High-resolution ensemble predictions at ECMWF: results and expectations

Franco Molteni

ECMWF, Reading, U.K.

Contributions:

- Richard Forbes, Elias Holm, Simon Lang, Martin Leutbecher, Linus Magnusson, Frederic Vitart

Outline:

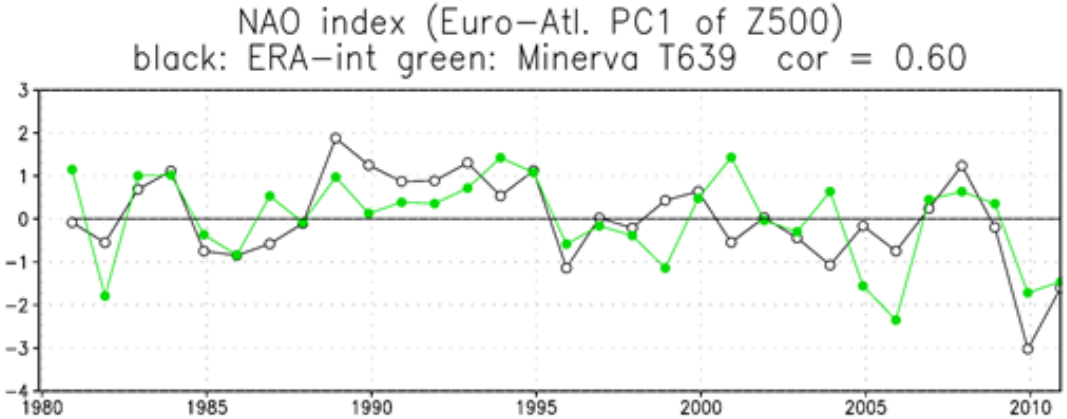
- Main messages from MINERVA
- Plans for operational resolution increase in 2016
- Forthcoming activities on long time scales: System 5 and Copernicus Services, PRIMAVERA project

MINERVA seasonal forecast experiments (COLA/ECMWF) :

ECMWF IFS cy 38r1 T319 / T639 / T1279 + NEMO v3.1 ORCA 1-deg

Positive impact:

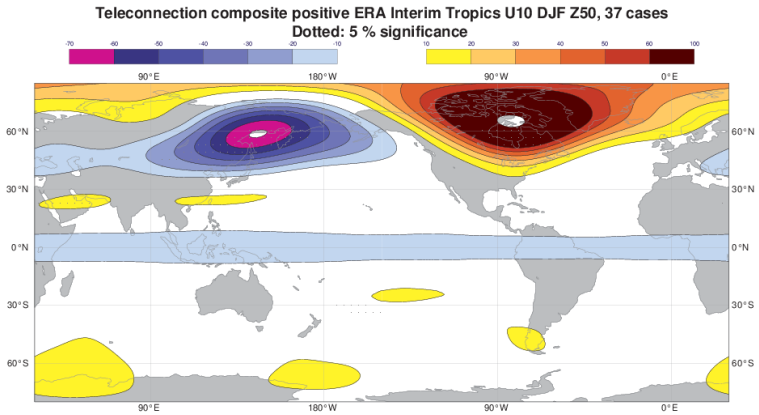
- Improved fidelity in the simulation of tropical cyclones
- Higher predictive skill for NAO in T639 vs T319



Neutral or small impact on:

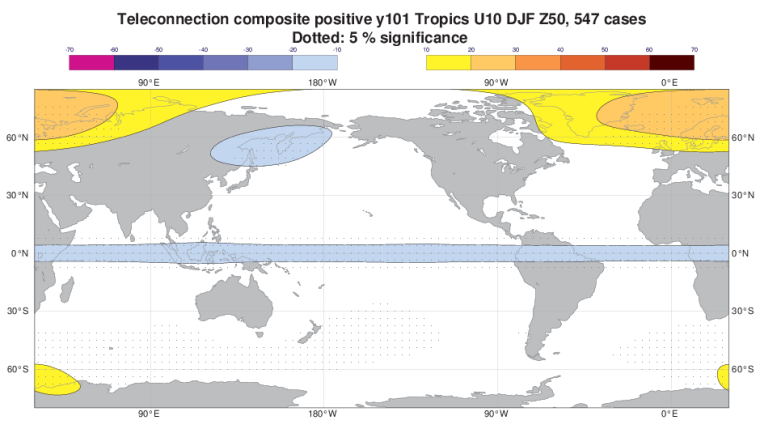
- Mean model climate
- ENSO and MJO predictive skill

