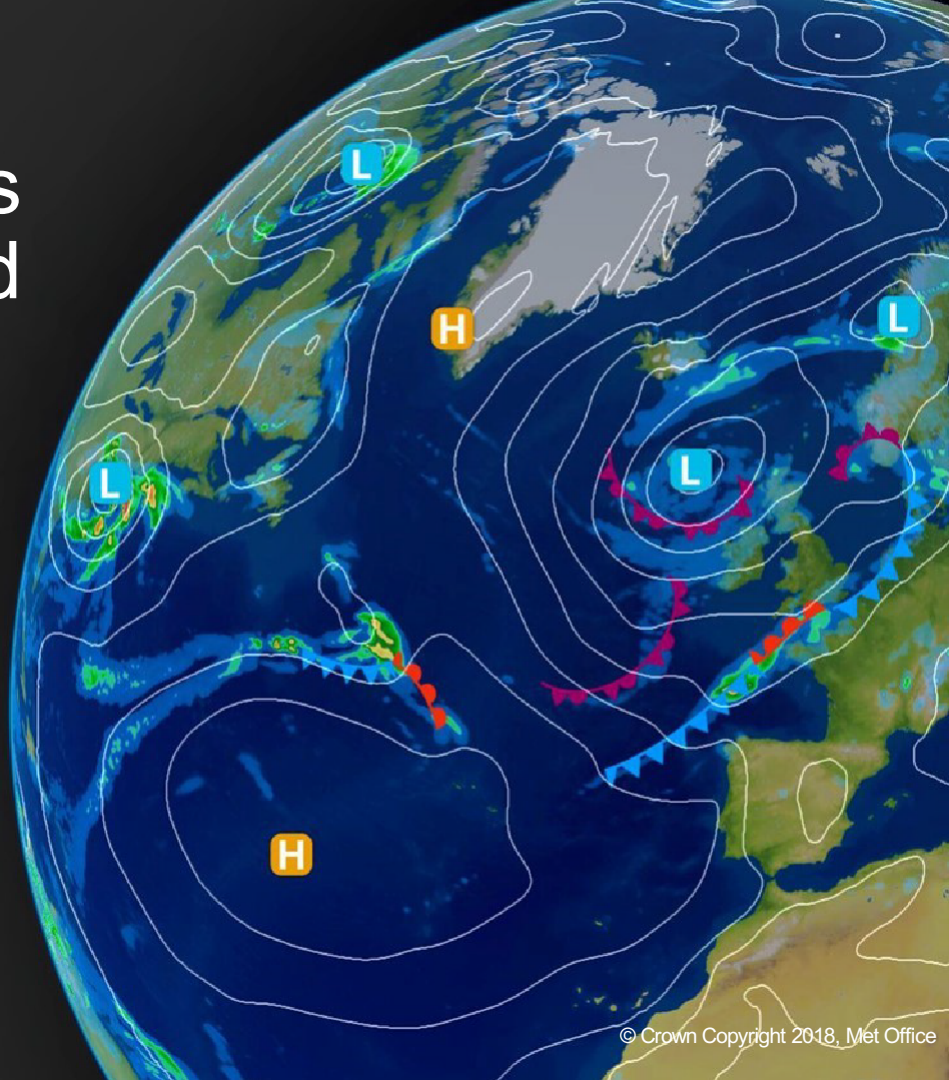
Perspectives on seamless prediction for weather and climate

