

# Observing System Impact Studies in ACCESS

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John le Marshall, Elaine Miles,  
Yi Xiao, Rolf Seecamp, Jin Lee,  
Susan Rennie, Xingbao Wang,  
Justin Peter, Alan Seed and  
Belinda Roux

**Fifth WMO Workshop on the Impact of  
various observing systems on NWP  
Sedona, AZ. May 2012.**

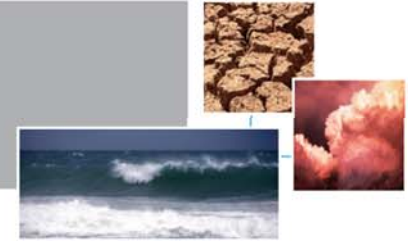


**Australian Government**  
Bureau of Meteorology

The Centre for Australian Weather and Climate Research  
A partnership between CSIRO and the Bureau of Meteorology



# OUTLINE



- Introduction to ACCESS
- Global & regional Satellite data impact experiments
- Radiosonde and AMDAR regional impact experiment
- Early results from SREP high resolution assimilation and LHN trials
- Future work



# Australian Community Climate and Earth System Simulator

A collaboration between the Bureau of Meteorology, CSIRO and universities

## ACCESS-NWP

Earth Systems Modelling Program Leader: **Kamal Puri**

Data Assimilation Team Leader: **Peter Steinle**

Atmospheric Modelling Team Leader: **Gary Dietachmayer**

Model Systems Team Leader: **Martin Dix**

Atmosphere-Land Observation and Assessment Program

Remote Sensing Team Leader: **John Le Marshall**

National Meteorological and Oceanographic Centre

Special acknowledgement to the Met Office

# ACCESS NWP COMPONENTS



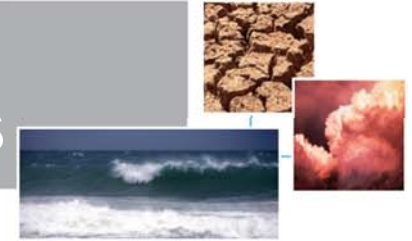
- Met Office

- Unified Model (UM)
- Observation Processing System (OPS)
- 4dVAR
- SURF
- Suite Control System (SCS) and component UIs

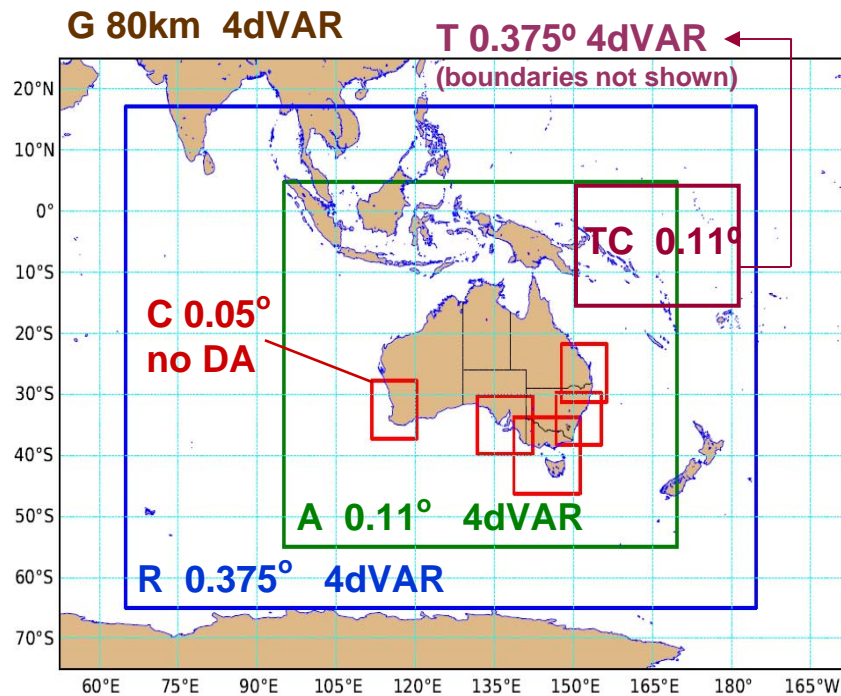
- ECMWF

- ODBs
- local version of “Verify”

# ACCESS NWP APS0 and APS1 domains

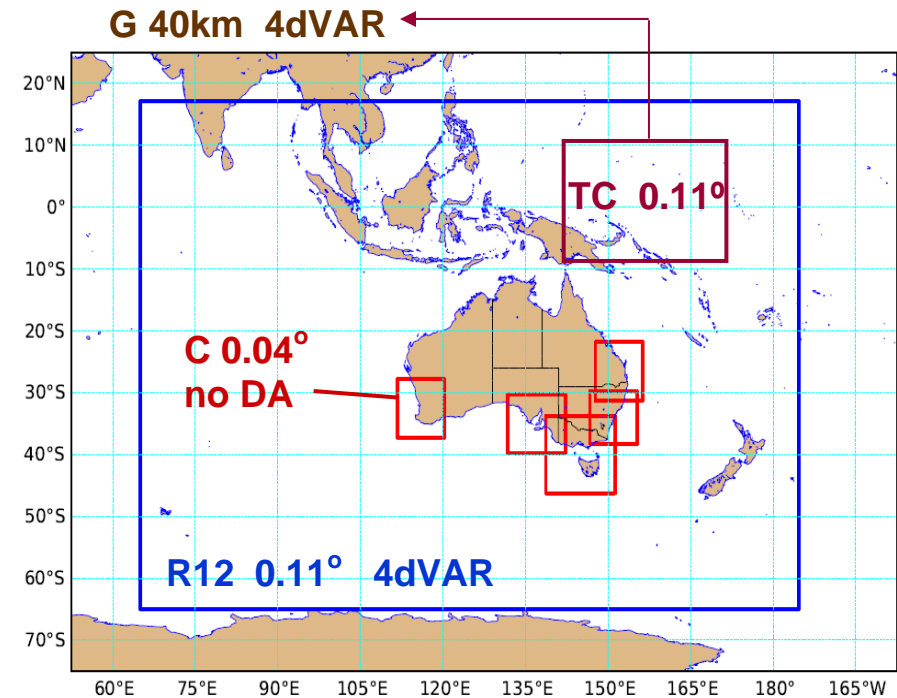


## APS0: all systems L50



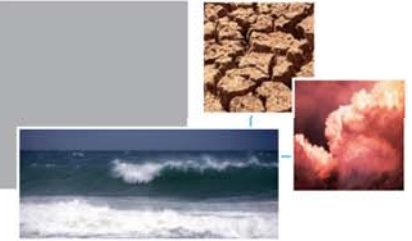
**APS0:** domains chosen to reproduce Bureau's previous NWP systems (which they replaced in 2010)

## APS1: all systems L70



**APS1:** significant rationalisation of domains + increased horizontal and vertical resolution; newer versions of UM, OPS, Var and Surf.

# OBSERVATION TYPES ASSIMILATED IN ACCESS

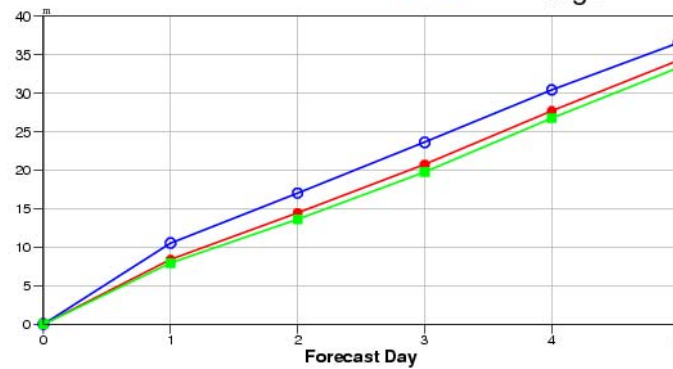


<b>APS0</b>	<p>Surface: synop, ship, buoy Balloons, profilers Aircraft: AIREPS, AMDARS</p> <p style="text-align: center;"><b>Satellite observations</b></p> <p><u>Winds</u> Scatterometer surface winds, Atmospheric Motion Vector tropospheric winds</p> <p><u>Radiances</u> Microwave: ATOVS (AMSU A,B and MHS) Infrared: ATOVS (HIRS), AIRS</p>
<b>APS1</b>	<p>All of the above, plus:</p> <p><b>IASI Infrared radiances</b> <b>GPS-RO bending angle observations</b> SSMIS (when available)</p>

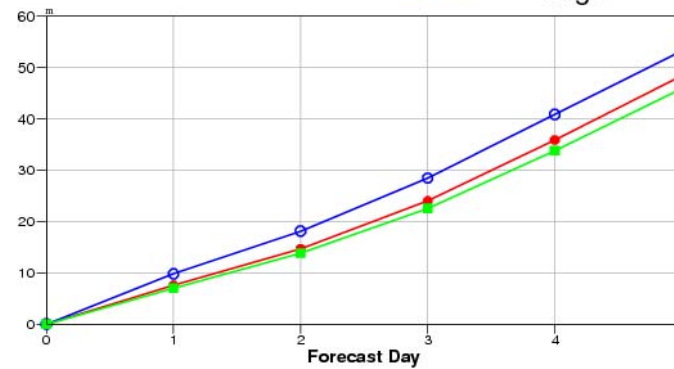
# APS1 versus APS0 forecast skill



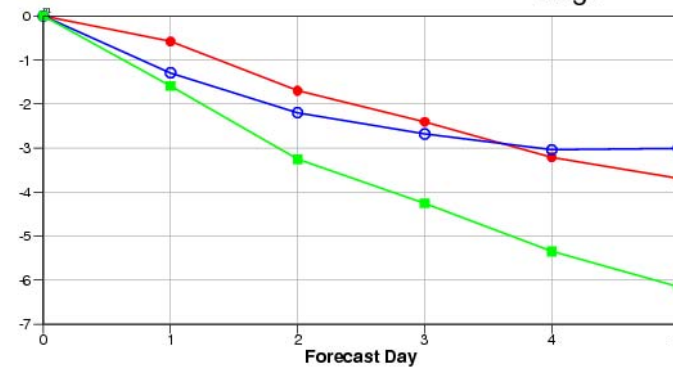
Forecast Lead time  
500hPa geopotential height  
S1 Skill Score  
Southern Annulus  
Date: 20120101 00UTC to 20120331 00UTC  
2.5x2.5 degree grid



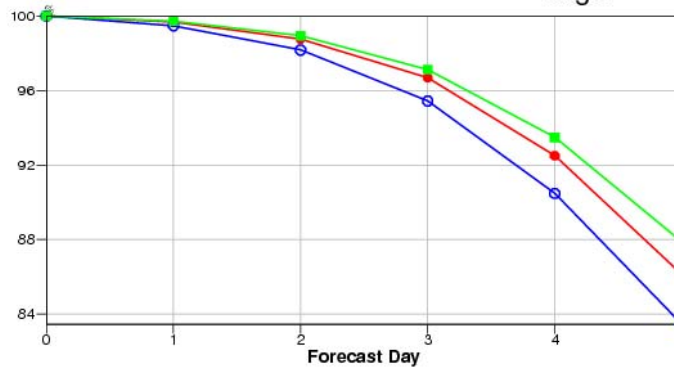
Forecast Lead time  
500hPa geopotential height  
RMSE  
Southern Annulus  
Date: 20120101 00UTC to 20120331 00UTC  
2.5x2.5 degree grid



Forecast Lead time  
500hPa geopotential height  
Bias  
Southern Annulus  
Date: 20120101 00UTC to 20120331 00UTC  
2.5x2.5 degree grid

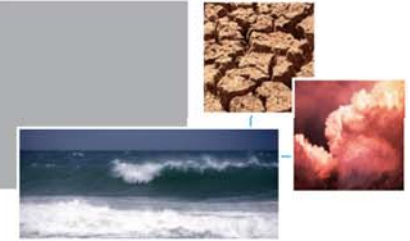


Forecast Lead time  
500hPa geopotential height  
Anomaly correlation coefficient (absolute)  
Southern Annulus  
Date: 20120101 00UTC to 20120331 00UTC  
2.5x2.5 degree grid



