Karlsruhe Institute of Technology

Model studies of heavy precipitation events in the western Mediterranean during the HyMeX campaign

Luisa Röhner | June 06, 2014

INSTITUTE FOR METEOROLOGY AND CLIMATE RESEARCH - TROPOSPHERE RESEARCH

Scientific questions

What is the role of convection for the initiation of local HPE in the western Mediterranean?

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PANDOWAE research questions:

- importance of diabatic processes for errors in prediction of weather systems
- interaction between moist processes and large scale dynamics
- relevance of small-scale diabatic processes for short and medium range weather prediction
- roles of spatial and temporal scales in limiting predictability of HIW

Case study

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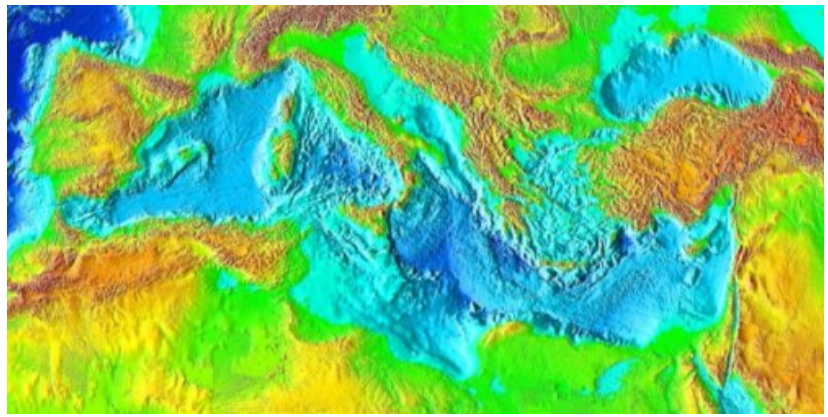
HyMeX campaign (2012):



HyMeX=Hydrological cycle in Mediterranean Experiment

Case: 28. September 2012 (IOP 8)

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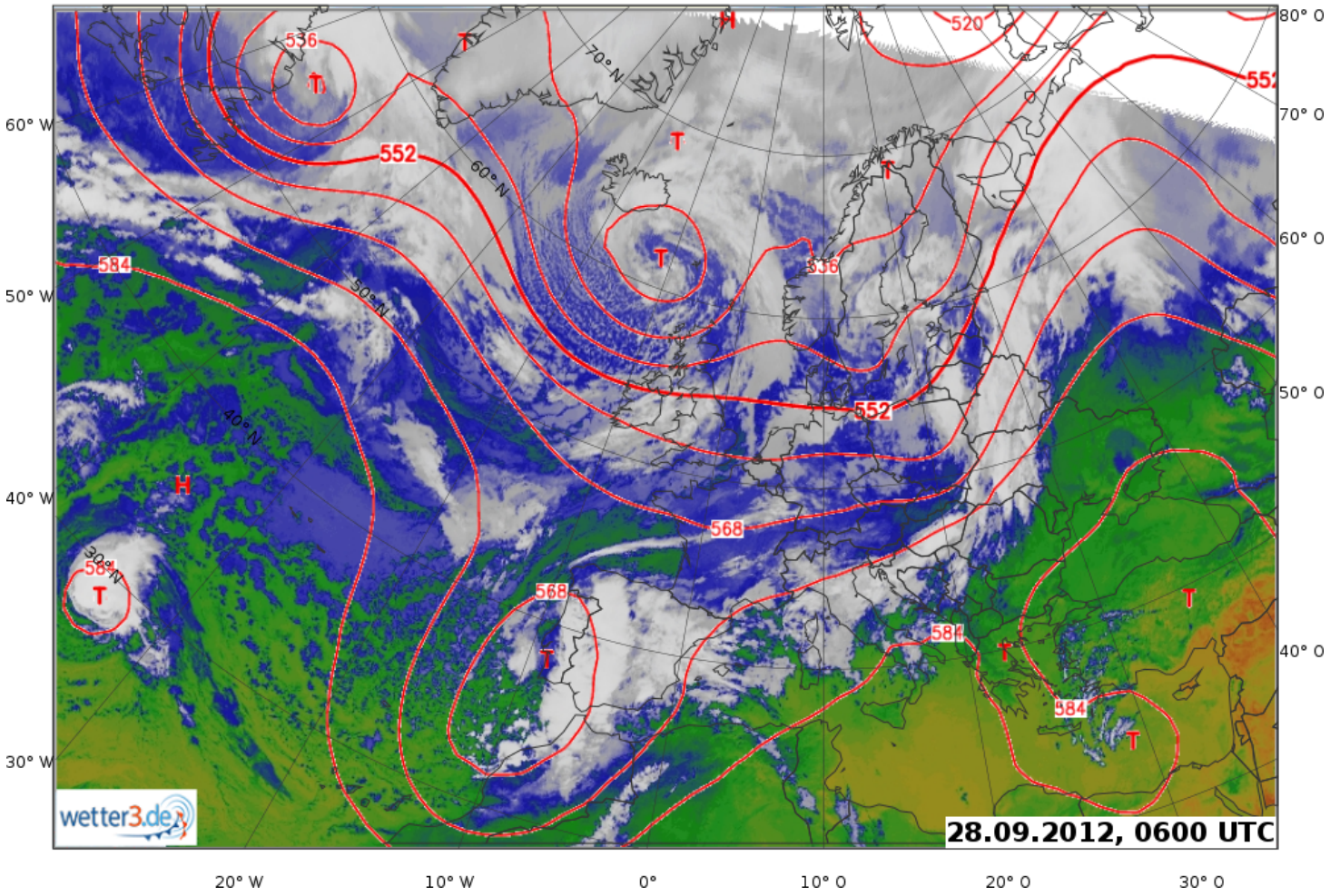

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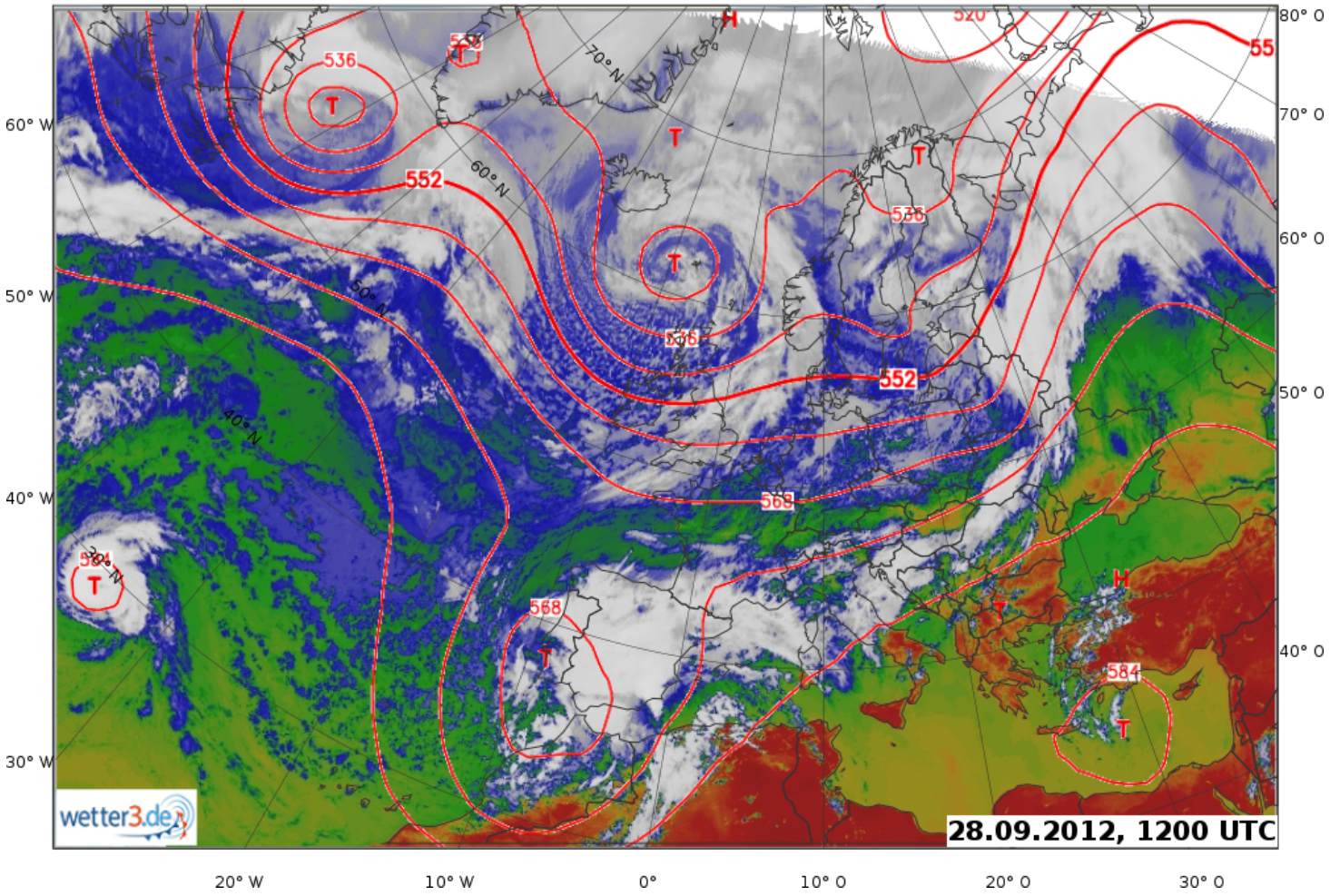

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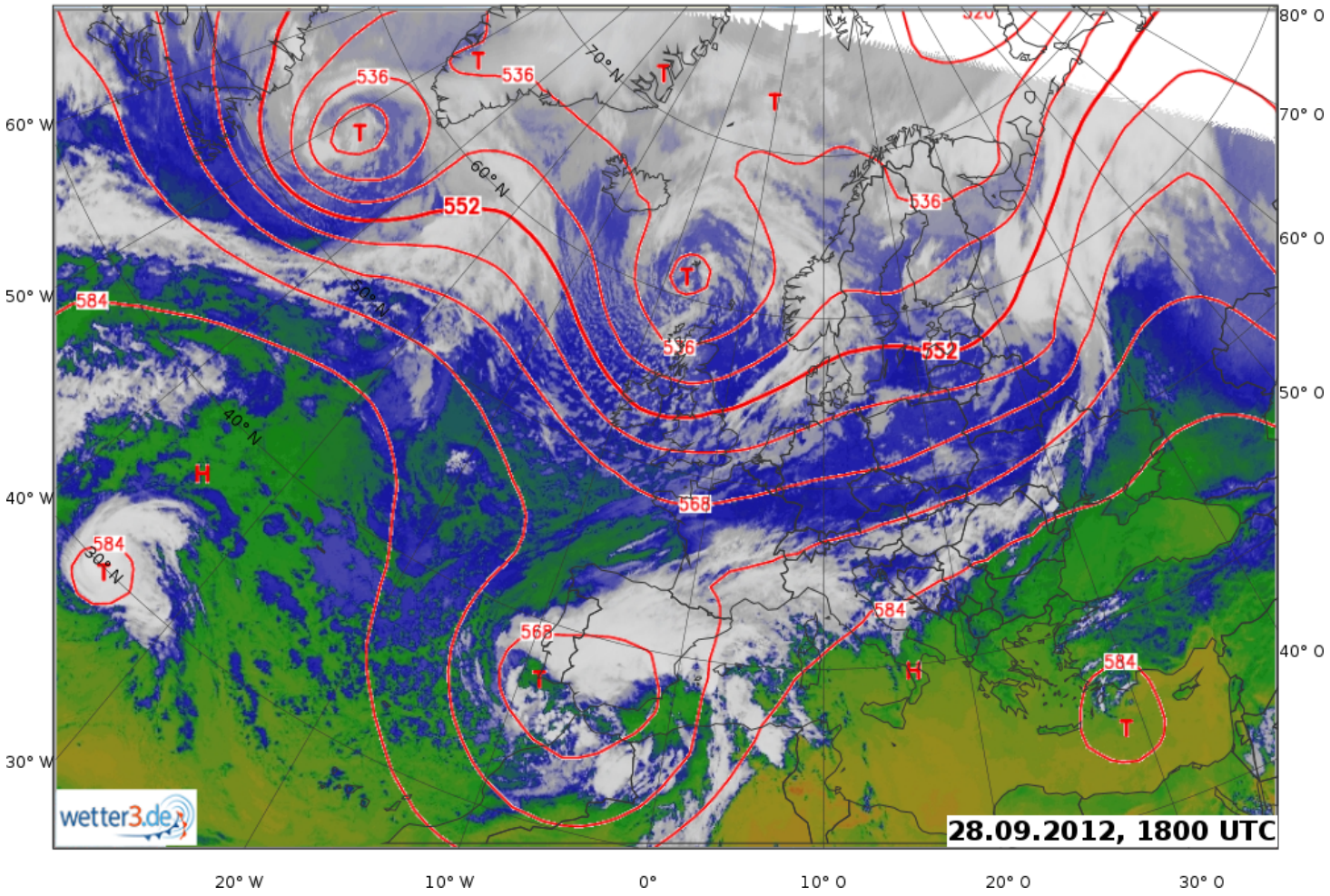

