Sub-seasonal prediction at ECMWF:

present, past (recent and less recent) and future

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With contributions from :

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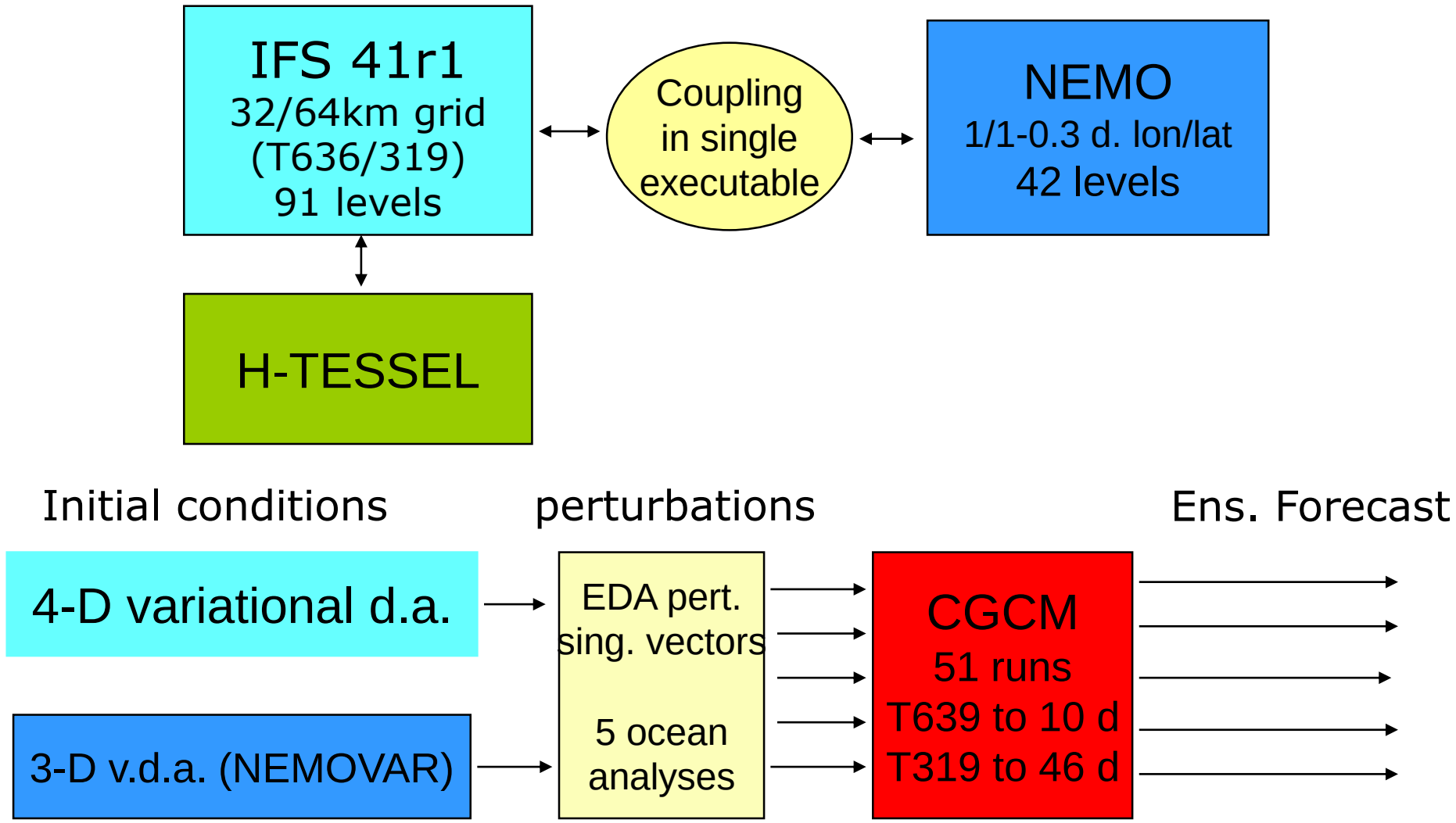
The ECMWF ensemble prediction system for the medium and sub-seasonal range



Evolution of the ECMWF sub-seasonal ensemble forecasts

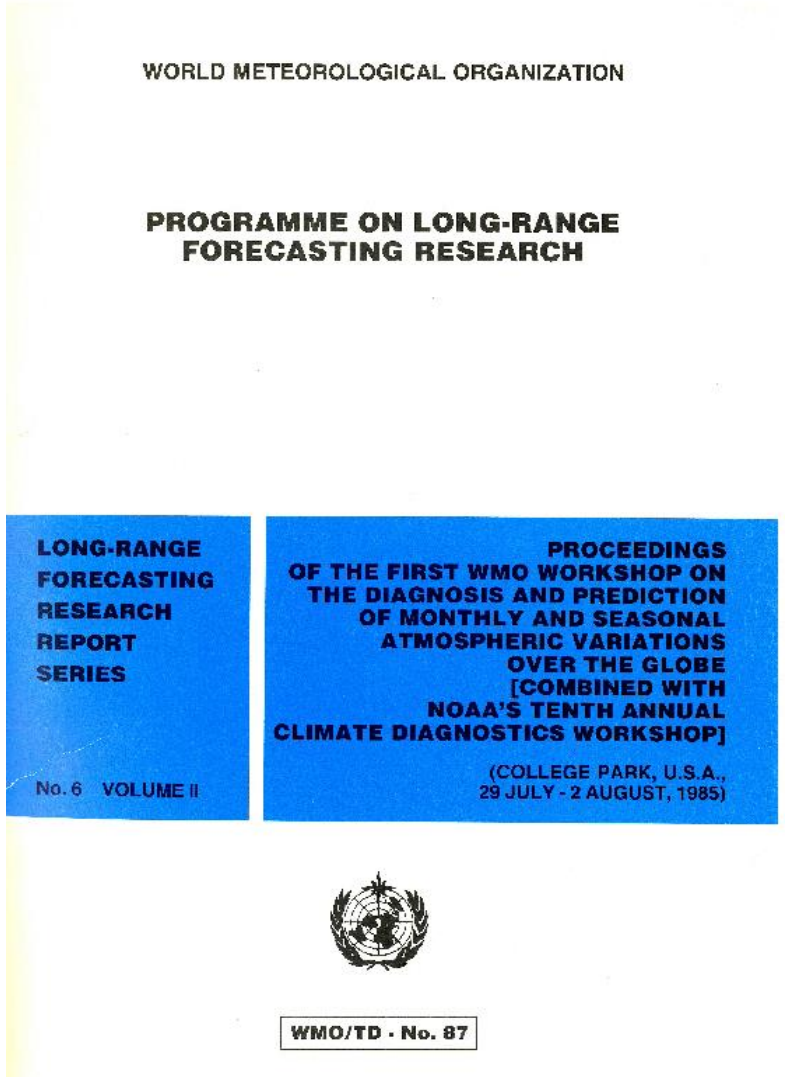
	Mar2002	Oct2004	Feb2006	Mar2008	Jan2010	Nov2011	Nov2013	May2015
Frequency	Every 2 weeks		Once a week			Twice a week		
Horizontal resolution	T159 day 0-32			**T319 day 0-10 T255 day 10-32**		T639 day 0-10 T319 day 10-32		T639 day 0-10 T319 **day 10-46**
Vertical resolution	40 levels Top at 10 hPa		62 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, once a week							**11 members, twice a week**
Initial conditions	ERA 40			ERA Interim				

First report to the international community

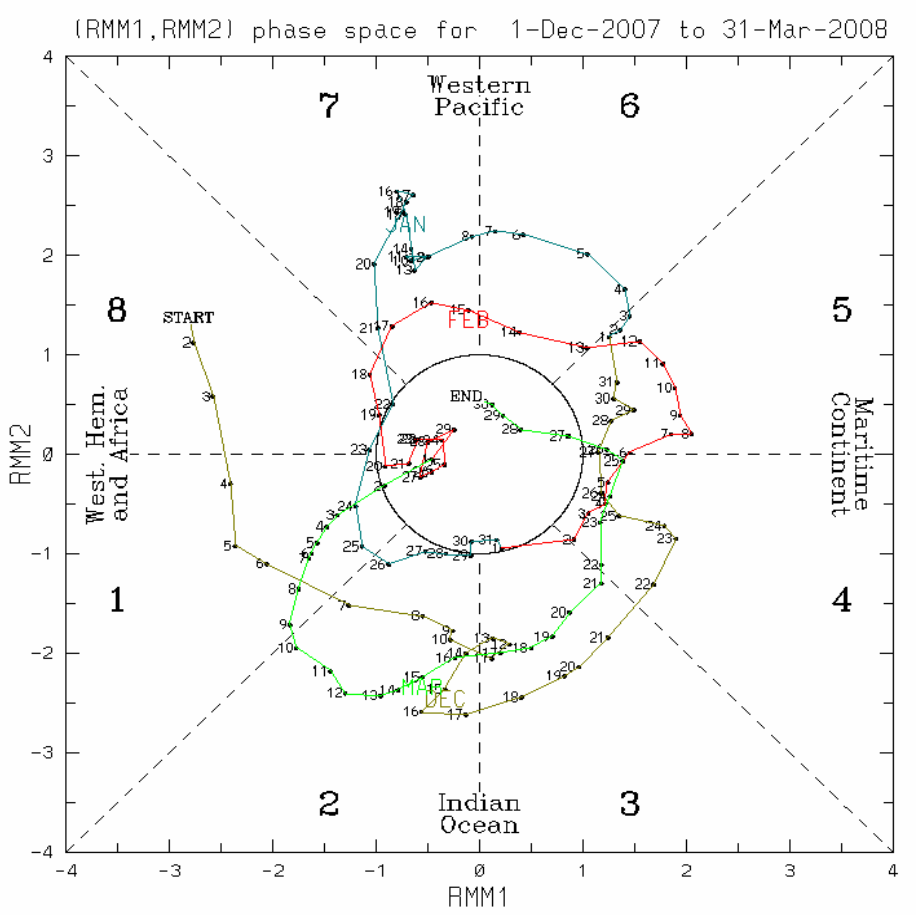
- Cubasch, Tibaldi, Molteni: Deterministic extended-range forecast experiments using the global ECMWF spectral model

