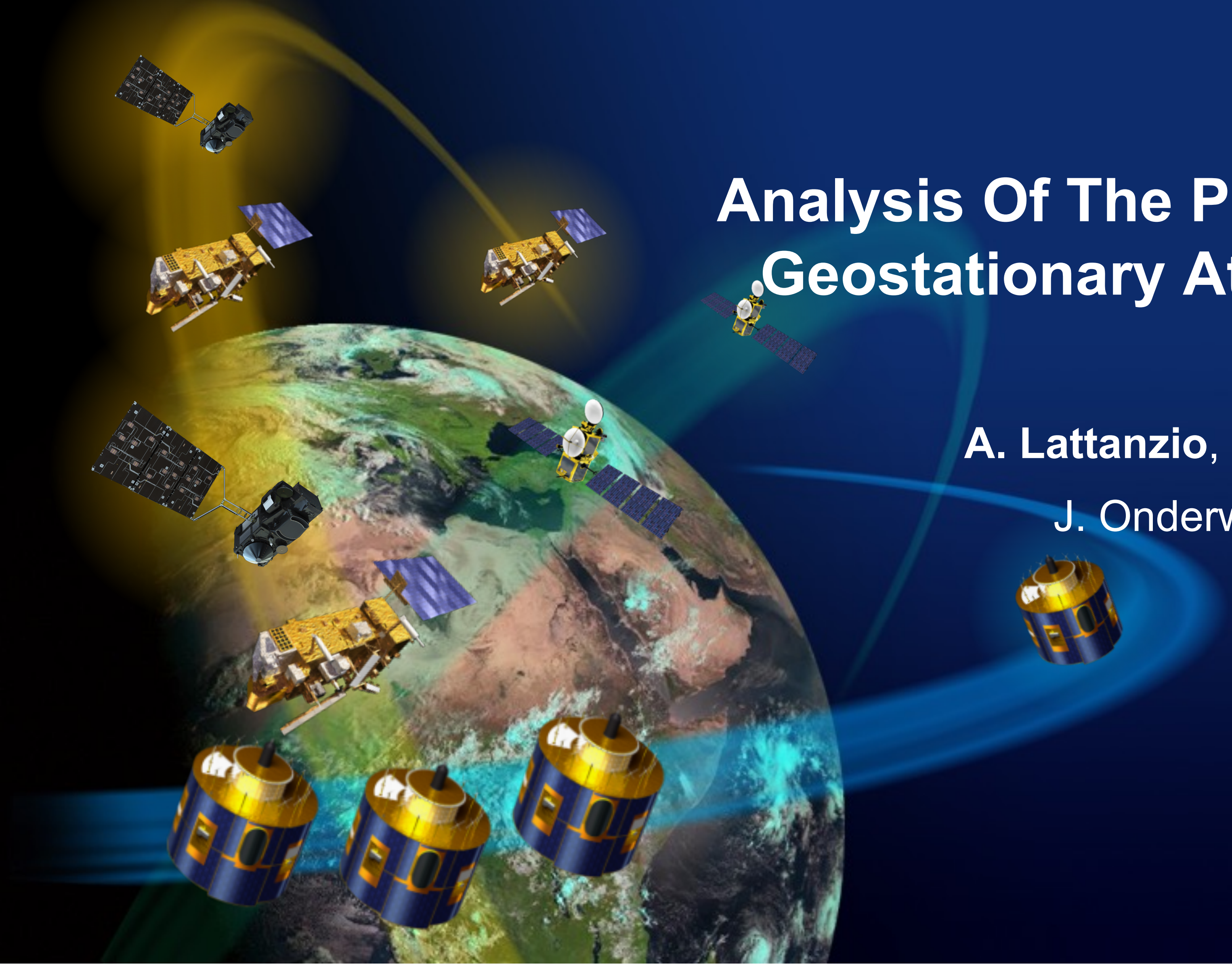
EUMETSAT

Analysis Of The Polar Jet With The Eumetsat Geostationary Atmospheric Motion Vectors Climate Data Record



A. Lattanzio, M. Doutriaux-Boucher, R. Huckle, O. Sus, J. Onderwaater, L. Medici, M. Grant, and J. Schulz

Outline

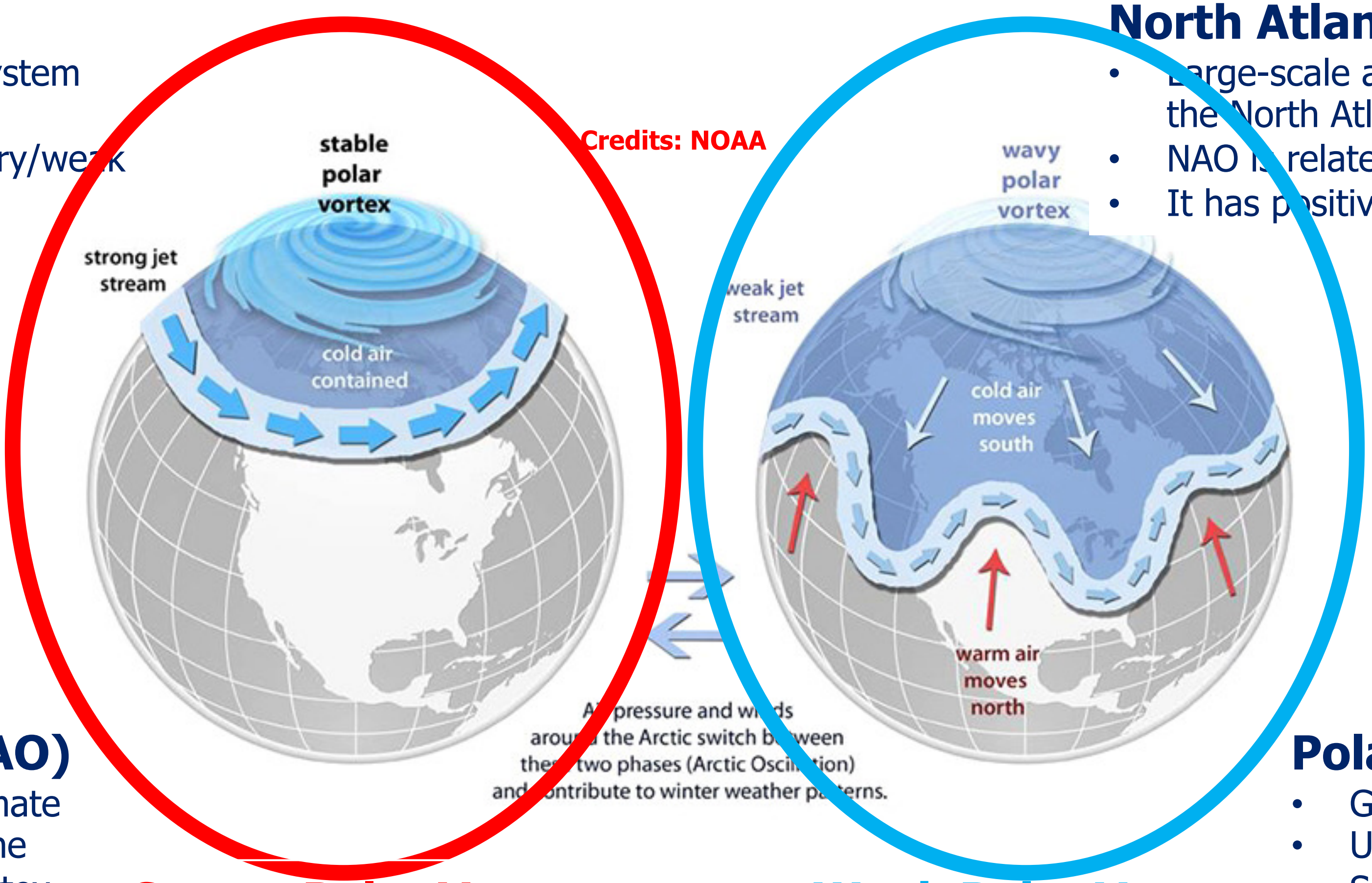
- ❑Jet streams: what, why, how?
- ❑ Jet Stream from GEO AMV CDR
- ❑ Jet Streams analysis: extremes and trend