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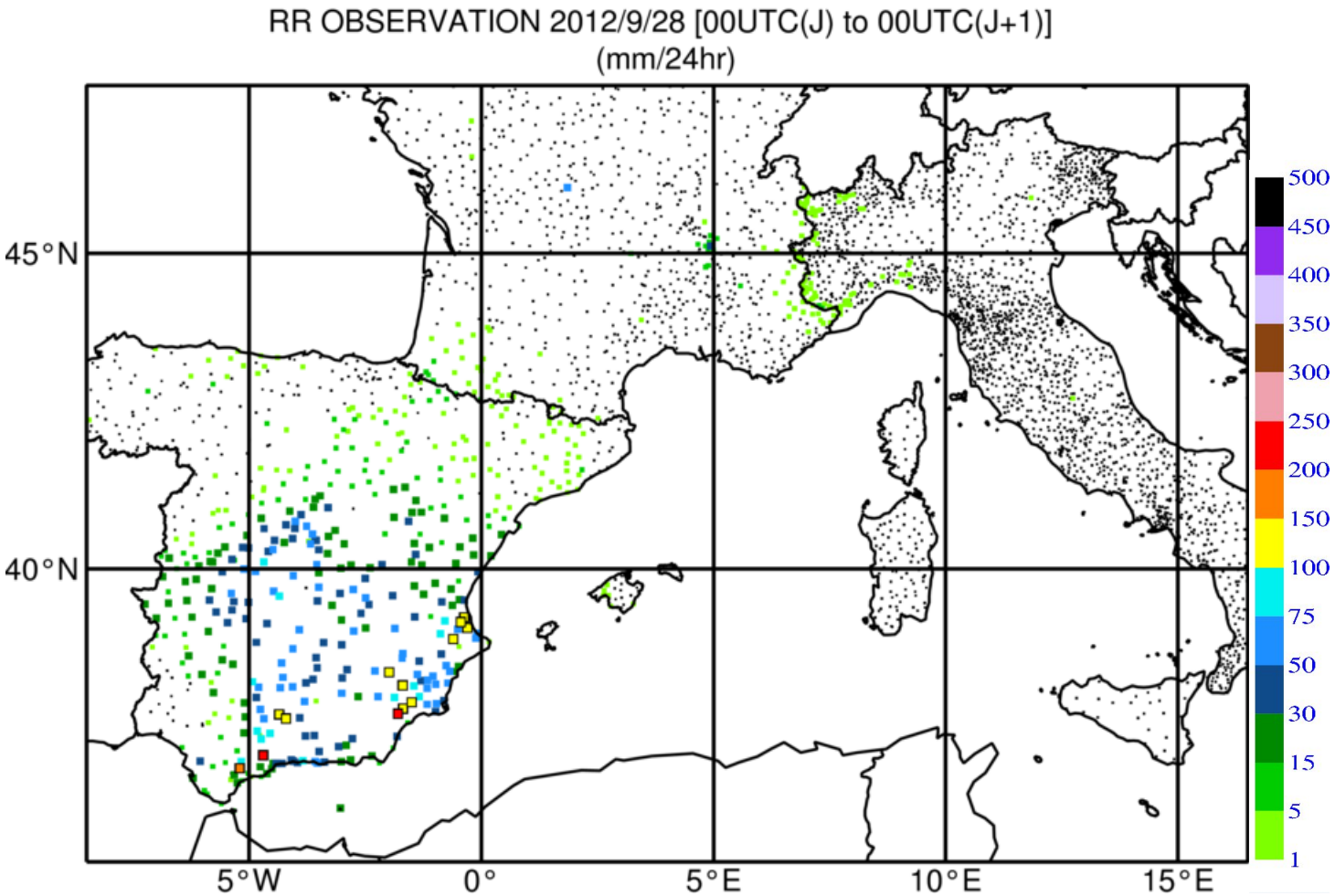

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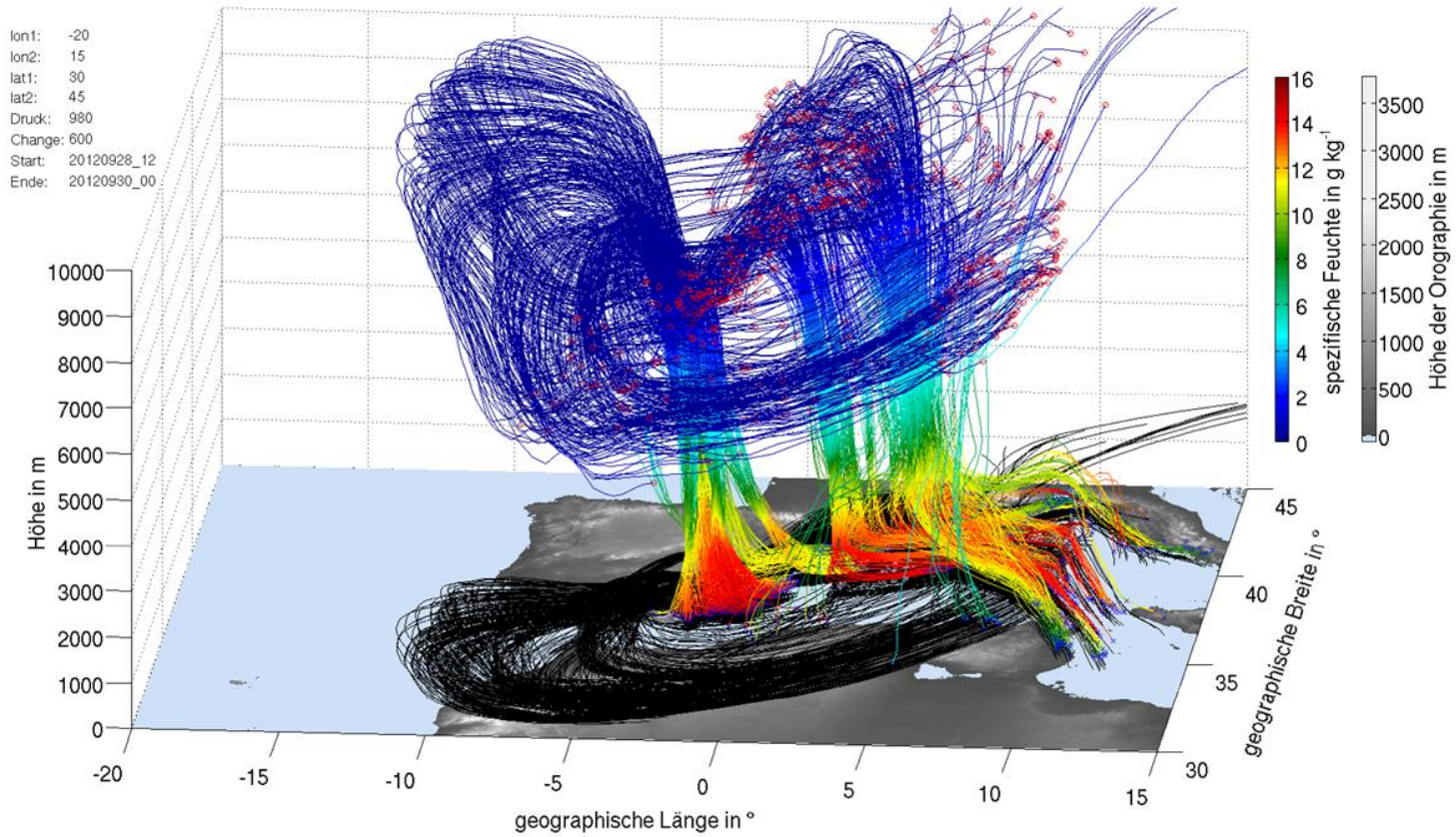

36h moisture trajectories startet at 28.12.2012, 1200 UTC
(by courtesy of Kai-Uwe Nerding)

Model studies

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- numerical simulations with the COSMO-model (COSMO=Consortium for Small-scale Modeling)

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  - non-hydrostatic model
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    $\rightarrow$ convection has to be parameterized

- initial and boundary conditions: ECMWF analyses (horizontal resolution of 0.25°)

High resolution runs

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aims:

1. good high resolution (COSMO 2.8) forecast to represent the “reality”
2. figure out important meteorological features of case study (mesoscale and small scale processes)

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approach for [1]:

→ high resolution COSMO simulations with different start times

→ comparison of COSMO run with AROME-WMED reanalyses data
→ calculation of scores:

- BIAS
- RMSE
- correlation coefficient
- threshold-based scores

High resolution runs

- different start times:
  - 28.09.2012 0600 UTC (morning of day with HPE)
  - 28.09.2012 0000 UTC
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  - 28.09.2012 0600 UTC (morning of day with HPE)
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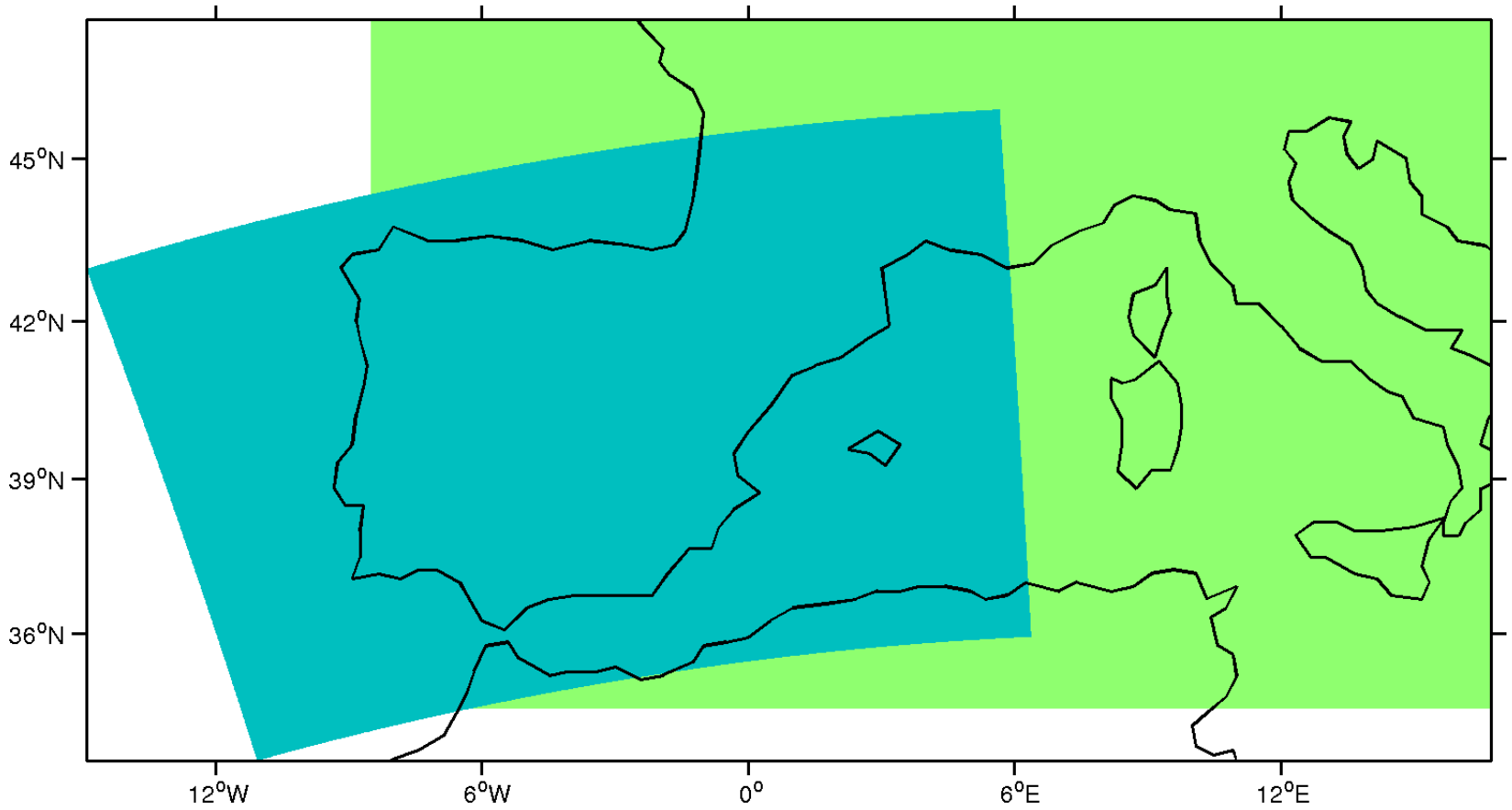
- COSMO vs. AROME-WMED:

