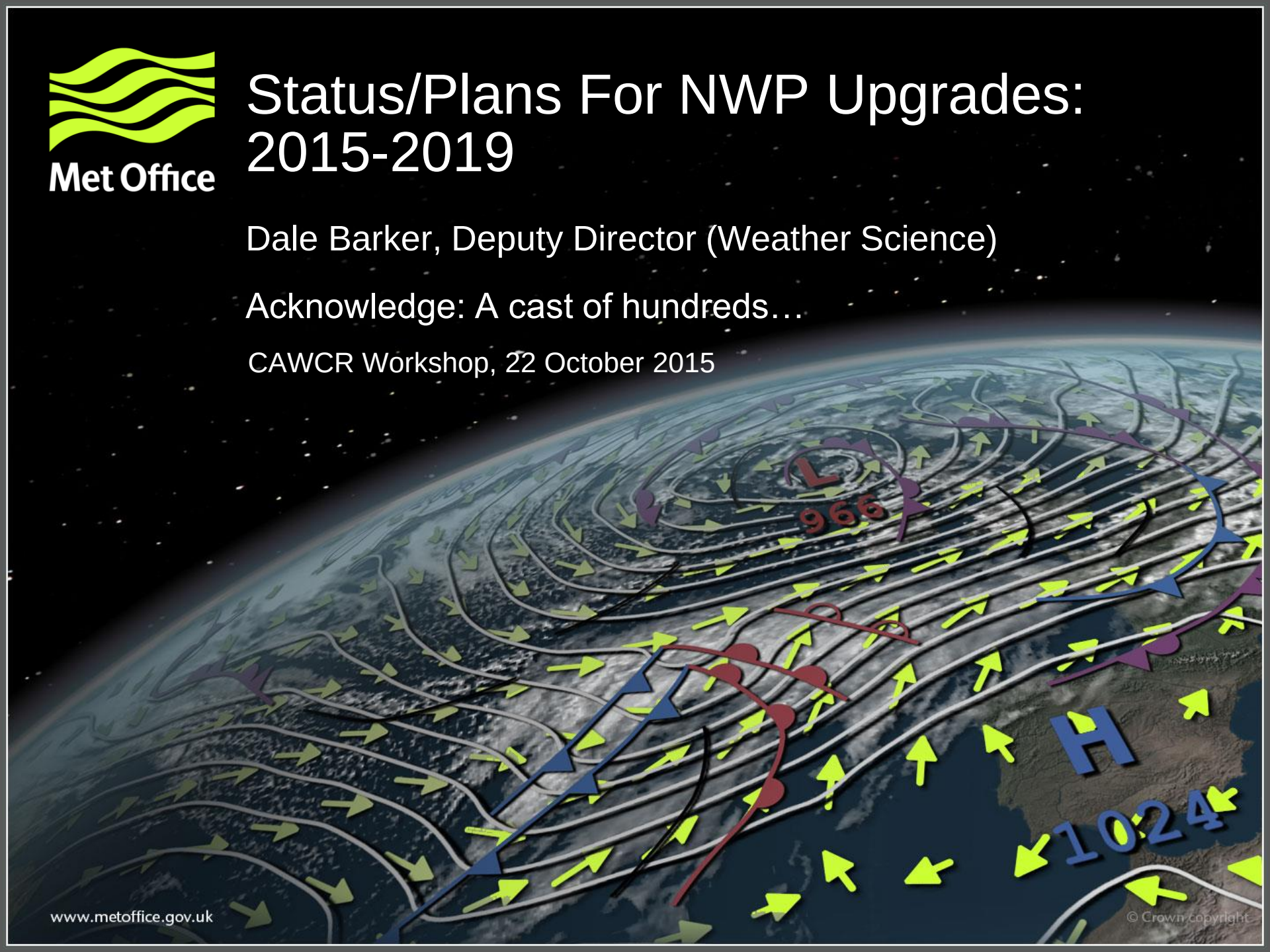
Status/Plans For NWP Upgrades: 2015-2019

Dale Barker, Deputy Director (Weather Science)

