



Updates to Land DA at the Met Office

Brett Candy & Keir Bovis



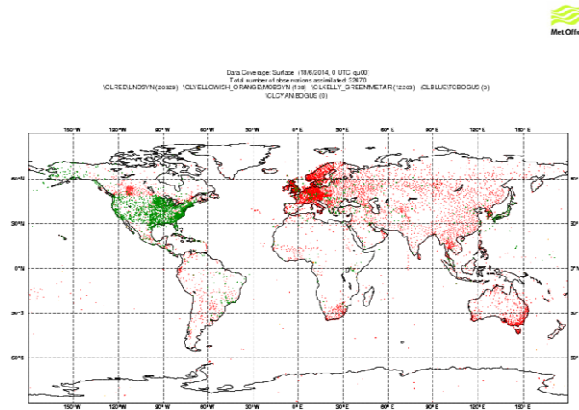
Land DA - The Story So Far

- Kalman Filter 18 months in operations
- Analyses of soil moisture using MetopA ASCAT & surface observations
- How can we improve performance? – based on monitoring & increased satellite usage

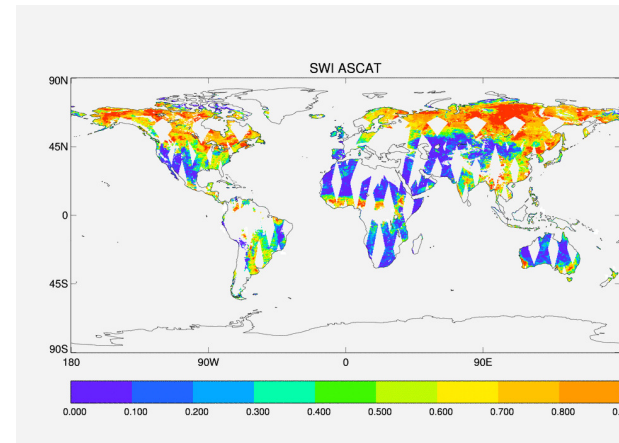


Global Land Surface Assimilation

Observation Inputs

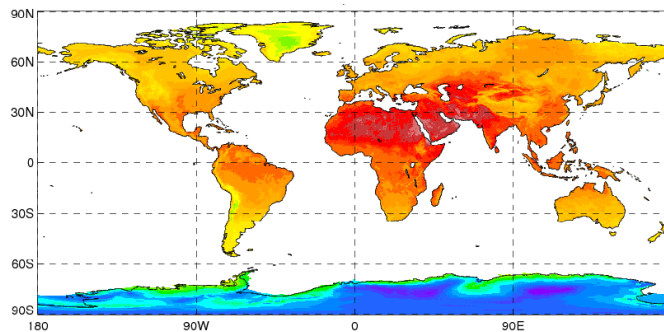


1.5m air temperature and humidity

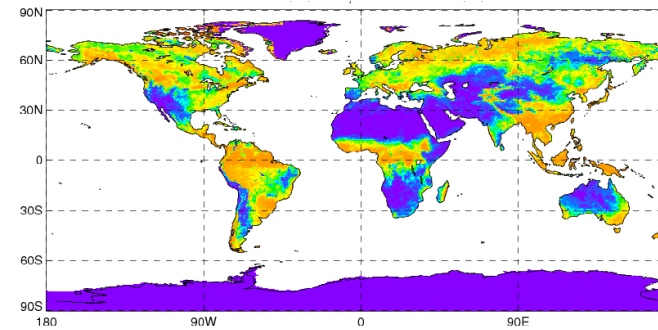


Scatterometer Soil moisture

Analysis Outputs



Soil temperature



Soil moisture



Contents

Where we are

Monitoring of the system