Simon Vosper
Director of Meteorological Science

Sean Milton
Associate Director of Foundation Science

EPIC Workshop
6 August 2019



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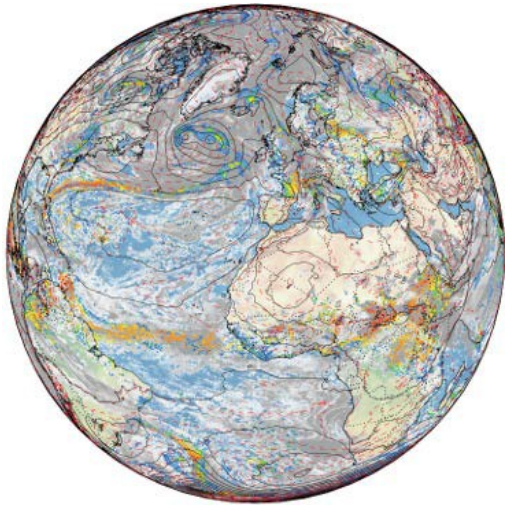
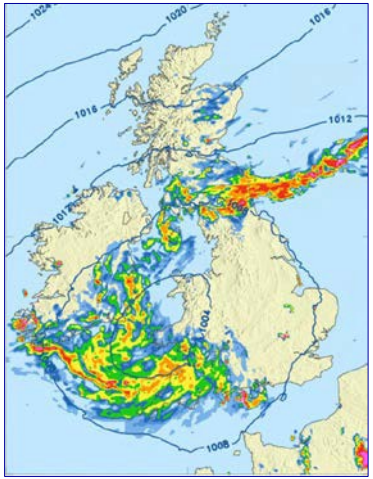
Met Office Modelling Strategy

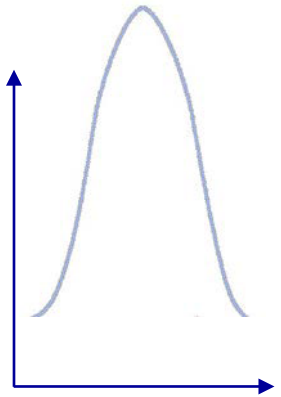
Seamless across Weather & Climate



N x **Global coupled model** at ~10km with lead times of days to years:
Synoptic drivers

