Benefit of Higher Resolution Analysis and Mesoscale Observing Networks in the UK Models

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Introduction

This study assesses the added benefit provided by high resolution data assimilation (DA) in the UK models relative to running in "forecast-only" mode from interpolated analyses of the driving global model. Additionally, we hope to be able to diagnose strengths and weaknesses in the LAM DA system. Whilst pre-operational trials focus on the benefit of an incremental change to the full DA system, running a UK downscaler trial suite creates an opportunity to set a baseline against which we can run Observing System Experiments to measure the gross benefit of the UK LAM DA system as a whole. We anticipate that the results will help justify the additional overheads associated with development and maintenance of the local DA system. Moreover, with the help of an additional trial observation configuration where we omit those 'non-conventional' observation types that are used exclusively in the local analysis, we also seek to partition the gross benefit between the 'non-conventional' obs types on the one hand, and the 'conventional' observations being assimilated at a higher resolution than in the parent global model on the other. It is hoped that an analysis of the results will help to identify relative strengths and weaknesses in the UK LAM DA system, particularly where highlighted by characteristic weather types - this in turn should assist in developing a more optimal UK LAM DA strategy.

1. Trial Configurations

A. Full local UK4 Data Assimilation

- As operational configuration
- 3DVAR (with FGAT) + IAU for all observations including MOPS cloud fraction *except*
  - Latent Heat Nudging for radar-derived surface rain rate
- VAR grid is uniform 4km resolution over whole domain

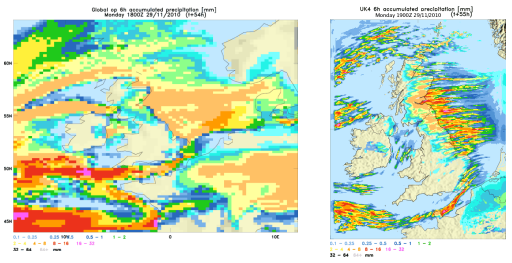
B. Partial UK4 Data Assimilation

- As **A** omitting extra observations not assimilated in global model operational configuration, ie the following observations were denied:
- *MOPS cloud fraction profiles* (3-hourly, 4.5km resolution)
- *radar-derived surface rain-rate* (hourly, 5km resolution)
- *visibility from SYNOPs* (hourly)
- T_{2m} & RH_{2m} *from Highways Agency roadside sensors* (hourly)
- *Doppler radial winds* (3-hourly)

C. The UK4 DownScaler

- Set-up in November 2010 as quasi-operational model in response to requests from forecasters for longer range hi-res guidance during the early wintry weather.
- Runs from interpolated Global Analysis (no local DA)
- Convenient Baseline to measure impact of local DA

Global underestimates east-coast snow shower penetration, downscaled UK4 more realistic



A vs **C** : total benefit of full high-res DA system
A vs **B** : benefit of 'local-only' obs types
B vs **C** : benefit of higher-res analysis

D. Single Obs-type Denials as appropriate

- *eg MOPS cloud, radar rain-rate, GNSS*

2. Verification by Trial Period

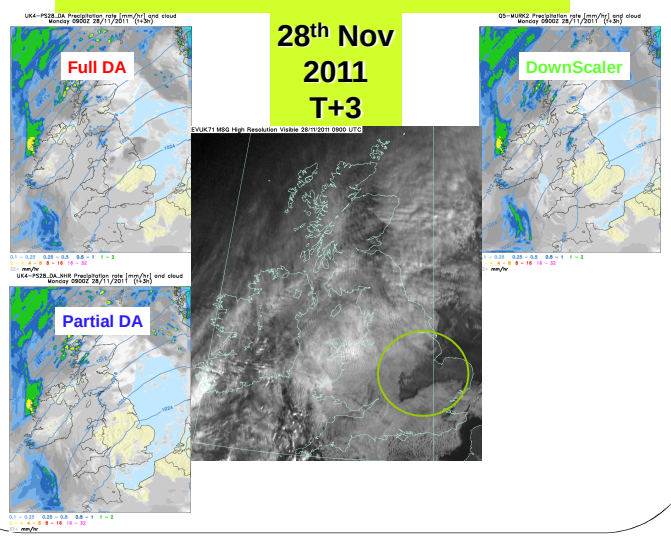
Forecasts to T+24 at 00Z, 06Z, 12Z & 18Z

Period	Dates	No. of Forecasts	*UK NWP Index Benefit*		
			of *full local DA system*	of *extra obs types not assimilated in the global model*	of *hi-res DA alone*
July 2011	Jul 1st → Aug 10th	**160**	**+2.54%**	**-0.96%**	**+3.50%**
November 2011	Nov 1st → Dec 14th	**176**	**+1.17%**	**+0.28%**	**+0.89%**
January 2012	Jan 3rd → Feb 10th	**152**	**+0.78%**	**-0.18%**	**+0.96%**
March 2012 See 6. & 7.	Mar 10th → Mar 31st	**84**	**-4.83%**	**-4.47%**	**-0.36%**

- Most consistent benefit from **full higher-resolution analysis** relative to downscaled analysis
- Mixed performance from the **extra observations** **but**
  - **+2.4%** benefit from **GNSS** in July trial
  - **+0.7%** benefit from **radar rain rates** in July trial