Metop-B ASCAT

Upgrade Package

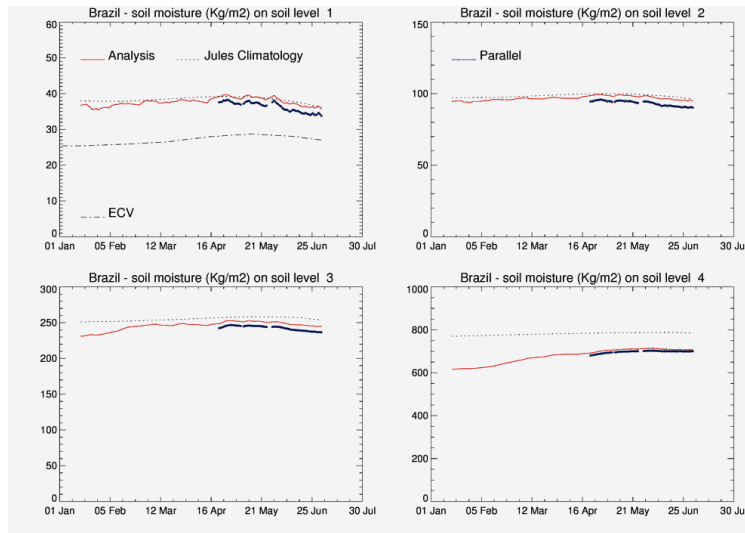
Regional EKF

Conclusions

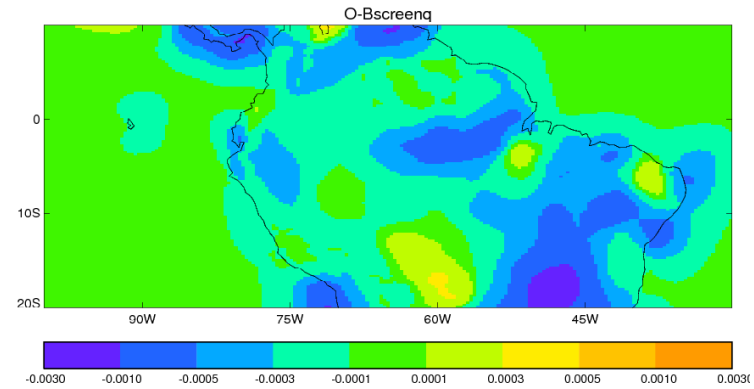


Monitoring – Subsurface soil moisture

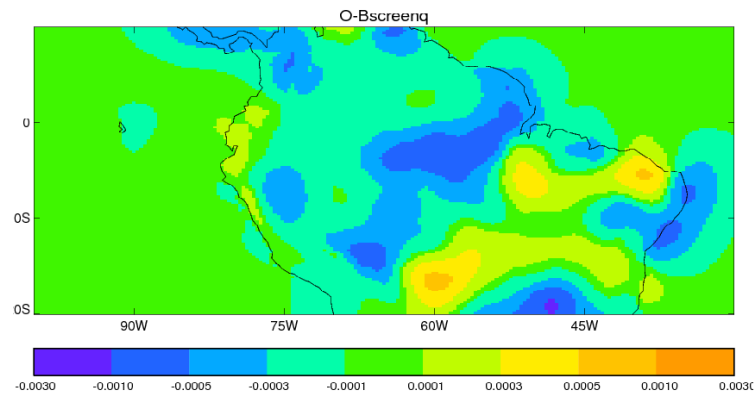
Amazon Region



January – humidity obs-model



August - humidity obs-model



Monitoring versus land model [*JULES*]
Climatology – forced by climate quality observations



QC of near-surface obs

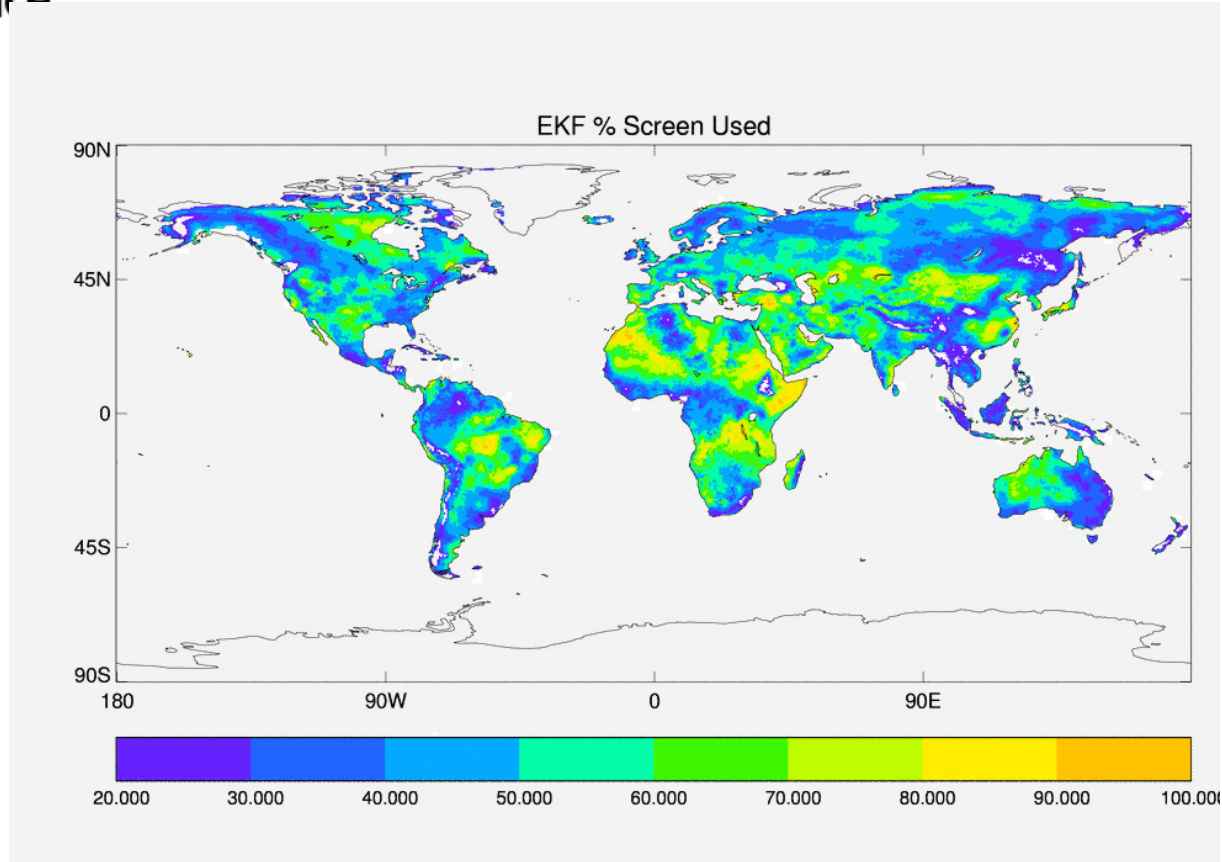
- The aim is to ensure that the Kalman Filter does not 'lock' to a model bias that is not due to soil moisture
- Idea typical soil moisture bias would give a response in the atmosphere in the following manner:

Ob-Model Difference		Diagnosis
1.5m temp	1.5 Humidity	
+	-	Soil moisture too moist
-	+	Soil moisture too dry

- Observations are rejected from use in the EKF if either of these conditions are not met [via resetting of Jacobian to zero]



Application of QC to screen

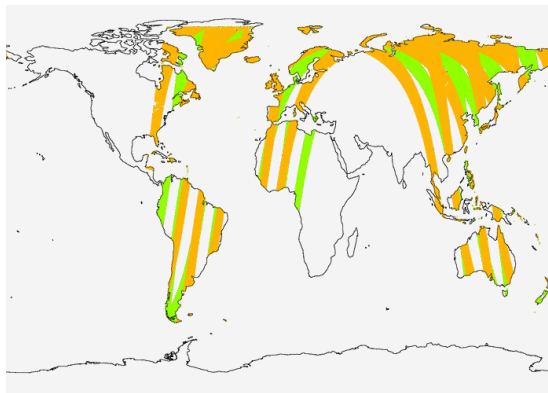


Summer 2013 - test



ASCAT on Metop-B

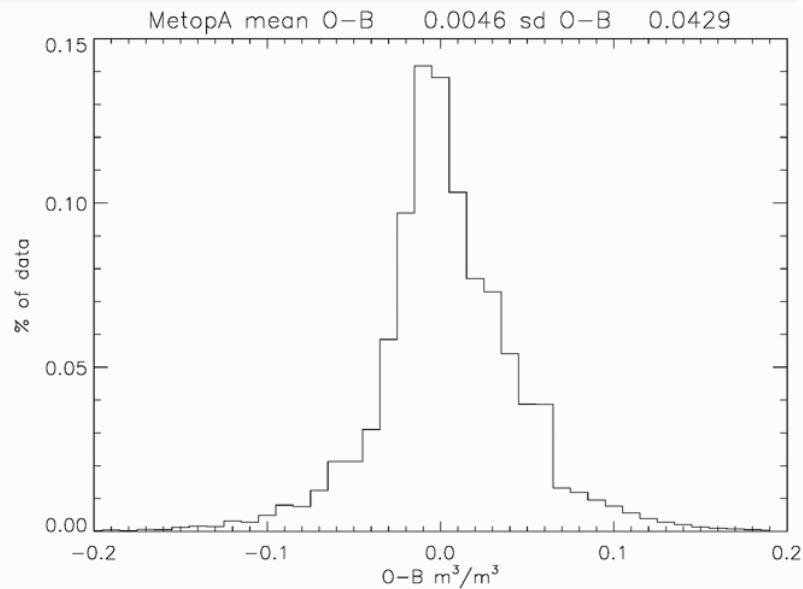
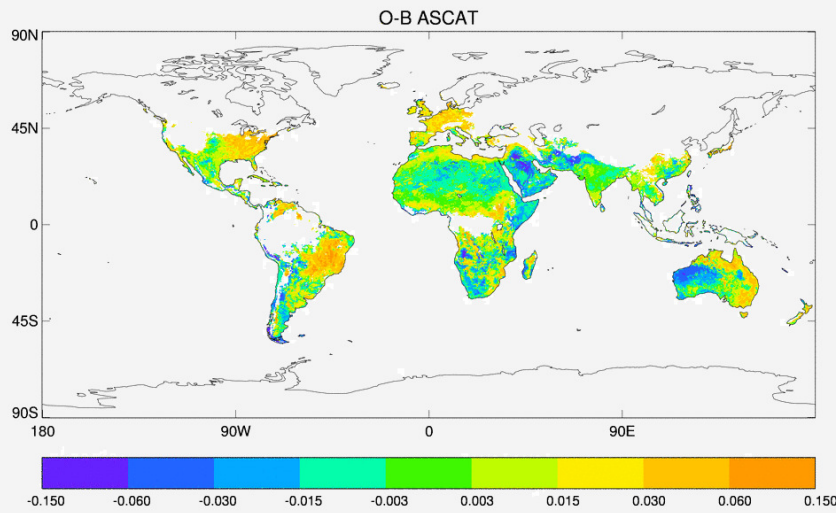
1. ASCAT from Metop-A in land system since before EKF.
 - From previous talks it is a key component
2. Since late 2012 Metop-B is available in near real time
 - Monitored it in our system and compared with 'A'
 - Particularly interested in bias.
3. Initially thought that this would entail a swap over A to B.
However 2 satellites in system is of interest



