EPIC2001 Ronald H. Brown
September 5 to October 5, 2001
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1. Week One

The RHB departed San Diego about 4 pm local time on September 5 and set a course for the EPIC2001 experimental area. A reasonably efficient course takes us through the national waters of Mexico, so we are unable to acquire data except for test/calibration purposes. After rounding the southern tip of Baja California, we set a course that would take us into international waters a few days before reaching the experimental area at 10 N 95 W.

On September 8 we stopped for approximately 3 hours to test various systems including the CTD, the MMP (University of Washington modular microstructure profiler), the SPMR (University of California at Santa Barbara solar radiative flux ocean profiler), and the balloon sounding system. All tests were successful. Conditions were already quite tropical with air temperature around 28.5 C and sea temperature around 30.5 C. Late on September 9 it began to rain intermittently.

Approximately 0800 GMT on September 10 we entered international waters at about 14 N and 103 W and began recording data. Weather was rapidly worsening and it turns out we were in the center of a tropical disturbance that was fast becoming a tropical storm (later named *Ivo*). Winds increased steadily and reached a peak of 18 m/s (half hour average) at 1800 GMT before declining rapidly. We received about 30 mm of rain in this event (over about 12 hours). The CSU group recorded some dandy C-band radar images of a tropical cyclone in its formation stages. The ETL flux system showed a peak cooling rate of the ocean of 700 W/m^2 at 1800 and the average net heat loss of the ocean was 266 W/m^2 for the day. This is about 10 times the typical daily average in the tropics. The driving rain did cause one unfortunate event by shorting out a connector on the cloud radar/radiometer van and shutting off the power. When power was restored, the computer that controls the microwave radiometers was sick and we are investigating ways to rebuilt its capabilities. The radar and mailbox radiometer are functioning normally. The Doppler lidar, ceilometer, wind profiler, and various ship systems are functioning normally. The UNAM chemistry and aerosol system is running, but a problem has been encountered with the gas chromatagraph that is intended for analysis of DMS concentrations in the sea water samples from the CTD rosette. Amparo Martinez is presently awaiting advice from the manufacturer on diagnosing the problem [see below].

On September 11 at 2200 GMT we reached the TAO buoy at 12 N 95 W and John Shanley commenced replacement of a guano-fouled rain gauge. Apparently the anti-bird spikes had failed (or had fallen off) and the rain gauge became a prime bird resting spot for the large local seabird population. The weather is once again fine with near surface air temperature about 27.5 C , RH 80%, and sea temperature about 28.6 C. Winds are from 315 at 3.0 m/s. A CTD was done at this site and another one at 11 N on the way to the next buoy.

On September 12 about 0130 GMT we had a short radio conversation with the R/V New Horizon. They expect to arrive in the experimental area about 1 day after we do. Despite the tragic events in New York and Washington DC, we intend to continue with our scientific efforts as planned.

We arrived at the buoy at 10 N 95 W at about 1400 GMT and commenced work on that buoy. One sensor was replaced in the meteorological package and a thermistor chain was attached below the buoy by divers from RHB. We then began operations in circle of radius 5 nm centered at 09 56.0 N 95 00.0 W. Waterside operations consist of drops by the MMP every 20 min. interrupted by short drops by the SMPR every hour during the day. For these operations the ship goes slow ahead at about 1 kt into the wind, which is optimal for atmospheric sampling. When reaching the edge of the circle, the ship powers up and relocates to the downwind edge of the circle and starts a new slow-into-the-wind leg. Preliminary results suggest about 50 drops a day to 300 m for the MMP and 7-10 for the SMPR (daytime only) to 100 m depth. The CSU group is launching 6 sondes a day, with about one-third losing GPS lock after launch (i.e., no wind profile).

On September 13 we talked by radio with the NCAR C-130 and the NOAA P-3 while they were in the general area. On September 14 about 1500 GMT the C-130 came right by the ship at an altitude of 100 ft. Amparo Martinez got the gas chromatagraph working so she can begin analyzing sea water samples for DMS. The UNAM system if fully functional except for an SO2 gas analyzer, which has a pump problem.

