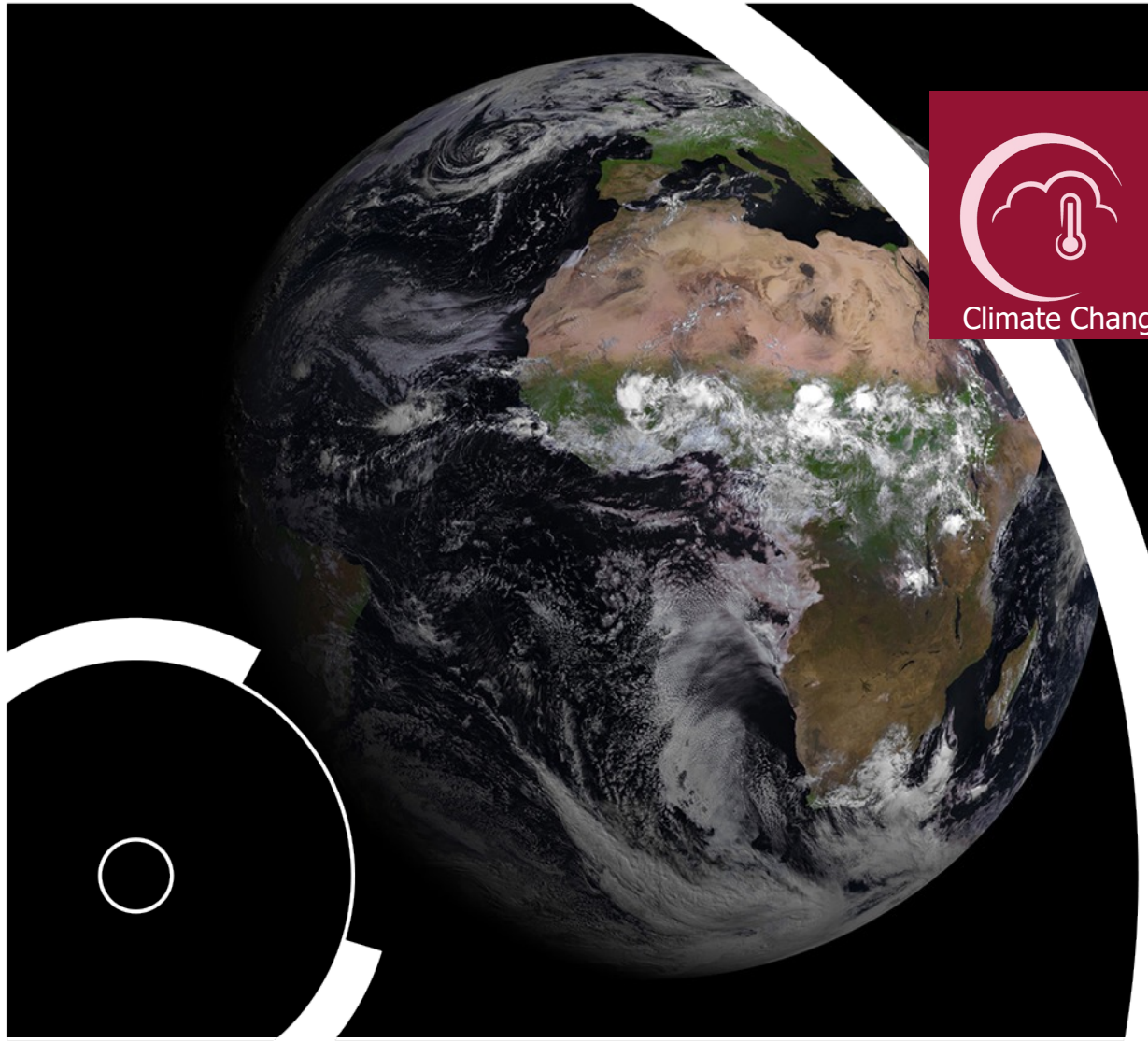


Climate Change

THE EUMETSAT SUSTAINABLE PRODUCTION OF ATMOSPHERIC MOTION VECTORS CLIMATE DATA RECORDs

M. Doutriaux Boucher, A. Lattanzio, R. Huckle, O. Sus, M. Grant, R. Borde and J. Schulz

European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT)

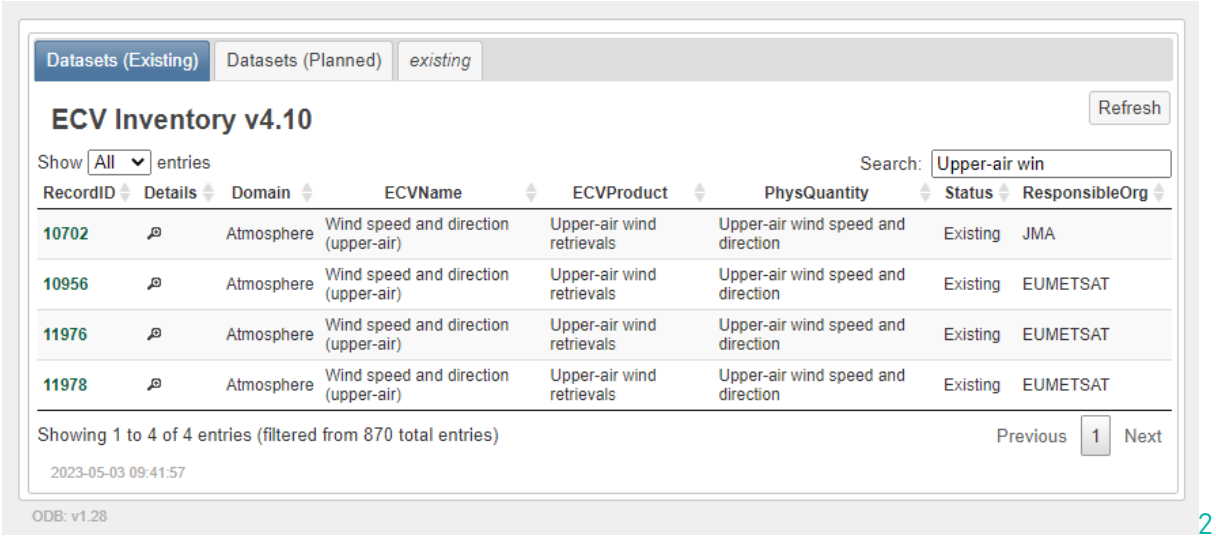
Atmospheric motion vector – AMV – for climate

- AMVs are assimilated in weather and climate models and have a significant impact on the forecast skills and quality of the climate reanalysis

- AMV CDR can also be used for climate understanding and monitoring (e.g. monsoon or jet stream evolution)

- AMV is one of the 40 GCOS ECVs that can be retrieved from satellite, it is the variable called **atmospheric upper-air wind speed and direction**

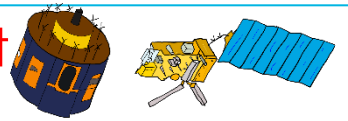
- Despite its importance, there are only a few AMV climate data records (4 existing and 7 planned) in the ECV inventory database (https://climatemonitoring.info/ecvinventory) from the joint CEOS-CGMS WGClimate



Terminology Near Real Time versus Climate Data Record

Near Real Time

Level 0

Measurement 

electric signal (voltage, count) = **count**

Level 1 / level 1a

First calibration/geolocation

radiance / brightness temperature

backscatter coeff / bending angles

Level 1.5 / level 1b/1c

Refinements of calibration/geolocation/rectification

radiance **+ latitude + longitude + time**

Level 2

Retrieval/algorithm + auxiliary data – model

geophysical product: e.g. AMV

Level 3

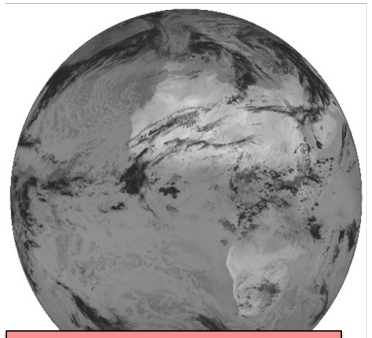
Temporal and spatial averaged (e.g.grided)

Reprocessing / climate

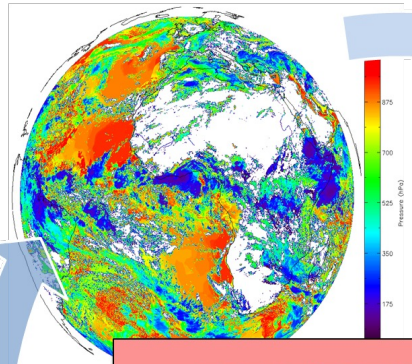
Fundamental Data Record (FDR)/ Fundamental Climate Data Record (FCDR)

Thematic Climate Data Record (TCDR)

A complete sustainable production at EUMETSAT

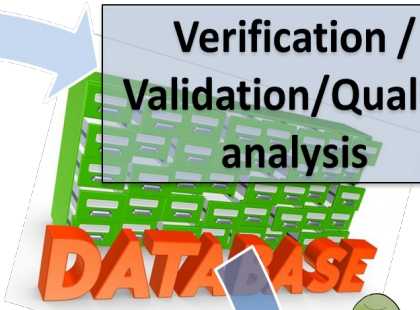


FCDR/Level 1

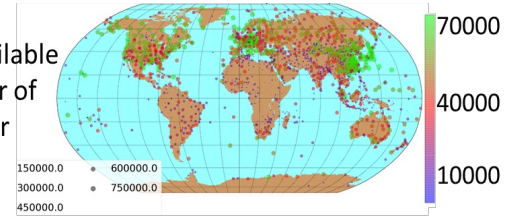


FCDR/TCDR

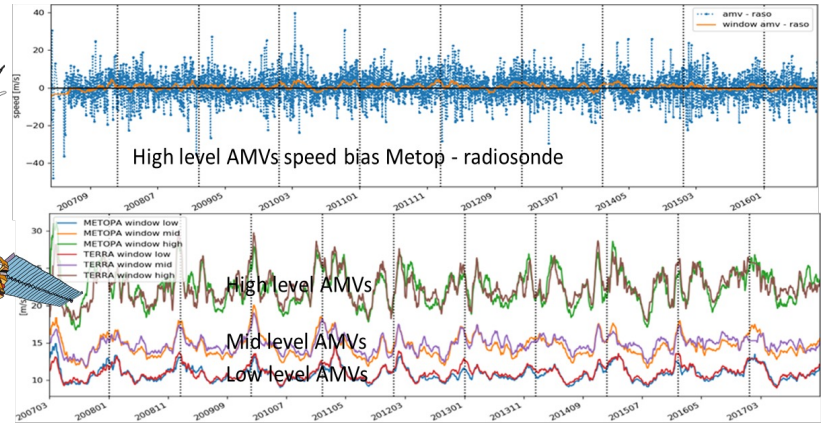
Verification / Validation/Quality analysis



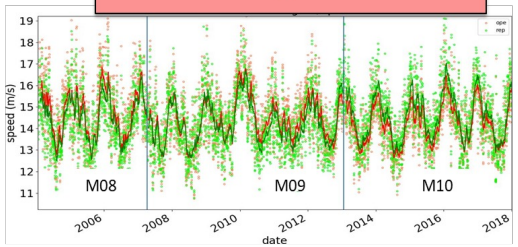
RAOBCORE observations available scaled by number of observations over 1980-2017



Example of a comparison against independent ground-based and satellite data: example of Metop-A AMVs speed over Arctic against RAOBS and MODIS

