Climatological Significance of Sea Temperature Extremes on the Florida Reef Tract in 2010

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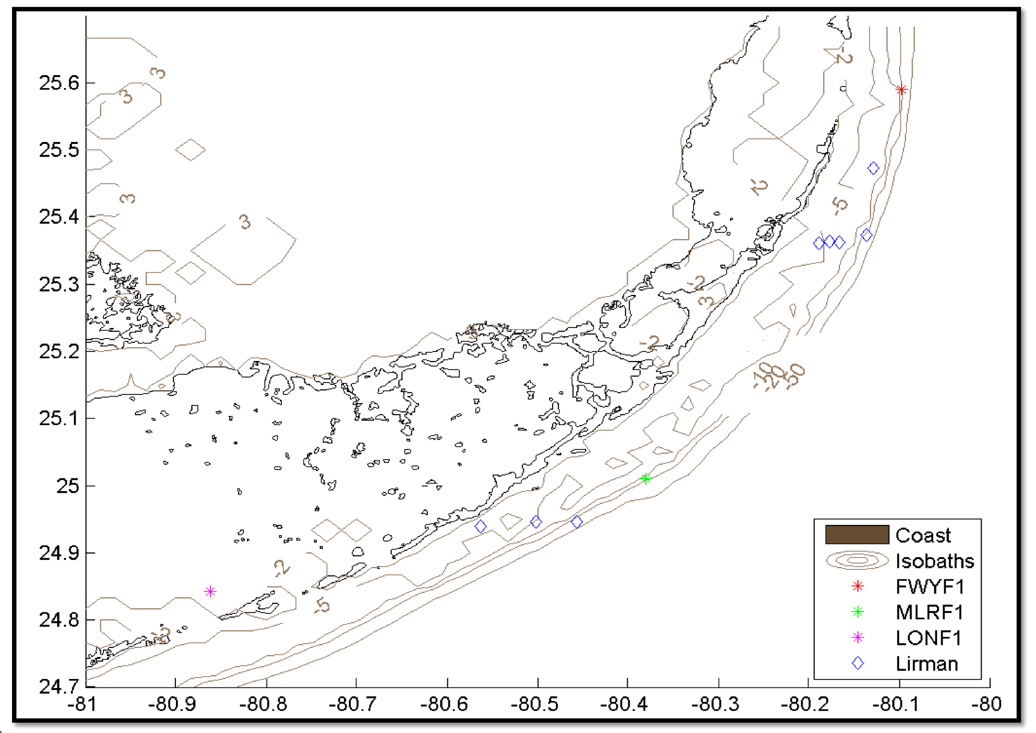
