OBSERVATIONS AND ANALYSIS OF THE MOISTURE SURGE OF JUL 12-14 DURING NAME 2004

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Introduction

The Gulf of Mexico "Moisture Surge" is a summertime phenomenon associated with the North American Monsoon System (NAMS) that transports low-level moisture from the Gulf of California GoC into NAMS core region. These surge phenomena have a significant influence on the intra-seasonal variability of NAMS.

MOISTURE SURGE major forcing mechanisms: tropical storms south of Baja California (Figure 1), cyclonic perturbations propagating from the east, Mesoscale Convective Systems (MCS).

A better understanding of the relationships between the MOISTURE SURGES and their triggering mechanisms is a potential prerequisite to improve predictions in the NAMS.

This poster describes observational aspects of moisture surges in the GoC during the North American Monsoon Experiment (NAME-2004). In particular, the attention is paid to the case of July 12-14, which has been categorized as a "major" moisture surge event. Observation from meteorological surface stations, radiosondes and aircraft data provides information of the four-dimensional structure of this specific case.

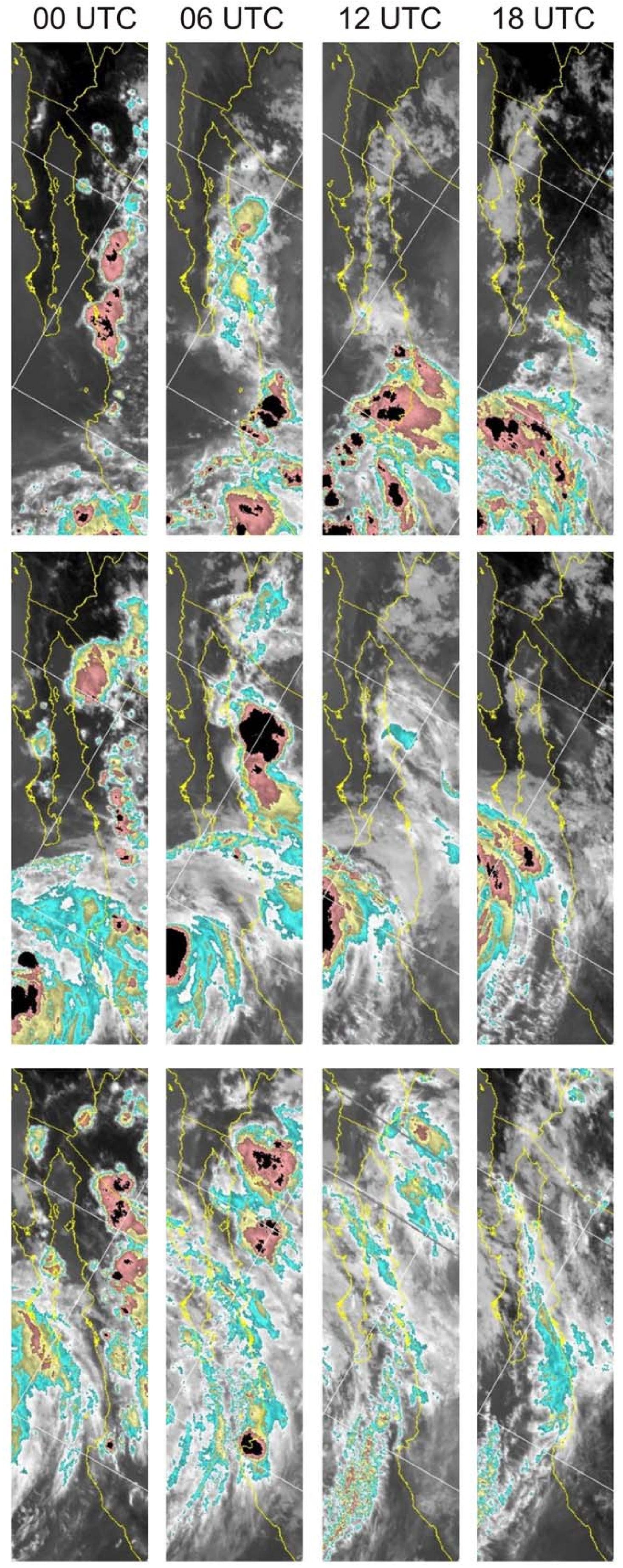

Figure 1 IR4 Satellite Imagery sequence from July 12th 00 UTC to 14th 18 UTC (From JOSS web site). TC Blass moves WNW right to the south of the GoC. Also notice the organized convection developing in the mid- and upper- GoC during the night and early morning (00 – 12 UTC) in the SMO foothills, in special the MCS that developed the night of the 13th.

