ASII-TF (“Tropopause Folding”)

EUMeTrain Aviation Event Week (3-7 December 2018)

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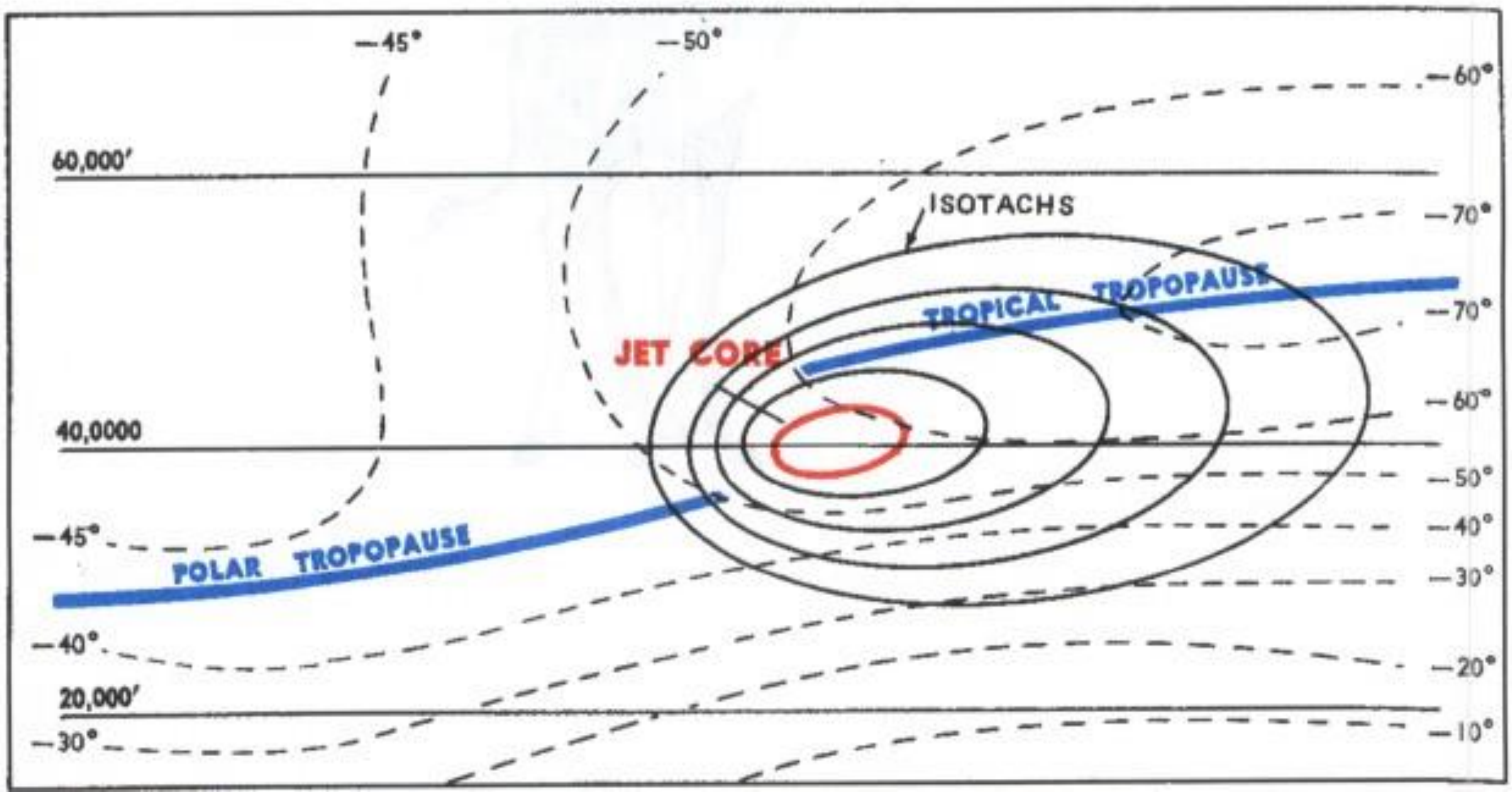
What is a tropopause fold?

