Wind products derived from polar orbiting satellites

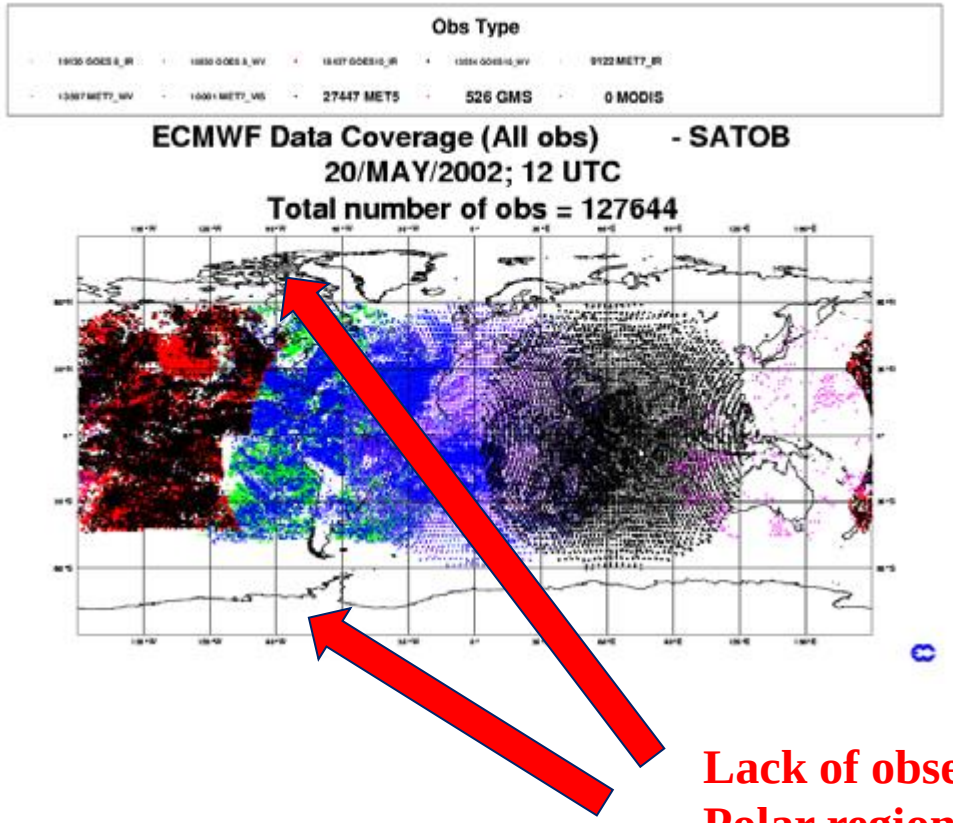
R. Borde

EUMETRAIN Wind Event Week, 2022

Polar winds

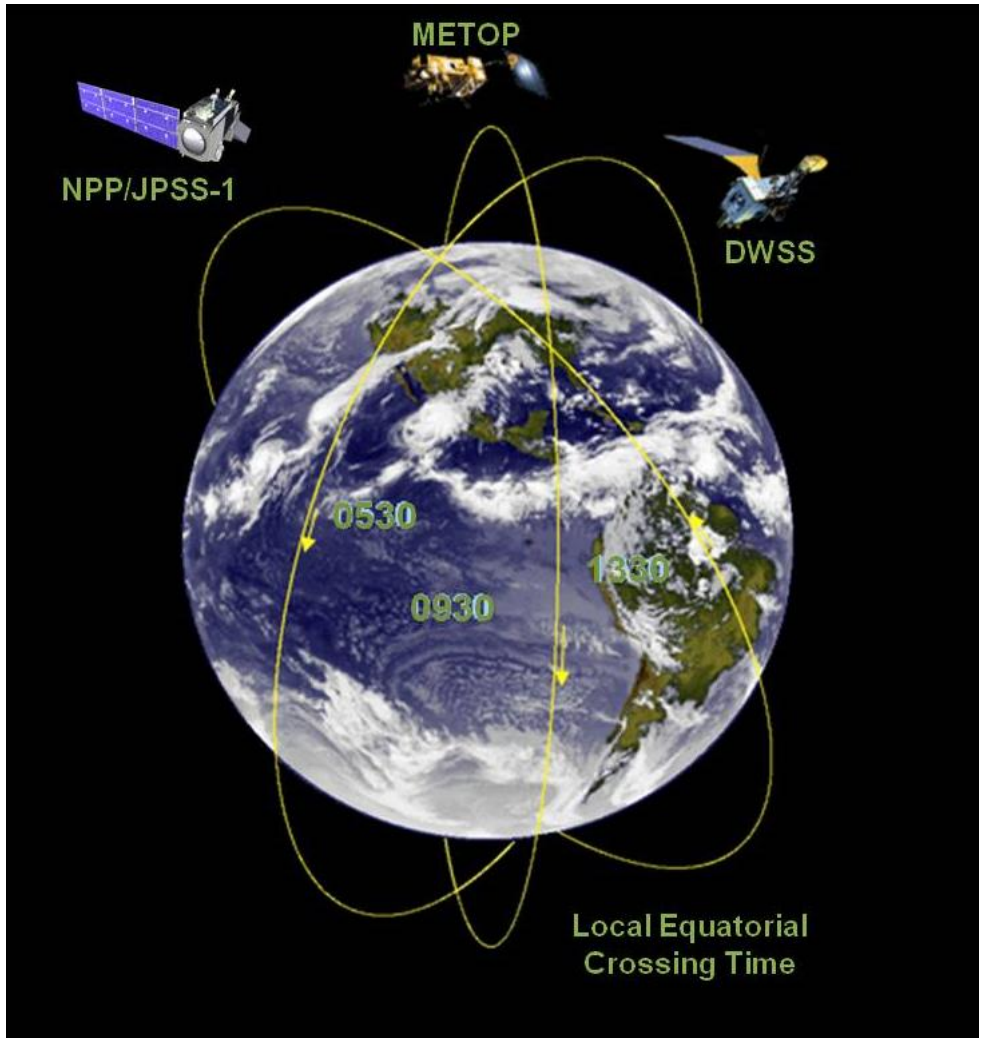
Why doing polar winds ?

Assimilation at ECMWF in 2002



Lack of observations in Polar regions

Polar winds
How doing polar winds ?



Needs:

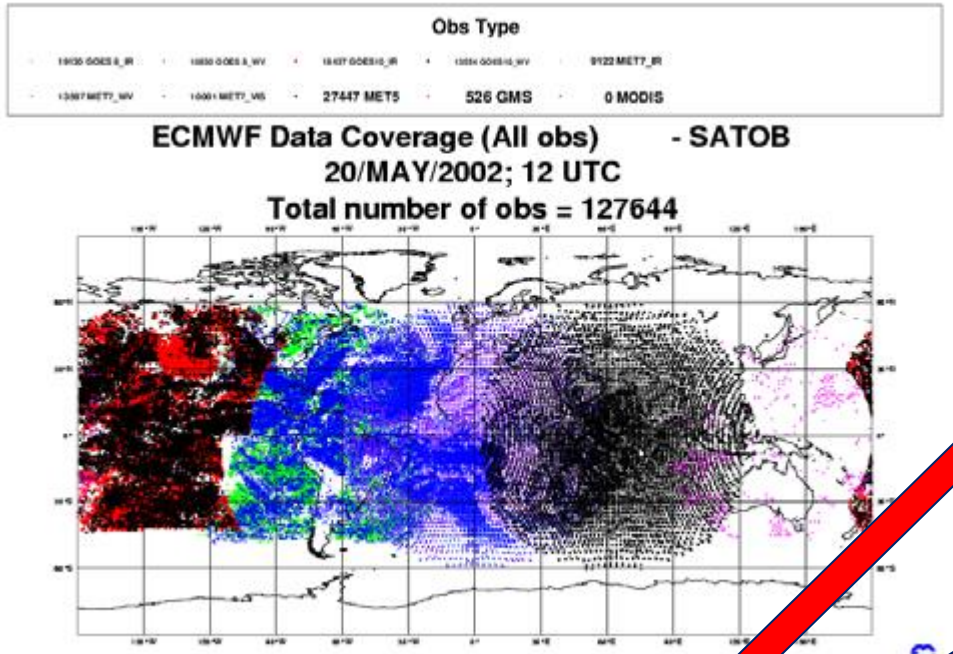
- **Low orbit polar satellites: NPP, METOP...**
- **Appropriate instruments: MODIS, AVHRR, VIIRS.**

But some new challenges:

- **Large timeliness (~100 min)**
- **Small areas to track features**
- **Problems of view angles, parallax and varying pixels sizes**
- **Polar region specificities like ground colder to air above**
- **...**

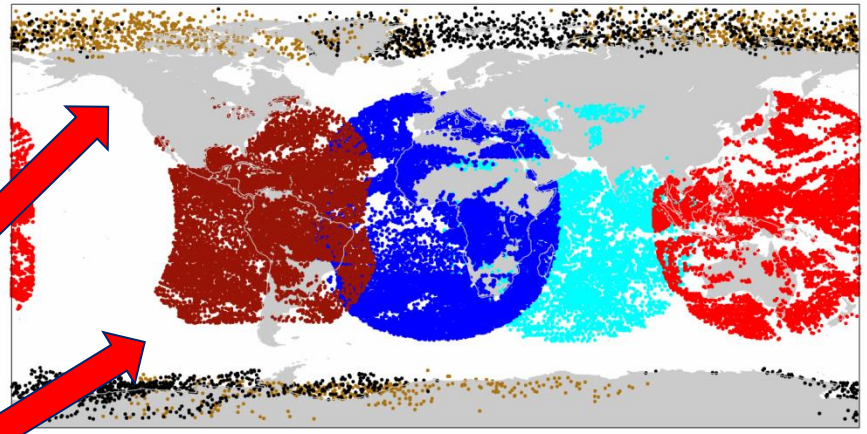
Polar winds
Why doing polar winds ?

