Operational Temperature and Humidity sounding from EUMETSAT hyperspectral missions

International Symposium Tropospheric Profiling 2019, Météo-France, Toulouse

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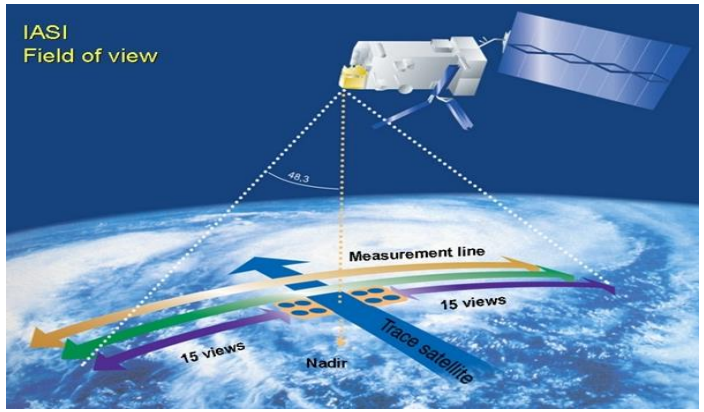
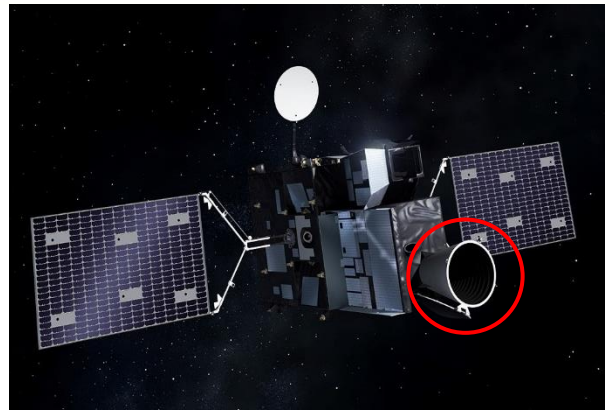
Outline

- EUMETSAT hyperspectral missions *(current and future)*
- T/q profiles + quality indicators, validation results
- EARS-IASI L2 Regional service
- Use in nowcasting:
  - Dialog with forecasters, ongoing studies
  - Preparing for future missions
  - Consolidate requirements

EUMETSAT hyperspectral sounders

EPS EPS-SG MTG

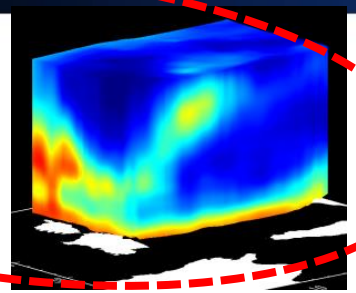


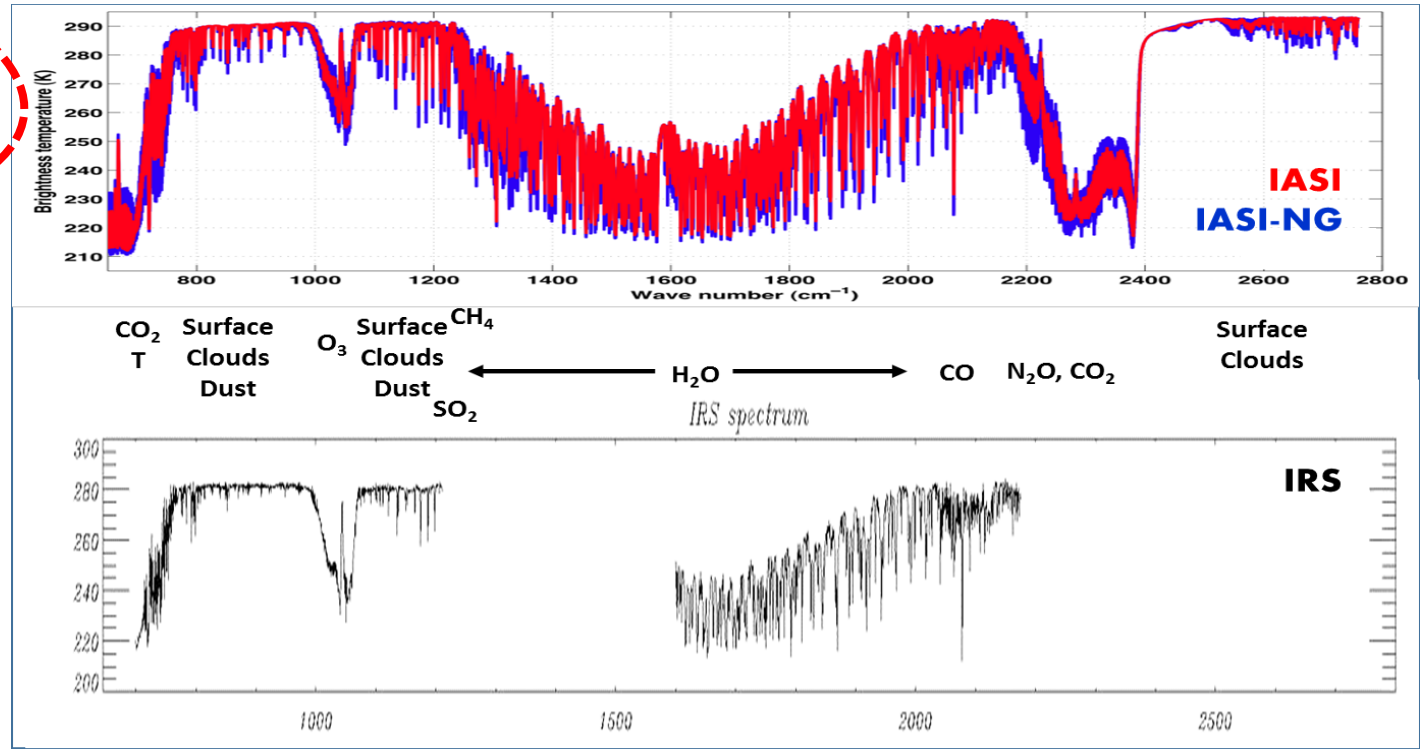


IASI	IASI-NG		MTG-IRS
Low-Earth orbit sun-synchronous (~820km)		**Orbit**	**Geo**stationnary
2x2	4x4	**Sensor**	160x160
12 km	12 km	**Spatial (Nadir)**	4 km
0.25 cm^{-1}	0.125 cm^{-1}	**Spectral sampling**	~0.6 cm^{-1}
2x / day	2x /day	**Temporal**	Every 30 min Europe
Metop-A 19 October 2006 Metop-B 17 September 2012 Metop-C 06 November 2018	2022		2023

