The WMO Observation Impact Workshop - developments outside Europe and lessons for SRNWP

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Outline

➔ Short introduction of the workshop

➔ Developments outside Europe

➔ Overall statements with special emphasis on regional NWP results

The workshop

➔ Fifth WMO Workshop on the Impact of Various Observing Systems on NWP

➔ The workshop is usually organised by WMO; this time it was cosponsored together with the THORPEX and held in Sedona, Arizona, USA, on 22 - 25 May 2012; In 2008 the fourth Workshop was organised in Geneva;

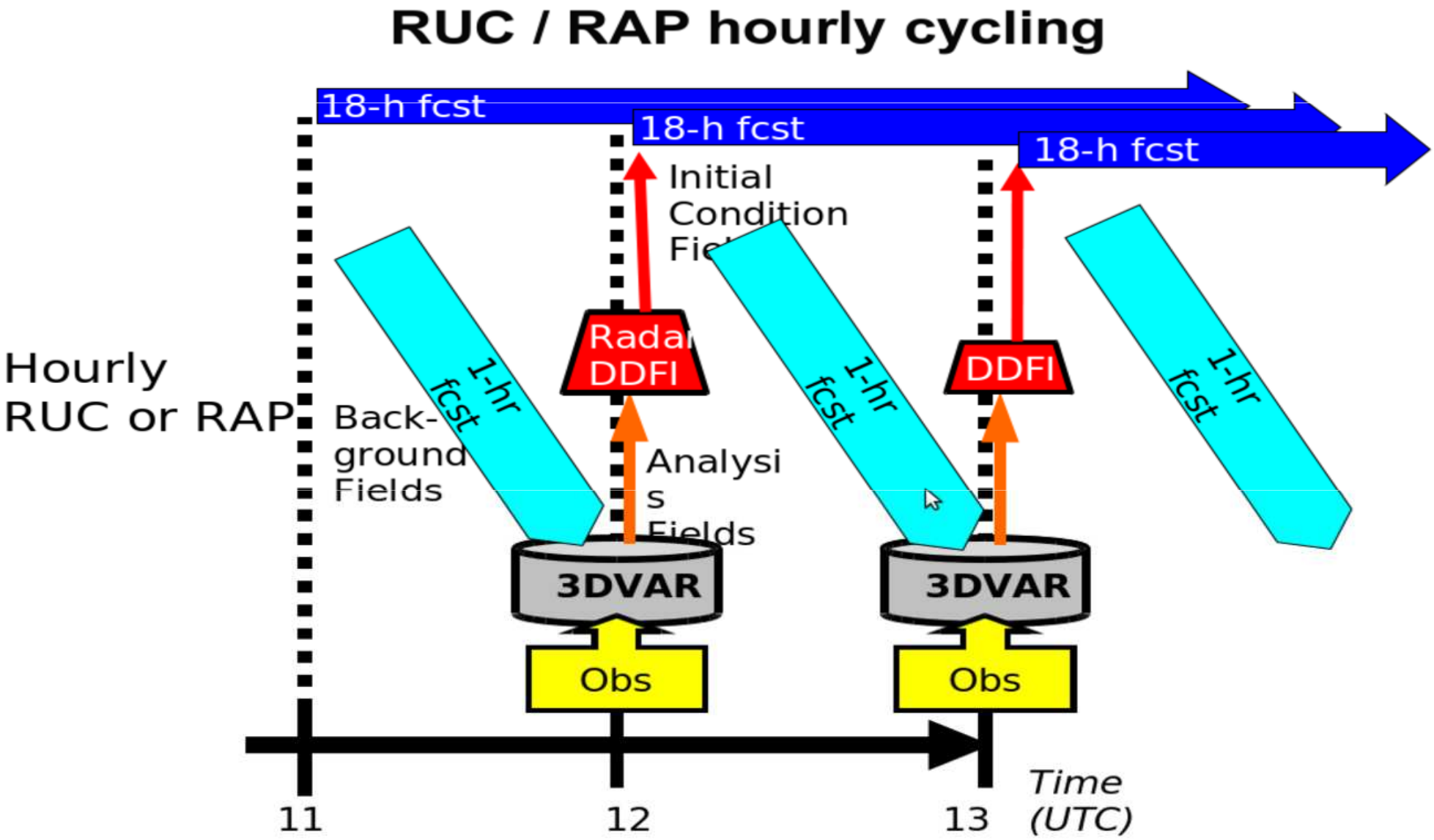
➔ The workshop was attended by 59 experts on data assimilation and observation impact, coming from national weather services, space agencies and managers of observing networks from 13 countries;

➔ The workshop was organised in three Sessions: 1) Global forecast impact studies; 2) Regional forecast impact studies, and 3) Scientific questions.

➔ There were up to 16 presentations in each Session, followed by discussion.

Developments outside Europe

➔ ***Stan Benjamin*** and his group (Eric James, Haidao Lin, Steve Weygandt, Susan Sahm, Bill Moninger), at NOAA Earth System Research Laboratory (Boulder, CO) reported results of comprehensive studies using **RUC and RAP** (Rapid Refresh) **techniques**

