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## PRP2 PROCESS BASE TIME SERIES

### PURPOSE

The purpose of this document is to describe the base time series, e.g. shortwave and longwave irradiance, pitch, roll, etc., and outline the steps to derive clean averaged files with calibrated data.

### REQUIREMENTS

Before beginning this procedure you must complete the following initial procedures:

- m1220\_prp2\_data\_files:** Describes all necessary data files and support files.
- m1221\_prp\_proc\_setup:** Describes the folders and setup files needed before beginning.
- m1222\_prp\_proc\_software** Describes the Perl and Matlab programs and libraries.

### 1. MAKE THE DA0 FILE, level1/da0\_avg.txt

The "da0" file is a summary of all simple time series averaged files.

The level0 "avg" files are combined to create a single time series file in 'R' format. The 'R' format has a single header line that names each vector (column) of the space-separated text file. The left-most column is an index that identifies each record (row).

### Terminal session

The program starts by defining the different paths and files.

```
~/swmain/apps/prp2_proc/$ ./2_prp2_proc_da0_avg.pl /Volumes/hd11/
prp2/111001-1202_gan
---
INPUT DATA PATH = /Volumes/hd11/prp2/111001-1202_gan  EXISTS
SETUP FILE = /Volumes/hd11/prp2/111001-1202_gan/PrpProcessing_INFO.txt  EXISTS
--
DAT FILES START TIME = 2011-10-03 (276) 04:48:00
BASE TIME FROM 2011-10-03 (276) 04:48:00 TO 2012-02-09 (040) 16:10:00
```

Then it opens the GPSyyMMdd.dat daily average files in order and reads all data into an array.

```
--- GPS
OPEN DAT FILE /Volumes/hd11/prp2/111001-1202_gan/level0/gps111003.dat
OPEN DAT FILE /Volumes/hd11/prp2/111001-1202_gan/level0/gps111007.dat
...
OPEN DAT FILE /Volumes/hd11/prp2/111001-1202_gan/level0/gps120208.dat
OPEN DAT FILE /Volumes/hd11/prp2/111001-1202_gan/level0/gps120209.dat
GPS reads 93252 records, irec=49780
```

At the end of the GPS data it begins processing the TCM (tilt-compass) data.

```
--- TCM
OPEN DAT FILE /Volumes/hd11/prp2/111001-1202_gan/level0/tcm111003.dat
```

## m1223\_prp\_proc\_base\_timeseries

```
OPEN DAT FILE /Volumes/hd11/prp2/111001-1202_gan/level0/tcm111007.dat
...
OPEN DAT FILE /Volumes/hd11/prp2/111001-1202_gan/level0/tcm120208.dat
OPEN DAT FILE /Volumes/hd11/prp2/111001-1202_gan/level0/tcm120209.dat
TCM reads 93252 records, irec=49781
```

Followed by the RAD radiometer (PSP, PIR) files.

```
--- RAD
OPEN DAT FILE /Volumes/hd11/prp2/111001-1202_gan/level0/rad111003.dat
OPEN DAT FILE /Volumes/hd11/prp2/111001-1202_gan/level0/rad111007.dat
OPEN DAT FILE /Volumes/hd11/prp2/111001-1202_gan/level0/rad111010.dat
...
OPEN DAT FILE /Volumes/hd11/prp2/111001-1202_gan/level0/rad120208.dat
OPEN DAT FILE /Volumes/hd11/prp2/111001-1202_gan/level0/rad120209.dat
```

After the GPS, TCM, and RAD files are ingested the output file is created with all the DA0 data fields.

```
--- DERIVED
---
OUTPUT AVG FILE: /Volumes/hd11/prp2/111001-1202_gan/level1/da0_avg.txt
```

### **The output average file**

The “DA0” files is as described in the appendices below. This is a simple text file that can be easily read by a Matlab routine for quality assessment and for plotting. Matlab routines are discussed in a later memo.

The table below shows the sizes per day of the three files, GPS, RAD, and TCM. The TCM is sampled at 1 Hz while the others report every 10 sec. The PRP operation program computes averages in real time of the measurements. The averages are 2 minutes and all have a common time base (0,2,4,...58) minutes each hour. The time is centered in the average. For example the 00 minute record is an average of all data  $\geq$  minute 59 to  $<$  minute 1.