# GPS-RO in ACCESS-G (1)

John Le Marshall and Yi Xiao



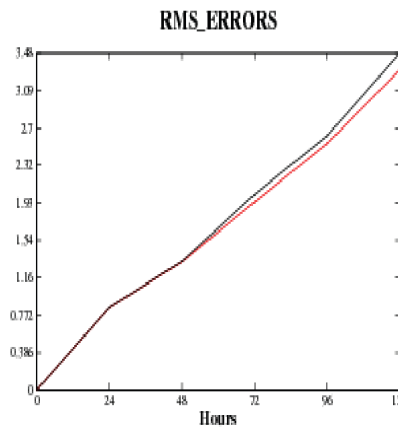
**Period: 26 Feb 2009 -  
26 March 2009**

**GPS-RO data from  
COSMIC, MetOp and  
GRACE**

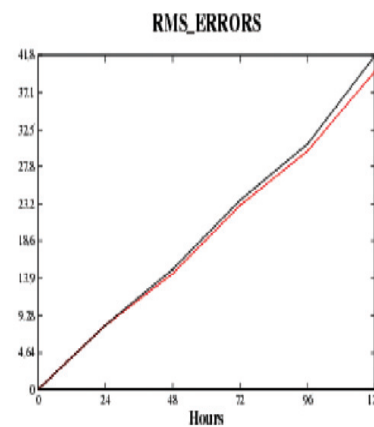
**Assimilate:  
refractivity  
in APS0 ACCESS-G**

**500 - 600  
observations every  
six hours**

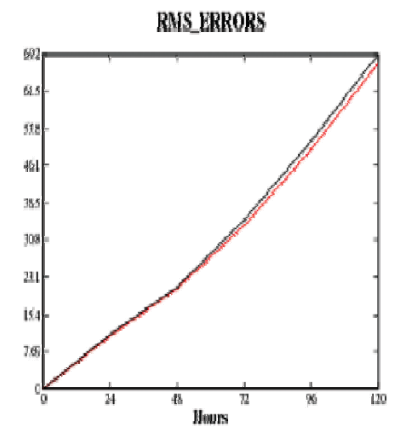
**RMS errors and anomaly correlations  
for ACCESS-G forecasts to five days,  
for the Australian region. Shown are  
results for Control (black), and with  
GPS RO data (red).**



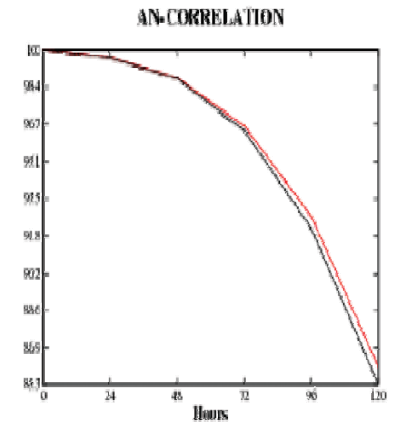
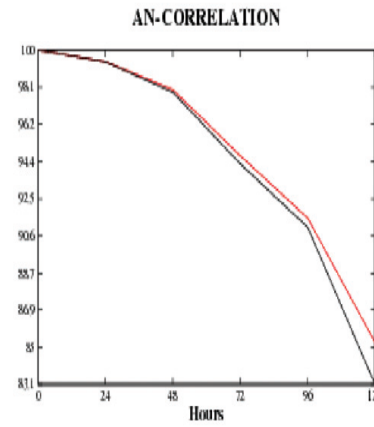
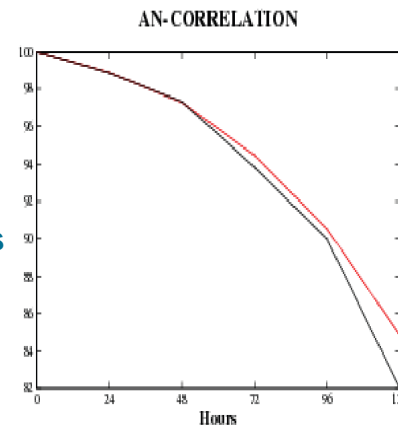
**MSLP**



**500 hPa**



**Geopotential Height 200 hPa**





# GPS-RO in ACCESS-G (2)

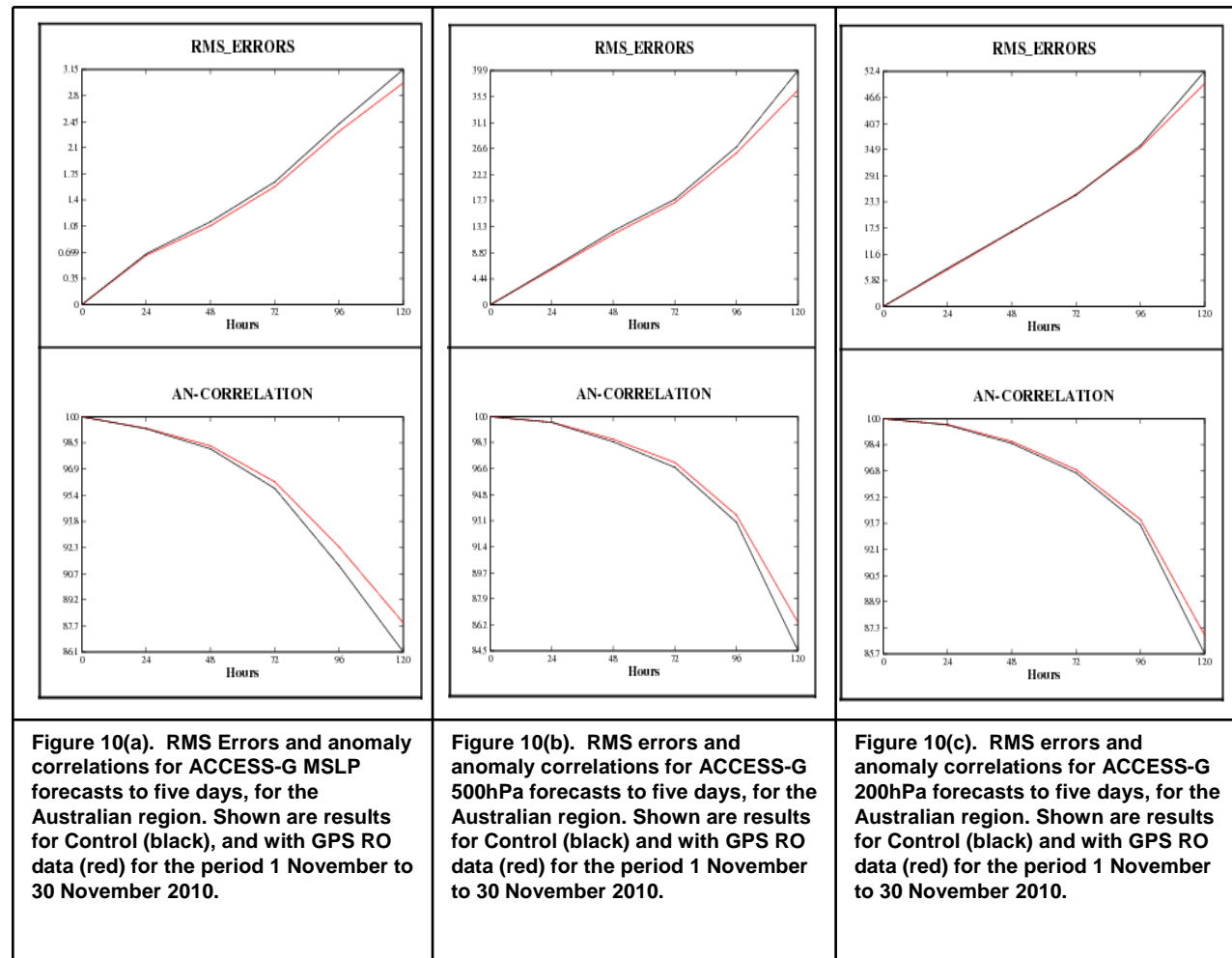


Second trial:  
November 1-30 2010

Assimilate bending  
angle data from  
COSMIC, GRACE  
and MetOp

in ASP0 ACCESS-G

Operational  
assimilation of  
bending angles  
commenced in  
March in APS1

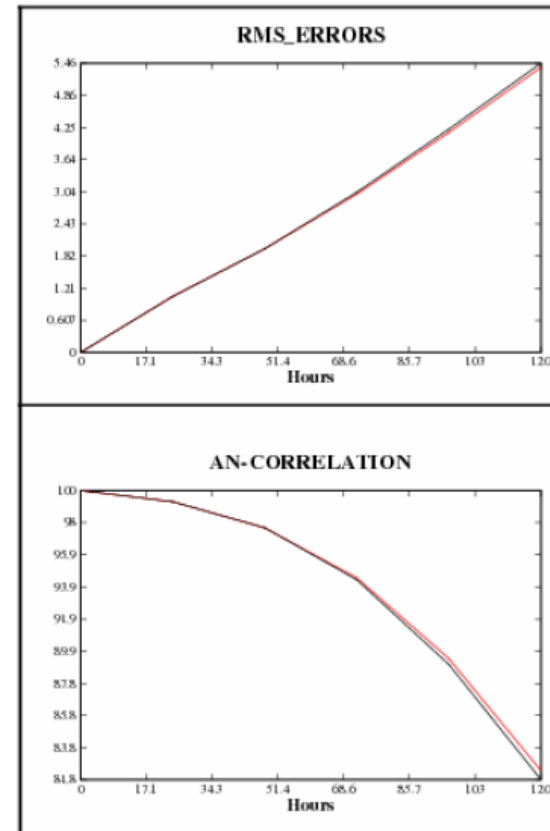
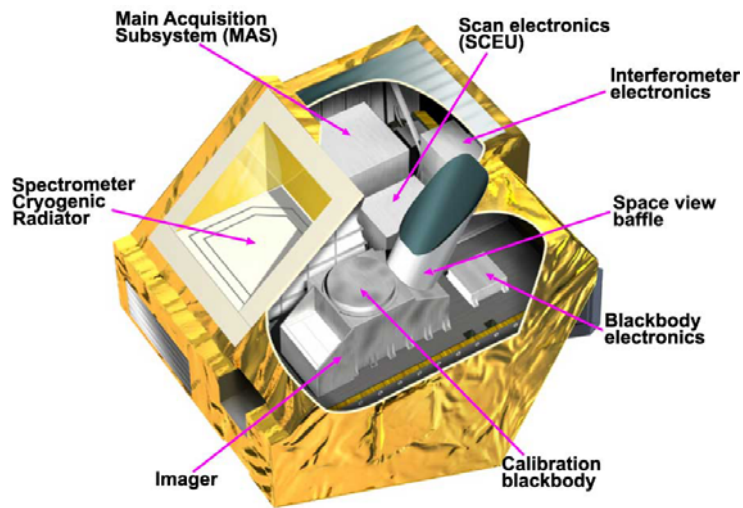


