Overview of Observing System Experiments

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Contents of talk

- What is an OSE?
- Designing and running OSEs
- Recent results
- Future OSEs
- Summary

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Observing System Experiments

- Investigates the interaction between data assimilation and observing systems.
- Run continuous data assimilation and forecasts using different ‘observation use’ scenarios.
- Observation scenarios:
  - remove observations to check data assimilation performance and the value of observations
  - add in observations to test enhancements to the Global Observing System (GOS).

Characteristics of OSEs

+ Use real observations.
+ Relatively 'easy' to run.

But ...

– Do not easily anticipate future observing systems.
– Use existing NWP.

Observing System Simulation Experiment (OSSE)

- Generate ‘synthetic’ observations that simulate a future observing system.
- Use one NWP model to generate synthetic observations; estimate observation errors.
- Use another NWP model to assimilate the synthetic observations.

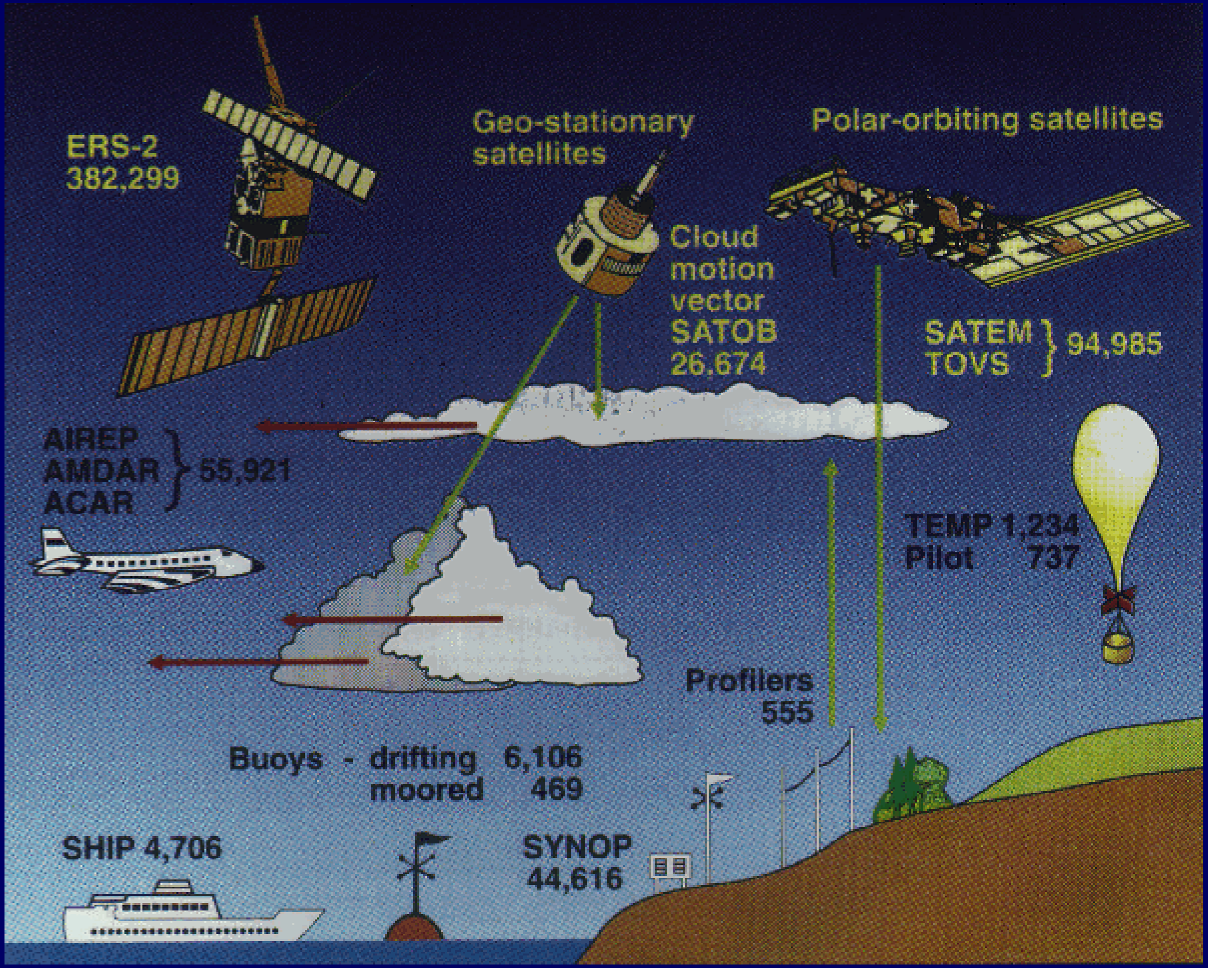
Characteristics of OSSEs

+ Anticipate future observing systems.

But ...

- Difficult to accurately specify future observing system characteristics e.g. errors.
- Synthetic observations generated by NWP.
- More difficult to run than OSE.
- Use existing NWP.

Observing systems



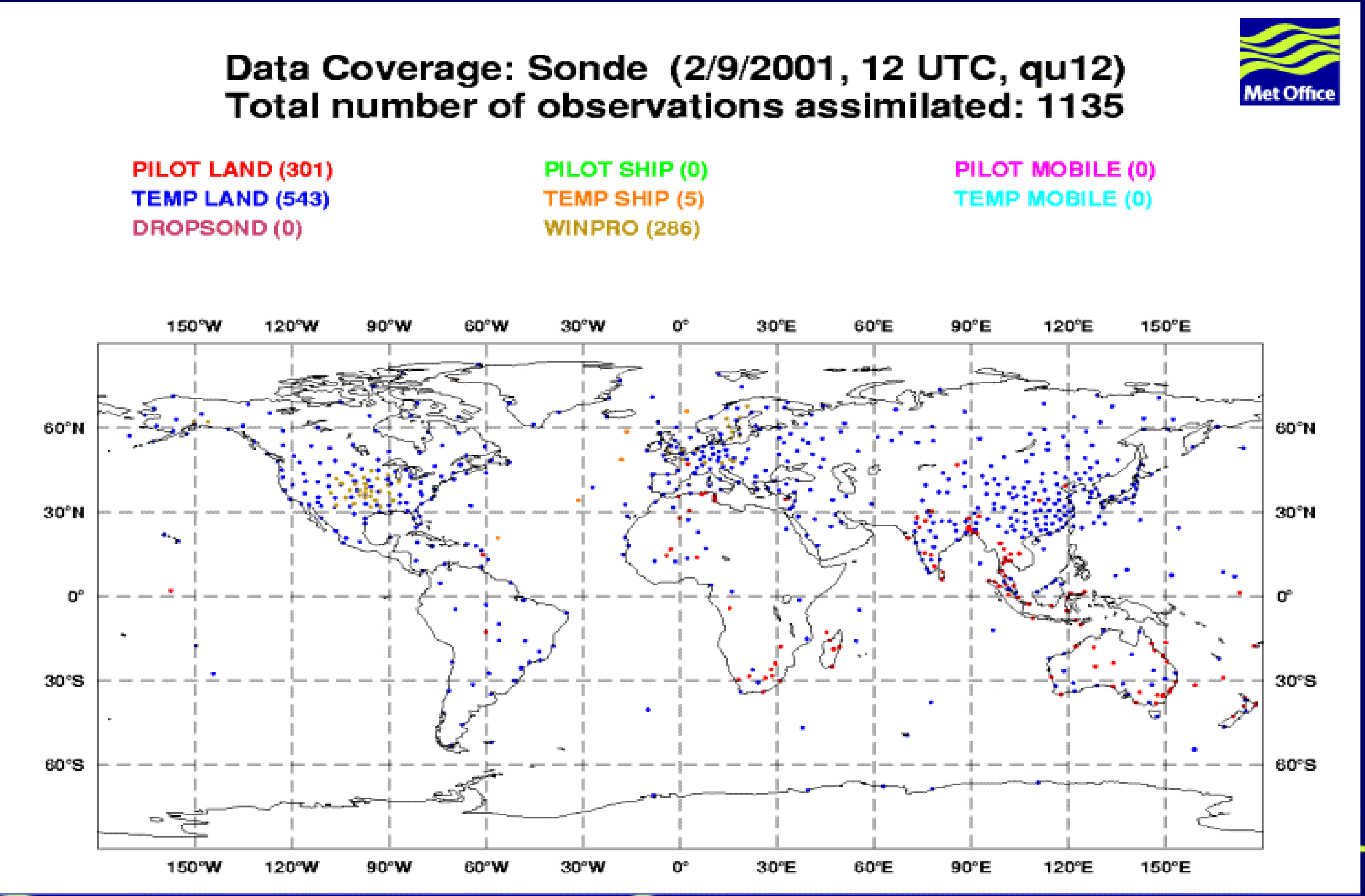
How to run an OSE

1. Decide on the questions to be answered.
2. Define the ‘observation use’ scenarios that will answer the questions.
3. Choose the period(s) for study.
4. Run the experiment with a fixed NWP system.
5. Assess the results.

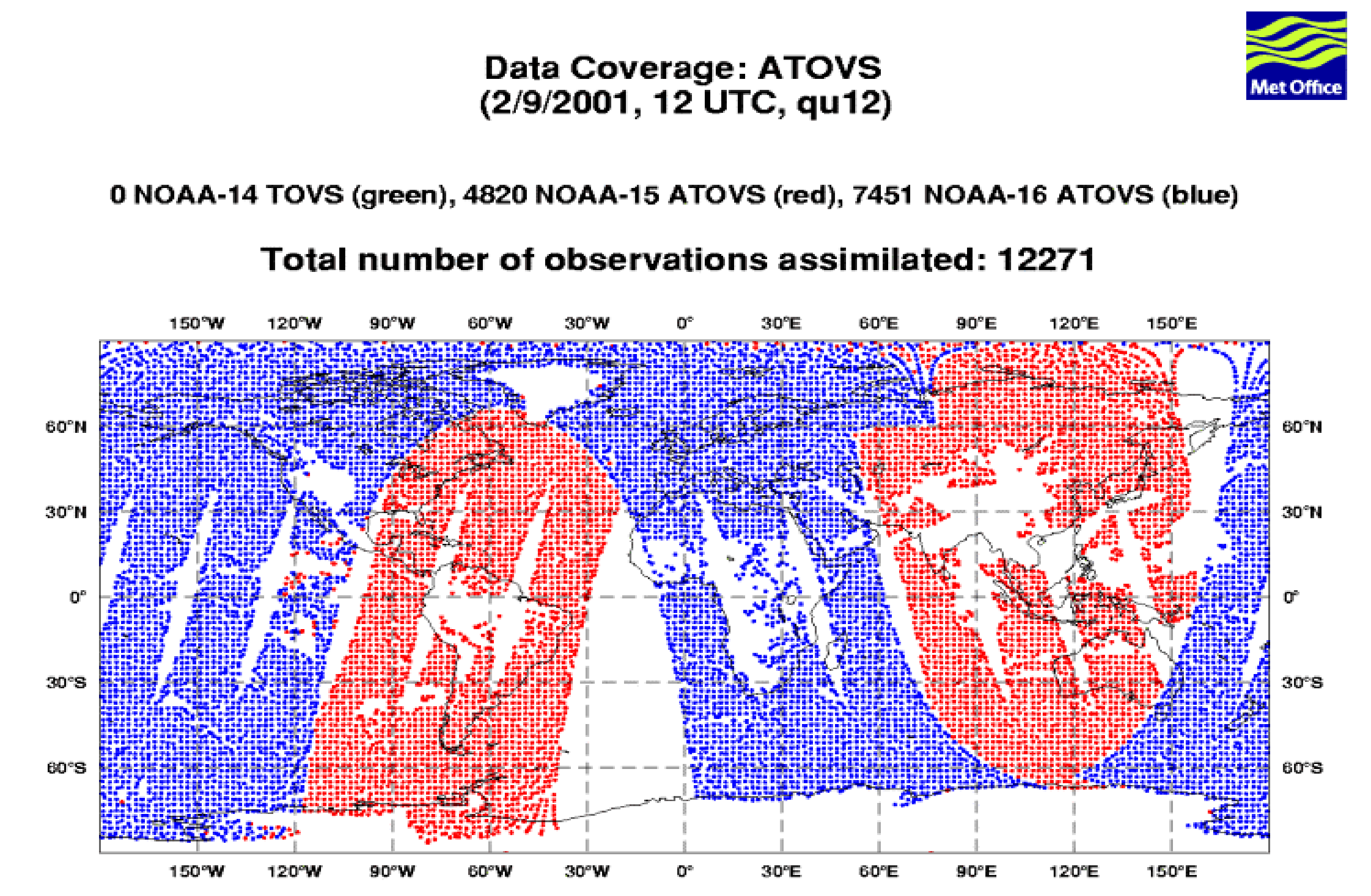
Results from OSEs

- Sensitive to:
  - observation availability: can be highly variable in space and time
  - verification method e.g. vs observations or analysis
  - sampling method: which periods and for how long
  - NWP system: data assimilation technique and forecast model.

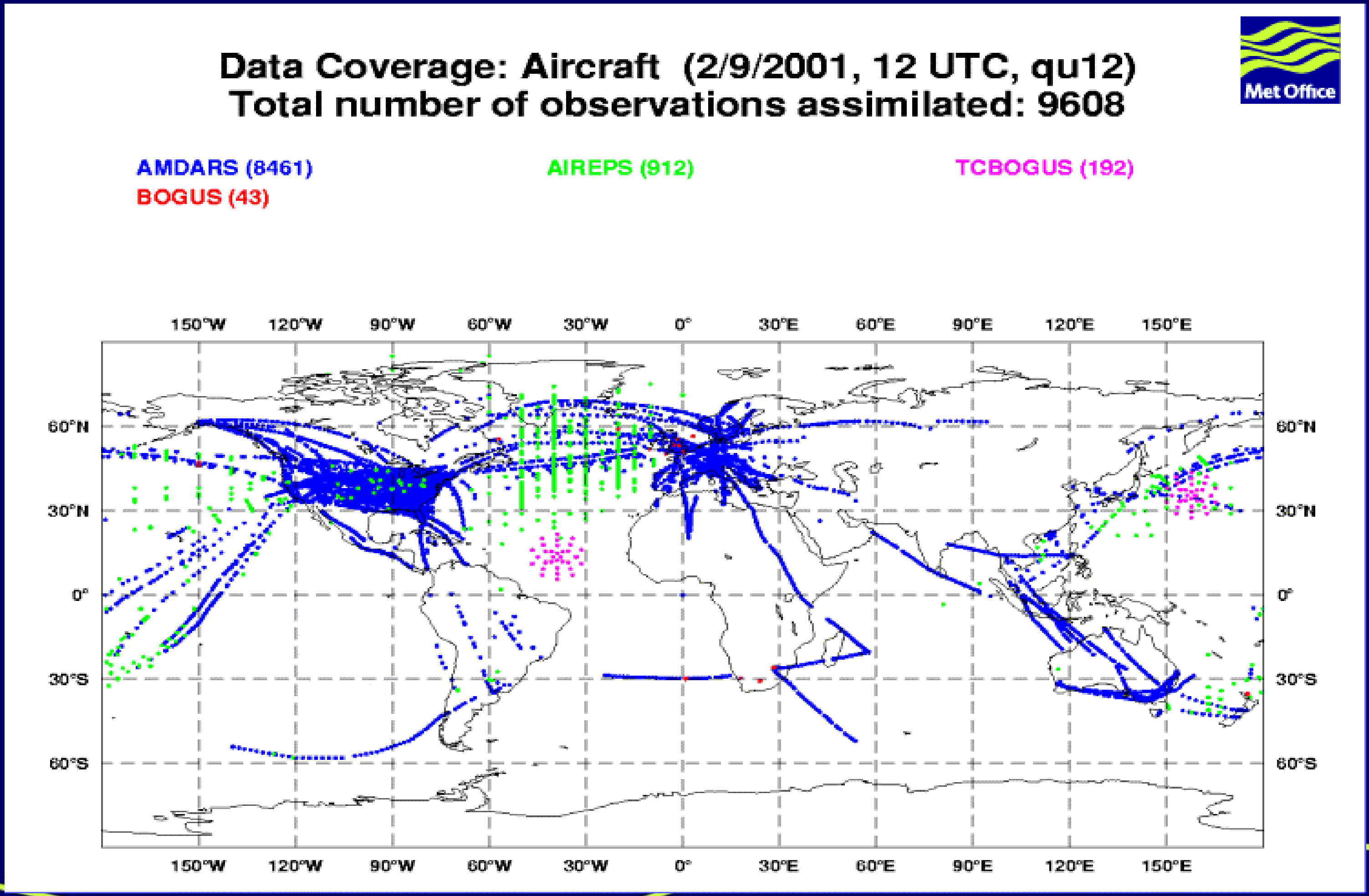
Dependence on observation availability: radiosonde distribution