Jet streams: what, why, how

Polar Vortex
- Upper level low pressure system rotating counter-clockwise
- Can be stable/strong or wary/weak

North Atlantic Oscillation (NAO)
- Large-scale atmospheric pressure see-saw in the North Atlantic region
- NAO is related with AO (most of the times)
- It has positive and negative phases

JS are stronger and located higher in latitude



JS are weaker and located lower in latitude

Arctic Oscillation (AO)
- Large scale mode of climate variability related with the patterns of the polar vortex
- It has positive and negative phases

Strong Polar Vortex
AO+
NAO+
Strong Jet Streams

Weak Polar Vortex
AO-
NAO-
Weak Jet Streams

Polar Jet Streams
- Geostrophic winds
- Upper Troposphere (<400 hPa)
- Speed>30 m/s
- Stronger in Winter
- Influence weather in US and Europe
- Influence trans-Atlantic aircraft routing

Jet Stream evolution: models and reanalysis

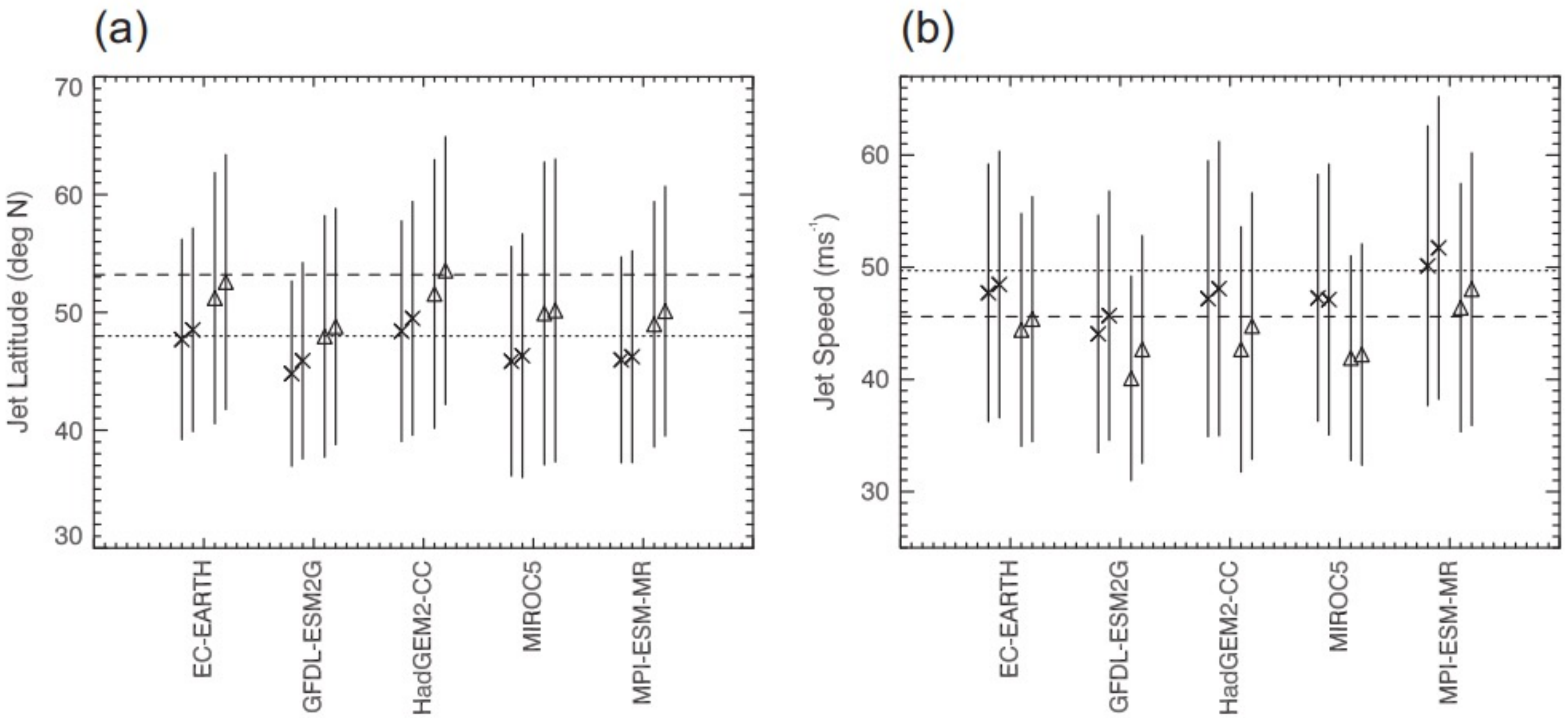


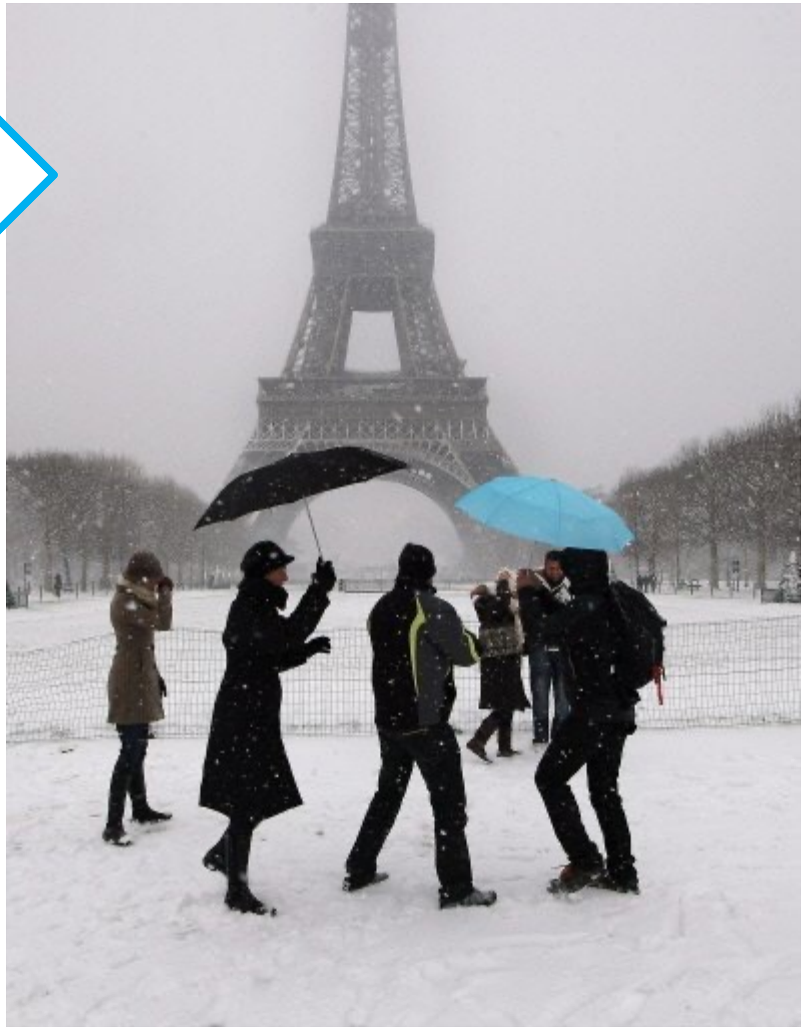
Fig. 2. (a) The mean jet latitude in the west Atlantic (cross) and east Atlantic (triangle) in five different climate models. For each pair of points, the mean value in the present-day climate (symbol) and daily variability given by the standard deviation (solid line) is on the left, and the mean value and its standard deviation in the future climate, 2073–2099, in a high greenhouse gas scenario is on the right. For comparison, the mean jet latitude in the ERA-Interim re-analysis data for the period 1979–2005 is shown for the west (dotted lines) and east Atlantic (dashed lines). (b) As (a) but for the jet speed.

