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Slovenian Environment Agency

Uncertainties of satellite derived stability indices

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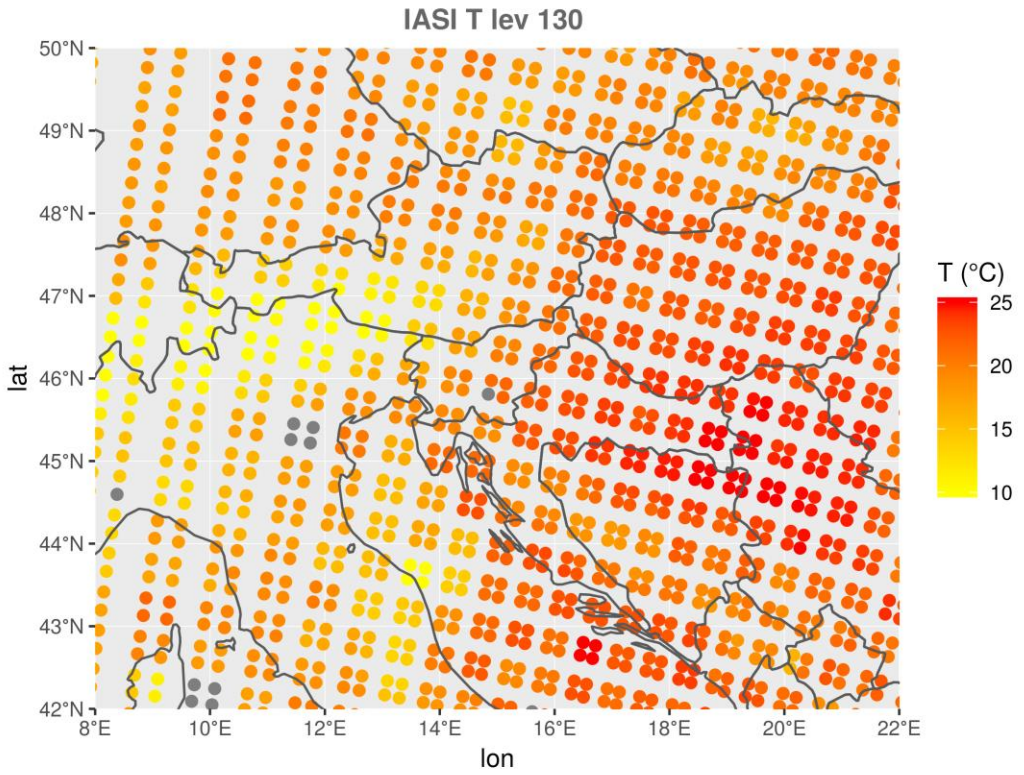
IASI near surface temperature 08:45 UTC



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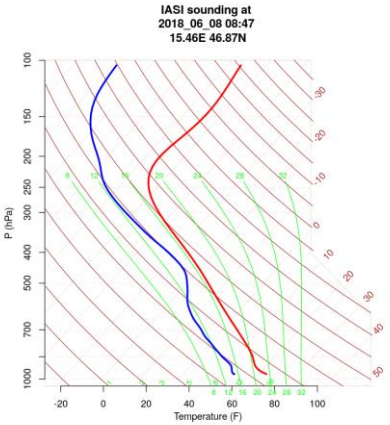
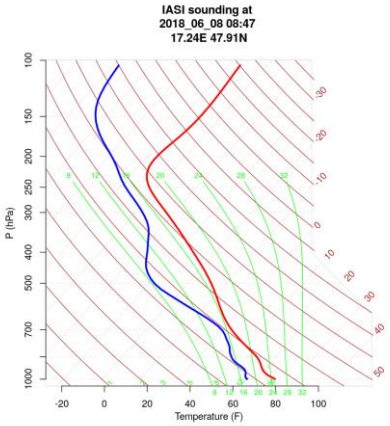
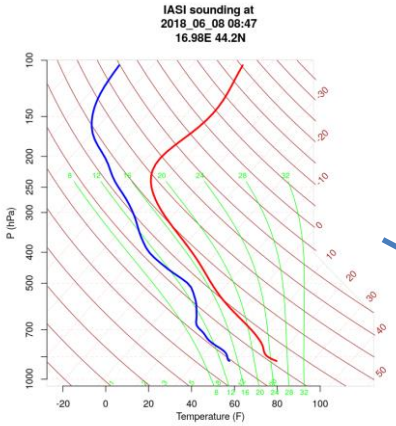
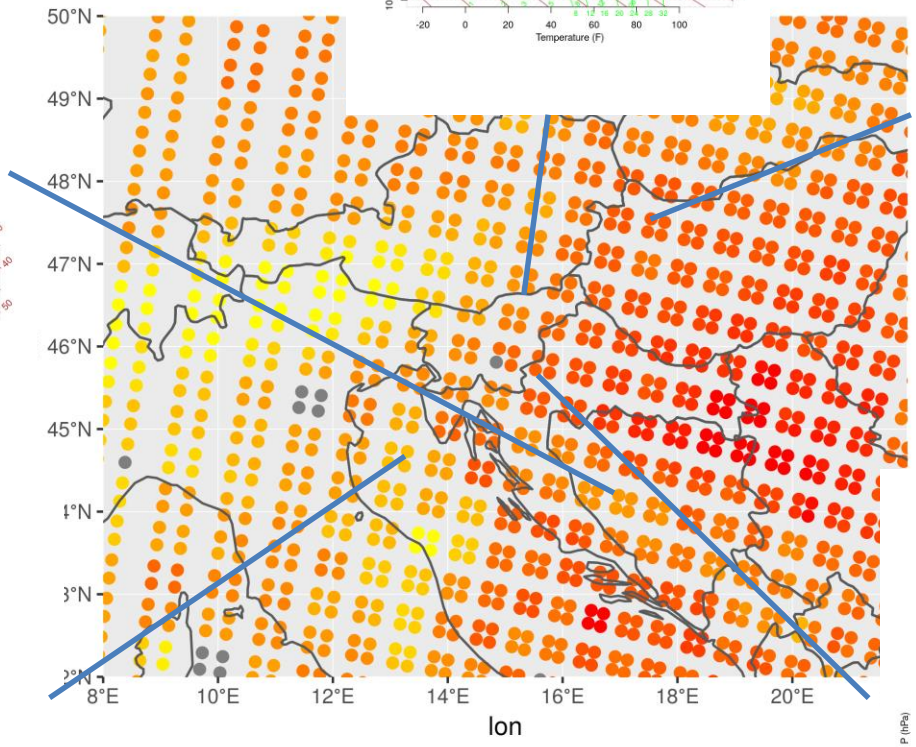
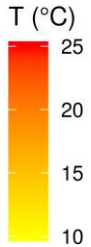
Which profile is the most unstable?

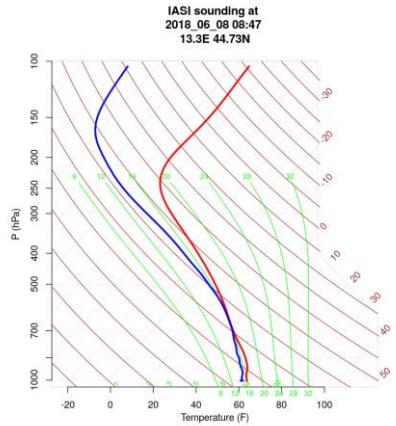


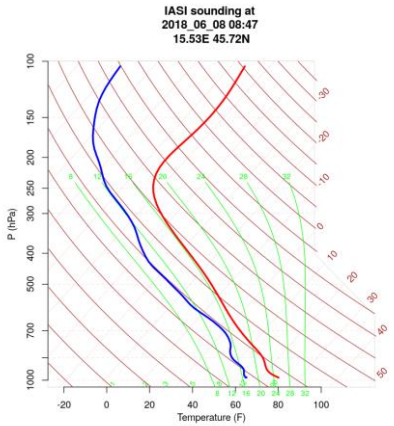












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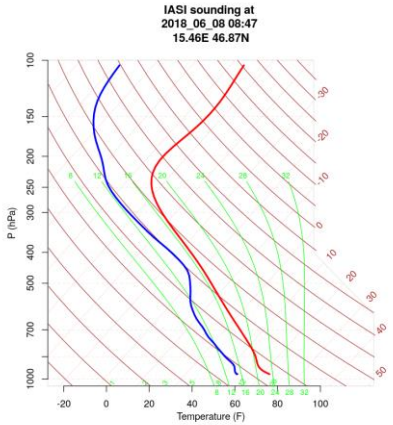
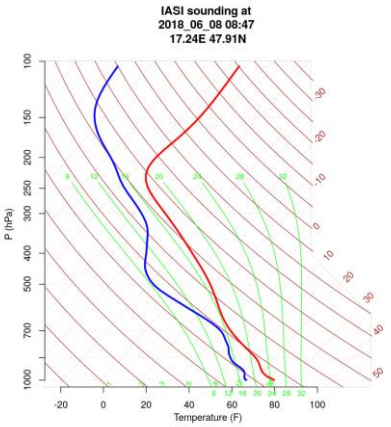
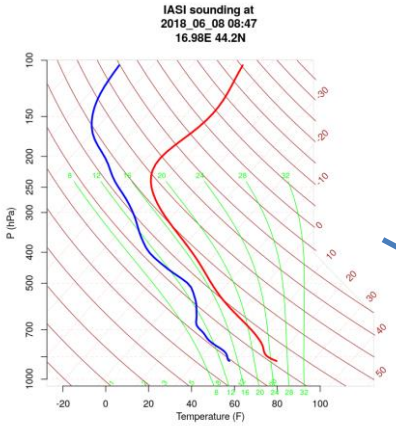
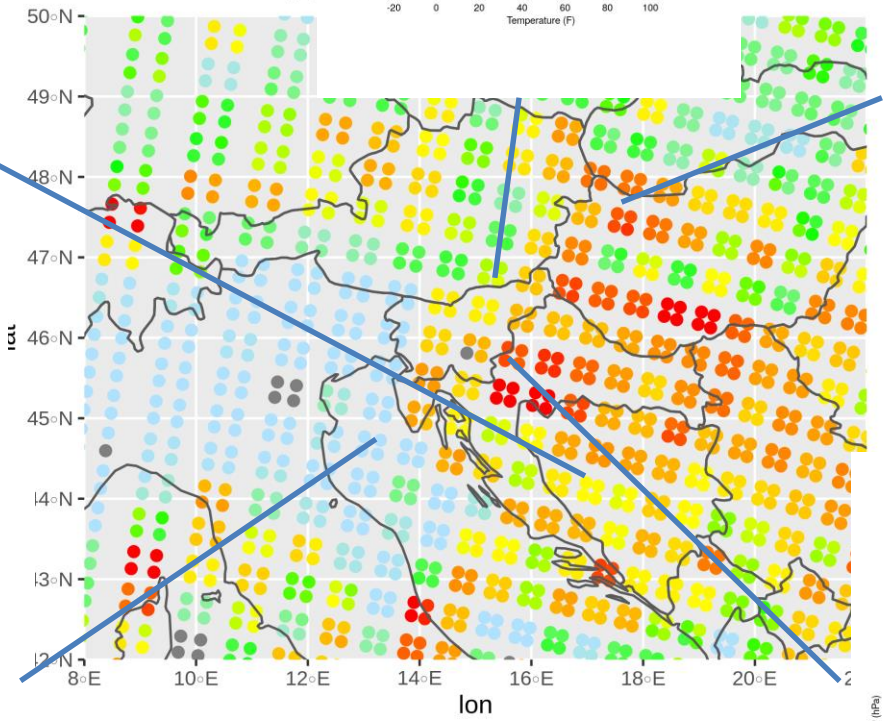
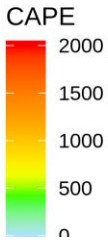
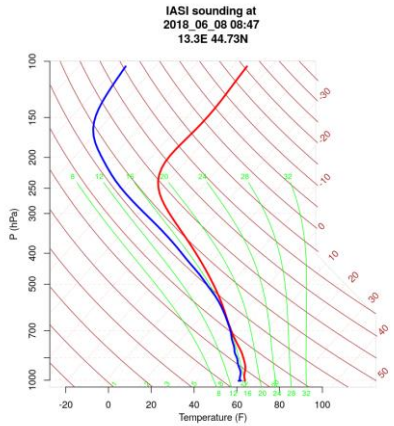