Acknowledge: A cast of hundreds…

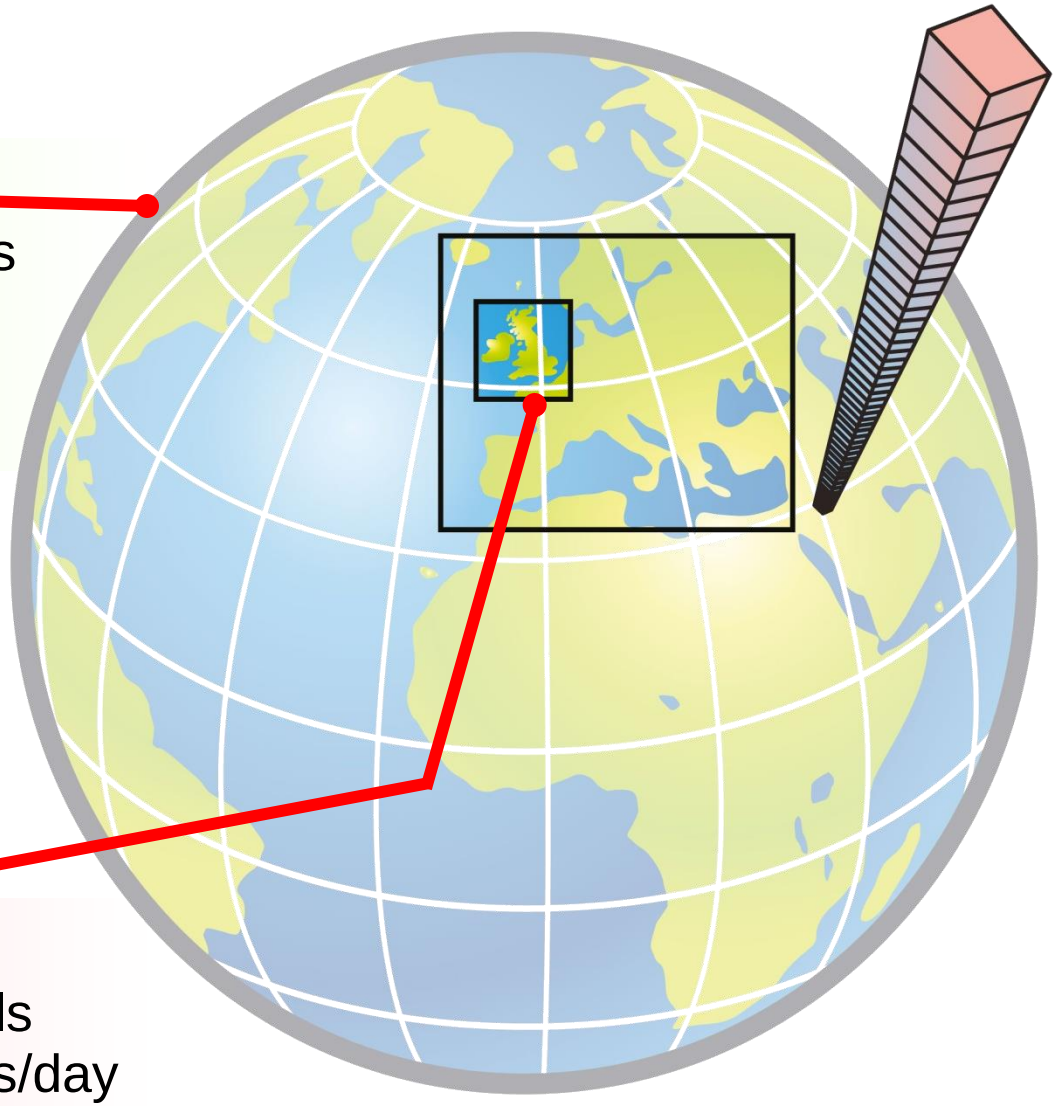
CAWCR Workshop, 22 October 2015



Main NWP Configs At The Met Office

Global

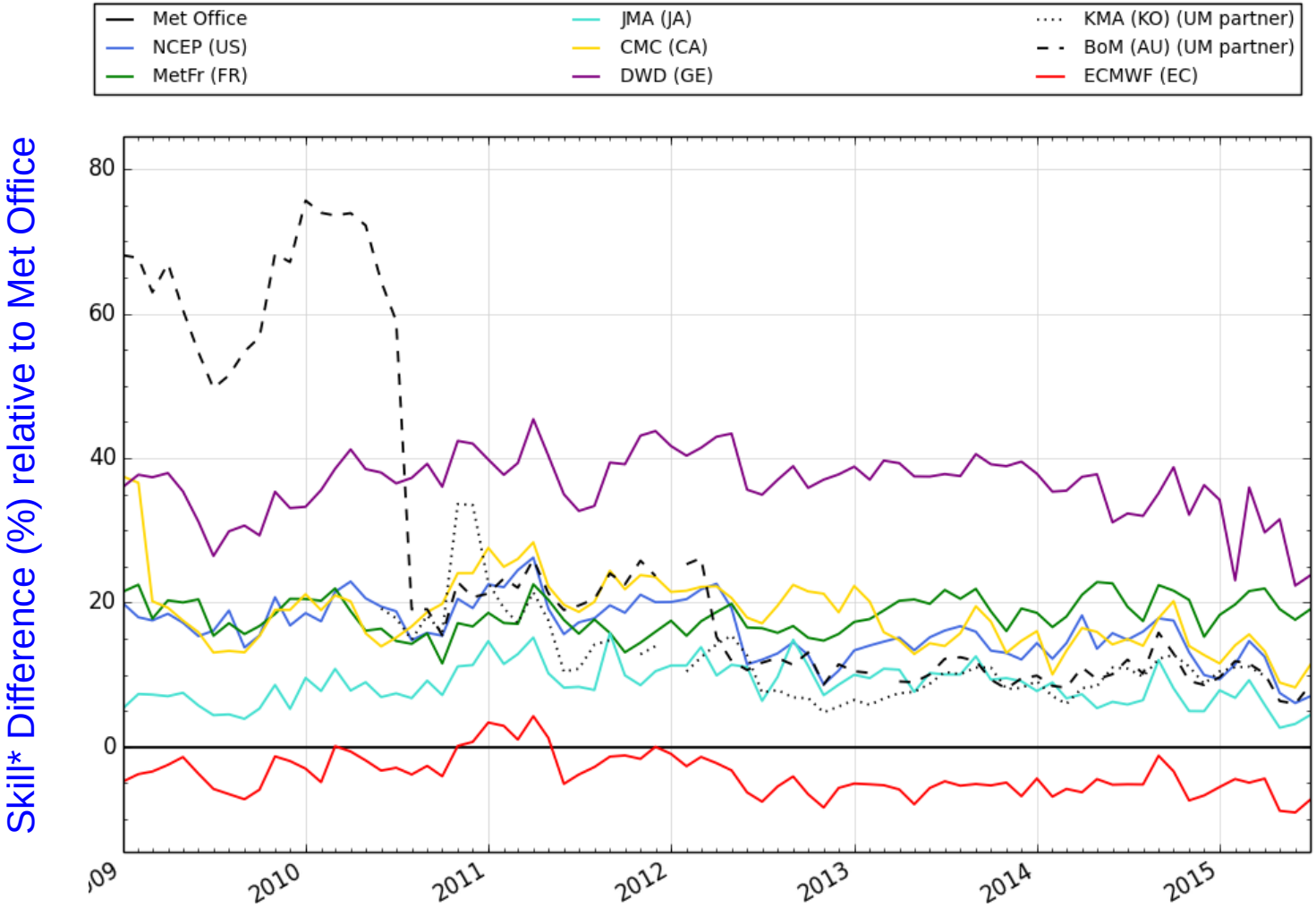
- 17km grid, 70 vertical levels
- 48 hour forecast twice/day
- 6 day forecast twice/day
- Hybrid 4DVar DA



UKV

- 1.5km grid, 70 vertical levels
- 36 hour forecast eight times/day
- 3DVar DA

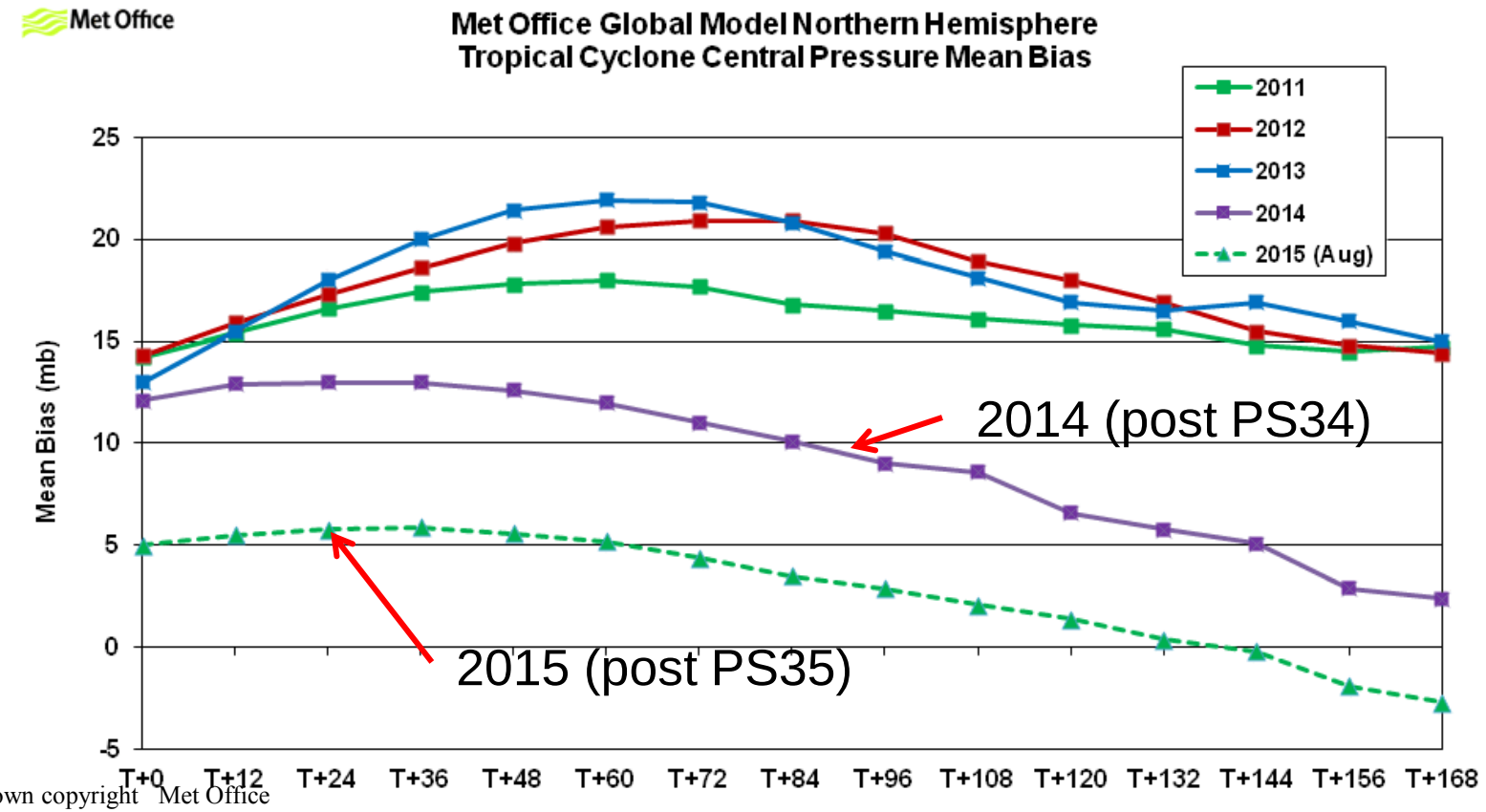
Skill Of **Global Model** Vs Other NMSs



* Parameters: Surface pressure, 500hPa geopotential height, 250hPa/850hPa Winds; Forecast ranges from T+24h to T+120h

