Impact of the Aeolus L2B HLOS winds in the ECCC global forecast system

by

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(3rd Aeolus NWP impact and L2B product quality working meeting)

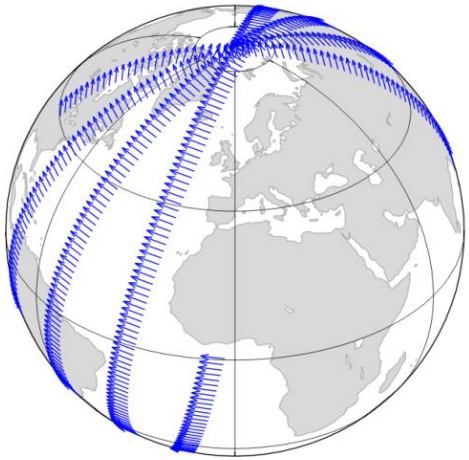
Outline

- Model and experimental setup
- Near real-time B06 and reprocessed B10 HLOS winds usage
- Look-up table bias correction method for 2B06 HLOS winds
- OSEs for Summer 2019 (August-September)
  - Impact bias-corrected B06 HLOS winds
  - Impact of B10 HLOS winds
  - Impact of AMVs
- Conclusions

The ECCC Global Deterministic Prediction System (GDPS) and Experimental Setup

- **Operational version** (July 2019)
  - Atmospheric GEM model coupled with NEMO ocean model
  - **15 km** horizontal grid spacing
  - 4D-EnVar data assimilation system with hybrid background error statistics ($\mathbf{B}_{nmc}$, $\mathbf{B}_{ens}$)
  - $\mathbf{B}_{ens}$ estimated from the ensemble forecast system
- **Simplifications made for the OSEs**
  - **39 km** horizontal grid spacing
  - $\mathbf{B}_{ens}$ and ocean fields from operational used in all experiments

HLOS wind processing as recommended by ECMWF



- Only **Rayleigh-clear** and **Mie-cloudy** HLOS winds are used
- Remove all HLOS winds within 20 hPa (~250 m) of the surface
- Remove Rayleigh winds at pressure level > 850 hPa.
- Remove Rayleigh winds with:
  - σ_{L2Bp} > 12 m/s if pressure <= 200 hPa
  - σ_{L2Bp} > 8.5 m/s if pressure > 200 hPa
  - Horizontal accumulation length < 60 km
  - Vertical accumulation length < 300 m
- Remove Mie winds with σ_{L2Bp} > 5 m/s

Additional data processing
- Gaussian background check
- VarQC

- Observation operator : **HLOS wind = - u sin θ - v cos θ**
- Assigned **HLOS wind errors** in the data assimilation system based on σ_{L2Bp}
  - **1.40 σ_{L2Bp} for Rayleigh winds**
  - **1.25 σ_{L2Bp} + 2.0 m/s for Mie winds**

Look-up table bias correction method for the B06 data

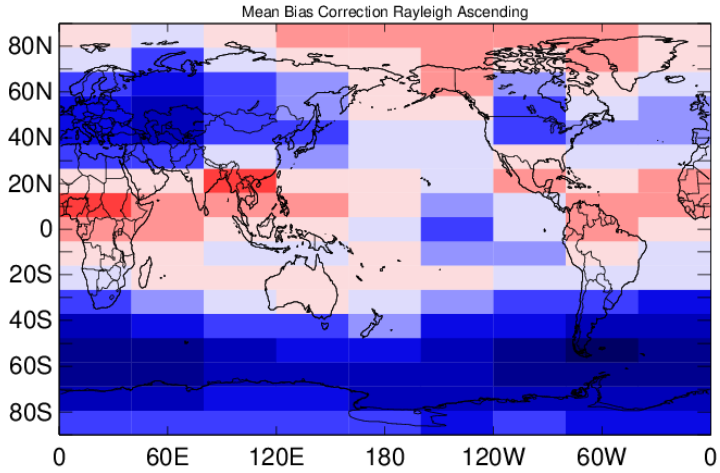
- We developed a bias correction scheme similar to the one first implemented at ECMWF :
  - The bias correction is based on the mean (O-B) from the previous 7 days as a function of orbit phase and latitude band (10^o wide) for both Rayleigh and Mie winds. O is the HLOS wind, B is the corresponding background (short-range forecast) from the operational (15 km) GEM model.
  - For Rayleigh winds, the correction is also as a function of longitude (36^o wide)
  - We applied this bias correction (BC) to the B06 data (hereafter **BC_B06**)

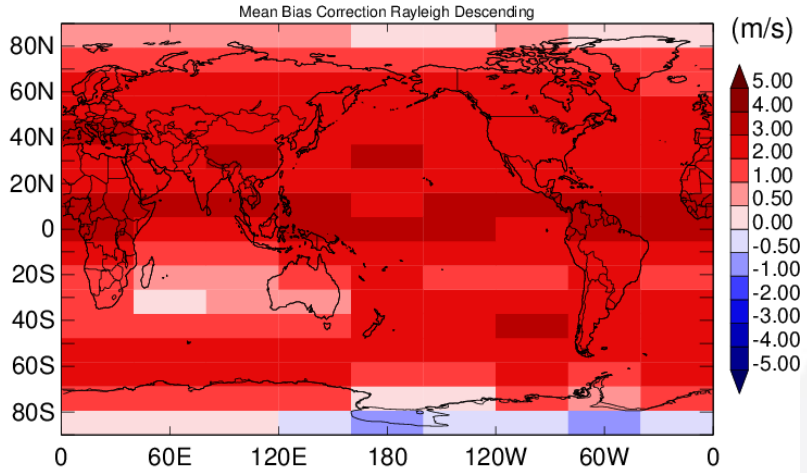
Mean Bias Correction for the B06 data Summer 2019