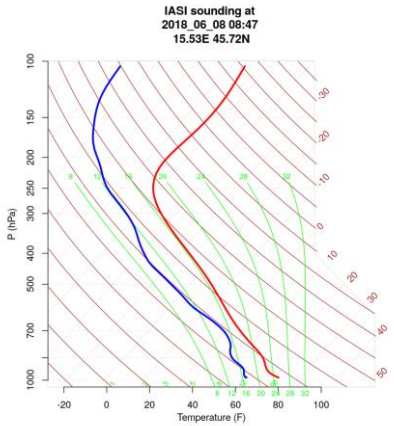




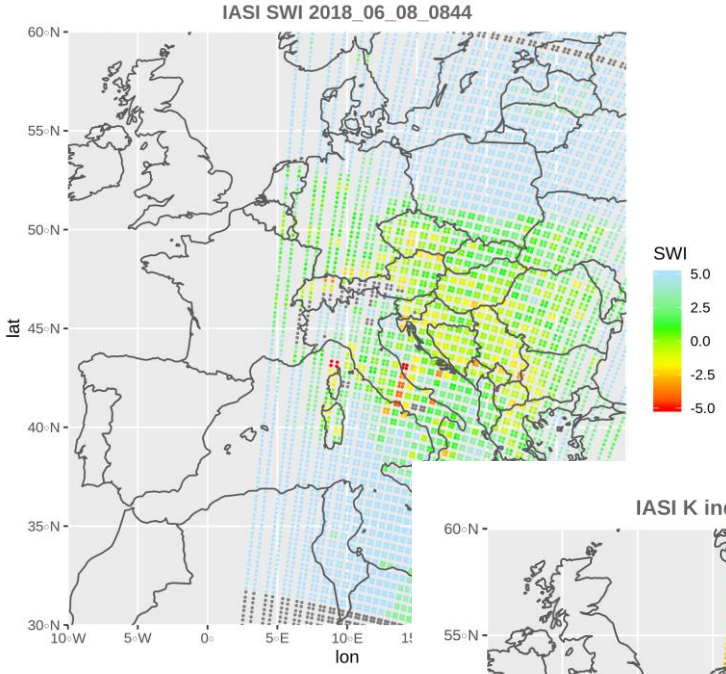


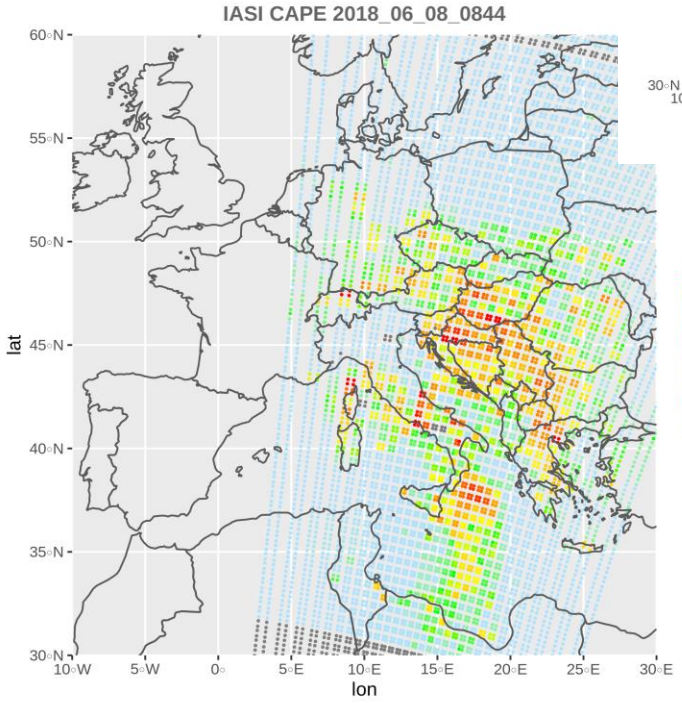


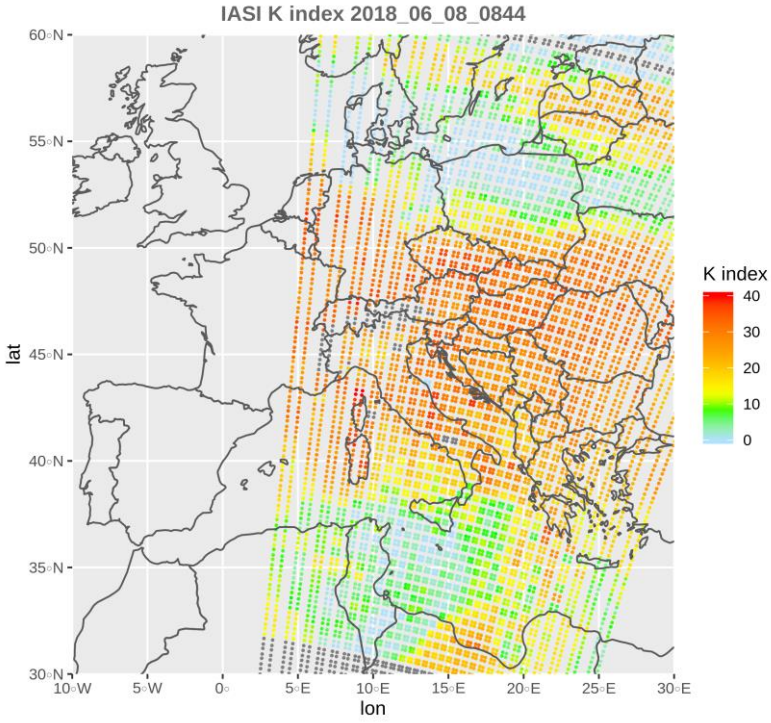




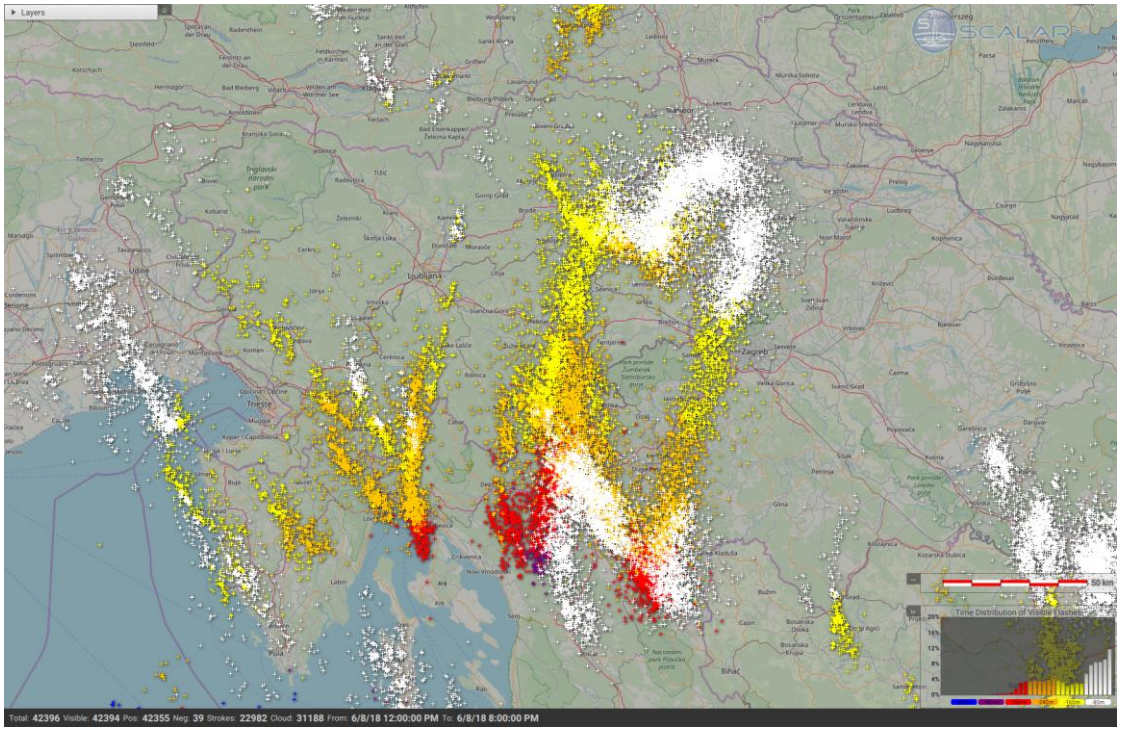
Preconvective environment on 8 June 2012.





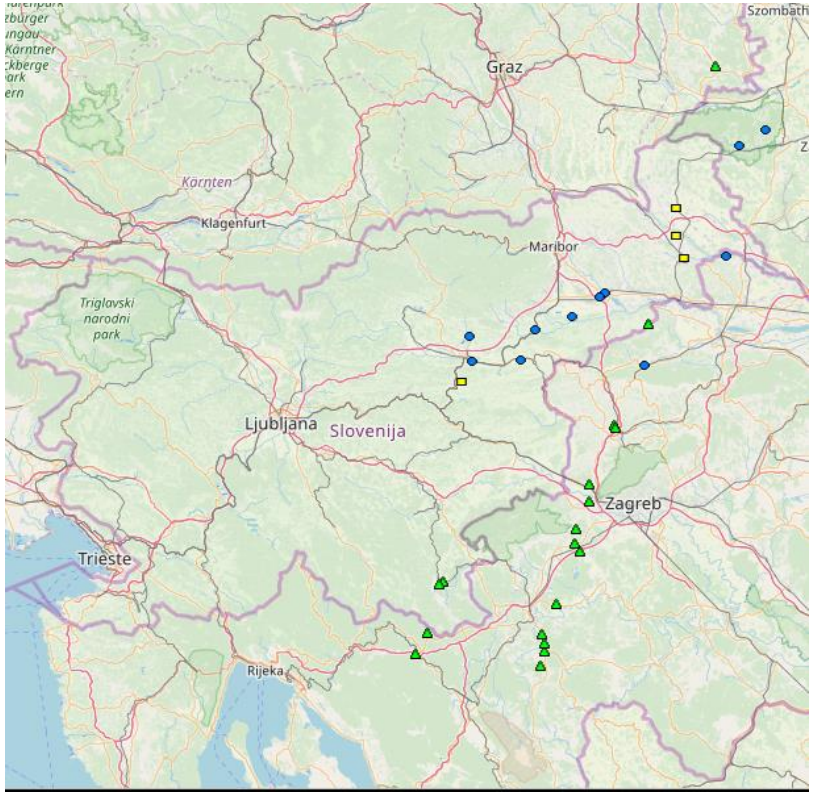


Result


Layers
Ljubljana
Zagreb
Trieste
50 km
Time Distribution of Visible Flashes
Total: 42396 Visible: 42394 Pos: 42355 Neg: 39 Strokes: 22982 Cloud: 31188 From: 6/8/18 12:00:00 PM To: 6/8/18 8:00:00 PM

Result

Thunderstorm with average hailstone size 8 cm, max. size 12 cm near Črnomelj.



©ESWD

Data – IASI level2 temperature and humidity

- 01 January – 31 December 2017
- “All-sky” conditions
- Retrieval method: PWLR[3] - Piece-wise linear regression (no NWP input!)
- Combination of IR (IASI) and collocated MW (AMSU/MHS) measurements
- Resolution: 12-39 km, 138 vertical sigma levels
- Quality indicators included

Data – AMDAR temperature and humidity

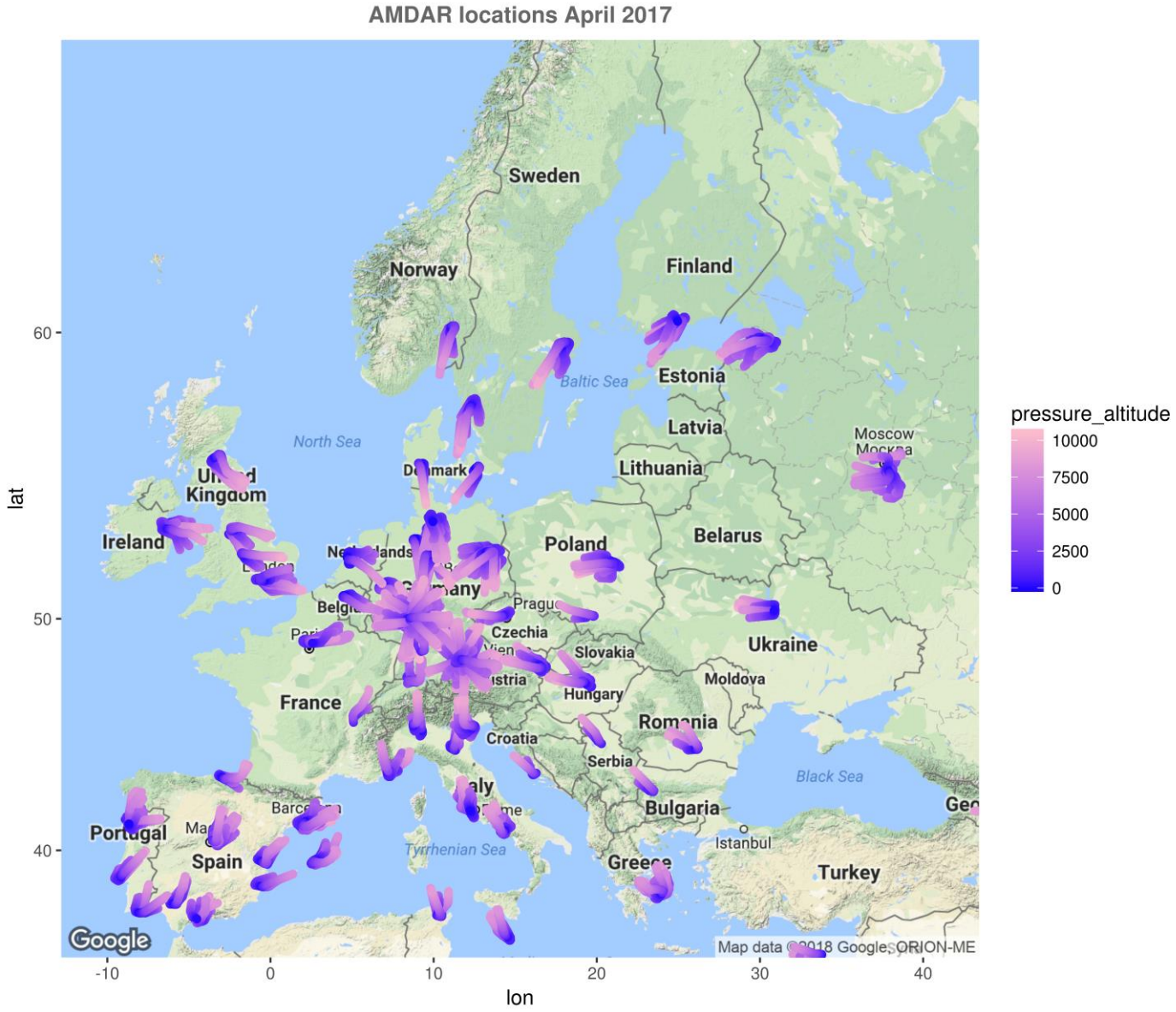
Aircraft **M**eteorological **DA**ta **R**elay –

