Diagnostics of observations impact on NWP forecasts

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Overview

- **Observations impact on forecasts: meaning and factors of influence**
- **Available impact diagnostics. Thoughts about their reliability.**
- **Assessment of current satellite impact on NWP forecasts**

What is observations impact on forecasts?

- **Contribution of observations to the reduction/increase of the forecast error (to be measured against the truth)**

- **What is the truth ? Not known but proxies are used:**

  - **Conventional (in situ) Observations ?**
    Poor (biased) spatial coverage
    They have errors (RS z500 ~ 10m)

  - **Satellite Observations**
    Excellent unbiased spatial coverage
    They have errors
    Limited vertical resolution

  - **NWP analyses**
    Unbiased spatial coverage
    They have errors

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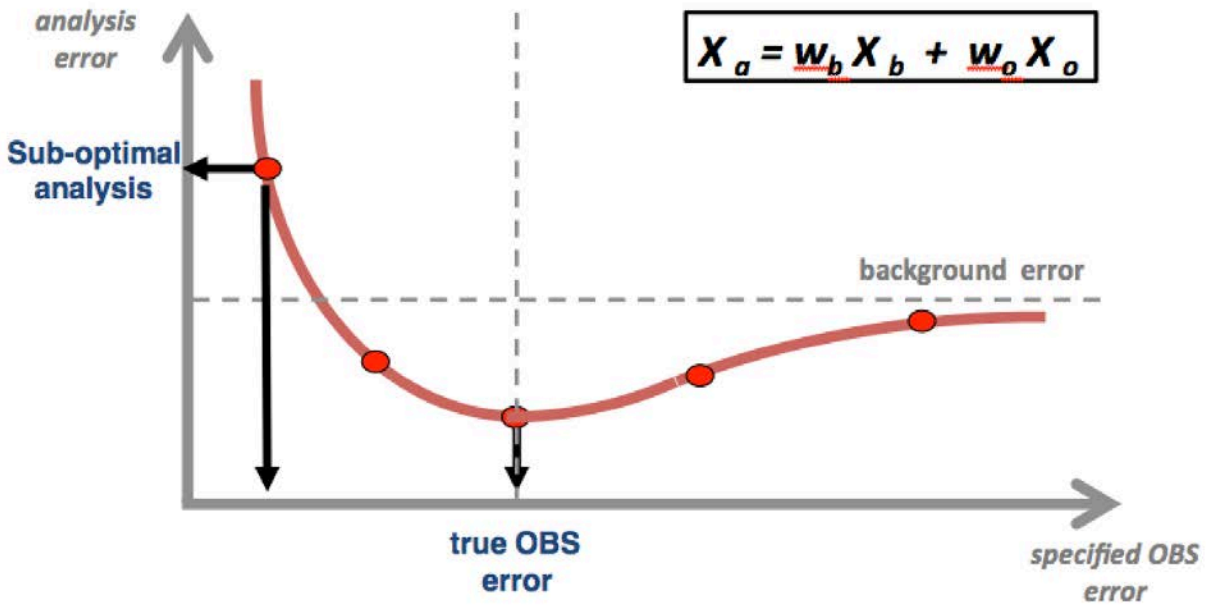
Factors that influence the impact ?

- Observation quality
- Observed quantity
- Observation usability (ambiguity)
- Observation spatial coverage
- Observation time (end of the DA window more influential)
- Tuning of the assimilation system (correct specification of B, R, BC, QC)



Diagnostics available

- **Observing System Experiments (OSE)**
  - Denial or addition experiments
  - Periodic statistical evaluations
  - Case studies
- **Adjoint Sensitivity Diagnostics (ASD)**
  - Impact assessed without denial
  - Periodic statistical evaluations

