Sub-seasonal predictions at ECMWF and links with international programmes

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Outline

- 30 years ago: the start of ensemble, extended-range predictions at ECMWF
- Predictions of MJO variability and its teleconnections in the Northern Hemisphere
- Recent progress and plans on sub-seasonal predictions at ECMWF
- The WWRP/WCRP Sub-seasonal to Seasonal (S2S) project and the ECMWF role

How did extended-range ensemble fc. start at ECMWF?

- 4 case studies in winter 1983/84, run in 1984 and 1985
- 9-member lagged-average forecasts, I.C. from operational analysis at 6-hour interval
- T21 and T42 spectral model
- Fixed SST, persisted from I.C. **(no cheating!)**
- Correction for systematic error, based on 10 30-day integrations in winters 1981/82 and 1982/83, started at 10-day intervals
- Comparison w.r.t. “deterministic” forecast from last I.C. and persistence

Looking at the output … (from 1984 ECMWF Annual Report)

The first case study: 17 Jan. 1984

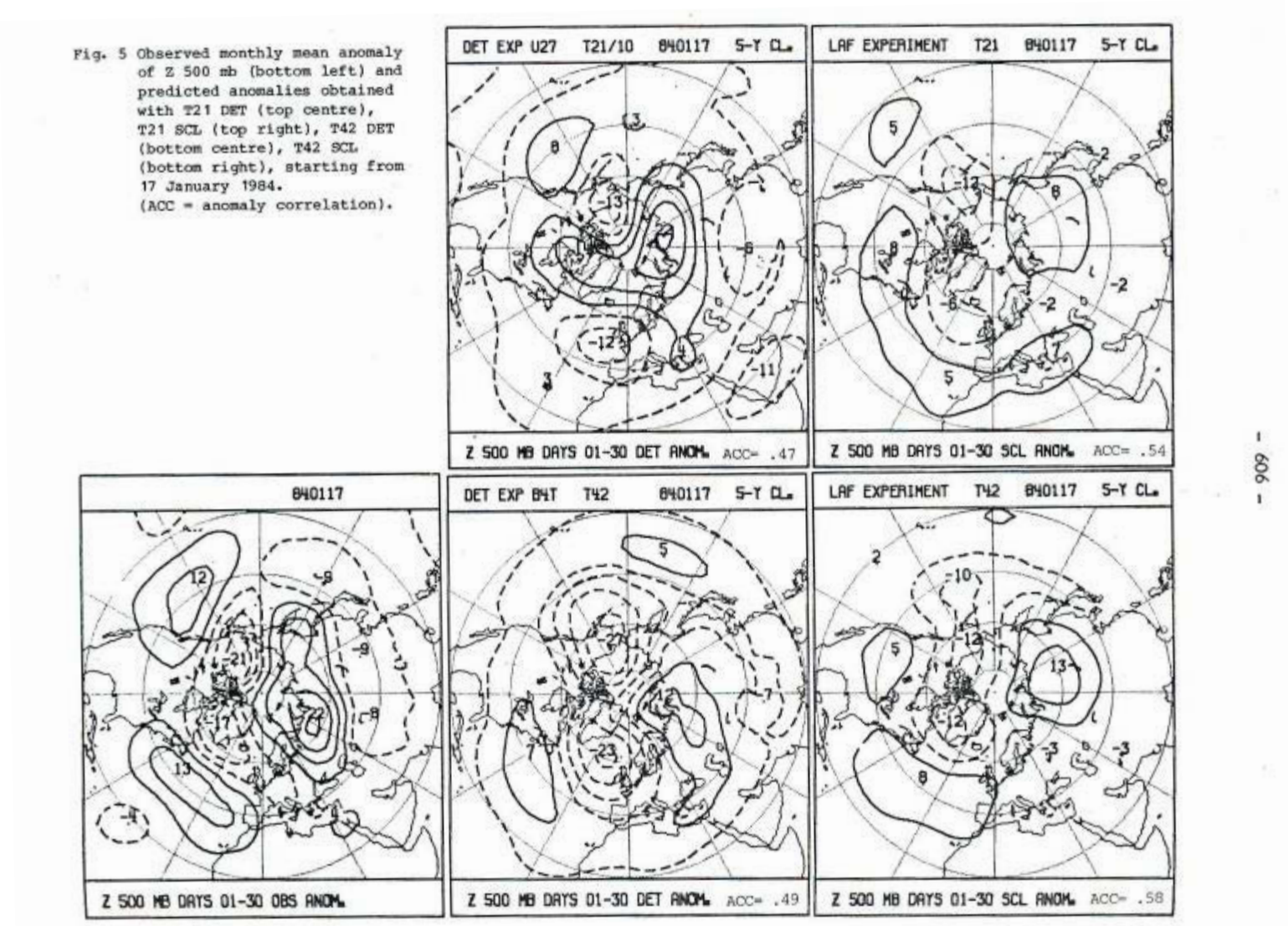

Fig. 5 Observed monthly mean anomaly of Z 500 mb (bottom left) and predicted anomalies obtained with T21 DET (top centre), T21 SCL (top right), T42 DET (bottom centre), T42 SCL (bottom right), starting from 17 January 1984. (ACC = anomaly correlation).

