



Nataša Strelec Mahović
DHMZ, Croatia

Floods in South-Eastern Europe

Outline

- Introduction
- Catastrophic floods in Central and Eastern Europe since year 2000
- May 2014 floods in South-Eastern Europe:
 - Case
 - Catastrophic consequences
 - Synoptic analysis
 - Hydrological context
 - Forecasts and warnings
 - Summary

Introduction

- In the last decades heavy floods in Europe seem to have become more frequent
- Large parts of the continent are almost every year hit by severe precipitation events causing floods
- Often the intensity of the flooding is enhanced by the water waves coming through rivers or by melting snow
- Especially critical were floods in 2002, 2005, 2013

Floods in Europe since 2000



Prague

August 2002

Dresden



Budapest

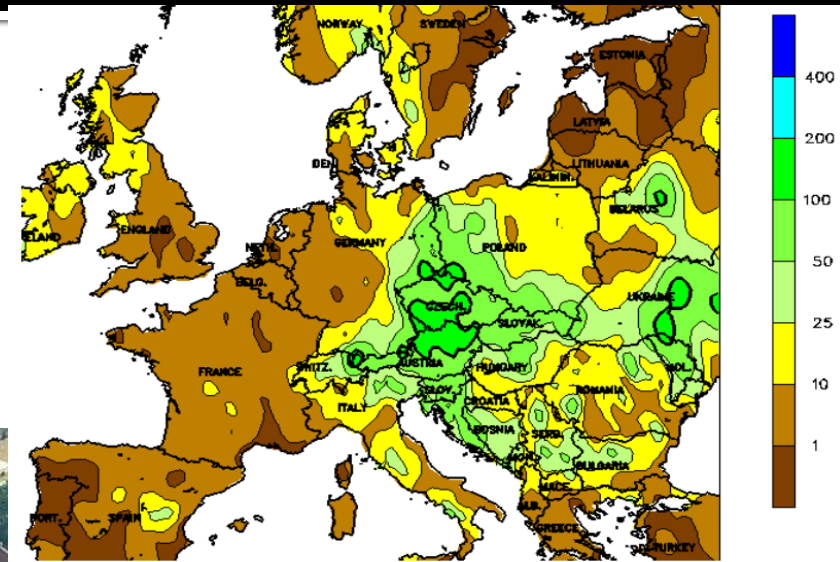
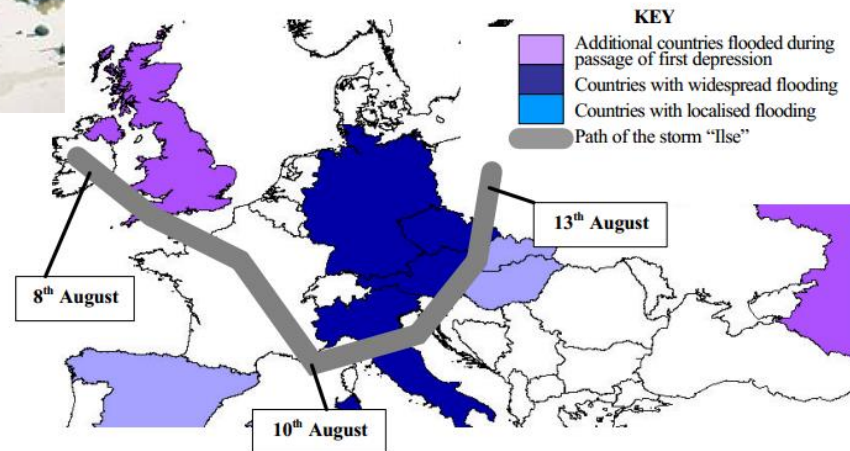
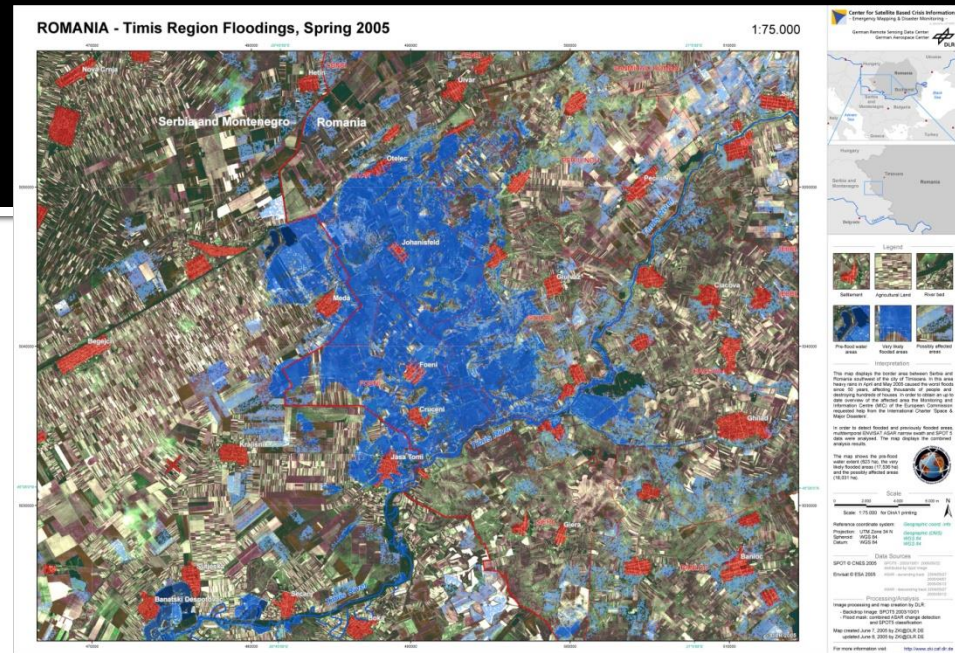


Fig. 3: Precipitation in Europe, August 11-17. Source: NOAA.





Spring 2005 Romania

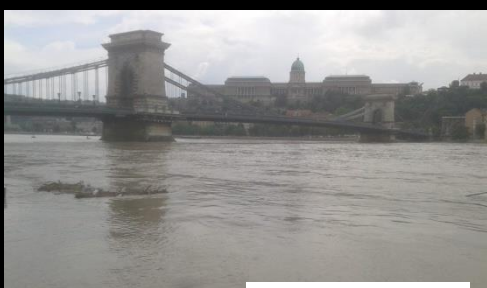


Summer 2005 Central and Eastern Europe

"Cities and towns across central Europe remain on alert as they deal with the impact of devastating floods which have killed at least 42 people."

