

GOES-9 Vis, IR &  
Water Vapor.  
9/25/97  
2100 GMT



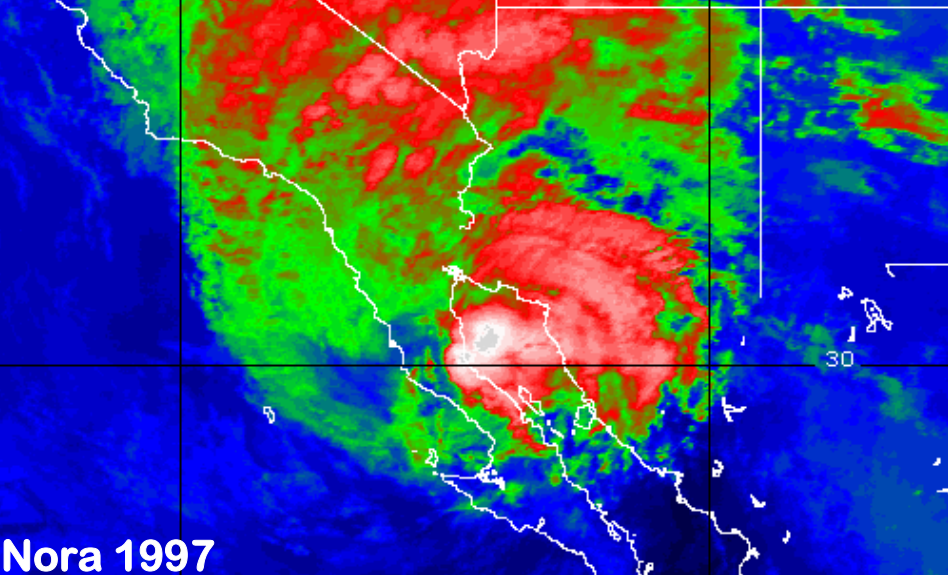
NOAA/NESDIS

Hurricane  
Nora, etc.

# The Contribution of Eastern North Pacific Tropical Cyclones to the Warm Season Rainfall Climatology of the Southwest US

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**Michael Dickinson (AEF) and Lance Bosart (SUNY Albany)**



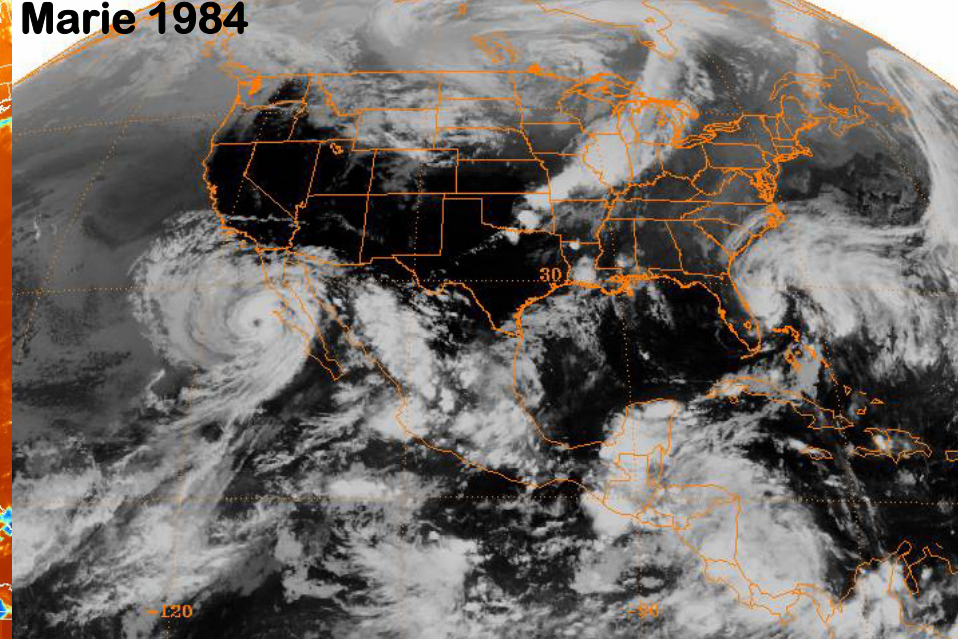
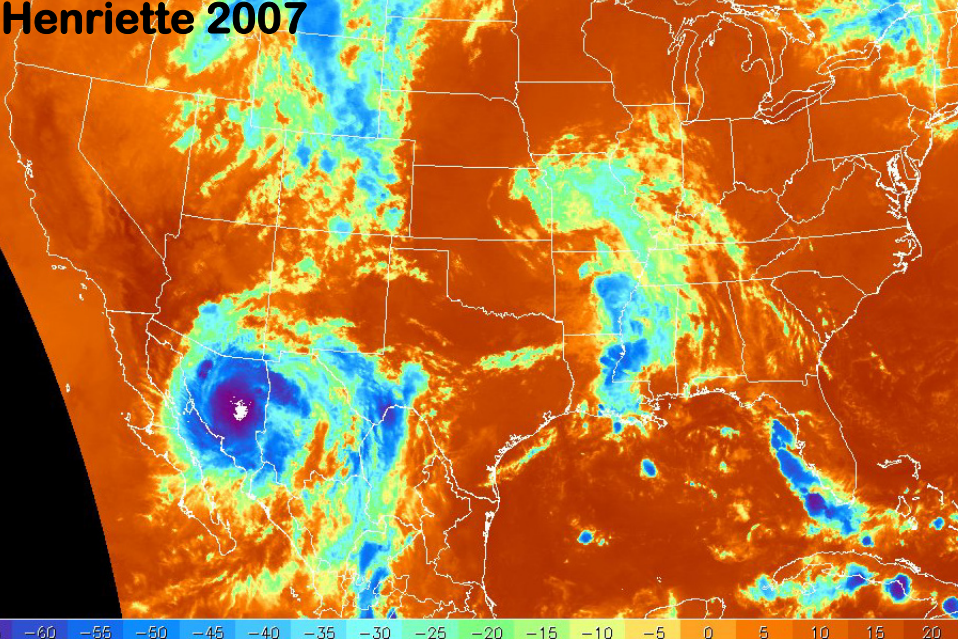
Nora 1997



Lester 1992

## Motivation:

- **Easterly waves and tropical cyclones (TCs) of the eastern North Pacific initiate Gulf of California moisture surges that account for a significant portion of summer rainfall in the southwest US**
- **The eastern North Pacific is the most active basin for tropical cyclone development per unit area, per unit time (length of the TC season)**



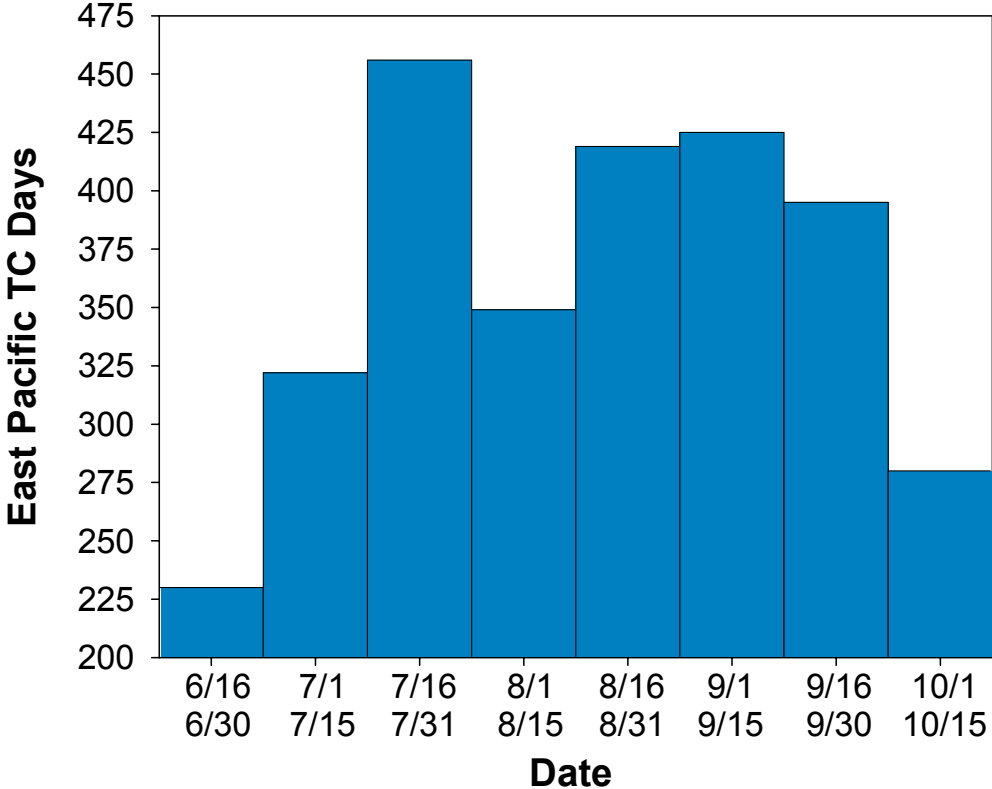
## Motivation:

- Do tropical cyclones ever reach the southwest US?
- Englehart and Douglas (2001) examined TC rainfall in western Mexico and found 3-4 storms per year affect the region bringing as much as 60% of the summer rainfall
- Extend the study of Englehart and Douglas (2001) north into the southwest US

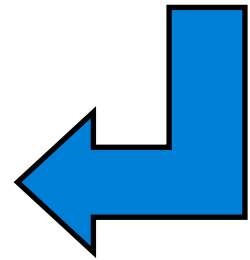
## Data and Methodology:

- **National Hurricane Center (NHC) Best Track data set to find all storms that crossed 25°N between June 16<sup>th</sup> and October 15<sup>th</sup> 1958 to 2003**
- **Climate Prediction Center's daily (12 UTC-12 UTC), gridded (.25° x .25°) Unified Precipitation Dataset (UPD)**  
(<http://www.cdc.noaa.gov/cdc/data.unified.html>)
- **European Centre for Medium-range Weather Forecasting re-analysis (ERA40; 1.125° resolution)**
- **Examined maps of rainfall and 700 hPa heights and relative vorticity to determine on which days, if any, rainfall associated with a tropical cyclone fell over the southwest US**

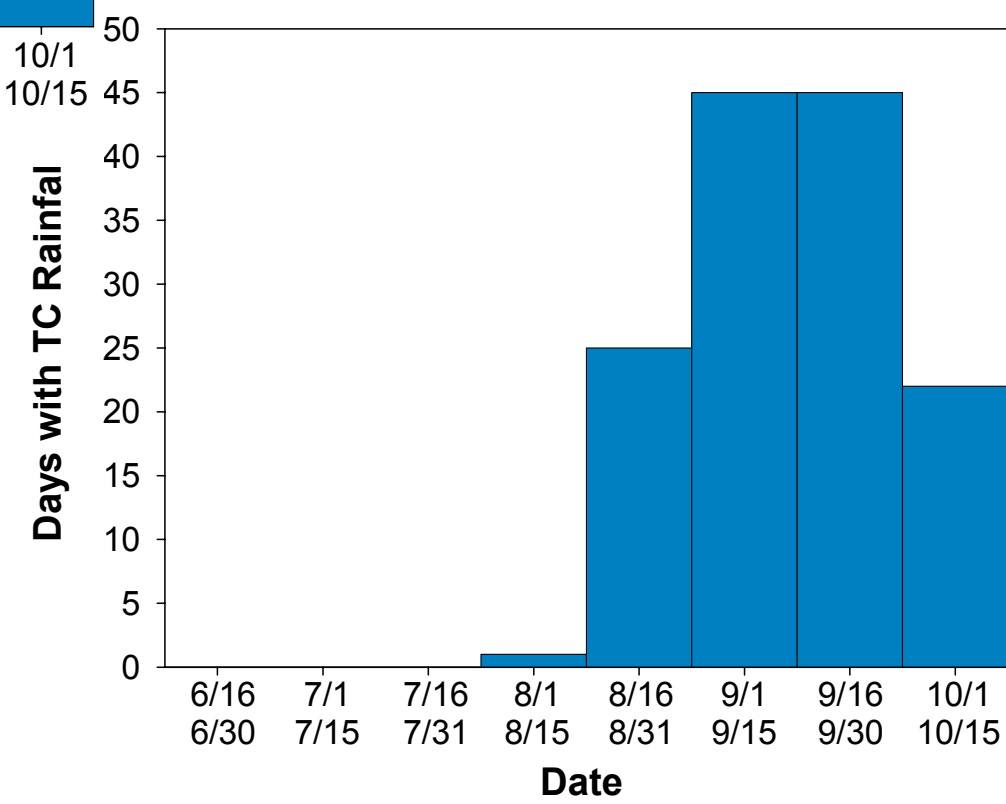
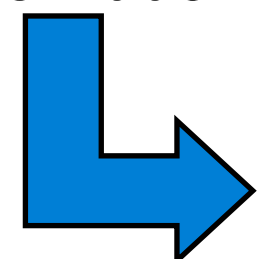




