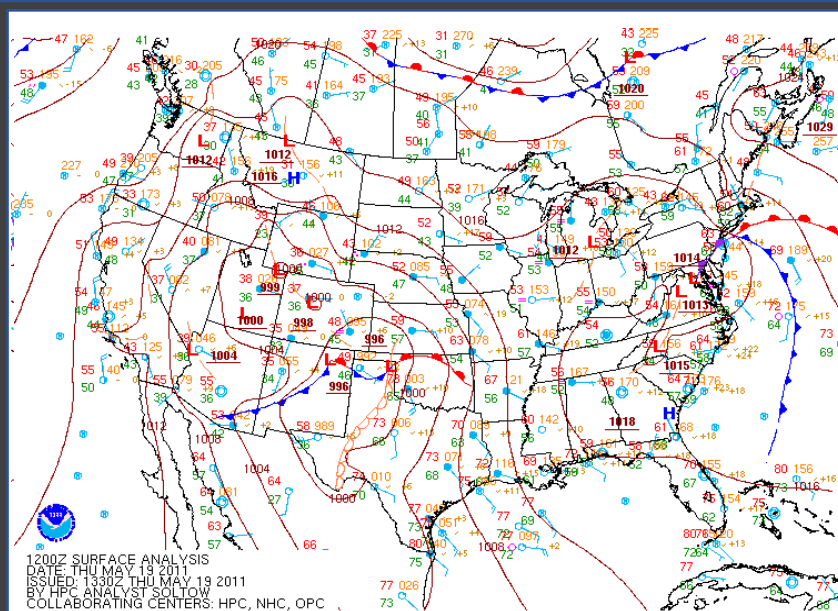
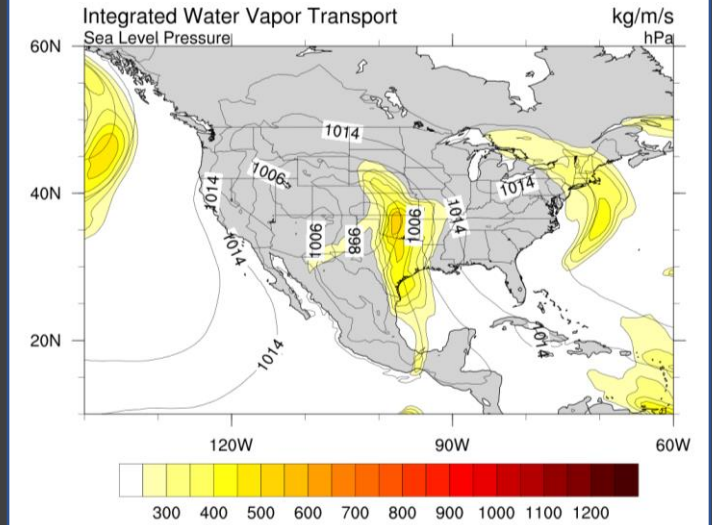
May 19, 2011



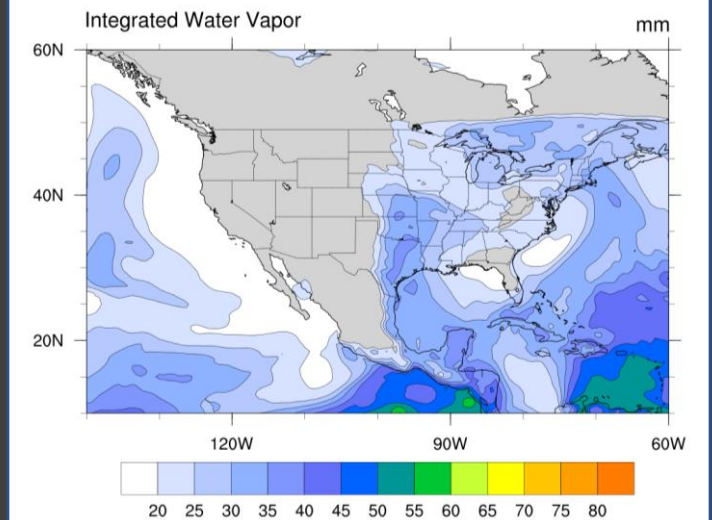
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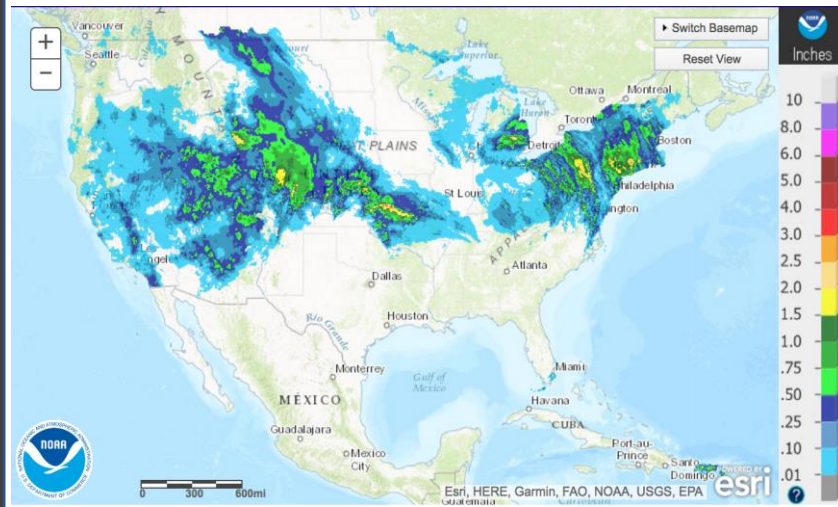
Average IVT for May 19 2011



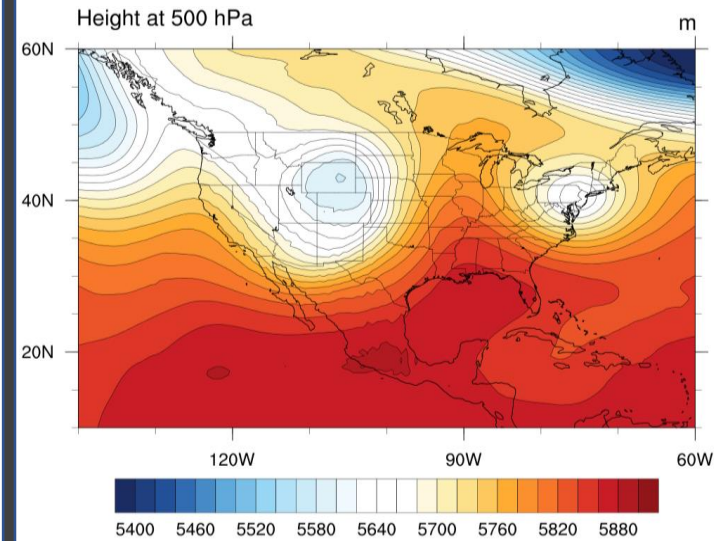
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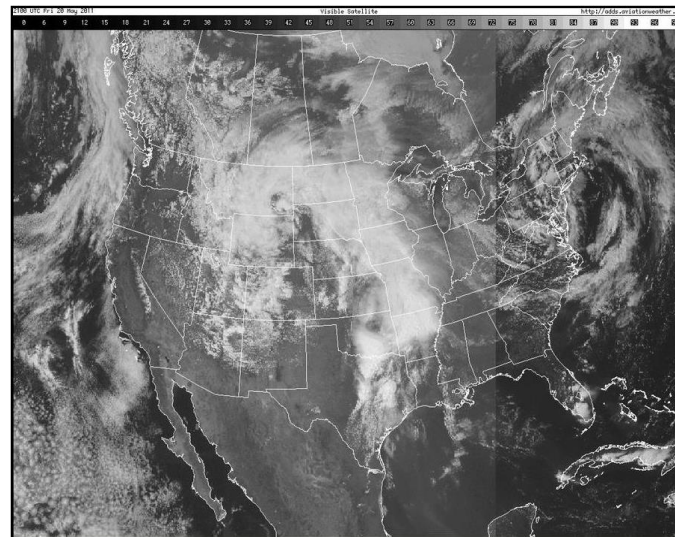
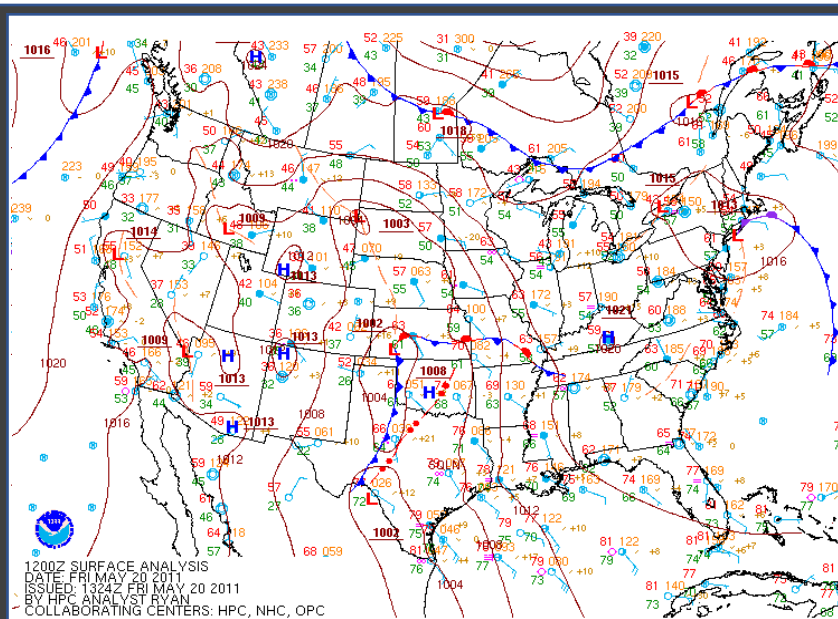
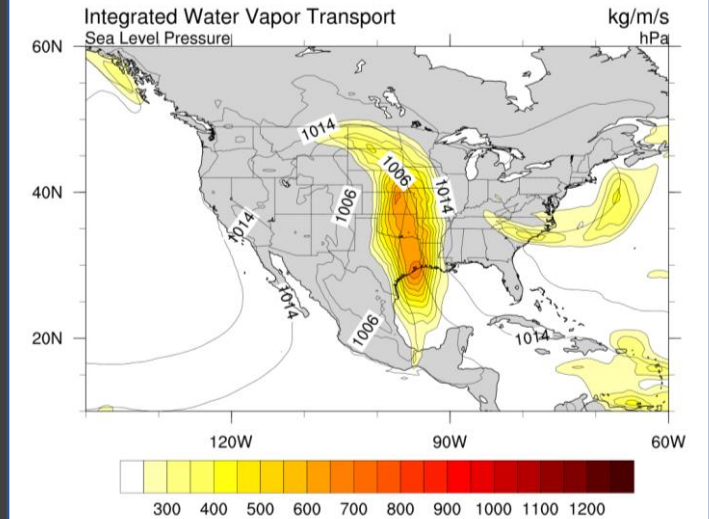
May 20, 2011



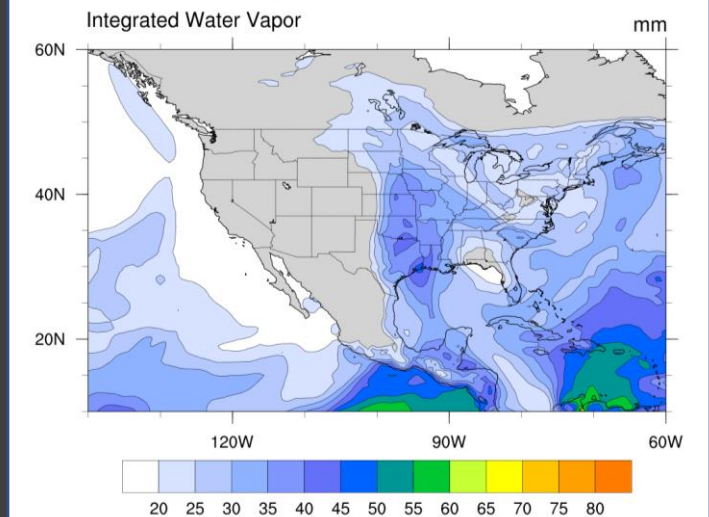
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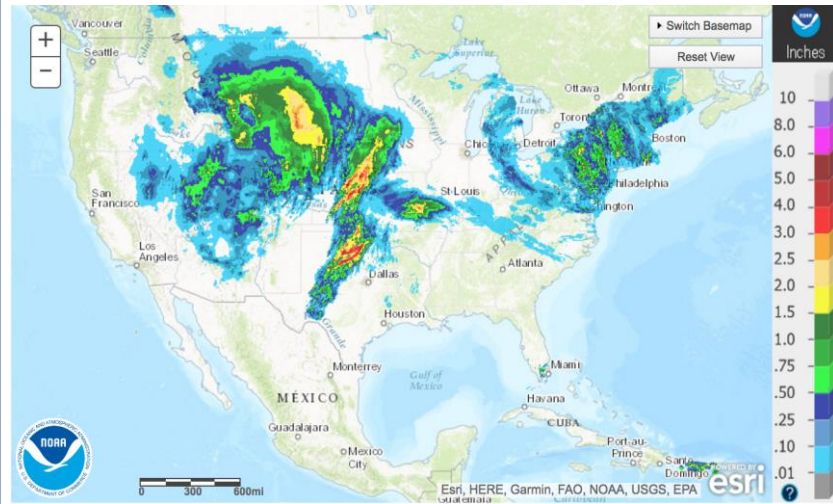
Average IVT for May 20 2011



