European Severe Storms Laboratory
Science & Training

EUMETSAT

Evaluating IASI profiles at the ESSL Testbed

and for selected cases

work commissioned by EUMETSAT
contract EUM/CO/184600002214/TA

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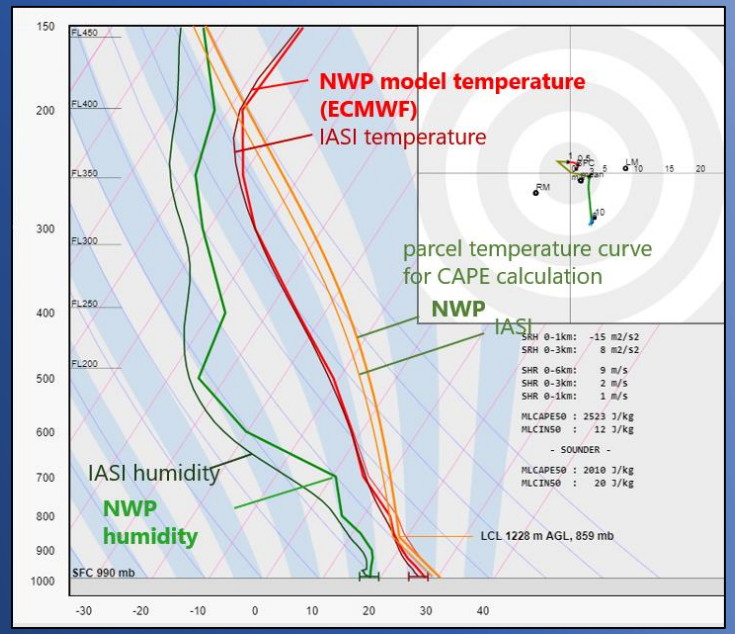
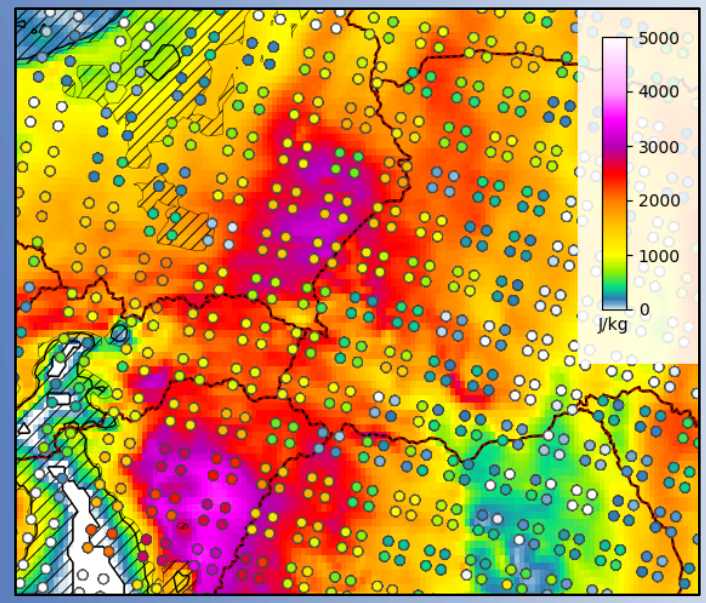
IASI Mini Event Week

15 September 2020

Infrared Atmospheric Sounding Interferometer (IASI)

Metop





Project goals

1. **Evaluate direct use** of hyperspectral sounding products in severe storm forecasting
   - Assess potential for use of such products, **also in the light of MTG-IRS**

2. Gain practical experience with users
   - **collect feedback to products**
   - **and to specific product visualizations/implementations**
   - **Identify possibilities for further visualizations/implementations**

3. **Raise awareness and preparedness** of potential users

4. Support the **consolidation of L2 product requirements**

Project components

1. **Integration of IASI-EARS L2 data into Testbed platform**
   - develop visualizations of the data

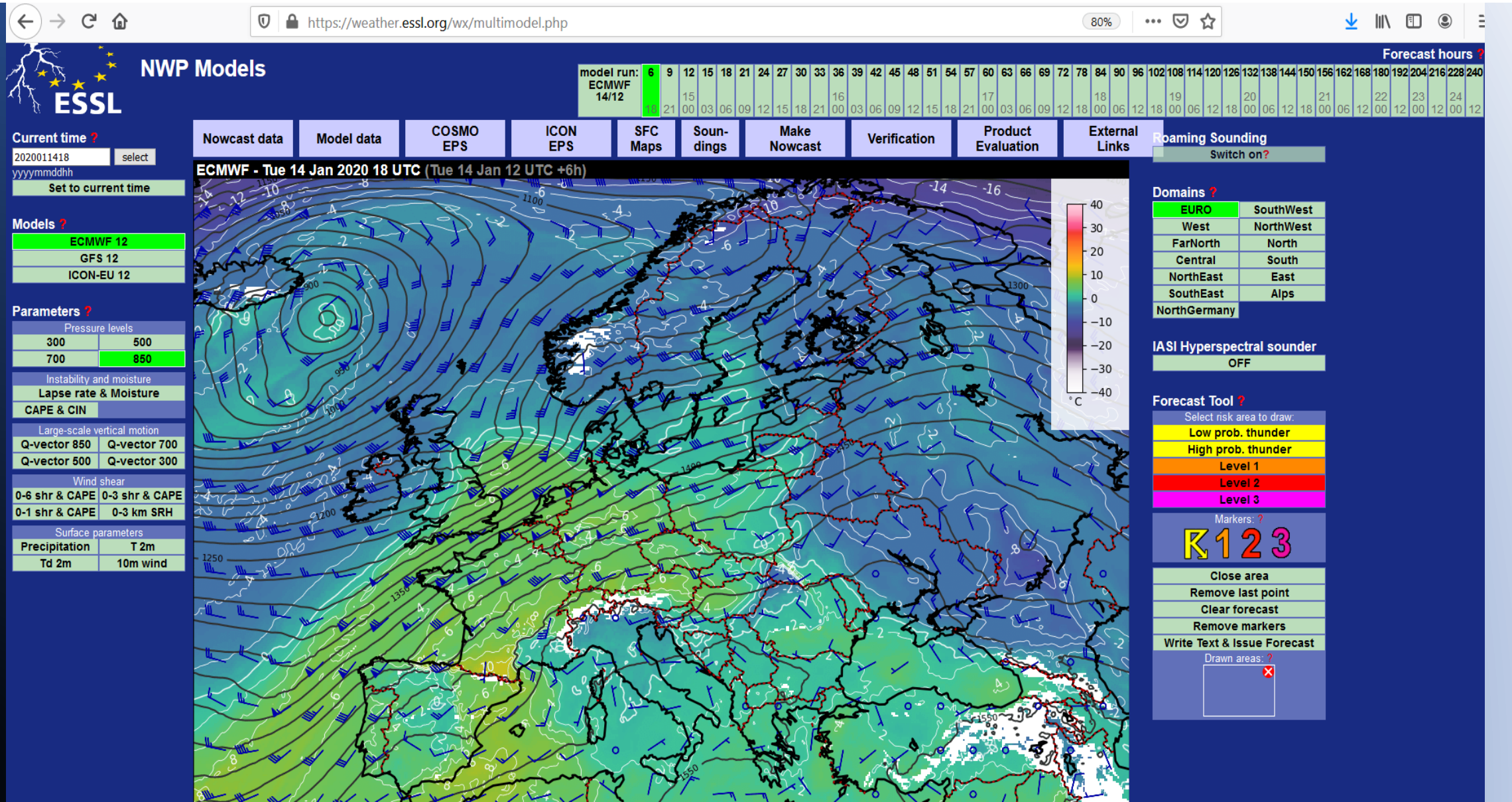
2. **Evaluation at the ESSL Testbed**
   - collect feedback from users

3a. **Perform 10 case studies**
3b. **Develop extended case catalogue** (40 cases)

4. **Provide training at EUMETSAT** (April 2019)

5. **Reporting:** 102-page (draft) report.

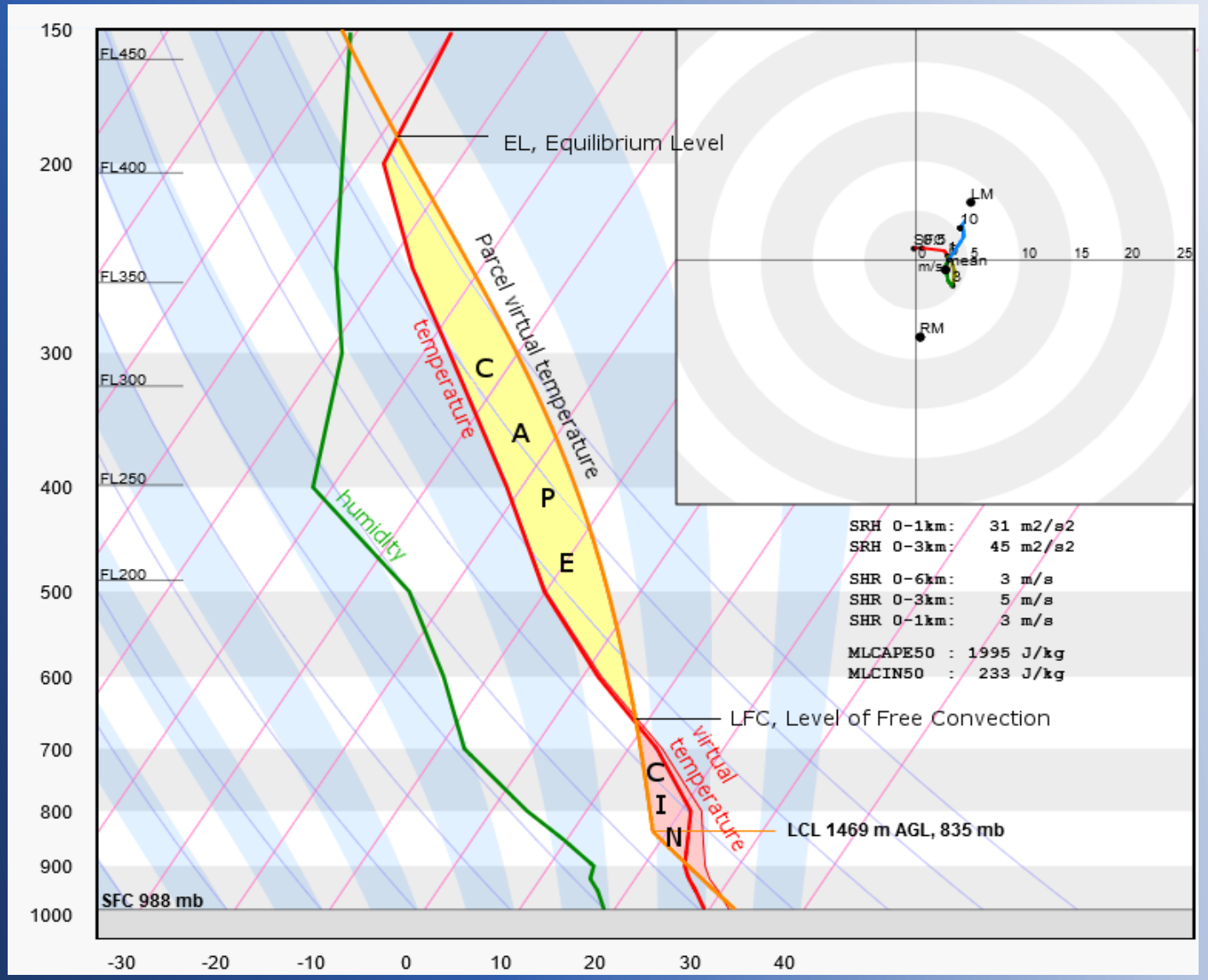
Integration into Testbed platform



Integration into Testbed platform

Selected parameters

- Based on the ingredients-based methodology



Convective parameters

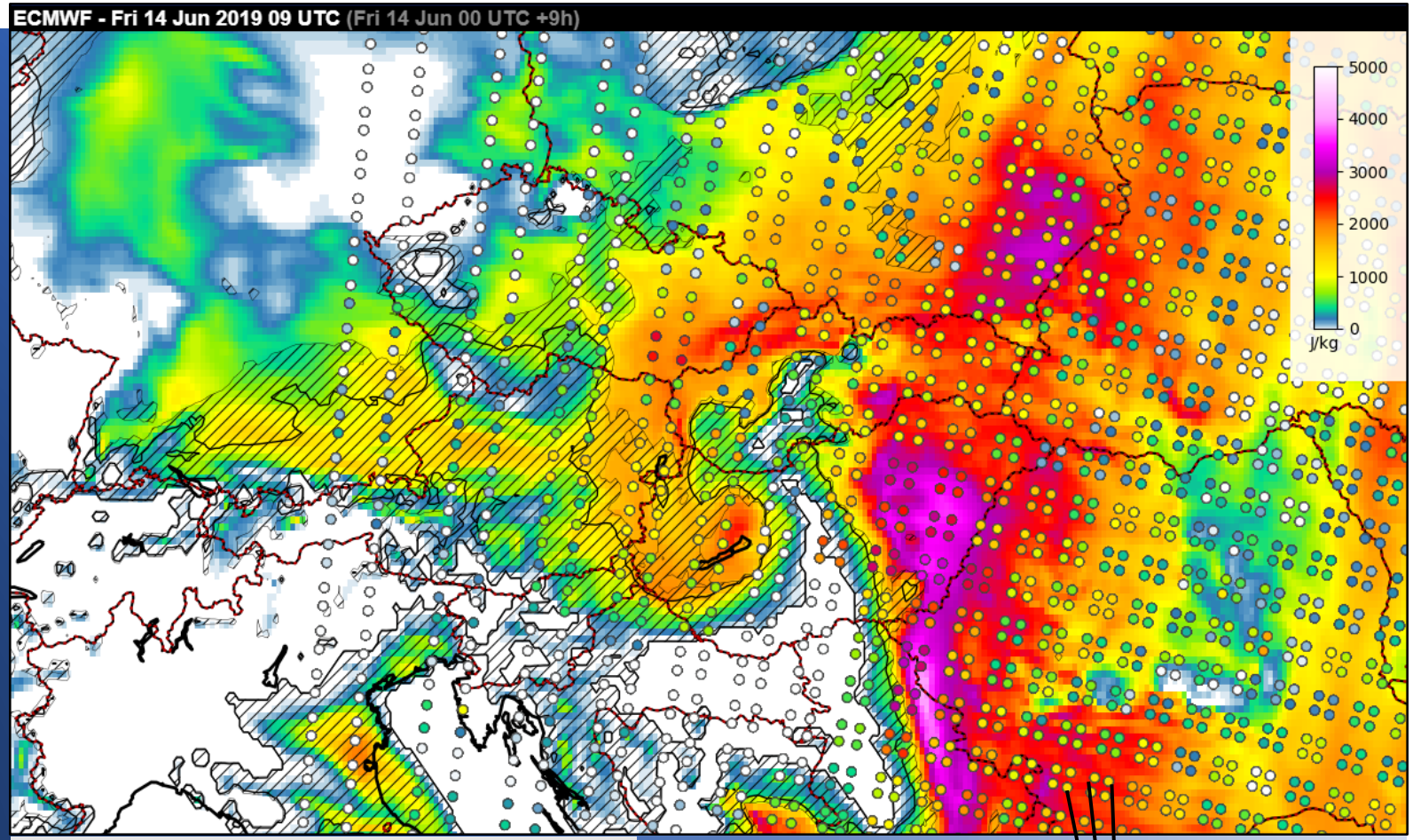
Selected parameters

- **Based on the ingredients-based methodology**
- **Computation was programmed in Python, using the IASI L2 data in HDF5 format.**
- **Code has been delivered to EUMETSAT in July 2019**

Parameter	Description	Unit
MLCAPE50	Mixed-layer Convective Available Potential Energy mixing layer: 50 hPa	J/kg or m^2/s^2
MLCAPE100	mixing layer: 100 hPa	J/kg or m^2/s^2
SBCAPE	Surface-based parcel, i.e. using lowest temperature/dew point	J/kg or m^2/s^2
MUCAPE	Most unstable parcel, i.e. parcel with the most CAPE	J/kg or m^2/s^2
MLCIN50	Convective inhibition for 50 hPa parcel	J/kg or m^2/s^2
SFC mixr	Mixing ratio at lowest level in the profile	J/kg or m^2/s^2
ML50 mixr	Mixing ratio for 50hPa mixed-layer parcel	g/kg or 10^{-3}
ML100 mixr	Mixing ratio for 100hPa mixed-layer parcel	g/kg or 10^{-3}
Total Precip. Water	Total precipitable water in the column	mm
SFC-500 mb lapse rate	Vertical temperature gradient (surface to 500 mb)	K/km or 10^{-3} K/m
850-500 mb lapse rate	Vertical temperature gradient (850 to 500 mb)	K/km or 10^{-3} K/m
MLLI50	Lifted index, or temperature difference between parcel and environment at 500 mb	K or °C

Comparison of convective parameters

Example visualization:



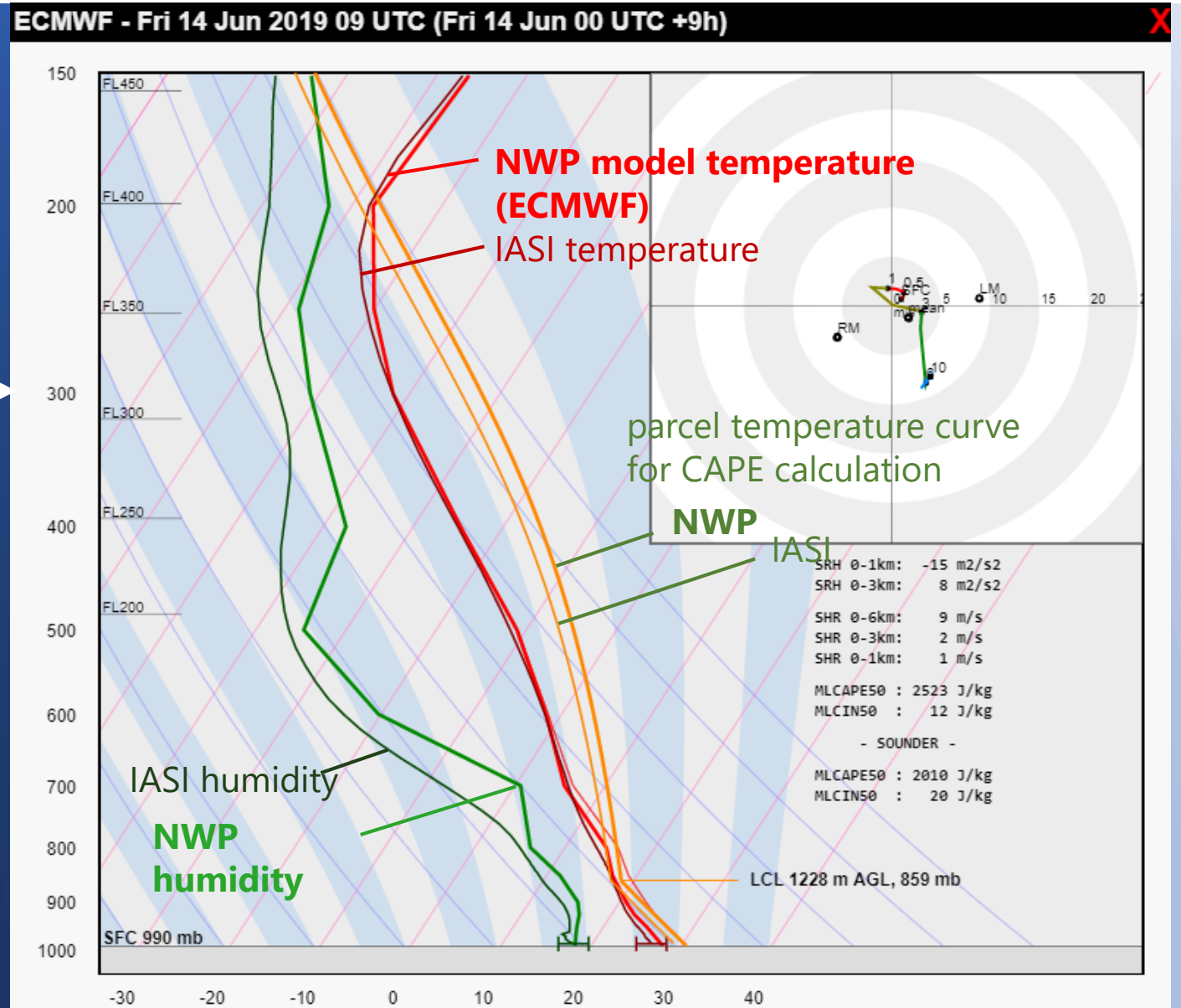
50 mb mixed-layer CAPE

background: values derived from +9 h model forecast (ECMWF IFS)