- A tropopause fold is a local folding of the tropopause over an intense cyclone. (AMS Glossary)
- Tropopause folds are formed by a steepening of the tropopause at a jet core.
- Tropopause folds occur in areas with large vertical shear and strong meridional thermal gradients. (Holton 2004)



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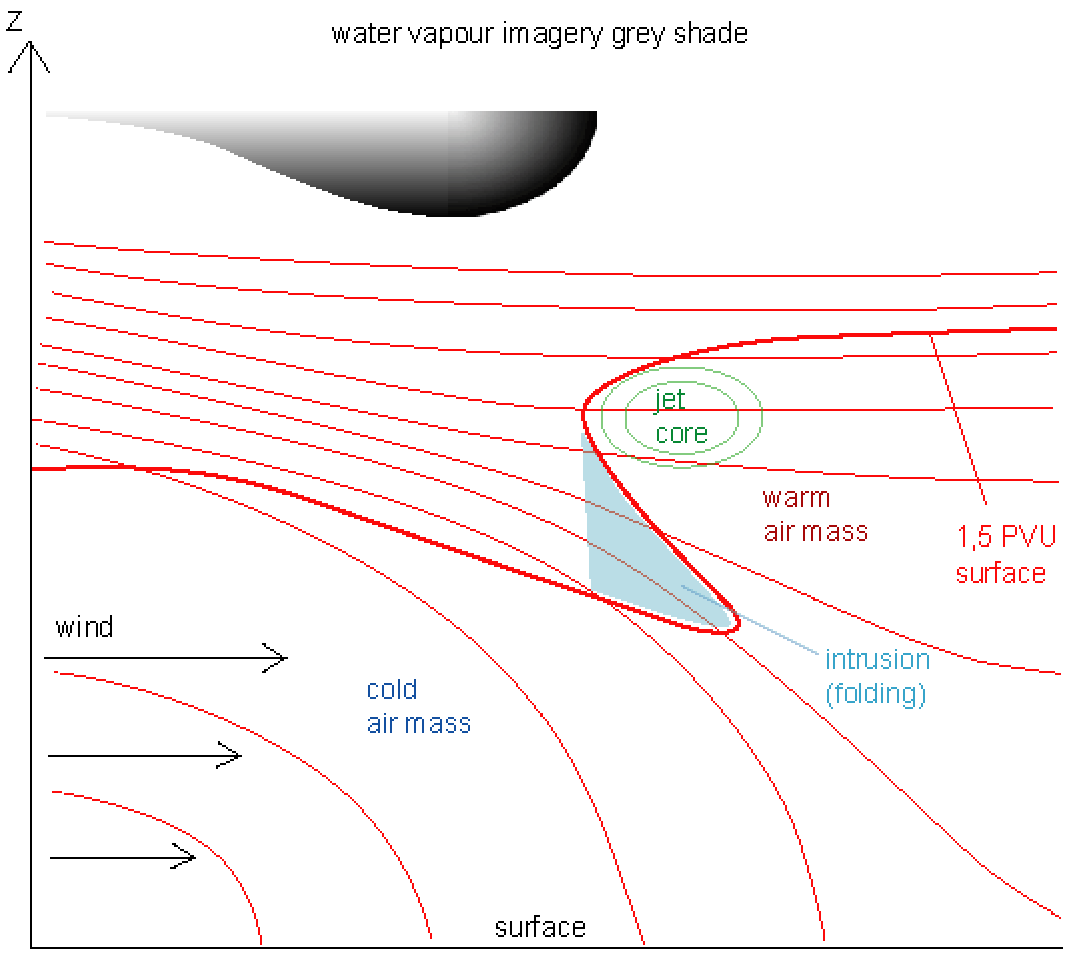
What is a tropopause fold?

- Tropopause folds are the dominant and most efficient form of short-term Stratosphere-Troposphere Exchange (STE).
- Potential vorticity is a good tracer for stratospheric air and tropopause folding events.



Tropopause folds : input parameter changes between v2016 and v2018

The tropopause detection module ASII-TF is part of the NWC-SAF software distribution. It has been first released in version 2016.

ASII-TF needs satellite data and NWP fields as input.

From NWP:	- ~~potential vorticity (multi-level up to 50 hPa)~~
	- specific humidity (multi-level up to 50 hPa)
	- wind speed at 300 hPa
	- shear vorticity at 300 hPa

From satellite:	- WV 6.2 µm
	- IR 9.7 µm (Ozone)
	- IR 10.8 µm

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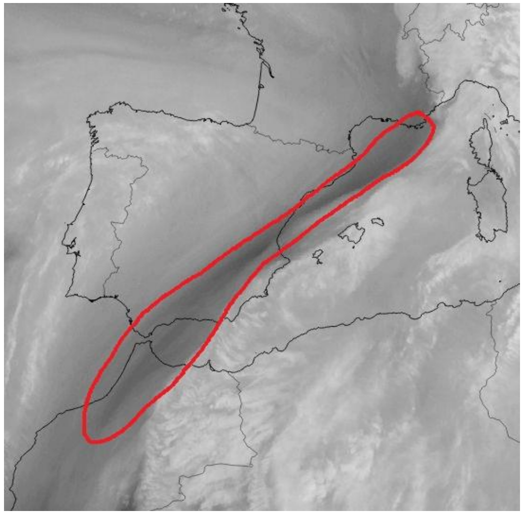
Tropopause folds : algorithm changes between v2016 and v2018

30 scenes (January to December 2014) were used to retrieve the coefficients from the logistic regression method; each scenery comprises 715 000 pixel.

