WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

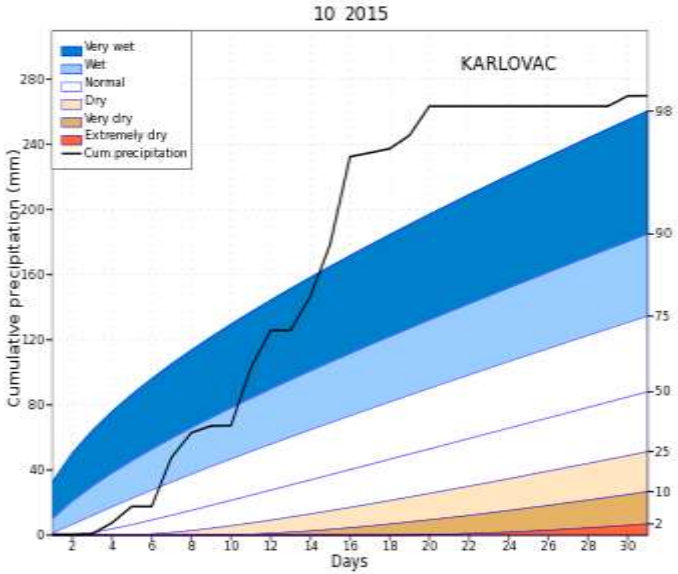
Case study:
Flash Flood in SEE Caused by Frontal and Convective Systems

WMO OMM

World Meteorological Organization
Organisation météorologique mondiale

Flash Flood in West part of SEE Region, October 2015

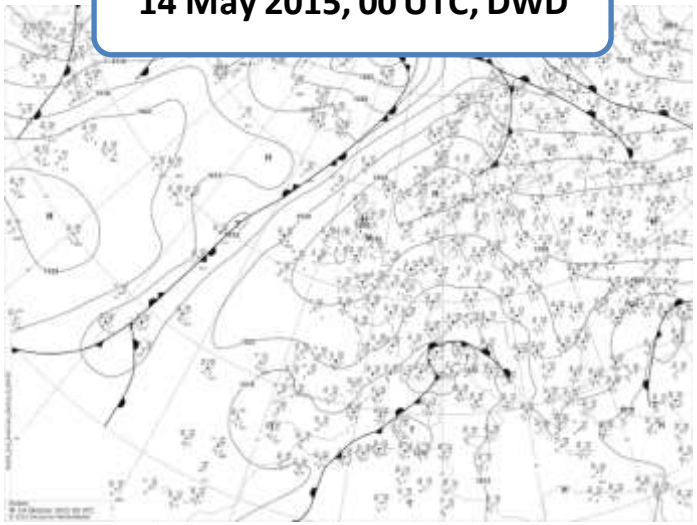
- The analysis of the precipitation amounts for October 2015, compared to 1961-1990 average, showed that the precipitation amounts throughout Croatia were exceeding climatological average.
- October 2015 was characterized as wet, very wet and in some parts of Croatia even as extremely wet.
- In the period from 10th to 16th October 2015 two cyclones from the central Mediterranean brought extreme amount of precipitation in certain parts of Croatia and Bosnia and Herzegovina causing great damage.



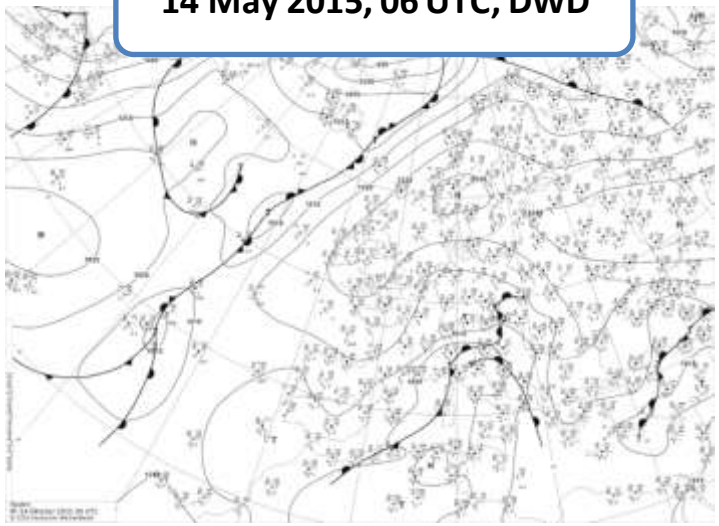
Cumulative precipitation amount (mm) in October 2015, Karlovac, Croatia

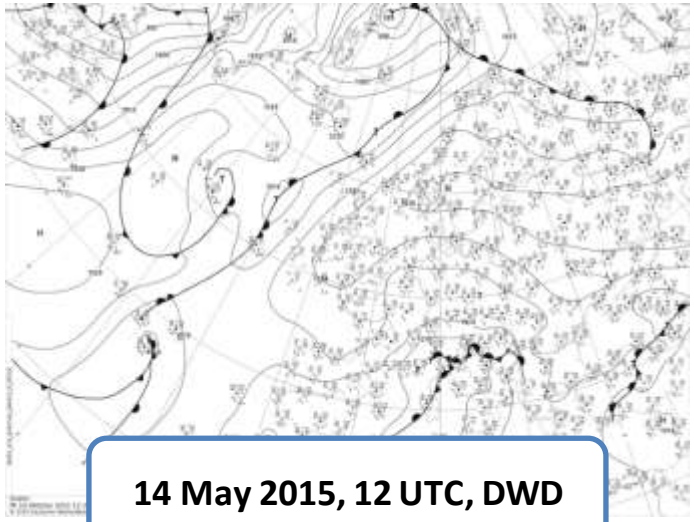
Synoptic Analysis: Surface Air Pressure

14 May 2015, 00 UTC, DWD



14 May 2015, 06 UTC, DWD





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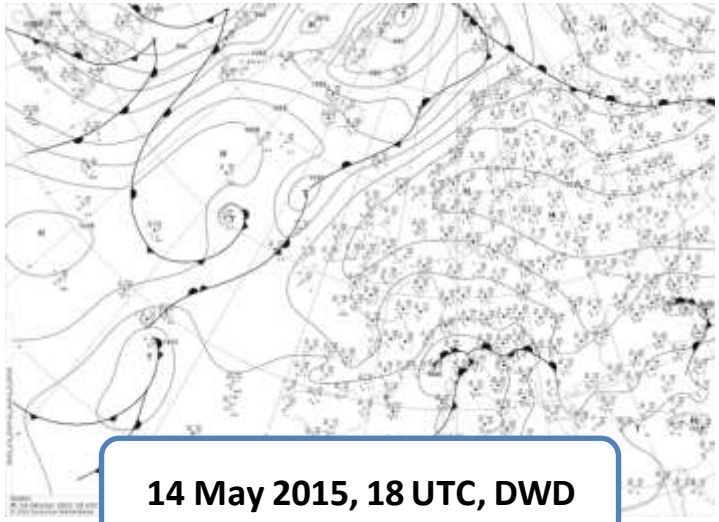
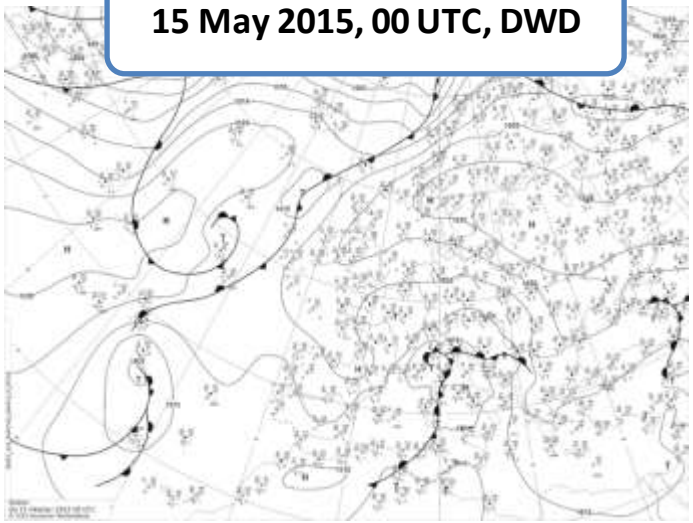


14 May 2015, 18 UTC, DWD

Synoptic Analysis: Surface Air Pressure

15 May 2015, 00 UTC, DWD



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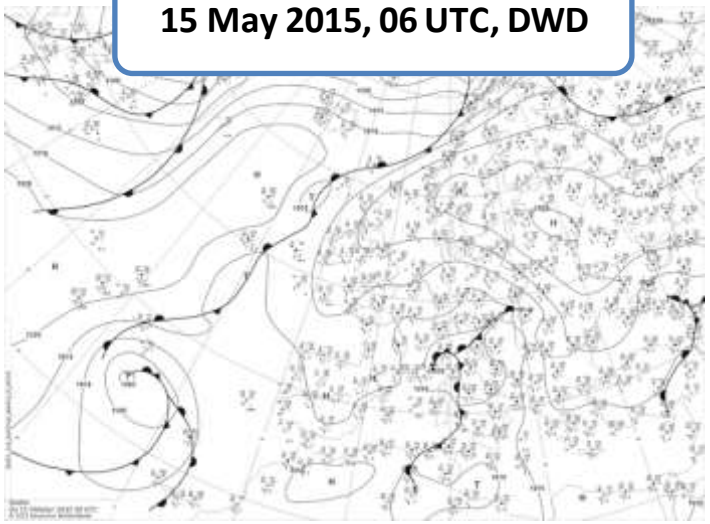

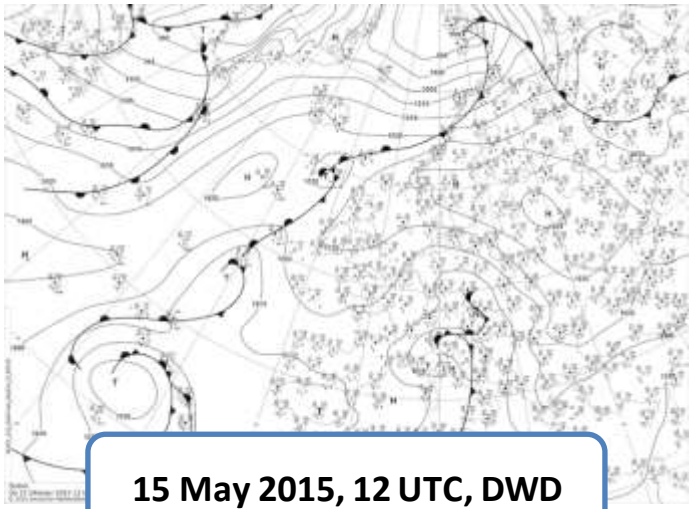

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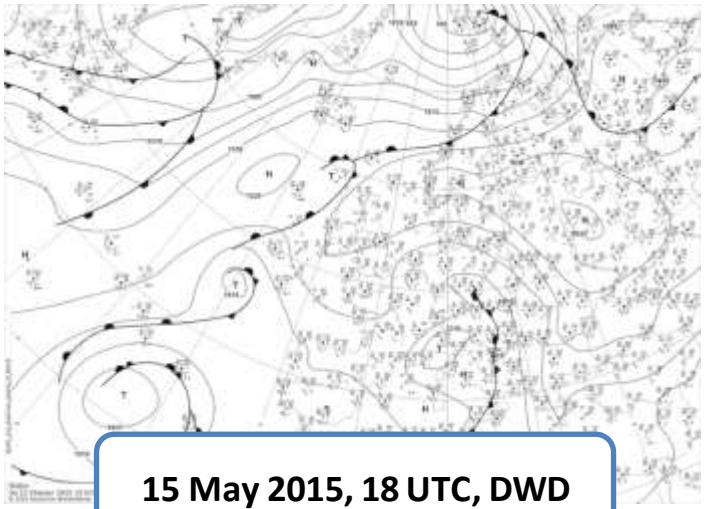
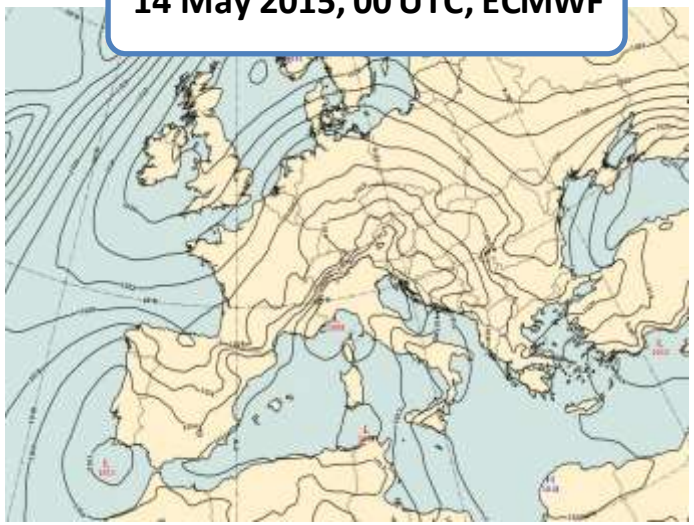


15 May 2015, 18 UTC, DWD

Synoptic Analysis: Mean Sea Level Pressure

14 May 2015, 00 UTC, ECMWF



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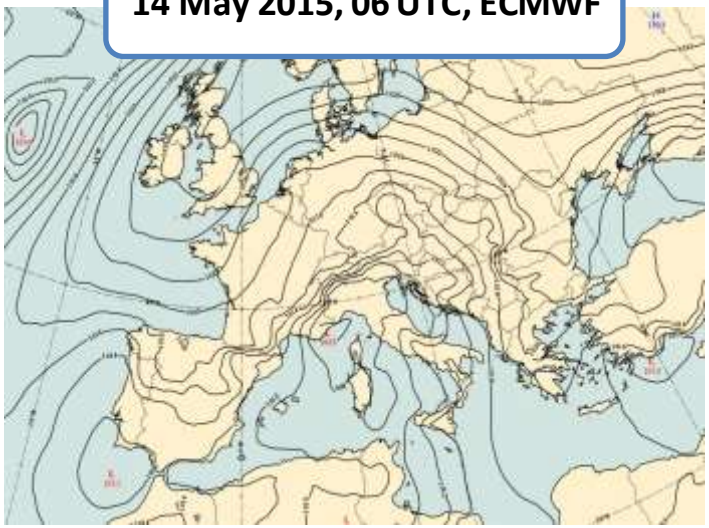

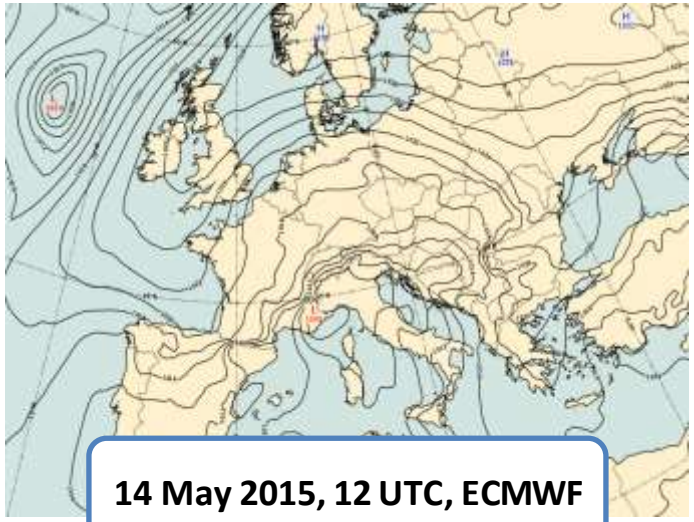

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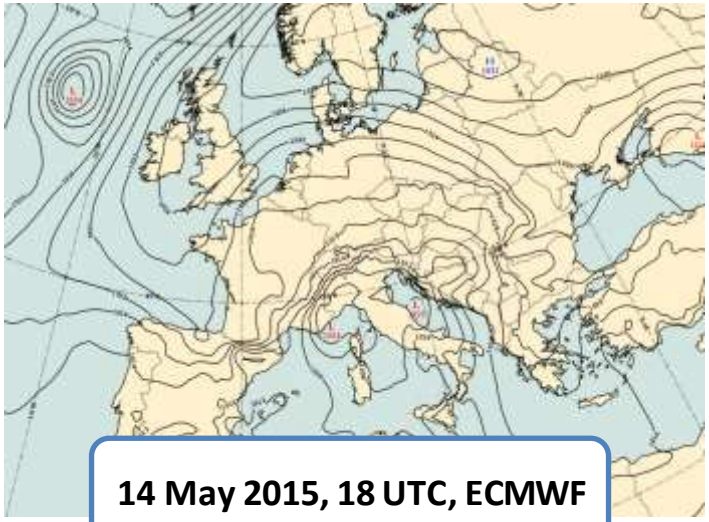

14 May 2015, 18 UTC, ECMWF

Synoptic Analysis: Mean Sea Level Pressure

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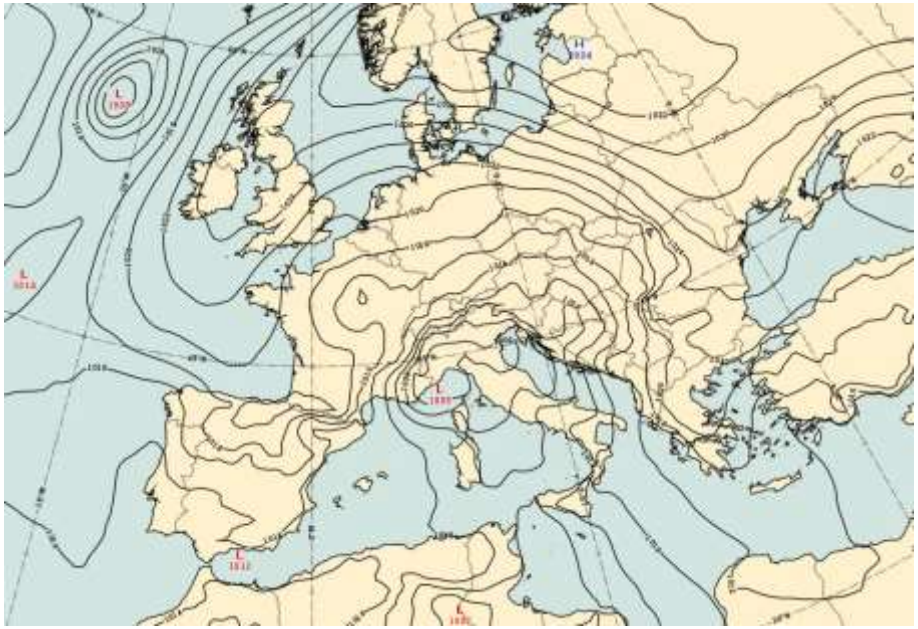
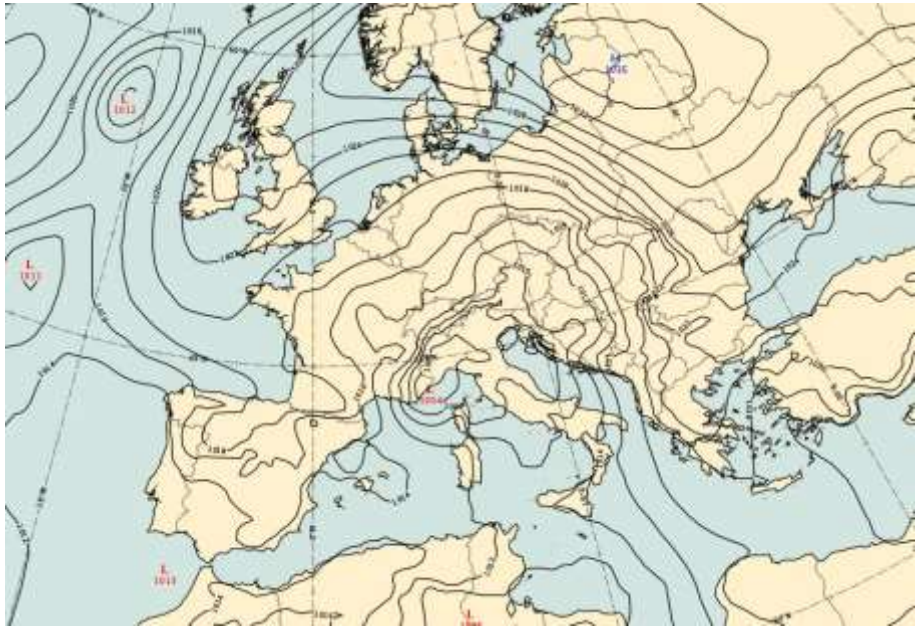
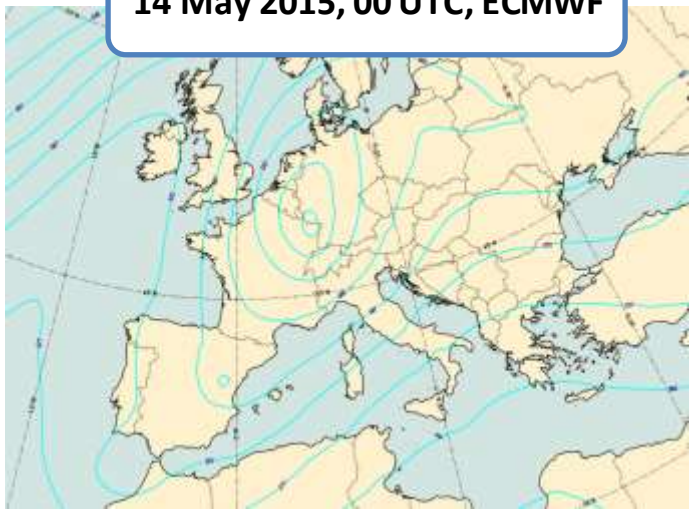


