The Monthly Forecast system at ECMWF

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Forecasting systems at ECMWF

ECMWF: Weather and Climate Dynamical Forecasts

Product

- Medium-Range Forecasts
  - Day 1-10(15)
- Extended range Forecast
  - Day 10-46
- 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
- Rossby waves

The ECMWF extended range forecast system
- Description
- Some examples of forecasts
- Skill

S2S database
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

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? “Predictability Desert” (D. Burridge)

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?

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 Tripathi et al. (2015)
Rossby Wave Packets
Rossby Wave Packets
Pioneers in subseasonal predictions

Miyakoda et al. (1983), Spar et al. (1976), Shukla (1981) opened the door for subseasonal predictions.

- explored the predictability at a subseasonal time-scale (beyond deterministic predictable limit),
- recognized that the subseasonal prediction can be seen as an initial value problem with external forcings (boundary value problem).

“Predictability In the Midst of Chaos” Shukla (1998), Palmer (1993)

Miyakoda et al. (1983) Simulation of a blooking event in January 1977. MWR
Spar et al. (1976) Monthly mean forecast experiments with the GISS model. MWR
Spar et al. (1978) An initial state perturbation experiment with the GISS model. MWR
January 1977

Picture Courtesy of Charles Trainor/Miami Herald

Source: NOAA/NWS
January 1977

T850 Forecast (Day10-30)

Miyakoda et al. 1983
ECMWF monthly forecasts

- A 51-member ensemble is integrated for 46 days twice a week (Mondays and Thursdays at 00Z)
- Atmospheric component: IFS with the latest operational cycle and with a Tco639L91 resolution up to day 15 and Tco319L91 after day 15.
- Ocean-atmosphere coupling from day 0 to NEMO (about ¼ degree) hourly.

Initial conditions:

- Atmosphere: Operational 4-D var analysis + SVs+ EDA perturbations
- Ocean: 3D-Var analysis (NEMOVAR) + wind stress perturbations
Biases (e.g., 2 mT as shown here) are often comparable in magnitude to the anomalies which we seek to predict.
The ENS re-forecast suite to estimate the M-climate

Initial conditions:
ERA Interim +
ORAS5 ocean ics +
Soil reanalysis

Perturbations:
SVs + EDA(2016) + SPPT + SKEB
The ECMWF monthly forecasts

ECMWF EPS-Monthly Forecasting System
2-meter Temperature anomaly
Forecast start reference is 28-04-2016
ensemble size = 51 , climate size = 440

Day 12-18
09-05-2016/TO/15-05-2016
Shaded areas significant at 10% level
Contours at 1% level
The ECMWF monthly forecasts

ECMWF EPS-Monthly Forecasting System
(Prob Precip. anom below 33%)
Forecast start reference is 02-05-2016
ensemble size = 51, climate size = 440

Day 8-14
09-05-2016/TO/15-05-2016
The ECMWF monthly forecasts

28-04-2014 week3 : step 336-504
Reg 1 ** Sub-cluster mean (2)

28-04-2014 week3 : step 336-504
Reg 2 ** Cluster mean (13) - CTR

28-04-2014 week3 : step 336-504
Reg 3 ** Cluster mean (11)

28-04-2014 week3 : step 336-504
Reg 4 ** Cluster mean (11)

28-04-2014 week3 : step 336-504
Reg 5 ** Sub-cluster mean (4)

28-04-2014 week3 : step 336-504
Reg 6 ** Cluster mean (9)
Tropical cyclone activity

Weekly mean Tropical Storm Strike Probability. Date: 20160502 0 UTC t+(504-672)
Probability of a TS passing within 300km radius
MJO Forecasts

ECMWF MONTHLY FORECASTS
FORECAST BASED 01/05/2014 00UTC

Western Pacific

Maritime Continent

Indian Ocean

West Hem. and Africa

RMM1

RMM2
ECMWF Extended-range 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

Day 12-18

Persistence of day 5-11

Monthly forecast day 12-18

Day 19-25

Persistence of day 5-18

Monthly forecast day 19-32
MJO skill scores

MJO Bivariate Correlation

- Blue line: 0.5
- Red line: 0.6
- Brown line: 0.8

Forecast Day vs. Year chart
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
Extension to 46 days

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

Winter
Current system

Summer

With sea-ice model (LIM2)
Active sea ice model: Z500 Forecast Skill (weeks 1-4)

The vertical bars represent the 95% level of confidence

SEA ICE  Control
WWRP-WCRP sub-seasonal to seasonal prediction Project (s2S)

- “To improve forecast skill and understanding on the sub-seasonal to seasonal timescale with special emphasis on high-impact weather events”