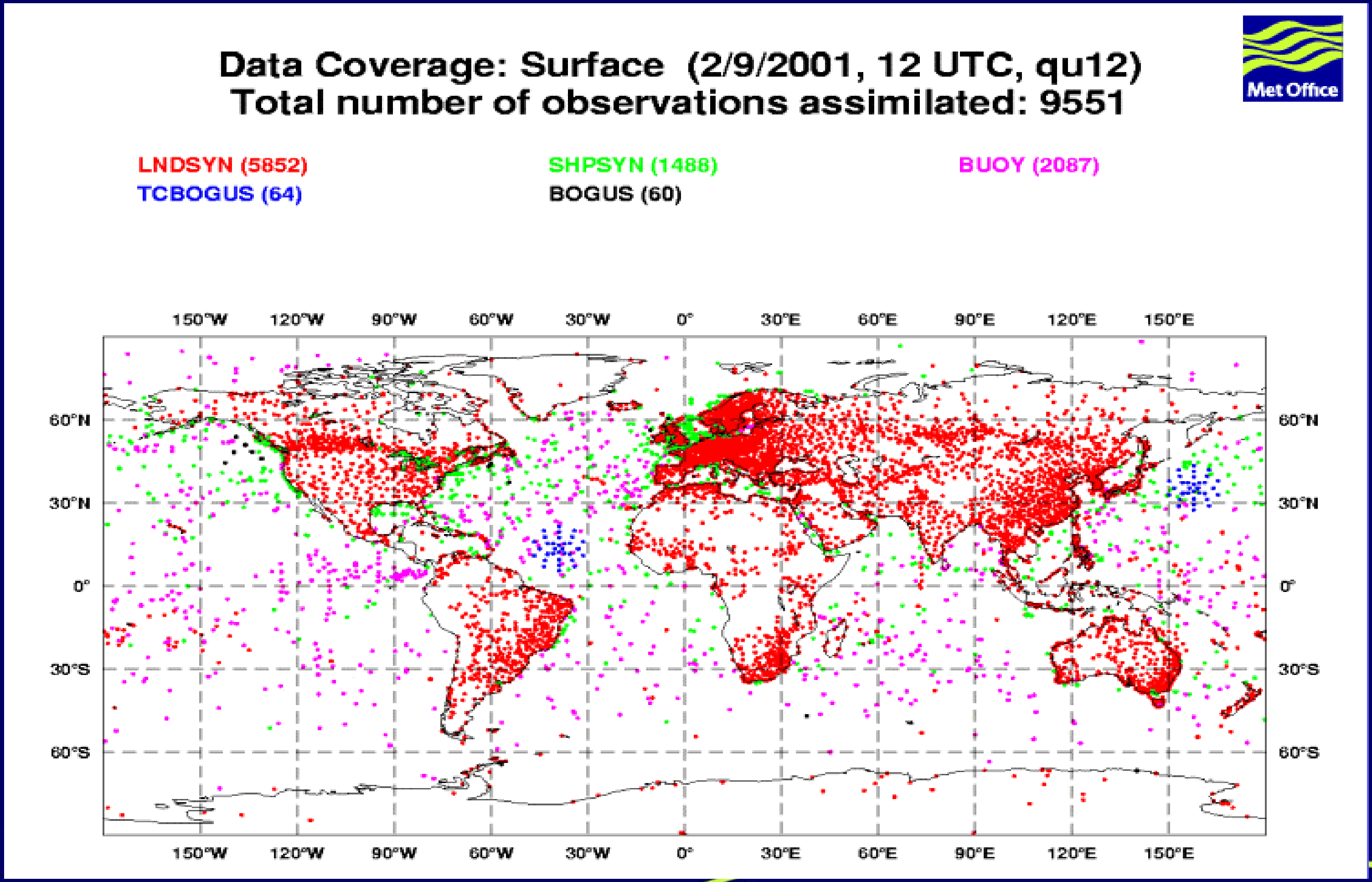
Dependence on observation availability: satellite radiances



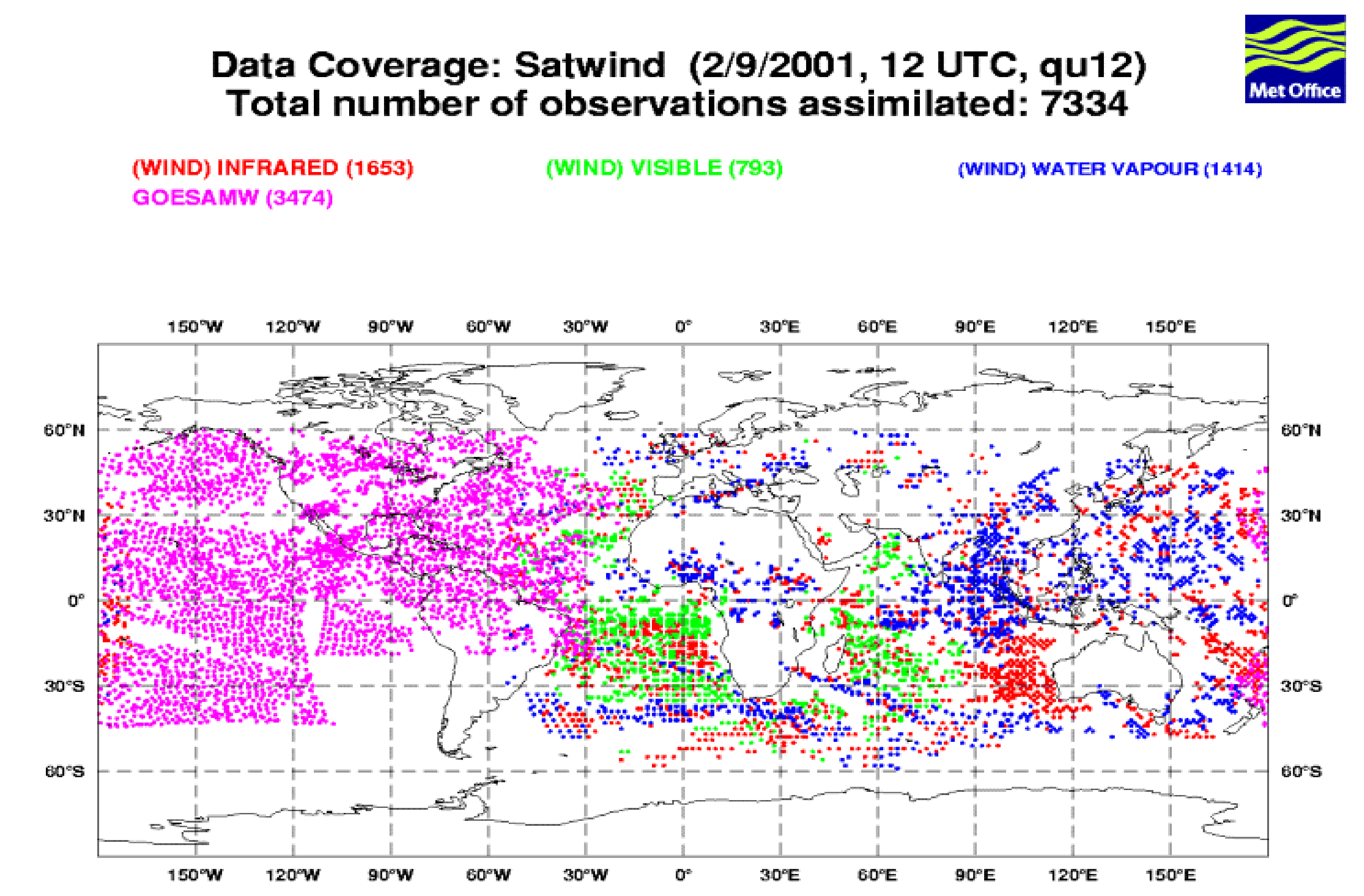
Dependence on observation availability: aircraft distribution



Dependence on observation availability: surface distribution



Dependence on observation availability: Atmospheric Motion Vectors (AMV)



Verification: versus observations or analysis ?

Versus observations:

+ ‘independent’ of NWP

but ...

– observations not uniformly distributed.

Versus NWP analysis:

+ uniform coverage

but ...

– not independent of NWP.

Choosing periods for study

Ideally:

- Choose periods from different seasons.
- Verify at least a month of forecasts.

… but in practice sampling method will be dependent on the availability of computer resources and observations.

OSE example (1): global data denial

- Are the observing systems having a positive impact on Met Office operational forecasts?
- Which data types are the most important?
- What is the relative magnitude of the impact?

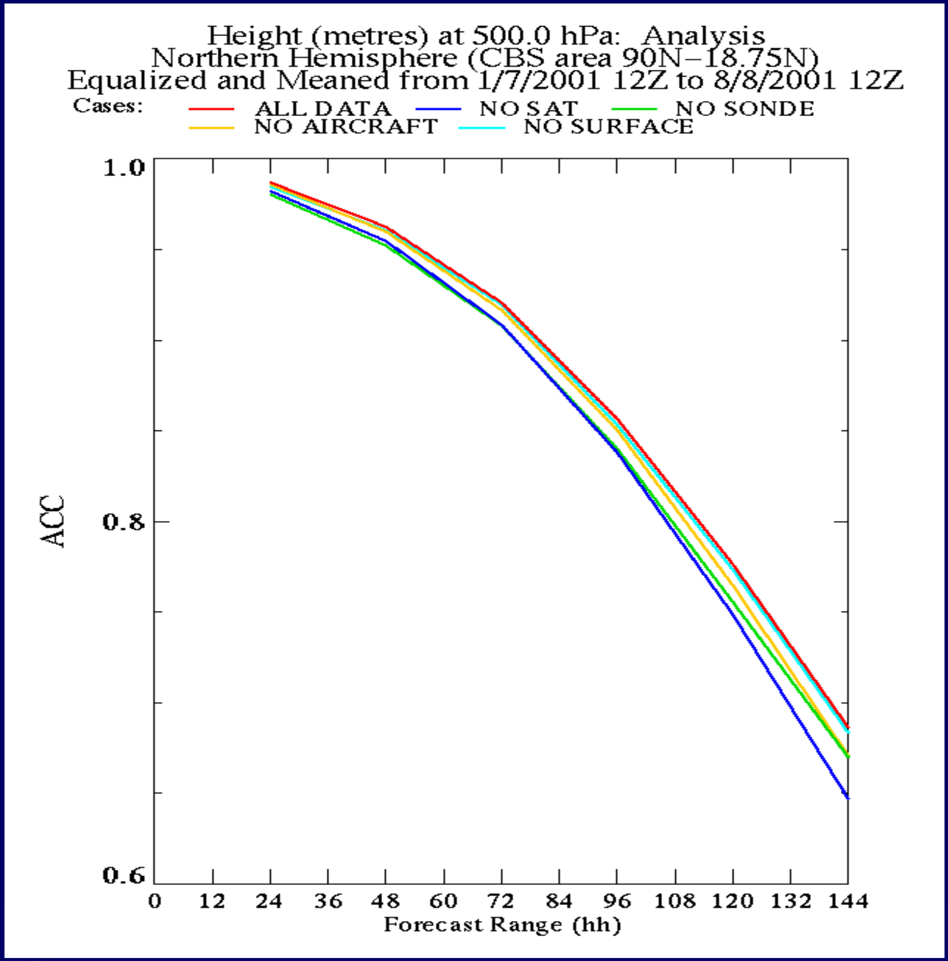
OSE example (1): global data denial

- Data denied from the whole globe.
- Observation scenarios:
  - all data - all satellite data (radiance + AMV + SSM/I)
  - all data - radiosonde data
  - all data - aircraft data
  - all data - surface data
  - all data - satellite radiance data
  - all data - atmospheric motion vectors (AMV).

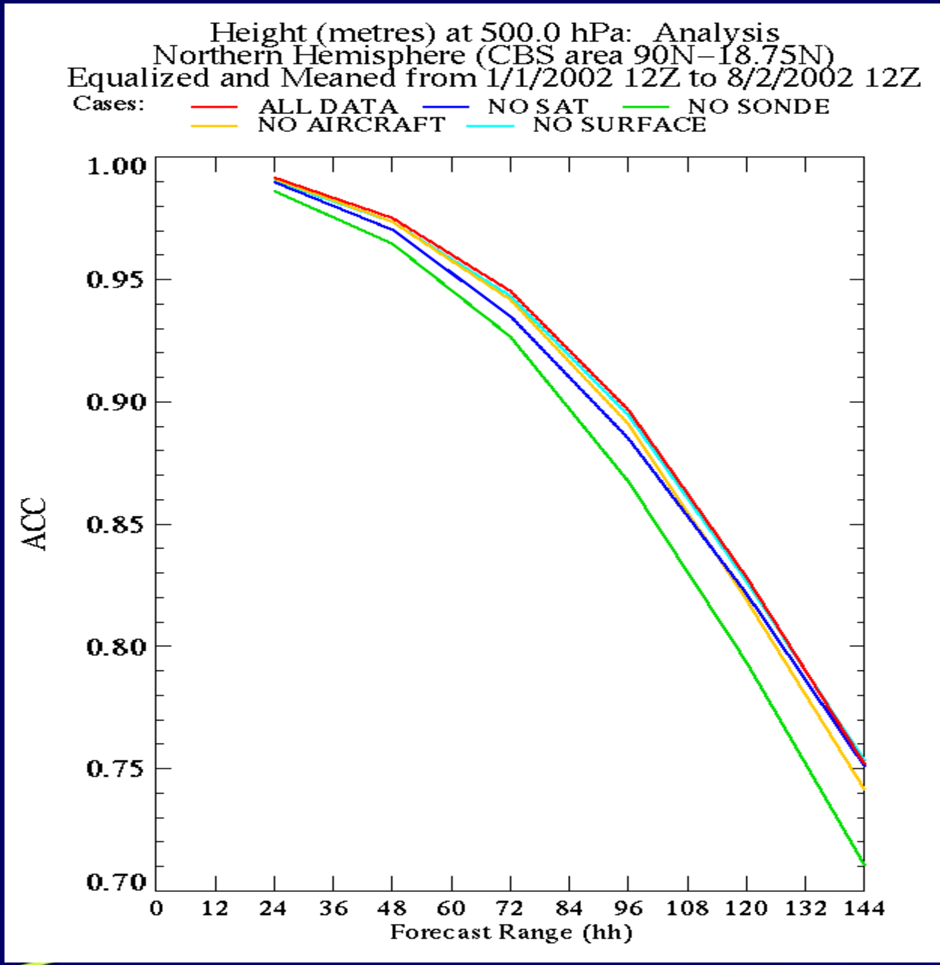
OSE example (1): global data denial

- Periods chosen:
  - July 2001 and January 2002
  - 60 6-day forecasts run from 12z data were verified.
- Met Office NWP system that was operational in Dec 2001 (3D-Var, 3 hr cut-off) run at reduced horizontal resolution (90km rather than 60km).