Reference field (truth): Gradient of the PV=2 height from NWP
– *In version 2016, a subjectively analyzed tropopause fold was used.*

The input parameters are transformed and/or combined before being used in the **logistic regression**.

- ~~The tropopause height derived from model potential vorticity and the gradient therefrom~~
- The tropopause height derived from model specific humidity and the gradient therefrom
- Gradient of the BTD 9.7 µm – 10.8 µm
- Gradient field of VW 6.2 µm ~~and IR 9.7 µm~~
- BT from WV 6.2 µm
- Black stripe detection from WV 6.2 µm
- ~~BT from IR 9.7 µm and IR 10.8 µm~~
- Wind speed at 300 hPa
- Wind shear at 300 hPa



Tropopause folds : algorithm changes between v2016 and v2018

Motivation for changing the input parameters and/or their pre-processing:

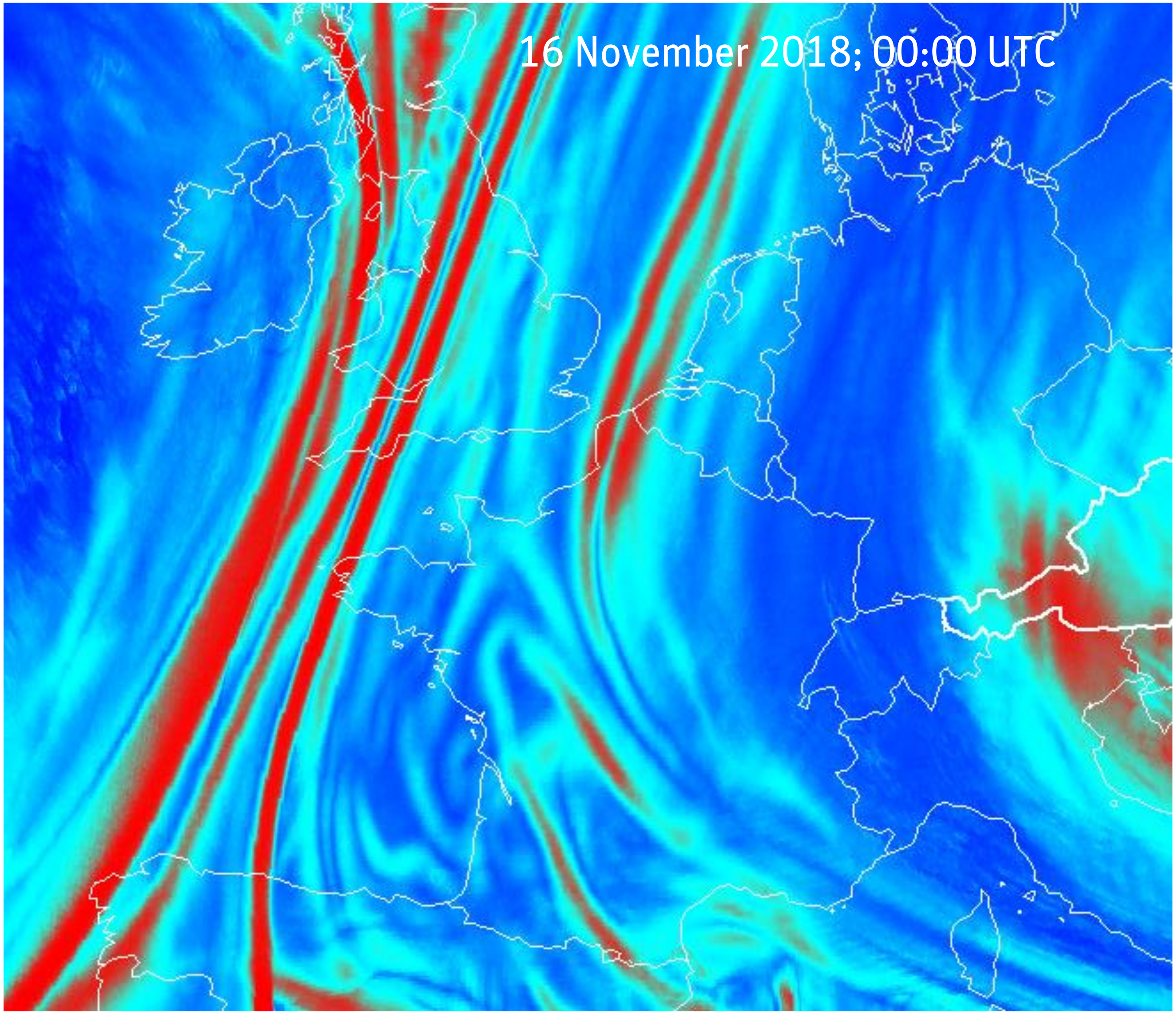
- The gradient of the tropopause derived from PV=1.5 was too similar to the reference field, hence it reduced the influence of all other parameters.
- BT from IR 9.7 µm and from IR 10.8 µm had only little effect on the output according to the coefficients retrieved from the logistic regression program.
- The median filter (25x25) takes too much computation time, hence an arithmetic filter (15x15) was used for some of the input fields.