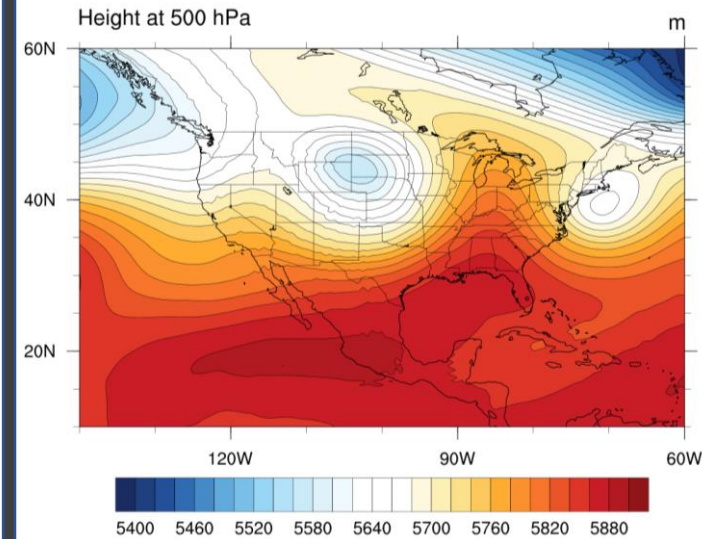
Average IWV for May 20 2011



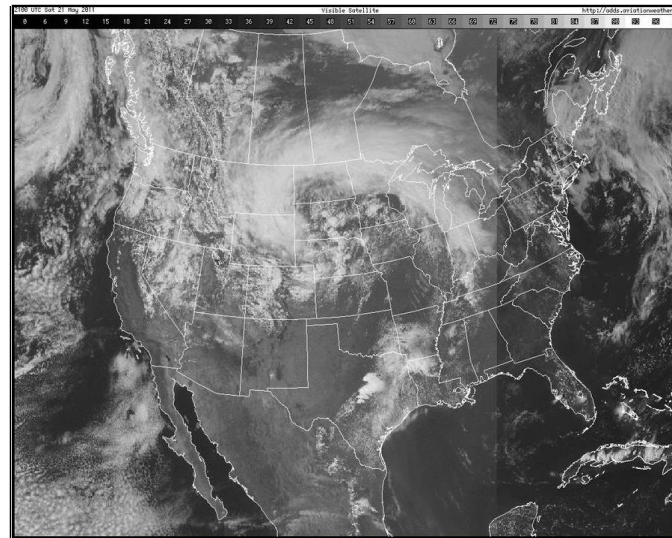
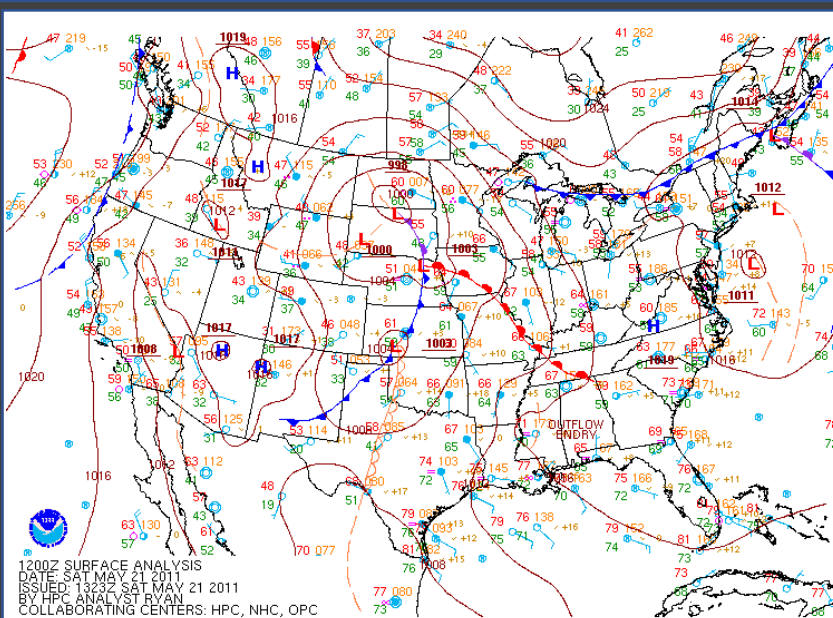
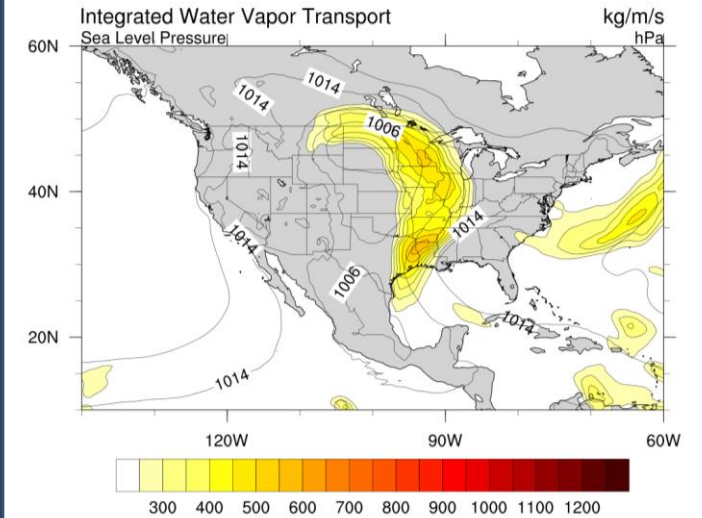
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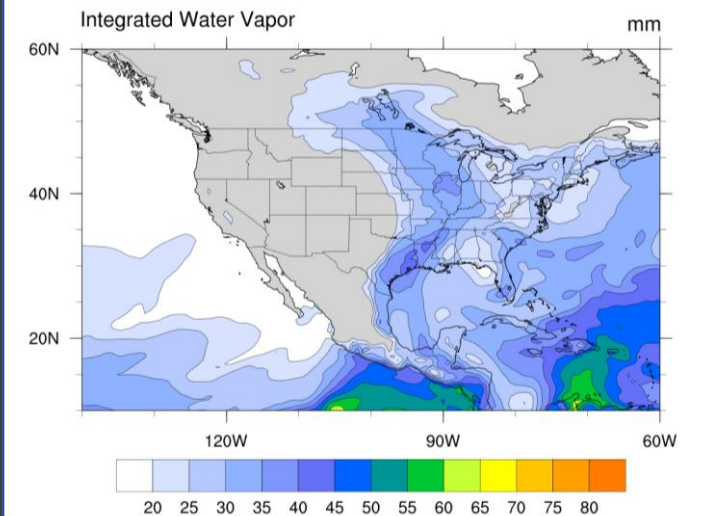
500 hPa Heights May 21 2011



Average IVT for May 21 2011



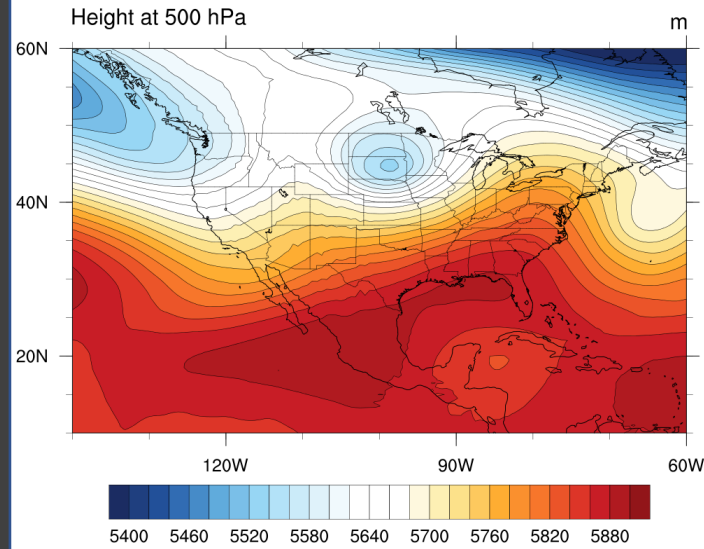
Average IWV for May 21 2011



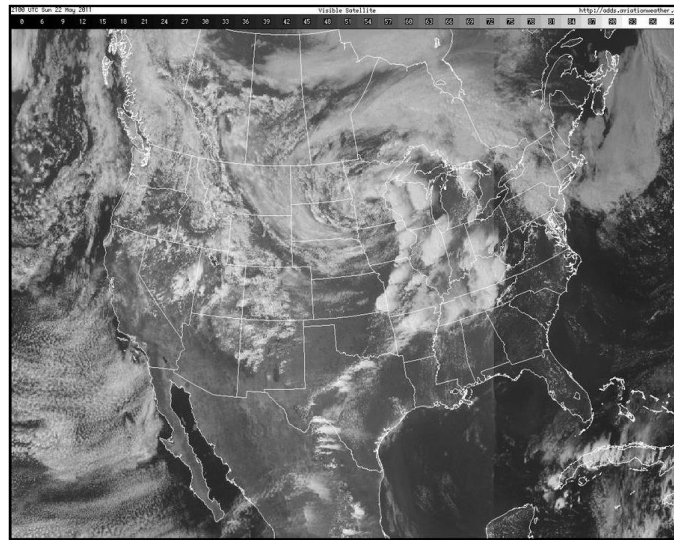
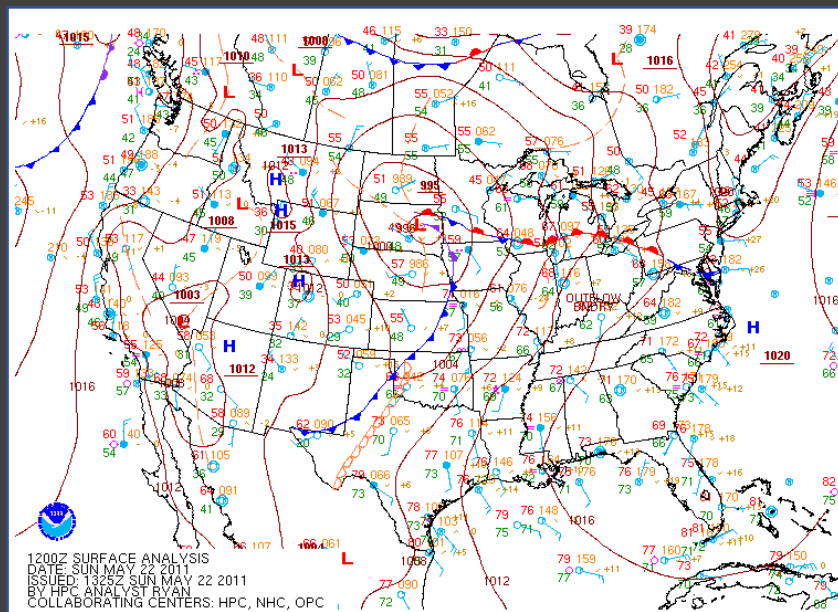
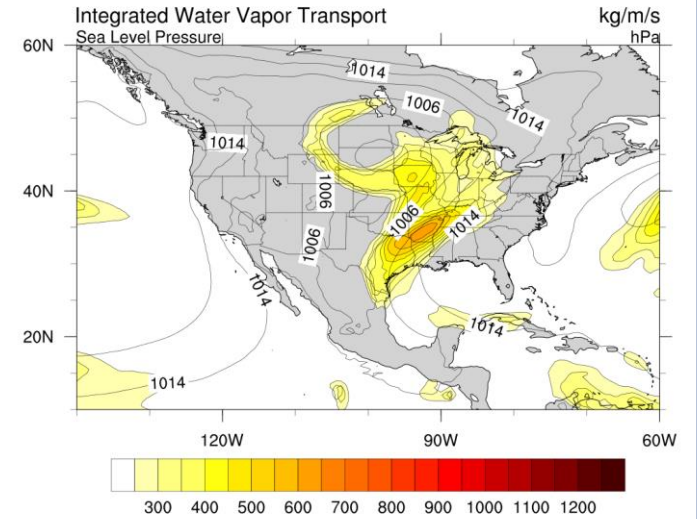
May 22, 2011



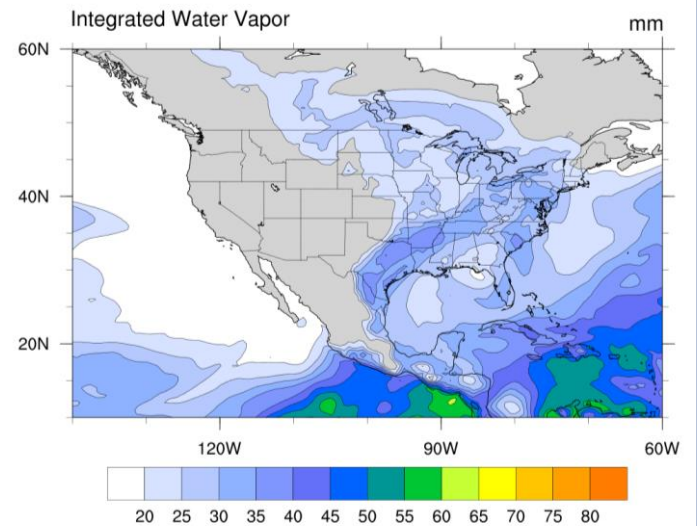
500 hPa Heights May 22 2011



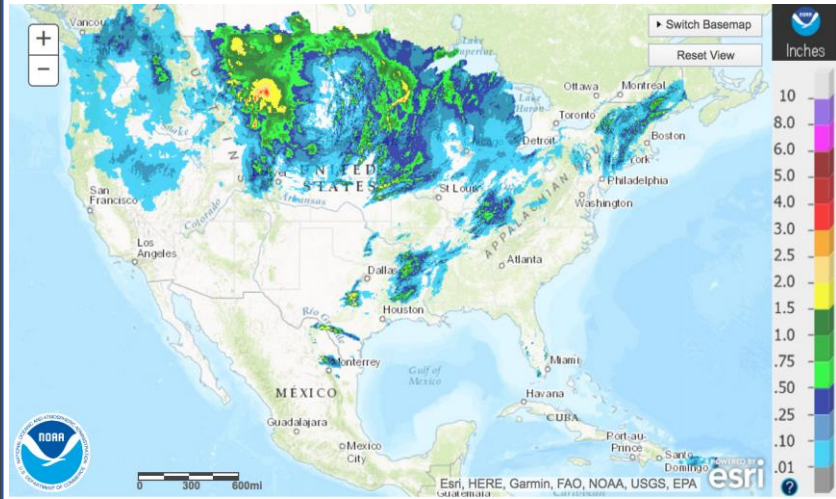
Average IVT for May 22 2011



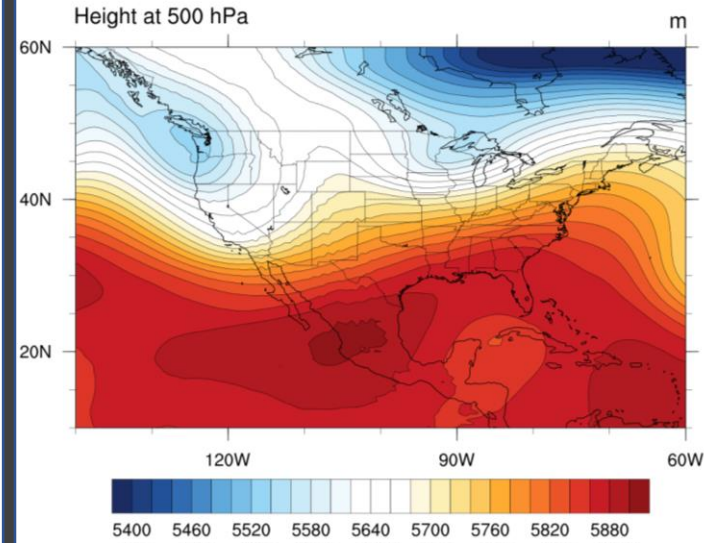
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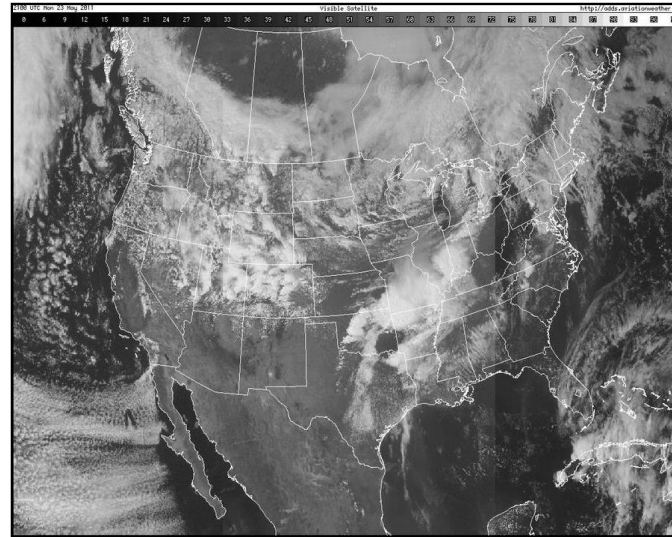
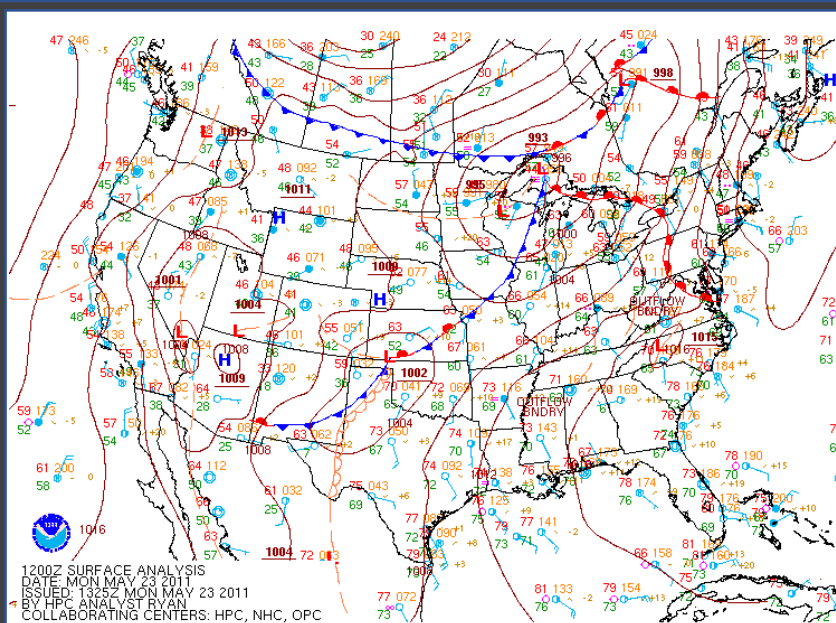
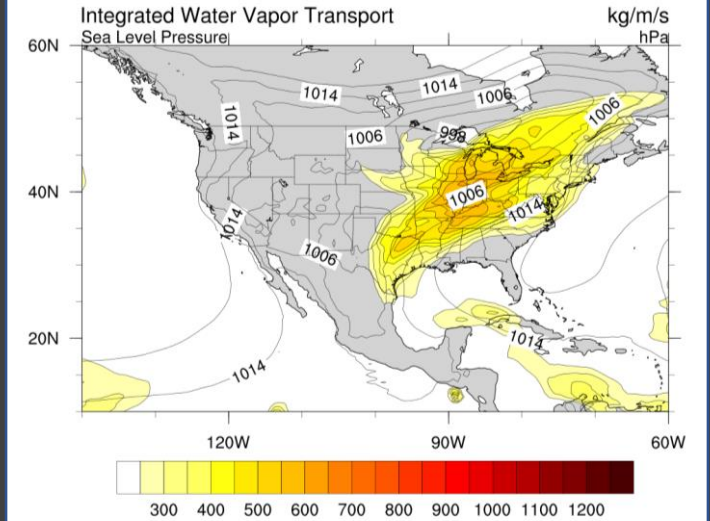
May 23, 2011



