Description of preliminary bulk fluxes from NOAA ESRL/PSD Observations:
CALWATER2 Daily flux summary files
Version 3

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NOAA PSD deployed and operated the seagoing air-sea flux and near-surface meteorology system on the NOAA ship Ronald H. Brown for 30 days (Jan 14 – Feb 12, 20215). The instruments are listed in Table 1. Most meteorology sensors are on the jackstaff for best exposure to undistorted flow (Fig. 1). The downward IR and Solar flux sensors were on 02 deck forward (Fig. 2). The seasnake SST sensor (not shown) was towed through the water from a boom off the port side.

Table I PSD sensor heights and sampling rates.

Sensor	Sampling rate	Height (m)
Bow sonic	10 Hz	17.75
Motion Pack	10 Hz	16.95
Riegl Laser wave ht sensor	10 Hz	17.0
ORG	0.1Hz, averaged to 1 sample/min	16.5
T/RH	0.1Hz, averaged to 1 sample/min	15.6
Licor7500 (CO2&H2O)	10 Hz	17.2
Radiometers	0.1Hz, averaged to 1 sample/min	12.6
Barometer	0.1Hz, averaged to 1 sample/min	10.6
SST	0.1Hz, averaged to 1 sample/min	-0.05 to -0.10

The ship departed Honolulu and Jan 14 and proceeded NE (see Fig. 3). Shortly after passing 30 N latitude, we turned due north and went to 38 N 140 W where we sat for 5 days near an atmospheric river (AR). On January 25 we headed due east and proceeded to 38 N 127 W. After less than a day, we moved to 38 N 124 W near Bodega Bay. On Jan 29-30 we were in port in San Francisco. After leaving San Francisco, we took a station at 37 N 127 W and remained there through February 7. We then departed and headed to port in San Diego.

The PSD data have been processed with our standard field processing software (see description below). Summaries of the meteorological time series (Fig. 4), the flux time series (Fig. 5), and the rainfall time series (Fig. 6) are shown.

Figure 1. PSD flux instruments on the RHB jackstaff.

Figure 2. PSD PIR and PSP radiative flux sensors on 02 deck.