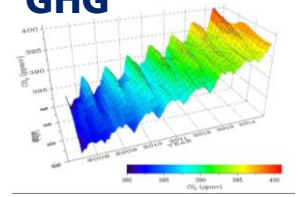
The hyperspectral sounding Swiss knife

Temperature, Humidity profiles





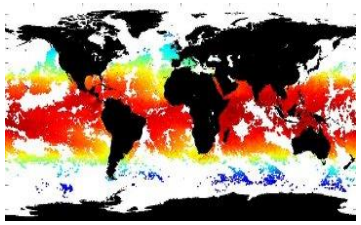
GHG



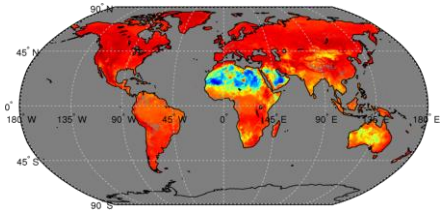
Cloud mask, fraction, top height

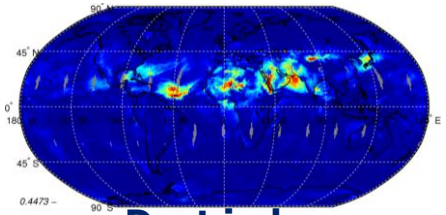
SO_2

Sea surface temperature

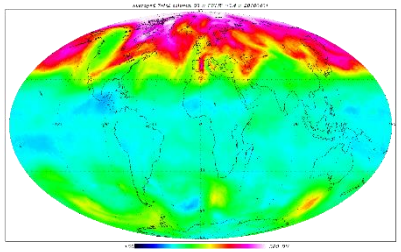


Land surface temperature and emissivity

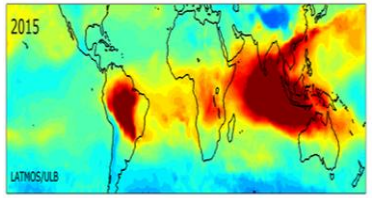




Dust index

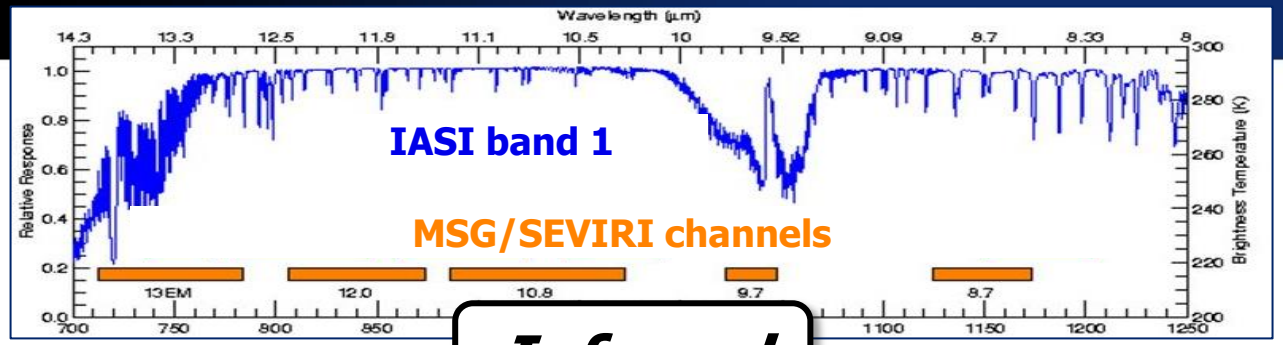


Ozone

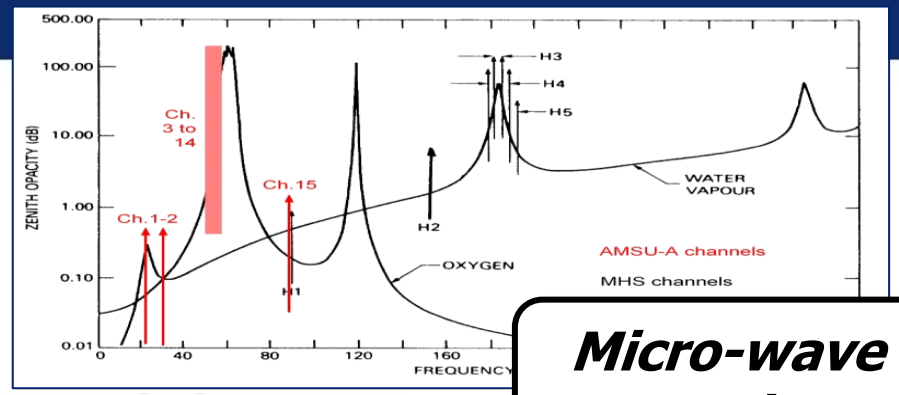


Carbon monoxide

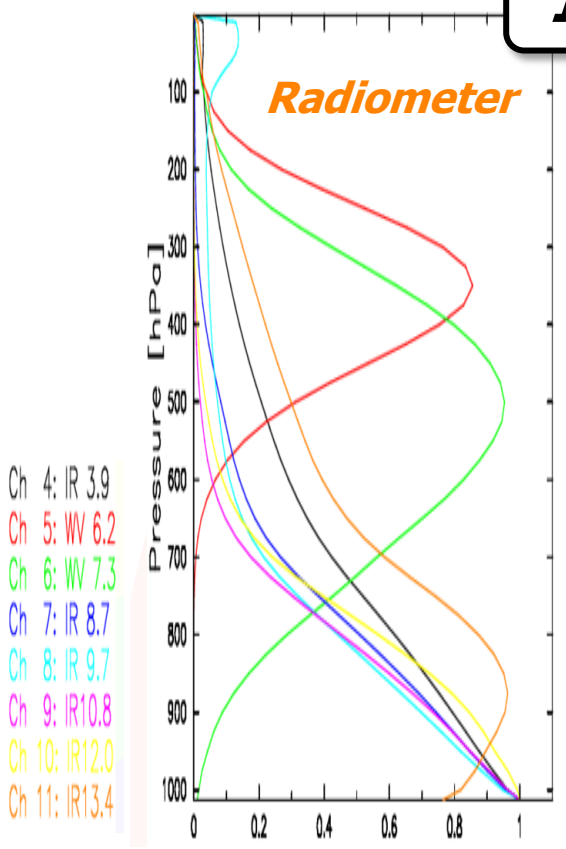
From spectral to vertical resolution

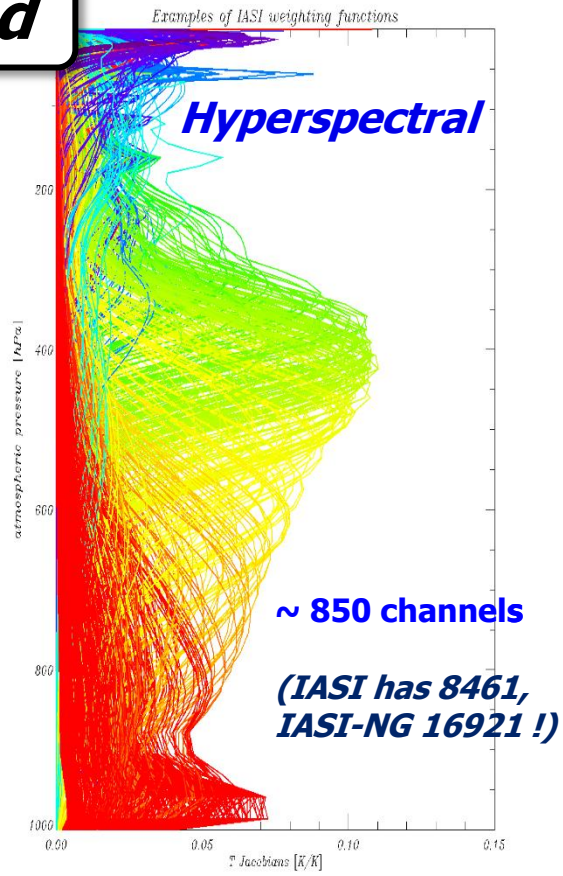


Infrared



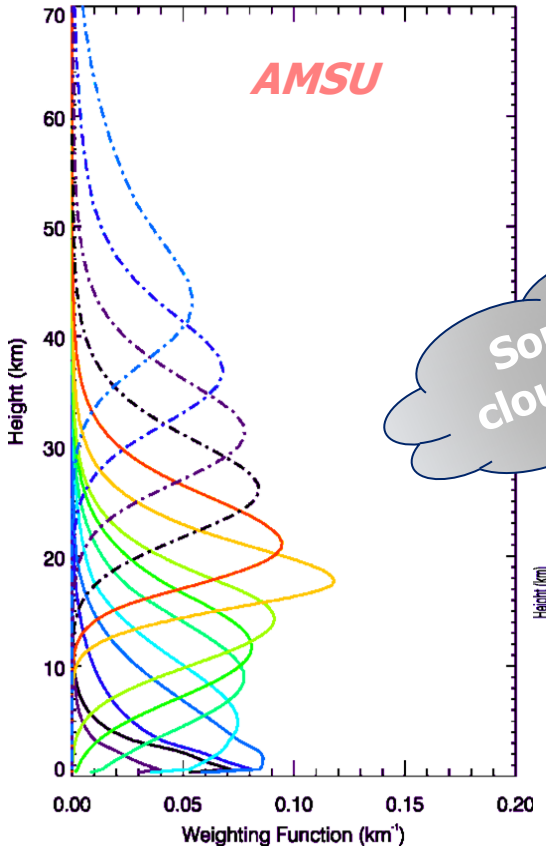
Micro-wave sounders



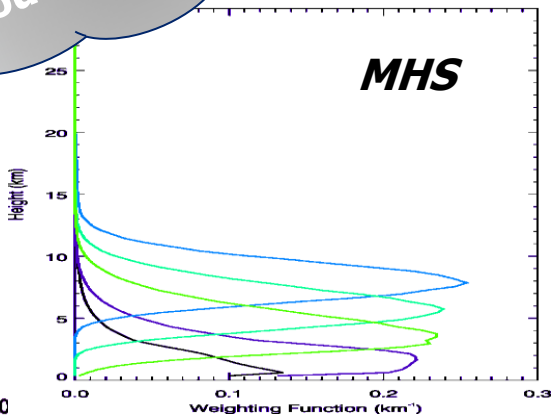


~ 850 channels

(IASI has 8461, IASI-NG 16921 !)



Sounding in clouds possible



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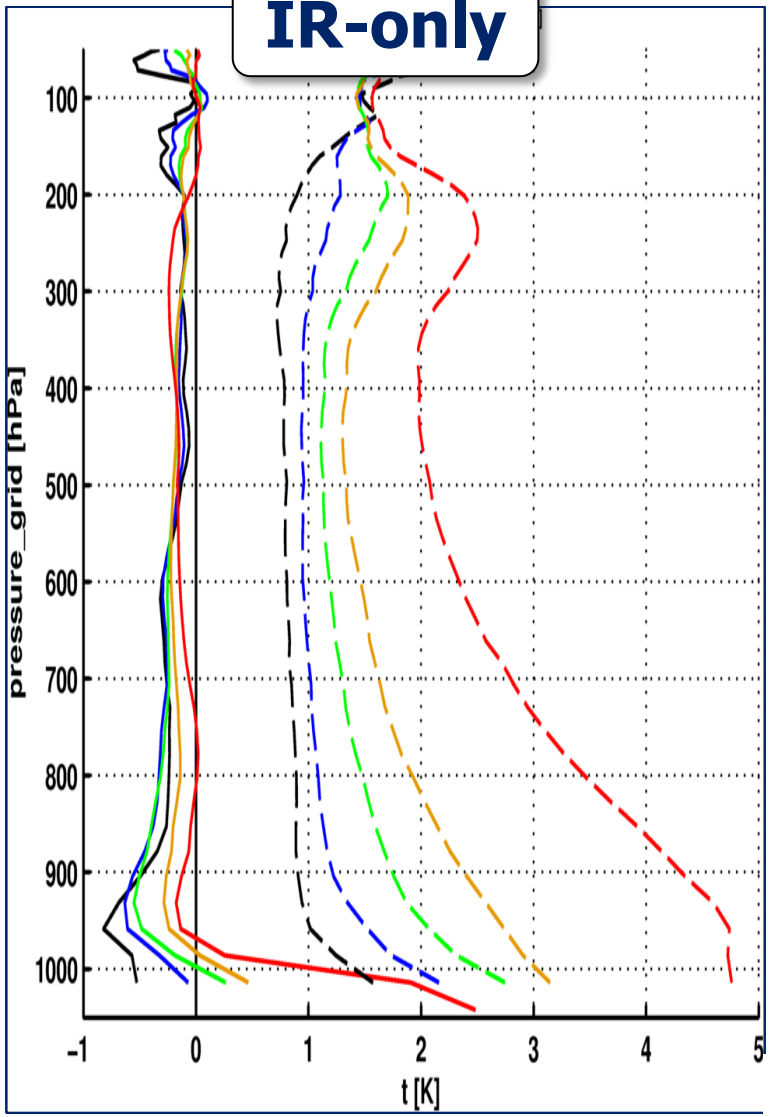
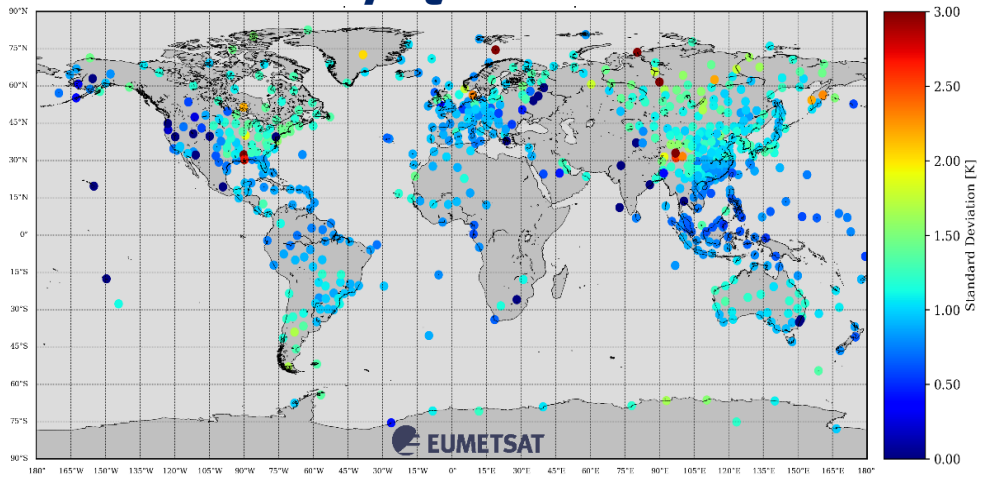
Temperature and quality indicator validation *vs* sondes

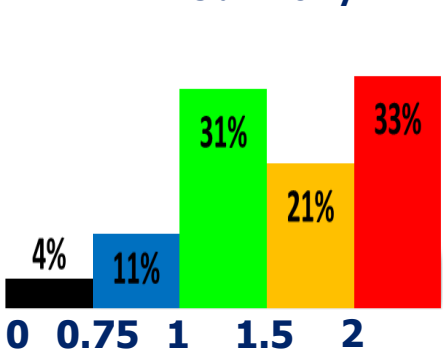
IR-only



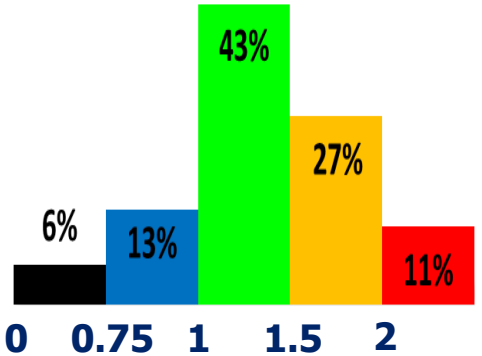
Jan. – Oct. 2017
< 50km ; < 3h
Match-up QC still needed