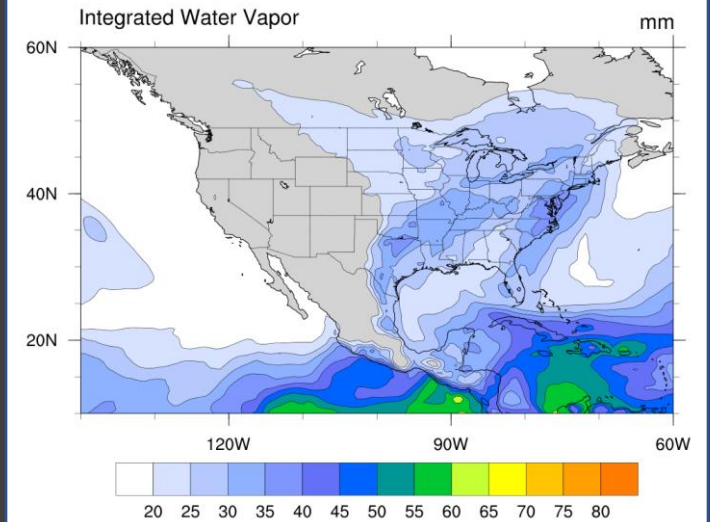
500 hPa Heights May 23 2011



Average IVT for May 23 2011

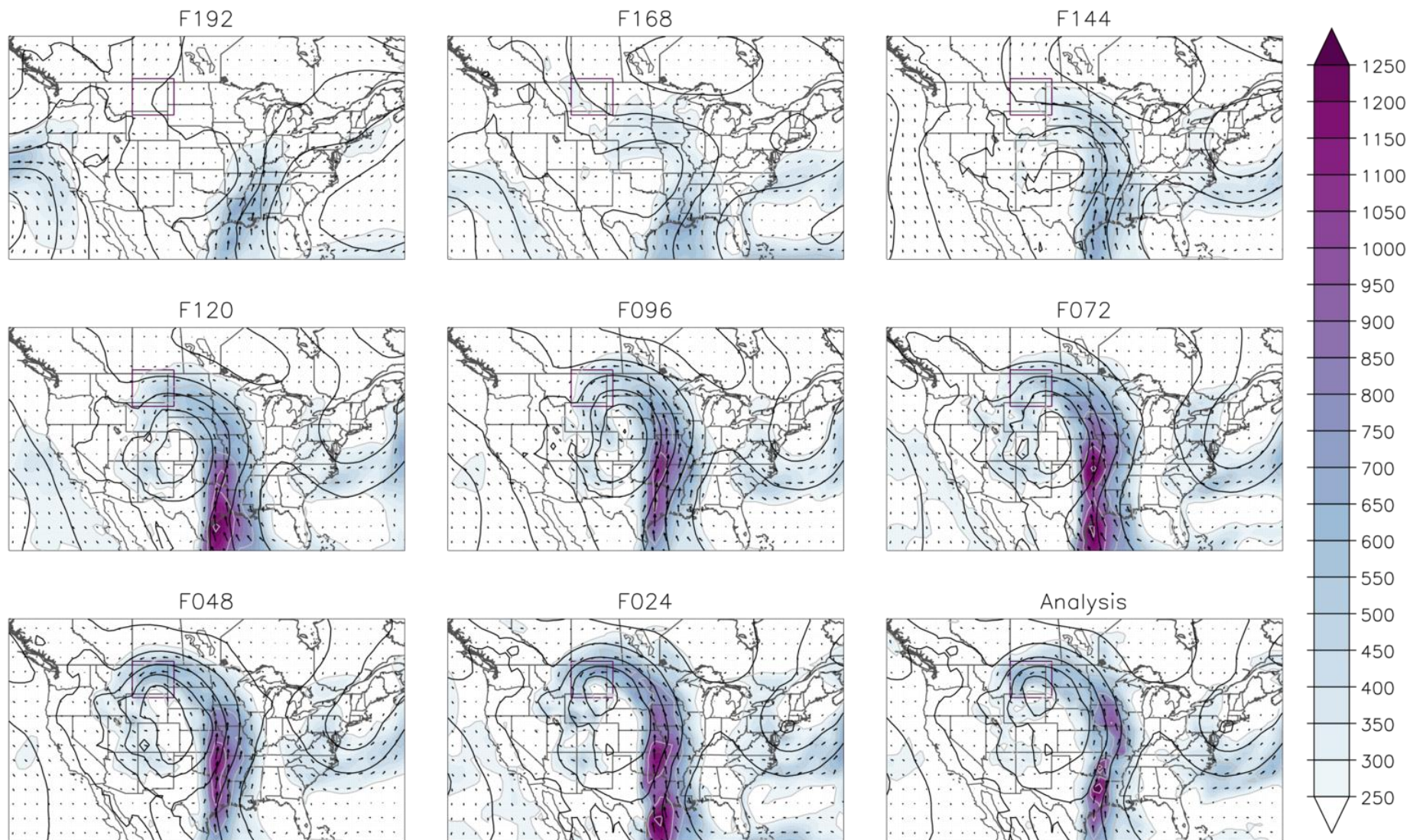


Average IWV for May 23 2011



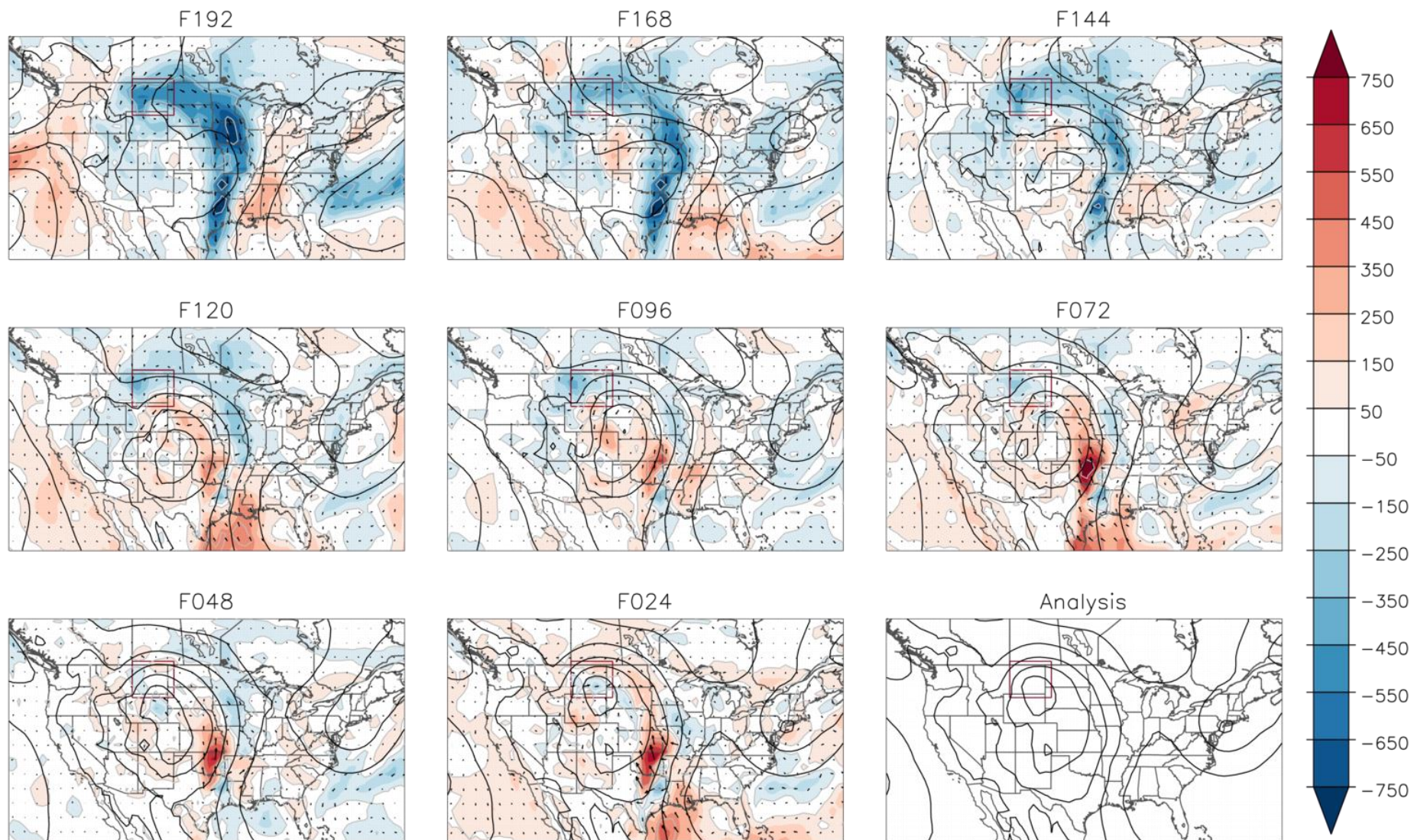
GEFS Mean Forecast Valid 00 UTC 21 May, 2011

Vertically-Integrated Water Vapor Transport (IVT)



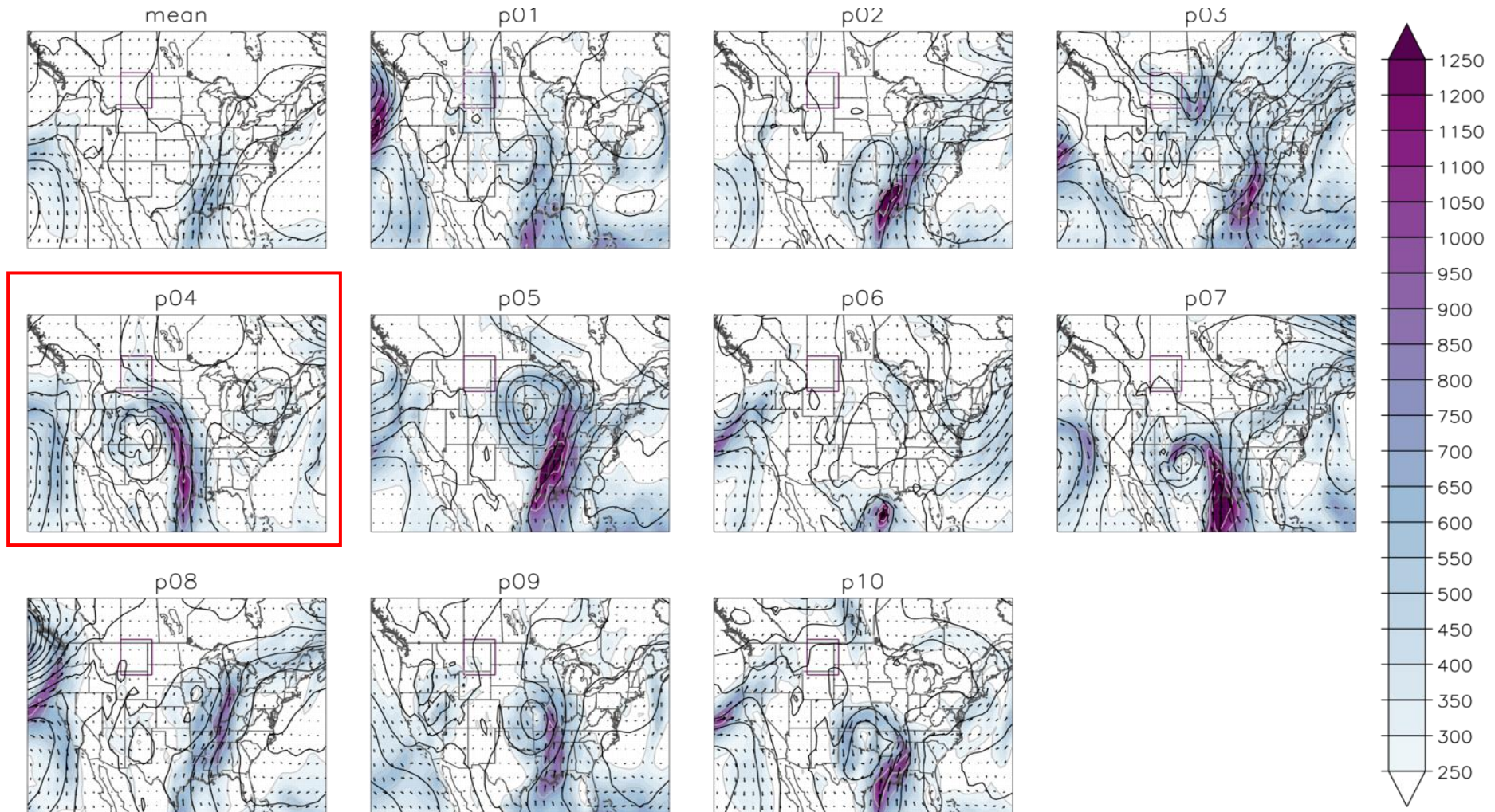
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Vertically-Integrated Water Vapor Transport (IVT)