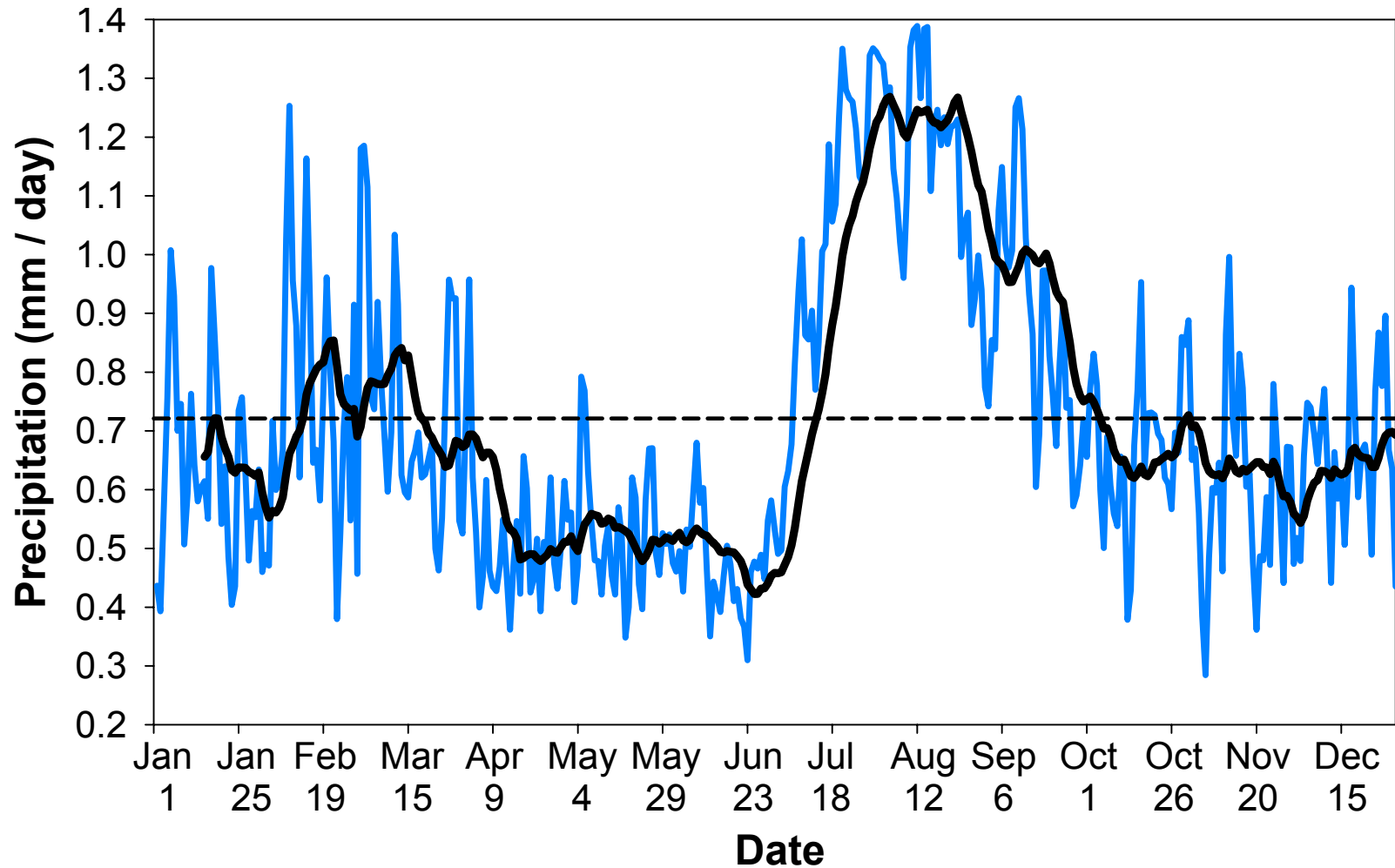
**Number of days with at least one active Eastern Pacific TC 1958-2003**



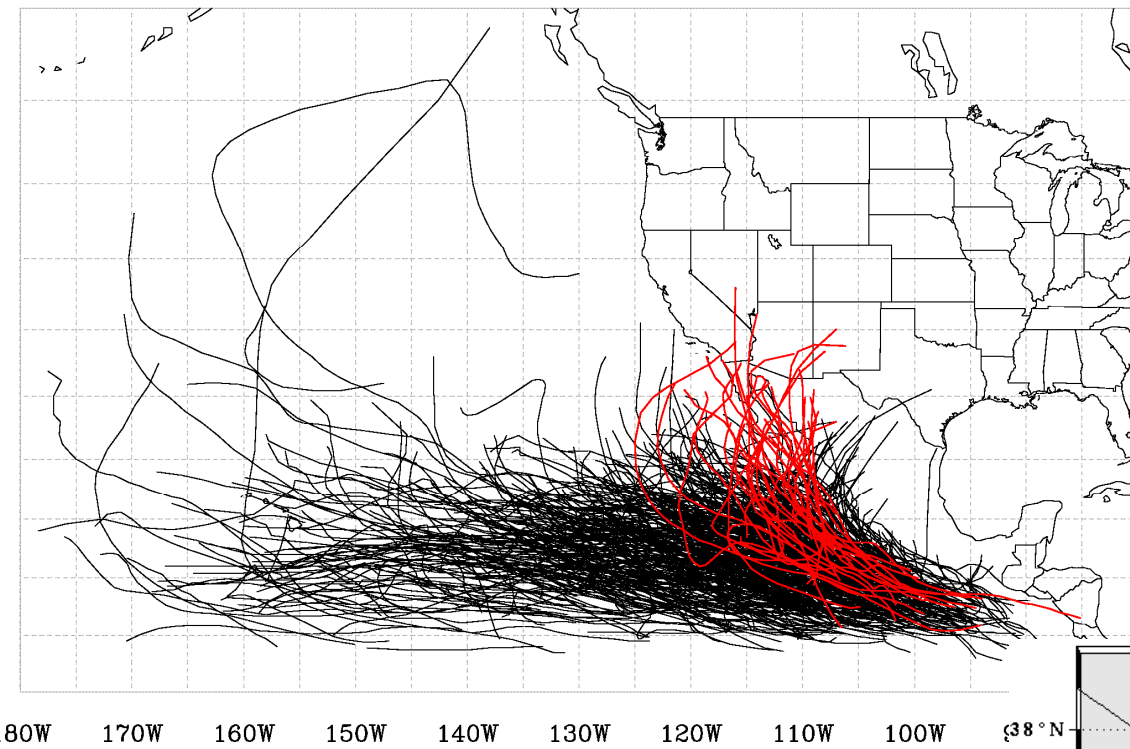
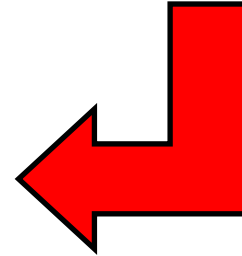
**Number of days rainfall associated with an Eastern Pacific TC fell in the southwest US 1958-2003**



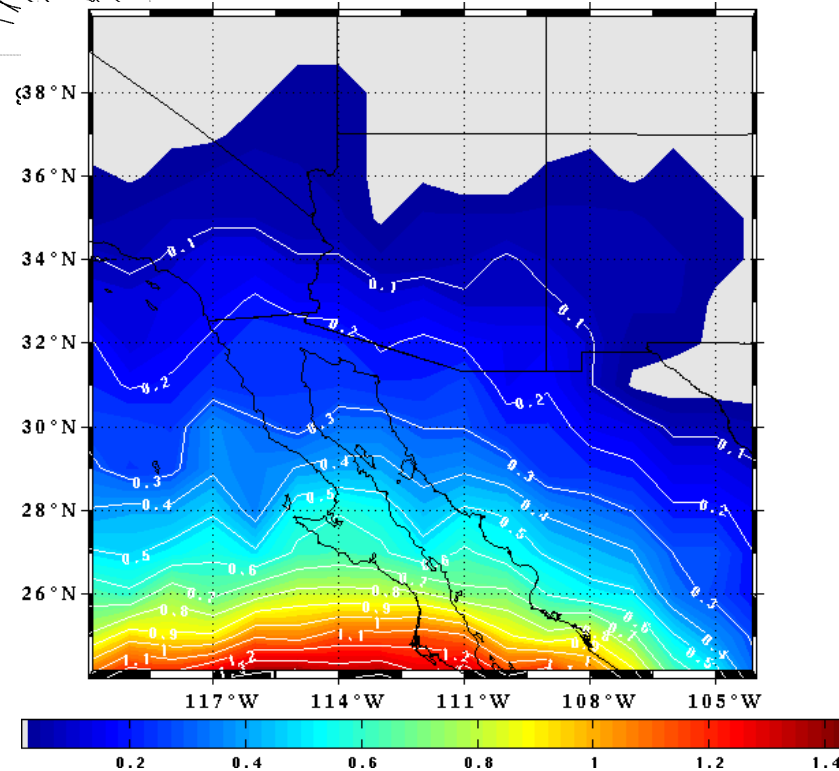
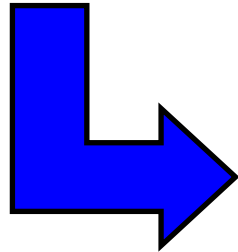
# Average Daily Precipitation Southwest US (31°-40°N, 104°-118°W) 1958-2003

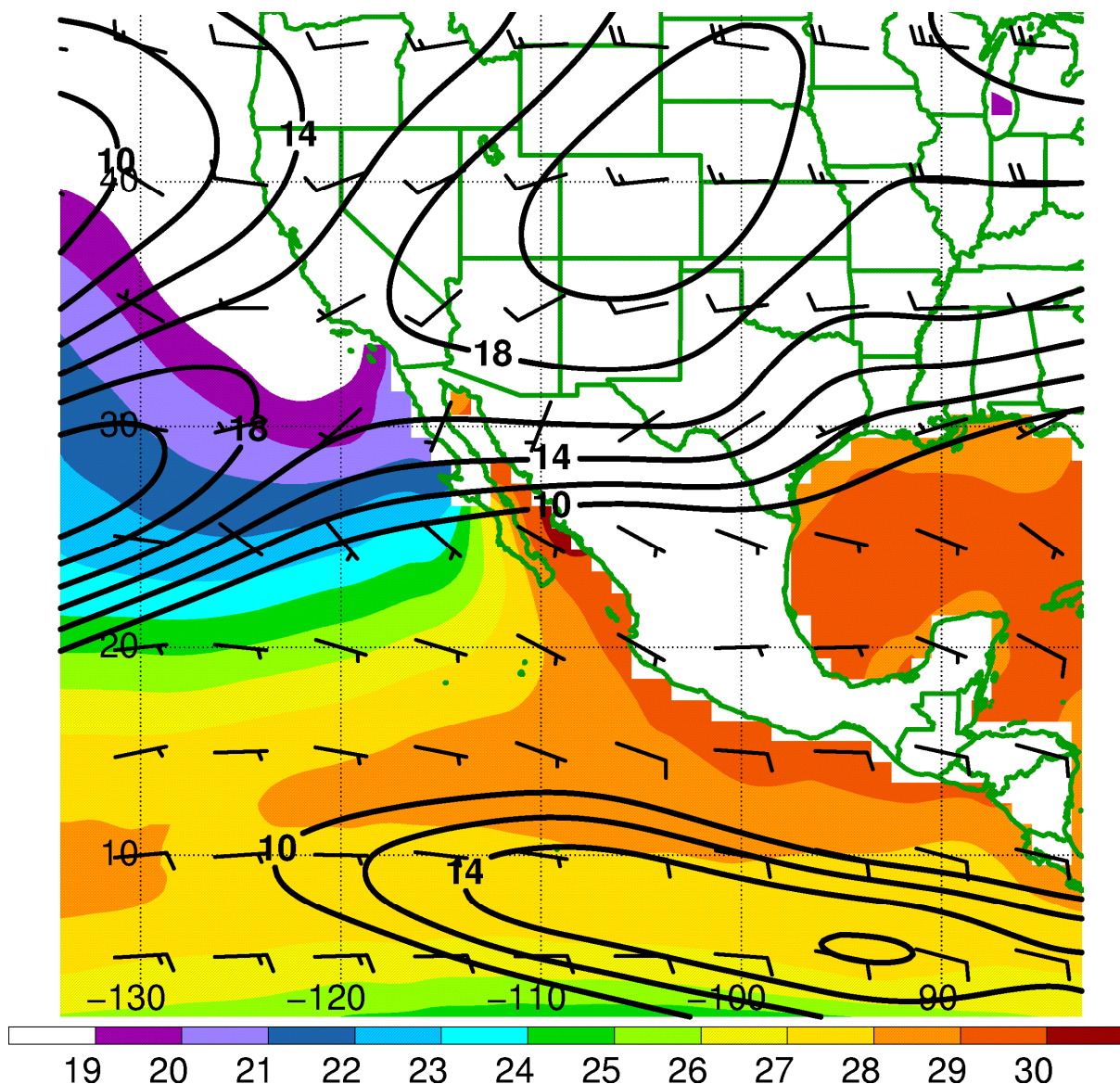


**NHC Best Track  
All Eastern Pacific  
TCs  
1958-2003**



**Return rate of a TC of any  
intensity to the southwest US  
1958-2003**



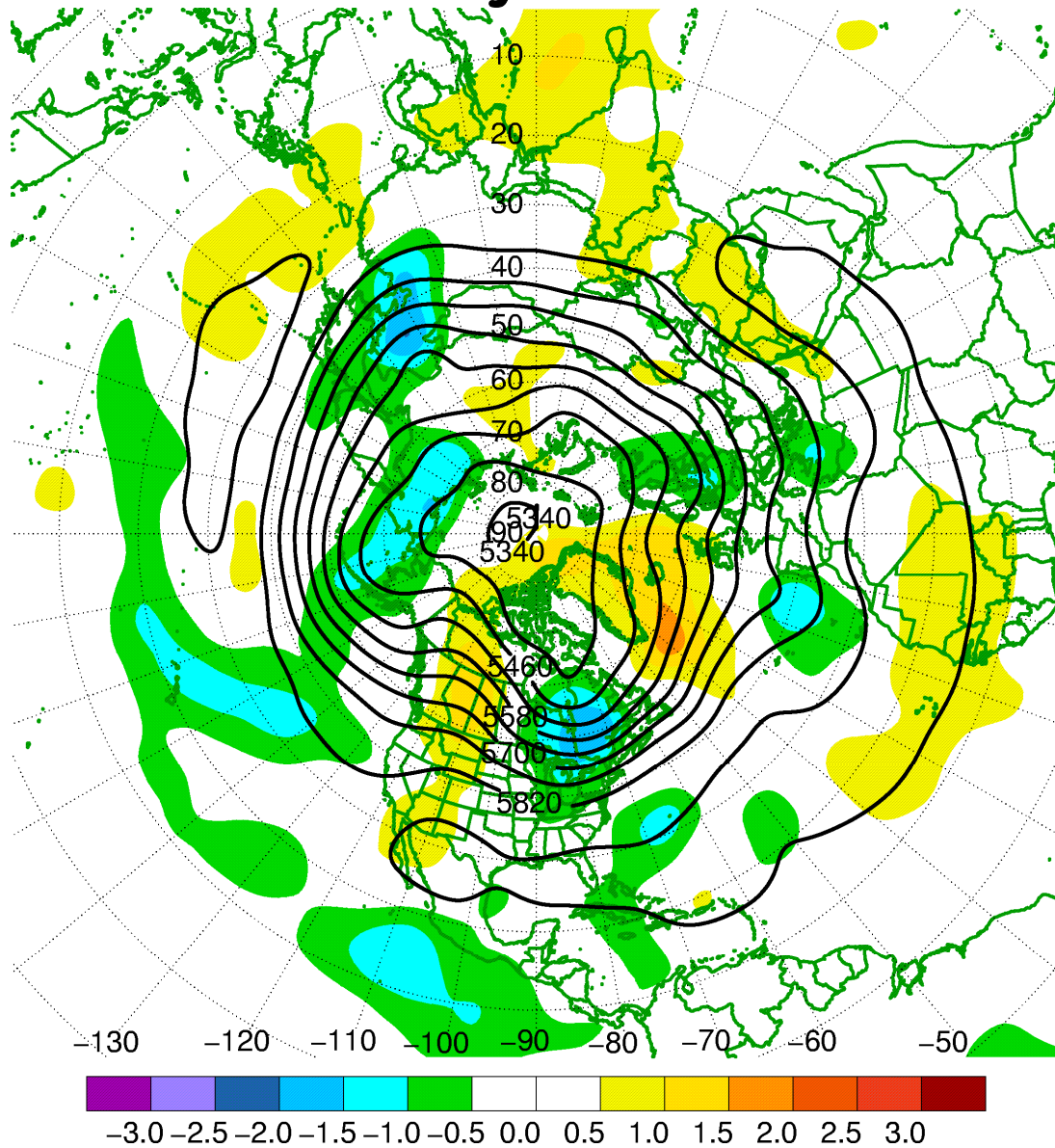


**Average September Eastern Pacific SSTs, 850-200 hPa vertical wind shear, & 500-700 hPa layer averaged winds 1968-1996**

