The initiation and upscale growth of convection within the diurnal cycle along the Sierra Madre Occidental

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Acknowledgements

This work was supported by NAME National Oceanographic and Atmospheric Administration (NOAA) funding under Mike Paterson and Jin Huang, as well as NAME National Science Foundation funding under Steve Nelson. We would also like to acknowledge Steve Rutledge, Rob Cifelli, Dave Ahijevych, and Rit Carbone for helpful science discussions.

Motivation

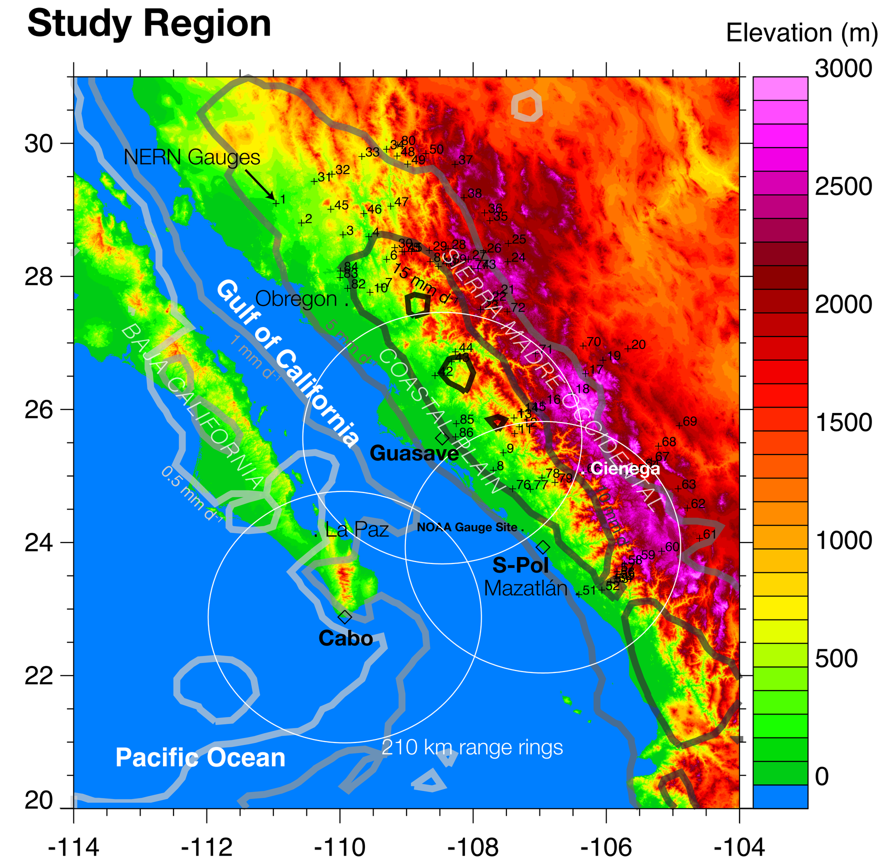
This poster examines modes and variability in the diurnal cycle of deep convection tied to topography within the NAME Tier-1 domain during the 2004 EOP. Specifically, ground-based precipitation retrievals the NAME Event Rain gauge Network (NERN) and polarimetrically- and NERN- tuned CSU/NCAR version 2 radar composite precipitation estimates over the southern NAME Tier-I domain will be compared with rainfall estimates from the CMORPH, TRMM 3B42, and PERSIANN to examine the timing and magnitude of the diurnal cycle along the western slopes of the Sierra Madre Occidental (SMO). In addition, half-hourly images of 11-micrometer brightness temperatures from GOES will be analyzed to examine the modes of vertical development of convection as a function of topography and the diurnal cycle. Furthermore, vertical profiles of radar reflectivity from the TRMM precipitation radar will be examined to elucidate convective vertical structure as a function of topography in context with the GOES results.