# IASI in ACCESS-G



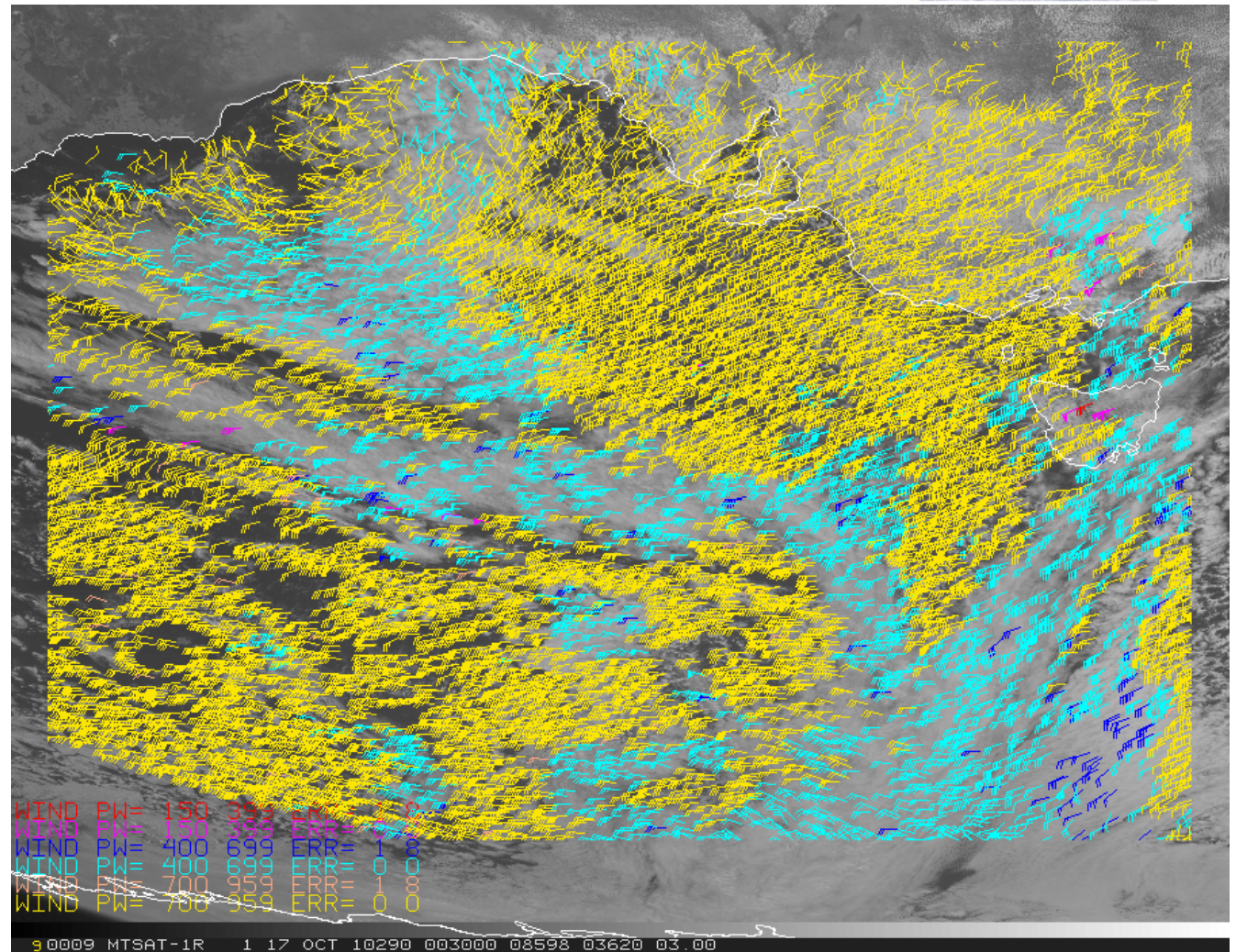
John Le Marshall and Yi Xiao

The impact of IASI data on APS0 ACCESS-G Southern Hemisphere Annulus geopotential height forecasts at 500hPa for 9 April – 14 May 2009; the red (black) curve shows the AC with (without) IASI data

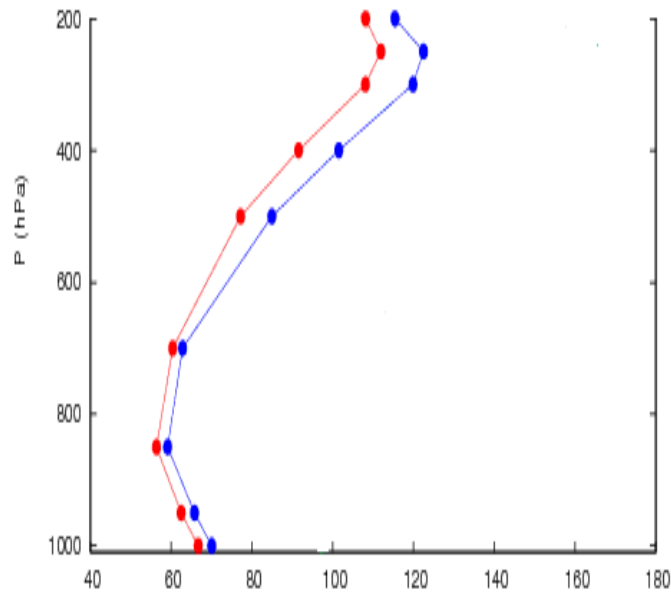


# Hourly AMVs in ACCESS-R

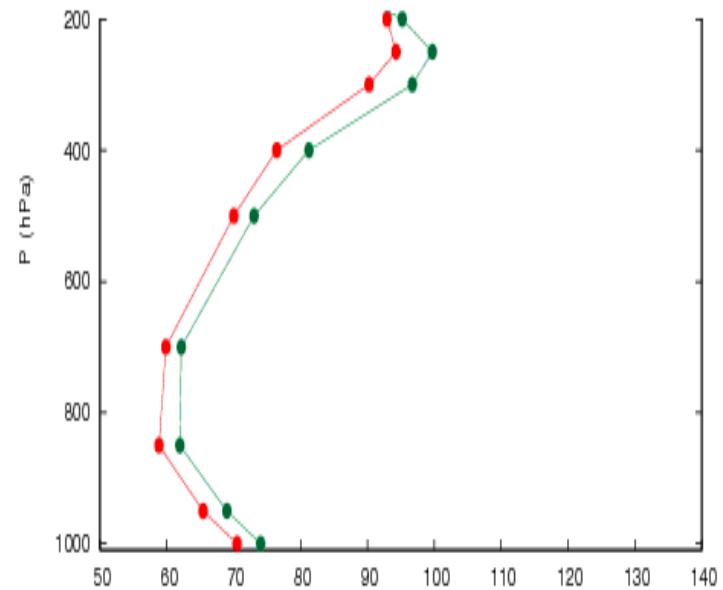
John le Marshall,  
Yi Xiao,  
Rolf Seecamp



# Hourly AMVs in ACCESS-R



The RMS difference between forecast and verifying analysis geopotential height (m) at 24 hours for ACCESS-R (blue) and ACCESS-R with Hourly AMVs (red) for the period 1 September to 10 October 2009



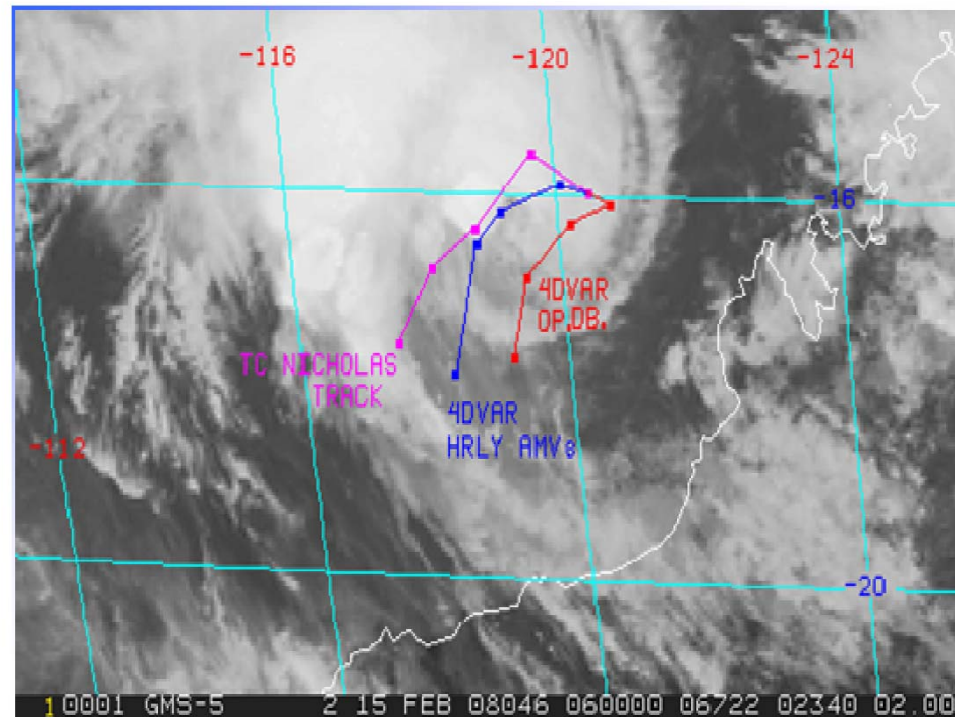
The RMS difference between forecast and verifying analysis geopotential height (m) at 24 hours for ACCESS-R (green) and ACCESS-R with Hourly AMVs (red) for the period 27 January to 23 February 2011

# Hourly AMVs in ACCESS-R



TC Nicholas Feb 2008

Forecast track error significantly reduced with the addition of hourly AMV observations



# Radiosondes and AMDARS

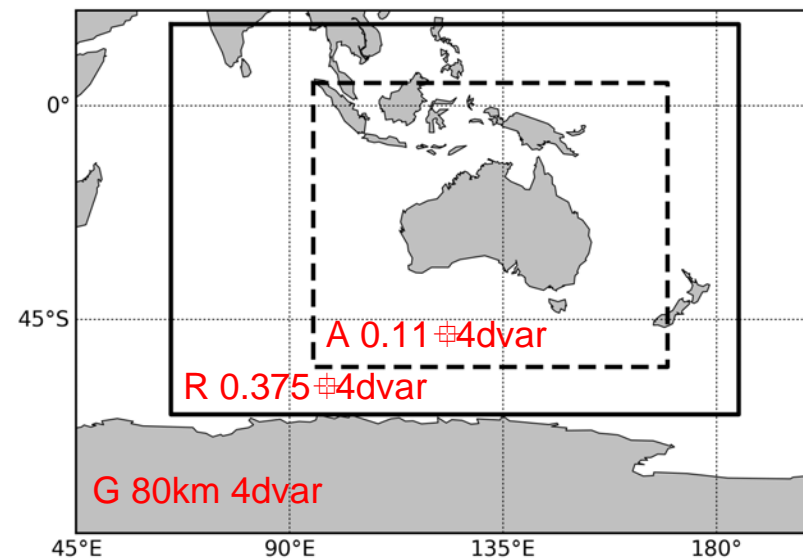


Elaine Miles and Peter Steinle

- Assessment of impact of radiosonde observations and AMDARs in Regional and Australian ACCESS NWP systems
- Observing System Experiments (OSEs) conducted March 22 2010 – June 30 2010 when additional 12UTC radiosonde flights flew at 24 mainland stations (“experiment of opportunity” – timing *not* ideal).

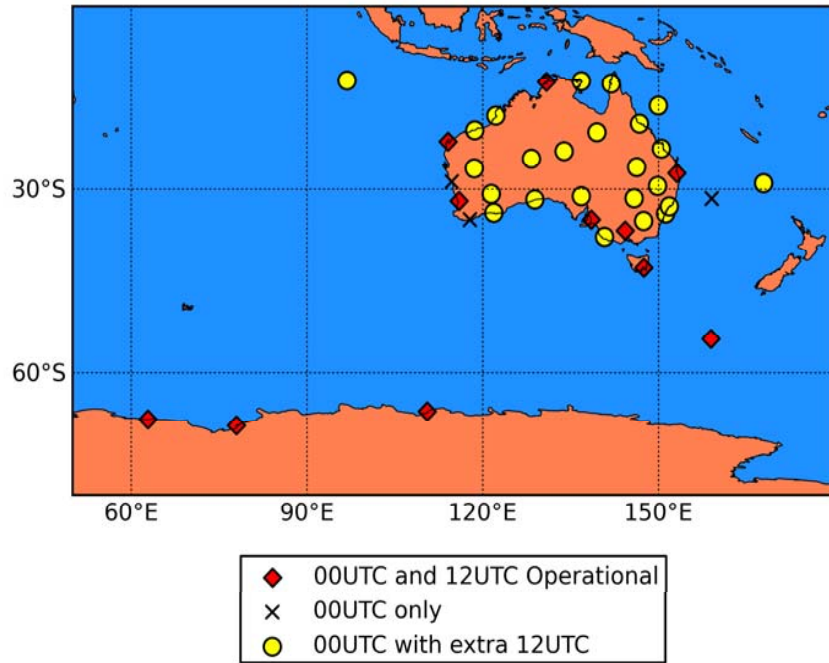
## OSE:

- **Control:** Rerun of operational forecasts using all available observations.
- **Without 12UTC Radiosondes:** Observations from extra 12UTC radiosondes excluded.
- **Without Australian radiosonde network:** Observations from entire Australia radiosonde network excluded.
- **Without AMDAR network:** Observations from the Australian AMDAR network excluded