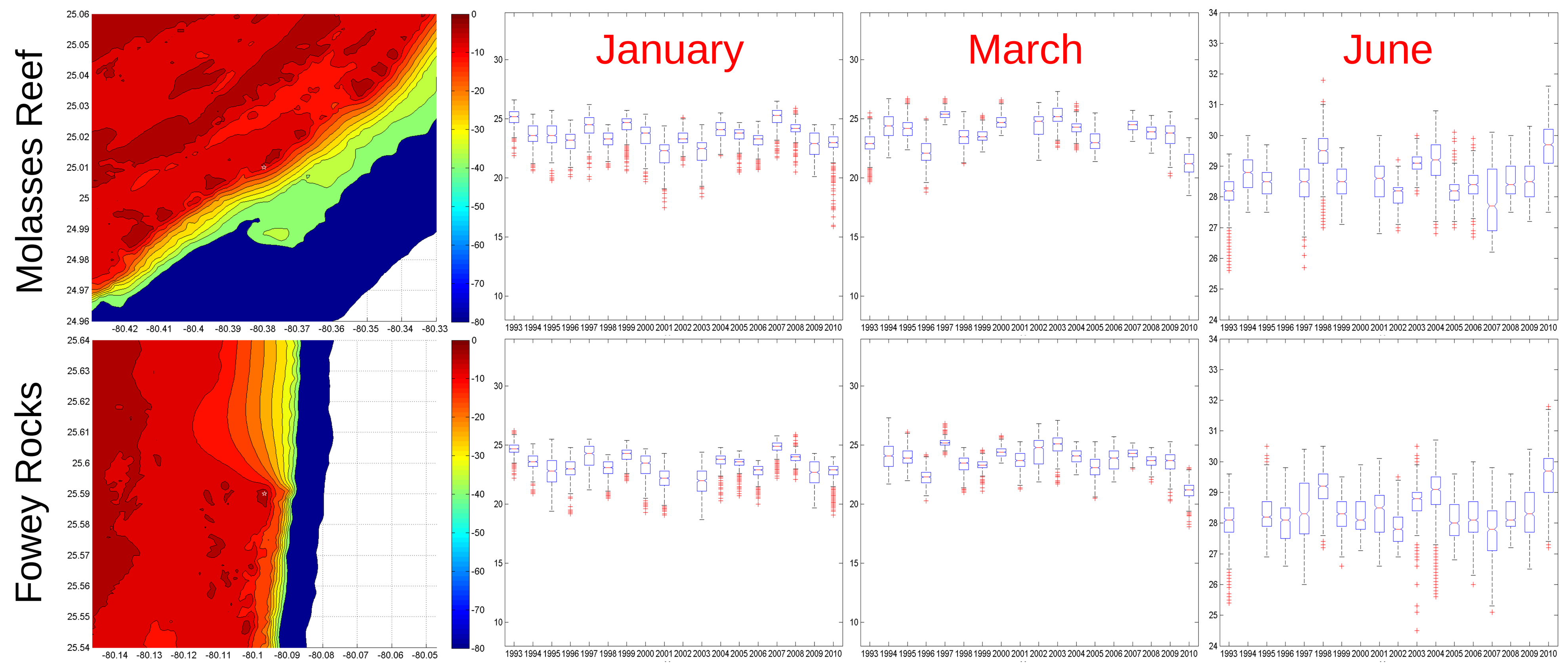
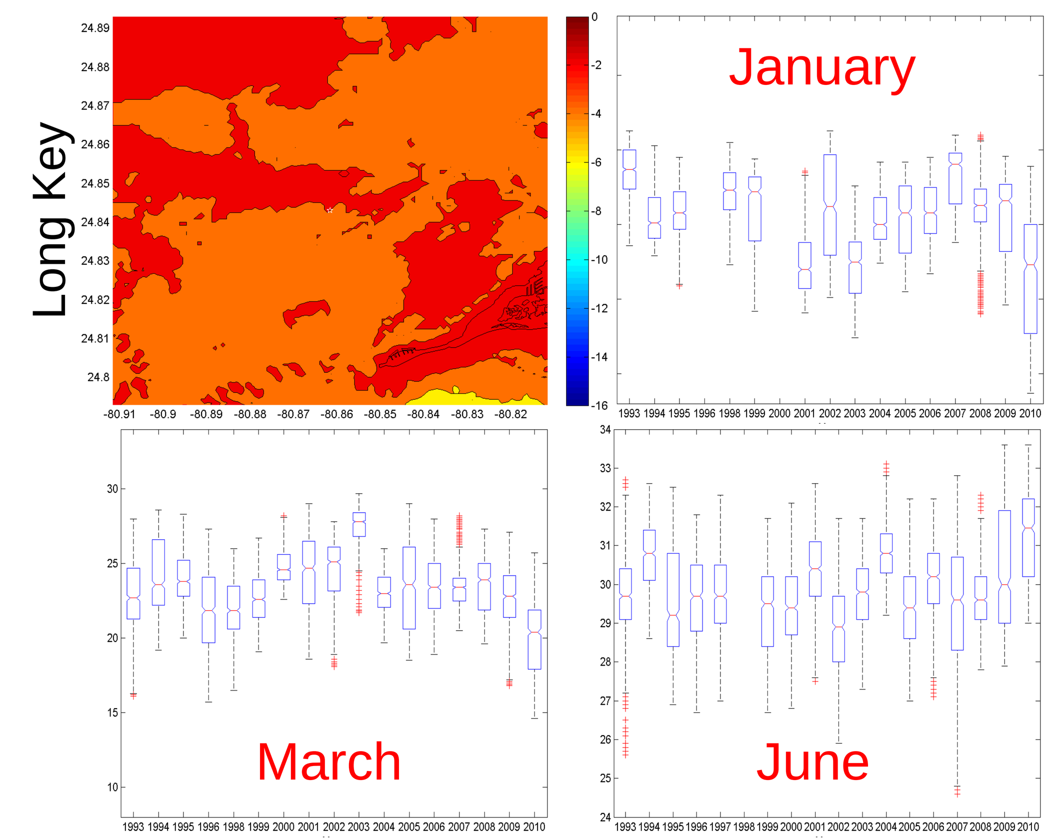
Florida Reef Tract monitored sites: All endured similar atmospheric extremes



