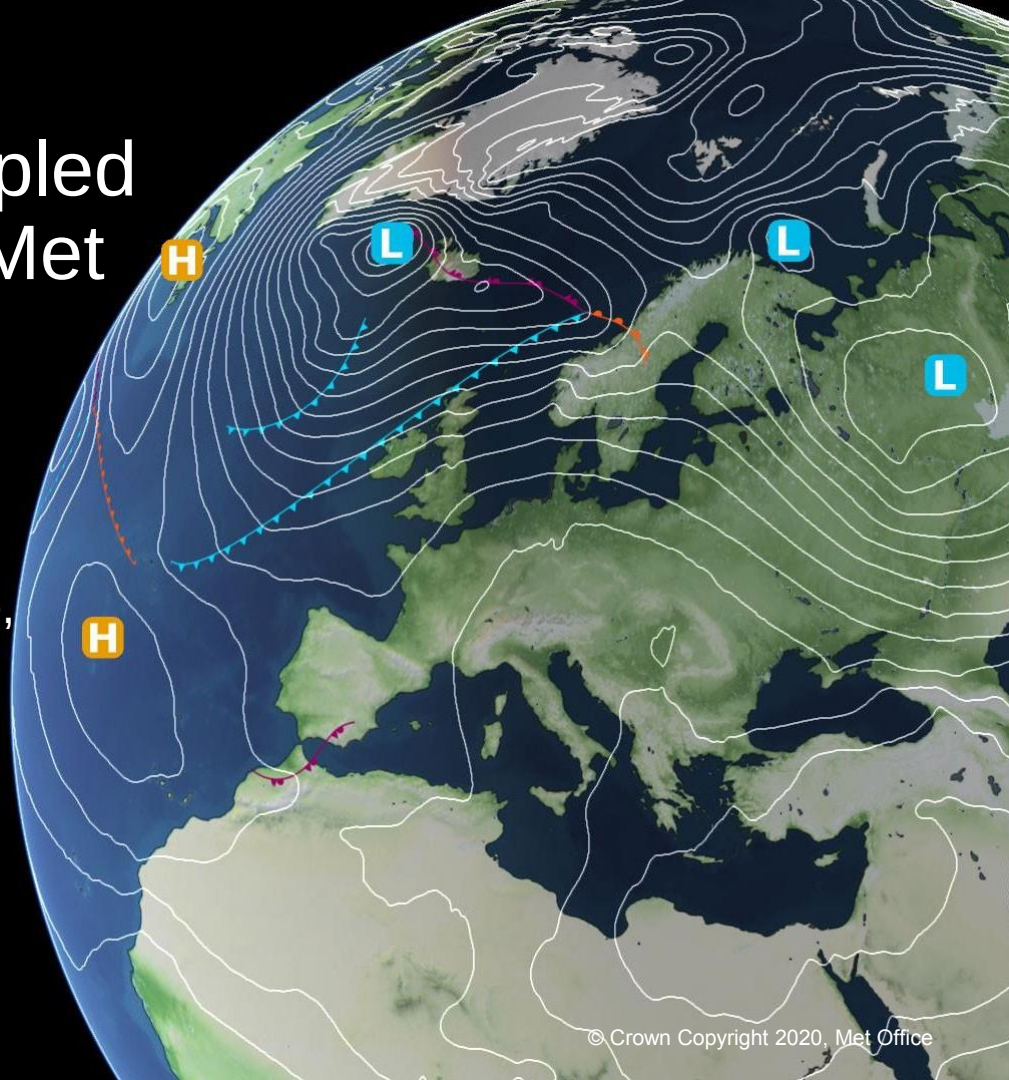
The development of coupled NWP forecasting at the Met Office

Tim Graham

Dan Copsey, Chris Harris, Tim Johns, Rick Rawlins, Ann Shelley, Livia Thorpe, Michael Vellinga.