	COSMO-2.8	**AROME-WMED reanalyses**
horizontal resolution	2.8 km	2.5 km
vertical levels	50	60
initial and boundary conditions	COSMO-7 (ECMWF)	ARPEGE
assimilated data	boundary conditions: ECMWF	several HyMeX measurement data

COSMO vs. AROME-WMED

- model areas (COSMO and AROME-WMED)



COSMO vs. AROME-WMED (mslp)

BIAS $\frac{1}{N} \sum (x_{COSMO} - x_{AROME})$

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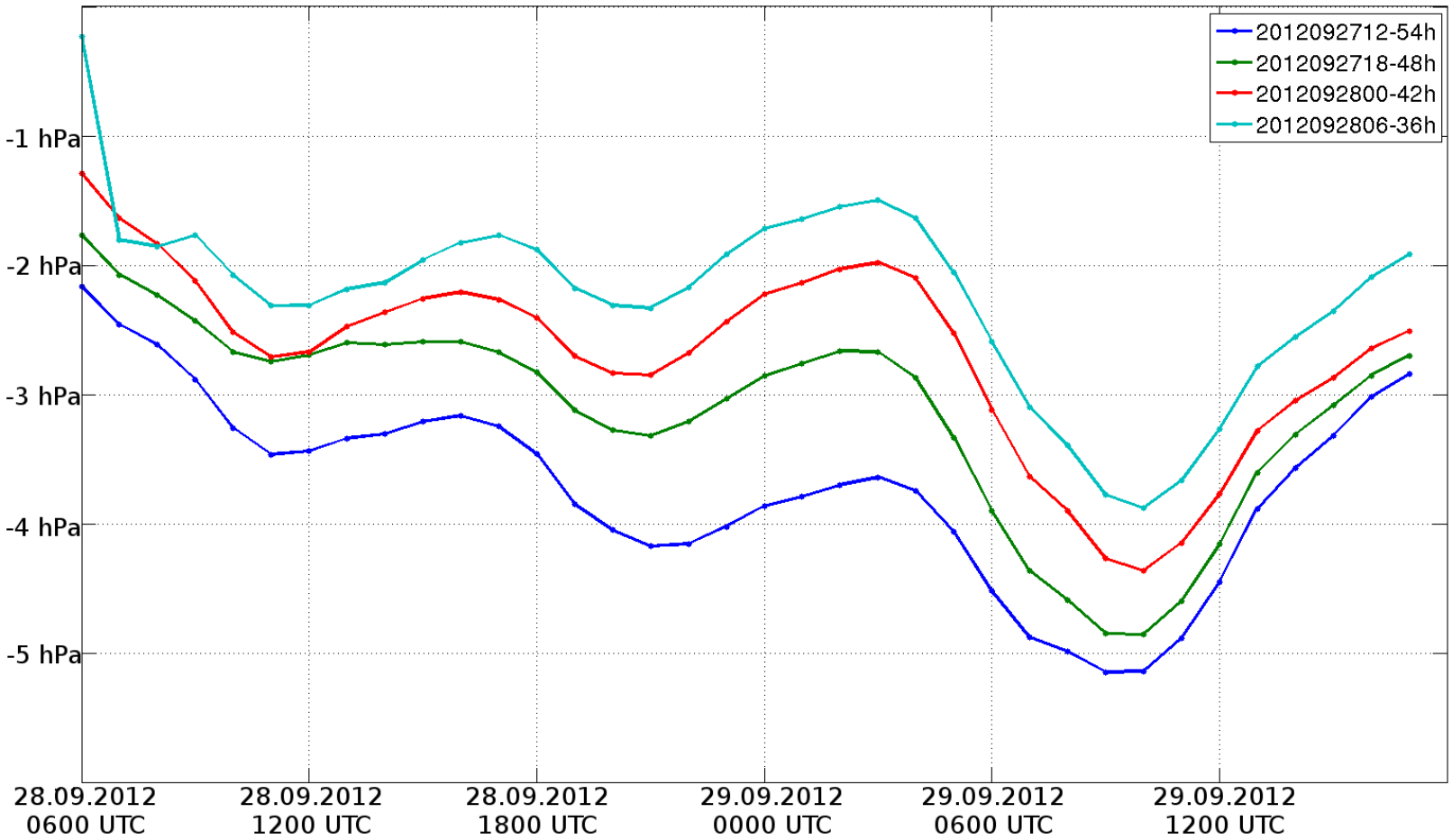

COSMO vs. AROME-WMED (mslp)

correlation coefficient $$\frac{\sum[(x_{COSMO}-\overline{(x_{COSMO})})(x_{AROME}-\overline{(x_{AROME})})]}{\sqrt{\sum[(x_{COSMO}-\overline{x_{COSMO}})^2]}\sqrt{\sum[(x_{AROME}-\overline{x_{AROME}})^2]}}$$

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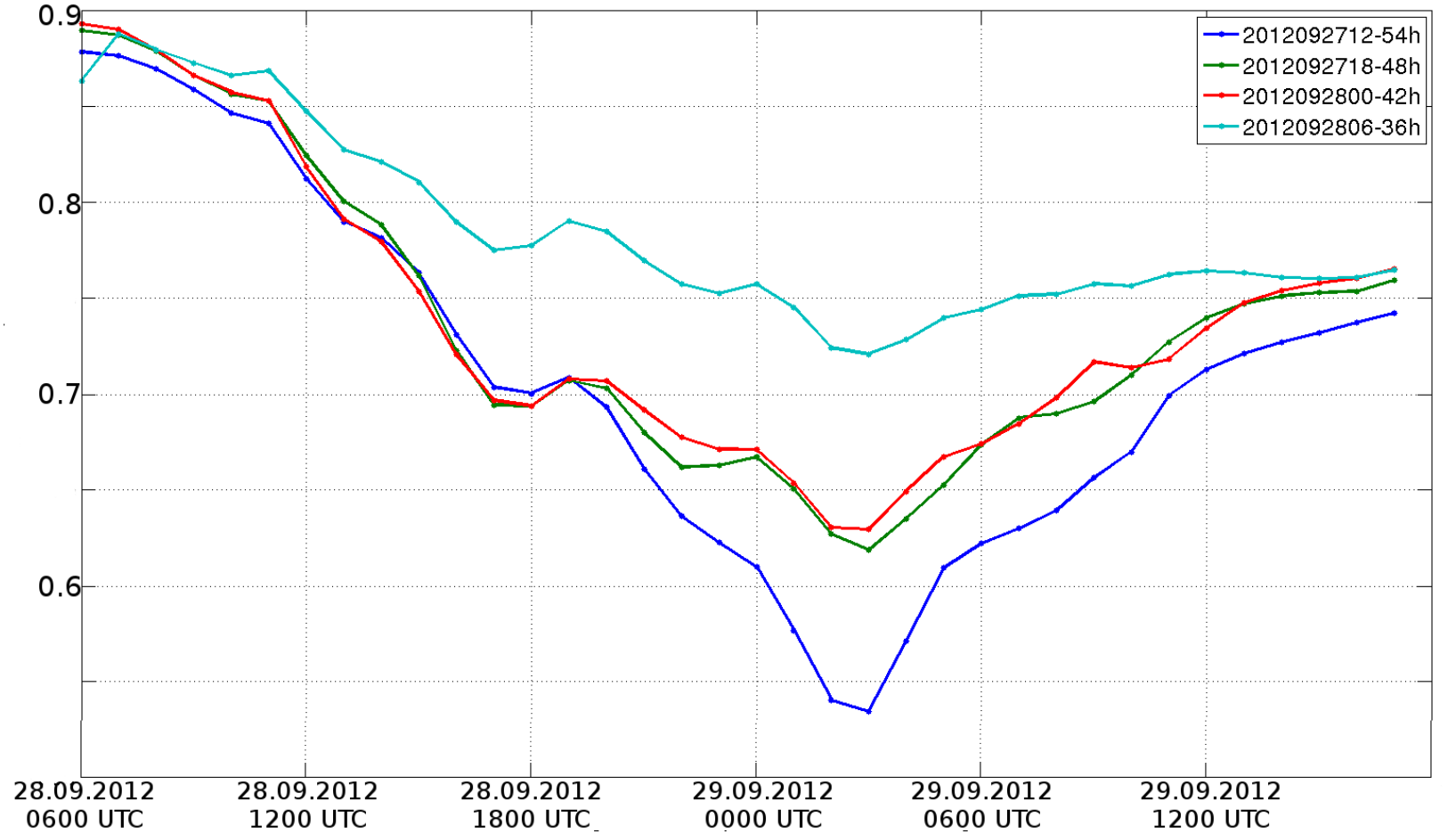

COSMO vs. AROME (mslp)

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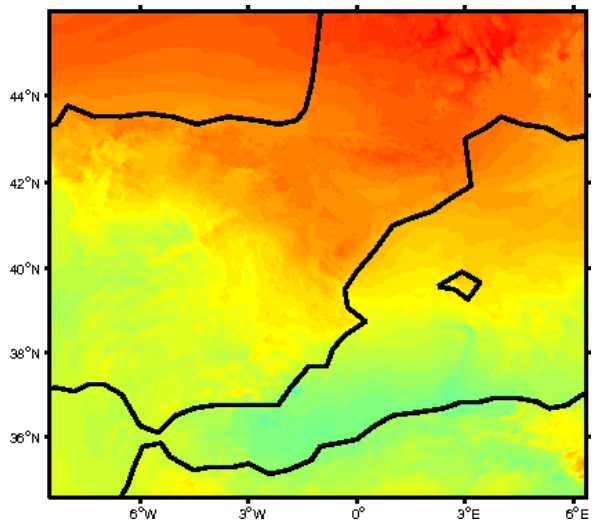
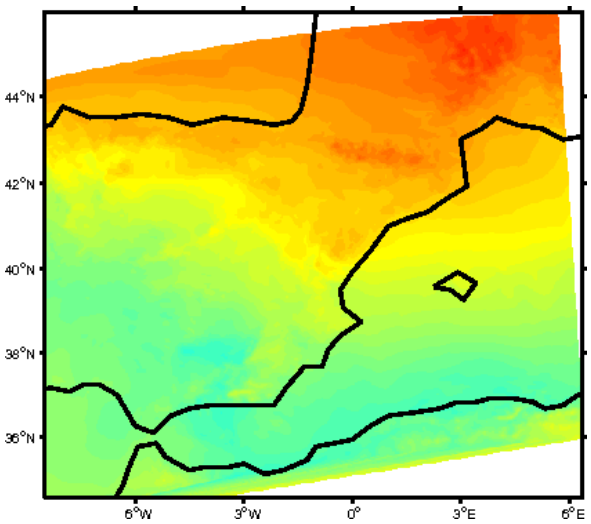
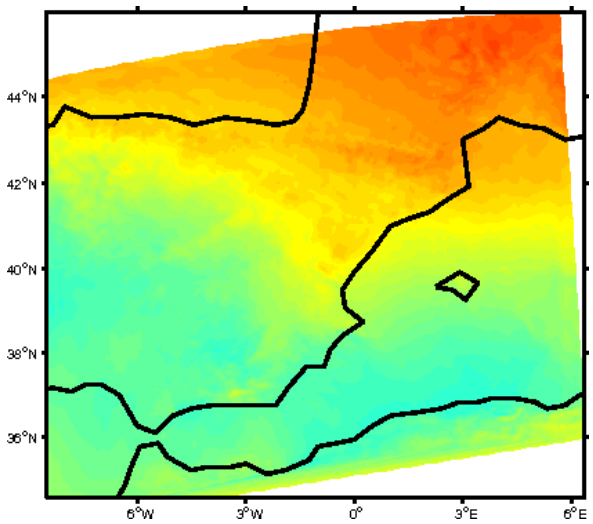
mean sea level pressure [hPa]
28 September 2012
0700 UTC



