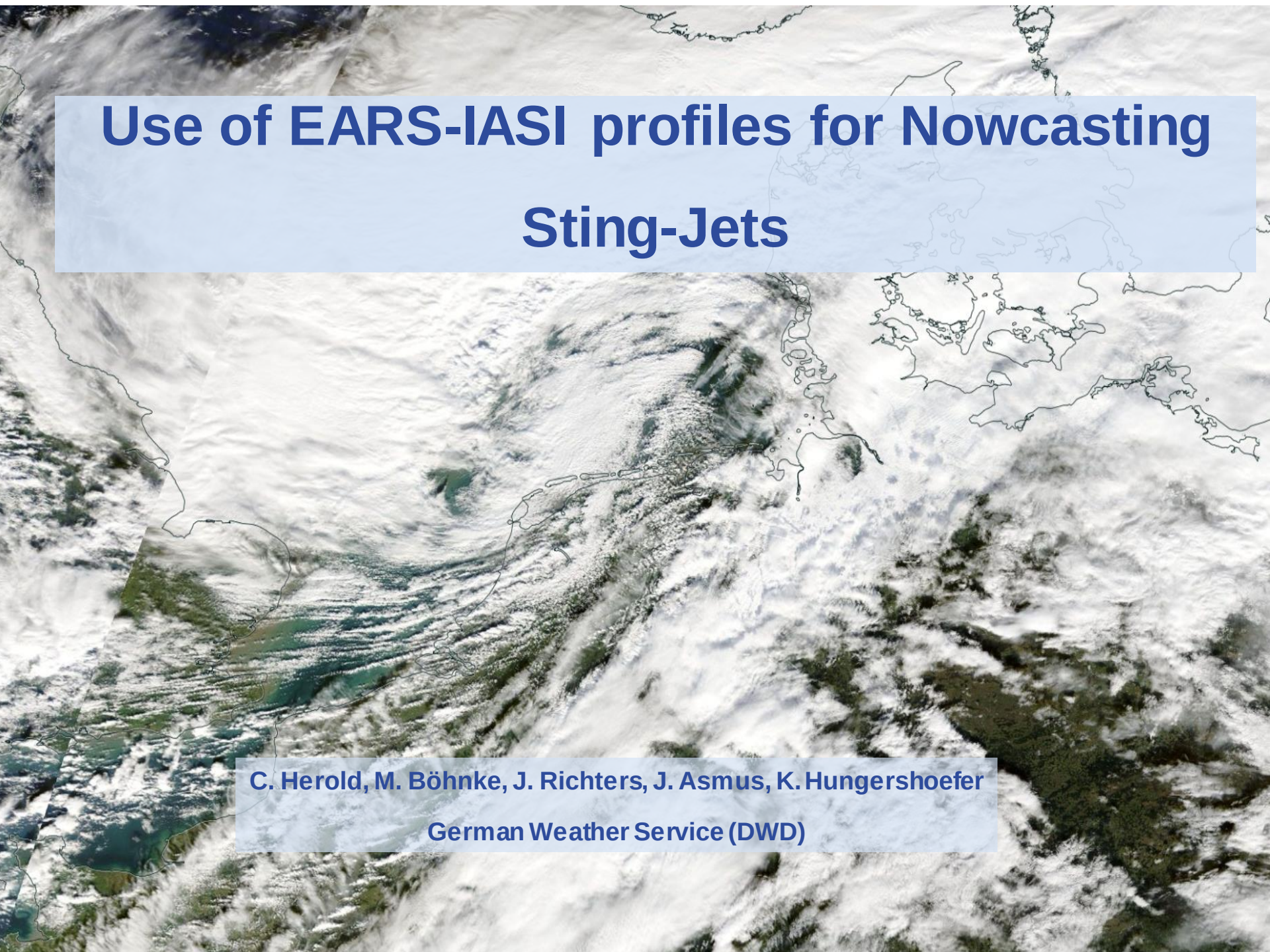
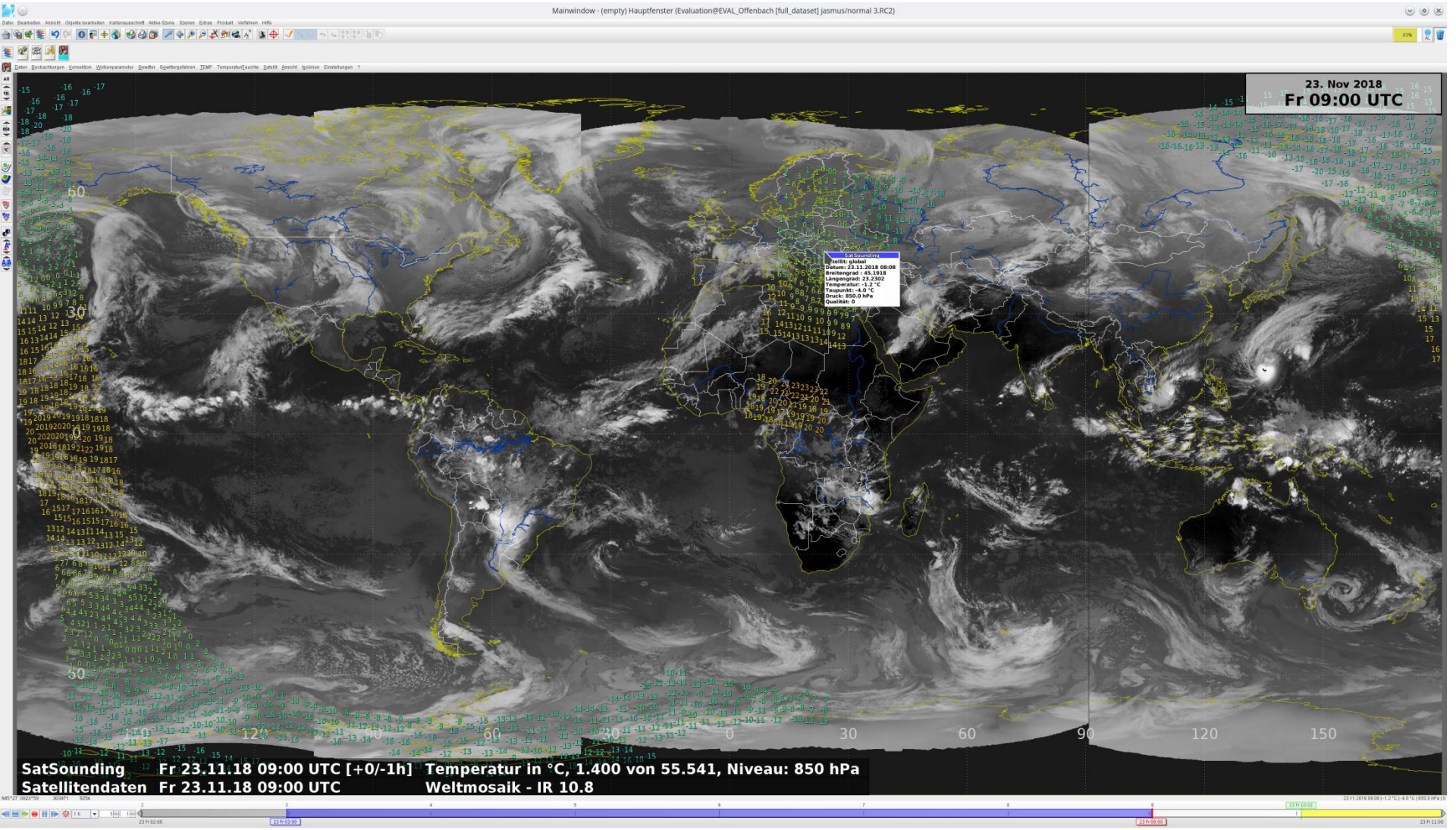
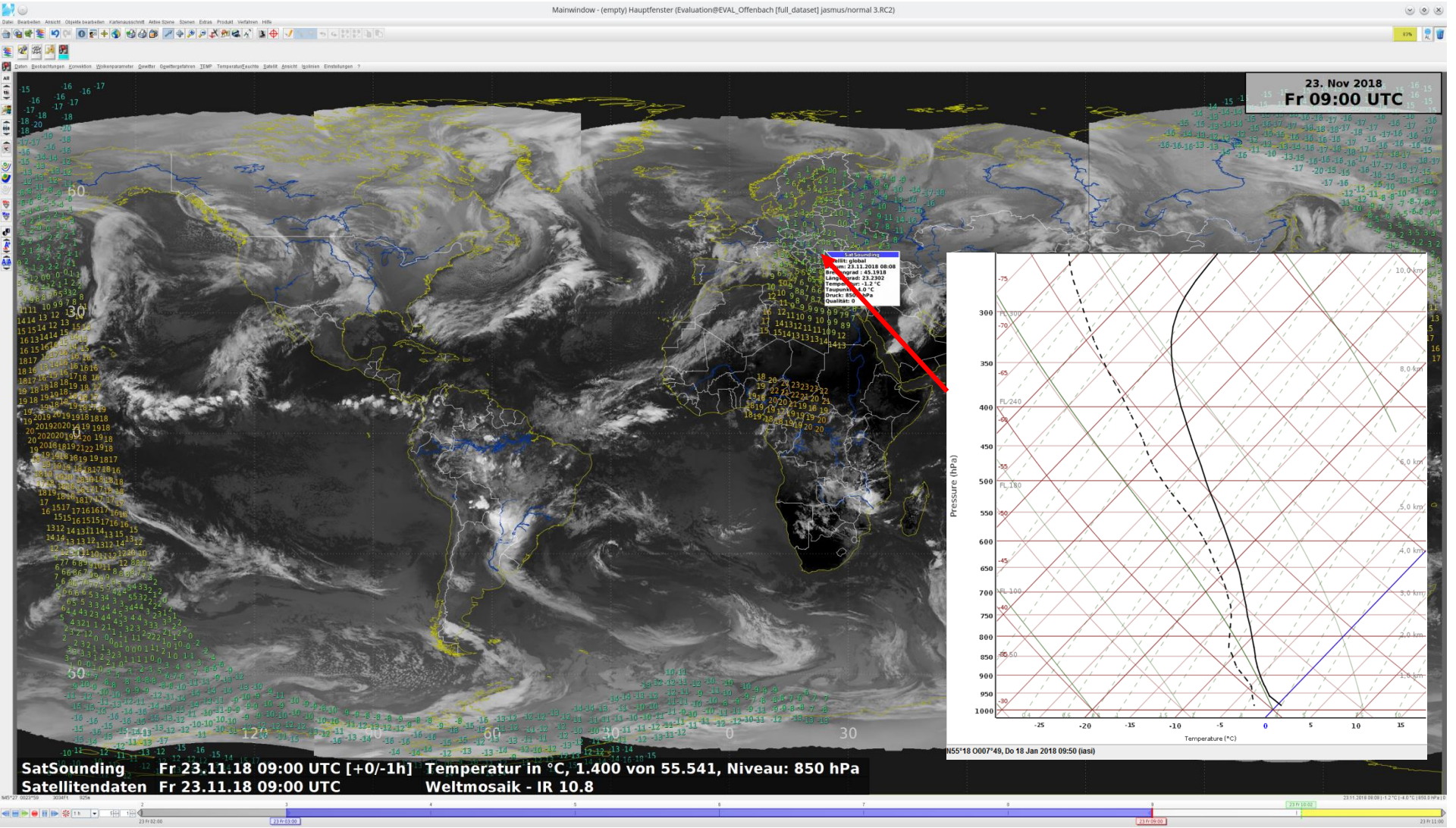
# Use of EARS-IASI profiles for Nowcasting Sting-Jets



C. Herold, M. Böhnke, J. Richters, J. Asmus, K. Hungershoefer

German Weather Service (DWD)


Mainwindow - (empty) Hauptfenster (Evaluation@EVAL_Offenbach [full_dataset] jasmus/normal 3.RC2)
23. Nov 2018
Fr 09:00 UTC
SatSounding
Satellit: global
Datum: 23.11.2018 08:08
Breitengrad: 45.1918
Längengrad: 23.2302
Temperatur: -1.2 °C
Taupunkt: -4.0 °C
Druck: 850.0 hPa
Qualität: 0
SatSounding Fr 23.11.18 09:00 UTC [+0/-1h] Temperatur in °C, 1.400 von 55.541, Niveau: 850 hPa
Satellitendaten Fr 23.11.18 09:00 UTC Weltmosaik - IR 10.8


Mainwindow - (empty) Hauptfenster (Evaluation@EVAL_Offenbach [full_dataset] jasmus/normal 3.RC2)
23. Nov 2018
Fr 09:00 UTC
Pressure (hPa)
Temperature (°C)
SatSounding Fr 23.11.18 09:00 UTC [+0/-1h] Temperatur in °C, 1.400 von 55.541, Niveau: 850 hPa
Satellitendaten Fr 23.11.18 09:00 UTC Weltmosaik - IR 10.8

# Motivation



- Global IASI L2 profile available in DWD's visualisation system NinJo since almost 10 years.
  main concern: data arrives too late
- 06/2015: Thomas August visits us at DWD, idea of EARS IASI L2 service
- 11/2016: trial dissemination of EARS-IASI L2 products starts
- 09/2017: EARS IASI L2 products in Ninjo
- NinJo Server with real-time data
- NinJo Replay Server for 3 case studies using reprocessed IASI L2 profiles from Tim Hultberg and Thomas August

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

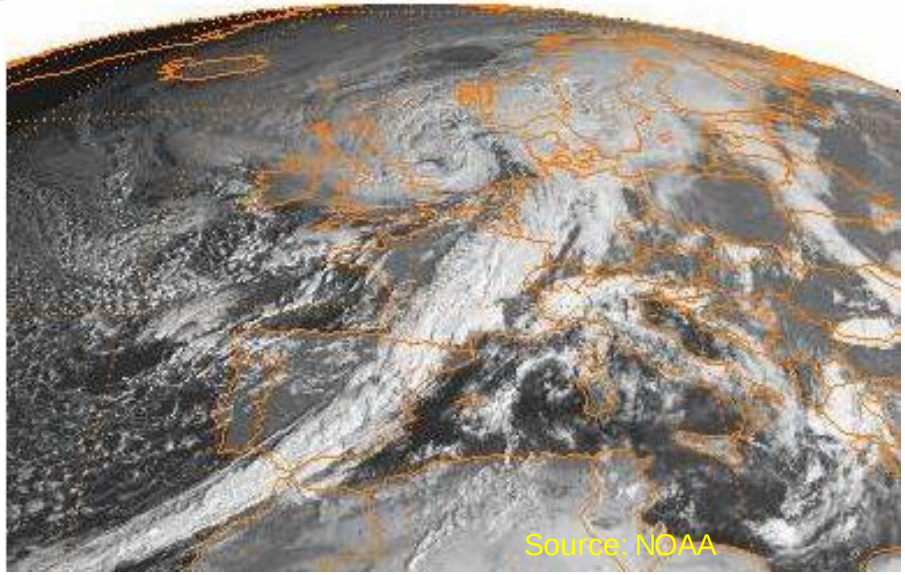
# Can IASI profiles help us for a better prediction of mesoscale severe wind events connected to sting jet (SJ)?

# What is a Sting Jet?

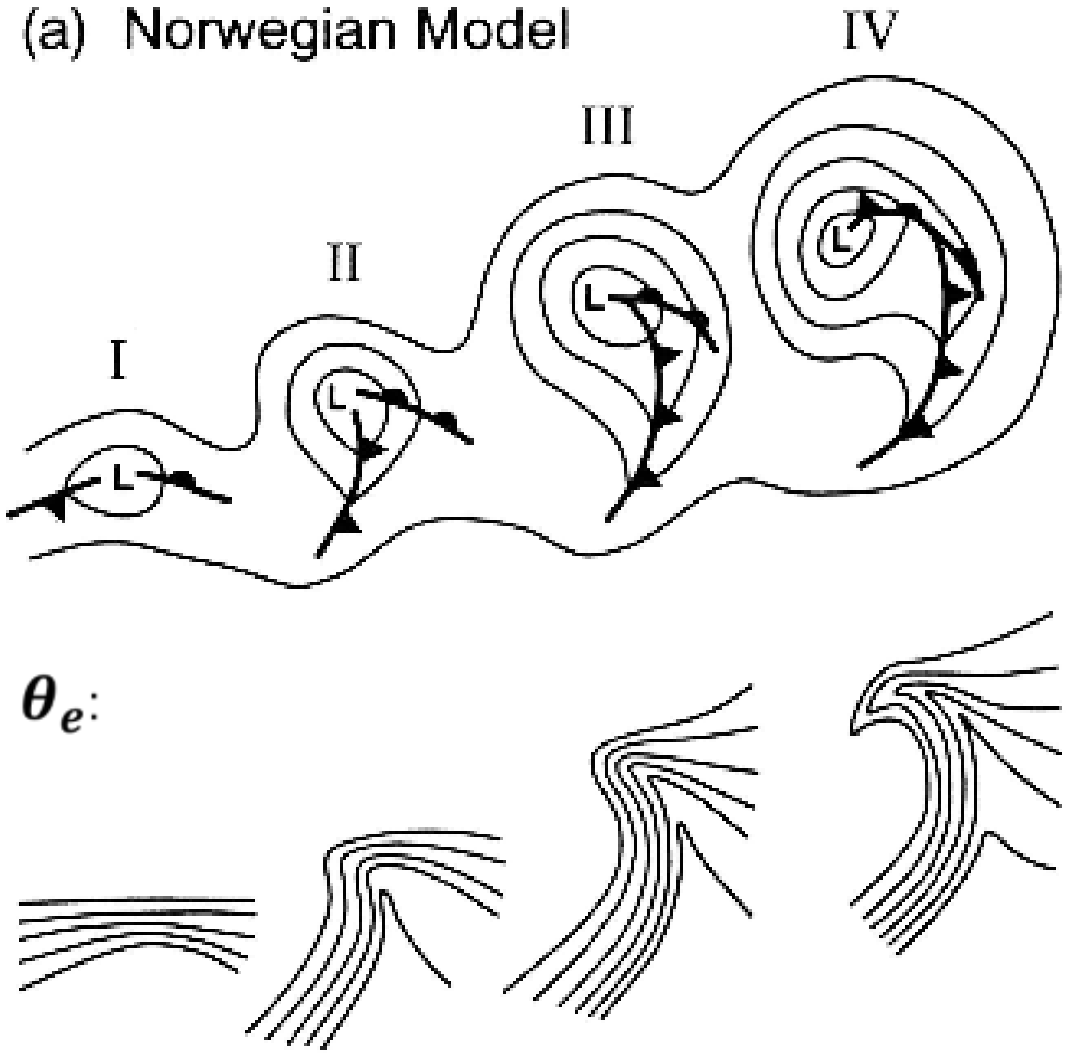


Great Storm of 1987:

- 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**




I : frontal wave ; incipient cyclone

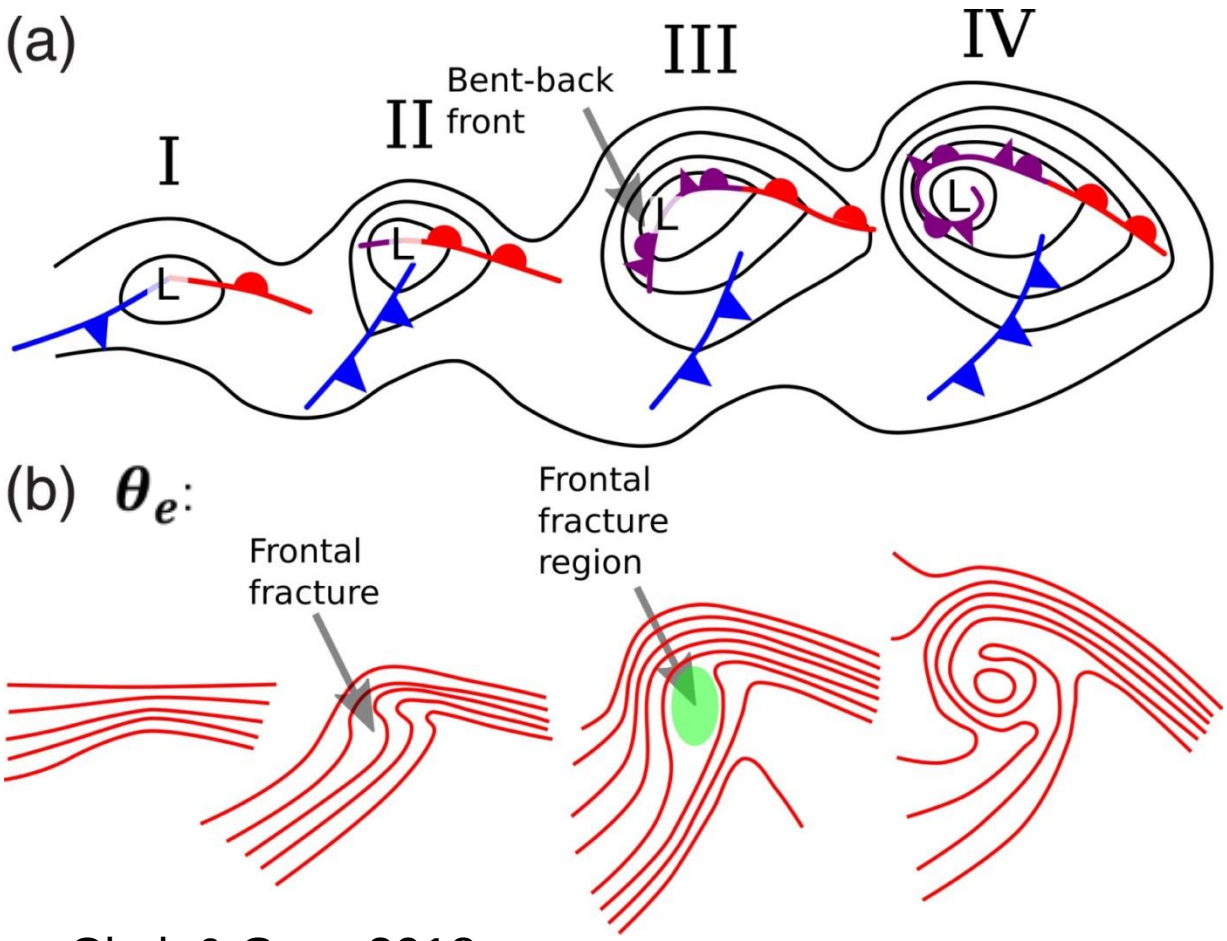
II – III: narrowing warm sector

IV : occlusion

Schultz et. al. 1998

# Shapiro Keyser Modell



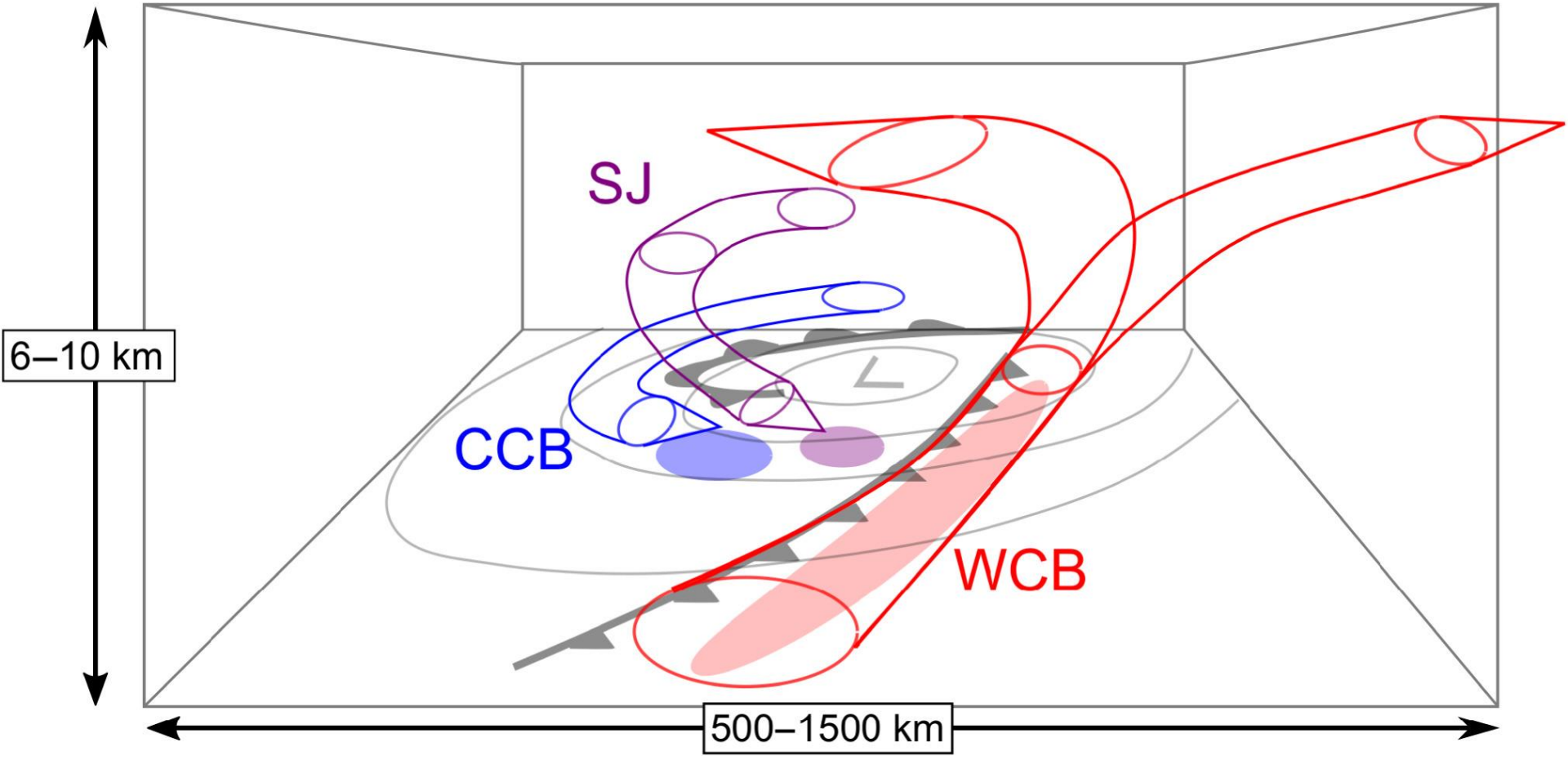



Clark & Gray. 2018

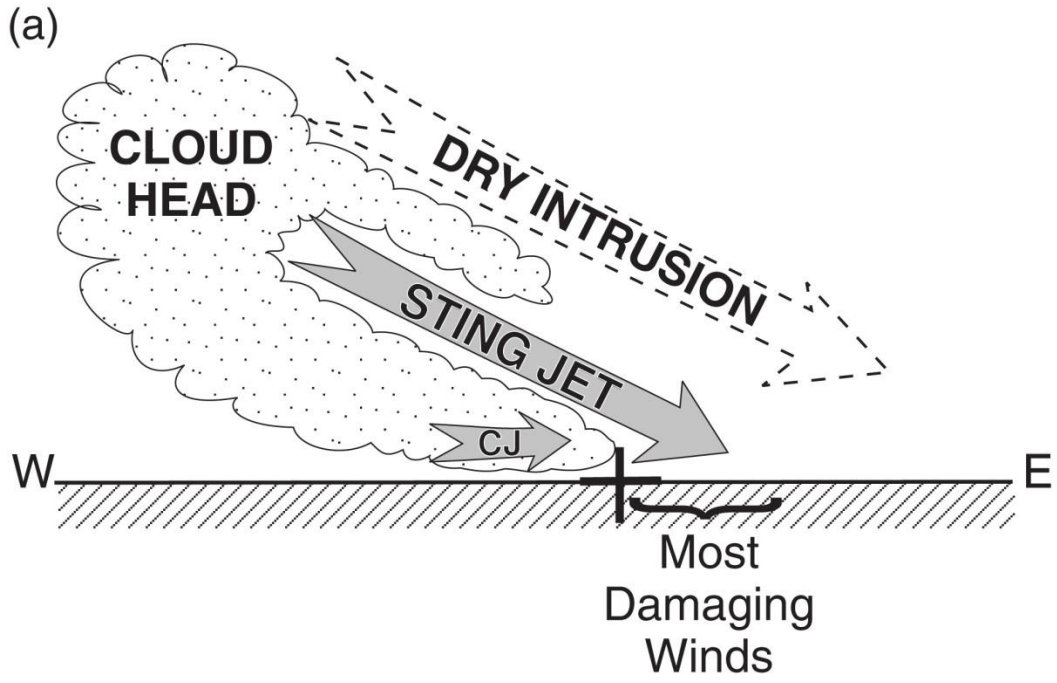
I : frontal wave ; incipient cyclone

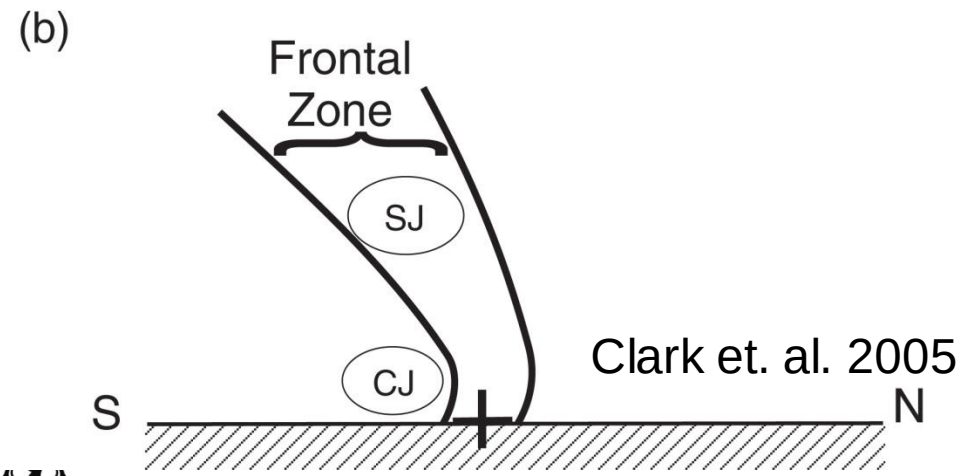
II – III: frontal fracture

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

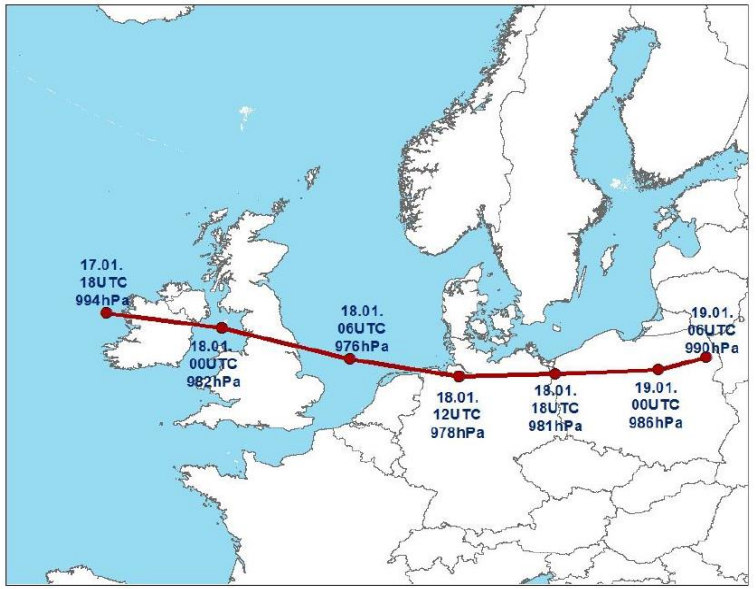
# Case Study I:

# 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.

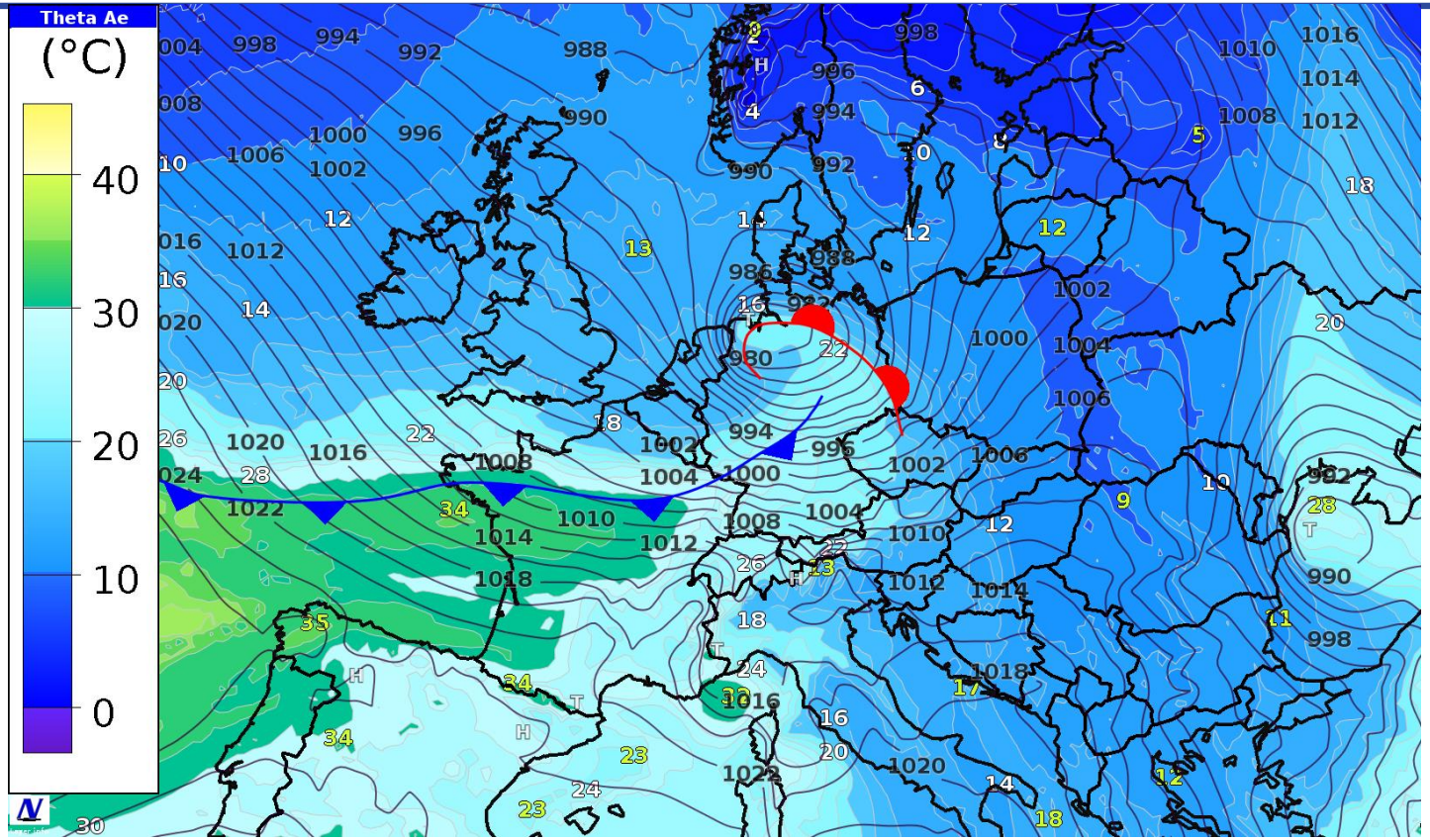



| Station | KYRILL 18.01.2007 | FIREDERIKE 18.01.2018 |
|---|---|---|
| Helgoland | **120 km/h** | 70 km/h |
| Göttingen | 105 km/h | **111** km/h |
| Brocken | 199 km/h | **203** km/h |
| Leipzig/Halle | 112 km/h | **129** km/h |
| Erfurt | 119 km/h | **130** km/h |
| Frankfurt a.M. | **95** km/h |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

