IMPROVING THE USE OF RADIOSONDE AND SATELLITE-DERIVED WINDS AT THE METEOROLOGICAL SERVICE OF CANADA

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Outline

- Why does the 4D position of radiosonde data now matter for NWP
- Estimation of the horizontal position and time of radiosonde data
- Impact of 4D radiosonde position on:
  - NWP
  - Collocation of AMV and radiosonde data

- Impact of AMV data at MSC
- Future plans

Canada

# Why does the 4D Position of Radiosonde Data now Matter for NWP

- Radiosondes can drift as far as 200 km away from the upper-air station location before bursting in the stratosphere, typically 1.5 to 2 h after its launch.

- The atmospheric state along the radiosonde trajectory can be significantly different from the vertical profile above the upper-air station at a given time due to the spatial and temporal variability of meteorological fields, as shown in the figure. This is especially true over the Northern Hemisphere extratropics in winter where the horizontal drift in the atmospheric circulation can be significant.

- With the increasing accuracy and horizontal resolution of NWP models, which is of the order of 20 km in global forecast systems and as high as 1 km in limited area mesoscale systems, accurate position and time of observations are now important to take into account.
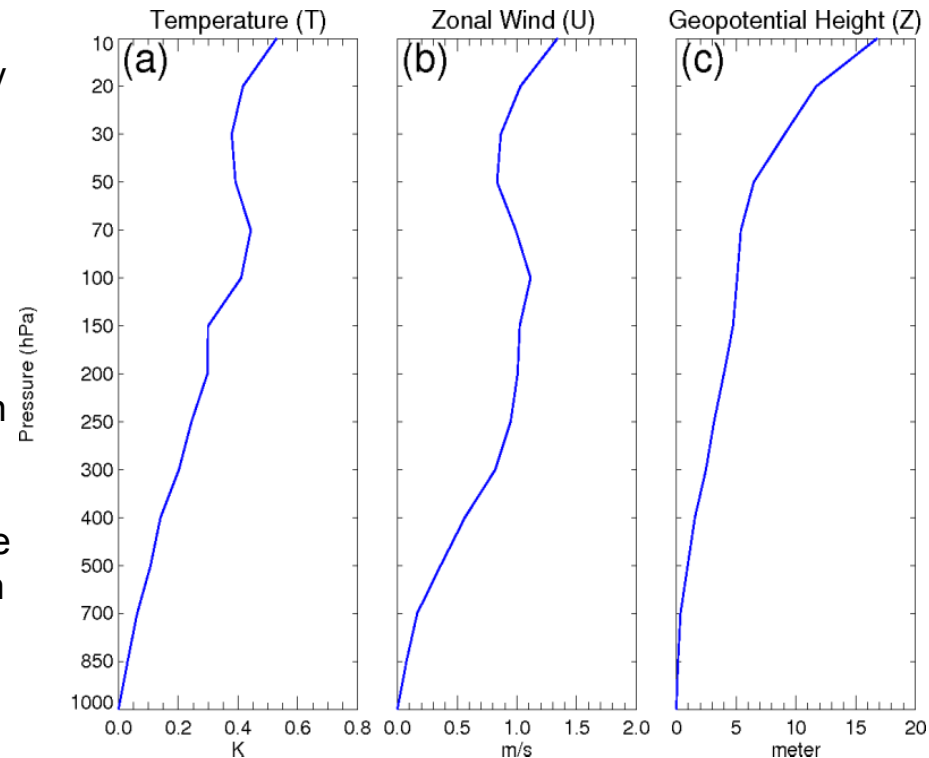
Standard deviation of differences between atmospheric variables along the balloon trajectory and over the upper-air station obtained from simulated observations at 5 degree lat/lon intervals in the Northern Hemisphere extratropics over oceans for January 2009.
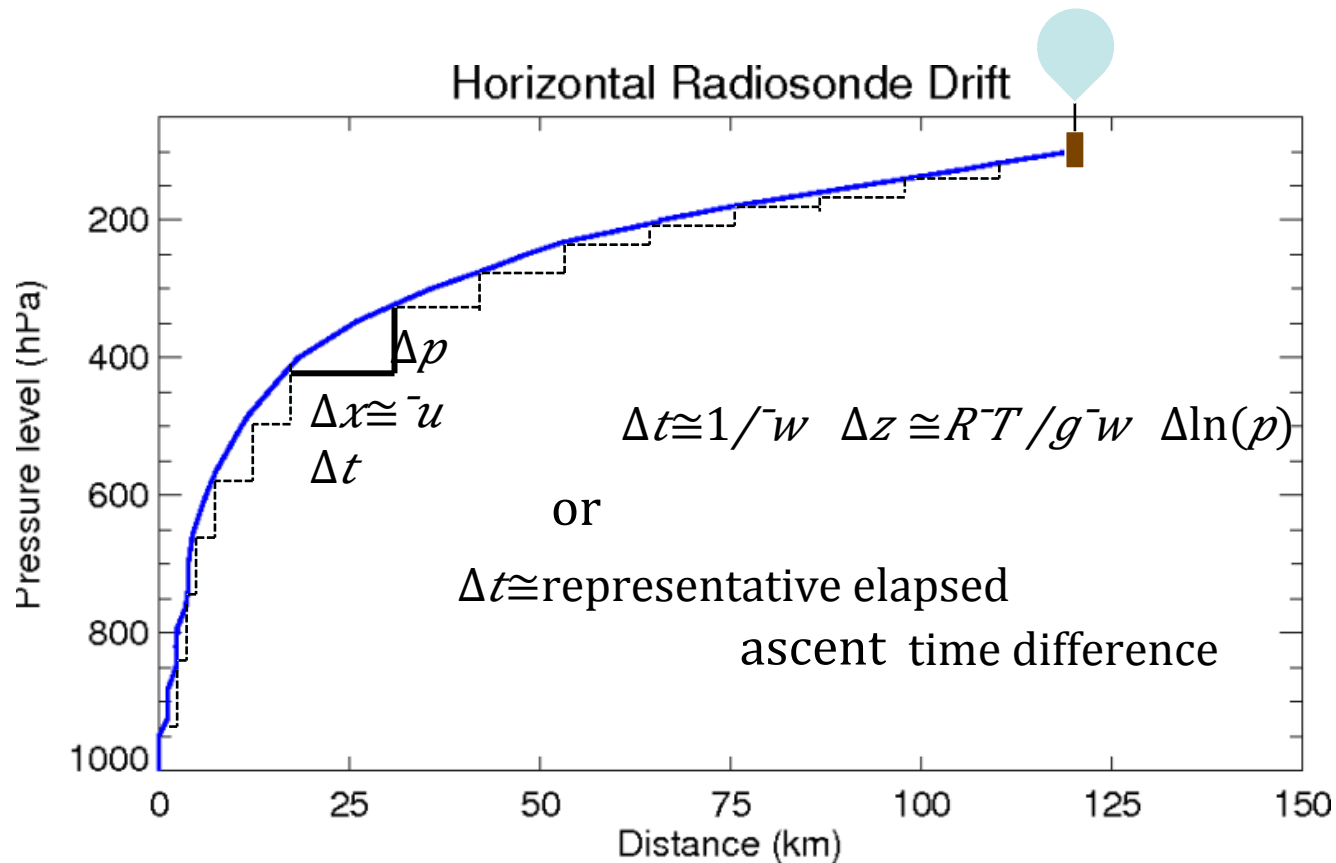
Radiosonde Data Reception and Pre-Processing

- Radiosonde observations are available on the GTS in alphanumeric codes (TEMP or PILOT), and more recently in BUFR. Information about the position and time of observations (i.e 4D trajectory) can now be reported in BUFR code, which is not possible in TEMP/PILOT codes.

