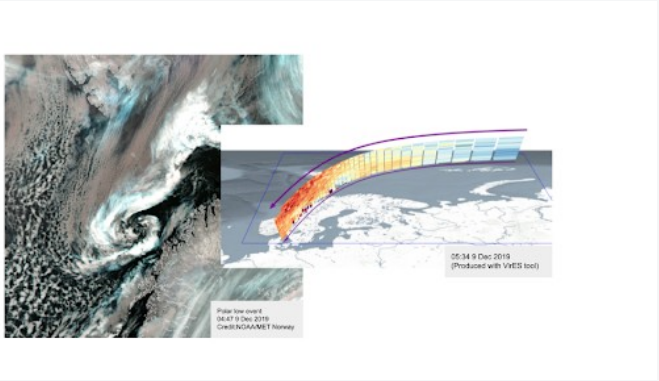

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IMPACT OF AEOLUS OBSERVATIONS IN A REGIONAL NWP MODEL DURING STRONG WIND EVENTS

Project objectives

- 2 year project “Optimising the exploitation of Aeolus winds in regional NWP” between SMHI, KNMI and Met Norway
- Investigate the impact of assimilation of reprocessed Aeolus winds in Harmonie-Arome over two domains using 4DVar
  - AROME-Arctic – many Aeolus overpasses
  - UWC-West – more representative of typical mid-latitude domain, more other observations to use in the evaluation
- Focus on cases with strong winds
  - Polar lows for AROME-Arctic
  - Wind storms for UWC-West

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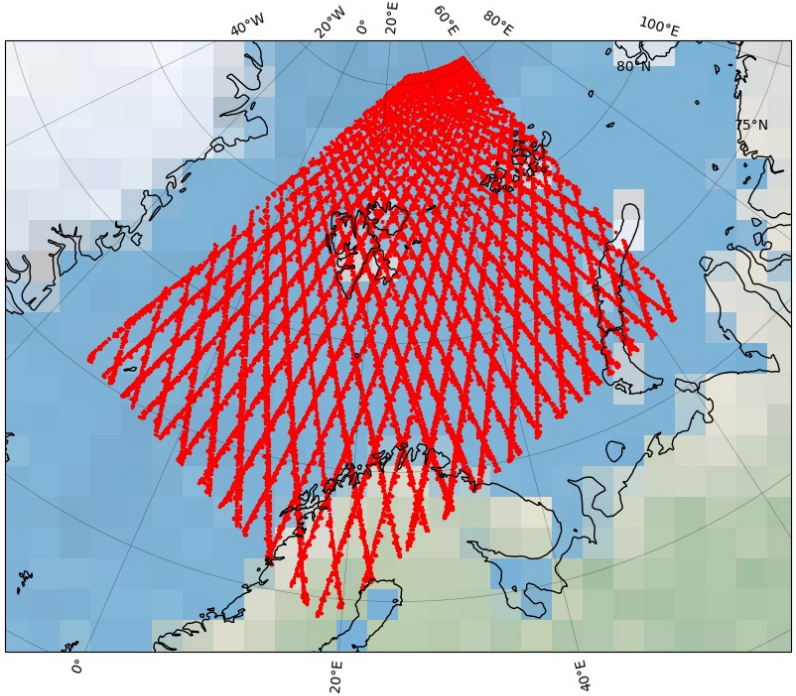
Project objectives

- Assimilate Aeolus HLOS winds from the second reprocessed dataset from June 2019 to October 2020 for the following two periods
  - Nov-Dec 2019 for Arome-Arctic, Polar Lows
  - Feb 2020 for UWC-west, winter storms Dennis and Ciara
- Using both Rayleigh-clear and Mie-cloudy together, and separately
- Lessons learned from previous Harmonie-Arome experiments and from assimilation in global models
- Find correct weights for the observations with respect to the model error as to maximise impact for mesoscale NWP.
- A previous study over a Nordic domain (Hagelin et al. 2021) mostly used global weights from ECMWF and, using 3DVar, found small impact on the analysis and neutral results on the forecast when assimilating Aeolus winds.