Dependence on sampling method: 30 forecasts from two seasons

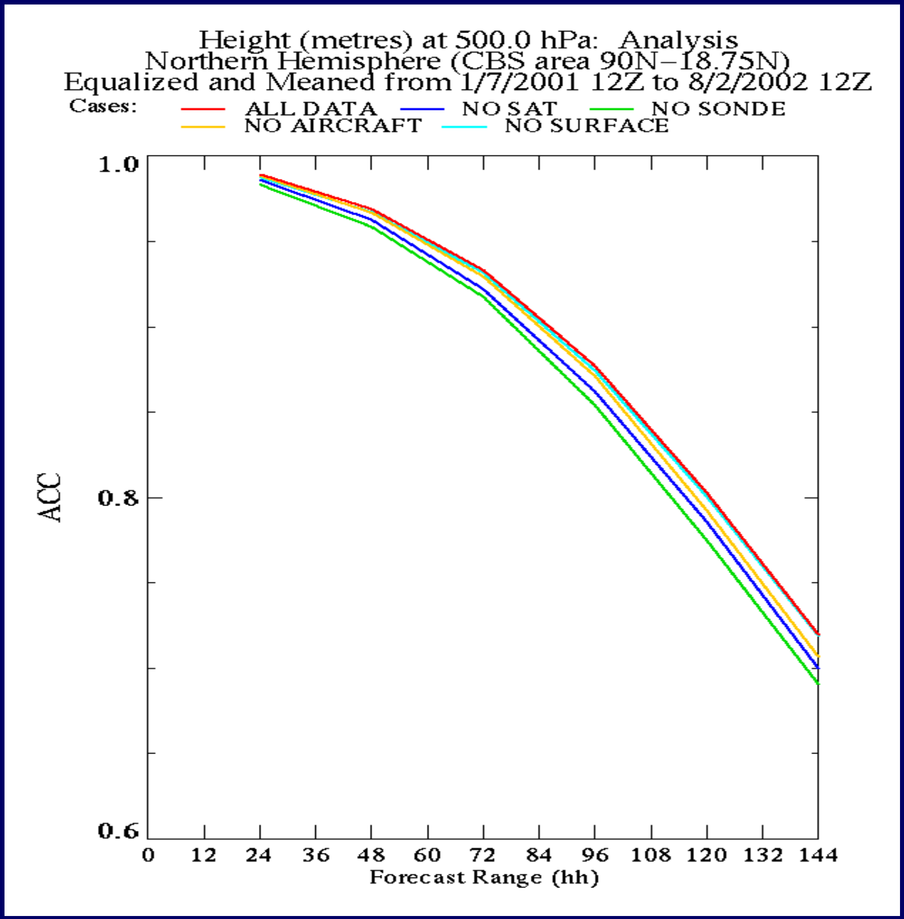


July 2001



January 2002

Dependence on NWP system: Met Office & ECMWF



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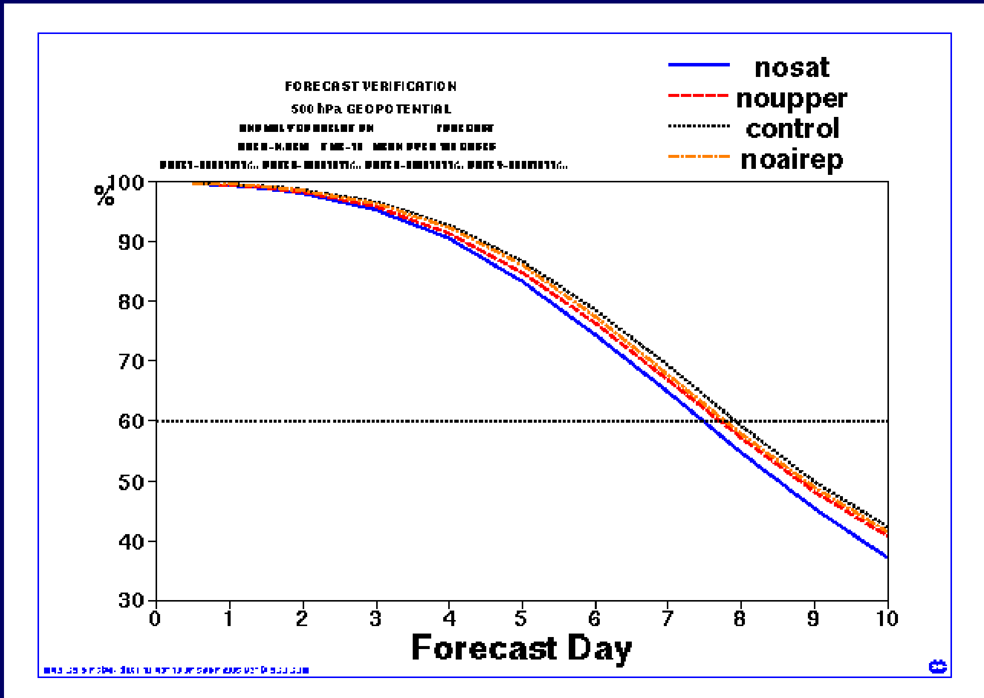
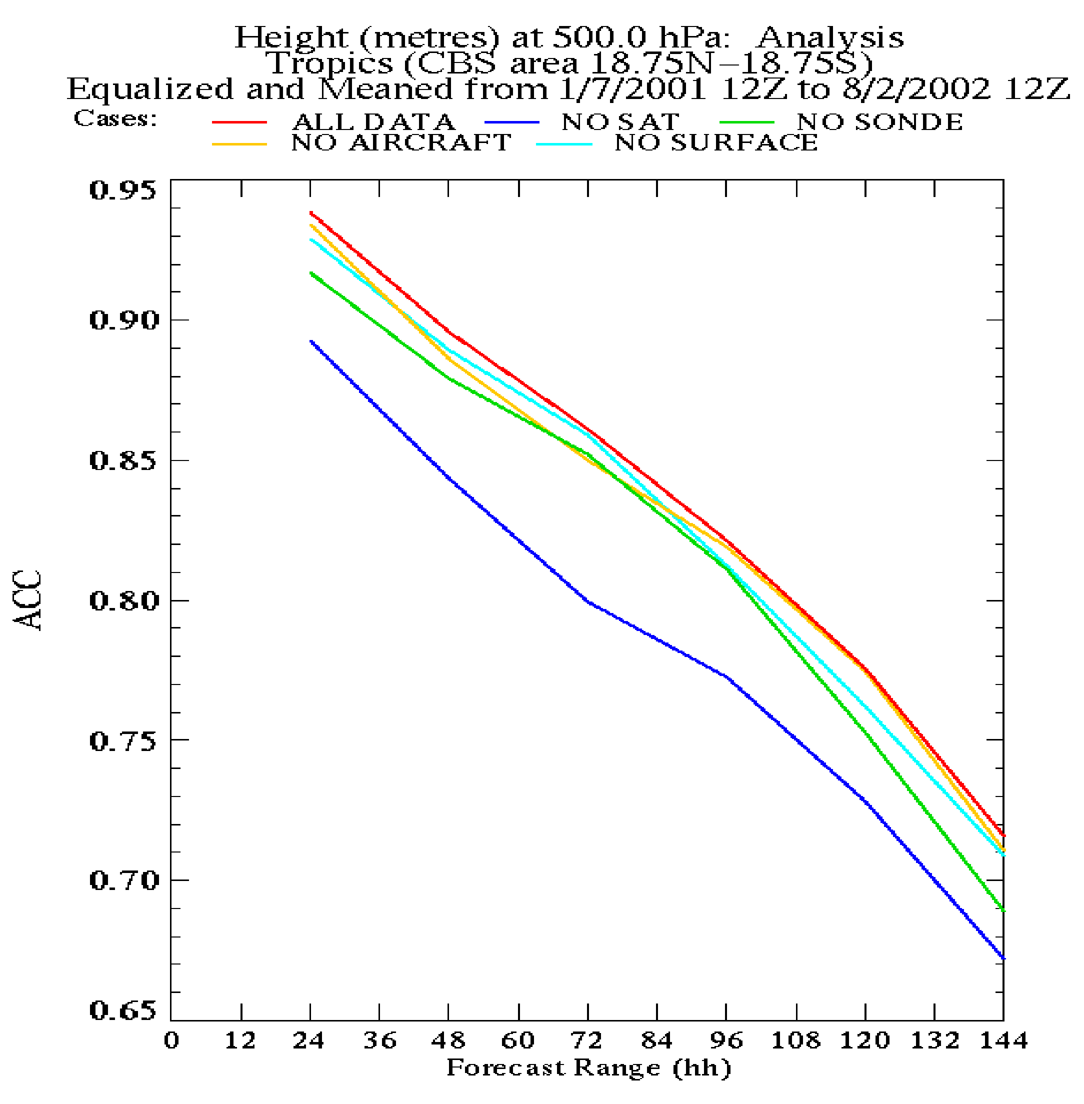
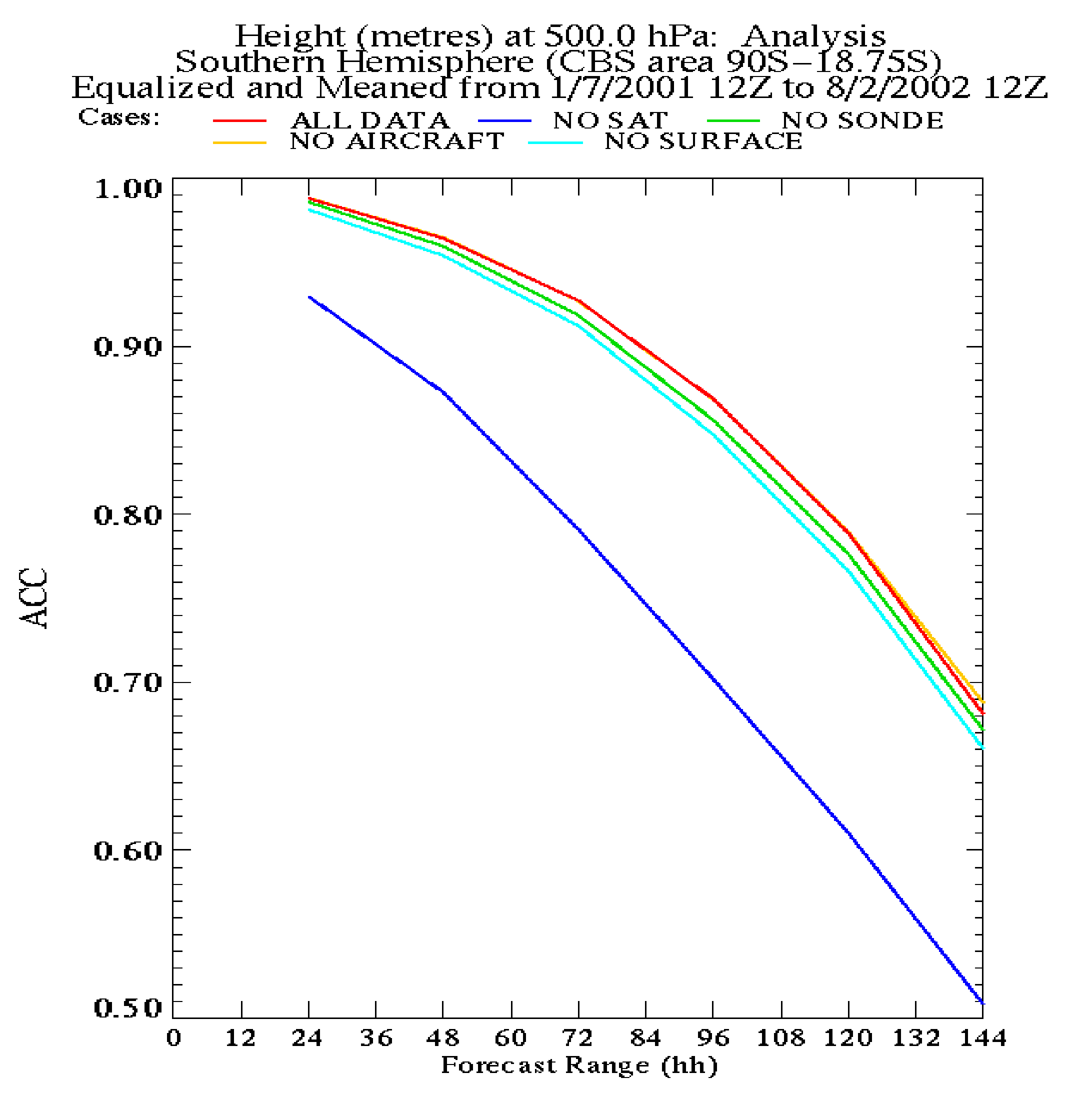


ECMWF(G. Kelly)

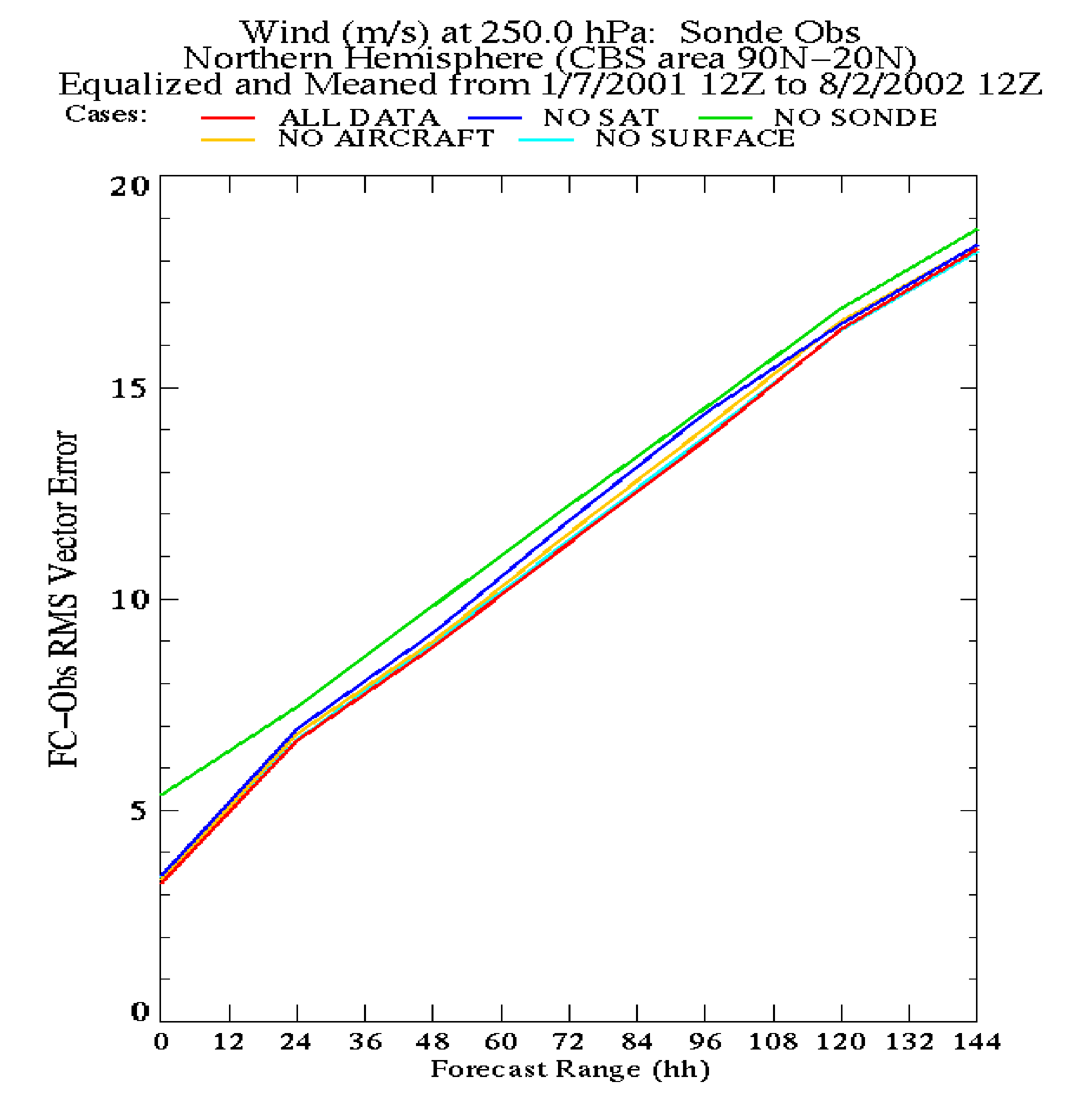
Terrestrial vs sat: height in TR (60 forecasts)