- Unfortunately, many radiosonde reports in BURF are currently transmitted without the horizontal position and time of observations.

- When the full 4D trajectory is not transmitted, this information can be estimated from the wind profile and the elapsed ascent time (or ascent speed).

- This pre-processing allow us to feed our data assimilation systems with the 4D trajectory of all radiosonde profiles.
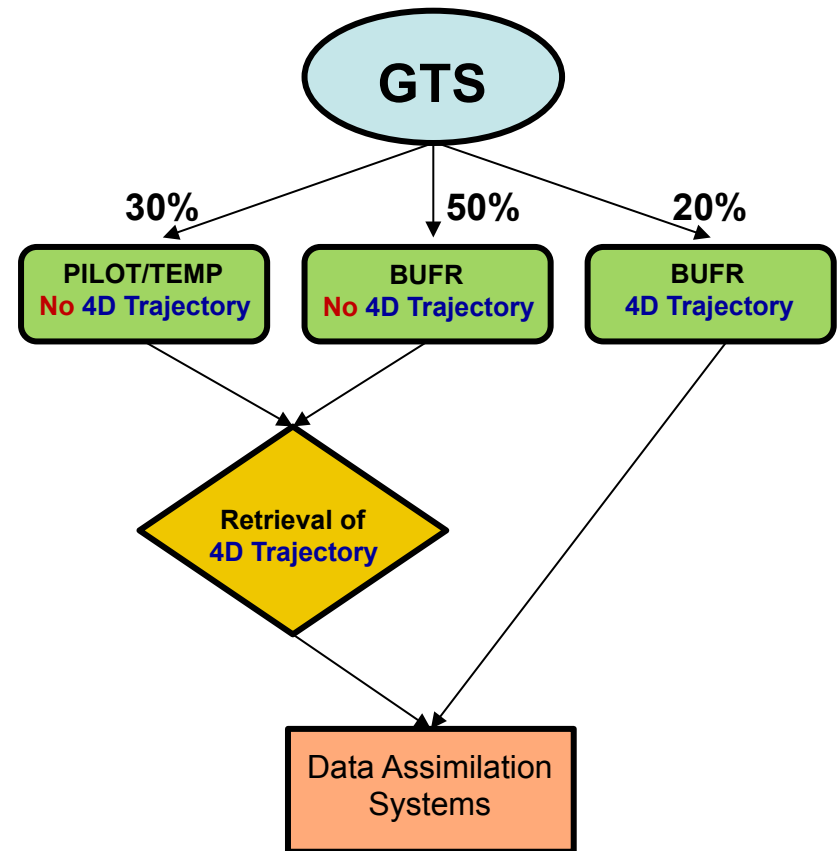
Radiosonde Data Pre-Processing

Estimation of the Horizontal Position and Time of Radiosonde Data

Horizontal Radiosonde Drift

Δp

$\Delta x \cong \bar{u} \ \Delta t$

$\Delta t \cong 1/\bar{w} \ \ \Delta z \cong R\bar{T}/g\bar{w} \ \ \Delta \ln(p)$

or

$\Delta t \cong$ representative elapsed
ascent time difference

Mean Ascent Time and Speed Estimates

- To estimate the mean ascent elapsed time and speed of radiosondes , we used the SPARC dataset in which radiosonde profiles with high resolution 4D positions are available.

- We selected data from a subset of 20 stations over North America in July and December 2008.

- We can see that the mean ascent time and speed for the summer and winter seasons are similar. The mean ascent rate is fairly constant with height and varies around 5 m/s, which is the ascent rate used at NCEP for estimating the horizontal drift position of radiosonde data. These results suggest that the mean of all ascent profiles can be used to estimate the horizontal displacement for all seasons.


Mean Ascent Speed

Mean Elapsed Ascent Time
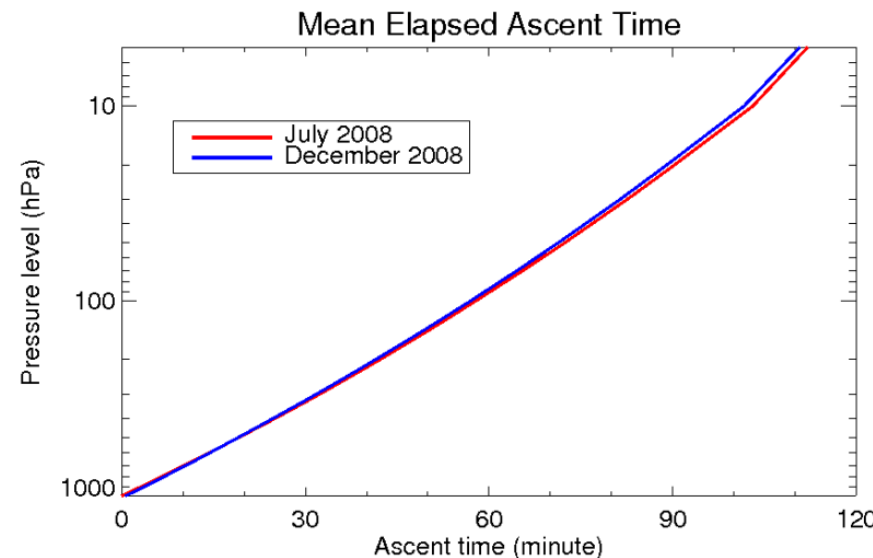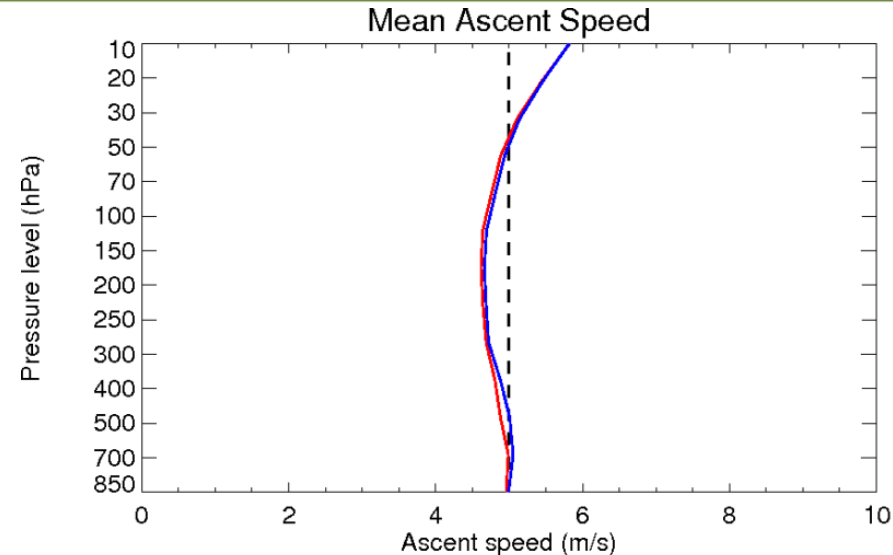
Mean Drift Distance and Position Error

- The position errors are calculated by comparing the retrieved positions with the actual positions from the SPARC dataset, which are obtained from the GNSS.