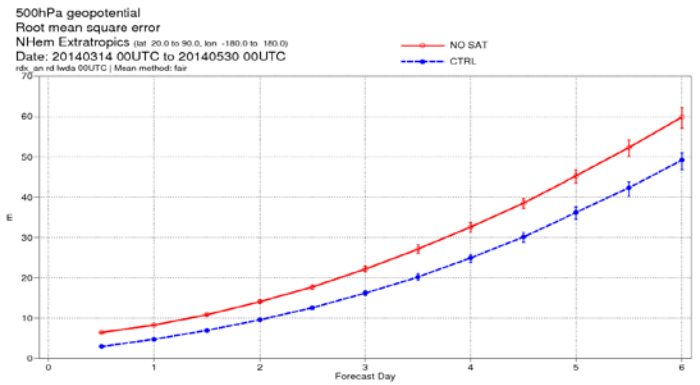
Observing System Experiments

Control assimilation system with all observations

A

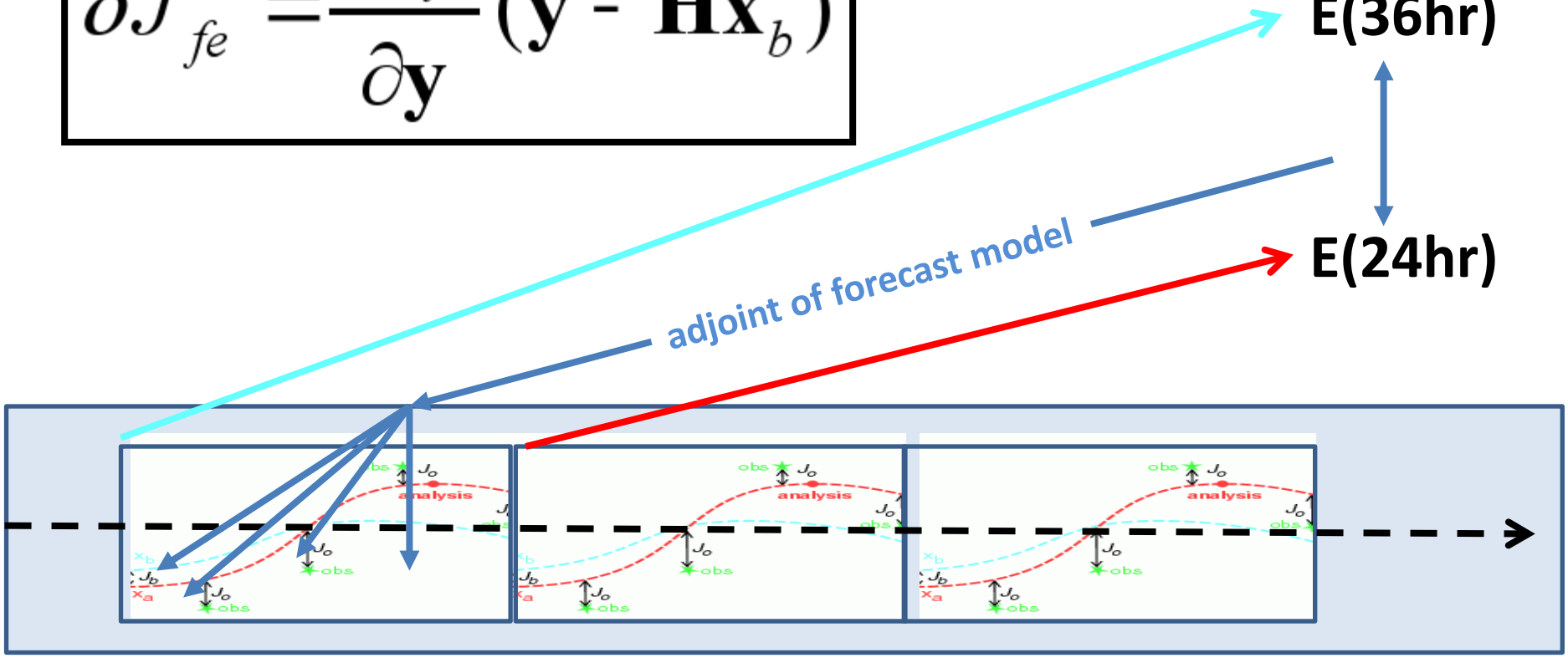
Assimilation system with some observations denied/added

B



Adjoint Sensitivity Diagnostics

$$\delta J_{fe} = \frac{\partial J_{fe}}{\partial \mathbf{y}} (\mathbf{y} - \mathbf{H}\mathbf{x}_b)$$



ECMWF FSOI monitoring statistics are routinely produced and published on the ECMWF monitoring website.

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Are the diagnostics reliable ?

All are reliable subject to :

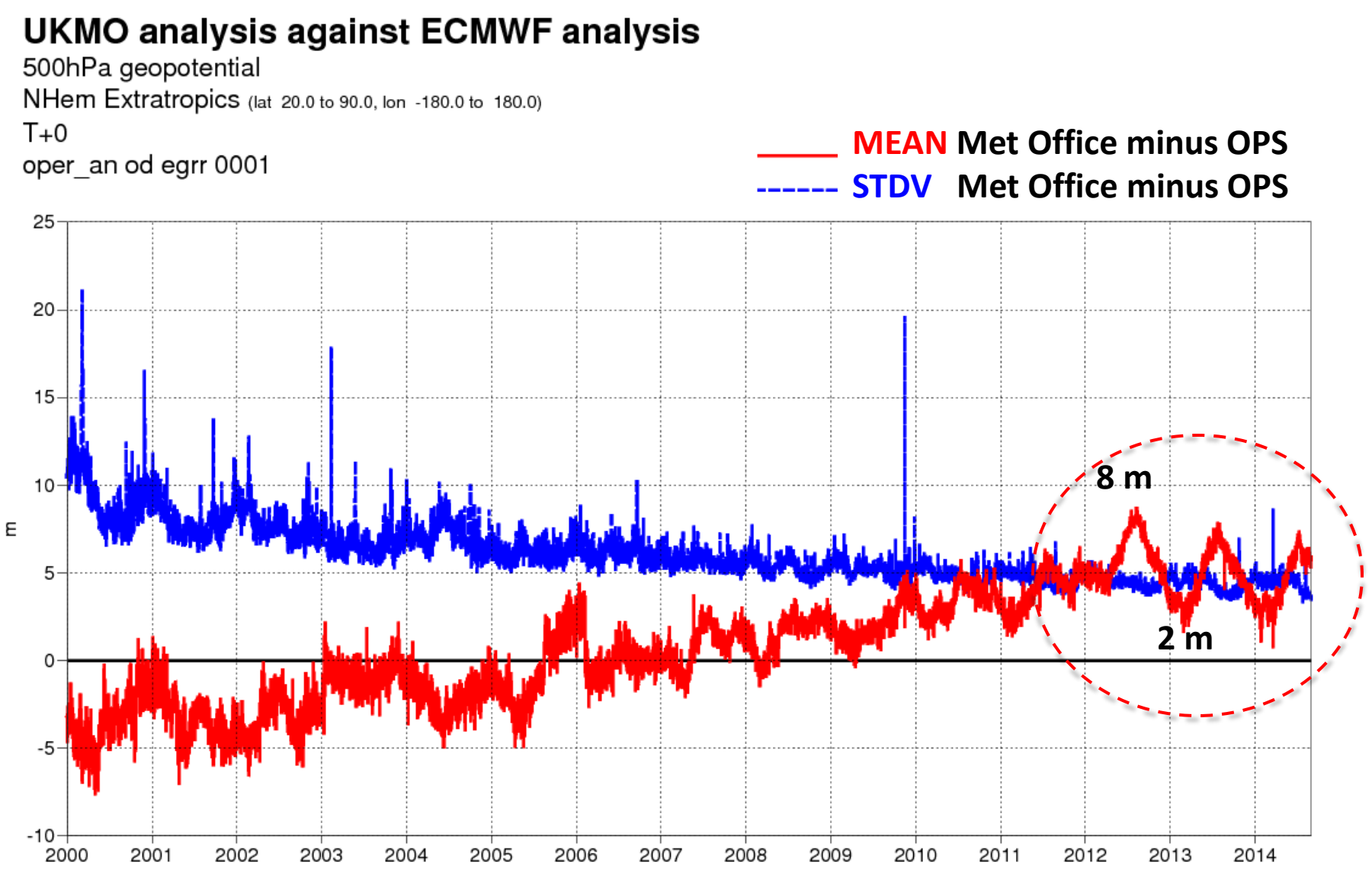
- **The accuracy of the verifying state**
- **Sampling noise (for statistical evaluations)**
- **Correct specification of system parameters (B/R)**
- **Appropriate interpretation !**