Source: DWD

# 850 hPa- ThetaE + MSLP and Fronts



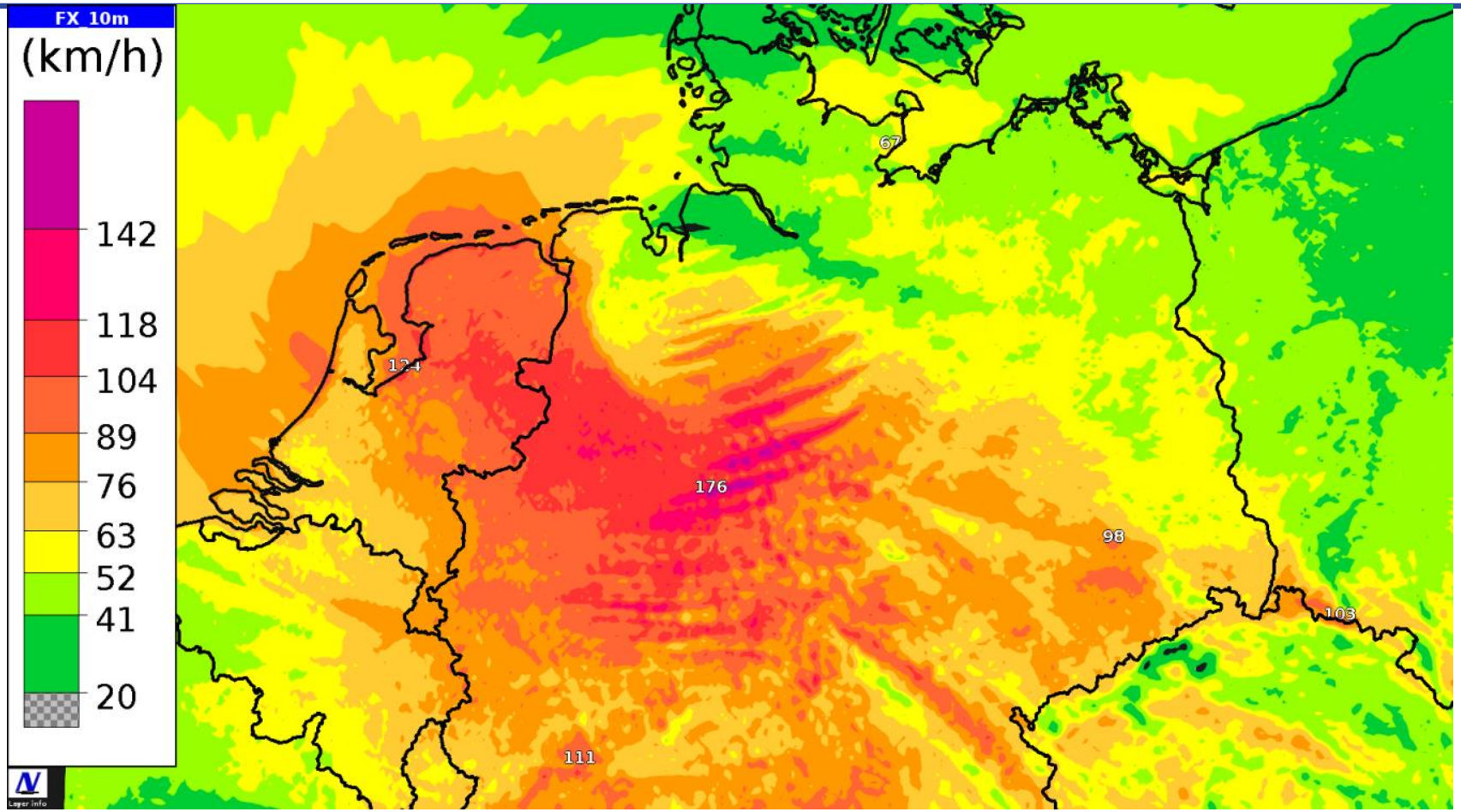



Typical structure of a SK-Cyclone:

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

# COSMO-DE-Forecast Max. Gust

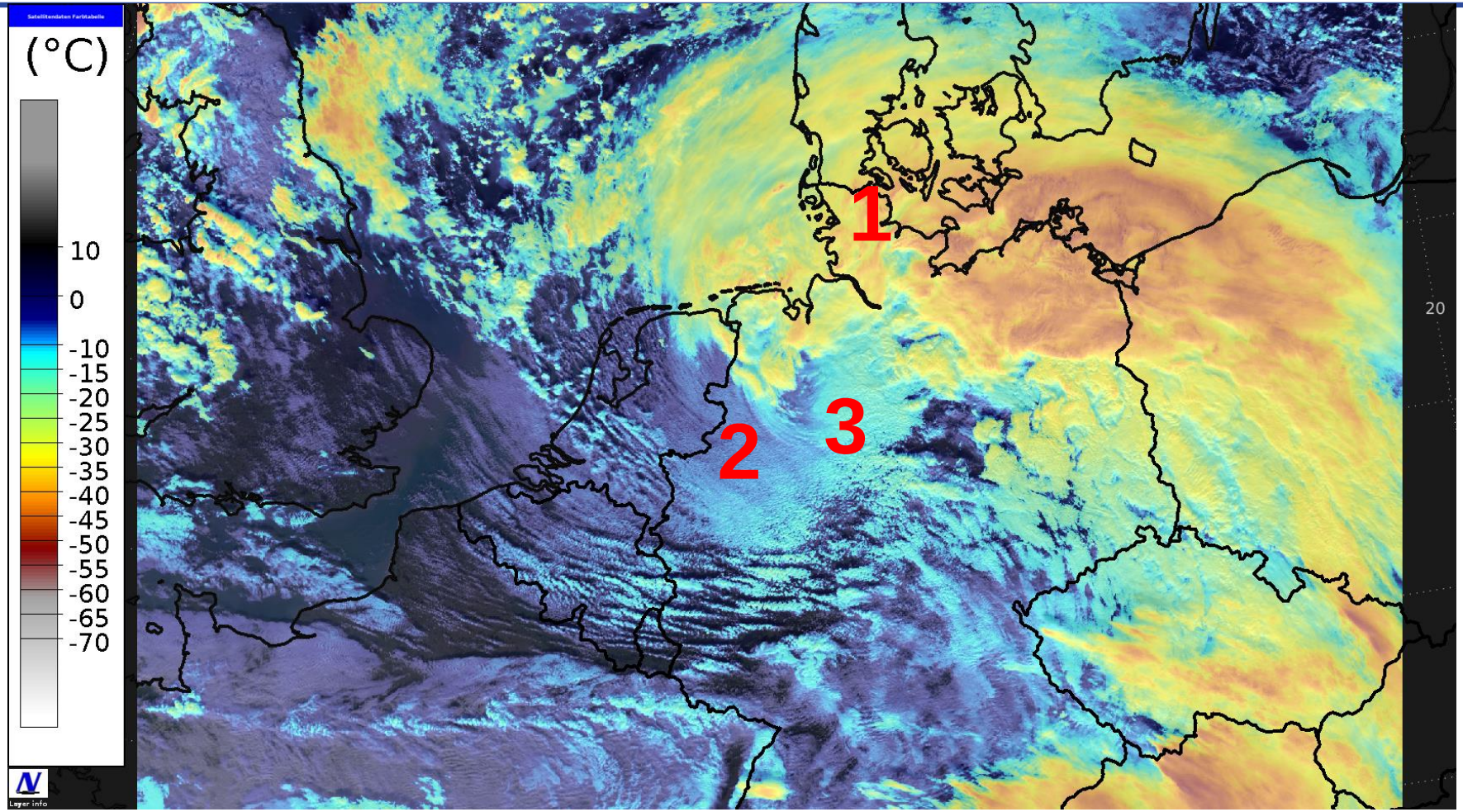





The regional model COSMO-DE predicted the development of a sting jet with gusts up to 170 km/h

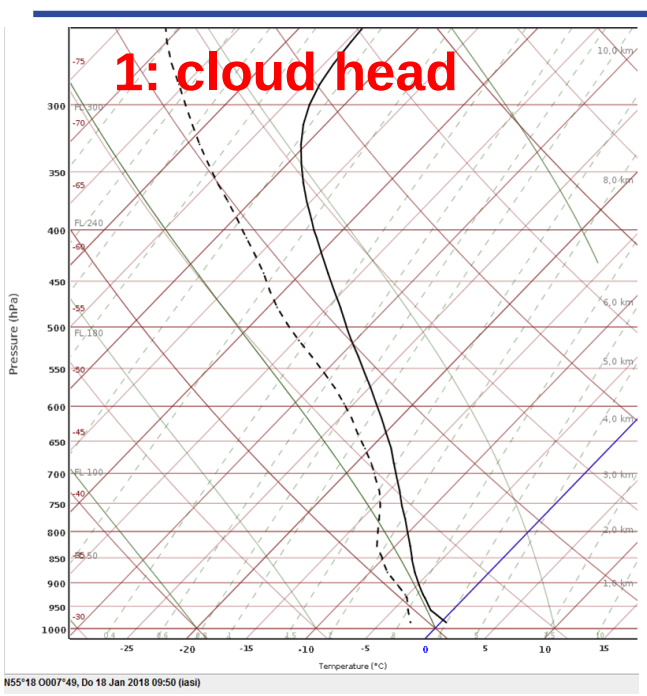
# Suomi NPP VIIRS RGB image

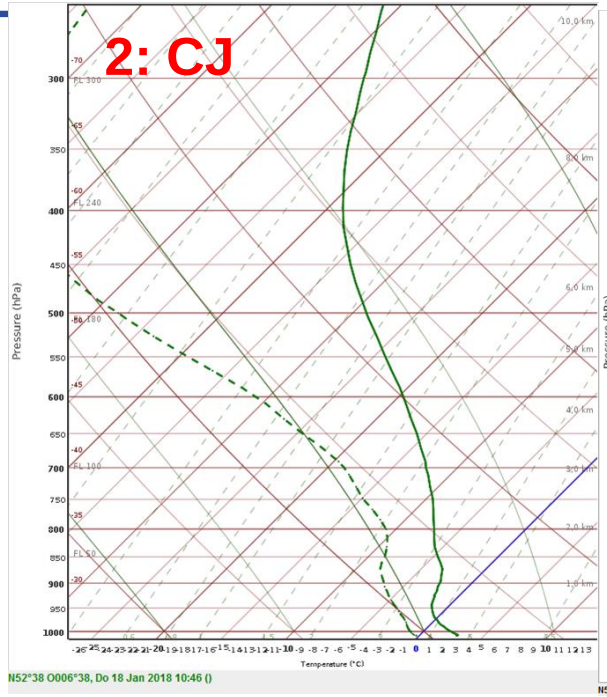


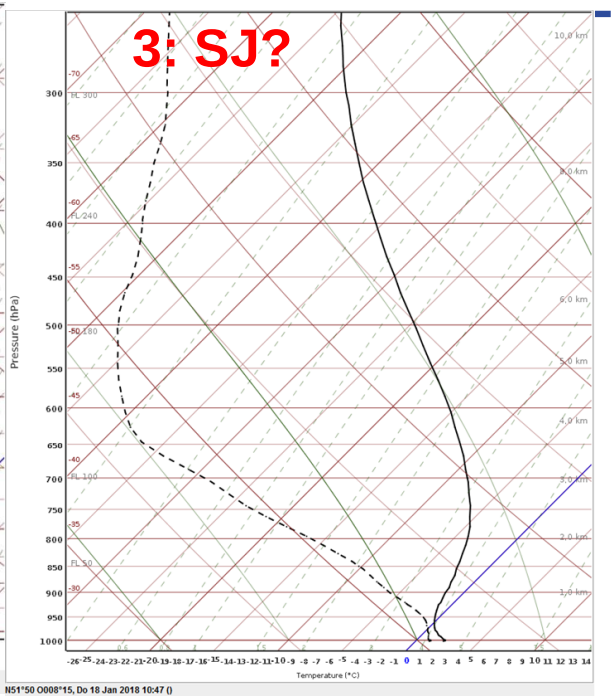


# IASI-Soundings





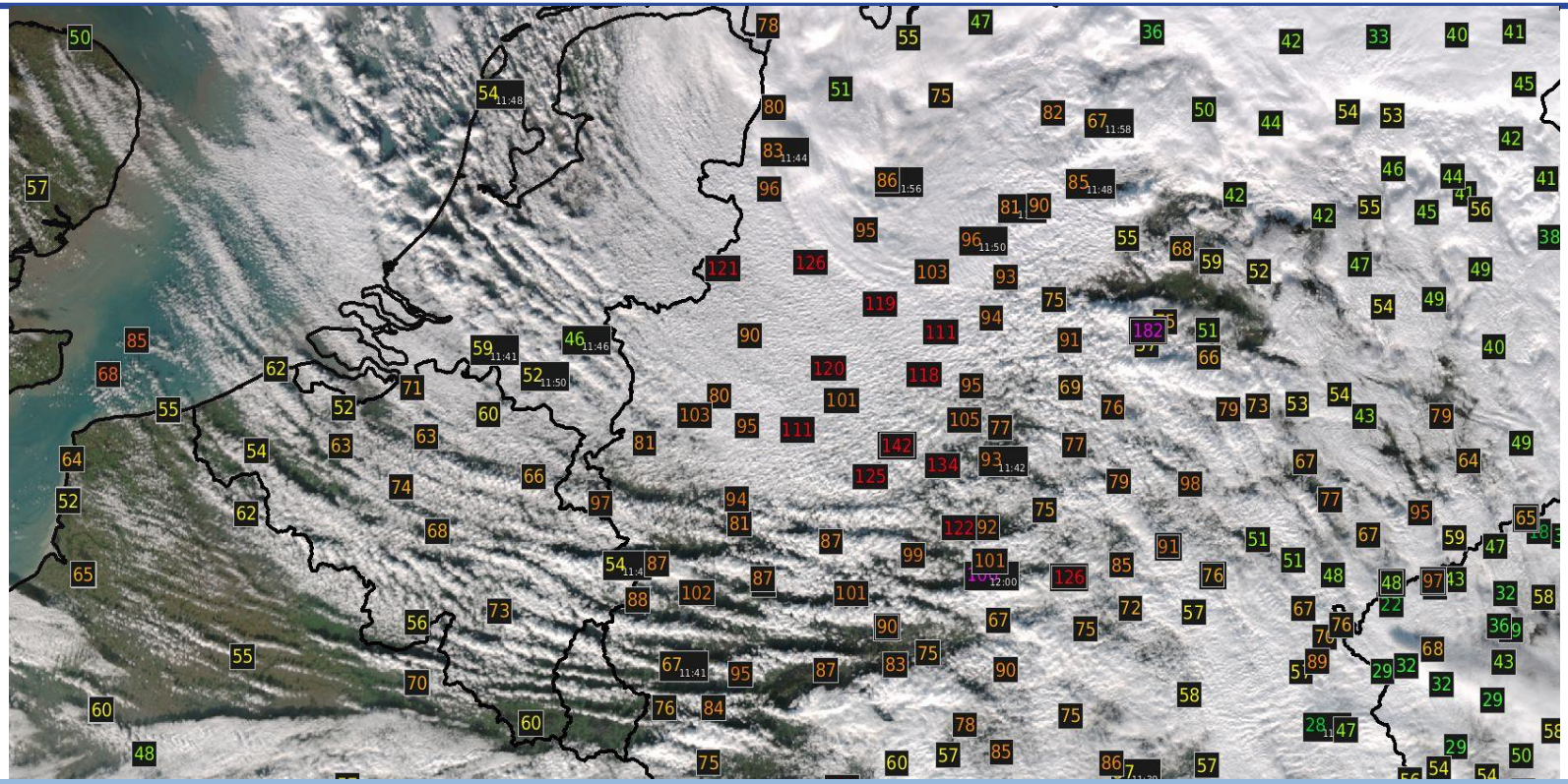




- Descending dry stratospheric air in sting jet region to top of boundary layer
  → hint for sting jet

- 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 ground
- Only the Harz was effected by the full power of the sting jet (Brocken 182 km/h)
- Strongest gusts in CJ-Region → convective rolls, cloud bands may be caused by CSI

# Conclusion Friederike



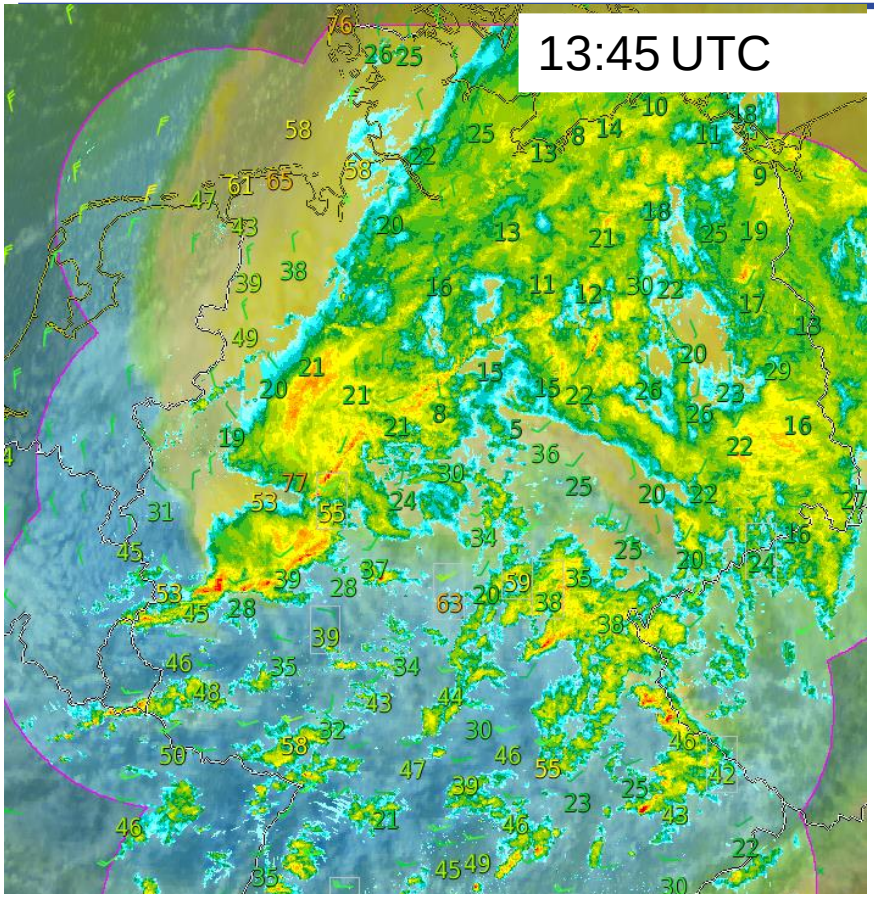
- COSMO-DE overestimated the gusts, but the stratocumulus clouds in the satellite picture gave hints that the sting jet would not reach the surface in the low lands.