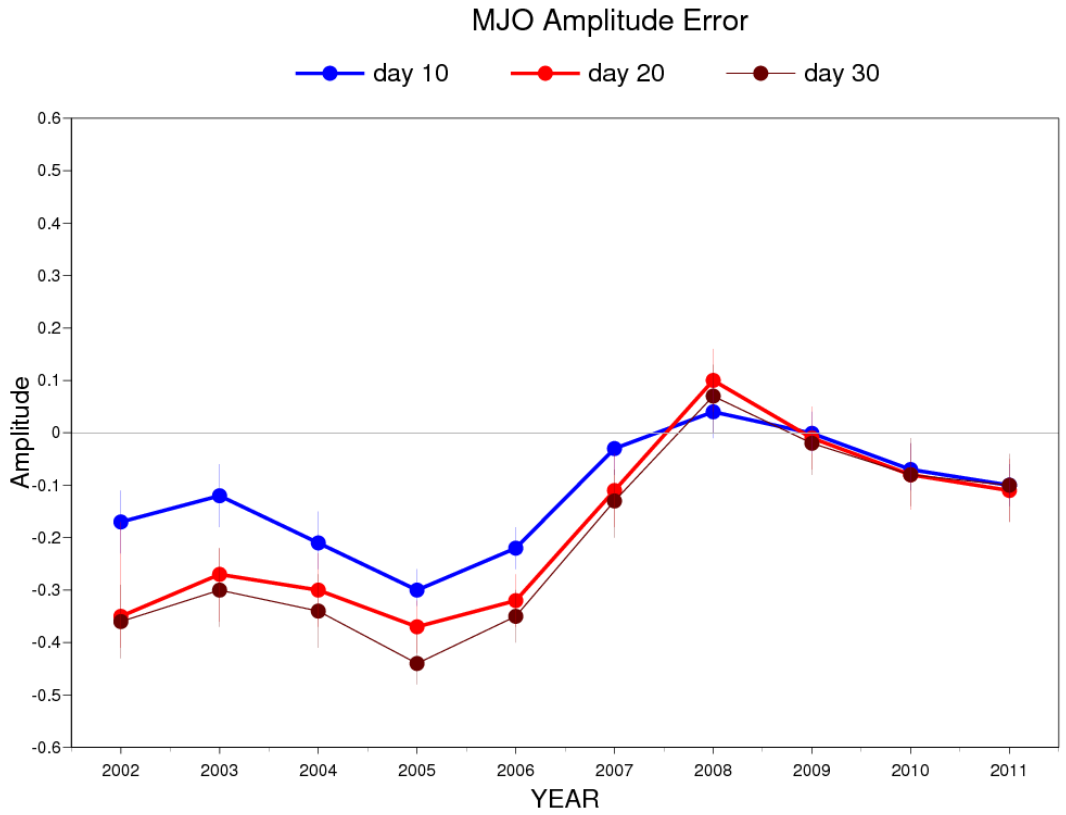
- Molteni, Cubasch, Tibaldi: Experimental monthly forecasts at ECMWF using the lagged-average forecasting technique

- 4 case studies in winter 1983/84
- 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