Assimilation at ECMWF in 2002



12-h sample coverage: used AMVs at ECMWF in 2012

GOES-13 MET-9 MET-7 MTSAT-2
TERRA AQUA
GOES-15 AMVs under evaluation since December 2011



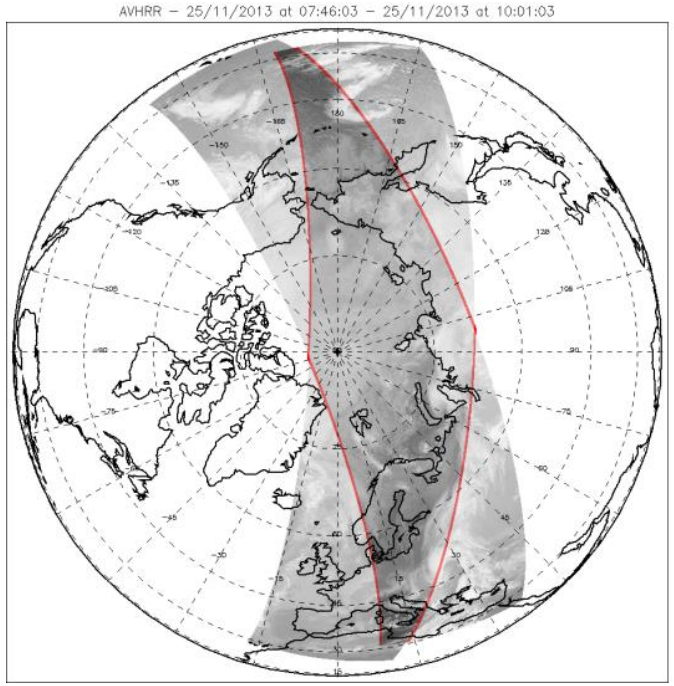
Still lack of observations in 40-70 Deg latitude bands

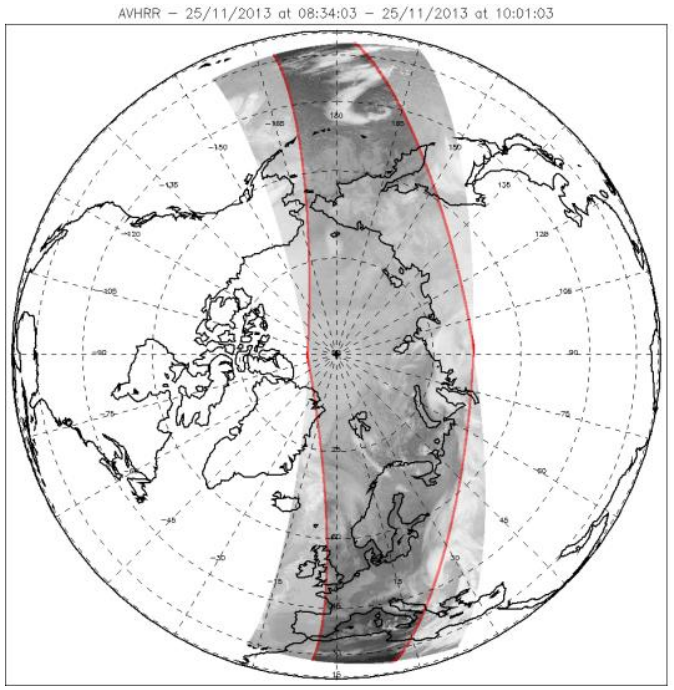
Key, J et al., 2003, Cloud-drift and Water Vapor Winds in the Polar Regions from MODIS, IEEE Trans. Geosci. Remote Sensing, 41(2), 482-492

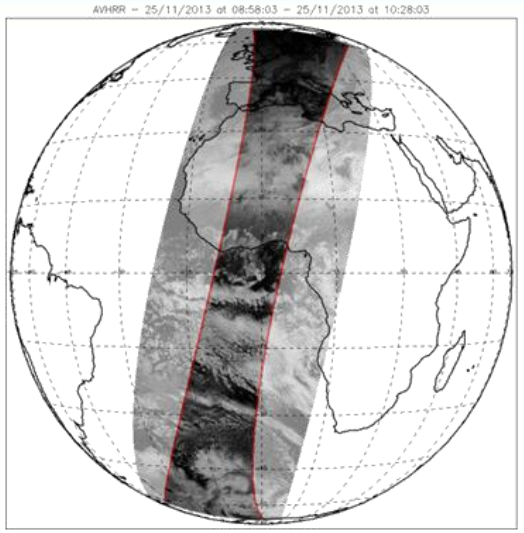
Single and Dual Metop platforms AMV products

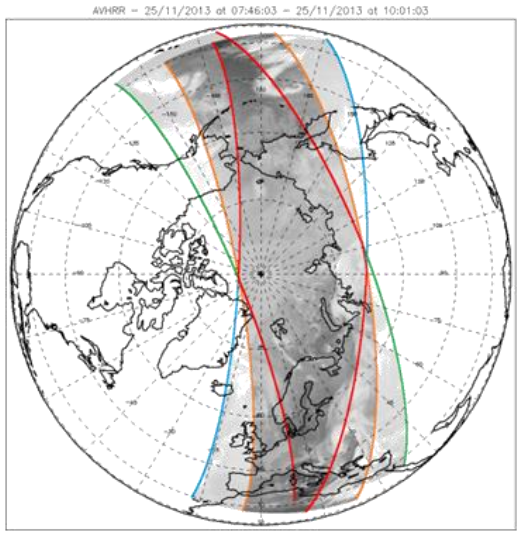
Single Metop

Dual AVHRR









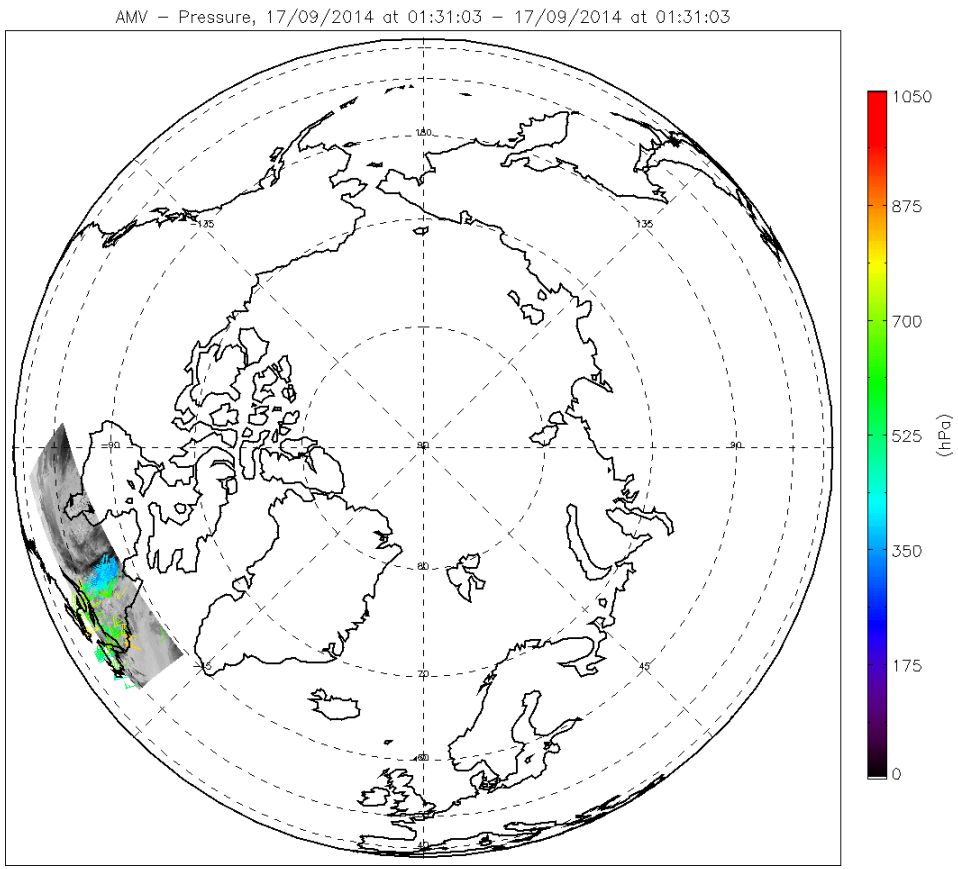
3 different AVHRR wind products at EUMETSAT.

- Single Metop AVHRR wind over polar regions
- Global AVHRR wind product.
- Triplet mode AVHRR wind product over polar regions.

