R/V *Roger Revelle* Flux, Near-Surface Meteorology, and Navigation Data

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1. Data Set Overview:

During DYNAMO, the R/V *Roger Revelle* was operated by Scripps Institution of Oceanography in the central and eastern Indian Ocean. The *Revelle* conducted four cruise legs, re-provisioning in Phuket, Thailand between legs. The DYNAMO moorings and sea glider were deployed during the first leg, and legs 2 and 3 were focuses on taking measurements near the station location, and the moorings were recovered during leg 4.

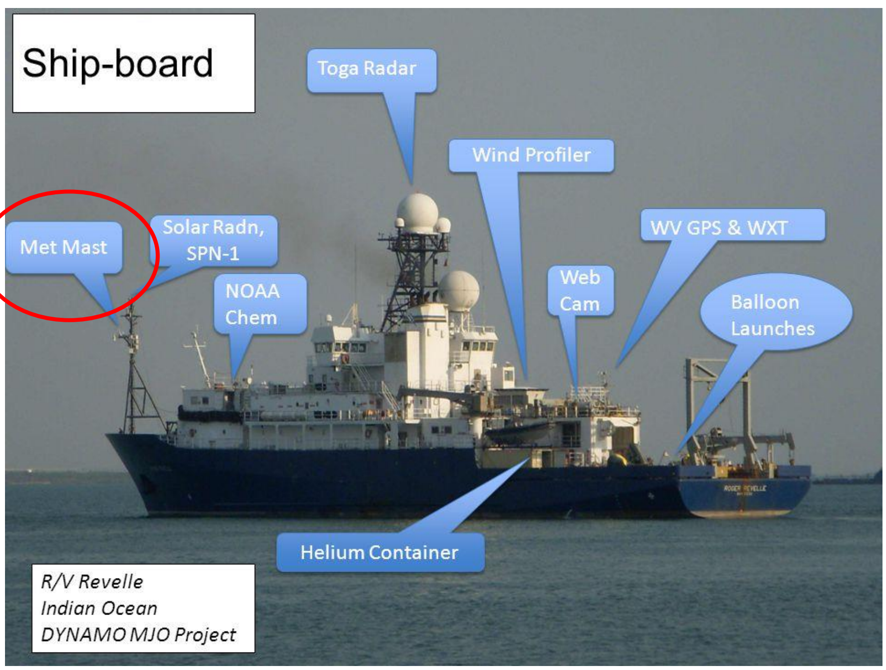
Time period: 3 September 2011 – 1 January 2012.

Physical location: The R/V Revelle spent most of the time near the station location of 0°N, 80.5°E.

Data source: The surface meteorological data, upper ocean temperature, and SST were measured using the standard ship suite of instruments. Air-sea fluxes were calculated using the COARE v3.0 algorithm.

2. Instrument Description

The R/V Revelle is equipped with an extensive standard suite of surface meteorological and upper ocean instruments.



Tair is taken from the calibrated PSD and UConn aspirated air temperature sensors on the bow mast ("Met Mast"). These were least affected by solar heating. Qair and Pair are computed the calibrated UConn RH/T/P sensors on the on the bow mast. Q is less sensitive to solar heating as long as the temperature and RH are measured simultaneously. RH is reconstructed from the Q, aspirated Tair and P measurements to remove the effects of solar heating.

The sonic anemometers on the bow mast are used to measure the wind speed and direction. Relative wind speed is taken into consideration to minimize flow distortion. Note: the provided winds are 10 m adjusted winds (from the mast height of ~27 m) using the COARE 3.0 algorithm.

Tsea is primarily measured by the sea snake with a few values provide by the IR radiometer deployed by LDEO. SST is estimated after correction for cool skin and this accounts for the difference between Tsea and SST. Similar corrections are applied to SSQ from Qsea.