2. Week Two

The RHB has been on station at 10 N 95 W for the entire preceding week. We have been conducting oceanographic and atmospheric operations as planned. The CTD, the MMP (University of Washington modular microstructure profiler), the SPMR (University of California at Santa Barbara solar radiative flux ocean profiler), and the balloon soundings are the primary externally deployed systems in operation. We are doing one CTD (around local noon), about 50 MMP's, about 7 SPMR's, and 6 balloon soundings per day. The success rate for winds on the balloon soundings is very good (about 5/6). We have also been capturing one or two SEAWIFS overpasses every day around noon. On September 19 we began a schedule of XCP (expendable current profiler) drops every 8 hours.

In the past week the weather has gone through a complete cycle from suppressed conditions with strong heat input to the ocean, to strong convection and cooling of the ocean, and back to heating again. These cycles can be seen in time-height cross-sections of the N and E wind components (see Figure 1). Figure 2 shows the corresponding time series of ocean and air temperatures. Two water temperatures are shown: one (blue circles) is very close to the surface while the other is 5-m deep. When winds are light and it is sunny, the surface temperature is much warmer (days 257-258); the cold spikes (days 259-262) are caused by rain during the convective period. At the ship we recorded about 175 mm of rain during this 3-day period. The large cool events in air temperature are caused by cold-air outflows from deep convection. Another interesting aspect is the large diurnal cycle of cloudiness and convection with the peak being just after midnight (LDT); about 3/4 of our rain accumulation has come at night. Figure 3 from the 35 GHz cloud radar shows the precipitating system from day 260 (September 17, 2001). The upper panel is the scattering intensity and the middle panel the fall velocity of the precipitation. You can see the transition from snow/ice to rain at about 5 km. Most of the rain at the ship came from the innocuous-looking spike at about 0700.

Sampling being performed by the UCSB group is proceeding as planned. To date they have collected more than 70 profiles (to 100 m; ~8 per day) of in-water solar radiation data, along with coincident surface irradiance data. A dozen CTD/rosette casts have been performed to 300 m. Water samples collected during each days CTD have been analyzed for chlorophyll concentration and frozen for nutrient analysis back at the UCSB lab. They have successfully collected high resolution SeaWiFS data
daily using the ships TeraScan system. The data show a mixed layer depth near 30 meters. A large temperature gradient exists beneath the mixed layer (~12C decrease over 20 meters). Chlorophyll values are less than 0.2 mg m^{-3} within the mixed layer. A chlorophyll maximum near 0.6 mg m^{-3}, at a depth of ~50m, persisted during the first 6 days of sampling. More recently the chlorophyll maximum has decreased to 0.3 mg m^{-3} and is found just beneath the mixed layer (near 30 m). Spectral diffuse attenuation coefficients computed from the in-water solar data show biologically-induced changes in solar transmission. The UCSB group is presently working to compute time series of solar transmission.

Mike Gregg reports mostly weak turbulence from the MMP data, with some hints of increased mixing and a deepening of the thermocline in the last few days. The thermocline is very shallow, so they are doing some further processing to try to dig out these small effects.

Amparo Martinez reports continued good measurements with the air aerosol/chemistry system except for SO2. Good phytoplankton samples have also been obtained. The chromatograph continues to have problems, so there have been no reliable DMS results as yet. Samples are still being stored for possible later analysis.

The CSU group is getting good C-band radar data and balloon launches are going very well (see their separate daily reports on JOSS). The cloud radar/microwave radiometers are fully function; the upward pointing IR is still down for lack of a power supply. The mini-MOPA lidar is operating almost about 60% of the time, distributed through the day. Range performance for doppler is 4-6 km and for water vapor is 0.5-1.0 km depending on aerosol and humidity.

