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

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

ITSC-22

From Global to Regional service — **21**

3D retrievals
Deeper validation
Potential for regional use? — **20**

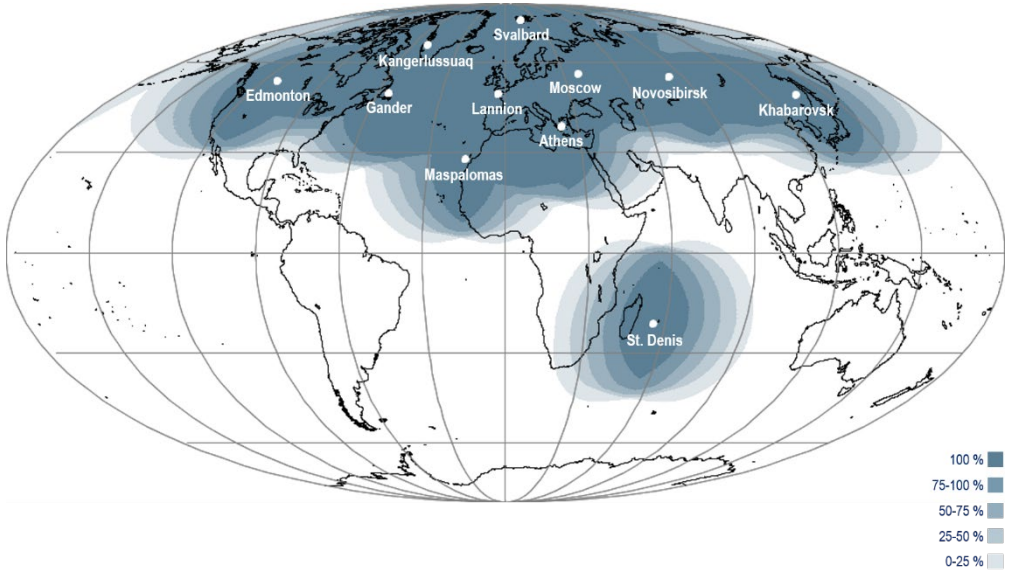
v6 first release
All-sky retrievals
Rec'd radiances — **19**

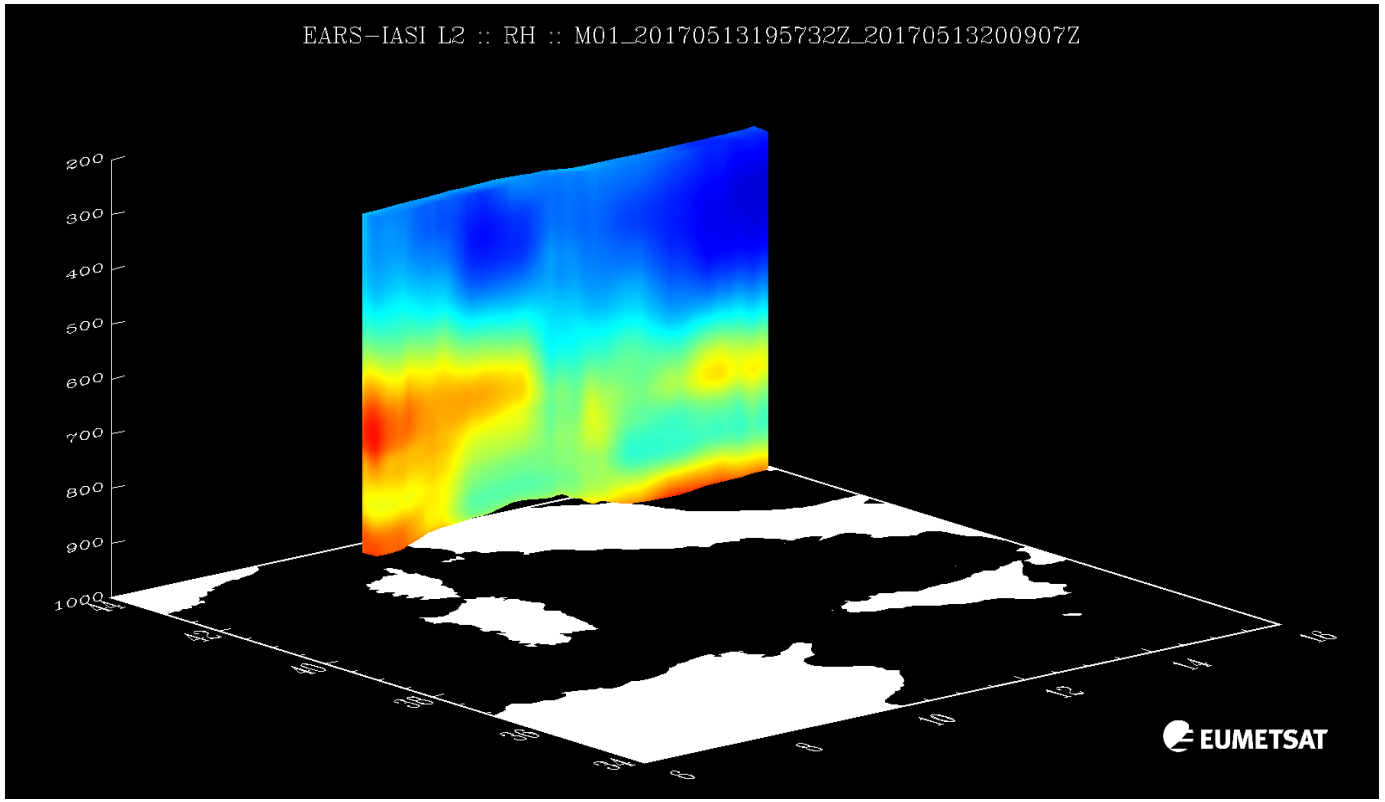
Lessons from v5
PCA and subspaces — **18**

Outreach
Exploring new regional applications
➔ specify future services

Algorithms improvements
Validation, uncertainty estimates

EARS-IASI L2 regional service – timely for nowcasting



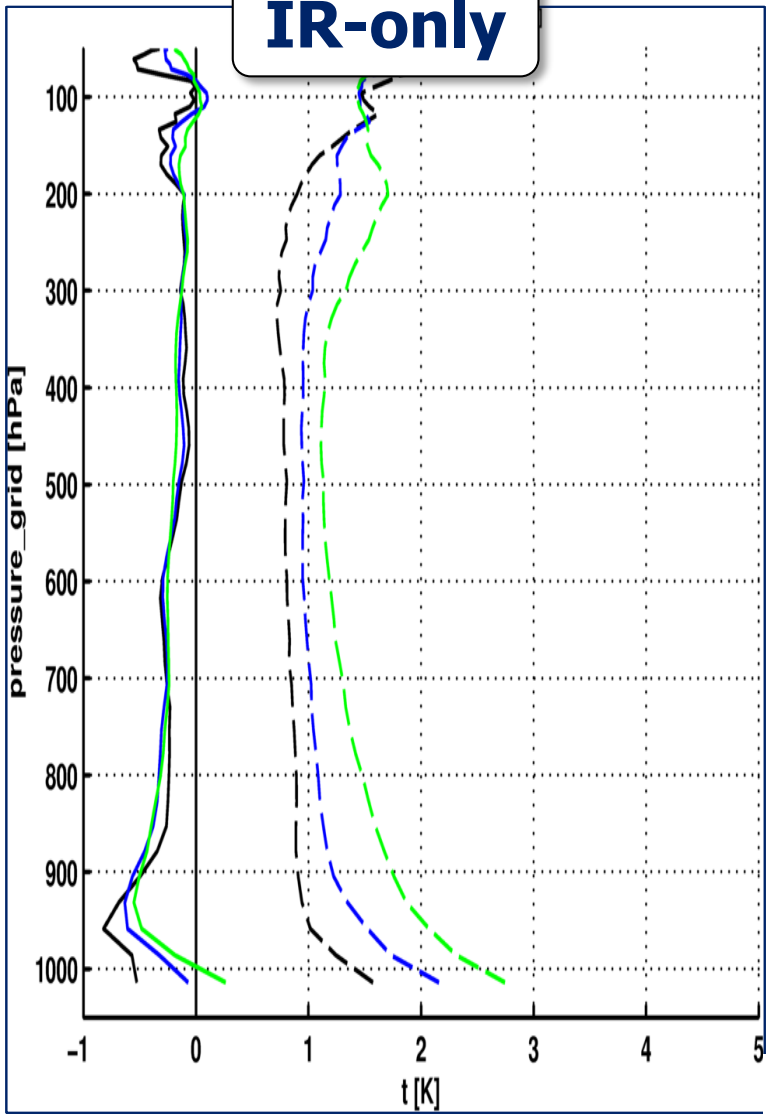


- ✓ Direct broadcast stations
- ✓ Timeliness < **30' from sensing**
- ✓ Pilot phase since Nov. 2017

