EUMETSAT

Derivation of Atmospheric Motion Vectors from Projected Low Earth Orbit Images

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Outline

1. Projection of Images: Principle
2. Applications

   i) SLSTR

   ii) METImage

   iii) AVHRR
3. Conclusion

1) Projection of Images: Principle

- EUMETSAT develops a common framework for S3 SLSTR, EPS-SG METImage (and EPS AVHRR): the data is first projected onto an equal-area grid (INRC team), and AMV are derived from the resulting images.

- On top of standardising the approach for all LEO sensors, this method allows deriving winds outside the frame of the reference image.

Input (AVHRR, SLSTR or METImage)

↓

Projection on an equal-area grid

↓ Binary data + projection parameters

AMV algorithm

↓ AMV Product

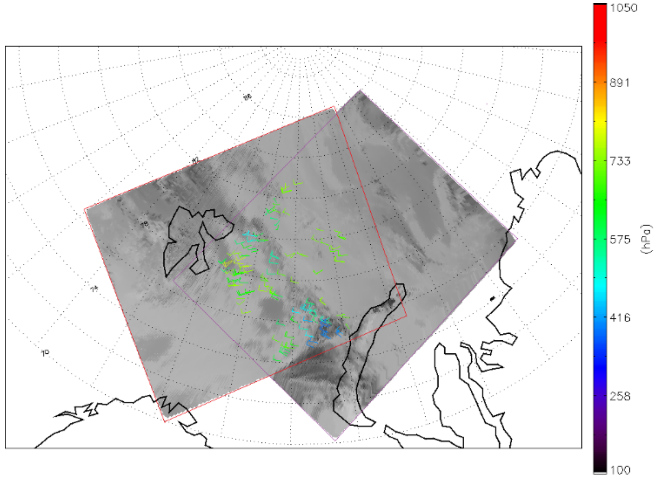


Figure: [left] flowgram of the method, [right] AMV derived from a pair of projected SLSTR images of the Arctic Ocean on 04/07/2018, UTC time: 15:53:21 (purple contour) and 17:34:20 (red contour).

Co-Registration of Images: Current Method

- For LEO satellites (e.g. Metop), the current way of co-registering images is to remap the pixels of one in the frame of the other via latitude/longitude.

