Use of EARS-IASI profiles for Nowcasting Sting-Jets

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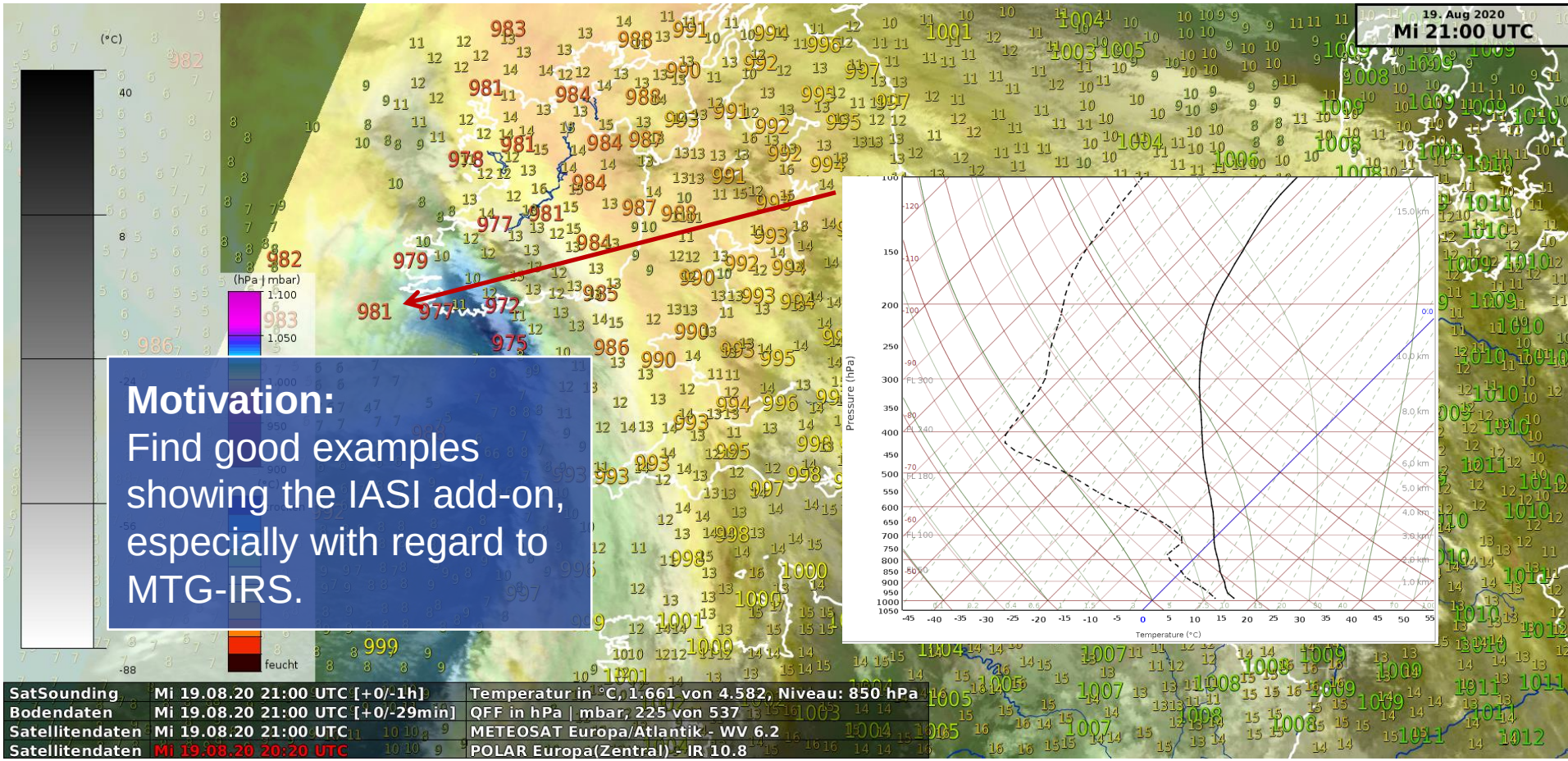


Motivation:
Find good examples showing the IASI add-on, especially with regard to MTG-IRS.

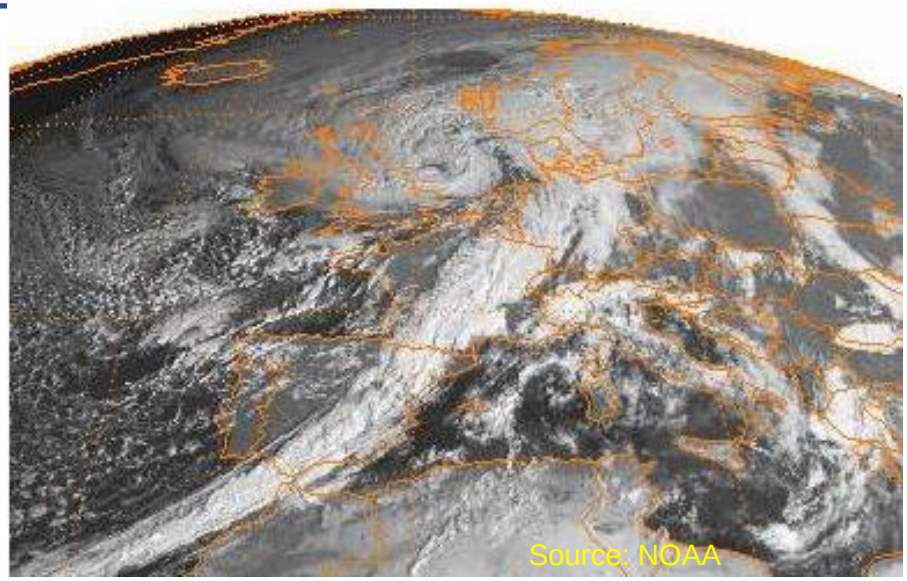
Can IASI profiles help us for a better prediction of mesoscale severe wind events connected to sting jets (SJ) or cold conveyor jet (CJ)?

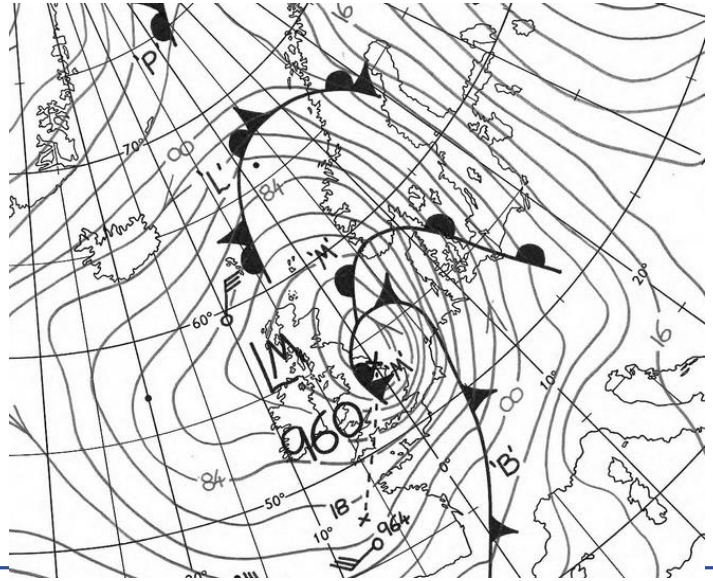
What is a Sting Jet?

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

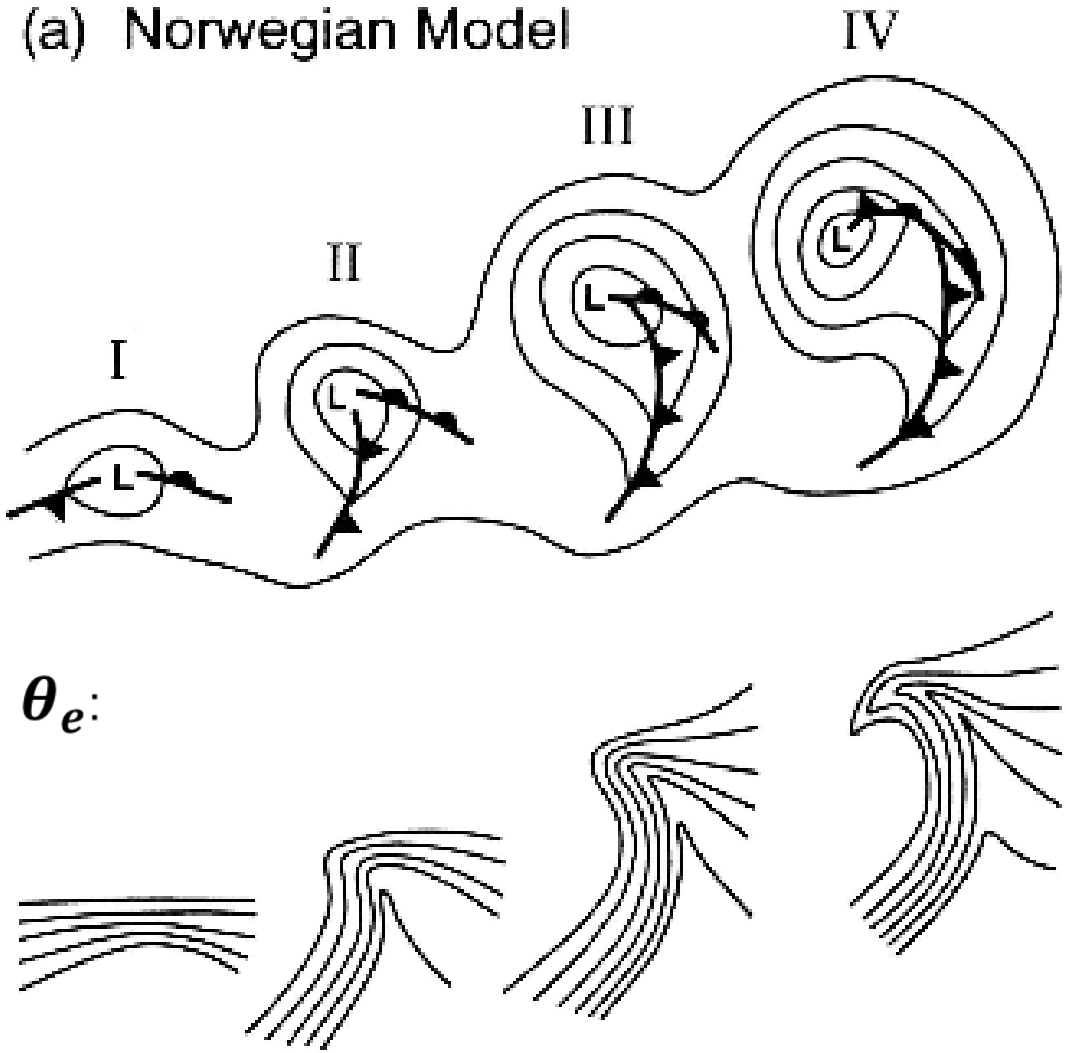
Great Storm of 1987:

- Strongest storm in UK since 1703
- 26 people died
- Second most expensive weather event in the UK
- Forecast failed
- Reanalyze showed a mesoscale flow with most damaging wind at tip of the cloud head south of the center of the cyclone → **Sting Jet**





