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Estimation of hail occurrence from satellite, lightning and radar data in Croatia

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This work was supported by the SWALDRIC (IZHRZO-180587) project, which is financed through the Croatian-Swiss Research Program of the Croatian Science Foundation and the Swiss NationalScience Foundation with funds obtained from the Swiss-Croatian Cooperation Programme.

Hail, radar and lightning measurements in Croatia

(Unfortunately, due to COVID-19 pandemic we were not able to finalize satellite data)

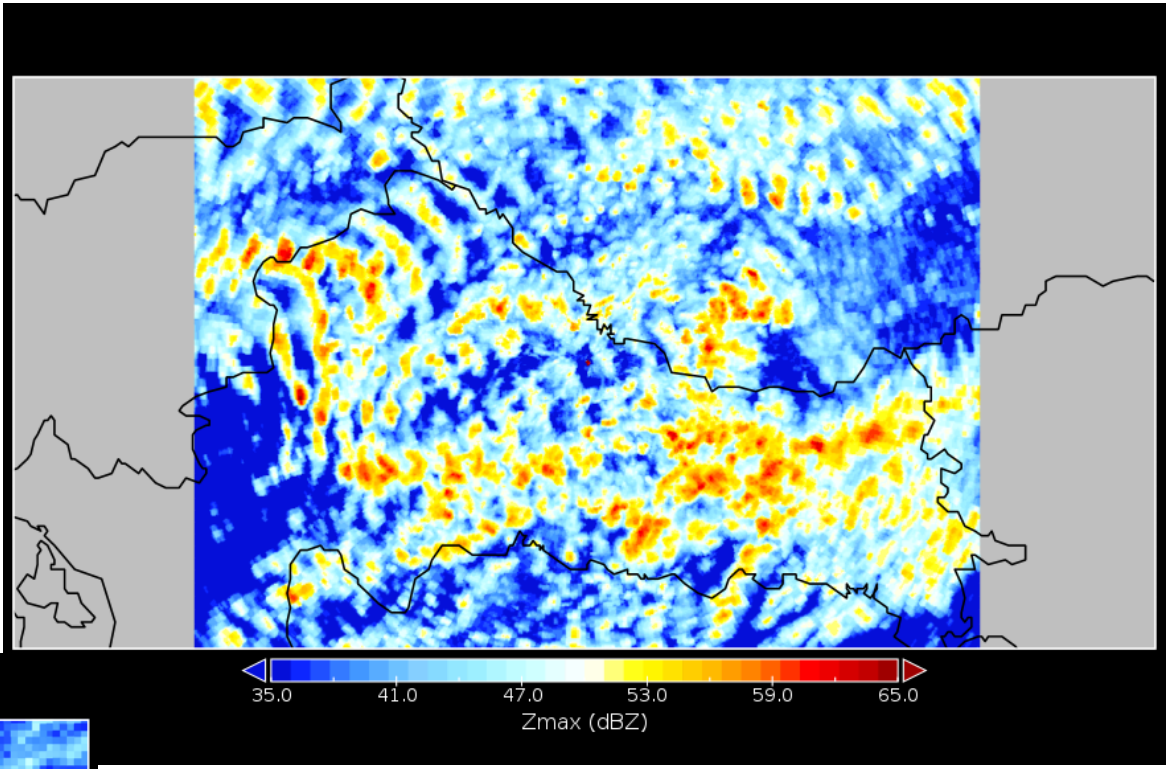
- On 25 June 2017 weather conditions were favorable for development of several MSC in the region, some of which organized into a squall lines, causing severe weather effects over larger portion of Croatia including whole continental region. In that region, Meteorological and Hydrological Service of the Republic of Croatia (DHMZ) has working network of 688 hail pads scattered over the region. That network reported 58 records of hail ranging from 0.5 cm to 3 cm in size which we are using for validation of radar and lightning estimation of hail.
- Continental region is covered with 3 S band Doppler radars from which we decided to use one centered in the middle so all stations fall under 150km of distance. Radar has 15 min full volume scan and we were able to obtain Zmax values which we used in validation.
- Lightning data were obtained from Lightning Detection Network in Europe (LINET) which offers IC, CC, and CG flashes for both positive and negative polarity. Location accuracy for our region is well below 1 km and we used data gridded on 3x3 km resolution. Using total lightning we computed newly developed Eulerian based lightning jump and validate it against hail measurements.