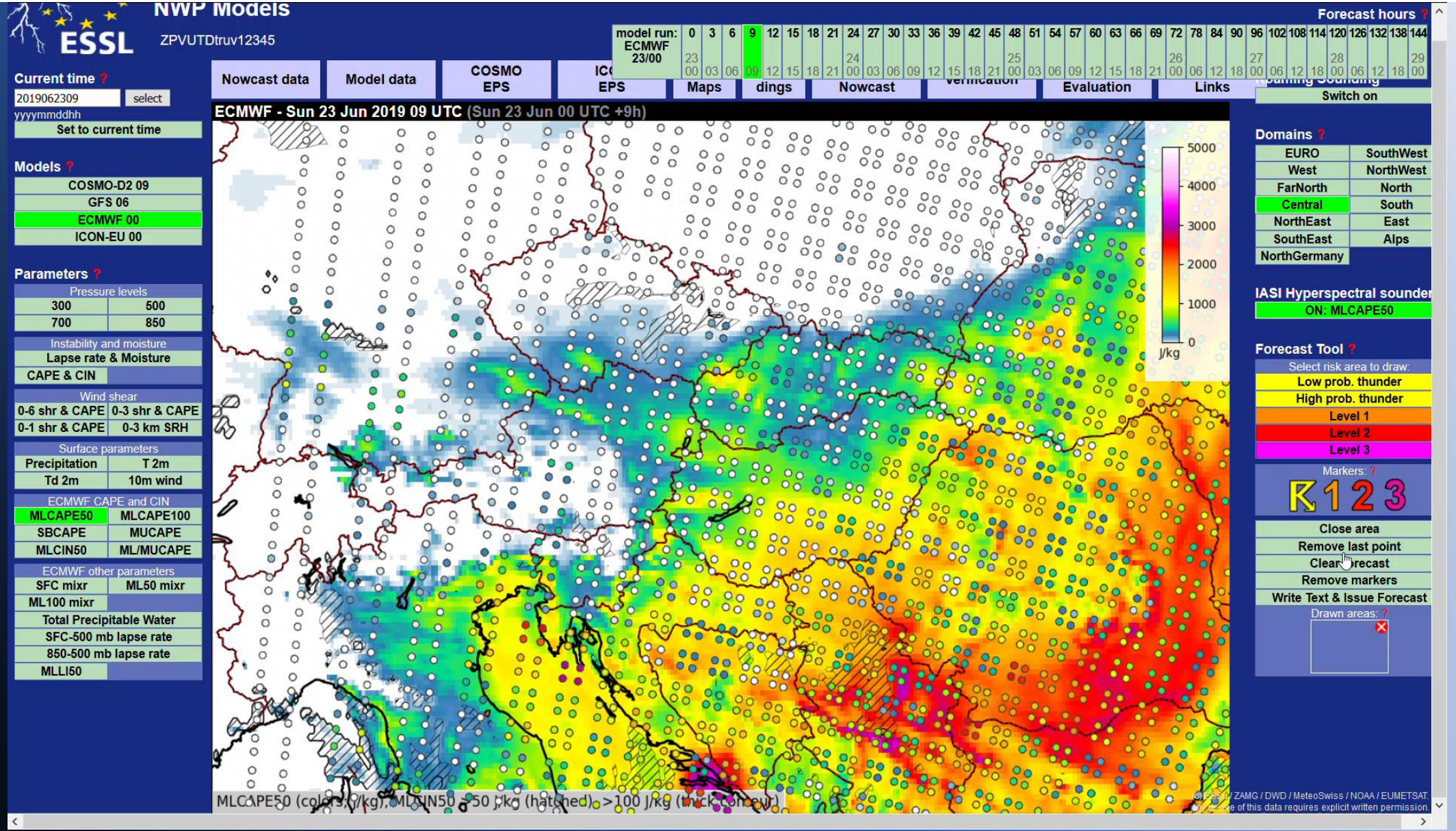
dots indicate IASI-derived values

Comparison of IASI with NWP

"Roaming sounding" diagram from the Testbed data interface



Comparison of convective parameters



Testbed evaluation

ESSL Testbed

41 Testbed participants from 14 countries

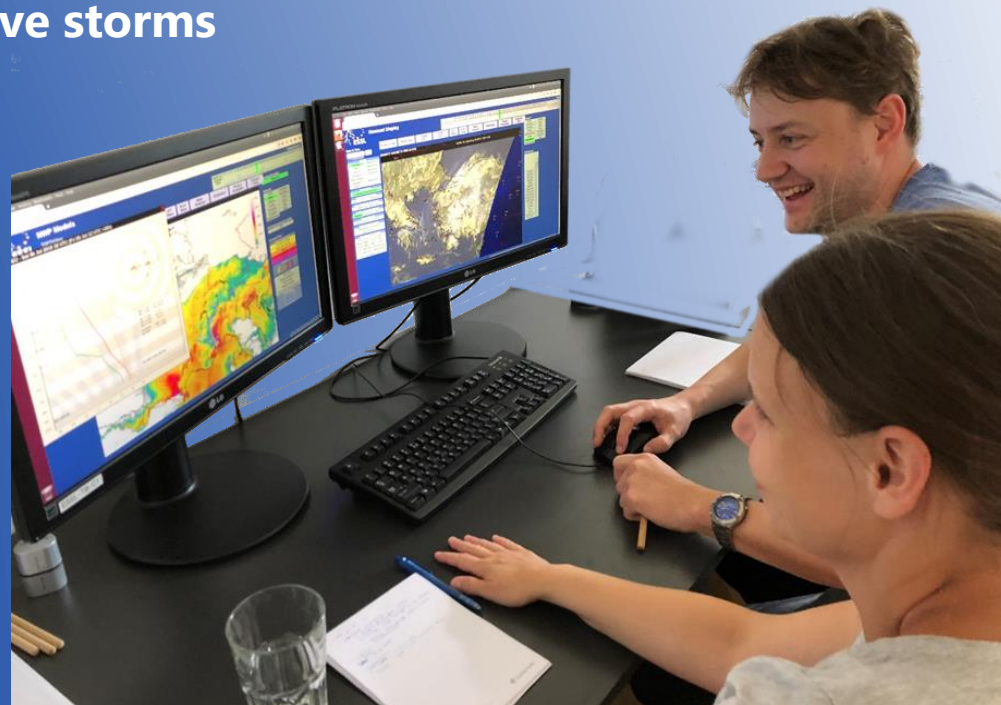
2019 Edition:

During four weeks in June and July

In Wiener Neustadt, Austria

ESSL Research and Training Centre

make experimental forecasts for (severe) convective storms



Testbed evaluation

IASI questions

Question 1

Could atmospheric soundings such as those provided from Metop/IASI (available within 30 minutes from sensing) be useful for your forecasting work? In what way?

Of 15 groups of respondents,

12 thought it was useful in principle

One other group found it a potential source of confusion and another commented on the need for knowing the quality of the data

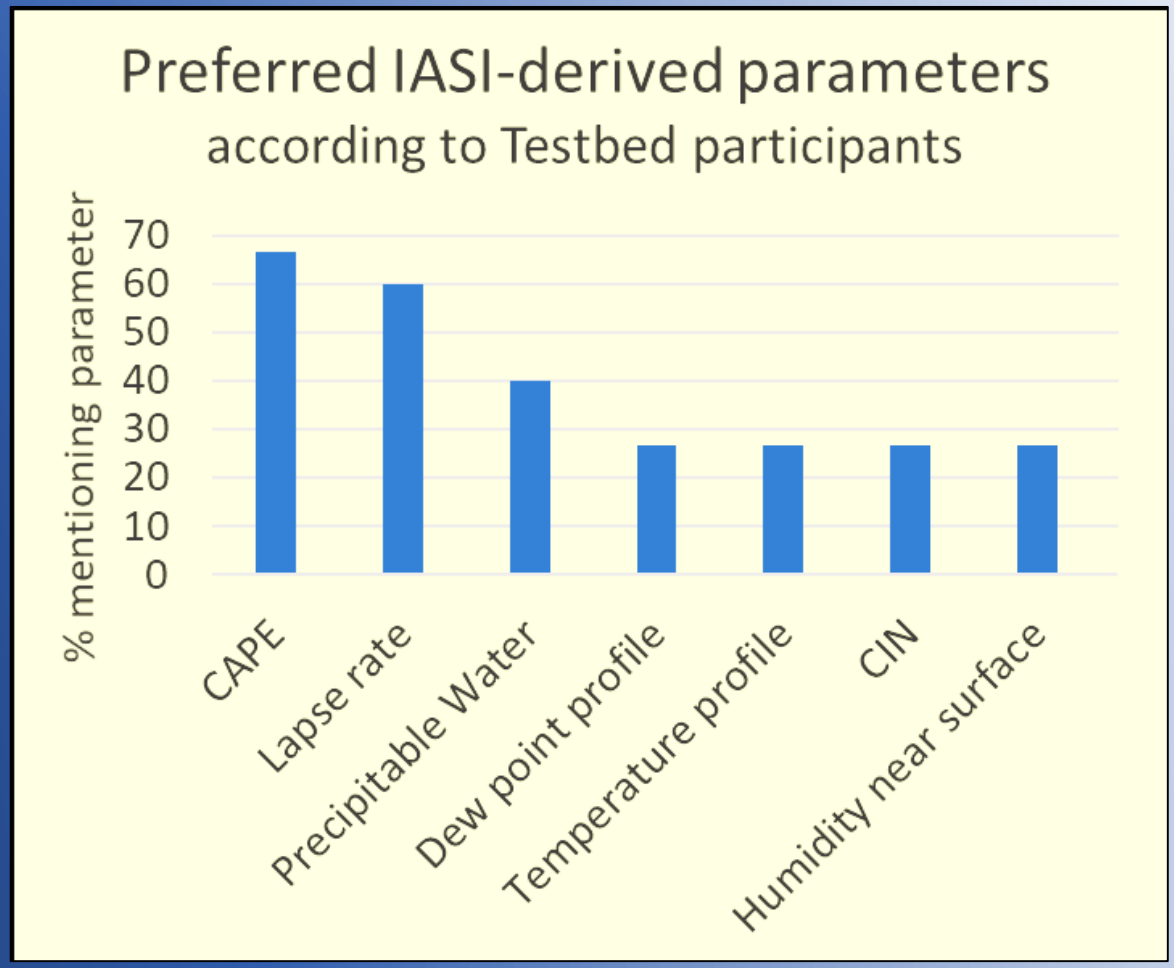
One responded that it was not useful in an experiment of assimilating the data at the Italian Weather Service —but that was not the question that was asked.

Testbed evaluation

IASI questions

Question 2

Which of the provided parameters based on the sounder data do you find most useful? Please mention the 3 to 5 most useful ones.



Testbed evaluation

IASI questions

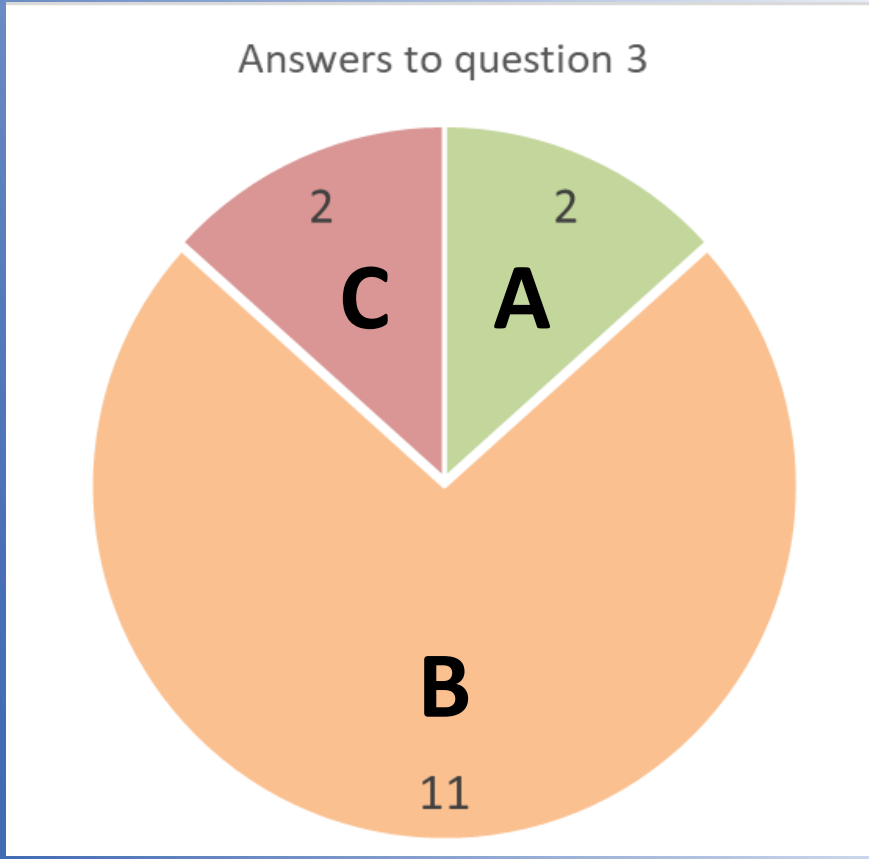
Question 3

Choose the statement that applies best

A. *I think the IASI products with their limited temporal availability (twice a day) already provide important additional information that makes the data interesting to use.*

B. *I think the IASI products could be useful for forecasting, but first it is necessary that more observations become available throughout the day.*

C. *I think the IASI products have limited value for forecasting, but are interesting to prepare for the MTG-IRS data, that will have better resolution.*



Testbed evaluation

IASI questions

Question 4

In principle, NWP (forecast model) data could be used to improve the limited vertical resolution of hyperspectral sounder products, but this would introduce a dependence on them. In their present form the data are available in the form of smoother/less resolved profiles (than e.g. sondes) and as integrated-/lapse-/instability quantities, but they are fully independent of any NWP model.

How important is it to your work that the products are independent of any NWP model?

Almost all participant groups (14 out of 15) stated that it was important or very important to have an IASI dataset that is independent from numerical model output.

"We think that it should be independent, so that observations are closer to reality and then we could compare them with model data. But of course, it is a good thing that the IASI data are assimilated into the model to improve the performance of the model."

Testbed evaluation

IASI questions

Question 5

The vertical profiles are currently provided with a single error estimate, displayed with an error bar at the bottom of the profile. In principle, it is possible to display errors for any given level.

How useful do you think this would be for your work?

In practice, how would you use this quality-control information?

12 out of 15 participant groups responded that they would find such information useful.

3 out of 15 thought it would not be useful, the main objection being the risk of overloading the user with information.

Testbed evaluation

IASI questions

Question 6

Do you have any additional comments or suggestions regarding the data?

Did something in particular catch your attention?

General comments:

- Half of the groups noted differences in near-surface humidity between the IASI data and NWP model, or between IASI and surface observations
- an **underestimation** of the humidity was most common.
- Two groups mentioned that the temperature profile seems to be (much) better.

Visualization suggestions:

1. enable a 3D (i.e. cross-section) view of sounder data
2. display low-level dew point temperature from IASI as a parameter
3. indicate the time difference between time of the sounder and the NWP model
4. highlight CAPE area in sounding profile by shading it

Testbed evaluation

Main outcomes:

1. most (80%) of participants found the data useful in principle
2. forecasters would welcome a higher (spatio-) temporal availability
3. IASI profiles should stay completely independent of the model data
4. There was concern about the accuracy of the near-surface humidity data

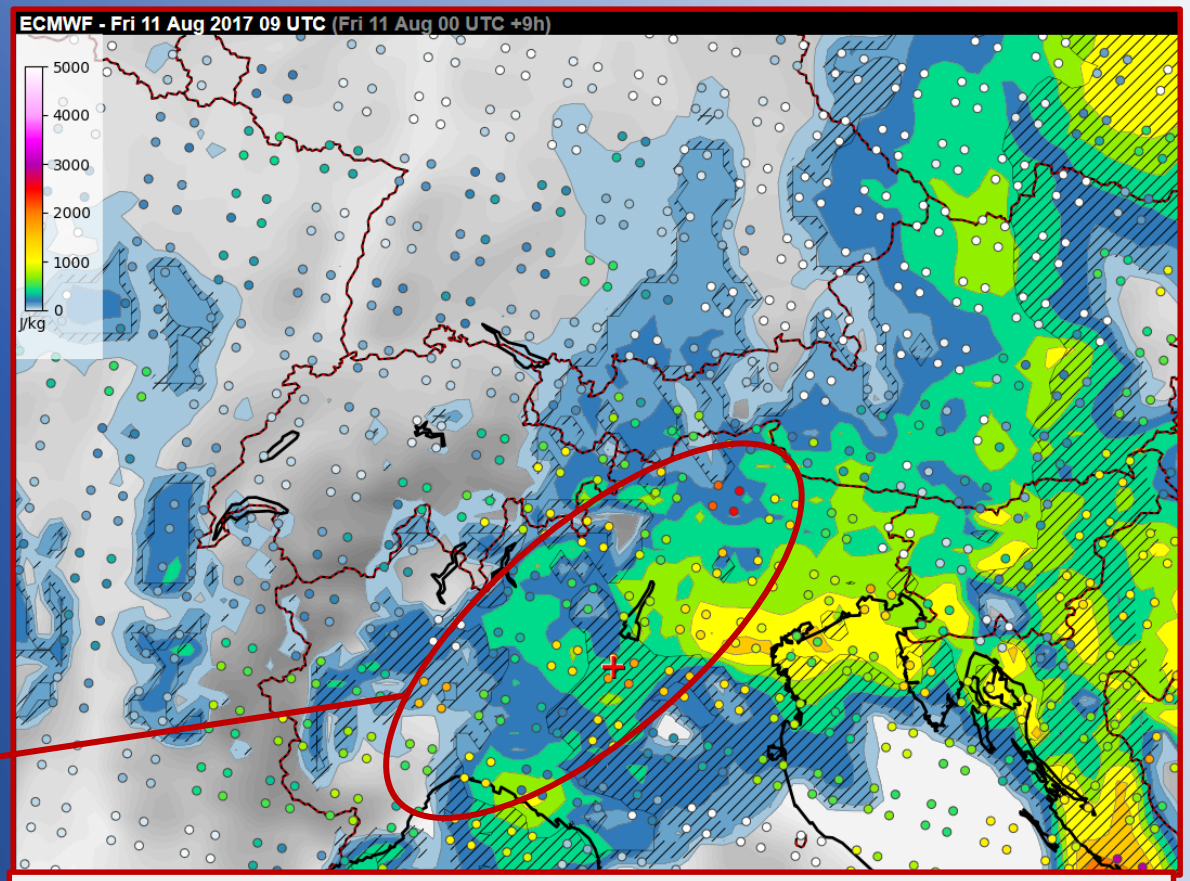
ESSL Testbed

Studies of past cases

ESSL studies past cases of severe convection that were impactful or not well anticipated by numerical weather prediction.