The Met Office MSLP Analysis 16 Oct 1987 00 UTC



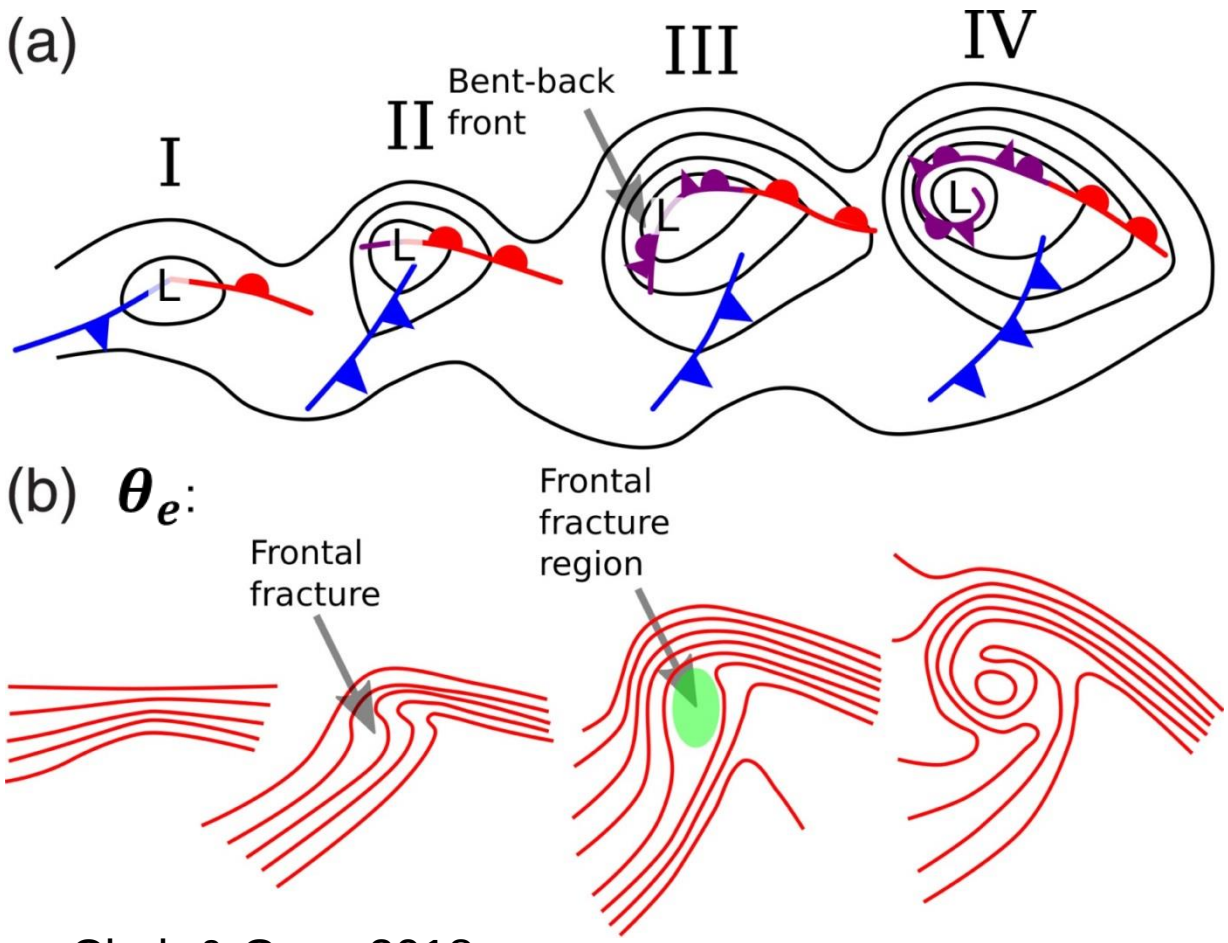
I : frontal wave ; incipient cyclone

II – III: narrowing warm sector

IV : oclusion

Schultz et. al. 1998

Shapiro Keyser Modell

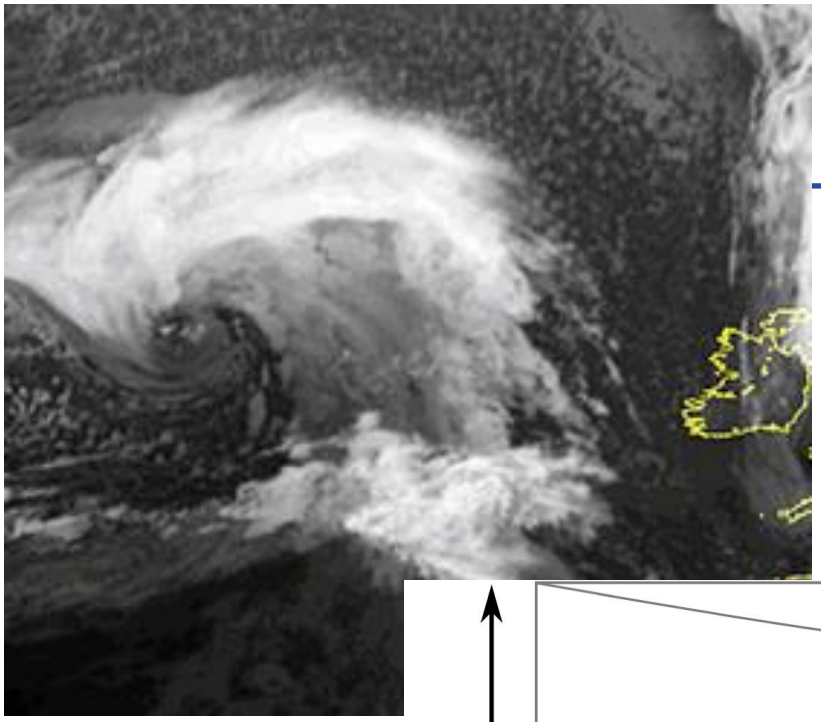


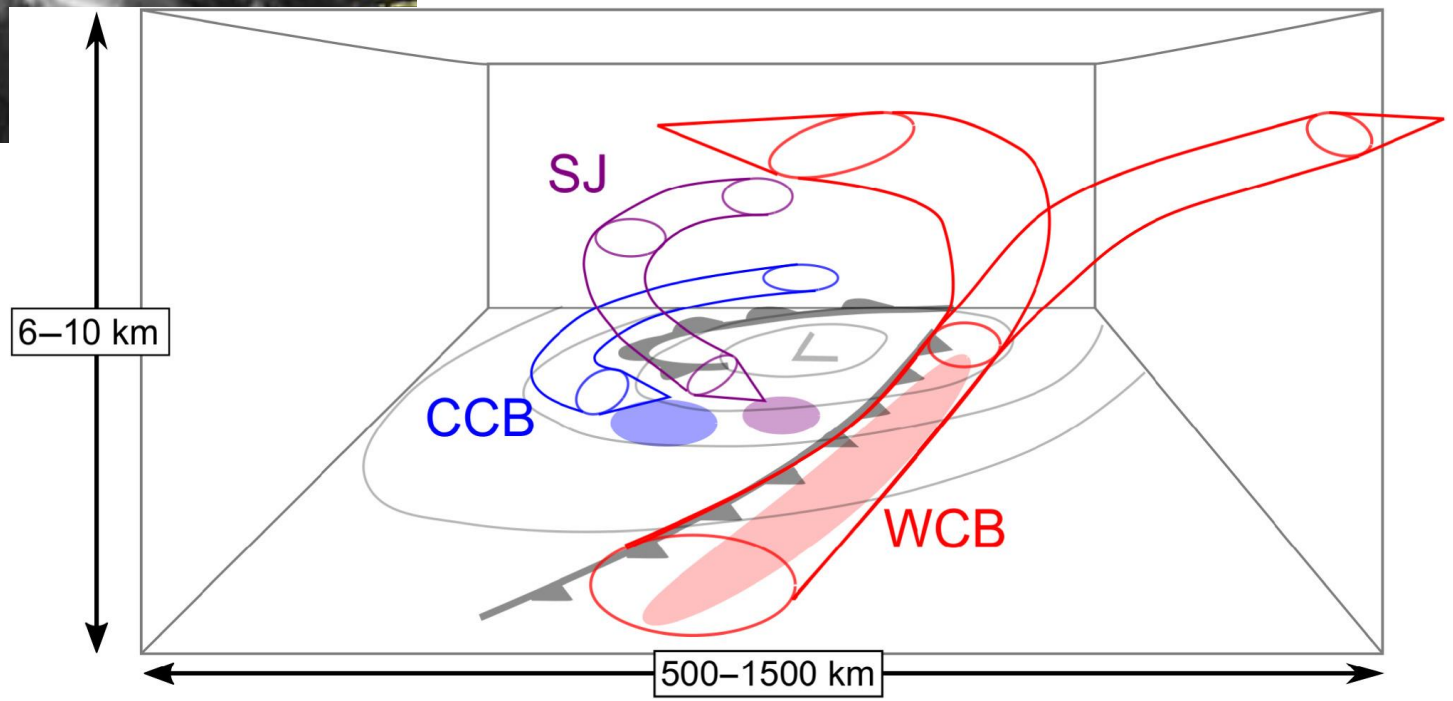
Clark & Gray. 2018

I : frontal wave ; incipient cyclone

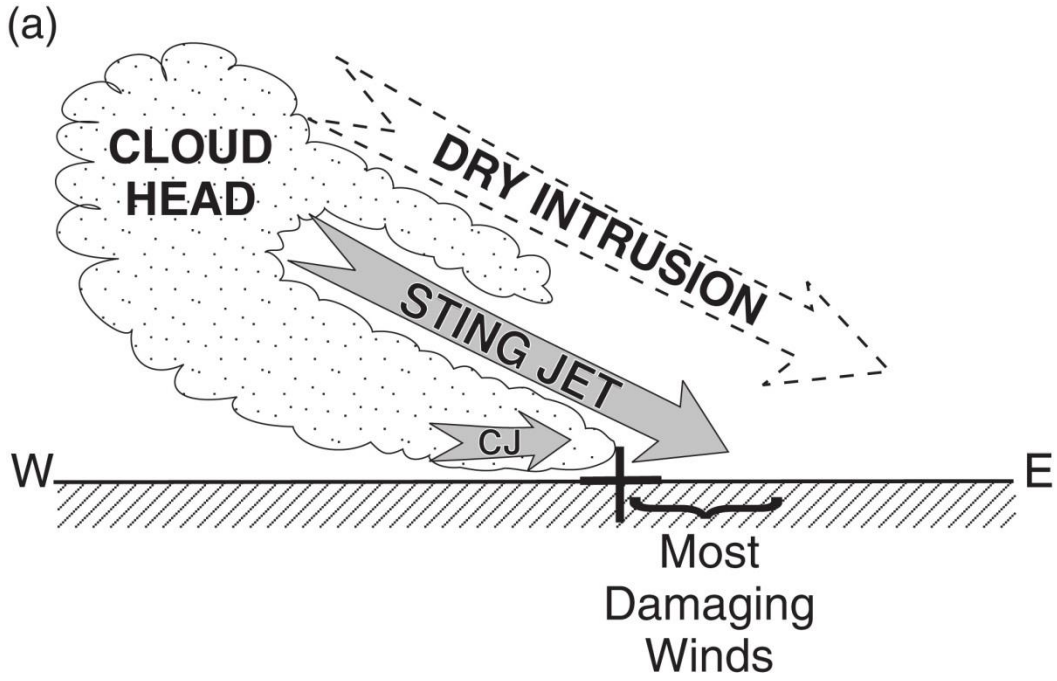
II – III: frontal fracture

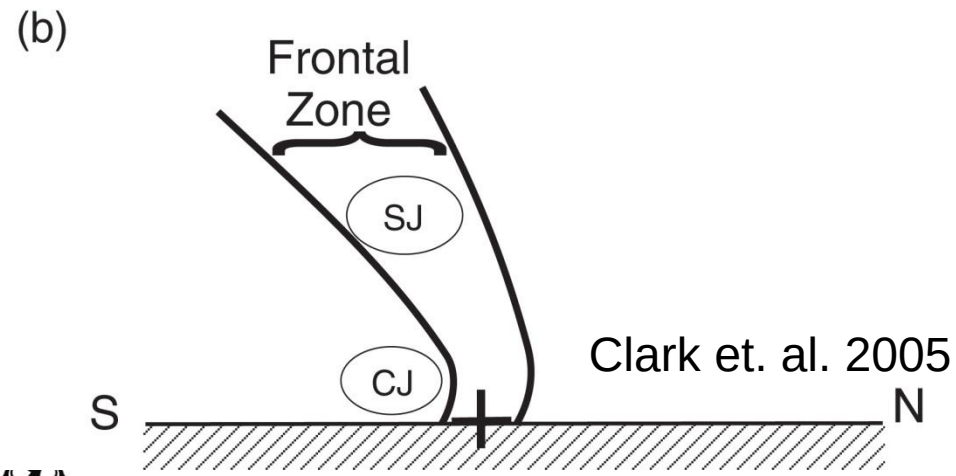
IV : frontal T-bone warm air seclusion





Clark & Gray 2018



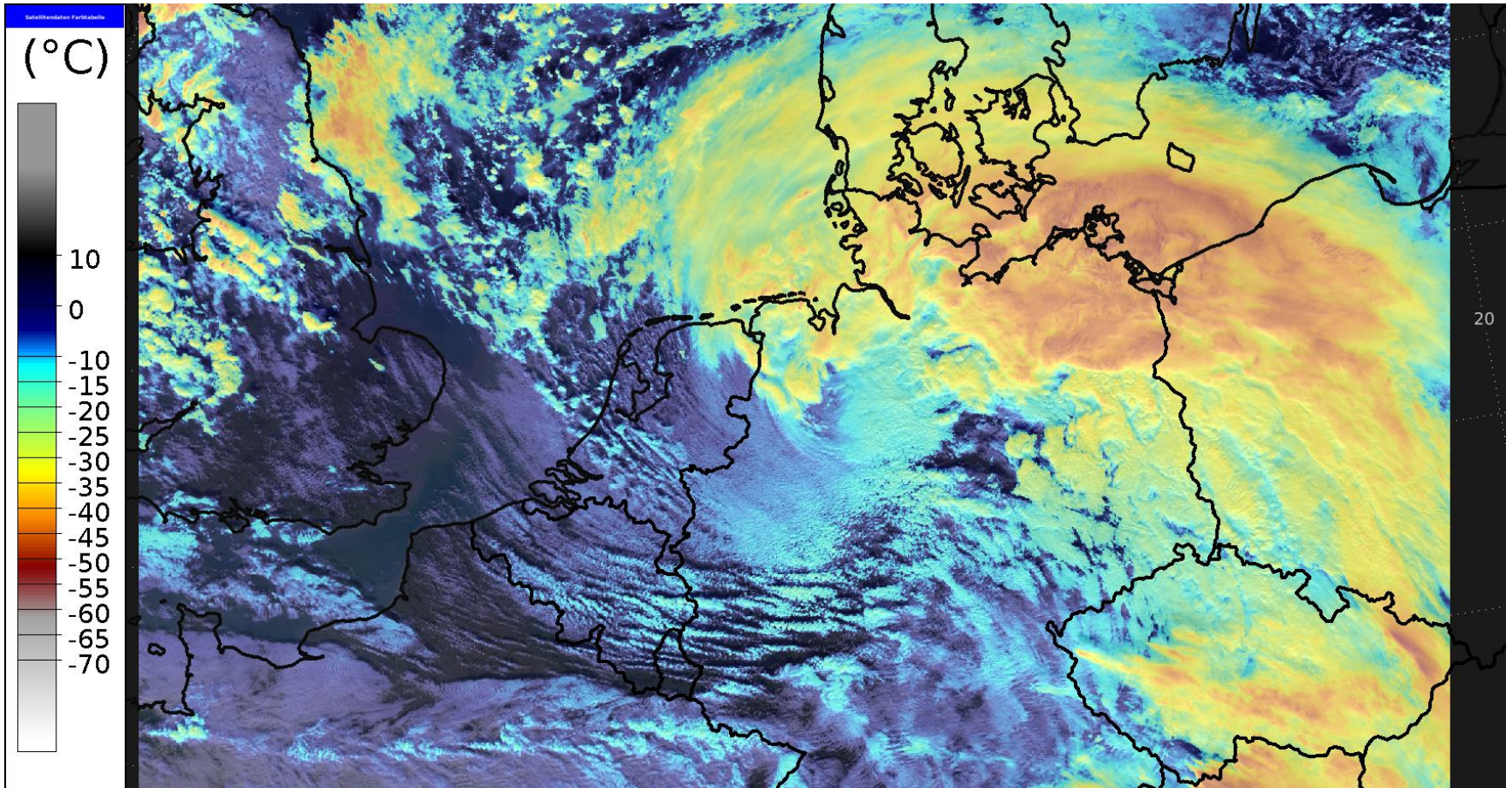


Clark et. al. 2005

Descending Sting jet out of the cloud head due:

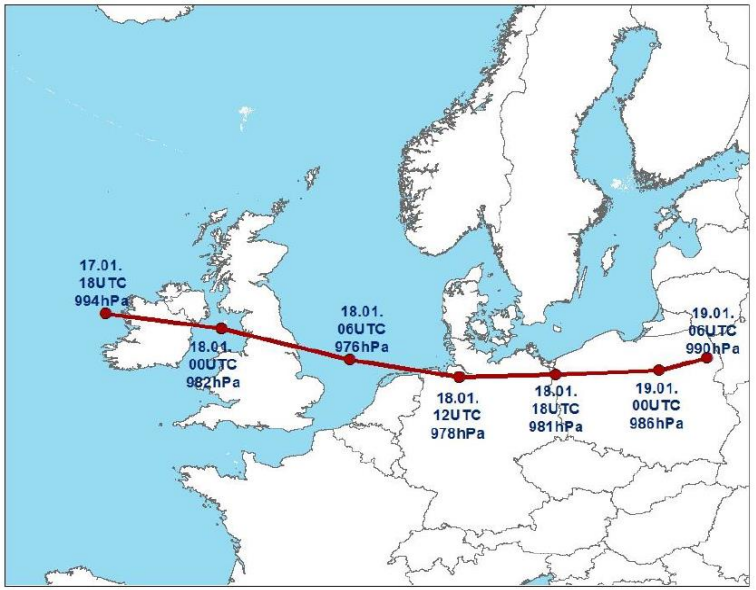
- Conditional symmetric instability (CSI)
- Frontolysis near the frontal fraction region
- Acceleration due low level pressure gradient
- Evaporation of precipitating clouds

Case Study I:
Storm „Friederike/Dave“
18.01.2018



Strom Friederike

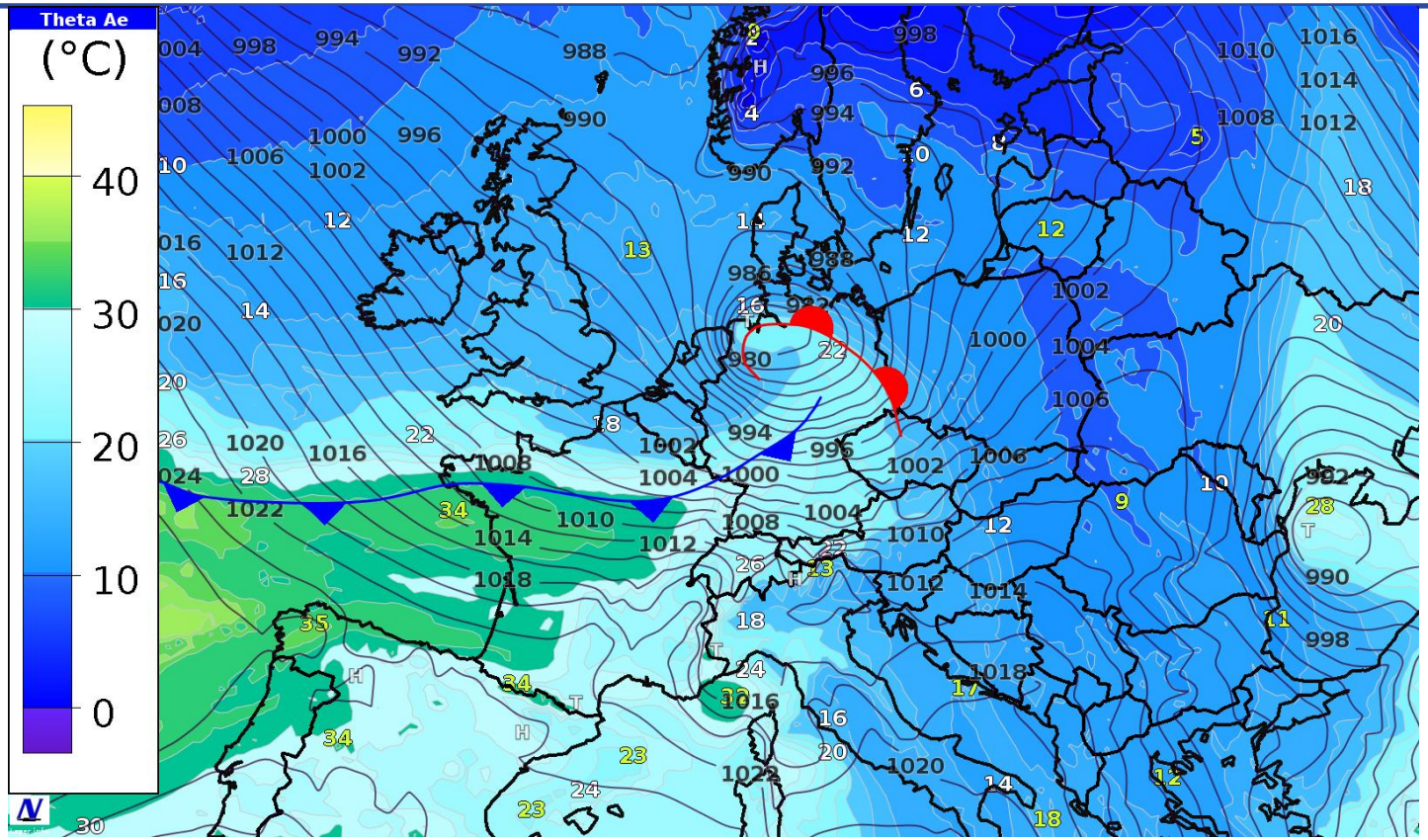
- Coming from the British Isles the storm Friederike passed over Germany on 18 January 2018 and continued to Poland afterwards.
- The highest wind speeds up to hurricane force appeared in GB, Benelux, Northwestern France, Germany and Poland.
- Traffic disturbances due to snow and ice, fallen trees and power outages were common.
- The center of Germany was particularly concerned. At the Brocken a maximum wind gust of 203 km/h was measured which exceeded the measurements during Kyrill in 2007.



Station	KYRILL 18.01.2007	FIREDERIKE 18.01.2018
Helgoland	**120 km/h**	70 km/h
Göttingen	105 km/h	**111** km/h
Brocken	199 km/h	**203** km/h
Leipzig/Halle	112 km/h	**129** km/h
Erfurt	119 km/h	**130** km/h
Frankfurt a.M.	**95** km/h	86 km/h
Feldberg/Schwarzwald	**166** km/h	144 km/h

Source: DWD

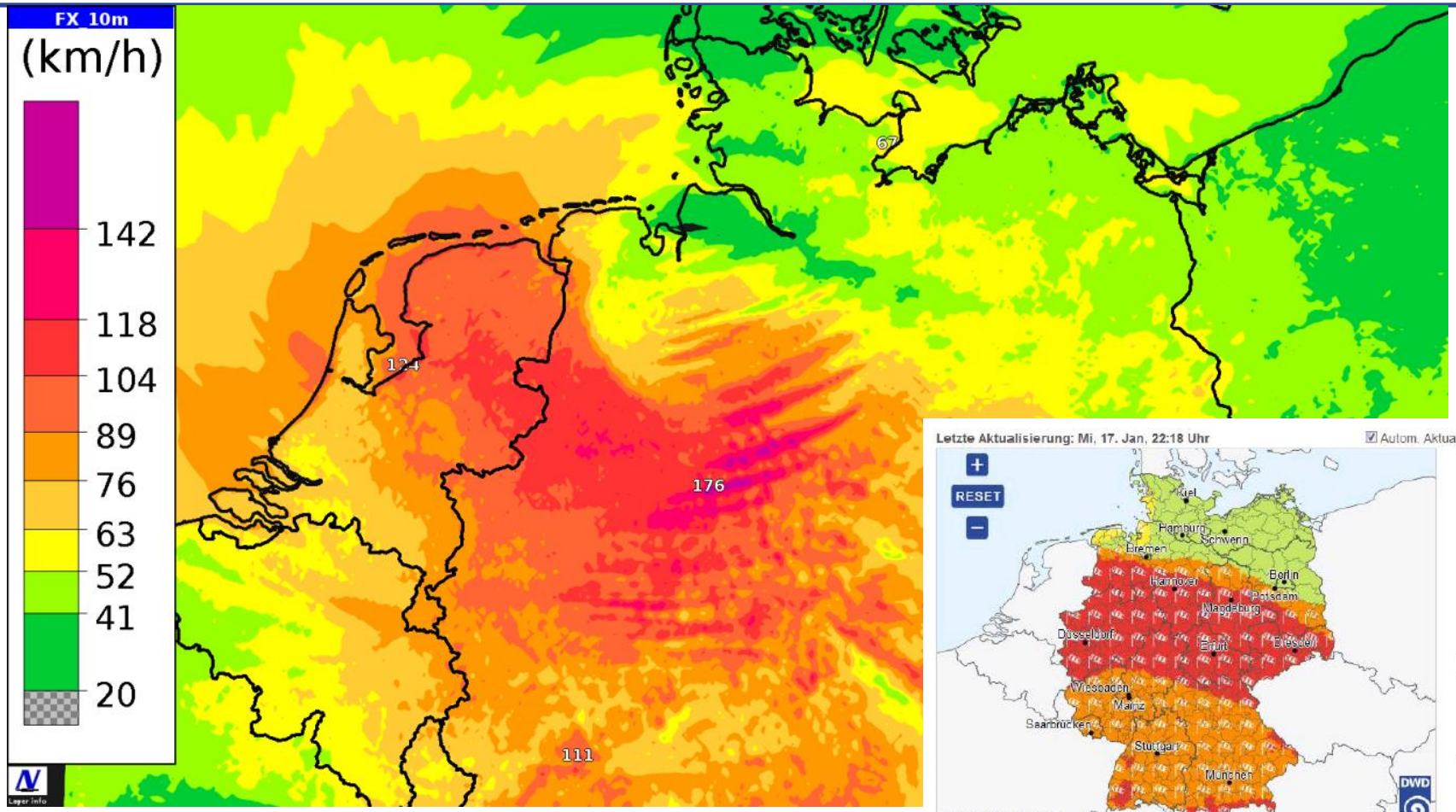
850 hPa- ThetaE + MSLP and Fronts



Typical structure of a SK-Cyclone:

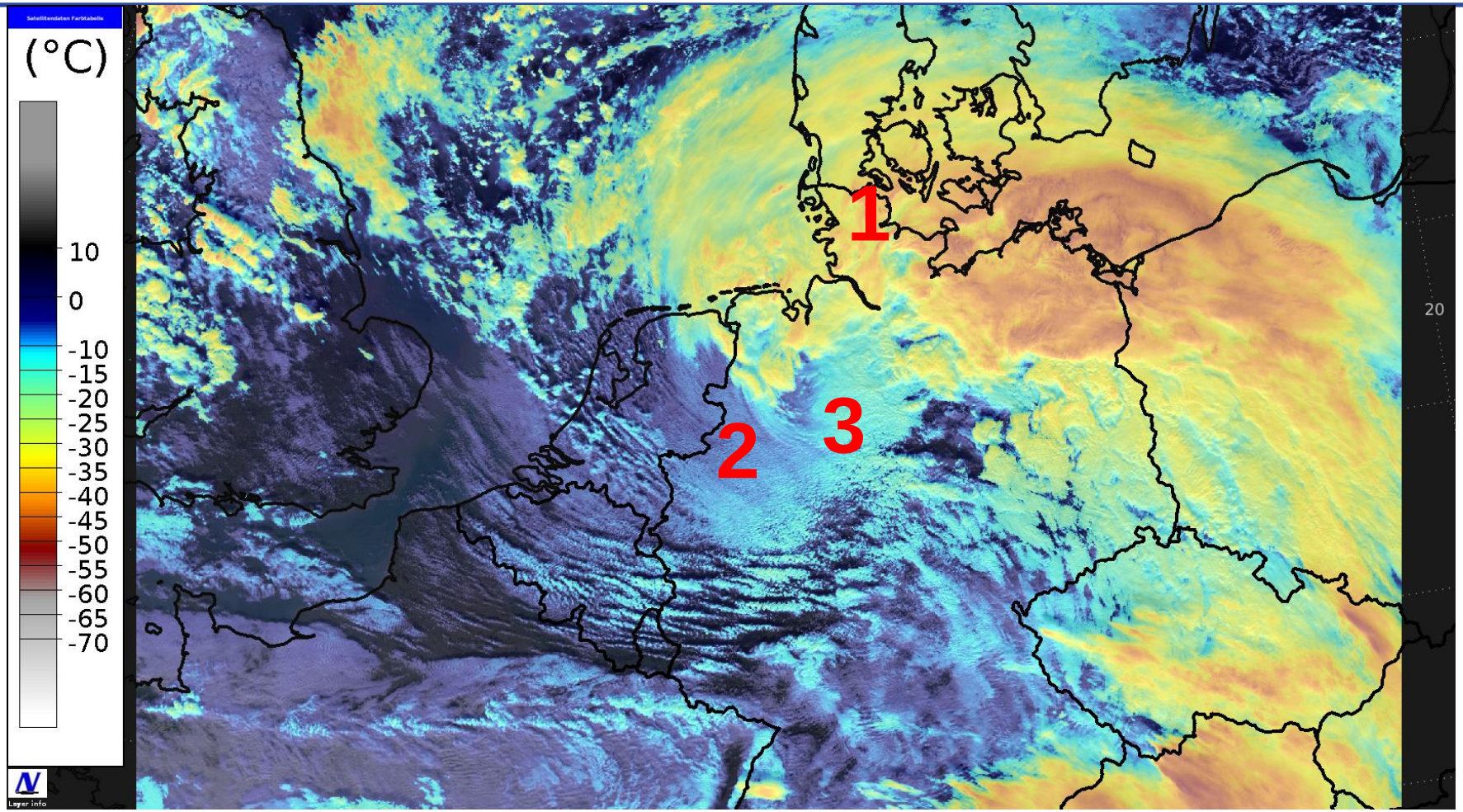
- Frontal fracture, developing warm air seclusion, T-Bone shape
- Strong pressure gradient at southwestern flank