Model setup for Arome-Arctic

- Harmonie-Arome:
  - A non-hydrostatic regional NWP system, one of three configurations in the ACCORD consortia
  - Used operationally at SMHI, KNMI and Met Norway
- For this project – model cycle 43h2.2 with 4DVar data assimilation on Atos (the new ECMWF HPC in Bologna)
- LBC and IC from operational ECMWF IFS and special project (with and without Aeolus, see next slide)
- Arome-Arctic:
  - Operational domain for Met Norway
  - 2.5 km resolution, 739x949 grid points with 65 vertical levels
  - Many Aeolus overpasses, but fewer other observations
  - Focus on polar lows (source: MET Norway database and Revokatova et al. 2021)



Boundaries with and without Aeolus from the ECMWF OSE

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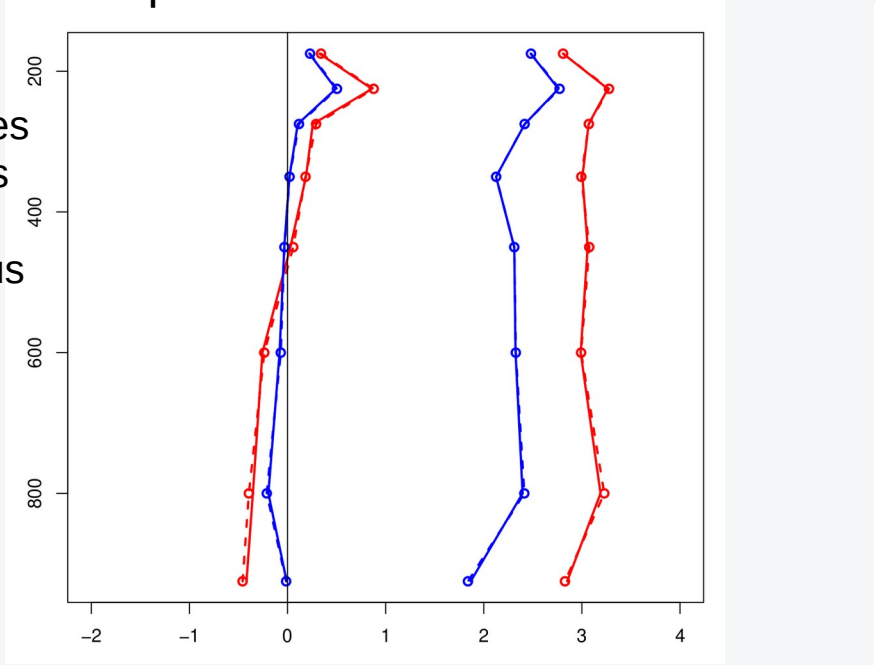
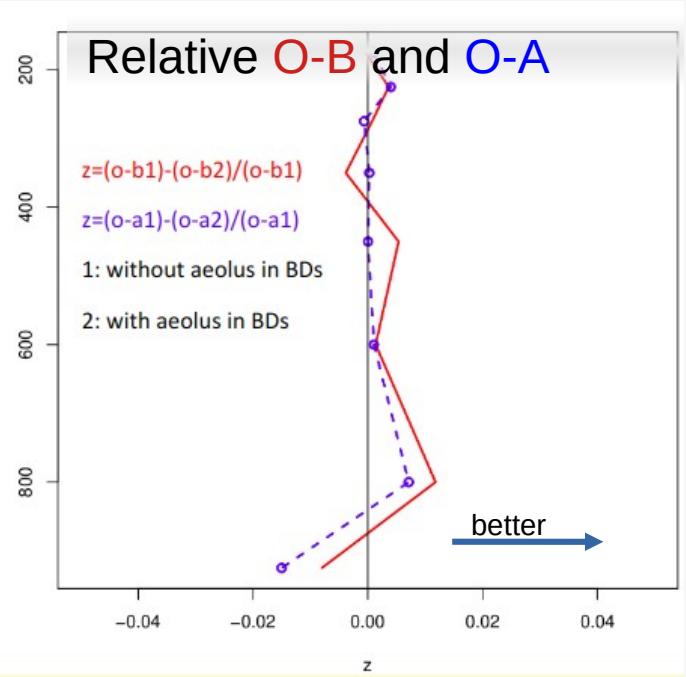
- These experiments cover the period 1-10 Oct 2019
- For technical reasons this set of experiments were run with 3DVar
  - Only 3 h global forecast from the ECMWF OSE archived, Harmonie-Arome 4DVar needs 1h forecast
- Overall an improvement in O-B and O-A with Aeolus in LBCs

Dashed lines
- no Aeolus
Solid lines
- with Aeolus





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First OSE – impact of Aeolus, without any modifications to the DA system