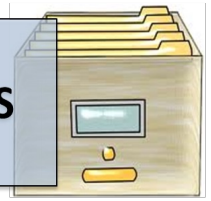


Auxiliary / forecast data



Best suitable algorithm

Archived and distribute to C3S users

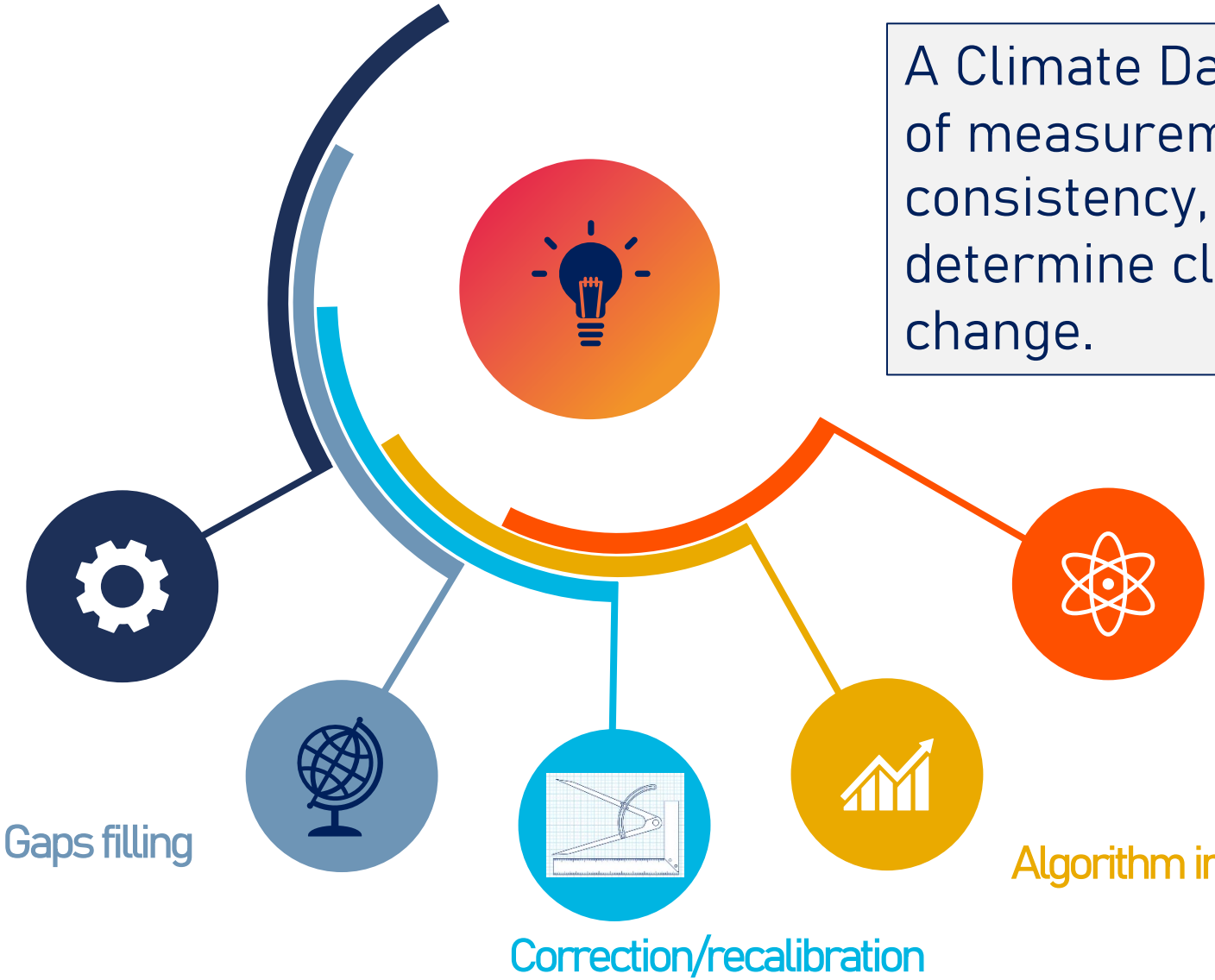


Climate Data Store

It must be **fast**, the processing requirement is **1 year per day**

Reprocessing CDR – the main reasons to do it

A Climate Data Record is a time series of measurements of sufficient length, consistency, and continuity to determine climate variability and change.



Did not exist in NRT for earlier periods

Gaps filling

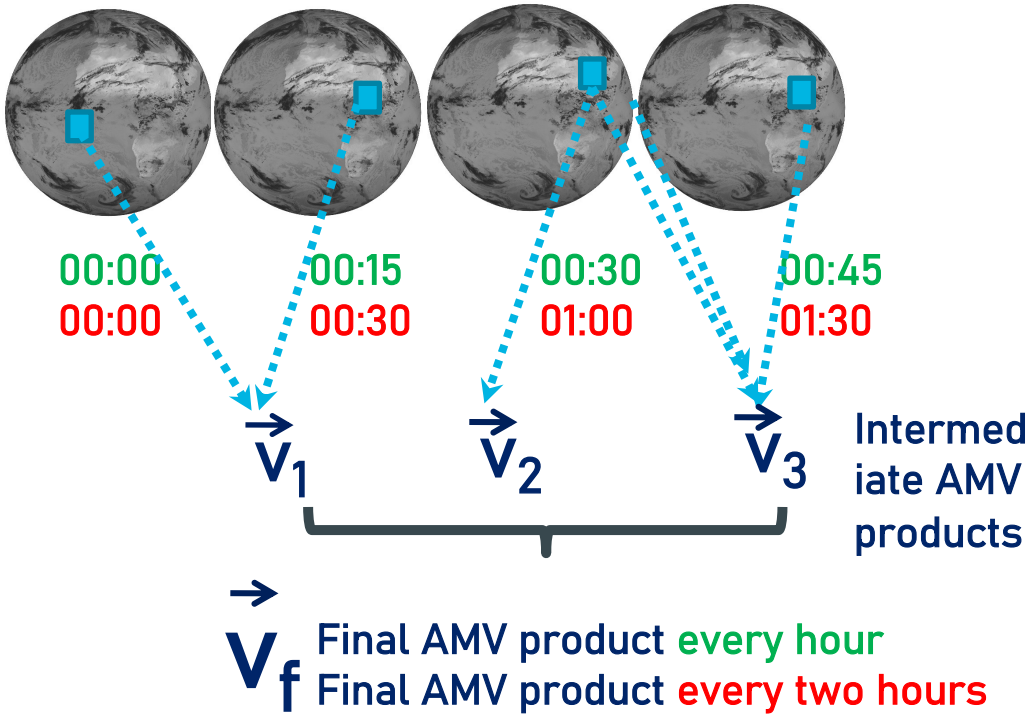
Correction/recalibration

Algorithm improvements

New auxiliary input data for the retrievals

Meteosat GEO AMV Climate Data Record at 0°

- We wanted a **seamless production of AMVs** from Meteosat first and second generation: we derive AMVs using only the **2** MVIRI and SEVIRI **'common' channels** IR10.8 and WV6.2. The full spectral capability of SEVIRI is not utilised to estimate the wind vectors altitude.

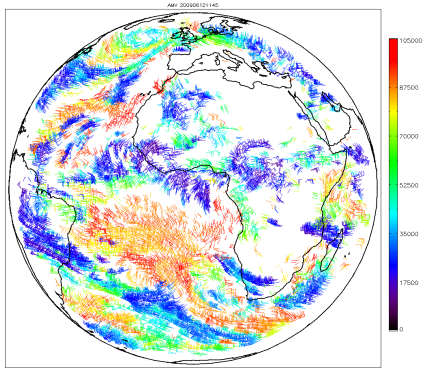


- Input data: Meteosat images

First generation MVIRI (Meteosat 1-7)	Second generation SEVIRI (Metosat 8-11)
2 channels	12 channels
30 minutes	15 minutes
5km	3km

- Cloud height information
  - Cloud mask CMSAF Cloud Fractional Cover (**DOI: 10.5676/EUM_SAF_CM/CFC METEOSAT/V001)**
  - CTH for each pixel: EBBT + IR/WV ratio for semi transparent clouds + low level inversion
- CCC method used for both MVIRI and SEVIRI
- Model information: ERA-interim

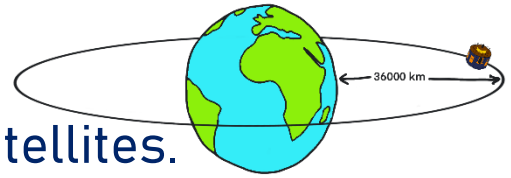
CDR AMVs for 2 channels:
- IR1 0.8
- WV 6.2

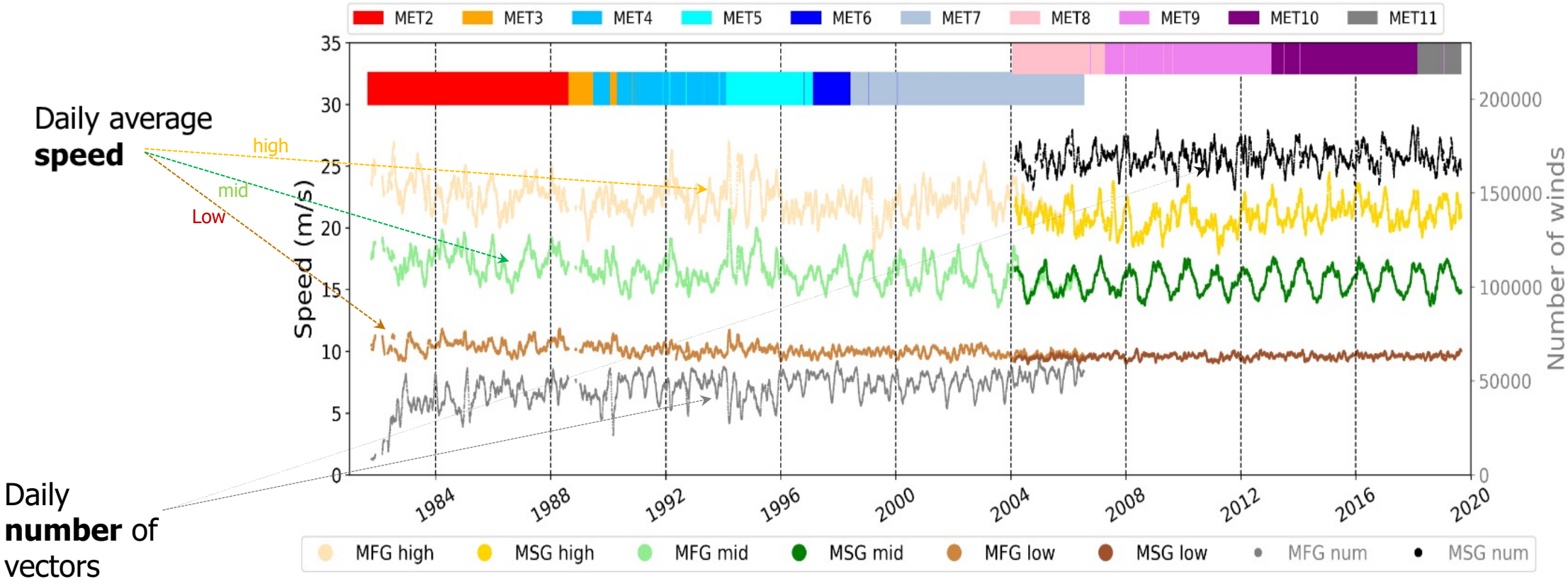


About 10000 SEVIRI winds/final vectors per hour are detected

Meteosat IR GEO AMV climate data record at 0°

- A unique Climate Data Record of geostationary AMV using the operational EUMETSAT algorithm adapted for time series processing;
- First AMV CDR based on cross-calibrated geostationary radiances;
- 38 years (1982-2019) years of Atmospheric Motion Vectors from 10 Meteosat satellites.





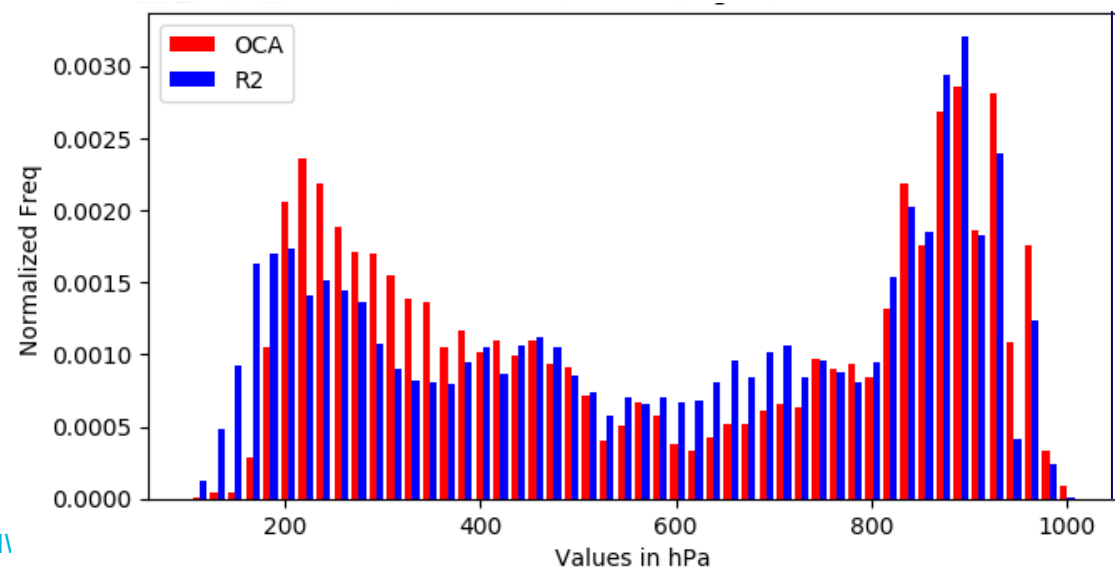
doi:10.15770/EUM_SEC_CLM_0020

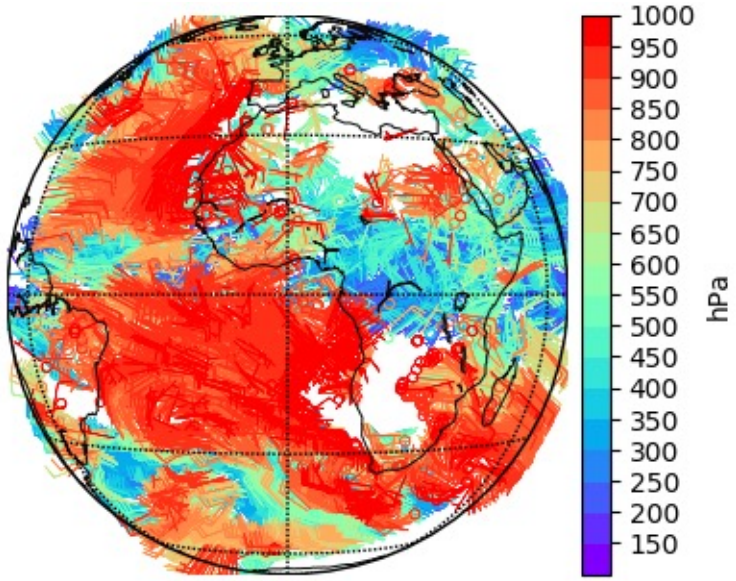
GEO AMV, next step: SEVIRI AMVs using OCA

- The current AMV CDR is homogeneous but only used 2 channels. This is perfect for usage in climate application.
- The full spectral capability of SEVIRI was not utilised to estimate the wind vectors altitude.