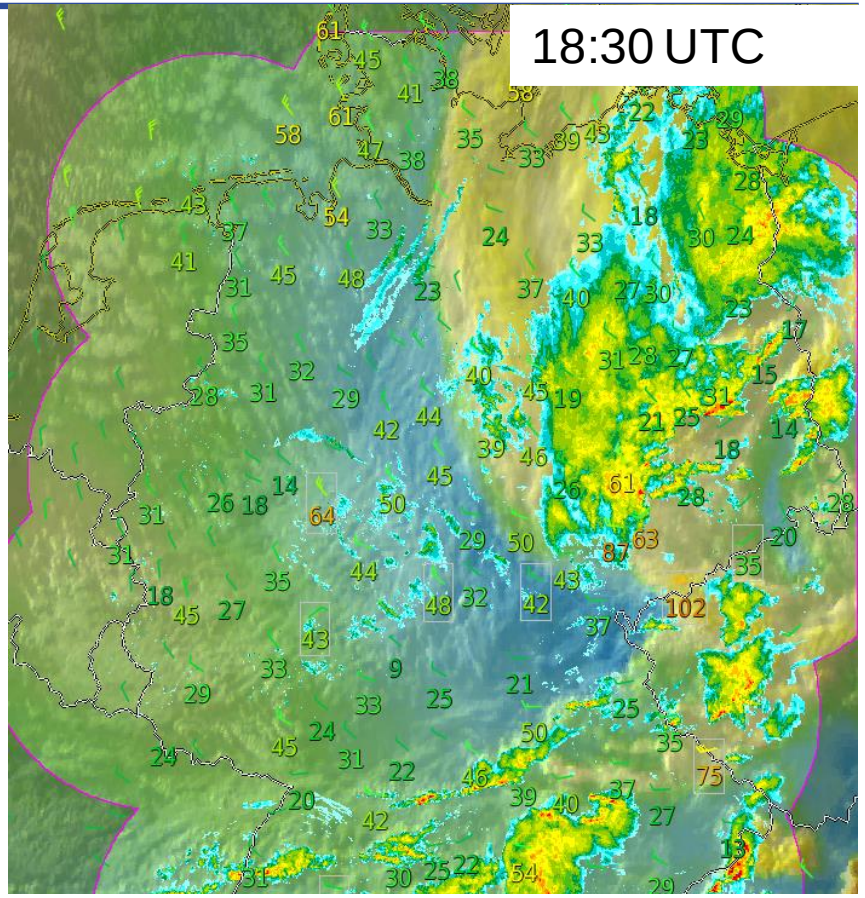
# Case Study II:

# Storm „Xavier“
# 12.07.2017

# Radar + Gusts



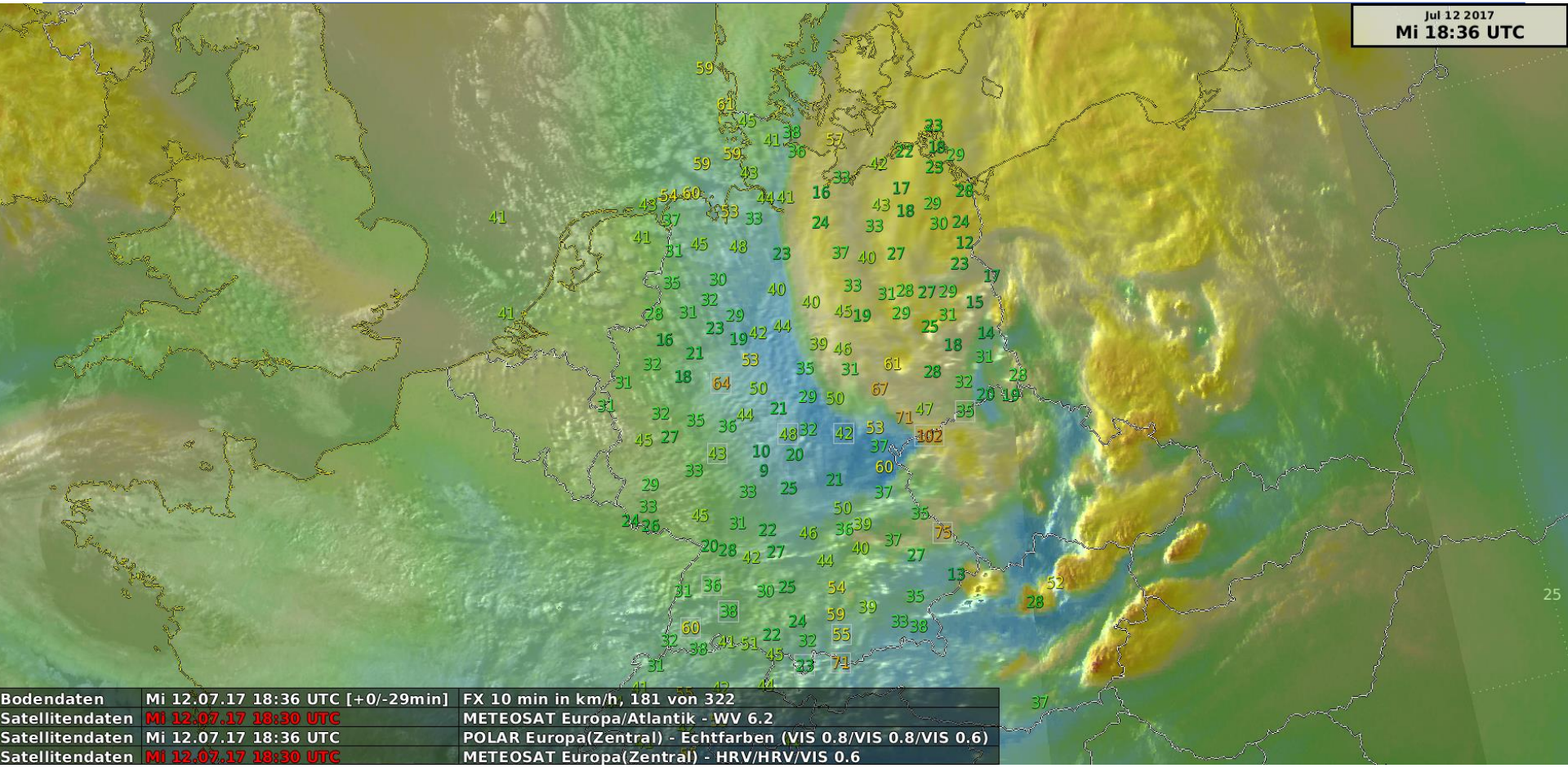



- SK cyclone with cold front crossed Germany
- Convective Line at the cold front
- Strongest gusts appeared behind the cold front at the southern flank of the cloud tip instead of the cold front area (thunderstorms)

# Water vapour sandwich and Gusts

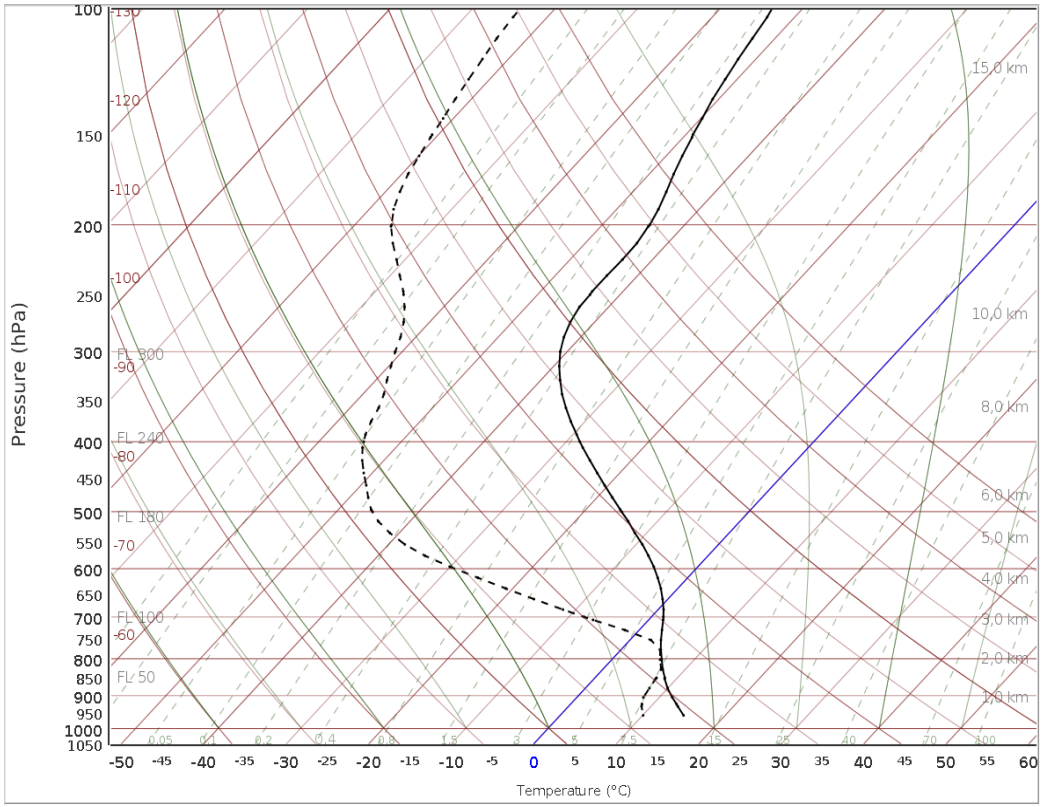
Deutscher Wetterdienst
Wetter und Klima aus einer Hand




➔ The blue colour shows dry descending stratospheric air → evaporation of clouds

# IASI-Sounding near Tip of the cloud head






- **Forecast:**
  - Wind gust up to 100 km/h were expected with the thunderstorms at the cold front.
- **Nowcasting:**
  - Only a few gusts within the thunderstorm region
  - Strongest and more wide spread gusts at tip of the cloud head
  - Stratospheric air had evaporated precipitating clouds
  - IASI sounding showed very dry air descending → cold conveyor jet

# Case Study III:

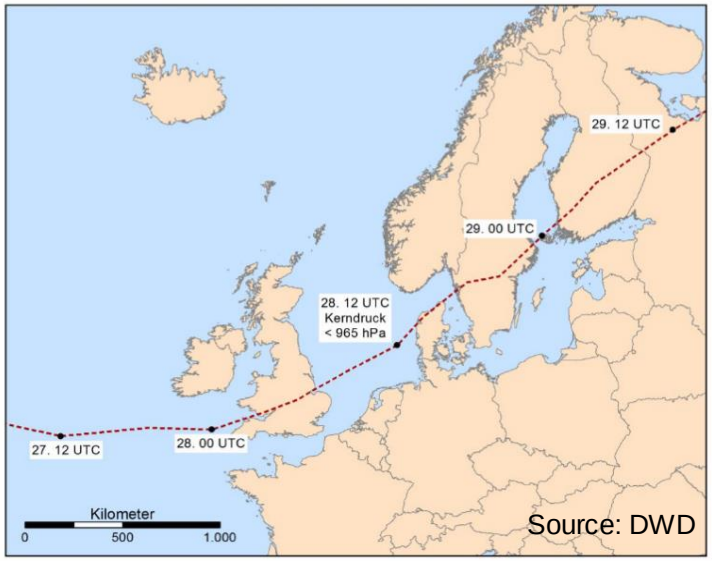
# Storm „Christian“/ St. Jude Storm

# 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.

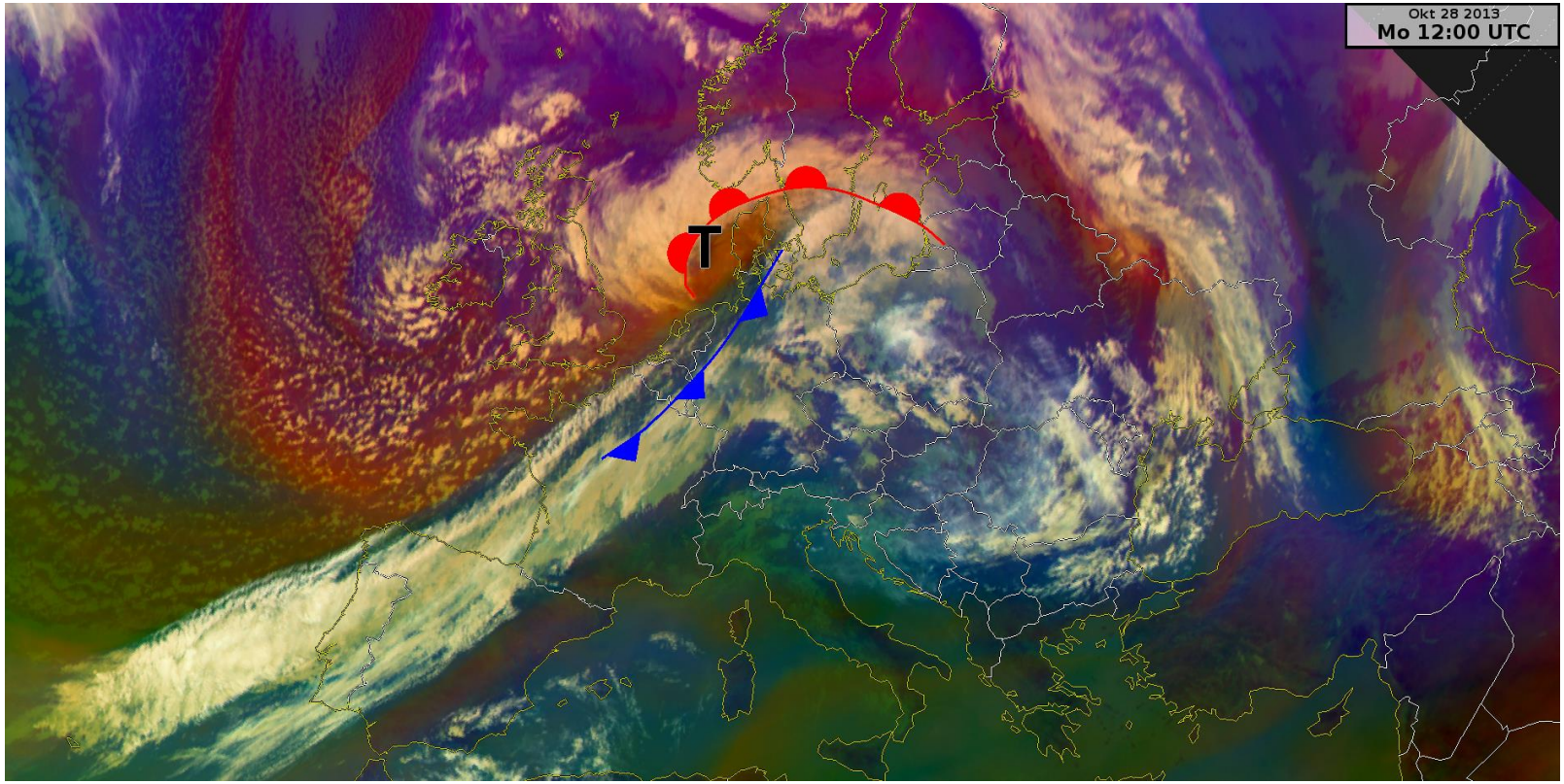




See also: https://en.wikipedia.org/wiki/St._Jude_storm

# Cyclone Christian

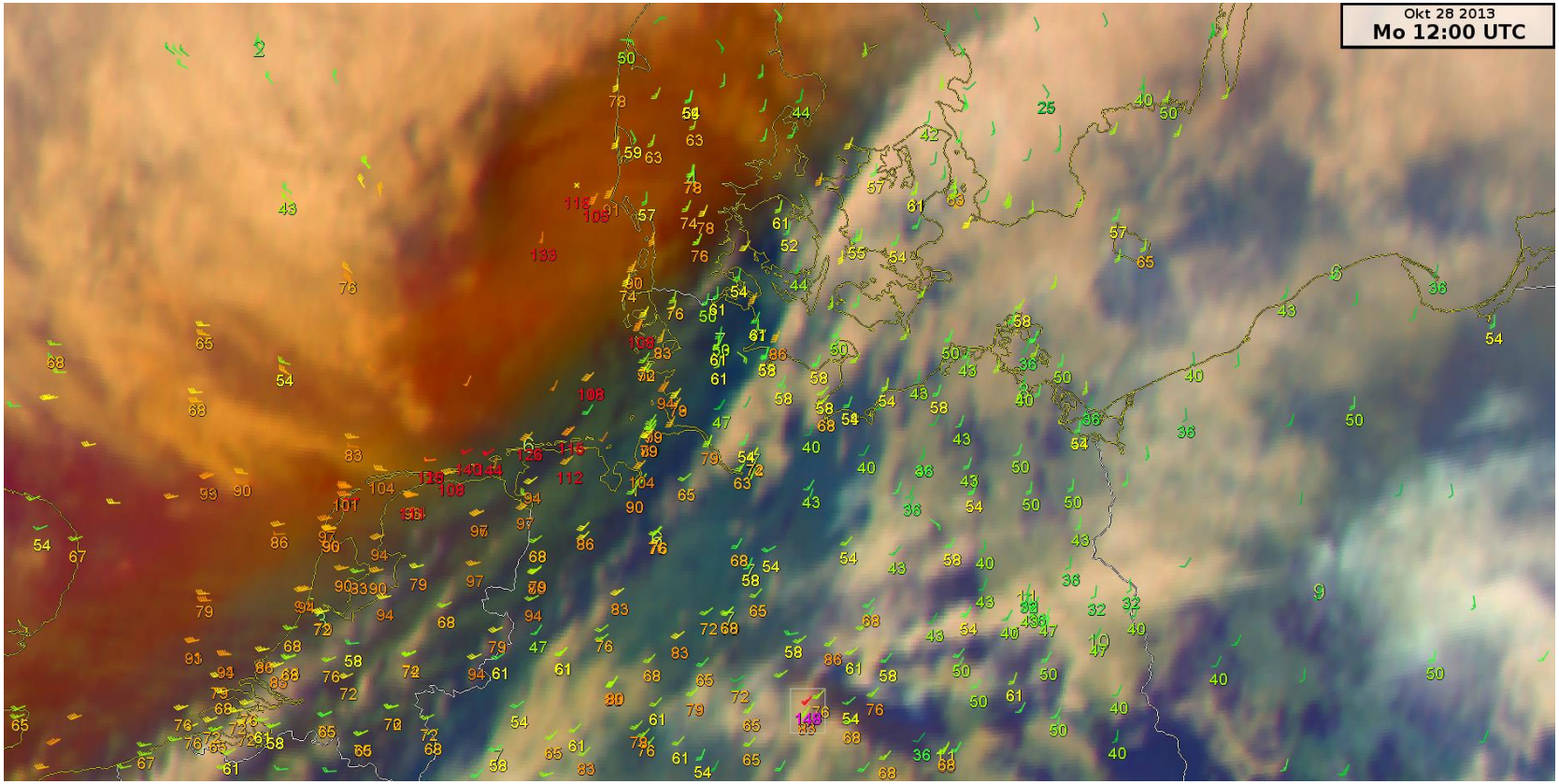





➔ The METEOSAT satellite image from Oct. 28 2013 12 UTC shows that Christian was a **Shapiro-Keyser Cyclone** and the **extremely high wind gusts** resulted from a **sting jet** that typically appears with those types of cyclones.

