Direct/bulk fluxes from the 2008 VOCALS Cruise – Version 1

PSD Air-Sea Interaction Group
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June 27, 2009
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This document is the Readme for *VOCALS08flux_hr.txt* and *VOCALS08flux_10.txt* files. The *_hr* refers to hourly averages and the *_10* to 10-minute averages. The is a version with a '*_nodh*' designator which has no headings to allow simple loading in MATLAB. Both direct (covariance) and inertial-dissipation (ID) turbulent flux calculations are included in this present data. The period covered is JD 294 (20 Oct 2008) through JD 336 (1 Dec 2008). The graph below gives the ship track for the data period.

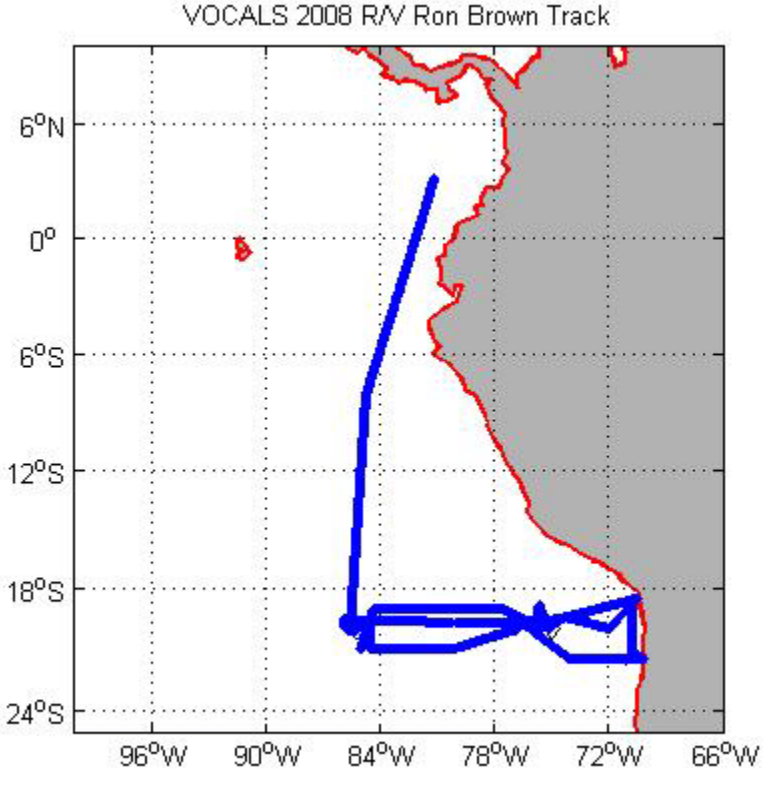

Figure 1. Track of NOAA R/V Ronald H. Brown during VOCLAS 2008

The files are 54 columns:

- First column is the decimal Julian date
- Columns 2 to 11 are mean variables from the PSD system
- Columns 12 to 21 are turbulent fluxes (covariance, ID, and bulk)
- Columns 22 to 23 are the radiative fluxes
- Columns 24 is the rain rate

- Columns 25 to 27 are turbulence data quality indicators

Columns 28 to 31 are the turbulent structure function parameters (indices of small-scale turbulence in the inertial subrange).

- Columns 32 to 33 are the minor (rain and Webb) heat flux components;
- Columns 34 to 35 are latitude and longitude;
- Columns 36 to 38 are the heights of the PSD wind, temperature, and humidity mean sensors.
- Columns 39 to 48 are mean variables from the ships sensors.
- Columns 49 to 52 and 54 are data computed from the LICOR-7500 open path IR sensor.
- Column 53 is the atmospheric pressure