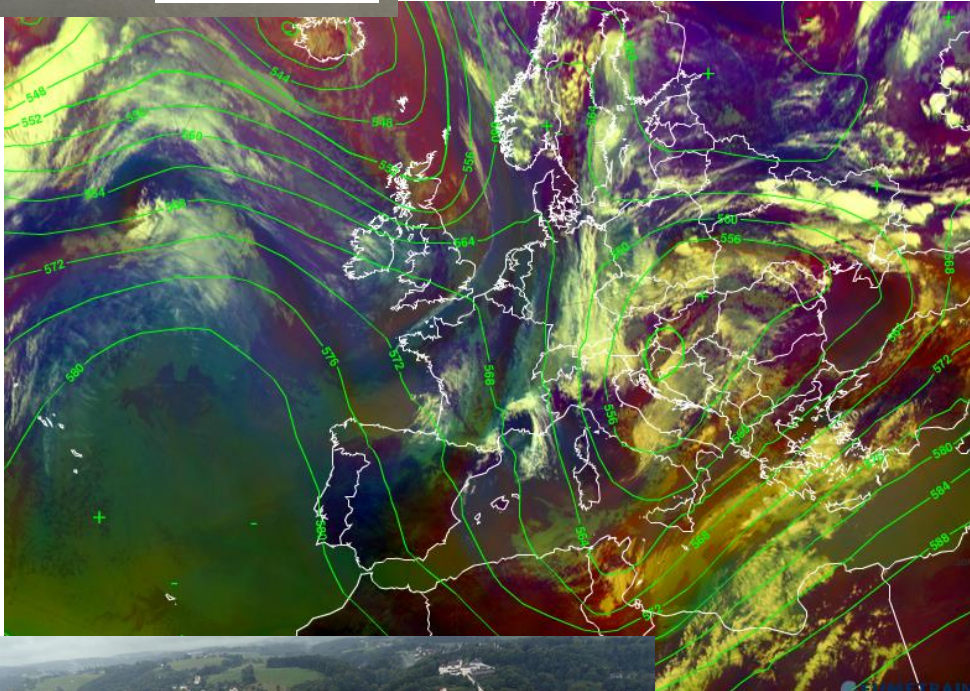
BBC News 26 August 2005



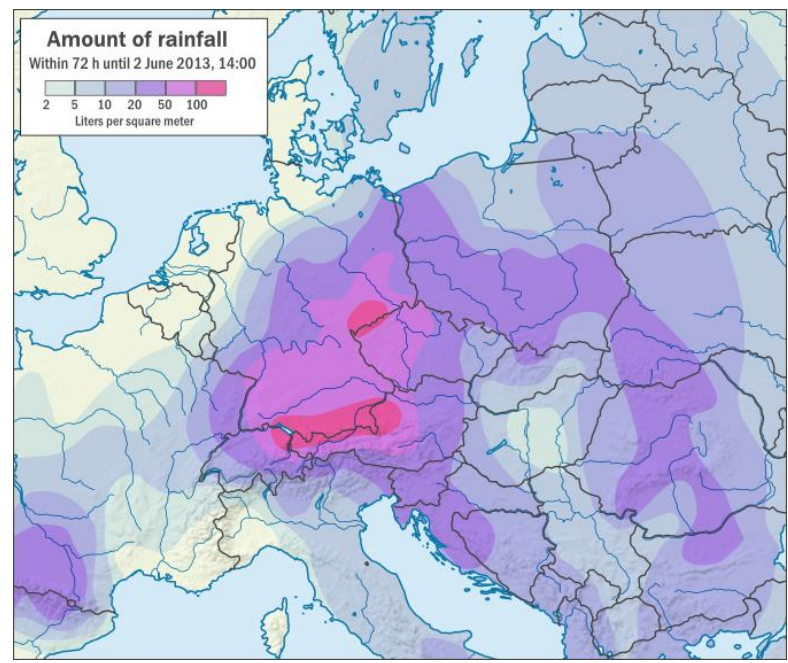


Budapest

June 2013

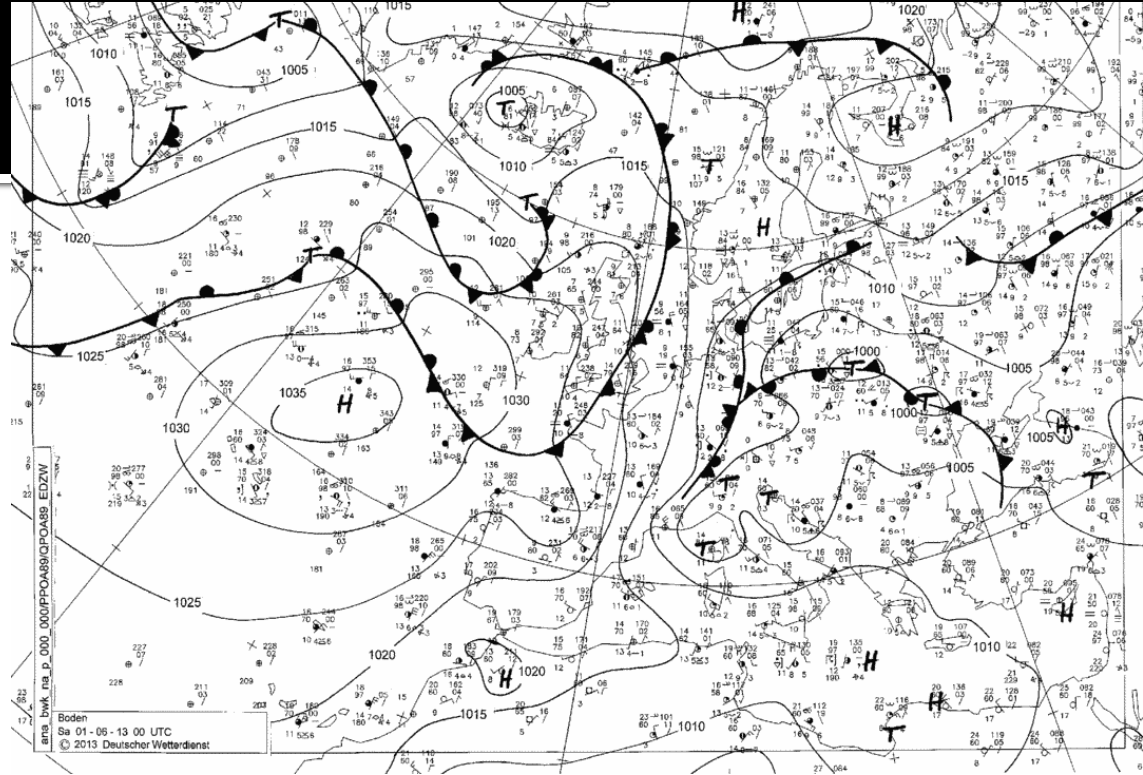


Passau



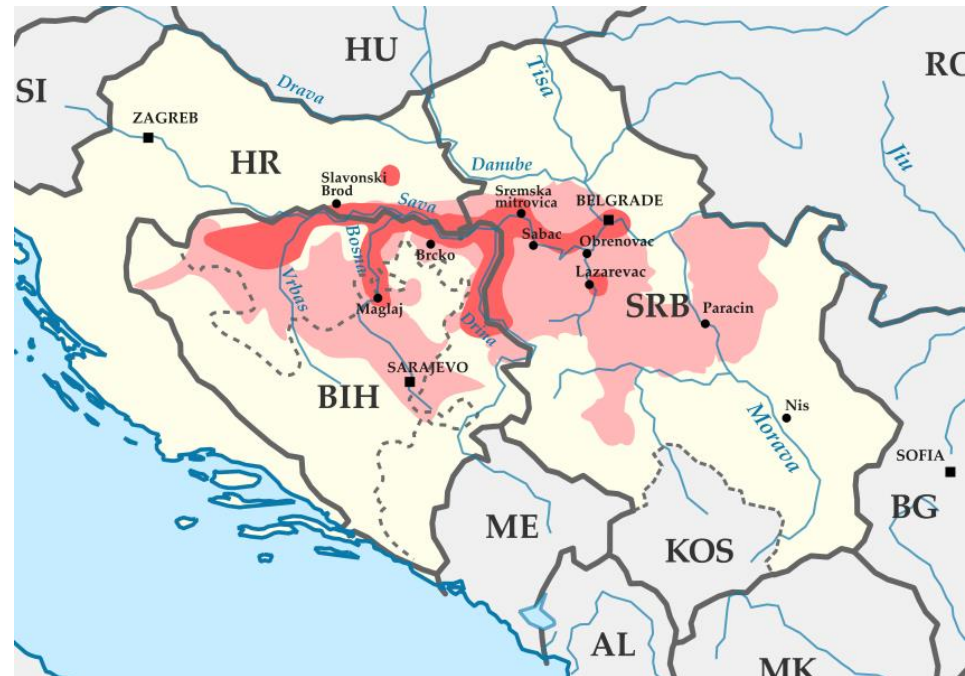
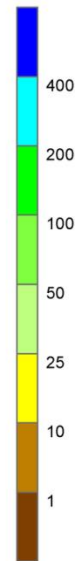
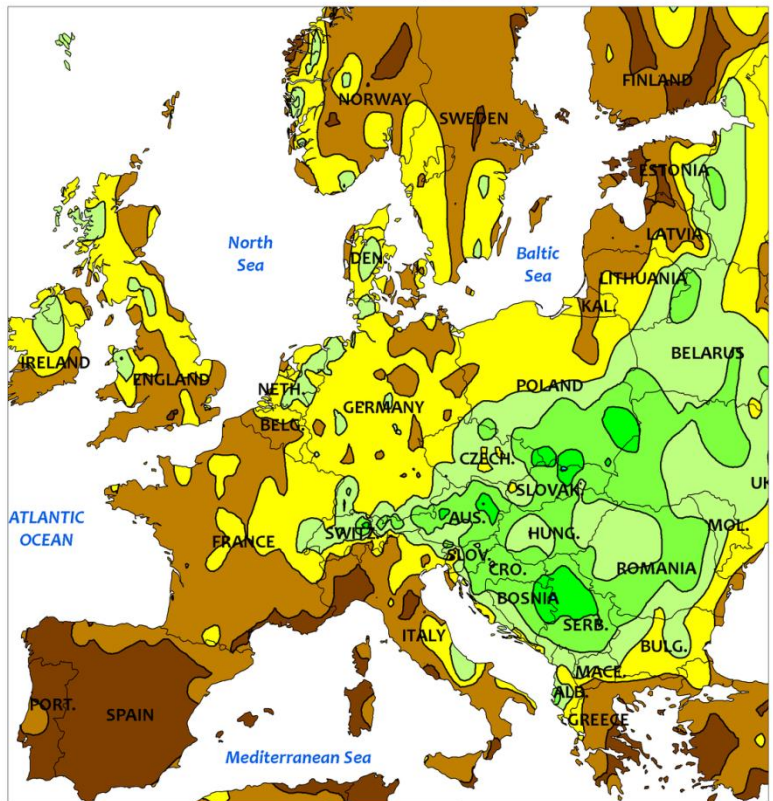
June 2013

- Two-months worth rainfall fell in just 2 days!
- Several people killed in Austria, Germany and Czech Republic
- Elbe and Donau basins were flooded, so the flooding spread to Hungary, and further Serbia and Croatia along the river



May 2014 floods in South-Eastern Europe

- Extensive extreme precipitation event between 11th and 17th May



Map of flooded areas

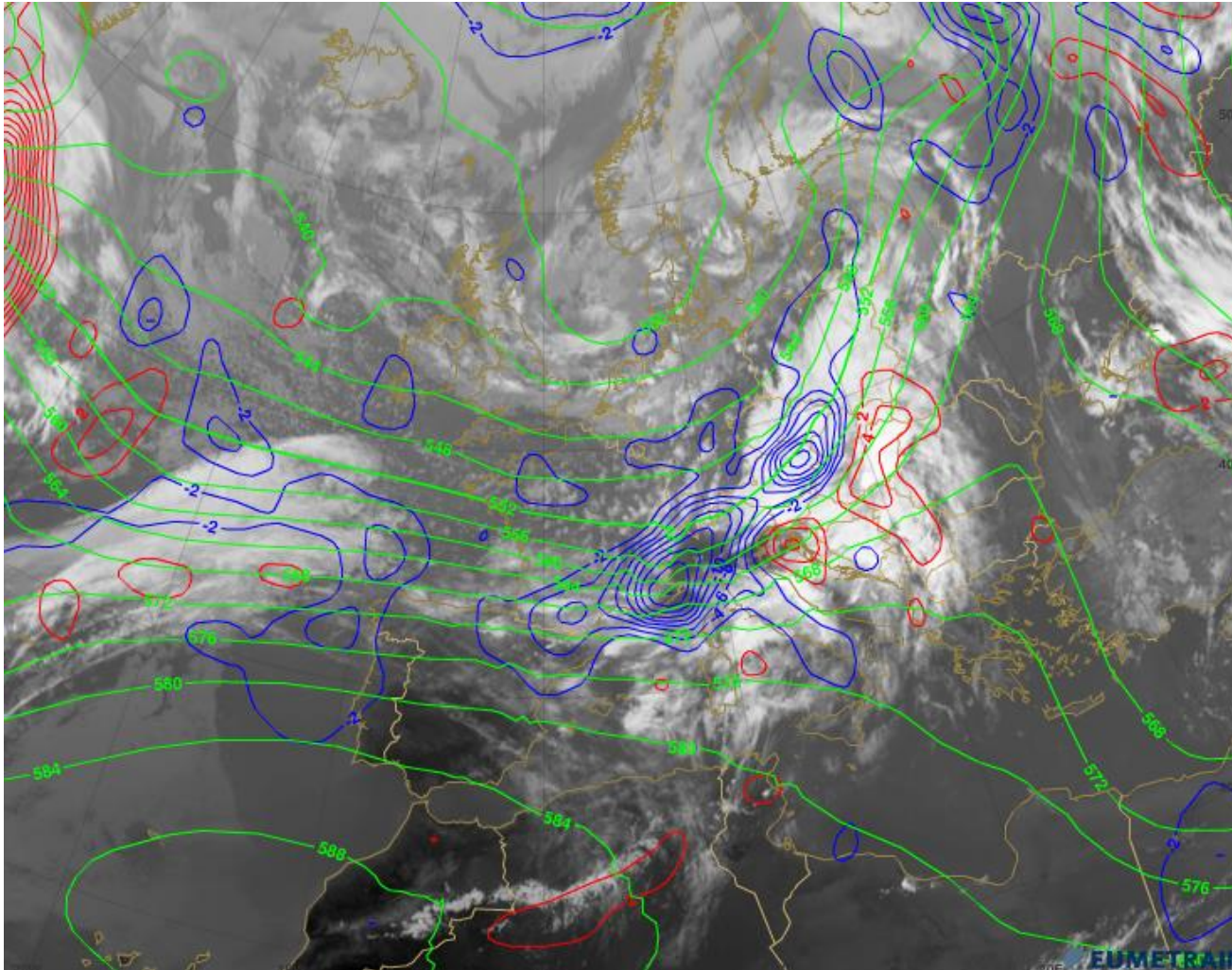
Total precipitation between 11th and 17th May (NOAA)

Catastrophic consequences

- More than 60 people died
- Over 100.000 homes and structures destroyed
- Thousands of livestock animals killed
- 3000 landslides caused by water
- Many landmines left from 1990s war exposed or moved
- The worst flooding in the region in 120 years of record-keeping