Ascending orbit phase

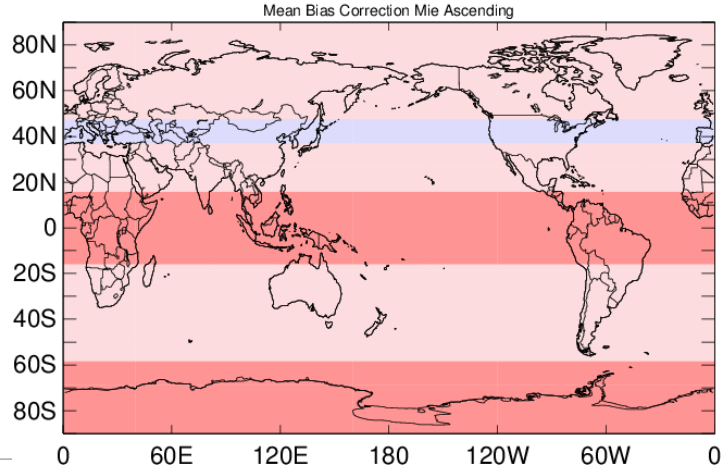
Descending orbit phase

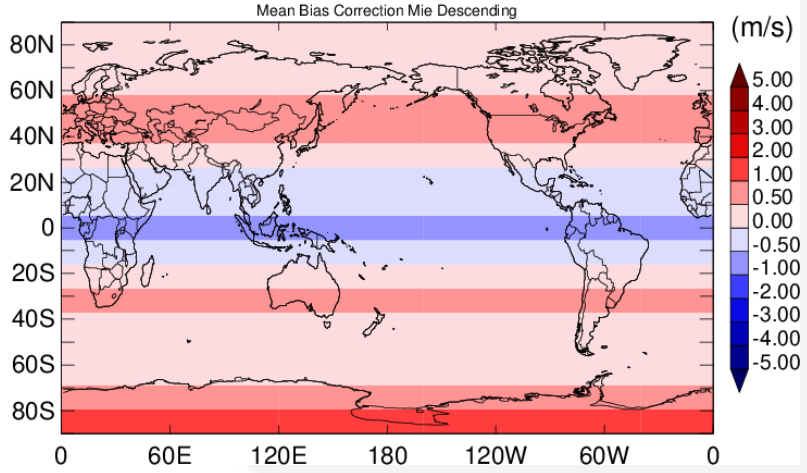
Rayleigh winds





Mie winds





From the look-up table bias correction method

Mean O-B for Rayleigh winds Summer 2019

B06

(No bias correction applied)