The files can be directly acquired with a MATLAB 'load' statement. For instance:
`x=load('your_local_directory\VOCALS08flux_hr_nohd.txt');%read file with hr average data; set your local directory.` The columns assignment is as follows:

```
jdy=x(:,1);%julian day at beginning of time average
ushp=x(:,2);%doppler log, SCS (m/s)
U=x(:,3);%true wind,PSD sonic (m/s)
dir=x(:,4);%true wind direction, PSD sonic (deg)
urel=x(:,5);%relative wind speed, PSD (m/s)
reldir=x(:,6);%relative wind dir (from),clockwise rel ship's bow, PSD sonic (deg)
head=x(:,7);%ship heading, deg clockwise rel north, SCS laser ring gyro
tsnk=x(:,8)-0.3;%sea snake temperature, PSD, 0.05 m depth (C)
ta=x(:,9);%air temperature, PSD (C)%
qse=x(:,10);%sea surface specific humidity, from snake (g/kg)
qa=x(:,11);%air specific humidity, PSD (g/kg)
hsc=x(:,12);%sensible heat flux, covariance, PSD sonic anemometer(W/m^2)
hsib=x(:,13);%sensible heat flux, ID, PSD sonic anemometer(W/m^2)
hsb=x(:,14);%bulk sensible heat flux, (W/m^2)
hlc=x(:,15);%latent heat flux, covariance, (W/m^2)
hlib=x(:,16);%latent heat flux, ID, (W/m^2)
hlb=x(:,17);%bulk latent heat flux, W/m^2 (includes Webb et al. correction)
taucx=x(:,18);%covariance streamwise stress, PSD sonic anemometer (N/m^2)
taucy=x(:,19);%covariance cross-stream stress, PSD sonic anemometer (N/m^2)
tauib=x(:,20);%ID streamwise stress, PSD sonic anemometer (N/m^2)
taub=x(:,21);%bulk wind stress along mean wind, (N/m^2)
rs=x(:,22);%downward solar flux, PSD units (W/m^2)
rl=x(:,23);%downward IR flux, PSD units (W/m^2)
org=x(:,24);%rainrate, PSD STI optical rain gauge, uncorrected (mm/hr)
J=x(:,25);%ship plume contamination index
tiltx=x(:,26);%flow tilt at PSD sonic anemometer, earth frame
Jm=x(:,27);%ship maneuver index
ct=x(:,28);%ct^2 (K^2/m^.667)
cq=x(:,29);%cq^2 ((g/kg)^2/m^.667)
cu=x(:,30);%cu^2 ((m/s)^2/m^.667)
cw=x(:,31);%cw^2 ((m/s)^2/m^.667)
hrain=x(:,32);%rain heat flux,Gosnell et al 1995, JGR, 18437-18442, (W/m^2)
hlwebb=x(:,33);%correction to measured latent heat flux, Webb et al.
lat=x(:,34);%latitude, deg (SCS pcode)
lon=x(:,35);%longitude, deg (SCS pcode)
zu_etl=x(:,36);%height of mean wind sensor, 17.7 m
zt_etl=x(:,37);%height of mean air temperature sensor, 15.5 m
zq_etl=x(:,38);%height of mean air humidity sensor, 15.5 m
%***** ships imet and scs data
sog=x(:,39);%speed over ground, SCS gps, (m/s)
U_scs=x(:,40); %true wind speed, imet propvane anemometer (m/s)
```

```
dir_scs=x(:,41);%true wind direction (from),clockwise rel north, imet,(deg)
cog=x(:,42);%%course over ground, SCS gps, (m/s)
tsg=x(:,43);%tsg water temperature, 5 m depth, (C)
ta_im=x(:,44);%imet air temperature (C)
qs_tsg=x(:,45);%imet bulk water specific humidity (g/kg)
qa_im=x(:,46);%imet air specific humidity, (g/kg)
rs_im=x(:,47);%imet solar flux, (W/m^2)
rl_im=x(:,48);%imet IR flux (W/m^2) – not connected for neaqs
wco2_lic=x(:,49);%LICOR CO2 flux, (micatm m/s)
q_lic=x(:,50);%Specific humidity from LICOR (g/kg)
sgq_lic=x(:,51);%Standard deviation of specific humidity from LICOR (g/kg)
co2_lic=x(:,52); %CO2 concentration from Licor (umol/mol)
press=x(:,53); %Atmospheric pressure (mb)
sgC_lic=x(:,54);%Standard deviation of CO2 concentration from LICOR (microatm)
```