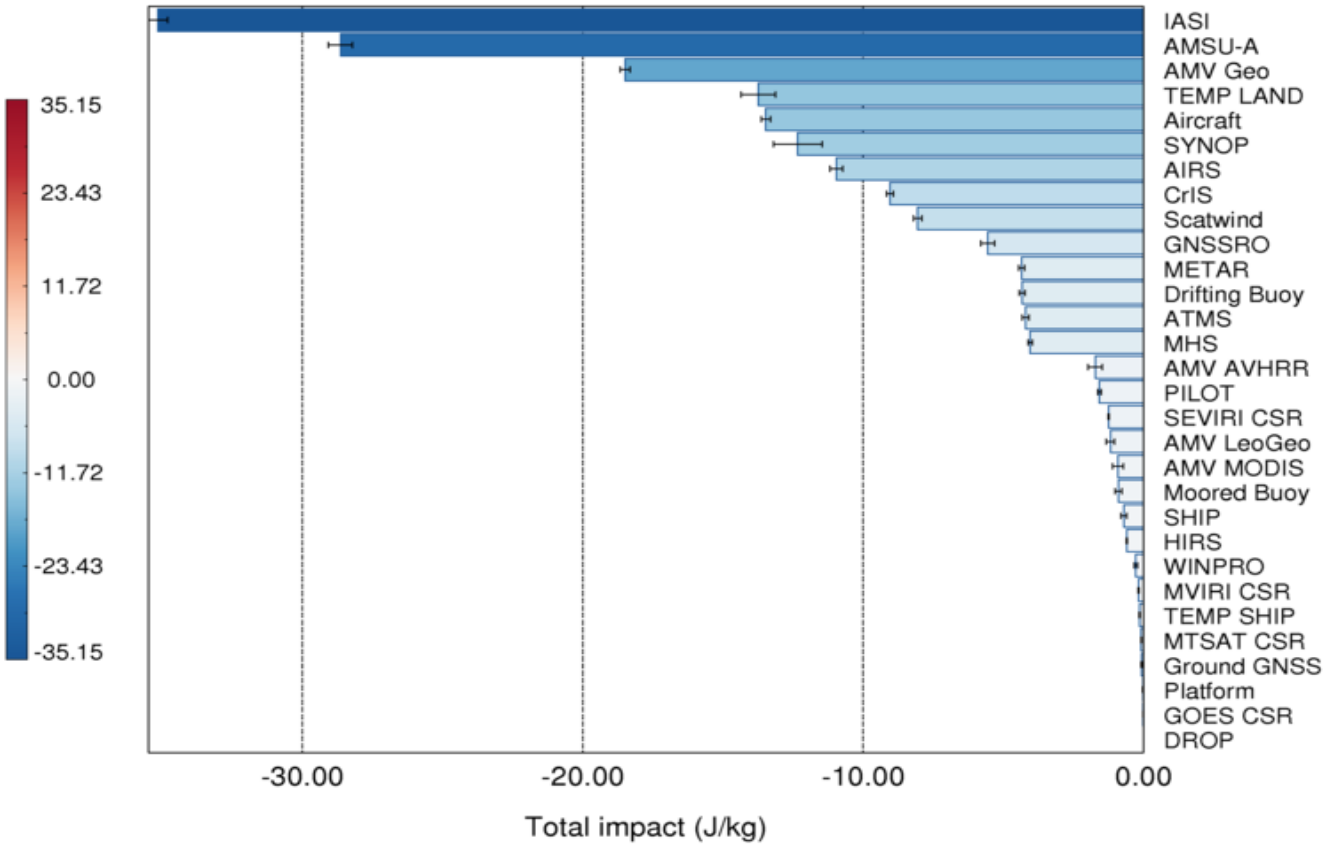
Tropical Cyclone Intensity Forecasts

- Numerous very intense tropical cyclones in the Pacific
- PS34 = 17km+ENDGAME+GA, PS35 = Single Ps Typhoon Bogus restored



Forecast Impacts Of Observations

May 2015 Observation Impacts (J/kg)



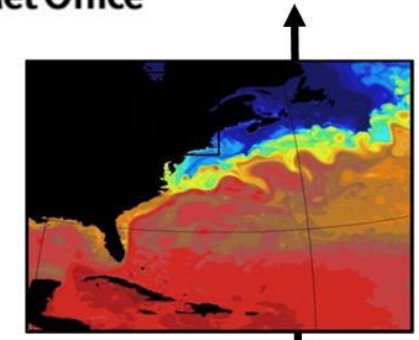
- Impact of on T+24 forecast (global energy norm).
- Notable: IASI (IR) now at top, AMV-Geo significant increase over past 1-2 yrs.
- Remember: FSO is not a perfect tool, need to interpret results carefully!

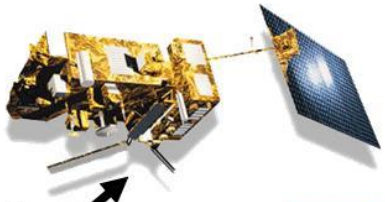
Cray XC40 Supercomputer

System	Capacity *(Volume –V)*	Planned Acceptance	Nodes
IBM P7 *(2014 twin clusters)* *- Baseline for Performance Measurement*	1		1056
IBM P7 *(All 3 clusters)*	1.15		1216
Phase 1a	1	25 Aug 2015	1088
Phase 1b	5.21	Feb 2016	4992
Phase 1c	9.63	Feb 2017	6060

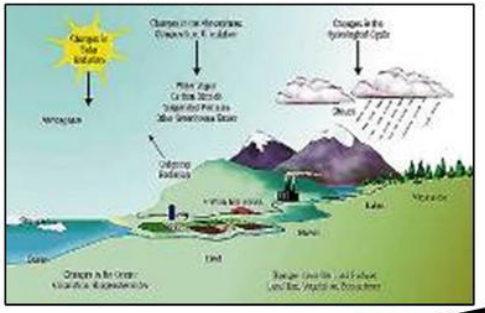
Improving forecast skill and use

Met Office





Earth Observation

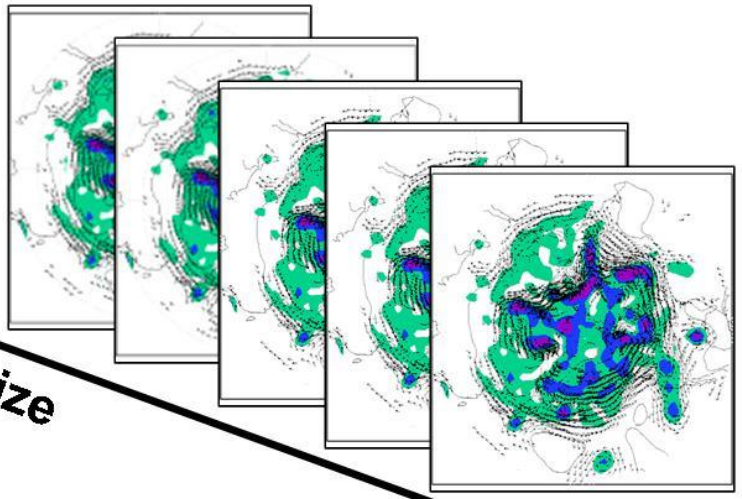


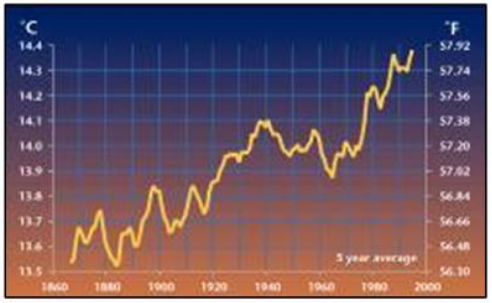
Resolution

Computing Resources

Complexity

Duration and/or Ensemble size





Global Model and DA Upgrades 2016-2018

- PS37 (Mar 2016)
  - **VarBC + Satellite Upgrade Package***
  - CVT swapped order transform
  - Prelim – part A (extend 'update' run to 7 days)
- PS38 (Jun 2016)
  - Prelim – part B (run 'main' run 1 hour earlier)
  - Increased VAR iterations (allow better convergence)
  - Coupled Ocean-Atmosphere with weakly-coupled DA (**Walters talk**)
- PS39 (Jan 2017)
  - GA7 (similar cost to GA6?)
  - Deterministic resolution: N768 (17km) -> N1280/1024 (10km/12km)
  - Ensemble resolution: N400 (33km) -> N640 (20km)
- PS40/41 (Jun 2017/Jan 2018)
  - **Replace ETKF (most likely ~100 member En-4dEnVar, later ~200 mem)**
  - **Global RUC**