Tropopause folds : coefficients

Coefficients from logistic regression:

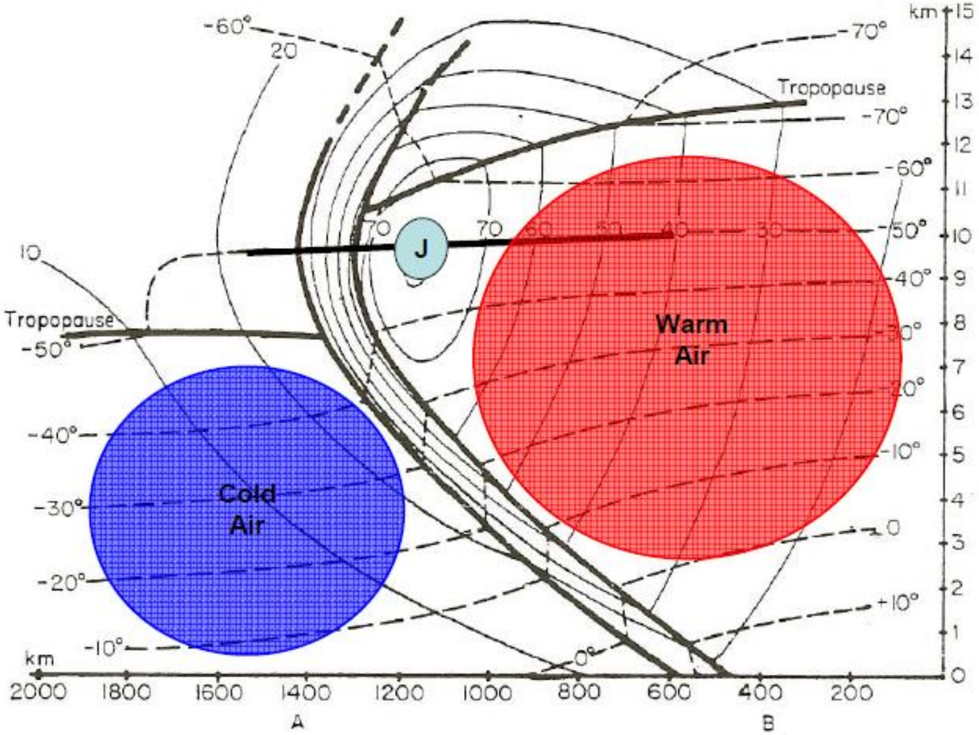
	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	-2.662e+01	1.084e-01	-245.58	<2e-16	***
d89_grad	3.023e+02	9.613e+00	**31.44**	<2e-16	***
ff300	1.982e-02	2.274e-04	**87.17**	<2e-16	***
q_grad	3.455e+01	1.589e-01	**217.40**	<2e-16	***
sh300	9.662e+03	5.251e+01	**183.99**	<2e-16	***
wv05_grad	6.027e+02	2.951e+01	**20.43**	<2e-16	***
wv05	1.045e-01	4.578e-04	**228.19**	<2e-16	***
bs05	7.480e-02	1.083e-03	**69.07**	<2e-16	***

Tropopause folds : Output [0-100%]