- The mean horizontal drift distance steadily increases with height and reaches 45 km at 10 hPa for July 2008 and close to 100 km for December 2008.

- Overall, the mean retrieved position is about **10%** of the mean balloon drift distance.

Mean position error July 2008
Mean position error December 2008
Mean drift distance July 2008
Mean drift distance December 2008
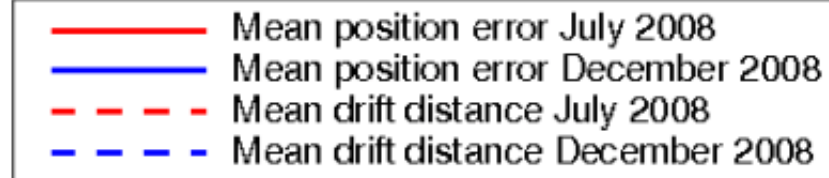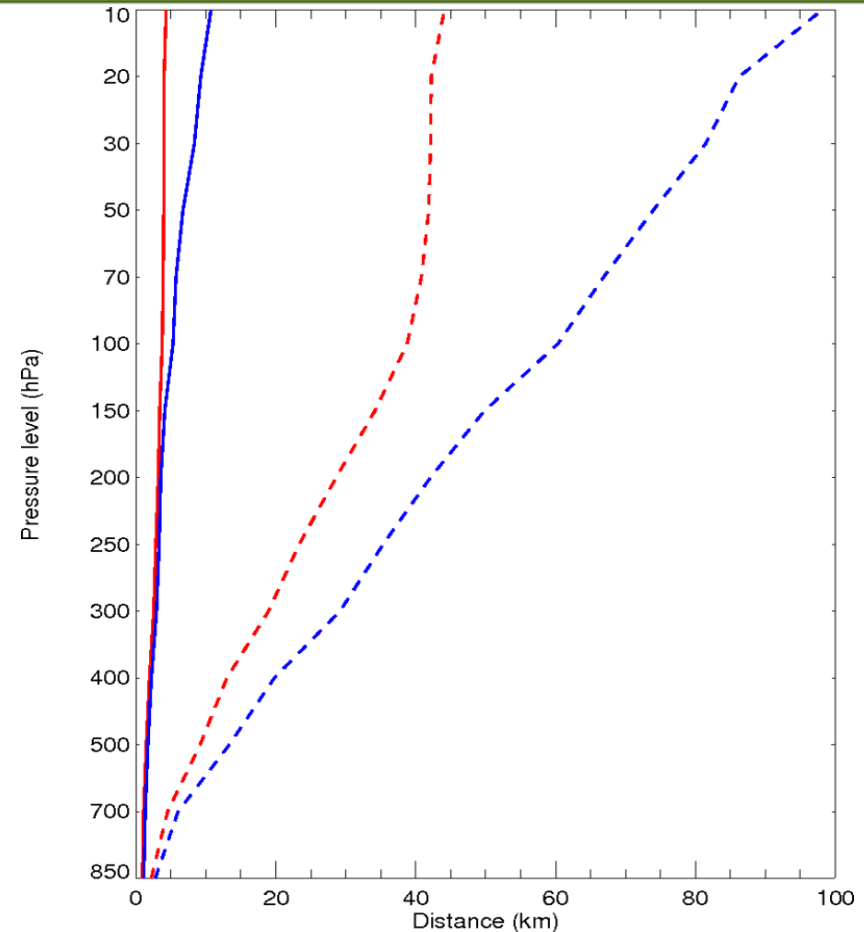
Retrieved Horizontal Position of Radiosonde Profiles over North America

1200 UTC 15 December 2008
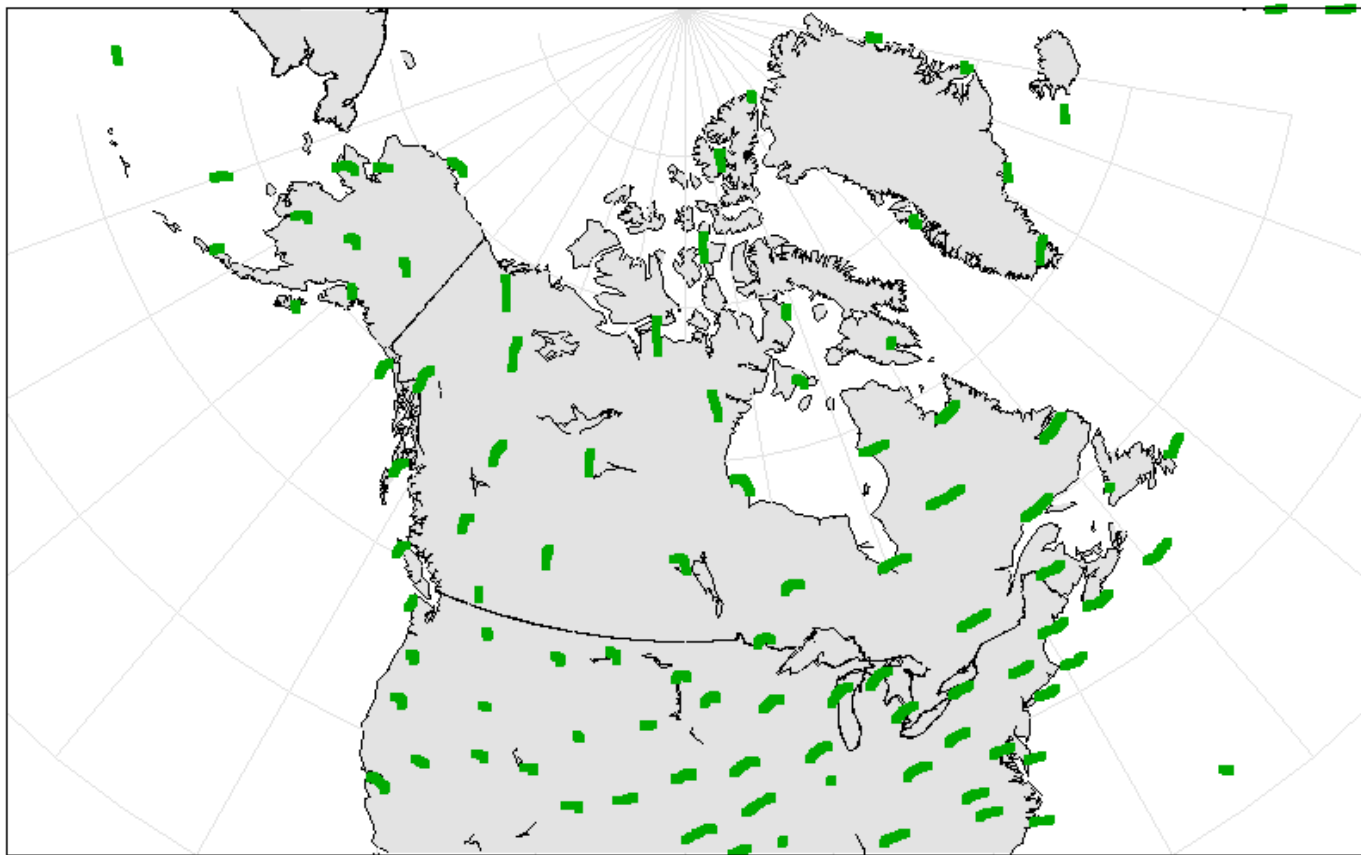
Experiments with the Global Deterministic Prediction System (GDPS)