*Satellite upgrade package likely at every Parallel Suite

PS37 Satellite Upgrade Package (operational Spring 2016)

Temperature

- ATOVS over land
- New AMSU RT coeffs

Also:
- Dust &
- ISS Rapidscat

Humidity

- **AMSR-2 (Imager, pm)**
- **M-T Saphir**
- **FY-3C MWHS-2**
- FY-3B MWHS-1
- Geo CSRs over low cloud (?)

Temperature and humidity

- **VarBC**
- **SSMIS (F-17, F-18 & F-19)**
  - **T-sounding**
  - **Q-sounding**
  - **Imager (am orbit)**
- **Correlated errors for CrIS**
- **CVT-2**

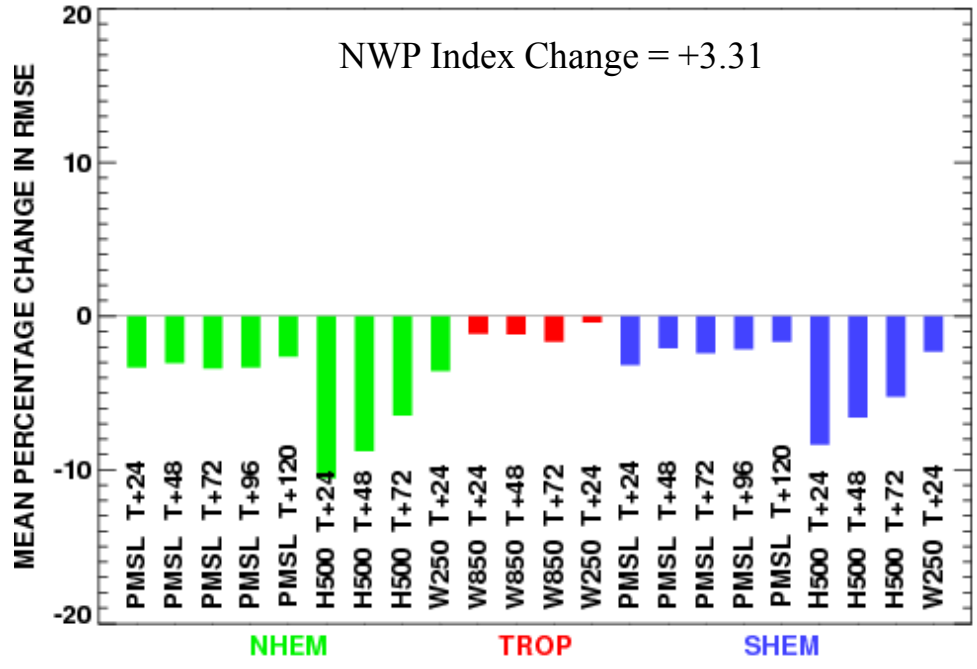
KEY

- Tested within SA package/ SA + CVT package
- Not included for PS37

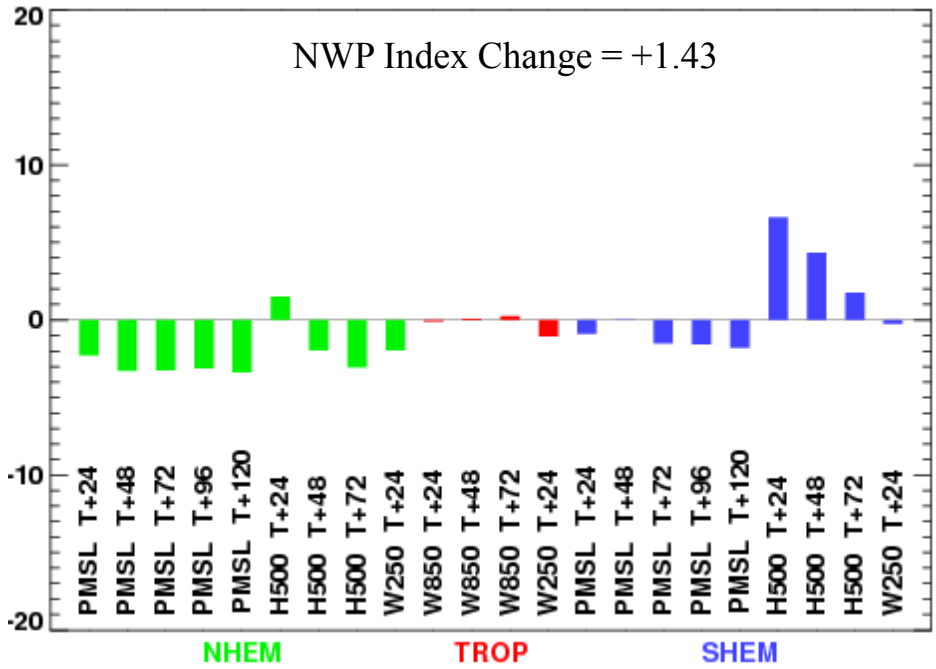
New 2015 Satellite DA Package: Variational Bias Correction + New Obs

Verification based on 79 days (10 April – 26 June 2015)