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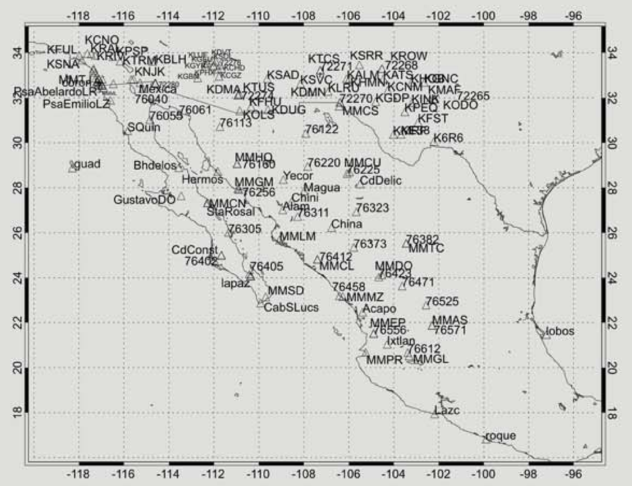
Surface Observations

A set of surface station were analyzed to study the propagation speed and the spatial influence produced by the moisture surge event of 12-14 July 2004. Moisture surges are traditionally defined from surface station observation (commonly Yuma, Arizona) as a sudden increase in dewpoint, decrease of temperature, wind shift with an increasing southerly component, and increase of surface pressure. Figure 2 shows the spatial distribution of the surface station obtained from different sources from the JOSS website.

Figure 2 Surface station distribution. Data obtained from JOSS web site especially collected during NAME (http://www.joss.ucar.edu/name/dm/archive/). Stations from the Mexico Navy SEMAR Automated Weather Station Data (30 min resolution); Station from the Mexican weather service SMN-CNA (10 min resolution); USA weather service (30-60 min resolution).