Yield IR-only

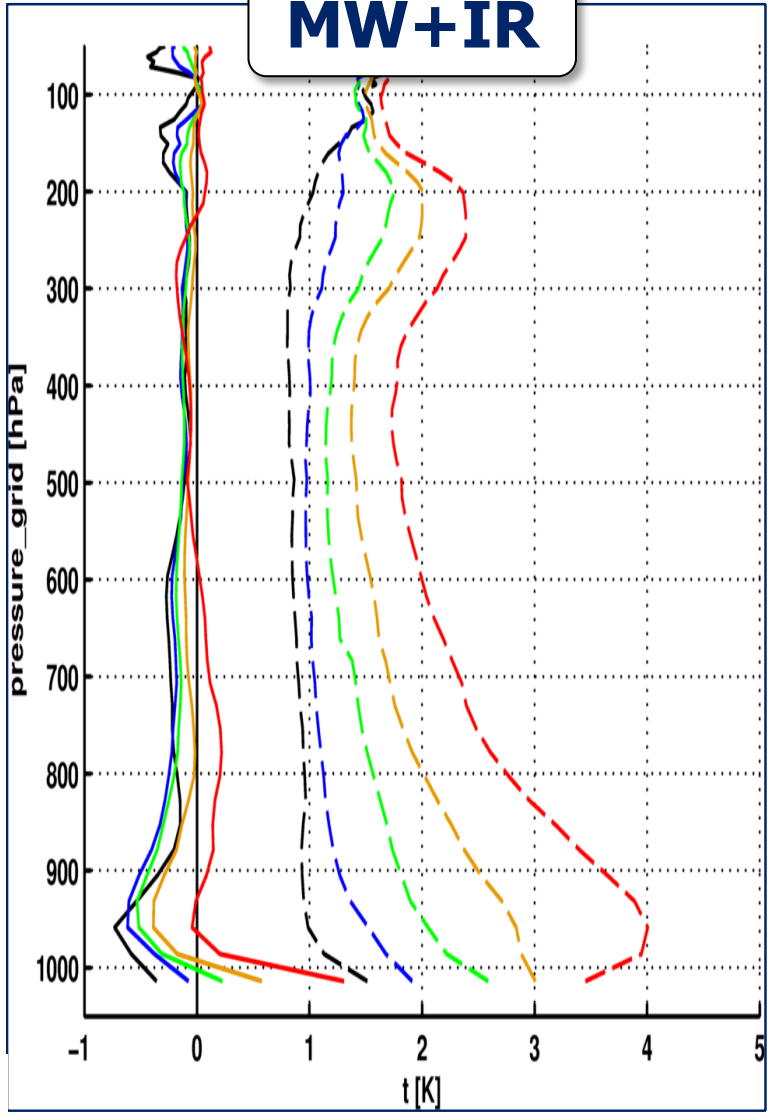


Yield MW+IR

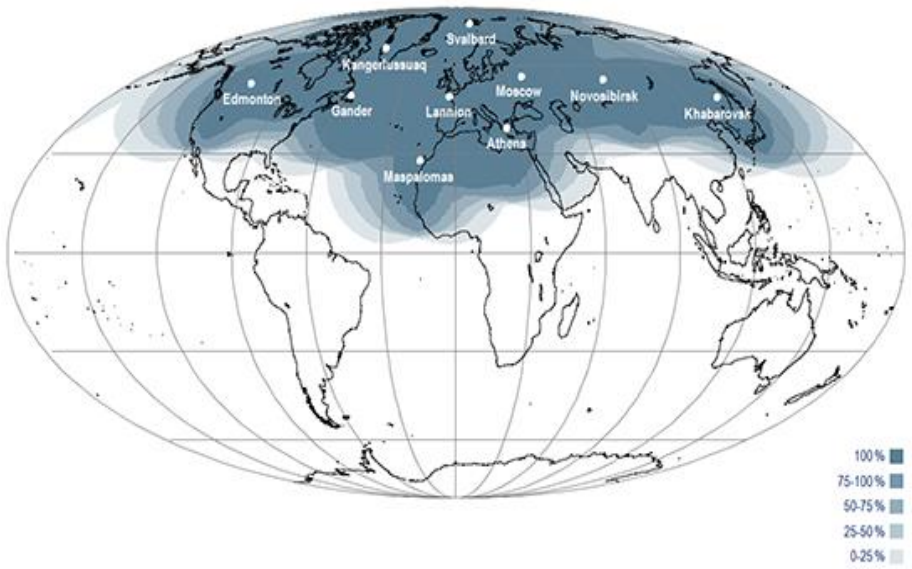


Error estimate in low-troposphere

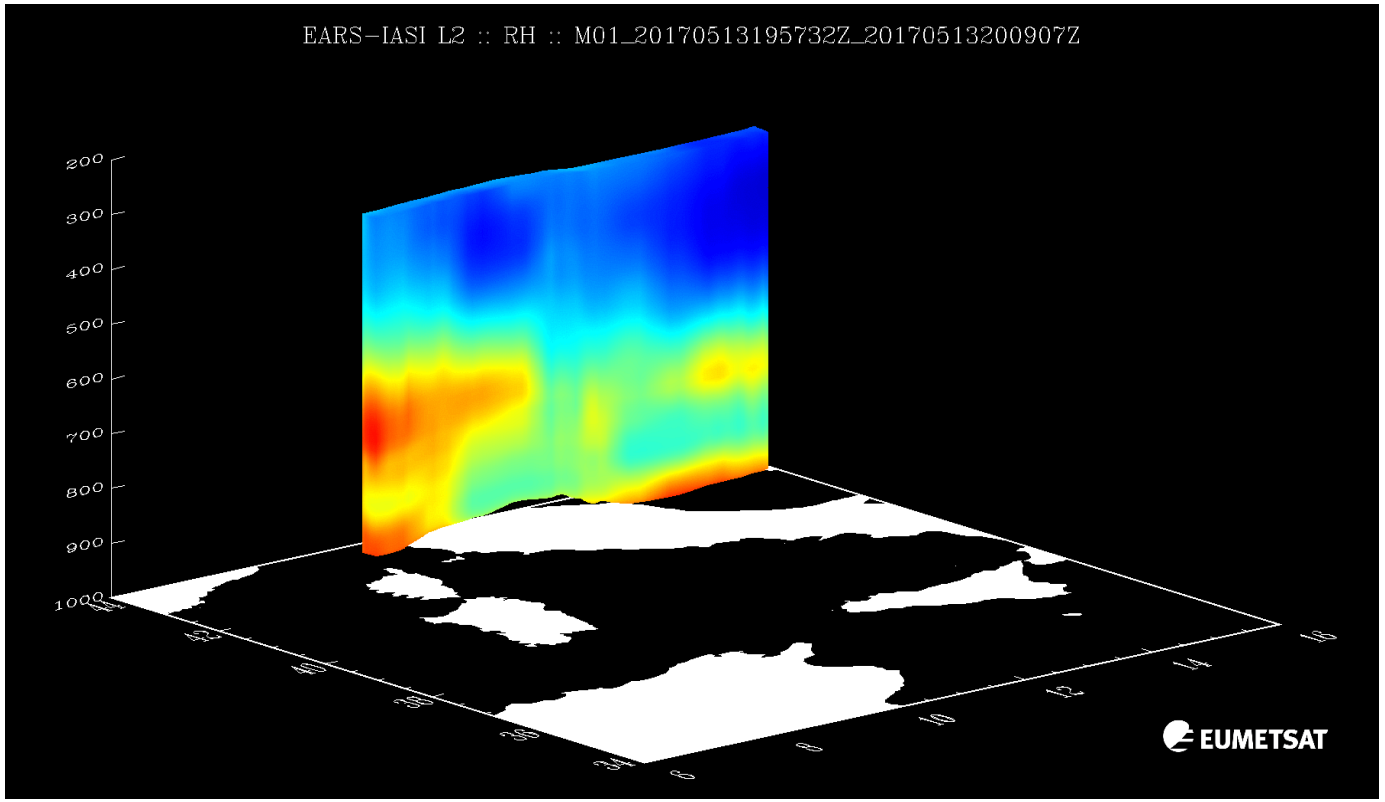
MW+IR



EARS-IASI L2, a new regional service – timely for nowcasting



- ✓ Direct broadcast stations
- ✓ Timeliness < **30' from sensing**
- ✓ Pilot phase since Nov. 2017



***Statistical MW+IR retrievals** (fast and accurate)*
'All-sky' forecast-free products

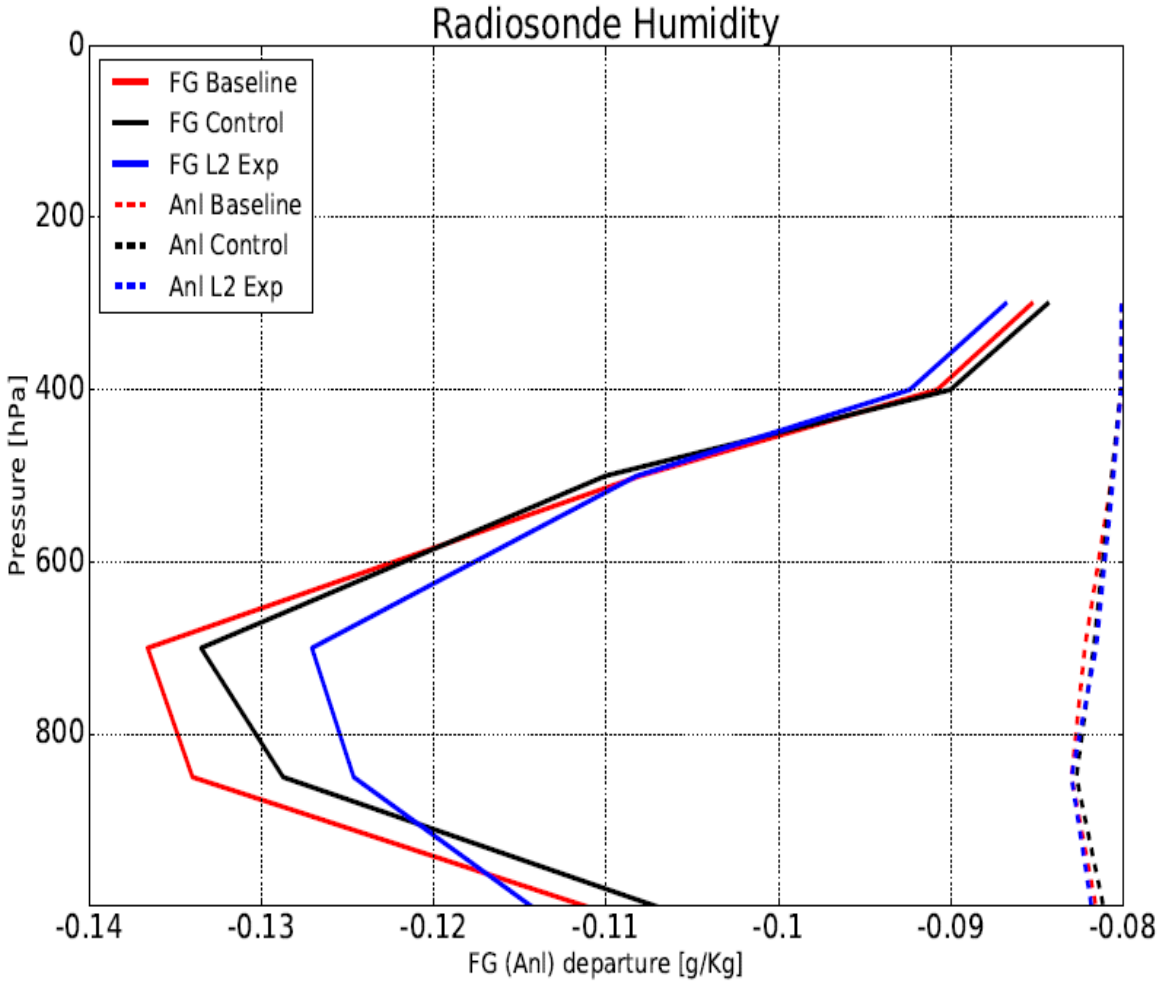
Assimilation of IASI L2 T/q in regional NWP (AROME, Météo-France)

Objectives:
Evaluate the feasibility and impact of assimilating the IASI L2 as pseudo-sondes in a regional model

First experiments in a nutshell:

- ✓ **Overall agreement L2 *vs* AROME**
- ✓ **IASI L2 suitable for assimilation in NWP**
- ✓ **Data thinning: 160km horiz.; 1-in-3 level**
- ✓ **Positive impact on forecast biases *vs in situ* obs.**
- ✓ **Some negative effects at some levels/FCT-steps**
- ✓ **Error specs/vertical correlation is critical** (diagonal error in these experiments)

Credits: Bruna Silveira, Vincent Guidard, Nadia Fourrié

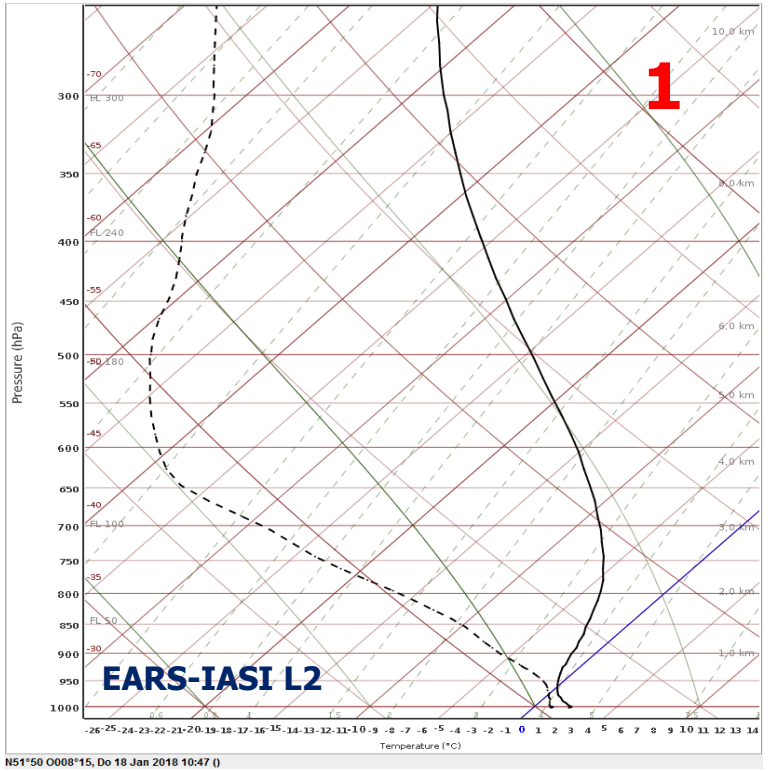


"Potential benefits of assimilating Metop combined retrieval L2 products in AROME-France", EUM Conference Tallinn 2018

DWD: case studies and routine monitoring of EARS-IASI L2

Case study: Cyclone Frederike 18/01/2018
(1 out of 3 cases)

Forecast: The regional model COSMO-DE predicted the development of a sting jet with gusts up to 170 km/h. The challenge for the forecaster was to decide if the sting jet would reach the ground resulting in fatal wind gusts.