→A new MSG/SEVIRI AMV using the information from the 12 channels is in preparation. This will allow a better height assignment and microphysical properties.

→OCA as input for the cloud top height + microphysical properties (phase, optical thickness and effective radius)

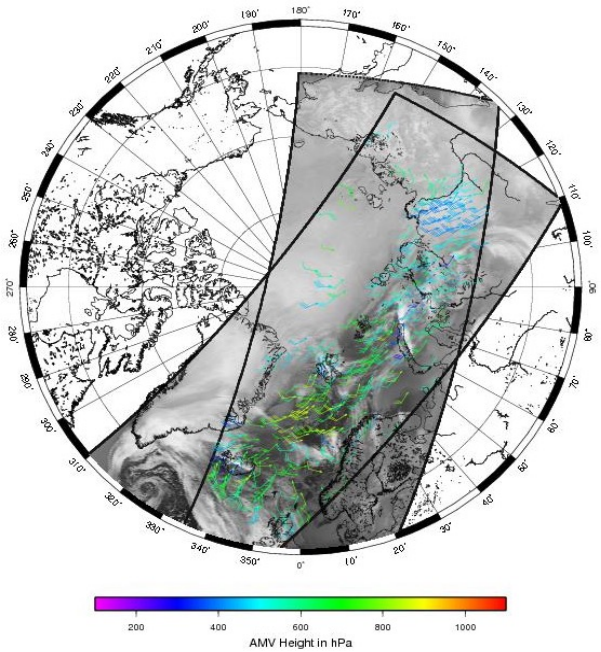


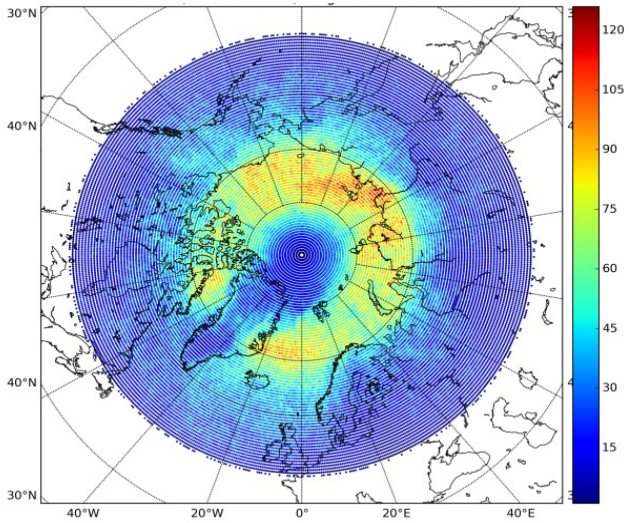


CDR AMV from LEO/polar satellites

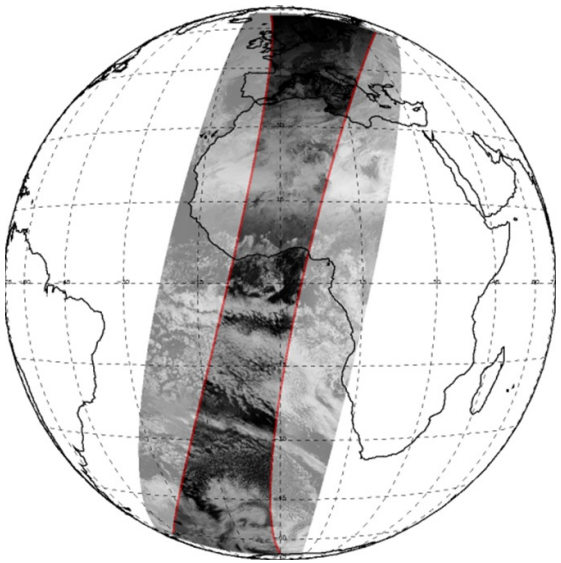
LEO satellites ~ 800 km

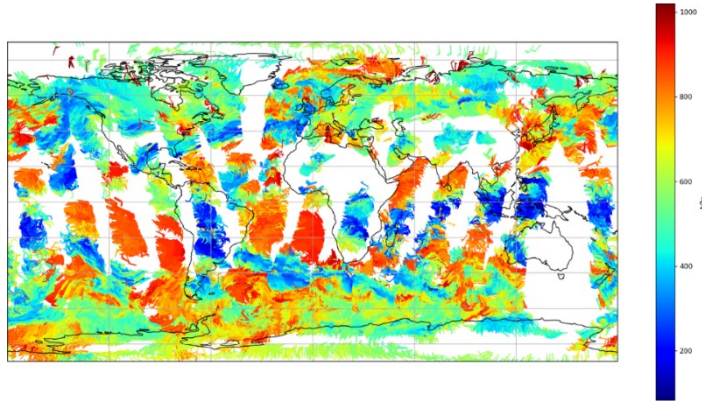
AVHRR on Metop + NOAAs





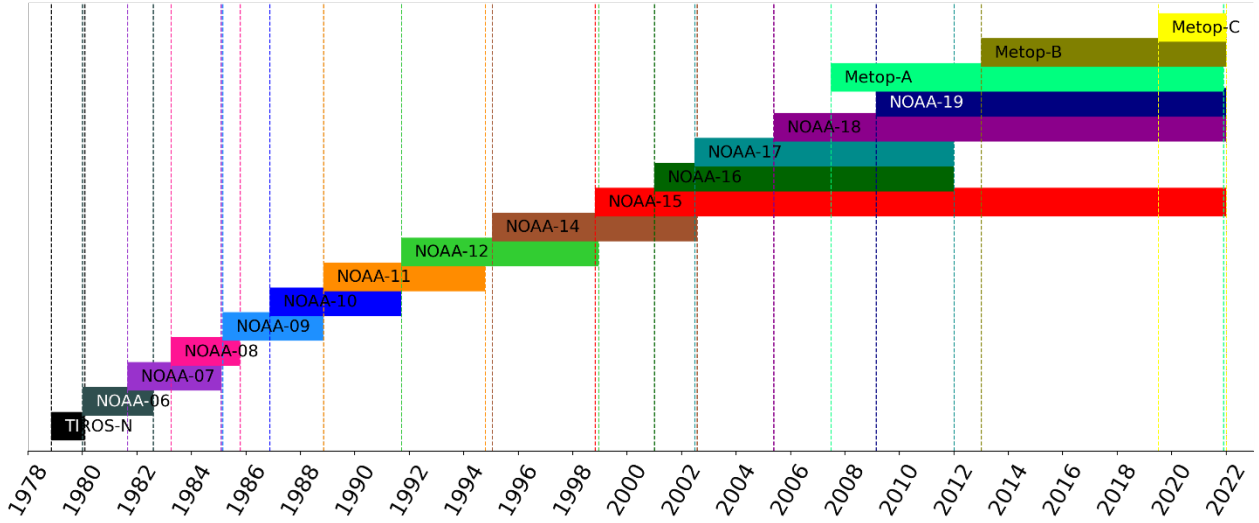
Over the polar areas using one single satellite

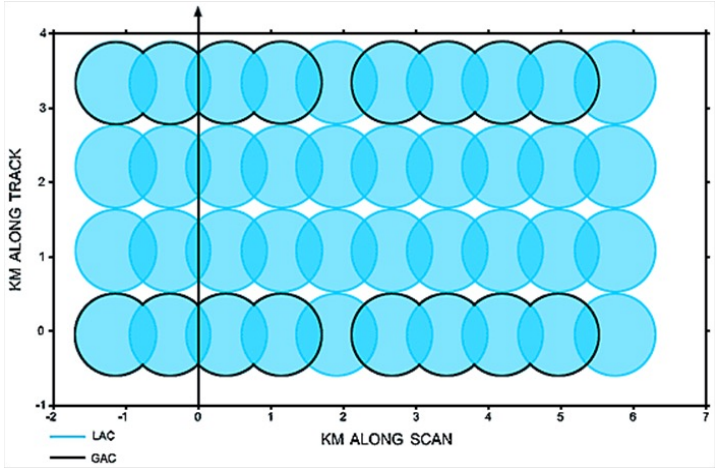




Global using **2** or more LEO satellites Metop-A/-B (limited to 2013-2018)

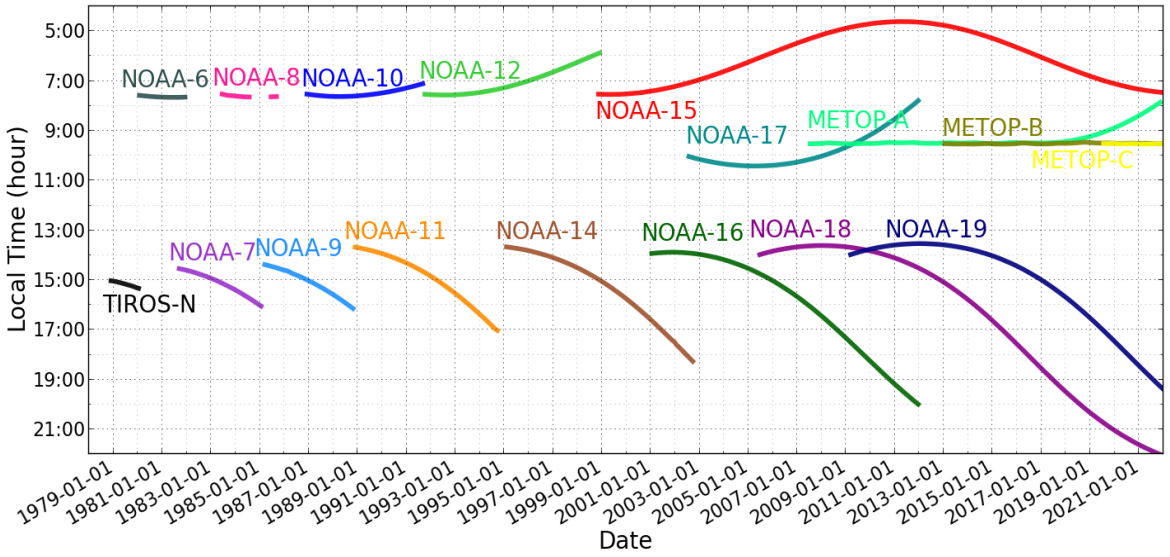
41 years of NOAA and Metop **AVHRR FDR** / DOI: 10.15770/EUM_SEC_CLM_0060