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Structure of presentation

Comparing coupled NWP vs atmosphere-only NWP

Operational implementation

Future changes after operational implementation

Introduction

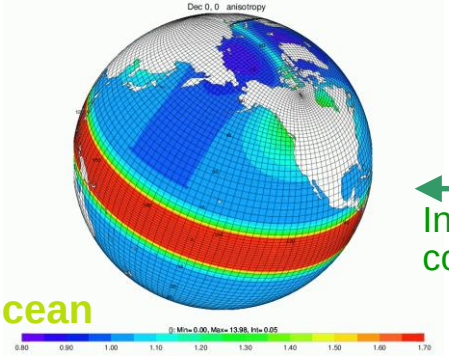
- Original motivation was a WGNE meeting to run Transpose CMIP experiments
- The Met Office plans to move to coupled NWP for its operational weather forecasts in late 2021.
- Results presented here is for PS41 coupled NWP which consists of components shown on right

UM atmosphere using GA6.1 physics

Internal communication

JULES land surface using GL8.0 physics

OASIS3-MCT coupler (every hour)



NEMO ocean using NEMO3.6 and GO6 physics

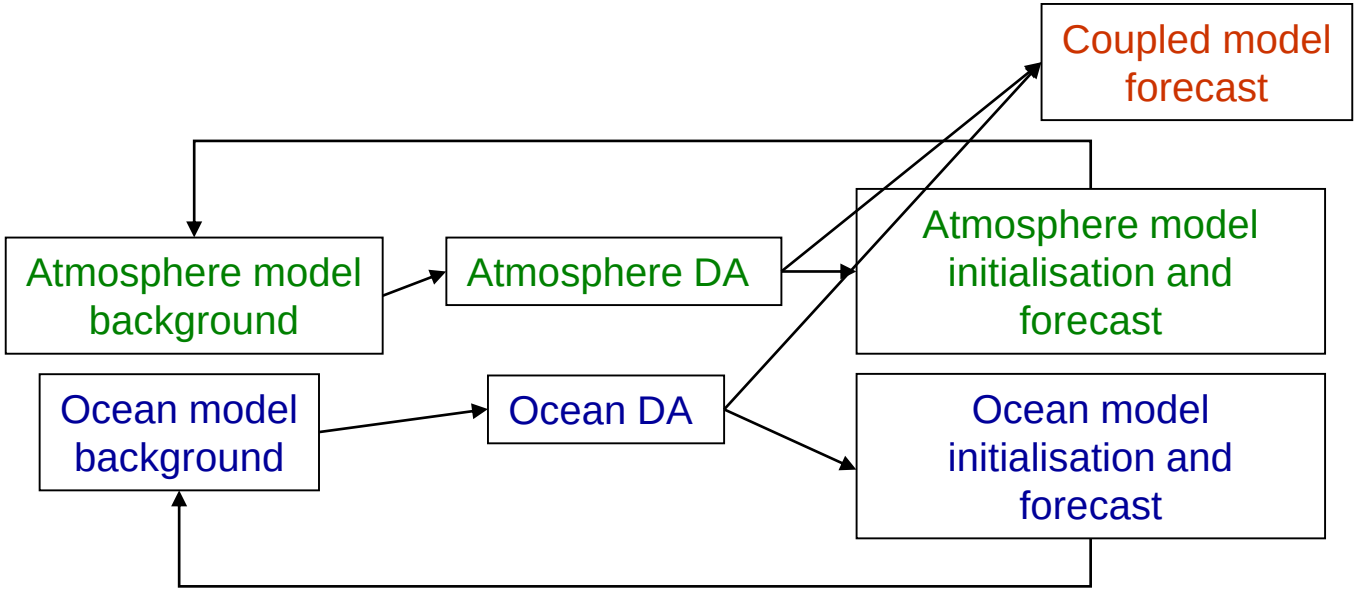
Internal communication

CICE sea ice using CICE5.1.2 and GSI8 physics

Models to compare

	Operational atmosphere only NWP model (UNCPLD)	Coupled NWP model (CPLDNWP)
Physics options	PS41	PS41
Atmospheric horizontal resolution	N1280 = 10km grid spacing in mid latitudes	N1280 = 10km grid spacing in mid latitudes
Atmospheric vertical levels	70 levels	70 levels
Sea surface temperatures and sea ice	Provided by OSTIA SST and sea ice analysis and kept constant	Provided by NEMO/CICE
Atmospheric model's land sea mask	Derived from IGBP including large lakes as sea points	Derived from NEMO mask
Ocean/sea-ice horizonal resolution		ORCA025 = 25km grid spacing
Ocean vertical levels		75
Coupling interval		Every hour