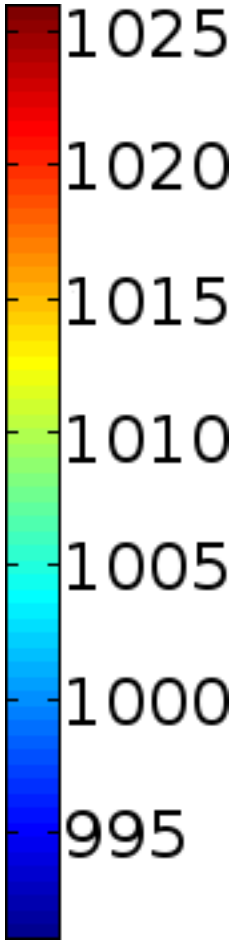
AROME-WMED



COSMO-2012092806

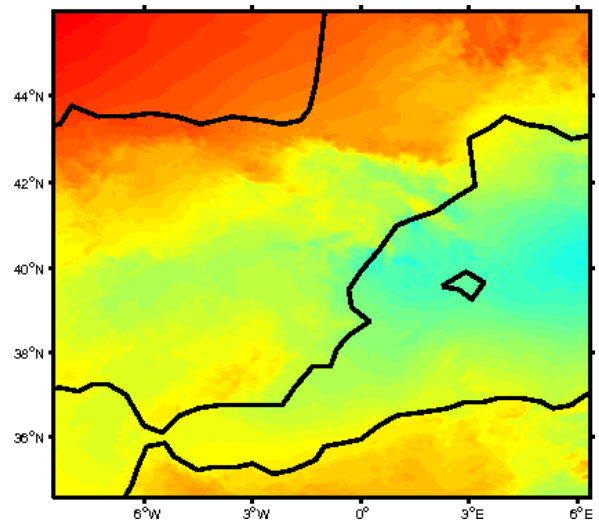


COSMO-2012092712

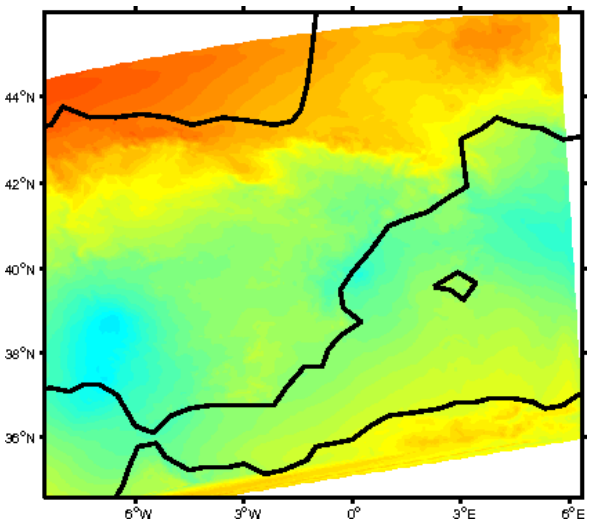


COSMO vs. AROME (mslp)

mean sea level pressure [hPa]
29 September 2012
0300 UTC



AROME-WMED



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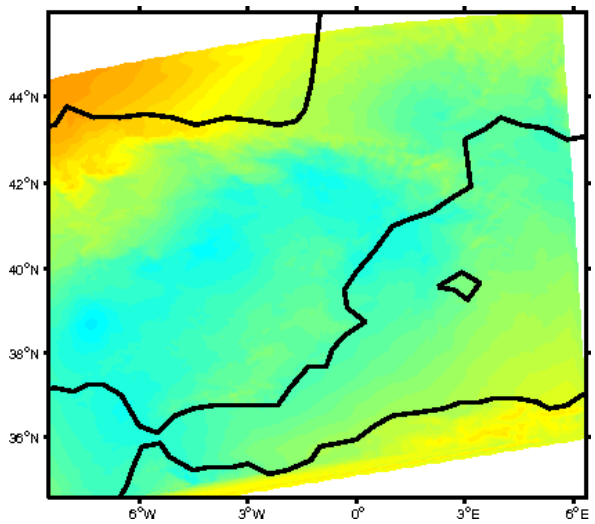

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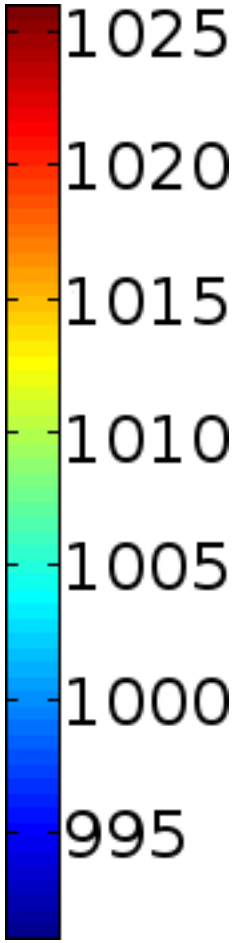

COSMO vs. AROME (mslp)

mean sea level pressure [hPa]
29 September 2012
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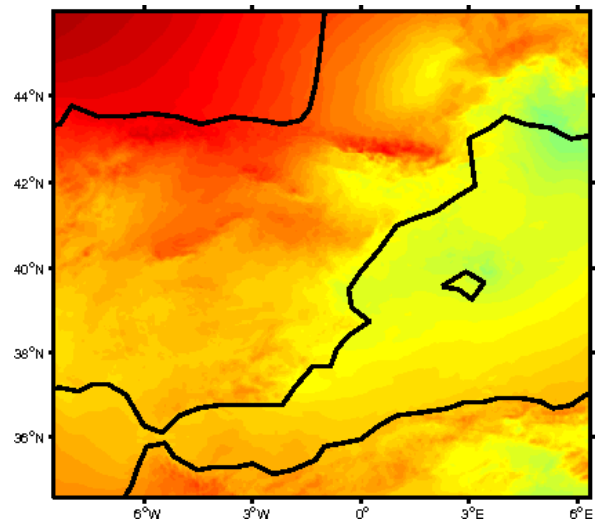

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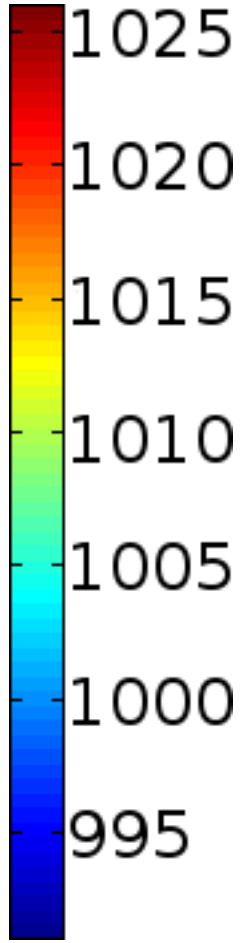

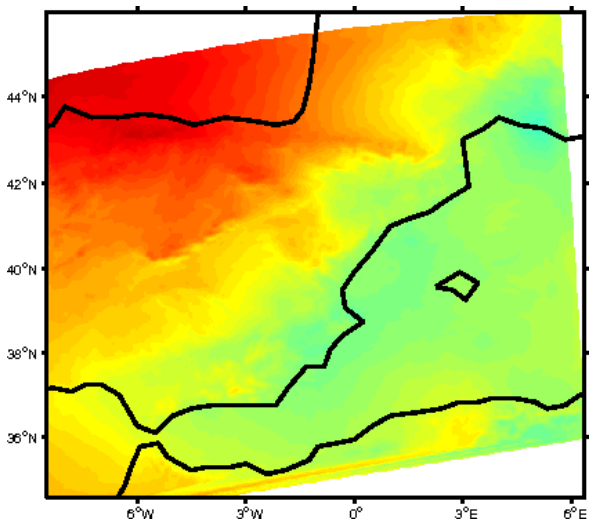

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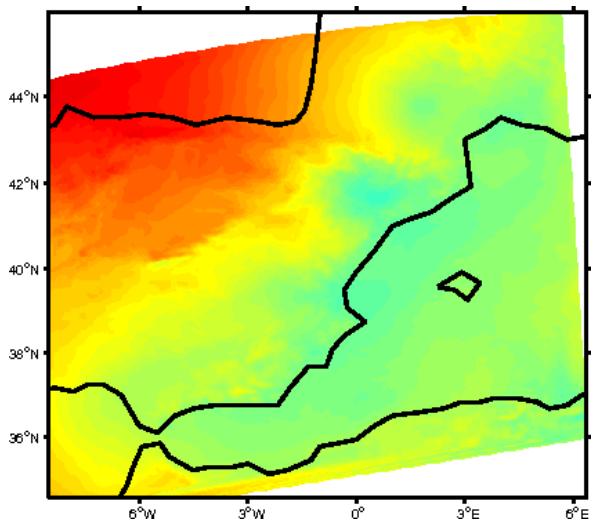

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COSMO vs. AROME (precip)

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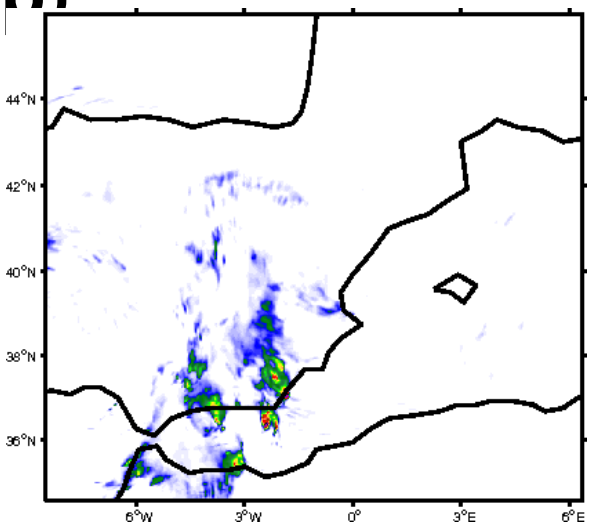
precipitation [mm]
28 September 2012
0700 UTC



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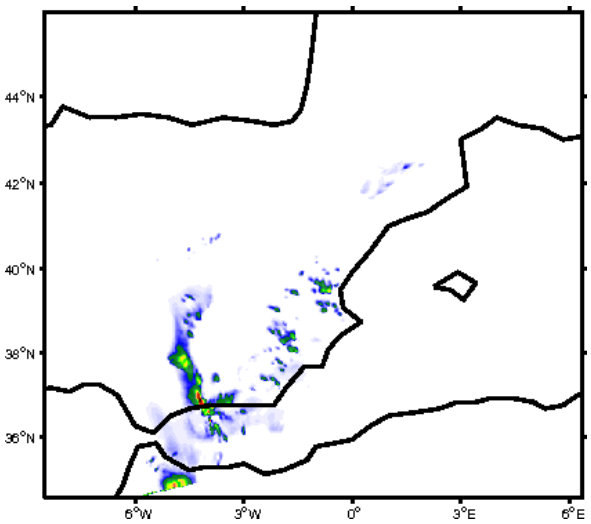

