11B.5

IMPACT OF THE TRADE-WIND STRENGTH ON THE WINDWARD RAINFALL AND CIRCULATION OVER THE ISLAND OF HAWAII

Mary Ann Esteban and Yi-Leng Chen*
University of Hawaii at Manoa, Honolulu, Hawaii

1. INTRODUCTION

The diurnal evolution of rainfall distribution and airflow over the windward side of the island of Hawaii for the 12 strongest and 12 weakest trade-wind days (Chen and Nash 1994) during the Hawaiian Rain Band Project (HaRP) from 11 July - 24 August 1990 is studied from the 50 Portable Automated Mesonet (PAM) stations and National Center for Atmospheric Research (NCAR) Electra N308D aircraft flight-level data. The purpose of this study is to improve our understanding of the complex interaction among island blocking, orographic lifting and the diurnal heating cycle under the summer trade-wind weather.

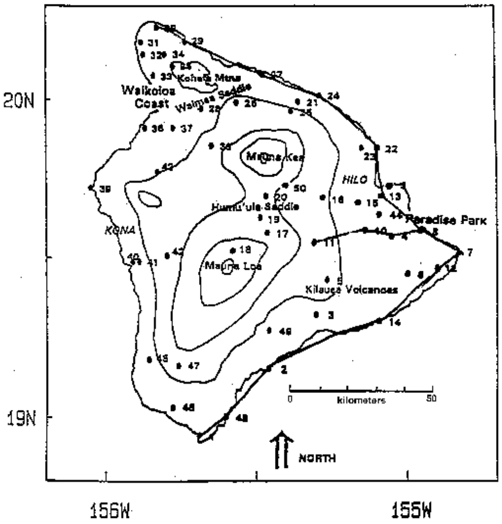

Figure 1. The distribution of the PAM stations over the island of Hawaii during HaRP. Elevation contours are 1000 m.

2. DATASET

The deployment of 50 PAM stations as shown in Figure 1 throughout the island allowed for high resolution of surface parameters to be recorded. Pressure, temperature, wet-bulb temperature, u and v winds, and rainfall were recorded at 1 minute intervals. Fifteen minute averages of the surface wind fields were used. Station 15 rainfall data is unworkable due to the malfunction of the tipping bucket raingauge.

The NCAR Electra provided aircraft flight-level data, of which 6 flights, 3 in the morning and 3 in the late afternoon were conducted using Flight Pattern G, in the shape of a rectangle, flown approximately 150 to 170 m above sea level. The three morning flights were carried out on 2 Aug 0611-0705 HST, 3 Aug 0551-0650 HST, and 10 Aug 0638-0732 HST while the evening flights were held on 1 Aug 1707-1803 HST, 2 Aug 1701-1757 HST, and 10 Aug 2115-2209 HST, all having upstream winds of about 5-8 m/s. Two additional flights with the same pattern on 8 Aug 0450-0544 HST (morning) and 7 Aug 2208-2303 HST (evening) was considered to be an unusually strong trade-wind case with upstream winds of ~11 m/s. Weak trade winds are normally in the range of 5-7 m/s while strong trades are about 7-9 m/s.

3. ANALYSIS PROCEDURES

The analysis of the evolution of rainfall distribution begins with mapping out the rainfall rate averages at 4-hour intervals over a horizontal plot of the island of Hawaii using PAM data for the 12 strongest trade days (~7-9 m/s) and the 12 weakest trade days (~5-6 m/s). Contours of 0.4 mm/hr intervals were drawn. Average winds and rainfall incidence were also analyzed.

Time series analysis was done over a 24 hour period of select PAM stations. The windward coastal cross section consisted of stations 30, 29, 24, 22, 13, 8, and 7. Another cross section ranging from the upper slopes to the coast corresponded to stations 11, 10, 4, and 8. A brief examination of the southeastern cross section of stations 1, 48, 2, 14, 12, and 7 was also done. All provide insight to the evolution of rainfall over the windward side of the island.

4. RESULTS

For the late afternoon regime, the orographic rains on the windward slopes are caused by orographic lifting of trades enhanced by anabatic winds. For weak trade-wind cases, the daytime anabatic flow is more significant than strong trade-wind cases with higher rainfall (~0.6-0.8 mm/h) on the slopes (Figs. 2 and 3). For strong trade-wind cases, more air is forced to move around the island.

For the nighttime flow regime, the convergence between the katabatic flow and stronger incoming trades produce higher nocturnal rainfall (~1 mm/h) on the windward lowlands around midnight (Figs. 2 and 3). When trade winds are weaker, the katabatic flow

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* Corresponding author address: Dr. Yi-Leng Chen, Univ. of Hawaii, Dept. of Meteorology, Honolulu, HI 96822; e-mail: dave@soest.hawaii.edu

extends farther toward the coast with less rainfall on the windward lowlands.

