



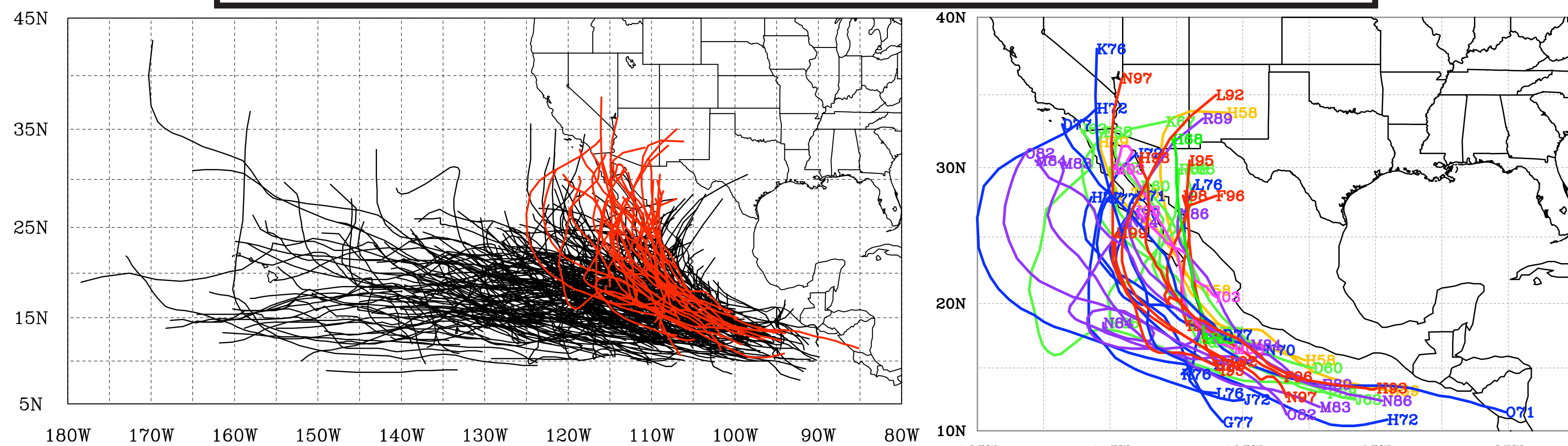
# Recurving Eastern North Pacific Tropical Cyclones

Kristen L. Corbosiero<sup>1</sup>, Michael Dickinson<sup>2</sup> and Lance Bosart<sup>3</sup>

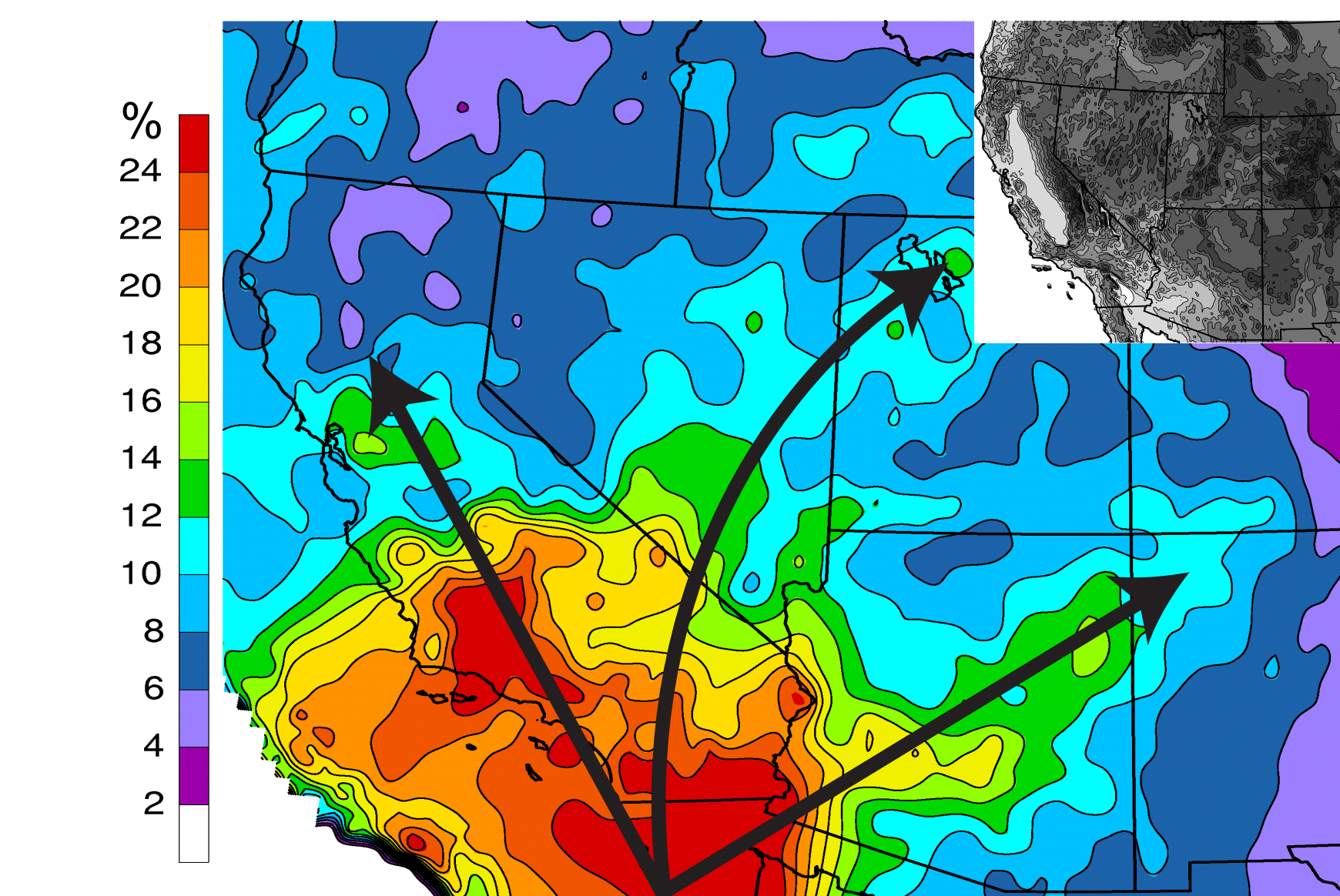
<sup>1</sup>University of California, Los Angeles <sup>2</sup>Weather Predict Consulting <sup>3</sup>University at Albany



