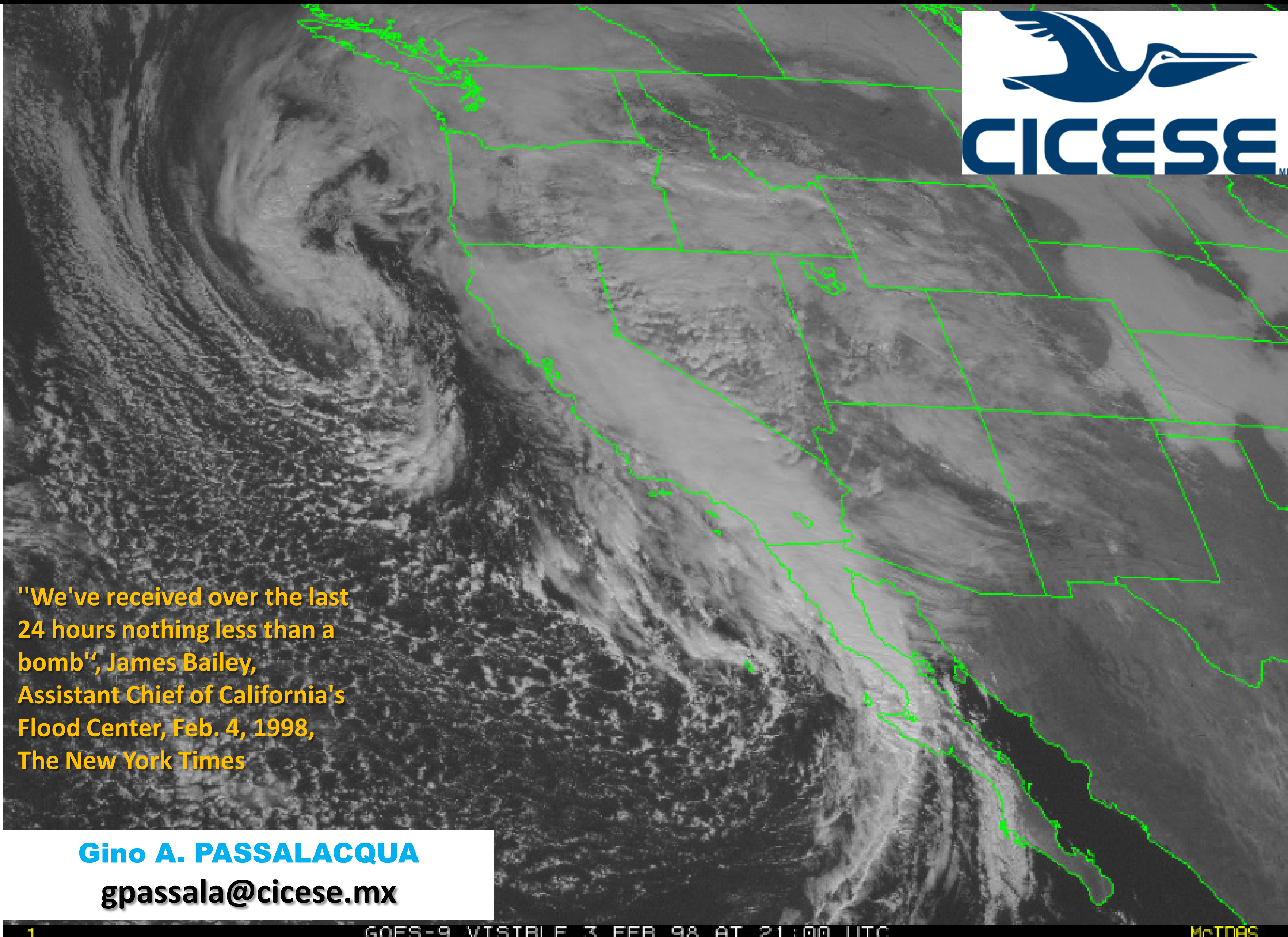
Oceanic Influence on Landfalling Atmospheric Rivers: the Intense Precipitations of February 2-3, 1998



"We've received over the last 24 hours nothing less than a bomb", James Bailey, Assistant Chief of California's Flood Center, Feb. 4, 1998, The New York Times

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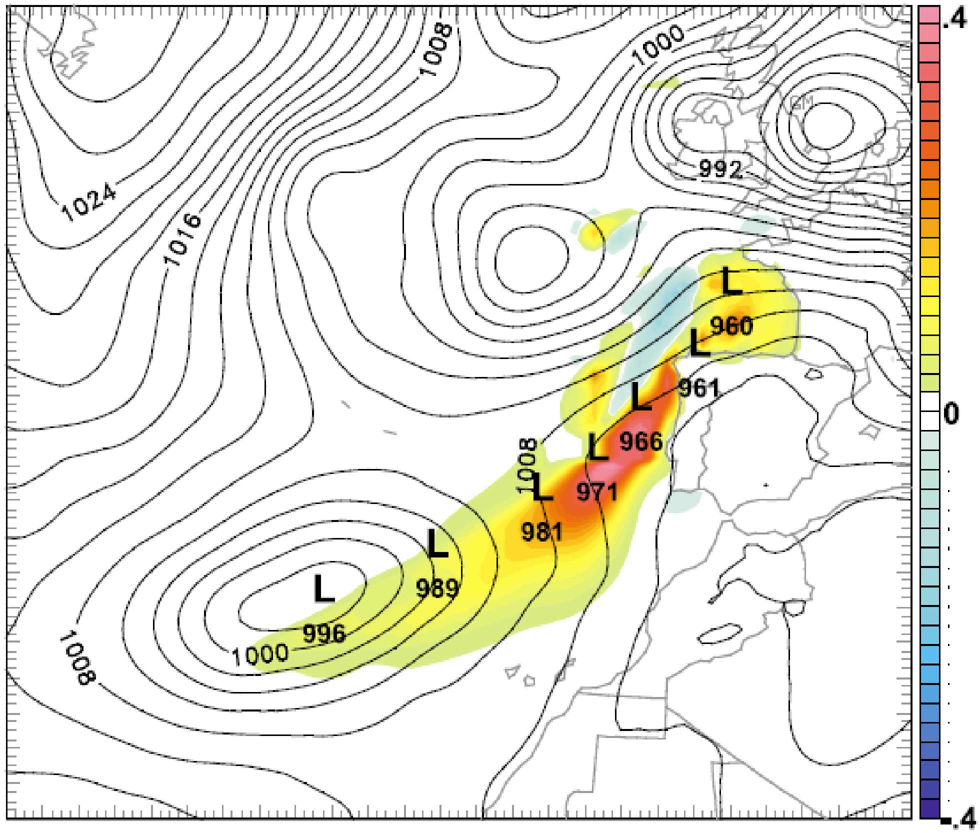
MOTIVATION: Air-Sea Interaction of Cold Fronts