A success story: forecasting the Madden-Julian Oscillation

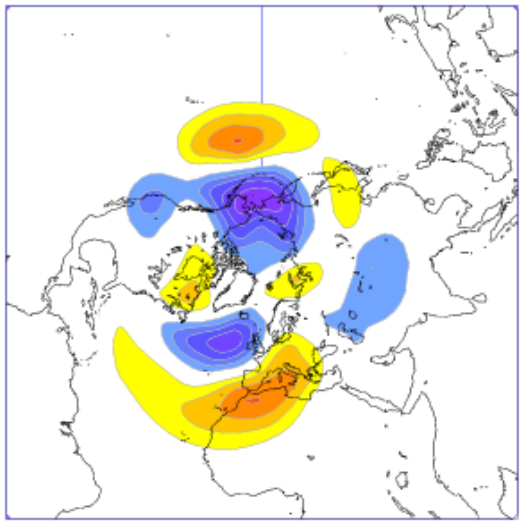




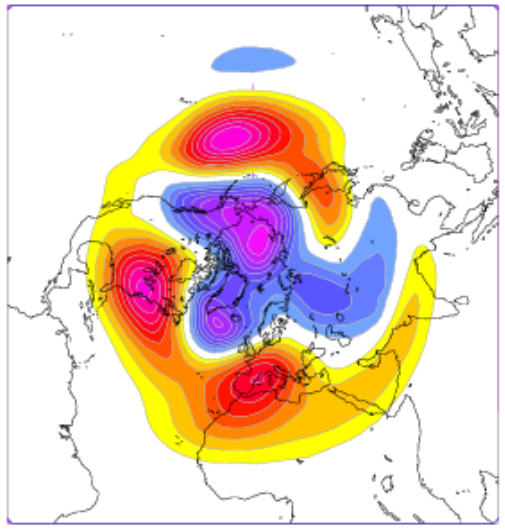
MJO teleconnections in October-March

500 hPa height, MJO phase 3 + 10 days

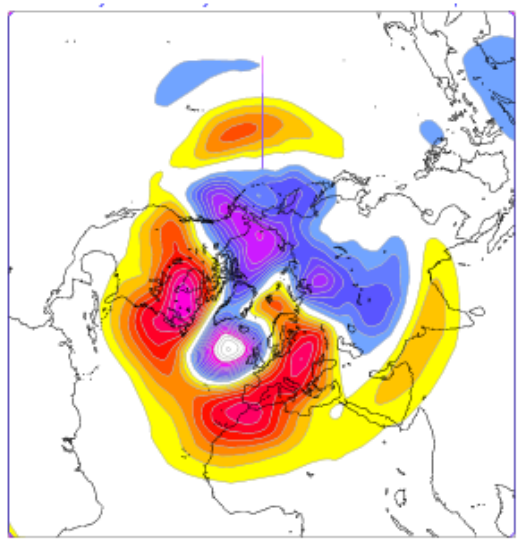
2002 MOFC hindcasts



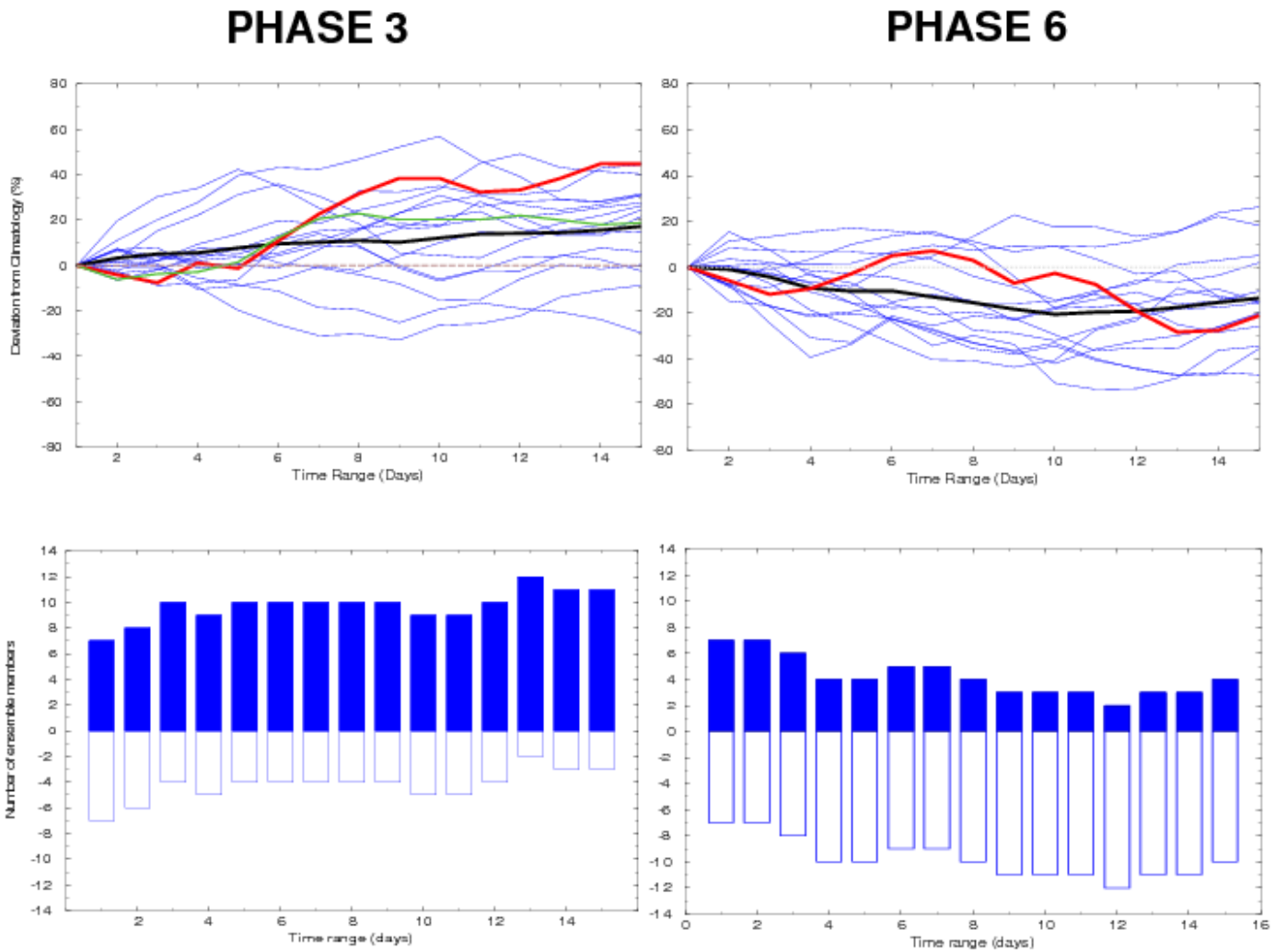
2011 MOFC hindcasts



ERA Interim

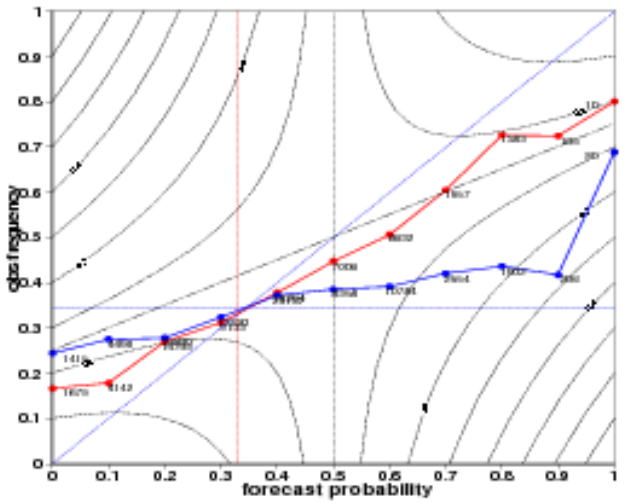


Impact of MJO on NAO+ frequency in 46-day EPS

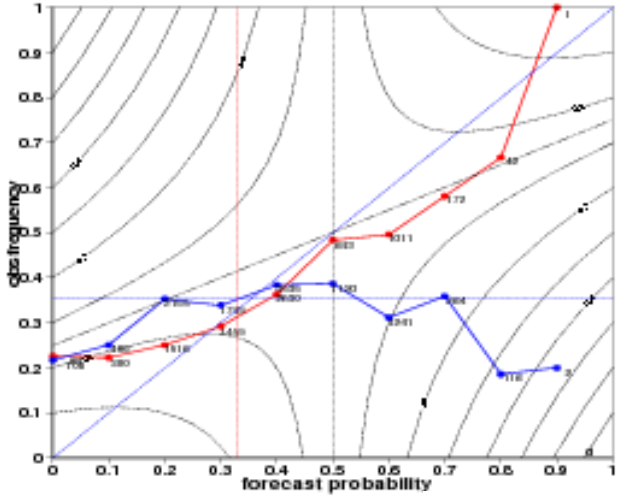


Impact of MJO on forecast reliability

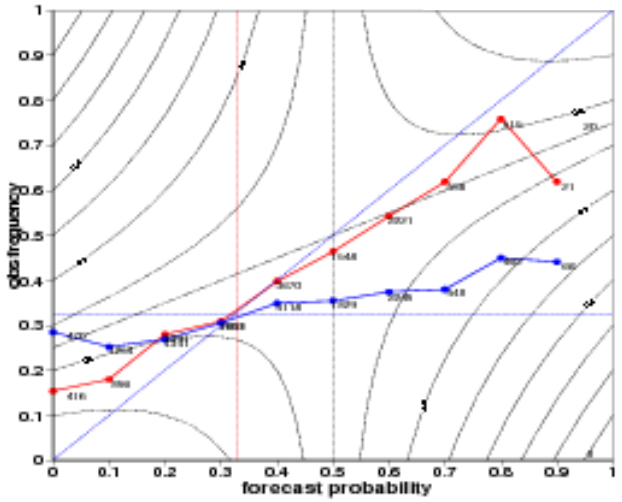
Northern Extratropics



Europe:



North America:



T_850 > upper tercile,
fc. day 19-25

Blue line: no MJO in IC

Red line: MJO in IC

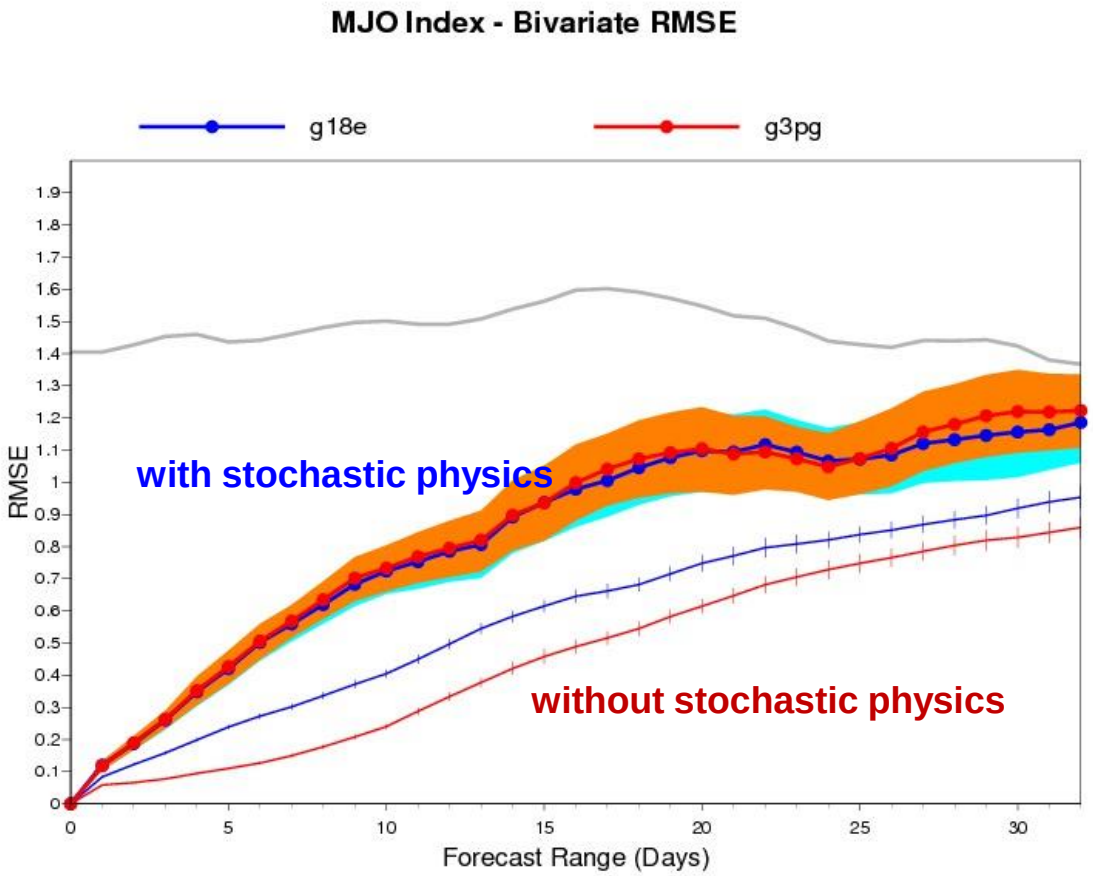
Impact of stochastic physical tendencies on MJO forecast skill

Model cycle: 40R1

Resolution: T399/T255 L91

Hindcast ensemble: 32-day forecasts initialised on 1st Feb/May/Aug/Nov 1989-2008 with 11 ensemble members