WMO program to collect met. data from commercial airplanes

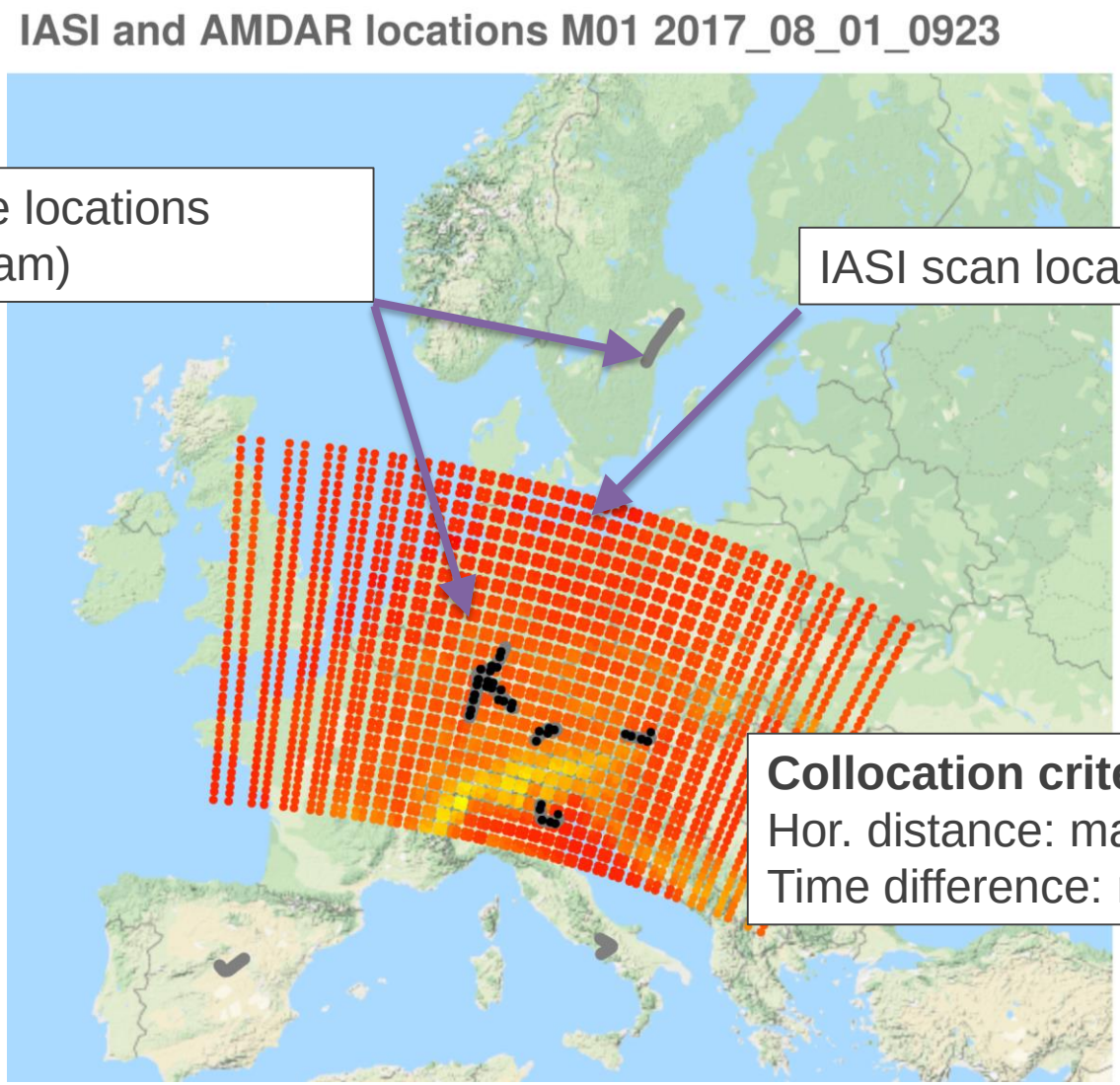
- Worldwide > 700,000 wind and T observations, > 11,000 humidity observations daily
- In Europe 10 Lufthansa aircraft equipped with humidity sensors (~ 3000 observations daily)

- Data acquisition rate: 20 s, switched off above 5.5/10 km
- Estimated T error: 0.4 °C, systematic errors of up to 1°C reported
- Humidity sensing limit 0.02g/kg (Hoff 2010, Petersen 2016)
- Possible hysteresis effect > small differences between ascent and descent

Data – AMDAR humidity measurement coverage



Data collocation

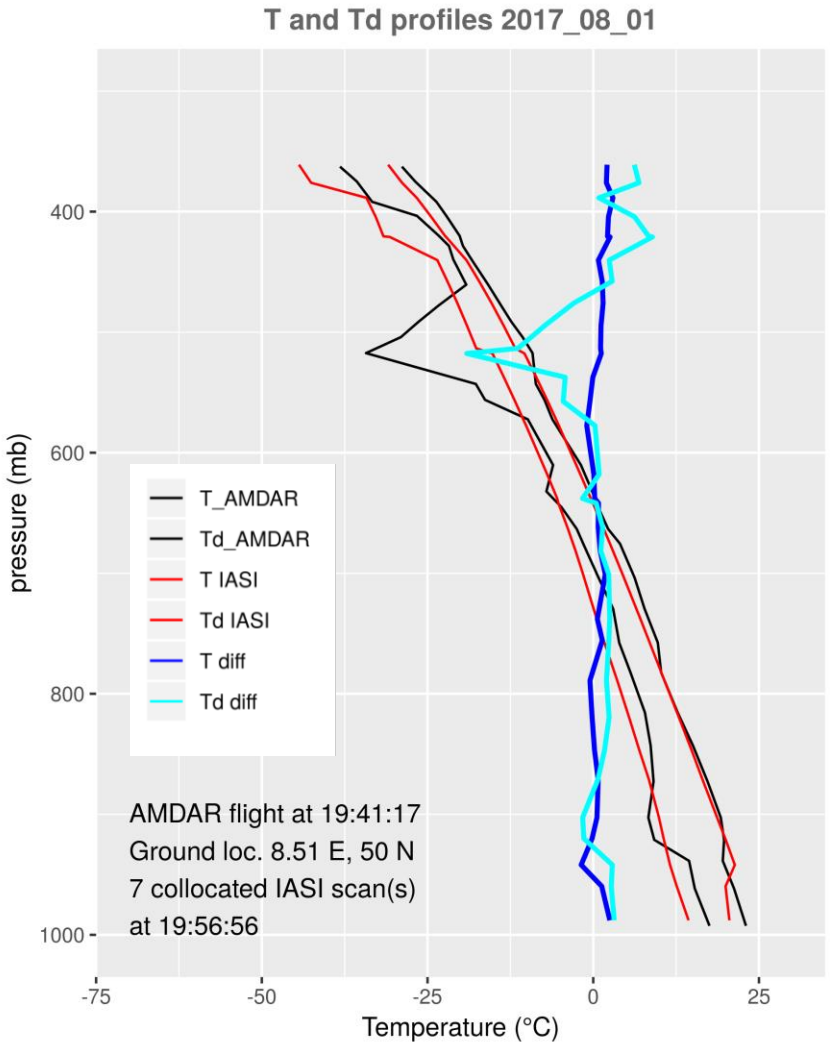


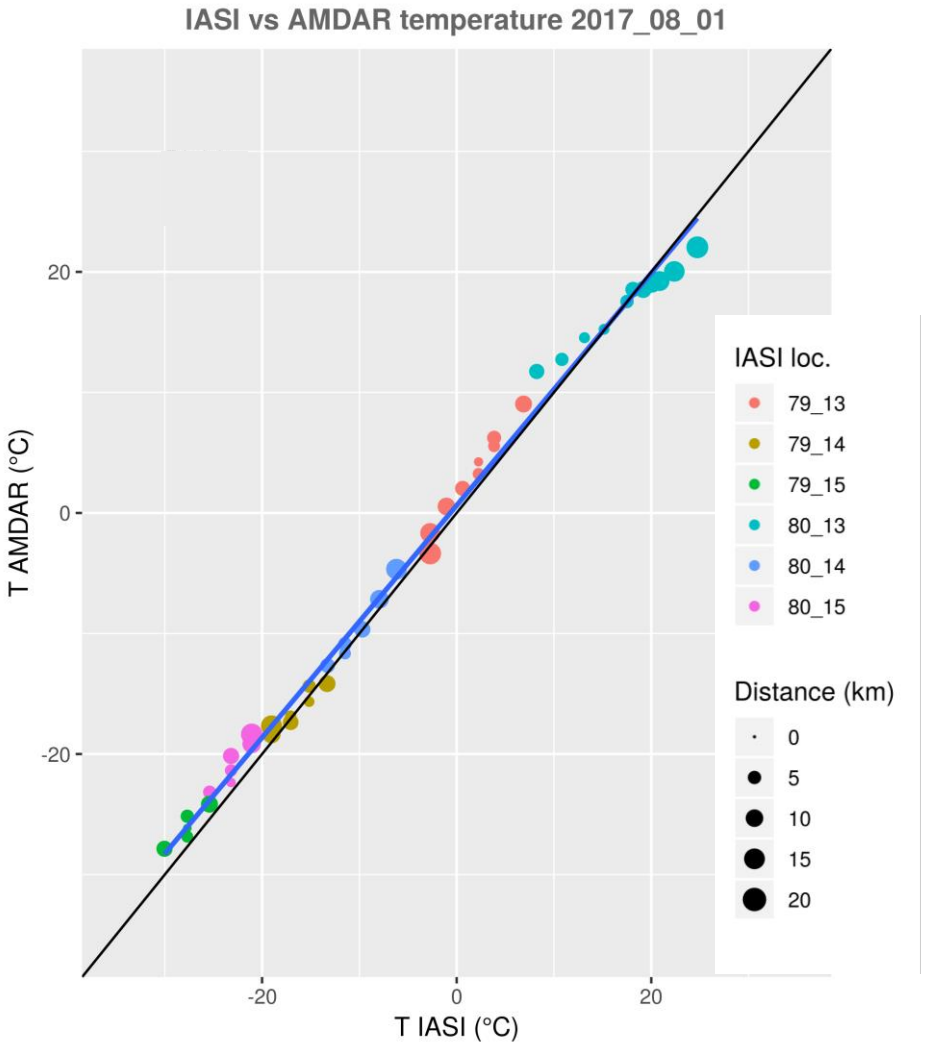
AMDAR profile locations
(8:23 – 10:23 am)

IASI scan locations

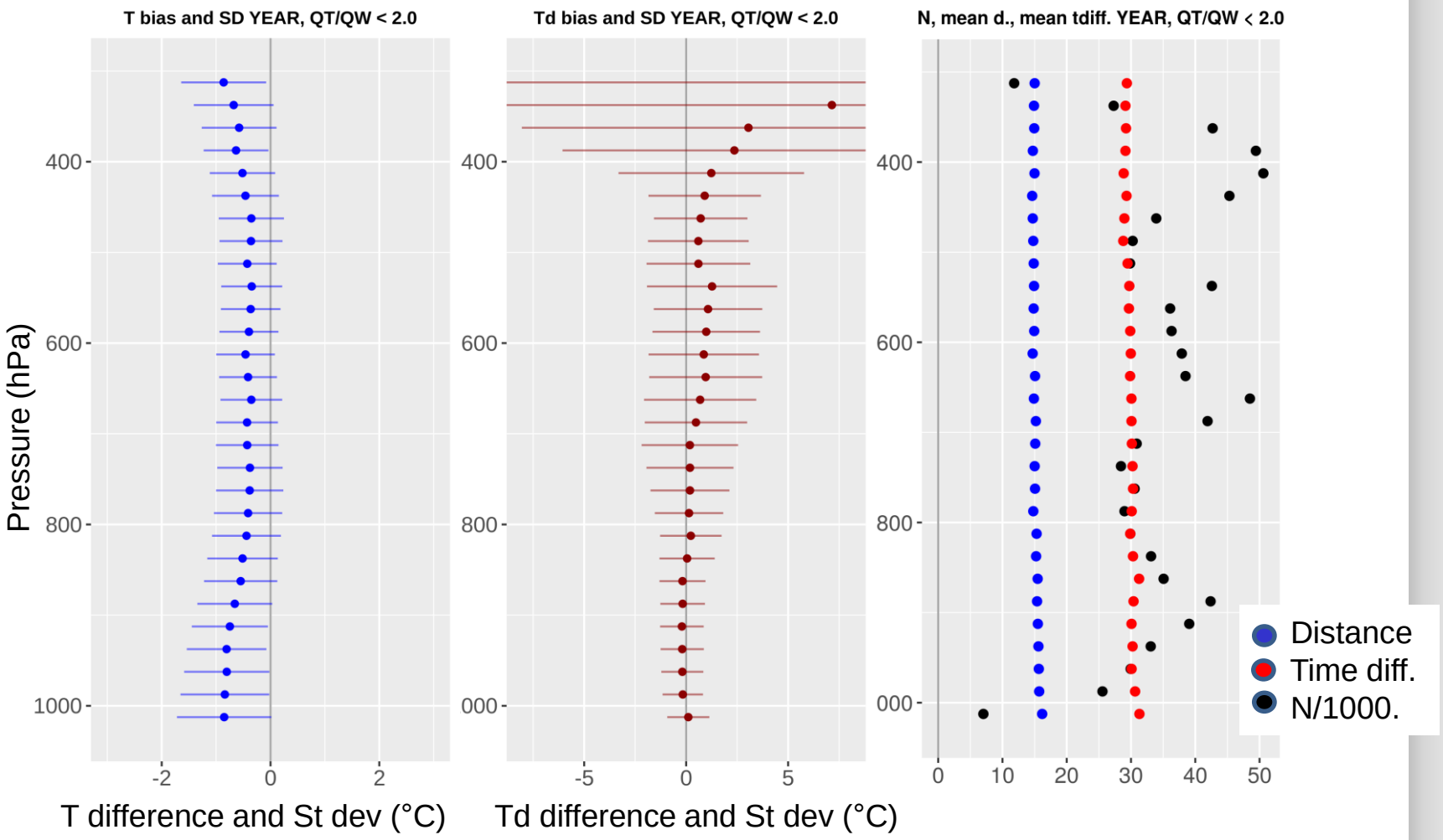
Collocation criteria:
Hor. distance: max 50 km
Time difference: max 1h