Doyle at al. (2014) SST sensitivity for Extratropical Cyclone Xynthia



Adjoint SST sentitivity (every 0.02 $m^2 s^{-2} K^{-1}$), SLP (every 2 hPa)
12:00 UTC 26 Feb 2010. Sensitivity scale 10^8 km^{-2}

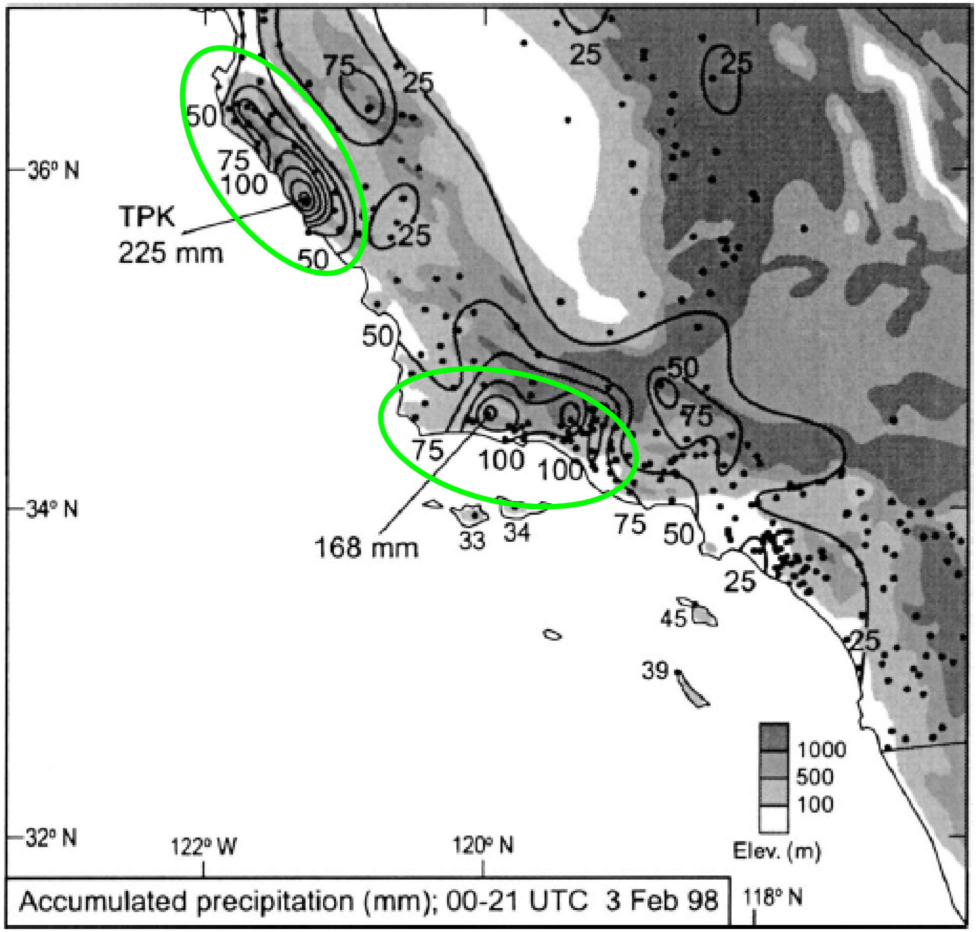
Severe Winds just prior to the front landfall were sensitive to perturbations in the moisture and temperature fields.

Sensitivity Maxima in the low- and midlevels, oriented in a sloped region along the warm front, and maximized within the warm conveyor belt.

Relatively Small Filament of moisture within an atmospheric river present at the initial time ***critically important*** for the development of Xynthia.

SST Sentivity over the warm sector and during storm undergoes rapid intensification.
(Doyle et al., 2014)

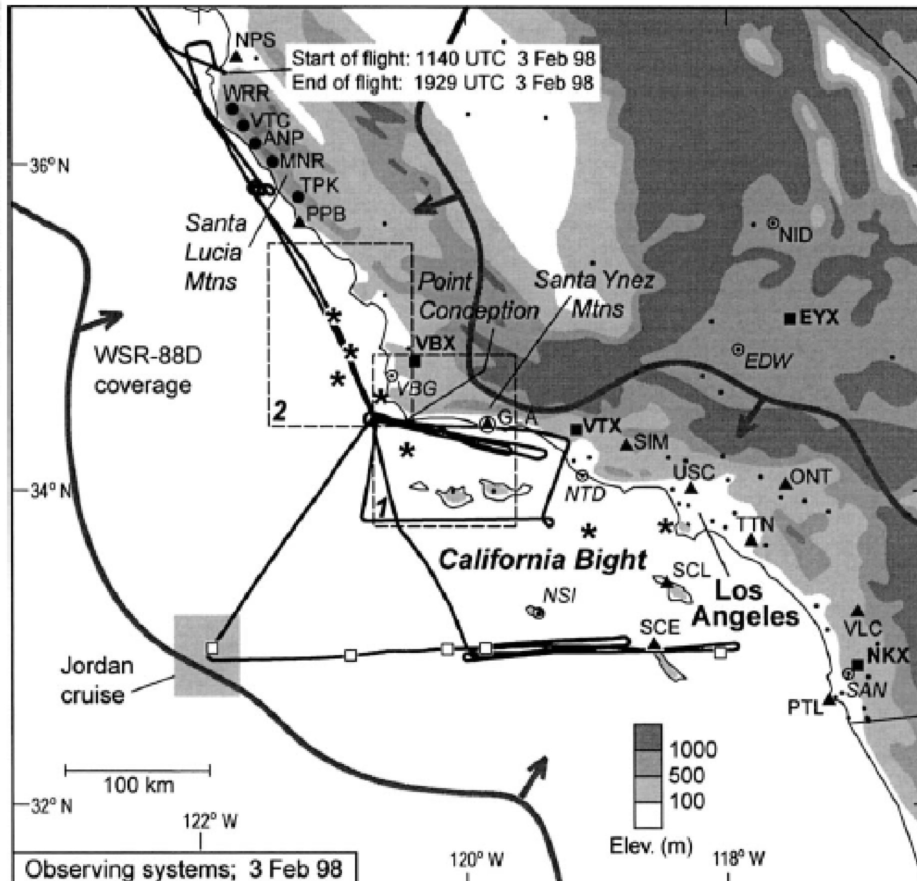
- The ocean maintains **cooler temperatures** for days after the passage of a front, affecting the air-sea interactions of the following meteorological system (Lebaupin Brossier et al., 2013).
- *The intensity of the storm **grows monotonically with the magnitude of the SST perturbations**, even when this perturbations debilitated the SST gradient (Booth et al., 2012) .*
- *The **propagation speed** of the cold front affects the accumulated winter precipitation in the GoM (Perez et al., 2014)*