Stochastic physics: 3-scale SPPT and SKEB as in operation



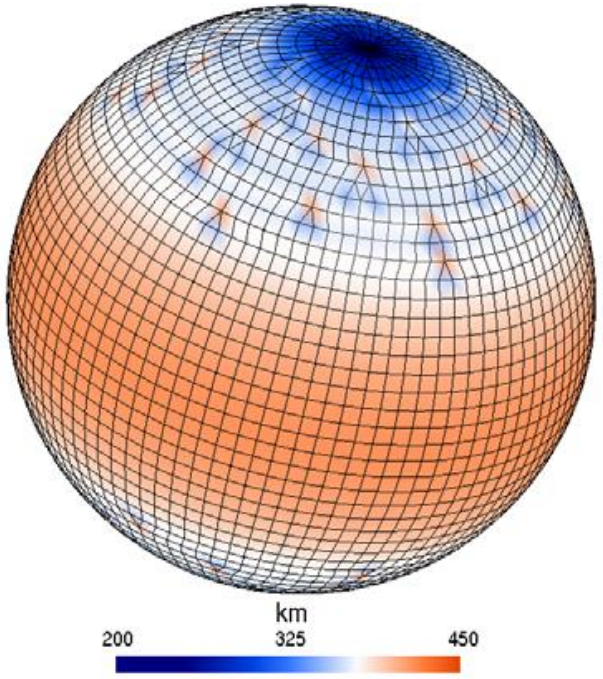
Significant increase in ensemble spread

→ Improved reliability

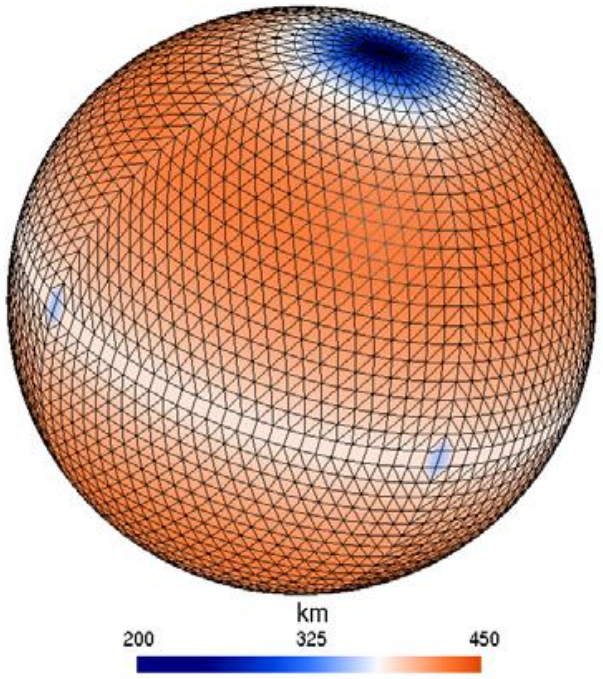
→ Improved probabilistic forecast scores

Grid mesh/resolution and sp. harmonic truncation in spectral models

Linear grid: spectral truncation N-1, 2N grid points at the equator
Quadratic grid: spectral truncation N-1, 3N grid points at the equator
Cubic grid: spectral truncation N-1, 4N grid points at the equator



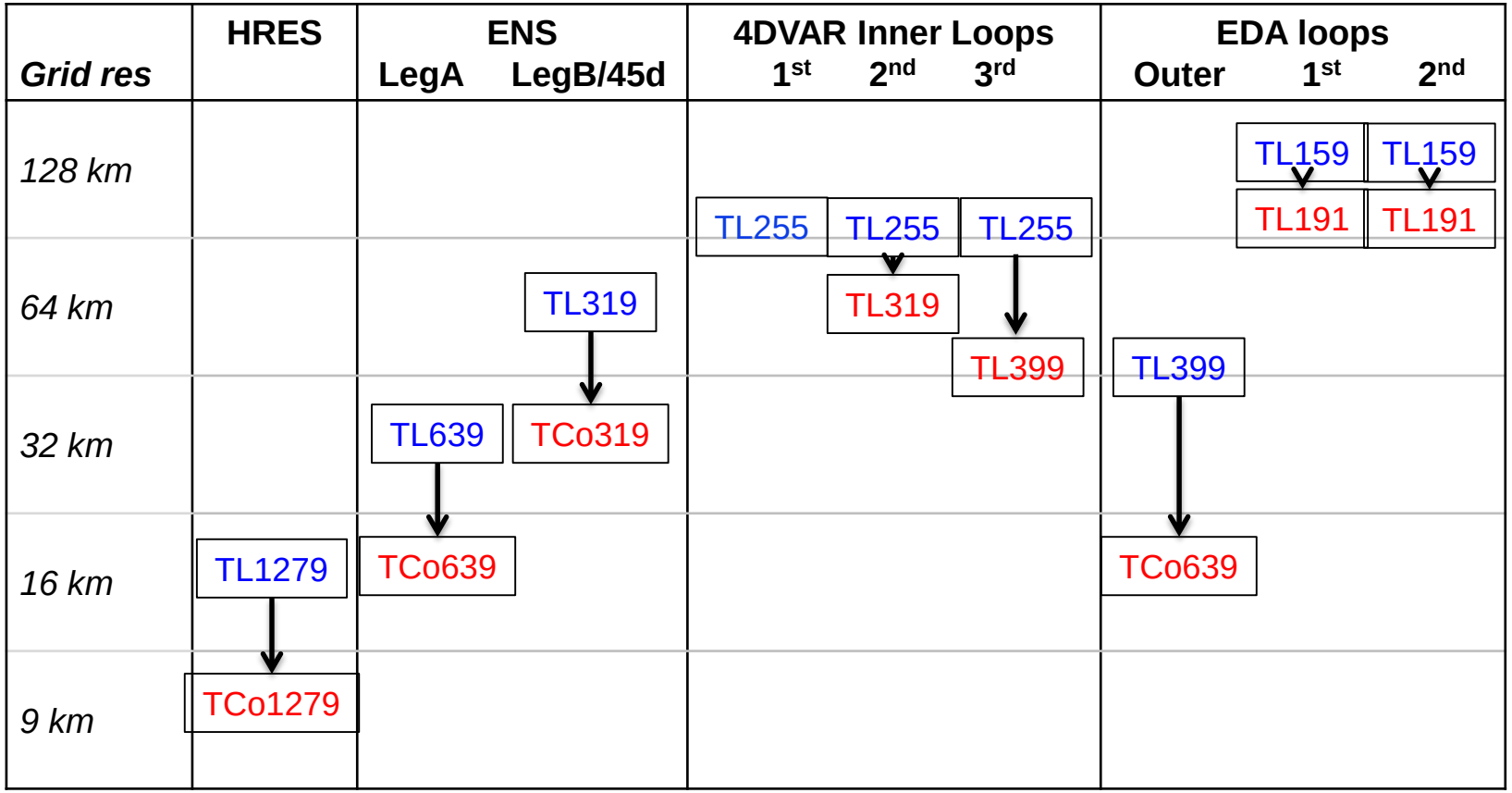
“Reduced” grid:
No. of points in longitude decreases in steps



Octahedral grid:
No. of points in longitude decreases continuously

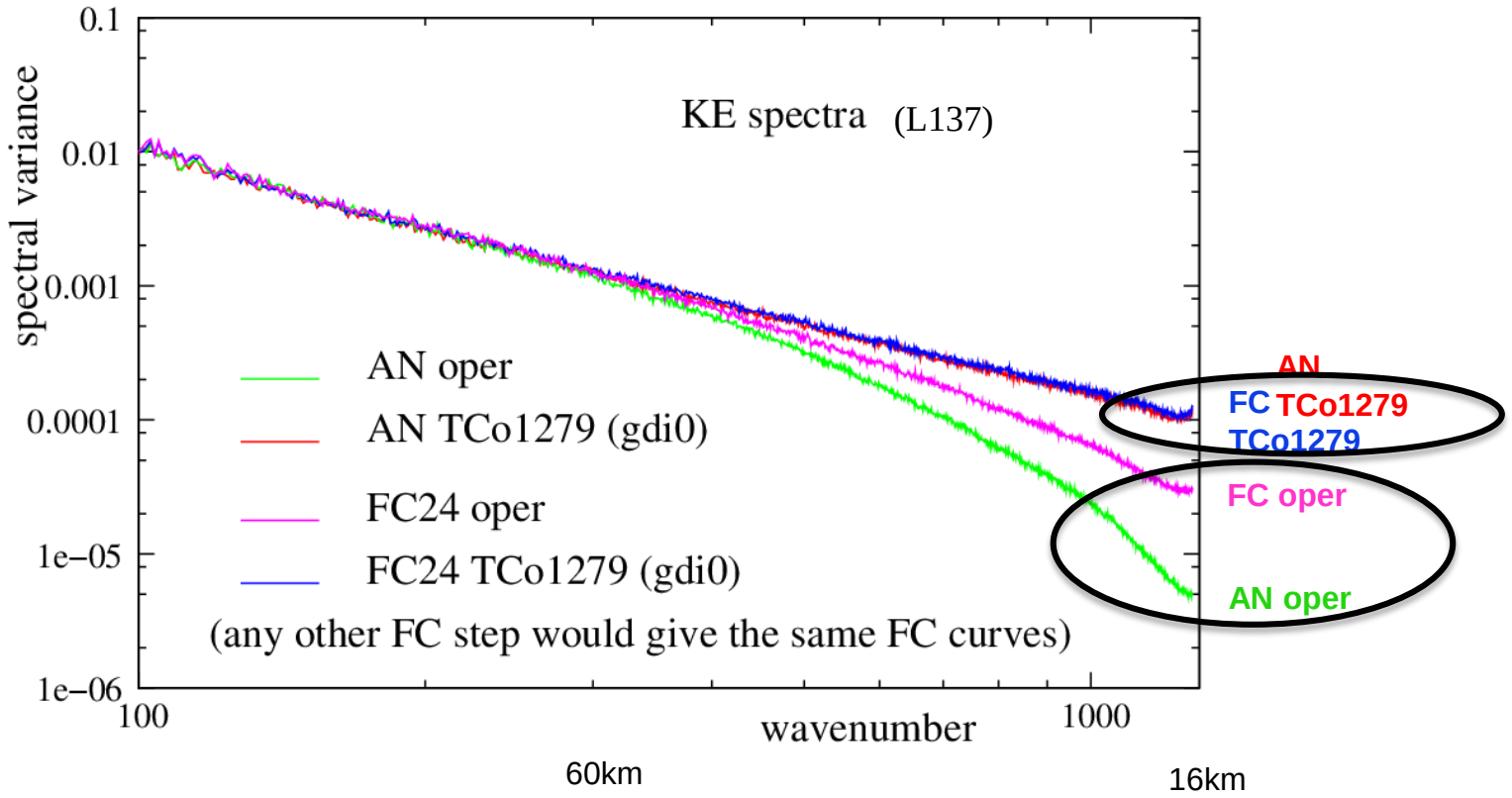
2016 atmos resolution upgrade: 41r1 → 41r2

