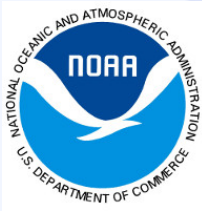


Assessing the Impact of Aircraft Observations on Model Forecasts



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S. Larouche, R. Sarrazin (Environment Canada)

C. Parrett, B. Ingleby (Met Office)

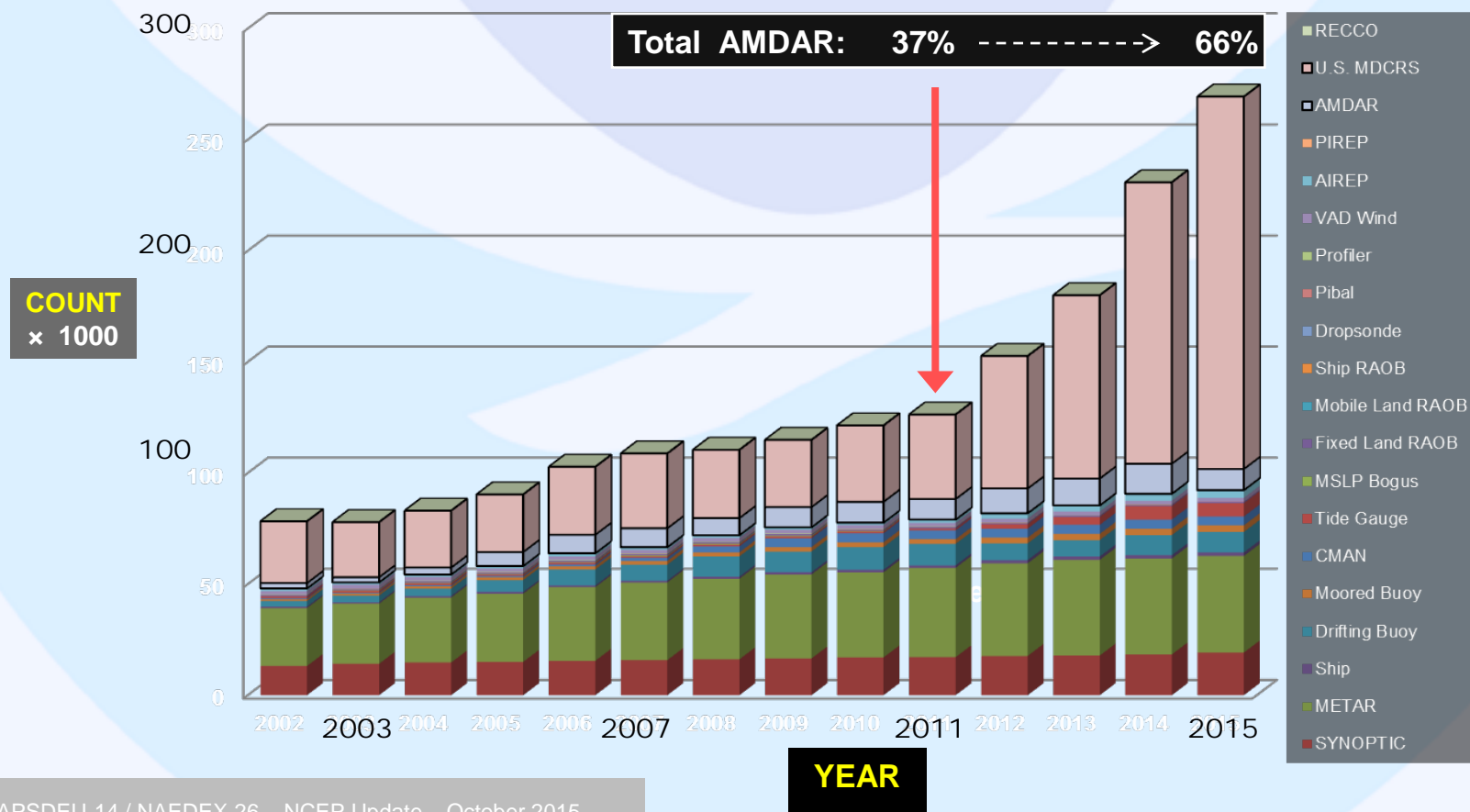
H. Bénichou, N. Boullot (Météo-France)

Introduction

- **The ultimate purpose of assimilating any kind of observation into NWP models is to improve the model forecast.**
- **Robust methods for determining the impact of the observations are therefore required. Operational centers typically have a wide range of tools available for this.**
- **The initial aim in any data assimilation system is to use the observations in such a way as to improve the accuracy in the analysis. Sometimes these improvements are not directly translated into increases in forecast skill due to the characteristics of the forecast model itself.**
- **In general this presentation is considering aircraft observations of temperature, humidity and wind vector together.**

