Direct/bulk fluxes from the 2011 STRATUS Cruise – Version 1

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August 5, 2011

This document is the Readme for *stratus2011_flux_10.txt* and *stratus2011_flux_hr.txt*. The *_hr* refers to hourly averages and the *_10* refers to the 10-minute averages. This is a version which can simply be loaded in MATLAB. Both direct (covariance) and inertial-dissipation (ID) turbulent flux calculations are included in this present data. The period covered is DOY 91 (April 01, 2011) through DOY 106 (April 16, 2011). The graph below gives the ship track for the data period.

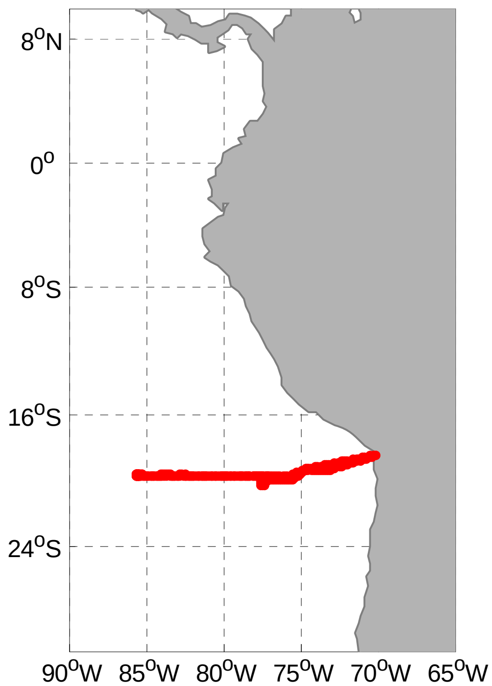

Figure 1. Track of R/V MoanaWave during STRATUS2011

The turbulent flux system was mounted on a portable tower just behind the ship's jack staff, as seen on Figure 2. Reference heights (with respect to water line) and sampling rates of the sensors used in the STRATUS2011 experiment can be found in table 1. More pictures of the instruments and setup can be found under ftp://ftp1.esrl.noaa.gov/psd3/cruises/STRATUS_2011/MoanaWave/Pictures/

Figure 2. Views of the jackstaff and the PSD flux tower deployed on the R/V Moana Wave during STRATUS 2011.

Sensor	Sampling rate	Height (m)
Bow sonic	10 Hz	15
Motion Pack	10 Hz	14.2
ORG	0.1Hz, averaged to 1 sample/min	12.3
T/RH	0.1Hz, averaged to 1 sample/min	12.8
Licor (CO2&H2O)	10 Hz	13.4
Radiometers (top wheelhouse)	0.1Hz, averaged to 1 sample/min	10.7
Radiometers (2nd deck)	0.1Hz, averaged to 1 sample/min	8.9
Barometer	0.1Hz, averaged to 1 sample/min	9.8
SST	0.1Hz, averaged to 1 sample/min	-0.05 to -0.10

Table 1. PSD sensor heights and sampling rates.

1) Column assignment for *stratus2011_flux_10.txt and stratus2011_flux_hr.txt* files

The files are 54 columns:
• First column is the decimal day-of-year 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. As no data from the ship were available, these variables were setup to Not-a-Number (NaN)
• Columns 49 to 53 are data computed from the LICOR-7500 open path IR sensor.
• Column 54 is the atmospheric pressure

The files can be directly acquired with a MATLAB 'load' statement. For instance:

```
x=load('your_local_directory\ stratus2011_flux_10.txt');%read file with 10-min average data; set your local directory.
```

The columns assignment is as follows:

```
jdy=x(:,1);%day-of-year at beginning of time average
ushp=x(:,2);%doppler log, SCS (m/s) →not available
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, PSD GPS
tsnk=x(:,8);%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_psd=x(:,36);%height of mean wind sensor, 14.2 m
zt_psd=x(:,37);%height of mean air temperature sensor, 12.8 m
zq_psd=x(:,38);%height of mean air humidity sensor, 12.8 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)
sgC_lic=x(:,53);%Standard deviation of CO2 concentration from LICOR
(microatm)
press=x(:,54); %Atmospheric pressure (mb)
```

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.