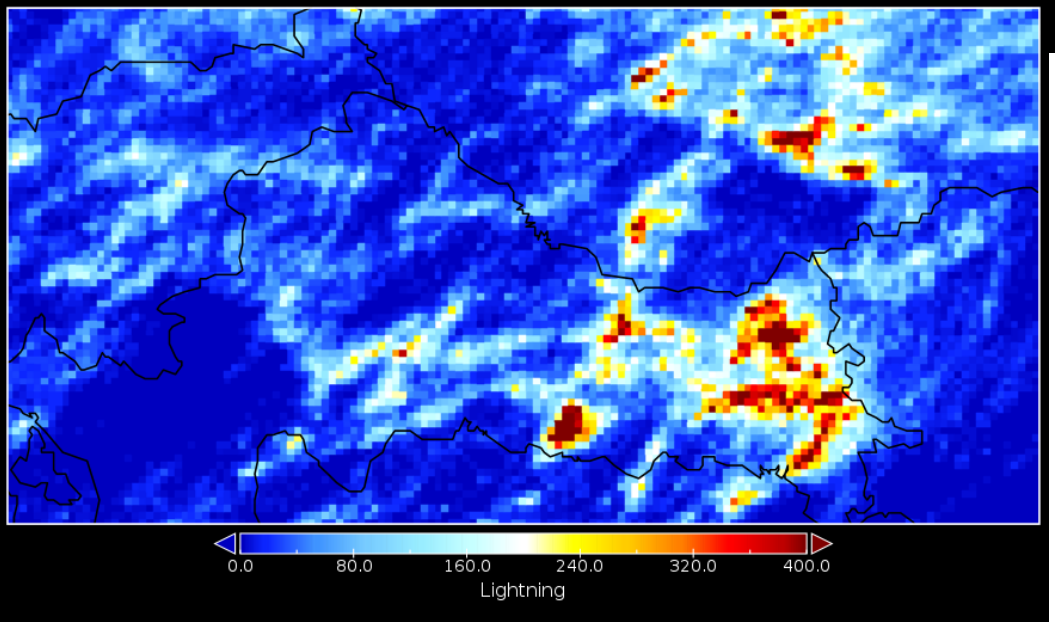
Eulerian based lightning jump

- Compared to already known method for calculation of lightning jump Eulerian based lightning jump is different in following points:
  - computations is performed in each grid point separately as the storm is passing over rather then tracking the storm
  - result is a trail of jumps providing information of storms lightning dynamics by highlighting areas over which storm was most active rather then providing initial lightning jump of the system
  - it has diagnostic value for lightning archive data rather then predicting value as shown in now-casting
  - it is possible to obtain several lightning jumps at same grid point
- Benefit of such approach is potential estimation of hail in areas laking more established measurements such as radars

Zmax and lightning

- Upper figure shows accumulated Zmax value larger then 35 dBZ of the whole day
- General direction of the system was from south-west to north-east starting from 12:00 UTC until 23:00 UTC
- Due to the scarce scanning interval of 15 min we can notice large gapes all over the figure and especially on northern and western part