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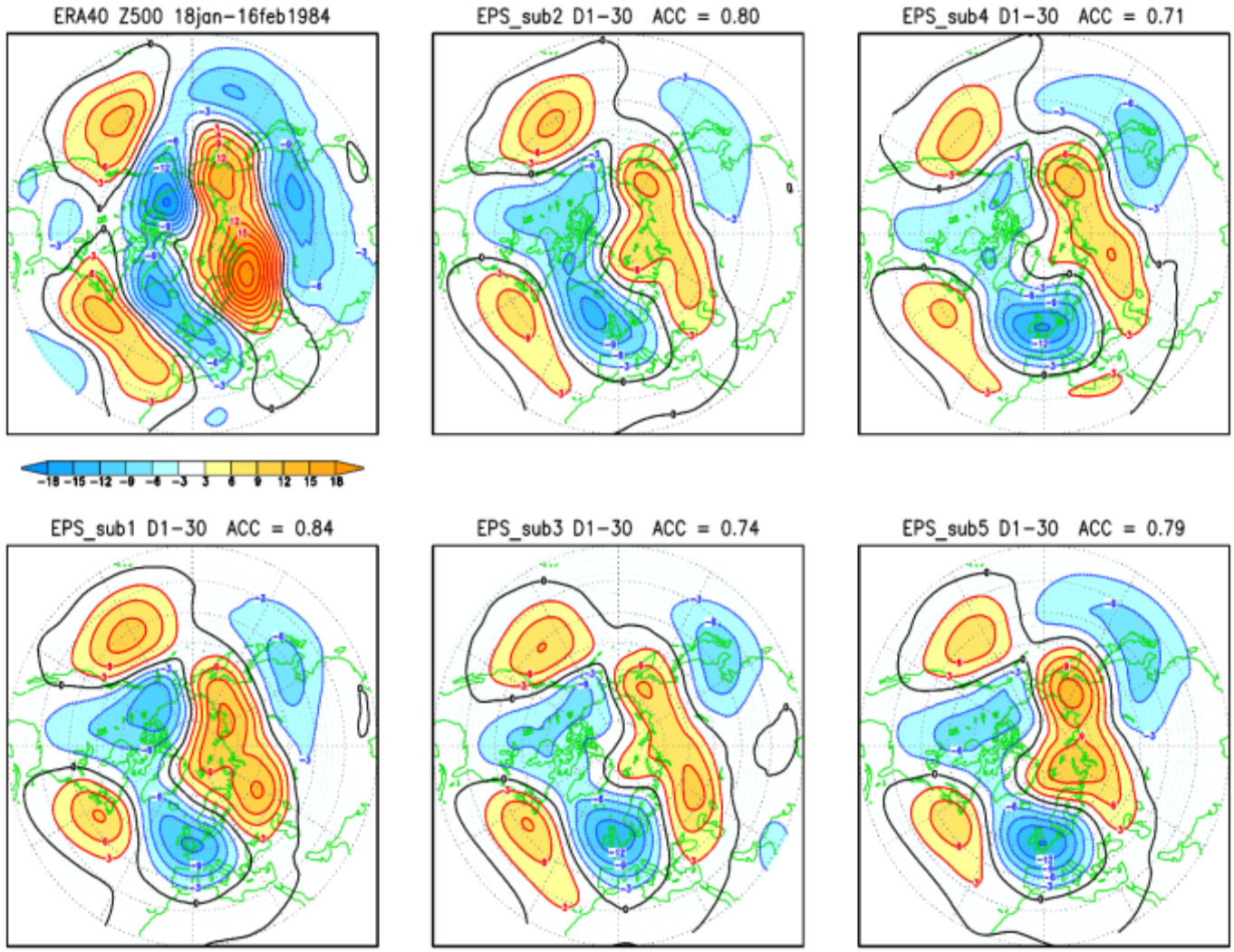
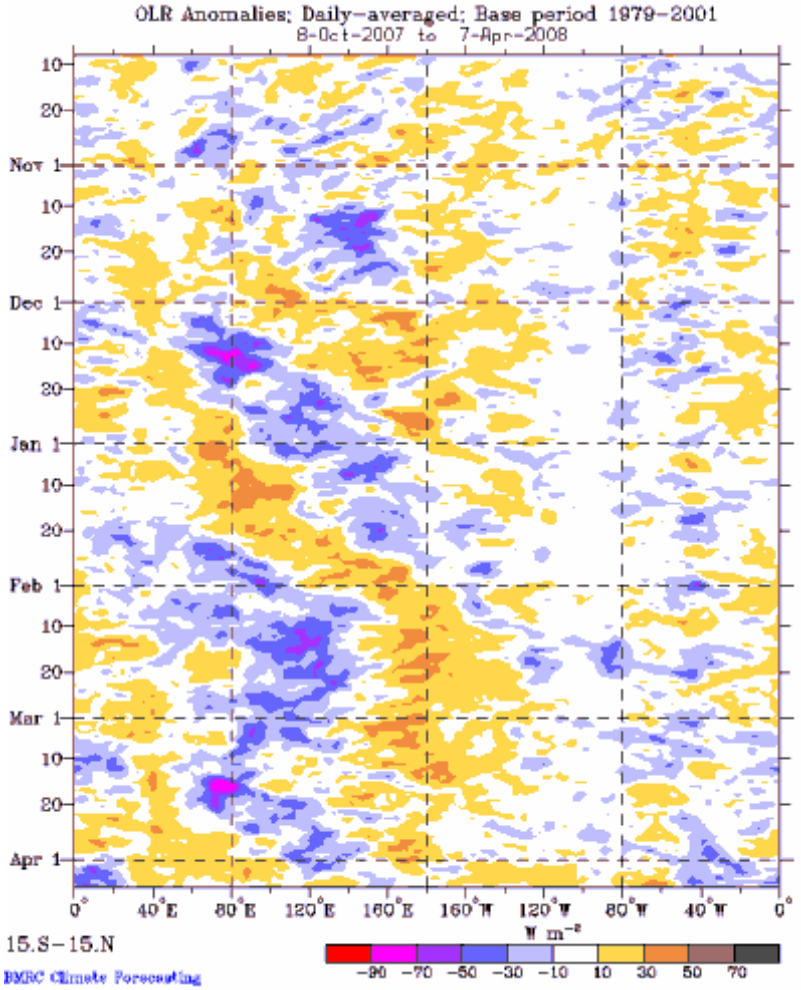
The 17/01/84 case with the 2009 EPS-monthly system