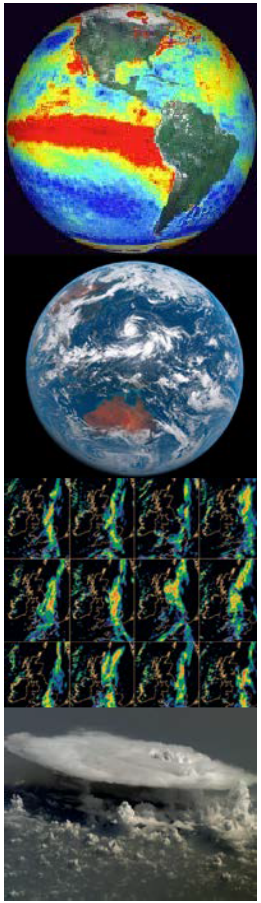


N x **local coupled model** at ~<=1km :
Local meteorology



PDF of local hazard:
Impacts

Met Office Seamless Prediction of Weather & Climate



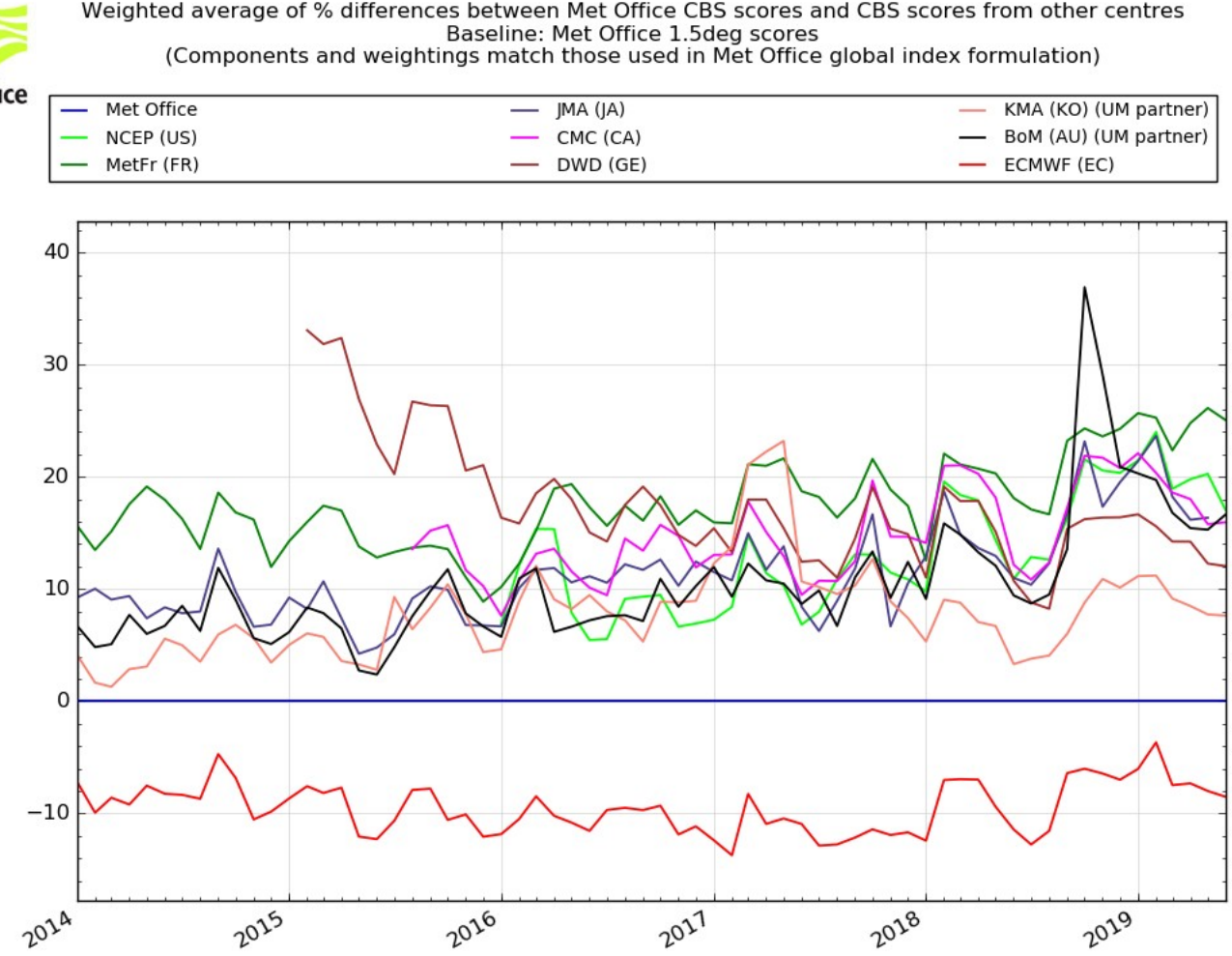
Science case: Same physical principles for weather and climate (but different processes acting on different timescales – initial vs. boundary conditions)

Seamless and traceable modelling framework: Hours to Decades & Local (km scale) to Global

Ensembles: probabilistic predictions/projections at all timescales.

Deliver: risk based predictions of high impact weather & climate events to provide resilience, societal and economic benefits.

Monthly NWP comparison



Global Seamless Physical Model

Hours | Days. | Weeks | Months | Seasons | Decades | Centuries

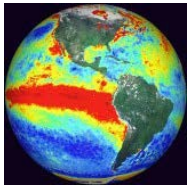
NWP

Deterministic Atmosphere & Marine

MOGREPS

Atmos. Ensemble

SEASONAL



GloSea (Seasonal)

CLIMATE

DePreSys (Decadal)

UKESM

Climate Change UKESM1, UKCP18

Global Coupled

GC Model

GC2.0, GC3.1...