Verification Against Own Analysis

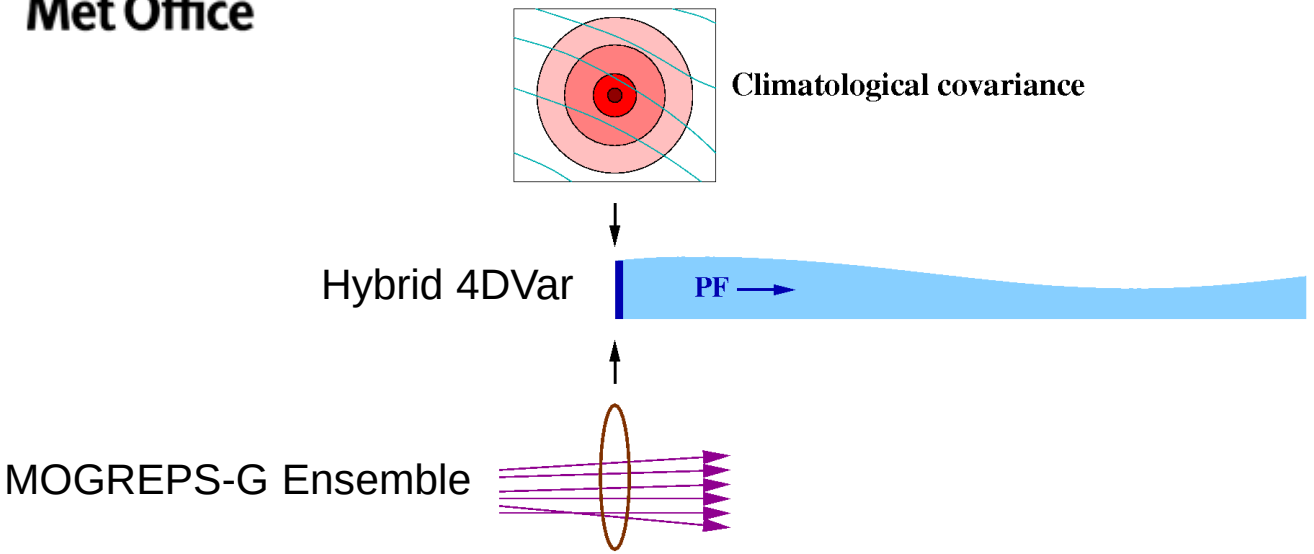


Verification Against Observations

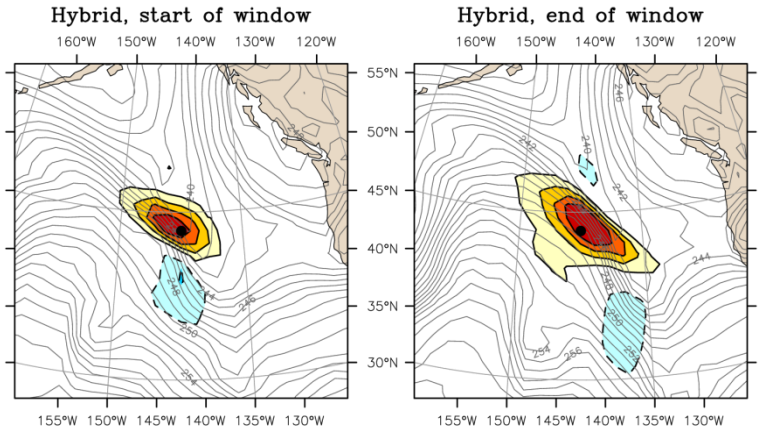


Operational global DA at the Met Office

2011 - present: Hybrid 4DVar

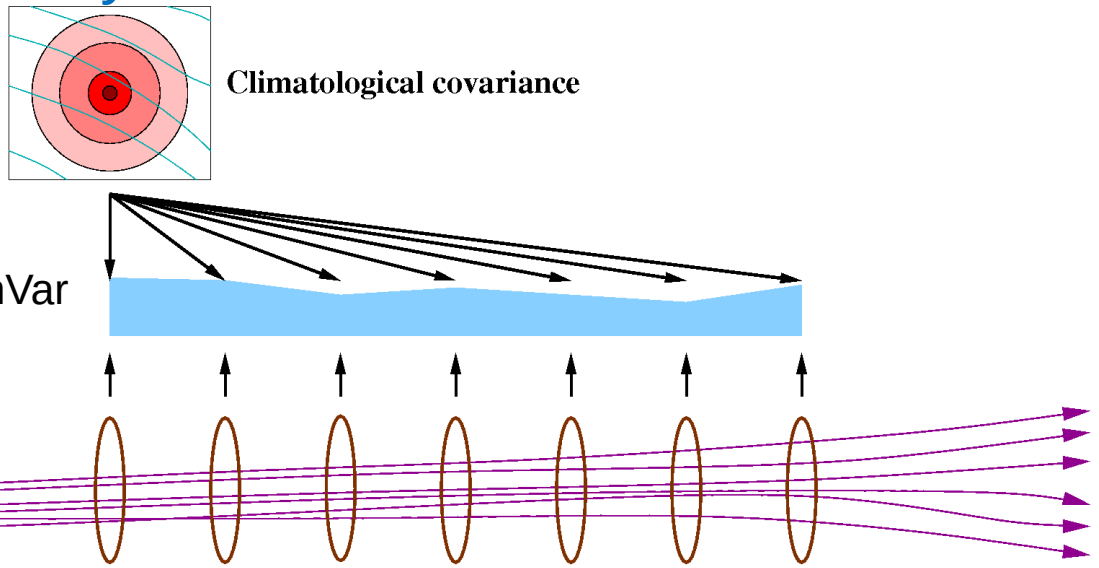


- Background error covariance at beginning of window: $\mathbf{B} = \beta_c^2 \mathbf{B}_c + \beta_e^2 \mathbf{B}_e$
- **B** propagated in time by linear "Perturbation Forecast" (PF) model.
- Response to a single wind observation:



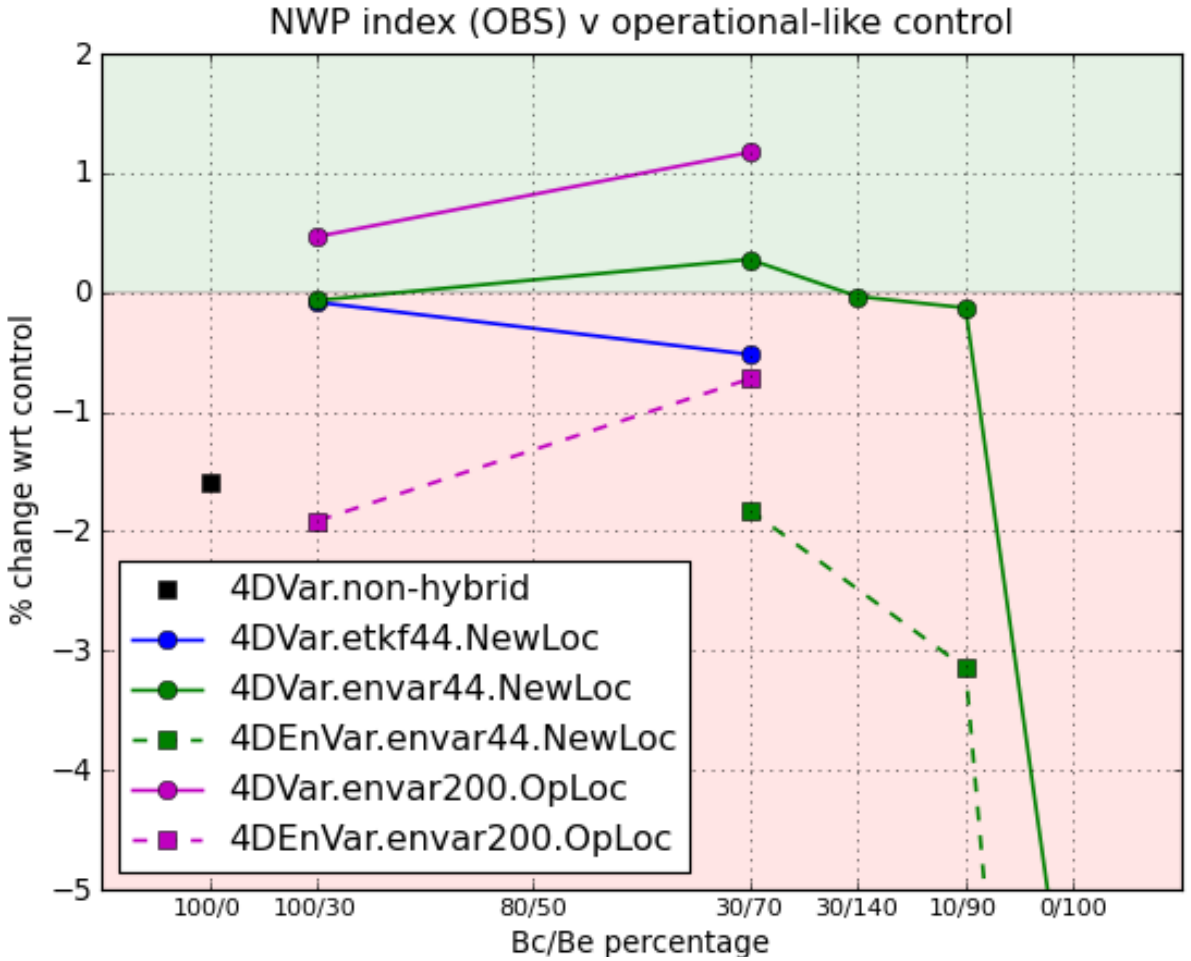
Operational global DA at the Met Office

Beyond Hybrid 4DVar: 4DEnVar?