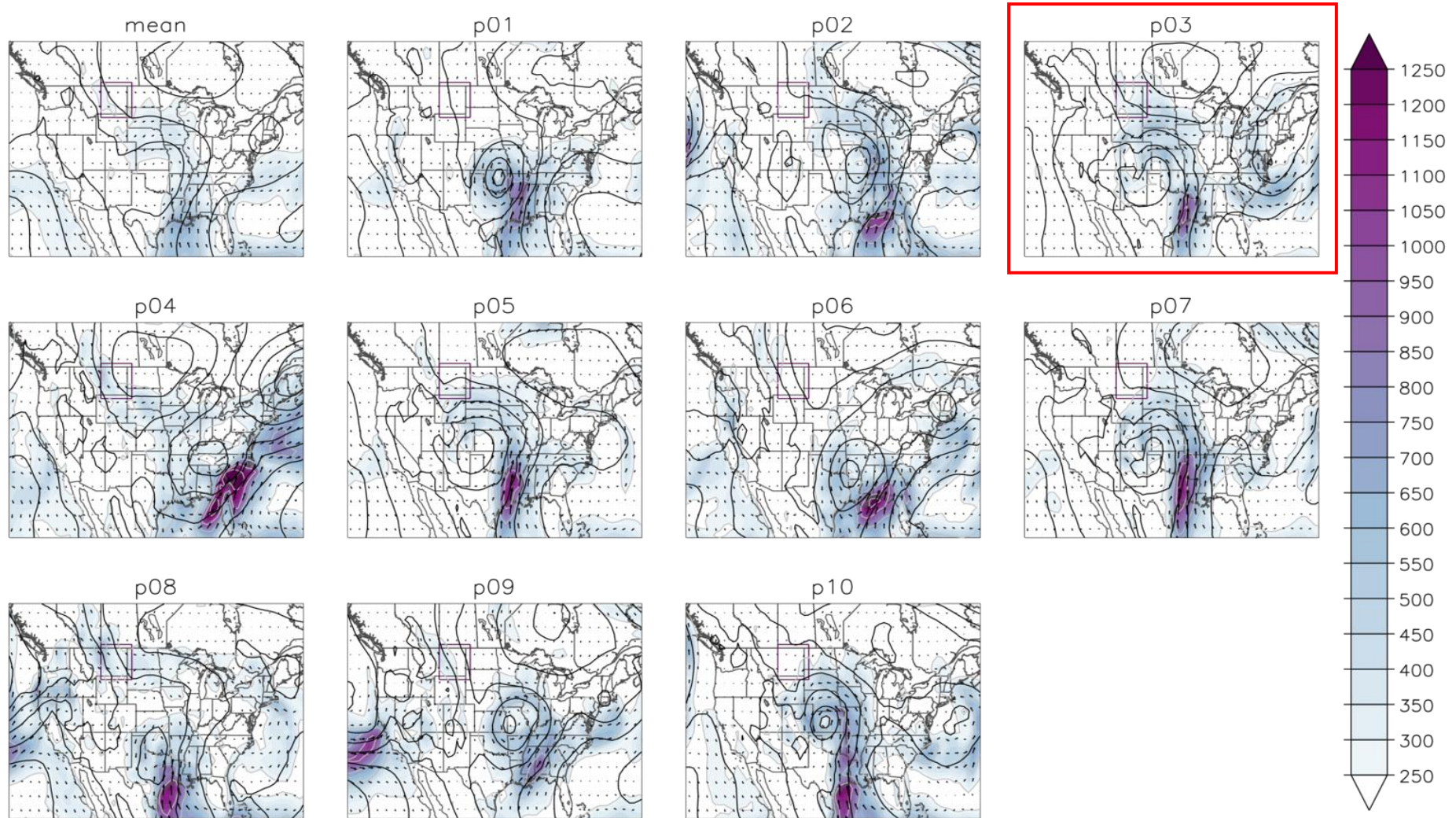
GEFS 192-h Forecasts Valid 00 UTC 21 May, 2011

Vertically-Integrated Water Vapor Transport (IVT)



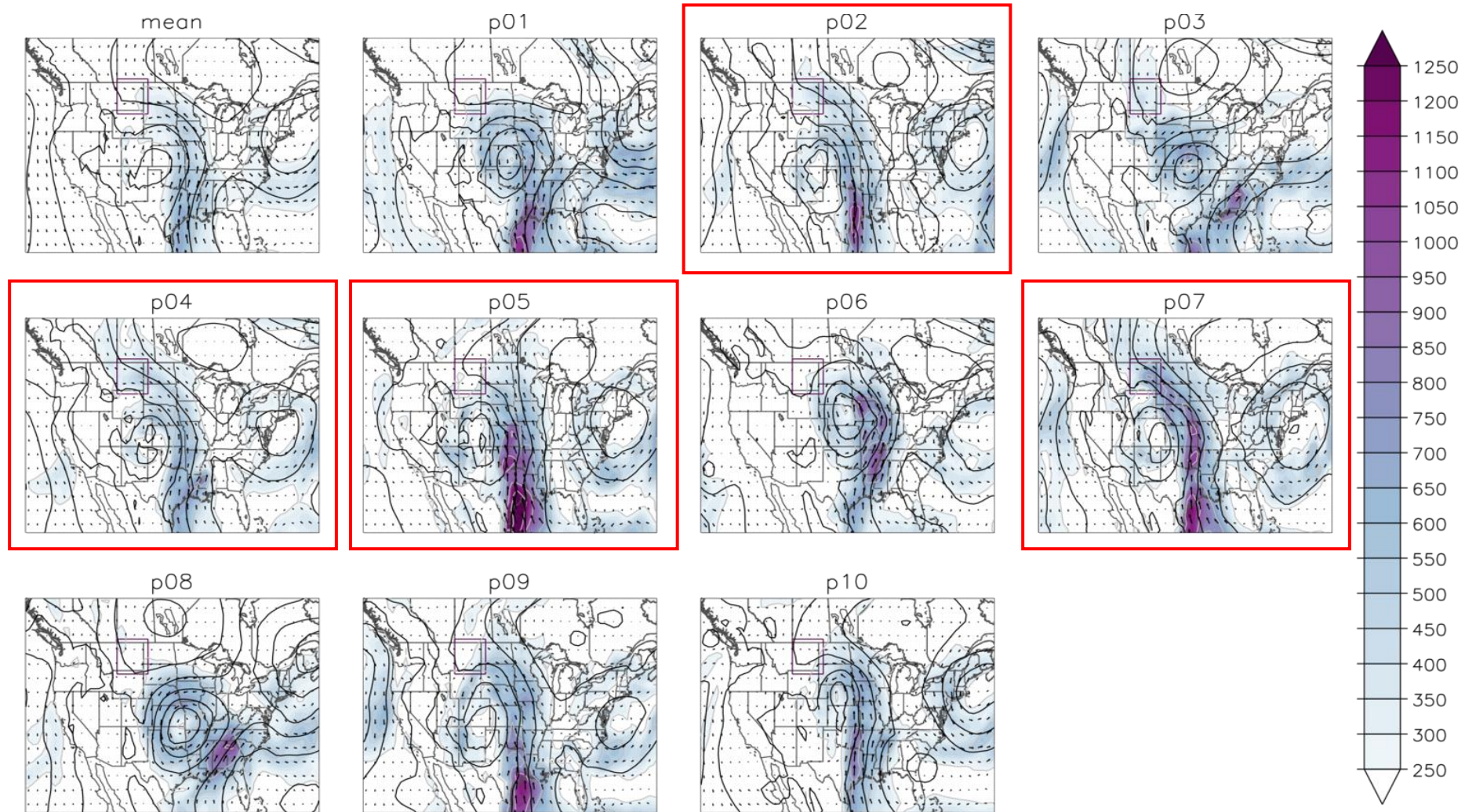
GEFS 168-h Forecasts Valid 00 UTC 21 May, 2011

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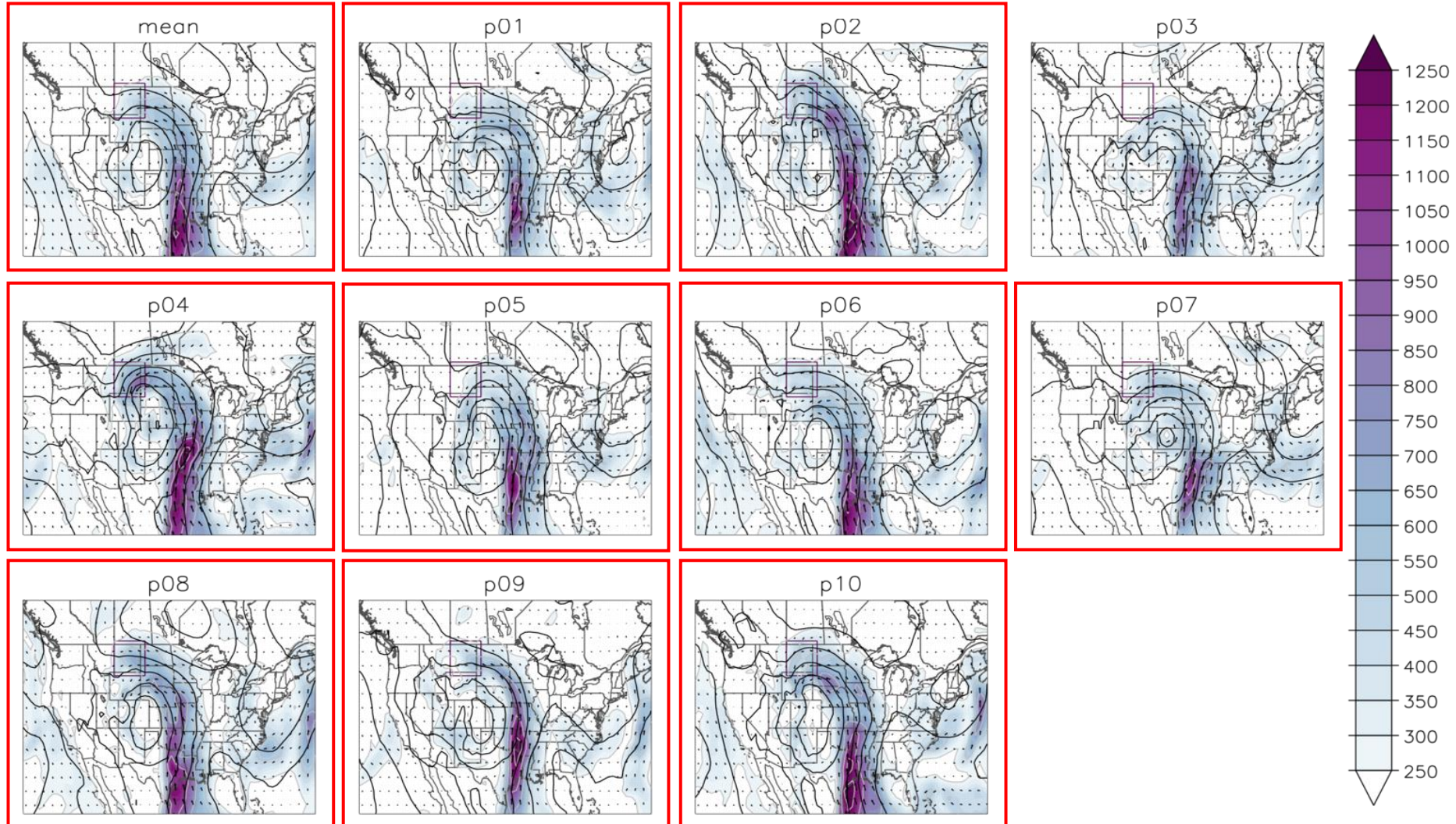
GEFS 144-h Forecasts Valid 00 UTC 21 May, 2011

Vertically-Integrated Water Vapor Transport (IVT)



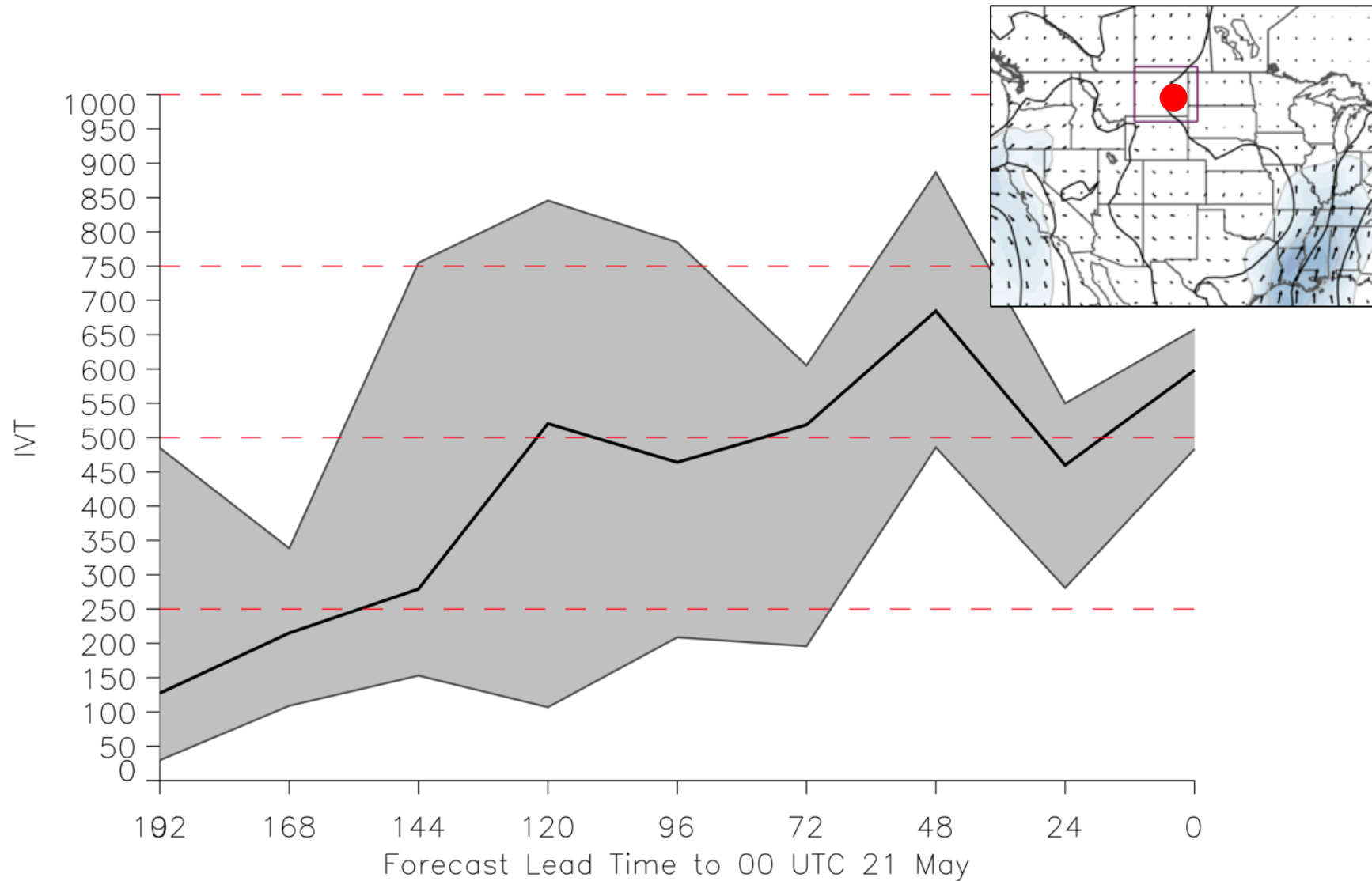
GEFS 120-h Forecasts Valid 00 UTC 21 May, 2011

Vertically-Integrated Water Vapor Transport (IVT)



