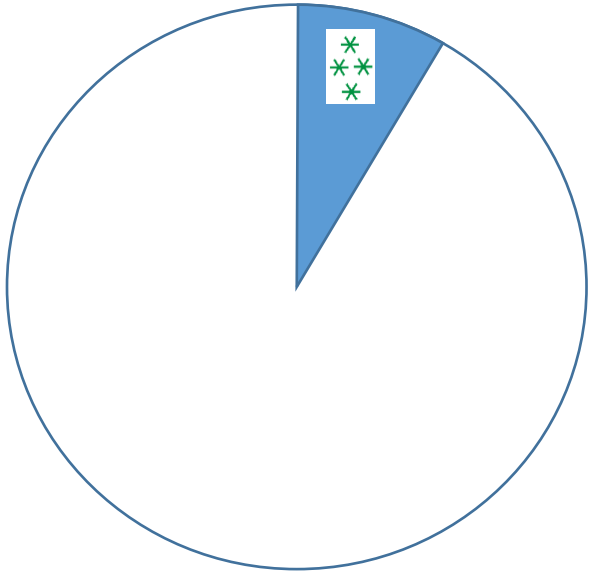
European Severe Storms Laboratory

Deep moist convection in winter

Tomas Pucik, Christoph Gatzen

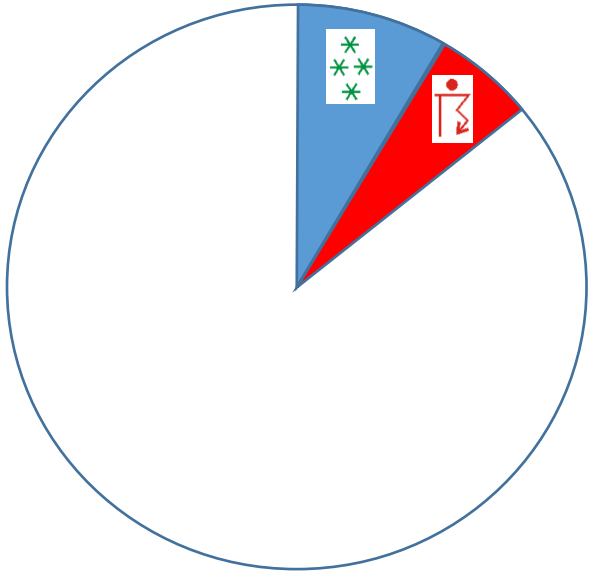
What forecasters want

- Snow



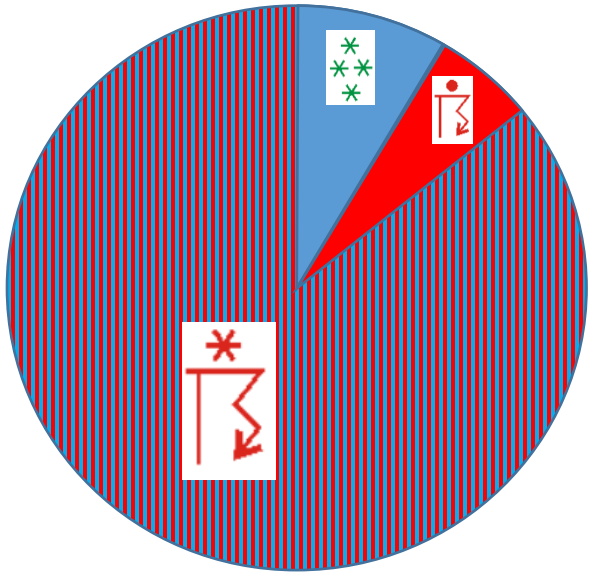
What forecasters want

- Snow
- Thunder



What forecasters want

- Snow
- Thunder
- Both at the same time



What forecasters want

Ingredients for thundersnow?

- Ingredients for snow:
  - Moisture
  - Cold air (wet-bulb ≤ 0°C) (e.g. due to melting of precip)
  - Lift

Ingredients for thundersnow?

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- Ingredients for lightning:
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  - Positive CAPE @ -10 to -20 °C
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Ingredients for thundersnow?

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  - Cold air (wet-bulb ≤ 0°C)
  - Lift
- Ingredients for lightning:
  - Moisture
  - Positive CAPE @ -10 to -20 °C
  - Lift
    - Ingredients for deep moist convection:
    - Low-level moisture
    - Steep mid-level lapse rates
    - Lift

How much CAPE for this much lightning?

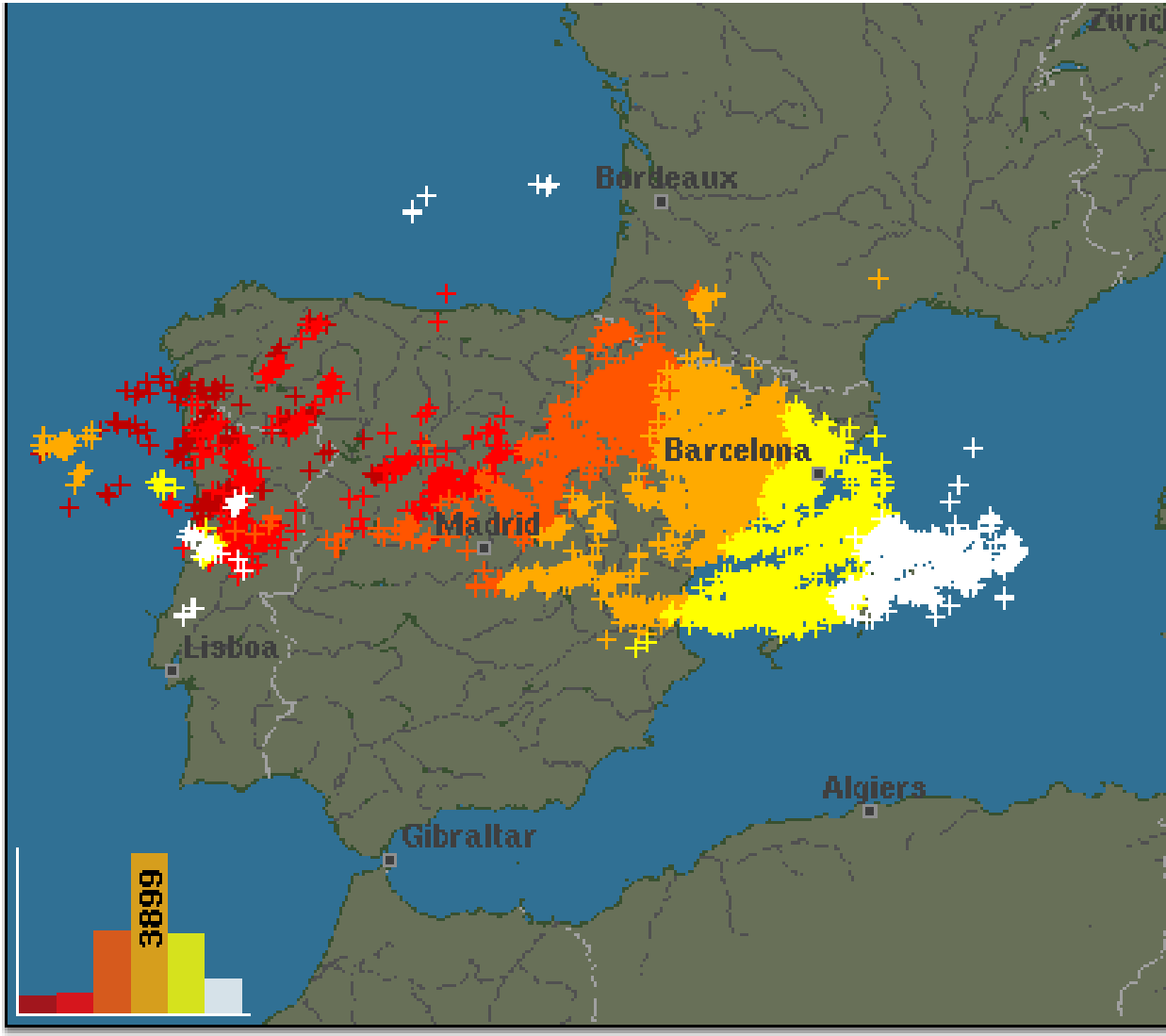
A. 1000 J/kg

B. 500 J/kg

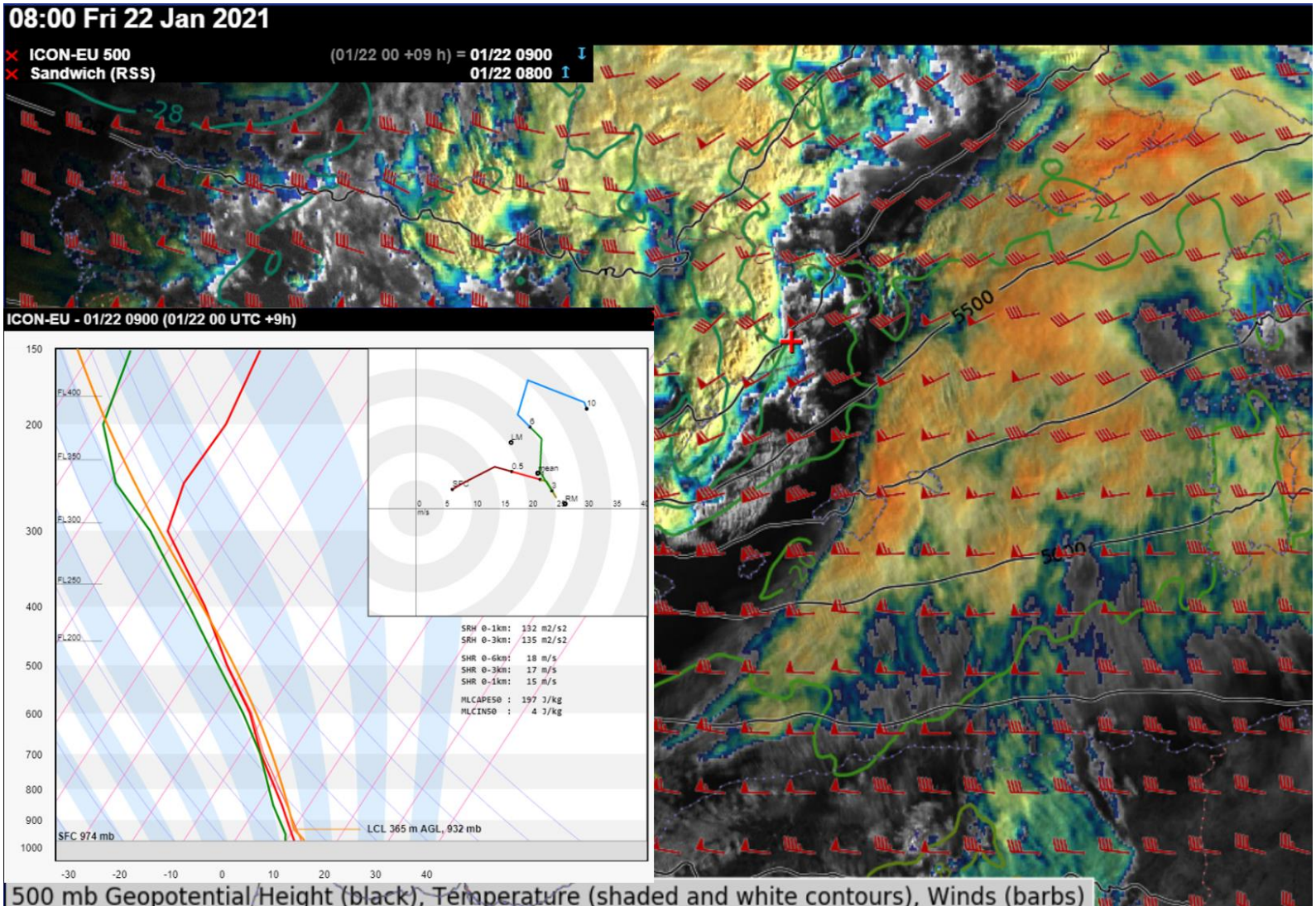
C. 2000 J/kg

D. 200 J/kg

E. 30 J/kg

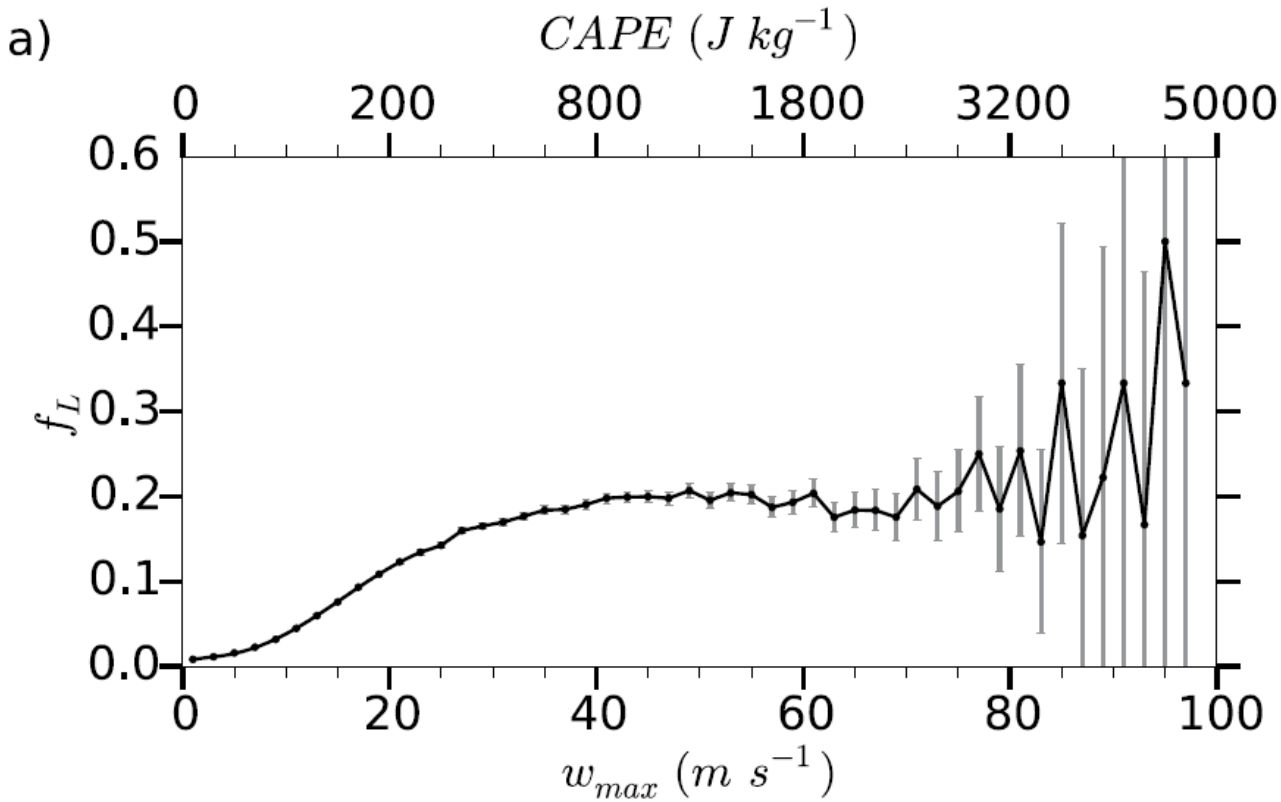


How much CAPE is needed for lightning?