Solardn is provided by the ship's pyranometer on the top of the forward mast. IRdn represents an average of the gyrostabilized PSD purgeometer on top of its van and the ship's purgeometer on the top of the forward mast. The ship's purgeometer was first corrected for the effects of solar heating. Solarup is taken from a commonly used parameterization for surface albedo of the ocean (Payne, 1972). IRup was derived from the SST measurements using the COARE 3.0 algorithm.

3. Data Collection and Processing

The original ascii data were obtained from Jim Muom at Oregon State University. The following notes were provided together with the data. The COARE 3.0 algorithm was also used to compute the 10-m values of wind speed, temperature and humidity. SOG, COG and Gyro were taken from the PSD GPS compass. These were used to compute the wind speed relative to earth. Surface currents are measured \nby the ship's ADCP and have been QCed by OSU Ocean Mixing group. These were used to compute the wind speed relative to water. The wind speed relative to water are used to compute the fluxes.

New calibrations were applied to the RH measurements from the UConn and\nETL sensors. The calibration raised the RH values 1-2%, which modifies slightly the flux estimates and any variables adjusted using MO similarity. Values of temperature, specific humidity and relative humidity adjusted to 2-m were added to the matlab and ASCII files.

07/23/13 New calibrations were applied to the RH/Tair measurements from the UConn and ETL sensors using Vaisala factory calibration and a RH/T calibration chamber at UConn. This results in small changes to the previous revision. The sea-snake measurements were reduced by 0.058 based on a comparison with the OSU T-chain SBE device.mThe TOGA-COARE warm layer correction is applied to the seasnake (causing a small increase during the day. The depth of the sea-snake was set to 5 cm.This value is then used to compute the fluxes using the TOGA-COARE 3.5 algorithm described by Edson et al., 2013: On the exchange of momentum over the open ocean," J. Phys. Oceanogr., 43, 1589-1610. Therefore, this value of Tsea can be used in the COARE algorithm without the need to run the warm layer code. However, the warm layer correction is saved in the matlab files for investigators that want to convert Tsea back to it measured value. This variable is called dsea in the matlab files and the measured value equals: Tsea_measured=Tsea-dsea.

Measurements of the sea temperature and salinity from the thermosalinograph (TSG) are provided. The intake for these measurements is reported as 5 m. The TSG temperature measurements were reduced by 0.05 C based on a comparison with the calibrated sea-snake.

Estimates of the significant wave height and phase speed of the dominant wave derived from laser altimeter measurements are provided. The 1 and 10 minutes values are determined from 1 hour averages, so the variability is representative of that time scale. Values that did not contain enough points resolve 2 second waves (on average) were removed and interpolated through. The phase speed of the dominant wave was determined from the frequency at the spectral peak. The search for the peak was limited to frequencies between 0.01 and 0.5 Hz or 100 down to 2 second waves. These values are preliminary and further refinements are expected with the inclusion of WaMOS data from the ship's radar. A placeholder has been included for the direction of the dominant waves once that becomes available. For now, this value is given by NaN. Also note that the laser altimeter was not operational during Leg 1 and those values are also given by NaN.

Measurements of the diffuse solar radiation from a sensor deployed on the topof the bow mast by NCAR are given. The solar zenith angle is provided, which takes into account the hour angle for the local solar time, inclination and latitude. Model estimates of the solar radiation at the surface in the absence of an atmosphere is provided using a solar constant of 1367 W/m2 and allowing for changes due to variations in the distance between Earth and Sun. Model estimates of the clear sky solar radiation (i.e. and atmosphere with no clouds) are provided using a parameterization technique from M. Iqbal in "Physical Climatology for Solar and Wind Energy", 1988, World Scientific, pp. 196-242. The model accounts for absortion and scattering by gases, aerosols, ozone and water vapor. Model coefficients were tuned using observations on the clearest days.

8/20/13 The 10-m wind speed was incorrectly given as the 2-m wind speed in revision 2. This error is corrected in revision 3, i.e., the 10-m values are correctly reported in Ur10 and U10.