GA6 , GL6, GO5, GSI6

Met Office Unified Model™ Global Atmosphere

JULES Global Land

NEMO Global Ocean

CICE Global Sea Ice

WaveWatch III Global Waves

UKCA

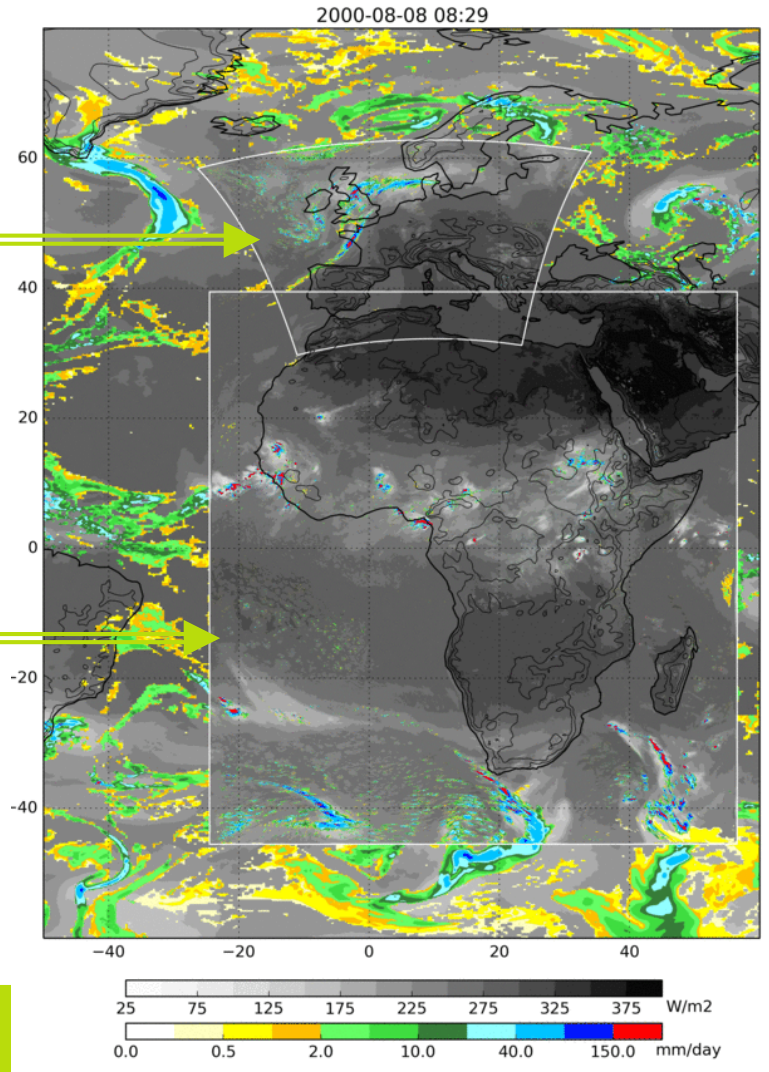
Met Office
Hadley Centre

Euro 2.2km (1536 x 1536 x 70)

10-year simulations:
Hindcast simulation
UKMO present day + future time-slice
(forced with 25km global model)

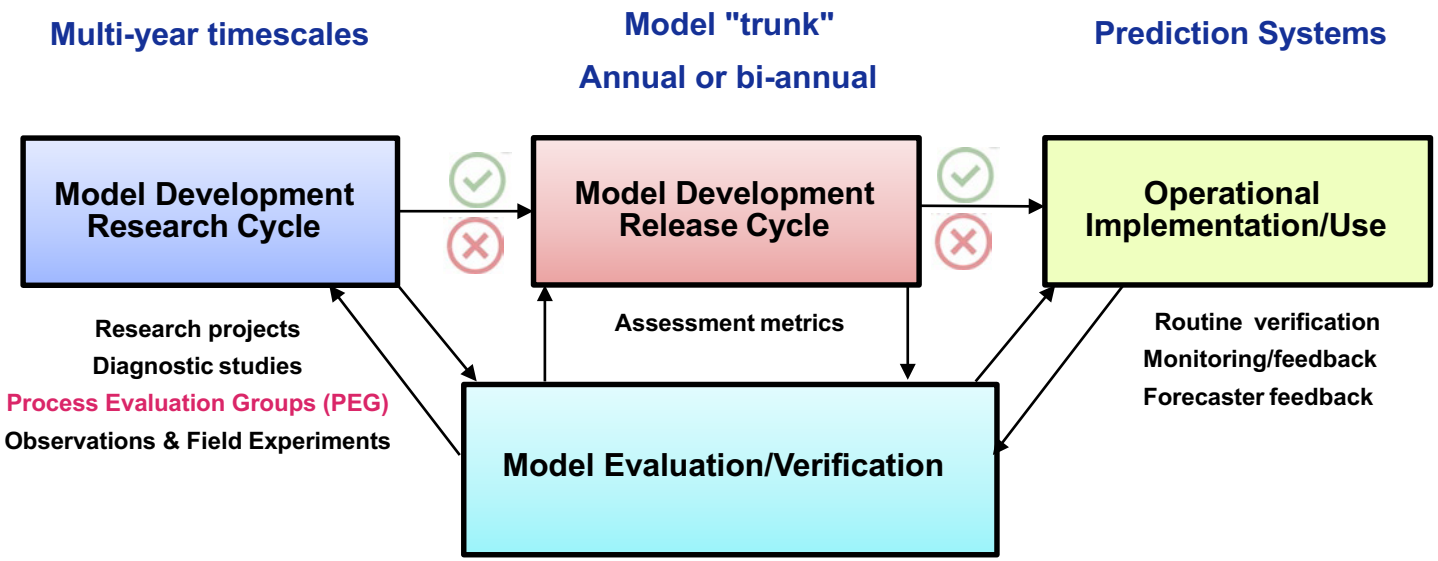
CP4Africa 4.5km (2000 x 2100 x 80)