Example profile

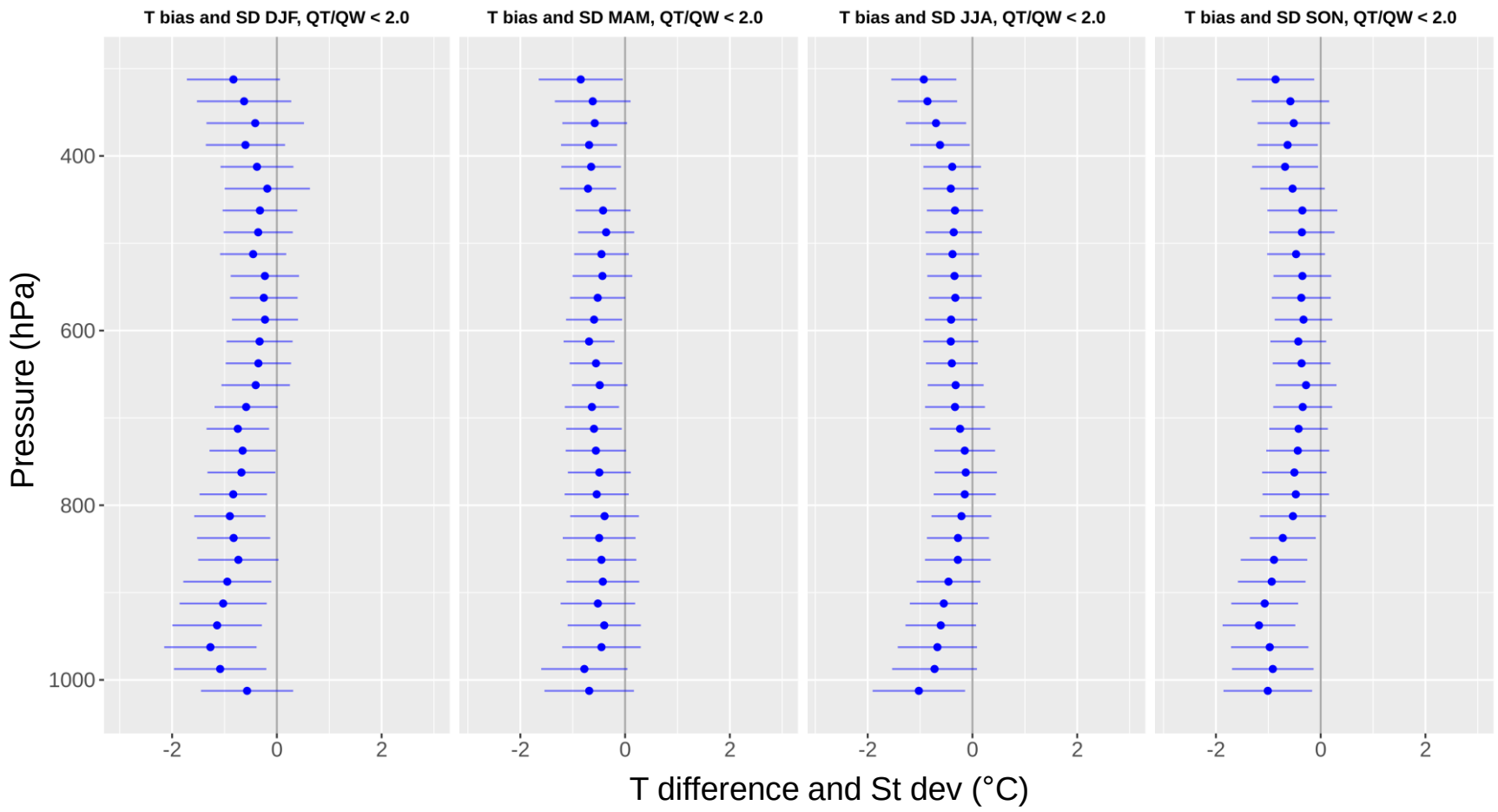




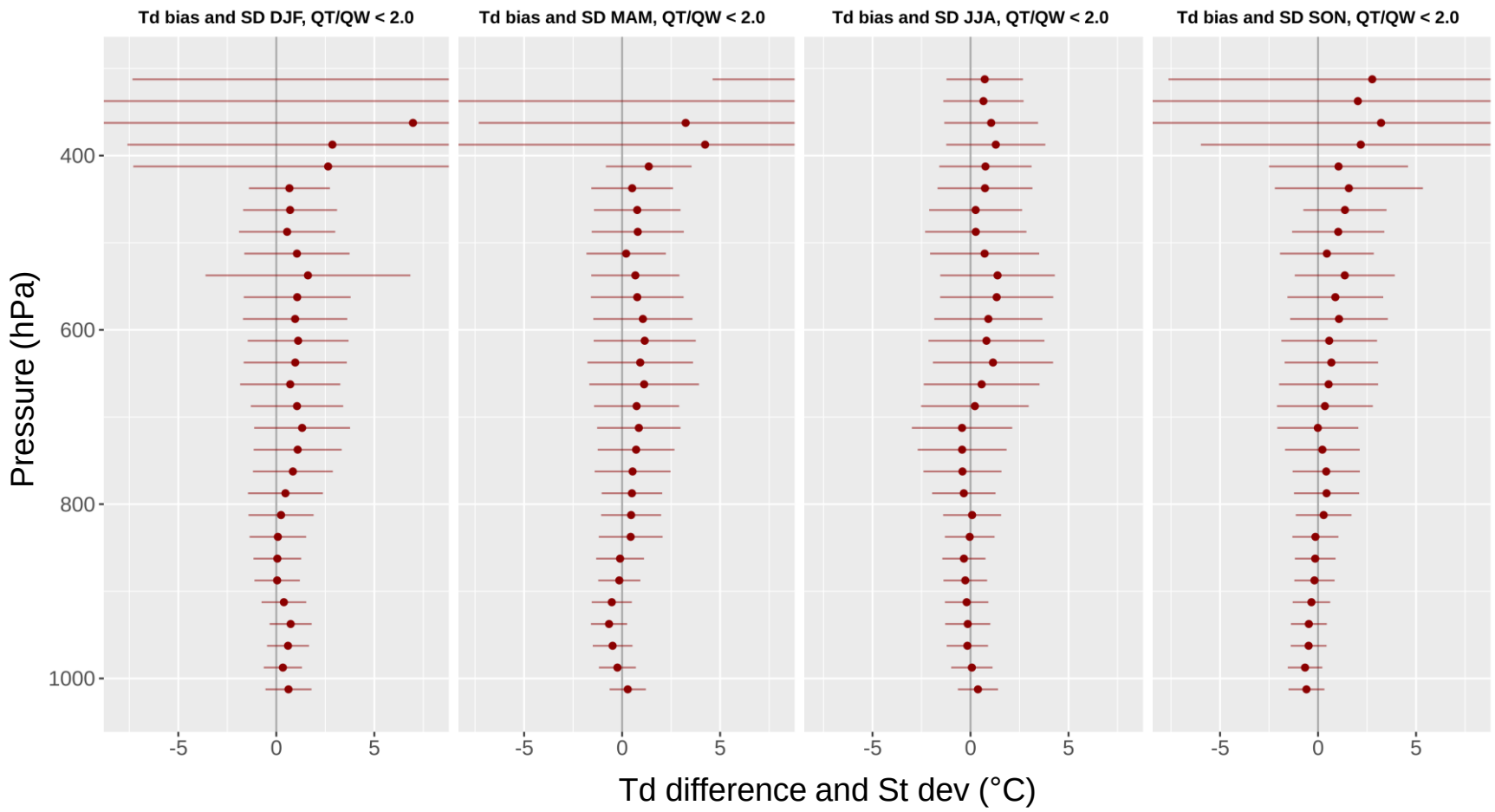
IASI vs. AMDAR T and Td



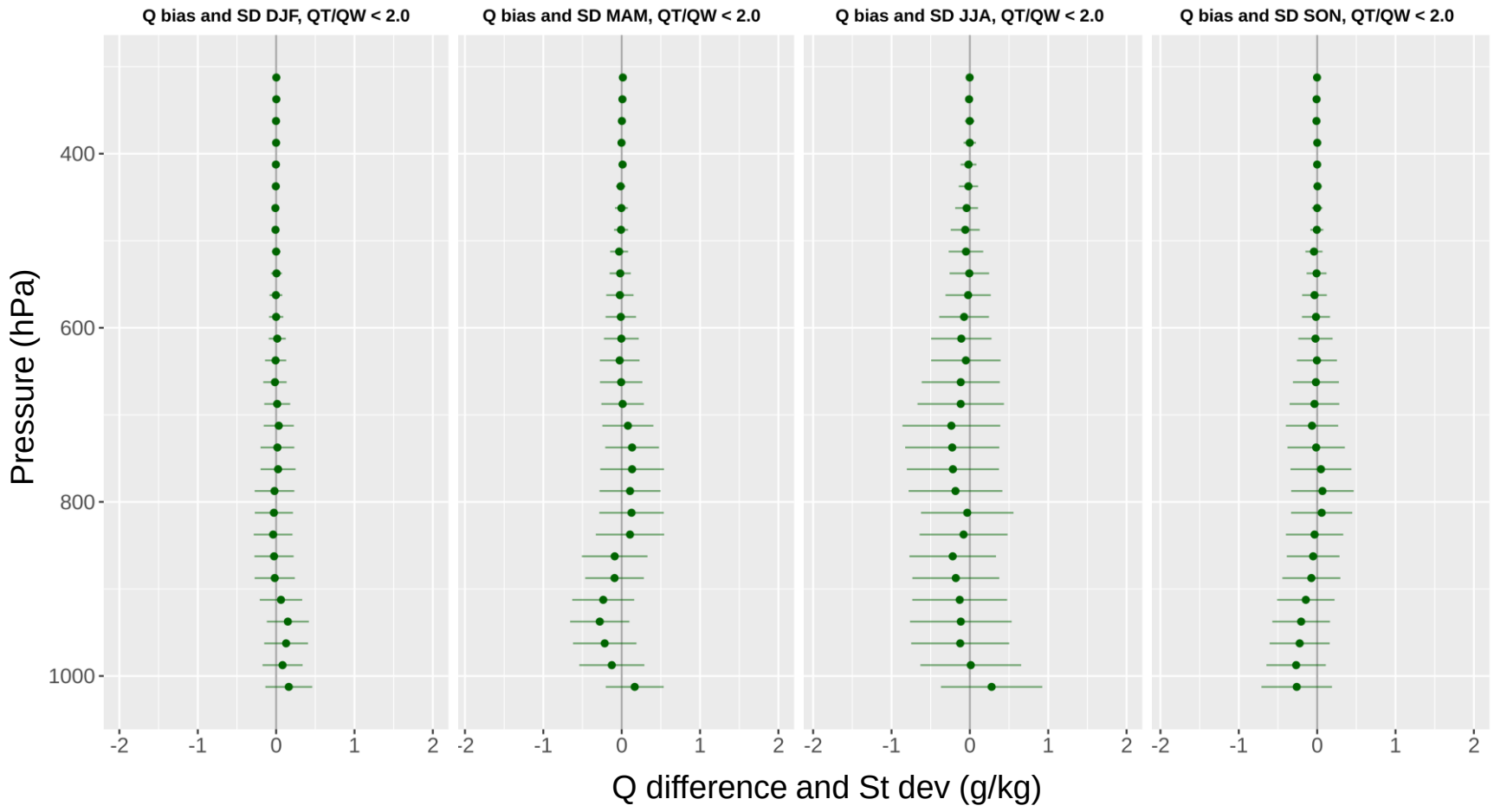
IASI vs. AMDAR temperature



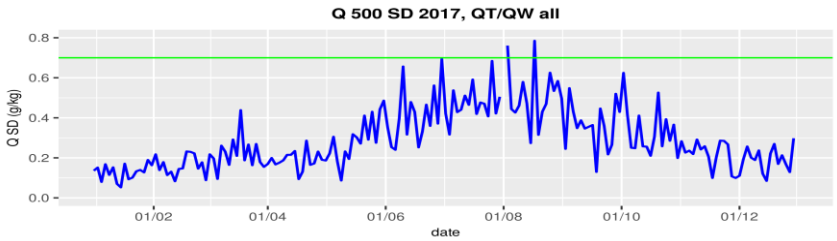
IASI vs. AMDAR dew point temperature

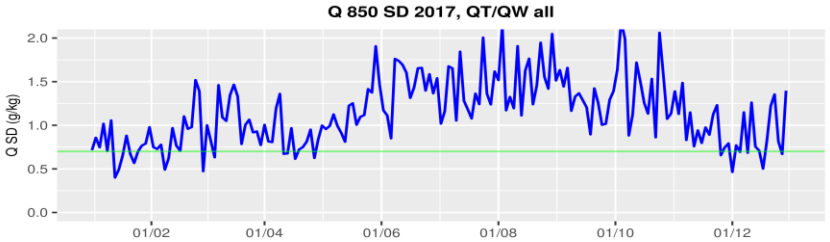


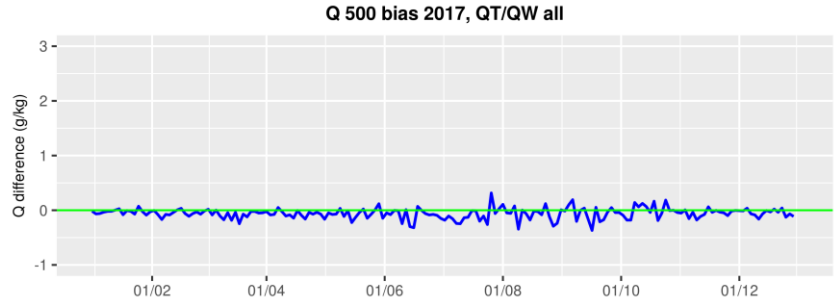
IASI vs. AMDAR specific humidity

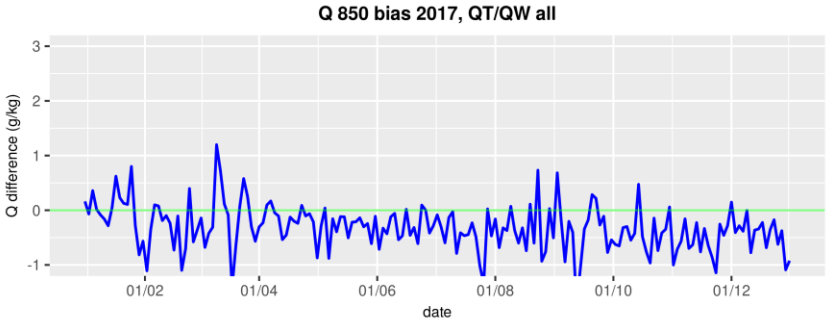


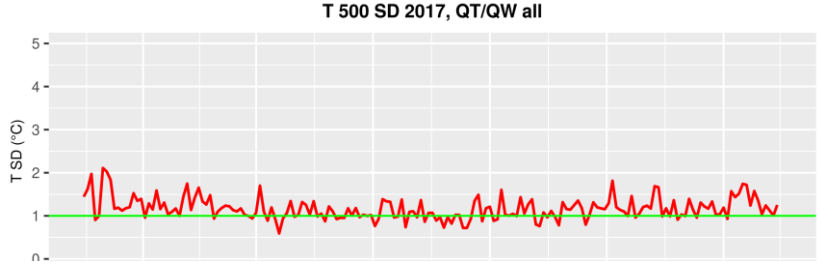
IASI vs. AMDAR temperature

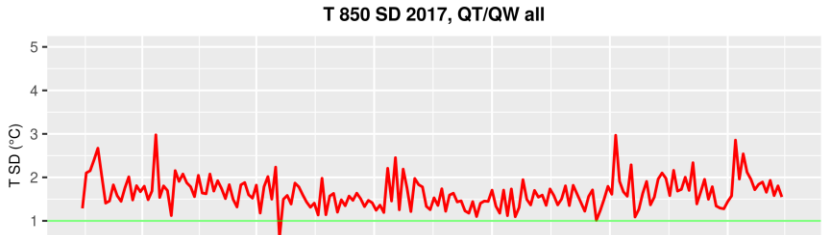


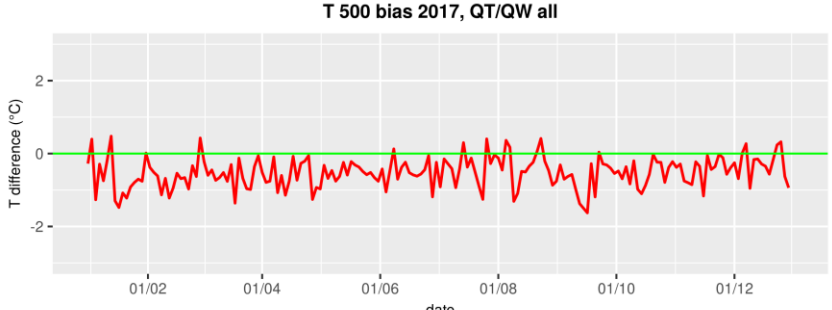


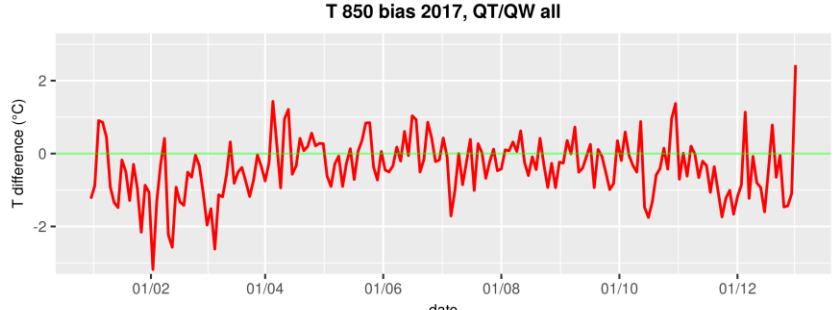












IASI vs. AMDAR stability indices

Convection

- K-index:

  $K = T_{850} + Td_{850} - T_{500} - (T_{700} - Td_{700})$

- Showalter index:

  $SWI = T_{env\_500} - T_{parcel\_500}$ (lifted from 850 hPa)

IASI vs AMDAR stability indices

SWI < 0	IASI YES	IASI NO
AMDAR YES	71	224
AMDAR NO	47	8781

POD = 0.24

K > 30	IASI YES	IASI NO
AMDAR YES	532	1146
AMDAR NO	1182	6263

POD = 0.32

IASI vs AMDAR stability indices

SWI < 3	IASI YES	IASI NO
AMDAR YES	3327	1298
AMDAR NO	1199	3299

POD = 0.72

K > 20	IASI YES	IASI NO
AMDAR YES	2327	1672
AMDAR NO	1371	3753

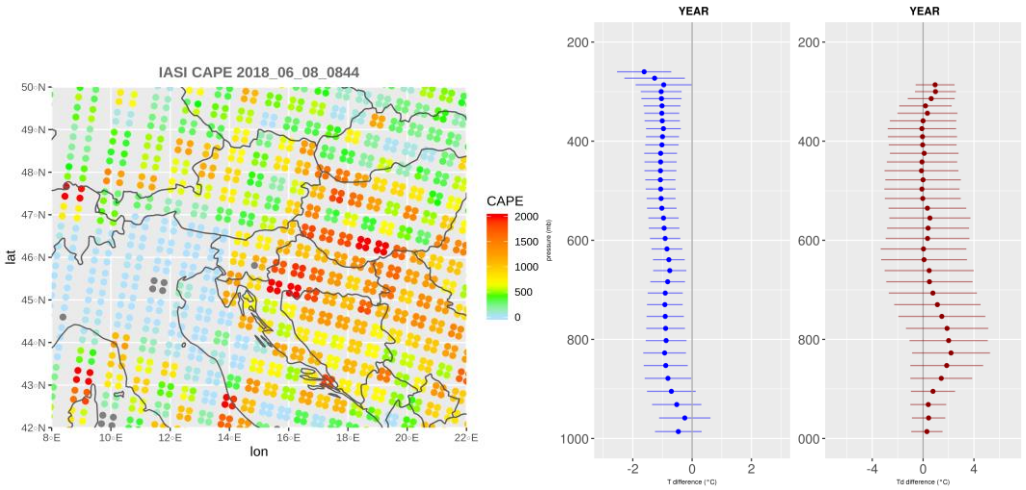
POD = 0.58

Summary

→ IASI instability information very promising on a case to case basis

→ IASI profiles much smoother than in-situ soundings – they miss some of the variability

→ A different interpretation of classical stability indices needed



K > 20	IASI YES	IASI NO
AMDAR YES	2327	1672
AMDAR NO	1371	3753

Uncertainty of indices, error propagation