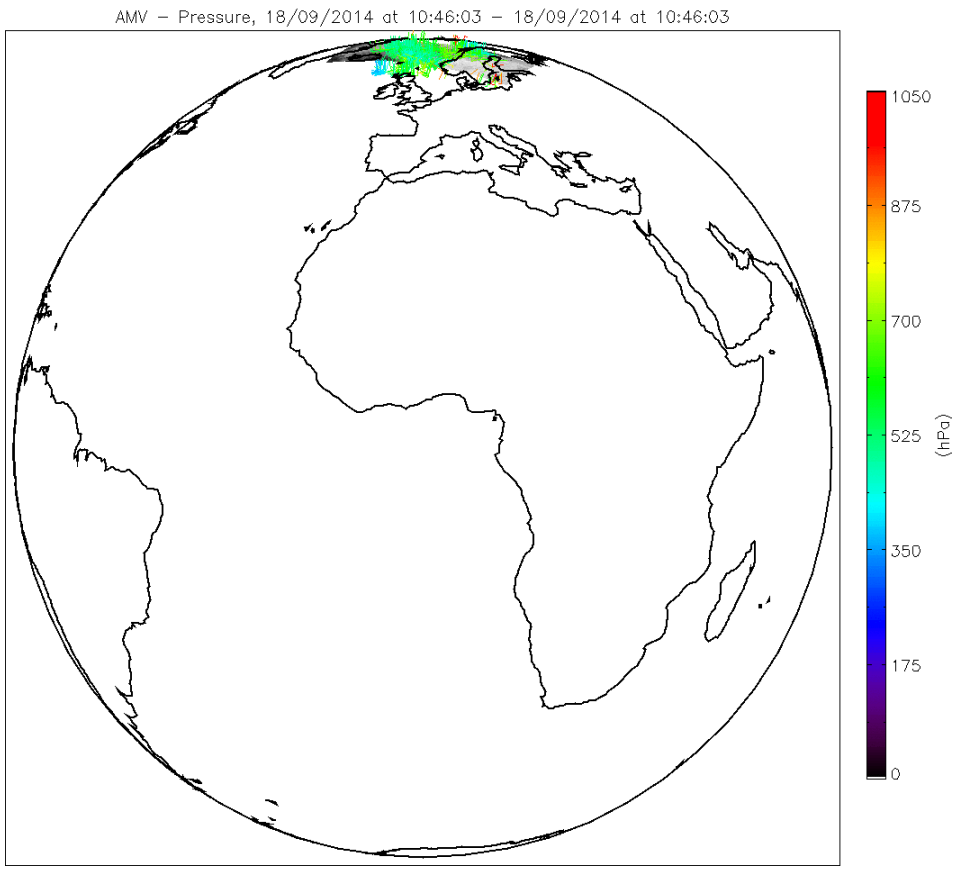
AVHRR wind products	*Number of satellite used*	*Number of images used*	*Time to derive the product (~min)*	*Coverage*
Single Metop polar	1	2	100	Polar areas
Global AVHRR	2	2	50	Global
Triplet mode	2	3	100	Polar areas

EUMETSAT AVHRR winds Examples

Single Metop polar, 17/09/2014, 1:31-1:52



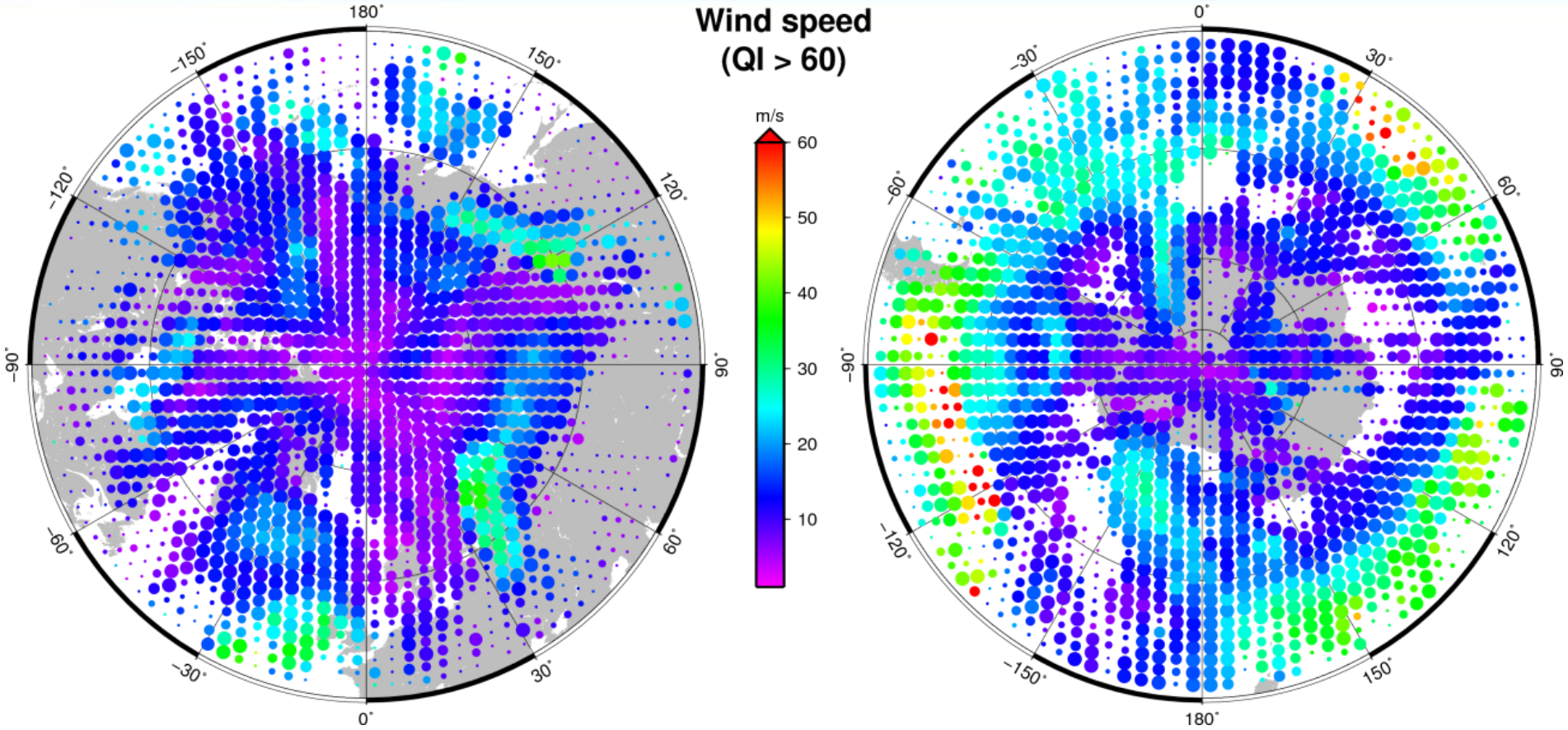
Global AVHRR , 18/09/2014, 9:04-9:46



Hautecoeur, O., and R. Borde, 2017, Derivation of wind vectors from AVHRR Metop at EUMETSAT, in press J. Atmos. Oceanic Technol, 34, 1645–1659, doi: 10.1175/JTECH-D-16-0087.1

Borde, R., O. Hautecoeur, and M. Carranza, 2015, EUMETSAT Global AVHRR winds product', J. Atmos. Oceanic Technol, 33, 429-438. DOI: http://dx.doi.org/10.1175/JTECH-D-15-0155.1