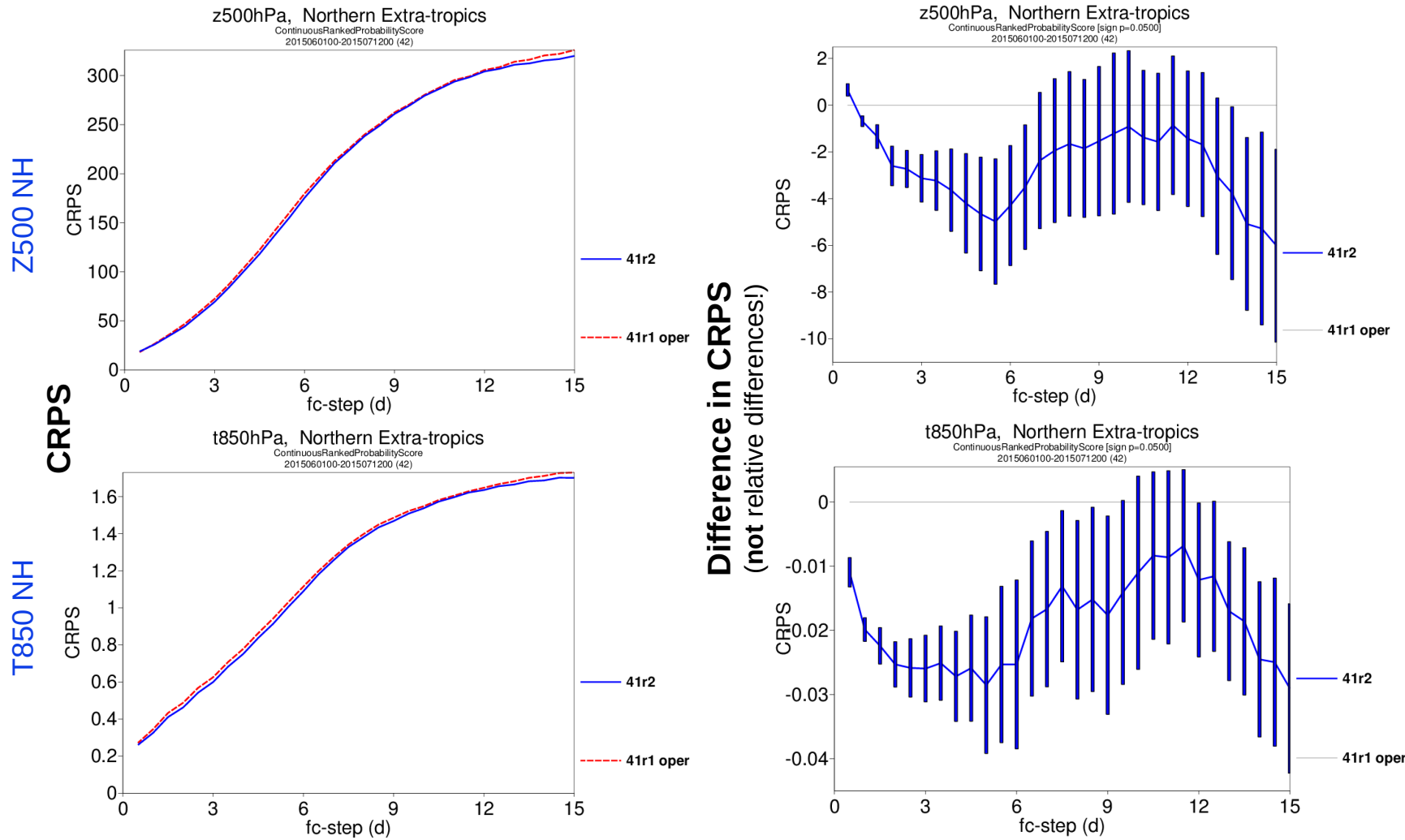
from linear (L) grid to cubic octahedral (Co) grid



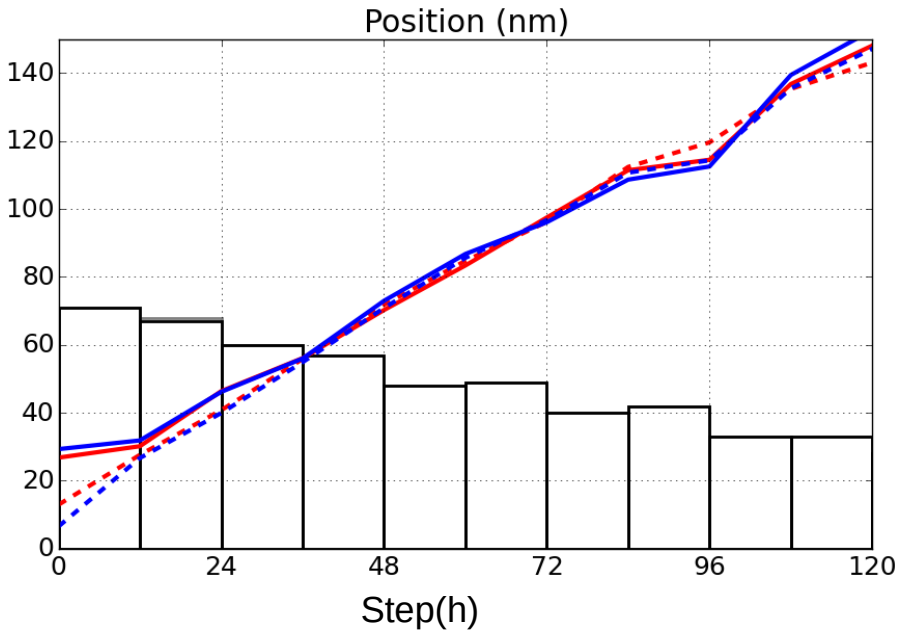
Ocean model in ENS (NEMO): from 1.0º /42 lev to 0.25º /75 lev in late 2016

KE spectra for Oper (TL1279) and TCo1279

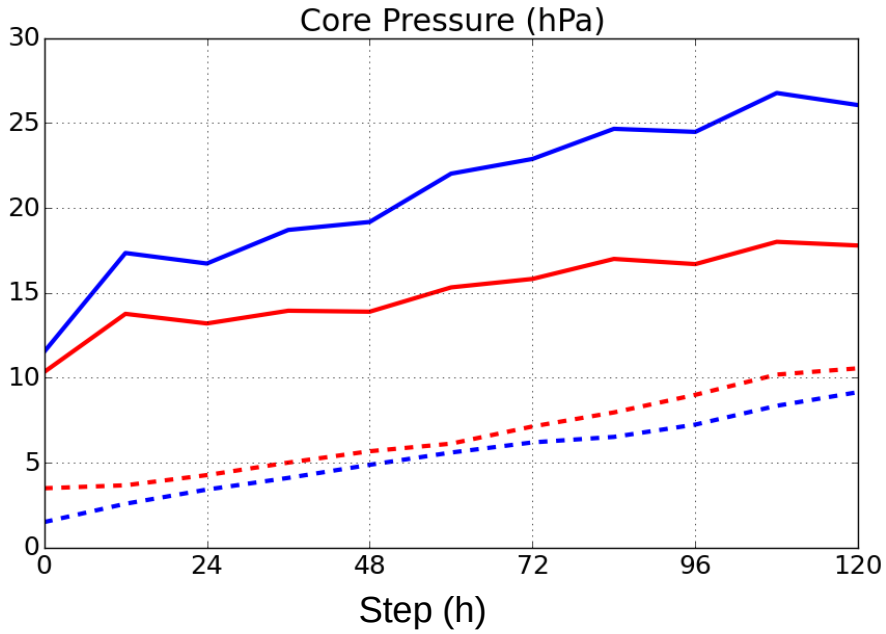



CRPS
Z500 NH
z500hPa, Northern Extra-tropics
ContinuousRankedProbabilityScore
2015060100-2015071200 (42)
CRPS
fc-step (d)
41r2
41r1 oper
T850 NH
t850hPa, Northern Extra-tropics
ContinuousRankedProbabilityScore
2015060100-2015071200 (42)
CRPS
fc-step (d)
41r2
41r1 oper
Difference in CRPS
(not relative differences!)
z500hPa, Northern Extra-tropics
ContinuousRankedProbabilityScore [sign p=0.0500]
2015060100-2015071200 (42)
CRPS
fc-step (d)
41r2
41r1 oper
t850hPa, Northern Extra-tropics
ContinuousRankedProbabilityScore [sign p=0.0500]
2015060100-2015071200 (42)
CRPS
fc-step (d)
41r2
41r1 oper