Conventional Data Received by NCEP

Average Number of Observations Received Daily
for GDAS 00 UTC Assimilation Cycle

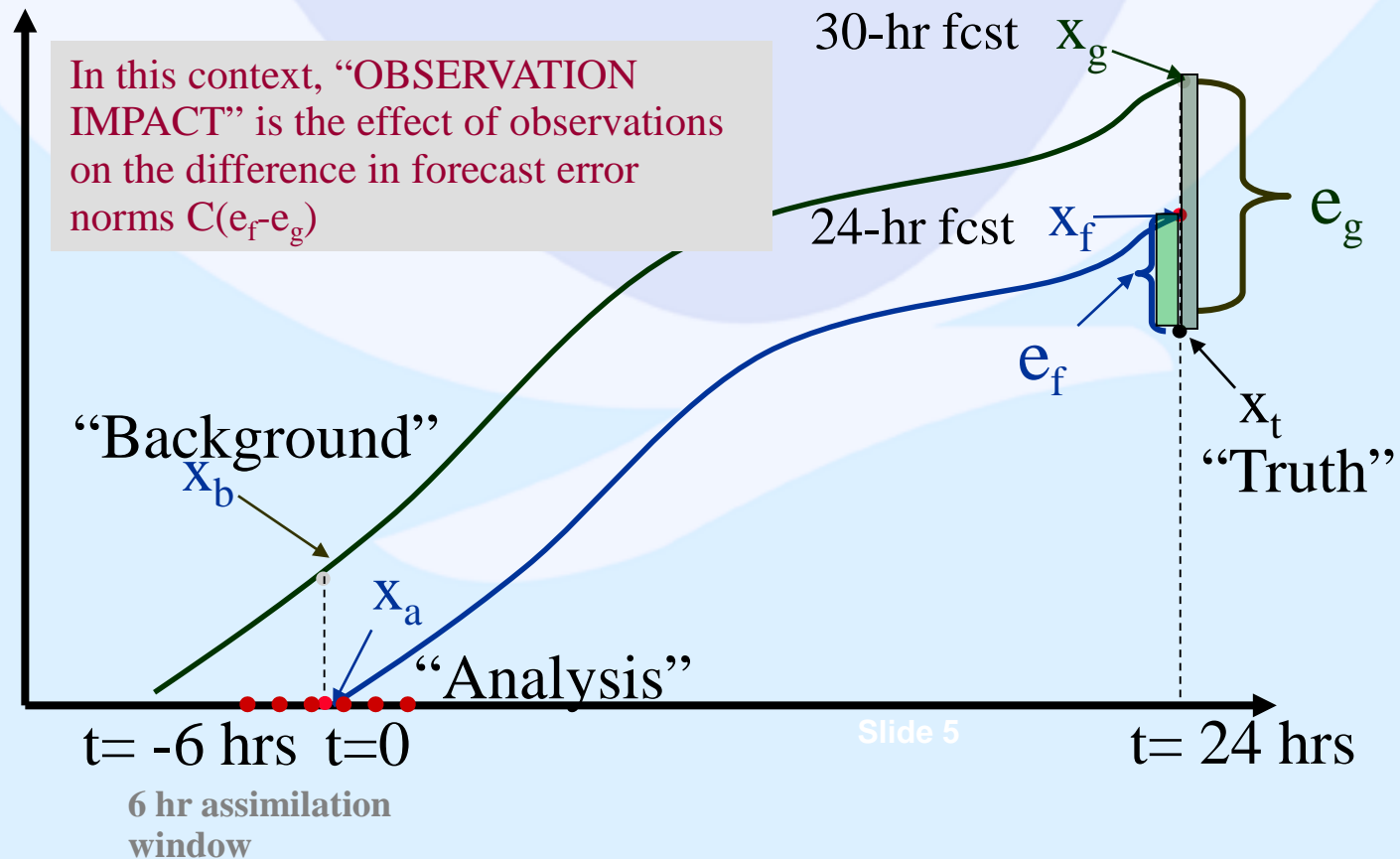


Data Denial

- **Data denial or Observation System Experiments (OSEs) are simply a way of investigating the impact of an observation or change by running full forecast experiments with and without the element to be tested.**
- **OSEs are expensive to run, particularly at full operational resolution, and they need to be run for many forecast cycles (60 days is a typical number for global forecast systems) before statistically significant results are obtained.**
- **Individual case studies are generally not trusted as a way of demonstrating forecast impact because of the dominance of statistical fluctuations.**
- **Forecast impact scores are generally presented with error bars indicating statistical significance.**
- **Scores are normally given in terms of differences between forecasts and “truth” in terms of RMS error or anomaly correlation coefficients**

Forecast Sensitivity to Observations (FSO)

Observations move the forecast from the **background trajectory** to the **trajectory starting from the new analysis**



Advantages and Disadvantages of FSO

Advantages

- Can infer the impact of observations to whatever level of detail is required (e.g. ob by ob, channel by channel) without having to re-run the full system repeatedly.
- Useful for determining relative impact of observations and for quality control of bad observations.
- Allows the impact of observations on the forecast to be monitored on a daily basis.

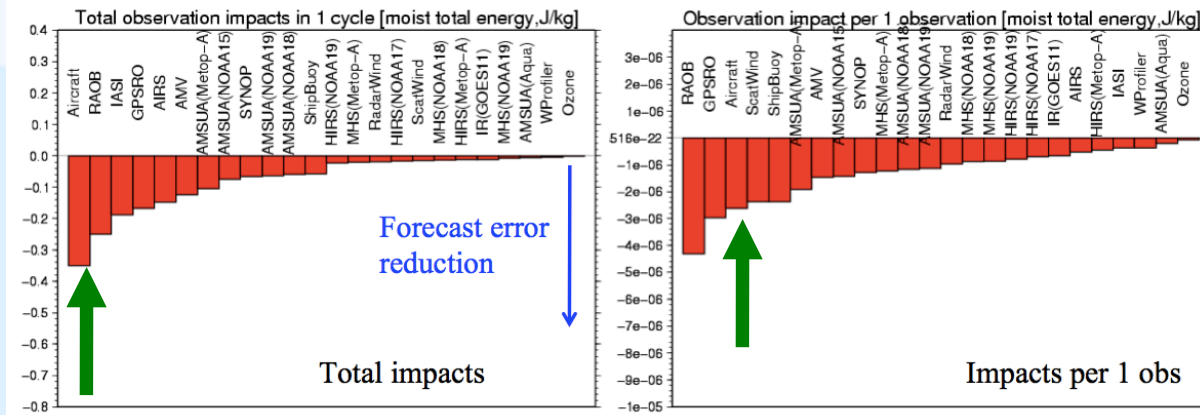
Disadvantages

- Limited to short-range forecasts
 - sensitivity to the accuracy of the verifying analysis
- Impact is always in the context of the total observing system as used
 - forecast impacts of an observation type may change as other observations are added/removed.
- Impact is insensitive to the information contributing to the forecast skill that was assimilated before the current analysis (and therefore contributing to the background state).

GLOBAL NWP DATA IMPACTS

Slide 7

ENSEMBLE FSO at NCEP



All observation types have positive impacts on average.