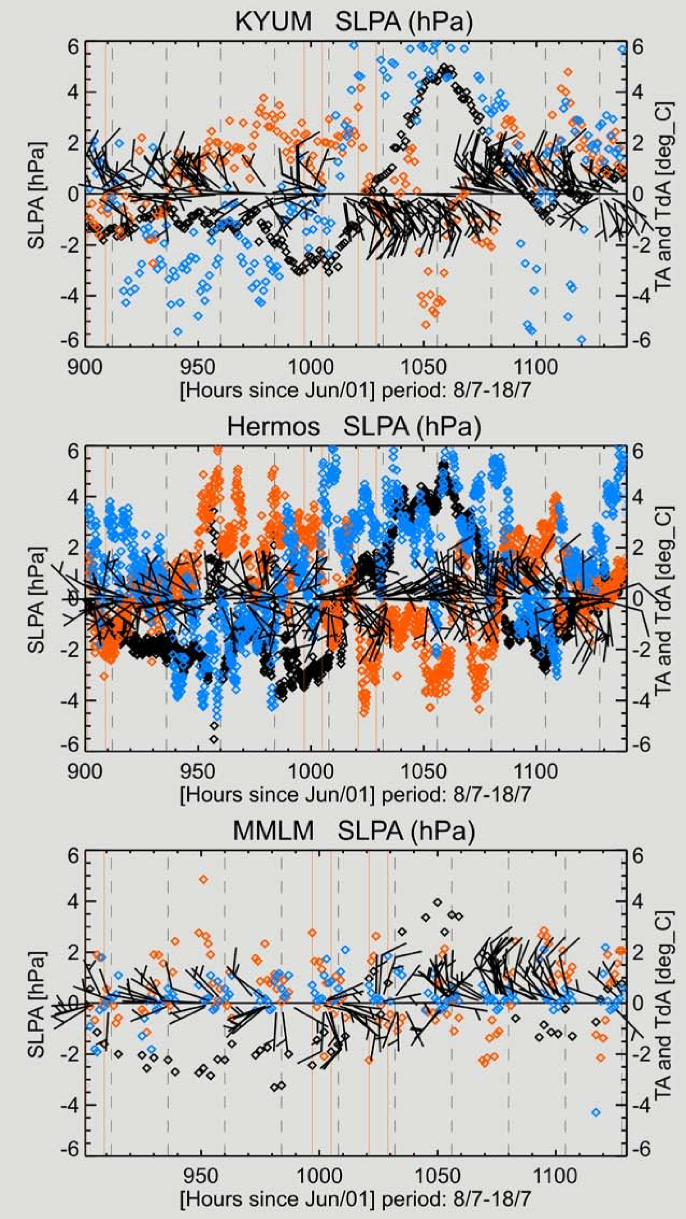


Figure 3 Diurnal cycle anomalies of sea level pressure, temperature, dewpoint and wind. Vertical dashed lines indicate the date change and vertical solid red lines indicate the time span of the NOAA WP-3D aircraft missions (July 8th, 12 and 13th flight). Upper panel shows Yuma, Arizona, in the middle Hermisillo and at the bottom Los Mochis, Sinaloa.

The diurnal cycle of the different quantities mentioned above were subtracted in order to obtained a clearer signal of the surge. A 10 day period around 15th July was used to estimate the diurnal mean, although the surge itself may change the diurnal cycle amplitude of the signal along its passage. Pressure diurnal and semi-diurnal tides, sea breeze and diurnal heating/cooling are expected to be filtered out with this technique. Figure 3 clearly shows the moisture surge like pattern in all the stations along the GoC, which seems to be heavily associated with the passage of TC Blas. The amplitude of the signal in any of the quantities vary along the GoC. For example the moisture change is more evident as one moves northward. Pressure changes show a slow frequency mode (3 day) surge like pattern and a higher frequency mode the strong bump early on the 13th (03-09 UTC) shown in Hermosillo, which seems to be associated with the convective development (Nocturnal MCS) located in the southern Sonora.

Figure 4 shows a phase diagram of different arrays of stations along the GoC and along the pacific coast of the Baja California Peninsula. The pressure perturbation travels at a mean speed of 14-15 m/s to the west of the SMO and the Baja California peninsula with a lag time of about 8 hours. Data suggest that the perturbation traveled faster to the west of the GoC but arriving at the same time in the northern end. In contrast with the transect along the GoC, the pressure disturbance along the E. Baja transect is related with an anomalous warming.

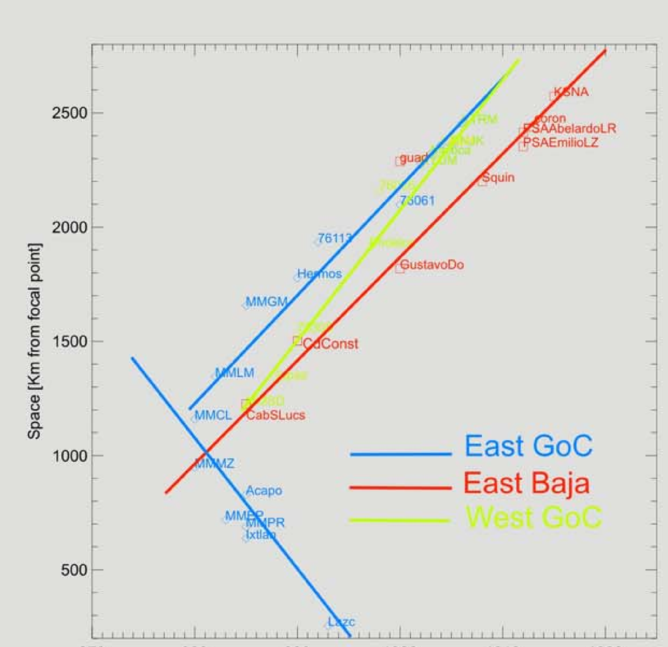


Figure 4 Phase diagram for the slow mode surface pressure perturbation. Three different set of stations: station along the eastern coast of the GoC (Blue solid line), stations along the western coast of the GoC (light green solid line) and station along the eastern coast of the Baja California peninsula.