Preliminary results, confirming the inference of Hong et al. (2006, accepted in *J. Hydromet.*) show that over the highest terrain (above 2000 m), shallow convection tends to form just west (downwind) of the highest terrain just before local noon, and thus warm rain microphysical processes are important in rainfall production early in the diurnal cycle. The onset of deep convection (defined as cloud tops which reach a cold IR brightness temperature less than 208K) is delayed until 1500 LT, and occurs almost exclusively in terrain below 2000 m elevation, where it continues to grow upscale and organize into mesoscale convective systems. In this poster, we will examine the intraseasonal variation in these processes, as well as the environments that control deep convective growth by examining limited surface thermodynamic data available in the high terrain of the SMO during the NAME EOP.

Datasets

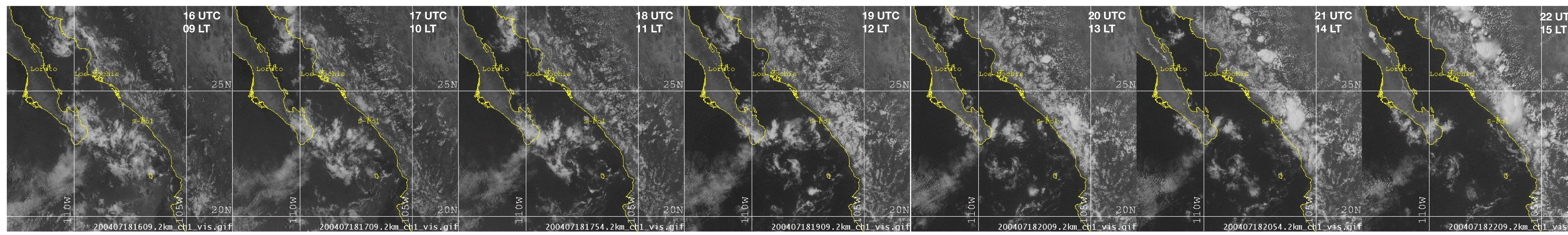
- **NAME Event Rain gauge Network (NERN)** described in Gochis et al. (2002, 2003)
- **NAME CSU/NCAR Version 2 Radar Composites** at 5 km resolution described in Lang et al. (2006)
- **GOES infrared brightness temperature** at 10 km resolution (from parallax-corrected global composites) were obtained from NOAA CPC through the NASA TRMM DAAC
- Satellite rainfall data obtained include **CMORPH (CPC MORPHing technique), TRMM 3B42, PERSIANN** (all 3-hr 0.25° x 0.25° products)

