Surface Radiation Budget Analysis at Dungsha During SCSMEX

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Abstract

Several radiation instruments were operated at Dungsha coral island during South China Sea Monsoon Experiment (SCSMEX) to study the surface radiation budget. Based on the time evolution of surface meteorological, radiation and satellite radiance measurements, weather patterns during SCSMEX are grouped into pre-onset, transient and monsoon break stages. Solar flux as measured at the surface for three clear-sky days are generally in good agreement with radiative transfer model calculation. The characteristics of daily mean shortwave flux and cloud radiative forcing at three monsoon stages are discussed.

1. INTRODUCTION

The rainfall variation in the western Pacific during the transition from spring to summer is influenced by the interaction between the mid-latitude frontal systems and the southwestern monsoon. The spatial and temporal variations of rainfall in this transient period are very difficult to simulate with global climate models (Kao,1998). One of the missions of South China Sea Monsoon Experiment (SCSMEX; Lau,1995) is to acquire atmospheric and oceanic data in South China Sea from May to June in 1998. Two periods of intensive observations (IOP) were conducted to study the processes associated with the northward propagation of southwestern monsoon in South China Sea. The first IOP, 5-25 May 1998, was designed to observe atmospheric and oceanic circulation before the monsoon passing through South China Sea. The second IOP, 5-25 June 1998, was designed to observe tropical weather under the influence of southwestern monsoon.

During the IOPs, downward shortwave (SW) fluxes were measured at Dungsha (20° 43'N, 116° 43'E) in three broad bands using Epply's pyranometer. These three bands are 0.28-2.8 μm, 0.4-2.8 μm, and 0.7-2.8 μm. The temporal resolution of the measurements is 1 minute. Sky radiances were measured at eight channels in the ultraviolet and visible spectral regions using Cimel's sun photometer. These radiances were used to derive the aerosol optical thickness. In addition to radiation measurements, surface winds, temperature, and humidity were measured every hour, and radiosondes were launched four times a day. In this study we investigate the radiation data quality and the characteristics of SW flux evolution over South China Sea.

2. EVOLUTION OF SOUTHWESTERN MONSOON IN 1998

Surface meteorological observations at the islands of Nansha (10° 43'N, 114° 40'E) and Dungsha and the GMS-5 hourly IR brightness temperature, Tbb, are used to identify the propagating stages of the southwestern monsoon through South China Sea. From the time-latitude sections of surface wind direction, rainfall, and Tbb (not shown), three stages of weather pattern can be identified: pre-monsoon onset (before 21 May), transient (21 May - 10 June) and monsoon break (11 June- 21 June). During the pre-onset stage, the weather in the middle and southern South China Sea is under the influence of the Pacific high-pressure system. The prevailing wind at Nansha is easterly. There are no large cloud systems in this stage. Meanwhile, the weather system at Dungsha is controlled by semi-stationary mid-latitude frontal systems extending from mainland China. The wind direction at Dungsha depends on the location of the frontal system. During the transient stage, the southwestern monsoon propagates to Nansha around 21 May and Dungsha around 31 May. It passes the region on 10 June. After southwestern monsoon break, which extends from 10 June to 21 June, there is another low frequency monsoon system propagating through this region. According to a number of studies (Hsu,1996;

Lu,1996; Lin and Lin,1997), the onset of southwestern summer monsoon in 1998 occurs in the period 21-30 May.

3. CHARACTERISTICS OF SHORTWAVE SOLAR RADIATION AT DUNGSHA

From the time evolution of the daily mean SW flux shown in Figure 1, three stages of the southwestern monsoon can be clearly identified. The large fluctuation of the SW flux at the transient stage is associated with the large cloud system moving into the region from south. Assuming a surface albedo of 0.05, which is representative of the large oceanic region, the net downward SW flux average over the pre-onset, transient, and break stages are 205.7, 160.1, and 253.8 W/m^2, respectively. The value of 160.1 W/m^2 at the transient stage is close to the measurement at two RVs and one buoy during the westerly wind bursts in the TOGA COARE IOP (Weller and Anderson, 1996).

