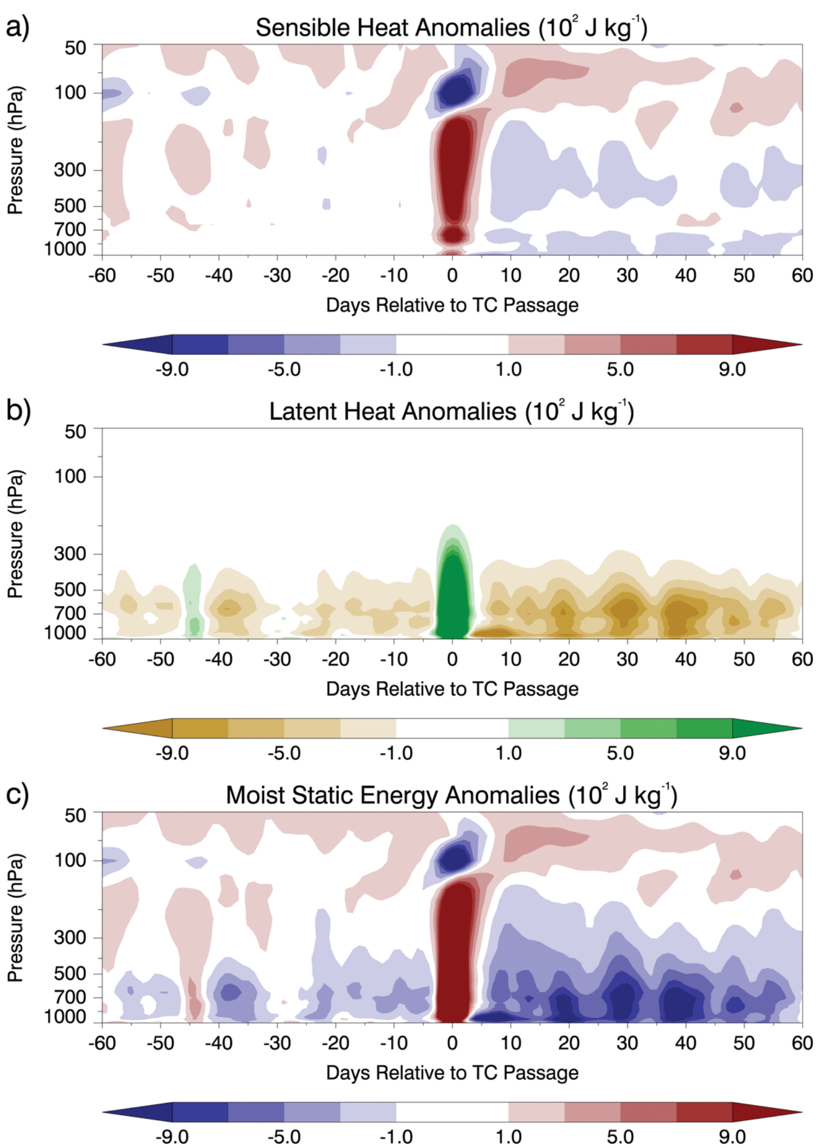
Potential Implications of Tropical Cyclone Passage

One of the great remaining unanswered questions in tropical meteorology is why there are approximately 90 tropical cyclones (TCs) globally, on average, per year and not more, or less. In contrast to extratropical cyclones, whose frequency can be roughly calculated given the large-scale characteristics of the midlatitudes, there is no equivalent theory that even justifies the order of magnitude of TCs that occur globally each year, let alone at such a relatively constant frequency. Despite this, individual TC basins have exhibited differences in the variability of TC frequency, intensity, and lifespan over the last several decades that may suggest some degree of interbasin compensation, which may be crucial toward forecasting future TC activity—especially in a warming world. Addressing these issues is fundamentally rooted in determining the role of TCs within the climate. Building upon previous research on this topic, our study examines the interaction between TCs and their environment on regional scales. Preliminary work indicates that the atmospheric environment is thermodynamically stabilized for several weeks following TC passage. This stabilization is initially beyond the spatiotemporal scales of the TC itself suggesting that TCs may be responsible for exciting larger scale feedbacks that together with the localized impacts help to limit the number of TCs.