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

Temperature and quality indicator validation *vs* sondes

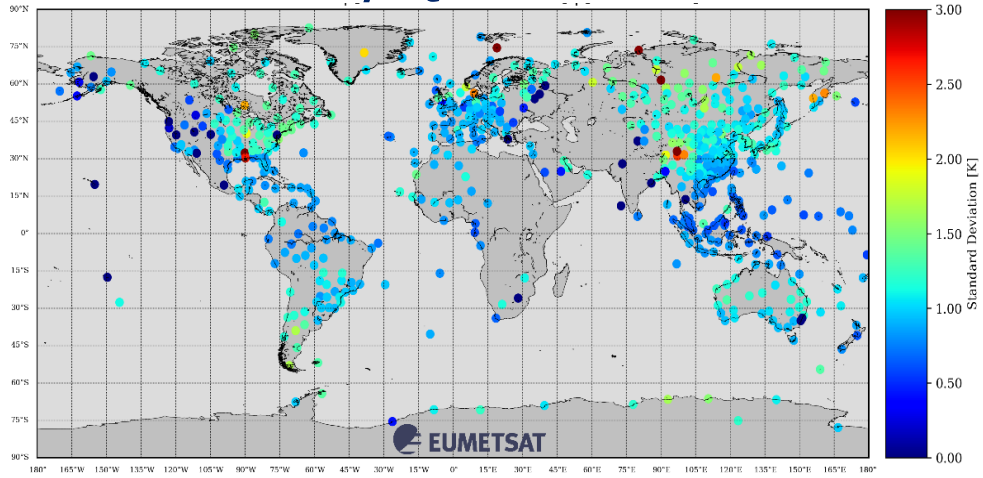
IR-only



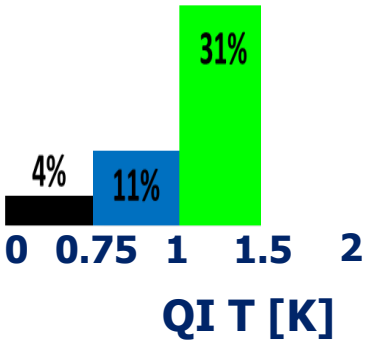
Jan. – Oct. 2017

< 50km ; < 3h

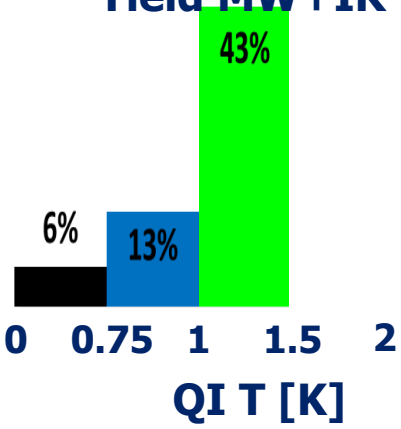
Match-up QC still needed



Yield IR-only

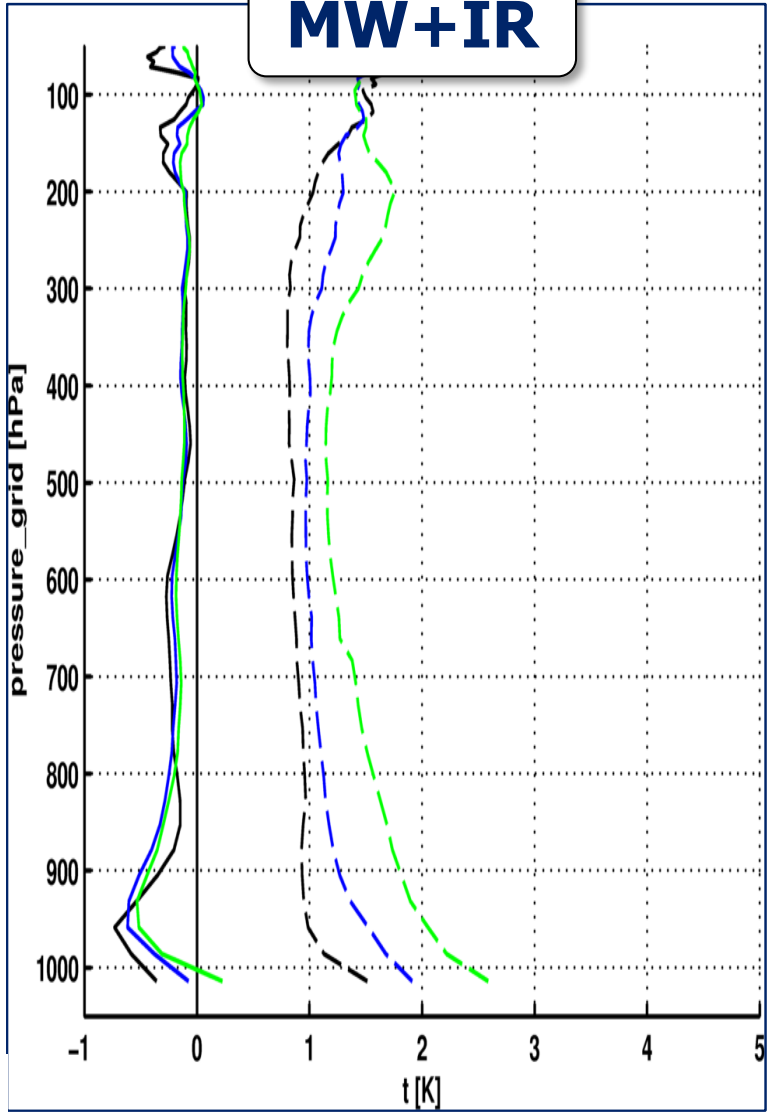


Yield MW+IR



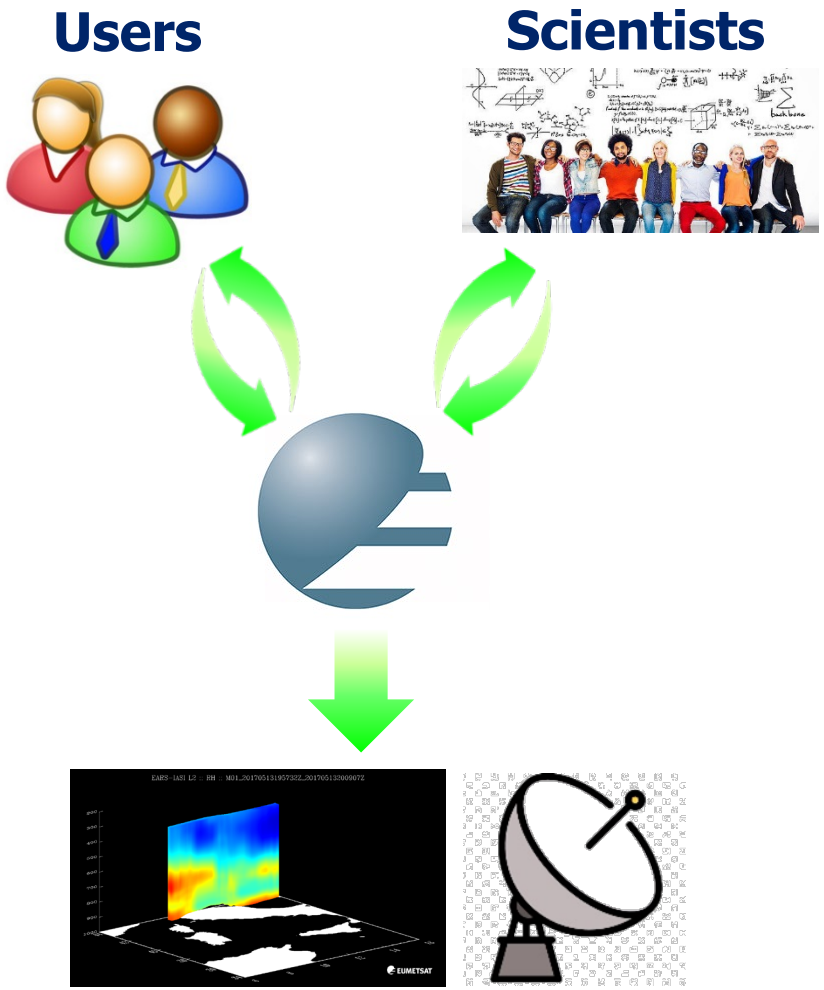
Error estimate in low-troposphere

MW+IR



EUMETSAT

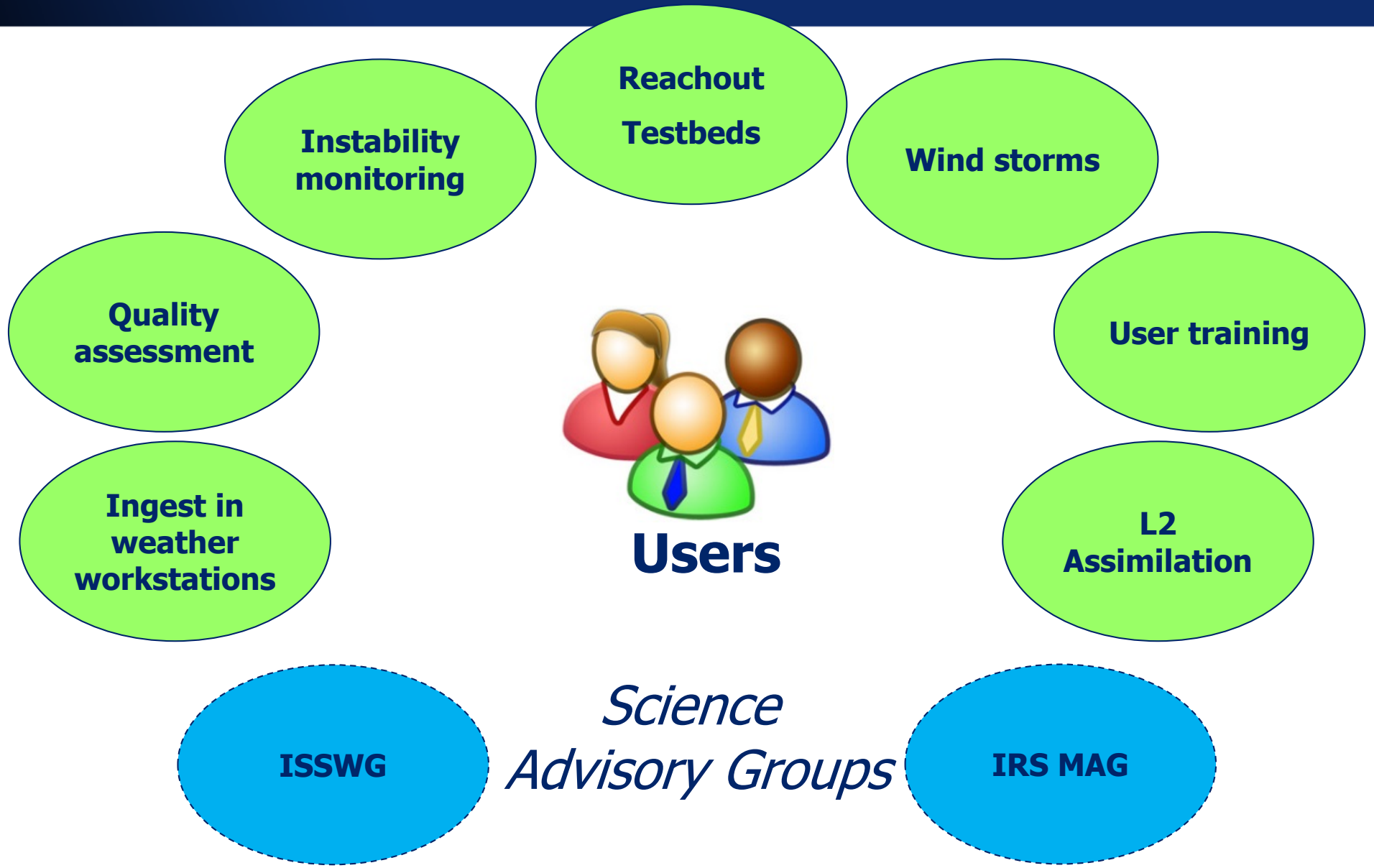
Dialog and studies with users



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?

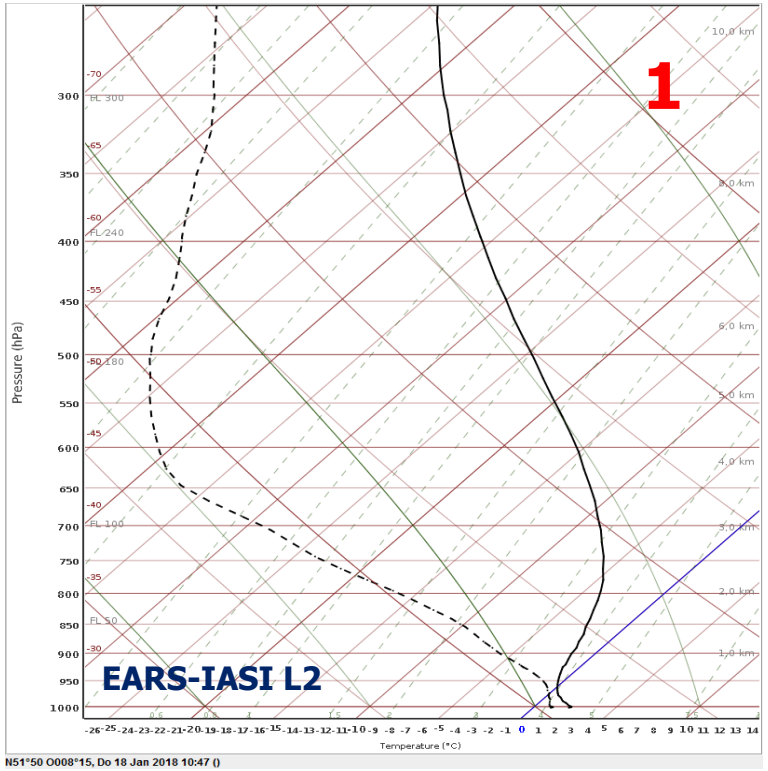