# NCEP/NCAR Reanalysis

## Mean and standardized anomaly, 500 hPa heights

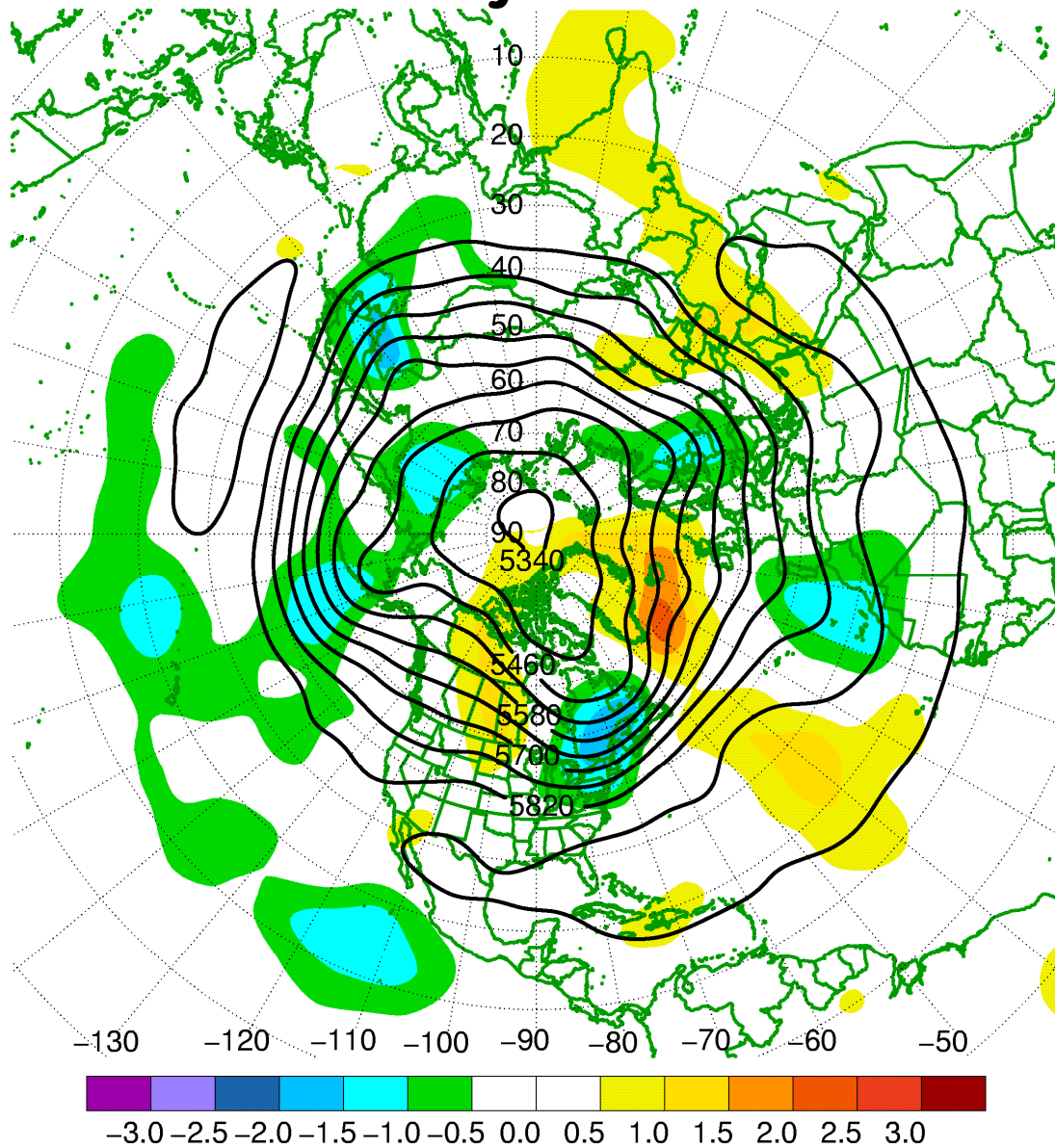
### Day T-5



# NCEP/NCAR Reanalysis

## Mean and standardized anomaly, 500 hPa heights

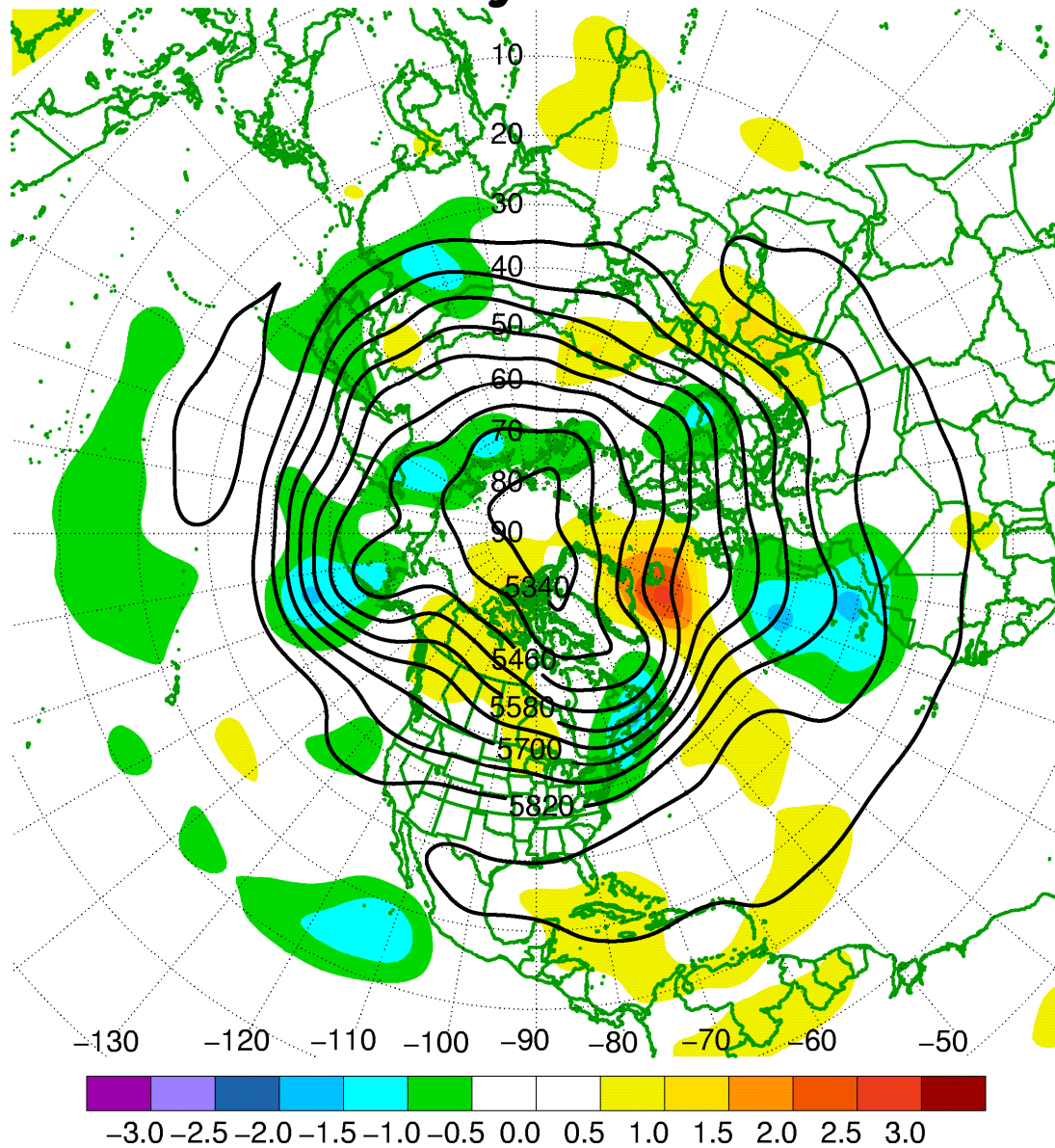
### Day T-4



# NCEP/NCAR Reanalysis

## Mean and standardized anomaly, 500 hPa heights

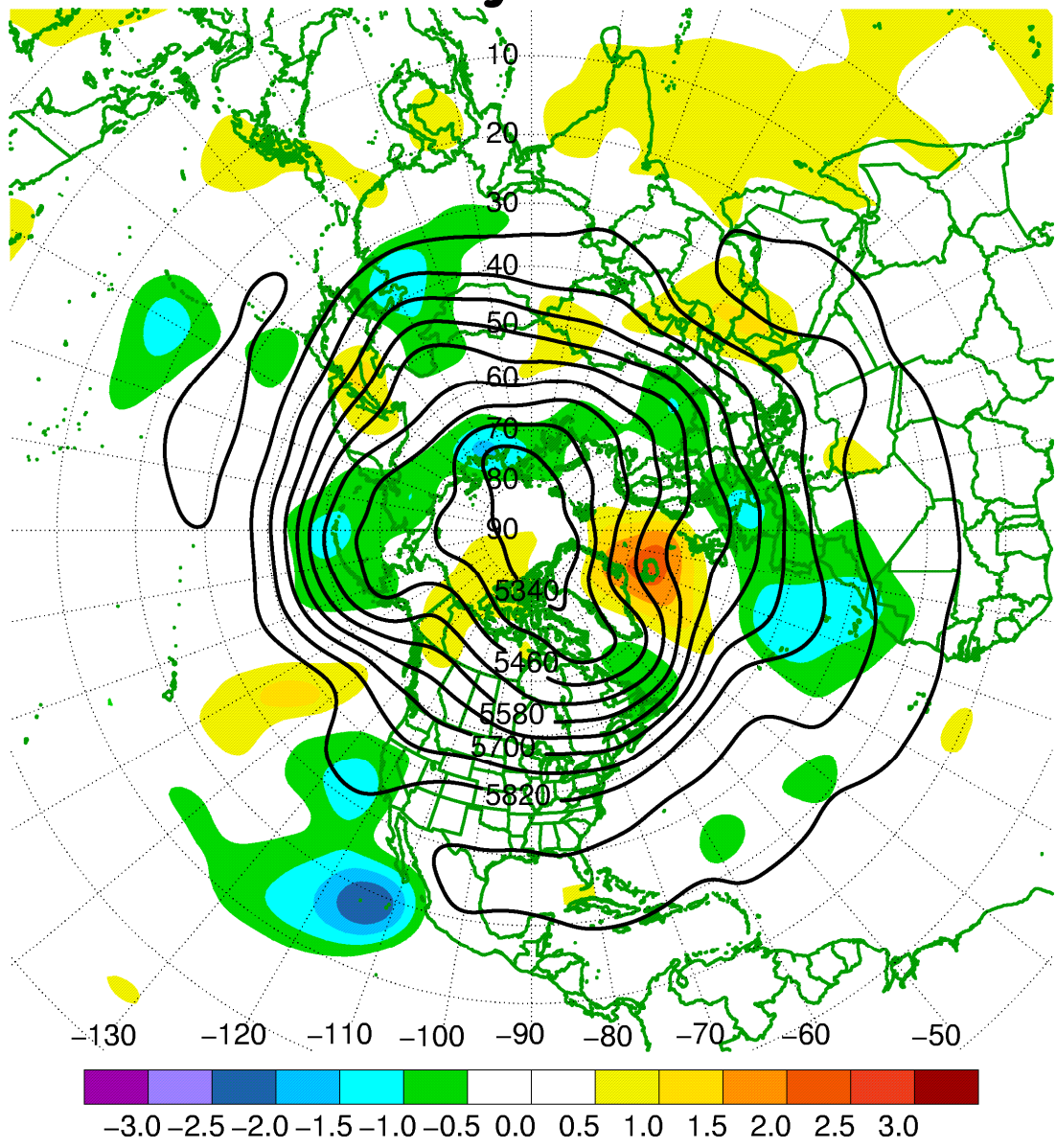
### Day T-3



# NCEP/NCAR Reanalysis

## Mean and standardized anomaly, 500 hPa heights

### Day T-2

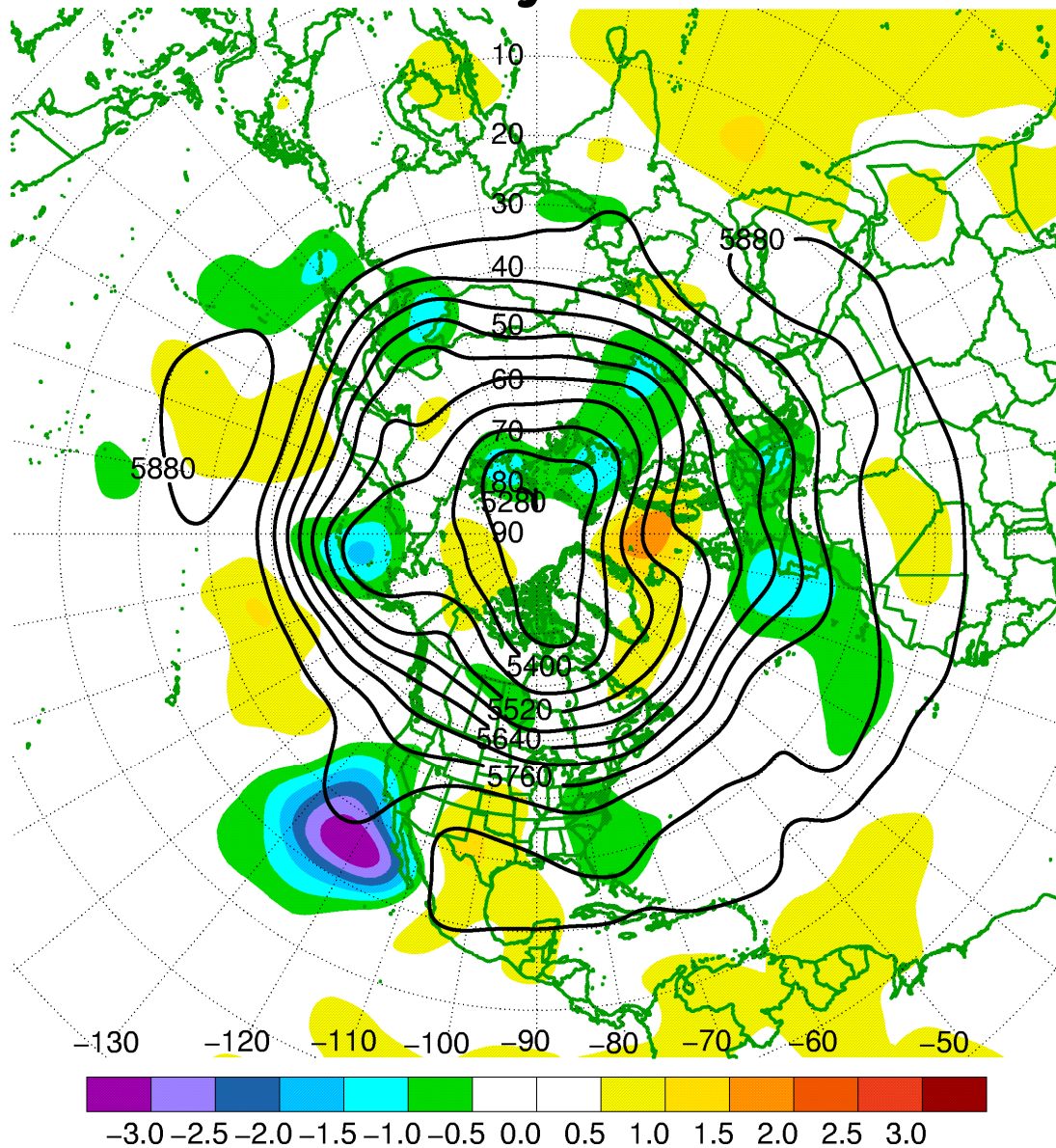