• 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 shows that tilt greater than about 10 deg give questionable fluxes.

2) Time series

Figures 3, 4 and 5 show the time series for stress, sensible heat, and latent heat for that cruise.

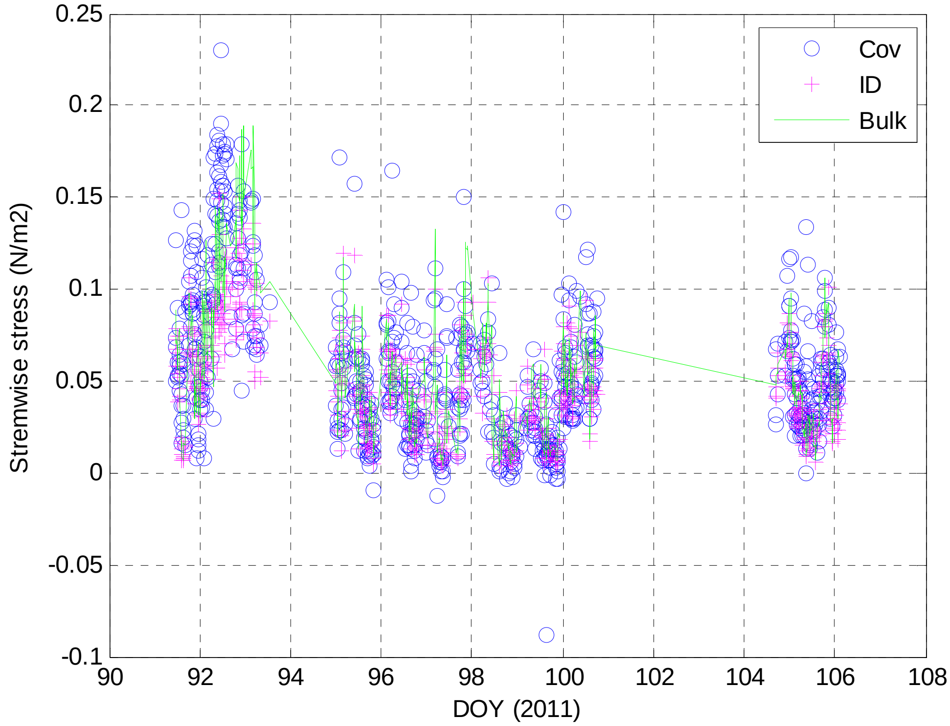

Figure 3. Time series of turbulent surface stress in STRATUS2011: green line - bulk estimate; magenta '+' - ID; blue circles - covariance measurement.