Upper air Observations

The slow mode of the surge ensures that we can track it by using low-resolution data as the one obtained from upper air obs. In any case, the timing of the surge is better depicted by using the surface data. The vertical extend of this particular surge is shown using Kino Bay integrated sounding system data (Figure 5). The diurnal cycle anomalies of pressure, dewpoint, temperature and meridional wind components show the moisture surge signal for 30 hPa layer increments. Dewpoint perturbation are shallower, being more significant below 900 hPa. In contrast, temperature and meridional wind anomalies are significant in a deeper layer (below 700 hPa) and the amplitude of the perturbation in these two quantities maximizes around 900 hPa.

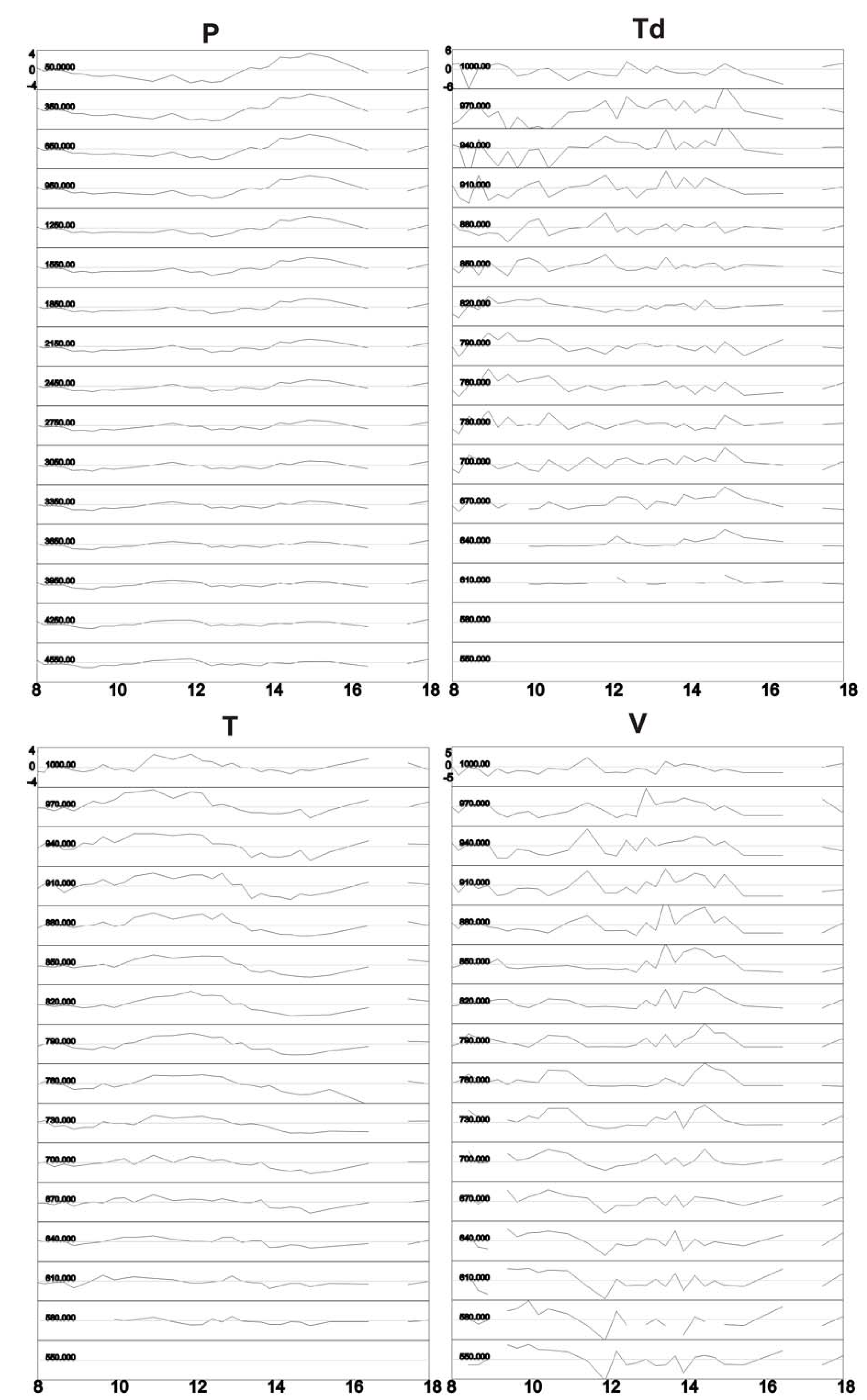