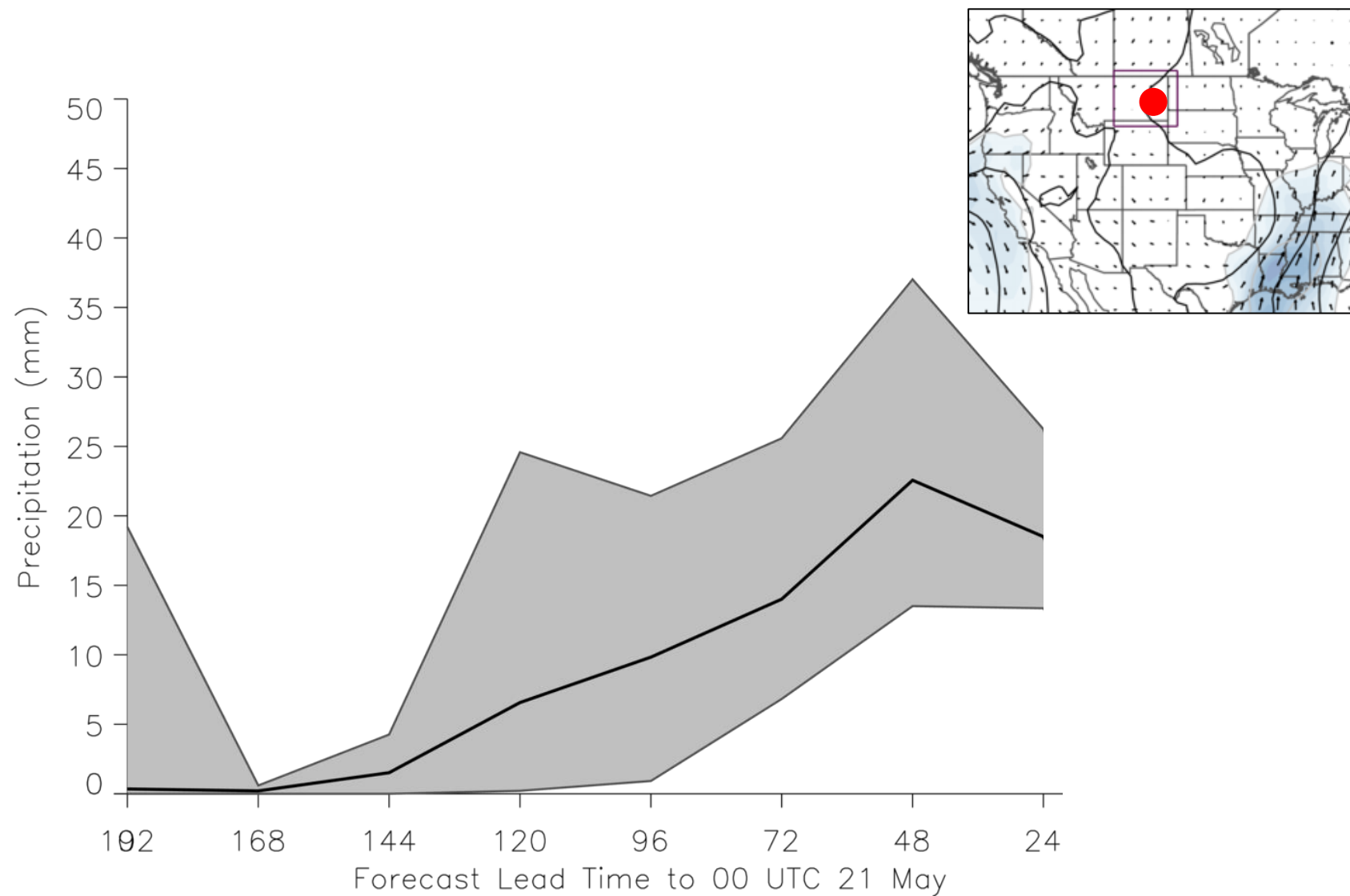
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Vertically-Integrated Water Vapor Transport (IVT)



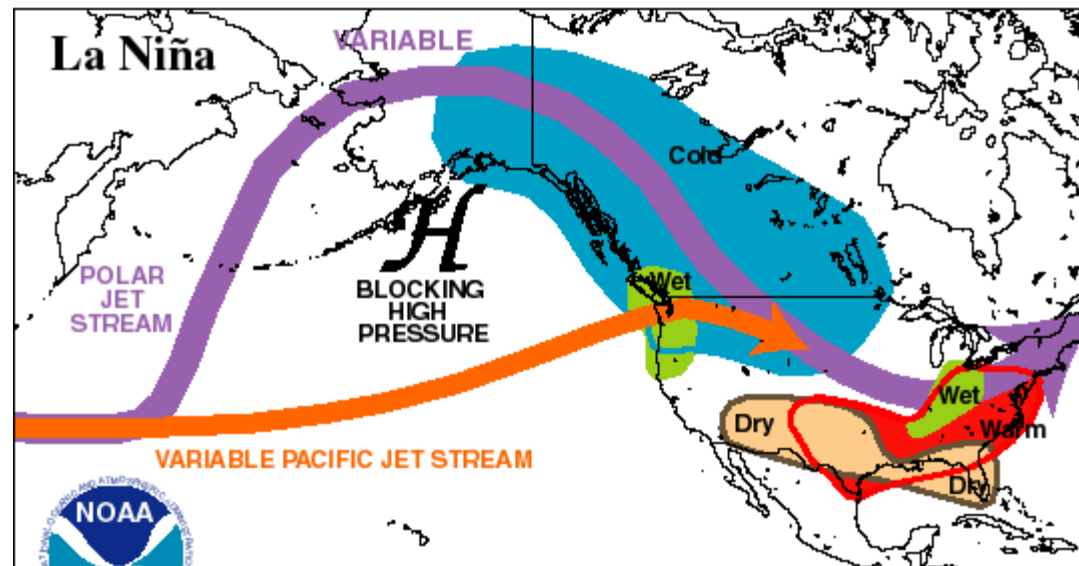
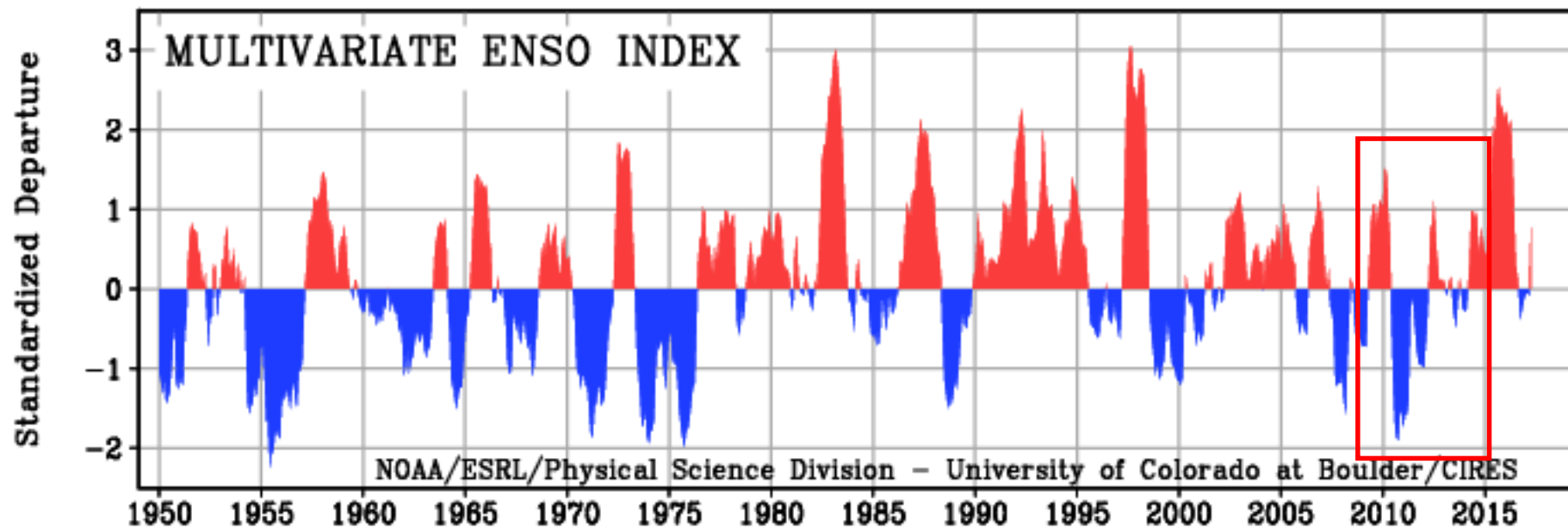
GEFS Forecast Valid 00 UTC 21 May, 2011

Precipitation



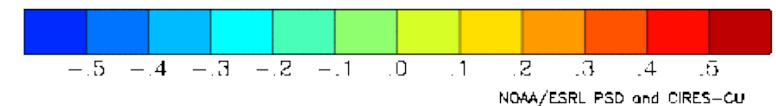
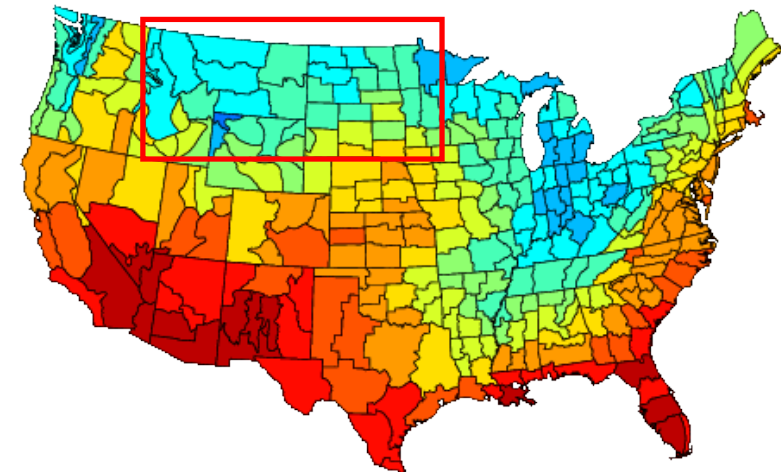
Summary

- A cyclone developing over the central Plains led to the development of an atmospheric river, which transported moisture northward and cyclonically around the low pressure system, producing heavy precipitation over MT
- GEFS mean does not signal northward extent of cyclone or intense IVT until ~120-h forecast lead time
 - GEFS-mean QPF struggled to “catch up”
- What about performance of the EC or other NWP
- Important to remember that even a relatively weak event being forecast would be cause for concern given environmental preconditioning



Climate Prediction Center/NCEP/NWS

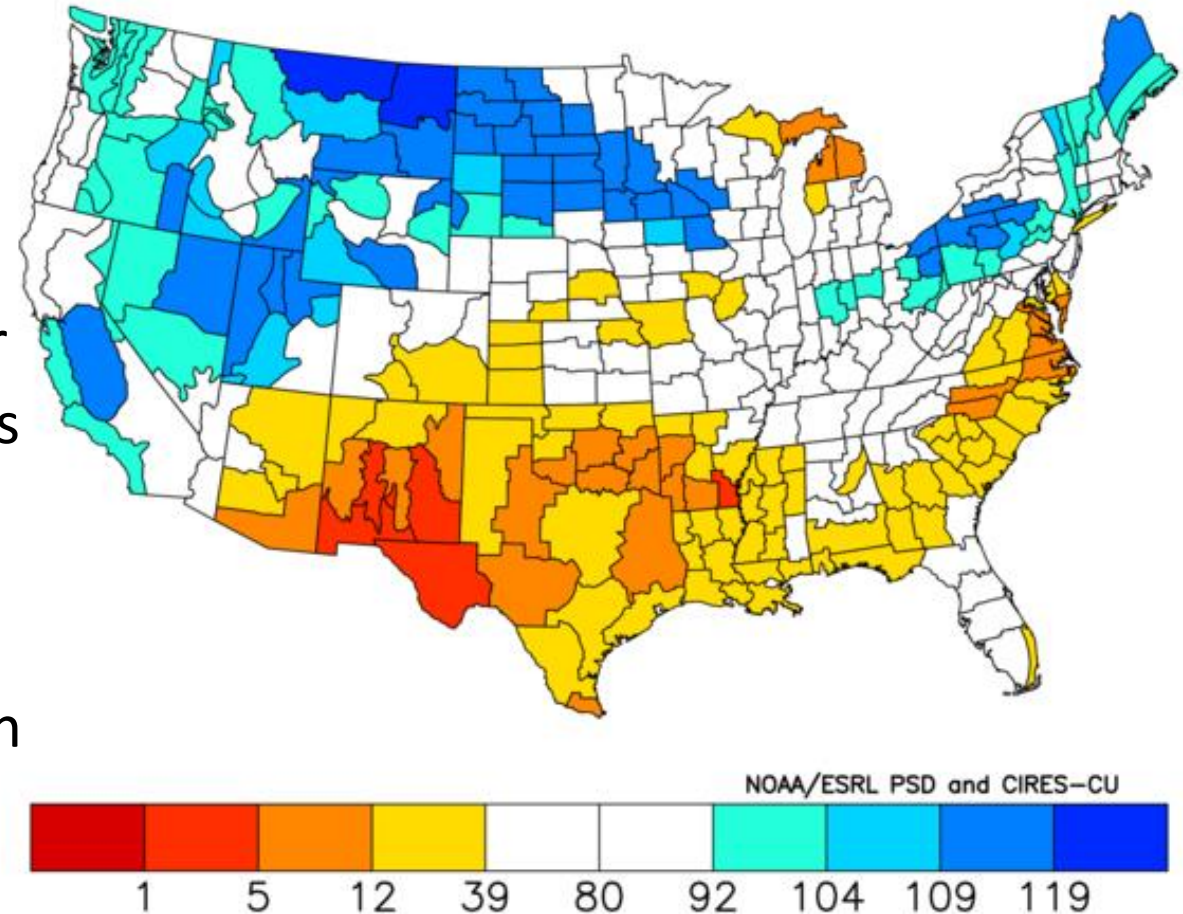
Correlation Precipitation Jan to May
With Jan to May Nino3.4
1948 to 2015



Environmental Preconditioning

- Northern Plains saw 100-400% above normal precipitation from June – November 2010
 - Some states hit wettest year records
 - Soil moisture also above normal 20-100% in MT, stayed above normal throughout winter
 - 2010-2011 snow season set snowfall records in many cities
 - Eastern MT saw up to 400% normal precipitation during DJF
 - Snow accumulation continued into May with peak SWE values near beginning of May, with 18-30 in. of SWE over the Missouri Basin mountain headwaters

NOAA/NCDC Climate Division Precipitation Rank Relative to 1895–2016
Nov to Mar 2010–11



May 2011 Precipitation and Snowpack Overview

- May 20-21st event not isolated
 - Parts of eastern MT saw as much as 15 in. of rain in May 2011 (400-600% of normal)
 - High rain amounts continued into June prolonging elevated flood stages
- A wet cool season had produced abundant snowpack across the northern Rockies
 - Much of this in areas that drain into the Missouri river and passing through eastern MT