How accurate are NWP analyses ?

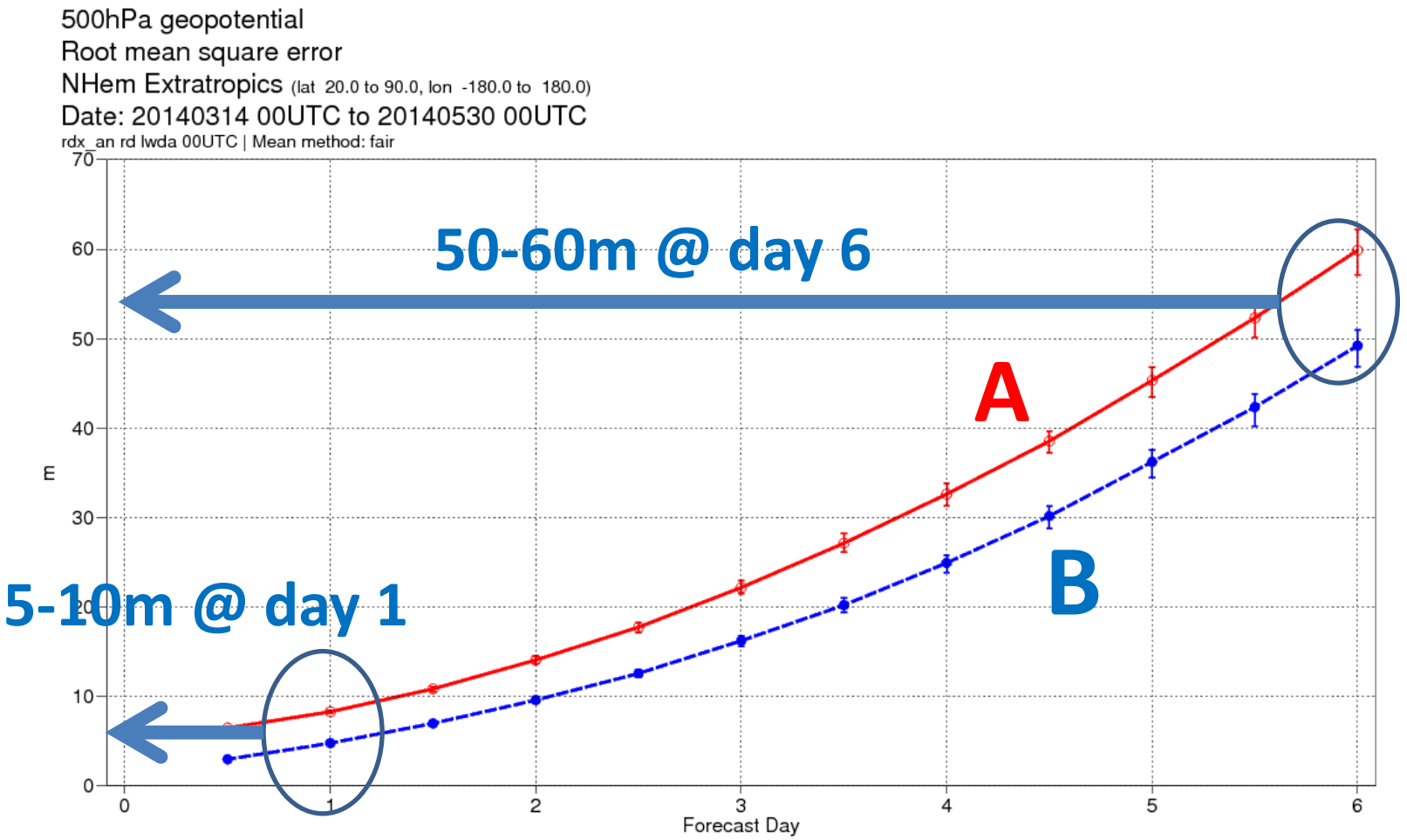
- **Simmons and Hollingsworth (QJ 2001) diagnosed errors of 7m for ECMWF and 10m for the Met Office…**

- **Very difficult question to answer but errors are decreasing**

How accurate are our analyses ?