# NCEP/NCAR Reanalysis

## Mean and standardized anomaly, 500 hPa heights

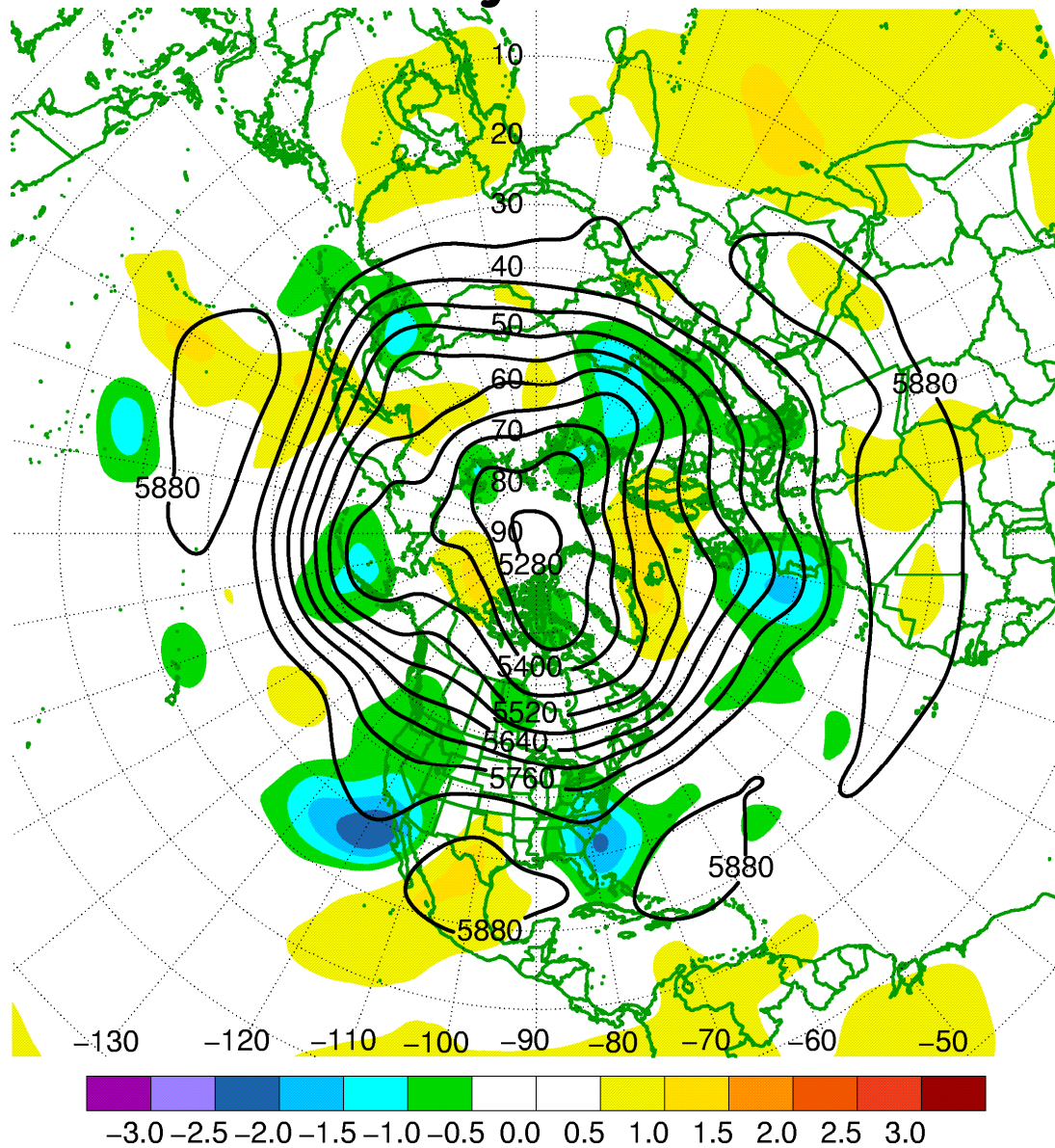
### Day T



# NCEP/NCAR Reanalysis

## Mean and standardized anomaly, 500 hPa heights

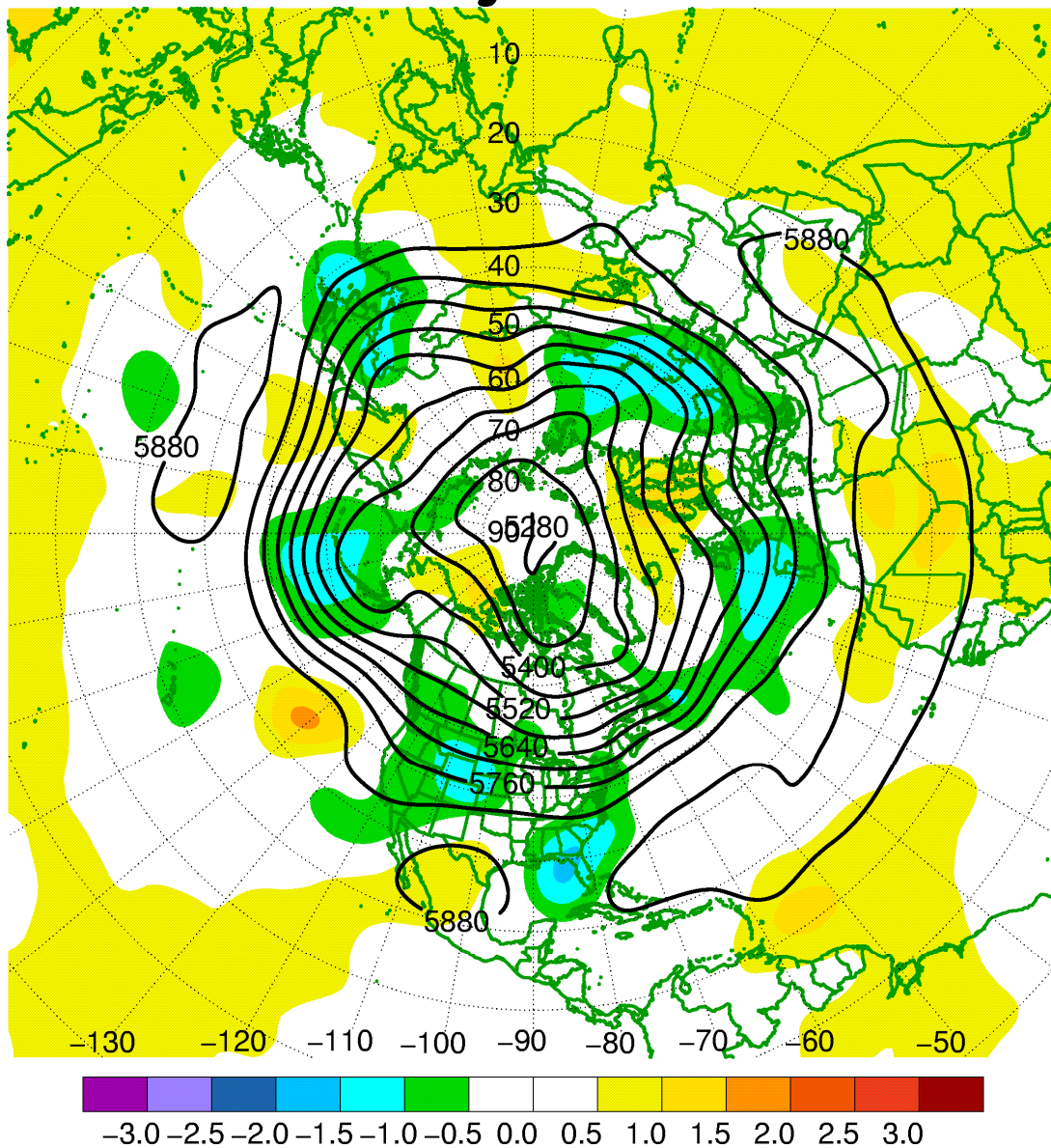
### Day T+1



# NCEP/NCAR Reanalysis

## Mean and standardized anomaly, 500 hPa heights

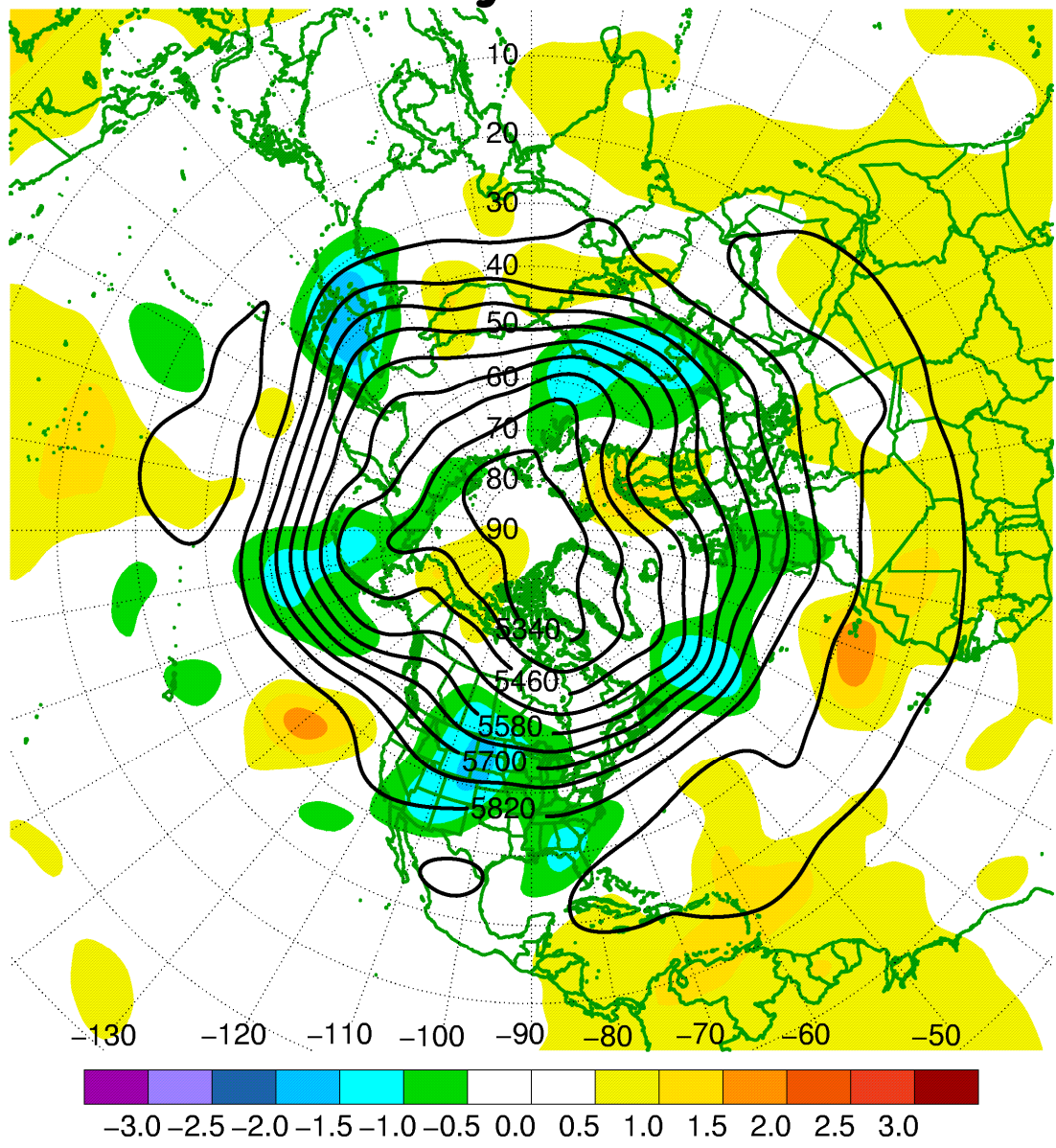