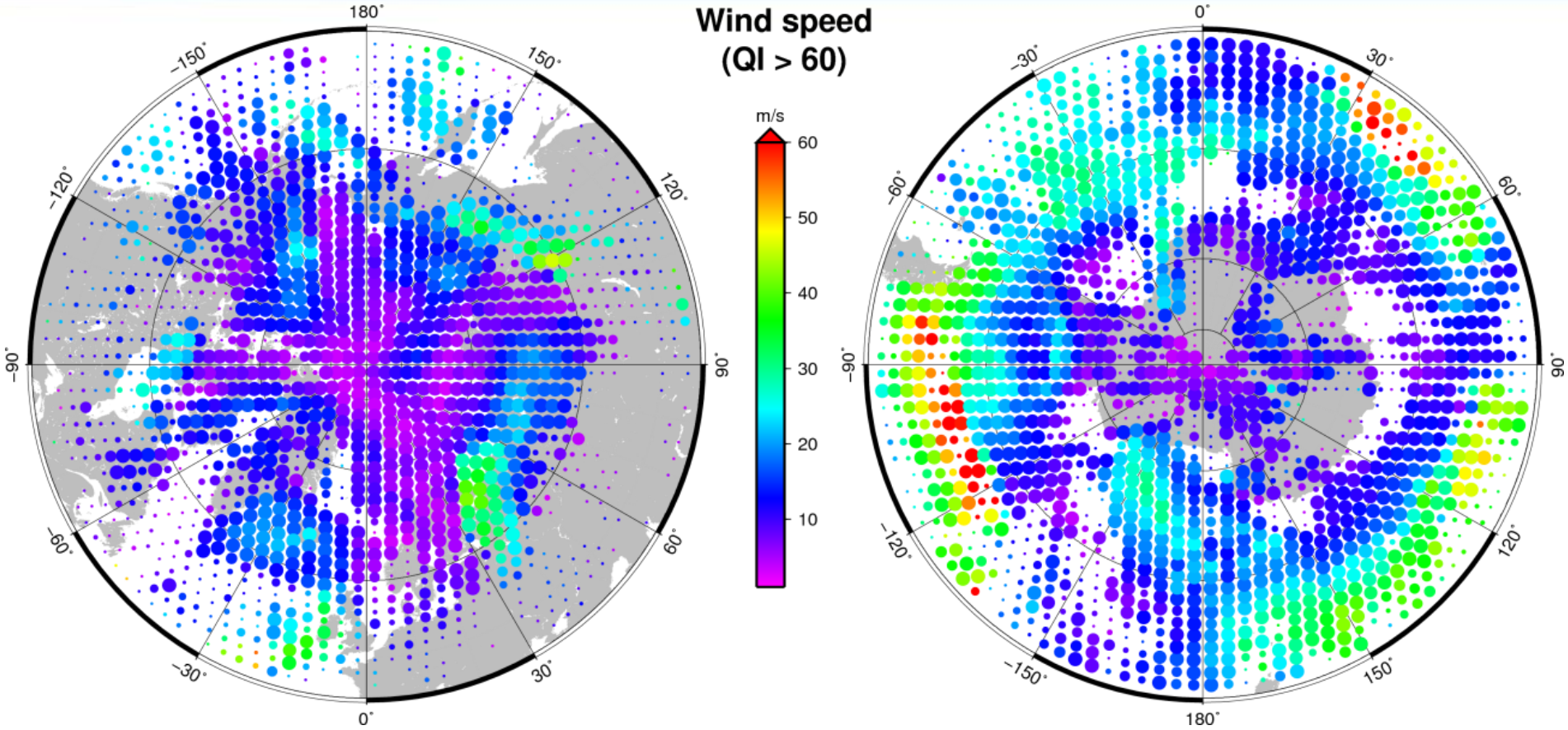
Intercomparison of the three modes 1/3



North Pole **South Pole**

AVHRR AMV, June 27th, 2015
Single AVHRR wind Product, QI > 60

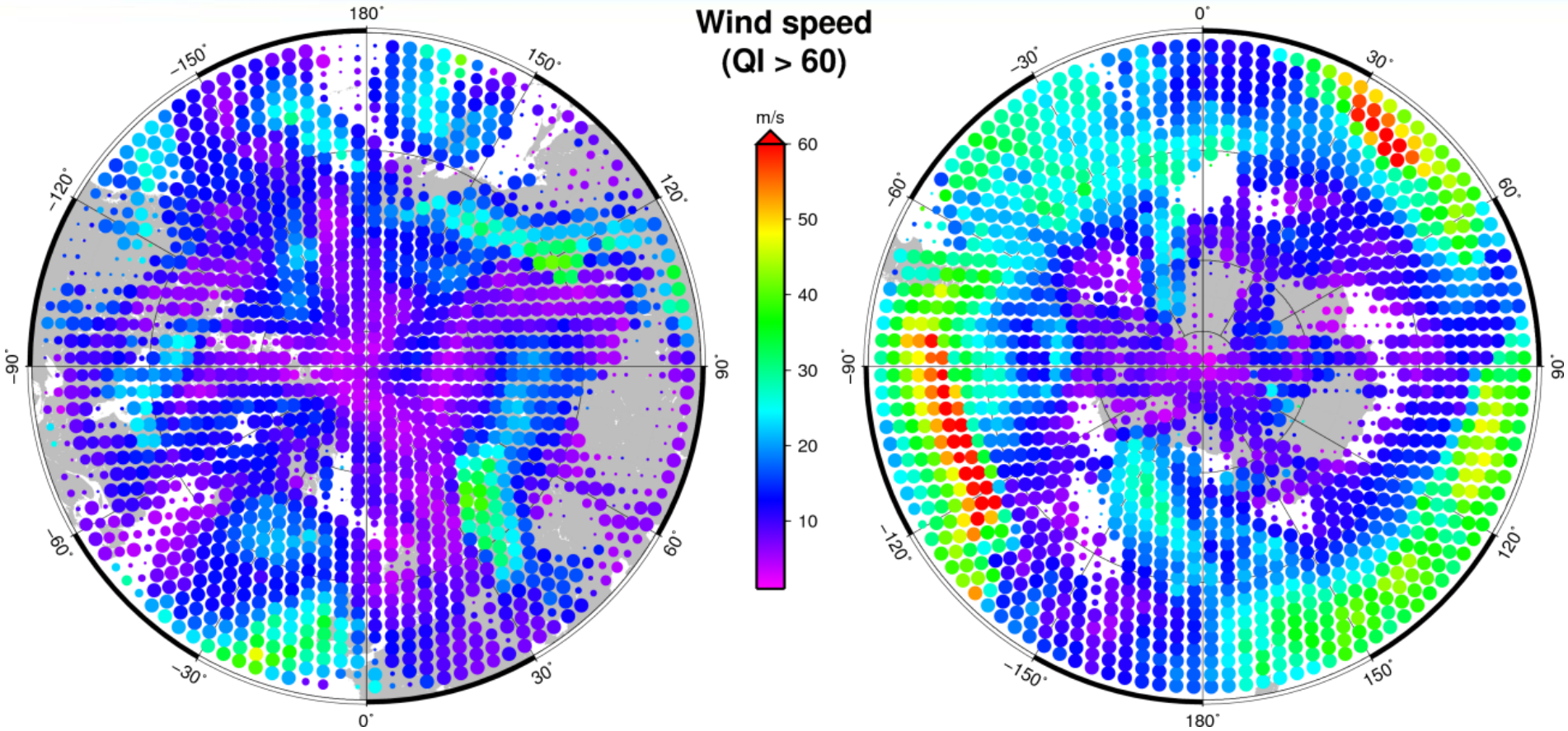
Intercomparison of the three modes 2/3



North Pole **South Pole**

AVHRR AMV, June 27th, 2015
Triplet mode Product, QI > 60

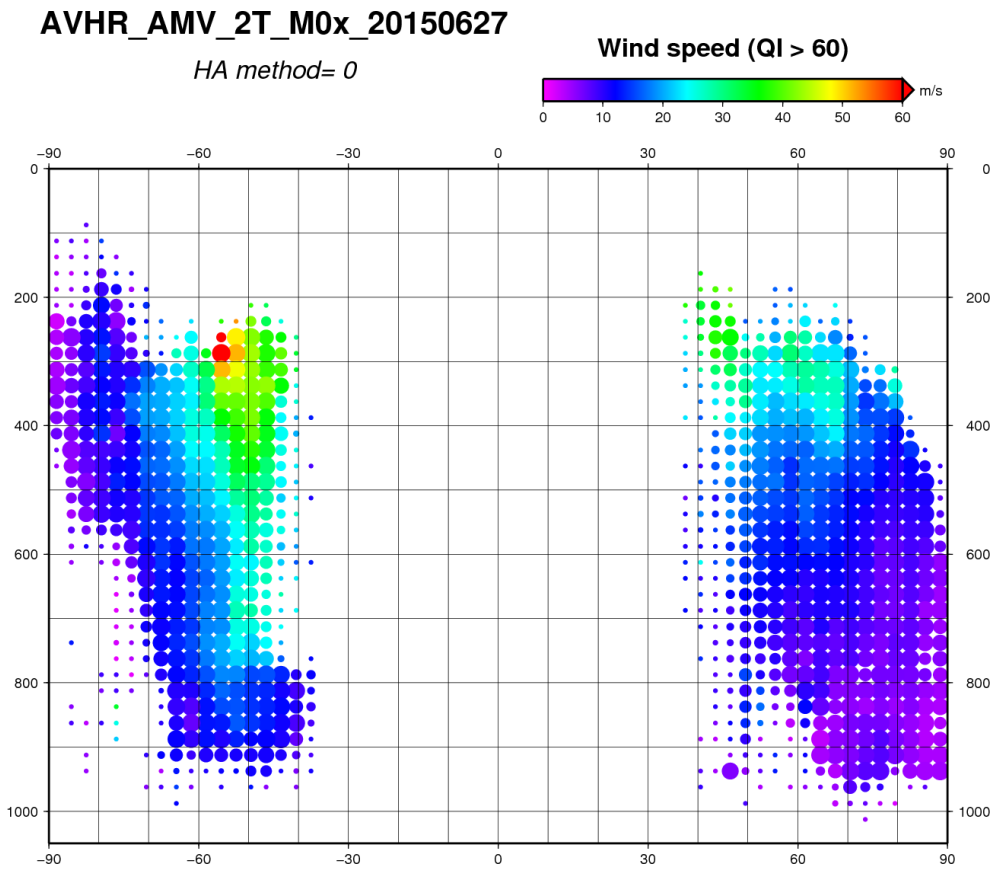
Intercomparison of the three modes 3/3

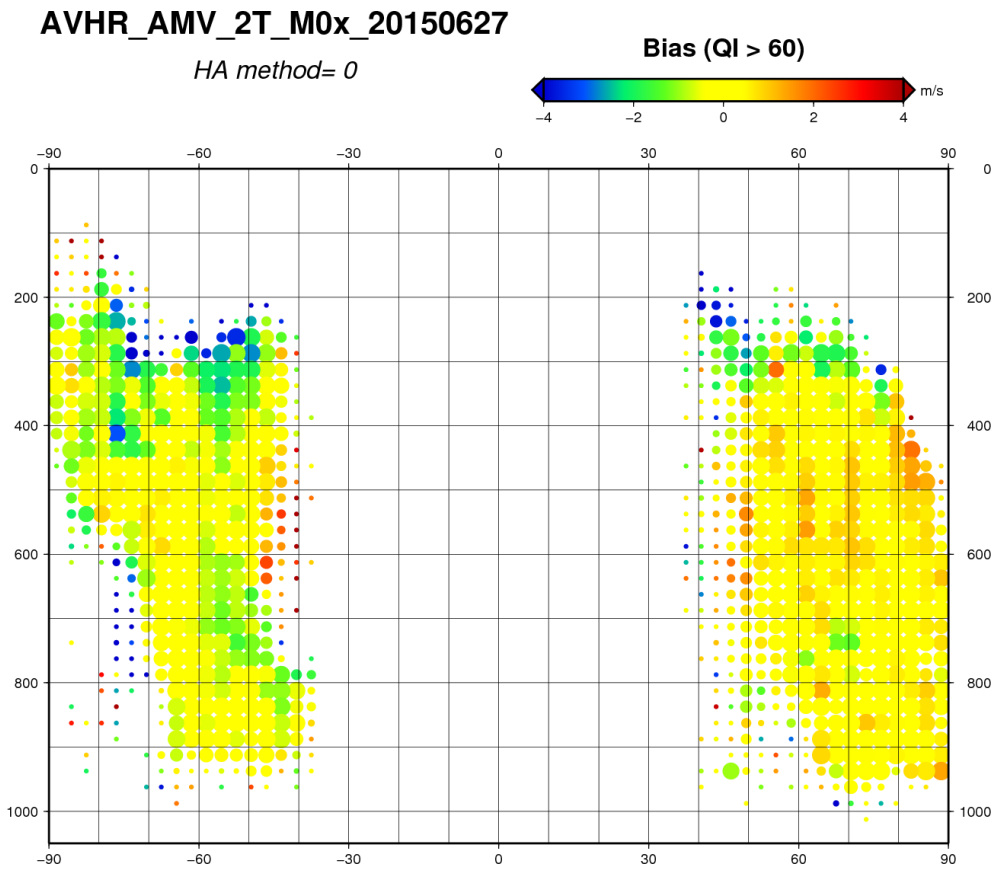


North Pole **South Pole**

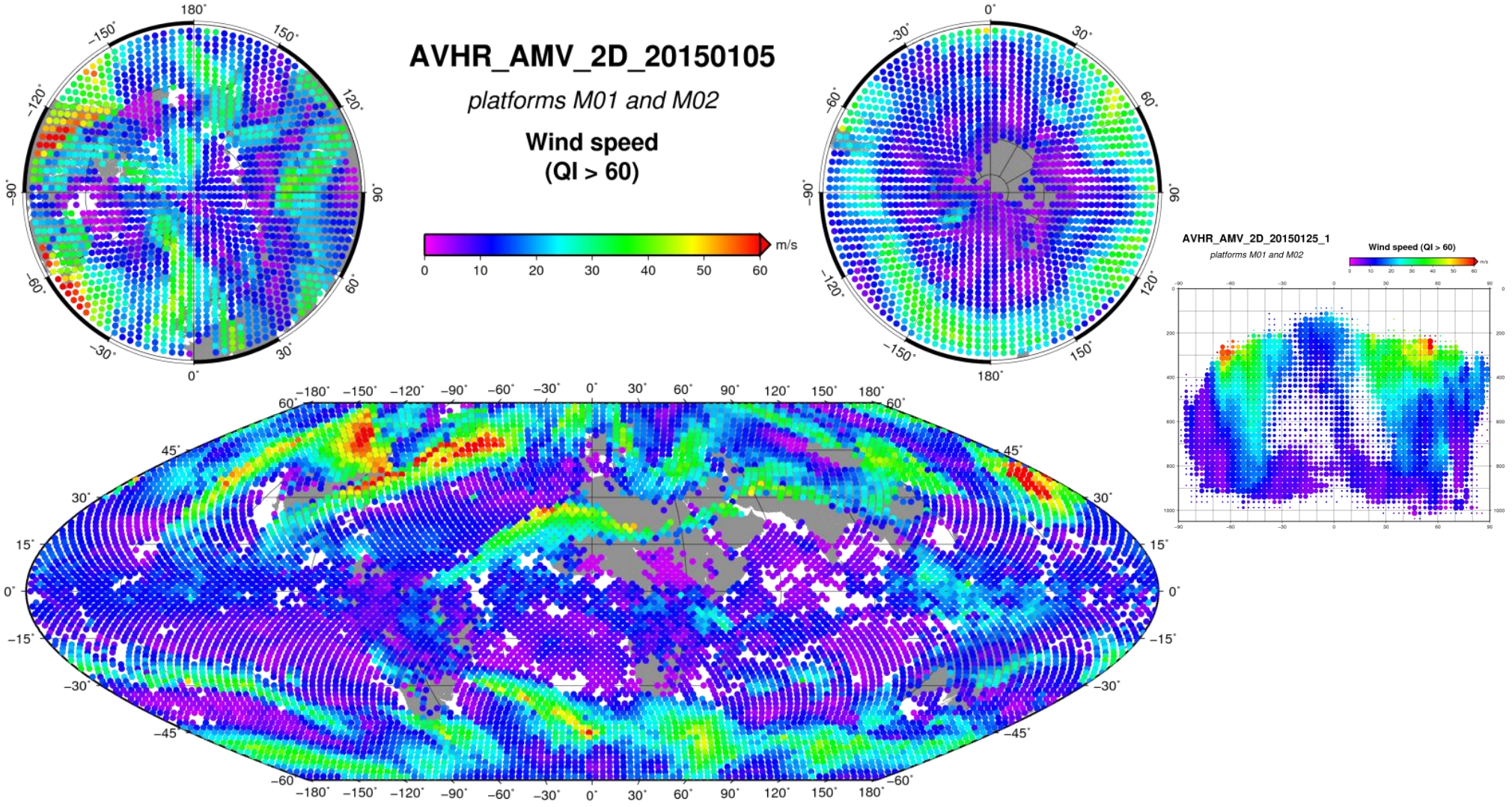