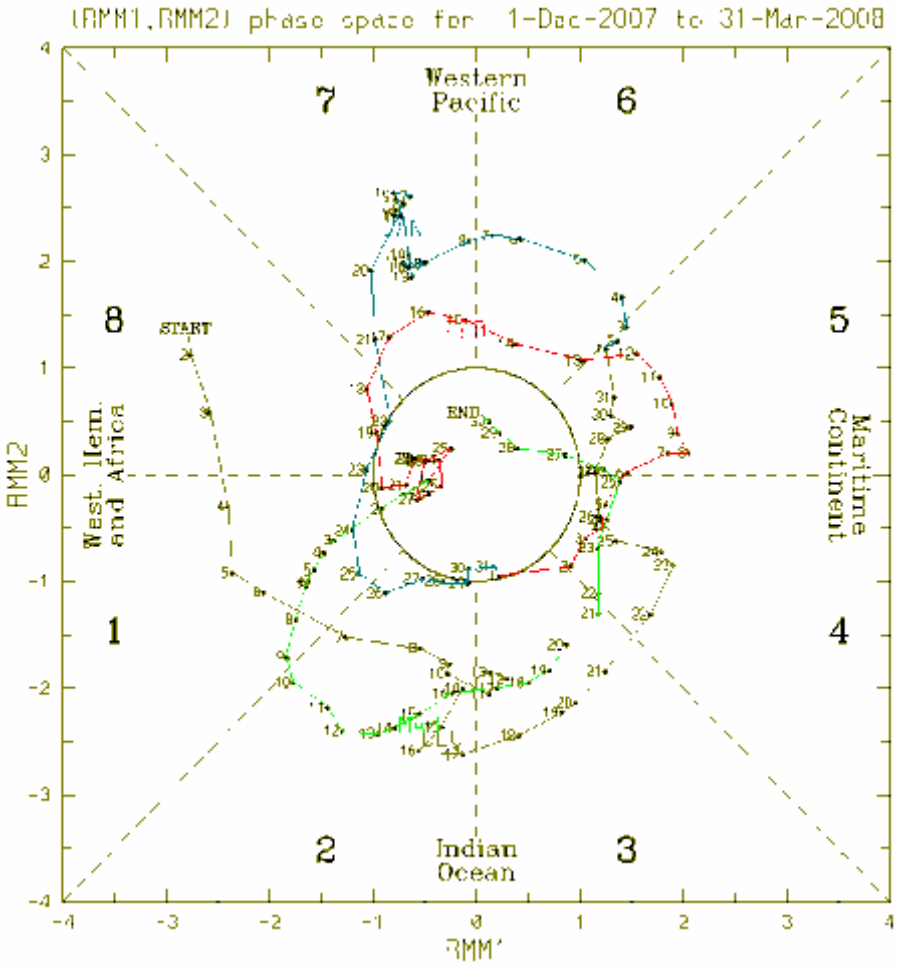
10-member sub-ensembles, 30-day mean



An elusive target: the Madden-Julian Oscillation

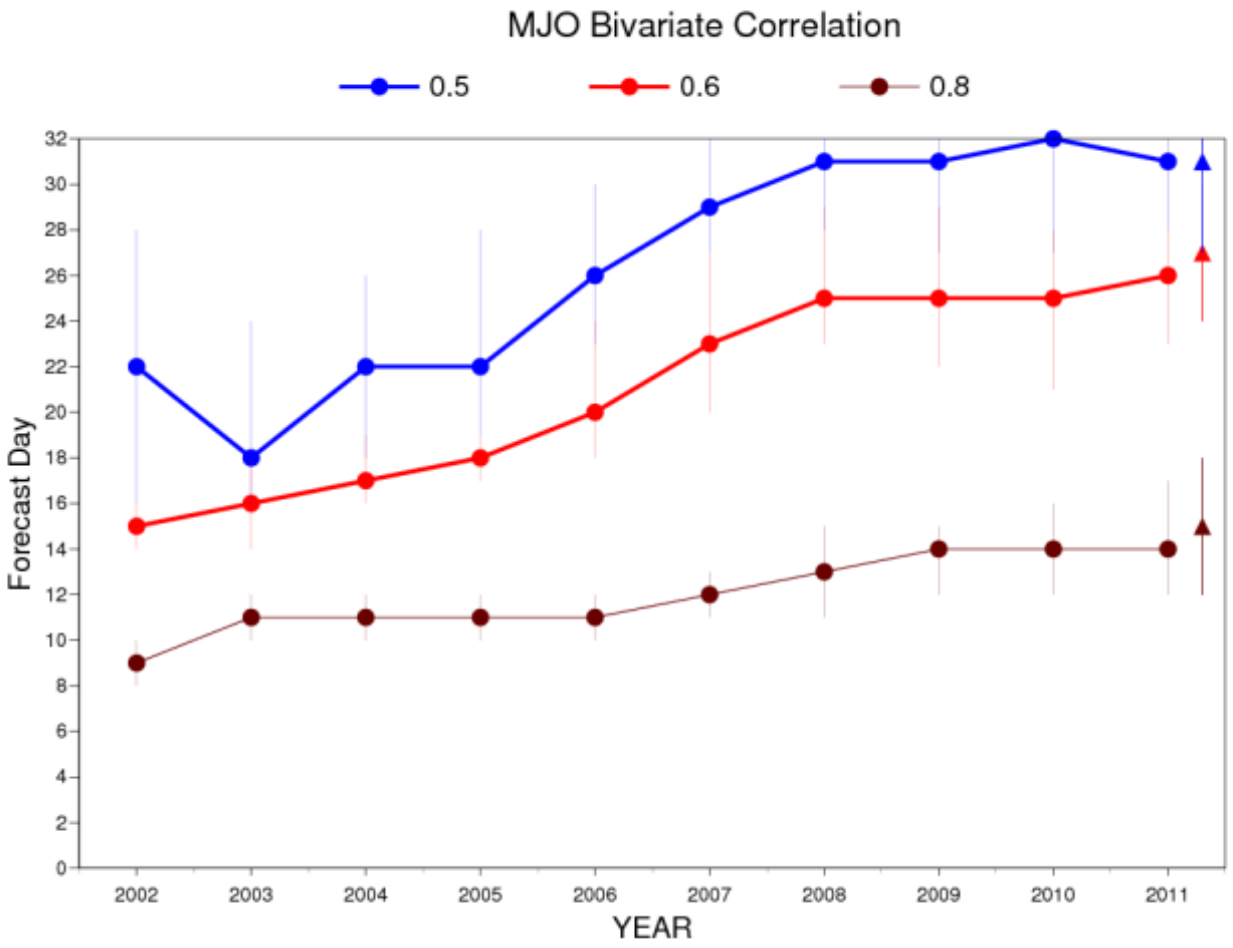
