Simulation of a heavy precipitation event in Senegal and its upstream features with the DWD Lokalmodell

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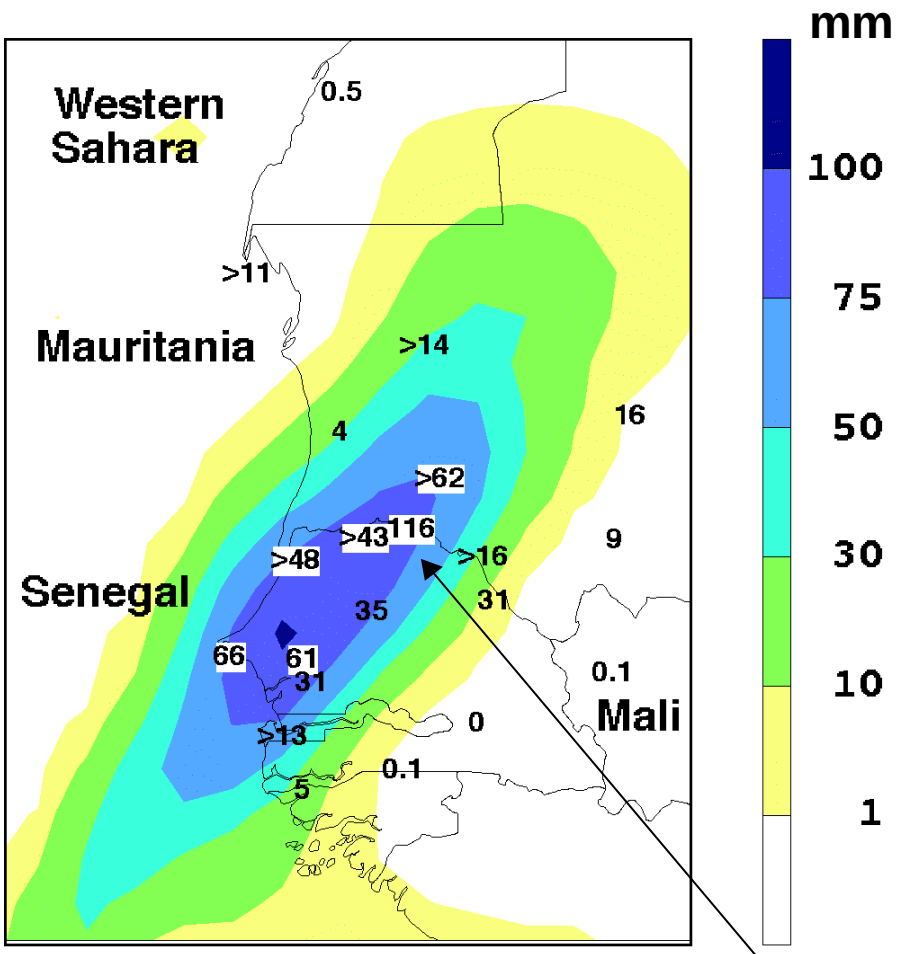
Overview

- The heavy precipitation event in January 2002 and its synoptic features
- Upstream development
- Used configuration of the Lokalmodell
- Preliminary results of the LM simulations of the precipitation
- Further planned investigations



Accumulated precipitation from

06 UTC

9 to 11 January 2002:

Observations and results of a

UW-NMS model simulation

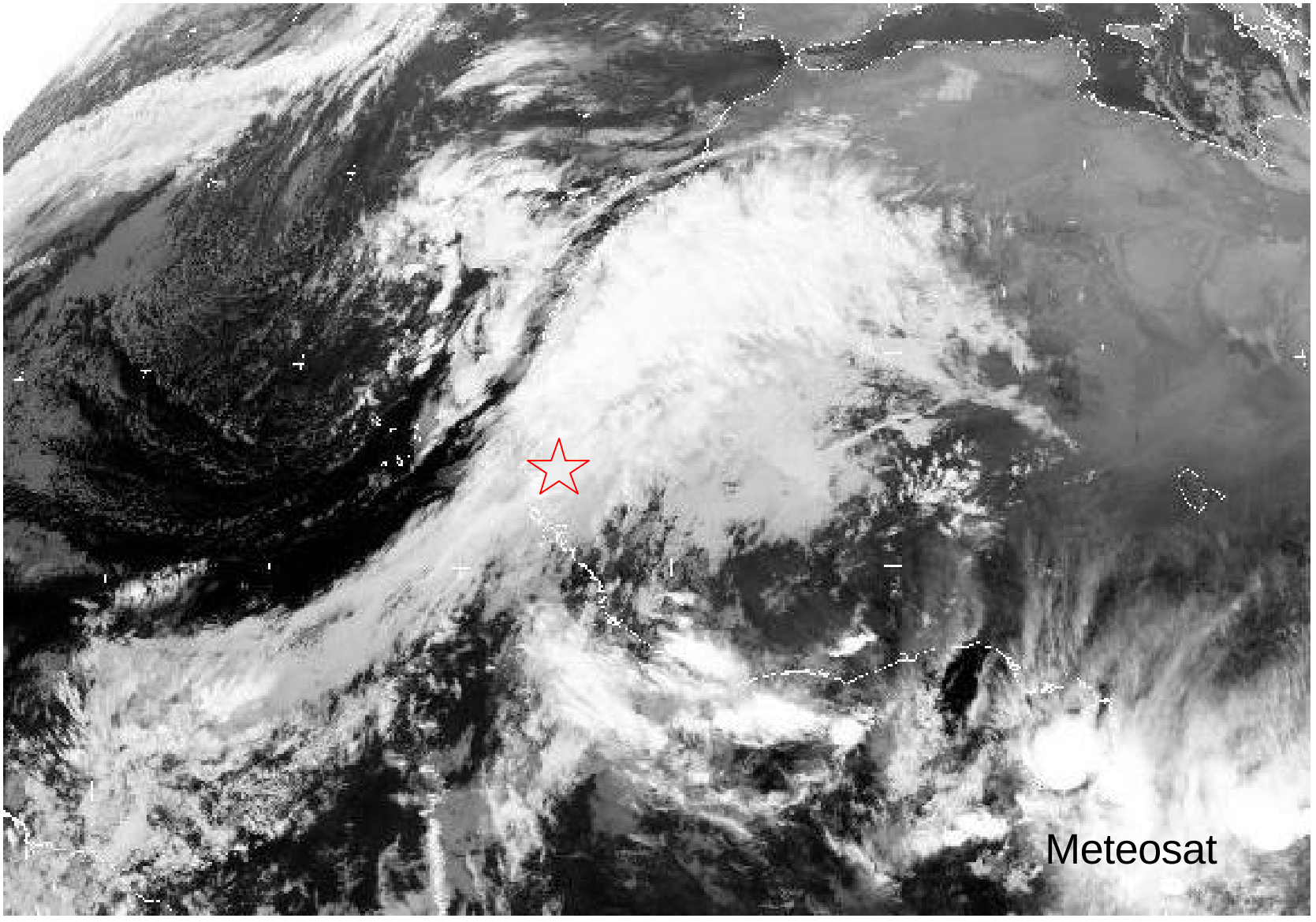
climatologic January mean: ≈ 1mm

116 mm in 48h in Podor

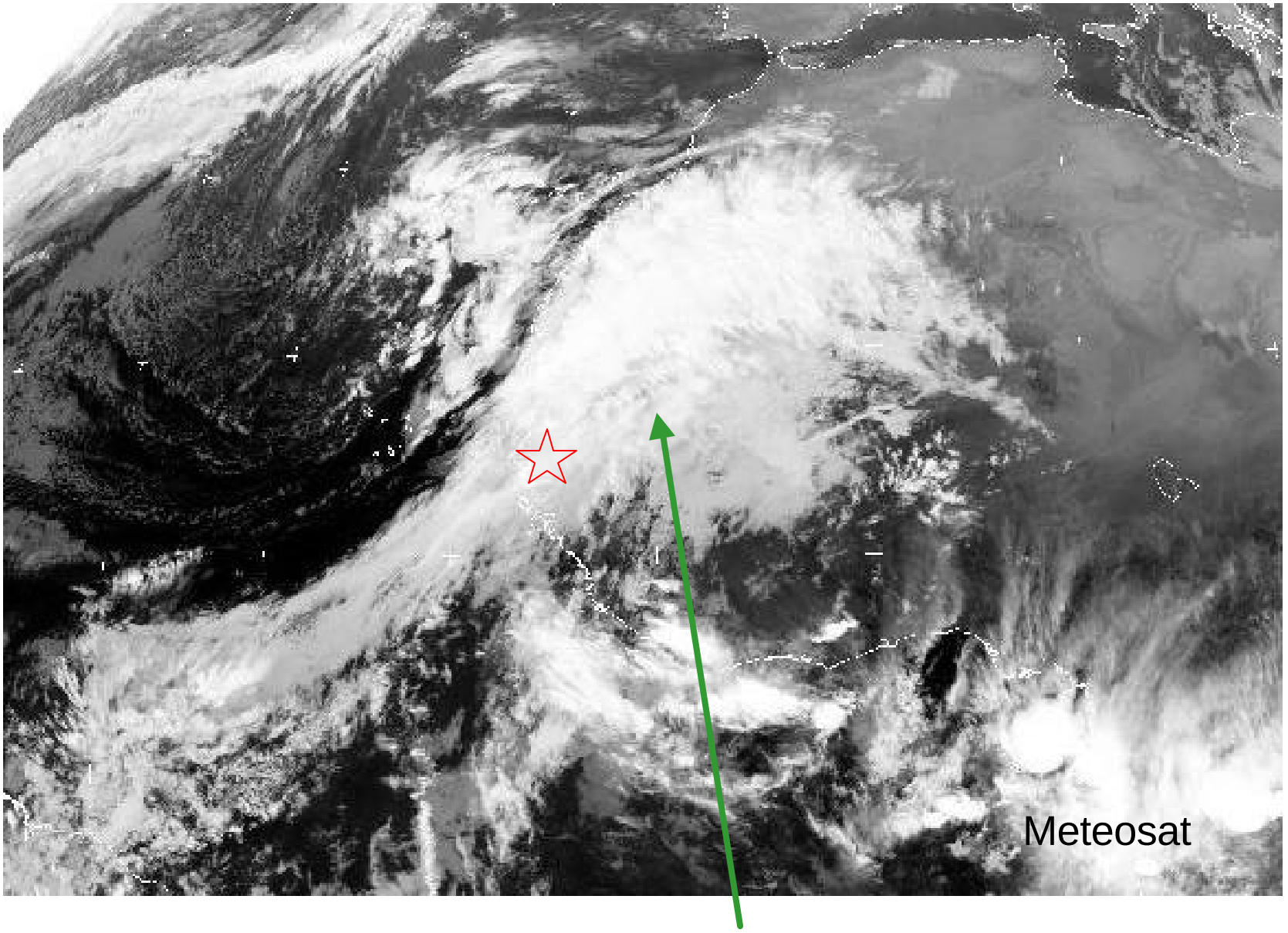
from Knippertz and Martin 2005

Consequences of the precipitation event

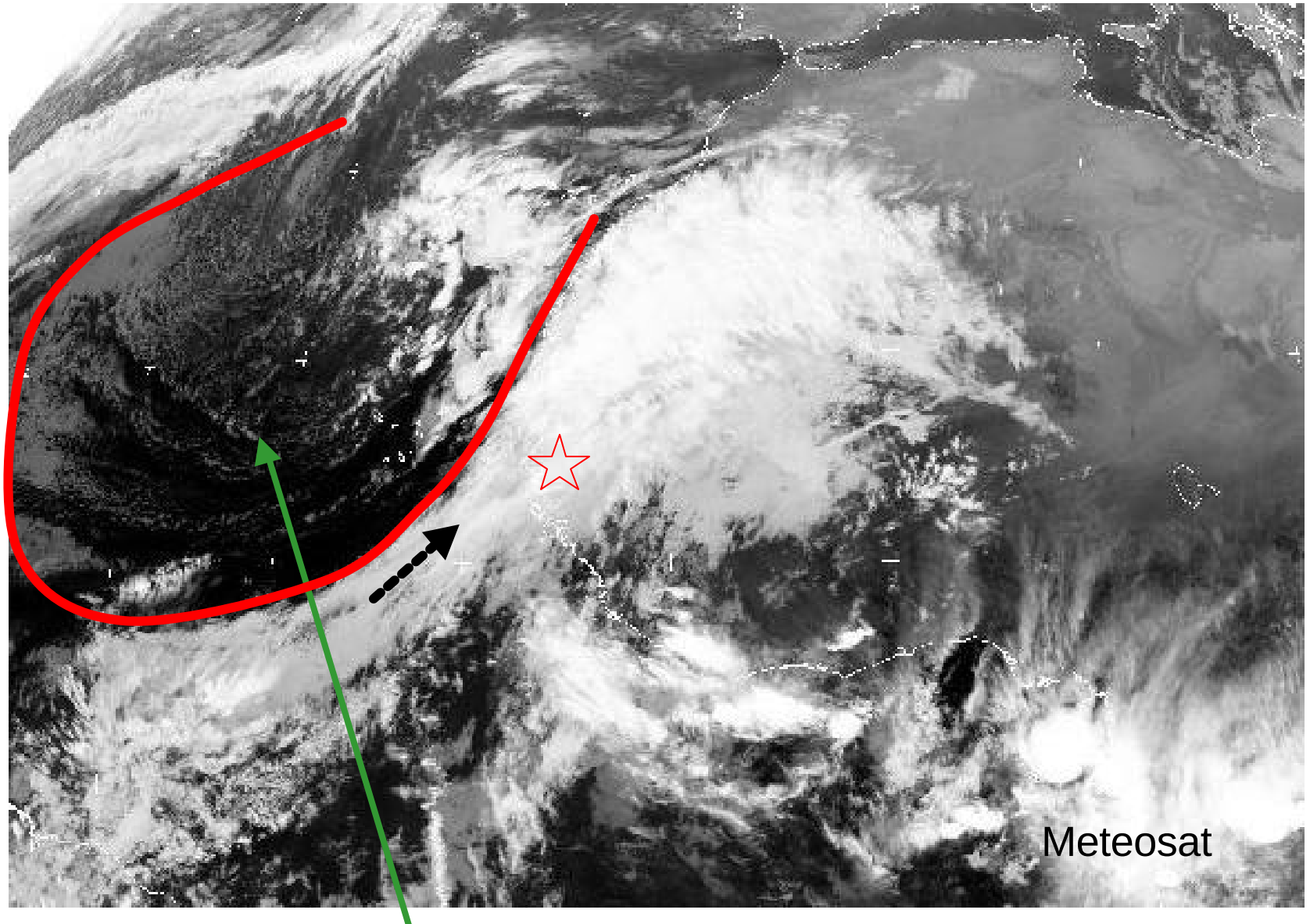
- flooding
- great damage in infrastructure and agriculture
- collaps of houses
- some deceased



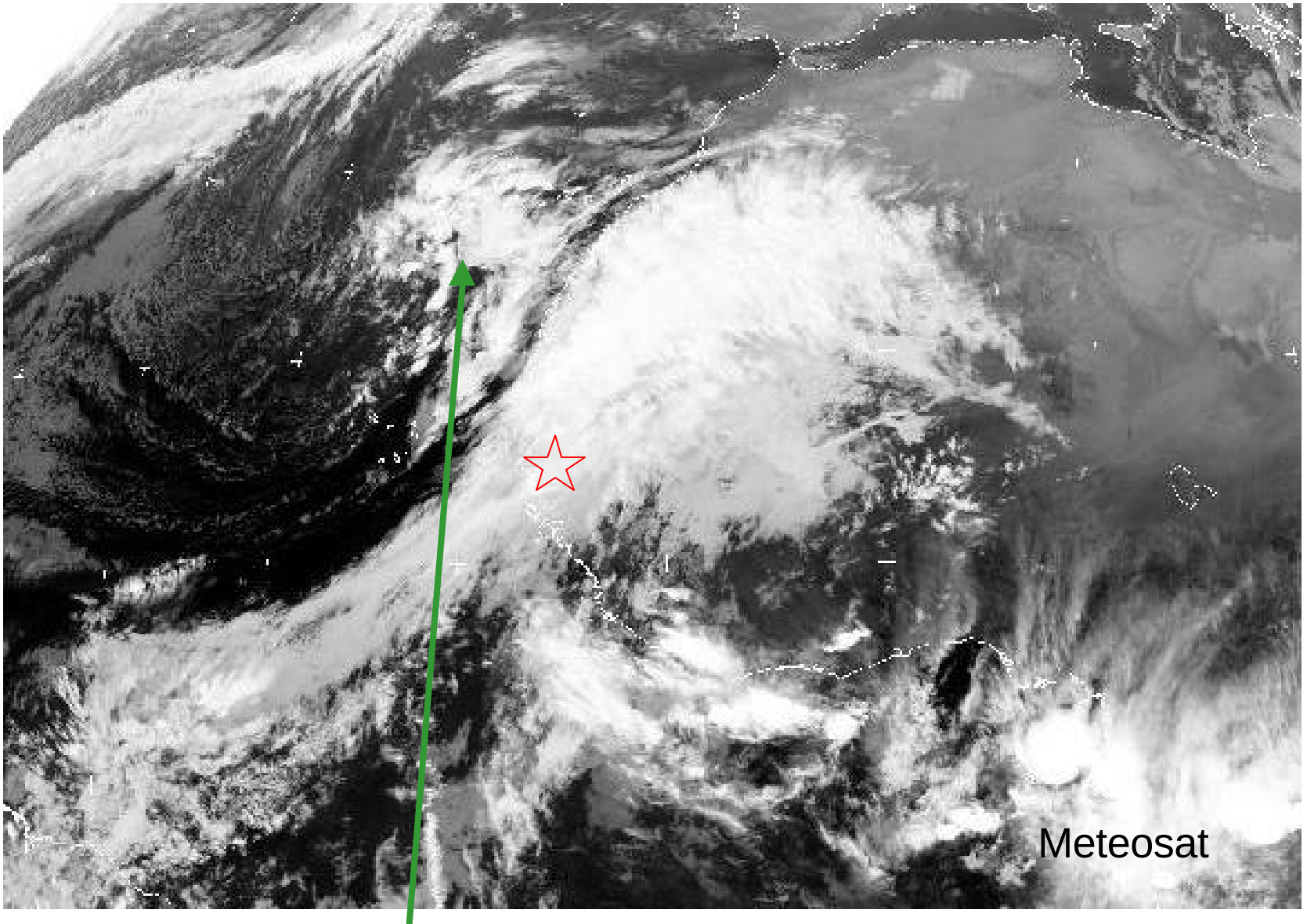
10 January 2002 00 UTC

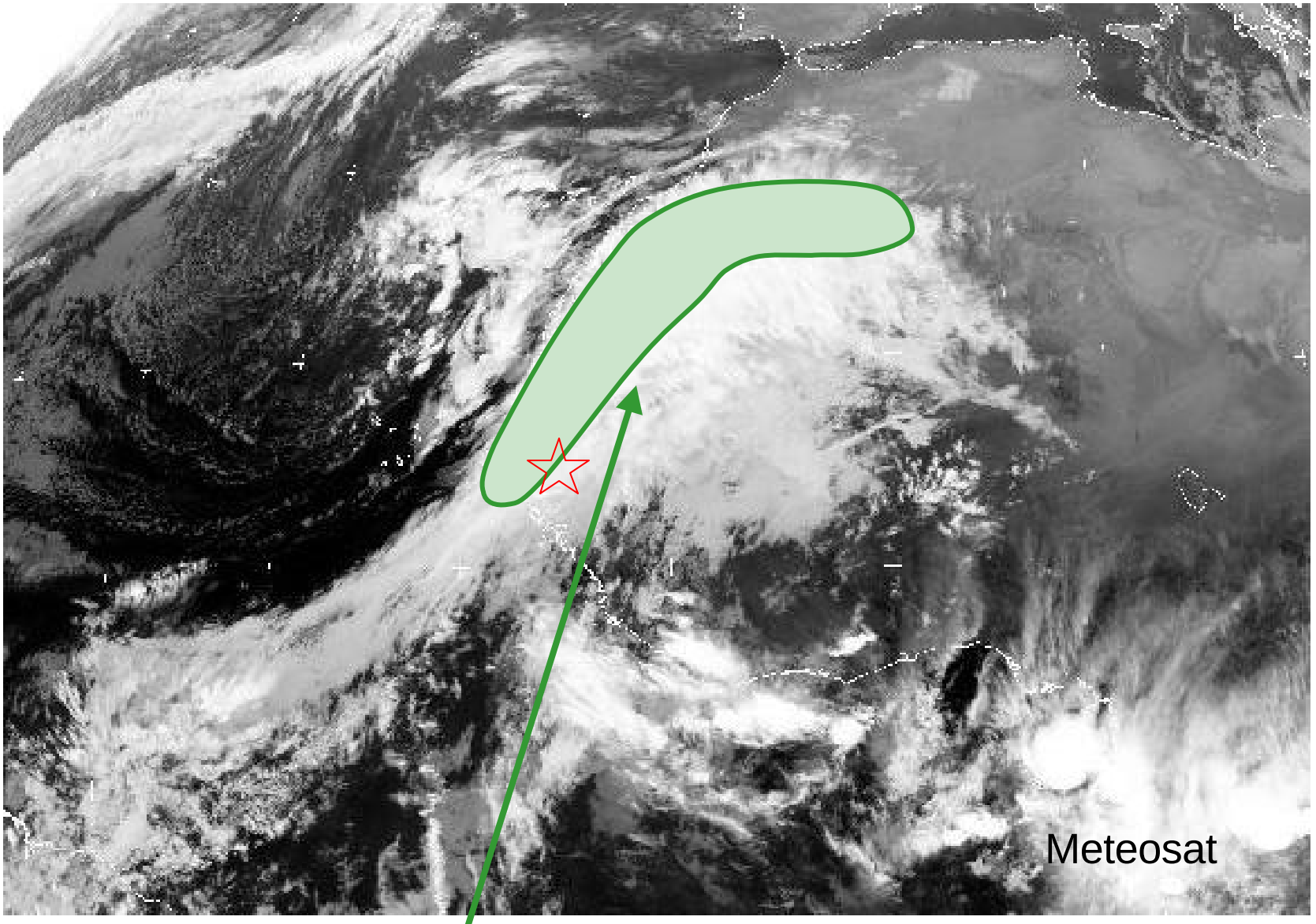


Tropical Plume (TP)



Trough protruded from the extratropics


Meteosat
subtropical cyclone



Subtropical jetstream

~ 60 m/s

Inertial Instability

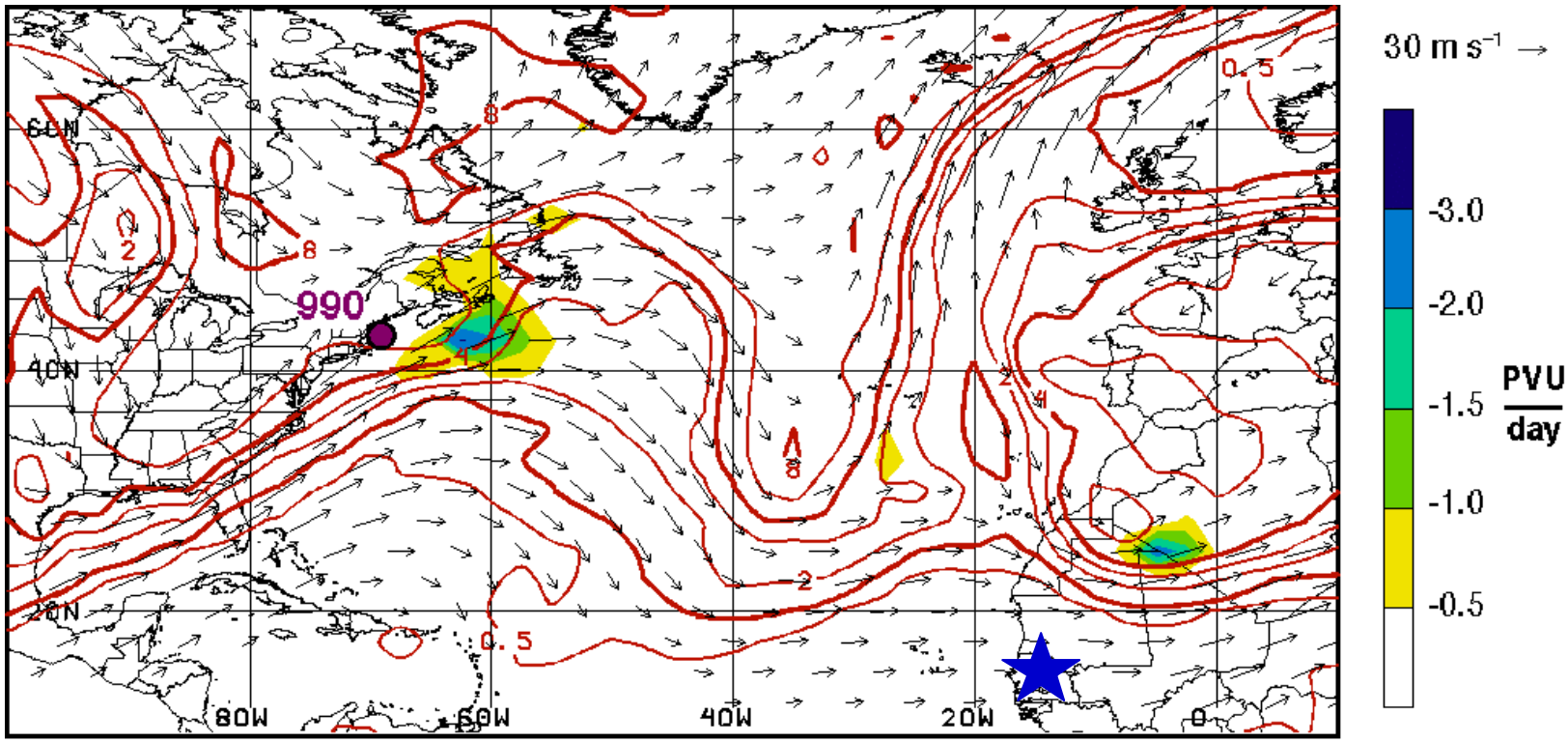
Upstream features of the precipitation event

- rapid cyclogenesis over the North Atlantic
- amplification of the upperlevel ridge
- development of a downstream trough penetrating to the West African coast

What is the role of latent heating for this process?