# Wind speeds

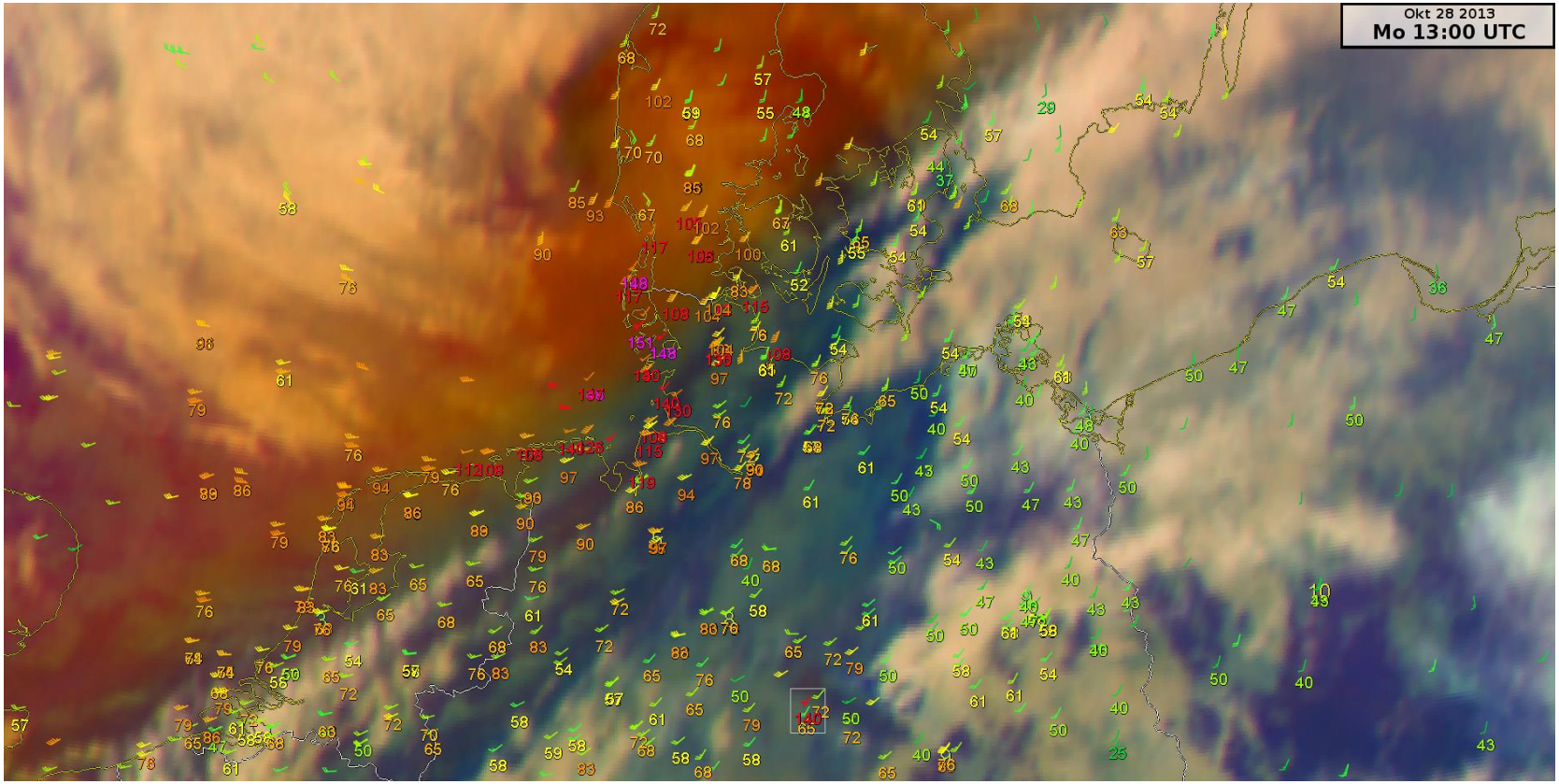





➔ In Germany the cyclone Christian caused maximum wind speeds in the time between 13 and 14 UTC over the German Bight and the west coast of Schleswig-Holstein.

# Wind speeds



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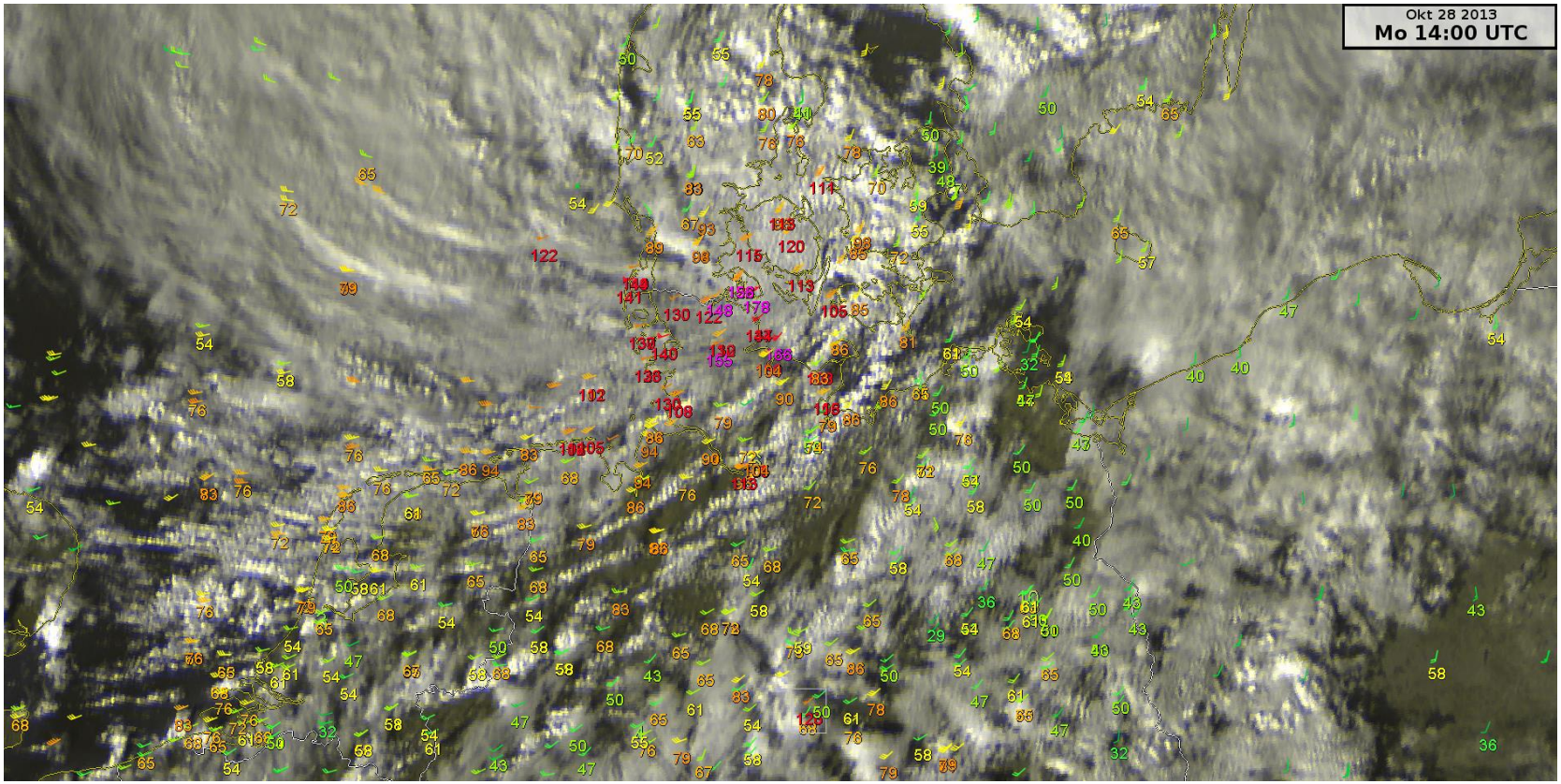
# Wind speeds



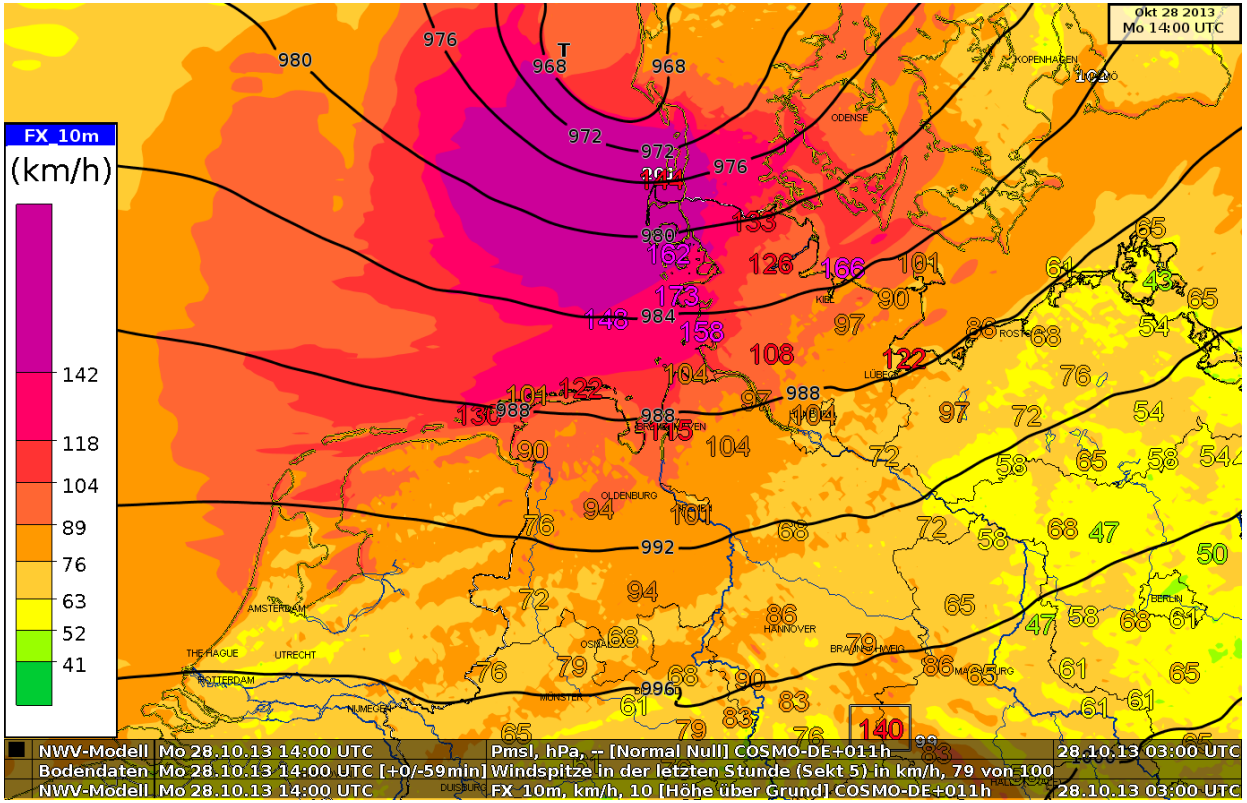



➔ In Germany the cyclone Christian caused maximum wind speeds in the time between 13 and 14 UTC over the German Bight and the west coast of Schleswig-Holstein.

# NWP Forecasts

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

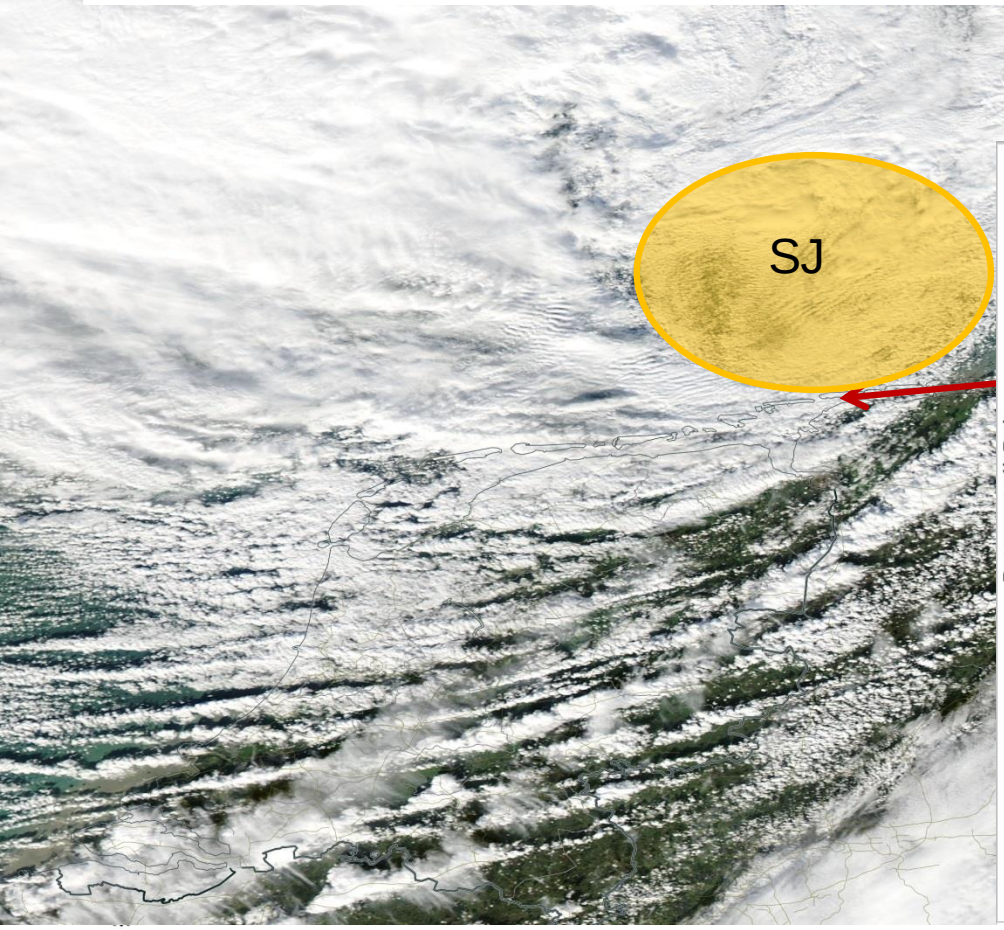
Wind gusts in km/h + pressure
Isolinien: COSMO-DE (28.10.13) 03 UTC + 11 h
Numbers: Observations (555) in km/h

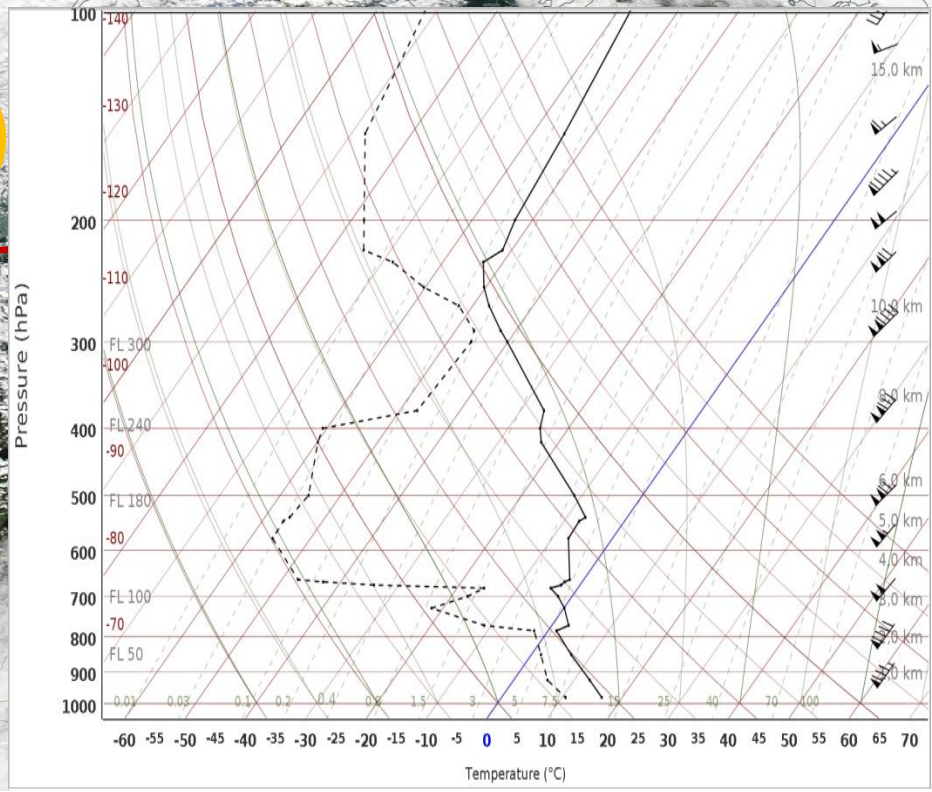



➔ The COSMO-DE wind gust forecasts 12 hours before the event were quite good. Only the sting jet and the location of the cyclone‘s centre were simulated too far north. Previous model global and regional model runs underestimated the wind gusts.

# MODIS Image 11:40 UTC and Radiosonde measurements

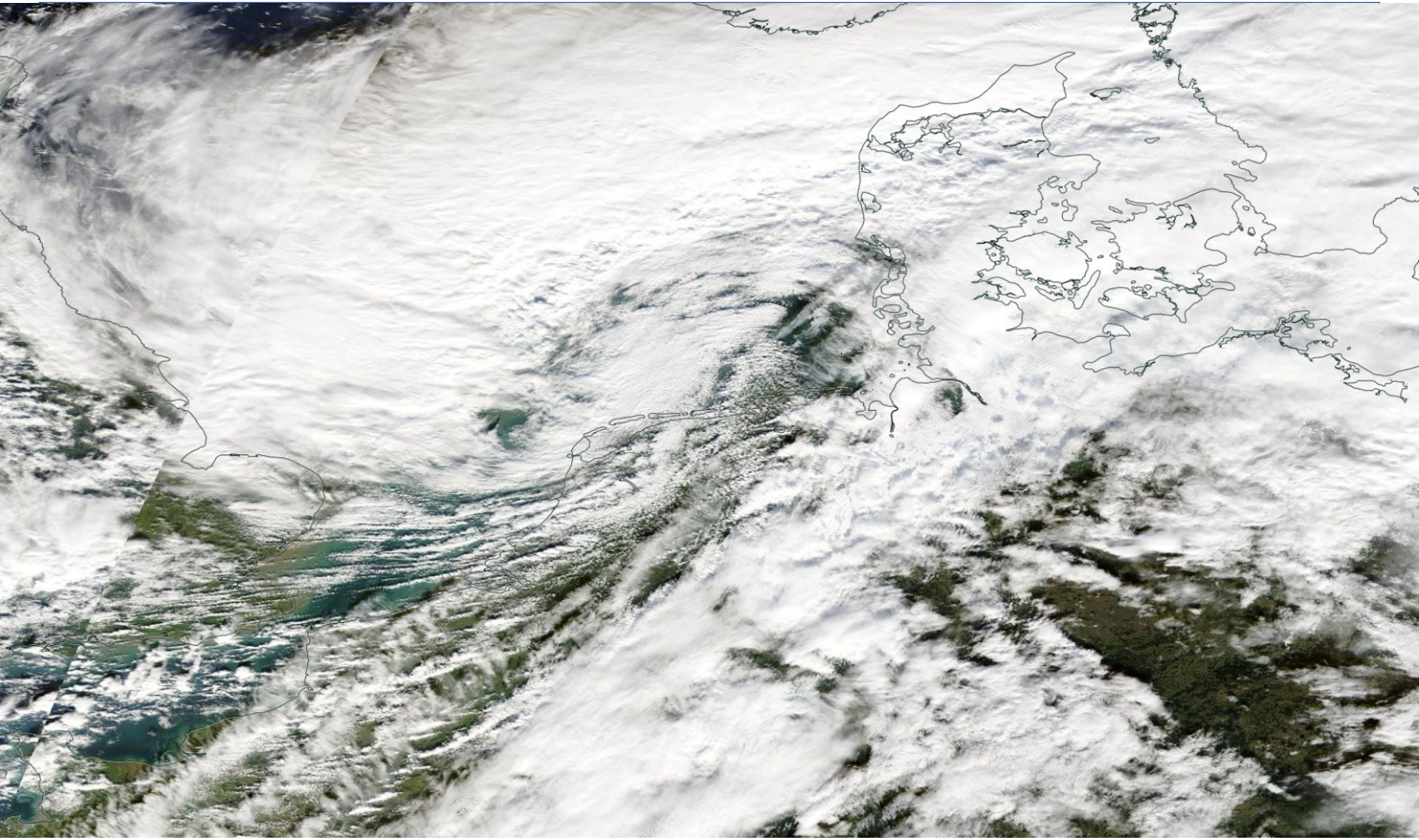
- The RAOB profile from the station Norderney at 12 UTC a little bit south of the sting jet shows the stratospheric air which had subsided until 800 hPa. Such a atmospheric layering is rarely observed.
- Conditional unstable layering in boundary Layer → momentum can easily transferred downward