Accumulated precipitation (mm); 00-21 UTC 3 Feb 98

California Landfalling Jets: CALJET

Thanks to Dr. Ola Persson & Tim Coleman at NOAA/ESRL Physical Sciences Division (PSD)

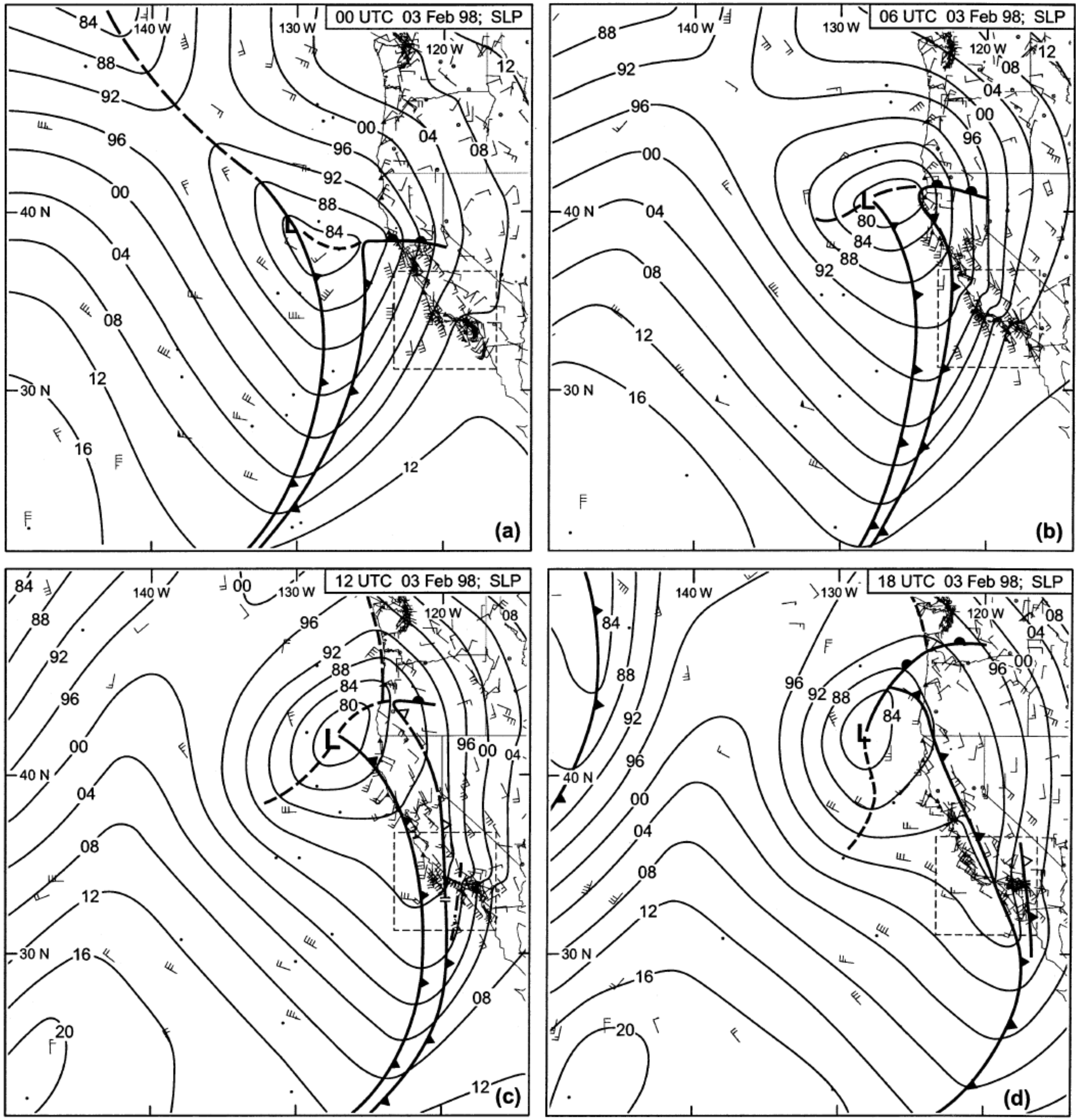


Observing systems; 3 Feb 98

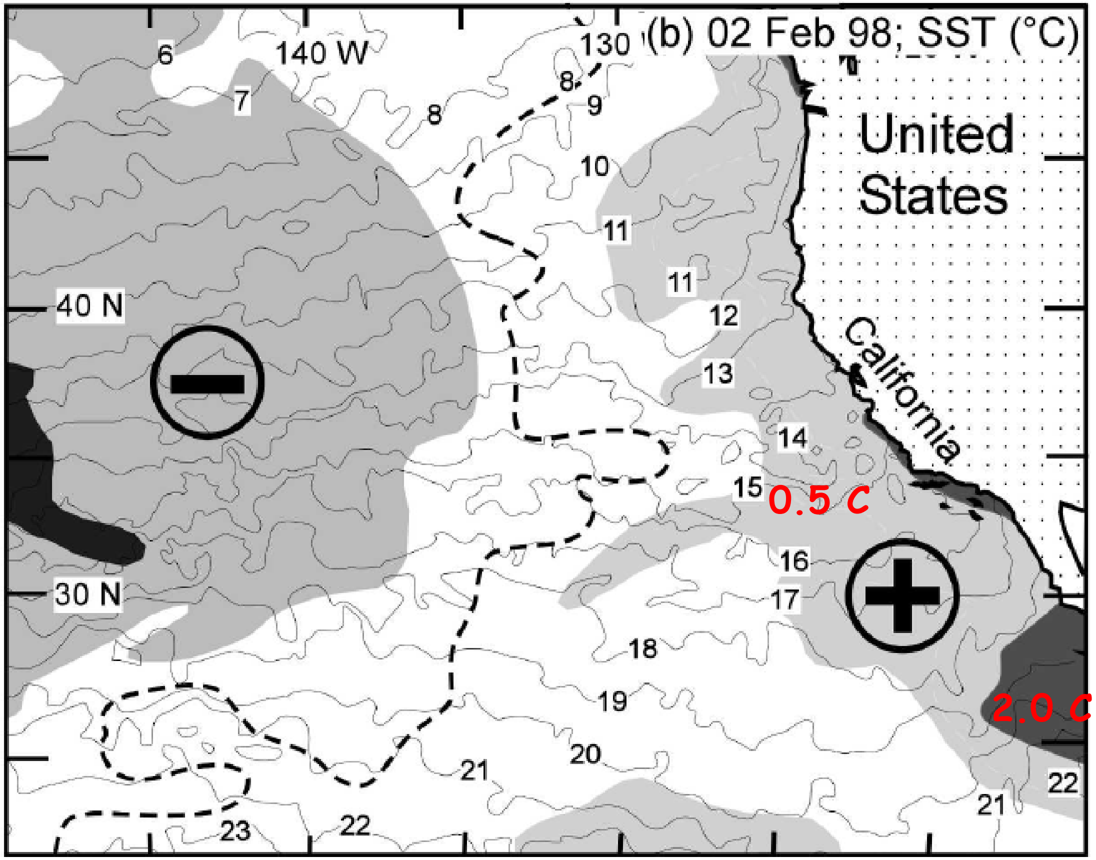
Accumulated Precipitation 00-21 UTC Feb 98