Question:

How do the errors in the profiles propagate to the indices, eg. CAPE?

→ Monte Carlo method: Take a profile, perturb it randomly and calculate CAPE many times, see its distribution

In cooperation with X. Calbet and N. Peinado Galan (NWC SAF)

Which CAPE do you use most often in forecasting?

Surface based CAPE

Most unstable CAPE

Mixed layer CAPE

Something else

CAPE - types

$$\mathrm{CAPE} = \int_{LFC}^{EL} \frac{T_{v,parcel} - T_{v,env}}{T_{v,env}} g dz$$

$$= - \int_{LFC}^{EL} R(T_{v,parcel} - T_{v,env}) d\ln(p),$$

→ Surface based CAPE – the rising parcel starts from the conditions (T and Tdew) at 2 m

→ Mixed layer CAPE – the parcel starts from the average conditions of the mixed layer (50, 100, 200 hPa, lowermost 1 km,...)

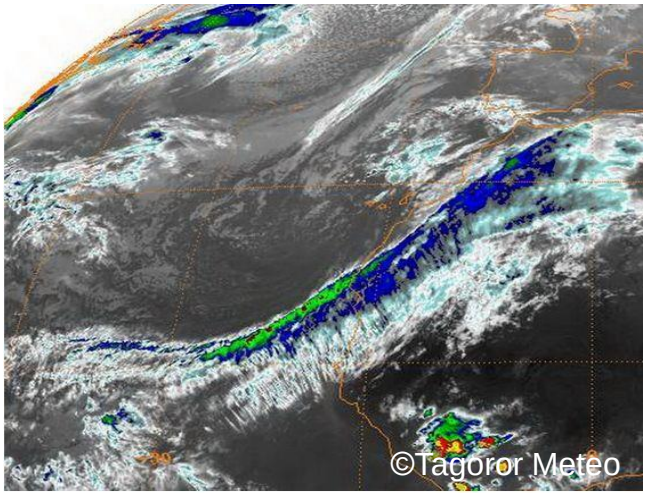
→ Most unstable CAPE – the highest CAPE from parcels starting in the lowermost 300 hPa

The Tenerife case

“La riada deTenerife” occurred in the afternoon hours of 31 March 2002.

A cut-off low with moist warm advection at low levels and cold air aloft destabilized the environment and enabled the generation of several stationary convective cells.

Heavy rain caused flash floods, severe damage and 8 casualties. Spain’s record precipitation amounts were recorded (162,2 l/m2 in one hour).

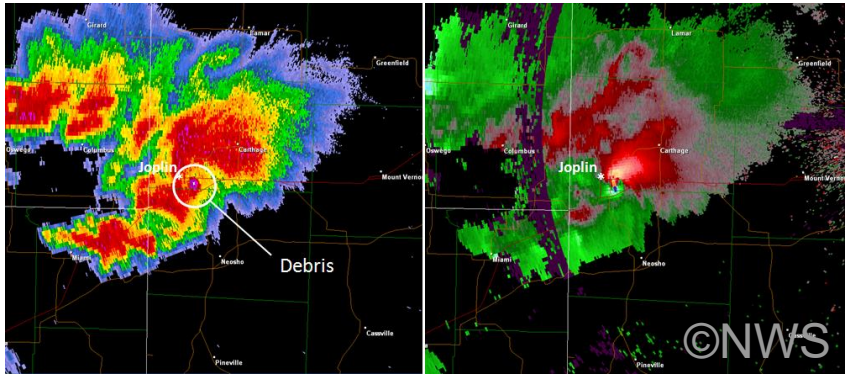


The Joplin case

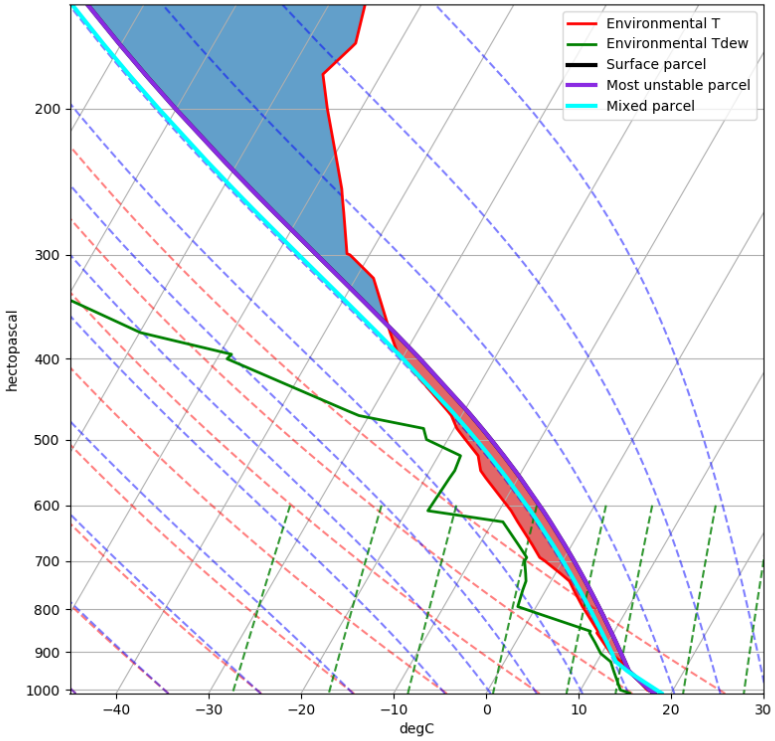
"The Joplin tornado" on 22 May 2011 was one of the deadliest tornados in the US.

A supercell storm approached from the W and produced a EF 5 tornado (and several others). Its path was 22 miles long and 1 mile wide.