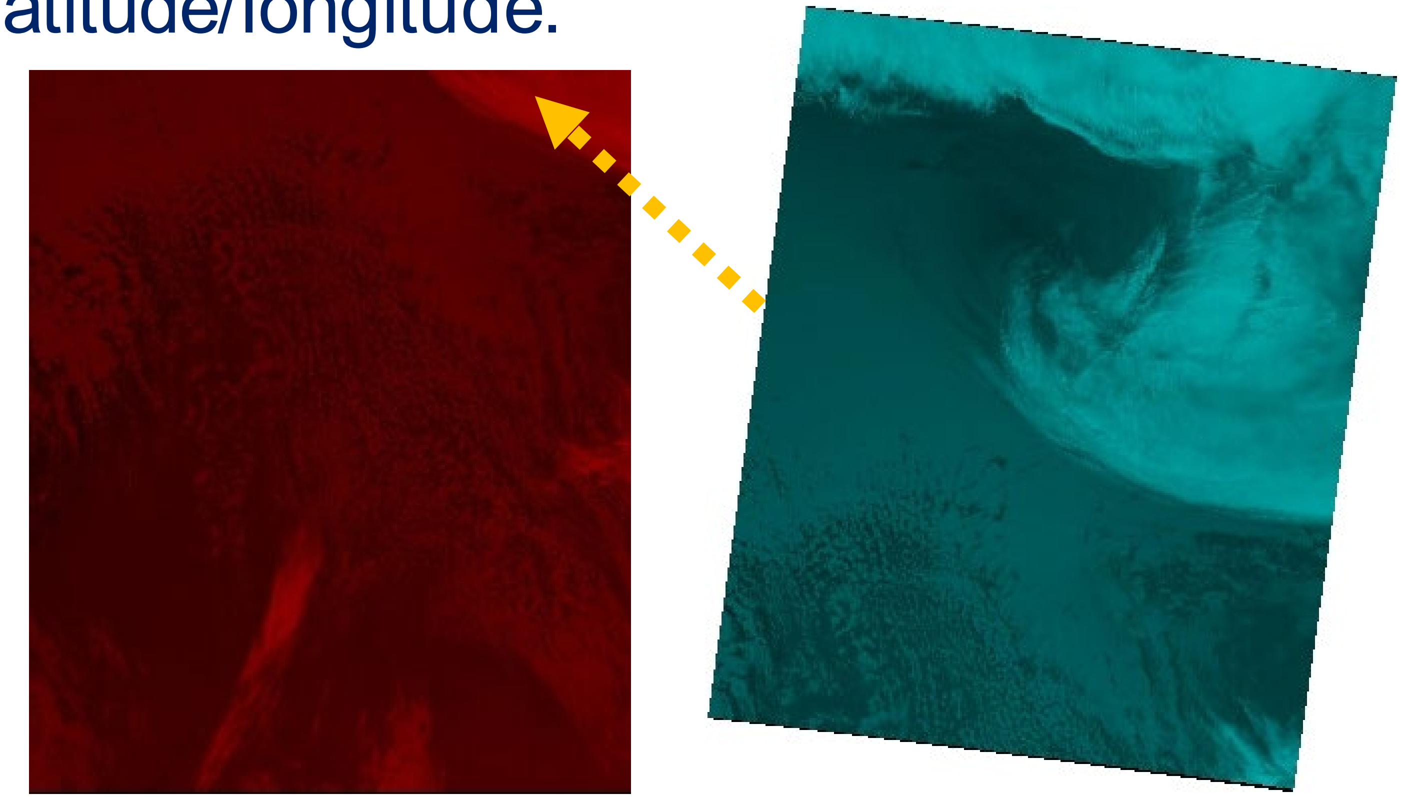


Figure: remapping the image pixels from the first overpass (in levels of cyan) to the frame of the reference image, from the second overpass, (in levels of red).

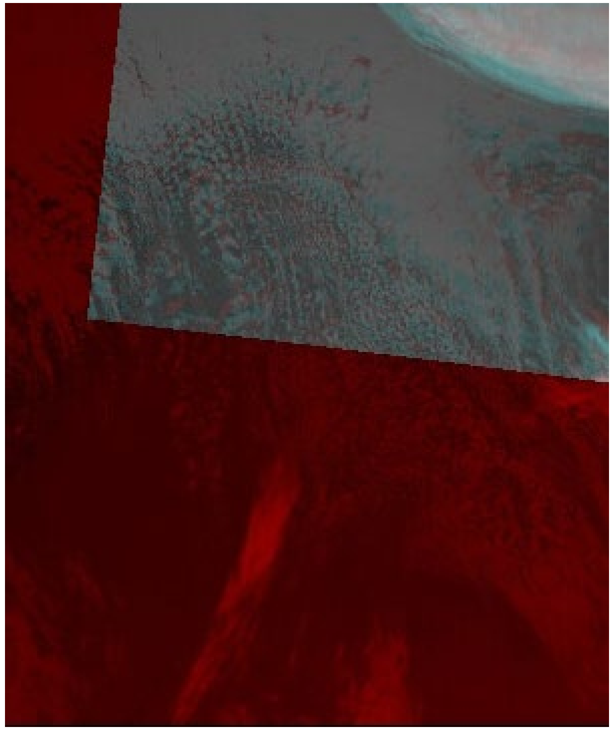


Figure: result of the remapping.

Co-Registration of Images: Current Method

This method has three drawbacks:

- The target box must lie entirely in the frame. Therefore, the derivation of AMVs is limited to the green area.
- Clouds entering the frame cannot be tracked.
- The pixel field of view varies within each image, and from one image to the other, possibly altering the tracking process.