AVHRR AMV, June 27th, 2015
Global AVHRR wind Product, QI > 60

Wind speed and speed bias for triple mode product





Daily global coverage for dual mode products



Other Winds Products developed from LEO Satellites

LEO-GEO winds from Composite Images.

Lazzara, M.A.; Dworak, R.; Santek, D.A.; Hoover, B.T.; Velden, C.S.; Key, J.R. High-latitude atmospheric motion vectors from composite satellite data. *J. Appl. Meteorol. Climatol.* **2014**, *53*, 534–547.

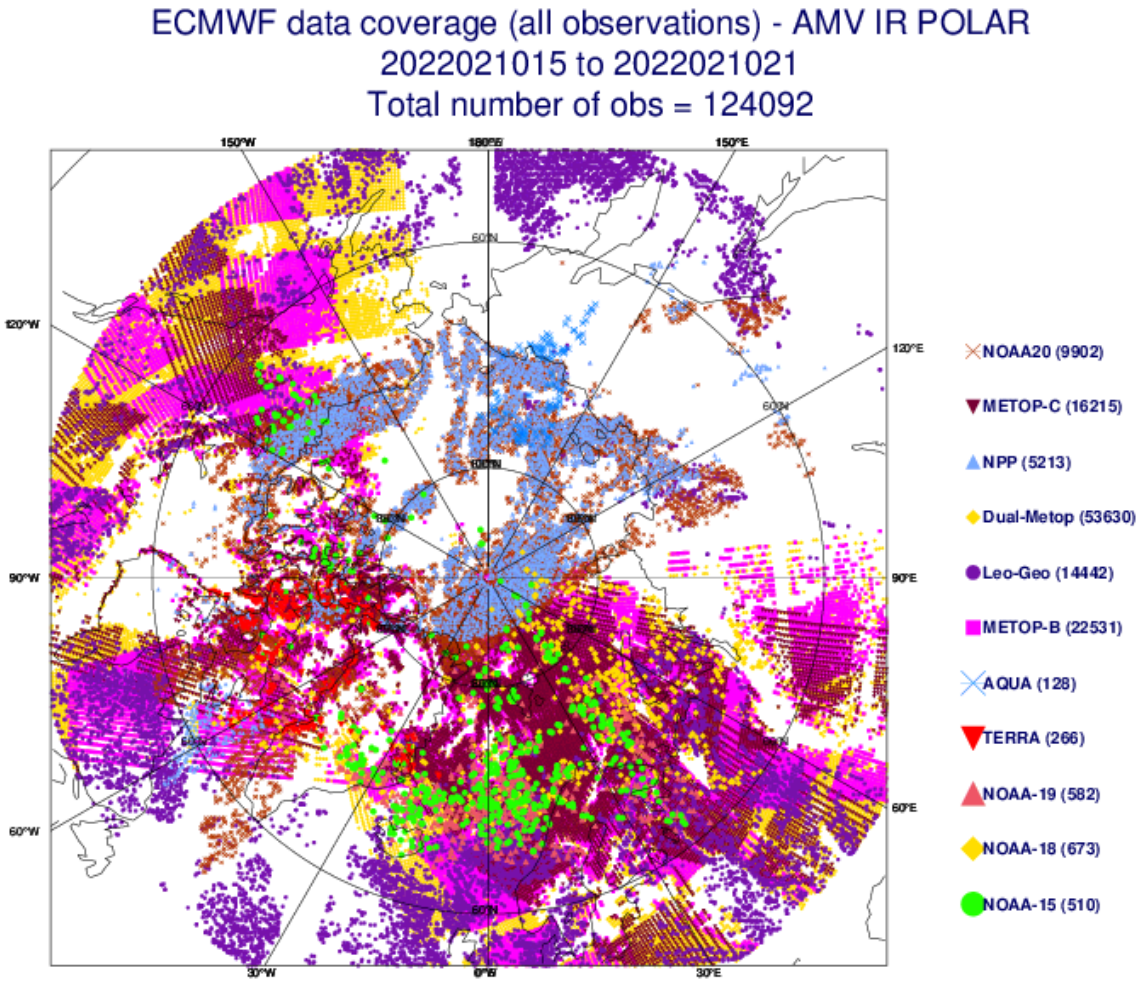
Winds from VIIRS.