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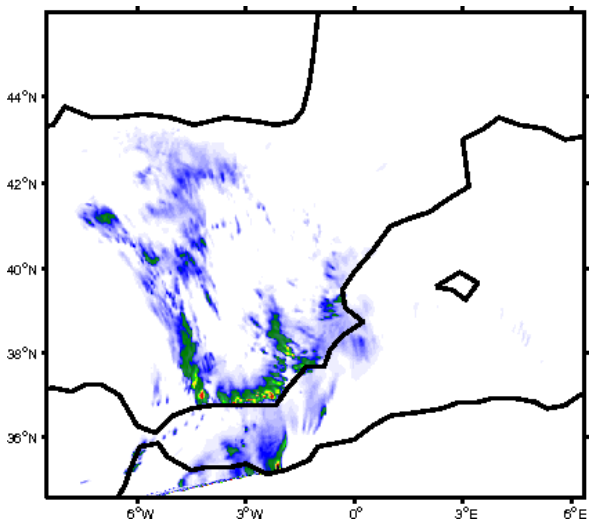

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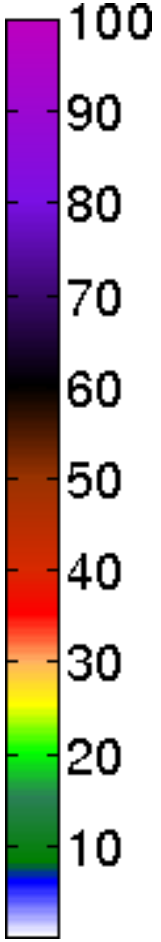

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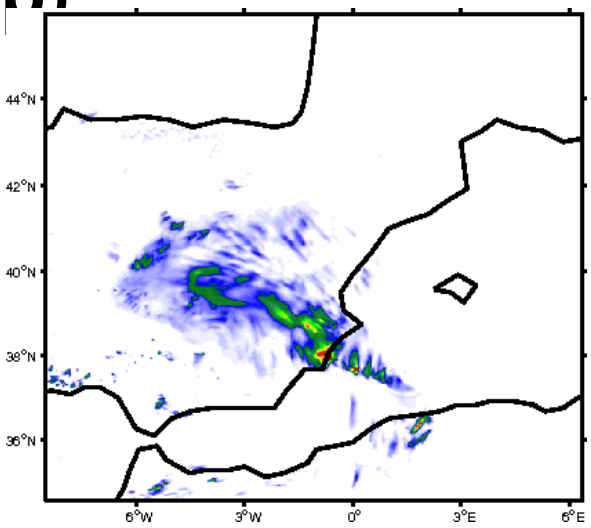

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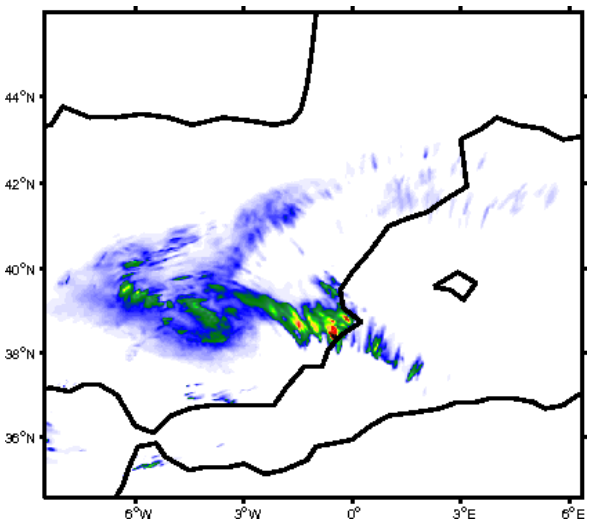

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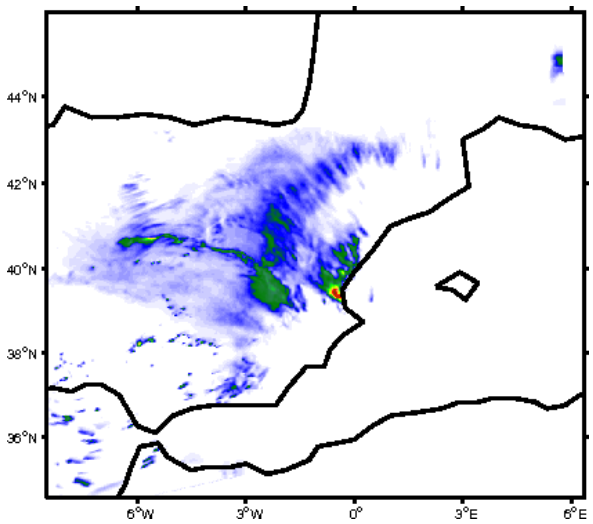

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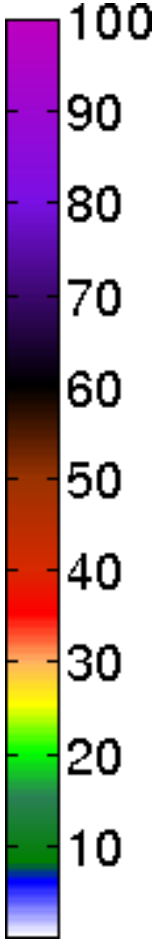

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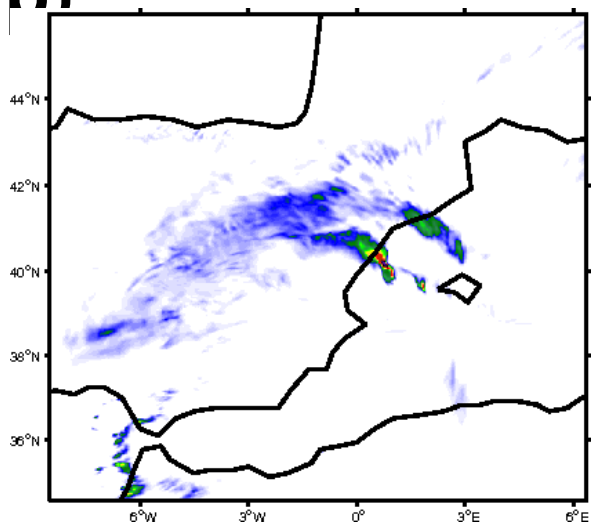

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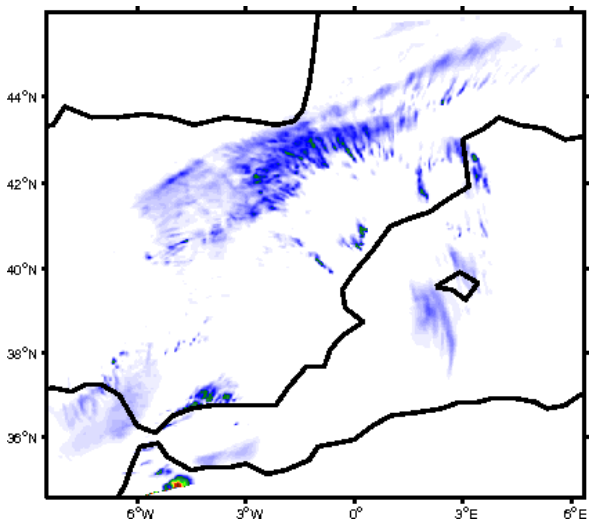

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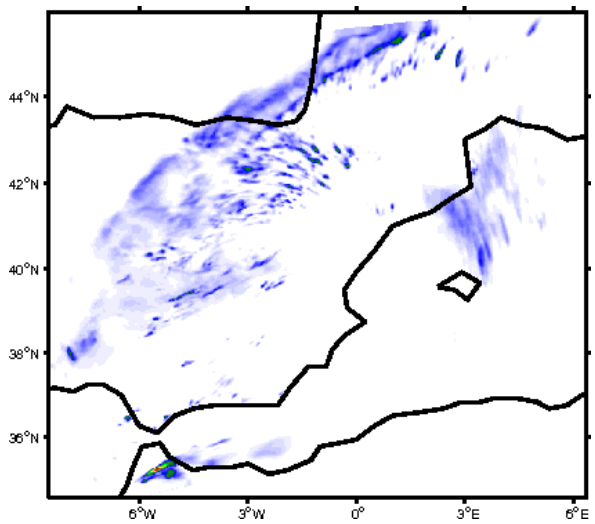

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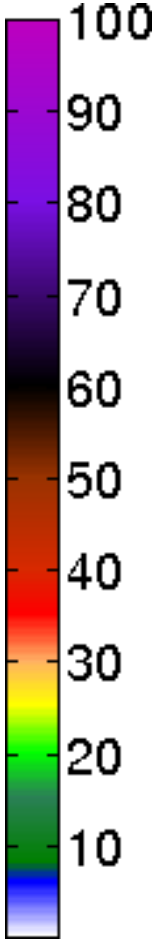

Contingency table

Contingency table

	Obs. YES	**Obs. NO**
Fcst. YES	Hit	False alarm
Fcst. NO	Miss	Correct negative

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for each “event” (e.g. threshold value of precipitation is exceeded) $\rightarrow$ contingency table is created

COSMO vs. AROME (precip)

Threshold based BIAS $\frac{N_{\text{COSMO}}}{N_{\text{AROME}}} = \frac{\text{hits+false alarms}}{\text{hits+misses}}$

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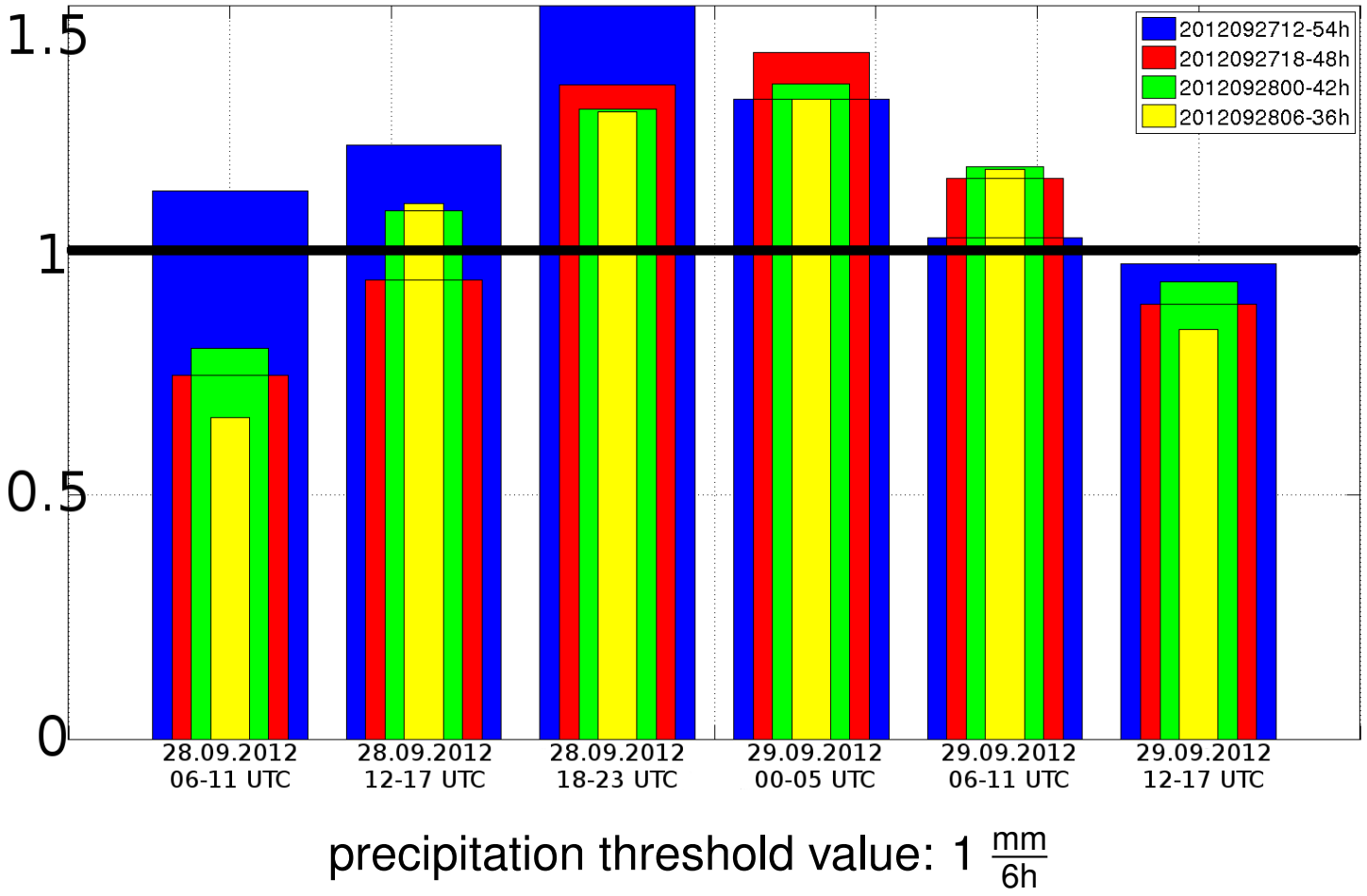