Forecasting lightning using CAPE

- Likelihood increases only in the range of 0 -> 200 J/kg of CAPE

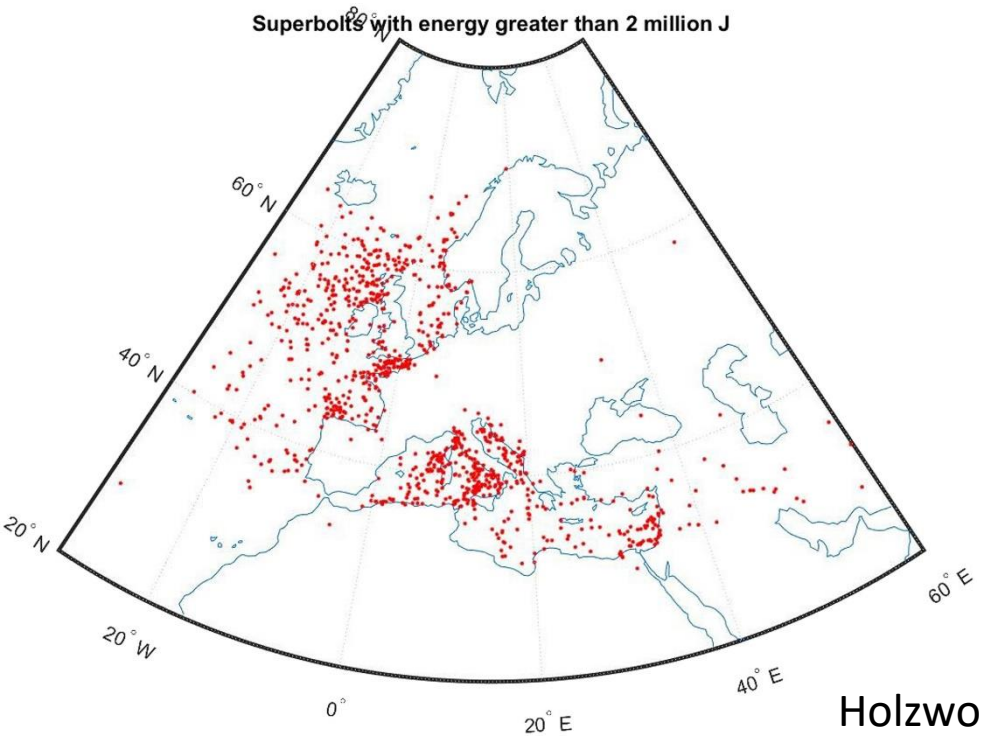


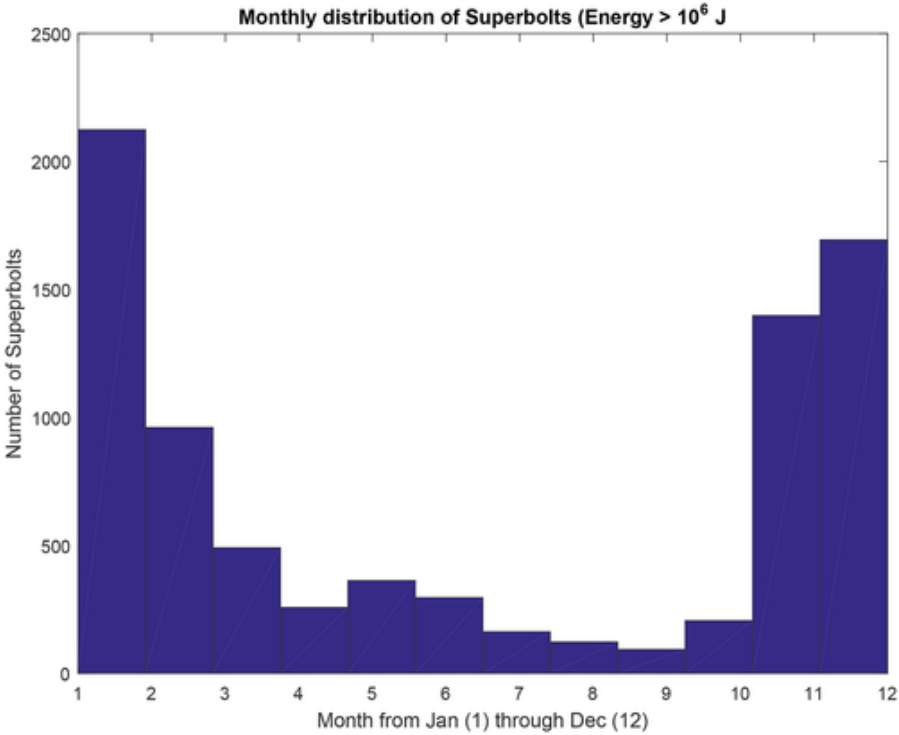
Westermayer et al. 2017

Winter-time lightning

Less frequent, but more powerful: „superbolts“

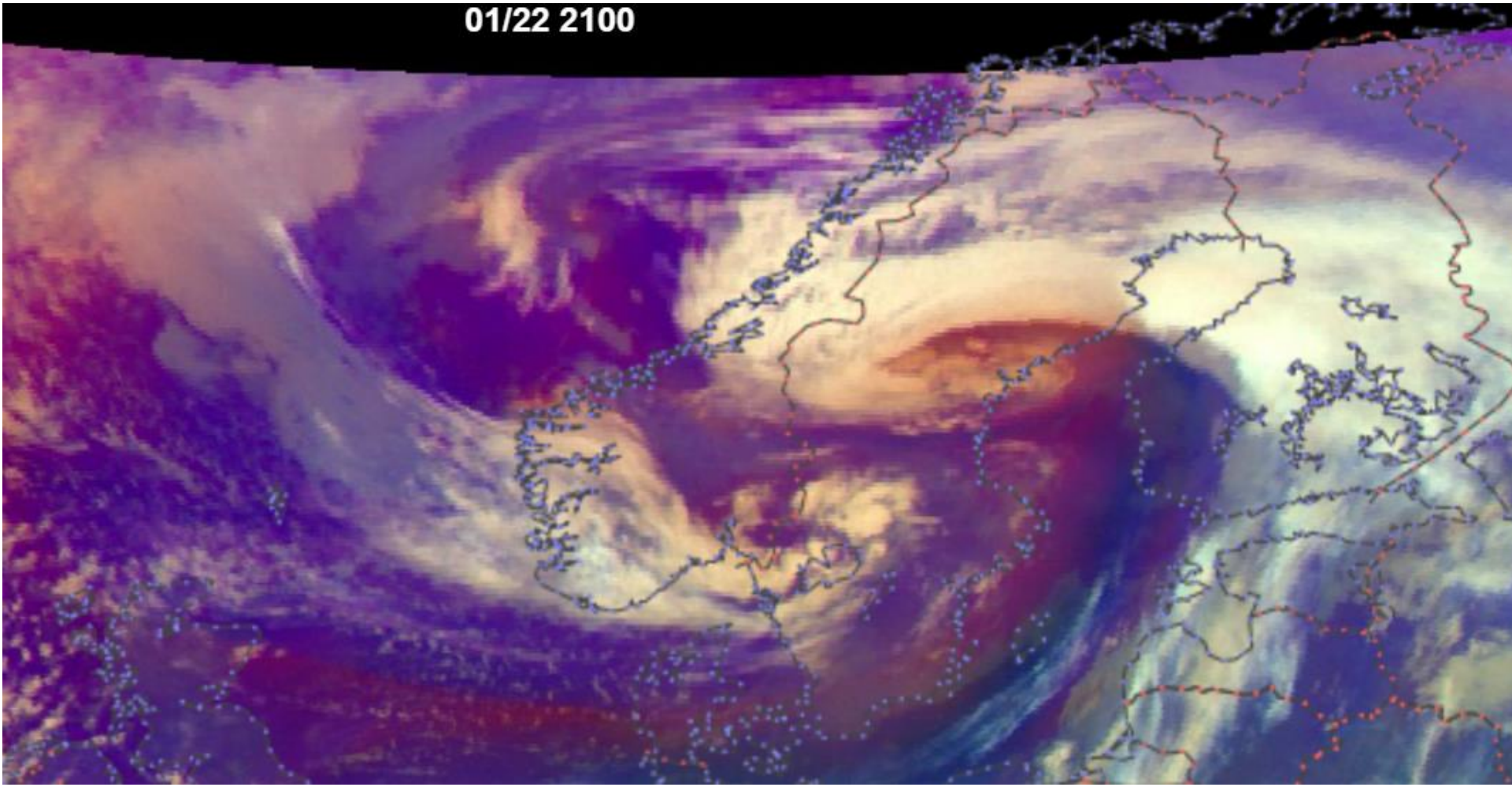
Reasons?