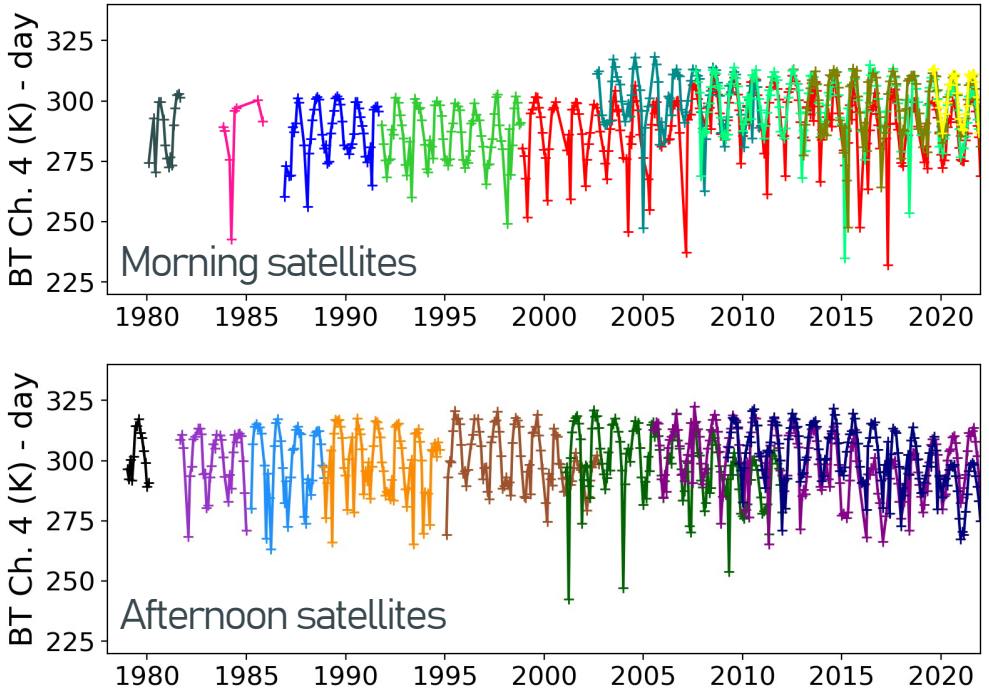


LAC resolution:
1050mx1050m at nadir

GAC resolution



Evolution of the channel 4 over Egypt:

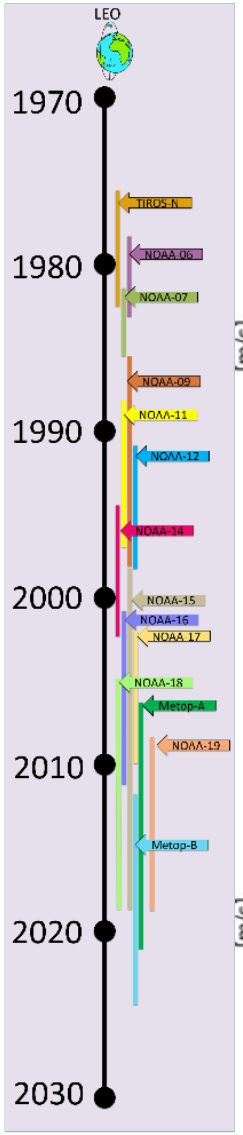


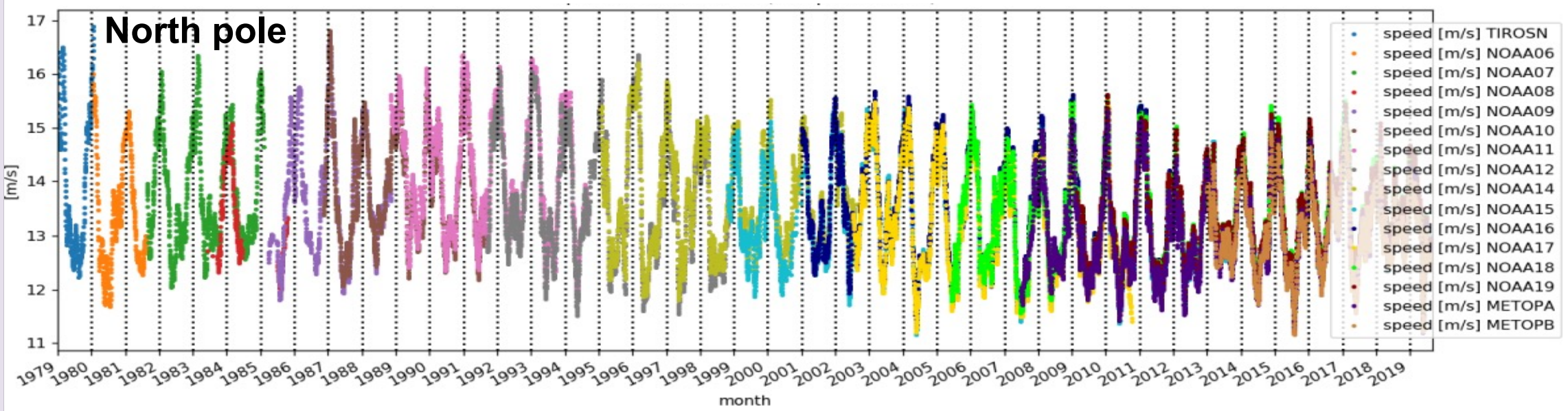
41 years of NOAA and Metop **GAC** AMVs

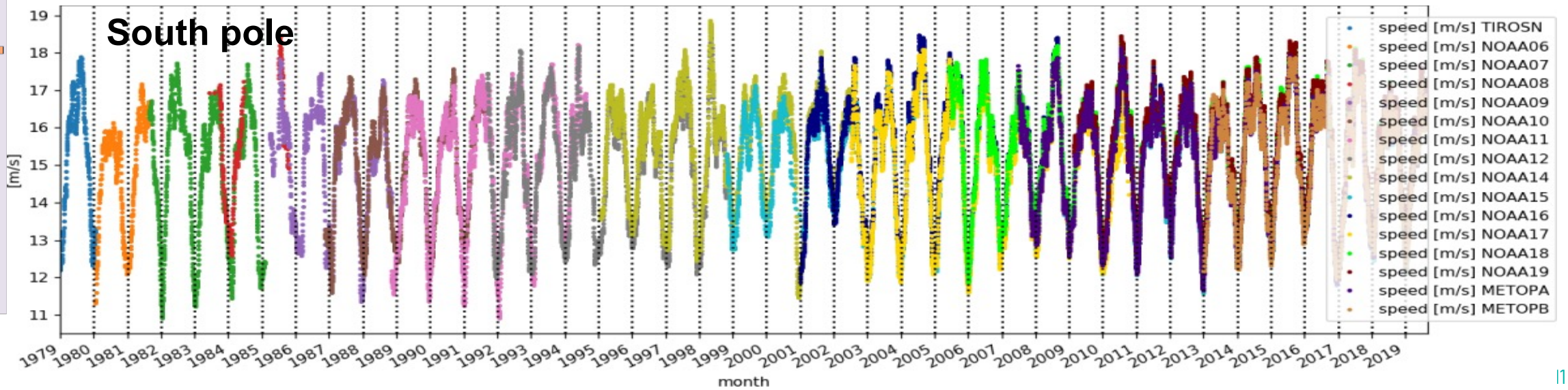
Climate Change Service

12 years of **LAC AVHRR** AMVs

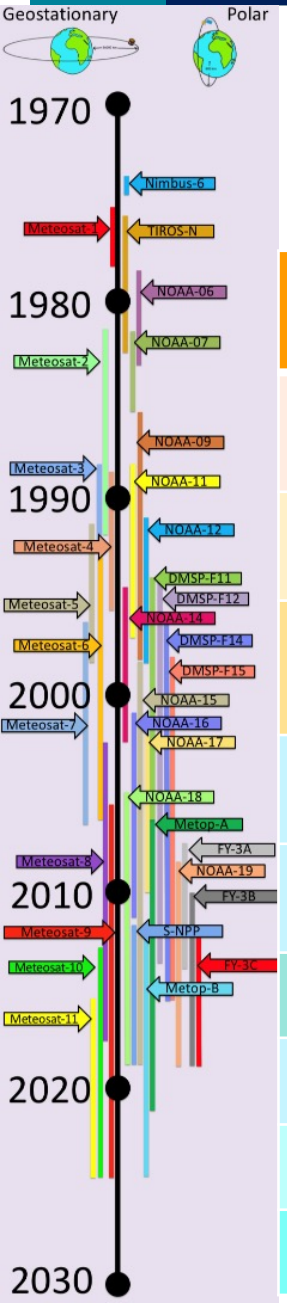
Daily average speed (m/s)







Existing EUMETSAT AMV CDR

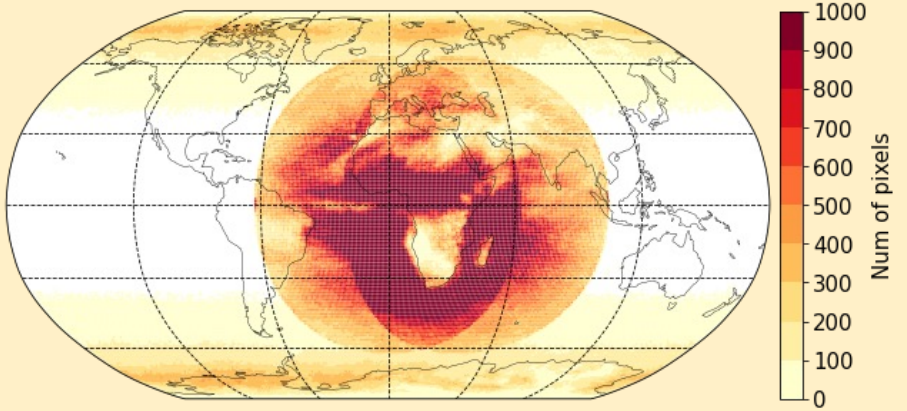


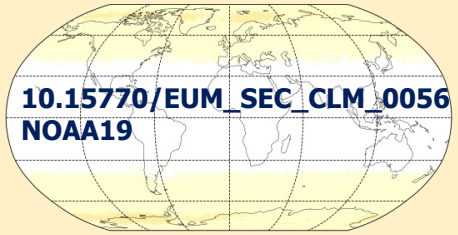
To get data browse the EUMETSAT data store.
links: https://data.eumetsat.int/ and our old PN https://navigator.eumetsat.int,
→ You need to register to access to the EUMETSAT datastore: https://eoportal.eumetsat.int/

Product	Release: period	Coverage	Reference doi
MSG AMV 0°	R1: 2004-2012	lat 60°-60°, lon 60-60°	10.15770/EUM_SEC_CLM_006
MSG/MFG AMV 0°	**R2: 1982- 2019**	**lat 60°-60°, lon 60-60°**	**10.15770/EUM_SEC_CLM_0020**
MSG/MFG AMV IODC (will be released in 2023)	*R1: 1998 - 2019*	*IODC ssp 63°, 57°, and 41.5°*	*10.15770/EUM_SEC_CLM_0022+ EUM_SEC_CLM_0021 EUM_SEC_CLM_0054 : in Q2 2023*
LAC Metop-A and -B AVHRR AMV EUMETSAT algo	R1: 2007-2014	Poles: lat > 40°	10.15770/EUM_SEC_CLM_0016
LAC Metop-A and -B AVHRR AMV CIMSS algo	R1: 2007-2014	Poles: lat > 65°	10.15770/EUM_SEC_CLM_0040
LAC Metop-A and -B AVHRR single	**R2: 2007-2017**	**Poles: lat > 40°**	**10.15770/EUM_SEC_CLM_0037**
LAC Metop-A/B B/A AVHRR dual	**R1: 2013-2017**	**Entire globe**	**10.15770/EUM_SEC_CLM_0038**
GAC from 13 AVHRR	R1: 1979-2012	Poles: lat > 40°	10.15770/EUM_SEC_CLM_0055
GAC from 16 AVHRR	**R2: 1979-2019**	**Poles: lat > 40°**	**10.15770/EUM_SEC_CLM_0056**

A complete coverage combining all CDRs – to analyse wind pattern

Number of AMVs - June 2018 averaged on 1X1° cells





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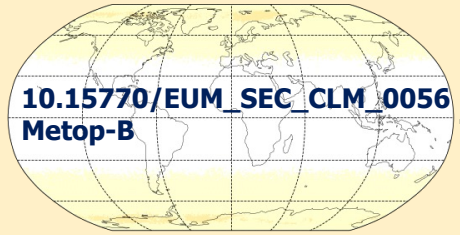

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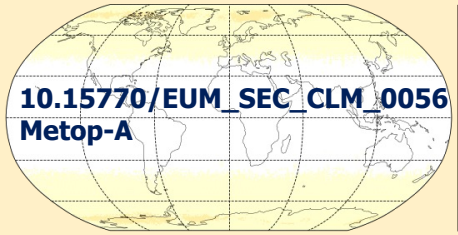

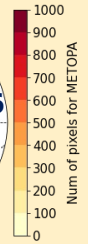

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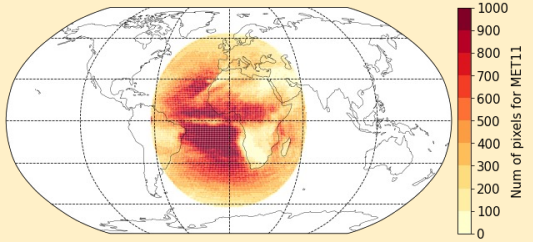