### Day T+2



# NCEP/NCAR Reanalysis

## Mean and standardized anomaly, 500 hPa heights

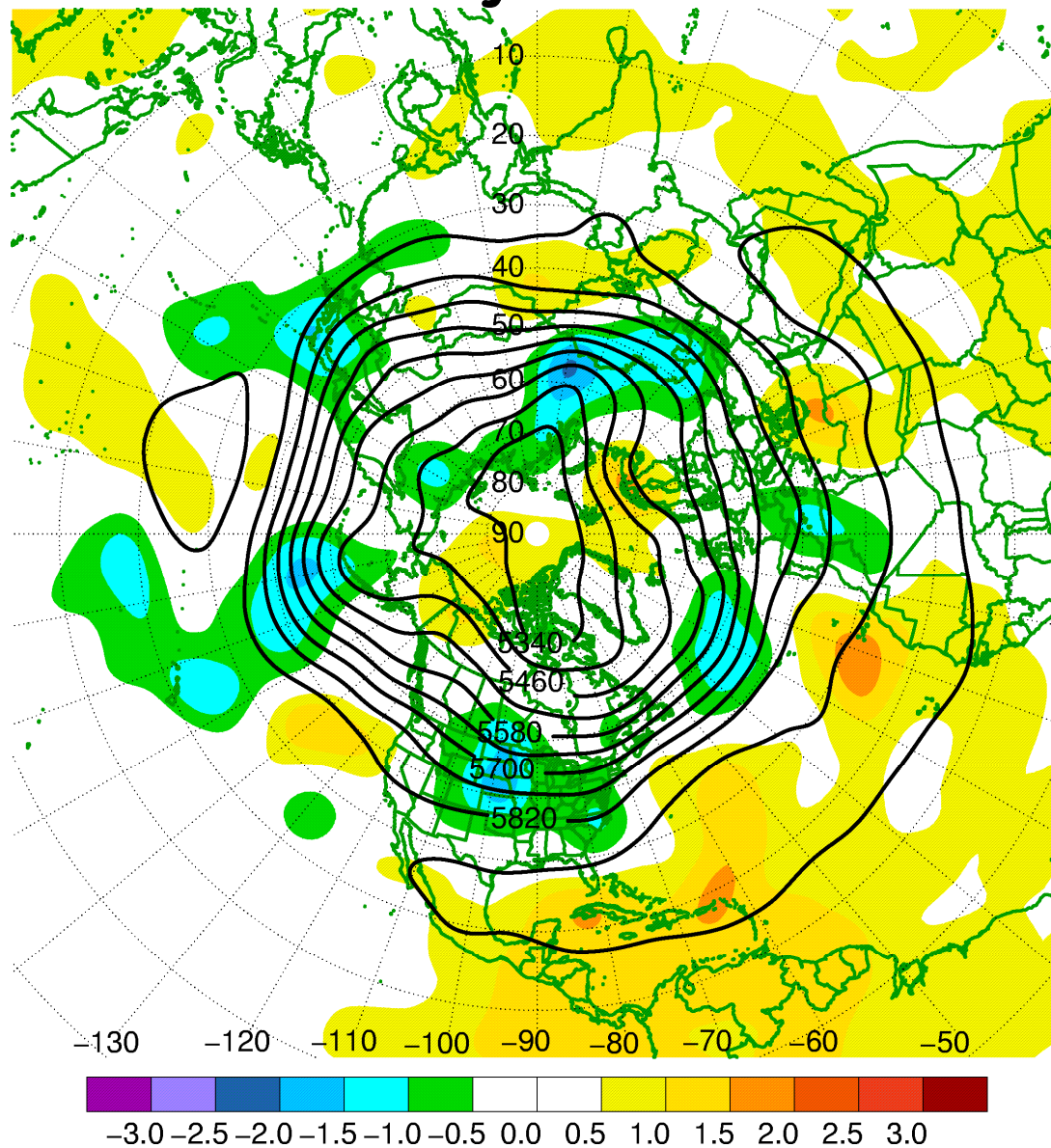
### Day T+3



# NCEP/NCAR Reanalysis

## Mean and standardized anomaly, 500 hPa heights

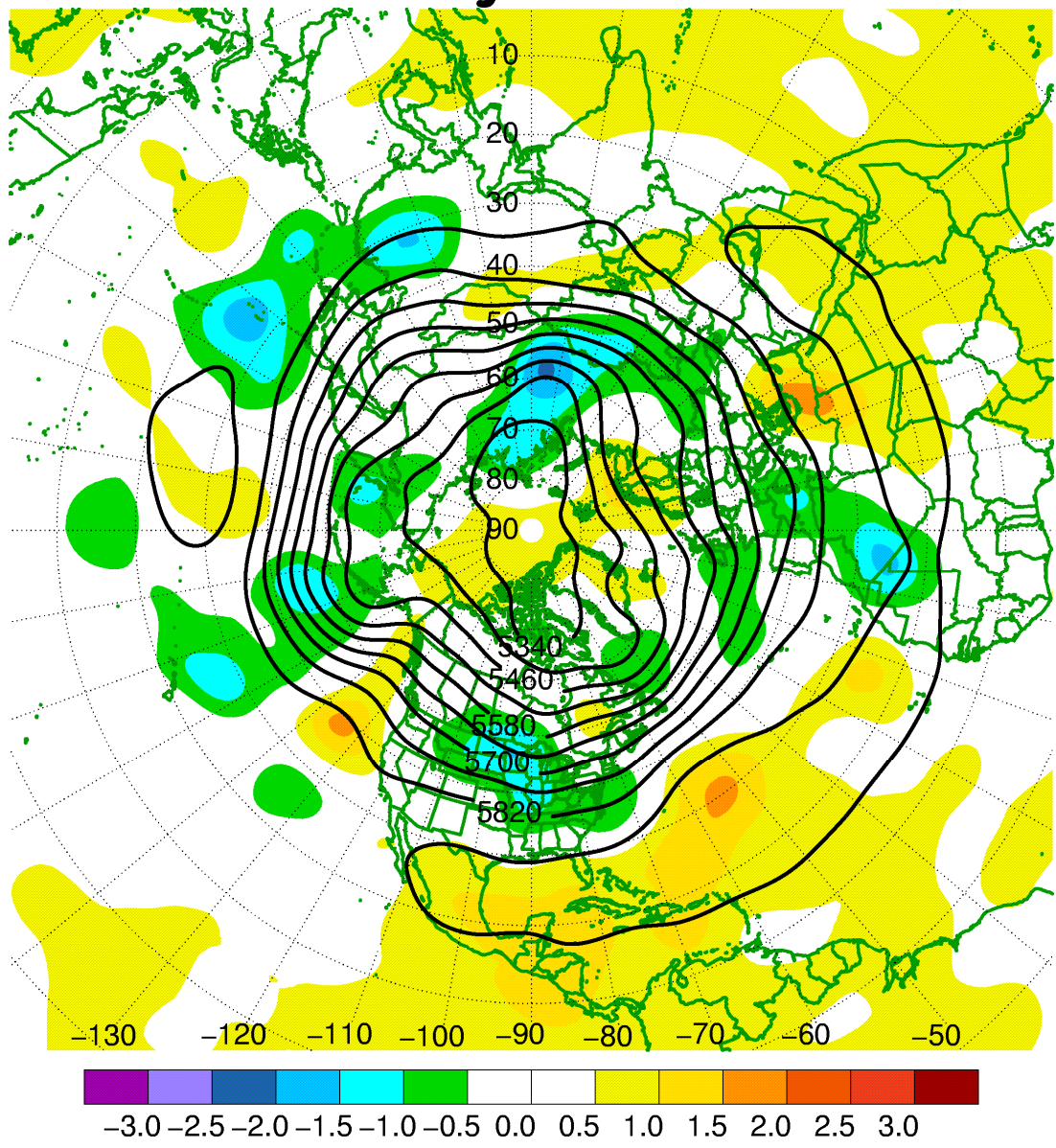
### Day T+4



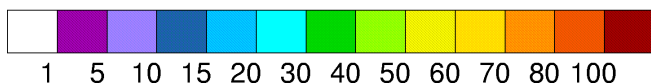
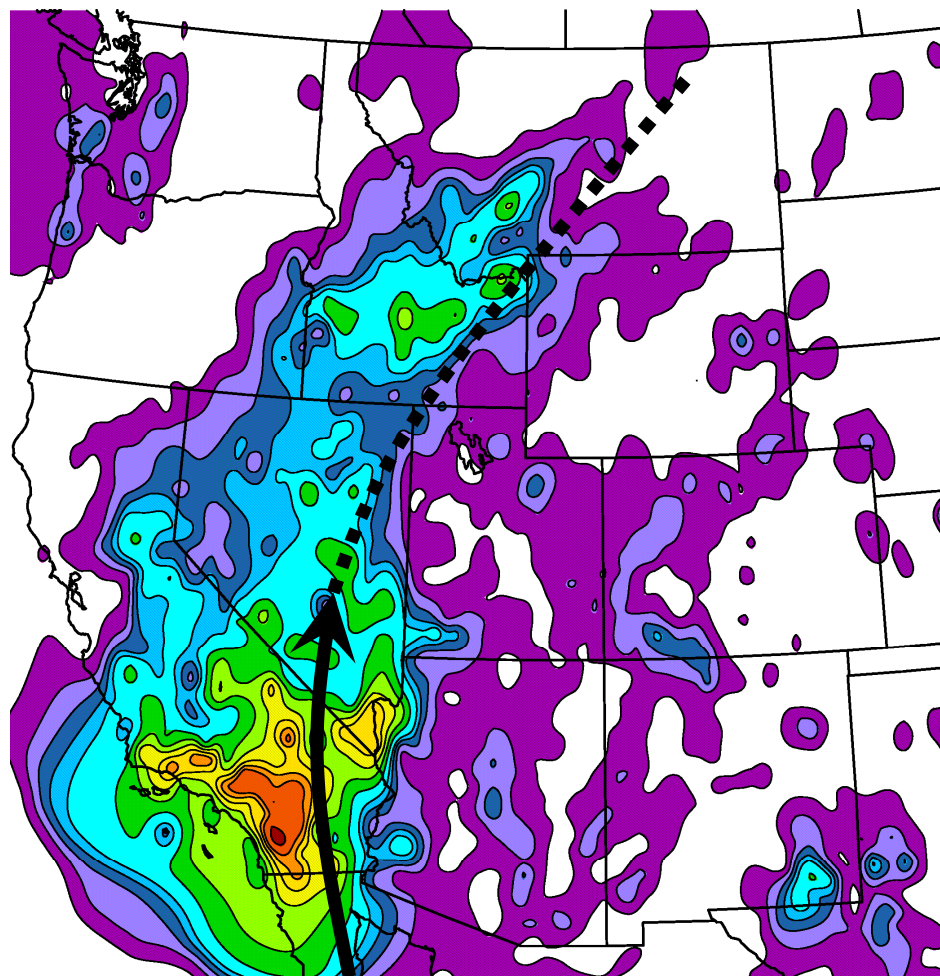
# NCEP/NCAR Reanalysis

## Mean and standardized anomaly, 500 hPa heights

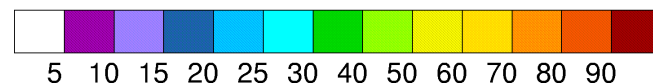
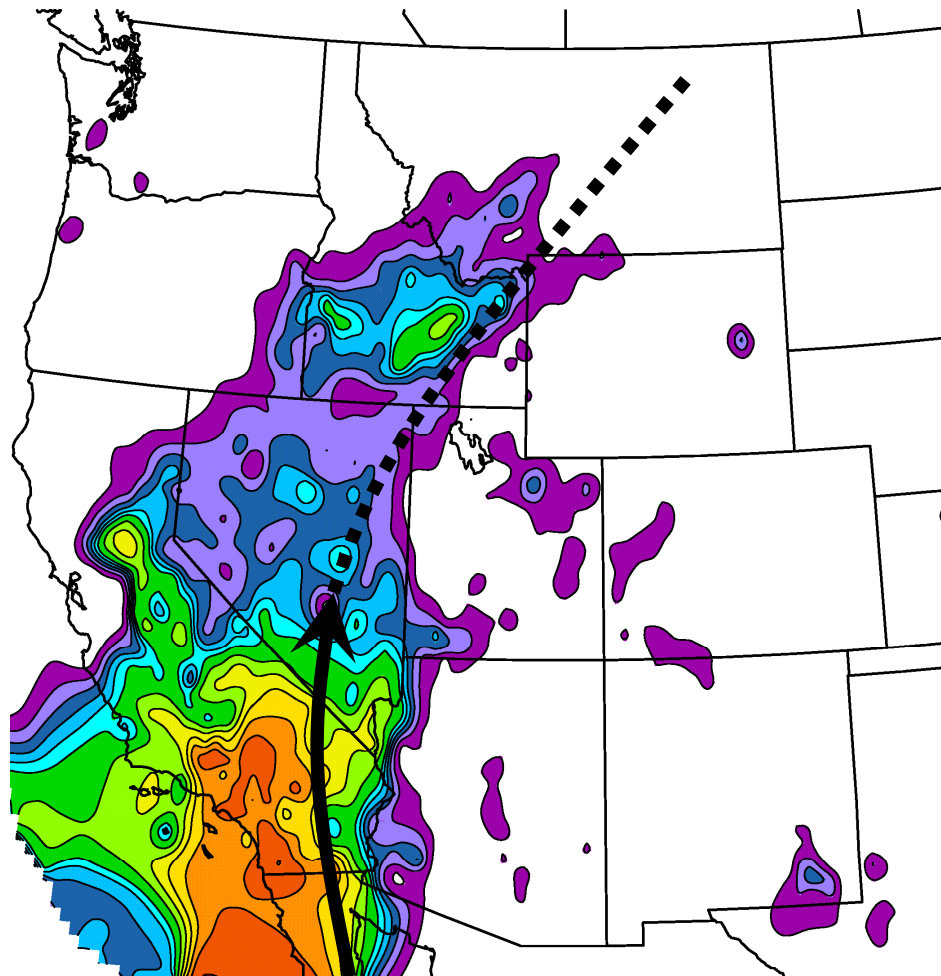
### Day T+5