- Experiment period 25 Nov – 15 Dec 2019
- Initial set of four experiments
  - Reference experiment (no Aeolus), uses same observations as the operational Arome-Arctic (conventional, AMV, AMSU-A, AMSU-B/MHS, IASI, scatterometer)
  - Aeolus experiment – as reference but also adding all Aeolus observations
  - Mie only – as reference, adding only Mie data
  - Rayleigh only – as reference and adding only Rayleigh observations
- Reference experiment starts 2 weeks earlier to spin-up the starting conditions for the experiments using Aeolus data

Data quality and availability over Arome-Arctic for 25/11 – 15/12 2019

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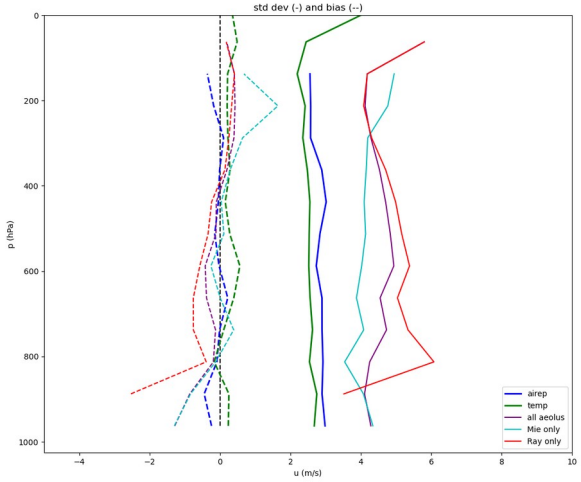
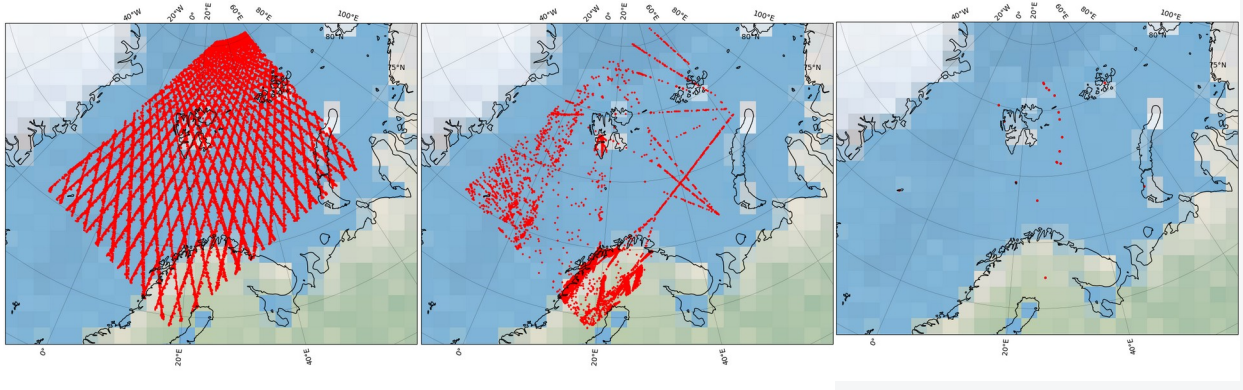
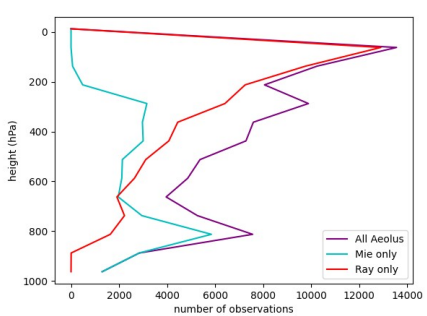
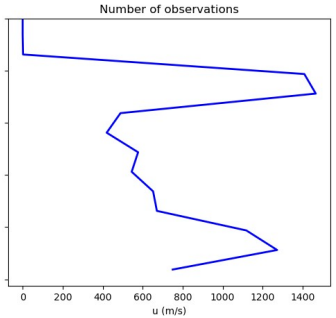
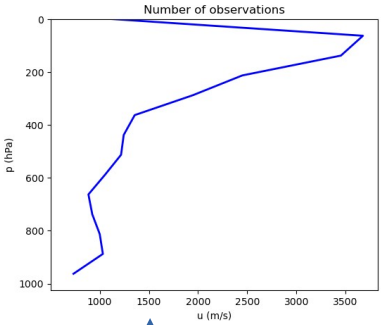










