The Madden-Julian oscillation in the ECMWF monthly forecasting system

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Monthly Forecasting System (1)

- **Coupled ocean-atmosphere integrations:** a 51-member ensemble is integrated for 32 days every 2 weeks.

- **Atmospheric component:** IFS with the latest operational cycle and with a T159L40 resolution

- **Oceanic component:** HOPE (from Max Plank Institute) with a zonal resolution of 1.4 degrees and 29 vertical levels

- **Coupling:** OASIS (CERFACS). Coupling every ocean time step (1 hour)
Monthly Forecasting System (2)

- **Atmospheric initial conditions**: ERA40 and ECMWF operational analysis

- **Oceanic initial conditions**: Last ocean analysis + real time forecast

- **Perturbations**:
  
  - **Atmosphere**: Singular vectors + stochastic physics
  
  - **Ocean**: SST perturbations in the initial conditions + wind stress perturbations during data assimilation.
Real-time Ocean Forecast

**Problem:** the last oceanic analysis is about 12 days behind real-time.
Monthly Forecasting System (3)

Background statistics:

- 5-member ensemble integrated at the same day and same month as the real-time time forecast over the past 12 years.

- This represents a 60-member ensemble.

- It is running once every 2 weeks (alternatively with real time forecast)
Verification

. The monthly forecasting system is semi-operational since 27 March 2002

. 30 cases have been verified.
Madden Julian Oscillation (1)

EOF analysis of velocity potential at 200 hPa along the 5N-5S equatorial band

EOF1 and EOF2 from analysis

EOF1 and EOF2 from MOFC
Madden Julian oscillation

EOF1-EOF2: 33%-30% 26%-21% 30%-20%
Madden Julian Oscillation (3)
Madden-julian Oscillation (3)

Temporal correlation

Potential Predictability  
Monthly Forecast  
Persistence

Informal Seminar 30 April 2003
Madden Julian Oscillation (4)

Anomaly Correlation

RMS Error

- Anomaly Correlation plots show time lag (days) vs. anomaly correlation for different scenarios: ensemble mean, persistence, and control.
- RMS Error plot shows time lag (days) vs. RMS error for MOFC, persistence, and climatology.
Madden-Julian Oscillation (5)

Time evolution of the variance of PC1

PC1
Madden-Julian Oscillation (6)
Madden-Julian Oscillation (7)
Madden-Julian Oscillation (9)

Starting date: 1 January 2003

Starting date: 4 June 2003
Madden-Julian Oscillation (8)

Starting date: 24 April 2002

Starting date: 26 March 2003

ECMWF Monthly Forecasting System
MODEL BIAS: Surface temperature
Forecast start reference is 1991-2002
ensemble size = 48

WEEK1: DAY 4 TO 10
WEEK2: DAY 11 TO 17
WEEK3: DAY 18 TO 21
WEEK4: DAY 22 TO 31

COUPLED-UNCOUPLED

Informal Seminar 30 April 2003
ECMWF Monthly Forecasting System
MODEL BIASES: Total Precipitation
Forecast start reference is 1951-2002
ensemble size = 5

WEEK 1-4

WEEK 1: DAY 4 TO 10

WEEK 2: DAY 11 TO 17

WEEK 3: DAY 18 TO 24

WEEK 4: DAY 25 TO 31

Model Bias
Model Bias (Total Precipitation)

Ocean-atmosphere Coupled

atmosphere only
Conclusion

- The model displays some skill in predicting the time evolution of the MJO.

- After about 10 days, the amplitude of the MJO simulated by the coupled GCM is reduced by a factor 2.

- The model has some problems in propagating the MJO across the maritime continent.

- The model displays some significant systematic errors in SSTs and precipitation. The atmospheric bias comes from the atmospheric model, rather than from the bias in SSTs.
Considerations

- What is the effect of the MJO? On El Nino, on lower frequencies.
- What about the Indian ocean?
- What about the extratropics.
- Can we extend the climate record?
- Intermediate models can be useful.
WWB/MJO debate  2nd Dec 02

● “..forecast models showing El Nino near its peak. ECMWF shows this particularly strikingly.”

● “My conjecture is that these weak forecasts would be correct in the absence of stochastic kicks from the MJO but that the next few months will show them to be wrong: this El Nino is going to grow more and continue to be strong for several more months than forecast. Further, the model forecasts will change decisively once the new westerlies are assimilated.”

● Comparison with Nov 1991
Forecasts for Nino3.4 from S2 Dec – May starts
NINO3.4 SST anomaly plume
ECMWF forecast from 1 Oct 2003
Monthly means plotted using HCEP adjusted OIv2 1971-2000 climatology

Forecast production date: 14 Oct 2003
Wind stress from 1 Oct 2002 for 6 months
D20 for 6 months from Oct 2002

HOPE gcm: EXPT 0001
D20 contoured every 5 m
Time-longitude plot at 0.00 deg N
Plot resolution is 1,4063 in x and 120 in y

19860101 + 17 yrs 178 days
difference from
19860101 + 15 yrs 168 days
Interpolated
Five Day Zonal Wind, SST, and 20°C Isotherm Depth Anomalies 2°S to 2°N Average

Zonal Wind (m s\(^{-1}\))  

SST (°C)  

20°C Isotherm Depth (m)
Marked variation in predictive skill as a function of decade (but only a few decades)

Heat content does not have a ‘spring barrier’ as does SST. (Maybe a weaker winter barrier). Combination of heat content and SST should give better predictions.