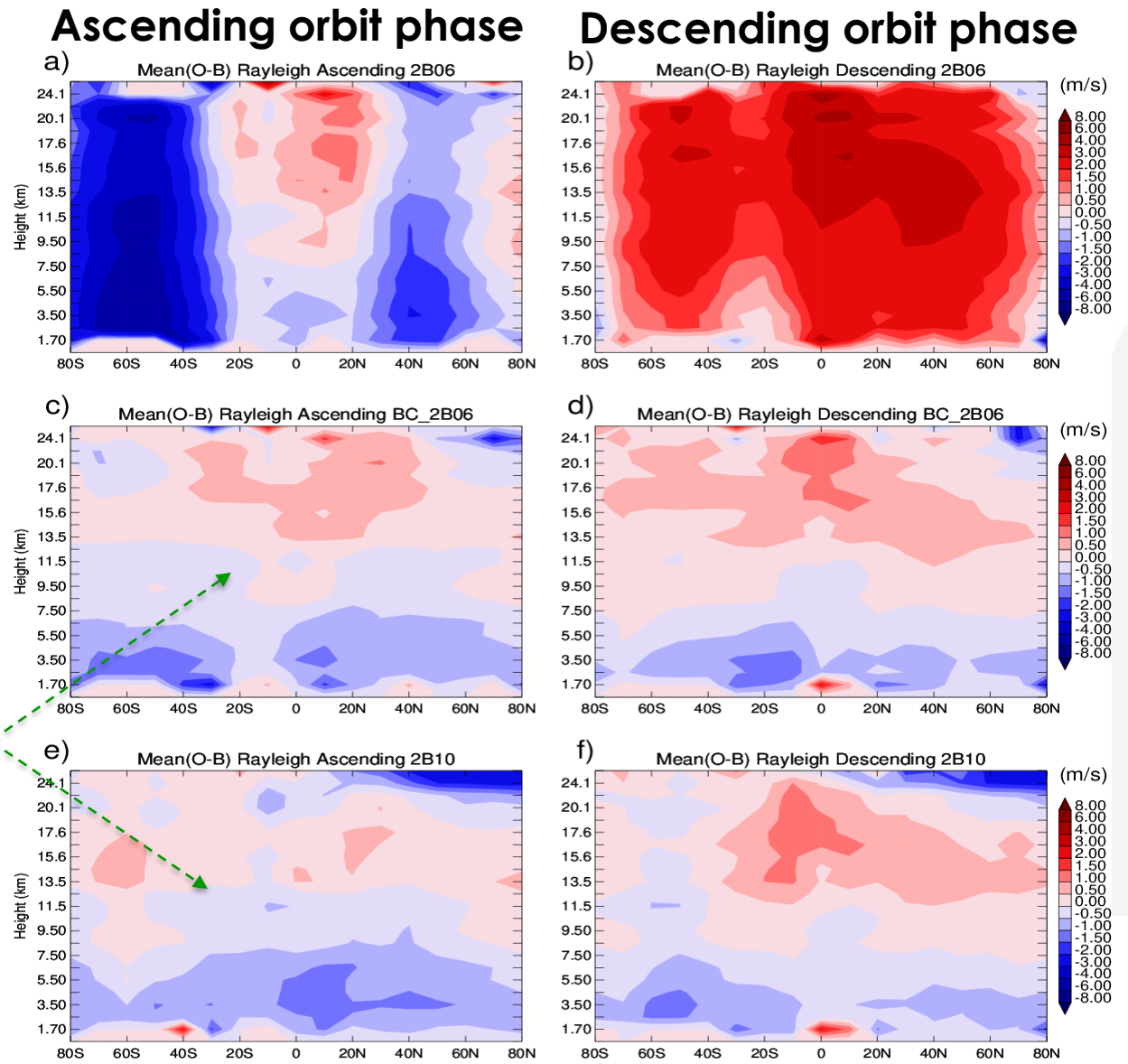
BC_B06

(Look-up table bias correction)

Mean residual biases in both **BC_B06** and **B10** data that mainly vary with height for both ascending and descending orbit phases

B10

(M1 temperature bias correction)

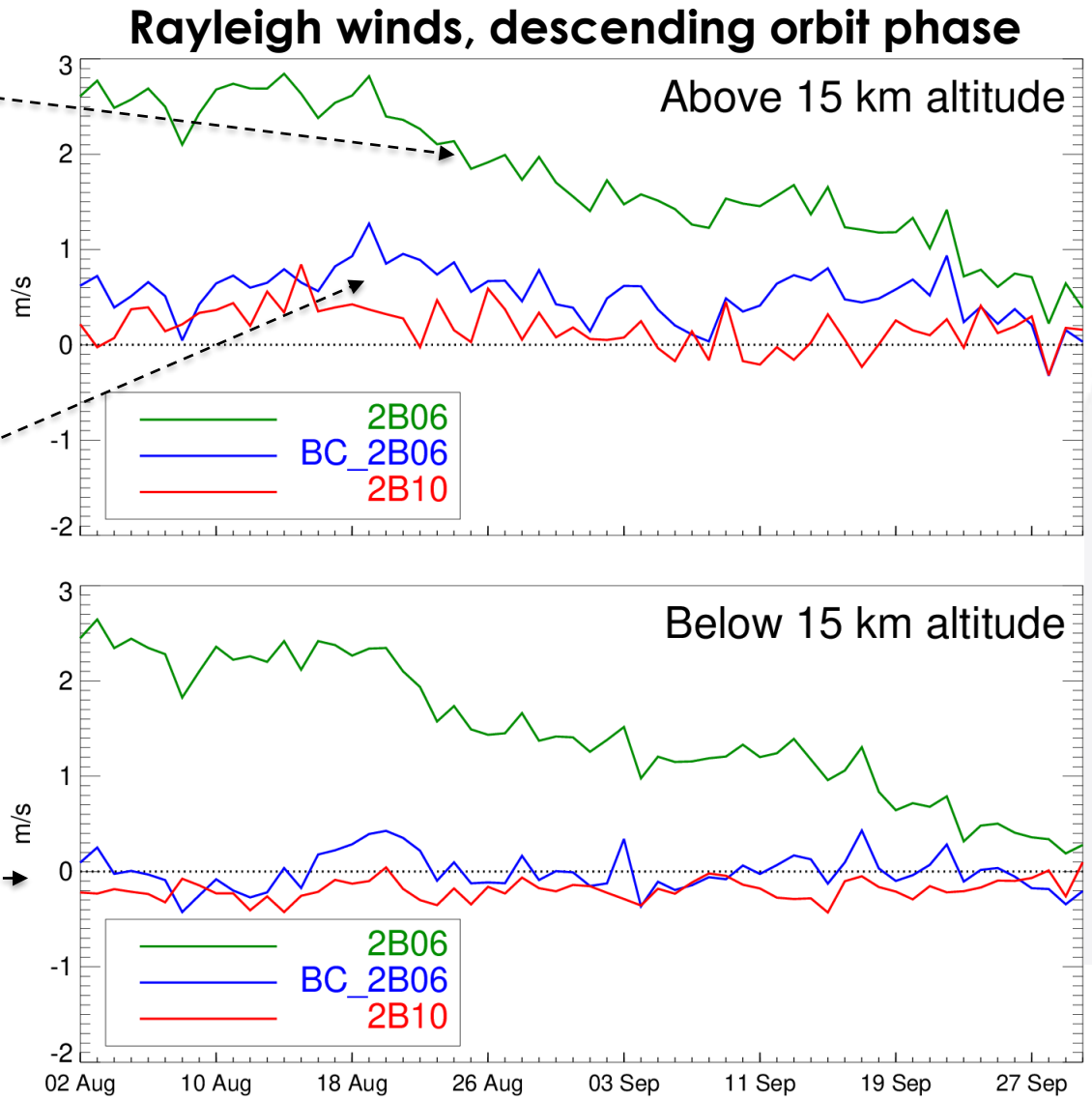


Daily mean O-B over Southern Hemisphere Summer 2019

Large mean O-B for the uncorrected **B06** data that decreases in time over the summer 2019 period