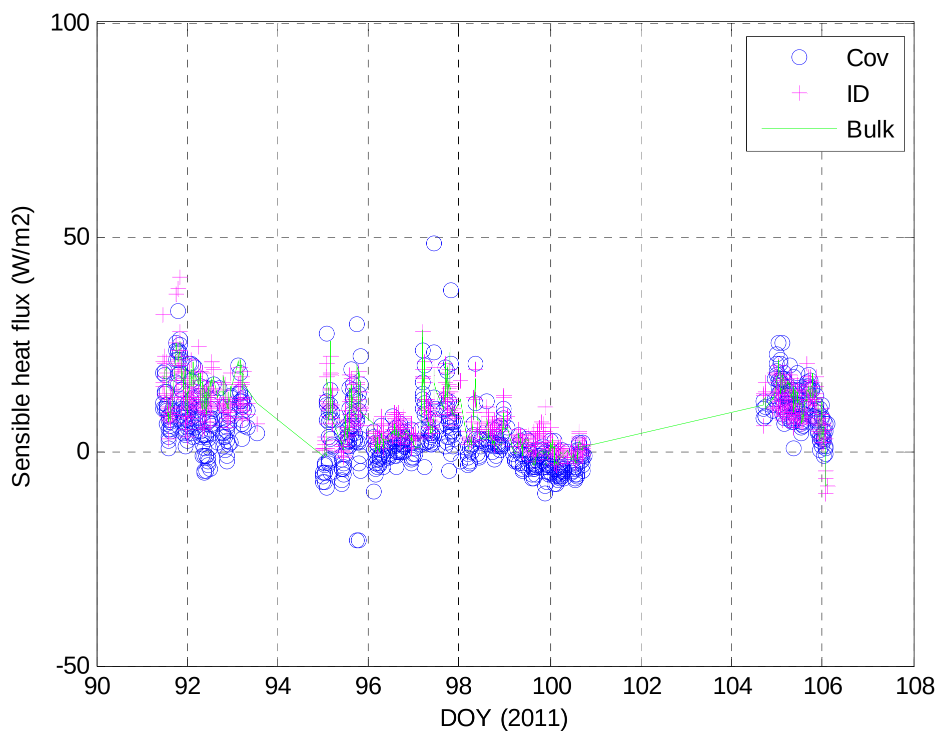

Figure 4. Time series of sensible heat flux in STRATUS2011: green line - bulk estimate; magenta '+' - ID; blue circles - covariance measurement.

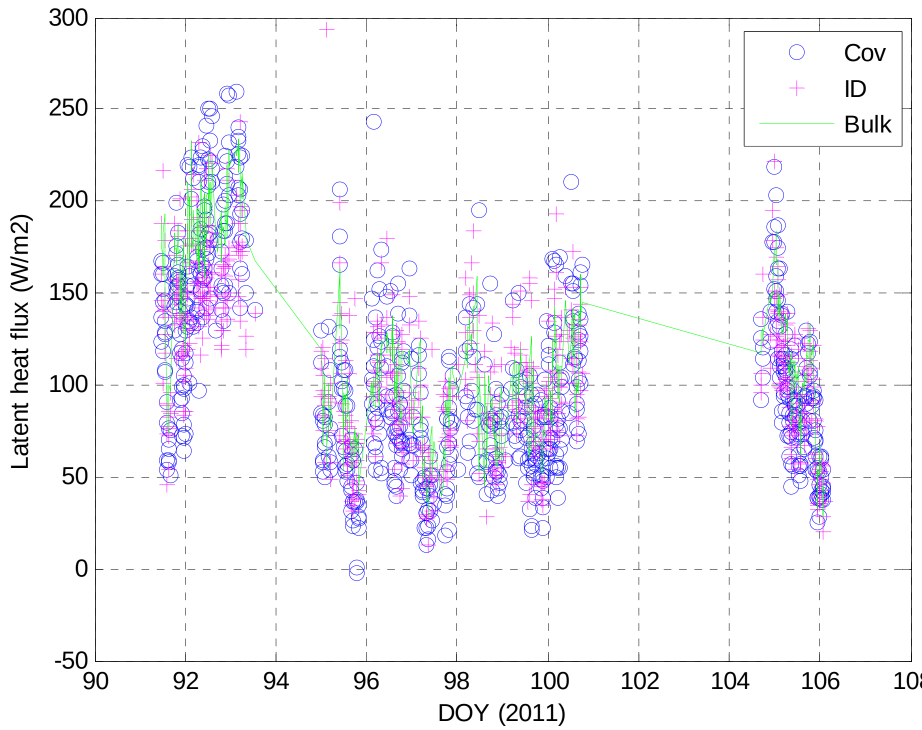

Figure 5. Time series of latent heat flux in STRATUS2011: green line - bulk estimate; magenta '+' - ID; blue circles - covariance measurement.

3) <u>Comparison with Buoy and WHOI met system</u>

During the cruise, an intercomparison was done between the different instruments onboard the ship and the newly deployed STRATUS buoy. Plots made available by Nan Galbraith are displayed below, figures 6 to 9.

Some of the variables were adjusted from this comparison:

- the seasnake measured about 0.2 ° C higher than the buoy.
- the relative humidity read about 5% lower when compare to the buoy and WHOI sensor
- the barometric pressure is about 1mb lower than the WHOI system.

Other variables such as air temperature, shortwave and longwave flux were not modified.