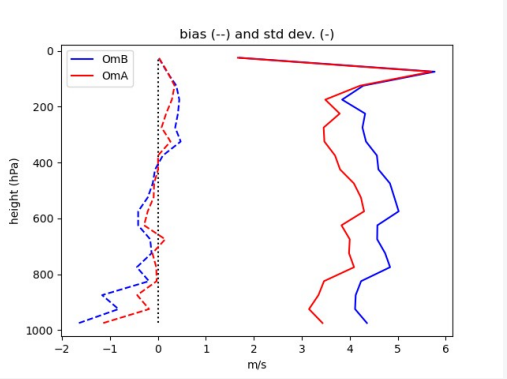
Similar bias
Aircraft and radiosonde data have smaller std deviation
Aeolus Mie lower std deviation than Aeolus Rayleigh

Many more Aeolus observations, blue arrows indicate 1500 obs.

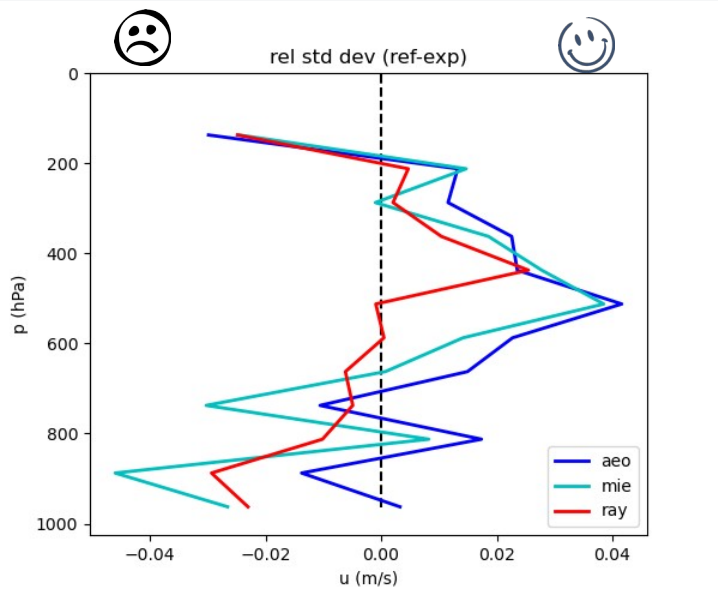
Impact of Aeolus in the data assimilation

- Adding Aeolus observations has an impact on the analysis (O-B and O-A for the experiment assimilating both Mie and Rayleigh winds)
- Relative O-B aircraft and radiosonde show improvement in the upper part of the atmosphere

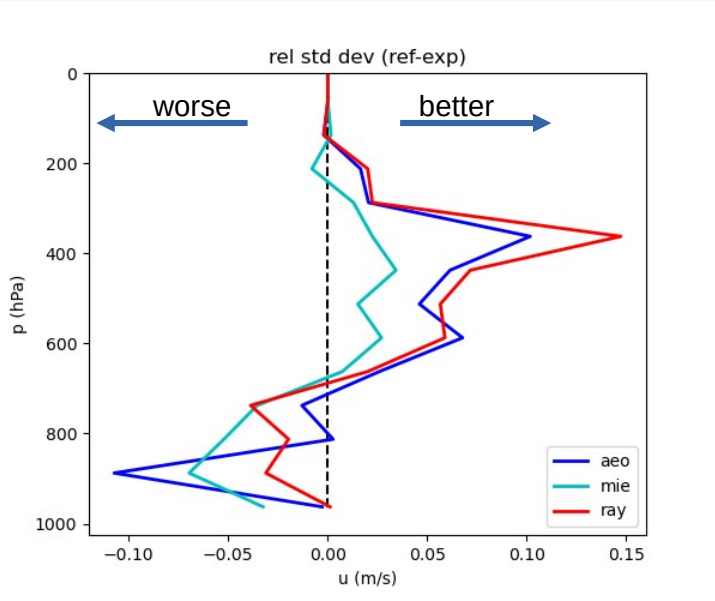
$$rel(O\text{-}B) = ((O\text{-}B)_{ref} - (O\text{-}B)_{exp}) / (O\text{-}B)_{ref}$$