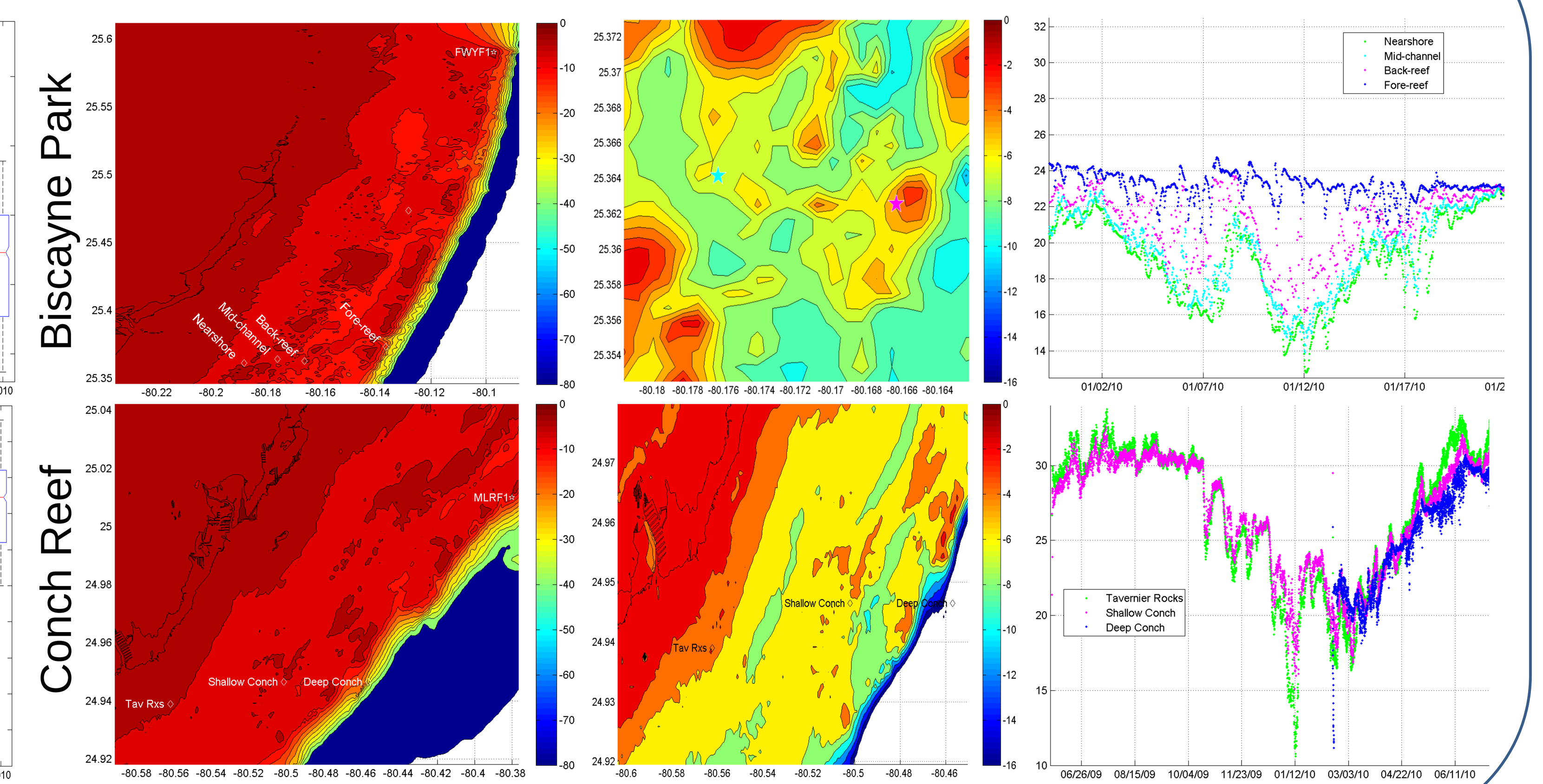
High-relief Sites – Responded weakly to atmospheric extremes in 2010