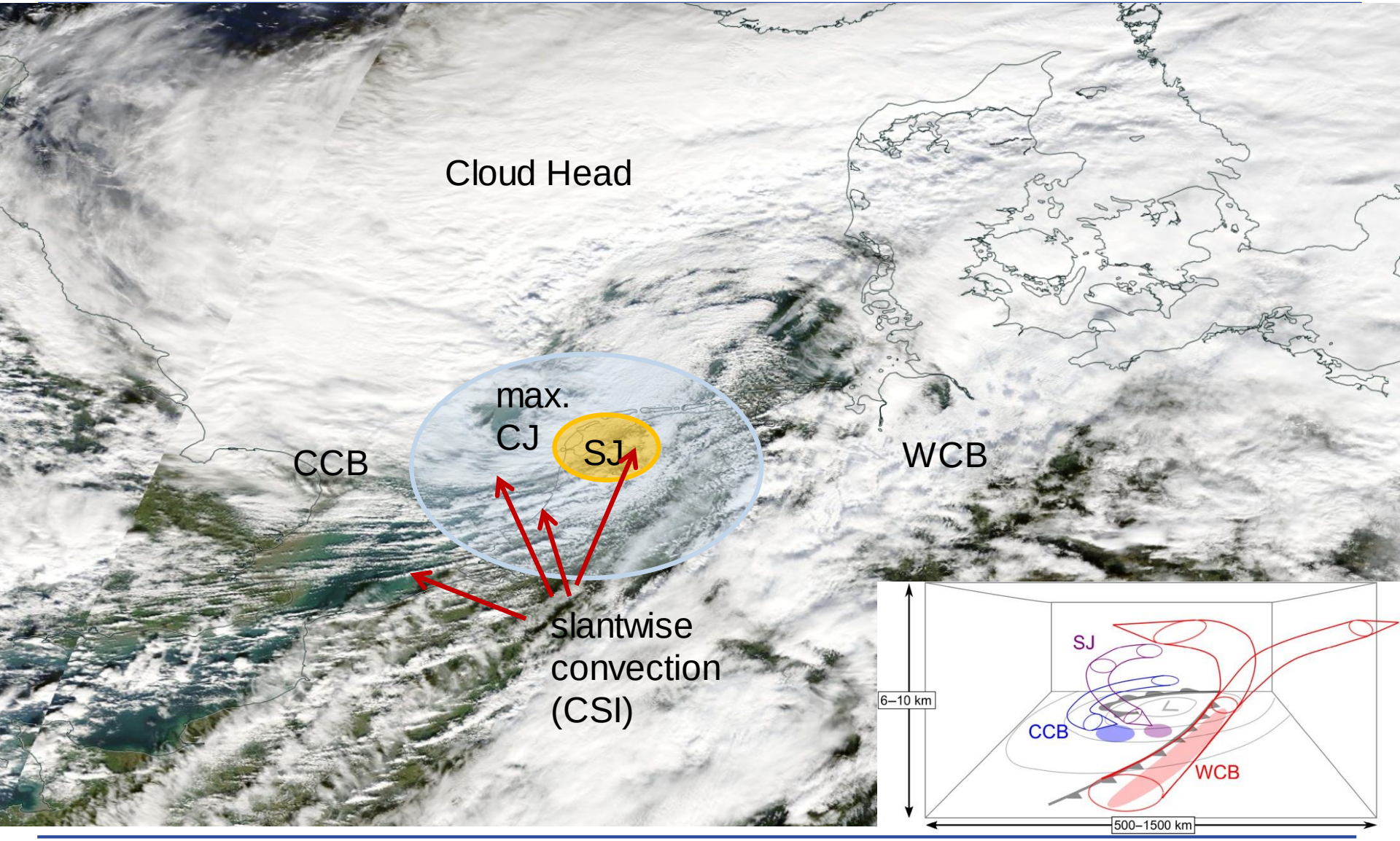
# MODIS image around 10:20 UTC





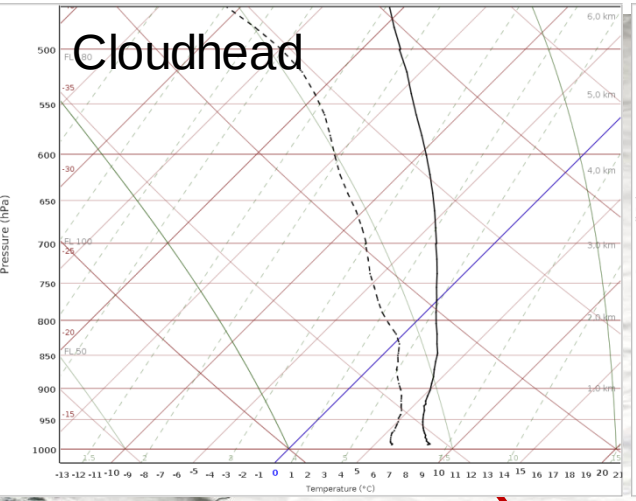
# MODIS image around 10:20 UTC

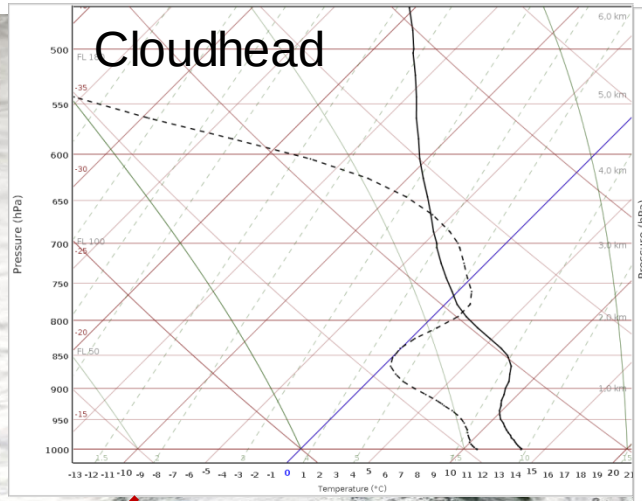


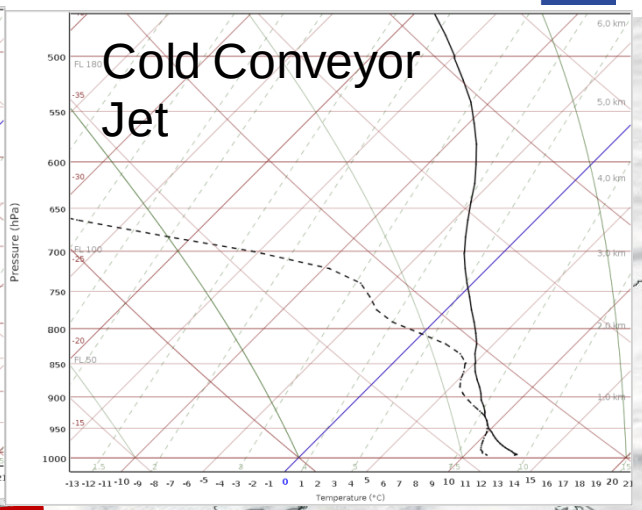


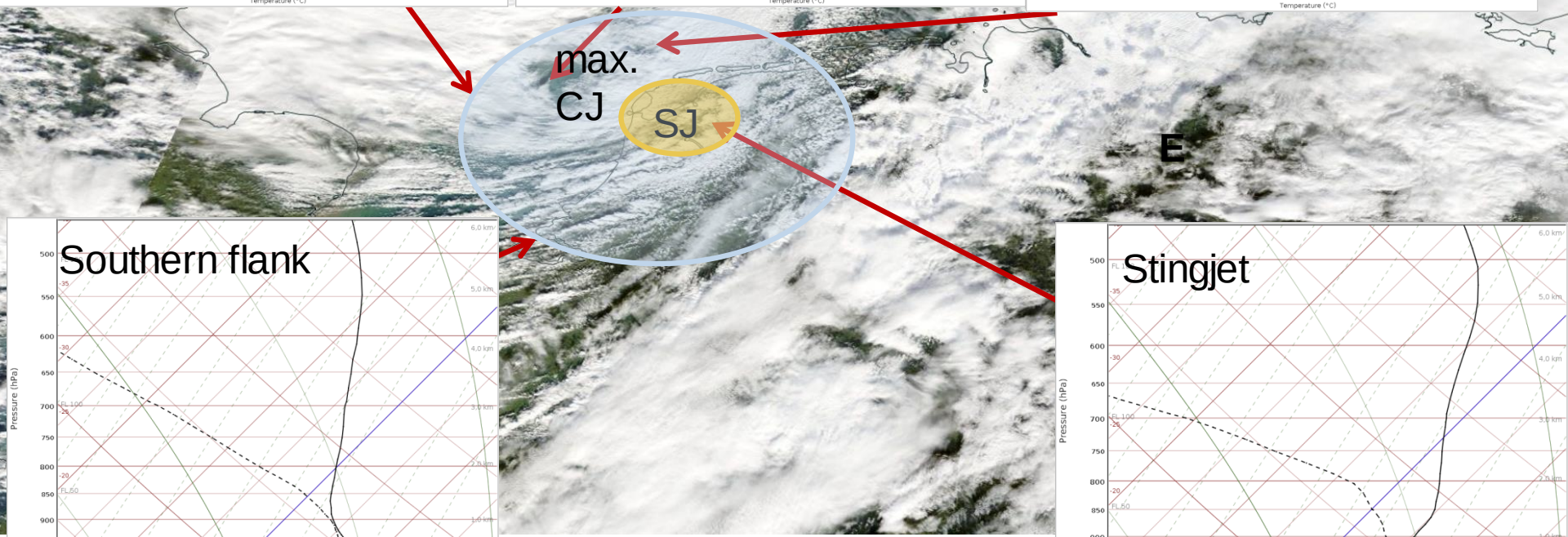
# IASI Profiles

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



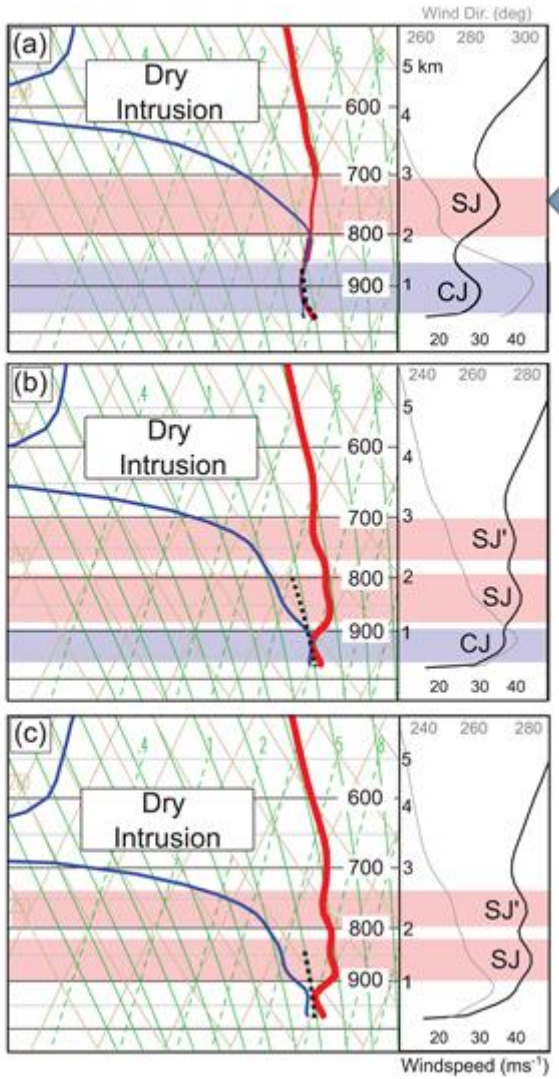



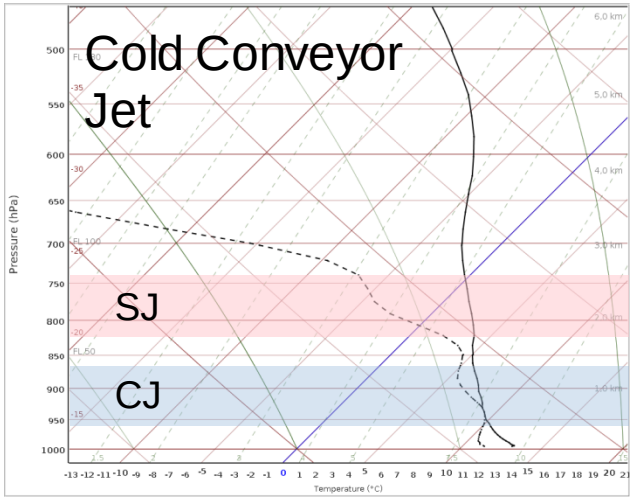



# Modell and IASI Sounding Boundary-Layer

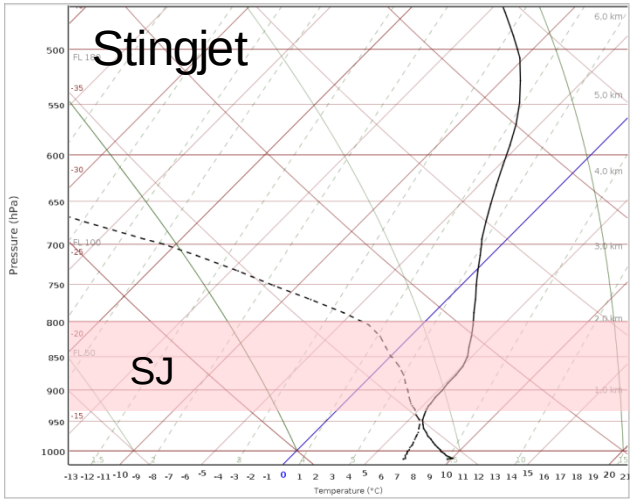





Browning et. al. 2015:
03:15 UTC Hi-Res-WRF-Modell
(120 – 240 m vertical spacing) near Sting Jet




IASI-Sounding ~10:20 UTC in Sting Jet



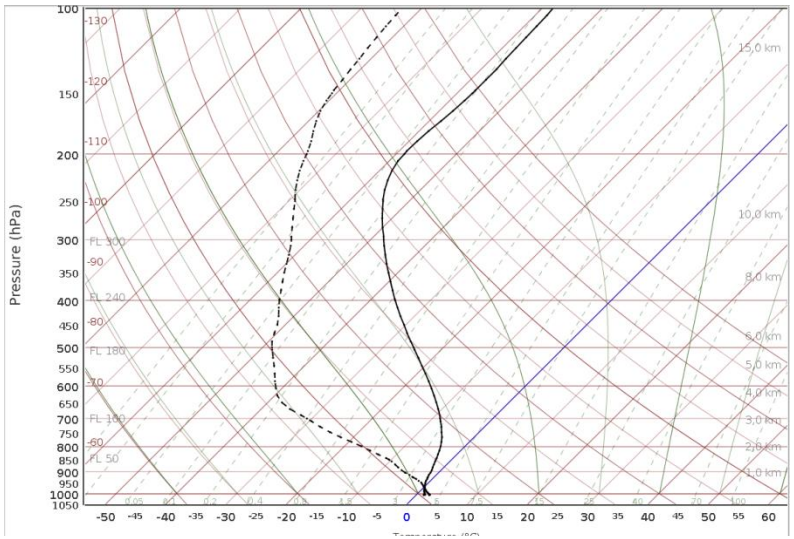
# IASI L2 Profiles



➔ 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

# Conclusion Storm Christian



- DWD‘s global (GME) and regional (COSMO-EU and COSMO-DE) NWP forecasts indicated wind gust of more than 140 km/h. In such extreme situations, the forecaster does not know how much he/she can trust those forecasts. Clearly, no one thought of wind speeds of 180 km/h at the time.

- **The IASI L2 soundings show impressively that dry stratospheric air was dragged down to the top of a very shallow boundary layer. Together with the satellite images this would have given a indication for the formation of a sting jet** and thus an **independent** information to the NWP forecasts.

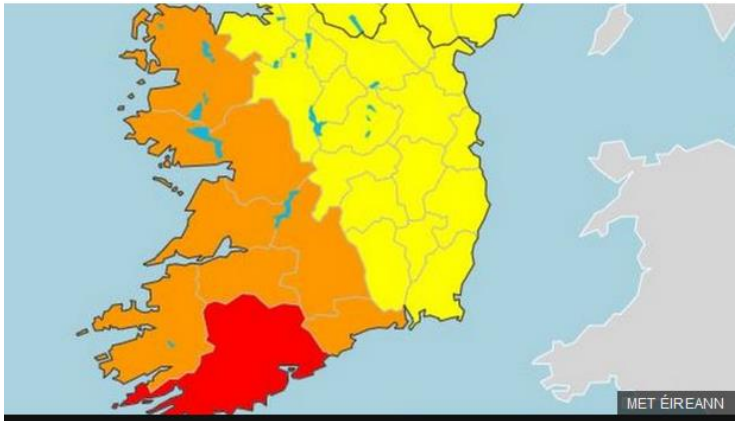
- As **additional information** the **cross section of the potential temperature and specific humidity along the CCB** as well as **sounding information one hour later (possible with MTG IRS)** when the sting jet had his full power would be helpful.