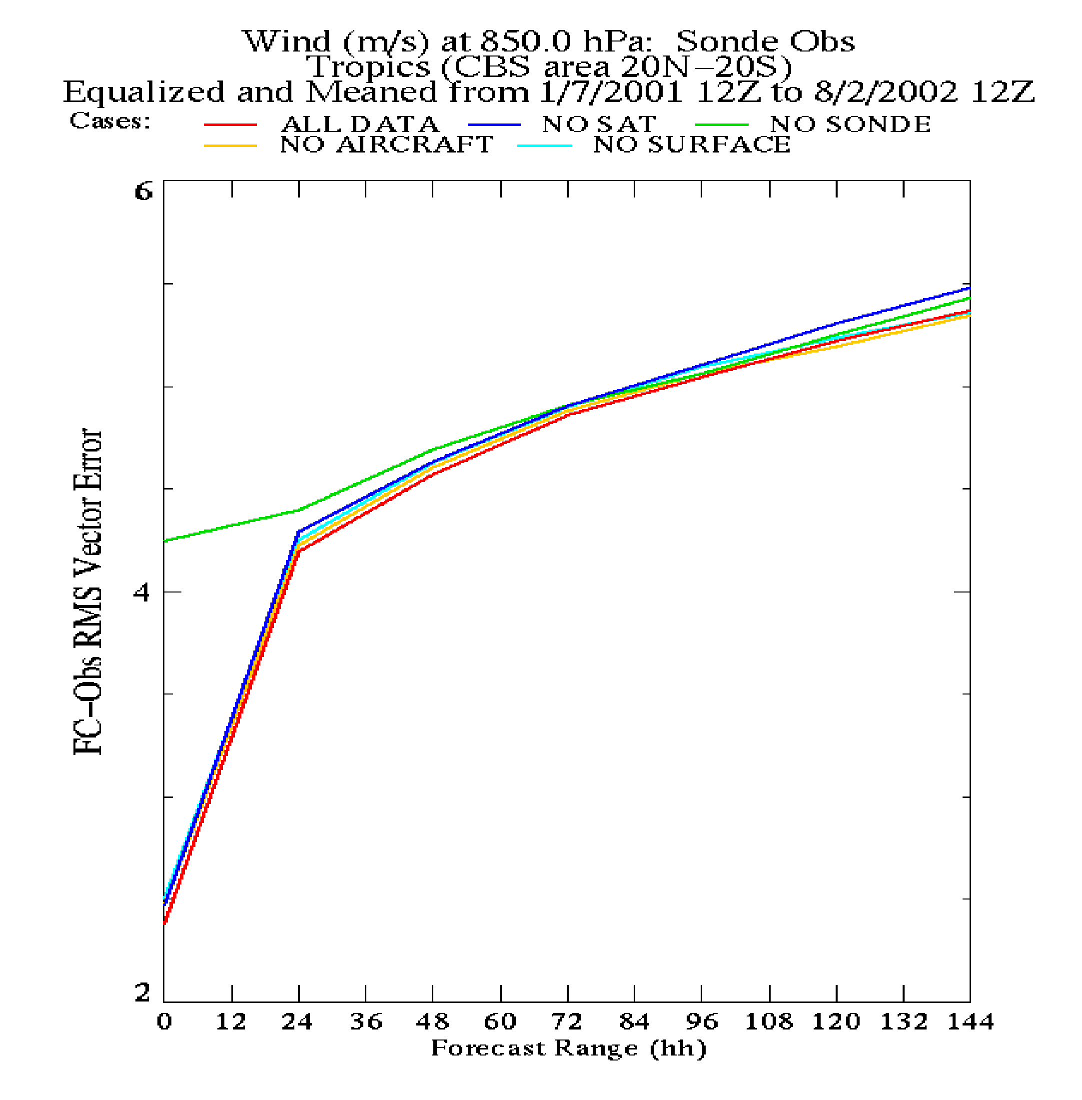
Terrestrial vs sat: height in SH (60 forecasts)



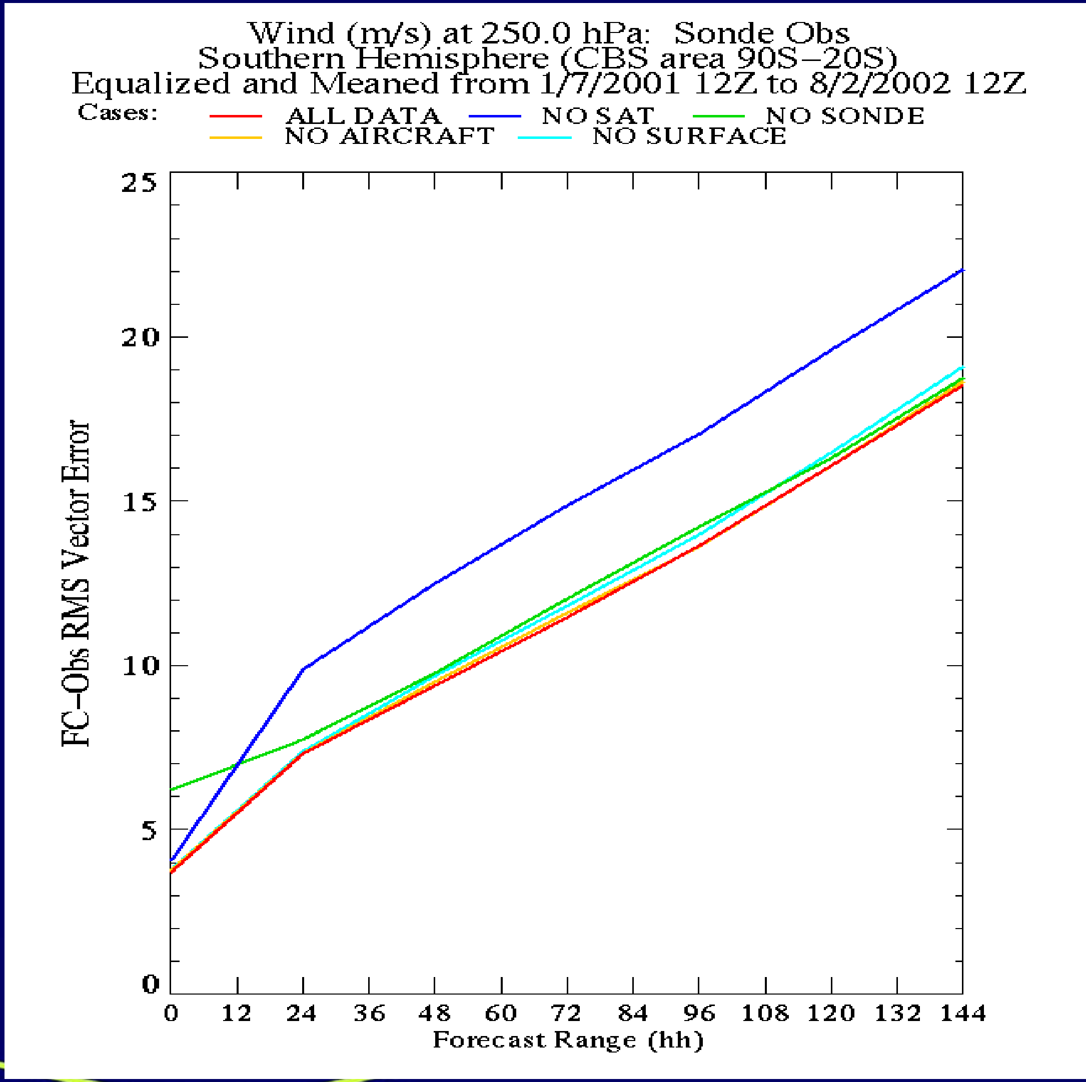
Terrestrial vs sat: wind in NH (60 forecasts)



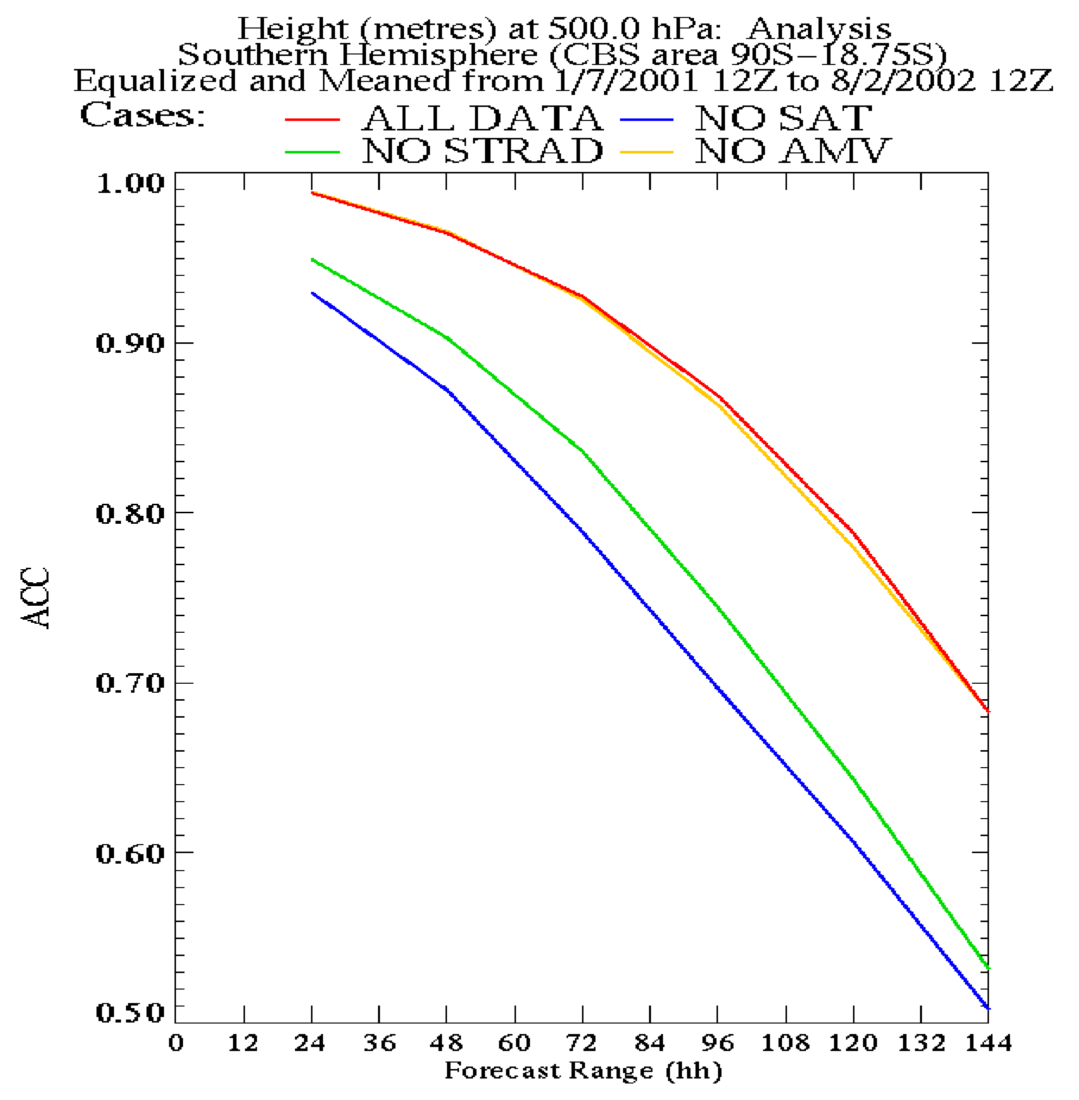
Terrestrial vs sat: wind in TR (60 forecasts)



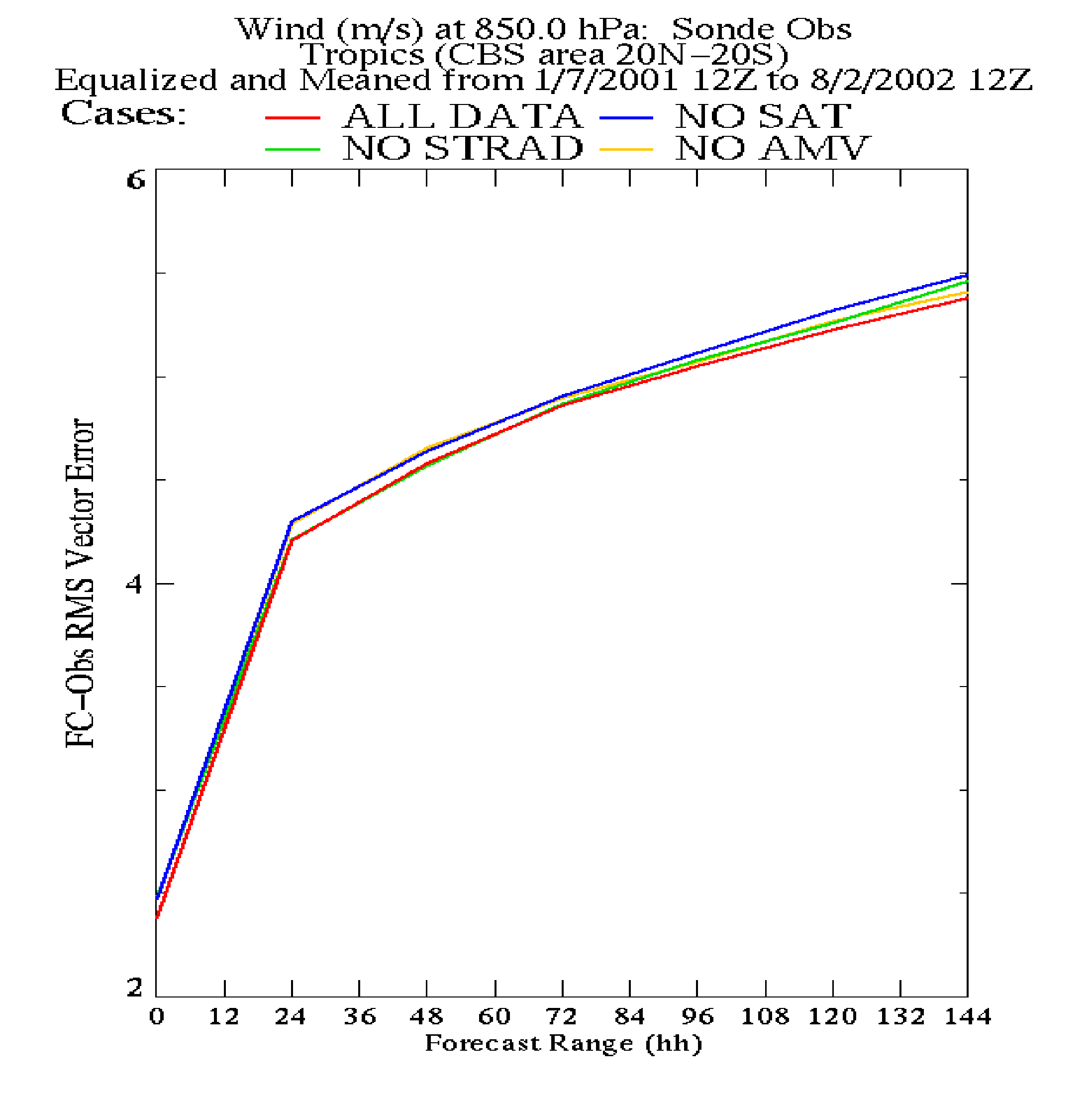
Terrestrial vs sat: wind in SH (60 forecasts)



