Status of regional IASI L2 products at EUMETSAT and studies in view of MTG-IRS

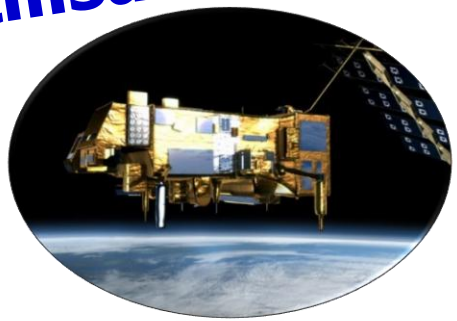
Thomas August, Tim Hultberg, Marc Crapeau,

Stefan Stapelberg, Cédric Goukenleuque

+ external partners acknowledged in the slides

Background and scope

Fostering IASI L2 utilisation …



… preparing for IRS

2012
Lessons from v5
PCA and subspaces

2014
v6 first release
All-sky retrievals
Rec'd radiances

2015
3D retrievals
Deeper validation
Potential for regional use?

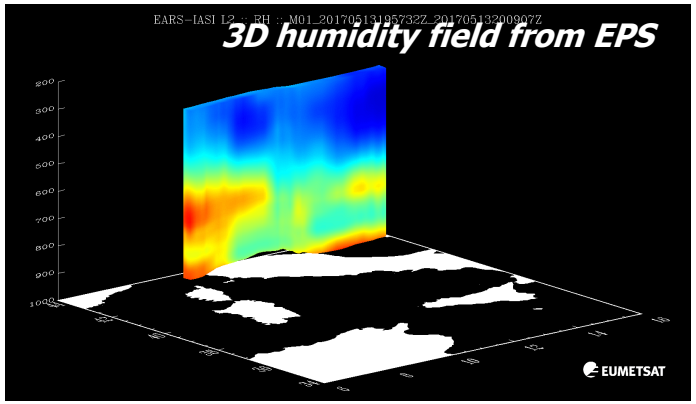
2017
From Global to
Regional service

2018-
Studies, Dialog with forecasters
First results & feed-back
IRS requirements & specificities

Algorithms improvements
Validation, uncertainty estimates

Outreach
Exploring new regional applications
➔ specify future services

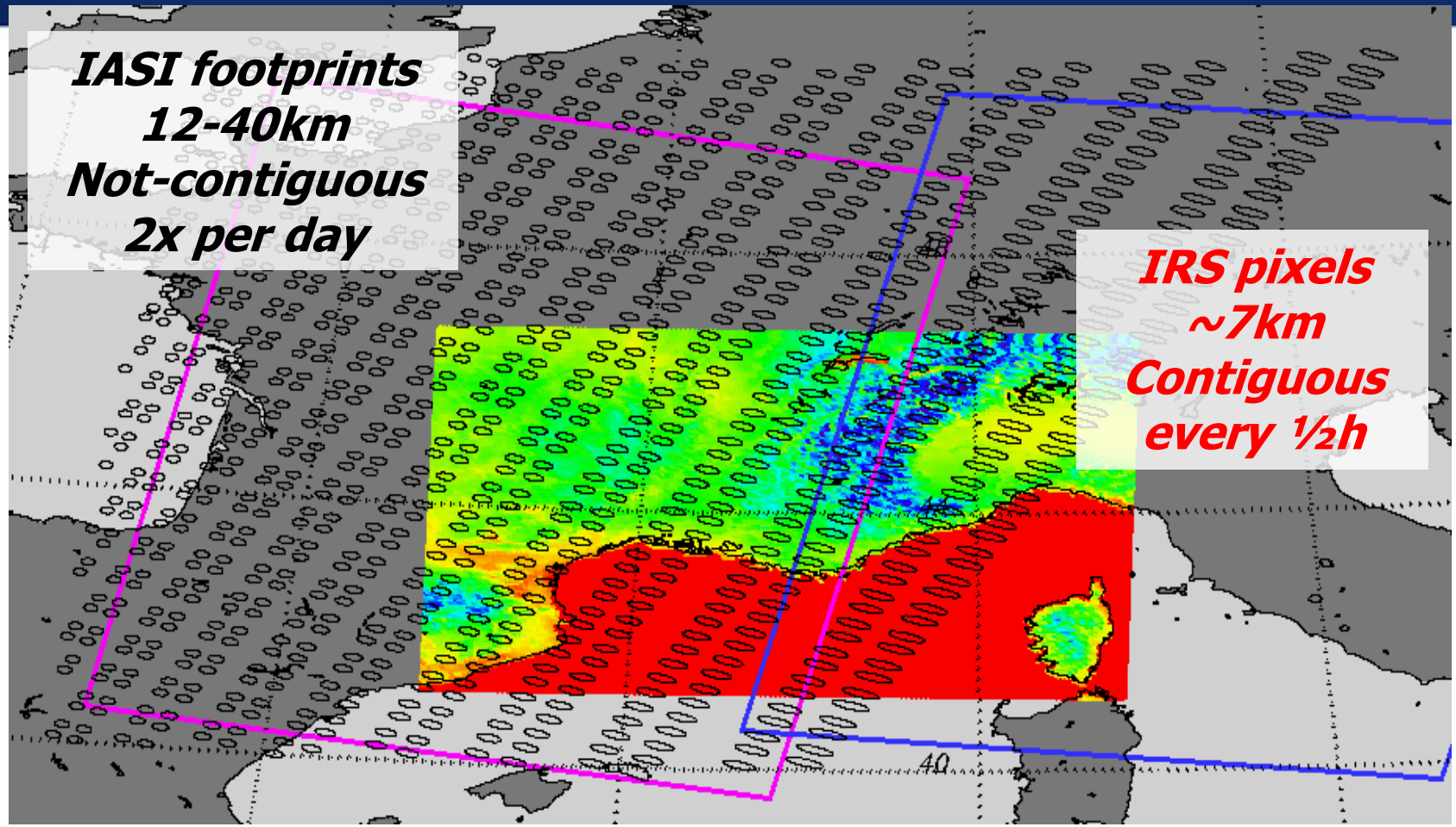
MTG-IRS – Unique 4D look into the atmosphere

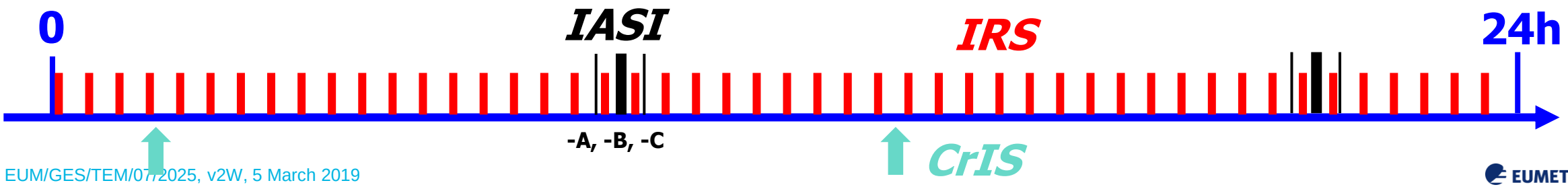


MTG- IRS

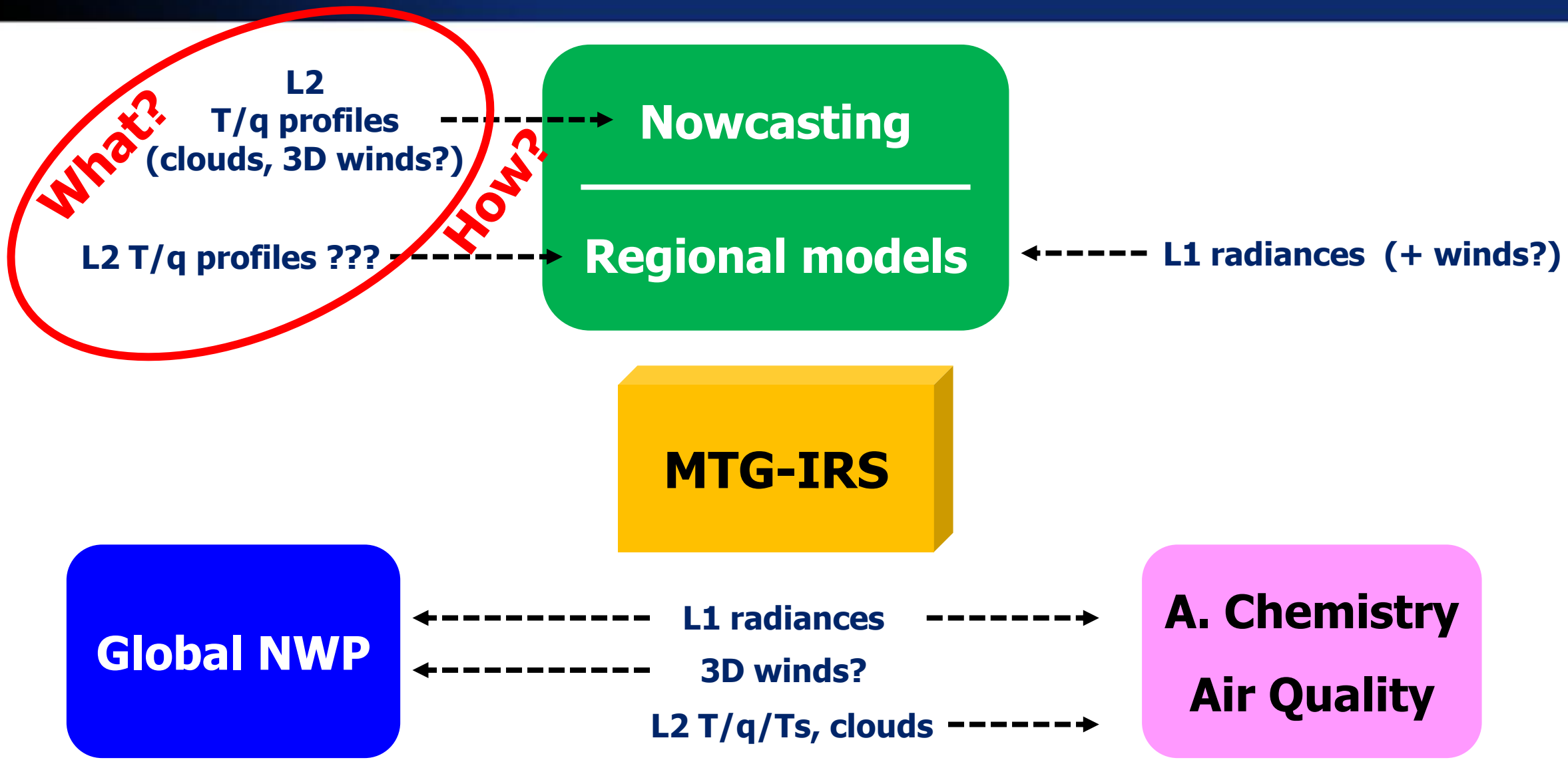
Atmospheric sounding
Unprecedented spatio-temporal resolution and sampling

Contains information about temperature, humidity, ozone and clouds ➔ atmospheric dynamics !





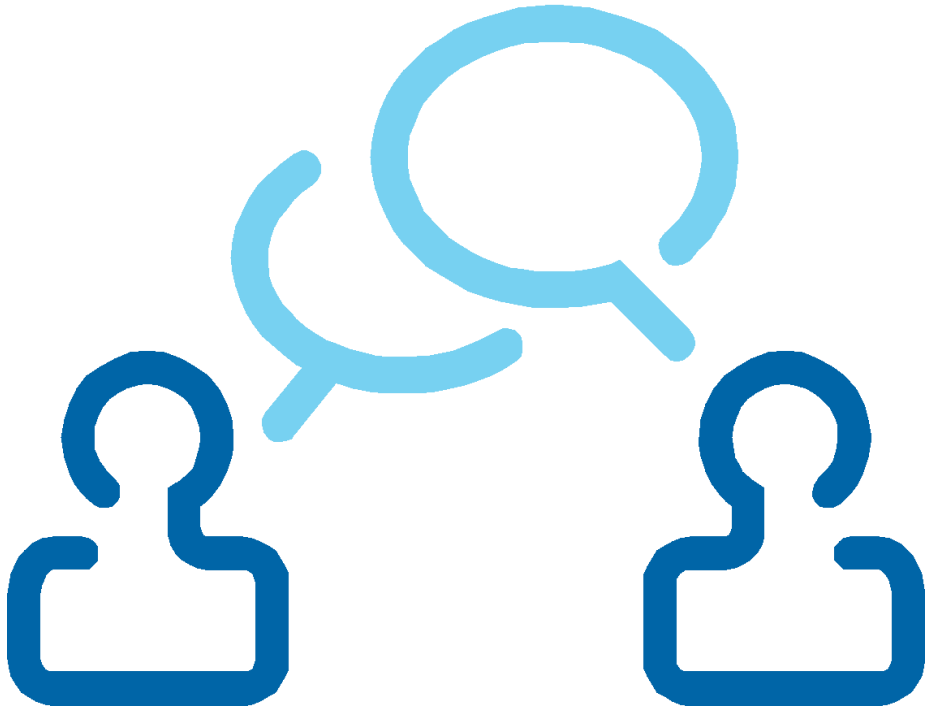
MTG-IRS – Unique 4D look into the atmosphere



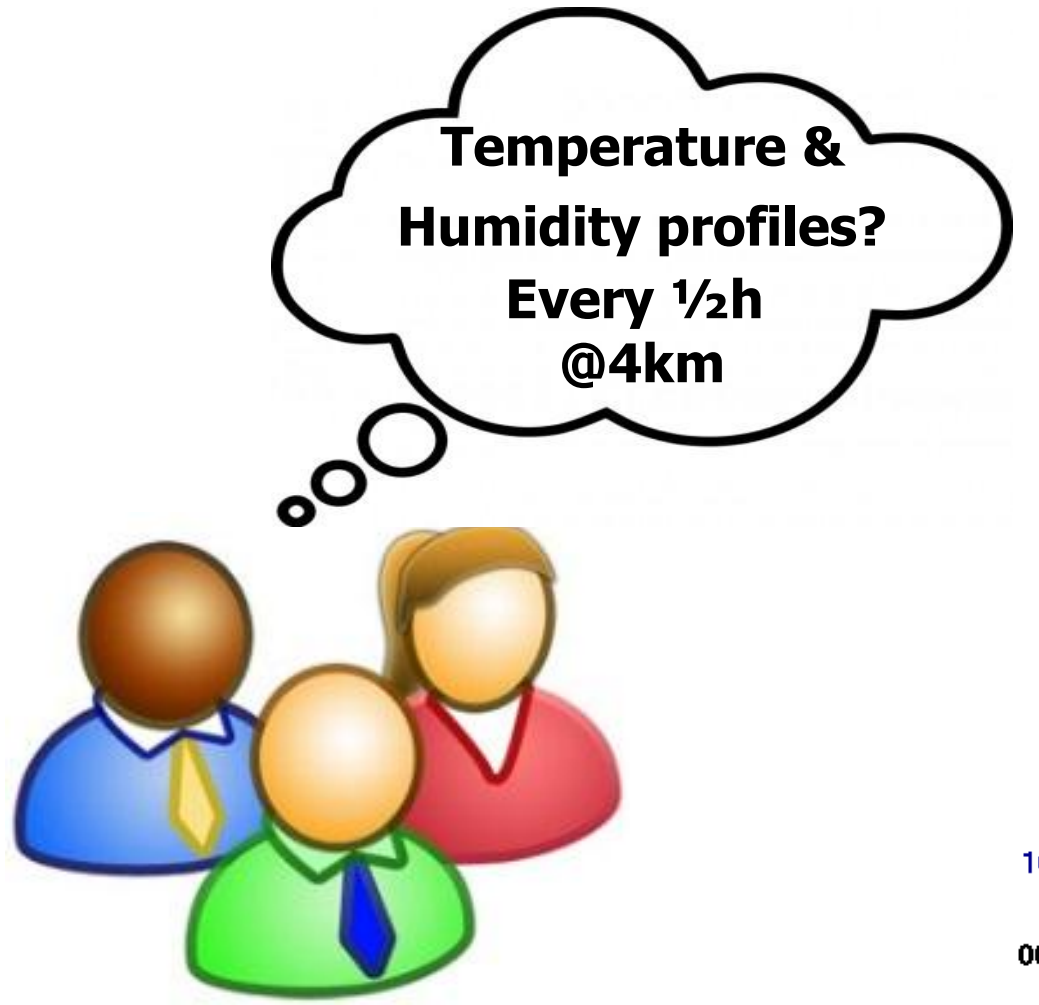
Objectives of the dialog with users

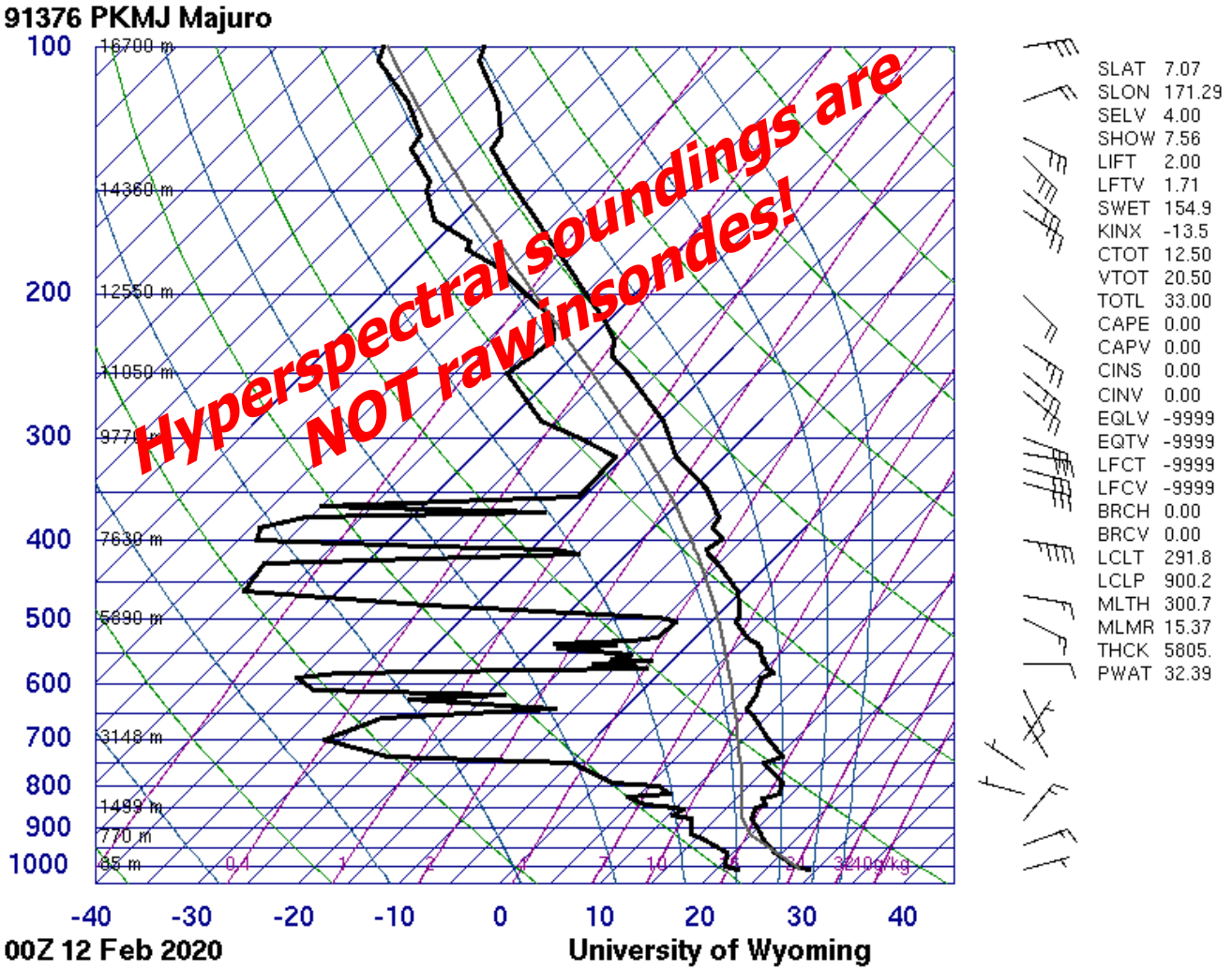
Explore new applications with IASI

- Raise awareness – what info is in the products
- Study use case & limitations
- Learn practical aspects
- Define User requirements