Figure 5 Vertical evolution of the diurnal cycle anomalies for pressure, dewpoint, temperature and meridional wind using Kino bay NCAR integrated Sounding System. Horizontal axis spans from July 8th to 18th.

Aircraft data

The NOAA WP-3D was implemented during NAME to measure the spatial structure of the moisture flux over the GoC. Ten flights were carried out and they were focused mainly on measuring moisture fluxes (QFLUX) and the low-level jet (LLJ) flow along the GoC as well as the evolution (GENESIS) and effect of the Sea Breeze on the surges. Figure 5 shows that the flights were carried out during different synoptic setting, e.g., a surge genesis flight on July 12th was likely because a well-marked mid-tropospheric wave was propagating from the east across central Mexico since the pervious day.

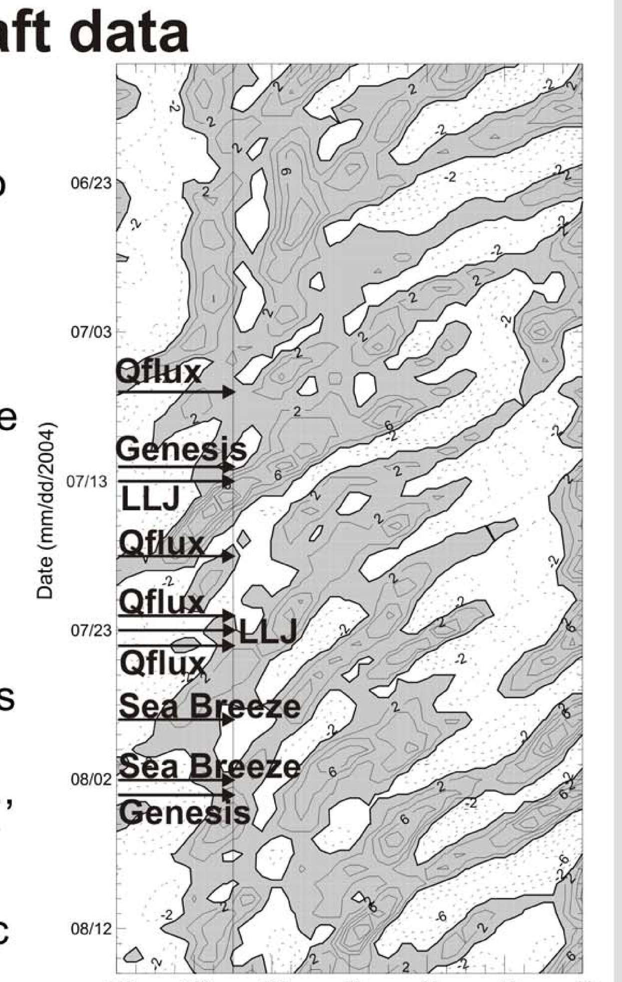


Figure 6 The mean daily meridional wind (along 22.5°N) from NCEP/NCAR Reanalysis data and the objective of the flights.

