

Current status of the IASI 3D Winds product at EUMETSAT

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Introduction

3D winds concept

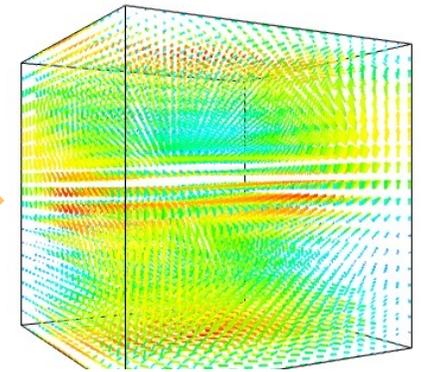
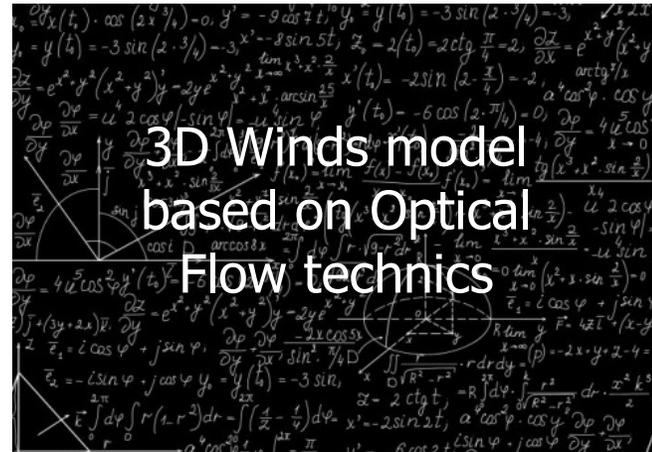
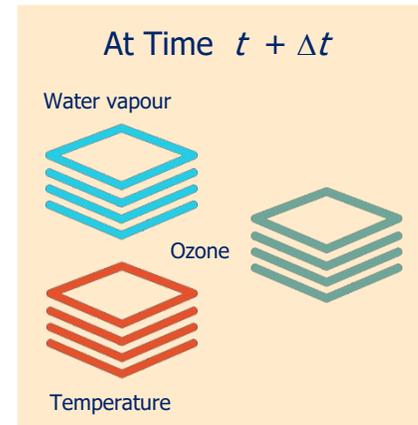
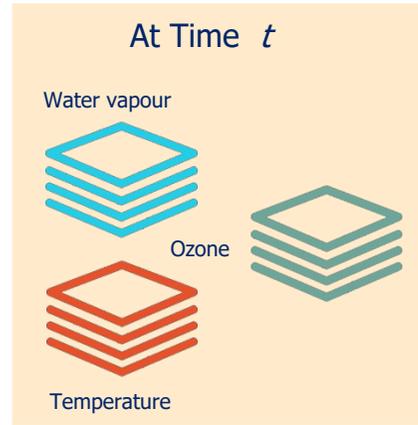
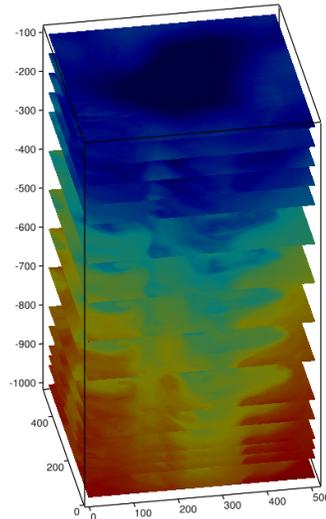
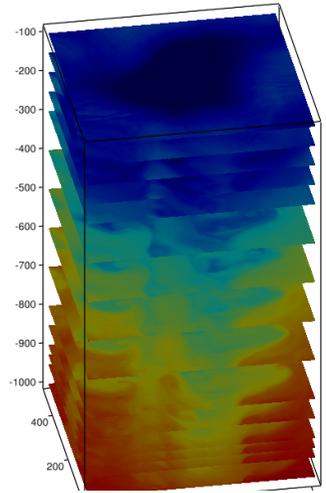
Status of the processor

Product examples and results

Future work

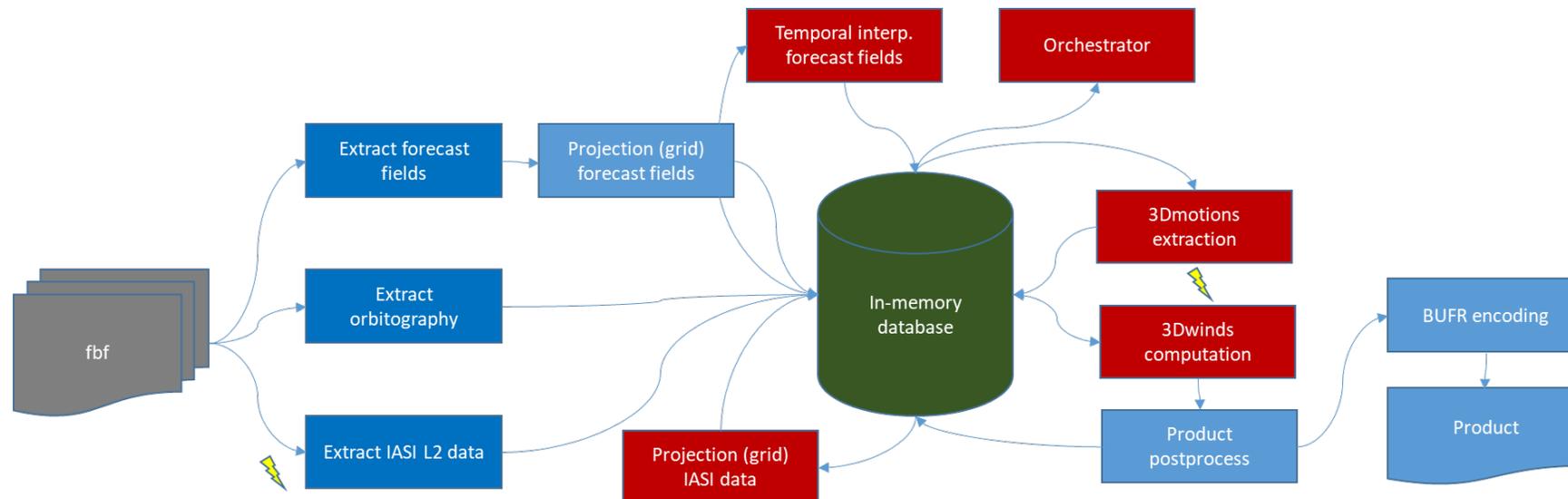
- General context, CGMS and IWWG :
 - OSCAR Database: observation requirements for 'Horizontal Winds' not fulfilled
https://space.oscar.wmo.int/variables/view/wind_horizontal
<https://space.oscar.wmo.int/gapanalyses?variable=179>
 - *IWW15 Recommendation endorsed by CGMS49 plenary:*
The IWWG recommends space agencies to address the gap of global 3D wind profile observations with high priority. Based on the Aeolus experience, a combination of lidar & IR missions can provide complimentary wind observations which look to be very promising.
 - CGMS50 set new HLPP to IWWG:
HLPP 4.2.3 Assess value of derivation of winds from GEO Hyperspectral IR.