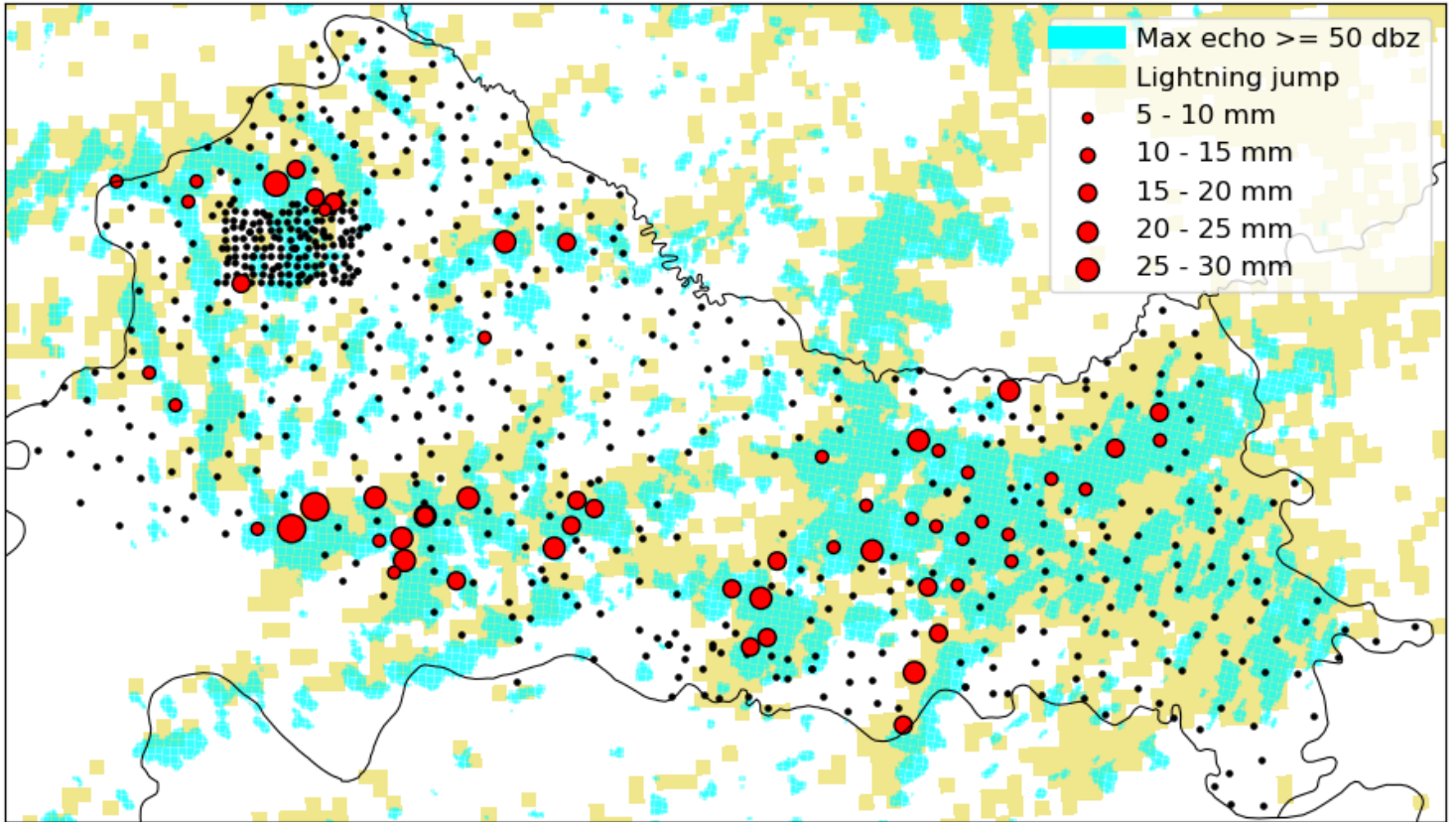




- Lightning activity followed the system accordingly. Very intense signal to the left is a consequence of 2 separate systems passing over same region, one in afternoon and one in the evening

Visual inspection and verification

- On the figure, black dots represent all working hail pads, and red circles highlight those pads which reported hail. Size of red circle indicated maximum reported hail stone size as indicated in figure legend
- Blue area shows values of Zmax equal or larger then 50 dBZ as some indicator of probable hail
- Brown shading indicates area where lightning jump is detected
- To verify quality of both radar and lightning jump we computed two contingency tables. One for hail pad vs. radar and second for hail pad vs. lightning jump
- Out of it, we computed some standard verification measures: POP, FAR, BIAS, CSI, HSS, PSS, DC and SEDI index