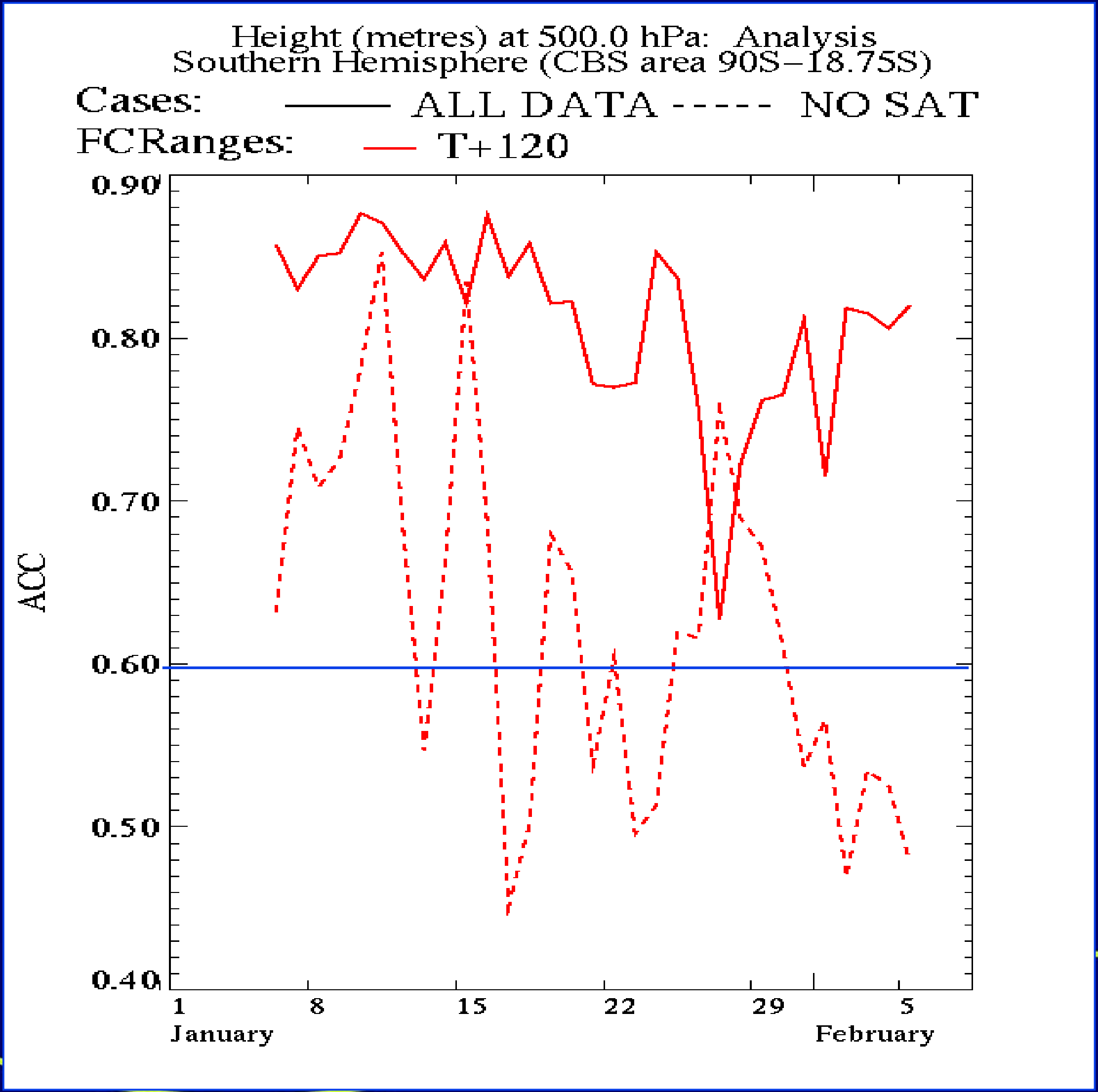
Sat vs sat: height in SH (60 forecasts)



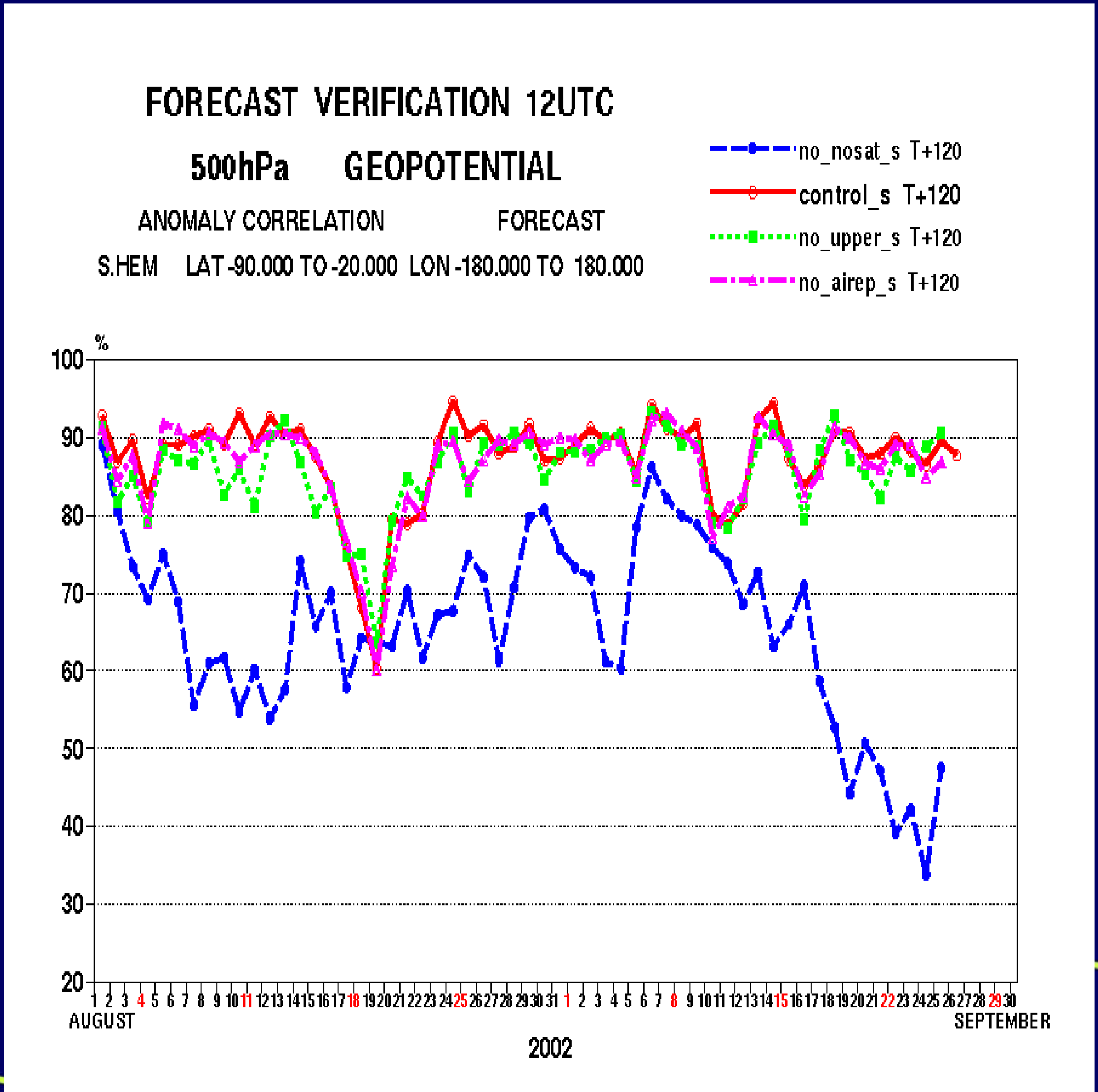
Sat vs sat: wind in TR (60 forecasts)



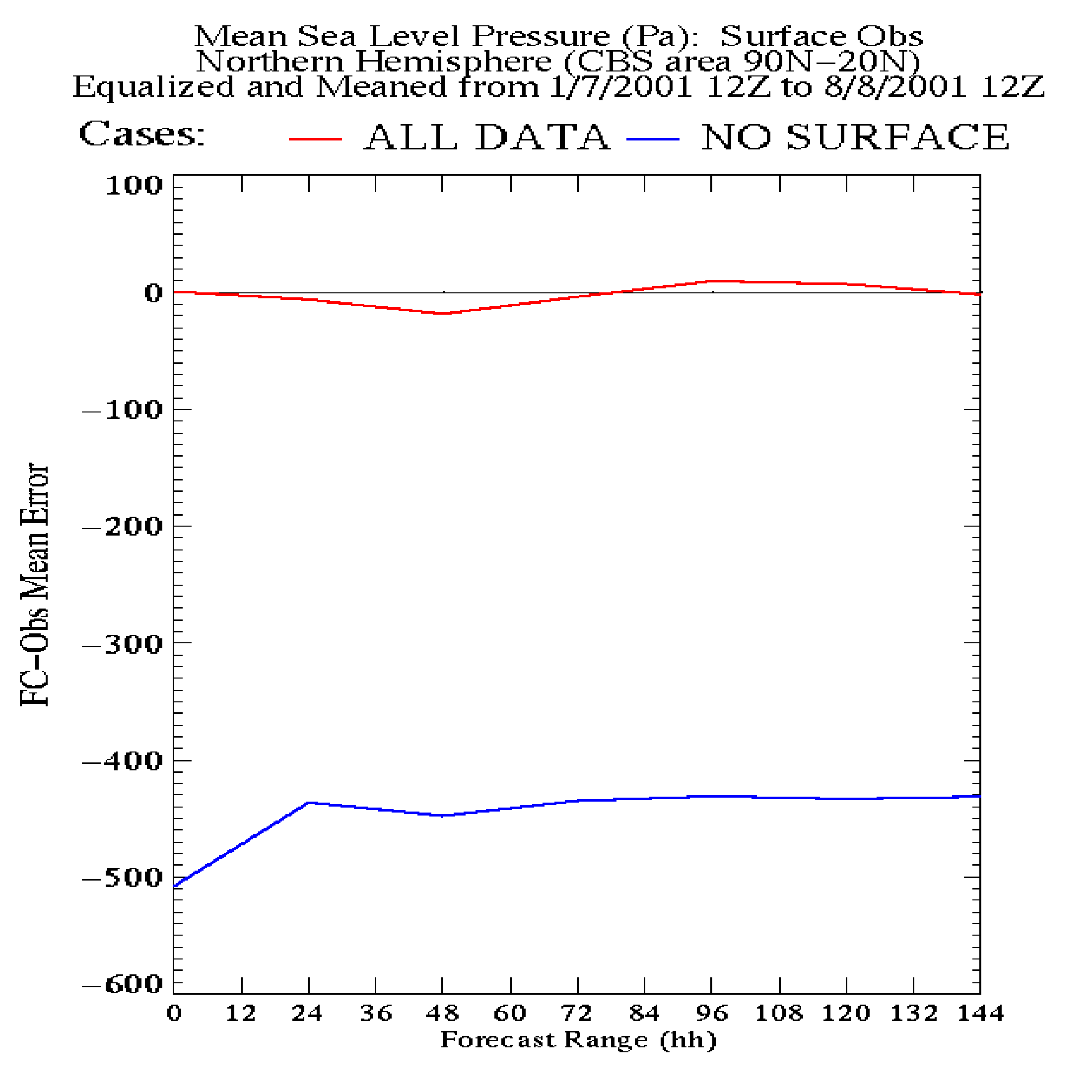
Daily impact: Met Office



Daily impact: ECMWF (Kelly)



Impact of surface data: Met Office

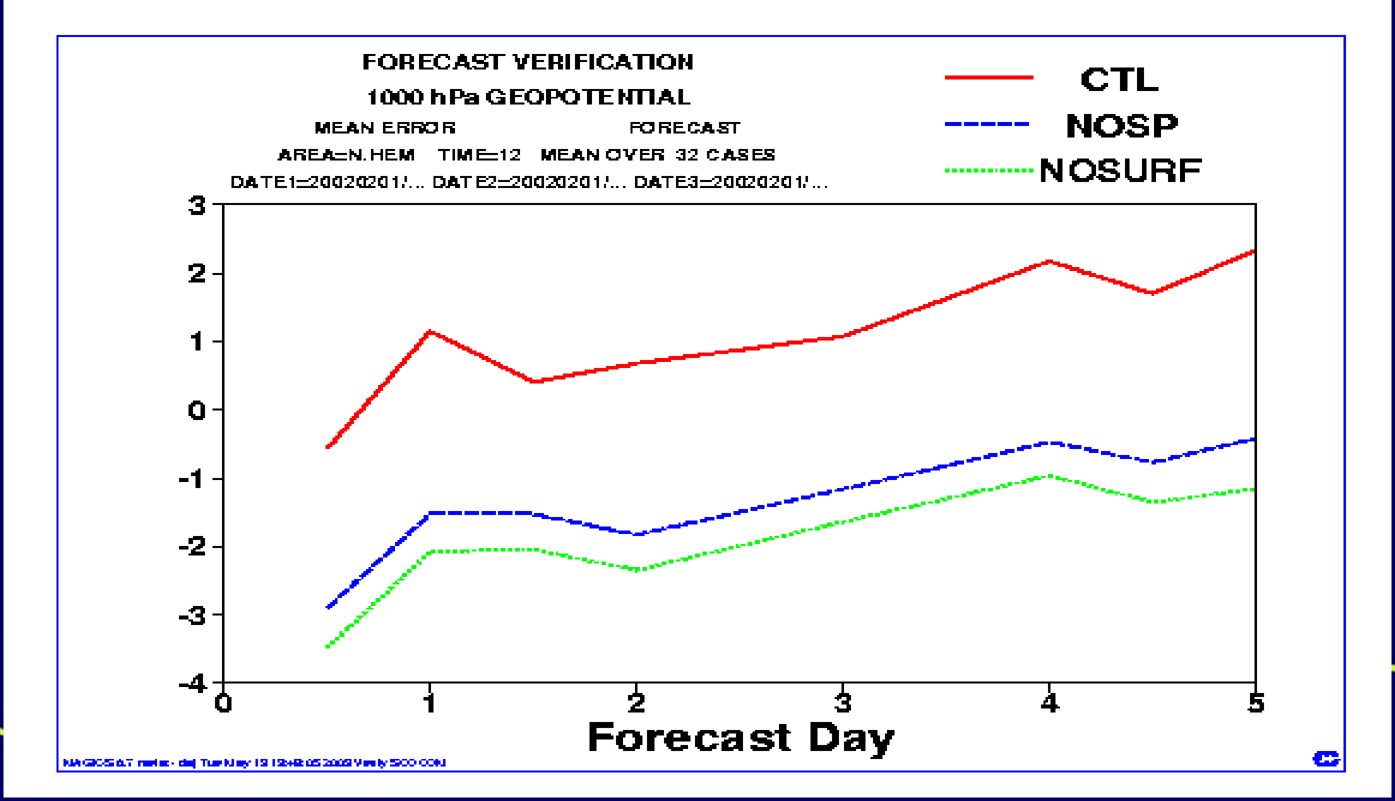


Impact of surface data: ECMWF (Thépaut, Kelly)