Initialisation of the forecasts



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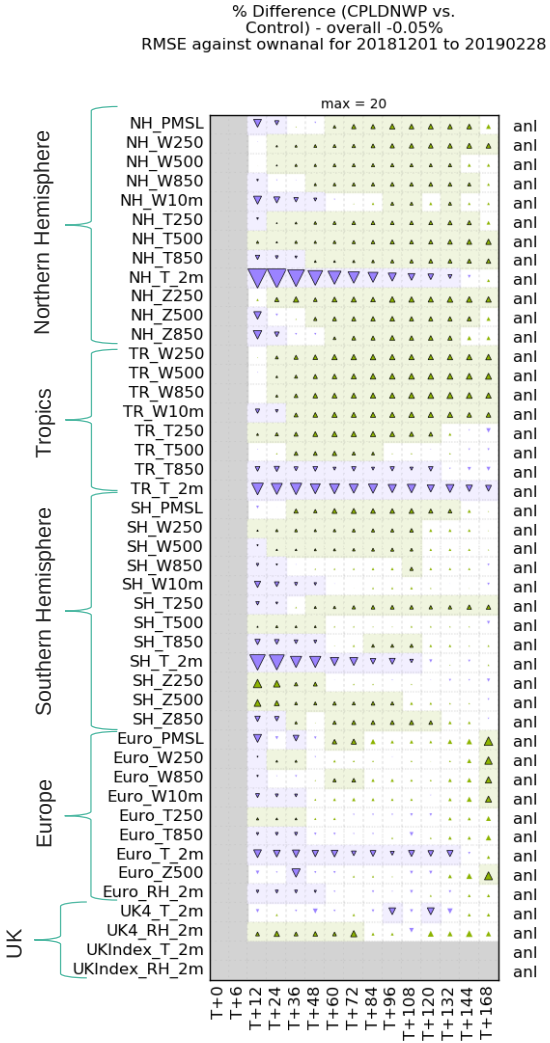
Verification statistics

Based on RMSE statistics against UM analysis.
Green up arrow = CPLDNWP improved over UNCPLD
Blue down arrow = CPLDNWP degraded over UNCPLD

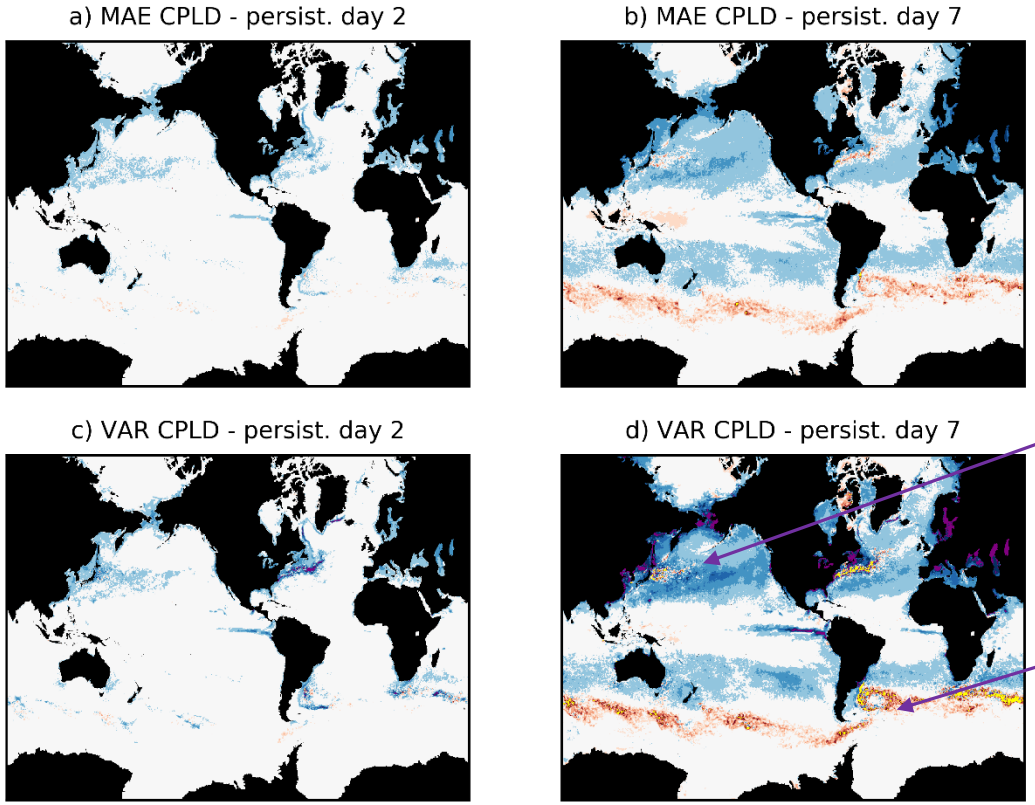
Almost all fields improved apart from 2m temperatures (T_2m). CPLDNWP penalised as not using OSTIA SSTs and OSTIA lakes (which both UM analysis and UNCPLD use).