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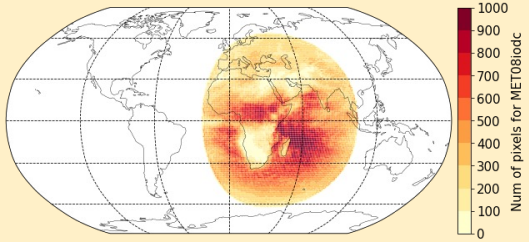
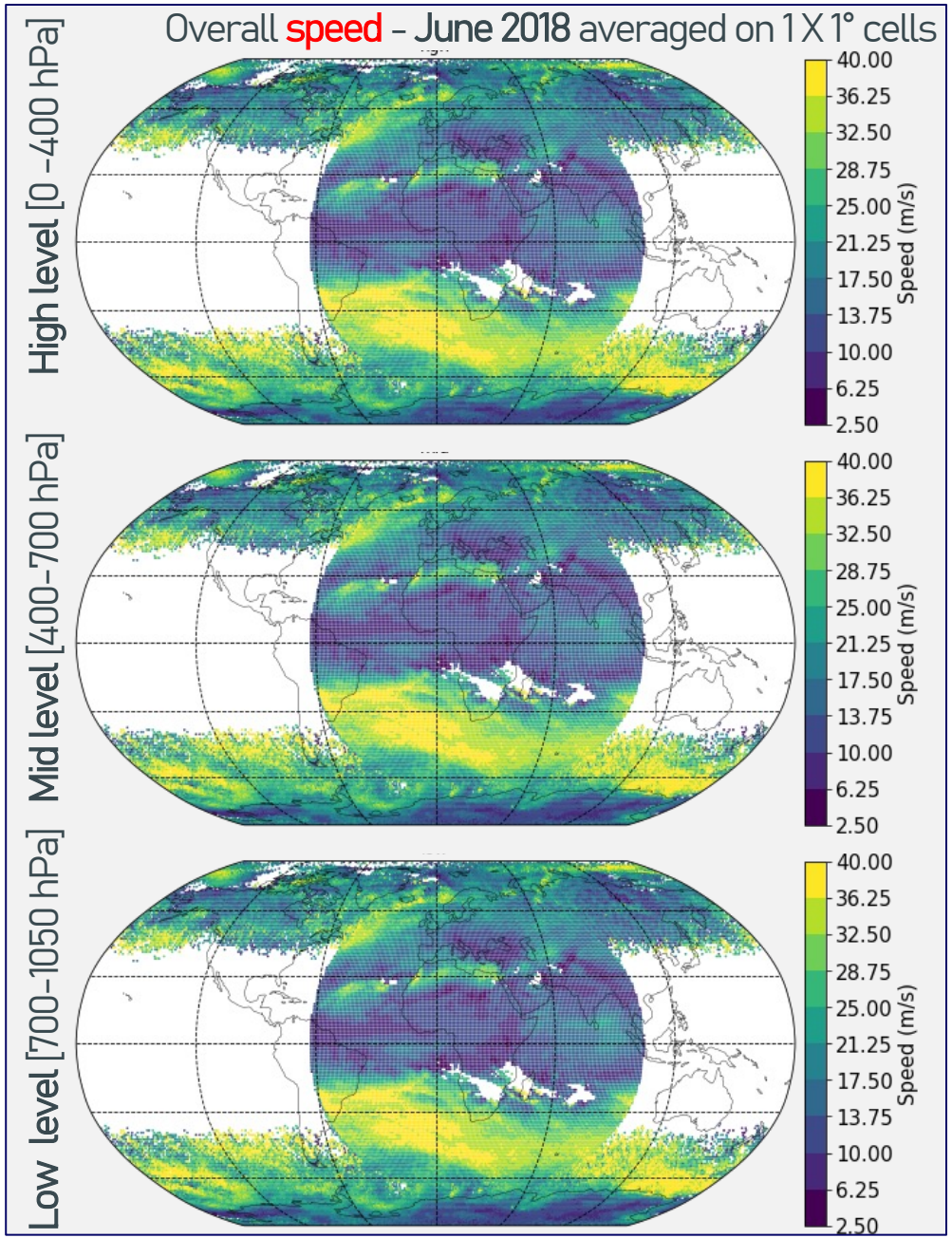


'Easy' to mix GEO AMVs but it requires more attention to mix with LEO

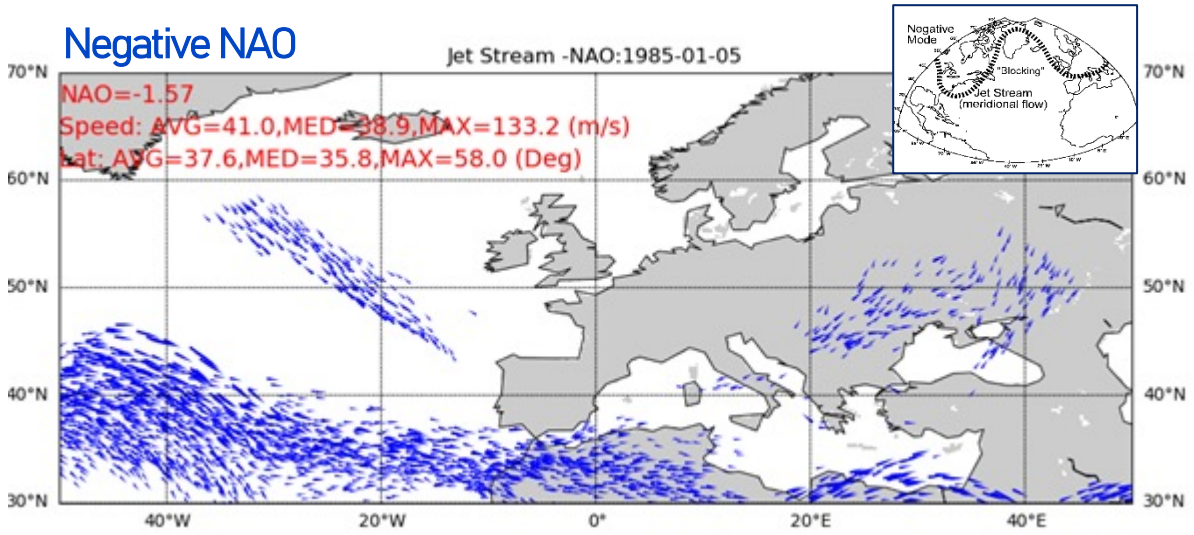
Overall speed - June 2018 averaged on 1 X 1° cells

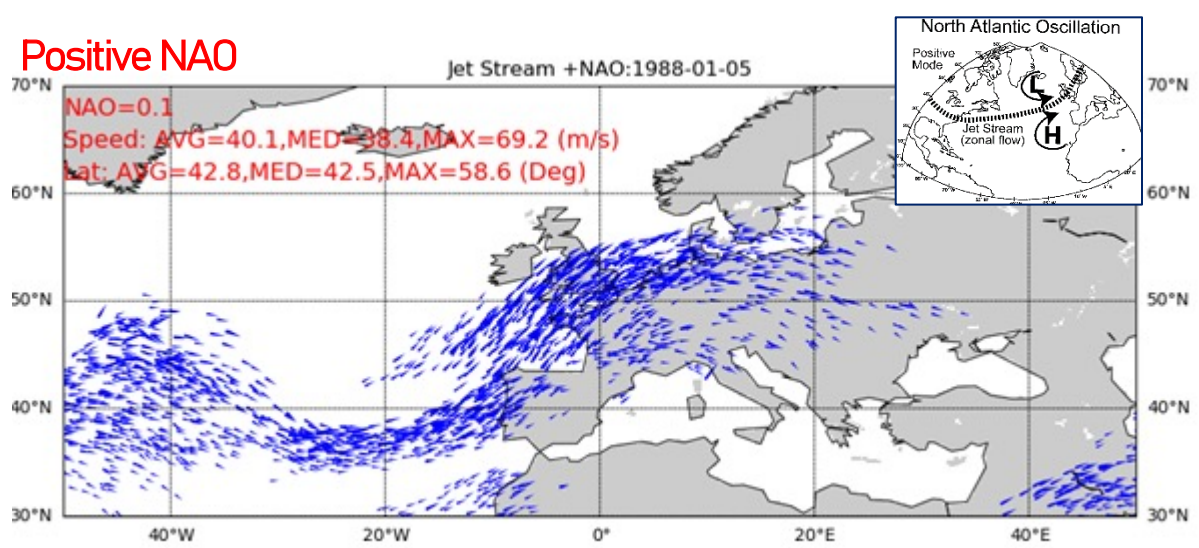


Application: analysing climate pattern – jet stream

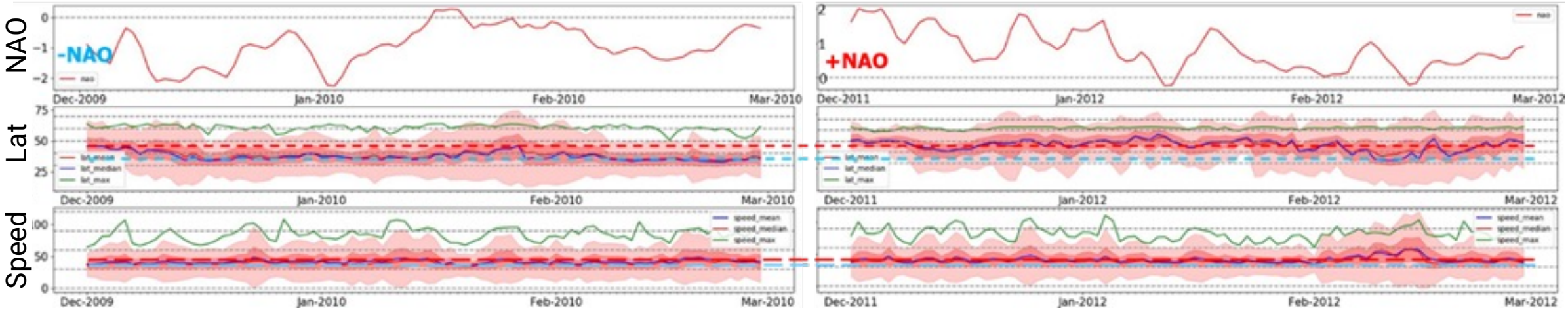
www.eumetsat.int

GEO 0° AMV CDR from **Meteosat** observations: speed, direction and height with associated quality indicator of winds covering the period 1981-2019





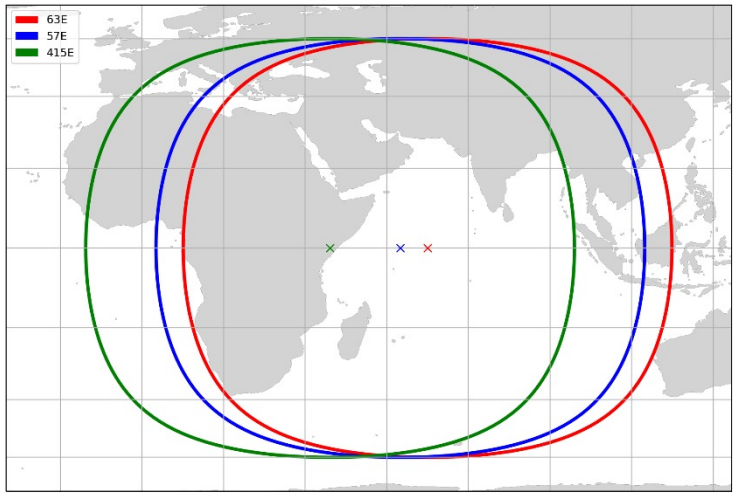
Polar jet stream selection from GEO AMV : Latitude > 30° North Height < 400 hPa Speed > 30 m/s QI > 60

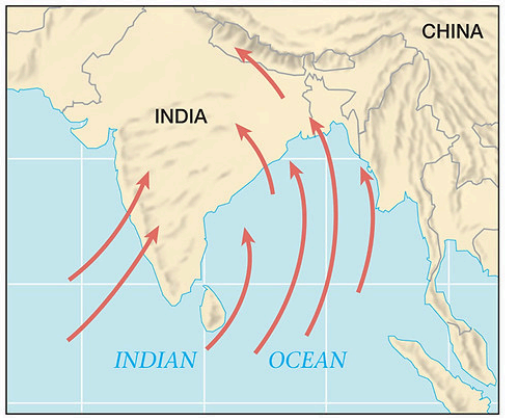


See: https://www.eumetsat.int/polar-jet-analysis-over-atlantic-ocean-europe

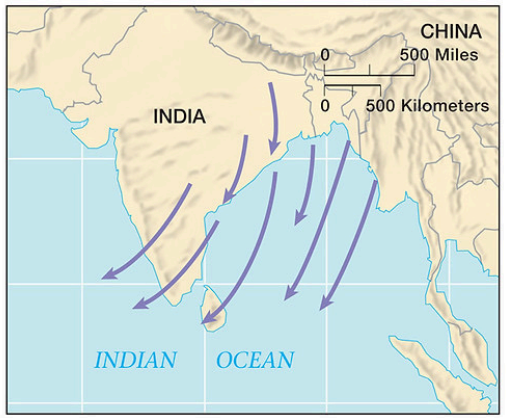
Application: analysing climate pattern Indian monsoon

GEO AMV CDR IODC Release 1 will be released in 2023. It includes three Meteosat satellites (M5, M7 and M8) over three close locations over the Indian Ocean from 1998 to 2019.





