Predictability and systematic error growth in Met Office MJO predictions

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1. Introduction

This work aims to characterise the UK Met Office Unified Model (MetUM) simulation of the MJO in terms of growth of systematic errors, with the ultimate aim of understanding deficiencies and improving the prediction of the MJO. The same unified modelling framework is used for numerical weather prediction (NWP) models and its climate models. Benefits of such unified modelling are that model errors can be investigated in NWP, seasonal and climate models and all can gain from the same improvements.

Method

The assessment is carried out through application of the Real Time Multivariate MJO Index of Wheeler and Hendon to 4 winters (NDJFM) of data between 2006–2010 and forming composites based on MJO phase. For details see Wheeler and Hendon (2004).

The MetUM configurations used in this work are:

MOGREPS-15

- Atmosphere only model (MetUM/NEMO)
- 24 member ensemble
- N144L38 (90 km)/ N216L70 (60 km)
- Run twice a day
- Initialised from MetUM analyses

GloSea4

- Coupled model
- Three member ensemble
- N96L38 (120km)/ ORCA1L38
- Run once a week
- Initialised from ERA interim

The MetUM analyses are used to verify wind and streamfunction, OLR is verified against NOAA daily interpolated OLR and precipitation is verified against GPCP (1º daily) and TRMM (0.25º 3B42 product) precipitation estimates.

We have combined the 8 Wheeler and Hendon MJO phases to form 4:

Phases 8 and 1 = phase 0

Phases 2 and 3 = phase 1

Phases 4 and 5 = phase 2

Phases 6 and 7 = phase 3

Composites in (2) are created based on the phase of the MJO in which the forecast is initiated. The amplitude of MJO must exceed 1.0 at time of analysis. This tests the ability of the forecast to sustain and evolve an MJO when it is already present in the initial conditions. Time-longitude composites in (3) are created based on an amplitude of less than 0.5 at time of analysis being followed by an amplitude of greater than 1.0 within the following 15 days. This tests the ability of the forecast to evolve an MJO when it is not present in the initial conditions.

4. Conclusions

- The MJO is well captured in MOGREPS-15 short range forecasts but errors develop with lead time.
- There is some ability to evolve an MJO when its amplitude is low on initialisation. This seems to be better captured in dynamical fields.
- Differences exist in the prediction of the MJO in GloSea4 and MOGREPS-15 configurations. These disparities need further characterisation. Work is underway to include an ocean at NWP timescales and there are plans for upgrading GloSea4 resolution to N216L85 in 2011. This will bring the two models closer together and facilitate a seamless assessment of error development.

Further work

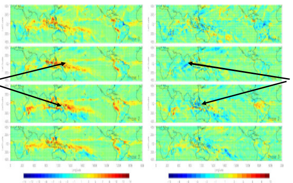
- Assess the impact of coupled ocean across all timescales from days to season.
- Calculation of diabatic heating rates from analyses and forecast using different methods, to diagnose why we are seeing error patterns outlined in this work and to investigate the coupling of diabatic heating the dynamics.

2. Investigating tropical systematic errors

Model deficiencies arising from physical and dynamical formulation contribute to systematic error development, making it difficult to disentangle the errors that arise as part of the MJO mode and those which are independent of the MJO. Removal of the mean model error may help to make apparent errors which may be arising as a result of the model failing to capture the MJO signal in its correct phase.

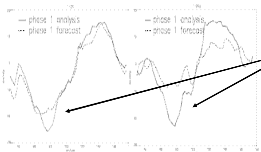
Figure 1: Composite precipitation forecast error at T+24 in each of the 4 MJO phases (left) Same as (a) but with the mean model error removed.

The MetUM overestimates precipitation over much of the tropical oceans, showing similar errors in all 4 phases.



Once the mean model error is removed, the errors look different in each phase.

Figure 2: Composite OLR observed anomalies and forecast between15N and 15S in phase 1 of the MJO at T+24 & T+240.



Well predicted in early forecasts but systematic errors increase with lead time = weaker MJO.

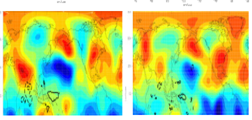
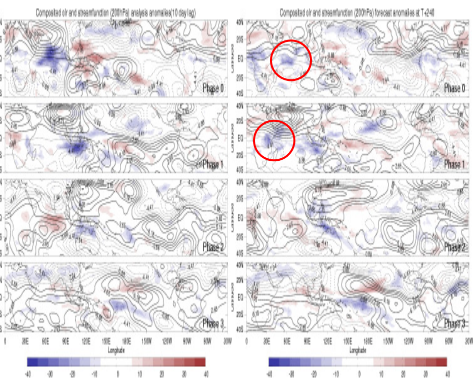


Figure 3: Evidence for teleconnections between tropics and extratropics via Rossby wave propagation in circulation (Analysis left, forecast right). Teleconnections are weaker in forecast as phase 1 heating (dashed) is less strong than observations at T+240.