precipitation threshold value: 1 $\frac{mm}{6h}$

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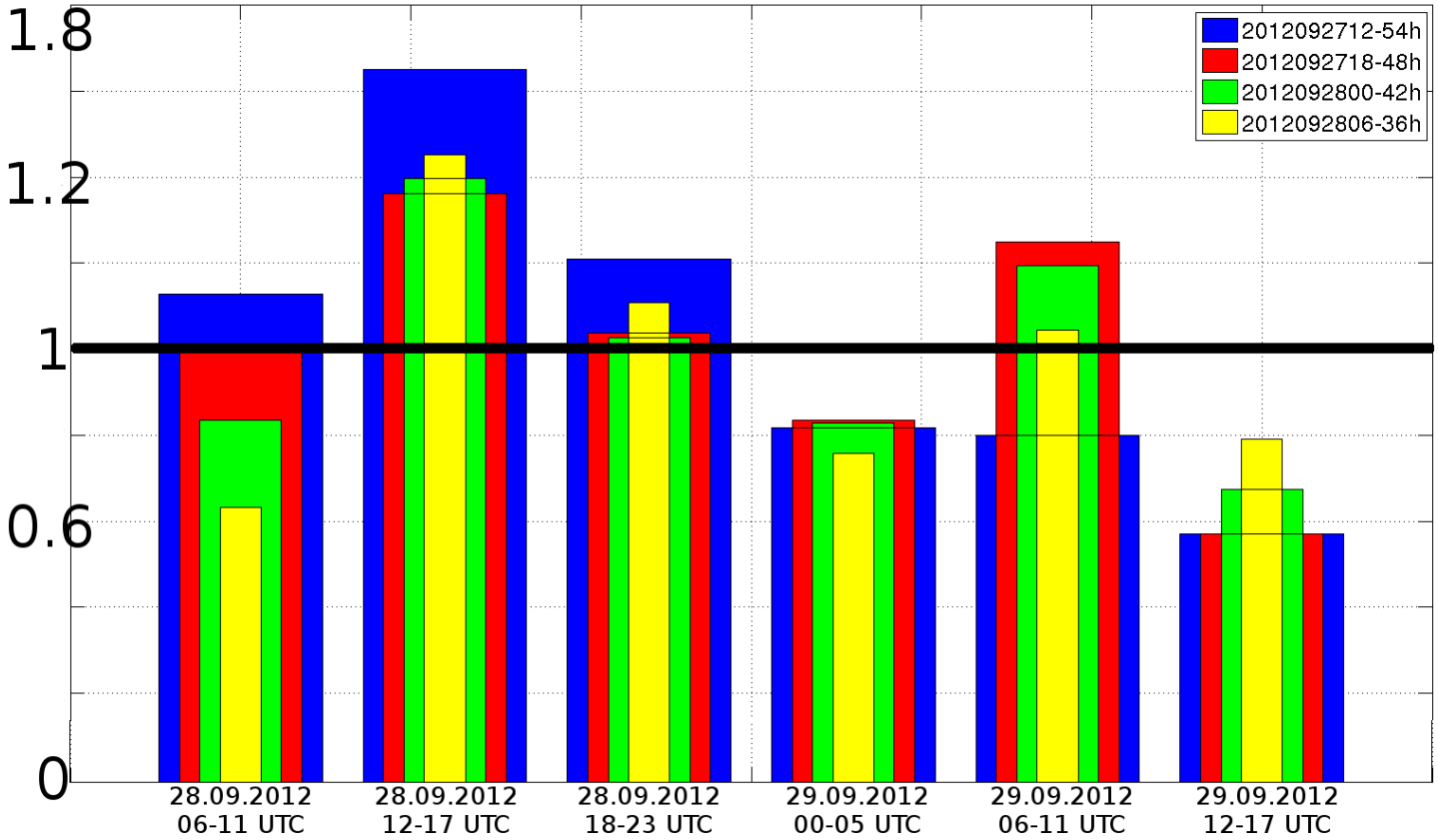

precipitation threshold value: 10 $\frac{mm}{6h}$

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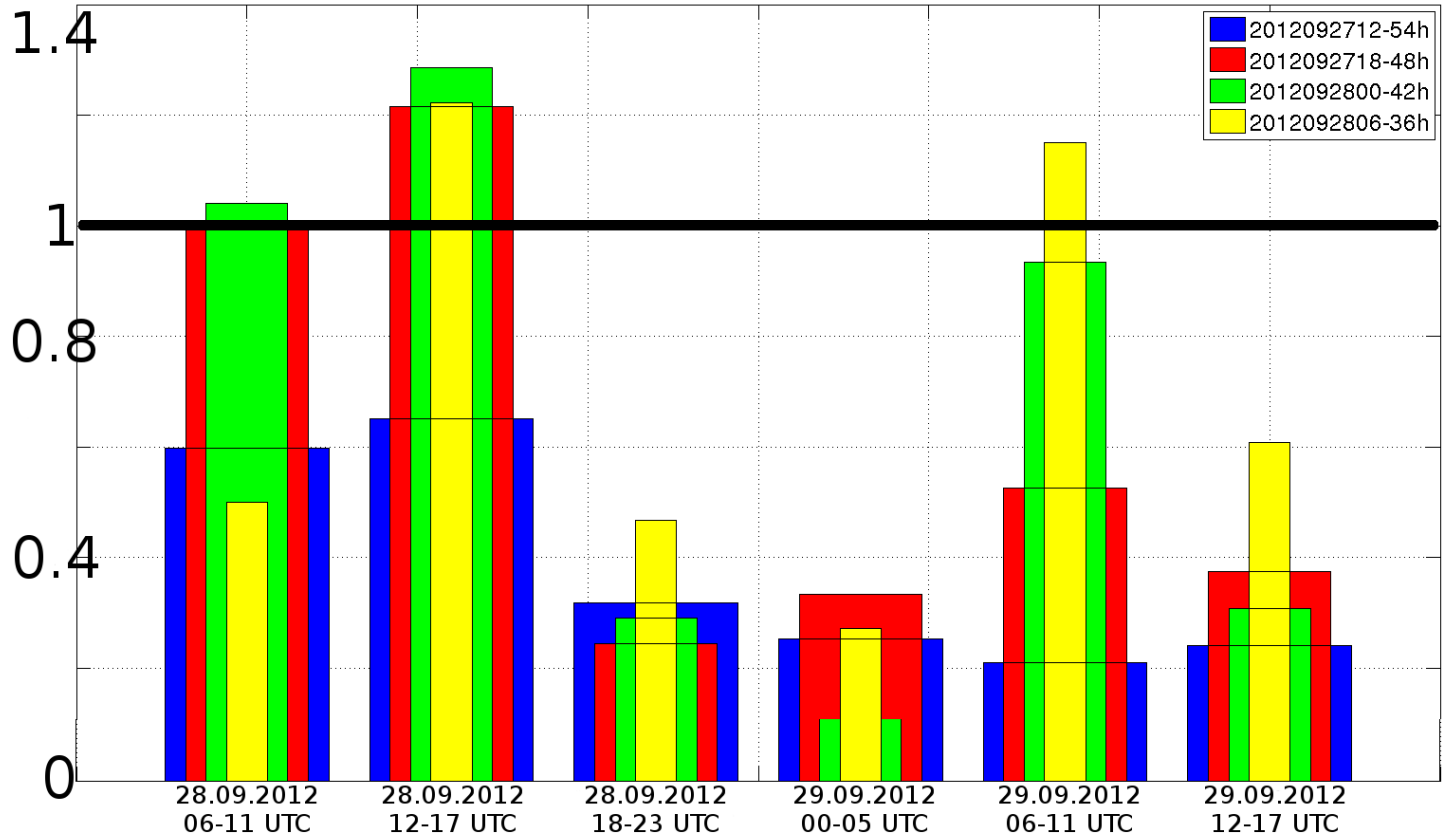

precipitation threshold value: 35 $\frac{mm}{6h}$

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ROC-curve $\frac{\text{POD}}{\text{POFD}}$

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with $\text{POD} = \frac{\text{hits}}{\text{hits + misses}}$ and $\text{POFD} = \frac{\text{false alarms}}{\text{correct negatives + false alarms}}$

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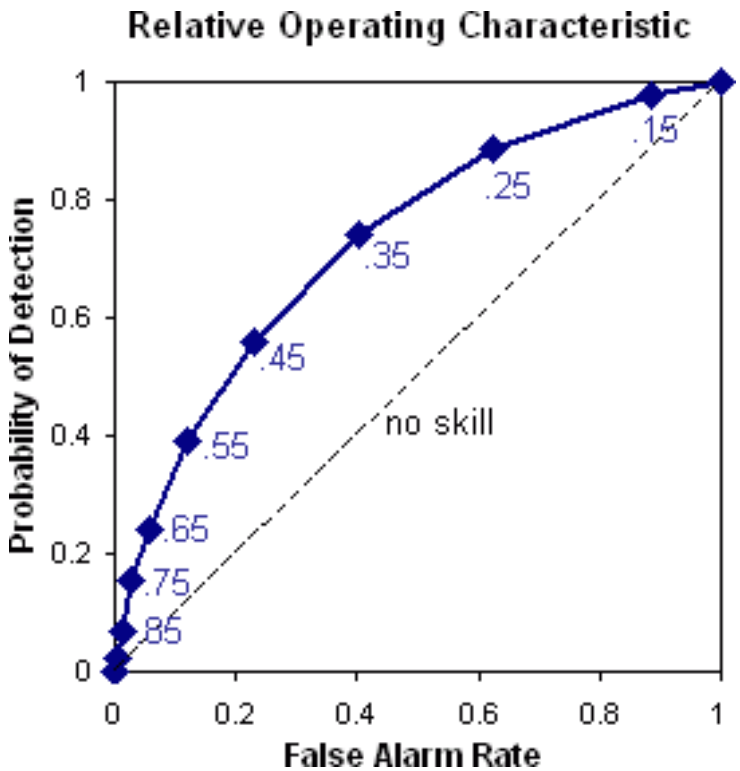