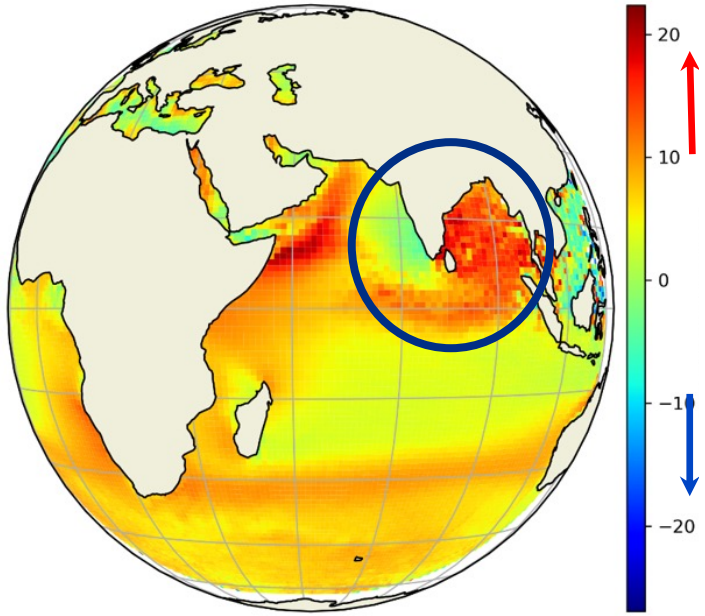
Summer



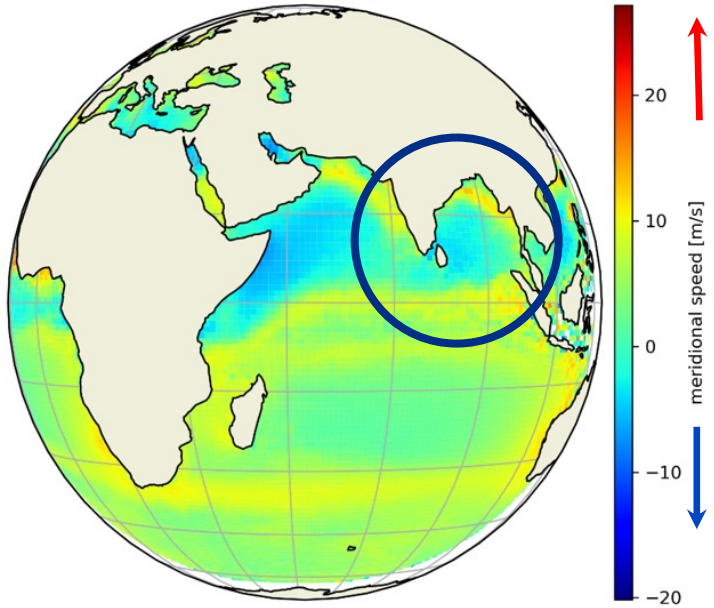
Winter

Averaged meridional component ($\vec{v}$) of the low level AMVs 1988 – 2009 from Meteosat IR MVIRI and SEVIRI measurements – speed > 5m/s and QI > 60

Summer (JJA)

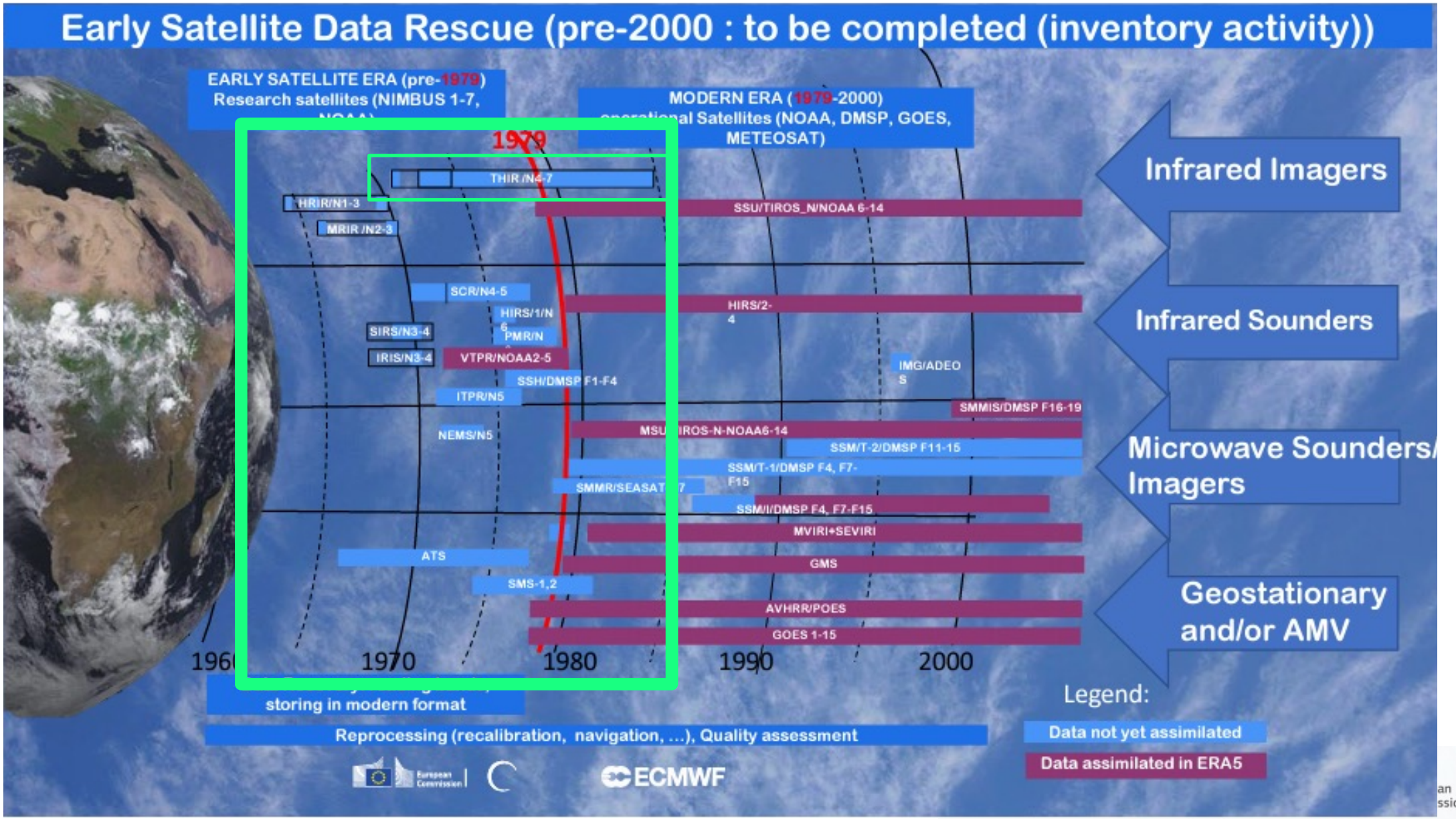


Winter (DJF)



Climate Change

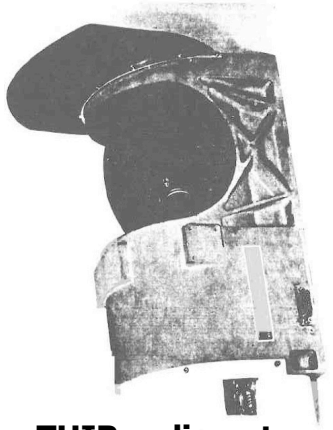
C3S311c – early era satellite data rescue



From P. Prunet et al. – C3S 311c

Potential for Atmospheric Motion Vectors (AMVs) in the 1970s

Climate Change



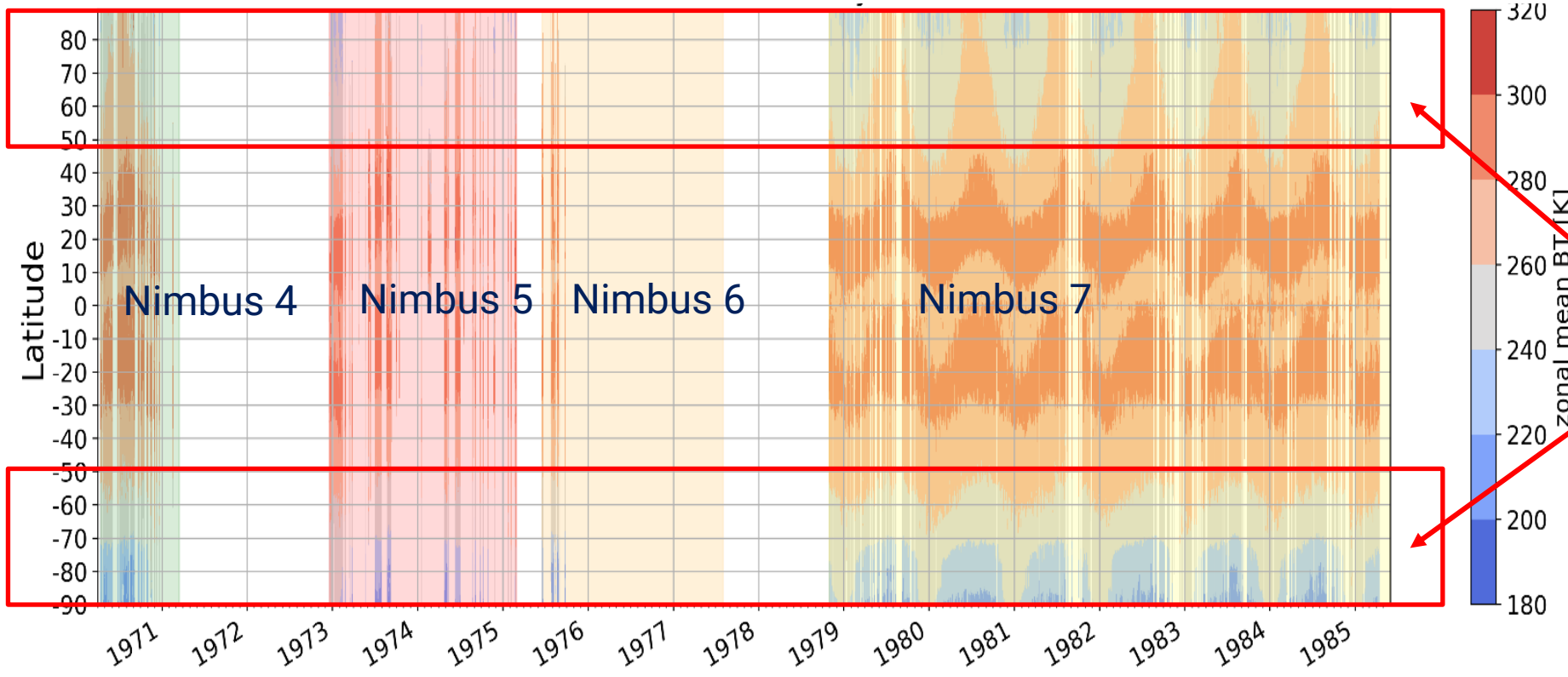
THIR radiometer
from Hwang, NIMBUS 7 THIR data user's guide, NASA/Goddard Space Flight Center, 1982.

