University: University of Hawaii

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Type of Project (Partners or Cooperative): Partners

Project Title: Analysis of an Unusual Heavy Rainfall Period over the Hawaiian Islands

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Section 1: Summary of Project Objectives:

During the period from 19 February to 2 April 2006, the State of Hawaii underwent 22 days with flash flood warnings, one damaging tornado, and three verified severe thunderstorms. Trade winds were present only for five days. The main objectives of this research are:

a. Identify anomalous weather features during the extraordinary wet period;
b. Examine the relationship between the anomalous weather features and circulation from the equatorial tropics (e.g., La Nina/Walker circulations, Madden-Julian oscillation) and/or extra-tropical circulations (e.g., Pacific-North America (PNA) pattern);
c. Diagnose the main moisture sources for this wet period, including the influence of tropical plumes.
d. Compare this event with historical long lasting anomalous winter weather events over the Hawaiian Islands;
e. Investigate the existence of precursors that may help predict this type of events.

Section 2: Project Accomplishments and Findings:

a. Analyses of the anomalous circulation patterns

The SSM/I, TRMM, QuikSCAT, and NCEP/NCAR reanalysis data are analyzed over the Pacific Ocean to study the anomalous circulation patterns during an unusually prolonged stormy weather event in Hawaii from 19 February to 2 April, 2006. In the tropics, La Niña features such as strengthening of Walker circulation with wetter than normal conditions over the maritime continent and in the SPCZ, drier than normal conditions over the Central and Eastern Pacific, and a relatively weak ITCZ in the Central and Eastern Pacific are present.

In mid-latitudes, a negative PNA pattern persists with a blocking high southwest of the Aleutian Islands, retraction and splitting of the zonal jet into a polar jet north of 50°N, and a persistent subtropical jet to the south over the Central Pacific. An anomalous low west of the Hawaiian Islands is embedded in the subtropical jet with a southerly wind component ahead of the low. The anomalous low in the subtropics first appears at 20°N, 160°W in January, shifts westward to 20°N, 180°E by February, and stagnates there in March, reaching its maximum intensity while it is south of the mid-latitude blocking pattern. It weakens in April and dissipates by May. The large-scale blocking pattern over the North Pacific starts in mid-February, intensifies by March, weakens by April and dissipates in May. For this unusual prolonged stormy weather over the Hawaiian Islands, moisture is advected from low latitudes by the southerly wind component. In addition, anomalous rising motion occurs ahead of the semi-permanent low embedded in the subtropical jet with a PNA blocking pattern in mid-latitudes and under a weaker than normal Hadley cell over the Central Pacific. For this period, the NCEP Climate Forecast System (CFS) shows skills in forecasting La Niña features at least 3 months ahead of time but shows limited skills in predicting the mid-latitude blocking pattern in advance.

Similar anomalous conditions are found for the March 1951 record-breaking heavy-rainfall period and during the unusual torrential rain period of February 1979.

b. Case study of a heavy rainfall event over Oahu on March 31, 2006

Favorable conditions for the development of the Kahala Mall Flood case on 31 March 2006 are studied. A semi-permanent anomalous low-pressure system west of Hawaii is accompanied by negative PNA pattern during the 2006 wet period. Rossby waves propagate along subtropical and polar jets downstream of the Asian jet. As transient disturbances pass through the semi-permanent low-pressure system, the strengthened southerly winds east of the low-pressure system bring abundant tropical moisture to Hawaii during the 5 heavy rainfall episodes through out the wet period.

For the Kahala Mall case, the pronounced southerly winds over Hawaii bring in tropical moisture from the south. The high low-level θe axis across Hawaii is evident indicating the existence of convective instability over Hawaii. A transient mid-latitude trough extending southward connects with the semi-permanent subtropical trough. The mid-latitude cold air behind the trough penetrates into the subtropics. The cold advection by northerly winds behind the subtropical trough and the warm advection by southerly winds ahead of the trough contribute to Q-G frontogenesis and tropopause folding in the subtropics. The intrusion of the high-PV statospheric air into upper troposphere spins up the Kona low. The advection of high absolute/relative vorticity converted from the high-PV air by thermal winds induces upward motion downstream over Hawaii. In the lowest levels, easterly winds prevail. The heavy rainfall occurs at the lee side of the Ko`olau Mountain Range with maximum rainfall at the summit as an intense storm and a shallow convection line pass south of Oahu, move onshore and anchored by the

Section 5: Publications and Presentations

Publications:

a. Yang, Y., and Y.-L. Chen, 2008: Effects of terrain heights and sizes on island-scale circulations and rainfall for the island of Hawaii during HaRP. *Mon. Wea. Rev.*, **136**, 120-146.

b. Esteban, M. and Y.-L. Chen, 2008: The impact of trade-wind strength on precipitation over the windward side of the island of Hawaii. *Mon. Wea. Rev.*, **136**, 913-928.

c. Yang, Y., Y.-L. Chen and F. Fujioka, 2008: Effects of trade-wind strength and direction on the leeside circulations and rainfall of the island of Hawaii. *Mon. Wea. Rev.* (In Press).

d. Jayawardena, I. S., 2007: Analyses of an unusual heavy rainfall period over the Hawaiian Islands during 19 February – 2 April 2006. MS Thesis, Dept. of Meteorology, Univ. of Hawaii, Honolulu, HI 96822.

e. Tu, C.-C, 2008: Favorable conditions for the development of a heavy rainfall event during the 2006 wet period. MS Thesis, Dept. of Meteorology, Univ. of Hawaii, Honolulu, HI 96822.

Presentations:

a. Carlis, D. L. and Y.-L. Chen 2008: Numerical simulations of the Maui Vortex under summer trade-wind conditions. Symposium on the Linkages among Societal Benefits, Prediction Systems and Process Studies for 1-14-day Weather Forecasts, New Orleans, LA 2008.

b. In addition to MS thesis defense, both Jayawardena and Tu gave a departmental seminar separately. These events were attended by the NWS Honolulu Forecast Office staff.

Section 6: Summary of University/Operational Partner Interactions and Roles

a. The daily RSM/MSM and WRF-NMM runs are conducted by UH. The outputs are brought to NWS AWIP system.

b. An MS student (Jayawardena) completed the study of anomalous circulation patterns during this record-breaking wet period. Another student (Tu) completed her analyses of a heavy rainfall event during this period. Both students were supervised by Dr. Chen.