Notes:

- In processing the 10-min data to one-hr averages, only the filtered data were used in averaging the turbulence variables. If there were no valid values in the 1-hr interval, the turbulence variables were set to NaN. The quality criteria were subdivided in two parts:
  - A value of J=0 implies no ship contamination.
  - A value of Jm<3 implies no significant maneuver during the average.
- Bulk estimates of air sea fluxes were computed using the COARE bulk algorithm version 3.0.
- Because the IR hygrometer detects water vapor mass concentration (ρ_v in kg/m^3), the water vapor -velocity correlation must be corrected as per Webb et al ($H_{latent} = L_e \langle w' \rho_v' \rangle$ + hl_webb). The values given for covariance and ID latent heat fluxes in the file are $L_e \langle w' \rho_v' \rangle$. Values for hl_webb are included in column 33. This should be applied to the covariance and ID values. It is already included in the bulk values given here.
- Both latent and CO2 fluxes are computed from the LICOR-7500 open path IR sensor. The CO2 fluxes have been corrected for the humidity Webb effect but not for the temperature Webb effect. The LICOR performance deteriorated on leg I and was replaced before leg II.
- Sensible heat flux was computed from vertical velocity -sonic temperature covariance and Inertial-dissipation (ID) methods. The humidity contribution to sonic temperature was removed using the bulk latent heat flux.
- Turbulent fluxes are computed by converting the anemometer 3-component velocities to fixed earth coordinates, correcting the fast time series for ship motion, and resetting the coordinate system normal to the 10-min mean flow through one rotation about the original vertical and one tilt. The variable *tiltx* gives the tilt used for the computation. Experience show that tilts greater than about 10 deg give questionable fluxes.

Other Details:

*The PSD T/RH sensor behaved erratically on leg I. This was traced to a dirty shield on the sensor. The shield was cleaned and replaced for leg II. The RHB T/RH sensor (also referred to as IMET or SCS) disagreed with the PSD sensor; it was 0.26 C warmer and 1.0 g/kg moisture. Based on comparisons with standards we had on board, we concluded that the PSD sensor was reading correctly To reduce the scatter in the T and q values in the leg I data, we fit a linear regression of SCS to PSD and computed estimates of the PSD values based on the IMET values in leg I. These corrected values appear in columns 9 and 11. The IMET values that appear in the file (columns 44 and 46) are unchanged.

*PSD measures wind speed and direction with a motion corrected sonic anemometer mounted on

aforward spar at the centerline on the jackstaff (18 m height above water). Mean flow distortion corrections have been applied. The IMET system is on a cross-arm at a lower level (15 m height above water); it is subject to greater flow distortion and is uncorrected. Comparisons with the NOAA Doppler lidar show the PSD system is accurate for wind speed. There is a 5 deg offset in true wind direction (if the lidar is correct, the PSD system is rotated 5 deg to port).