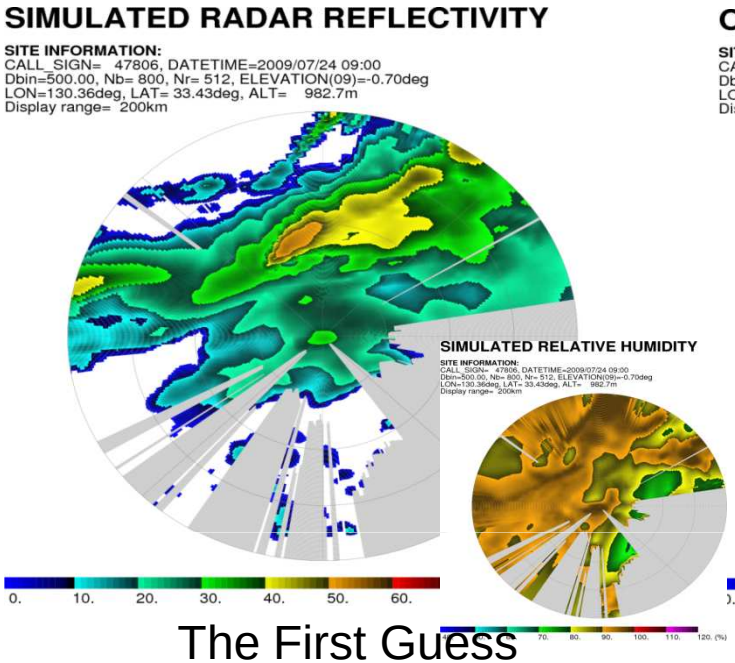


Yoshiaki SATO and colleagues

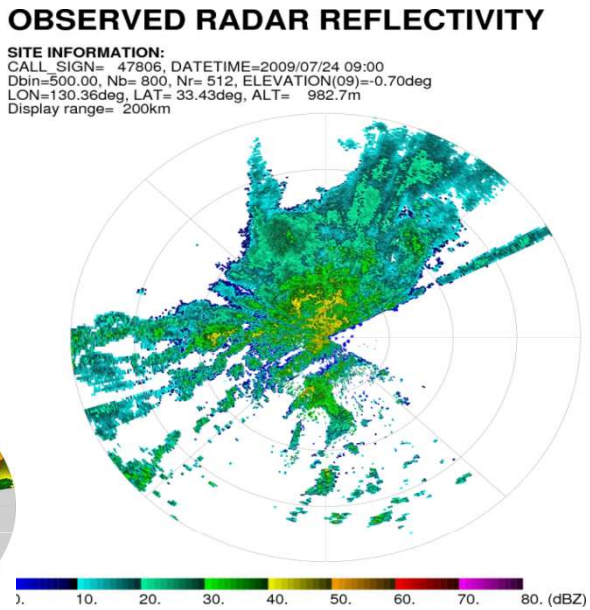
Japan Meteorological Agency / Numerical Prediction Division

Radar Reflectivity assimilation

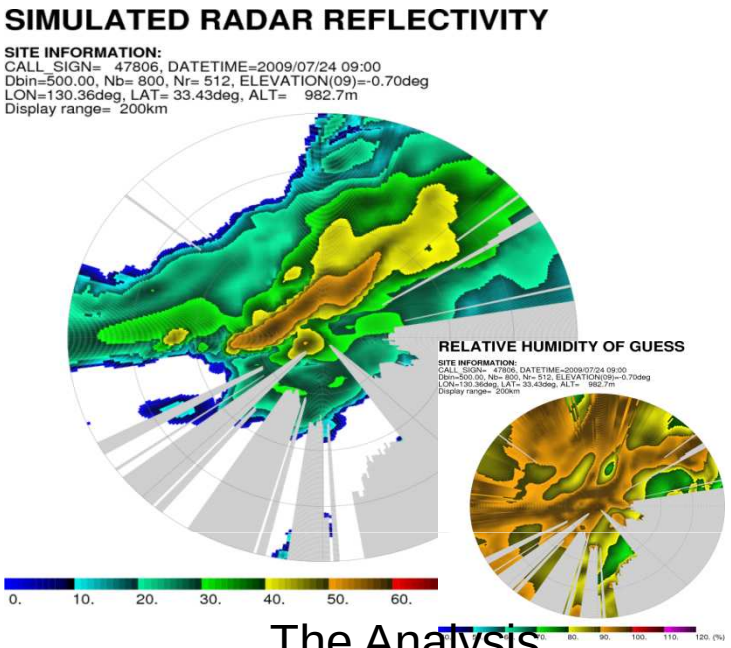
JMA started assimilation of the pseudo-RH data retrieved from 3D radar reflectivity by Bayesian method.



The First Guess



Observation



The Analysis

Pseudo-RH assimilation with 4D-Var

The echo position was relocated appropriately!