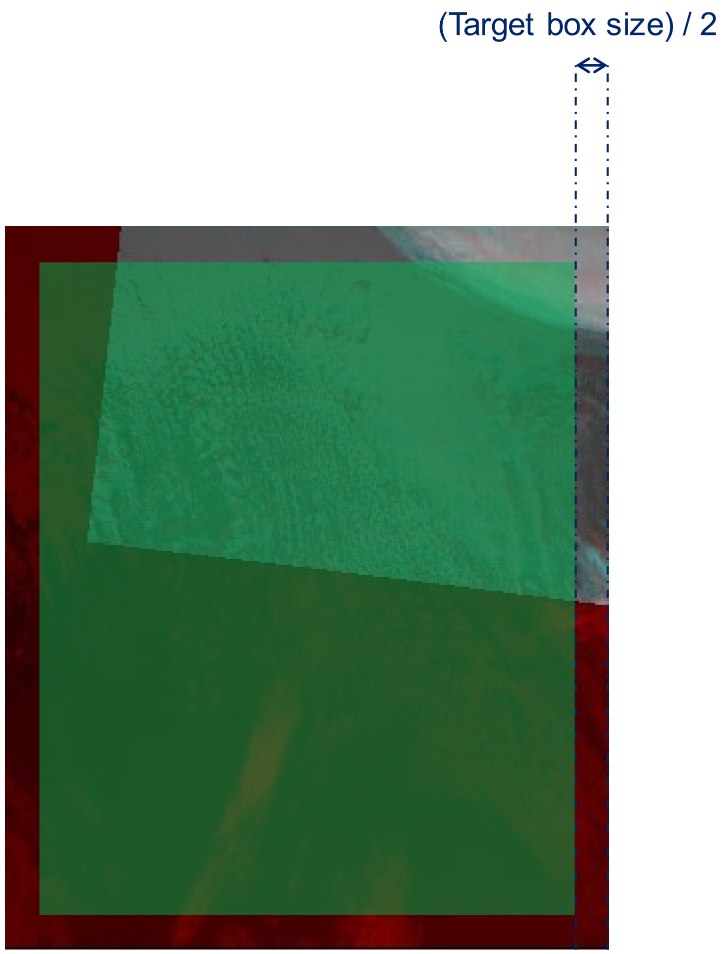


Figure: result of the remapping.

Co-Registration of Images: New Method

- To remedy those limitations, we project[1] both images, and neighboring images in time, onto an equal-area grid.

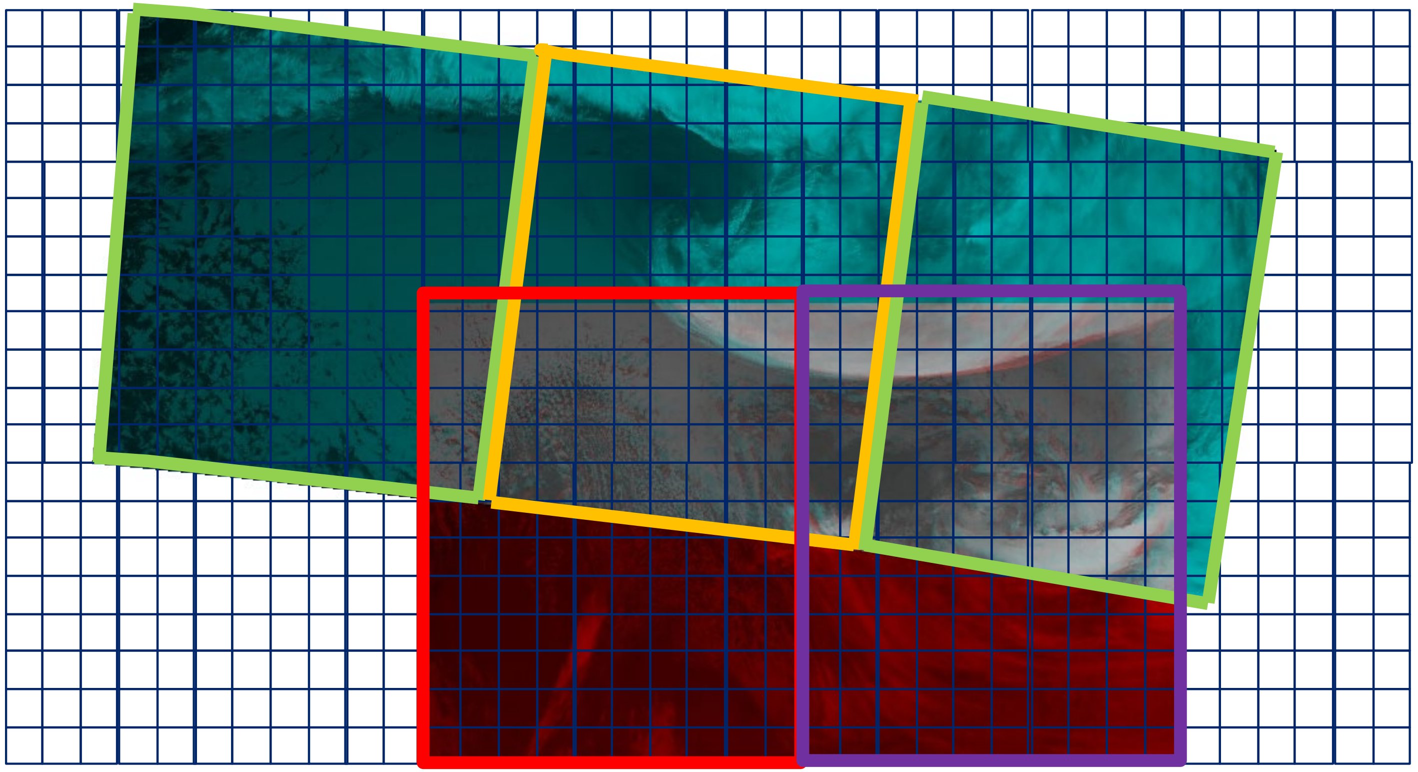


Figure: projection of 5 images on an equal-area grid. Images from the first overpass in levels of cyan, images from the second overpass in levels of red.

