

# Flooded in Drought? An Examination of the Frequency of Drought Conditions in the Southern United States in Relation to High Flow Conditions on the Mississippi River at Memphis, TN



Royce Fontenot  
NWS/Lower Mississippi River Forecast Center  
Slidell, LA

## Background

- In 2011 The Ohio and Mississippi Rivers reached record or near record levels while at the same time portions of the southern United States were experiencing severe to extreme drought conditions.
- The flooding along the Mississippi River system was extreme enough that the U.S. Army Corps of Engineers operated all three floodways for the first time in history.
- Many areas in the lower Mississippi River basin had drought related restrictions in place (such as fire bans, water restrictions) while actively flood fighting.
- Drought conditions in neighboring states such as Texas reached critical levels with many reservoirs reaching record low levels.
- The question: How often does severe drought occur when the Mississippi River is at elevated levels and are the two related?

## Data

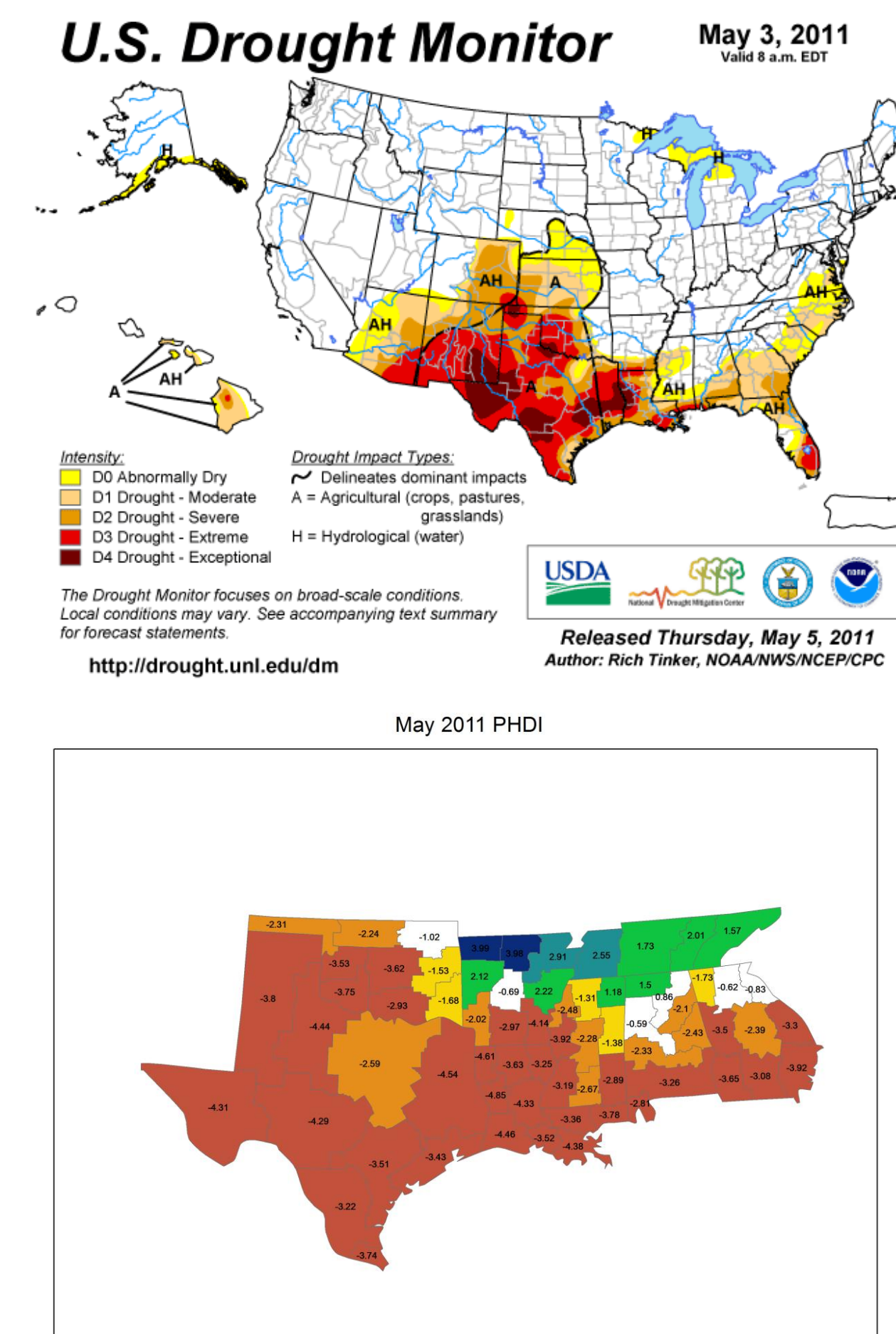
- Memphis, TN was selected at the study point for high flows due to its data record and location just downstream from the confluence of the Ohio and Upper Mississippi Rivers
- Mean monthly flow data was obtained from the USGS Hydro-Climatic Data Network (HCDN) Streamflow dataset and the Army Corps of Engineers
- PHDI, SPI, and ENSO data were obtained from NCEP. ONI data from before 1950 were calculated from the ERSST.v3b dataset for the Niña 3.4 region.
- Upper Air data was obtained from the NOAA/ESRL online data browser
- Initial research used both SPI and PHDI data, but the PHDI was selected due to the long-term water-balance approach of the PHDI.