Larger residual mean O-B for the **BC_B06** data in the stratosphere

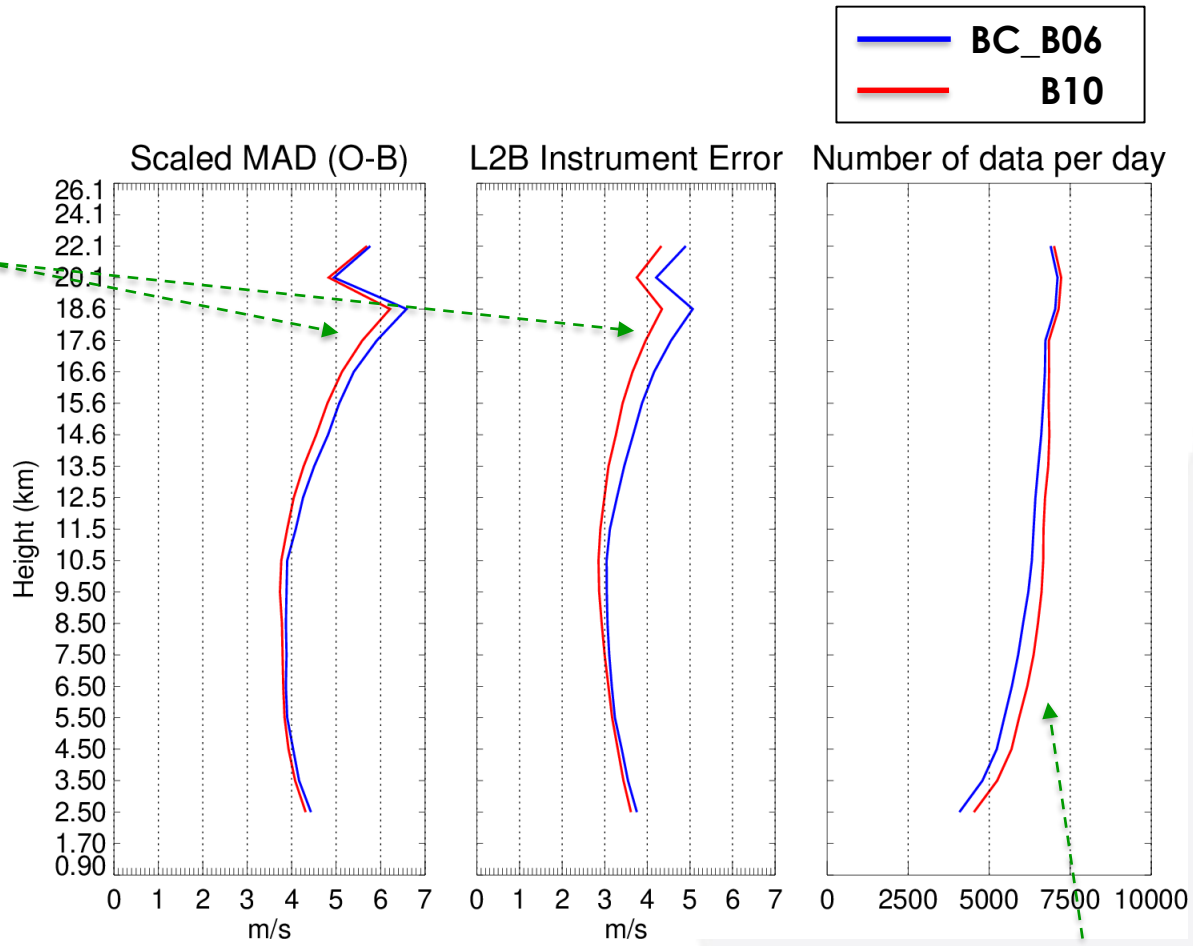
Residual mean O-B smaller than 0.5 m/s for both **BC_B06** and **B10** data in the troposphere



Random errors and number of observations for Rayleigh winds over the Globe Summer 2019

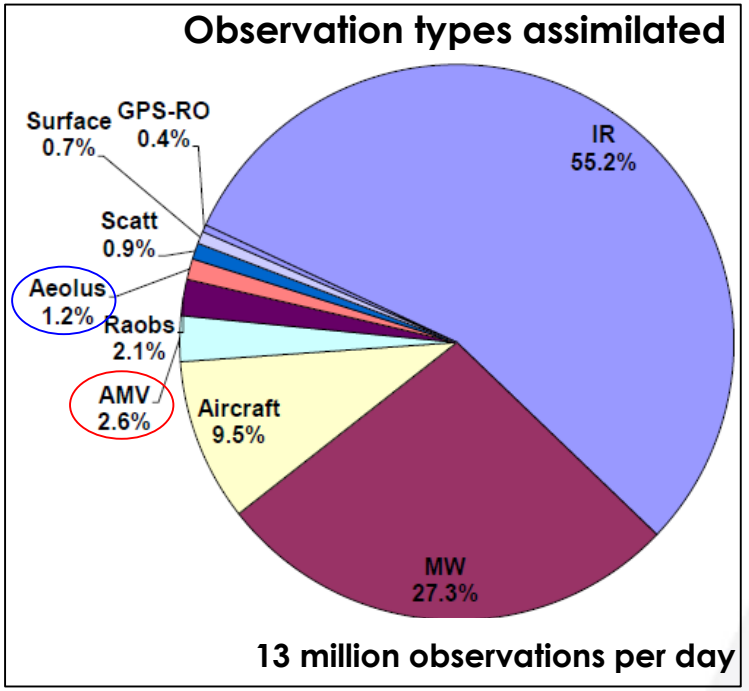
Smaller MAD of O-B and L2B instrument error for the reprocessed data, especially in the stratosphere