- “To promote the initiative’s uptake by operational centres and exploitation by the applications community”

- “To capitalize on the expertise of the weather and climate research communities to address issues of importance to the Global Framework for Climate Services”
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
S2S Database

11 data providers and 2 archiving centres

- Data provider
- Archiving centre

Data providers: ECMWF, UKMO, CNR, Météo France
Archiving centres: JMA, KMA, CMA, HMCR, CAWCR
<table>
<thead>
<tr>
<th>S2S partners</th>
<th>Time-range</th>
<th>Resol.</th>
<th>Ens. Size</th>
<th>Freq.</th>
<th>Hcsts</th>
<th>Hcst length</th>
<th>Hcst Freq</th>
<th>Hcst Size</th>
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<td>ECMWF</td>
<td>D 0-46</td>
<td>T639/319L91</td>
<td>51</td>
<td>2/week</td>
<td>On the fly</td>
<td>Past 20y</td>
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<td>CNR-ISAC</td>
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<td>1981-2010</td>
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Subseasonal to Seasonal Instantaneous and Accumulated

Select date
- Select a date in the interval 2015-01-01 to 2015-03-09
  - Start date: 2015-01-01
  - End date: 2015-03-09

Select a list of months
- Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec
  - Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec

Select step
- 0, 9, 12, 18, 24, 30, 39, 42, 48, 54, 60, 66, 72, 78, 84
  - 90, 102, 108, 114, 120, 129, 132, 139, 144, 150, 158, 162, 169, 174
  - 180, 189, 198, 207, 216, 225, 234, 243, 252, 261, 270, 279, 288, 297
  - 300, 309, 318, 327, 336, 345, 354, 363, 372, 381, 390, 400
  - 400, 409, 418, 427, 436, 445, 454, 463, 472, 481, 490, 500
  - 540, 549, 558, 567, 576, 585, 594, 603, 612, 621, 630
  - 690, 700, 710, 720, 730, 740, 750, 760, 770, 780, 790, 800

Select parameter
- 10 metre U wind component
- 10 metre V wind component
- Convective precipitation
- Eastward turbulent surface stress
- Land sea mask
- Maximum temperature at 2 metres in the last 6 hours
- Mean sea level pressure
- Minimum temperature at 2 metres in the last 6 hours
- Northward turbulent surface stress
- Orography
- Snowfall equivalent
- Soil type
- Surface net solar radiation
- Surface pressure
- Surface sensible heat flux
- Surface latent heat flux
- Surface net thermal radiation
- Surface runoff

http://apps.ecmwf.int/datasets/data/s2s/levtype=sfc/type=cf/
S2S Database current status

- Open access to researchers from ECMWF (since May 2015) and CMA (since Nov 2015). Subset of data also available from IRI. Data from nine data providers:
  - ECMWF, NCEP, JMA, BoM, CMA, Météo-France, HMCR, ISAC and UKMO
  - Total size of the database: 37.7 Tbytes:
    - real-time: 5 Tbytes
    - re-forecast: 32.6 Tbytes

- Plans
  - End of 2016: all 11 Data Providers
  - Add new ocean sub-surface and sea-ice variables
  - Compute and archive indices such as MJO RMMS, SSW index, Weather regimes, Tropical storm tracks, Monsoon indices to be available for the research community from ECMWF and IRI servers.

See also S2S museum http://gpvjma.ccs.hpcc.jp/S2S/
Bivariate Correlation – Ensemble

MJO Bivariate Correlation
S2S REFORECASTS 1999-2010

Ensemble Mean
Control

Lead Time

ECMWF  NCEP  JMA  CMA  CNRM  EC*  HMCR  BOM  ISAC  UKMO*  MODEL

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S2S verification – S2S real-time forecasts
MC crossing

Percentage not crossing the MC
S2S REFORECASTS DJFM 1999-2010

Day 1-30
Teleconnections (S2S re-forecasts)
ONDJFM 1999-2010

Analysis

ECMWF

JMA

NCEP

ISAC

BoM

CNRM

EC

UKMO

CMA
Modulation of tropical cyclone density anomaly by MJO

MJO Phase 2-3 | MJO Phase 4-5 | MJO Phase 6-7 | MJO Phase 8-1

OBS

ECMWF

NCEP

JMA

BoM

Multi
Tropical Cyclone Pam case study

Multi-model prediction of TC strike probability anomalies- 9-15 March 2015
(NCEP/ECMWF/BoM/JMA/CMA)

2015/02/19 day 19-25  2015/02/26 day 12-18
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.

- S2S database is now available. It is an important tool to better identify model’s sources of predictability and teleconnections.