1 PVU=10^{-6} Km^2 / kg s

PV, diabatic PV tendencies & wind at 335 K

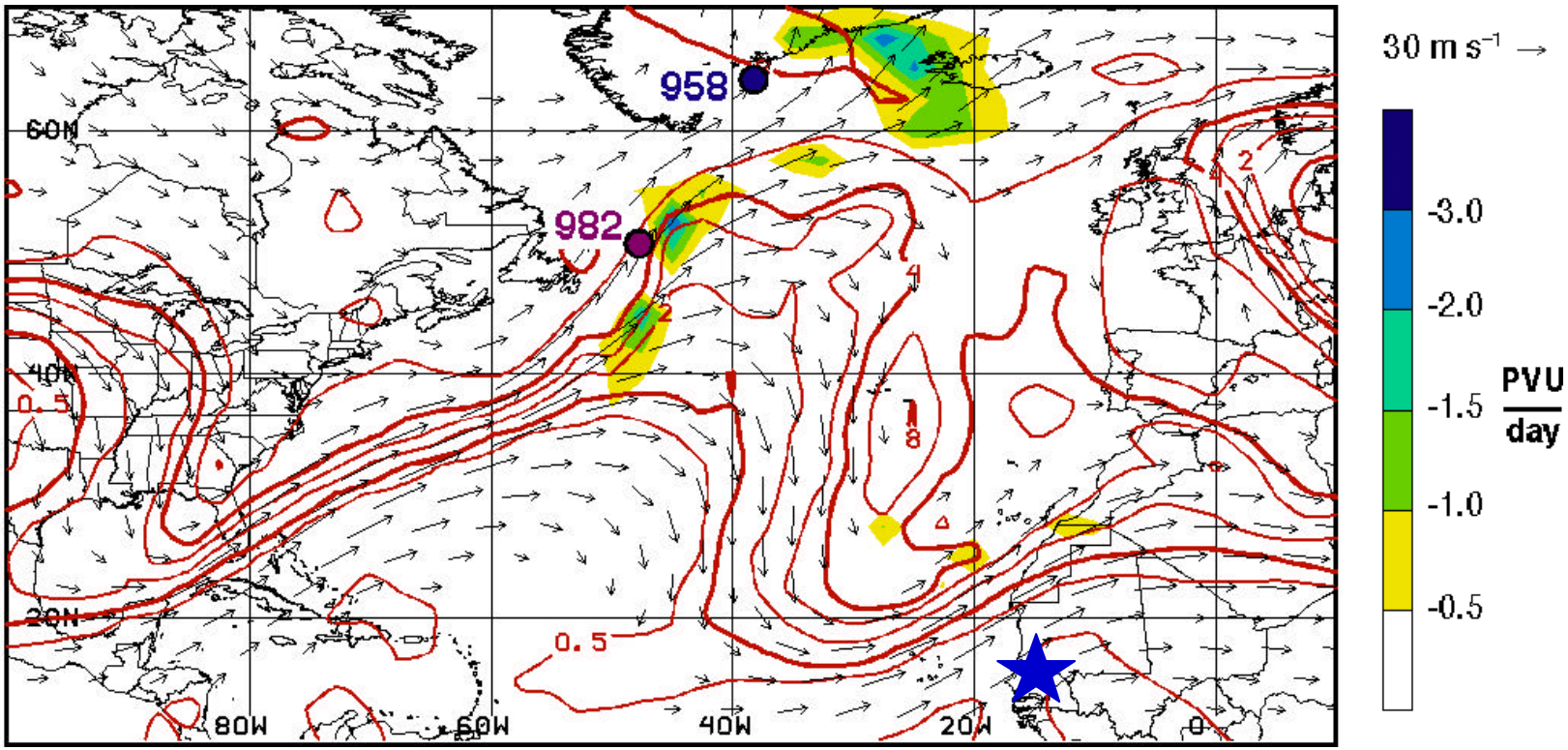


12 UTC, January 07, 2002

from Knippertz and Martin

1 PVU=10^{-6} Km^2 / kg s

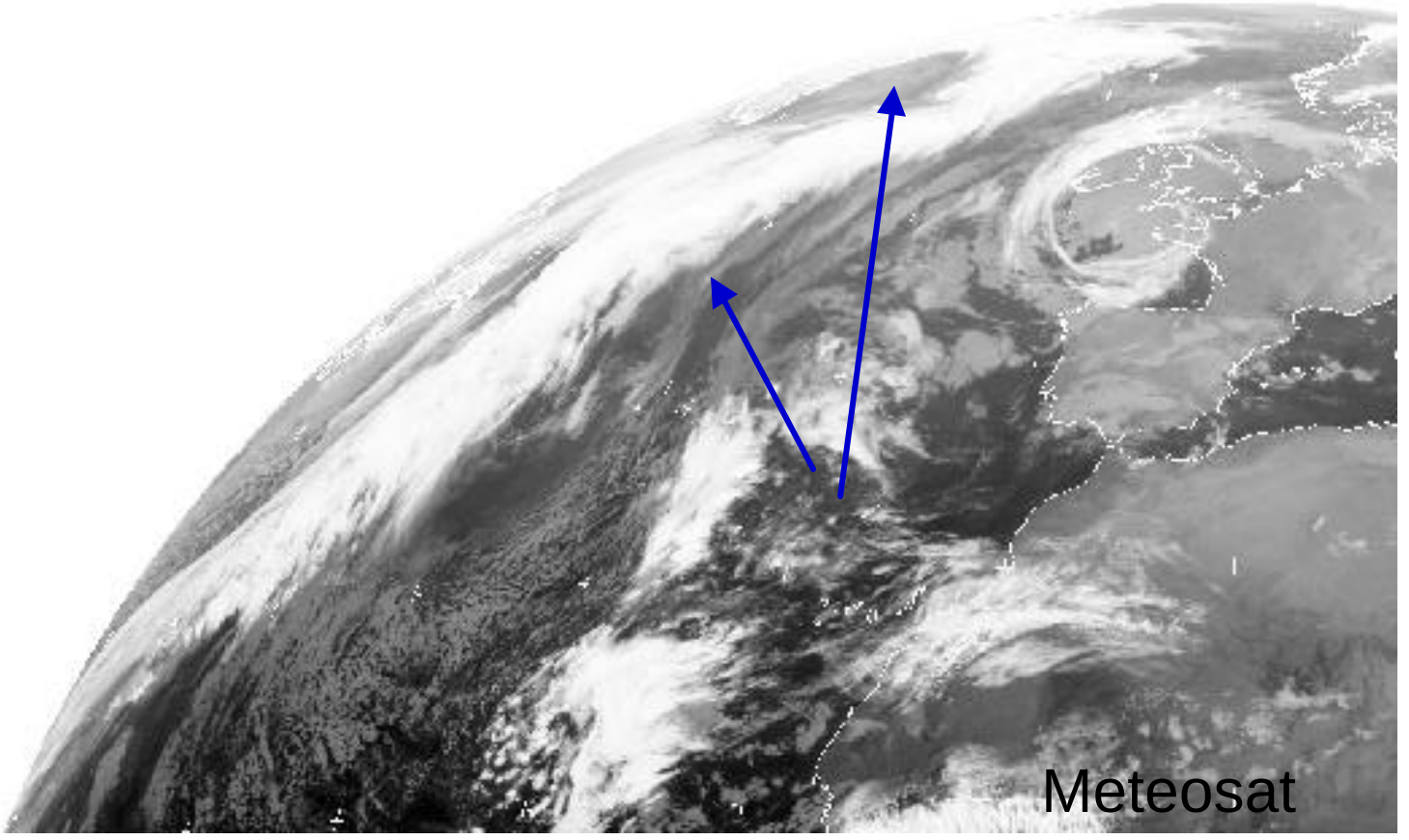
PV, diabatic PV tendencies & wind at 335 K



00 UTC, January 09, 2002

from Knippertz and Martin

2002-01-09 00 UTC

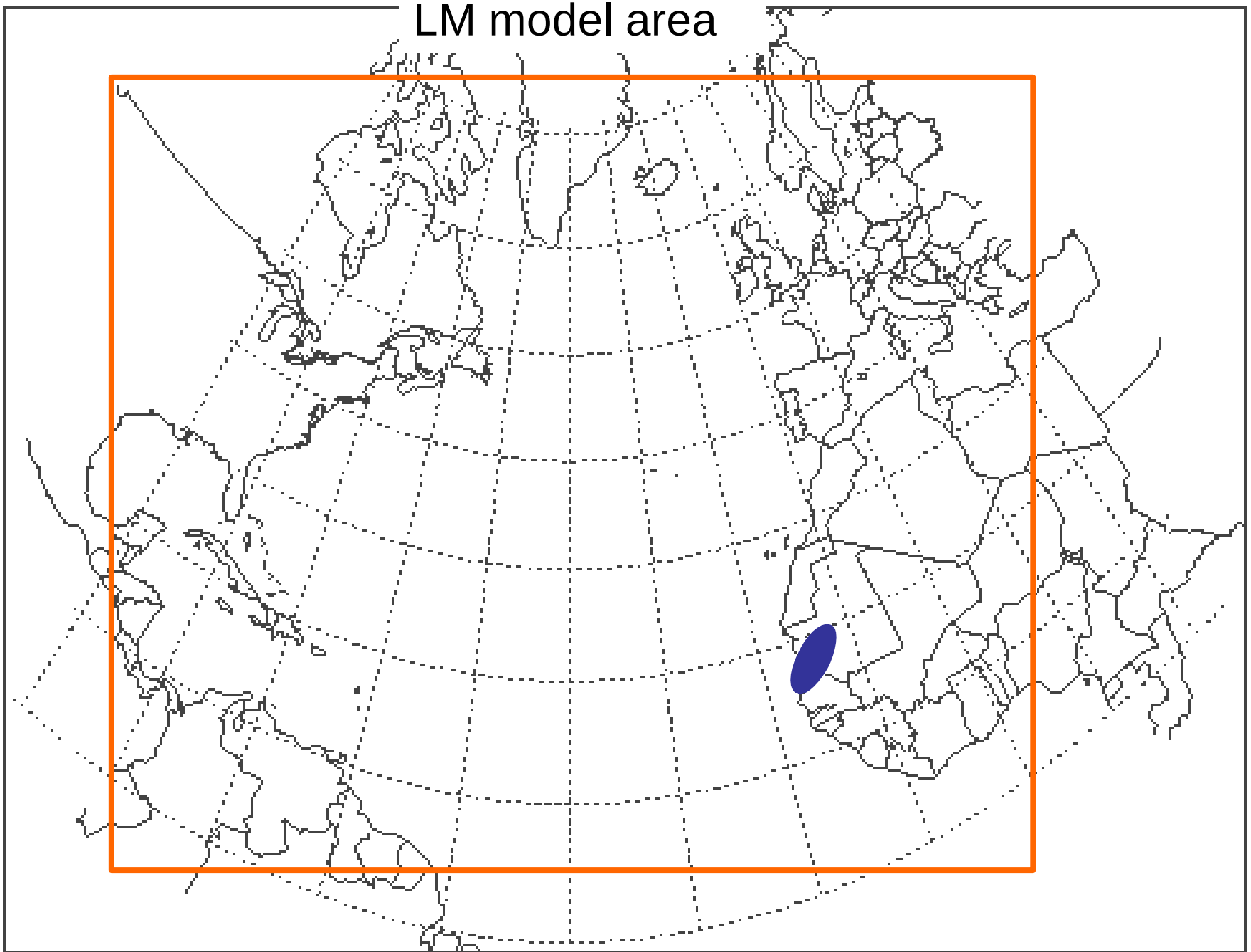


- Sensivity experiments concerning the role of latent heating for the wave amplification with LM

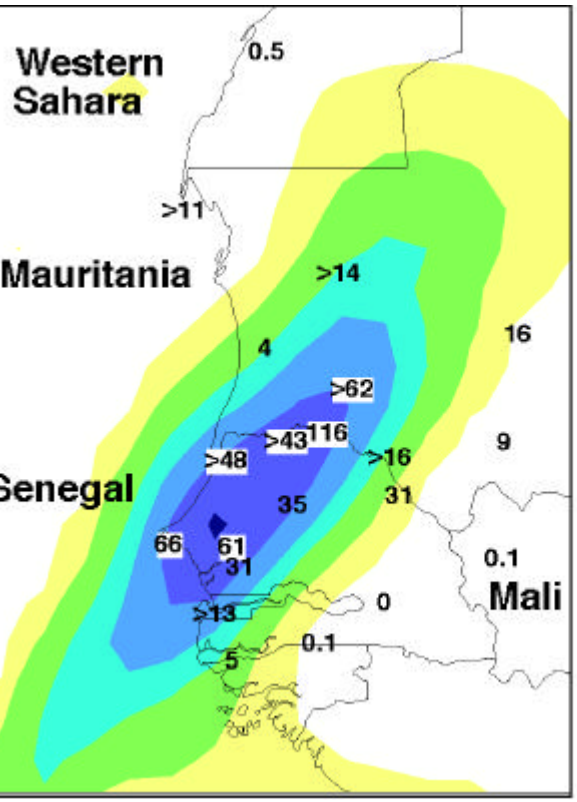
- First: realistic simulation of the precipitation event with LM needed

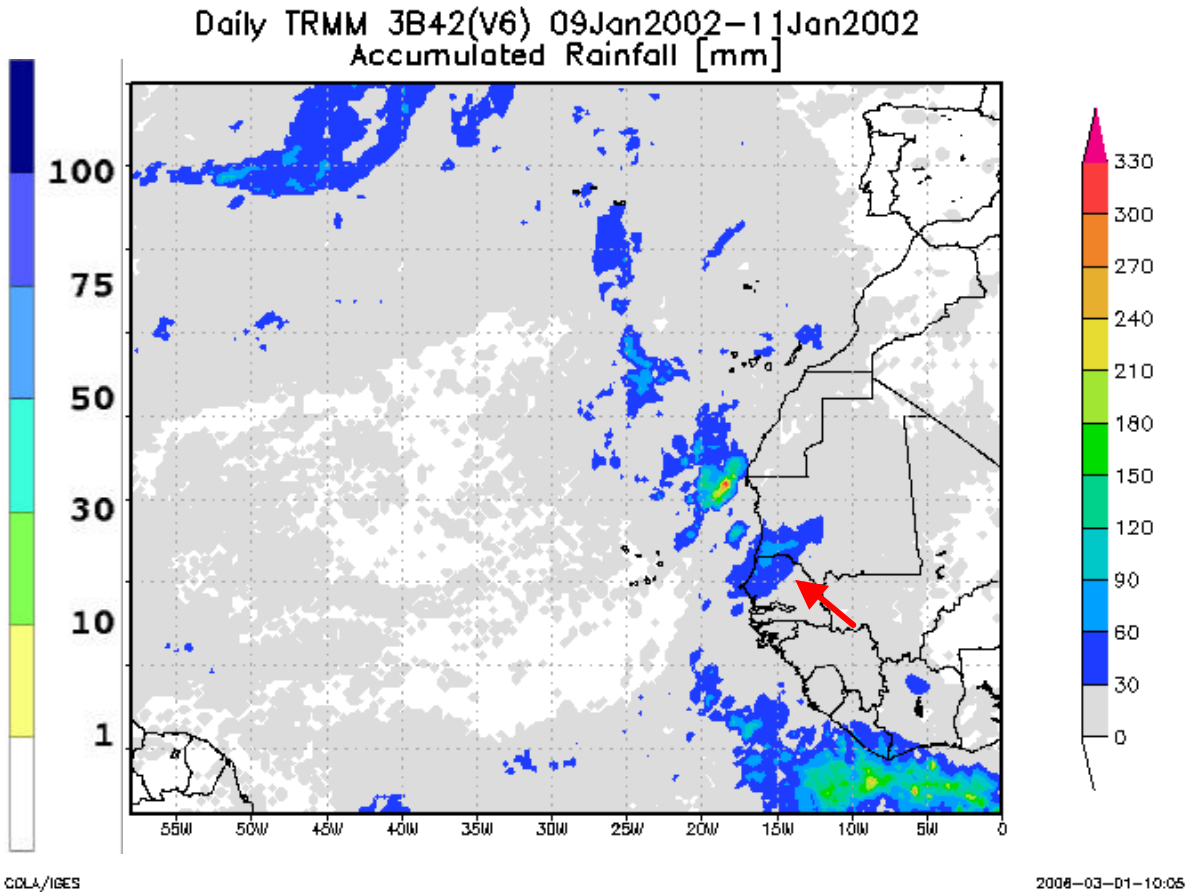
LM configuration

- resolution: 0.4° x 0.4° ; 40 vertical layers
- rotated north pole at 45° N, 140° E
- GME or ECMWF boundary values (6 hourly)
- timestep 60s ; convection scheme: 6 min
- Tiedtke scheme or Kain-Fritsch scheme
- cloud-ice scheme or graupel scheme
- start at 00 UTC 2 January 2002
- Linux cluster at University of Mainz


LM model area

Observations of precipitation





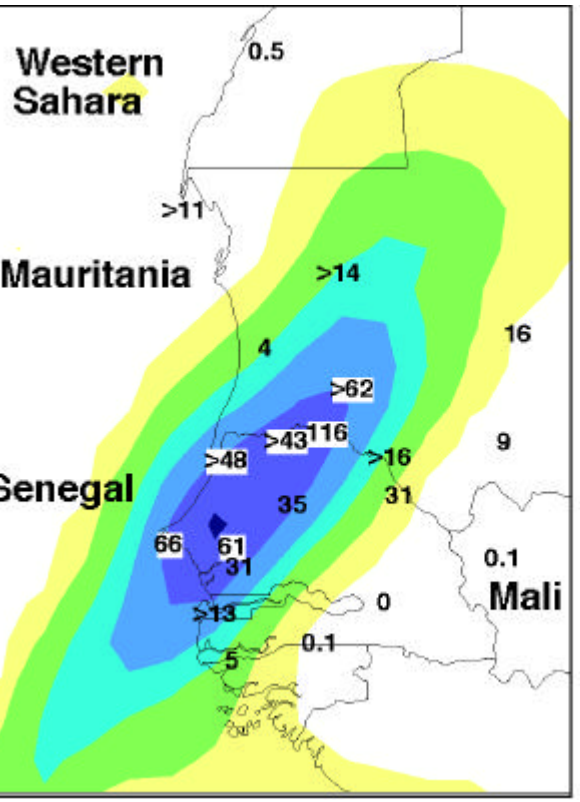
UW-NMS

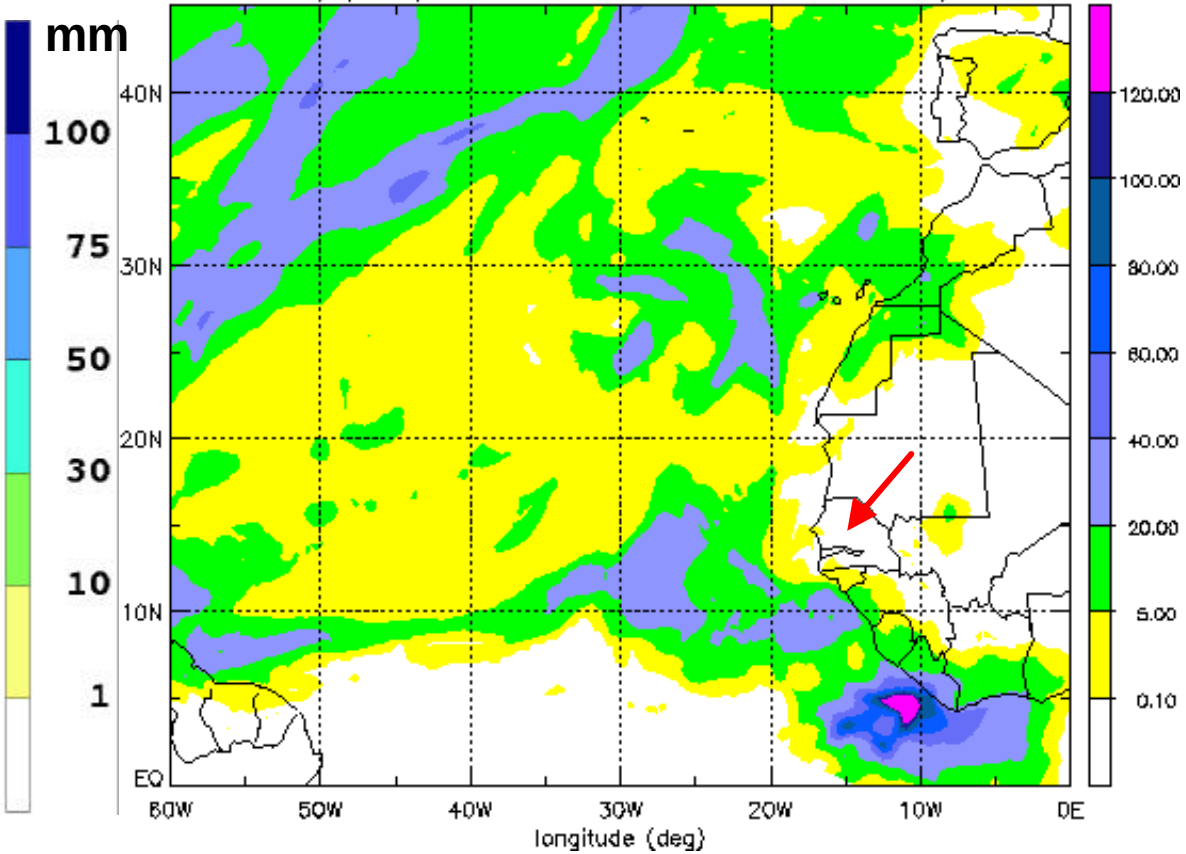
derived precipitation from TRMM satellite

from Knippertz and Martin 2005

LM simulation of the accumulated precipitation

from 9 to 11 January





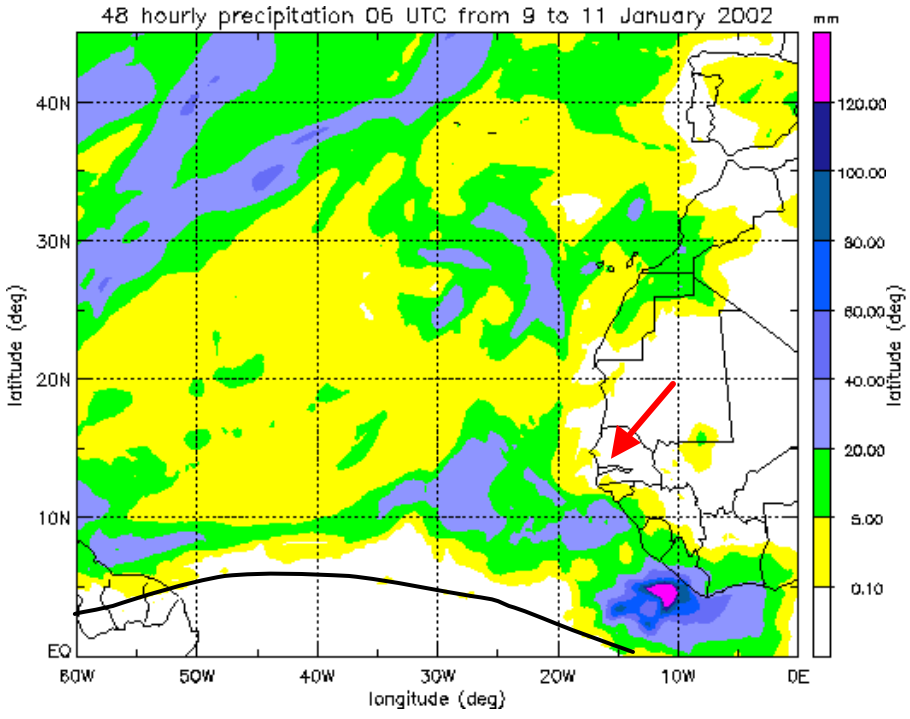
UW-NMS

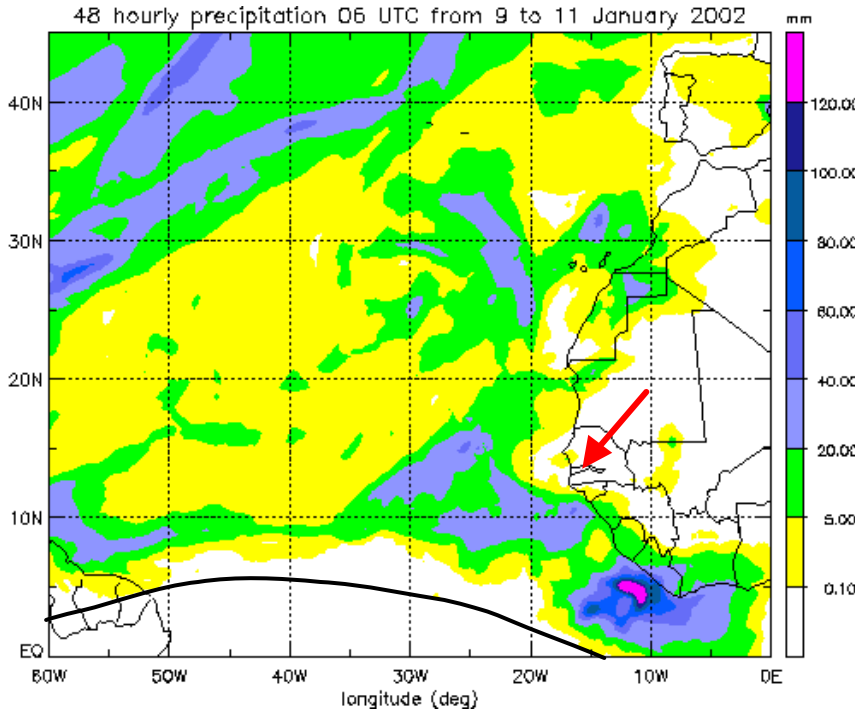
from Knippertz and Martin 2005

LM-simulation: start 2 January 2002 00 UTC

GME boundary data, cloud ice scheme,

Tiedtke convection scheme, timestep 60 s



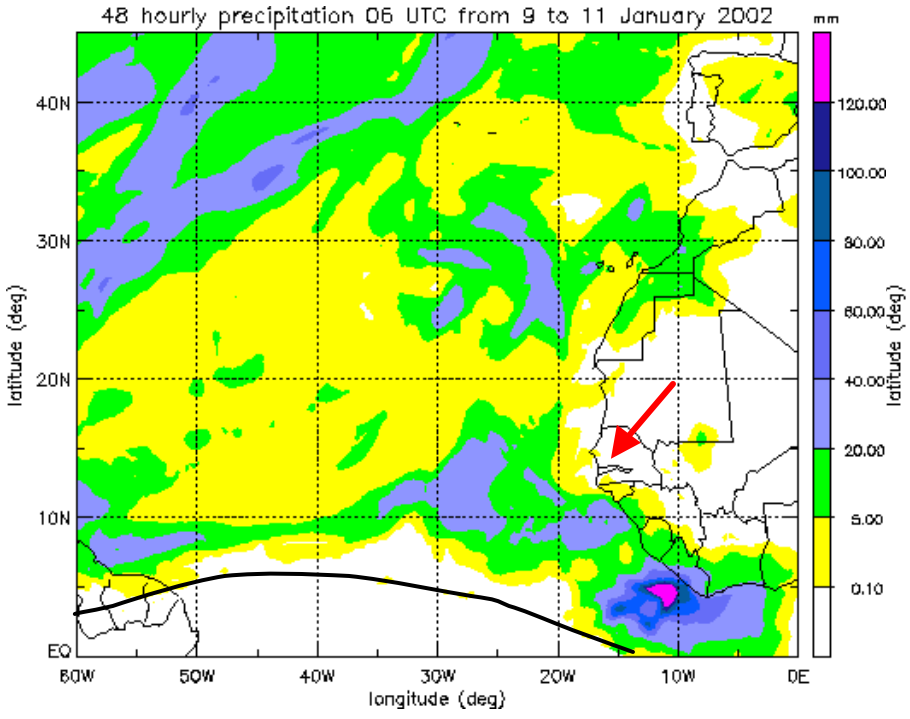


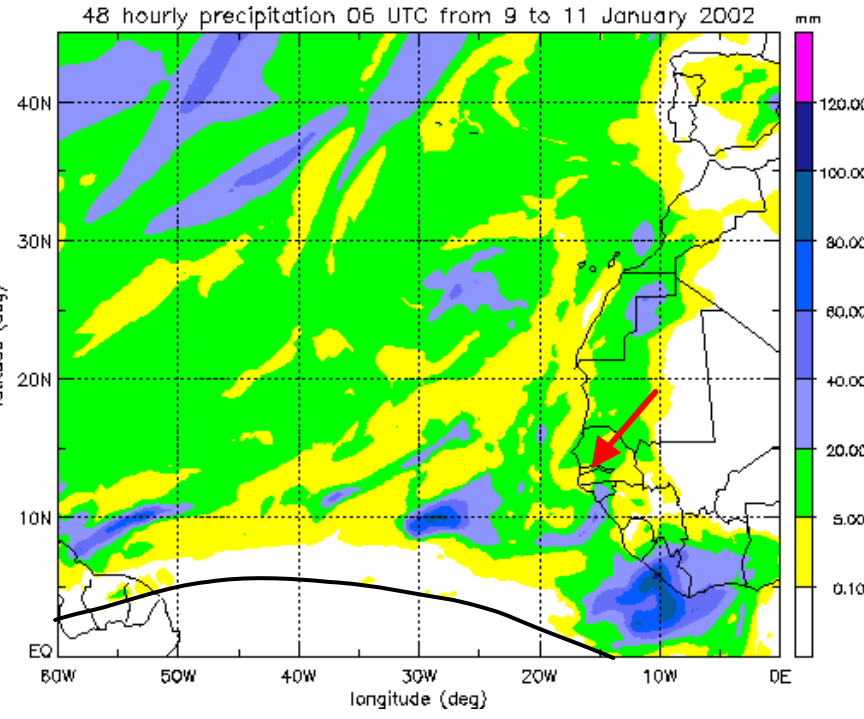
LM-simulation: start 2 January 2002 00 UTC

GME boundary data, cloud ice scheme,

Tiedtke convection scheme, timestep 60 s

graupel scheme





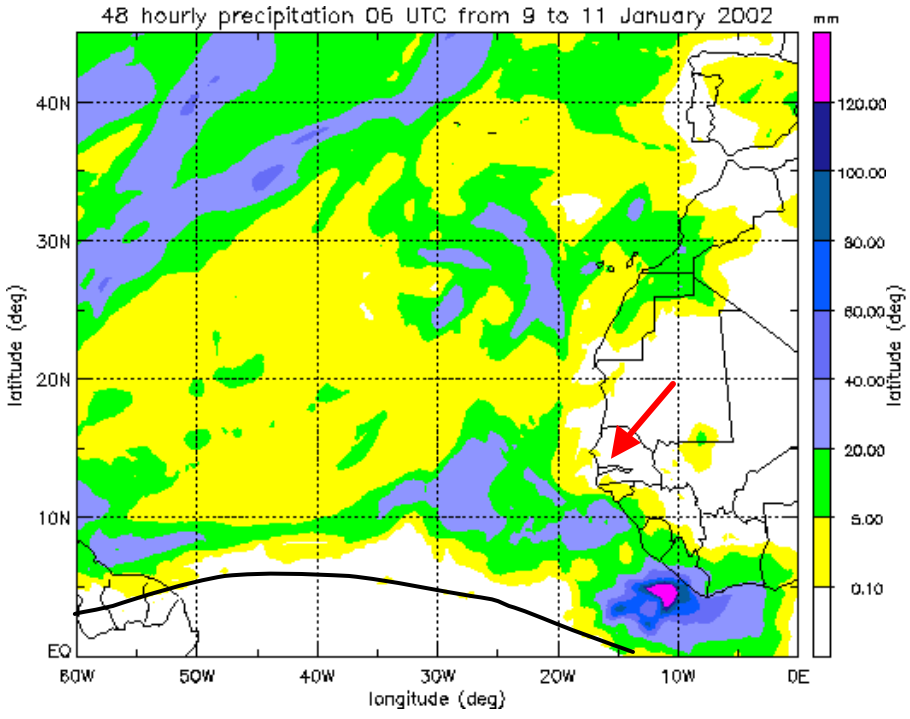
LM-simulation: start 2 January 2002 00 UTC