Dialog and studies with users



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.



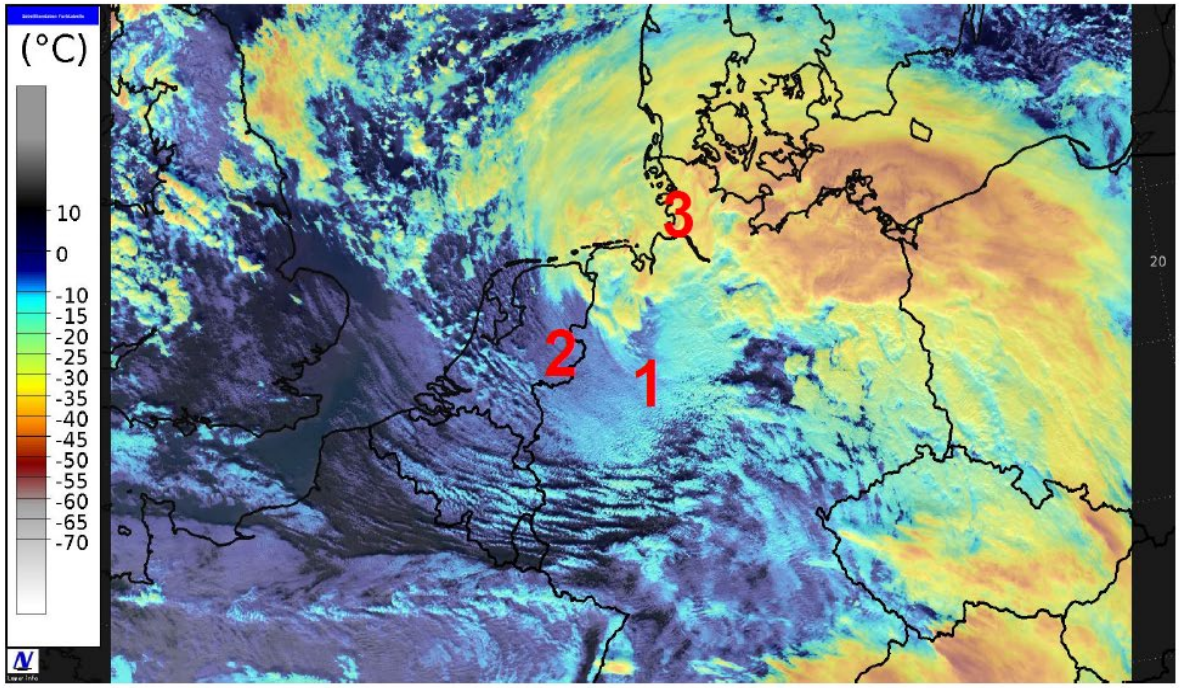


Fig.6: Suomi NPP VIIRS RGB image for 01-18-2018 11:30 UTC (top) and selected EARS-IASI L2 profiles (bottom) from the areas of the potential sting jet (1), the cold jet (2) and the cloud head (3). Source: DWD

Credits: K. Hungershöfer, Christian Herold 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 wouldn't reach the surface in the low lands.

Instability tracking with IASI L2, OMSZ

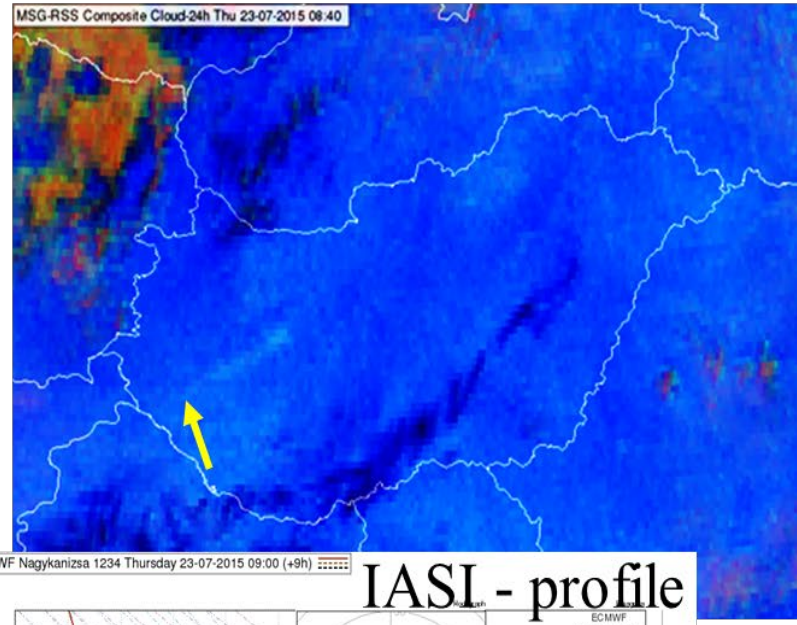
Credits: Z. Kocsis, A. Simon, M. Putsay (OMSZ, Hungarian Met. Services)