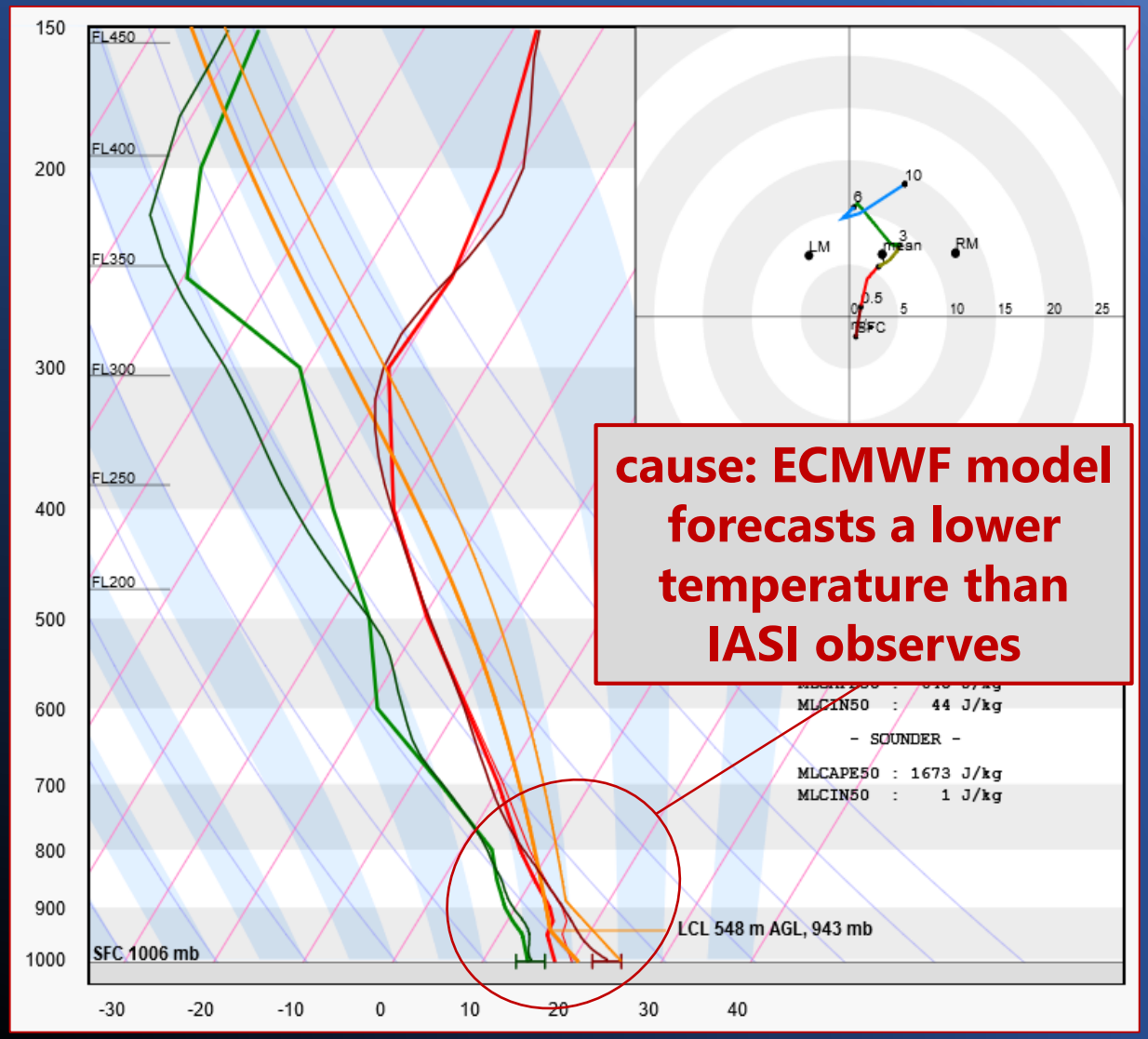
An example…

area with higher CAPE according to IASI than in the ECMWF model

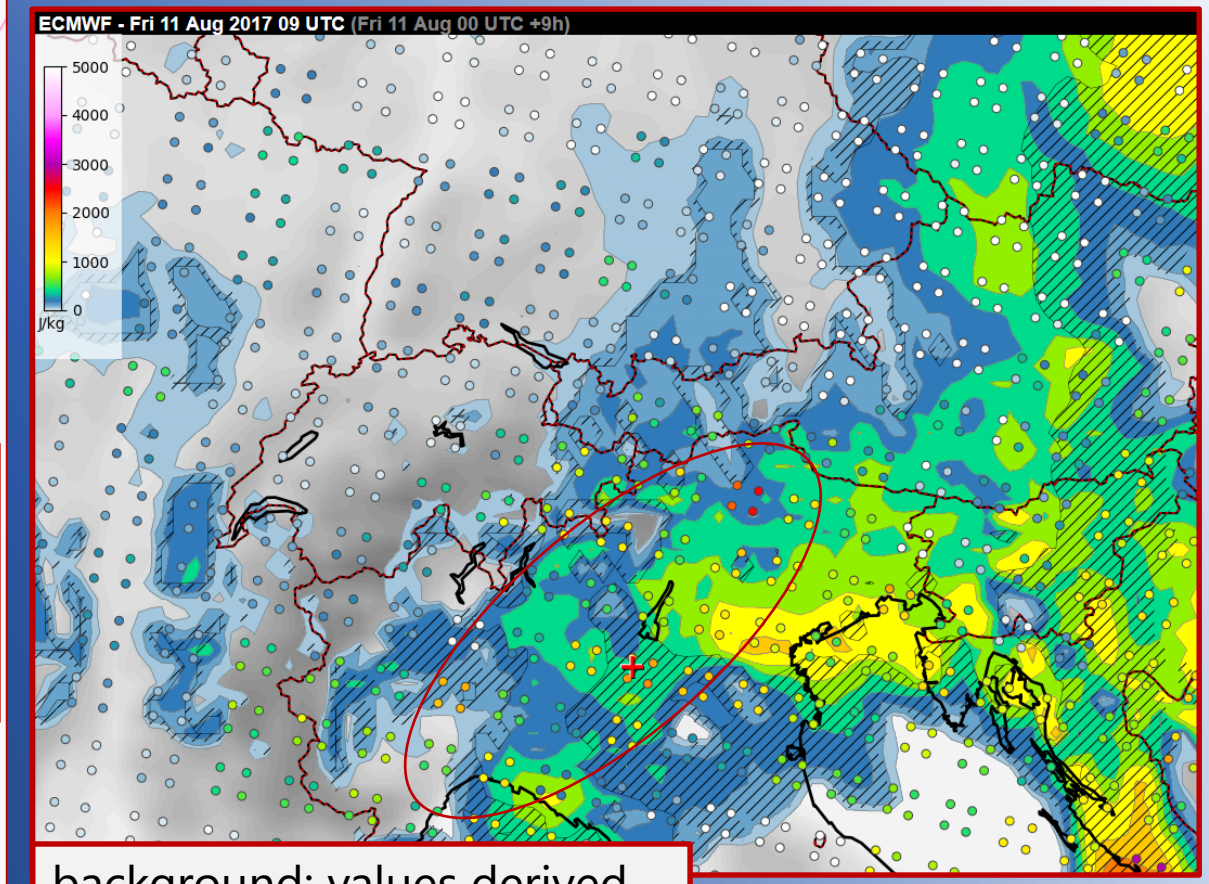


background: values derived from +9 h model forecast (ECMWF IFS). Dots indicate IASI-derived values

Studies of past cases



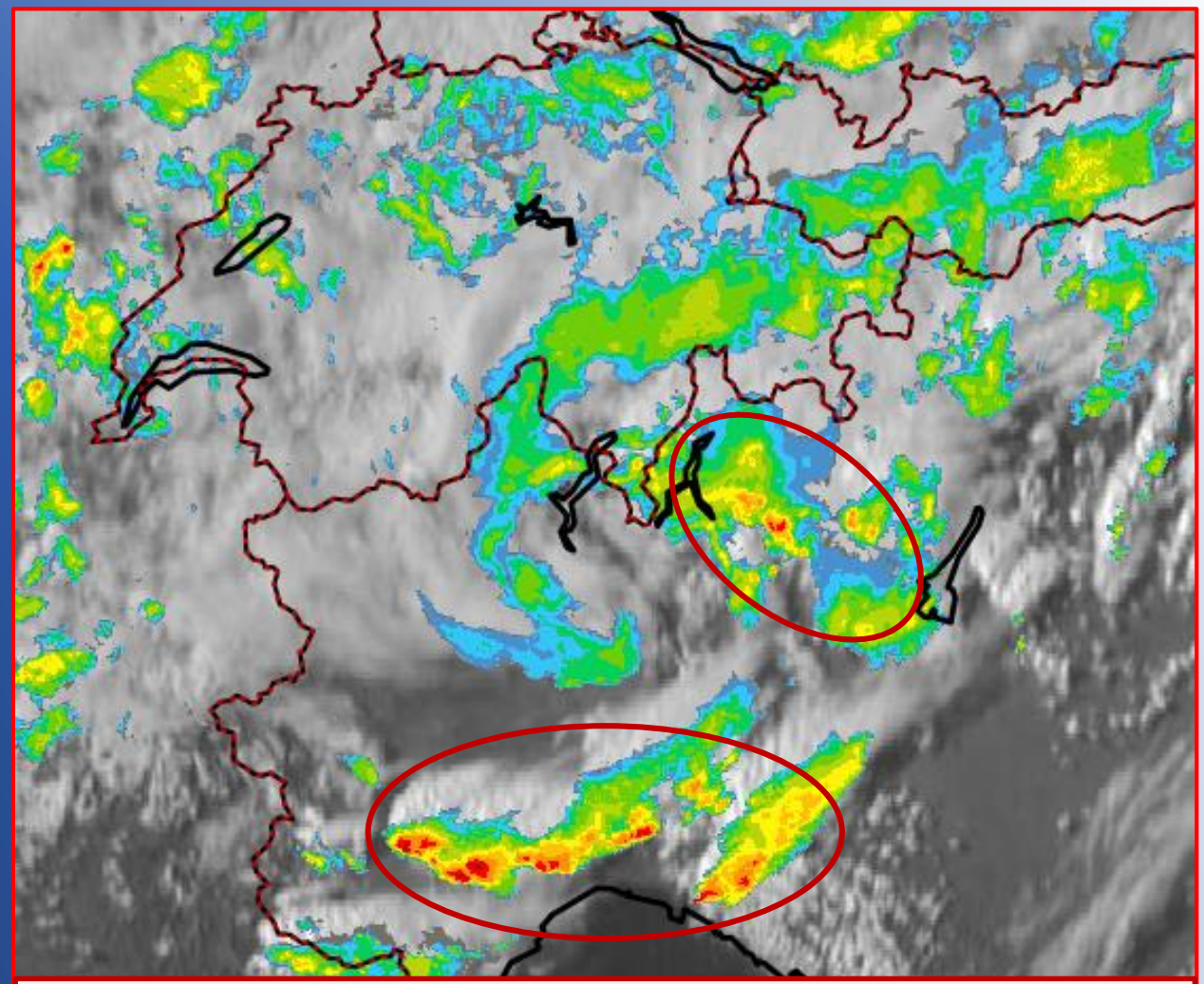
cause: ECMWF model forecasts a lower temperature than IASI observes



background: values derived from +9 h model forecast (ECMWF IFS). Dots indicate IASI-derived values

Studies of past cases

widespread convective storm development by 1500 UTC

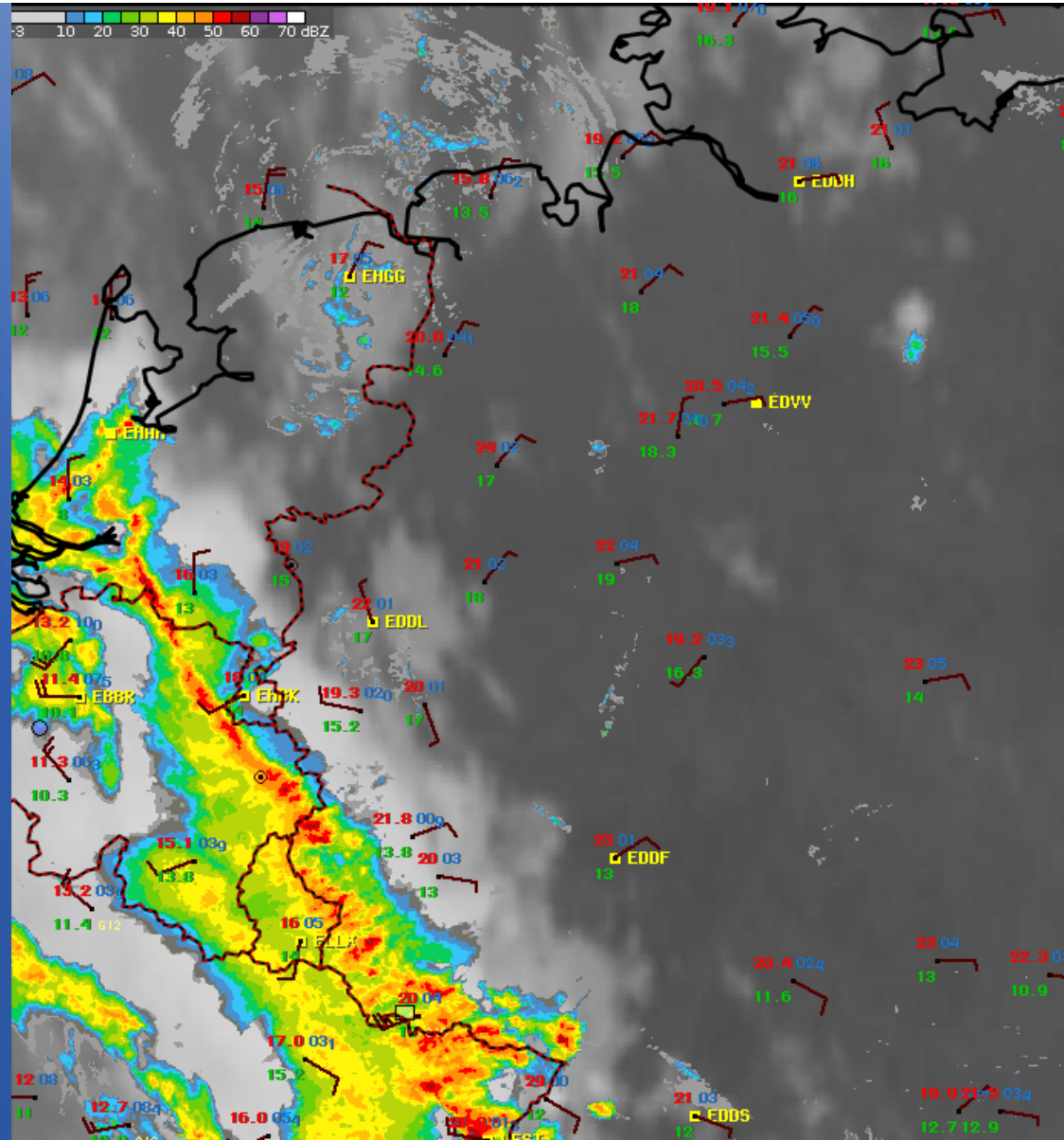


radar and VIS satellite at 1500 UTC

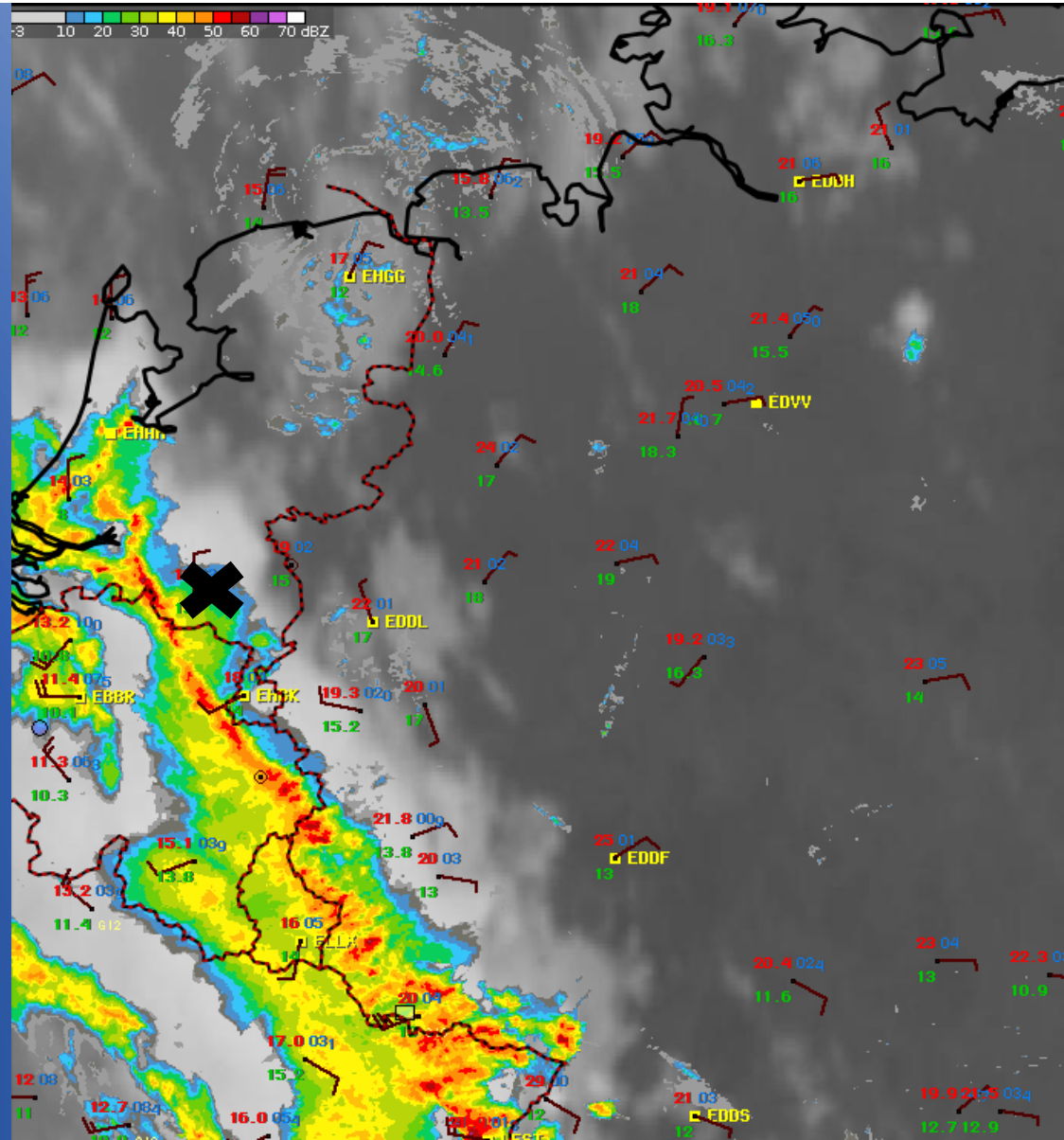
5 June 2019

Fast moving convective system

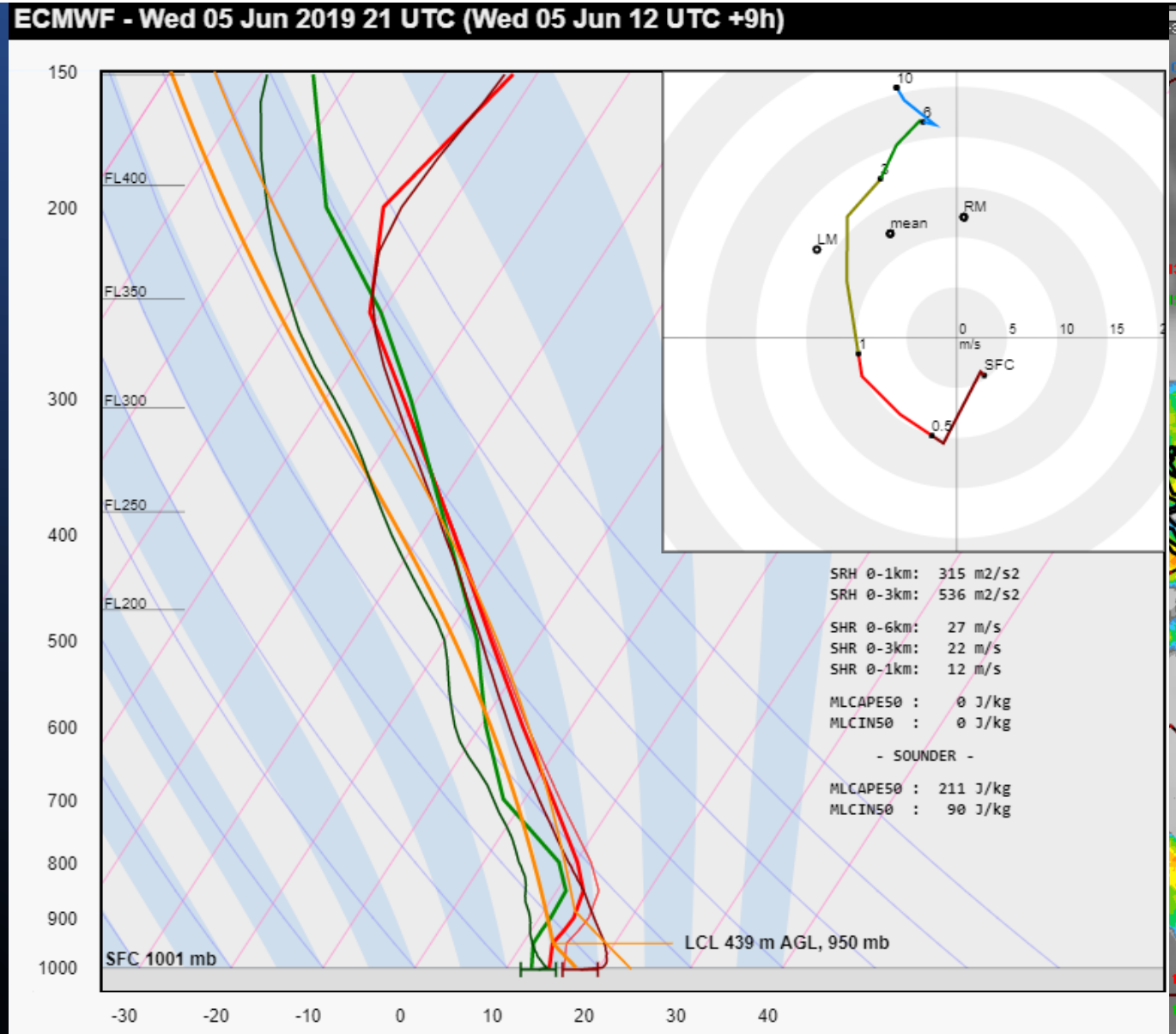
Is it capable of severe wind gusts?