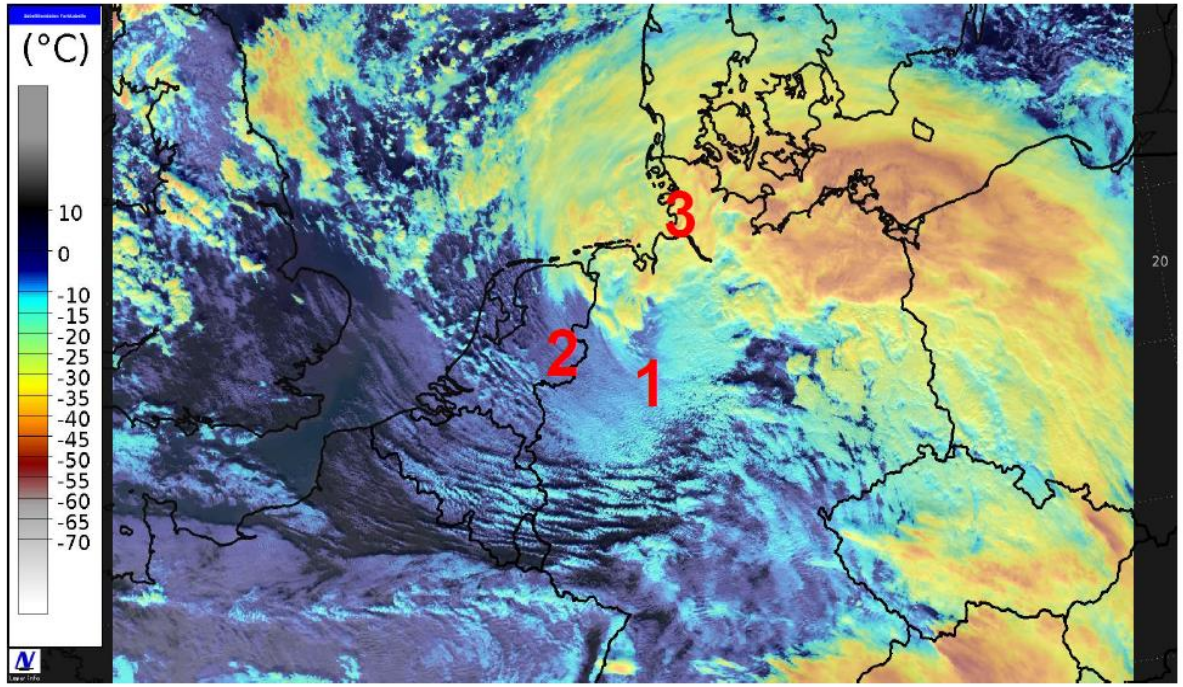
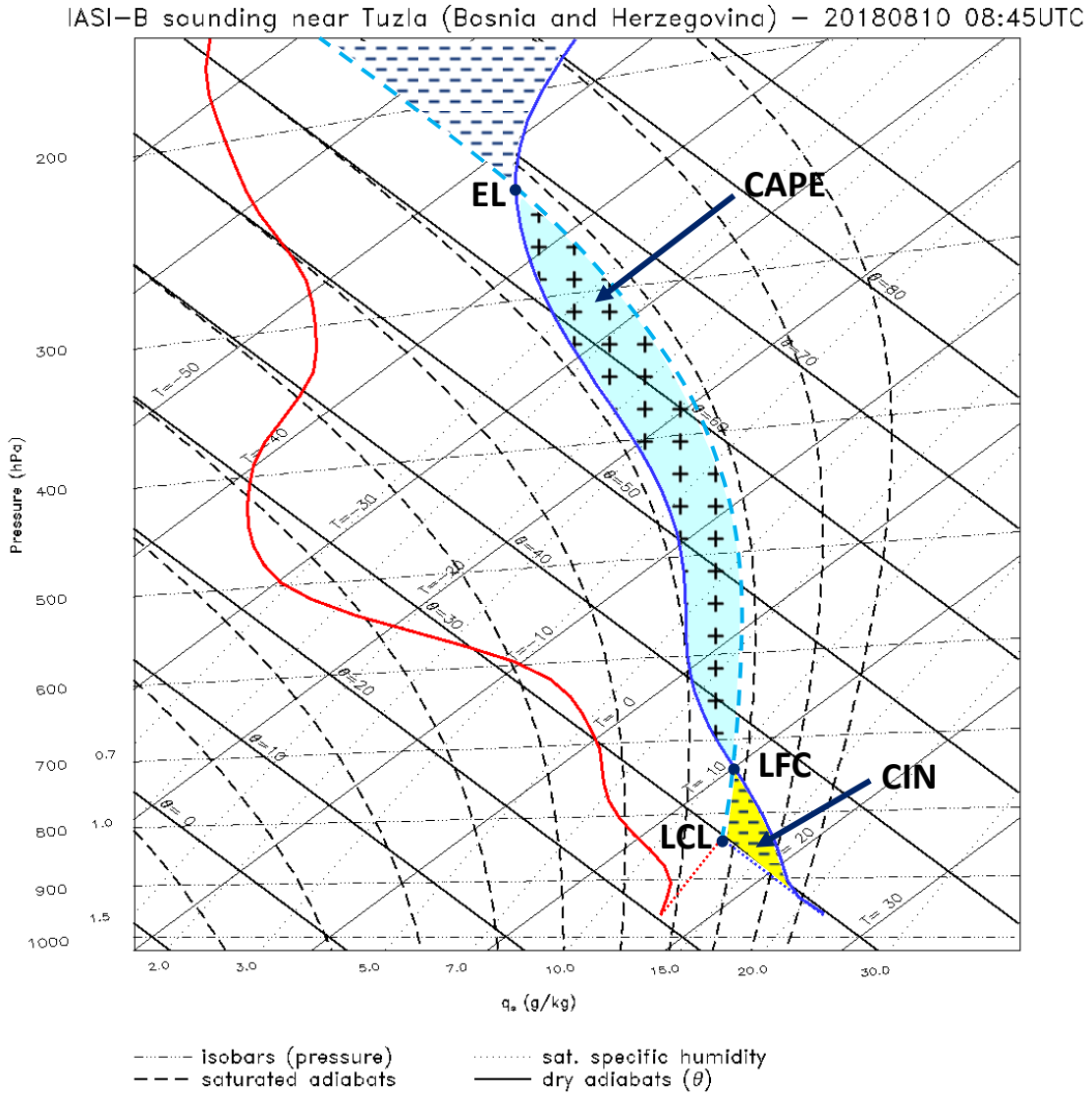


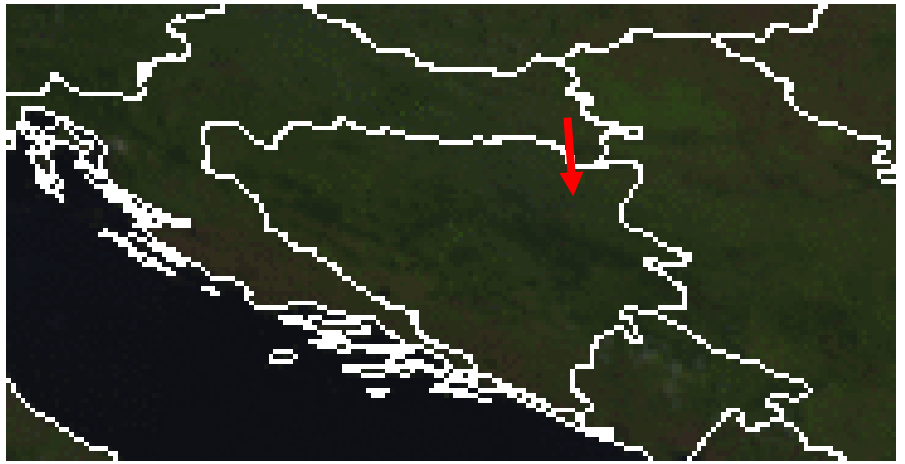
Fig.6: Suomi NPP VIIRS RGB image for 01-18-2018 11:30 UTC (top) and selected EARS-IASI L2 profiles (bottom) from the areas of the potential sting jet (1), the cold jet (2) and the cloud head (3). Source: DWD

Credits: K. Hungershöfer et al. (DWD)
"Are EARS-IASI L2 products useful for Nowcasting?"
EUM User conference, Tallinn 2018

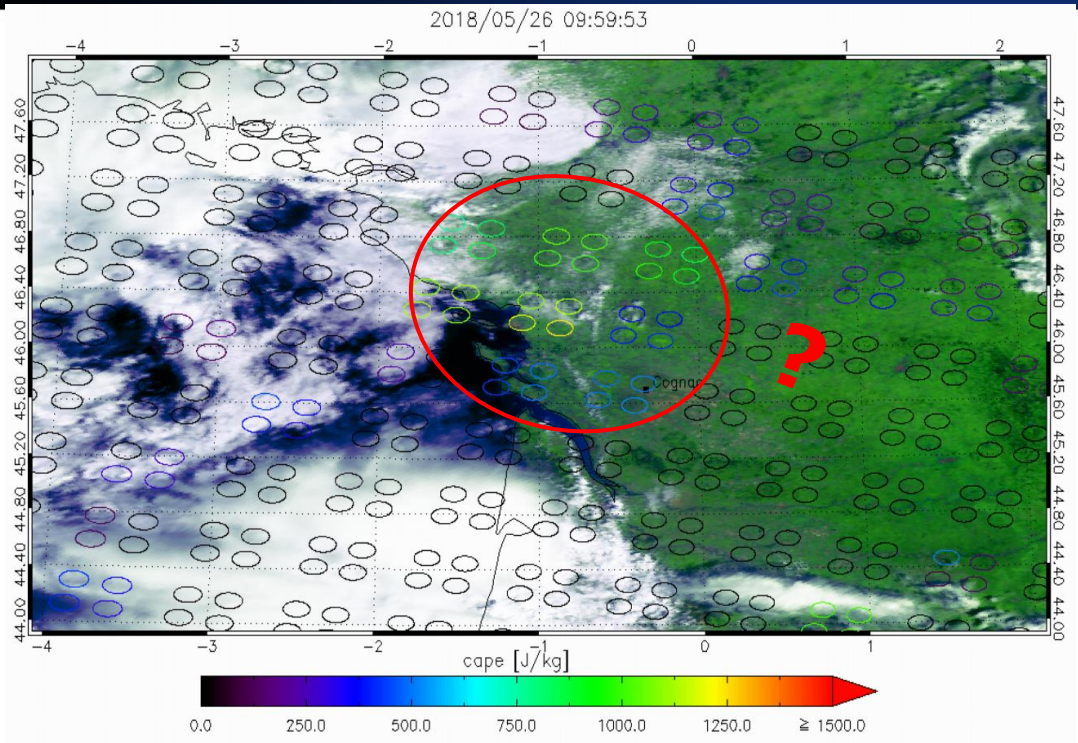
Conclusion: COSMO-DE overestimated the gusts, but the stratocumulus clouds in the satellite picture and the IASI-Soundings (showing strong boundary layer) gave hints that the Sting Jet would not reach the surface in the low lands.