- **Model** : Operational GDPS (25 km horizontal resolution)
- **Data assimilation system**
  - 4D-EnVar (analysis increments at 50 km resolution)
  - Hybrid background error statistics (50% NMC, 50% EnKF)

- **Observations**
  - All operational data from conventional and satellite platforms

- **Period : 1 February – 31 March 2011**
  - **Control** : Time and horizontal position at the launch location are assigned to all radiosonde data
  - **Trial** : Retrieved 4D trajectory for all radiosonde data

Residual and Innovation Statistics
(February and March 2011)

- Verification scores against radiosonde data for wind components for the control (blue) and the trial (red) over the Northern Hemisphere extratropics.

- The bias (dashed) and standard deviation (solid) are shown.

- As expected the impact of the horizontal drift become significant above 300 hPa.

U component   **V component**

Observation - Analysis

Observation - Background
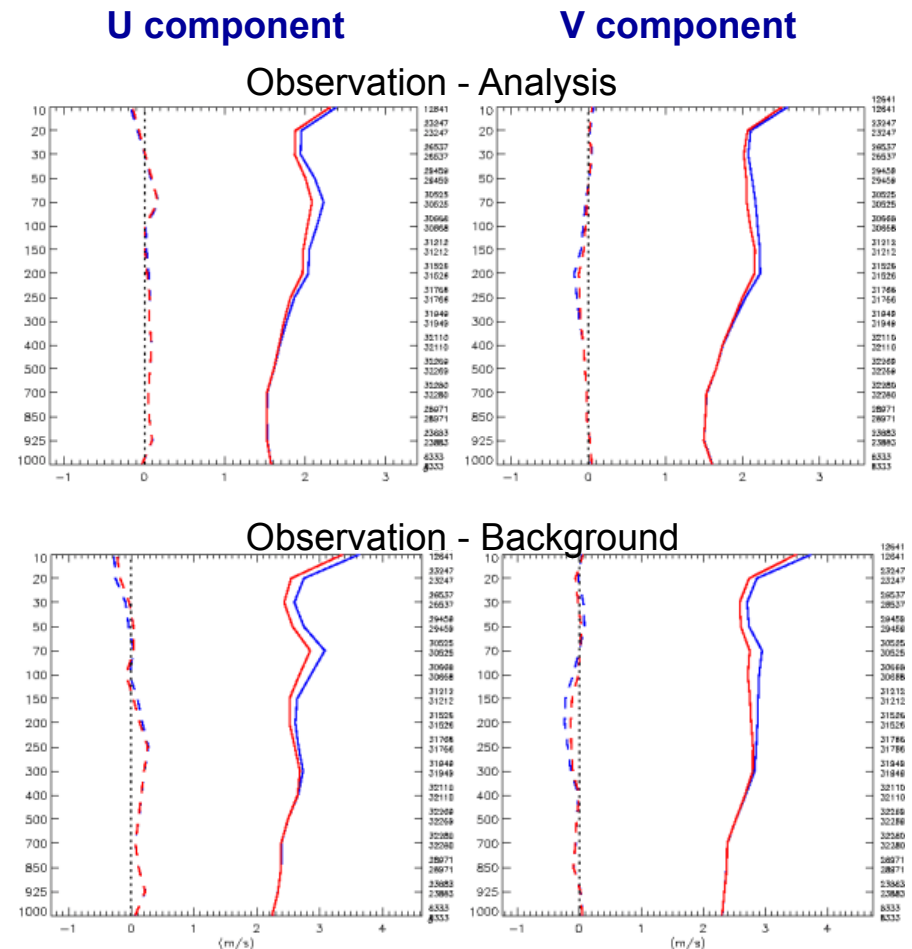
Control : Time and Horizontal Position at the Launching site assigned to all Radiosonde Data
Trial : Retrieved 4D trajectory for all Radiosonde Data

Impact of Radiosonde Horizontal Position and Time on Day-1 to Day-3 Forecasts over the Northern Hemisphere