Study Region

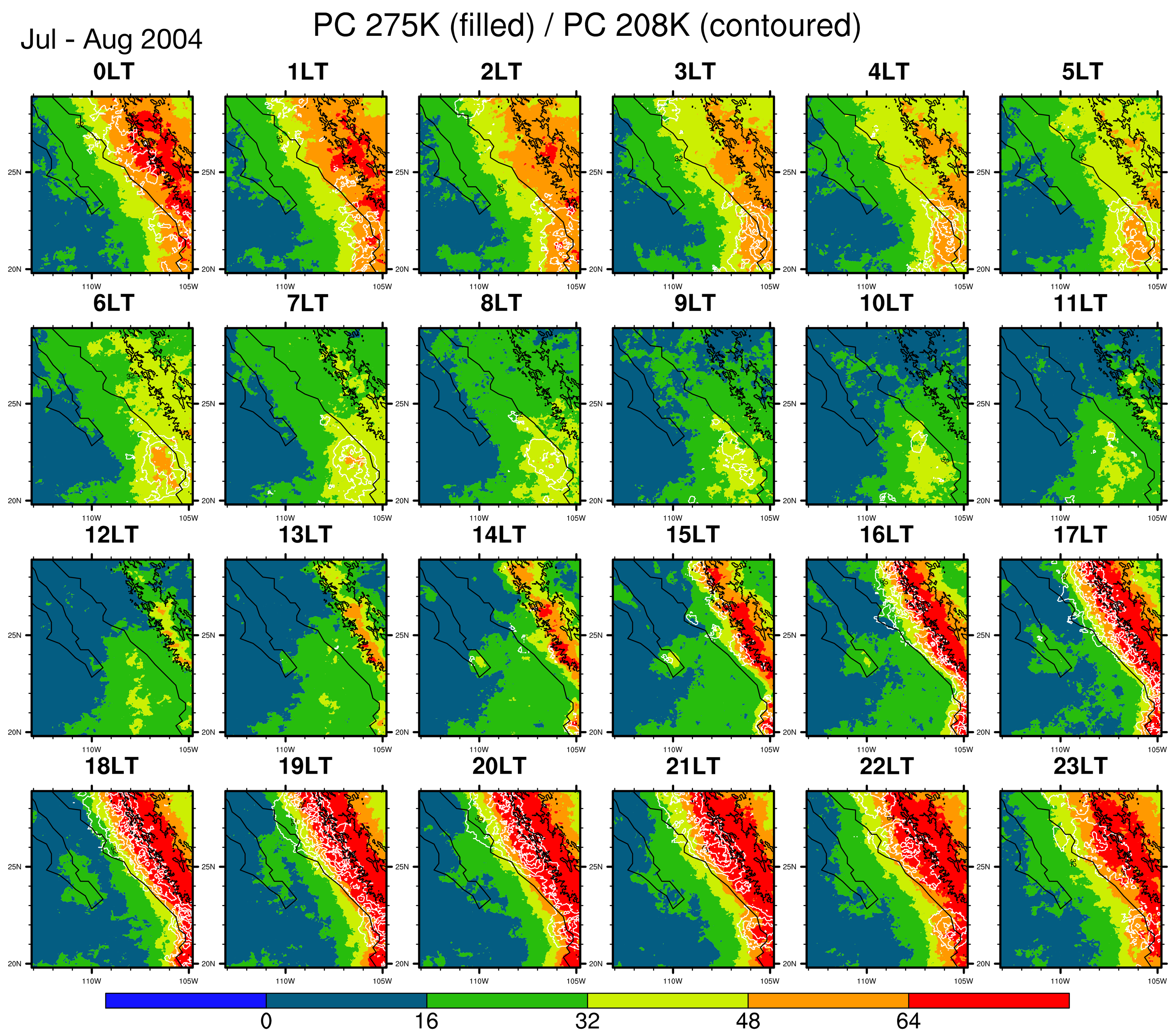


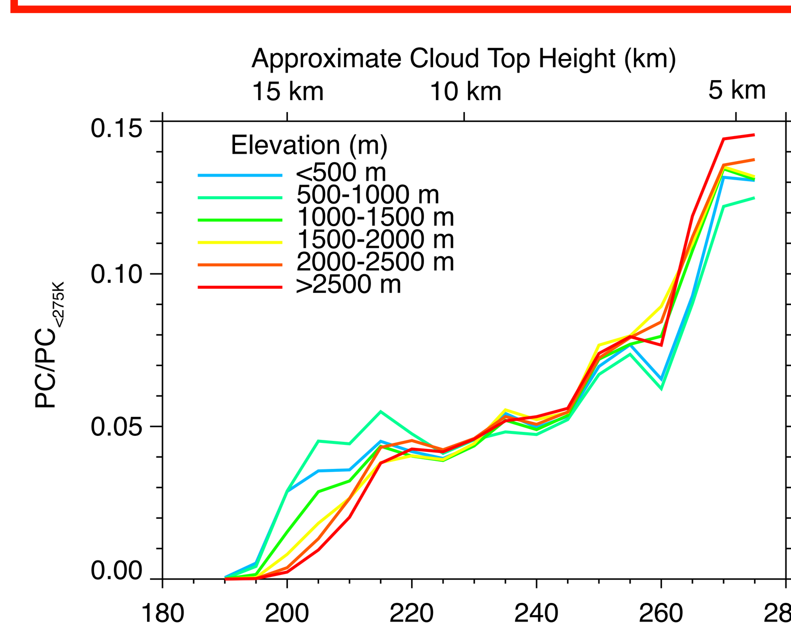
A case study of the early afternoon diurnal cycle of clouds: 18 July 2004, 1600 to 2200 UTC (0900 to 1500 LT)

GOES 1-km visible imagery shows the transition of shallow to deep convection over the west slopes of the SMO. (Images courtesy of UCAR-JOSS)