Wheeler – Hendon (2004) MJO metric based on composite EOFs





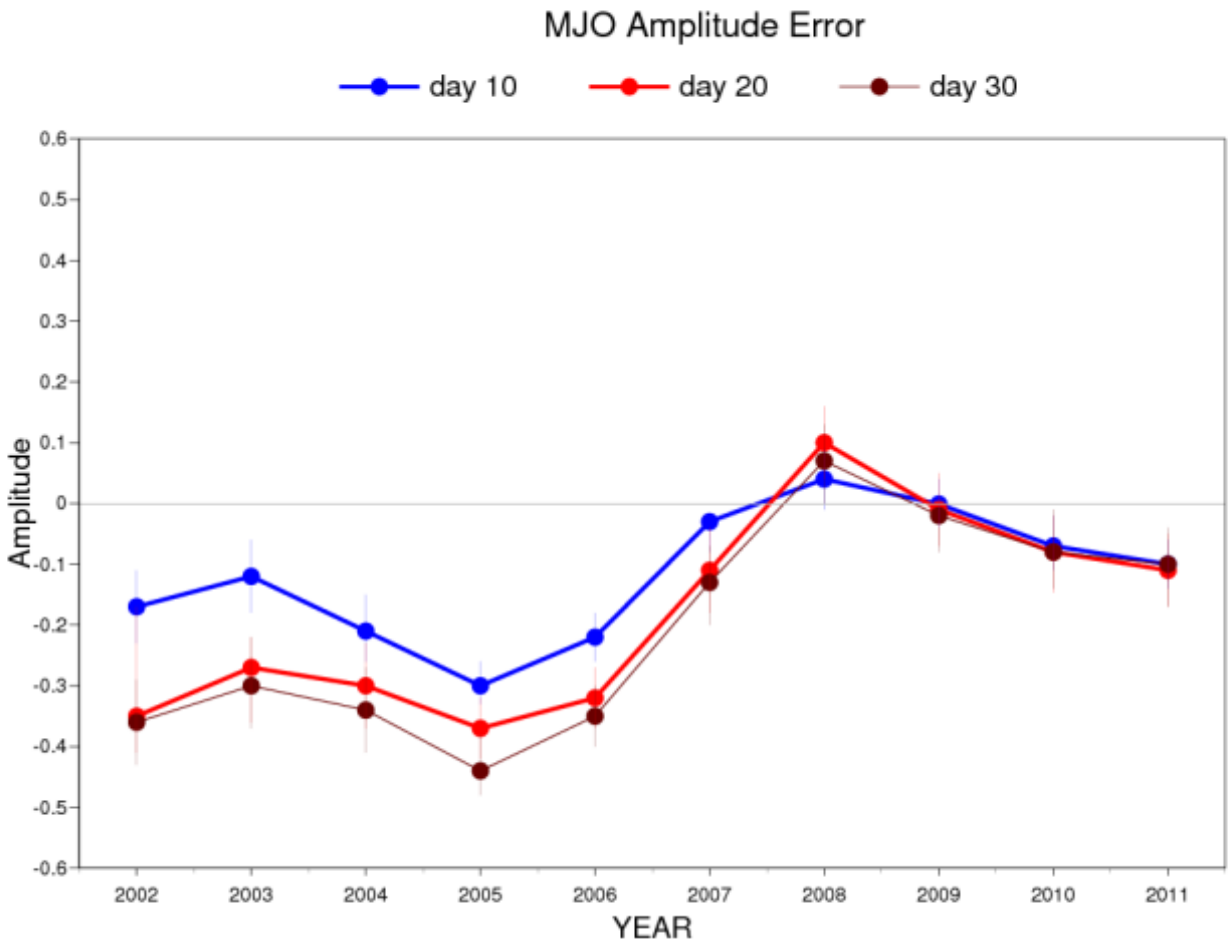
Skill of MJO predictions in monthly fc.