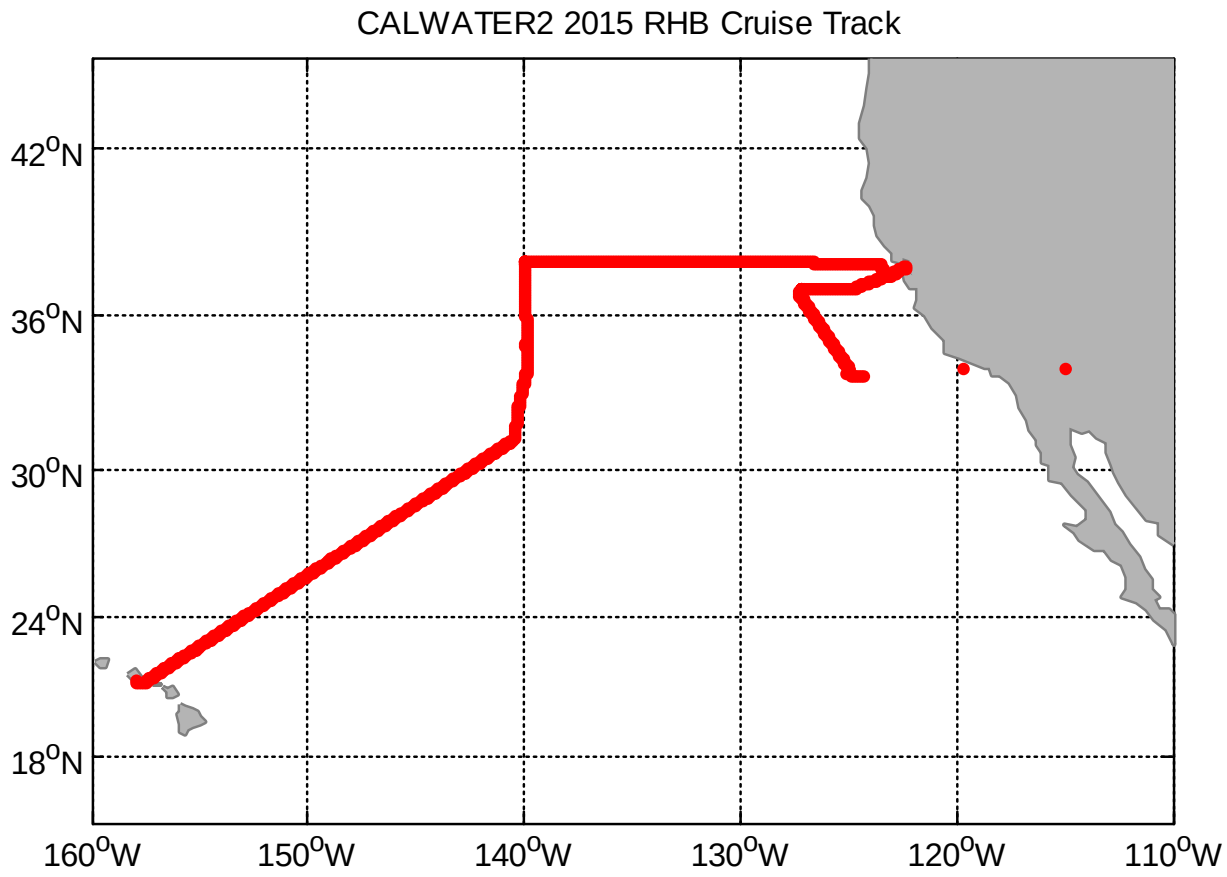

Figure 3. RHB cruise track for CALWATER2.