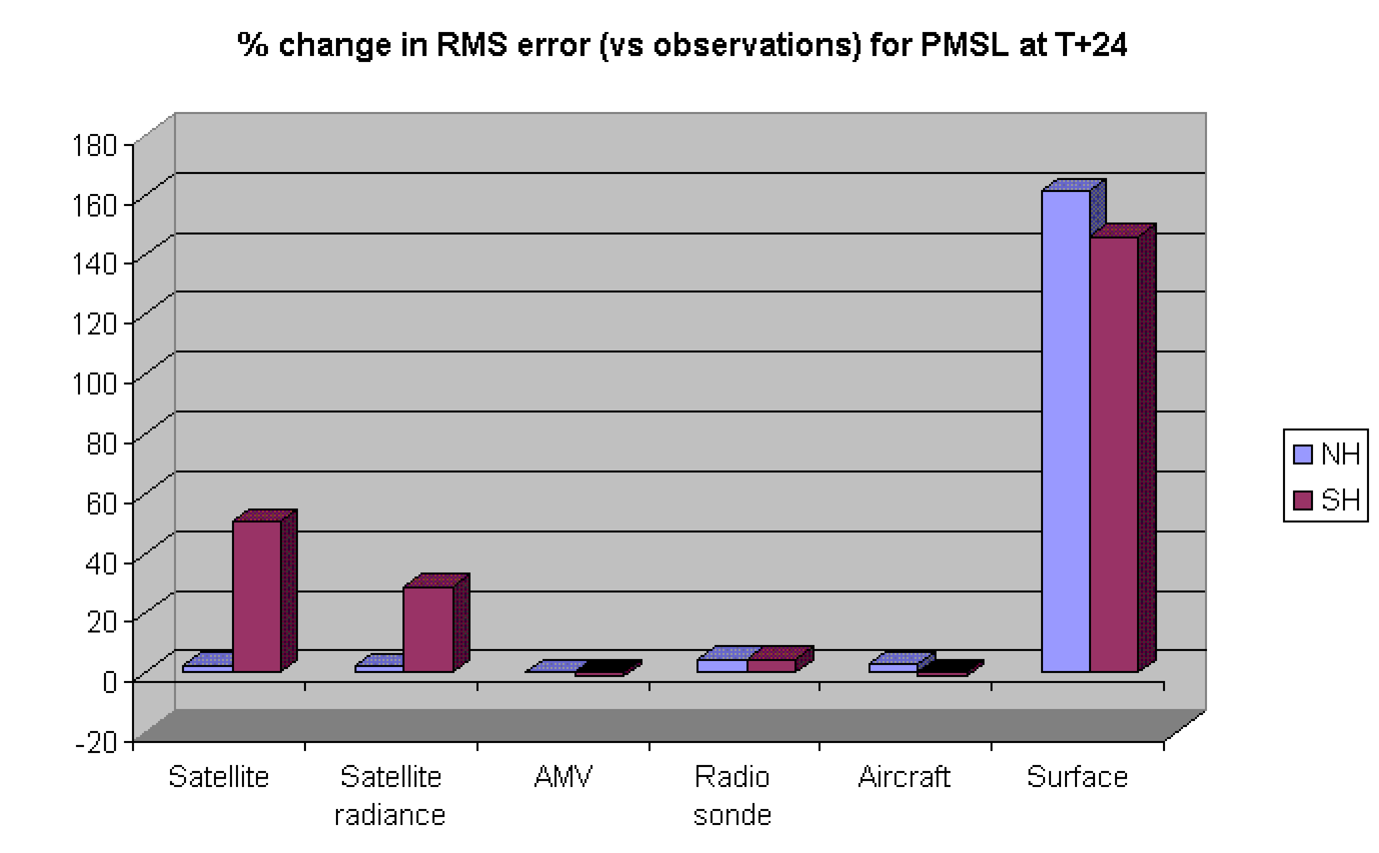
Large biases in case of no surface pressure observations

Small compensation by surface wind observations

Surface winds alone have a detrimental impact in SH (not shown)



Impact of surface data on mslp forecasts



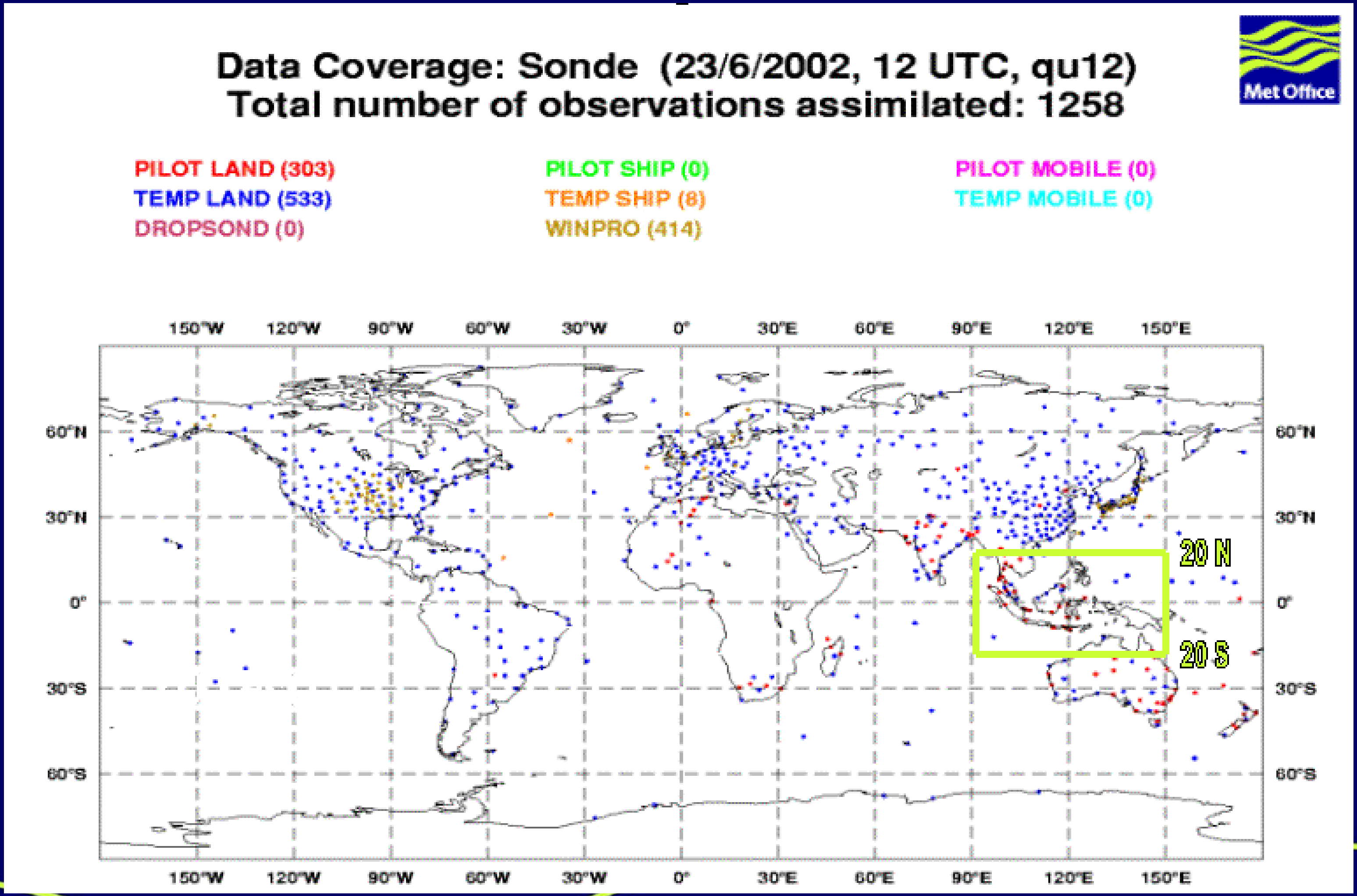
OSE example (2): tropical 'in-situ' profile data

- Problem with upper air observation coverage in the tropics.
- Current observation coverage not good even in some land areas.
- Neither 'in-situ' or satellite data available.

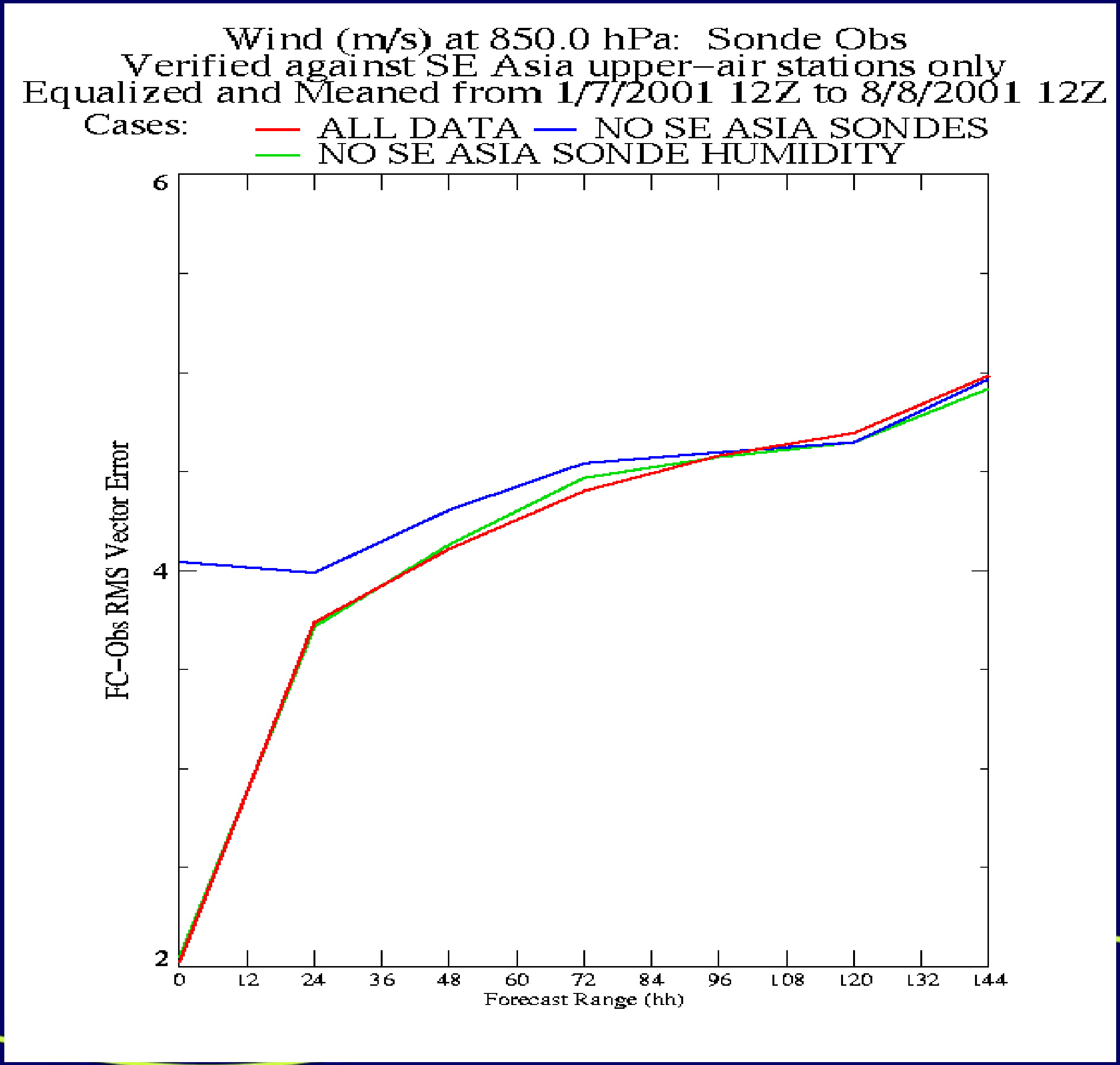
Benefit of tropical 'in-situ' profile data

- WMO Expert Team: will extra 'in-situ' profile data in Africa benefit forecasts for Africa?
- Answer by denying profile observations from South East Asia and assessing the local impact.
- Ran OSE using July 2001 data with scenarios:
  - No profile data (current situation)
  - Wind and temperature profiles (more AMDARs)
  - All data (more radiosondes)