(from re-fc. 1995-2001)

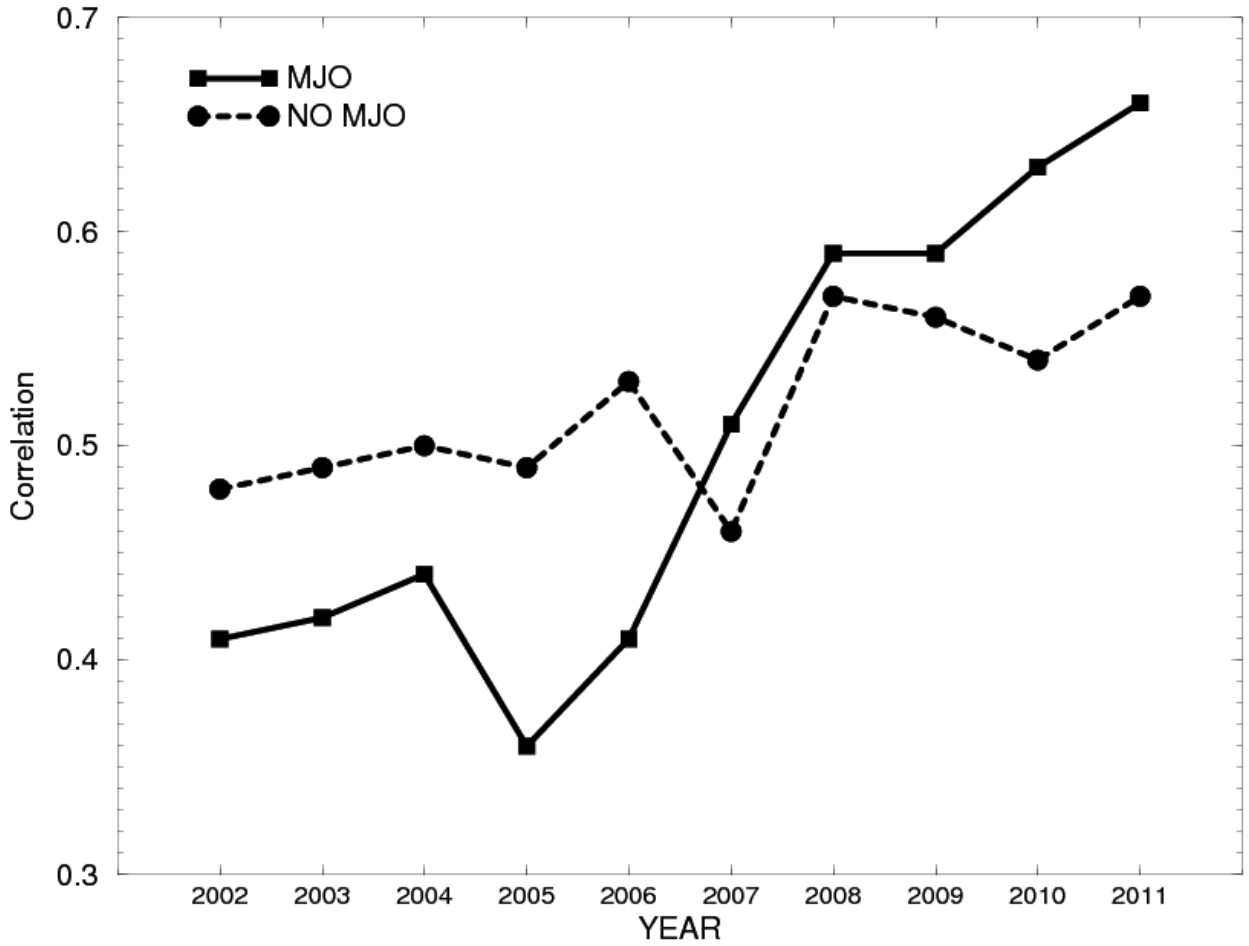


←cy38r1

MJO amplitude in monthly forecasts



Correlation of ens-mean NAO index at day 19-25



Recent progress and plans on sub-seasonal predictions at ECMWF

- Introduction cycle 40r1 (Nov. 2013) including:
  - ocean-atmosphere coupling from fc. day 0
  - Increase in IFS vertical resolution to 91 levels, top at 1 Pa
  - New NEMO version with improved upper ocean physics
  - 25 EDA perturbations, including land-sfc. component
- Extension of ENS re-forecast data set in cycle 40r3
- Increase in resolution for both the atmosphere and ocean components of the coupled model (mid 2015)