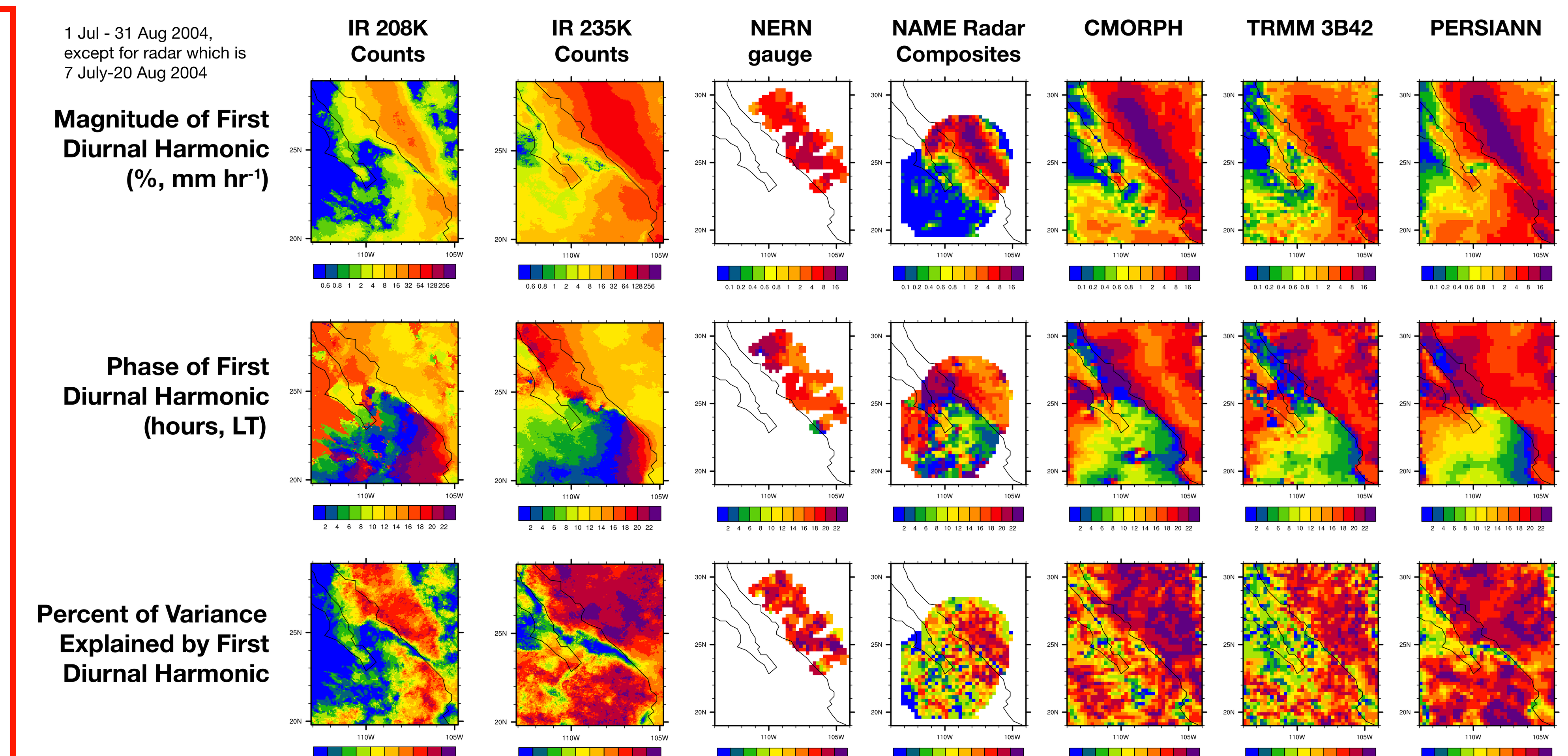


Hourly (local time) contours of the relative percent occurrence of IR brightness temperature < 275 K (filled, indicating shallow clouds), < 208 K (white contours between 0 and 20 every 5 percent, indicating deep clouds) relative to the 2000 m elevation contour (black line) show the development of relatively shallow convection over the high SMO peaks around 11 LT. Four to five hours later, deep convection develops in terrain less than 2000 m and begins to propagate towards the coast through the evening hours.