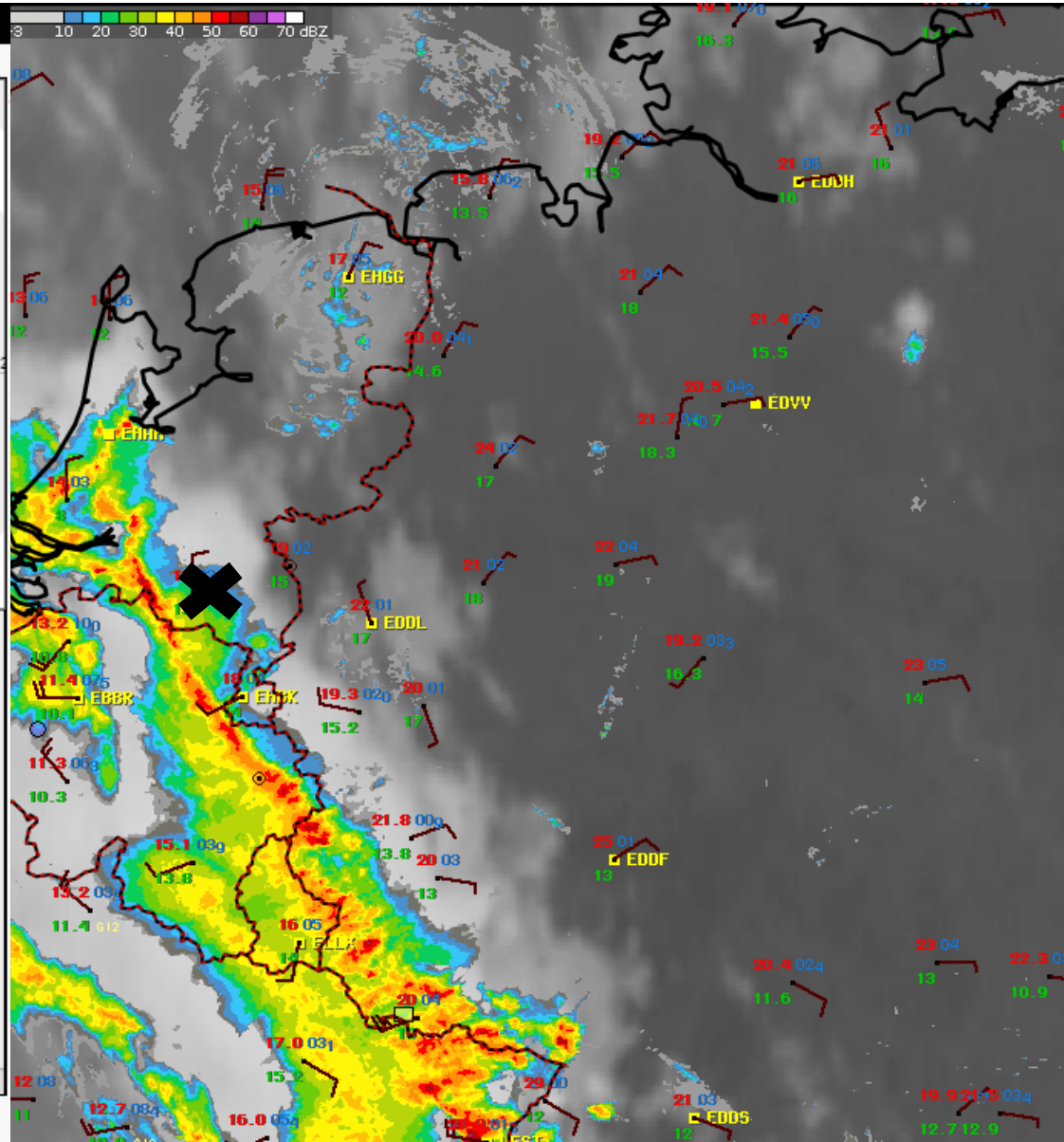


5 June 2019 – ahead of system



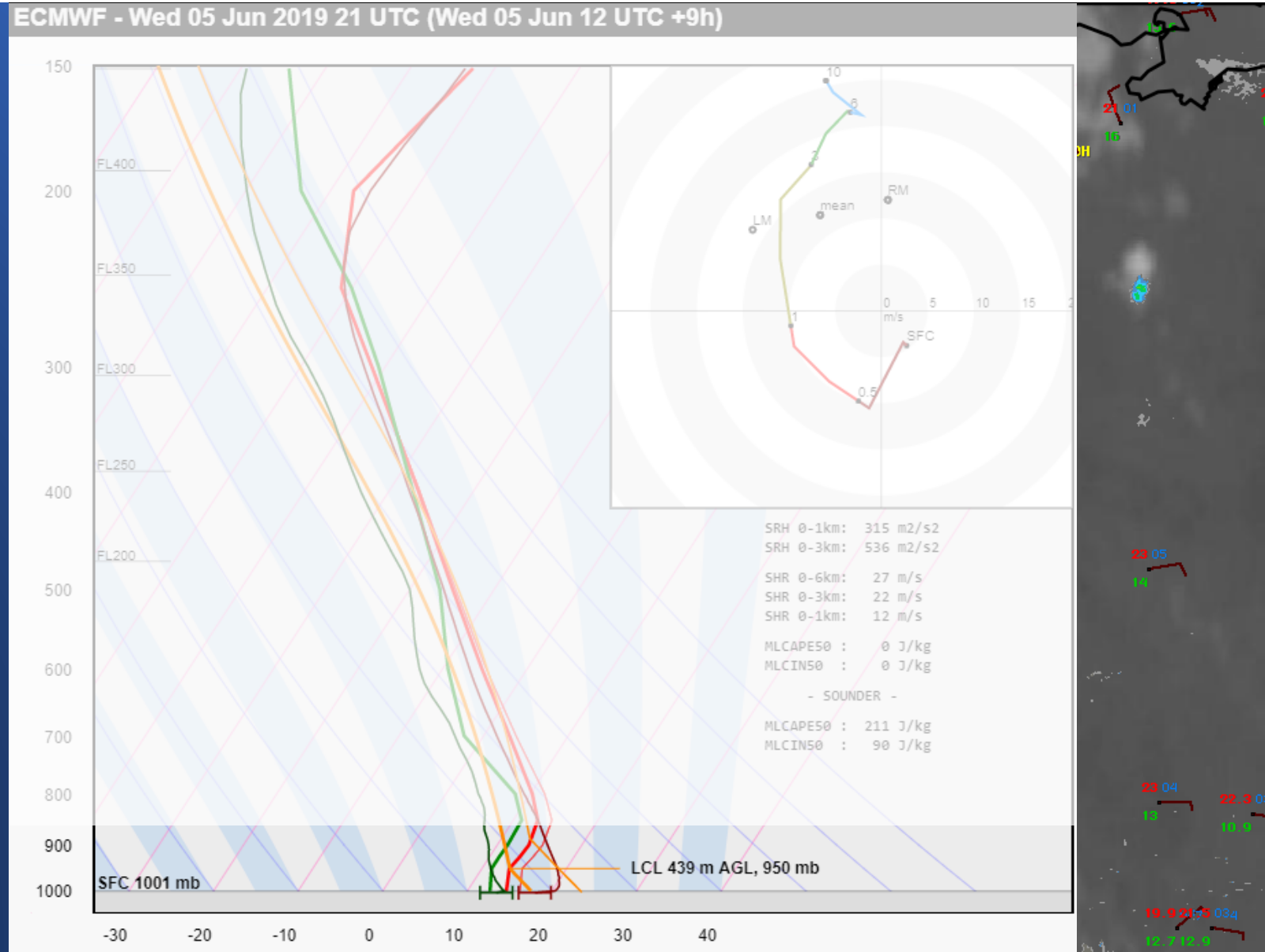
5 June 2019 – ahead of system





5 June 2019 – ahead of system

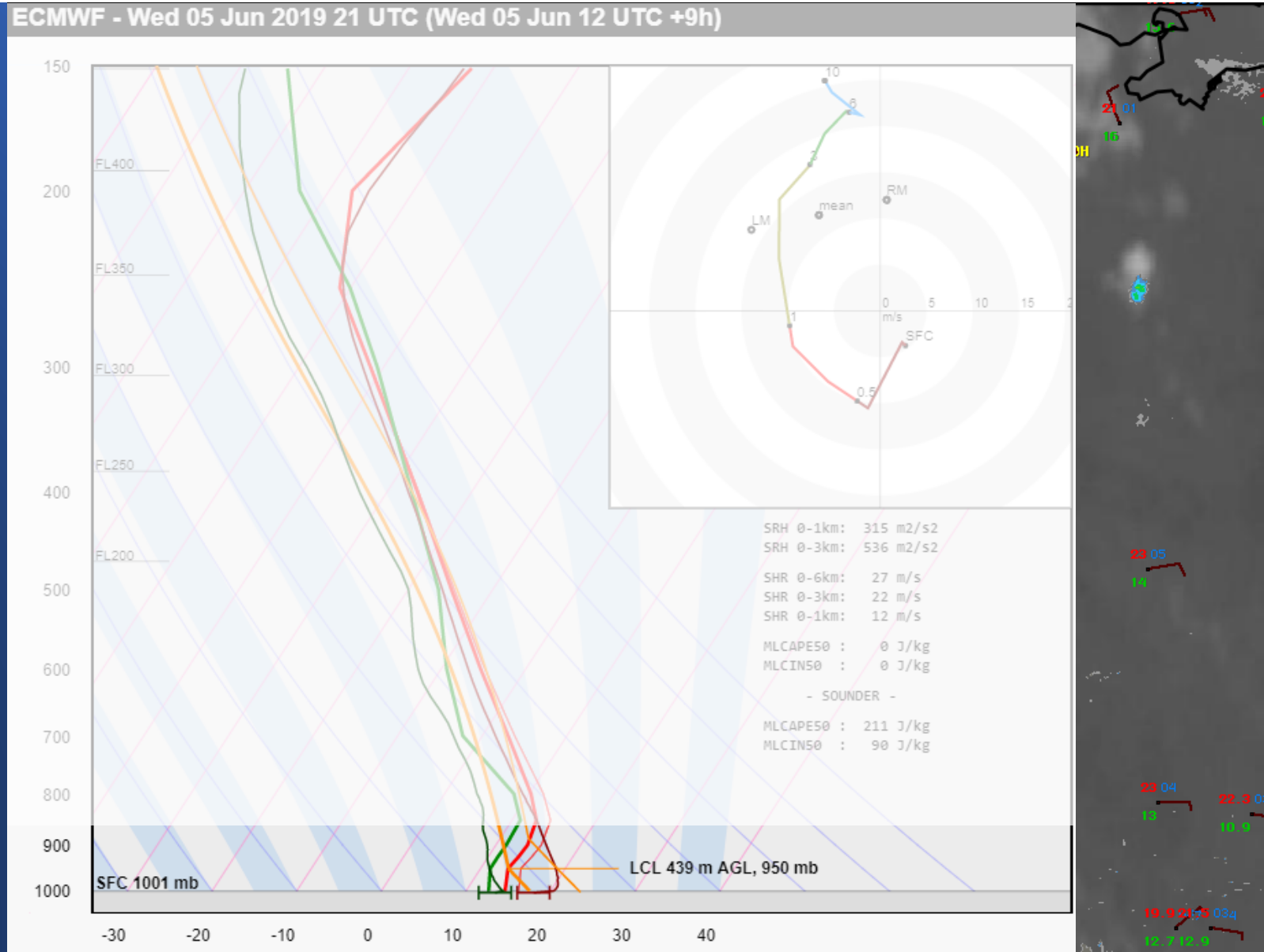
Surface temperature higher than forecast



5 June 2019 – ahead of system

Surface temperature higher than forecast

Observations confirm this

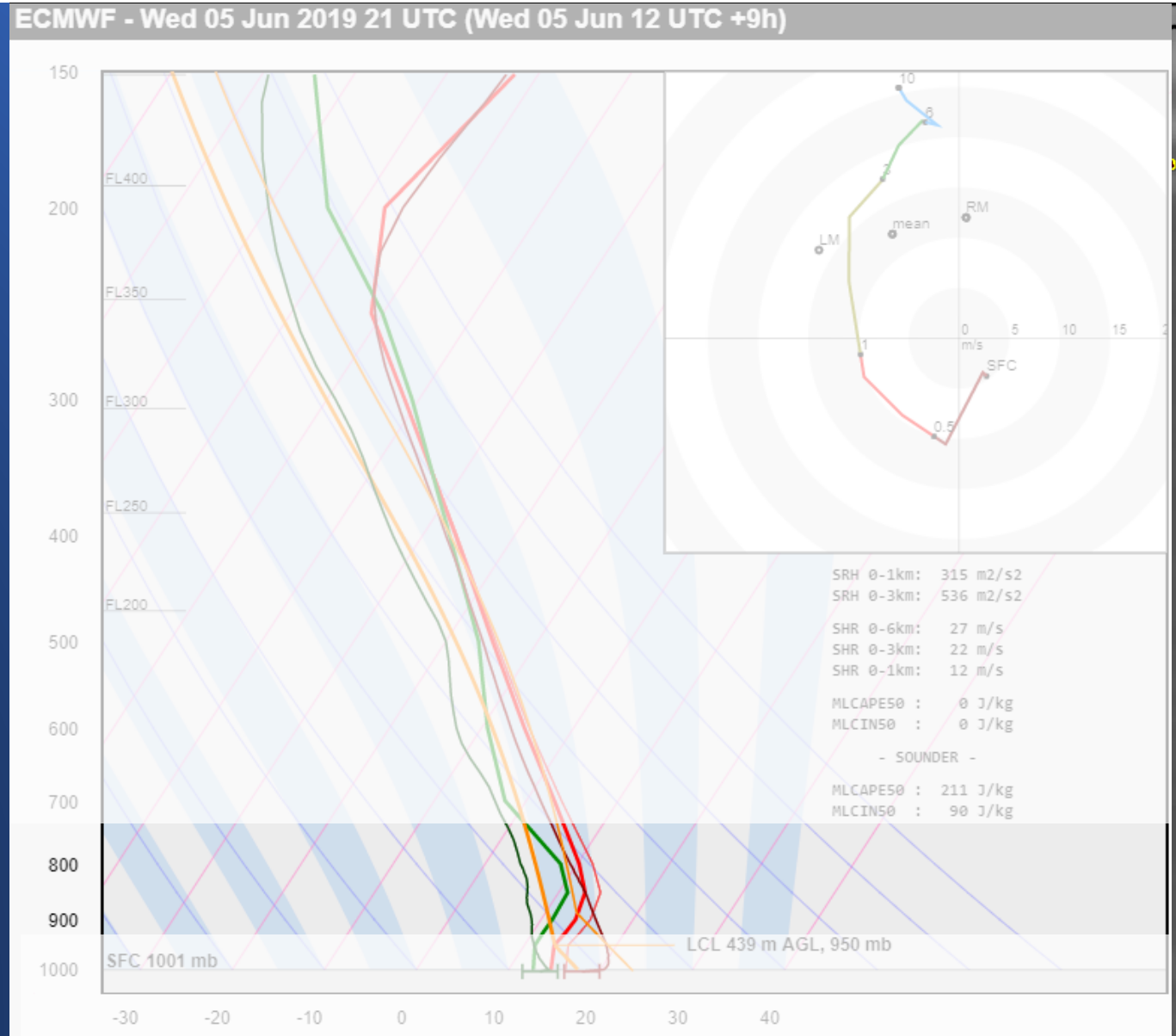


5 June 2019 – ahead of system

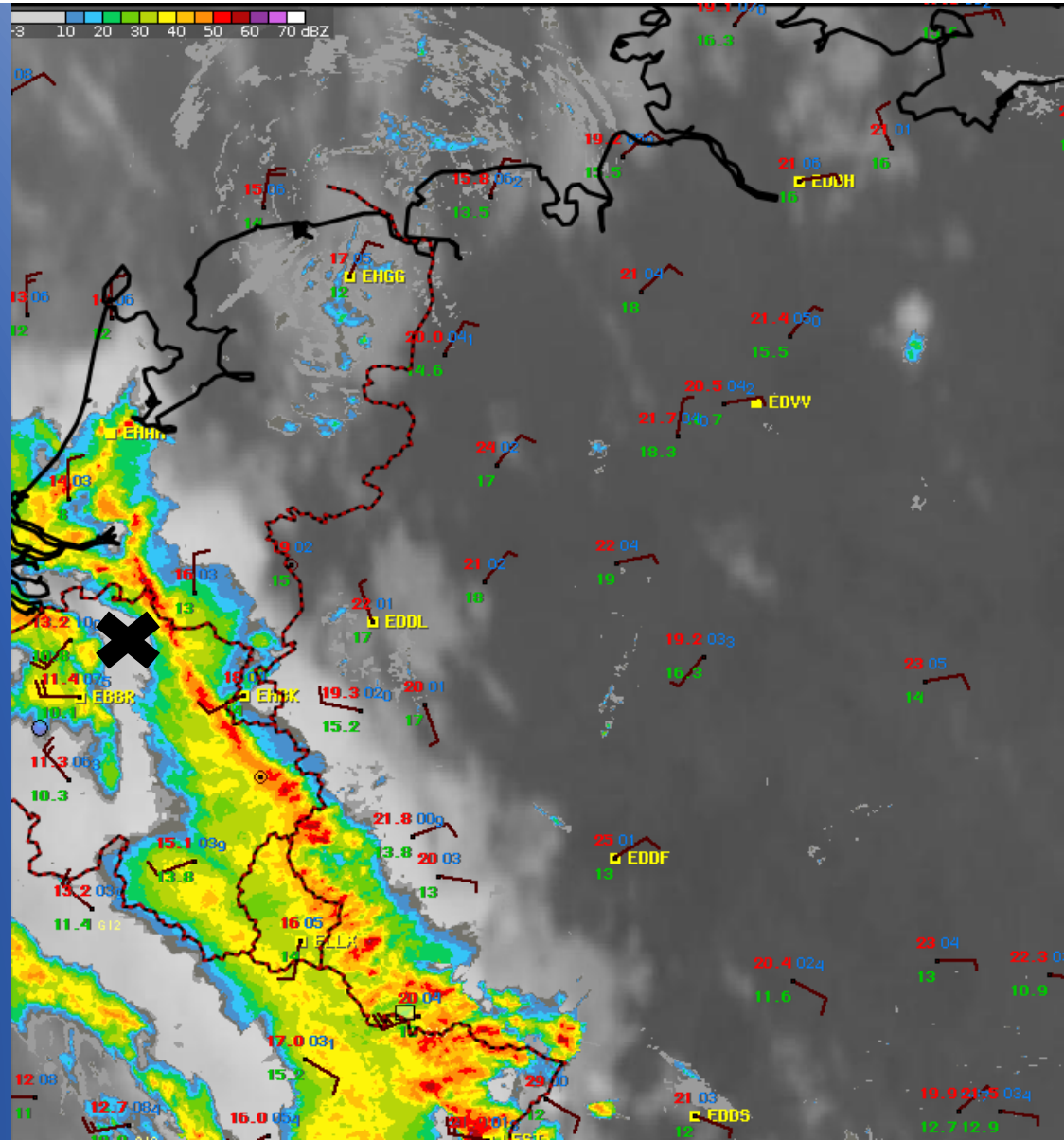
Surface temperature higher than forecast

Observations confirm this

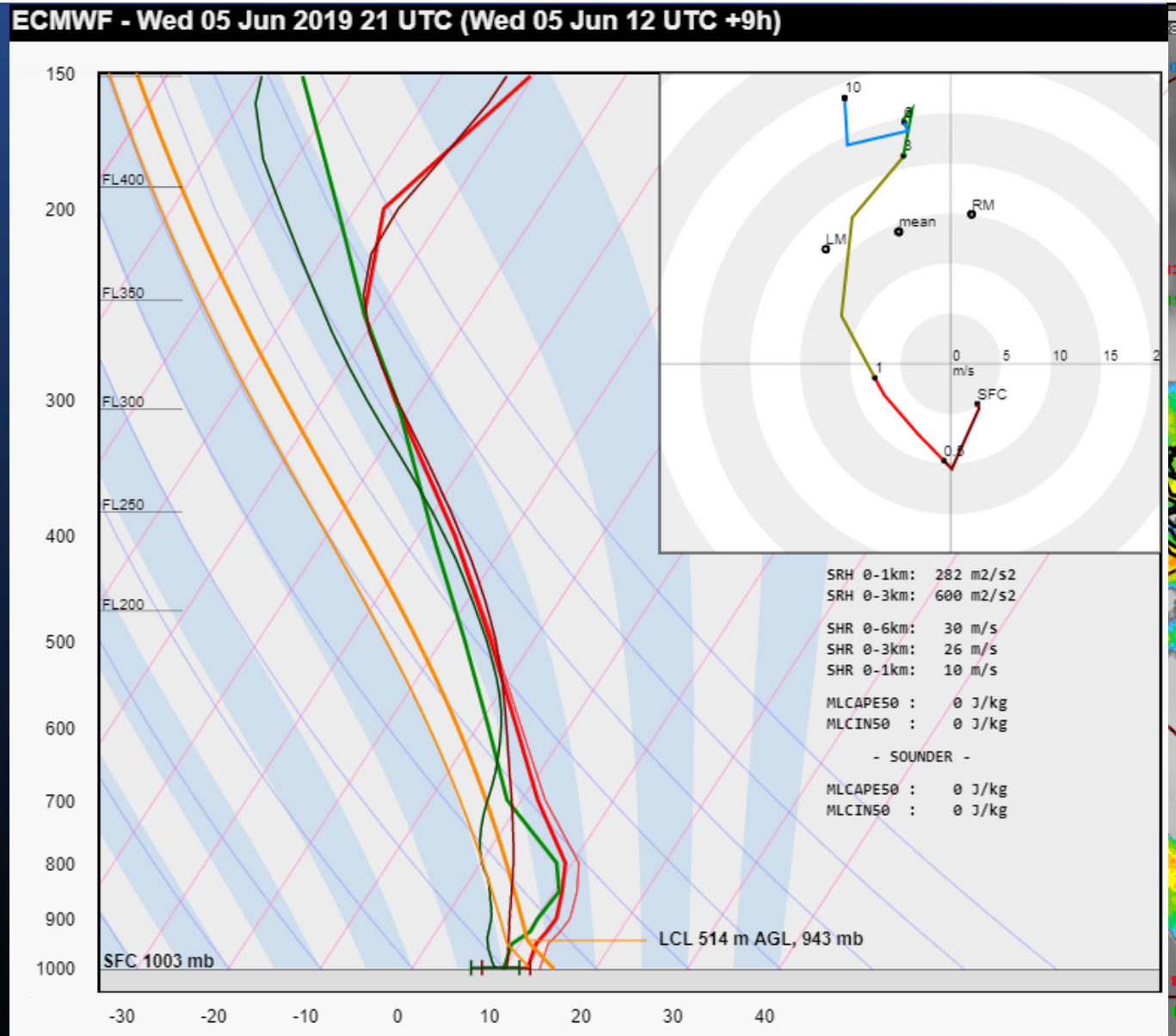
Layer with substantial CAPE not detected