## Methods

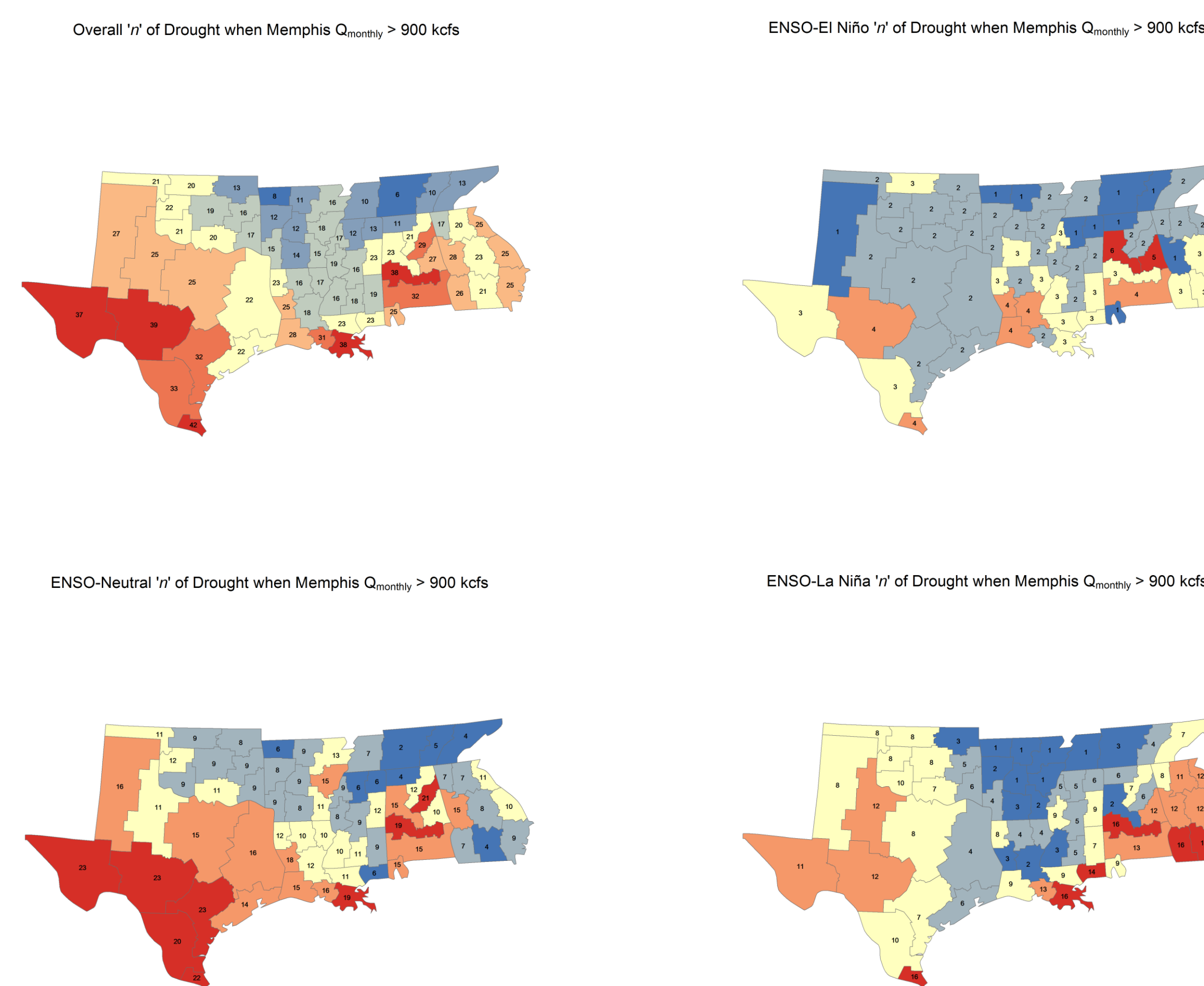
- The study initially examined correlations between high streamflow values and statewide and composited PHDI values to see if there was a general link between high flows at Memphis and drought in the southern U.S.
- Correlation statistics were overall low, implying little link outside a single month, so it was decided to examine events on a wide scale divisional basis, specifically looking at defining high flow/drought pairing events and looking at frequency.
- The mean monthly flow of 900 kcms was selected because that value generally represents higher than normal flow on the Upper Mississippi River System system (Upper MS/OH). 900 kcms is roughly 25' at the Memphis gage, which generally equates to 40' at Cairo, IL (Flood Stage). 900kcms is also the boundary for the top 10% of mean monthly flows
- The published PHDI criteria for drought (-1.25 or less) was used and combined with a mean monthly discharge at Memphis of 900 kcms or greater to select events for each state/division
- A Flow/Drought Event defined as at least one division meeting the -1.25 threshold during a high flow event
- ENSO phases were assigned to each month per established ONI guidelines
- Events were separated by ENSO phase
- Data manipulation was done in Excel and Python. GIS analysis used ArcGIS