Expose the satellite products with great care

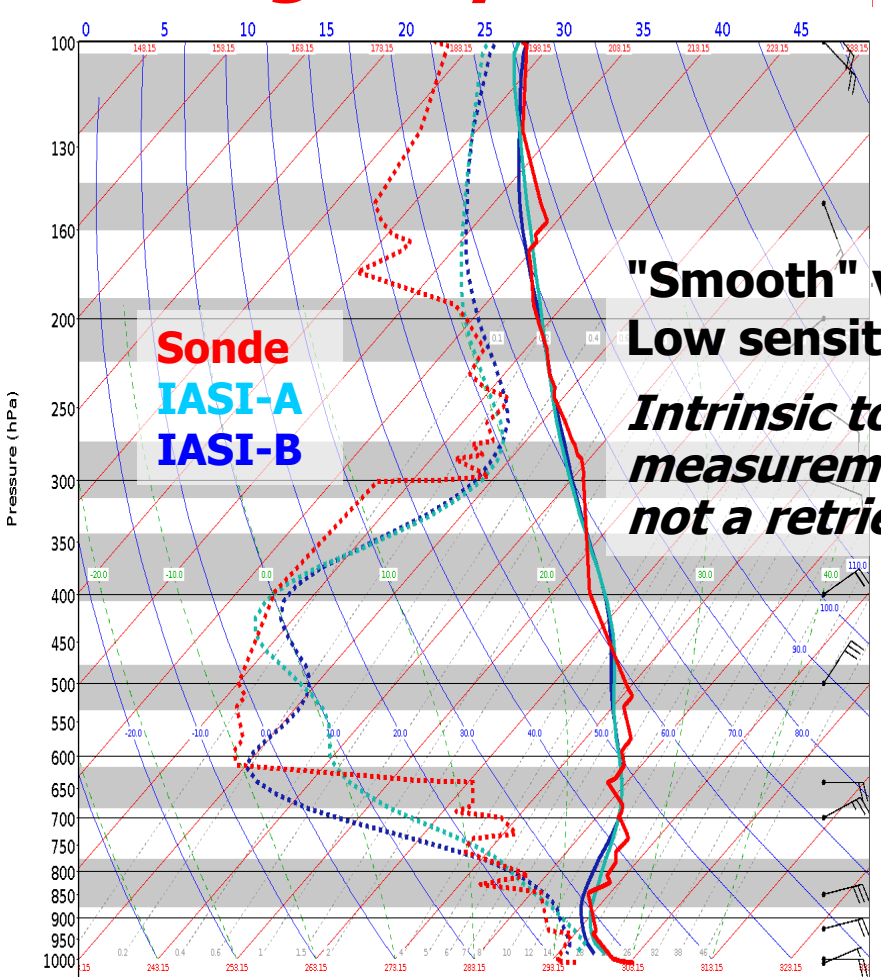




Train the trainers

Case studies with experts

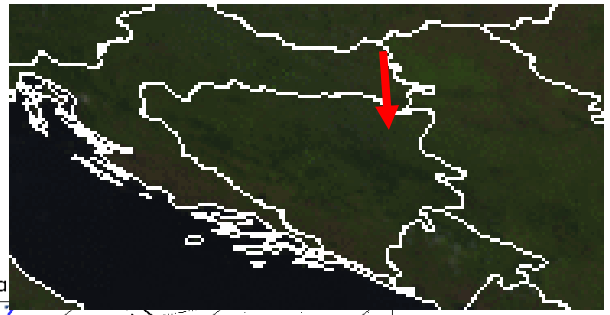
Manage expectations

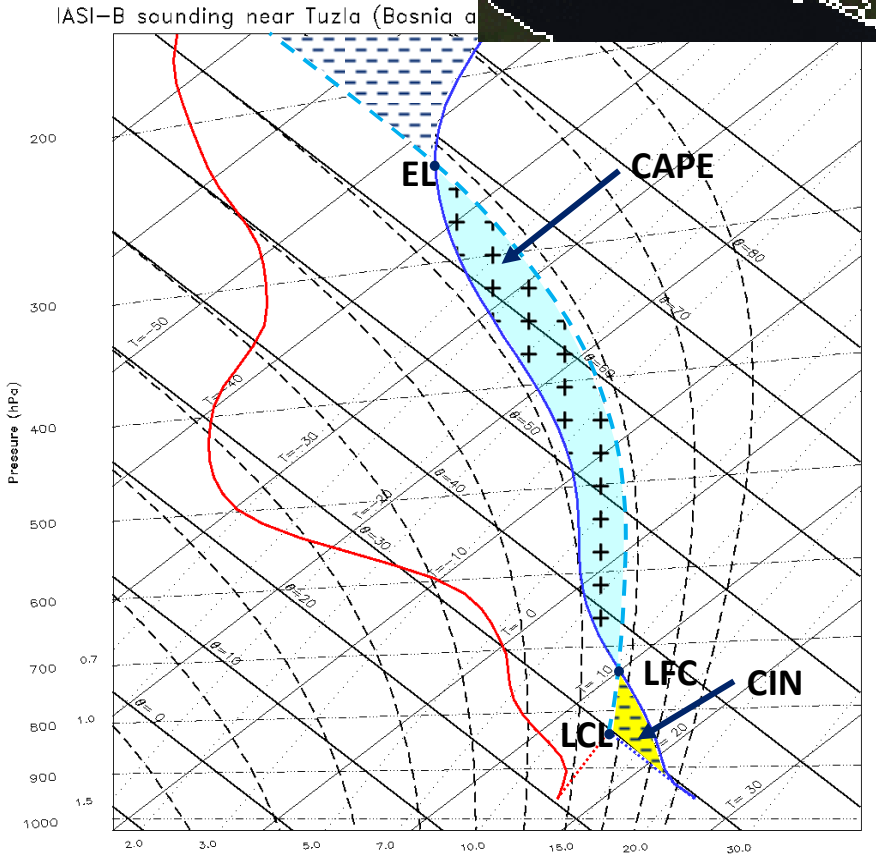


"Smooth" version of the truth
Low sensitivity near surface

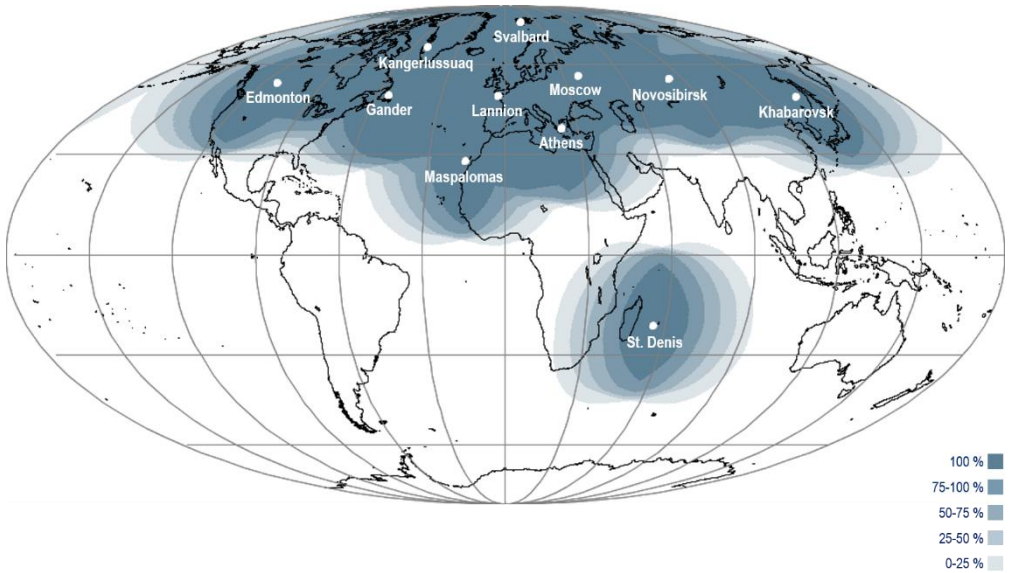
Intrinsic to the info in the measurements, not a retrieval weakness.

Identify needs: What is useful? How to use it?

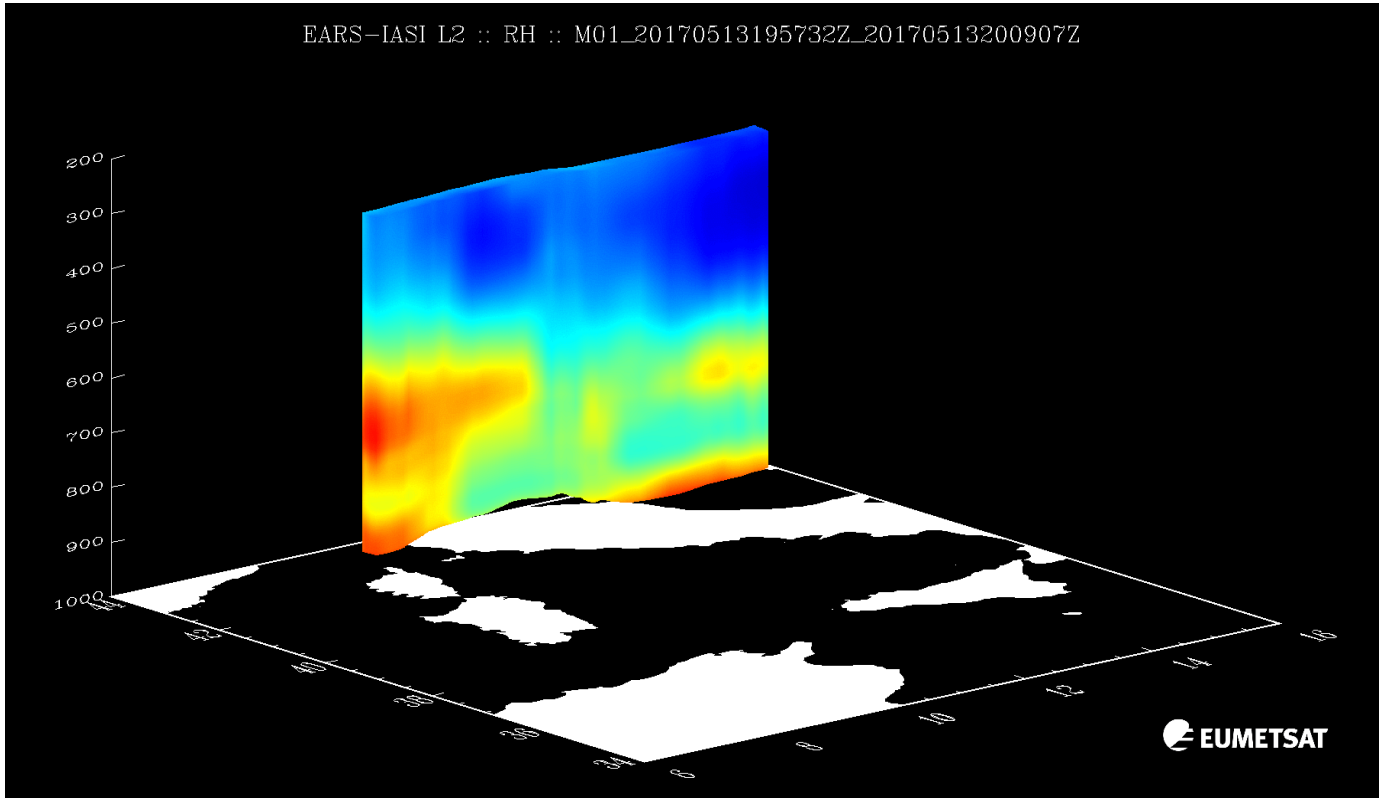




EARS-IASI L2 regional service – timely for nowcasting



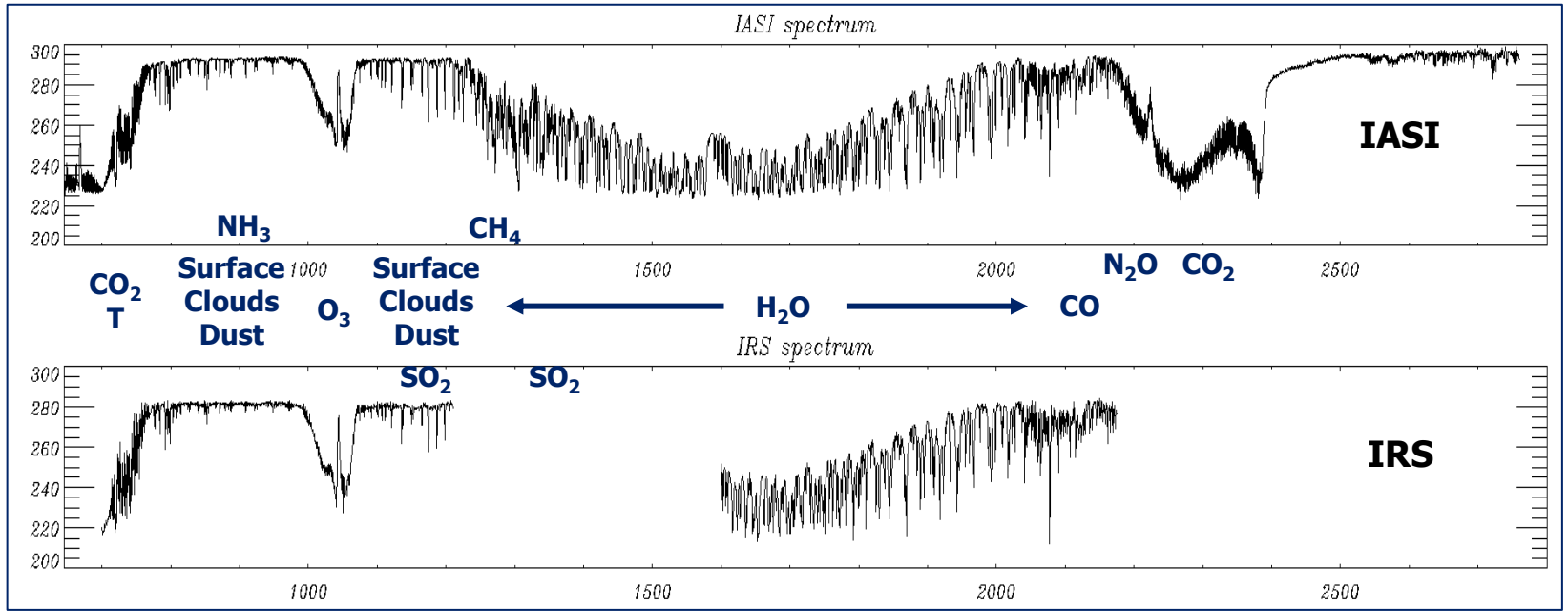
- ✓ Direct broadcast stations
- ✓ Timeliness < **30' from sensing**
- ✓ Pilot phase since Nov. 2017



***Statistical MW+IR retrievals** (fast and accurate)*
'All-sky' forecast-free products: T/q + QC

IRS processing, specificities and commonalities with IASI

- Strong applicable heritage, assuming harmonised spectra (L1 processing)
- Similar types of measurements, from GEO in 160x160 array *vs* *from LEO in 2x2 detectors*
- Differences:



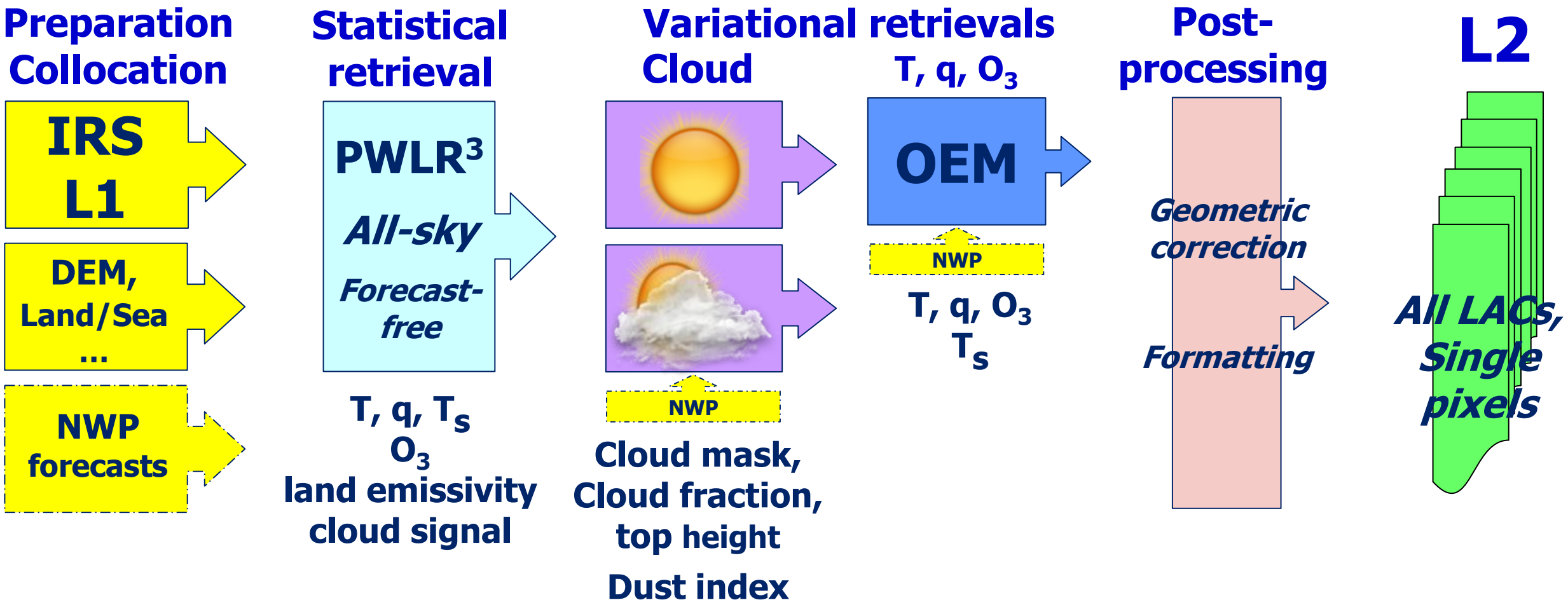
++ Opportunities

- Spatial resolution
- Temporal repetition
- Complementarity GEO/LEO

!! Challenges

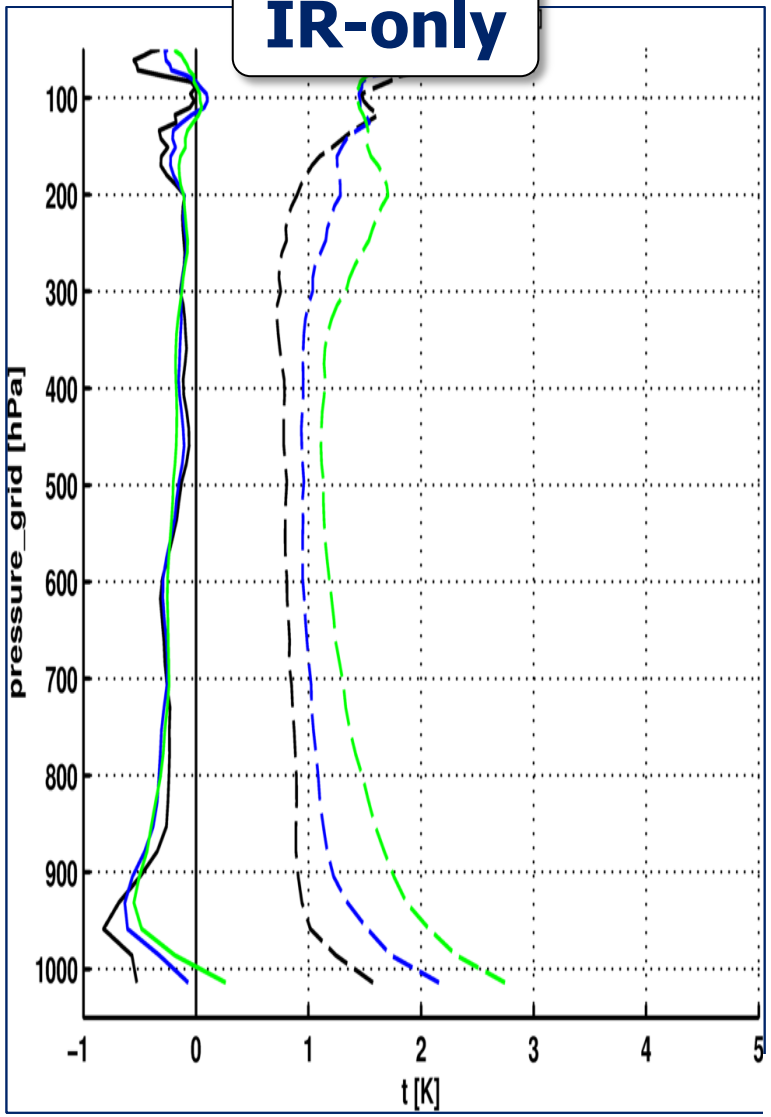
- coarser spectral resolution/coverage ➔ *sounding precision, AC/AQ detectability*
- viewing geometry ➔ *high local zenith angles, quasi-limb view*
- Data volume: ~100x more than IASI ➔ *CPU-effective processing required*
- IR-only, no micro-wave companion ➔ *more sensitive to clouds*

1. IRS L2 Day-1 High-level processor overview

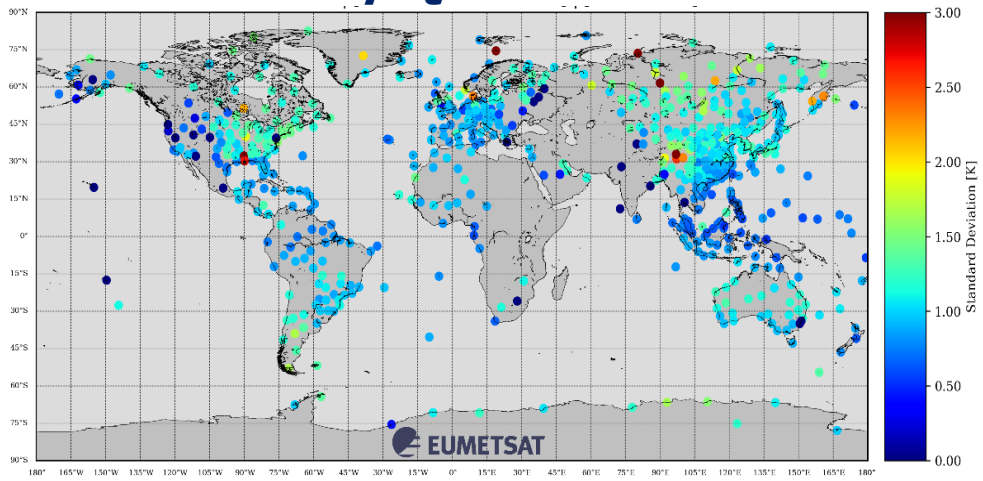


Temperature and quality indicator validation *vs* sondes

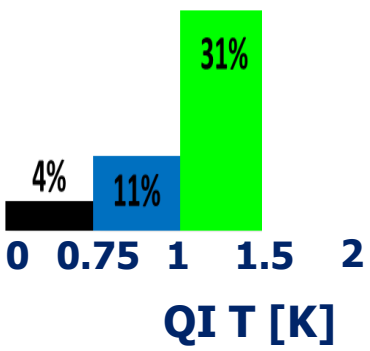
IR-only



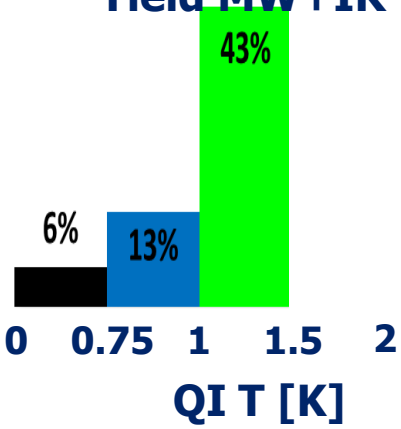
Jan. – Oct. 2017
< 50km ; < 3h
Match-up QC still needed



Yield IR-only

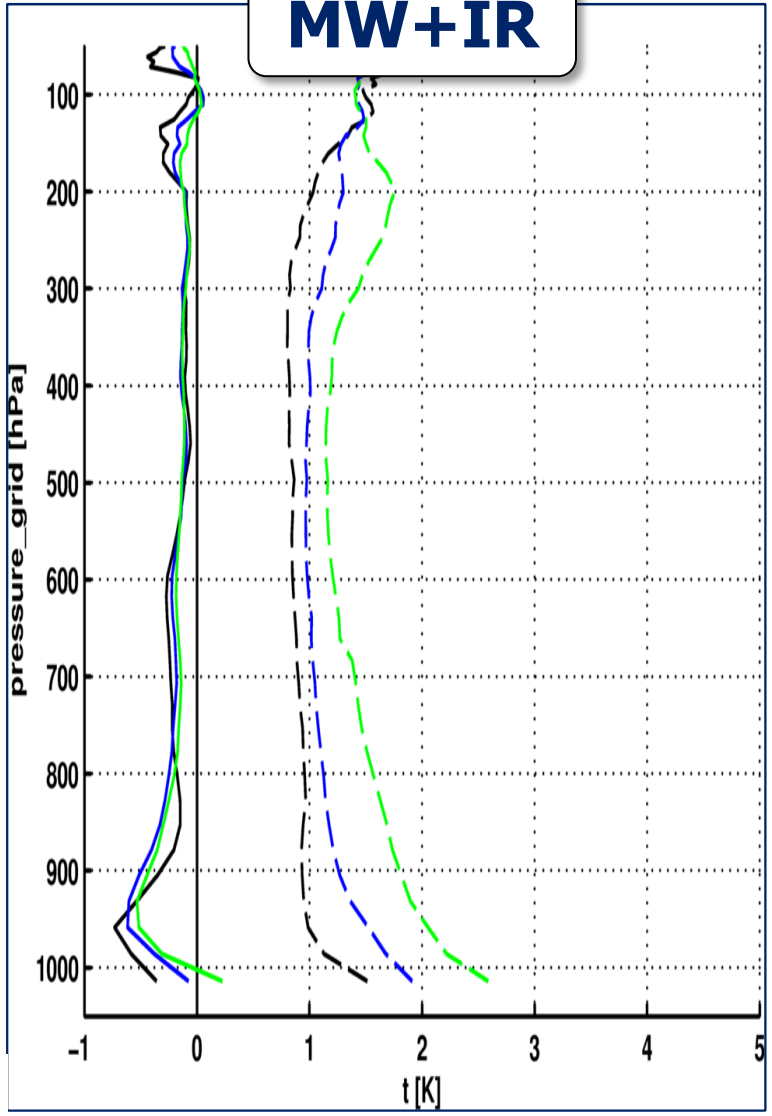


Yield MW+IR

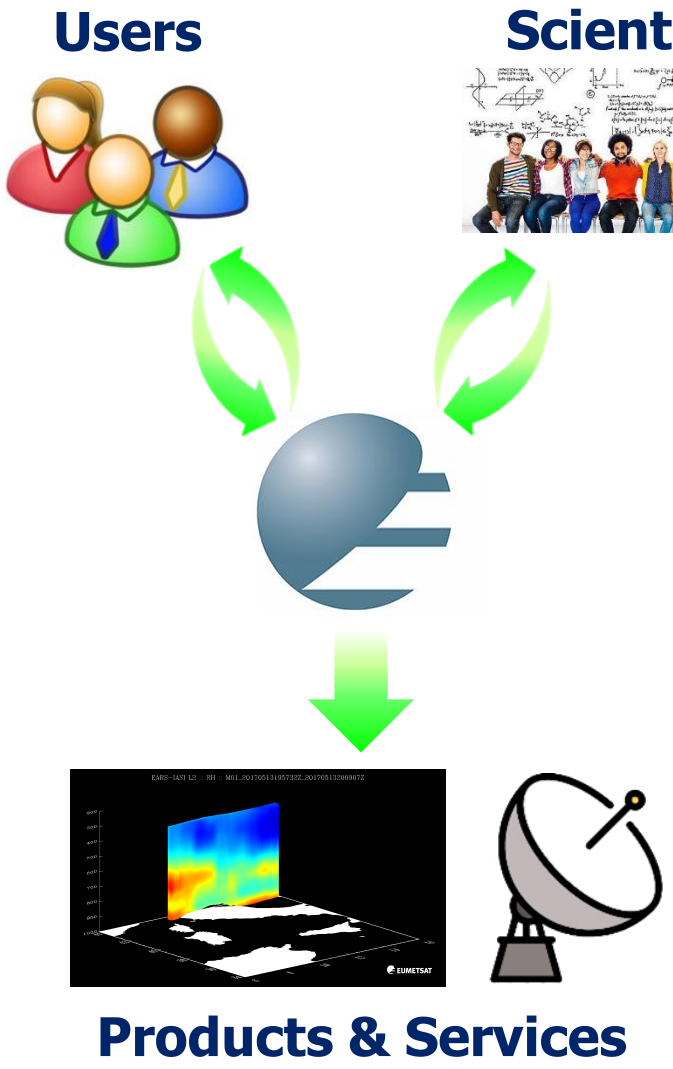


Error estimate in low-troposphere

MW+IR



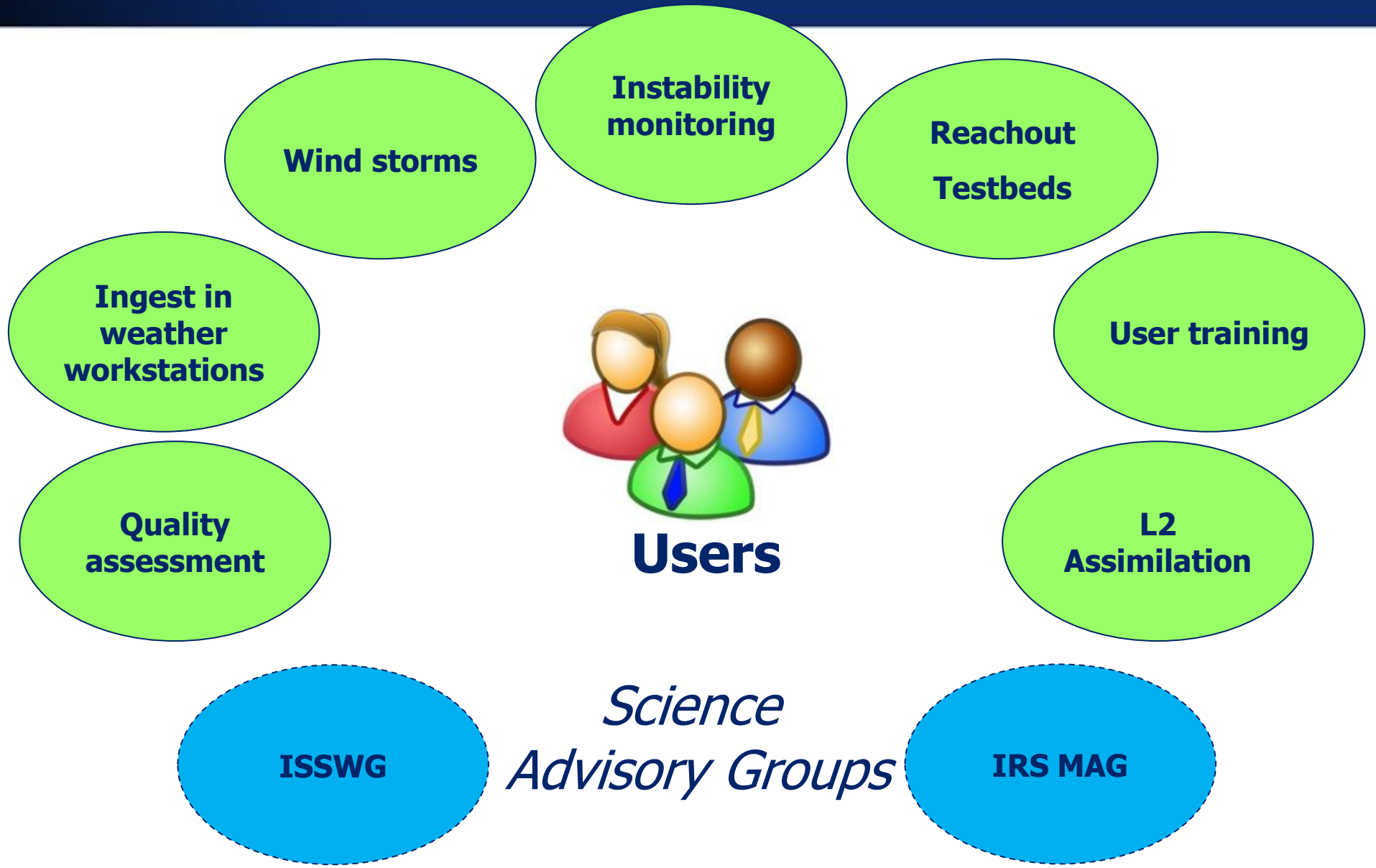
Dialog and studies with users



Potential of HSIR L2 for nowcasting

- ¿ What can we do already with EPS?
- ¿ What can we learn today ?
  - ➢ to evolve current Polar services
  - ➢ to consolidate requirements for MTG-IRS?