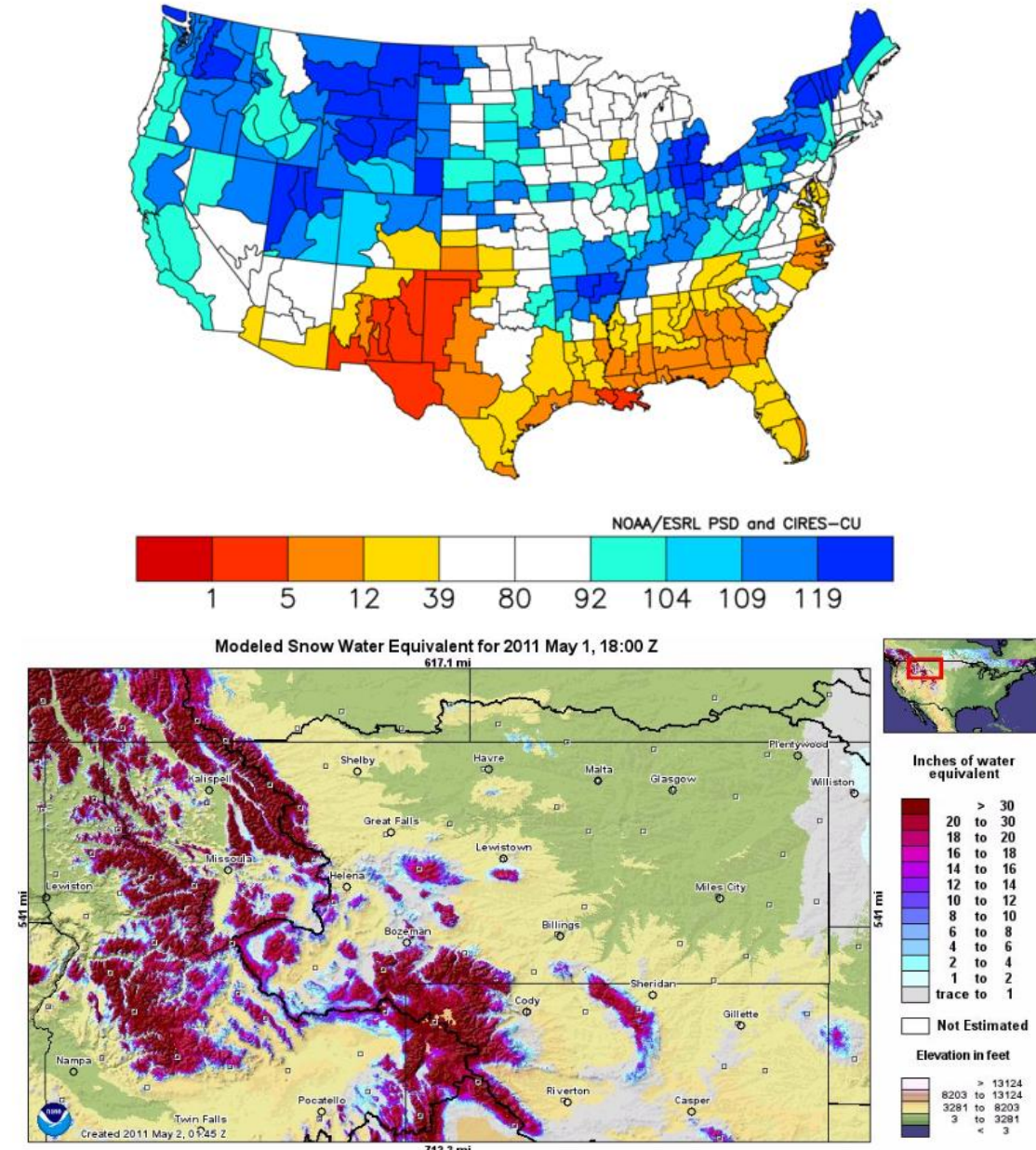
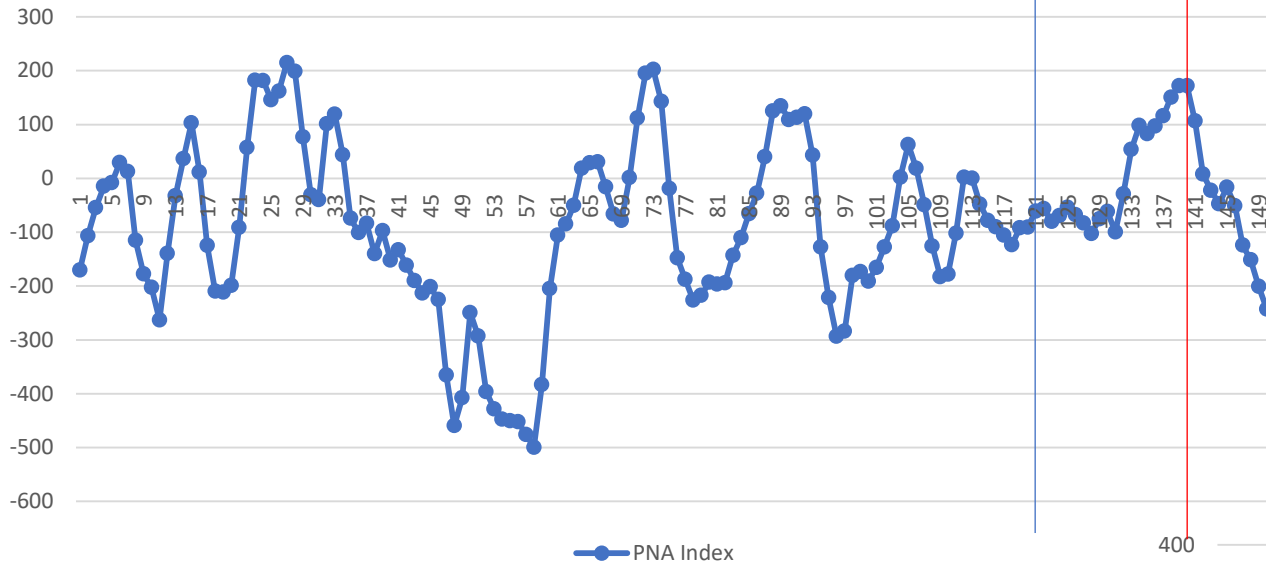


Figure 14. Modeled snow water equivalent for May 1, 2011.
Image courtesy of NOHRSC.

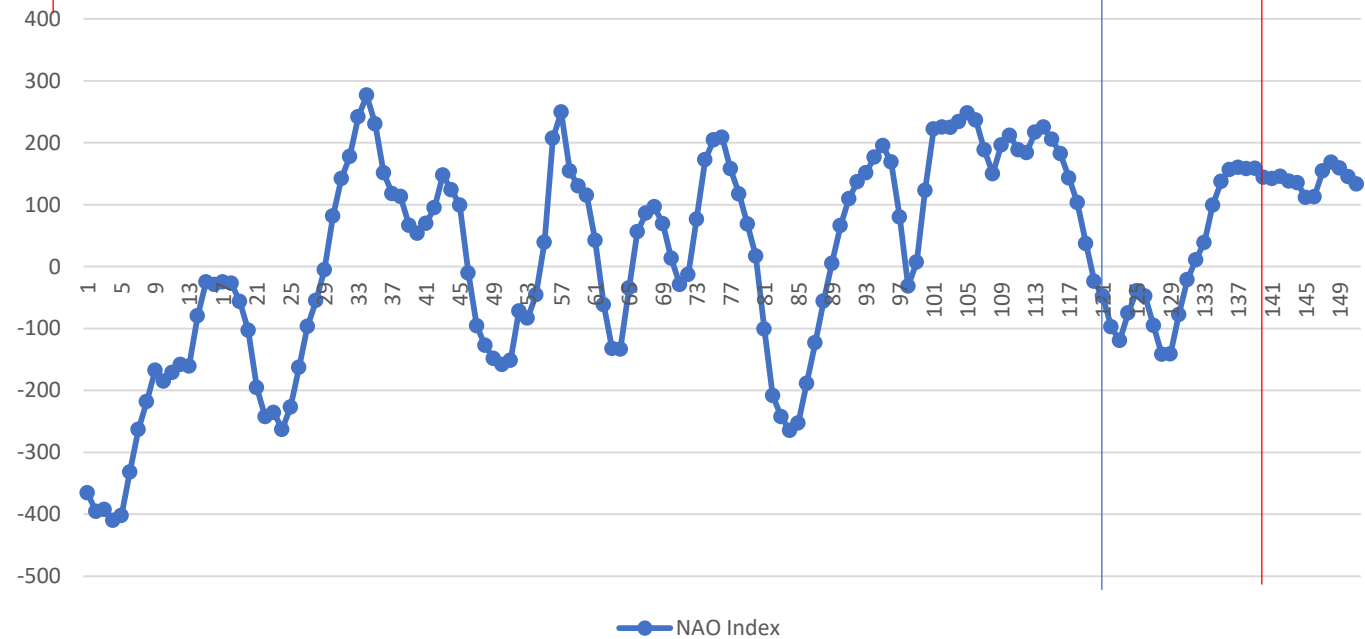
PNA and NAO Climate Indices

PNA Index January 1, 2011 - May 31, 2011

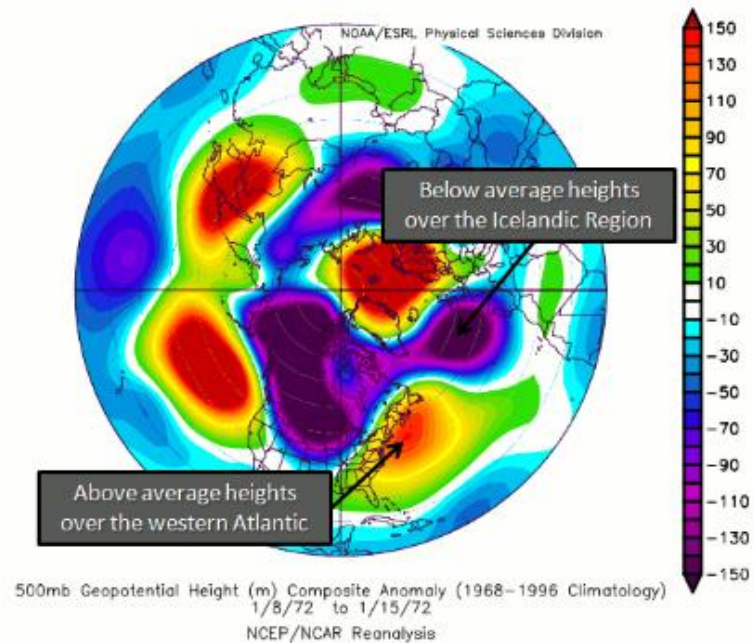


- Features to note:
 - Rapid increase in index strength
 - Both changing from neutral to positive
 - Both indices above 100 (fairly strong signal)
 - Difference in duration of sign and magnitude

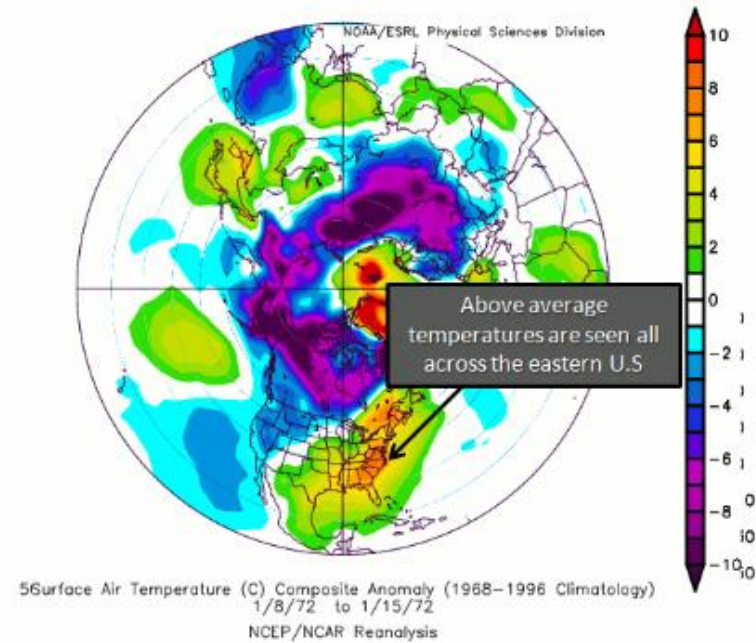
NAO Index January 1, 2011 - May 31, 2011



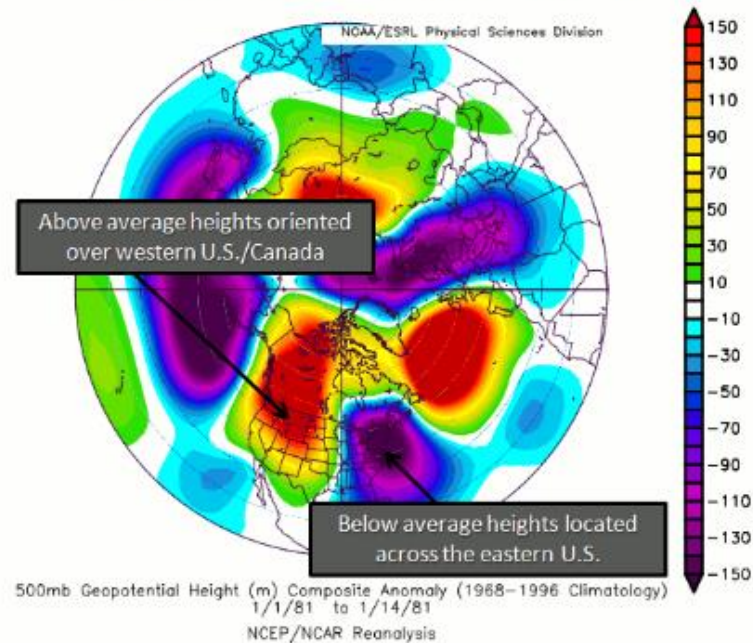
500mb Height Anomalies During a Positive NAO



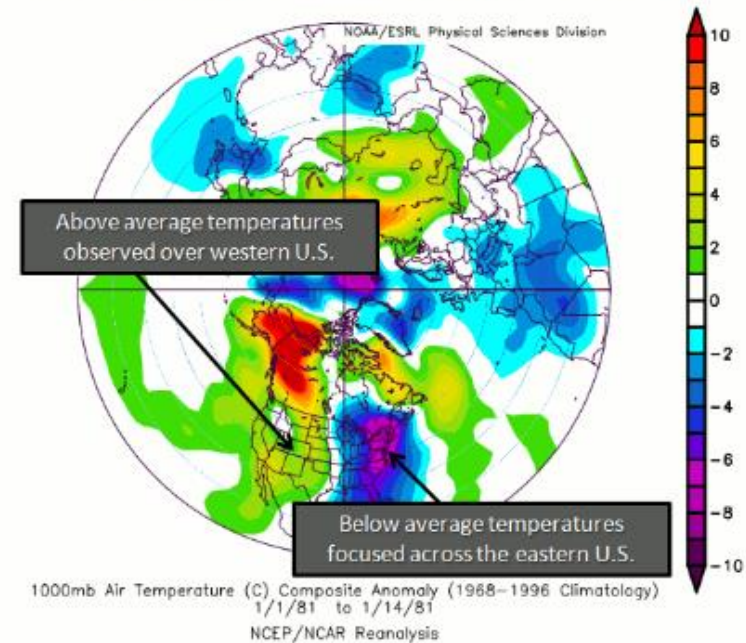
Surface Temperature Anomalies During a Positive NAO



500mb Height Anomalies During a Positive PNA

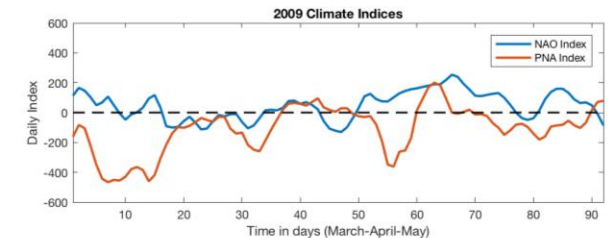
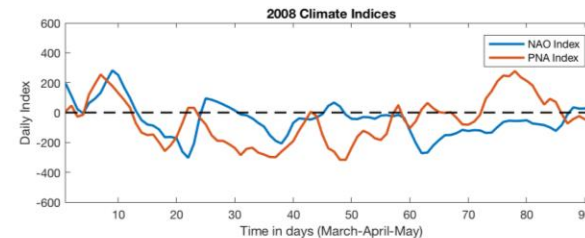
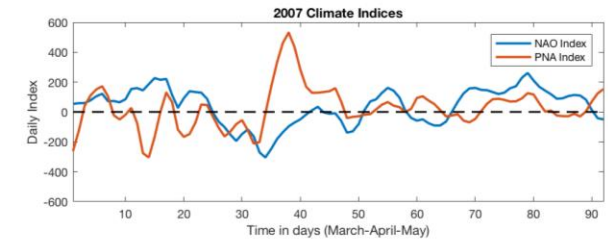
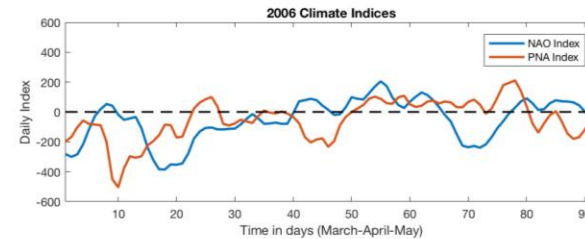
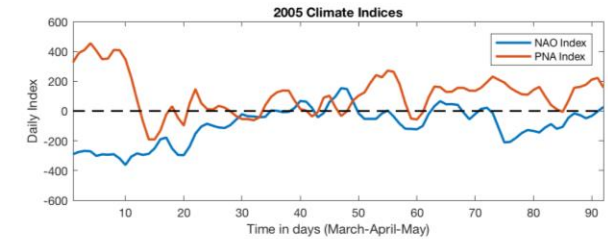
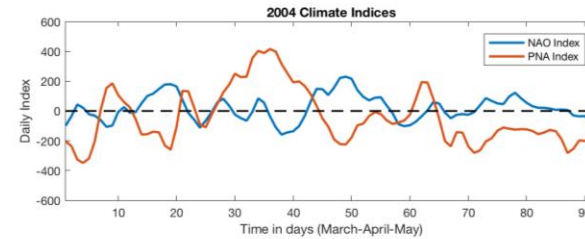
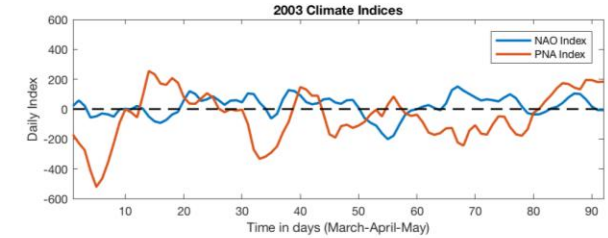
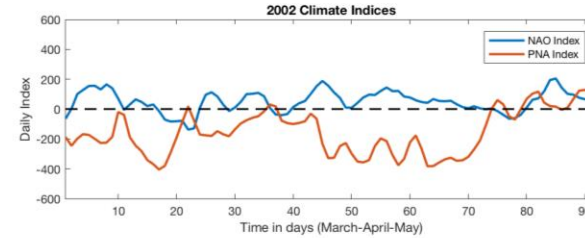
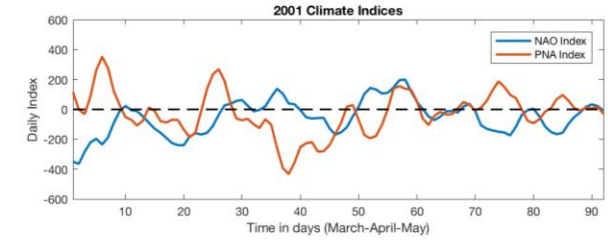
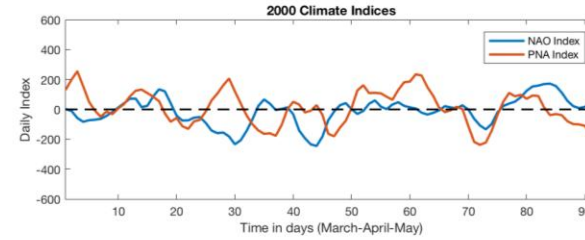