- No PF model – more appropriate DA for coupled ESM and LFRic?
- 4DEnVar ~1/11 cost of 4DVar – can afford higher res/more members.
- However, I/O and memory challenges replace scalability one.
- 4DEnVar can also be the basis for an ensemble predictions system (En4DEnVar)

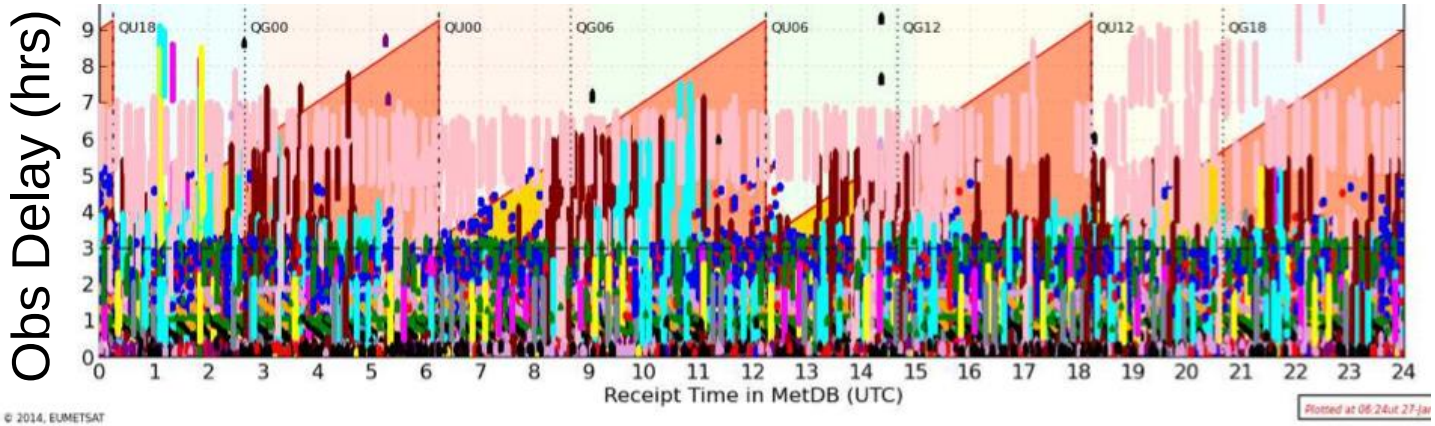
4DEnVar Project: Summary

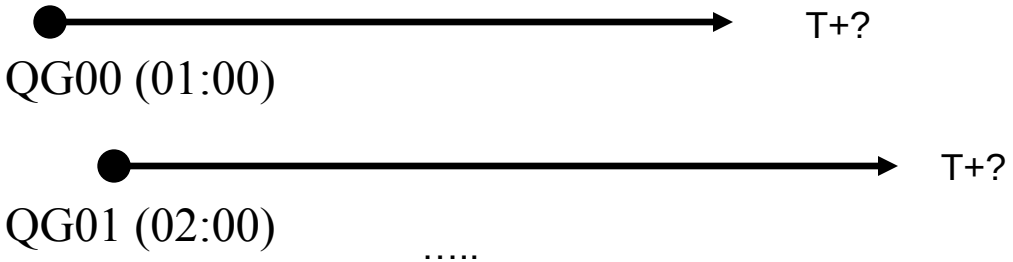


Conclude:

- 4DEnVar cannot beat hybrid 4DVar (which will remain DA scheme to 2020), but
- En4DEnVar better ensemble generation than ETKF so will retire latter.

Global Rapid Update Cycling (RUC) (Example 00UTC analysis shown)





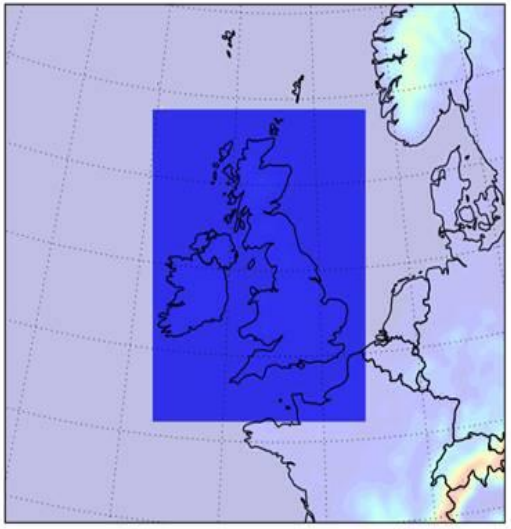
Rapidly updating global provides:

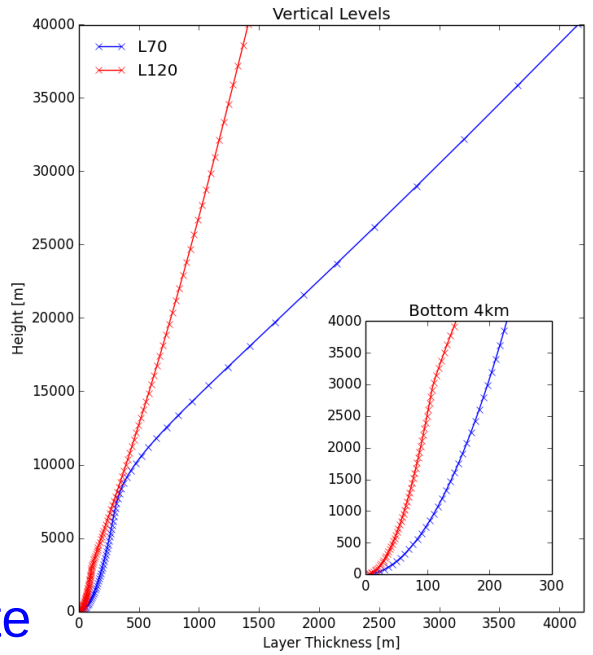
- Much greater flexibility to decide when to run global forecasts
- Smoother transition between subsequent analyses.
- DA (affordable via preconditioning) benefits e.g. smaller increments
- Basis for unified global NWP/cloud analysis system

UK Model Upgrades 2016-2018

Provisional schedule*:

- PS37 (Mar 2016)
  - MOGREPS-UK centred around UK DA plus stochastic physics
  - Physics upgrades (e.g. snow)
- PS38 (Jun 2016)
  - Expanded domain and forecast length
- PS39 (Jan 2017)
  - **Hourly 4DVar-based NWP-Nowcasting System**
- PS40 (Jun 2017)
  - RA3.0 Physics (first release from new RA process).
- PS41 (Jan 2018)
  - Vertical resolution (L70 – L120?)