Dialog and studies with users



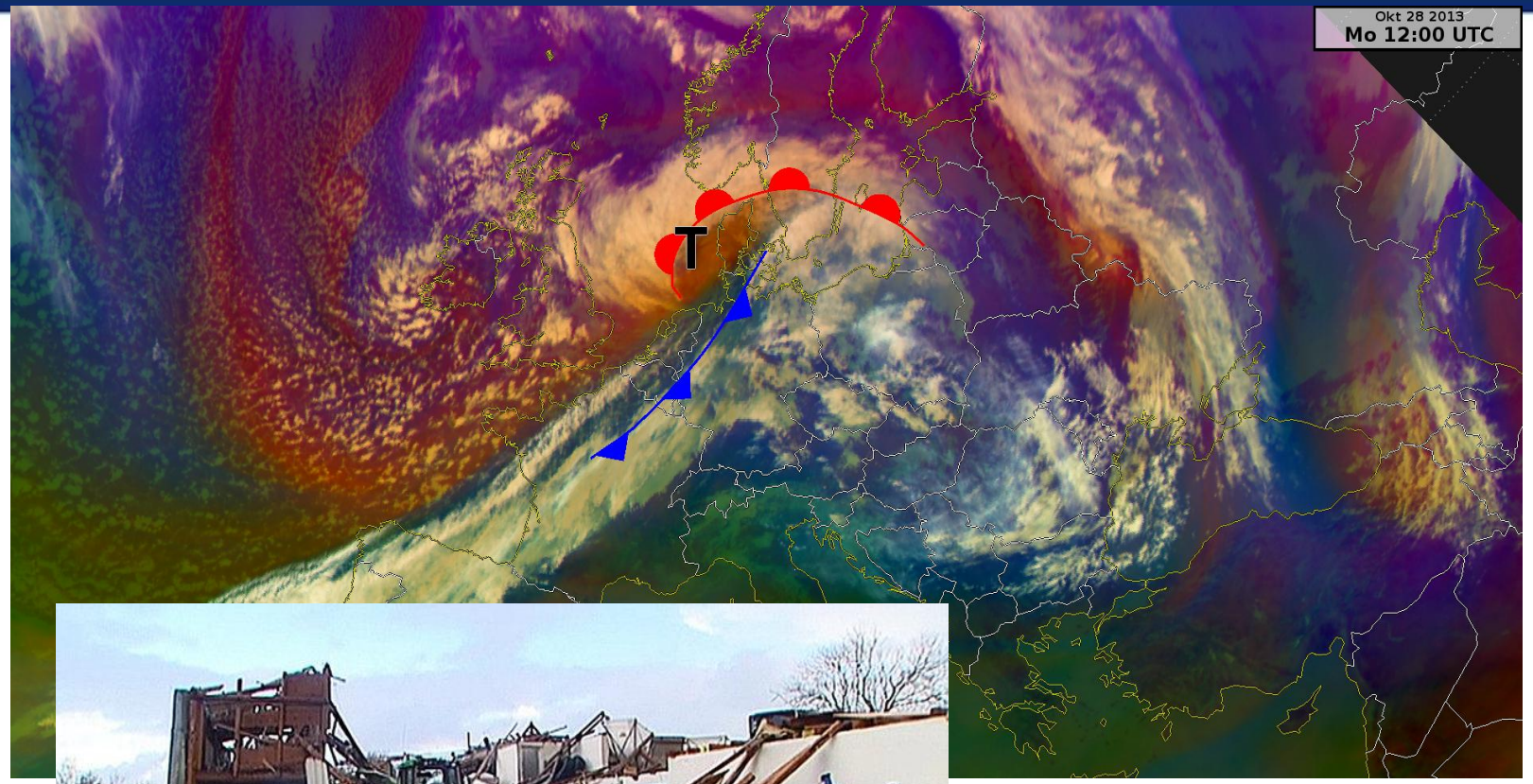
Case studies with IASI L2 at DWD

Cyclone Christian 27/10/2013

- Shapiro-Keyser **Cyclone „Christian“**
- Northern Europe 27-28/10/2013

- Hurricane-force gusts (sting jet)
- **More than 15 people died**
- **Destructions,** ground/air **traffic chaos**
- Low-pressure system from Western Atlantic and passed over Southeast England, Northern Germany, Denmark and Sweden.
- Record breaking wind gust of **191 km/h** at Helgoland (DE).

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



Credits: C. Herold et al. (DWD)
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

More case in K. Hungershöfer, Christian Herold et al. (DWD)
"Are EARS-IASI L2 products useful for Nowcasting?"
EUM User conference, Tallinn 2018

Cyclone Christian 27/10/2013

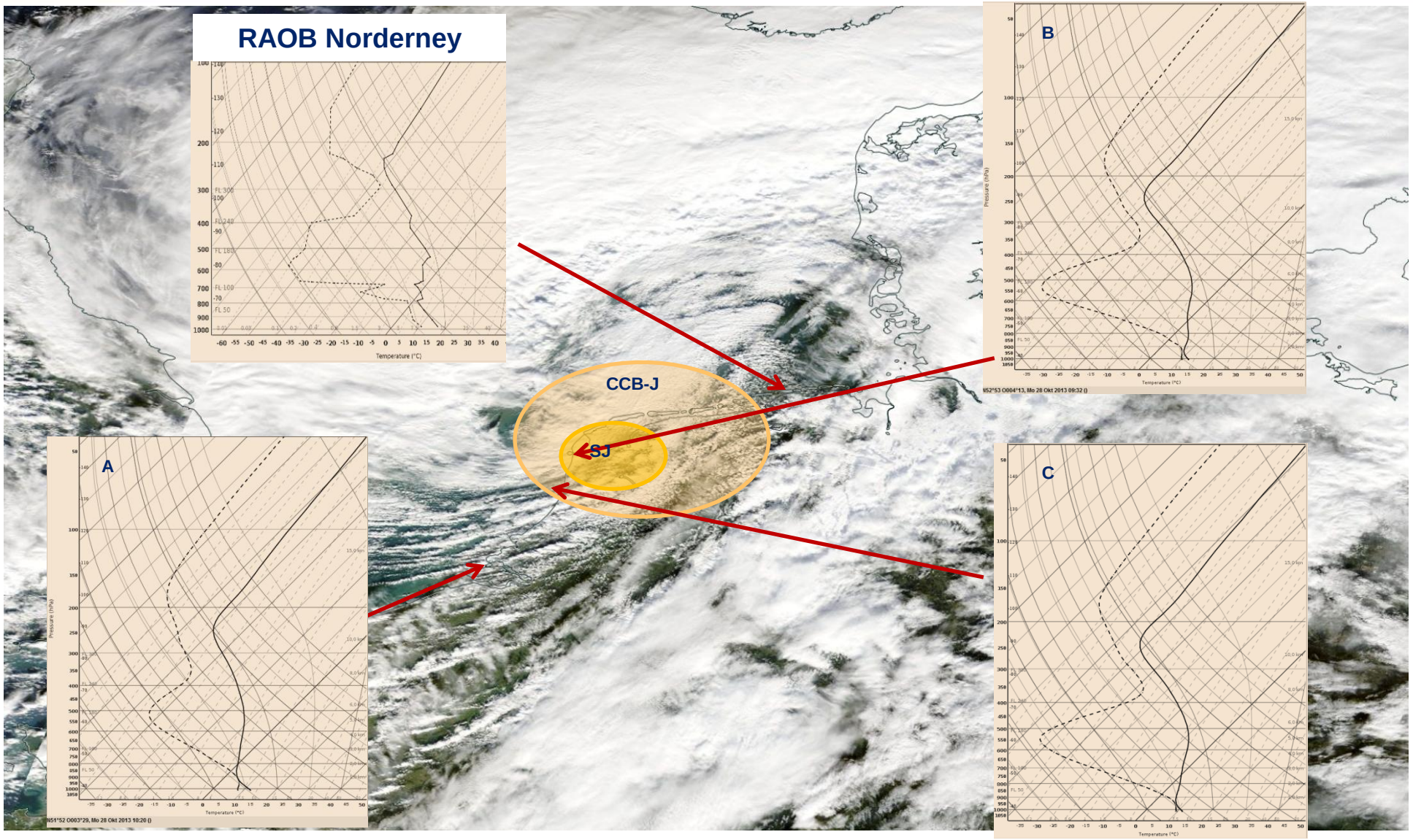
IASI Profiles

in and around the Sting jet (SJ) and the Cold conveyor belt (CCB)

The descending dry stratospheric air in the sting jet area is clearly seen in IASI profiles B and C.

Both profiles agree well with radiosonde measurements.

Such profiles are extremely rare!



Instability tracking with IASI L2, OMSZ

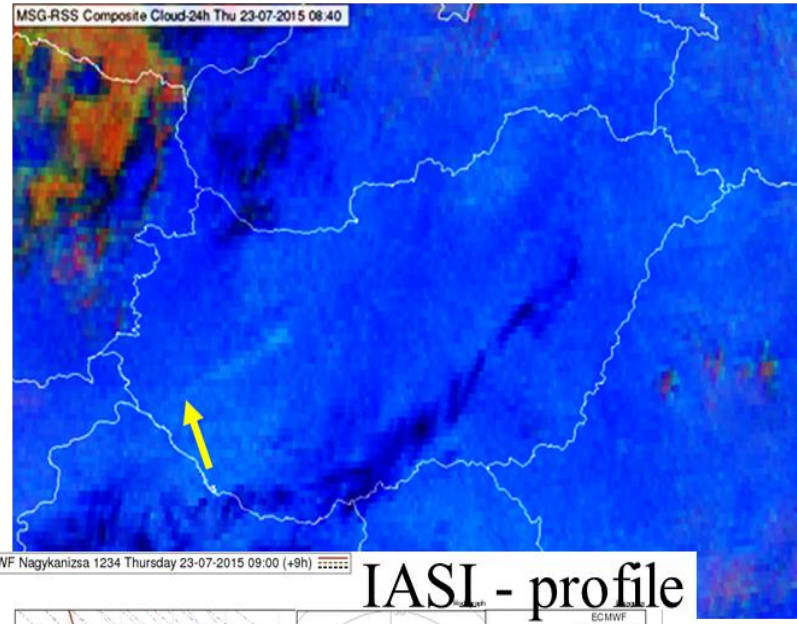
Credits: Z. Kocsis, A. Simon, M. Putsay (OMSZ, Hungarian Met. Services)

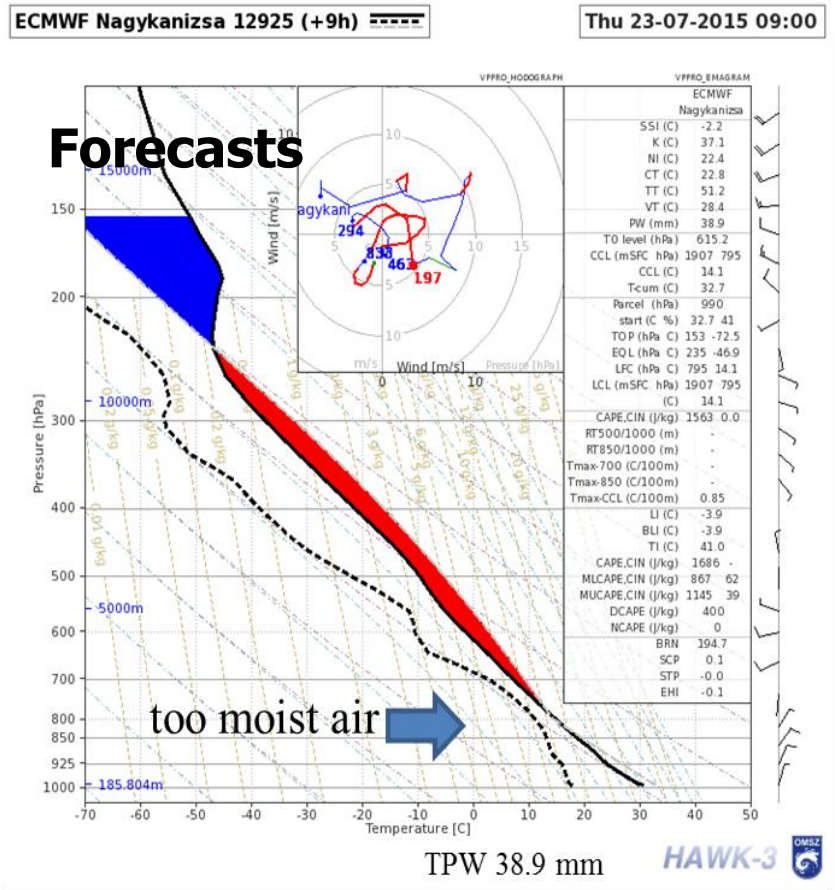
"Possible Usage of IASI L2 Profiles in Nowcasting",

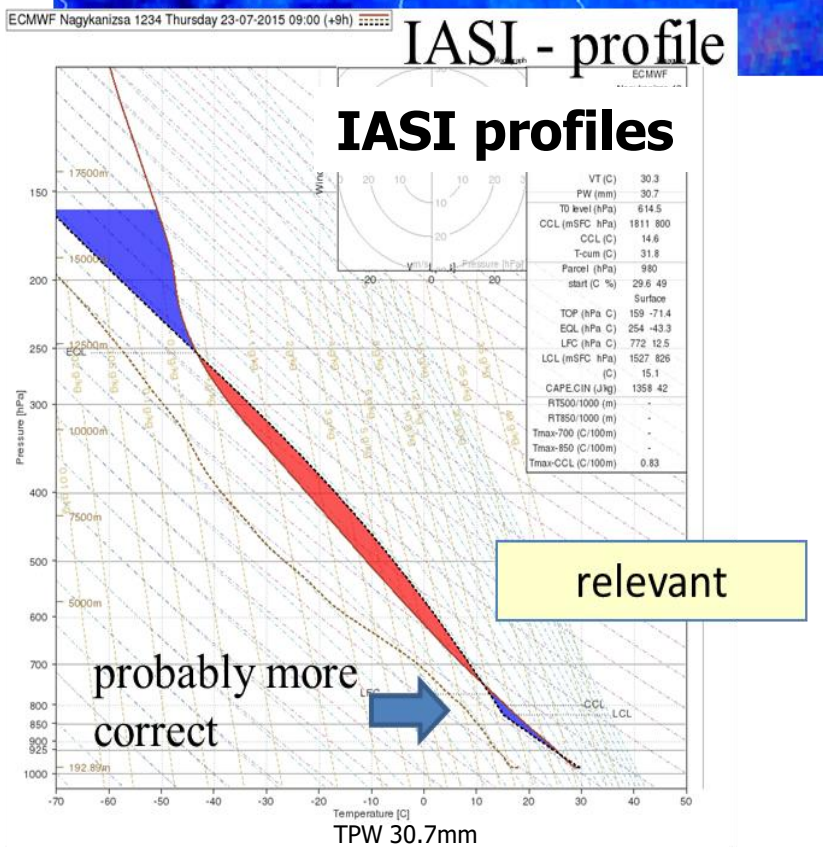
EUM User conference, Tallinn 2018

Evaluation

- IASI profile is less moist at 800 hPa
- The 24h Microphysics RGB indicated relatively dry air (green component: BT10.8-BT8.7), this agrees with IASI profile
- The thunderstorms in this area were short-lived,







OMSZ: IASI-derived instability parameters in support to Nowcasting

Benefits and limitations of IASI-derived environmental parameters

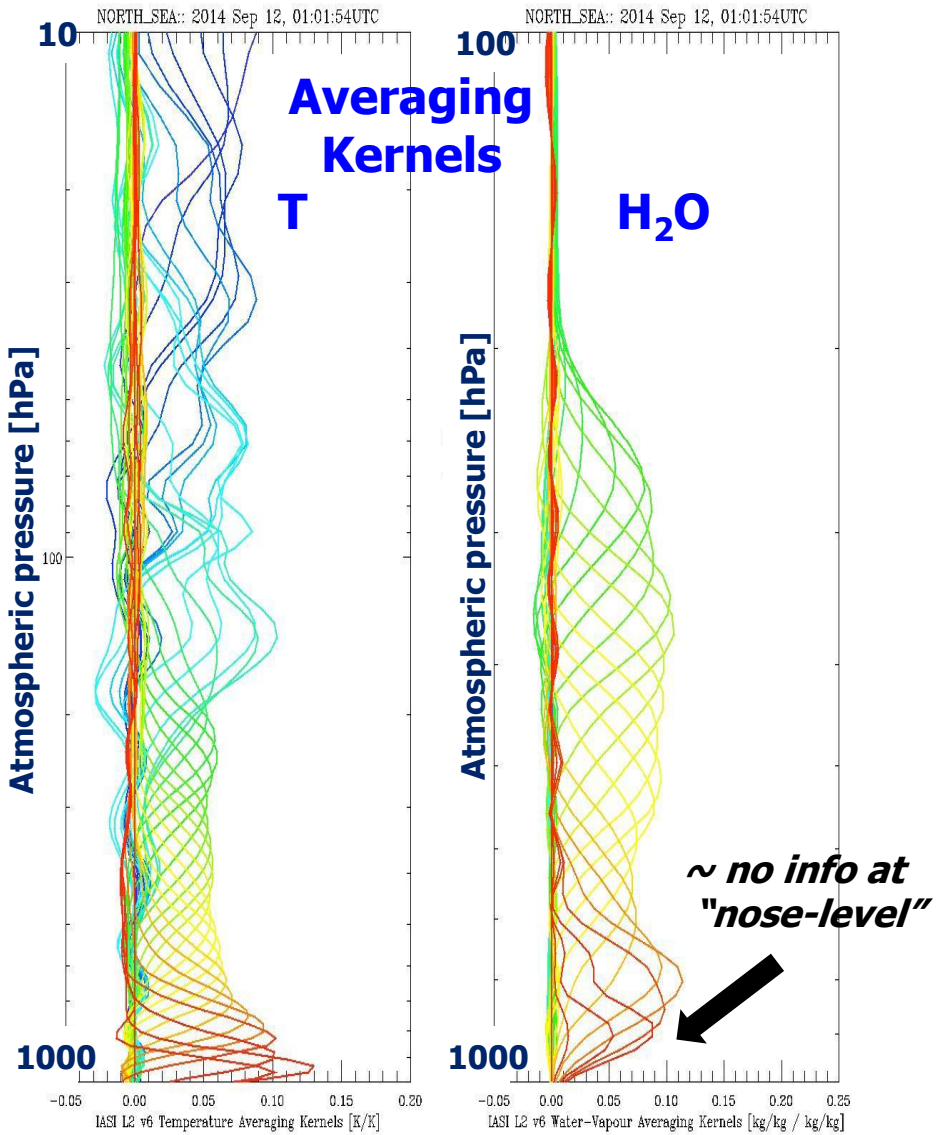
Benefits	Limitations
NWP – independent **The NWP-based forecasts can be checked and corrected.** In case of large differences a 'warning signal' might be given.	IASI profiles (mainly dewpoint) are **very smooth**, which might be misleading. **The precision of low-level data is often uncertain.**
Data are available in cloudy areas as well (big advantage with respect to GII).	Some parameters depend strongly on surface temperature and dewpoint temperature
Measured when **only few upper-air data, often well before convection initiation.** Information for many points	**Low temporal resolution** There is no information on lift or wind shear
The IASI derived convective parameter distribution mostly fits the situation and the later development of convection	In **rapidly changing situations**, its forecasting applicability is limited (though still better compared to soundings).
It can be also used as additional sounding or pseudotemp, ***It might be beneficial to modify the profile with measured surface data.***	

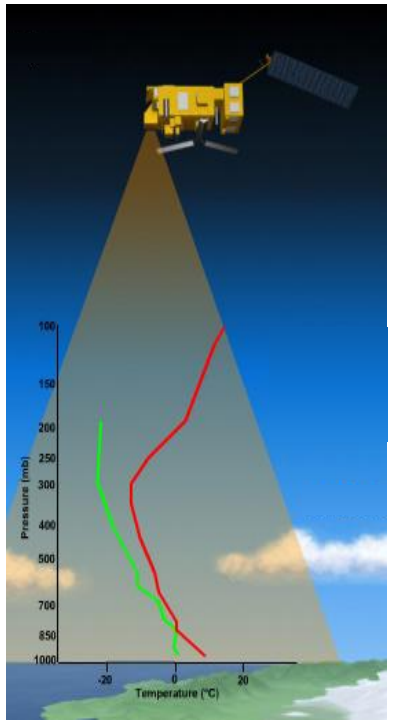
Blend with surface observations?