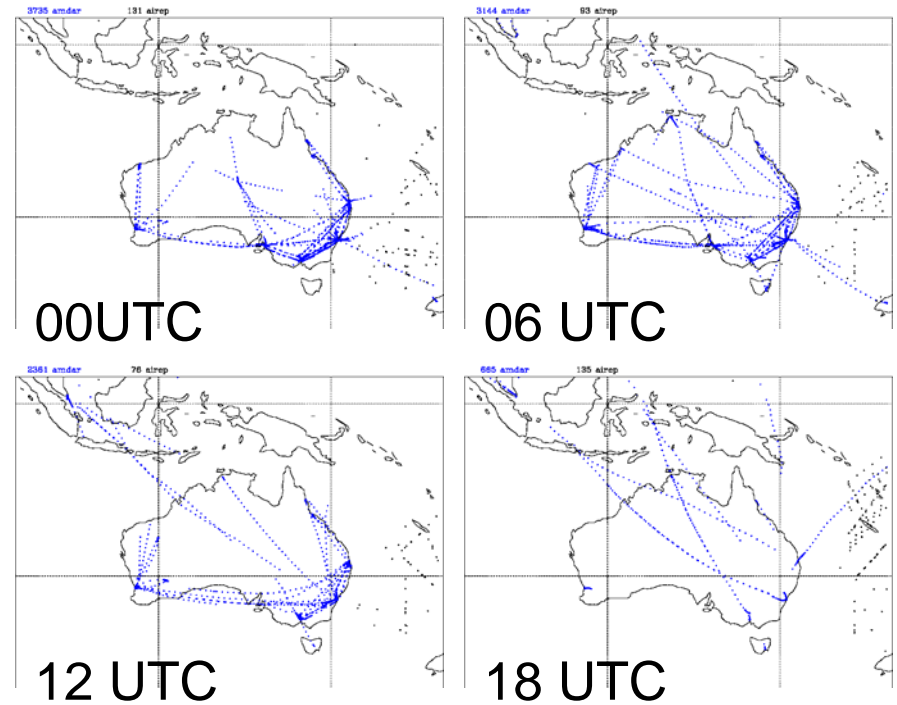


**Nested domains of APS0 ACCESS  
Regional (solid line) and Australia  
(dashed line)**

# Radiosondes and AMDARS



**The Australian radiosonde network.**

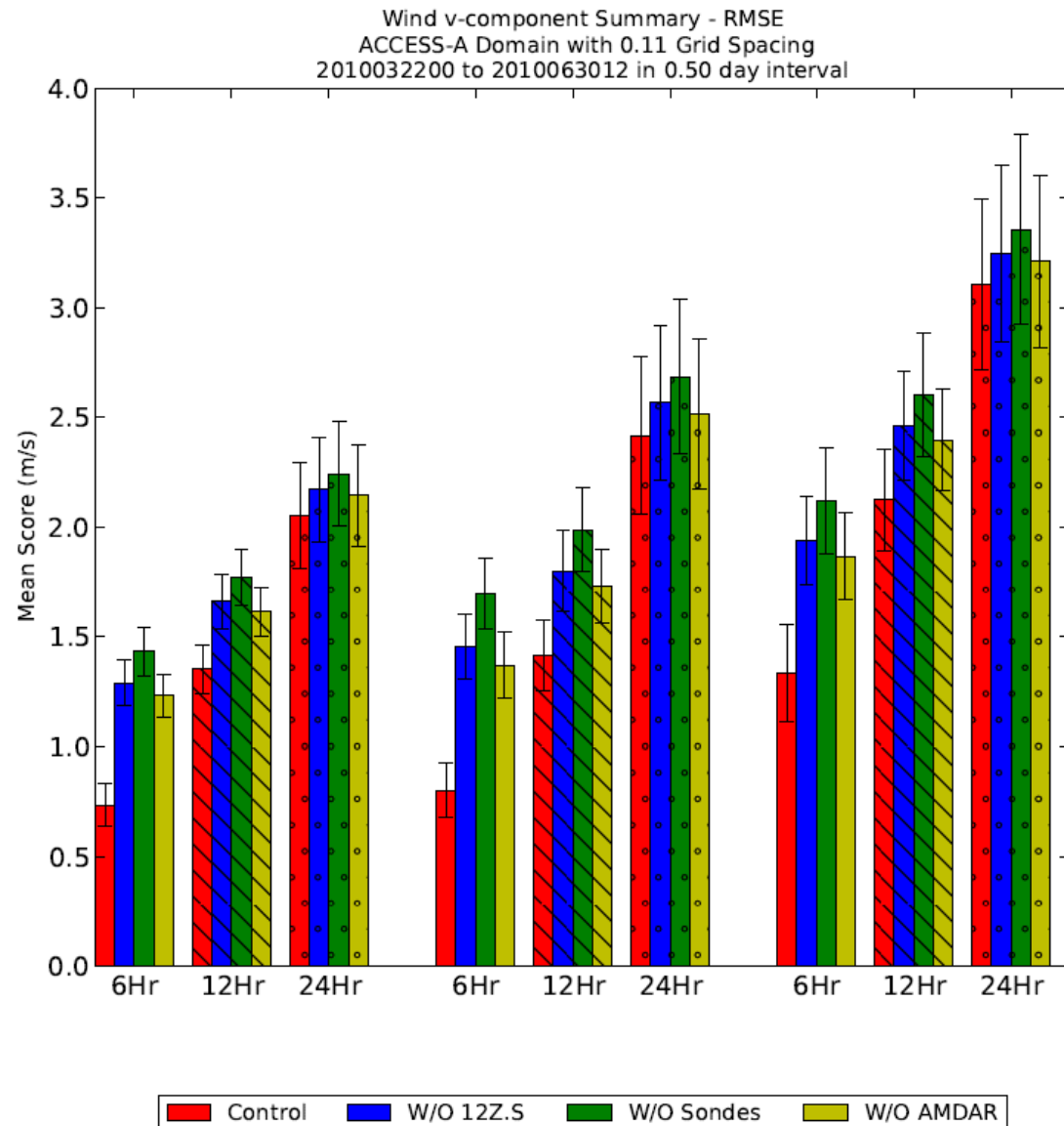


**The Australian AMDAR network.**

# 850/500/250 meridional wind RMSE (00Z & 12Z)



- Higher score = bigger impact
  - Removing obs has bigger degradation on scores
- Whiskers are +/- 1 std.dev.

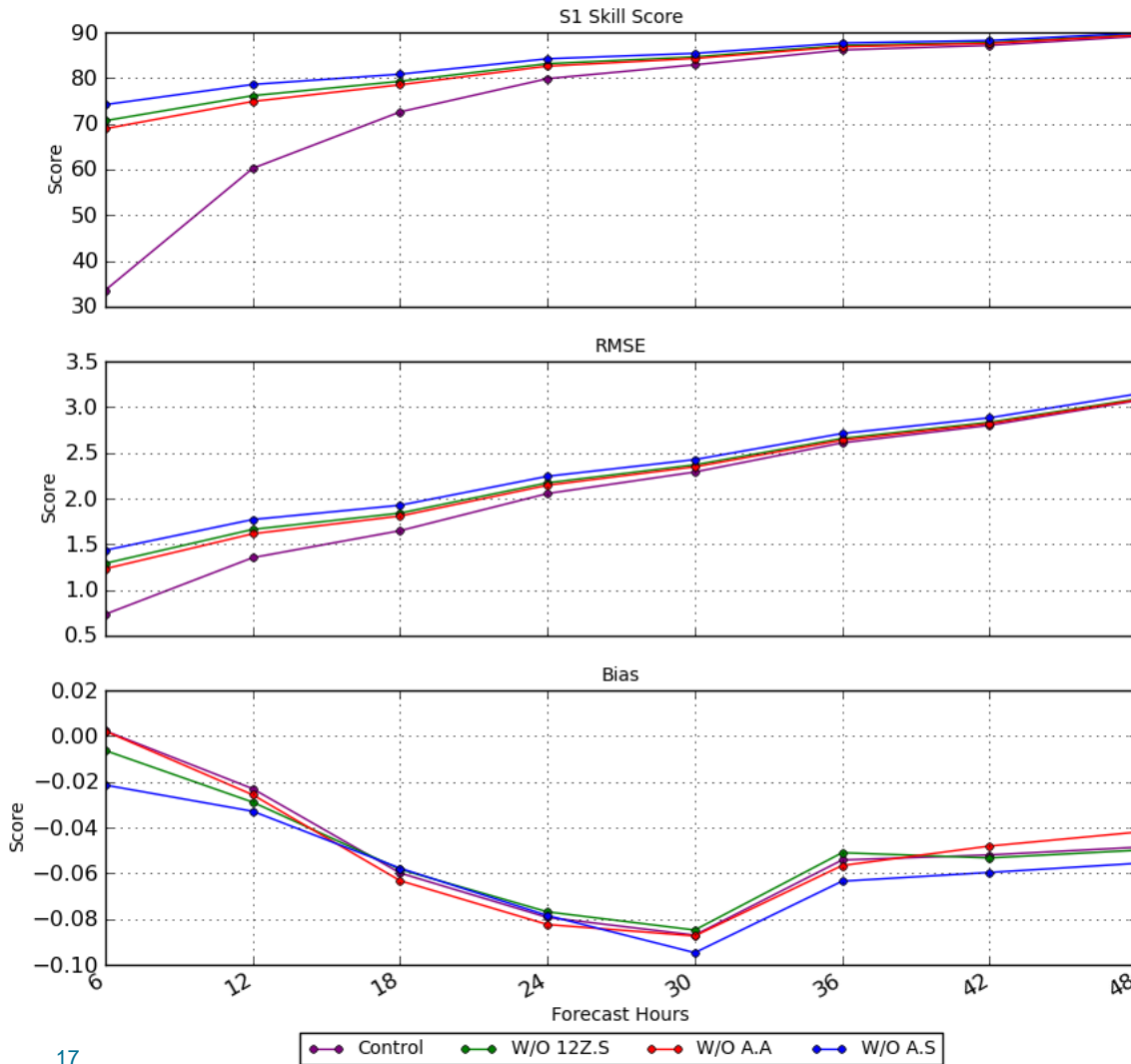




# Verification vs lead time



A - ANALYSIS - Wind v-component  
850hPh - Access A - 0.11 grid - av  
Dates 2010032200 to 2010063012 - 12.0hr Interval