ERA Interim

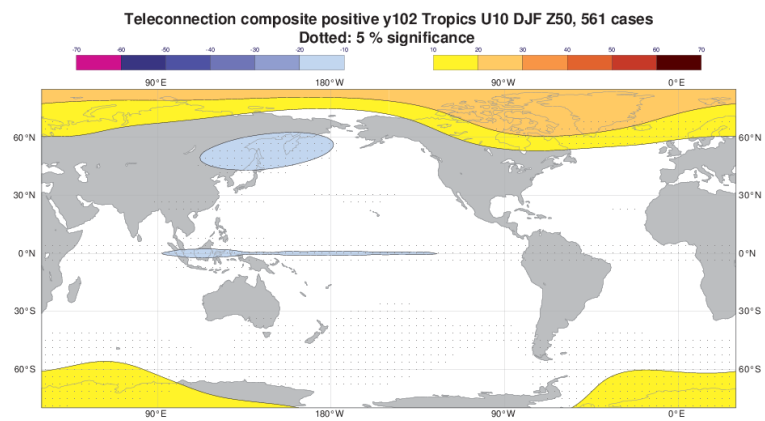


Composite Z-50hPa during positive QBO (westerly)
Anomaly larger than 0.5 stdev

Minerva T319

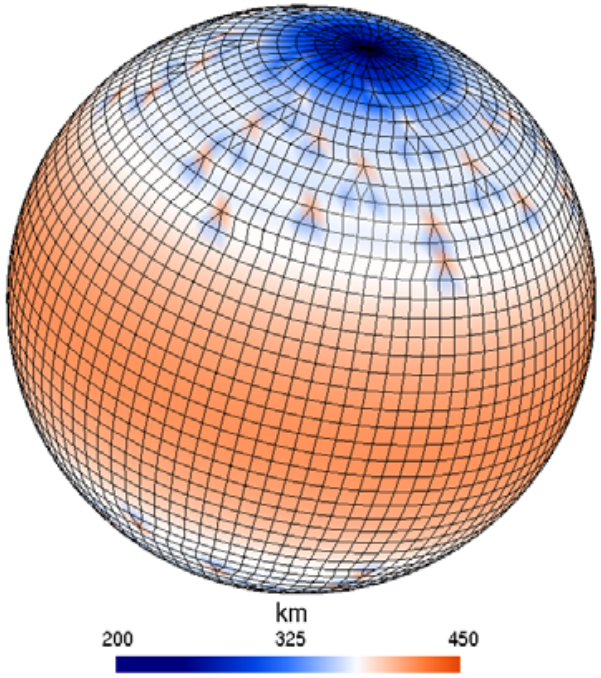


Minerva T639

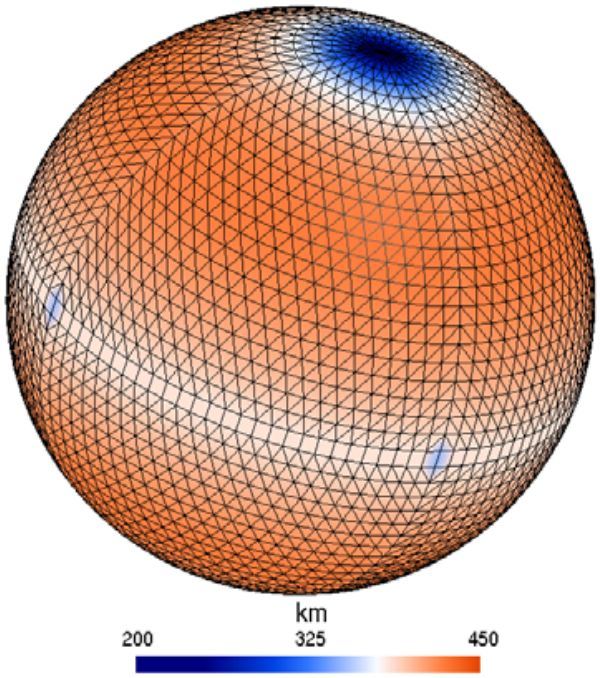


Grid mesh/resolution and sp. harmonic truncation in spectral models

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

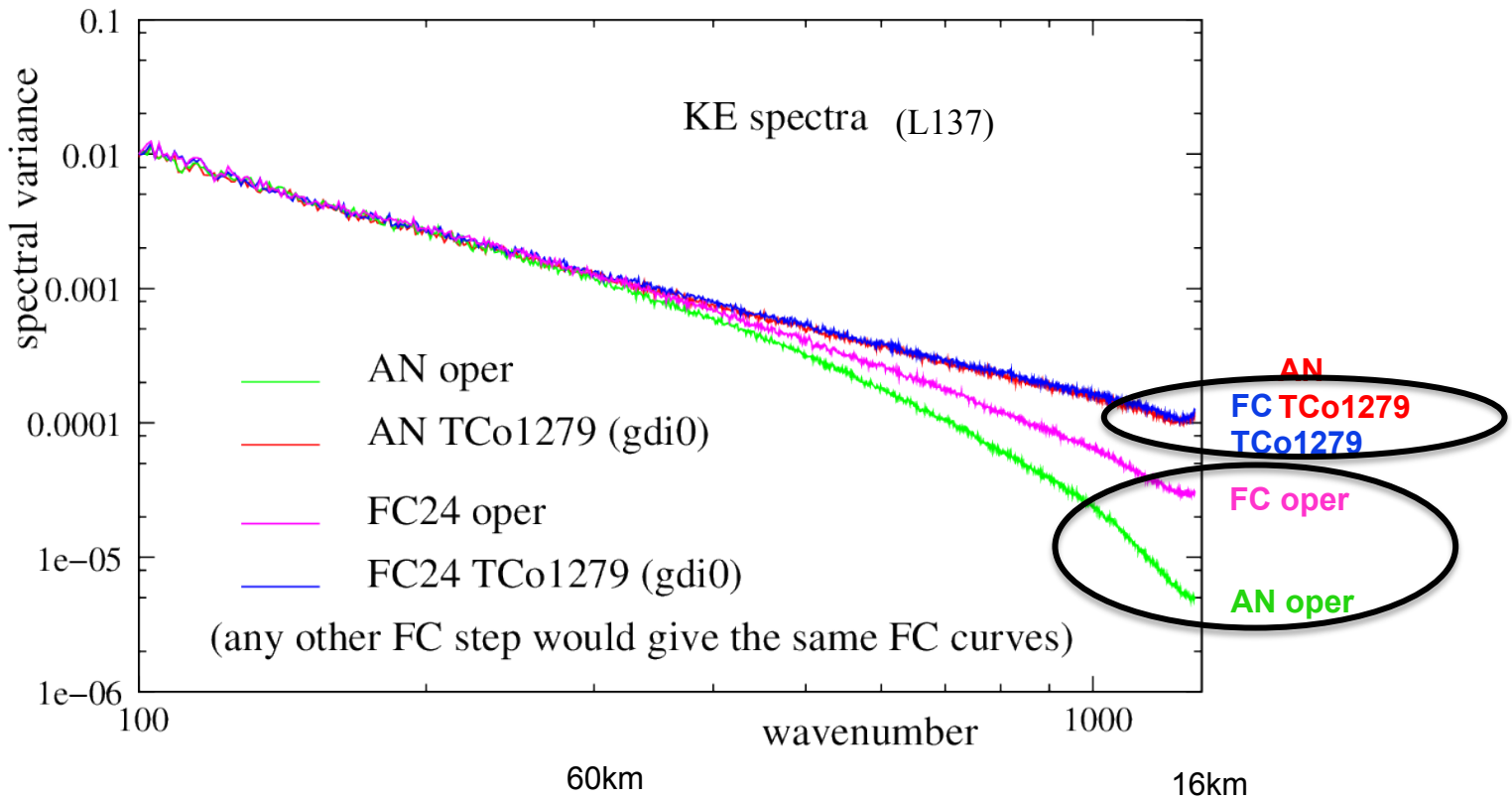
2016 atmos resolution upgrade: 41r1 → 41r2