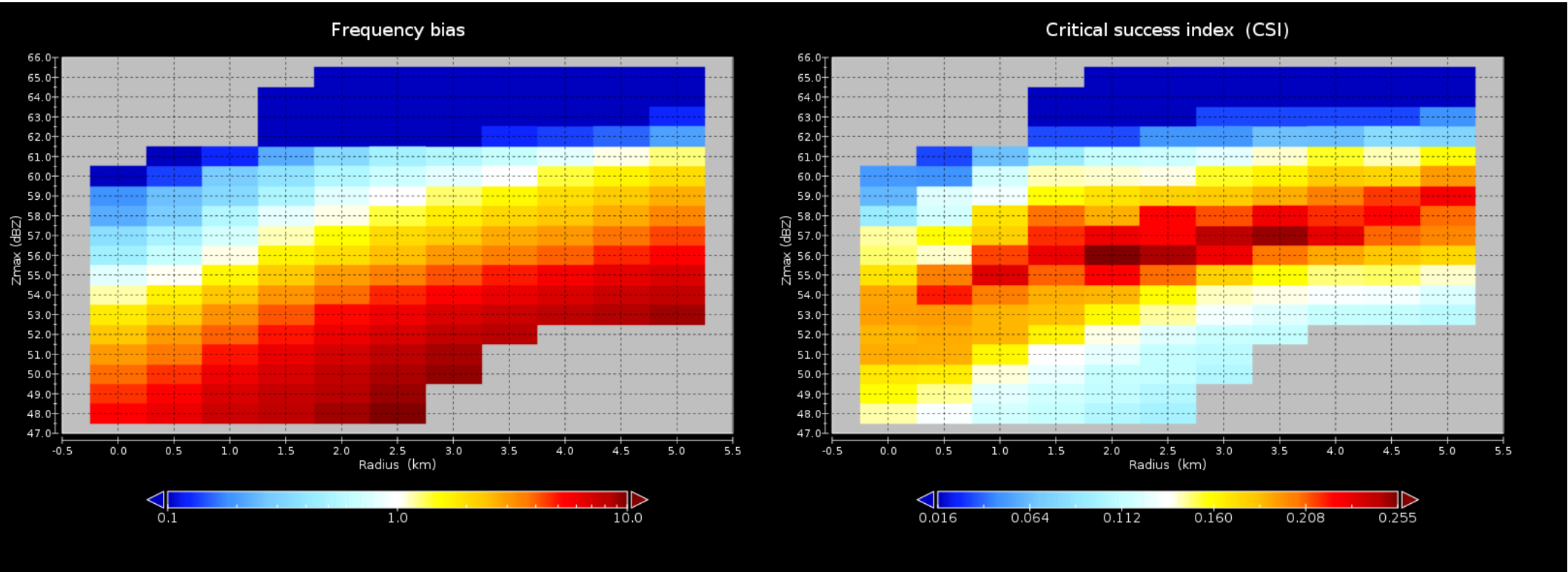


Hail pad vs Zmax

From all calculated verification measures there are 2 options suggesting best fit:

A1) CSI (right figure), HSS and DC suggested the best values for radar estimates based on Zmax value for this case is radius of 2km and threshold reflectivity of 56 dBZ

B1) while PSS and SEDI index suggested radius of 3.5 km and 57 dBZ reflectivity
However, BIAS (left figure) is much smaller in option A1) 1.9 vs. option B1) 2.8 thus we consider option one as the best fit.