ENS 41r2 TCo639 vs 41r1 TL639: TC position and intensity

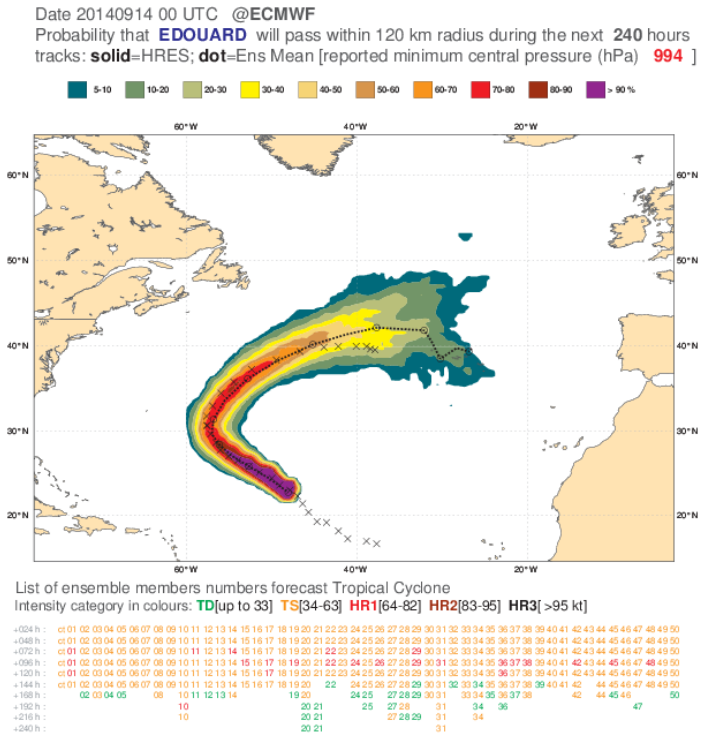


41r1 Oper Position RMSE (Solid)
41r1 Oper Position Spread (Dashed)
41r2 Position RMSE (Solid)
41r2 Position Spread (Dashed)
Bars : Sample size

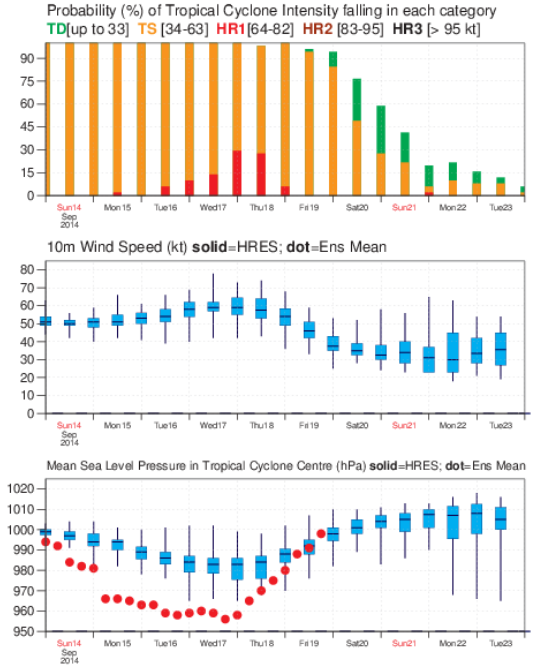


41r1 Oper Intensity RMSE (Solid)
41r1 Oper Intensity Sperad (Dashed)
41r2 Intensity RMSE (Solid)
41r2 Intensity Spread (Dashed)
Same sample size as for position plot