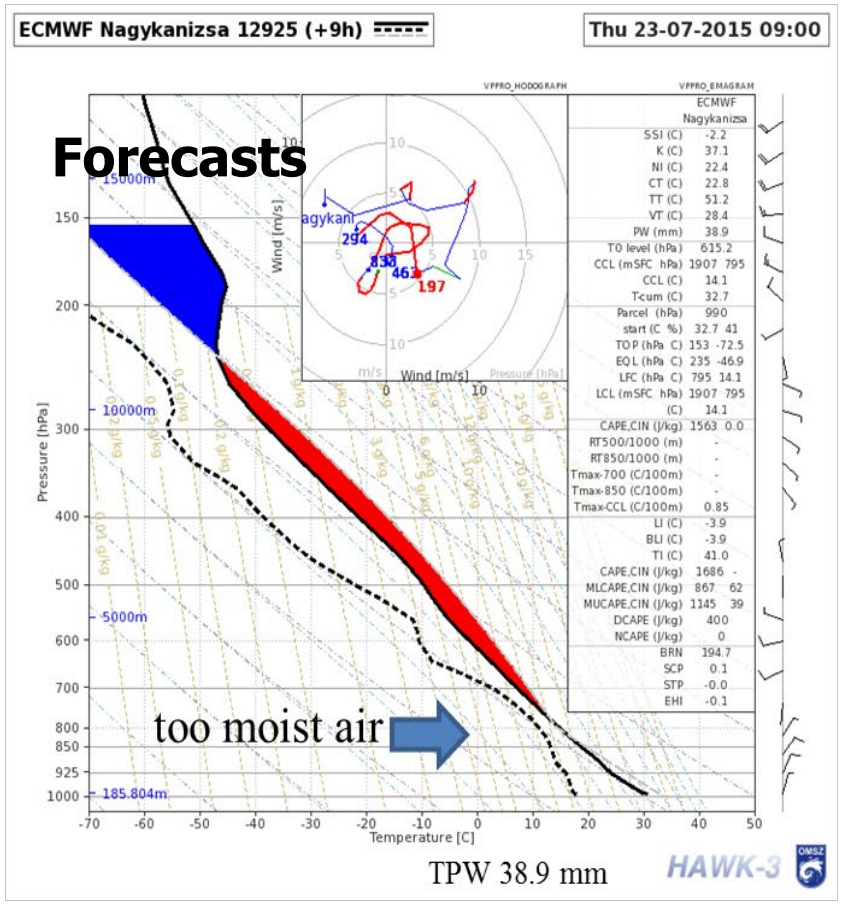
"Possible Usage of IASI L2 Profiles in Nowcasting",

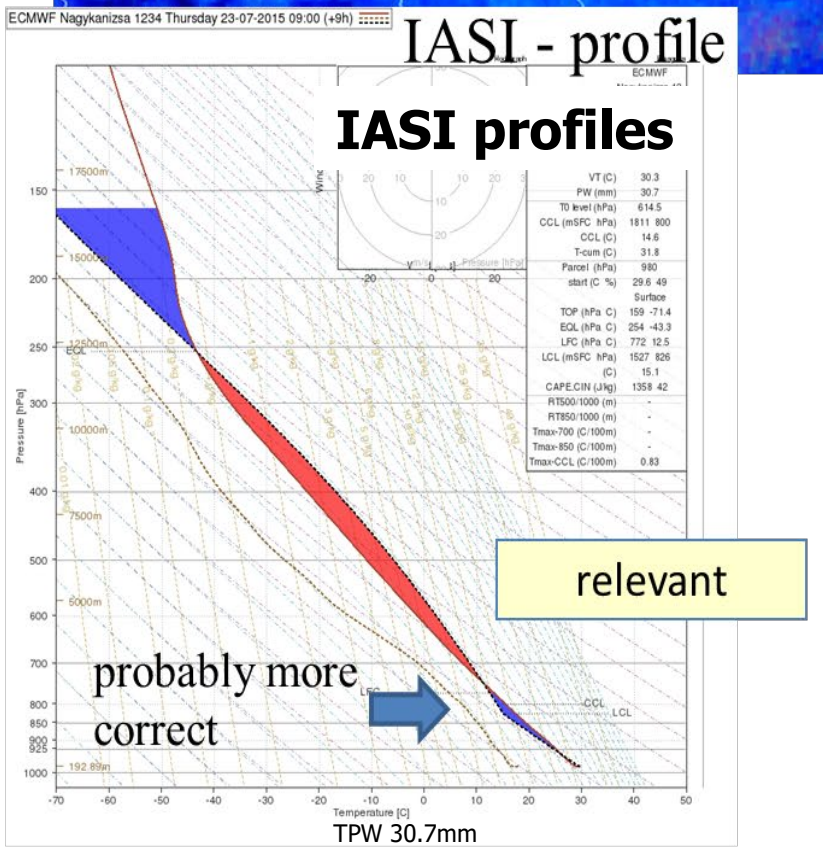
EUM User conference, Tallinn 2018

Evaluation

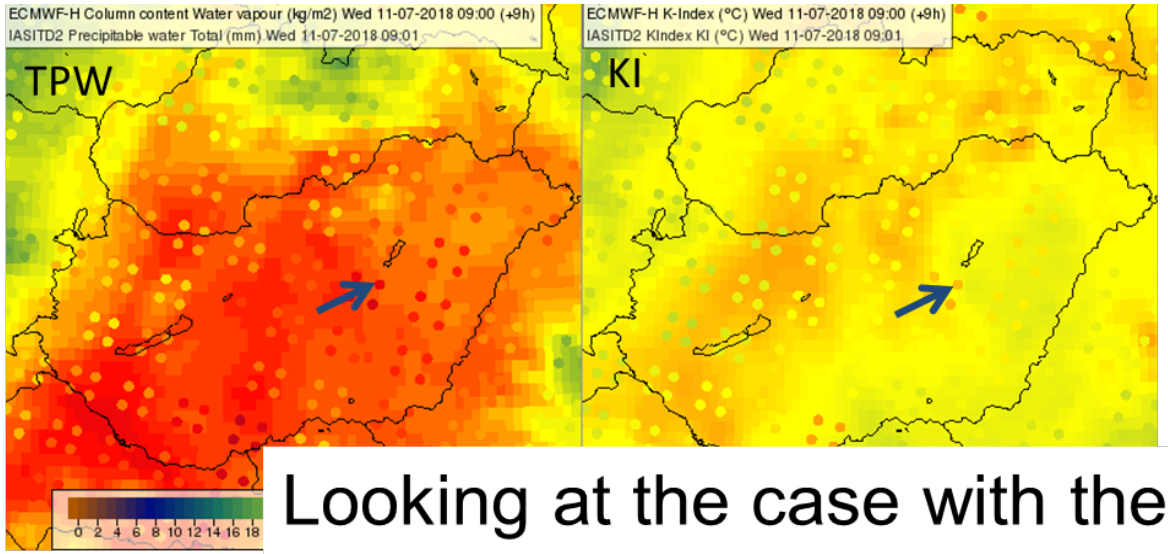
- IASI profile is less moist at 800 hPa
- The 24h Microphysics RGB indicated relatively dry air (green component: BT10.8-BT8.7), this agrees with IASI profile
- The thunderstorms in this area were short-lived,