Aircraft

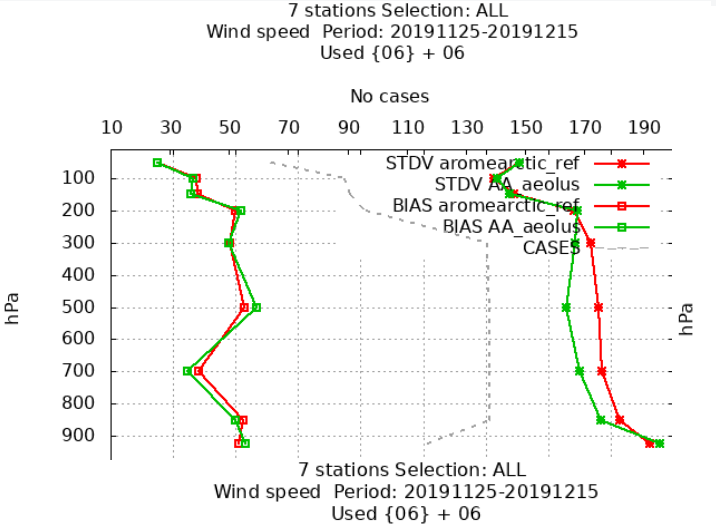


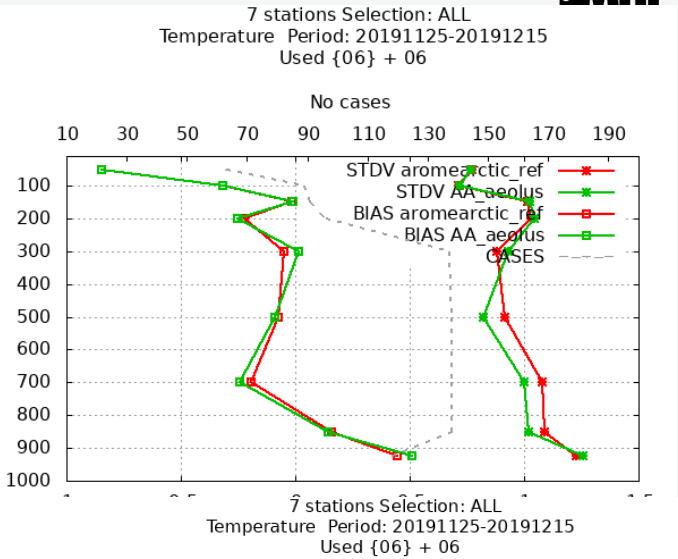
Radiosonde

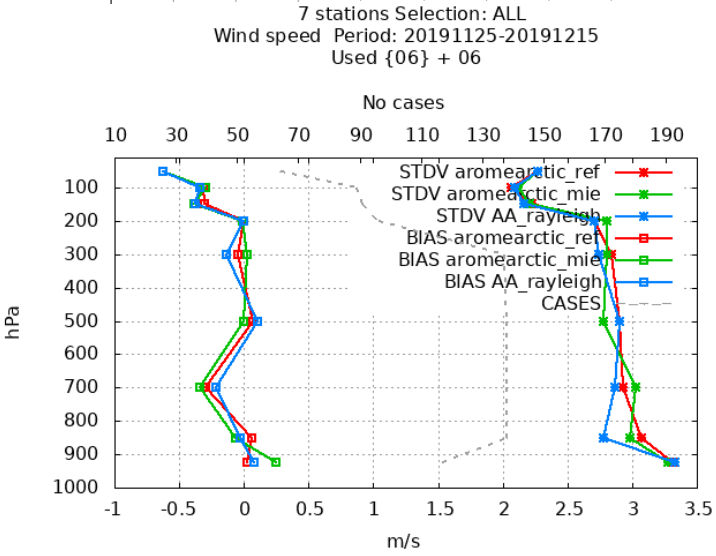


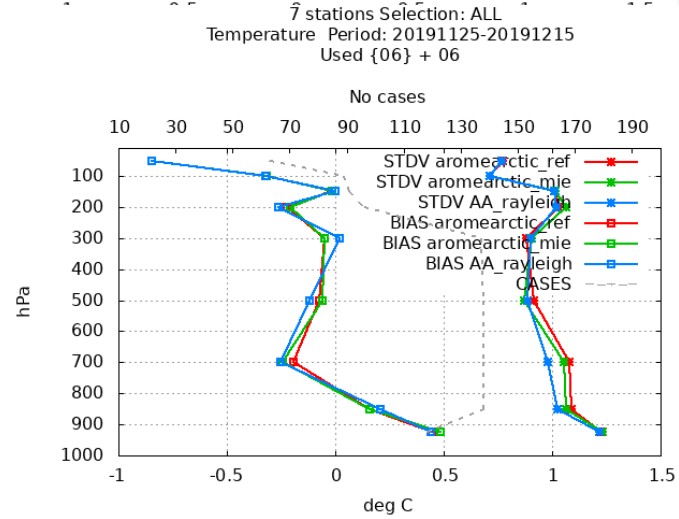
Verification after 6h

- wind speed (left) and temperature (right) compared against radiosonde data
- Top row: all Aeolus vs ref
- Bottom row: Mie only and Rayleigh only vs ref



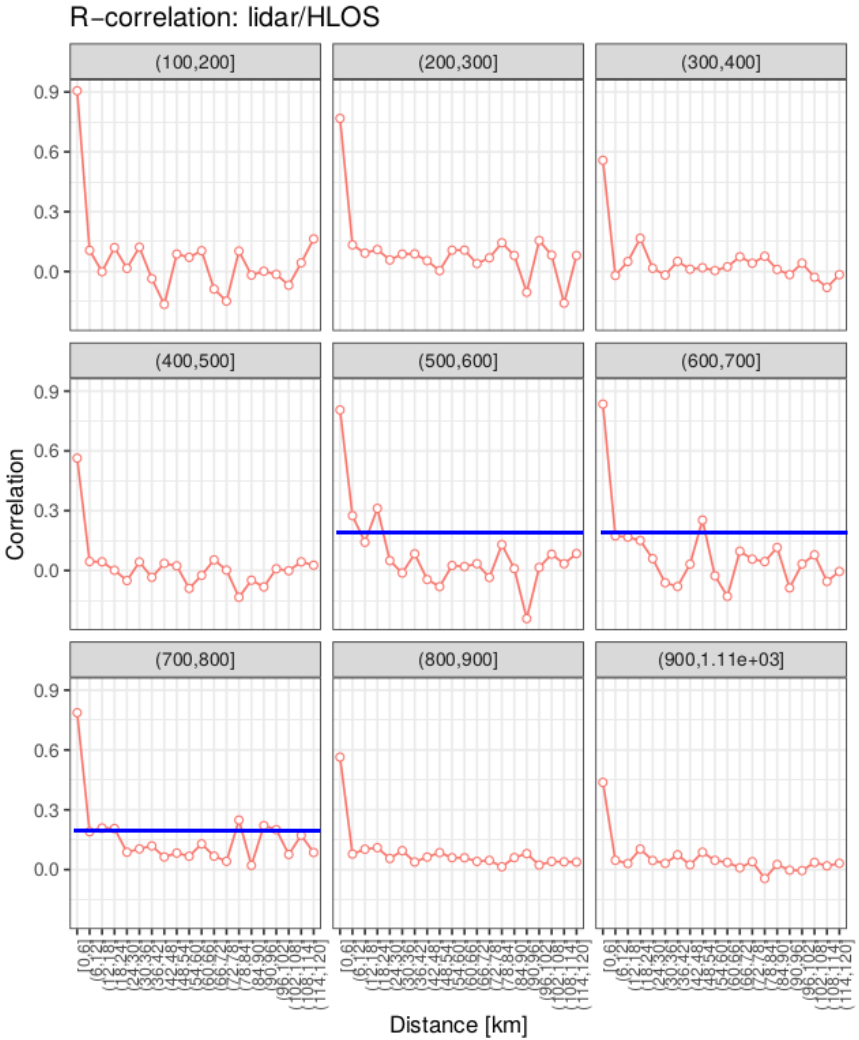






Error correlations

- Only Mie, without obs error inflation
- The smallest analysis error is obtained when a thinning scale corresponds to the distance at which error correlation reaches 0.2
- Blue line shows correlation = 0.2
- Between 800 - 500 hPa thinning up to 24 km is needed
- One solution is to take into account the correlation error correlations, especially for higher resolution Mie observations, is to inflate the observations errors prior to assimilation
- It seems for these levels we need obs error inflations since Aeolus thinning code does not exist in our Harmonie system



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Error inflation – first attempt