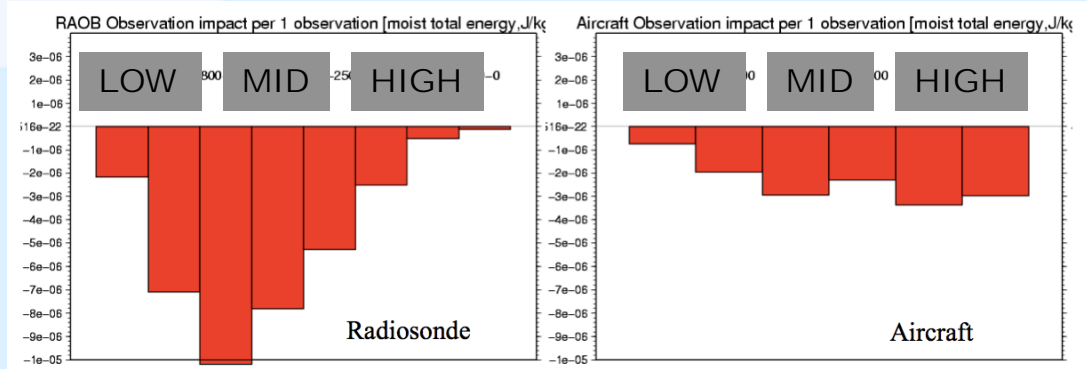
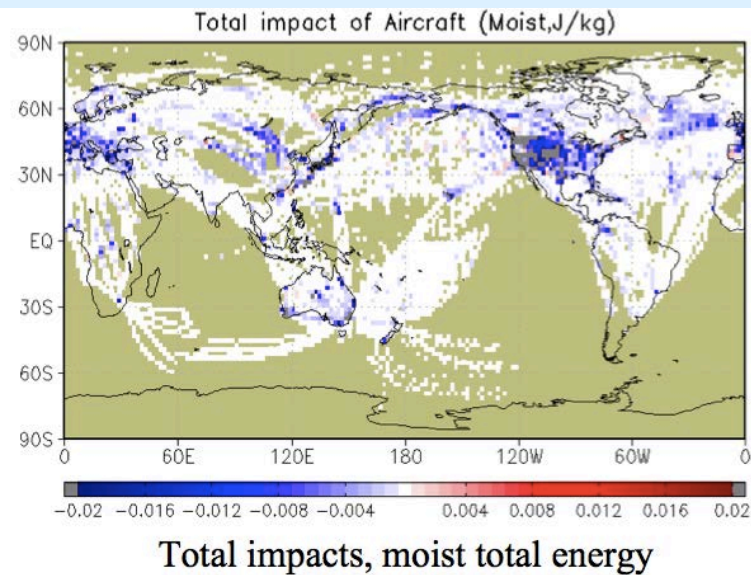
For the total impact, 1: aircraft, 2: AMSU-A, 3: radiosonde, 4: IASI, 5:

For impact per 1 obs., 1: radiosonde, 2: GPSRO, 3: aircraft, 4: Scattrometer wind, 5:

Aircraft obs have provided the greatest reduction of NWP fcst error due to their great number, wide spatial distribution, and overall good quality

Singular aircraft observations are highly impactful due to their unique placement in time and space

Radiosonde and GPSRO data provide more impact due to their more balanced presence in the vertical space.