Instability tracking with IASI L2, OMSZ



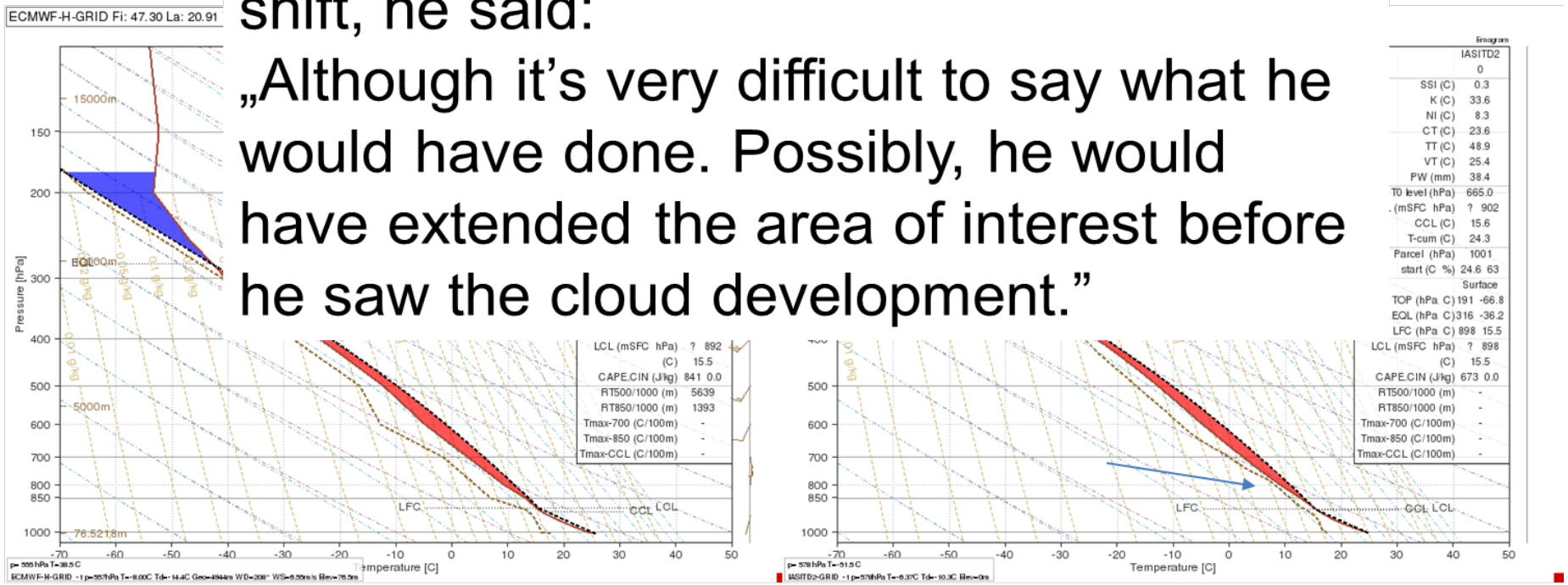
ECMWF and IASI profiles 09 UTC

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

"Possible Usage of IASI L2 Profiles in Nowcasting",

EUM User conference, Tallinn 2018

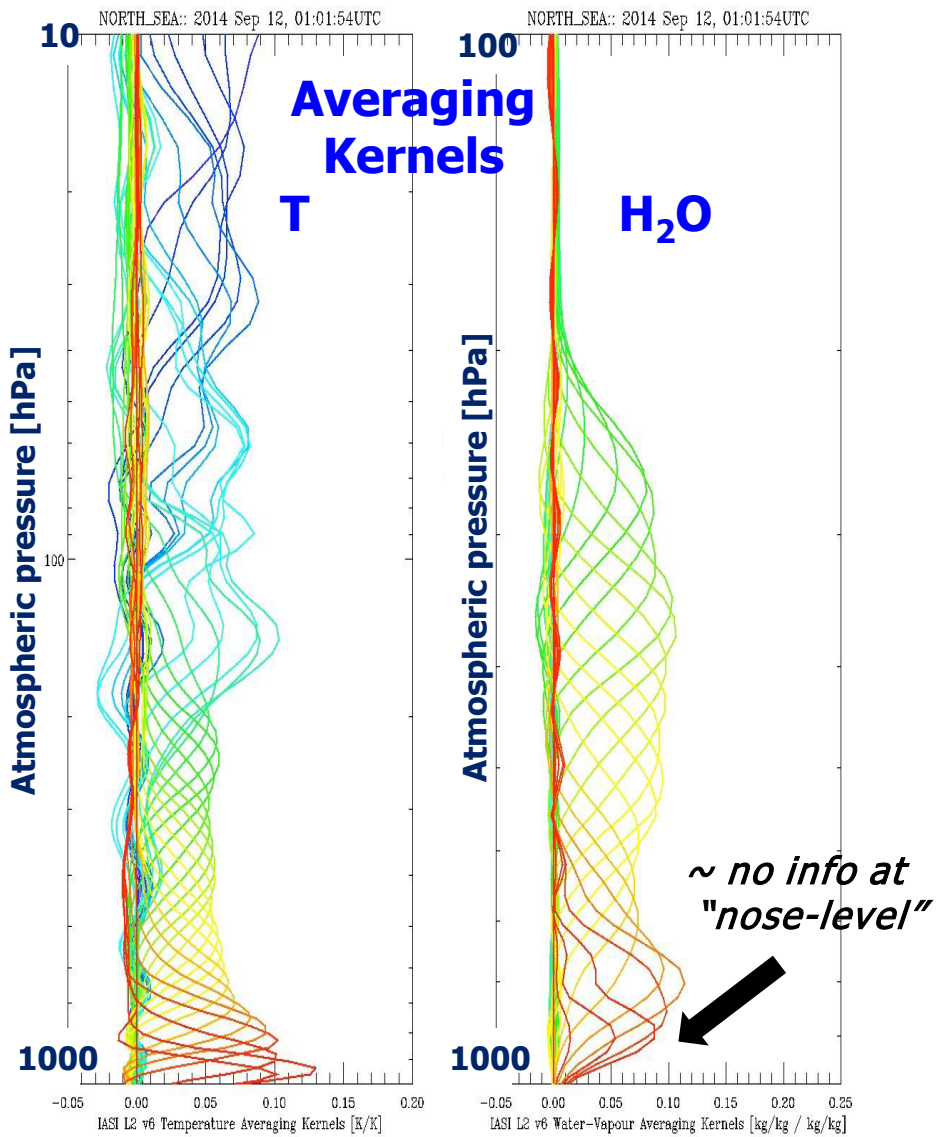
Looking at the case with the forecaster on shift, he said:
„Although it's very difficult to say what he would have done. Possibly, he would have extended the area of interest before he saw the cloud development."

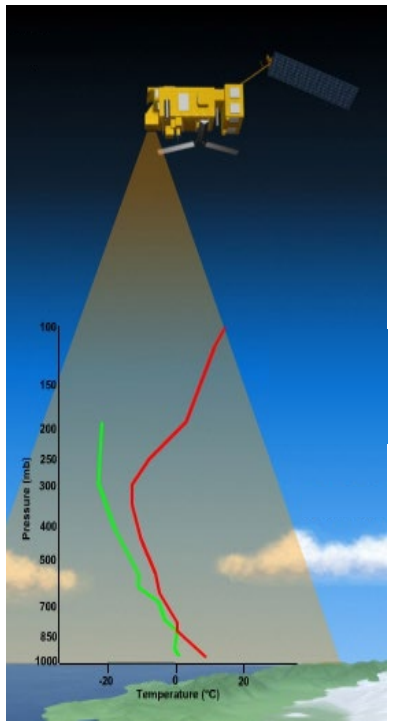


ECMWF TPW = 34.4 mm IASI TPW = 38.4 mm

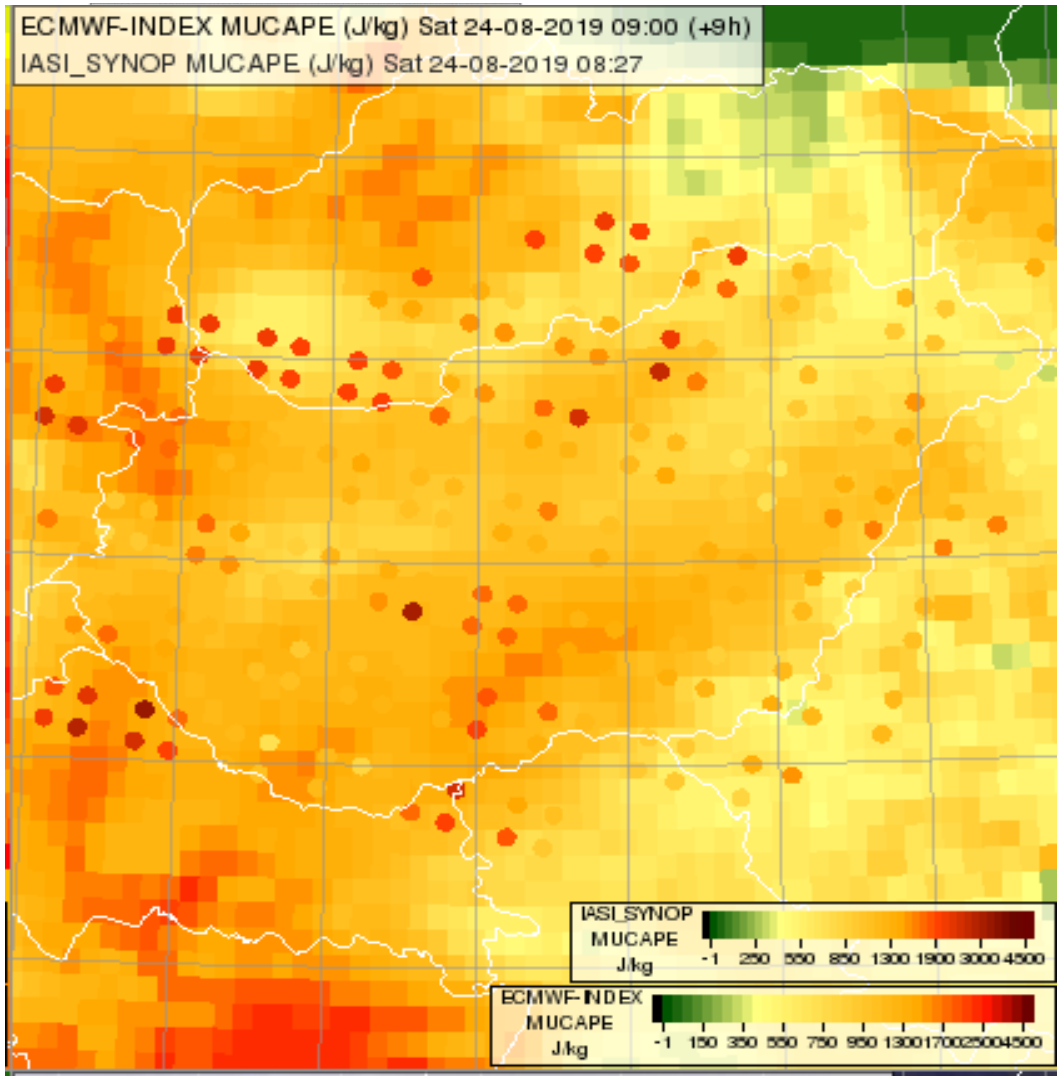
EUMETSAT

Blending satellite and surface observations (OMSZ)