Against Own Analysis
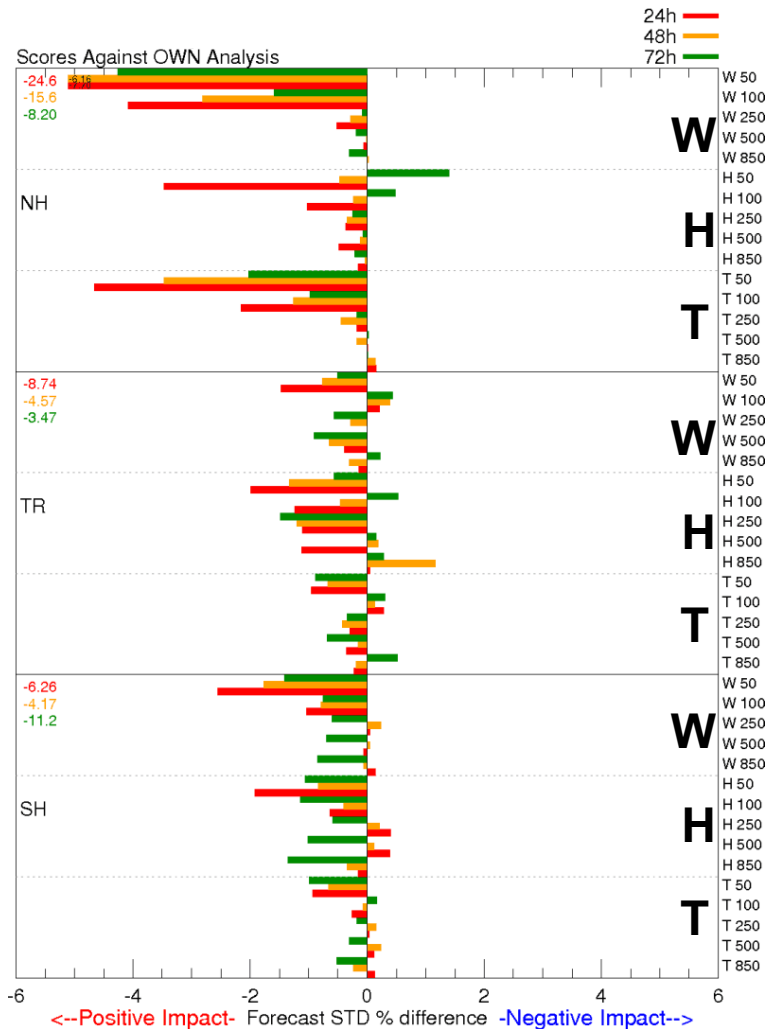
Against Radiosonde data
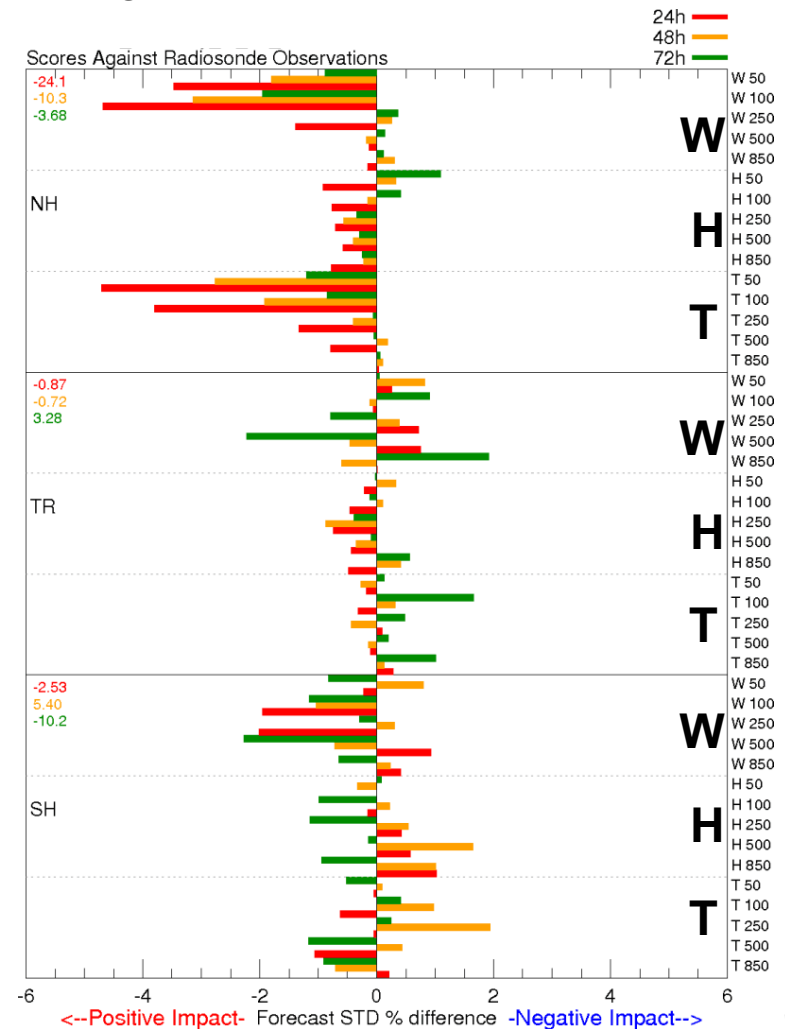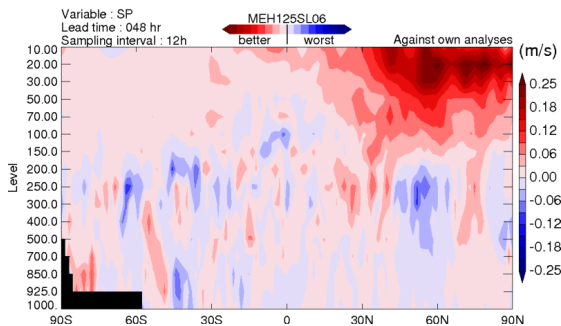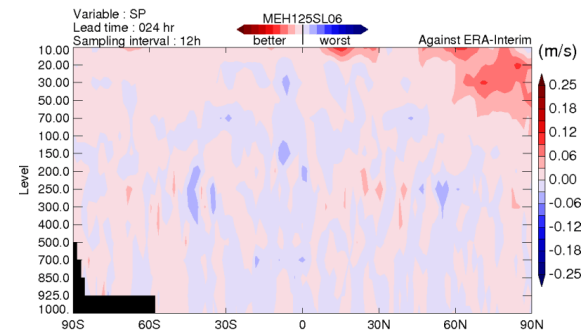
Impact of Radiosonde Horizontal Position and Time
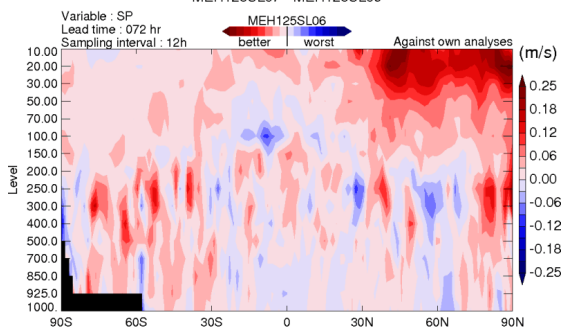## Day-1 to Day-3 Zonal Mean STD Error Difference for Wind Speed (Control – Trial)