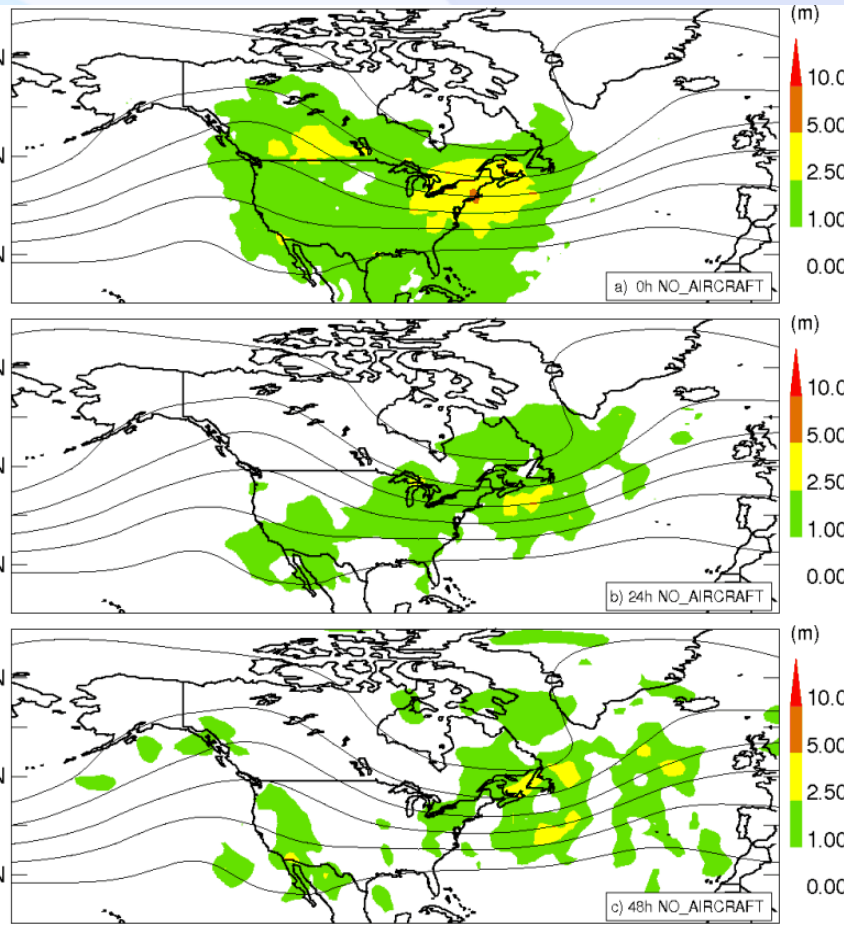


RAOB impact greatest in lower/mid troposphere

Aircraft obs impact greatest in upper troposphere

RMSE differences for Z500

Impact of aircraft reports

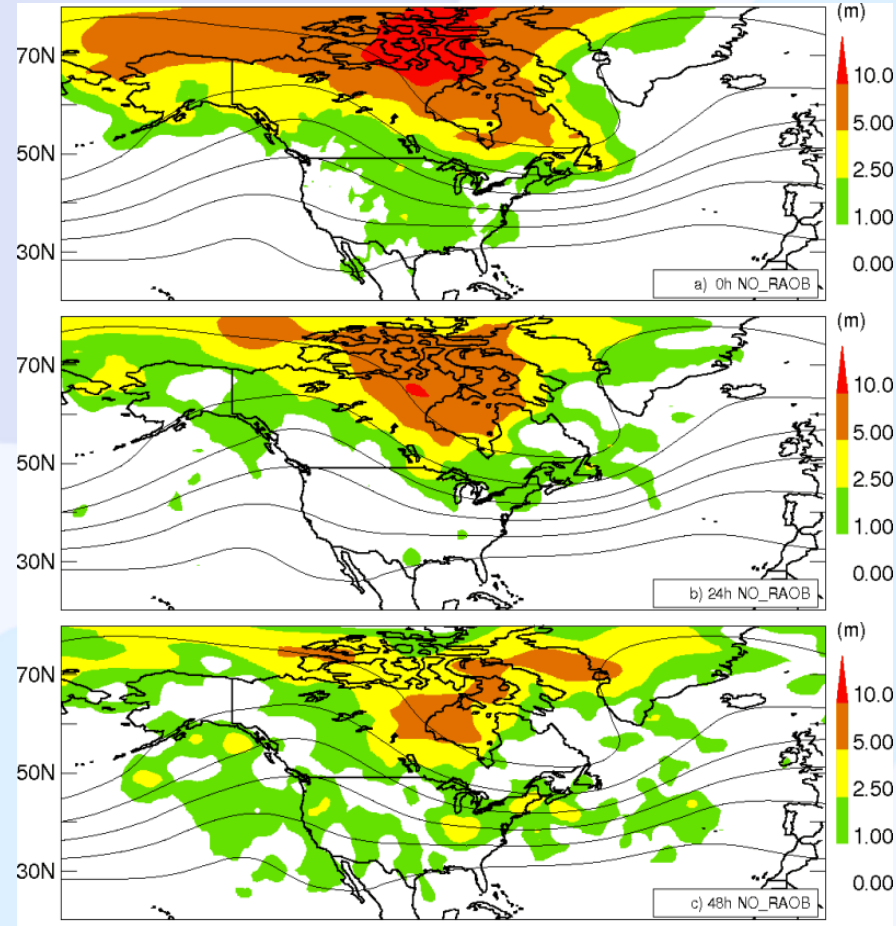


0h

24h

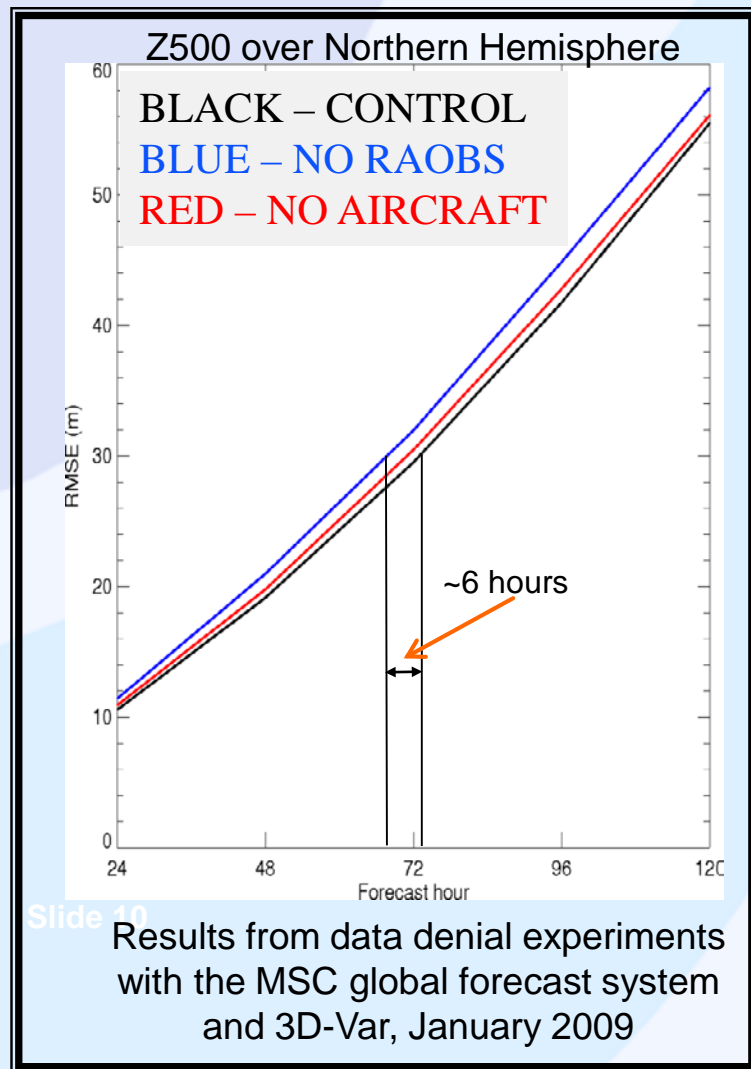
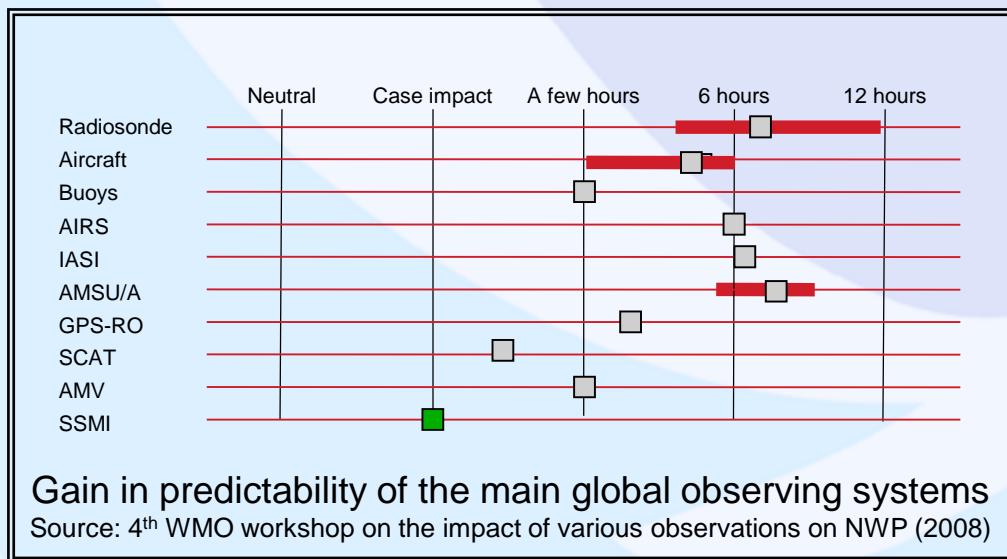
48h