15 May 2015, 06 UTC, ECMWF

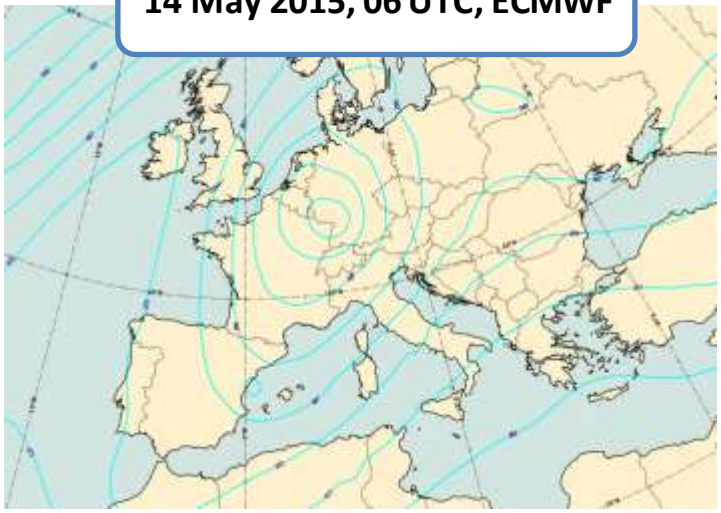


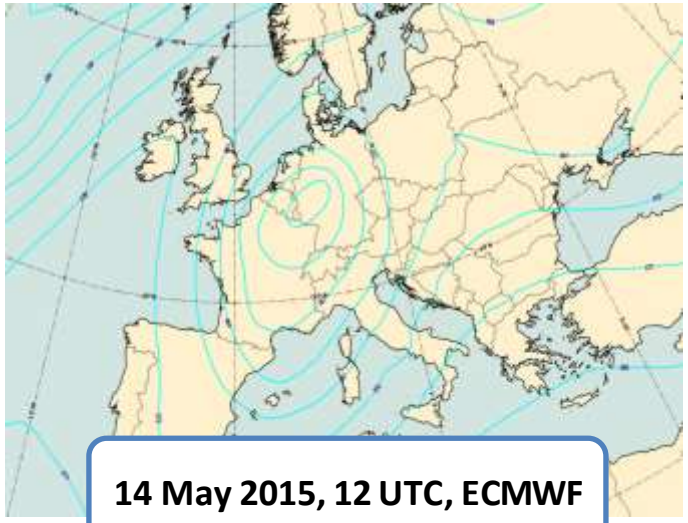
Synoptic Analysis: 500 hPa

14 May 2015, 00 UTC, ECMWF



14 May 2015, 06 UTC, ECMWF





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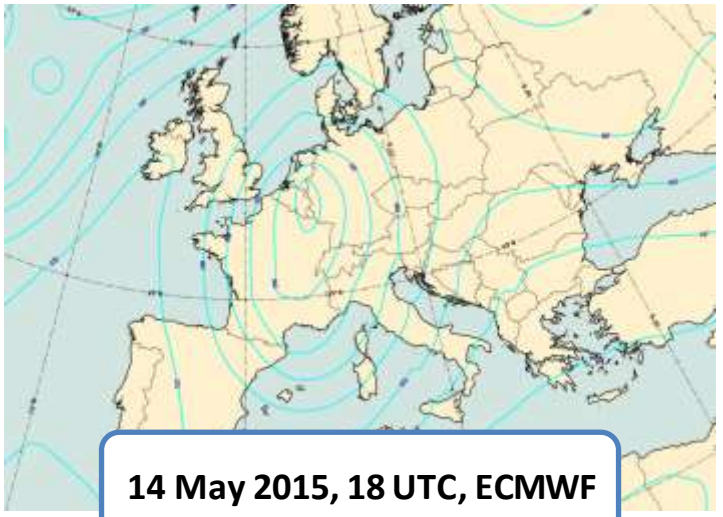
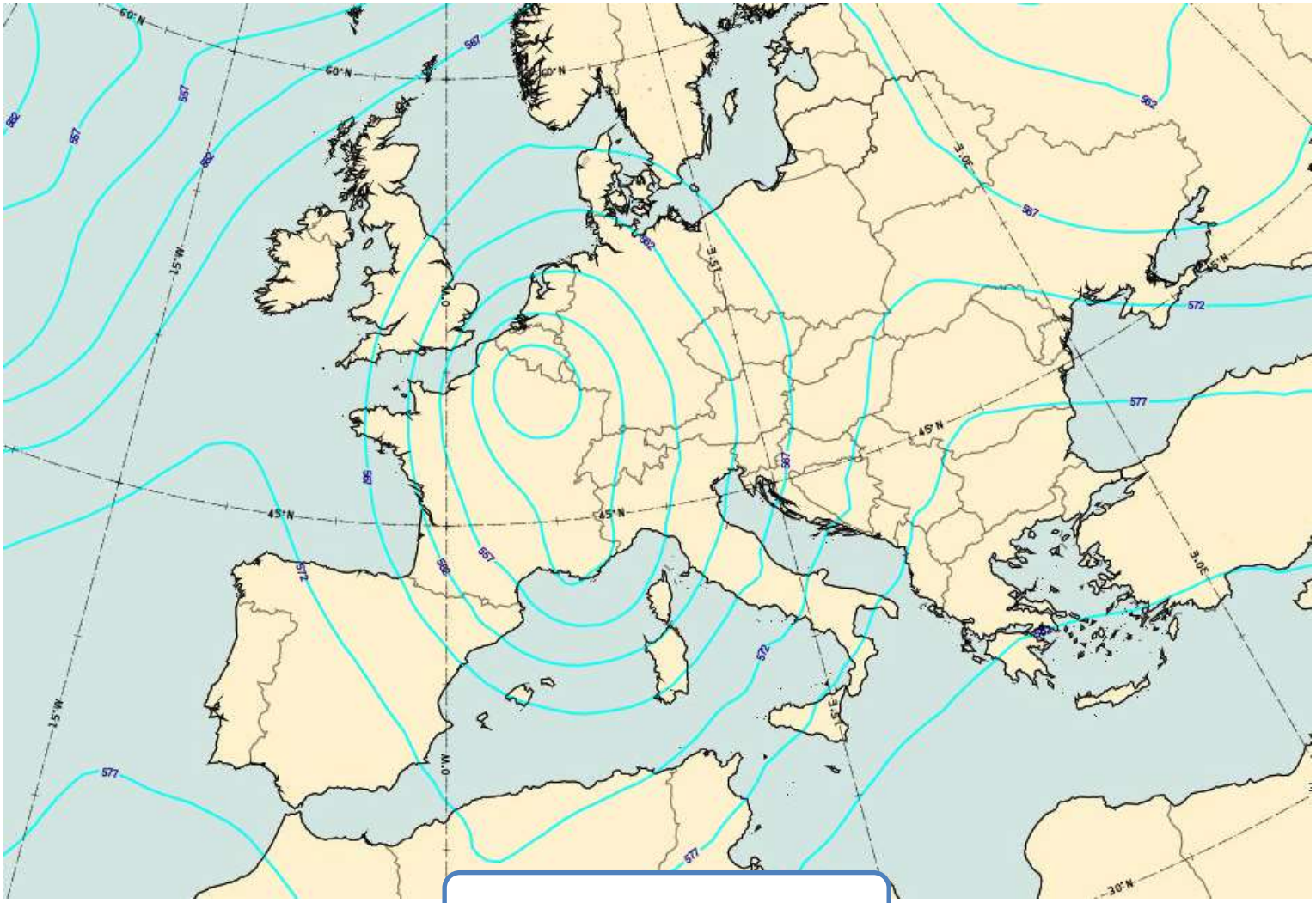


14 May 2015, 18 UTC, ECMWF

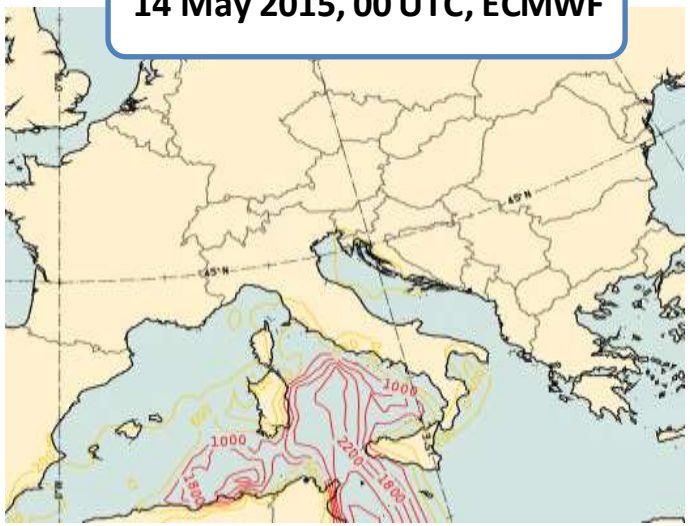
Synoptic Analysis: 500 hPa



15 May 2015, 00 UTC, ECMWF

Instability analysis: CAPE

14 May 2015, 00 UTC, ECMWF



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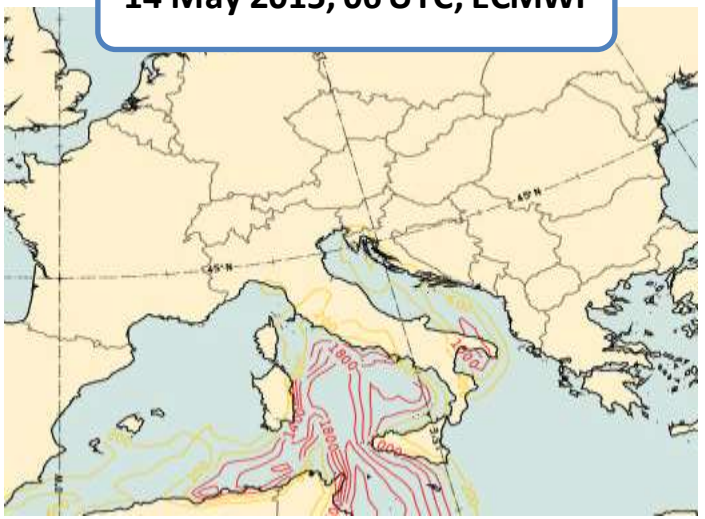

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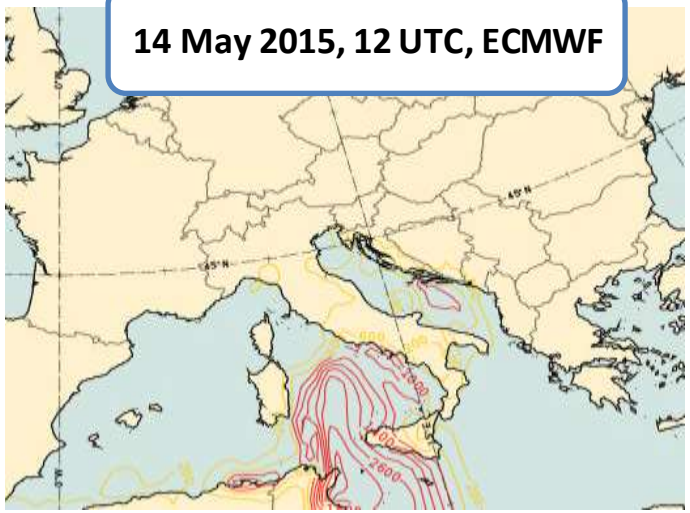

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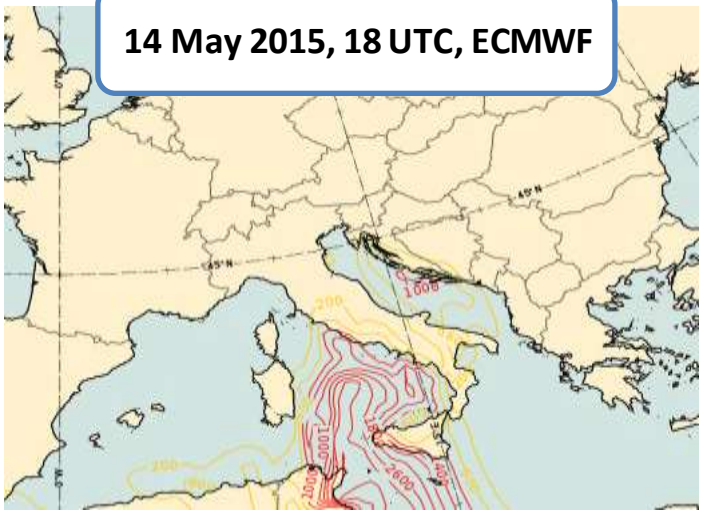
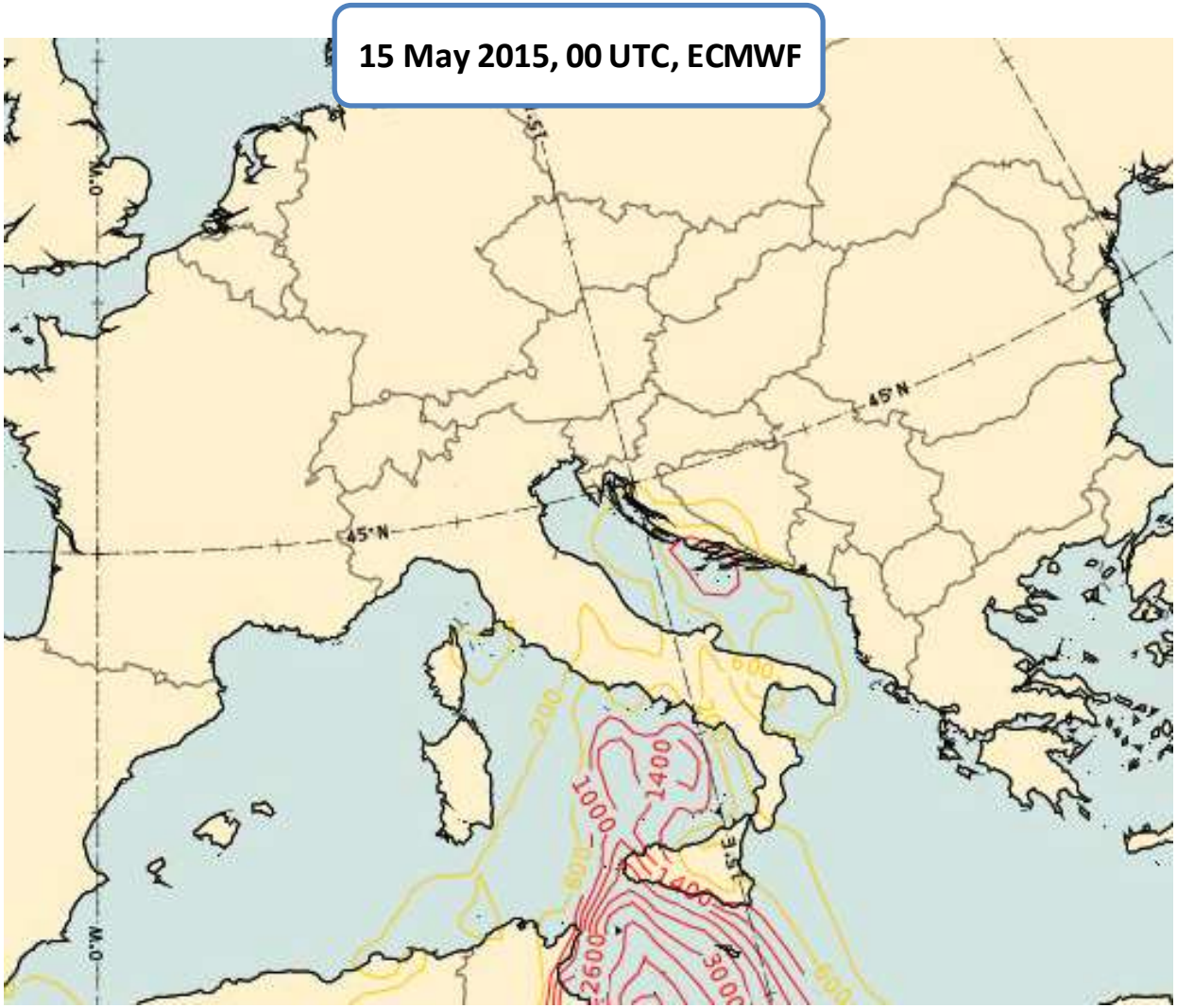
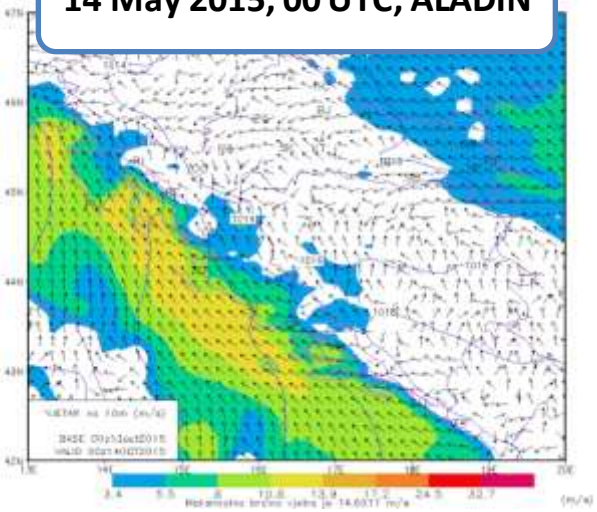


Instability analysis: CAPE



Wind

14 May 2015, 00 UTC, ALADIN



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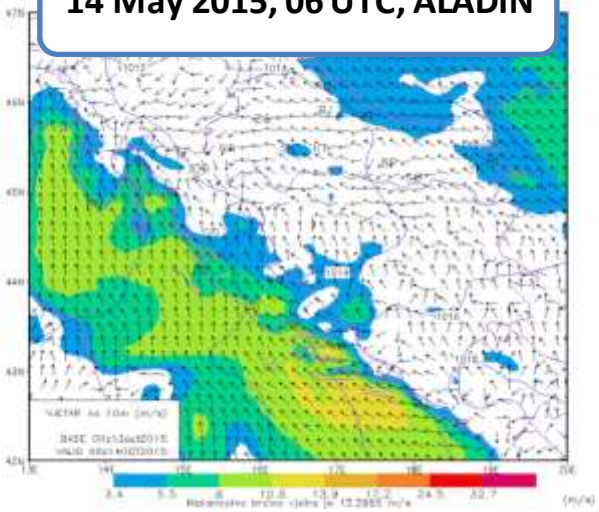

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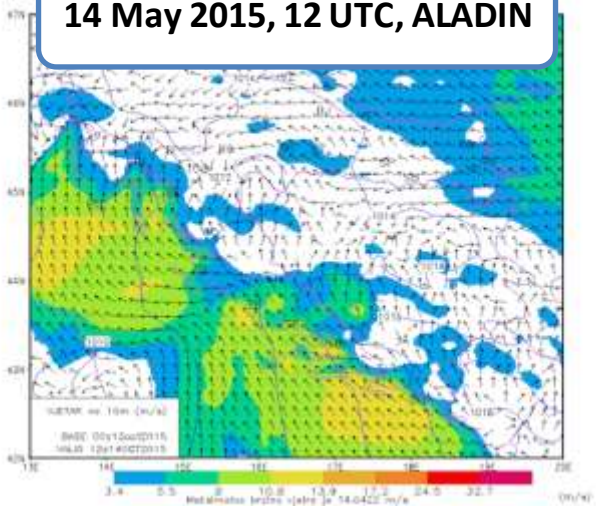

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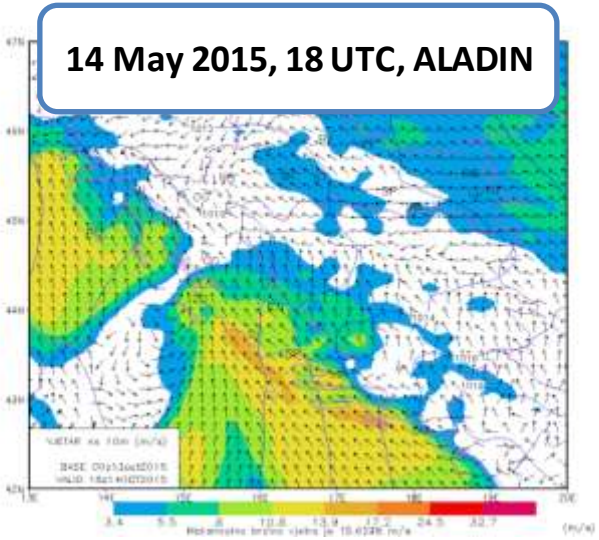

Wind

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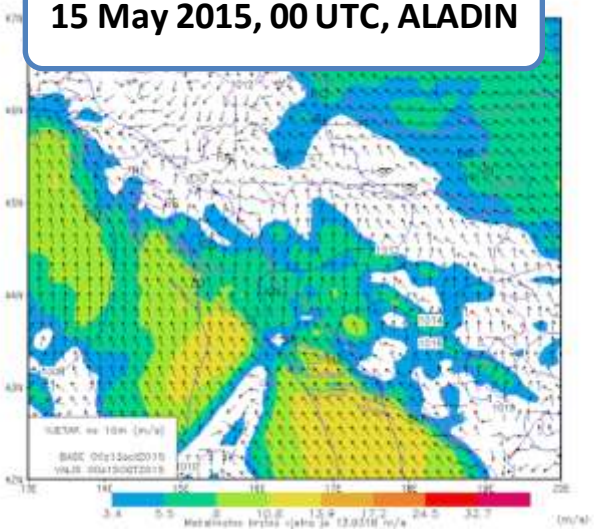