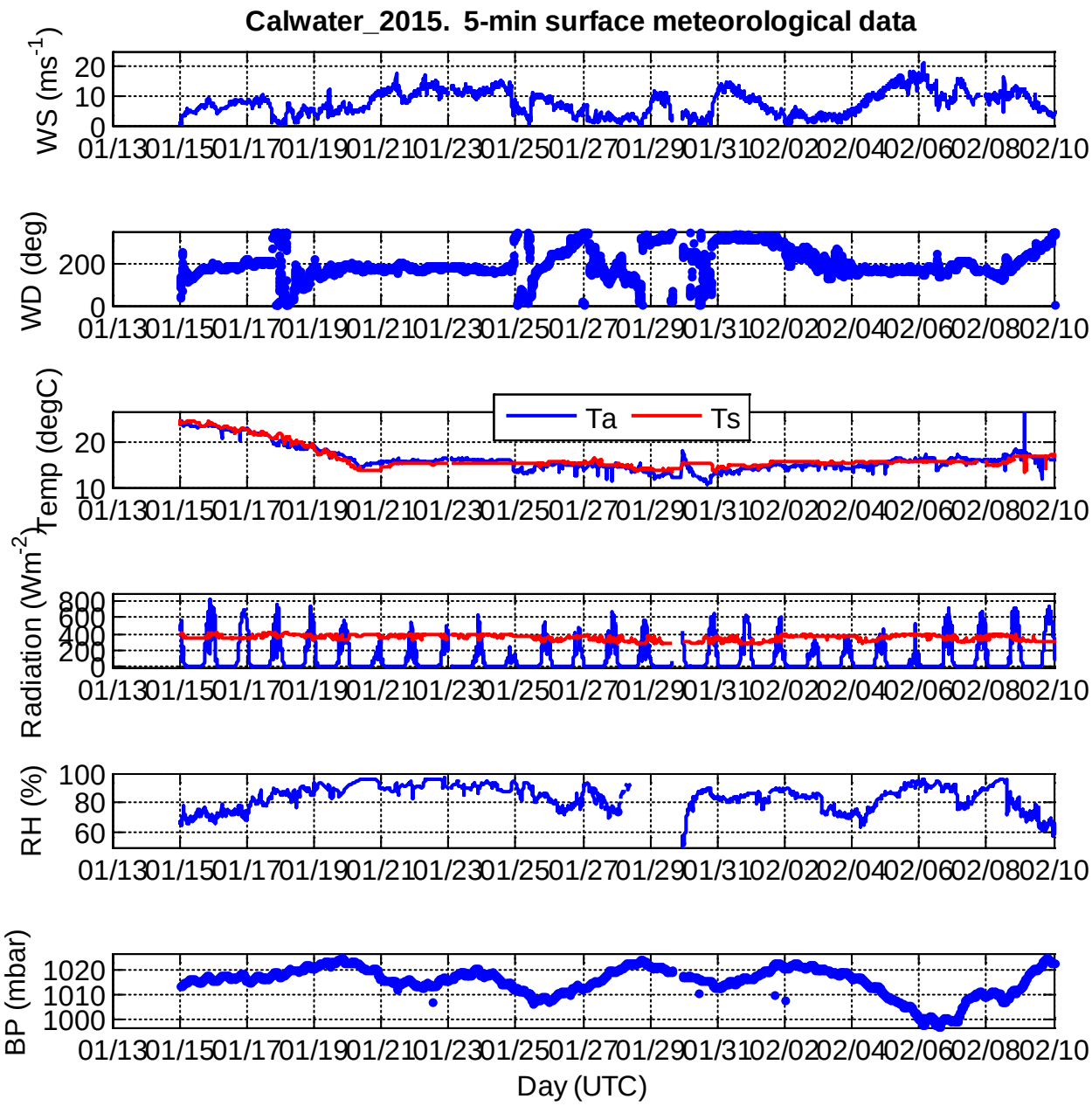

Figure 4. Mean near-surface meteorology time series for CALWATER2: Wind speed (WS), wind direction (WD), air temperature (Temp), IR and Solar radiative fluxes, relative humidity (RH), and barometric pressure (BP).

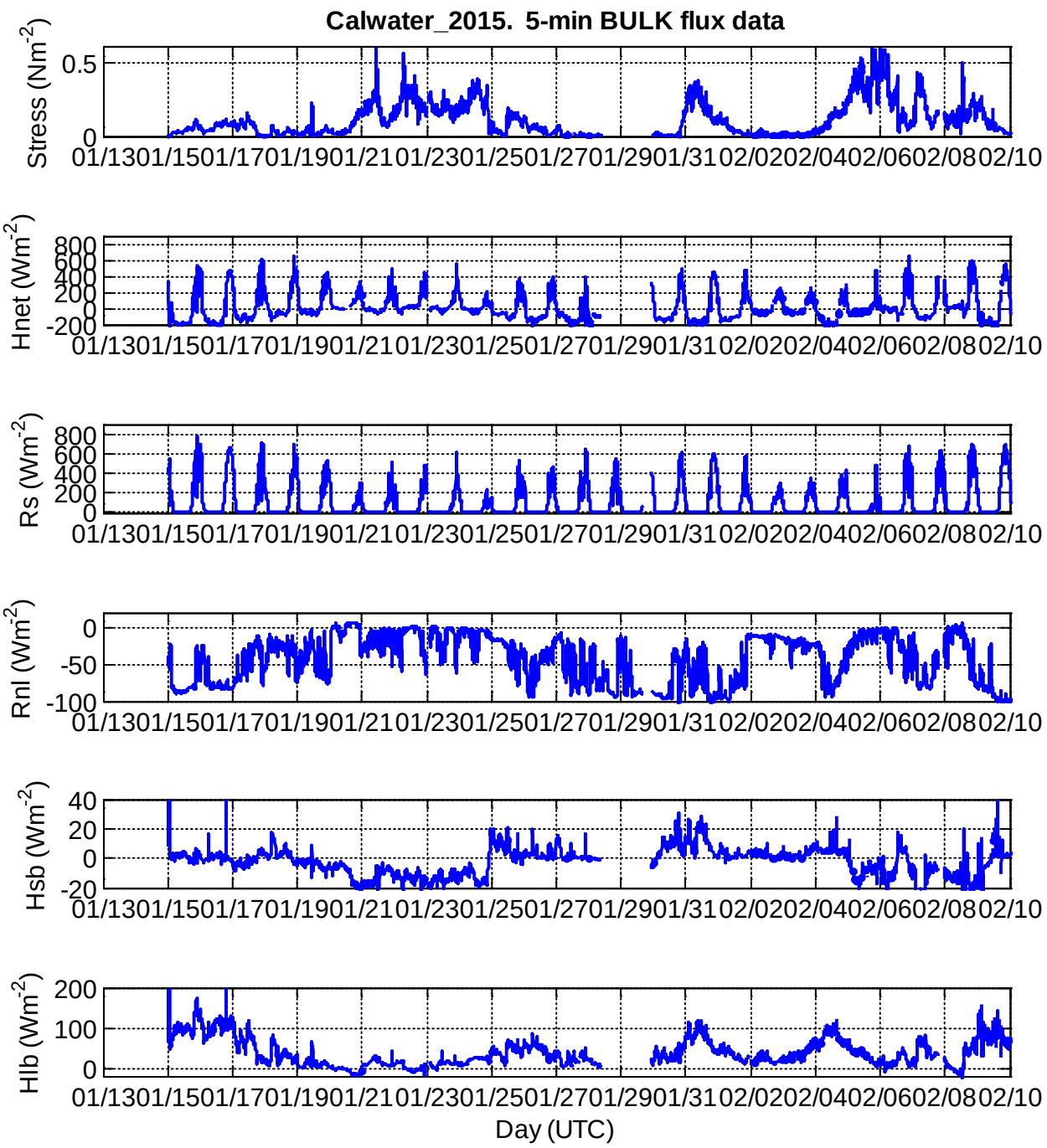

Figure 5. Mean near-surface air-sea flux time series for CALWATER2: wind stress, net heat flux (Hnet), downward solar flux (Rs), net IR flux (Rnl), sensible heat flux (Hsb), and latent heat flux (Hlb).