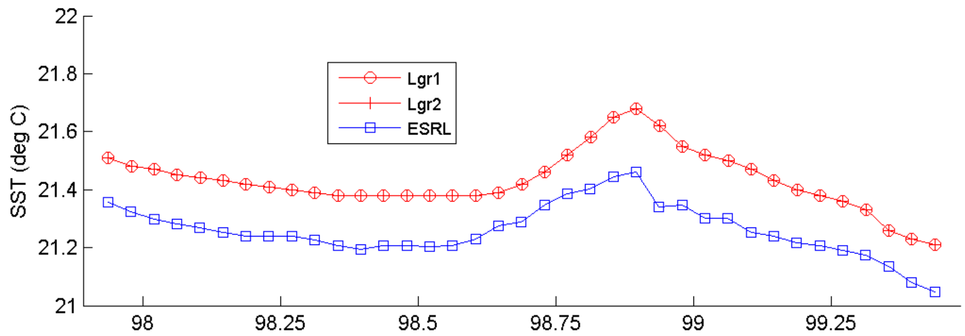

Figure 6. Comparison plots of SST between PSD (blue) and the buoy (red).

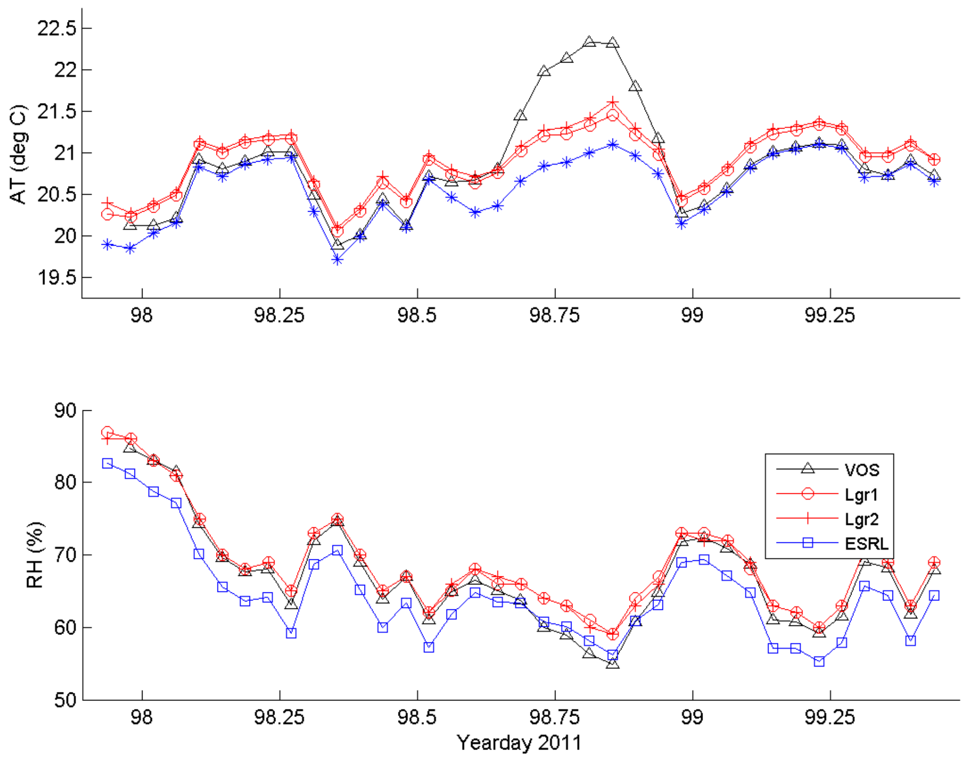

Figure 7. Comparison plots of T/RH between PSD (blue), the buoy (red) and the WHOI system (black)