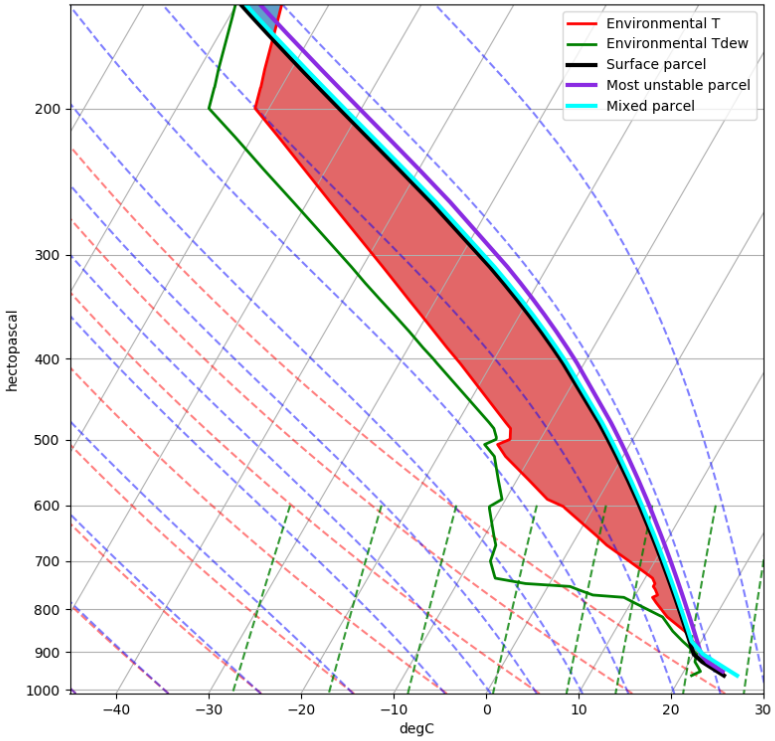
Severe winds exceeding 200 mph caused immense damage and 15 fatalities.



Tenerife case



Joplin case



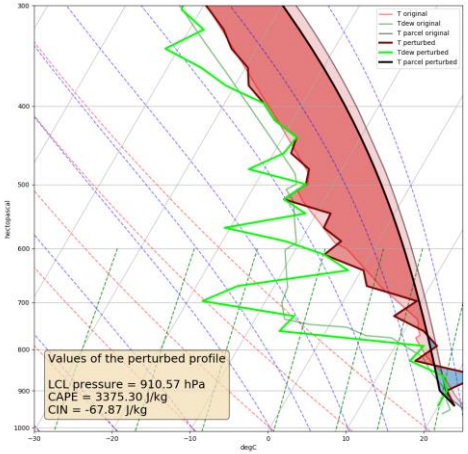
Data from: weather.uwyo.edu/upperair/

Applied perturbations

Random perturbations:

Amplitude estimated by uncertainty covariance matrix from NWC SAF retrieval algorithm (90 p levels, an appropriate subset selected)

Independent perturbations



Applied perturbations

Random perturbations:

Amplitude estimated by uncertainty covariance matrix from NWC SAF retrieval algorithm (90 p levels, an appropriate subset selected)

Diagonalization:

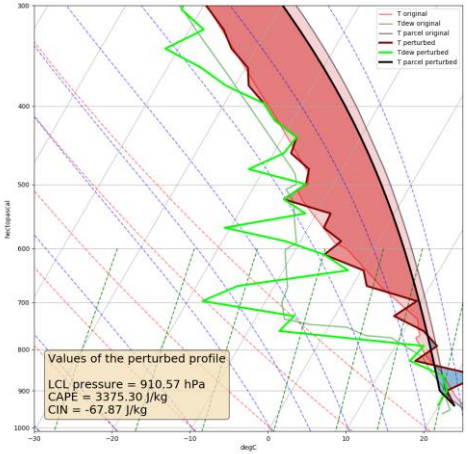
Uncertainty covariance matrix not diagonal