"**The annual-mean location of the jet stream is predicted to move northwards in all models** (Fig. 2a), with a mean increase of 0.8⁰ in the west Atlantic (range: 0.3–1.1 ⁰ from the five models), and 1.1 ⁰ in the east Atlantic (range: 0.2–2.0 ⁰). **The mean jet stream speed is also predicted to increase in all models** (Fig. 2b), with a mean increase in the sector-averaged wind speeds of 0.9 m/s in the west Atlantic (range: 0.2 to 1.6 m/s) and 1.5 m/s in the east Atlantic (0.3–2.6 m/s)."

From: Irvine, E. A., Shine, K. P. and Stringer, M. A. (2016) What are the implications of climate change for transAtlantic aircraft routing and flight time? Transportation Research Part D: Transport and Environment, 47. pp. 4453. ISSN 13619209 doi: https://doi.org/10.1016/j.trd.2016.04.014

Jet Stream: weather extremes

Can JS position cause extreme weather events like these?



Statistical nomenclature for the analysis

- Time series decomposition is done using the STL with LOESS (locally estimated scatterplot smoothing) method (Cleveland et al. 1990):

$$\mathbf{Yt = Tt + St + Rt \ (for\ t=1..N)}$$

- **Tt** is the Trend component (green curve in the plots), **St** is the seasonal component and **Rt** contains the residuals.

- Trend regression: is the linear fit for **Tt**. It is used to compute the decadal trend (DT), i.e. the trend value over 10 years.

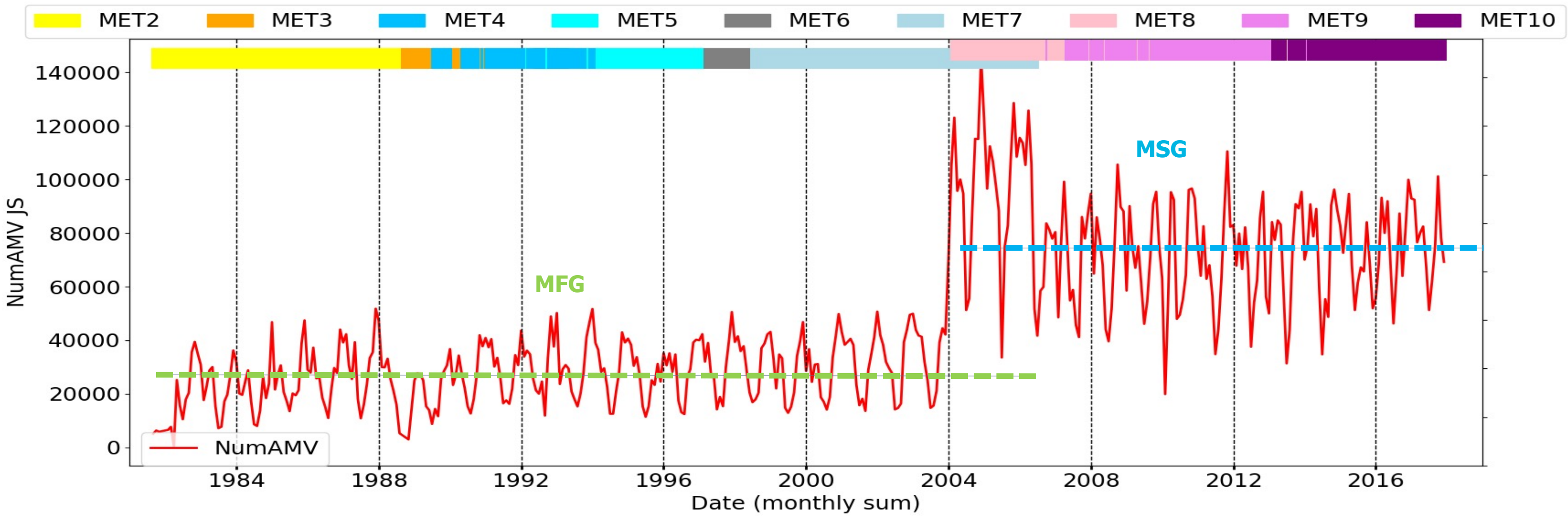
- The mean trend value is the mean value of **Tt** over the full period of the time series.