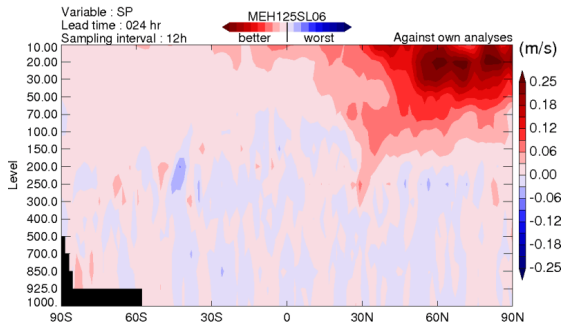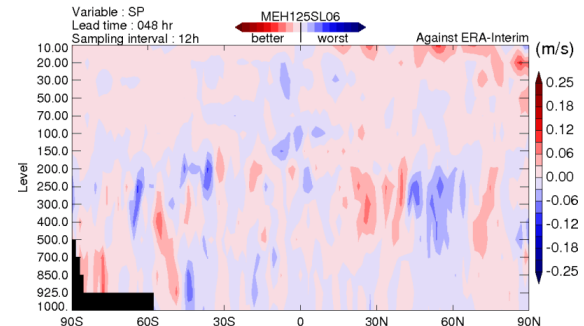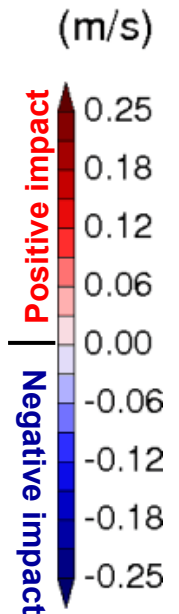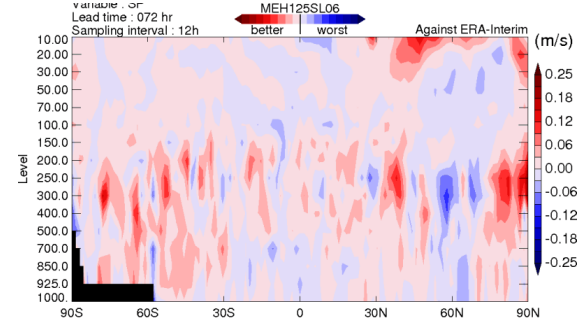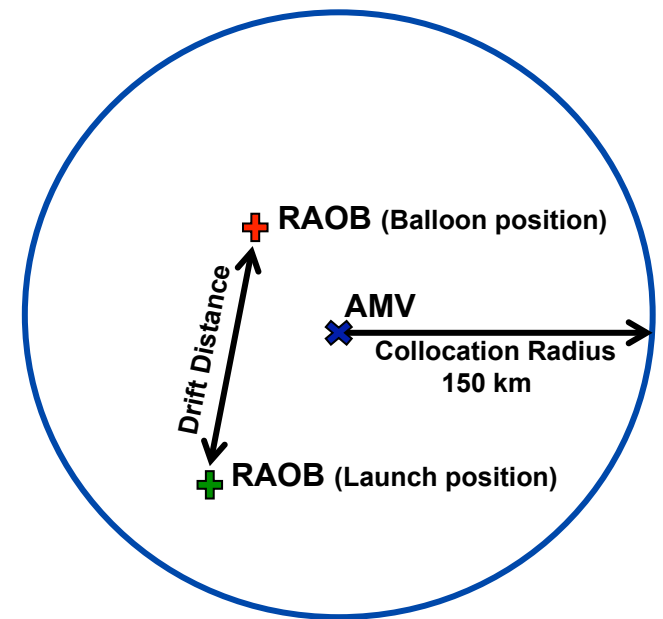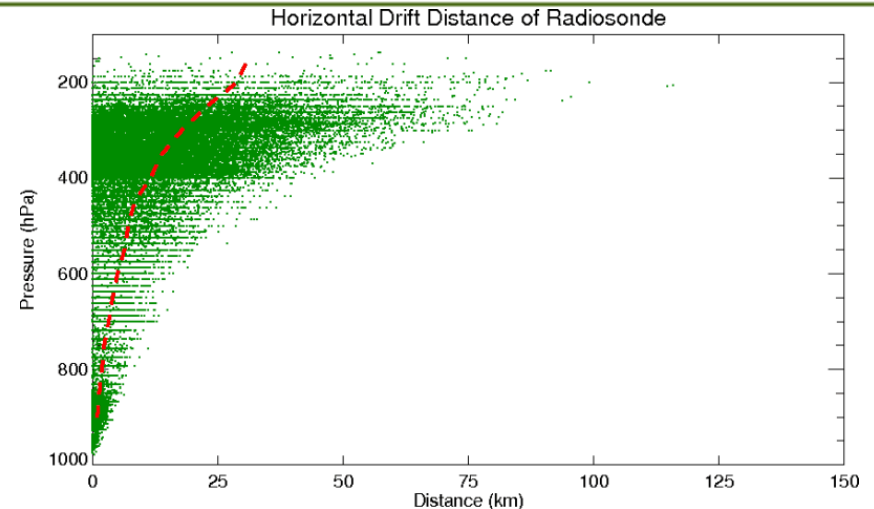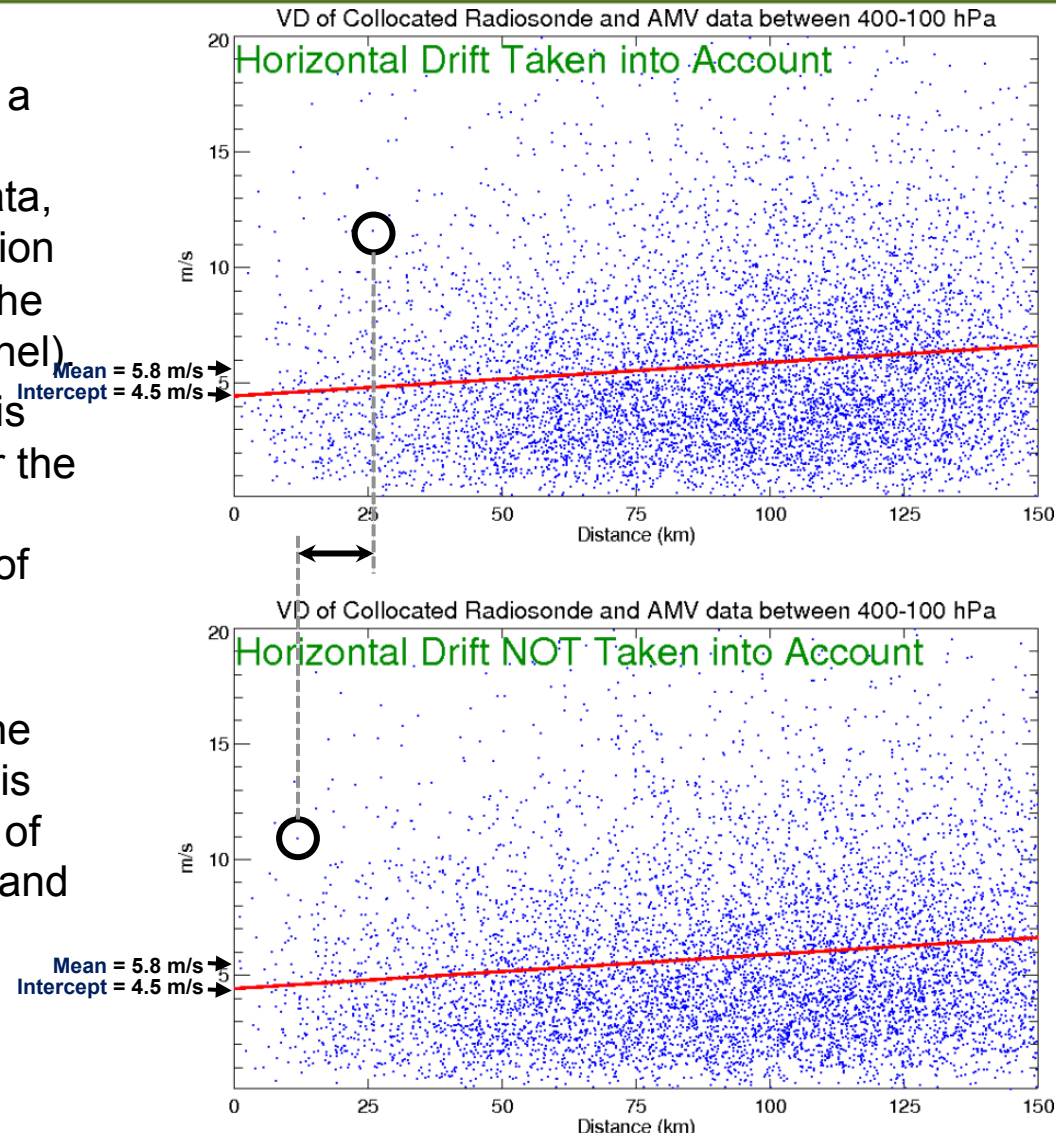
Impact of the Horizontal Position of Radiosonde on the Comparison between Radiosonde and AMV Data