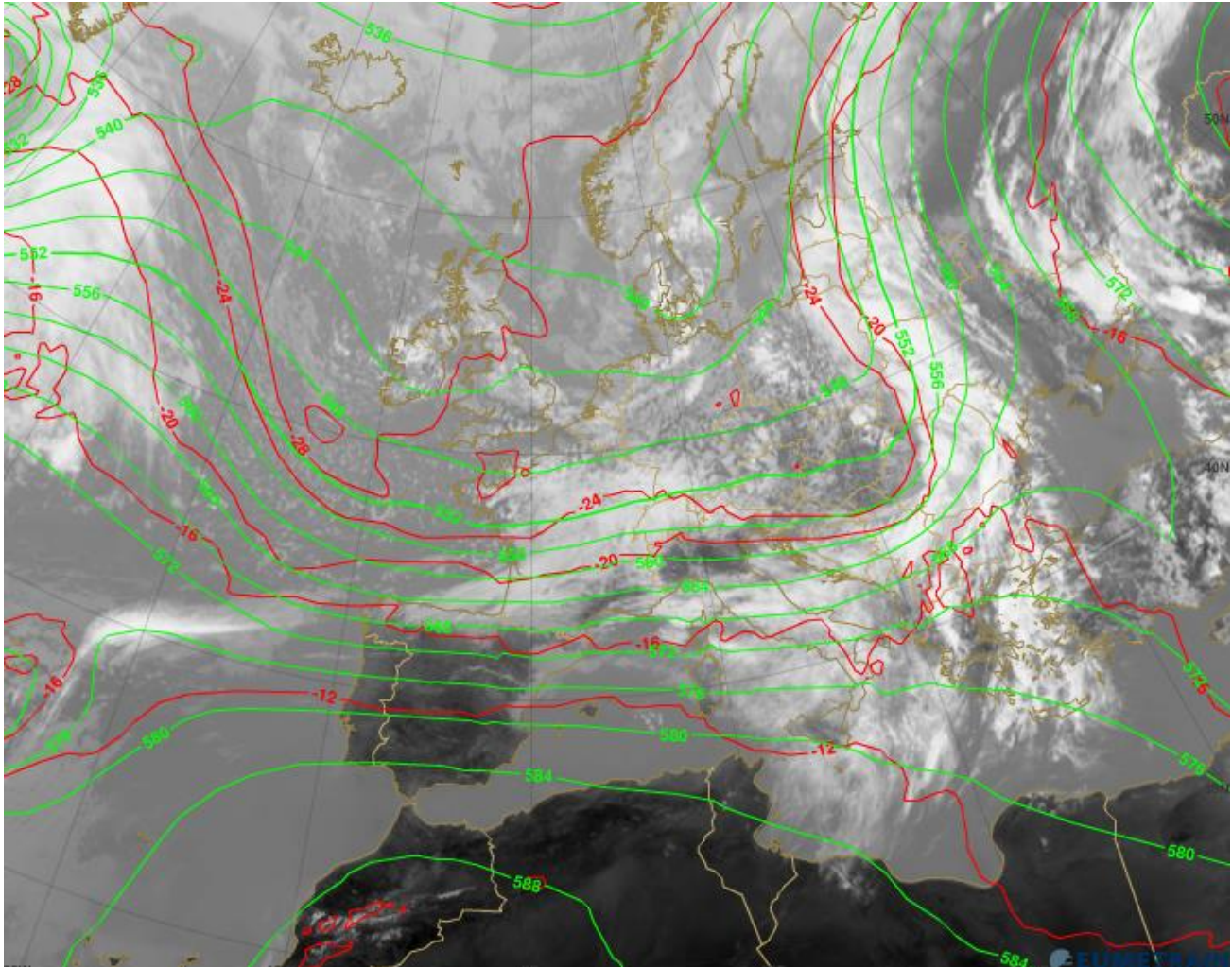


Synoptic situation



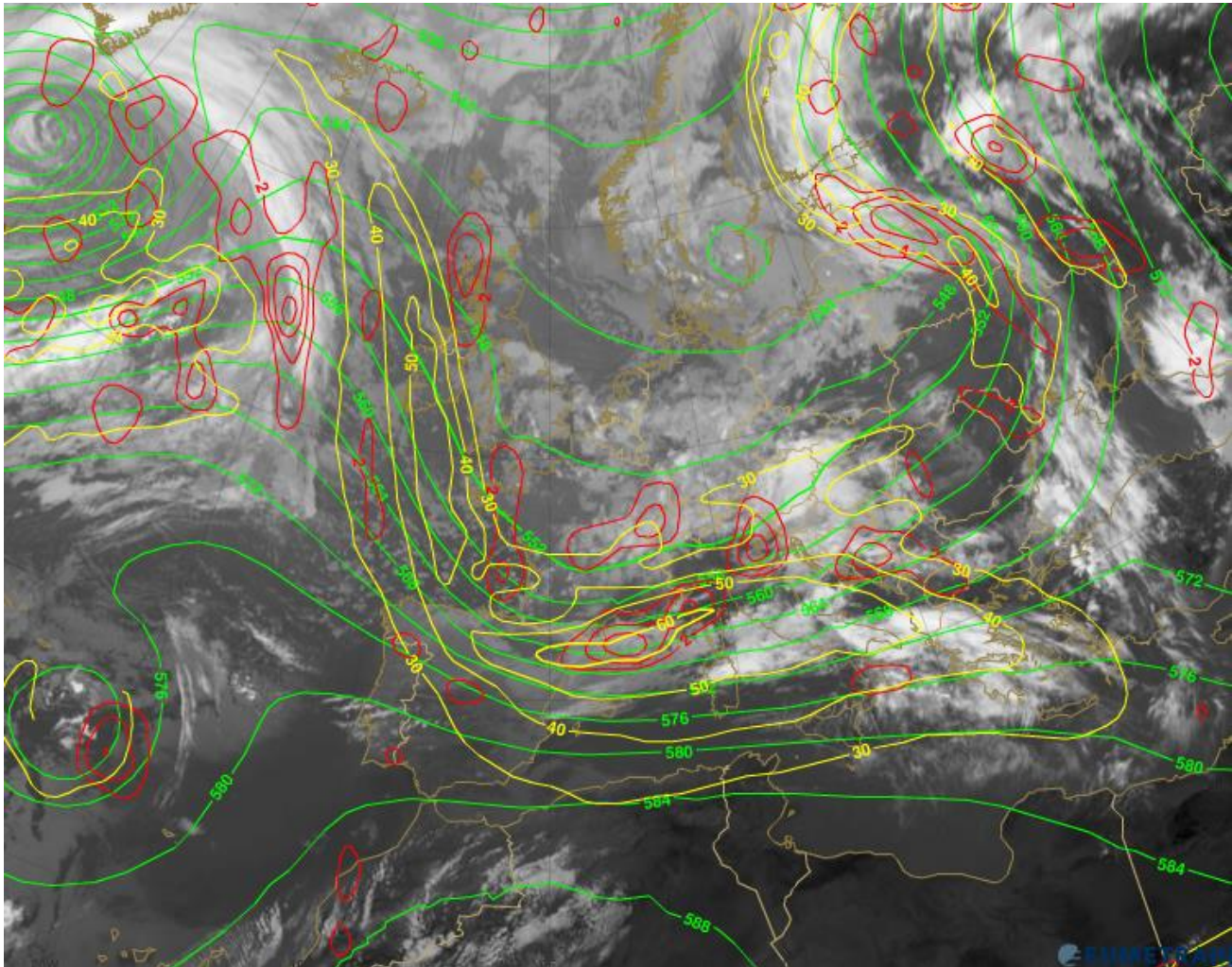
**11 May 2014, 18 UTC
IR + AT500 + TA700**

After the passage of a cold front, between the evening of 11 May and morning 12 May, cold air from the north was advected southwards



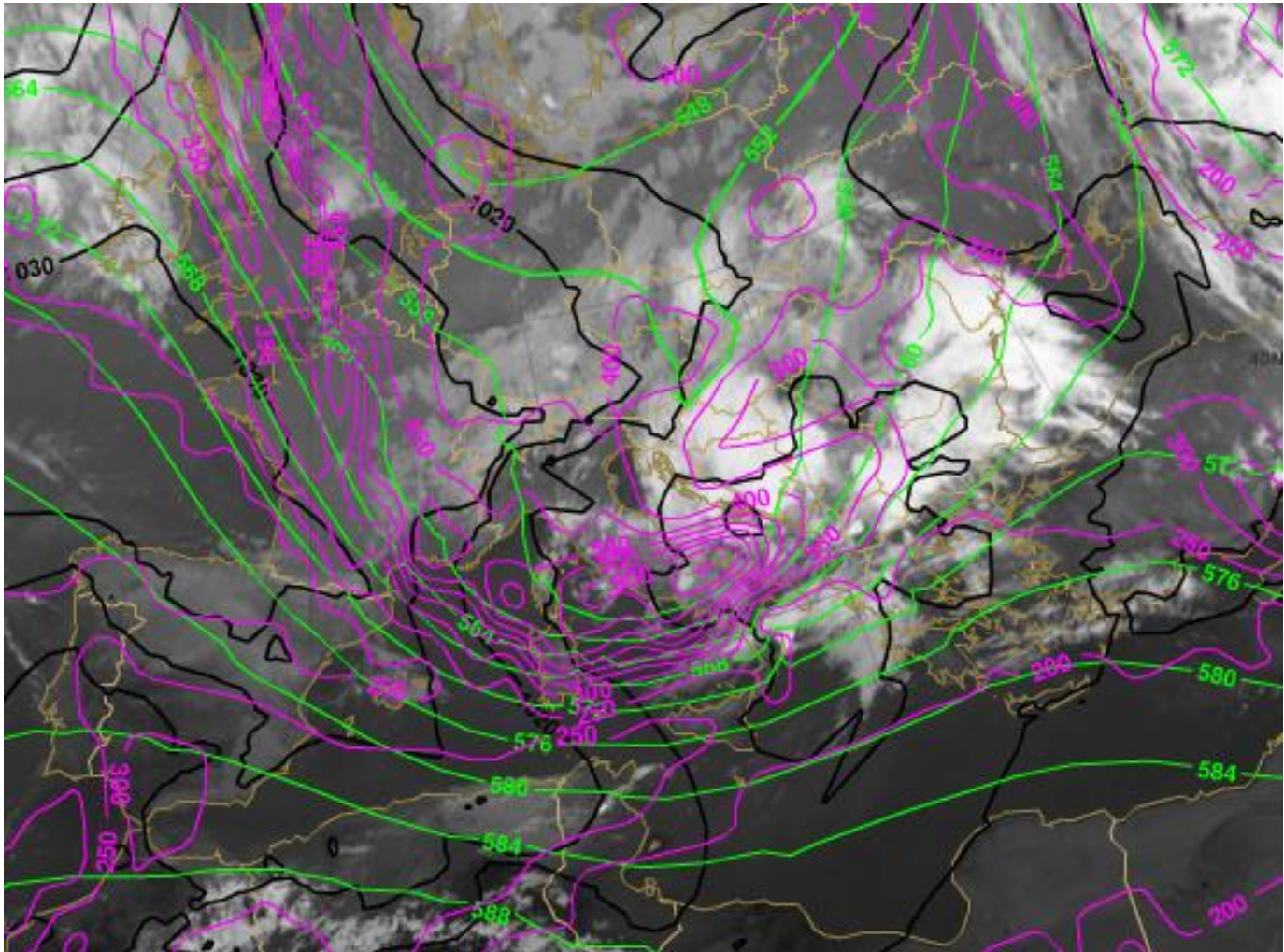
**12 May 2014, 12 UTC
IR + AT 500 + T500**