- As part of its C3S2.0 activities EUMETSAT performs a feasibility study to assess the quality of Temperature-Humidity Infrared Radiometer imager data to retrieve AMVs in the 1970s. If feasible, AMV CDR will be produced for future C3S global reanalysis.
- These new AMVs would represent an important addition to global reanalyses, given the scarce in situ upper-air observing network over the polar regions and the general paucity of satellite data prior to 1979.
- THIR was operating day and night.
  It had two channels:
  - Water vapour: 6.7 µm (6.5 µm — 7.0 µm), resolution: 22km at ssp not used for AMVs retrieval
  - Infrared: 11.5 µm (10.5 µm — 12.5 µm), resolution: 8km (Nimbus 4, 5 and 6), 6.7km (Nimbus 7)

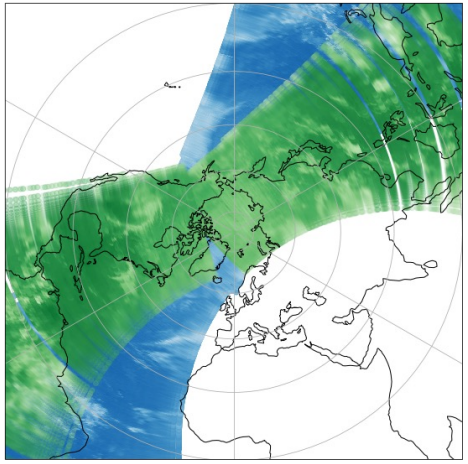
	Start date	End date	Number of files
Nimbus 4	13 April 1970	31 March 1971	1743
Nimbus 5	19 December 1972	1 March 1975	2414
Nimbus 6	18 June 1975	11 August 1977	461
Nimbus 7	30 October 1978	13 May 1985	30370

Potential for Atmospheric Motion Vectors (AMVs) in the 1970s

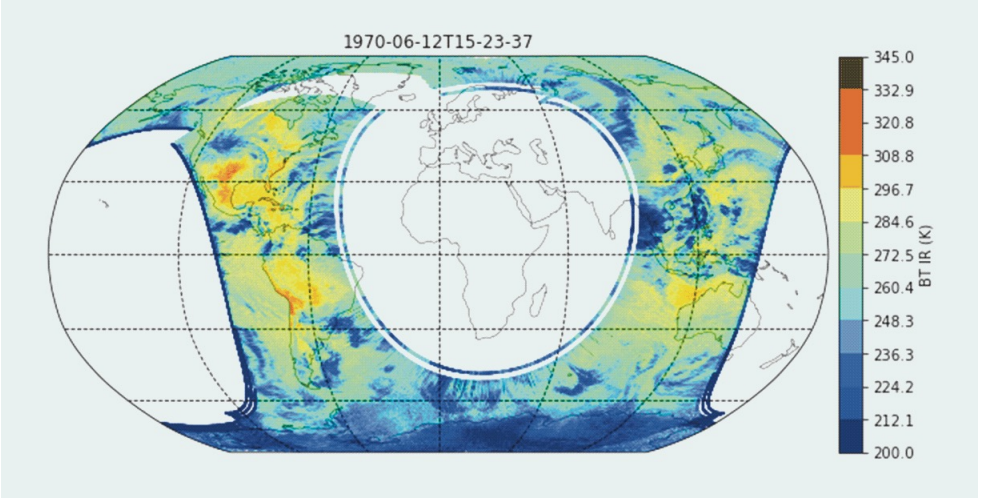
Climate Change



"Traditional" LEO-AMV retrieval area

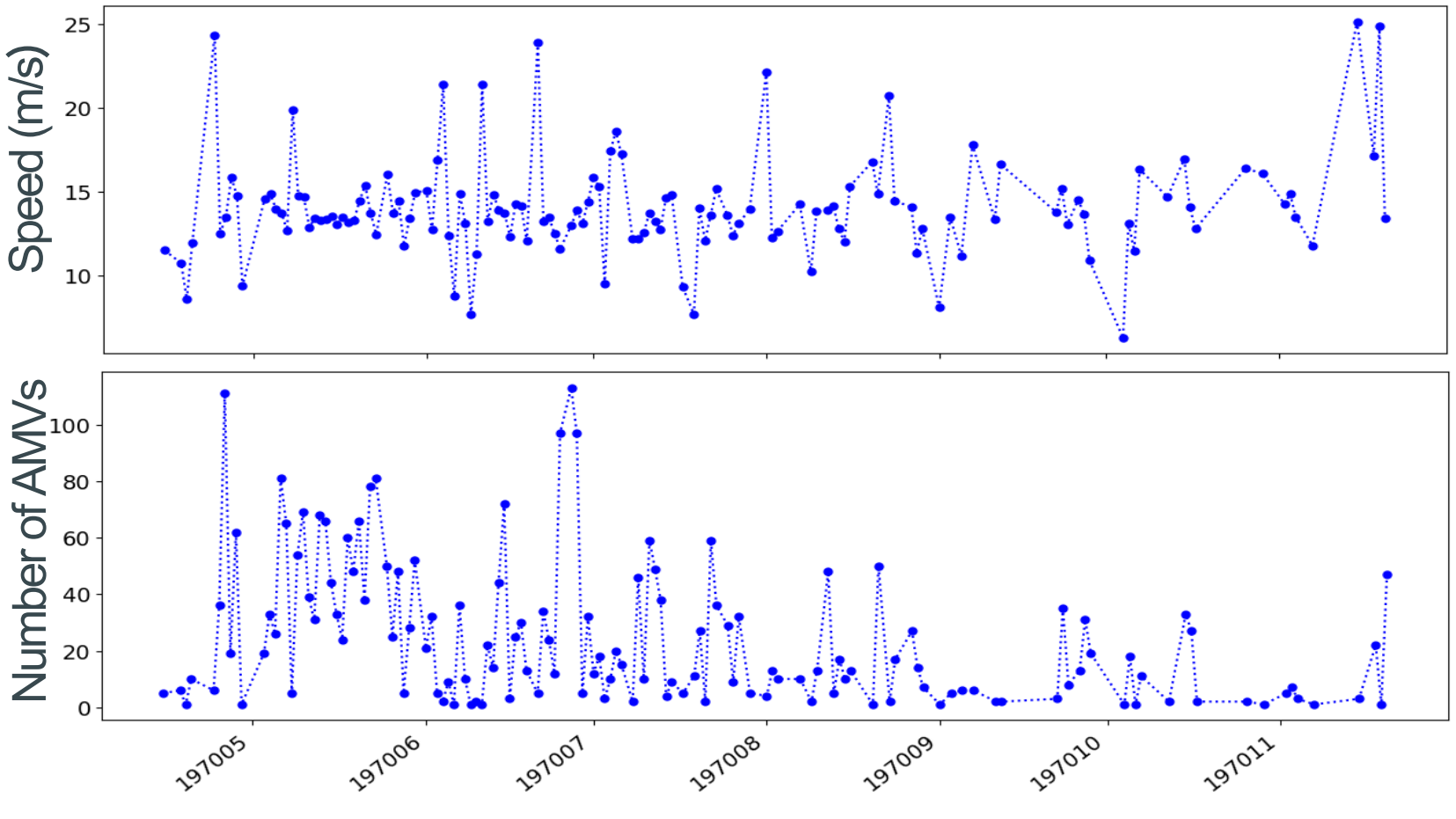


Thanks to THIR large swath it should be possible to retrieve AMV globally from 2 successive THIR orbits