Flat Sea-floor – Responded strongly

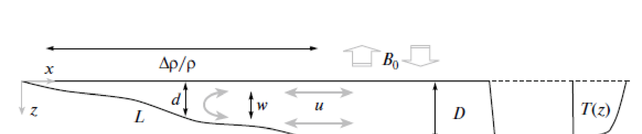


Similar Depths – Effects of differing bottom relief

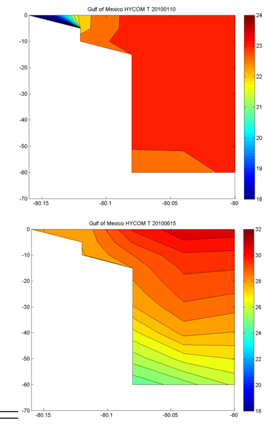


Why do similar sites within Florida's reef tract persistently respond differently under similar atmospheric forcing?

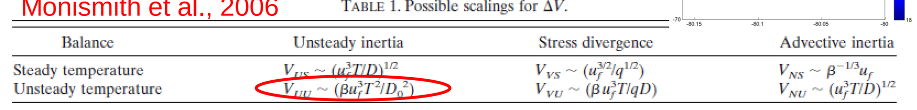
"Thermal siphon" – persistent moderation of heating/cooling