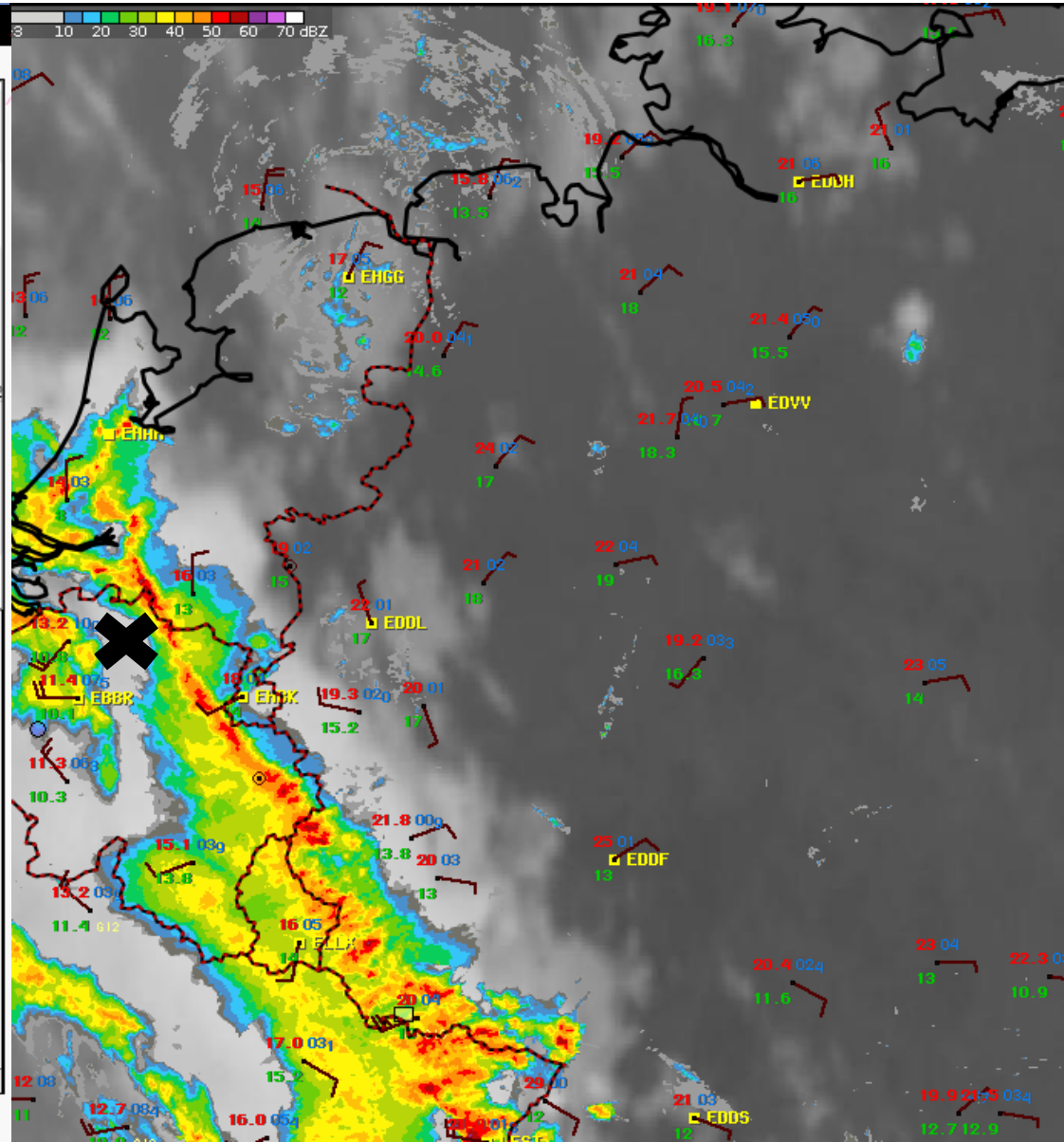


5 June 2019 – behind system



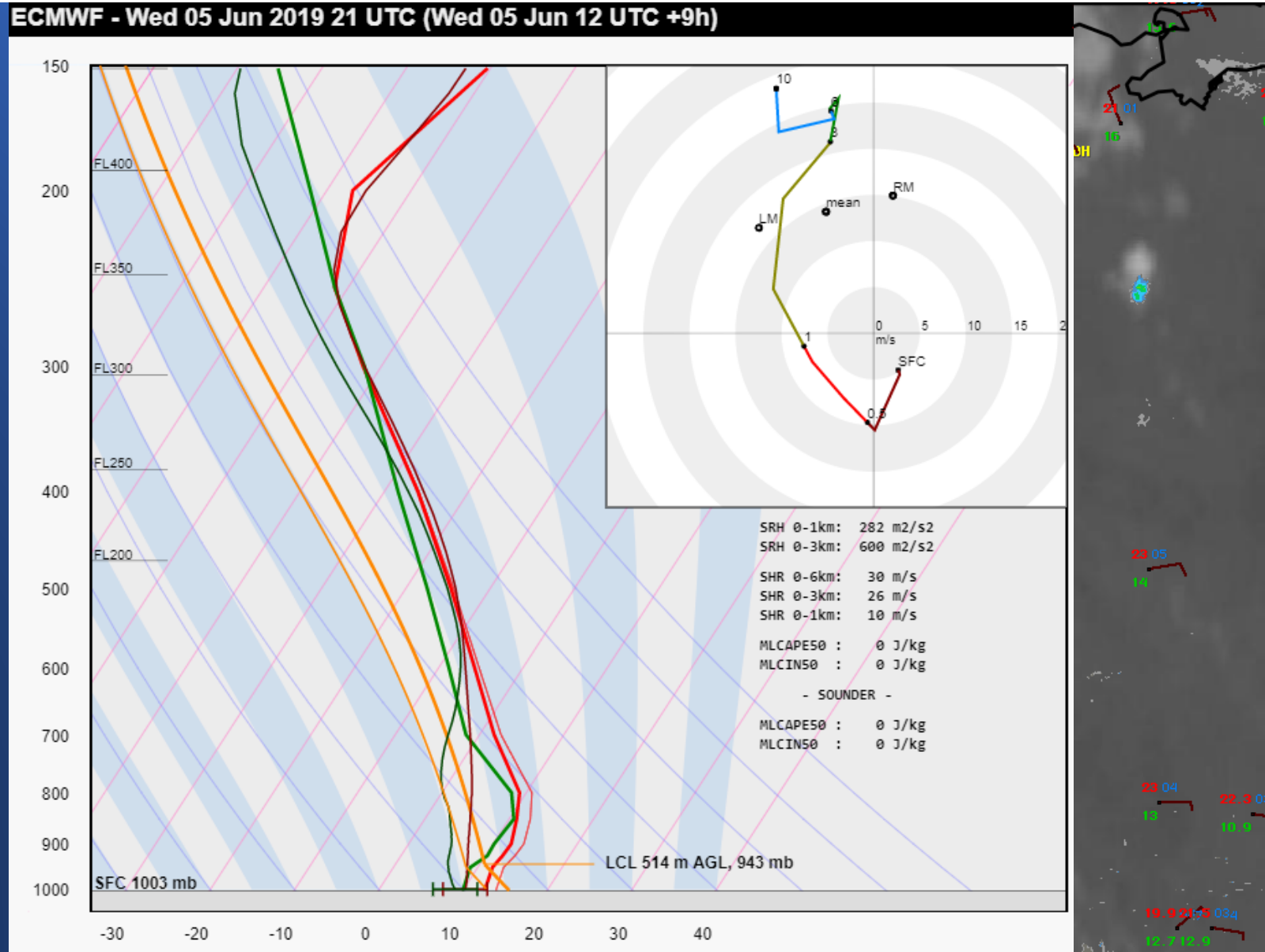
5 June 2019 – behind system





5 June 2019 – behind system

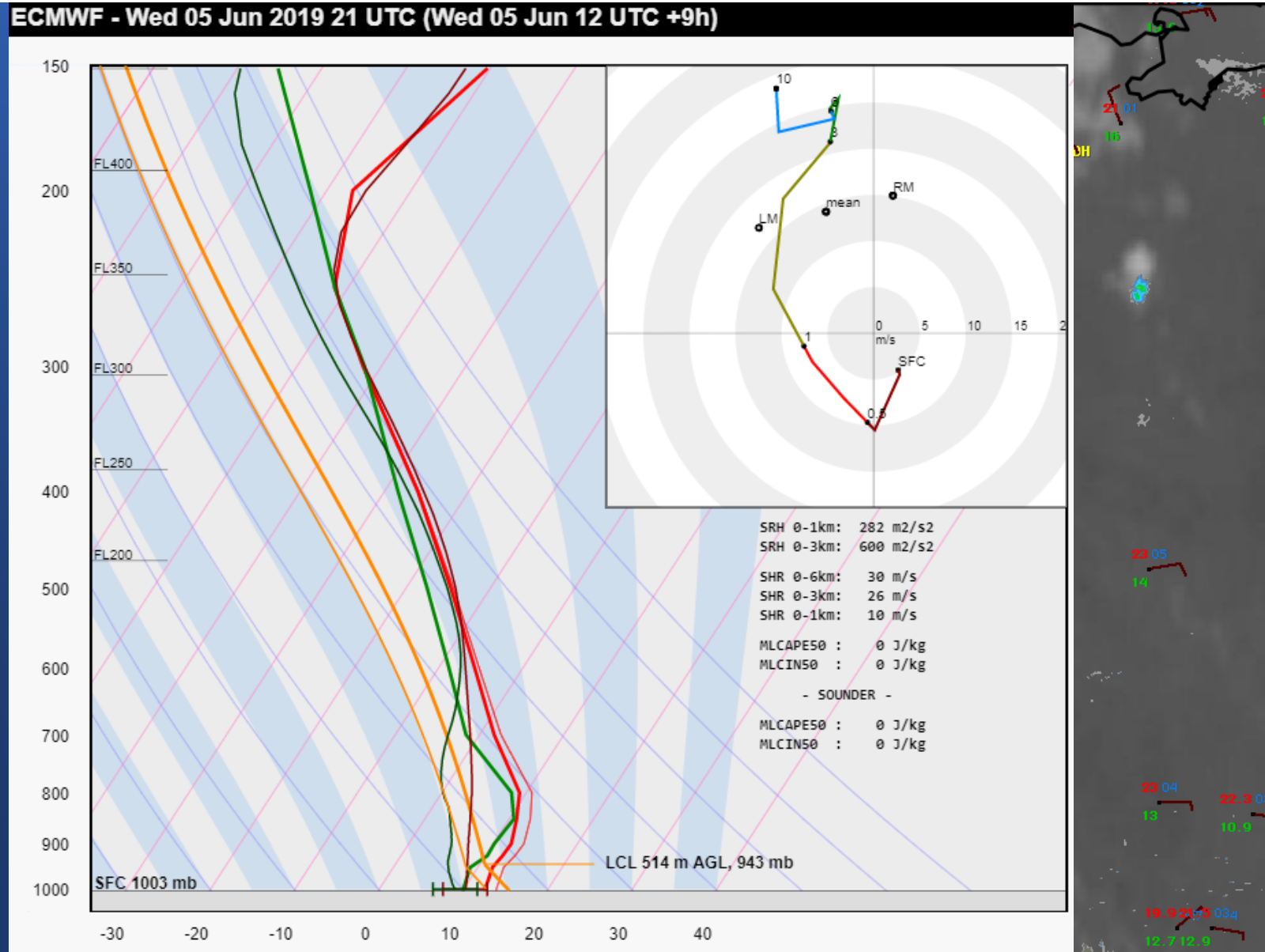
Decrease in temperature and dewpoint



5 June 2019 – behind system

Decrease in temperature and dewpoint

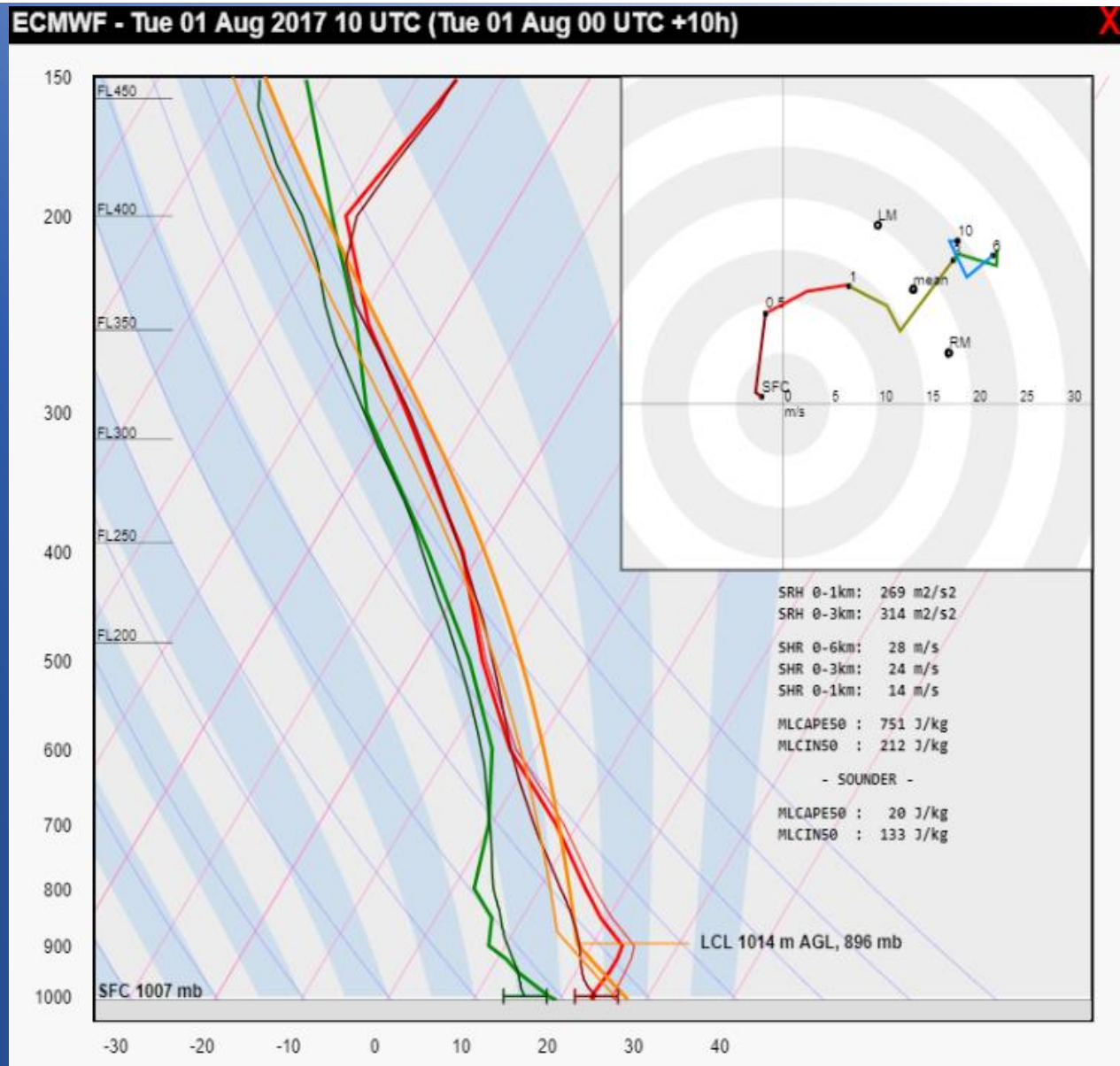
Reduction in CAPE



1 August 2017

Failure in convective initiation

Can we measure the convective inhibition?