Analysis uncertainty in verification

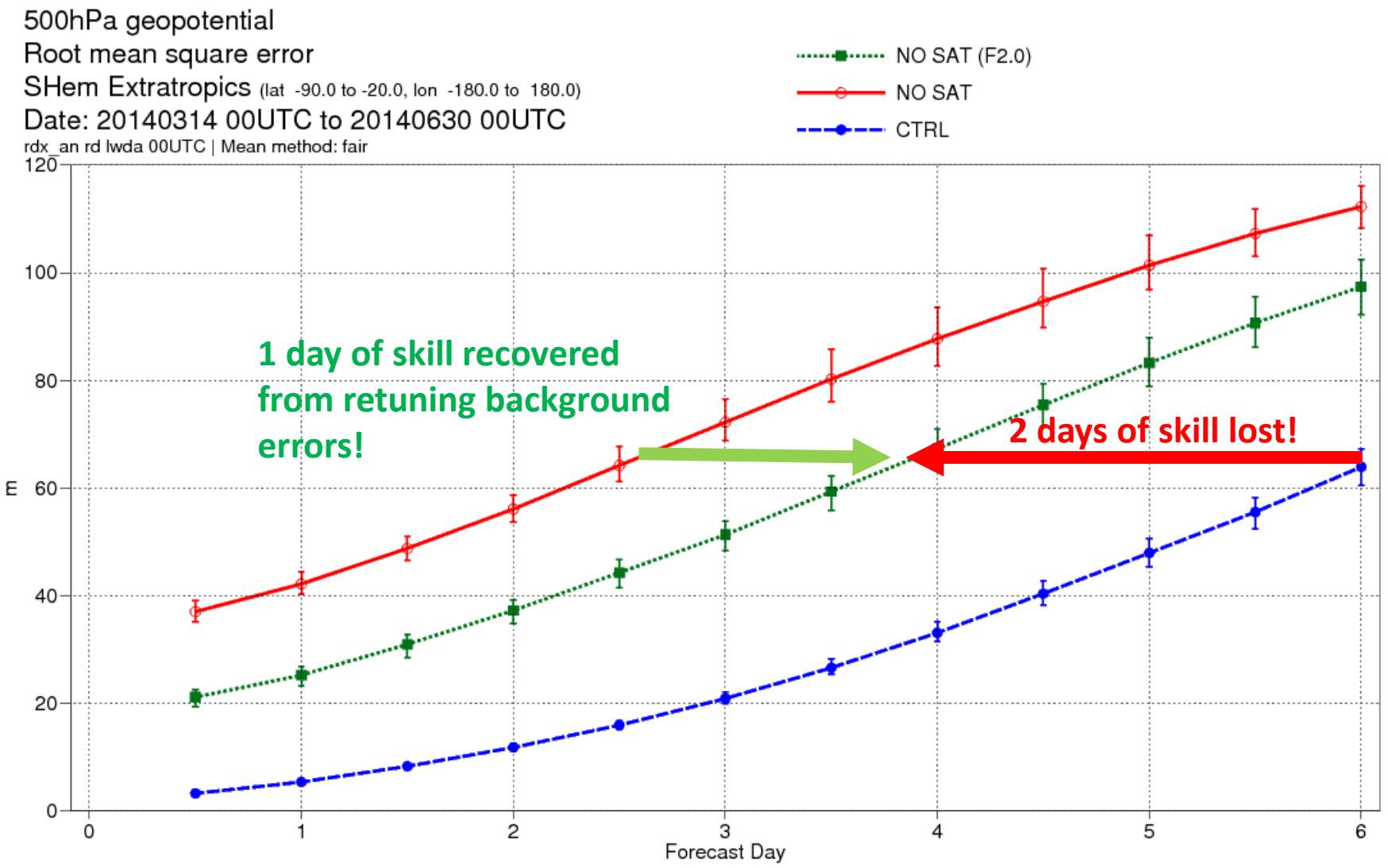


Pros and Cons of OSE

- Extremely (prohibitively?) expensive to run long periods (needed for small signals)
- Denying a data type may require background errors to be retuned
- Verifying short-range forecasts is less reliable

- The only measure of medium-range observation impact
- They give the only clear definitive answer to the question “what if I did not have this satellite ?”