Figure 4(a) Composite observed OLR (shading) and 850hPa streamfunction (contours) anomalies in each of the 4 MJO phases (b) same as (a) but for forecast at T+240.

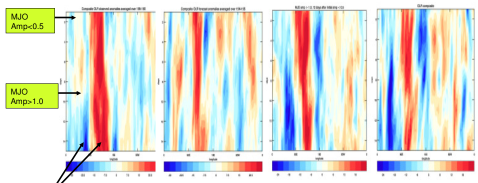


Convection in phase 0 is too weak and consequently the stream function anomalies straddling the equator are also too weak.

Anomalous convection occurs to the east of Africa in phase 1, likely inducing the erroneous strong localised westerlies. Comparatively, observed convection has advanced to the Maritime Continent and a positive streamfunction anomaly is centred on the Bay of Bengal rather than the Arabian Sea. The MJO amplitude and spatial representation is somewhat better when initialised in phase 2 and 3.

3. MJO forecast from low amplitude initial conditions

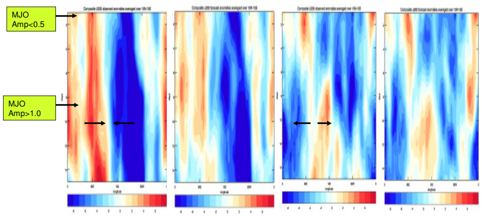
Figure 5: Time-longitude composites of phase 0 (left) and phase 1 (right) OLR anomalies (observed left, forecast right) formed when MJO amplitude exceeds 1.0, nine days after the amplitude was less than 0.5 (13 & 12 cases respectively band averaged over 15N-15S).



Observed dipole of convection and suppression

Dipole is much weaker in the phase 0 forecast. Convection initiates too far west (also seen in figure 4) and starts about two days later than was observed. However, despite systematic errors there does seem to be a weak signal. Lack of data is probably a constraint. There is a clear dipole structure in phase 1, which is well forecast, but with both convection and suppression too far west.

Figure 6: Time-longitude composites of phase 0 (left) and phase 1 (right) u200 anomalies (observed left, forecast right in both phases) formed when MJO amplitude exceeds 1.0, 9 days after the amplitude was less than 0.5 (13 cases band averaged over 15N-15S).

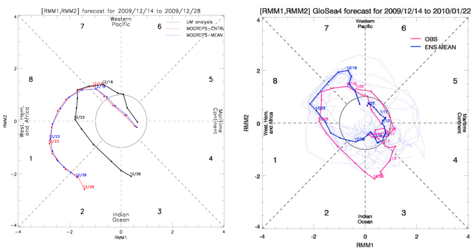


Phase 0 U200 analysis field is dominated by convergence of westerlies and easterlies aloft. Easterlies begin to develop west of 90E after day 12. Corresponding forecast u200 field demonstrates a similar pattern to analysis but is weaker, possibly due to weaker suppression seen in fig 5. Easterlies also begin to develop west of 90E after day 11.

By phase 1, both analysis (left) and forecast (right) develop anomalous easterlies and westerlies over the Indian Ocean, indicating divergence in the upper troposphere past day 8. The forecast westerlies are weaker than portrayed in the analysis especially by day 15, but the pattern of winds aloft is well replicated. This suggests that there may be some predictability in dynamical fields out to day 15.

To compare the performance of the MJO with the GloSea4 seasonal system, we look at a case study of a forecast for 14 December 2009.
The MJO index is low at time of initialisation and both model configurations are able to develop a strong MJO from this point. However there are differences between the two systems. They are currently run at different resolutions and GloSea4 is run in coupled mode but there are plans to run at the same resolution and to test MOGREPS in coupled mode.

Figure 7: Wheeler and Hendon diagrams for MOGREPS-15 (left) and for GloSea4 (right) for forecast start date of 14/12/2006. MOGREPS runs out to 15 days and GloSea4 runs out to 40 days.



MOGREPS amplitude is greater than was observed. This is interesting as figures 4,5,and 6 suggest that the amplitude is too weak. The forecast lags behind a phase in the Indian Ocean (also seen in figures 4 and 5.)

GloSea4 develops an MJO but it is not sustained past phase 1. The amplitude is closer to what was observed than is seen in MOGREPS. This disparity between models needs further investigation.

References

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