The use of a reliability budget with CESM-DART to discern model biases

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The CESM-DART coupled assimilation system

Model: CESM1 global coupled @ nominal 1°
Method: 30 member DART/EAKF
Observations:
OCN: in-situ T/S (daily)
ATM: temp and winds (6-hourly)*
*radiosondes, aircraft, satellite drift winds, GPSRO-COSMIC
Duration: 1970 - 1981
Data: monthly history files + 6-hr/daily instantaneous + restarts
Reliability Budget (Rodwell et al)

\[
\frac{1}{n-1} \sum_{j=1}^{n} (\bar{x}_j - x_{Oj})^2 = \frac{1}{n(n-1)} \left( \sum_{j=1}^{n} (\bar{x}_j - x_{Oj}) \right)^2 + \frac{m+1}{mn(m-1)} \sum_{j=1}^{n} \sum_{i=1}^{m} (x_{ij} - \bar{x}_j)^2 + \frac{1}{nm} \sum_{j=1}^{n} \sum_{i=1}^{m} e_{Oij}^2 + R
\]

(Depar^2) (Bias^2) (EnsVar) (ObsUnc^2) (Residual)

### Sources of Data

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Structure of the Reliability Budget

Combined Wind Magnitude

Combined Temperature
Structure of the Reliability Budget

Combined Wind Magnitude

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Combined Wind Magnitude Climatology

Combined Temperature Climatology
Structure of the Reliability Budget

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Combined Temperature Climatology
Structure of the Reliability Budget

Differences in Reliability Budget responses

- Pacific Ocean during MJO
- Indian Ocean during MJO
- Pacific Ocean without MJO
- Indian Ocean without MJO

Variables:
- $\Delta$ Departure$^2$
- $10^*\Delta$ Bias$^2$
- $\Delta$ Ens. Var.
- $\Delta$ Obs. Unc.$^2$
- $\Delta$ Residual

Units: m$^2$ s$^{-2}$
Review

- Southern hemisphere tropics have an increased variance in all parts of the reliability budget.
- Upper troposphere has more departure than the lower troposphere.
- MJJ provides the most decrease in departure while NDJ provides the most increase.
- Bias dominates the contribution to the full departure, while ensemble variance and observation uncertainty remain at similar magnitudes.
- MJO events cause a reduction in the total departure.
Questions?
CESM-DART vs other reanalyses

Surface Flux Anomaly bias against OA Flux

Latent Heat (Nf = 60W/m²)
Sensible Heat (Nf = 20W/m²)
Surface Wind Stress (Nf = 0.1W/m²)

GPCP Error Estimate

CESM/DART - GPCP difference

Precipitation Error (mm/day)

ERA 20C - GPCP difference

NCAR R1 - GPCP difference

Normalized Flux
MJO Response