Good agreement in the vertical variation between scaled MAD of O-B and L2B instrument error



Larger number of reprocessed data in the troposphere

Observation System Experiments Summer 2019



Experiments	Aeolus data used	Bias correction method
1.0 All operational observation assimilated (CNTRL)	-	-
1.1 CNTRL plus HLOS Winds (CNTRL+BC_B06)	Bias-corrected B06	Look-up table
1.2 CNTRL plus HLOS Winds (CNTRL+B10)	Reprocessed : B10	M1-temperature
2.0 CNTRL without AMVs (CNTRL-AMV)	-	-
2.2 CNTRL-AMV plus HLOS Winds (CNTRL-AMV+B10)	Reprocessed : B10	M1-temperature

Impact of BC_B06 HLOS winds on forecasts

(CNTRL+BC_B06 vs CNTRL)

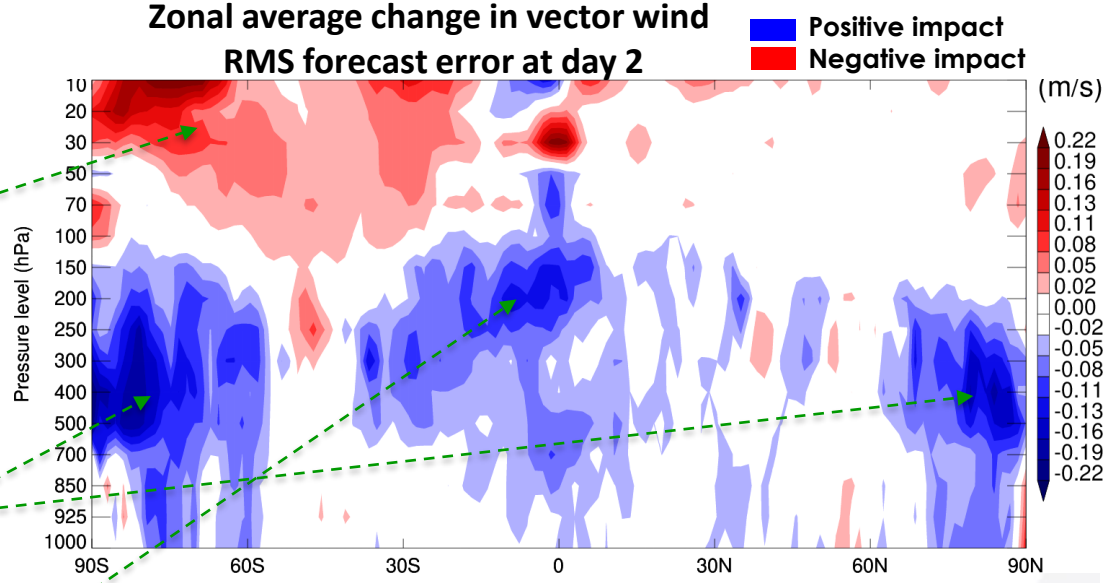
Negative impact in the stratosphere over the Southern Hemisphere

Positive impact in the mid-upper troposphere over the polar regions

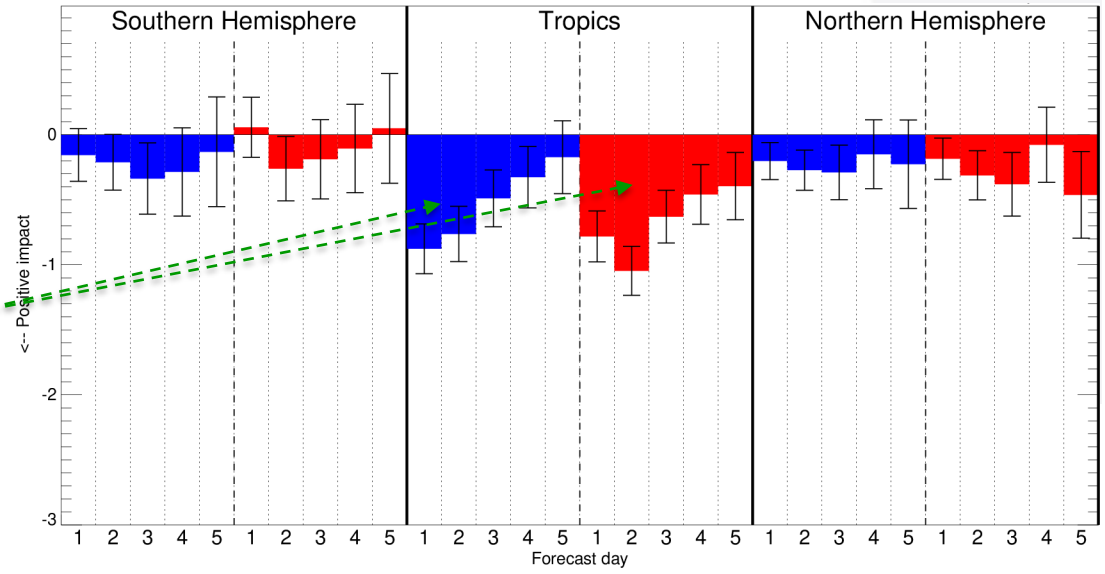
Positive impact in the UTLS over the tropics