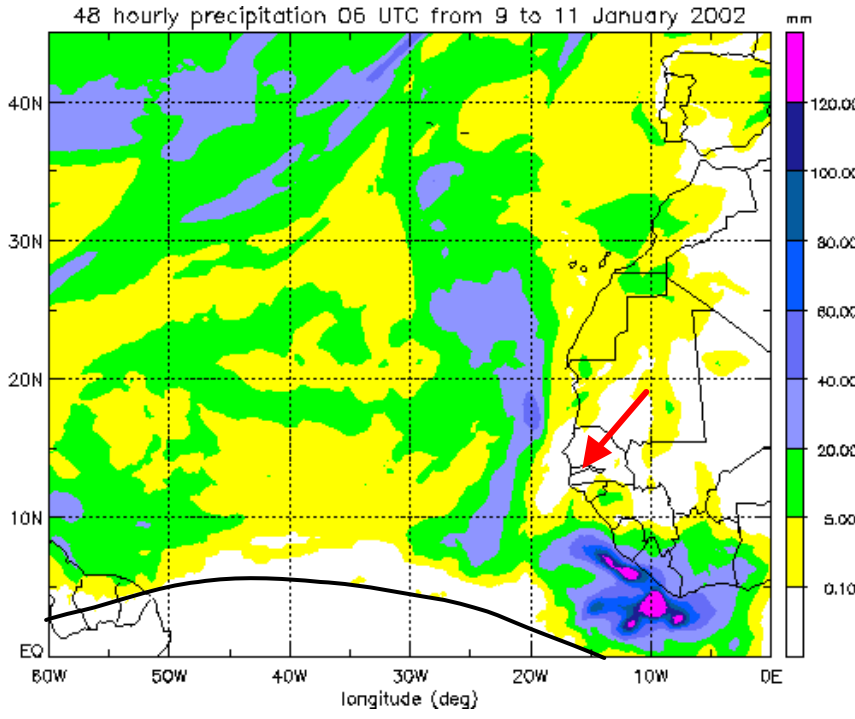
GME boundary data, cloud ice scheme,

Tiedtke convection scheme, timestep 60 s

Kain-Fritsch

convection scheme



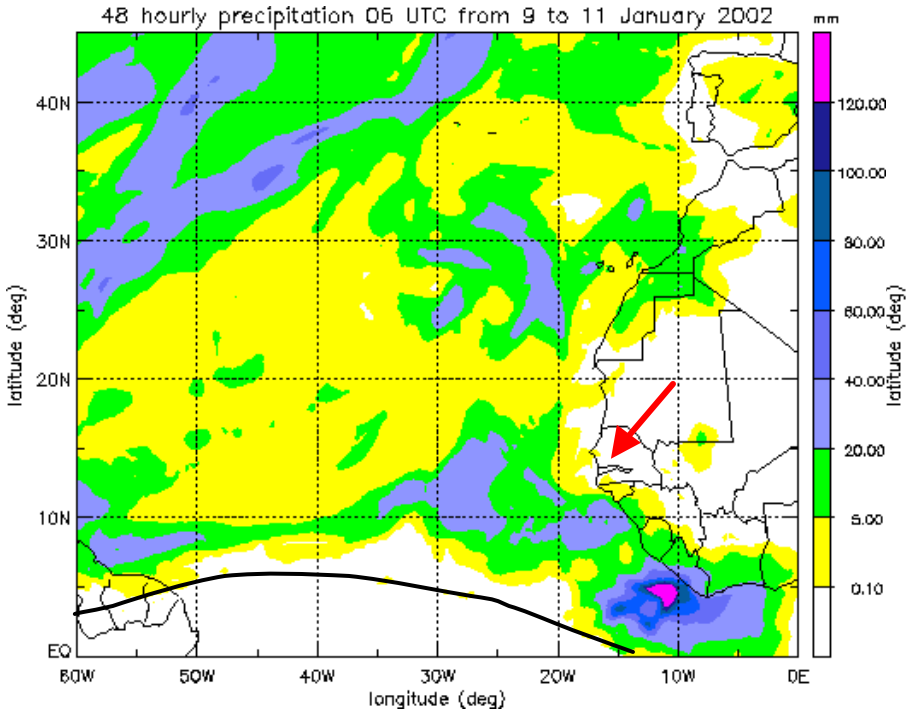


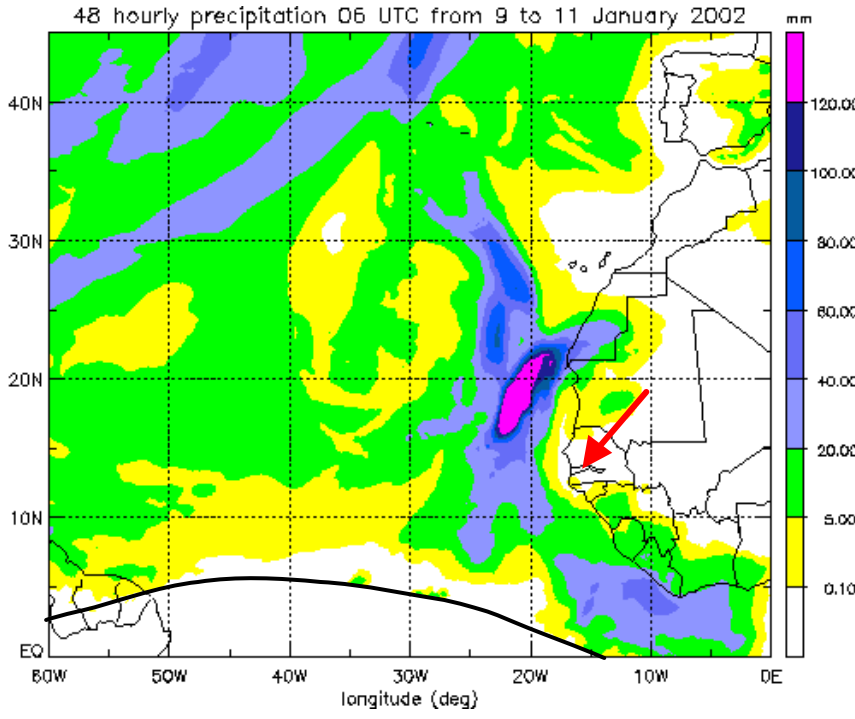
LM-simulation: start 2 January 2002 00 UTC

GME boundary data, cloud ice scheme,

Tiedtke convection scheme, timestep 60 s

started at 8 January 2002 00 UTC



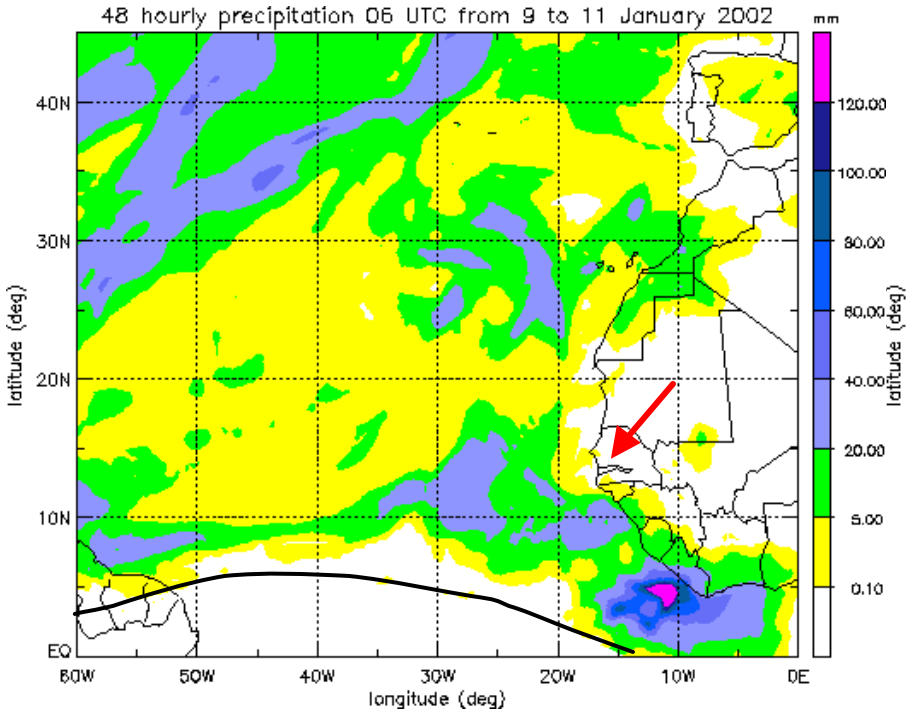


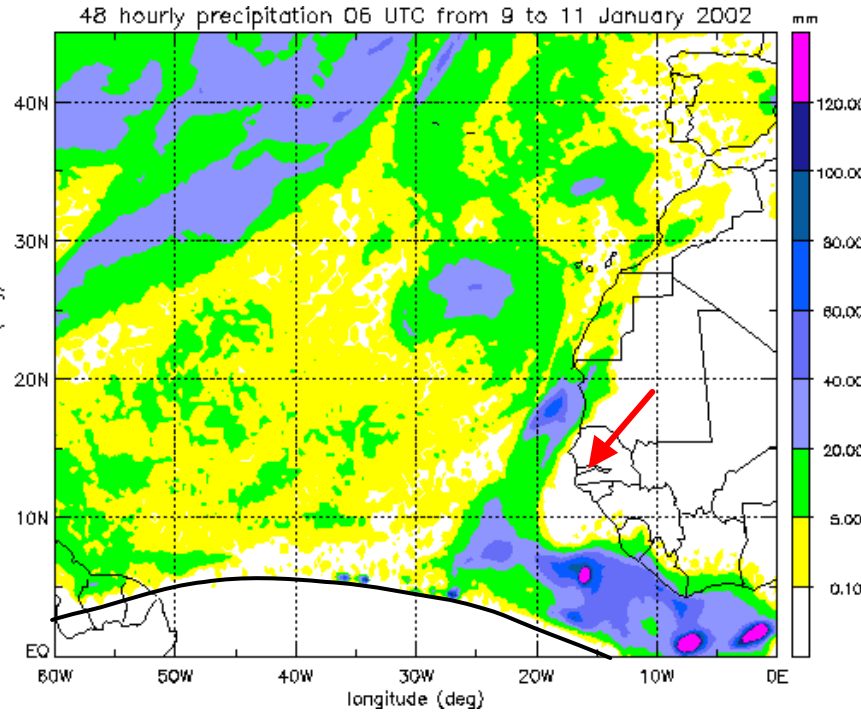
LM-simulation: start 2 January 2002 00 UTC

GME boundary data, cloud ice scheme,

Tiedtke convection scheme, timestep 60 s

timestep 15s



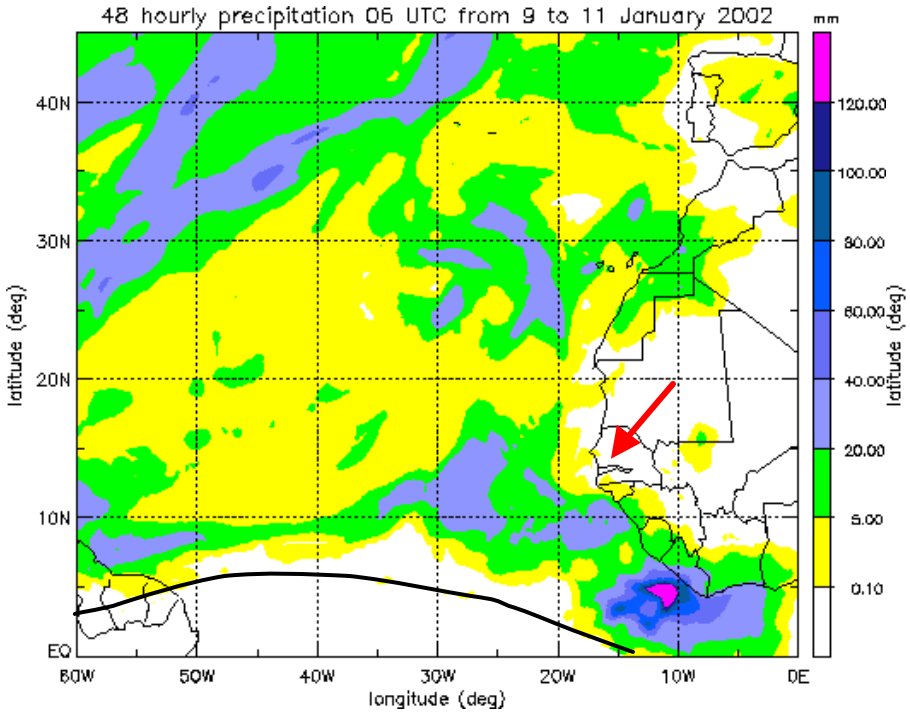


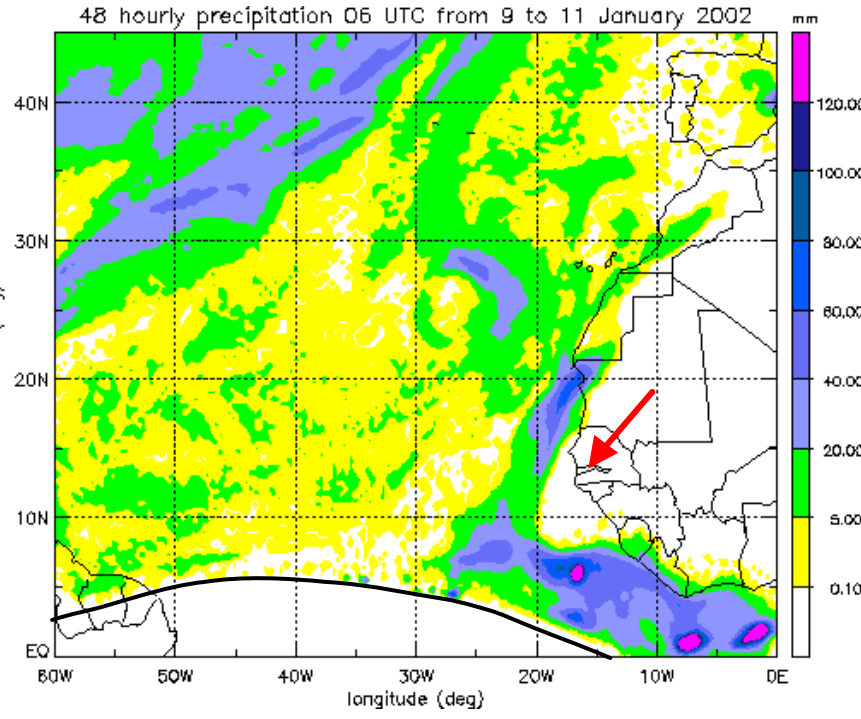
LM-simulation: start 2 January 2002 00 UTC

GME boundary data, cloud ice scheme,

Tiedtke convection scheme, timestep 60 s

ECMWF boundary and initial data



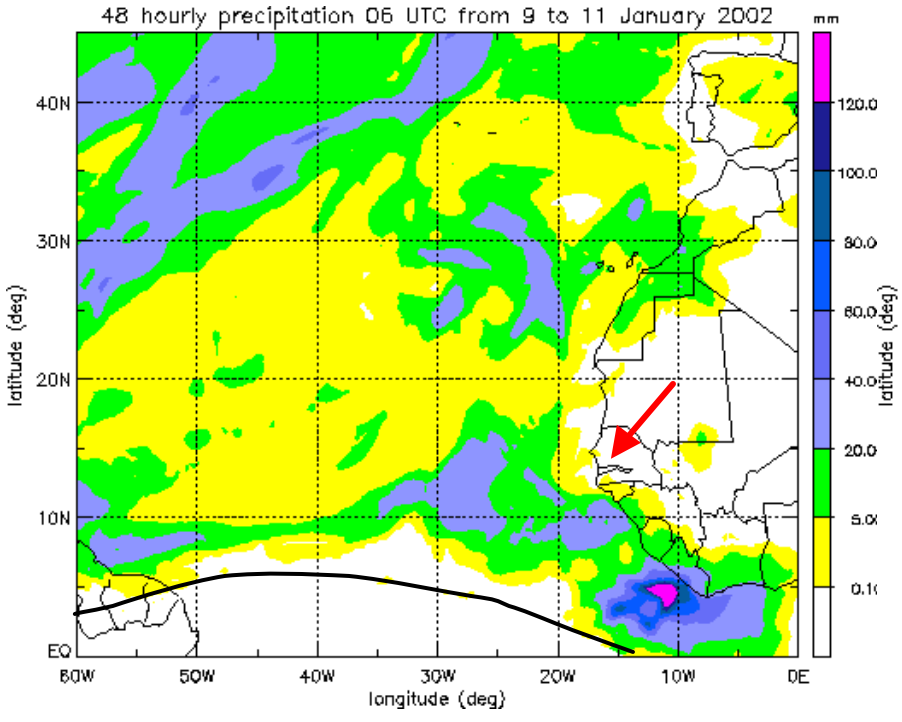


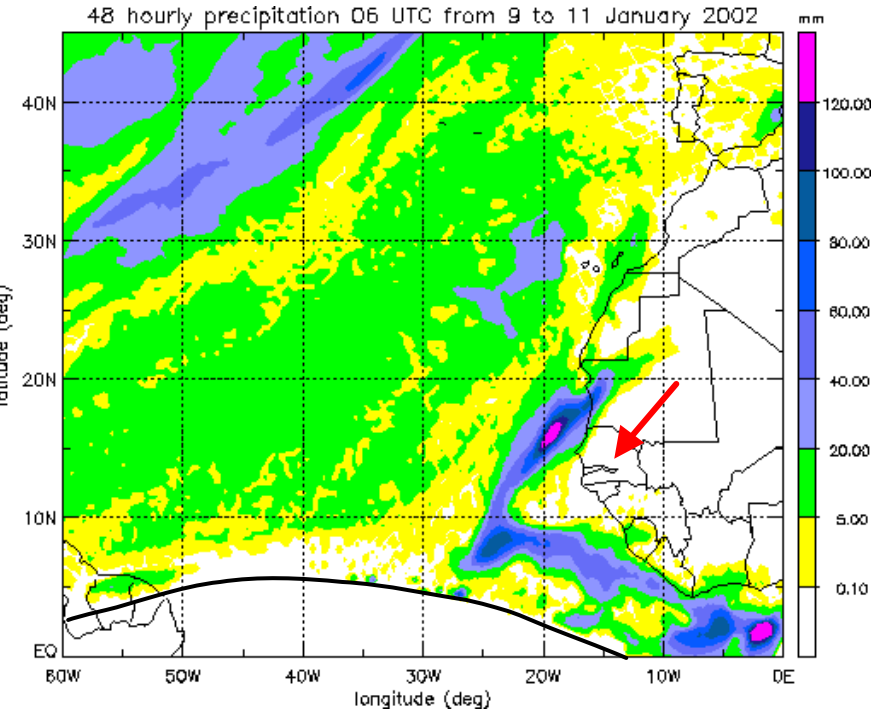
LM-simulation: start 2 January 2002 00 UTC

GME boundary data, cloud ice scheme,

Tiedtke convection scheme, timestep 60 s

ECMWF boundary and initial data, graupel scheme





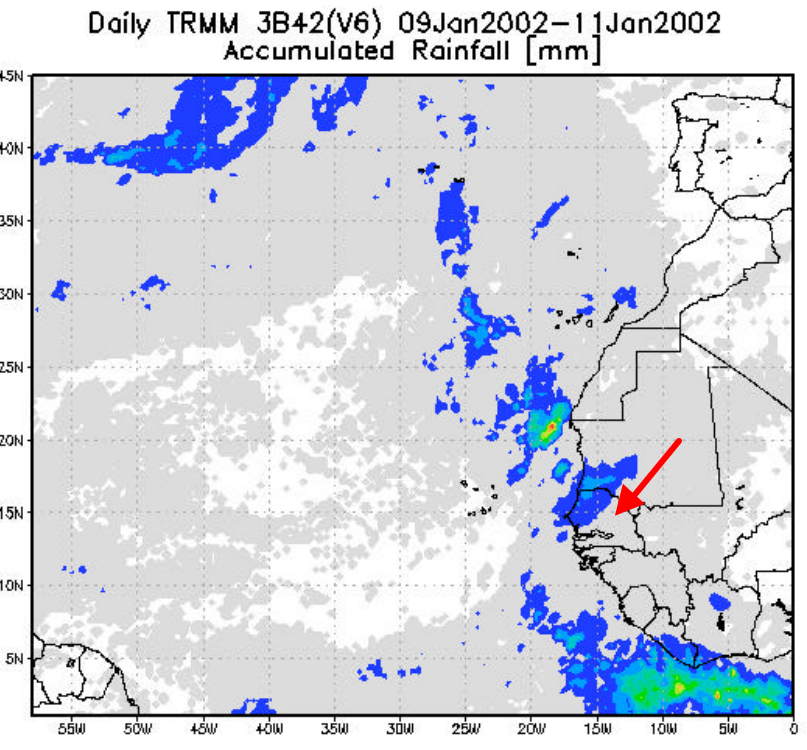
LM-simulation: start 2 January 2002 00 UTC

GME boundary data, cloud ice scheme,

Tiedtke convection scheme, timestep 60 s

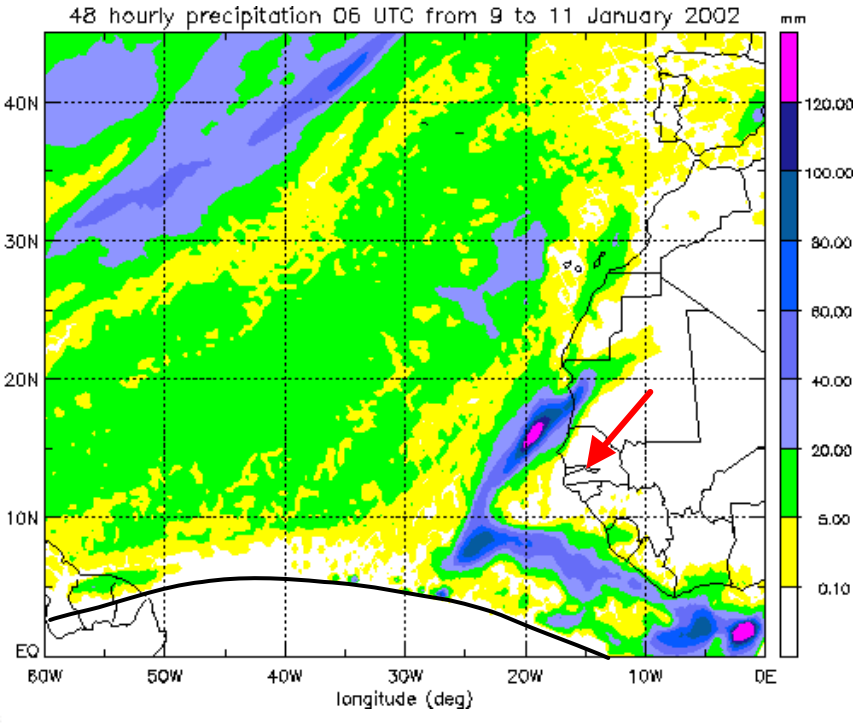
ECMWF boundary and initial data, graupel scheme

Kain-Fritsch convection scheme



TRMM satellite

LM simulation



- The simulation of the precipitation event is satisfactory
- still problems with the position of the precipitation area
- great influence of boundary data, timestep and used convection scheme on the simulation of precipitation

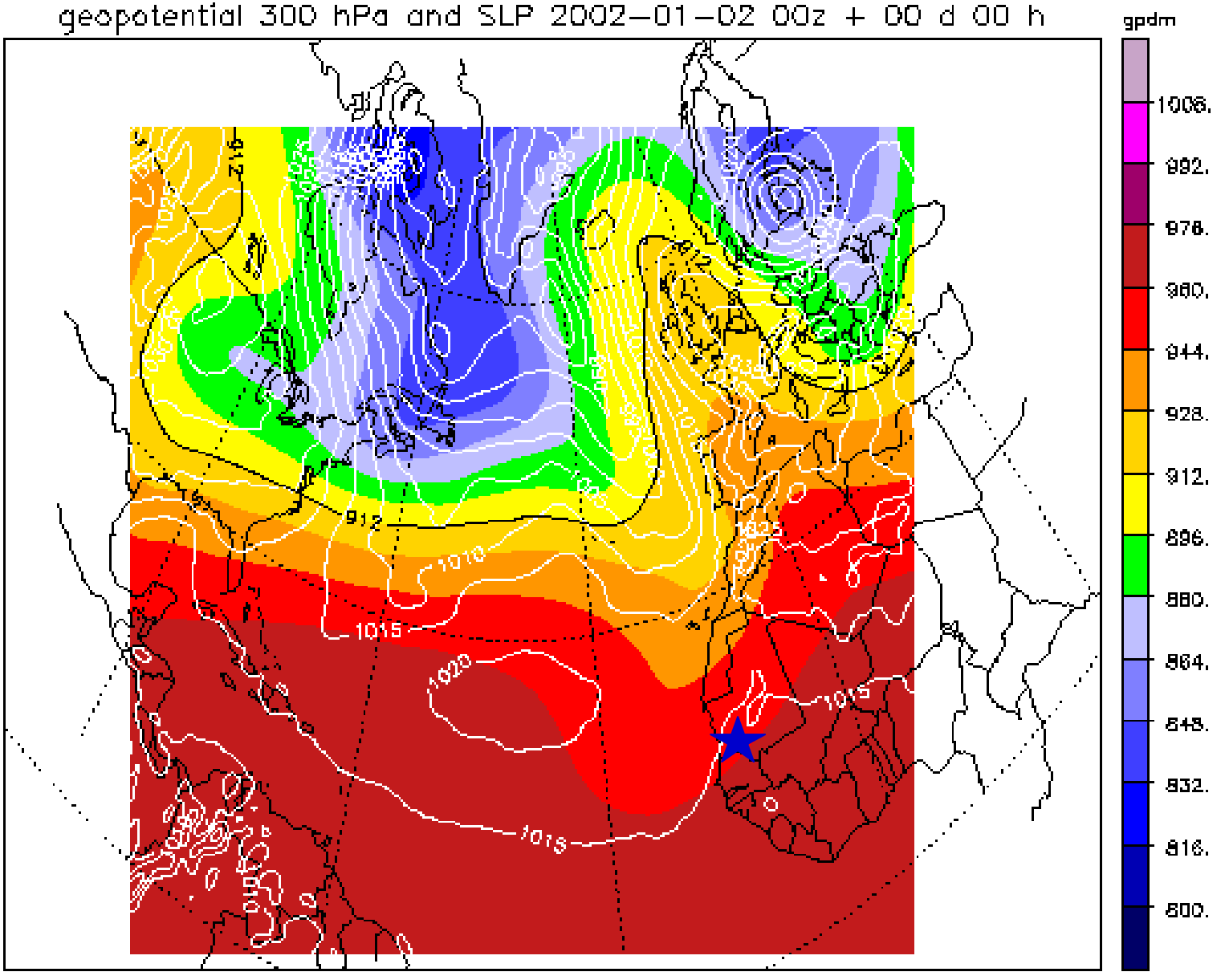
Further planned investigation

- Sensivity experiments with LM referring to latent heating
- Investigation of other heavy precipitation events over north-western Africa

  (March 2002, October 2003)