1st Dec 2018 – 28th Feb 2019. 00Z forecasts.



Vellinga et al. 2020 – published in Weather and Forecasting

SST forecast performance vs persistence



Verification against FOAM analysis
MAE = mean absolute error
VAR = variance of difference between forecast and observations

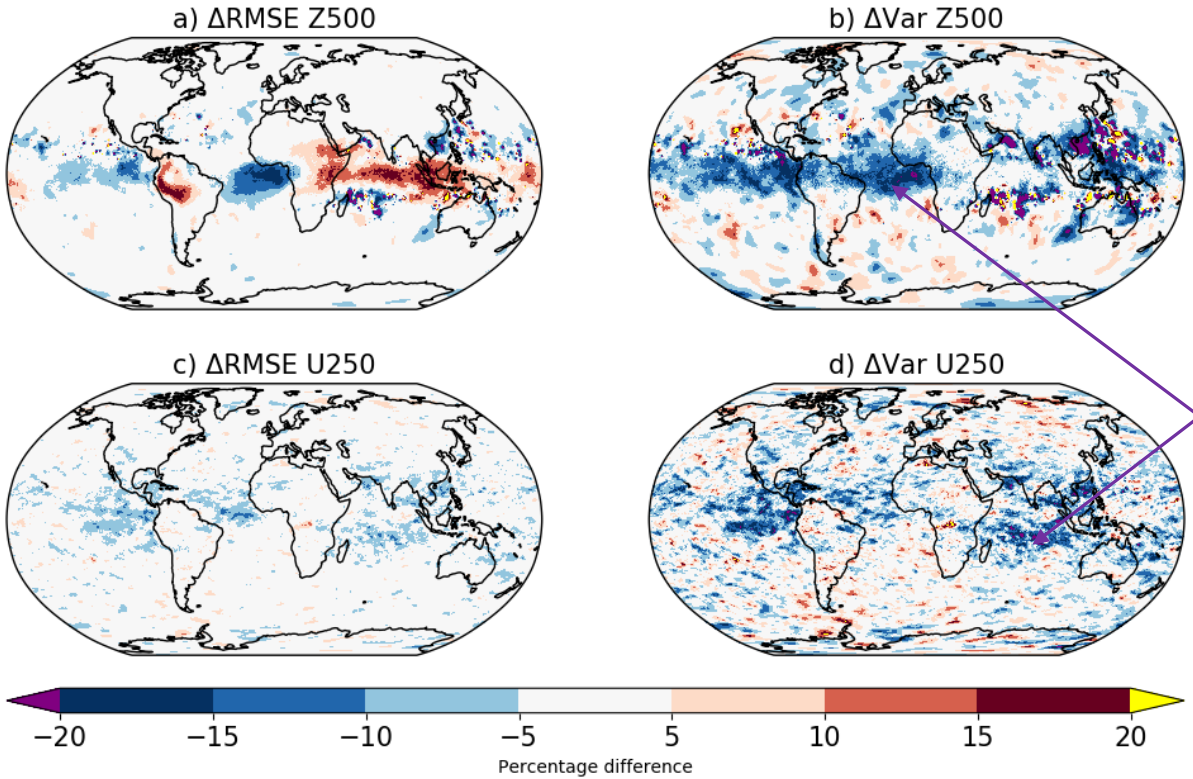
SST forecast improved in North Pacific, North Atlantic and southern sub-tropics

SST forecast degraded in Southern Ocean

26th Sept 2018 – 25th Sept 2019. 00Z forecasts.