- In preliminary studies of the impact of inflating the observation error for Mie and Rayleigh, we saw the largest difference when inflating the Mie observation error
- Two new experiments run for the full Polar Low period

  a) Mie only, inflating the Mie observation error by a factor of 2

  b) Mie and Rayleigh, both with inflated observation errors

  - Mie observation error x 2
  - Rayleigh observation error x 1.4

Impact of inflating the observation error

- Relative O-B (ref-exp) with and without inflating the observation error
- Overall, inflating the observation error for the Aeolus data decreases the impact
- Compared against radiosonde, degradation at lower altitudes is improved with observation error inflation
- Compared against aircraft data Mie Only reduced negative impact at ~900 hPa, but increase at 650 hPa for the experiment with all Aeolus observations
- Same tendencies are seen in the forecast verification

aircraft → better → radiosonde

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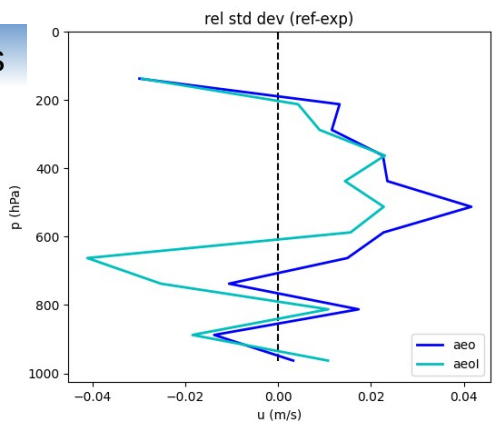
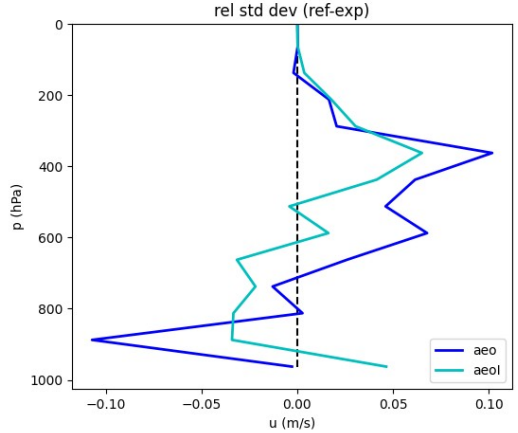
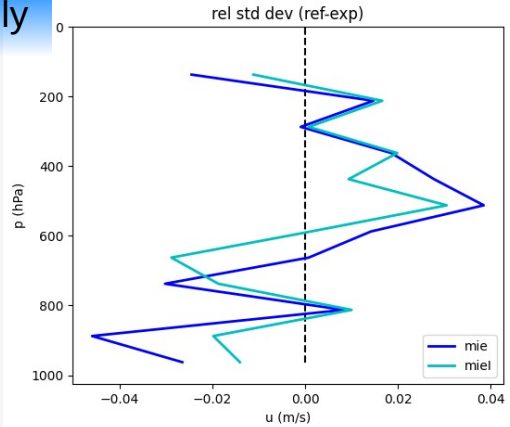
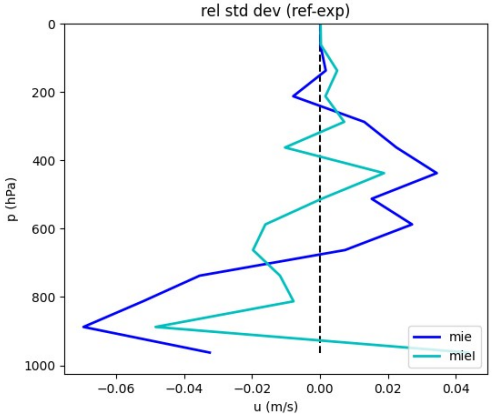
Aeolus





Mie only





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Summary and outlook

- Using Aeolus in the 4DVar data assimilation in Harmonie-Arome over the Arome-Arctic domain show improvements in the O-B statistics and forecast scores
- With the data from the ECMWF OSE we see that having Aeolus in the initial and boundary conditions has a positive impact over the Arome-Arctic domain
- Inflating the observation error of Aeolus observation changes the impact of Aeolus in the data assimilation system
- Further experiments with adjustments of the inflation of the observation error over Arome-Arctic are ongoing
- Preparing to start experiments over the UWC-West domain

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Thank you for your attention!

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OPTIMISING THE EXPLOITATION OF AEOLUS WINDS IN REGIONAL NWP