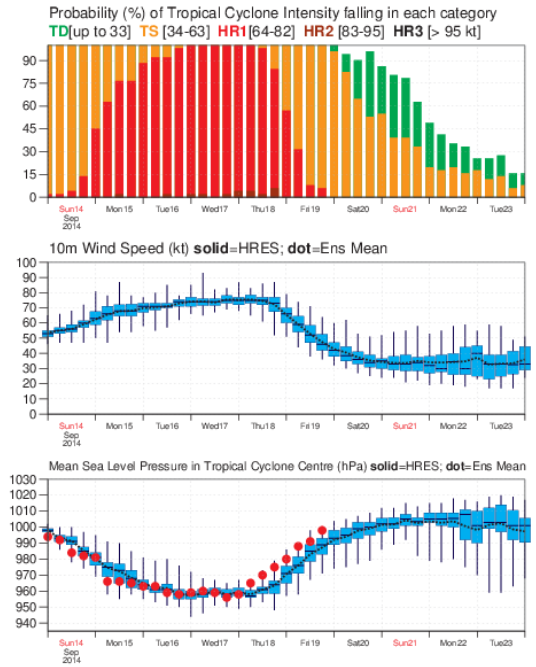
Tropical Cyclones: ENS TL639 → TCo639



TL1279 An
TL399 EDA



TL639 ENS

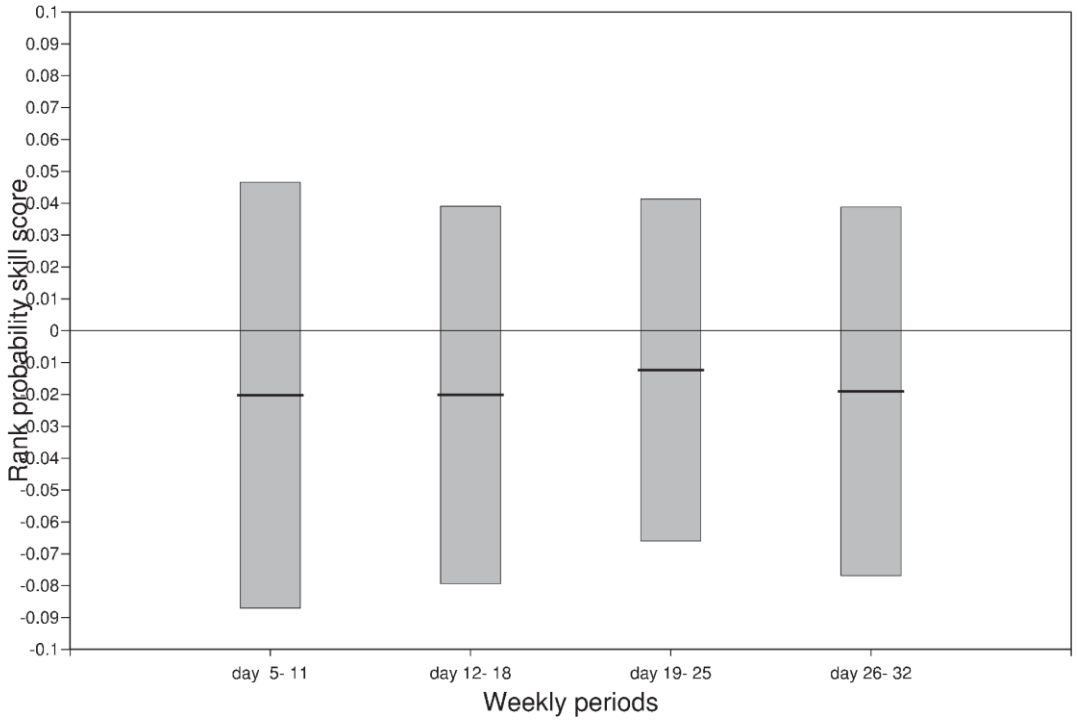


TCo639 ENS

Impact of resolution upgrade on sub-seasonal scores

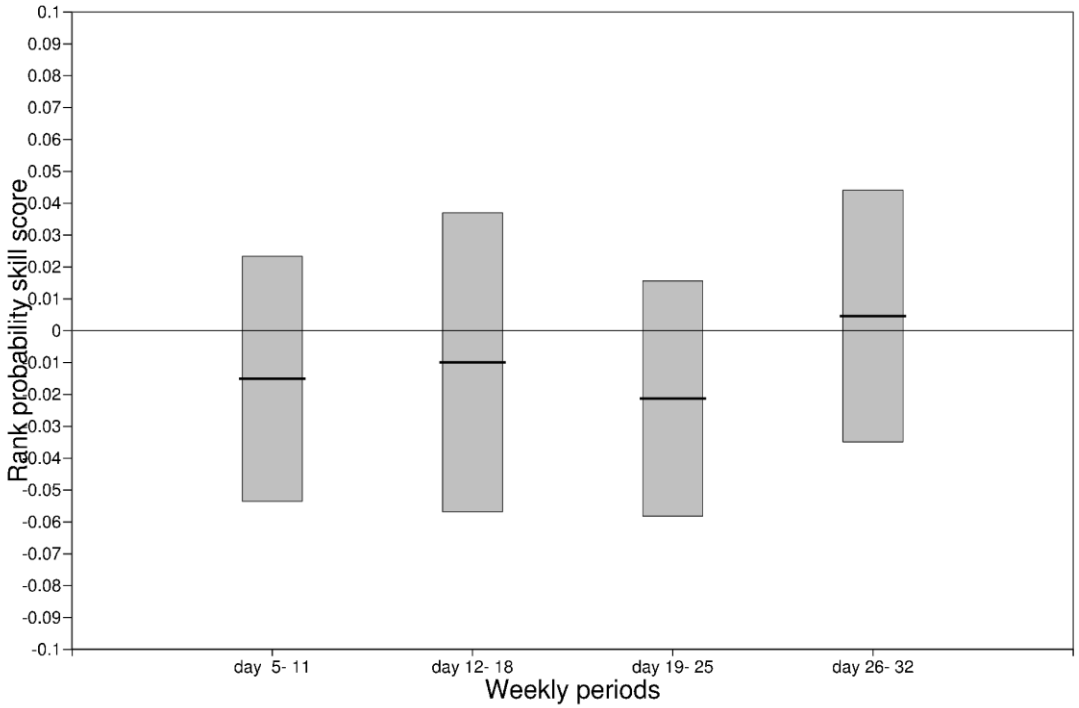
Rank probability skill score
g7v0-g7v2
Total Precipitation

Weekly periods
Tropics
30.0:-30.0:-180.:180.



Rank probability skill score
g7v0-g7v2
Z500

Weekly periods
Northern Extratropics
87.5:30.0:-180.0:180.0

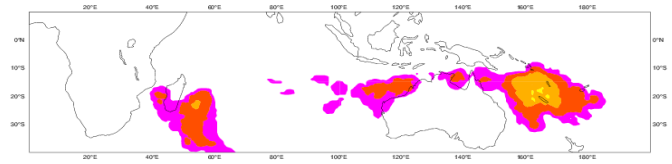


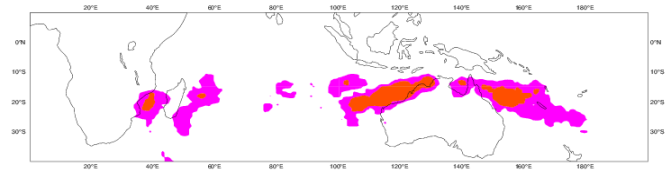
Impact of resolution on track probability- Tropical cyclone PAM, 9-15/03/ 2015

Day 12-18

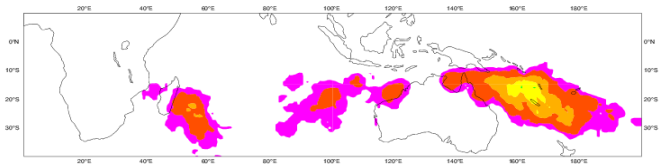
Day 19-25

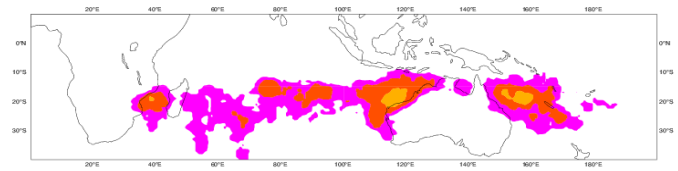
Oper
TL639/319



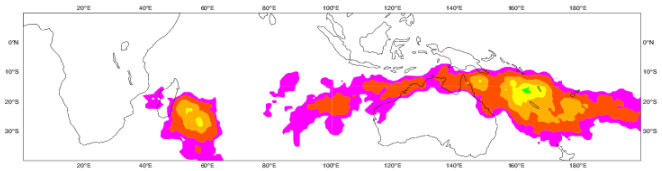


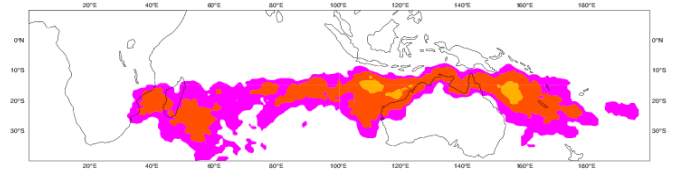
High
Tco639/319



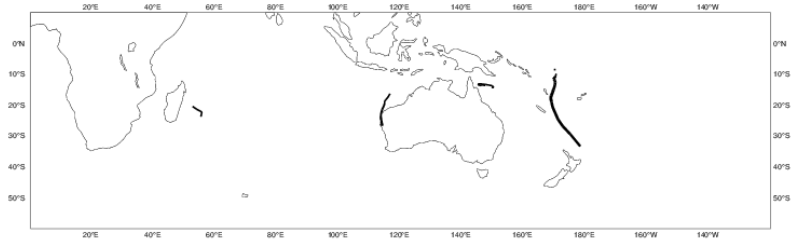


Tco639





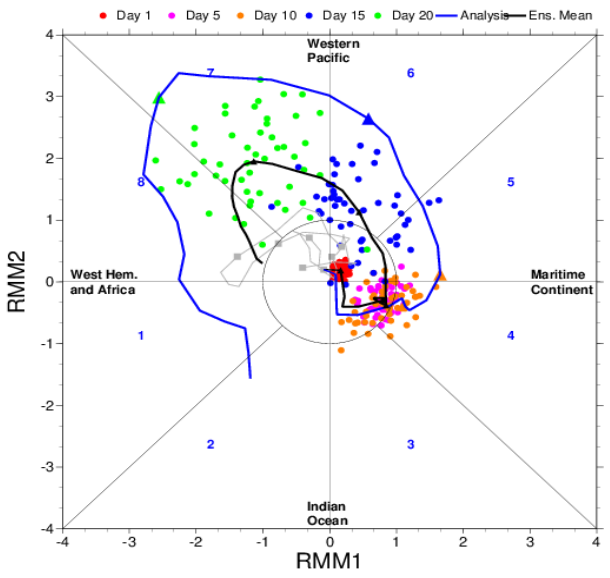
< 10% | 10.. 20 | 20.. 30 | 30.. 40 | 40.. 50 | 50.. 60 | 60.. 70 | 70.. 80 | 80.. 90 | > 90%