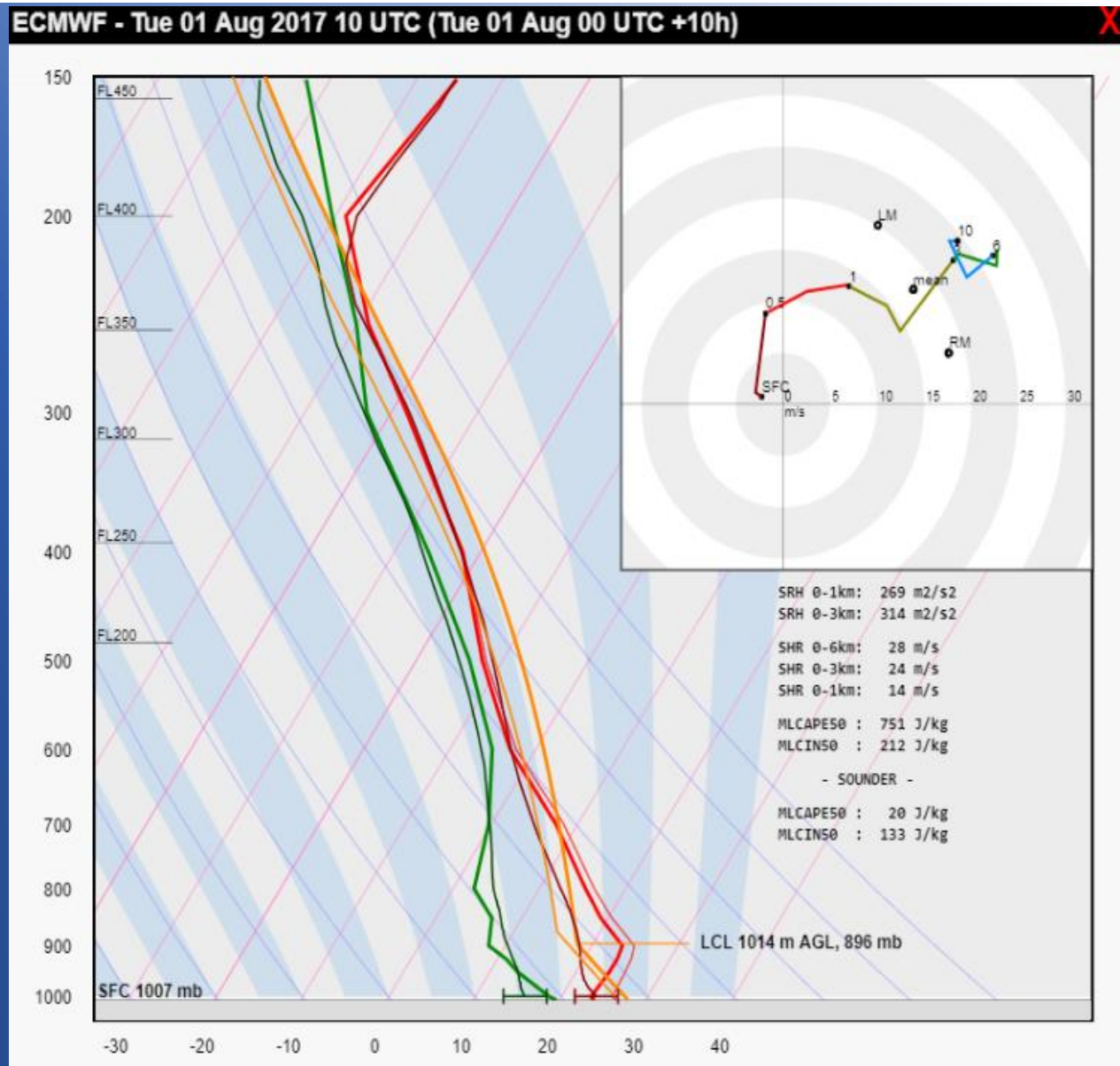


1 August 2017

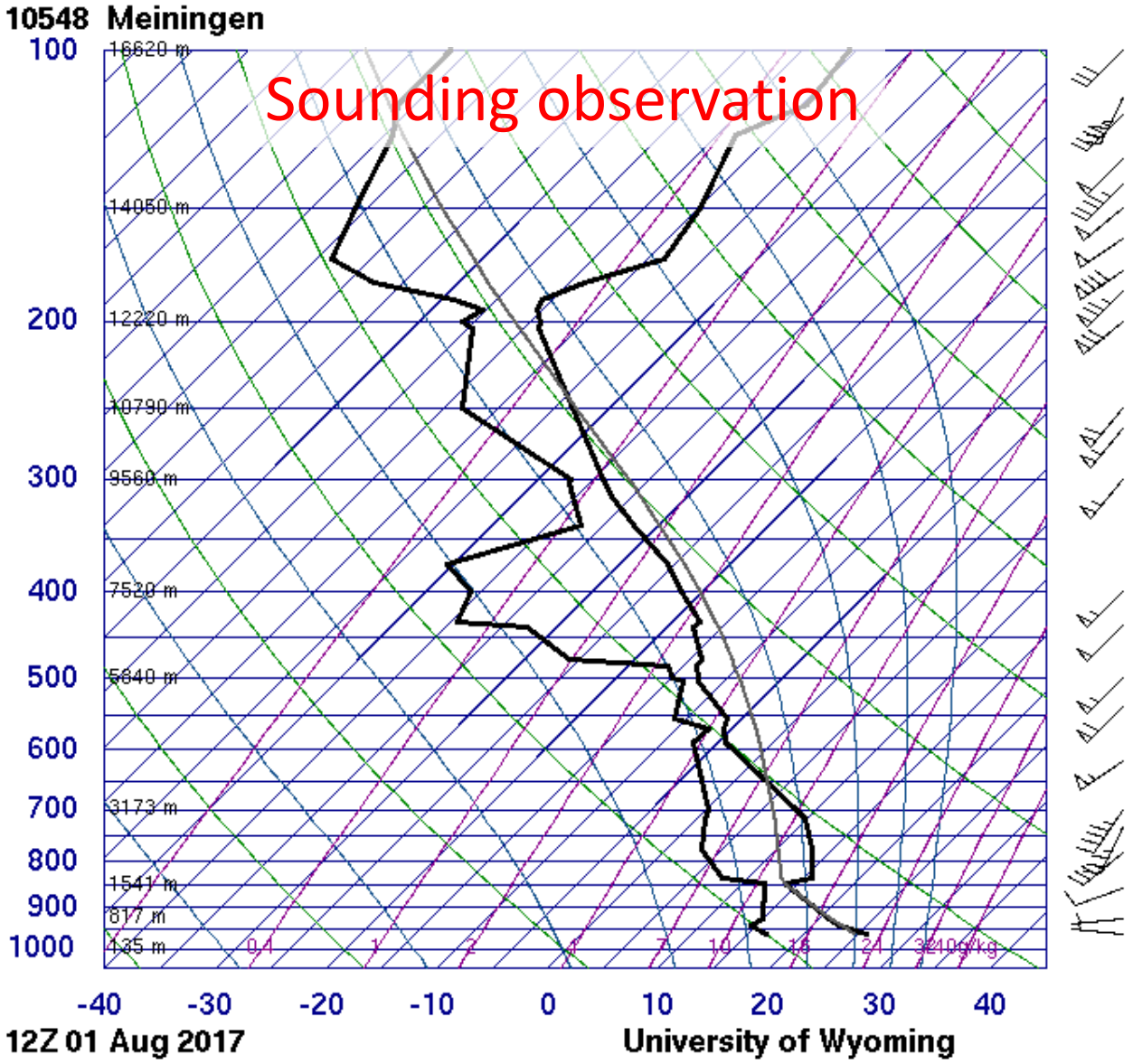
No stable layer in IASI data

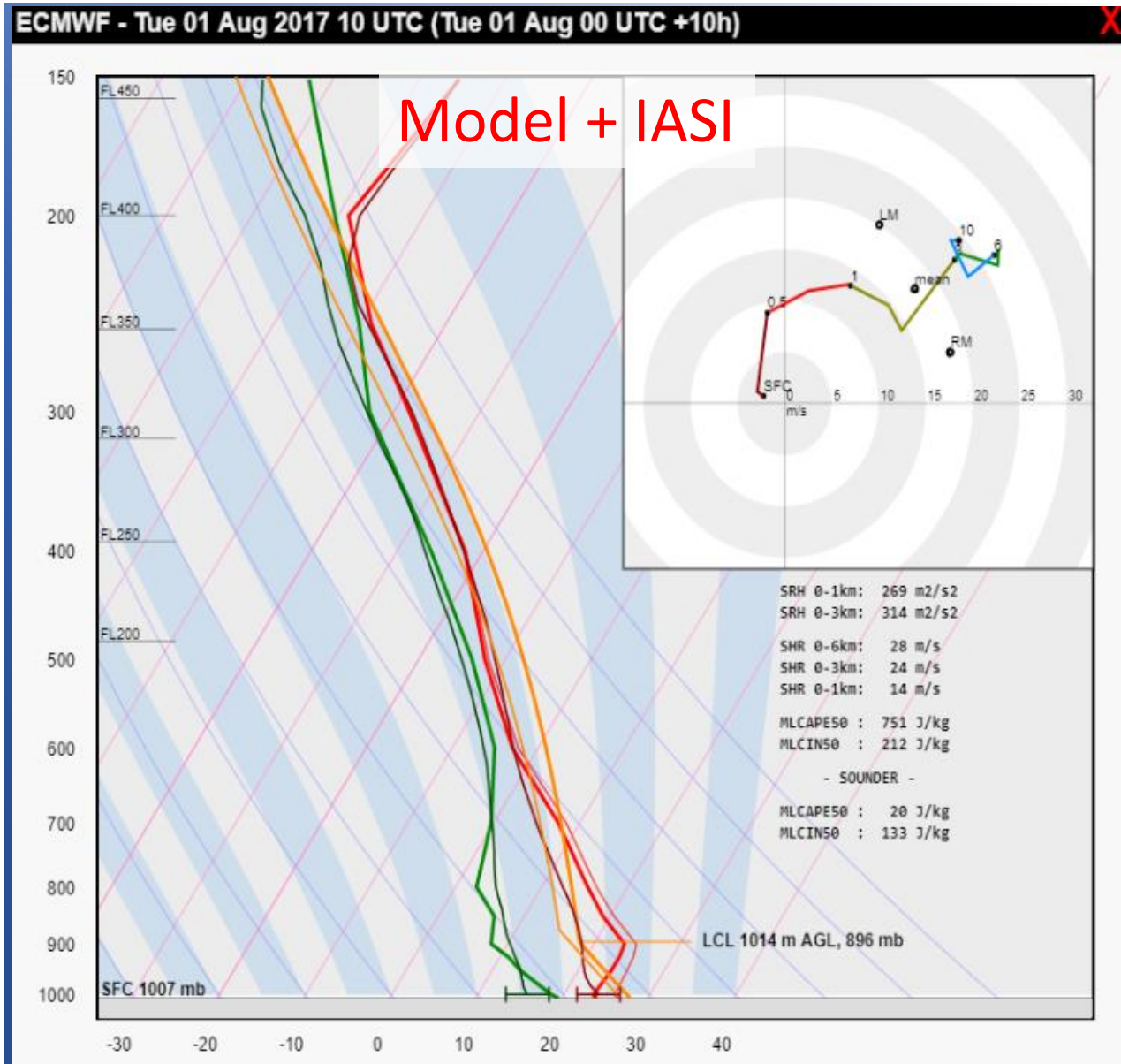
Less moisture than in model

Model closer to reality than IASI



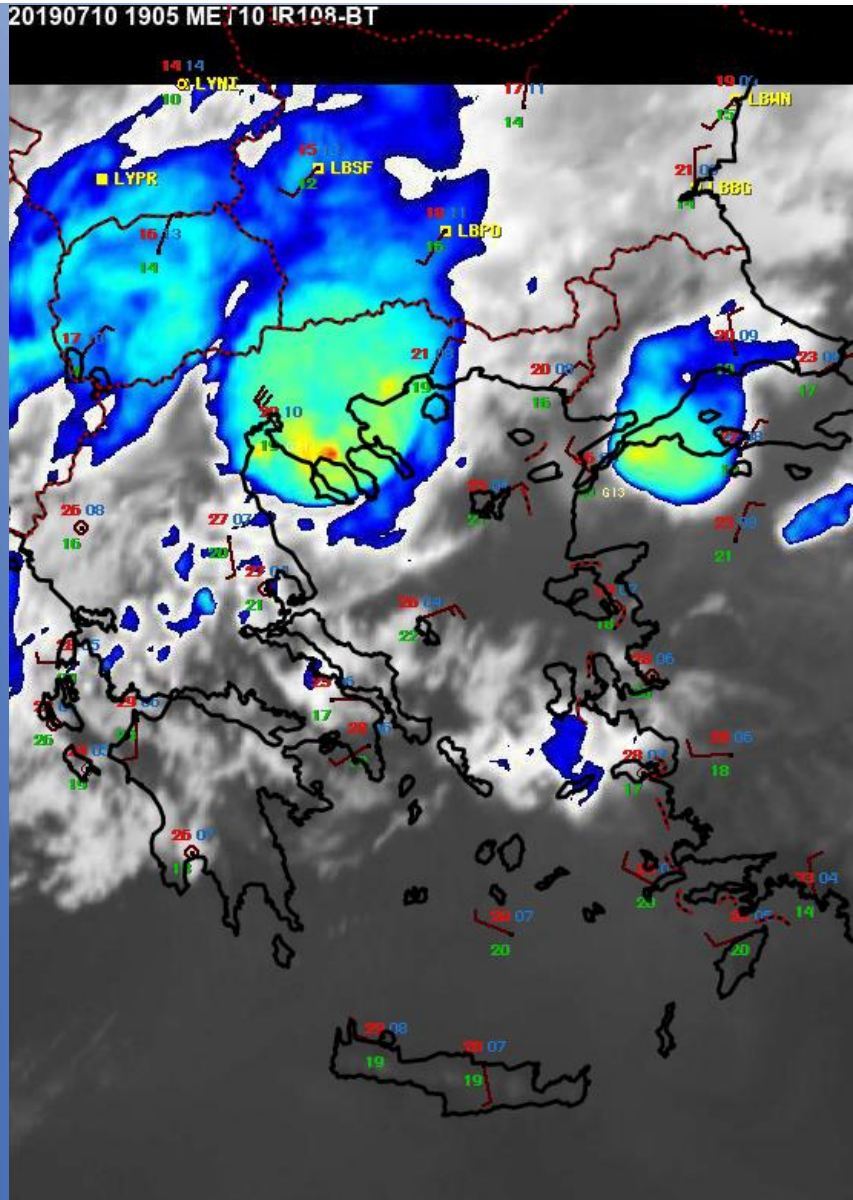
1 August 2017





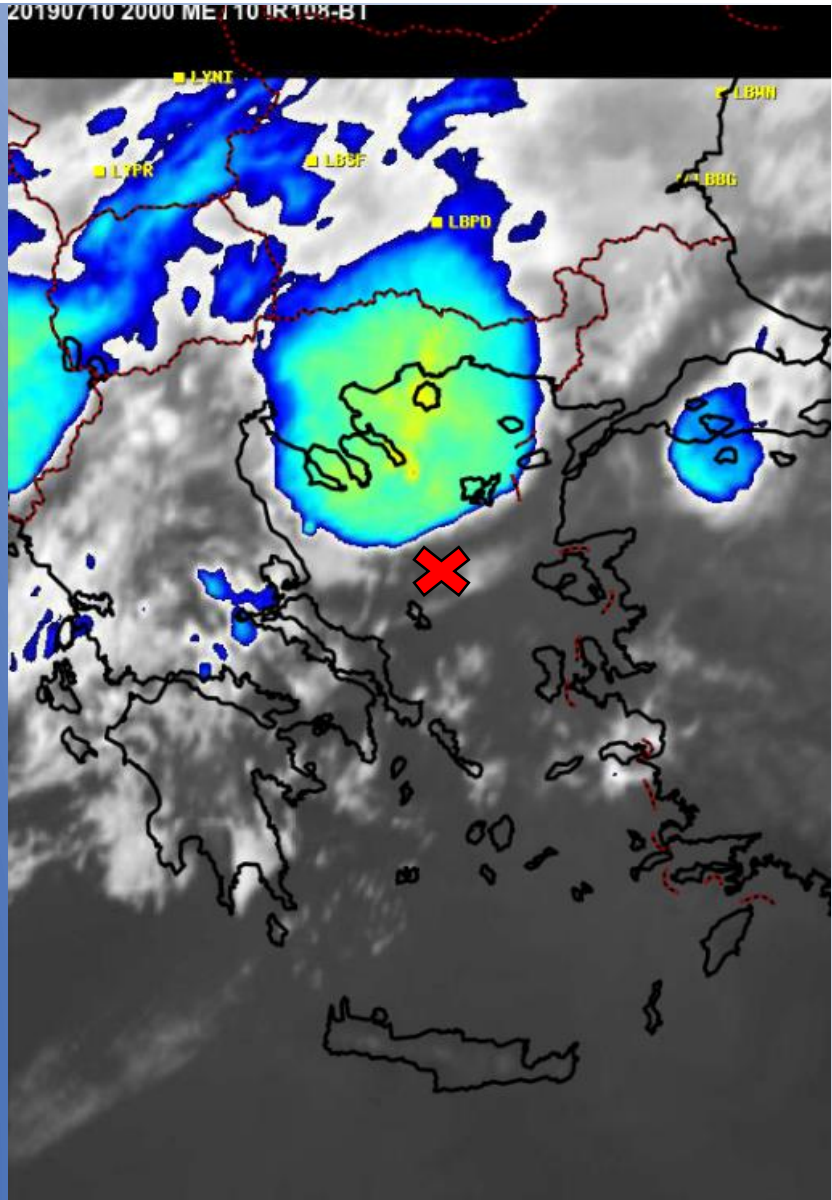
10 July 2019

Damaging windstorm over Halkidiki, Greece



10 July 2019

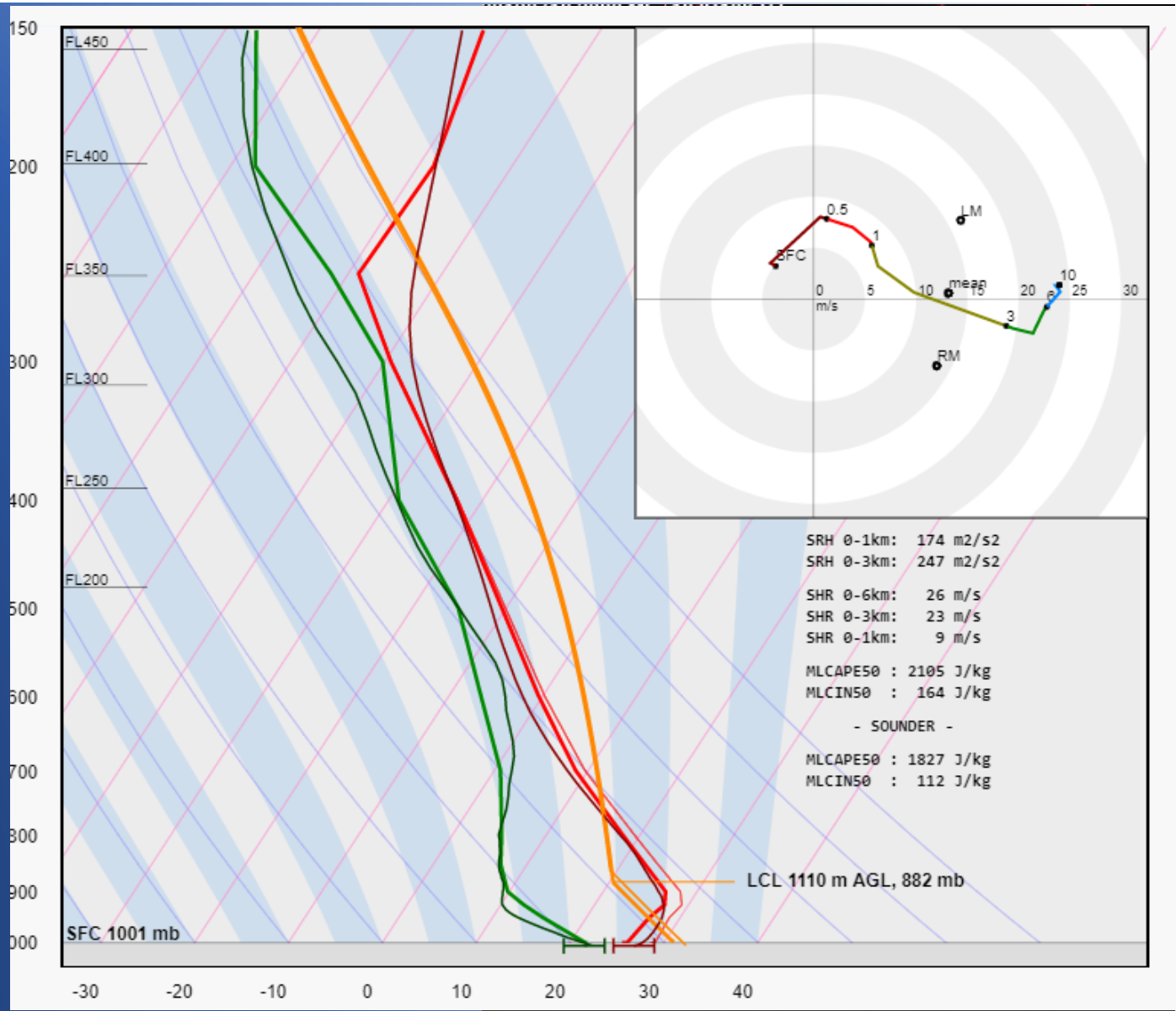
Storm weakening as it moves southeastward