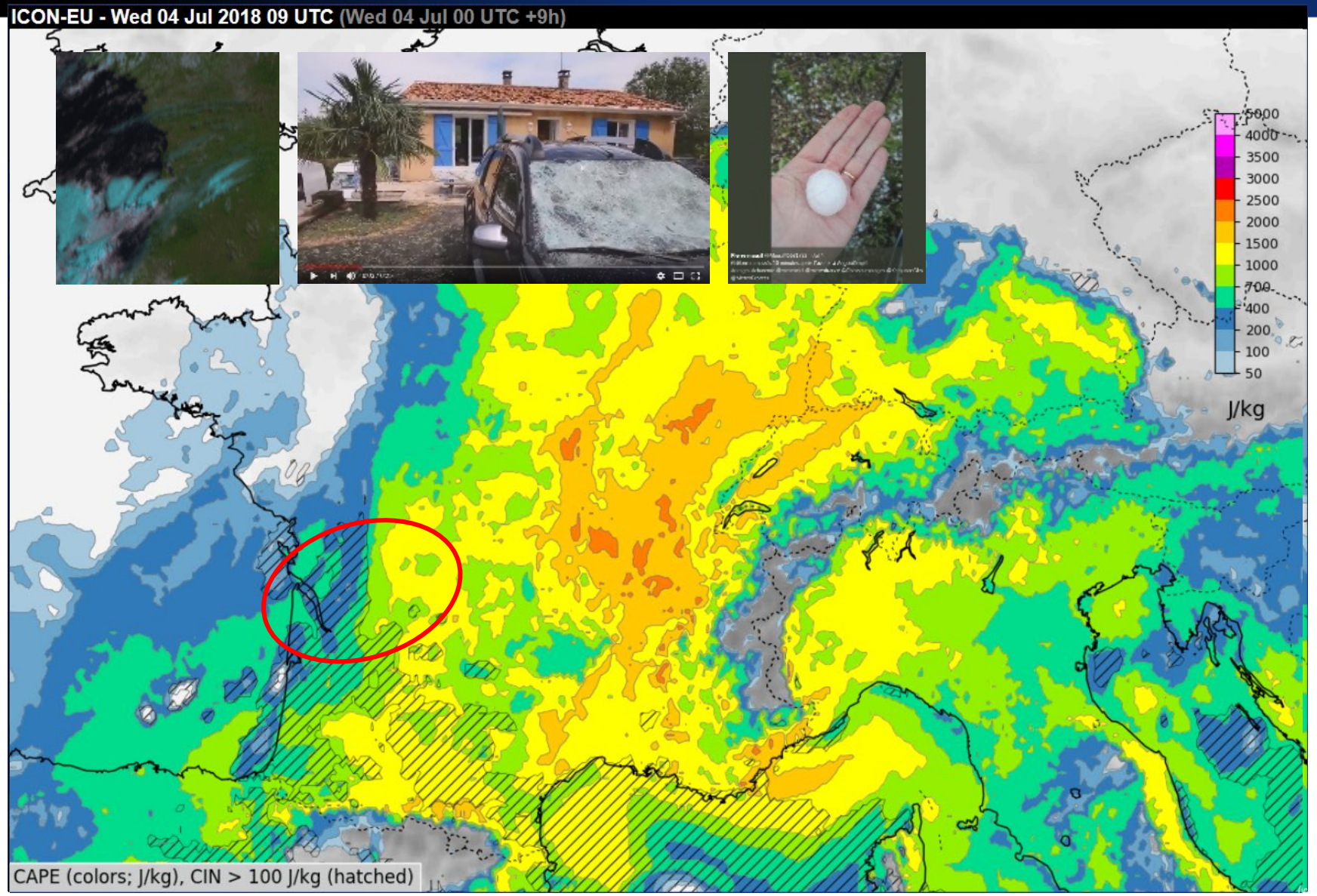
+



Hungary 24.08.2019.
IASI+synop 08:27UTC ; ECMWF fct 09:00UTC
Credits: M Putsay, Z. Kocsis (OMSZ)

EUMETSAT

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.

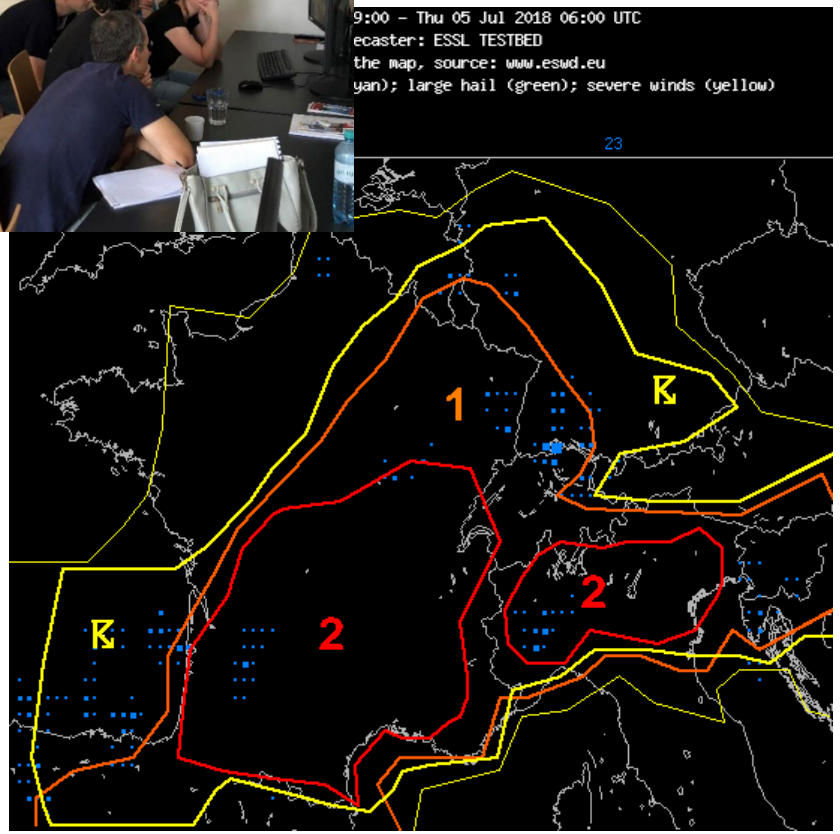
There is deep experience of using e.g. radiosondes *(sparse)*, imager cloud masks and layer quantities/indices *(limited vertical information)*.

➔ **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.

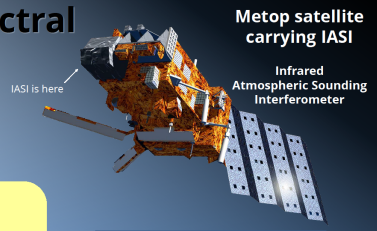


European Severe Storms Laboratory
Science & Training

EUMETSAT

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

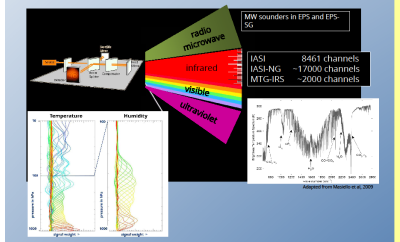
Pieter Groenemeijer, Tomáš Púčik (ESSL)
Thomas August (EUMETSAT)



Metop satellite carrying IASI

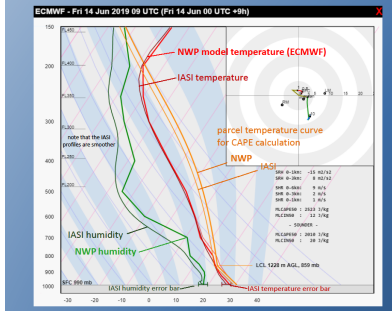
Infrared Atmospheric Sounding Interferometer

The IASI sounder measures infrared radiances ...

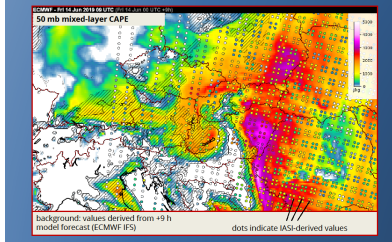


...from which vertical profiles of temperature and humidity are derived.

They can be compared to the profiles from numerical weather prediction (NWP) models:



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

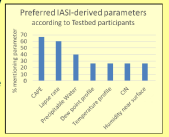


ESSL Testbed

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

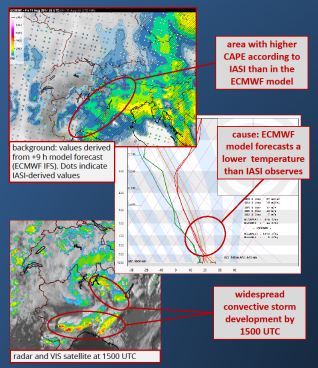
Main conclusions:

- **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...

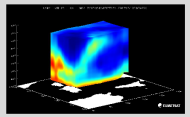
Meteosat Third Generation – InfraRed Sounder

- 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**

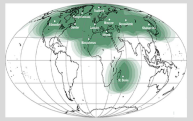
The first MTG sounder satellite is scheduled to be launched in **2023**.