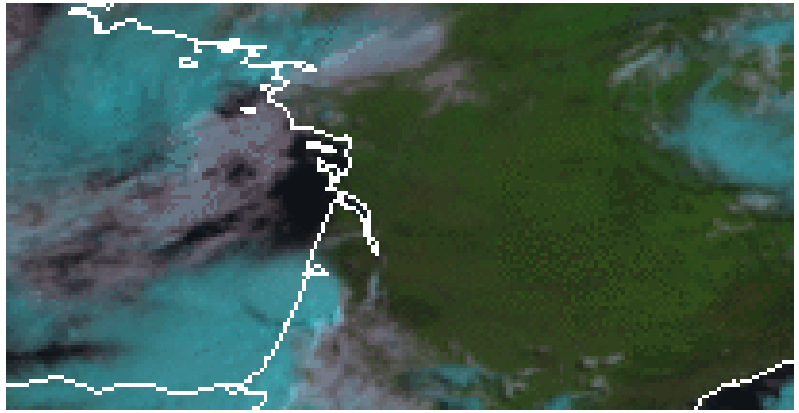
Conditional instability detection with IASI?



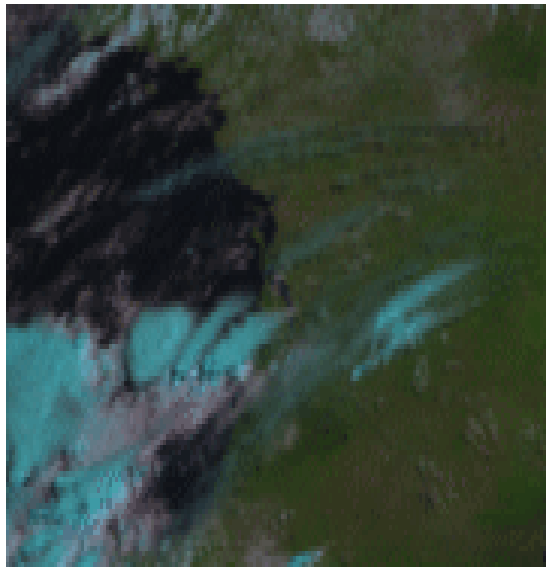


Severe hail storms – Bordeaux Cognac 26/05/2018



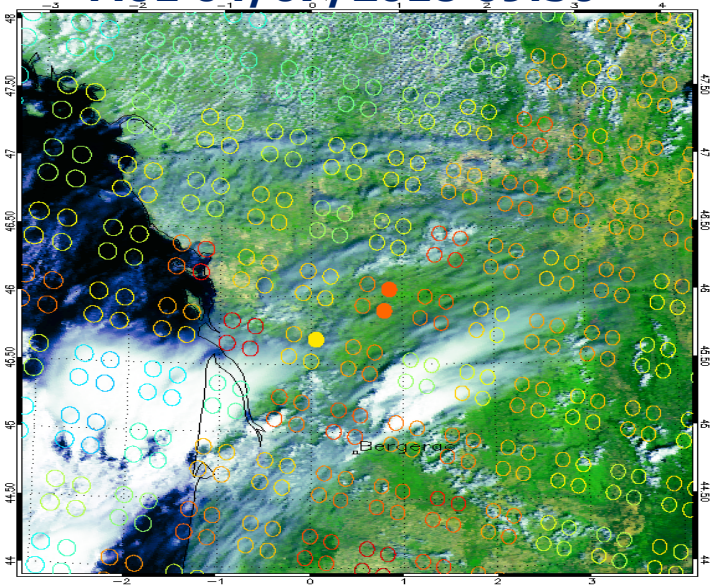


Wind, Lightning Hail storm in Dordogne – 04/07/2018

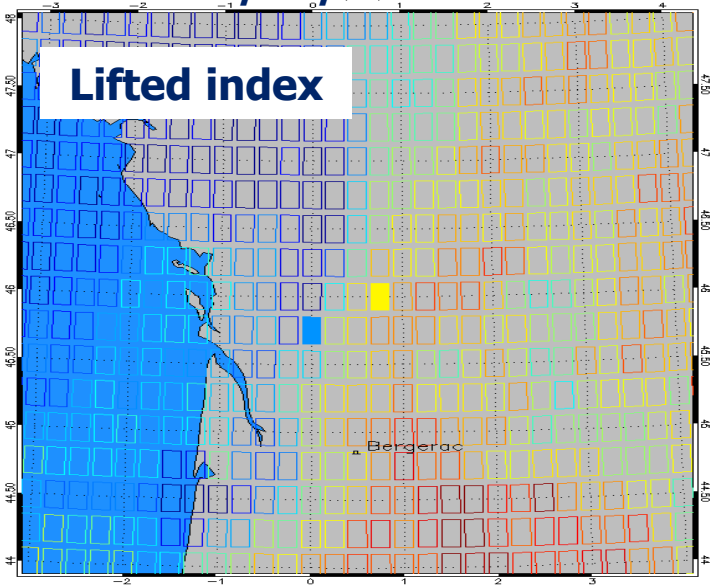


Wind, Lightning, Hail storm in Dordogne – 04/07/2018

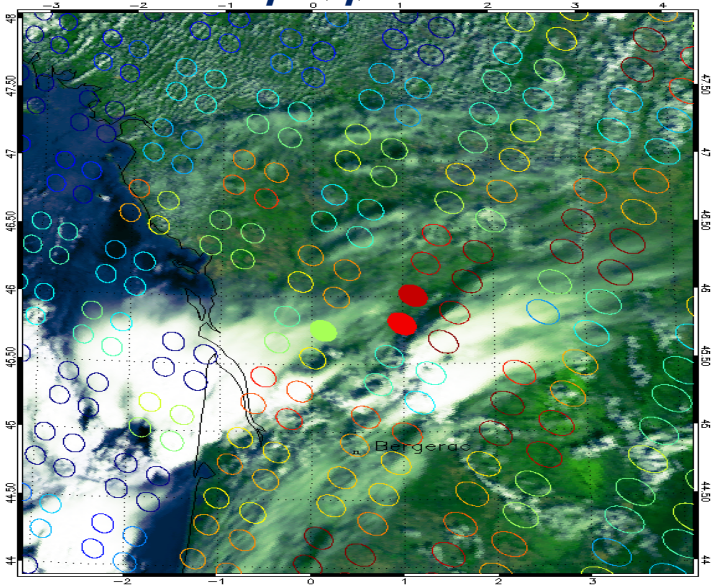
M01 04/07/2018 09:50

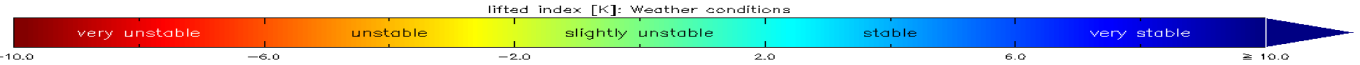


ECMWF 04/07/2018 00+09UTC

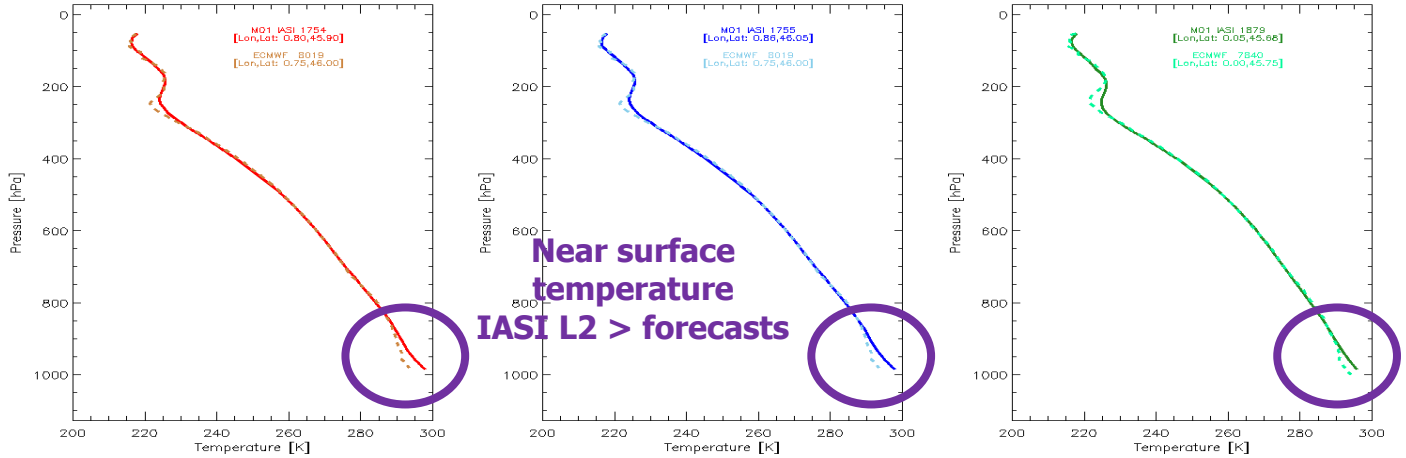


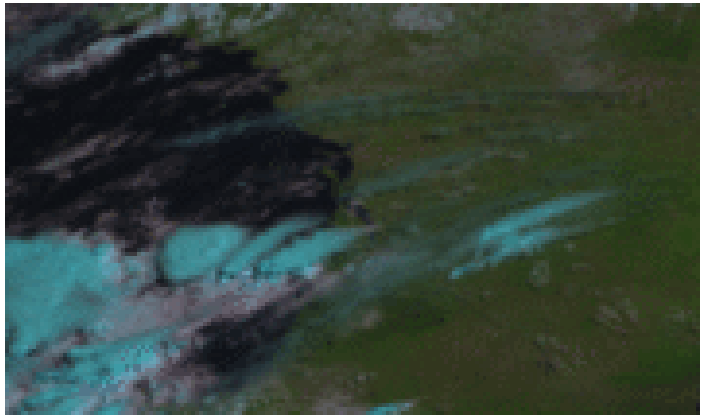
M02 04/07/2018 10:30



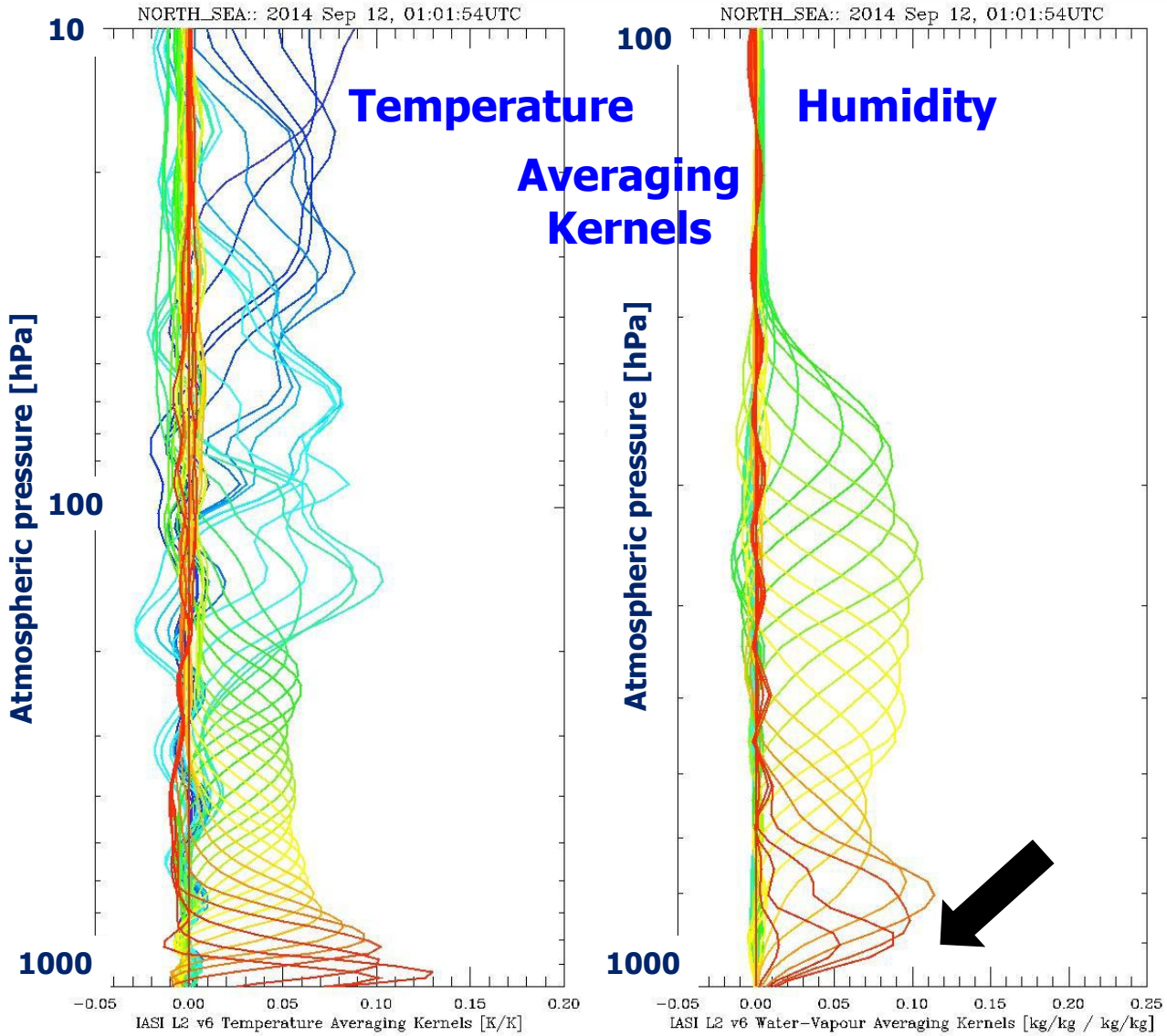


Wind Lightning Hail Storm Dordogne 20180704





Blend satellite + surface obs. for instability monitoring



! Hyperspectral infrared have low sensitivity and coarser vertical resolution near-surface

➔ Impact surface-based instability indices
