Monthly Forecasting at ECMWF

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Forecasting systems at ECMWF

ECMWF:
Weather and Climate Dynamical Forecasts

- **Medium-Range Forecasts**
  - Day 1-10(15)

- **Monthly Forecast**
  - Day 10-32

- **Seasonal Forecasts**
  - Month 2-7
Use of monthly forecasts in applications

Main sources of predictability on the monthly time-scale

- Madden Julian Oscillation
- Soil Moisture
- Stratospheric Initial conditions

The ECMWF monthly forecast system

- Description
- Some examples of forecasts
- Skill
Use of sub-seasonal forecasts in applications

Growing, and urgent, requirement for the employment of sub-seasonal predictions for a wide range of societal and economic applications which include:

- Warnings of the likelihood of severe high impact weather (droughts, flooding, wind storms etc.) to help protect life and property
- Humanitarian Planning and Response to disasters
- Agriculture particularly in developing countries — e.g. wheat and rice production
- Disease planning/control — e.g. malaria, dengue and meningitis
- River-flow — for flood prediction, hydroelectric power generation and reservoir management for example
Opportunity to use information on *multiple* time scales

**Ready**
- Seasonal forecasts
- Begin monitoring mid-range and short-range forecasts
- Update contingency plans
- Train volunteers
- Sensitize community
- Enable early-warning system

**Set**
- Mid-Range forecasts
- Continue monitoring shorter-time-scale forecasts
- Mobilize assessment team
- Alert volunteers
- Warn community
- Local preparation activities

**Go!**
- Short-Range forecasts
- Deploy assessment team
- Activate volunteers
- Distribute instructions to community, evacuate if needed

Red Cross - IRI example
Bridging the gap between Climate and weather prediction

A particularly difficult time range: Is it an atmospheric initial condition problem as medium-range forecasting or is it a boundary condition problem as seasonal forecasting?

Some sources of predictability:

- Sea surface temperatures
- Land surface conditions: snow-soil moisture
- The Madden Julian Oscillation
- Stratospheric variability
- Atmospheric dynamical processes
  (Rossby wave propagations, weather regimes…)
- Sea ice cover – thickness?
Impact of soil moisture

Koster et al, GRL 2011
Sudden Stratospheric Warmings

Chui and Kunz, 2009
Stratospheric influence on the troposphere?

\textbf{Composite of 18 Weak Vortex Events}

\textbf{Weather from above.} A weakening stratospheric vortex (red) can alter circulation down to the surface, bringing storms and cold weather farther south than usual.

Baldwin and Dunkerton, 2001
Stratospheric influence on the troposphere?

Z1000 Response (Weak vortex-CTL)

From T. Jung et al 2005
Impact of SSWs on skill scores

From Om Tripathi (2015)
The Madden-Julian Oscillation (MJO)

From Madden and Julian (1972)
The Madden Julian Oscillation (MJO)

Why is the MJO so important?

- Impact on the Indian and Australian summer monsoons (Yasunari 1979), Hendon and Liebman (1990)

- Impact on ENSO. Westerly wind bursts produce equatorial trapped Kelvin waves, which have a significant impact on the onset and development of an El-Niño event. Kessler and McPhaden (1995)

- Impact on tropical storms (Maloney et al, 2000; Mo, 2000)

- Impact on Northern Hemisphere weather
MJO Prediction

Combined EOF1

Madden and Julian’s (1972) schematic

Like negative EOF 2

Like positive EOF 1

Like positive EOF 2

Like negative EOF 1

From Wheeler and Hendon, BMRC
Impact of the MJO on precipitation

JJA
Impact on Tropical Cyclone Density (Summer)

Vitart, GRL 2009
Impact of the MJO on Extratropics

Lin et al, MWR 2010
See also
Simmons et al JAS 1983
Ting and Sardeshmukh JAS 1993
Impact on the Extratropics - Z500 anomalies
Probabilistic skill scores – NDJFMA 1989-2008

Reliability Diagram
Probability of 2-m temperature in the upper tercile
Day 19-25

N. Extratropics
- MJO in IC
  - 0.04
  - -0.06

Europe
- MJO in IC
  - 0.03
  - -0.09
A 51-member ensemble is integrated for 32 days twice a week (Mondays and Thursdays at 00Z)

Atmospheric component: IFS with the latest operational cycle and with a T639L91 resolution up to day 10 and T319L91 after day 10.
Ocean-atmosphere coupling from day 0 to NEMO (about 1 degree) every 3 hours.