# Case Study IV

# Storm Ellen

# 20.08.2020

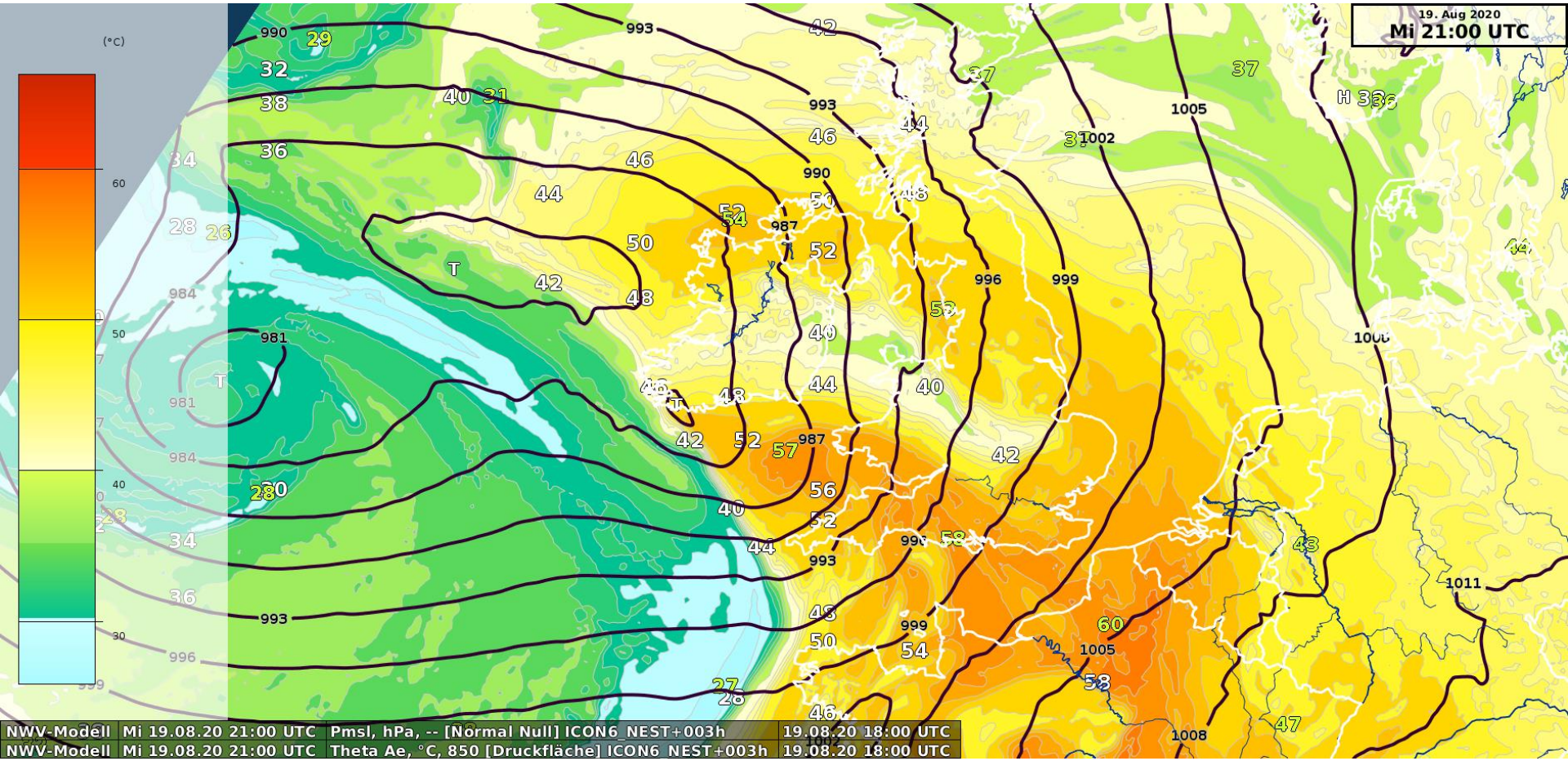
- Formed over the atlantic, including the remenants of Hurrican „Kyle“
- Unsesionably strong storm → fallen trees, powerdisruption
- Over 194.000 homes were left without power
- New mean wind speed records for the month August in Ireland



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

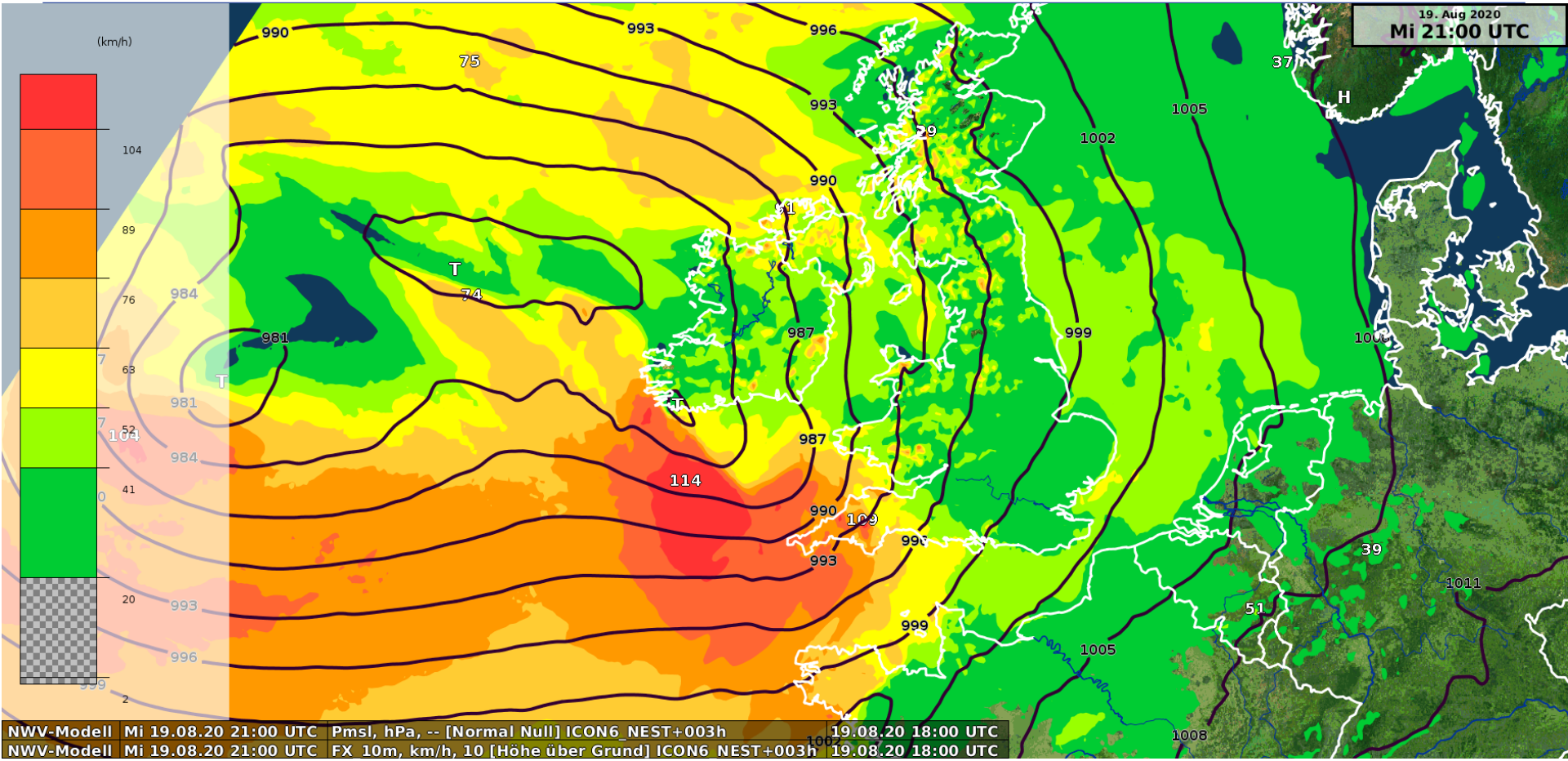
# ICON-18z+3h-Forecast MSLP+850 hPa -ThetaE

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



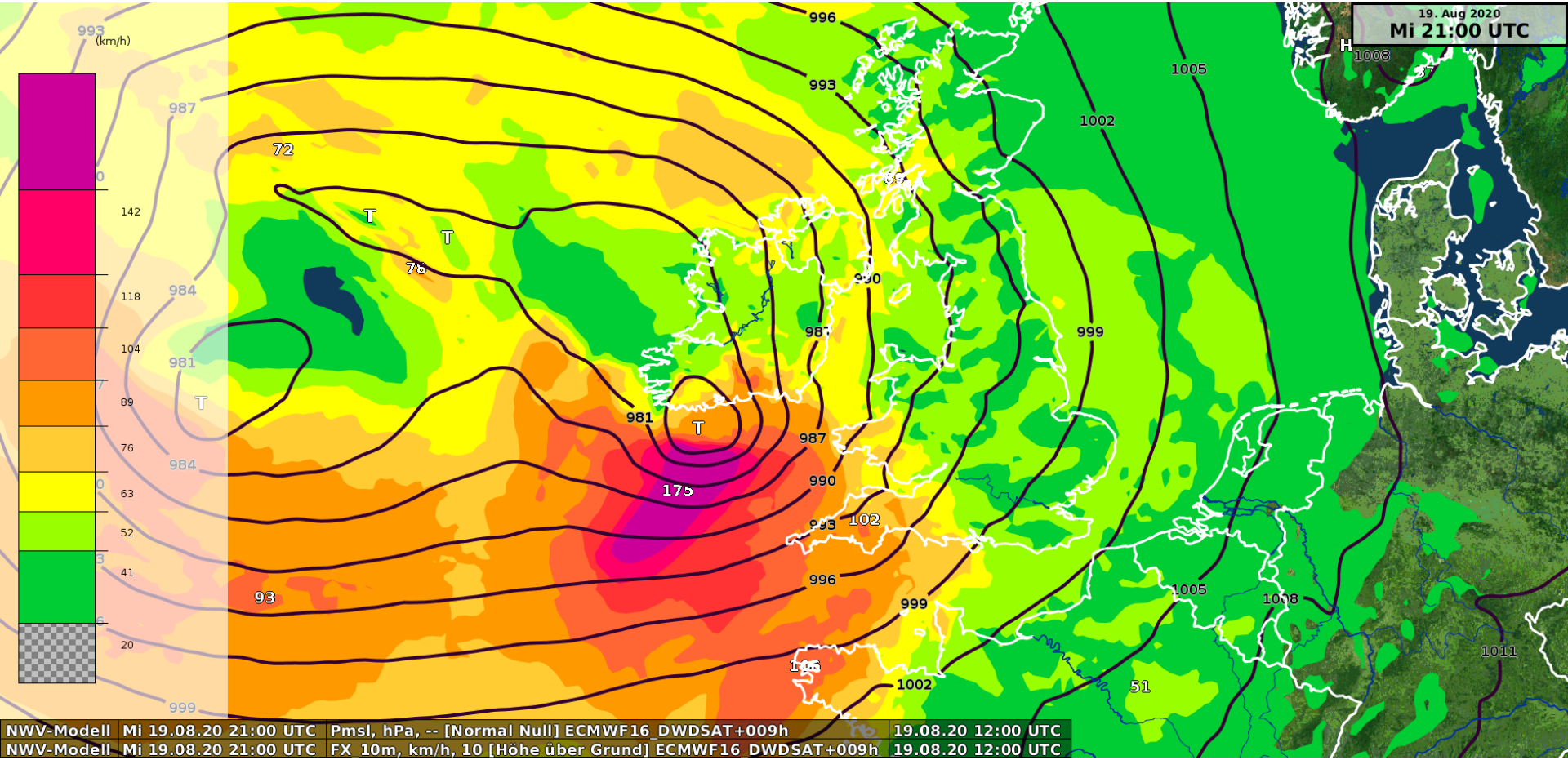
# ICON-18z+3h: MSLP+Maximum Gusts

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



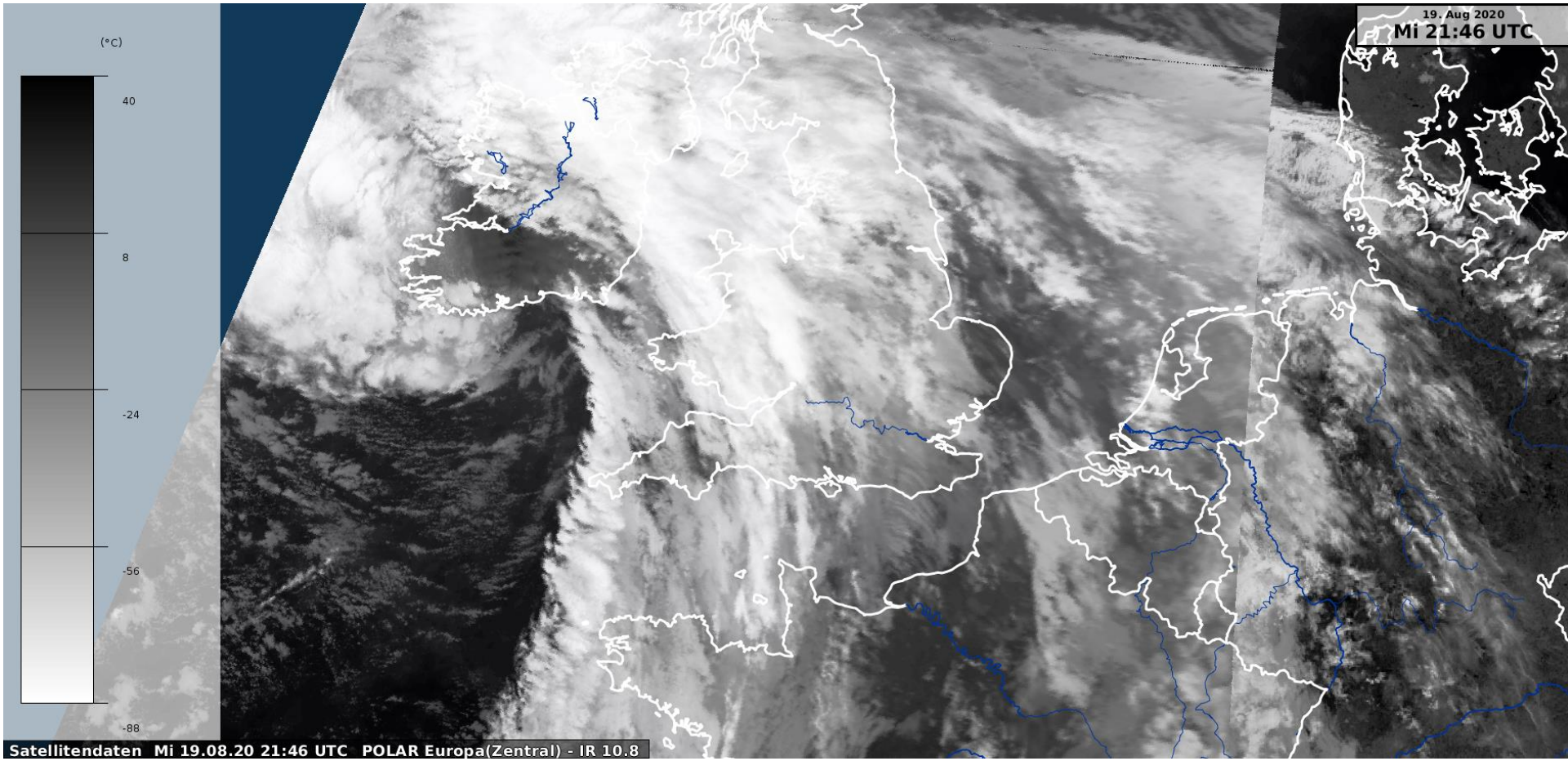
# ECMWF12z+9h: MSLP+Maximum Gusts

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



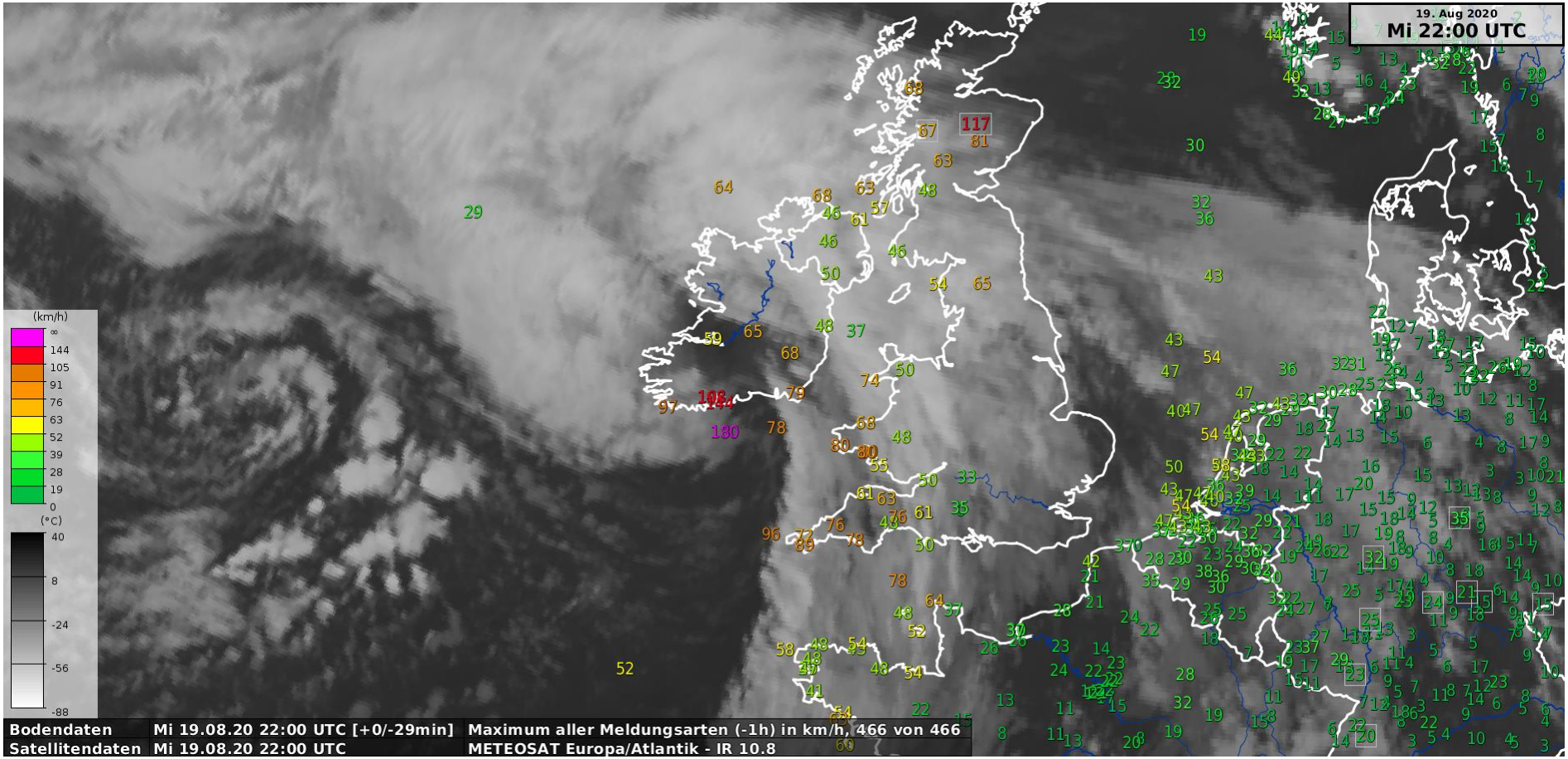
# NOAA IR




(°C)
40
8
-24
-56
-88
19. Aug 2020
Mi 21:46 UTC
Satellitendaten Mi 19.08.20 21:46 UTC POLAR Europa(Zentral) - IR 10.8