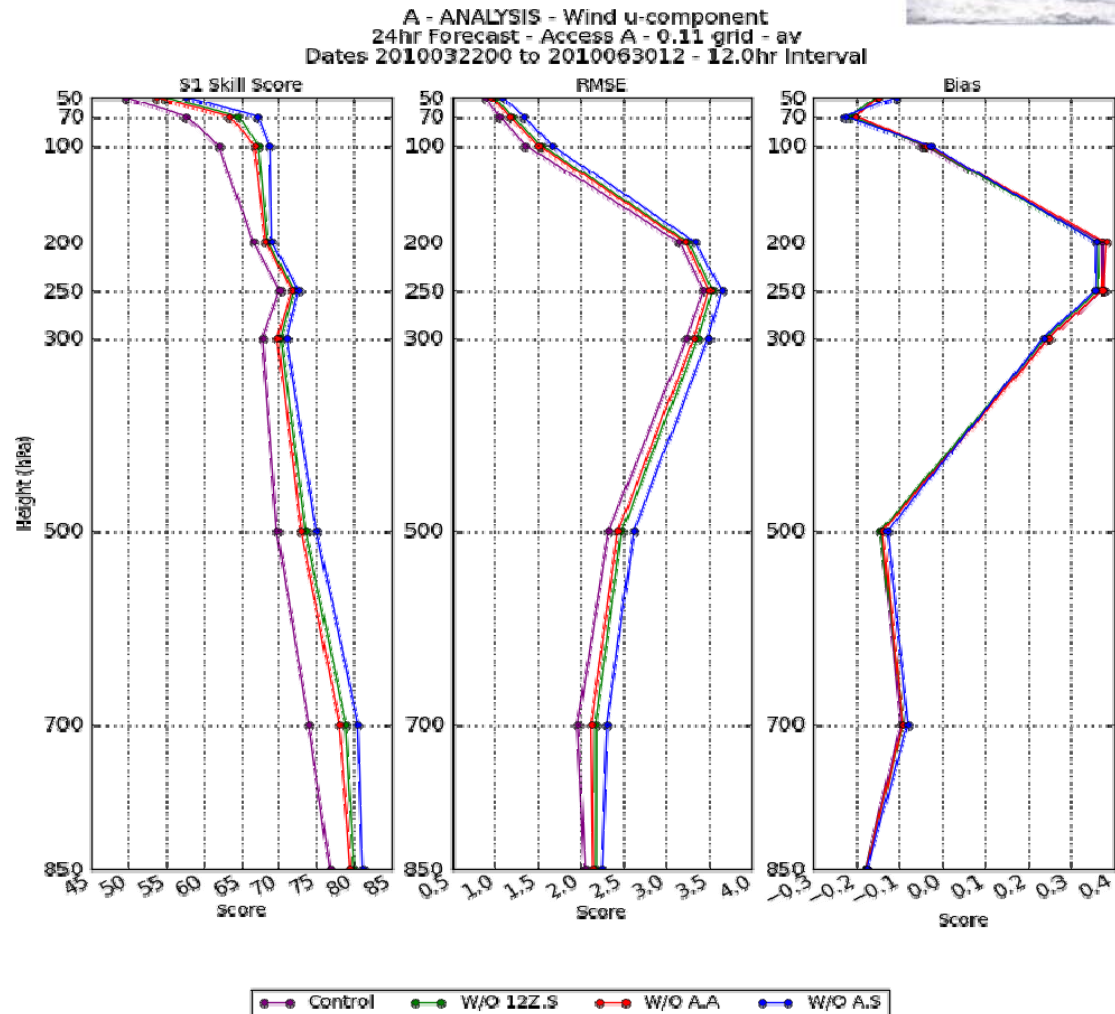


- Similar S1 & RMSE results for other
  - Variables
  - Levels

# Vertical structure



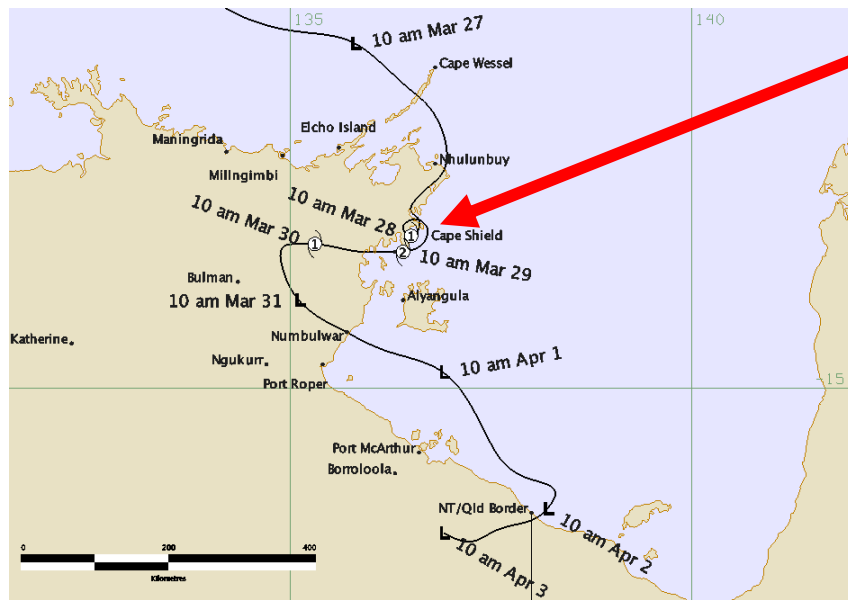
Vertical structure:  
+24 h forecast  
wind u component  
verified against  
operational analyses



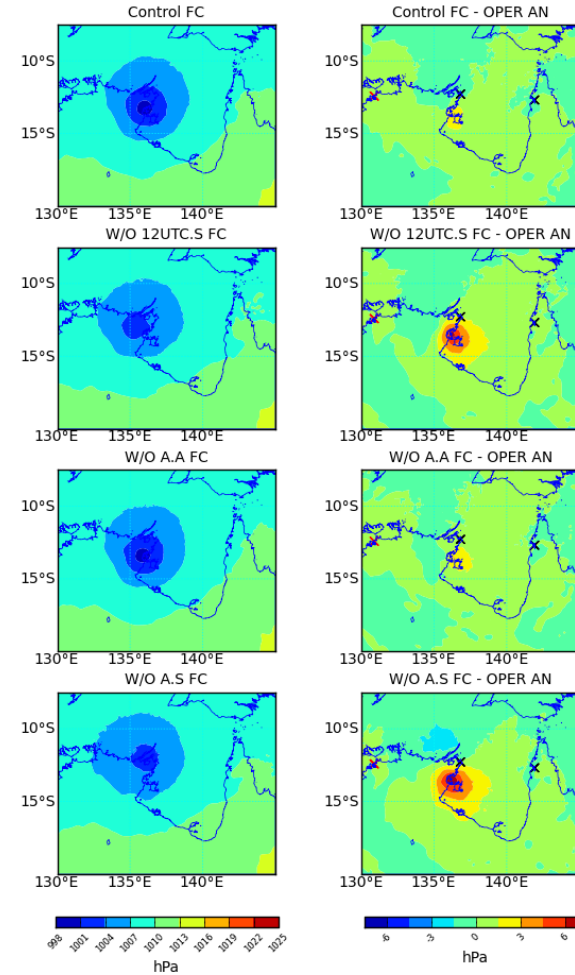
# Radiosondes and AMDARS



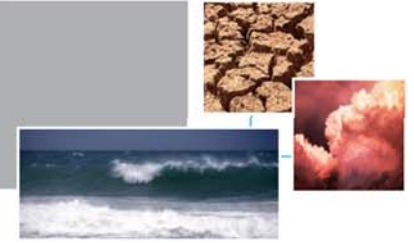
## Synoptic Study – Cyclone Paul



12K AUST MODEL - MSLP 0 hPa  
 DATE = 2010032812, STEP = 12 hr  
 ANALYSIS DATE = 2010032900

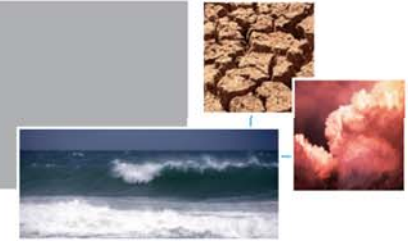


# Results



- Impact only at short lead time ( $< \sim 36$ hrs)
  - Expect this is due to distribution of stations and error propagation speed
  - Impact  $< 6$  hours of forecast skill
  - Similar story for temperature and wind
  - 00Z verifications similar to 12Z
- 12Z sondes have some impact ( $\sim 5\%$ )
  - Looking for specific cases where can be sure differences are large enough to warrant forecast modification
- Impact of AMDARs less than 12Z sondes
- Impact may be greatest in ACCESS-A
  - resolution?

# SREP: high resolution assimilation



## Strategic Radar Enhancement Project (SREP)

- Advancing the science of using of radar data in numerical weather prediction: 7 year project.
- Improving the quality of the radar data
  - Reflectivity quality control
- Assimilation of Doppler winds
  - Value & quality of clear air echoes?
- Development of a suitable NWP system
  - Assimilation of precipitation data

# NWP context



- Met Office Unified Model (UM7.5/L70)

- 6 hourly 4dVAR

- Global, Region

- 4km City Systems (UM7.5/L70)

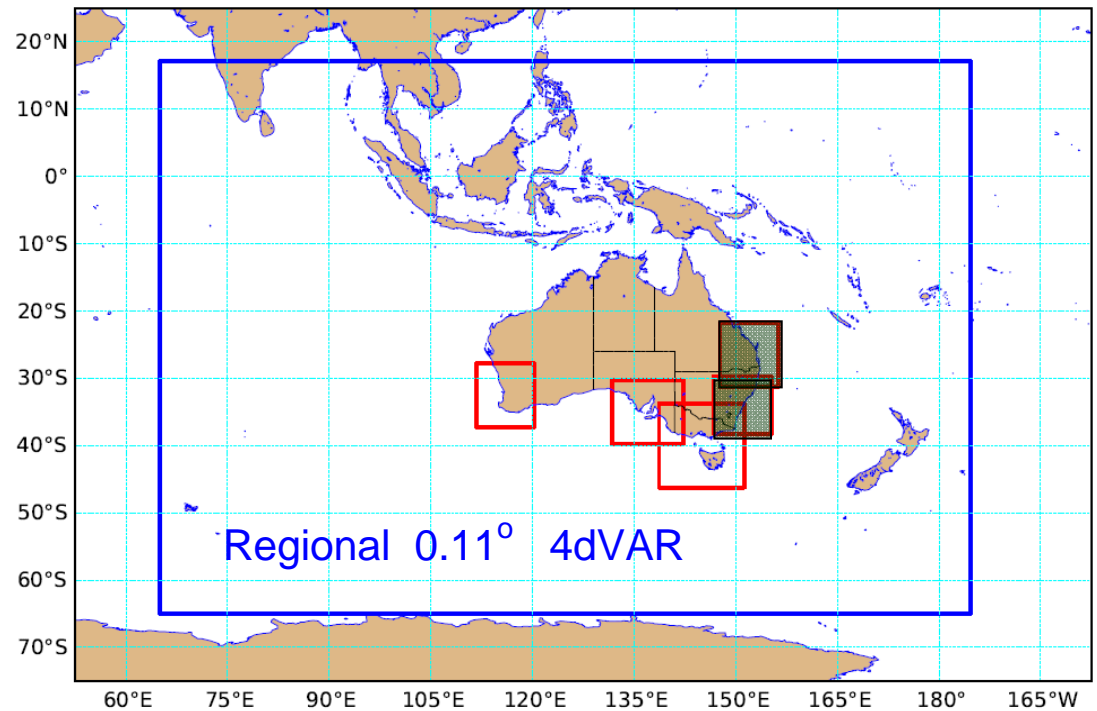
- No Assimilation
- Grey zone

- 1.5km UM7.6/L70

- 3dVAR + radar winds & precip(LHN)
- Relocatable
- Transition to operations 2014-15

- Ensembles

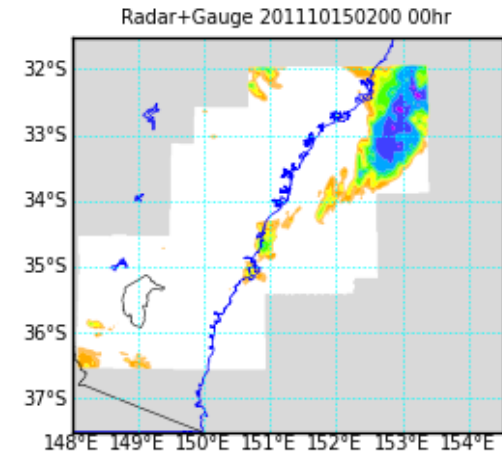
- Need Global & Regional EPS
- Need deterministic high res.