→ eigenvalue decomposition

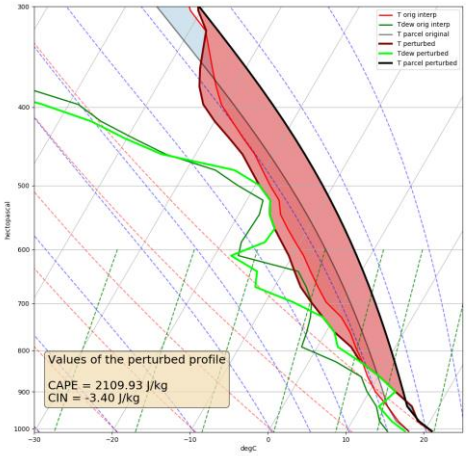
→ in eigenspace the matrix is diagonal

→ apply perturbations and transform back into physical space

Independent perturbations

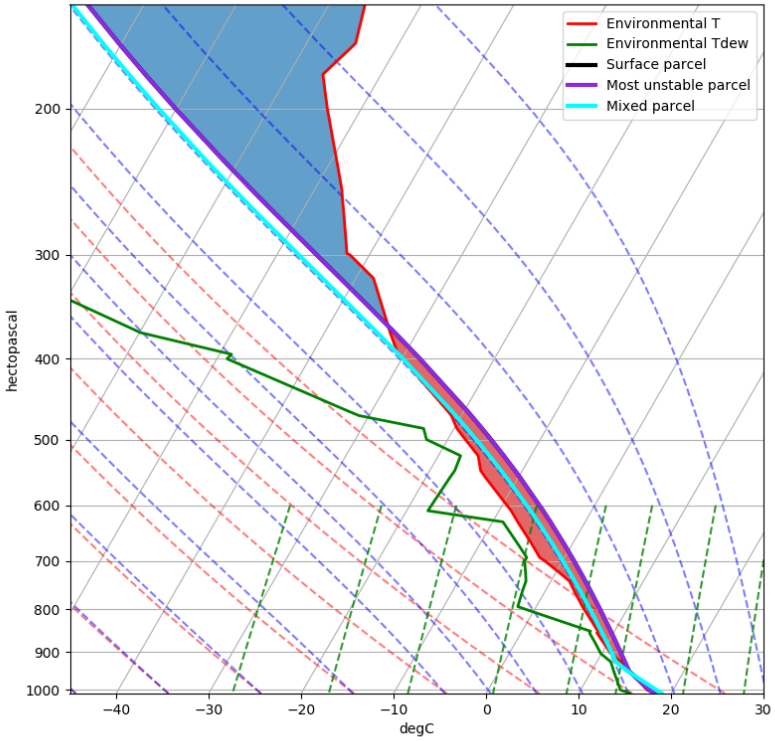


Eigenvector perturbations

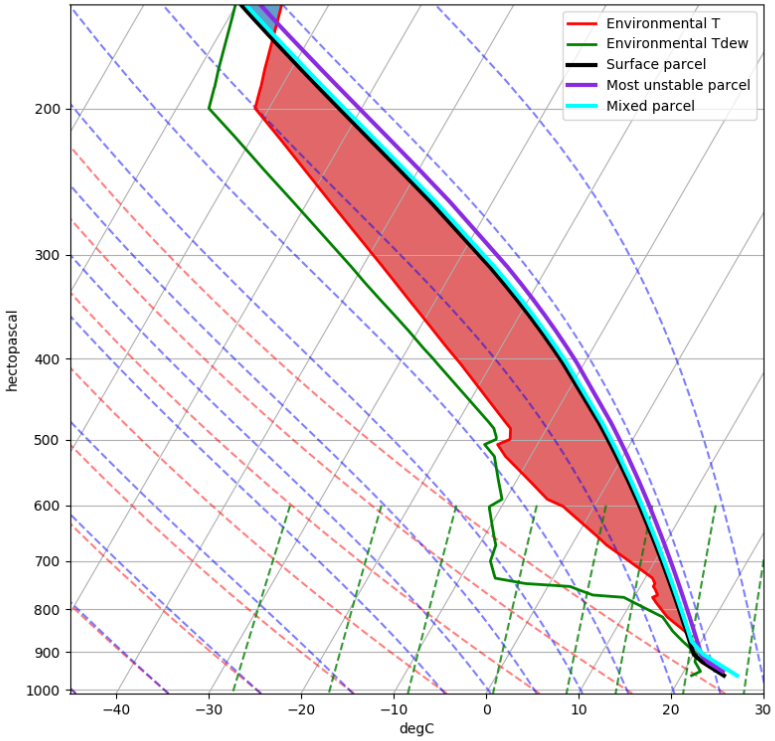


Original profiles

Tenerife case

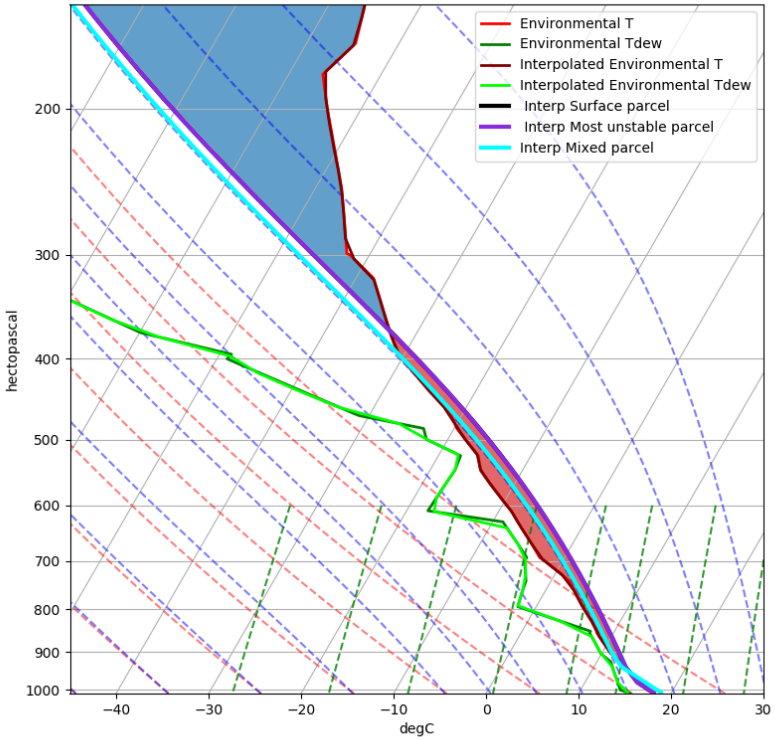


Joplin case

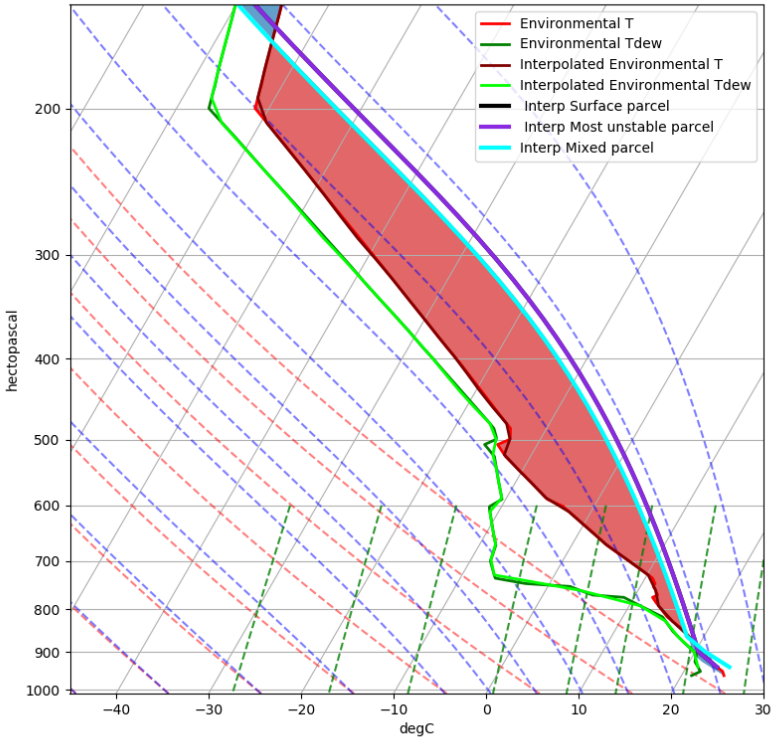


Interpolated profiles

Tenerife case

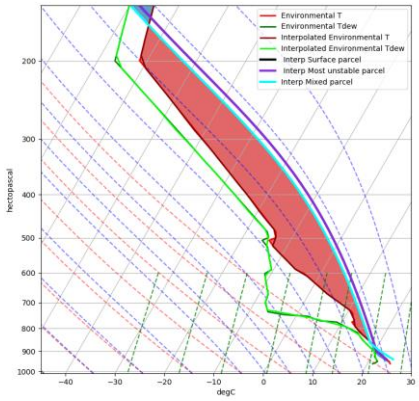


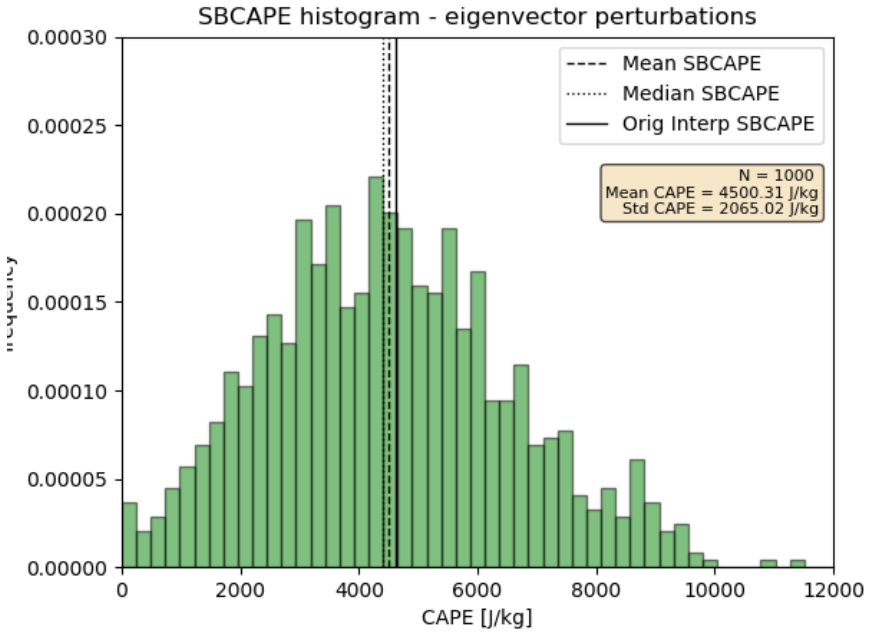
Joplin case



CAPE histogram

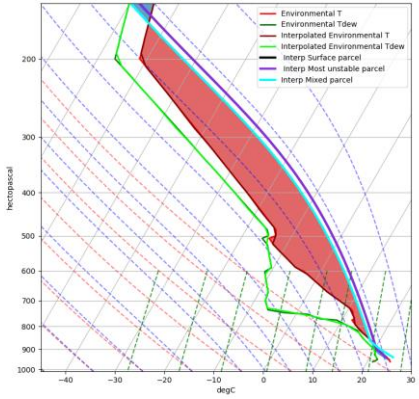
Joplin case

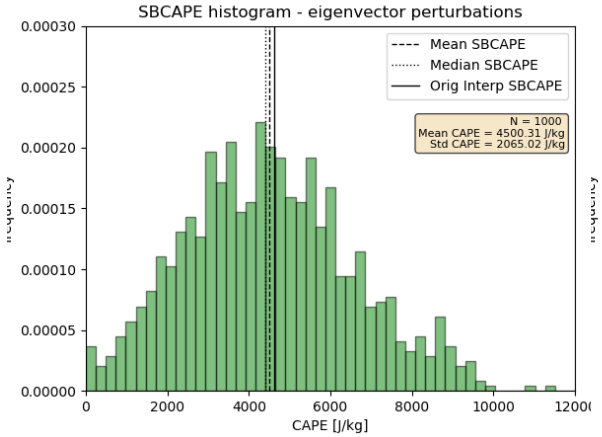


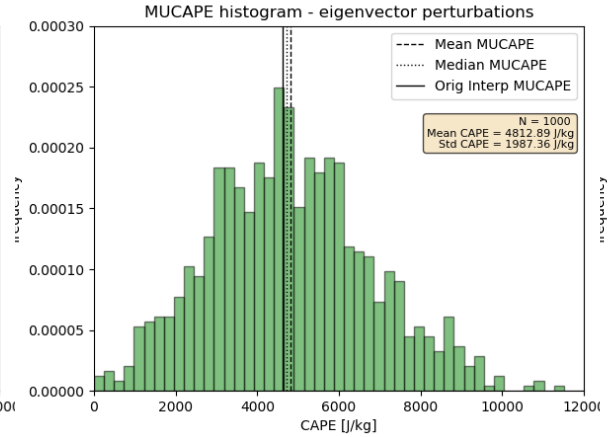


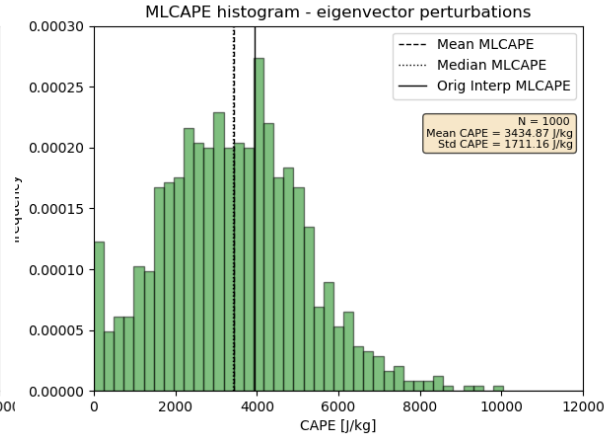
CAPE histogram

Joplin case



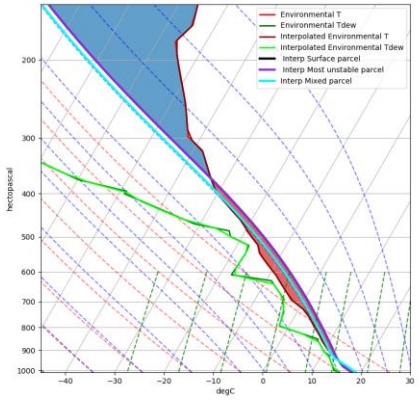


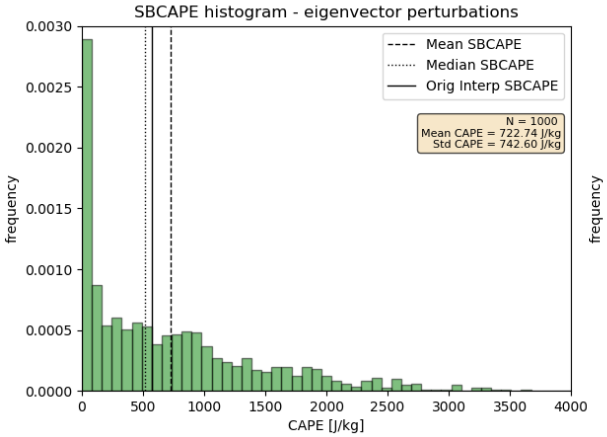


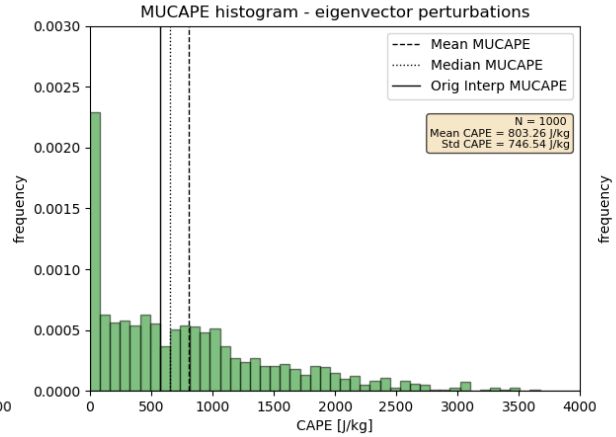


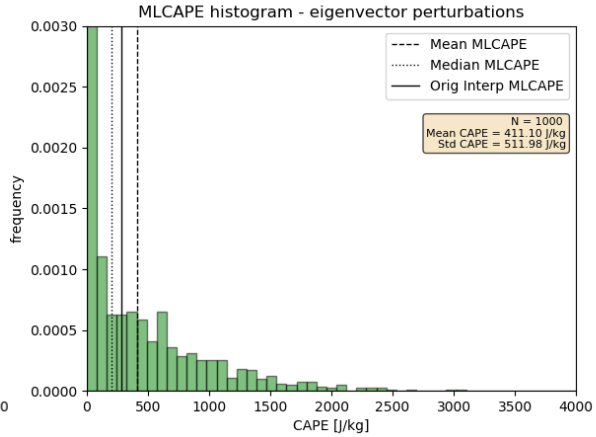
CAPE histogram

Tenerife case









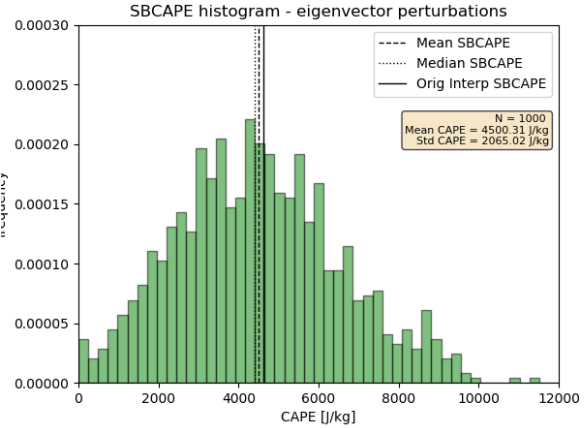
Applied profile corrections

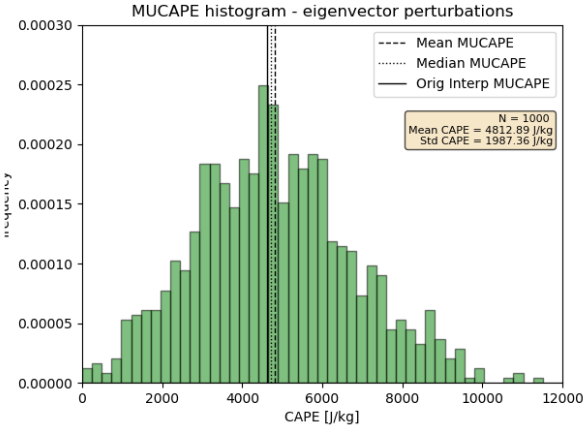
Bias correction – 1K correction at every level towards the original profile

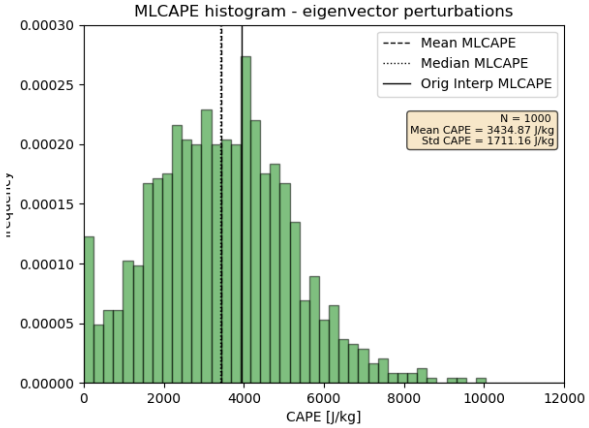
Surface correction – 50% reduction of perturbation at the surface