Tropopause Folds : Validation

1. Validation with PIREPs:

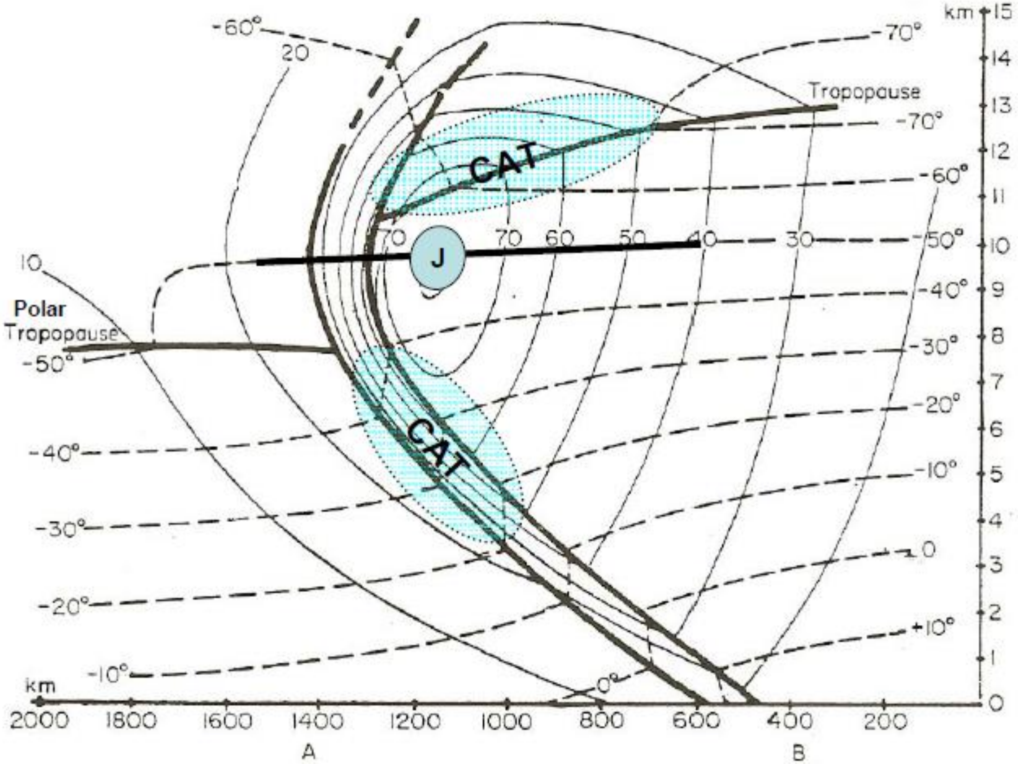


2. Validation with IASI level-2 data:

- Eyeball validation of the ASII-TF output with IASI derived tropopause height (from specific humidity profiles).

Tropopause Folds : Validation

1. Validation with PIREPs:



2. Validation with IASI level-2 data:

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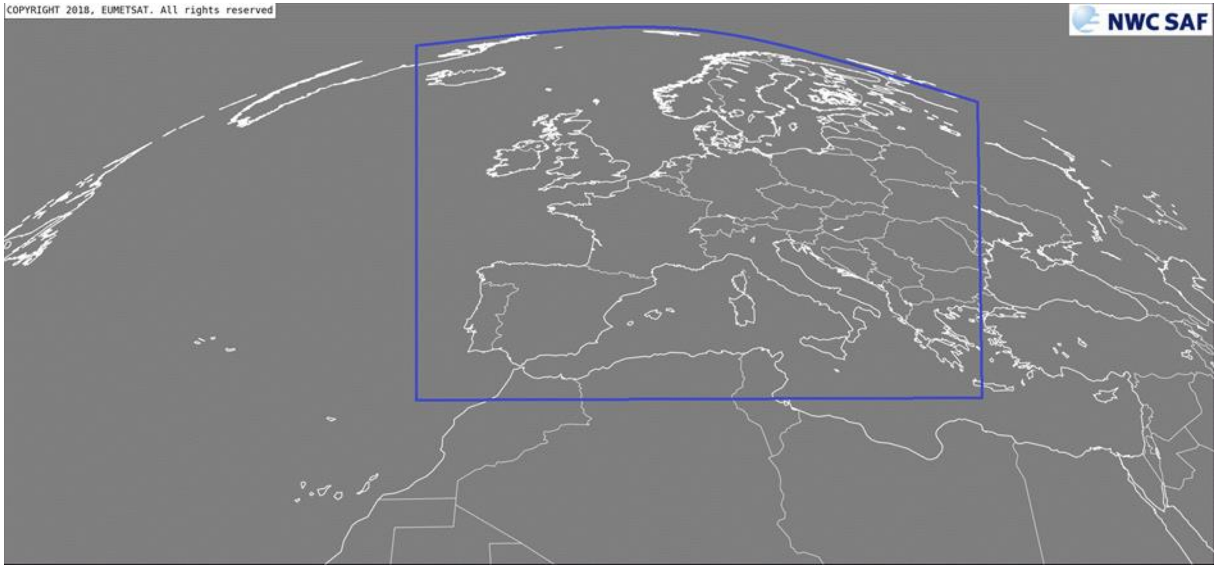
Tropopause Folds : Validation with PIREPs