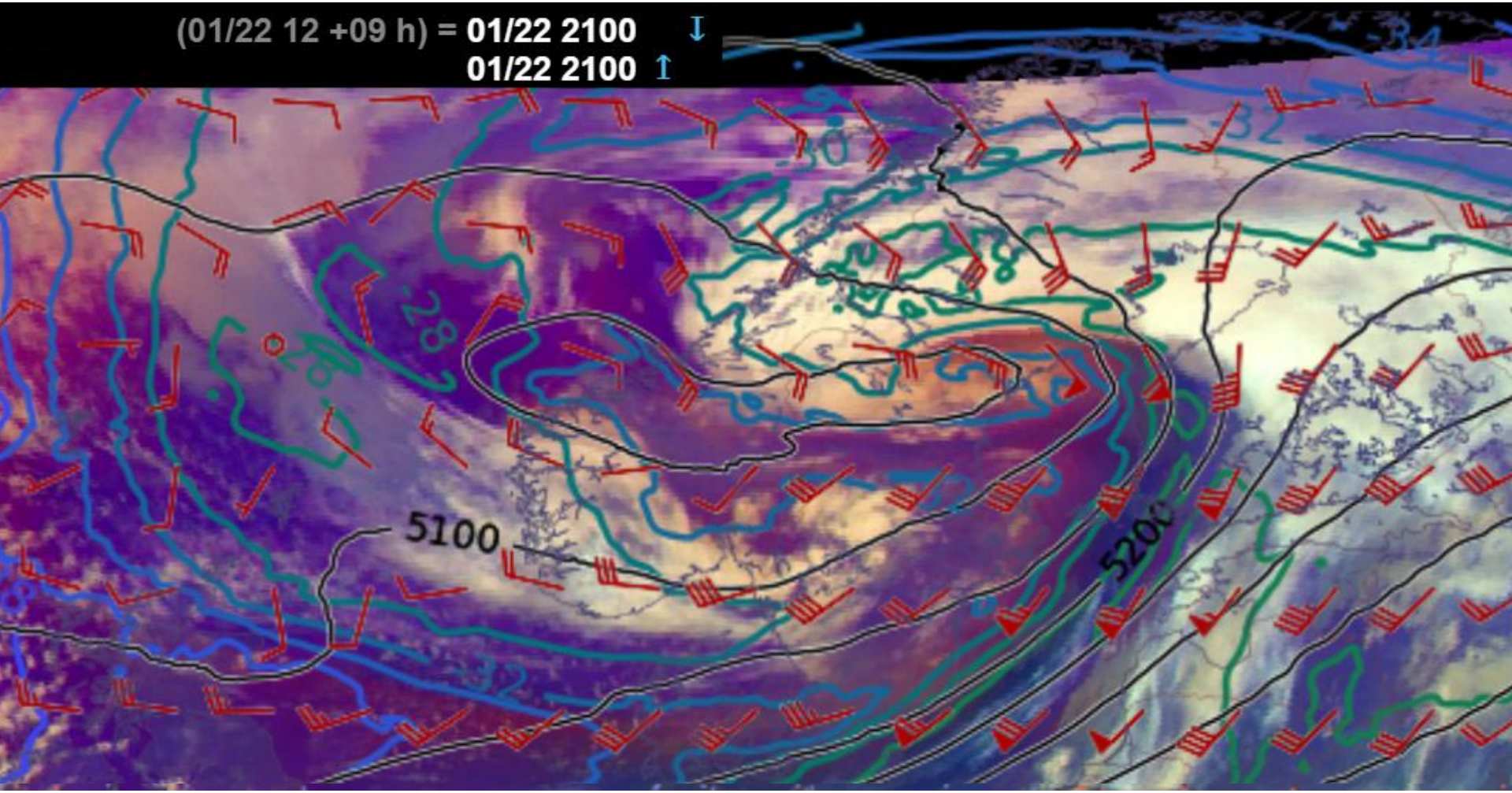


Holzworth et al. 2019

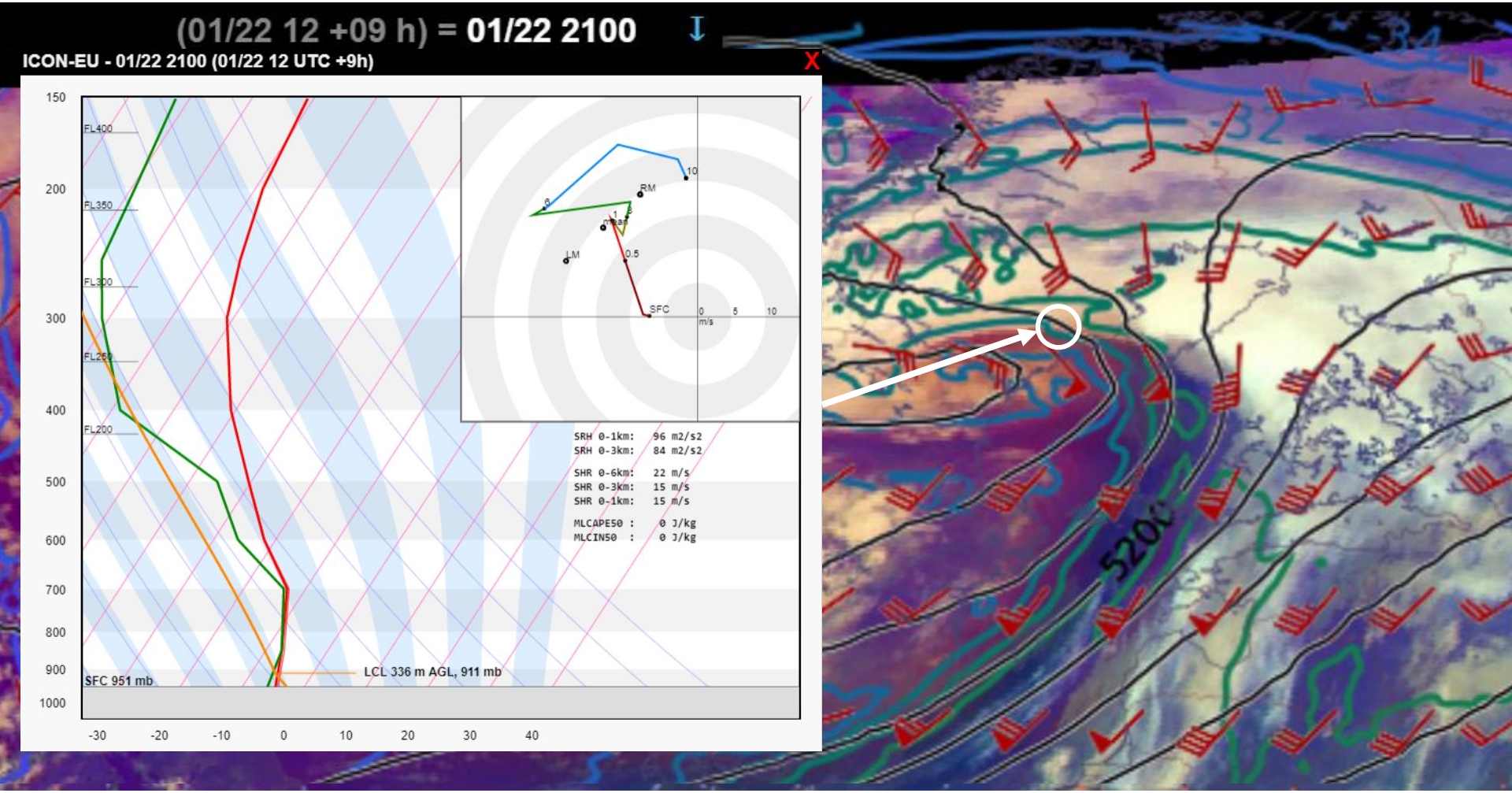
Elevated CAPE thundersnow



Elevated CAPE thundersnow



Elevated CAPE thundersnow



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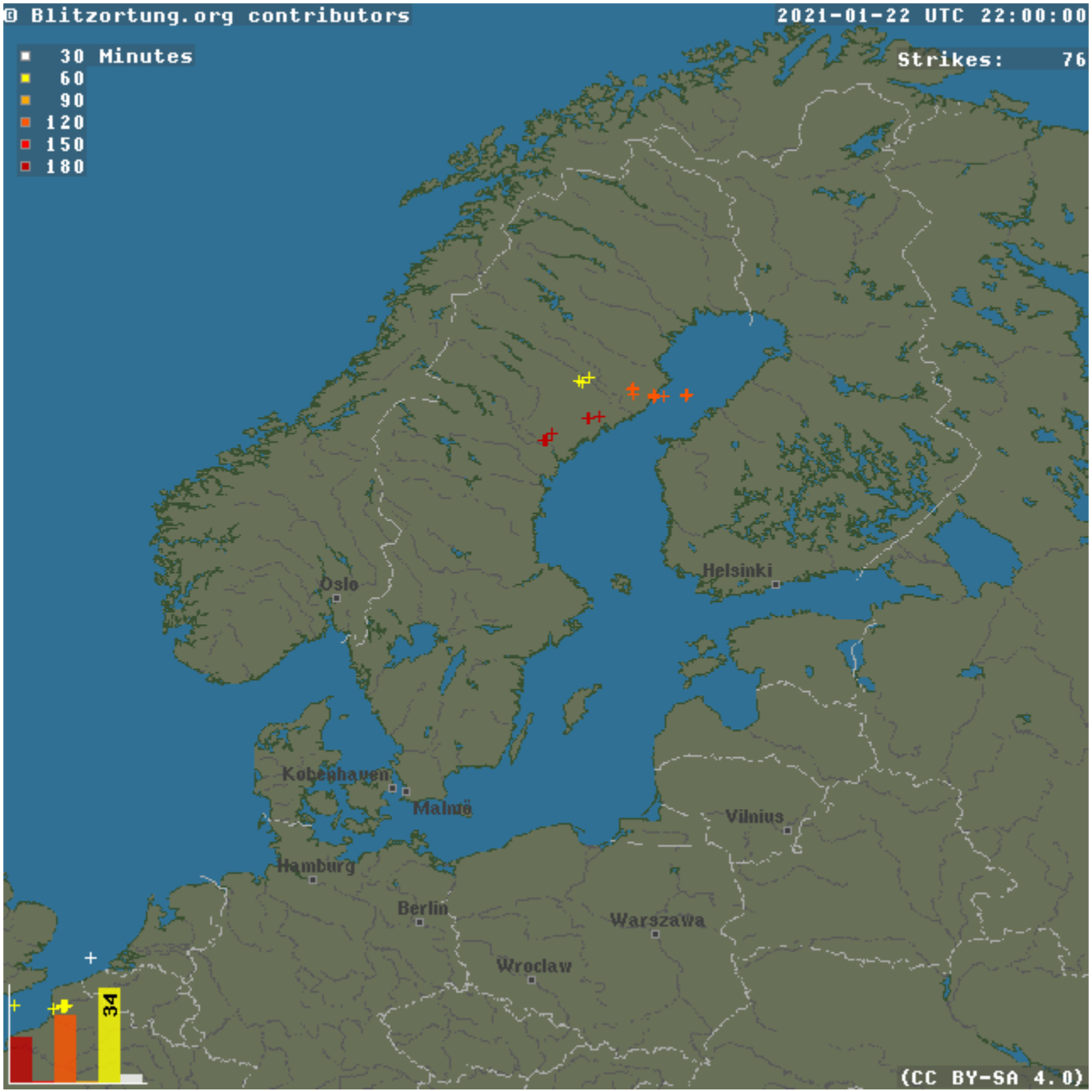
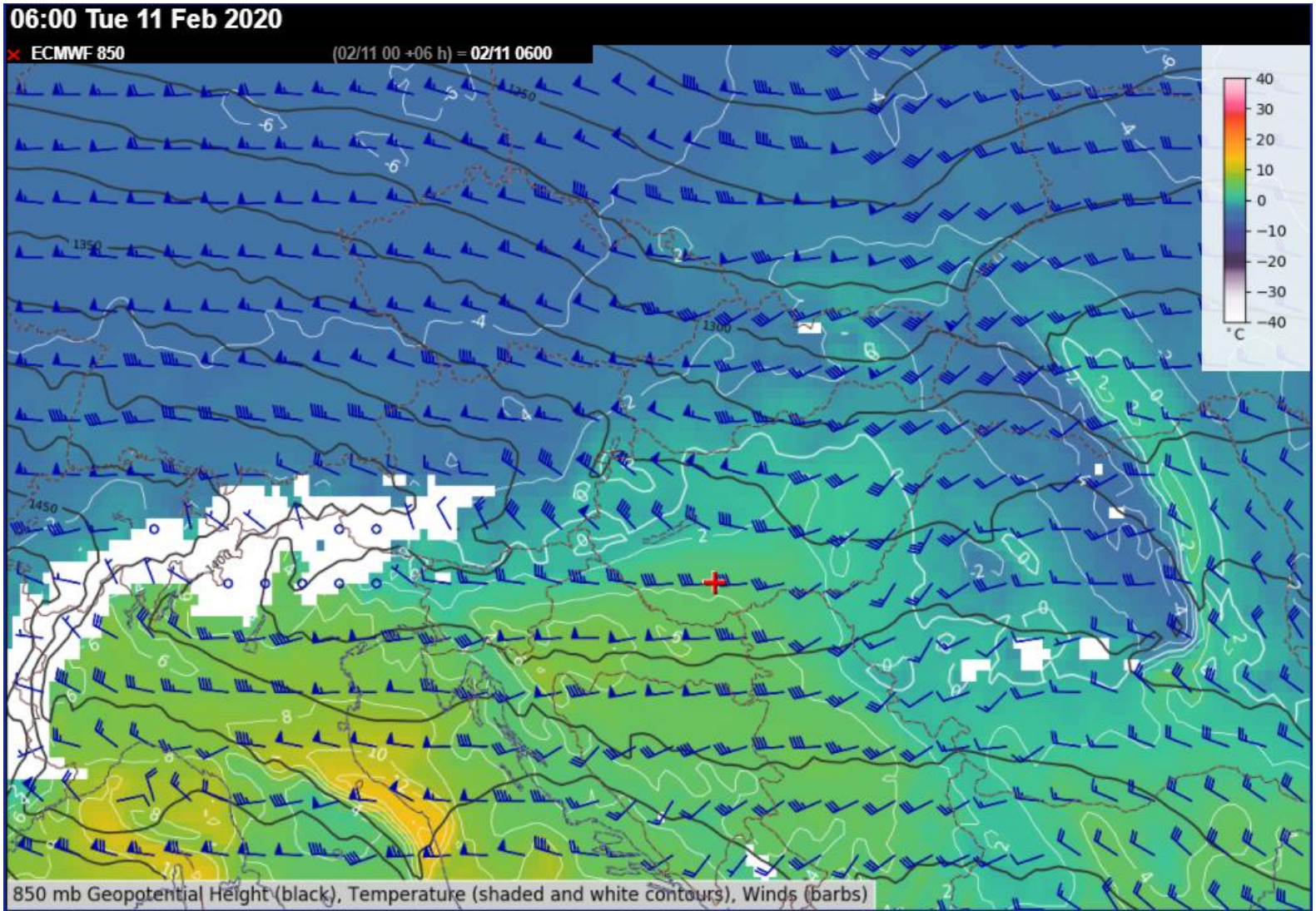
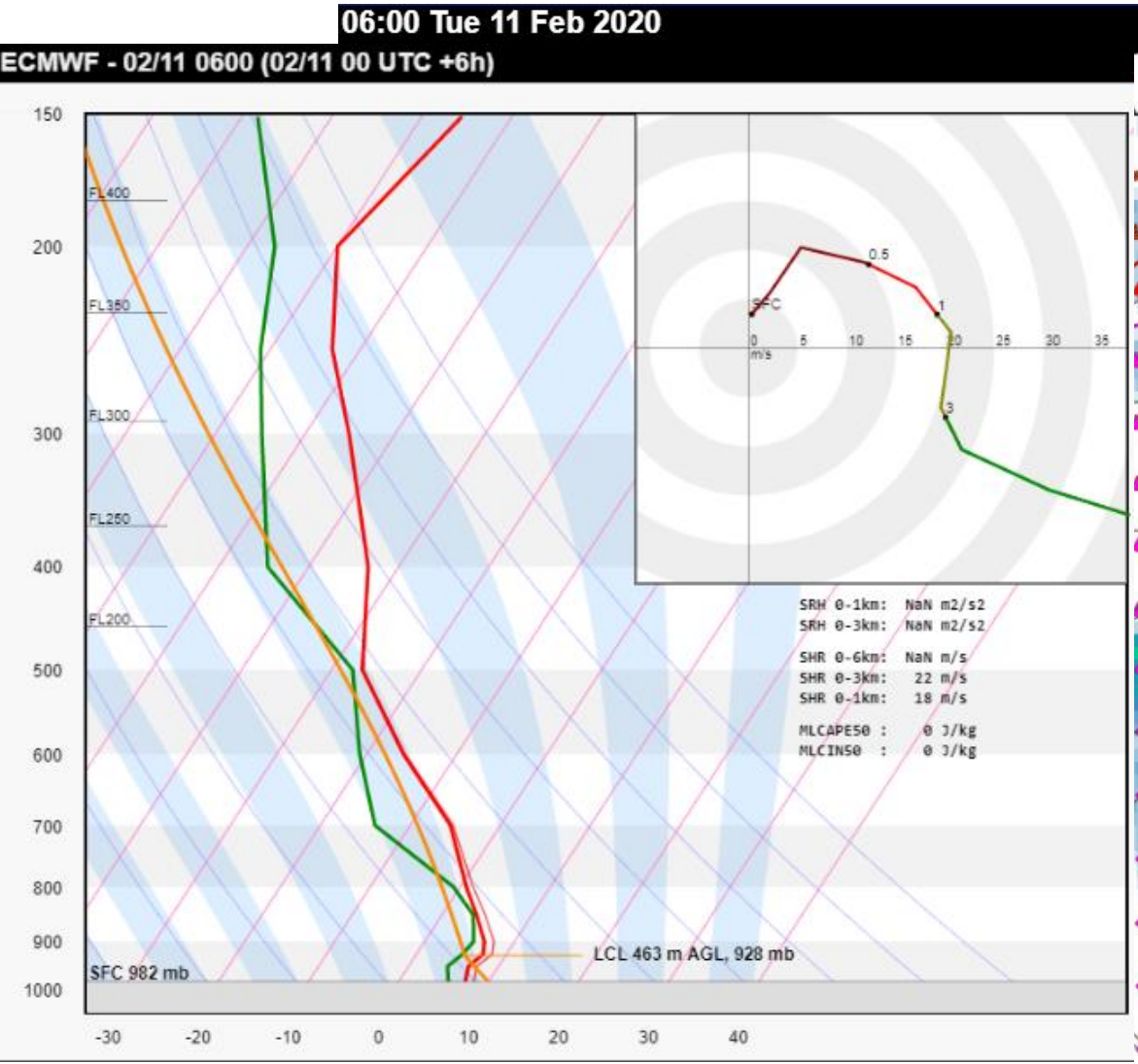
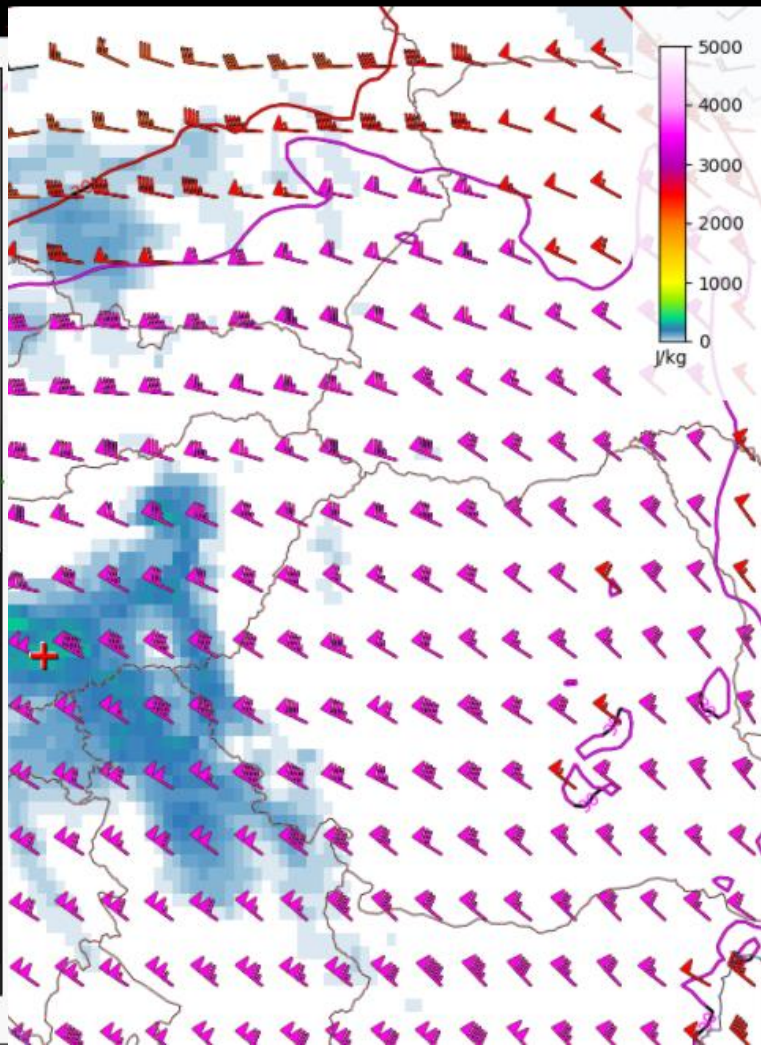


Elevated CAPE



Where does the „elevated“ parcel start?





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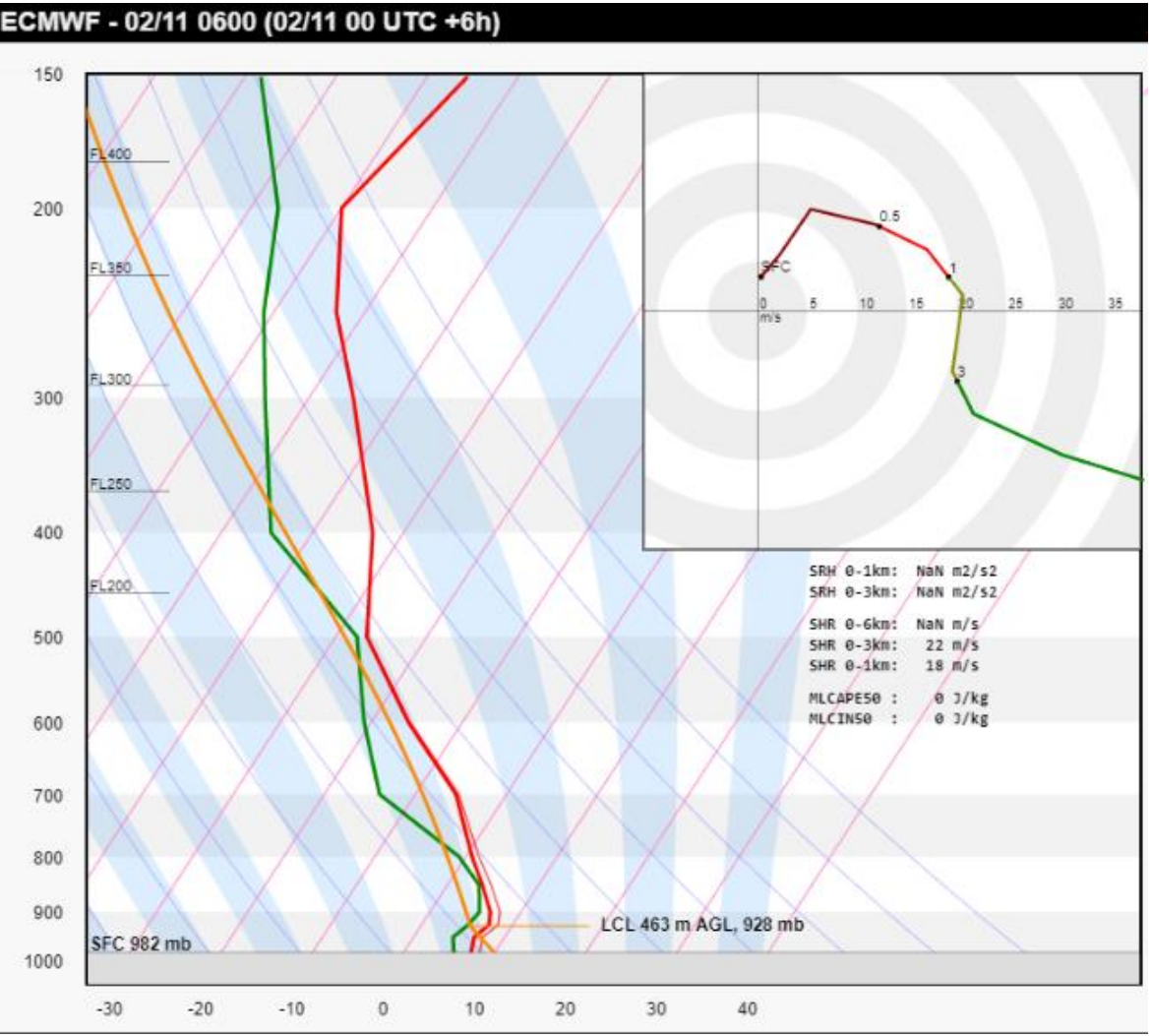

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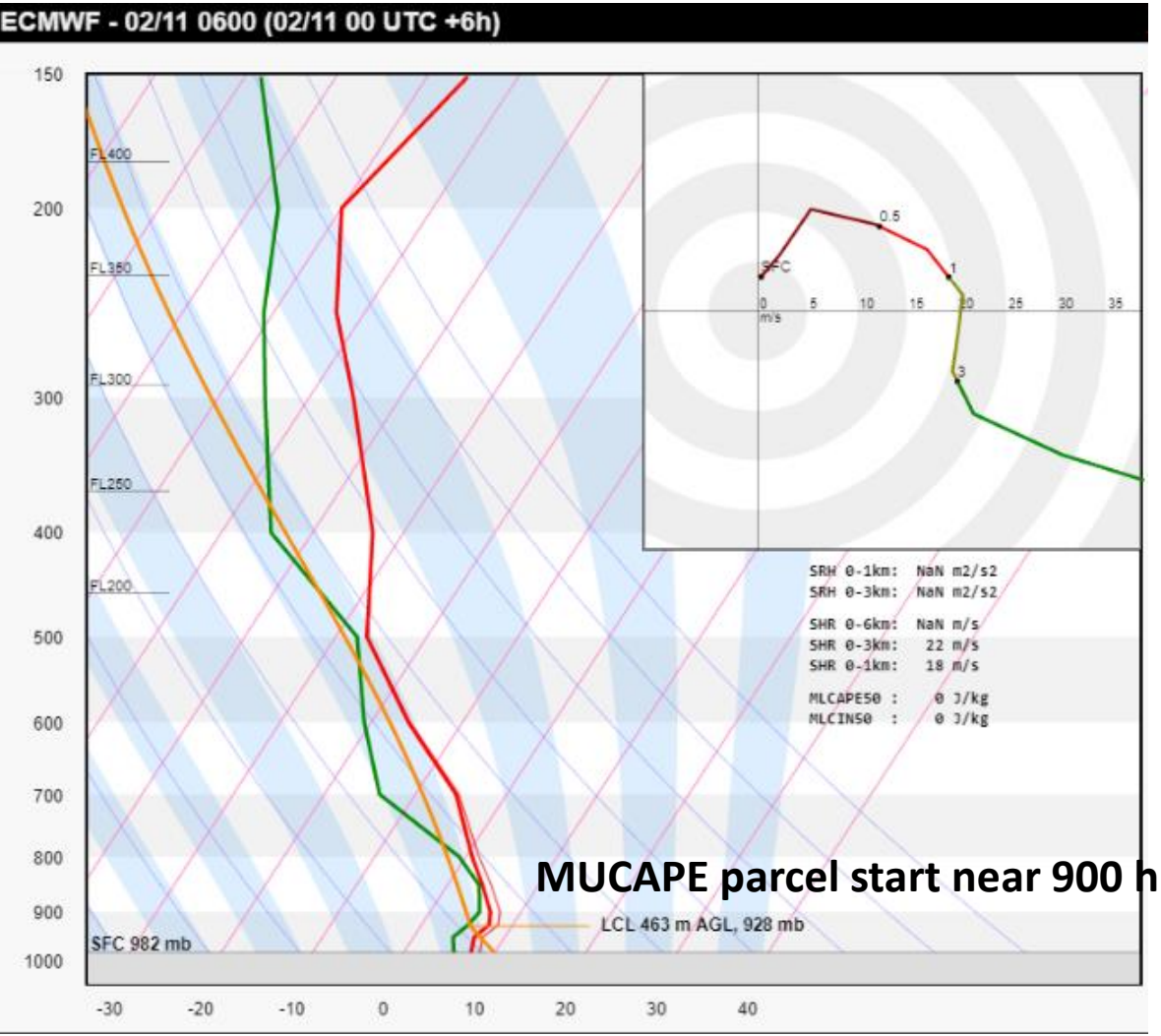