Vellinga et al. 2020

500 hPa geopotential height (Z500) and 250 hPa zonal wind (U250)



Plots are for T+168 (day 7)

Verification against UM analysis
VAR = variance of difference between forecast and observations

Largest improvements to the atmosphere are near the equator

26th Sept 2018 – 25th Sept 2019. 0Z fcst.

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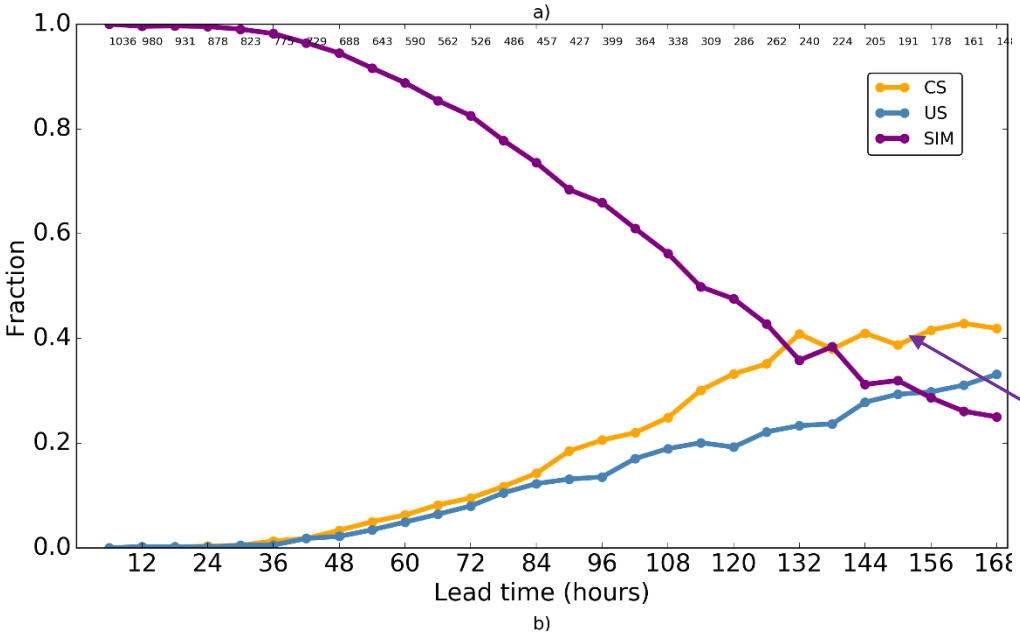
Tropical cyclone tracks



Track error superior counts averaged over all tropical cyclones:

CS = CPLDNWP is Superior

US = UNCPLD is Superior

SIM = Both systems Similar

Coupled model gives lower track errors most often

11th July 2017 – 1st Nov 2019. 0Z forecasts.

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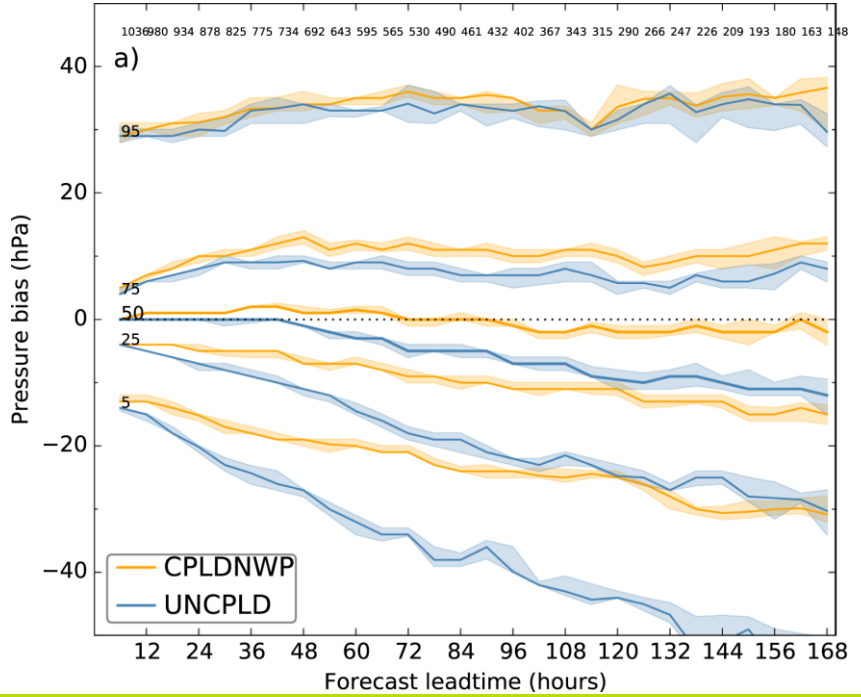
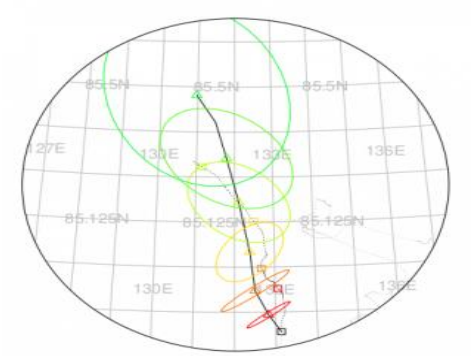
Tropical Storm Intensity