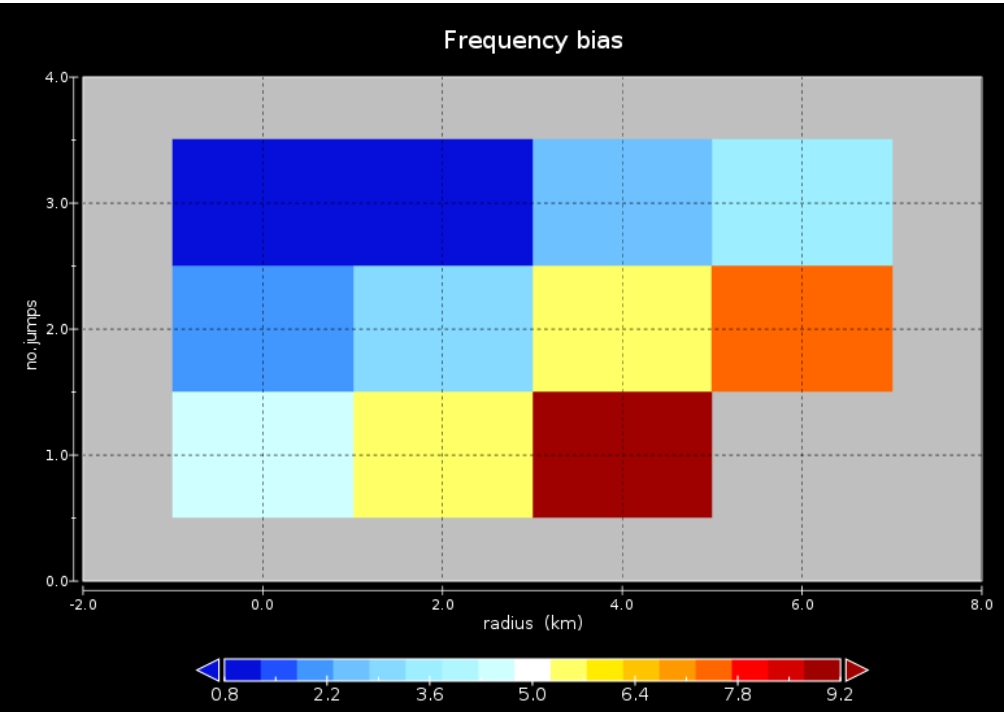


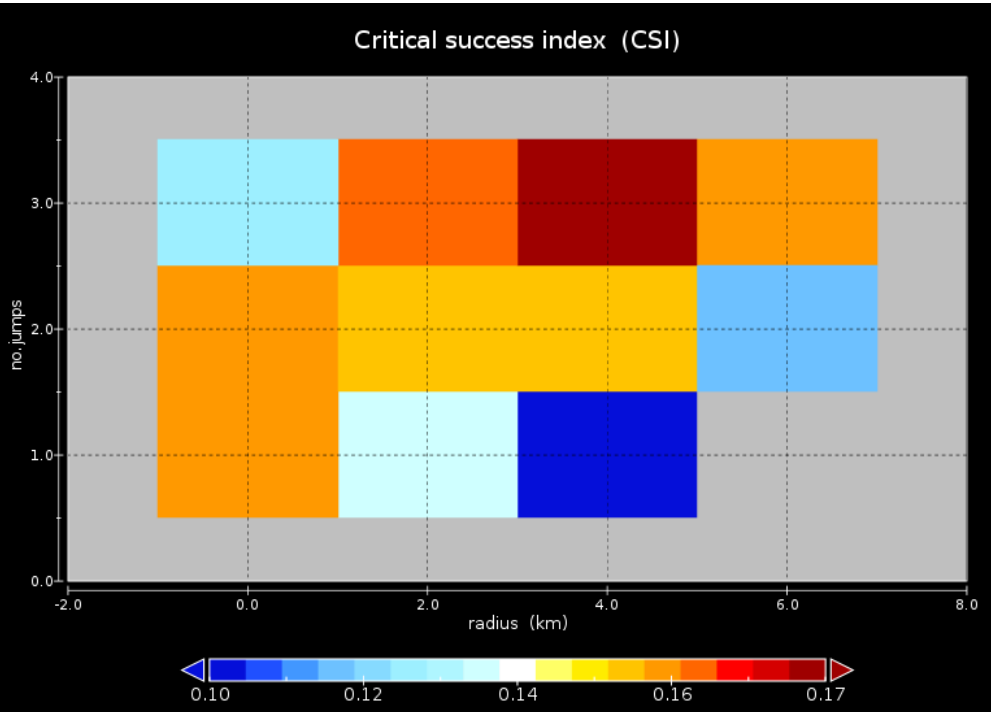
Hail pad vs Lightning jump

Due to lower resolution and data available, lightning jump has much less iterations. Radius categories move for each 2 km and due to computation method used number of jumps per grid point rarely pass value of 3. Considering all, results for lightning jump are not so conclusive although there are three indications:

A2) Considering CSI (right figure), HSS and DC index, best fit is radius od 4 km and at least 3 jumps per grid point. BIAS (left figure) is 2.5