History of the ECMWF ENS re-forecasts

	March 2002	Oct. 2004	Feb. 2006	March 2008	Jan. 2010	Nov. 2011	Nov. 2013
Frequency	Every 2 weeks	Once a week					*Twice a week **
Horizontal resolution	T159 day 0-32			T319 day 0-10 T255 day 10-32		T639 day 0-10 T319 day 10-32	
Vertical resolution	40 levels Top at 10 hPa			62 levels Top at 5 hPa			91 levels Top at 1 Pa
Ocean/ atmosphere coupling	Every hour from day 0			Every 3 hours from day 10			Every 3h From day 0
Re-forecast period	Past 12 years			Past 18 years		Past 20 years	
Re-forecast size	5 members						
Initial conditions	ERA 40			ERA Interim			

Current ENS re-forecasts

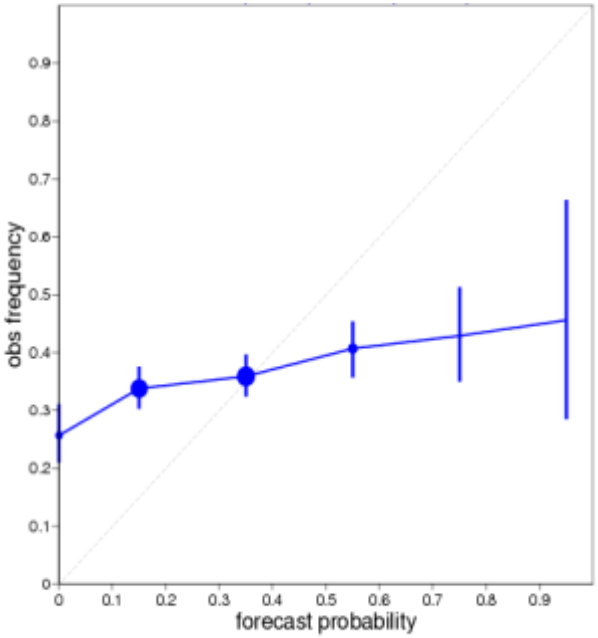
- 5-member ensemble integrated at the same day and same month as the Thursday MOFC
- 20 start dates (past 20 years)
- Initial conditions:
  - ERA Interim + offline soil re-analysis
  - ECMWF Ocean re-analysis

- Perturbations:
  - Atmosphere: Singular vectors + stochastic physics + EDA
  - Ocean: Wind stress perturbations applied during data assimilation