10-year simulations:
UKMO present day + future time-slice



Seamless global and regional climate modelling

Global Model Development Process

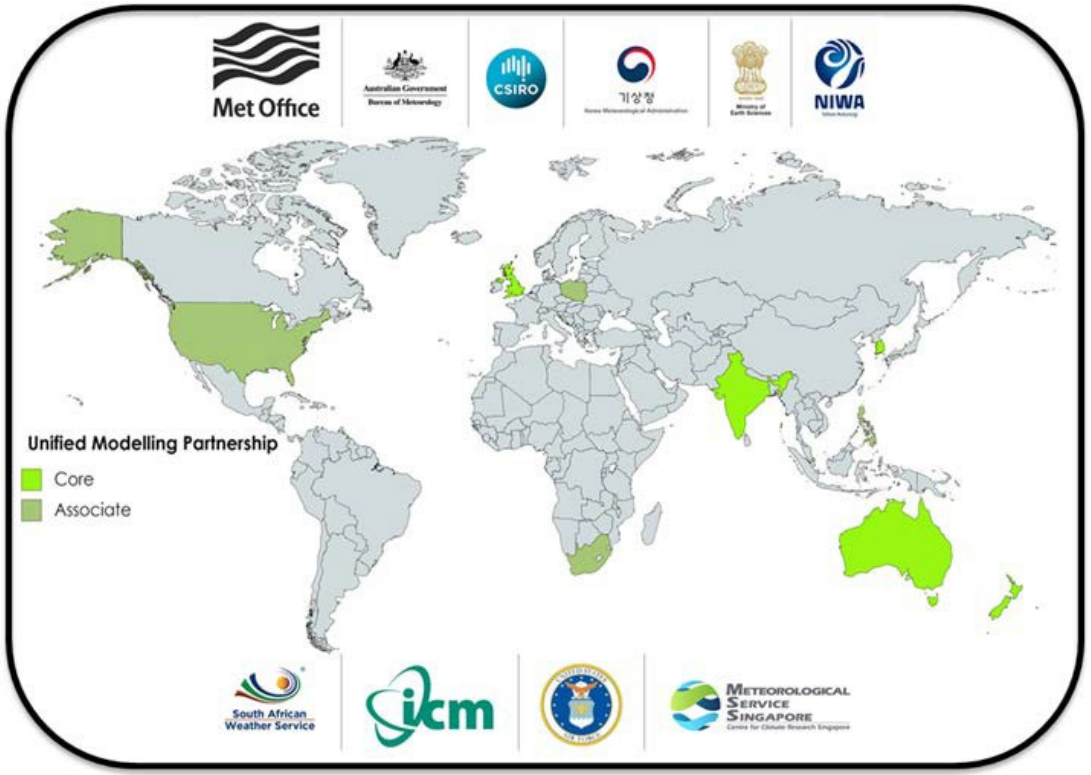


Key Decision Point

Met Office Science Partnerships

1. International UM Partnership
2. Met Office Academic Partnership (Universities of Exeter, Reading, Leeds and Oxford)
3. Met Office - NERC Joint Weather and Climate Research Programme

- Annual meetings & workshops
- Visiting scientists & secondment scheme
- Active joint model development programme
- Joint strategic research programmes



Global Trialling Frameworks

Individual component testing

- NWP Cases studies
- AMIP
- Coupled NWP
- Low Resol. DA runs
- Seasonal testbed
- Coupled climate runs
- AMIP +4K (Future Climate)

Package testing

- NWP case studies
- AMIP
- Coupled NWP
- DA/Model trials
- Seasonal testbed
- Coupled climate runs
- LAM testing (LBC)

Final production/parallel suites

- **Full hybrid-VAR DA trials**
- **MOGREPS**
- **GloSea Hindcast ensemble**
- **CMIP6/UKCP1**
- **Parallel Suites**