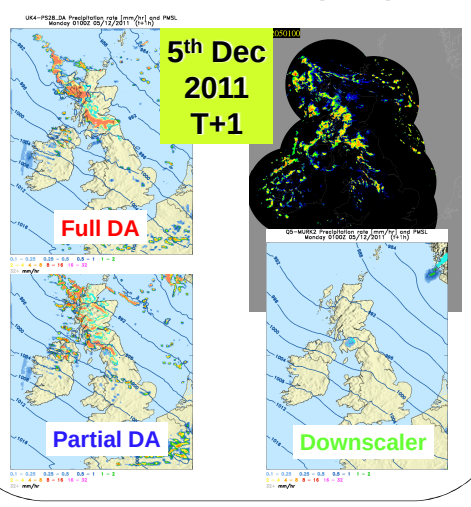
3. Benefit from Cloud assimilation

28th Nov 2011 T+3

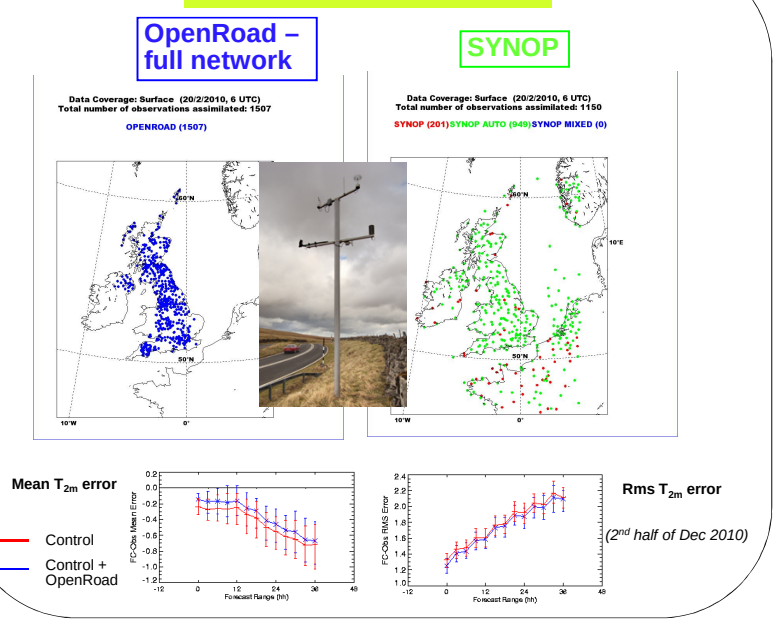


4. Benefit from Radar rain rate assimilation (LHN)

5th Dec 2011 T+1

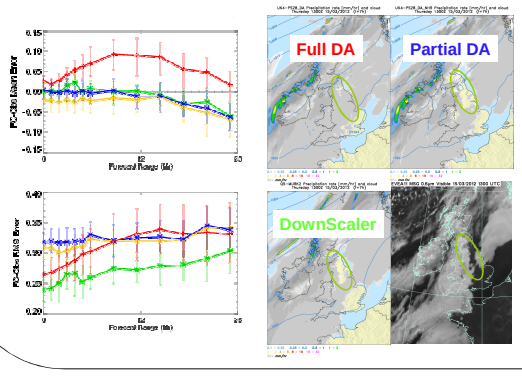


5. Road Sensor Network

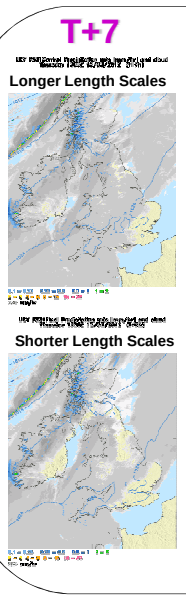


6. Stratocumulus Period March 10th-15th 2012

- Cloud not breaking soon enough in **Full DA** case
- Maximum positive bias at ~ T+12 (small at T+1)
- Analysed cloud depth too large
- Suspect Cloud Top Height too high
- Significant T_{2m} errors



7. Shorter Covariance Length Scales and SCu



Covariances were derived for the 1.5km UKV model using new software giving horizontal length scales consistent with the forecast difference training data, replacing estimates based on Hollingsworth & Lonnberg analysis of o-b statistics. This produced much shorter diagnosed length scales for some control variables (unbalanced pressure, humidity and aerosol).

When tested in pre-operational UKV trials over the same March period as in 6. we saw an appreciable positive impact from the cloud observations (which had previously caused a detriment when using the longer covariance length scales). Outwith this SCu period, however, the impact of the shorter length scales appeared to be small and variable.

8. Conclusions

- Consistent Benefit for all variables from **full higher-resolution analysis** (except perhaps for wind) relative to downscaled analysis
- Mixed performance from the **extra observations** Sometimes detrimental to the UK Index scores
- Consistent summer precipitation benefit up to T+6 from Radar Rain Rate (**LHN**) and for some thresholds to T+12
- Benefit from **MOPS cloud** under SCu conditions is conditional on consistent humidity length scales
- **Visibility** – higher thresholds benefit from vis assimilation, lower thresholds sensitive to RH bias
- **Shower spin-up** is a significant weakness in the **downscaler**
- DA impacts don't necessarily appear at **T+1** !

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