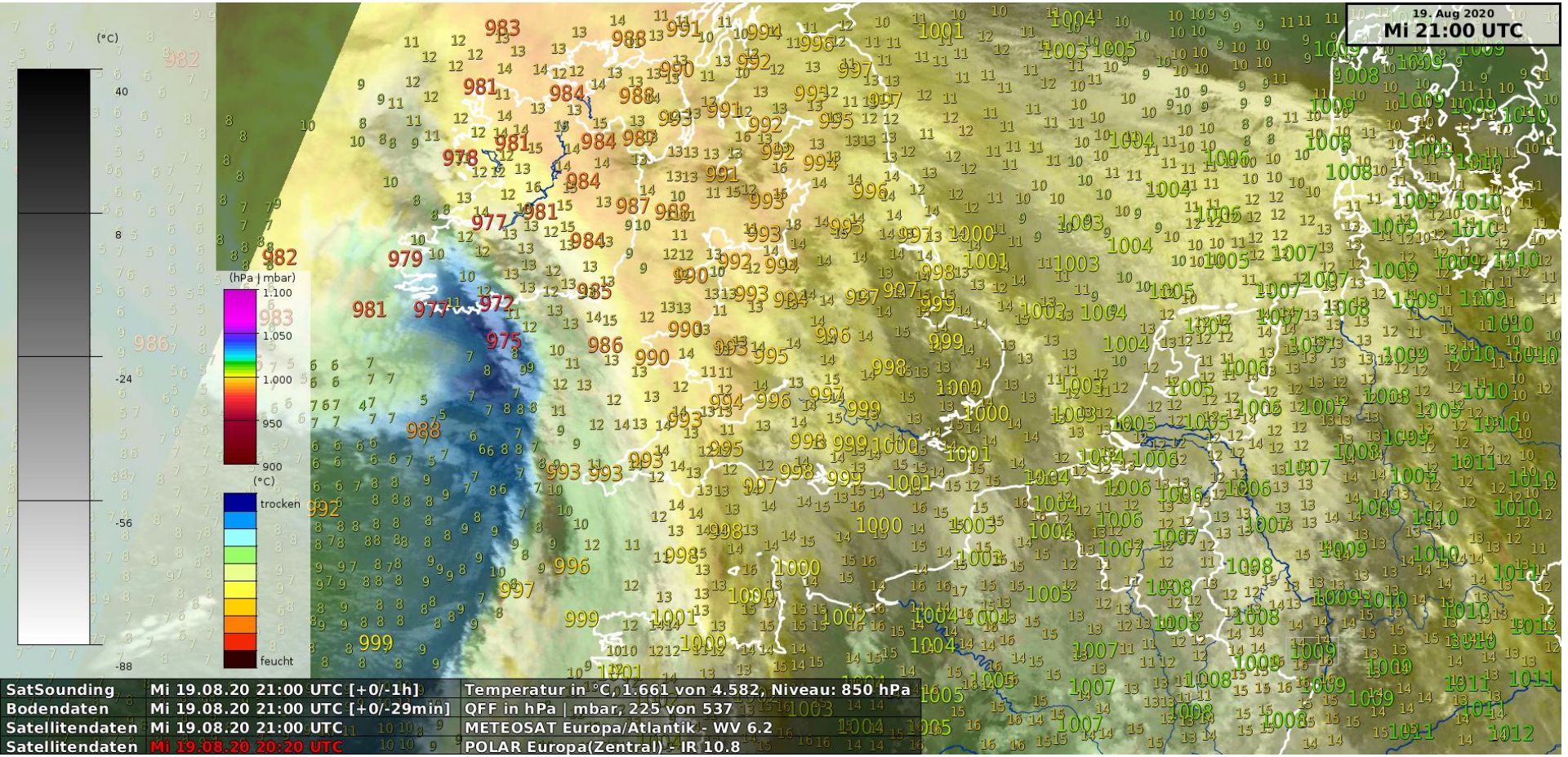
# Meteosat IR Image + Wind Gust

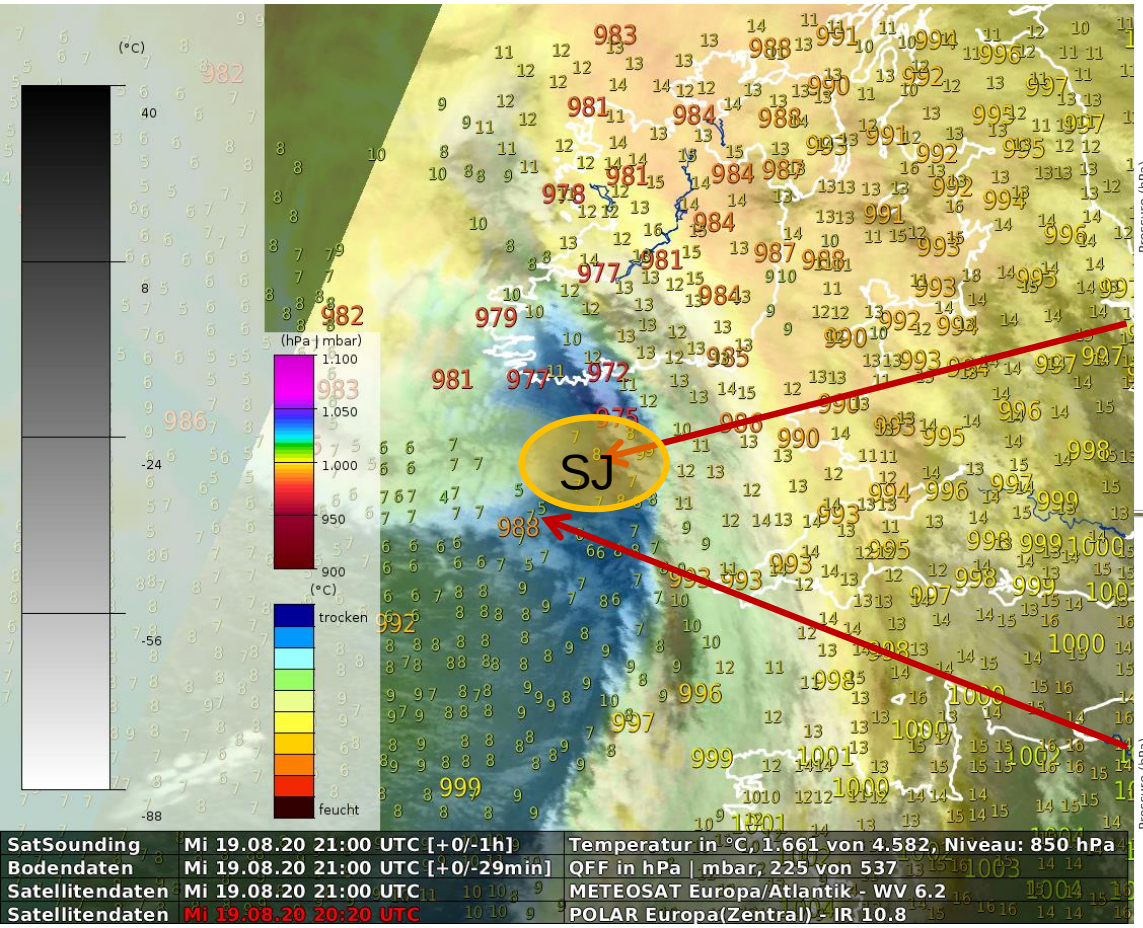
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

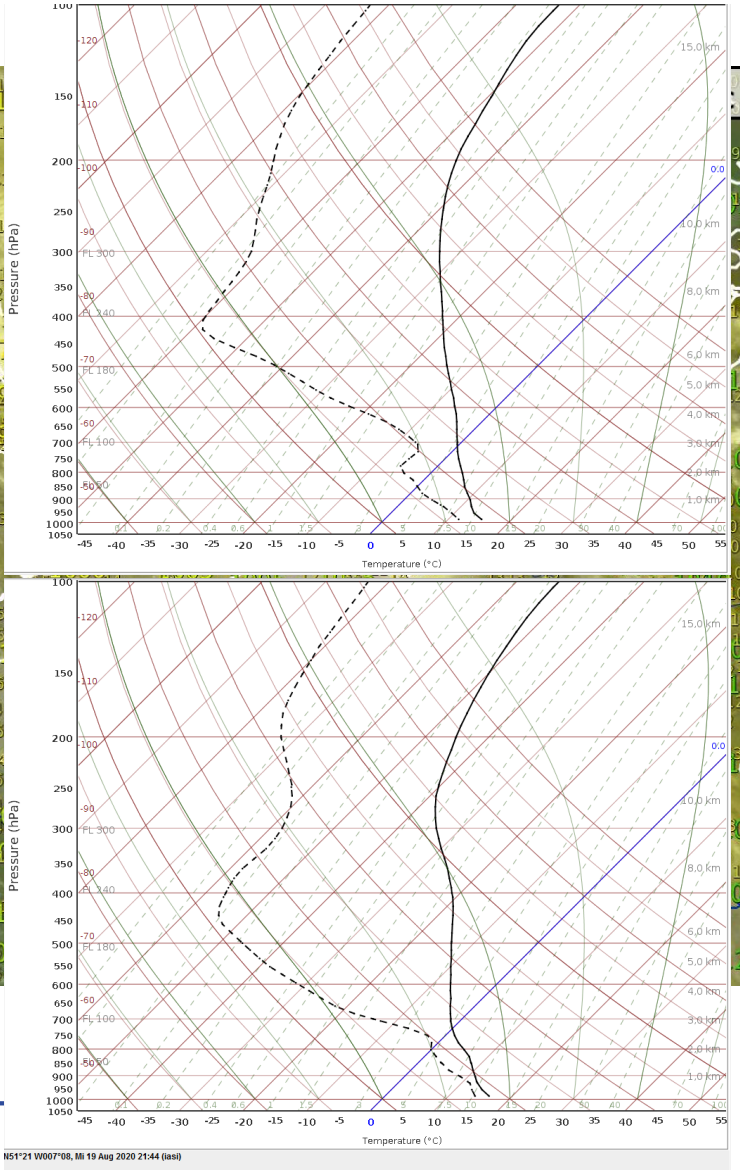


# Water Vapour Sandwich/ MSLP+ $T_{850}$ IASI

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

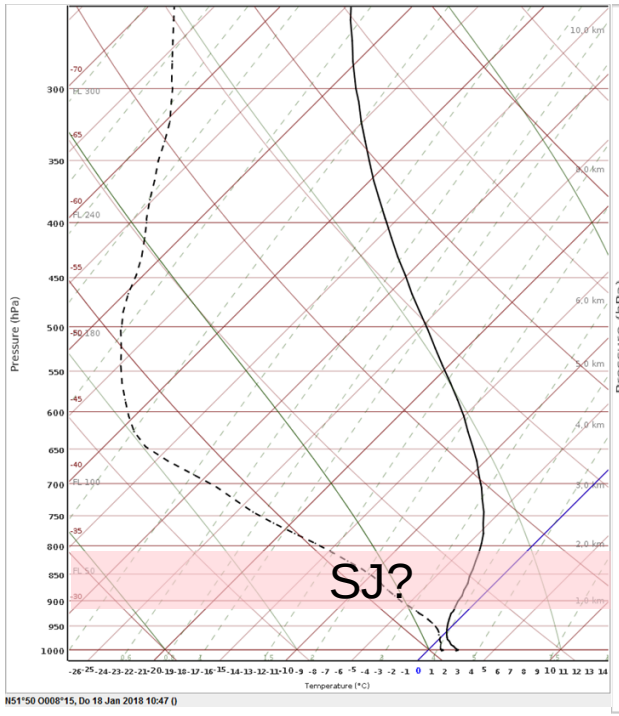



(°C)
40
8
-24
-56
-88
(hPa | mbar)
1.100
1.050
1.000
950
900
(°C)
trocken
feucht
SJ
SatSounding | Mi 19.08.20 21:00 UTC [+0/-1h] | Temperatur in °C, 1.661 von 4.582, Niveau: 850 hPa
Bodendaten | Mi 19.08.20 21:00 UTC [+0/-29min] | QFF in hPa | mbar, 225 von 537
Satellitendaten | Mi 19.08.20 21:00 UTC | METEOSAT Europa/Atlantik - WV 6.2
Satellitendaten | Mi 19.08.20 20:20 UTC | POLAR Europa(Zentral) - IR 10.8

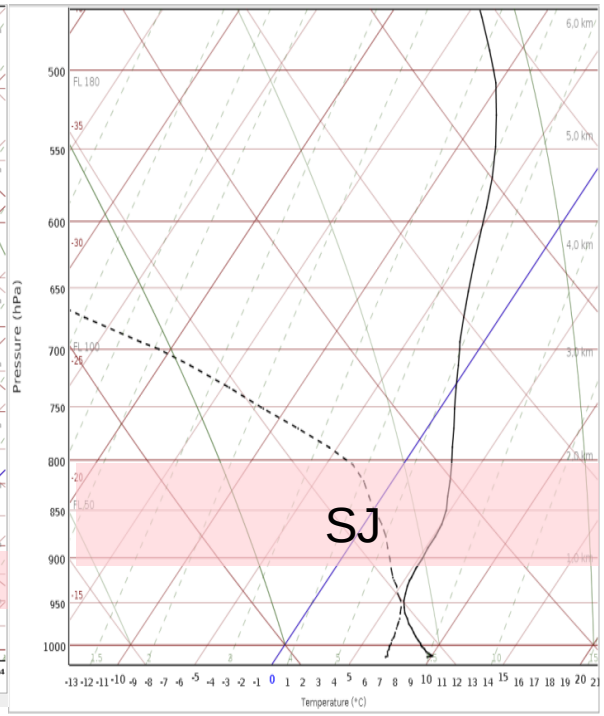

Pressure (hPa)
Temperature (°C)
N51°21 W007°08, Mi 19 Aug 2020 21:44 (iasi)

# Summary

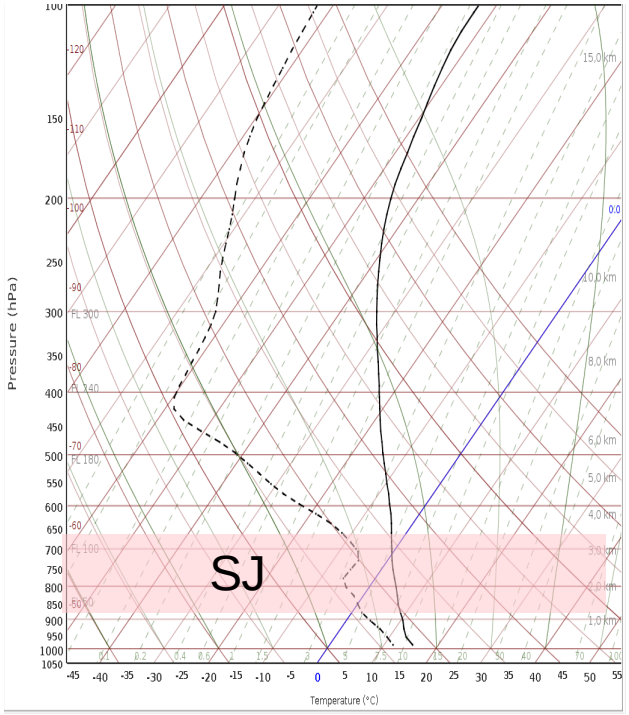




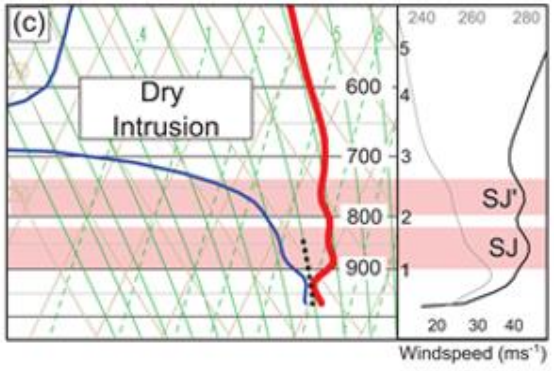

Dave/Frederike




Christian




Ellen



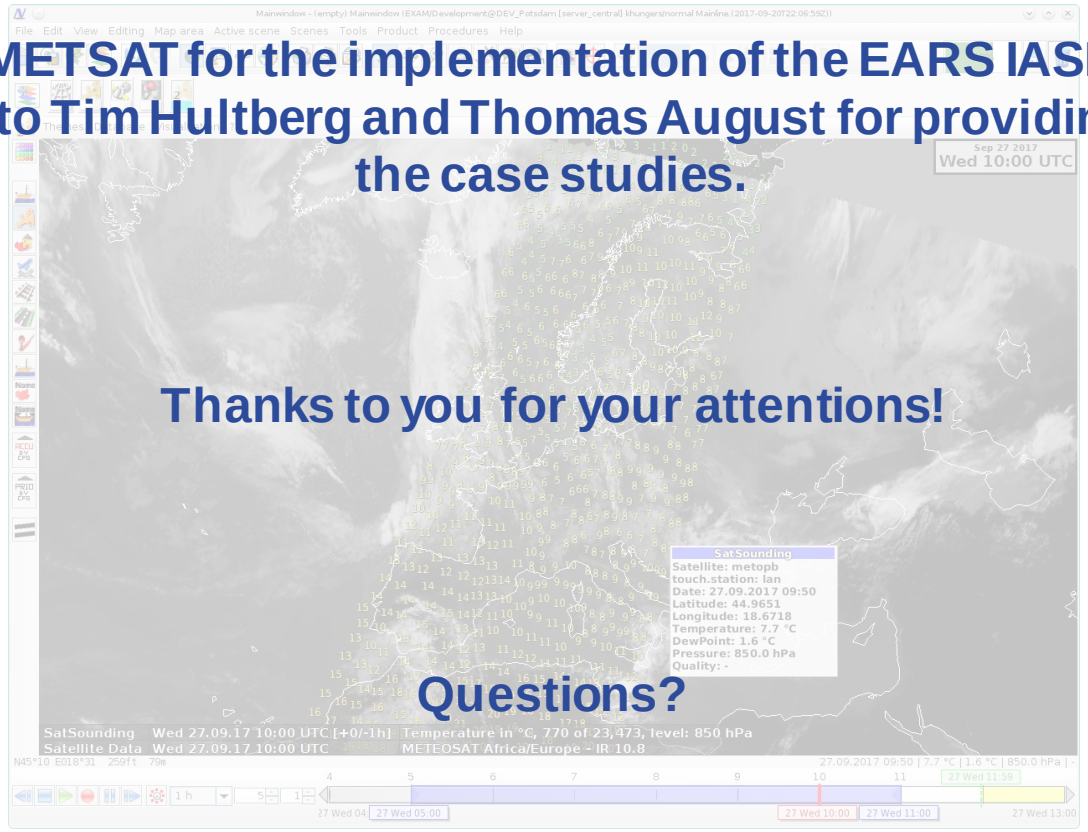
# Summary



- Rising early warnings is a main forecaster task. Due to the better timeliness, EARS IASI L2 products are of great interest.
- All four case studies showed the usefullness 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). Hence, it should not contain any NWP information.
- More experiences with IASI profiles are needed.

# Use of EARS-IASI profiles for Nowcasting

**We thank EUMETSAT for the implementation of the EARS IASI L2 Service. A great thanks to Tim Hultberg and Thomas August for providing the data for the case studies.**




**Thanks to you for your attentions!**

**Questions?**

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German Weather Service (DWD)