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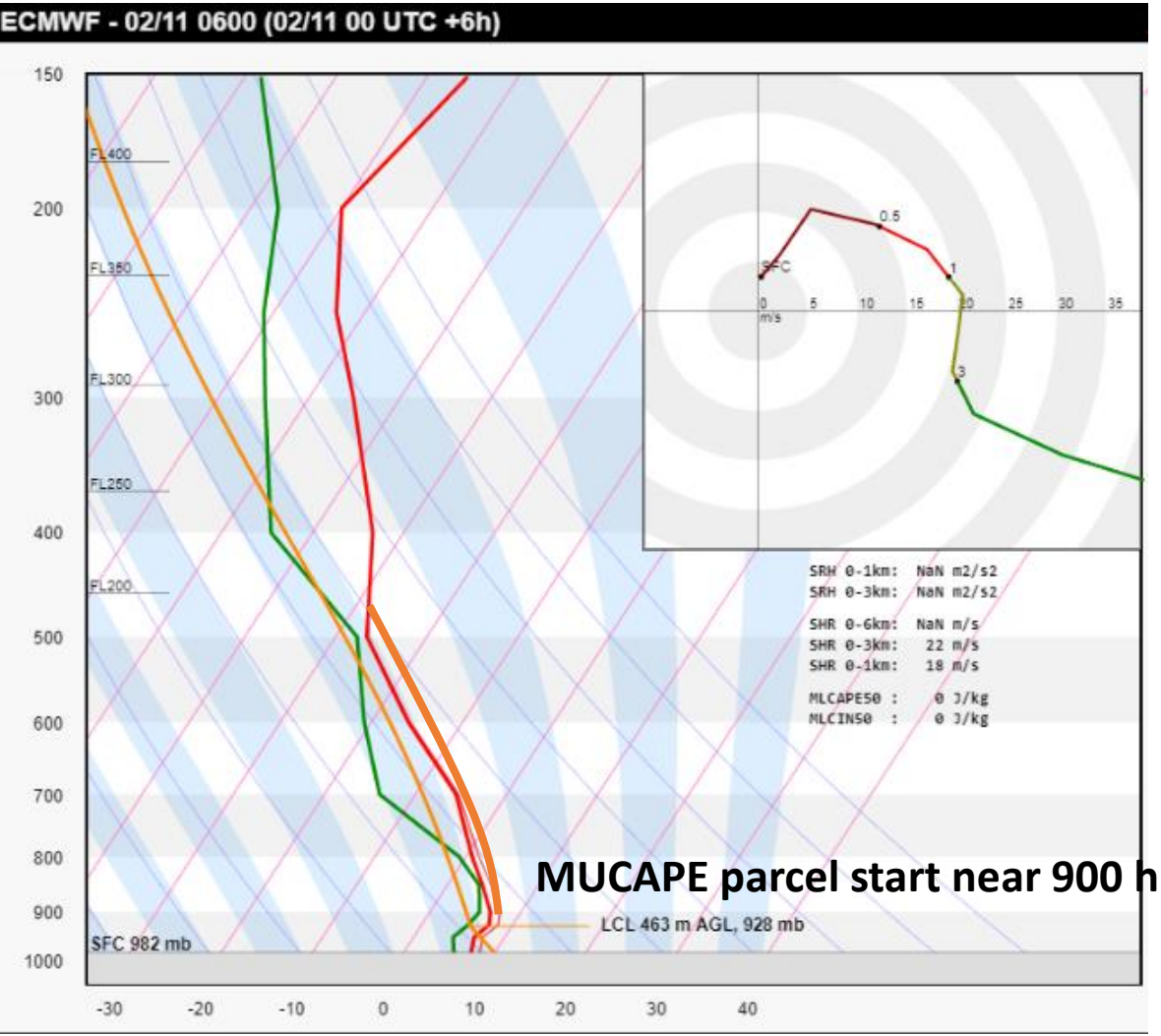
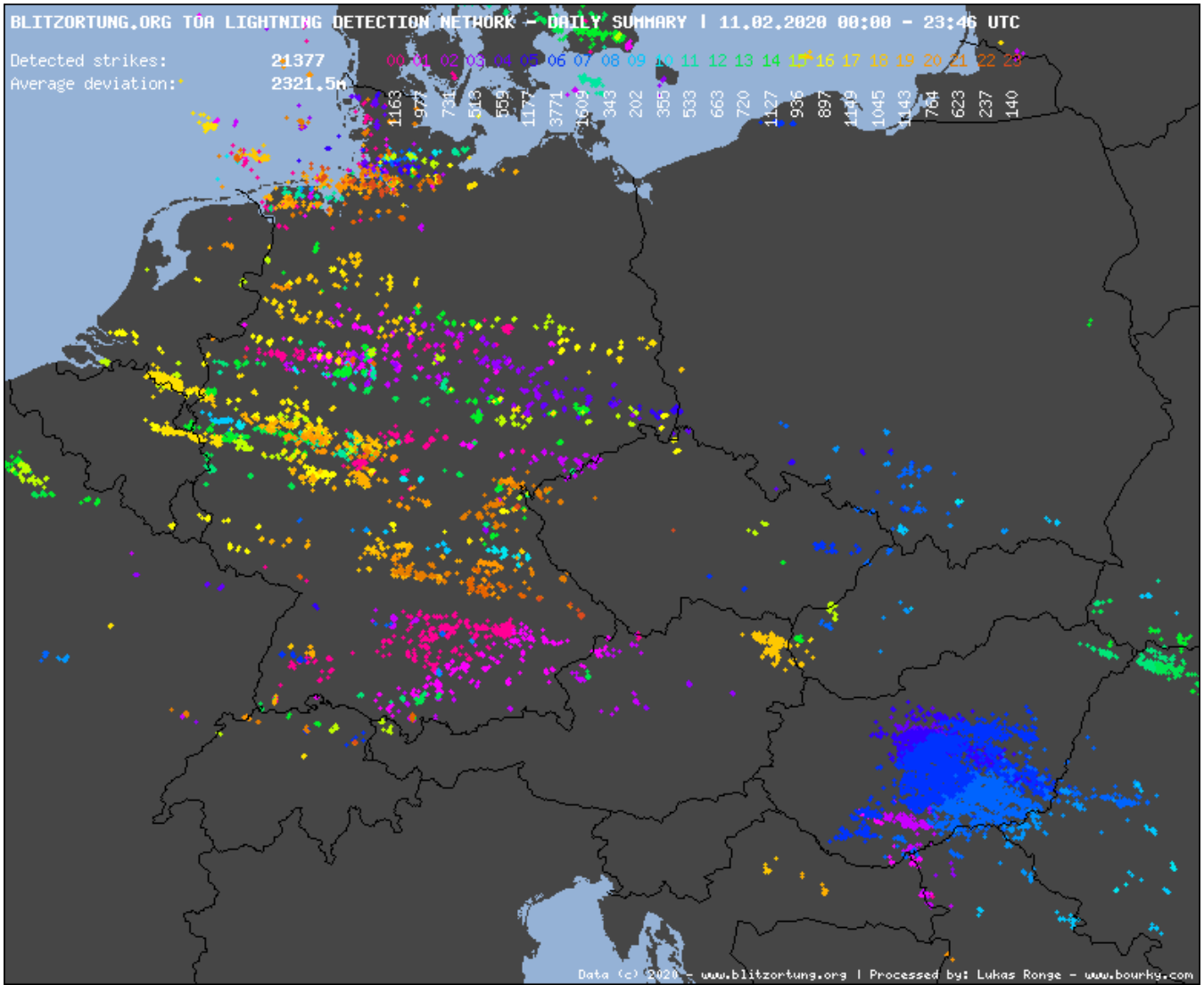
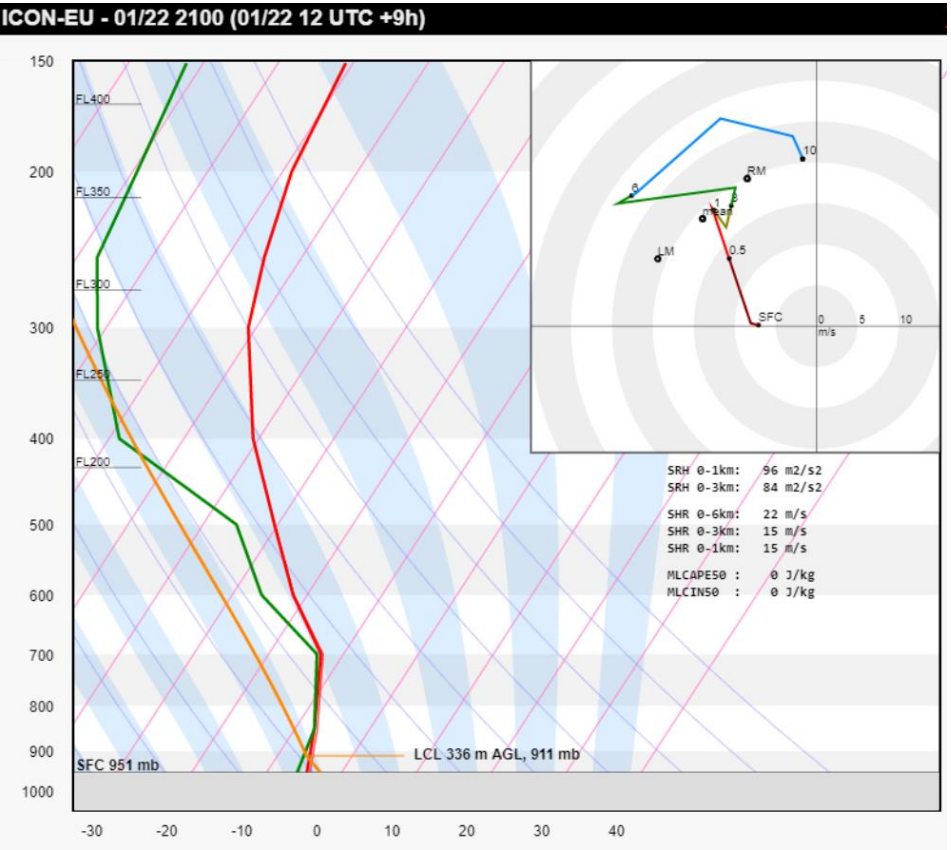
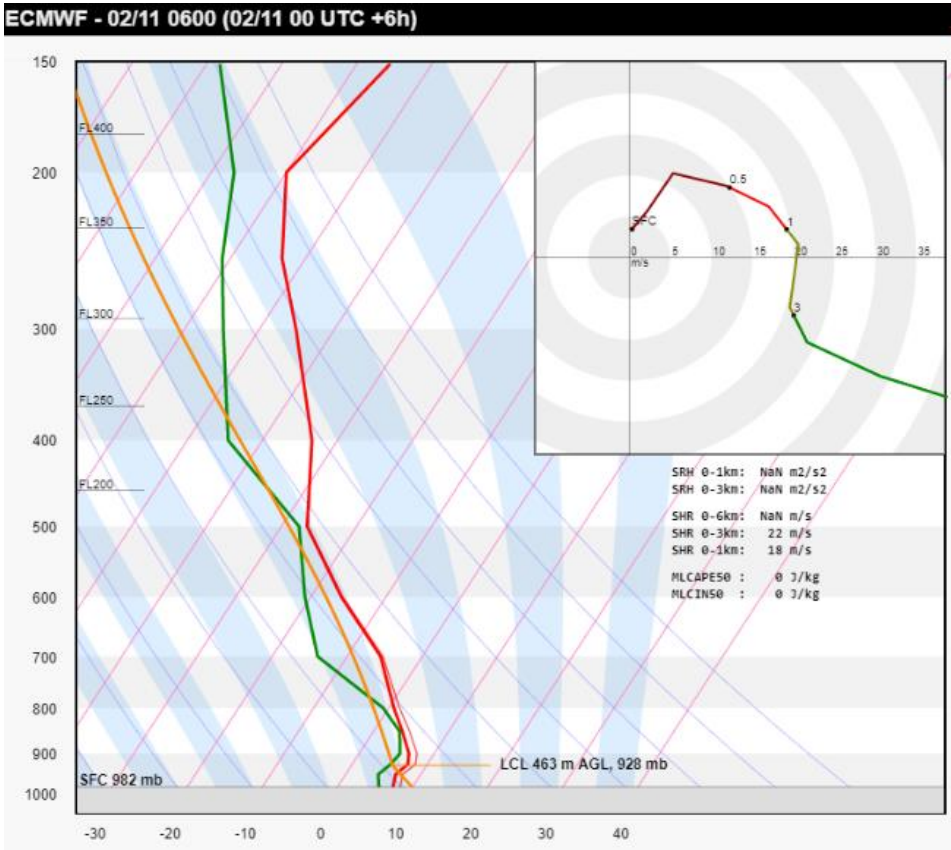


Outcome


BLITZORTUNG.ORG TOA LIGHTNING DETECTION NETWORK - DAILY SUMMARY | 11.02.2020 00:00 - 23:46 UTC
Detected strikes: 21377
Average deviation: 2321.5m
00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23
1163 977 731 515 559 1177 3771 1609 343 202 355 533 663 720 1127 936 897 1449 1045 1143 764 623 237 140
Data (c) 2020 - www.blitzortung.org | Processed by: Lukas Ronge - www.bourbg.com

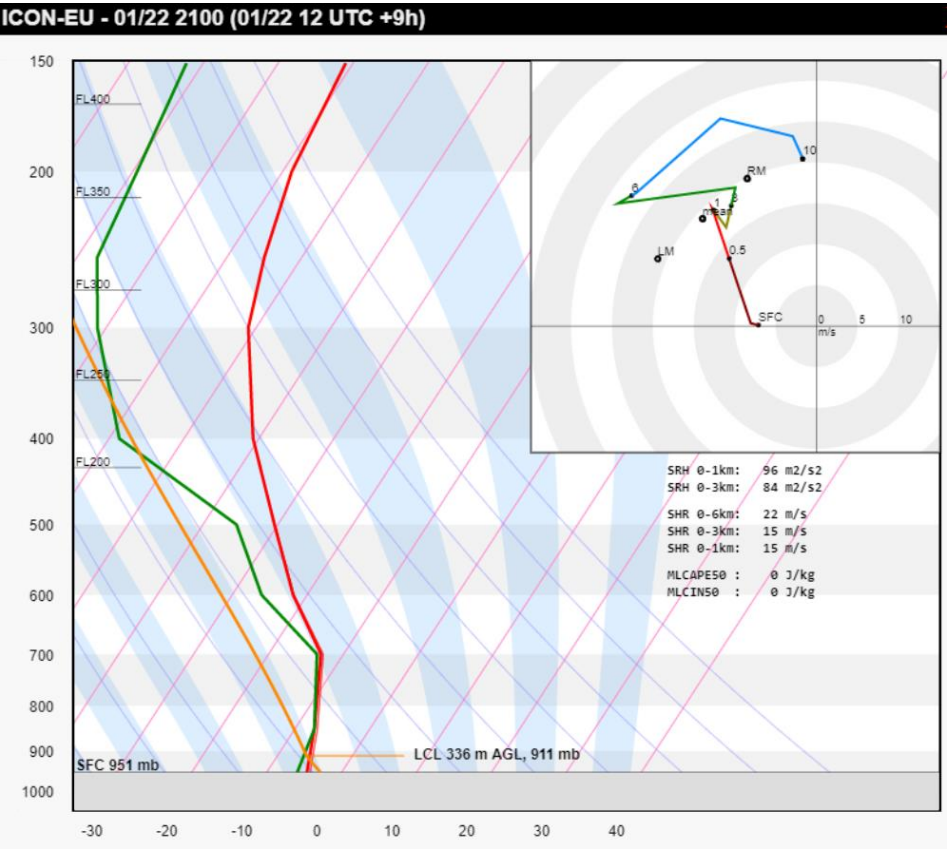
What do these have in common?

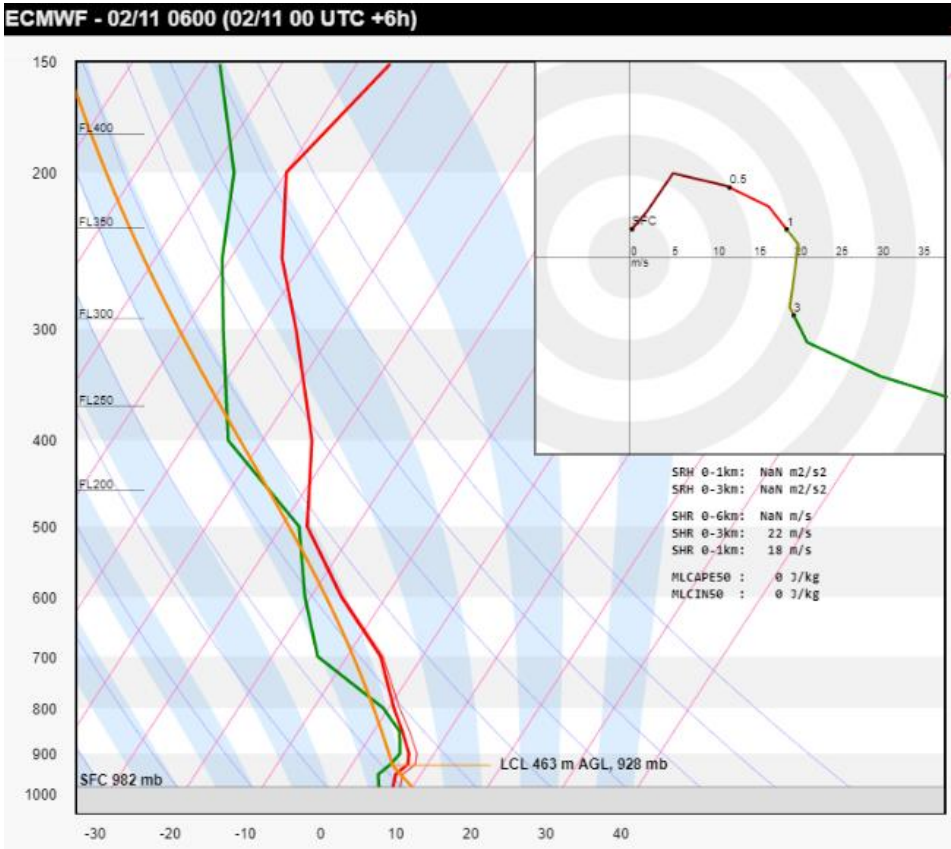




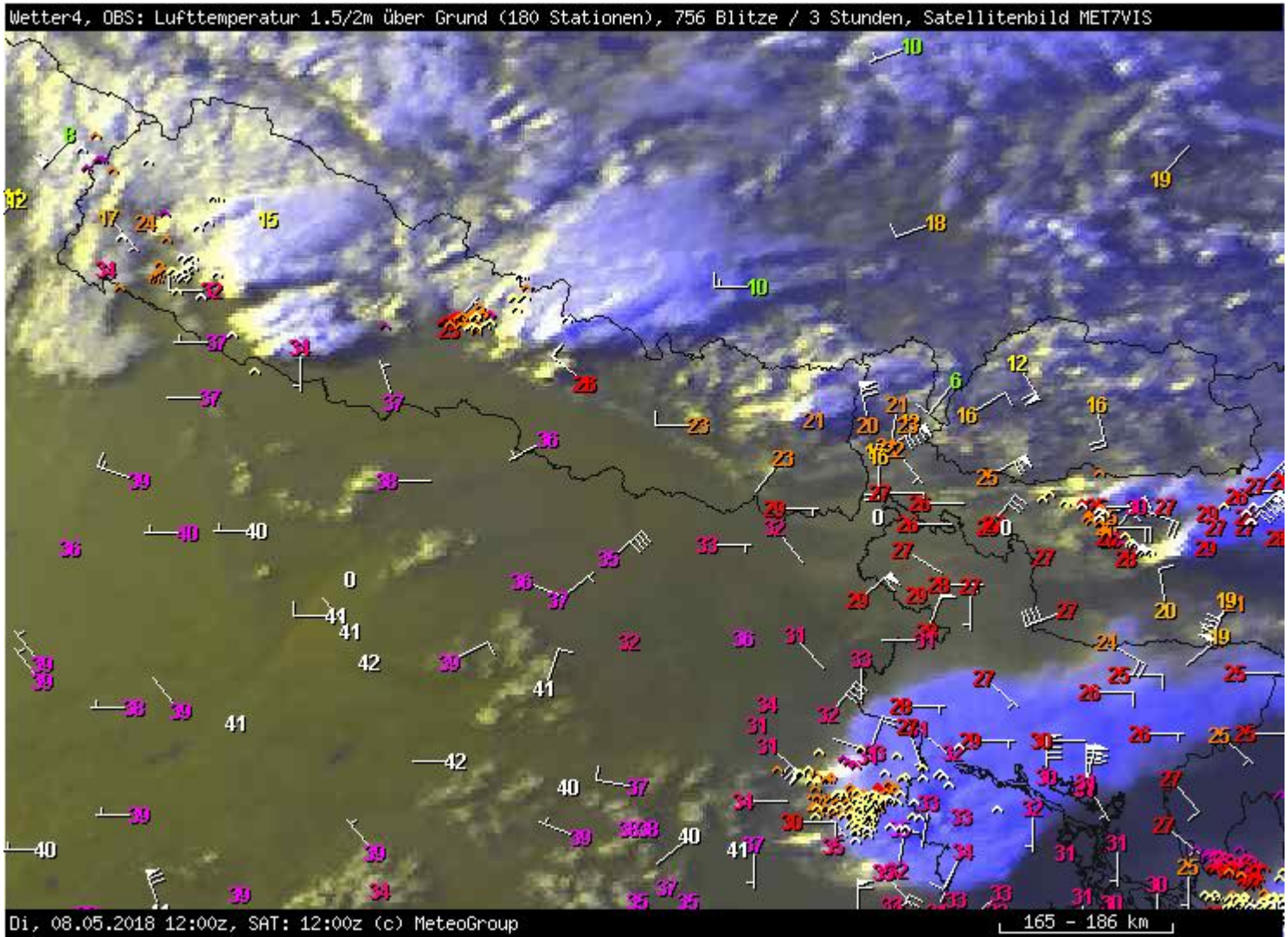
What do these have in common?

