Ocean Cooling by Tropical Cyclones

Wenqing Tang and W. Timothy Liu, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109

The Tropical Cyclone Heat Potential, the variability of which is determined from radar altimeter measurement, has been suggested and examined as an indicator of the intensification of approaching tropical cyclones. A few studies also show intense cooling of the surface ocean caused by the passage of tropical cyclones and the cooling is suggested to exert negative feedback to the intensity of the tropical cyclone. The availability of microwave sensors, which measure sea level anomalies, surface wind/stress vector, and sea surface temperature, under both clear and cloudy conditions allows us to examine the ocean-atmosphere interaction related to the intensification of tropical cyclones. All the hurricane-strength tropical cyclones in the Pacific, Atlantic, and Indian Oceans for eight years between 1998 and 2005, have been examined using space-based data. Reduction of both the heat potential and sea surface temperature, may start at cyclone passage but the strongest manifestation of ocean cooling occurs after cyclone passage. The air-sea interaction and feedback mechanism under various conditions will be postulated and explored.

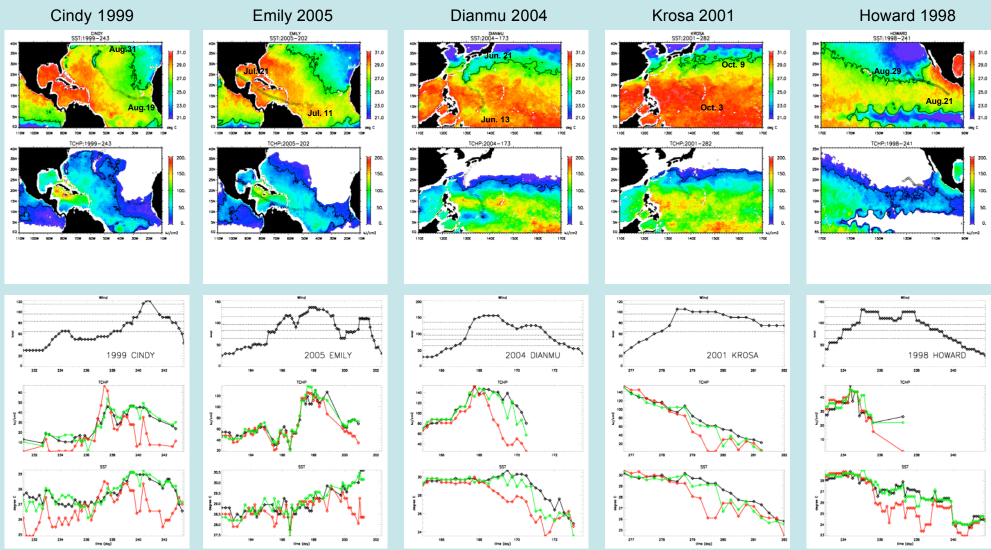

Figure 1. Top two color panels are SST and TCHP maps on the day near end of the storms. Lower plots are wind speed, TCHP and SST along track, where black (red) curves indicate parameters 2 days before (after) of, and green curves on the same day of storm passing.

Tropical Cyclone Heat potential (TCHP), defined as temperature departure from 26°C, vertically integrated from surface to 26 °C isotherm, were estimated by combining satellite observations of sea surface height anomaly (SSHA) from TOPEX/Poseidon and JASON-1, sea surface temperature (SST) from TRMM/TMI, and climatological ocean data from National Ocean Data Center, based on method of [Goni et al, 1996].

The tropical cyclone data are derived from the best track archives from the Joint Hurricane/Typhoon Warning Centers. TCHP and SST were extracted along the track of tropical storms reached hurricane scales (with wind speeds above 64 knot), from 1998-2005.

The five examples show upper ocean cooling with the passage of the storm, but high TCHP and SST are not required for the intensification of the storm as in the case of Krosa and Howard.