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

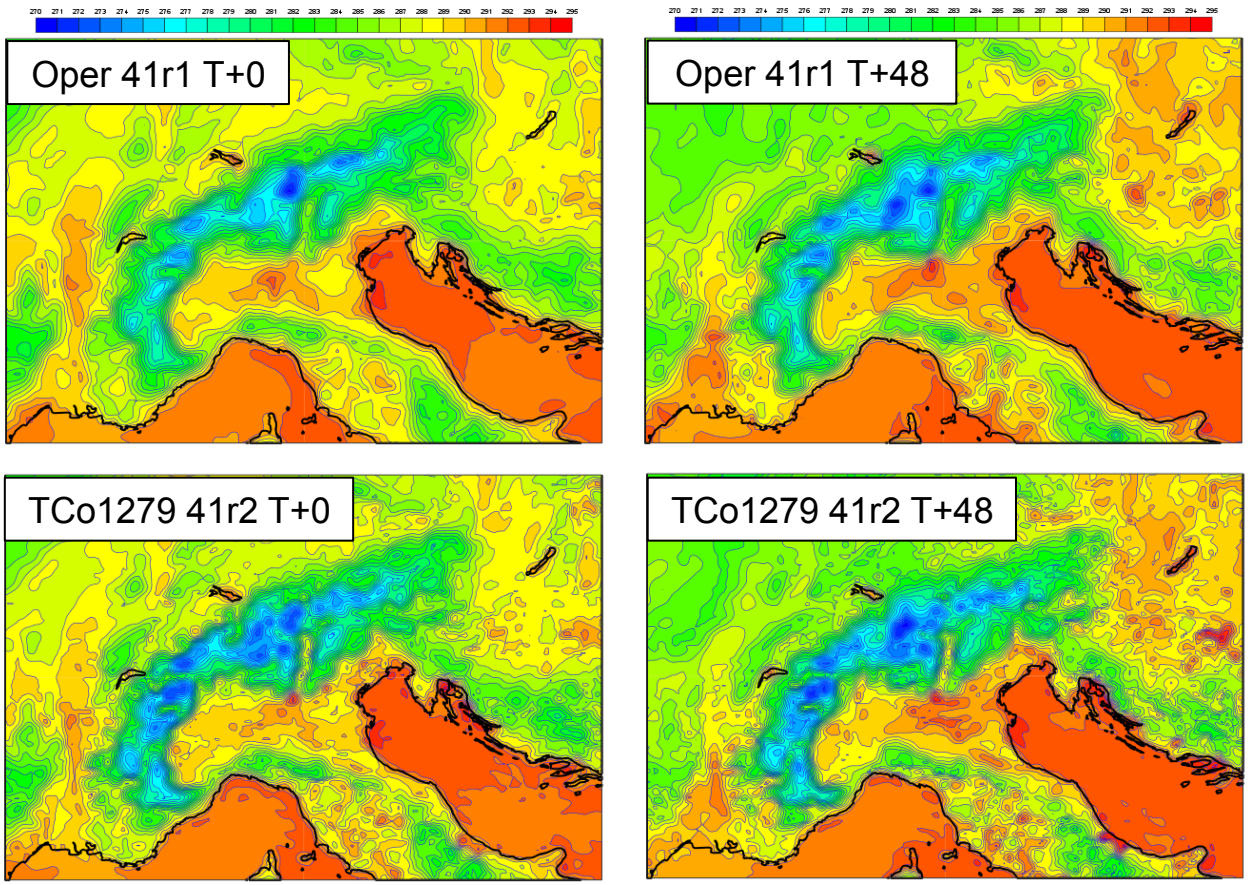
Grid res	HRES	ENS LegA	ENS LegB/45d	4DVAR Inner Loops 1st	4DVAR Inner Loops 2nd	4DVAR Inner Loops 3rd	EDA loops Outer	EDA loops 1st	EDA loops 2nd
128 km								TL159	TL159
				TL255	TL255	TL255		TL191	TL191
64 km			TL319		TL319				
						TL399	TL399		
32 km		TL639	TCo319						
16 km	TL1279	TCo639					TCo639		
9 km	TCo1279								

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

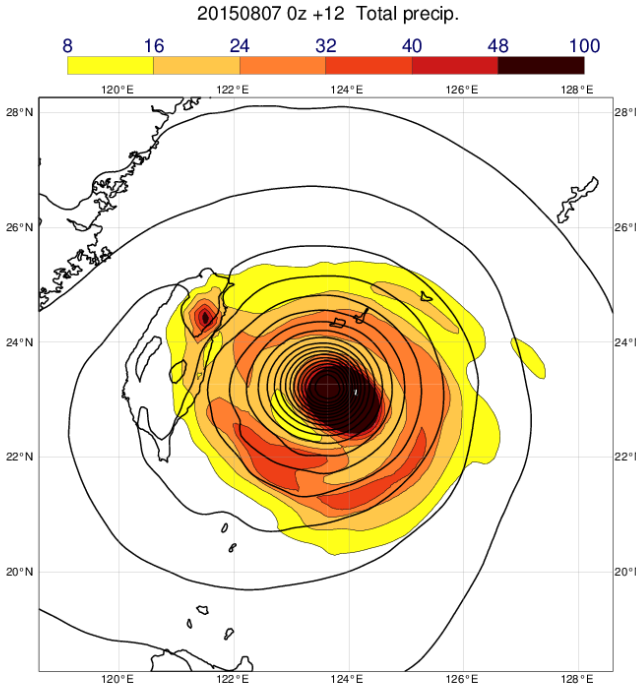


Example: 2m temperature over the Alps valid 01 June 2015 00z

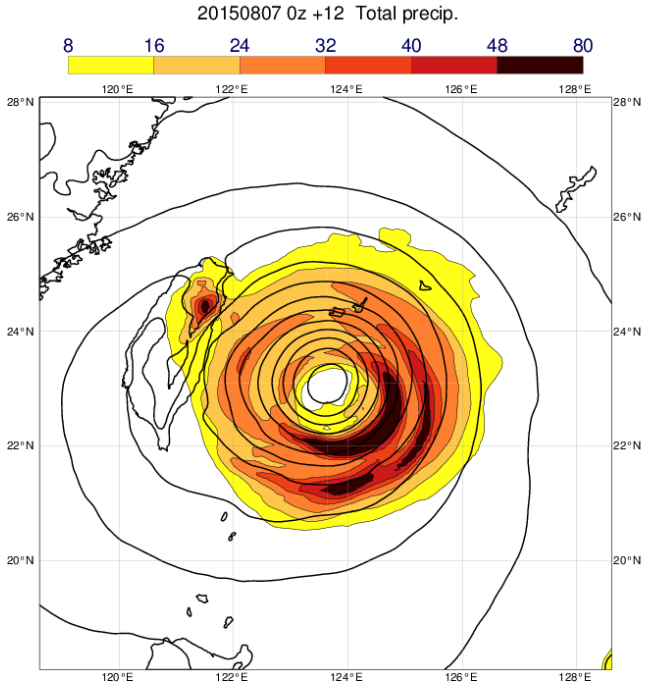


TC Soudelor 3-hourly precipitation (mm/h)