Steepest lapse rates and MUCAPE can be found in the typical charge separation zone





Thundersnow at Mt. Everest



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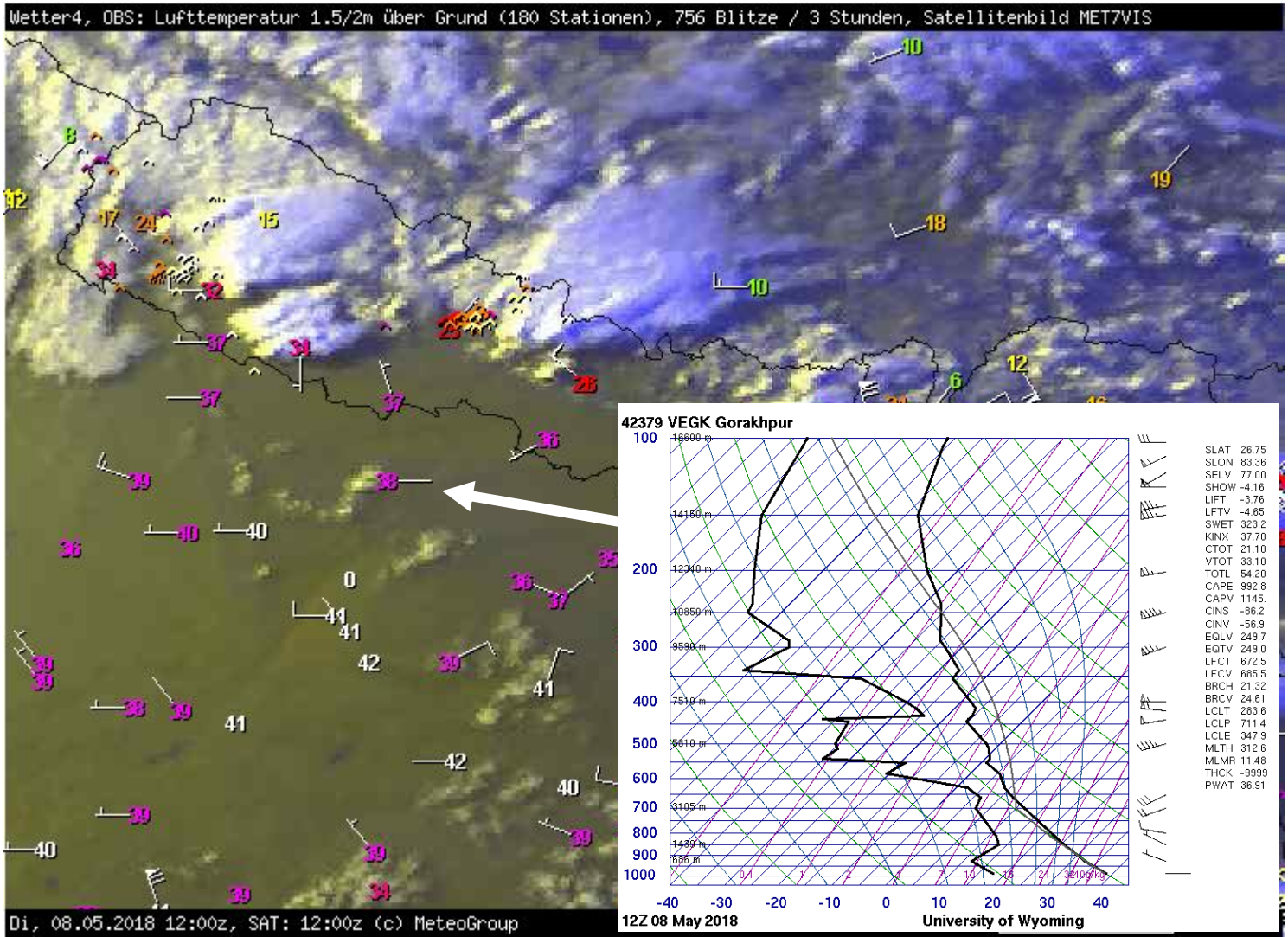

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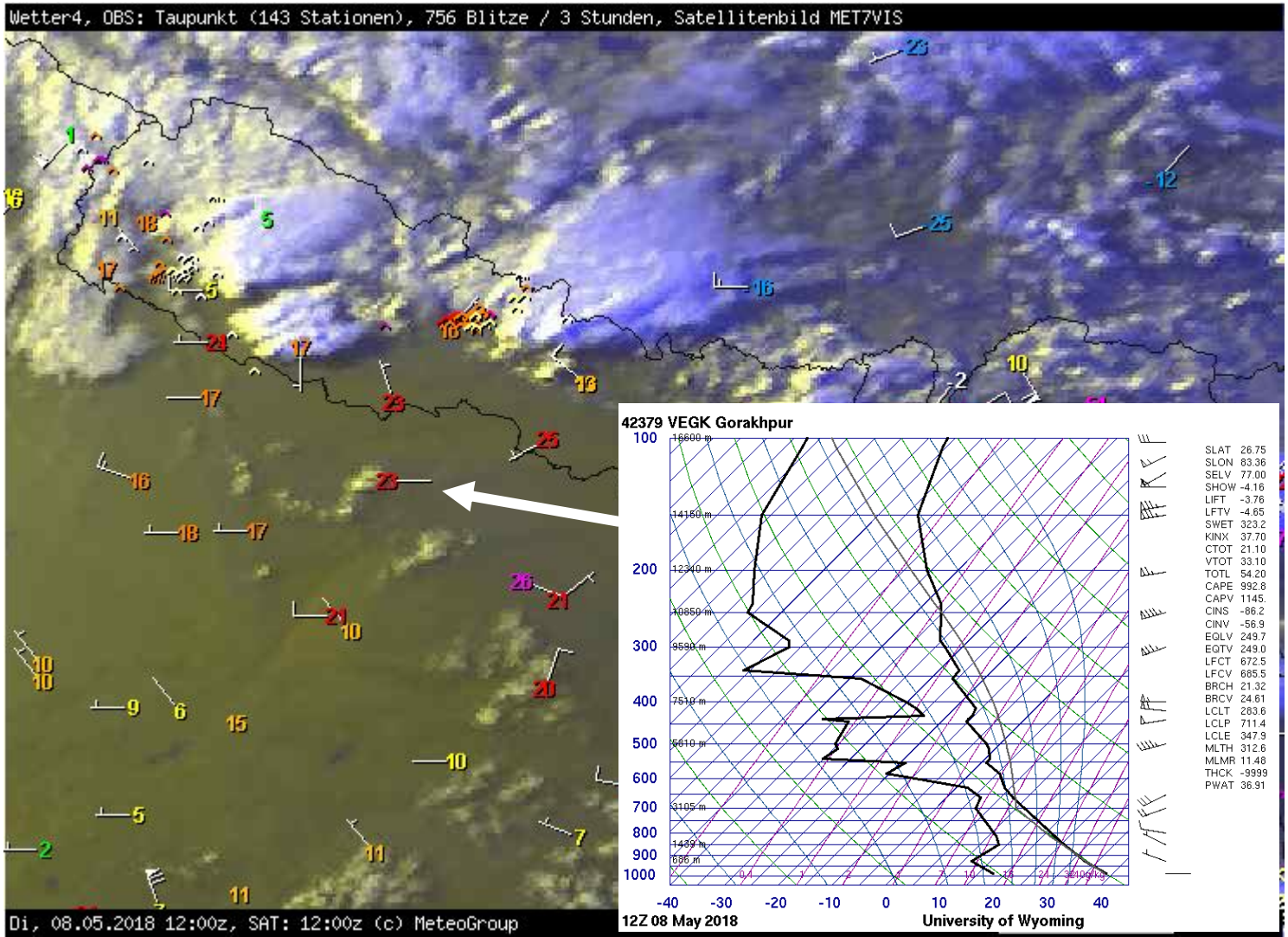

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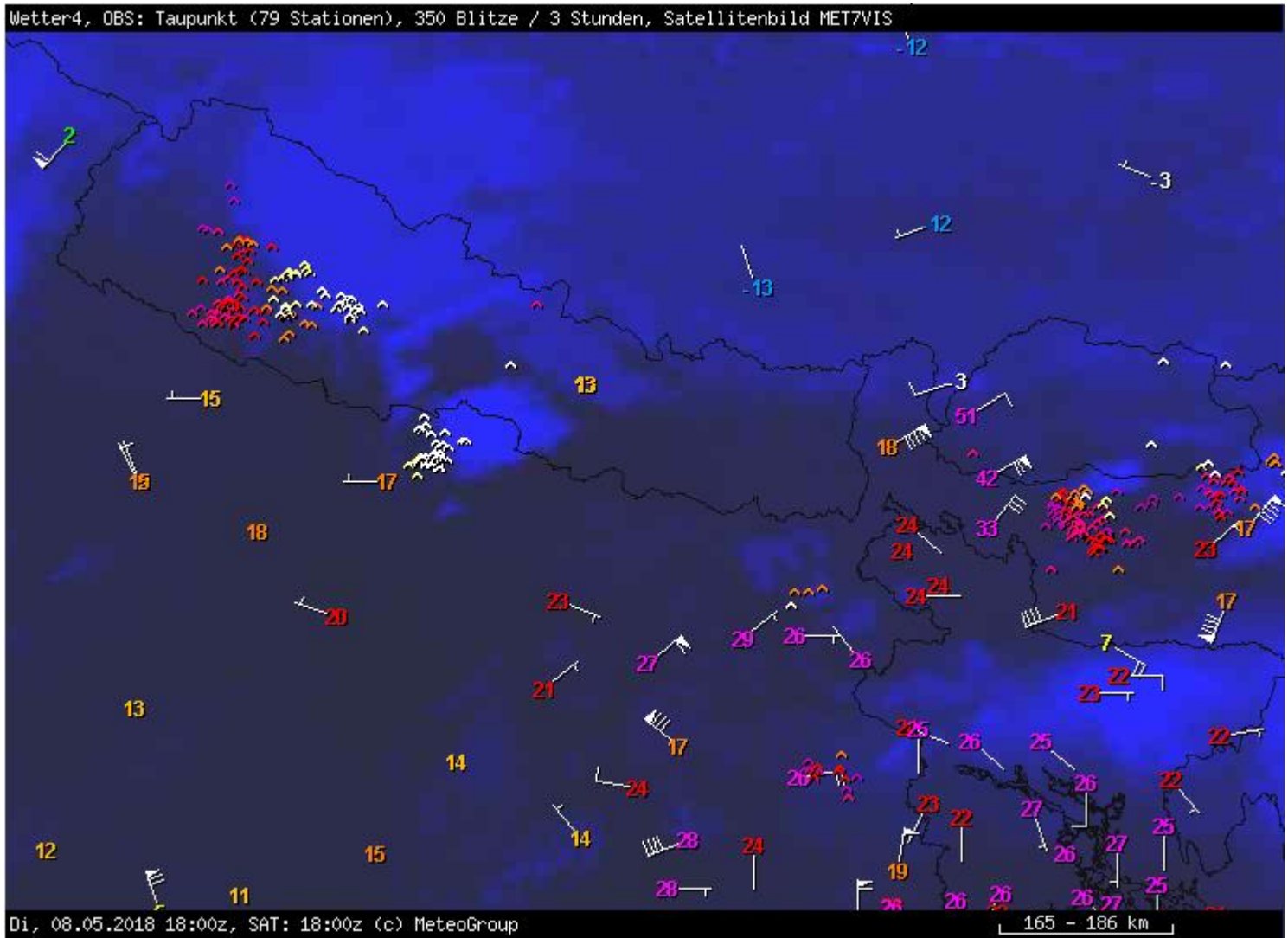

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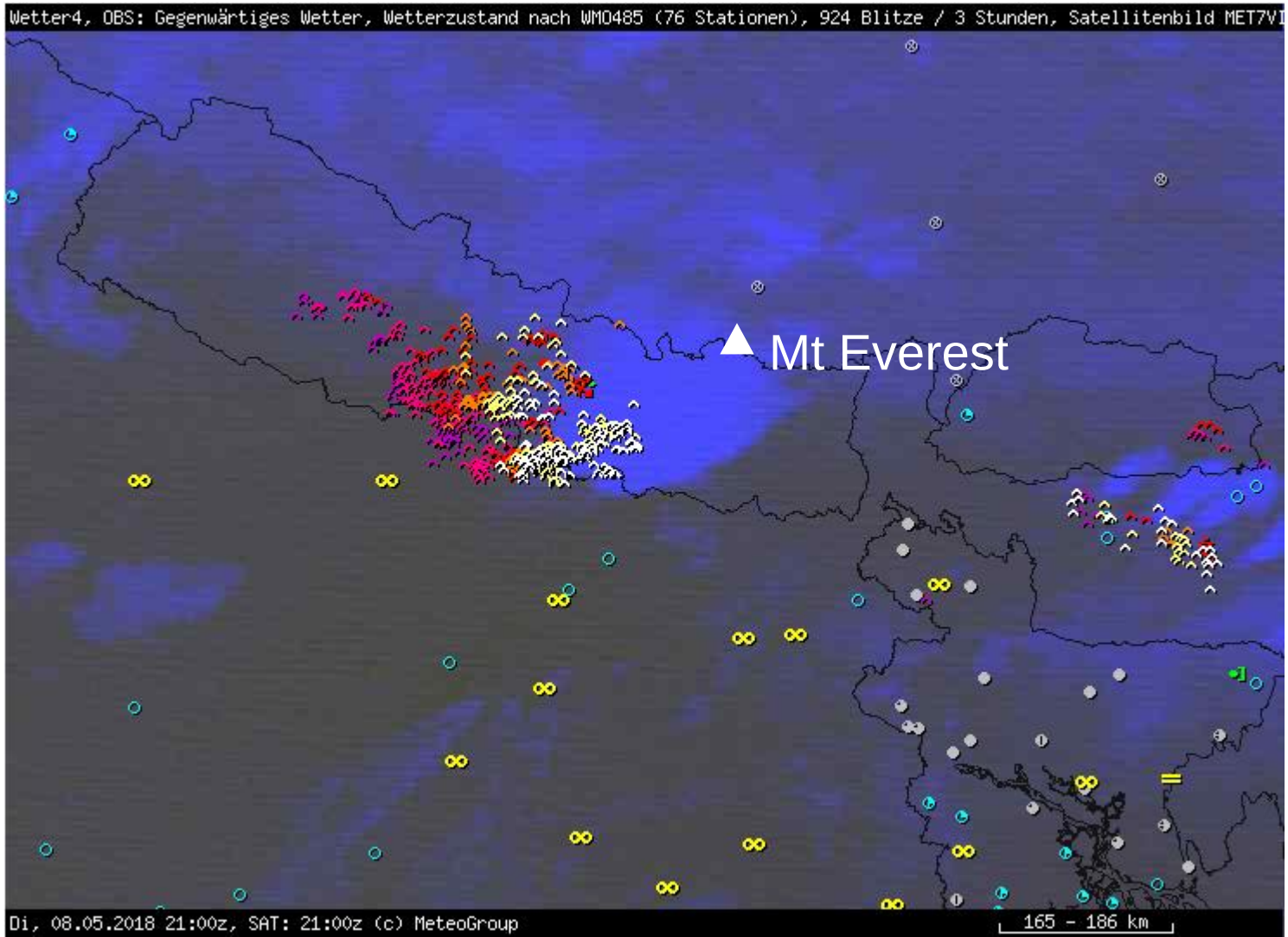