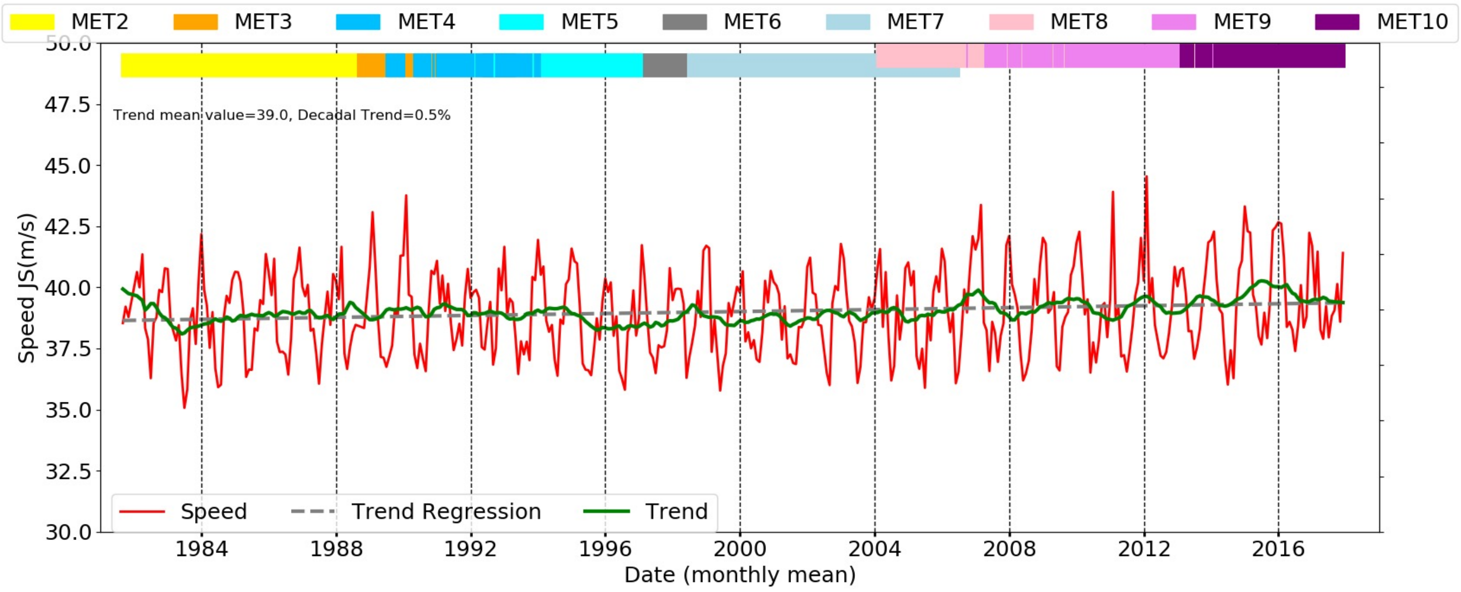
Jet Streams from Meteosat observations

GEO AMV for JS:

- CDR exploiting NRT algorithm modified to process MFG as well

- Channel IR (10.8 µm)
- Latitude > 30º North
- Height < 400 hPa
- Speed > 30 m/s
- QI > 60



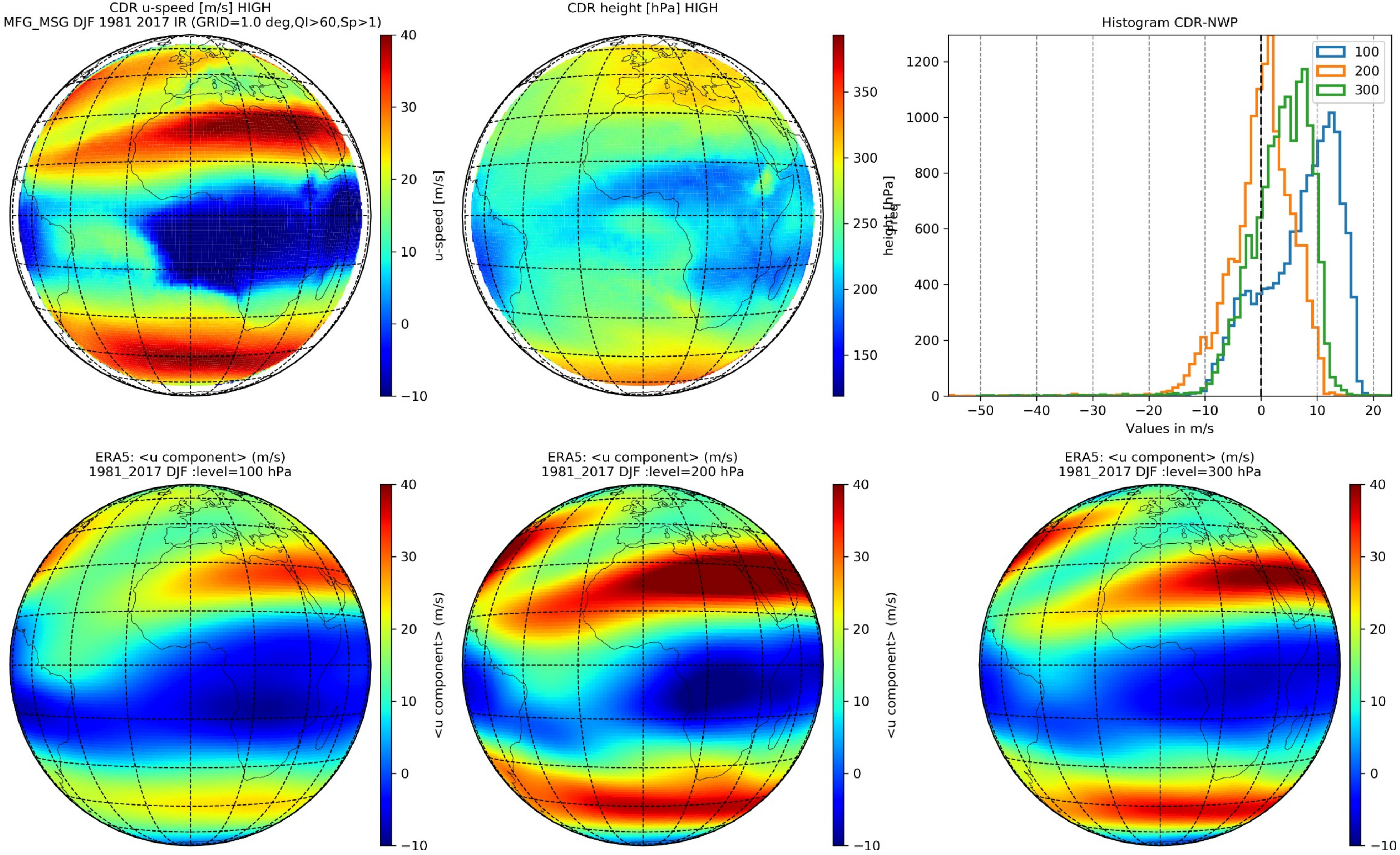


- Due to the higher both spatial and temporal resolution, MSG retrieves ~3 times AMV compared with MFG

- Speed retrieval consistent between MFG and MSG. Removing the seasonal component, there is +0.5% decadal trend over a trend mean value of 39 m/s.