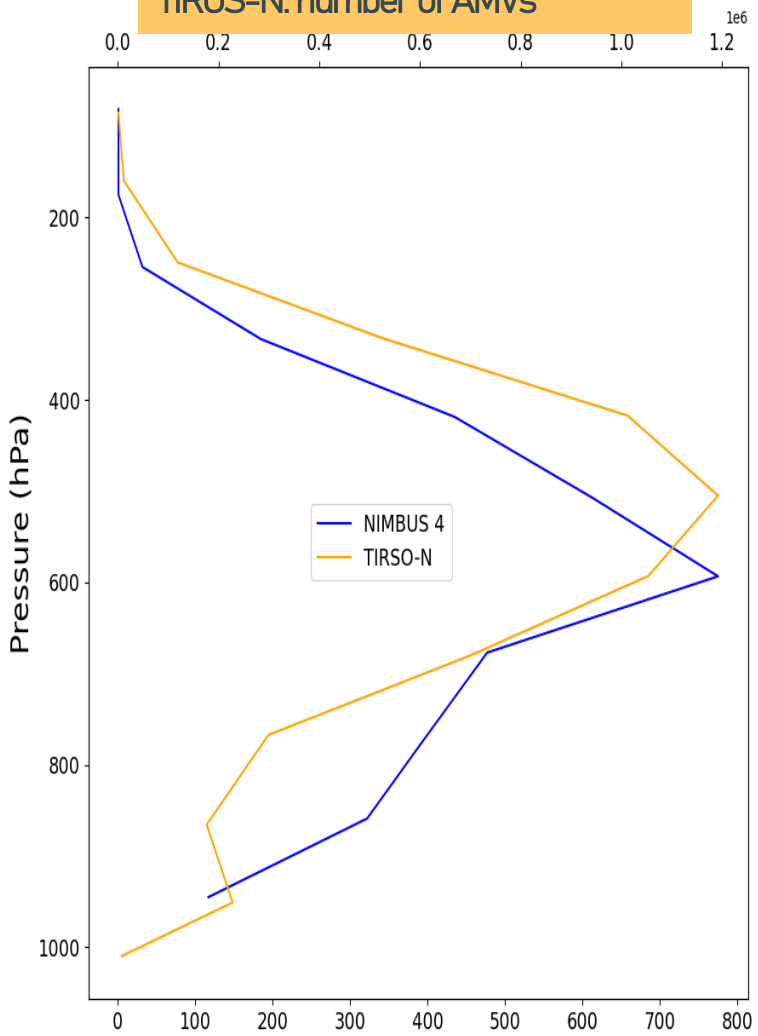
NIMBUS 4 time series

Daily average for AMV with a QI > 80



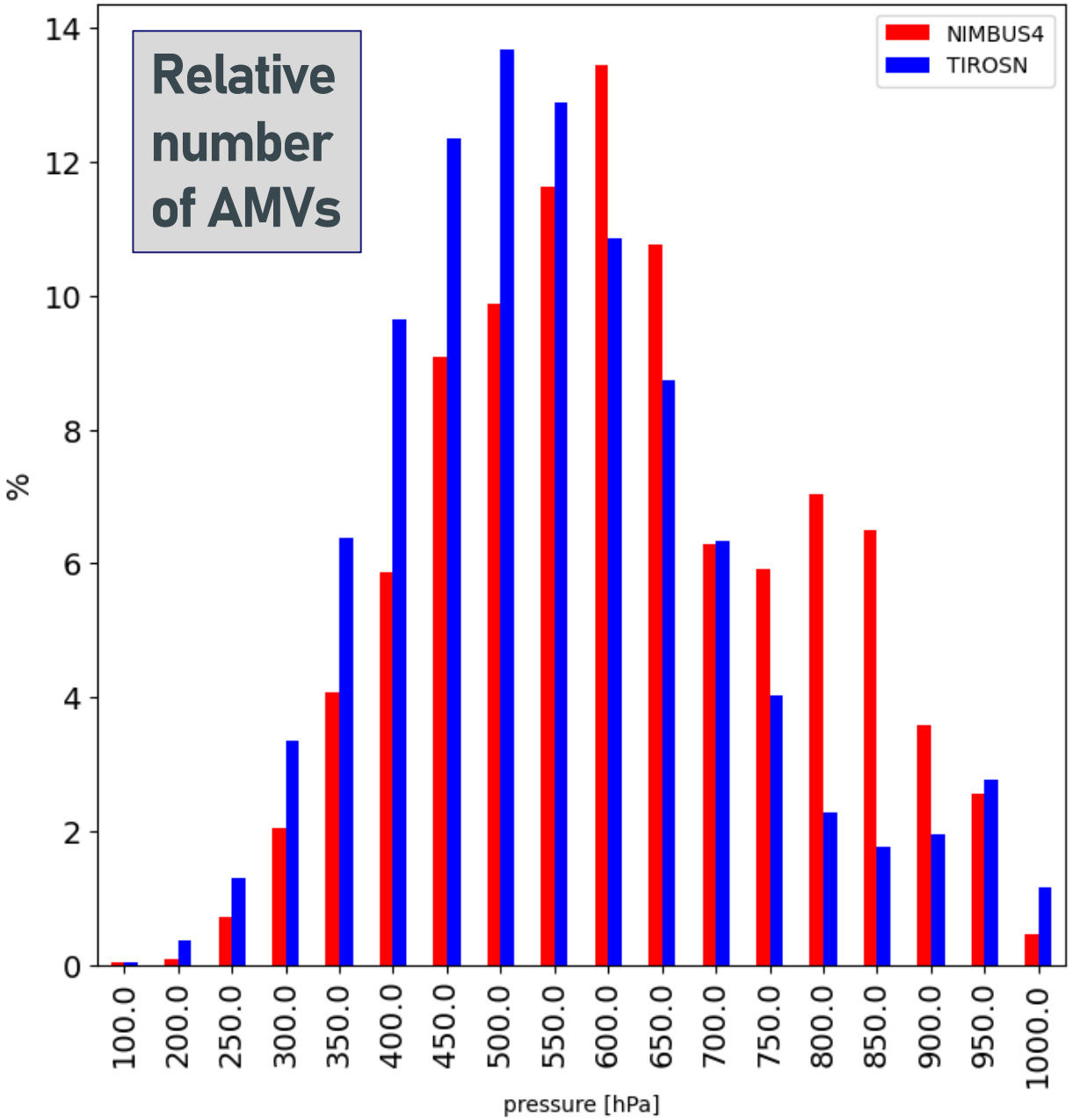
Apr-Dec 1970 and 1979

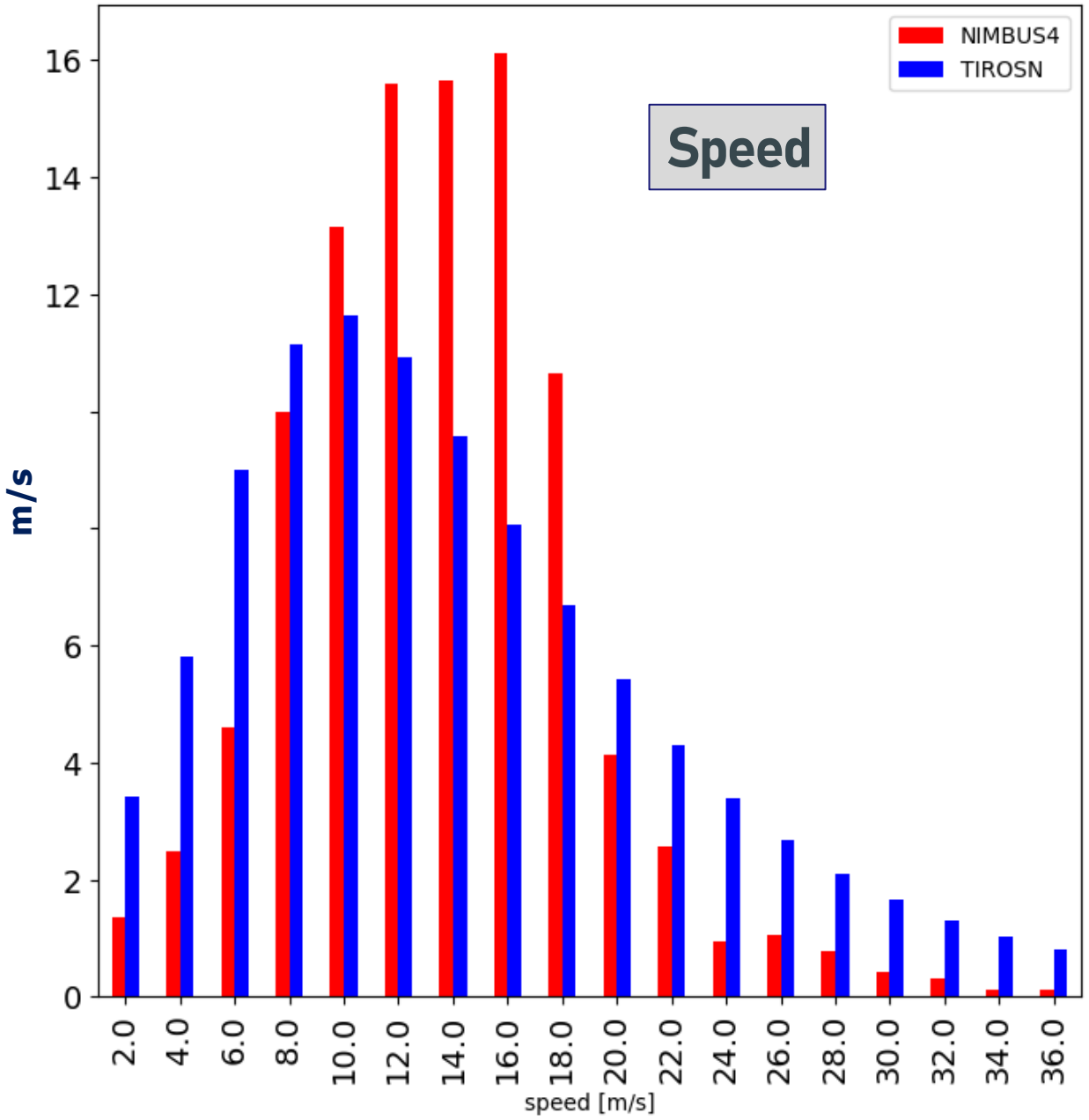
TIROS-N: number of AMVs



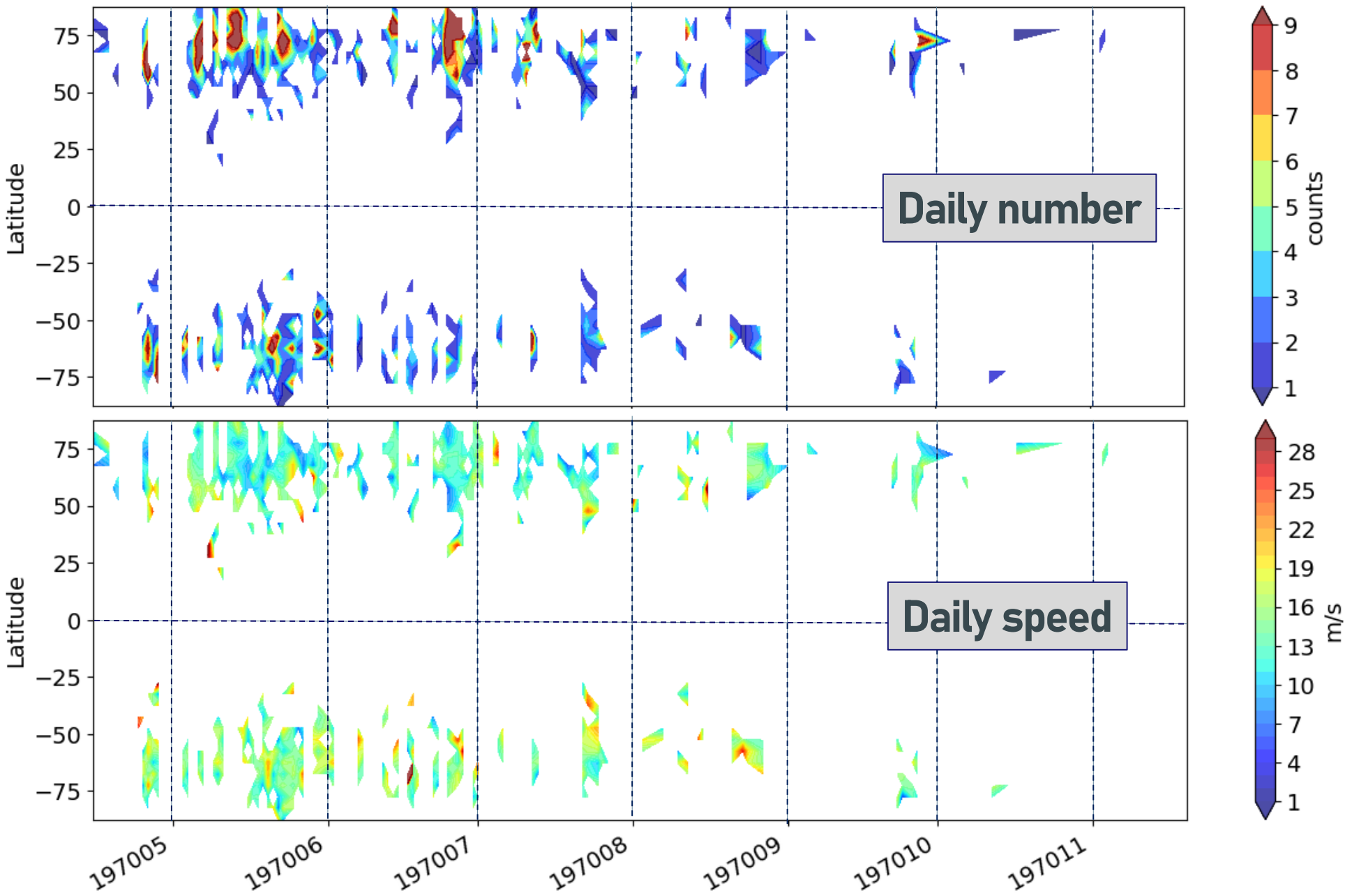
NIMBUS 4: number of AMVs

Histograms for number of AMVs and speed for NIMBUS 4 and TIRSO-N

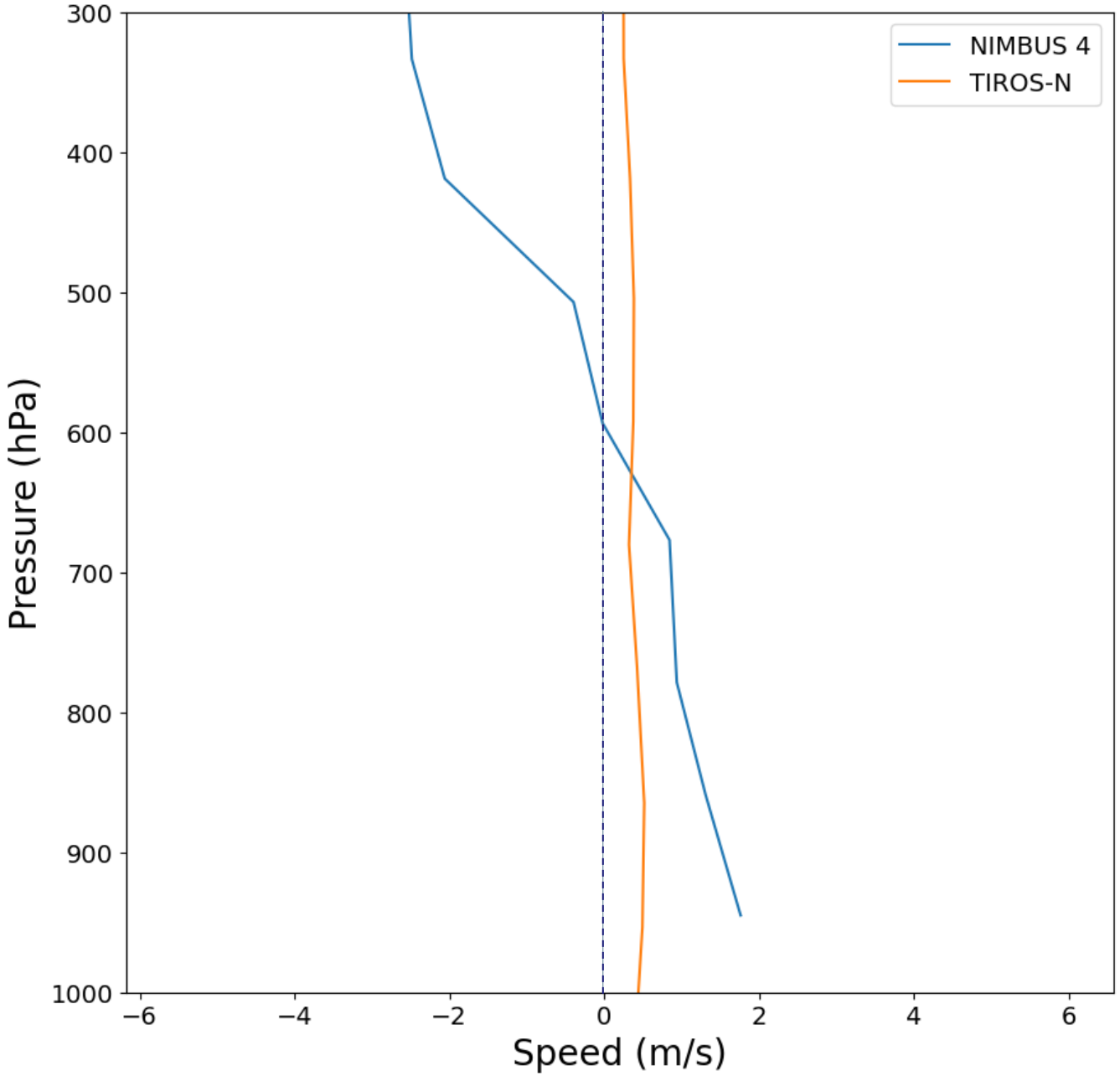




NIMBUS 4 AMVs numbers and speed as Hovmoeller plot (QI>80)



AMV – ERAinterim (speed bias)



- Apr-Dec 19**70**:
  NIMBUS 4: ±2m/s, lower AMV speeds higher it the atmosphere

- Apr-Dec **1979**:
  TIROS-N: speed bias slightly positive and constant with height

Conclusion

- EUMETSAT CDR production is based on the long history of EUMETSAT NRT AMVs software
- Climate data record are now produced at EUMETSAT from imagers onboard both LEO and GEO satellites
- CDR have been extensively validated and are of good quality to be used for the production of reanalysis and climate analyses. We have demonstrate that AMV CDR can play a role in analyzing climate pattern and in assessing their evolution
- Thanks to the recent production of reprocessed Fundamental Data Records of early imaging satellites by C3S, feasibility studies are ongoing for extending the CDR AMVs prior to 1980. The AMV from early era satellite era pre-1980 are very important for reanalyses .
  - AMV from THIR (on-board Nimbus 4,5, 6 and 7) is in development and testing at EUMETSAT
    - The temporal coverage is sparse for Nimbus 4 to Nimbus 6
    - The first tests show that the difference to TIROS-N and reanalyses are quite large for Nimbus 4
  - Feasibility study to derive AMV from earlier instruments will start next year (HRIR Nimbus 1-3, 1964-1972; SR NOAA 1-5 1970-1979, and VHRR NOAA 2-5, 1972-1979)
- New global homogeneous GEO AMV CDR using the upcoming GEOring in 2027
- The sustained production of CDR will continue with the new generation of instruments to sustain the climate series

Thank you !
Merci !

Question ?