COSMO-DE-Forecast Max. Gust

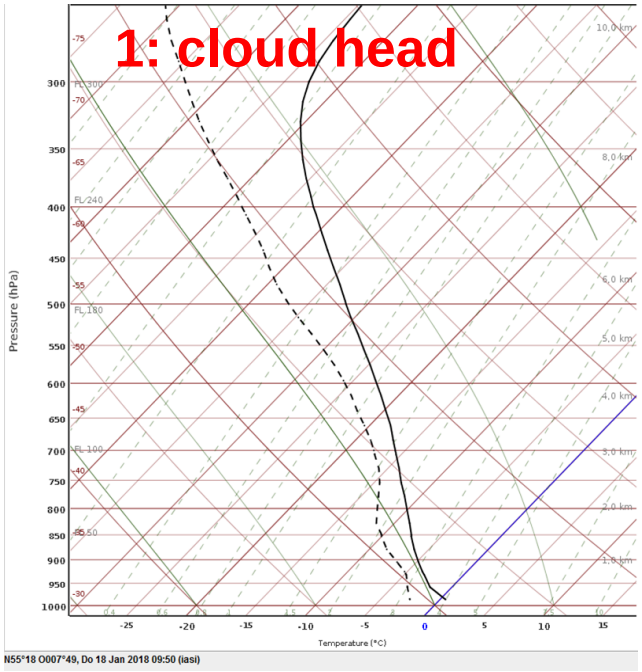


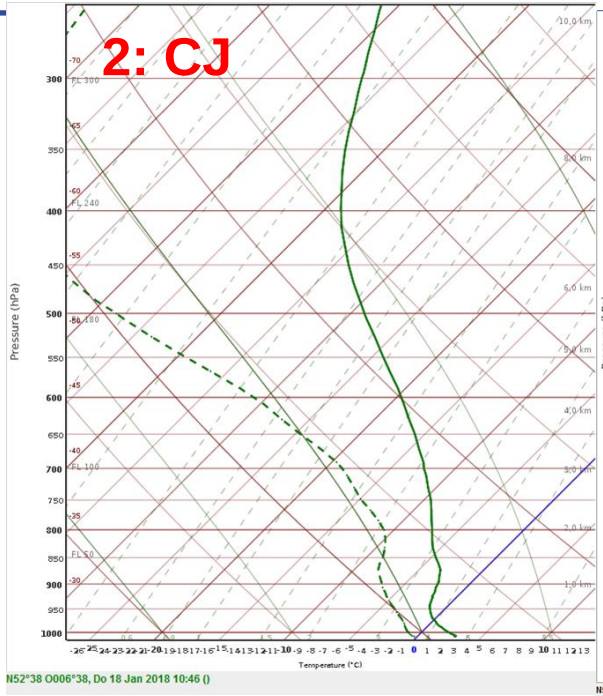
The regional model COSMO-DE predicted the development of a sting jet with gusts up to 170 km/h

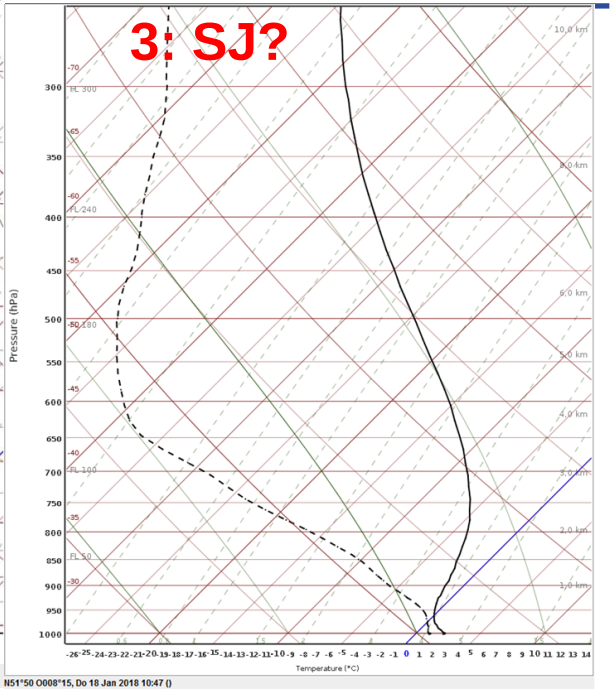
Suomi NPP VIIRS RGB image



IASI-Soundings



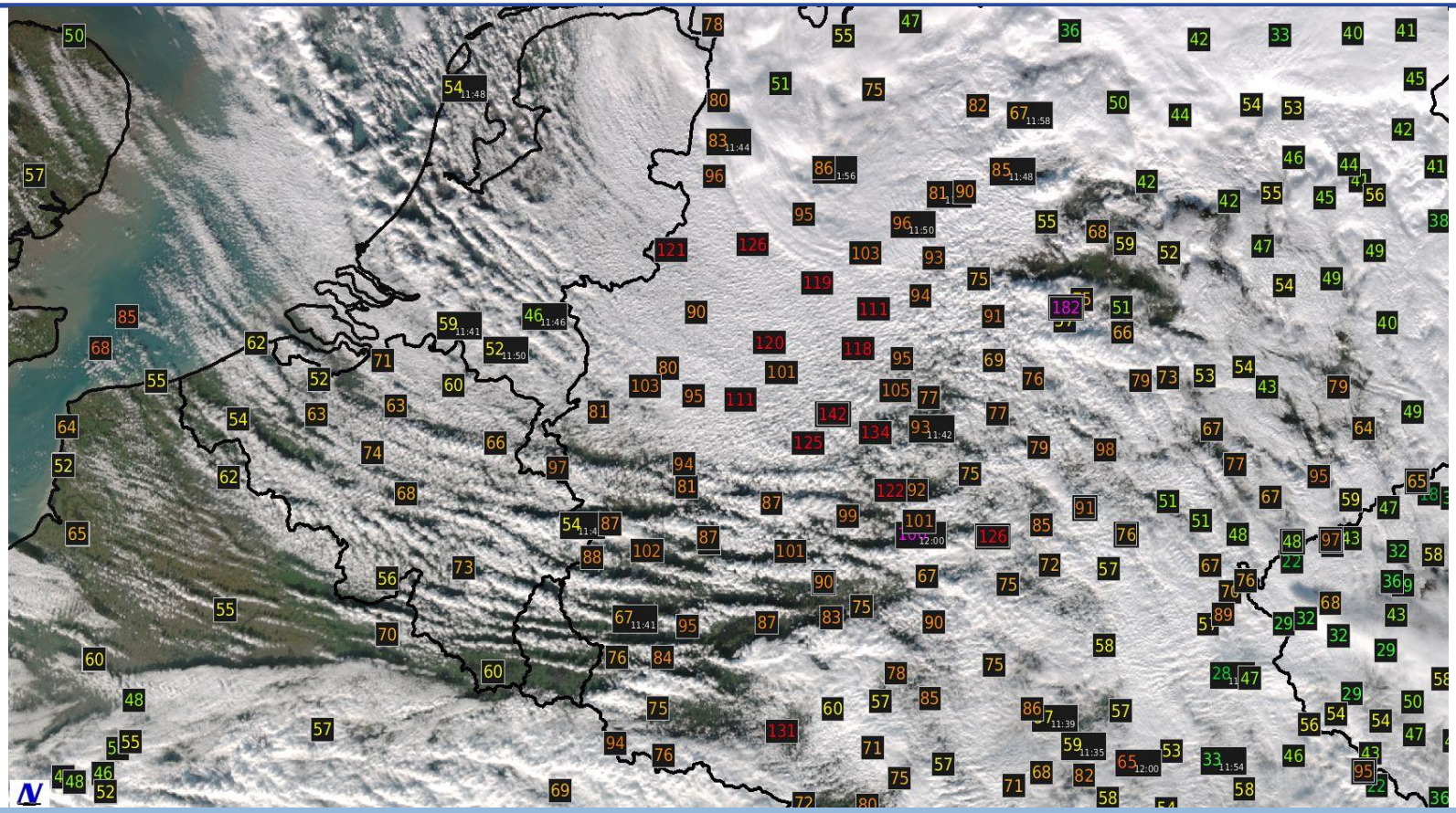




- Descending dry stratospheric air in sting jet region to top of boundary layer
  → hint for sting jet

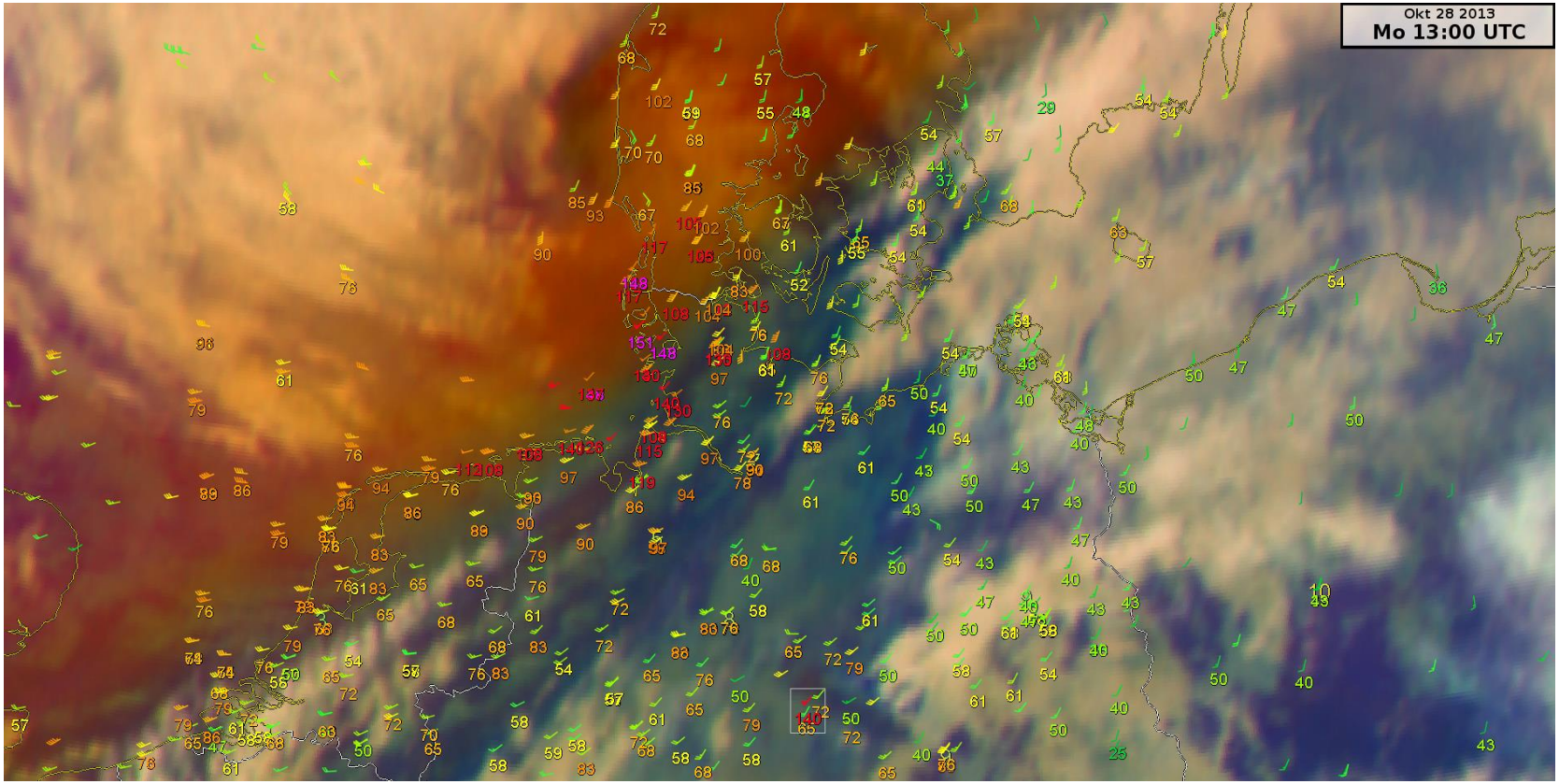
- Stronger boundary layer inversion

Suomi-NPP HIRES-VIS



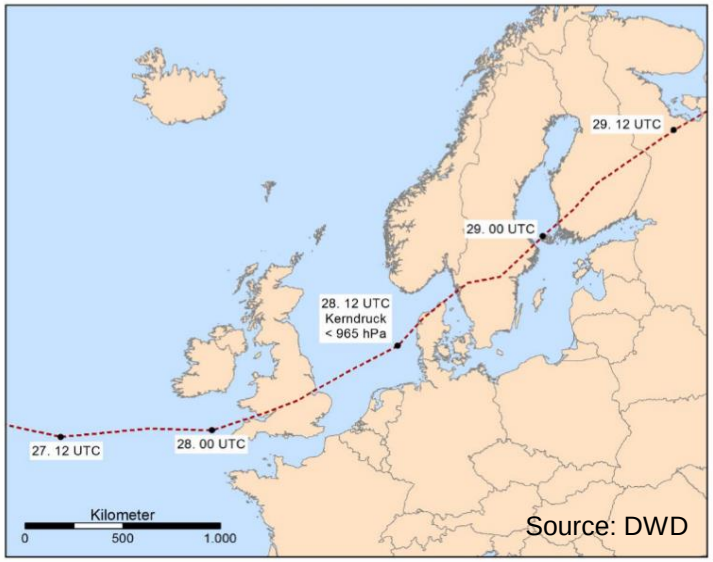
- Only faint Cloudbands at the sting
- Stratocumulus clouds at tip of the cloud head → boundary layer inversion
- Sting jet didn‘t reach the surface
- Only the Harz was affected by the full power of the sting jet (Brocken 182 km/h)

Case Study II:
Storm „Christian“/ St. Jude Storm
28.10.2013



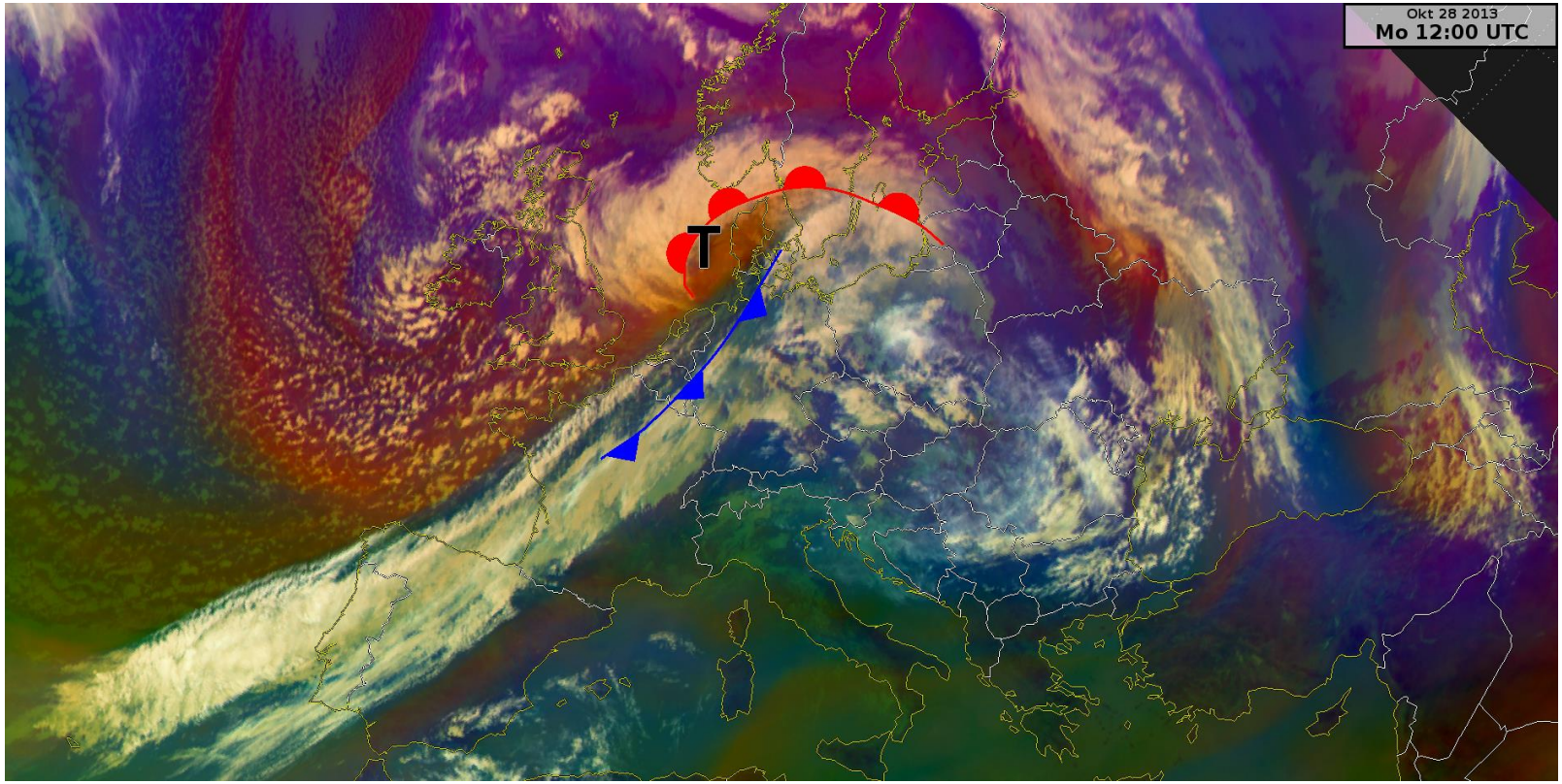
Cyclone Christian 2013

- On October 27 and 28 the **Cyclone „Christian“** passed over Northern Europe and led to destructions and traffic chaos. More than 15 people died.
- Due to the high wind speeds and hurricane-force gusts, trees were brought down and buildings were damaged. Several flights and train services were cancelled.
- The intense low-pressure system formed on Oct 26 over the Western Atlantic and passed over Southeast England, Northern Germany, Denmark and Sweden.
- Record breaking wind gust of **191 km/h** at Helgoland (DE) were reached.