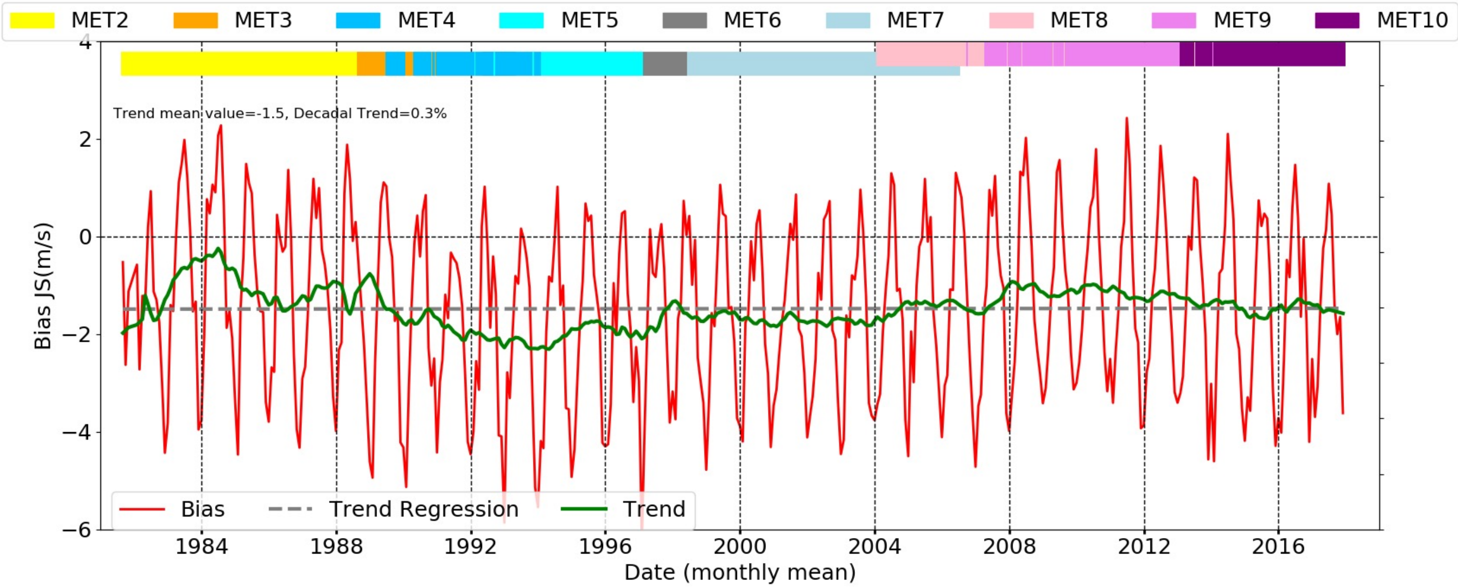
EUMETSAT

Visual quality check Zonal speed CDR vs ERA5 (DJF)



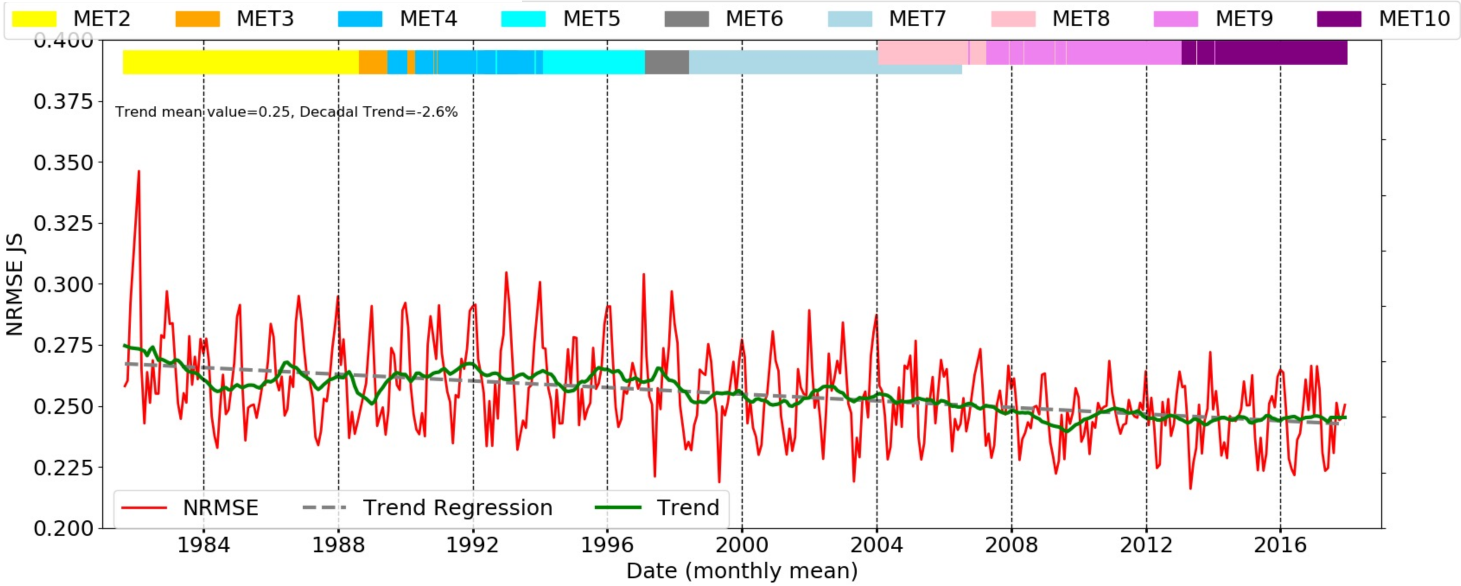
- ❑ Comparison of mean values over the period 1981-2017 (winter months DJF)
- ❑ GEO CDR AMV High levels winds are retrieved mainly between 200 and 300 hPa in winter;
- ❑ ERA5 at 200 hPa shows similar pattern (histogram in orange);
- ❑ Long term CDR average shows clearly the jet stripes (red: west to east) and trade winds (blue: east to west).

Quality check: Speed comparison against ERA-Interim



- JS show a small negative bias (trend level -1.5 m/s) common feature in all AMV retrievals for high level NH vectors;
- Small trend in the bias (+0.3% of decadal trend).