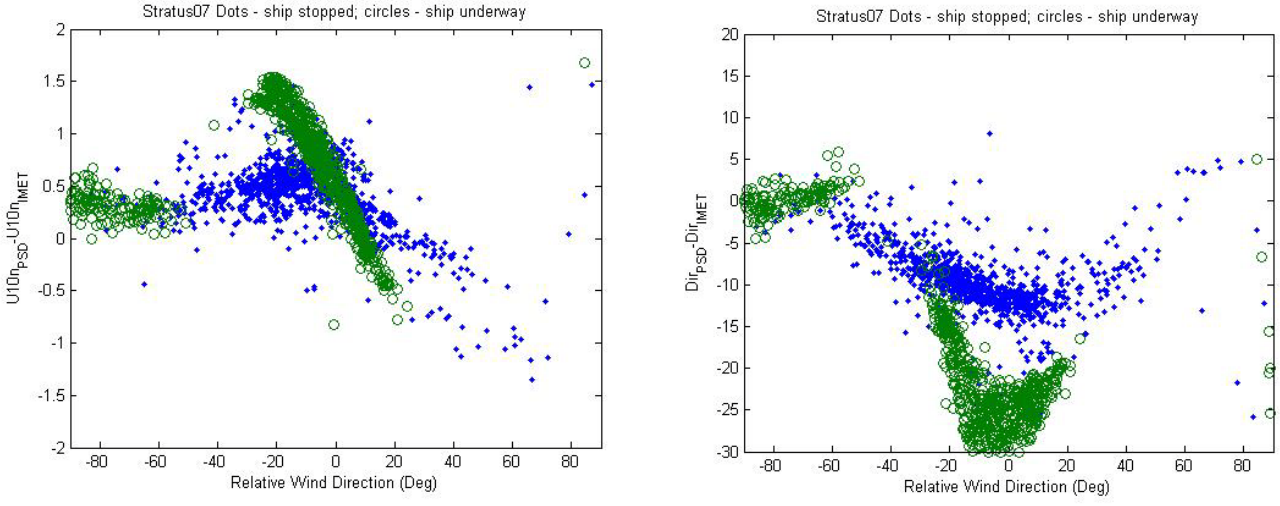

Figure 2. Difference between PSD and IMET wind sensors on VOCALS08: left panel - wind speed; right panel - wind direction. Here the height dependence of wind speed has been removed.

*The flux time series for VOCALS is similar to previous cruises to this area. The three figures below show the time series for stress, sensible heat, and latent heat. The gap from 310 to 314 is a port call.

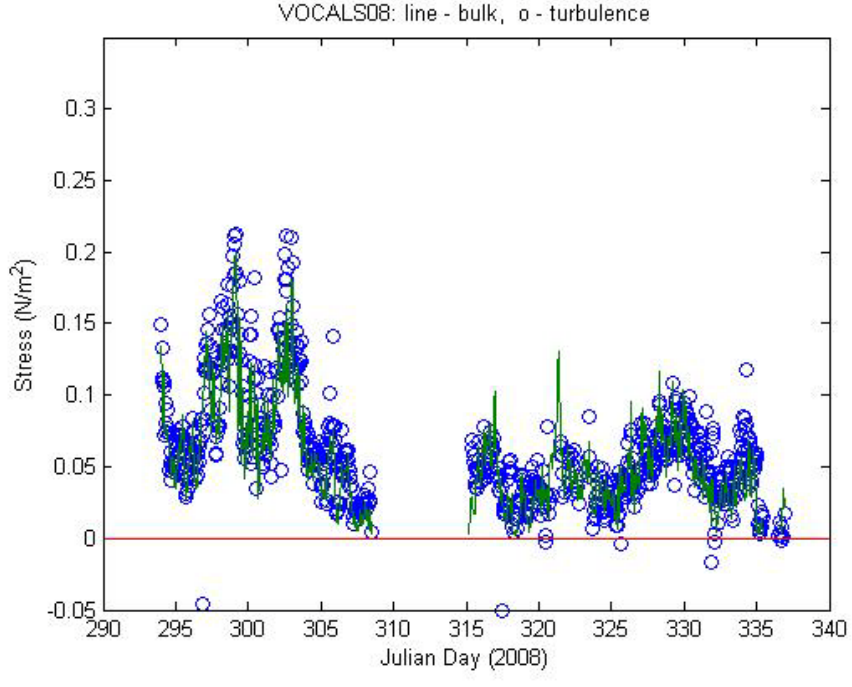

Figure 3. Time series of turbulent surface stress in VOCALS08: line - bulk estimate; circles - covariance/ID measurement.