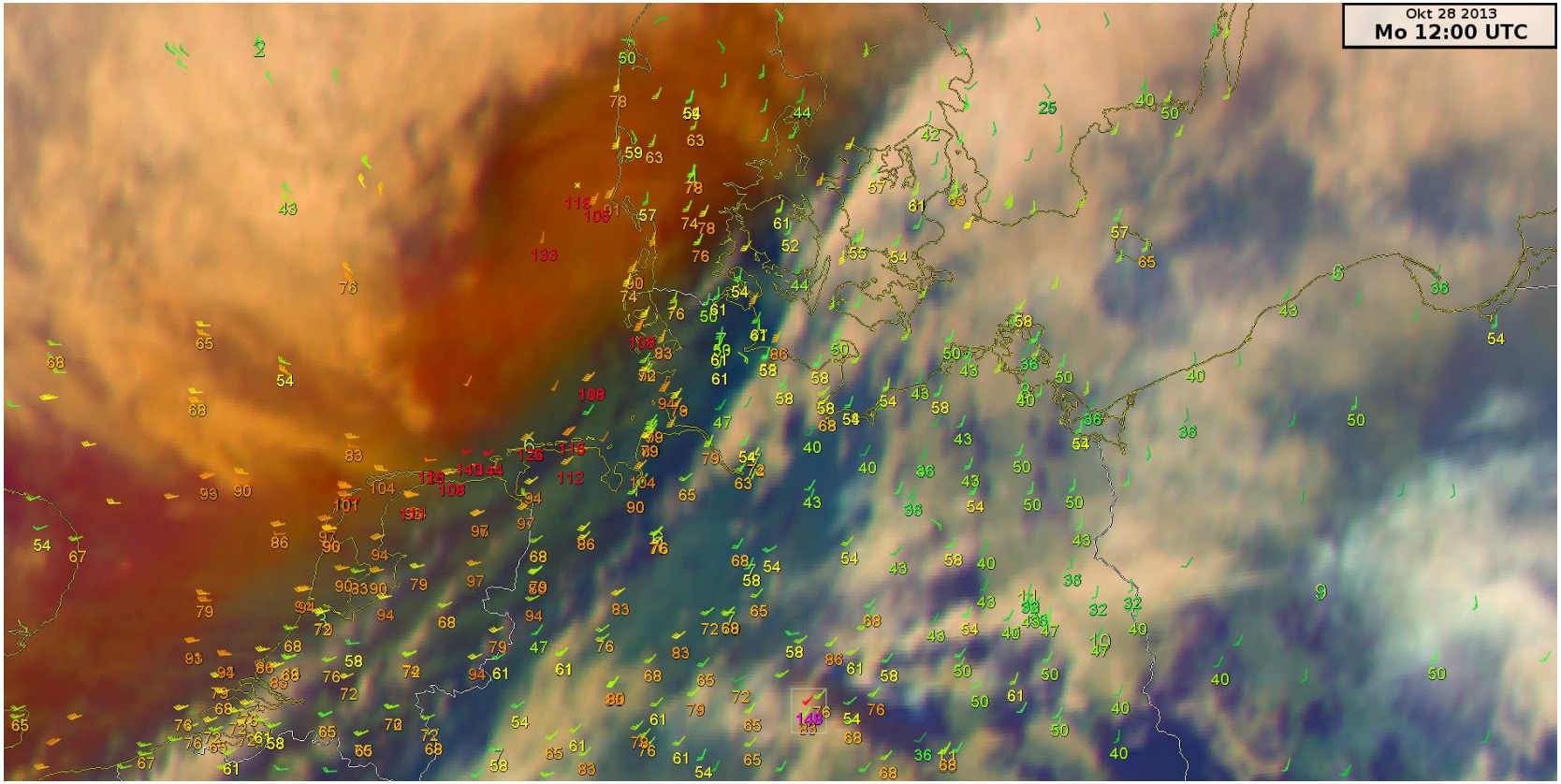
See also: https://en.wikipedia.org/wiki/St._Jude_storm

Cyclone Christian



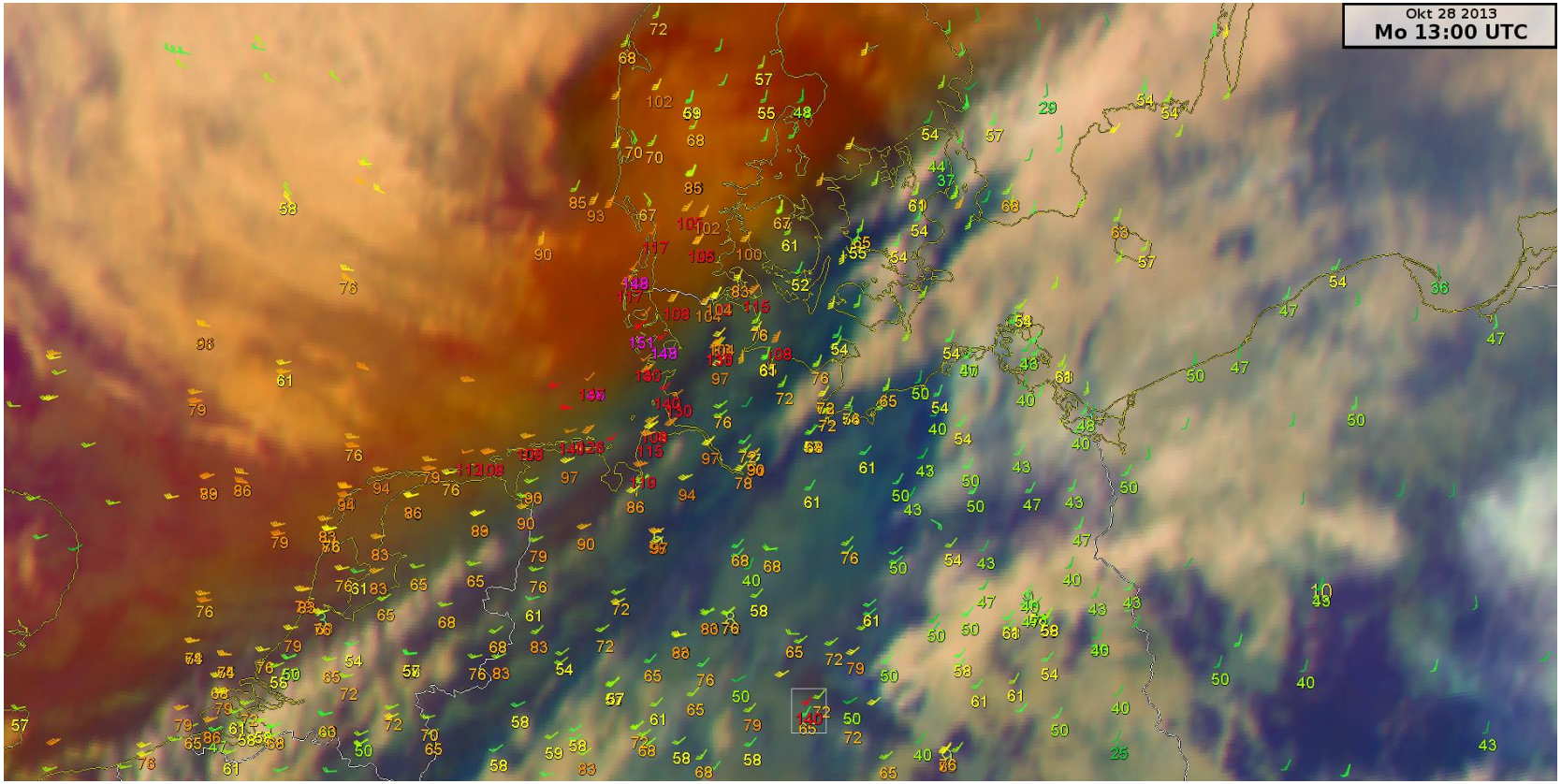
➔ The METEOSAT satellite image from Oct. 28 2013 12 UTC shows that Christian was a **Shapiro-Keyser Cyclone** and the **extremely high wind gusts** resulted from a **sting jet** that typically appears with those types of cyclones.

Wind speeds



➔ In Germany the cyclone Christian caused maximum wind speeds in the time between 13 and 14 UTC over the German Bight and the west coast of Schleswig-Holstein.

Wind speeds



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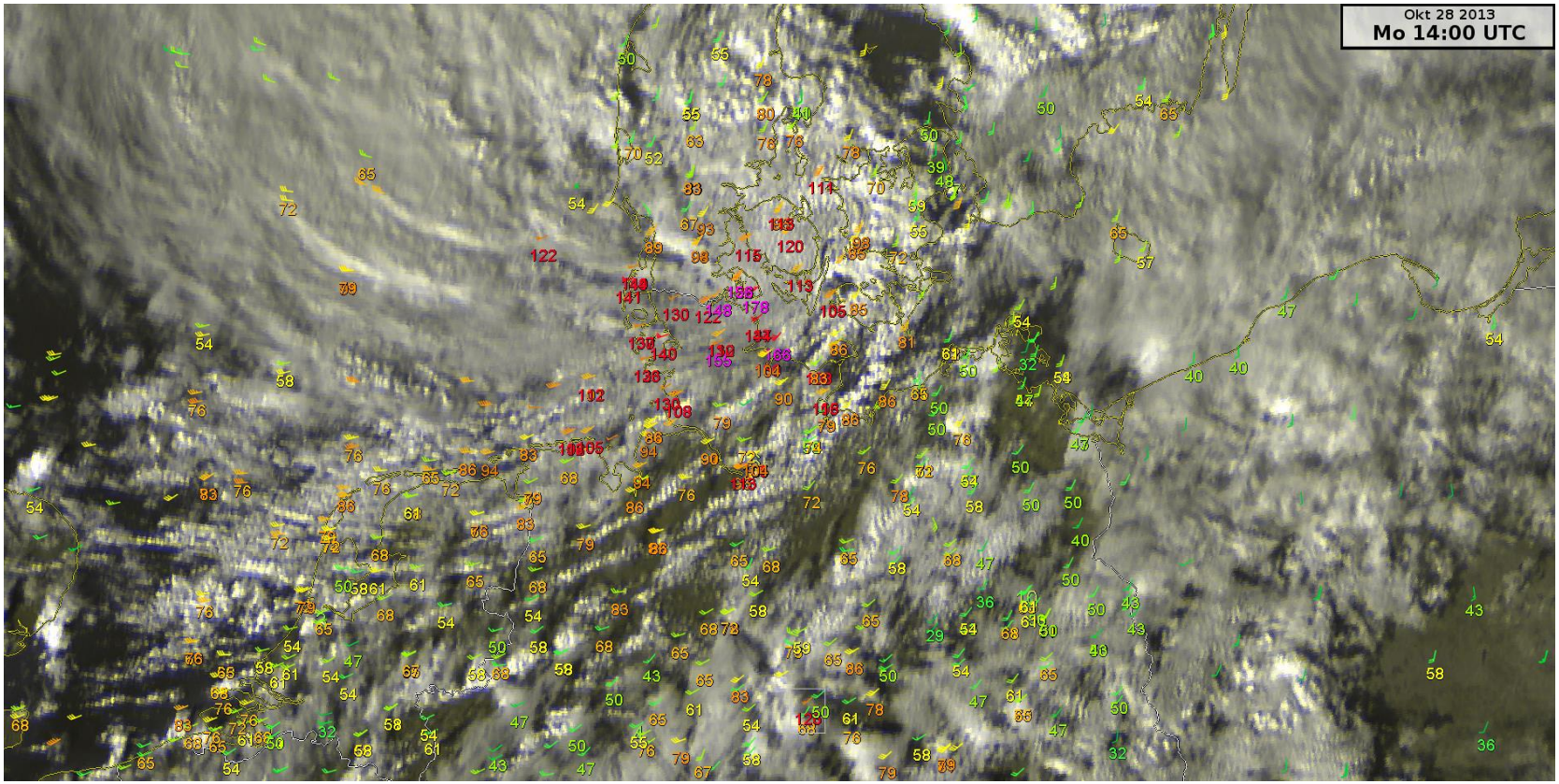
Wind speeds



➔ In Germany the cyclone Christian caused maximum wind speeds in the time between 13 and 14 UTC over the German Bight and the west coast of Schleswig-Holstein.

NWP Forecasts

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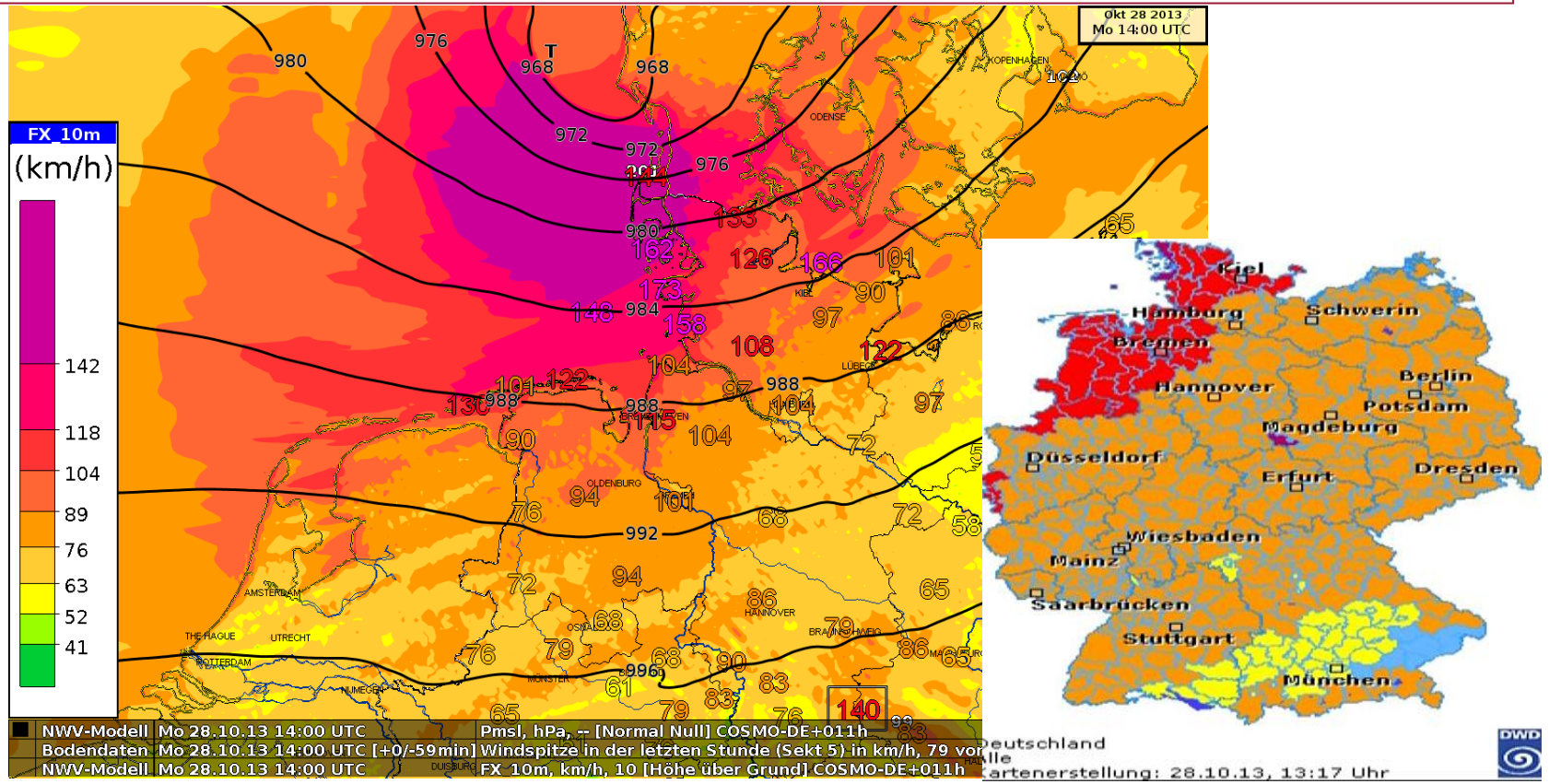
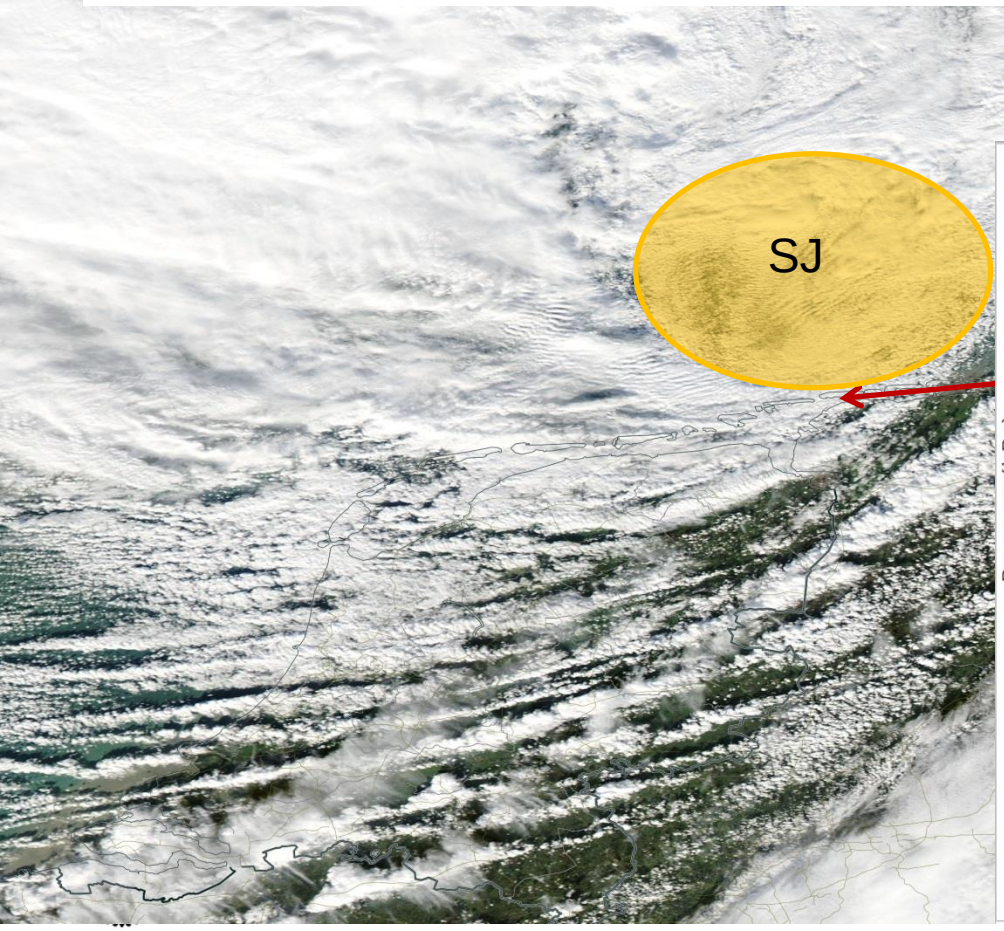
Wind gusts in km/h + pressure
Isolinien: COSMO-DE (28.10.13) 03 UTC + 11 h
Numbers: Observations (555) in km/h

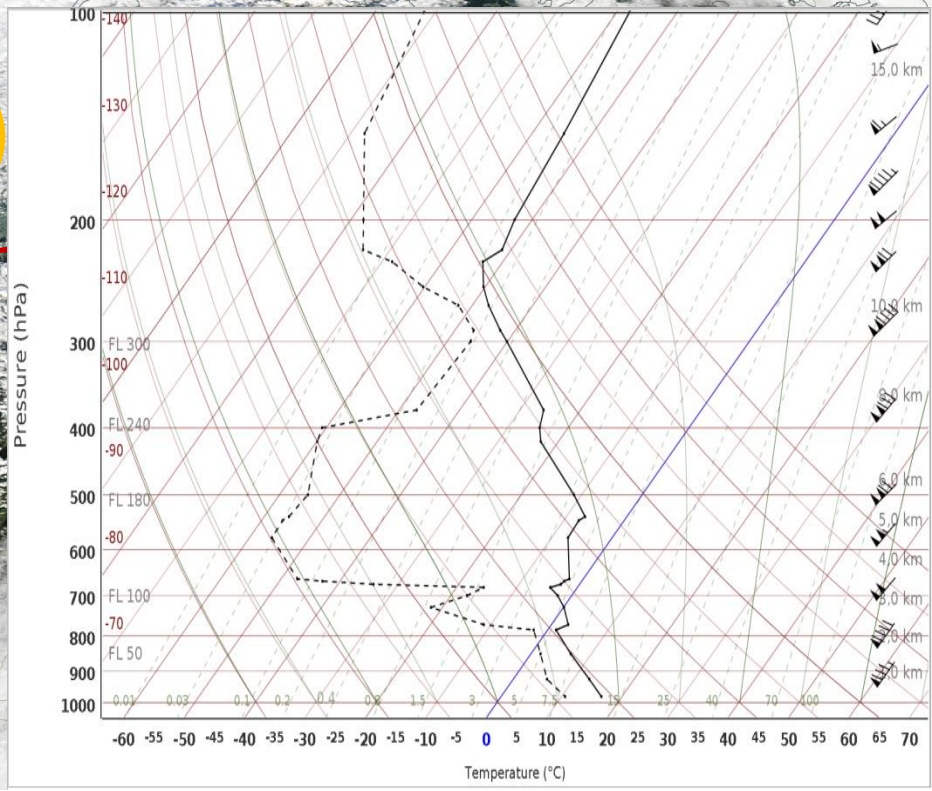


➔ The COSMO-DE wind gust forecasts 12 hours before the event were quite good. Only the sting jet and the location of the cyclone‘s centre were simulated too far north. Previous model global and regional model runs underestimated the wind gusts.