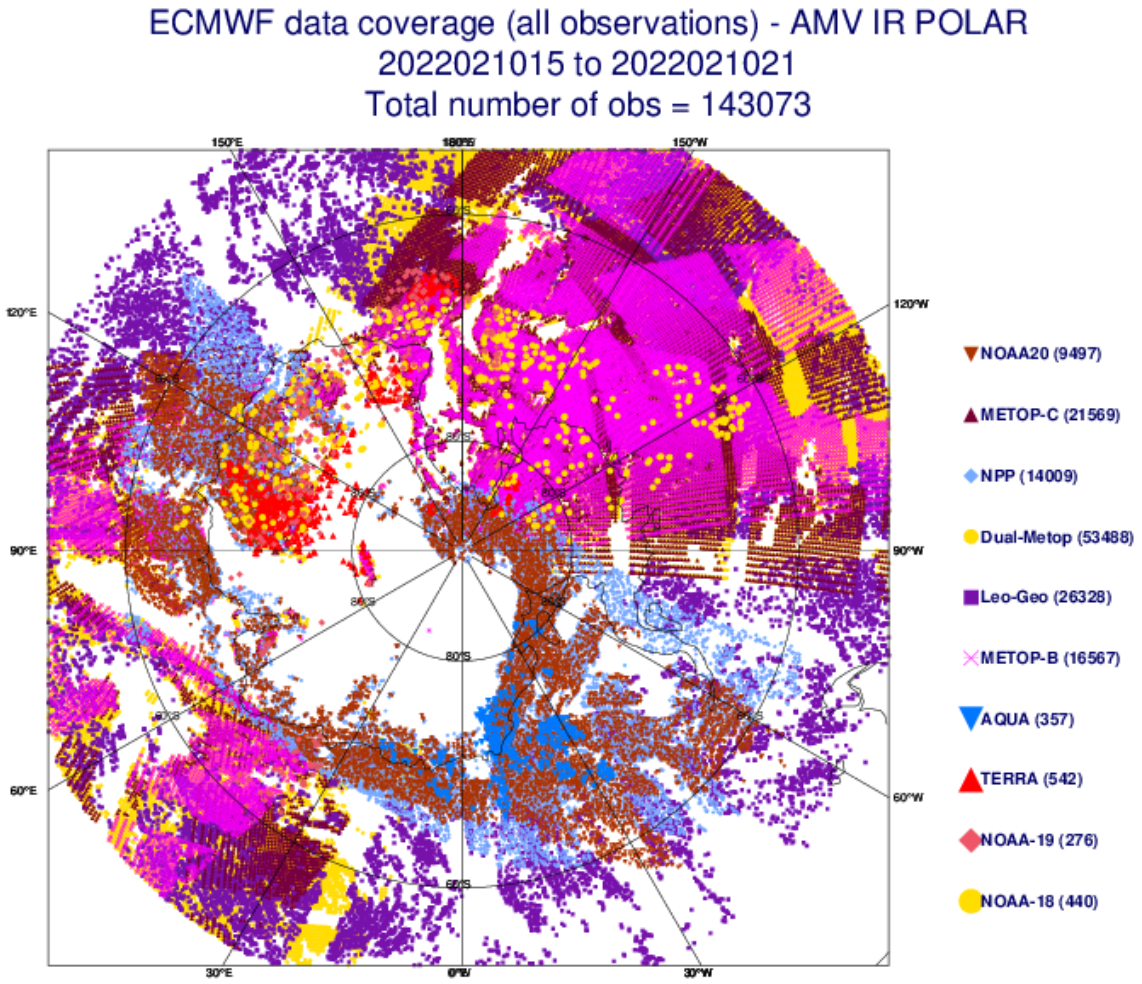
Key et al., Polar winds from VIIRS, Conference: Eleventh International Winds Workshop, Auckland, New Zealand, February **2012**

Winds from MISR.

Mueller, K.J.; et al., Assessment of MISR Cloud Motion Vectors (CMVs) Relative to GOES and MODIS Atmospheric Motion Vectors (AMVs). J. Appl. Meteorol. Clim. **2017**, 56, 555–572

Polar Orbiting satellite AMV production





AMVs monitored in ECMWF system, 10 Feb 2022 at 18:00 UTC.

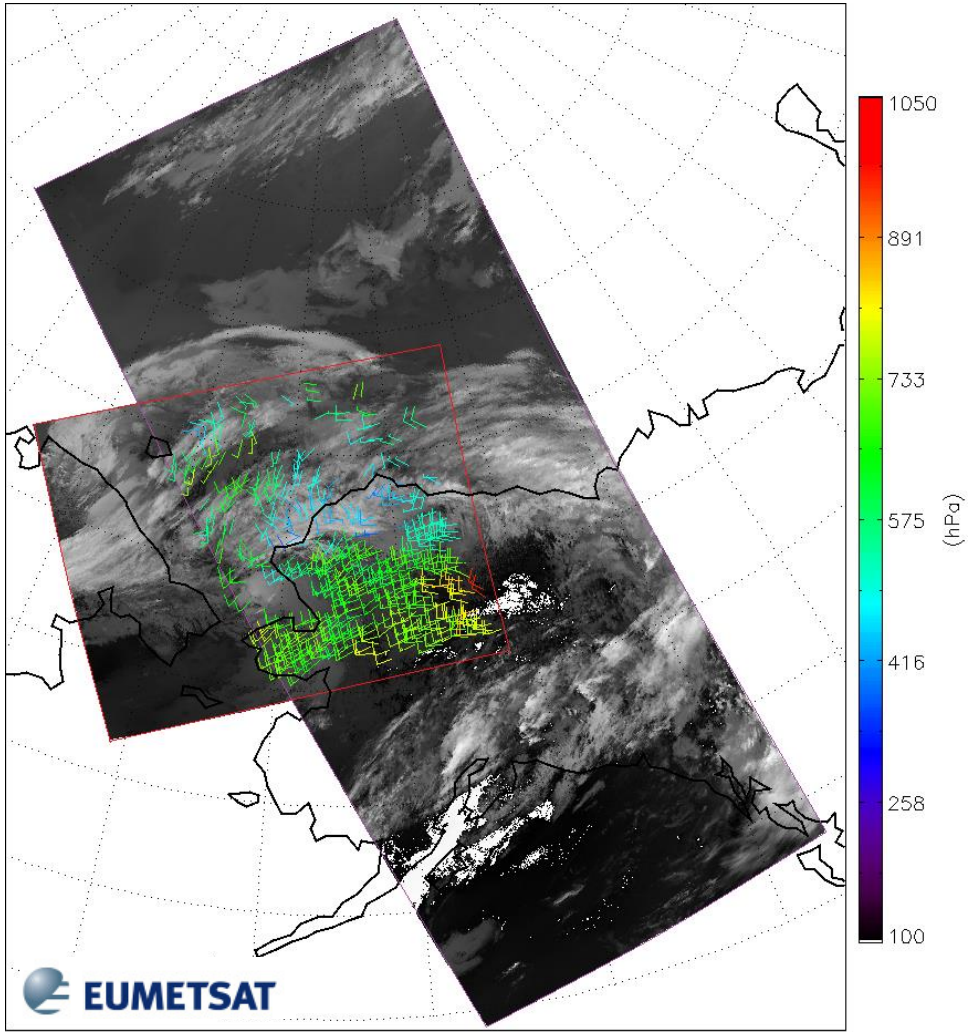
EUMETSAT Sentinel-3 AMV - Status

- ➢ Processor is finished and documentation is up-to-date (ATBD and Validation report).

Barbieux, K., O. Hautecoeur, M. De Bartolomei, M. Carranza, and R. Borde, 2021, *The Sentinel-3 SLSTR Atmospheric Motion Vectors Product at EUMETSAT*, Remote Sens. 2021, 13, 1702. https://doi.org/10.3390/rs13091702

- ✓ Sentinel-3 AMV estimation based on normalized cross-correlation technique on a equal-area grid minimizing distortion and scale effects
- ✓ Using Sentinel-3/SLSTR TIR (10.8 um) Nadir view Dual satellites operation (A+B).
- ✓ Mid-/High-latitude bands (polewards of 40 deg.) to be covered (including the 60-70 deg. latitude bands).
- ✓ Off line production since January 2021

AMV extracted from SLSTR images taken over Northern Alaska on 14/08/2019 at 08:00:43 UTC (S3B - red contour) and from 06:56:15 to 07:05:15 UTC (S3A - purple contour). K. Barbieux and R. Borde (EUM)



EPS-SG METImage AMV

Same framework as Sentinel 3 / SLSTR AMVs
Barbieux, K., O. Hautecoeur, M. De Bartolomei, M. Carranza, and R. Borde, 2021, *The Sentinel-3 SLSTR Atmospheric Motion Vectors Product at EUMETSAT*, Remote Sens. 2021, 13, 1702. https://doi.org/10.3390/ rs13091702

Prototype code is developed. It includes AMV extraction from 5 channels: Vis0.8, IR3.7, WV6.73, WV 7.3 and IR10.7

Dataset V1 distributed in Sept 2019
Feedback on dataset V1 received from CIMSS (D. Santek)
Comparison with MODIS winds shows good agreement.