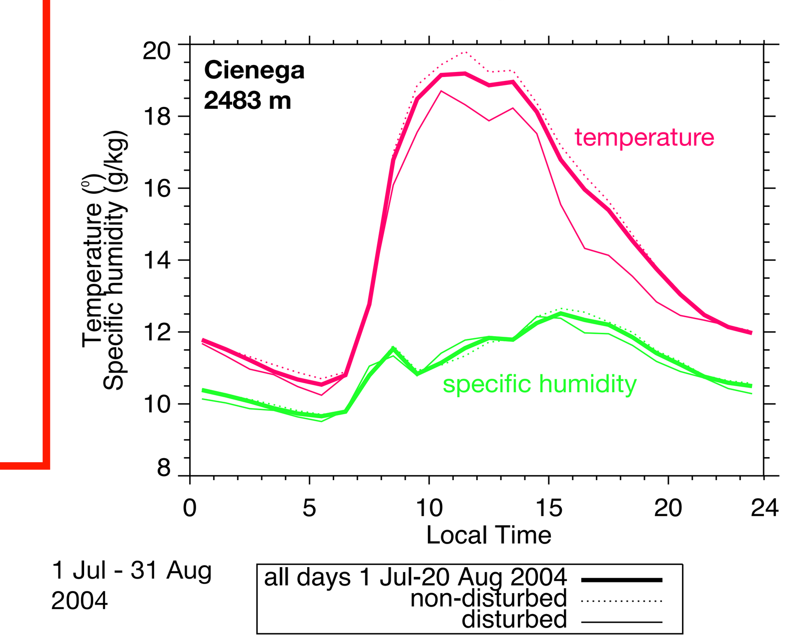




Histograms of the fraction of brightness temperature counts observed in each bin (at 5 K intervals) relative to 275 K brightness temperature counts as a function of elevation shows the higher relative occurrence of pixels with brightness temperatures < 210 K (inferring a higher fraction of deep clouds) in terrain above 1500 m, while warmer brightness temperature pixel fractions are found more often in high terrain (indicating more shallow convection). Approximate heights relative to optically thick coulds at the indicated brightness temperatures are shown on the top axis.



Harmonic analysis of brightness temperature fields (left two columns) at 208 K and 235 K show the relative westward displacement of the 208 K harmonic amplitude relative to the 235 K brightness temperature threshold data. There is also a bifurcation in the inferred propagation speed of cold cloud tops near 24N latitude. Ground-based and satellite-based precipitation estimates maximize the precipitation diurnal magnitude in the foothills of the SMO and along the coastal plain, with a transition of early afternoon convection over high terrain to afternoon to evening convection over the coast and Gulf of California. The bifurcation in inferred offshore propagation speed appears in the rainfall estimates as well.



Preliminary analysis of 30 minute surface data at a HOBO surface station at Ceniega (elevation 2483 m, see location on map at left) indicates that mean temperatures for the entire period (thick red line) rise sharply just after sunrise, and plateau near 19°C by 1000 LT, then begin to decrease around 1400 LT. Mean specific humidity values spike around sunrise, then more slowly increase to a maximum near 12 g/kg at around 1500 LT (likely due to evapotransporative surface fluxes), then slowly decrease.

When periods are separated into disturbed and undisturbed conditions according to having widespread rainfall along the coastal plain (regime AB in Lang et al. 2006), specific humidity values during disturbed periods are not significantly different from periods of undisturbed convective activity. However, temperatures are signficantly cooler in the late morning through the evening hours during disturbed periods relative to undisturbed periods. This implies lower cloud bases, more efficient warm rain processes, and less evaporation in precipitating cloud systems in the region. The lower temperatures may also be the result of more vigorous convective downdrafts on average.

Conclusions

- The diurnal cycle of convection along the SMO shows a distinct transition from shallow convection forming along the high terrain around 1100 LT, followed by deep convection forming in terrain below 2000 m around 4-5 hours later (around 1500 LT
- Brightness temperature histograms indicate the relative paucity of deep convection over the highest peaks, this impacts rainfall production and may be the cause of low biases in IR-based satellite rainfall retrievals in high terrain (e.g. Hong et al. 2006)
- Preliminary analysis of surface data shows that cool conditions in the foothills may be related to longer lived convective systems along the SMO coastal plain; we plan to examine flux, surface, and NARR reanalysis data further to examine conditions which modulate the diurnal cycle along the SMO.