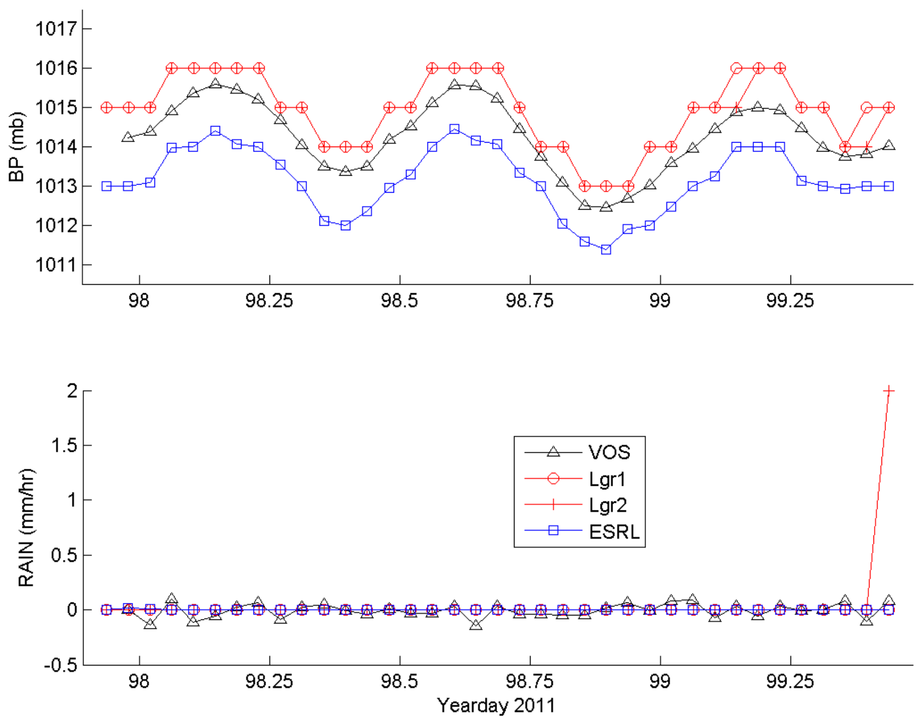

Figure 8. Comparison plots of rain and barometric pressure between PSD (blue), the buoy (red) and the WHOI system (black)

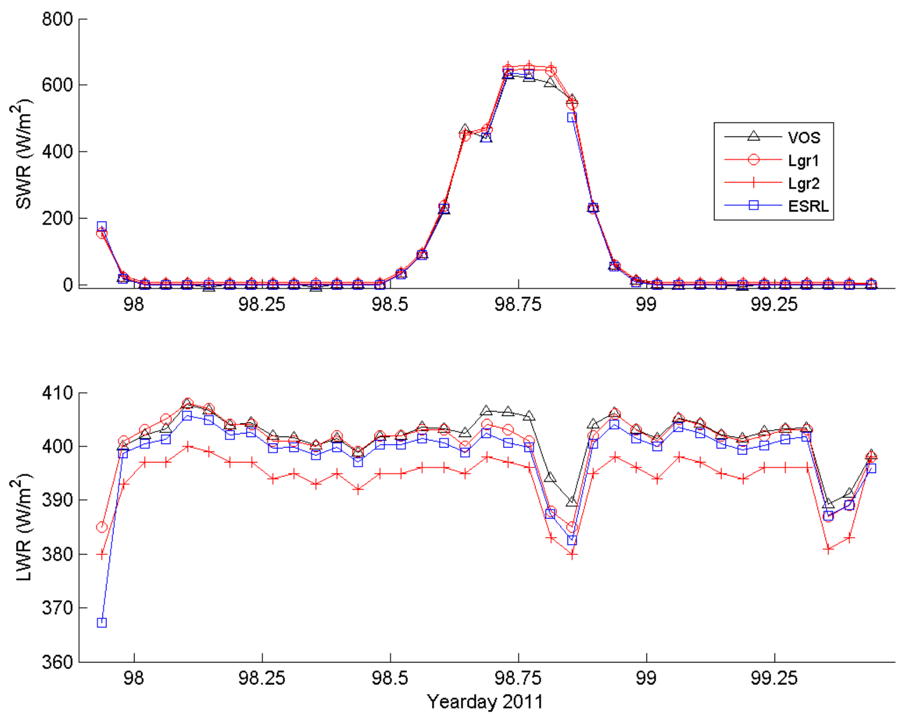

Figure 9. Comparison plots of shortwave and longwave measurements between PSD (blue), the buoy (red) and the WHOI system (black)