The “revision 3” data were converted to NetCDF by an undergraduate student at the University of Miami, Jimmy Ge. No additional quality control was done. Notes from Jimmy Ge: I got most variable information from the Readme that came with the data. However I was unable to find a few standard names for some variables, and it was difficult for others, so I applied the best I could find. If there are better standard names, please notify me. The readme also contained various notes on the data. It is too long to put in this section, so I created a new attribute, "dataset.notes", and put that information there. Missing standard names: curr_dir (current direction) doy (day of year, probably not needed) waves_phase_spd (Phase speed of dominant waves) wdir10_ocean_rel (Wind direction from relative to water) wspd10_ocean_rel (Wind speed relative to water adjusted to 10m) Need references attribute. Again, please review and change title, description, etc. as needed.

Brandon Kerns corrected the time variable in the files from Jimmy Ge.

4. Data Format

The data are in CF compliant NetCDF format.

```
dimensions:
        time = UNLIMITED ; // (4249 currently)
variables:
        double time(time) ;
                time:units = "seconds since 1970-01-01 00:00:00.0 0:00" ;
        float rh2(time) ;
                rh2:long_name = "Relative humidity adjusted to 2m (%)" ;
                rh2:standard_name = "surface_relative_humidity" ;
                rh2:units = "1" ;
        float lon(time) ;
                lon:long_name = "Longitude" ;
                lon:standard_name = "longitude" ;
                lon:units = "degree_east" ;
        float curr_spd(time) ;
                curr_spd:long_name = "Current speed" ;
                curr_spd:standard_name = "sea_water_speed" ;
                curr_spd:units = "m/s" ;
        float evap(time) ;
```

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		evap:long_name = "Evaporation rate" ;
		evap:standard_name = "lwe_water_evaporation_rate" ;
		evap:units = "mm hr-1" ;
	float shf(time) ;
		shf:long_name = "Sensible heat flux" ;
		shf:standard_name = "surface_upward_sensible_heat_flux" ;
		shf:units = "W m-2" ;
	float solar_zenith(time) ;
		solar_zenith:long_name = "Solar zenith angle" ;
		solar_zenith:standard_name = "solar_zenith_angle" ;
		solar_zenith:units = "degree" ;
	float wdir10_ocean_rel(time) ;
		wdir10_ocean_rel:long_name = "Wind direction from relative to water" ;
		wdir10_ocean_rel:standard_name = "" ;
		wdir10_ocean_rel:units = "degree" ;
	float waves_phase_dir(time) ;
		waves_phase_dir:long_name = "Direction of dominant waves" ;
		waves_phase_dir:standard_name = "sea_surface_wave_to_direction" ;
		waves_phase_dir:units = "degree_Celsius" ;
	float ssq(time) ;
		ssq:long_name = "Sea surface specific humidity from Qsea minus cool
skin (g/kg)" ;
		ssq:standard_name = "surface_specific_humidity" ;
		ssq:units = "1" ;
	float lat(time) ;
		lat:long_name = "Latitude" ;
		lat:standard_name = "latitude" ;
		lat:units = "degree_north" ;
	float q2(time) ;
		q2:long_name = "Specific humidity adjusted to 2m (g/kg)" ;
		q2:standard_name = "surface_specific_humidity" ;
		q2:units = "1" ;
	float solar_diffuse(time) ;
		solar_diffuse:long_name = "Measured diffuse radiation" ;
		solar_diffuse:standard_name =
"diffuse_downwelling_shortwave_flux_in_air" ;
		solar_diffuse:units = "W m-2" ;
	float waves_phase_spd(time) ;
		waves_phase_spd:long_name = "Phase speed of dominant waves" ;
		waves_phase_spd:standard_name = "" ;
		waves_phase_spd:units = "m s-1" ;
	float t_ocean(time) ;
		t_ocean:long_name = "Near surface sea temperature from Sea snake with
warm layer correction" ;
		t_ocean:standard_name = "sea_surface_subskin_temperature" ;
		t_ocean:units = "degree_Celsius" ;
	float precip(time) ;
		precip:long_name = "Precipitation rate" ;
		precip:standard_name = "lwe_precipitation_rate" ;
		precip:units = "mm hr-1" ;
	float rhf(time) ;
		rhf:long_name = "Sensible heat flux from rain" ;
		rhf:standard_name = "surface_upward_sensible_heat_flux" ;
		rhf:units = "W m-2" ;
	float curr_dir(time) ;
		curr_dir:long_name = "Current direction from" ;
		curr_dir:standard_name = "" ;
		curr_dir:units = "degree" ;
	float solar_up(time) ;
		solar_up:long_name = "Reflected solar estimated from Payne (1972)" ;
		solar_up:standard_name = "upwelling_shortwave_flux_in_air" ;
		solar_up:units = "W m-2" ;
	float waves_sigH(time) ;
```