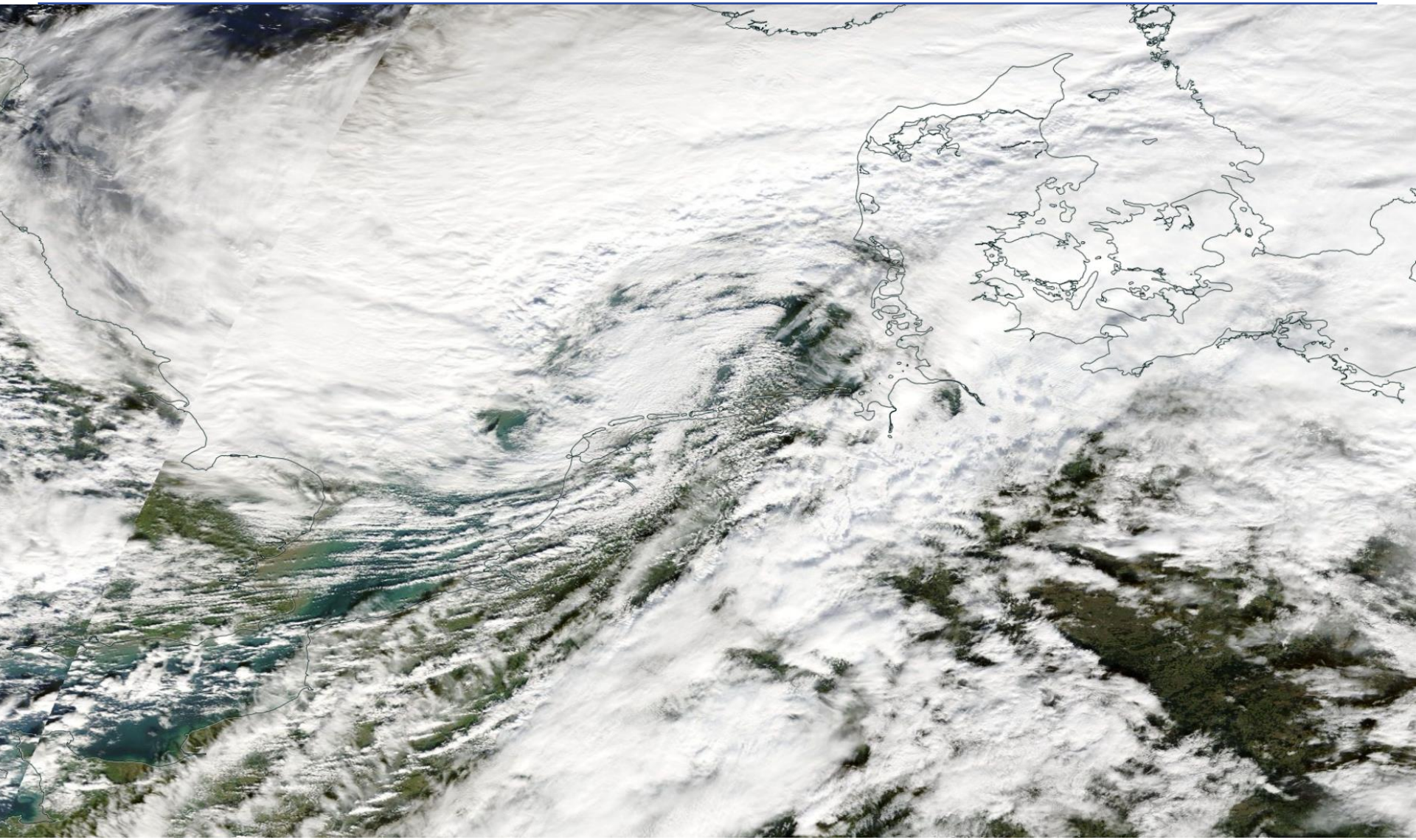
MODIS Image 11:40 UTC and Radiosonde measurements

- The RAOB profile from the station Norderney at 12 UTC a little bit south of the sting jet shows the stratospheric air which had subsided until 800 hPa. Such a atmospheric layering is rarely observed.
- Conditional unstable layering in boundary Layer → momentum can easily transferred downward

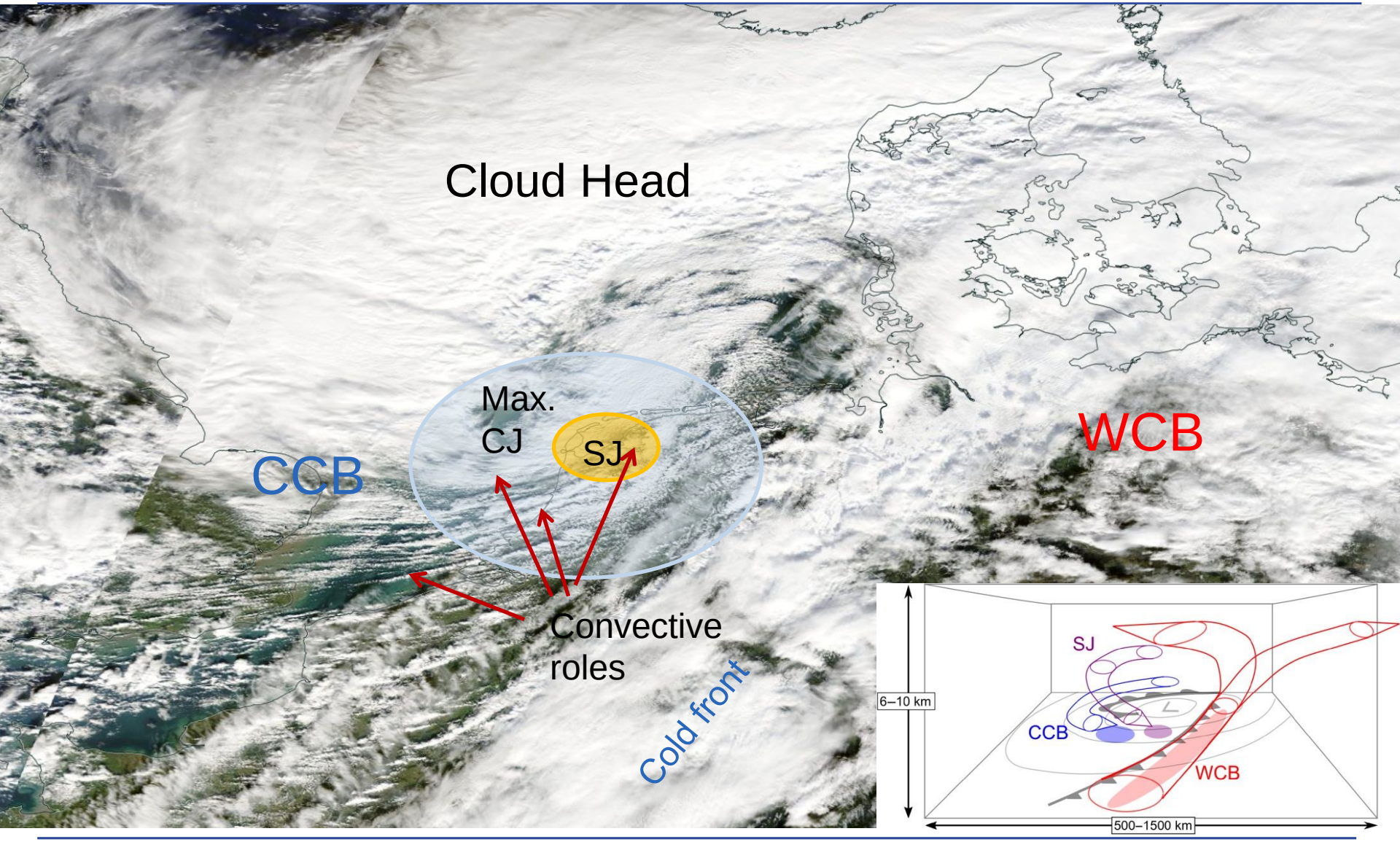




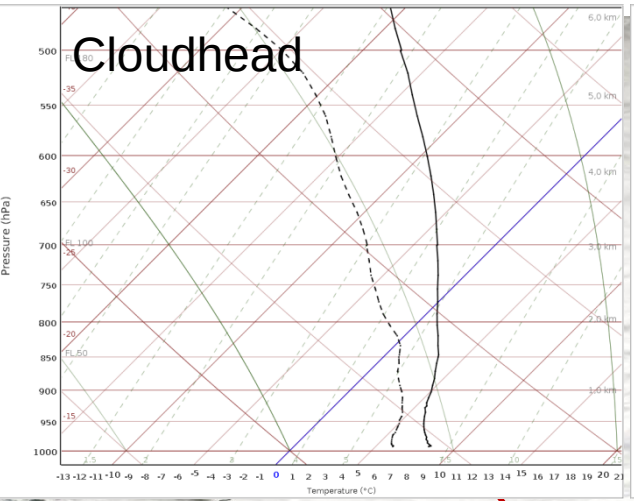
MODIS image around 10:20 UTC

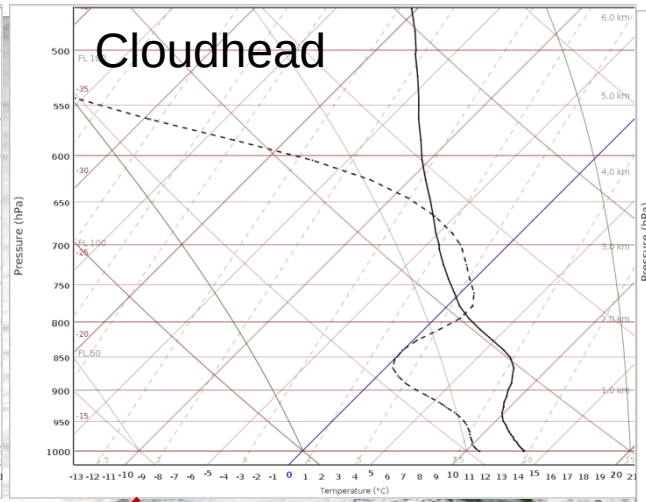


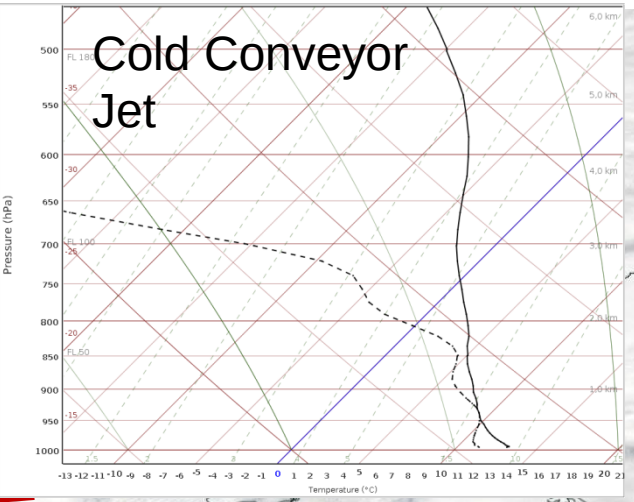
MODIS image around 10:20 UTC

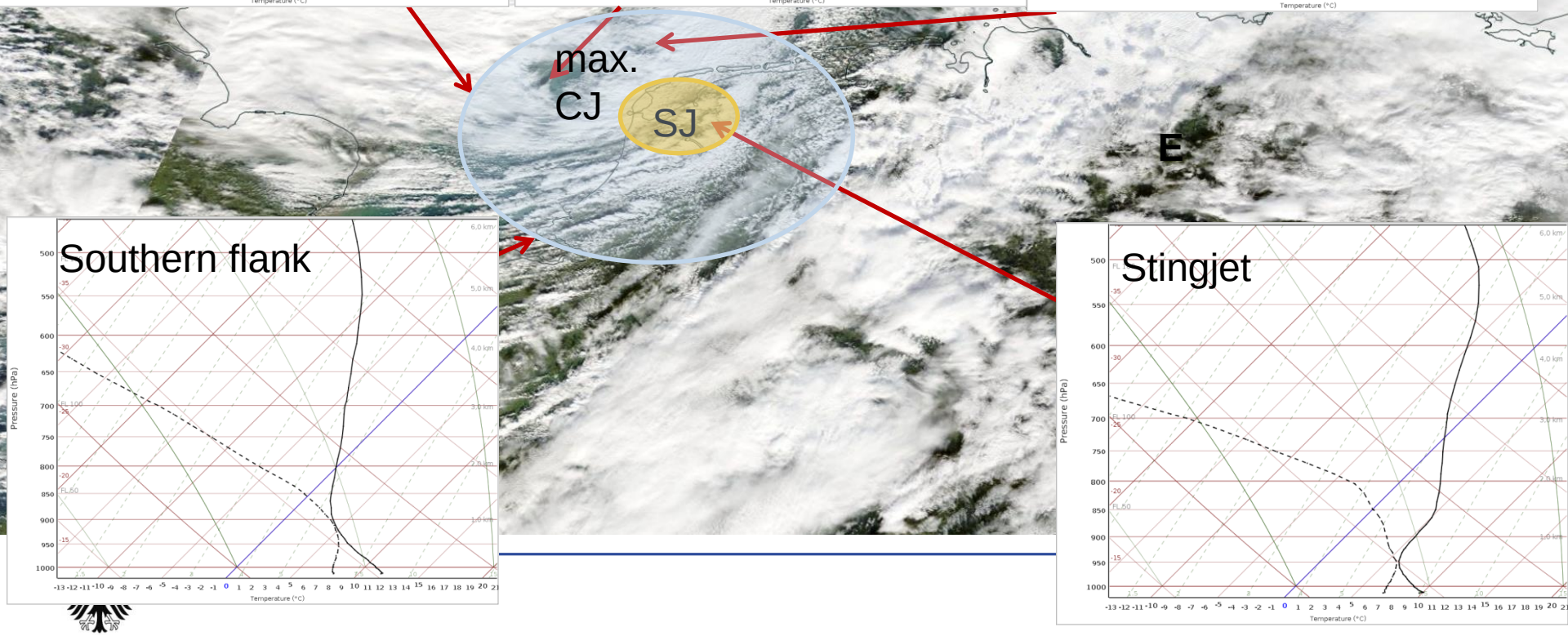


IASI Profiles

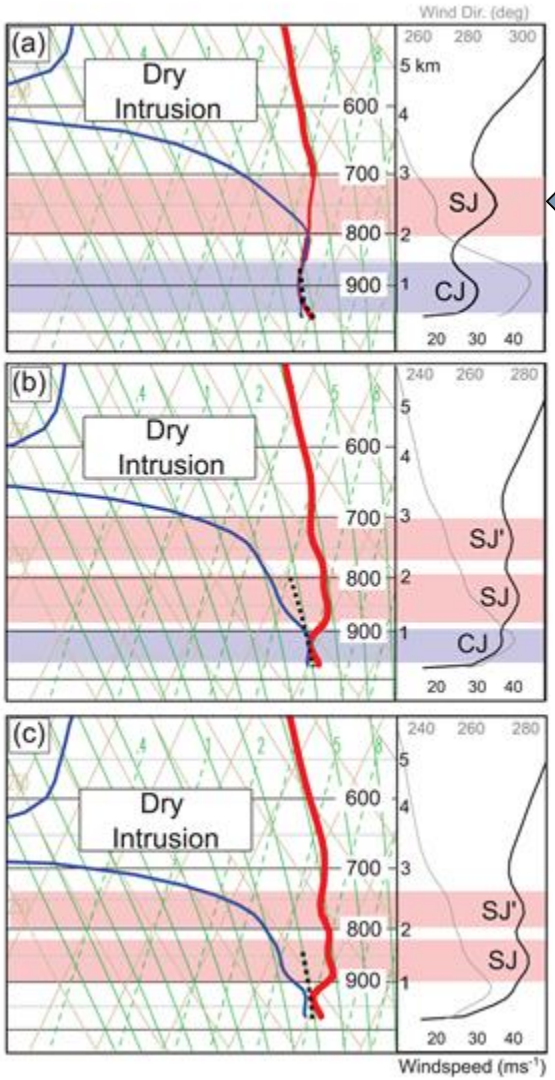




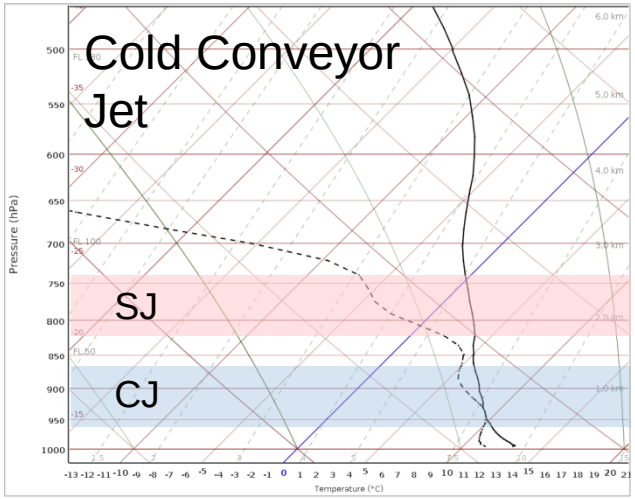




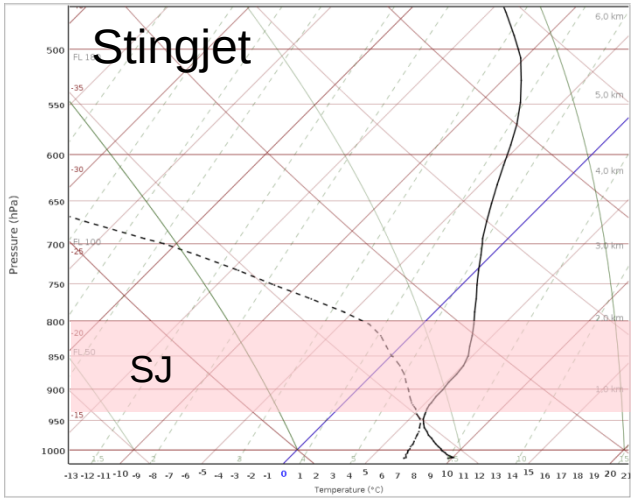
Modell and IASI Sounding Boundary-Layer



Browning et. al. 2015:
03:15 UTC Hi-Res-WRF-Modell
(120 – 240 m vertical spacing) near Sting Jet



IASI-Sounding ~10:20 UTC in Sting Jet

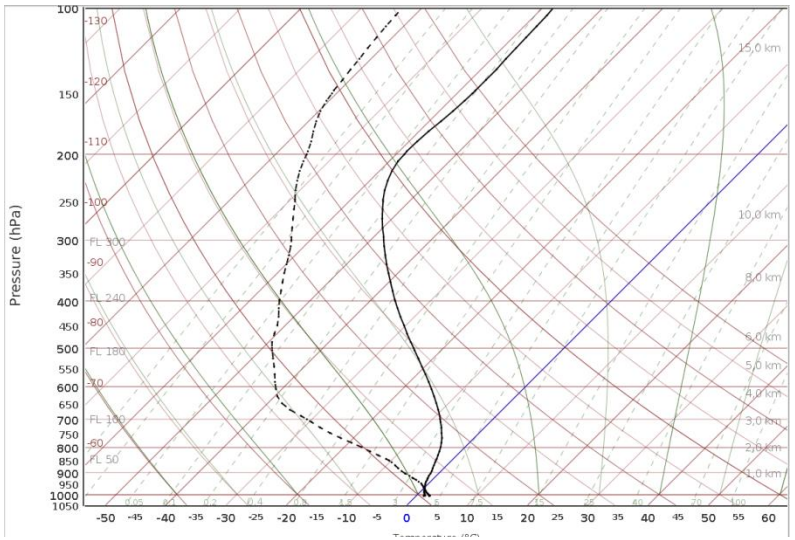


IASI L2 Profiles

➔ The descending dry stratospheric air in the sting jet area is clearly seen in IASI profiles. The profiles agree well with the radiosonde measurements at Norderney and model simulations. Such soundings are extremely rare.