Thanks to

- Dr. Jörg Trentmann (University of Mainz)
- DWD data service for the GME boundary values
- Dr. E. Heise (DWD) for the external parameter files
- Dr. U. Schättler (DWD)
- Dr. M. Sprenger (ETH)
- my collegues at University of Mainz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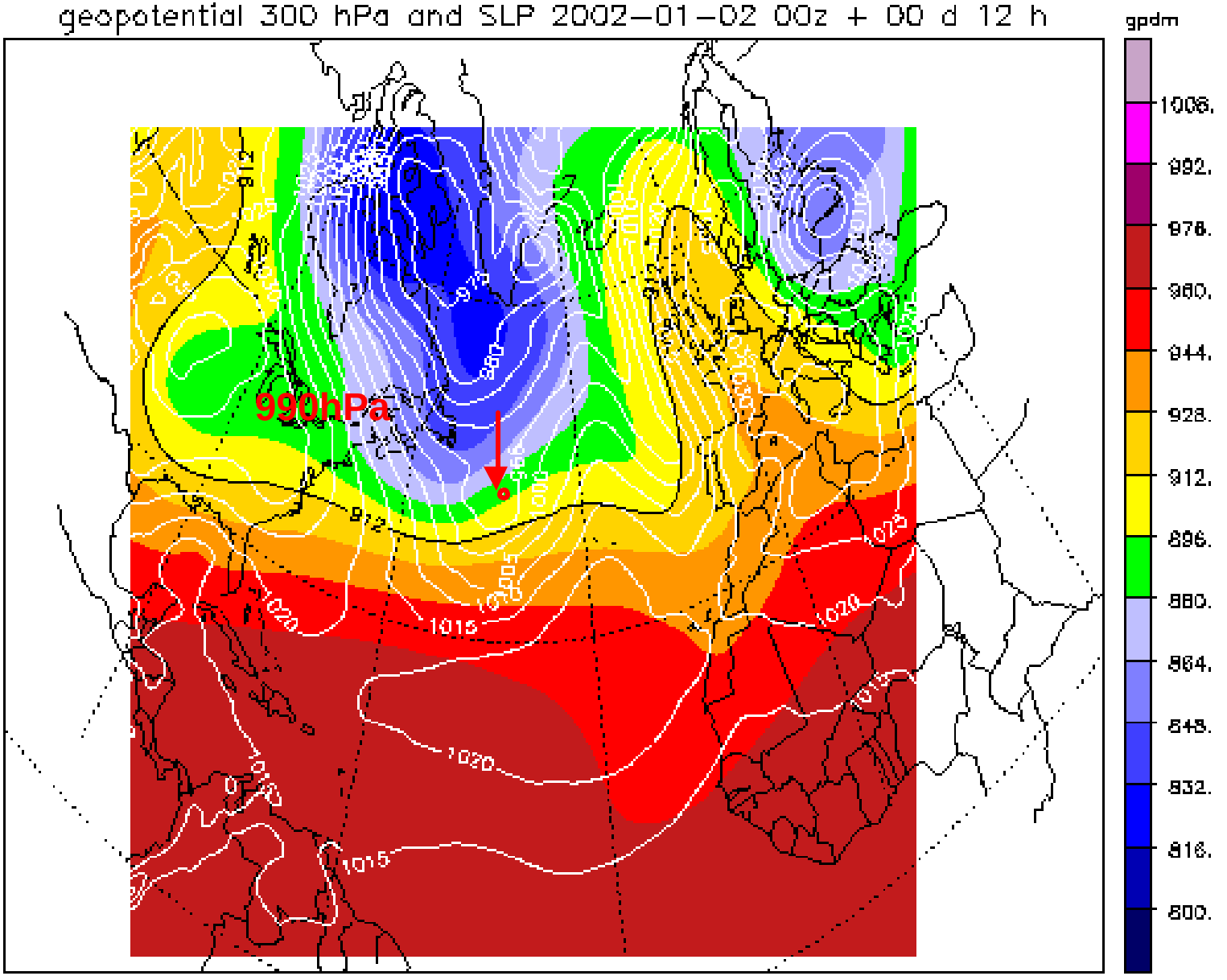
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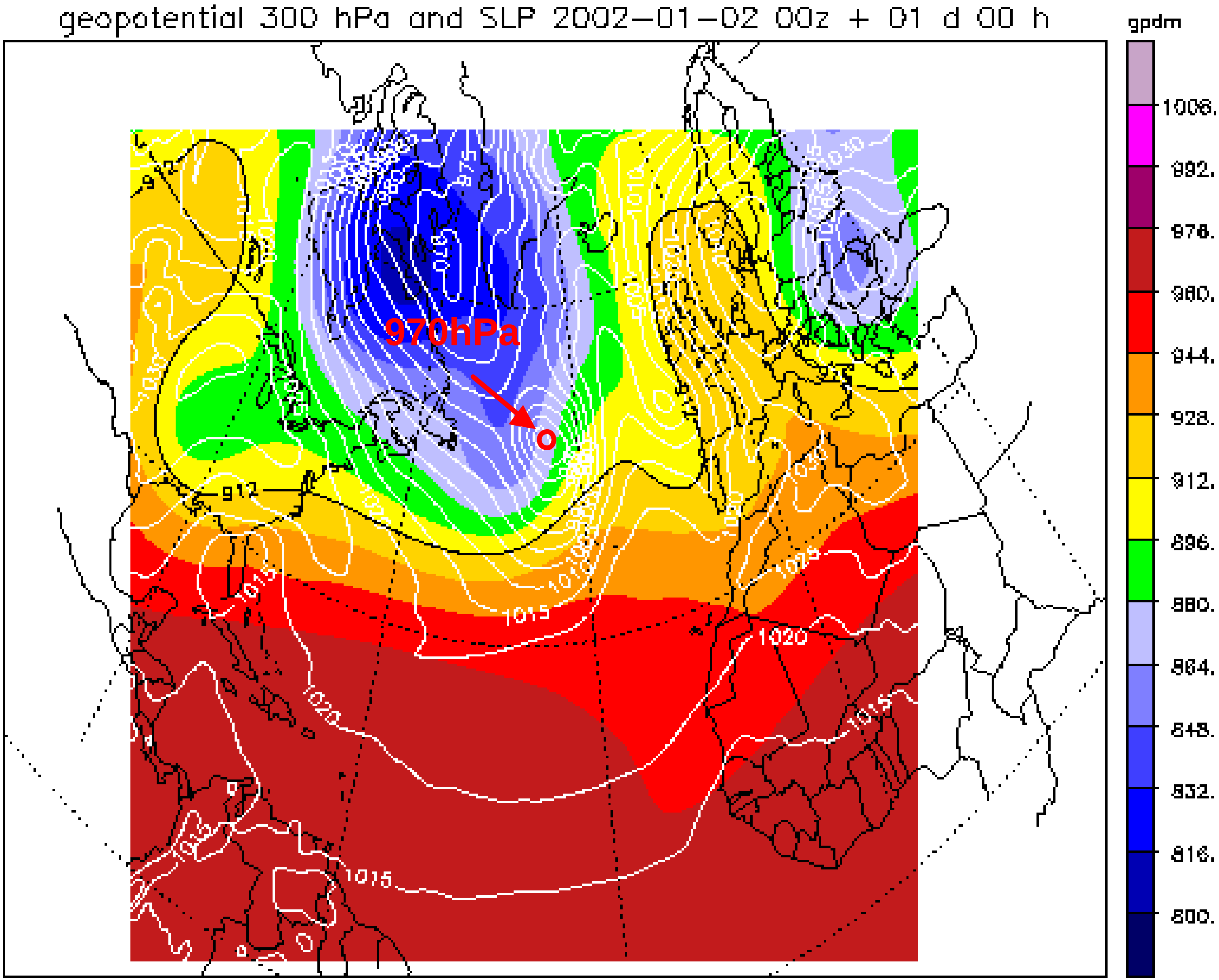

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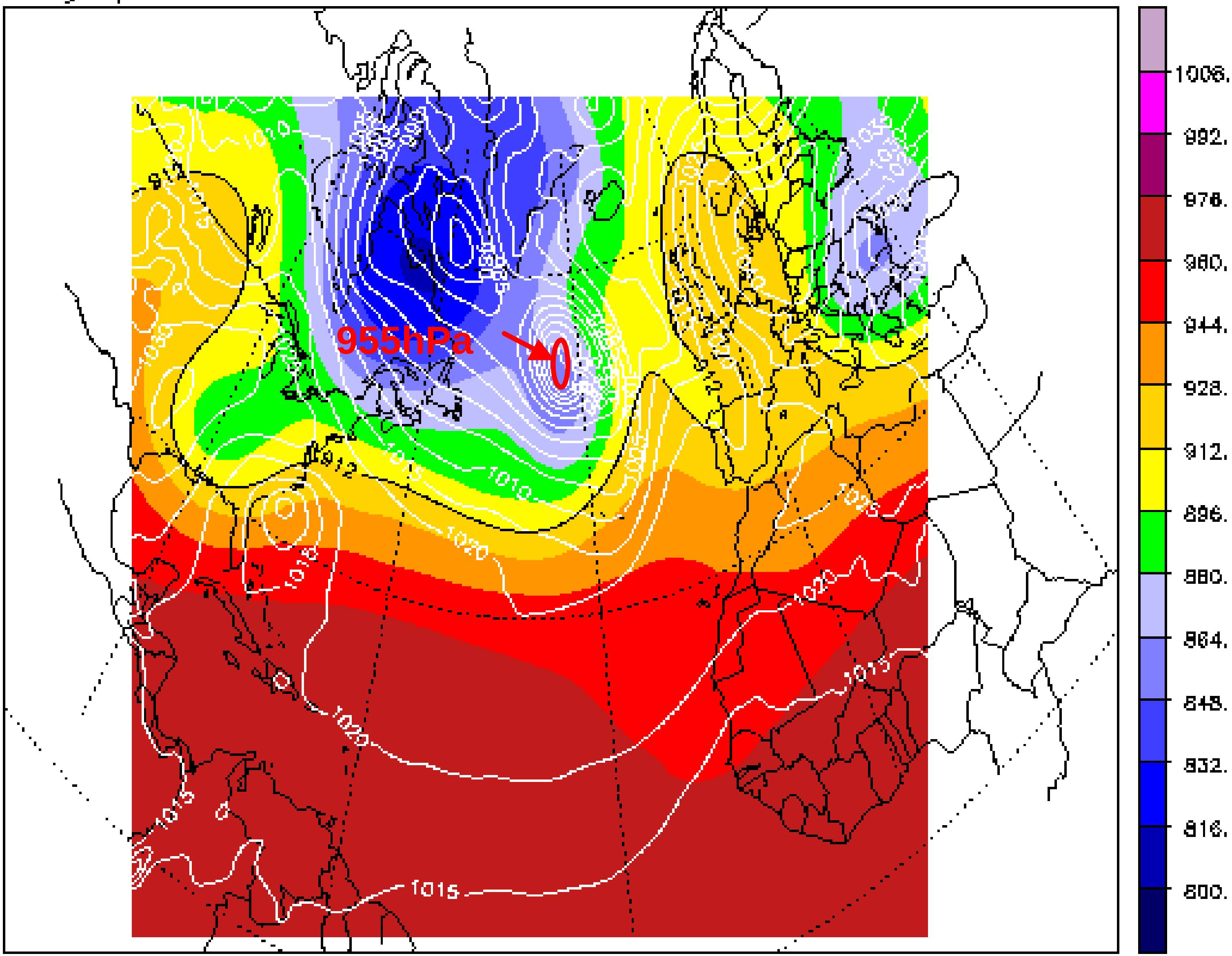