Retuning background errors for an extreme OSE

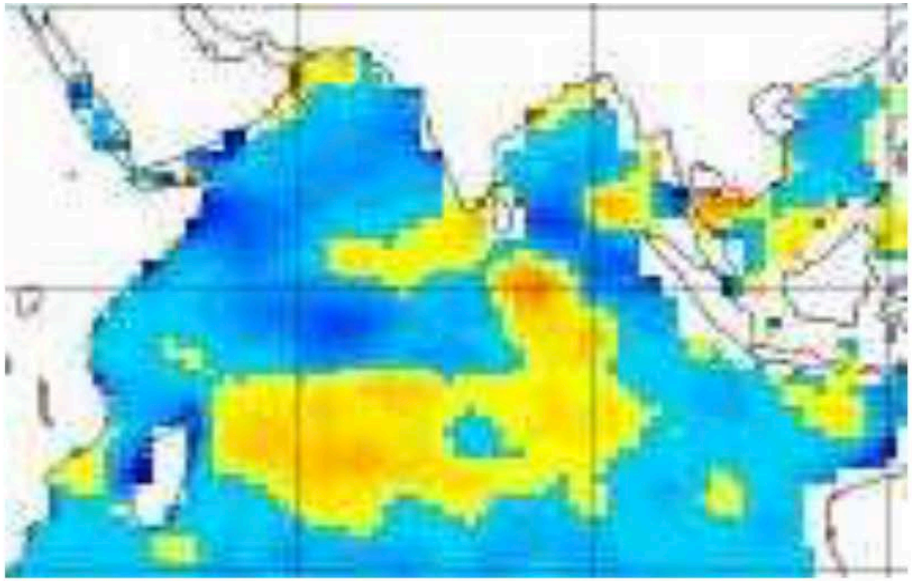


Pros and Cons of ASD

- Can only operate a short-range where verification is least reliable
- Analysis and model errors can mask observations impact and some times produce misleading results
- Poor observation error tuning can produce misleading results

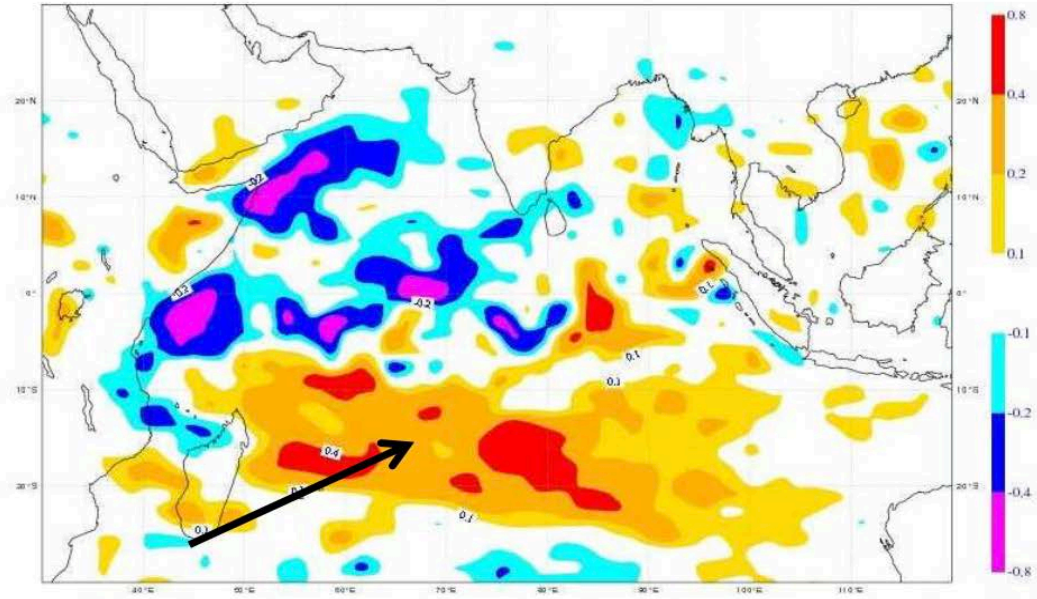
- Very affordable (compared to OSE)
- Allows detailed evaluation of observation impact (e.g. by channels)
- Impact accessible on a daily basis

METEOSAT-7 AMV apparent degradation (model errors)



AMV observations reinforce the zonal circulation

NOAMV-CNTR mean analysis difference



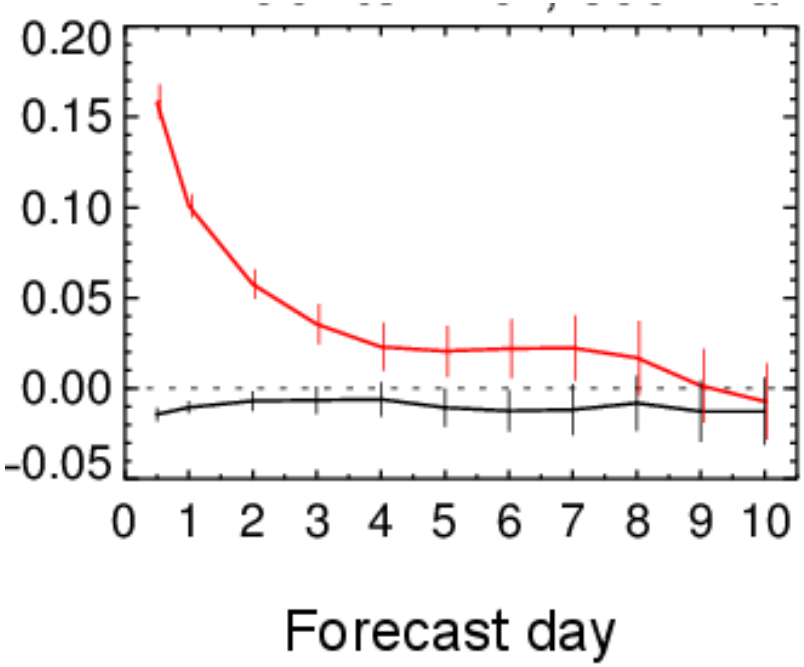
Do results of OSE and ASD disagree ?