This surge event was observed using the WP-3D during two consecutive days. The first flight (July 12th) was mainly focused in the moisture surge genesis and the second one (July 13th) on the low-level jet in the far northern Gulf. Figure 6 shows the potential temperature and mixing ratio analysis at 950 hPa using the aircraft level data. The cold/moist pool at the entrance of the Gulf is clearly associated with the organized convection that took place right to the south (see Figure 1 July 12th, 12 UTC). Stronger southeasterly winds at low levels (Figure 7) are co-located with these strong moisture and temperature gradients suggesting that the surge is initially associated with the convective outflow induced by the storm.

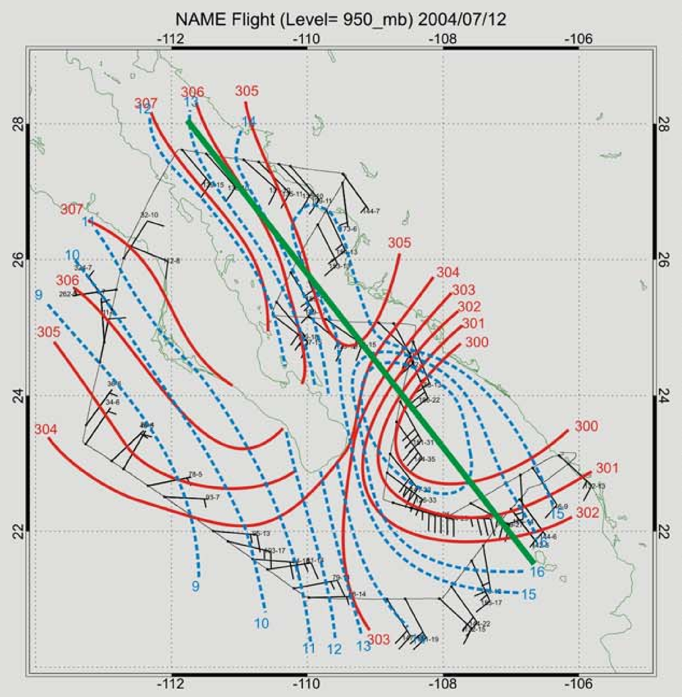
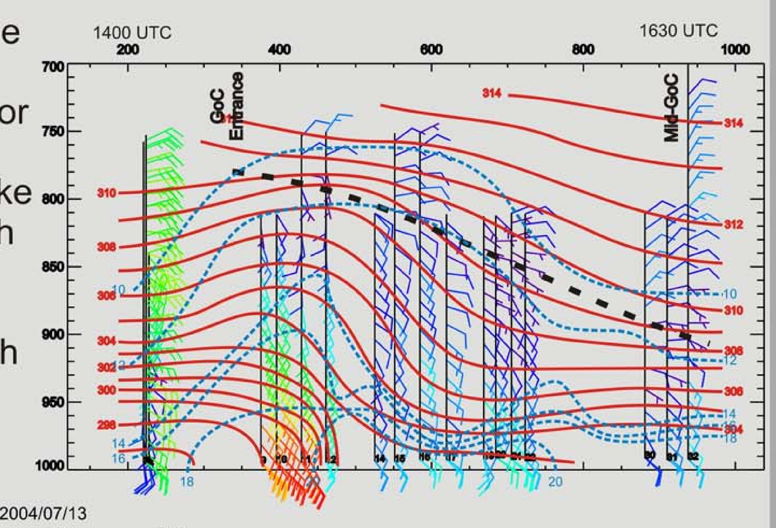


Figure 6 (Left) Potential temperature (red solid lines, every 1 K) and mixing ratio (blue dashed lines, every 1 g/kg) analyses at 950 hPa during July 12th flight. Wind barbs and flight track are shown in black. A complete barb indicates 10 Knots. This flight mission started in Mazatlant, Sinaloa at 13 UTC and ended at 20 UTC. The green solid line shows the location of the vertical analysis (bottom) of potential temperature (red solid lines, every 1 K) and mixing ratio (blue dashed lines, every 2 g/kg). Wind barbs are colored to indicate the relative wind magnitude (reds are stronger winds). Black dashed line show the level of strong directional wind shear.

The vertical analysis of the aircraft data show other complicated structures. For example, there is a smoother-deeper surge like pattern farther north which also exhibits a relatively cool/moist flow below the directional shear line. Both structures conform the beginning of this surge event.