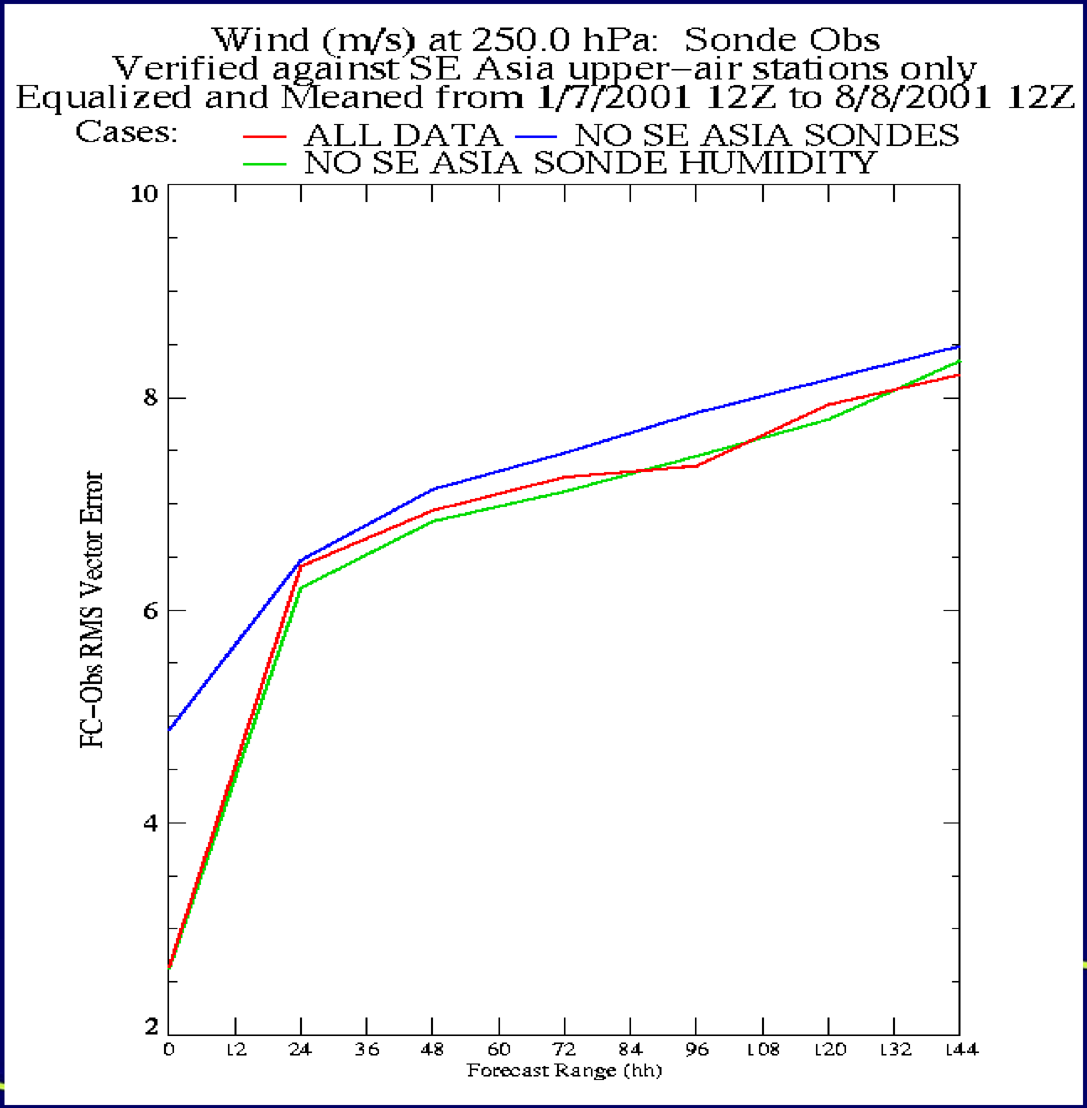
Area of denial



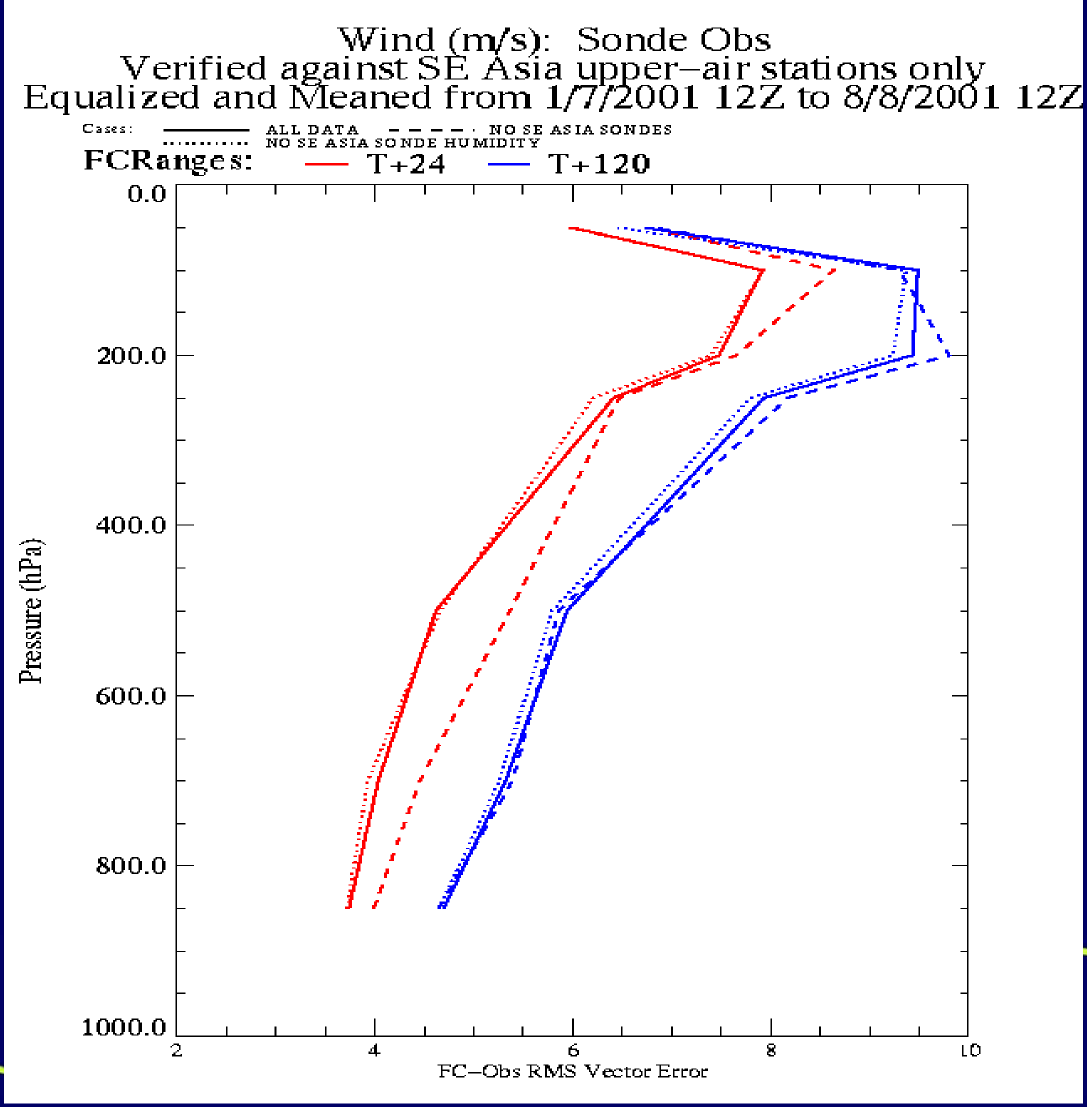
850 hPa RMS vector wind vs SE Asia radiosondes



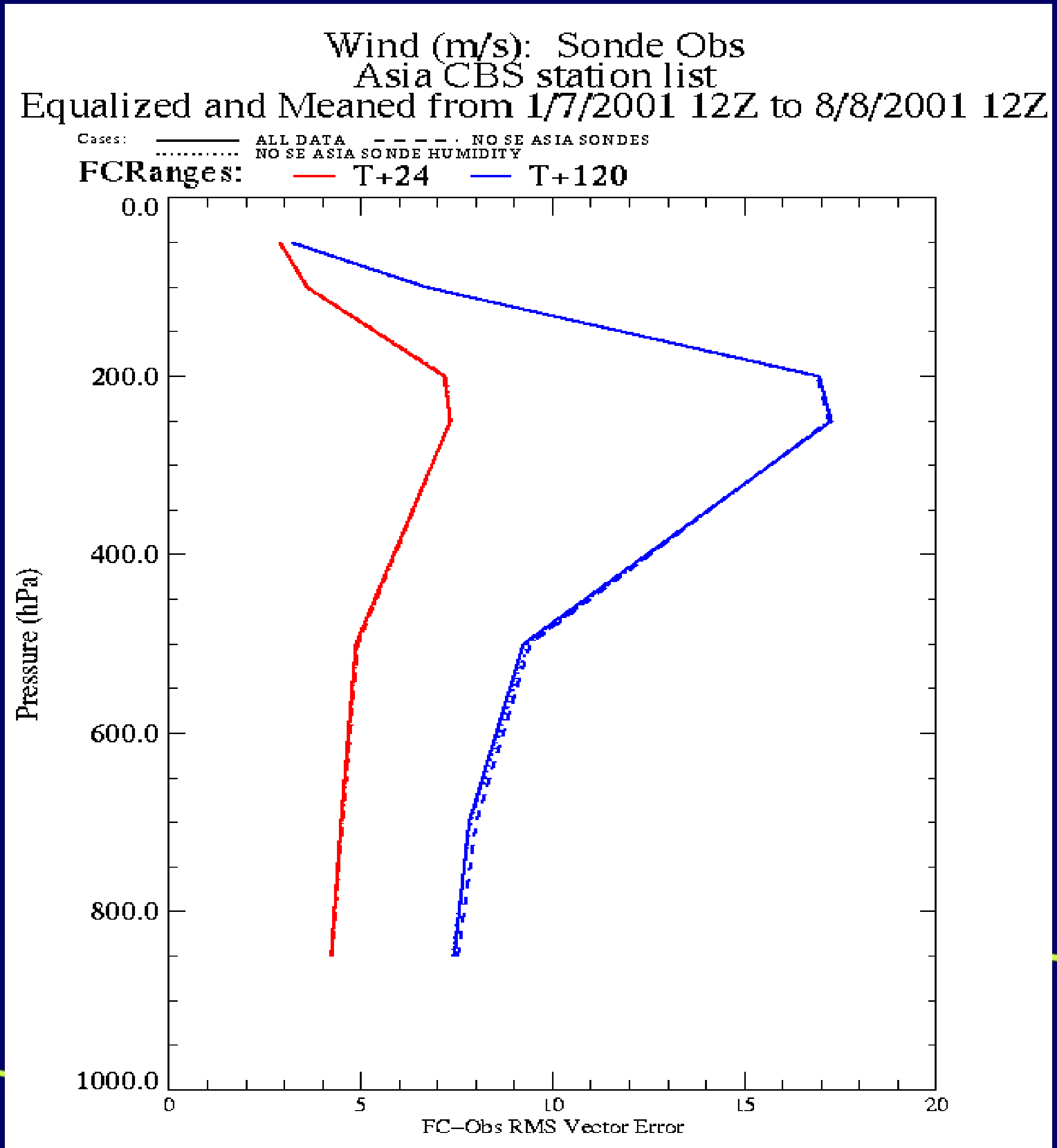
250 hPa RMS vector wind vs SE Asia radiosondes



Profile of RMS vector wind vs SE Asia radiosondes



Profile of RMS vector wind vs Asia radiosondes



OSE example (3): European observing network design

- Collaborative European project managed by EUMETNET Composite Observing System (EUCOS).
- ECMWF, Meteo-France, DWD, HIRLAM, Met Office etc. involvement.
- Aims to re-deploy observations so that the European observing network is more cost-effective.

OSE example (3): E-ASAP trial

- Two month field experiment from September 1st - October 31st 2001.
- Extra ASAPs deployed over the North Atlantic, plus extra ascents from the Azores radiosondes.
- Are forecasts for Europe improved?
- Observation scenarios: with and without the ASAP data and Azores radiosonde.
- NWP system: operational, global at Dec 2001.

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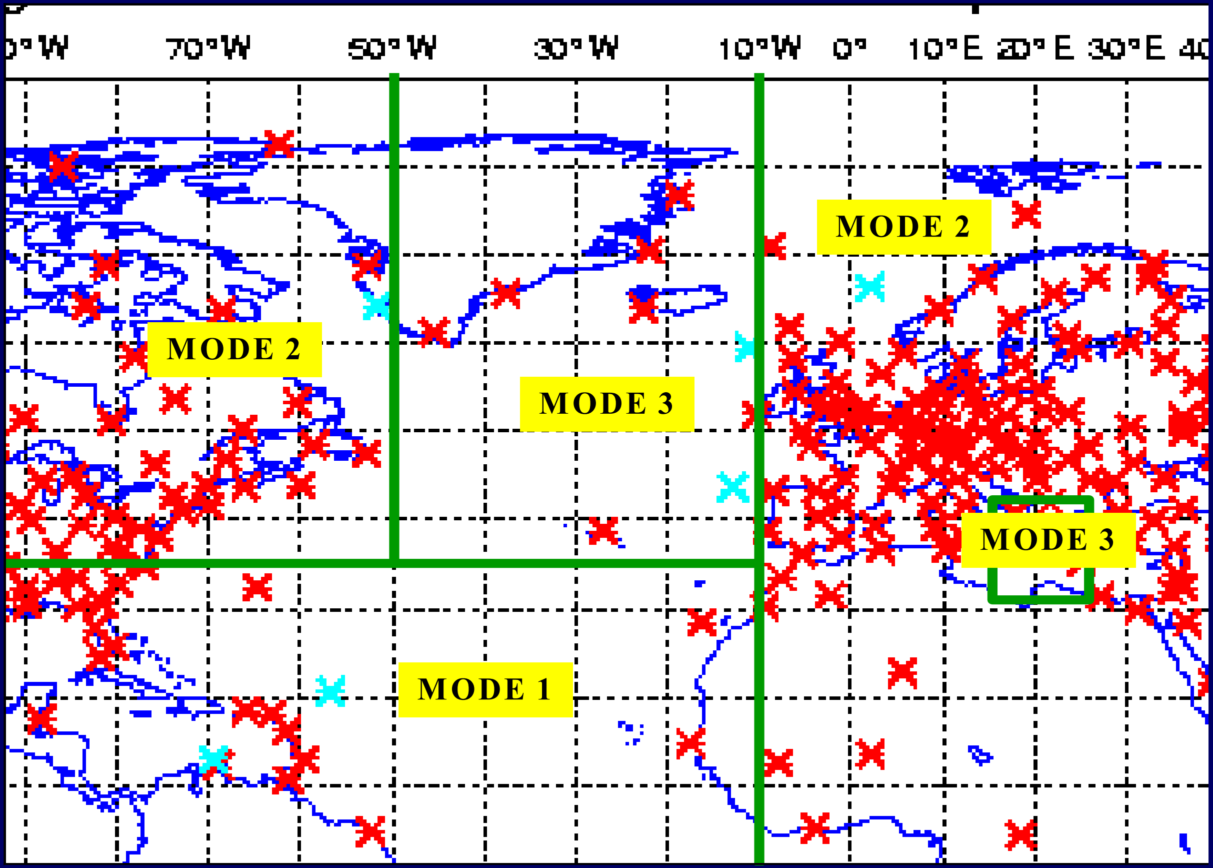
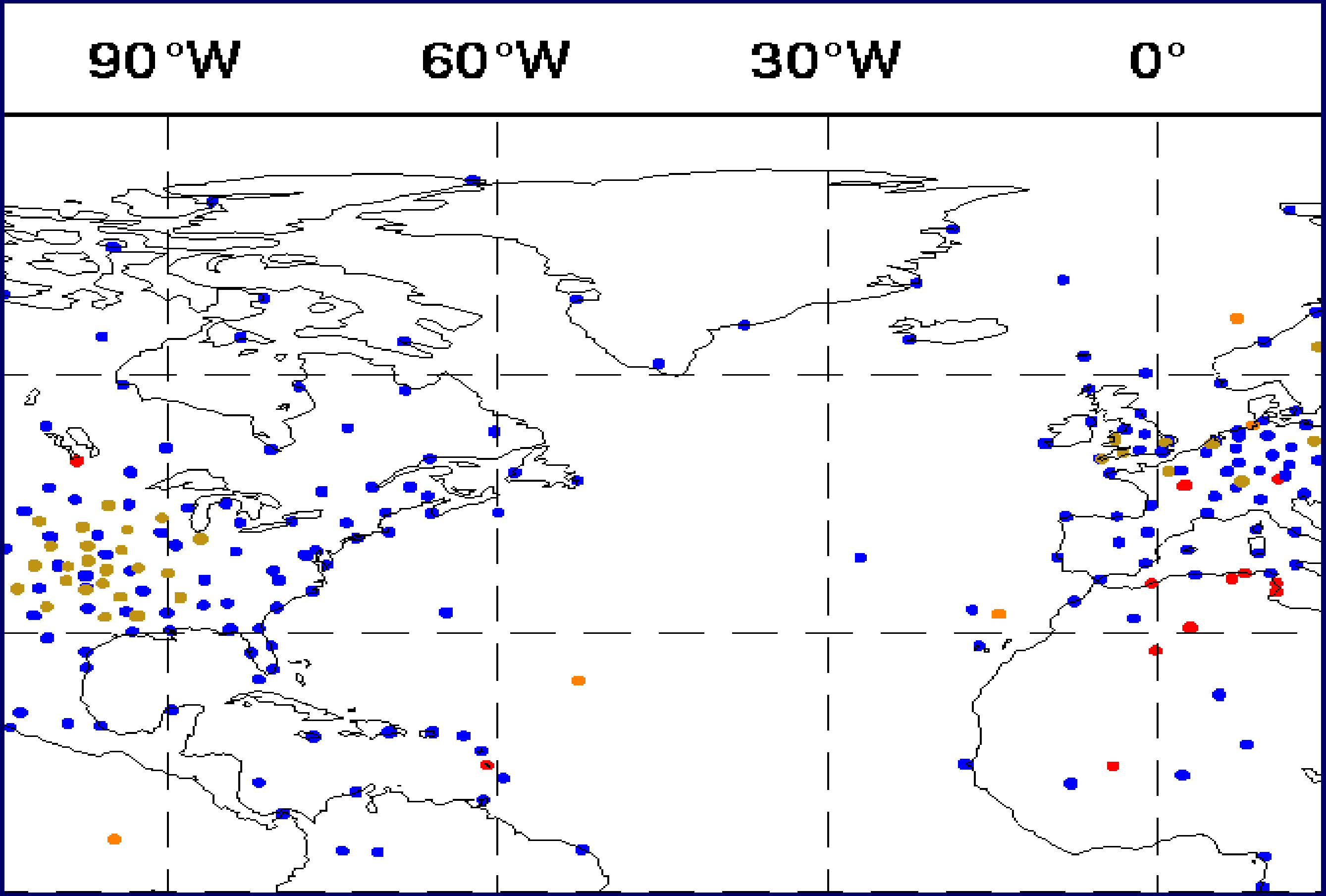
E-ASAP: modes of operation