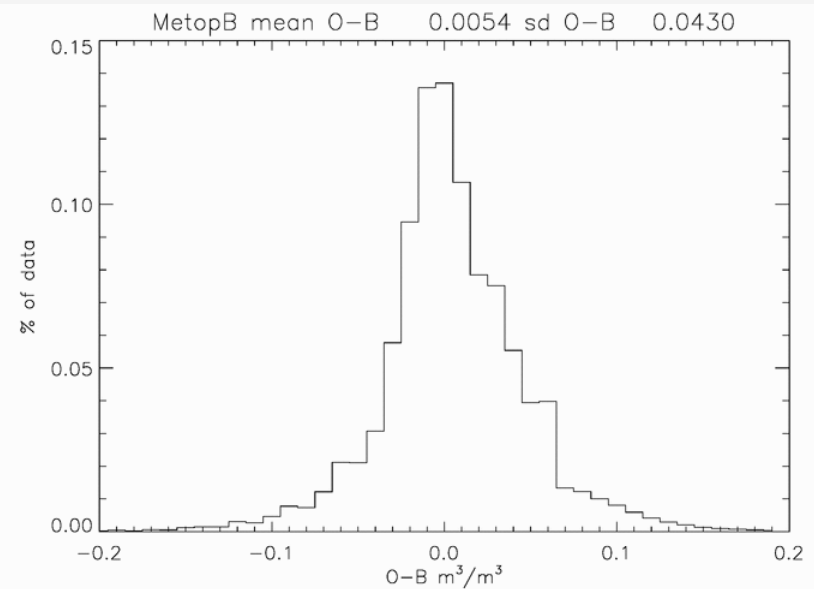
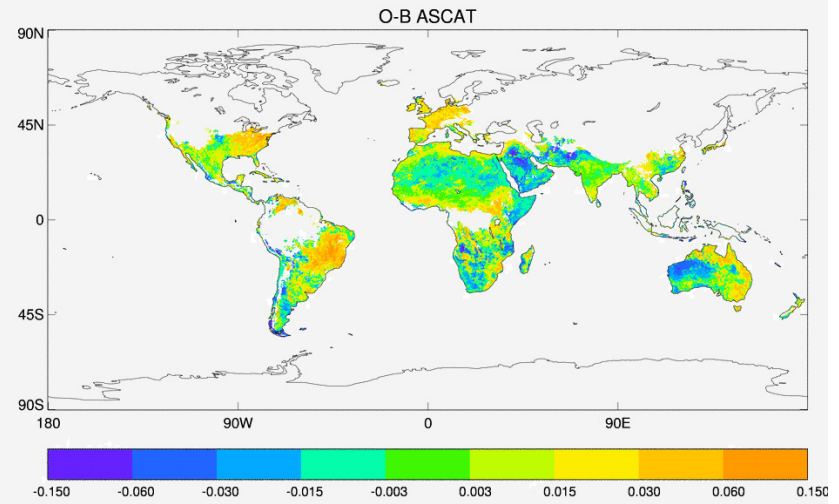


ASCAT instruments compared

MetopA



MetopB





Background Errors for soil moisture

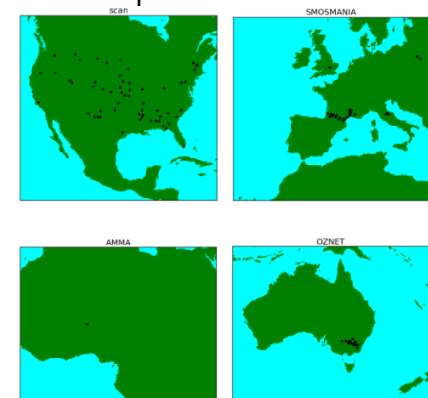
Met Office

Good estimate at the surface layer – based on *SMOS*, *ASCAT* and *SCAN triple collocations*. But difficult to determine for lower layers

Took 1 year of observations from each available network for 2011 in the **ISMN** and compared to NWP analyses. – extended to 7 different networks and we took a range of stations with differing vegetation types

Soil Level	Sensor depth	Nstns passing QC	Correlation coefficient	Mean (station-model) m3/m3	SD (station-model) m3/m3	Ratio SDleveli/SDlevel1
1	5 cm	33	0.61	-0.081	0.061	-
2	20cm	36	0.61	-0.082	0.051	0.84
3	50cm	30	0.62	-0.045	0.043	0.70

Other networks show similar stats – suggests that the errors at depth are lower. ~0.75 value of the surface value. **Currently the operational EKF assumes smaller error.**





Package of Potential Improvements to the operational land DA system

1. Switch on second ASCAT instrument (Metop-B stored since mid 2013)
2. Observation errors for screen humidity in terms of RH, rather than fixed q . Other observation error estimates considered ok (ASCAT monitoring suggests reduce errors over bare soil)
3. EKF quality control. (legacy QC) Only use screen observations where the innovation signs are opposite.
4. Updated soil moisture background errors (increased at depth below 10cm)
5. Effect of Jacobian integration time – little impact
6. Analysed soil temperatures supplied to forecast – ongoing