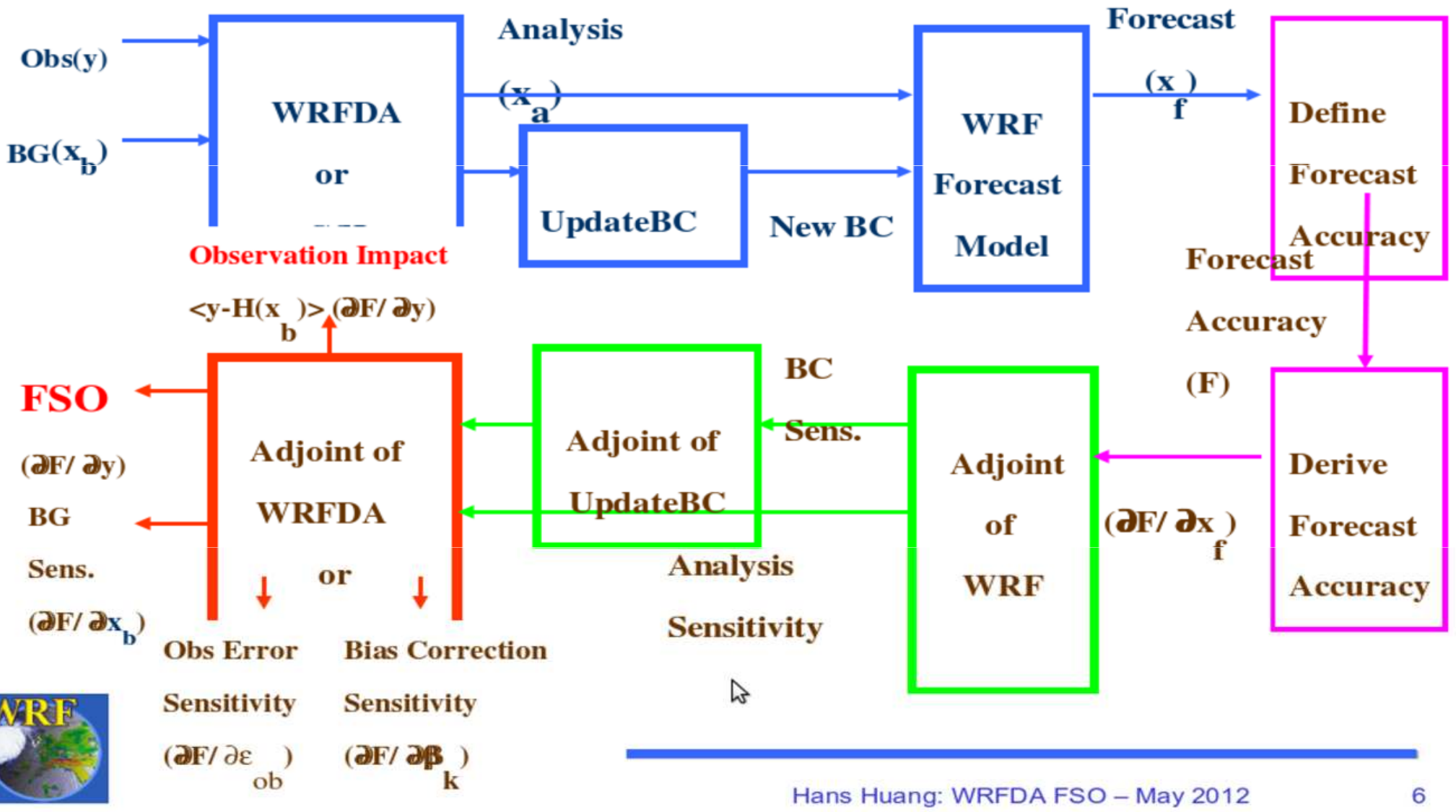
➔ **José Antonio Aravéquia** and his group (Bruna Silveira , Maria das Dores da Silva Medeiros and CPTEC's DAS Group) reported The role of assimilating satellite data over South America using **LETKF**

→ The AQUA/AMSU-A was used in this study

For more details see:

Aravéquia, A. J., I. Szunyogh, E. J. Fertig, E. Kalnay, D. Kuhl, and E. J. Kostelich, 2011: Evaluation of a strategy for the assimilation of satellite radiance observations with the local ensemble transform Kalman filter. Mon. Wea. Rev. Vol. 138, Issue 10, pp. 1932–1951.

➔ **Xiang-Yu Huang** from NCAR made an overview of the WRFDA 2012. Among other developments, he presented the FSO developed for regional systems



Few statements

The applied DA schemes and diagnostic techniques

The applied assimilation schemes were:

→ 3D/4D-Var, Ensemble Kalman Filter and hybrid systems

The following diagnostic techniques were used to evaluate the impact of observations in the different assimilation schemes:

1- „classical" OSEs (observations denial experiments);
2- adjoint-based technique such as forecasts sensitivity to observations (FSO);
3- energy-norm-based technique, which consists of computation of the moist total energy loss attributed to the denied/withdrawn observation;
4- degrees of freedom for signals (DFS);
5- reduction of error variance.

➔ In context of regional NWP, the last four techniques were recognised as new, and 3- and 5- were applied with regional models only.

Impact of the observations on global NWP systems

➔ **In global models**, the order of the "top 5" (the highest-ranked contributors to forecast skill) changed from centre to centre, although the list remained almost the same:

AMSU-A (microwave temperature sounder), **AIRS/IASI** (hyper-spectral infrared temperature and humidity sounders), **radiosondes, aircraft** observations and atmospheric motion vectors (**AMVs**) from geostationary and polar orbiting satellites

➔ **GPSRO** has also substantial impact, but the data volume is now declining because the COSMIC RO is approaching the end of its lifetime. According to the study done at ECMWF, operational DA systems can process up to 10,000 profiles per day.