## Results

- Mean monthly flows of 900 kcms or greater occurred in 93 of the 924 study months (~10%). However, 91 (97%) of these events have some drought in the study region as defined by the PHDI
- Initial research showed some moderate to strong negative correlation values between high streamflow at Memphis and statewide and selected divisional PHDI data during the month of February in the study area, but values were not statistically significant in other times of the year
- Severe drought (PHDI of -2.00 or less) is present in 91.3% of flood events, but extreme drought is found in 52.6% of events
- Extreme drought is present in only 49 (5.3%) of the total months
- Neutral conditions see more events with 49 of the 91 events
- La Niña has more events than El Niño events
- 2011 was an exceptional event and not typical of La Niña events
- 2011 was also a-typical hydrologically with a two crest year above 50' at Cairo, IL
- Upper air patterns for most events indicate a general shift of the best synoptic forcings for precipitation north of the study region with increased low-level inflow (850mb)
- Further research would be warranted into looking at other climate indices such as NAO, PDO, etc and their impact

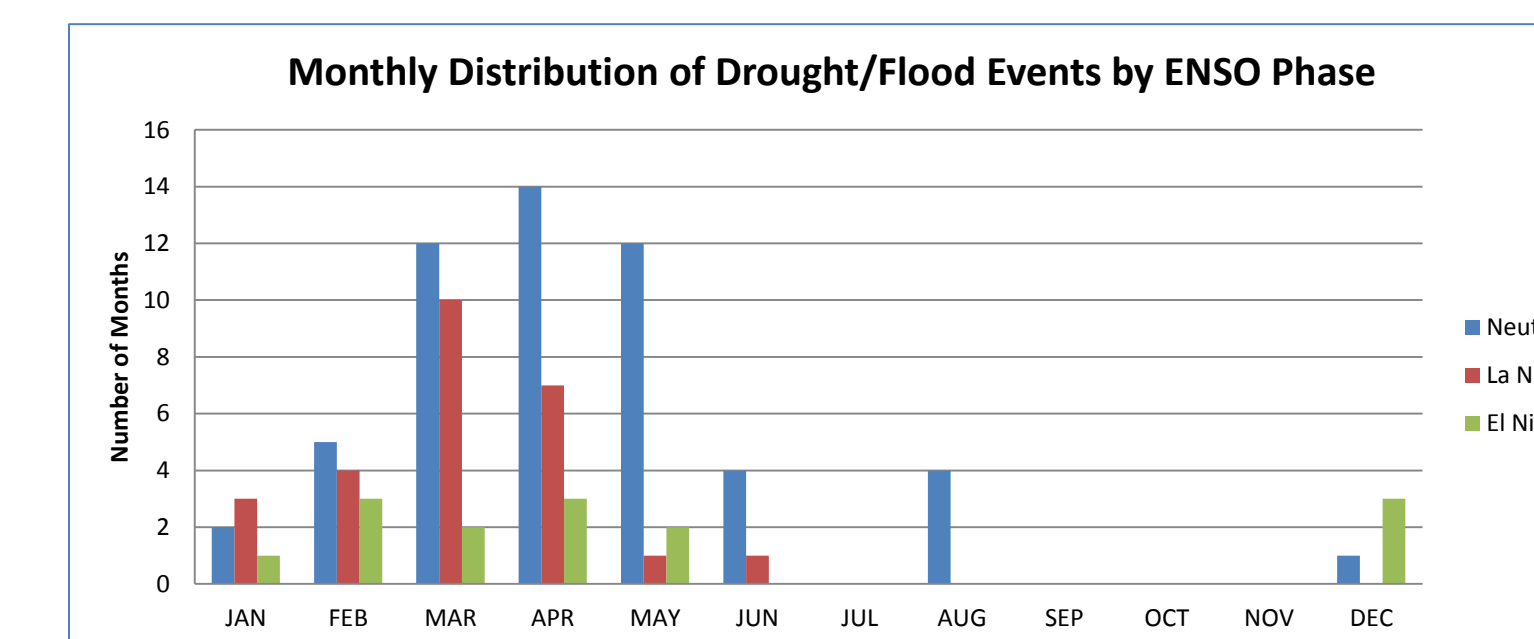


