NOAA P3 Flight Level Data: DYNAMO Legacy Collection

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1. Data Set Overview:

"The [NOAA P-3 and French Falcon] aircraft missions aimed to address three main science objectives of DYNAMO to better understand 1) multiscale convection–environment interactions, 2) water vapor variability and three dimensional (3D) dynamical and microphysical structure in convective cloud systems, and 3) air–sea fluxes and boundary layer structure in the MJO initiation over the Indian Ocean" [Chen et al., 2016].

This document describes the flight level data. Other NOAA P3 data in the DYNAMO Legacy Data Collection include: dropsondes, AXBTs (under oceanography data), and dual Doppler tail radar data for the convective modules.

Time period: 12 missions during 11 October – 13 December 2011

Physical location: The aircraft was based out of Diego Garcia (DGAR: 7.3°S, 72.4°E). The missions were conducted within the following geographical area: 14.5°S – 1.2°N, 69.8°E – 80.9°E. The P3 flew at an average altitude of 2 km and reached a maximum of around 8 km.

Data source: Data were collected with the P3 onboard navigation and data collection system.

Any web address references (i.e., additional documentation such as Project web site)

2. Instrument Description

Several instruments are used for the flight level data collection:

- Latitude, longitude, altitude, time, and horizontal wind (calculated) were recorded by the aircraft's navigational GPS and inertial navigation INE.
- Altitude was also determined using a radar altimeter and pressure altimeter.
- Pressure and temperature (derived) are from the Rosemount probe.
- Dewpoint is from the General Eastern probe.
- SST is derived from the AOC modified PRT-5 downward looking radiometer.

The datasets included here are from the "slow" data record at 1 Hz.

For more information, consult Friedman et al. [1982, 1984] and OFCM [2017].

Table of specifications ("Reconnaissance Requirements")

Parameter	Accuracy
Aircraft position	3 nautical miles (6 km)
Aircraft altitude	10 m
Horizontal Wind Speed	4 kts (2 m/s)
Horizontal wind direction	5 deg.
Pressure height	Below (above) 500 hPa, 10 m (20 m)
Air temperature and SST	1°C

[NOTE: Present weather reconnaissance capabilities do not completely satisfy these requirements; data will be collected as close to stated requirements as possible.]

3. Data Collection and Processing

The data were collected by the NOAA WP-3D (a.k.a. P3) "Miss Piggy" N43RF. Flight level data are collected centrally and recorded on tape by the main aircraft data system. Original data collected from the onboard data system have been modified as follows:

1) For days with multiple data files (e.g., the data record system was restarted in flight), the data have been concatenated into a single file using the "NetCDF Kitchen Sink" ncks, which is a part of the NetCDF Operators (NCO, http://nco.sourceforge.net).
2) The HHMMSS time_stamp, where HH is the hour of the day, MM is minutes, and SS is seconds, was converted into CF convention "Time," variable and data with missing time stamps removed, using Python.
3) Using ncks, variable names have been changed to reflect CF conventions, as specified in the following table:

DYNAMO Legacy Variable Name	Original Variable Name
lon_gps	LonGPS.1
lat_gps	LatGPS.1
altitude_gps	AltGPS.1
altitude_radar_altimeter	AltRa.1
altitude_press_altimeter	ALTPA.1
time_stamp	GPS_Fxtime.1
downward_radiometer_temperature	TRadD.1
wind_from_direction	WD.1
wind_speed	WS.1
potential_temperature	THETA.1
dew_point_temperature	TD.1
relative_humidity	HUM_REL.1
air_temperature	TA.1
geopotential_height	ALTGA.1
air_pressure	PS.1

4. Data Format

- The DATA are in CF compliant NetCDF format.
- There is one file for each day named **aircraft.dgar.p3.flightlevel.YYYYMMDD.nc**
- Where **YYYY** is the 4-digit year, **MM** is the two-digit month, and **DD** is the two-digit day.
- The data frequency is 1 Hz.