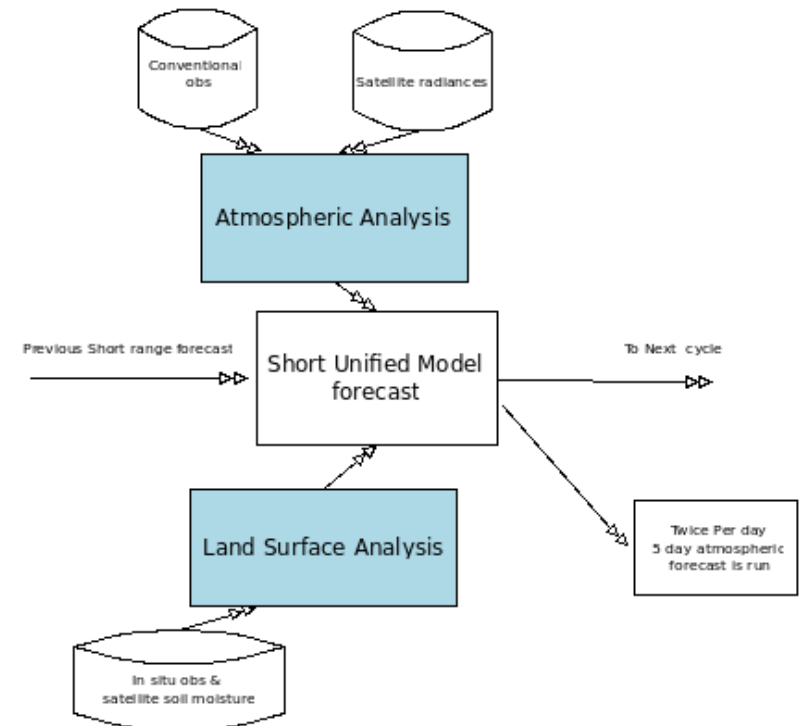


Assimilation Experiment

- NWP system used is the Met Office research version:
 - N320 horizontal resolution (40km) 70 levels in the vertical
 - Full atmospheric analysis via 4D-Var (in situ + satellite radiances)
 - Land analyses provided every six hours by the Kalman Filter Scheme

(control run: Kalman Filter as operations)

(experiment run: Package changes)
- Repeated for two seasons
- Assess impact via Verification of the atmospheric forecasts *and* quality of the land analyses

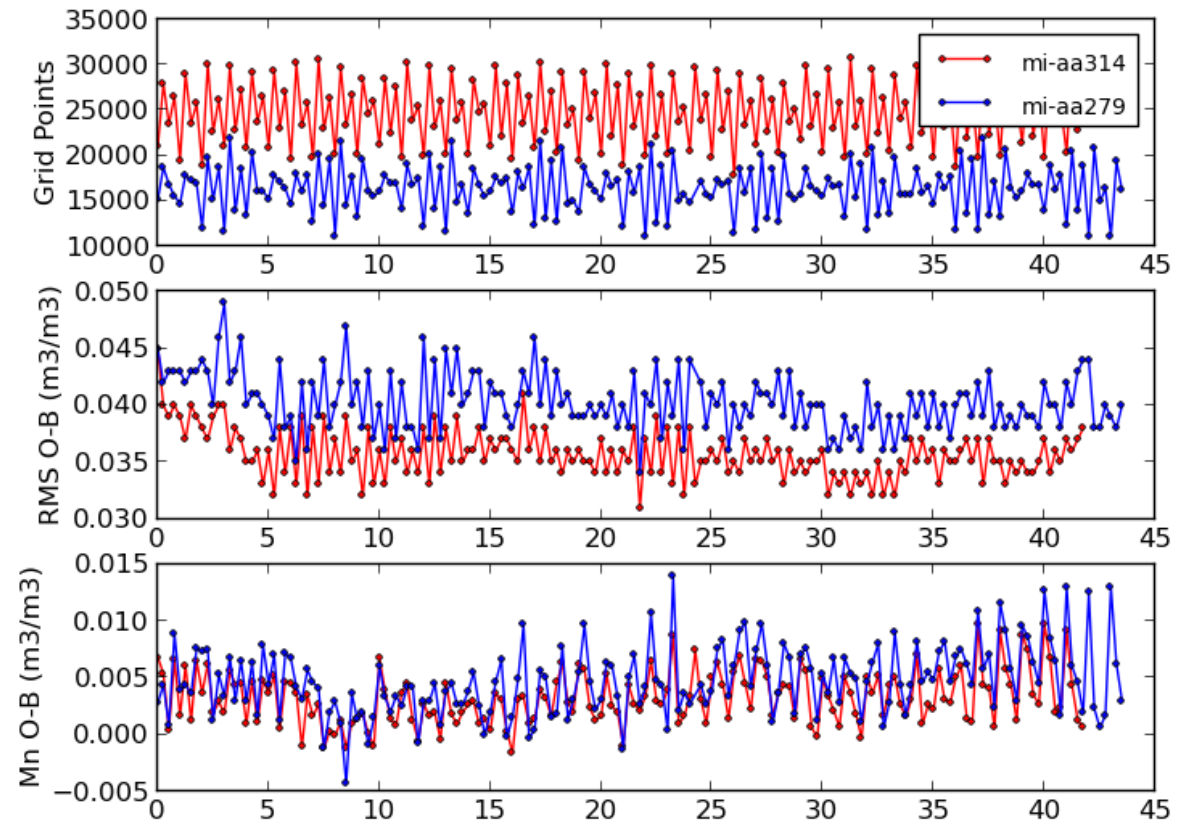
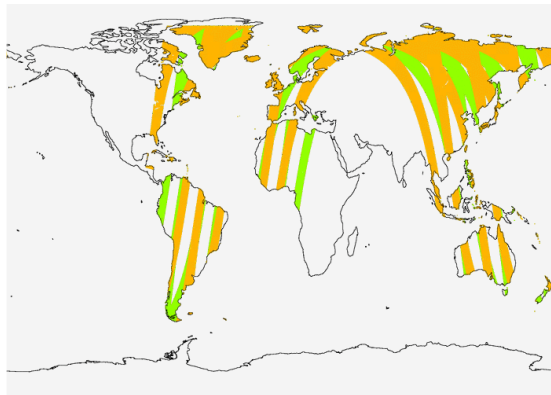