In the afternoon of 12 May another trough followed from the Atlantic, forming a cloud spiral in the Bay of Biscay



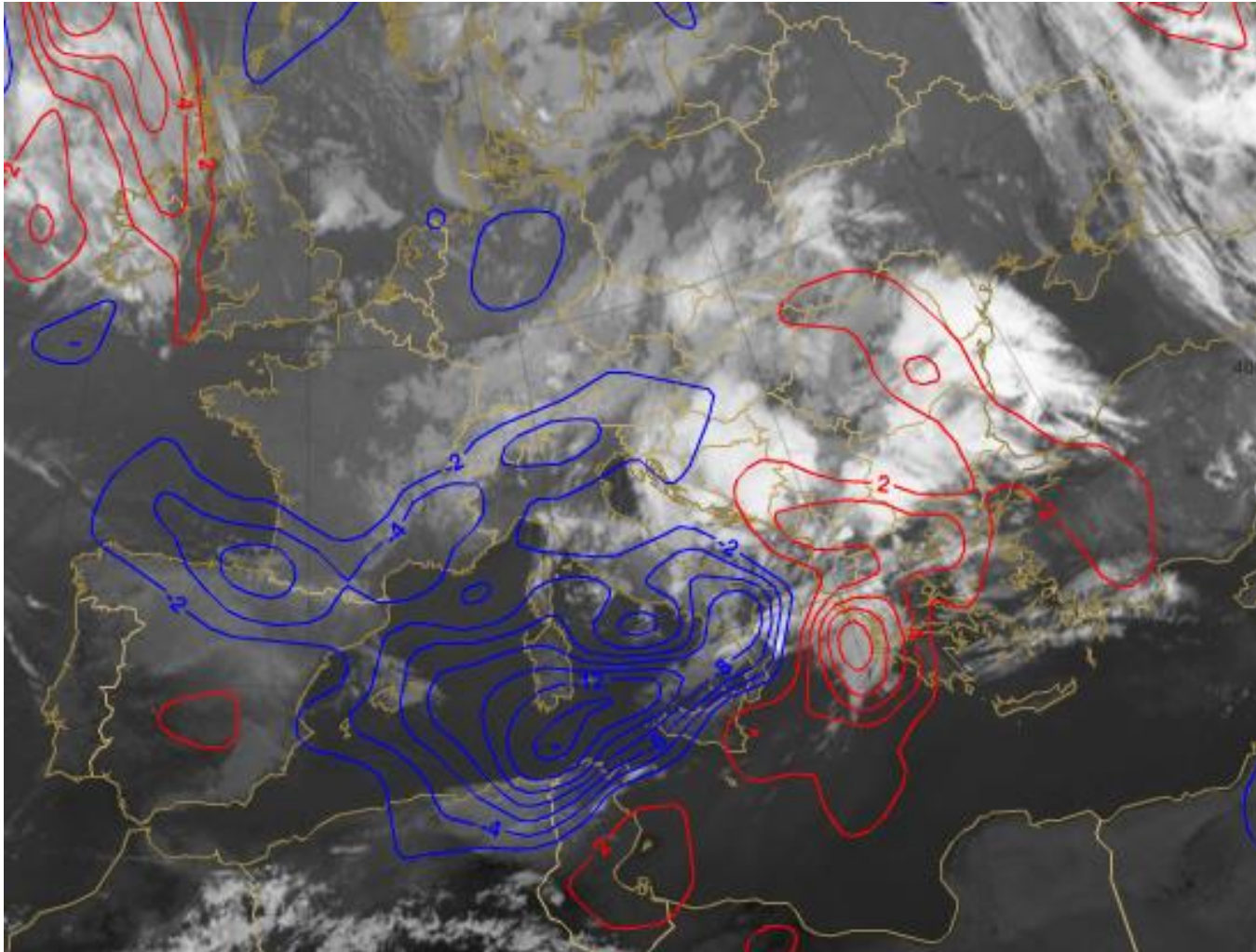
13 May 2014, 06 UTC
IR+AT500+isotachs 300
+PVA300

With strong
westerly wind the
system moved very
rapidly towards
east



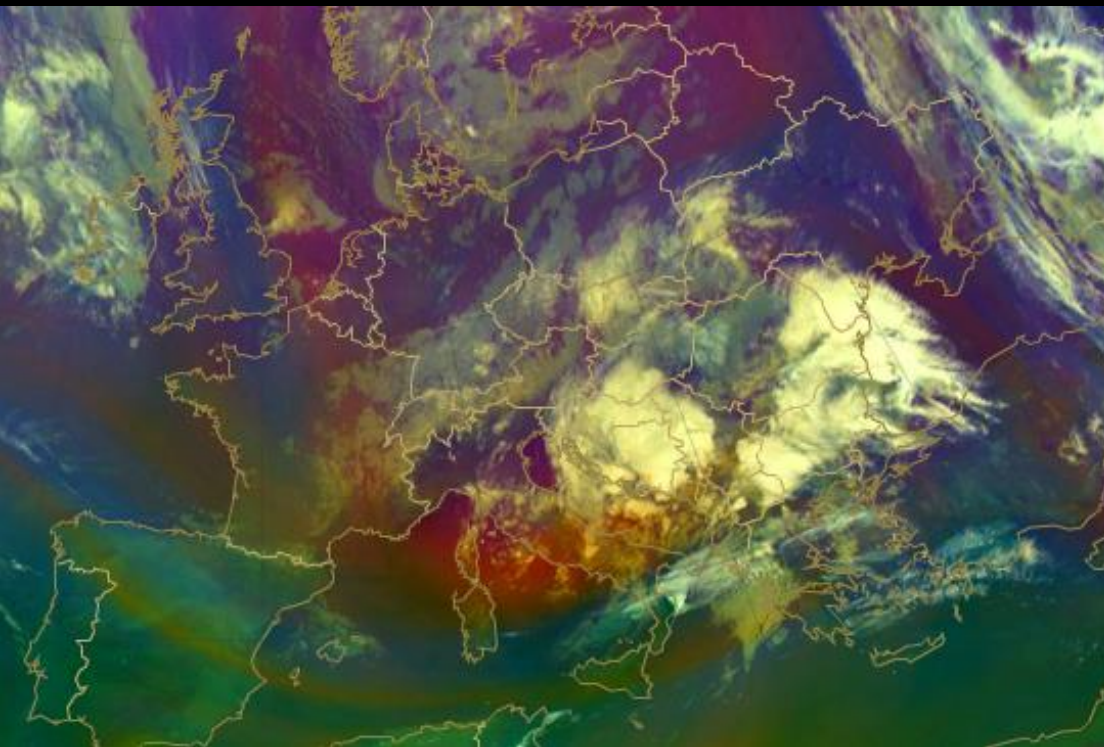
14 May 2014, 00 UTC
IR + AT500 + MSLP
+ height of IPV=1.5 PVU

Surface low was formed in the Adriatic on 13 May, moving slowly towards NE



**14 May 2014, 00 UTC
IR + TA 700**

Cold air being advected from the north towards warm and humid Mediterranean air coming from the south – dipole typical for strong cyclogenesis