```
                waves_sigH:long_name = "Significant wave height" ;
                waves_sigH:standard_name = "sea_surface_wave_significant_height" ;
                waves_sigH:units = "m" ;
        float s_ocean_TSG_5m(time) ;
                s_ocean_TSG_5m:long_name = "Sea salinity from the Thermosalinograph at
5m depth" ;
                s_ocean_TSG_5m:standard_name = "sea_water_salinity" ;
                s_ocean_TSG_5m:units = "degree_Celsius" ;
        float ir_down(time) ;
                ir_down:long_name = "Measured downwelling IR" ;
                ir_down:standard_name = "surface_downwelling_longwave_flux_in_air" ;
                ir_down:units = "W m-2" ;
        float t10(time) ;
                t10:long_name = "Temperature adjusted to 10m" ;
                t10:standard_name = "air_temperature" ;
                t10:units = "degree_Celsius" ;
        float doy(time) ;
                doy:standard_name = "" ;
                doy:long_name = "Decimal Day of Year" ;
                doy:units = "1" ;
                doy:note = "1.0 --> 0000 UTC 01 January 2011." ;
        float ir_up(time) ;
                ir_up:long_name = "Upwelling IR computed from SST" ;
                ir_up:standard_name = "surface_upwelling_shortwave_flux_in_air" ;
                ir_up:units = "W m-2" ;
        float solar_down(time) ;
                solar_down:long_name = "Measured downwelling solar" ;
                solar_down:standard_name = "downwelling_shortwave_flux_in_air" ;
                solar_down:units = "W m-2" ;
        float solar_max(time) ;
                solar_max:long_name = "Solar radiation at surface with no atmosphere"
;
                solar_max:standard_name =
"surface_downwelling_shortwave_flux_in_air_assuming_clear_sky" ;
                solar_max:units = "W m-2" ;
        float solar_clr_air(time) ;
                solar_clr_air:long_name = "Modeled clear sky radiation at ocean
surface" ;
                solar_clr_air:standard_name =
"downwelling_shortwave_flux_in_air_assuming_clear_sky" ;
                solar_clr_air:units = "W m-2" ;
        float wspd10_ocean_rel(time) ;
                wspd10_ocean_rel:long_name = "Wind speed relative to water adjusted to
10m" ;
                wspd10_ocean_rel:standard_name = "" ;
                wspd10_ocean_rel:units = "m s-1" ;
        float ship_heading(time) ;
                ship_heading:long_name = "Ship\'s heading" ;
                ship_heading:standard_name = "platform_orientation" ;
                ship_heading:units = "degree" ;
        float stress(time) ;
                stress:long_name = "Surface stress measured relative to water" ;
                stress:standard_name = "magnitude_of_surface_downward_stress" ;
                stress:units = "N m-2" ;
        float interp(time) ;
                interp:long_name = "Interpolation" ;
                interp:standard_name = "" ;
                interp:units = "" ;
        float wspd10(time) ;
                wspd10:long_name = "Wind speed relative to earth adjusted to 10m" ;
                wspd10:standard_name = "wind_speed" ;
                wspd10:units = "m s-1" ;
        float ship_gnd_spd(time) ;
```

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                ship_gnd_spd:long_name = "Ship speed over ground" ;
                ship_gnd_spd:standard_name = "platform_speed_wrt_ground" ;
                ship_gnd_spd:units = "m s-1" ;
        float t_ocean_TSG_5m(time) ;
                t_ocean_TSG_5m:long_name = "Sea temperature from the Thermosalinograph
at 5m depth" ;
                t_ocean_TSG_5m:standard_name = "" ;
                t_ocean_TSG_5m:units = "degree_Celsius" ;
        float ship_gnd_course(time) ;
                ship_gnd_course:long_name = "Ship course over ground" ;
                ship_gnd_course:standard_name = "platform_course" ;
                ship_gnd_course:units = "degree" ;
        float wdir10(time) ;
                wdir10:long_name = "Wind direction from relative to earth" ;
                wdir10:standard_name = "wind_from_direction" ;
                wdir10:units = "degree" ;
        float q_ocean(time) ;
                q_ocean:long_name = "Specific humidity \'near\' ocean surface from sea
snake (g/kg)" ;
                q_ocean:standard_name = "surface_specific_humidity" ;
                q_ocean:units = "1" ;
        float rh10(time) ;
                rh10:long_name = "Relative humidity adjusted to 10m (%)" ;
                rh10:standard_name = "relative_humidity" ;
                rh10:units = "1" ;
        float evap_accum(time) ;
                evap_accum:long_name = "Accumulated evaporation for Leg" ;
                evap_accum:standard_name = "lwe_thickness_of_water_evaporation_amount"
;
                evap_accum:units = "mm" ;
        float precip_accum(time) ;
                precip_accum:long_name = "Accumulated precipitation for Leg" ;
                precip_accum:standard_name = "lwe_thickeness_of_precipitation_amount"
;
                precip_accum:units = "mm" ;
        float t2(time) ;
                t2:long_name = "Temperature adjusted to 2m" ;
                t2:standard_name = "surface_temperature" ;
                t2:units = "degree_Celsius" ;
        float q10(time) ;
                q10:long_name = "Specific humidity adjusted to 10m (g/kg)" ;
                q10:standard_name = "specific_humidity" ;
                q10:units = "1" ;
        float pressure10(time) ;
                pressure10:long_name = "Pressure adjusted to 10m" ;
                pressure10:standard_name = "air_pressure" ;
                pressure10:units = "mb" ;
        float lhf(time) ;
                lhf:long_name = "Latent heat flux" ;
                lhf:standard_name = "surface_upward_latent_heat_flux" ;
                lhf:units = "W m-2" ;
        float sst(time) ;
                sst:long_name = "Sea surface (skin) temperature from Tsea minus cool
skin" ;
                sst:standard_name = "sea_surface_skin_temperature" ;
                sst:units = "degree_Celsius" ;
```