Could be mitigated with afternoon sounders, until MTG-IRS

Credits: Z. Kocsis, A. Simon, M. Putsay (OMSZ) "Possible Usage of IASI L2 Profiles in Nowcasting", EUM User conference, Tallinn 2018

Blending satellite and surface observations (OMSZ)





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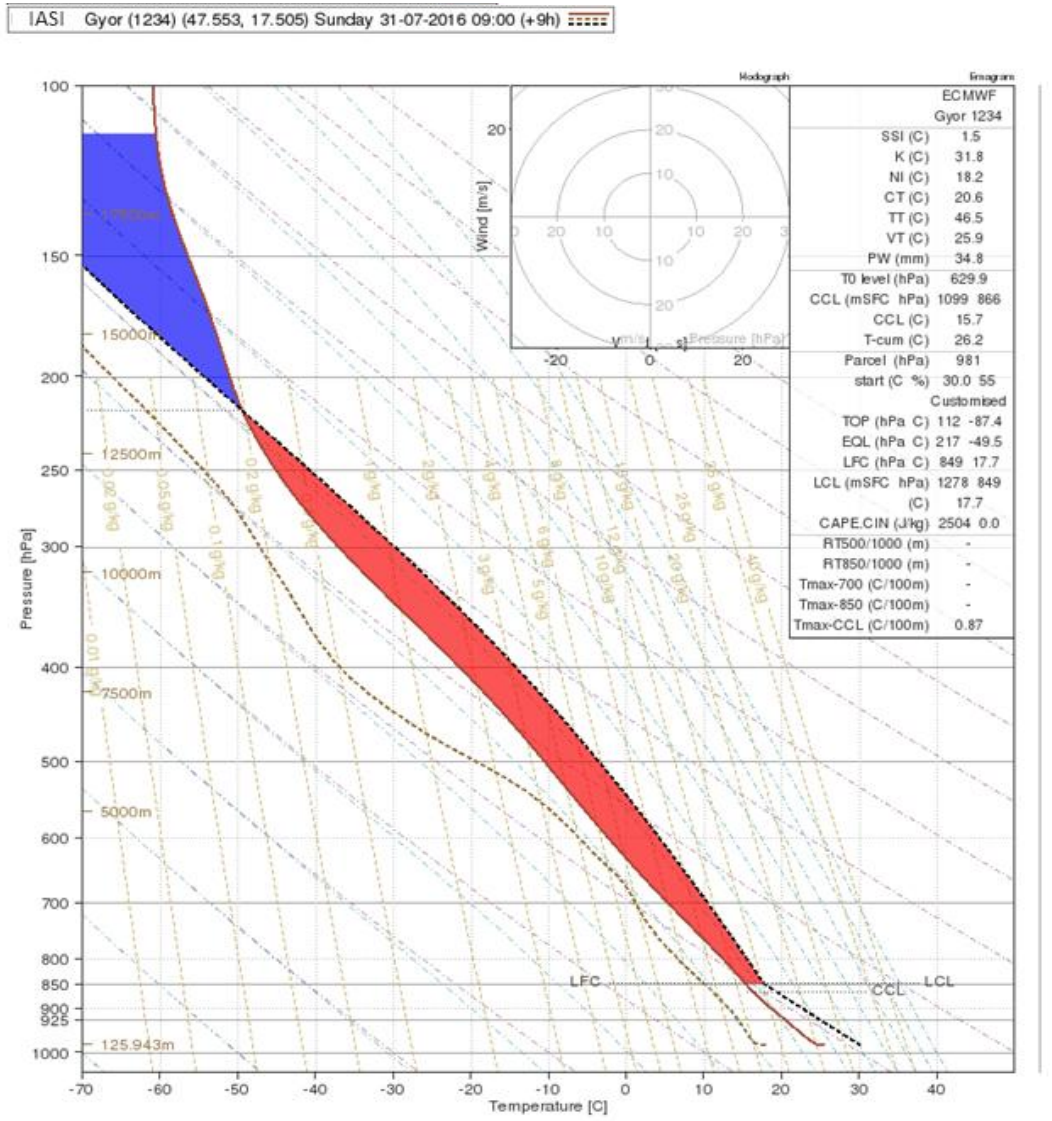
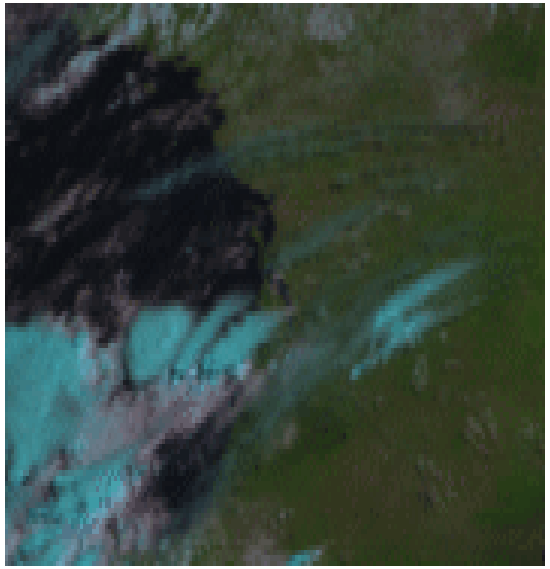
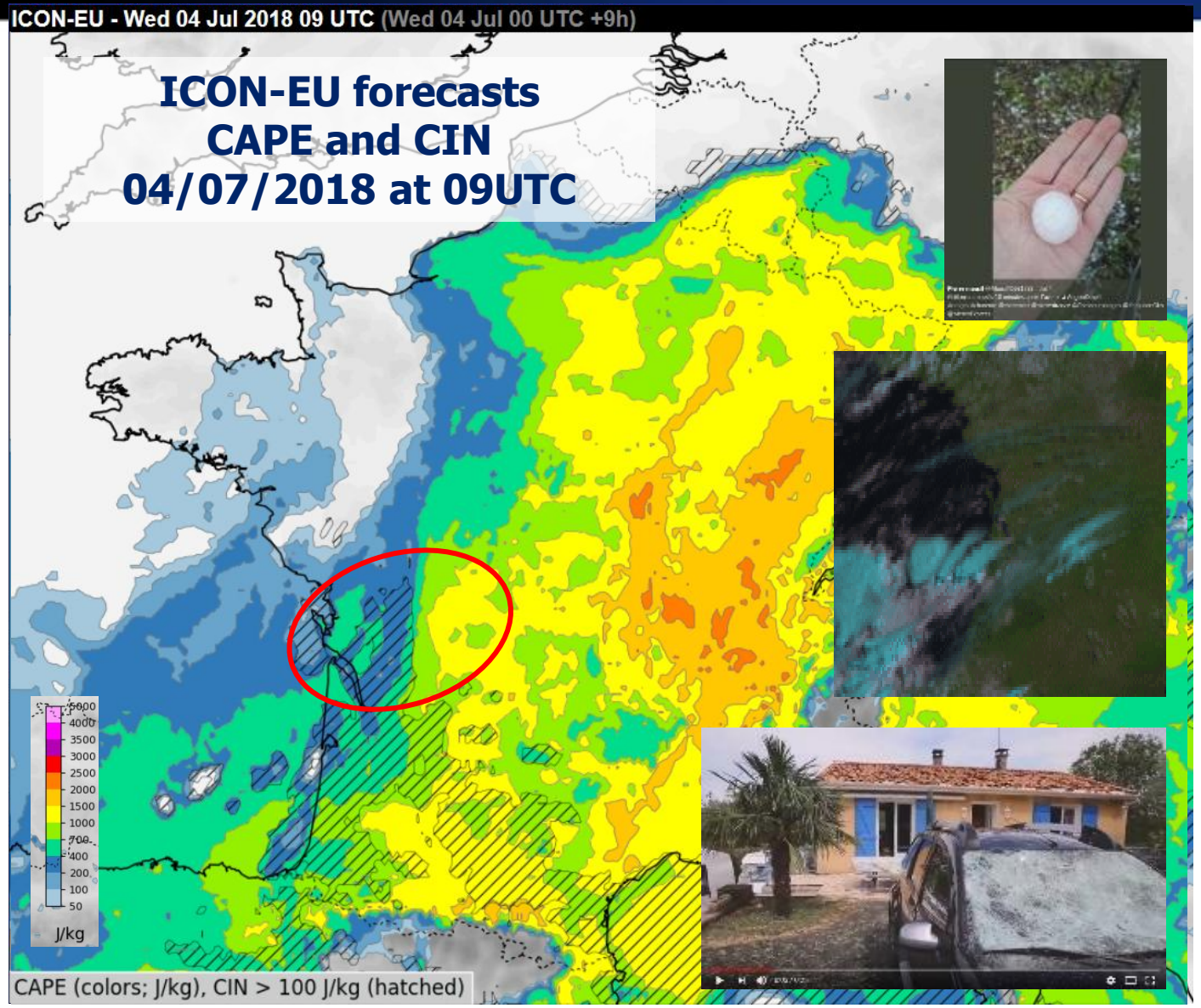


EUMETSAT

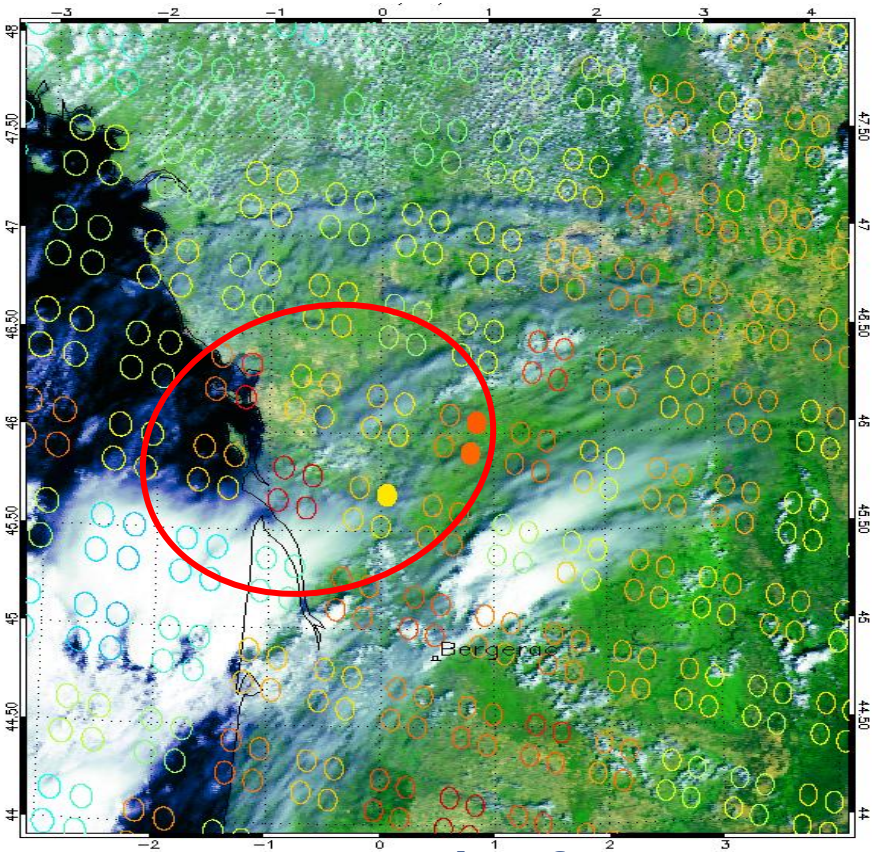
Wind, Lightning Hail storm in Dordogne – 04/07/2018



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

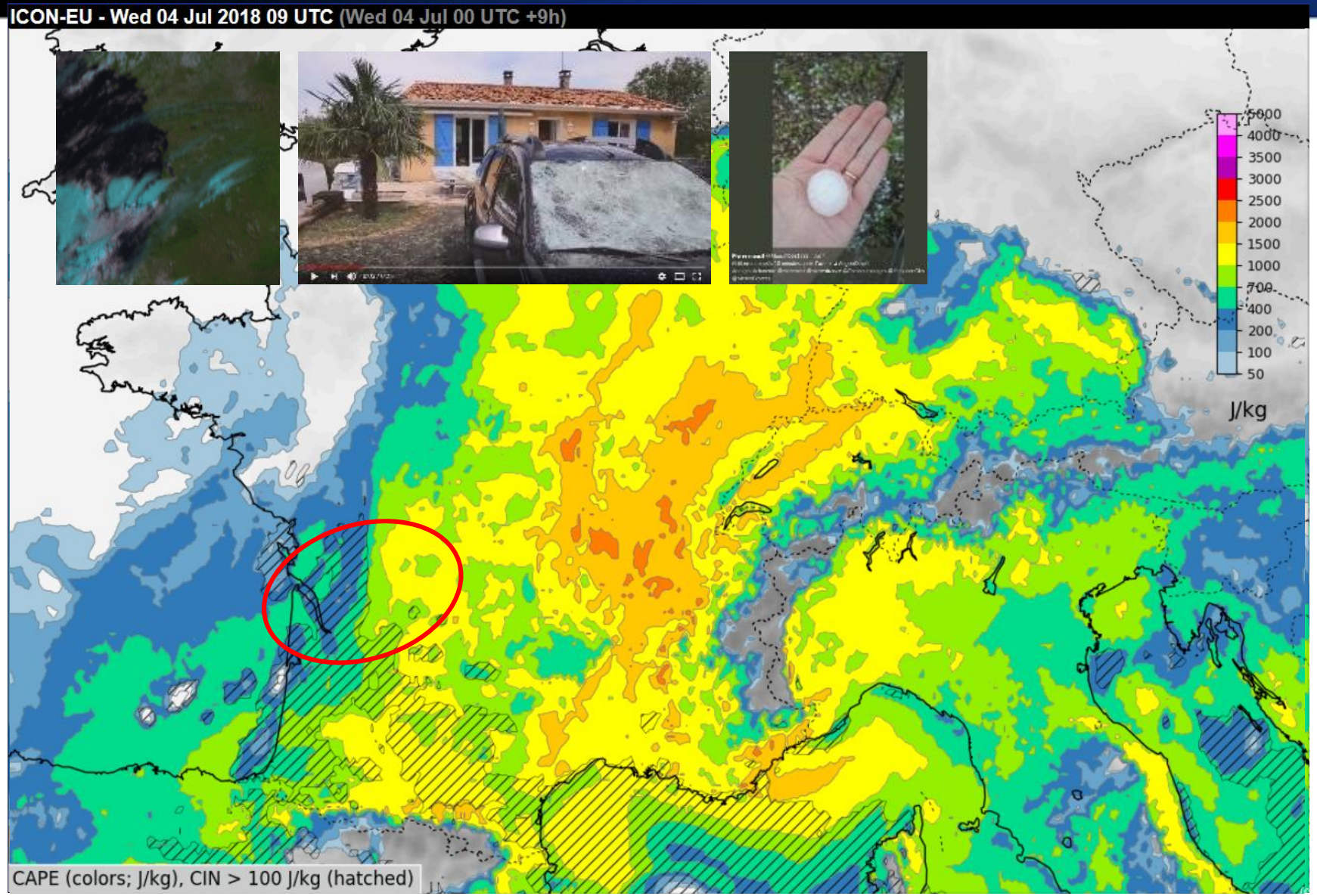


Metop-B/IASI
04/07/2018 09:50
Lifted index



IASI warmer than forecasts in the bottom layers → potential instability

Learn from forecasters direct experience



ICON-EU forecasts CAPE and CIN 04/07/2018 at 09UTC

The forecasters have intimate experience of the various models. Differences can come from e.g. timing the front, precip or convection.

Independent observations are needed to complete the picture and anticipate the course of events.