- To assess the impact of the horizontal drift on collocation statistics, we use collocated radiosonde and AMV data (both IR and WV that passed the quality check) from all geostationary satellites available in February and March 2011.

- Radiosonde data are vertically interpolated at the reported AMV levels.

- Only data that match within 150 km and 1 hour from both the launch and radiosonde positions and times are retained.

- Only data north of 30N and within the 400-100 hPa layer are considered.

- With all these criteria, a total of 8274 matches are found for the two-month period.

Horizontal Drift Distance of Radiosonde

Impact of the Horizontal Position of Radiosonde on the Comparison between Radiosonde and AMV Data

- All collocated vector root-mean-square differences are plotted as a function of separation distance between AMV and radiosonde data, when the actual radiosonde position is used (upper panel) and when the launch position is used (lower panel).

- By construction, the mean value is the same in both cases. However the zero intercept is expected to be smaller when the actual position of the radiosonde is employed.

- However, the zero intercepts are here the same, suggesting that the position error of radiosonde data is small compared to other sources of error (e.g. AMV tracking, vertical and horizontal positions of both observation types, etc.).

VD of Collocated Radiosonde and AMV data between 400-100 hPa
Horizontal Drift Taken into Account
Mean = 5.8 m/s
Intercept = 4.5 m/s

VD of Collocated Radiosonde and AMV data between 400-100 hPa
Horizontal Drift NOT Taken into Account
Mean = 5.8 m/s
Intercept = 4.5 m/s

AMV Usage at MSC

- **Platforms**
  - GEO : GOES 13/15 ; Meteosat 7/10 ; MTSAT-2
  - POLAR : AVHRR NOAA 15/18/19 Metop A/B; MODIS Terra/Aqua

- **Spatial thinning/screening**
  - 1.5 degrees for GEO AMVs; 180 km for POLAR AMVs
  - 11 vertical layers; zenith angle < 55 degrees
  - No GEO AMVs over Land North of 25N (20N for GOES)

- **Temporal thinning**
  - 2-hourly for GEO AMVs; no temporal thinning for POLAR AMVs

- **Quality control**
  - QI > 85 ; RFF > 60 to 80 for GOES and MODIS
  - Background check and Var-QC

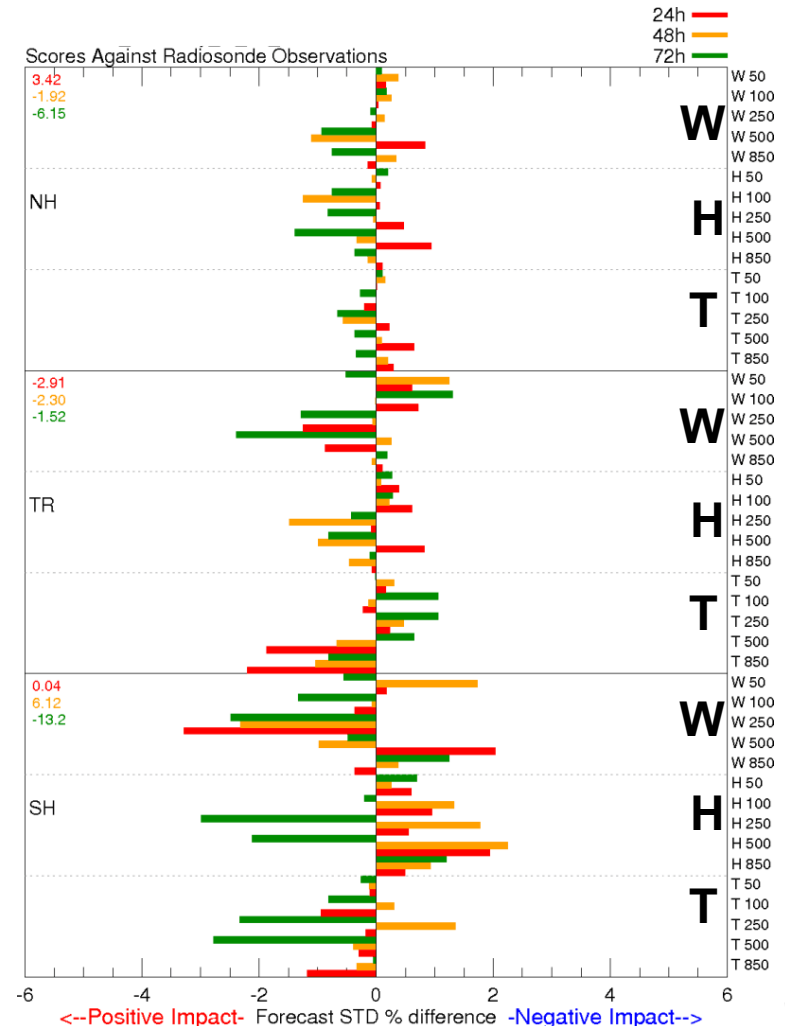- **Observation errors**
  - Static for all AMVs

Level (hPa)	Error (m/s)
100	6.0
150	5.5
200	5.5
250	5.5
300	5.0
400	4.5
500	4.0
700	3.0
850	2.5
925	2.5
1000	2.5

Impact of AMV Data on
Day-1 to Day-3 Forecasts over the Northern Hemisphere
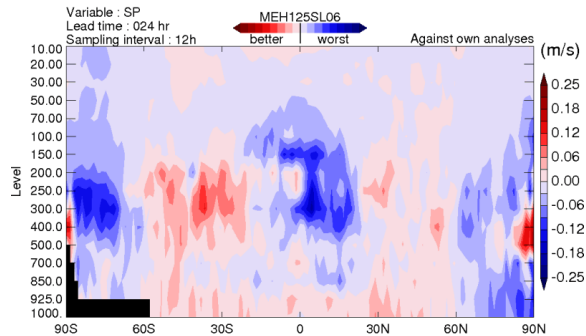## (February-March 2011)