Joint inversion of all vertical levels

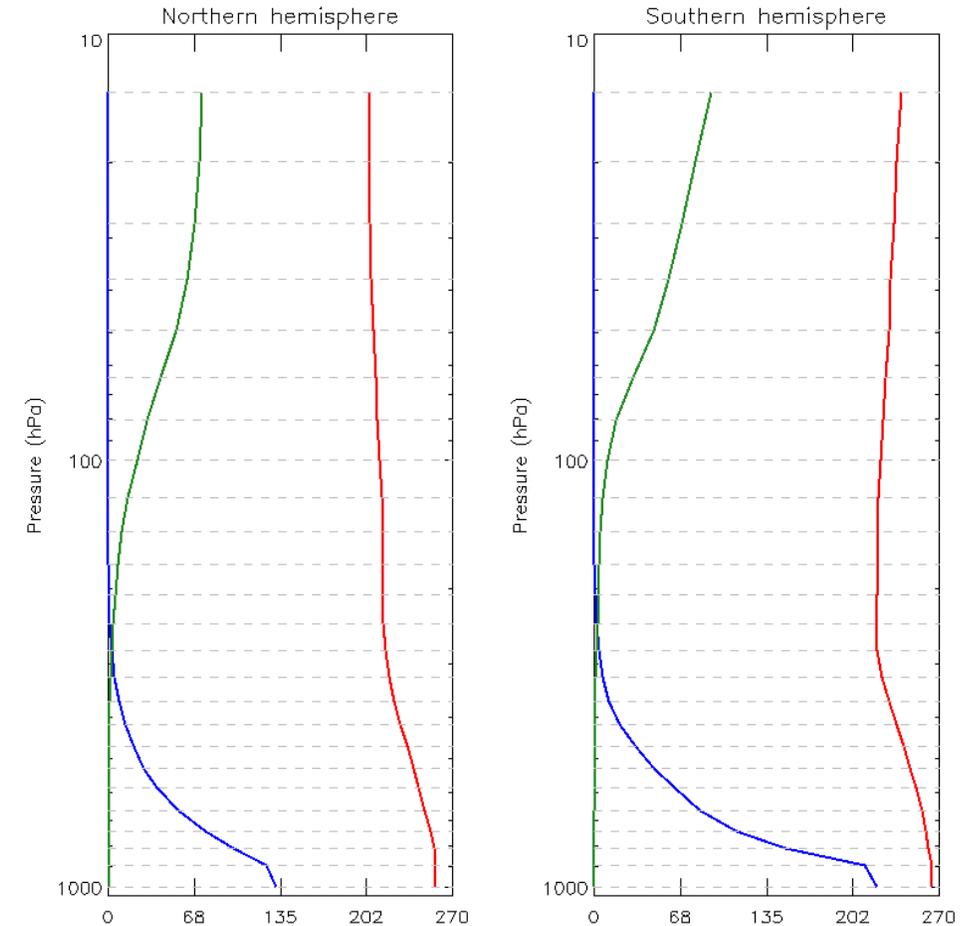


3D wind field
U,V,W fields derived from observations

- Operational implementation is ongoing:
 - Processor is based on optical flow technics. Development of Version 1 is finished.
 - The target for operational implementation on the new EPS GS is currently 2024 (demonstration status).
 - Offline production is planned in the meantime, pending on availability of adequate computing resources.
 - The target for offline implementation is Q2 2023.



- Product description:
 - Based on IASI Level-2 products: all-sky water vapour, ozone and temperature profiles.
 - Dual-satellite operations (Metop-B and Metop-C); 29 products per day and per area (NH and SH).
 - High-latitude regions (poleward of 45°).
 - Troposphere and low stratosphere; 25 layers (from 10 to 1000 hPa).
 - After users' feedback (DWD and Met Office) a spatial binning strategy was implemented to reduce number of profiles, reduce the variance and limit the problem of spatial correlation (super-pixels $\sim 100 \times 100 \text{ km}^2$).
 - Specific BUFR template designed.



IASI temperature (K, in red), humidity ($\times 10^5$, in blue) and ozone ($\times 10^7$, in green) profiles on 01/01/2023 over the North pole at 00:54:34 (left), and over the South pole at 00:52:37 (right).

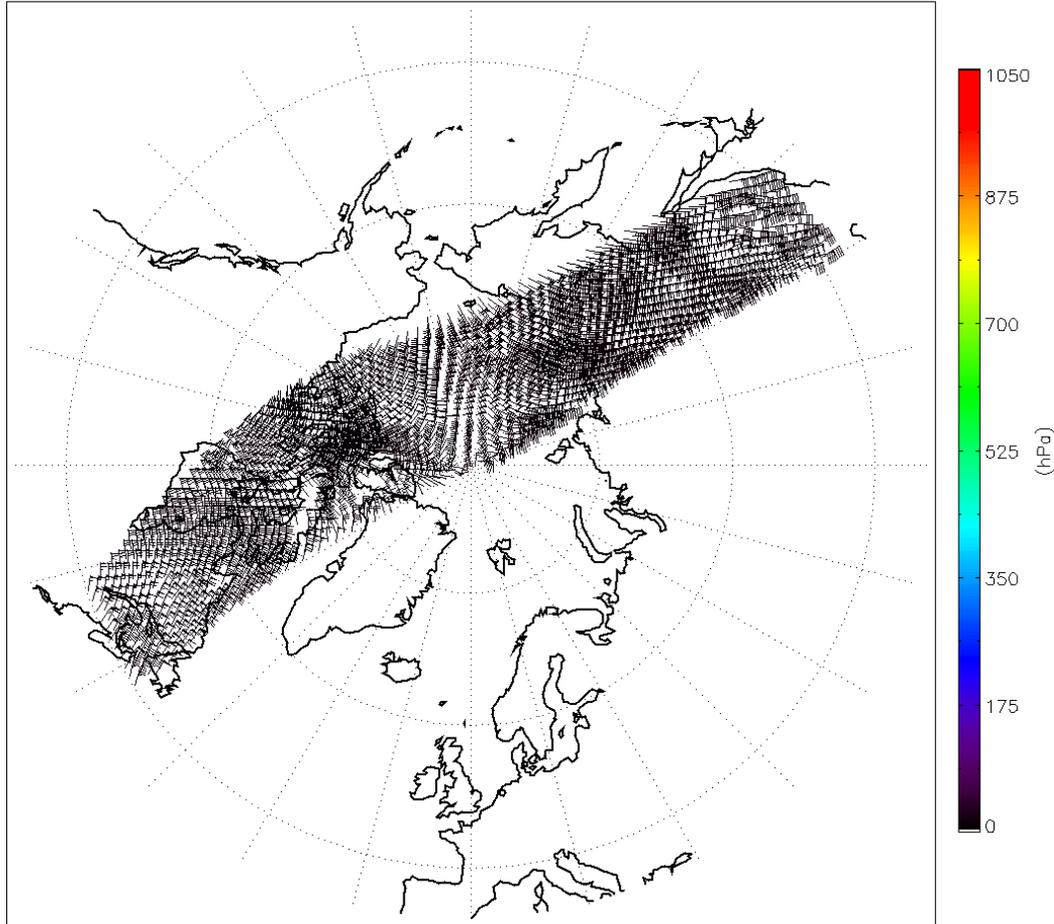


IASI 3D winds – Product examples (Northern hemisphere)