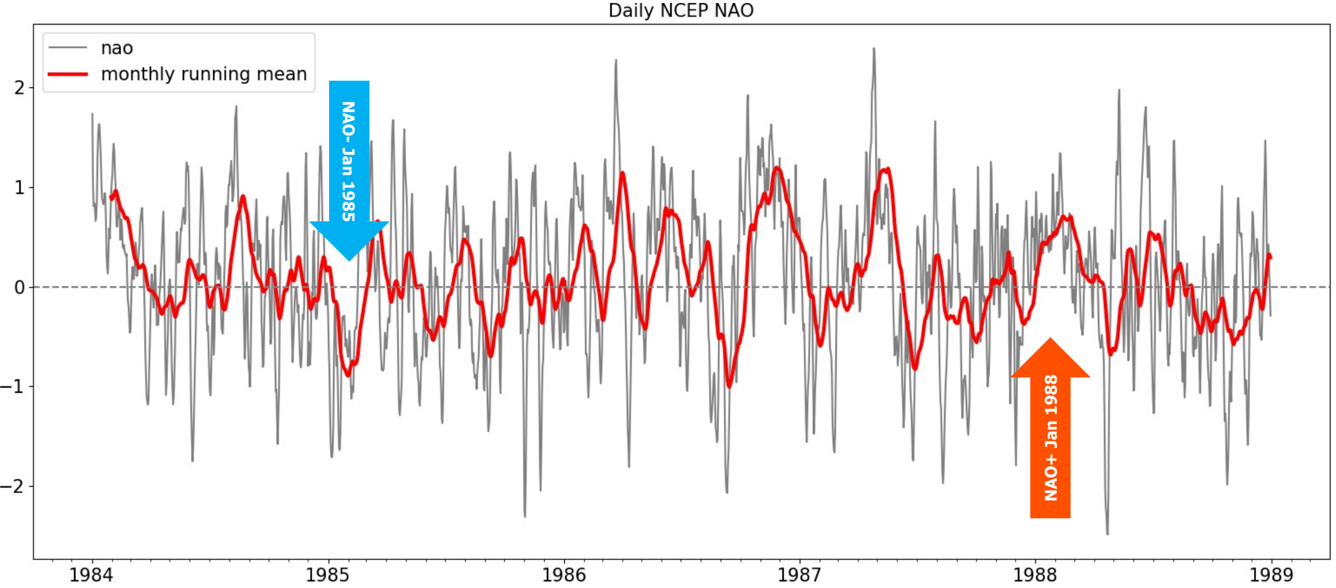
- The Normalized RMSE decreases over time (-2.6% of decadal trend on a trend mean value of 0.25). Considering that the speed shows a smaller trend (+0.5% of decadal trend), this means a real decrease in the difference between GEO AMV and ERA-Interim.



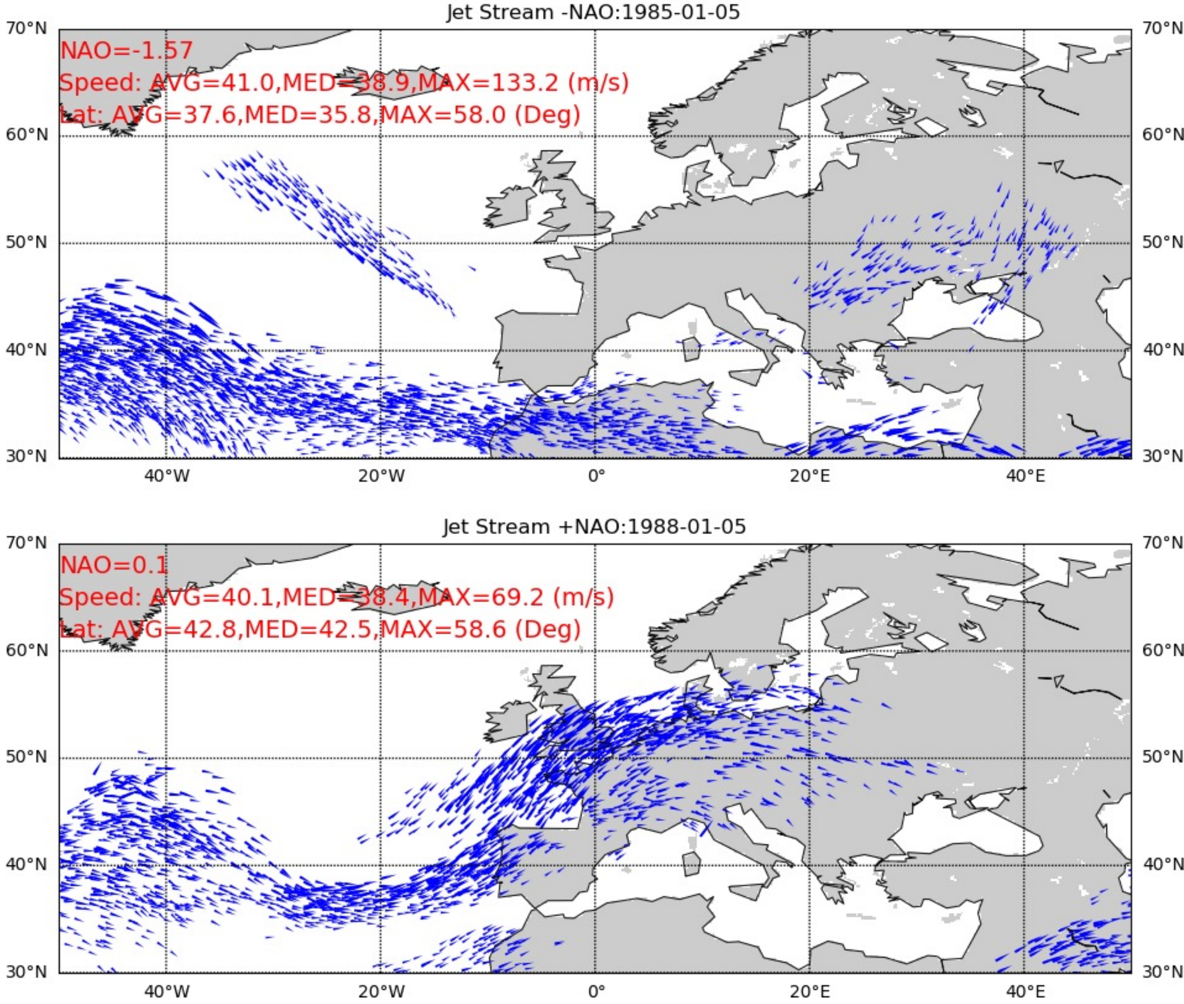
EUMETSAT

GEO AMV CDR Jet streams: extremes (MFG)

Meteosat-2: 1985 (negative NAO) vs 1988 (positive NAO)



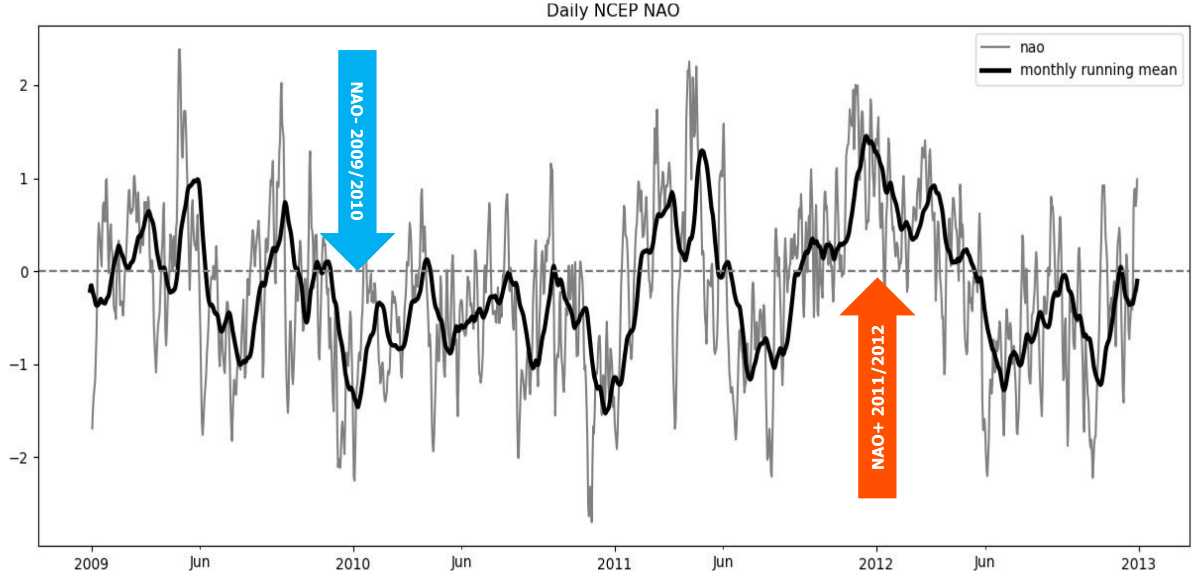
Compared Vectors with: QI>60 speed>30 m/s and height<400 hPa