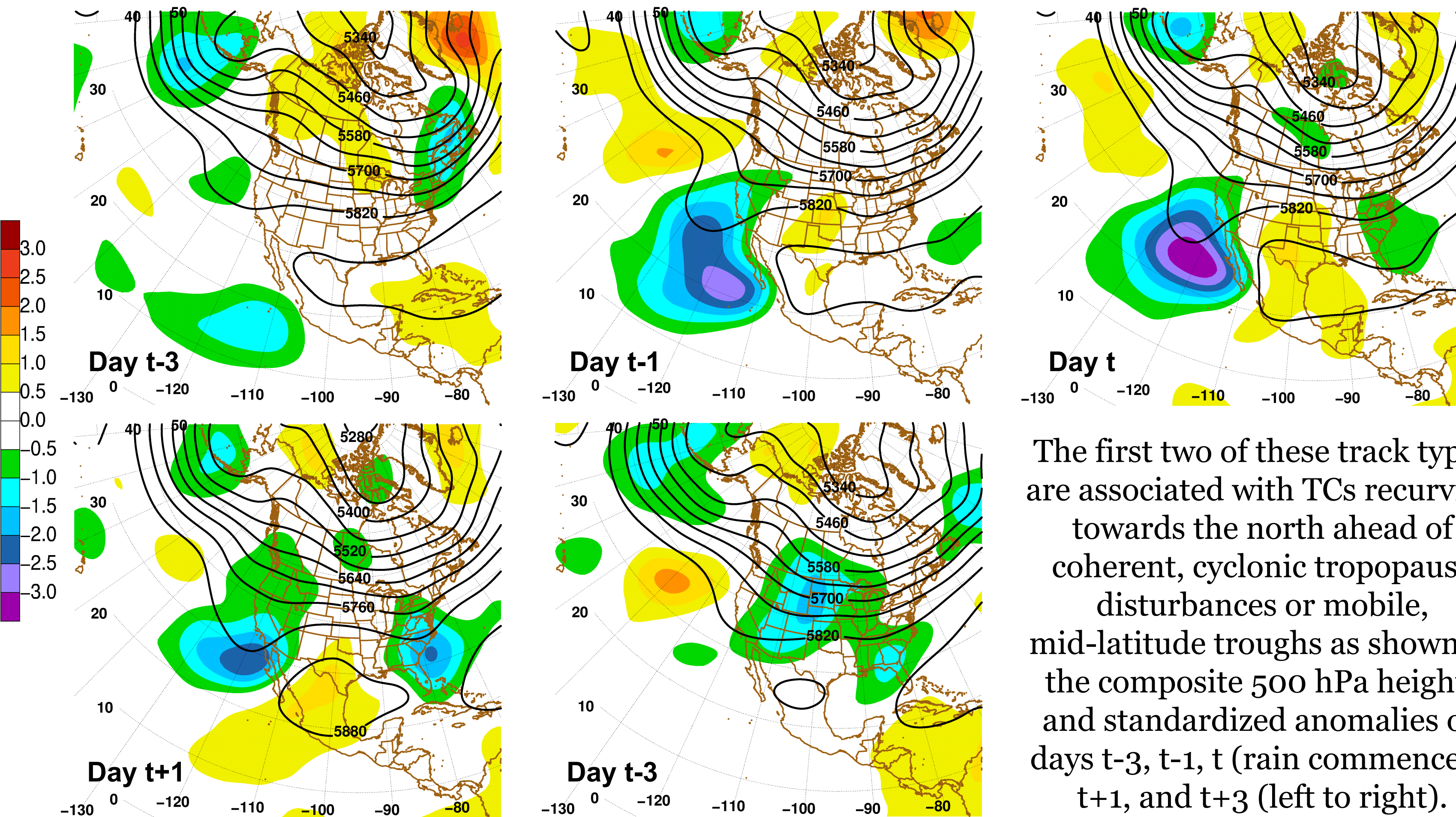
## Introduction and Climatology



Corbosiero et al. (2009) identified 35 eastern North Pacific tropical cyclones (TCs) between 1958 and 2003 that brought rainfall to the southwestern United States, representing less than 10% of TCs in the basin.



