Aircraft Measurements of the Atmosphere and the Upper Ocean During DYNAMO Using NOAA P-3

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Topics of Discussion

• the overall variability of the atmospheric boundary layer and the upper ocean seen from NOAA P-3 expendable measurements
• the impact of convection on the atmospheric boundary layer and upper ocean
• Characteristics of air-sea temperature difference
• Evolution of SST and air-sea temperature difference through different phases of MJO
NOAA P-3 for DYNAMO

Flight level *in situ* and remote sensors:
- Navigational parameters
  - Pressure, temperature, and water vapor
  - Mean winds and turbulence
  - Cloud physics
  - Sea surface temperature
  - Radiation

Radars:
- Lower fuselage C-band research radar (cloud survey)
- Tail X-band Doppler radar (radial velocity and reflectivity)

Expendables:
- GPS dropwindsonde (PTU and derived vertical velocity)
- AXBT (water temperature)
- AXCTD (water temperature and salinity)

Others:
- Scanning wave lidar (surface topo)
- SST imagery (SST variability)
DYNAMO Expendables

Dropsonde locations
(482 drops, 468 profiles)

AXBT/AXCTD locations
(316 AXBTs, 289 BT profiles
114 AXCTDs, 106 CTD profiles)
104.5 science flight hours

Western Pacific

Western Hemisphere and Africa

Indian Ocean

Maritime Continent

November 2011

December 2011
• Well-mixed boundary layer height $s \sim 600$ m in non-convective environment
• Low-level stable stratification up to several hundred meters under convection and cold pool with temperature difference of $\sim 5$ K or less
• Saturated below cloud layer under convection, boundary RH $\sim 65$-85% in lower 300 meters in non-convection locations
71 out of 253 convection soundings (28%) have two layer

71 out of 96 soundings with two layers are under convective conditions (74%)
Boundary Layer Height vs LCL

Two-layered structures not related to surface processes

LCL is a good BLH indicator in undisturbed boundary layer
Upper Ocean Characteristics

Seen from AXBT/AXCTD Measurements

- Thermocline top between 45 and 100 m
- 26 to 30 °C
- 34 to 35.5 ppt
- 34.8 to 35.2 ppt
Large Scale Variability

P3 RF02 20111113, Temperature, [DG to Mirai]

P3 RF02 20111113, Temperature, [DG to Revelle]

DG DG Revelle Mirai

DG Revelle

DGAR

Gan

Mirai

Revelle
Large Scale Variability

Vertical Cross –Section of Temperature going from Diego Garcia to Gan
Large Scale Variability

Temperature

Salinity

Density
Upper Ocean Thermo Stratification

16-Nov-2011 08:29:00

Cool and fresh water

13-Nov-2011 05:14:00

Warm layer
Upper Ocean Thermo Stratification

Non-convection

Convection

S. of DYNAMO domain

mean $\Delta T$ (non-conv) = 0.25 °  mean $\Delta T$ (conv) = -0.01 °
SST and OHC, DYNAMO Domain Average

Preliminary results!!
Vertical Profiles At 79.1523° Ion, -1.1748° lat recorded at 10:28 (UTC) on 11-13-2011
Air-Sea Temperature Difference

Preliminary results!!
Conclusions

DYNAMO expendable measurements based on the NOAA P-3 revealed:

• two-layered vs single-layered atmospheric boundary layer structure. Near surface temperature in convective region that averages to 1 K cooler and decoupled from sea surface
• cooler ocean surface under convective conditions and a warm thin layer in non-convective region. Stronger thermo-stratification of the upper ocean in the pre- and post- active phase of MJO
• daily domain averaged SST shows high SST before MJO active phase and to a minimum at the end of the active phase. Upper ocean heat content seems to show opposite trend
• Largest air-sea difference seen in the convective conditions in pre-MJO phase. Air-sea temperature difference in both convective and non-convective conditions decrease through the MJO phases.

Important Note:
• The results here are preliminary, will be re-visited once final data QC for AXBT/AXCTD data are completed.
• Further work planned for physical explanations for the observed variability
• Welcome collaborations with the atmosphere/ocean modeling community for a full understanding of the physical processes