5. Data Remarks

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.

The data are provided through a collaborative effort between NOAA/PSD/Earth Systems Research Laboratory, Oregon State University, and the University of Connecticut. The data is intended for use by DYNAMO investigators. Although the data has been through some quality control, it should be considered as preliminary data and users should expect revisions.

Fluxes are defined as negative downward and positive upwards. For example, the net heat flux is defined as: Qnet = Solarup+Solardn+IRup+IRdn+lhf+shf+rhf where Qnet<0 is heating the ocean. The wind and current directions are in meteorological convention (i.e., direction from).

6. References

Moum, J. N., de Szoeke, S. P., Smyth, W. D., Edson, J. B., DeWitt, H. L., Moulin, A. J., et al., 2014: Air–Sea Interactions from Westerly Wind Bursts During the November 2011 MJO in the Indian Ocean. *Bulletin of the American Meteorological Society*, **95(8)**, 1185–1199. https://doi.org/10.1175/BAMS-D-12-00225.1

de Szoeke, S. P., Edson, J. B., Marion, J. R., Fairall, C. W., and Bariteau, L., 2015: The MJO and Air–Sea Interaction in TOGA COARE and DYNAMO. *Journal of Climate*, **28(2)**, 597–622. https://doi.org/10.1175/JCLI-D-14-00477.1