



Evaluating 15-day ensemble forecasts of the Madden-Julian Oscillation

Nicholas Savage and Sean Milton

Introduction

We have tested the skill of the UK Met Office MOGREPS-15 Ensemble and the ECMWF Var-EPS system in forecasting the Madden-Julian Oscillation (MJO) by applying the Real Time Multivariate MJO Index of Wheeler and Hendon.

Real Time Multivariate MJO Index

- Based on first two EOFs of the combined fields of 15°S – 15°N averaged anomalies of 850 hPa zonal wind, 200 hPa zonal wind, and satellite-observed outgoing longwave radiation (OLR) data.
- EOF1 leads EOF2 by ¼ cycle
- Remove annual cycle and components of interannual variability from observed/forecast OLR, U850, U200 fields
- Project anomaly fields onto EOFs
- Principle components known as RMM1 and RMM2
- Advantages for monitoring NWP forecasts – can be applied without need for temporal (band-pass filtering) & applicable across full annual cycle
- For full details see Wheeler and Hendon (2004).

Model descriptions

- MOGREPS-15.** 24 member ensemble using the UK Met Office Unified Model with a non-hydrostatic, fully compressible, deep atmosphere dynamical core with semi-implicit semi-Lagrangian time integration. All model runs used a horizontal resolution of N144L38 (~130 x 90km, model top 10 hPa).
- ECMWF Var-EPS.** T399L62 (~33x33 km) to day 7, then T255L62 (~50x50 km) to day 15, model top ~5hPa, 51 members.

Data

Operational forecasts from 1/10/2006 to 22/9/2007 from both ensemble prediction systems (328 MOGREPS and 334 ECMWF forecasts) have been used for this study.

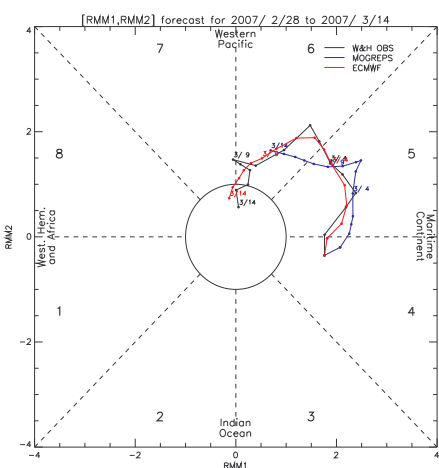
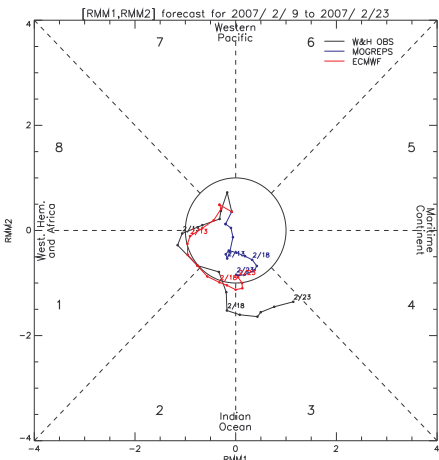
For certain diagnostics subsets of the forecasts have been created:

- Initial MJO Amplitude >1, labelled as A(0)>1 (197 MOGREPS, 200 ECMWF fcasts)
- Amplitude of verifying analysis >1 (199 MOGREPS, 200 ECMWF fcasts)
- MJO Sectors (see figures below).
 - Sectors 8 and 1. 67 MOGREPS, 65 ECMWF
 - Sectors 2 and 3. 60 MOGREPS, 62 ECMWF
 - Sectors 4 and 5. 61 MOGREPS, 65 ECMWF
 - Sectors 6 and 7. 77 MOGREPS, 77 ECMWF

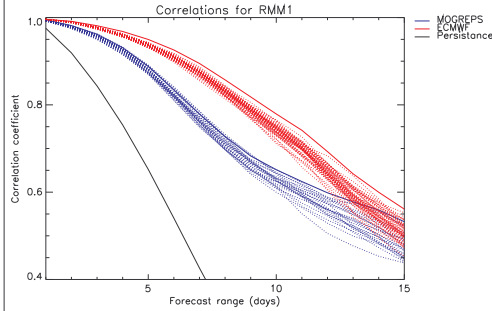
Reference

Matthew C. Wheeler and Harry H. Hendon, 2004, Mon. Wea. Rev., 132, 1917-1932.