: reference image

: main overlapping image from previous overpass

: neighboring image on the reference overpass

: neighboring images on the previous overpass

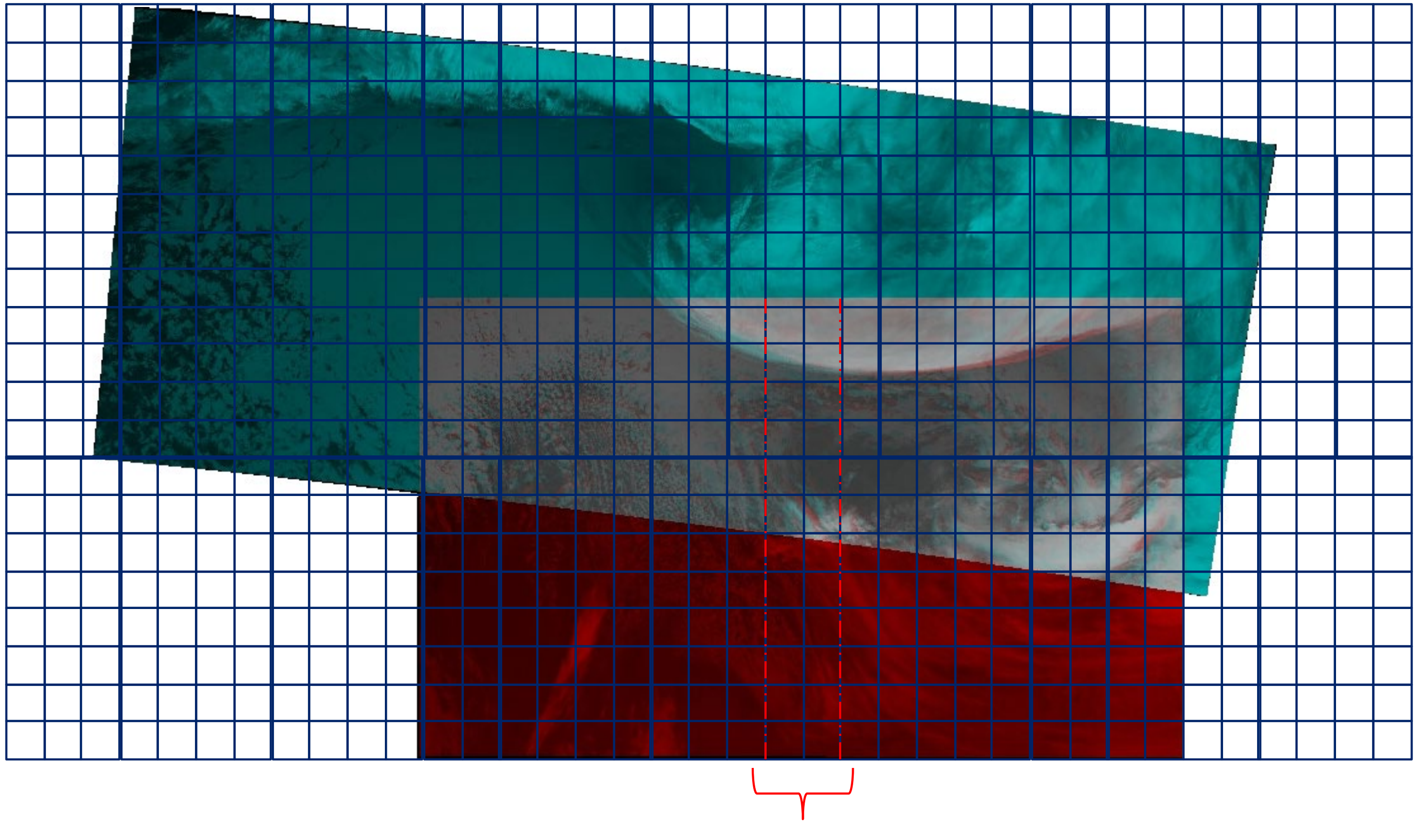
[1] De Bartolomei, Maurizio. Generic Projection Tool - Technical Note. EUMETSAT internal document. 2019, EUM/RSP/TEN/18/1030434.

Co-Registration of Images: New Method

Advantages:

- Clouds entering the reference frame, from outside, may be tracked.
- Features at the edge between consecutive frames can be tracked.
- The pixel field-of-view is made uniform through bilinear interpolation.

Figure: result of the projection.