Impact of radiosonde data



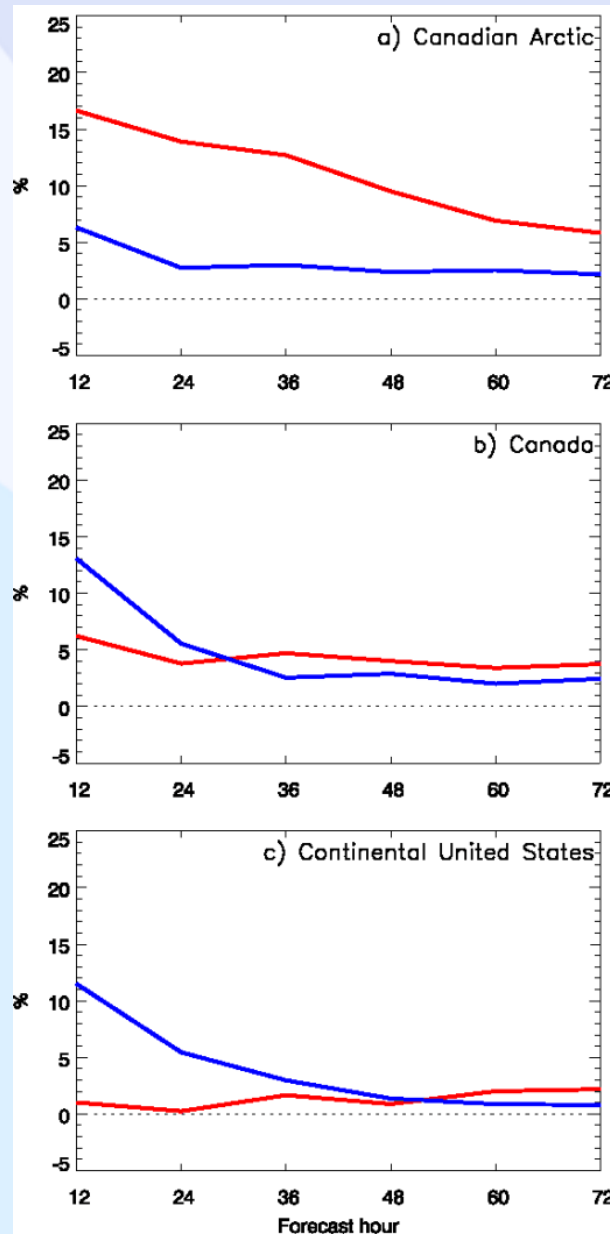
Impact of the main global observing systems on NWP in terms of gain in predictability