Below is a list of the parameters with units and attributes from ncdump:

```
variables:
        double Time(Time) ;
                Time:_FillValue = -999. ;
```

```
        Time:units = "Seconds since 2011-1-1 0:0:0" ;
double air_pressure(Time) ;
        air_pressure:_FillValue = -999. ;
        string air_pressure:Quantity = "PS" ;
        string air_pressure:Application = "" ;
        string air_pressure:Location = "" ;
        string air_pressure:Routine = "PSf" ;
        air_pressure:Tag = 515 ;
        air_pressure:Instance = 1 ;
        string air_pressure:units = "mb" ;
        string air_pressure:ParamName = "PS.1" ;
        string air_pressure:Description = "Static Pressure Corrected" ;
        air_pressure:Min = -10.f ;
        air_pressure:Max = 1100.f ;
double air_temperature(Time) ;
        air_temperature:_FillValue = -999. ;
        string air_temperature:Quantity = "TA" ;
        string air_temperature:Application = "" ;
        string air_temperature:Location = "" ;
        string air_temperature:Routine = "TA" ;
        air_temperature:Tag = 253 ;
        air_temperature:Instance = 1 ;
        string air_temperature:units = "C" ;
        string air_temperature:ParamName = "TA.1" ;
        string air_temperature:Description = "Ambient Temperature (C)" ;
        air_temperature:Min = -100.f ;
        air_temperature:Max = 100.f ;
double altitude_gps(Time) ;
        altitude_gps:_FillValue = -999. ;
        string altitude_gps:Quantity = "AltGPS" ;
        string altitude_gps:Application = "" ;
        string altitude_gps:Location = "" ;
        string altitude_gps:Routine = "xlM1553" ;
        altitude_gps:Tag = 54 ;
        altitude_gps:Instance = 1 ;
        string altitude_gps:units = "m" ;
        string altitude_gps:ParamName = "AltGPS.1" ;
        string altitude_gps:Description = "GPS ALTITUDE (MSL)" ;
        altitude_gps:Min = -39950.f ;
        altitude_gps:Max = 39950.f ;
double altitude_press_altimeter(Time) ;
        altitude_press_altimeter:_FillValue = -999. ;
        string altitude_press_altimeter:Quantity = "ALTPA" ;
        string altitude_press_altimeter:Application = "" ;
        string altitude_press_altimeter:Location = "" ;
        string altitude_press_altimeter:Routine = "ALTPAf" ;
        altitude_press_altimeter:Tag = 216 ;
        altitude_press_altimeter:Instance = 1 ;
        string altitude_press_altimeter:units = "m" ;
        string altitude_press_altimeter:ParamName = "ALTPA.1" ;
        string altitude_press_altimeter:Description = "Pressure Altitude" ;
        altitude_press_altimeter:Min = 0.f ;
        altitude_press_altimeter:Max = 15240.f ;
double altitude_radar_altimeter(Time) ;
        altitude_radar_altimeter:_FillValue = -999. ;
        string altitude_radar_altimeter:Quantity = "AltRa" ;
        string altitude_radar_altimeter:Application = "" ;
        string altitude_radar_altimeter:Location = "" ;
        string altitude_radar_altimeter:Routine = "xlM1553" ;
        altitude_radar_altimeter:Tag = 52 ;
        altitude_radar_altimeter:Instance = 1 ;
        string altitude_radar_altimeter:units = "m" ;
        string altitude_radar_altimeter:ParamName = "AltRa.1" ;
```