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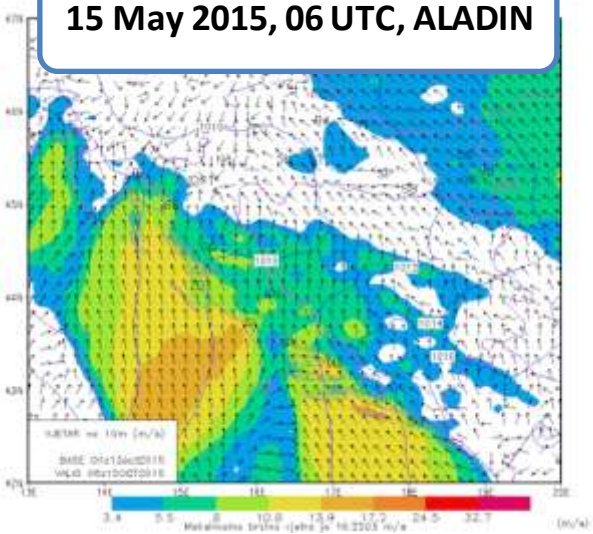

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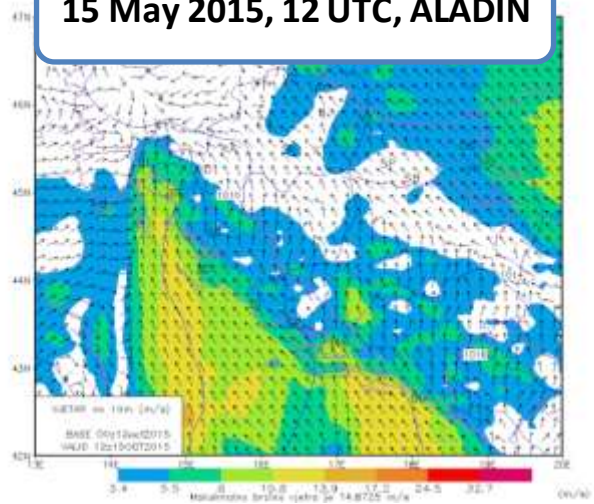

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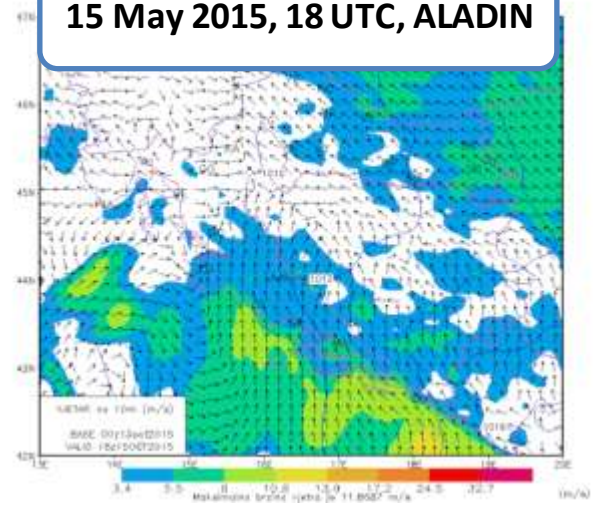
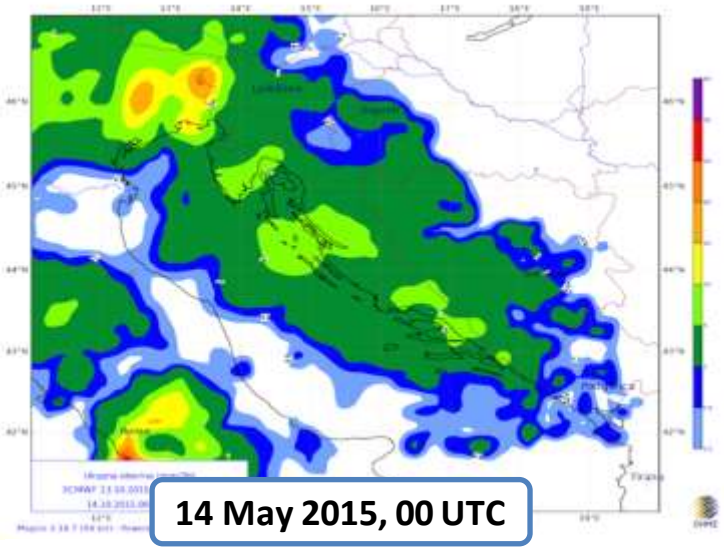


3-hr Quantitative Precipitation Forecast (QPF) ECMWF



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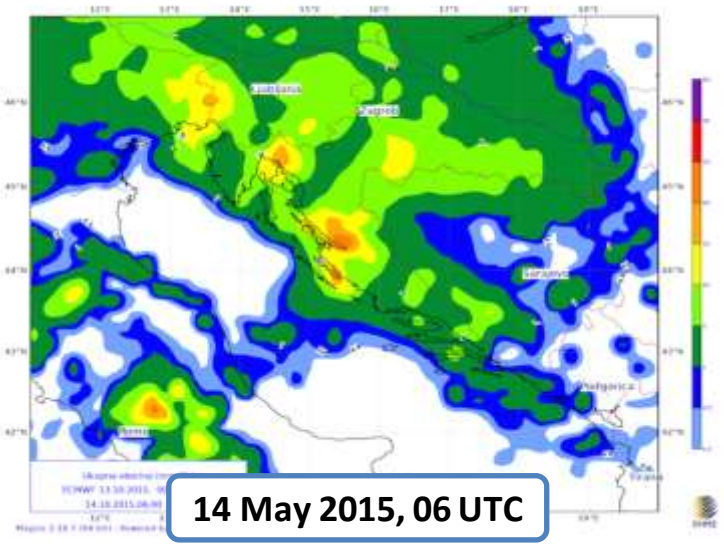

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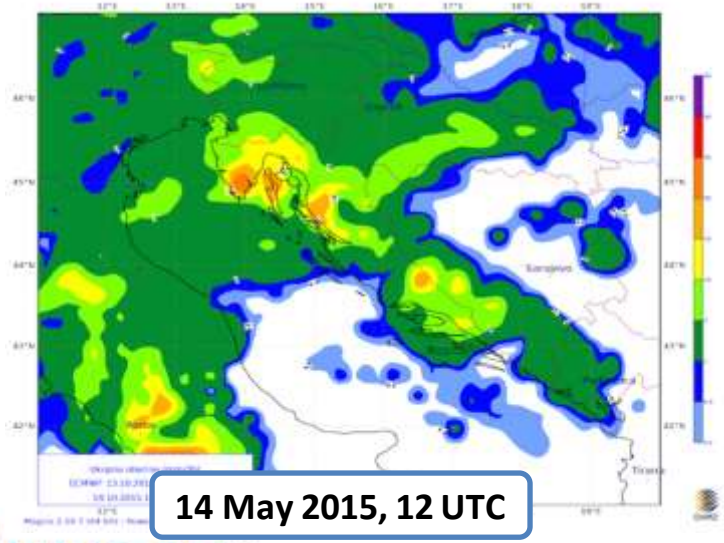

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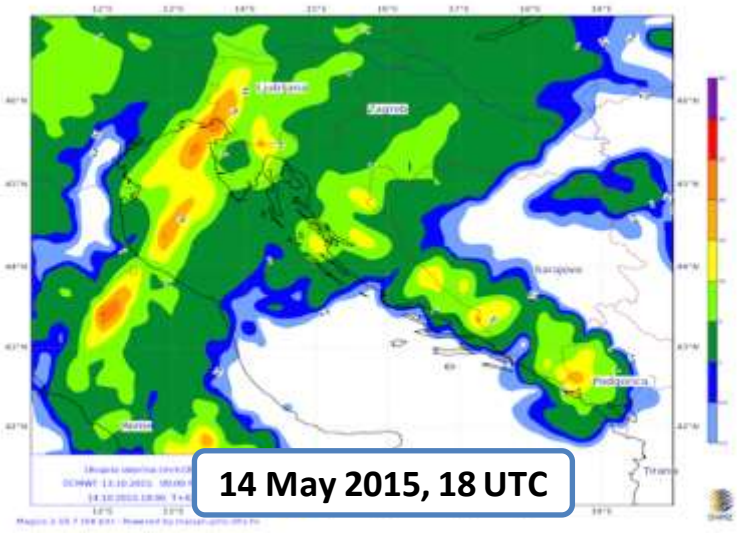
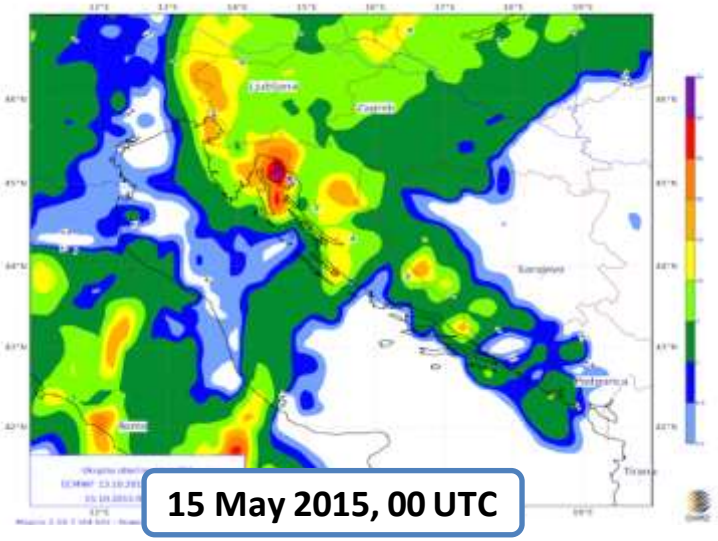
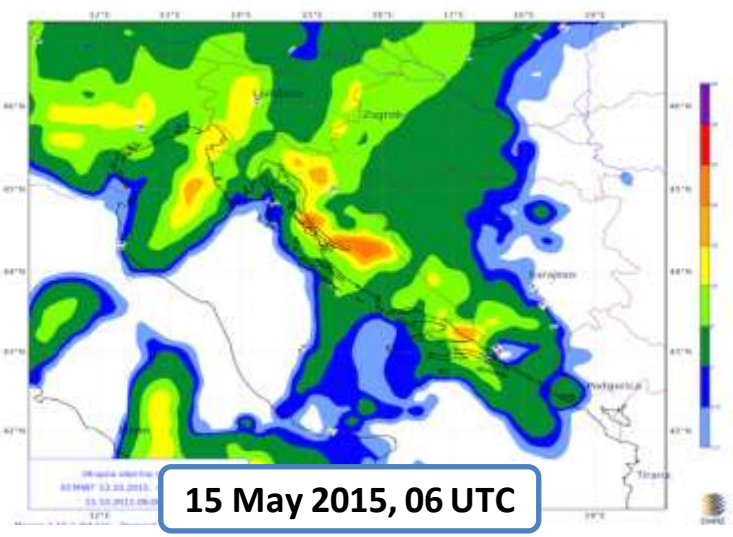
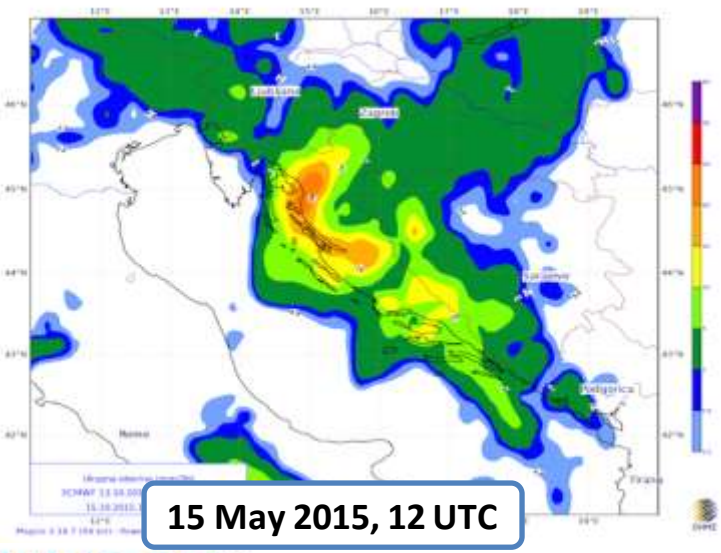


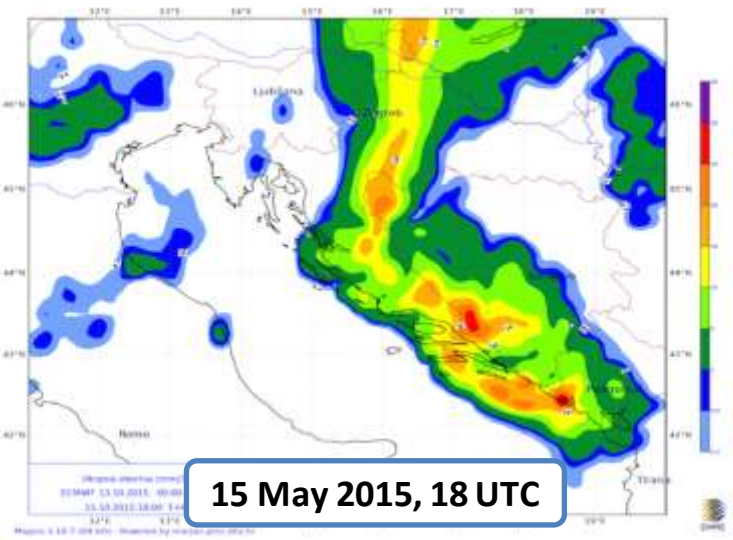
14 May 2015, 18 UTC

3-hr Quantitative Precipitation Forecast (QPF) ECMWF

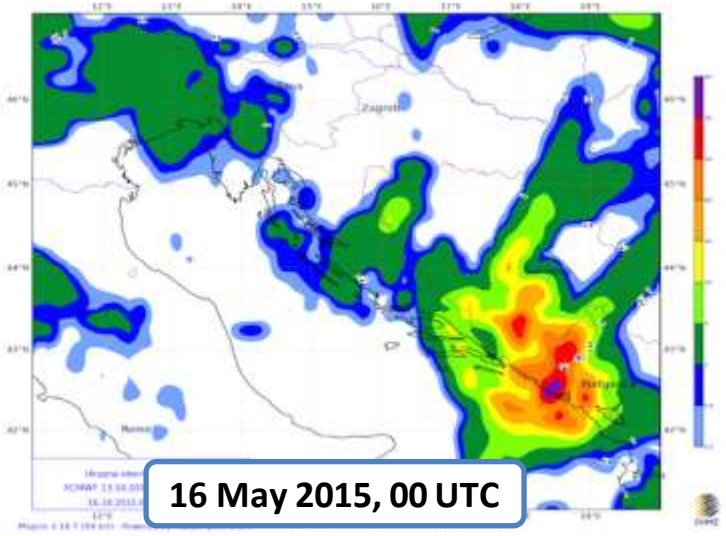


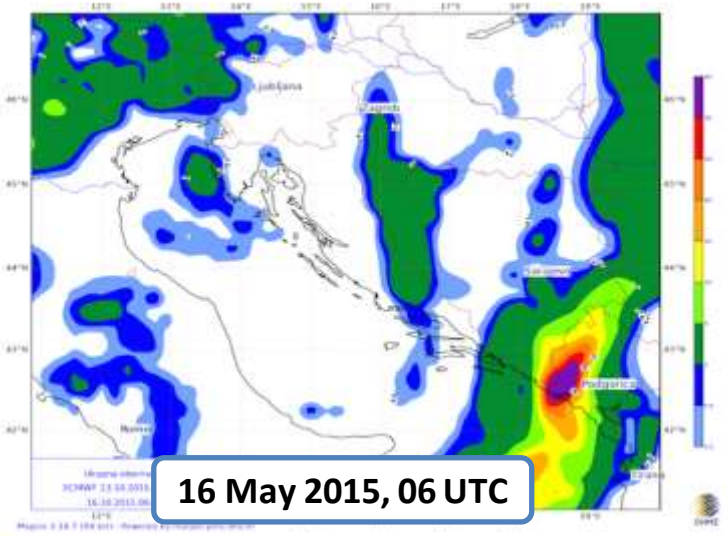


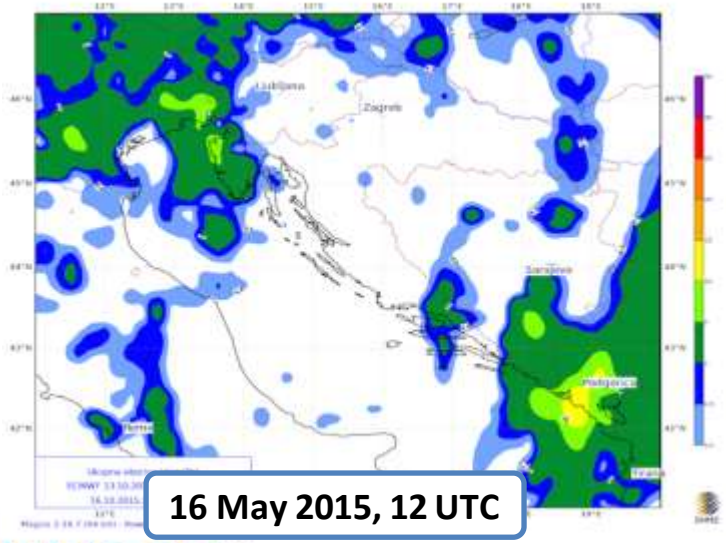




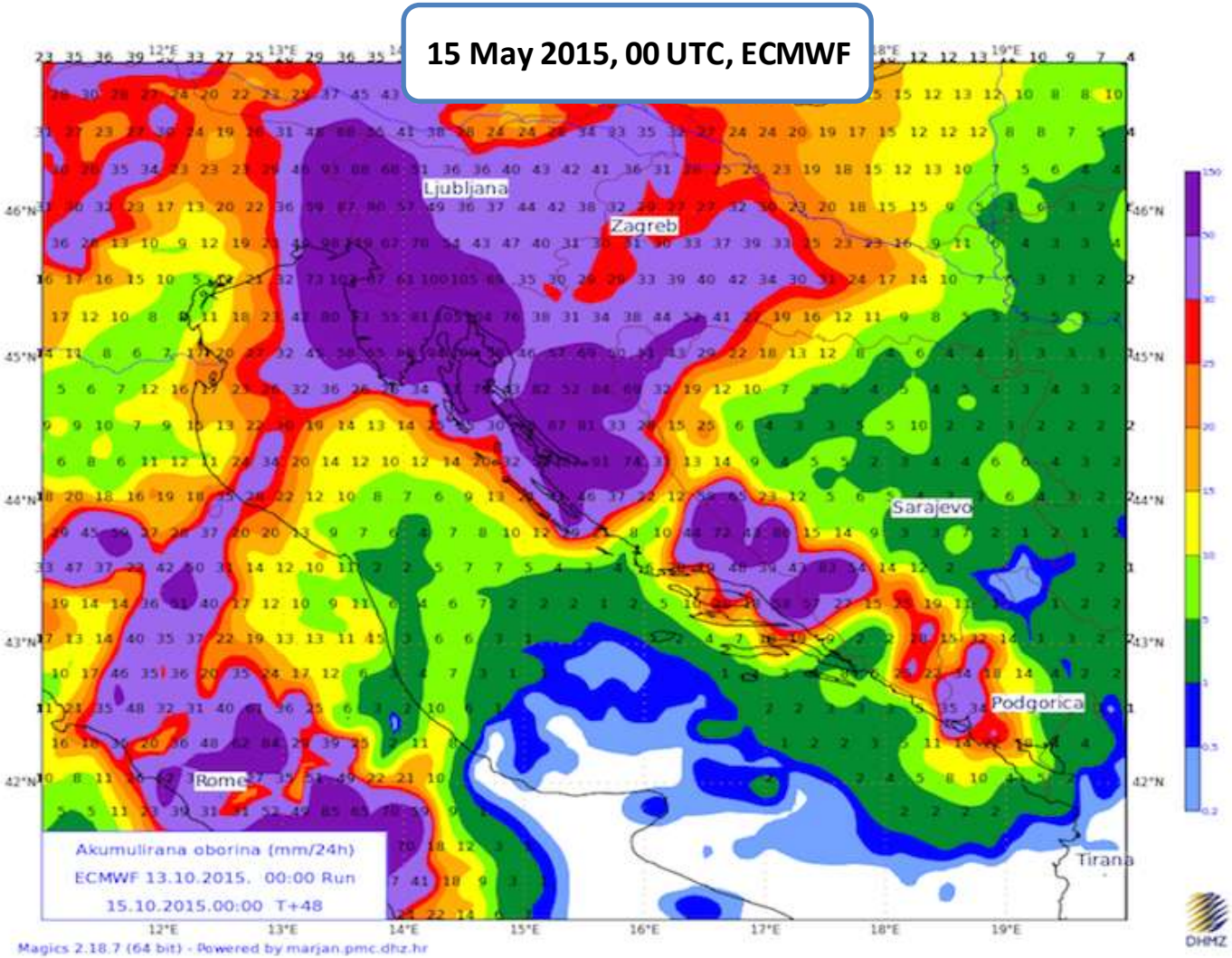
3-hr Quantitative Precipitation Forecast (QPF) ECMWF