- **CAPE dynamic smaller than with sondes…**
- **? Enough to anticipate severe weather**

➔ Blend satellite profiles + surface obs (T/q)
- **✓ FCT-independent obs. for forecasters**
- **? Significance in relation to severe weather**
- **? Operational feasibility**

Formerly studied at University of Wisconsin J. Gartzke et al., JAMC 2017, "Comparison of Satellite-, Model-, and Radiosonde-Derived Convective Available Potential Energy in the Southern Great Plains Region"

Instability monitoring from IASI in view of IRS (OMSZ, Hungary)

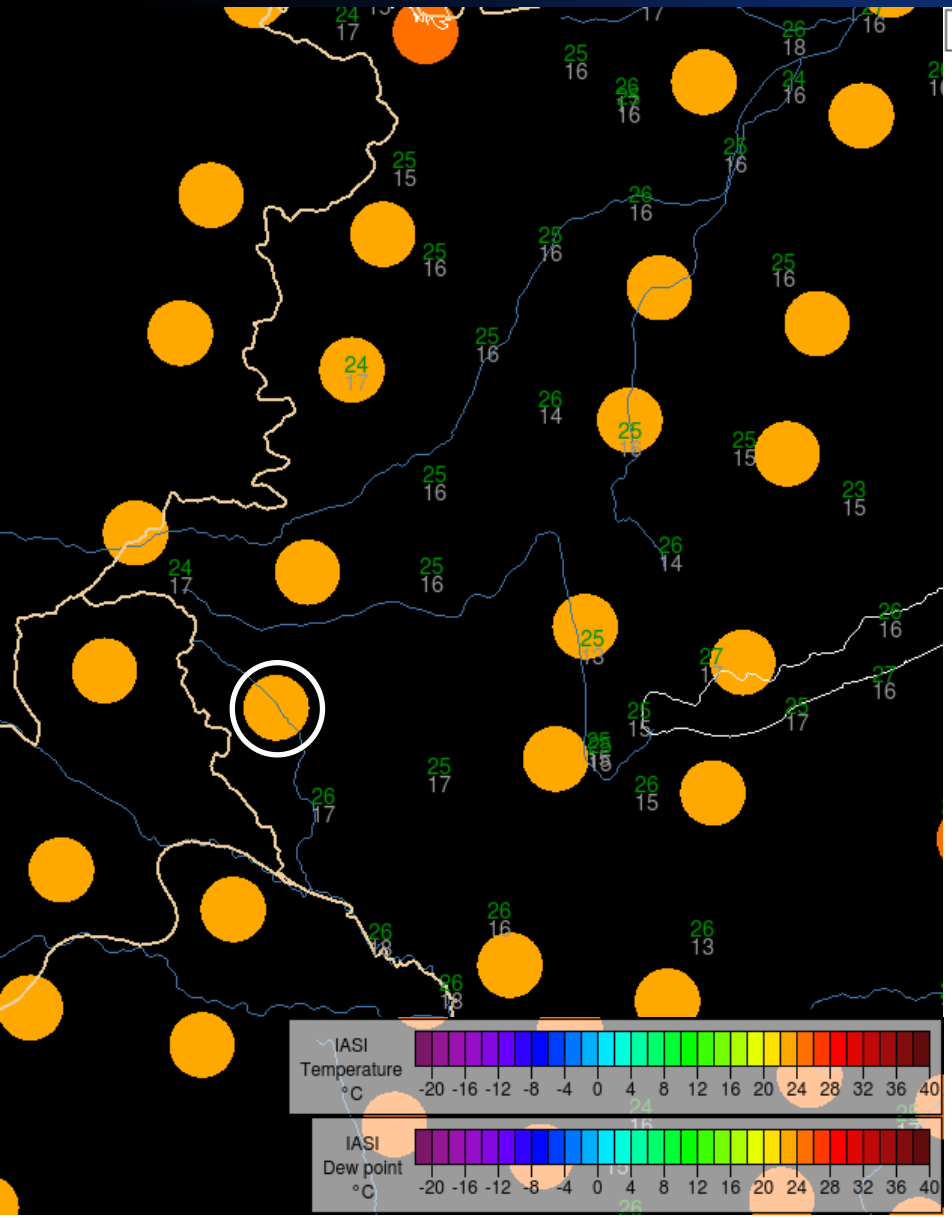
Excerpts from an early case study

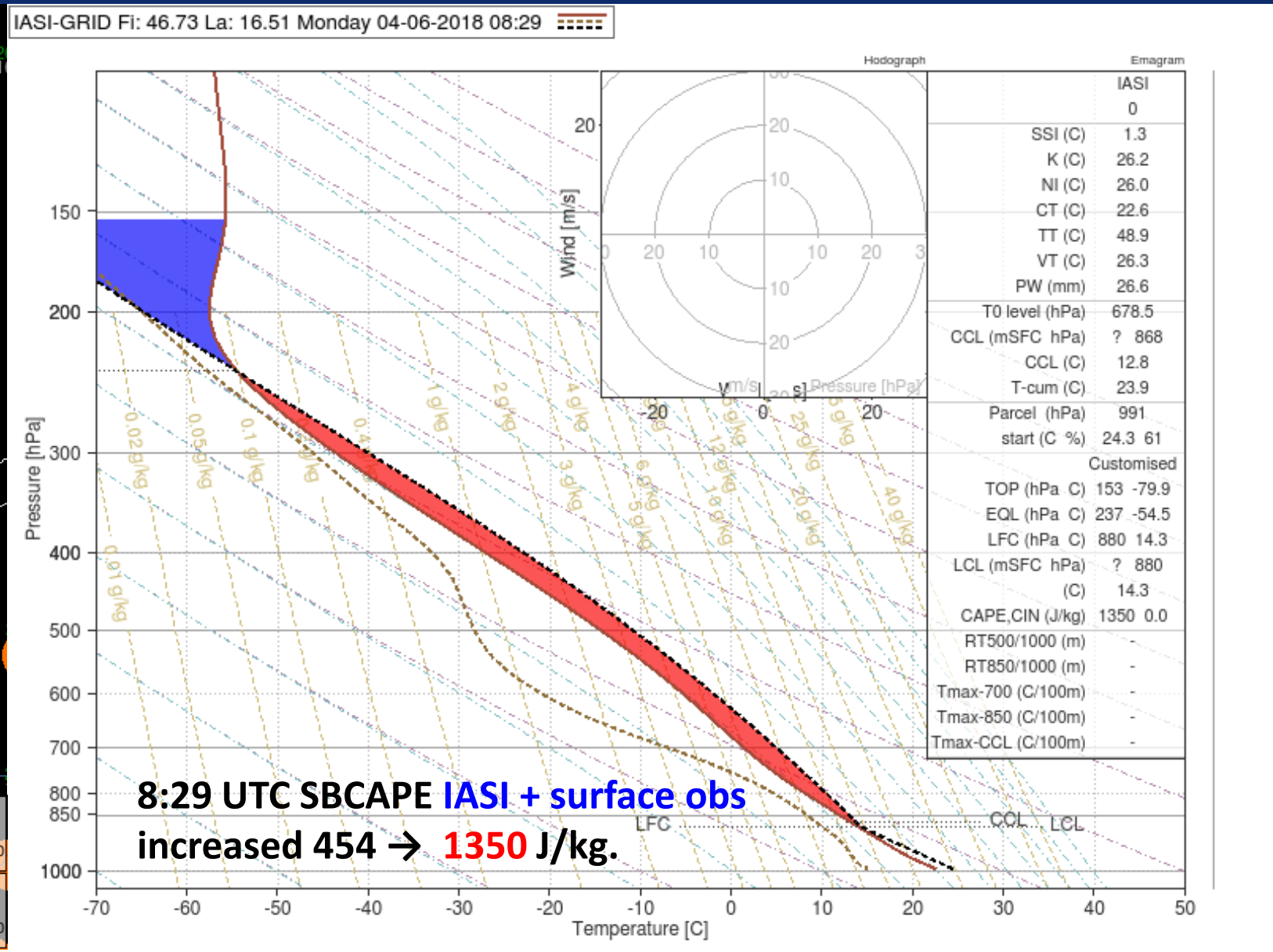
- Deep convective thunderstorm
- Slovenian border
- 4 June 2018 at 10 UTC

- IASI overpasses 08:29 and 09:11
- ECMWF forecasts 8 and 9 UTC
- Blending IASI L2 (and NWP FCT) with ground-based to evaluate SBCAPE