Model Evaluation – Top 10 Problems & PEGs

Top Model Problems –

Currently Reviewed annually at UM User Workshop

Priority: critical (2 matches)

Ticket	Summary	Keywords
#244	Lack of model/DA consistency	ga_operational_implementation
#255	Warm biases in 9 tile JULES runs over regions with heterogeneous surface type	

Priority: high (13 matches)

Ticket	Summary	Keywords
#201	Southern Ocean warm SST & sea ice bias	SOceanBiases
#202	Dry precipitation bias over India	TropicalConvection
#212	Tropical convection behaviour at grid-point/timestep level	TropicalConvection
#213	Lack of propagating MJO	TropicalConvection
#214	Blocking biases	StormsAndBlocking
#216	Biases over the maritime continent	Maritime
#217	Sahel dry bias / AEW rainfall coupling too weak	TropicalConvection
#233	High pressure bias over high-lat oceans	Drag StormsAndBlocking
#238	NWP dust visibilities not sufficiently low within areas of high dust concentration	
#241	Excess global mean precip / water cycle too strong	WaterEnergyCycle
#253	Aerosol forcing too strong	
#328	Cost of model	
#329	Seasonal signal to noise in NAO	

Full list on GMED trac: https://code.metoffice.gov.uk/trac/gmed

Process Evaluation Groups:

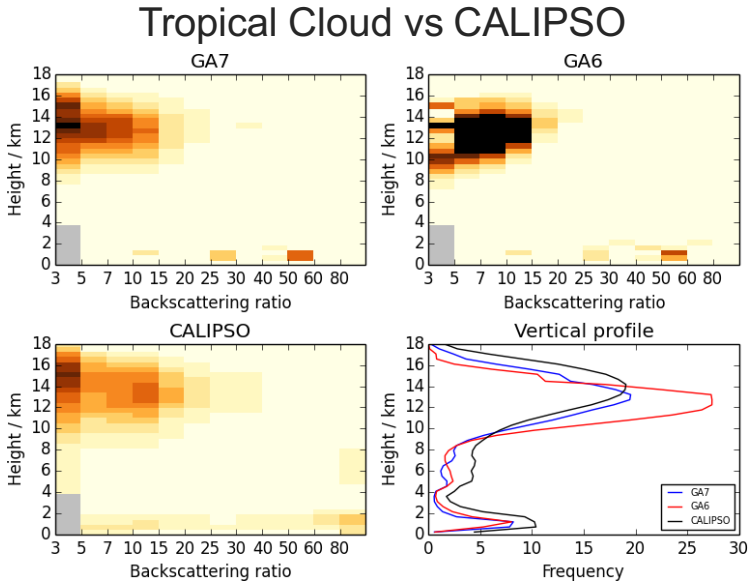
- Tropical convection
- Blocking and storm tracks
- Southern Ocean biases
- Cloud Evaluation
- Tropical tropopause T/q bias
- Maritime Continent errors
- NWP Model-DA Interactions

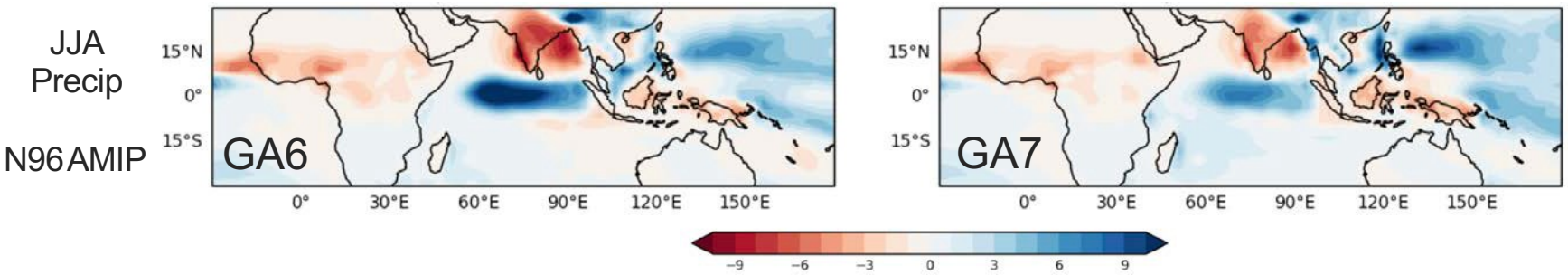
Other working groups:

- Model conservation
- S. Asian monsoon
- East Asia
- North Atlantic MOC
- Processes over Africa
- Tropical cyclones

GC3 GA7, GL7, GO6, GSI8

- Frozen in Jan 2016 ~40 science changes.
- Cloud improvements and realistically deeper convection - Improved tropics
- Reduced SO SST biases
- GC3.1 ”physical core” of UKESM1 CMIP6
- GA7.2 for Global NWP @ PS43 Aut 2019





Coupling global model developments to DA

GA7 vs GA6.1 – Tropical verification vs analysis

Model-only NWP tests

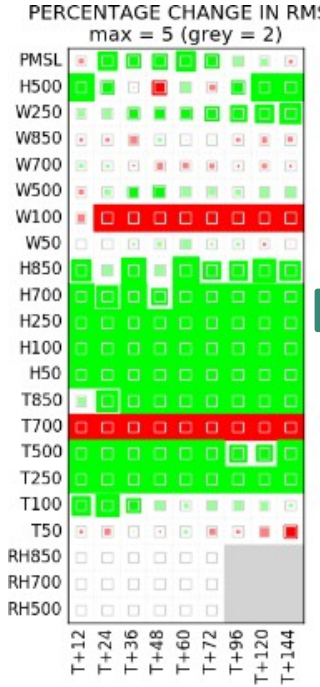
- Consistent performance between Obs and Analysis verification

Data-assimilation trials

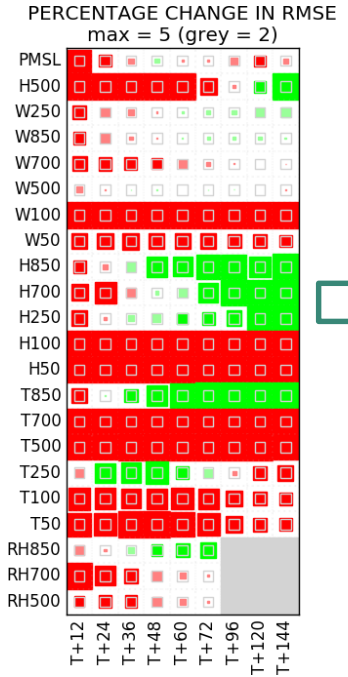
- N320 and N640 trials inconsistent between Obs and Analysis verification
- 4DVar trial performance is relatively poor

The complexity of the NWP system makes it very difficult to understand the causes of the performance issues

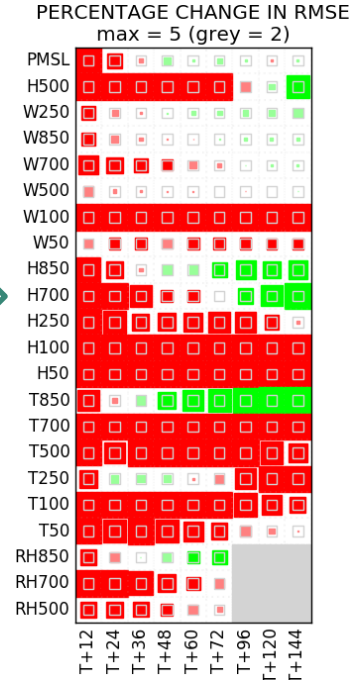
Case studies from EC Analysis



n320 non-hybrid 4DVar



n640 hybrid 4DVar



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Summary

Significant benefits of seamless modelling approach. Common "trunk" science and code for:

- Global weather-seasonal-climate modelling
- Regional (convection-permitting) weather and climate modelling

NB pragmatic branches are sometimes required for system implementation

Significant benefits from coordinated partnerships, in particular from:

- Model evaluation (global and regional)
- Joint model development e.g. Earth System (UKESM) and component models – land, ocean, chemistry
- Joint technical programmes e.g. model evaluation toolboxes, suite control (rose/cylc)

But there are also challenges!

- Testing strategy very important - this is a significant overhead
- System and software complexity – access to test suites (including DA) is essential
- Enabling partner contributions – the UM design is old, and not modular; pull through of model upgrades from partners still heavily dependent on Met Office expertise.