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

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

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**

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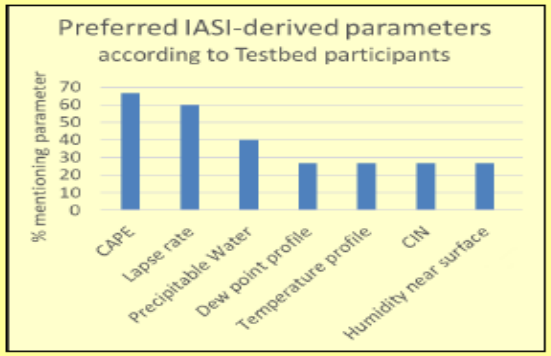


P. Groenemeijer, T. Pucik (ESSL)
European Meteorological Society
Copenhagen 2019

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

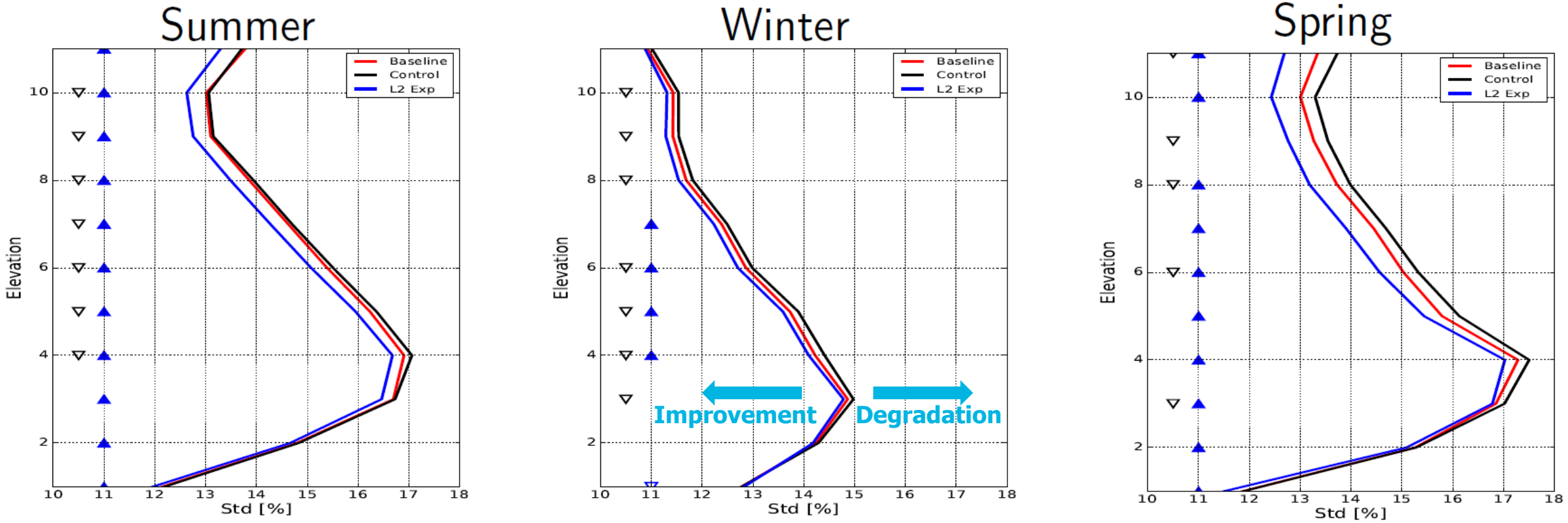
$$J = (x\text{-}xb_b)^T B^{-1} (x\text{-}x_b) + (y\text{-}Hx)^T R^{-1} (y\text{-}Hx)$$

No observation operator besides levels selection
Vertical sensitivity <u>not</u> accounted yet

M-F: diagonal *(pseudo-sondes)*
ECMWF: full matrix

IASI L2 in AROME: %RH forecasts skills *vs* radar (stddev)

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

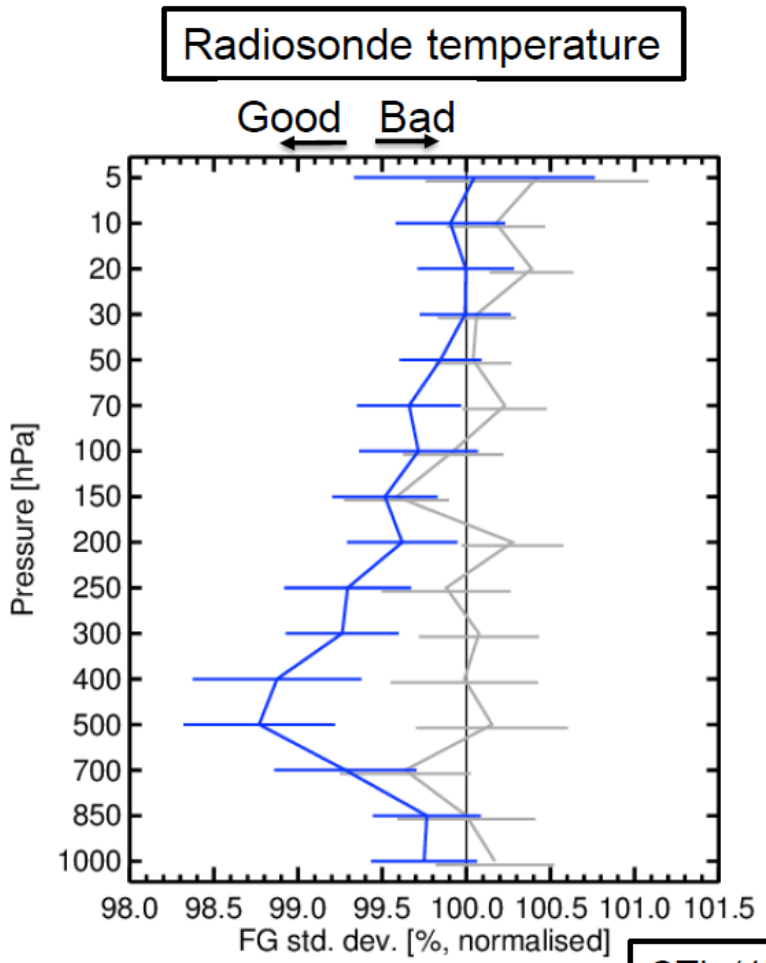


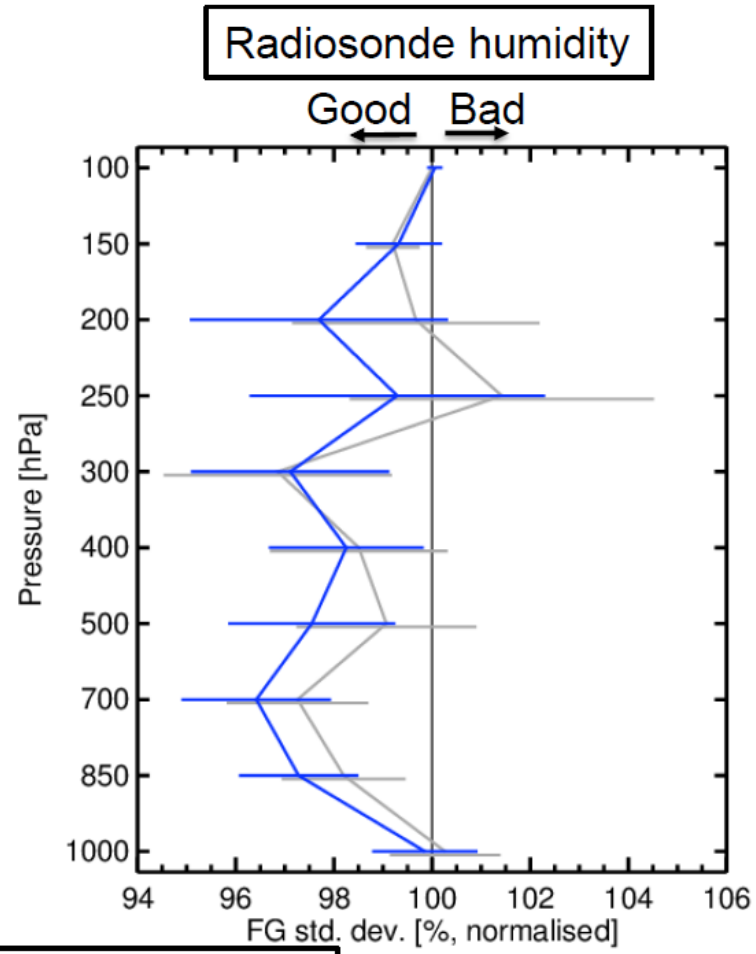
▲ L2 Experiment is better than the baseline with 95 % of confidence (t-student)
▲ Control Experiment is better than the baseline with 95 % of confidence (t-student)
▽ Baseline is better than the L2 Experiment with 95 % of confidence (t-student)
▽ Baseline is better than the Control Experiment with 95 % of confidence (t-student)