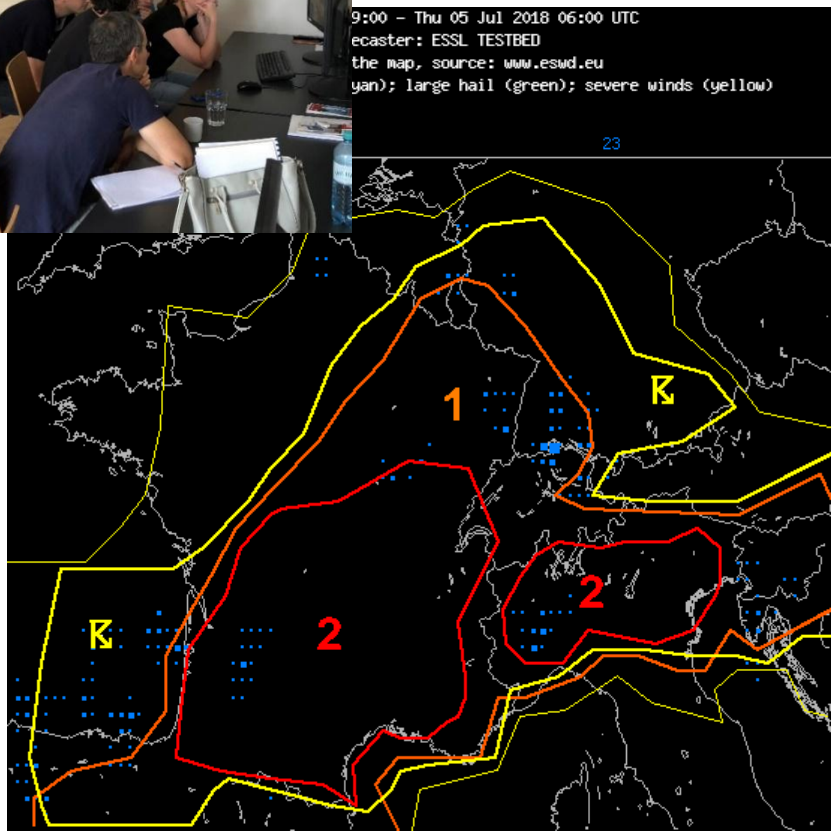
There is deep experience of using e.g. radiosondes *(sparse)*, imager cloud masks and layer quantities/indices *(limited vertical information)*.

➔ Build the same intimacy btw forecasters and hyperspectral atmospheric sounding.

European Severe Storm Laboratory

IASI T/q products evaluation and dialog with users in ESSL Test Beds June-July 2019

- to ***raise awareness and train European forecasters*** *with products derived from EUMETSAT hyperspectral Infrared sensors for the prediction of severe storm*.
- to ***collect the feed-back from European users*** to evaluate and ***consolidate the requirements*** on hyperspectral products and associated services for short-term severe weather forecasting.
- to ***constitute a catalogue of relevant situations***, to serve as test bed for algorithms experiments, case studies and feed into products and services developments.
- to ***perform detailed case studies*** by ESSL experts from the above catalogue with existing L2 products.

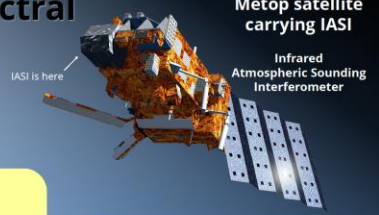


European Severe Storms Laboratory
Science & Training

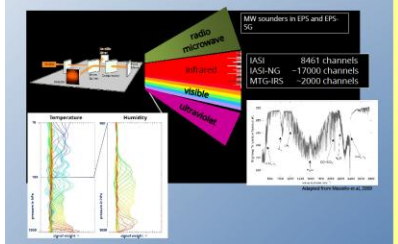
EUMETSAT

Evaluating the use of IASI hyperspectral sounder data for severe storm forecasting at the ESSL Testbed

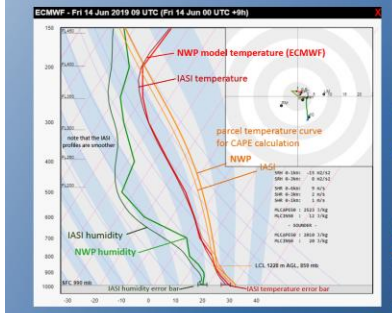
Pieter Groenemeijer, Tomáš Púčik (ESSL)
Thomas August (EUMETSAT)



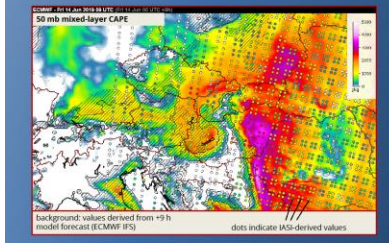
The IASI sounder measures infrared radiances ...



...from which vertical profiles of temperature and humidity are derived.
They can be compared to the profiles from numerical weather prediction (NWP) models:



... from those, we can compute convective parameters, such as CAPE:

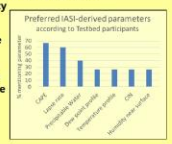


ESSL Testbed

In June and July 2019, over 40 Testbed participants worked with IASI profiles and parameters to make experimental forecasts for severe convective storms

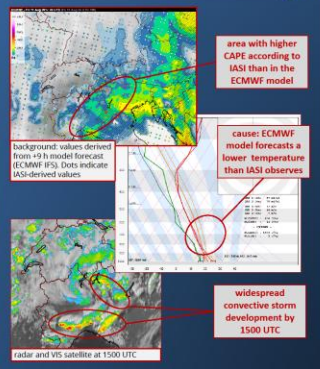
Main conclusions:

- **almost all forecasters found the type of data useful**
- **forecasters would like to have a higher (spatio-) temporal availability**
- **IASI profiles should stay completely independent of the model data**
- **forecasters found greatest discrepancies between IASI and NWP in the near-surface humidity**
- **preferred parameters are**
  - **CAPE**
  - **lapse rates**
  - **precipitable water**



Studies of past cases

ESSL is evaluating the potential of IASI by evaluating past cases of severe convection that were impactful or not well anticipated by NWP models. An example is provided below:



Operational IASI — now available!

Infrared Atmospheric Sounding Interferometer

- flies on polar satellites Metop-A/-B/-C launched 2006, 2012, 2018
- has a pixel size of 12 km at Nadir – 2000km swath
- Two overpasses per day across central/southern Europe, in the morning and evening
- More frequent overpasses in northern Europe

IASI-NG — coming soon...

IASI-Next Generation

- will have the same coverage but **improved** sounding performance

MTG-IRS — coming soon...

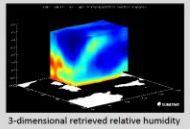
Meteosat Third Generation – InfraRed Sounder

- will fly on the geostationary Meteosat Third Generation
- Similar sounding data to IASI, but **every 30 min** and with a pixel size of **7 km**

The first MTG sounder satellite is scheduled to be launched in **2023**.

EARS – IASI service — now available!

The EARS-IASI level 2 service is routinely providing temperature and humidity sounding from IASI within 30 minutes maximum from sensing. The products are available through the EUMETCast service, for the areas covered by the local receiving stations of the EARS-IASI network. The products exploit the MW companion instruments, hence data is also provided in most cloudy regions. The retrievals are fully independent from numerical weather forecasts.


3-dimensional retrieved relative humidity


areas covered by local EARS-IASI receiving stations

The **European Severe Storms Laboratory** is a non-profit research organization located in Germany and Austria (Wiener Neustadt). It supports by operating the European Severe Weather Database, organizing the ESSL Testbed and scientific meetings. It carries out research on the climatology, impacts and forecasting of severe storms and provides forecaster trainings. Its members include 20 European weather services and research centres, as well as 17 commercial supporting members.
For more information, visit: www.essl.org

Corresponding author: Pieter Groenemeijer (pieter.groenemeijer@essl.org)

Reference:
Masiello et al, 2009: Application of φ-IASI to IASI: Retrieval products evaluation and radiative transfer consistency, *Atmos. Chem. Phys.*, **9**, doi: 10.5194/acpd-9-9647-2009.

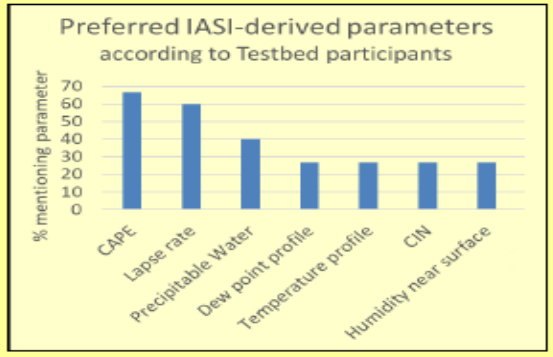
This study is carried out by European Severe Storms Laboratory – Science & Training for EUMETSAT under contract EUM/CO/184600002214

ESSL Testbed

In June and July 2019, over 40 Testbed participants worked with IASI profiles and parameters to make experimental forecasts for severe convective storms

Main conclusions:

- **almost all forecasters found the type of data useful**
- **forecasters would like to have a higher (spatio-) temporal availability**
- **IASI profiles should stay completely independent of the model data**
- **forecasters found greatest discrepancies between IASI and NWP in the near-surface humidity**
- **preferred parameters are**
  - **CAPE**
  - **lapse rates**
  - **precipitable water**



P. Groenemeijer, T. Pucik (ESSL)
European Meteorological Society
Copenhagen 2019

EUMETSAT

Assimilation of IASI Level 2 T/q in NWP

Studies

- ECMWF: global IFS, IASI L2 IR-only (proxy for IRS)
- Météo-France: regional AROME, IASI L2 MW+IR

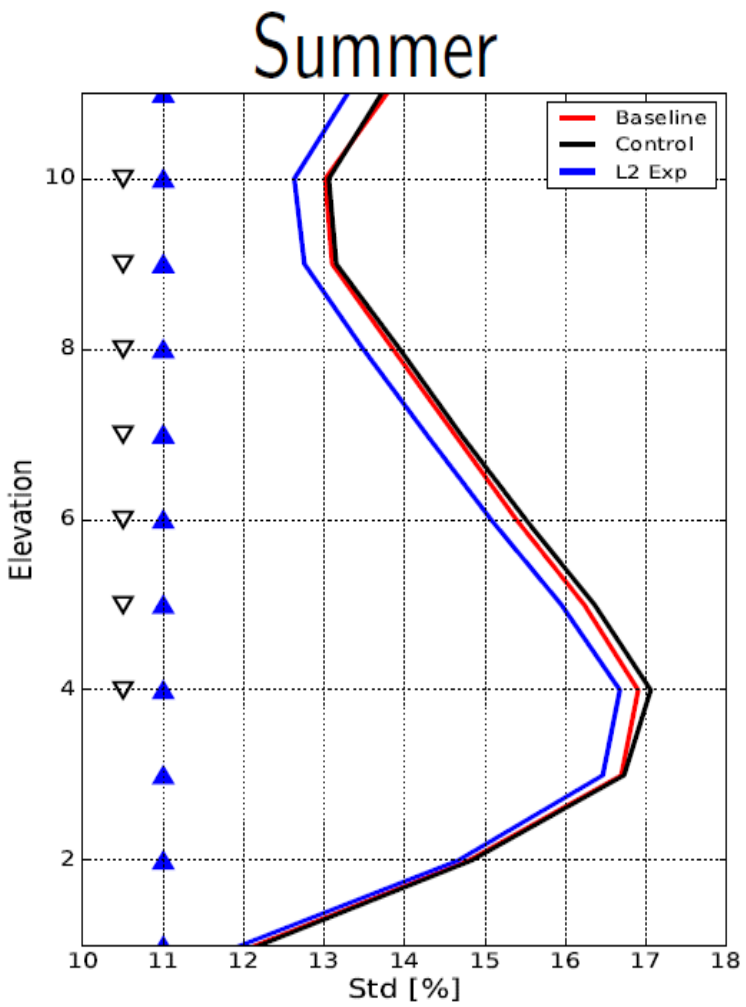
$$J = (x\text{-}xb_b)^T B^{-1} (x\text{-}x_b) + (y\text{-}Hx)^T R^{-1} (y\text{-}Hx)$$

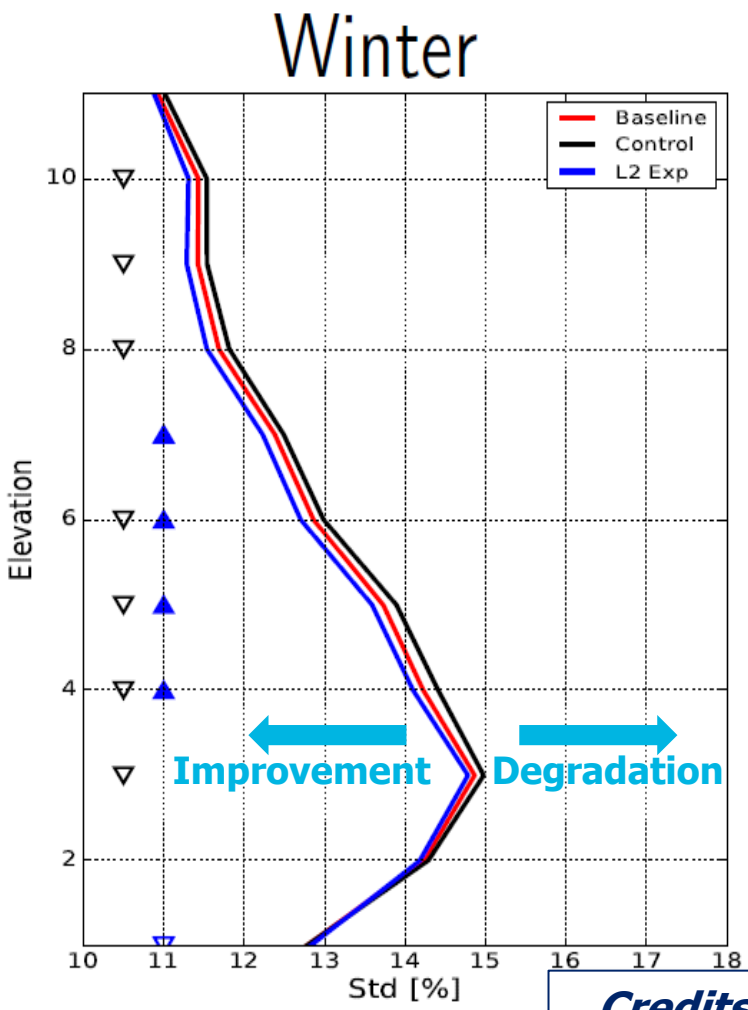
Observation operator not accounting for the vertical sensitivity and resolution

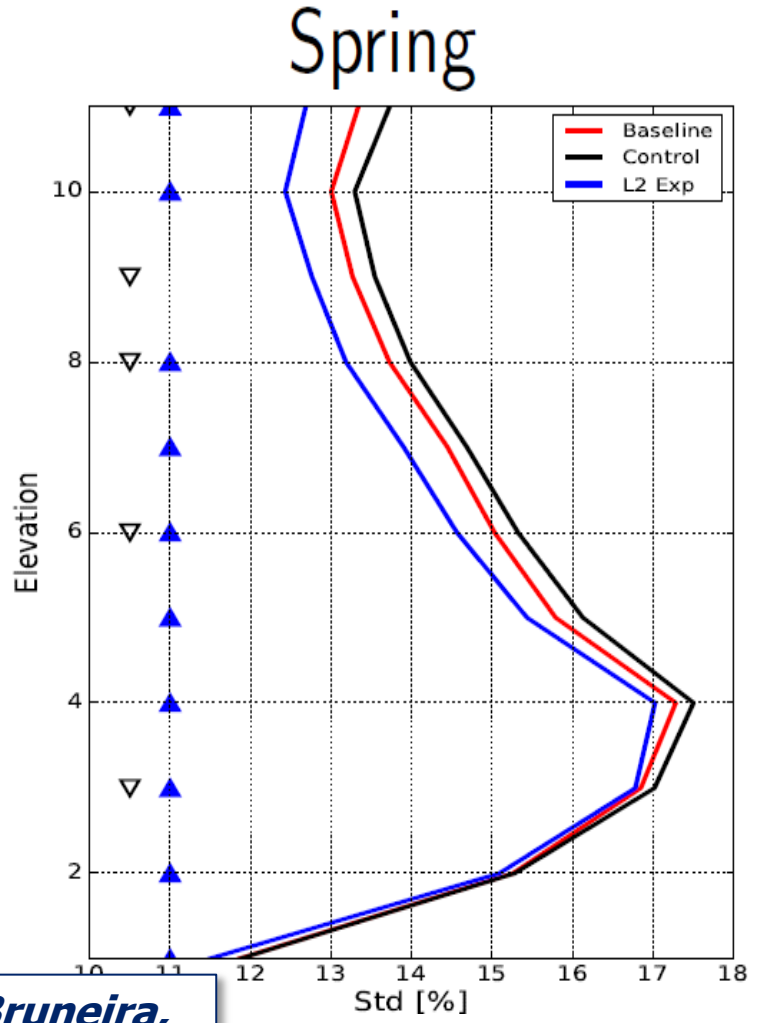
M-F: static diagonal *(pseudo-sondes)*
ECMWF: full matrix, static + first attempts for scene-dependent

IASI L2 in AROME, completed – *paper in preparation*
%RH forecasts skills *vs* radar (stddev)