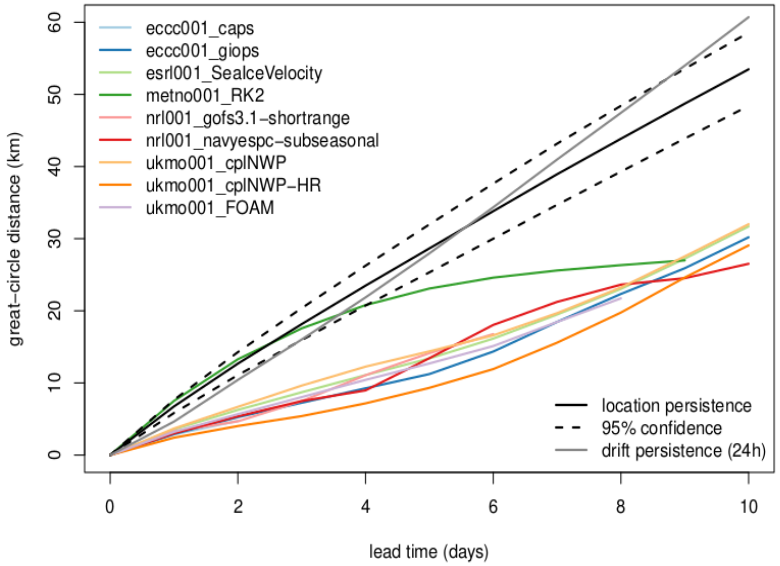
- Storms are grouped by intensity in percentiles.
- Little difference when considering strongest 95% of storms.
- Much bigger impact when considering the strongest 50%.



Sea Ice Drift Forecast Experiment for MOSAiC



Example consensus forecast (solid line, coloured triangles and uncertainty ellipses) of 7-day MOSAiC drift. Actual ship position overlain (dotted line, coloured squares).

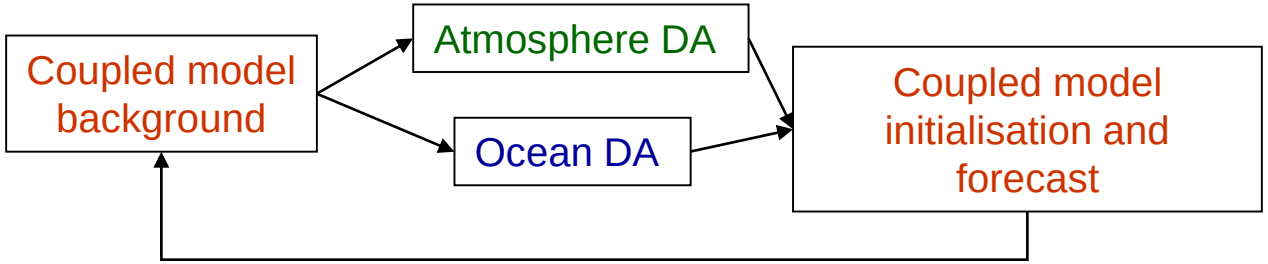


10-day forecast error (km) for predictions for the trajectory of IABP buoy #300234063991680 on 5th June 2019 compared with simple location and drift persistence forecasts