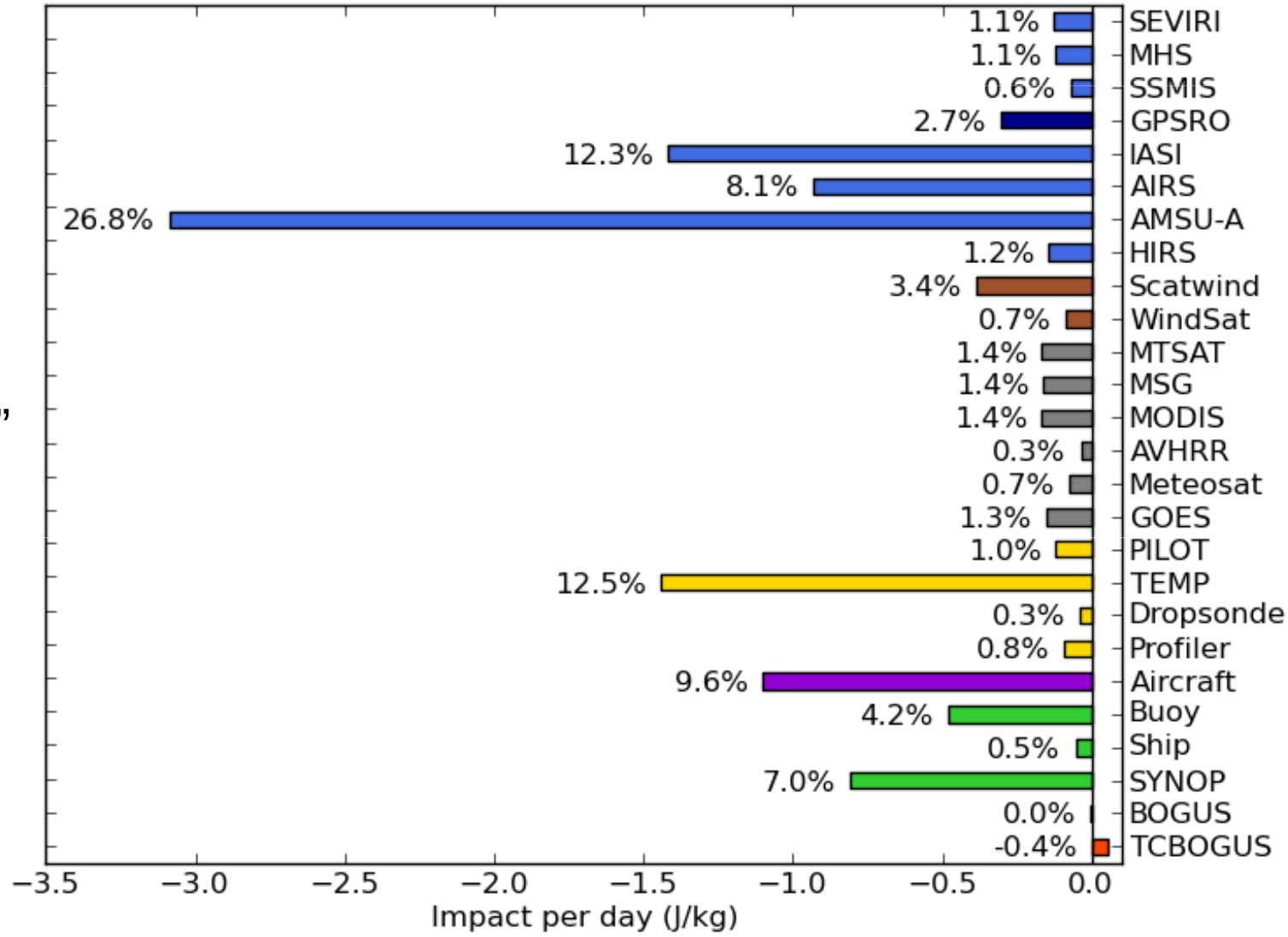
➔ At present, there is no single dominating satellite sensor; there are several sensors that contribute to forecast skill.

→ There is more complementarity between satellite sensors than it was reported in previous workshop (Geneva 2008).

Richard Marriott, Met Office, UK

Observation impacts per day

Example of
“top observations”



Impact of the observations on global NWP systems

➔ The impact of any single data type depends on the mix of other data types assimilated in any particular NWP system;

→ NWP centres that use less radiance data typically show relatively higher impacts of atmospheric motion vectors (AMVs). Globally, satellite data tend to dominate, although conventional data still have a substantial global impact and tend to be dominant in the northern hemisphere.

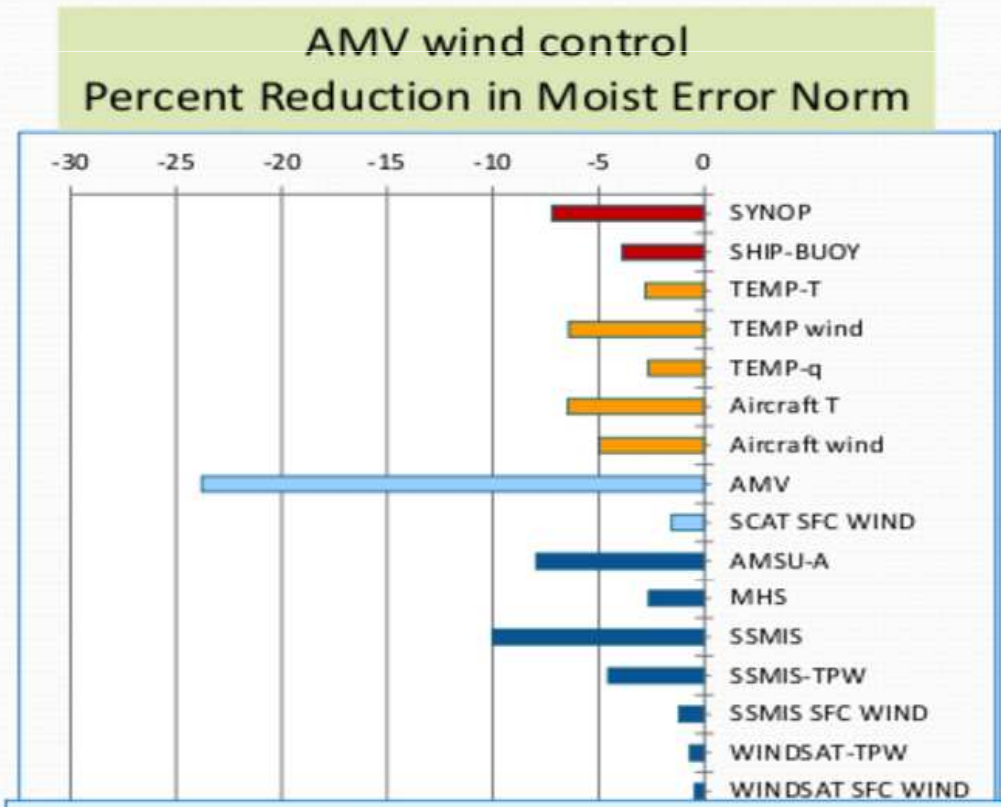
➔ Since the Geneva 2008 workshop there has been good progress on the use of humidity observations. There is now increased evidence that humidity observations have a beneficial impact on forecast skill.