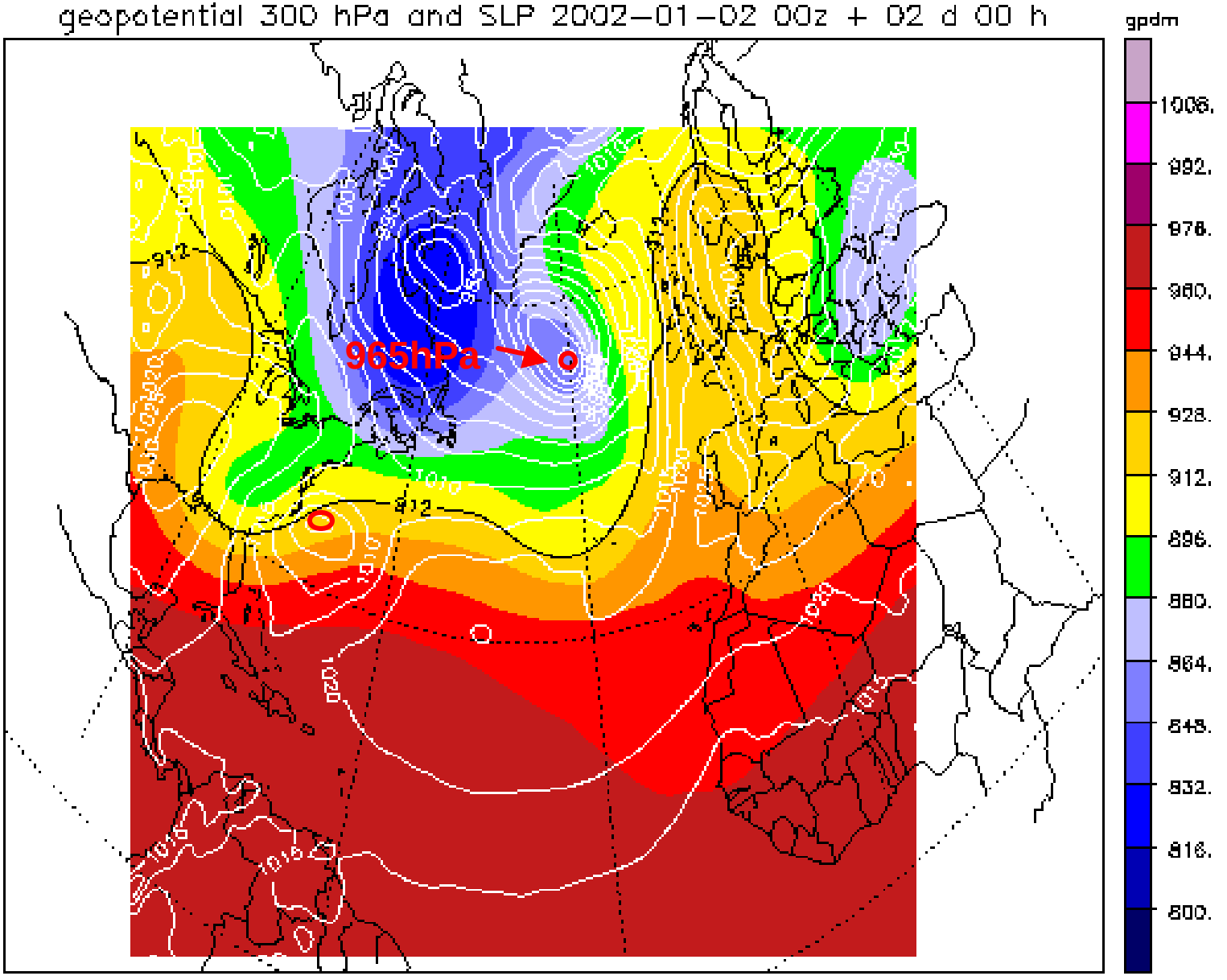
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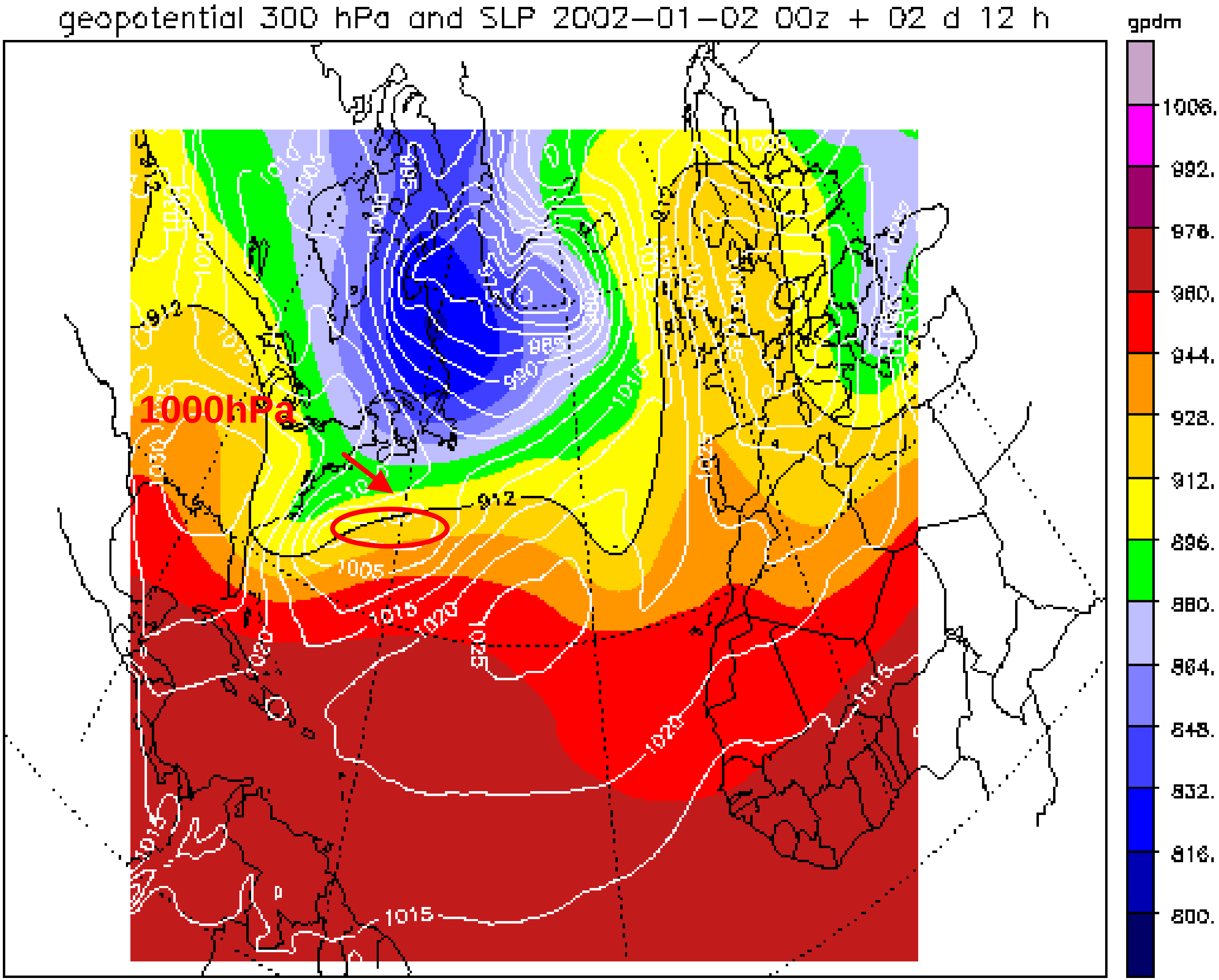
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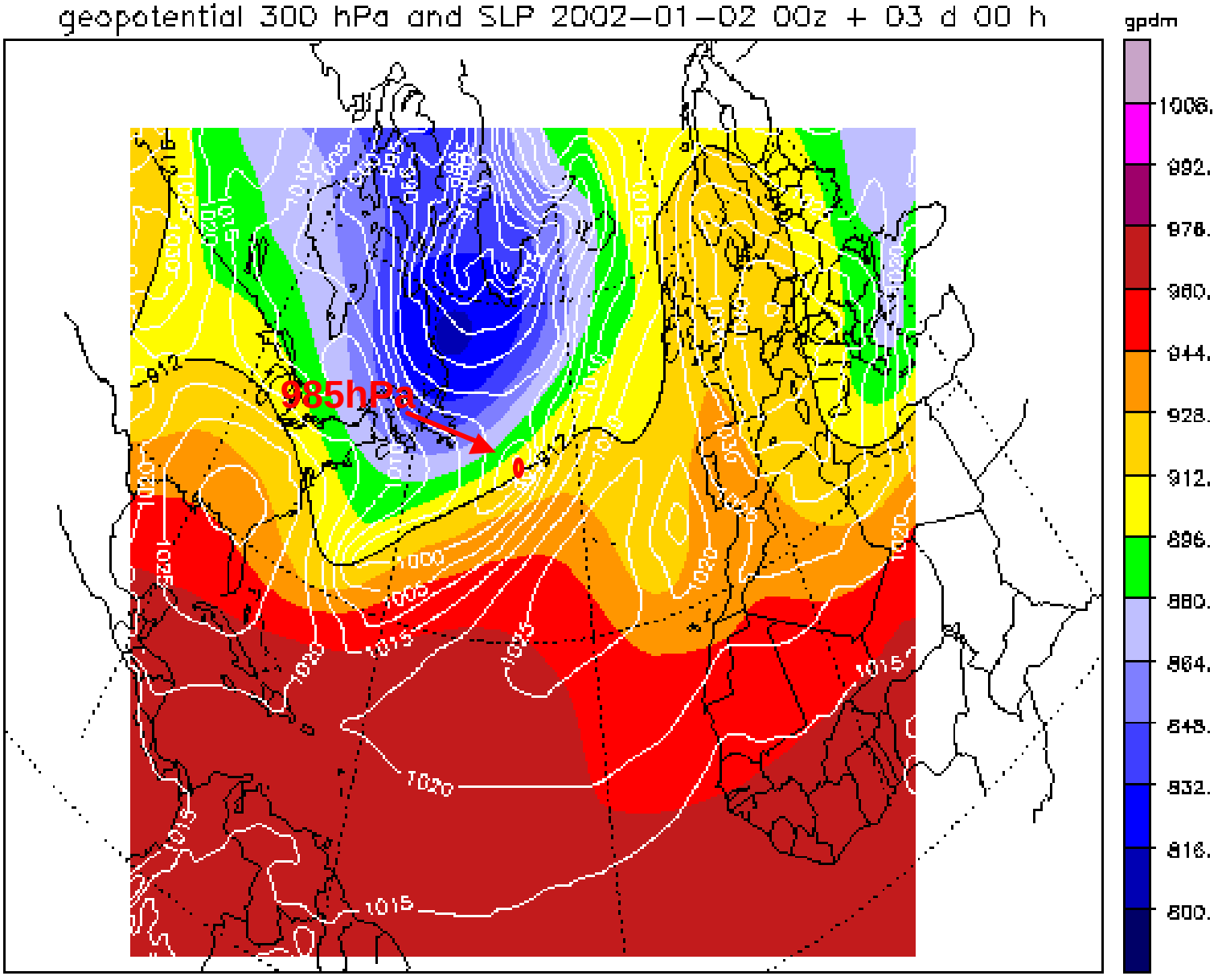
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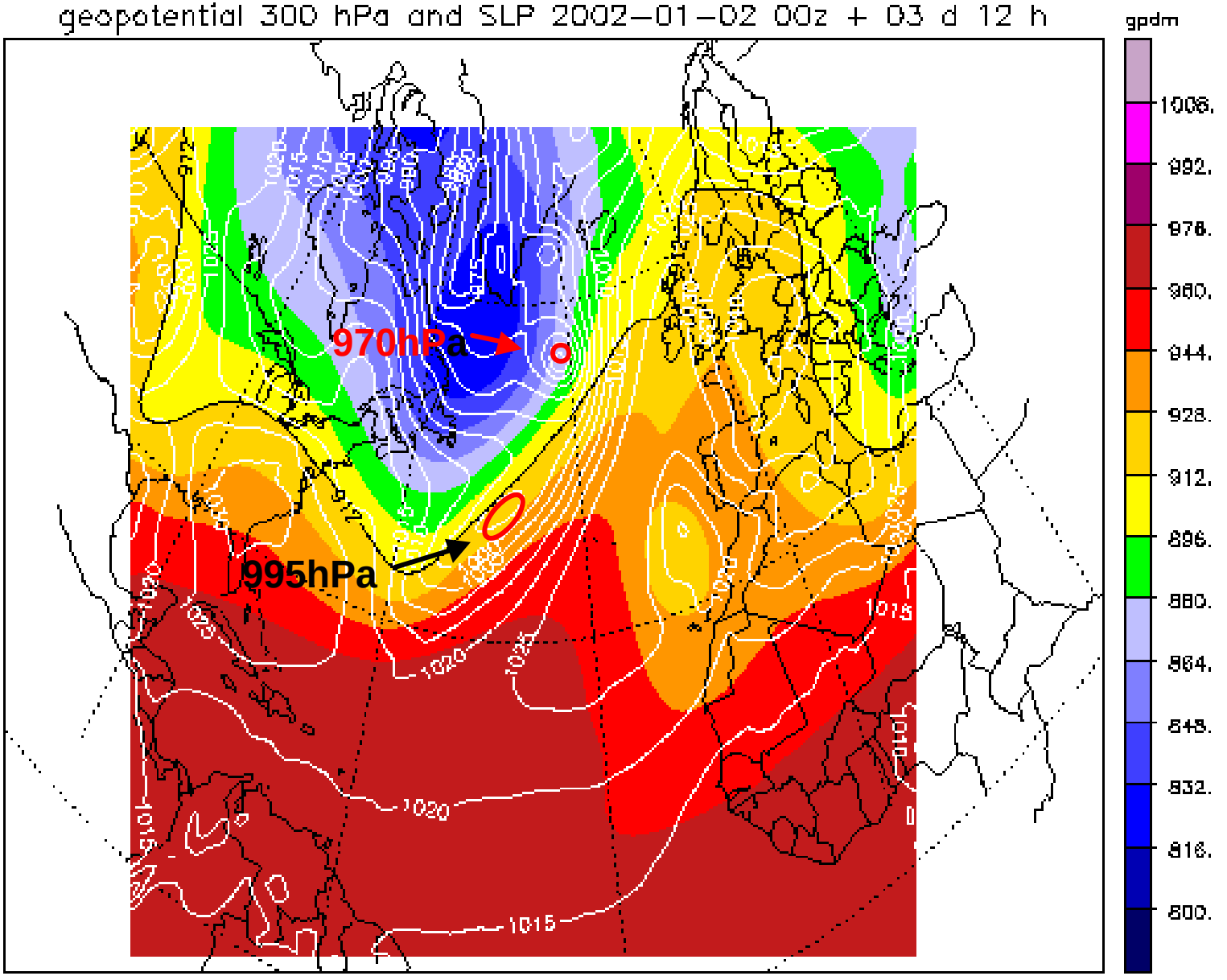
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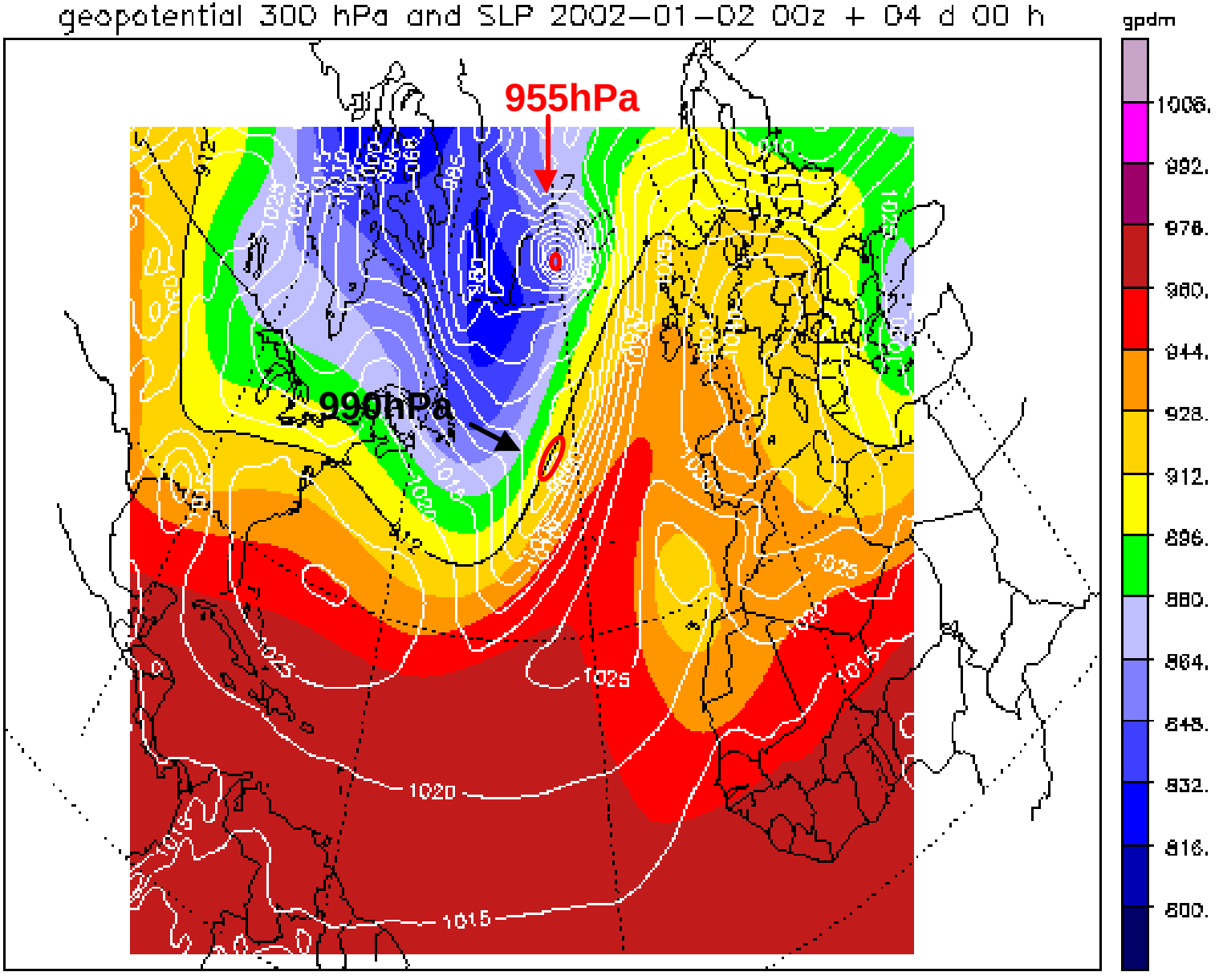
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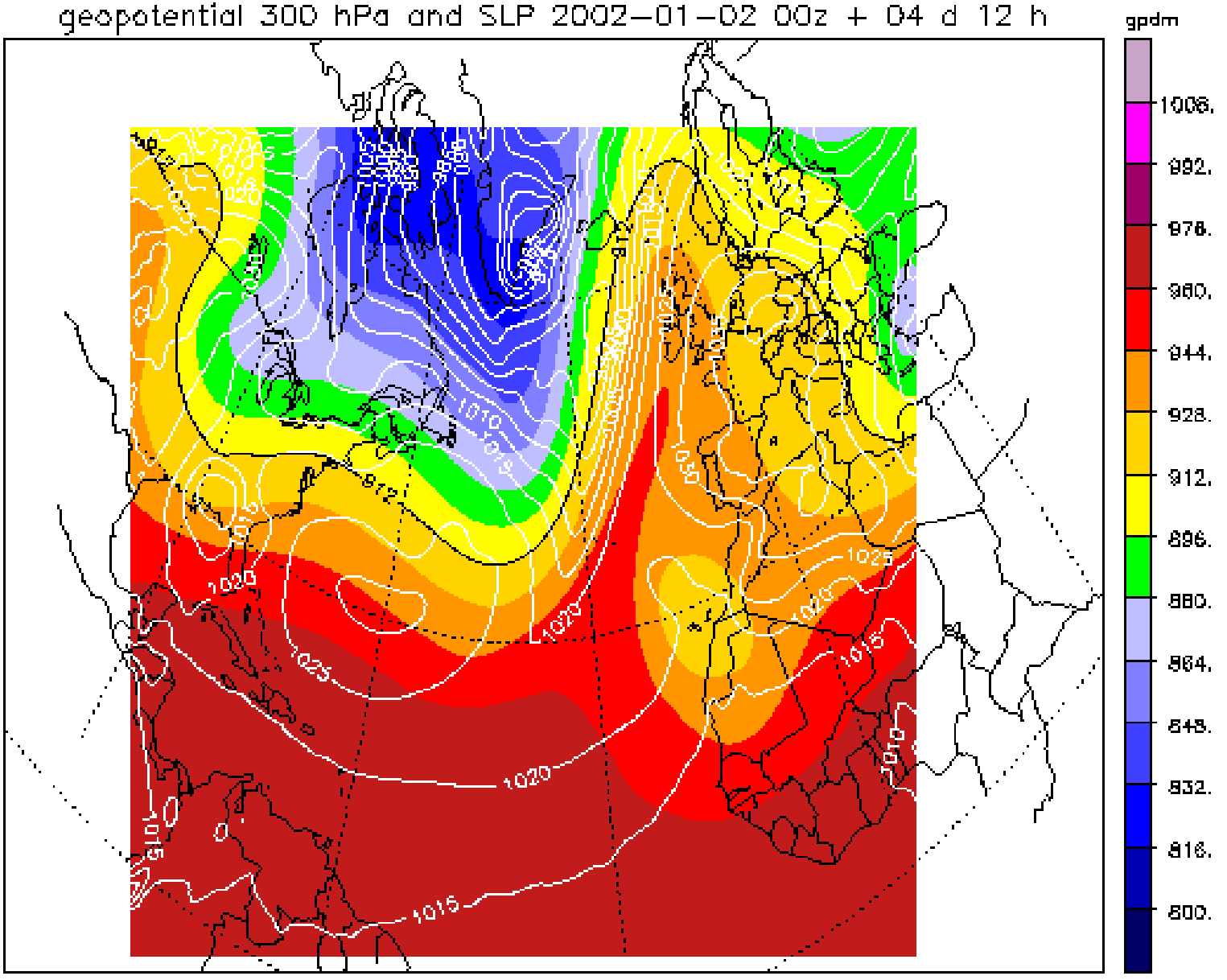
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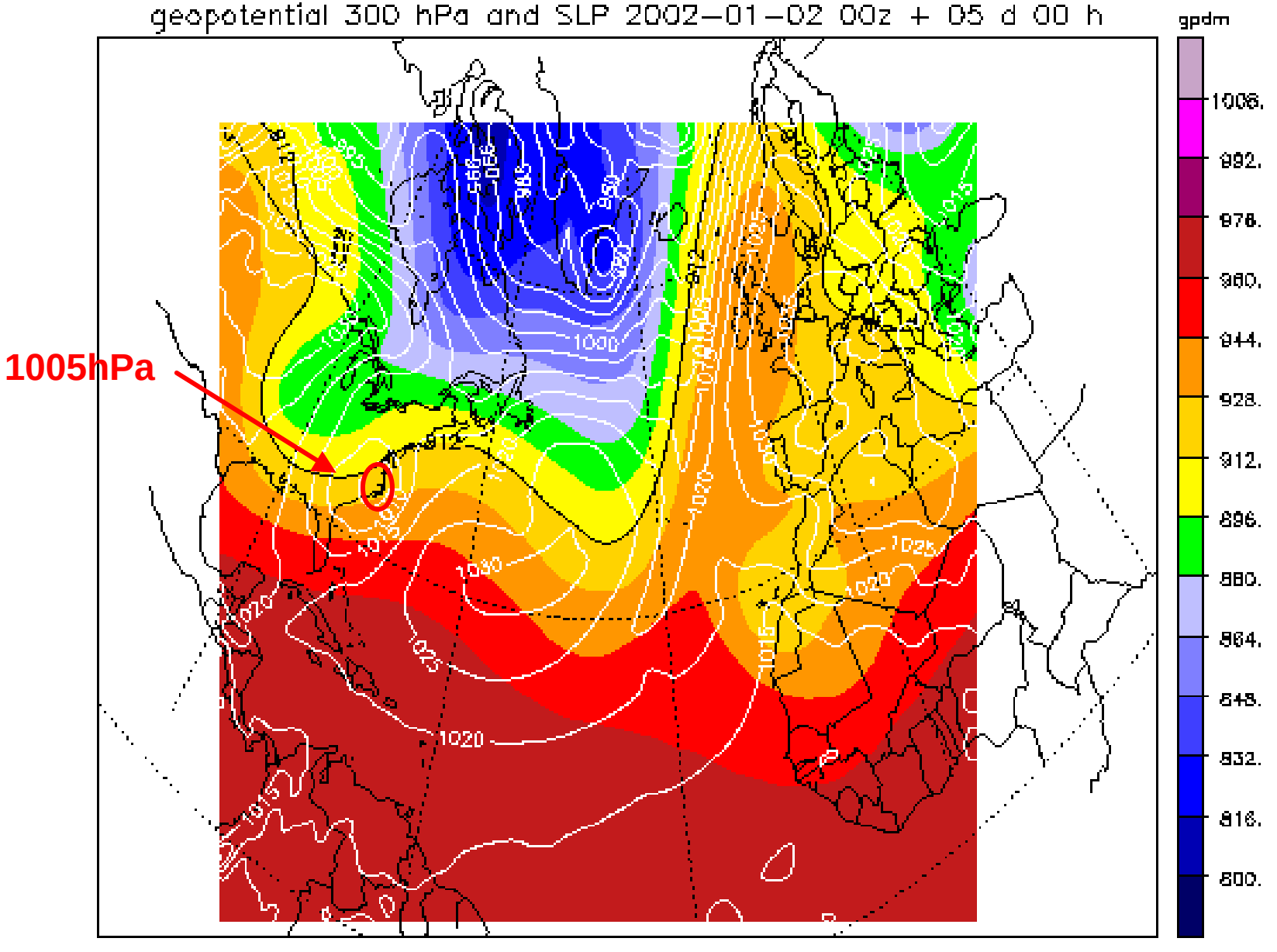
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gpdm
1008.
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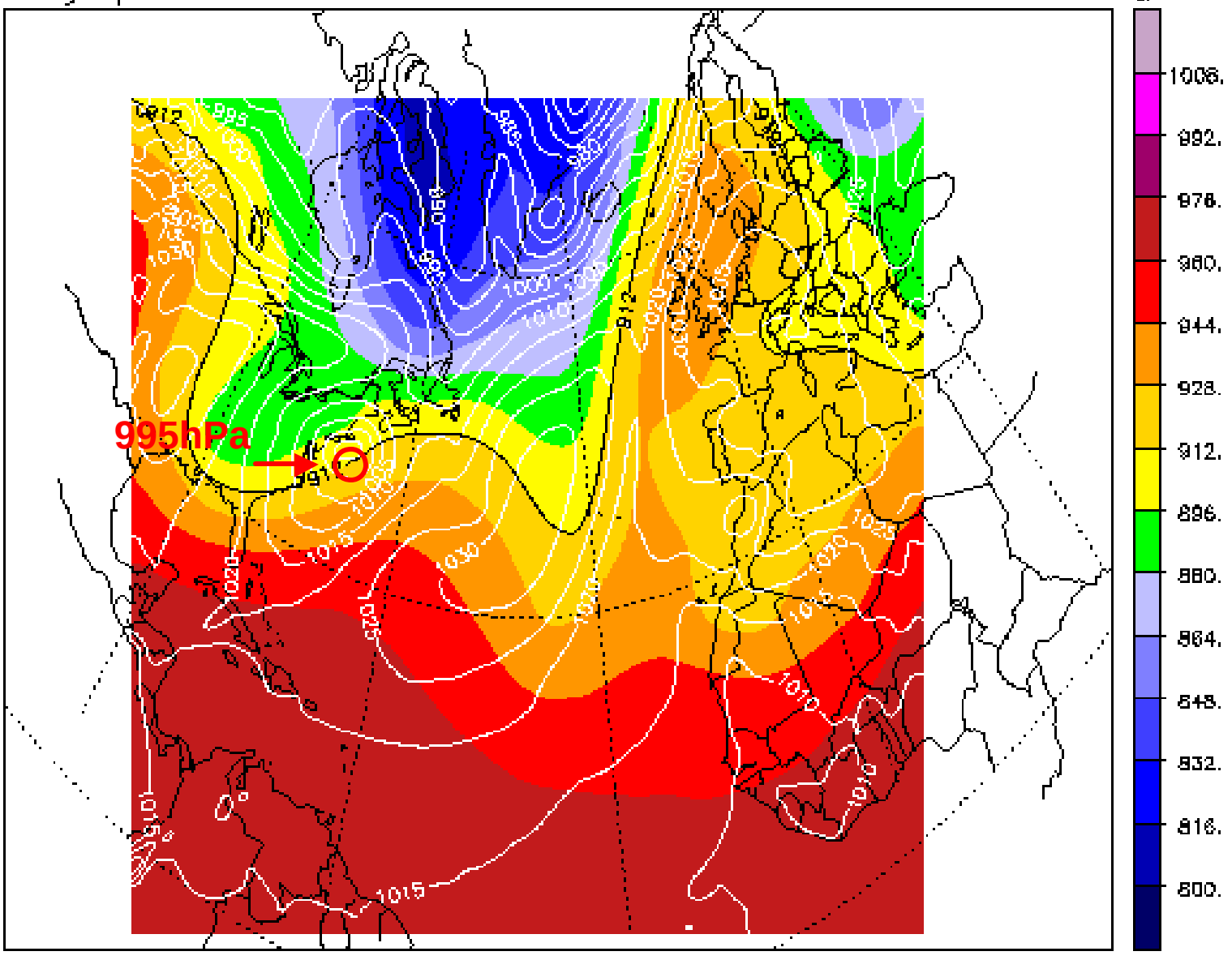
1005hPa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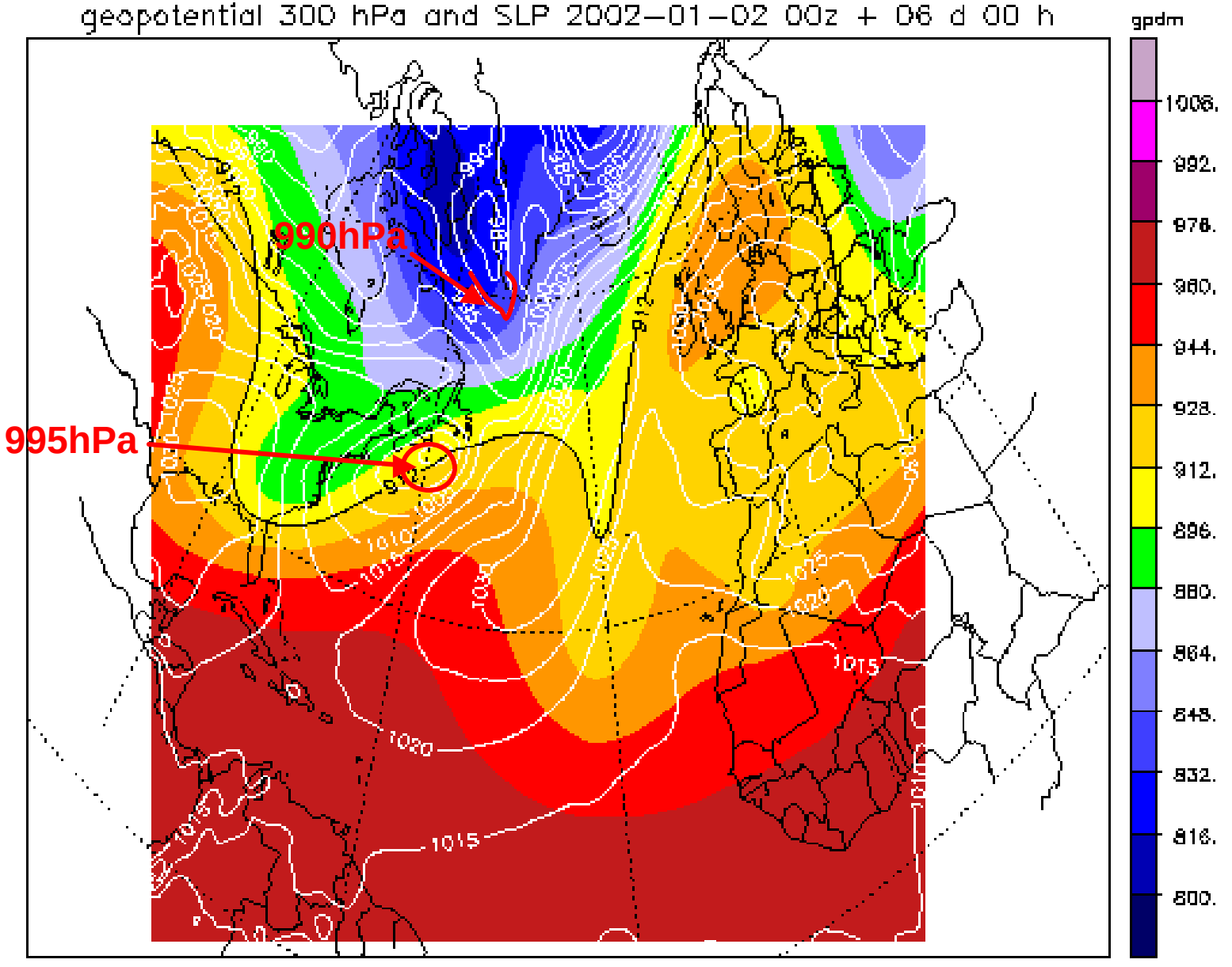
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990hPa
995hPa
1025
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1015
1010
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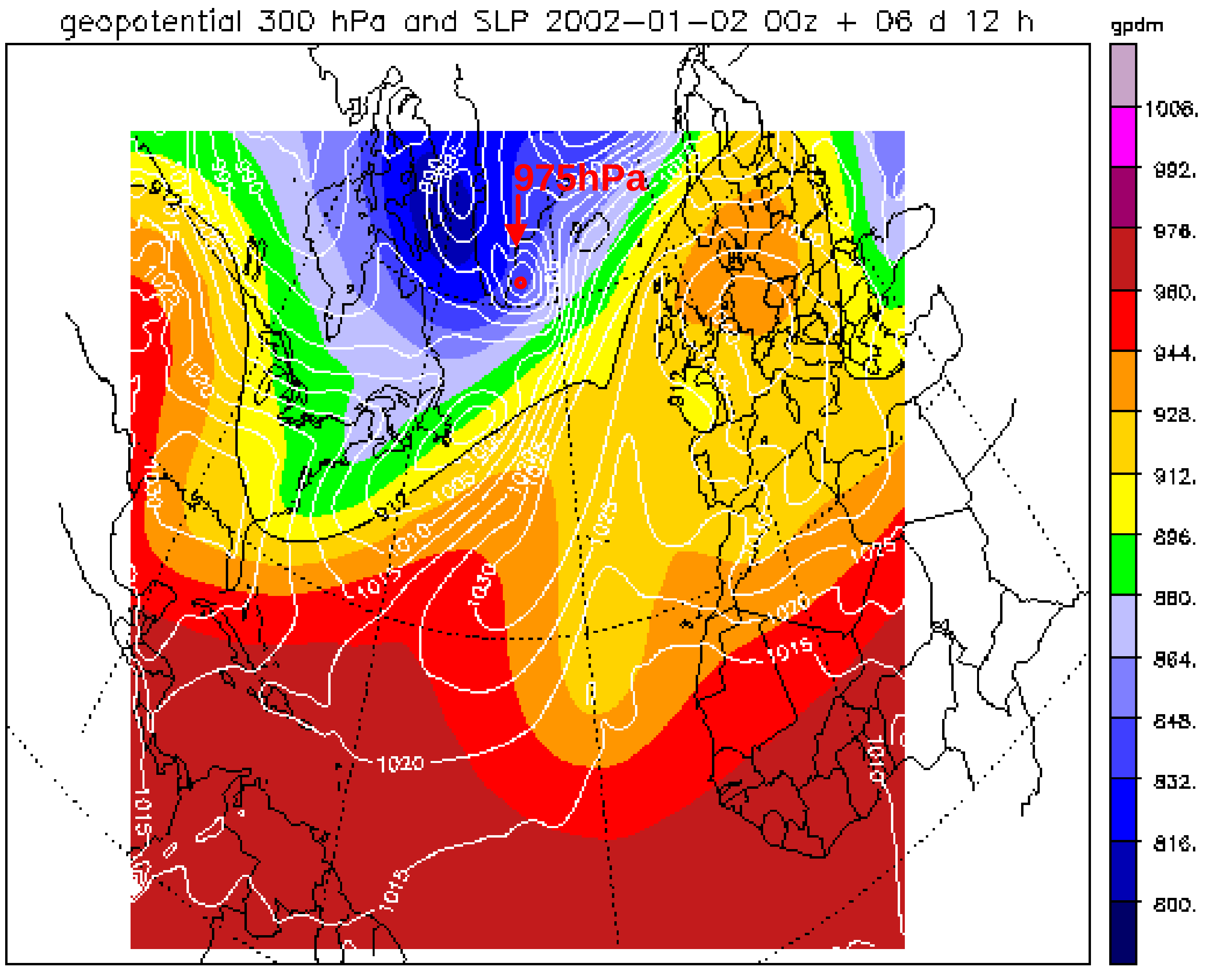

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864.
848.
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816.
800.
975hPa
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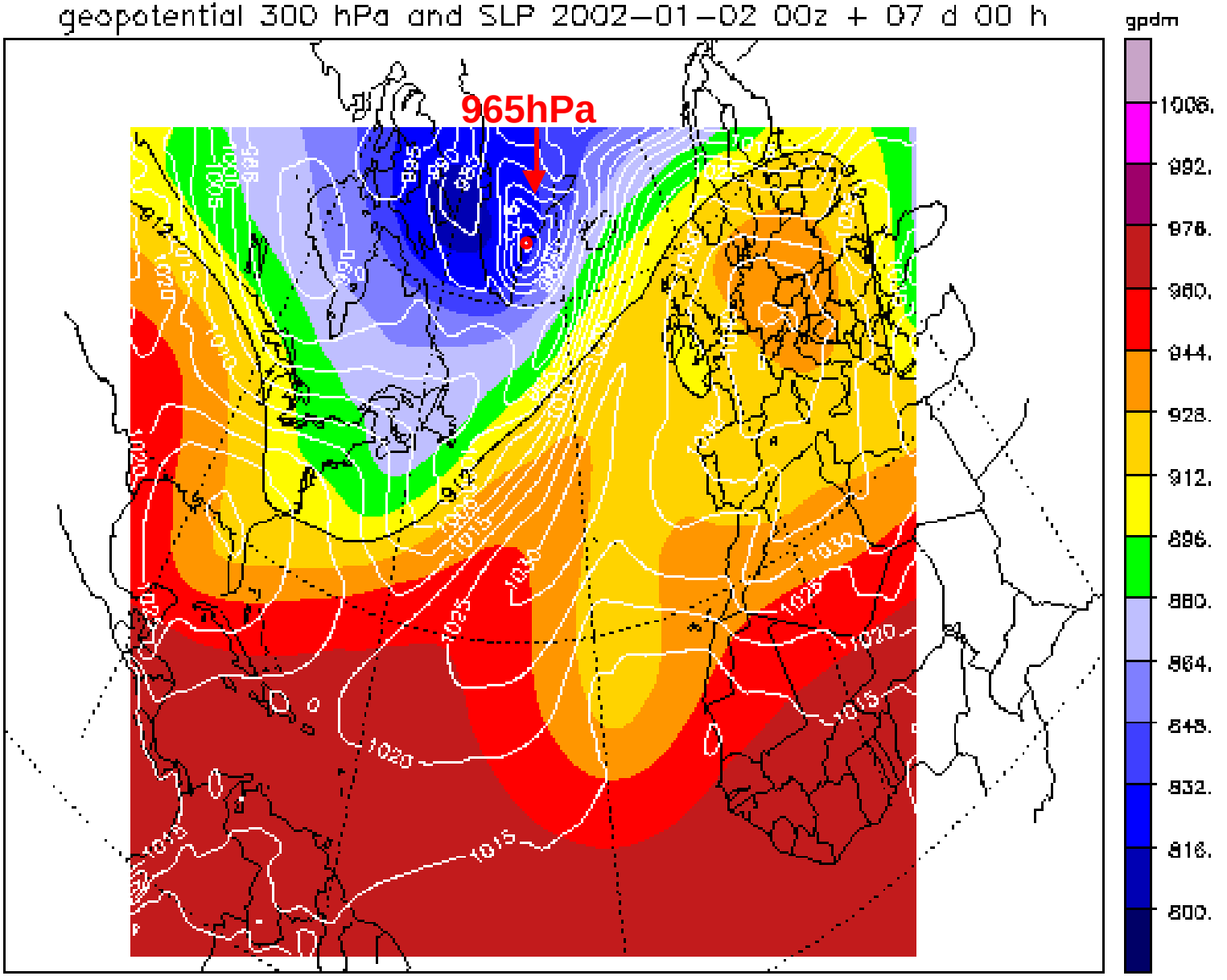
1015
1010
1005
1030
1025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965hPa
gpdm
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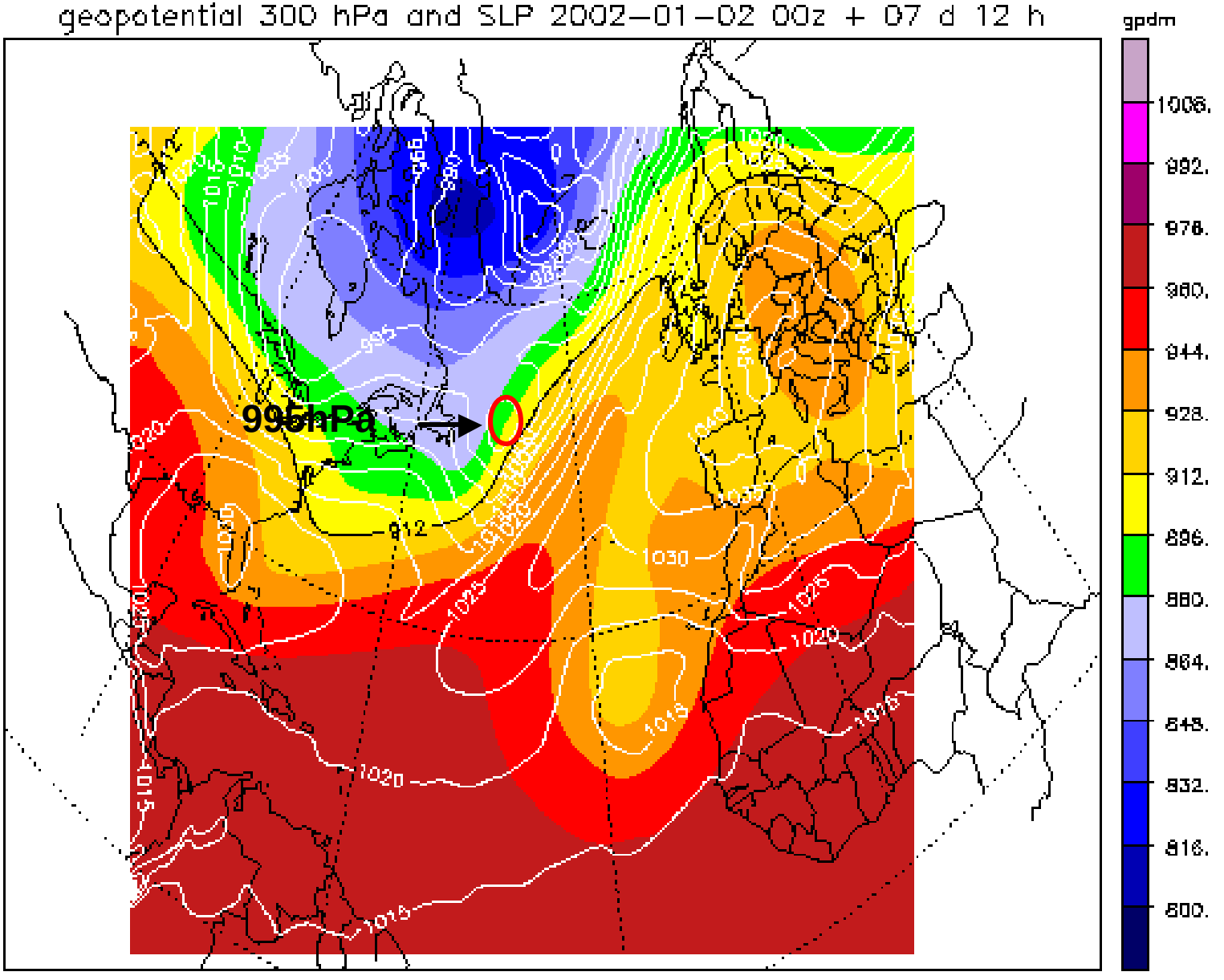
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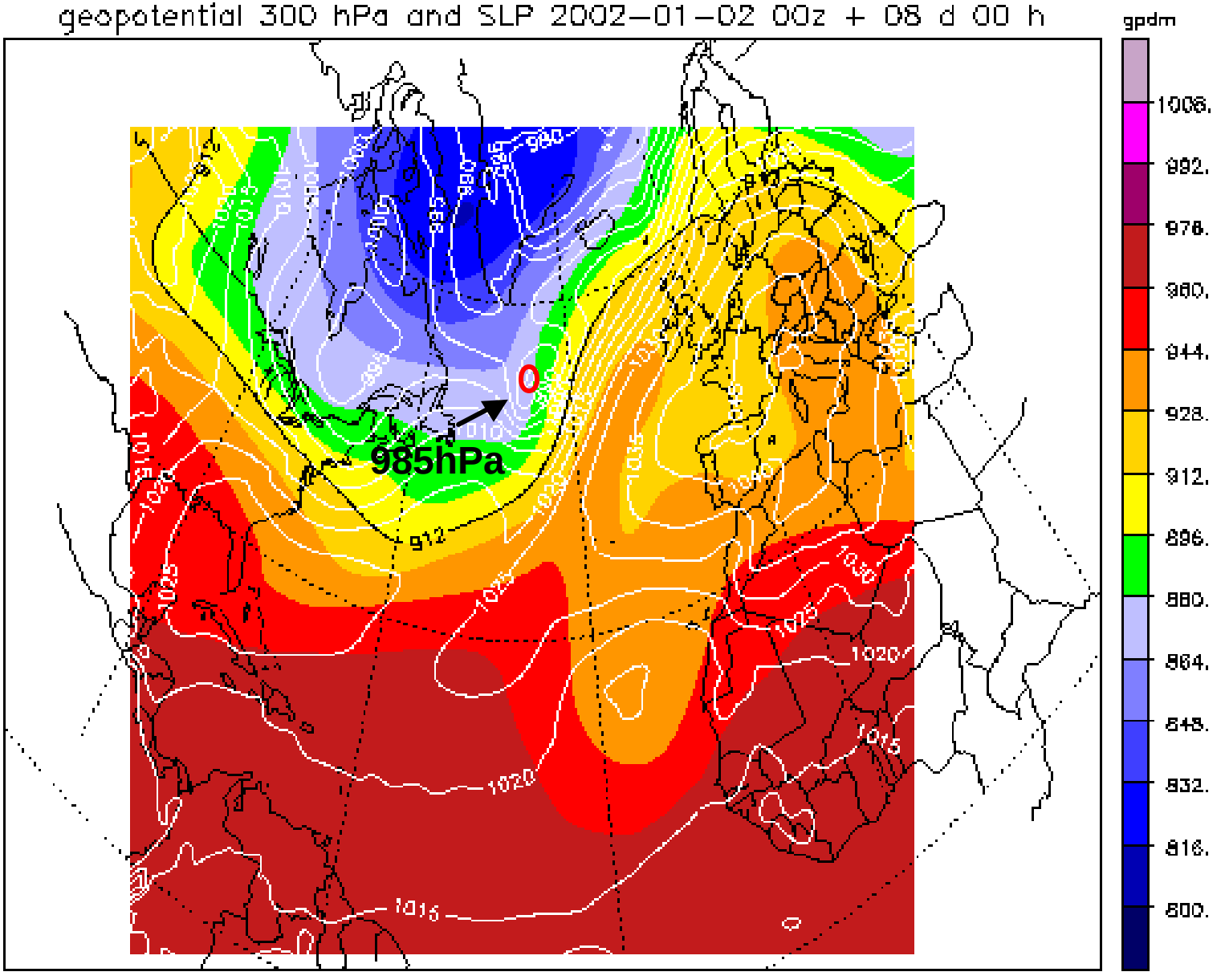
996hPa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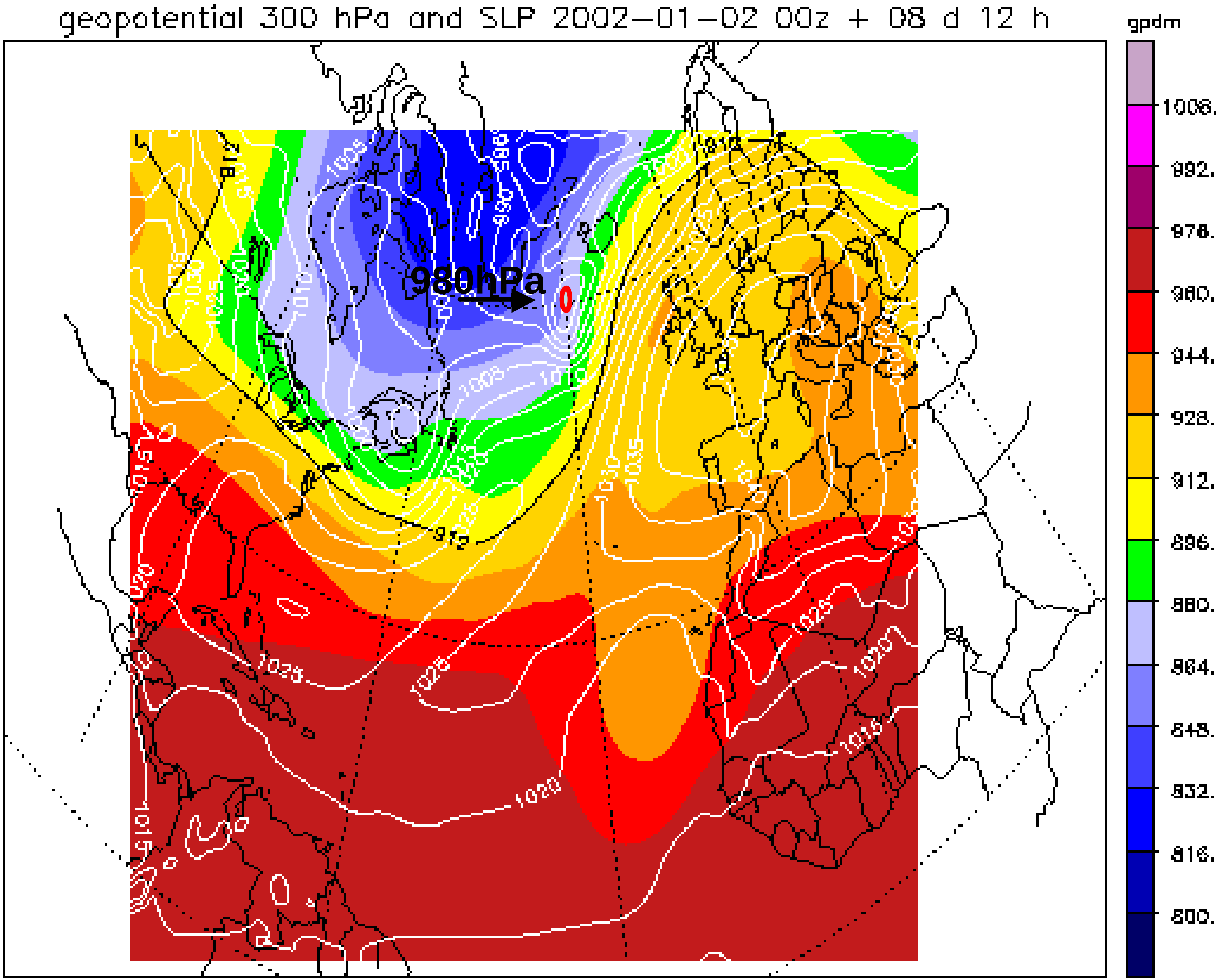
1016
1020
1024