In order to check the radiation data quality, three clear-sky days (May 2, May22 and June 29) are chosen from the one-minute resolution SW flux measurements to make comparison with the calculation of radiative transfer model (Chou and Lee,1996). Figure 2 shows the measured and model-calculated SW fluxes at the surface. Also shown in the figure is the incoming solar flux at the top of the atmosphere. The model-calculated SW flux is systematically lager than the measured SW flux by 29.8 W/m^2 average in three clear-sky days, which is within the 3% uncertainty range of the surface measurement. Figure 3 highlights the detail of differences happened at June 29 case. Model computing flux less at ultraviolet band (0.3~0.4 μ m) could be caused by using tropical ozone climate profile. The overestimated amount at visible band (0.4~0.7 μ m) almost be balanced by the ultraviolet band. But the component at infrared band has bigger difference happened.

The role of cloud SW radiative forcing (defined as the difference between the all-sky flux and clear-sky flux) is an important information for climate studies. Figure 4 illustrates the daily mean cloud forcing evolution during field operation. The daily mean cloud forcing during the two months of SCSMEX IOPs is about 81 W/m^2. The cloud forcing associated with the frontal systems at the pre-onset stage is smaller than that associated with the monsoon at the transient stage.

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Figure 1: Time evolution of daily mean SW flux during SCSMEX IOPs.

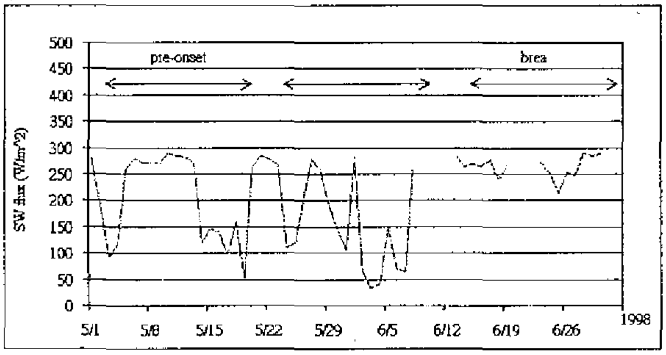

Figure 2: Daily variations of measured and model-calculated SW flux at the surface, also the SW flux at the top of atmosphere. (a) May 2,1998 (b) May 22,1998 (c) June 29,1998.

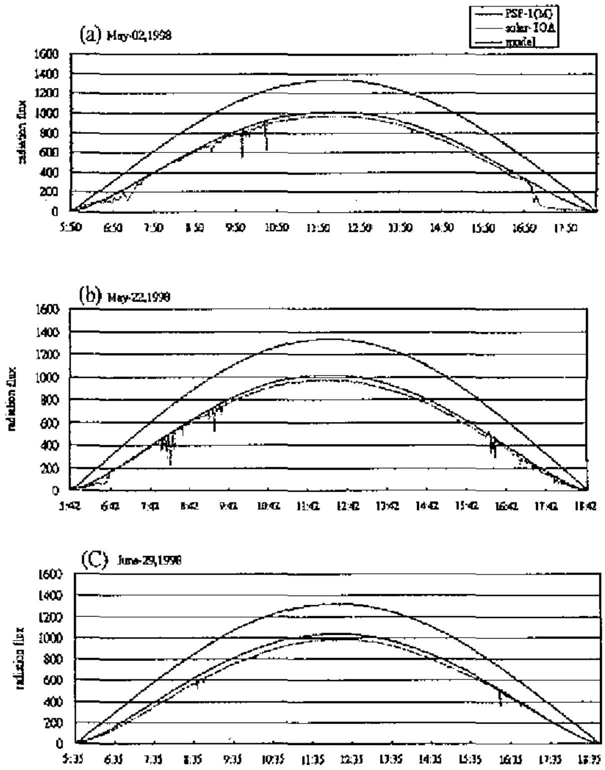

Figure 3: Time evolution of the differences of measured minus model-calculated SW flux at June 29,1998.

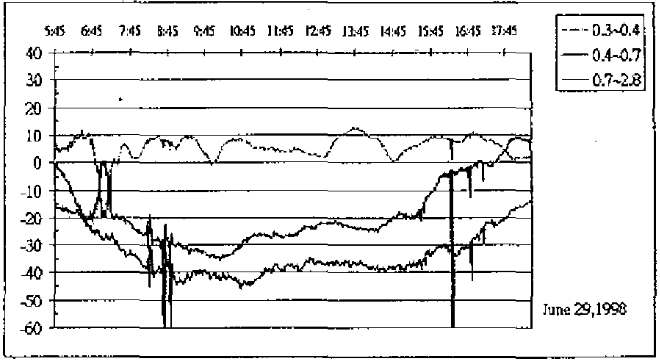

Figure 4: Time evolution of daily mean cloud forcing during SCSMEX IOPs.