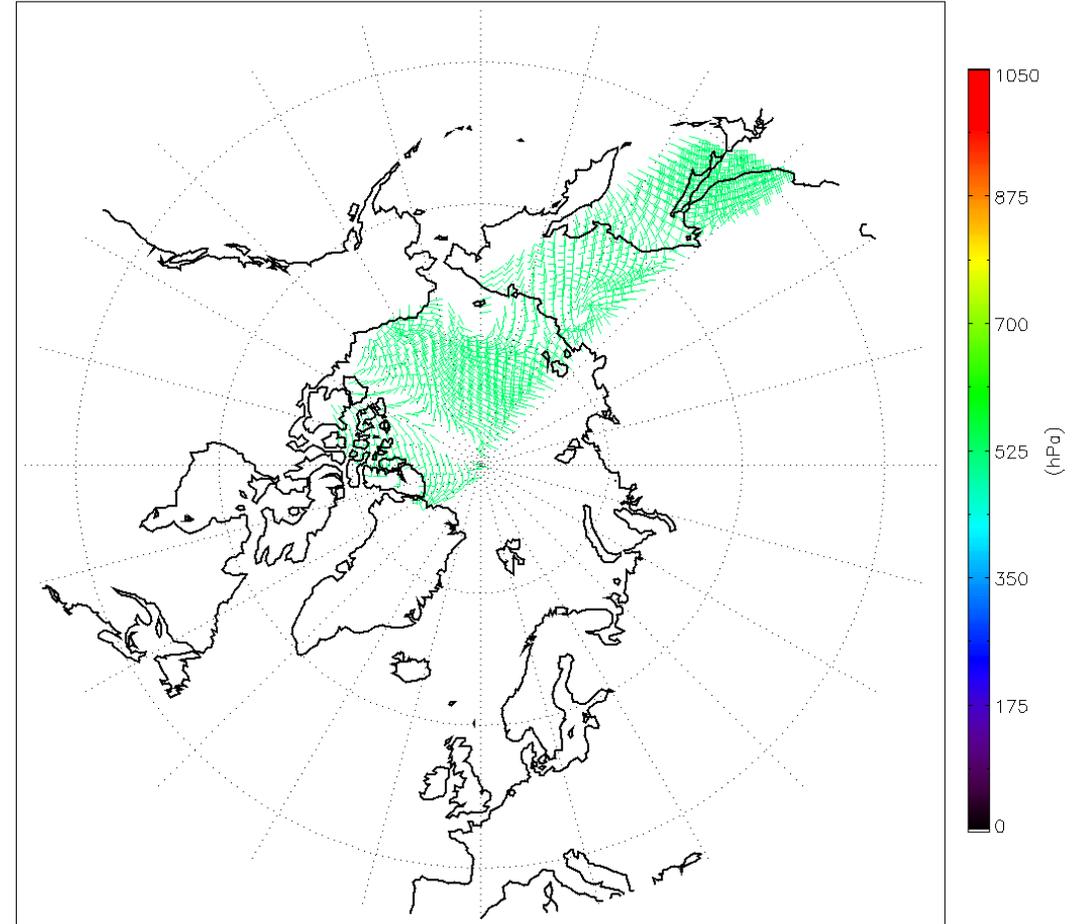
Animation of all pressure levels for IASI 3D winds over the North pole on 01/01/2023 at 01:43:18.

Animation of all IASI 3D winds at 525 hPa over the North pole on 01/01/2023.

IASI 3D Winds – Pressure, 13 hPa, 01/01/2023 at 01:43:18



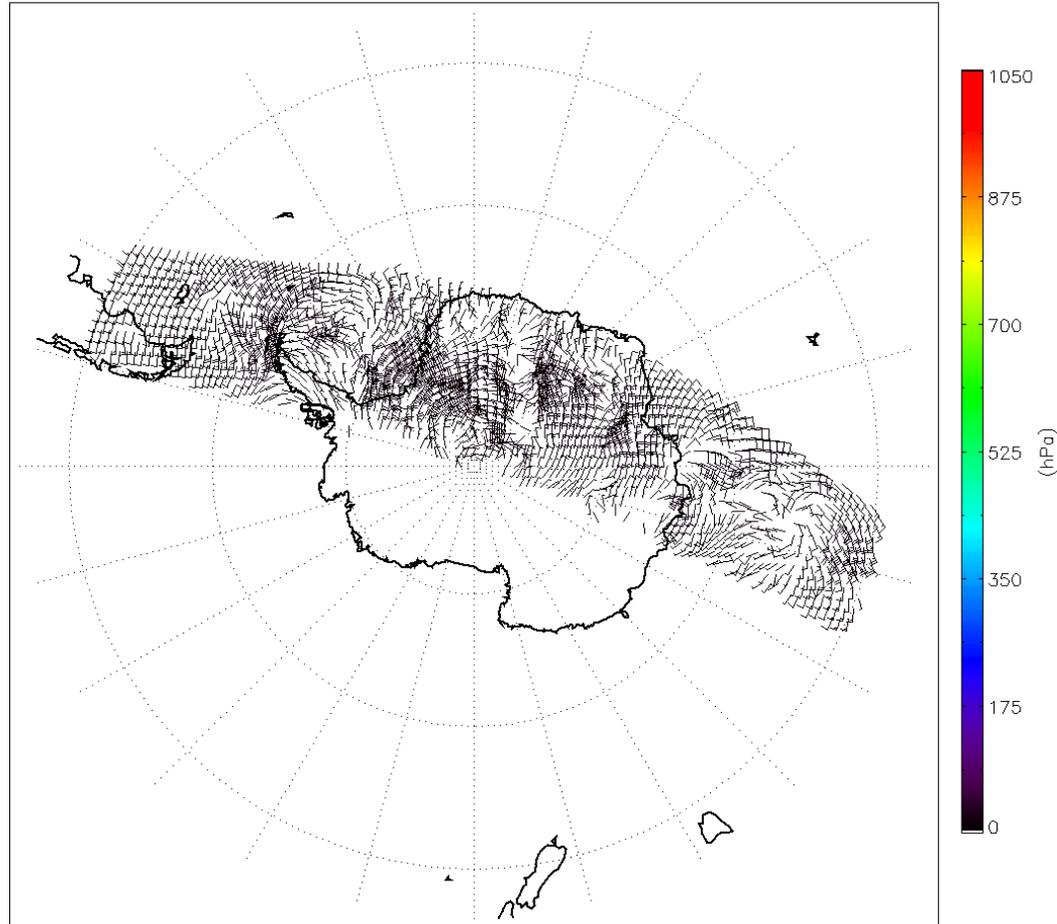
IASI 3D Winds – Pressure, 525 hPa, 01/01/2023 at 00:54:34



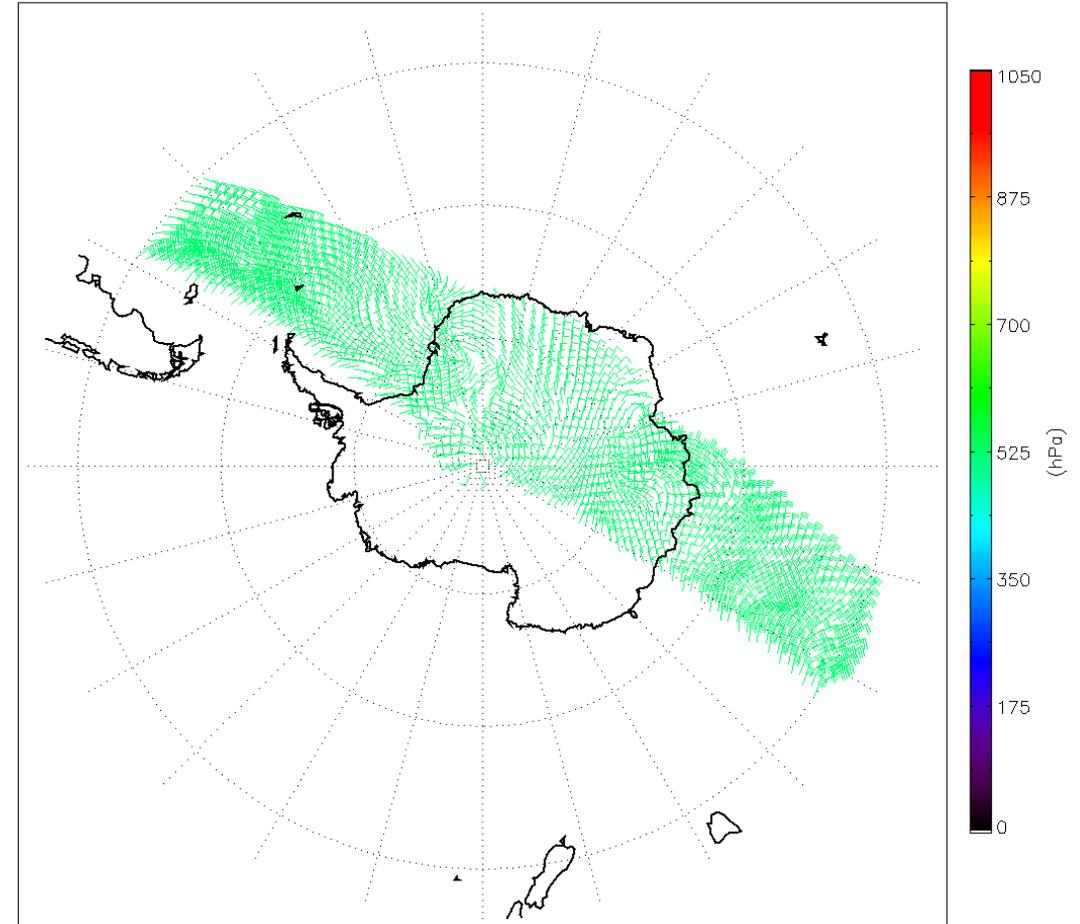
Animation of all pressure levels for IASI 3D winds over the South pole on 01/01/2023 at 02:33:58.