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gpdm
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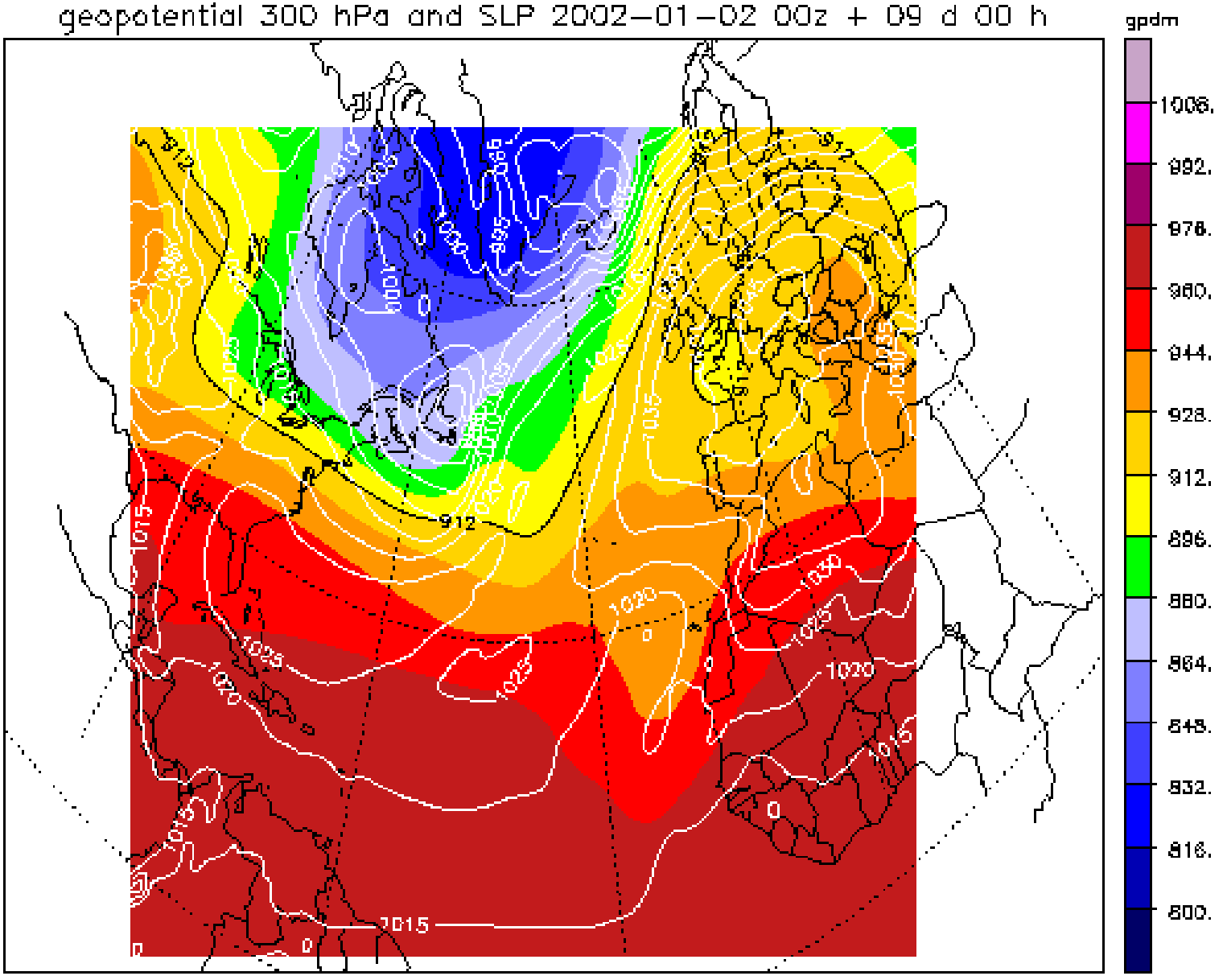
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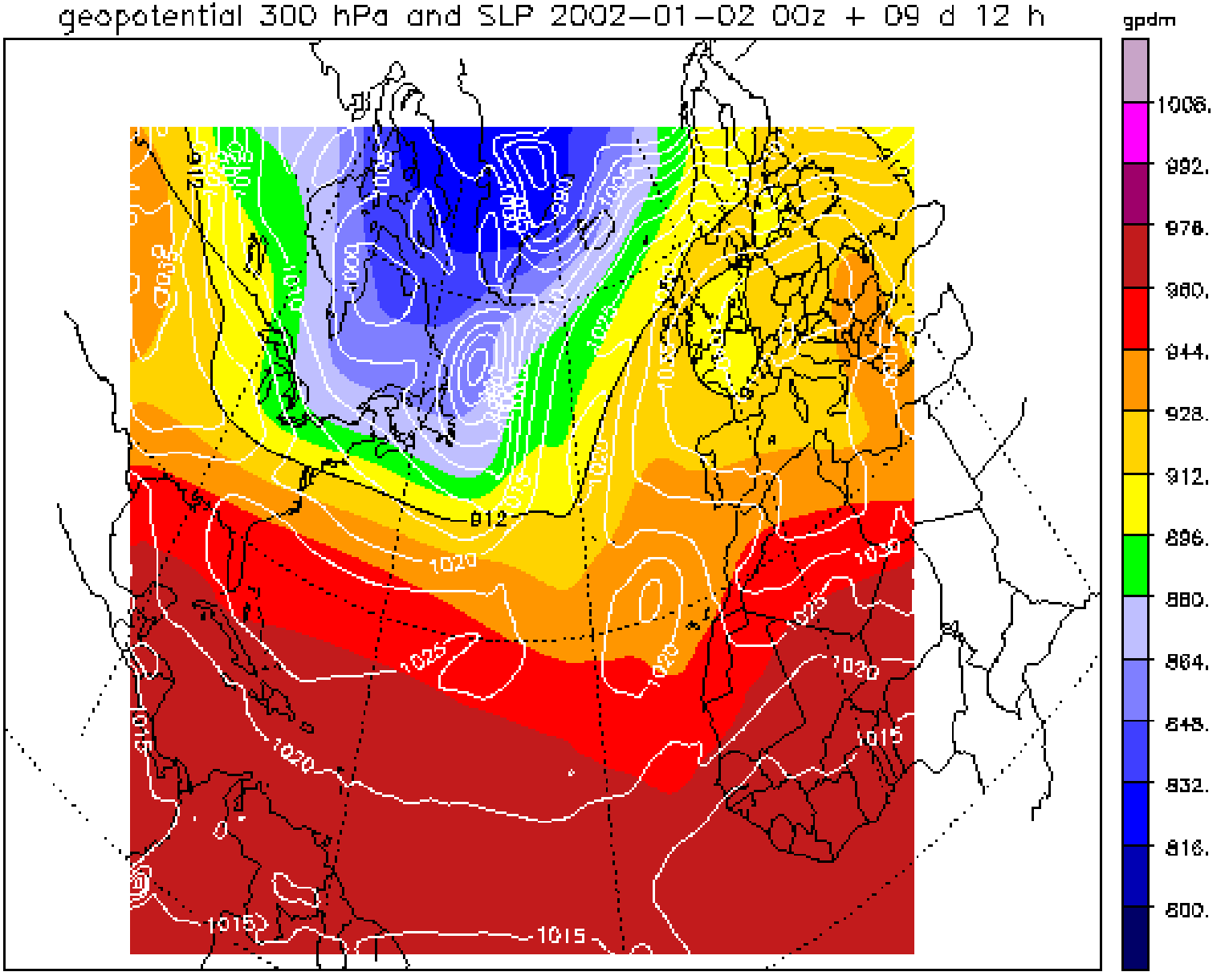
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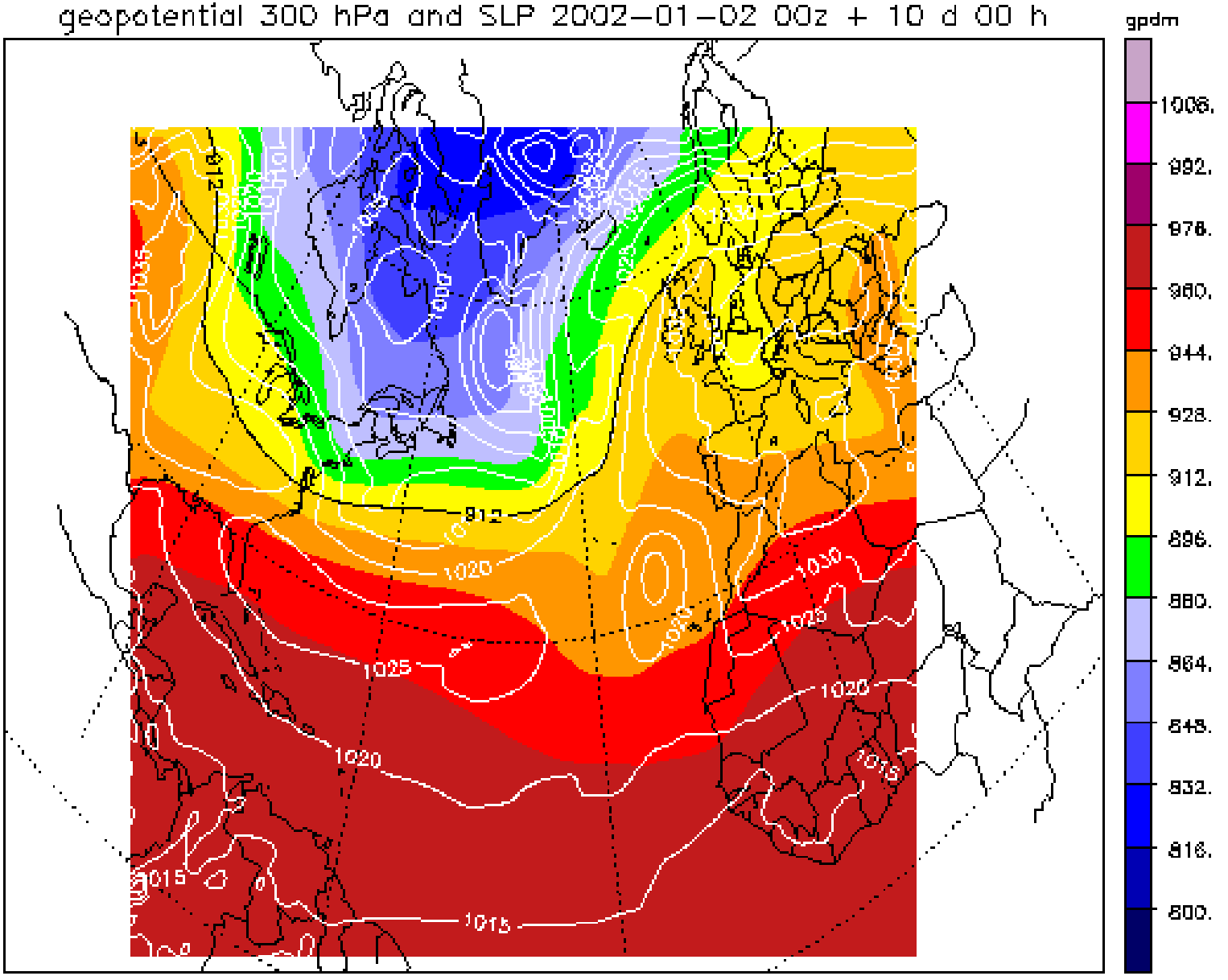
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912
1020
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1020
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1020
1015
1015

Further planned investigation

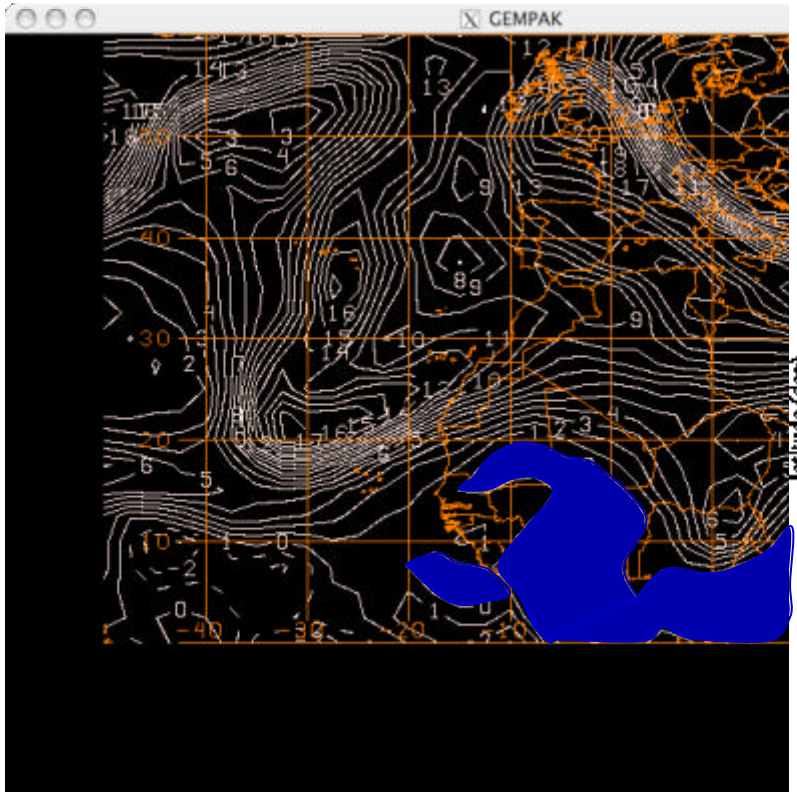
- Sensivity experiments with LM
- Investigation of other heavy precipitation events over north-western Africa

  (March 2002, October 2003)

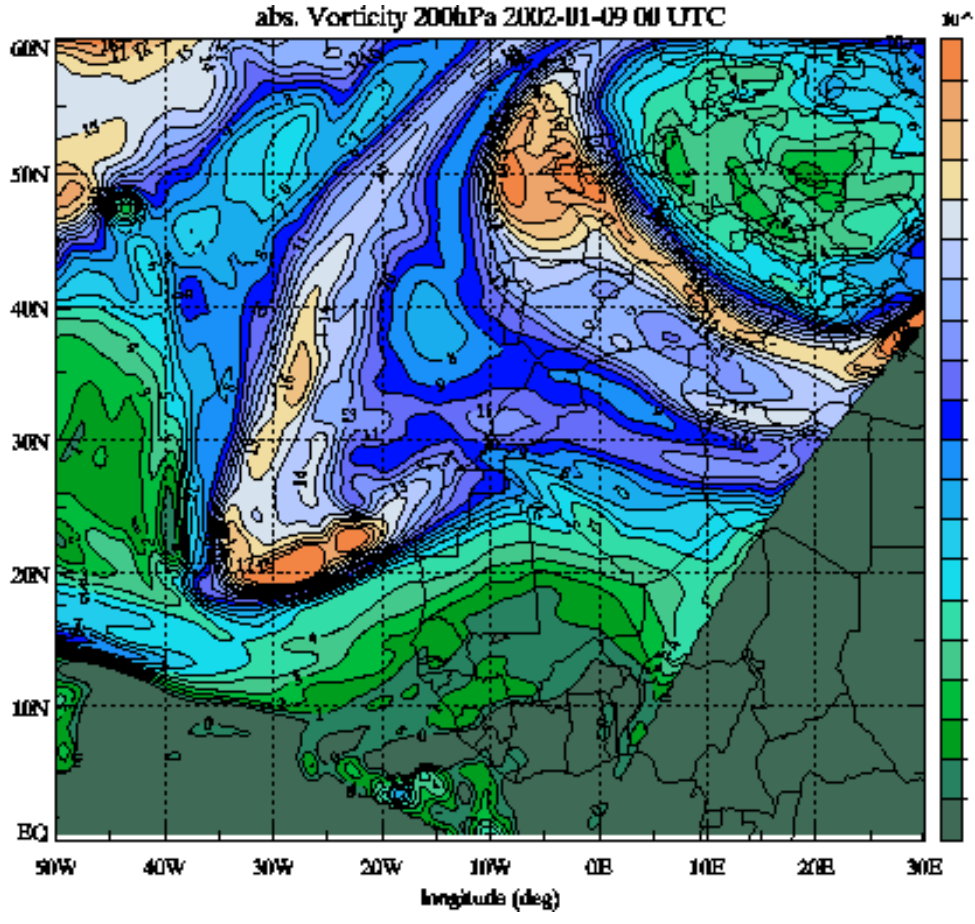
Thanks to

- Dr. Jörg Trentmann (University of Mainz)
- DWD data service for the GME boundary values
- Dr. E. Heise (DWD) for the external parameter files
- Dr. U. Schättler (DWD)
- Dr. M. Sprenger (ETH)
- my other collegues at University of Mainz

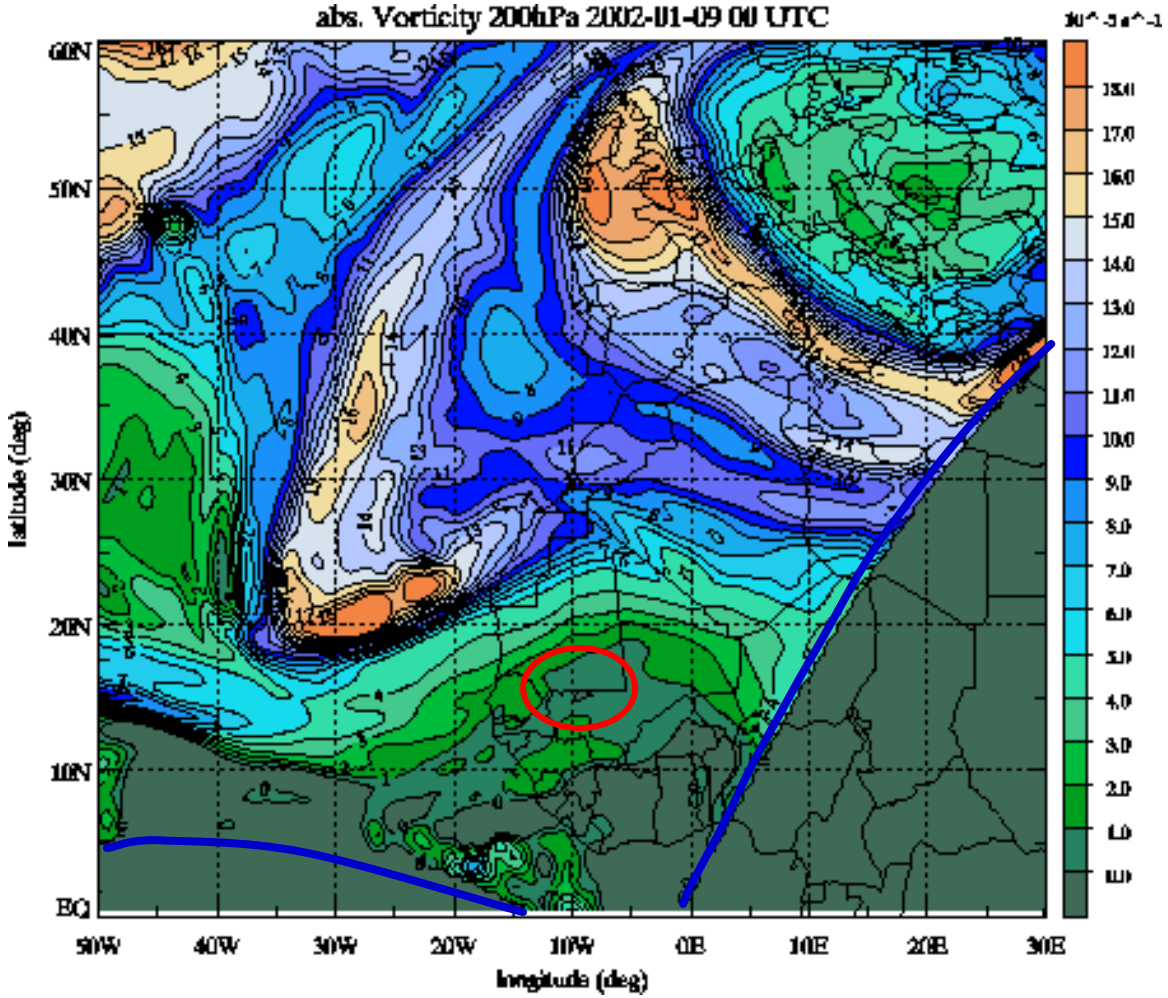
abs. Vorticity

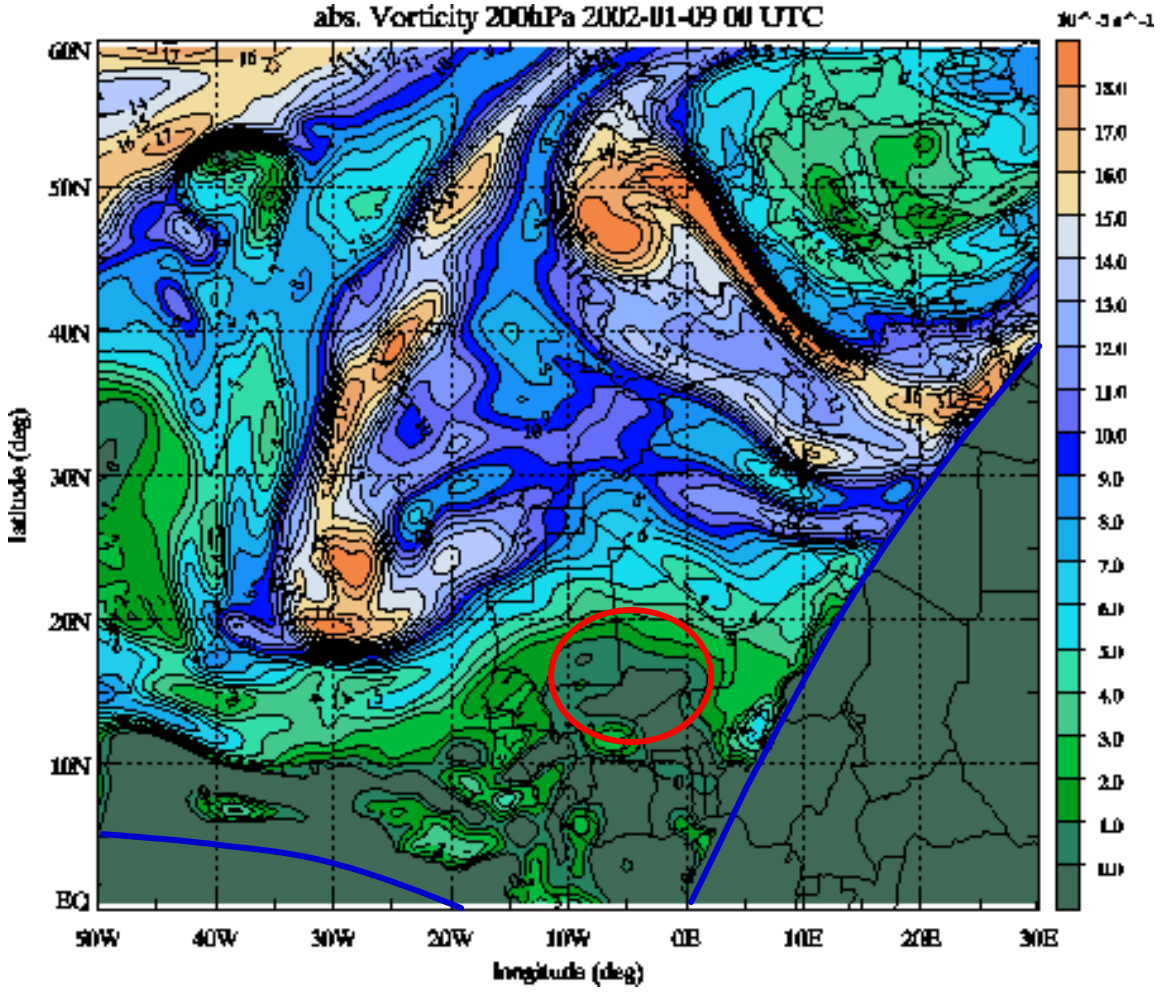


UW-NMS



LM (ECMWF)