Operational implementation

Weakly coupled data assimilation

- Background for data assimilation taken from coupled model
- Data assimilation run separately for ocean and atmosphere



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Operational Implementation

- Plan to make coupled NWP with weakly coupled DA operational from late 2021

- Resolution will be N1280L70 (~10km) ORCA025L75 for the deterministic model and N640 (~20km) ORCA025L75 for the ensemble

- Ensemble will use ocean analysis from the deterministic model + SST perturbations but development of an ocean ensemble DA system is underway for future implementation.

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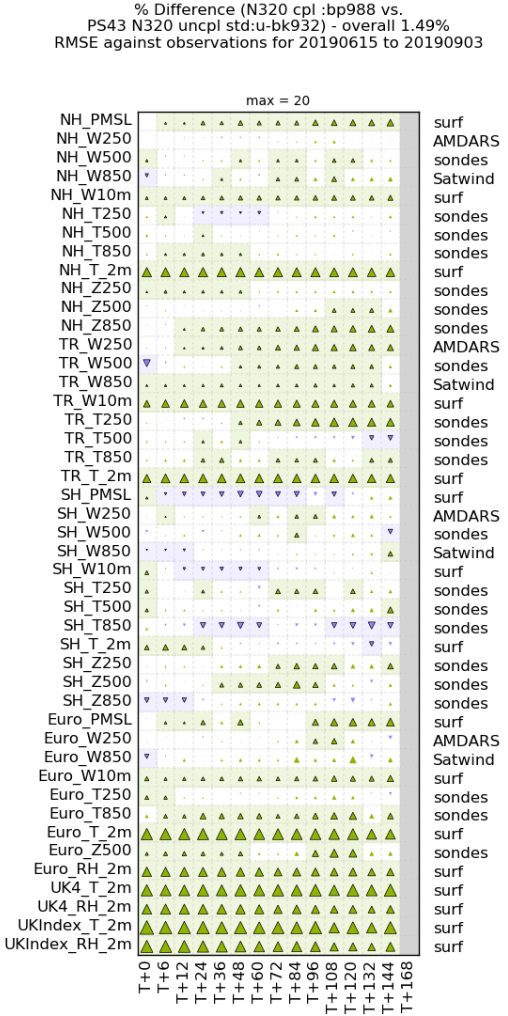
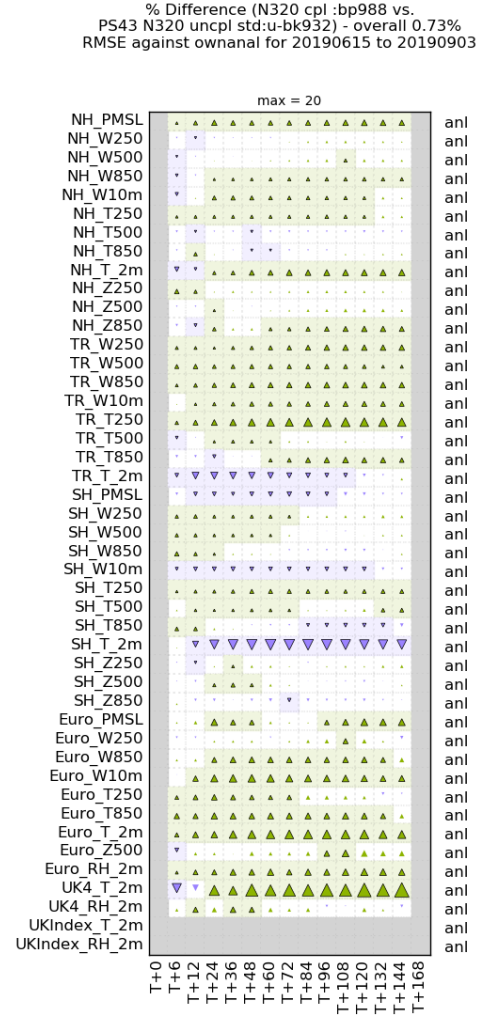
Scorecard for N320 summer trial

- Model now compared against own analysis
- 2m temperature bias much improved.
- Overall improvement