Northern Hemisphere Extra-Tropics

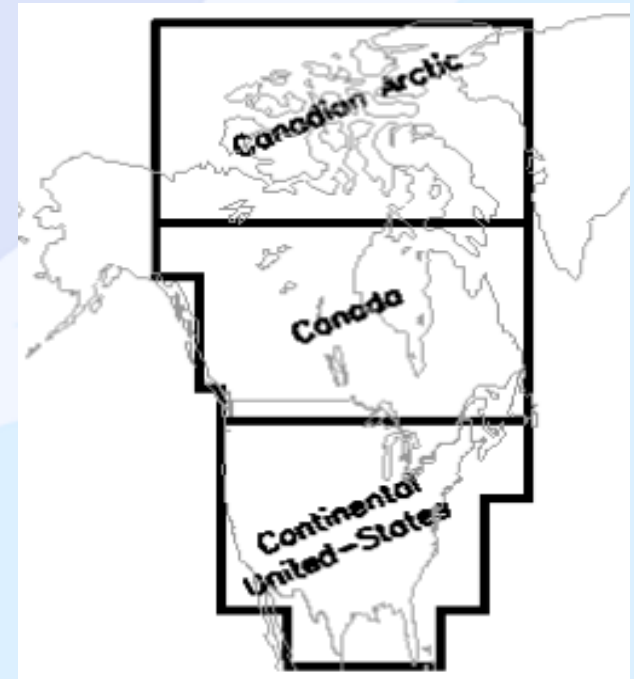


Forecast impacts (FI%) over regions of North America

U250



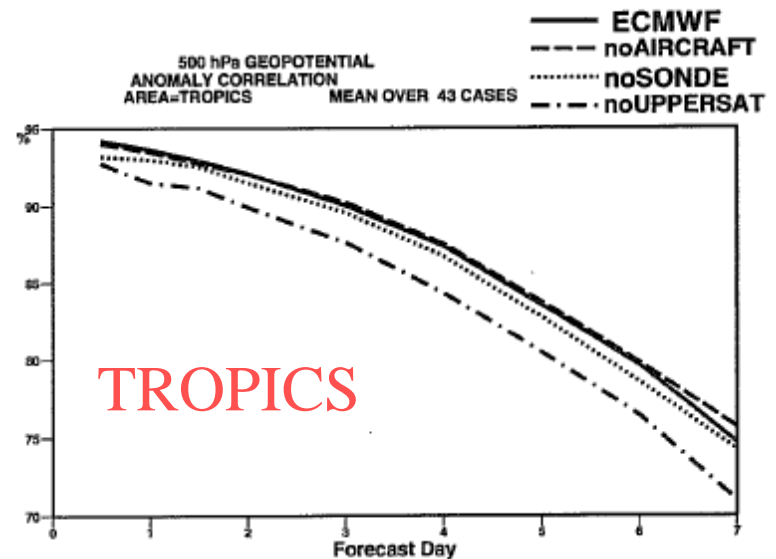
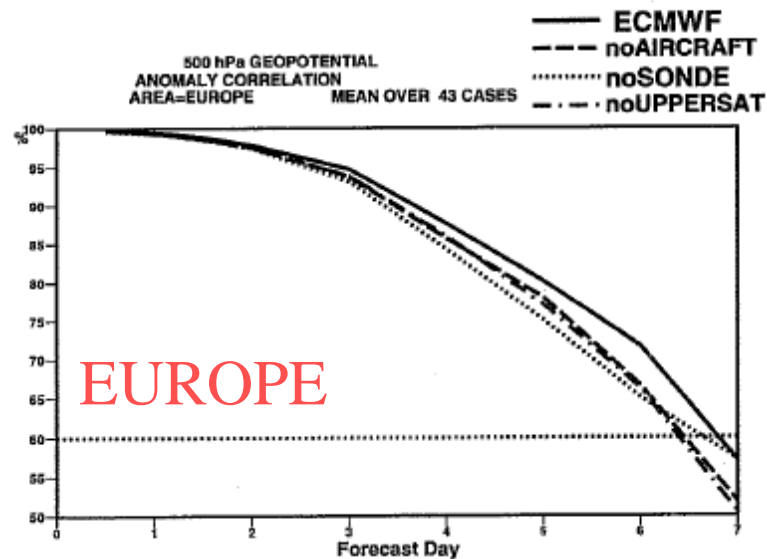
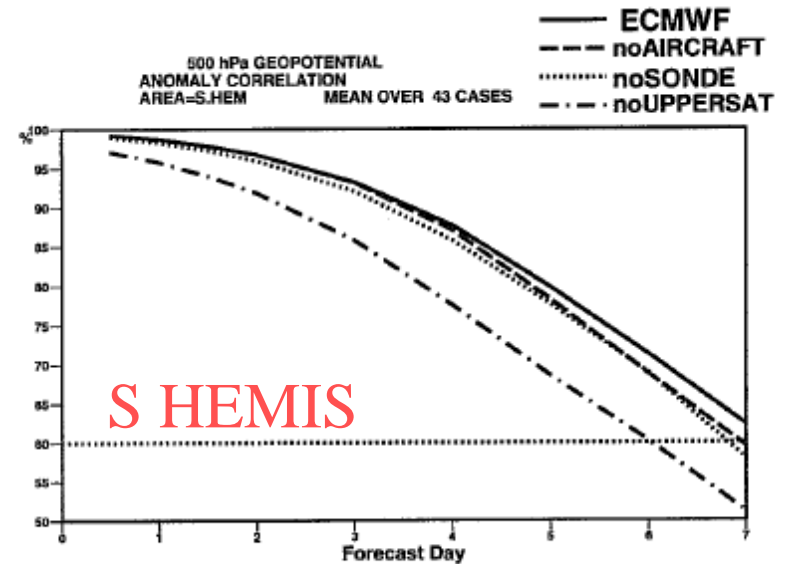
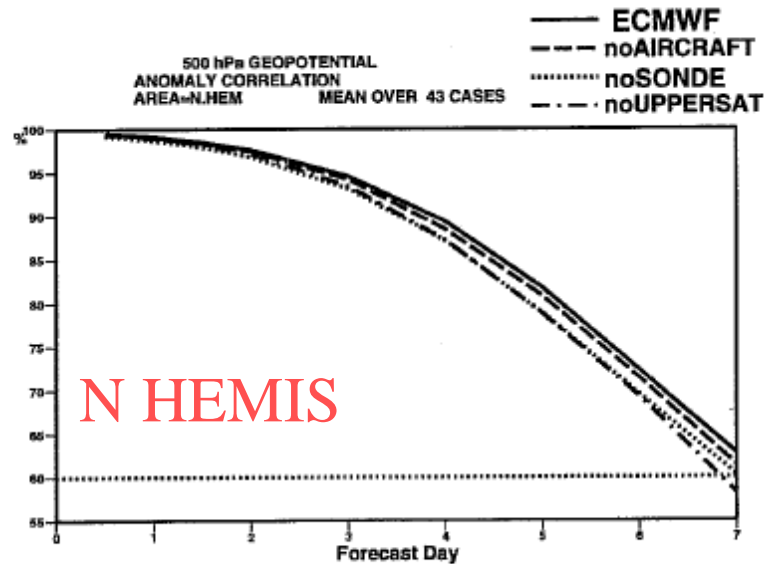
— No Radiosonde over North America
— No Aircraft over North America