Edge between the image of interest and the one sensed immediately before. Projecting both allows to track otherwise untraceable features lying at the edge.

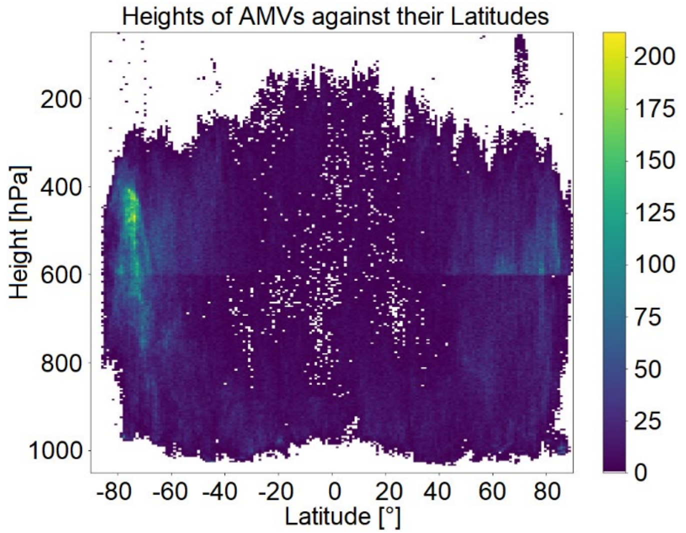
2) Applications

	Channels used for AMV	Resolution	Swath Width	Geographical Area
SLSTR	S8 (10.854 µm)	1 km	1420 km (nadir view)	Single mode: not derived Dual mode: Latitude > 45°
METImage	VII-17 (0.865 µm) VII-26 (3.74 µm) VII-33 (6.725 µm) VII-34 (7.325 µm) VII-37 (10.69 µm)	0.5 km	2670 km	Single mode: Latitude > 50° Dual mode: global
AVHRR	AVHRR-4 (10.8 µm)	1.1 km	2600 km	Single mode: Latitude > 50° Dual mode: global

Sentinel-3 SLSTR AMV - Status

- A demonstration period of one month (June-July 2020) has been disseminated to users
  - Positive feedback was received from ECMWF
  - Small corrections applied in the algorithms after user feedback
  - Performance similar to AVHRR AMVs

- Operational implementation is ongoing
  - Important technical challenges to solve (S3A and S3B not on the same GS)
  - The target for operational production is now 2022 (TBC)
  - Products are routinely derived offline and can be made available to users for testing



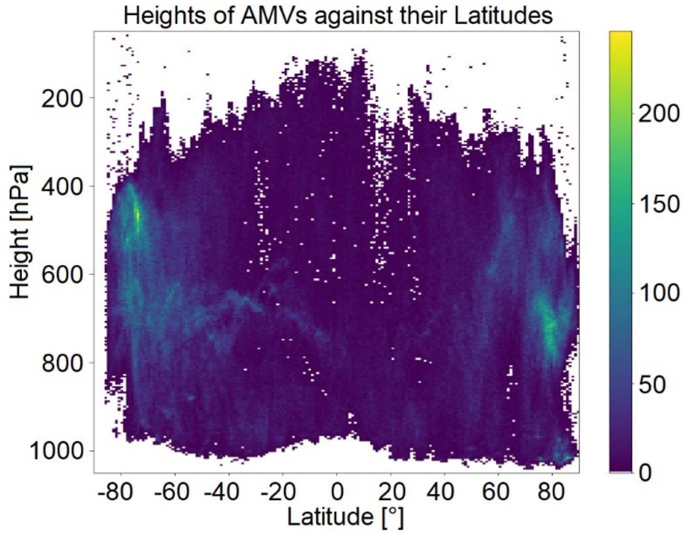
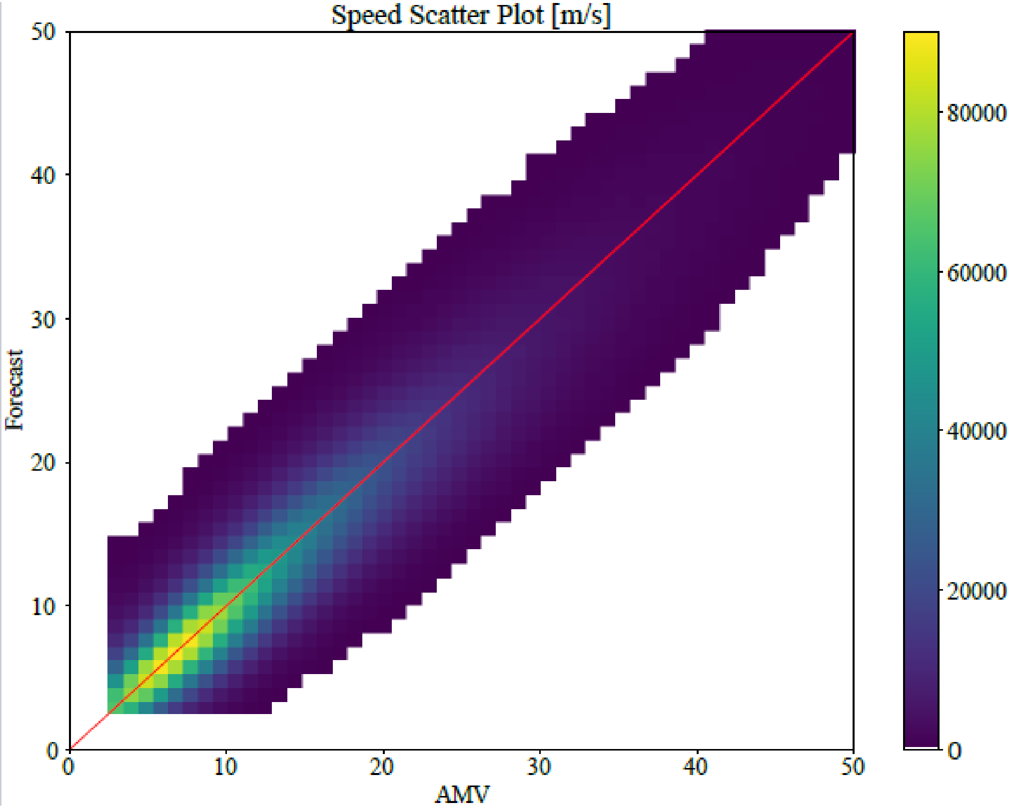