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                string altitude_radar_altimeter:Description = "RADAR ALTIMETER" ;
                altitude_radar_altimeter:Min = 0.f ;
                altitude_radar_altimeter:Max = 15240.f ;
        double dew_point_temperature(Time) ;
                dew_point_temperature:_FillValue = -999. ;
                string dew_point_temperature:Quantity = "TD" ;
                string dew_point_temperature:Application = "" ;
                string dew_point_temperature:Location = "" ;
                string dew_point_temperature:Routine = "TD" ;
                dew_point_temperature:Tag = 210 ;
                dew_point_temperature:Instance = 1 ;
                string dew_point_temperature:units = "C" ;
                string dew_point_temperature:ParamName = "TD.1" ;
                string dew_point_temperature:Description = "AOC dew point" ;
                dew_point_temperature:Min = -100.f ;
                dew_point_temperature:Max = 100.f ;
        double downward_radiometer_temperature(Time) ;
                downward_radiometer_temperature:_FillValue = -999. ;
                string downward_radiometer_temperature:Quantity = "TRadD" ;
                string downward_radiometer_temperature:Application = "" ;
                string downward_radiometer_temperature:Location = "" ;
                string downward_radiometer_temperature:Routine = "xlAnalog" ;
                downward_radiometer_temperature:Tag = 87 ;
                downward_radiometer_temperature:Instance = 1 ;
                string downward_radiometer_temperature:units = "C" ;
                string downward_radiometer_temperature:ParamName = "TRadD.1" ;
                string downward_radiometer_temperature:Description = "Radiometer Down"
;
                downward_radiometer_temperature:Min = -100.f ;
                downward_radiometer_temperature:Max = 40.f ;
        double geopotential_height(Time) ;
                geopotential_height:_FillValue = -999. ;
                string geopotential_height:Quantity = "ALTGA" ;
                string geopotential_height:Application = "" ;
                string geopotential_height:Location = "" ;
                string geopotential_height:Routine = "ALTGA" ;
                geopotential_height:Tag = 144 ;
                geopotential_height:Instance = 1 ;
                string geopotential_height:units = "m" ;
                string geopotential_height:ParamName = "ALTGA.1" ;
                string geopotential_height:Description = "Geopotential Altitude" ;
                geopotential_height:Min = 0.f ;
                geopotential_height:Max = 15240.f ;
        double lat_gps(Time) ;
                lat_gps:_FillValue = -999. ;
                string lat_gps:Quantity = "LatGPS" ;
                string lat_gps:Application = "" ;
                string lat_gps:Location = "" ;
                string lat_gps:Routine = "xlM1553" ;
                lat_gps:Tag = 33 ;
                lat_gps:Instance = 1 ;
                string lat_gps:units = "deg" ;
                string lat_gps:ParamName = "LatGPS.1" ;
                string lat_gps:Description = "LATITUDE GPS" ;
                lat_gps:Min = -90.f ;
                lat_gps:Max = 90.f ;
        double lon_gps(Time) ;
                lon_gps:_FillValue = -999. ;
                string lon_gps:Quantity = "LonGPS" ;
                string lon_gps:Application = "" ;
                string lon_gps:Location = "" ;
                string lon_gps:Routine = "xlM1553" ;
                lon_gps:Tag = 29 ;
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```
        lon_gps:Instance = 1 ;
        string lon_gps:units = "deg" ;
        string lon_gps:ParamName = "LonGPS.1" ;
        string lon_gps:Description = "LONGITUDE GPS" ;
        lon_gps:Min = -180.f ;
        lon_gps:Max = 180.f ;
double potential_temperature(Time) ;
        potential_temperature:_FillValue = -999. ;
        string potential_temperature:Quantity = "THETA" ;
        string potential_temperature:Application = "" ;
        string potential_temperature:Location = "" ;
        string potential_temperature:Routine = "THETA" ;
        potential_temperature:Tag = 267 ;
        potential_temperature:Instance = 1 ;
        string potential_temperature:units = "K" ;
        string potential_temperature:ParamName = "THETA.1" ;
        string potential_temperature:Description = "Potential Temperature" ;
        potential_temperature:Min = 0.f ;
        potential_temperature:Max = 374.f ;
double relative_humidity(Time) ;
        relative_humidity:_FillValue = -999. ;
        string relative_humidity:Quantity = "HUM_REL" ;
        string relative_humidity:Application = "" ;
        string relative_humidity:Location = "" ;
        string relative_humidity:Routine = "HUMREL" ;
        relative_humidity:Tag = 272 ;
        relative_humidity:Instance = 1 ;
        string relative_humidity:units = "%" ;
        string relative_humidity:ParamName = "HUM_REL.1" ;
        string relative_humidity:Description = "Relative Humidity" ;
        relative_humidity:Min = 0.f ;
        relative_humidity:Max = 200.f ;
double time_stamp(Time) ;
        time_stamp:_FillValue = -999. ;
        string time_stamp:Quantity = "GPS_Fxtime" ;
        string time_stamp:Application = "" ;
        string time_stamp:Location = "" ;
        string time_stamp:Routine = "NovatelTm" ;
        time_stamp:Tag = 366 ;
        time_stamp:Instance = 1 ;
        string time_stamp:units = "N/A" ;
        string time_stamp:ParamName = "GPS_Fxtime.1" ;
        string time_stamp:Description = "Novatel GPS Time of Fix" ;
        time_stamp:Min = 0.f ;
        time_stamp:Max = 0.f ;
double wind_from_direction(Time) ;
        wind_from_direction:_FillValue = -999. ;
        string wind_from_direction:Quantity = "WD" ;
        string wind_from_direction:Application = "" ;
        string wind_from_direction:Location = "" ;
        string wind_from_direction:Routine = "WD" ;
        wind_from_direction:Tag = 286 ;
        wind_from_direction:Instance = 1 ;
        string wind_from_direction:units = "deg" ;
        string wind_from_direction:ParamName = "WD.1" ;
        string wind_from_direction:Description = "Wind Direction" ;
        wind_from_direction:Min = 0.f ;
        wind_from_direction:Max = 360.f ;
double wind_speed(Time) ;
        wind_speed:_FillValue = -999. ;
        string wind_speed:Quantity = "WS" ;
        string wind_speed:Application = "" ;
        string wind_speed:Location = "" ;
```

```
string wind_speed:Routine = "WS" ;
wind_speed:Tag = 285 ;
wind_speed:Instance = 1 ;
string wind_speed:units = "m/s" ;
string wind_speed:ParamName = "WS.1" ;
string wind_speed:Description = "Wind Speed" ;
wind_speed:Min = -131.f ;
wind_speed:Max = 131.f ;
```

5. Data Remarks

The data have not gone through any quality control beyond what was done in the onboard data processing.

The data can be accessed using the myriad of software that is able to interact with NetCDF format files, including ncdump, ncview, Matlab, Python, IDL, and NCL. Consult the user help system within each software package.

The data can be accessed in most modern analysis software packages using OpenDAP, without physically downloading the file to your system. For example, in Matlab, to access the data from the Nov. 24 flight, the following can be used:

lon = ncread('http://dynamo.fl-ext.ucar.edu:8080/thredds/dodsC/p3/flightlevel/aircraft.dgar.p3.flightlevel.20111124.nc', 'lon_gps');

6. References

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OFCM, 2017: National Hurricane Operations Plan, 185 pp. [Available from Office of the Federal Coordinator for Meteorological Services and Supporting Research, Suite 1500, 8455 Colesville Rd., Silver Spring, MD 20910 and online at http://www.ofcm.gov/publications/nhop/FCM-P12-2017.pdf]