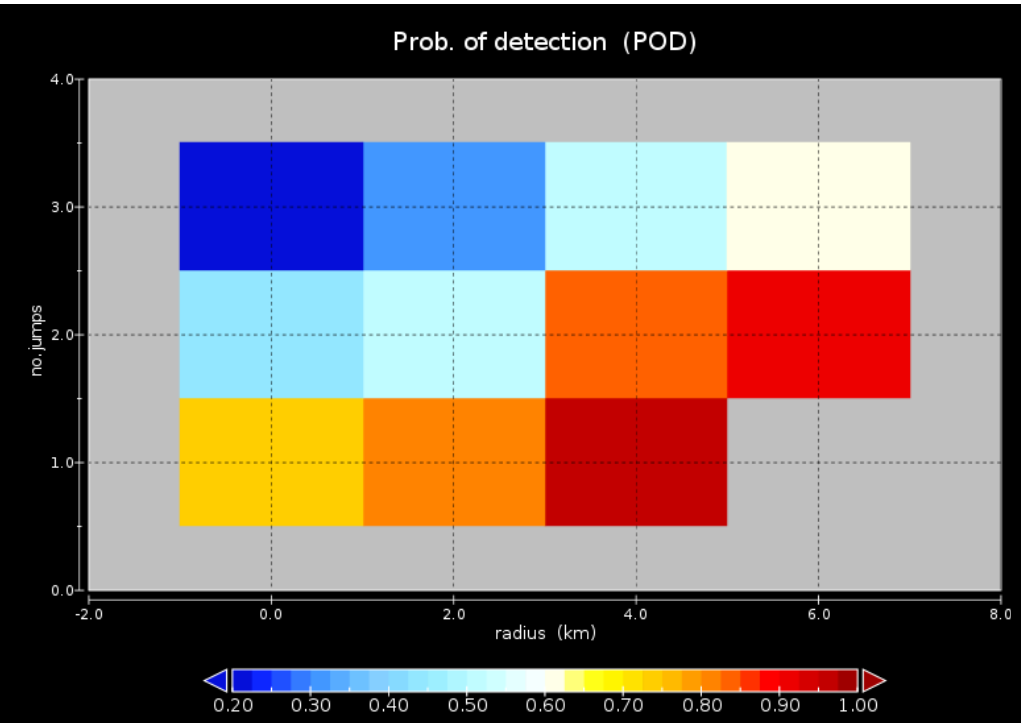
B2) PSS and SEDI index suggest also 4 km but atleast 2 jumpsper grid point. BIAS is 5.3