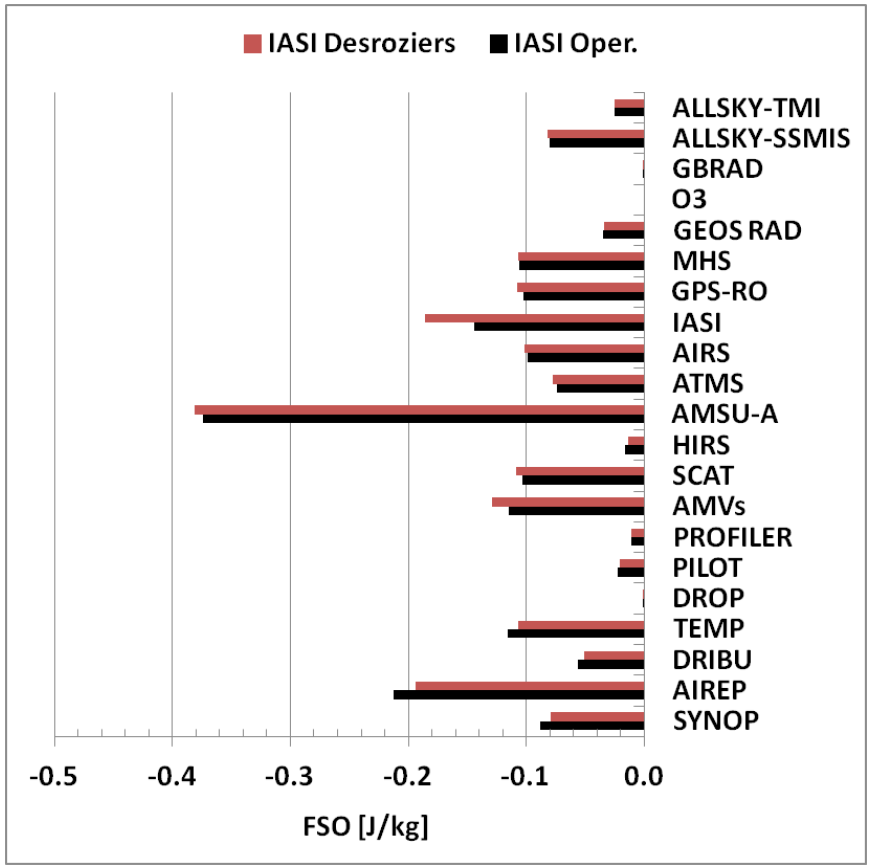
Impact measured using operational observation error model (values 0.4K to 2K)

Impact measured using unrealistic observation error model (unscaled Desrosier values)

RMSE(IASI) minus RMSE(NO-IASI)

RMSE(IASI*) minus RMSE(NO-IASI)