Example phase space diagrams

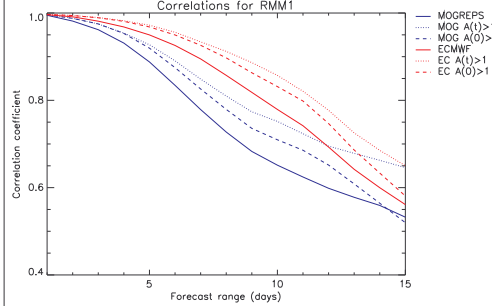


Correlation of PC time-series with analysis



Correlations for the ECMWF system are higher, both the ensemble mean (solid lines) and the individual ensemble members (dotted) at most forecast ranges. RMM2 correlations are similar.

The correlations of the ECMWF ensemble mean is higher than the best individual ensemble member whereas for MOGREPS the skill of the best members is similar to the ensemble mean.



When only ensemble members with A(t) >1 are taken correlations are increased with the same correlation for 1-2 days longer (see table below)

A similar increase in skill is seen for A(0) >1 but it is smaller

Days with correlation > threshold	Correlation > 0.9		Correlation > 0.7	
	RMM1	RMM2	RMM1	RMM2
MOGREPS ALL	4	5	8	11
MOGREPS A(t) > 1	5	7	11	12
ECMWF ALL	6	7	11	12
ECMWF A(t) > 1	8	8	13	13

Conclusions

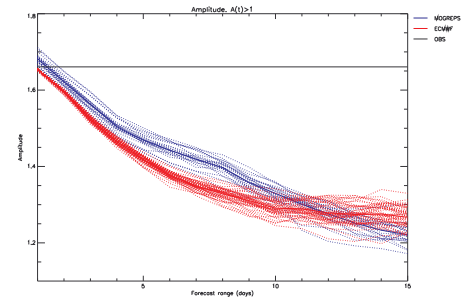
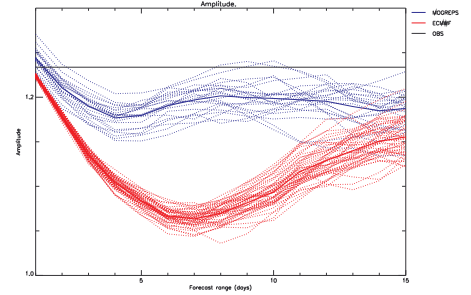
- Overall Var-EPS has greater forecast skill than MOGREPS
- Slightly less loss of amplitude with forecast range in MOGREPS
- MJO error is a function of sector and amplitude

Further work

- Comparison to global 5 day and seasonal models
- Impact of coupled ocean
- Multi-model ensemble, more models
- More detailed investigation of good/bad forecasts
- Impact of recent MOGREPS physics upgrade
- Calculate skill scores using statistical forecasts

MJO Amplitude

The MJO amplitude is the distance from the centre of the RMM phase space plot. This is shown here as a function of forecast lead time, first for all forecasts and then for a subset of forecasts where the amplitude of the verifying analysis > 1.



There is a small reduction in MJO amplitude in the MOGREPS over the first 5 days and this is steady thereafter. There is a larger loss of amplitude in ECMWF with a minimum at about 6 days

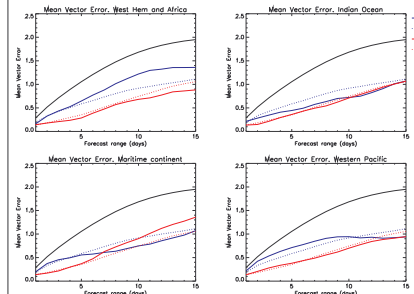
For those forecasts where the observed amplitude is greater than one, both forecasts have a steady loss of amplitude with forecast range which is much larger than for the complete set of forecasts.

This loss of amplitude is slightly less in MOGREPS than the ECMWF forecast for 5 to 10 day forecasts

Sector dependence

To quantify forecast error as a function of sector the distance between forecast and analysis in phase space (or the vector error) has been used:

$$\text{Error} = ((RMM1_{an} - RMM1_{fc})^2 + (RMM2_{an} - RMM2_{fc})^2)^{1/2}$$



Model error is dependent on sector for both models

MOGREPS errors are lower than average for Maritime Continent and Indian Ocean. At longer forecast ranges in the Maritime Continent MOGREPS has smaller errors than ECMWF

In contrast ECMWF Var-EPS errors are larger than average in the Maritime Continent

Some evidence of errors saturating towards end of fcasts