Trial Results – Summer 2013

ASCAT Observation-Background

EKF Innovations



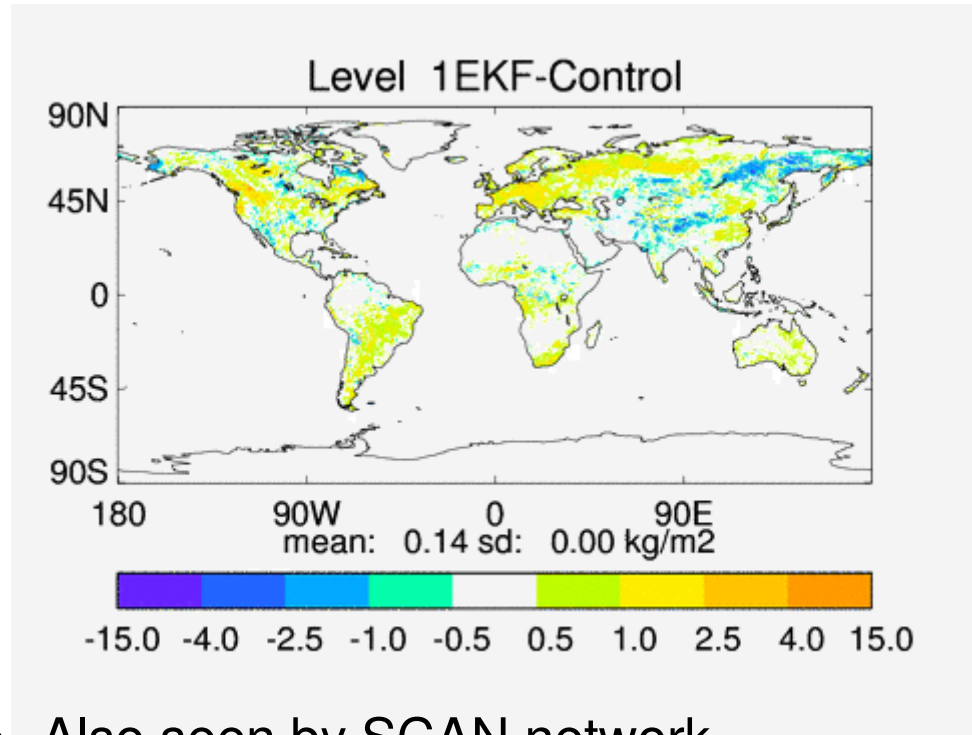
Red
upgrade
Blue
control



Met Office

Analysis differences- Summer 2013

- Moisture level 1 (10cm)



- Also seen by SCAN network

Experiment	Nstns passing QC	Correlation coefficient	Mean (station-model) m ³ /m ³	SD (station-model) m ³ /m ³
Control	61	0.55	-0.046	0.039
Upgrade	63	0.55	-0.053	0.039

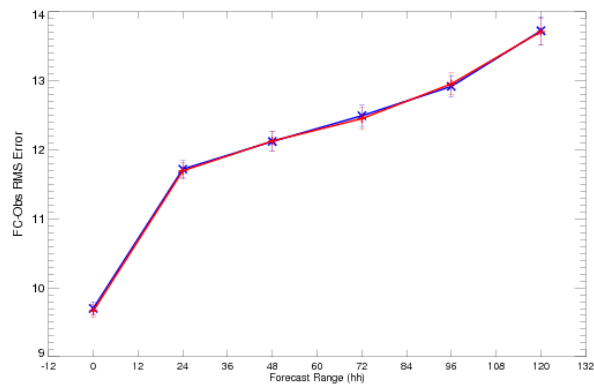
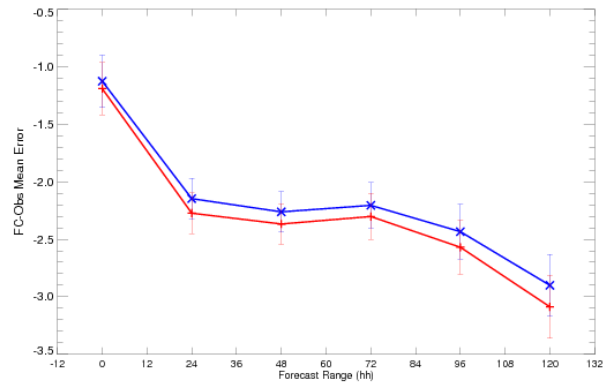