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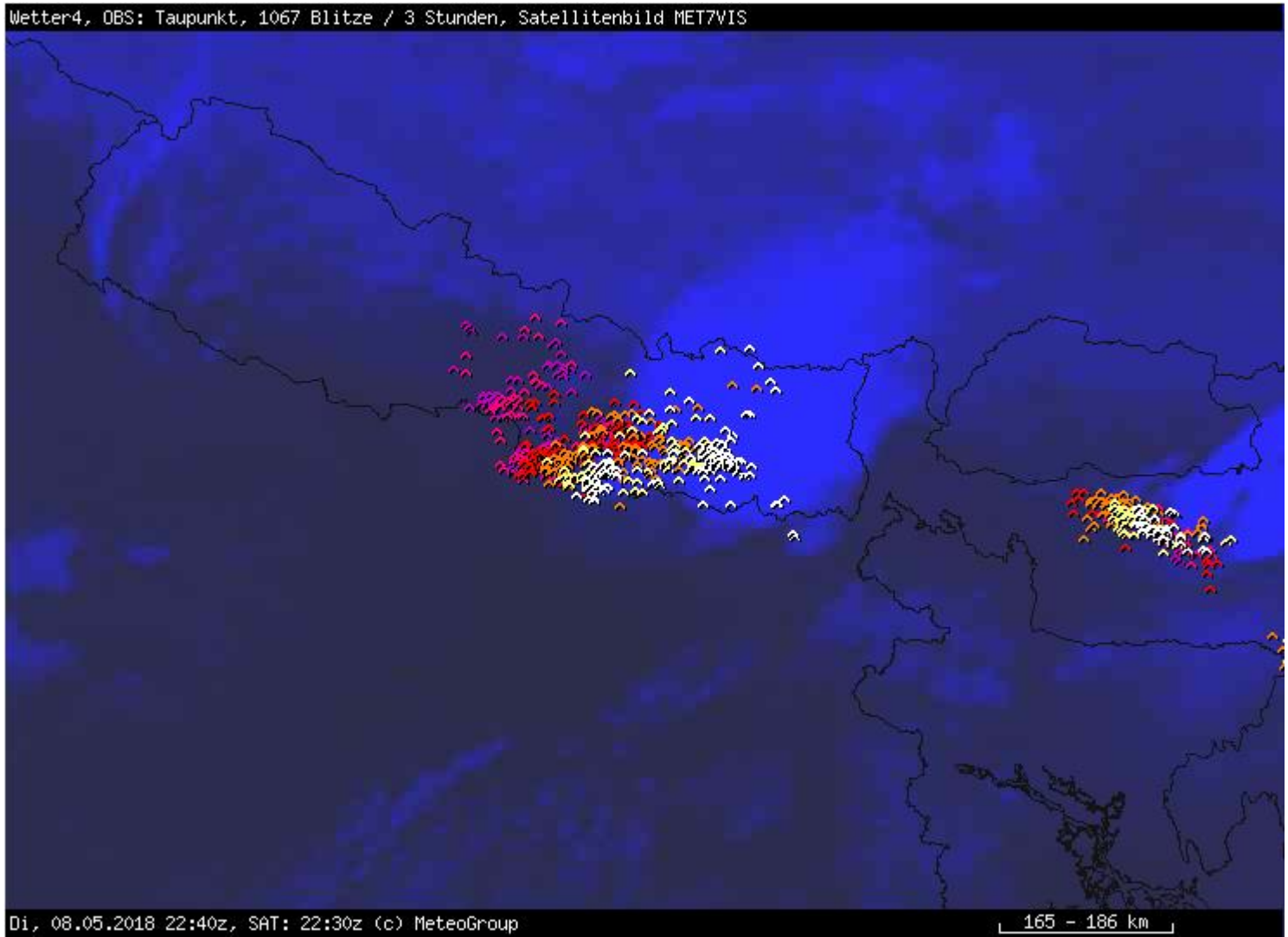

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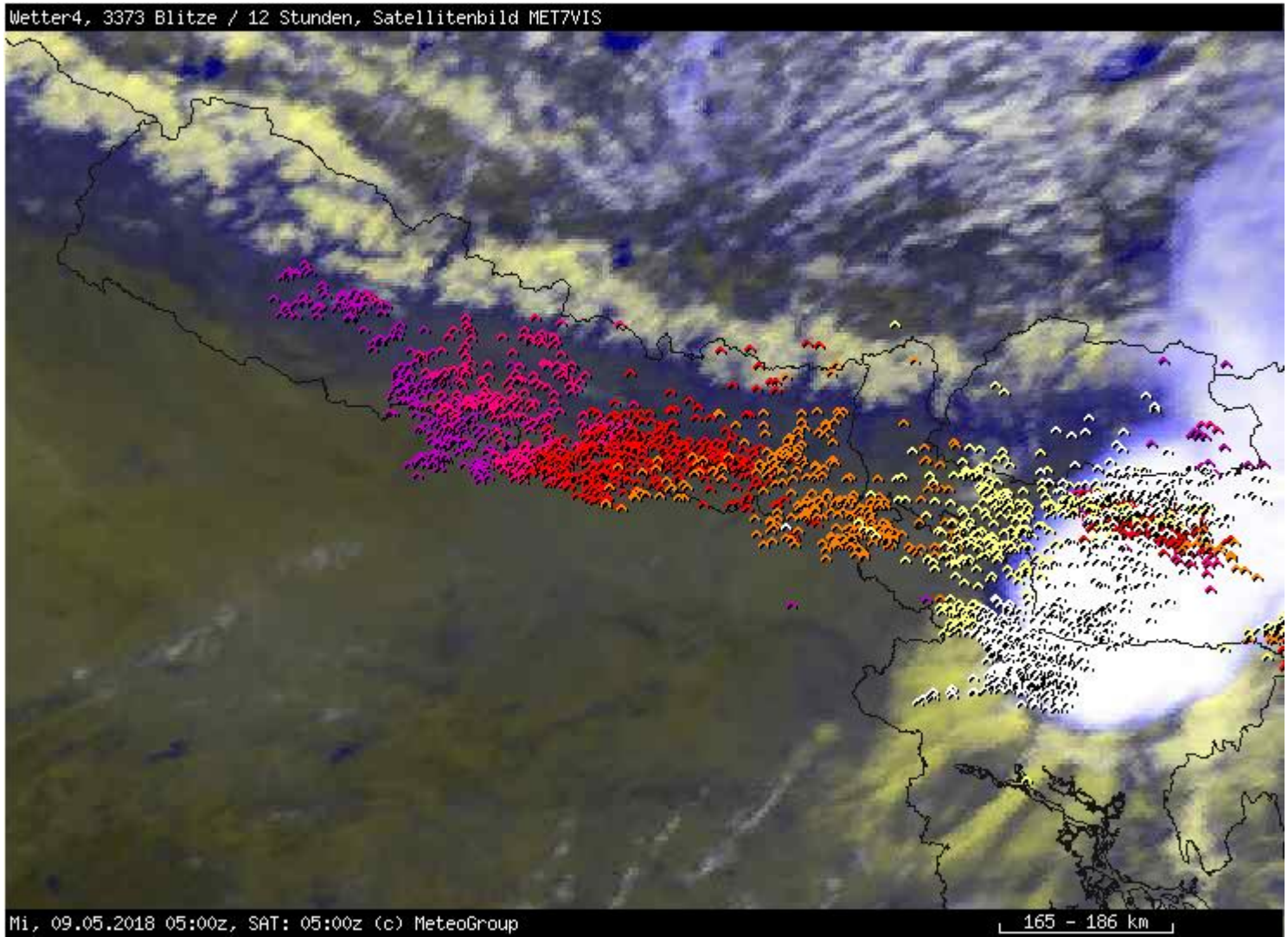
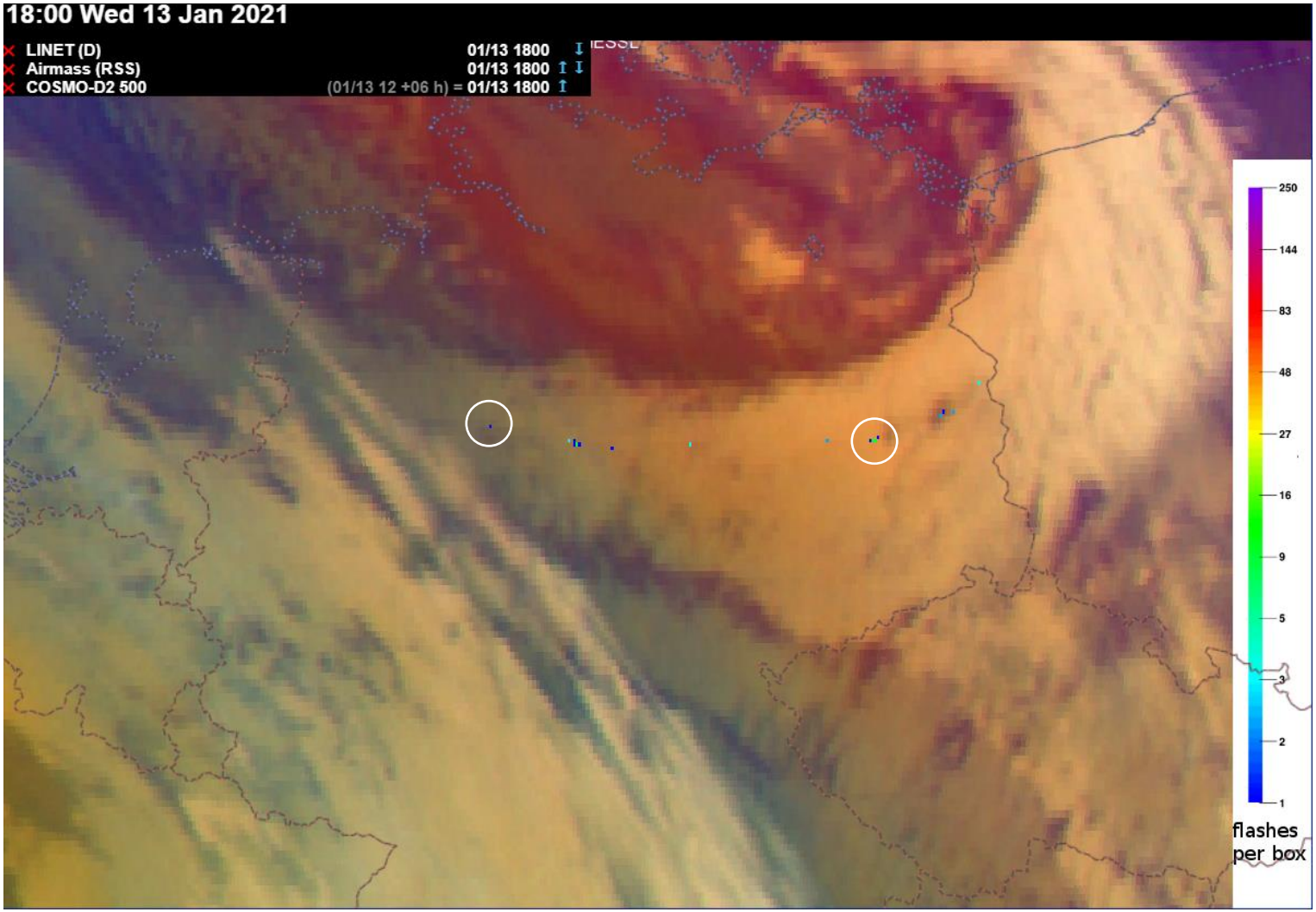


High-shear, low-CAPE thundersnow



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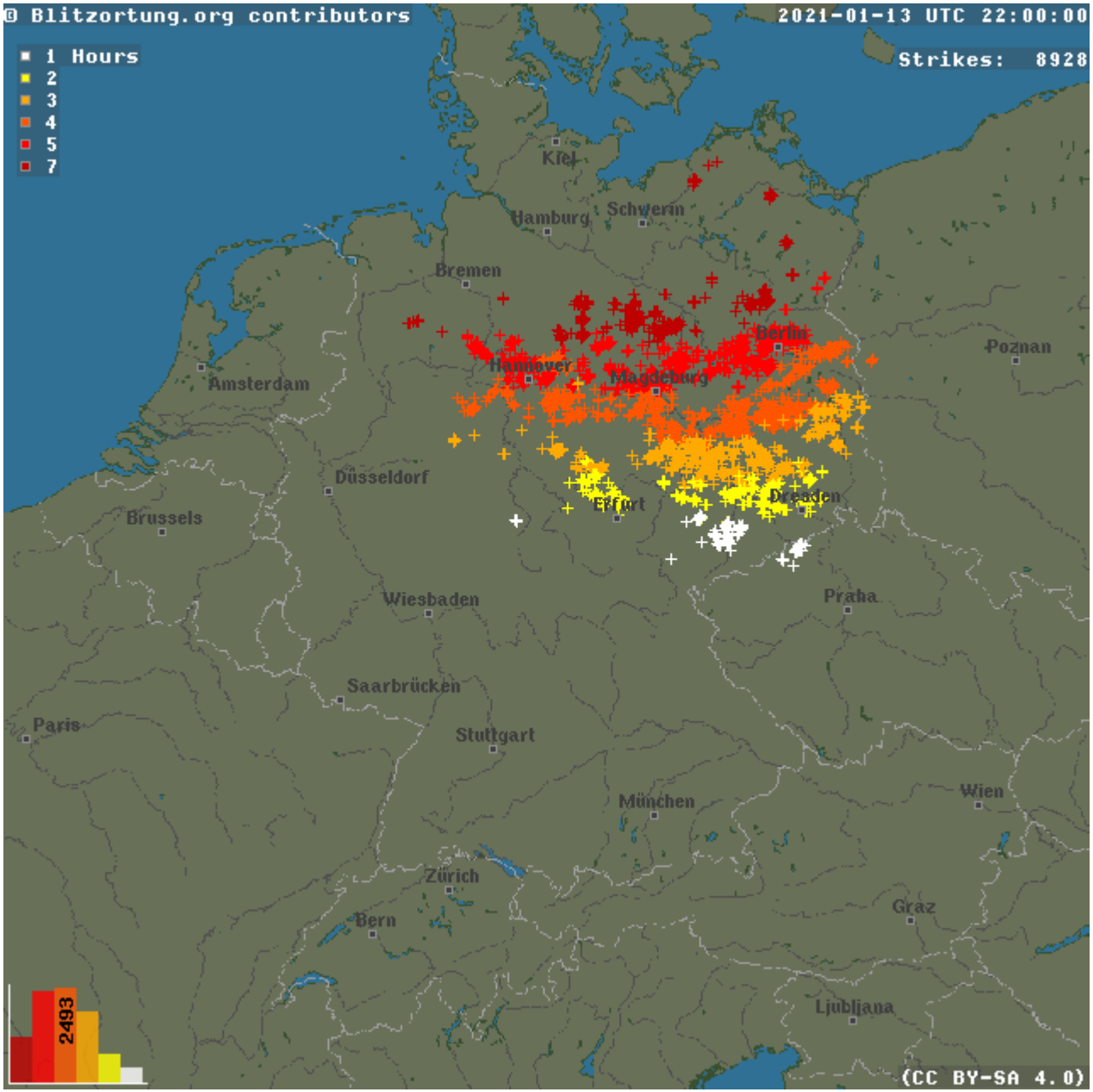
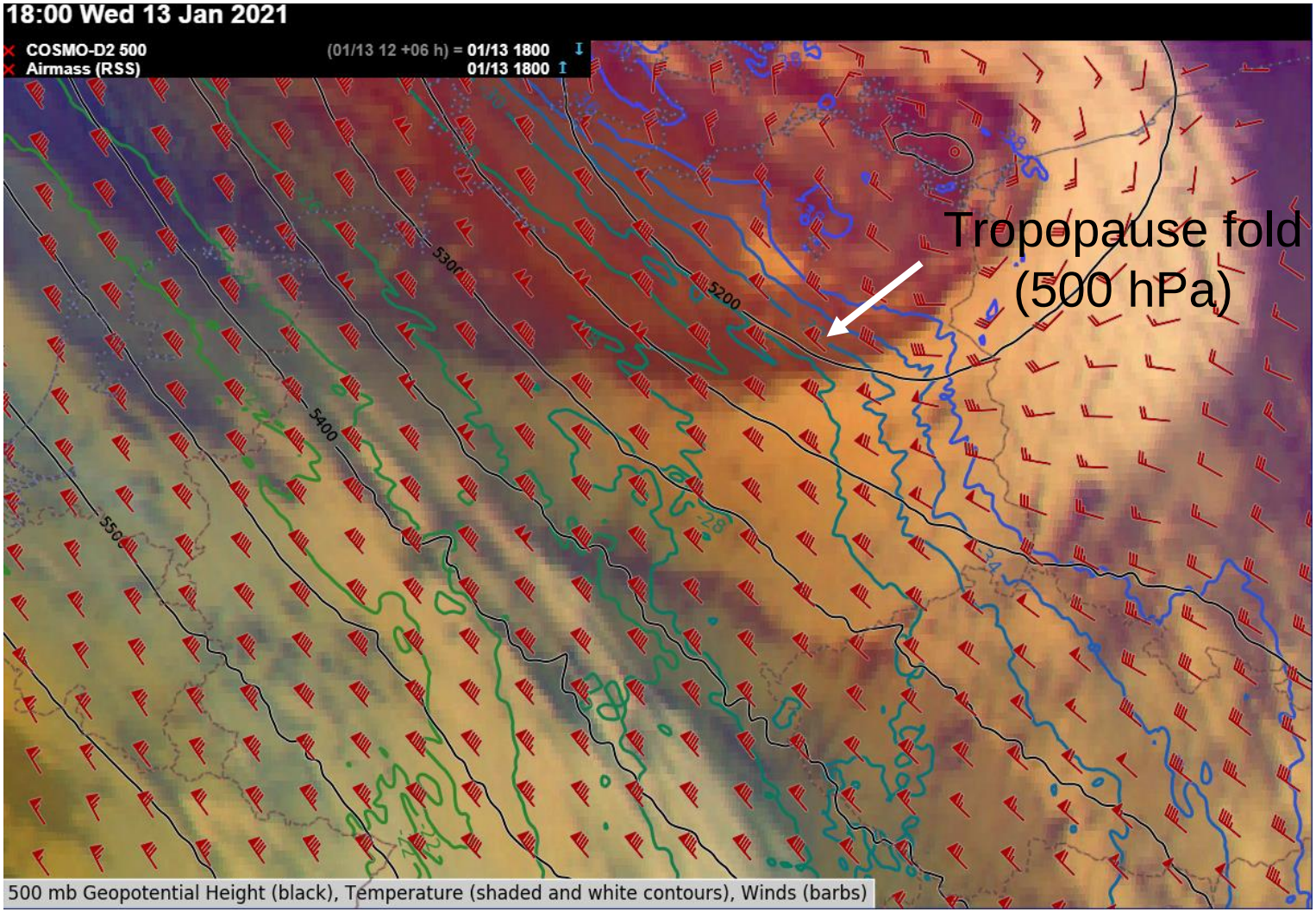
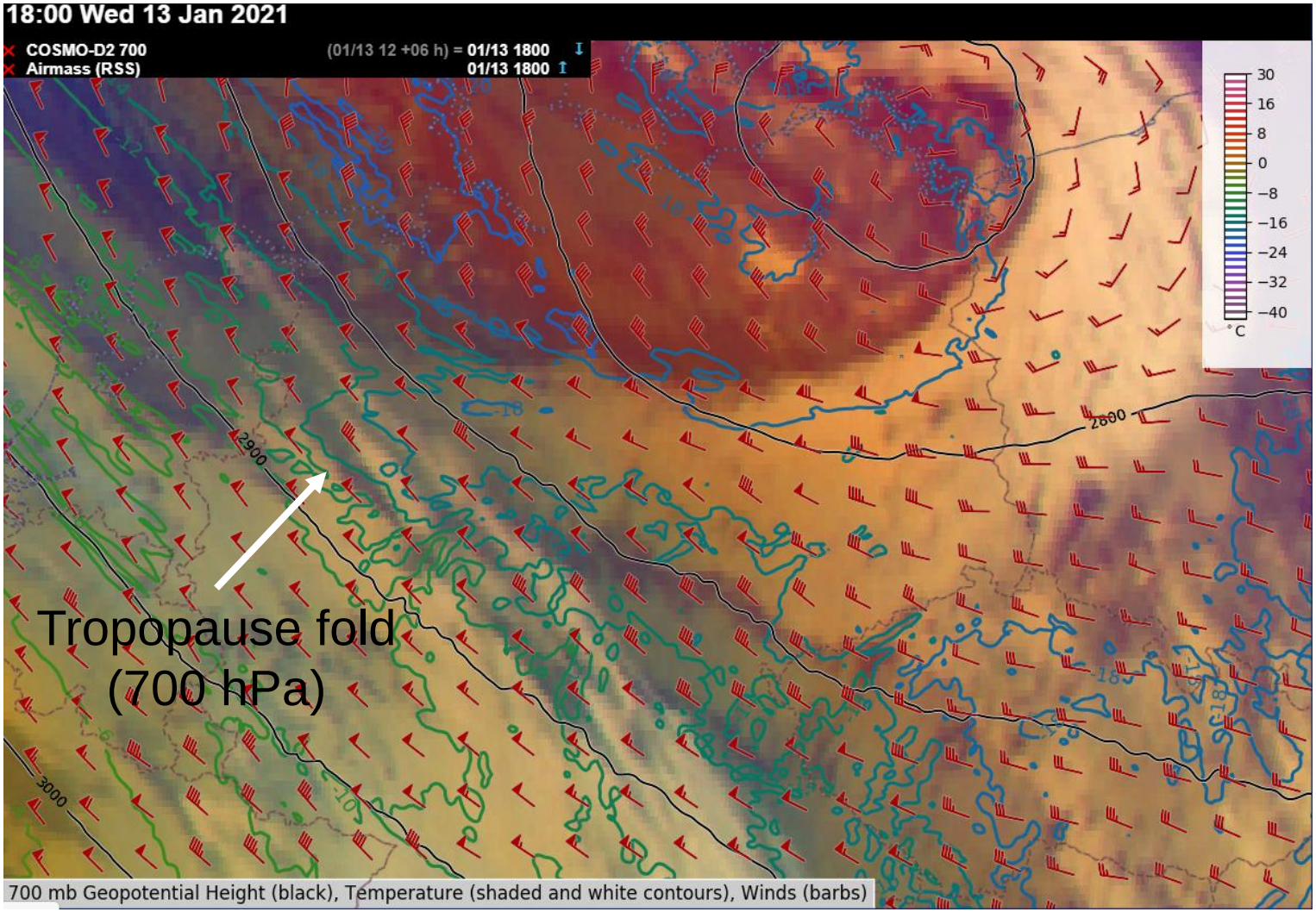