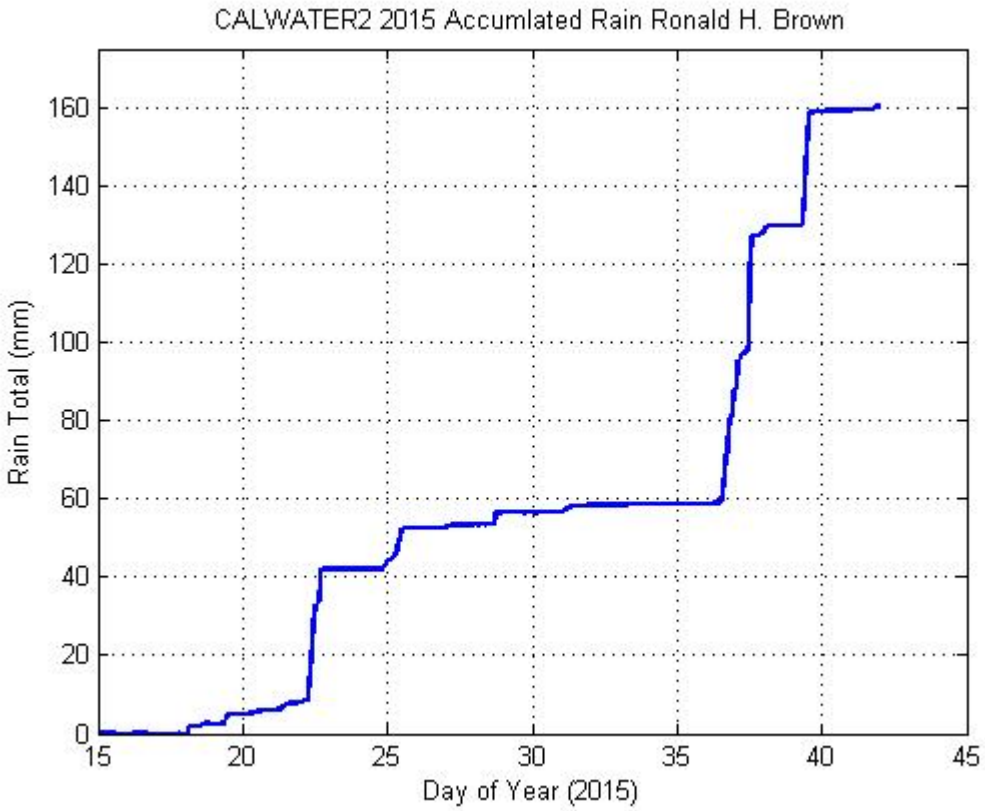

Figure 6. Time series of accumulated rainfall for CALWATER2. This time series is the consensus mean from six rain gauges.

The data files `CALWATER_2015_PSD_flux_5min_allcruise3.txt` and `CALWATER_2015_PSD_flux_5min_allcruise3.mat` contain 5-minute averages of bulk meteorological variables and fluxes computed from the PSD shipborne system aboard the R/V *RHB*, based on preliminary analysis of observations made during the CALWATER2 cruise in the NE Pacific Ocean. Most quantities given are subject to future modification based on accounting for other sources of data and revised calibrations. No direct turbulent flux calculations are included in this present data.