# Hurricane Kathleen 1976

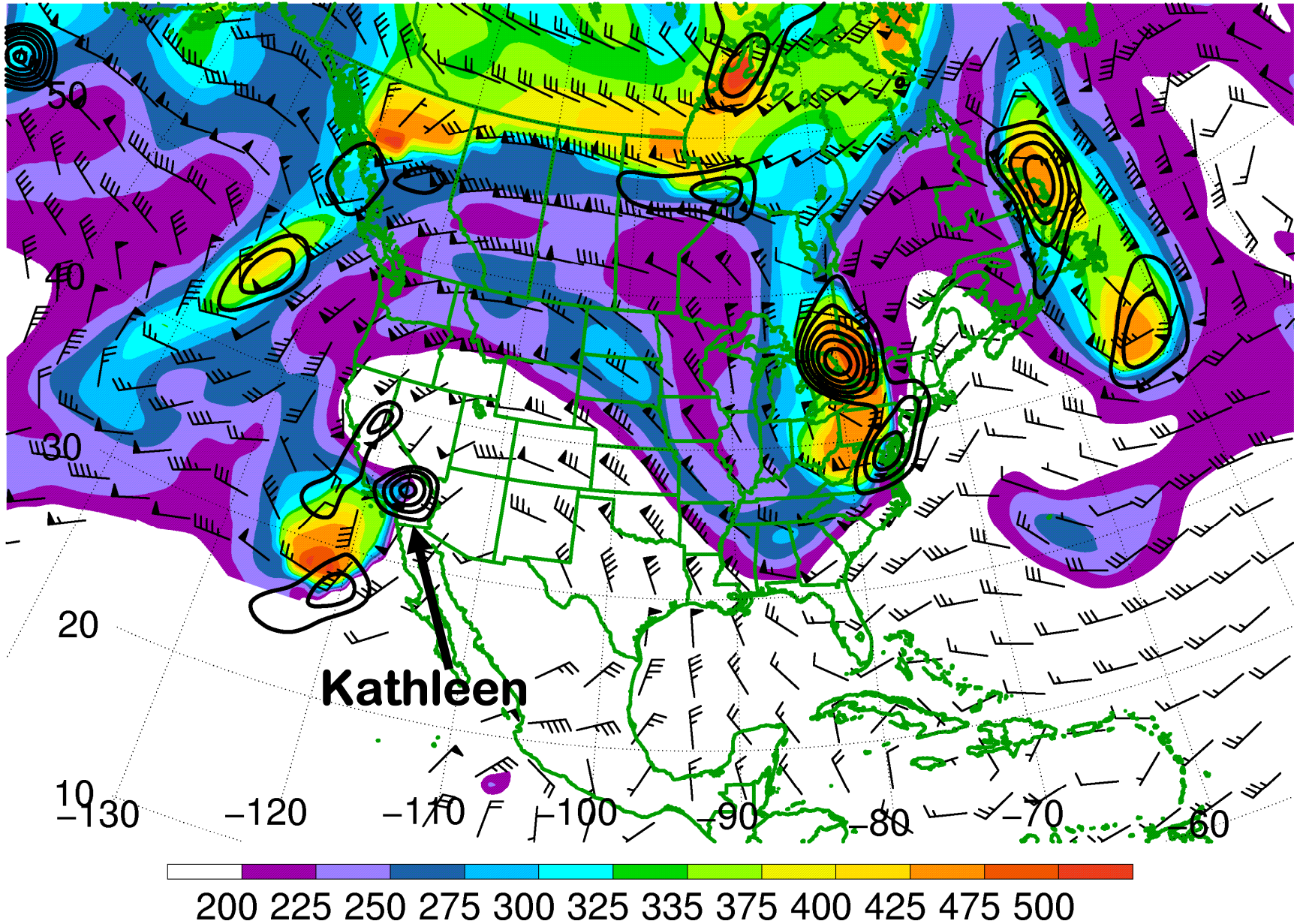


**Storm total  
precipitation (mm)**

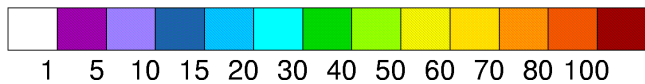
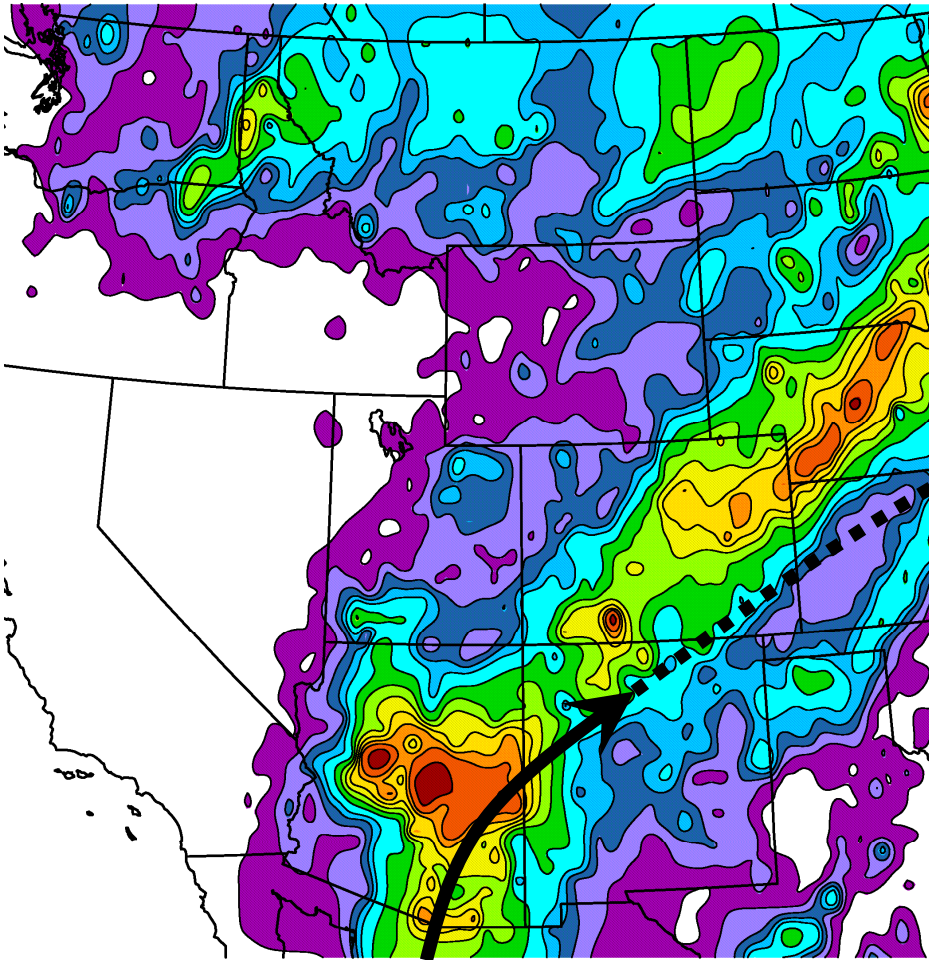


**Storm contribution to  
warm season rainfall (%)**

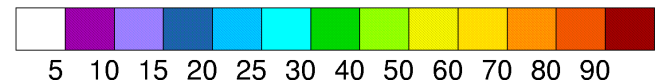
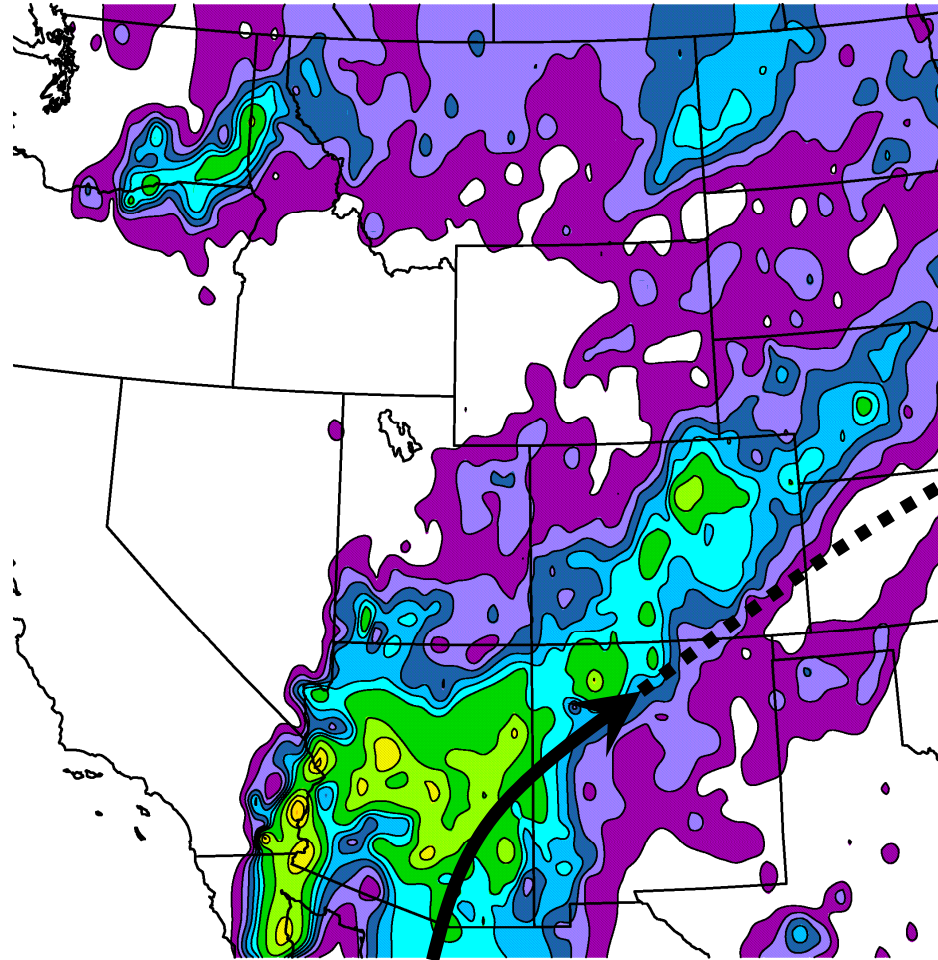
# DT pressure (hPa), DT winds, & 700 hPa vorticity 00 UTC 11 September 1976



# Hurricane Lester 1992

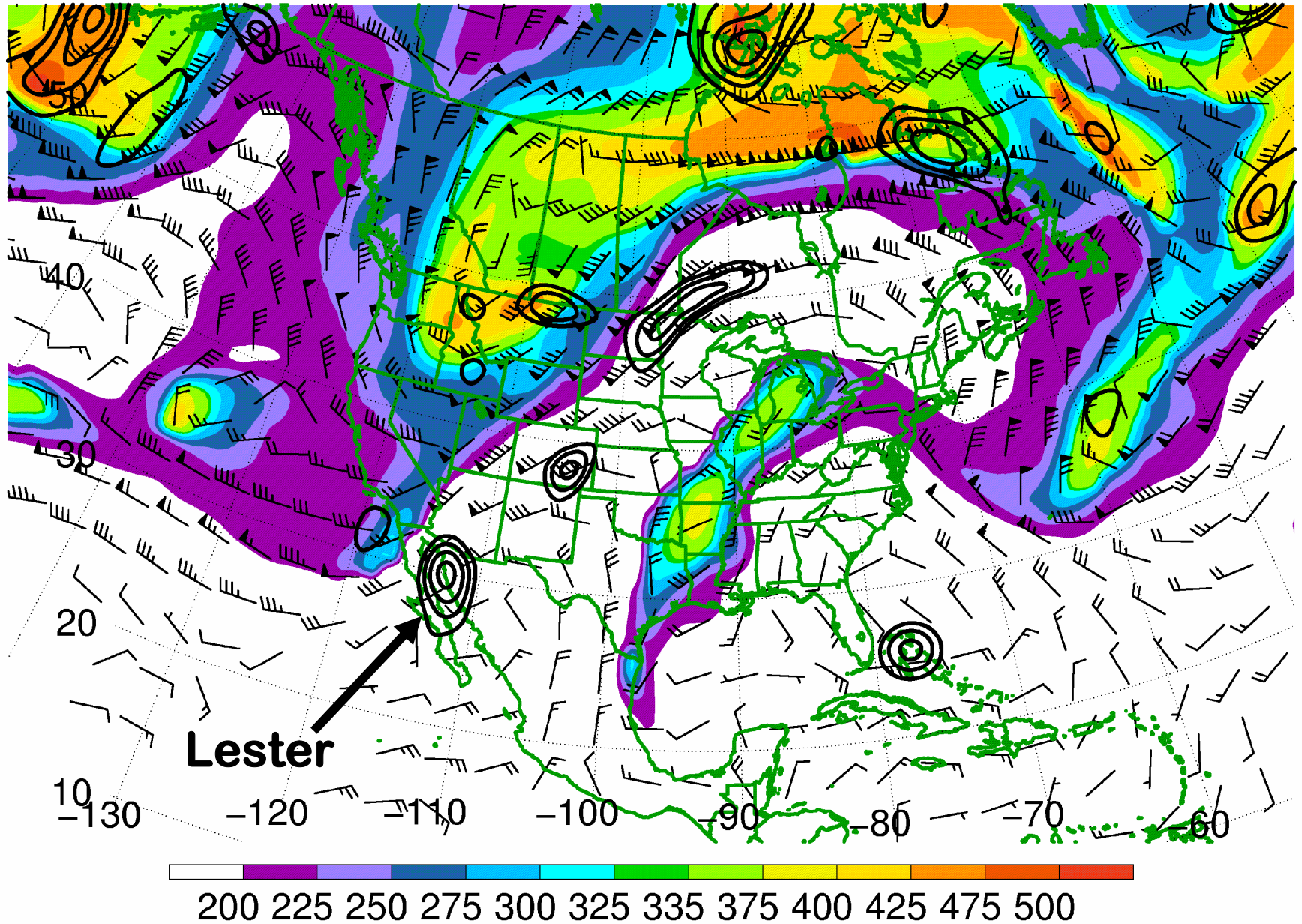


**Storm total  
precipitation (mm)**

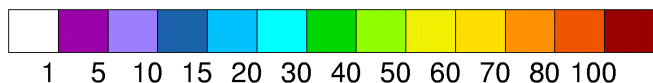
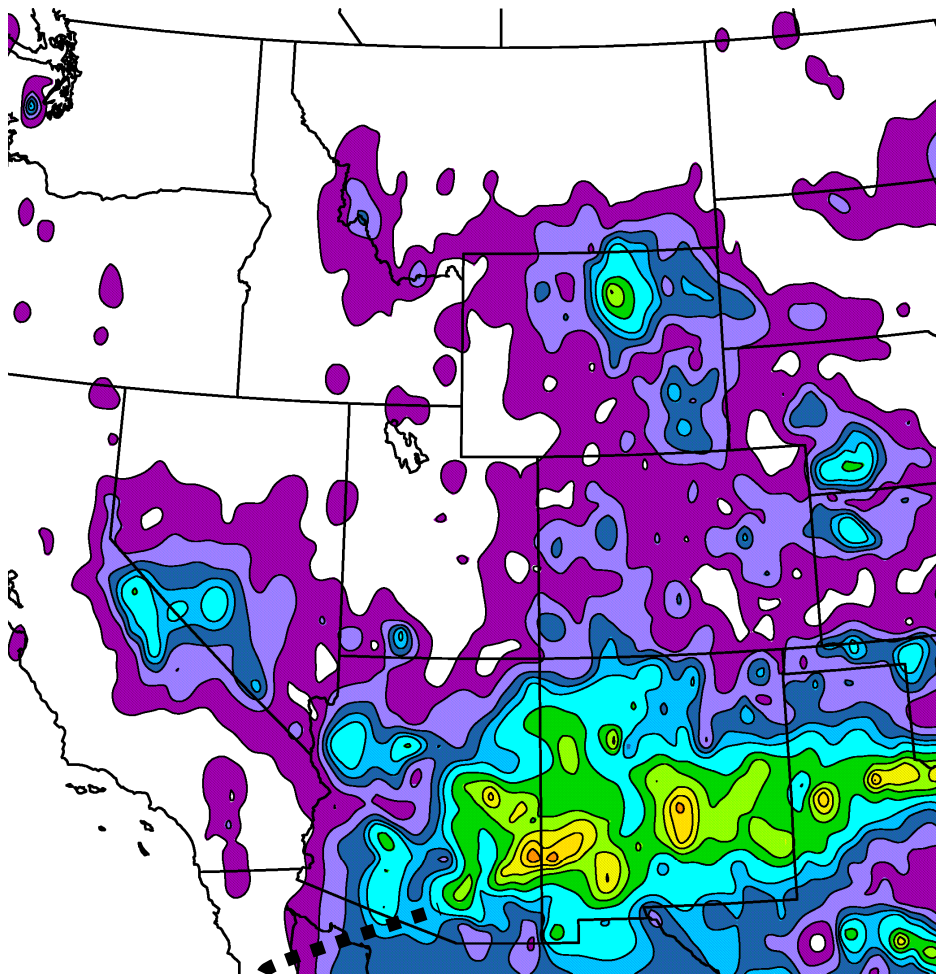