Initial conditions:
- Atmosphere: Operational 4-D var analysis + SVs + EDA perturbations
- Ocean: 3D-Var analysis (NEMOVAR) + wind stress perturbations

Background statistics:
5-member ensemble integrated at the same day and same month as the real-time time forecast over the past 20 years (a total of 100 member ensemble).
Initial conditions: ERA Interim. Produced once a week (to be extended later this year with Cycle 40r3 to 11 members, twice a week)
The ECMWF monthly forecasts

Anomalies (temperature, precipitation..)
The ECMWF monthly forecasts

Probabilities (temperature, precipitation..)
The ECMWF monthly forecasts
Tropical cyclone activity

Weekly Mean Tropical Cyclone Strike Probability. Date 20100108 0 UTC t+(264-432)
Probability of a TC passing within 300 km radius

- < 10%
- 10.. 20
- 20.. 30
- 30.. 40
- 40.. 50
- 50.. 60
- 60.. 70
- 70.. 80
- 80.. 90
- > 90%
MJO Forecasts
Precip anomalies: 26 July 2010 – 01 August 2010
Skill of the ECMWF Monthly Forecasting System

ROC score: 2-meter temperature in the upper tercile

Day 5-11

Day 12-18

Day 19-25

Day 26-32
Skill of the ECMWF Monthly Forecasting System

2-meter temperature in upper tercile - Day 12-18

ROC score

Persistence of day 5-11
Monthly forecast day 12-18

Persistence of day 5-18
Monthly forecast day 19-32
MJO skill scores

MJO Bivariate Correlation

- 0.5
- 0.6
- 0.8

Forecast Day vs. Year (2002-2013)
Impact of the MJO on the N. Extratropics

2002 MOFC hindcasts

2012 MOFC hindcasts

ERA Interim
NAO skill scores – Day 19-25
14 Feb 2013 - Day 26-32
Control

Tropics relaxed

Analysis

Relax-Control
Performance of the monthly Forecasts

2-metre temperature ROC area over Northern Extratropics

2-meter temperature anomalies over the Northern Hemisphere

- Day 12-18
- Day 19-25
- Day 26-32
Future model changes

- Re-forecast extension (twice a week, 11 members) (MAY 2015)

- Extension to 46 days (May 2015)

- Increased atmospheric resolution (2015/2016)

- Sea-ice – NEMO ¼ degree (2016/2017)
Extension to 46 days

Europe

Rank probability skill score

Day 1–15
Day 16–30
Day 31–45

80 case, starting on 1st Feb/May/Aug/Nov 1989-2008
Correlations for week 4
Northern Hemisphere

Winter

Current system

With sea-ice model (LIM2)

Summer

Legend:
-1  -0.8  -0.6  -0.4  -0.2  0  0.2  0.4  0.6  0.8
Active sea ice model: Z500 Forecast Skill (weeks 1-4)

- SEA ICE
- Control

Rank probability skill score

Weekly periods

day 5-11
day 12-18
day 19-25
day 26-32
WWRP/WCRP Sub-seasonal to Seasonal Prediction (S2S) database

- Daily real-time forecasts + re-forecasts
- 3 weeks behind real-time
- Common grid (1.5x1.5 degree)
- Variables archived: about 80 variables including ocean variables, stratospheric levels and soil moisture/temperature
- Archived in GRIB2 – NETCDF conversion available
TIGGE-S2S Database

11 data providers and 2 archiving centres

- Data provider
- Archiving centre
## S2S partners

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<th>Ens. Size</th>
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**S2S Multi-model prediction**

Day 12-18 2-m temp anomalies - Forecasts starting on 15/01

Verification

ECMWF

JMA

NCEP
**Conclusion**

- SSTs, Soil moisture, stratospheric initial conditions and MJO are sources of predictability at the intra-seasonal time scale. The MJO has a significant impact on the forecast skill scores beyond day 20.

- The monthly forecasting system produces forecasts for days 12-18 that are generally better than climatology and persistence of day 5-11. Beyond day 20, the monthly forecast is marginally skilful. For some applications and some regions, these forecasts could however be of some interest.

- There has been a clear improvement in the monthly forecast skill scores since 2002. This improvement is likely to be related to improved prediction in the Tropics and most especially improved MJO prediction.