10 July 2019

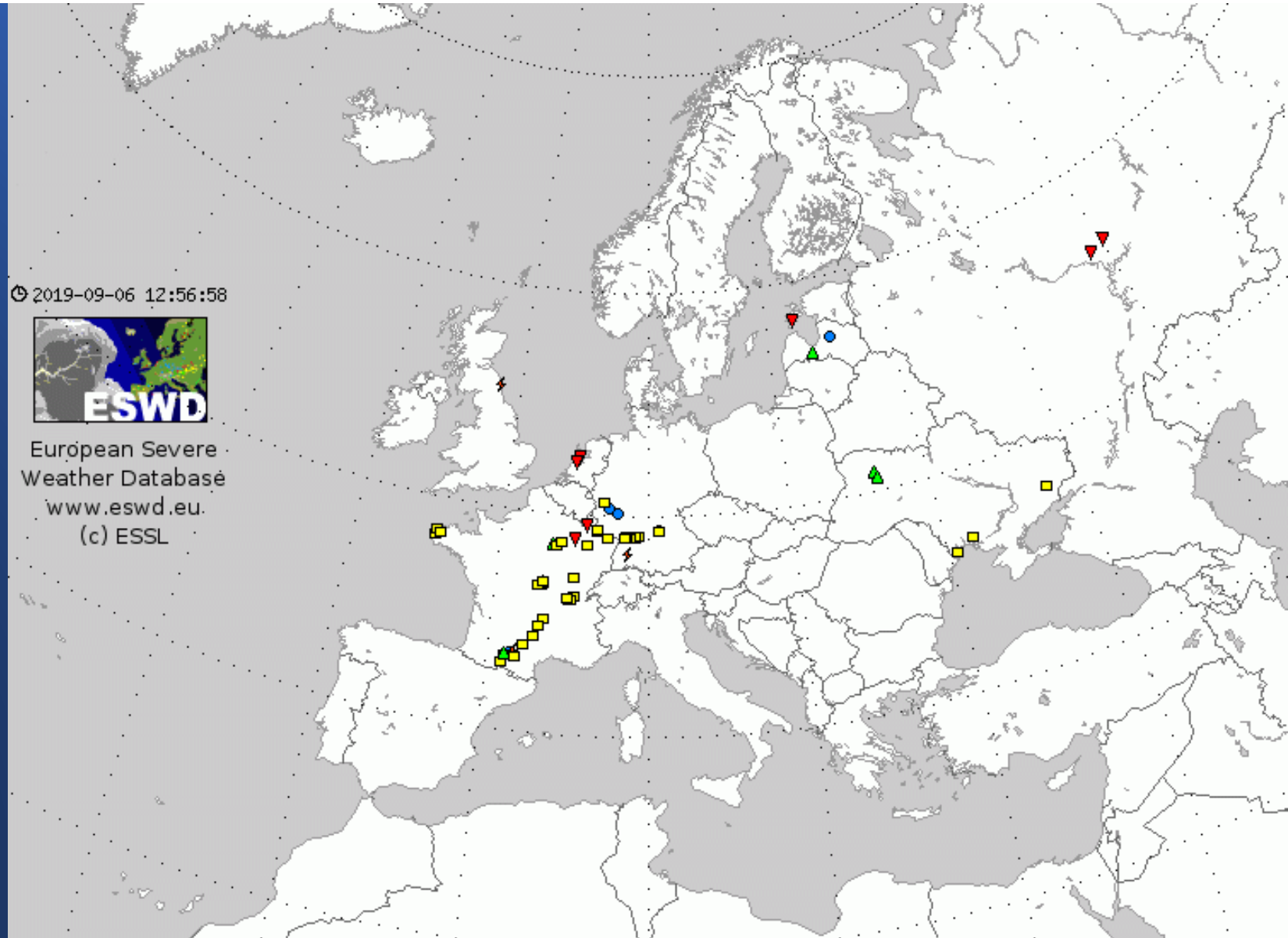
Reason: high CIN over the Aegean Sea

Stable layer well represented by the IASI



9 August 2019

Tornadoes and damaging wind gusts



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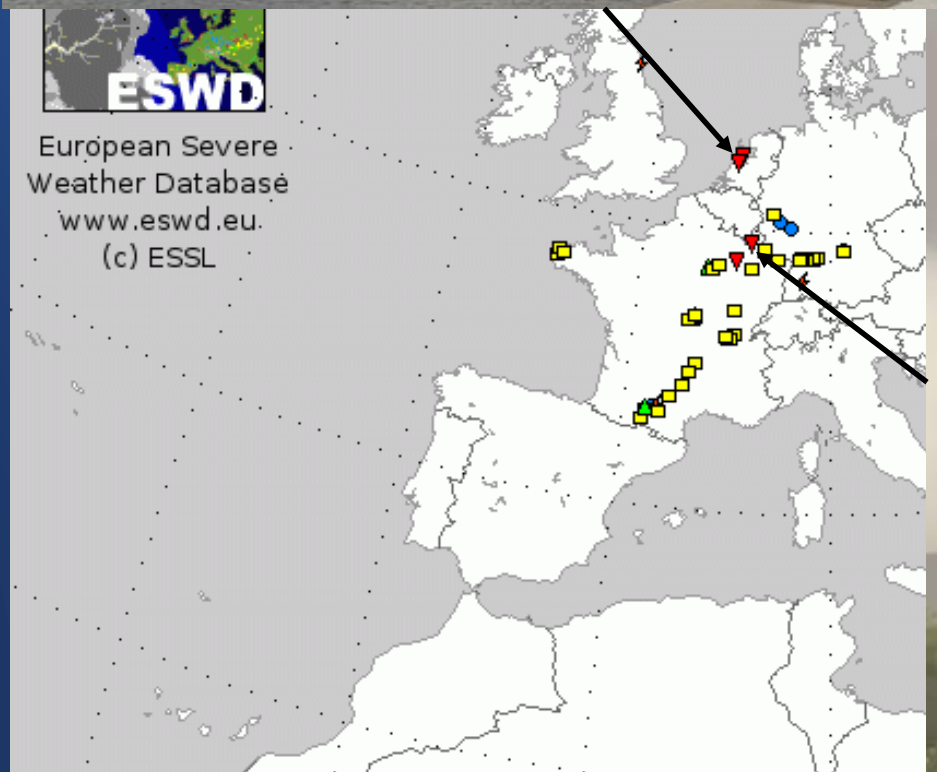
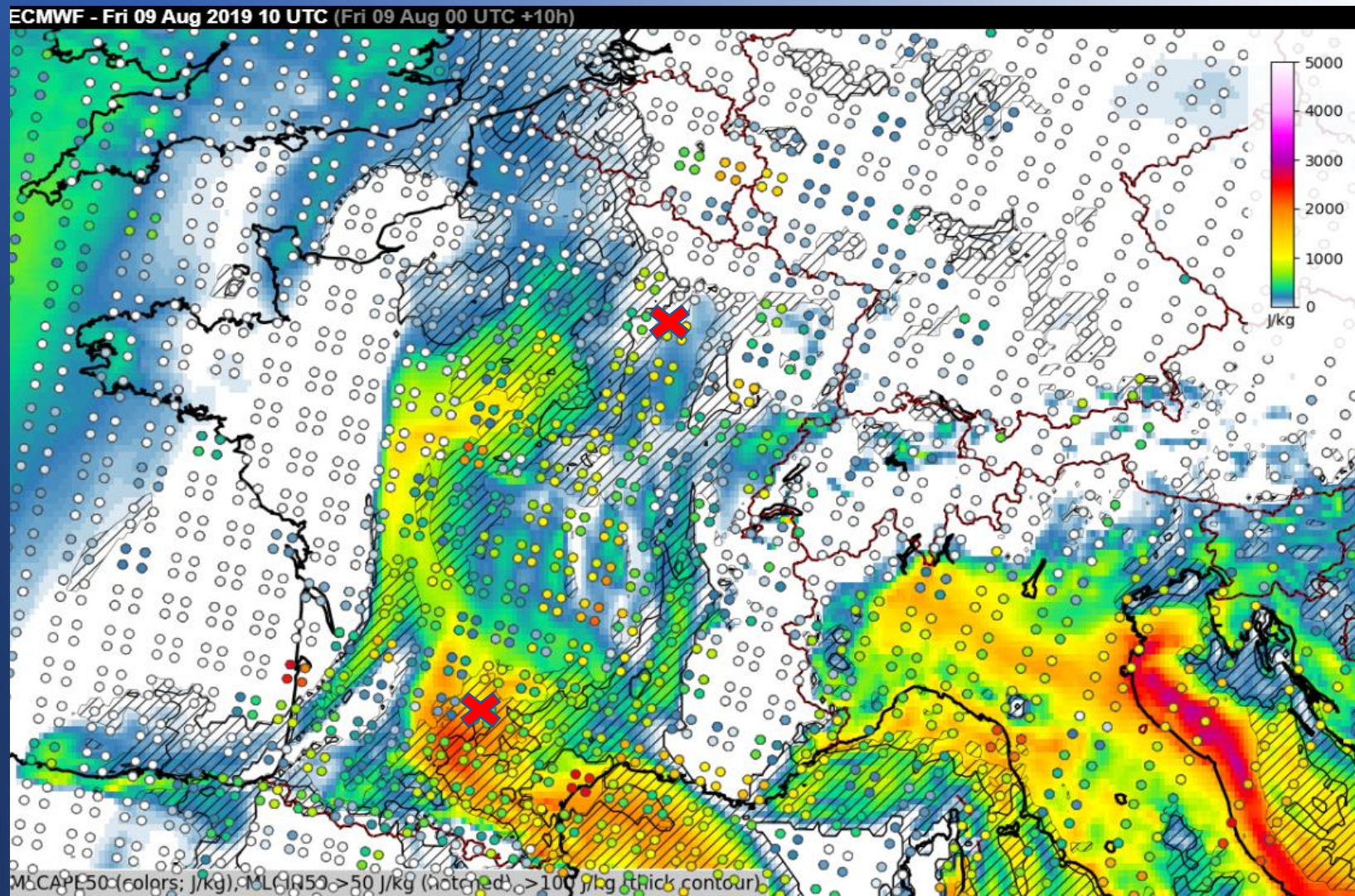


9 August 2019

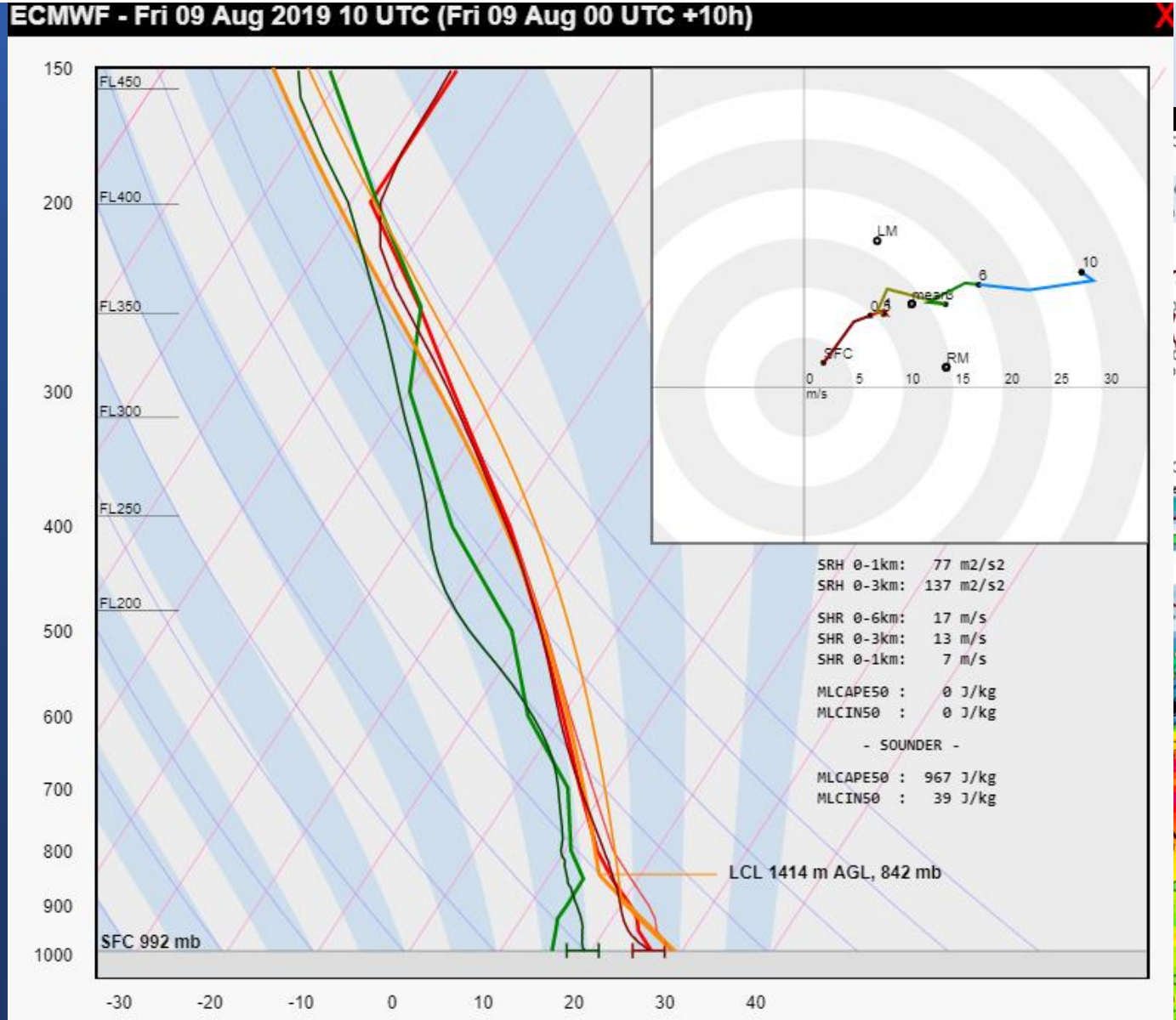
Morning overpass

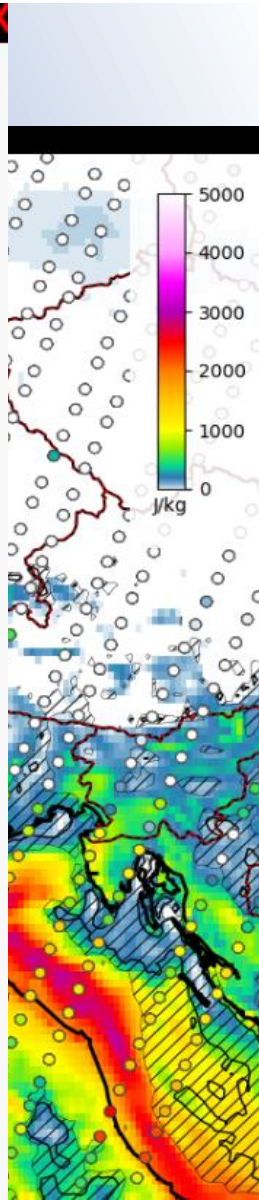


9 August 2019

N France:

Higher dewpoint than forecast





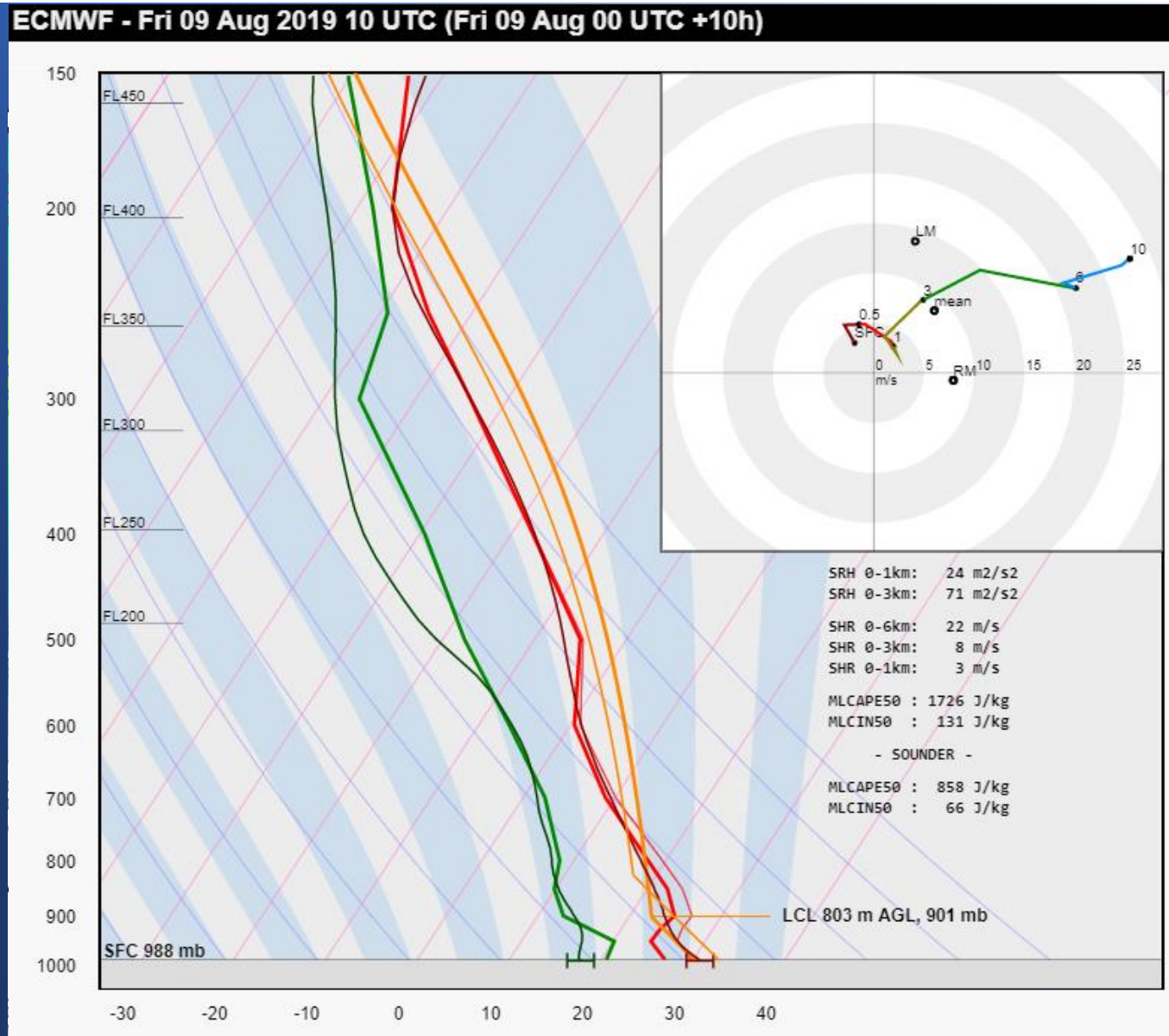
9 August 2019

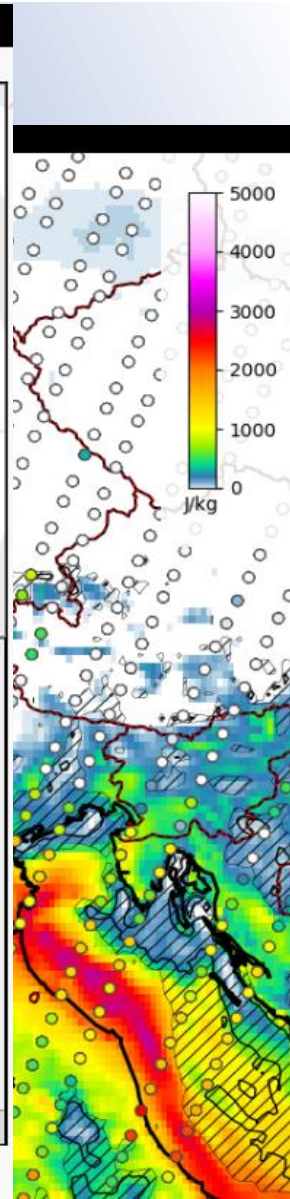
S France:

Higher temperature

BUT

Lower dewpoint



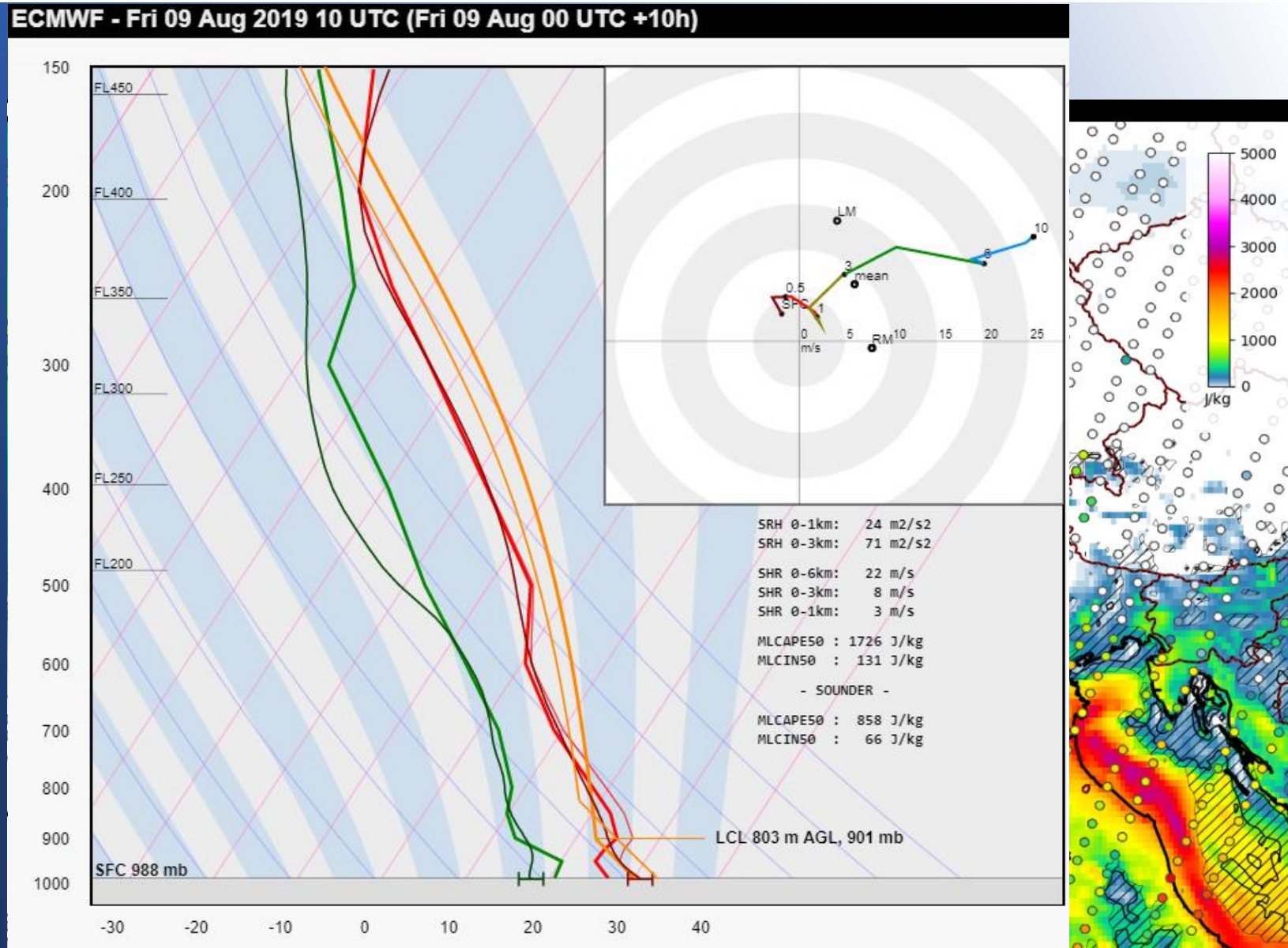


9 August 2019

Regarding moisture:

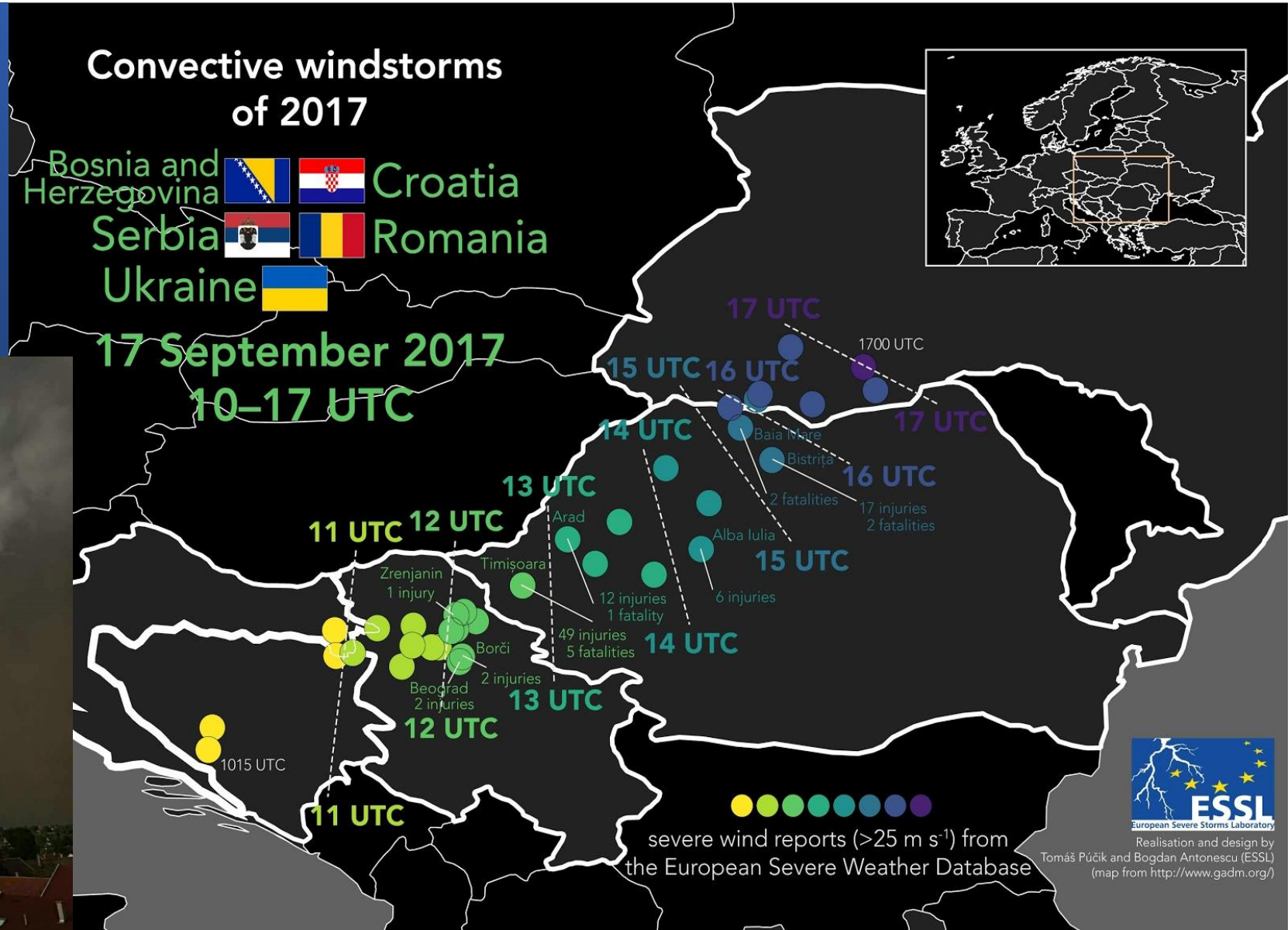
IASI closer to reality than model over N France but worse over S France

Depth of moisture?