The AOML underway pCO2 system was not operating correctly. After consulting with Bob Castle, it was fixed by the ship's chief survey technician Jonathon Shannahof.. Presently showing water CO2 concentrations about 400 ppm vs 370 ppm for the atmosphere.

3. Week Three

The RHB has been on station at 10 N 95 W for 17 days and we plan to depart tonight. We have been conducting oceanographic and atmospheric operations as planned. The CTD, the MMP (University of Washington modular microstructure profiler), the SPMR (University of California at Santa Barbara solar radiative flux ocean profiler), and the balloon soundings are the primary externally deployed systems in operation. We are doing one CTD (around local noon), about 50 MMP's, about 7 SPMR's, and 6 balloon soundings per day. The success rate for winds on the balloon soundings is very good (about 5/6). We have also been capturing one or two SEAWIFS overpasses every day around noon. On September 19 we began a schedule of XCP (expendable current profiler) drops every 8 hours. The launches were concluded on September 25 with 18 of 20 completely successful.

In the past 8 days the weather has been predominantly very active convectively with only a short break in the disturbances on September 25. In that 8-day period we received about 270 mm of rain, average net heat flux into the ocean was about -100 W/m^2, and the ocean cooled about 0.5 C.

Mike Gregg reports that during the last week MMP profiles show mixing increased in the lower part of the thermocline, and the data record grew long enough to show convincing evidence of mixing following the vertical propagation of near-inertial motions. Simultaneously, the thermocline thickened and isolines of salinity and oxygen descended, suggesting that the mixing may have been responsible. Oxygen and salinity changes, however, also were found deeper in the water column. Advection is the only feasible reason for these changes. Determining how much of the thermocline changes resulted from mixing and how much from advection will require detailed analysis.

The UCSB ocean radiant heating group continues to measure profiles of in water spectral irradiance, and collect water samples for chlorophyll and nutrient analysis. A preliminary look at the in-water solar flux data shows spectral diffuse attenuation coefficients that are mostly invariant within the upper ocean mixed layer (~30 m). This suggests that the fraction of the incident solar flux that passes beyond 30 meters is changing only slightly during the sampling period. However, we see more substantial changes in the solar flux divergence (normalized to surface values) near the top of the thermocline. The heating rate of a 10 m thick layer at the top of the thermocline (30 to 40 m) varies by more than 10 W m^2 (based on a climatological surface value of 170 W m^2). Such changes in (surface normalized) ocean radiant heating follow variations in chlorophyll concentration within the "deep chlorophyll maximum" (~40m). Chlorophyll concentration at 40 meters ranges from near 0.2 to more than 0.6 mg m^3.
A doubling of chlorophyll concentration (from ~0.15 to just over 0.3 mg m^3) within the mixed layer was just recently observed (9/28). We expect a noteworthy change in the (surface normalized) solar flux at the mixed layer base. A large amount of cloud variability needs to be sorted out before reporting on these data. We will begin CTD/Rosette/SPMR data collection along the 95W line (from 10N to the equator) shortly.

Amparo Martinez reports continued good measurements with the air aerosol/chemistry system. A pump problem with the SO2 system was fixed. The system has a small unexplained negative bias, but seems to be indicating reasonable temporal variability and shows noticeable sensitivity to the ship's plume. Good phytoplankton samples have also been obtained. The chromatograph continues to have problems and efforts to repair it have been for nought. Samples are still being stored for later analysis.