High-shear, low-CAPE thundersnow



High-shear, low-CAPE thundersnow



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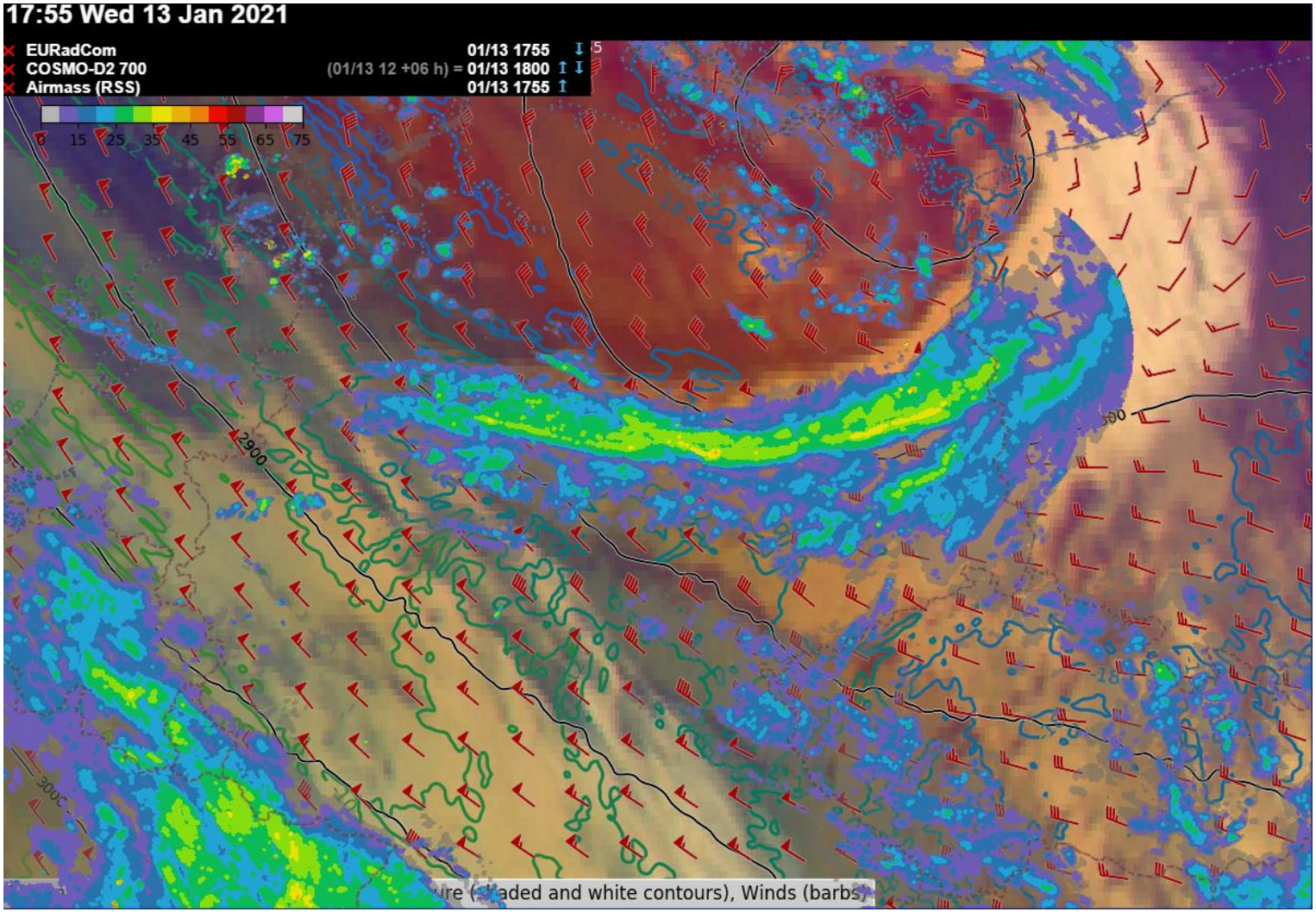

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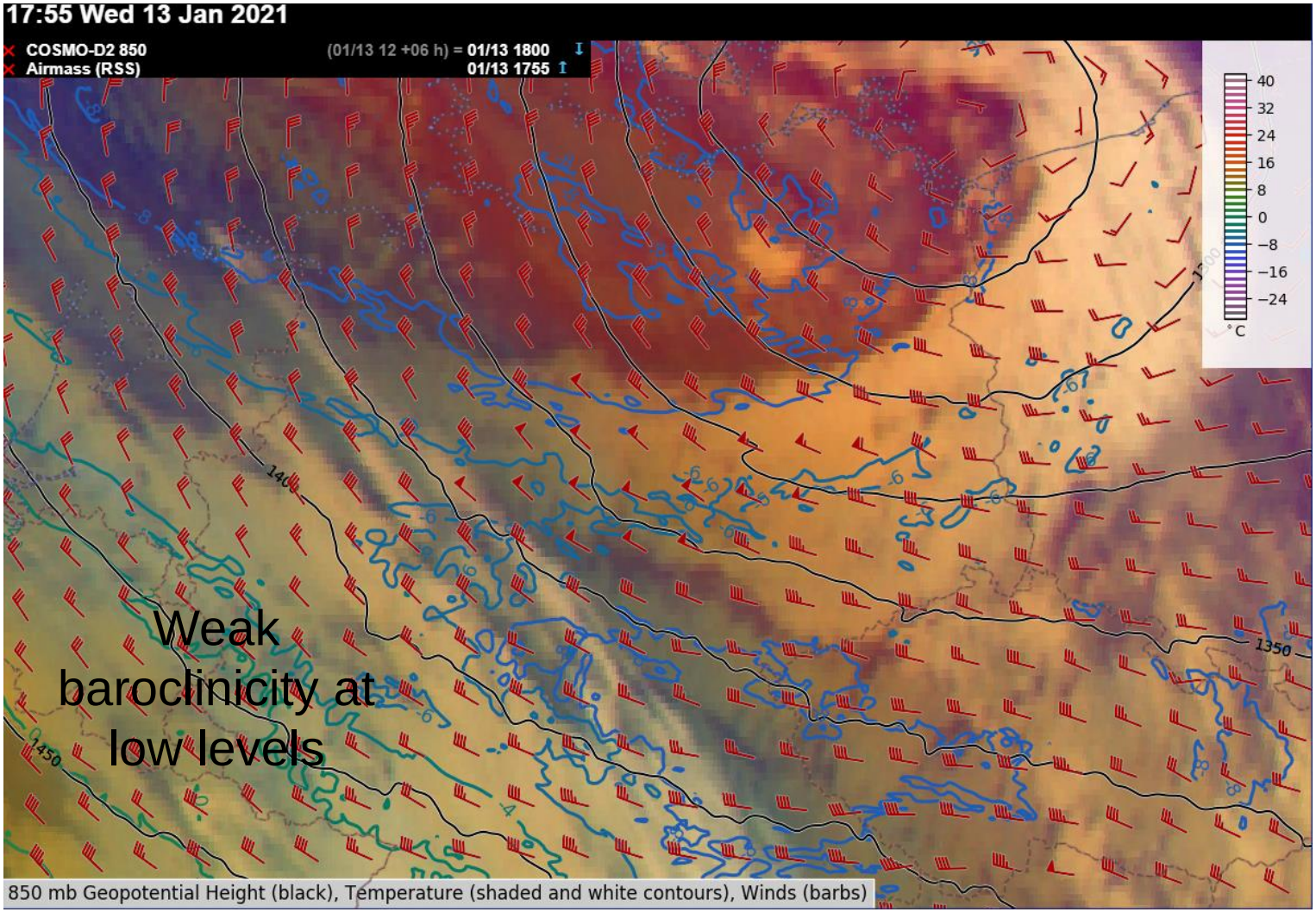

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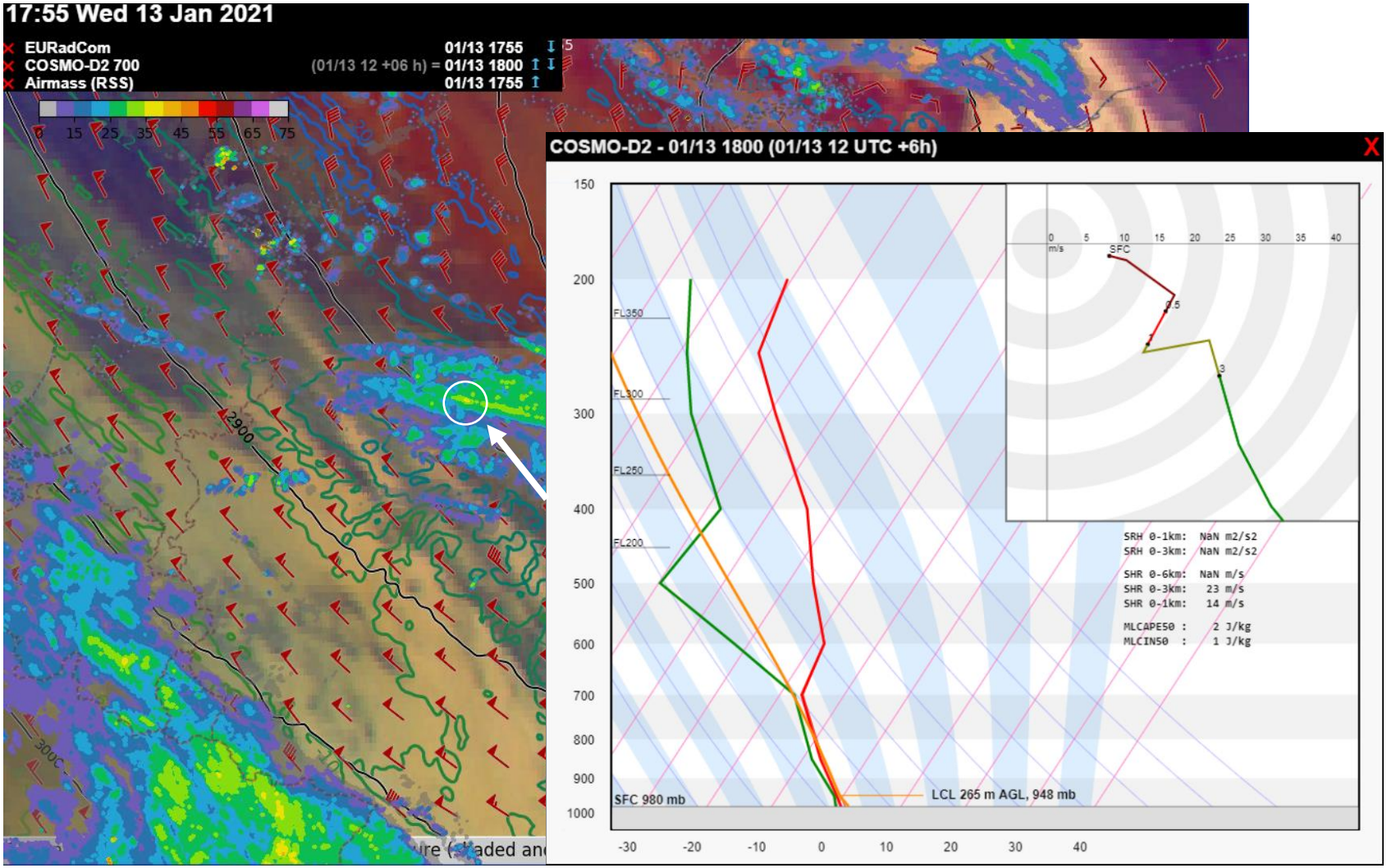