Animation of all IASI 3D winds at 525 hPa over the South pole on 01/01/2023.

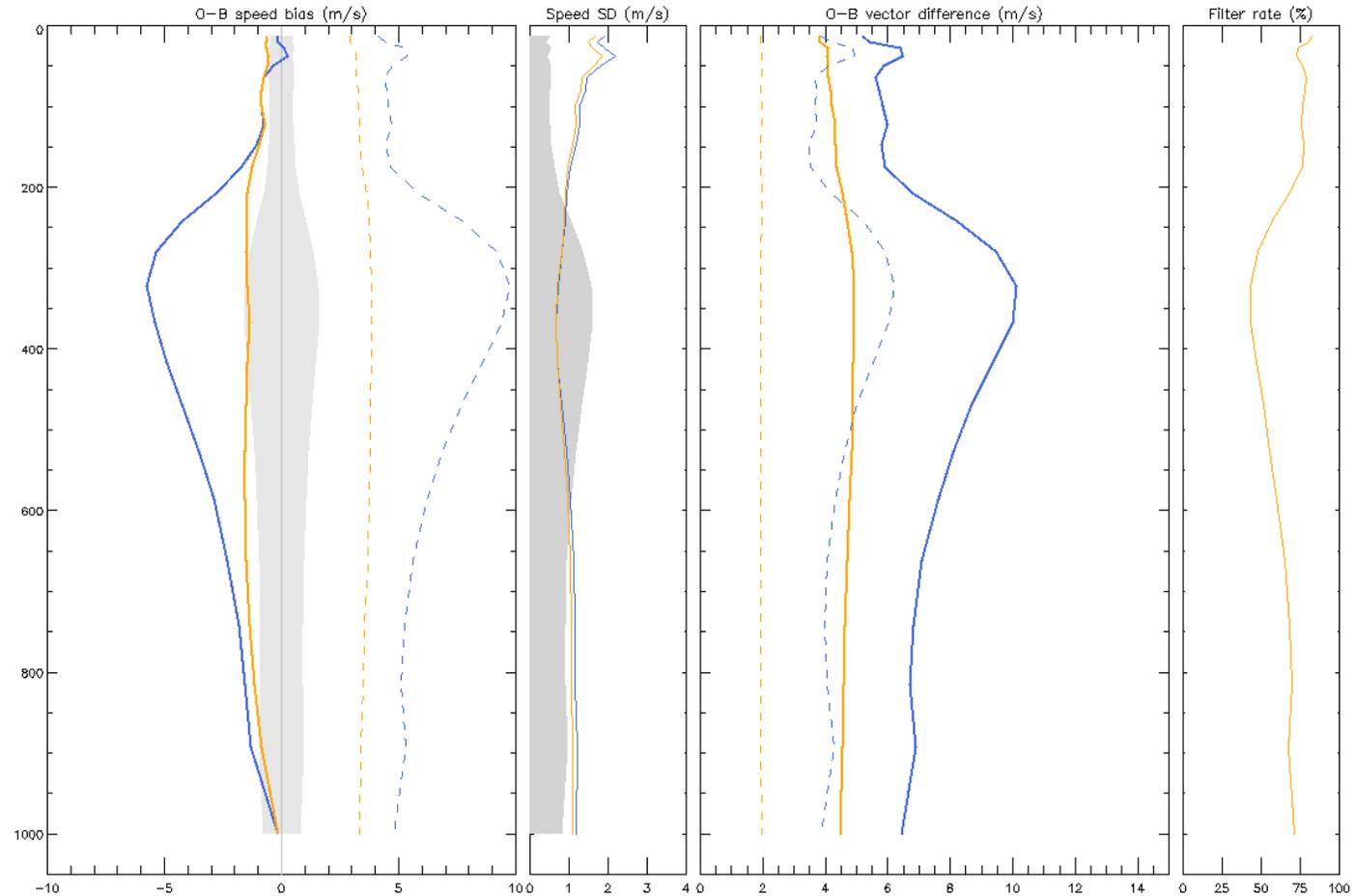
IASI 3D Winds – Pressure, 13 hPa, 01/01/2023 at 02:33:58