## Results

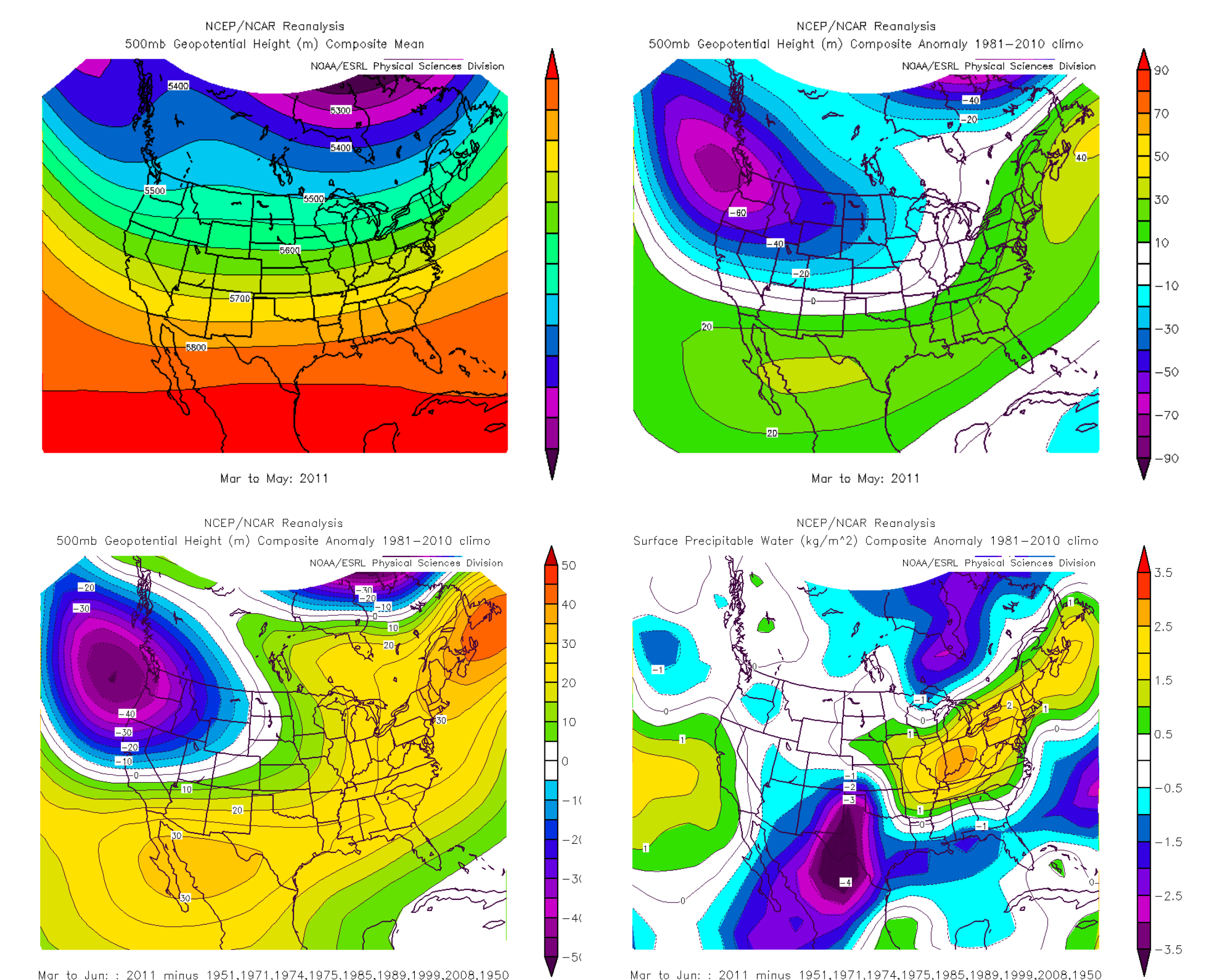


### Overall Statistics: 1934-2010

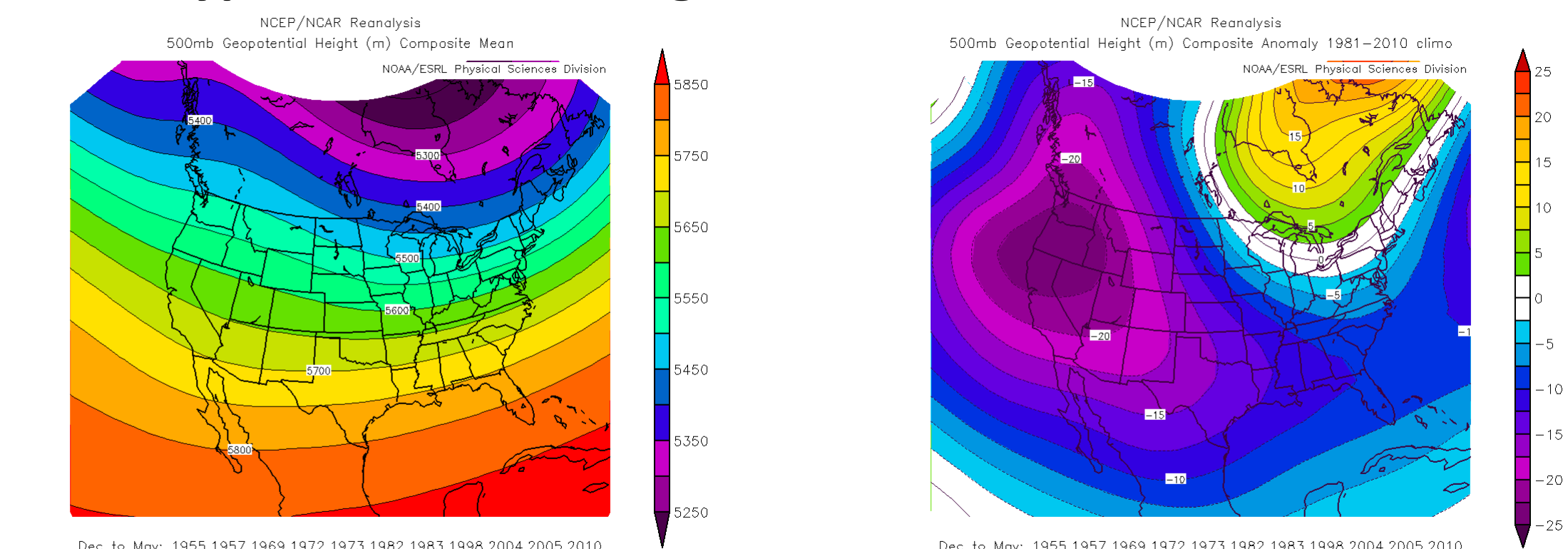
	All Drought Events (PHDI $\leq -1.25$ )			Severe Drought Events (PHDI $\leq -2.00$ )		Extreme Drought Events (PHDI $\leq -2.75$ )	
	Number of Months	Event Frequency (Out of 924 Months)	Percentage	Number of Months	Percentage	Number of Months	Percentage
Total Flow events of 900 kcms or above	93	N/A	10.86%	N/A	91.3%	N/A	52.6%
Overall (All Phases)	924	91	9.84%	85	9.19%	49	5.30%
ENSO-Neutral	451	49	10.86%	43	9.53%	26	5.76%
ENSO-La Niña	261	27	10.34%	26	9.96%	20	7.66%
ENSO-El Niño	212	15	7.07%	6	2.83%	3	1.41%