**Storm contribution to  
warm season rainfall (%)**

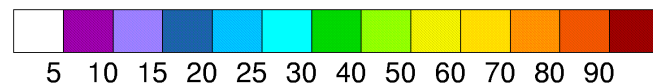
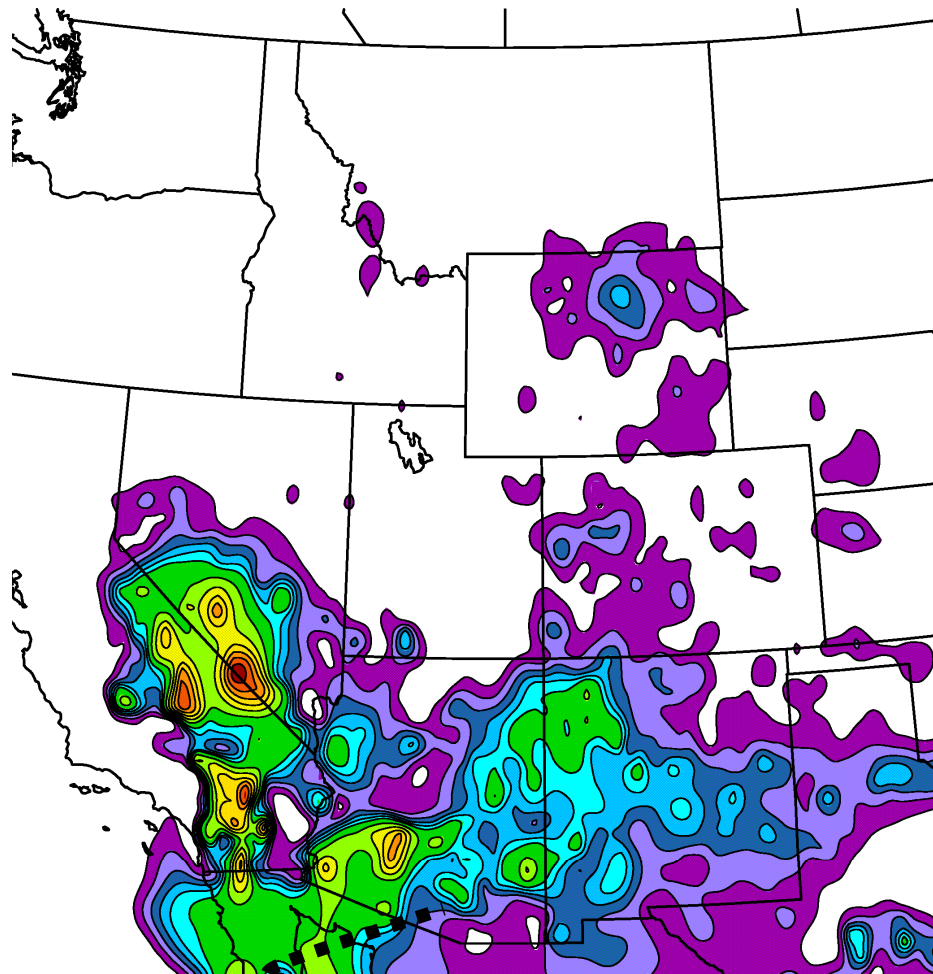
# DT pressure (hPa), DT winds, & 700 hPa vorticity 00 UTC 24 August 1992



# Tropical Storm Claudia 1962

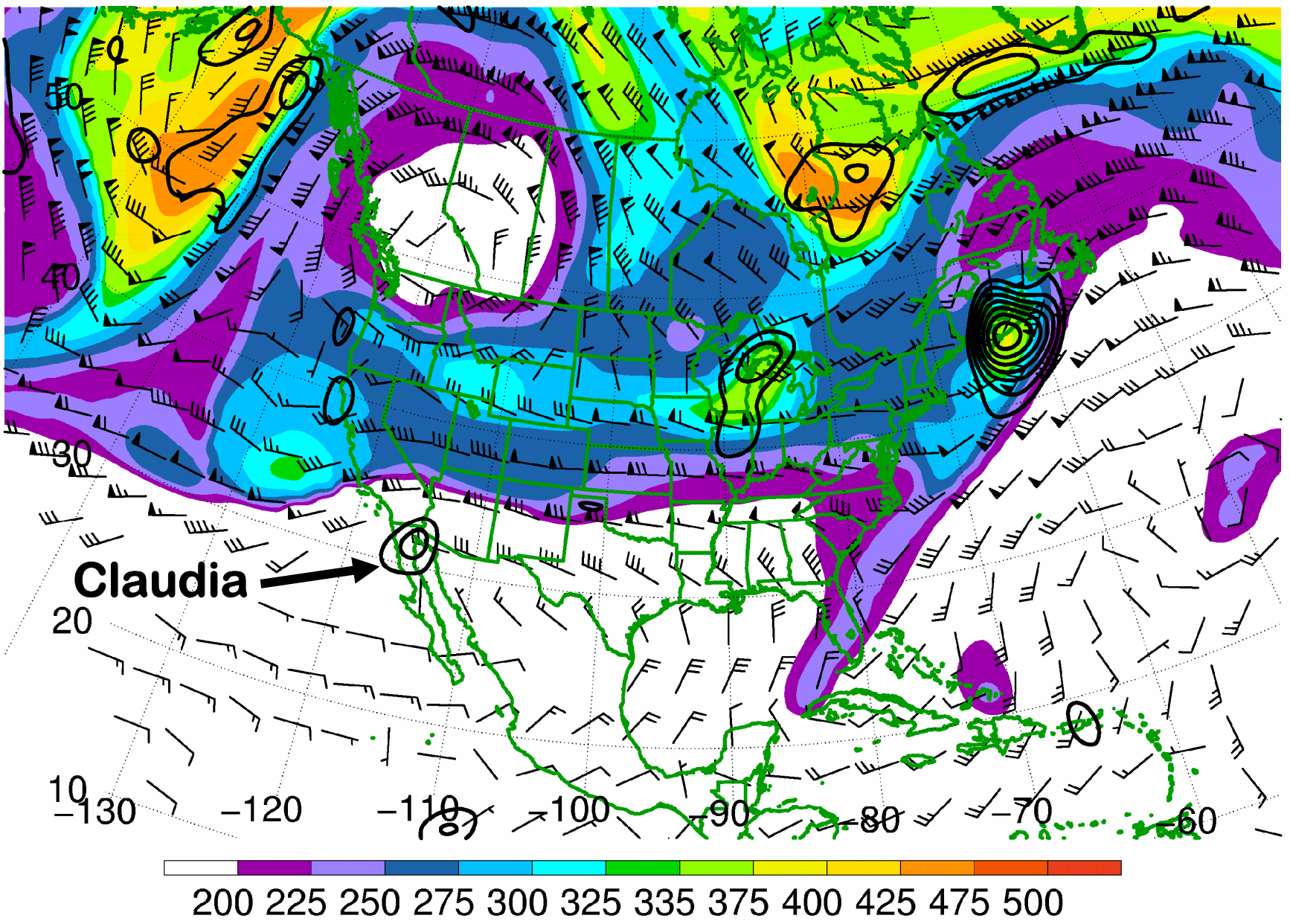


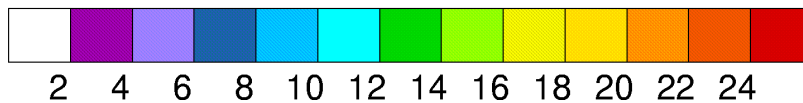
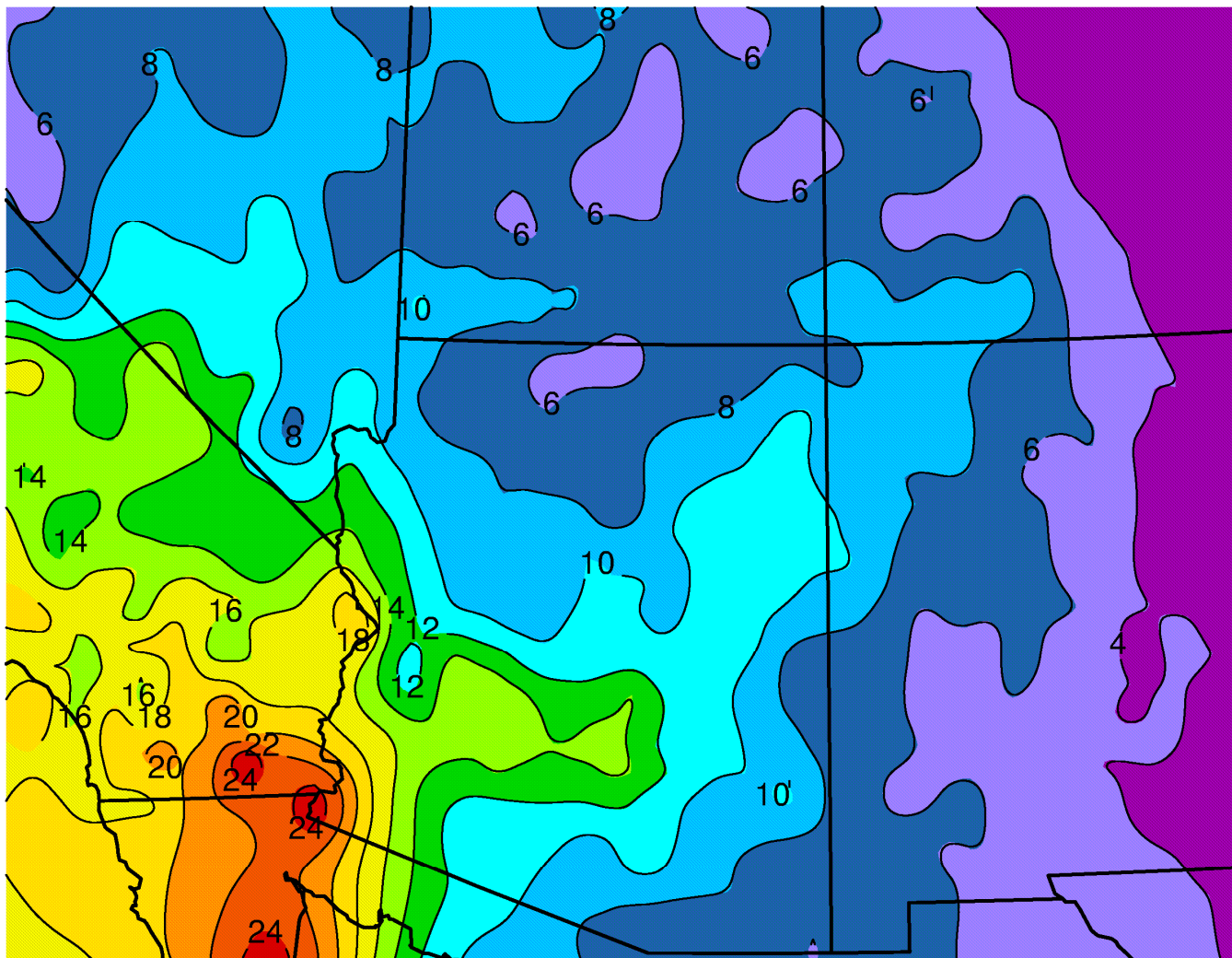
**Storm total  
precipitation (mm)**



**Storm contribution to  
warm season rainfall (%)**

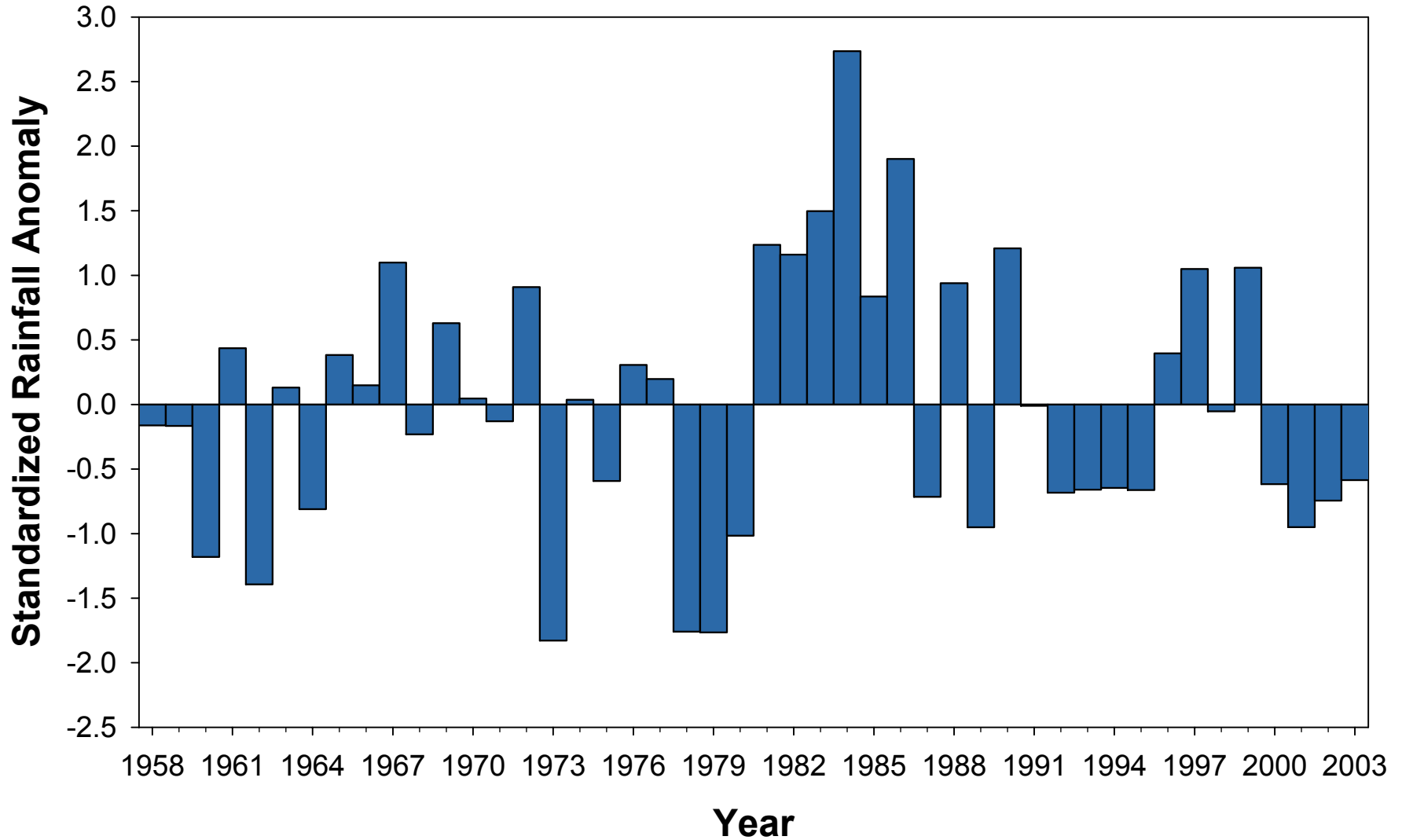
# DT pressure (hPa), DT winds, & 700 hPa vorticity 06 UTC 25 September 1962