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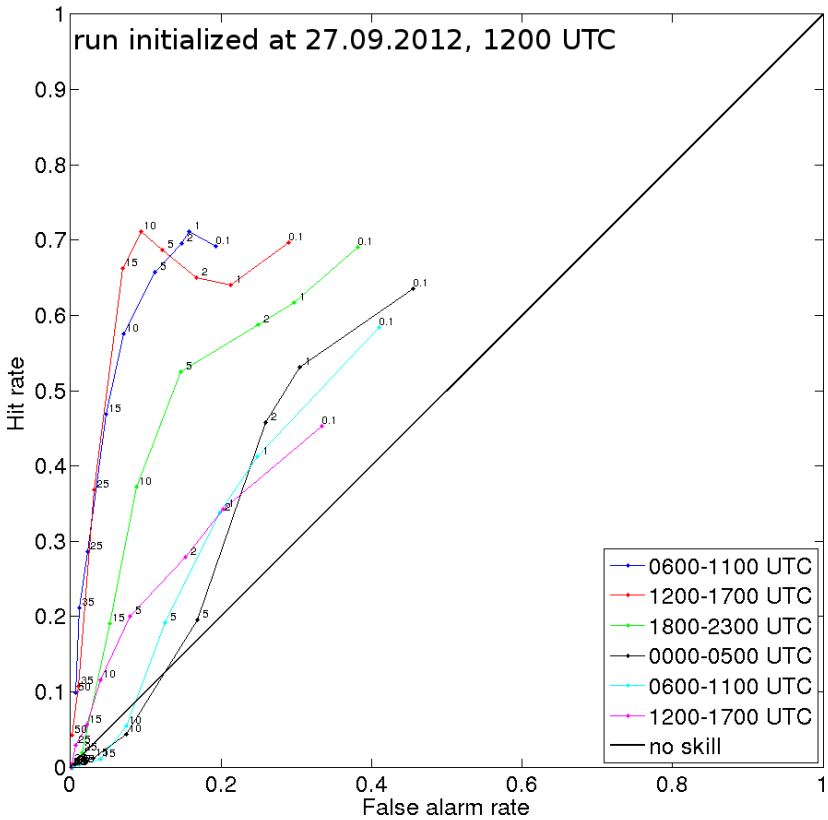
ROC-curve $\frac{\text{POD}}{\text{POFD}}$

threshold values (mm/6h): 0.1 - 1 - 2 - 5 - 10 - 15 - 25 - 35 - 50



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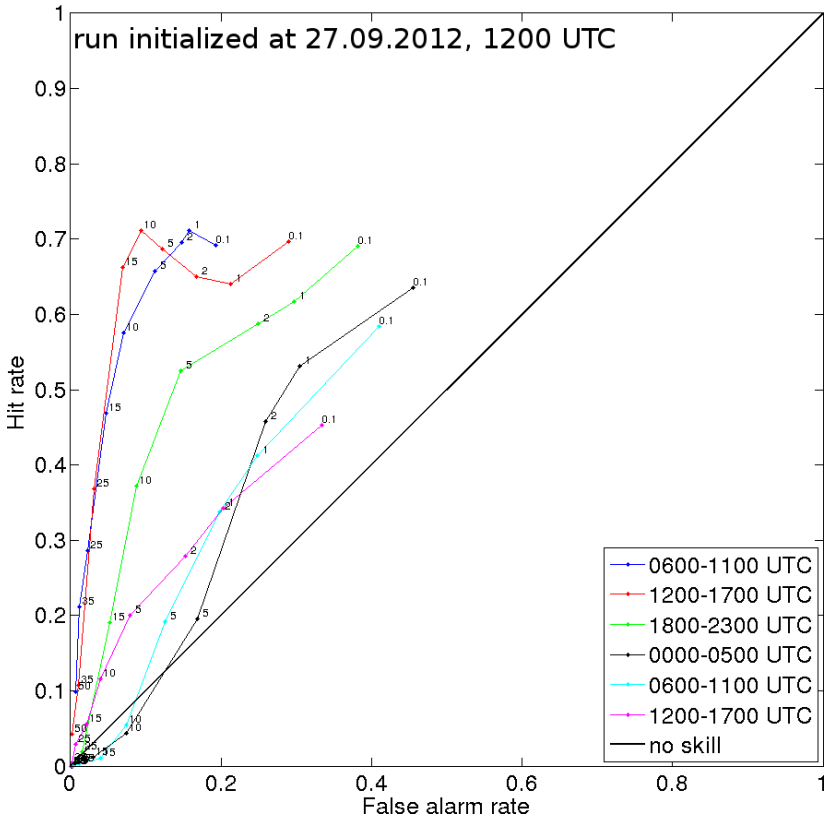

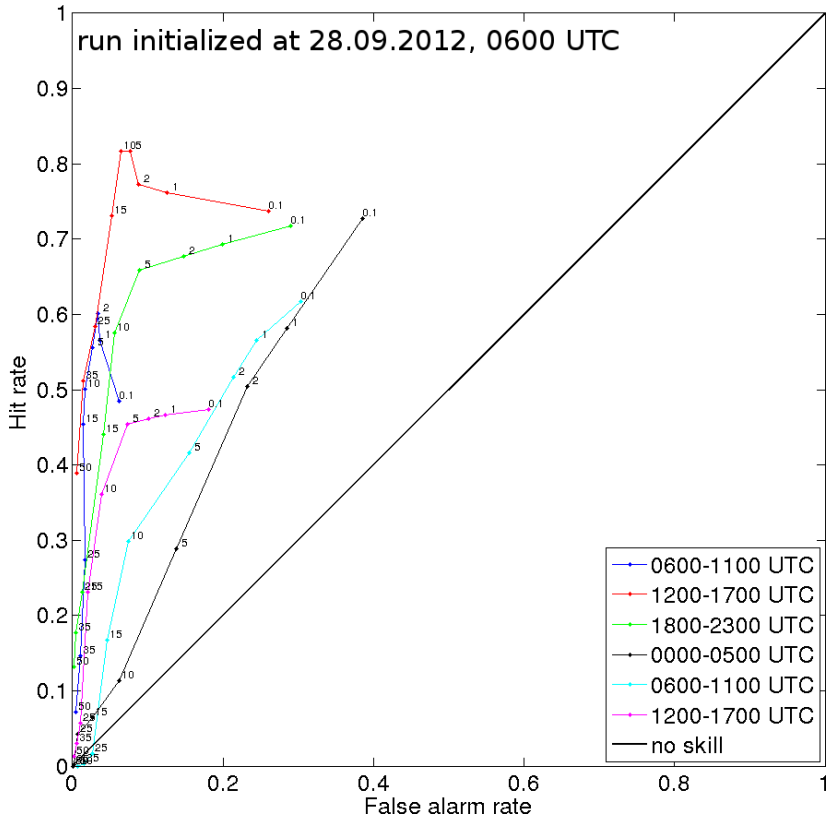

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approach for [2]:

$\rightarrow$ investigation of chosen COSMO simulation $\rightarrow$ meteorological variables:

- equivalent potential temperature
- precipitable water
- PV
- convective indices
- ... ?

Diagnostic study

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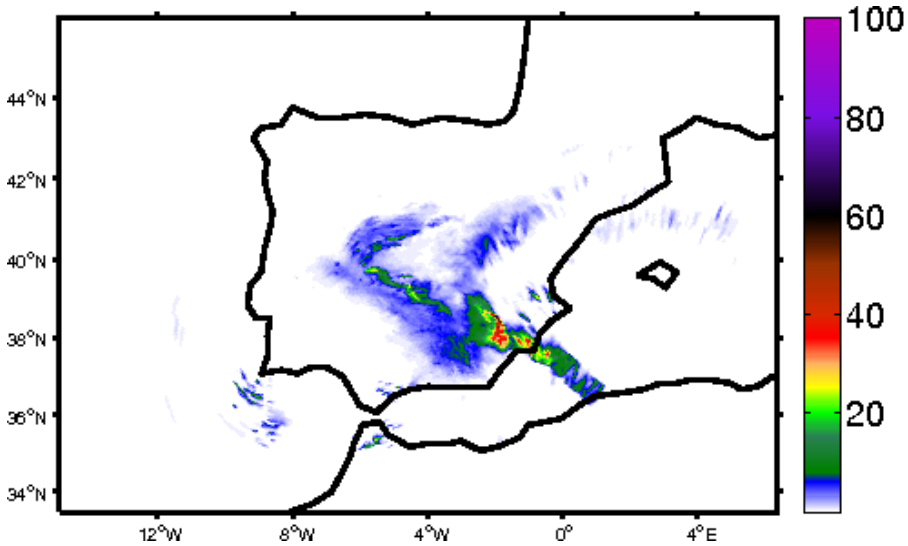
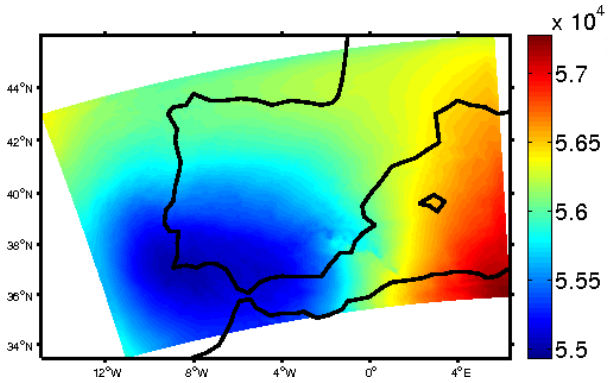
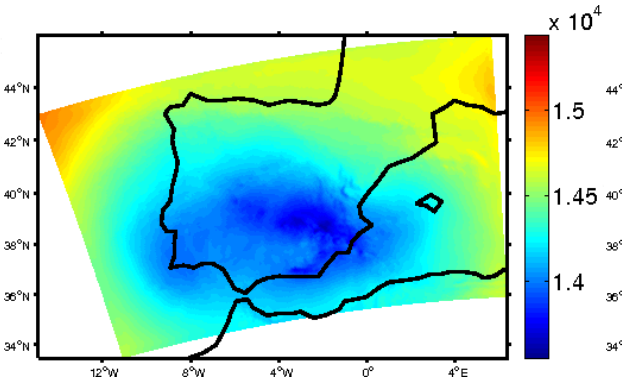


precipitation [mm] $\leftrightarrow$
geopotential [$m^2\,s^{-2}$]

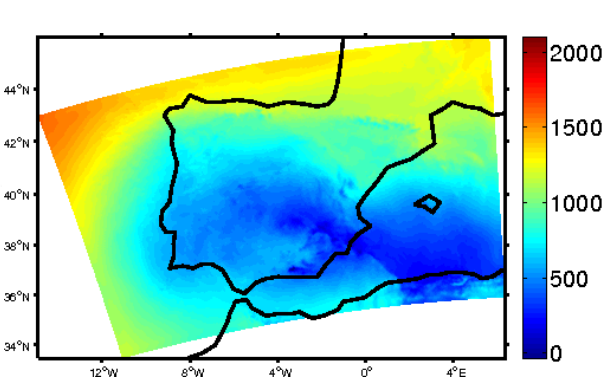
500 hPa



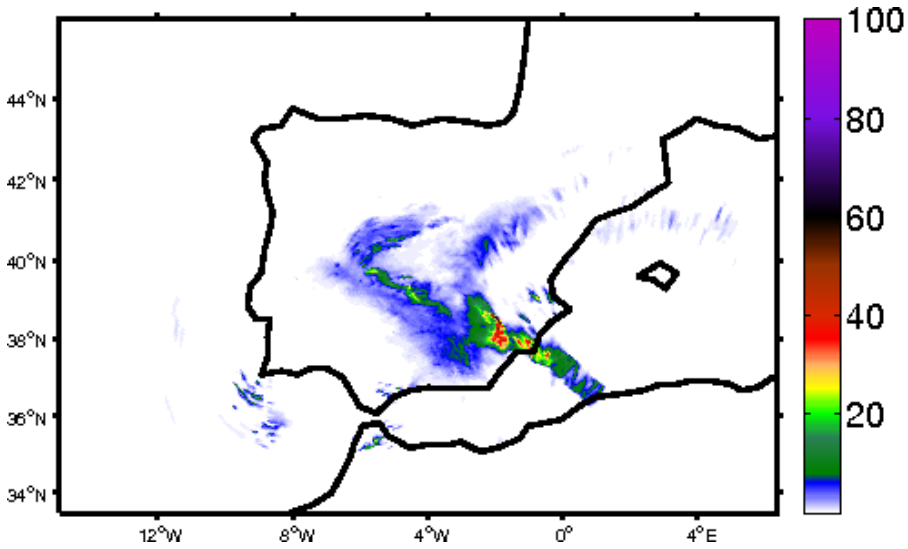
850 hPa



1000 hPa

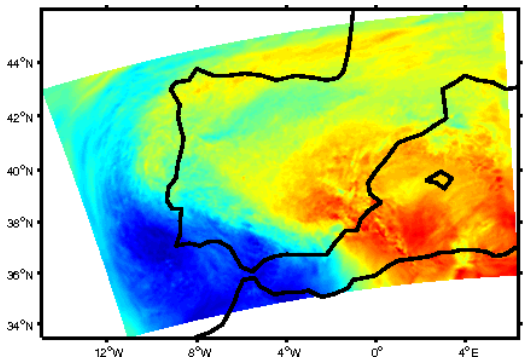


Diagnostic study

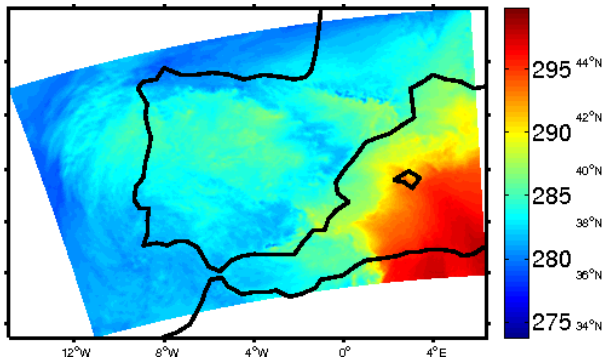


precipitation [mm] $\leftrightarrow$
temperature [K]