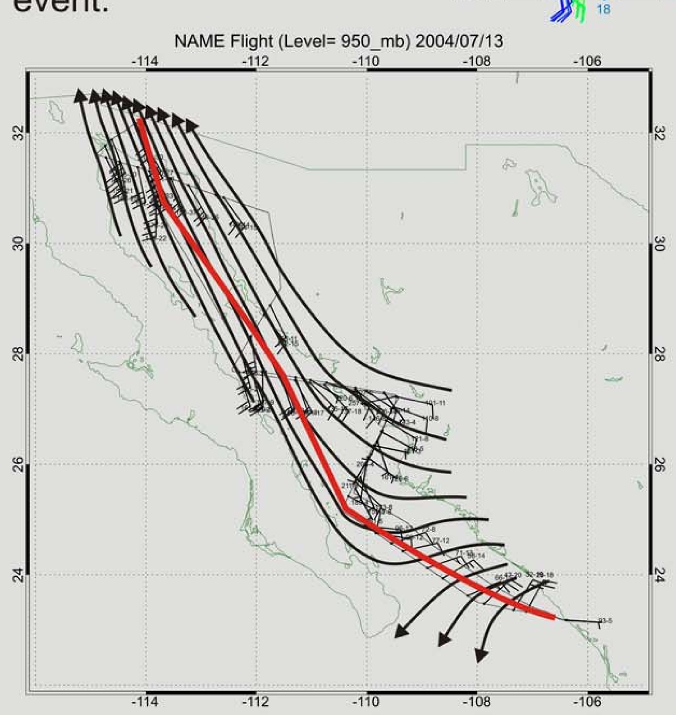
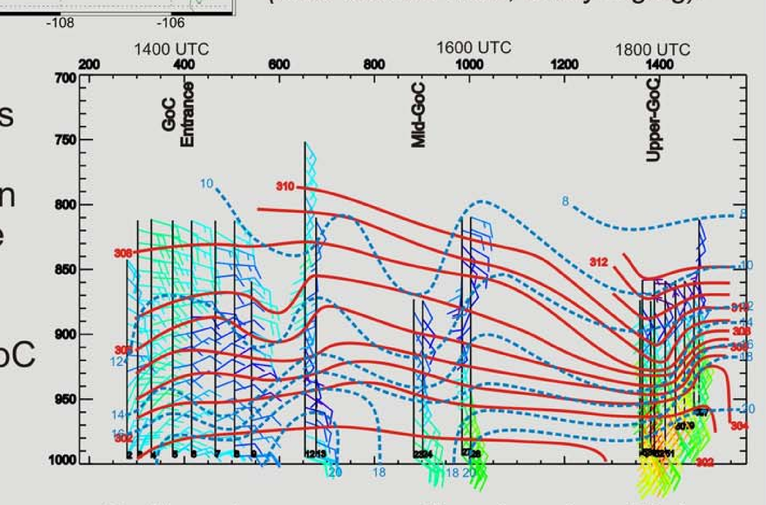


Figure 7 (Left) Streamline analysis (black arrows) at 950 hPa during July 13th flight. Wind barbs and flight track are shown in black. A complete barb indicates 10 Knots. This flight mission started in Mazatlant, Sinaloa at 13 UTC and ended at 21 UTC. The red solid line shows the location of the vertical analysis (bottom) of potential temperature (red solid lines, every 1 K) and mixing ratio (blue dashed lines, every 2 g/kg).

On July 13th, enhanced southerly/moist/cool winds were up the entire Gulf (Figure 7). Strong winds in the far northern Gulf were observed, reaching 43 knots around 960 hPa. A strong MCS in the mid-GoC (Figure 1, July 13th 06 UTC) produces a meso-high which enhances the southeasterly flow in the upper-Gulf and consequently a low-level jet-like pattern with center observed over the Gulf. Flow in the lower-Gulf is now from the northeast spinning aroung TC Blas center of circulation, which is now located to the west of the Gulf entrance.



Acknowledgment

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