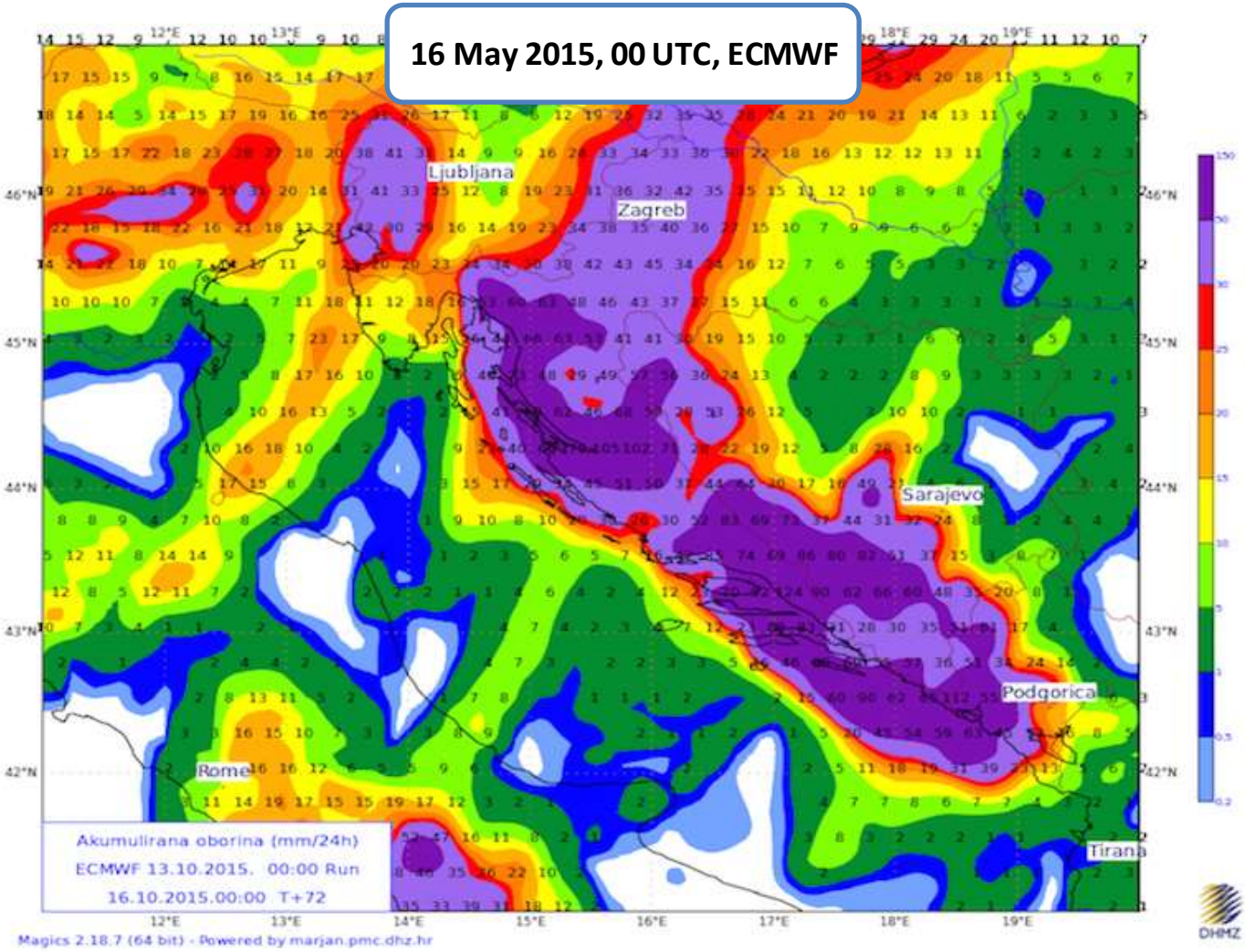




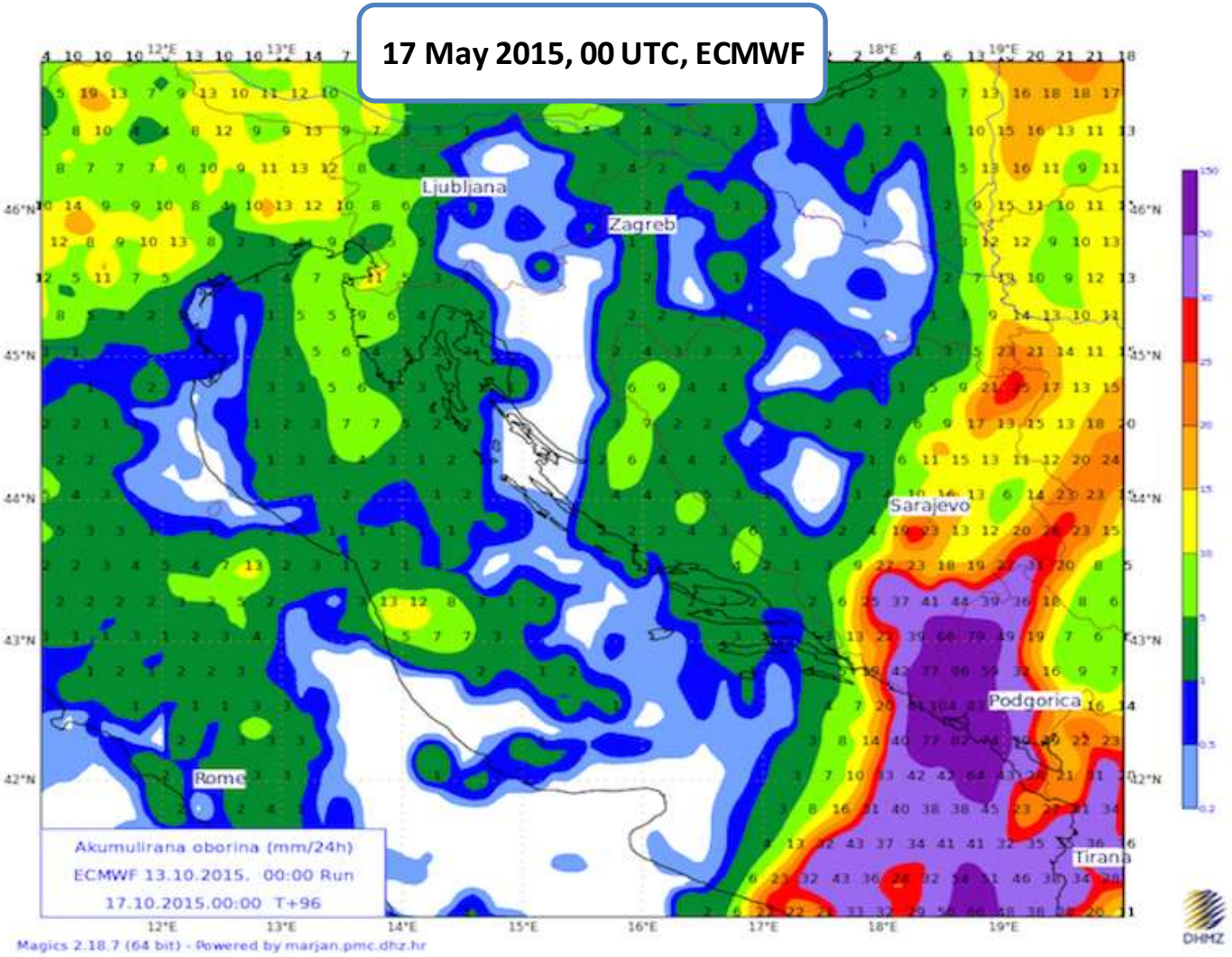
24-hr Quantitative Precipitation Forecast (QPF) ECMWF



24-hr Quantitative Precipitation Forecast (QPF) ECMWF

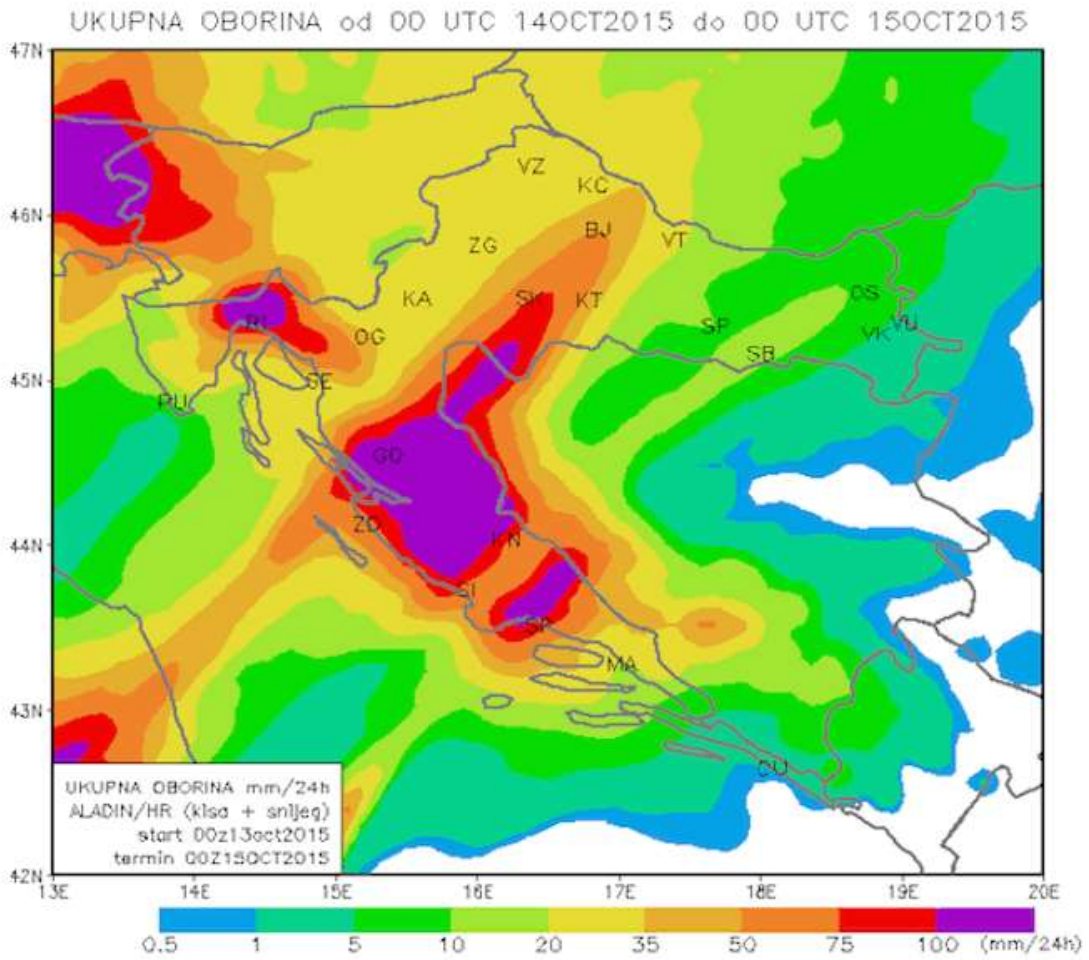


24-hr Quantitative Precipitation Forecast (QPF) ECMWF



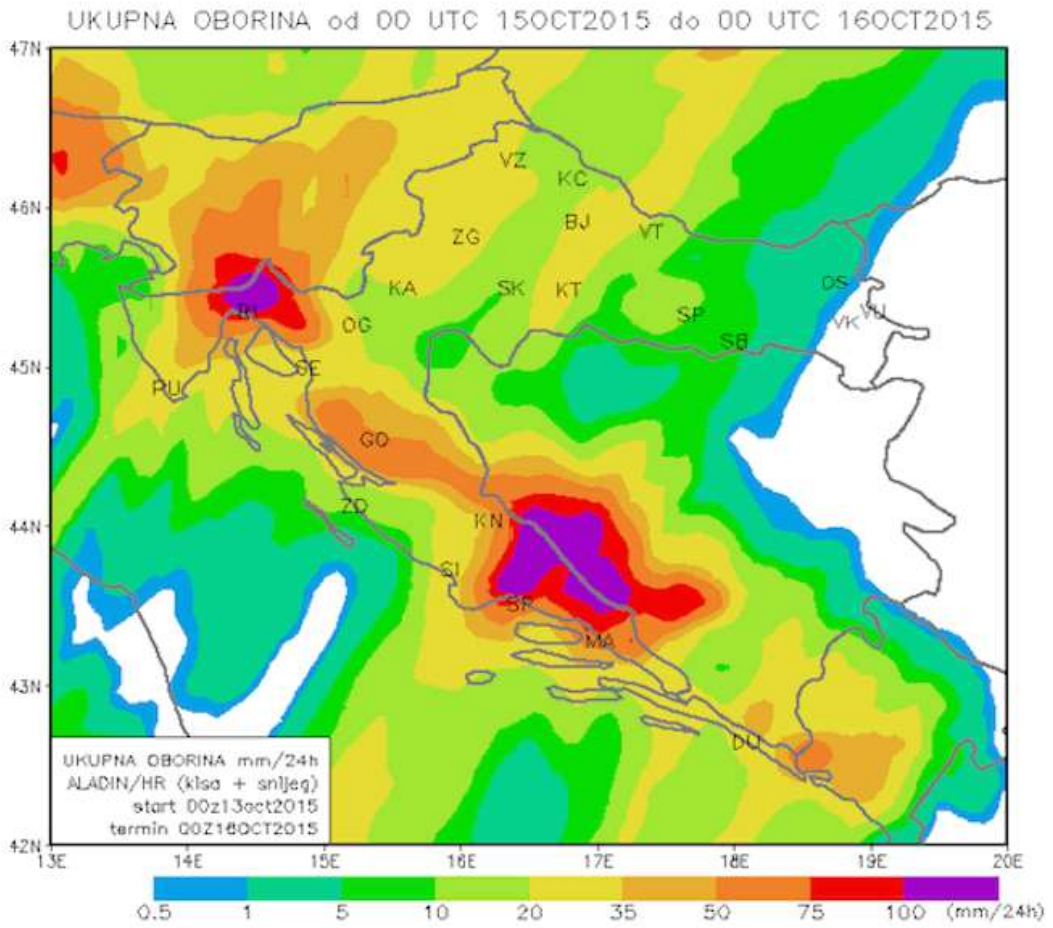
24-hr Quantitative Precipitation Forecast (QPF) ALADIN-HR