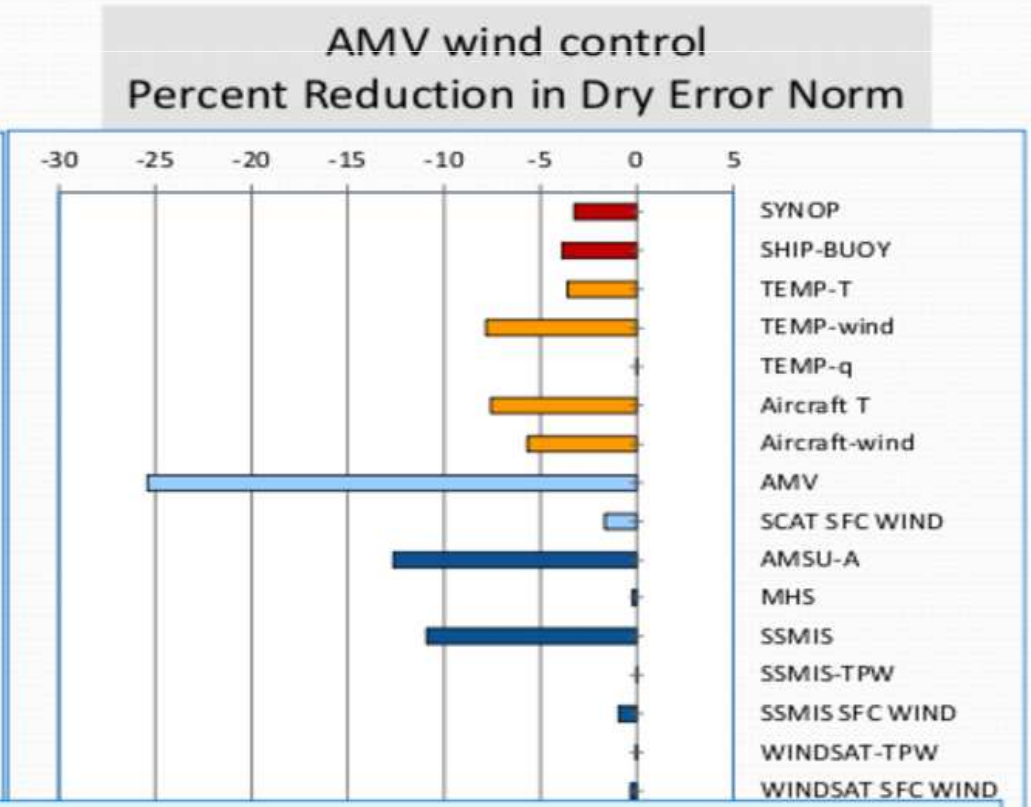
→ It was questioned if the impact was appropriately measured?

Nancy Baker, R. Langland, P. Pauley, Liang Xu, D. Merkova, R. Gelaro and C.Velden, NRL/GMAO

Summer 2010

Aug 15th, 12 UTC through Sept. 30th, 12 UTC





Moist Error Norm: NRL top 6: AMV, raob, aircraft, land surface, IASI, AMSU
Dry Error Norm: NRL top 6: AMV, aircraft, AMSU, raob, SSMIS, AQUA AIRS
Dry Error Norm: GMAO top 6: AMSU, raob, aircraft, IASI, AMV, AQUA AIRS

The results are qualitatively the same for moist and dry error norms, except for moisture obs

More statements based on regional NWP results

Stan Benjamin et al. *NOAA Earth System Research Laboratory, Boulder, CO*

RUC/RAP observation denial experiments

Experiments with observations denied	Aircraft	Profilers	VAD winds	RAOBs	Surface (w/ METAR clouds)	GPS prec water	Mesonet	Atmos motion vectors	Radar reflectivity
RUC - Winter 2006	✔	✔	✔	✔	✔	✔	✔	✔	
RUC – Summer 2007	✔	✔	✔	✔	✔	✔			
RAP – Summer 2011	✔	✔	✔	✔	✔	✔		✔	✔

RUC vs RAP see: http://www.youtube.com/embed/TlFhKDrNqL4?

Hourly Updated NOAA NWP Models

Rapid Refresh (RAP)