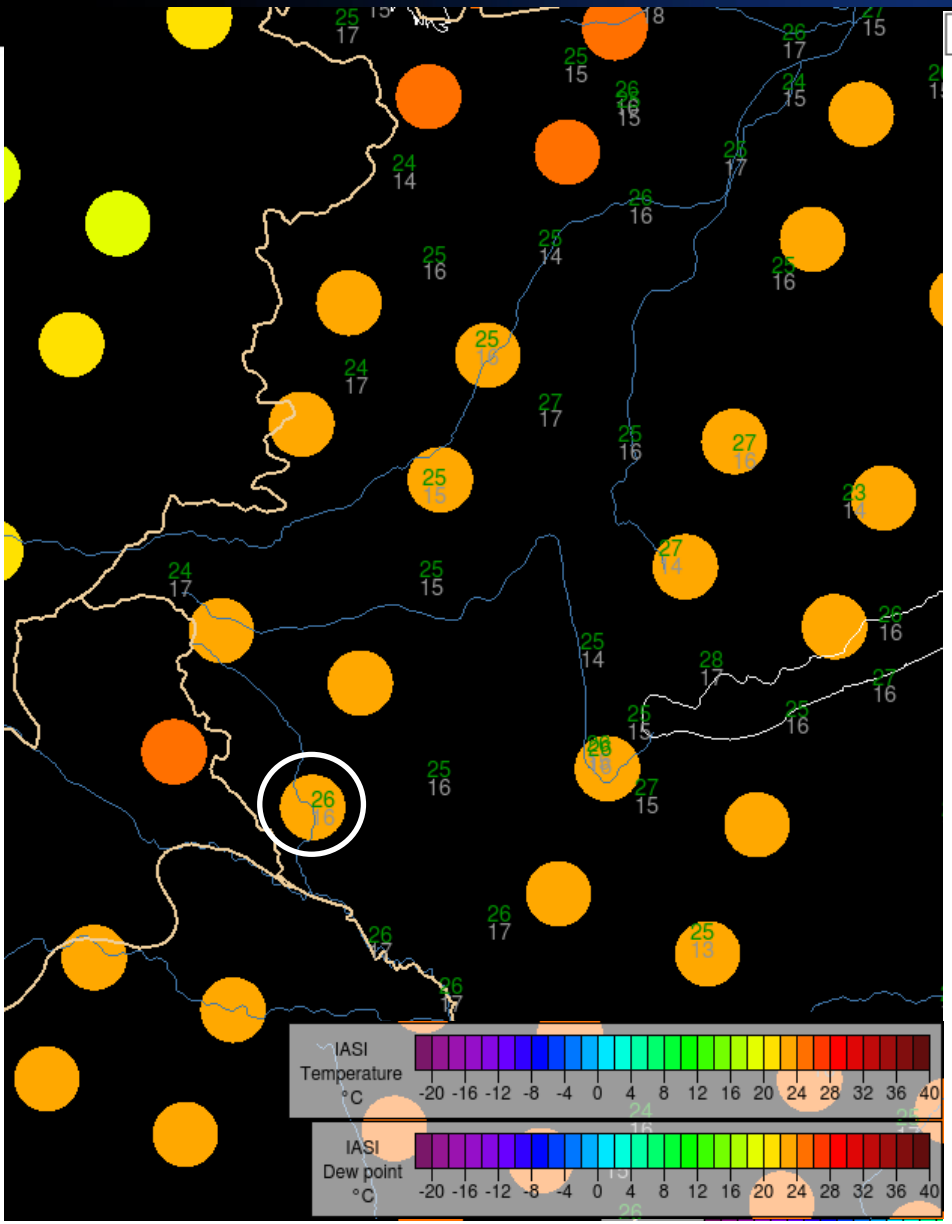
Study team: Kalman Csirmaz, Zsofia Kocsis, Maria Putsay (OMSZ)

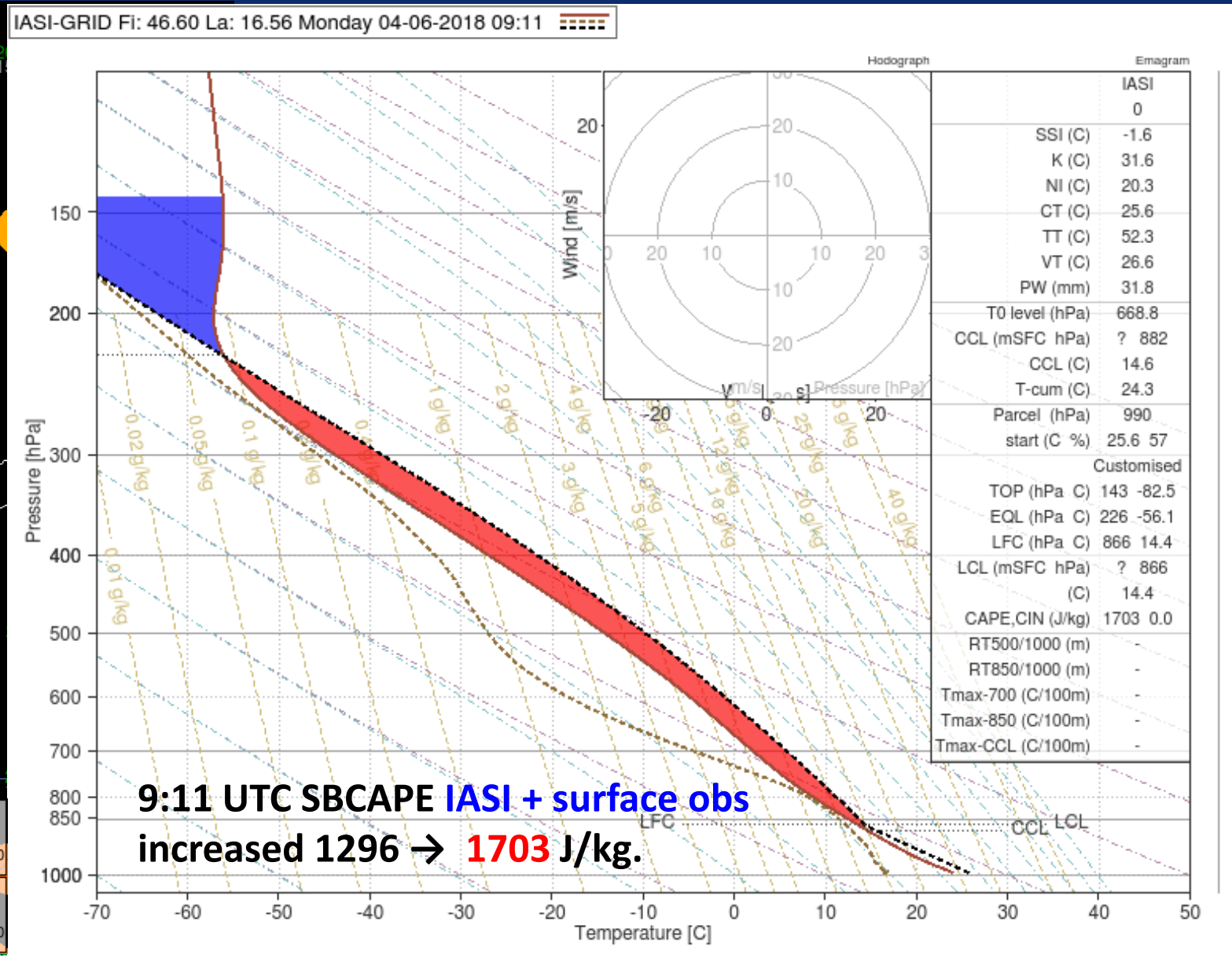
Instability monitoring from IASI in view of IRS (OMSZ, Hungary)





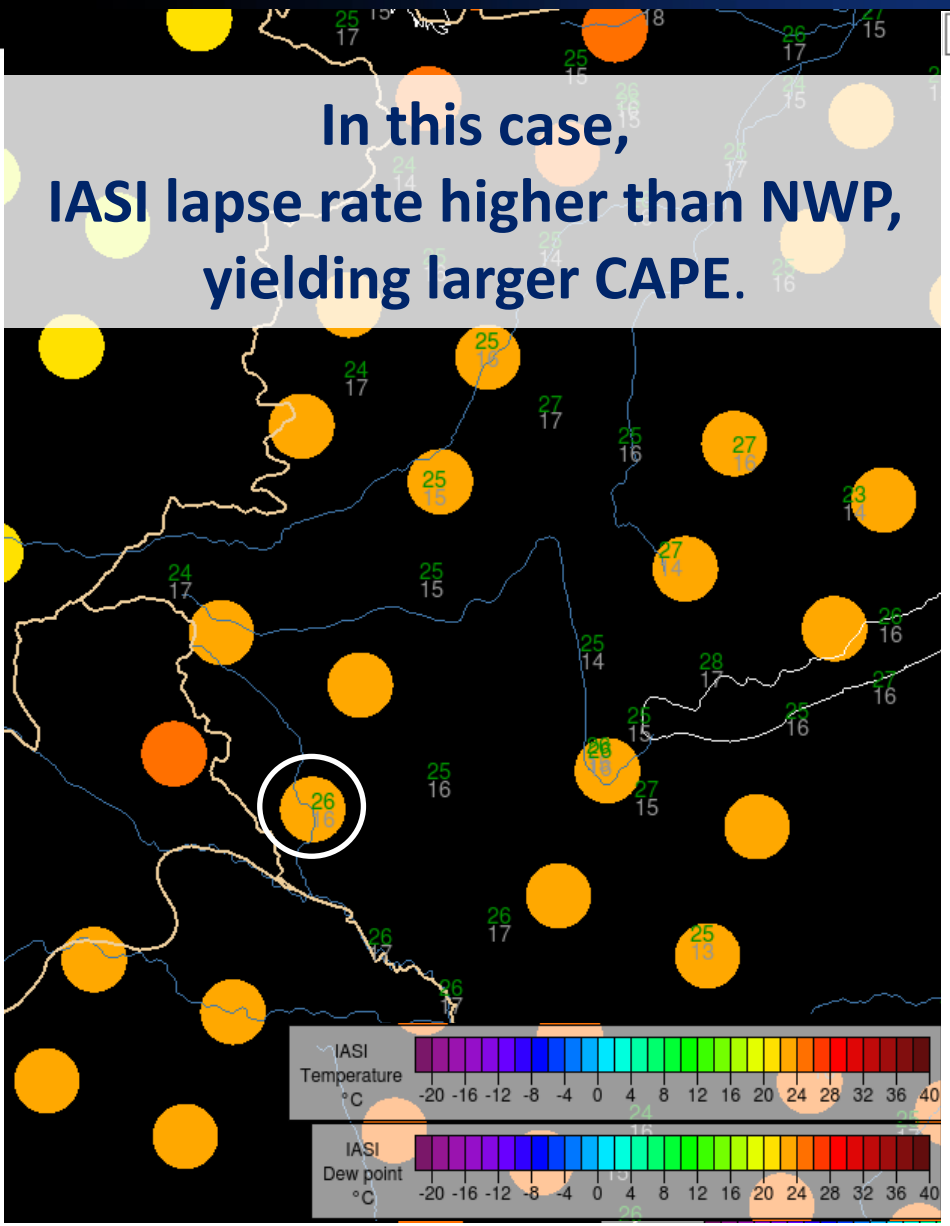
Instability monitoring from IASI in view of IRS (OMSZ, Hungary)