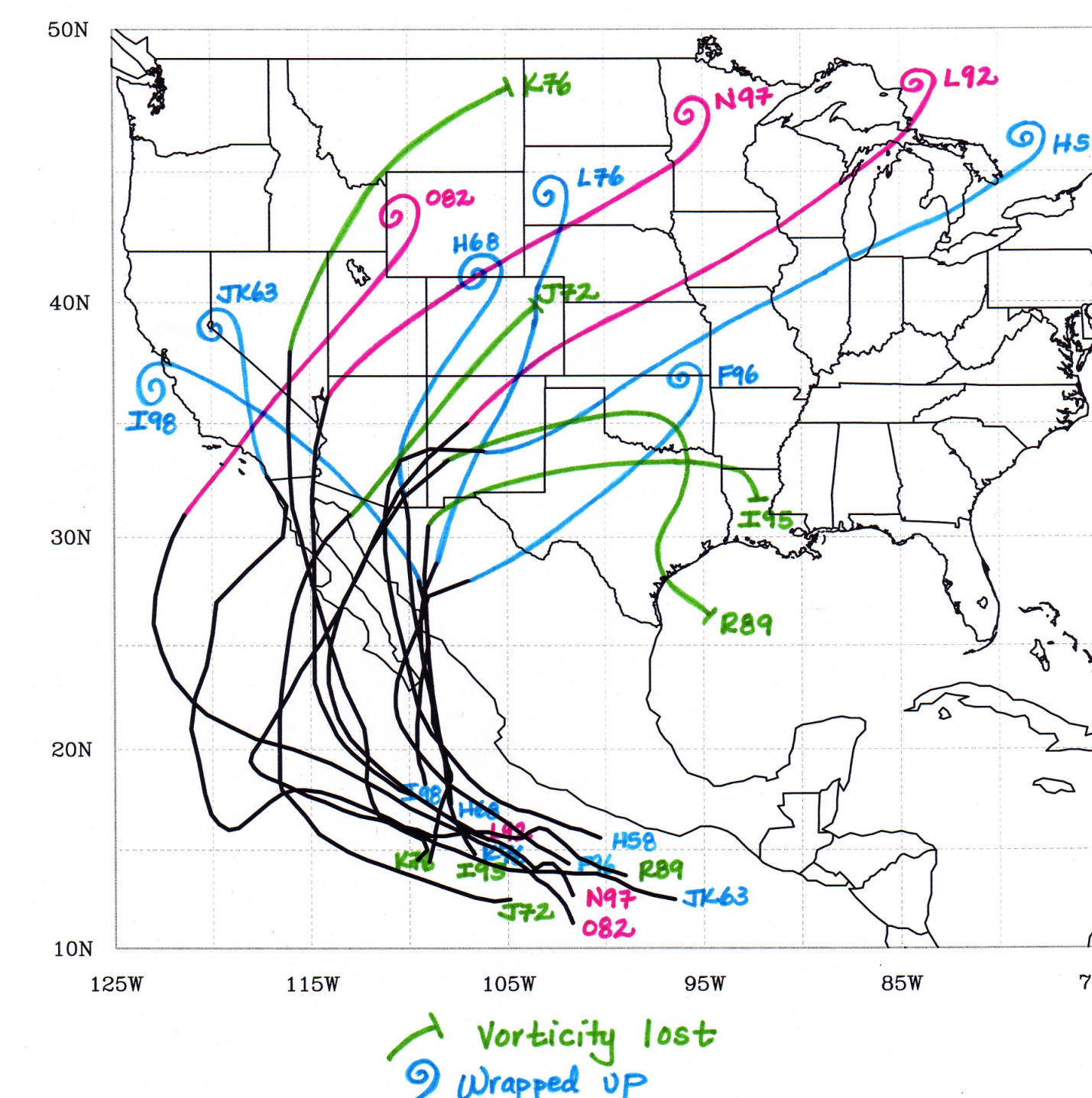
The distribution of rainfall for these TC events revealed three main types: 1) northward and northwestward tracks into California and Nevada, 2) distinct southwest-northeast oriented swaths, and 3) broad, light precipitation areas with maxima tied to the terrain.



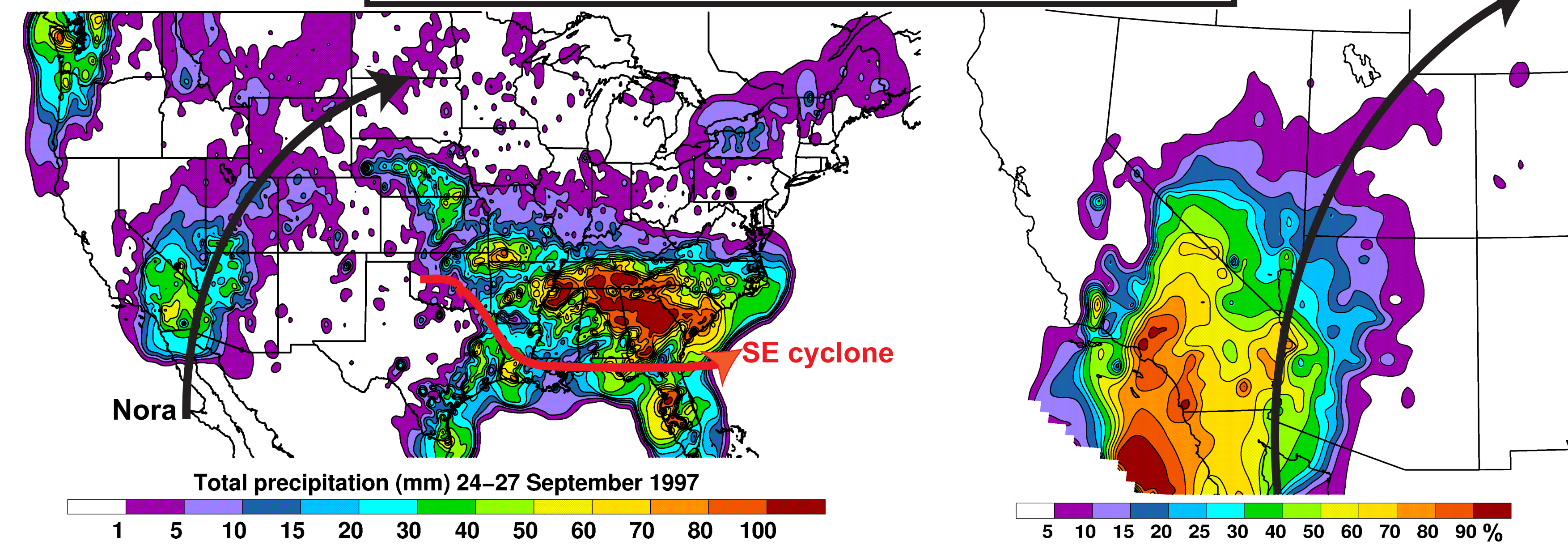
The first two of these track types are associated with TCs recurving towards the north ahead of coherent, cyclonic tropopause disturbances or mobile, mid-latitude troughs as shown in the composite 500 hPa heights and standardized anomalies on days t-3, t-1, t (rain commences), t+1, and t+3 (left to right).