Synoptic Overview of the Storm - Feb 03, 1998

Neiman et al., 2004



ENSO 1997-98: SST Conditions



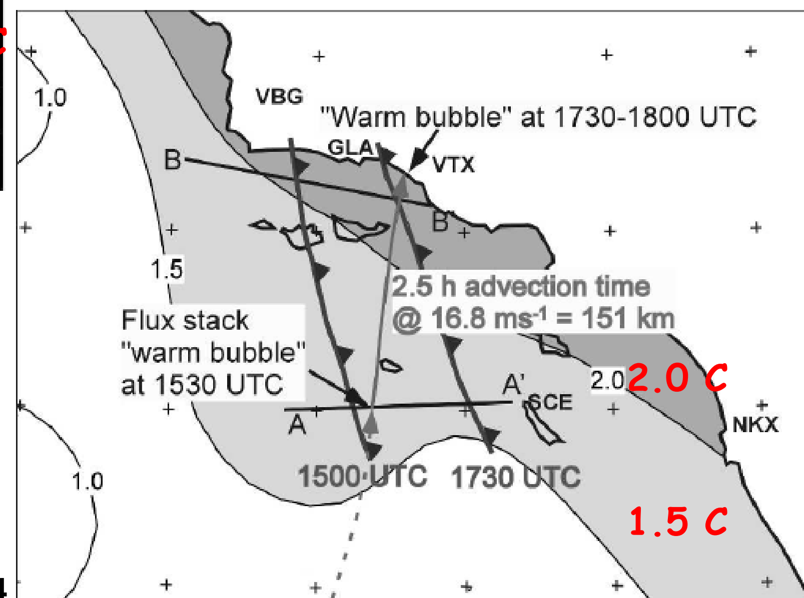
Persson et al., 2004

Surface fluxes increased CAPE by about 26% due to anomalous SST caused by ENSO

(Persson et al., 2004)

SST Anomalies

02 Feb 98

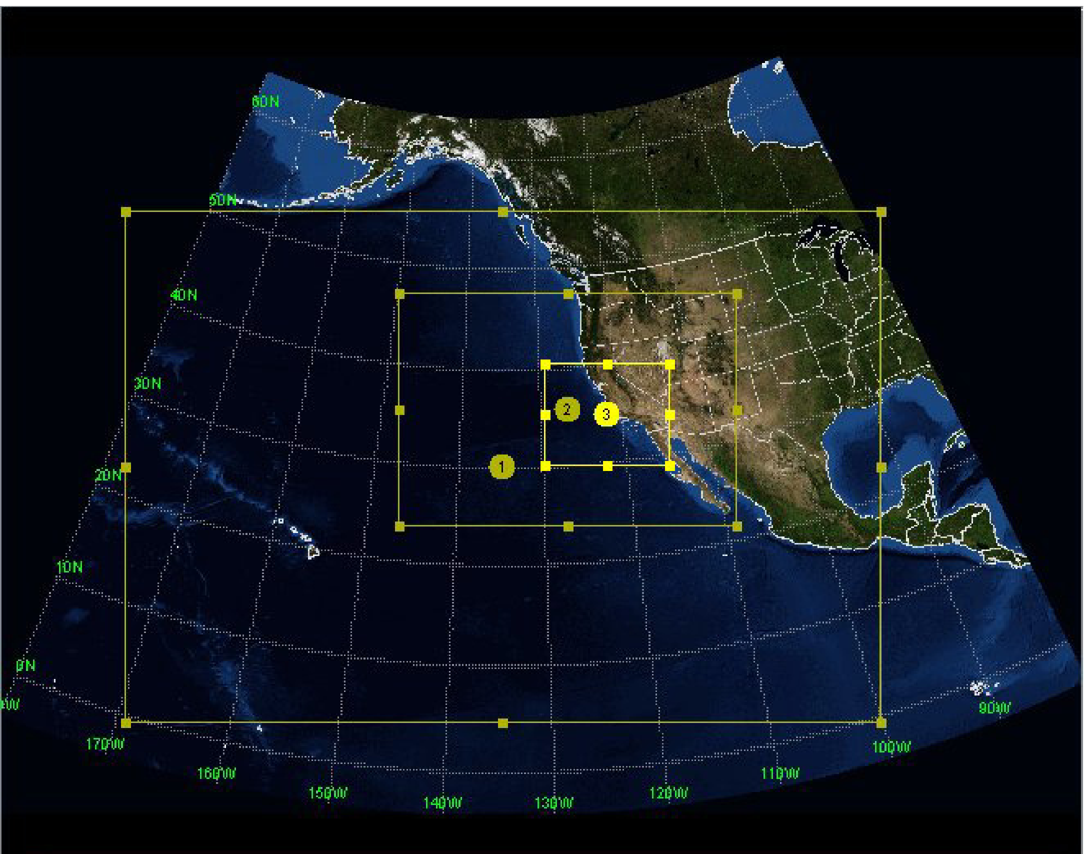


Persson et al., 2004

WRF – AR : SST Experiments

OCEAN : 3D Price-Weller-Pinkel (PWP) ocean model based on Price et al. (1994). Predicts horizontal advection, pressure gradient force, as well as mixed layer processes. Accounts for surface heat fluxes.

SST : Daily RTG SST update, Diurnal SST cycle.



Simulation Characteristics

Three Domains: D01 - 36 km, D02 - 12 km & D03 - 04 km
Projection: Lambert Conformal
Vertical Resolution: 58 Levels