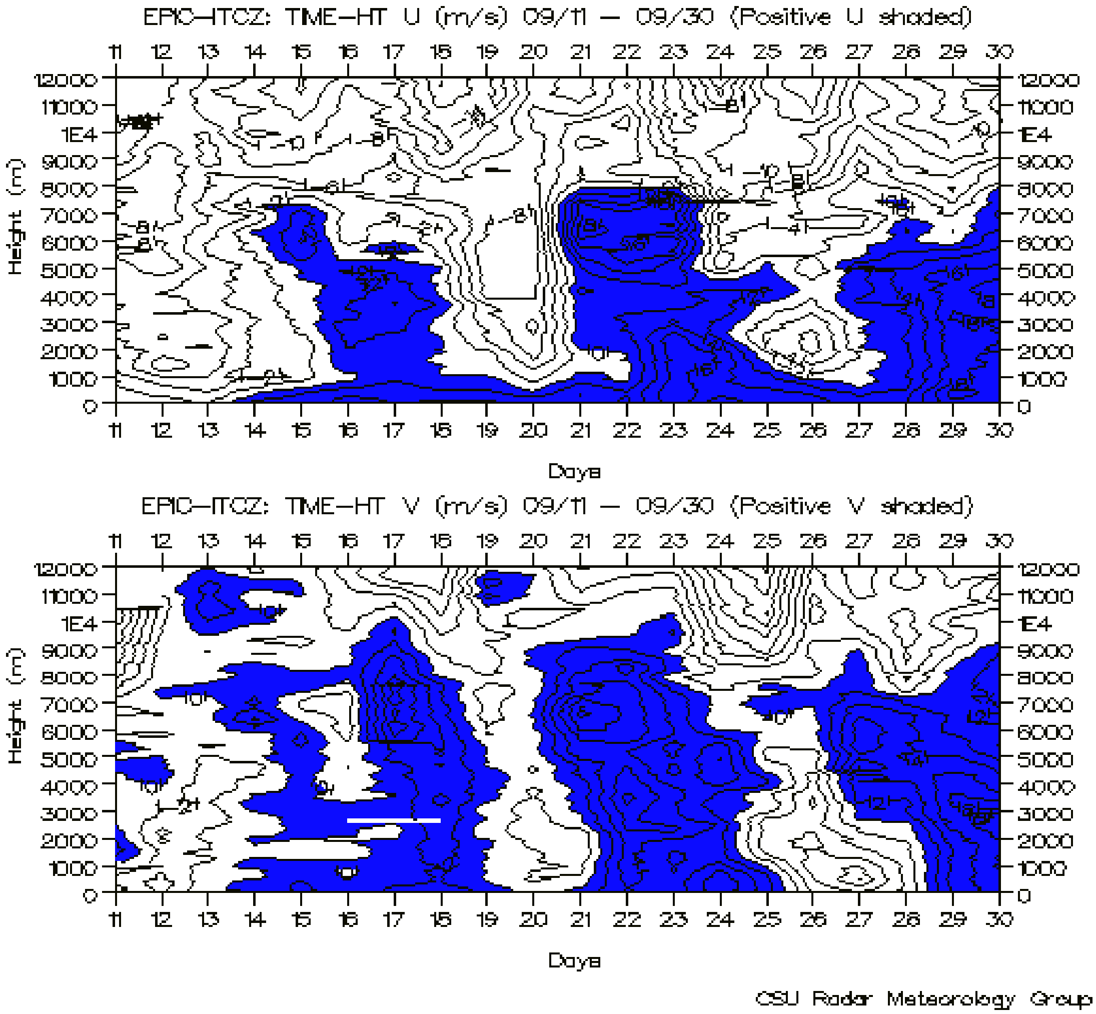
The CSU group is getting good C-band radar data and balloon launches are going very well (see their separate daily reports on JOSS). The cloud radar/microwave radiometers are fully function; the upward pointing IR is still down for lack of a power supply. The mini-MOPA lidar is operating almost about 60% of the time, distributed through the day. Range performance for Doppler is 4-6 km and for water vapor is 0.5-1.0 km depending on aerosol and humidity.

Some problems were discovered in logging of some of the SCS events around September 28 and 1 or 2 days of data may not be archived. Jonathon Shannahof is investigating.