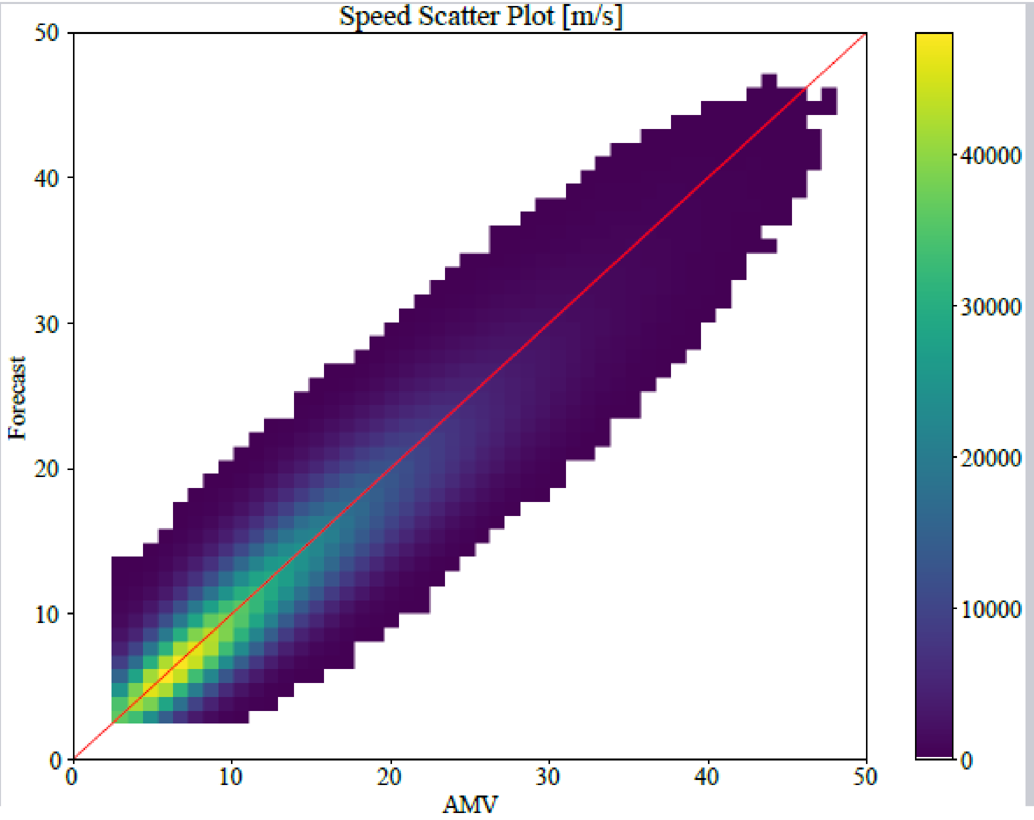
Figure: SLSTR AMV height against latitude scatter plots, (top) before and (bottom) after correction of the height inversion computation, 12 Dec 2020. Correction implemented after feedback from ECMWF.