41r1 TL1279



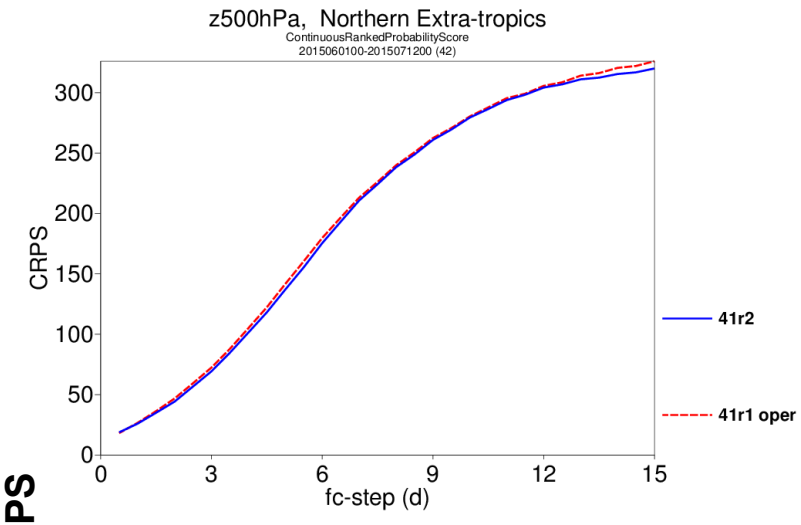
41r2 TCo1279

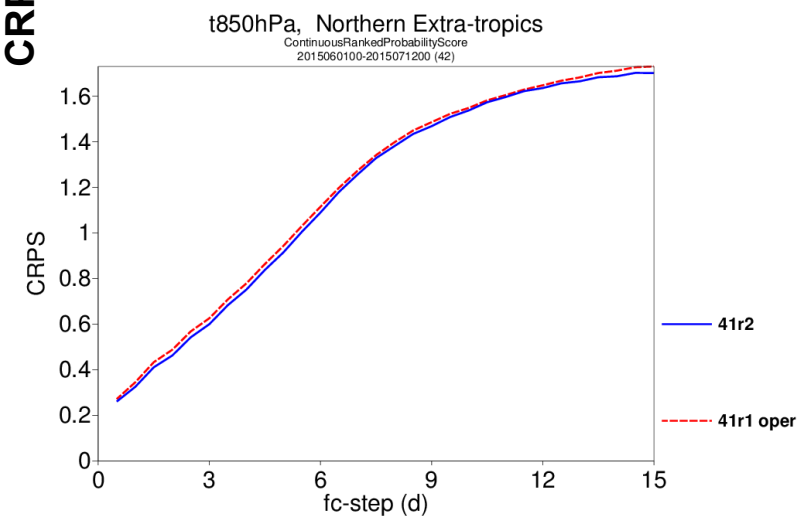


Z500 NH

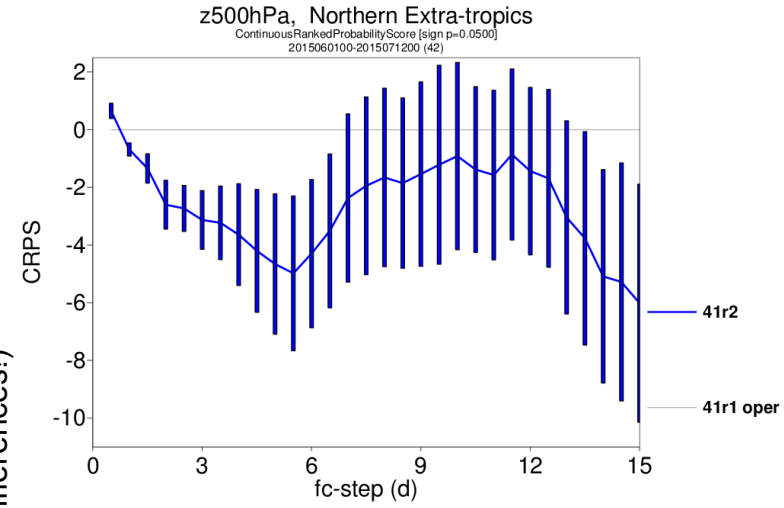
T850 NH

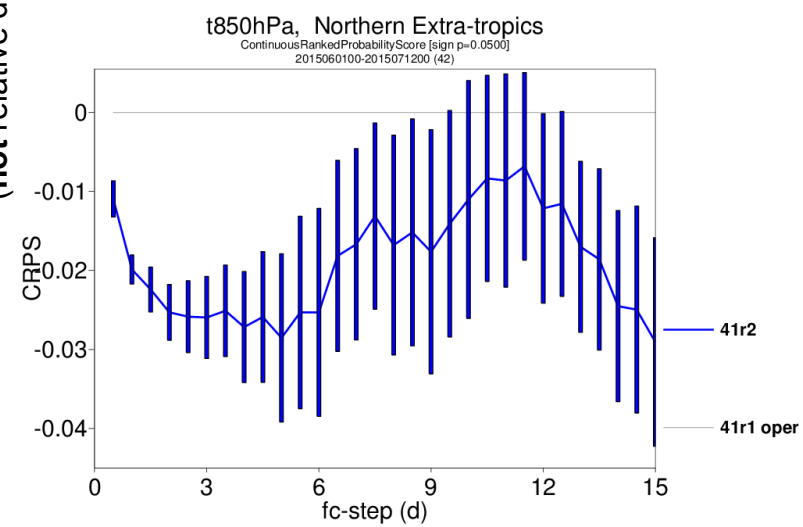
CRPS



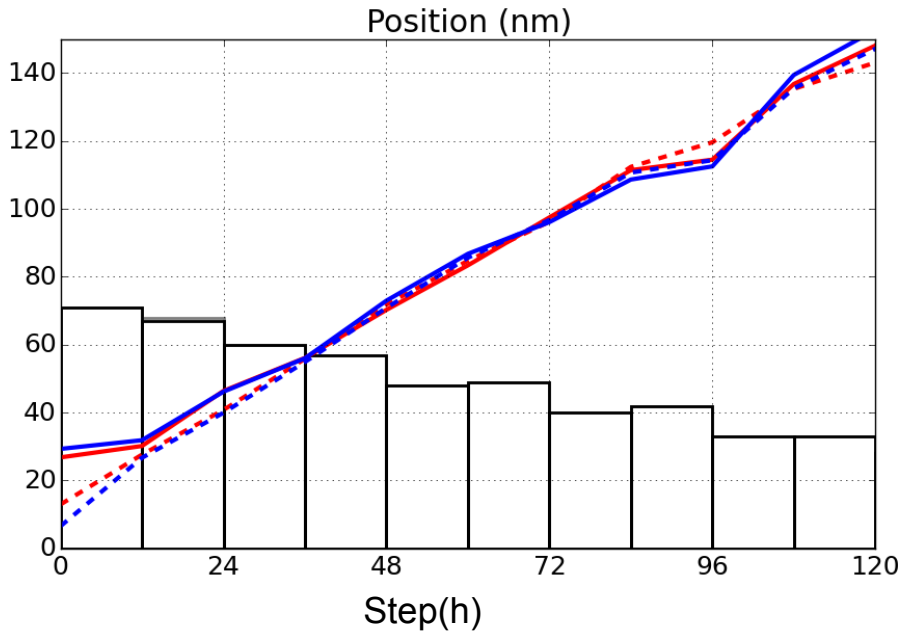


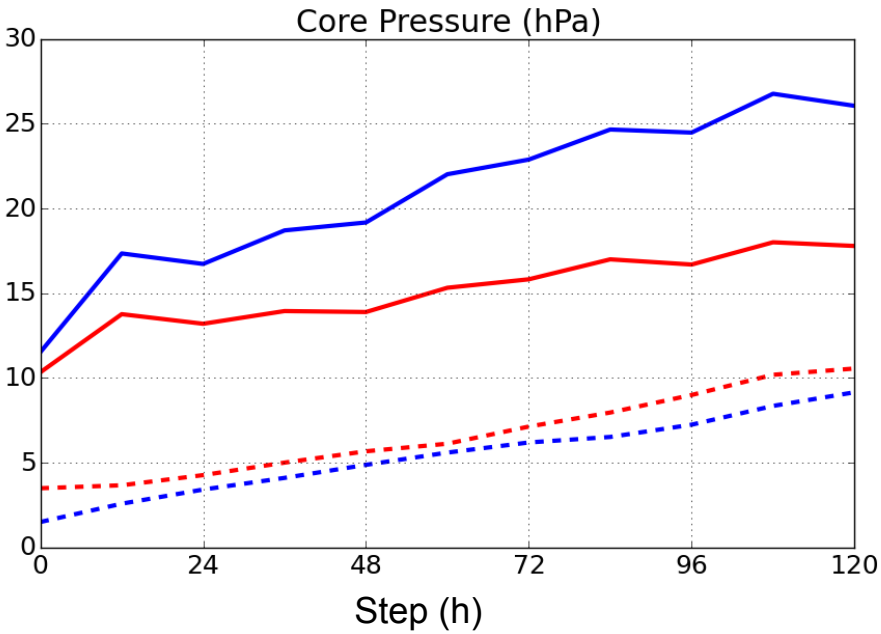
Difference in CRPS