While most TCs weaken well below NHC tracking limits as they approach the southwestern United States, due to a combination of strong vertical wind shear and cold sea surface temperatures, 13 of the 35 TCs listed above maintain an ERA-40 700 hPa relative vorticity signature greater than  $4 \times 10^{-5} \text{ s}^{-1}$  and can be tracked thousands of kilometers downstream over the continental United States.

The remnant vorticity and moisture can interact with the mid-latitude flow in a rich array patterns, including significant amplification of the downstream flow pattern, becoming wrapped up in a developing mid-latitude system, or remaining as a separate vorticity maximum and exhibiting the classic signatures of extratropical transition.



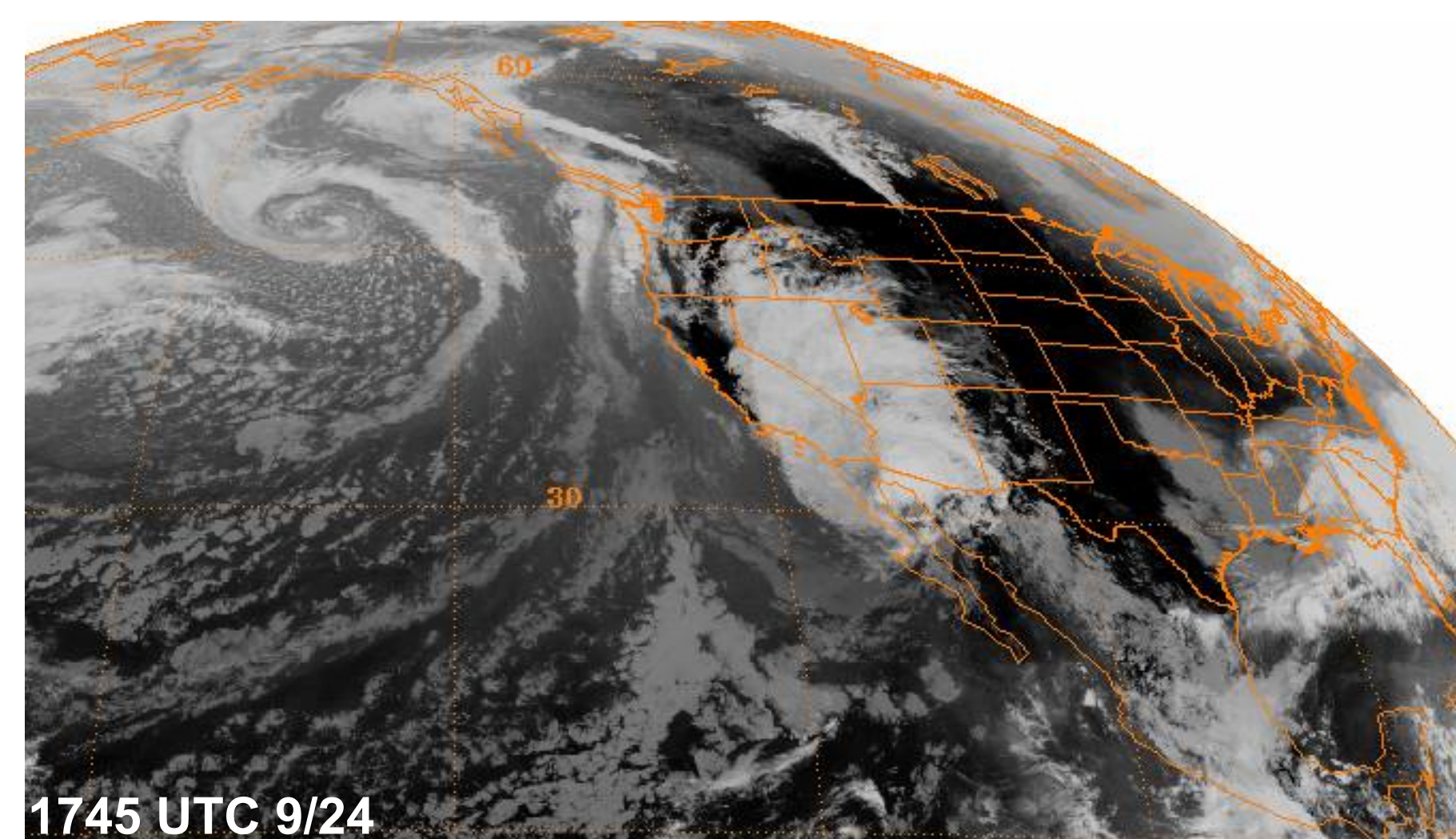
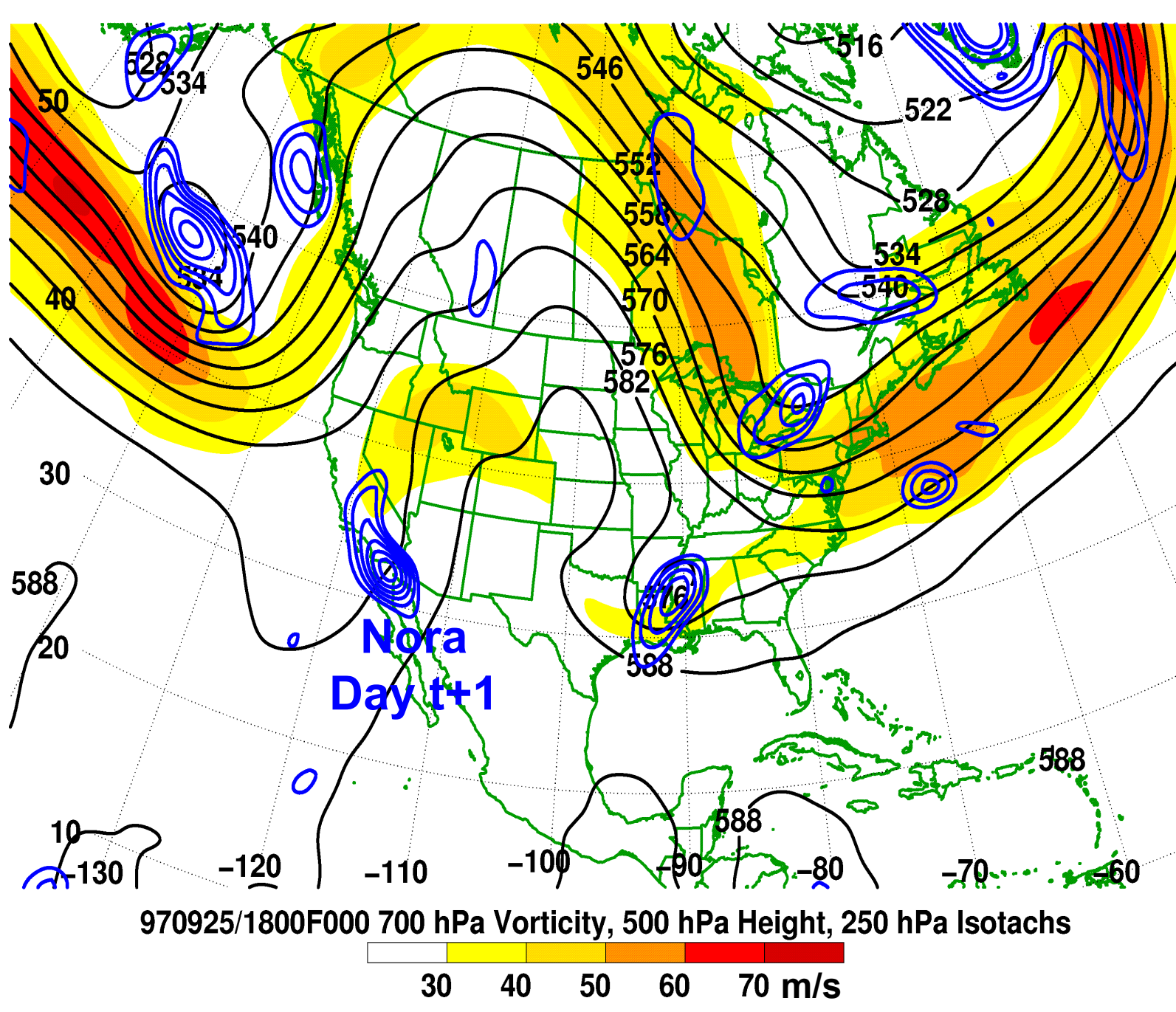
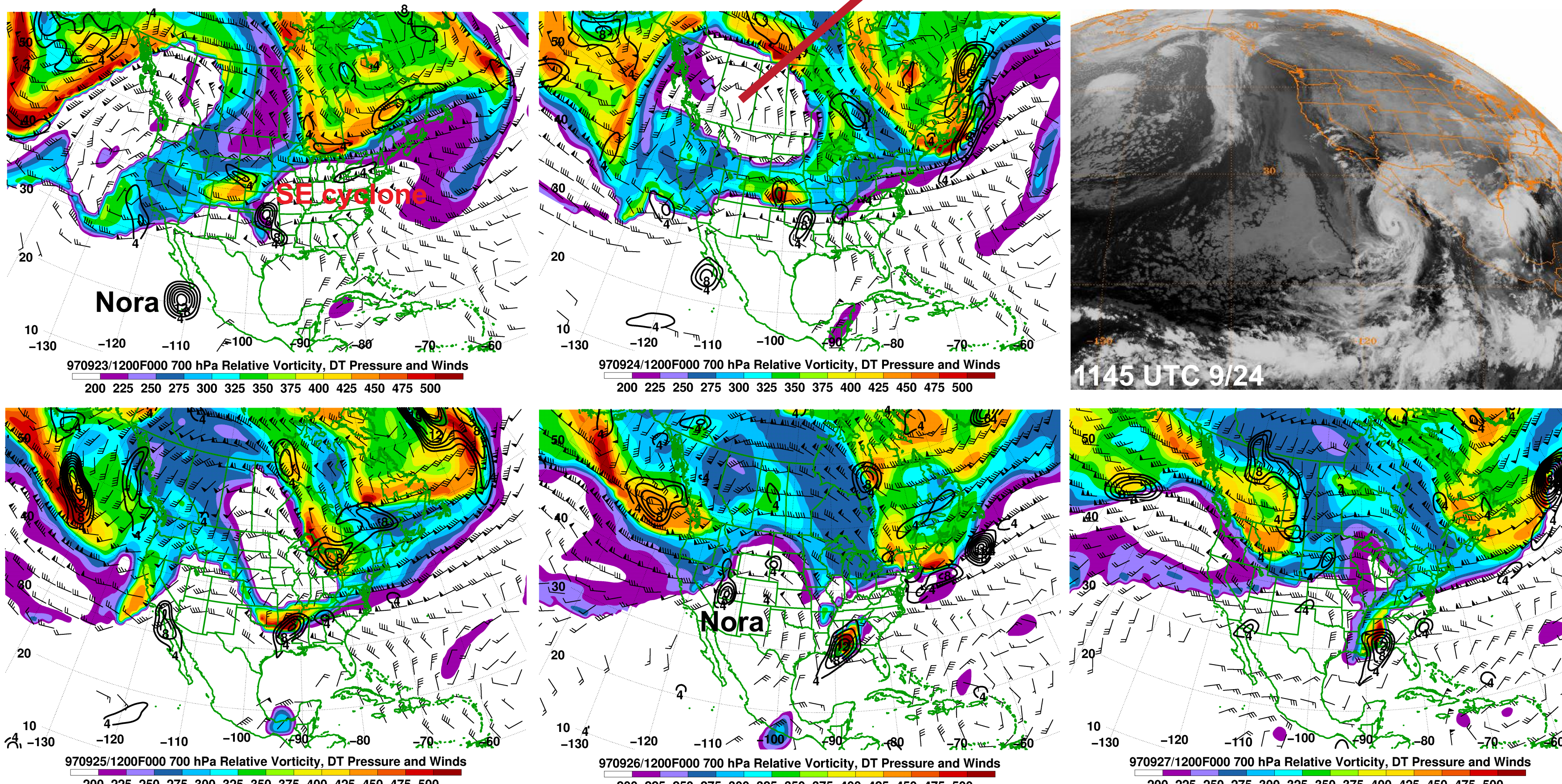
## Hurricane Nora (1997)