The files are 34 columns and 7776 (5-min) lines covering the Julian year-day 15.000 (000 on Jan. 1, 2015, JJJ=1.000) through Year-day 42.9965. The data columns are not labeled so they can be directly acquired with formatted read statements or with the following MATLAB `load` statement:

```
x=load('path\ CLAWATER_2015_PSD_flux_5min_allcruise2.txt');%read file with 5-min average data; set path
```

The columns are as follows:

```
jdy=x(:,1);%julian day at beginning of time average
U=x(:,2);%true wind,PSD sonic (m/s)
dir=x(:,3);%true wind direction, PSD sonic (deg)
tsnk=x(:,4);%sea snake temperature,PSD, 0.05 m depth (C)
tsg=x(:,5);%tsg water temperature, 5 m depth, (C)
sal=x(:,6);%tsg salinity (psu)
ta=x(:,7);%air temperature, PSD (C)
qse=x(:,8);%sea surface specific humidity,from snake (g/kg)
qa=x(:,9);%air specific humidity, PSD (g/kg)
psp=x(:,10)*1.01;%downward solar flux, PSD units (W/m^2)
rl=x(:,11);%downward IR flux,  PSD units (W/m^2)
org1=x(:,12);%rainrate, PSD STI optical rain gauge, uncorrected (mm/hr)
ushp=x(:,13);%doppler log, SCS (m/s)
head=x(:,14);%ship heading, deg clockwise rel north, SCS laser ring gyro (deg)
urel=x(:,15);%relative wind speed, PSD (m/s)
reldir=x(:,16);%relative wind direction (from),clockwise rel ship's bow, PSD sonic (deg)
lat=x(:,17);%latitude, deg  (SCS pcode)
lon=x(:,18);%longitude, deg (SCS pcode)
zts=x(:,19);%depth for bulk flux Ts reference, =0.05 when snake is used
sig_u=x(:,20);%std dev of ship speed, m/s (>.2 indicates maneuver during half hour average)
taub=x(:,21);%bulk wind stress along mean wind, (N/m^2)
hsb=x(:,22);%bulk sensible heat flux, (W/m^2)
hlb=x(:,23);%bulk latent heat flux, W/m^2 (includes Webb et al. correction)
hrain=x(:,24);%rain heat flux, as per Gosnell et al 1995, JGR, 18437-18442, (W/m^2)
ta_im=x(:,25);%ship IMET air temp @21 m (degree C)
qa_im=x(:,26);%ship IMET air specific humidity (g/kg)
s_ship=x(:,27);%ship speed over ground (m/s)
dir_ship=x(:,28);%ship gyro heading (degrees)
psp_ship=x(:,29);%ship IMET pyranometer (solar flux, W/m^2)
pir_ship=x(:,30);%ship IMET pirgeometer (IR flux, W/m^2)
barpress=x(:,31);%IMET barometric pressure (hPa)
```

```
RH=x(:,32);%PSD RHvais, %
press_im=x(:,33);%Barometeric pressure (mb) from the ship's system
rain_rhb=x(:,34);%Mean rainrate (mm/hr)averaged from 6 raingauges
```

The data in this file come from three sources: The PSD sonic anemometer (acquired at 10 Hz), the ships SCS system (acquired at 15 sec intervals), and the PSD mean measurement systems (sampled at 10 sec and averaged to 1 min). The sonic is 5 channels of data; the SCS file is 16 channels, and the PSD mean system is 44 channels. A series of programs are run that read these data files, decode them, and write daily text files at 1 min time resolution. A second set of programs reads the daily 1-min text files, synchronizes the three data sources, computes fluxes, averages them to 5 or 30 minutes, and writes these cruise-long files. The mean rainrate was computed as the average or 6 raingauges (see below).

Further experimental details are as follows:

True wind speed is computed from the sonic anemometer using the ship's GPS system; thus, it is interpreted as the speed relative to the fixed earth. Some modest flow distortion corrections have been used in an attempt to reduce the transitions when stopping for stations. The height for this measurement is 18.5 m.

SST is from the PSD seasnake, which measures within 0.1° C of the ship's TSG when there are no solar-flux induced heat gradients. The depths of the seasnake is about 5 cm; the depth of the TSG is 5 m.

Air temperature and humidity are derived from PSD (aspirated Vaisala HMP-235) at a height of 18 m. The PSD temperature sensor is calibrated to be accurate within 0.1° C. The ship's IMET temperature system agrees with the PSD system at night, but shows some modest solar warming during the day.

PSD Longwave and shortwave radiative fluxes are measured on an unstabilized platform. Longwave (LW) flux was obtained from 2 Eppley PIR units, logged and computed as per Fairall et al. *Jtech*, 1998. Ship LW unit reads within 5 W/m^2 of PSD but has some occasional artifacts and hints that it is solar contaminated (may not be dome temperature corrected).
Shortwave flux was obtained from 2 Eppley PSP units. Agreement with IMET system is fairly good. There is some shadowing (depending on ship heading) of the PSD system at low solar zenith angles.