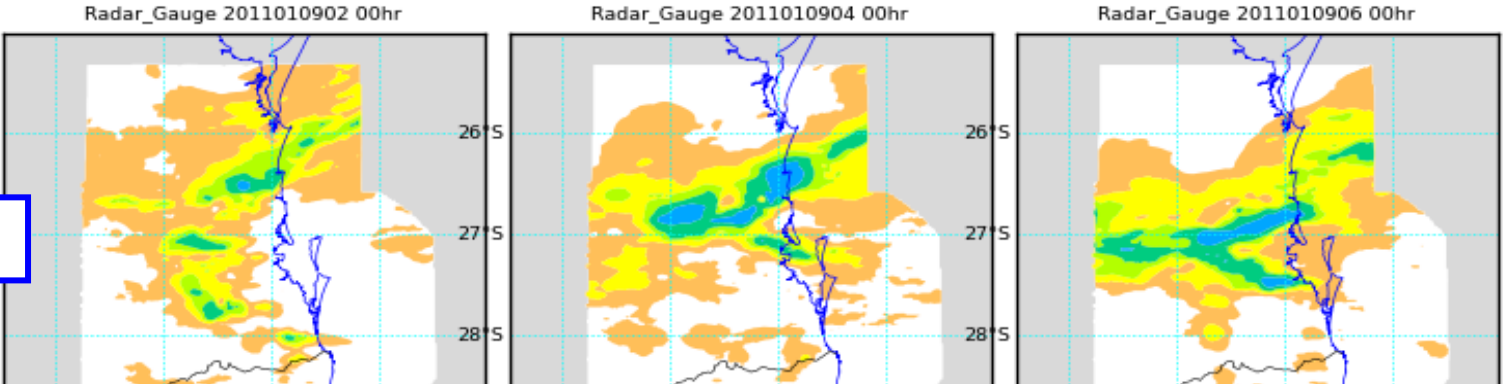
# Experimental 1.5km system



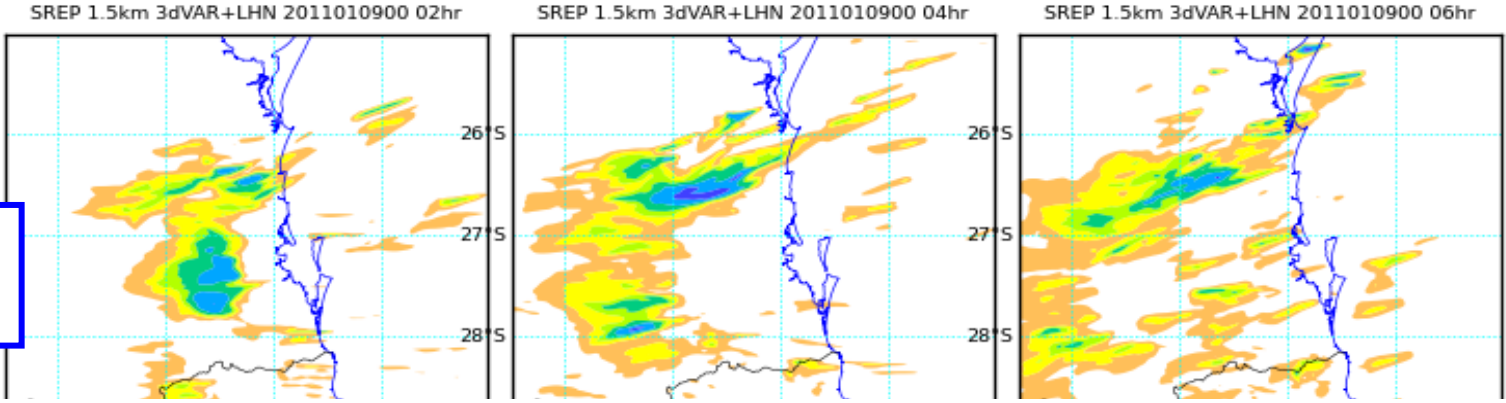
- Aim for trial system capable of using radar data
  - 3dVAR (3 hourly initially)
  - Latent Heat nudging
  - Doppler winds
    - Best coverage is over Eastern NSW (Sydney Domain)
- Main focus so far has been on
  - Radar & QPE quality control
    - Errors in radar QC introduce spurious rainfall patterns
  - Doppler (clear air) wind QC
  - Assessing model performance
  - Configuring 3dVAR and Latent Heat Nudging and assessing impact



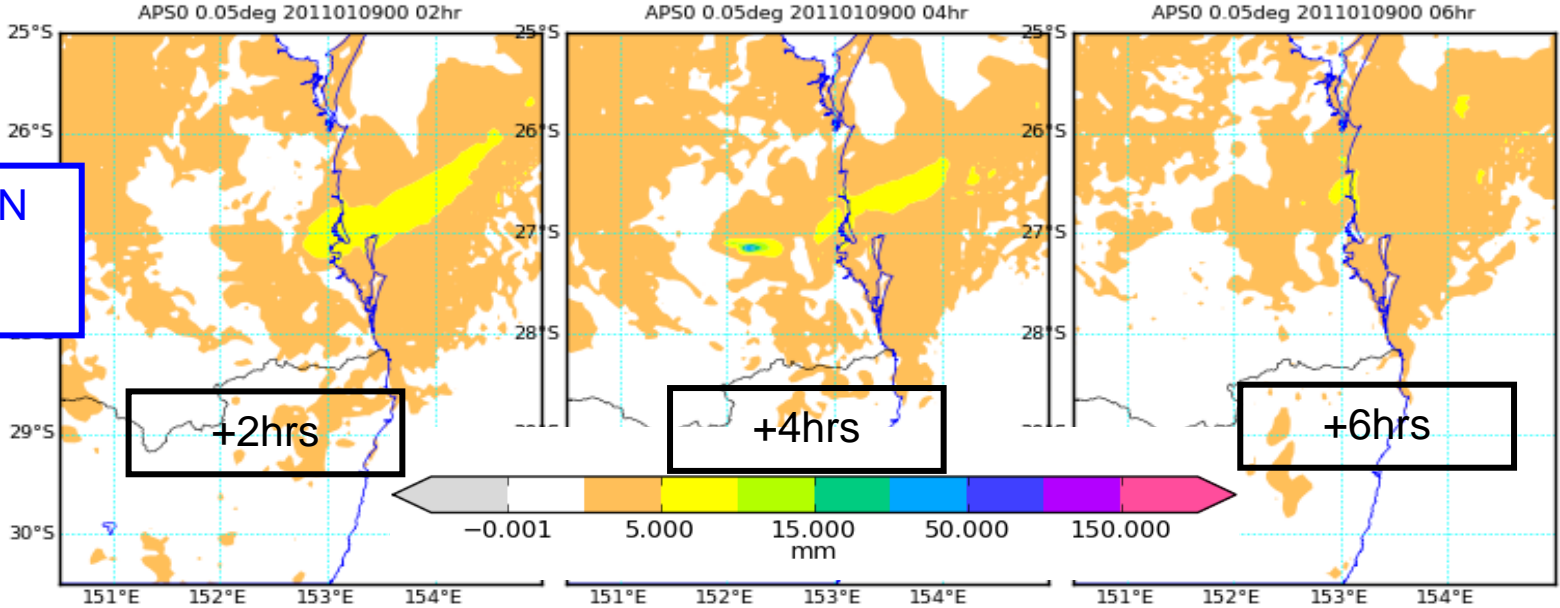
Radar+Gauge



1.5km, 3dVAR & LHN



ACCESS-BN  
APSO



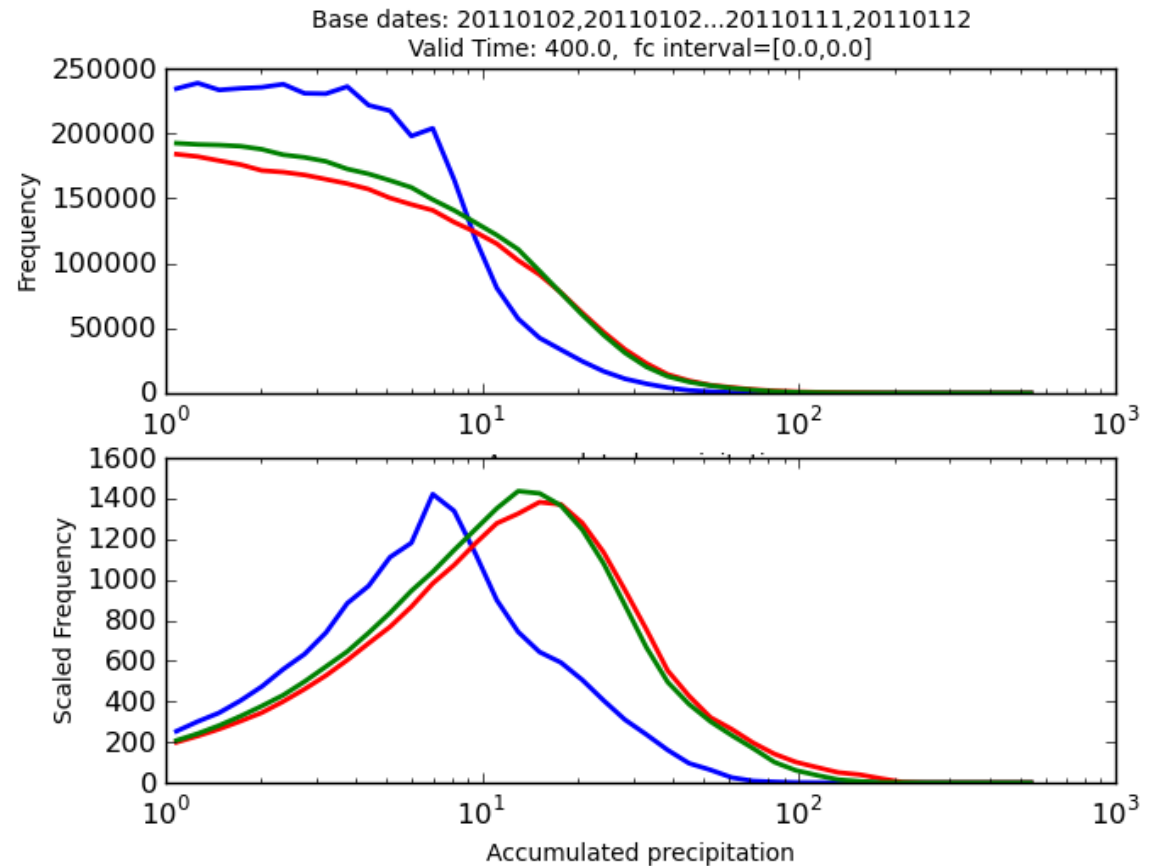


# Area & Volume vs Rainfall Rate (Brisbane Jan2011)

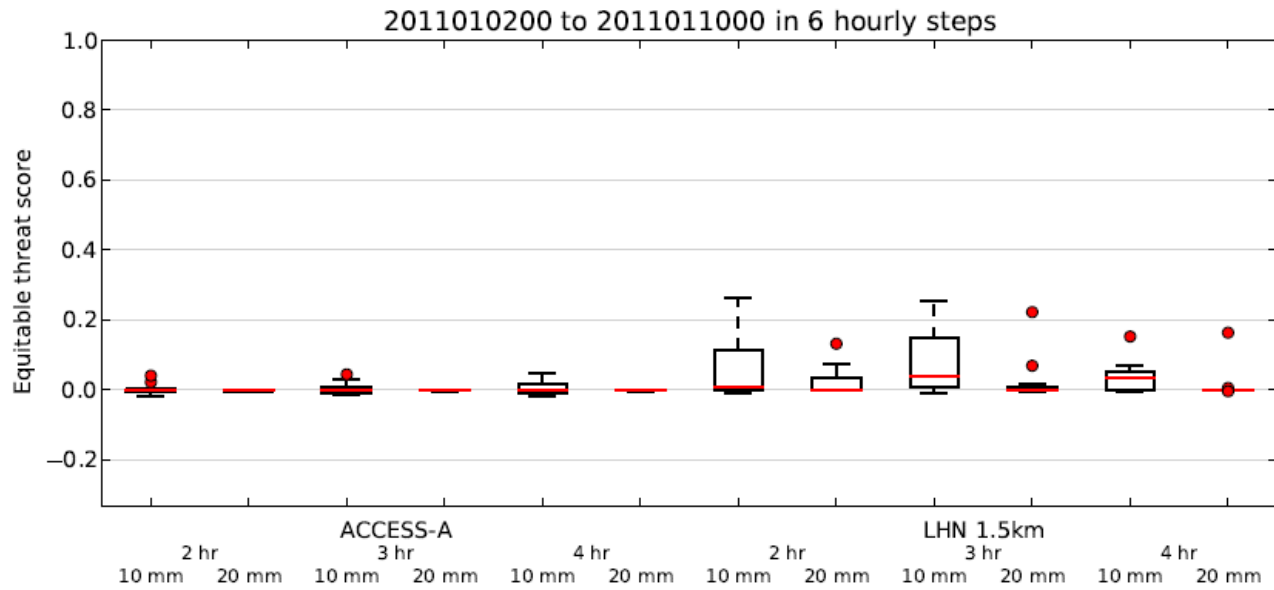


- 1.5km – too much convection & too strong
- 4,5 & 6 hour forecasts
- DA has only small effect on precipitation intensity distribution
- May still have some value