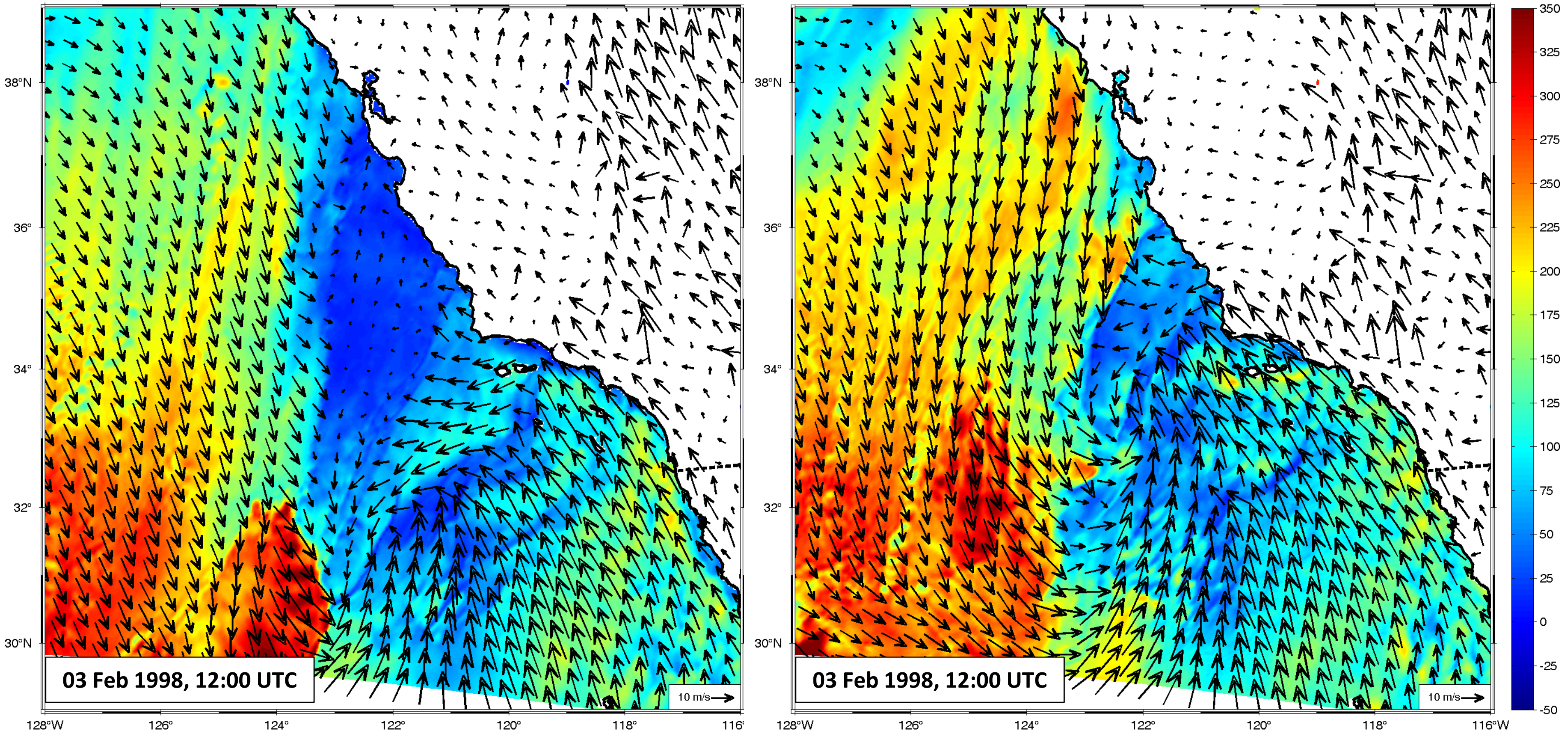
Input: NCEP Climate Forecast System Reanalysis (CFSR) 6 hrs, Daily RTG SST update, Diurnal SST cycle

Output: 1 hrs

Start Date & Time: Jan 31, 1998 00 hrs UTC
End Date & Time: Feb 5, 1998 0 hrs UTC

Domain 03 – 4 Km: Latent Heat Flux (w/m²) & 10m Winds (m/s)

Feb 03, 12:00 UTC

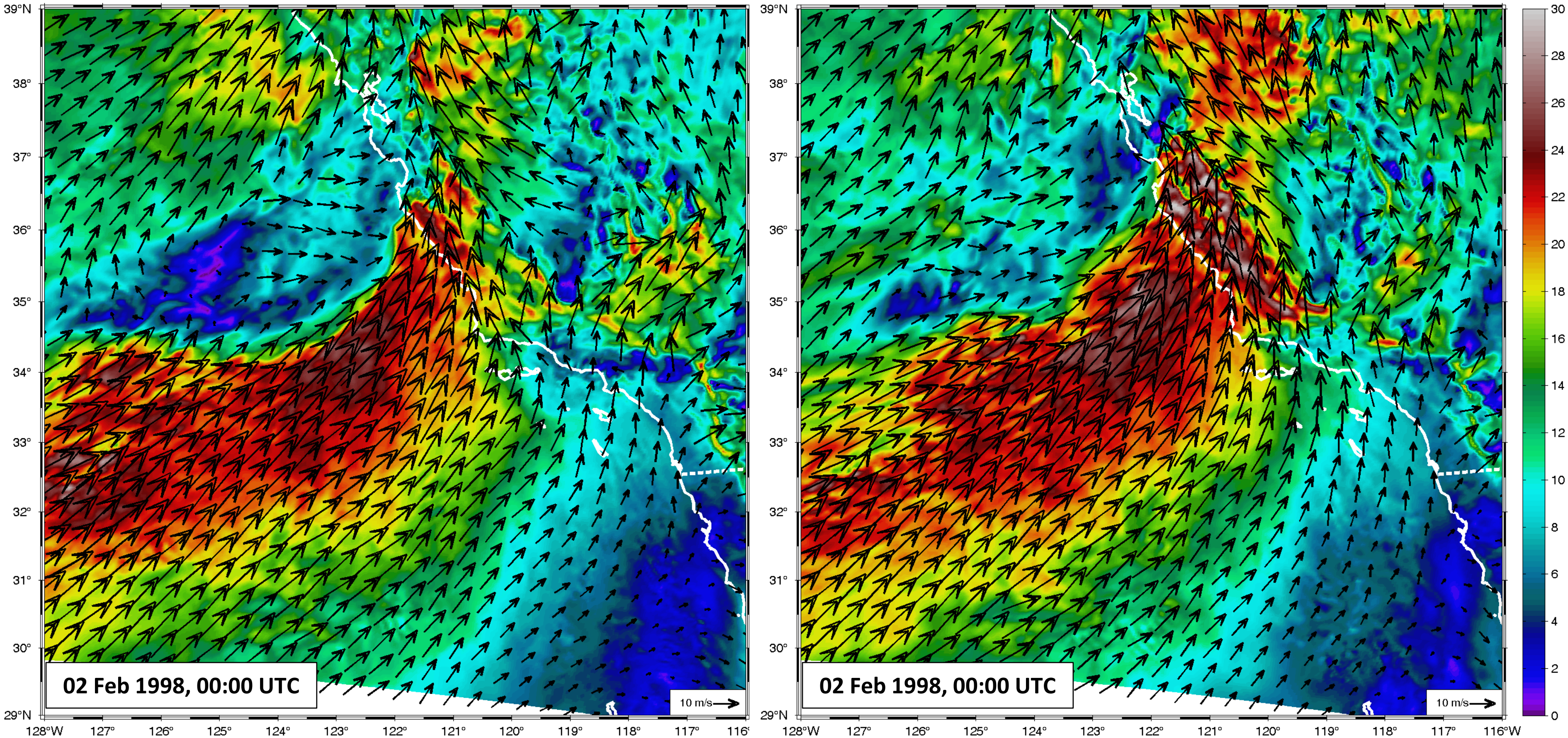


SST **OCEAN**

- Different position and structure of the surface cold front, based on the 10 m wind direction and magnitude changes; see Simmonds et al. (2012). Winds intensity and structure is different over land, especially over Santa Barbara and Ventura counties.
- Post frontal Latent Heat structure and magnitudes are significantly different.