Hurricane Nora (1997) brought more than 30 mm of rain to a large portion of the southwestern United States, accounting for more than 60% of the summer rainfall in southern California.

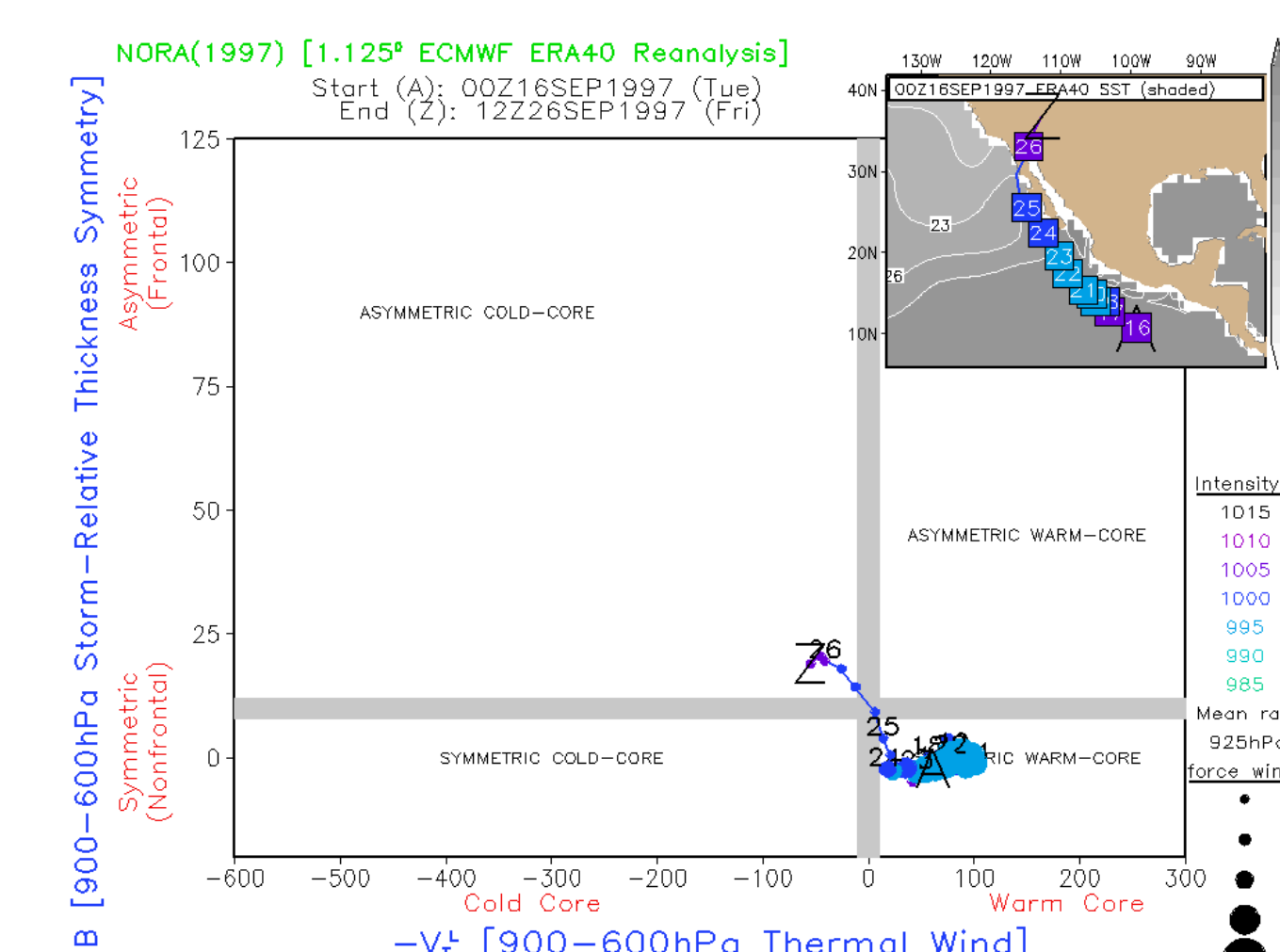
The diabatically generated, anticyclonic warm pool from the extratropical transition (ET) of western Pacific TC David played a significant role in the development and propagation of the mid-latitude trough that caused the recurvature and ET of Nora.

Together, the David and Nora warm pools influenced the strength of a cyclone over the southeastern United States through downstream development.