Significant positive impact over the tropics on both temperature and wind fields up to day 4

Zonal average change in vector wind RMS forecast error at day 2



Normalized change (in %) in forecast error of temperature (blue) and vector wind (red) in the troposphere



The verification scores are made against the ECMWF operational analyses. Vertical bars indicate the 95% statistical confidence intervals.

Impact of B10 HLOS winds on forecasts

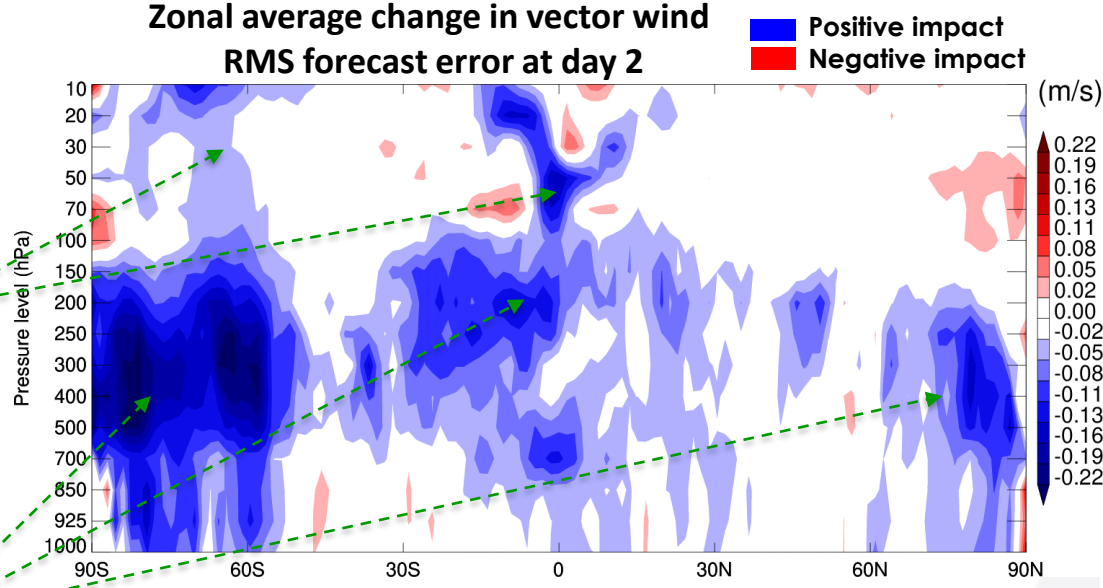
(CNTRL+B10 vs CNTRL)

Slightly positive impact in the stratosphere over the Southern Hemisphere and tropics

Enhanced positive impact over the tropics and polar regions

Mostly positive and significant impact over all areas

Zonal average change in vector wind RMS forecast error at day 2



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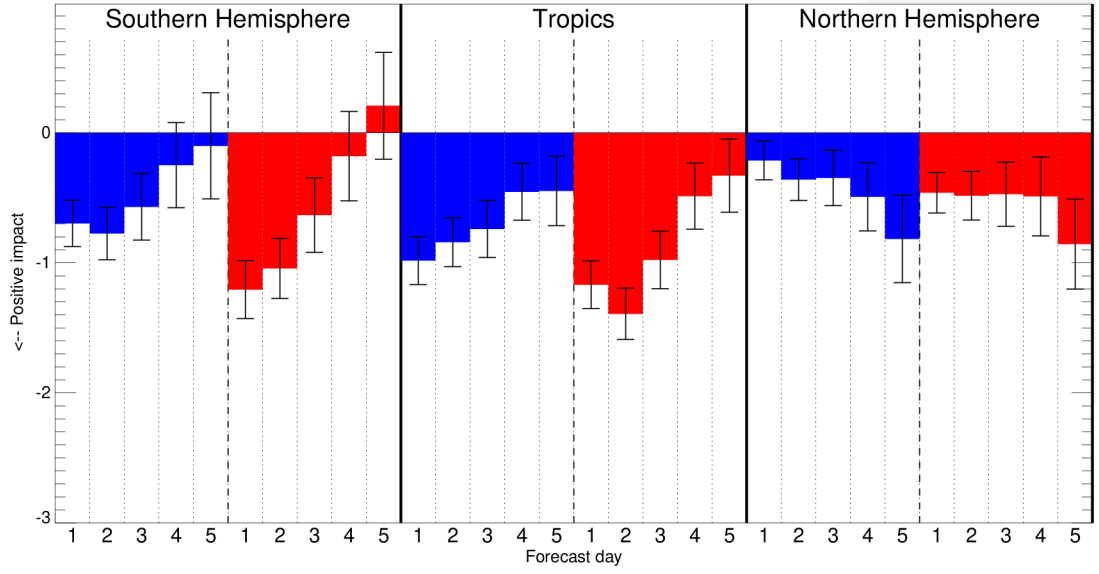


The verification scores are made against the ECMWF operational analyses. Vertical bars indicate the 95% statistical confidence intervals.