4. Week Four

On October 1 RHB departed our station in the ITCZ and started down the 95 W TAO buoy line. Ocean microstructure measurements ended when we got underway but 4-hourly rawinsondes and ½ degreee CTD profiles were continued. At noon we did a SPMR profile. We were visited by the NCAR C-130 for boundary-layer turbulence legs on the afternoons of Oct. 3 and 4 (about 4 and 2 degrees N). We stopped briefly at two buoys on the way down and made extensive stops at 2 N and 0 N. The later stops were to deploy new moorings to replace the ones that were missing from these locations. Stratus clouds and stable surface layers were encountered near the equator. It took us about a day to go from 0 N 95 W to Isla Santa Cruz, were we dropped anchor to complete leg I of the EPIC2001 cruise.

One interesting result on the boundary layer transition from the equator across the temperature front at 2-3 N is shown in Figure 4. This figure shows the wind speed (upper panel), sea (circles) and air (x's) temperatures (middle panel) and the sensible (circles) and latent (x's) heat fluxes as a function of latitude between 0 and 5 N. Note the sea surface temperature gradient is maximum at about 0.75 N while the wind speed and fluxes tend to peak near 2 N and then start to decline again. The NCAR C-130 obtained very similar results. These data on the PBL structure across the ITCZ-cold tongue complex will be a critical test for models.



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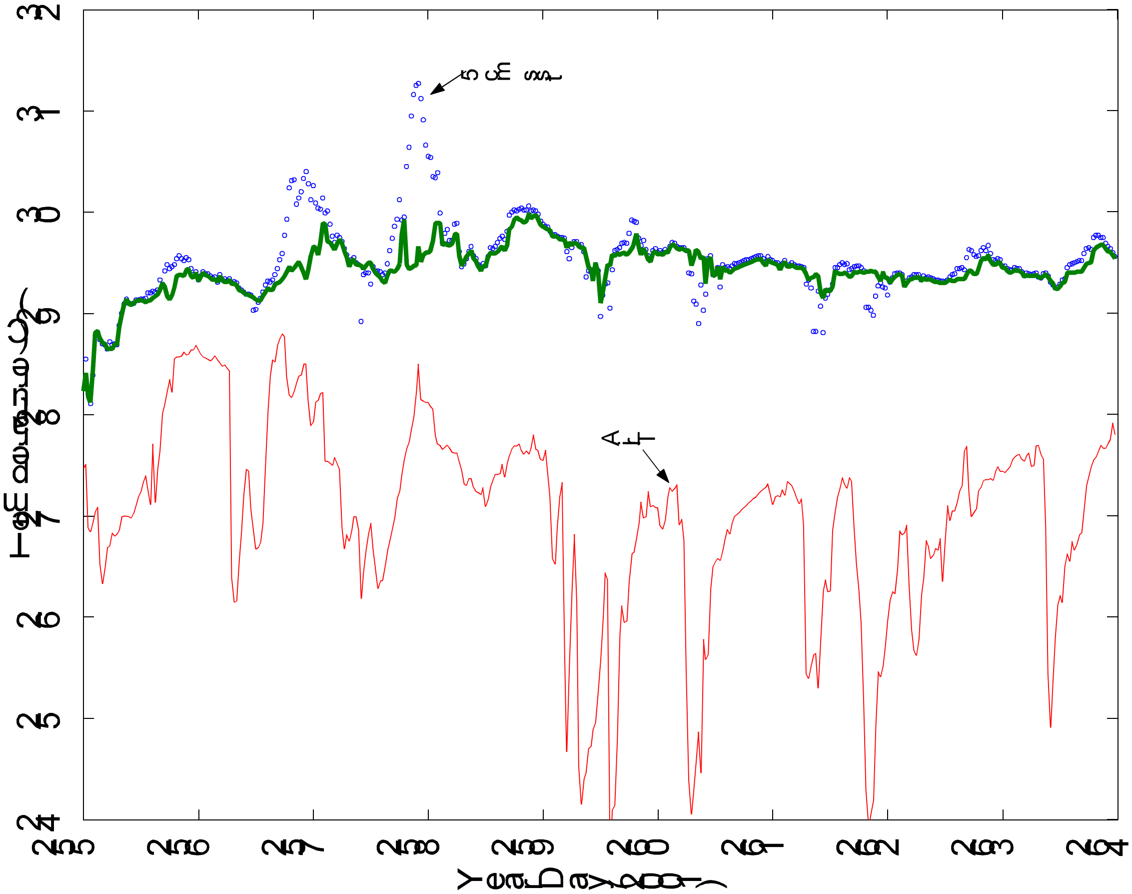