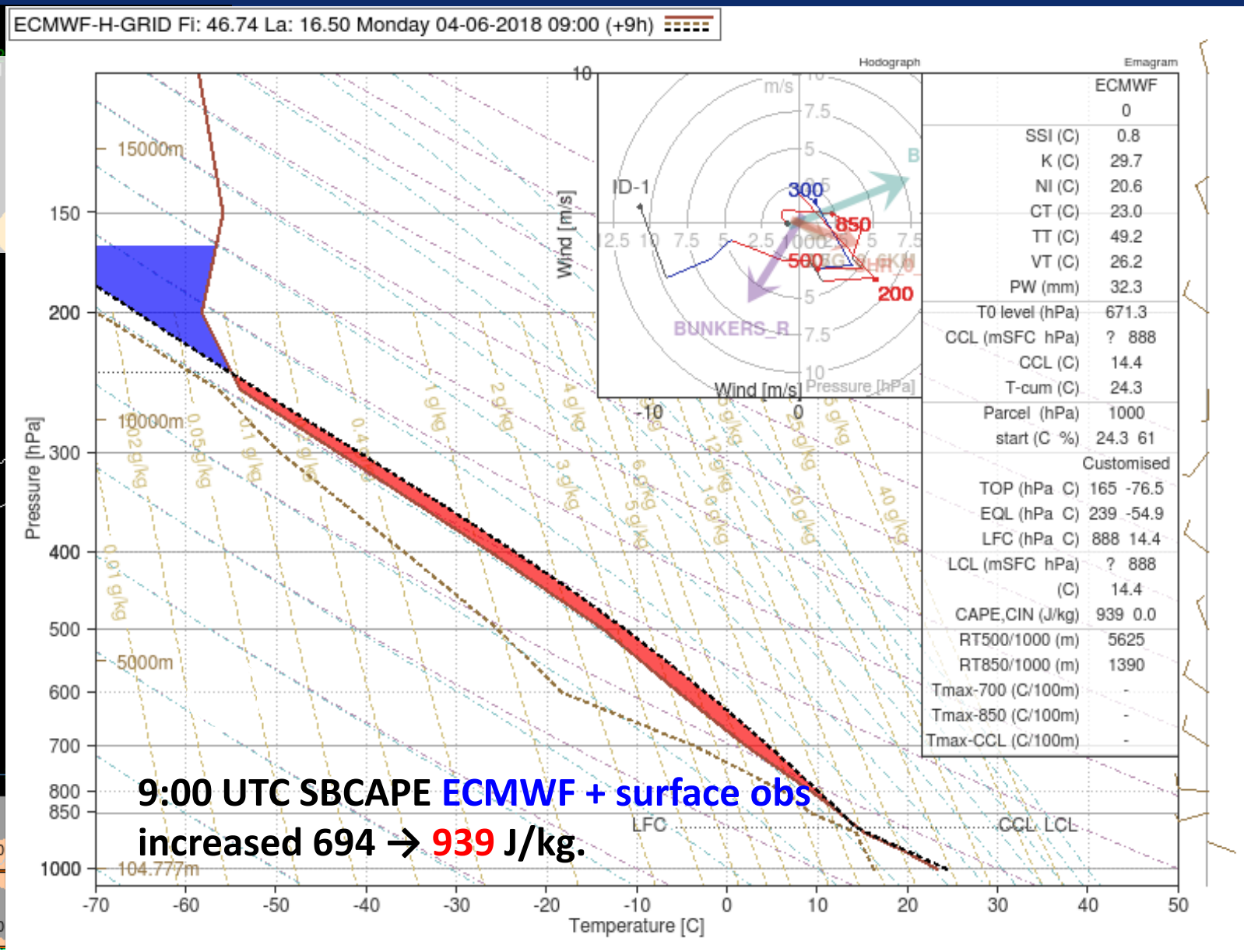




Instability monitoring from IASI in view of IRS (OMSZ, Hungary)

In this case,
IASI lapse rate higher than NWP,
yielding larger CAPE.





9:00 UTC SBCAPE ECMWF + surface obs increased 694 → 939 J/kg.

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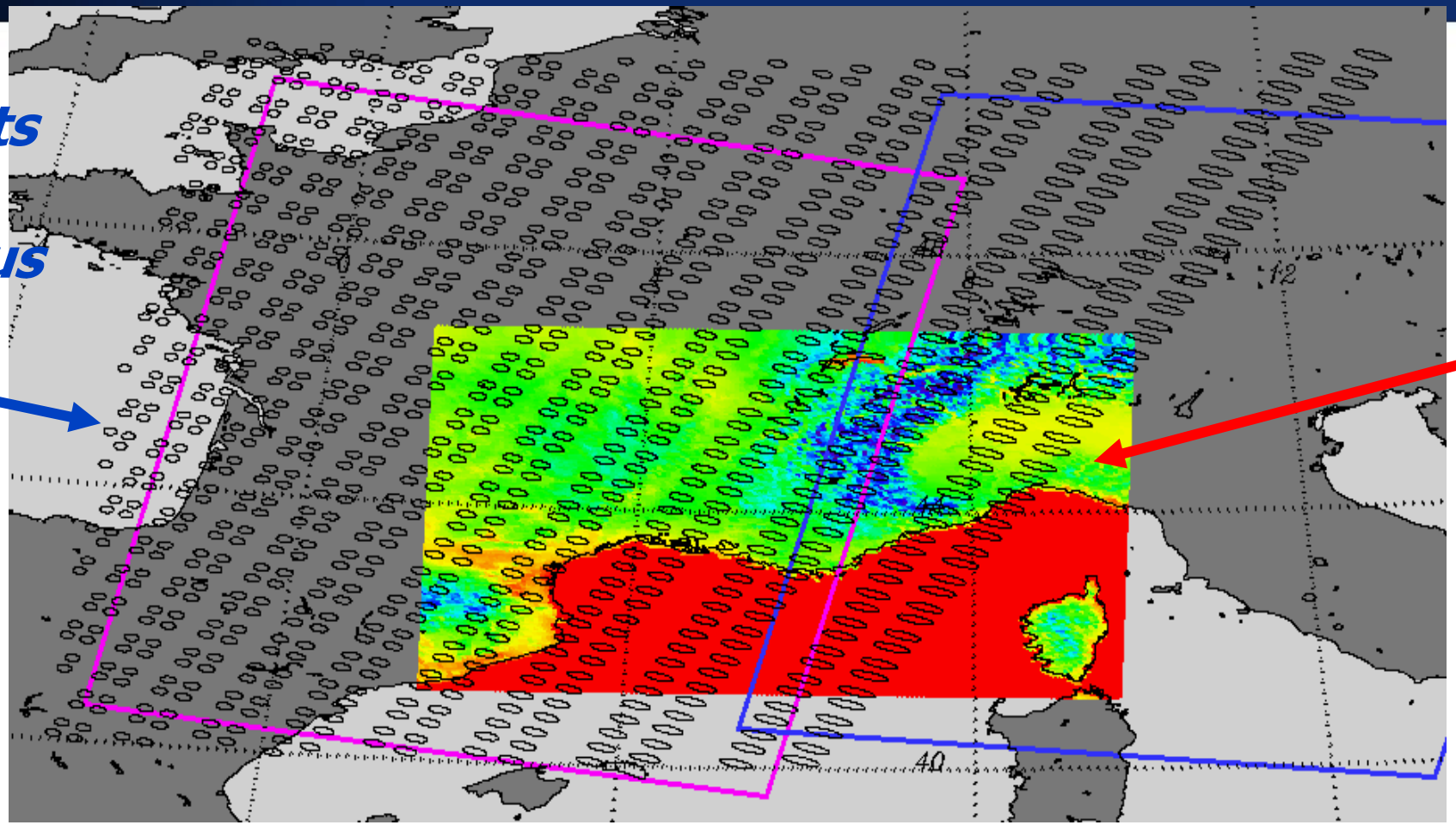
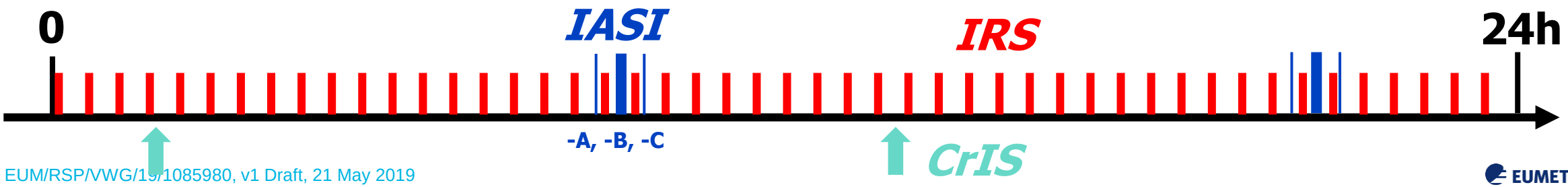
MTG-IRS: unique 4D look into the atmosphere

IASI footprints
12-40km
Not-contiguous
2x per day



IRS pixels
~7km
Contiguous
Every 30'



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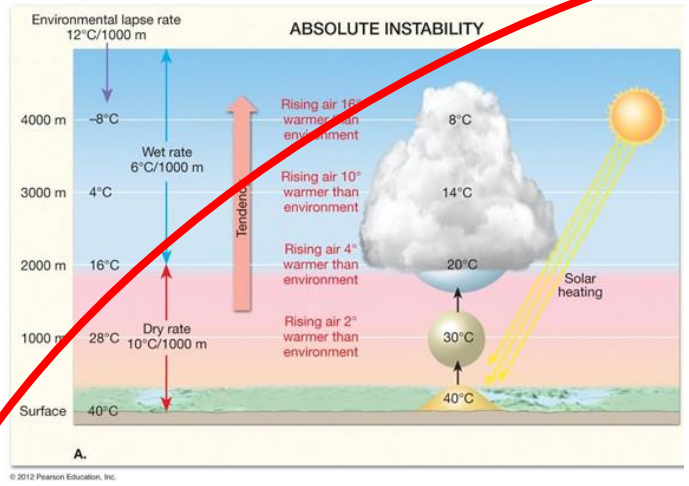
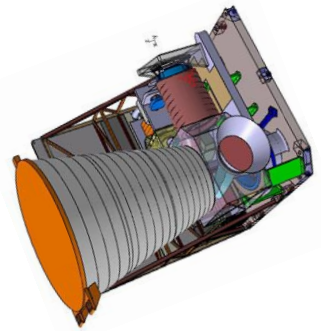
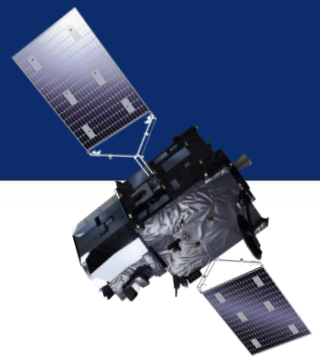
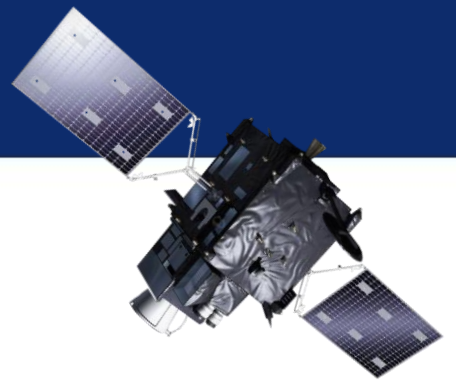
A full weather story with MTG



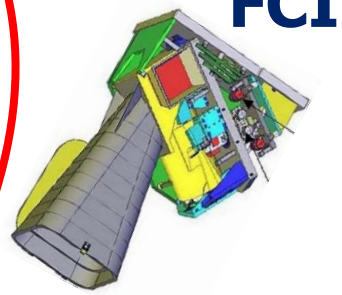


IRS

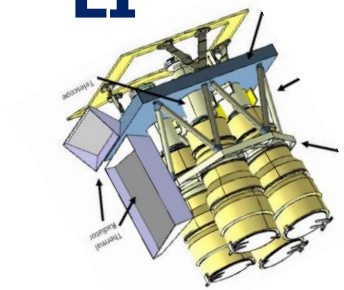




FCI



LI



Evaluate the thermodynamic state before clouds form.

Gain precision and lead-time in the assessment of potential severe weather.

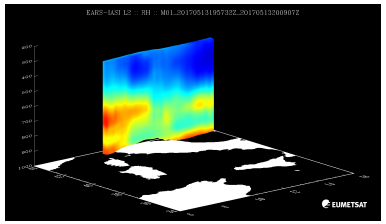
Summary - Outlook

Merci pour votre attention!

Retrieval methods
- AI, machine learning…
- Physics modelling
- Instruments synergy, data fusion?
- New products, e.g. cloud µ-physics

Validation / Monitoring
Need reference measurements:
- Traceable uncertainties
- Continuous streams
- Campaign opportunities?
- Challenges (methods/instruments)
  - ? Representativeness error
  - ? Validate T/q at 0.7K/5%
  - ? Cloud microphysics

Scientists ISTP **Users**



Products & Services

Regional applications
- ✓ Timely 'all-sky' T/q profiles
- ➢ Studying pre-convection monitoring
- ➢ Practical operational aspects
  - assimilation experiments
  - direct use, displaying information
  - blending satellite + surface obs
- ➢ Consolidate requirements
  - ✓dialog with forecasters
  - ? which parameters
  - ? forecast-dependency
- ➢ IRS unique 4D look into atmosphere

Try out EARS-IASI L2 !
Get ready for MTG-IRS !