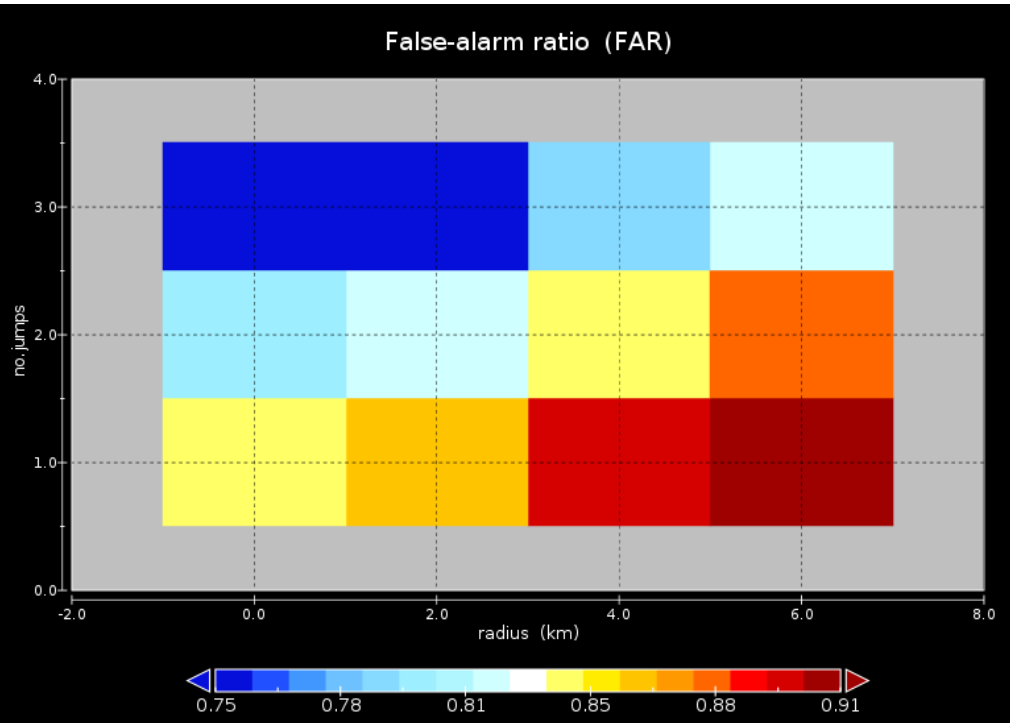




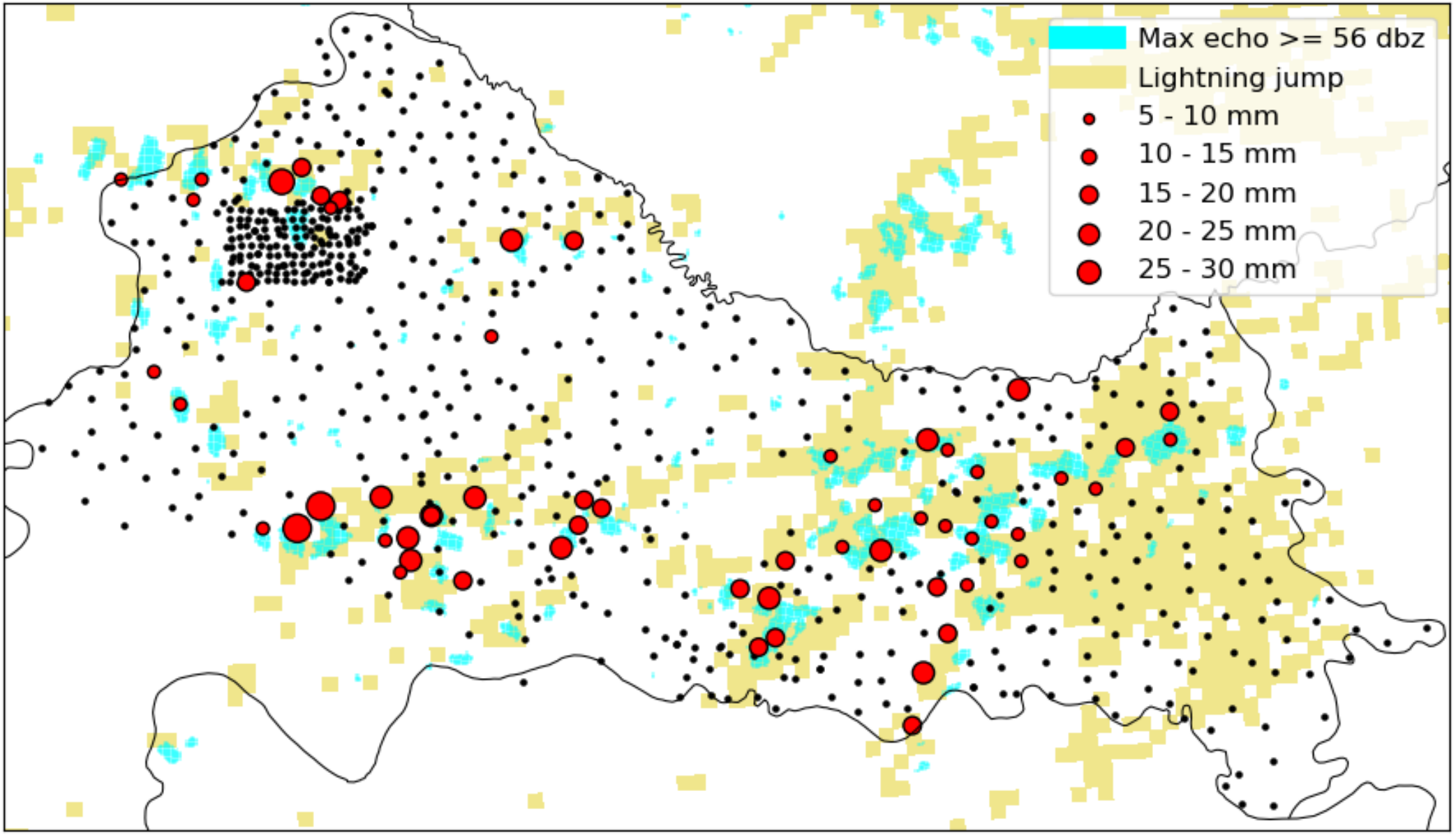
If we consider POD (left figure) and FAR (right figure) for both options A2) and B2) we see there is very low POD value if number of jump per grid point is 3. FAR values are proportionally large. Thus option A2) seems more favorable.

Also, there is option C2) which would be radius of 0 km and at least 1 jump per grid point. That option offers some compromise between all considered indices (figure was shown in slide 5).





Visual display of best fit parameters A1) and B2)



Conclusion

- Radar assessment of hail based on Zmax values on the case from 25.6.2017. shows good results.
- Potential problem is scarce sampling frequency of 15 min
- Eulerian based lightning jump offer potential informations about hail, however it tended to overestimate area.
- Improvements toward larger number of possible iterations is needed and also consideration of other paramethers, such a freezing level hight or similar since largest overestimation occurred on the East part where convective systems arrived later afternoon and night.

Thank you for your time!

- For any discussion on the topic feel free to contact me via djelic@gfz.hr
- Skype is also preferred option