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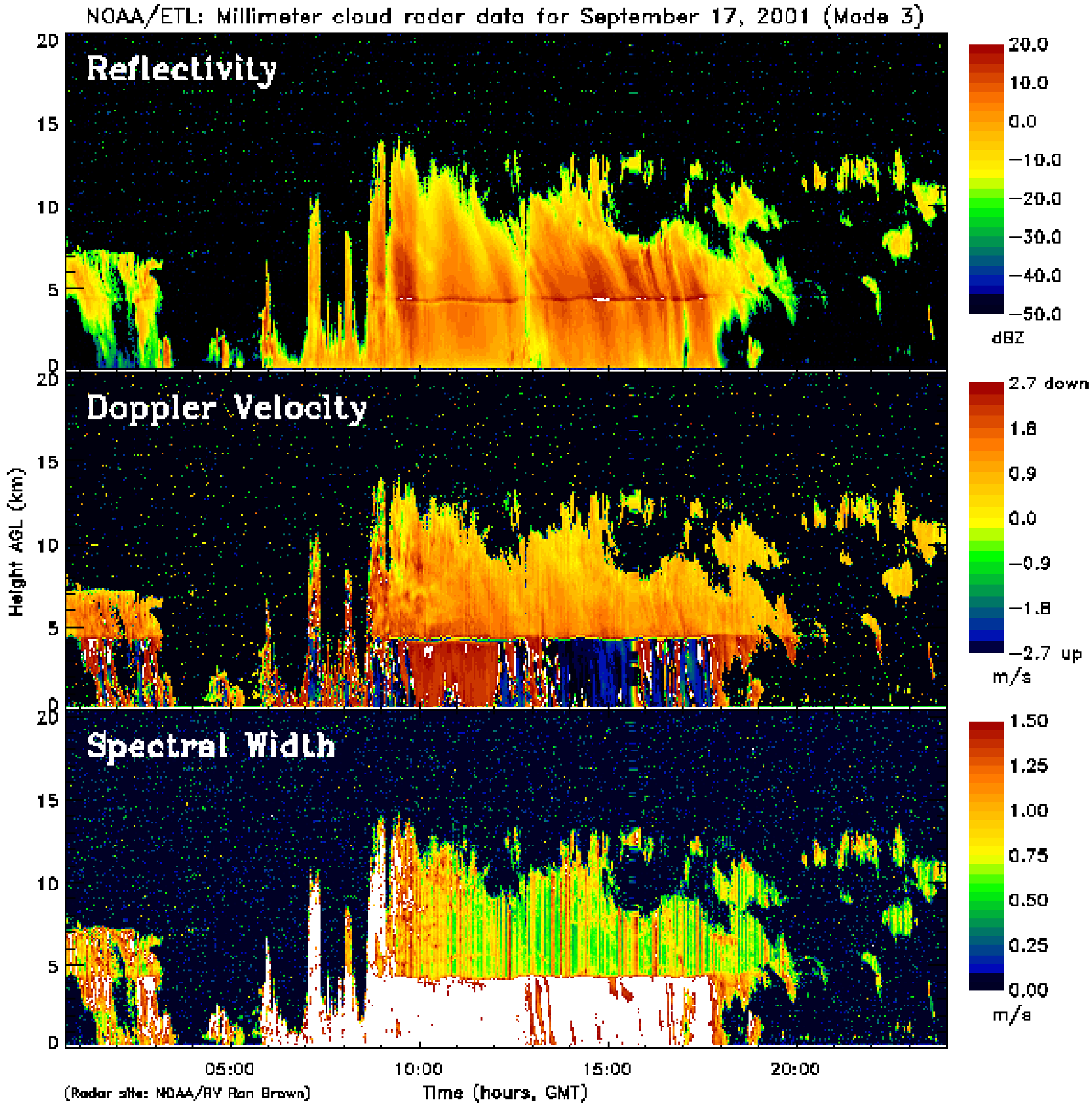