replaced RUC at NCEP 1 May 12

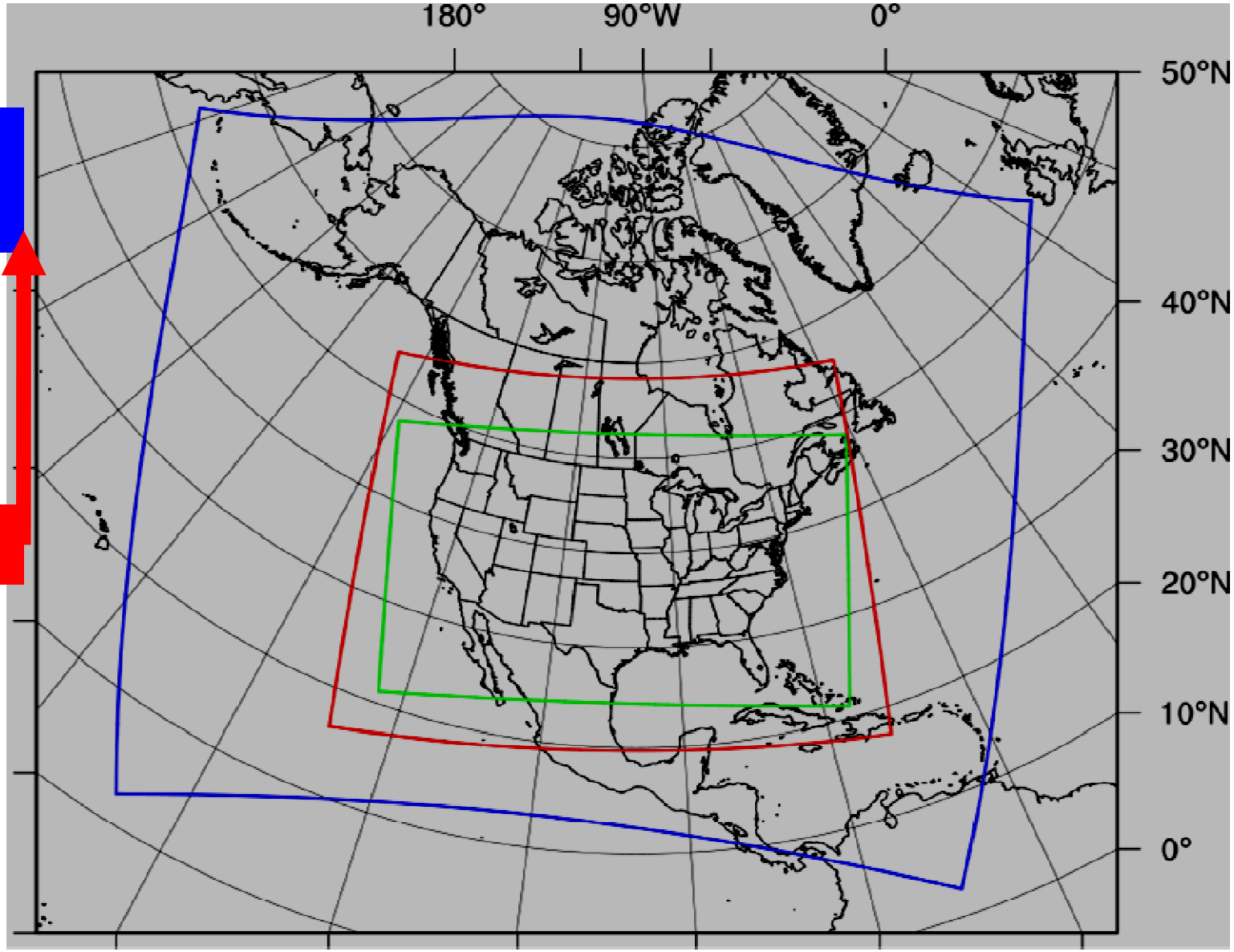
Uses WRF, GSI with RUC features

13km Rapid Refresh

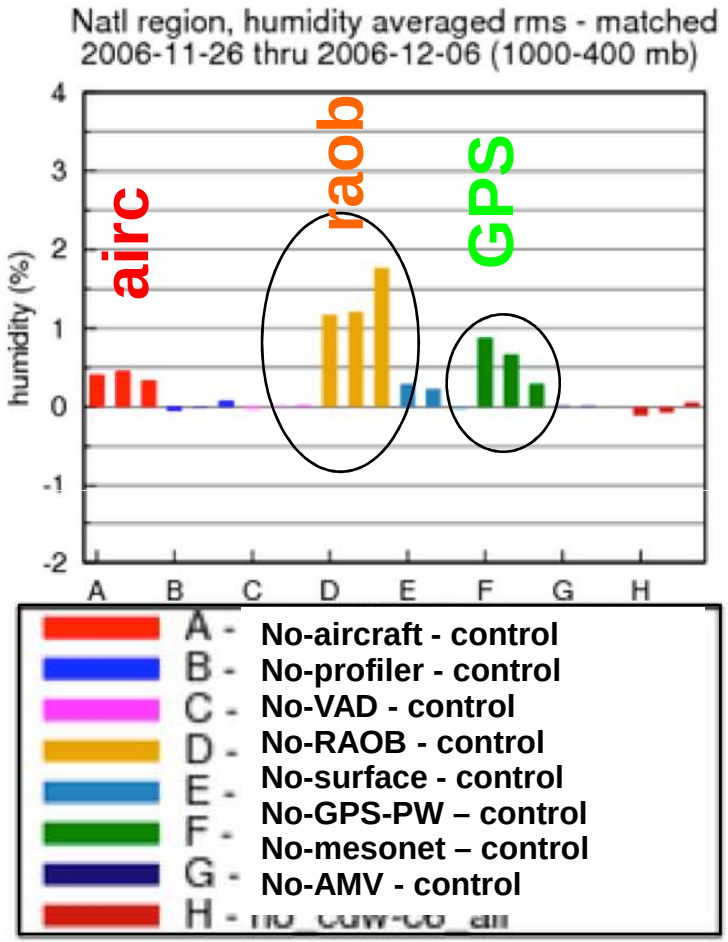
new operational model, new 18h fcst every hour

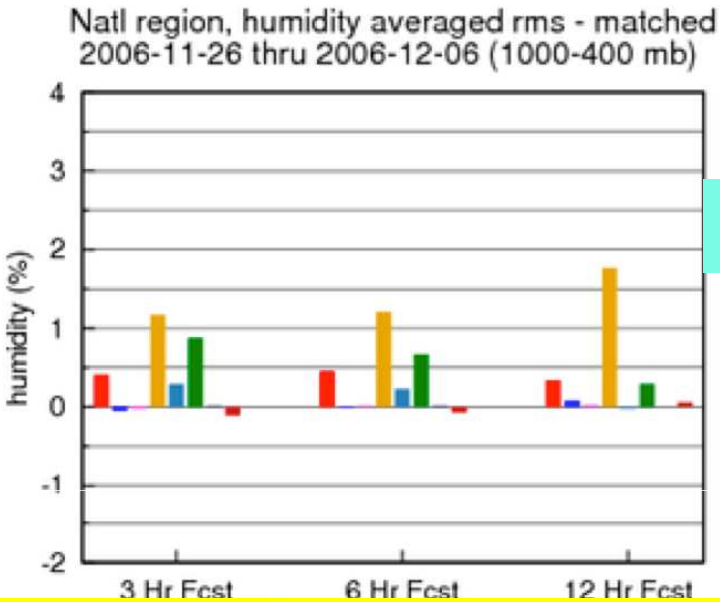
13km RUC

prior operational model, new 18h fcst every hour



RUC vs RAP see: http://www.youtube.com/embed/TlFhKDrNqL4?