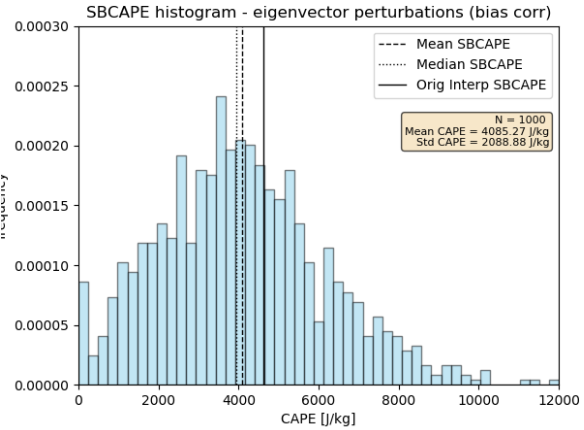
Bias correction

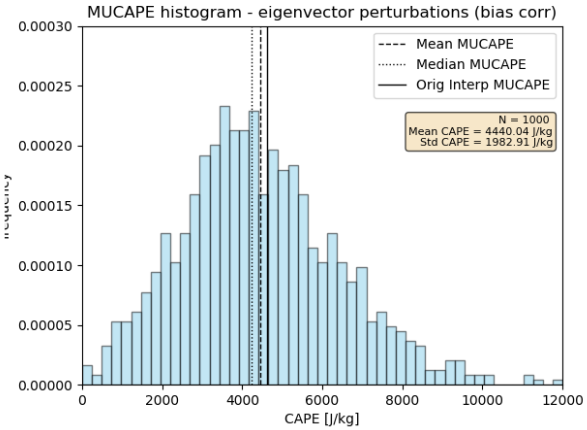
Joplin case

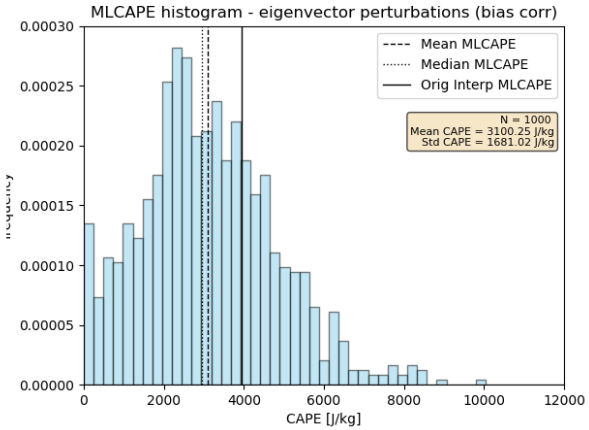






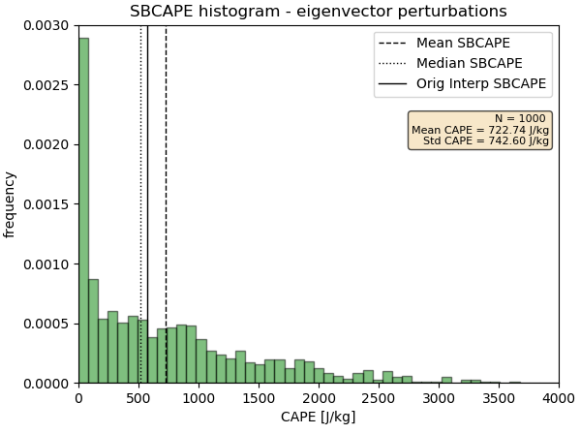


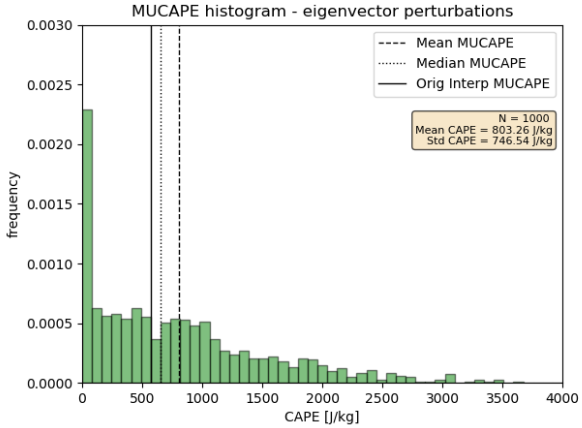


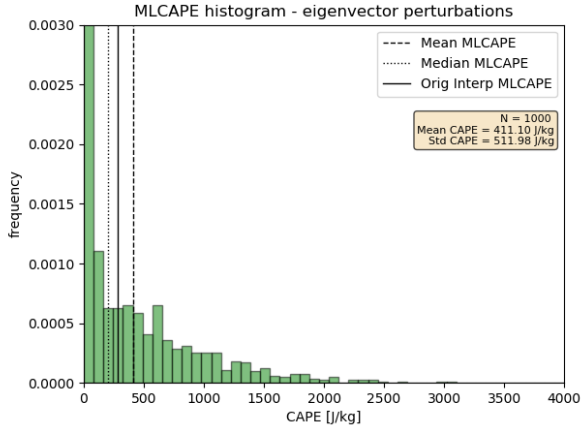


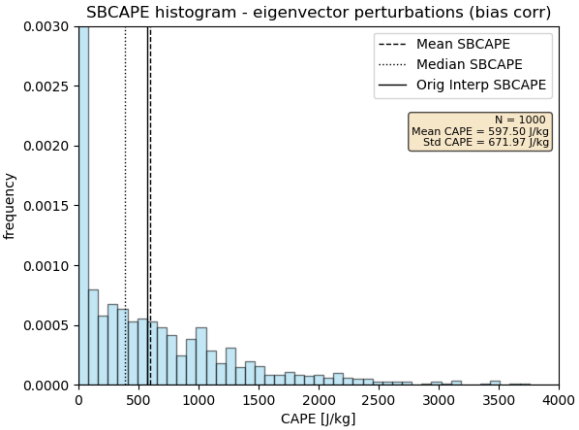
Bias correction

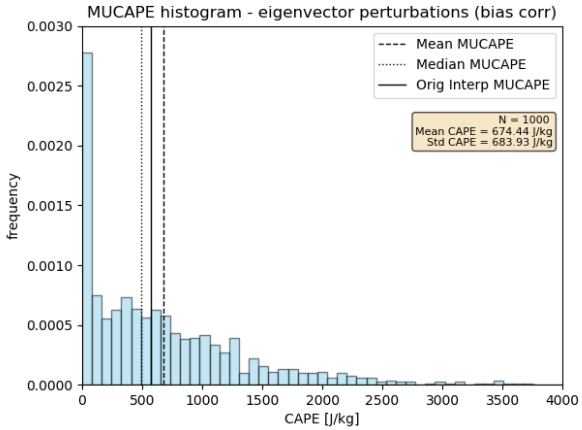
Tenerife case

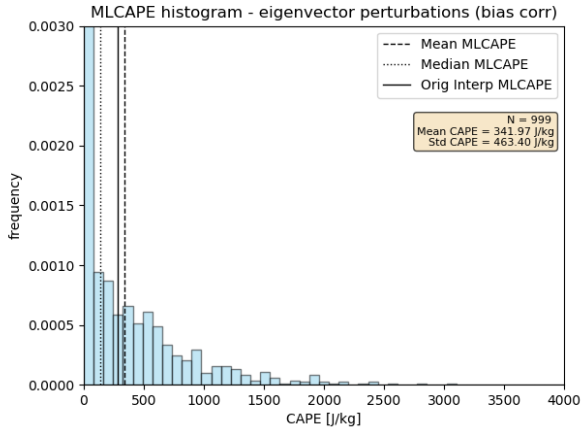






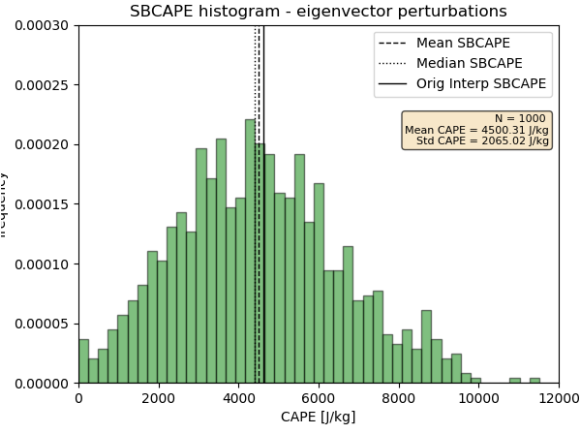


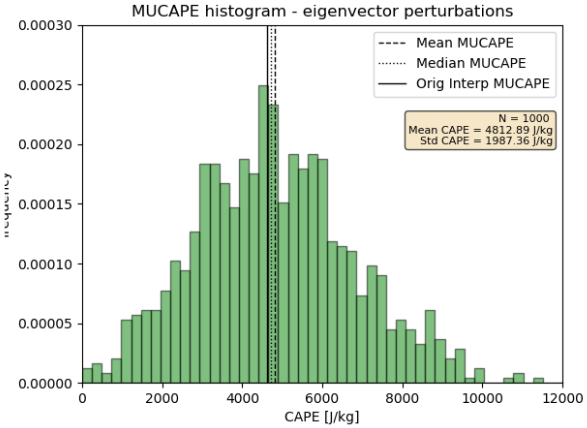


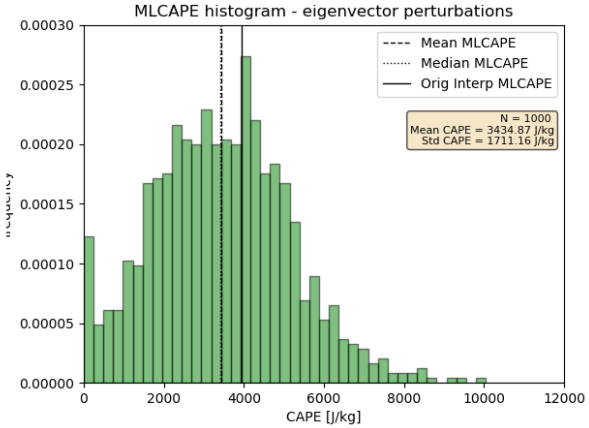


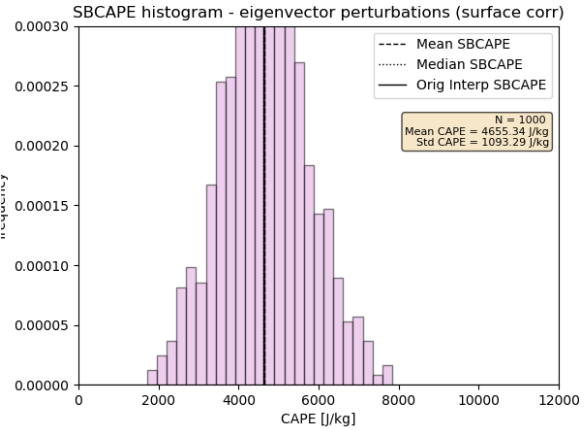
Surface correction

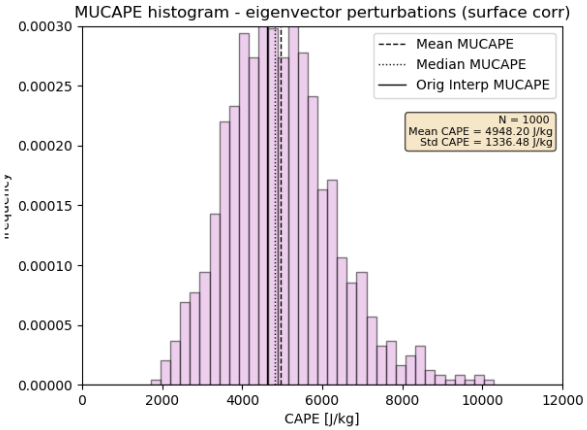
Joplin case

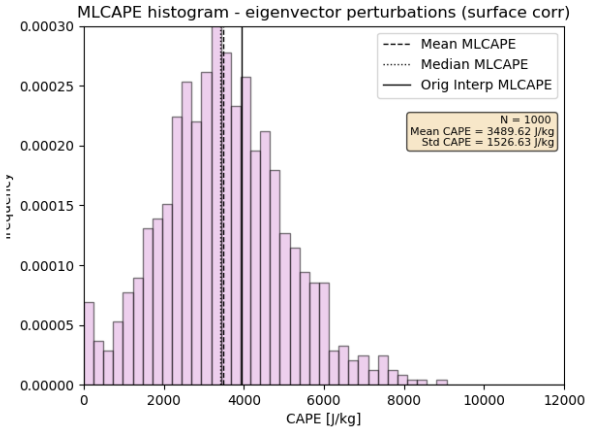






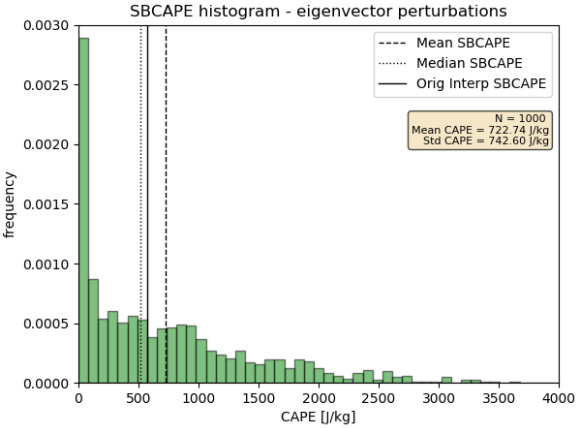


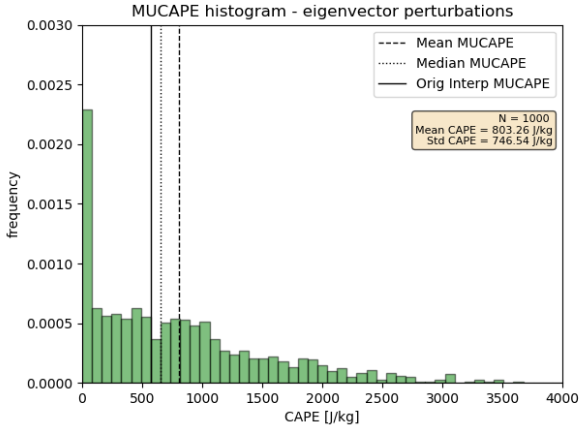


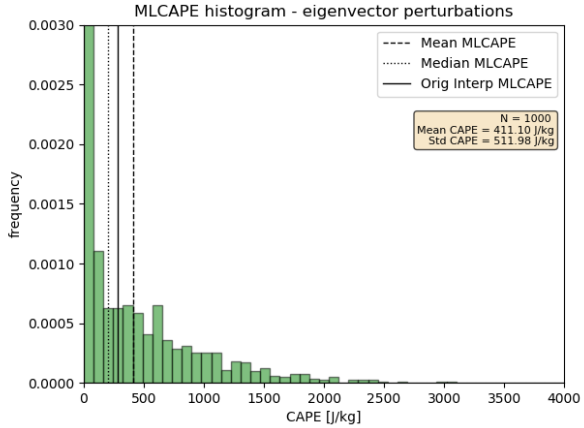


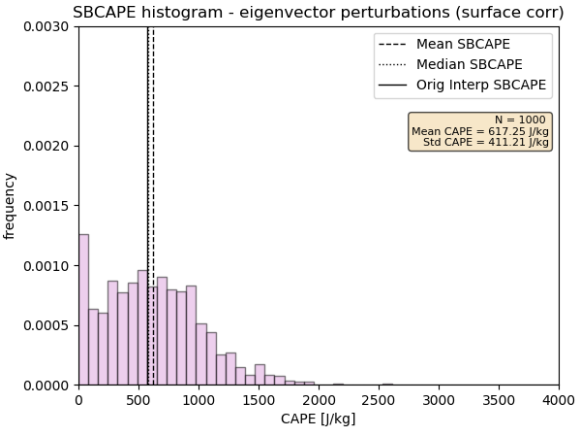
Surface correction

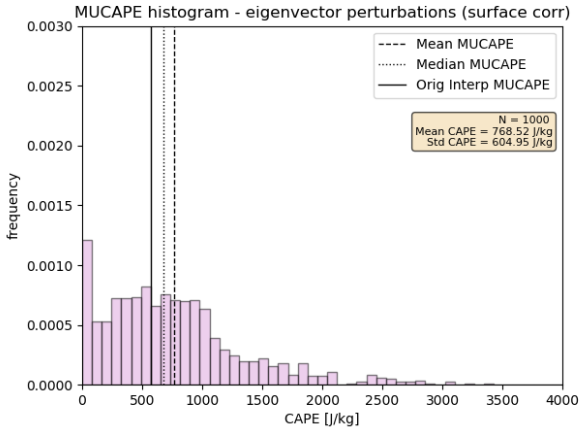
Tenerife case

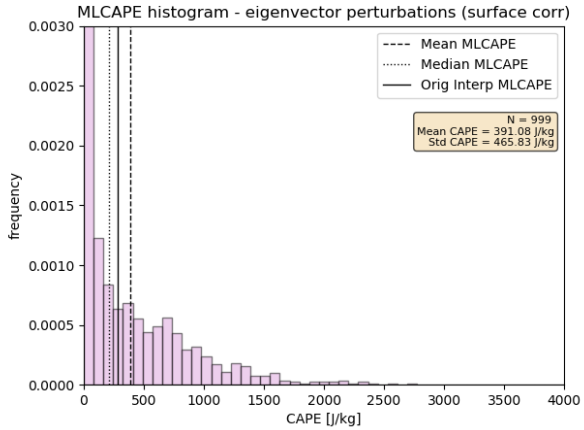












Summary

→ Uncertainties in retrieved profiles lead to large uncertainties in calculated CAPE values; for “narrow CAPEs” this leads to missed cases

→ Uncertainty of MLCAPE is slightly lower than other CAPEs

→ For smoother profiles MUCAPE is more likely the same as SBCAPE

→ Bias correction reduces CAPE values but does not reduce the spread significantly

→ Surface correction has a large impact on SBCAPE and MUCAPE, but less on MLCAPE