15 May 2015, 00 UTC

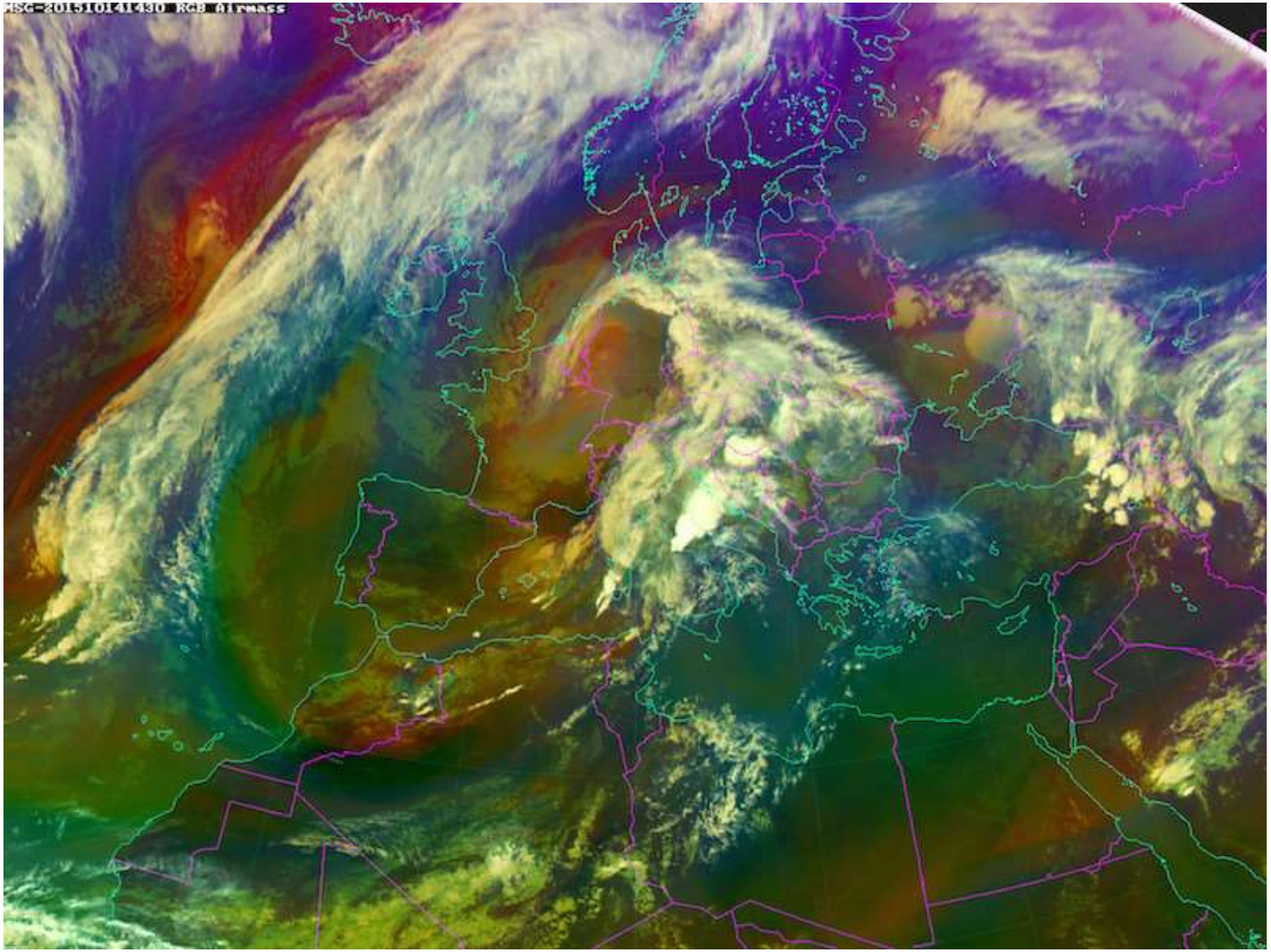


24-hr Quantitative Precipitation Forecast (QPF) ALADIN-HR

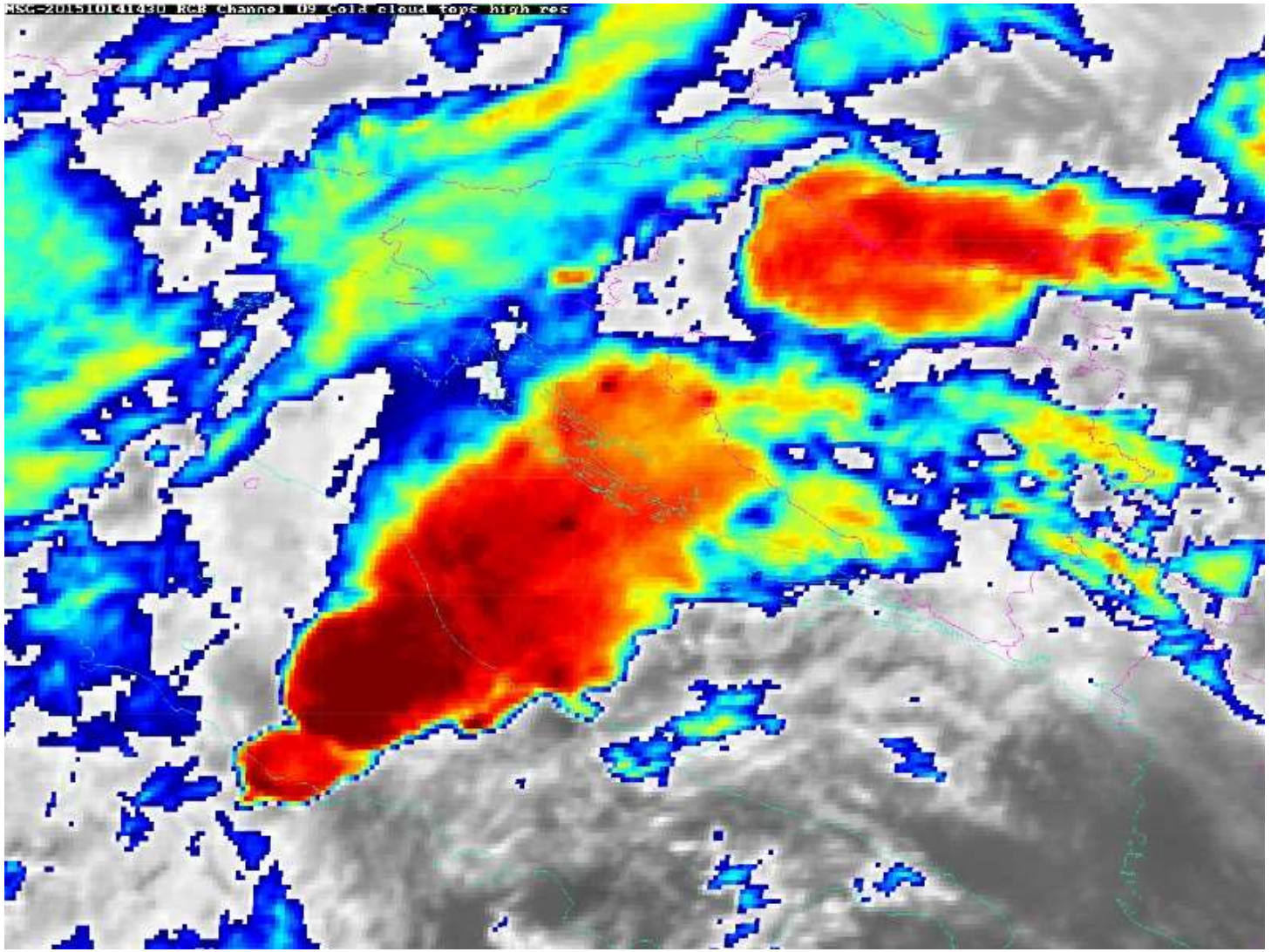
16 May 2015, 00 UTC, ECMWF



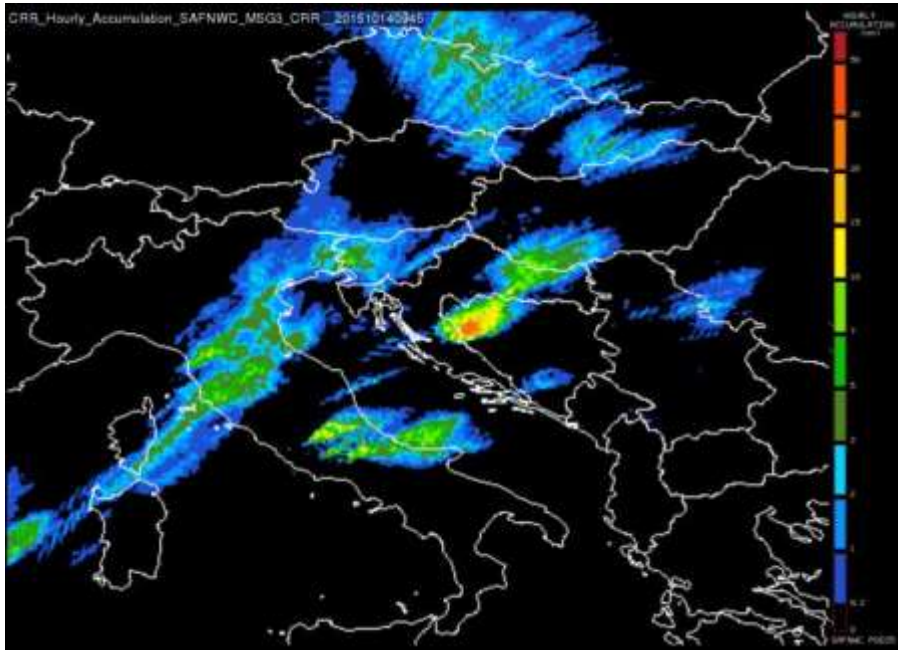
Satellite images: Airmas RGB

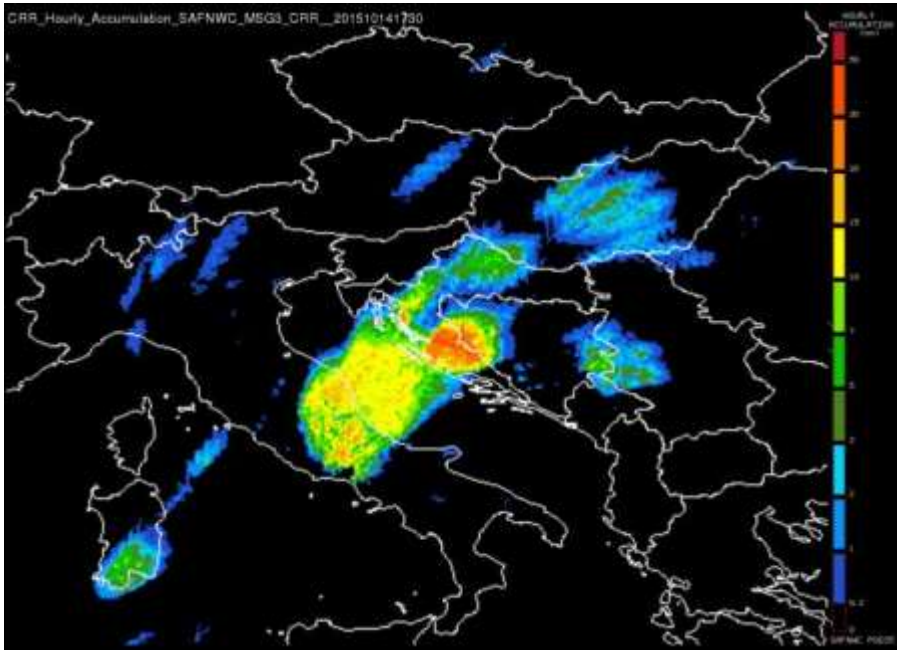


Satellite images: IR Color-Enhanced



Nowcasting SAF: Convective Rainfall Rate

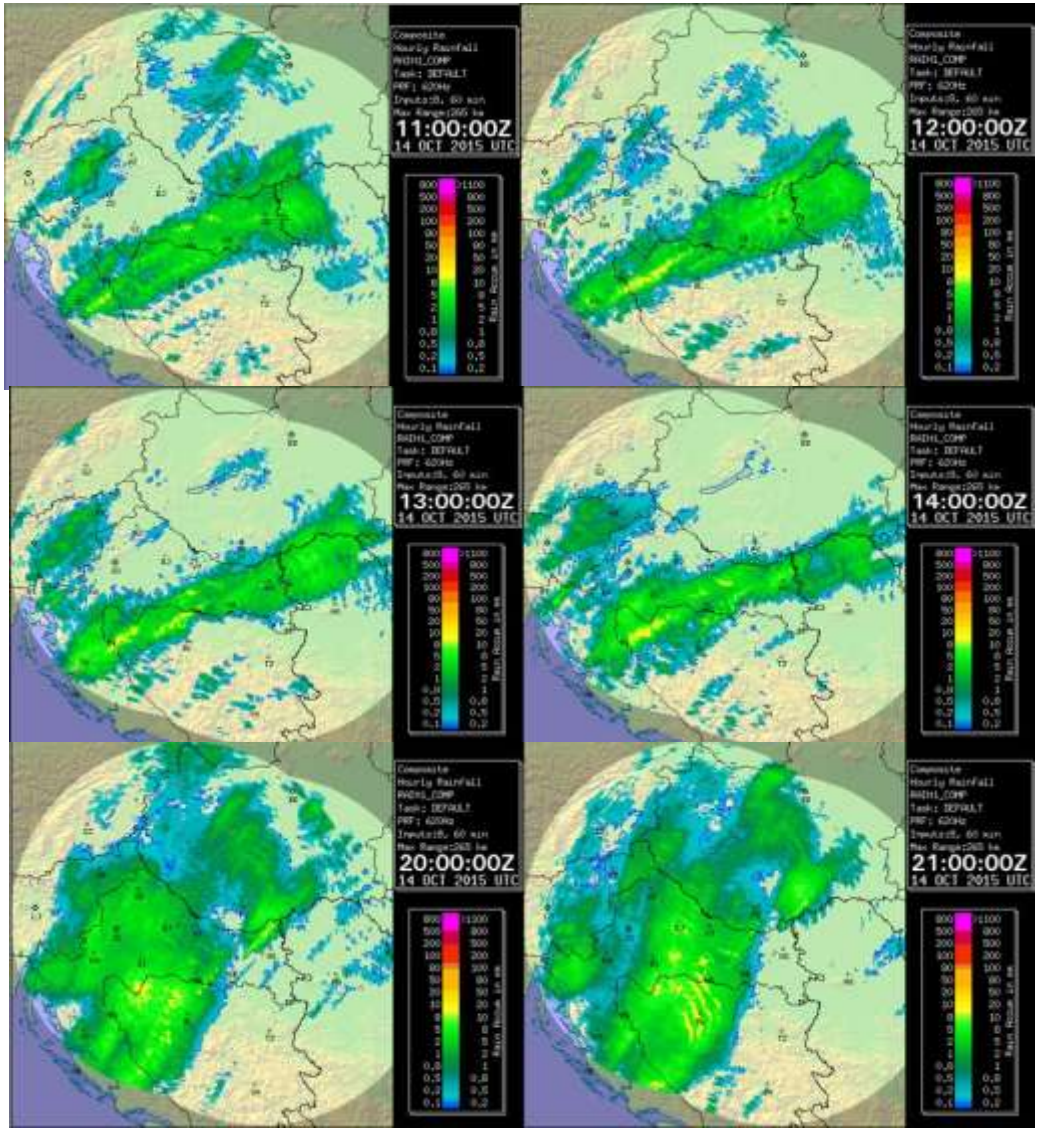




Radar Images

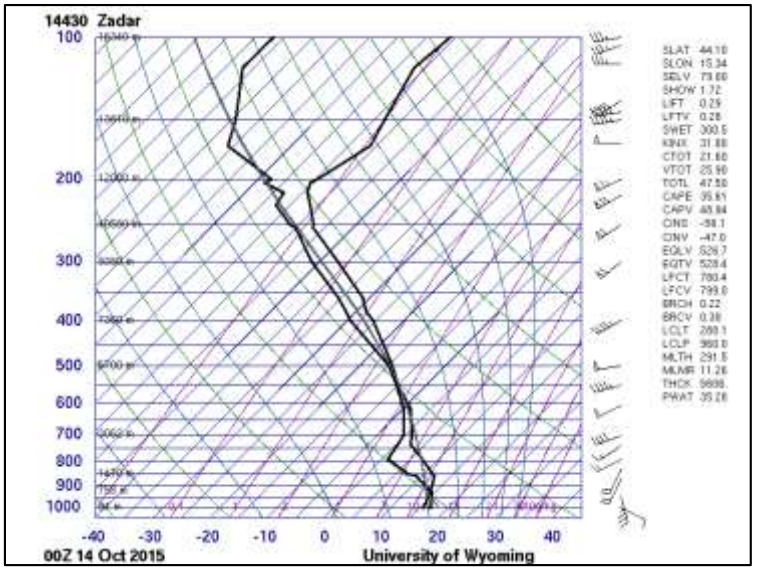
- Since radar provides near real time 2D and 3D scans of the weather with finer spatial and temporal coverage, it is strongly advised to use radar products in particular vertical cross sections of a storm and its spatial and temporal development for the flash flood warnings.

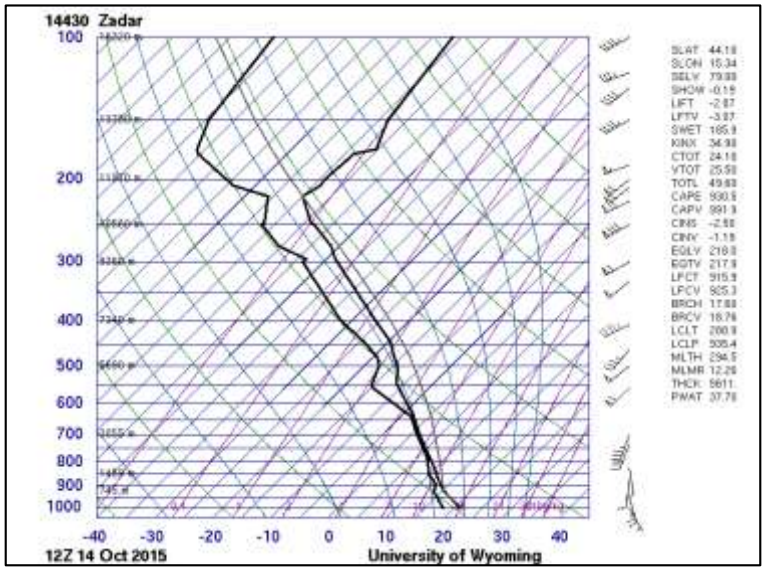
- Particularly, radar is a very good tool to monitor convective activities that may occur in warmer part of the year.

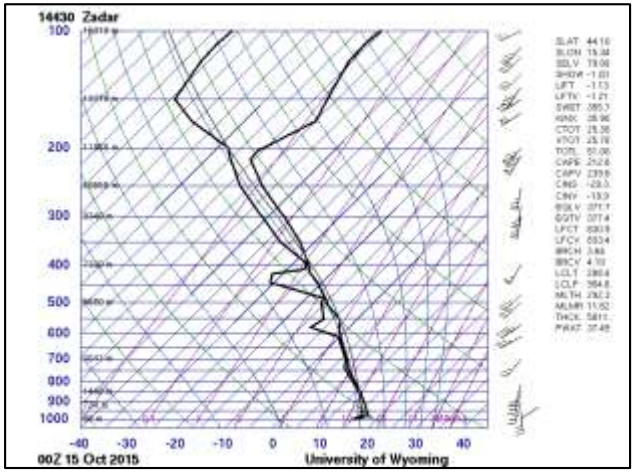


1-hour radar rainfall accumulations, Meteorological and Hydrological Service Croatia

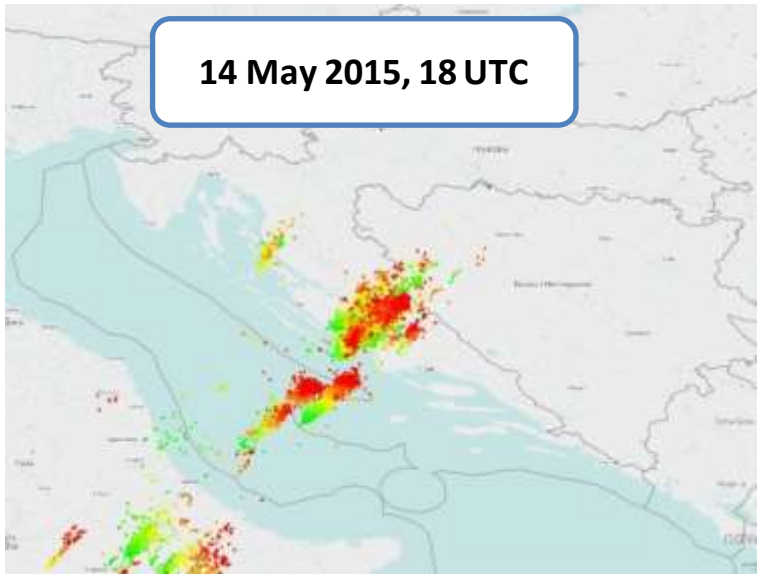
Skew-T Log-P diagrams of Zadar Sounding Station, Croatia

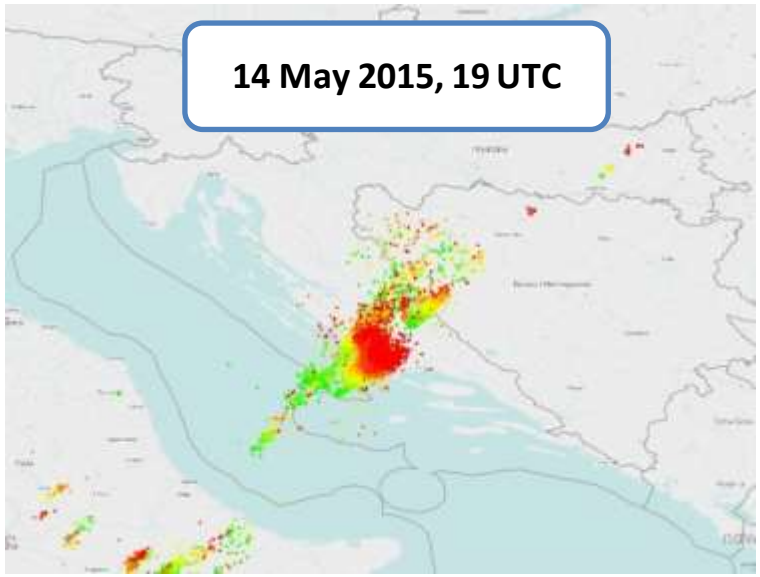






Lightining


14 May 2015, 18 UTC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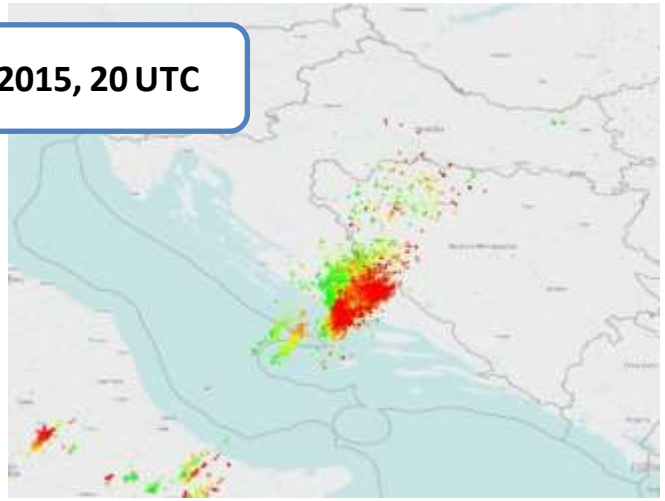
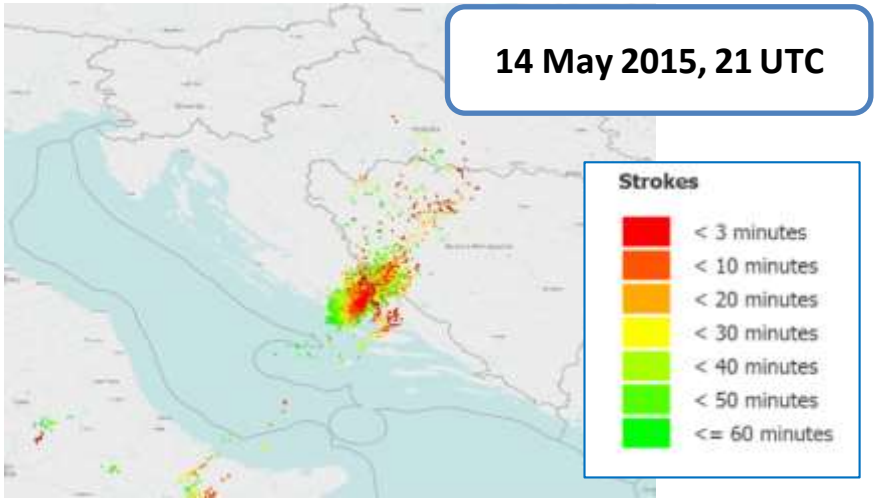
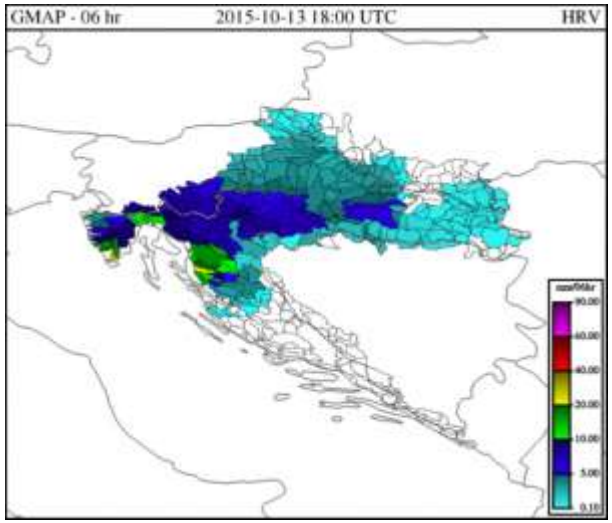
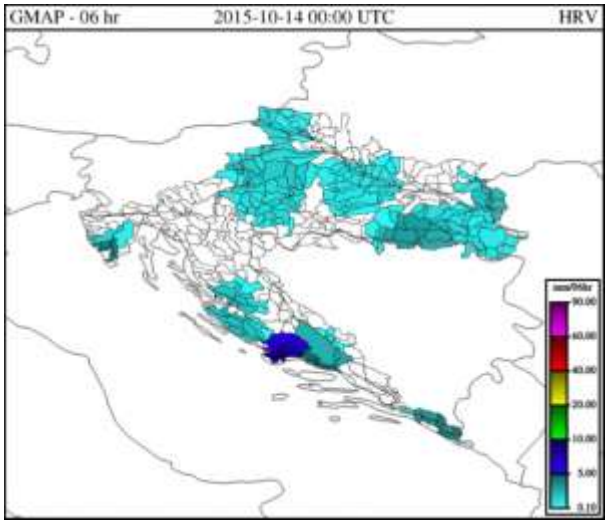
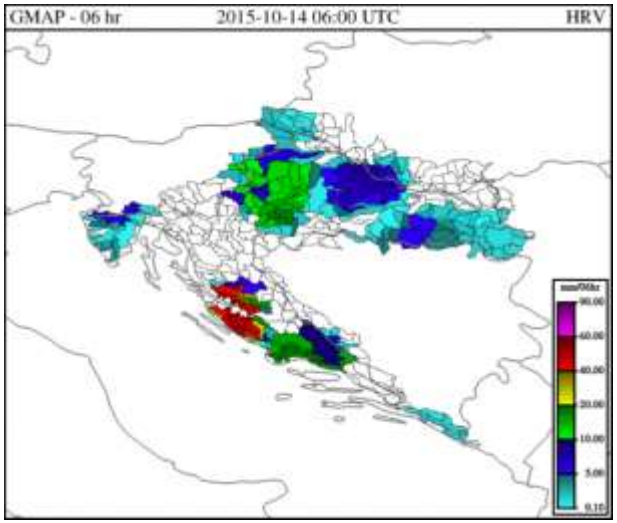