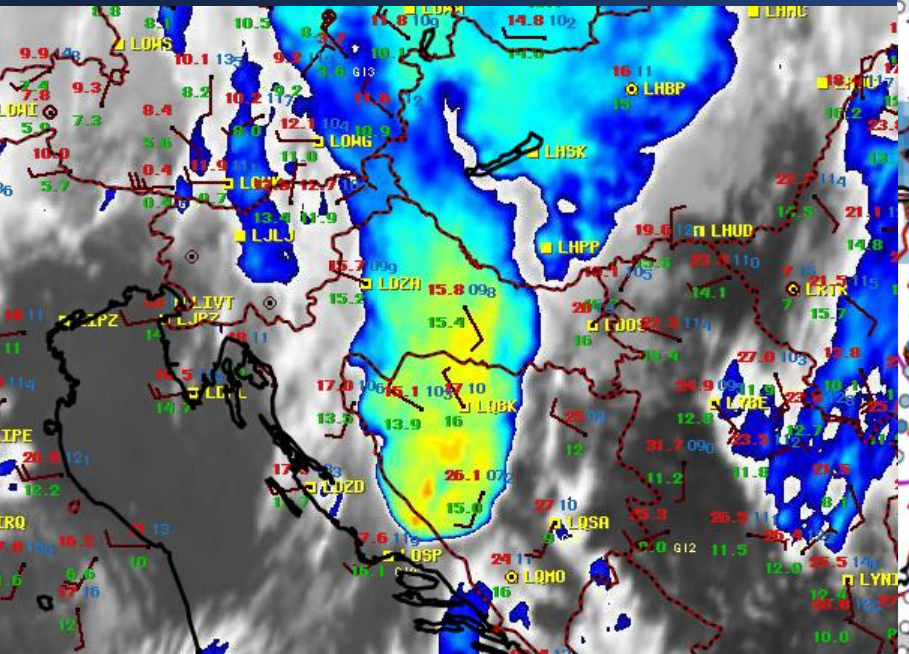
17 September 2017

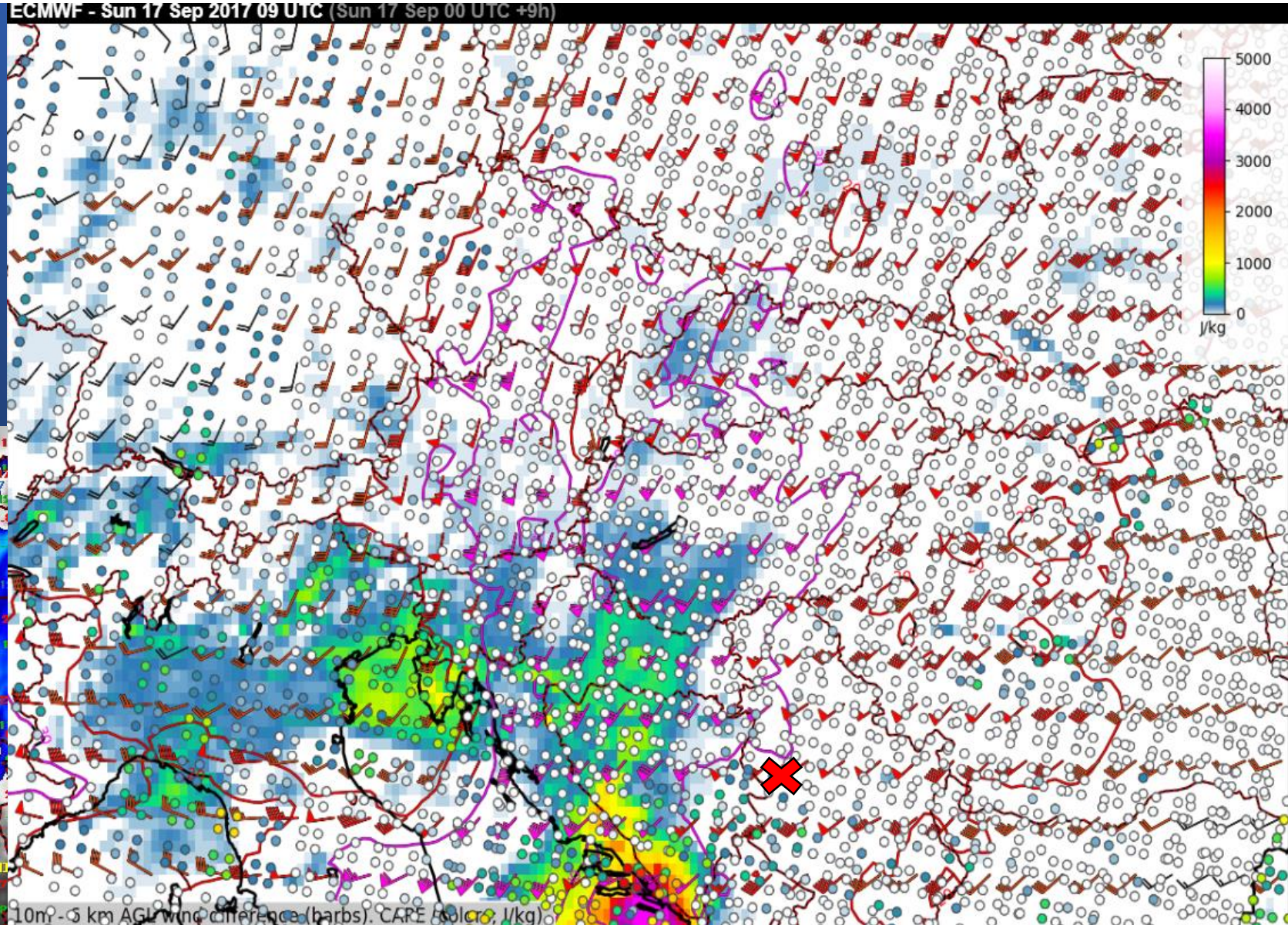
Extremely severe gusts in low CAPE regime



17 September 2017

IASI detects higher CAPE in path of the storm

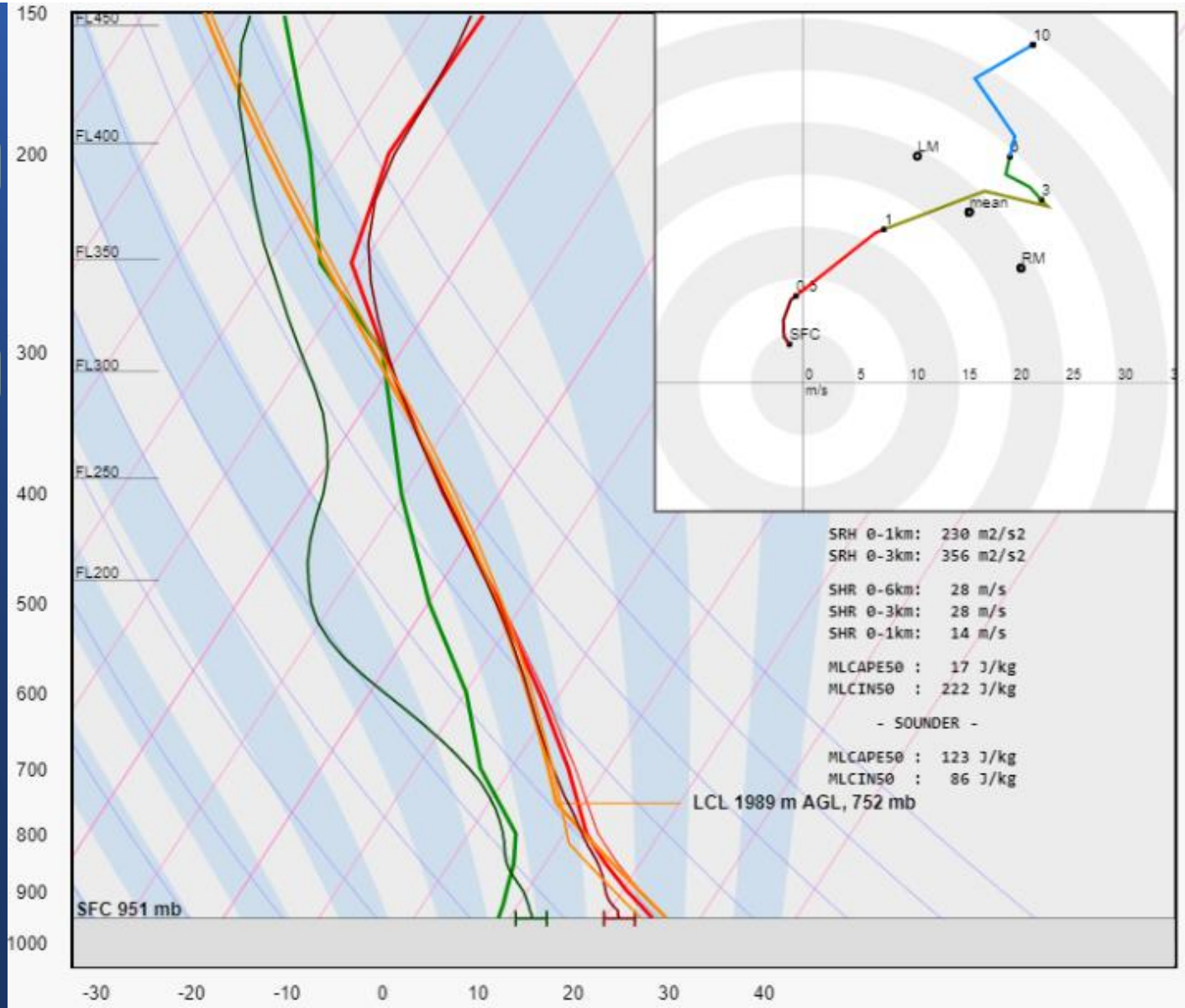




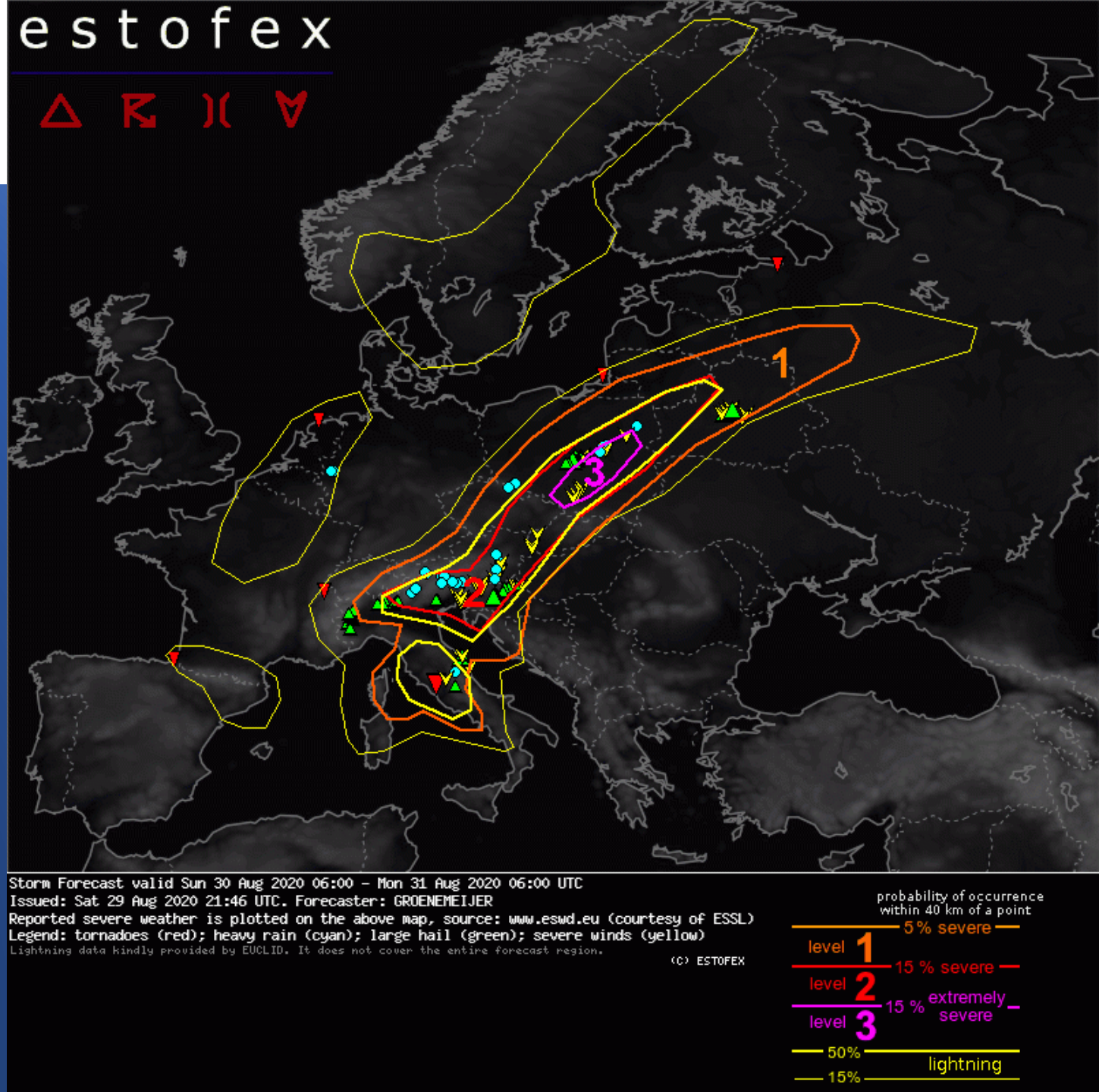
17 September 2017

Higher CAPE due to higher moisture

Confirmed by surface observations

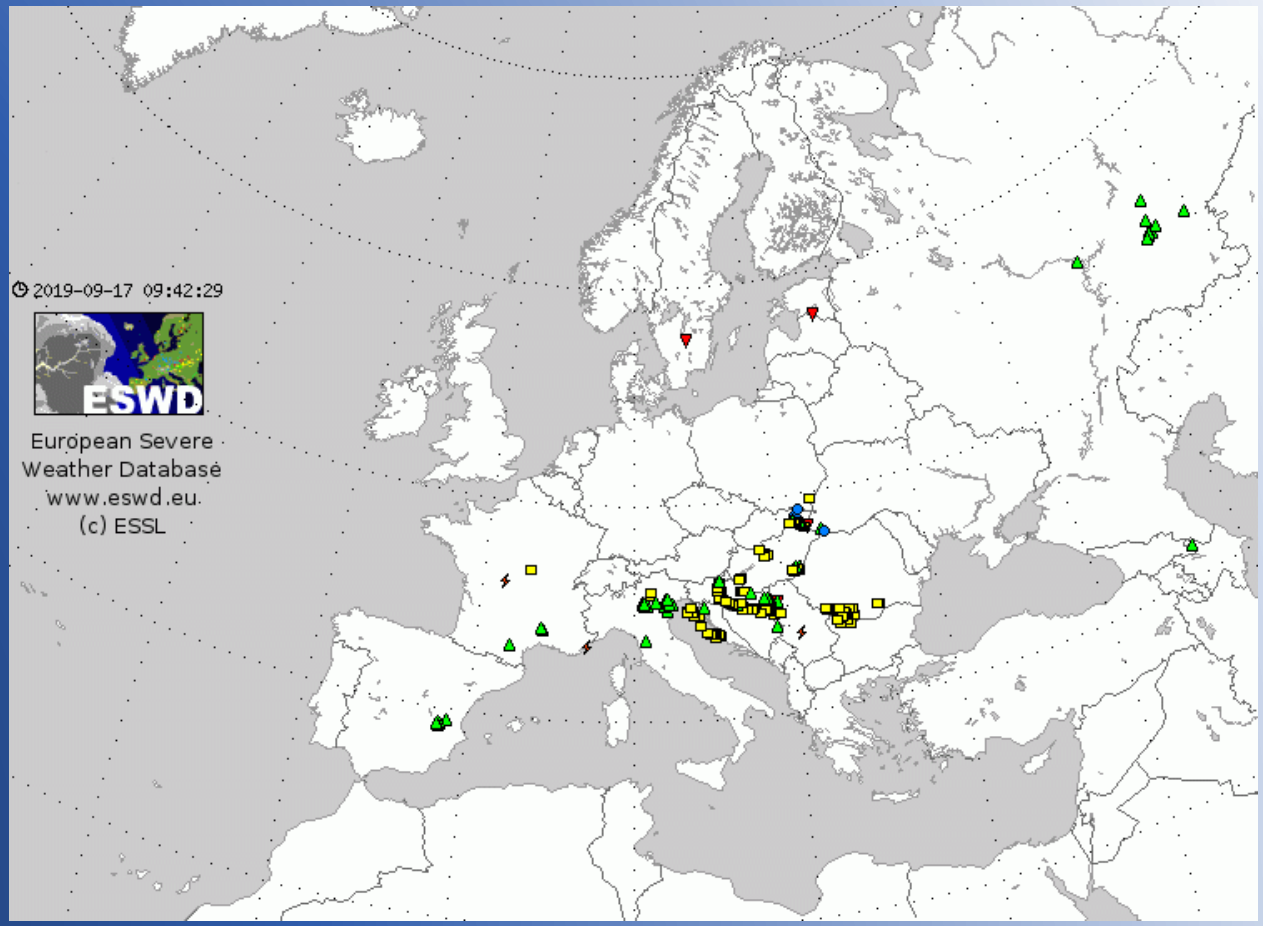


30 August 2020



Catalogue of short cases

- 40 cases containing:
- Short overview
- Model to reality check
- ESWD reports map



Conclusions

1. **The independence of the soundings from NWP is (very) important,** since it can only then serve as a check on those models

2. **The soundings sometimes give an important clue about model bias**
   - especially in case of low-level temperature biases

3. **IASI soundings were appreciated by forecasters**
   - Forecasters can live with limited vertical resolution
   - Temporal resolution is a more important limiting factor

4. **Limited accuracy of low-level humidity is an important issue, since storm potential strongly depends on it**

Potential follow-up work

1. Include surface (and possibly AMDAR & LIDAR) observations to create an improved observation-based 3D grid of temperature and humidity

2. Investigate further retrievals for low-level humidity

3. Visualize gridded NWP-IASI difference fields for selected parameters

4. Implement error estimates of the measurements throughout the retrieved vertical profiles and the (minor) visualization improvements suggested by forecasters

5. Facilitate further forecasters' feedback on the products and their evolutions