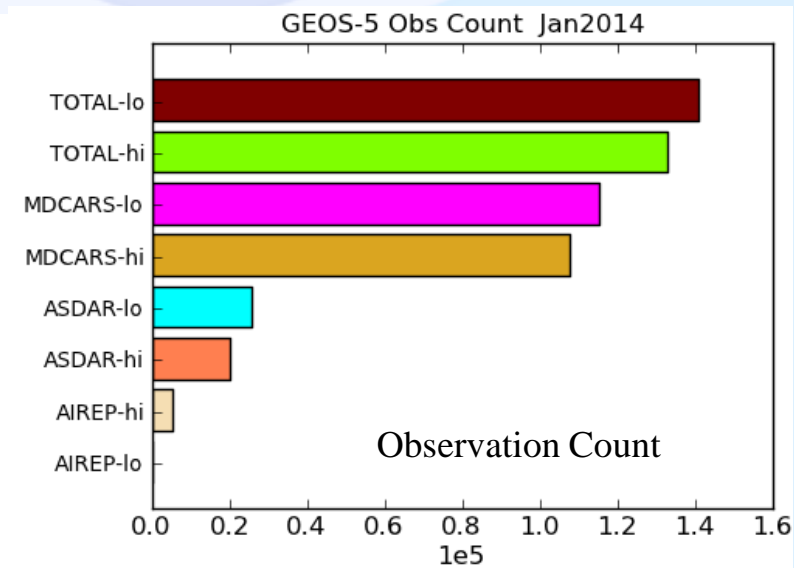
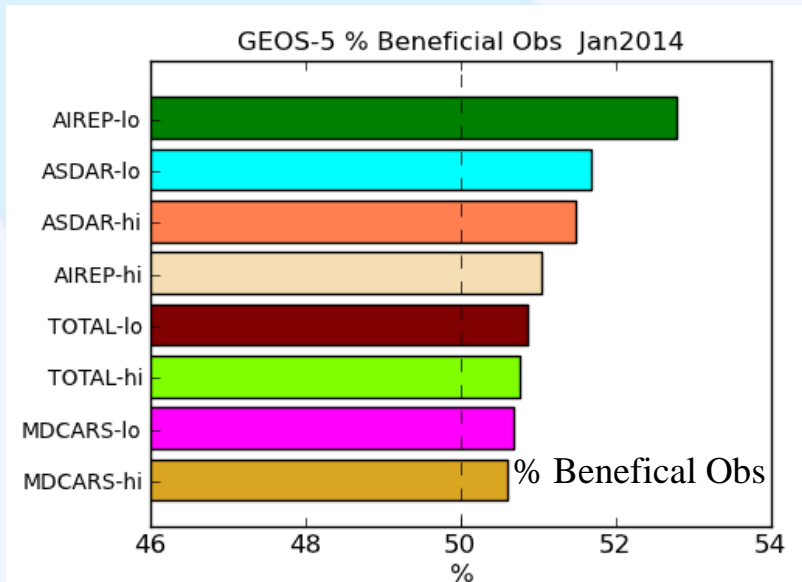
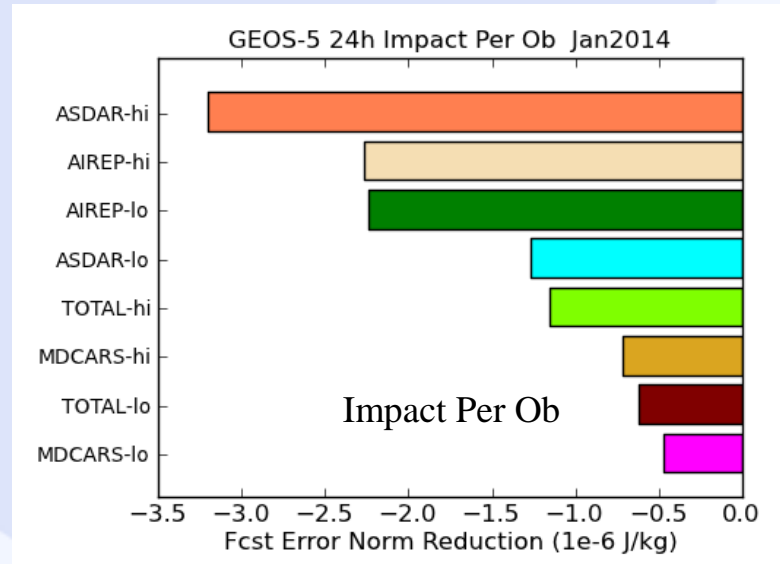
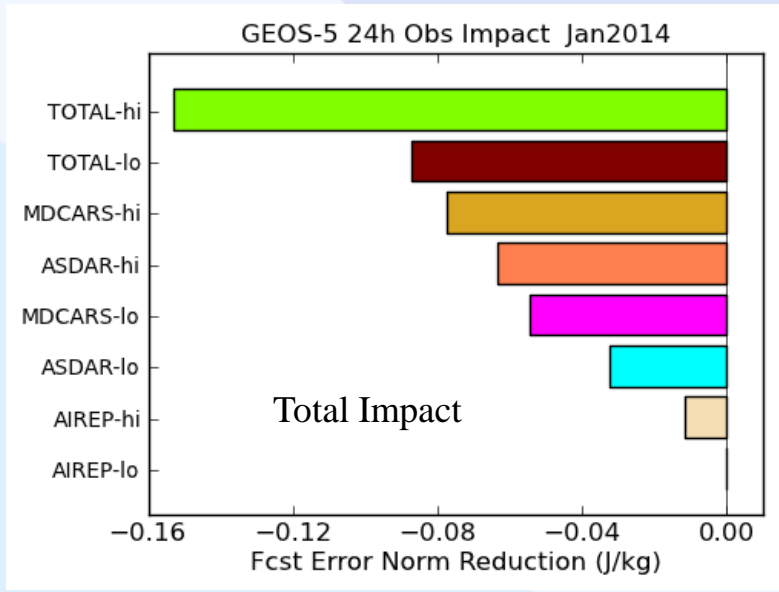
Slide 11

Environment Canada

Impact at ECMWF: Bouttier & Kelly 2001



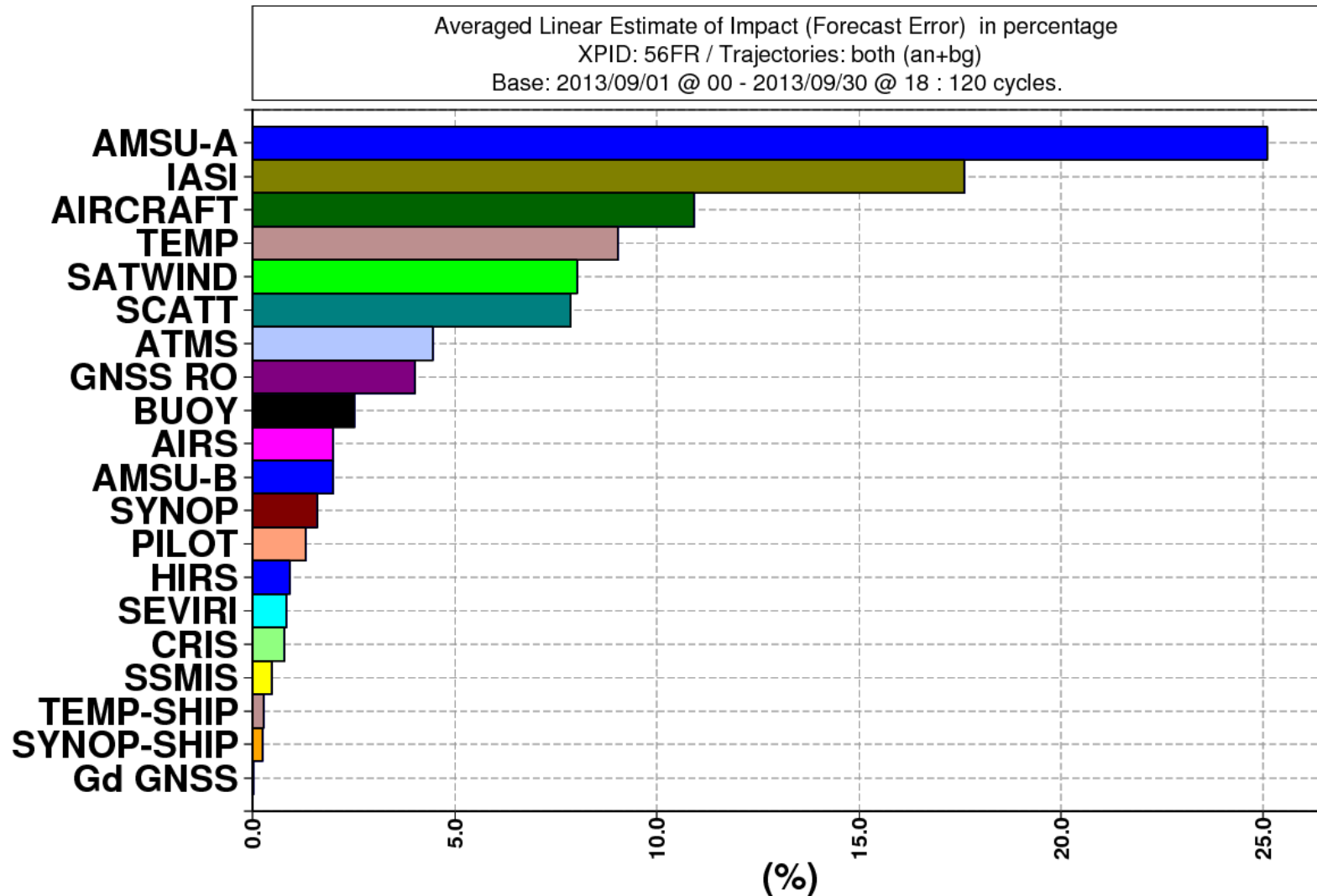
GMAO GEOS-5 24h Adjoint-Based Observation Impact January 2014 00Z