IASI 3D Winds – Pressure, 525 hPa, 01/01/2023 at 01:45:14

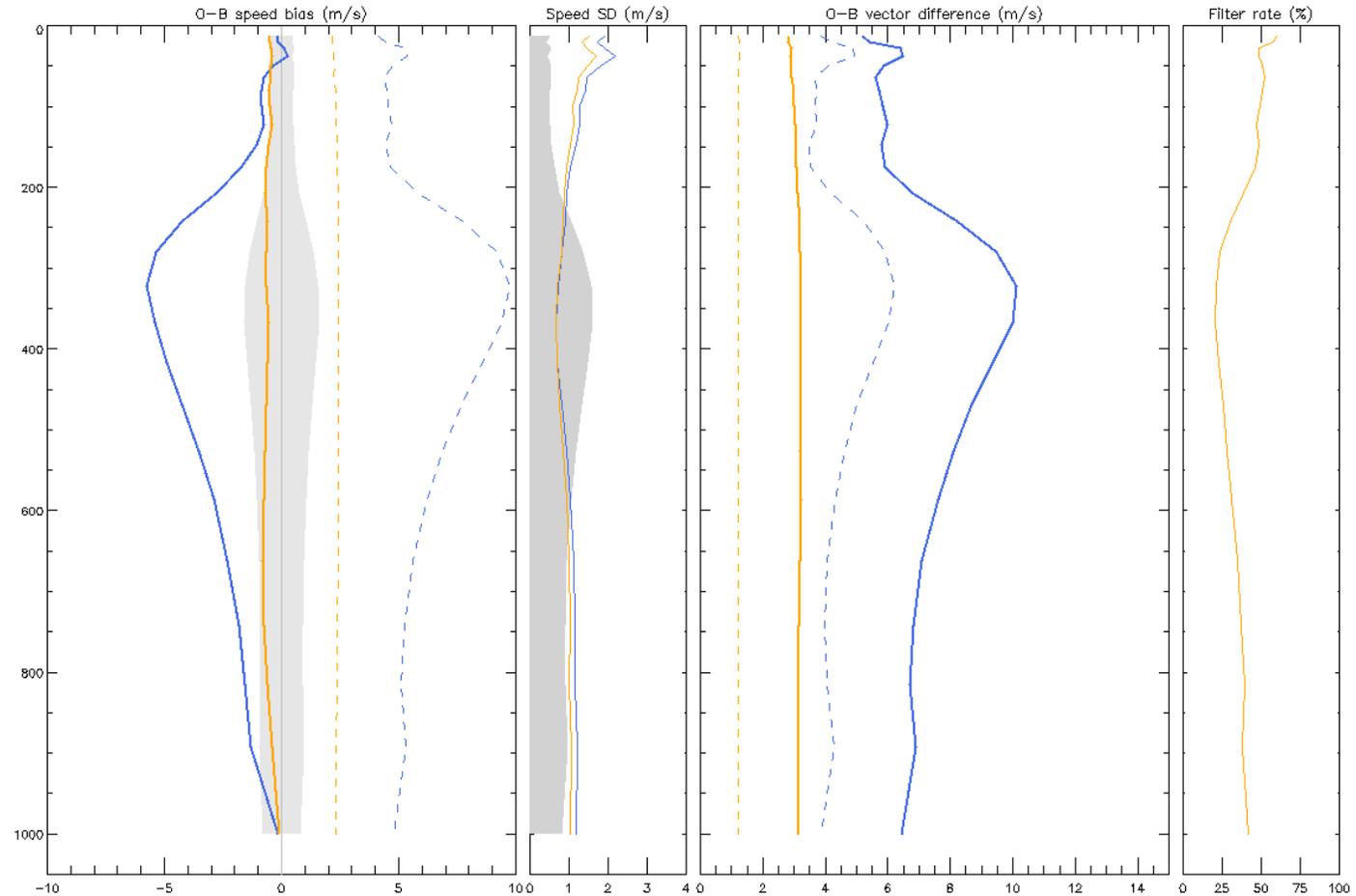


- O-B speed biases (solid line) and RMS (dashed line) profiles of IASI 3D winds against ECMWF forecast:
 - *All wind vectors*
 - *Filtered on the vector difference against forecast wind ($vd < 8$ m/s)*
 - *Shaded zone shows the ECMWF variability inside the binning area*
- **After cut-off at 8 m/s for O-B:**
 - Mean bias ≈ -1.1 m/s, RMS ≈ 3.5 m/s.
 - Speed SD within the box comparable to ECMWF model field variability.
 - 67% of the wind vectors left.
 - Statistics consistent on the whole vertical range.

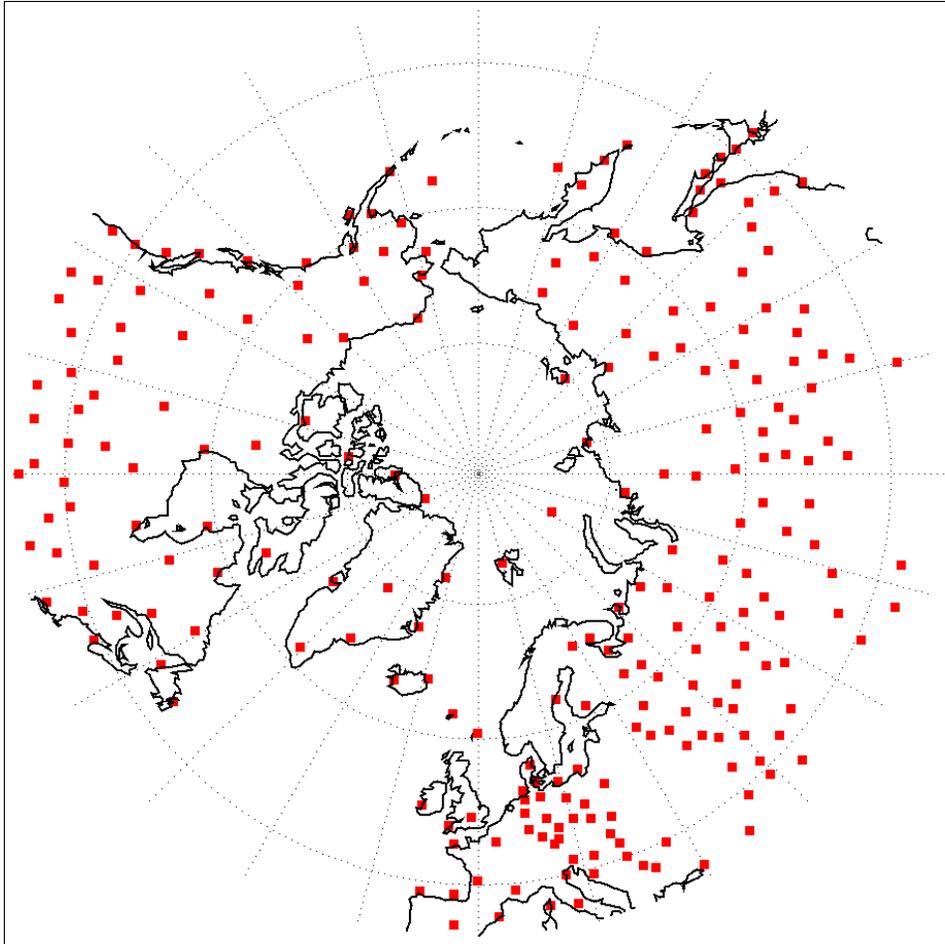


IASI 3D winds statistics against forecast over the North pole on 01-07/04/2023.

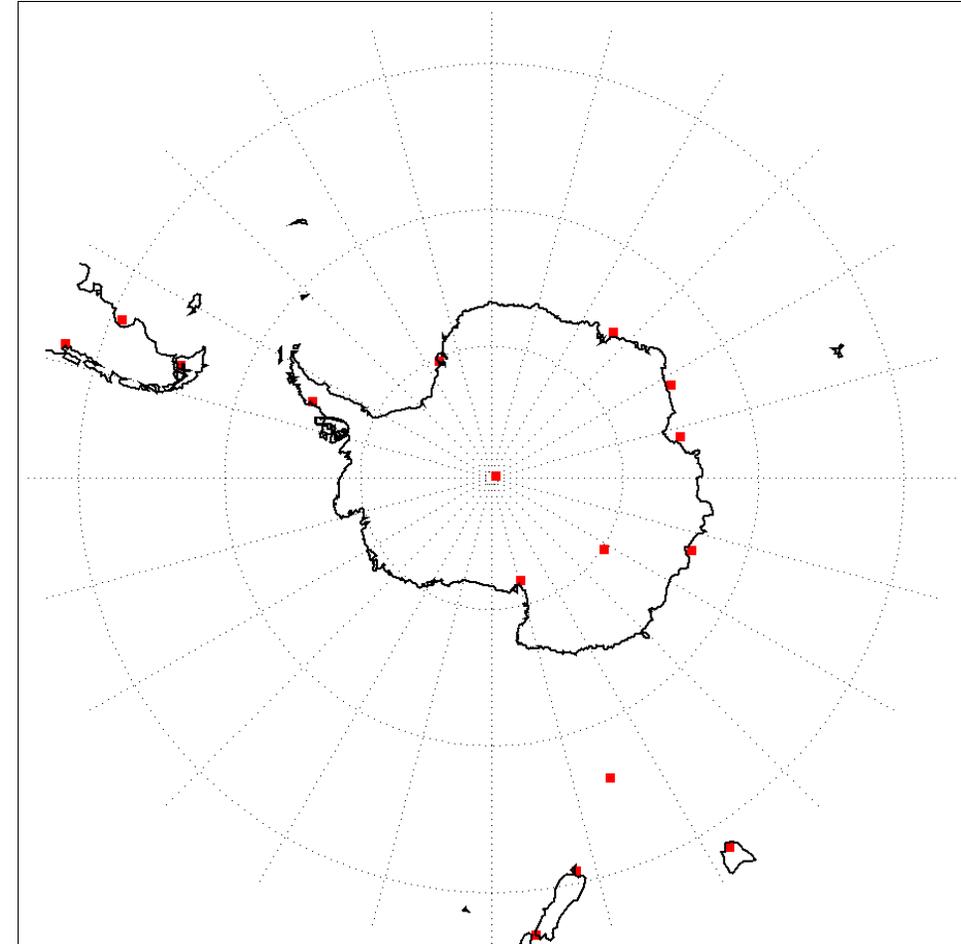
- O-B speed biases (solid line) and RMS (dashed line) profiles of IASI 3D winds against ECMWF forecast:
 - *All wind vectors*
 - *Filtered on the vector difference against forecast wind ($vd < 5$ m/s)*
 - *Shaded zone shows the ECMWF variability inside the binning area*
- **After cut-off at 5 m/s for O-B:**
 - Mean bias ≈ -0.6 m/s, RMS ≈ 2.3 m/s.
 - Speed SD within the box comparable to ECMWF model field variability.
 - 40% of the wind vectors left.
 - Statistics consistent on the whole vertical range.



IASI 3D winds statistics against forecast over the North pole on 01-07/04/2023.