14 May 2015, 20 UTC

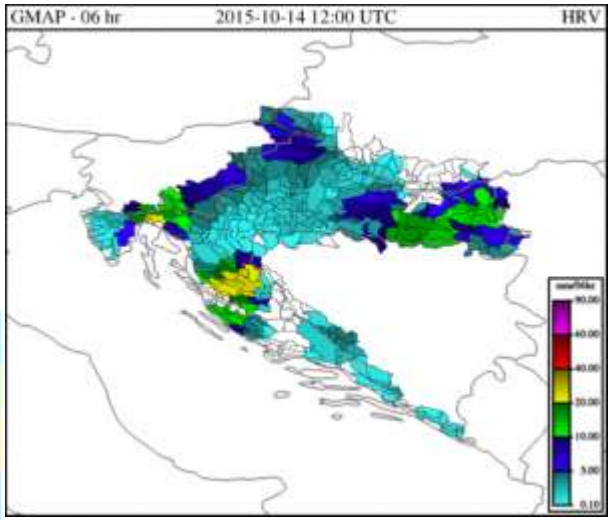

14 May 2015, 21 UTC
Strokes
< 3 minutes
< 10 minutes
< 20 minutes
< 30 minutes
< 40 minutes
< 50 minutes
<= 60 minutes

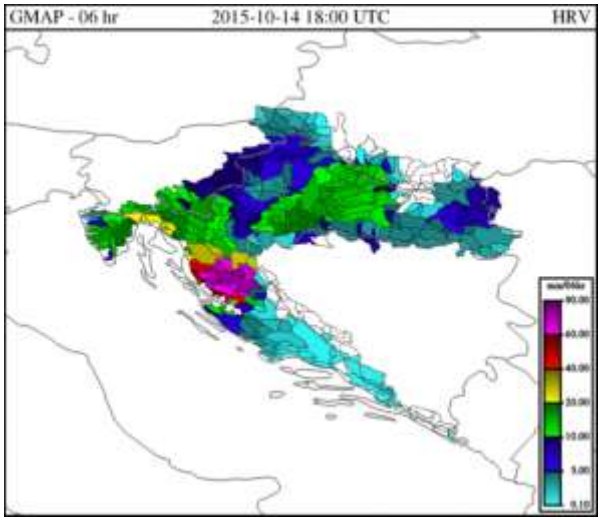
Gauge MAP (Croatia)

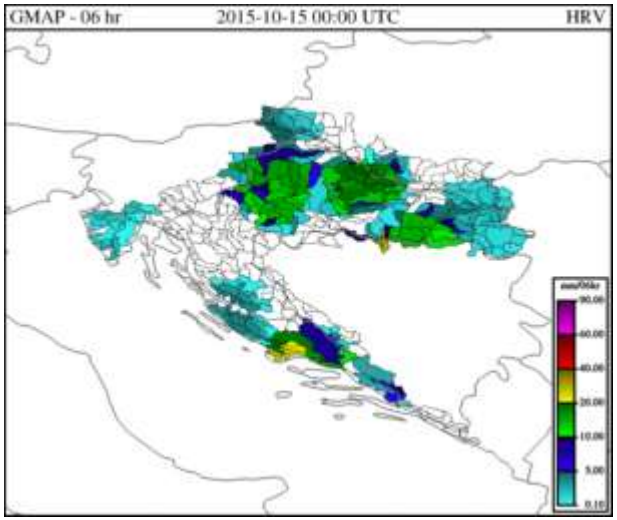




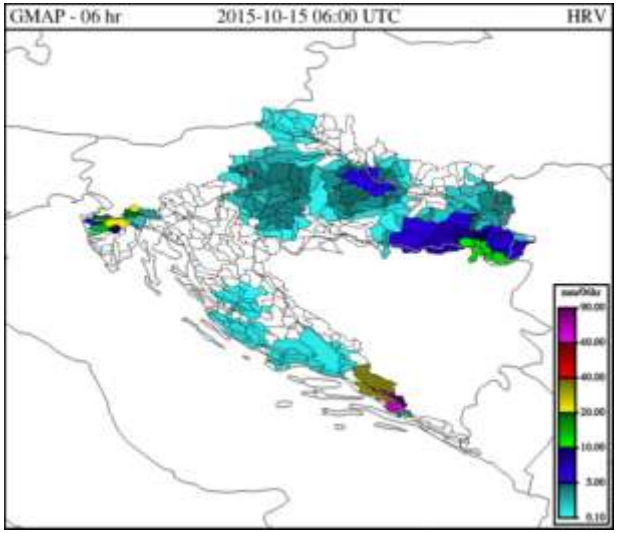


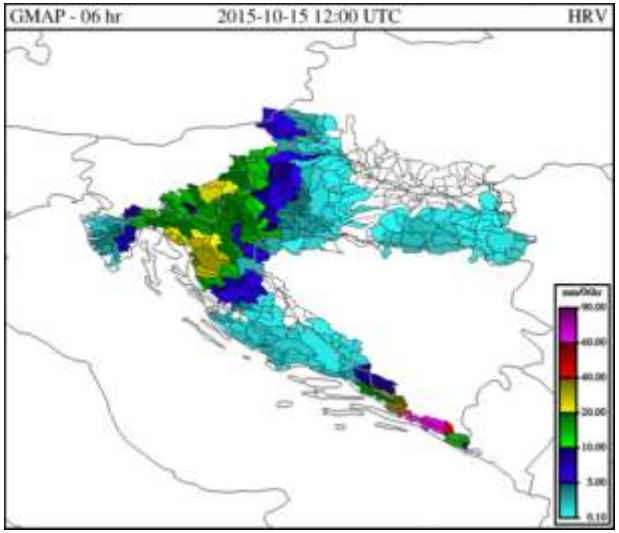


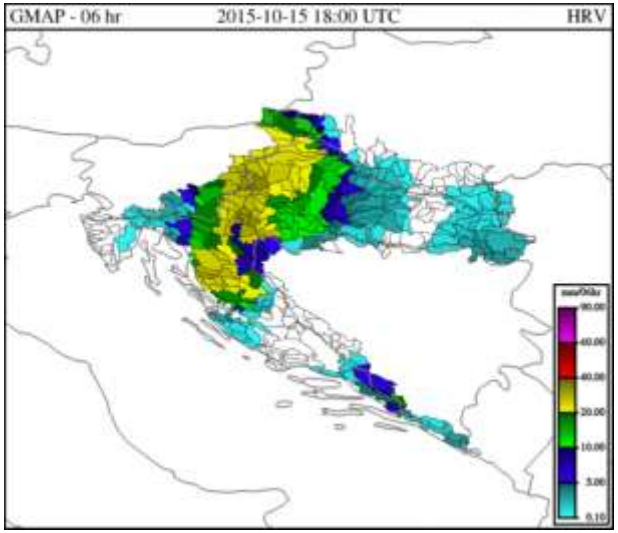




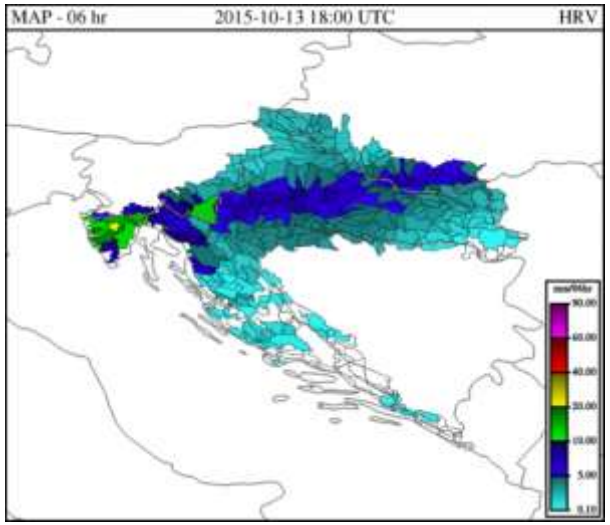
Gauge MAP (Croatia)

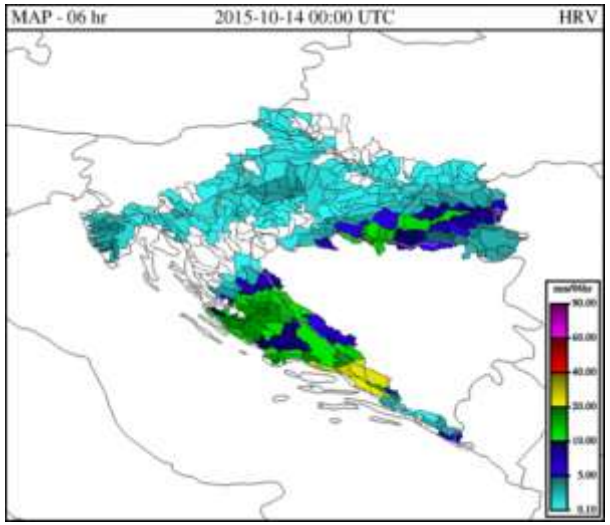


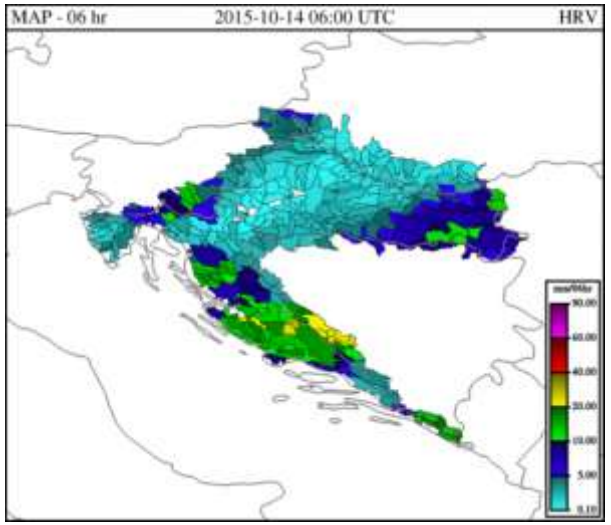


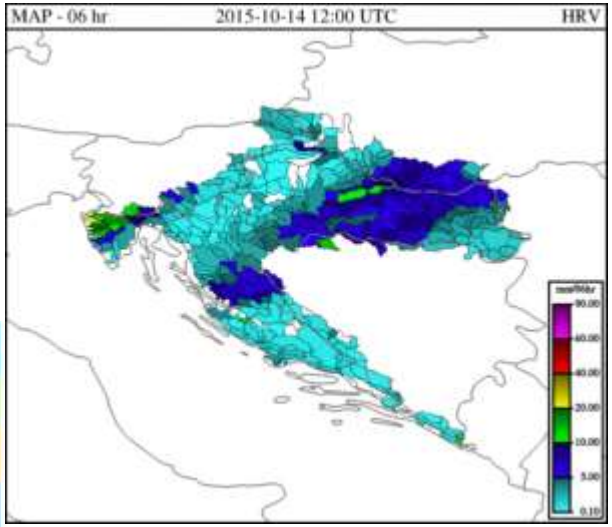


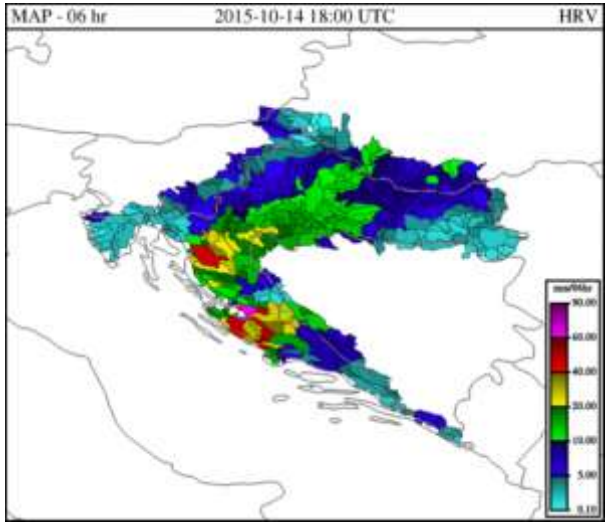
Merged MAP (Croatia)

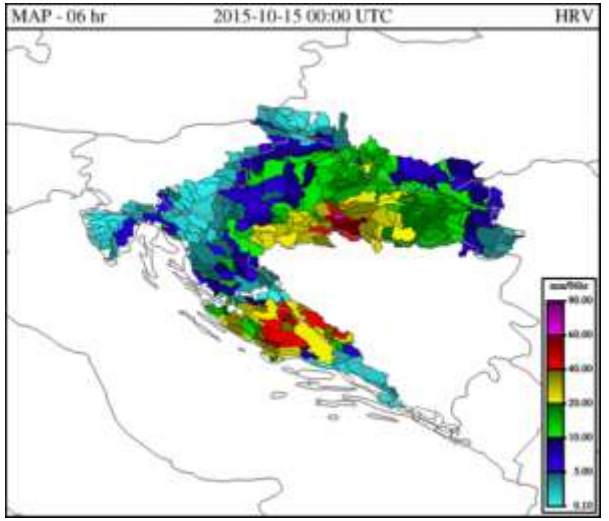




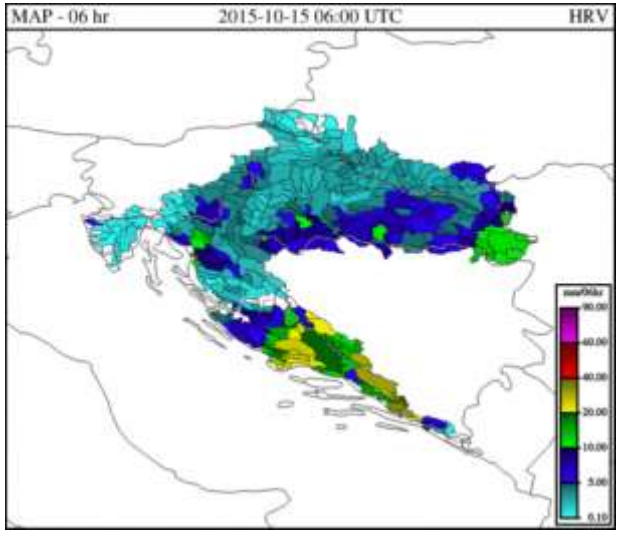


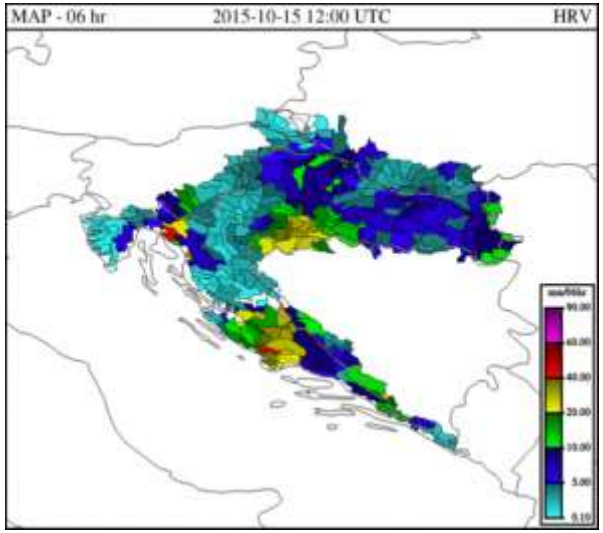


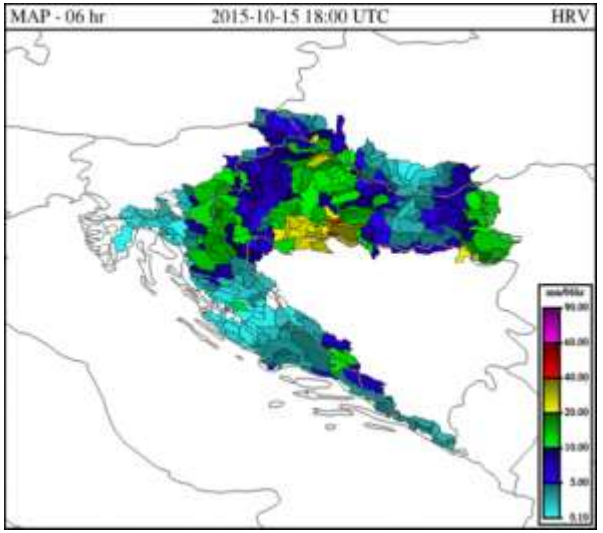




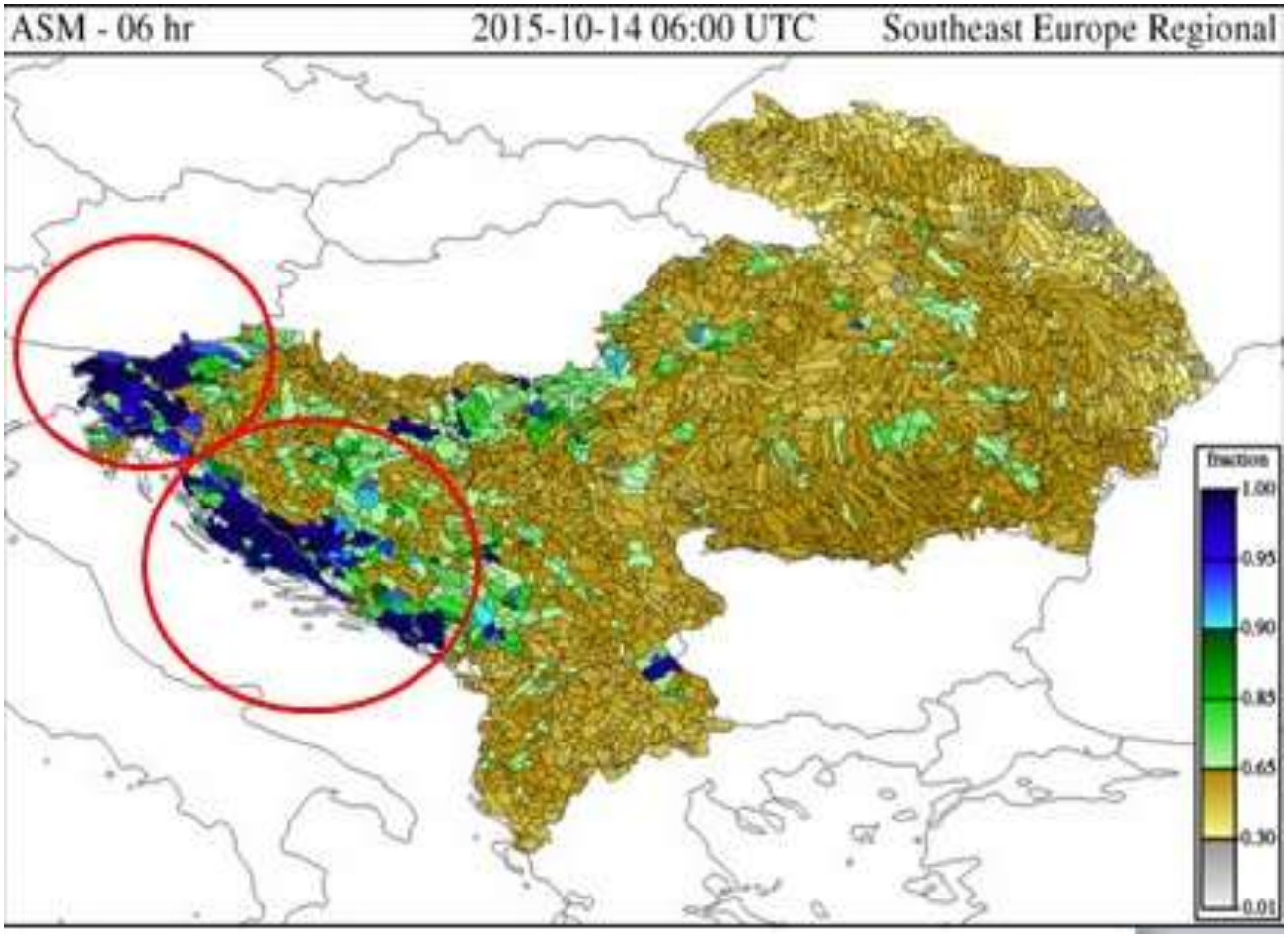
Merged MAP (Croatia)