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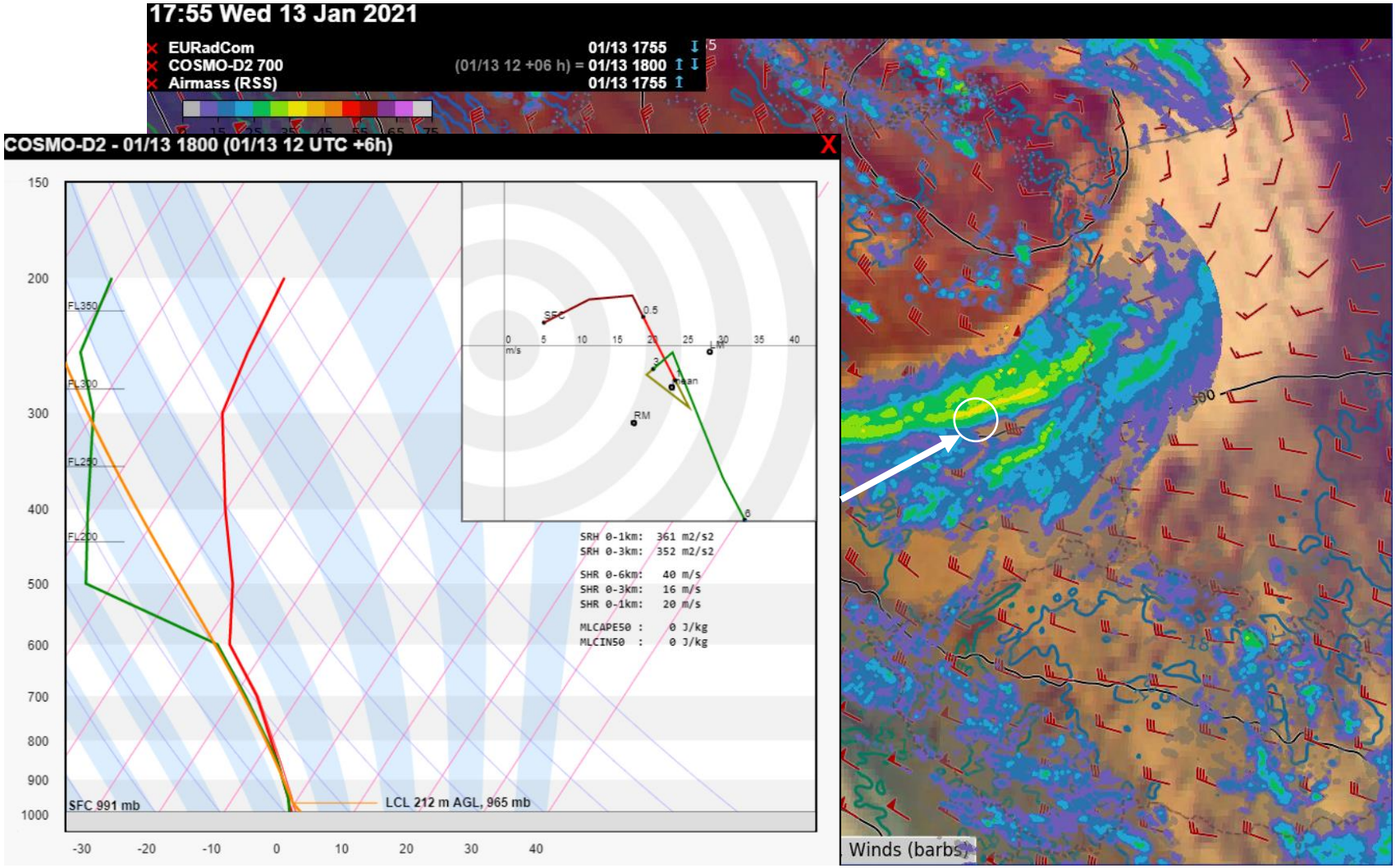
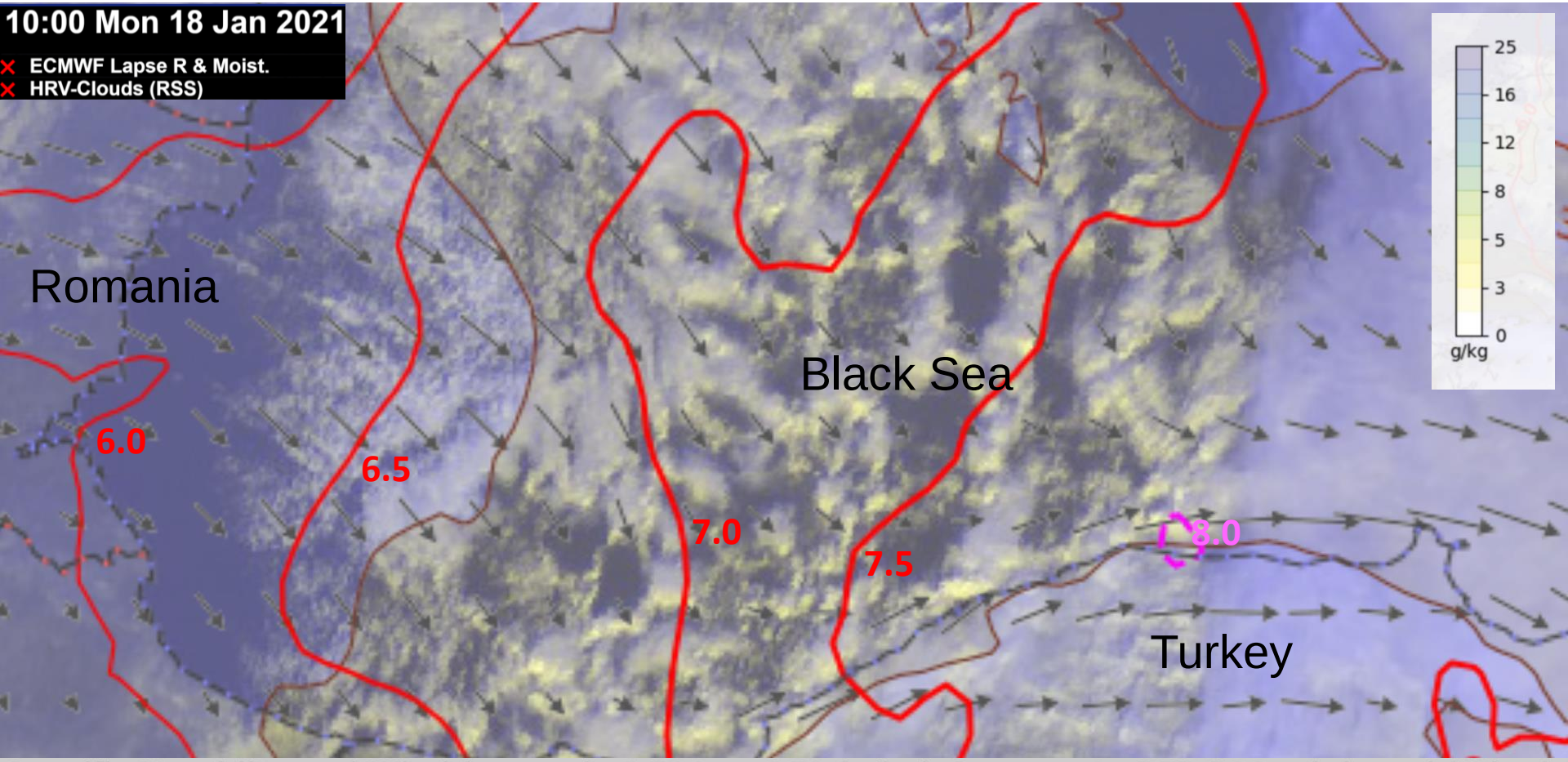
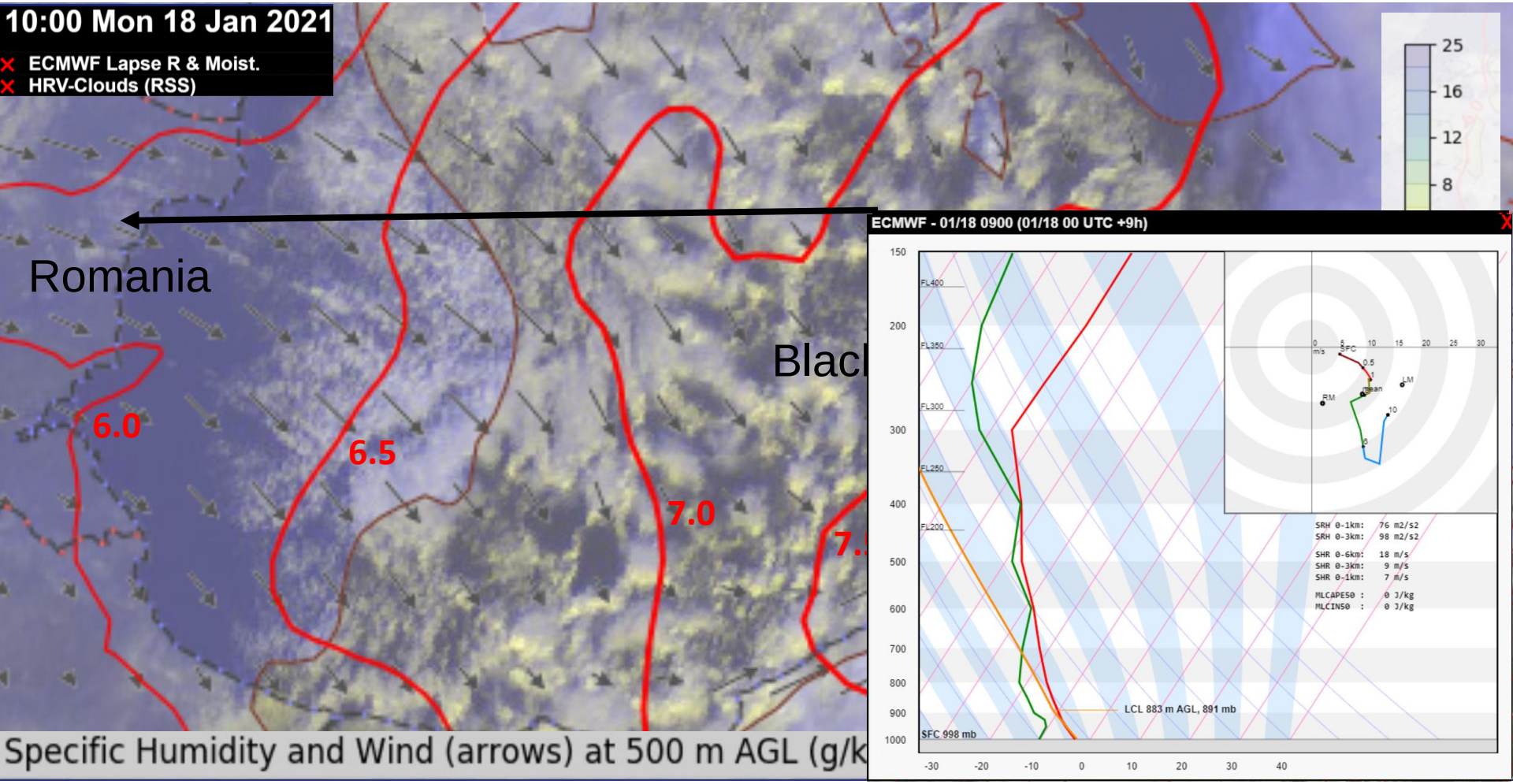


Lake Effect Thundersnow



Specific Humidity and Wind (arrows) at 500 m AGL (g/kg), Lapse rate 850-500 mb in red (K/km).

Lake Effect Thundersnow



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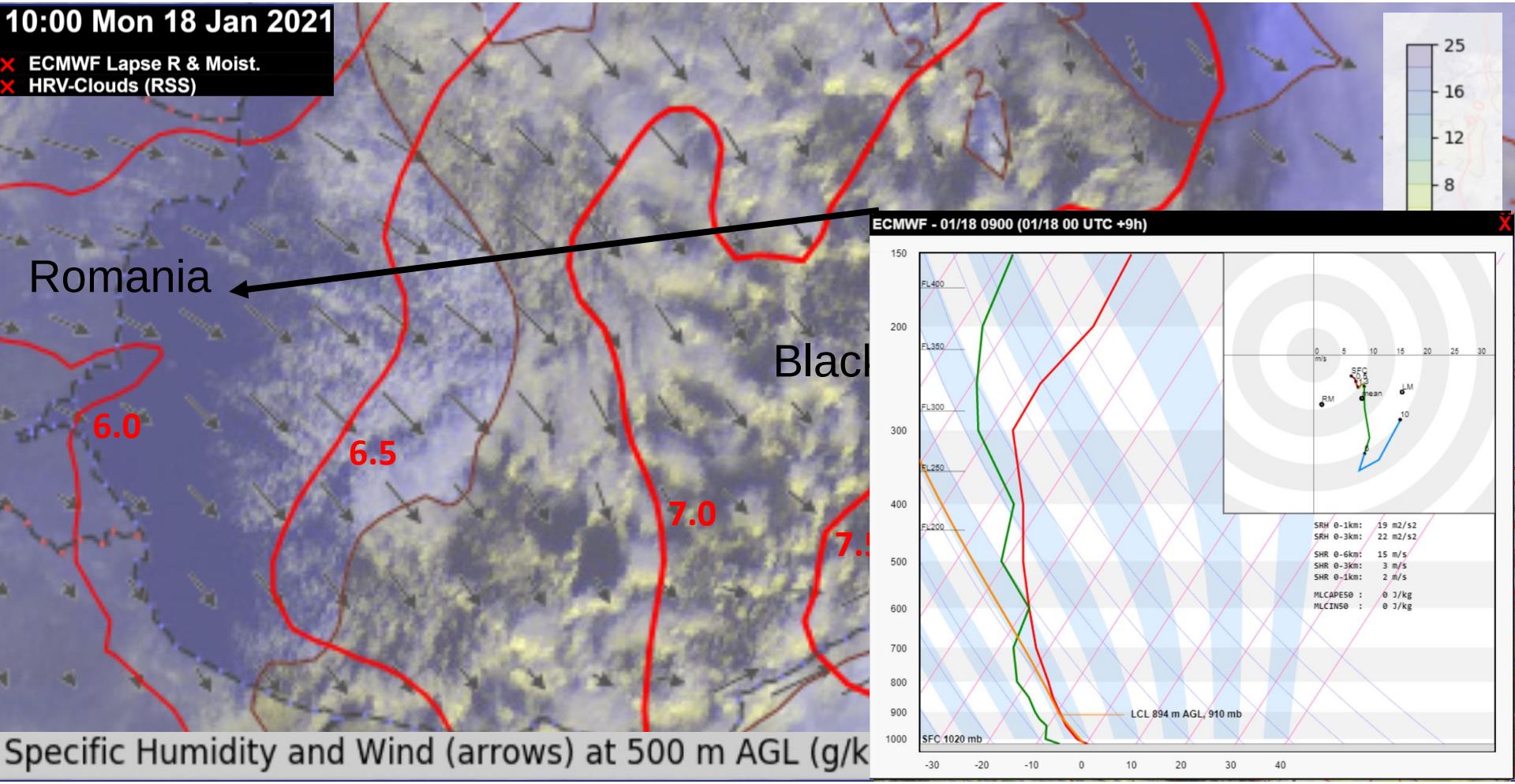
Lake Effect Thundersnow



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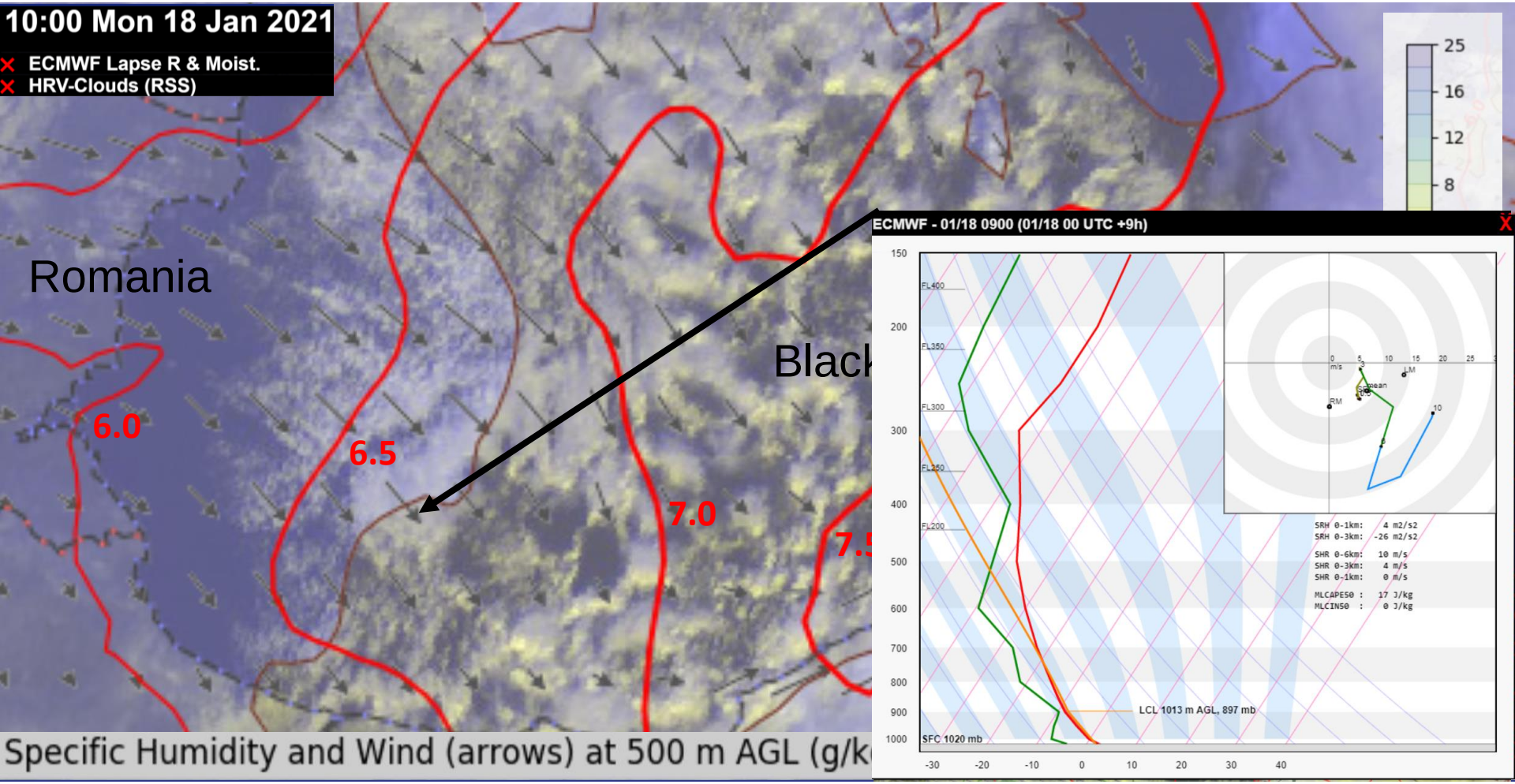

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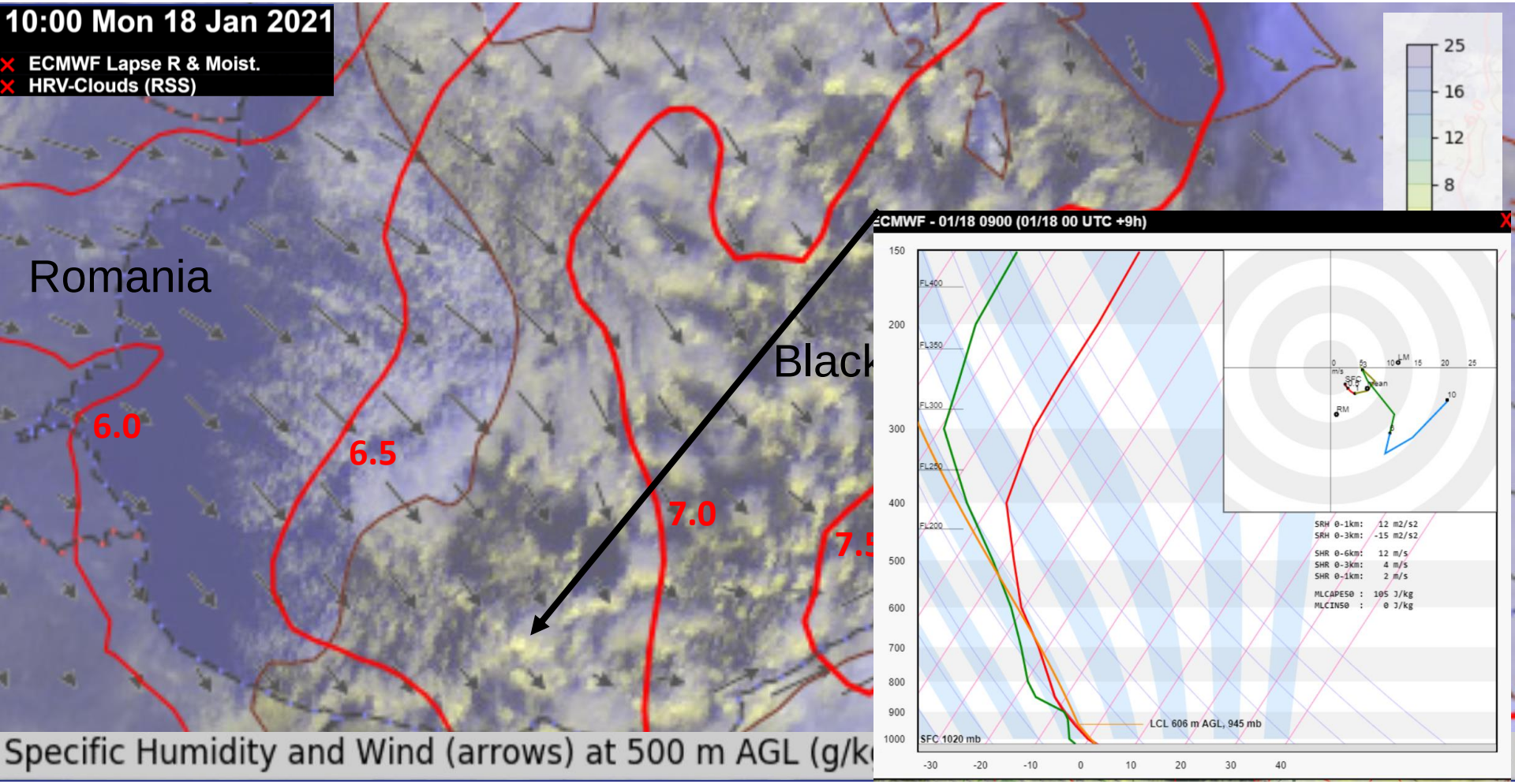

Jim should move to Europe!

Other conclusions?

Look for ingredients! Winter-time lightning cases often involve:

- Strong forcing
- Marginal moisture
- Steep lapse rates throughout the charge separation zone

Have you seen any interesting case or do you have some questions?

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