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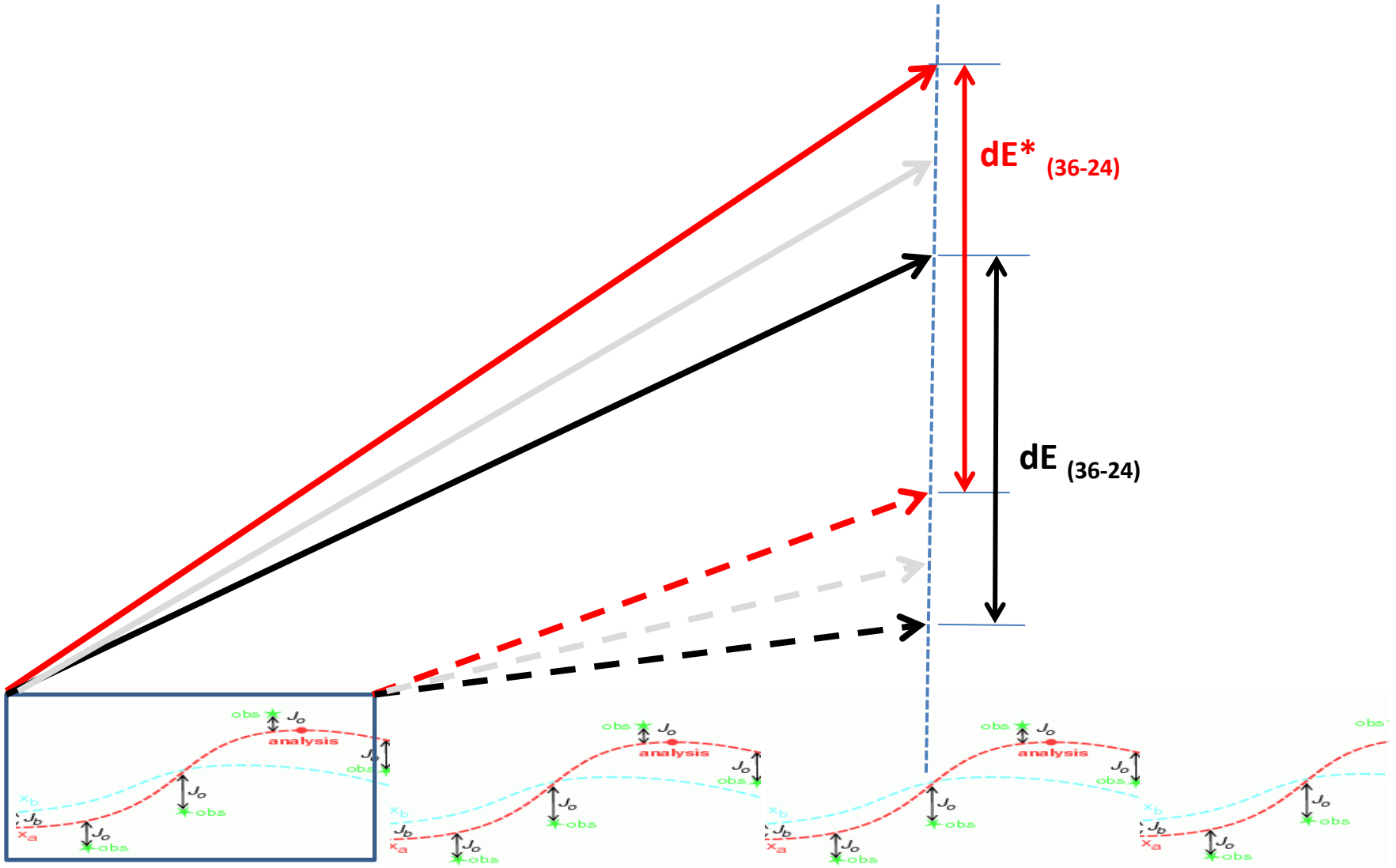
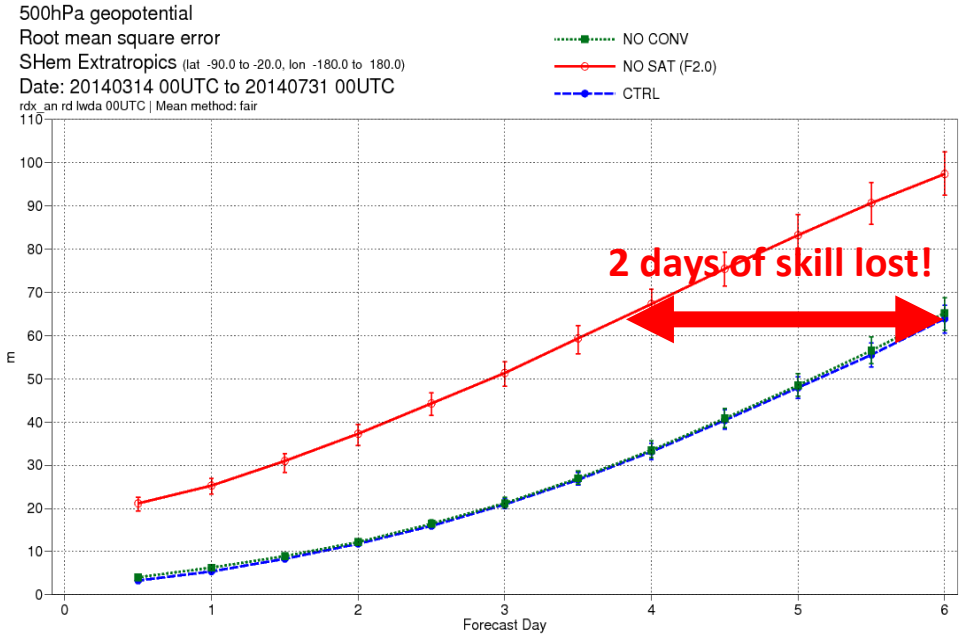
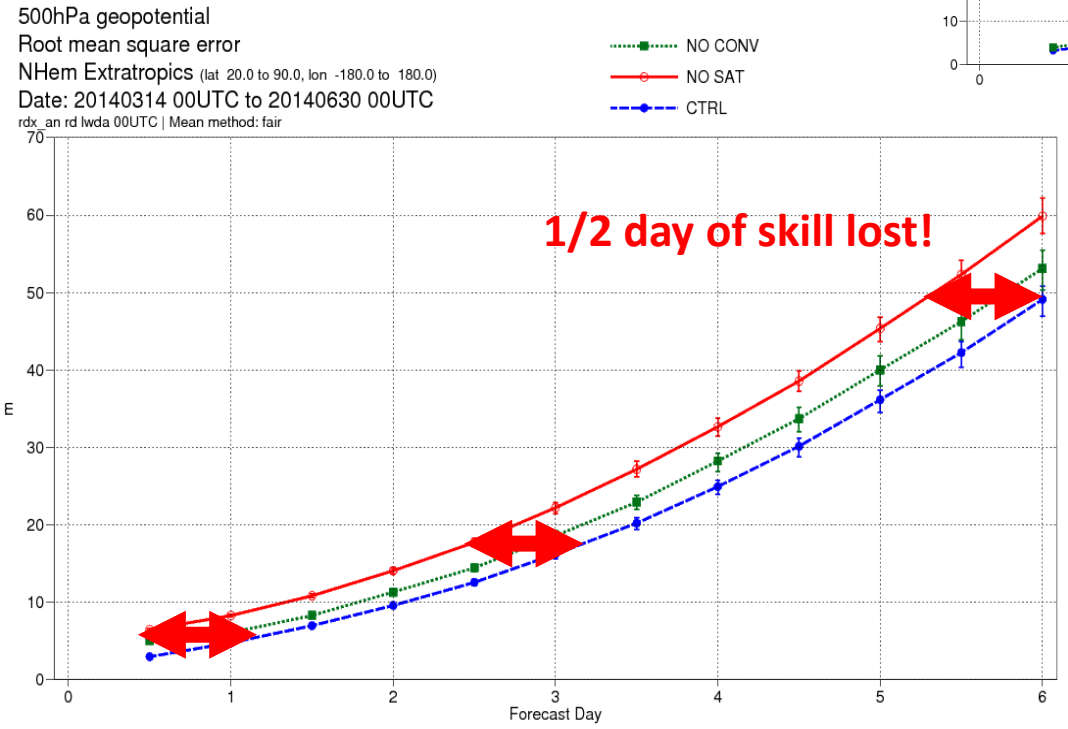