- Baseline **- Control (L1)** **- Exp. L2**



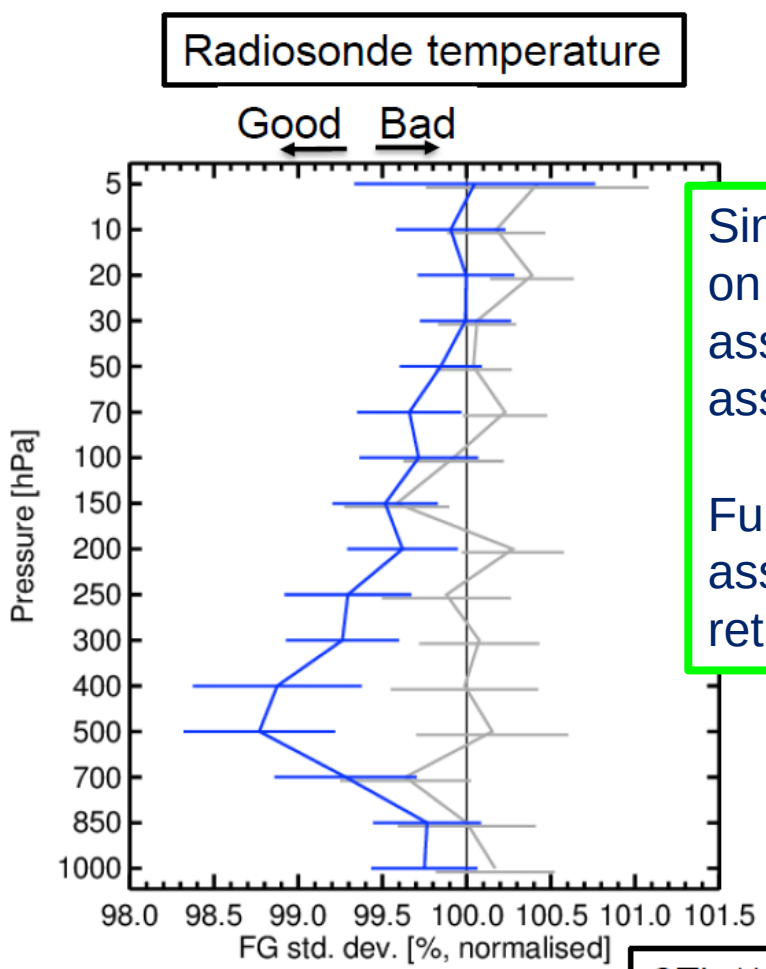


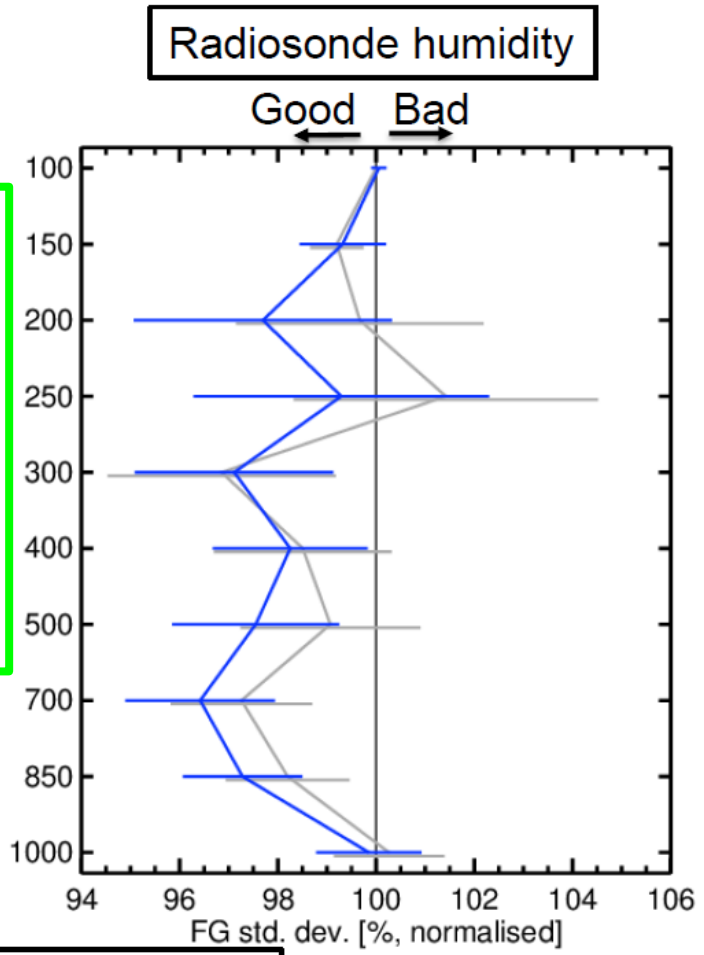


Credits: S. Bruneira, V. Guidard, N. Fourrié

IASI L2 IR-only assimilation at ECMWF - completed

Assimilation experiments with q only, depleted observing system





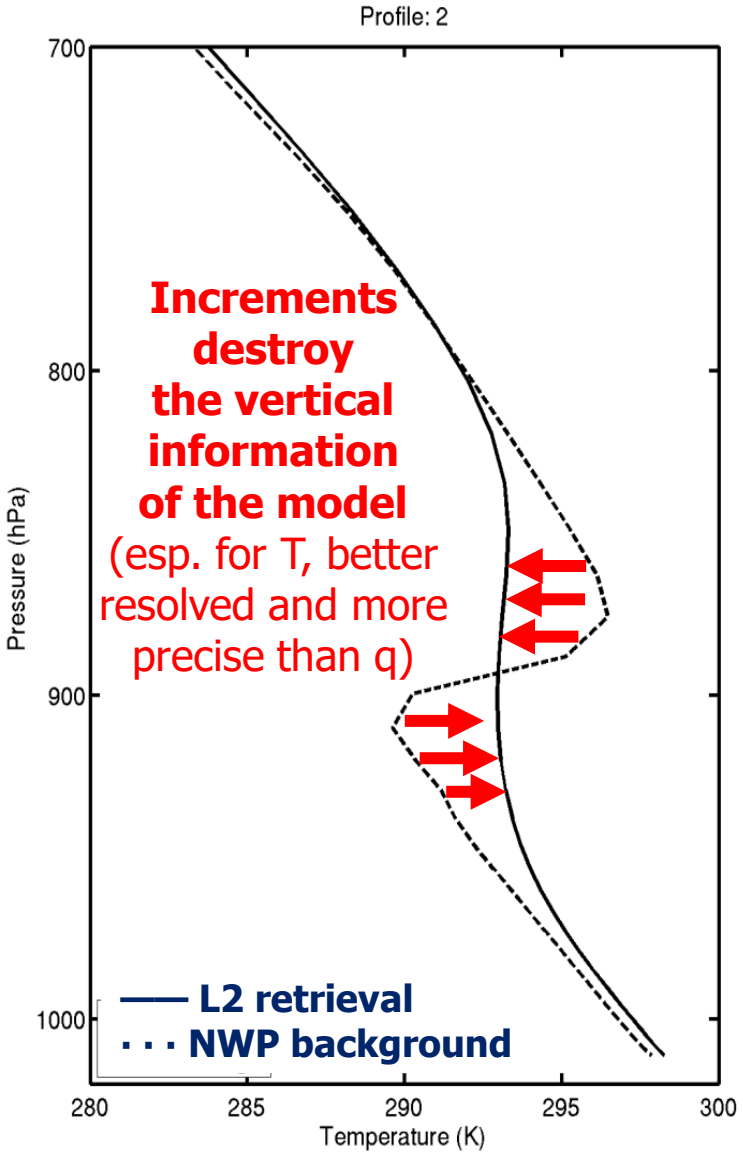
Similar positive impacts on humidity forecasts of assimilating L2 q than assimilating radiances!

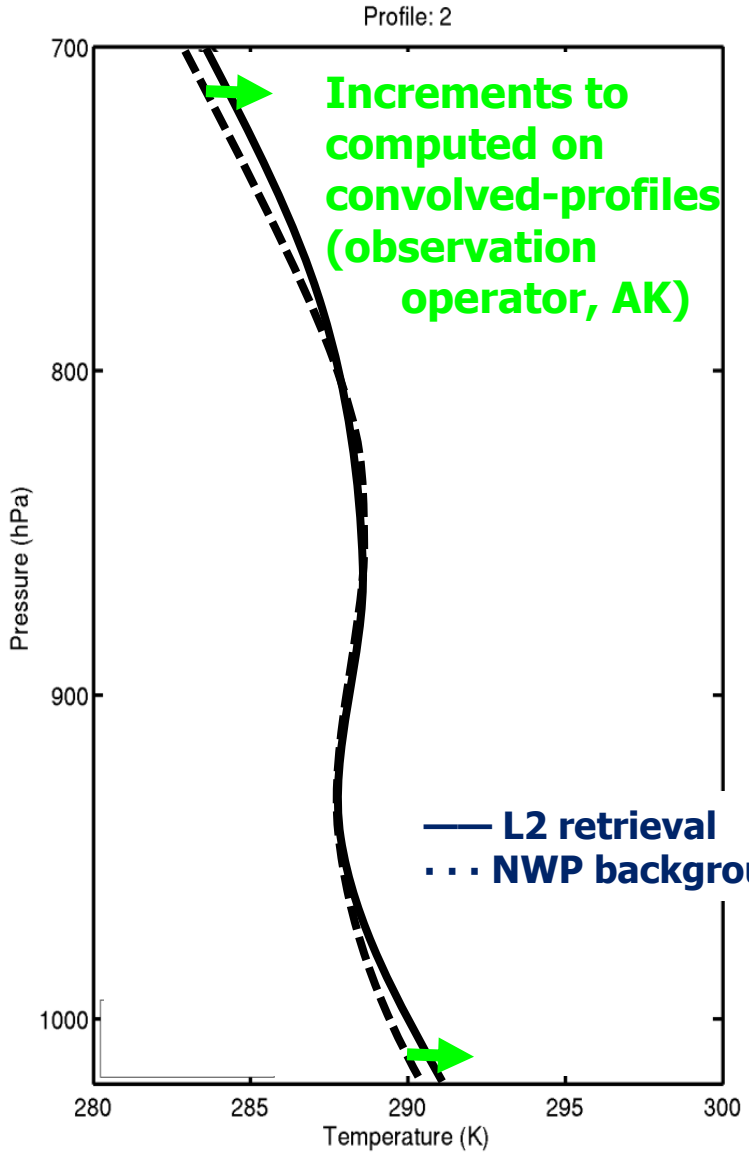
Further benefits of assimilating cloudy retrievals

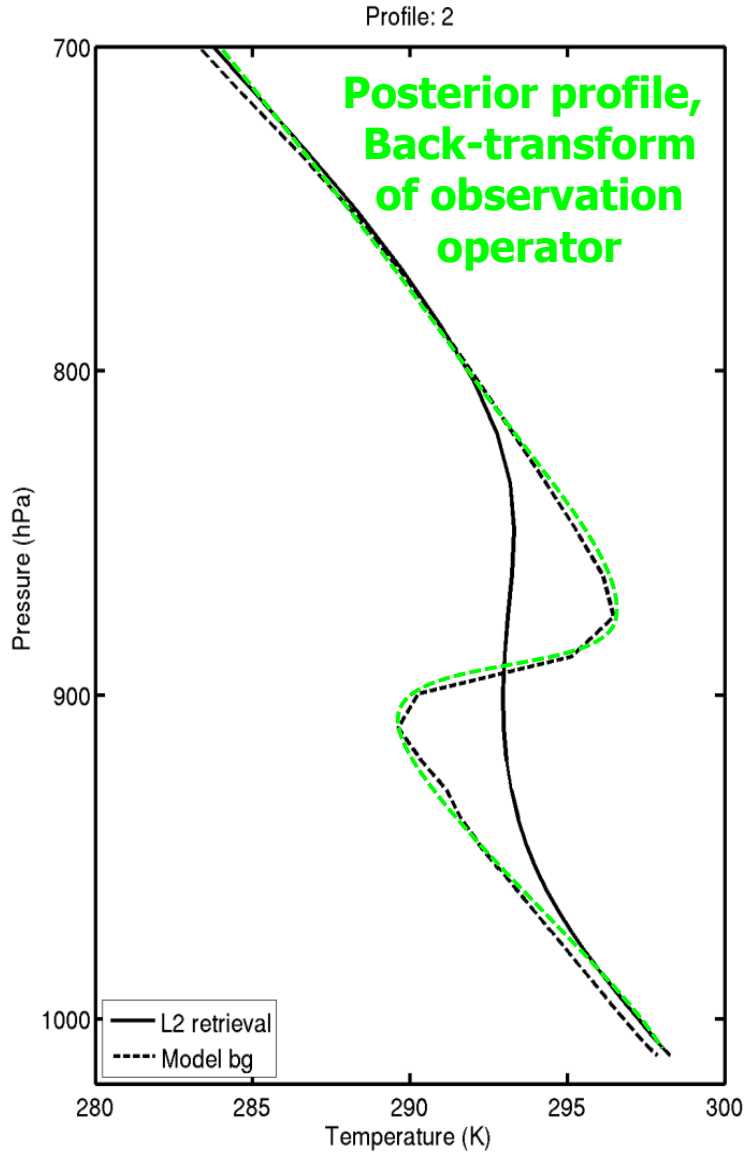
CTL (100%): Conv + AMSU-A
CTL + IASI L2 q with full **R**
CTL + IASI radiances

Credits:
K. Salonen, T. McNally

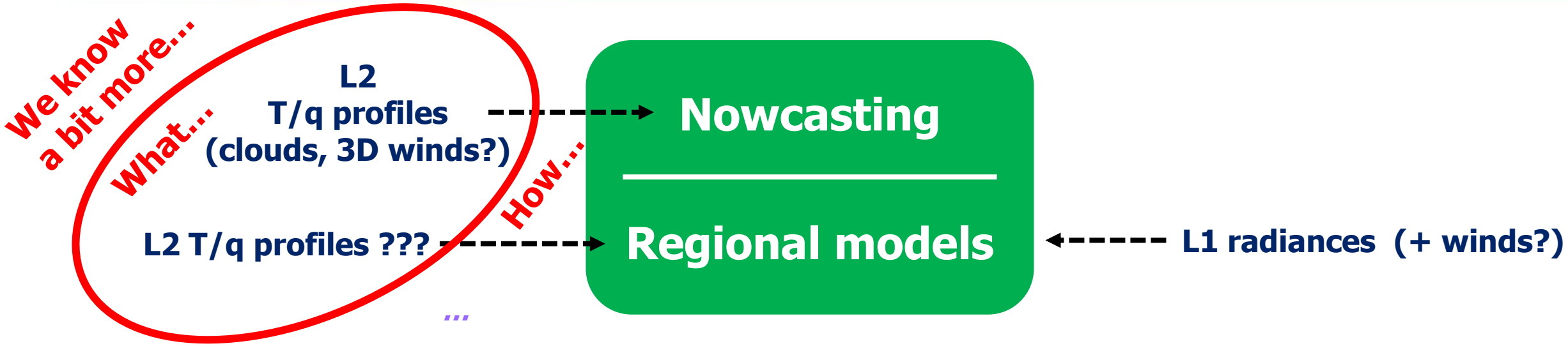
Follow-up L2 assimilation study at ECMWF, with obs. operator: account for HSIR vertical resolution and sensitivity







HSIR L2 requirements for regional applications



…

"Fine vertical structures are required for Nowcasting"

"Forecasters will look away if forecasts do condition the L2 products – NWP fields are already available to the forecasters"

"Beyond the absolute values/precision, it is the evolution of atmospheric quantities and 3D structures that forecasters will monitor with IRS" [similar feed-back from 3D-winds]

"Differences between observations and forecasts always mean something and forecasters need to find the why behind the what."

…

Summary

Regional applications

- ✓ IASI L2 all-sky T/q profiles < 30min
- ➢ Polar service + Learning in view of IRS
- ➢ Studying pre-convection monitoring
- ➢ Study practical utilisation
  - ✓ direct use in weather workstations
  - ✓ assimilation experiments
  - ✓ blending satellite + surface obs

Requirements

- ✓ Forecast-free
- ✓ Lapse-/layer- quantities
- ✓ Uncertainty profiles (+AK)
- ➢ Choice of instability indices
- ? flag L2 != models
- ? auxiliary/quality information

Users

Scientific questions

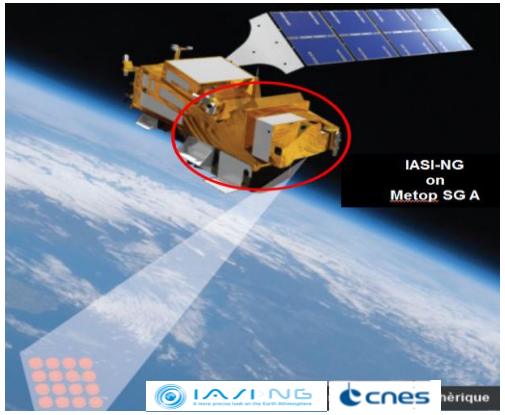
- ✓ Case studies complementarity forecasts + satellite observations
- ✓ Limitations and potential at high viewing angles (outer ring)
- ✓ Low sensitivity and dry bias? near surface

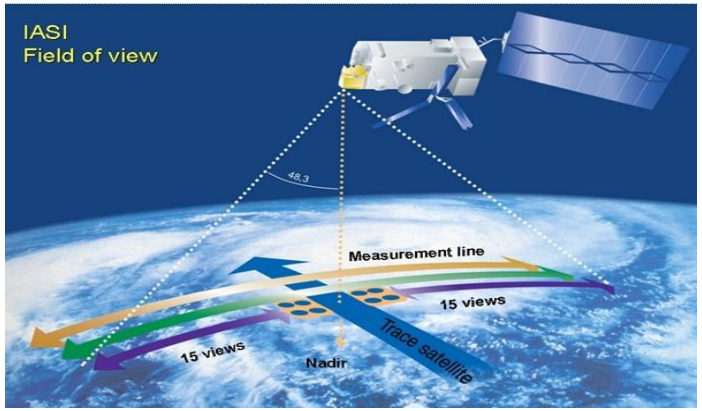
User preparation

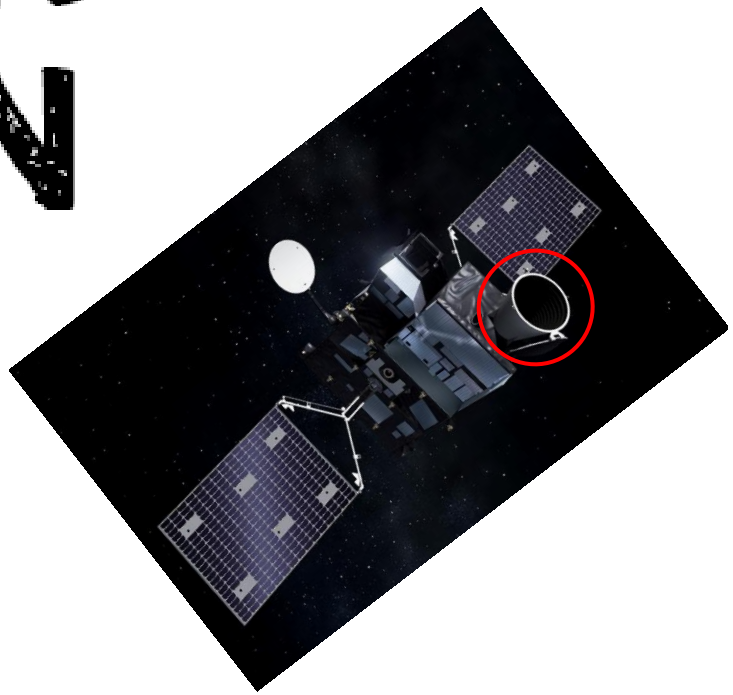
- ➢ EUM NWC SAF & HQ joint effort
- ➢ Convection Working Group
- ➢ MTG-Up EPS-SG-Up
- ➢ User training
- ➢ ….