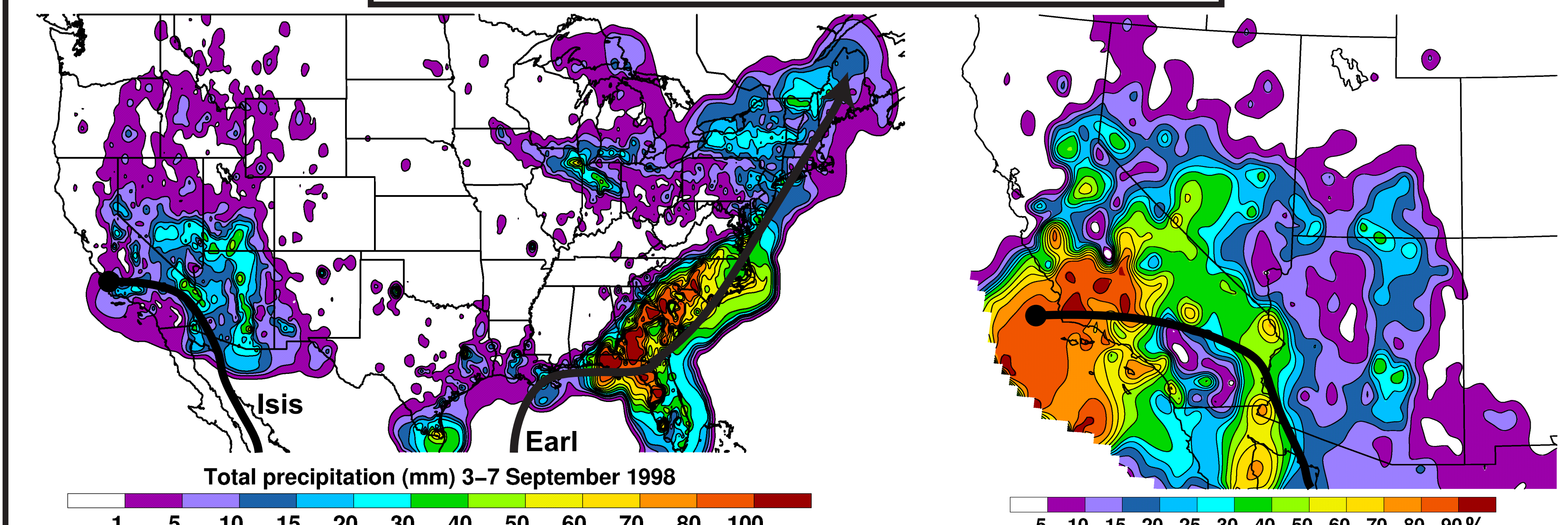


Hurricane Nora exhibited several of the classic signatures of extratropical transition, including:

- 1) The superposition between, and mutual intensification of, the storm and the cyclonic disturbance on the dynamic tropopause (DT).
- 2) The development of an anticyclonically curved outflow jet at 250 hPa.
- 3) The transition of the IR cloud field and low level thermal fields from symmetric to asymmetric.
- 4) A left of track precipitation maximum.

