DYNAMO

NOAA P-3 Science Summary for 28 November 2011

Explosive Development of Intense MCSs and Synoptic-Scale Equatorial Low Pressure System

Falko Judt, Shuyi S. Chen, and Chiaying Lee
RSMAS/University of Miami

Note: This report is based on preliminary results and may be updated as new information becomes available.

During the time period of the NOPP P-3 operation from early November to mid-December in the Indian Ocean, 28 November 2011 will be remembered as the most convectively active day within the DYNAMO domain. Multiple long-lived, intense MCSs populated the area between Diego Garcia, Gan, R/V Revelle and R/V Mirai throughout the day and later in the evening one of them offered a spectacular showing on the METEOSAT7 infrared satellite imagery.

1) Equatorial low-pressure system
A synoptic-scale area of low pressure formed on 27 November close to the array, its center located just south of the equator, near the R/V Revelle. Due to its proximity to the equator, the northern part of the low’s circulation reached into the northern hemisphere – where the curvature of streamlines was anticyclonic (i.e. clockwise, but still circling the low pressure with the center in the southern hemisphere!). Over the next a few days, the surface low drifted to the south and later southwest, and was centered between the Revelle and Mirai at 0000 UTC 28 November 2011, at the time the P-3 group was having the pre-flight weather briefing. The area of low pressure is clearly depicted in Image 1, which shows the 0000 UTC 28 November 2011 CSU streamline analysis at 925 and 850 mb on the left and the French ALADIN model wind and moisture analysis fields on the right. The streamline analysis clearly shows that the northern part of the low’s circulation at 850 mb reaches beyond the equator to around 5°N. The fact that the prominent anticyclonically curved streamlines in the northern hemisphere belong to a low pressure system centered south of the equator is quite counterintuitive – as the canonical thinking is that synoptic-scale atmospheric features cannot cross the equator because the Coriolis parameter switches sign. Apparently, the relative vorticity associated with this low-pressure system is so strong that the weak northern hemisphere Coriolis force has a little effect on it. By 12000 UTC, the surface low has shifted westward to be vertically lined up with the low at 850 mb (Image 2). During the P-3 weather discussion on 27 November, we noted the odd location of this feature, and because the low-pressure system behaves in a way that is atypical compared with the traditional textbook thinking, we referred to the system as an “illegal low”.

2) Explosive development of large MCSs
At 0000 UTC on 28 November, METEOSAT7 IR image showed multiple MCSs within and east of the DYNAMO array (Image 3), with an extensive area of cloud top temperatures < 195 K. The large numbers of organized, intense MCSs were remarkable compared to convective episodes before and after this event. Whether and how exactly these MCSs were forced and sustained by the large-scale low-level convergence and with the aid from the high moisture content in the environment (Image 1 and Image 2). There were two alternative flight plans for
the P-3 mission. One will be focused on the large MCSs and their interaction with the large-scale atmospheric flow and the upper ocean with RCE/FLX modules and extensive dropsonde/AXBTs deployments. It would target the systems in the DYNAMO domain indicated as “Target 1” (Image 3), which is preferable especially given that R/V Mirai will depart the SE corner of the array at the end of 28 November. The other will focus on the atmospheric boundary structure with extensive flux mapping near convection. A decision was made to fly a boundary layer mission and, unfortunately, the intense MCSs and the flow associated with the larger-scale low could not be sampled. The P-3 cannot safely operate at low levels (~200 ft) in heavy precipitation, which is necessary for the boundary layer flux measurements, and the PIs decided to sample an area with relatively weak to moderate convection (“Target 2” in Image 3).

The evolution of MCSs inside of the DYNAMO domain turns out to be extraordinary in several respects. By 0500 UTC, the large MCS (Target 1 in Image 3) has “propagated” westward and the area of cloud top <208 K has maintained its strength (Image 4). During the next 2-3 hours, the MCS weakened rapidly and has mostly dissipated by 0830 UTC (Image 5). An explosive development of a new large MCS near the same location as the previous large MCS occurred only a few hours later. By 1500 UTC, the “nuclear-bomb-like” MCS appears on the METEOSAT7 IR data (Image 6), which is one of the fastest developing intense MCSs observed in the DYNAMO array. The cloud shield was remarkably symmetric and an almost circular area with a diameter of > 300 km was colder than 208 K. The recovery time (if any) for a possibly cold-pool eroded surface and boundary layer was so fast that one would wonder how and why the first system dissipated and the second system developed all in a record speed? It is difficult to speculate without direct measurements in and near these systems, dropsonde data east of Diego Garcia show some ample instability (Image 7).

Image 8 highlights the special synoptic situation on this day. The CSU array-averaged divergence (upper panel) and vertical motion (lower panel) clearly show that the magnitude of both variables is at levels that have not been reached since the beginning of the sounding network (image from DYNAMO field catalog, Sounding Network Report 29 November 2011). The first maximum occurred on 24 November, which is most likely related to enhanced convection on the equator from 22-24 November, accompanied by a pronounced westerly wind burst, which were sampled by the P-3 on both 22 and 24 November (see P-3 Science Summary on the DYNAMO EOL field catalog for these two days). The second maximum occurred on 27-28 November is apparently associated with the intense convection and the equatorial low-pressure system described here.

For this group whose research interests are also in tropical cyclones, it is attempting to make a comparison of the large MCSs near the equator with a TC. The area surrounding this symmetric “nuclear-bomb-like” MCS was characterized by a ring of relatively warmer cloud top temperatures, and another ring of active MCSs was in turn surrounding this warm ring at about 600 km distance from the center of the solitary MCS in the center of the domain (Image 6). In comparison, this MCS had a satellite signature that was as impressive as the tropical cyclone that was active in the northern Arabian Sea at the same time (Image 9)! The convection associated with this MCS started to wane shortly after it reached its peak, sending the remaining anvil and associated light, stratiform precipitation towards Diego. They arrived in DGAR during the early morning hours, while the synoptic scale area of low pressure continued to drift southwest and settled south of the DYNAMO domain, still favoring convection to build over the next couple of days.