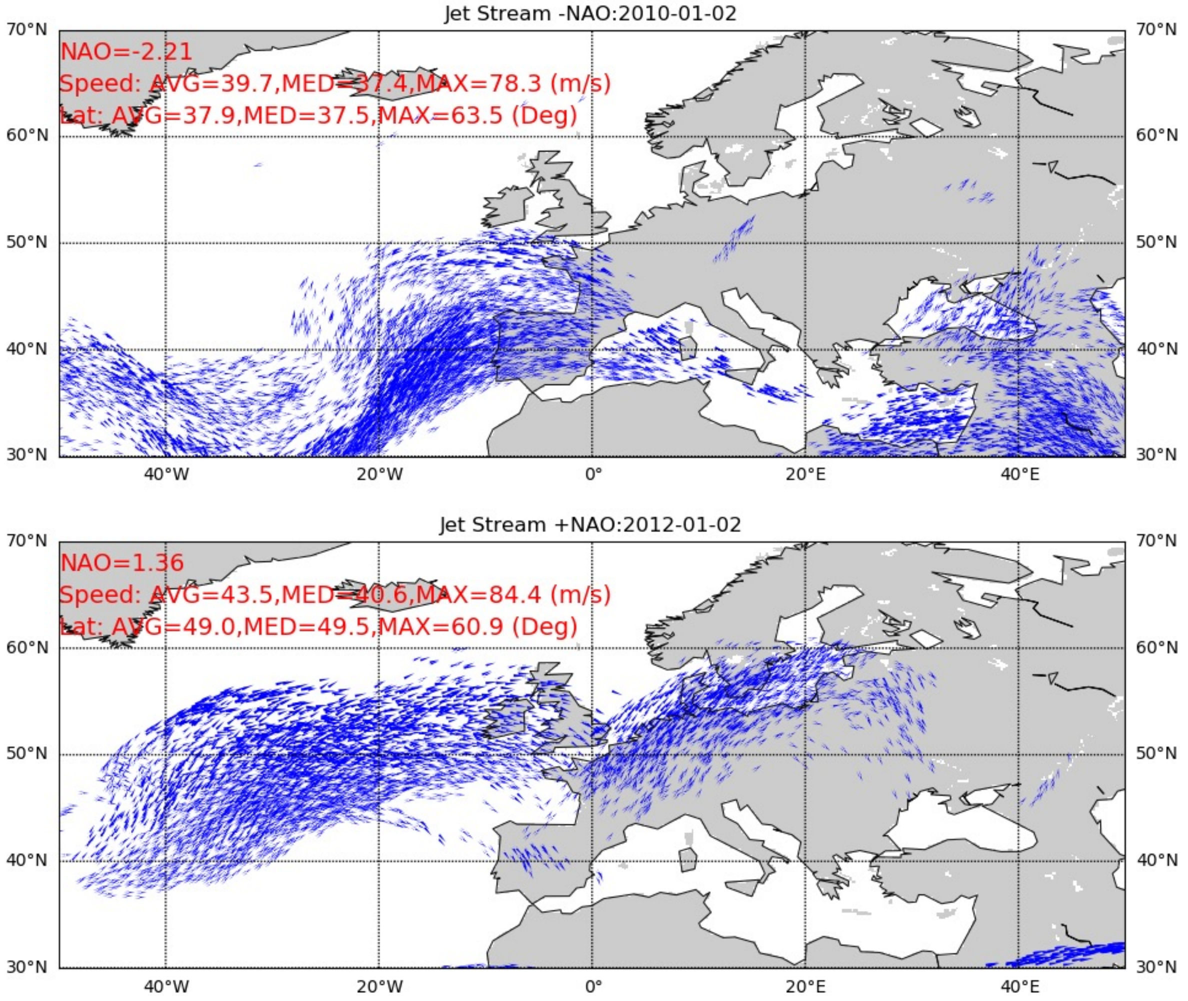
GEO AMV CDR Jet streams: extremes (MSG)

Meteosat-9: 2009/2010 (negative NAO) vs 2011/2012 (positive NAO)

Winter 2009/2010 is recorded as one of the hardest in the past years



Compared Vectors with: QI>60 speed>30 m/s and height<400 hPa



GEOPHYSICAL RESEARCH LETTERS, VOL. 37, L17707, doi:10.1029/2010GL044256, 2010

Winter 2009–2010: A case study of an extreme Arctic Oscillation event

Judah Cohen,[1] James Foster,[2] Mathew Barlow,[3] Kazuyuki Saito,[4,5] and Justin Jones[1]

Received 8 June 2010; revised 27 July 2010; accepted 5 August 2010; published 11 September 2010.