(not relative differences!)





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

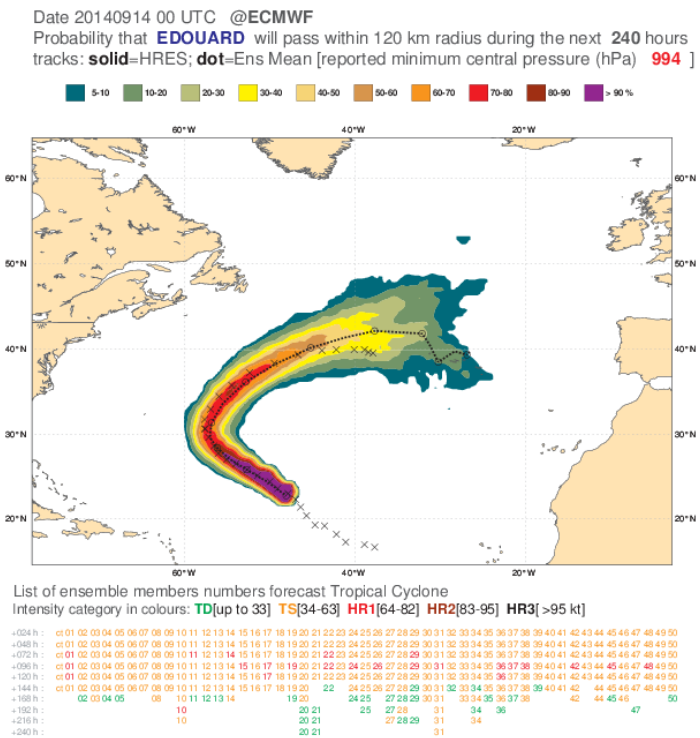




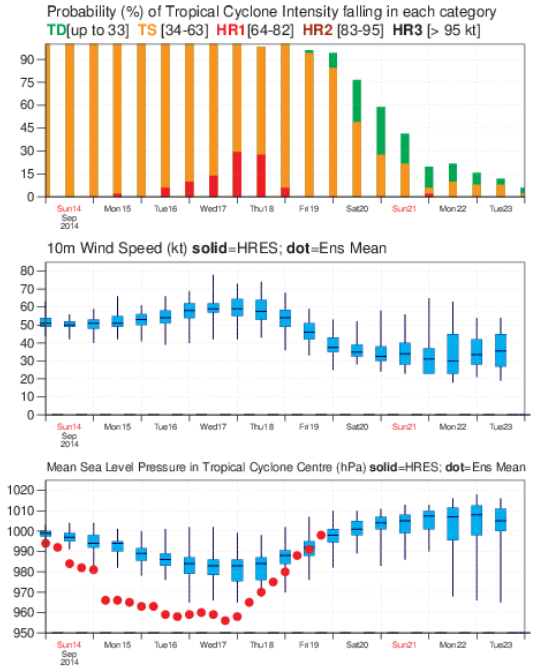
41r1 Oper Position RMSE (Solid)
41r1 Oper Position Spread (Dashed)
41r2 Position RMSE (Solid)
41r2 Position Spread (Dashed)
Bars : Sample size