Domain 03 – 4 Km: 950 mb Wind Speed & Vectors (m/s)

Feb 02, 00:00 UTC

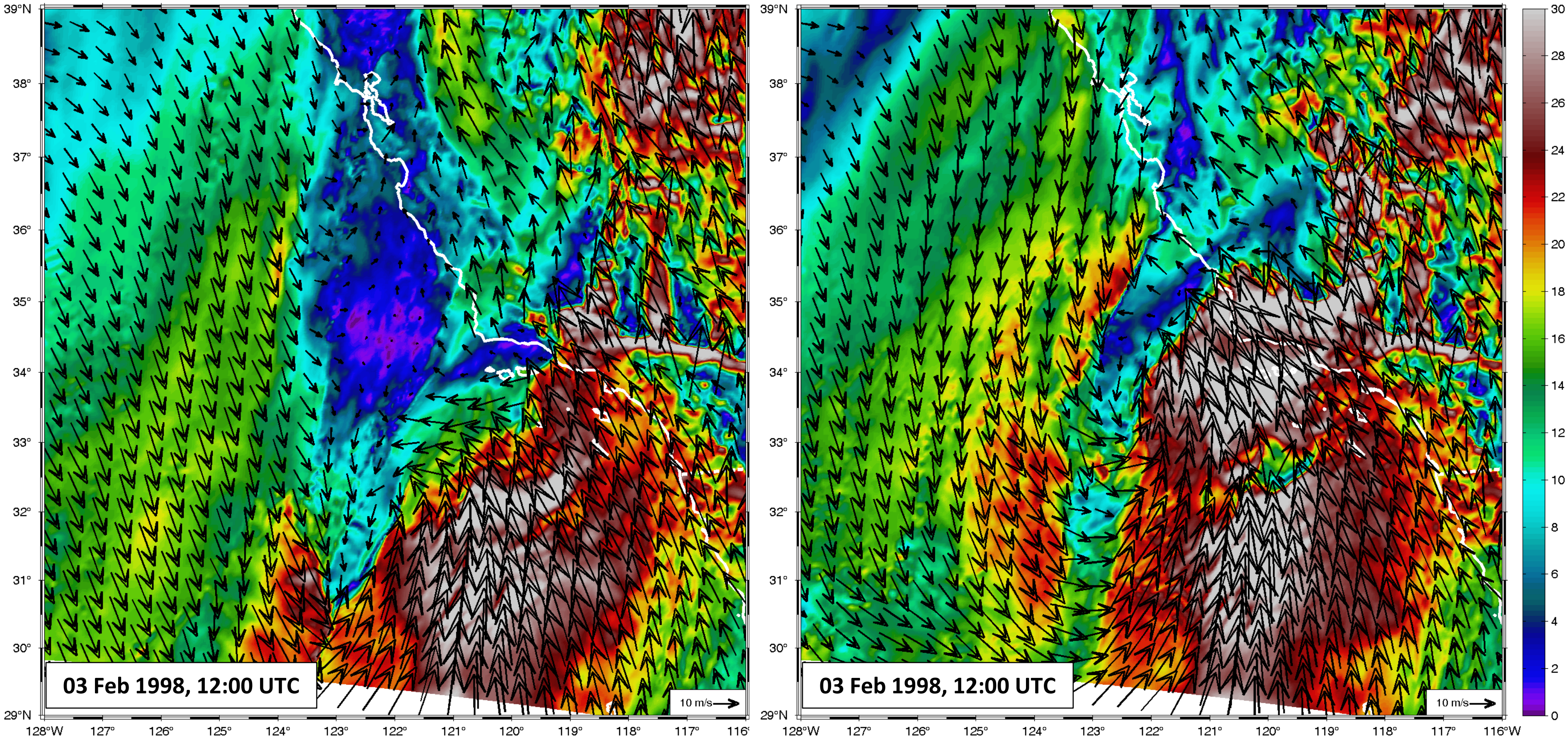


SST **OCEAN**

- Width, intensity, structure and landfalling position of the Low Level Jet (LLJ) is different between the experiments; suggesting that the SST boundary conditions in WRF could affect the evolution of an AR (see Slide 10).
- High wind speeds penetrating farther inland, possibly caused by different propagation speeds of the cold fronts in each SST experiment, as suggested by Passalacqua et al. (2016). Need to investigate more.

Domain 03 – 4 Km: 950 mb Wind Speed & Vectors (m/s)