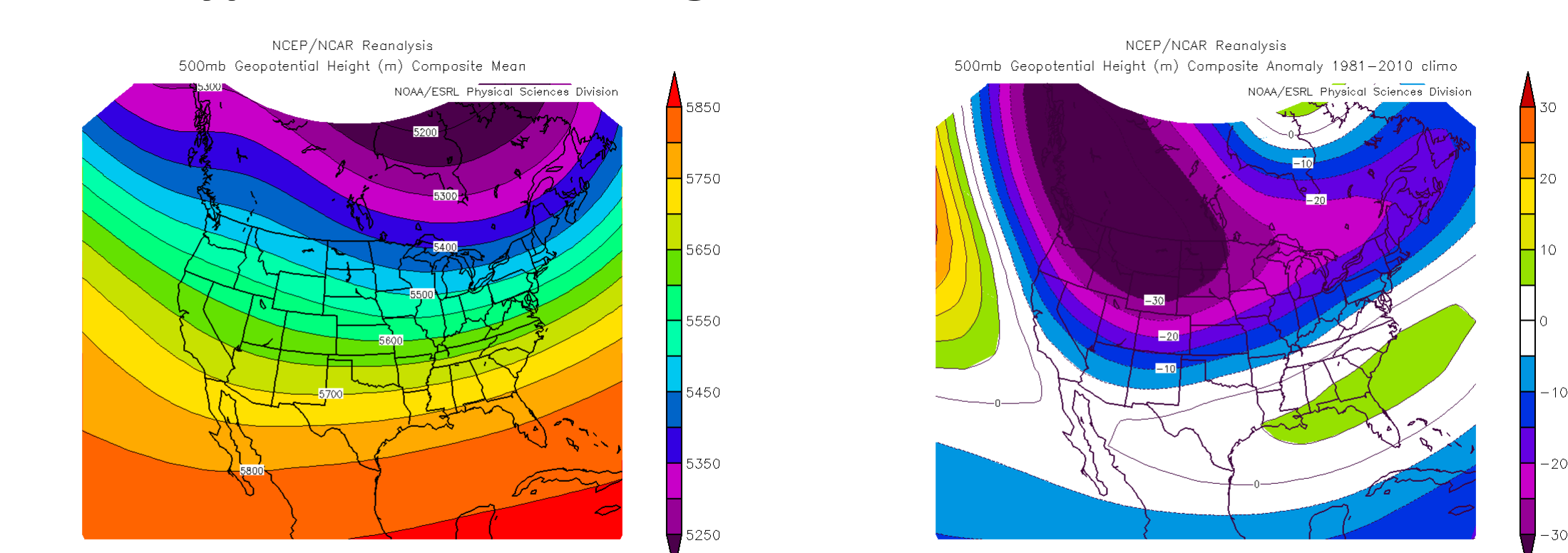
## 2011 Upper Air Patterns



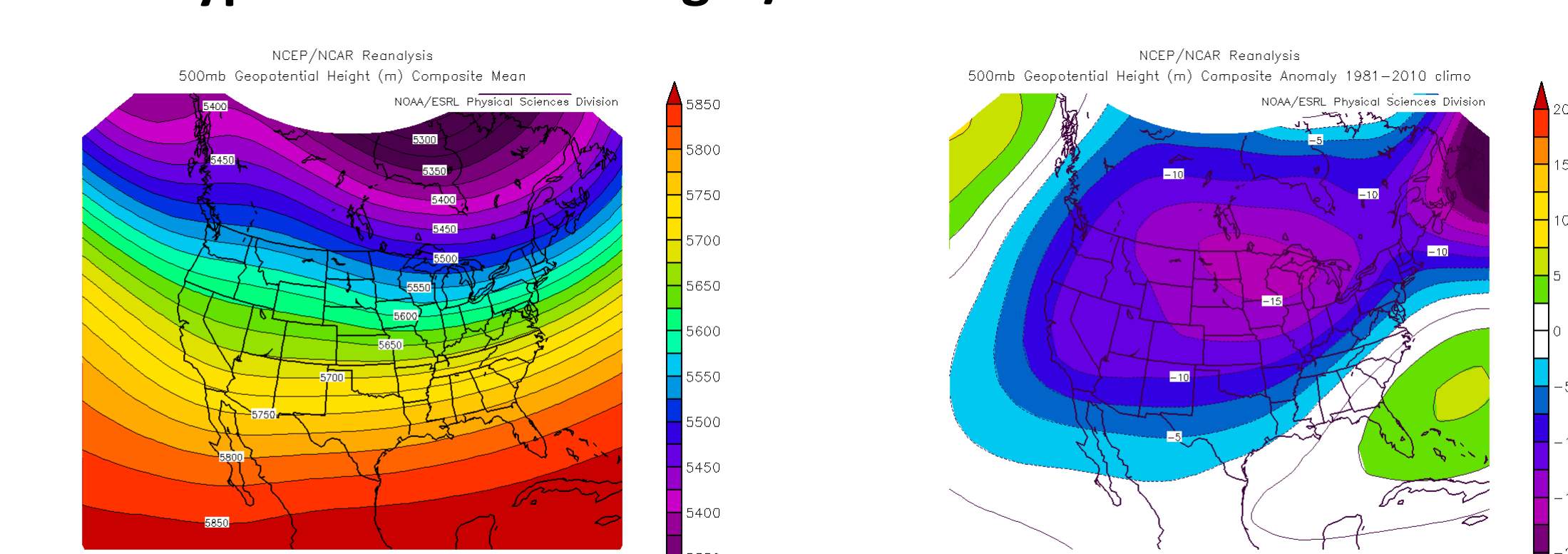
## Typical El Niño Drought/Flood Event 500mb Pattern



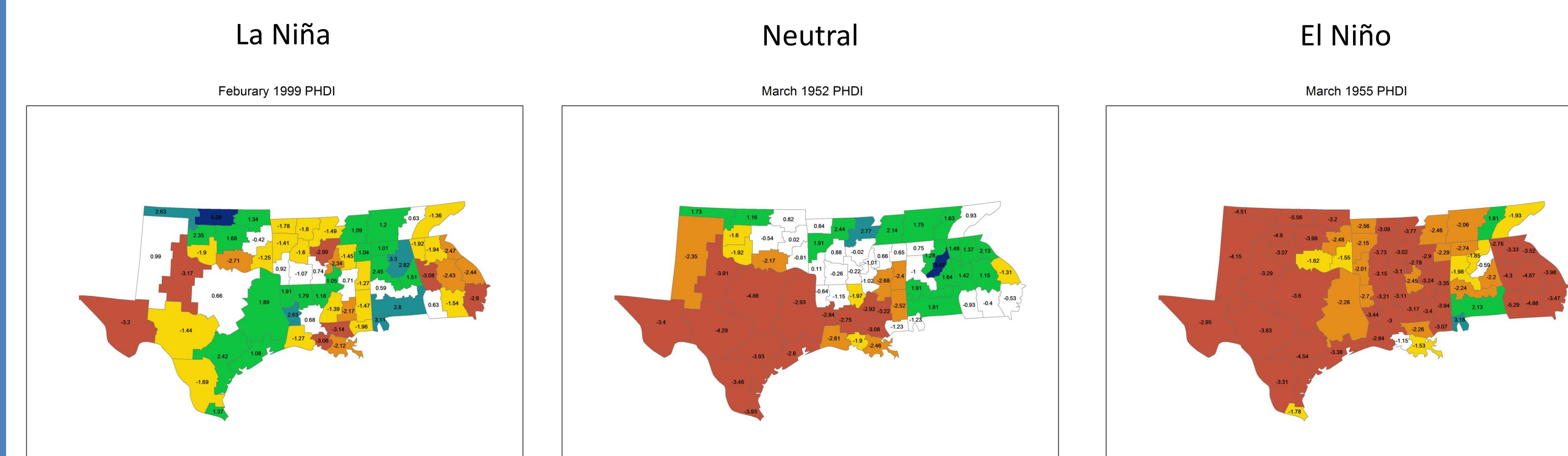
## Typical La Niña Drought/Flood Event 500mb Pattern



## Typical Neutral Drought/Flood Event 500mb Pattern



## Example Events By ENSO Phase



For additional information, please contact:  
Royce Fontenot  
Lower Mississippi River Forecast Center  
DoC/NOAA/National Weather Service  
royce.fontenot@noaa.gov