Questions ?

GRACIAS POR SU ATENCIÓN

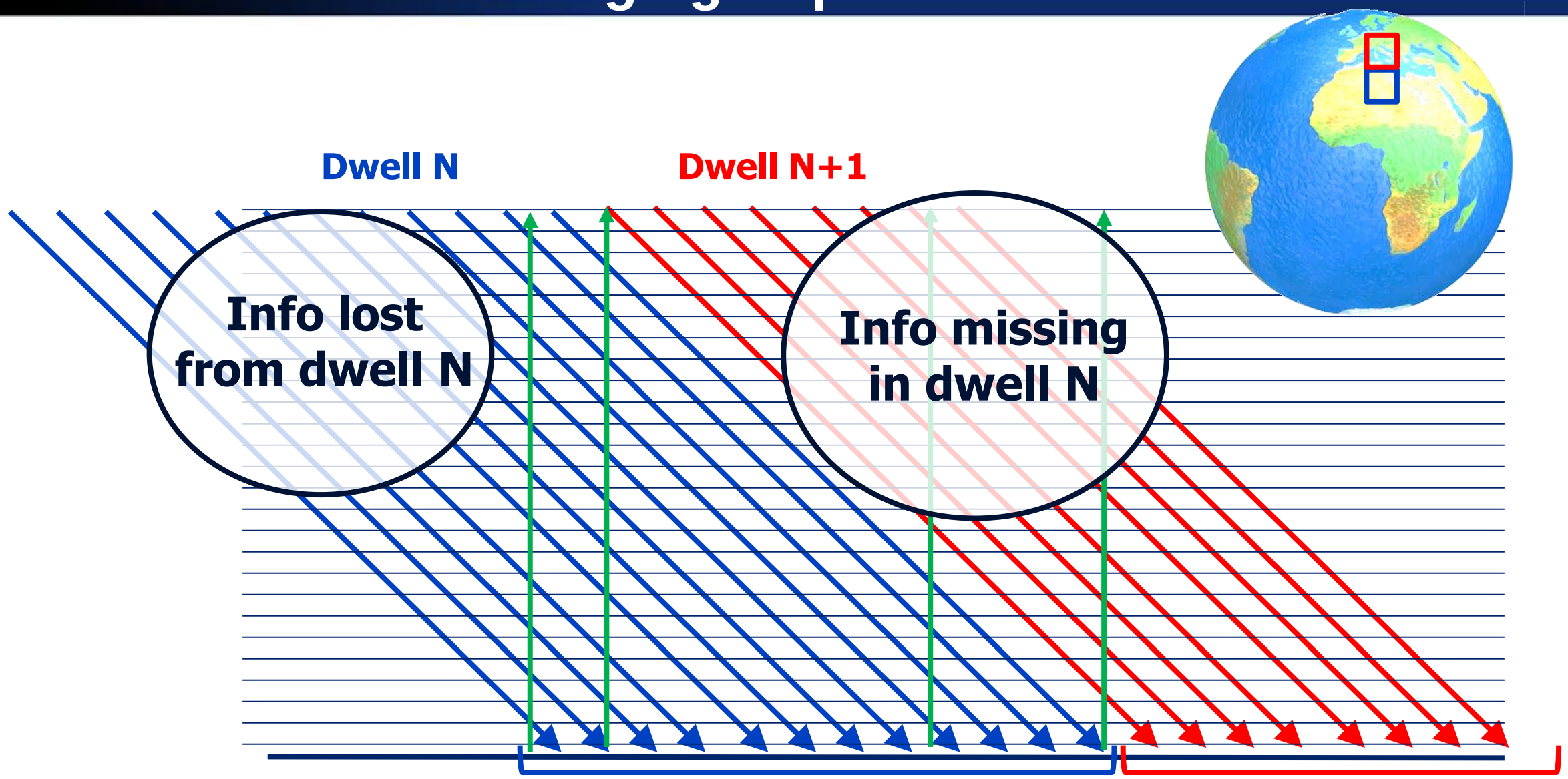




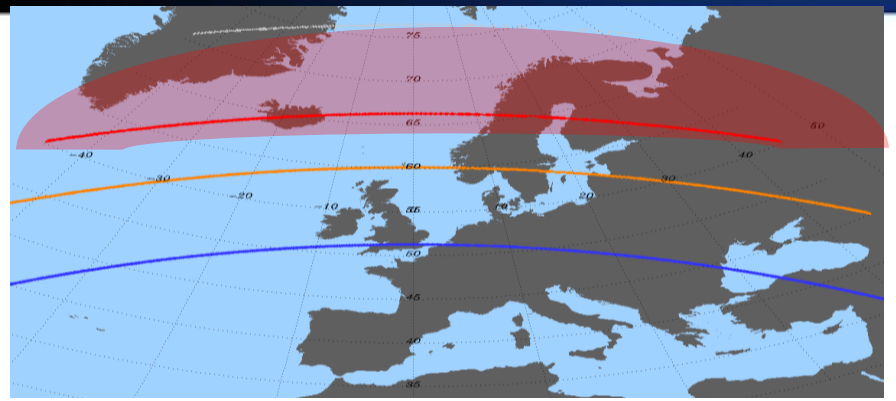


5th IASI Conference, ~~20-24~~ April 2020, Evian (France)

Reconstruct vertical?
Border effects ➔ staging required

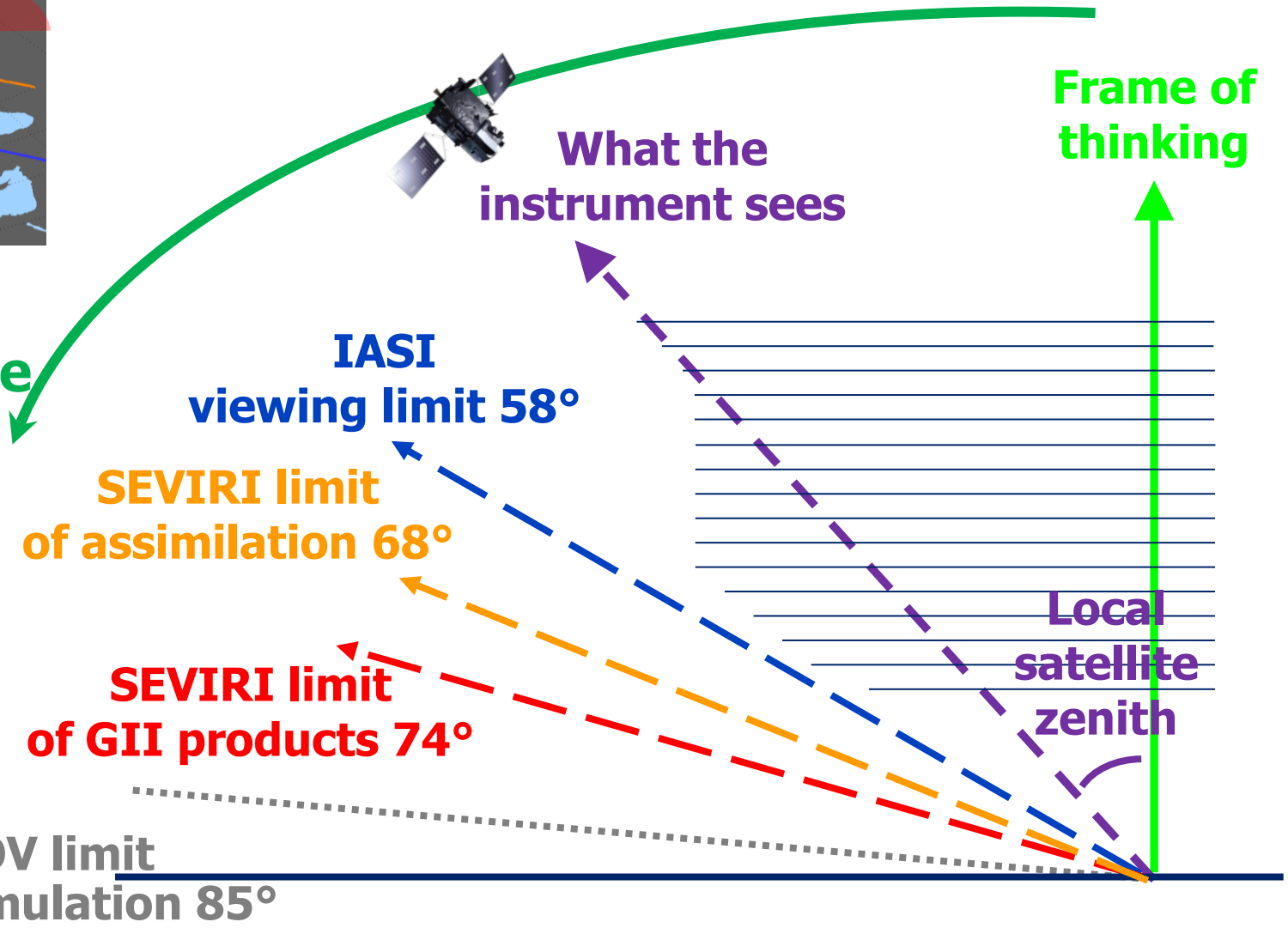


MTG-IRS viewing geometry and L2 application range



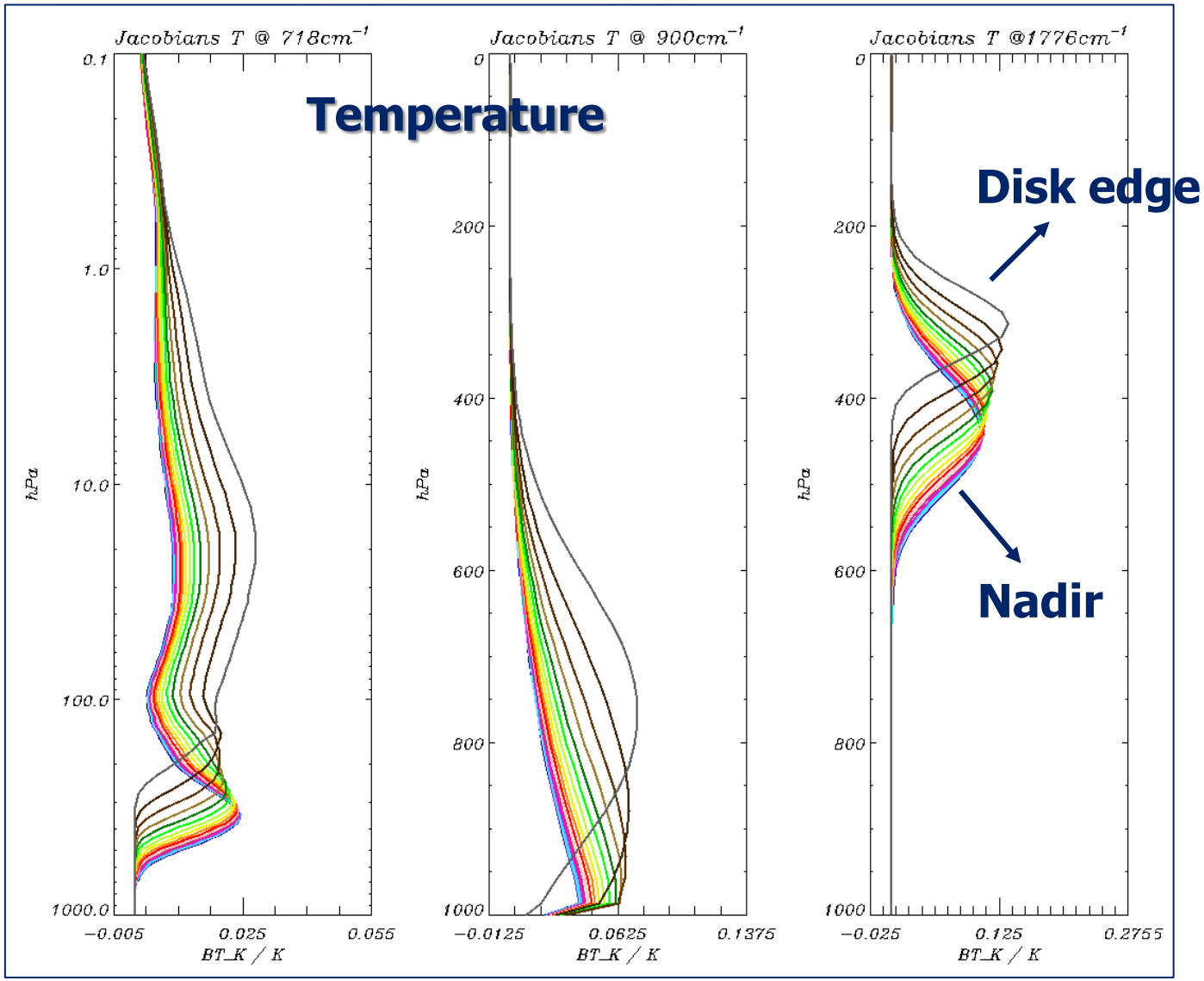
Demonstrated operational heritage

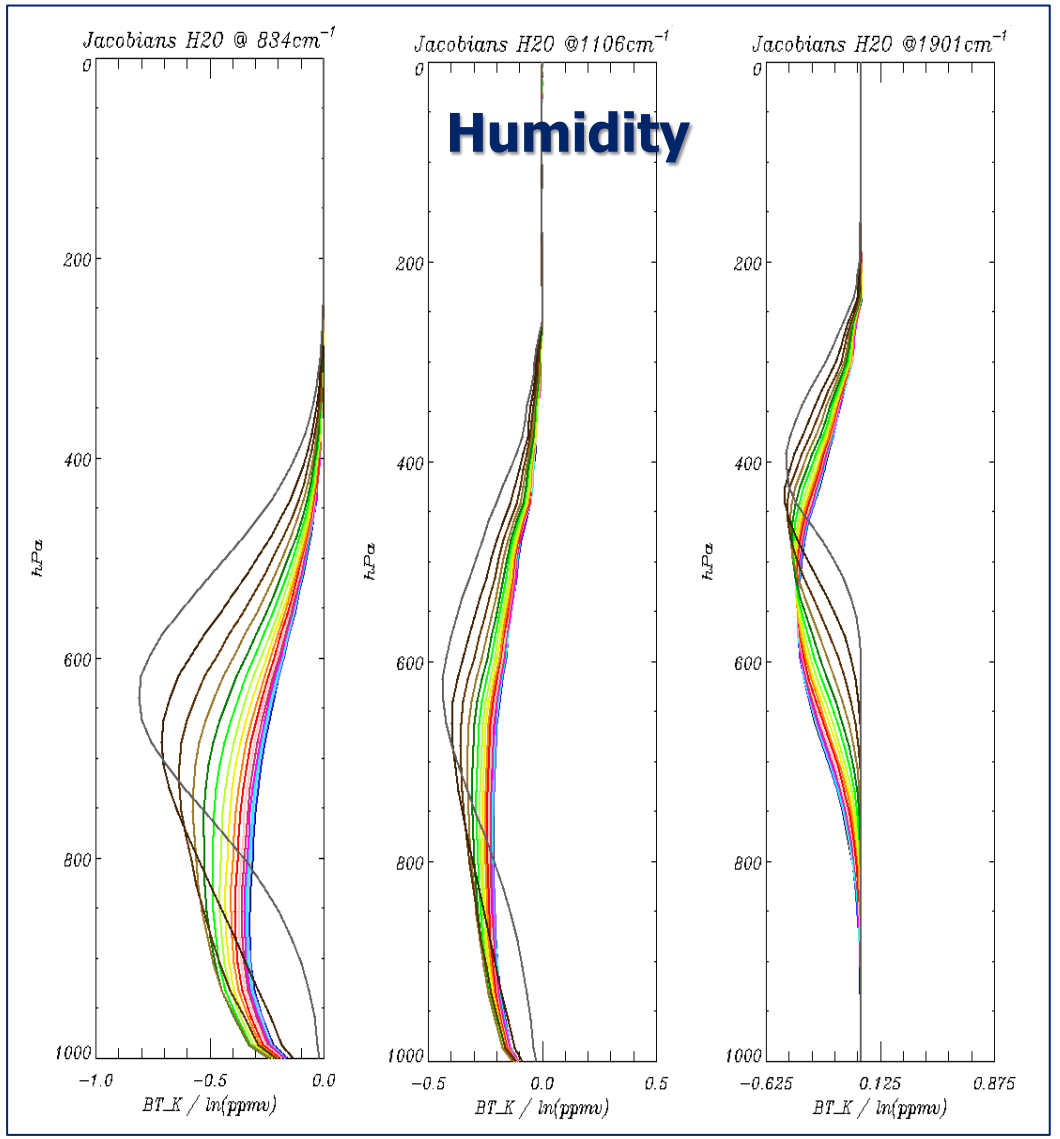
Sounding in the "rim", to be studied



Sensitivity shift with viewing angle

Limitations and potential in outer ring?





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