Feb 03, 12:00 UTC

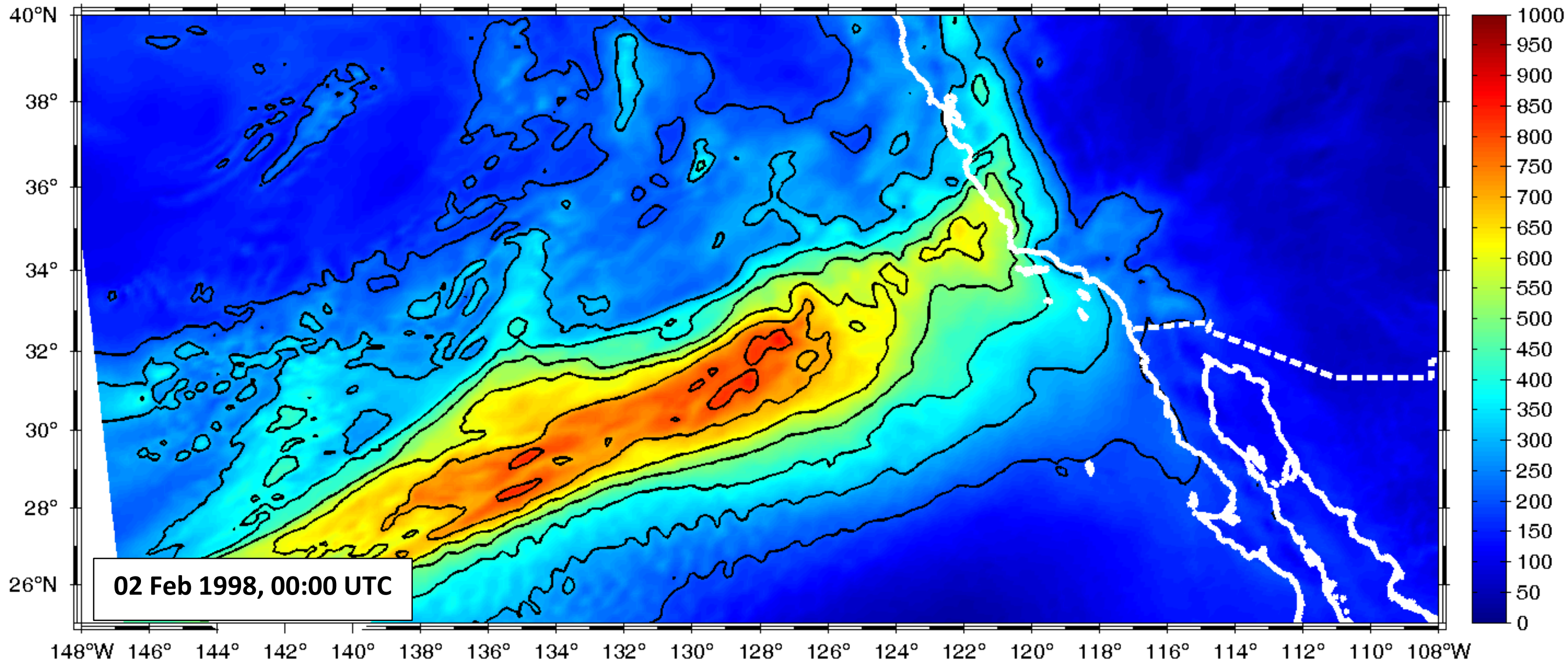


SST

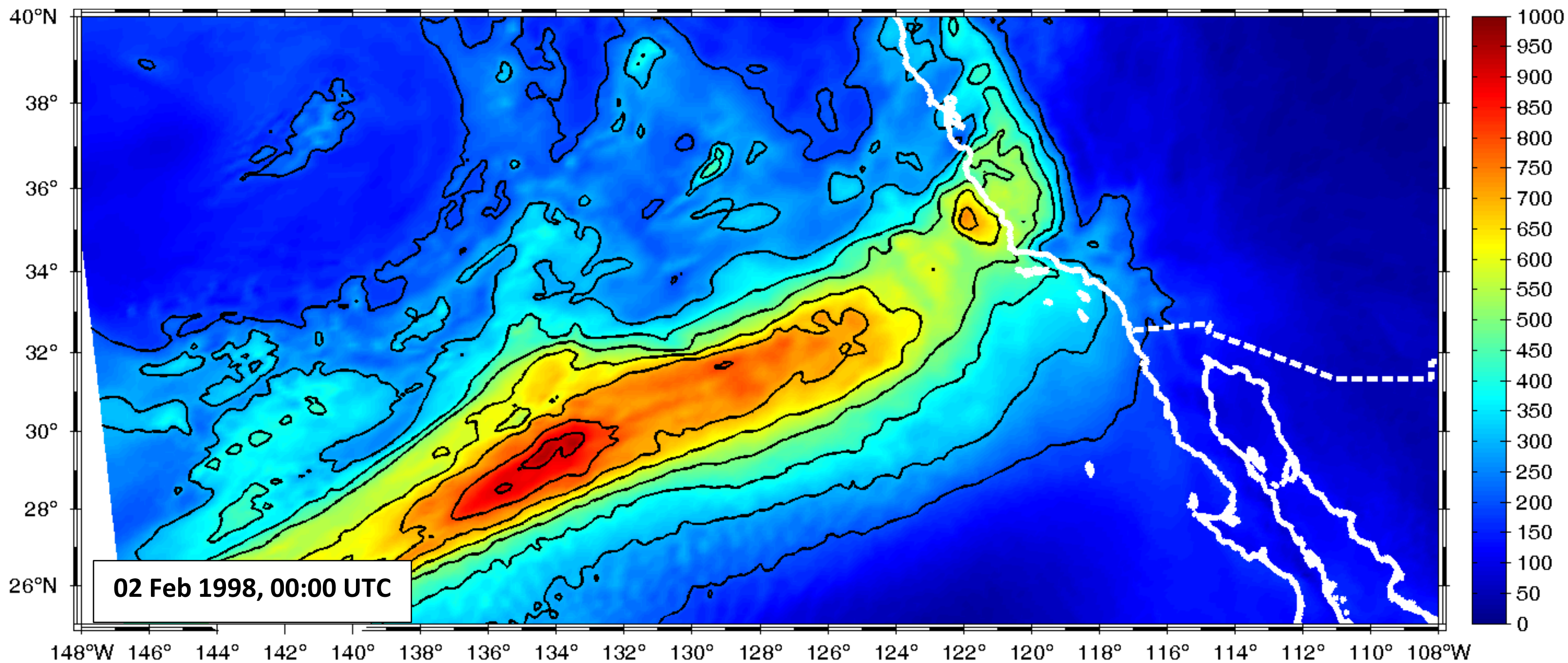
OCEAN

- Landfalling position, intensity and structure of the LLJ is considerably different between the experiments, especially over the Santa Barbara, Ventura and Kern counties. This translates on a higher water vapor flux over those areas, as shown in slide 11.