The PSD STI optical raingauge (Model 705) was operational during the second leg of the cruise. There are some artifacts (about once per day) caused by the washing of sensors on the mast.

Air sea fluxes were computed using the COARE bulk algorithm version 3.0.

A mean rainrate was computed as the average or 6 raingauges. The bucket raingauge was corrected for undersampling associated with the horizontal relative wind. A mean rainrate time series was compute and a gain corrected for each gauge was determined. A new mean was computed by averaging the gain-corrected time series for all six gauges. The gauges are listed

below and the gain-correction for each gauge is given. A value of 1.71 means the gauge overestimates the rainrate by a factor of 1.71.

PSD STI ORG	Optical scintillation	G=1.71
RHB IMET	Weighing bucket	G=1.35
SCS WIMRA	A second STI ORG log on SCS	G=1.53
AMF Parcivel 1	Optical rain spectrometer	G=0.57
AMF Parcivel 2	Optical rain spectrometer	G=0.77
AMF Vaisala WXT520	Acoustic rain sensor	G=1.11

At each 5-min interval a standard deviation can be compute from the 5 individual gauges (there was at least one in-operative gauge at all times). This std was about 50% of the mean, so the statistical uncertainty of the mean at any given 5-min value is about 23 % - 50%/SQRT(5).
A sample 12-hr time series is shown below.

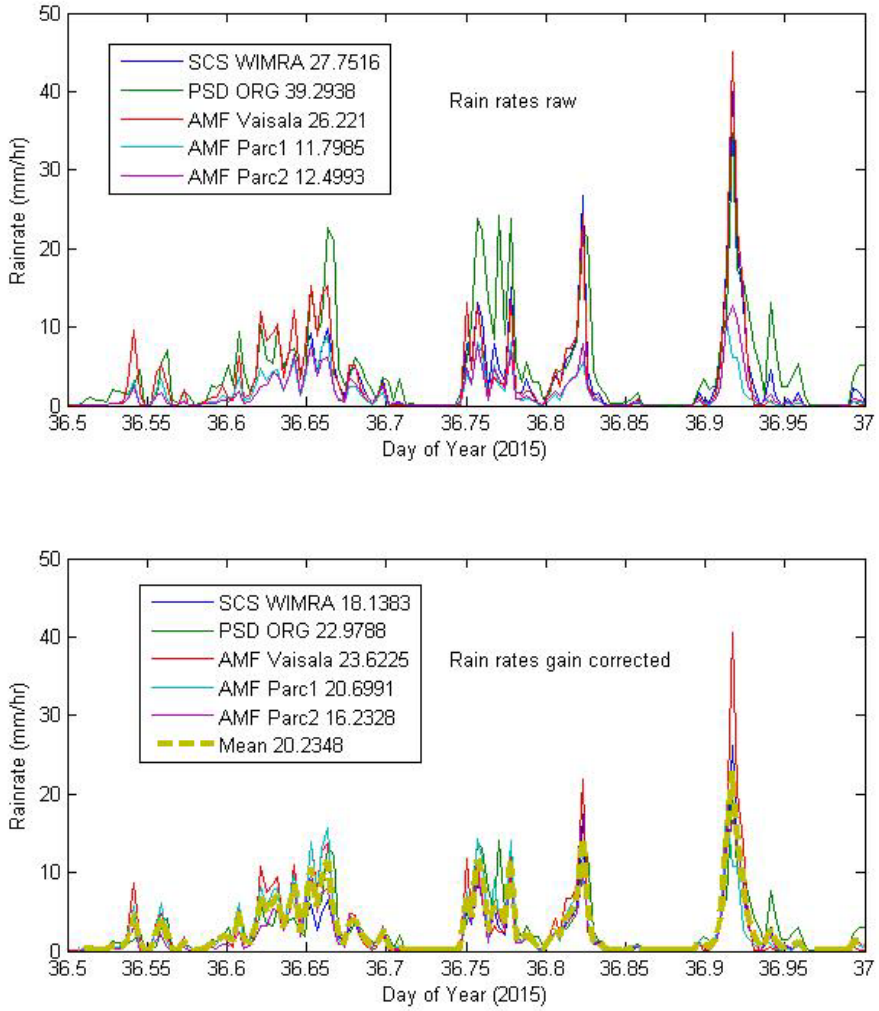

Figure 7. Time series of rain rate for 12 hours on Year day 36. Upper panel is raw rain rate from 5 gauges. The lower panel is the rain rate from the 5 gauges after gain correction. The heavy line is the mean of the 5 corrected gauges.