FILE	RAW (MB)	AVG (KB)
GPS (10 s)	0.81	50
RAD (10 s)	2.9	88
TCM (1 s)	8.2	133

## APPENDIX DA0 FILE DESCRIPTION

### The header line for DA0:

```
nrec yyyy MM dd hh mm ss lat lon saz sze sw swstd lw lwstd piru tcase tdome pitch
pstd roll rstd az sog cog hdg sol_n sol_d
```

### DA0 records

nrec	Record count.
yyyy MM dd hh mm ss	Record time stamp, UTC, middle of the average.
lat	Latitude, floating point, + for N. hemisphere, - for S. hemisphere.
lon	Longitude, f.p., + for E of Greenwich, - for W.
saz	Solar azimuth, deg east of true north.
sze	Solar zenith angle, deg from solar apex.
sw	Solar shortwave irradiance average from PSP, W/m <sup>2</sup> .
swstd	Standard deviation of shortwave, 10 sec samples, W/m <sup>2</sup> .
lw	Longwave (infrared) irradiance average, W/m <sup>2</sup> .
lwstd	Standard deviation of longwave, 10 sec samples, W/m <sup>2</sup> .
piru	Measured PIR thermopile average output, millivolts.
tcase	PIR case temperature average, degC.
tdome	PIR dome temperature average, degC.
pitch	Average platform pitch, + bow up, - bow down, deg.
pstd	Standard deviation of the pitch, 3 sec samples, deg.
roll	Average platform roll, + port up, - port down, deg.
rstd	Standard deviation of the roll, 3 sec samples, deg.
az	Azimuth average, from flux-gate compass, deg magnetic (note 1)
sog	Speed over ground from GPS, vector average, knots.
cog	Course over ground from GPS, vector average, deg True.
hdg	Heading, deg True. (note 2)
sol_n	Theoretical clear sky solar beam, direct normal, W/m <sup>2</sup> . (note 3)
sol_d	Theoretical clear sky diffuse irradiance, W/m <sup>2</sup> . (note 3)

### Note 1 -- Flux-gate compass issues.

The Precision Navigation Instruments (PNI) flux-gate compass is mounted on the FRSR plate and it used to measure the mean pitch, roll, and azimuth of the instrument. The mean pitch and roll are used to

correct the MFR head response for beam angle. The azimuth output is the compass direction of the plate, but like any compass is susceptible to error from nearby magnetic fields. In a moving platform such as a ship this reading might be accurate after a careful correction. However, since a ship is the equivalent of a 300 m bar magnet, the azimuth reading from the PNI is usually of no value.

What is required is an input from an external motion sensor such as the Kearfott SeaNav ring-laser gyro. For a fixed site the setup file allows user input of the alignment of the plate---which should be roughly north.

### **Note 2 -- Heading**

The heading (hdg) is the actual pointing of the plate reference relative to true north. For PRP data processing the heading is used for correcting the MFR head output for solar beam angle. The correction is weakly dependent on heading, so approximations to heading can be used with no loss in accuracy in the derived variables.

Heading is derived in the following ways:

- a. Fixed site                      Point the plate at a fixed direction (approximately North) and record the direction in the setup file. This should be done at deployment, but can be changed during post processing.
- b. GPS COG                        The GPS provides a course over ground (cog) which is the vector direction of motion of the GPS antenna. In most cases this angle is very close to the actual pointing angle of the ship, the actual heading. If we have no navigation record, we can use COG.
- c. Navigation gyro                Most ships have a good inertial navigation system (INS) or modern ring-laser gyroscope. The SeaNav used by the AMF2 is an excellent motion system. The heading is a standard output from the gyro (they call it "yaw"). If the gyro data are available in real time it can be incorporated into the PRP data acquisition. For post processing the gyro yaw data must be sampled and averaged onto a common time base as the PRP.

### **Note 3 -- Theoretical clear sky solar irradiance**

Given the latitude, longitude, and time, the solar zenith angle and azimuth angle can be computed with a good ephemeris. If assumptions are made on the moisture and aerosol loading of the atmosphere, the diffuse and direct beam irradiances can be computed.

Clear sky variables are calculated using a parameterization technique from M. Iqbal ["Physical Climatology for Solar and Wind Energy", 1988, World Scientific, pp. 196-242.]. Inputs required are zenith angle, integrated water vapor ( $\text{g}/\text{cm}^2$ ) typically 5 for the tropics, surface pressure, aerosol optical thickness at 380 nm, aerosol optical thickness at 500 nm, ozone-layer thickness in cm(NTP).

The Iqbal algorithm computes direct-normal flux at surface, diffuse flux at surface, transmittance by Rayleigh scattering, transmittance by ozone, transmittance by uniformly mixed gases, transmittance by water vapor, and transmittance by aerosol.

We write the direct normal (sol\_n) and diffuse (sol\_d) fields to the DA0 file. These are very useful for diagnosing time problems or instrument failure.