High/Lo=Above/below 400hPa

ASDAR=Non-US AMDAR

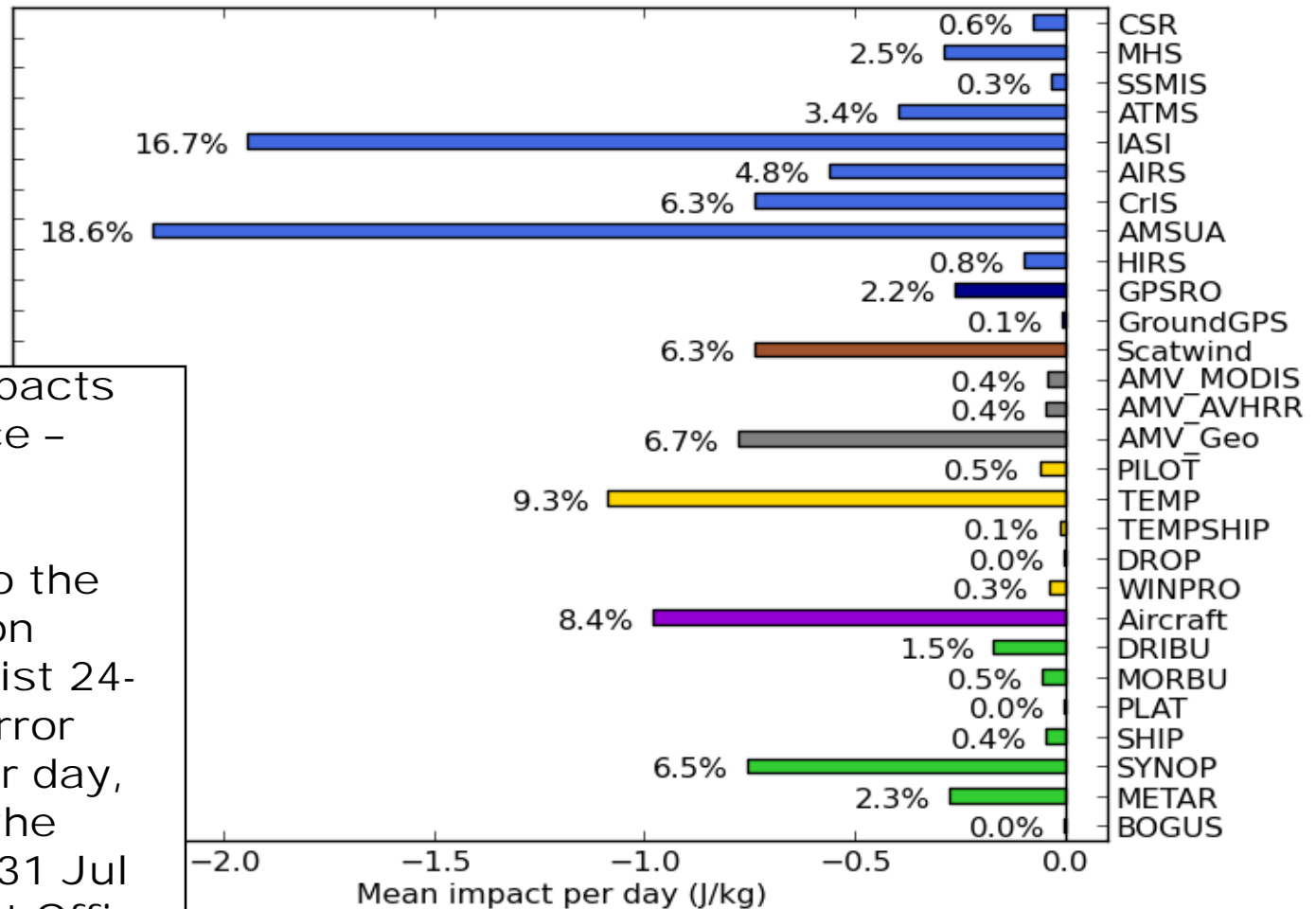
Global NWP Data Impacts: FSO at Météo-France



Global NWP Data Impacts: FSO at UKMET

Observation impacts
at the Met Office –
FSO results

Contributions to the
total observation
impact on a moist 24-
hour forecast-error
energy-norm per day,
averaged over the
period 01 Apr - 31 Jul
2013 for the Met Office
Global Model



Conclusions

- **Positive impact from aircraft observations has been demonstrated in short-range forecasts at global and regional scales**
- **Forecast sensitivity experiments consistently show aircraft observations as one of the most important data types**
- **FSO experiments show greater impact from aircraft observations higher in the atmosphere**