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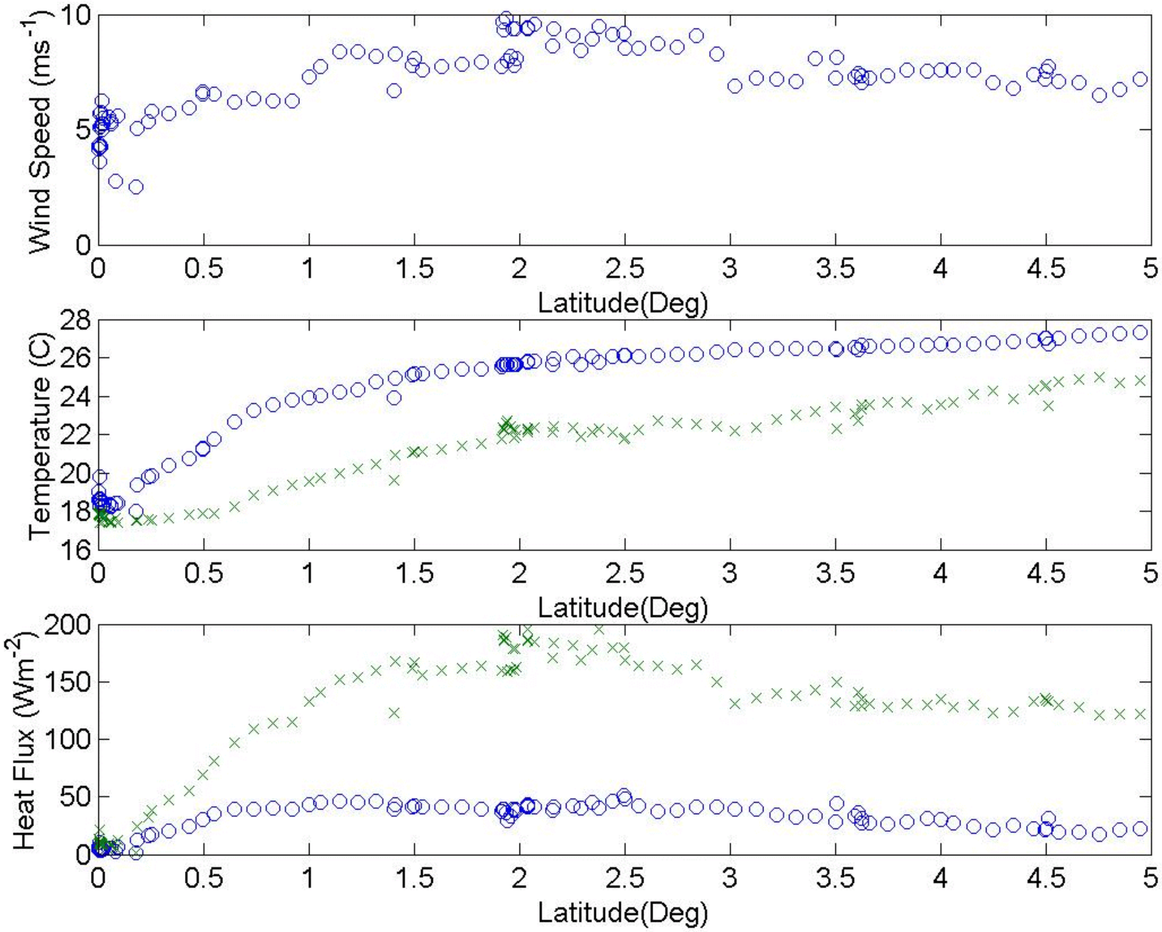

Fig.4 figure4.200110051400.ron_brown.jpg