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

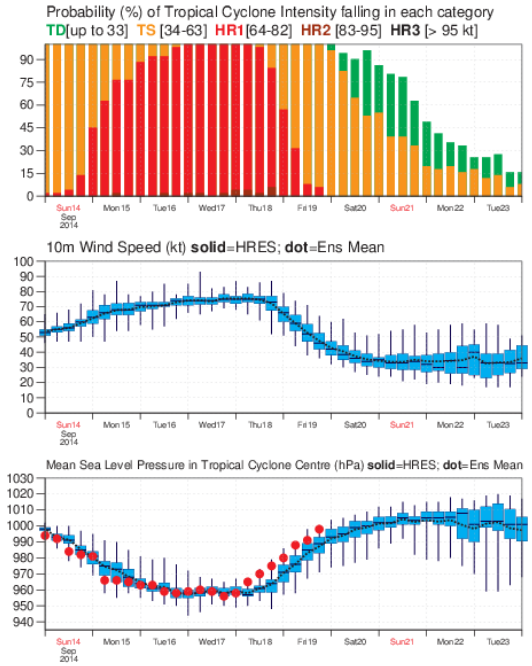
Tropical Cyclones: ENS TL639 → TCo639



TL1279 An
TL399 EDA



TL639 ENS

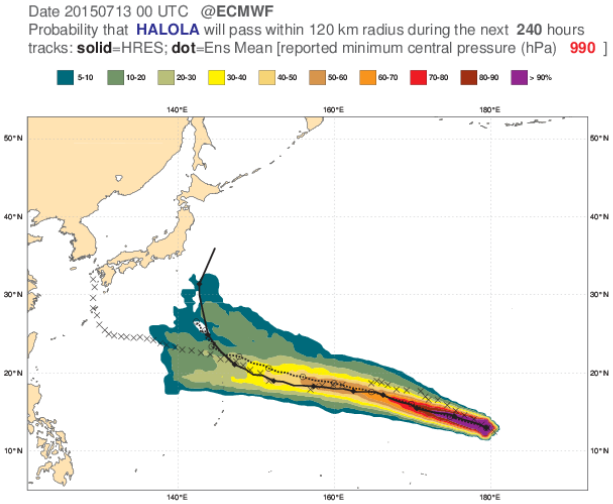


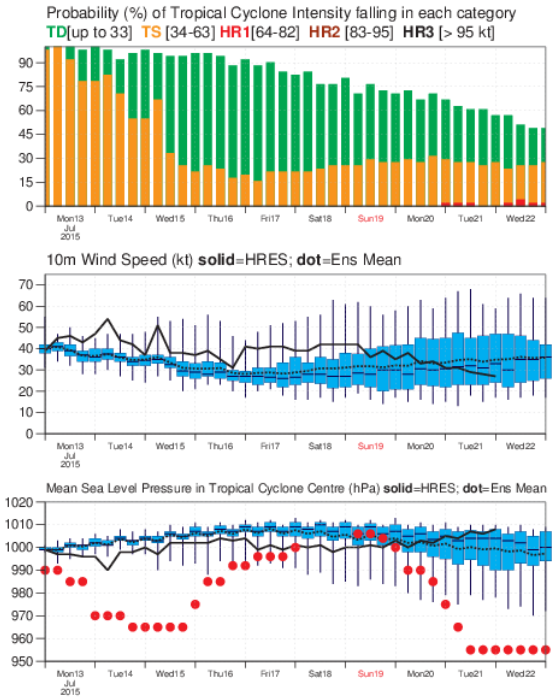
TCo639 ENS

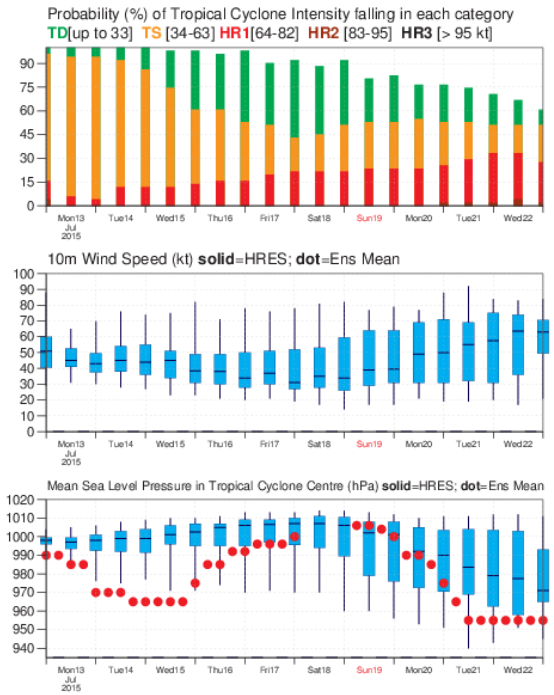
Tropical Cyclones: EDA/ENS TL399/639 → TCo639