abs. Vorticity 200hPa 2002-01-09 00 UTC
60N
50N
40N
30N
20N
10N
EQ
50W
40W
30W
20W
10W
0E
10E
20E
30E
latitude (deg)
longitude (deg)


abs. Vorticity 200hPa 2002-01-09 00 UTC
10^-5 s^-1
60N
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EQ
latitude (deg)
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30W
20W
10W
0E
10E
20E
30E
longitude (deg)
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15.0
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12.0
11.0
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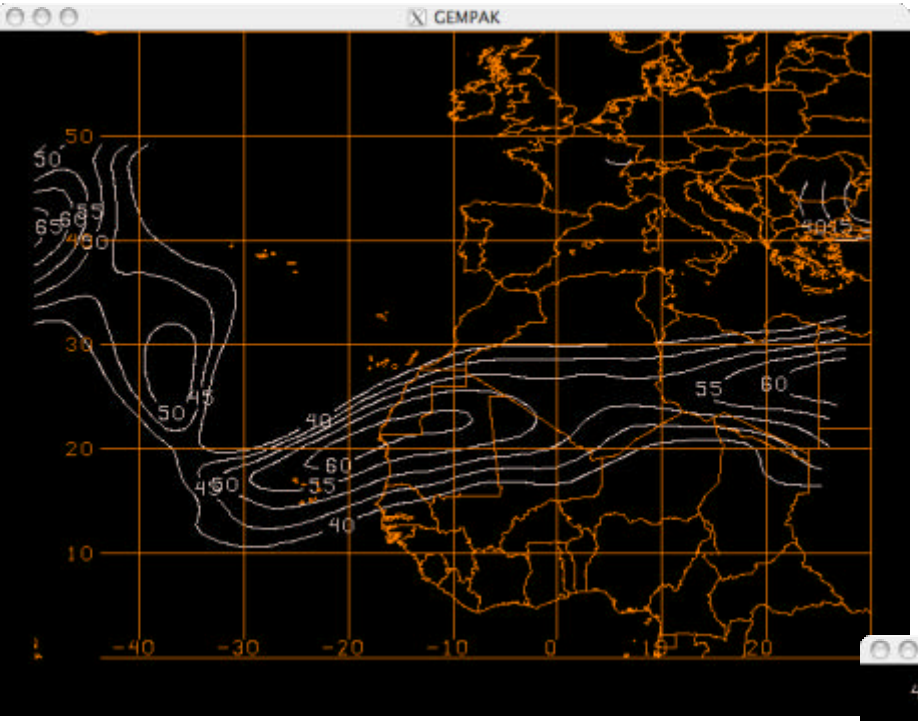
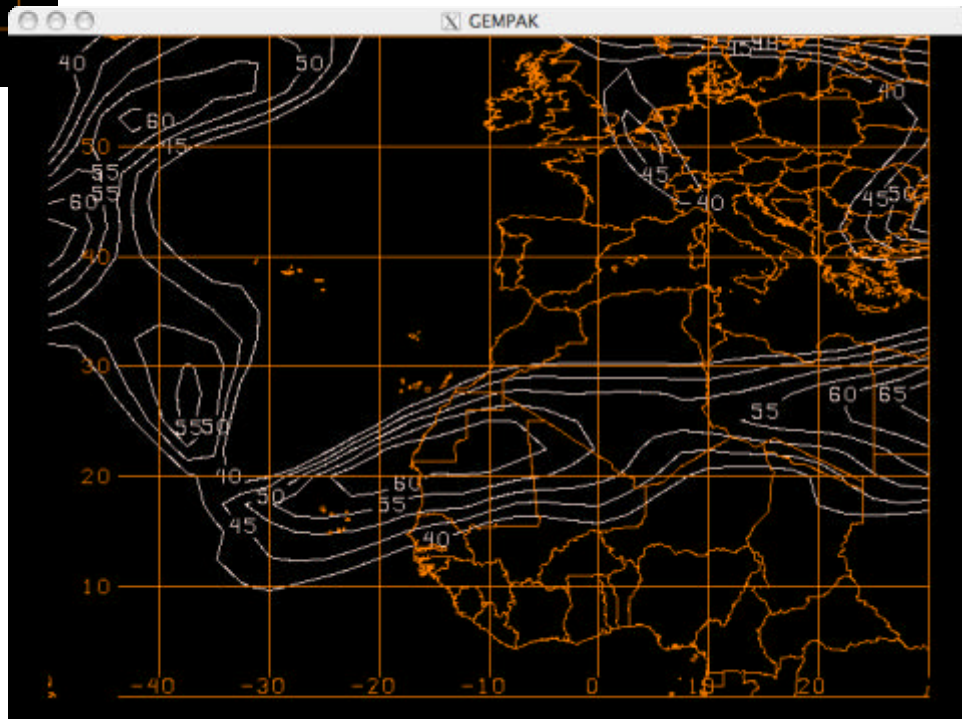
Windspeed 200hPa [m/s]

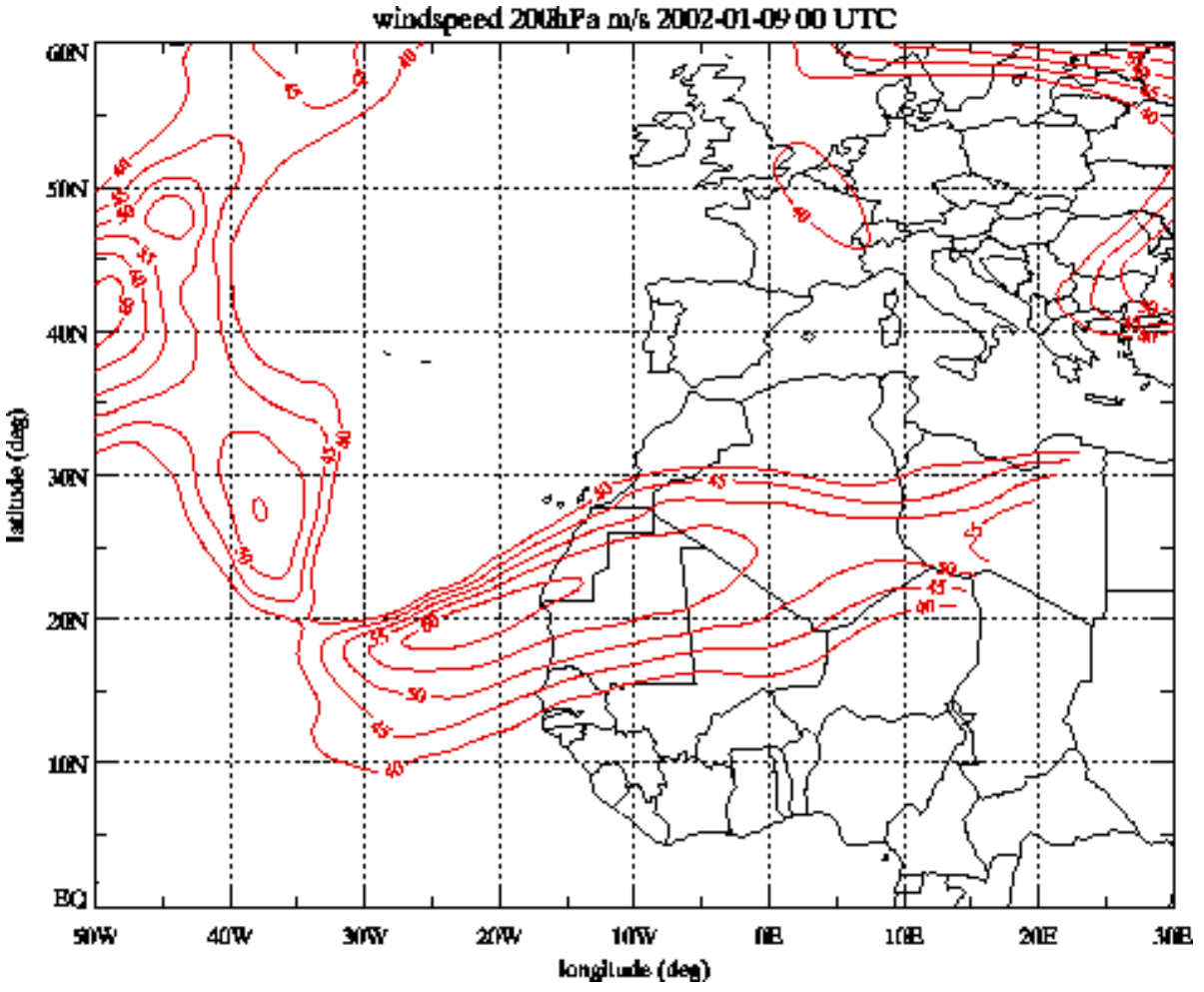


ECMWF

UW-NMS



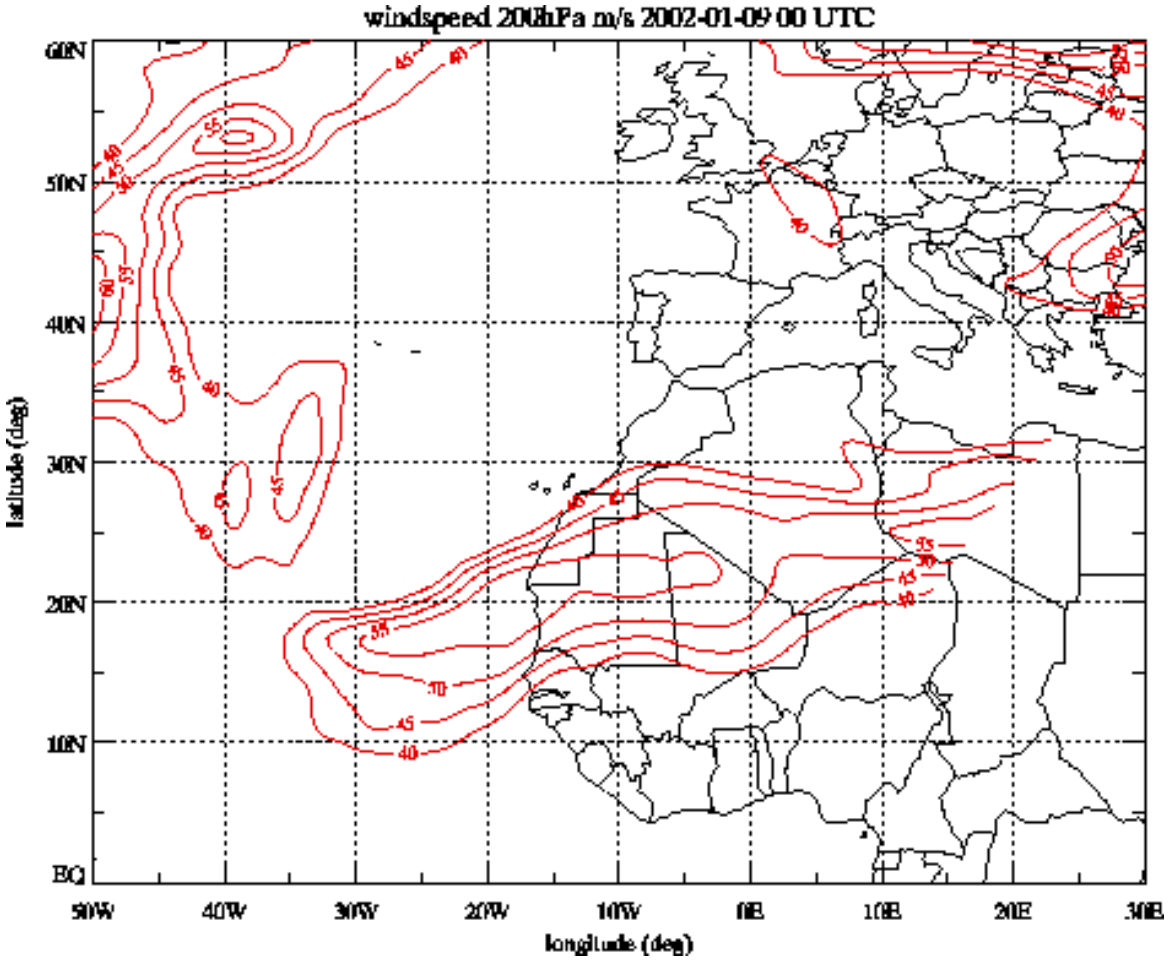
Windspeed 200hPa
[m/s]



LM (ECMWF)

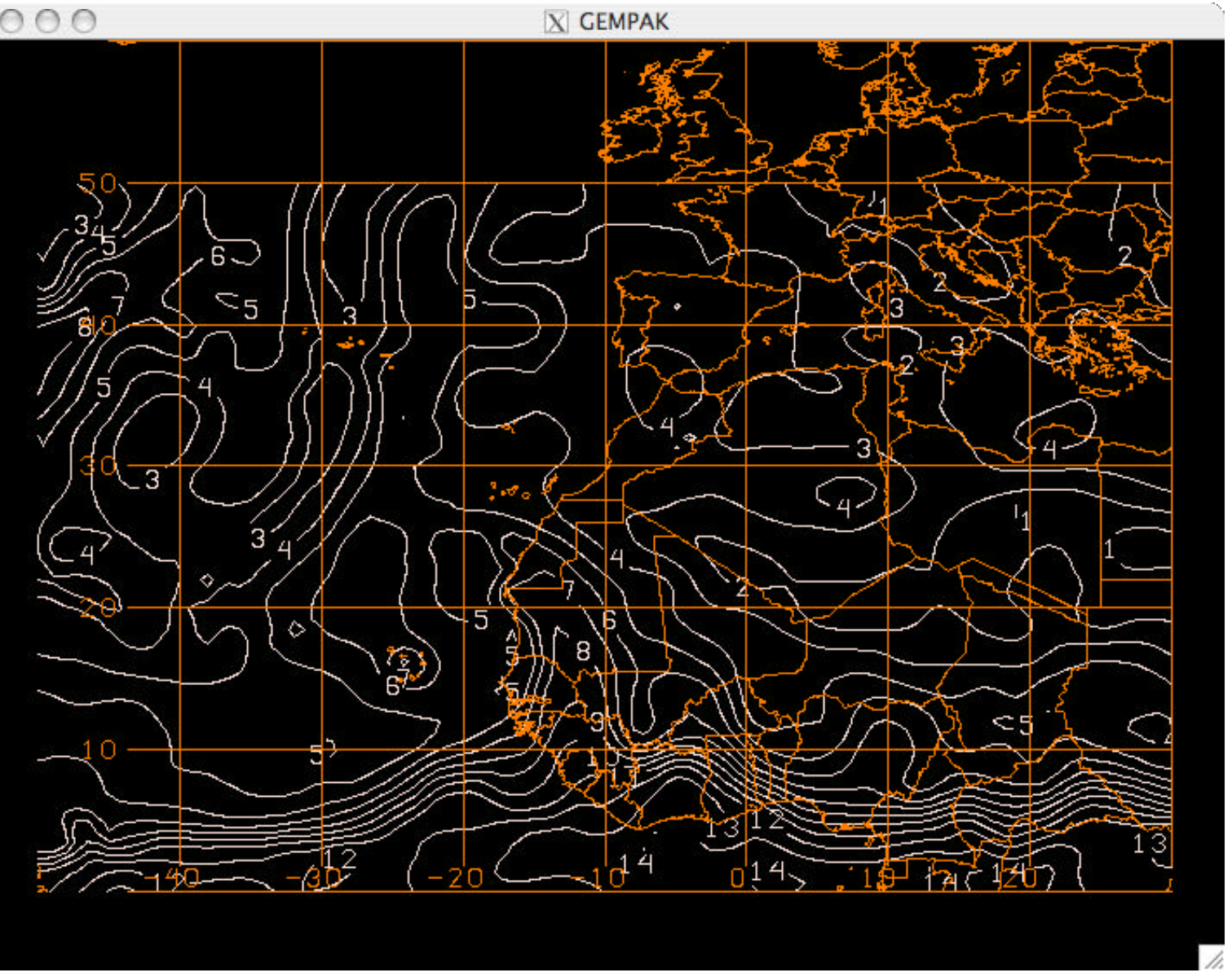
Windspeed 200hPa
[m/s]

LM (GME)

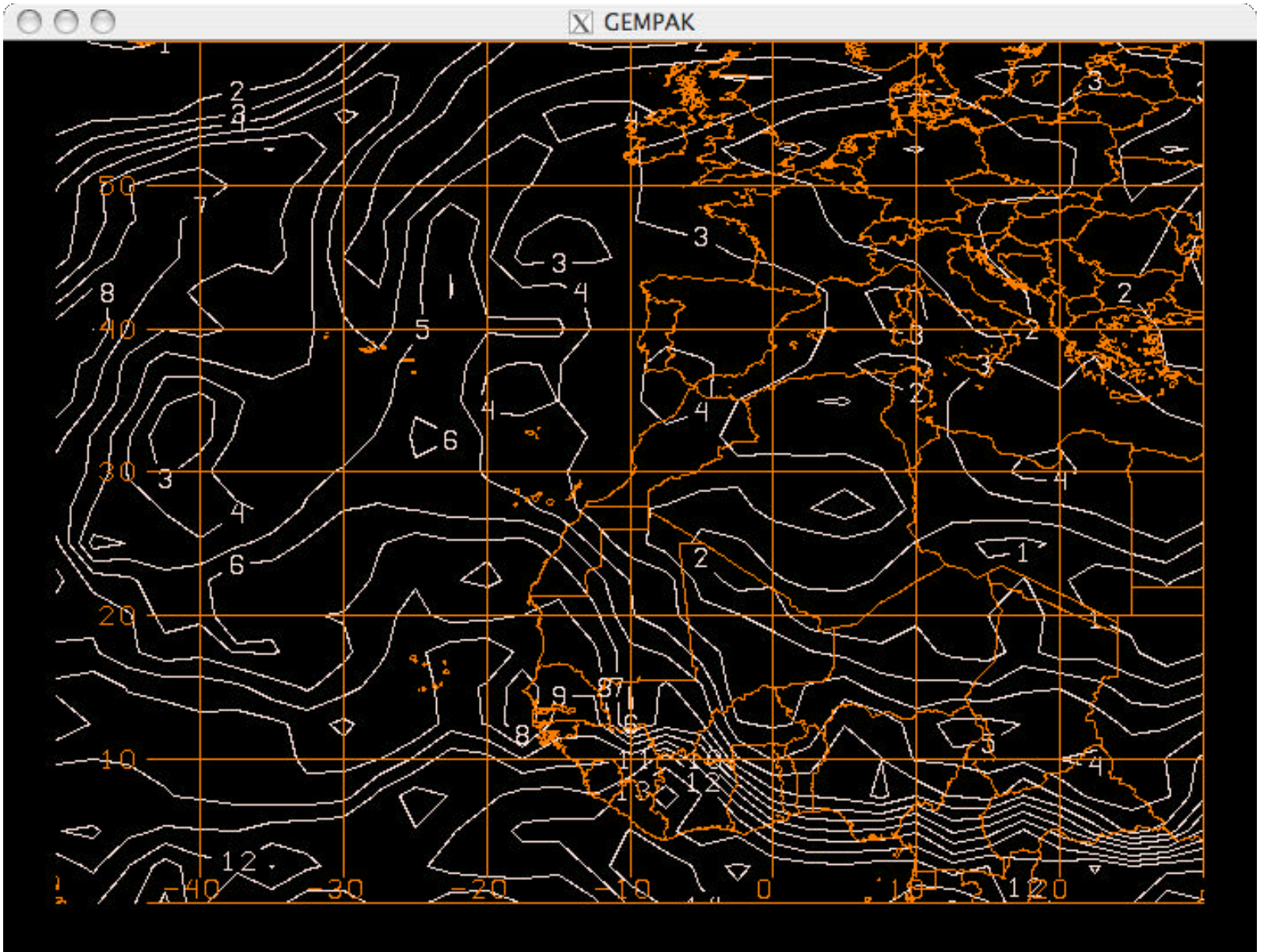


mixingratio 850hPa [g/kg]

UW-NMS

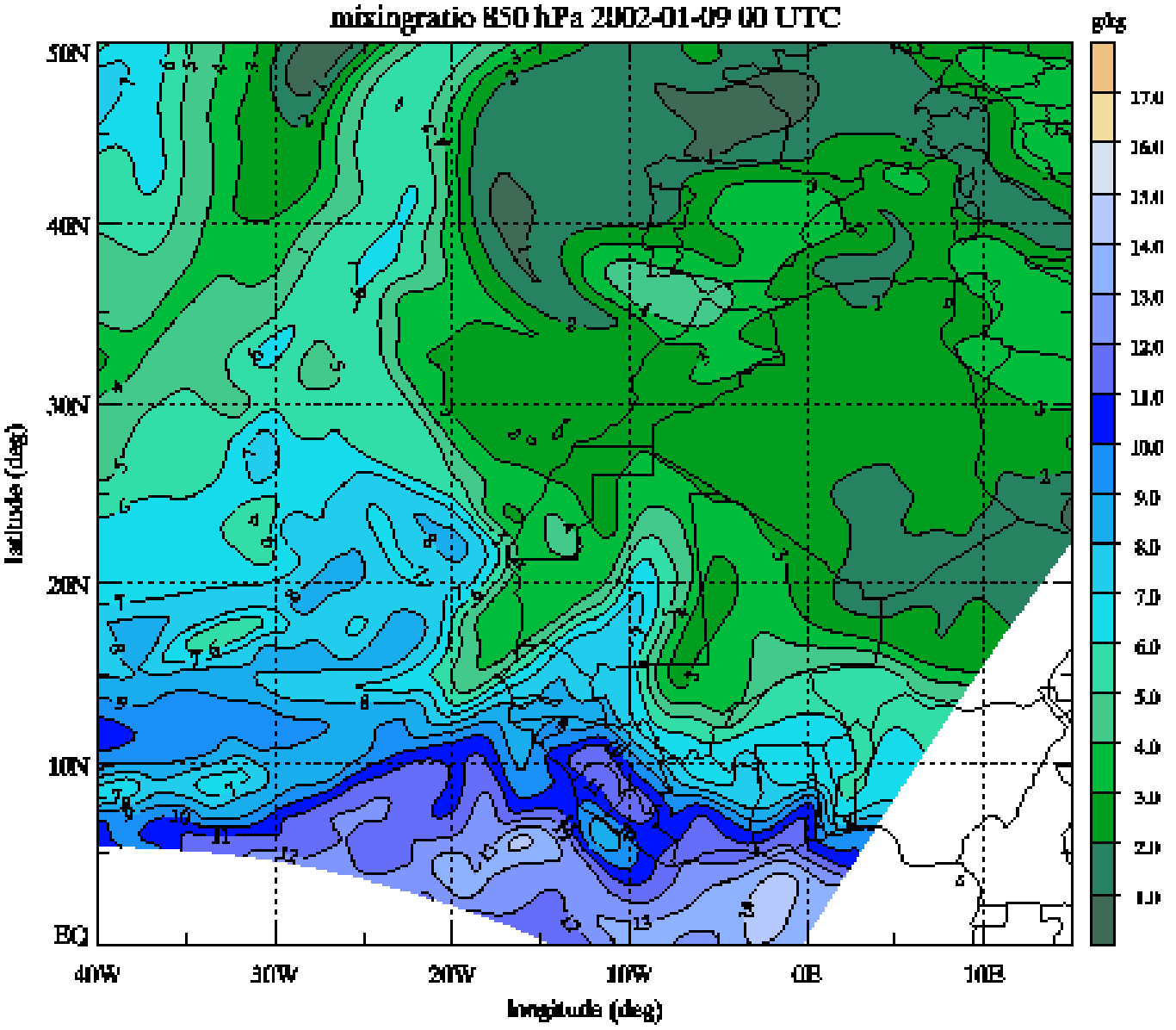


mixingratio 850hPa [g/kg] ECMWF



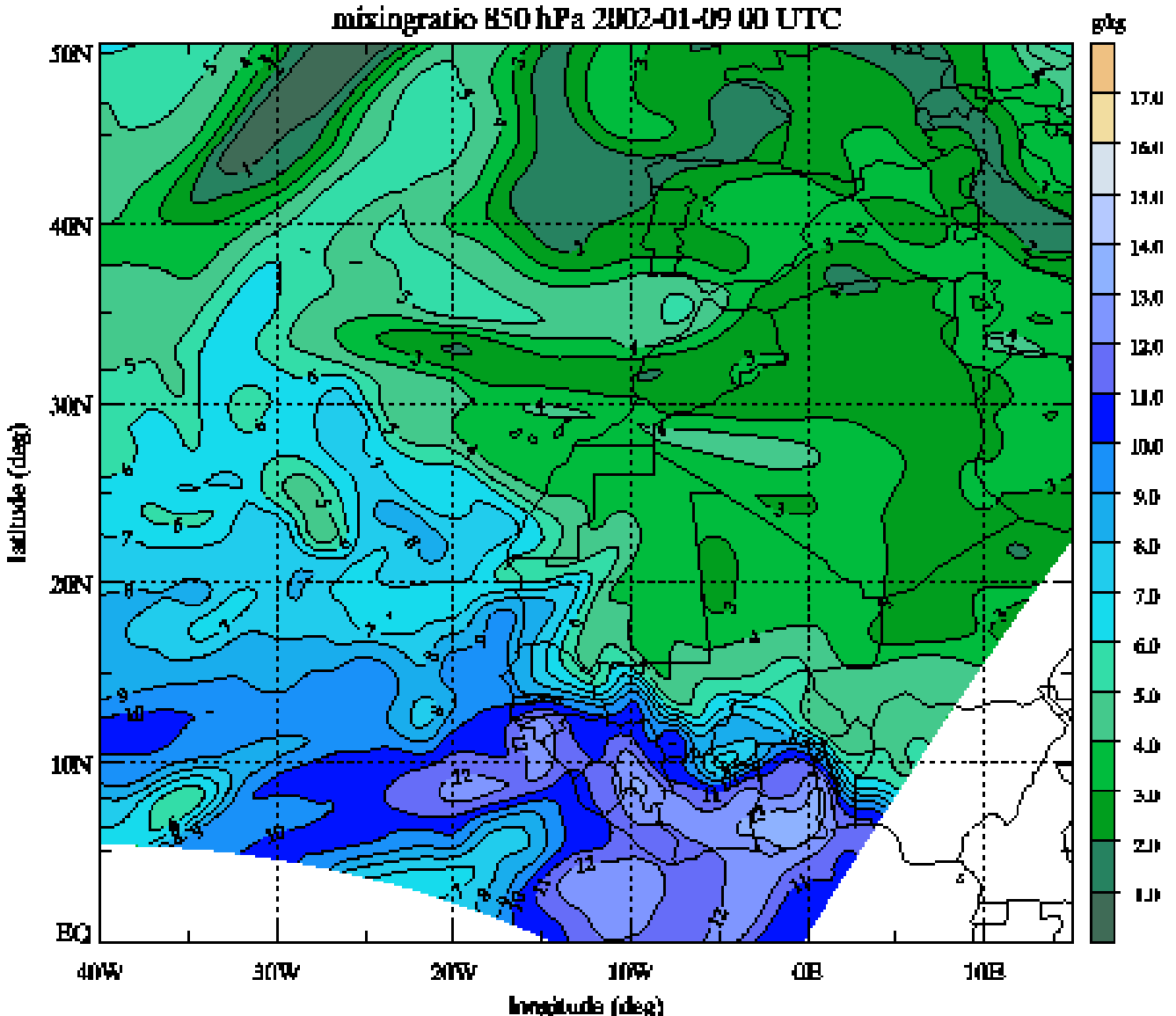
mixingratio 850hPa [g/kg]