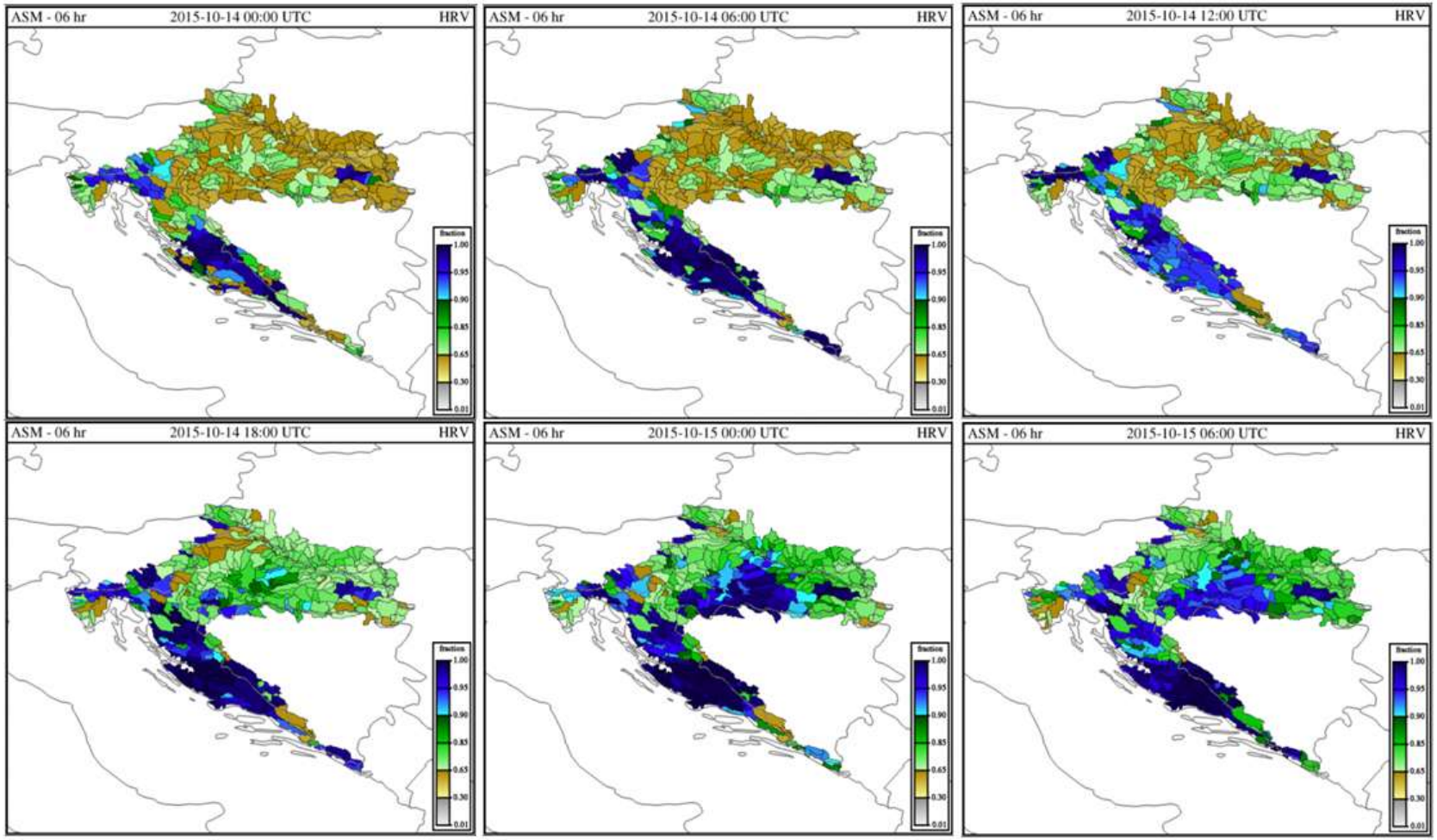


Average Soil Moisture (ASM)



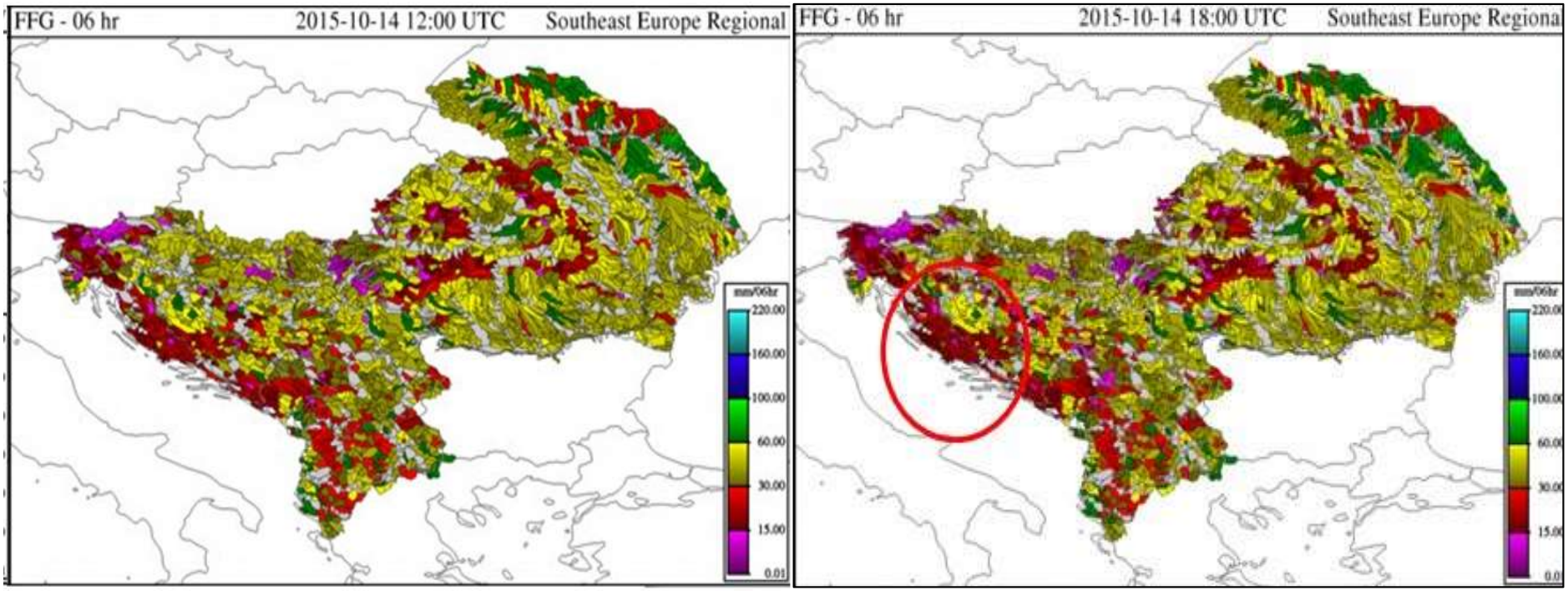
Average soil moisture (ASM) for SEE region on 14 October 2015 at 06 UTC

Average Soil Moisture (ASM)



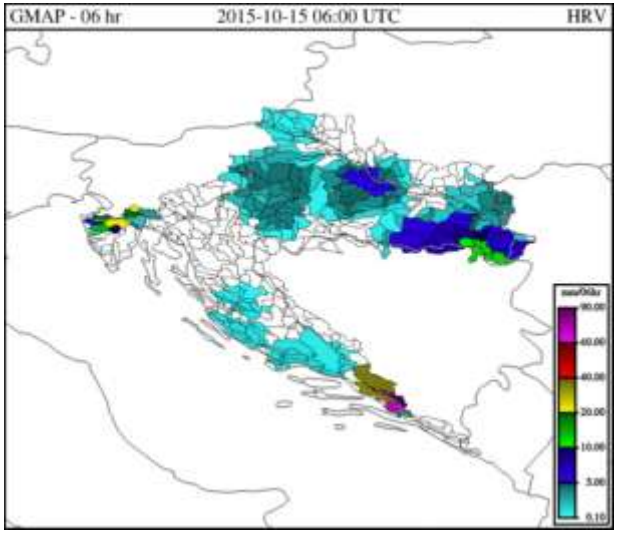
Temporal and spatial distribution of Average Soil Moisture (ASM), Croatia

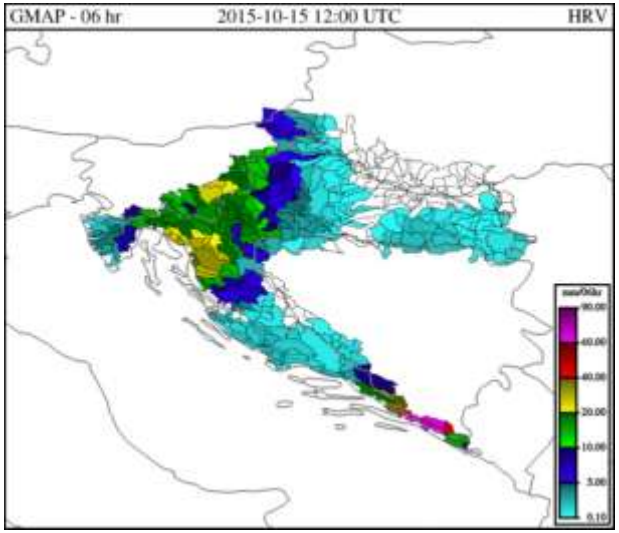
Flash Flood Guidance (FFG)

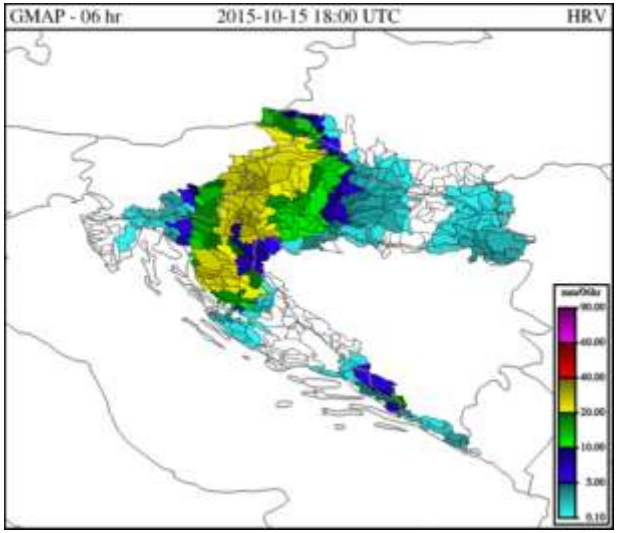


Flash Flood Guidance (FFG) on 14 October 2015 at 12 and 18 UTC, South East Europe

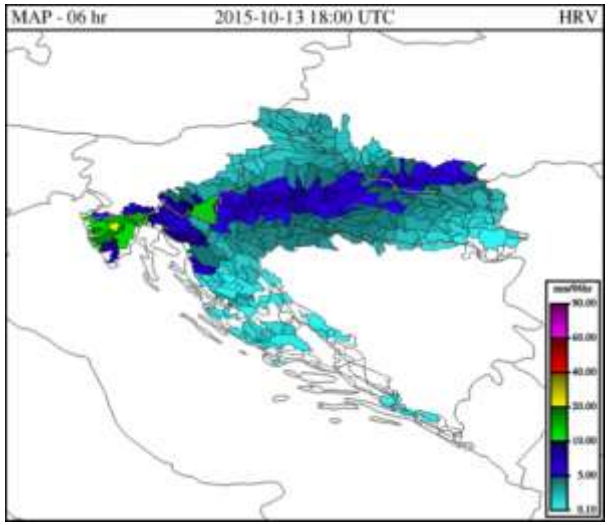
Gauge MAP (Croatia)

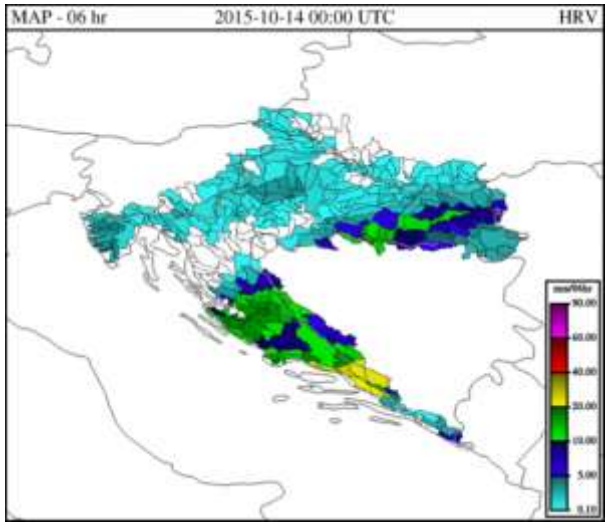


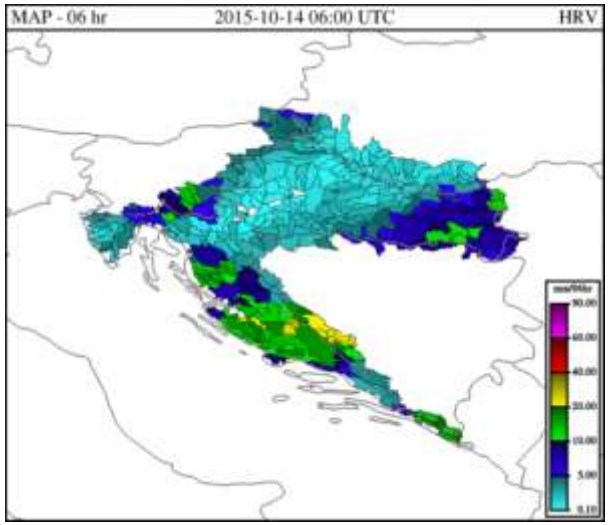


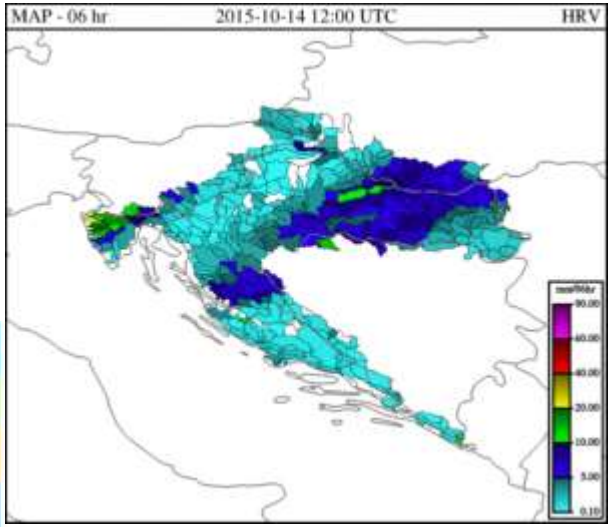


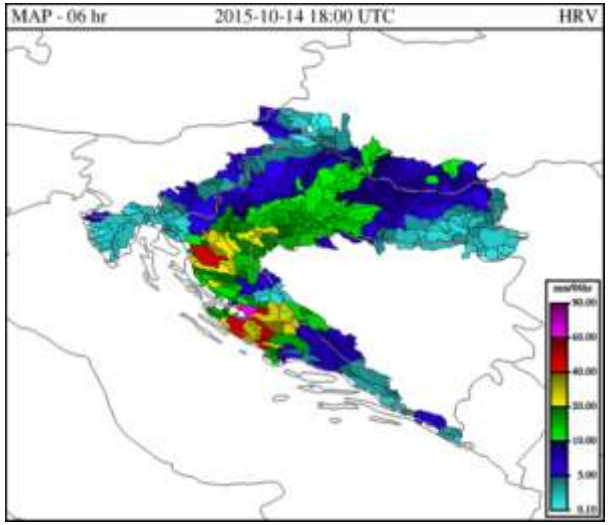
Merged MAP (Croatia)

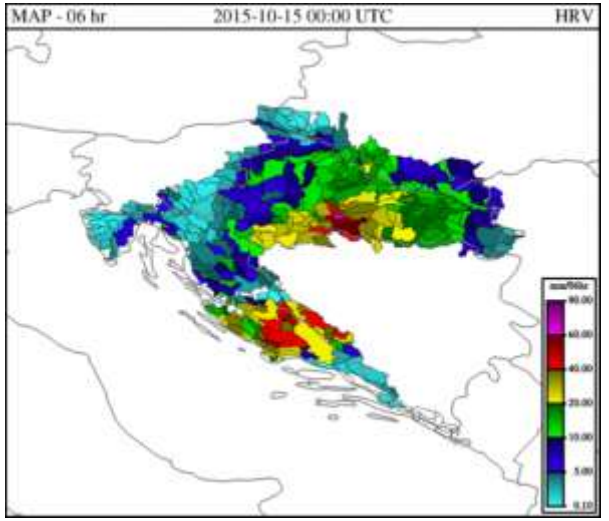




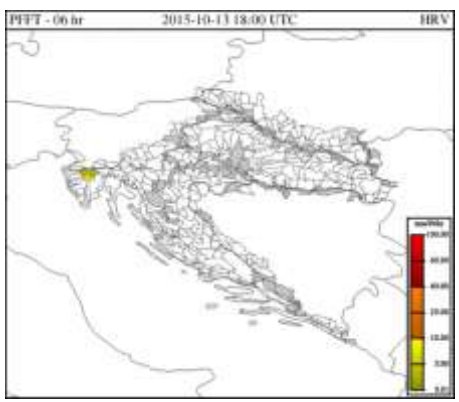


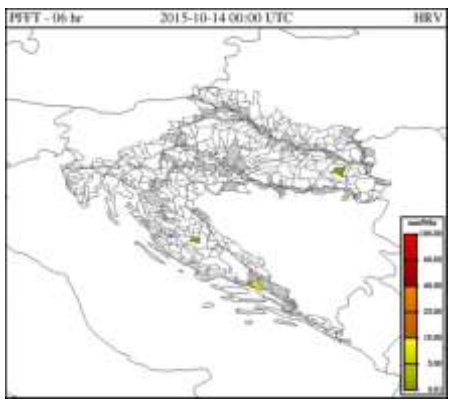


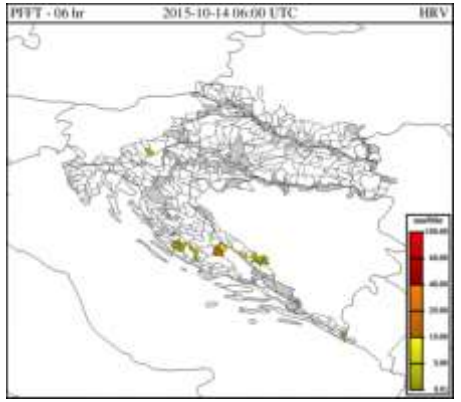


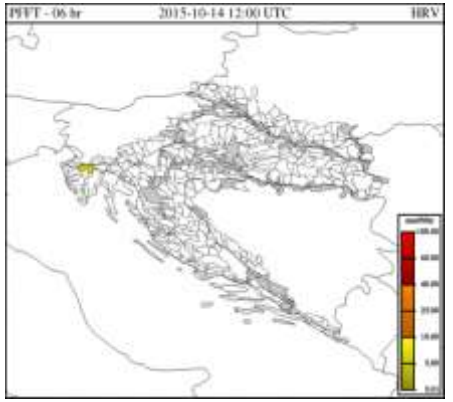


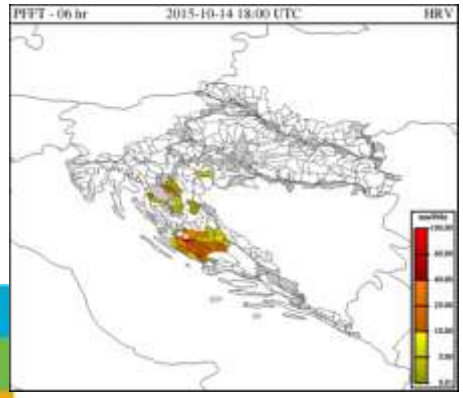
Persistent Flash Flood Threat (PFFT) (Croatia)