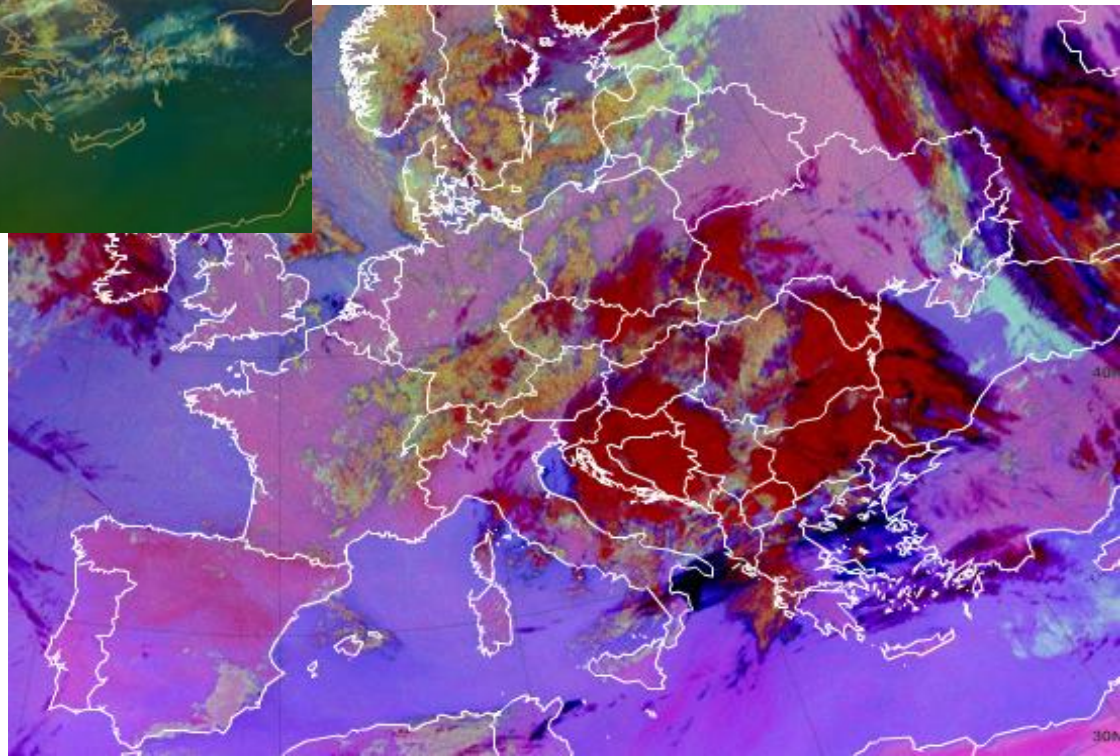


14 May 2014, 00 UTC

AIRMASS RGB

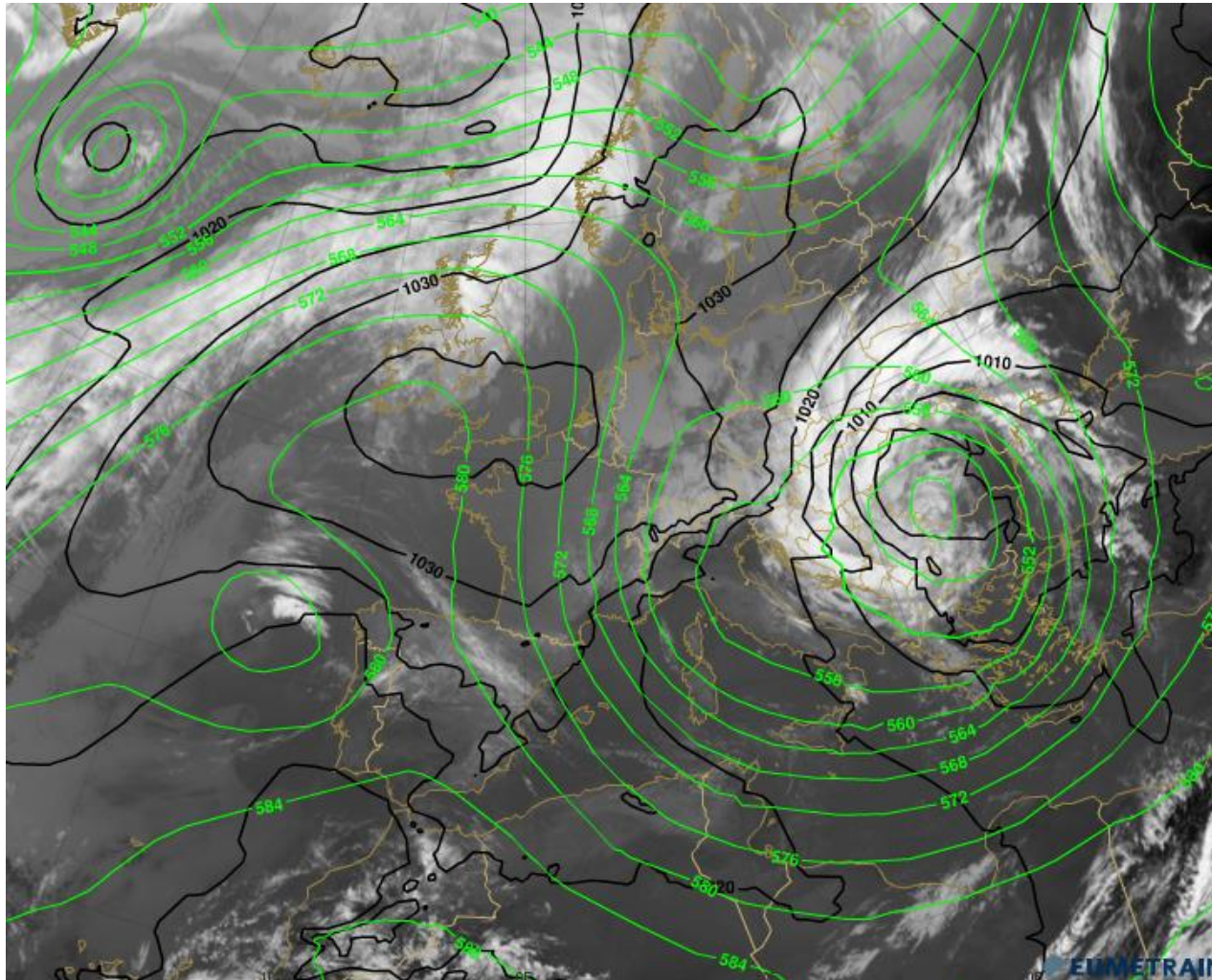
NIGHT MICROPHYSICAL RGB

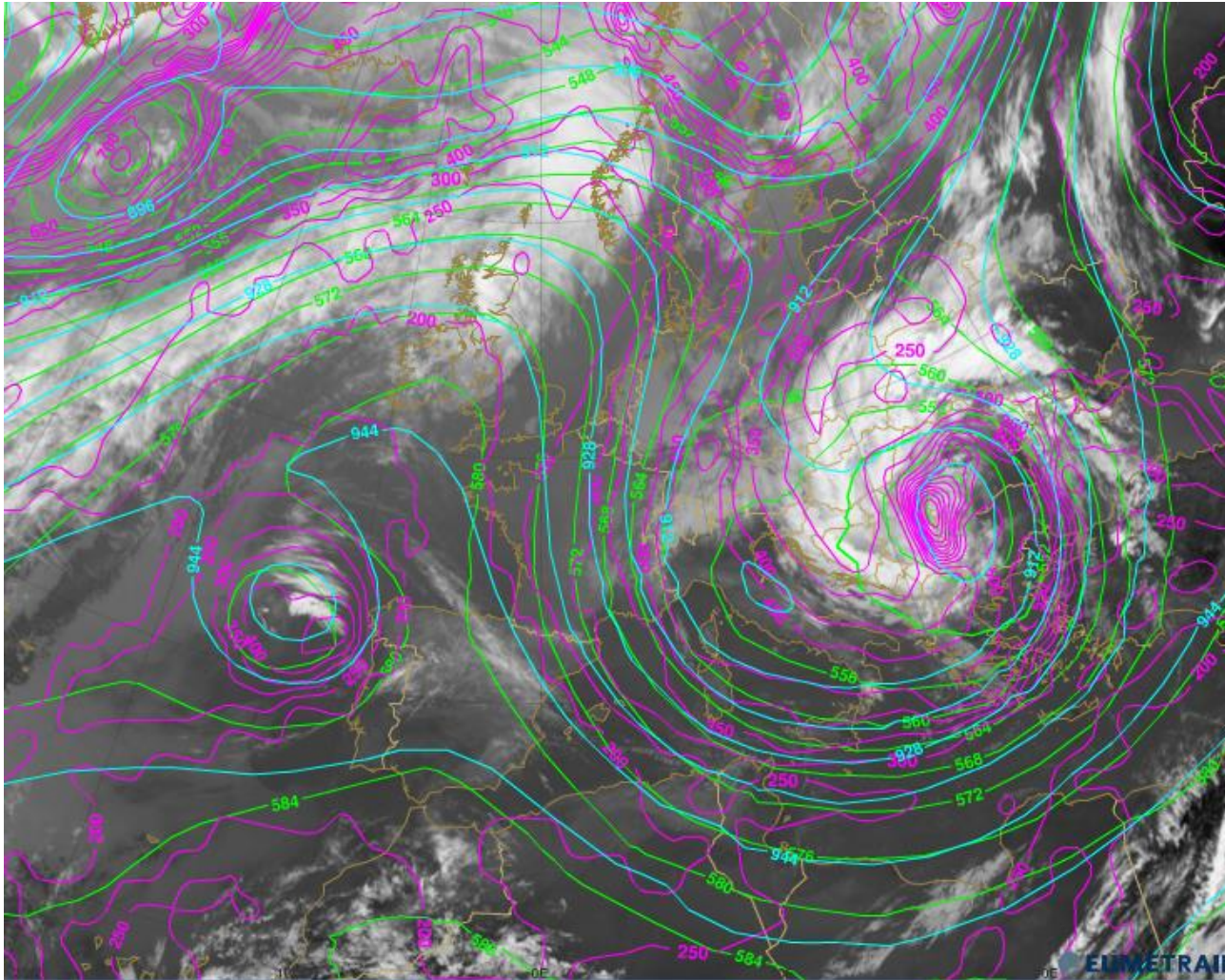
At this time the most intense precipitation started....



15 May 2014, 06 UTC
IR+MSLP+AT500

- Within the next 24 hours a deep low intensifies, stretching vertically throughout the whole troposphere..
- The axis of the low is vertical, with no tilt, making the cyclone stationary and very intense



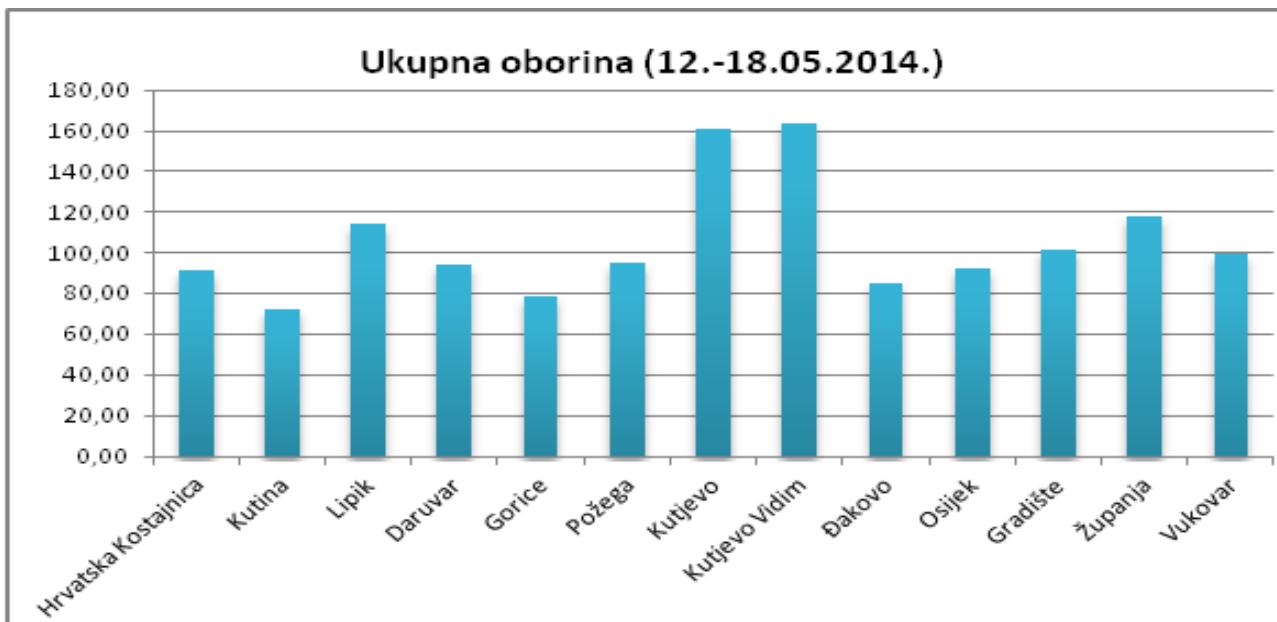
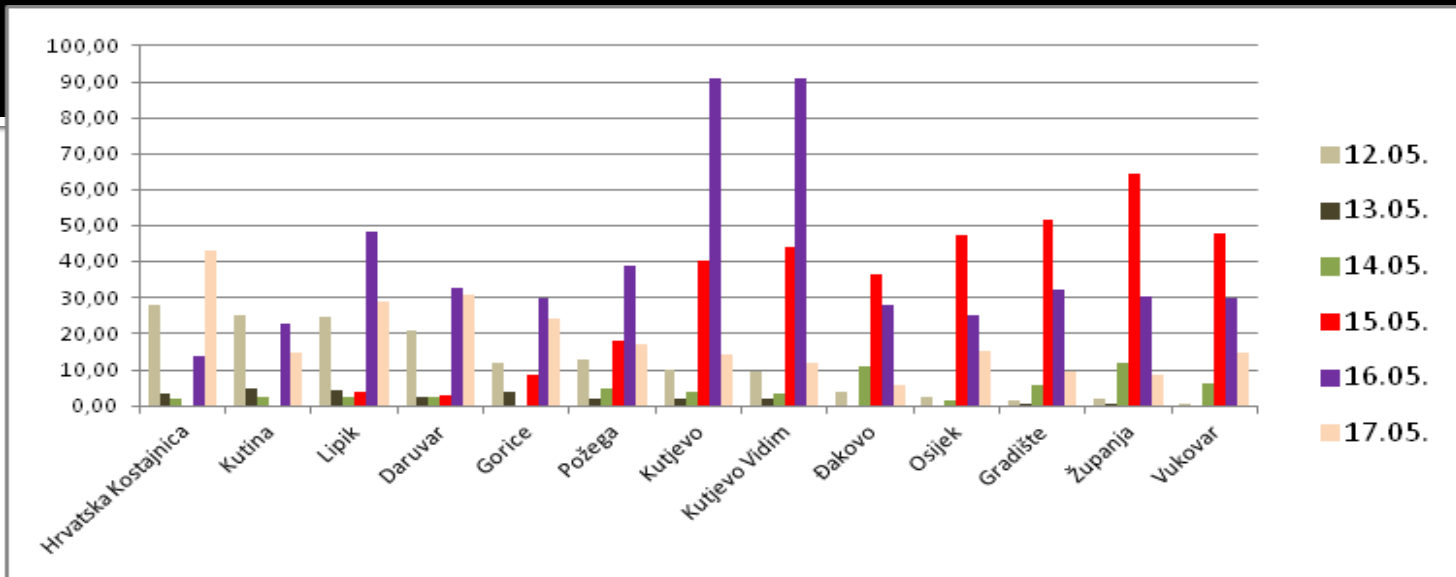