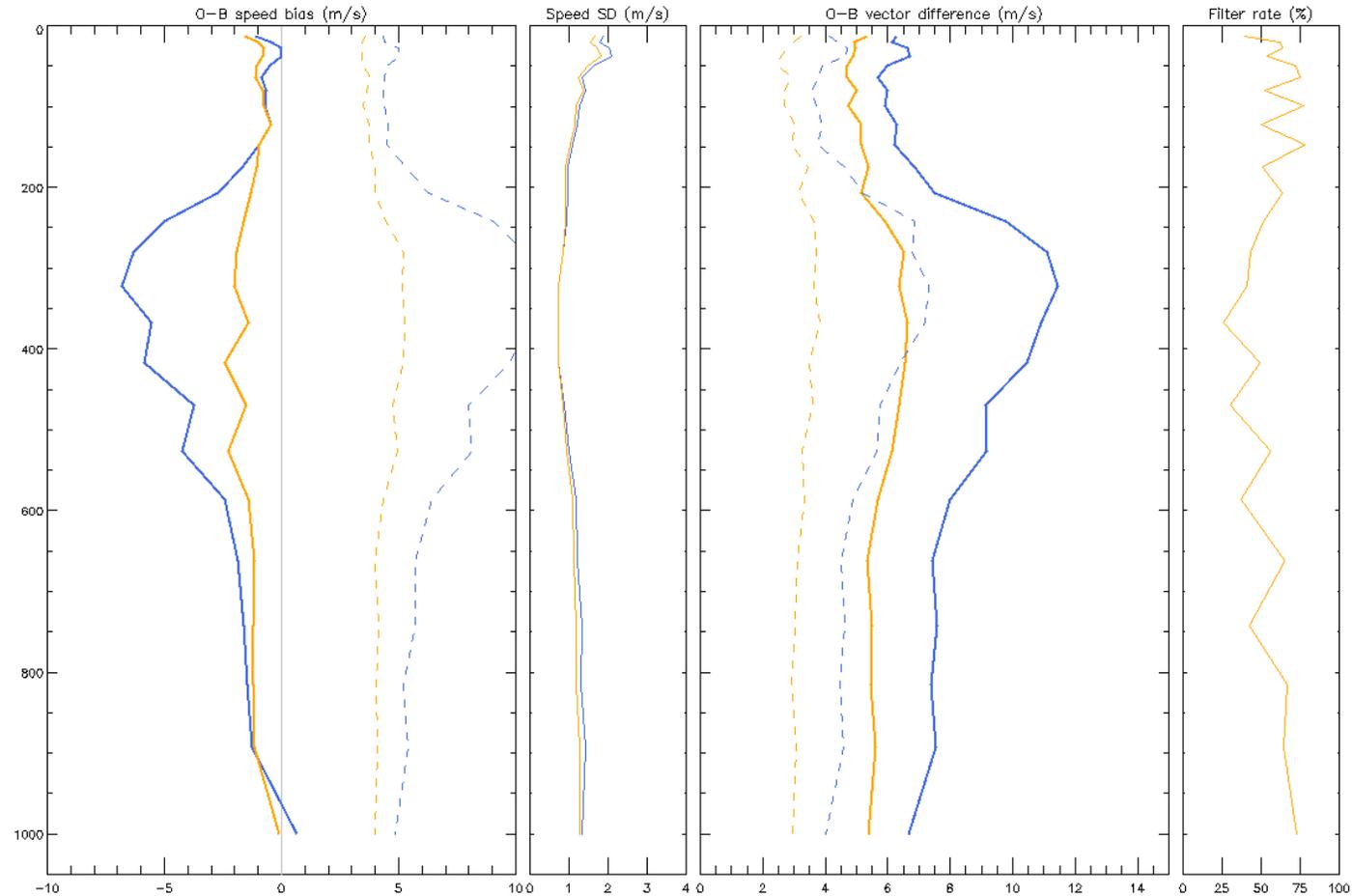


IGRA radiosonde stations over the North pole.



IGRA radiosonde stations over the South pole.

- Radiosonde observations within ± 3 hours of the 3D wind product, collocated on the super-pixels.
- O-B speed biases (solid line) and RMS (dashed line) profiles of IASI 3D winds against IGRA radiosonde data:
 - *All wind vectors*
 - *Filtered on the vector difference against forecast wind ($vd < 8$ m/s)*
- After cut-off at 8 m/s for O-B:
 - Mean bias ≈ -1.2 m/s, RMS ≈ 4.1 m/s.
 - 55% of the wind vectors left.
 - Statistics consistent on the whole vertical range.

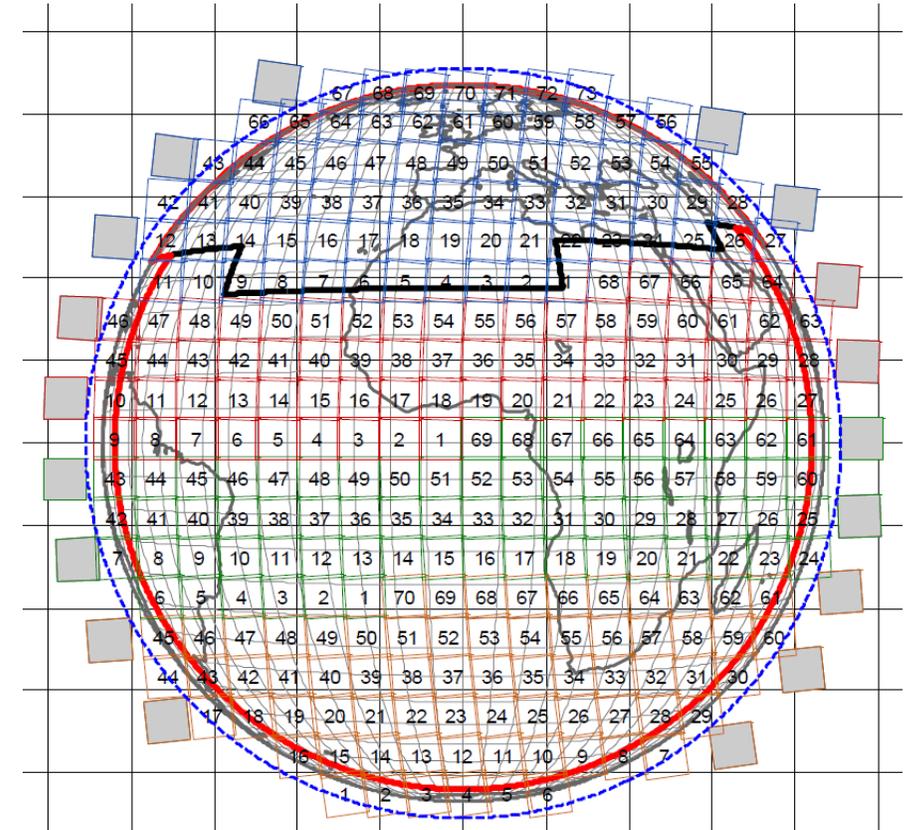


IASI 3D winds statistics against radiosonde data over the North pole on 01-07/04/2023.



- Description of demonstration dataset:
 - Four months of data (January to April 2023 – and growing).
 - 3D winds computed for North and South pole over 25 pressure levels.
 - Processed offline (no NRT capabilities yet).
- Potential users for testing demonstration product:
 - ECMWF, Met Office, DWD, Hungary and Met Norway Met services expressed their interest.
 - Test dataset sent to Naval Research Laboratory (NRL) for impact study.
- Future work:
 - Scientific validation on Q2–Q4 2023, including comparison to radiosonde, AMV, aircraft and Aeolus data.
 - Preparation of version 2 for MTG-IRS and EPS-SG IASI-NG, in collaboration with Patrick Héas (Inria):
“3D wind field profiles from hyperspectral sounders: revisiting optic-flow from a meteorological perspective” ([arXiv:2303.05154](https://arxiv.org/abs/2303.05154)).
 - Investigate extraction of wind shear information for nowcasting application.