*Satellite upgrade package likely at every Parallel Suite

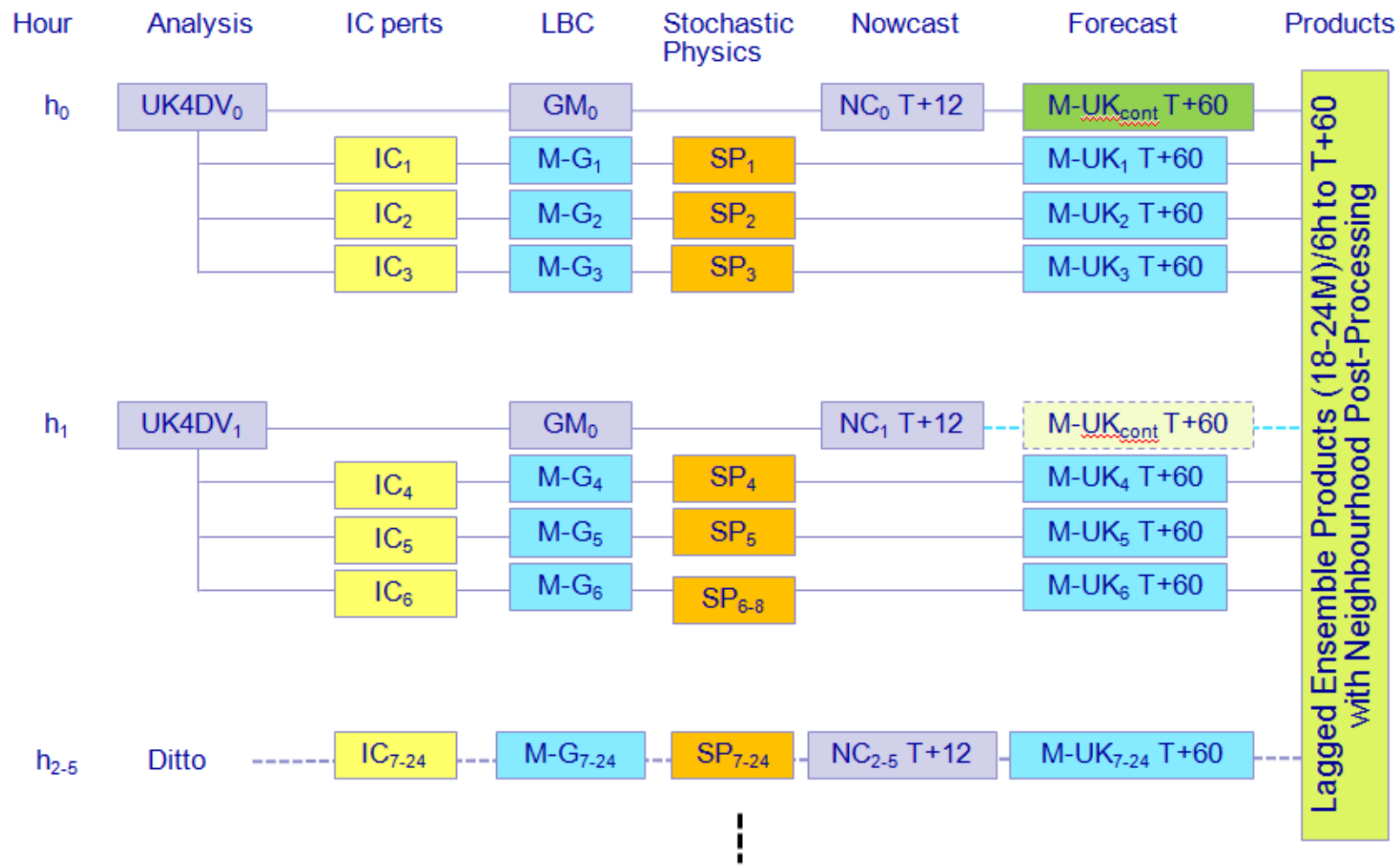
Hourly UK-wide 4DVAR

- **Status & Plans:**
  - **March 15: reported on evaluation of upgraded NWP-Nowcasting system based on hourly 4DVAR**
  - **Sept 15: new ‘vn2’ baseline hourly 4DVAR suite released to developers**
  - **Dec 15: upgrade to ‘vn3’ with latest 4DVAR science + PS37, prior to longer trials run at ECMWF**
  - **March 16: report on trials of hourly 4DVAR system suitable for ‘nowcasting’ (ie when HPC power available)**
  - **Dec 16: Deliver hourly 4DVAR system, suitable for nowcasting within expanded UK model domain, ready for inclusion in a package trial**
  - **Operational implementation targeted at PS39**

Future Ensemble Organisation

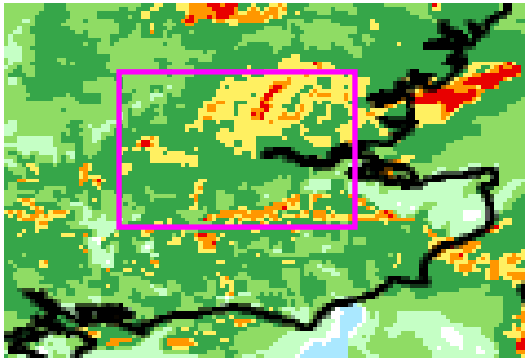
19-24M/6h MOGREPS-UK Nested in 18-24M MOGREPS-G with hourly UK4DV nowcast

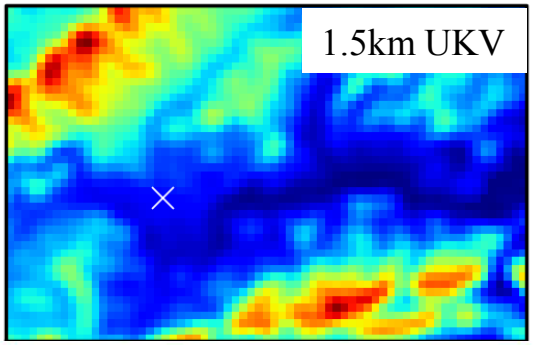
***Assumptions**: GM and MOGREPS-G initiated 3h earlier; all UKV runs at same resolution*

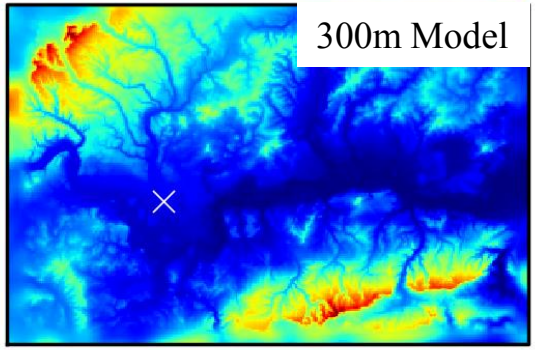


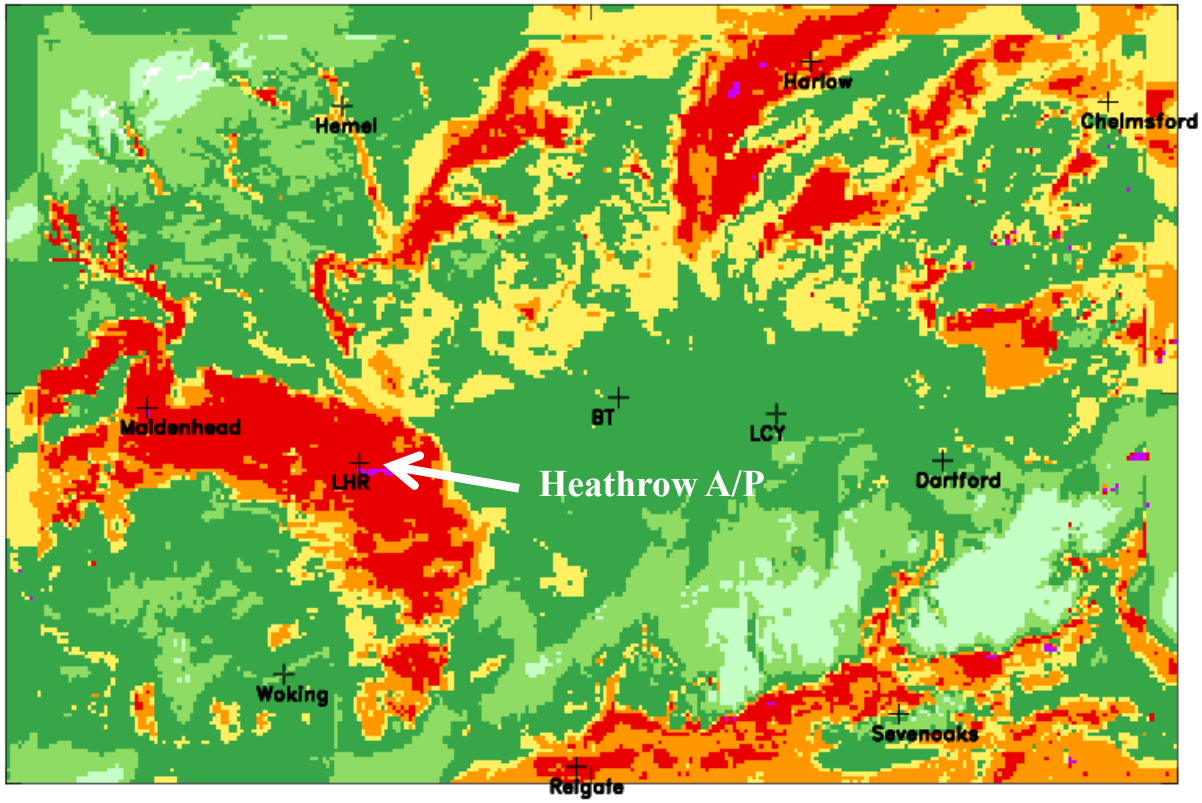
The Future: Very high resolution modelling