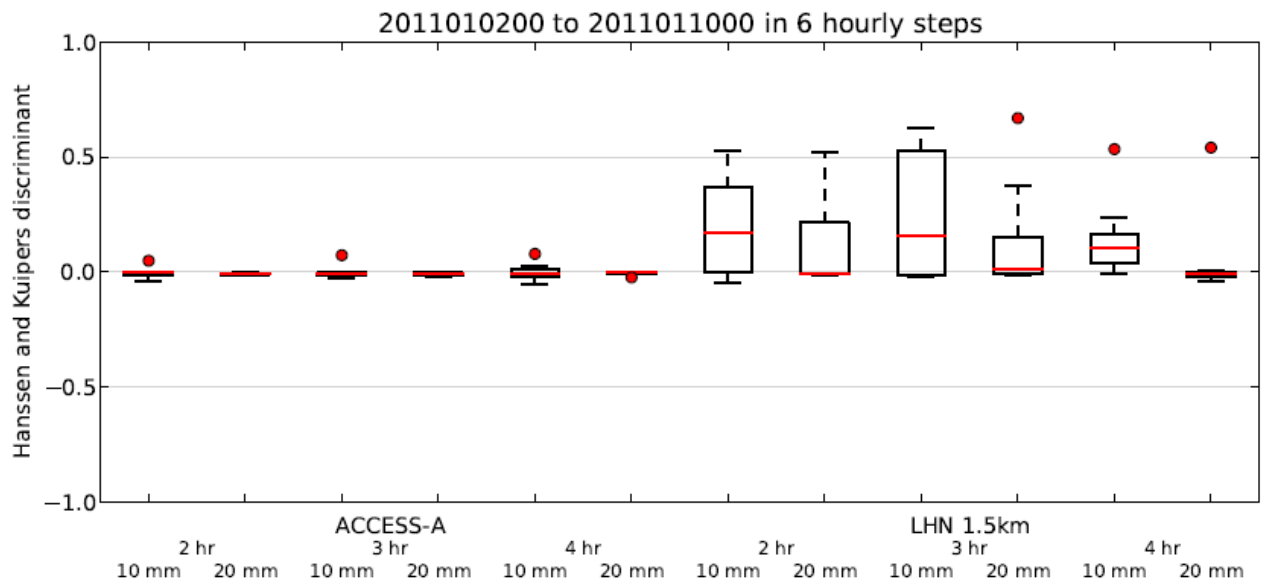
**Obs**  
**3dVAR+LHN**  
**3dVAR only**



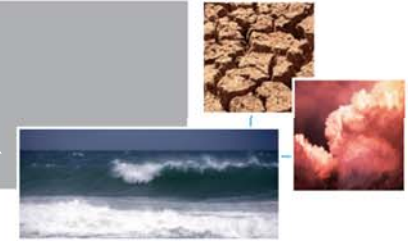
# APSO & SREP Scores vs 10mm & 20mm thresholds



Hourly Precip &  
Model native grid

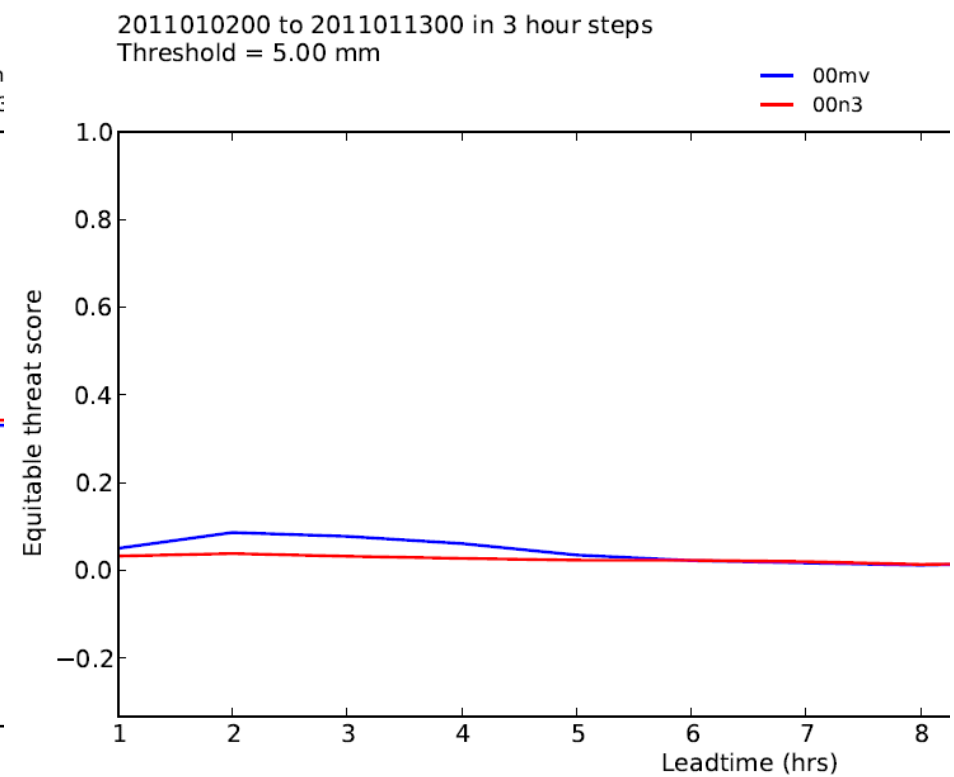
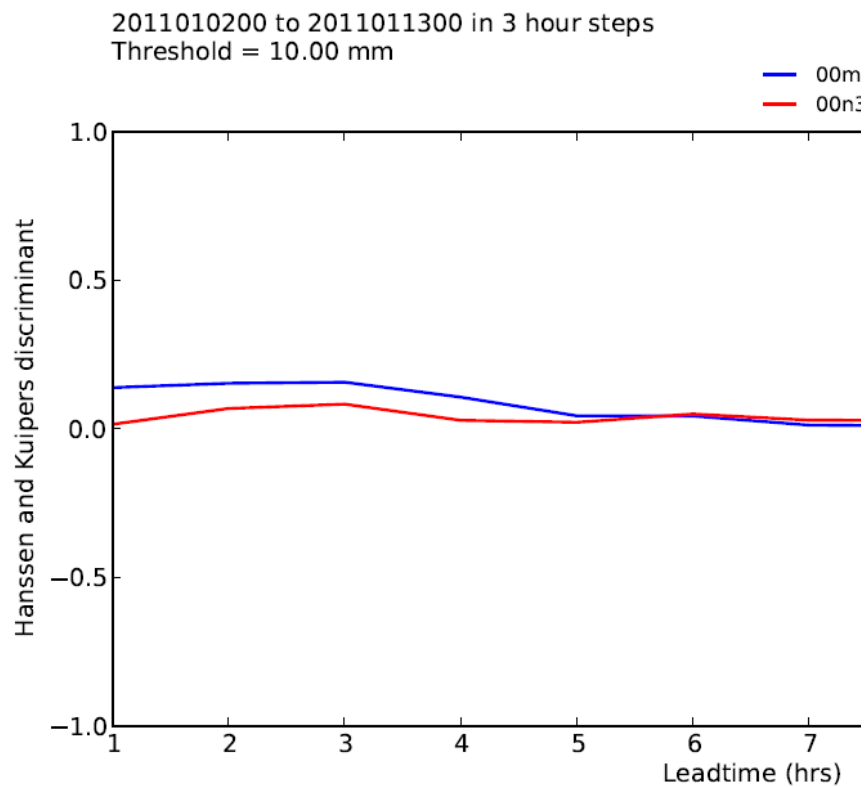


# Value-added by Latent Heat Nudging over 3dVAR



## Latent Heat Nudging + 3dVAR

### 3dVAR only



# Fractions Skill Score (Sep2011-Feb2012)

70+ days : 02Z, 05Z, 08Z... 23Z

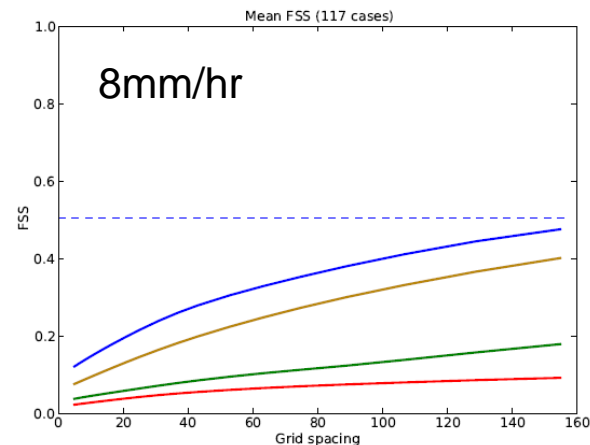
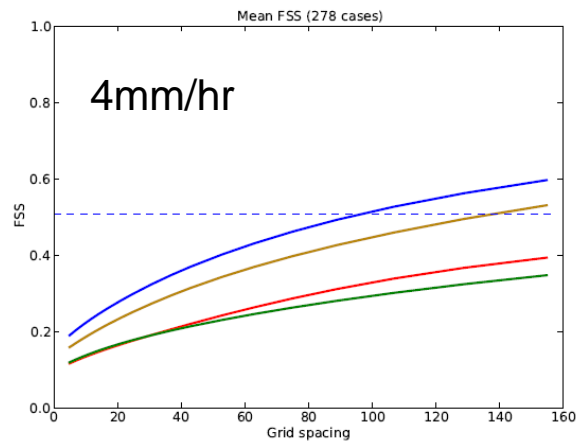
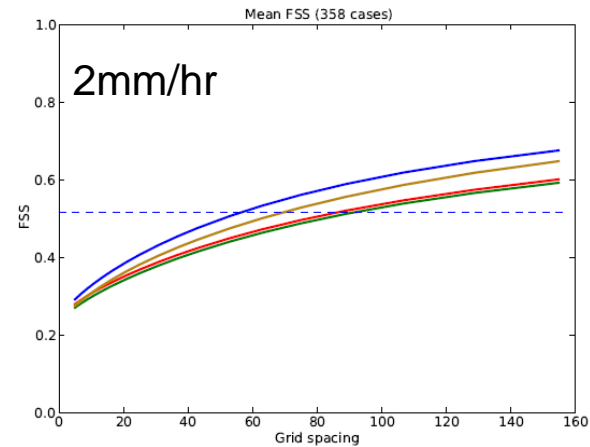
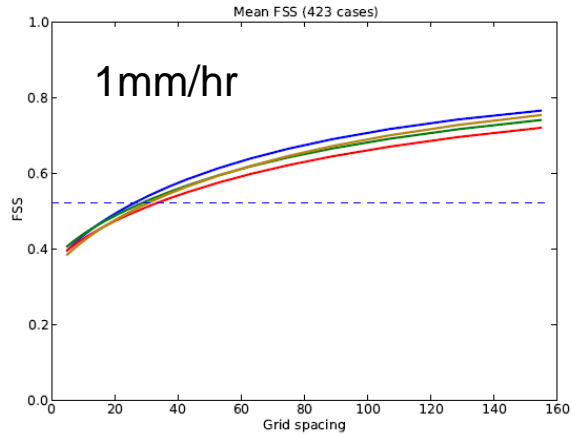


- Neighbourhood verification

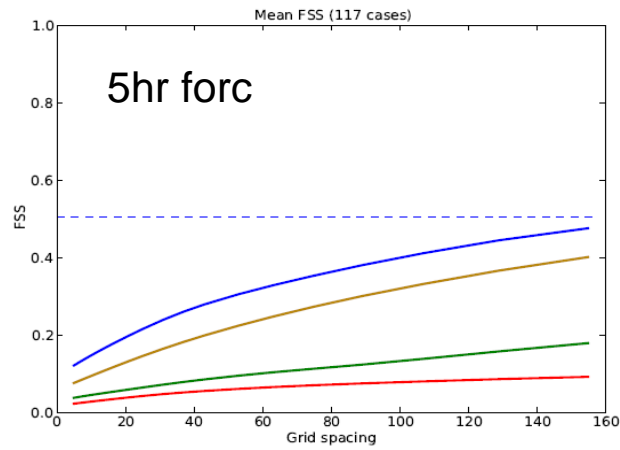
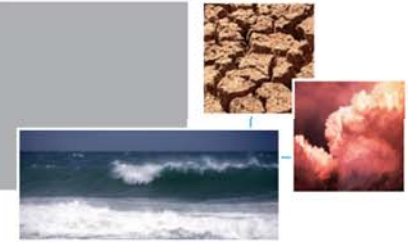
- Gives indication of “accurate resolution”
- 5 hour forecasts

**1.5km+3dVAR+LHN**  
**ACCESS-A 12km**

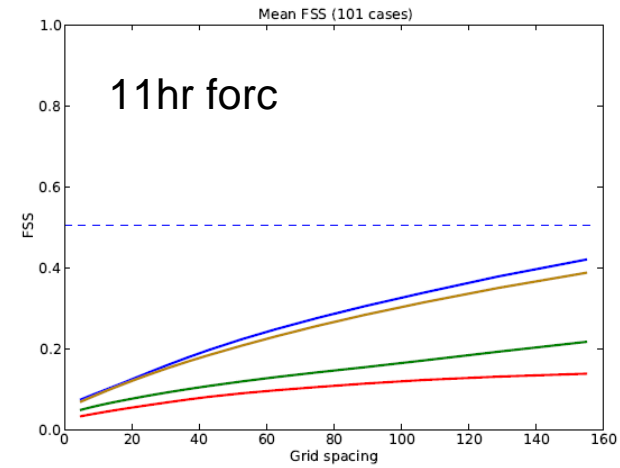
**ACCESS-SY 0.05° (APS0)**  
**ACCESS-SY 4km (APS1)**



- Effect of meso DA fades by ~12hours (LBC's, predictability etc.)