Validation period: 16 April to 20 June 2018

Number of PIREPs: 196



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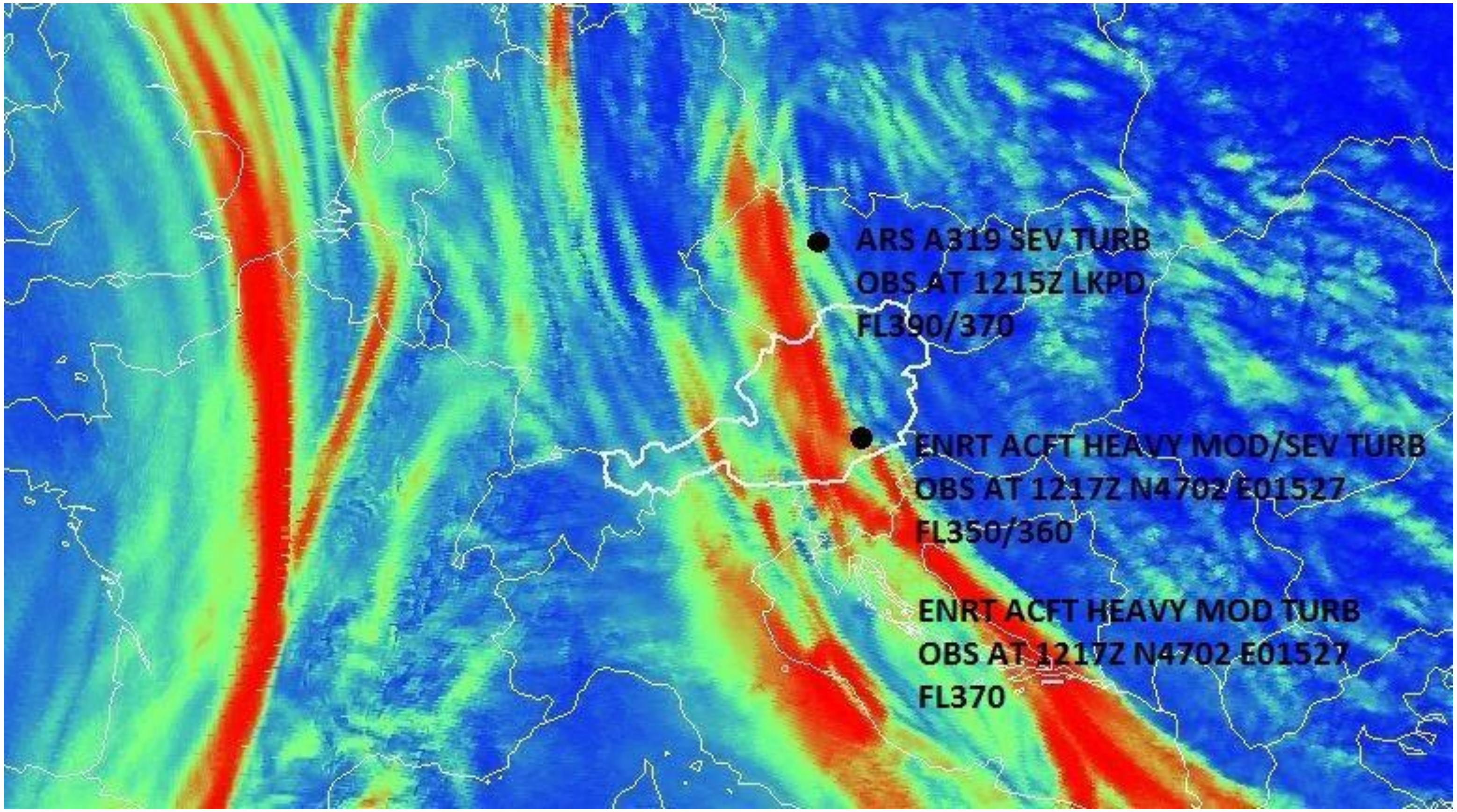
Tropopause Folds : Validation with PIREPs



PIREP issue date superimposed on chronological nearest ASII-TF analysis

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Tropopause Folds : Validation with PIREPs

Only shear related turbulence reports are considered.

ASII-TF [%]	total	LGT/MOD	MOD	MOD/SEV	SEV
67-100	40	6	26	2	6
34-66	74	17	51	2	4
0-33	17	2	14	1	0

Table 4: *Number of turbulence reports caused by strong vertical wind shear as a function of their intensity and their assigned ASII-TF probability (LGT: light, MOD: moderate and SEV: severe).*

Most MOD/SEV and SEV turbulence reports falling in the category [67-100%] probability for an ASII tropopause fold.

More than 87% of the turbulence reports fall into the categories [34 - 66%] and [67 – 100%]

Still the majority of turbulence reports come from the middle category.