- Satellite to be launched in 2024

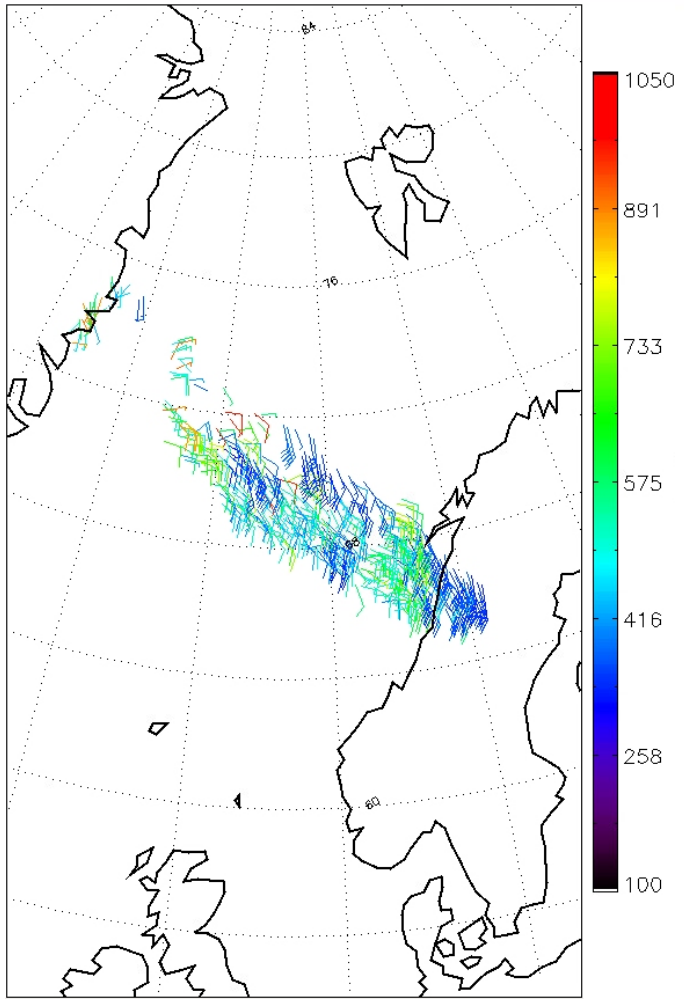


Figure: AMVs derived from simulated METImage band 37 (10.69 µm) images, West of Norway. Altitudes in hPa.

Toward 3D winds profiles from satellites data

- ✓ Current AMVs limitations:
  - AMVs give an information at a single level of the troposphere.
  - Height assignment is known to be an important problem.
  - Recurrent AMV problems in tropics area where important mesoscale phenomena impact the medium range forecast.

- ✓ 3D wind profiles expected from Lidar measurements and IR sounders data

2. ESA-Aeolus Overview

- ESA Earth Explorer 4
- ESA / ECMWF Cooperation

- Orbital parameters:
  - SSO
  - 320 km mean altitude
  - 96.97 deg inclination
  - LTAN:18:00 (dawn-dusk orbit)
  - 90,8 min period
  - 7 days repeat cycle (111 orbits)

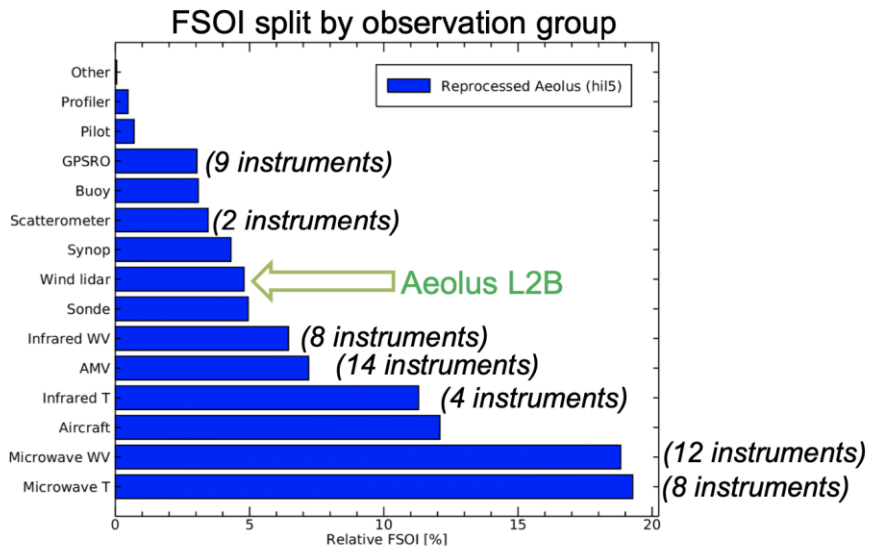
- Launch: 22.08.18 on Vega
- Design lifetime: 3 years

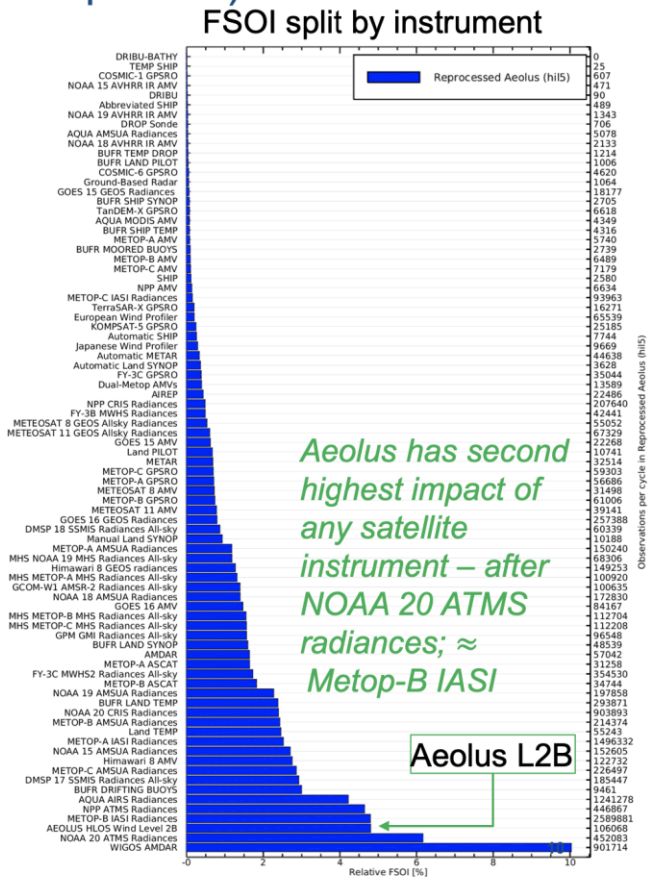
- ALADIN (Atmospheric Laser Doppler INstrument)
  - 2 receiver channels
    - Mie receiver
      to determine winds from aerosol & cloud backscatter
    - Rayleigh receiver
      to determine winds from molecular backscatter

- **Mission objectives fully achieved**
  - Demonstrated the Doppler Wind Lidar technique for measuring wind profiles from space
  - Positive impact on NWP assessed
  - HLOS winds assimilated since 2020 in number of MET services
  - Lifetime over the expected 3 years.

Aeolus Impact

FSOI for reprocessed L2B data period (3 July to 27 Sept 2019)





- ***For this period*** with ***good atmospheric signal*** and **reprocessing**, Aeolus provides **4.8% relative FSOI** – compare this to ~3.2% for first half 2020 operations
  - Aeolus ≈ radiosondes, > scatterometer & GPSRO
- **Shows the importance of DWL in NWP**
  … even with less useful signal than expected pre-launch