Question:

➔ How accurate are the IASI profiles in the boundary layer? The IASI profiles look similar to the ones obtained for Cyclone Friederike (Fig), but the sting jet only reached the surface in case of cyclone Christian.



IASI L2 profile from the area of the sting jet during Cyclone Friederike on Jan 18, 2018

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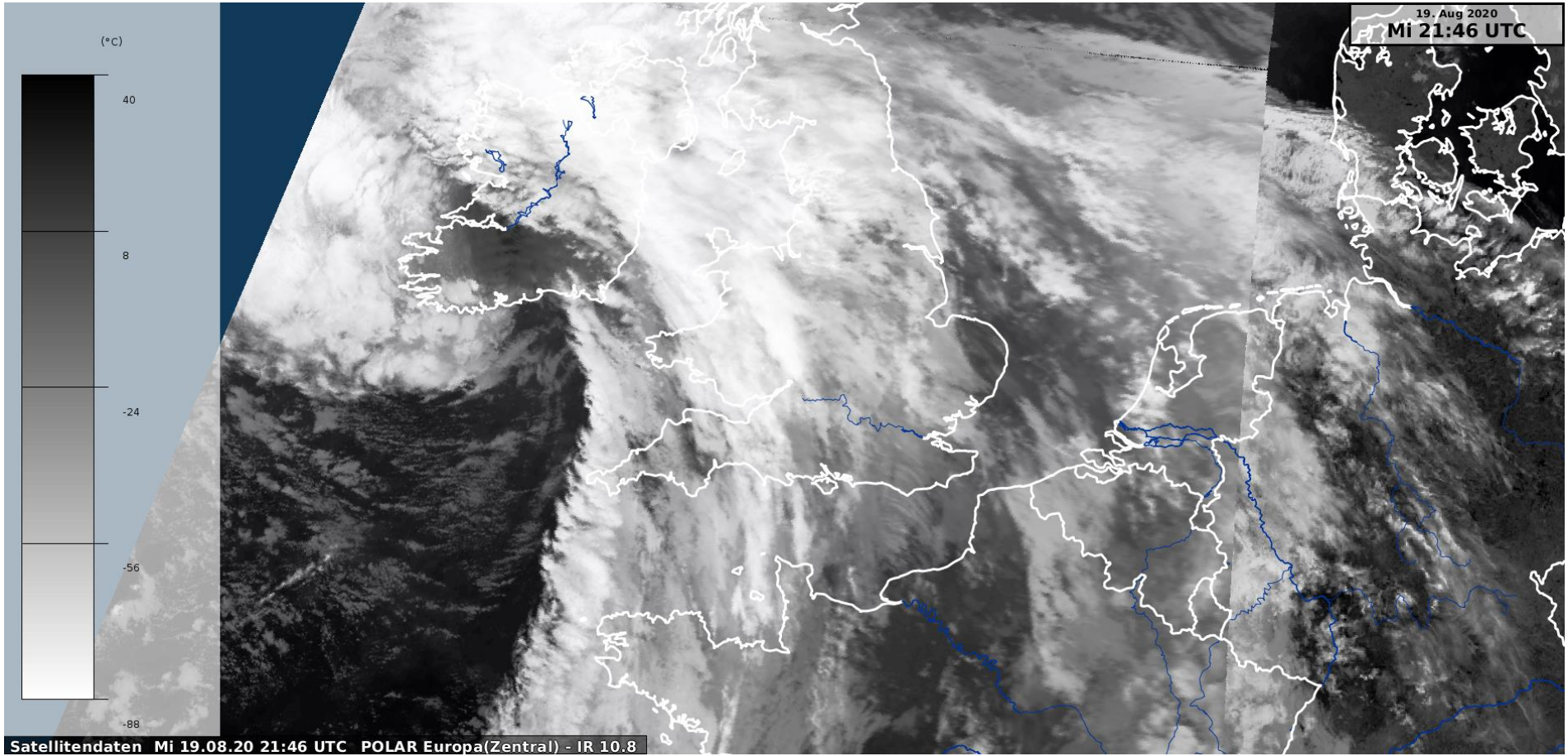
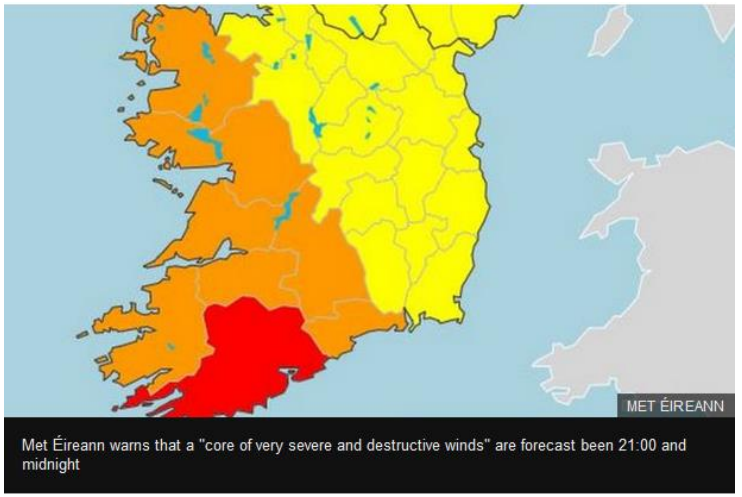
Wetter und Klima aus einer Hand

Case Study III
Storm Ellen
20.08.2020



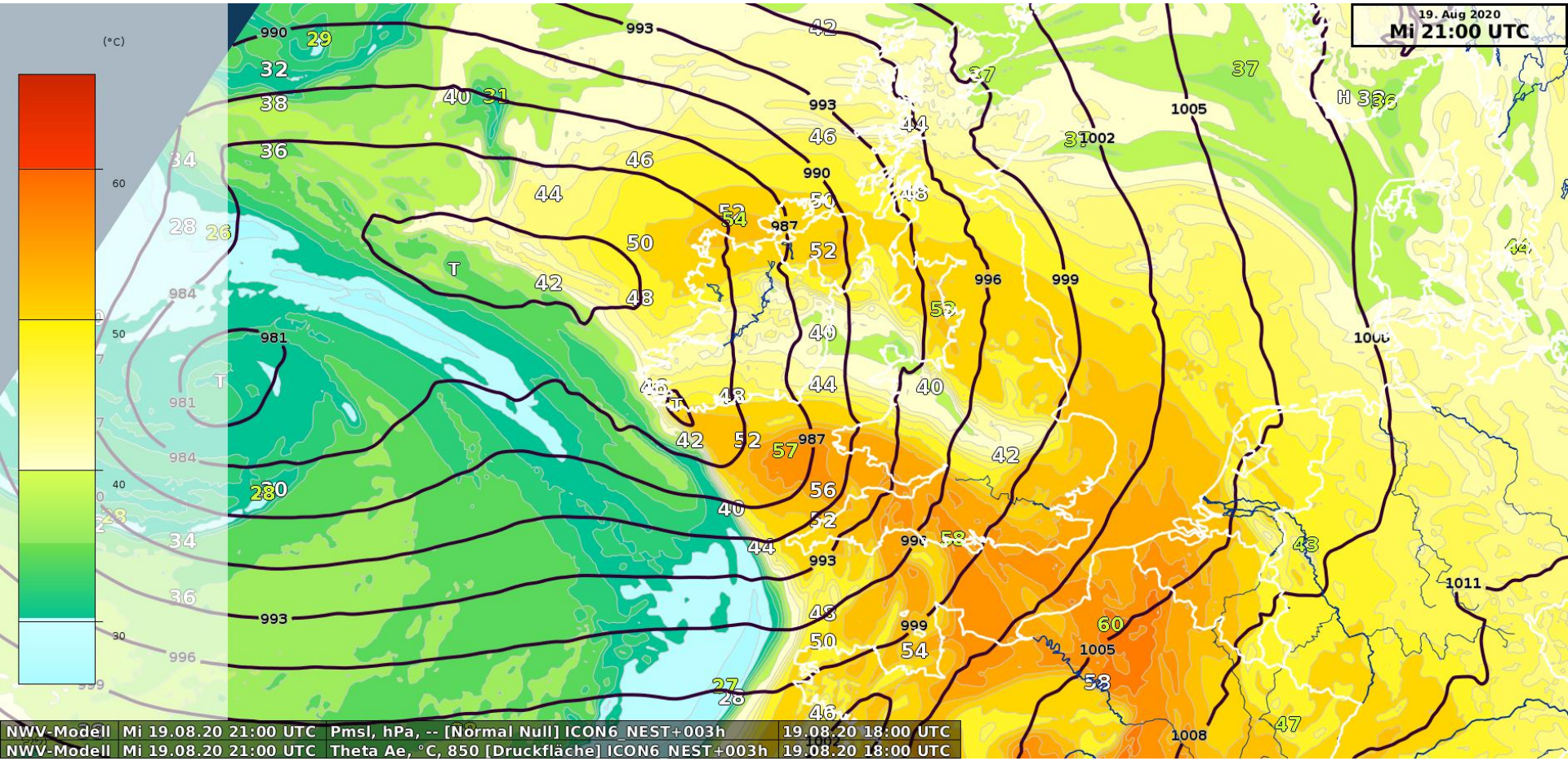
- Formed over the atlantic, including the remenants of Hurrican „Kyle“
- Unsesionably strong storm → fallen trees, powerdisruption
- Over 194.000 homes were left without power
- New mean wind speed records for the month August in Ireland



Met Éireann warns that a "core of very severe and destructive winds" are forecast been 21:00 and midnight

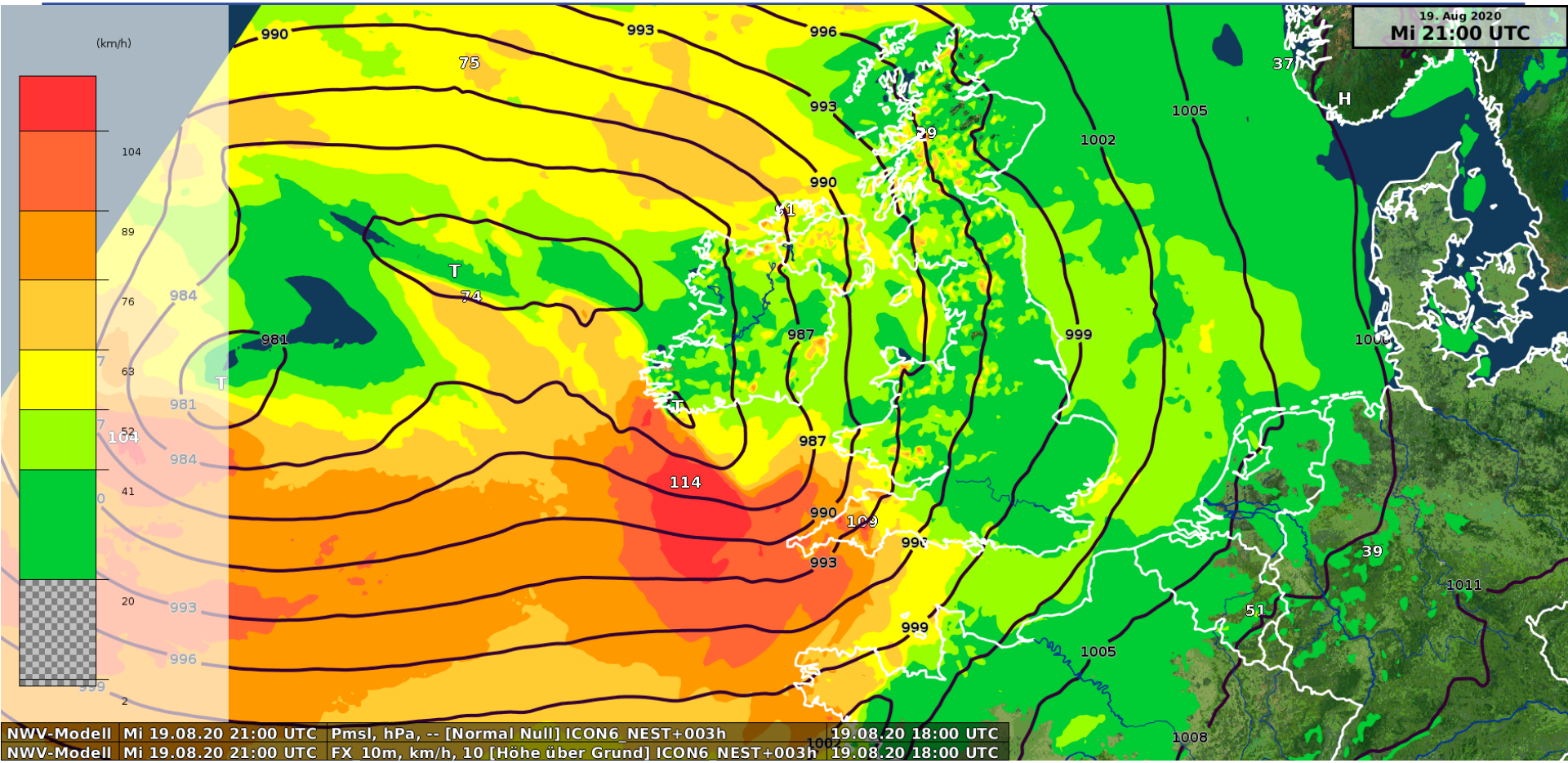
ICON-18z+3h-Forecast MSLP+850 hPa -ThetaE