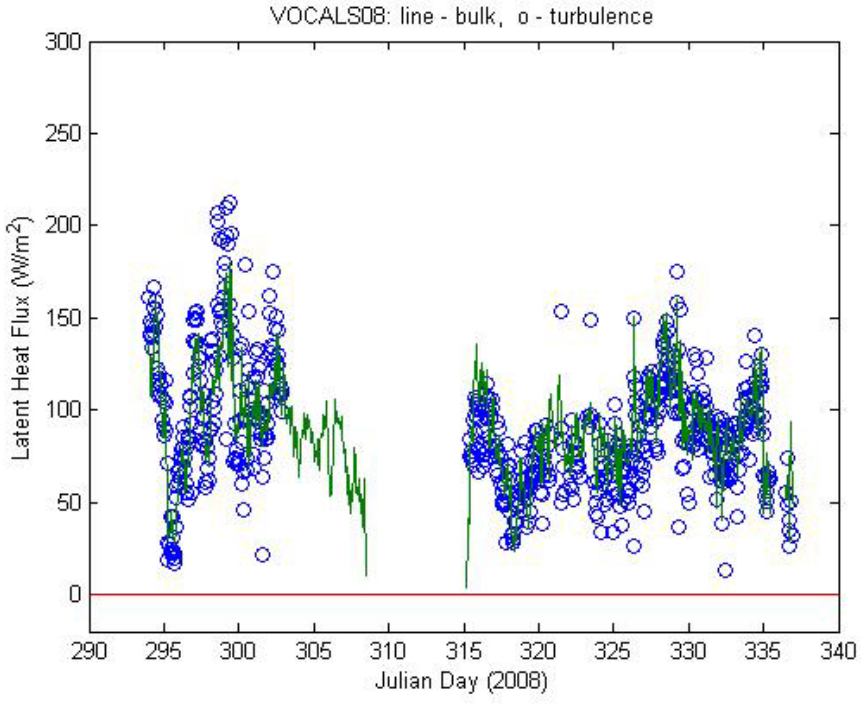

Figure 4. Time series of turbulent latent heat flux in VOCALS08: line - bulk estimate; circles - covariance/ID measurement.

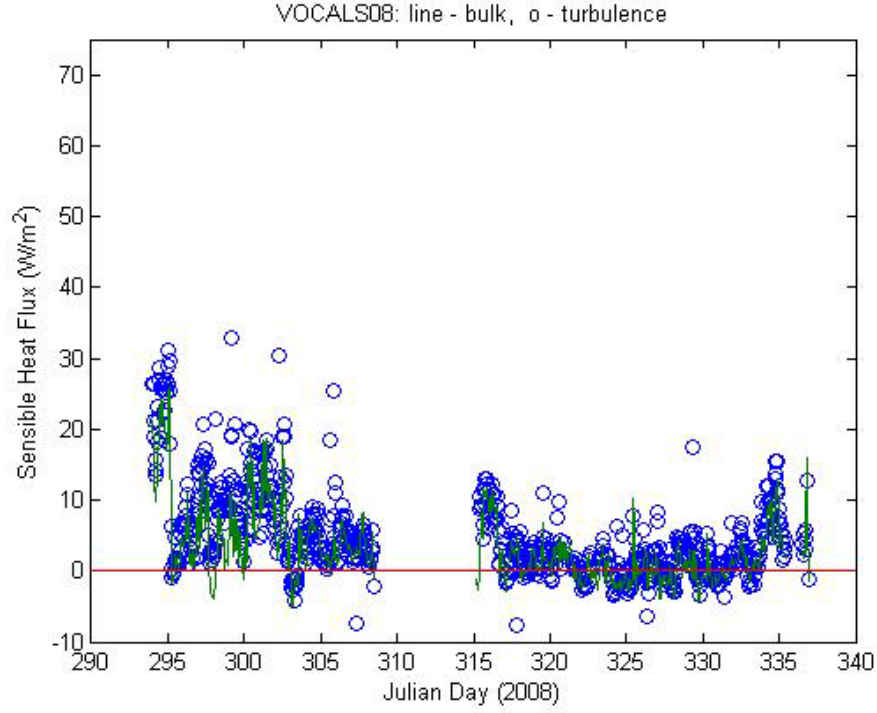

Figure 5. Time series of turbulent sensible heat flux in VOCALS08: line - bulk estimate; circles - covariance/ID measurement.