Dual SLSTR AMVs compared to ECMWF forecast model winds, 15 Dec 2020 – 15 Jan 2021, speed>2.5 m/s, QI[1]>60

Satellite	Sentinel-3A/B (S3A as reference)	Sentinel-3B/A (S3B as reference)
RMS[2] [m/s]	3.60	3.27
RMSVD[3] [m/s]	5.06	4.65
Bias [m/s]	0.08	0.29
Number of AMVs	9 158 914	4 730 554

Scatter plot of AMVs against the forecast model, in speeds, for QI[1] > 60%.





[1] Quality Index; [2] Root Mean Square Difference; [3] Root Mean Square Vector Difference

Derivation of AMVs from the Upcoming EPS-SG Program

Dataset V1 distributed in September 2019. Comparison with MODIS winds (David Santek, CIMSS) showed good agreement.

Next steps:

- Verification against the code from the industrial partner (2021-2023)
- Scientific validation of the products.

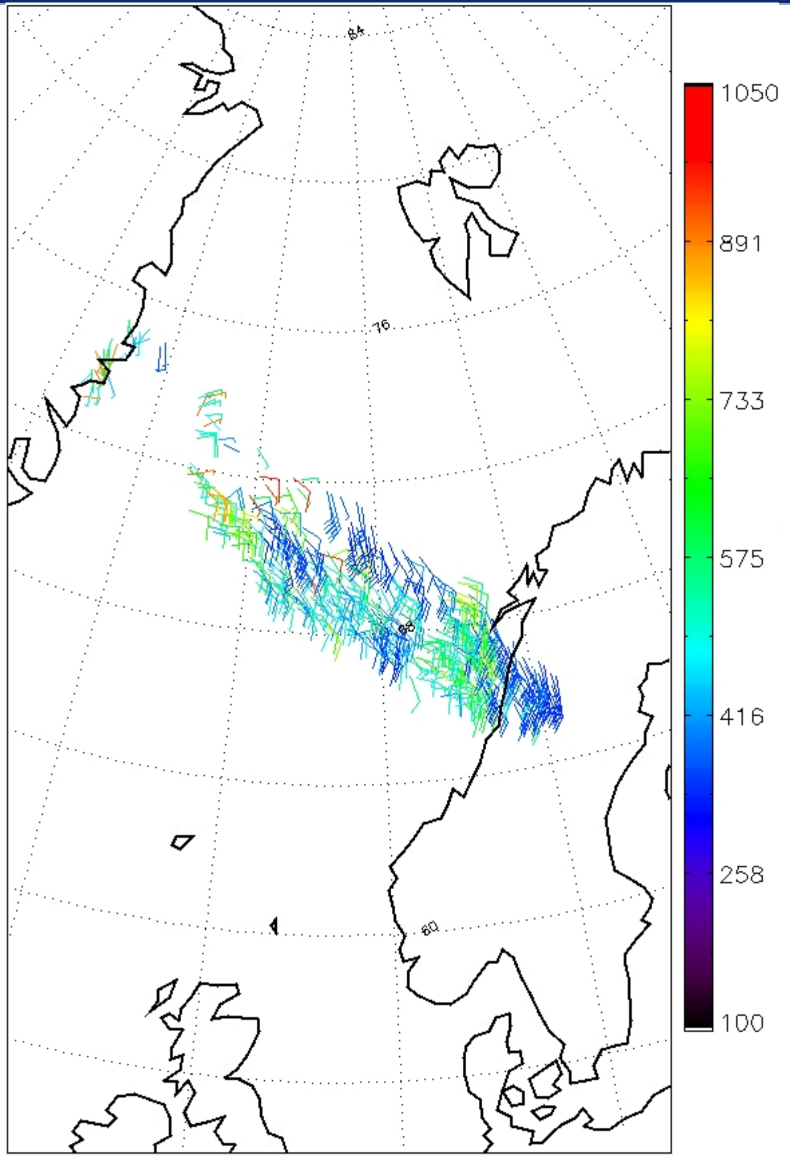
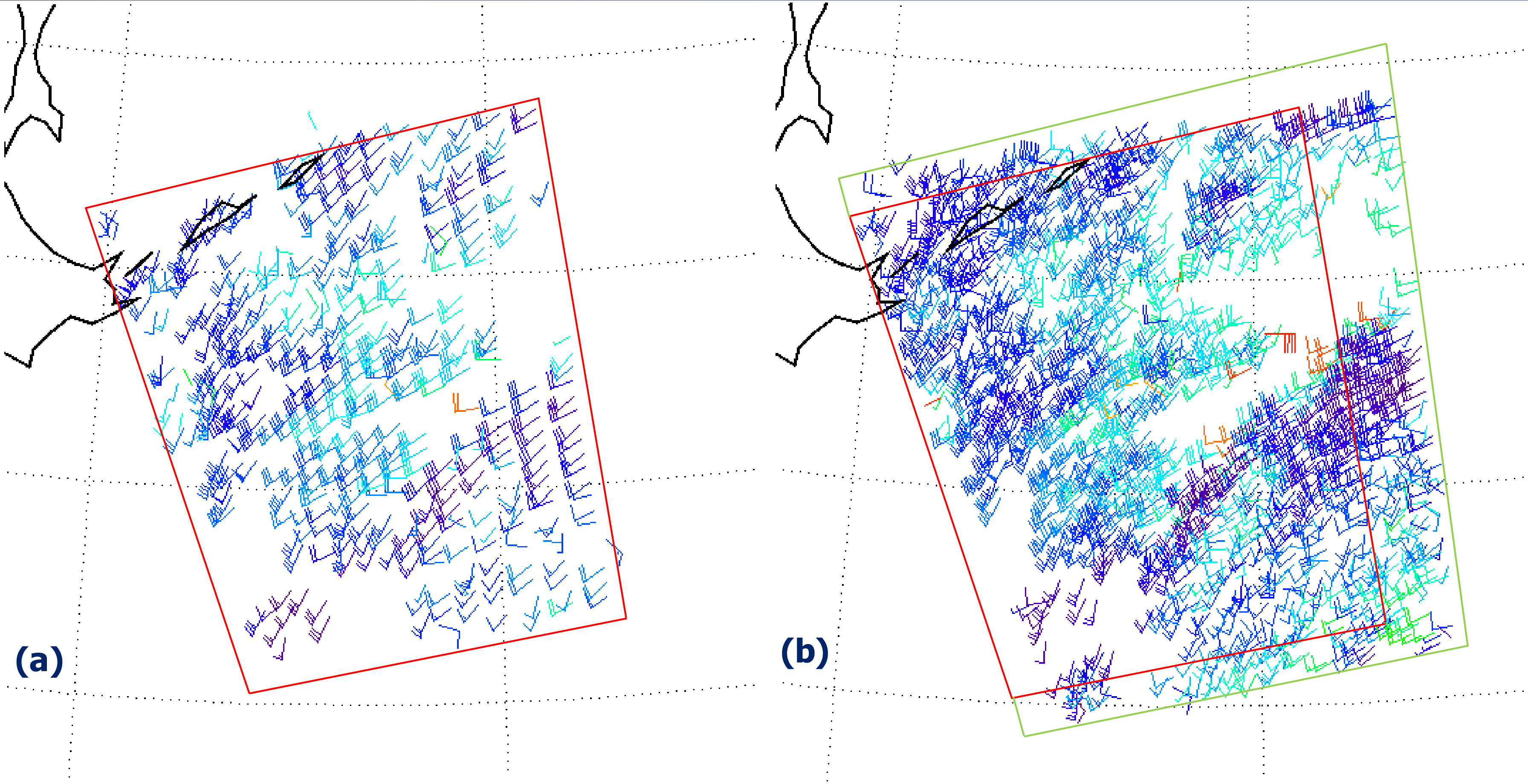


Figure: AMVs derived from simulated METImage band 37 (10.69 µm) images, West of Norway. Altitudes in hPa.

Increase in Number of AMVs: the example of AVHRR



(a) (b)

(a) AMVs derived from EPS-AVHRR with the current operational implementation, October 1st 2020, 10:28 UTC. The red area corresponds to the overlap between the two granules used for the derivation.

(b) Prototype AMVs derived from EPS-AVHRR images projected using the projection tool, October 1st 2020, 10:28 UTC. The red area is the same as in (a); the green area is the area within which the derivation of AMV is possible, following the projection of the granules.

=> Using the projection, the on-ground resolution is constant at 1km, which allows to derive **78% more AMVs**. **The bigger area of derivation, by itself, allows to derive nearly 14% more AMVs**.

Conclusion

The projection can be used for any LEO satellite. Projecting allows deriving far more AMVs, whose quality is similar to that of AMVs currently derived from EPS-AVHRR.

New AMV products, making use of the projection, are on the way:

- Sentinel-3 SLSTR AMVs, with an operational release expected by the end of 2022.
- EPS-SG METImage AMVs, in 2023.
- A possible update of the EPS-AVHRR algorithm (TBD).