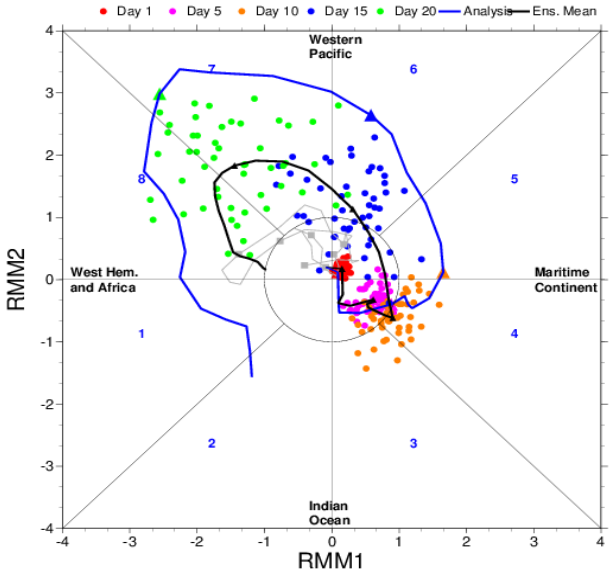
Observed track

MJO event, 26/02/2015

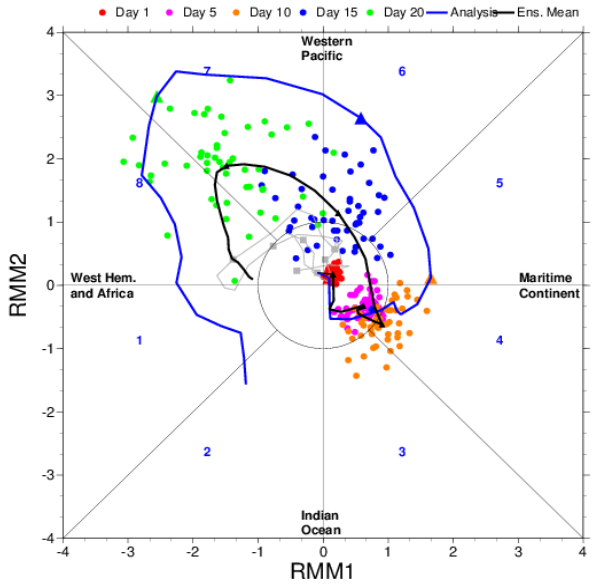
OPER



Tco639/ 319

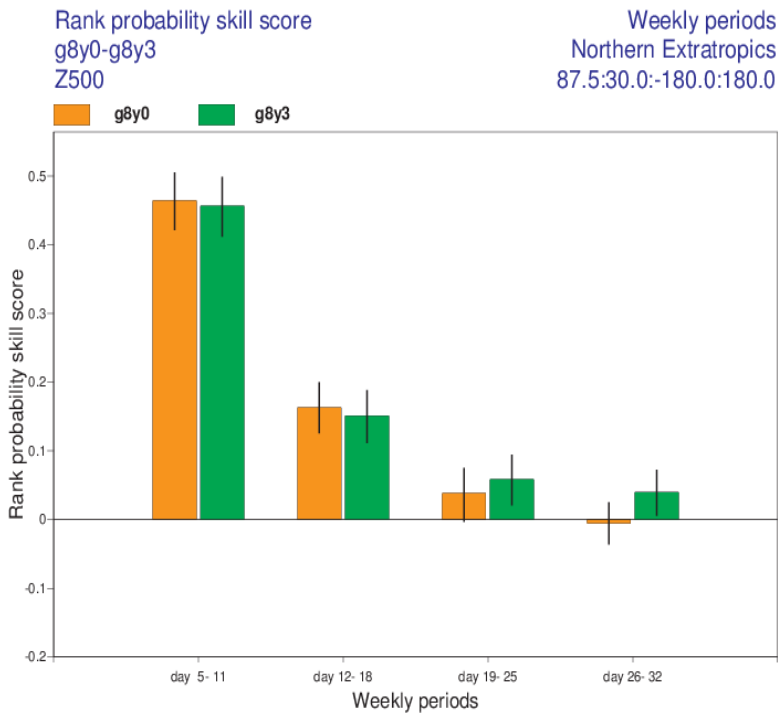


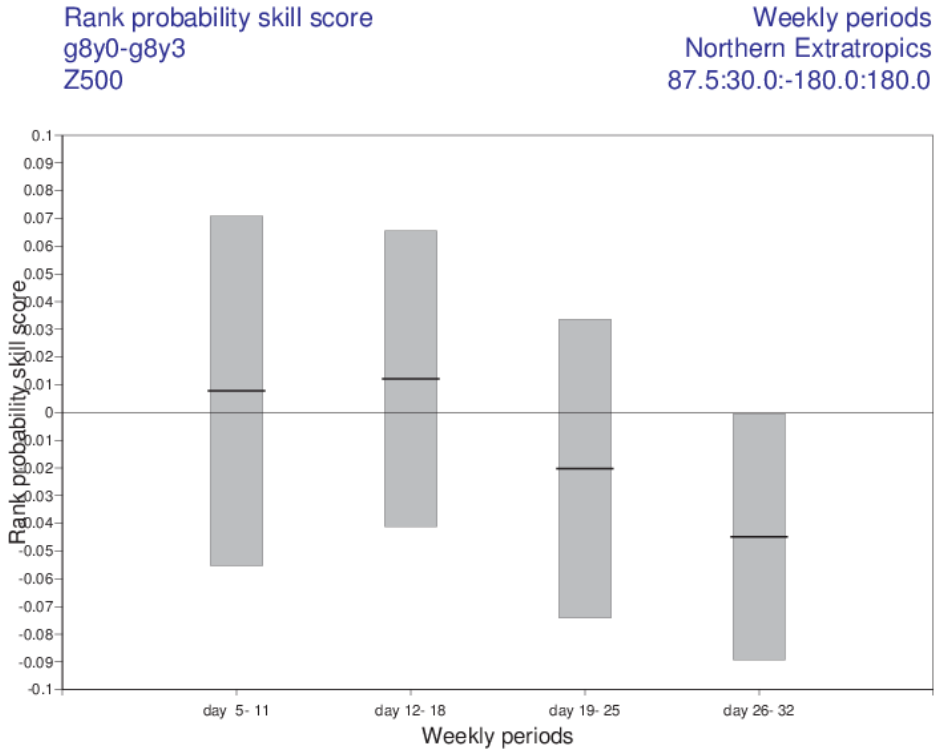
Tco639



New higher-resolution ocean model

1/4 vs 1 degree – Z500 skill scores -NH

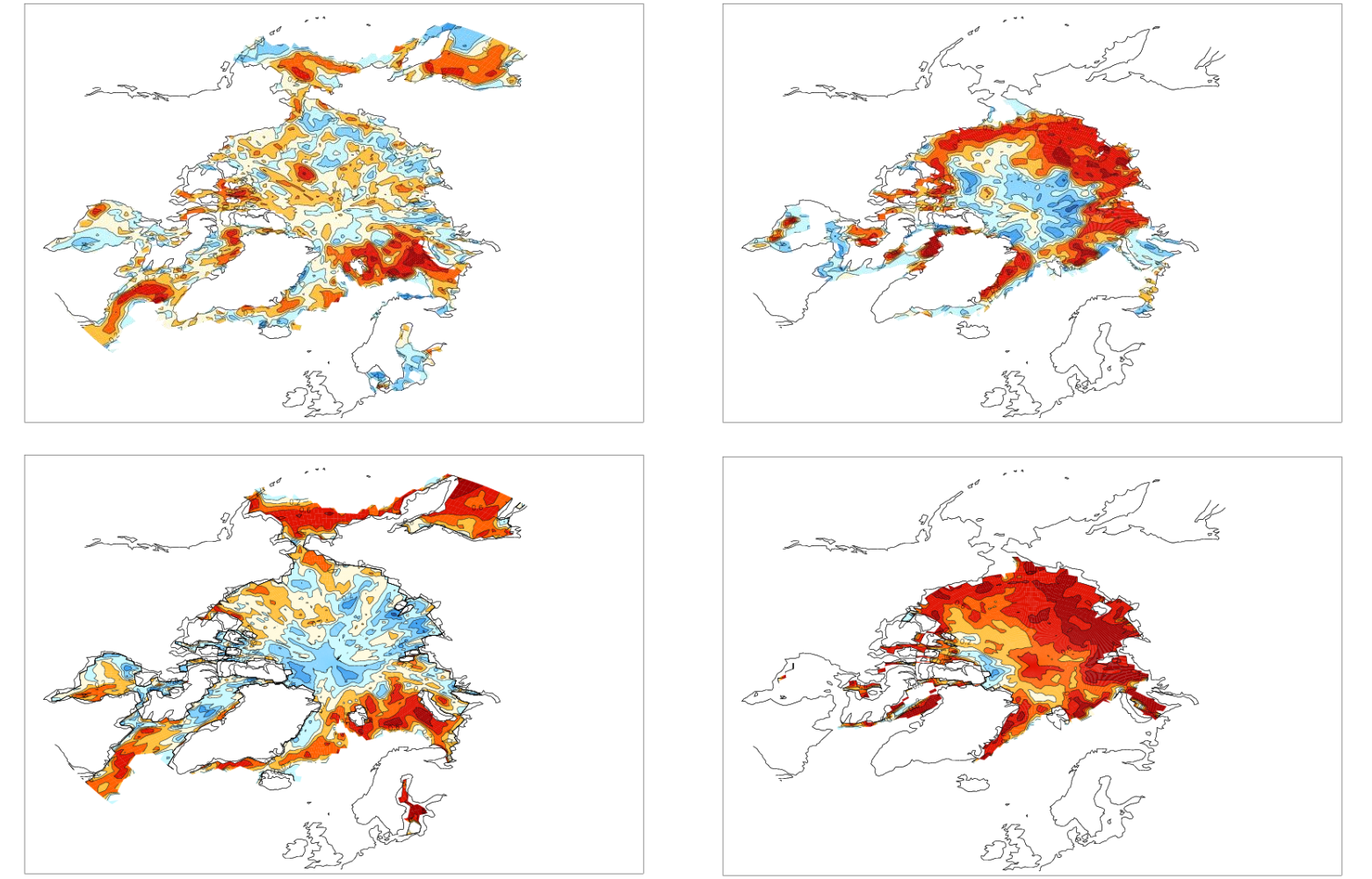




Correlations for week 4 Northern Hemisphere

Current system

With sea-ice model (LIM2)



Summary

- Sub-seasonal predictions at ECMWF have shown substantial progress in the last 10 years, thanks to increased resolution, improved physical parameterizations (especially convection), unification of medium-range and sub-seasonal ensemble systems, ocean-atmosphere coupling from day 0, extended re-forecast set.
- The planned increase in atmospheric horizontal resolution beyond ~40 km improves fidelity and probabilistic predictions for intense phenomena and events, but has a smaller impact on traditional large-scale scores.
- Promising results from experiments with ¼-degree ocean model (NEMO) and dynamical sea-ice (LIM2), but still a lot of work to do!

Thanks !