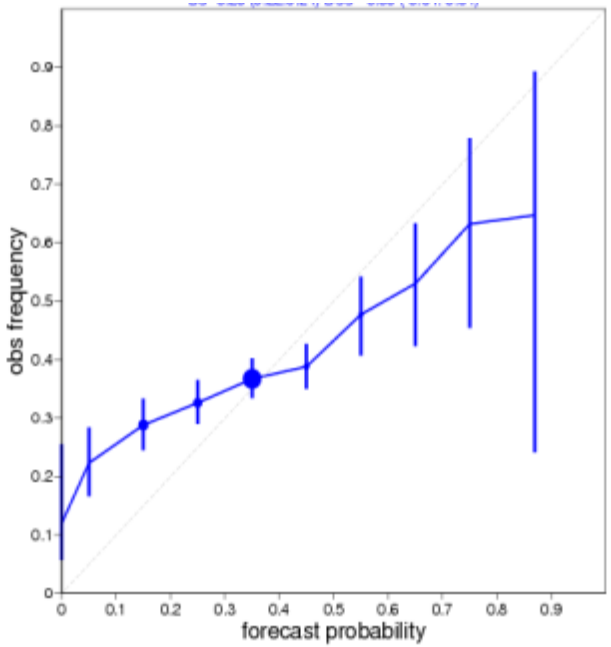
Impact of ensemble size on verification

T_2m anomalies – Day 26-32

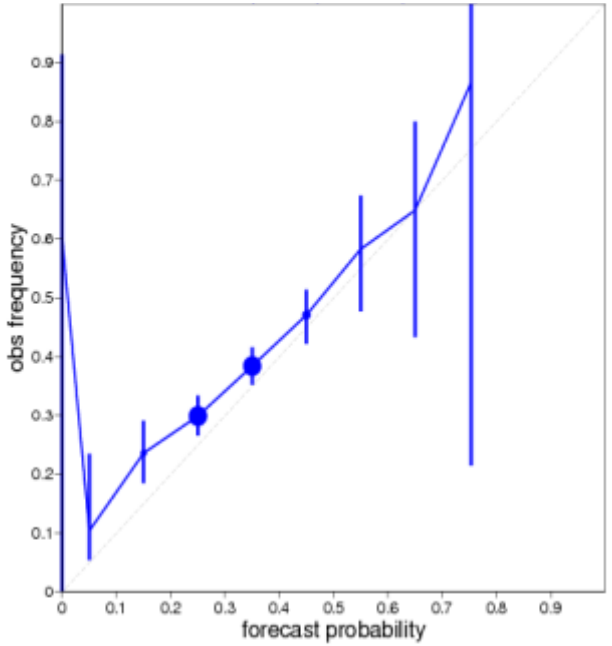
5-members



15-members



51-members



Re-forecast Extension

- 11 members instead of 5 members
- Twice a week (Mondays and Thursdays) instead of once a week (Thursdays)
- Will be implemented with cycle 40R3
- The monthly forecast calibration will use a 1-week window, with no weights applied (i.e. 3 consecutive set of re-forecasts).
- The ensemble size of the climatology used to calibrate the monthly forecasts will be 660 members (11*20*3) for both Monday and Thursday MOFC, instead of 100 (5*20) for the Thursday MOFC and 200 (2*5*20) for the Monday MOFC in the current configuration.

Increase in ENS resolution

- Current configuration:
  - IFS, leg A (day 0-10) : ~ 32 km (T639), 91 levels
  - IFS, leg B (day 10-32) : ~ 64 km (T319), 91 levels
  - NEMO: ~ 1 deg, ~ 1/3 deg. Lat. at Equator, 42 levels

- Planned configuration (for ~ 2015):
  - IFS, leg A (day 0-10) : ~ 20 km, 91 levels
  - IFS, leg B (day 10-32) : ~ 40 km, 91 levels
  - NEMO: 0.25 deg., 75 levels

Impact of hor. resolution on sub-seasonal skill

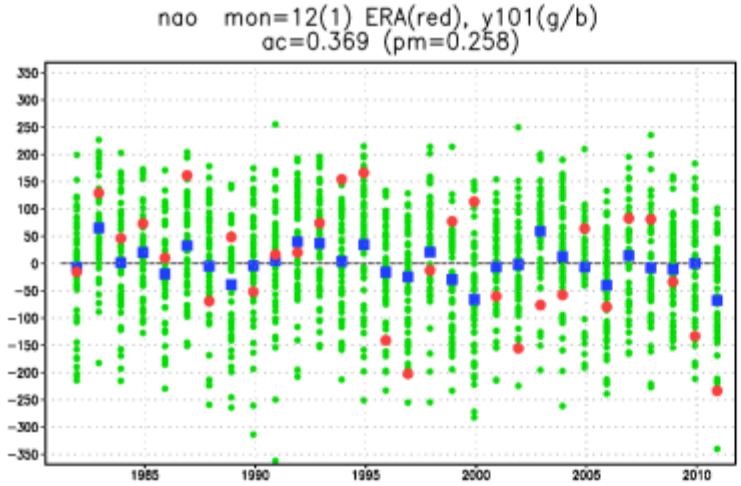
MINERVA: a COLA-ECMWF project sponsored by the NCAR Accelerated Scientific Discovery programme:

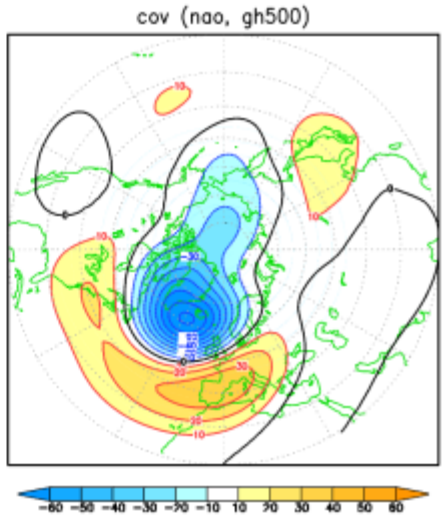
- seasonal re-forecasts at T319, T639 (30yr, May & Nov IC) and T1279 (22yr, May & Nov IC) with IFS cy38r1 + NEMO v3.1
- T319 ensembles: 51 members to 7 mn
- T639 ensembles: 51 members, 15 e.m. to 7 mn, 36 e.m. to 4 mn
- T1279 ensembles: 15 members to 4/5 mn
- run on NCAR Yellowstone HPC, 28M core-hours

NAO, Dec (month 2)