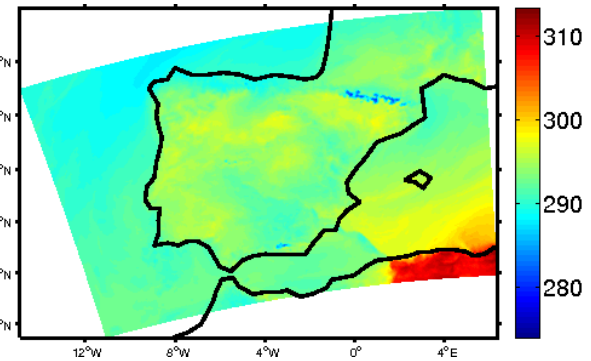
500 hPa



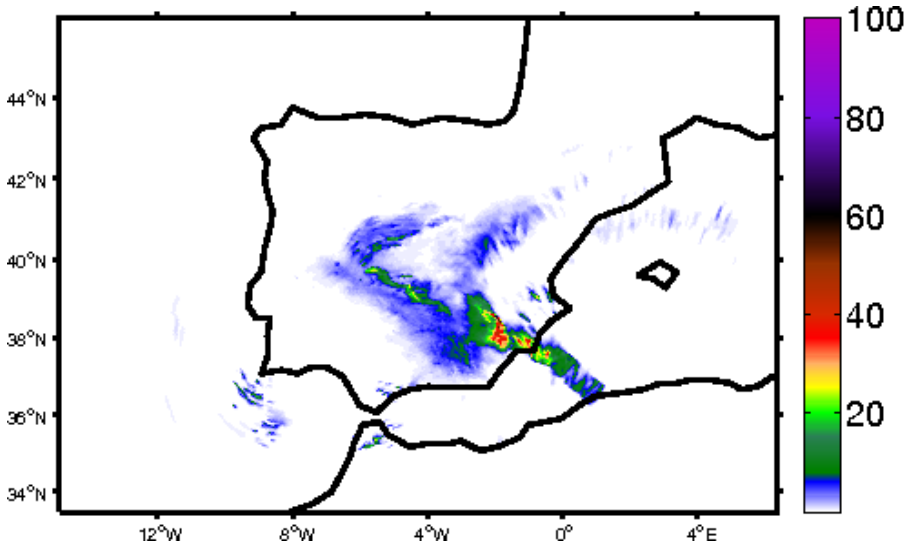
850 hPa



1000 hPa

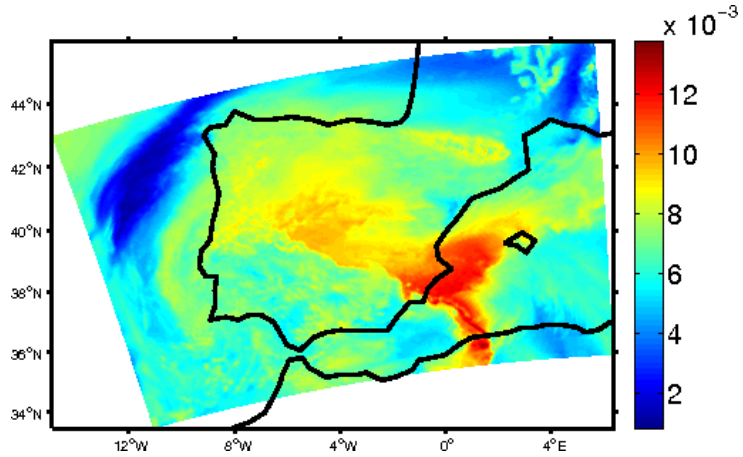


Diagnostic study

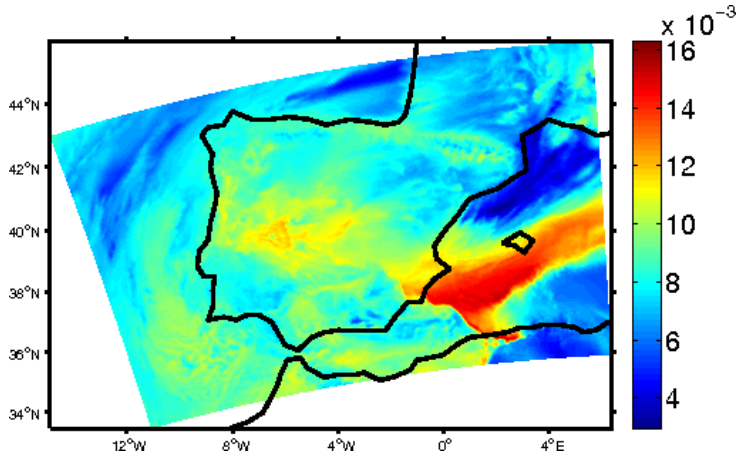


precipitation [mm] $\leftrightarrow$
specific humidity [kg kg^{-1}]

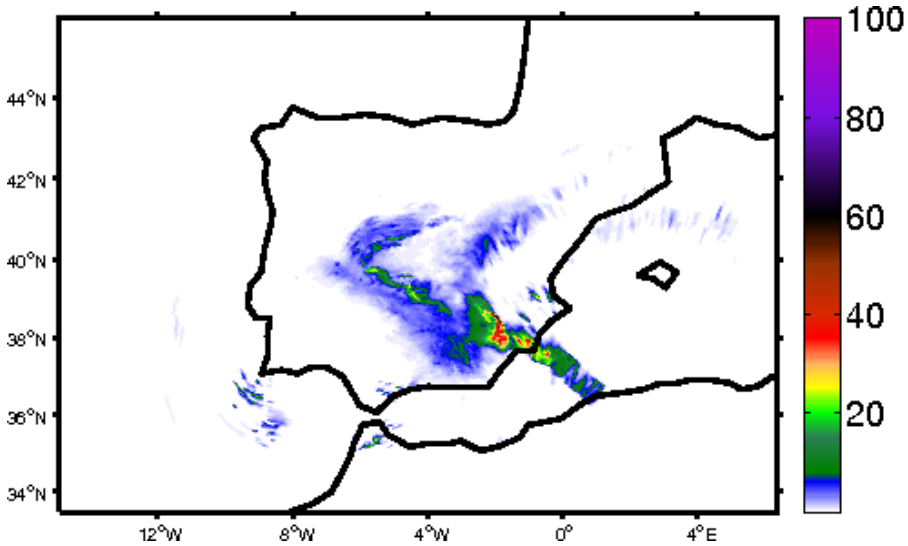
850 hPa



950 hPa

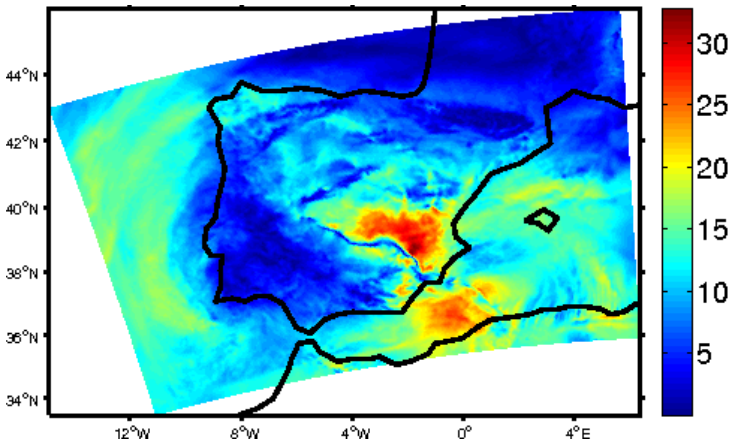


Diagnostic study

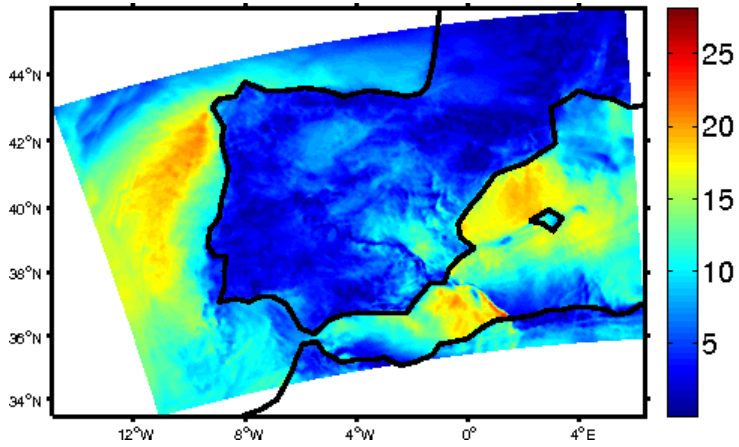


precipitation [mm] $\leftrightarrow$
horizontal wind [m s^{-1}]

850 hPa



1000 hPa



Ensemble runs

aims:

- What is the role of convection for the initiation of local HPE in the western Mediterranean?
- Is it possible to reproduce natural variability of convective clouds?

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- Is it possible to reproduce natural variability of convective clouds?

approach:

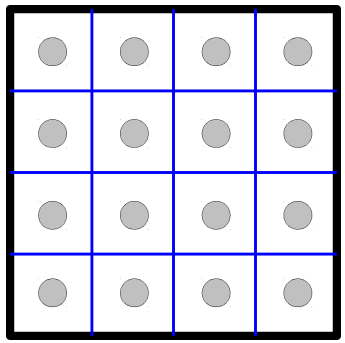
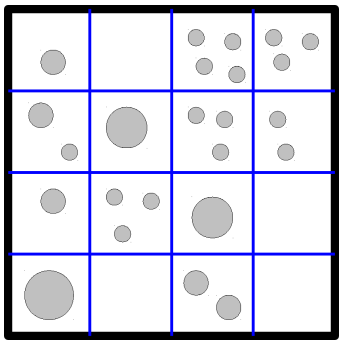
1. ensemble with stochastic cumulus convection scheme (various cloud distributions on grid scale)
2. validation by ensemble scores

Ensemble runs

1. Stochastic cumulus convection scheme

Ensemble runs

1. Stochastic cumulus convection scheme

	Tiedtke (operational)	**Plant-Craig**
type of parameterization	mass flux	mass flux
closure assumption	moisture convergence	CAPE
stochastic feature	no (deterministic)	in each gridbox, a random number of clouds (with individual mass flux) is initiated
variability regarding distribution of convective precipitation	small 	large 

Ensemble runs

2. validation of ensemble runs

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   - “Structure-Amplitude-Location (SAL)” (Wernli et al., 2008)
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$\rightarrow$ iterative changing of parameters in Plant-Craig convection scheme
$\rightarrow$ re-calculation of scores

Summary

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Model studies of heavy precipitation events in the western Mediterranean during the HyMeX campaign

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- high resolution COSMO simulations (2.8 km):
  - changing forecast start time: best control run to represent reality
  - validation with AROME-WMED analyses by different statistical scores

Summary

Model studies of heavy precipitation events in the western Mediterranean during the HyMeX campaign

- high resolution COSMO simulations (2.8 km):
  - changing forecast start time: best control run to represent reality
  - validation with AROME-WMED analyses by different statistical scores
- simulation with parameterization of convection (7 km):
  - validation by different statistical ensemble scores
  - changing of parameters in Plant-Craig convection scheme

Thank you for your attention!