E-ASAP: distribution of ships at 12z 2/10/01



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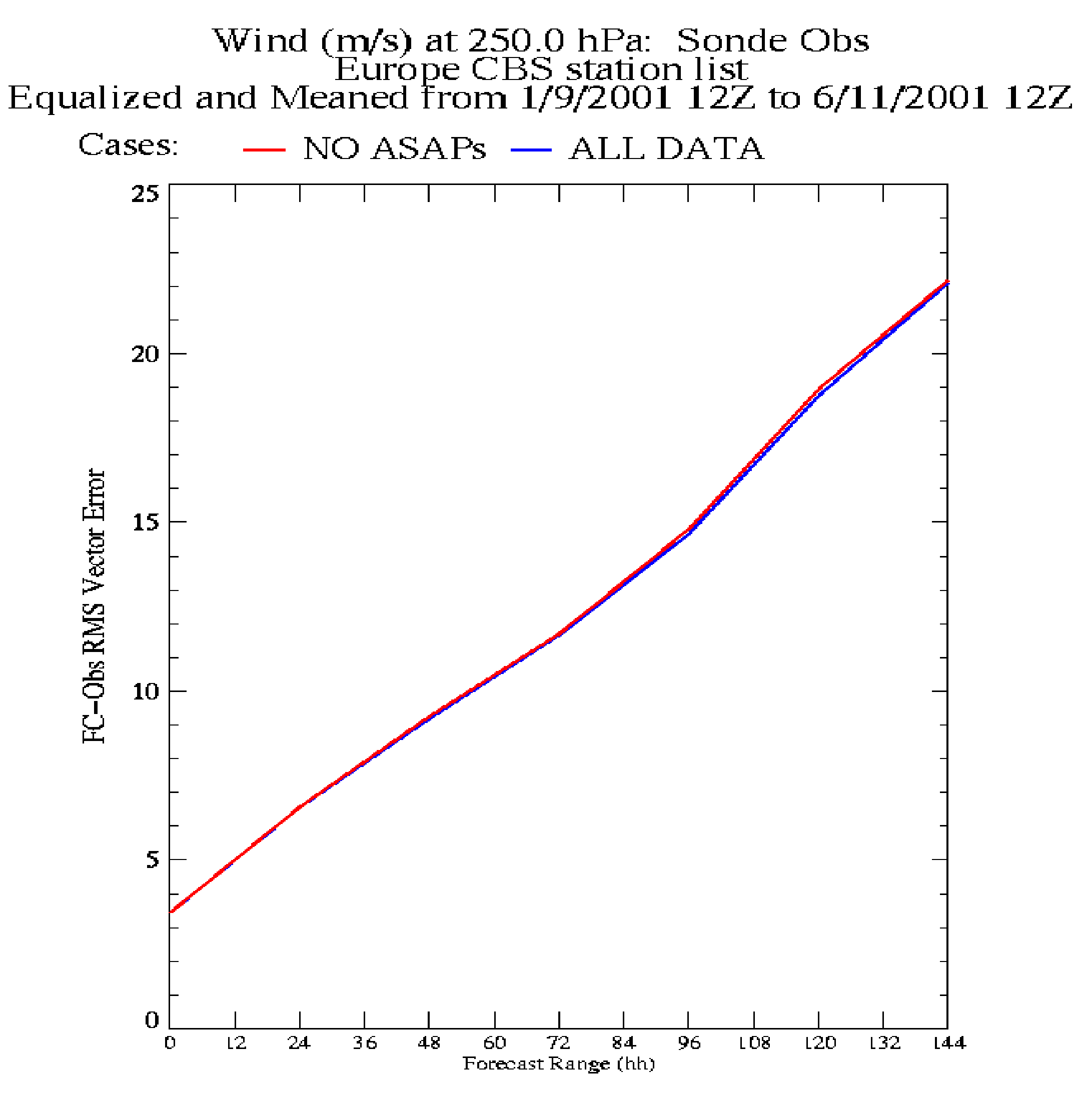
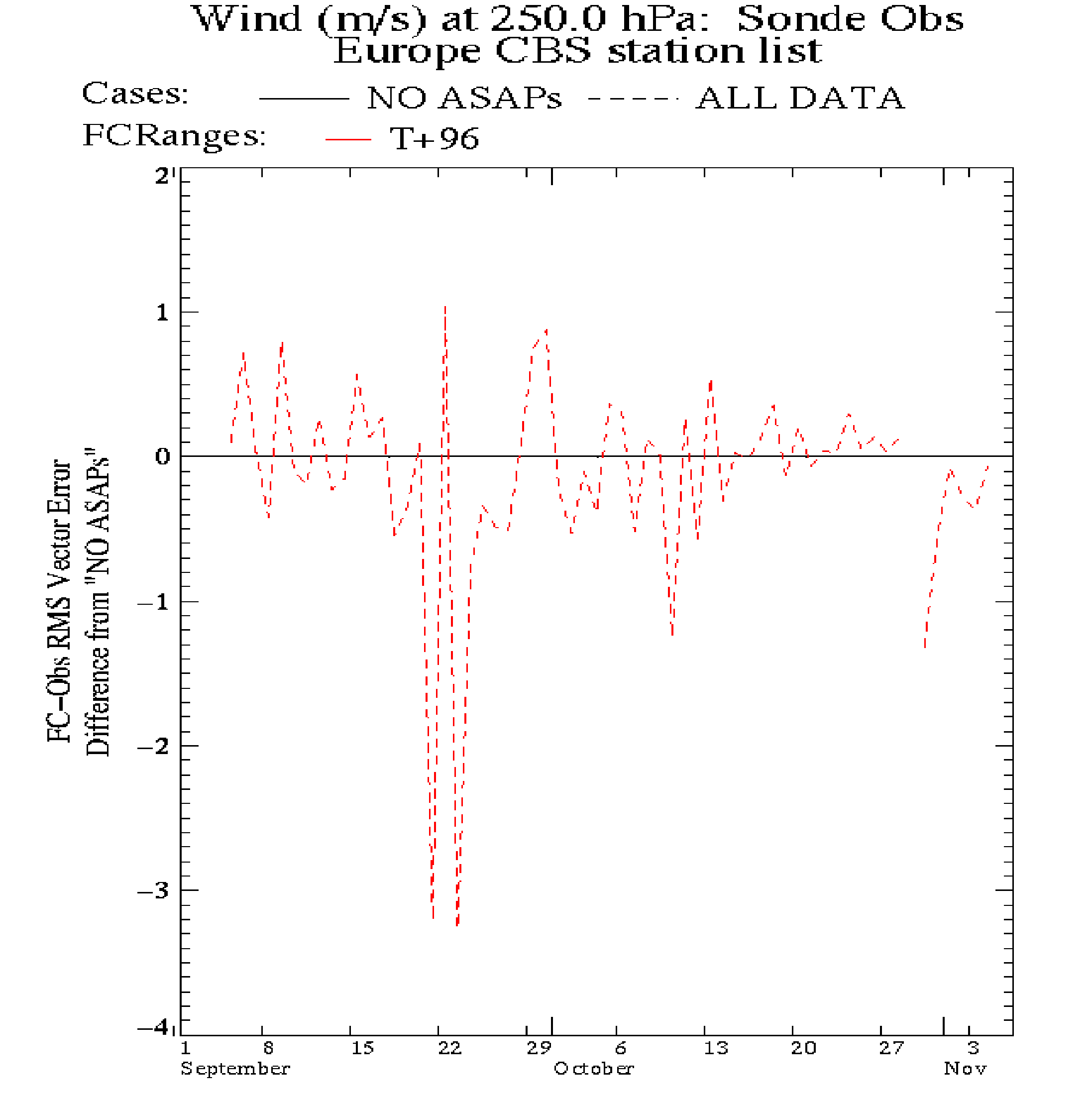
E-ASAP: wind verification over Europe

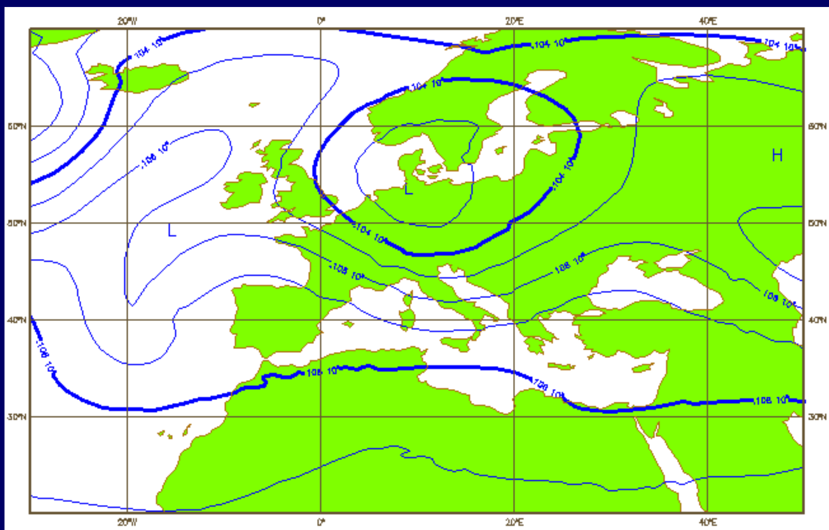


E-ASAP: time series of differences

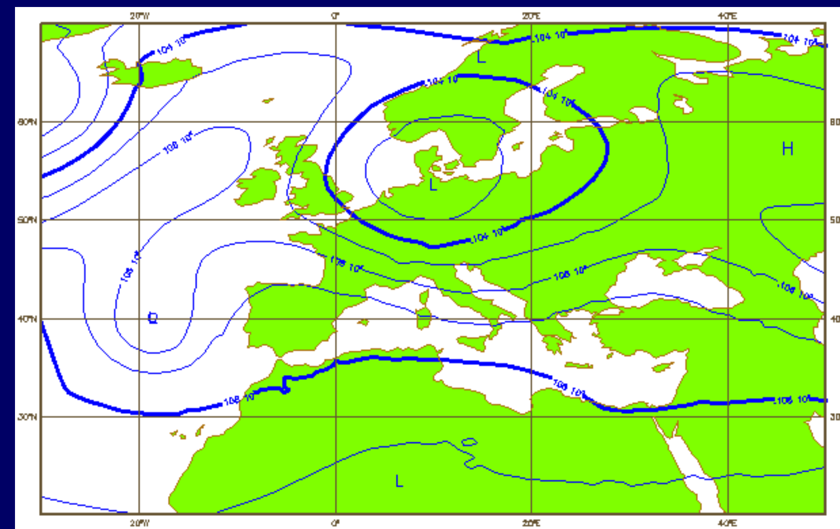


E-ASAP: case study

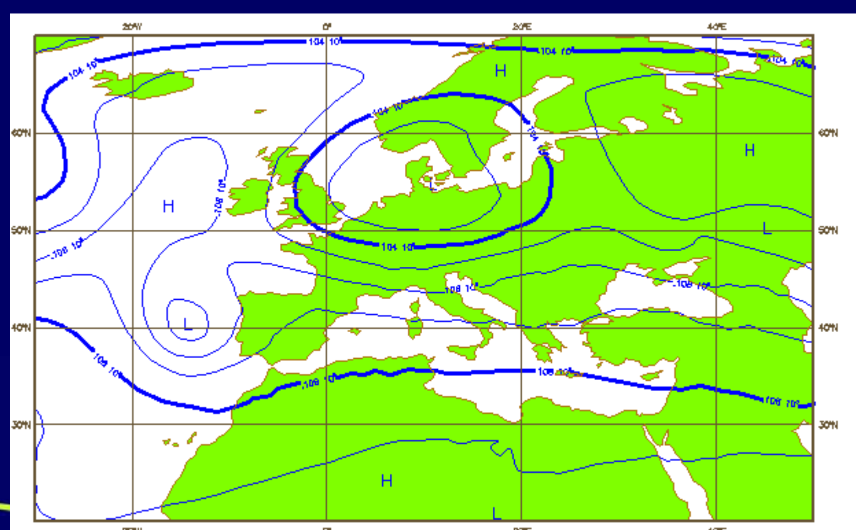
No ASAP



With ASAP



Analysis



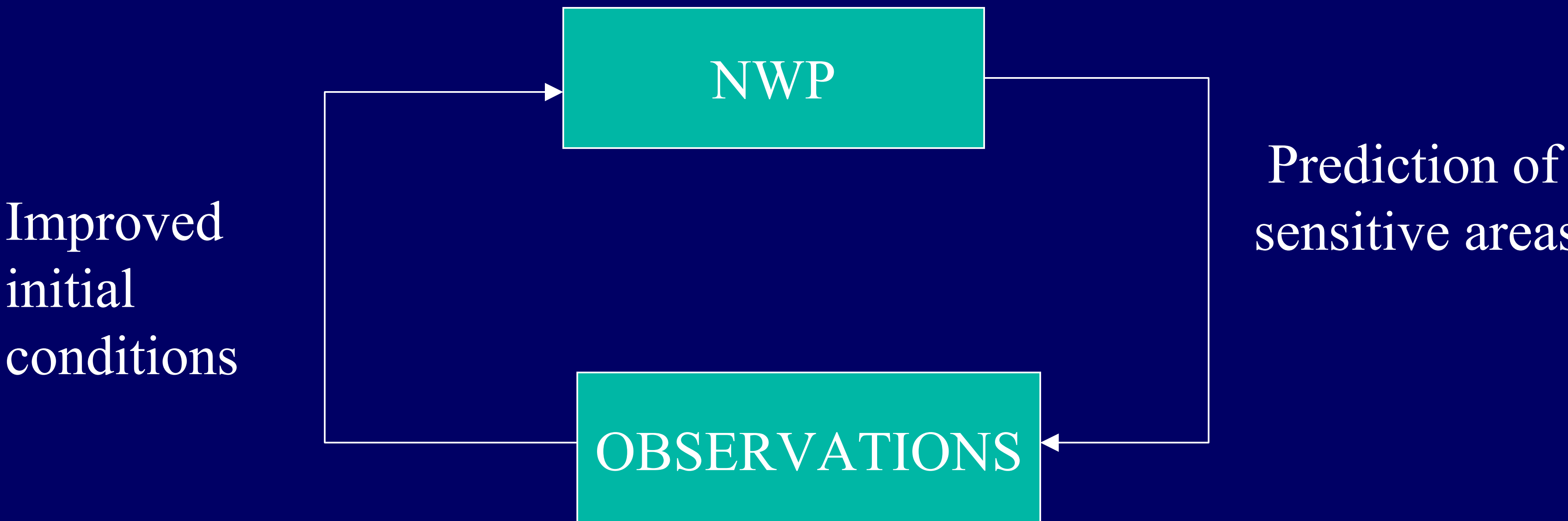
Other OSE results on observation networks

- West coast observations important for North America (P A Hirshberg et al 2001).
- North American/Canadian network is important for Europe (A Cress and W Wergen 2001).
- Reducing spacing of sondes but increasing temporal frequency over Europe (+ aircraft profiles) has neutral impact (EUCOS).
- Deploying dropsondes in Pacific using ETKF targeting improves forecasts over US.

Future work: EUCOS questions

- Can observations be deployed selectively (‘targeted’) in real time in order to improve the forecasting of ‘high impact’ weather events over Europe?
- What mix of observing technologies gives the most cost-effective impact?
- Can Europe replicate the performance of the Winter Storms Reconnaissance Program?

Adaptive observation network



Future OSEs - TOST

- THORPEX Observing System Test (TOST).
- Observation field campaign Oct - Dec 2003: largest since FASTEX.
- Observation deployment based upon the real-time selection of cases and calculation of sensitive areas.

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Future OSEs: space/terrestrial link

- What is the optimum mix of satellite data and terrestrial data?
- Run OSEs or OSSEs ?
- E-SAT preferred OSEs because of difficulty of specifying future observing system characteristics e.g. observation errors.

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Space/terrestrial link

Run OSEs as data inclusion experiments:

- Satellite data only
- Satellite data + surface data
- Satellite data + surface data + aircraft data
- Satellite data + surface data + aircraft data + radiosonde data

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Summary

- Carefully run OSE s are useful for testing data assimilation performance and designing observation networks.
- Recent results indicate that 3D-Var/4D-Var data assimilation schemes are performing well.
- Future OSEs will assess the value of real-time observation targeting and guide development of the GOS.