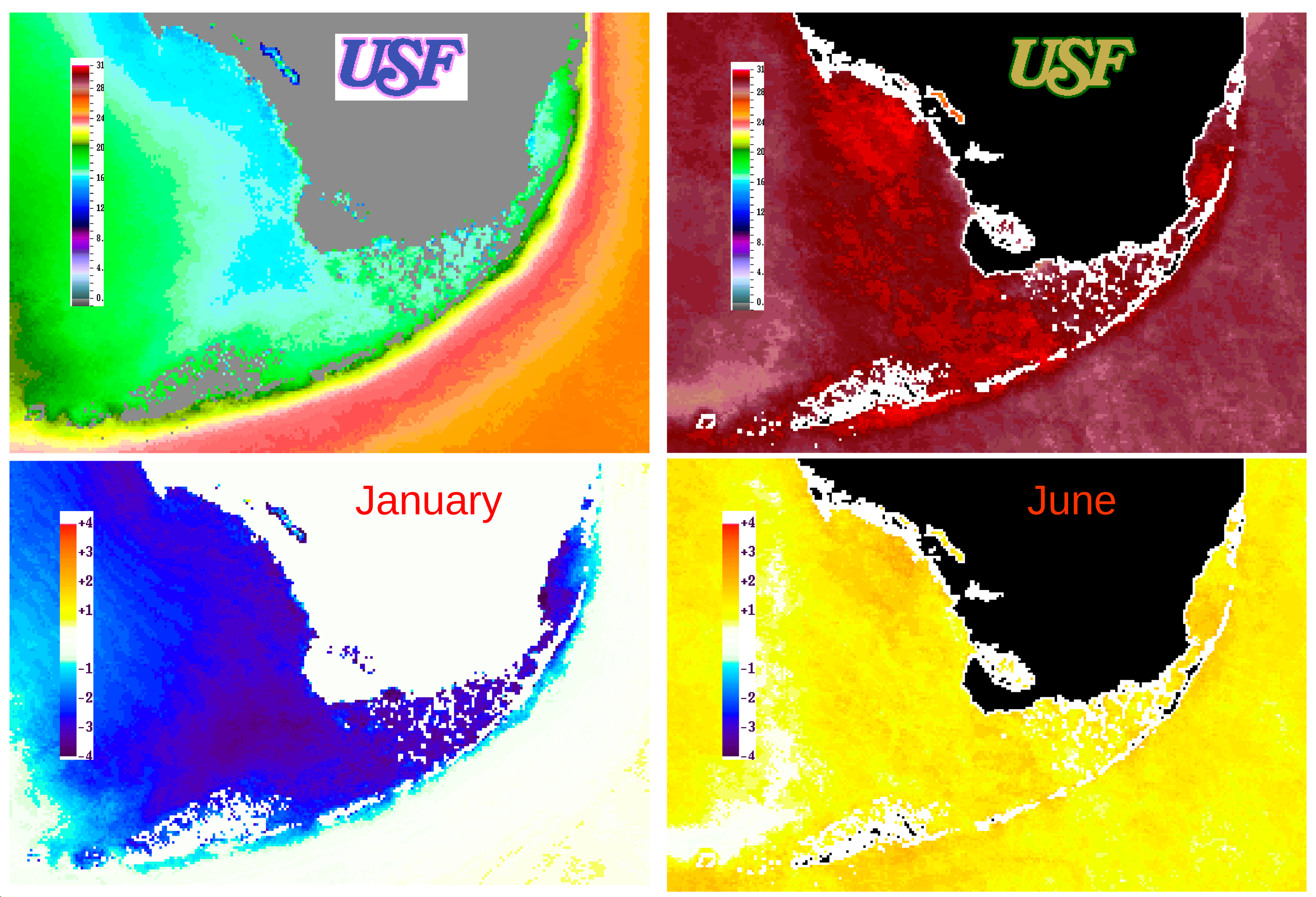


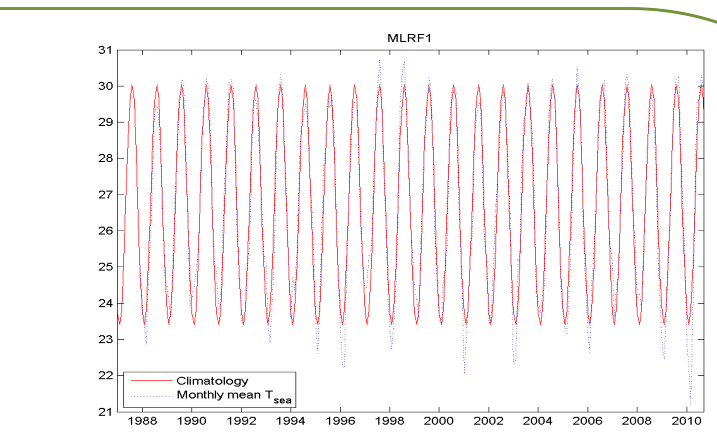
Chubarenko, 2010

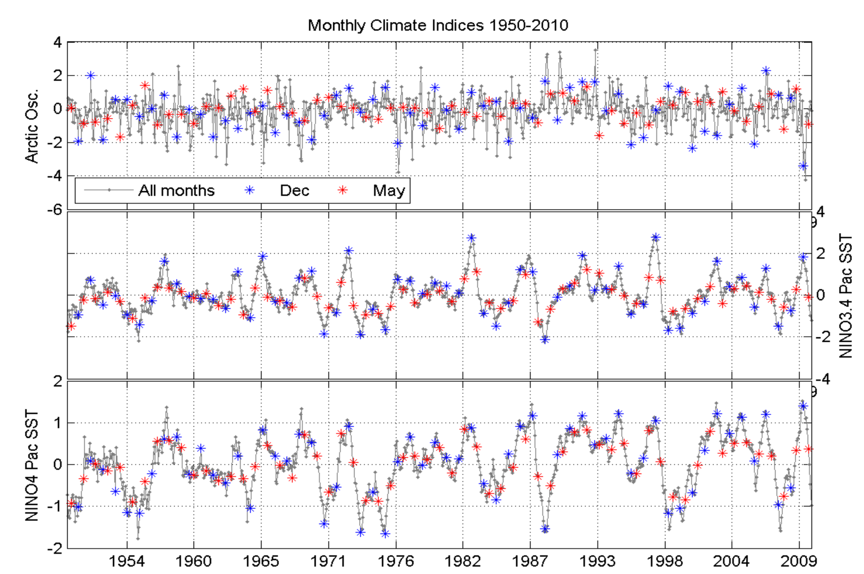


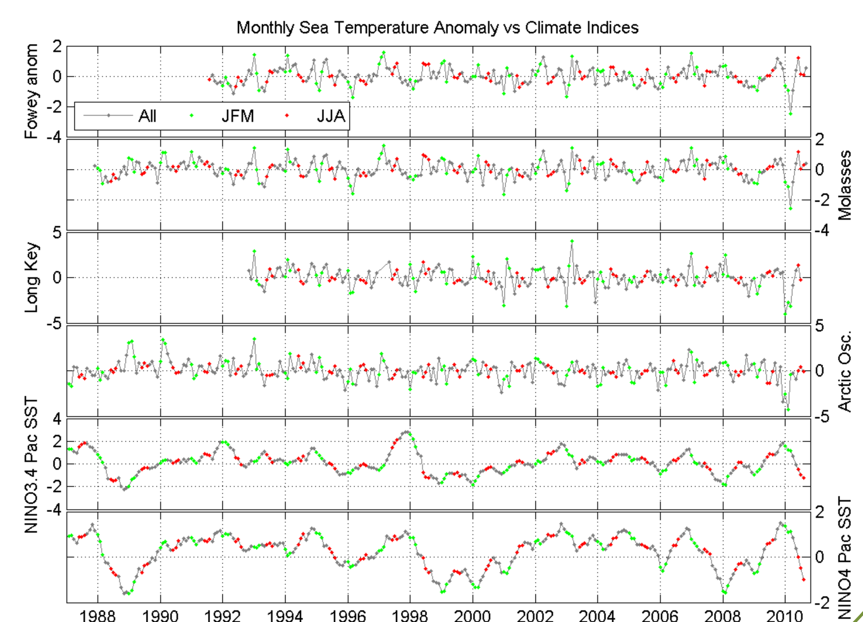
Monismith et al., 2006











Conclusions

1. **Large-scale climatic indices** – the Arctic Oscillation index of atmospheric pressure height, and El Nino-Southern Oscillation indices of equatorial Pacific SST anomaly – **reached historical extrema in early 2010**. Atmospheric forcing in Florida and the Caribbean reflected these extremes for several months following. Ocean waters on Florida reefs responded to this forcing.

2. Persistent extremes in sea temperature on the Florida reef tract (FRT) were observed in January, March, and June of 2010, on shallow reef sites throughout the FRT. (Monthly mean at three SEAKEYS reef monitoring stations outside those of all prior month-years with 5% confidence, p>0.01, N>200.) However, **response to atmospheric forcing was greater at some sites**.

3. At shallow sites with relatively strong response, an important distinguishing criterion was sea-floor slope – both monthly climatological anomalies and hourly data showed direct response to extreme atmospheric cooling in January and warming in June **only at sites with topographic slopes significantly less than 1%**. At other sites, response to both cooling and heating was less at all of diurnal, weekly, and monthly periodicities. A notable feature of this small-scale difference was its persistence.

4. An oceanographic mechanism that can explain this difference is the small-scale heat advection process called the "***thermal siphon"*** (Monismith 2007). This process is sensitive to spatial variations in sea-floor topography on scales of 100s of meters.

5. By considering this process and its effect on reef resilience, Marine Protected Area managers may be able to **focus conservation and transplantation efforts more narrowly and effectively** in the face of future climate-scale variability.