15 May 2014, 06 UTC
IR+AT500+AT300
+height of IPV=1.5 PVU

Stratospheric air down to the surface! In the centre of the low IPV=1.5 PVU level was at 900 hPa

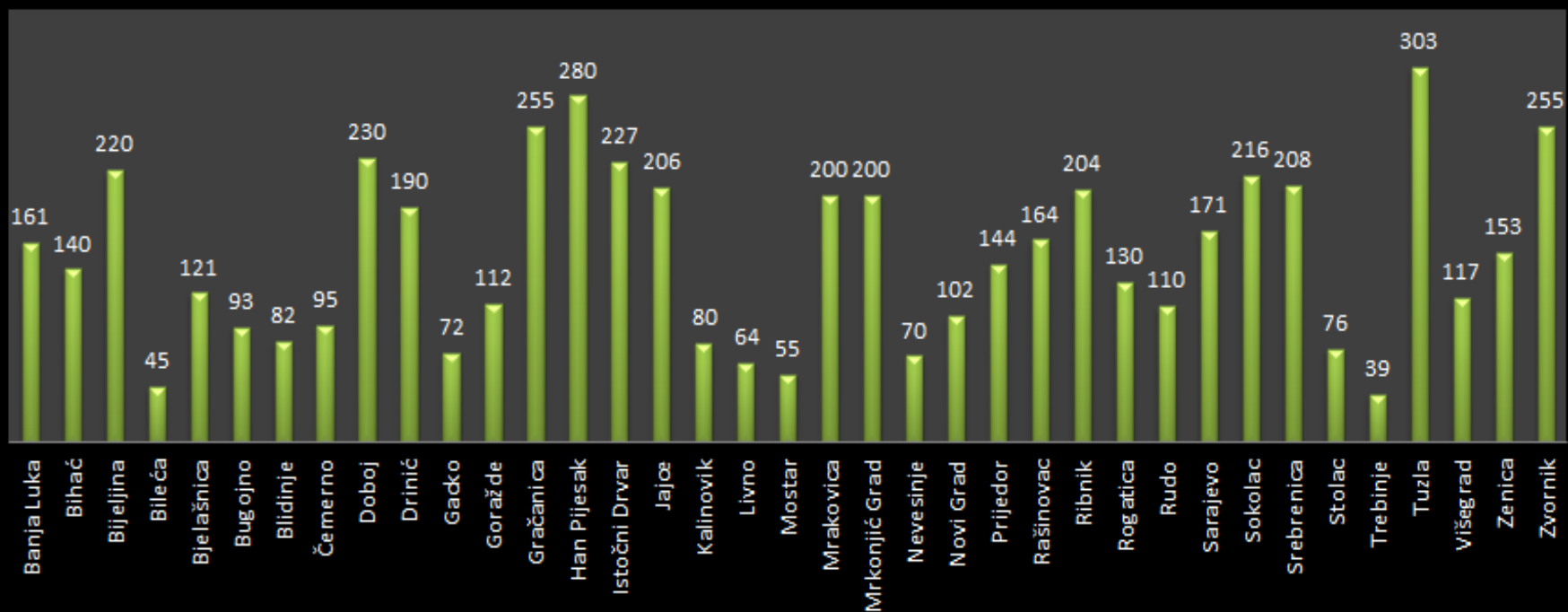
Low centres at surface, 500 hPa and 300 hPa at the same place

Precipitation data



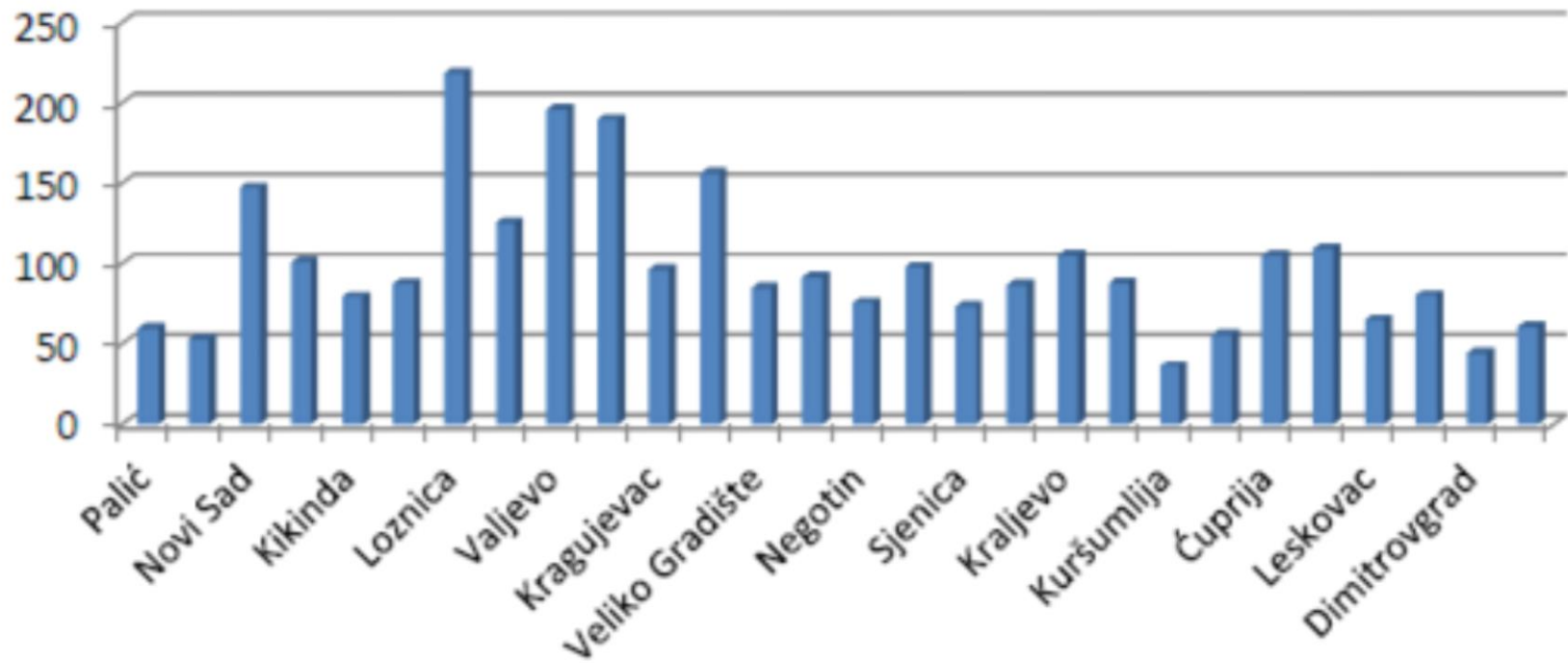
CROATIA

Padavine za period 01. - 16.05.2014 (mm)



BOSNIA

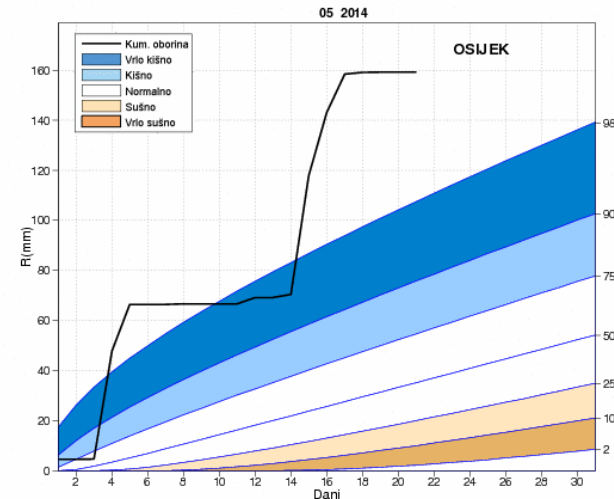
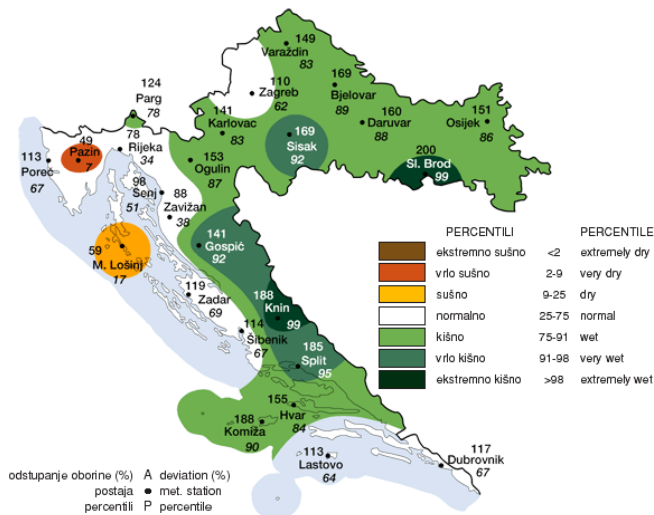
RR (mm) in Synoptic station. Period from 12. to 17. May 2014



SERBIA

What made the precipitation so extreme?

- Low was stationary for more than 3 days
- Very deep low vertically stretched throughout the whole troposphere with centers at all levels at the same place
- Constant supply of warm, moist air from the Mediterranean
- Orographic enhancement of precipitation on the Bosnian mountains – many thunderstorms were embedded
- Soil already saturated by water due to very rainy spring



Hydrological context

- Lower Sava river basin was flooded, together with affluent Bosnian rivers Bosna and Vrbas as well as river Drina on the border between Bosnia and Serbia



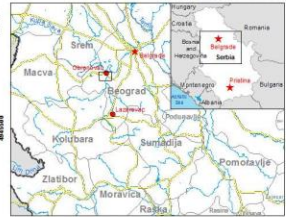
MODIS (false colour, bands 7-2-1) image of the flooding on Sava river on 19 May 2014

430500 501714 432000 501714 433500 501714 435000 501714 436500 501714 438000 501714 439500 501714 441000 501714

GLIDE number: FF-2014-00005-SRB
Activation ID: EMSR-006
Product N.: 03.Lazarevac_v2

Lazarevac - SERBIA Flood - 15/05/2014 Delineation Map - Detail 01 - Moni01

Production date: 24/05/2014



Cartographic information
Full color ISO A1, low resolution (100 dpi)



Grid: WGS 1984 UTM Zone 34N map coordinate system
Tick marks: WGS 84 geographical coordinate system

Legend

Crisis Information	Hydrology	Transportation
Flooded area 15/05/2014 09:32 UTC	Stream	Canal
Flooded area 15/05/2014 16:25 UTC	Canal	Bridge
General Information	Water	Primary Road
Newly irrigated	Water	Secondary Road
Administrative boundaries	Industry / Utilities	Local Road
Municipality	Power line	
Settlements	Power Station	Land Use - Land Cover
Populated Place		Features available in vector data

Residential	Commercial	Industrial	Medical	Recreational	Land Use
Residential	Commercial	Industrial	Medical	Recreational	Land Use
Commercial	Industrial	Medical	Recreational	Land Use	
Industrial	Medical	Recreational	Land Use		
Medical	Recreational	Land Use			
Recreational	Land Use				
Land Use					

Map Information
Due to prolonged heavy rainfalls and widespread flooding that hit large parts of Serbia, the State of Emergency was declared in the whole territory of the country on 15.05.2014. The core users of the map are Civil Protection authorities involved in in-field operations. The scope of the map production is planning and support to logistic.