Tropopause Folds : Validation with PIREPs

PIREPs related to shear, but subdivided into further shear categories

ASII-TF [%]	Total number	1. Vertical velocity shear between different levels	2. Curvature shear in the same level	3. Directional shear between different levels
67-100	40	40	0	0
34-66	74	63	10	1
0-33	17	8	4	5

Table 5: *Number of turbulence reports associated with strong curvature of the wind trajectory (green), by vertical wind shear resulting from velocity (orange) and by directional shear (blue) as a function of their assigned ASII-TF probability.*

Velocity shear represents the most frequent source for reported turbulence and this category is best correlated with the ASII-TF output.
Again, most of them (orange box) are located in the middle category [34-66%]
→48 of the 74 reports were located next to a maximum of ASII-TF.

- Validation with PIREPs confirms a close relation between TF and wind shear.
- The tropopause folding model shows significant skill at predicting upper-tropospheric turbulence.

Tropopause Folds : Validation with IASI level-2 data

- The **tropopause height** was calculated from vertical humidity profiles from **IASI level-2** data (independent data source).
- Subsequently, the **tropopause height gradient** was calculated.

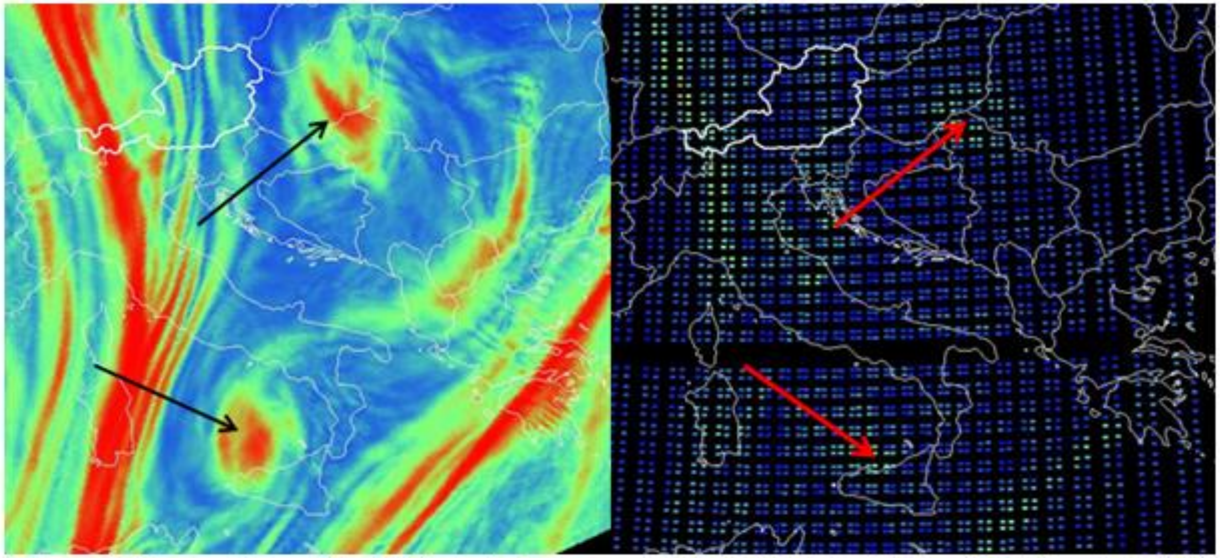

Figure 6: *Comparison of the IASI-derived tropopause folds (right) with the ASII-TF output (left). Date: 27 March 2018, 08:45 UTC. High probabilities for being located at a tropopause fold are depicted in red in the ASII-TF product; high gradients of the tropopause height are depicted in green in the IASI output.*

Tropopause Folds : Comparison with IASI data

An eyeball verification was done between ASII-TF output and IASI derived tropopause gradients.