Impact of B10 HLOS winds on forecasts when AMVs are withheld

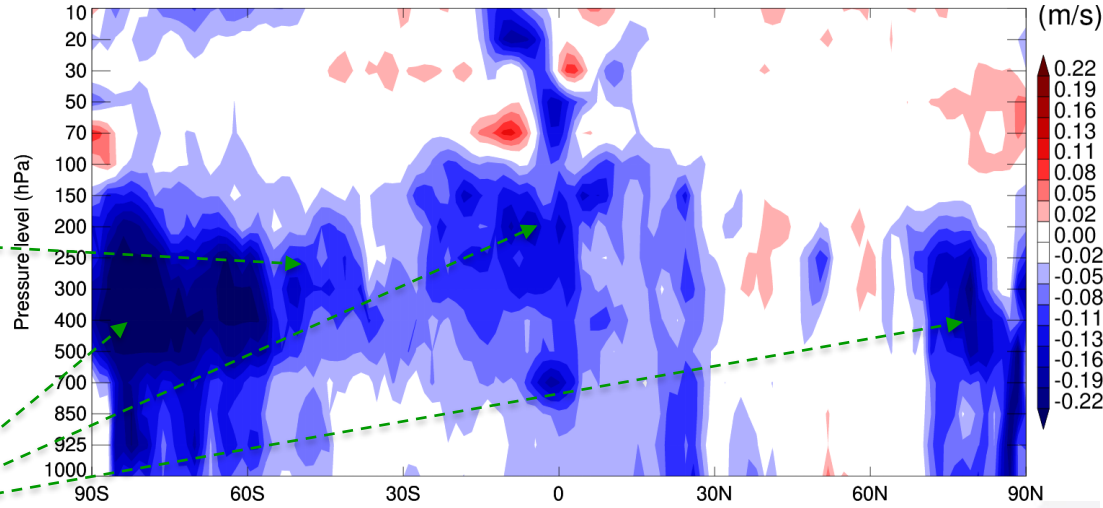
(CNTRL-AMV+B10 vs CNTRL-AMV)

Positive impact in the mid-upper troposphere over the Southern Hemisphere extratropics

Enhanced positive impact over the tropics and polar regions

The impact of the HLOS winds on forecasts is enhanced by approximately 40% over the Southern Hemisphere and tropics when the AMVs are not assimilated

Zonal average change in vector wind RMS forecast error at day 2



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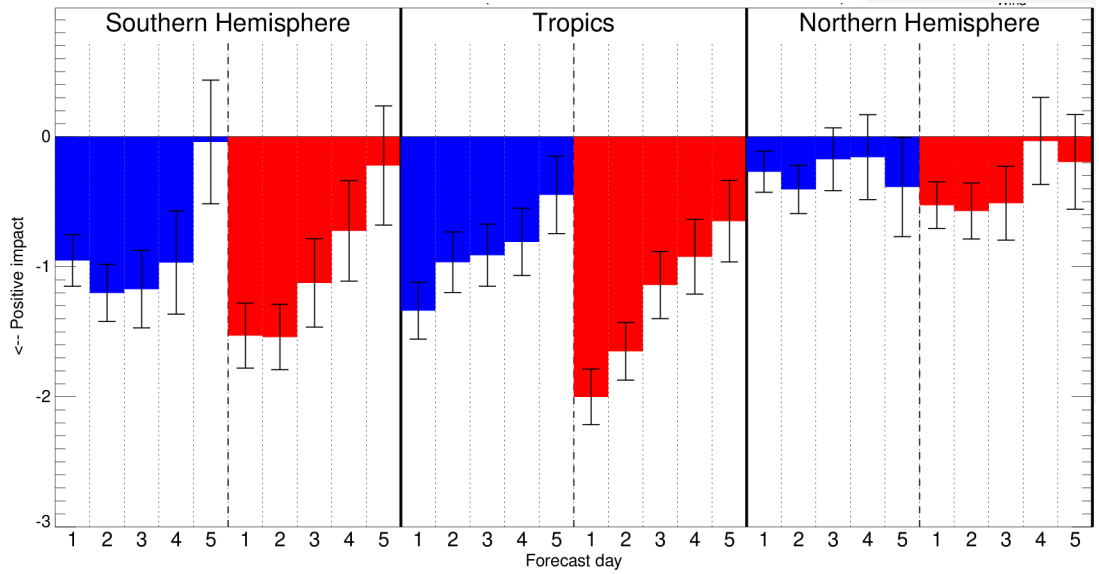


The verification scores are made against the ECMWF operational analyses. Vertical bars indicate the 95% statistical confidence intervals.