Observations Considered

All conventional (in situ) data	CONV	TEMP/AIRCRAFT/SYNOP/SHIP
All Satellite Data	SAT	
Microwave sounding radiances	MWS	7 x AMSUA, 1 x ATMS, 4 x MHS
Infrared sounding radiances	IRS	2 x IASI, 1 x AIRS, 1 x HIRS
All GEO data (AMVs and radiances)	GEO	2 x GOES, 2 x METEOSAT, 1 x MTSAT, polar AMVs
GPS-RO bending angle data	GPS	COSMIC, 2 x METOP-GRAS
Microwave imager radiances	MWI	1 x TMI, 1 x SSM/IS
Scatterometer surface wind data	SCAT	2 x ASCAT

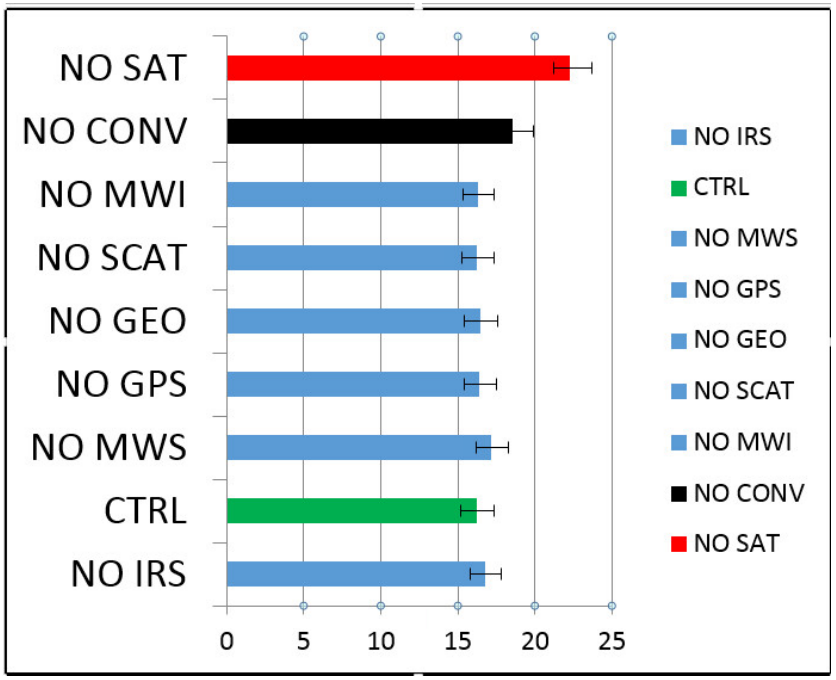
Importance of SAT v CONV data

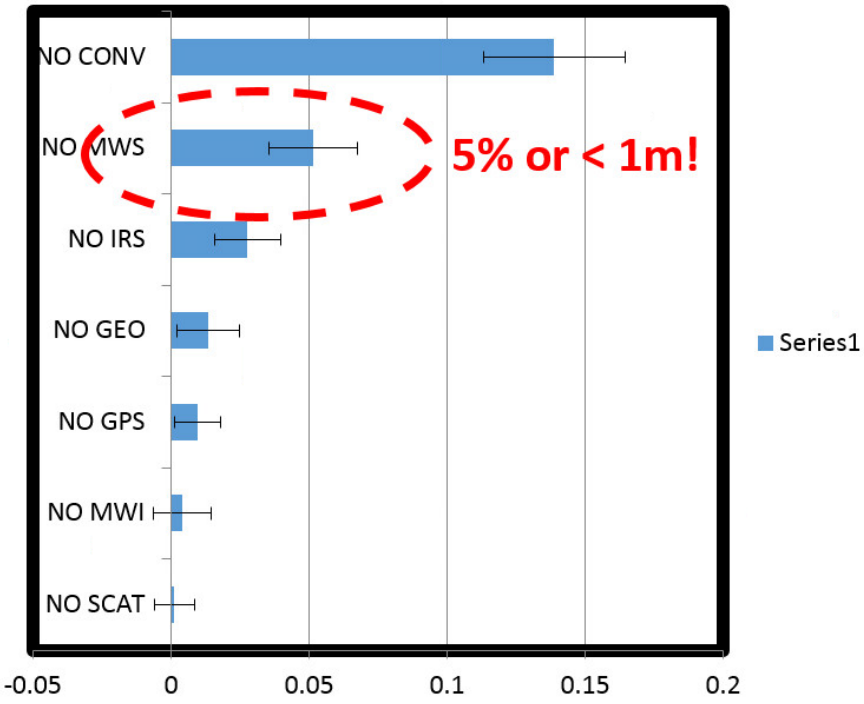




Day-3 Forecasts of 500hPa Z over NH

Differences with the errors of the control are **normalised** with the errors of the control





Summary

- **Many factors influence observations impact that are unrelated to the quality of the observations.**
- **Impact diagnostics have limitations. Appropriate interpretation is always needed.**
- **Collectively satellite data dominate NWP forecast accuracy everywhere, but conventional data are still important (more than any single SAT system).**

Thank you!
Questions?