8mm/hr



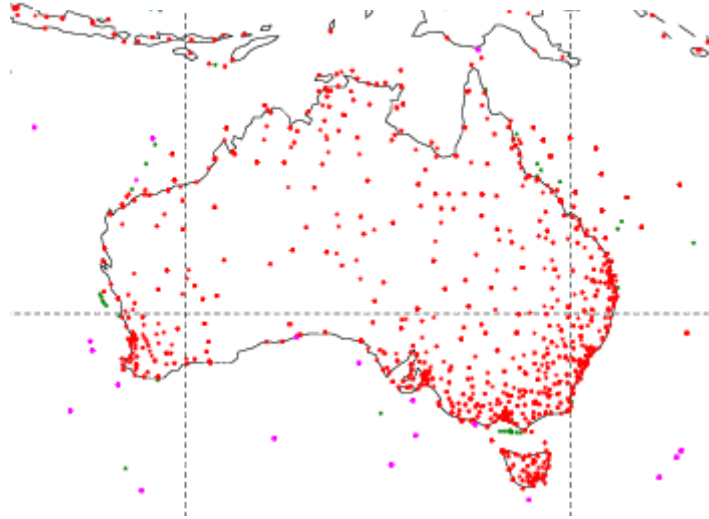
**1.5km+3dVAR+LHN**  
**ACCESS-A 12km**

**ACCESS-SY 0.05° (APS0)**  
**ACCESS-SY 4km (APS1)**

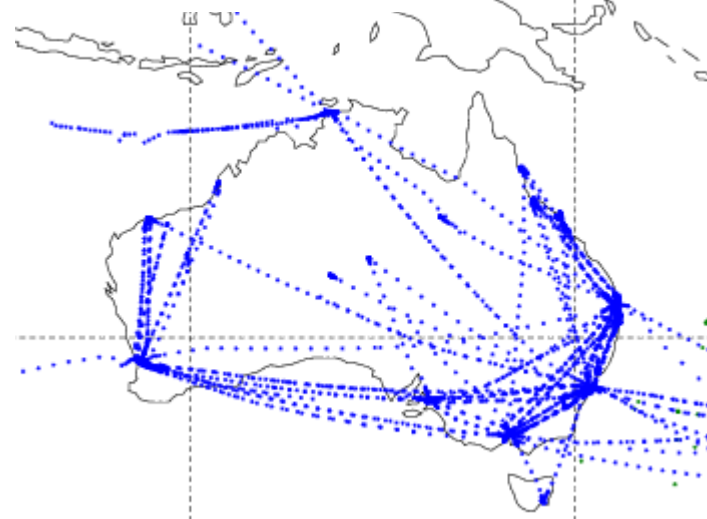
# Issue of Observation Coverage



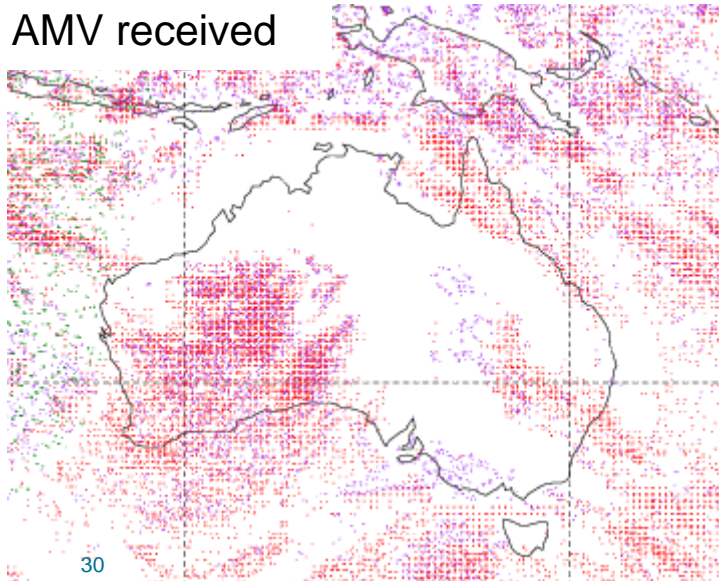
Surface: T, Td, wind, Ps



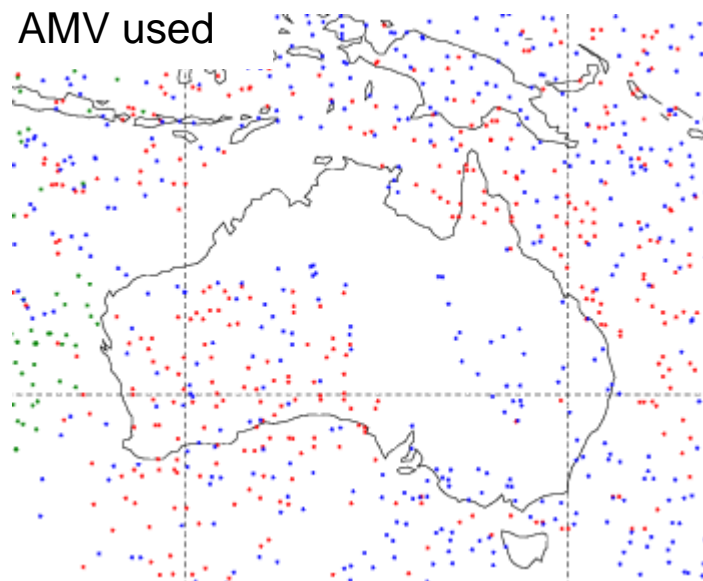
Aircraft – T, wind



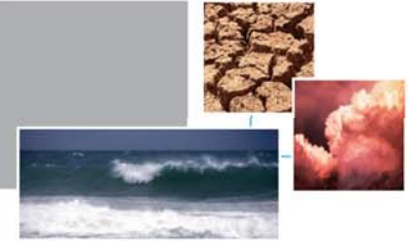
AMV received



AMV used



# 1.5km in-situ obs usage



Australian BoM ACCESS-PH Accepted observations coverage Aircraft 20120428 0600 UTC Total number of obs = 122  
Australian BoM ACCESS-PH Accepted observations coverage Satwind 20120428 0600 UTC Total number of obs = 12  
Australian BoM ACCESS-PH Accepted observations coverage Surface 20120428 0600 UTC Total number of obs = 98

122 amdar

0 airep

11 GOES

0 ESAC

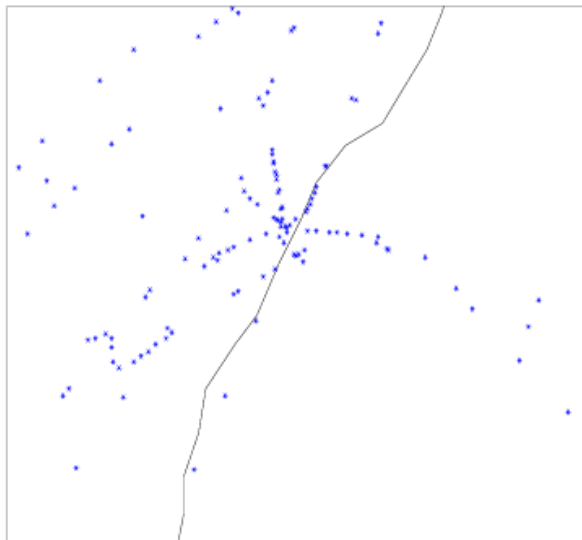
1 JMA

0 MSG

97 synop land

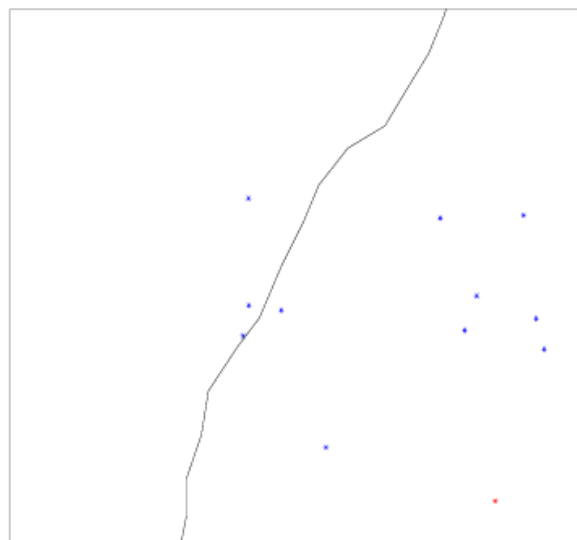
1 synop ship

0 buoy



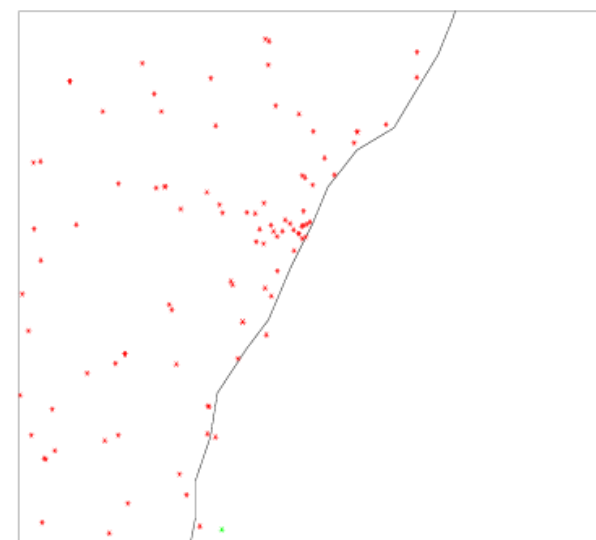
Aircraft

Issue time 01UTC 11 May 2012



AMV

Issue time 01UTC 11 May 2012



Surface

Issue time 01UTC 11 May 2012

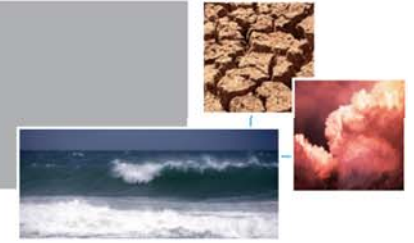


## Some preliminary conclusions:

- **1.5km + 3dVAR +LHN have skill for short range hourly precip forecasts**
  - current systems have marginal to no skill at higher hourly rain rates
  - Hourly rainfall amounts are challenging
  - Resolution matters (both for UM & VAR: 1.5km vs 12km)
- **Latent heat nudging adds value for ~6 hours**
  - Better at suppressing incorrect precipitation
  - Can spin up some weaker precipitation
  - Cloud nudging for deep convection?



# Future ACCESS obs impact work



- Update and extend OSEs already done with early version of ACCESS
  - how much of the APS0 to APS1 improvement is due to extra satellite observation types ?
- Impact of observation thinning, particularly satellite observations
- Impact of Regional ATOVS Retransmission System (RARS) in ACCESS
- Adjoint sensitivity studies
- Ongoing work to assess value of Bureau's observing network to NWP



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