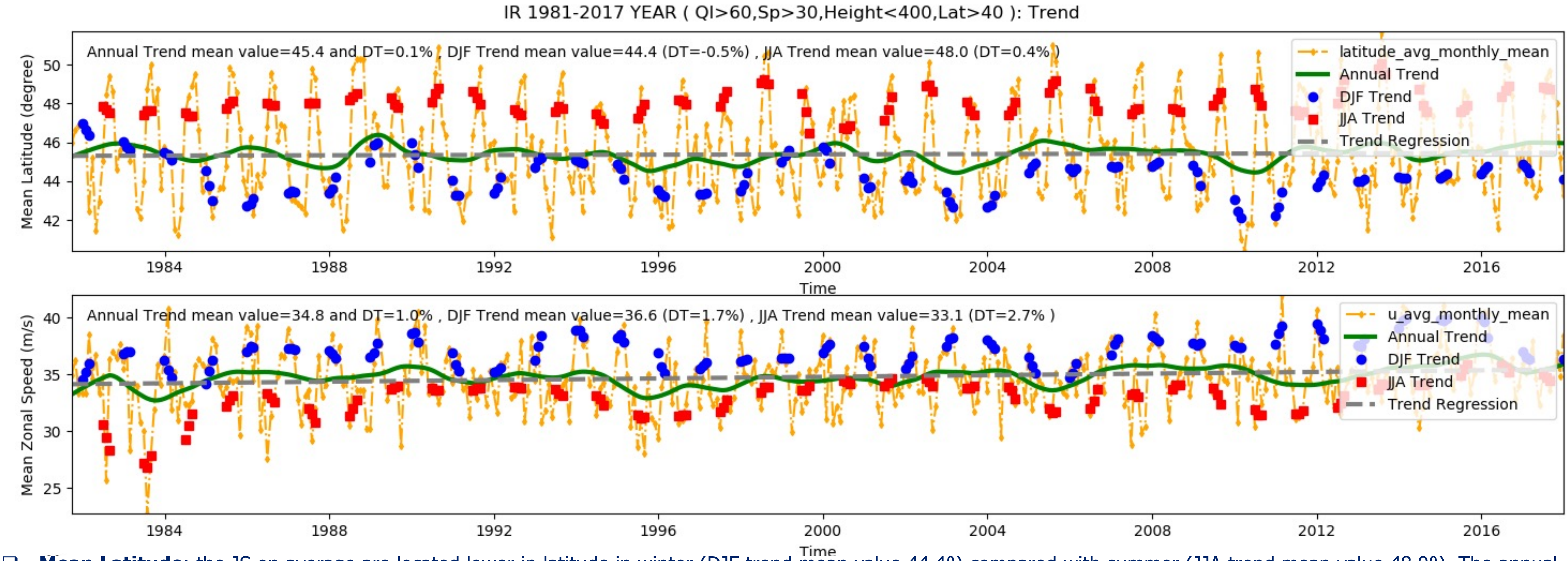
[1] Winter 2009–2010 made headlines for extreme cold and snow in most of the major population centers of the indus-

skepticism towards global warming (e.g., New York Times Feb 10, 2010; Wall Street Journal Feb 16, 2010). Therefore,

Classification

EUMETSAT

Trends in Jet Stream: Seasonal analysis



- **Mean Latitude**: the JS on average are located lower in latitude in winter (DJF trend mean value 44.4º) compared with summer (JJA trend mean value 48.0º). The annual value is in between (Annual trend mean value 45.4º). The decadal trend (DT) is -0.5% (JS getting lower) in winter, and +0.4% in summer, resulting in a positive annual value of +0.1%;

- **Mean zonal speed**: the JS are faster in winter (DJF trend level 36.6 m/s) and slower in summer (JJA trend mean value 33.1 m/s). The zonal speed shows an increase in winter (decadal trend +1.5%) and in summer (decadal trend +2.7%), resulting in a positive annual value of +1.0%;

- **Outcome**: even if those results require a deeper analysis, they are in line with results from climate models (E.A. Irvine et al., 2016).

Summary

- EUMETSAT owns a data archive covering 40 years. It can be exploited to generate several Climate Data Records (CDR). One of those is the GEO AMV exploiting all available Meteosat observations from 1981 .

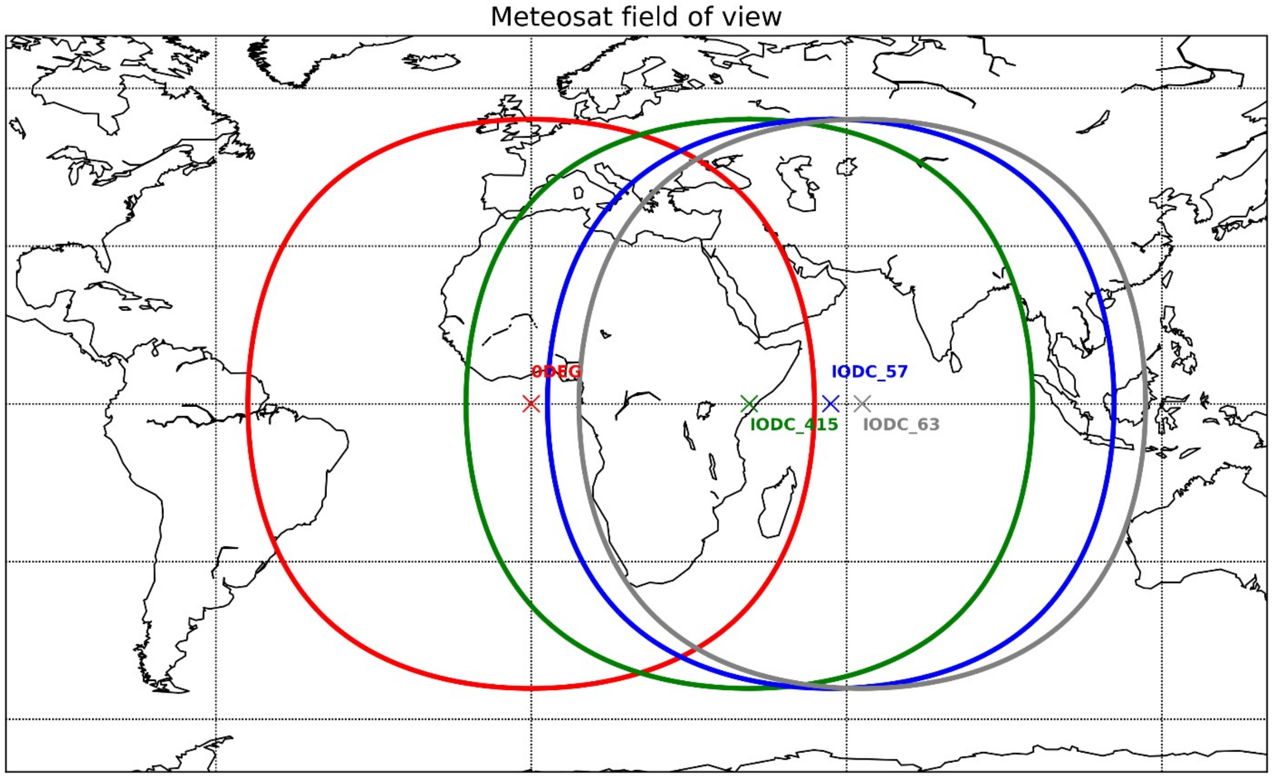
- The analysis shows an overall good stability and the possibility to detect jet stream during the whole time period. The JS derived from Meteosat follow the NAO variability (extreme weather events). The annual trend is in line with the outcome from climate models (increase in both mean latitude and speed). They can be further investigated for climate studies;

- Comparison against ECMWF reanalysis show a bias trend mean value of ~-1.5 m/s with a very small trend (0.3% each 10 years). The NRMSE shows an improvement over time with a decadal trend of -2.6% on a trend mean value of 0.25. Those results mean that the GEO AMV CDR are of good quality;

- All data can be requested from EUMETSAT: ops@eumetsat.int.

THANK YOU!

“The Meteosats”: the European GEO satellite family



	Rep Cycle	Bands	Pixel Size
MFG (2-7)	30 min	2 (WV/IR) 1 (VIS)	5 km 2.5 km
MSG (8-11)	15 min	11 (WV/IR/VIS) 1 (HRV)	3 km 1 km