- Coverage:
 - 4 LAC (Local Area Coverage) defined
 - LAC4 covers Europe, Mediterranean Basin and North Atlantic. It is acquired every 30 minutes.
 - Pixel sampling = 4 km at SSP
 - *Spatial resolution enhanced will allow the use in High Res NWP application*
- Profile:
 - 25 levels from 10 to 1000 hPa, covering Low Stratosphere to Surface
- Frequency:
 - Number of products per day depends on acquisition scheme.
 - Current baseline:
 - 48 products for LAC4
 - 16 products for LAC3
 - 12 products for LAC2
 - 8 products for LAC1
- Timeliness (expected):
 - ~45 minutes after LAC acquisition
- *Fulfill the Global NWP and High Res NWP application requirements*





IR sounder 3D wind - Overall roadmap





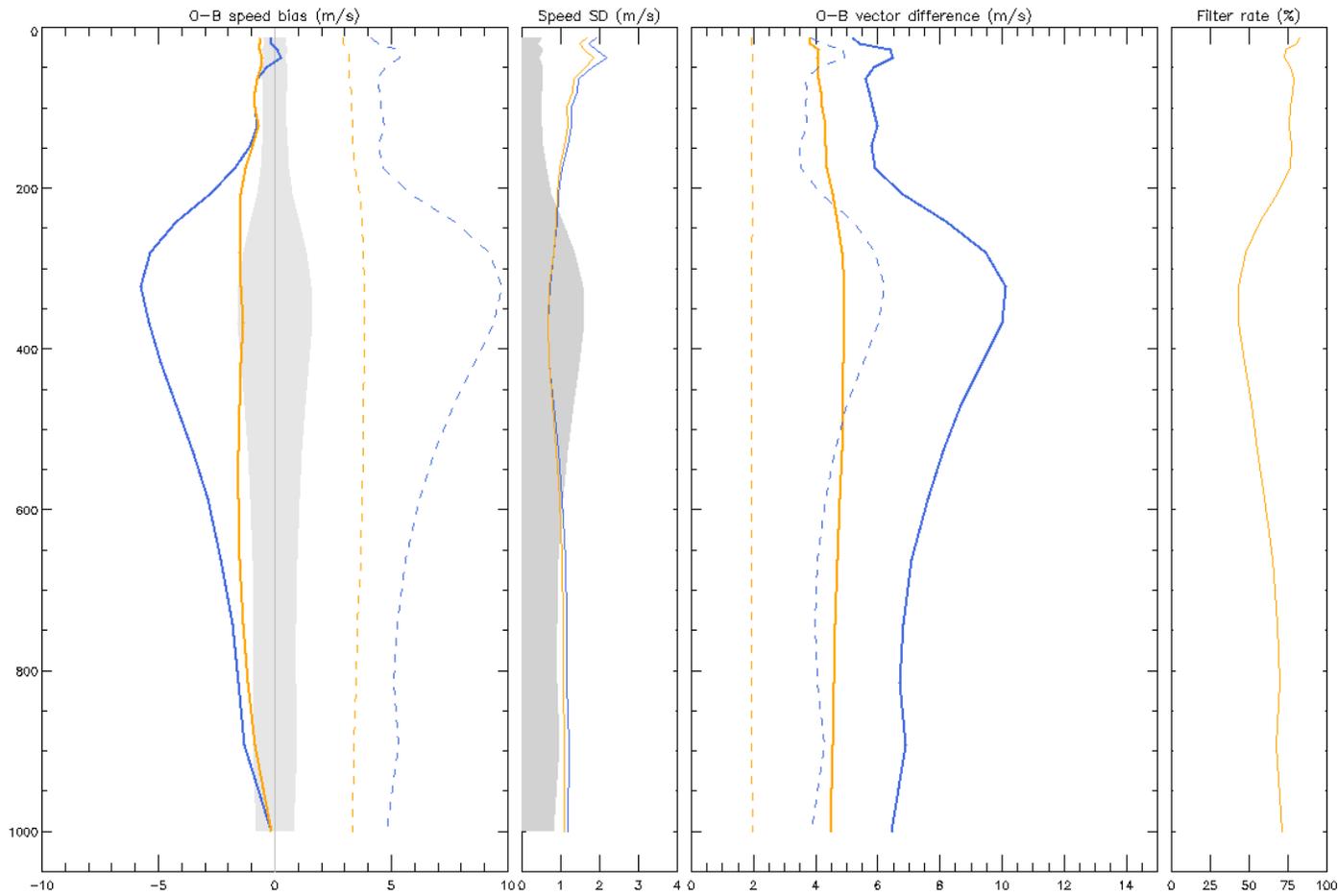
- Version 1 of the algorithm is finished and running offline.
- Demonstration dataset available since January 2023 (growing daily). To be converted to BUFR soon.
- Statistics against forecast and radiosonde data show promising results.
- These IR sounder products need to be tested by Met services (cf. CGMS and IWWG HLPP). Interest already shown by ECMWF, Met Office, NRL and others.
- Could be complimentary/back up observations with Lidar, as per CGMS.
- Version 2 to be implemented in 2023/2024, which includes modern optimisation techniques, the management of noisy and incomplete data, as well as atmospheric turbulence.



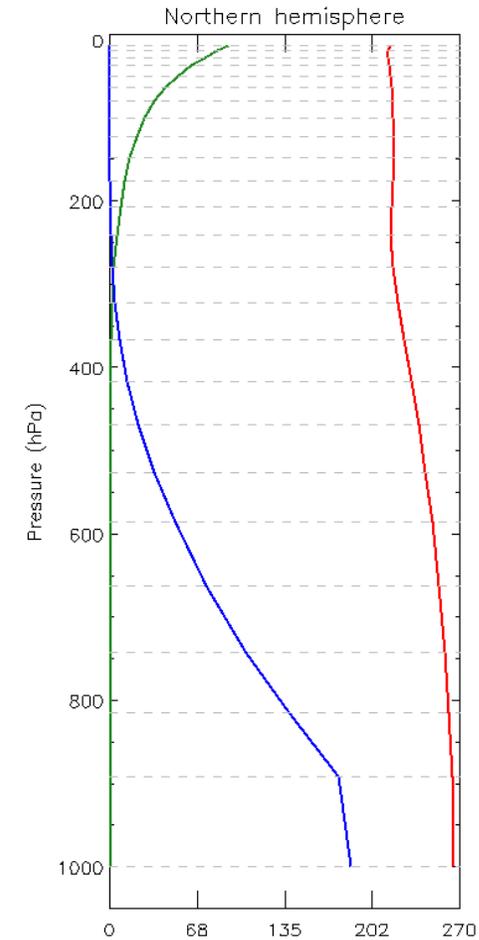
Thank you!
Questions are welcome.



IASI 3D winds – Comparison against forecast (NH)