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



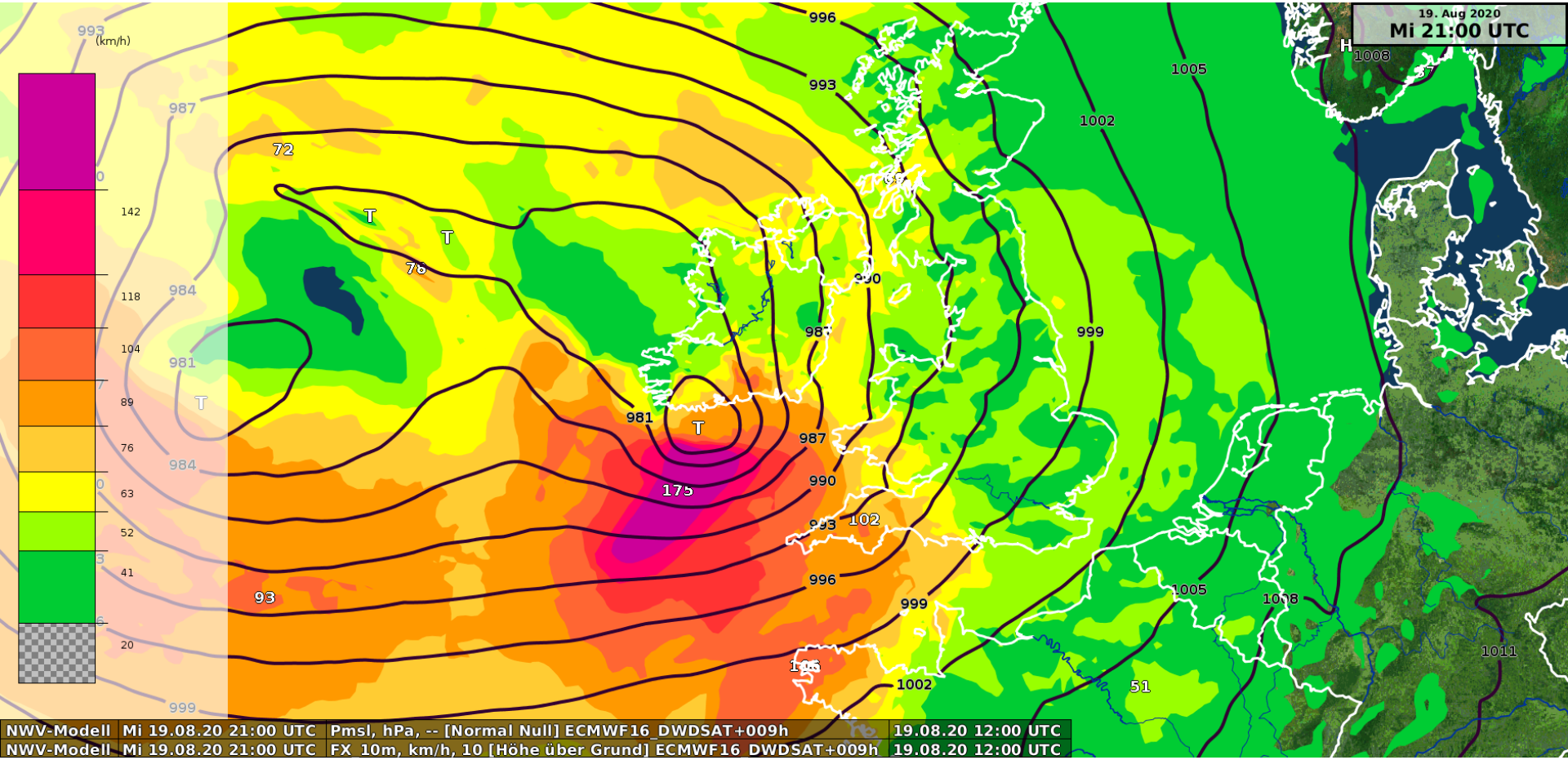
ICON-18z+3h: MSLP+Maximum Gusts

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



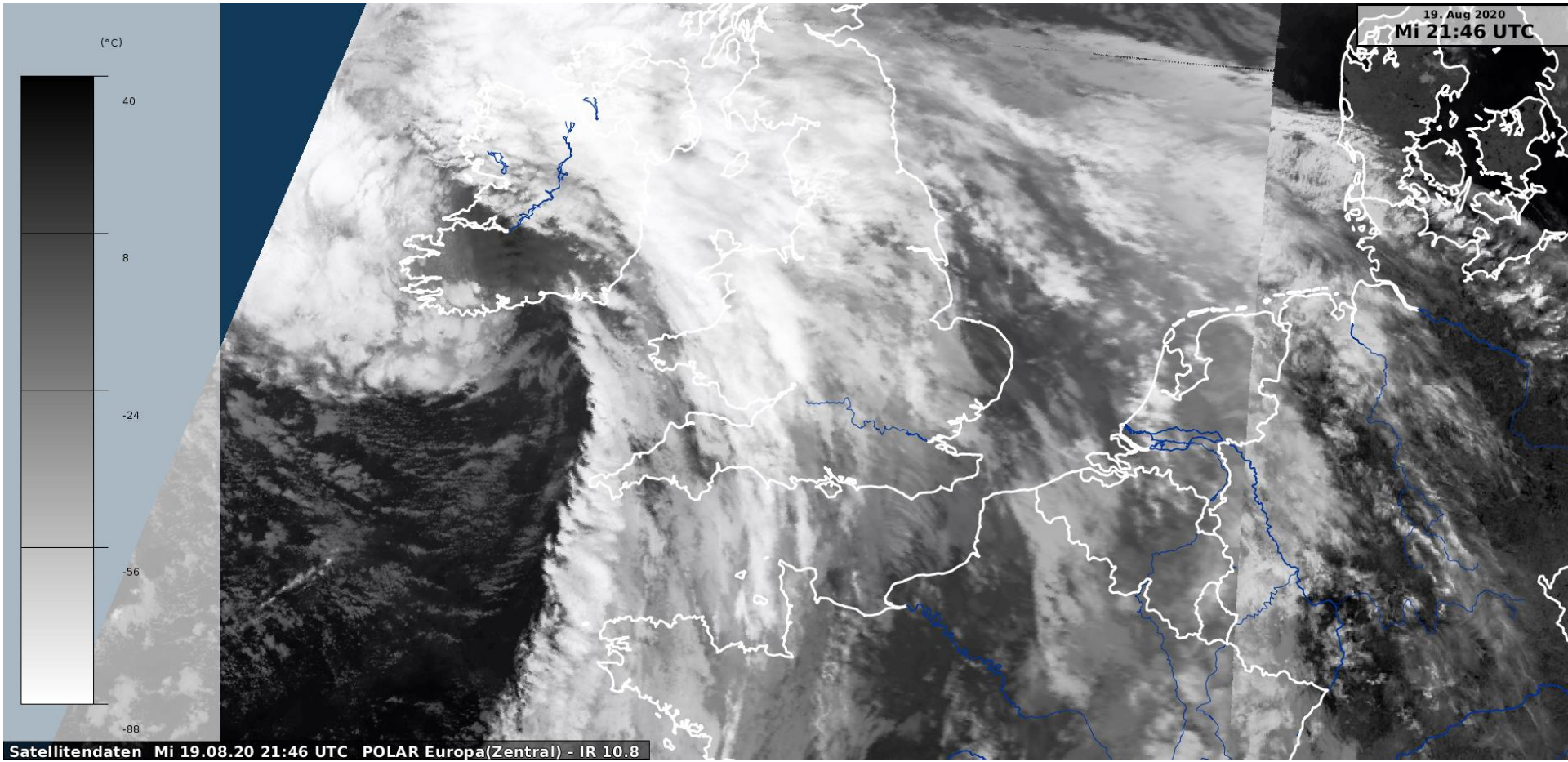
IFS12z+9h: MSLP+Maximum Gusts

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



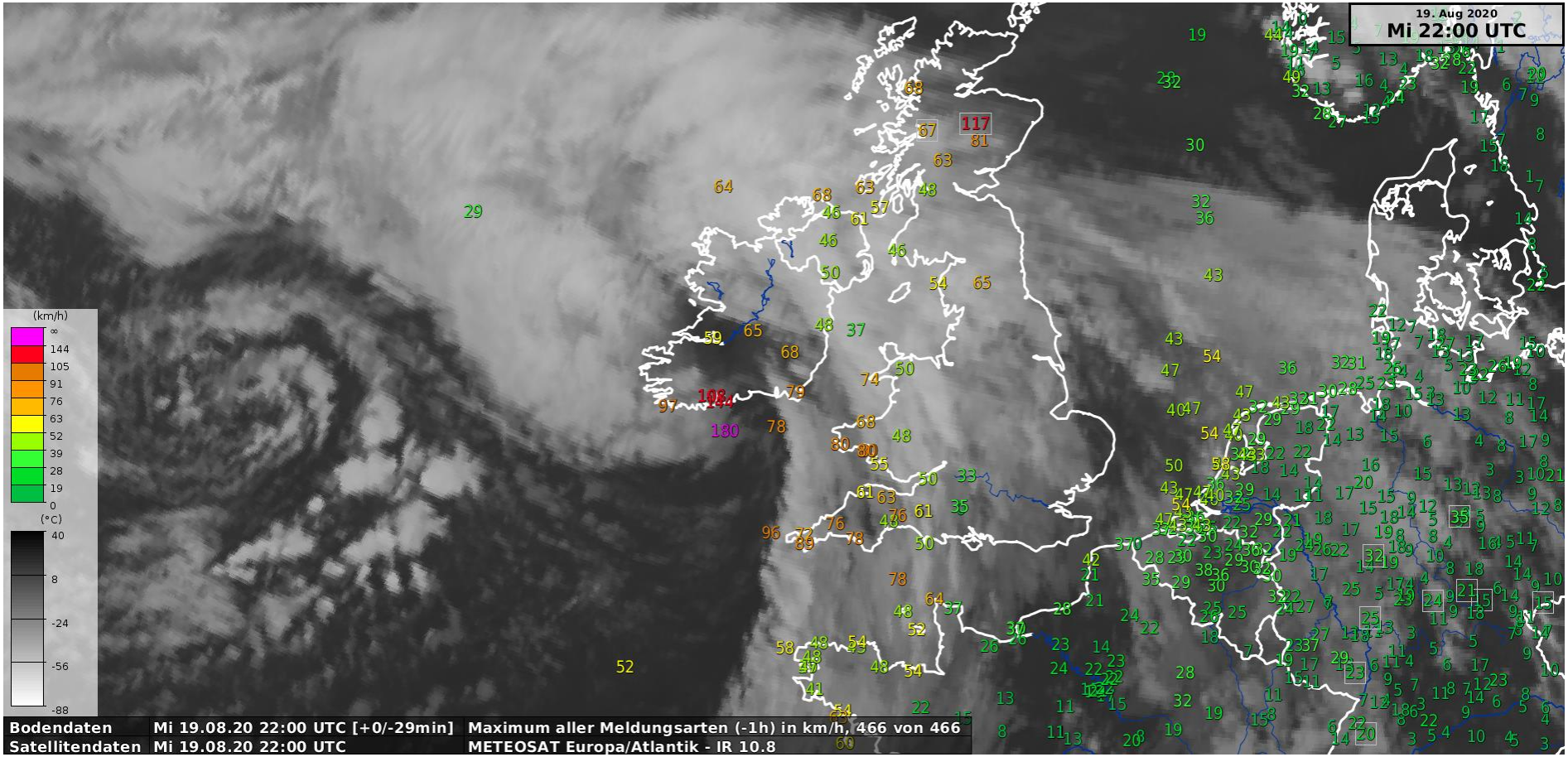
NOAA IR

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



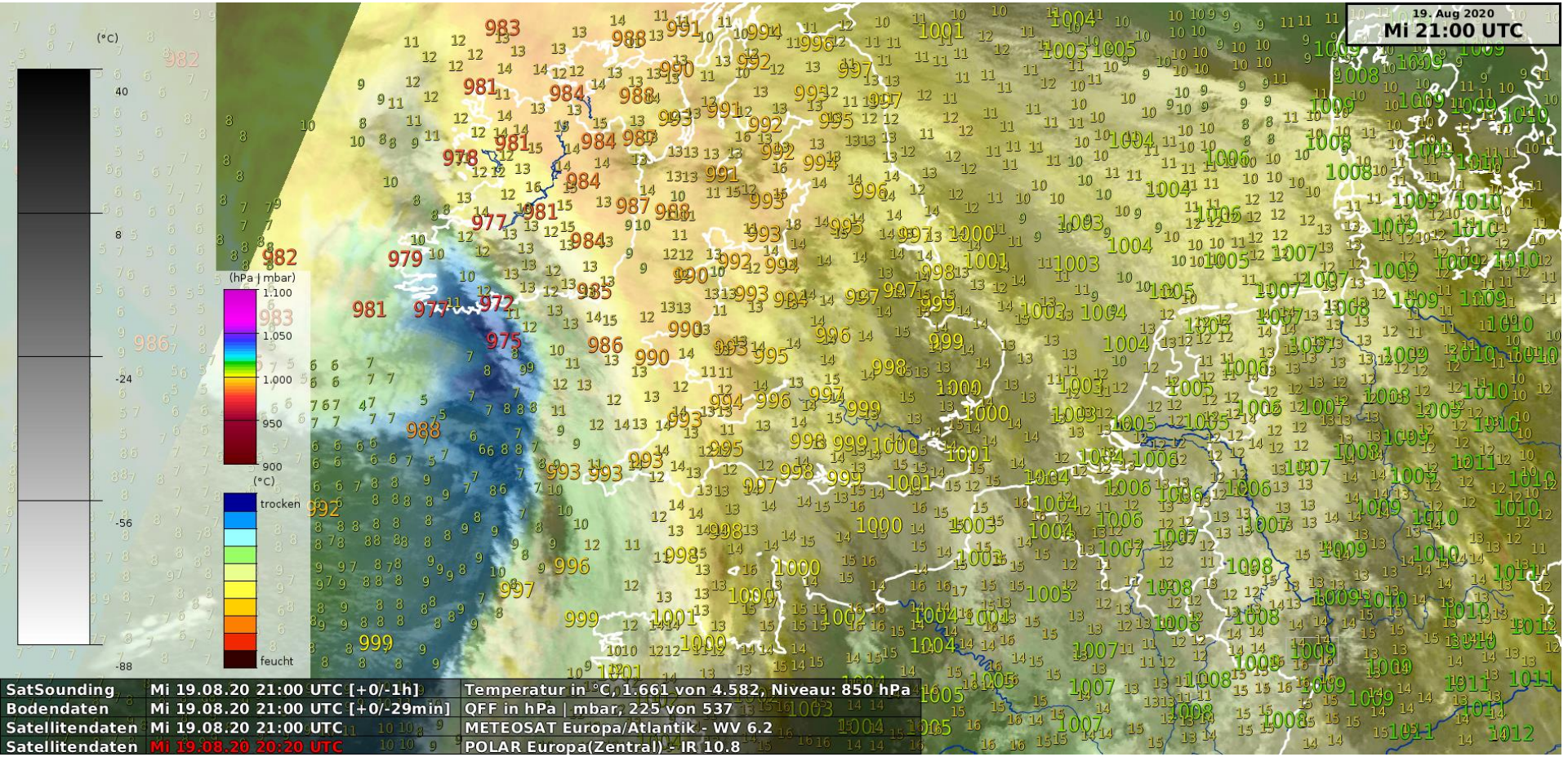
Meteosat IR Image + Wind Gust

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



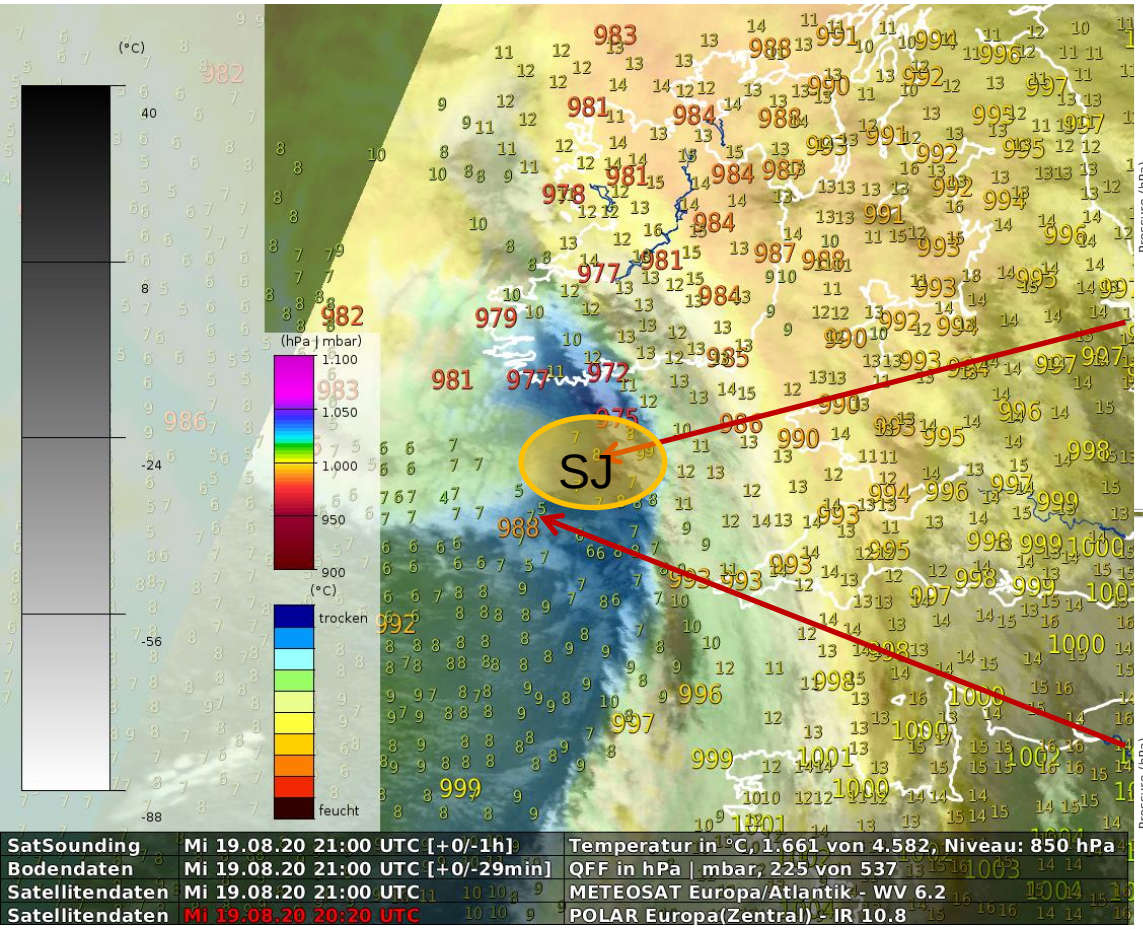
Water Vapour Sandwich/ MSLP+ T_{850} IASI

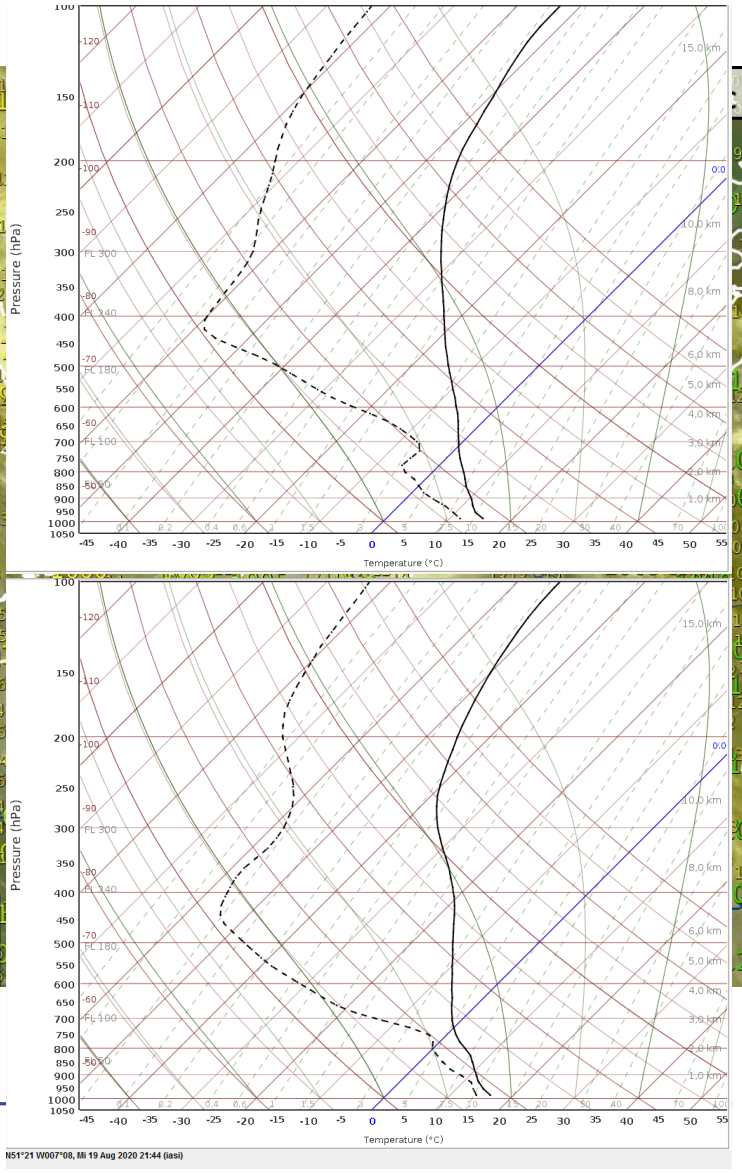
Deutscher Wetterdienst
Wetter und Klima aus einer Hand