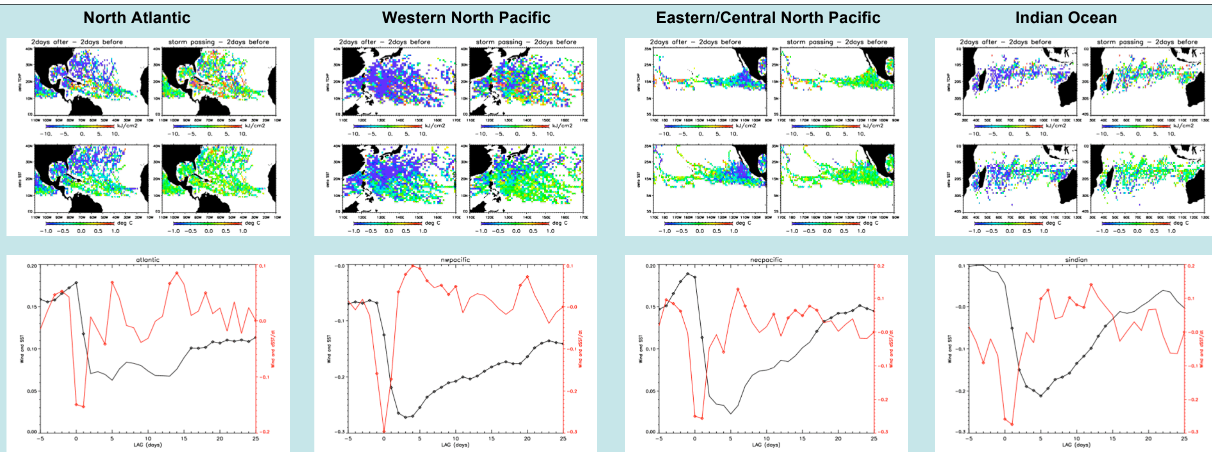

Figure 2. Color panels are hurricane composites bin-averaged on 1x1 grid. Low plots are lag-correlation, where positive lag means wind leading SST. Symbols indicate the corresponding correlation coefficients is 95% or higher significant.

A composite was created based on data from 1998 to 2005 for North Atlantic, Eastern/Central North Pacific, Western North Pacific and Southern Indian Ocean basins respectively, for the changes in TCHP and SST (2 days after - 2 days before), and storm passing - 2 days before. Such composed ensemble for each basin were used to analyze the ocean-atmosphere interactions associated with hurricanes.

The large negative correlation between wind speed and dSST/dt at zero lag, and between wind speed and SST a few day after storm passage show that the storms start to cool the ocean right away but the lowest SST is realized a few days later.

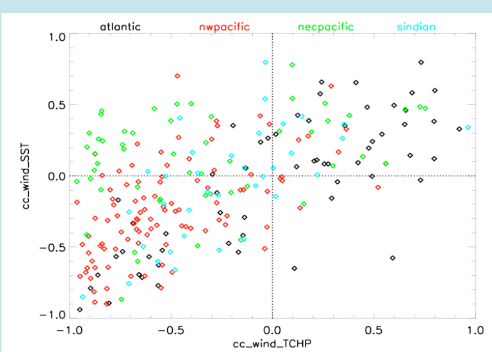

Figure 3. Correlation coefficients between wind and TCHP (x-axis); wind and SST (y-axis) for each storm between 1998-2005 along the storm track.

We also calculated correlation coefficients, for each storm along its track, between maximum wind speed and TCHP, and maximum wind speed and SST respectively. The pair of correlation coefficients for each storm is shown in the scatter-plot, with color indicates the ocean basin where storm traveled through.

The clustering of the correlation coefficient for each ocean basin may indicate different roles of SST and TCHP in affecting the intensification of storm. For North-Western Pacific, the correlation coefficients (red) are largely negative. In North Eastern/Central Pacific (green) the wind of most storms correlate positively with SST but not with TCHP. In North Atlantic (black) and South Indian Oceans (cyan), maximum winds are correlated similarly with SST and TCHP.

Number of hurricanes included in this study from 1998 to 2005 for each ocean basin

	1998	1999	2000	2001	2002	2003	2004	2005	Total
Atlantic	10	8	8	9	4	6	8	12	65
Western North Pacific	9	11	11	18	14	9	19	15	106
Eastern/Central North Pacific	8	6	5	8	8	7	6	6	54
Southern Indian Ocean	8	5	7	8	11	12	8	6	65
Total	35	30	31	43	37	34	41	39	290