300m model running experimentally for London

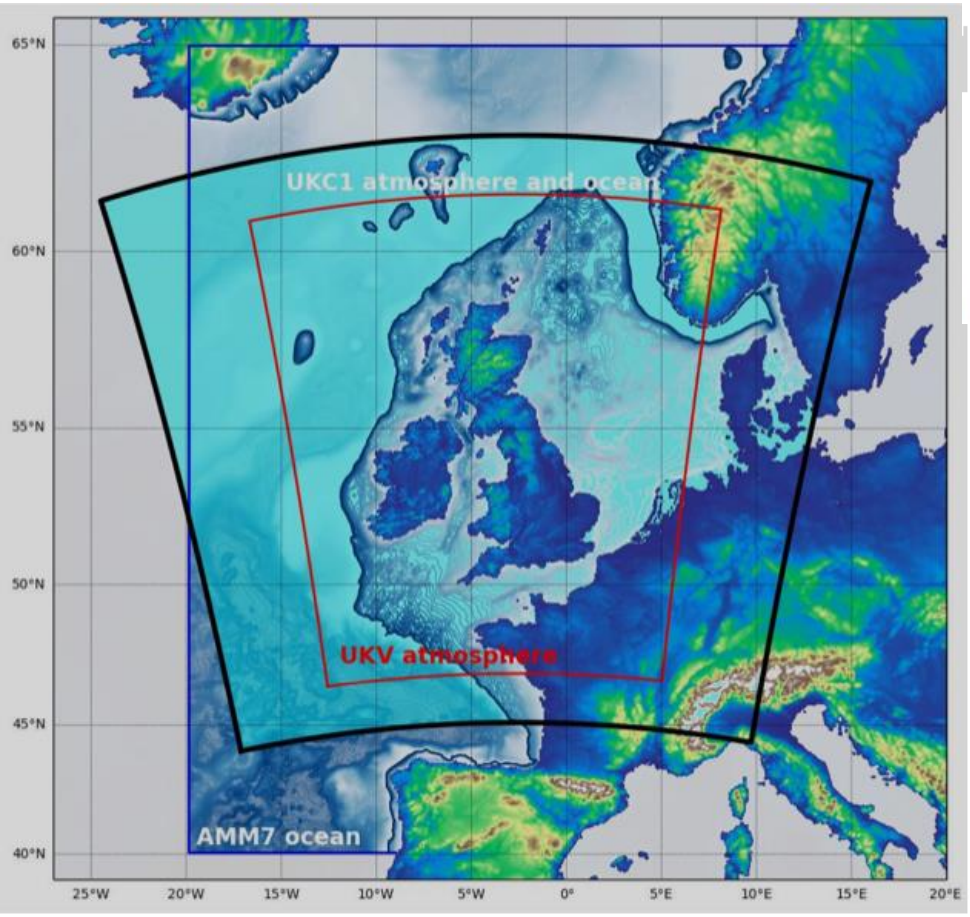




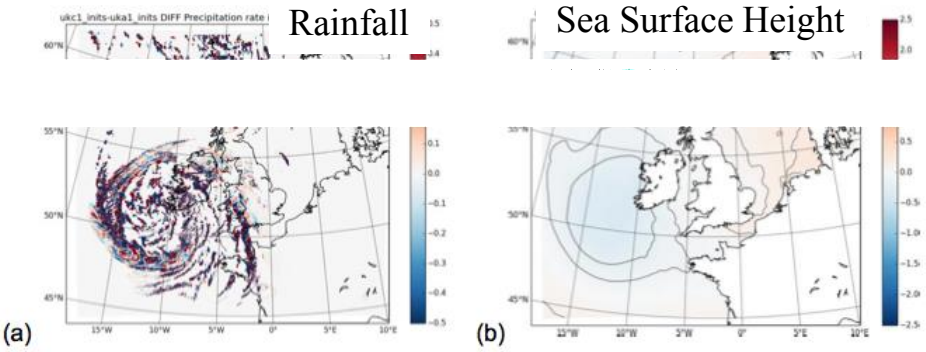




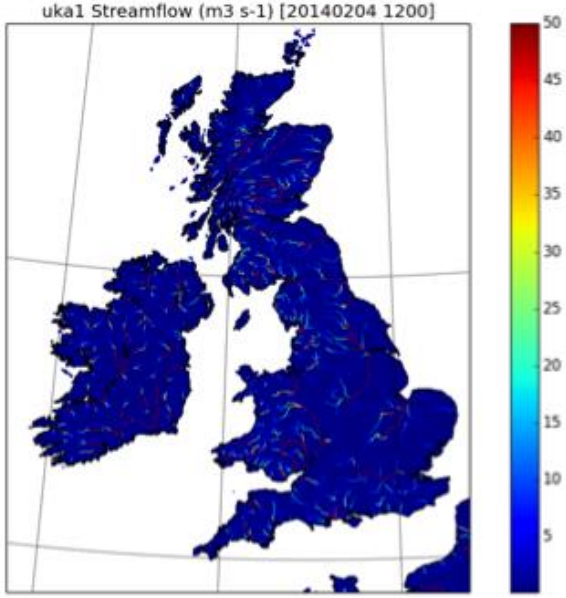
The Future: UK Environmental Prediction



Coupled (O-A-L) – Uncoupled Model Differences



River routing (RFM model):



2019 Operational Suites (draft)

(Red) = factor HPC resource increases relative to 2015 config (Purple) = To be confirmed

UM Atmosphere	Wet Models	Other
PUBLIC SERVICE ▪ Global Coupled 10-12km (x10) ▪ Euro Downscaler 4.4km (x1) • UK 1.5km (x3) or 1.0km? • NWP-Nowcasting (Current UK x7) • MOGREPS-G Coupled 18/24*20km (x10) • MOGREPS-UK 19/24*1.5-2.2km (x15) **OTHER CUSTOMERS** • Arabian Peninsula 4.4km • Afghanistan 4.4km • Eastern Mediterranean 4.4km • Falklands 4.4km • North Africa 4.4km • S. E. Asia 4.4km • Lake Victoria 1.5-2.2km • London 'demonstration' model (x2.7) • 3D VOM (x1)	**OCEAN - NEMO FOAM** • 1/12° Global (x10) • 1/60° North West Shelf (x50) • Arabian Gulf 4km (x10) **WAVE WAVEWATCH III** • Global 25-3km (x3) • 1/60° North West Shelf (x50) • UK 2-1-0.5km (x10) • Arabian Gulf 4km (x1) • Atlantic EPS 25-3km (x3)	**STORM SURGE** • <4km North West Shelf (x20-50) • EPS 12*7km to 7 days (x15) **SEA SURFACE TEMPERATURE** • OSTIA 1km global (x1) **AIR QUALITY** • AQUM 4/12km UK/Europe (x3) **MONTHLY / SEASONAL EPS** • GloSea5 25km (1 month, 7 month and hindcast) (x5) **SPACE WEATHER** • WSA-Enlil Solar Wind

Thanks.

Any Questions?

Costing the Plans?

GL	1.8-2.8	1.7	1.5-1.9	-	-	1.1?	>1	>5-10
	1.8-2.8	1.7	1.5-1.9	-	1-1.5	1.1?	?	5-15
UK	1-2.3	1.7	1-1.5	1.4	-	-	1.5-2.5	4-21
	2.3	1.7	1.5	1.4	1.5-2	-	1.5	18-25

We intend to run representative configs. on phase 1b in Q1 2016

Now we are just guessing UM costs based on grid-point/time-step scale-up.

- *Cannot estimate impact of imperfect scalability without testing*
- *More difficult to estimate accurate cost of complex DA suite changes*
- *Need to understand whether candidate suites can be scheduled*
- *SUGGEST WE ARE NOT OVER AMBITIOUS*