TL1279 An
TL399 EDA
TL639 ENS

TCo1279 An
TCo639 EDA
TCo639 ENS







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

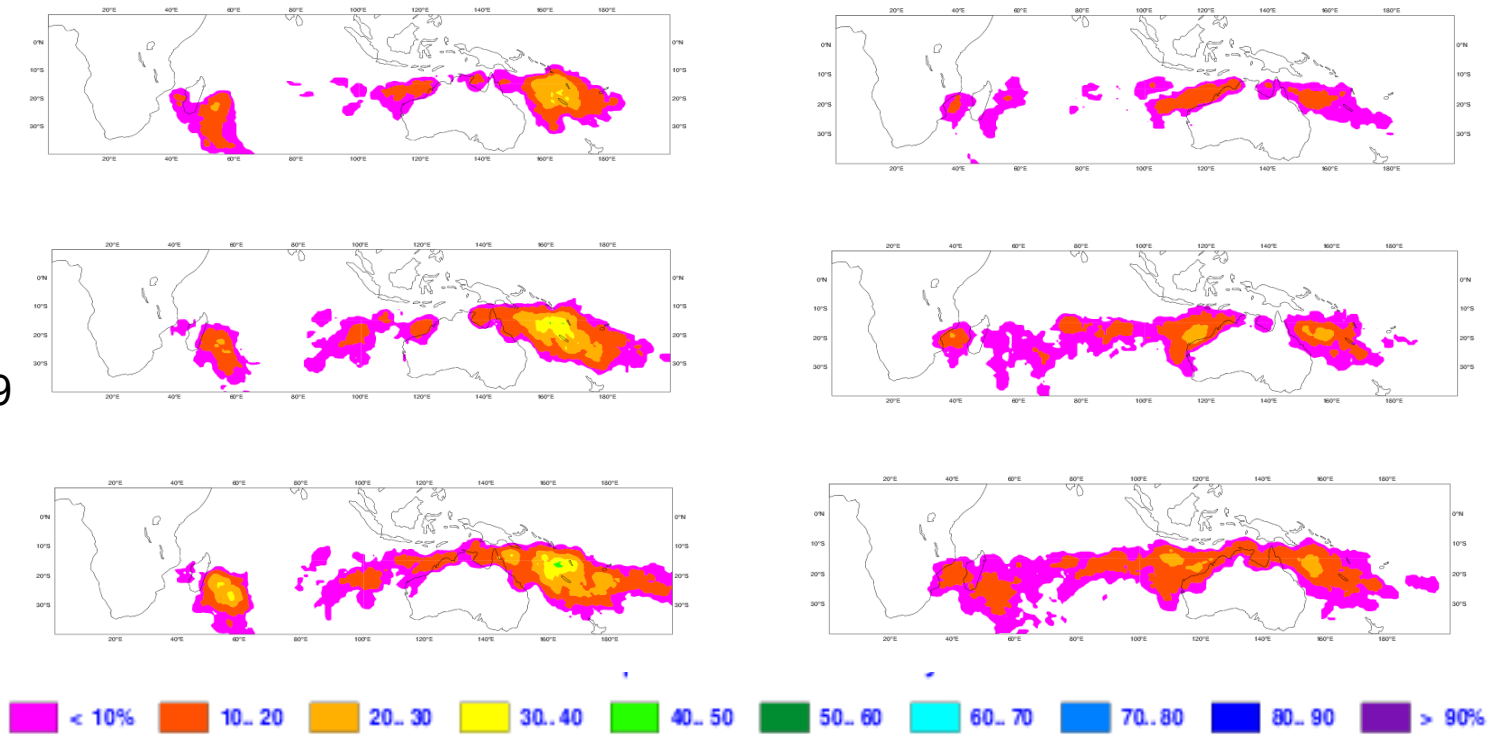
Day 12-18

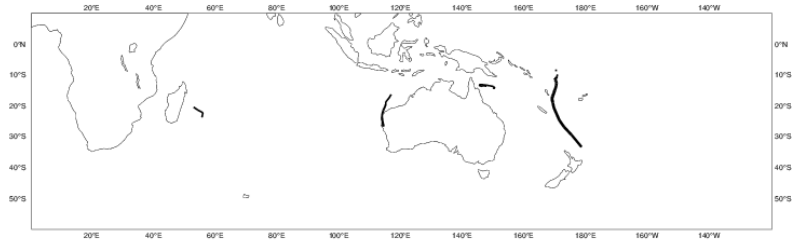
Day 19-25

Oper
TL639/319

High
Tco639/319

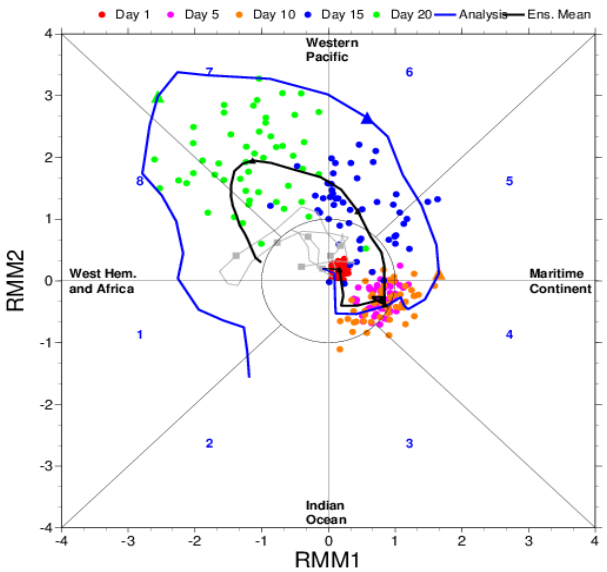
Tco639





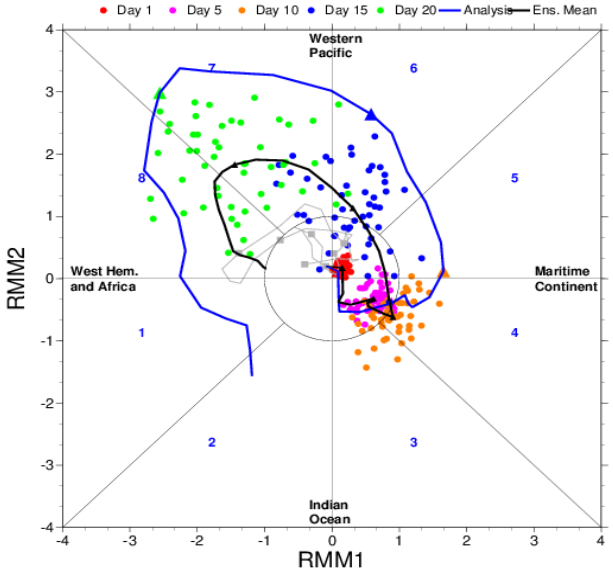
Observed track

MJO event, 26/02/2015

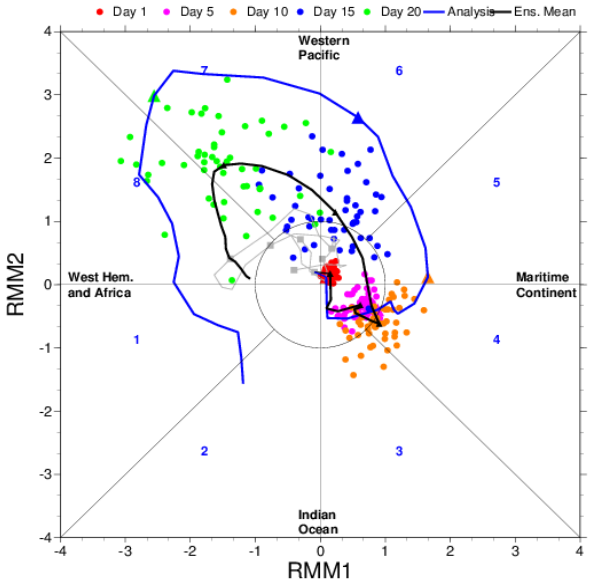


OPER

High res.