T319

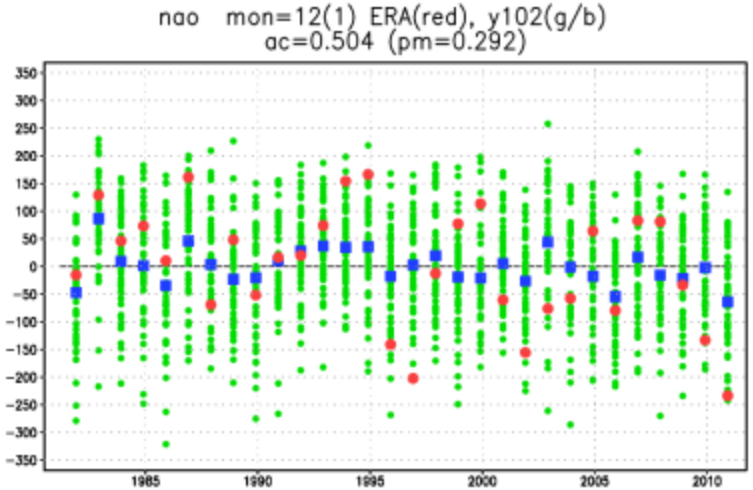
ac = 0.37

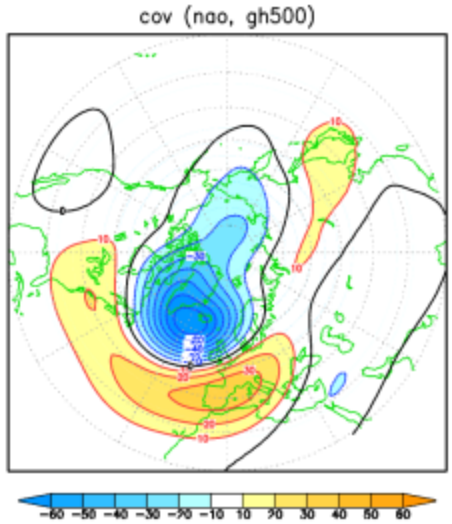




T639

ac = 0.50





The Sub-seasonal to Seasonal prediction project (S2S)

- A WMO/WWRP-WCRP joint project and one of the 3 Thorpex-legacy projects
- 5-year project, started in Nov 2013.
- Project office: KMA in Jeju island.

Mission Statement

- "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"

The project will focus on the forecast range between 2 weeks and a season

Research areas :

Service-oriented research

Societal and economic research applications (SERA)

Verification

Underpinning research

Sources of predictability :
Teleconnections, MJO, Monsoon, Stratosphere, Snow/sea-ice/soil moisture …

Modelling

Resolution, Initial conditions, ensemble generation, ocean-atmosphere coupling, systematic errors

S2S Subprojects

- Monsoons
  – e.g., predicting the timing of monsoon onsets, and active/break phases, all monsoons
- MJO
  – Passage over the Maritime Continent and its interaction with the diurnal cycle of rainfall over islands (w/MJO-TF/GEWEX GASS); air-sea interaction
- Africa
  – link to CBS & SERA; weather-within-climate; rain-fed agriculture; capacity building
- Extreme Weather
  – Predictability of extreme events (heat/cold waves, drought, tropical cyclones..)
  – develop a metric
  – case studies
- Verification
  – Recommended set of metrics & datasets for verifying S2S forecasts; provide guidance on verification topics to be researched, including methods for probabilistic predictions.

S2S Database

- Same protocol as for TIGGE.
- Daily real-time forecasts + re-forecasts
- 3 weeks behind real-time
- Common grid (1.5 x 1.5 degree)
- Variables archived: most of TIGGE variables + ocean variables and stratospheric levels + soil moisture/temperature
- ECMWF will be a main archiving centre. UKMO will archive a subset of the data (Climate Cloud)
- Data archiving will start end of 2014.

Sub-seasonal real-time Operational Forecasts

	Time-range	Resol.	Ens. Size	Freq.	Hcsts	Hcst length	Hcst Freq	Hcst Size
ECMWF	D 0-32	T639/319L62	51	2/week	On the fly	Past 18y	weekly	5
UKMO	D 0-60	N96L85	4	daily	On the fly	1989-2003	4/month	3
NCEP	D 0-60	N126L64	16	daily	Fix	1999-2010	daily	4
EC	D 0-35	0.6x0.6L40	21	weekly	On the fly	Past 15y	weekly	4
CAWCR	D 0-120	T47L17	33	weekly	Fix	1989-2010	3/month	33
JMA	D 0-34	T159L60	50	weekly	Fix	1979-2009	3/month	5
KMA	D 0-30	T106L21	20	3/month	Fix	1979-2010	3/month	10
CMA	D 0-45	T63L16	40	6/month	Fix	1982-now	monthly	48
Met.Fr	D 0-60	T63L91	41	monthly	Fix	1981-2005	monthly	11
SAWS	D 0-60	T42L19	6	monthly	Fix	1981-2001	monthly	6
HMCR	D 0-60	1.1x1.4 L28	10	monthly	Fix	1979-2003	monthly	10

Summary

- Experimental sub-seasonal forecasts at ECMWF started 30 years ago, with operational implementation in 2004; recent changes in model physics have substantially improved their skill.
- Apart from a change in IFS hor. resolution at day 10, medium-range and monthly ensemble forecasts at ECMWF are run in a seamless way using a coupled ocean-atmosphere model.
- The increase of re-forecast ensemble size (planned for late 2014) will improve estimates of reliability and predictive skill obtained from the re-forecast set, and provide a larger data set for calibration.
- Results of MINERVA runs suggest that the increase in IFS resolution planned for 2015 is likely to have a positive effect on extra-tropical fc. skill in the sub-seasonal range.
- ECMWF has taken a leading role in the WWRP/WCRP S2S project: project co-chair (F. Vitart), implementation of S2S archive.
- The S2S database will extend the benefits of TIGGE to the sub-seasonal range and allow multi-model predictability studies using state-of-the-art operational ensemble forecast systems.