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

IASI L2 IR-only assimilation at ECMWF

Assimilation experiments with q only, depleted observing system

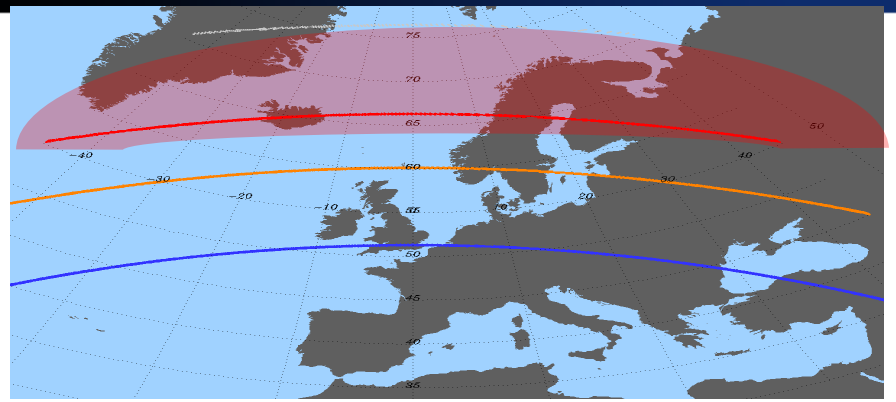




CTL (100%): Conv + AMSU-A
CTL + IASI L2 q with full **R**
CTL + IASI radiances

Credits:
K. Salonen, T. McNally

MTG-IRS viewing geometry and L2 application range



Demonstrated operational heritage

Sounding in the "rim", to be studied

What the instrument sees

Frame of thinking

IASI viewing limit 58°

SEVIRI limit of assimilation 68°

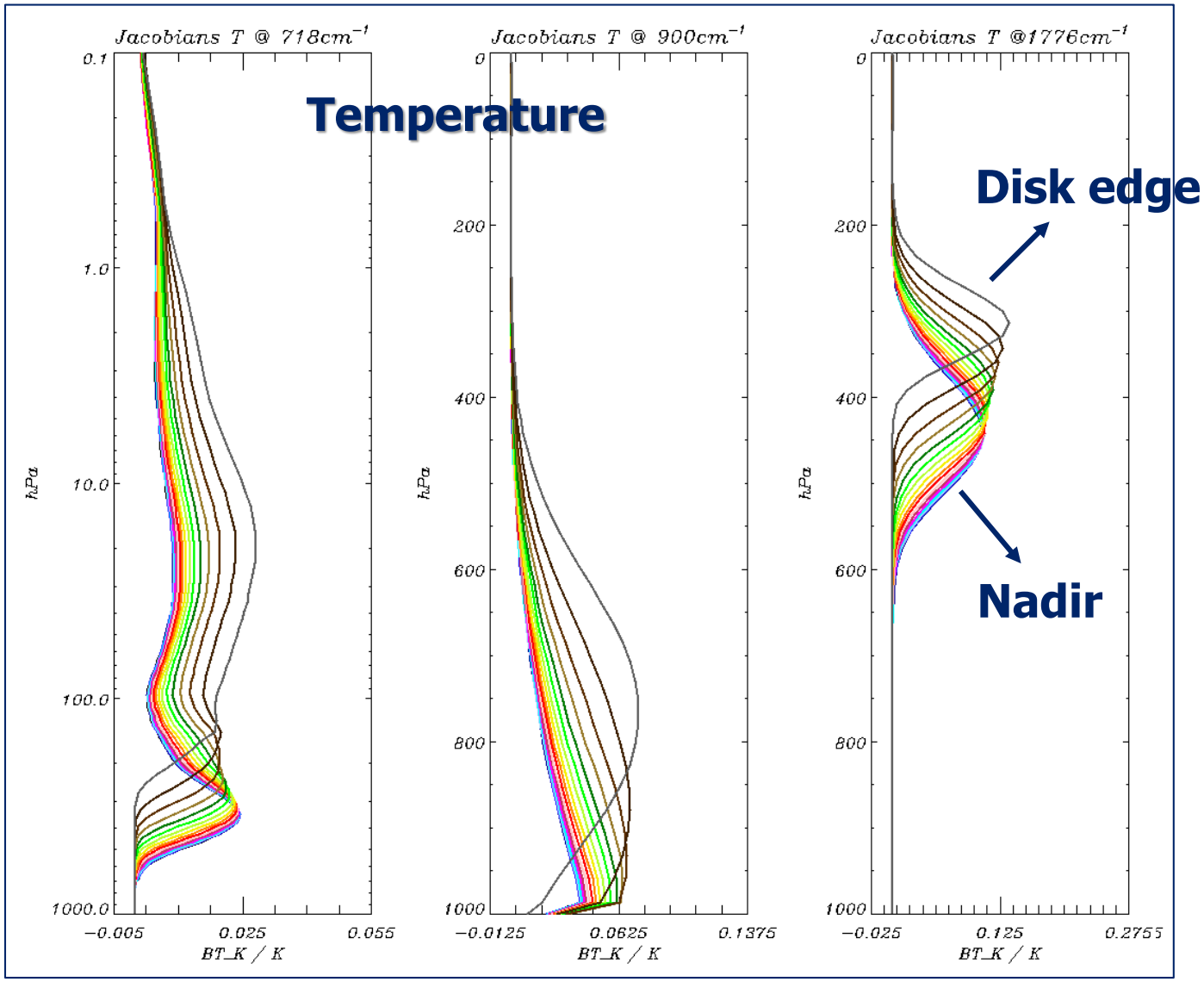
SEVIRI limit of GII products 74°

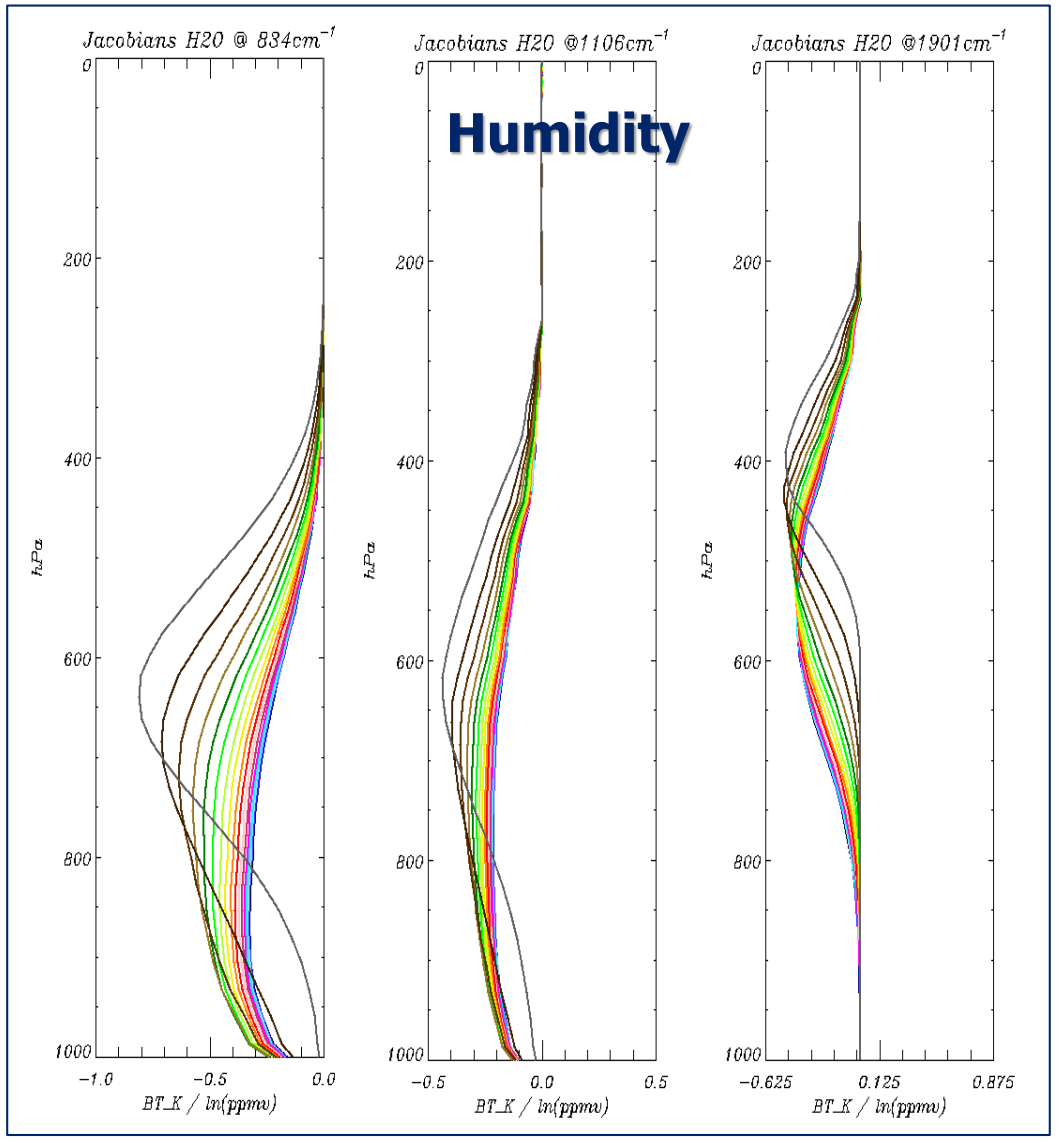
Local satellite zenith

RTTOV limit of simulation 85°

Sensitivity shift with viewing angle

Limitations and potential in outer ring?





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

- ➢ Increase diurnal coverage with more Polar orbits
- ➢ Convection Working Group
- ➢ IR sounders in SCOPE-NWC
- ➢ MTG-Up EPS-SG-Up
- ➢ User training

Questions ?

Merci pour votre attention!

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