Tco639



EU Copernicus Climate Change Service (C3S)

The Climate Change Service will combine observations of the climate system with the latest science to develop authoritative, quality-assured information about the past, current and future states of the climate in Europe and worldwide.

The Service will build upon and complement capabilities existing at national level and currently being developed through a number of climate-change research initiatives. It will become a major contribution from the European Union to the WMO Global Framework for Climate Services (GFCS) and its Climate Monitoring Architecture.

ECMWF is operating C3S on behalf of the European Union.

The portfolio of Service products will include *(specific ECMWF contributions in red):*

- Consistent estimates of multiple Essential Climate Variables
- Global and regional reanalyses (on Earth-system domain: atmosphere, ocean, land, carbon)
- Products based on observations alone (gridded; homogenised station series; reprocessed Climate Data Records)
- A near-real-time climate monitoring facility
- Multi-model seasonal forecasts
- Climate projections at global and regional scales

ECMWF contribution to C3S M-M seasonal forecasts: System 5

Expected components:

- New IFS cycle (42r1 or 42r2)
- Atmos. resolution:
  TCo319 (grid ~ 32km) L91 or TL511 (grid ~ 40 km) L91
- Ocean and sea-ice:
  NEMO v3.6, ORCA 0.25 grid, 75 levels,+ LIM-2 sea-ice model
- Re-forecasts:
  1981 to 2015, ~25 members, initialized from ERA-Interim + ORA-S5
- IC for land-surface and ozone from off-line runs of model components

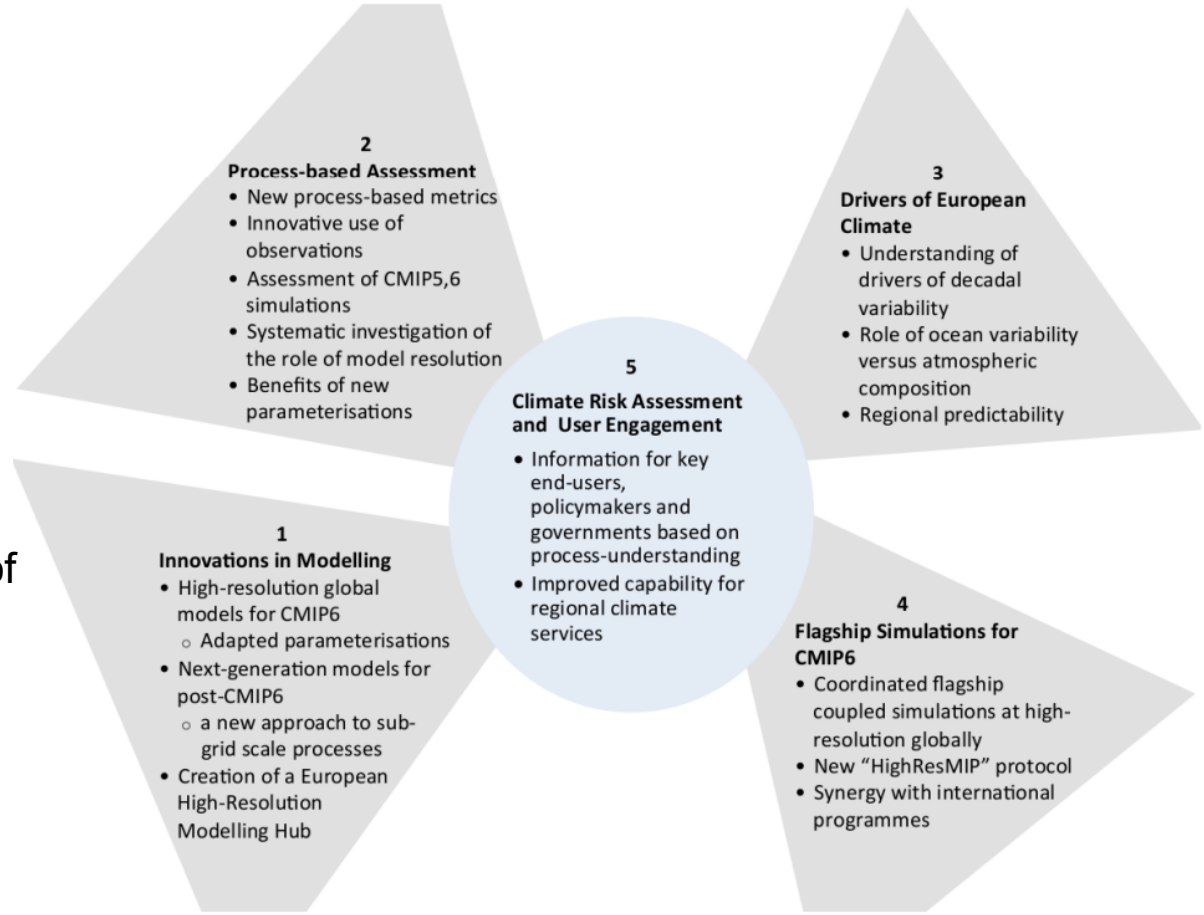
PRIMAVERA: a European Union Horizon-2020 project
(www.primavera-h2020.eu)

Main goal: To develop a new generation of advanced and well-evaluated high-resolution global climate models, capable of simulating and predicting regional climate with unprecedented fidelity

19 Partners

Coordination: UKMO/ Univ. of Reading

ECMWF contribution based on ~30 and ~60-year historical runs (as in CMIP6 HighResMIP) with IFS TCo399 + NEMO 0.25° (TBC)



Summary

- Increase in atmospheric horizontal resolution beyond ~40 km improves fidelity and probabilistic predictions for intense phenomena and events, but has a small impact on traditional large-scale scores.
- Increased resolution should be seen as a way to increase the fidelity in the simulation of physical (as well as dynamical) processes, but it is not the only way to achieve that.
- At ECMWF, the impact of increasing ocean resolution (to eddy permitting levels) will be assessed in sub-seasonal predictions, the System-5 seasonal system and historical simulations within the PRIMAVERA project.