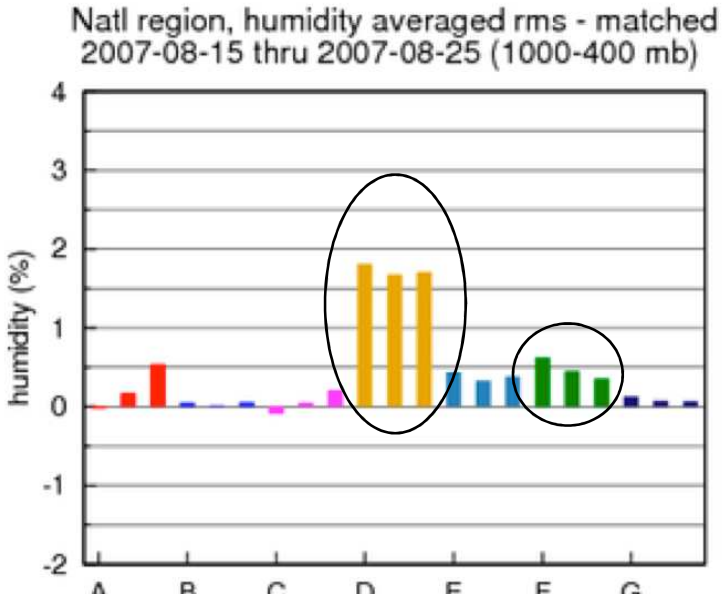
RUC

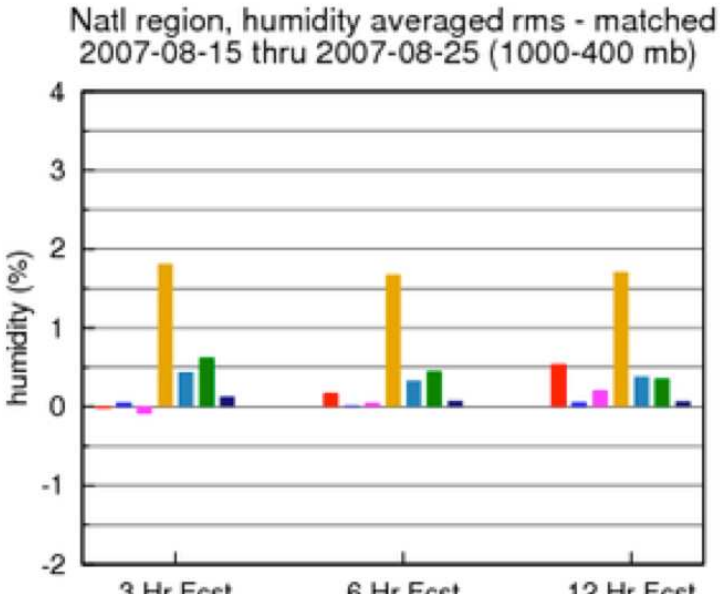
WINTER

RH - national – 1000-400 hPa

#1 obs type = Raobs

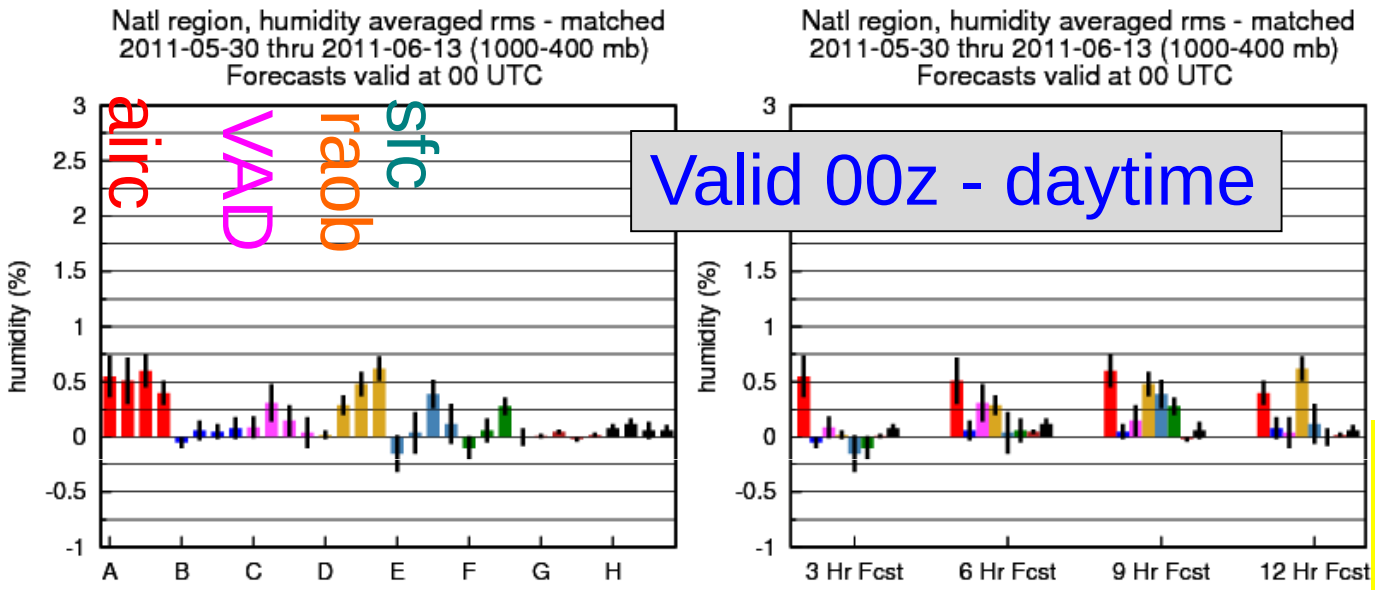
#2 = GPS-PW



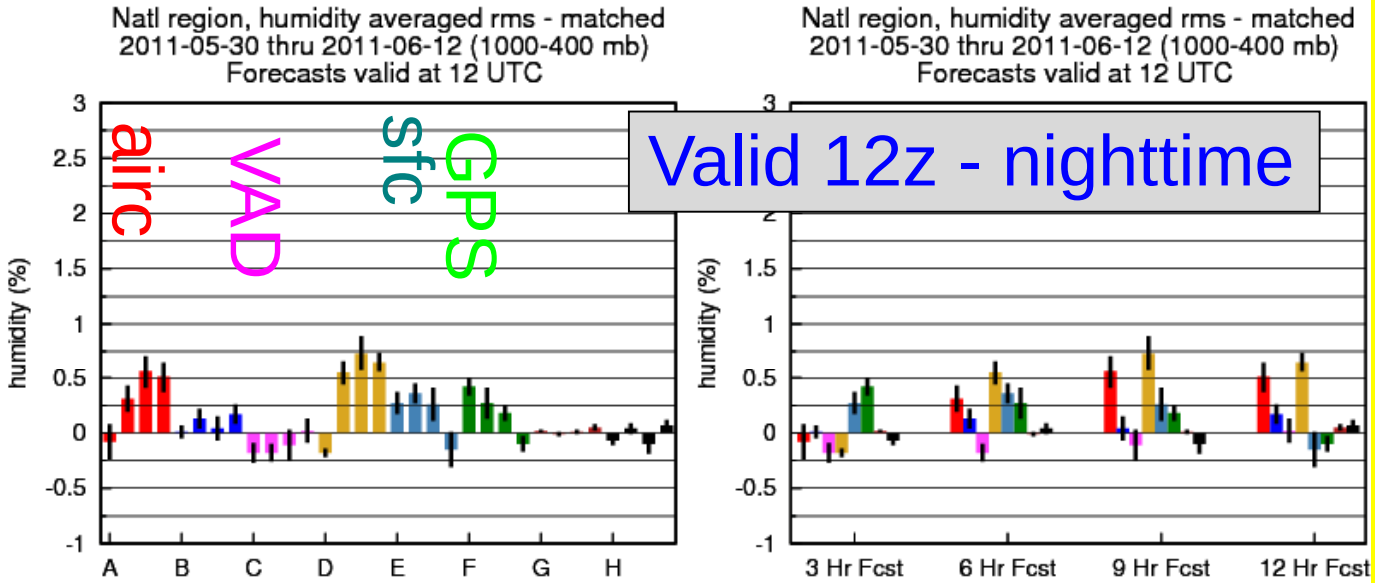


SUMMER

RAP



Valid 00z - daytime



Valid 12z - nighttime

A - withhold aircraft obs - Exp v6 - control
B - withhold all profiler obs - Exp v7 - control
C - withhold VAD winds - Exp v11 - control
D - withhold rawinsonde obs - Exp. v5 - control
E - withhold surface obs incl METAR cloud - Exp v9 - control
F - withhold GPS-Met PW obs - Exp v12 - control
G - withhold AMVs - Exp v10 - control
H - withhold radar refl- Exp v8 - control

RH - national – 1000-400 hPa

#1 obs type = Raobs

Close #2 = aircraft

#3 – GPS at night

- VAD in day
- sfc – day/night

More cross-covariance effect w/ GSI/RAP for wind-moisture than w/ RUC

Stan Benjamin et al. *NOAA Earth System Research Laboratory, Boulder, CO*

Diurnal dependencies for observations

- Aircraft
  - minimum in commercial traffic at night (06z-11z) over N. America
- Profiler, VAD winds –
  - vulnerable to bird migration contamination at night in spring/fall
- Surface –
  - Winds/temperature/dewpoint obs representative over deeper boundary layer in daytime

Impact of the observations on regional NWP systems

➔ Current regional NWP systems use **3D** or **4D** data assimilation techniques at high horizontal resolution (**2** to **10 km**) with short data cut-off times;

➔ In regional NWP, impacts were demonstrated from: **radiosonde**, conv. **Surface** obs and ground based **GPS**, **aircraft** (AMDAR and MODE-S, **radar** (precipitation, radial wind and refelctivities), **radiances** (AMSU-A, MHS, AIRS/IASI and geos. Imagers), high-res **AMVs**, **clouds** (geos. Imagery), **ships** and **buoys**, **profilers** and **GPS RO**;

➔ Compared with the 4th WMO NWP Impact Workshop (Geneva 2008), substantial progress was reported on the assimilation of radiances as well as on the assimilation of radar reflectivities and Doppler winds;

➔ Progress has been also made on addressing model spin-up, but this still remains a significant problem;

Impact of the observations on regional NWP systems

➔ The observing systems providing the highest forecast skill impacts on regional NWP different from that found in global NWP;

➔ There are also substantial differences between the respective results reported by different regional NWP centres;

I did not talk about targeting observation, which was also discussed during the workshop.

Thank you for your attention