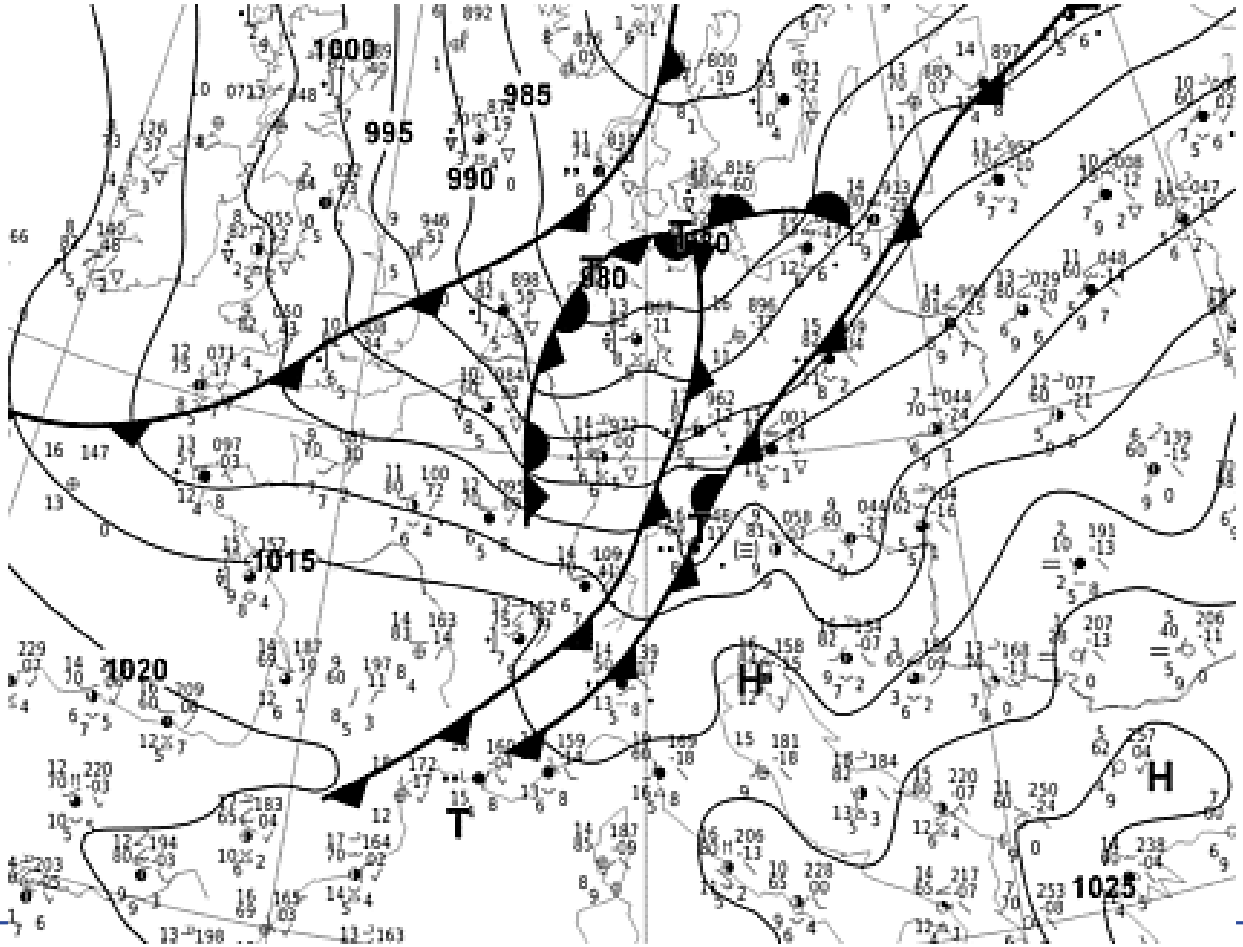
IASI-Soundings 20:20 UTC

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

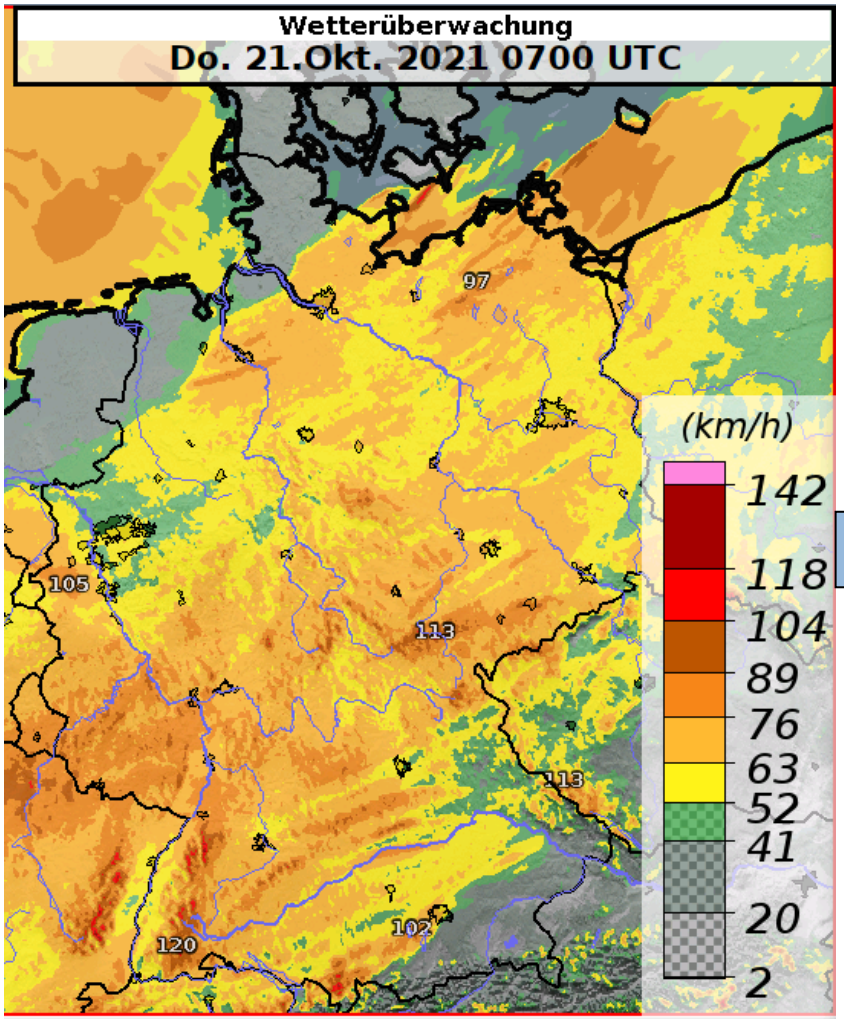


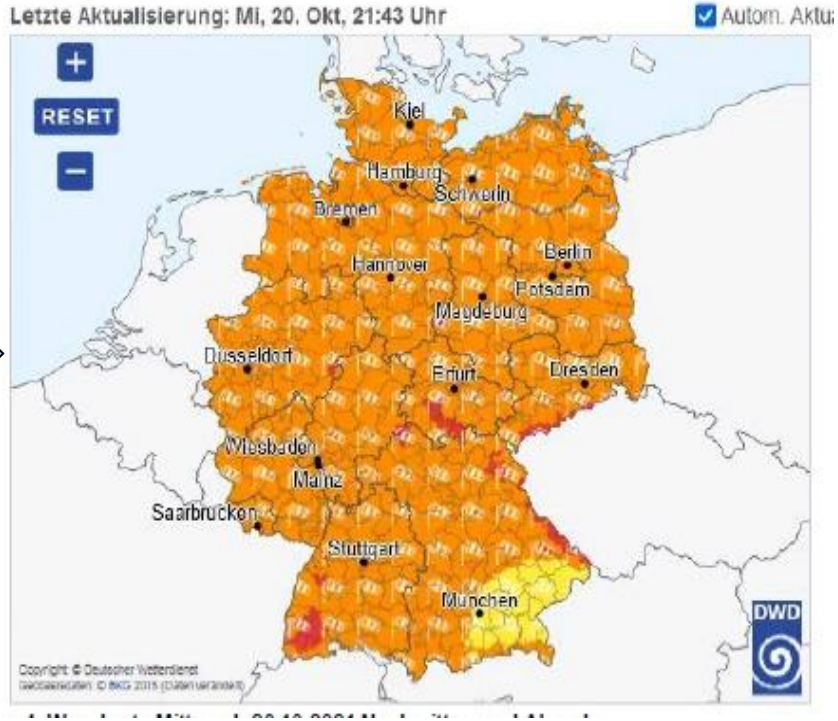


Case Study IV
Storm Hendrik II
20/21.10.2021

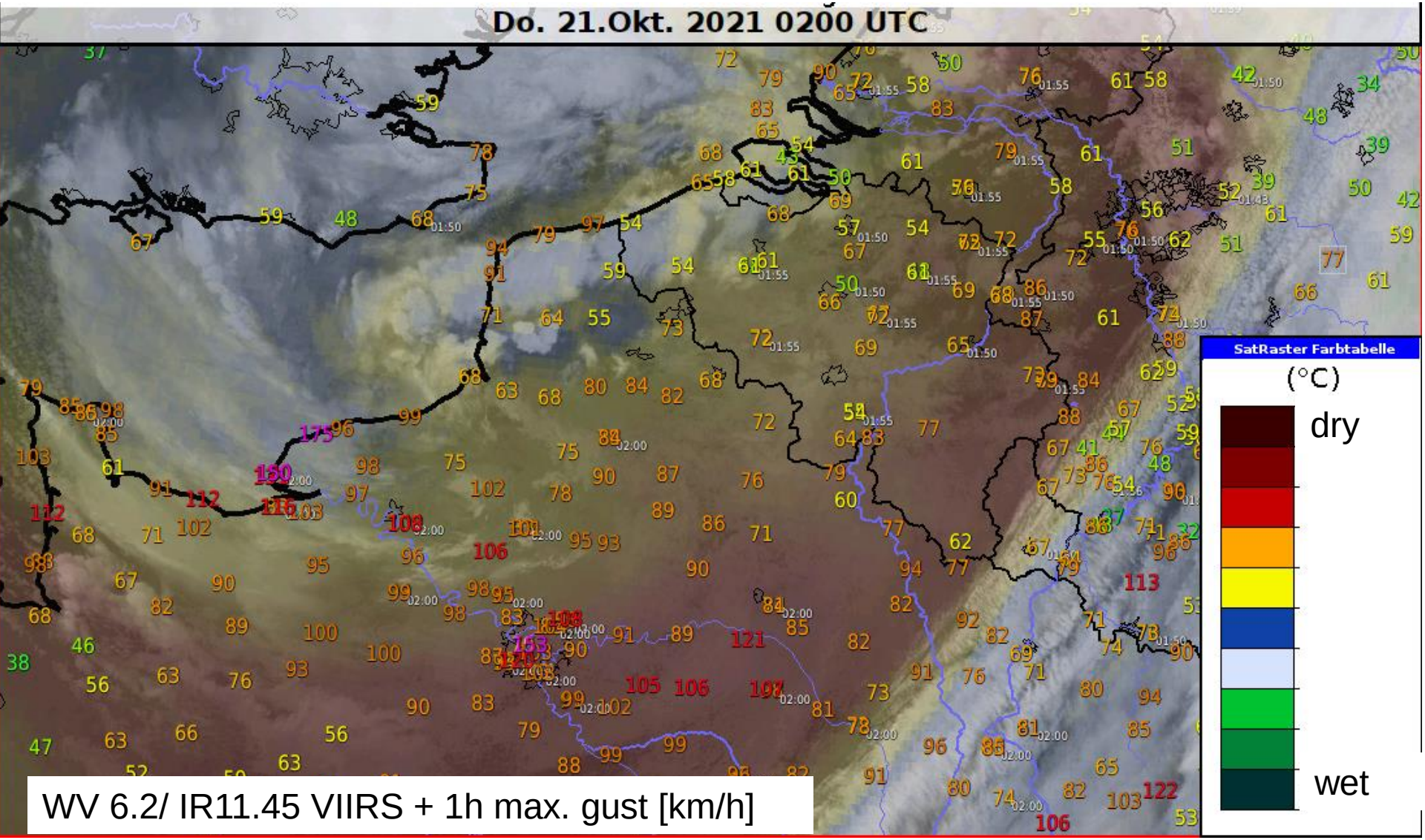


ICON-D2 18z + 13h 1h- Max Gust

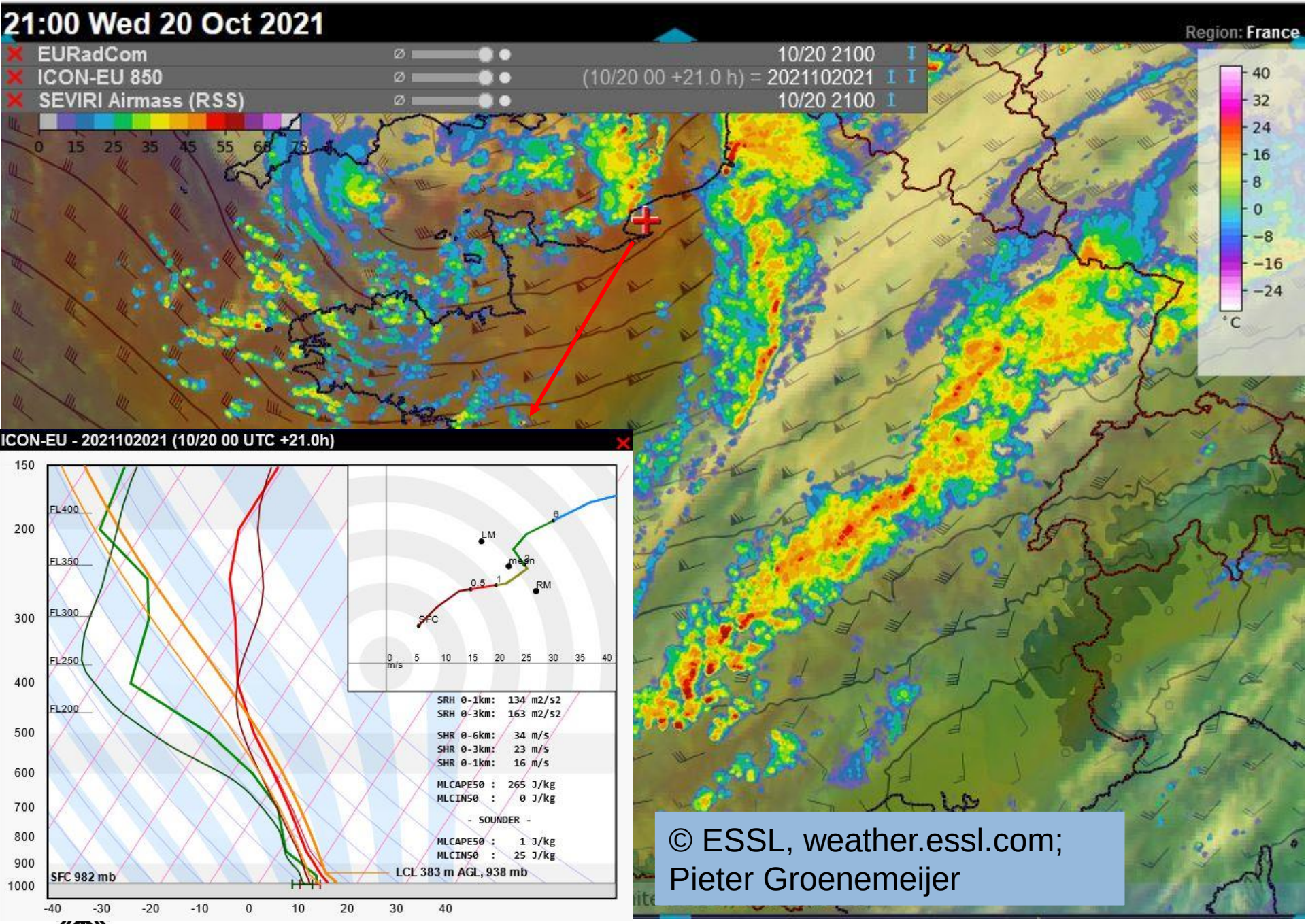




Looking upstream (Sat. + gusts)

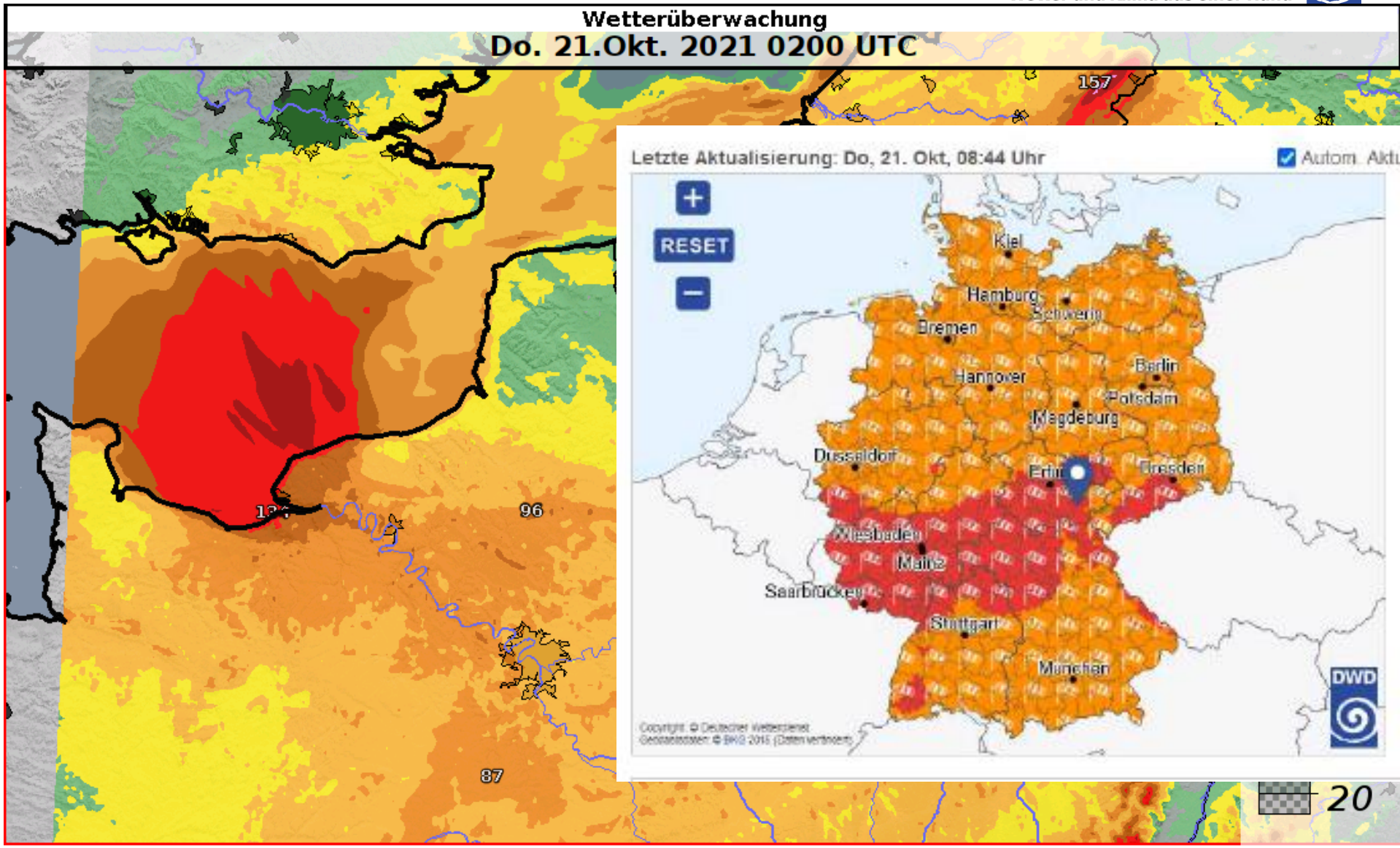


WV 6.2/ IR11.45 VIIRS + 1h max. gust [km/h]

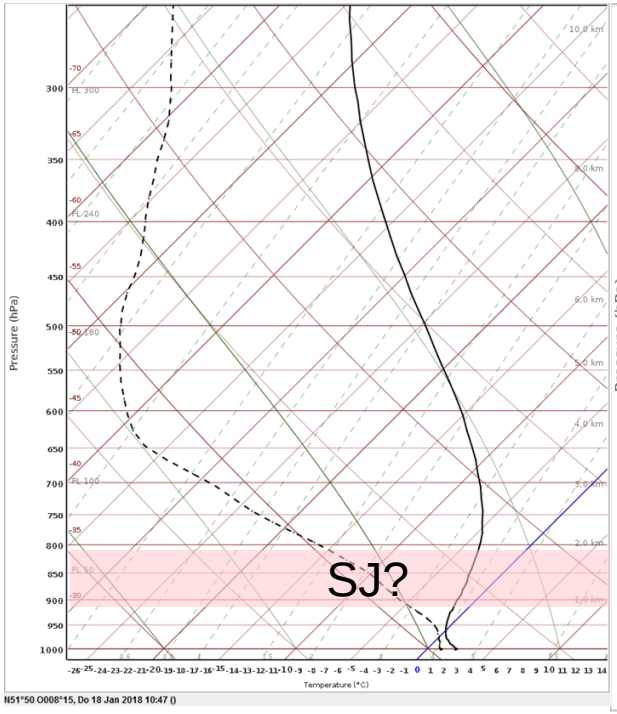


ICON-D2-18z+08h Max. Gust.

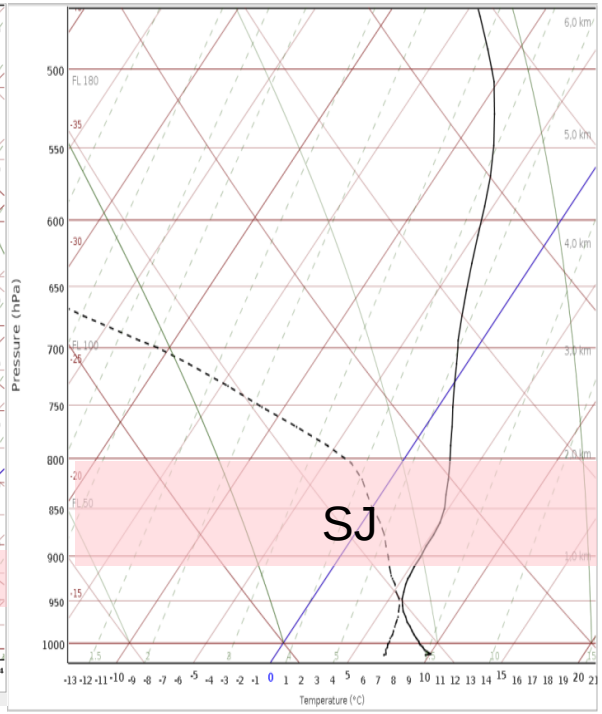
Deutscher Wetterdienst
Wetter und Klima aus einer Hand



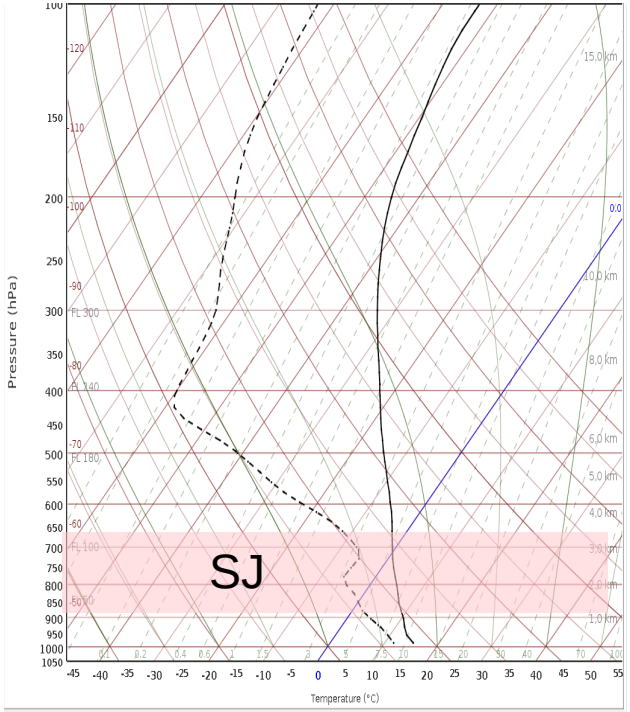
Summary



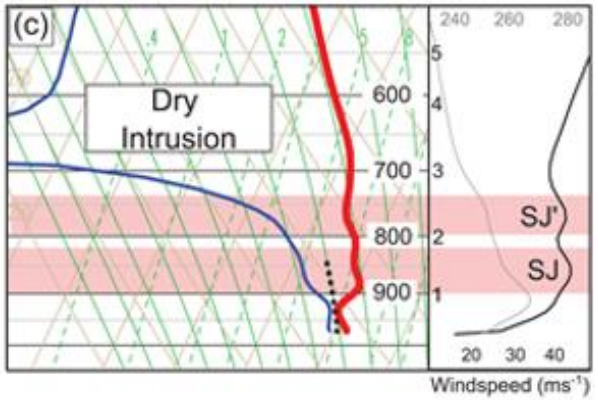
Dave/Frederike



Christian



Ellen



Summary

- All case studies showed the usefulness of IASI profiles for wind gust warnings.
- The remaining issue regarding the low temporal resolution regarding Metop IASI data will be solved with MTG IRS measurements.
- IASI L2 is useful as independent information source (especially if the NWP forecasts are wrong).
- More experiences with sting jets and IASI profiles are needed.

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Thanks to you for your attentions!

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