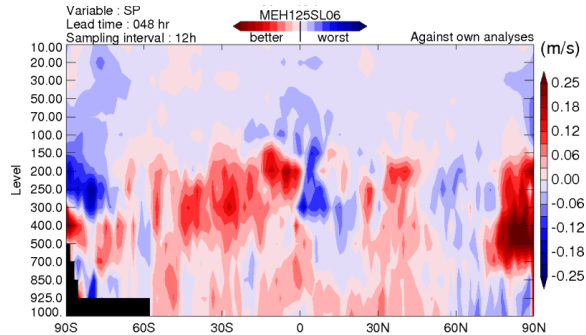### Against Own Analysis
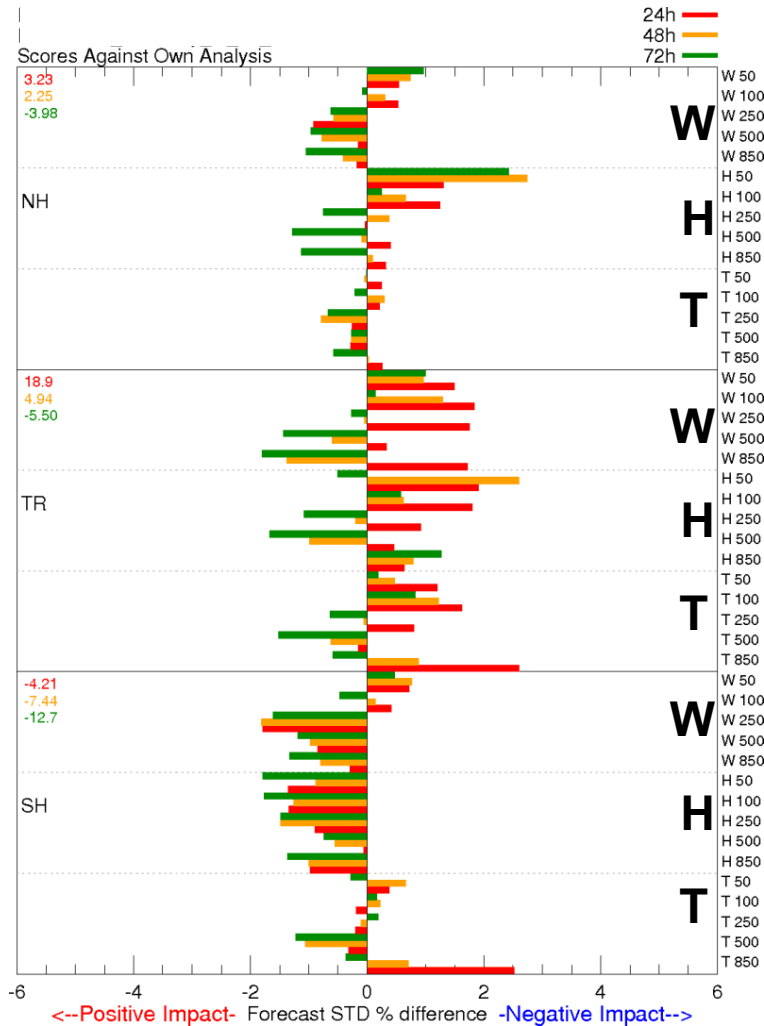
Against Radiosonde data

Impact of AMV Data
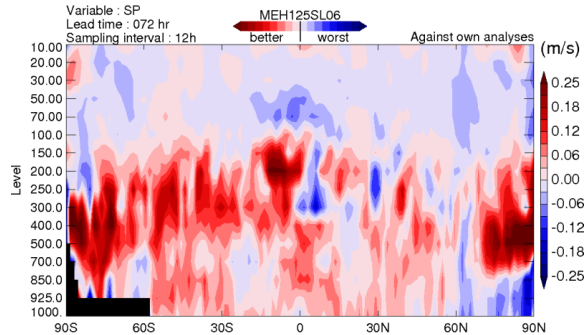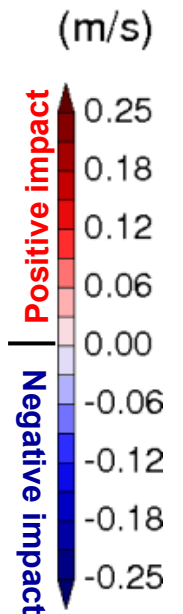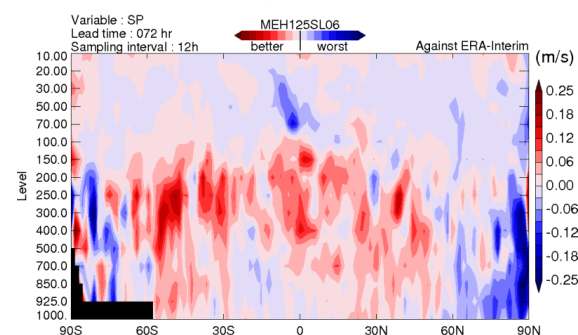## Day-1 to Day-3 Zonal Mean STD Error Difference for Wind Speed (Control – No AMV)
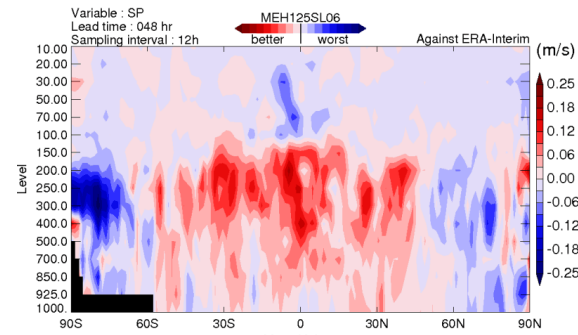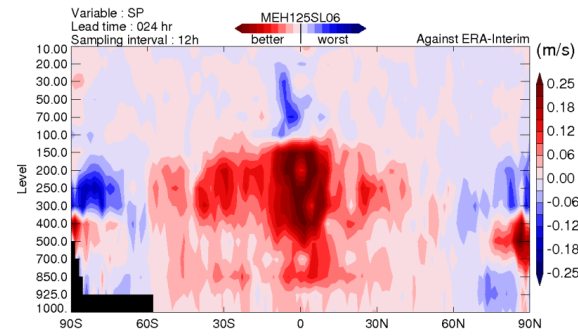
Plans for Improving AMV Usage at MSC

- Examine the consistency between AMVs and short-range wind forecasts over the Tropics.
- Assimilate additional AMVs with zenith angle beyond 55, those over Land North of 20N, and from other data providers.
- Revisit the spatial and temporal thinning strategies based on observation error correlation estimates.
- Improve the quality control processing.
- Upgrade the observation error statistics (static vs situation dependent).

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O-F 400-100 hPa

O-F 700-400 hPa

O-F 1000-700 hPa