Future changes after operational implementation

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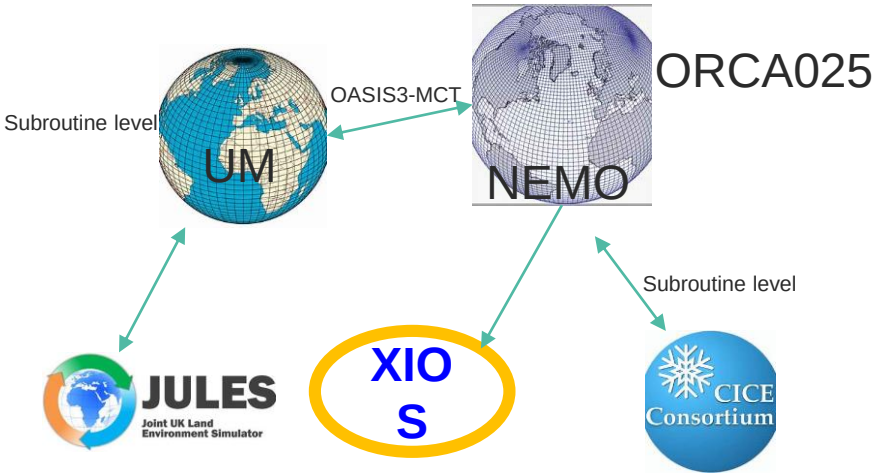
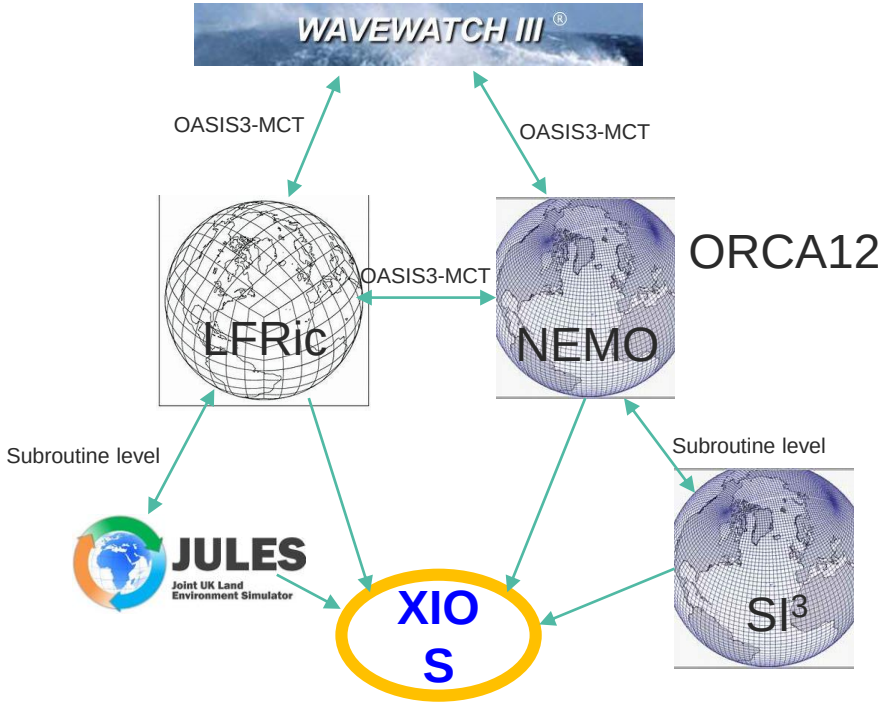
Initial operational coupled NWP



Future coupled NWP



Summary

- Using a coupled NWP model gives better verification scores than an atmosphere only model (except 2m temperatures).
- Remaining 2m temperature issues can be fixed by verifying vs a weakly coupled DA analysis and by using OSTIA lake SSTs.
- SST forecasts are improved over persistence, (except in Southern Ocean).
- 500 hPa heights, 250 hPa winds and tropical cyclones are all (on average) improved.
- We are aiming for the operational coupled NWP model to be GC4 in autumn 2021.
- The Met Office coupled NWP is moving to a new sea ice model (SI^3 – GC5), a higher resolution ocean (ORCA12) and then a cubesphere grid atmosphere (LFRic – GC6), with possible wave model.