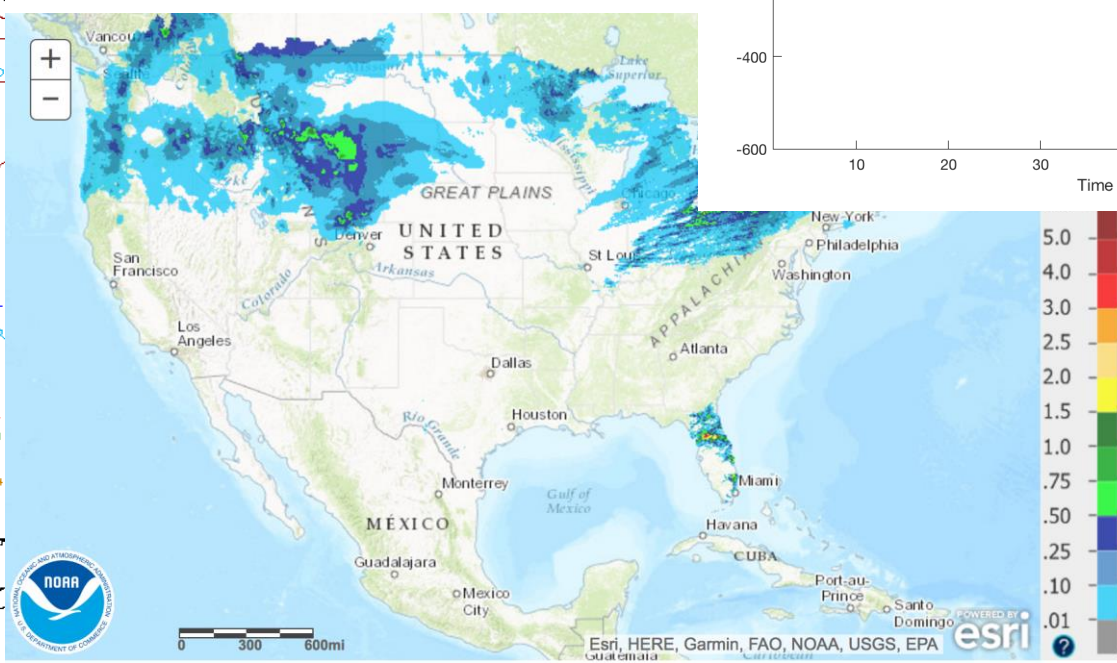
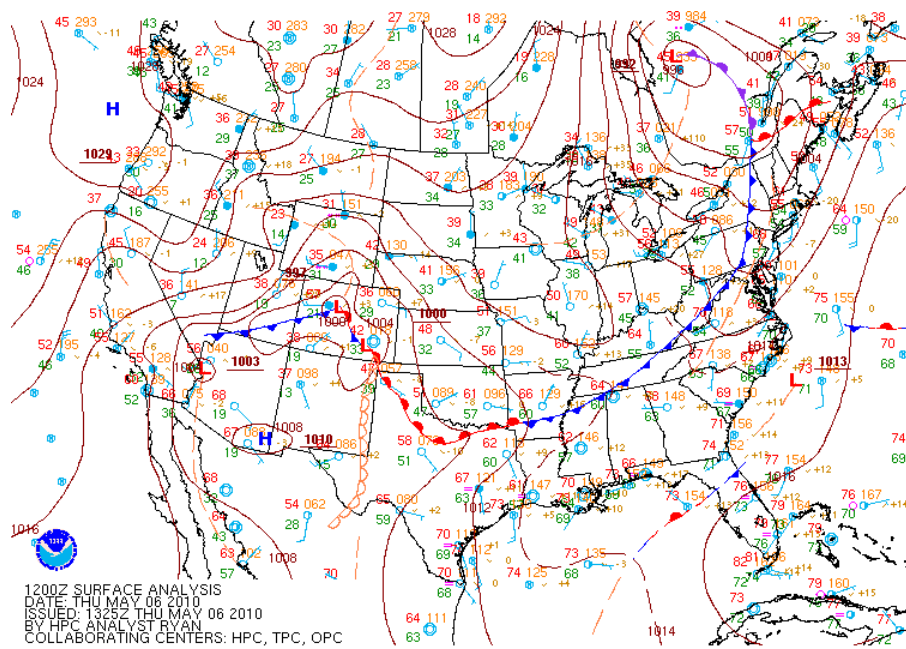
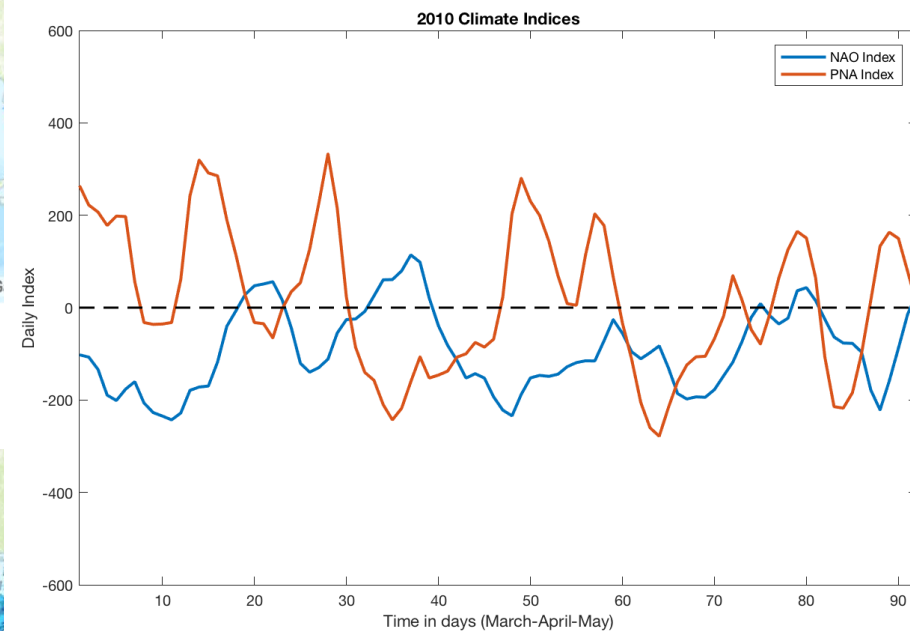
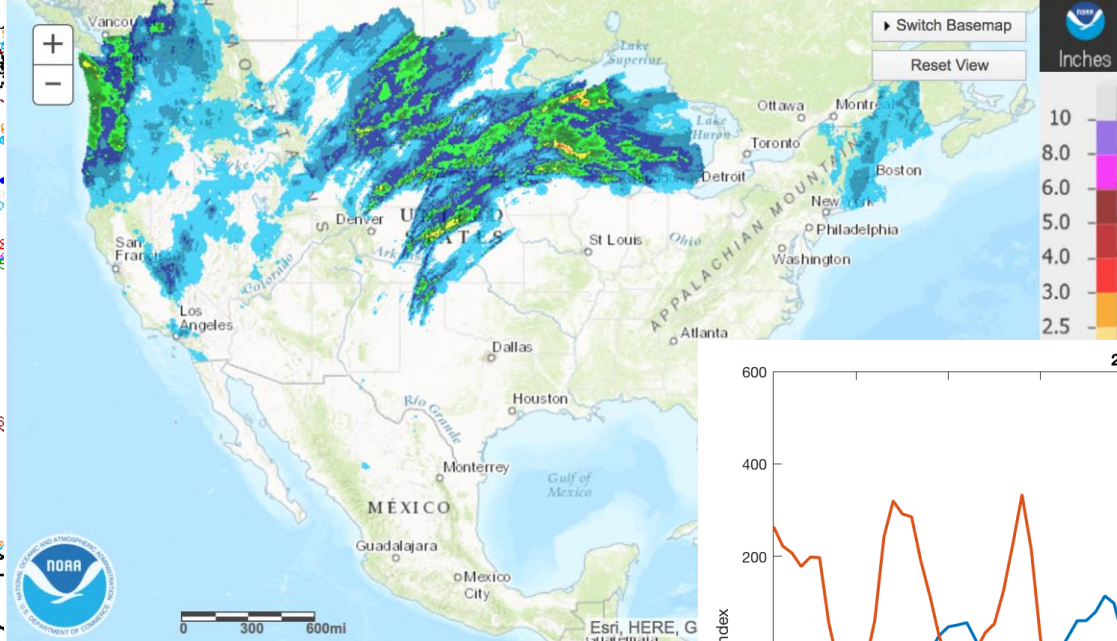
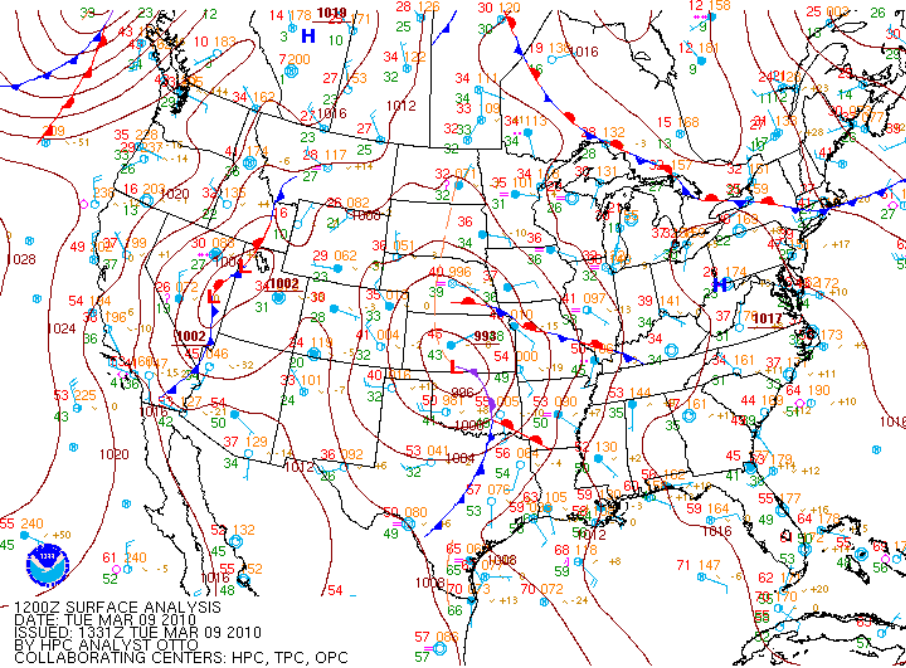
Surface Temperature Anomalies During a Positive PNA

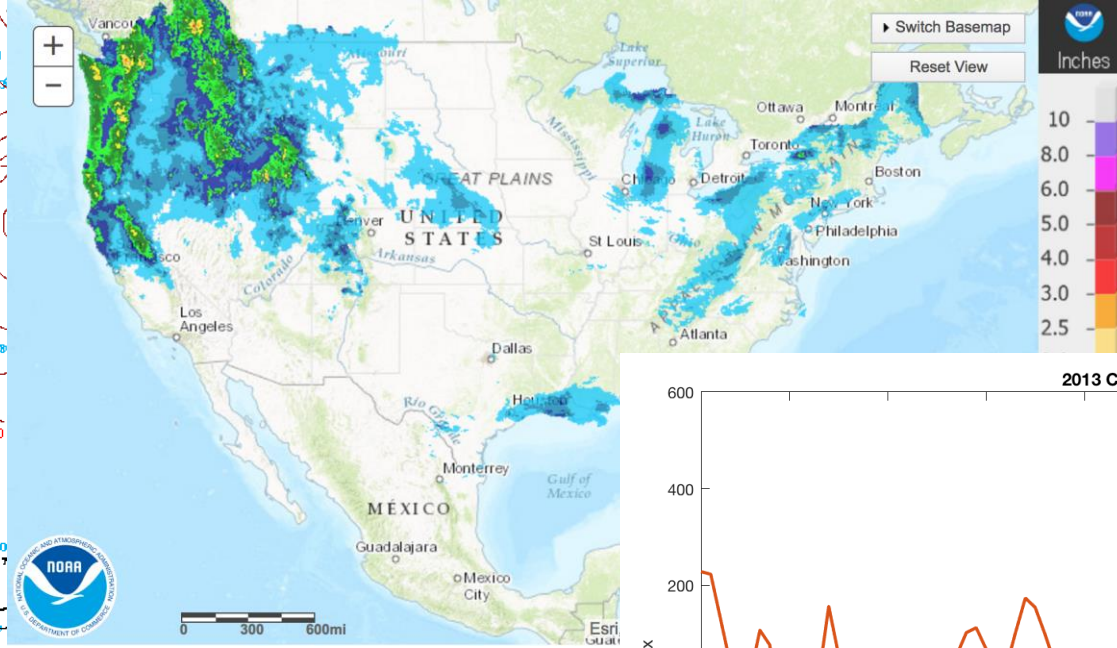
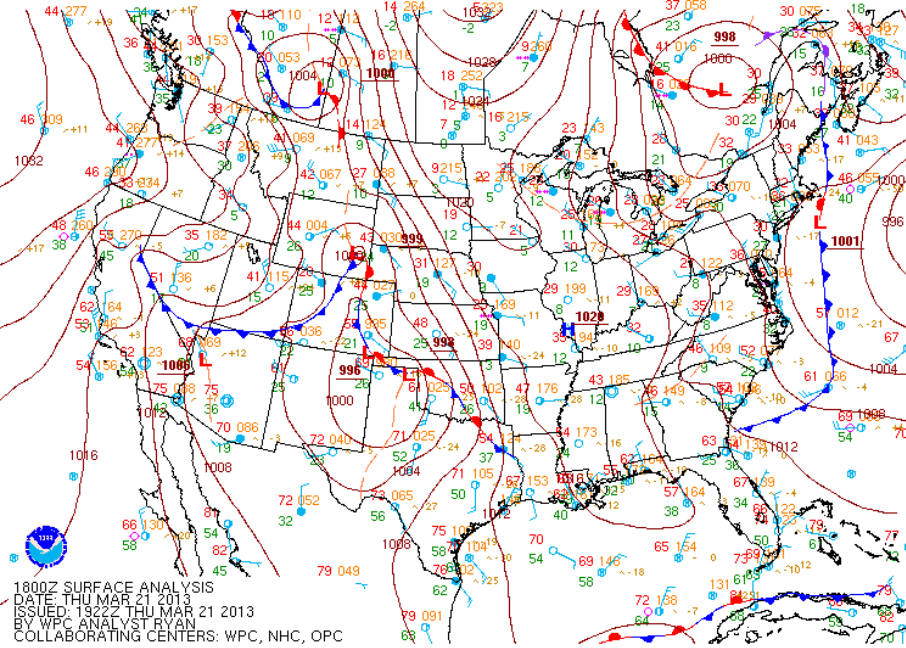


Looking to the past...