Data Sources
Map data based on: Administrative boundaries (ISC, 2011), GISCO 2010, © EuroGeographics, Topography, Transportation (Natural Earth, 2010), CGIAR-CSI SRTM 30 SEC (2007), Settlements (OpenStreetMap, 2013), SPOT-5 © Airbus Defence and Space (acquired on 21/05/2014 09:32 UTC, ISO 1.5 m, 0% cloud coverage). All rights reserved provided under ESA-GEO-CAD/DWI License. Topographic data: Interim Data collected on 15/05/2014 16:25 UTC, ISO 1.5 m. All rights reserved provided under ESA-GEO-CAD/DWI License.
Pre-visit imagery: SPOT-5 © Airbus Defence and Space (acquired on 15/05/2011 09:32 UTC, ISO 1.5 m, 0% cloud coverage). All rights reserved provided under ESA-GEO-CAD/DWI License.
Base location based on: CORINE Land Cover © European Union, OpenStreetMap © OpenStreetMap contributors, Vlizmap.org, GeoNames (approx. 1:10 000, selected on 15/05/2014), retrieved by GISCO. Source information is available in vector data. Elevation data: SRTM30 (DEM dataset), height in meters above mean sea level; Production data: launched SPOT-5 © Airbus Defence and Space, © Airbus Defence and Space. All data sources are complete and valid to date.

Dissemination/Publication
No restrictions on the publication of the mapping apply. Delivery formats are GeoTIFF, GeoPDF, GeoPEG and vector (shapefile and KML formats).

Framework
The products included in the framework of current mapping in real mode activation are related to the best of our ability, within a very short time frame during a crisis, optimizing the available data and information. All geographic information has been derived from satellite, terrestrial, data and interpretation of the original data sources. The products are compliant with ISO 9126 Product Portfolio specifications.

Map Production
The present map shows the flood delineation in the area of Obrenovac, near Lazarevac (23°55' E, 44°55' N). The base topographic features are derived from vector datasets, derived by the present map. The present map is based on SPOT-5 © Airbus Defence and Space (acquired on 21/05/2014 09:32 UTC, ISO 1.5 m, 0% cloud coverage). All rights reserved provided under ESA-GEO-CAD/DWI License. SPOT-5 © Airbus Defence and Space (acquired on 15/05/2011 09:32 UTC, ISO 1.5 m, 0% cloud coverage). All rights reserved provided under ESA-GEO-CAD/DWI License. All satellite images have been radiometrically enhanced and orthorectified with SPC (Spatial Precision) 0.25 m elevation map, and projected to the present map. The estimated geometric accuracy of this product is 15m CE 90 or better, from native geometric accuracy of the background satellite map. The estimated thematic accuracy of the product is 85% or better, as it is based on visual interpretation of responsive items on very high resolution raster imagery. Associated version data is a flood field over the area enclosed by the Area of Interest has been analyzed. Map produced on 24/05/2014 by ITT, using version 201215 with the European Commission and products are © of the European Commission. Name of the map: Flood (Quality control): GeoTIFF (ISO 19115). Map production available in: Map (emergency operation) mapping list of components: EMSR006

SERBIA

Area of Interest - Detail 01

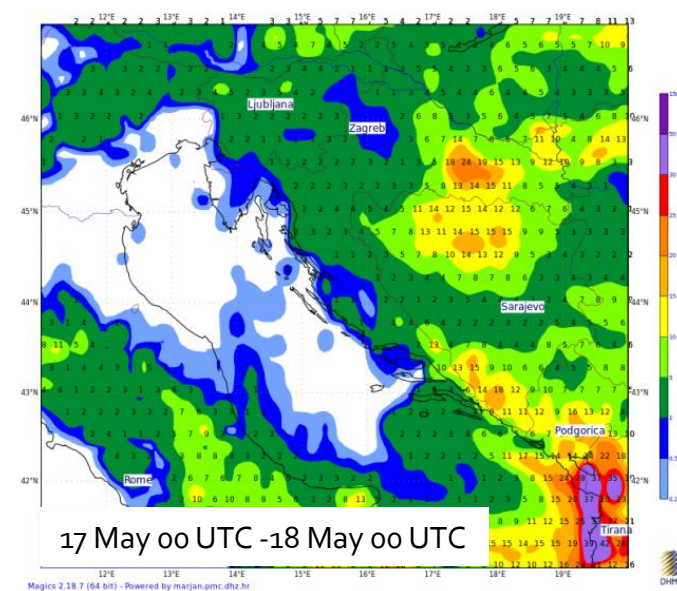
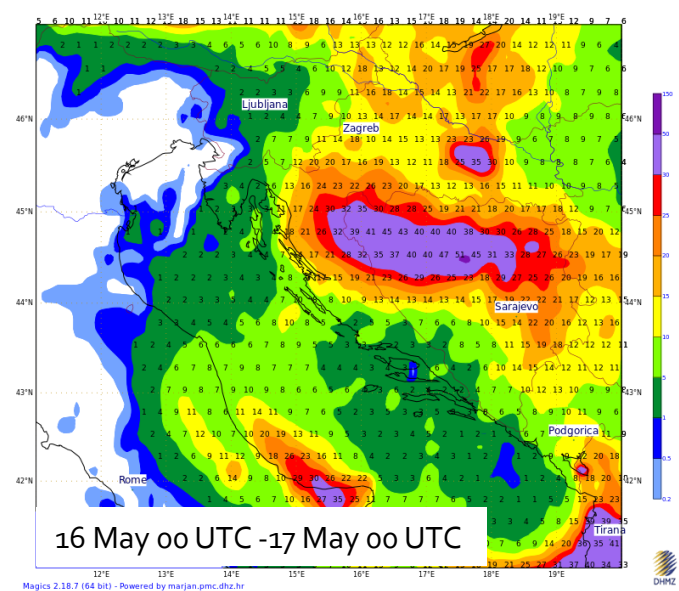
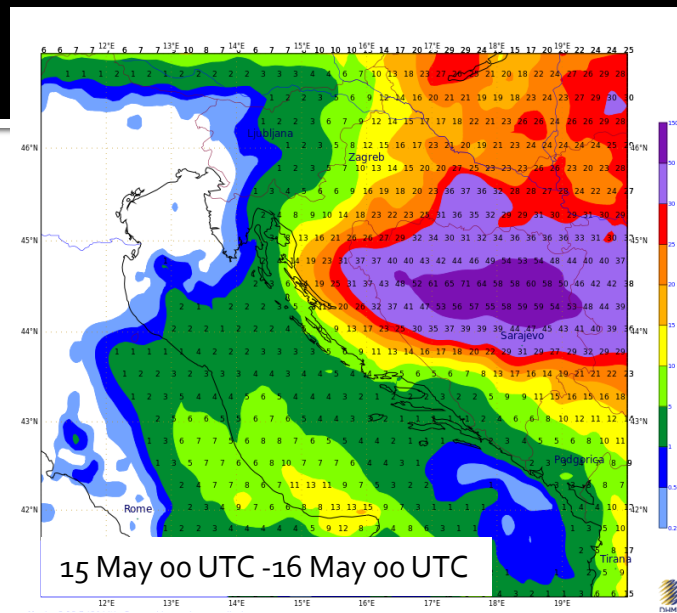
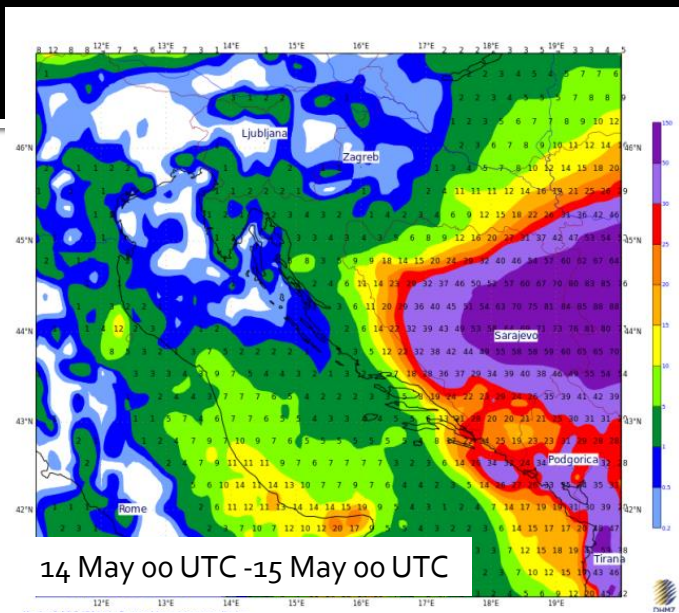
430500 501714 432000 501714 433500 501714 435000 501714 436500 501714 438000 501714 439500 501714 441000 501714

Civil Protection
 Response
 Delineation Map - Detail
 Planning
 SPOT-5 (c) Airbus Defence and Space
 15-05-2014