In the early morning, the katabatic flow is more significant when trade winds are weaker. The maximum rainfall (~0.6 mm/h) axis is along the coast for weak trade-wind cases. For strong trades, the coastal rainfall in the Hilo area (stations 7, 8, 13) is less (Figs. 4 and 5) but the rainfall is higher on the windward slopes as compared to weak trade-wind cases (Figs. 2 and 3).

In summary, the diurnal evolution of summer trade-wind rainfall on the windward side of the island of Hawaii differs under strong and weak trade-wind regimes. These differences are related to a complex interaction among island blocking, orographic lifting and the diurnal heating cycle.

6. REFERENCES

Chen Y.-L., and A. J. Nash, 1994. Diurnal variations of surface airflow and rainfall frequencies on the island of Hawaii. *Mon. Wea. Rev.*, **122**, 34-56.

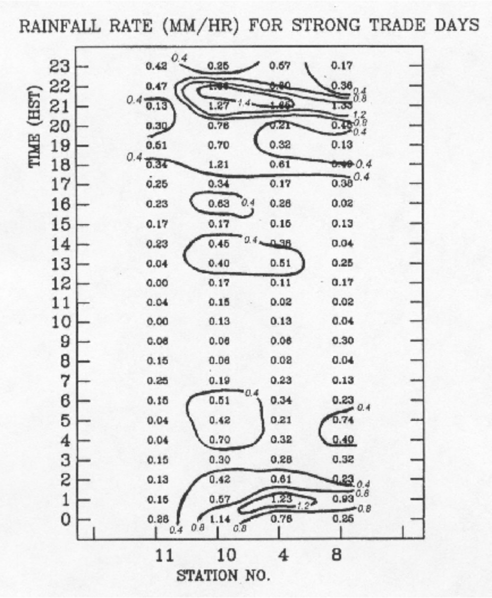

Figure 2. Rainfall rate (mm/hr) average for the 12 strong trade wind days in HaRP for the upper slope to coastal transect composed of stations 11, 10, 4, 8.

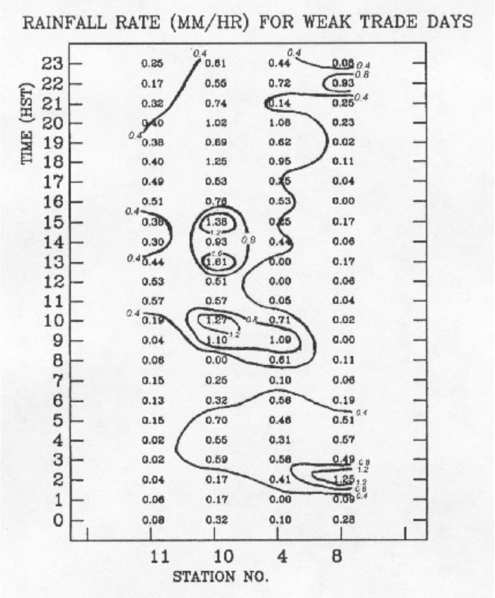

Figure 3. Same as Figure 2 for the 12 weak trade wind days.

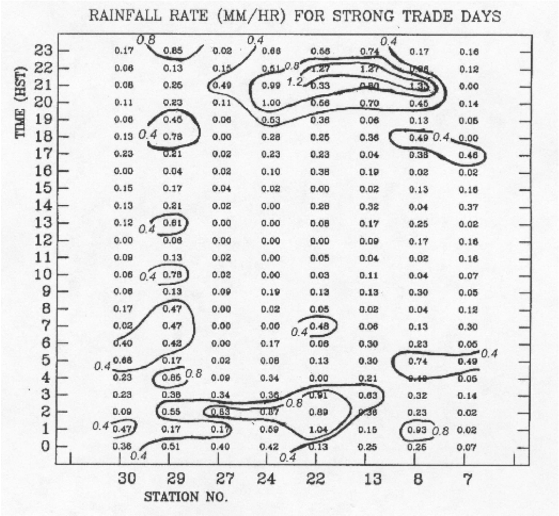

Figure 4. Same as Figure 2 for the coastal transect composed of stations 30, 29, 27, 24, 22, 13, 8, 7.

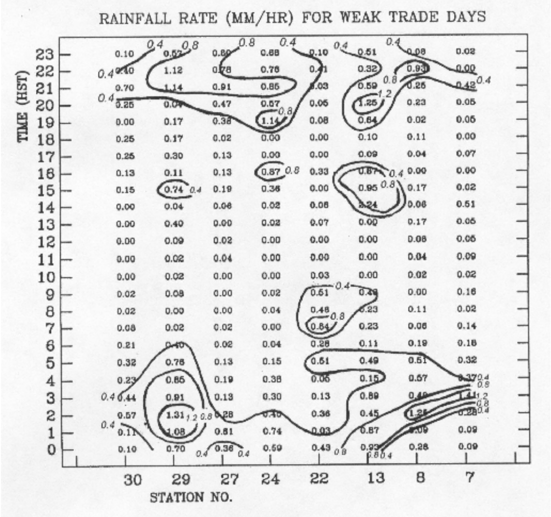

Figure 5. Same as Figure 4 for the weak trade wind days.