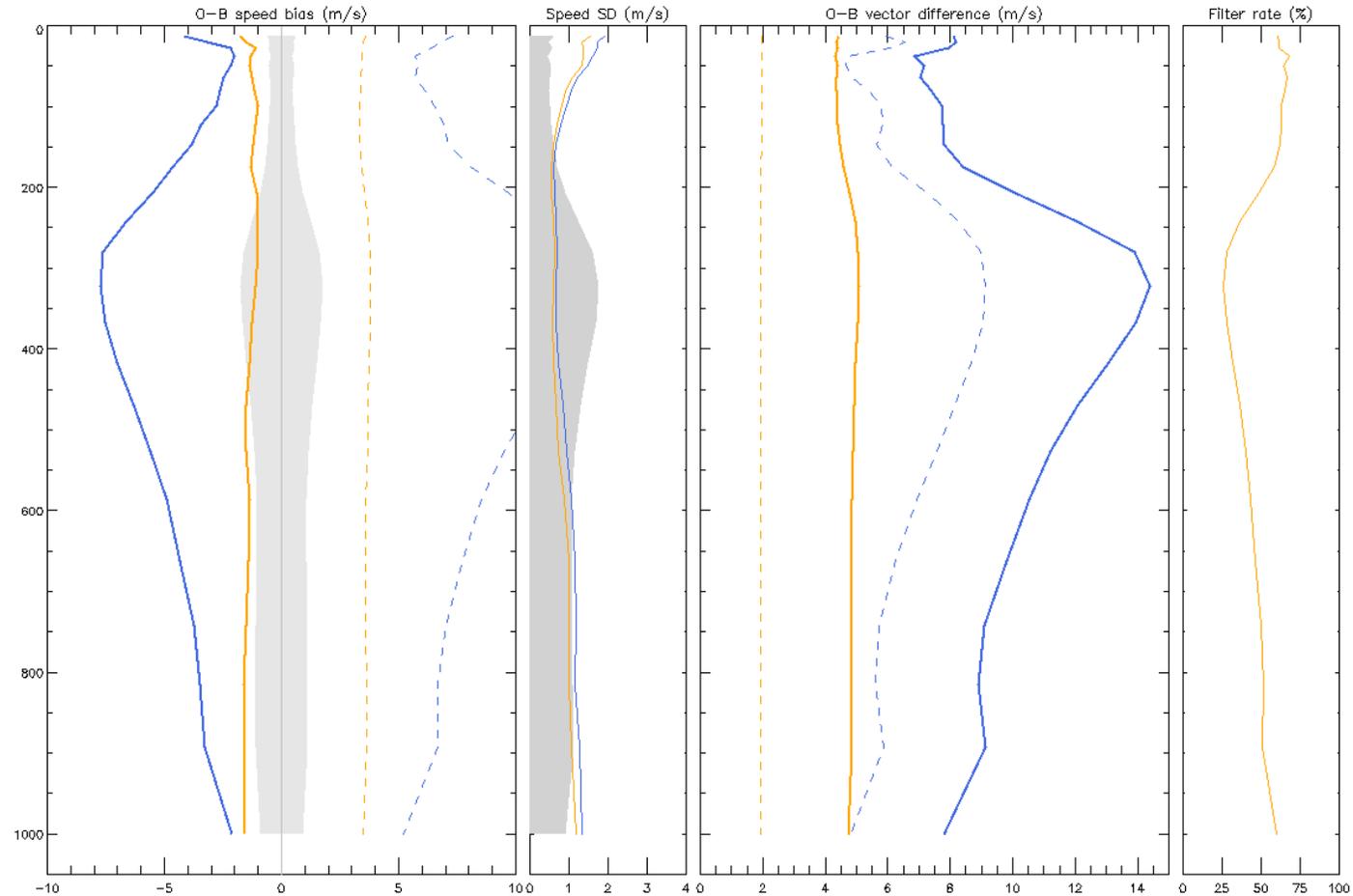


IASI 3D winds statistics against forecast over the North pole on 01-07/04/2023.



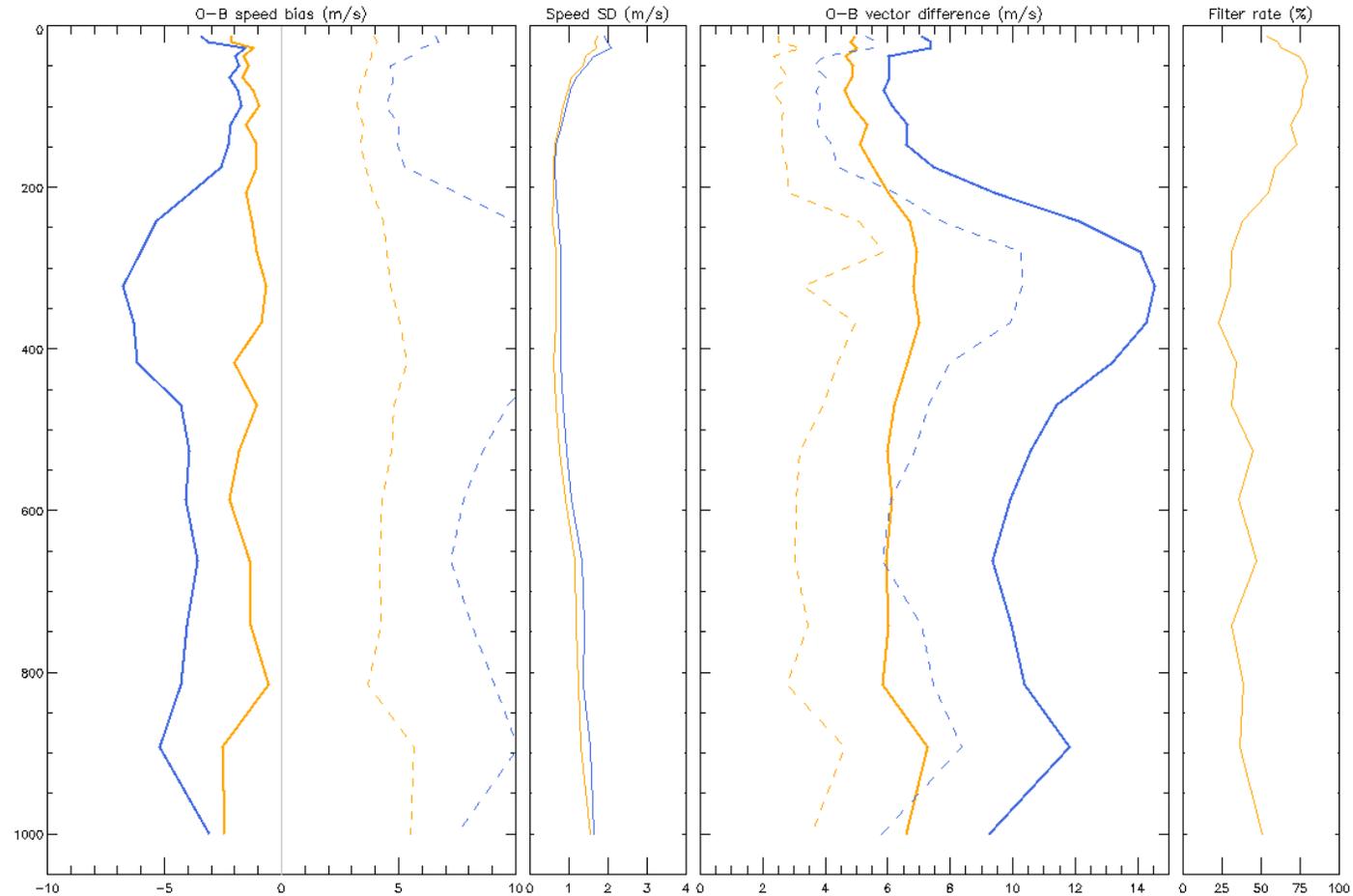
IASI temperature (K, in red), humidity ($\times 10^5$, in blue) and ozone ($\times 10^7$, in green) profiles on 01/04/2023 over the North pole at 12:29:31.

- O-B speed biases (solid line) and RMS (dashed line) profiles of IASI 3D winds against ECMWF forecast:
 - *All wind vectors*
 - *Filtered on the vector difference against forecast wind ($vd < 8$ m/s)*
 - *Shaded zone shows the ECMWF variability inside the binning area*
- **After cut-off at 8 m/s for O-B:**
 - Mean bias ≈ -1.3 m/s, RMS ≈ 3.5 m/s.
 - Speed SD within the box comparable to ECMWF model field variability.
 - 51% of the wind vectors left.
 - Statistics consistent on the whole vertical range.



IASI 3D winds statistics against forecast over the South pole on 01-07/04/2023.

- Radiosonde observations within ± 3 hours of the 3D wind product, collocated on the super-pixels.
- O-B speed biases (solid line) and RMS (dashed line) profiles of IASI 3D winds against IGRA radiosonde data:
 - *All wind vectors*
 - *Filtered on the vector difference against forecast wind ($vd < 8$ m/s)*
- After cut-off at 8 m/s for O-B:
 - Mean bias ≈ -1.5 m/s, RMS ≈ 4.2 m/s.
 - 52% of the wind vectors left.
 - Statistics consistent on the whole vertical range.



IASI 3D winds statistics against radiosonde data over the North pole on 01-07/04/2023.