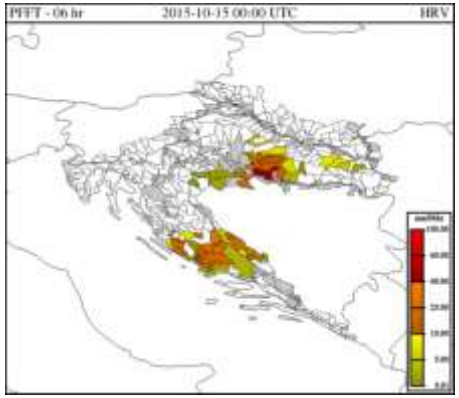


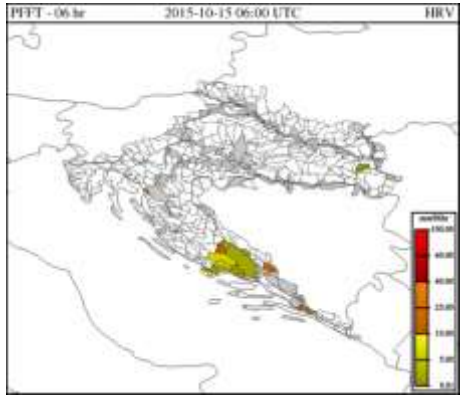


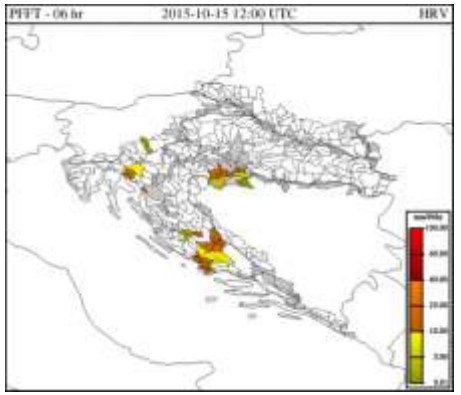




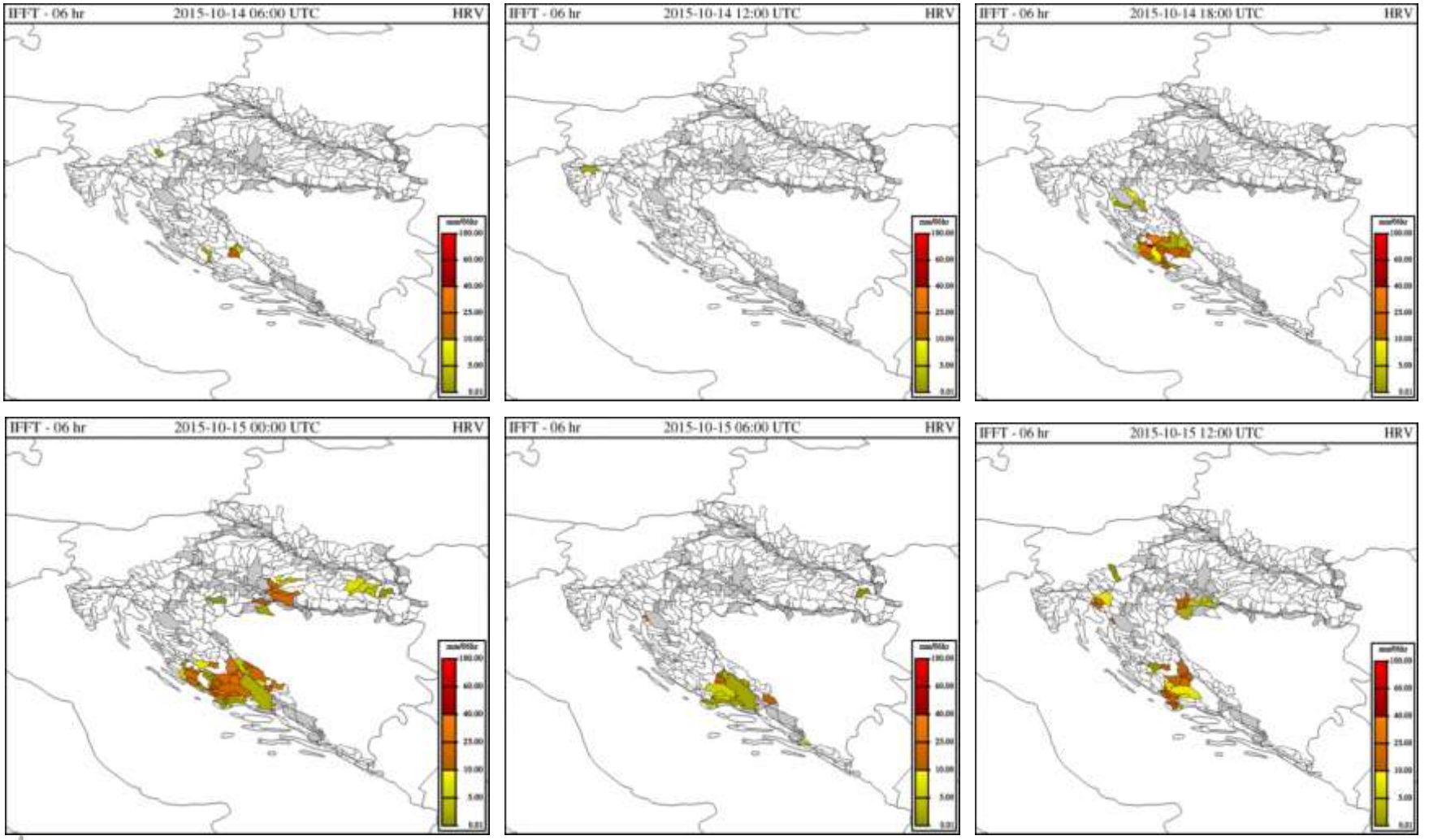




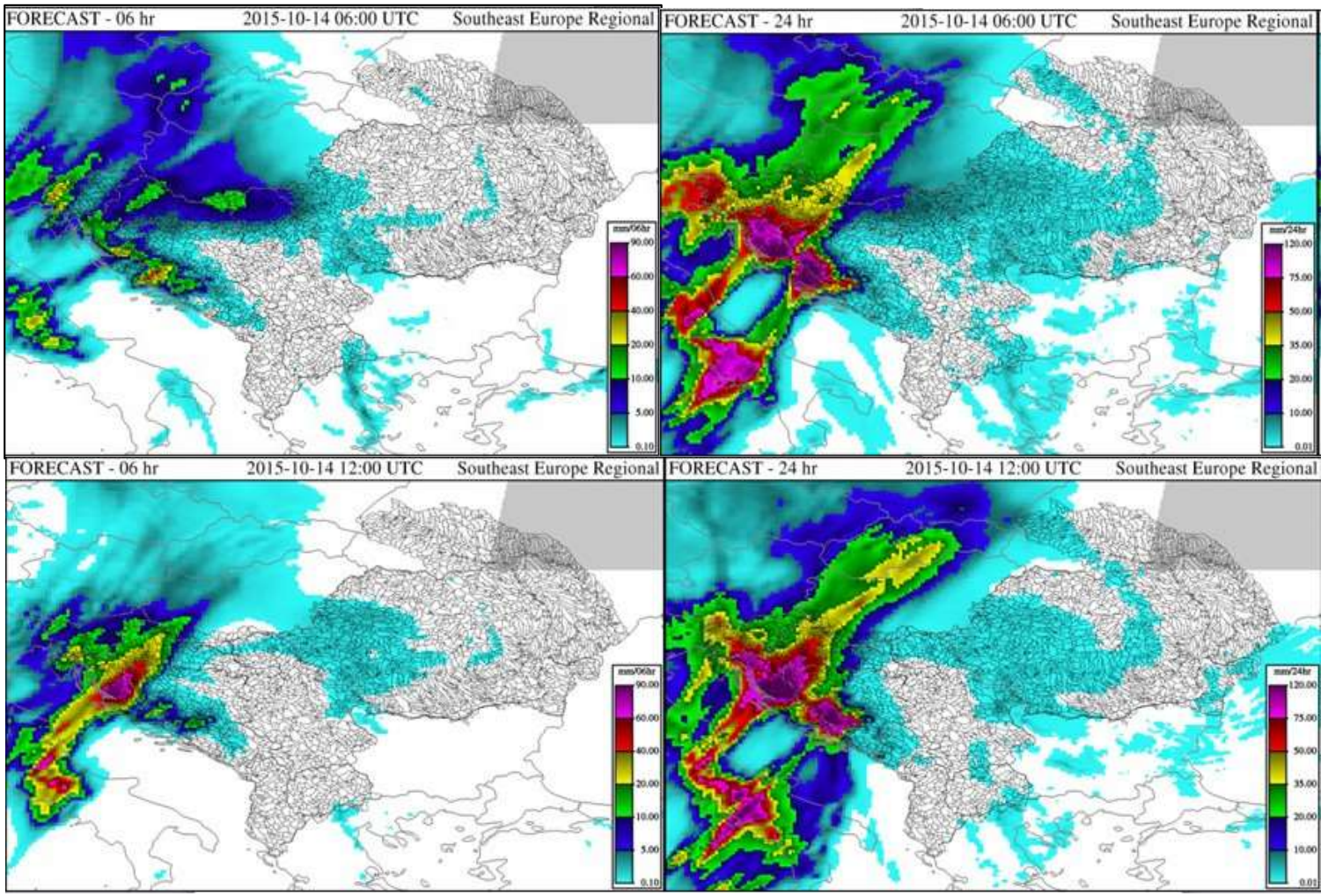




Imminent Flash Flood Threat (IFFT) (Croatia)

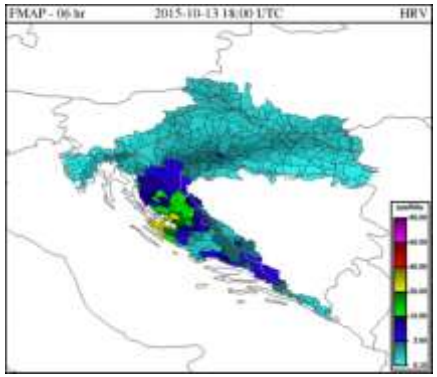


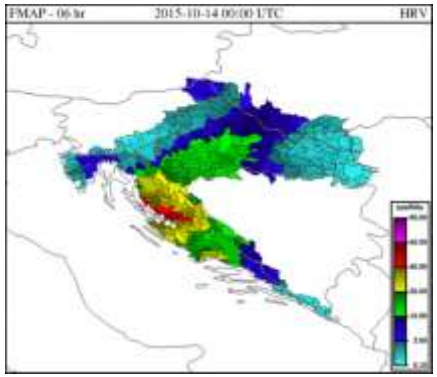
Precipitation Forecast

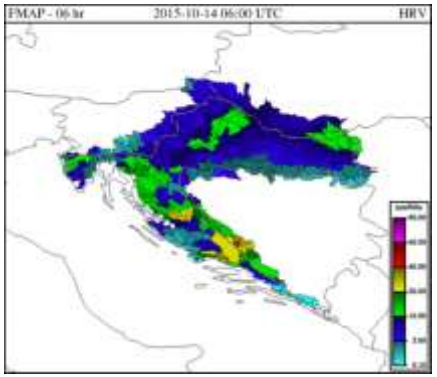


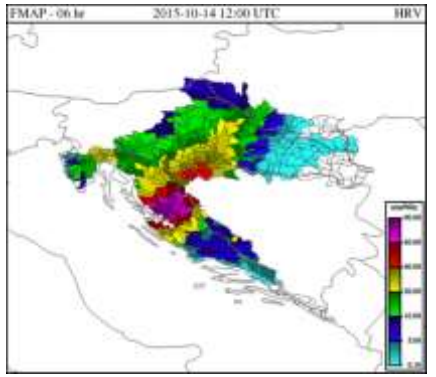
6-hr and 24-hr ALADIN QPF on 14 October 2015 at 06 UTC and 12 UTC, South East Europe

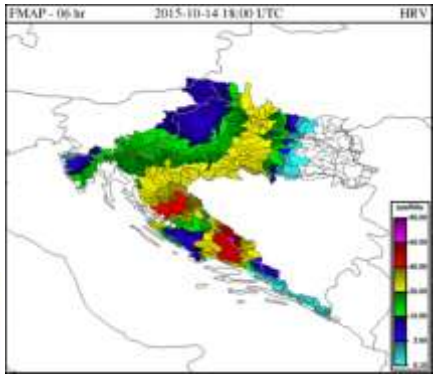
Forecast MAP (FMAP) (Croatia)

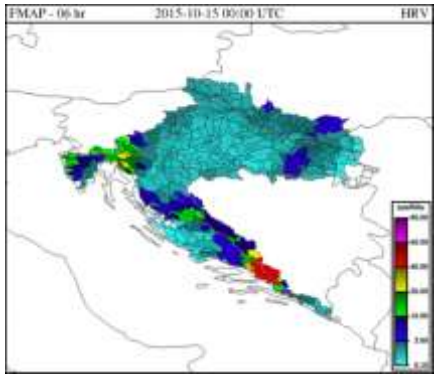


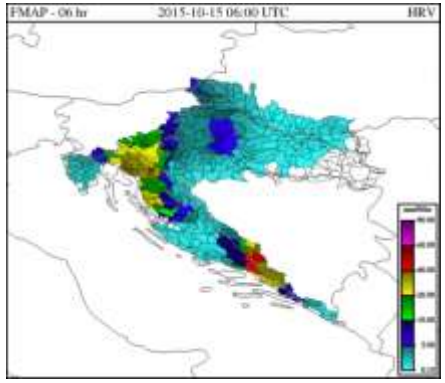


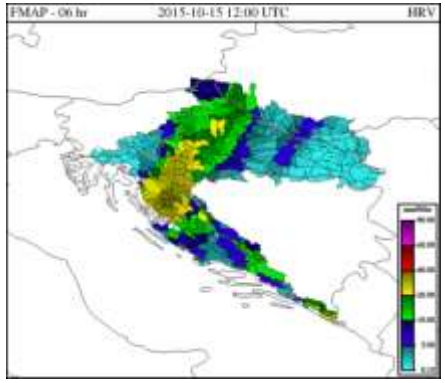




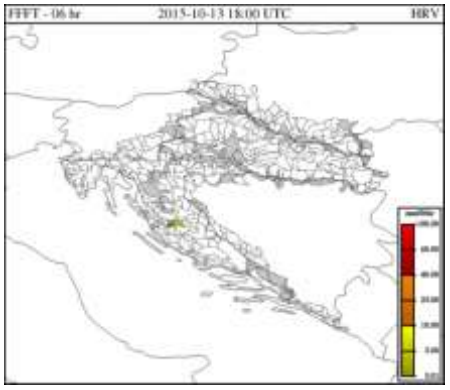


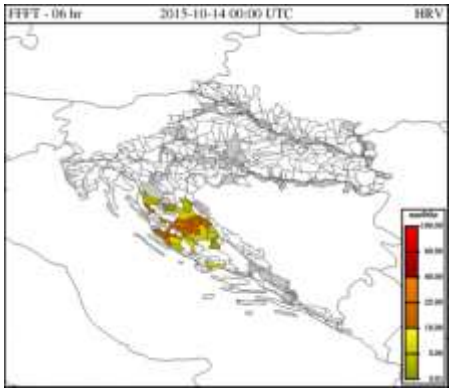


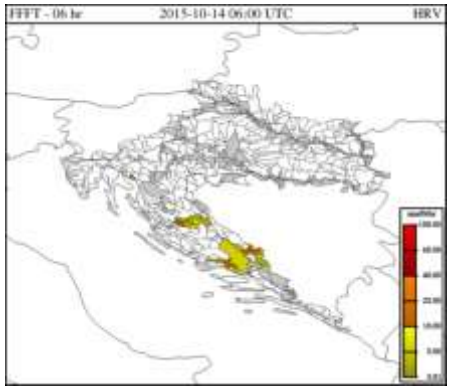


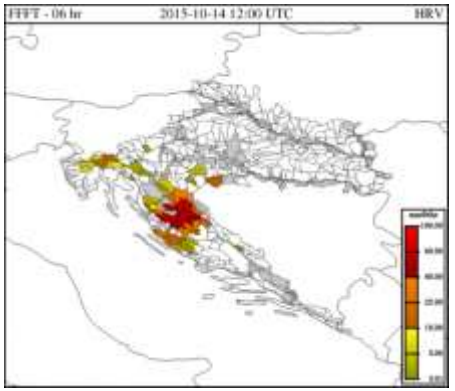


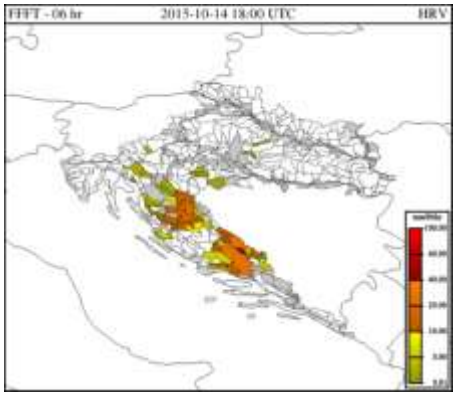
Forecast Flash Flood Threat (FFFT) (Croatia)

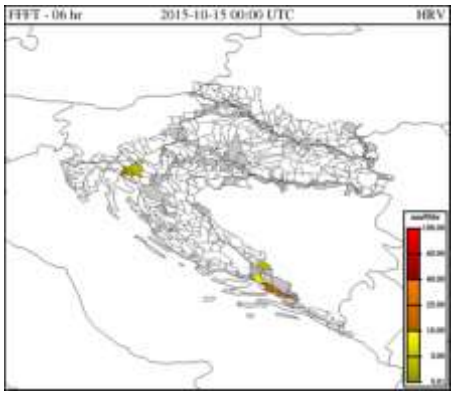


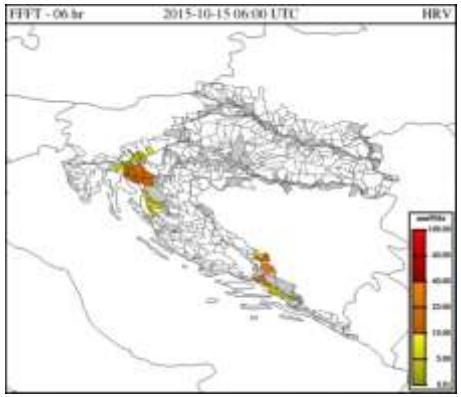


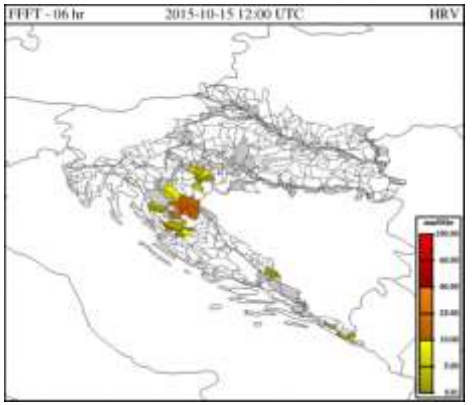




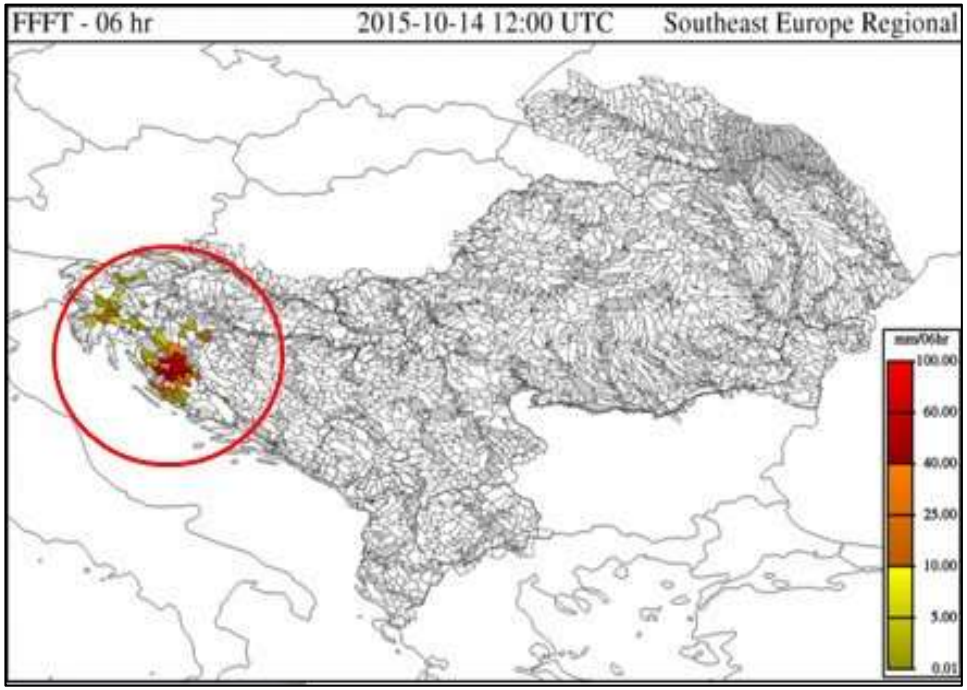


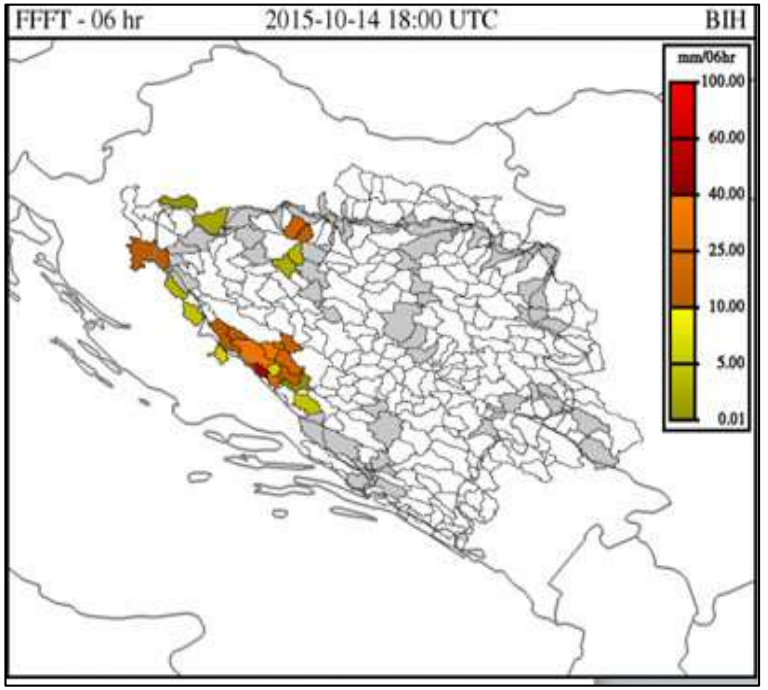






Forecast Flash Flood Threat (FFFT)





Conclusion

- In Bosnia and Herzegovina and Croatia, a flash flood bulletins were prepared to issue warnings for these sub-basins, where actually flash flood happened.
- The Croatian Meteorological and Hydrological Service issued several flash flood warnings to the National Protection and Rescue Directorate (NPRD) and also via Meteoalarm to the public and media during the event.
- Post-event assessment indicated a probability of detection of 90% and a probability of a false alarm of 10%.
- In addition, approximately 100 landslides occurred during this event. Infrastructure was flooded, roads and vents were damaged but fortunately there were not any human losses.

Flash floods along the coastal Croatia on 14 and 15 October 2015

Conclusion

- This case study indicates accurate forecasts and warnings during this event.
- However, both countries need more effective action strategies.
- For affected countries, the SEEFFG system was very valuable supplementary tool for forecasting flash floods events.

Flash floods in Bosnia and Herzegovina 15 October 2015

Thank you

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For more information please visit:	**http://www.wmo.int/ffgs**
	http://www.hrcwater.org

WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

WMO OMM
World Meteorological Organization
Organisation météorologique mondiale