IVT (Kg $m^{-1}s^{-1}$) - 02 Feb, 1998 00:00

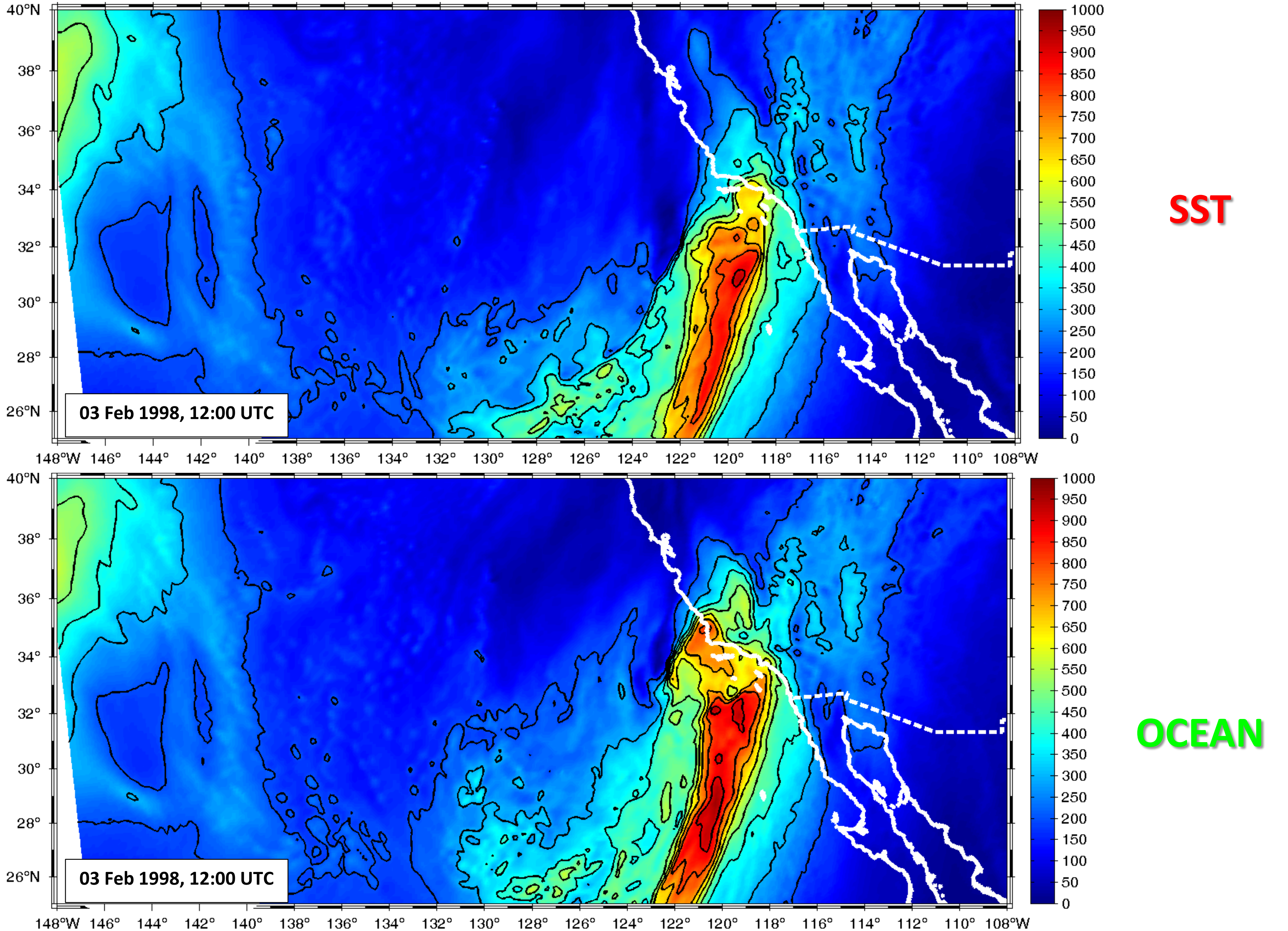


SST



OCEAN

IVT (Kg m^{-1}s^{-1}) - 03 Feb, 1998 12:00



Preliminary Conclusions & To Do

- Different ***SST boundary*** conditions on WRF simulations seem to have considerable impacts on the AR.
- The SST boundary conditions have an influence on ***surface fluxes, modifying the low-level circulation***; and could produce the following consequences:
  - Changes on the LLJ intensity and propagation speed of its core.
  - Variations on the landfalling position of the AR core.
  - Differences on the magnitude, and inland penetration of the IVT flux.

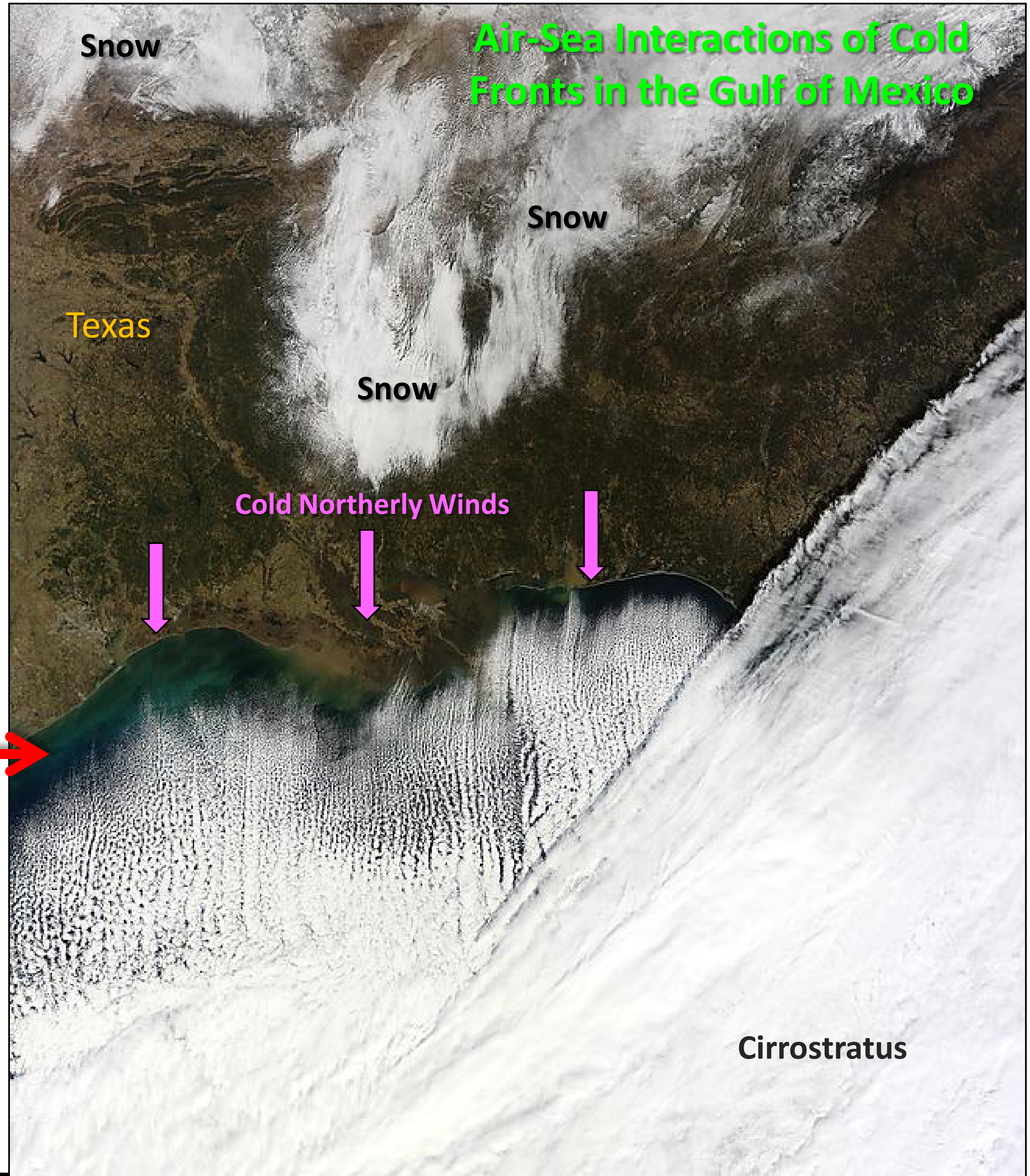
- TO DO:
  - Check if upper level dynamics are in the correct positioning (PV Anomalies).
  - Compare WRF output with wind profilers and P-3 flight data (CALJET data set).
  - Analyze the air-sea interactions with SST-storm intensity metrics (Booth et al., 2012).
  - Check Momentum and Thermodynamic equations output from WRF to better understand dynamics.

MODIS Terra True Color Image: 09 Jan, 2010

High Pressure
Cold Dry Air

Gulf of Mexico
"Warm" Waters

Gradual Modification
of Polar Airmass



Passalacqua, Gino A. (2016), Ph.D. thesis