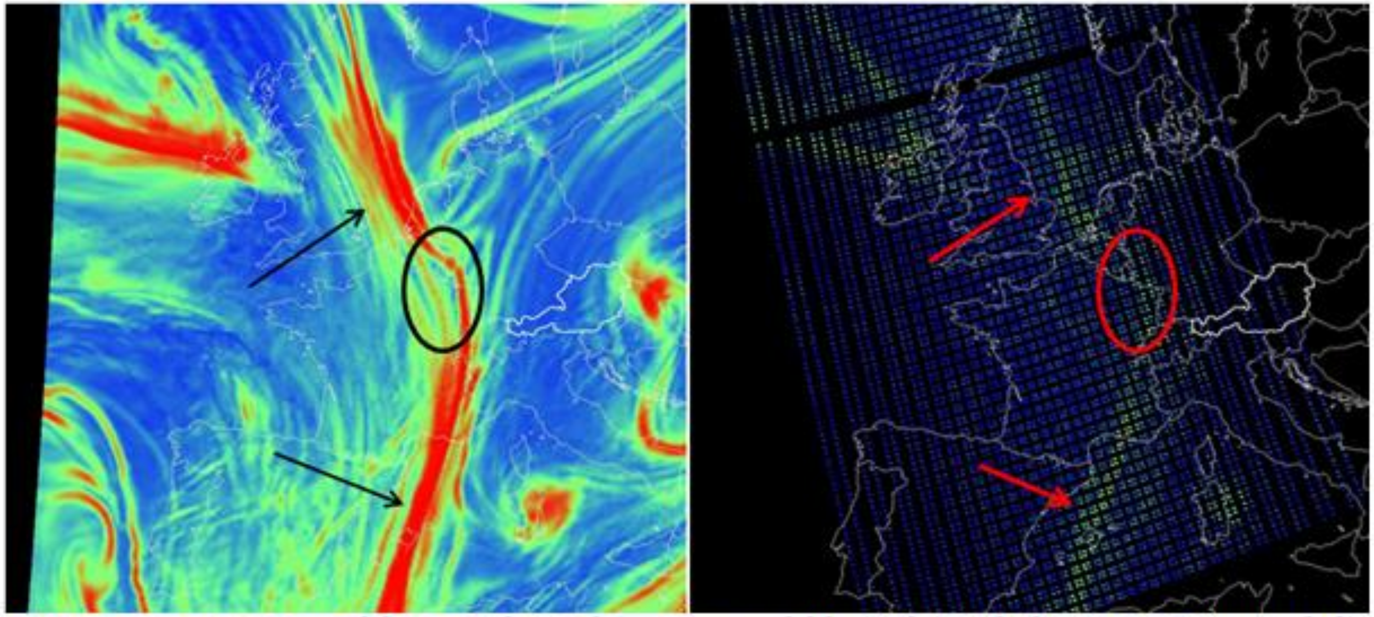

Figure 5: *Comparison of the IASI derived tropopause folds (right) with the ASII-TF output (left). Date: 26 March 2018, 20:45 UTC. High probabilities for being located at a tropopause fold are depicted in red in the ASII-TF product; high gradients of the tropopause height are depicted in green in the IASI output.*

The two fields show a fairly good agreement of the position of the tropopause folds.

Related Documents

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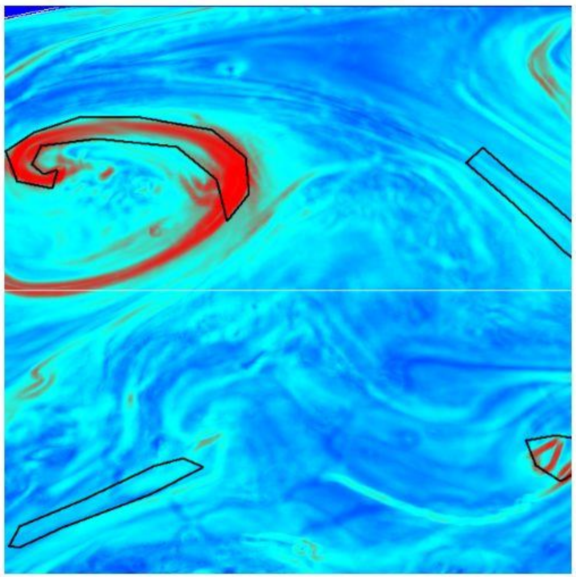

Automatic Satellite Image Interpretation-Next Generation
PGE17 NWCSAF/GEO

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Access to **"Algorithm Theoretical Basis Document for the "Automatic Satellite Image Interpretation" product (ASII-NG PGE17, v1.1)"** for a more detailed description.

1. Goal of ASII-NG product

ASII-NG aims at detecting atmospheric features which are of interest to meteorologists and other users. In contrast to the ASII product (further development is frozen) where the identification of conceptual models was in the center of interest, the ASII-NG product identifies Clear Air Turbulence (CAT) which is directly relevant for meteorologists and e.g. aviation end users.
Clear-air turbulence is non-convective turbulence outside the planetary boundary layer, often in the upper troposphere. CAT typically has a patchy structure and horizontal dimensions of 80-500 km in the along-wind direction and 20-100 km in the across-wind direction. Vertical dimensions are 500-1000 m, and the lifespan of CAT is between half an hour and a day (**Overeem 2002**). As CAT involves physical processes with scales usually smaller than the resolution of numerical weather prediction (NWP) models, forecasts of CAT with NWP are difficult to perform. Therefore, it is of interest to identify areas with risk of CAT from satellite observations. CAT is preferentially triggered by:

http://www.nwcsaf.org/asii-ng description

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