Evaluation of Model Operational Analyses during DYNAMO

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Introduction:
A primary component of the observing system in the DYNAMO/CINDY2011/AMIE field campaign was an enhanced sounding network comprised of two sounding quadrilateral arrays, one north and one south of the equator over the Central Indian Ocean (IO). During the experiment a major effort was undertaken to ensure the real-time transmission of these data onto the GTS for dissemination to the operational NWP centers (ECMWF, NCEP, etc.). Preliminary estimates indicate that ~95% of the soundings from this network were successfully transmitted and used in their data assimilation systems.

Objective:
Because of the wide use of operational and reanalysis products (e.g., in process studies, initializing numerical simulations, construction of large-scale forcing dataset for CRMs, etc.), their validity is examined by comparing a variety of basic and diagnosed fields from these products to similar analyses based solely on sounding data. Particular attention is given to the vertical structures of diabatic heating, from the Operational Analyses (OA), which are strongly influenced by cumulus parameterizations, a source of model infidelity.

Analyses Used in this Study:
- CSU gridded analyses (1°, 25-hPa, 6-hr resolution) computed with multiquadric interpolation and based on a combination of high vertical resolution and GTS-resolution upper-air soundings.
- ECMWF OA (0.25°, 18 vertical levels from sfc to 50 hPa, 6-hr resolution).
- NCEP GFS OA (1°, 30 vertical levels from sfc to 50 hPa, 6-hr resolution).

These analyses are examined for the Special Observing Period (SOP from 1 October - 30 November 2011) when the enhanced network was most complete. During this period, two MJOs were captured by the sonde network.

- Wheeler-Hendon MJO index indicating two significant MJO events over the Indian Ocean during the SOP.

Comparison of SOP-Mean Basic Fields:
- Small differences exist among three analyses in mean wind and temperature profiles.
- Large differences in mean RH profiles at upper-levels with ECMWF and GFS values near saturation. GFS is drier at surface but its low-level moist layer extends deeper.
- Drier conditions at upper-levels in CSU analysis are due, in part, to using uncorrected RHs at some sites. Work is underway to correct these data.

Comparison of SOP-Mean Derived Fields:
- Larger vertical separation between Q1 and Q2 peaks over SSA suggest that convective eddies are stronger in this region than in NSA.
- Absence of low-level drying in NSA Q2 mean is due to a period (1-14 Oct.) of moisture in this layer from shallow non-precipitating clouds.
- Shallower low-level convergence in GFS compared to ECMWF results in weaker mean upward motion and heating profiles in GFS.
- Weak mean drying below 800 hPa over NSA is present in GFS Q2 profile consistent with CSU, but is absent in ECMWF.
- Strong low-level drying over SSA in CSU and GFS Q2 profiles is not present in ECMWF where moistening is observed below 800 hPa.

Rainfall over NSA shows strong modulation associated with MJOs.
- When Revelle is offsite, CSU estimate is higher than TRMM.
- Over both regions GFS rainfall is lowest, consistent with its weaker vertical motion.

Comparison of Rainfall Time Series
- TRMM 3B42 V7 product (0.25°, 3-hr), used as an independent estimate for rainfall, compares well to surface gauge estimates over IO (not shown).
- Budget rainfall computed as $P = \langle Q \rangle + L + E$, where $\langle >$ is the vertical integral and E (surface evaporation rate) is from WHOI OAFlux product.

In general, these OA products did a reasonable job at capturing the mean rainfall in this region by 1.3 mm/day. This underestimate increases five-fold when the Mirai was offsite.

Budget uncertainty analysis was conducted by using the full hi-res ECMWF dataset to determine the effects of budgets of discrete sonde sampling associated with various network configurations including changes to arrays due to the port calls of the RV’s Revelle and Mirai. Budgets were computed using: (1) the full hi-res dataset and (2) by sampling this dataset at discrete sounding locations then objectively analyzing these stimulated soundings onto a single grid. Comparisons between budget analyses (1) and (2) were then made. Uncertainty analysis indicates:
- Quadrilateral (QD) sampling of the NSA overestimates mean rainfall by ~1 mm/day. This underestimate doubles when the Revelle was offsite.
- For both regions the NSA underestimates mean rainfall in this region by ~1.3 mm/day. This underestimate increases five-fold when the Mirai was offsite.
- Budget errors nearly double during the ship port calls.

Summary
- Approximately 95% of the enhanced upper-air sondes were used in producing the ECMWF and NCEP operational analyses (OA).
- In general, these OA products did a reasonable job at capturing the mean and temporal characteristics of convection during the DYNAMO SOP.
- Budget sampling errors nearly double when sonde networks collapsed from quadrilateral to triangular configurations due to ship port calls.

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