Forecast Impacts – Summer 2013

Australia

Relative humidity (%) at Station Height: Surface Obs
 Australia / NZ (CBS area 10S-55S, 90E-180E)
 Equalized and Meaned from 2/7/2013 00Z to 15/8/2013 12Z

Cases: + N320 4DVAR Control x EKF Upgrade Package1

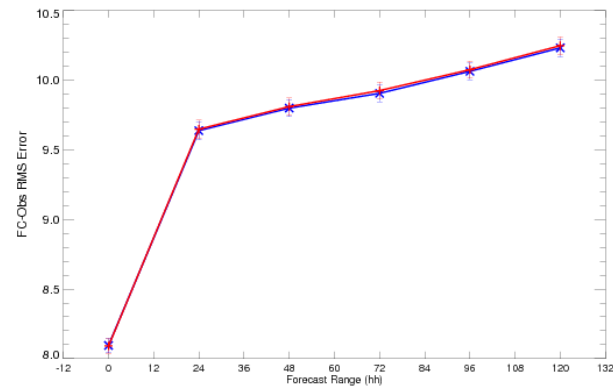
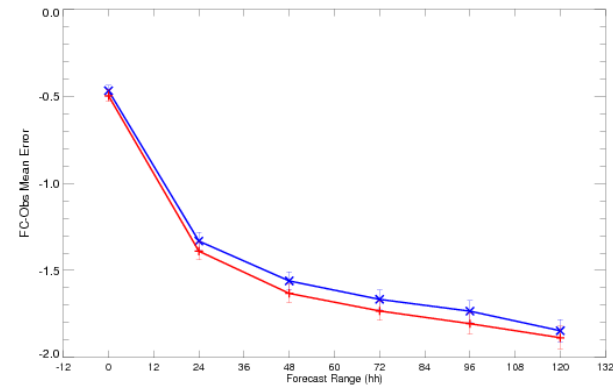


68% error bars calculated using $S/(n-1)^{1/2}$

Tropics

Relative humidity (%) at Station Height: Surface Obs
 Tropics (CBS area 20N-20S)
 Equalized and Meaned from 2/7/2013 00Z to 15/8/2013 12Z

Cases: + N320 4DVAR Control x EKF Upgrade Package1



68% error bars calculated using $S/(n-1)^{1/2}$



What's Next

- *Autumn 2014* – package will go into Parallel suite
- Update ASCAT soil wetness conversion
 - Improved forcing climatology
 - Updated Soil parameters
 - Apply to soil moisture ECV data too
- Test Kalman Filter Scheme in our convective scale model



Conclusions

- A package of changes has been described to build on and improve the initial implementation of the land Kalman Filter. This includes the second ASCAT instrument and updated observation and background errors.
- Generally the assimilation change yields larger increments at surface and rootzone
- Indication of a moister top layer. ASCATs have good inter satellite agreement. Follows our goal to use more satellite data in the system
- Evidence of improvements to atmospheric forecasts (via reduced bias in two regions)
- Next steps will attempt to use a modified DA scheme in convective scale model.



Additional Slides



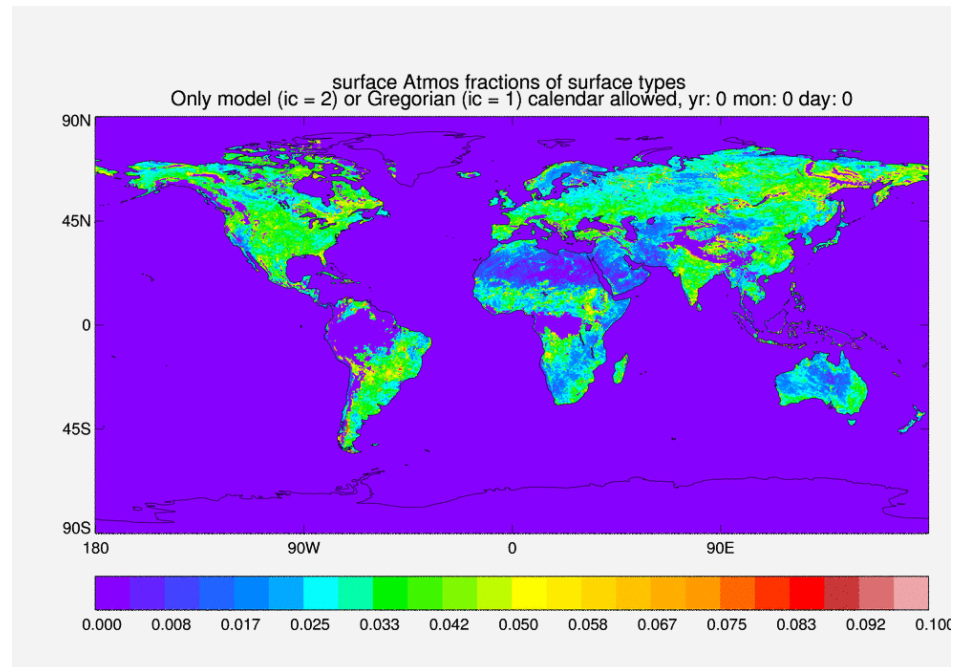
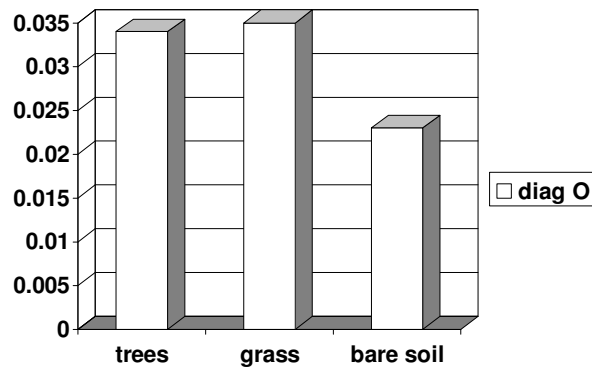
ASCAT –towards variable error