We used four-dimensional, storm-relative, composited anomalies constructed from atmospheric reanalysis data to examine the response of the atmosphere to the passage of Category 3–5 (i.e., major) western North Pacific (WPAC) TCs. Our results show that the pas-



Time series of the vertical cross-section of (a) sensible heat anomalies (10^2 J kg^{-1}); (b) latent heat anomalies (10^2 J kg^{-1}); and (c) moist static energy anomalies (10^2 J kg^{-1}) averaged over a 500 km x 500 km box located at the composite domain center for Category 3–5 (major) WPAC TCs. This figure quantifies the thermodynamic impacts of TCs upon their environment via energy considerations. These impacts are represented by changes in moisture (latent heat), temperature (sensible heat), or vertical displacements of parcels (potential energy; not shown since these anomalies are only substantial near the day of TC passage). Moist static energy (the sum of latent heat, potential energy, and sensible heat) represents the total thermodynamic energy change of the environment. According to (b) and (c), TCs primarily affect the atmospheric environment by drying the lower to middle troposphere as indicated by the negative latent-heat anomalies.

sage of a TC initially results in the possible excitation of larger-scale mechanisms beginning on Day 7 after TC passage, as evidenced by a drying and cooling of the atmospheric environment that spans the majority of the storm-relative domain. Within two weeks, these anomalies are found to become primarily localized over the region through which the TC directly passed. Calculations of energy anomalies within 250 km of the track of each TC indicate that the largest reductions occur for latent heat within the lower and middle troposphere. This result suggests that the drying of the environment is the most anomalous thermodynamic change associated with TC occurrence.

Initially, the post-TC latent and sensible heat anomalies are likely due to a reduction in surface fluxes as a result of the cold sea surface temperatures (SSTs) left behind by the TC. An additional potential factor is the dehydration of the atmospheric environment that occurs as a result of the focusing of precipitation within the TC inner core and the subsident secondary circulation associated with the outer circulation of the TC. In the weeks following TC passage, the spatial distribution of the latent and sensible heat anomalies suggests that an anomalous suppression of deep convection due to the underlying SST cold wake may be the predominant factor in maintaining these energy anomalies. Furthermore, the periodic pulsation in the magnitude of the dry anomalies approximately every 10 days following TC passage indicates that the passage of tropical waves generated either independently of the TC or in response to the passage of the TC itself, or both, further serves to increase the stabilization of the atmospheric environment.

In their totality, these results suggest that TCs may serve as an efficient mechanism for regulating atmospheric instability within the tropics. The TC-induced stabilization may also provide a constraint on the future occurrence of TCs in both space and time as the atmosphere recharges back to climatology, possibly helping to explain why the global number of TCs is on the order of 100. Furthermore, the variability of TC activity among basins may be in response to the differing amounts of drying and cooling necessary to reduce both meridional and zonal basin-scale energy gradients through a reduction in local instability and the redistribution of this energy. On global scales, the movement of a significant fraction of TCs into the midlatitudes (or beyond) implies that energy is extracted from the tropics and deposited into midlatitudes, suggesting that TCs may serve to significantly reduce the global meridional energy gradient.

Future work will focus on quantifying the mean aggregate meridional transport of energy in the atmosphere attributable to TCs, to complement existing calculations of TC-induced oceanic energy transport given in previous research. Through these calculations, we hope to provide greater insight into the role of TCs within the climate system such that the impacts of their global change can be anticipated.—Benjamin Schenkel (Florida State University) and R. Hart. *"Potential Precursors to and Implications of Tropical Cyclone Passage: A Regional Climate Perspective," presented as a poster at the 23rd Conference on Climate Variability and Change, 23–27 January 2011, Seattle, Washington.*

SURGE SLOWDOWN

Venice—the "City of Water"—can't take too much more without becoming the "City Under Water," so a new study of Mediterranean atmospheric circulation that forecasts a decline in storm surges near the city is welcome news. Published recently in *Climatic Change*, the research utilized storm observations, atmospheric and surface conditions, the ERA-40 reanalysis, climate scenario simulations, and modeling to project a 30% decrease in storm-surge events that impact Venice by the end of the twenty-first century. The study also predicts a decrease in extreme tidal events there. Storm surges around Venice form when deep Mediterranean low pressure systems cause strong southeasterly winds to pile water into the northern portion of the Adriatic Sea, where the city is located. Venice has been battling the waters of the Adriatic for centuries, and global sea-level-rise scenarios as projected by the IPCC, when offset by the reduction in storm surges, "would leave the pattern of flooding largely unaltered," CSIRO's Alberto Troccoli, lead author of the study, says, keeping the future of the city in question. But this new research suggests that climatic influences on storm surges and rising tides need to focus more on specific locations rather than have a global perspective. (Source: CSIRO)