Impact of AMVs on forecasts

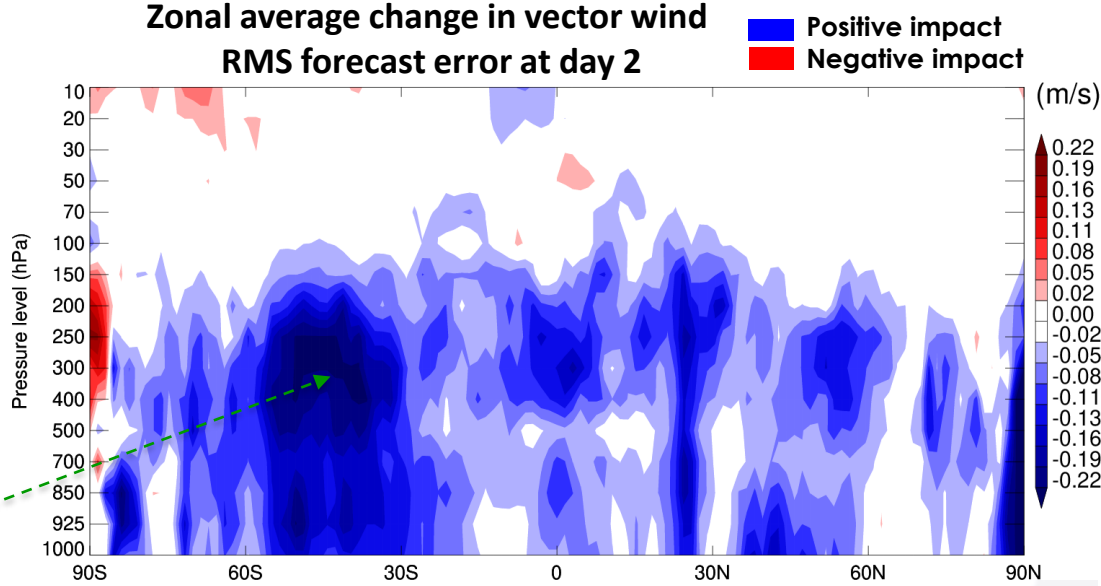
(CNTRL vs CNTRL-AMV)

Positive impact of AMVs in the troposphere (below 100 hPa) over most of the globe

Largest impact over the Southern Hemisphere extratropics

The impact of AMVs is approximately twice larger than the impact of the HLOS winds in the extratropics. Conversely, the impact of HLOS winds on forecasts is generally larger in the tropics, except at day 1

Zonal average change in vector wind RMS forecast error at day 2



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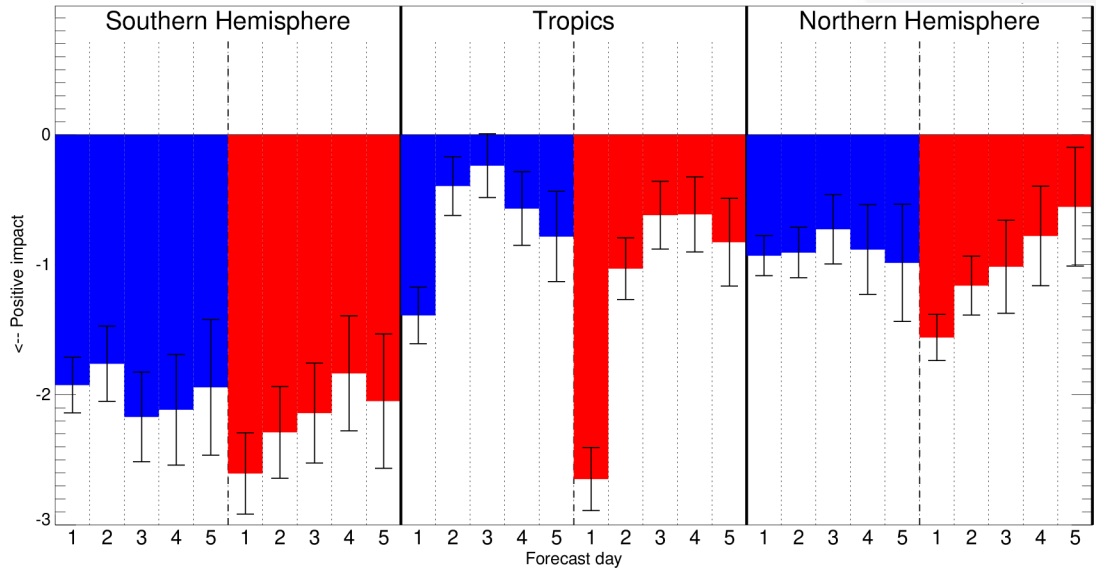

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Conclusions

- For the period examined (Summer 2019), the impact of assimilating the Aeolus winds from both bias-corrected (BC_B06) and reprocessed (B10) data on forecasts is generally positive in the troposphere over the tropics and polar regions

- The positive impact of the reprocessed data on forecasts is significantly larger, indicating that the M1 temperatures bias correction and the better quality of the reprocessed data are important

- When the AMVs are not assimilated, the impact of Aeolus winds on forecasts is enhanced by approximately 40% in the tropics and Southern Hemisphere

- The impact of AMVs is approximately twice larger than the impact of the HLOS winds in the extratropics. Conversely, the impact of Aeolus winds on forecasts is generally larger in the tropics

Conclusions

- The impact of the BC_B06 data is negative in the stratosphere over the Southern Hemisphere where the residual biases for the Rayleigh winds are still large

- These results indicate that the forecast skill in the stratosphere over that region is sensitive to the quality of the Rayleigh winds assimilated in the ECCC forecast system. Further investigation is needed to better understand this

- A publication on these results has been submitted to QJRMS special issue on Aeolus (under review)