Desroziers Diagnostic – 10months operational data

Global ASCAT diagnosed error – 0.033 m³/m³

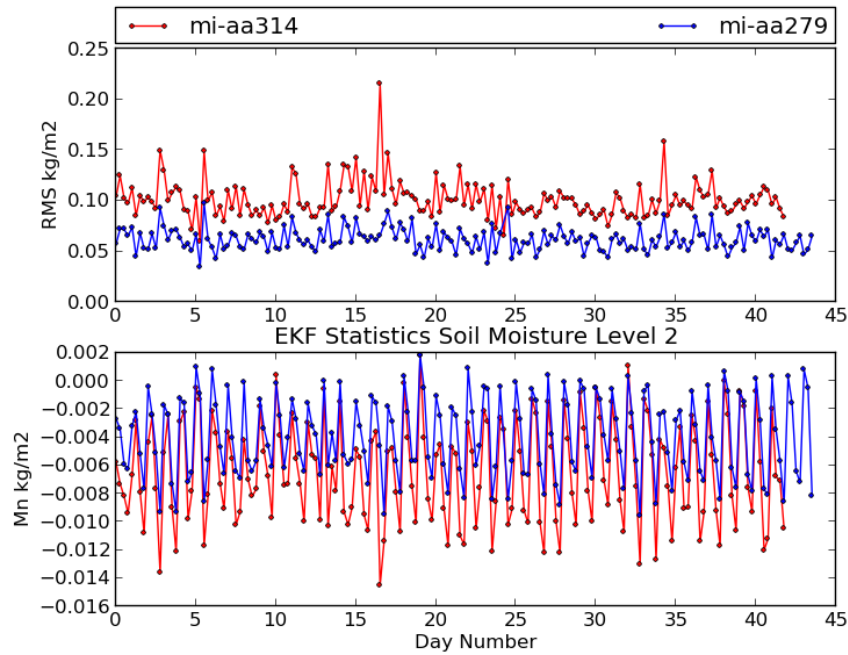
But over differing surface types (after qc)

Suggest we should lower error over bare soil

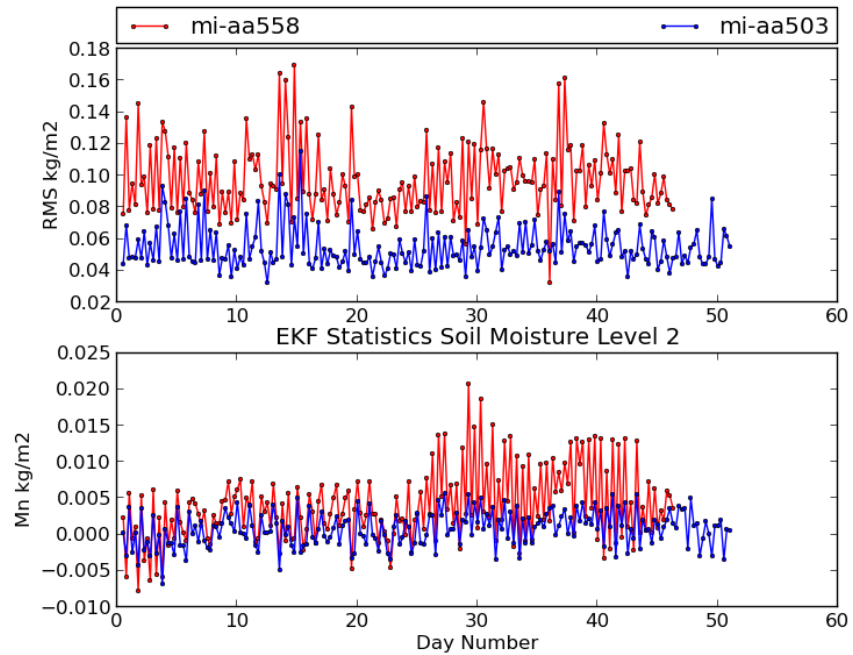




Increments at depth



JulAug 2013



NovDec 2013



Jacobian Runtime

- Since start of the project Jules runs are set at 3hours (convenience & runtime)
- What happens if we extend to 6 hours?
- 1 month test.
- Completely neutral on index and extended index
- Very marginal improvement in NH humidity forecasts
- Stronger coupling to level 2 (scatterometer?)
- Evidence that the soil temp increments are smaller