References and Acknowledgments

Thermistor data at eight shallow reef sites courtesy of Dr. Diego Lirman, UM RSMAS. Coastal Relief Model 3-arcsec sea-floor topography courtesy of NOAA National Geodetic Data Center. Gulf of Mexico 1/25o HYCOM data courtesy of Naval Research Lab and HYCOM Consortium. Climate indices courtesy NOAA National Centers for Environmental Prediction.

Hendee JC, Gramer LJ, Manzello D, Jankulak M (2009) Ecological forecasting for coral reef ecosystems. In: Dodge R (ed) Proceedings - 11th International Coral Reef Symposium, Ft. Lauderdale, FL 534-538

Hoegh-Guldberg O, Fine M, Skirving W, Johnstone R, Dove S, Strong A (2005) Coral bleaching following wintry weather. Limnology and Oceanography 50:265-271

Hu CM, Muller-Karger F, Murch B, Myhre D, Taylor J, Luerssen R, Moses C, Zhang CY, Gramer L, Hendee J (2009) Building an Automated Integrated Observing System to Detect Sea Surface Temperature Anomaly Events in the Florida Keys. Ieee Transactions on Geoscience and Remote Sensing 47:2071-2084

Manzello DP, Berkelmans R, Hendee JC (2007) Coral bleaching indices and thresholds for the Florida Reef Tract, Bahamas, and St. Croix, US Virgin Islands. Marine Pollution Bulletin 54:1923-1931

Monismith SG (2007) Hydrodynamics of coral reefs. Annual Review of Fluid Mechanics 39:37-55

Monismith SG, Genin A, Reidenbach MA, Yahel G, Koseff JR (2006) Thermally driven exchanges between a coral reef and the adjoining ocean. Journal of Physical Oceanography 36:1332-1347

Peng G, Mooers CNK, Graber HC (1999) Coastal winds in south Florida. Journal of Applied Meteorology 38:1740-1757

Porter JW, Battey JF, Smith GJ (1982) Perturbation and change in coral-reef communities. Proceedings of the National Academy of Sciences of the United States of America-Biological Sciences 79:1678-1681