Copernicus
 European Commission

Forecasts and warnings

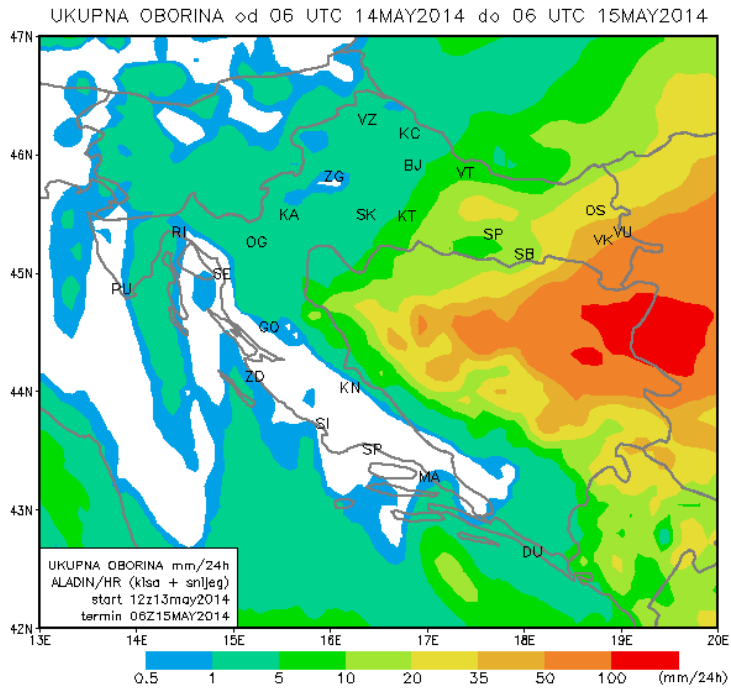
ECMWF 24 hours total precipitation



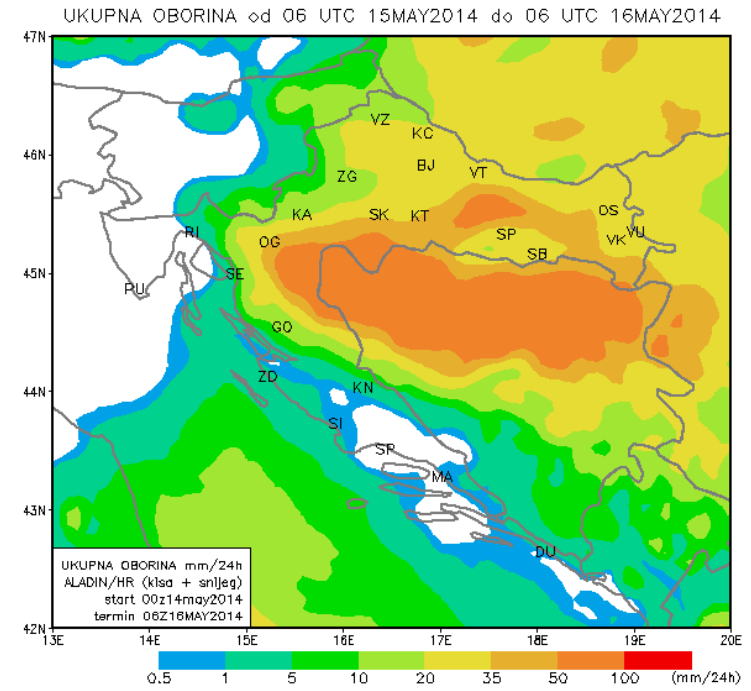
Models captured the process correctly in space and time but underestimated precipitation intensity



ALADIN 24 hours total precipitation

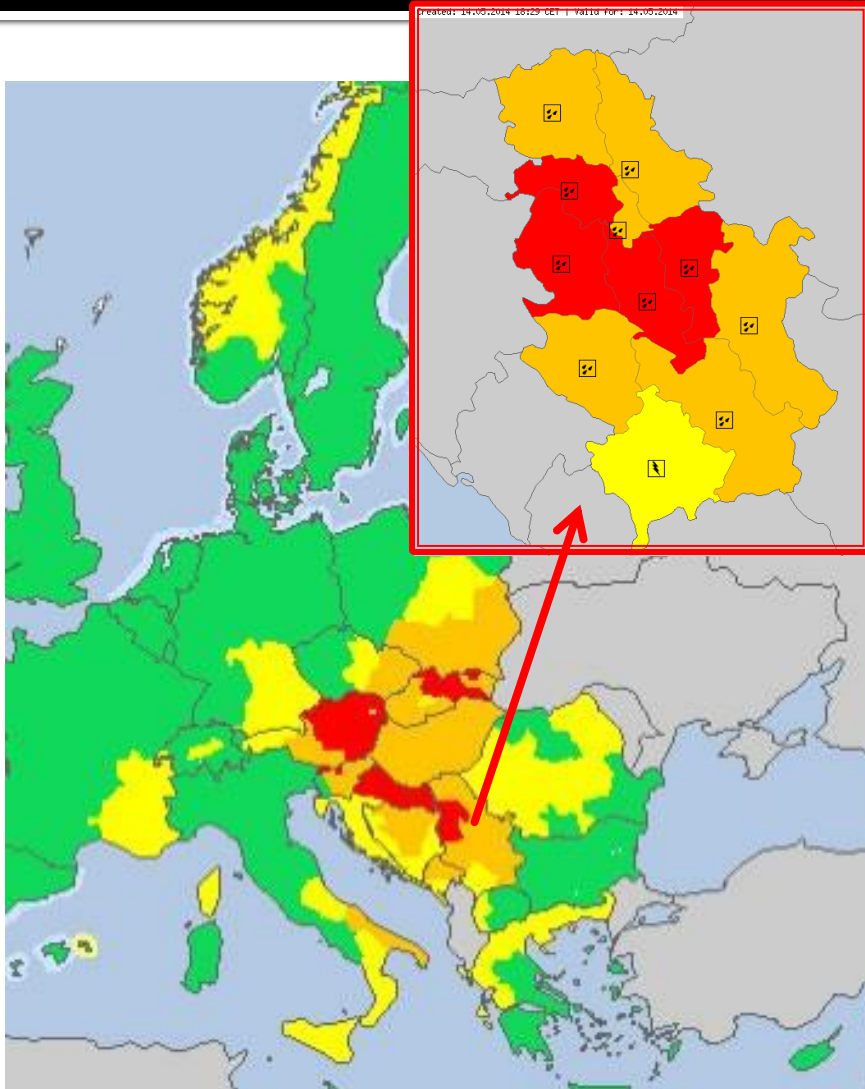


14 May 06 UTC – 16 May 06 UTC



15 May 06 UTC – 16 May 06 UTC

- Meteo services in the region issued orange and red warnings for precipitation!



Awareness Reports - You can find detailed information about warnings in the awareness reports issued for each country. the relevant country.

AT					IS	
BA					IT	
BE					LU	
BG					LV	
CH					ME	
CY					MK	
CZ					MT	
DE					NL	
DK					NO	
EE					PL	
ES					PT	
FI					RO	
FR					RS	
GR					SE	
HR					SI	
HU					SK	

Summary

- Deep cyclone developed in the Adriatic on 13 May 2013
- The cyclone remained quasi-stationary for more than 3 days over SE Europe
- Very cold polar air coming from the north, warm and moist Mediterranean air injected from the south
- Precipitation forecast by the models – underestimating the quantities

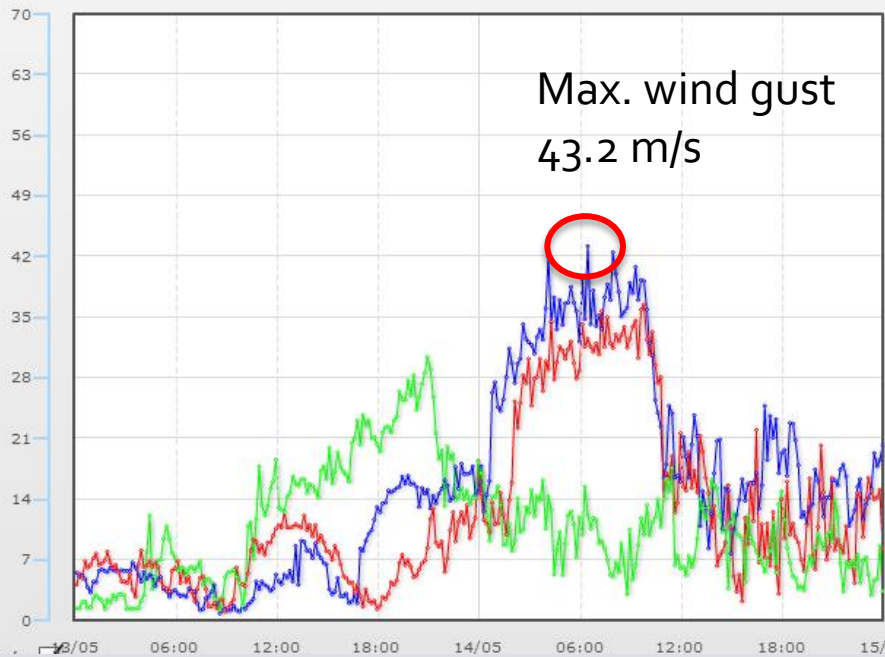
Summary - continued

- Record precipitation, in some places more than 200 mm in just a few days
- Soil already saturated from rainy spring season
- Sava river, together with affluent rivers Vrbas, Bosna and Drina, flooded large areas of Bosnia, Serbia and Croatia
- Thousands of people left without a home

- Together with rain some damage was caused by windstorm
- At the coast wind gusts up to 42 m/s, over the northern parts of Croatia very strong northerly wind with constant gusts of 15 to 22 m/s for 24 hours, with maximum gust 28 m/s!

Severe windstorm

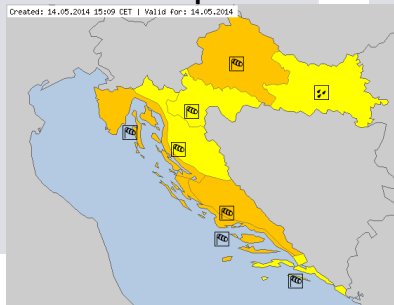
Maximum wind speed



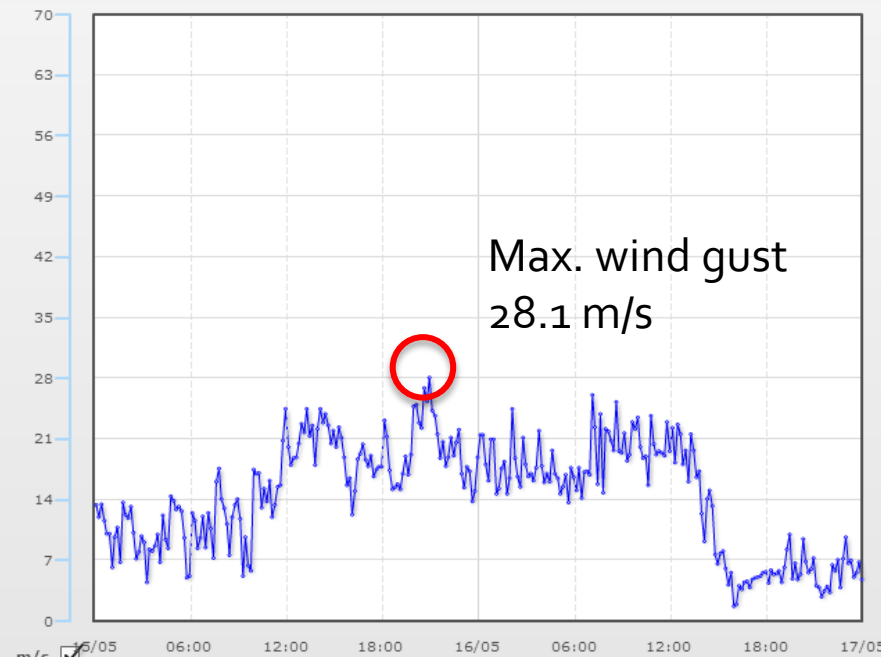
13 MAY 2014

14 MAY 2014

- KRK bridge
- MASLENICA bridge
- PAG bridge



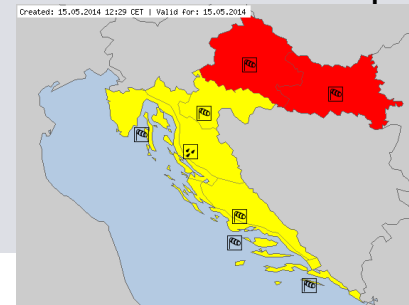
Maximum wind speed



15 MAY 2014

16 MAY 2014

- ZAGREB GRIČ



THANK YOU!

- Any questions? Suggestions? Comments?....

strelec@cirus.dhz.hr