ECMWF

Figures courtesy of Michael Rennie, ECMWF

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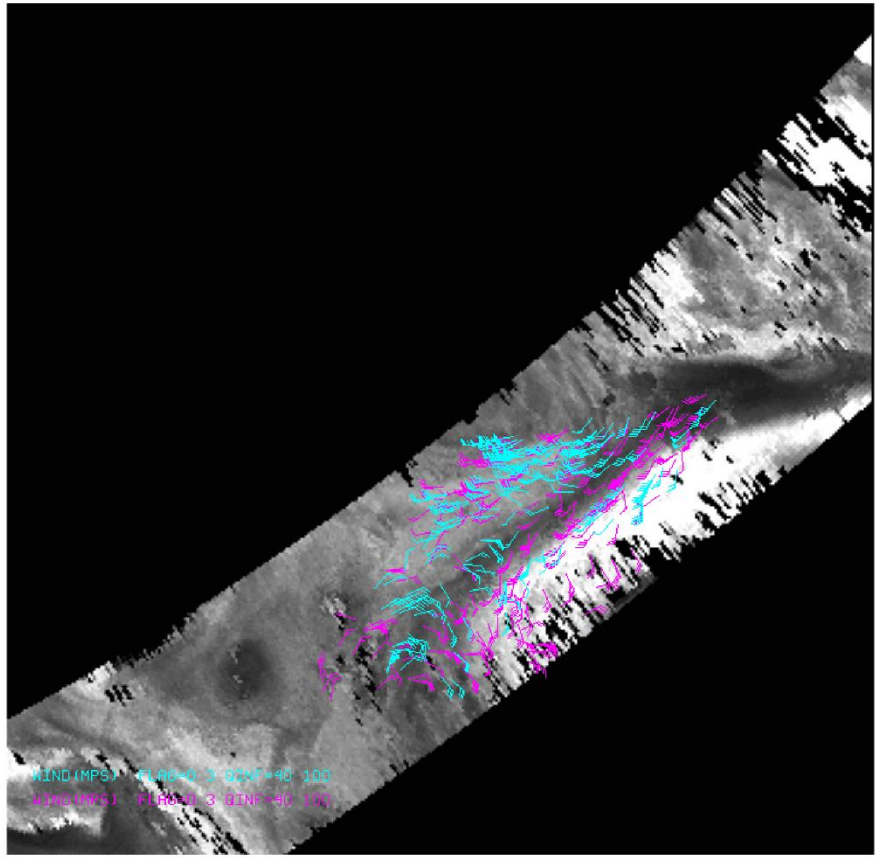
Potential Aeolus follow on – DWL - Status

- Assumptions and bases, Phase 0 (Sept 2020 - March 2021)
  - ✓ The mission shall be “affordable”, Reuse of existing assets shall be priority
  - ✓ Mission duration: 10+ years, 2 satellites, Launch of first satellite: ~2030
  - ✓ Basis of observational requirements defined by Aeolus SAG
- Mission observational requirements
  - ✓ Good progress on consolidation of the observational requirements via several workshops organised with ESA in H2 2021
- Draft EURD consolidation
  - ✓ Initial Draft presented & released to SWG delegates & Aeolus SAG
  - ✓ Update still planned by summer 2022 (ie. target: Joint Workshop with Member States) covering review and mission observational requirements consolidation ESA programme approval planned @ Cmin 2022
- Main drivers
  - ✓ Workshop with ESA and EUMETSAT member states – Planned 08-09 September 2022 in Darmstadt
  - ✓ ESA programme approval planned @ Cmin 2022
  - ✓ Final approval by EUMETSAT member states foreseen in 2025

3D winds from IR sounders

- Product from AIRS in demonstration at CIMSS.
  - ✓ Based on moisture and ozone fields from AIRS
  - ✓ High-latitude regions (polewards of 70° latitude)
  - ✓ Troposphere and stratosphere; 29 layers
  - ✓ Assimilation experiment in GEOS-5 found neutral to slighltly positive impact on FC, but a good impact per AMV observation.

Santek, D.; Nebuda, S.; Stettner, D. Demonstration and Evaluation of 3D Winds Generated by Tracking Features in Moisture and Ozone Fields Derived from AIRS Sounding Retrievals. Remote Sens. 2019, 11, 2597



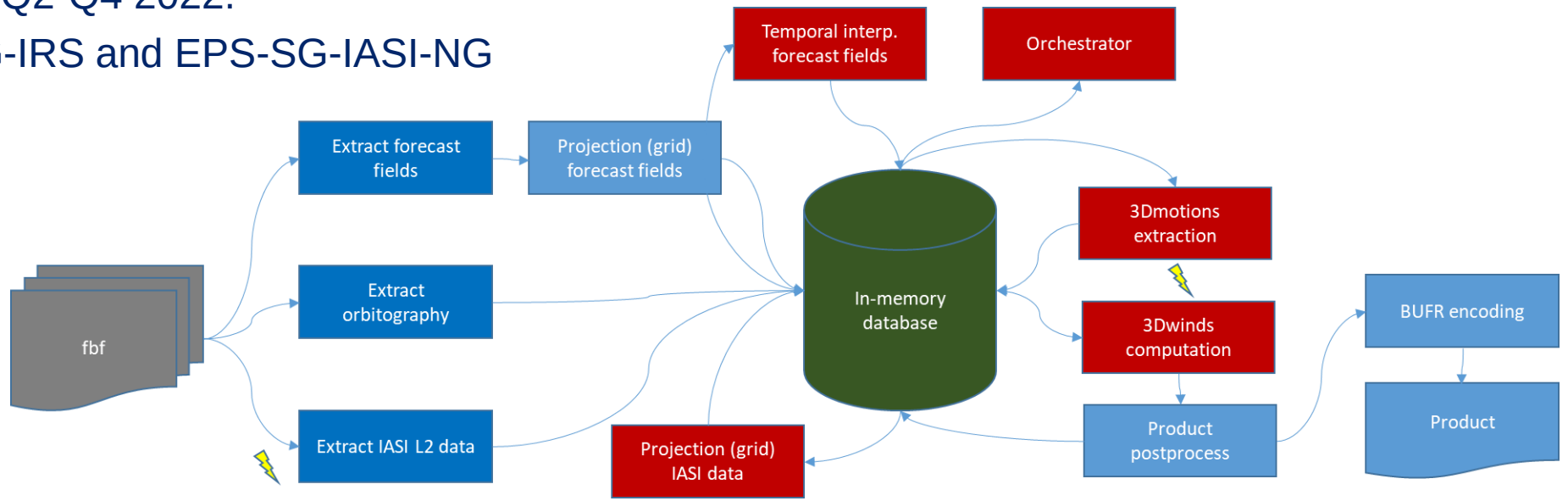
AIRS retrieval atmospheric motion vectors (AMVs) over a 400 hPa AIRS retrieved moisture field from 20 July 2012 0551 UTC. The North Pole is in the center of the picture, with Greenland in the lower-left region (not visible). These wind barbs are all moisture and ozone tracked AMVs color- coded by pressure level: cyan 400 to 699 hPa; magenta above 399 hPa

Figure courtesy of Dave Santek, CIMSS

EUMETSAT IASI 3D winds – Status

- Operational implementation is ongoing
  - ✓ Processor is finished.
  - ✓ Based on optical flow technics
  - ✓ Off line production started in Q1 2022
  - ✓ The target for operational implementation on EPS GS is 2023

- Future work
  - ✓ Scientific validation, Q2-Q4 2022.
  - ✓ Preparation for MTG-IRS and EPS-SG-IASI-NG



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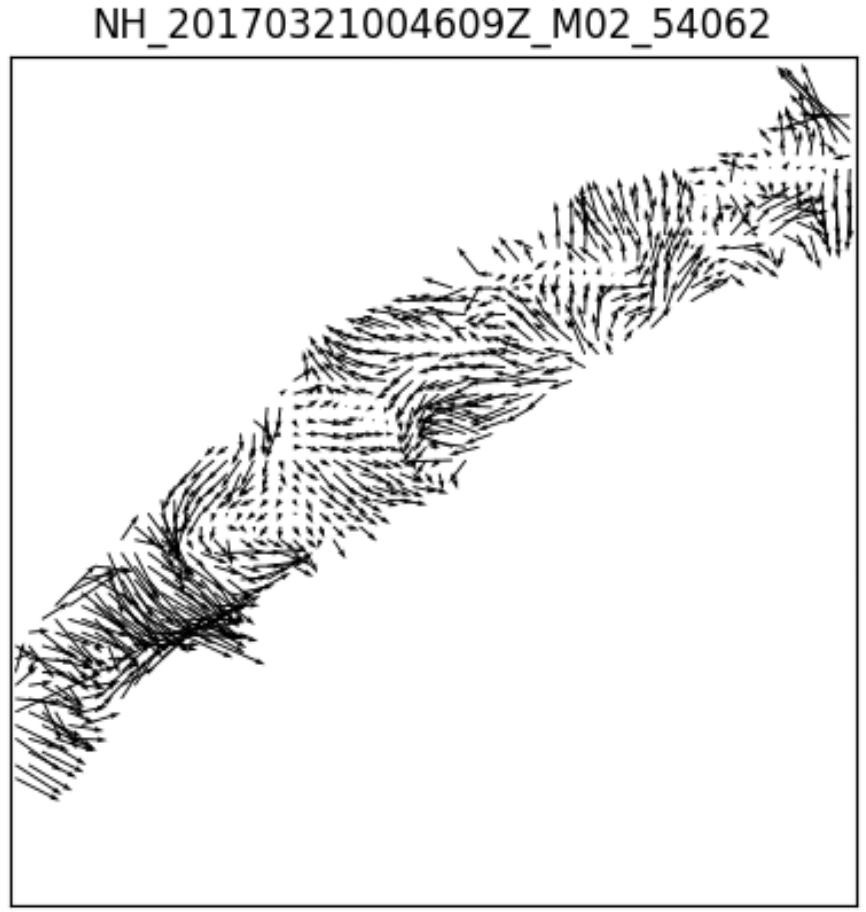
IASI 3D winds – Product

- Product description.
  - ✓ Based on IASI Level 2 products: All-sky water vapour, ozone and temperature profiles
  - ✓ Dual satellite operations; 29 products per day and per area.
  - ✓ High-latitude regions (polewards of 45°)
  - ✓ Troposphere and low stratosphere; 19 layers (from 10 to 1000 hPa)
  - ✓ Spatial binning strategy implemented to reduce number of profiles, reduce the variance and limit problem of spatial correlation. (Super-pixels ~100km size)
  - ✓ Specific BUFR template designed



Thanks

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