- During March-May, many instances of rapidly changing indices and both indices of the same sign
- In the past 7 years (2010-2016), looked for similar trends in the time series to see if similar events occurred

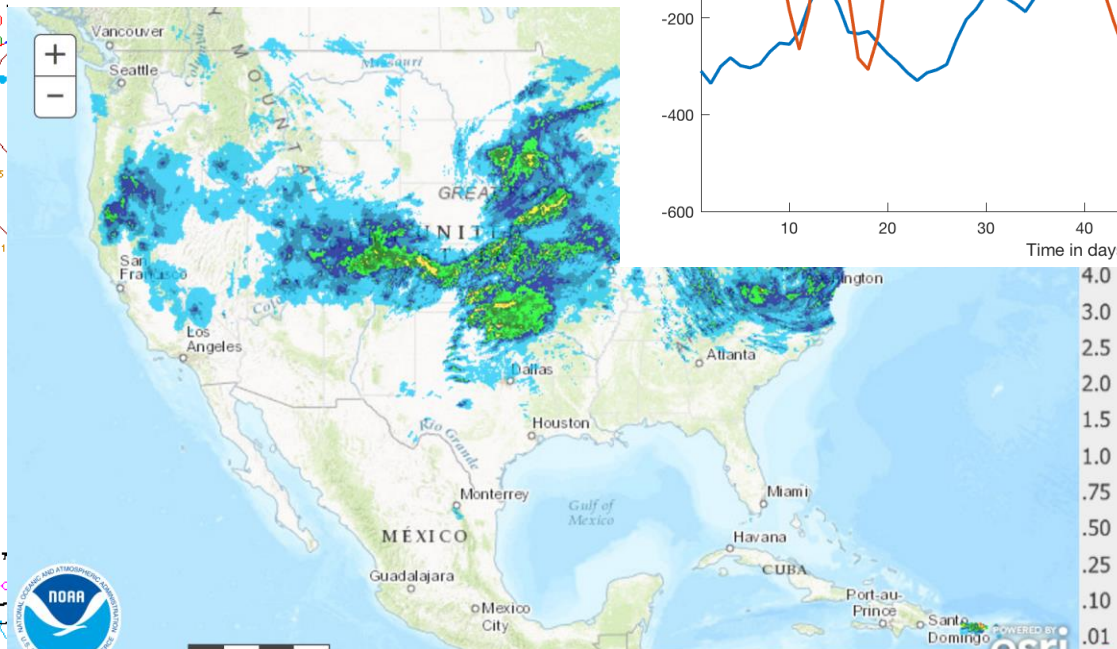
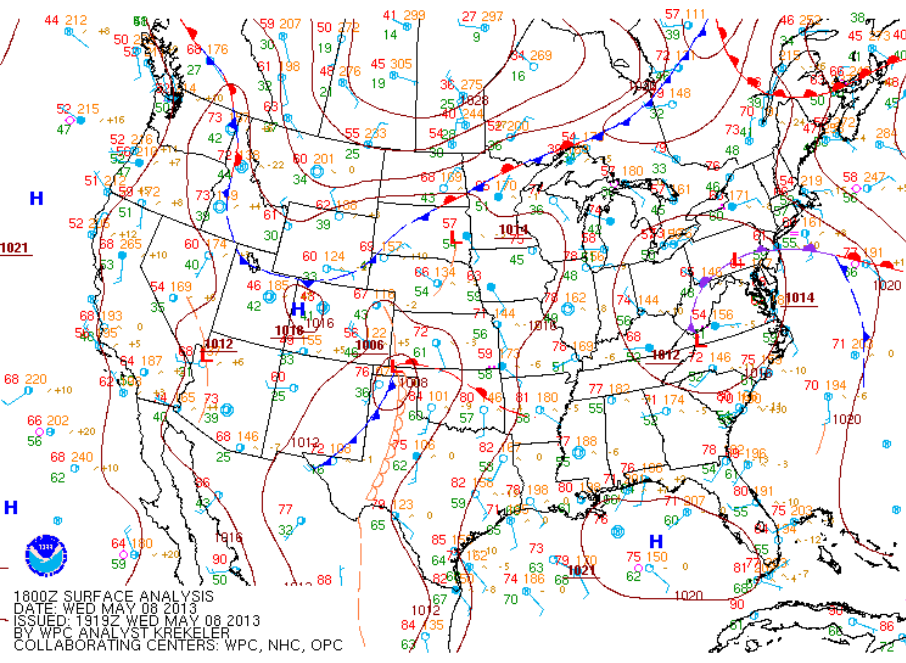
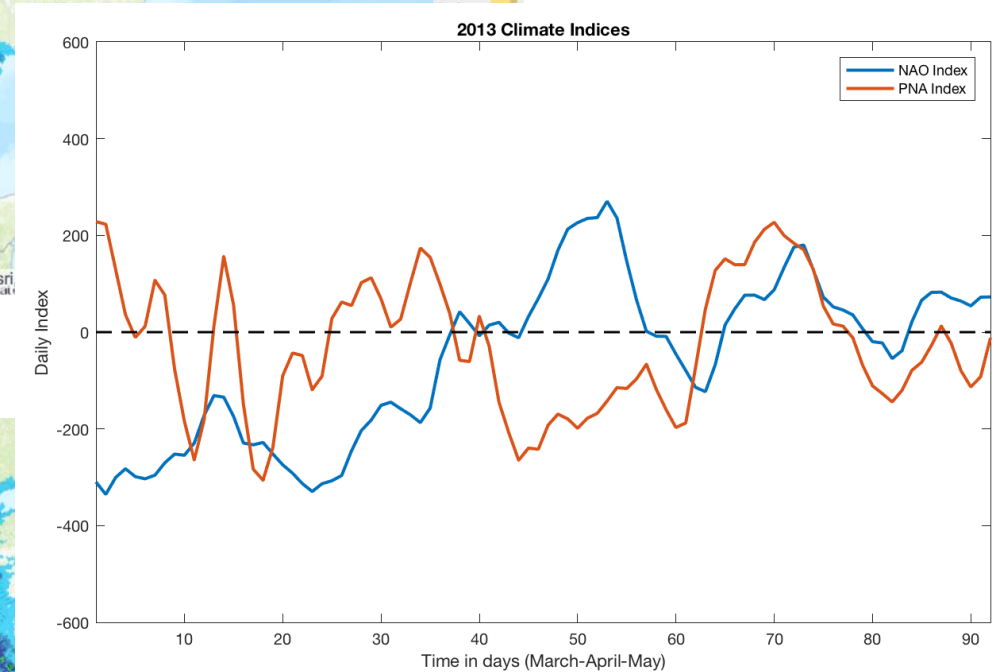






March 21, 2013

- Large change in signal
- Period of both negative

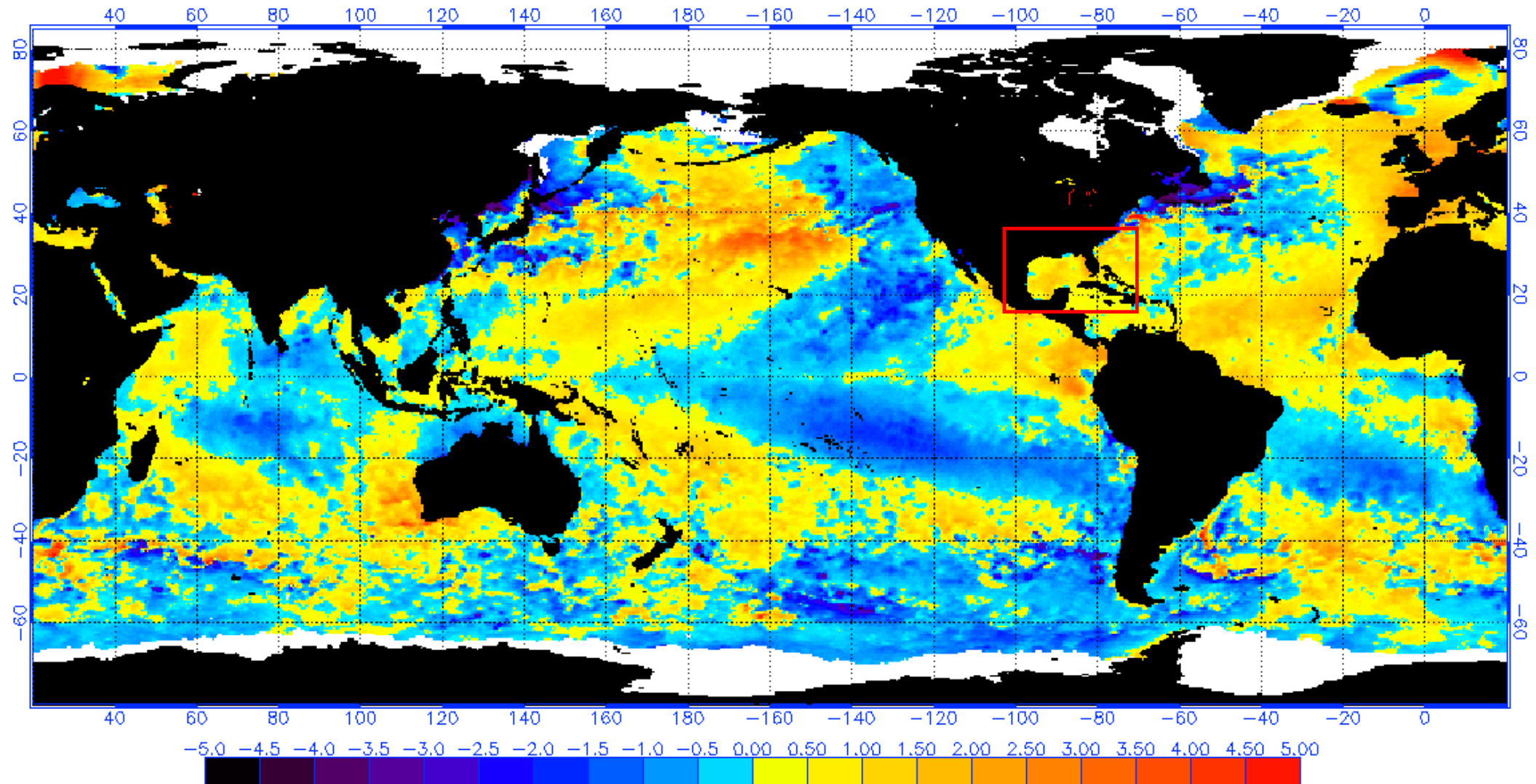


May 9, 2013

- Large change in signal
- Period of both positive

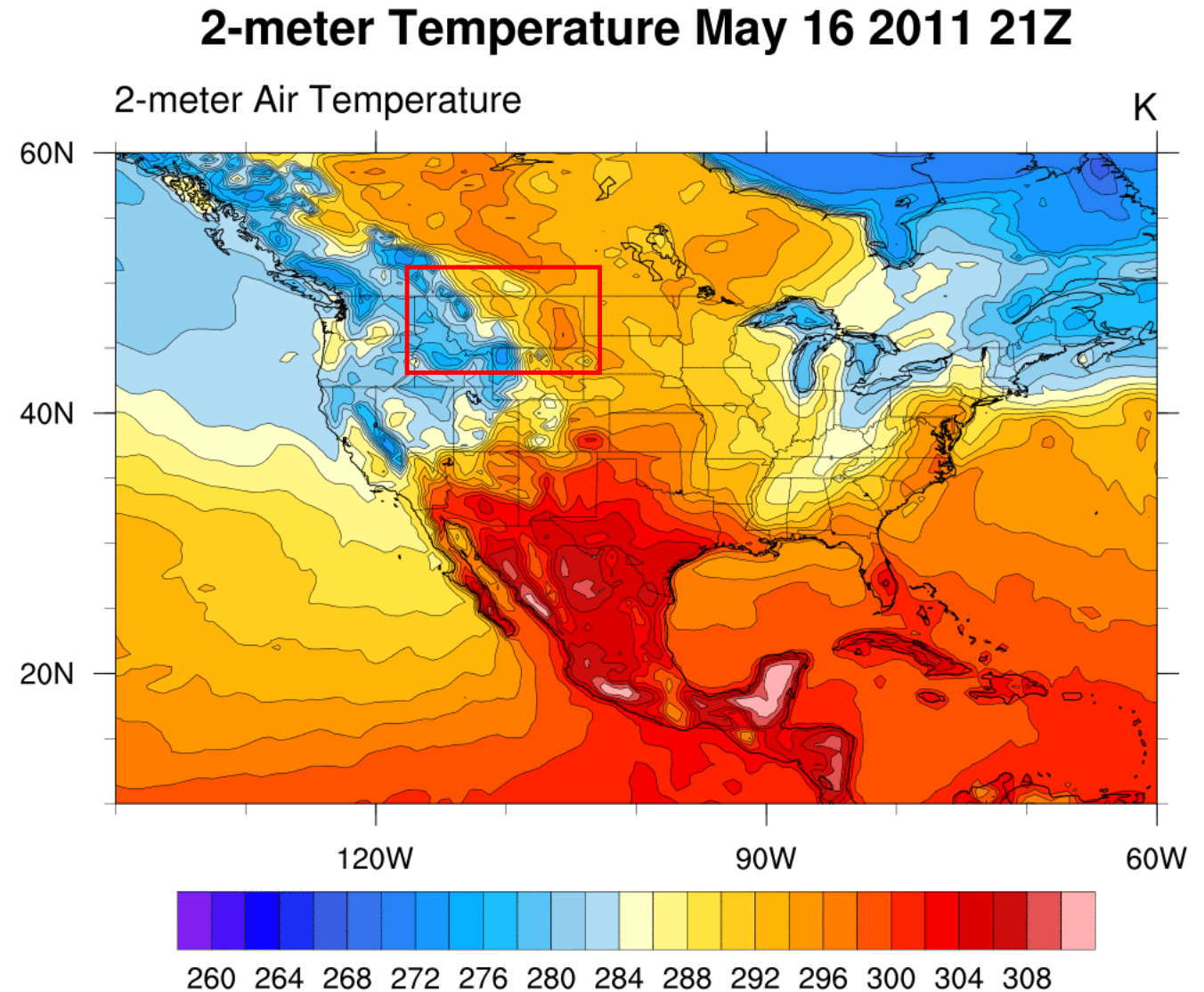
Global SST Anomalies 5.9 – 5.19

NOAA/NESDIS 50 KM GLOBAL ANALYSIS: SST Anomaly (degrees C), 5/9/2011
(white regions indicate sea-ice)



Was there a rapid warm up during the event?

- Temperatures generally warm from the 16th through 23rd, both during the day and overnight
- Initially (16th /17th), temperatures do not support much snow melt, particularly in the mountains or overnight
- Starting on the 20th, temperatures increase to the mid-60's and the higher elevations rise to the high 30s – mid-40s
- After the 21st, warm temperatures throughout MT promote snow melt, even at higher elevations



Summary of Predictability

- Above average soil moisture and snowpack accumulated during winter months due to La Nina conditions
- The rapidly changing and unstable PNA/NAO pattern led to the notion of potential instability
- Anomalously warm SSTs in the Gulf region, the moisture source for the AR, provided extra energy
- As the event unfolded, temperatures rapidly warmed also contributing to higher impacts