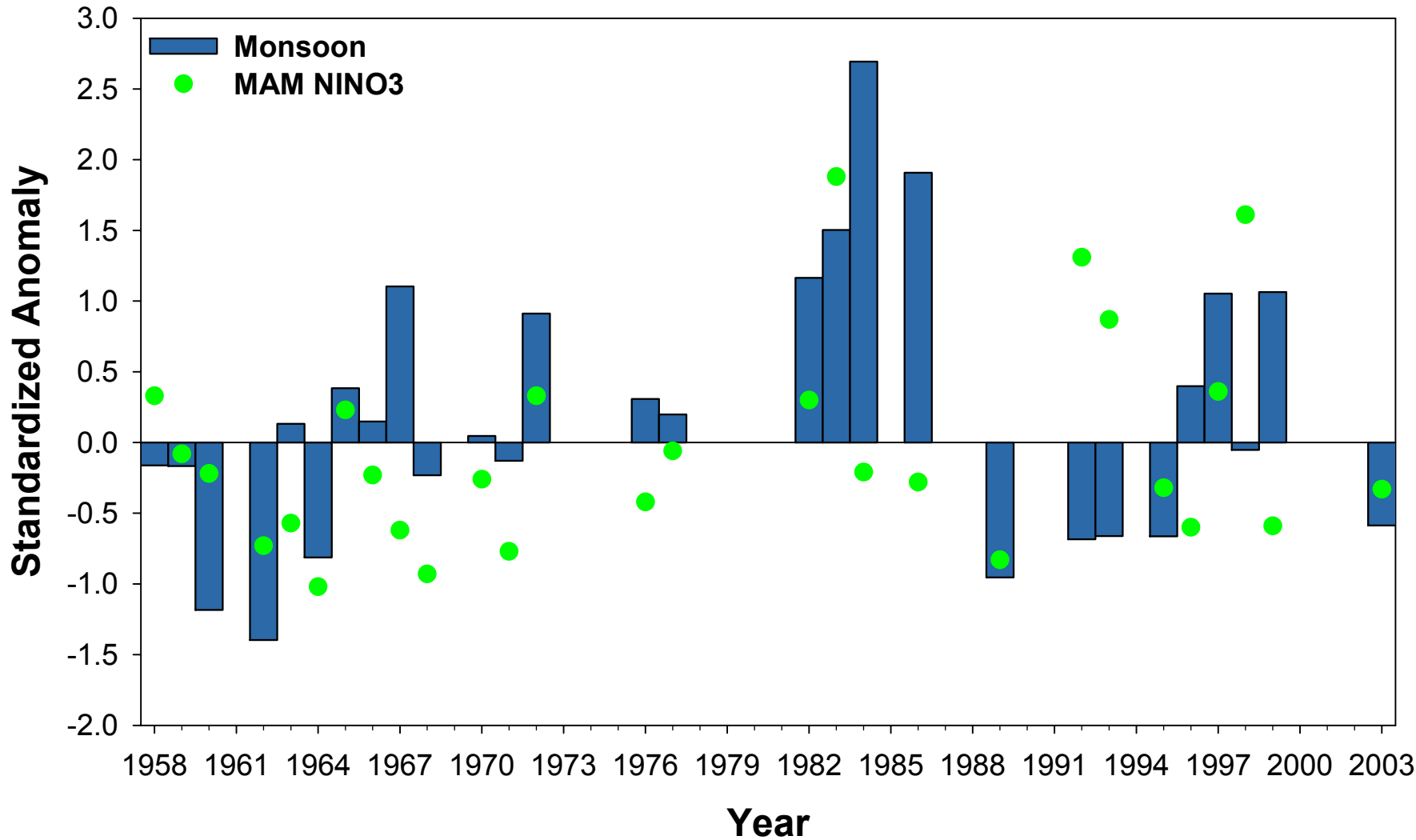


**Average percentage of the warm season precipitation associated with Eastern Pacific TCs**

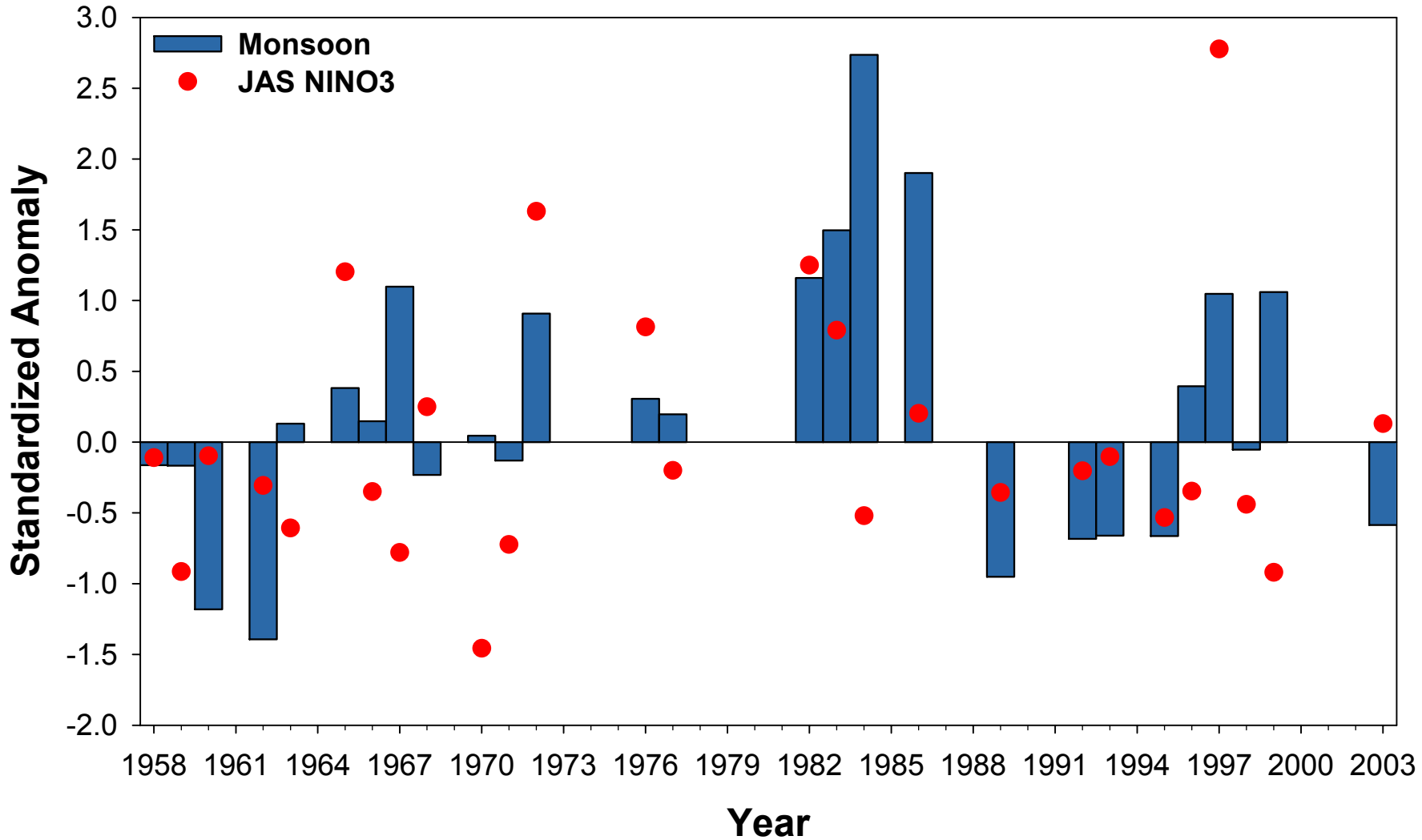
# Southwest US Warm Season Standardized Rainfall Anomalies

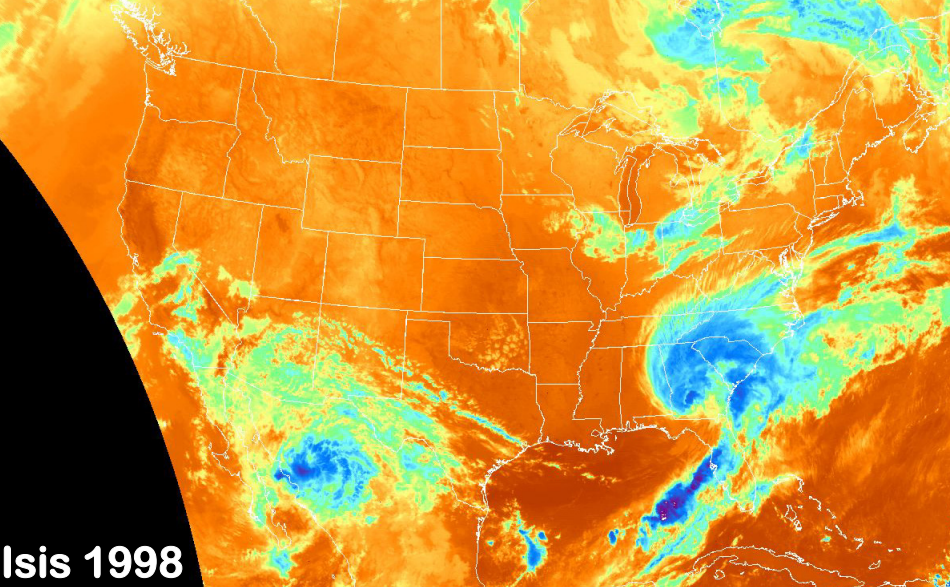


# Southwest US Warm Season Standardized Rainfall and NINO3 Anomalies



# Southwest US Warm Season Standardized Rainfall and NINO3 Anomalies





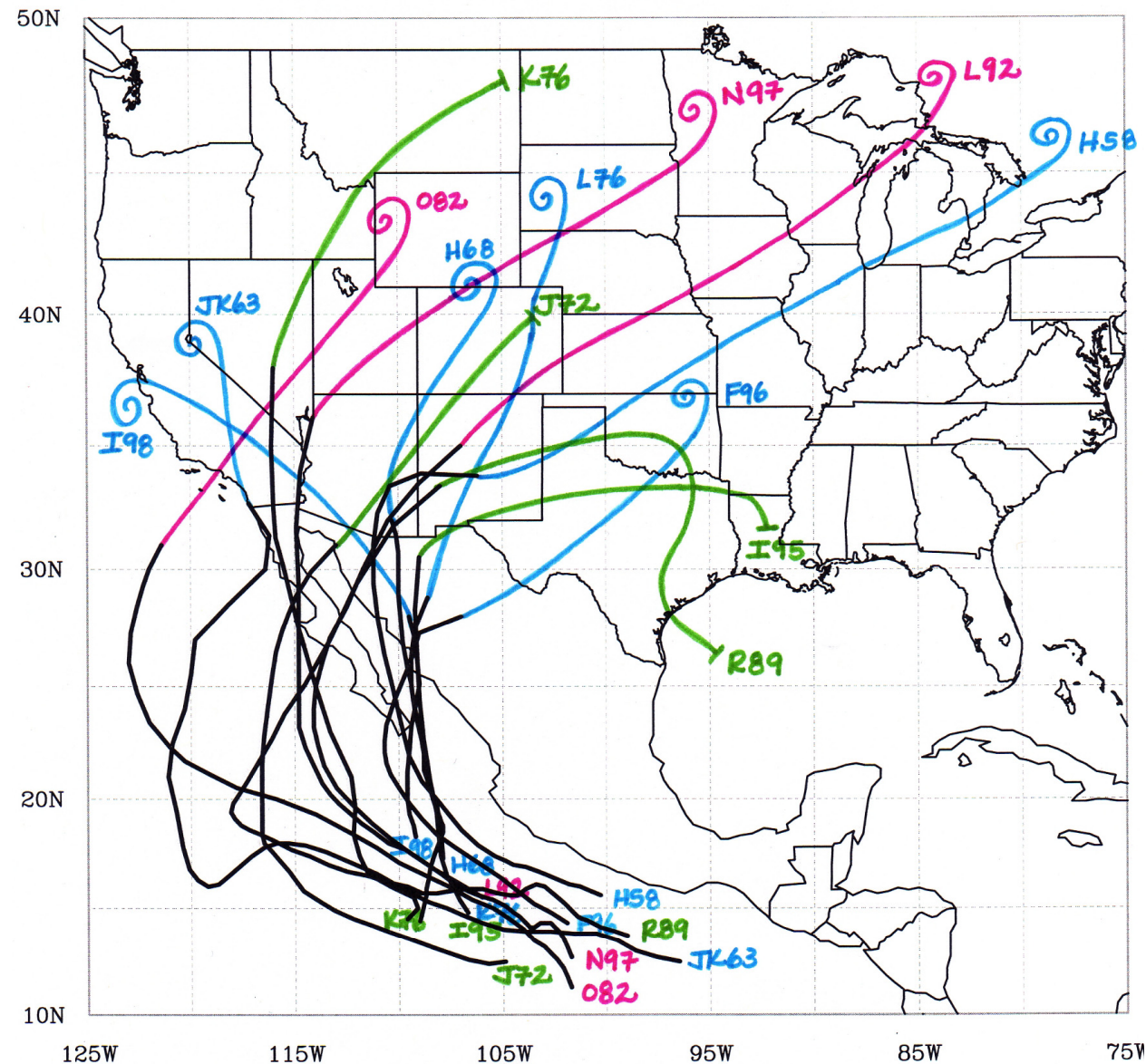
Isis 1998



Lester 1992

## Summary:

- **35 Eastern Pacific TCs brought significant rainfall to the southwest US between 1958 and 2003**
- **On average, 10-15% of the summer rainfall is contributed by TCs, increasing from east to west across Arizona**
- **Two main tracks for TCs into the monsoon region: 1) south to north path into CA and NV, and 2) southwest-northeast “recurvature” track through AZ, NM and CO**



**NHC Best Tracks  
(black)**

**ERA40 700 hPa  
vorticity tracks  
(colors)**

**14 long lived east  
Pacific TCs**