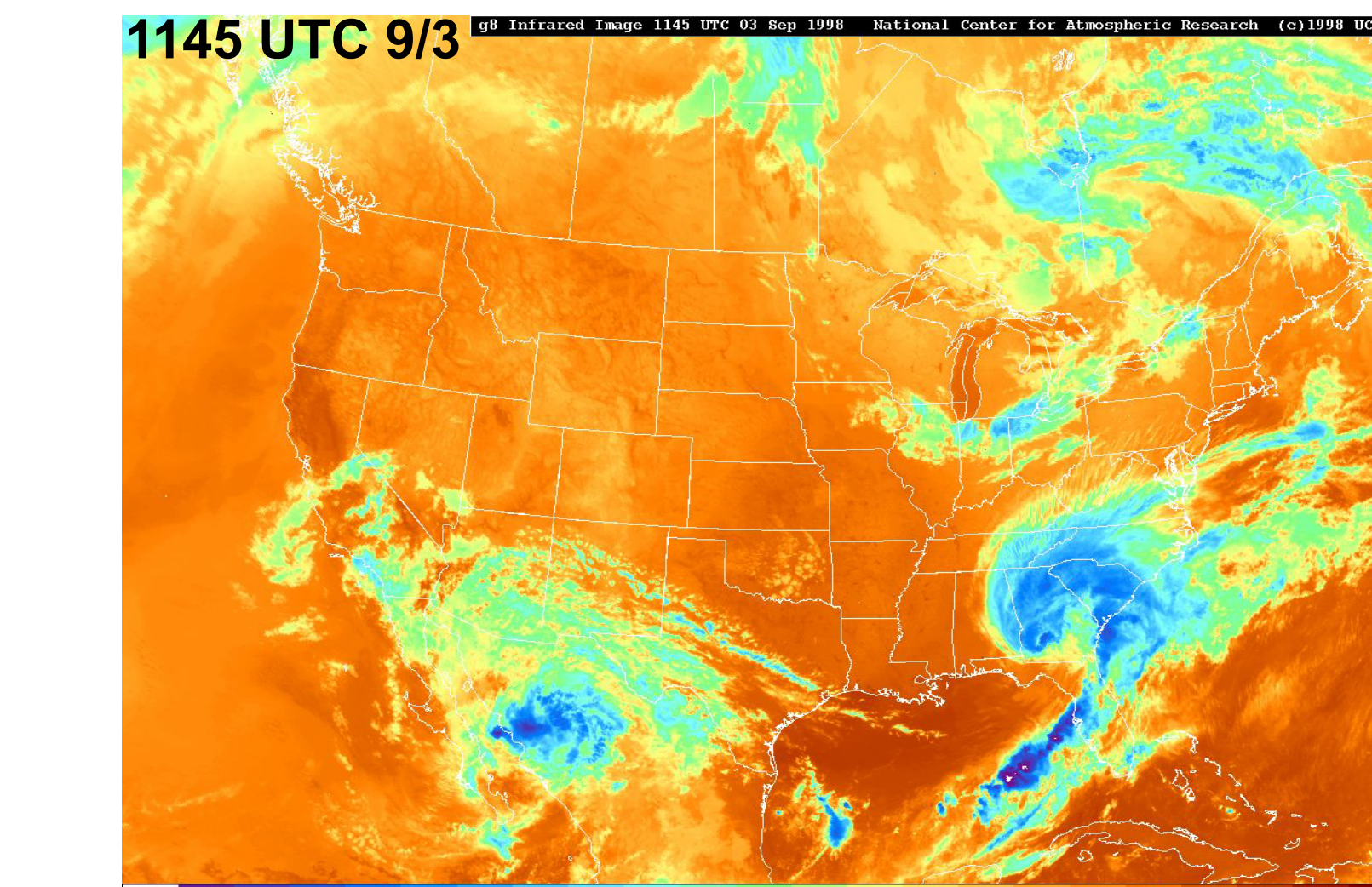
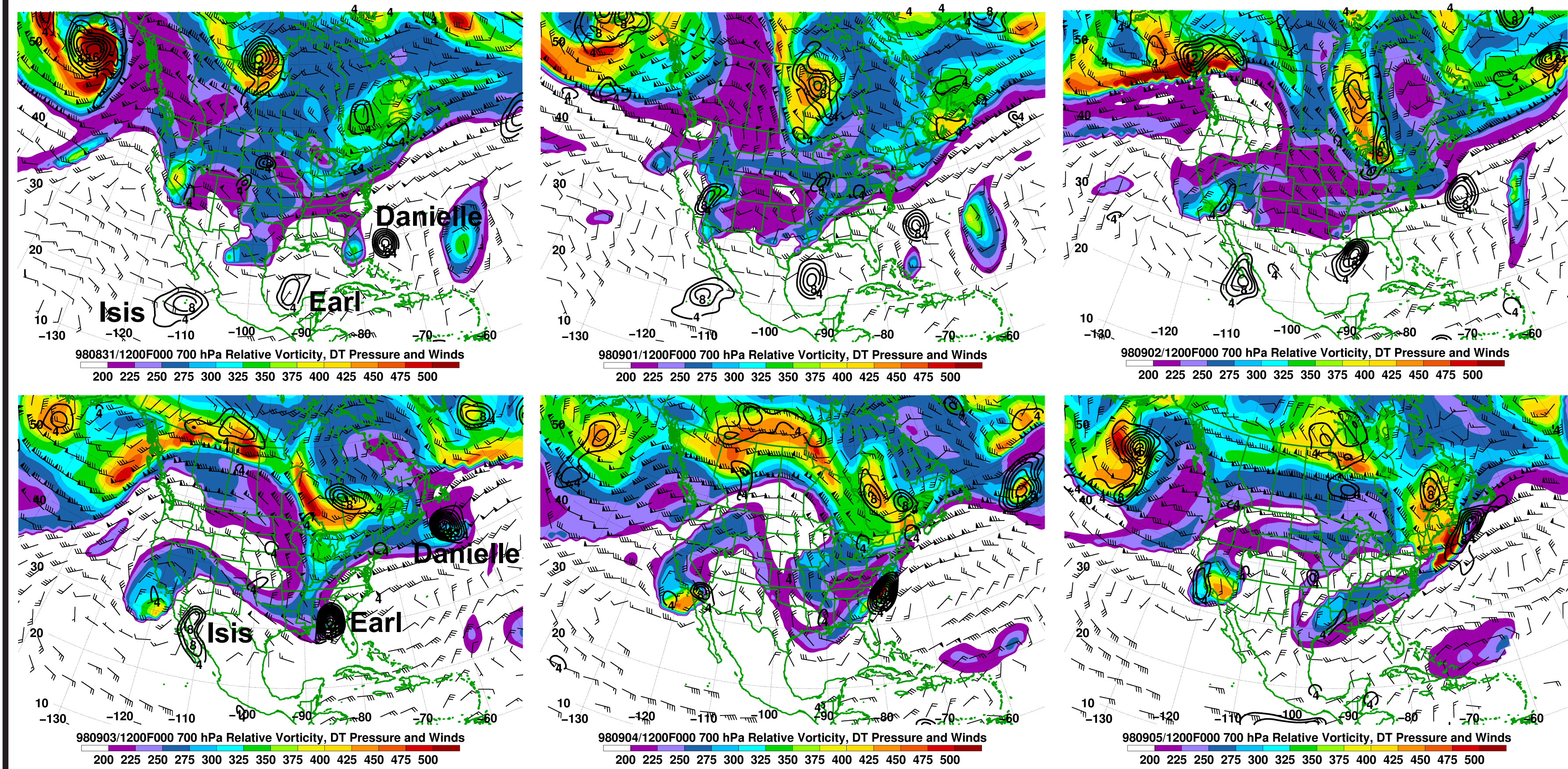


## Hurricane Isis (1998)



Hurricane Isis (1998) produced widespread light precipitation over much of the southwestern U.S. as it propagated slowly northwestward and then westward around the periphery of a large, stationary, cyclonic disturbance on the DT.

The diabatic, anticyclonic outflow generated as Isis interacted with the disturbance eroded and thinned the PV strip connecting the DT disturbance to the flow, amplifying the downstream ridge-trough couplet and jump starting the ET of Hurricane Earl over the southeastern U.S.



After downgraded by NHC below tropical depression strength, the low level vorticity signature and half of the moisture associated with Isis propagated to the northwest while the remaining moisture moved to the northeast and quickly dissipated.

The zonally oriented ridge over the mid-latitude, eastern Pacific at 500 hPa on the day before rain commenced in the southwestern U.S. looks significantly different than the composite, highlighting the importance of a DT perspective when investigating eastern Pacific TC recurvature events.