LM
(ECMWF)



mixingratio 850hPa [g/kg]

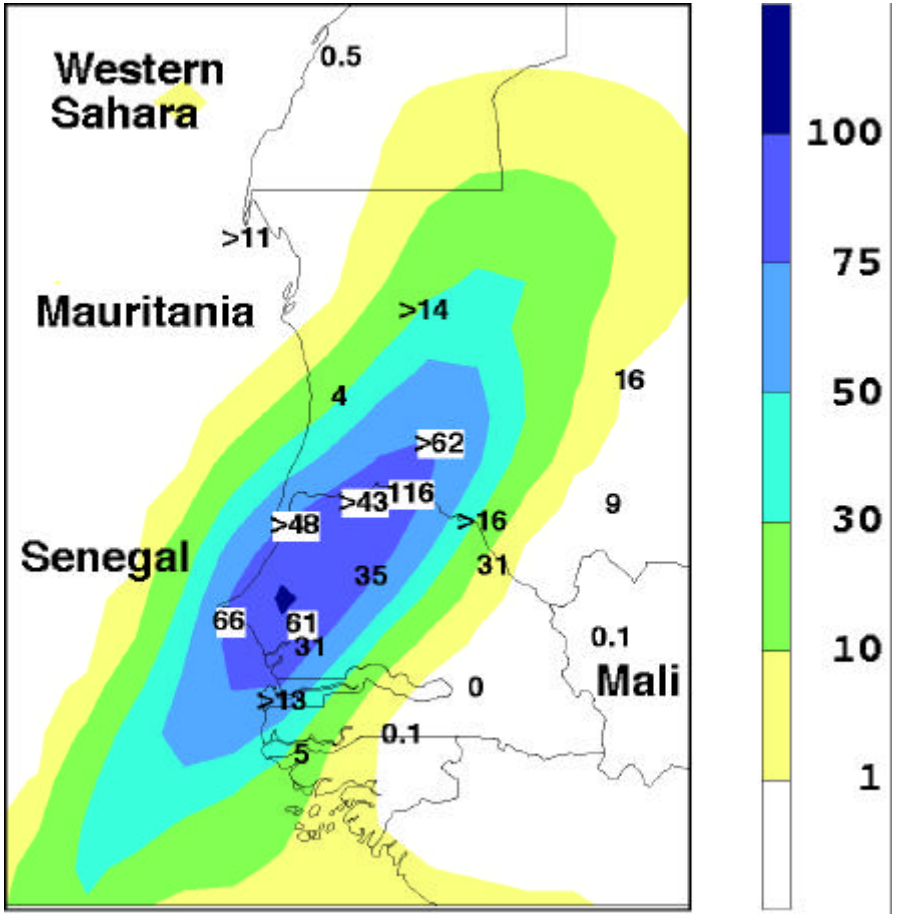
LM (GME)



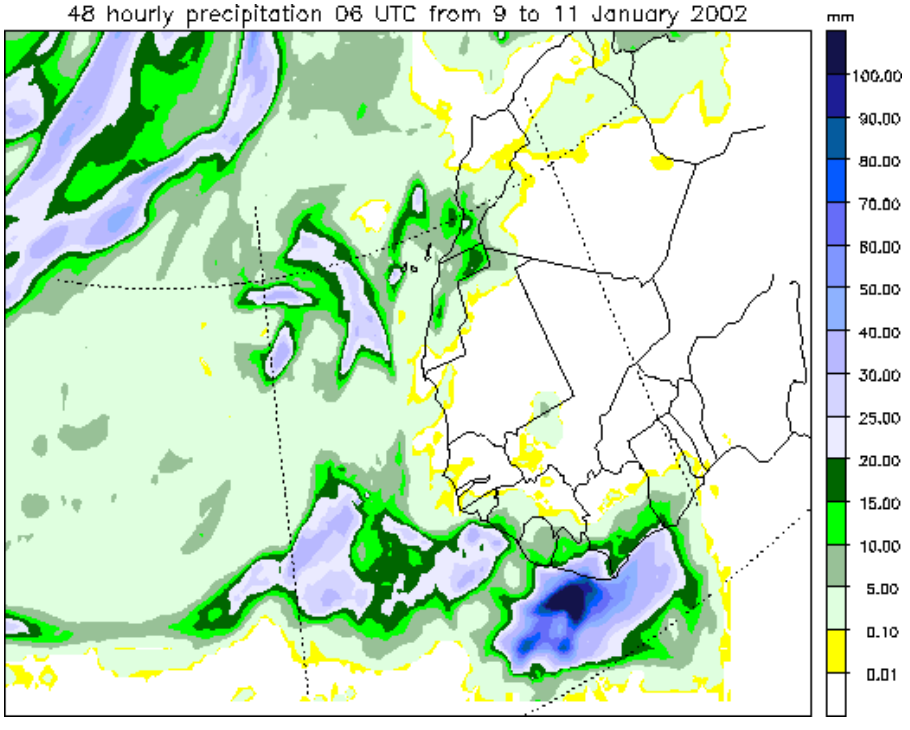
ENDE

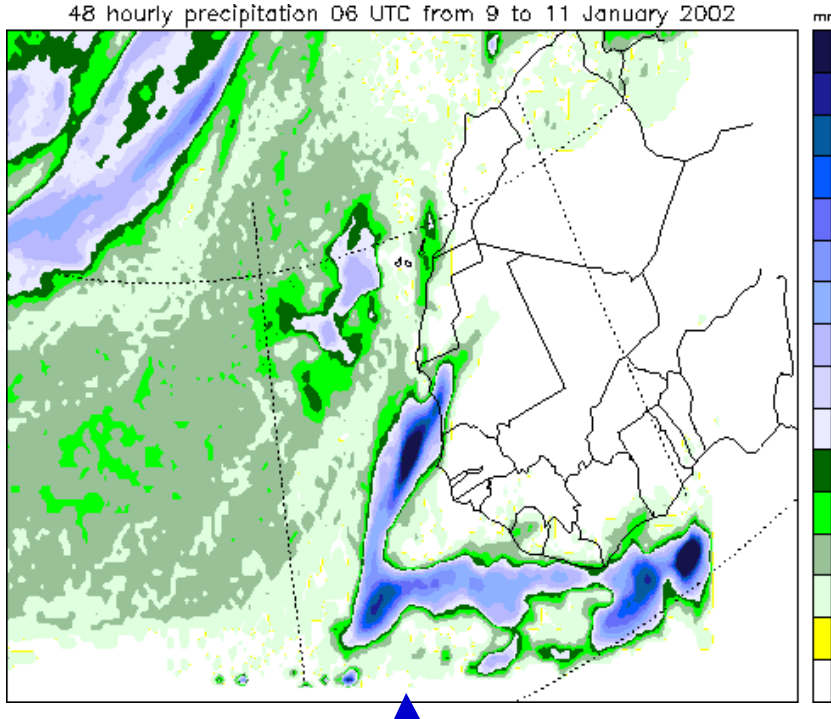
Precipitation

- Middle of the **dry season** (usually = 2 mm)
- 116 mm in Podor correspond to 54% of average annual total
- Most intense January event on record
- Humanitarian catastrophe



48-h accumulated precipitation [mm]
January 9–11 2002



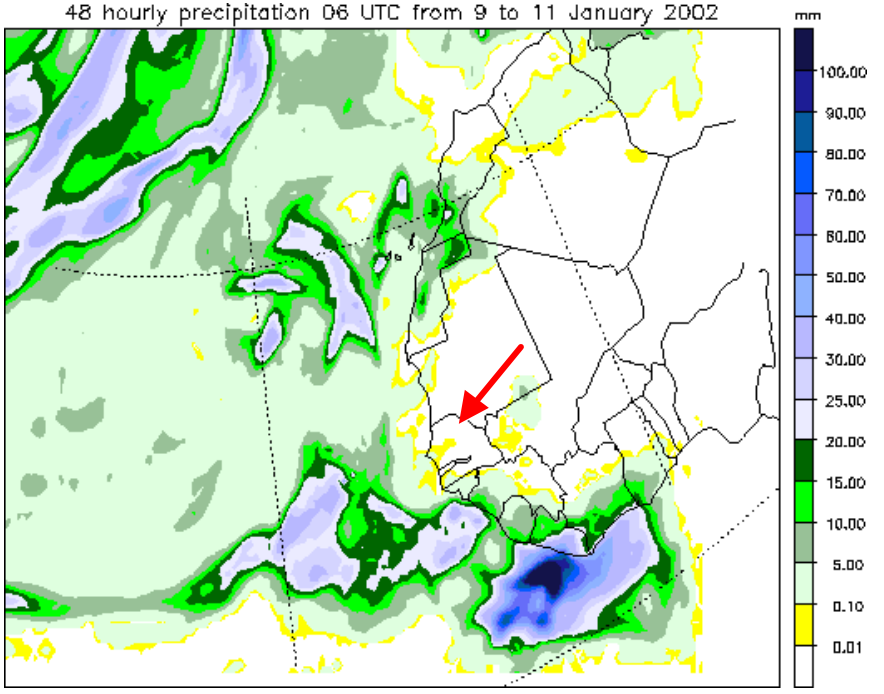


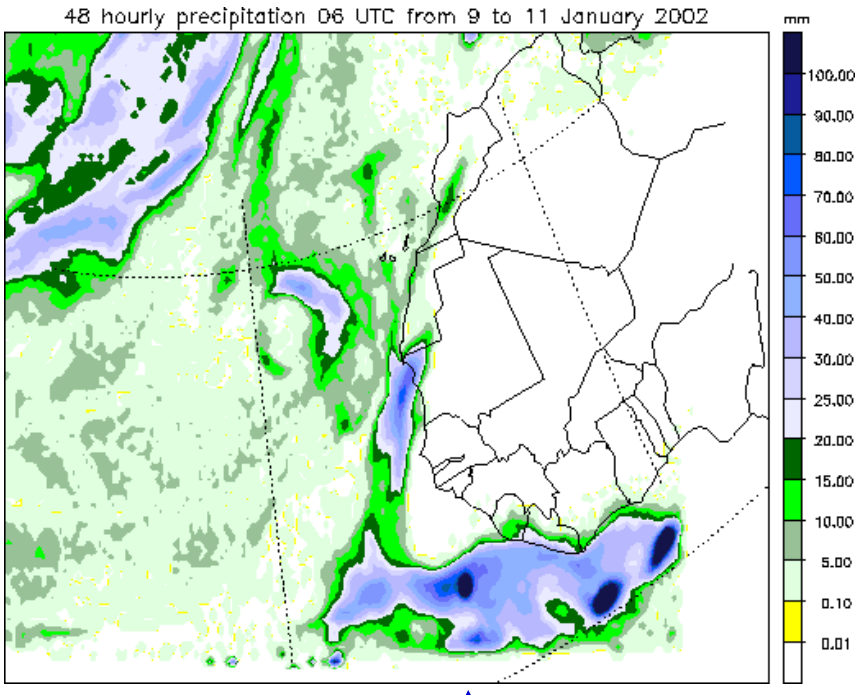
LM-simulation: start 2 January 2002 00 UTC

GME boundary data, cloud ice scheme,

Tiedtke convection scheme, timestep 60 s

ECMWF boundary and initial data, graupel scheme,Kain Fritsch scheme





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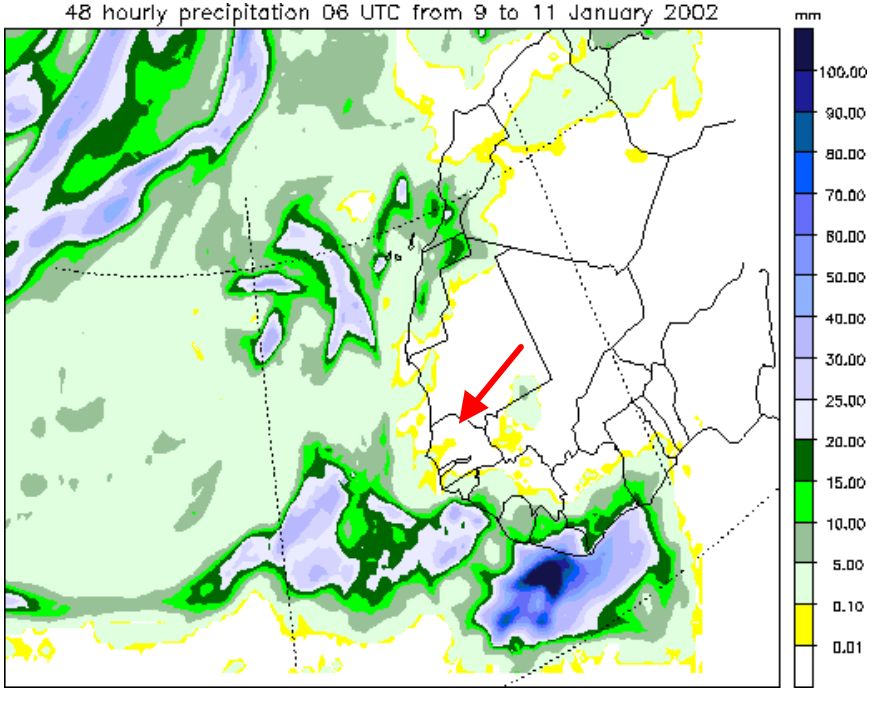
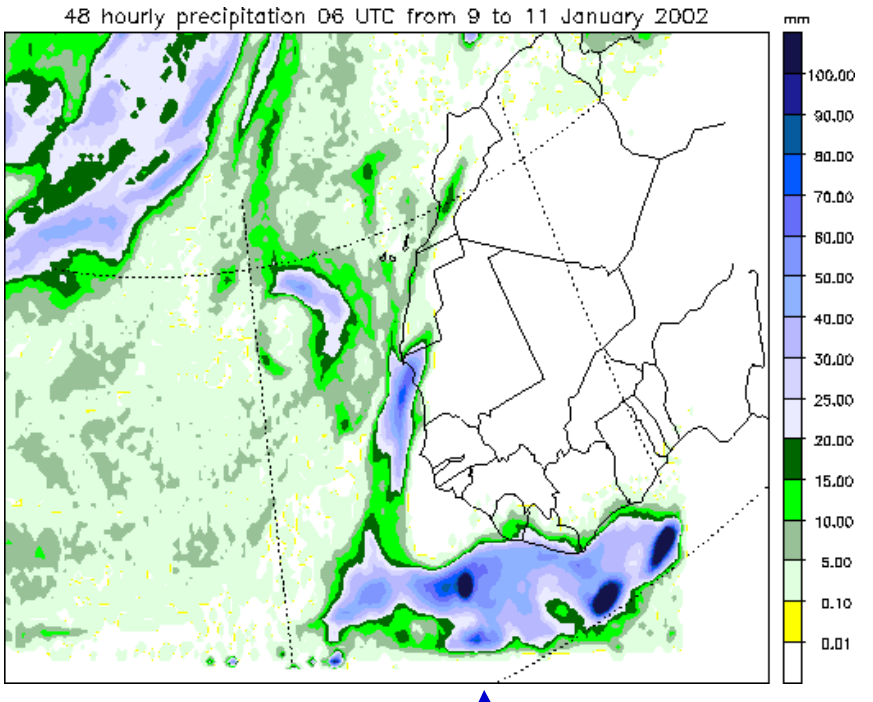
Tiedtke convection scheme, timestep 60 s

graupel scheme,ecmwf



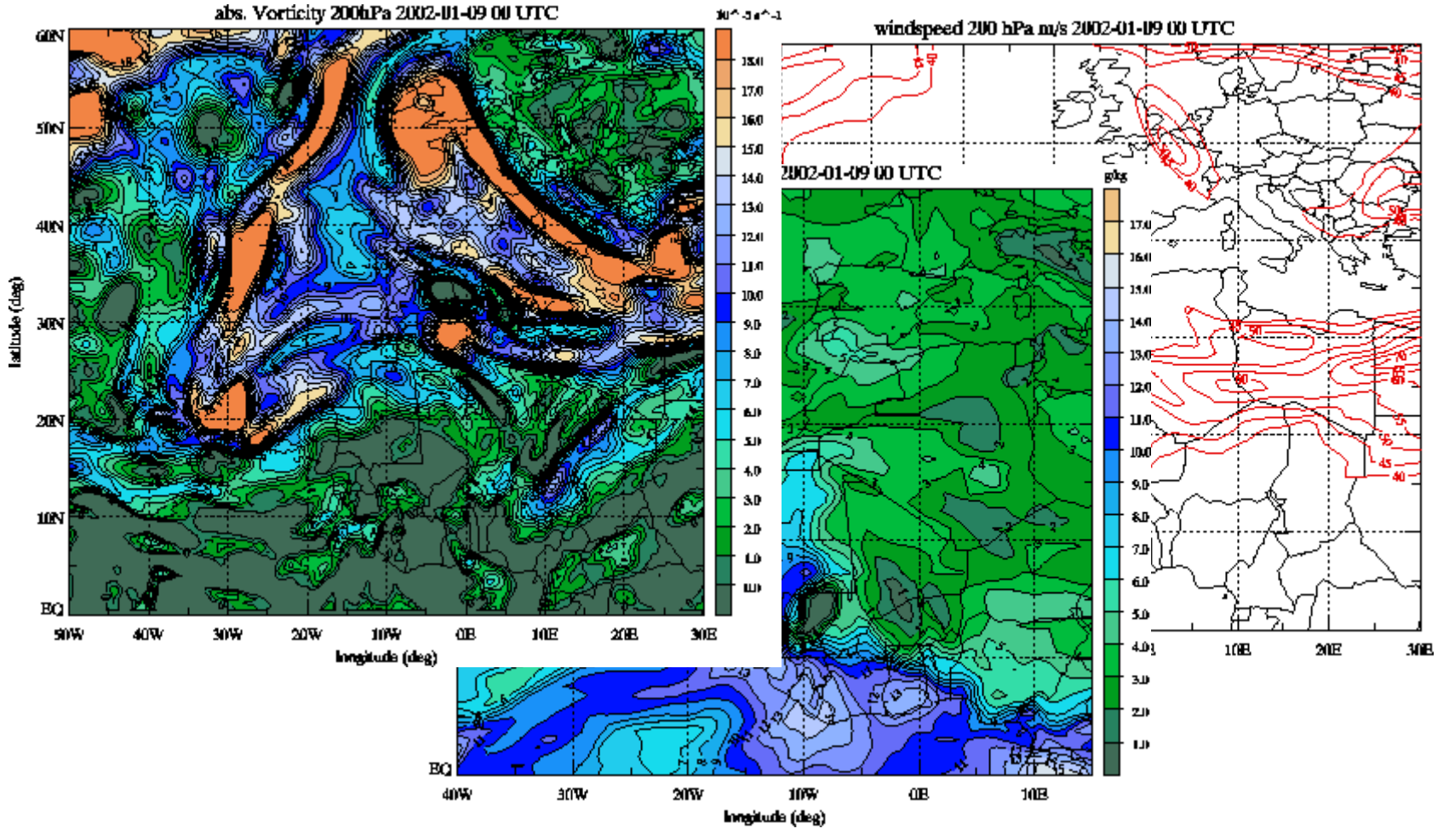


LM-simulation: start 2 January 2002 00 UTC

GME boundary data, cloud ice scheme,

Tiedtke convection scheme, timestep 60 s

ECMWF boundary and initial data, graupel scheme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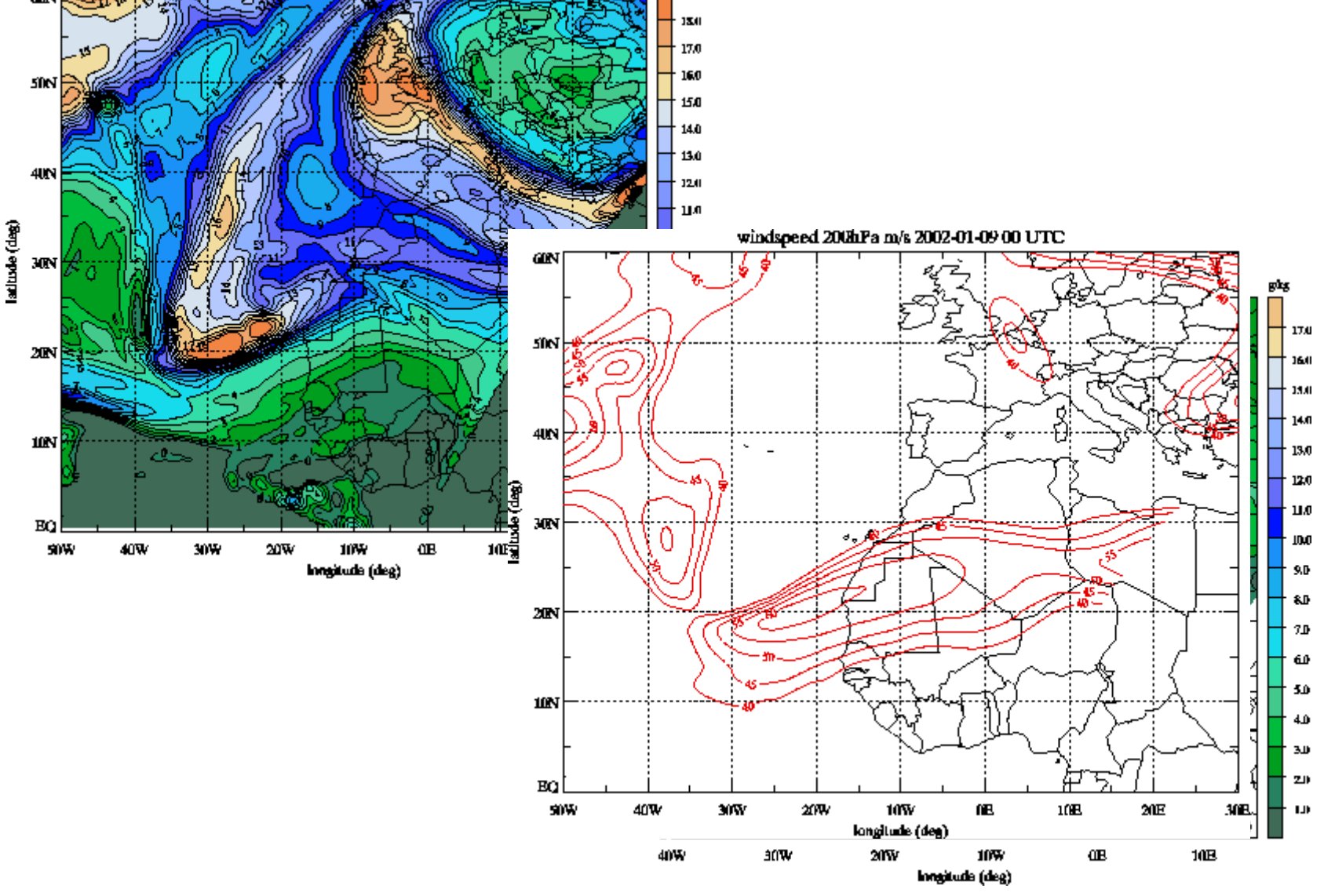
60N
50N
40N
30N
20N
10N
EQ
50W
40W
30W
20W
10W
0E
10E
20E
30E
latitude (deg)
longitude (deg)
windspeed 200 hPa m/s 2002-01-09 00 UTC
2002-01-09 00 UTC
g/kg
10E
20E
30E
EQ
40W
30W
20W
10W
0E
10E
longitude (deg)

Gmeanalyse



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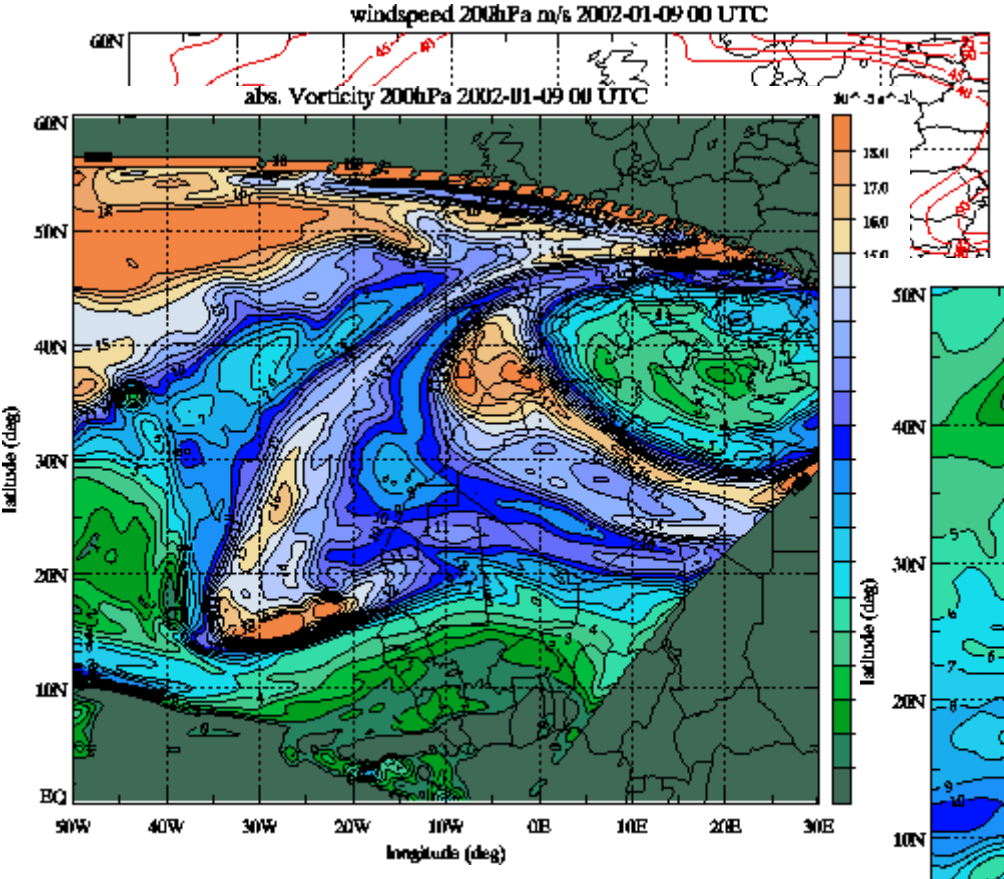
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abs. Vorticity 200hPa 2002-01-09 00 UTC
60N
50N
40N
30N
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10N
EQ
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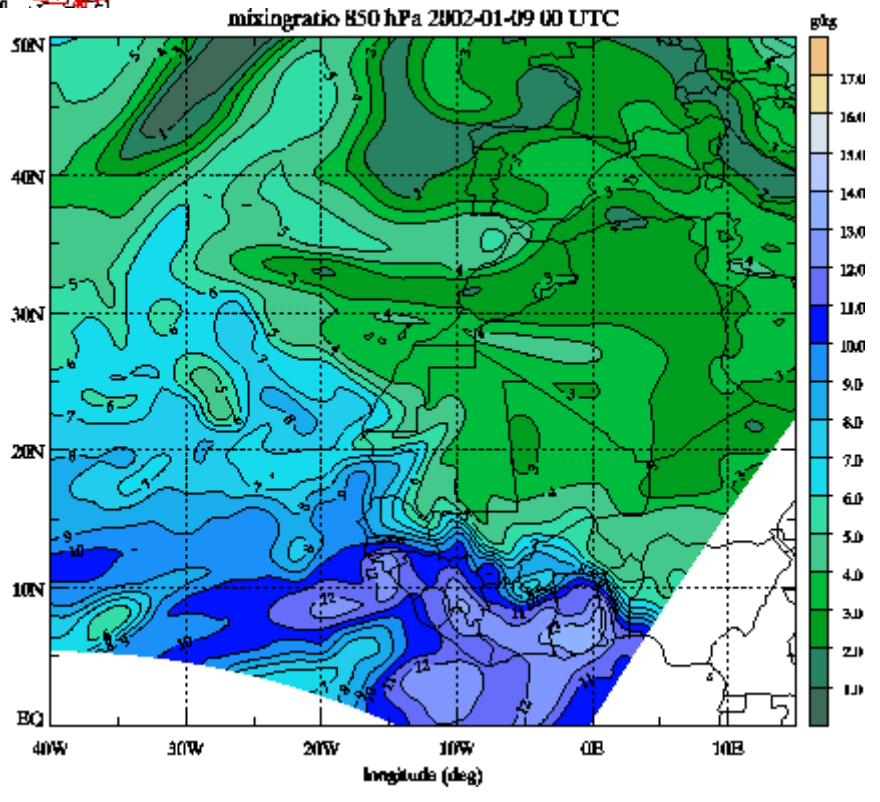
40W
30W
20W
10W
0E
10E
20E
30E
latitude (deg)
longitude (deg)


mixingratio 850 hPa 2002-01-09 00 UTC
g/kg
50N
40N
30N
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EQ
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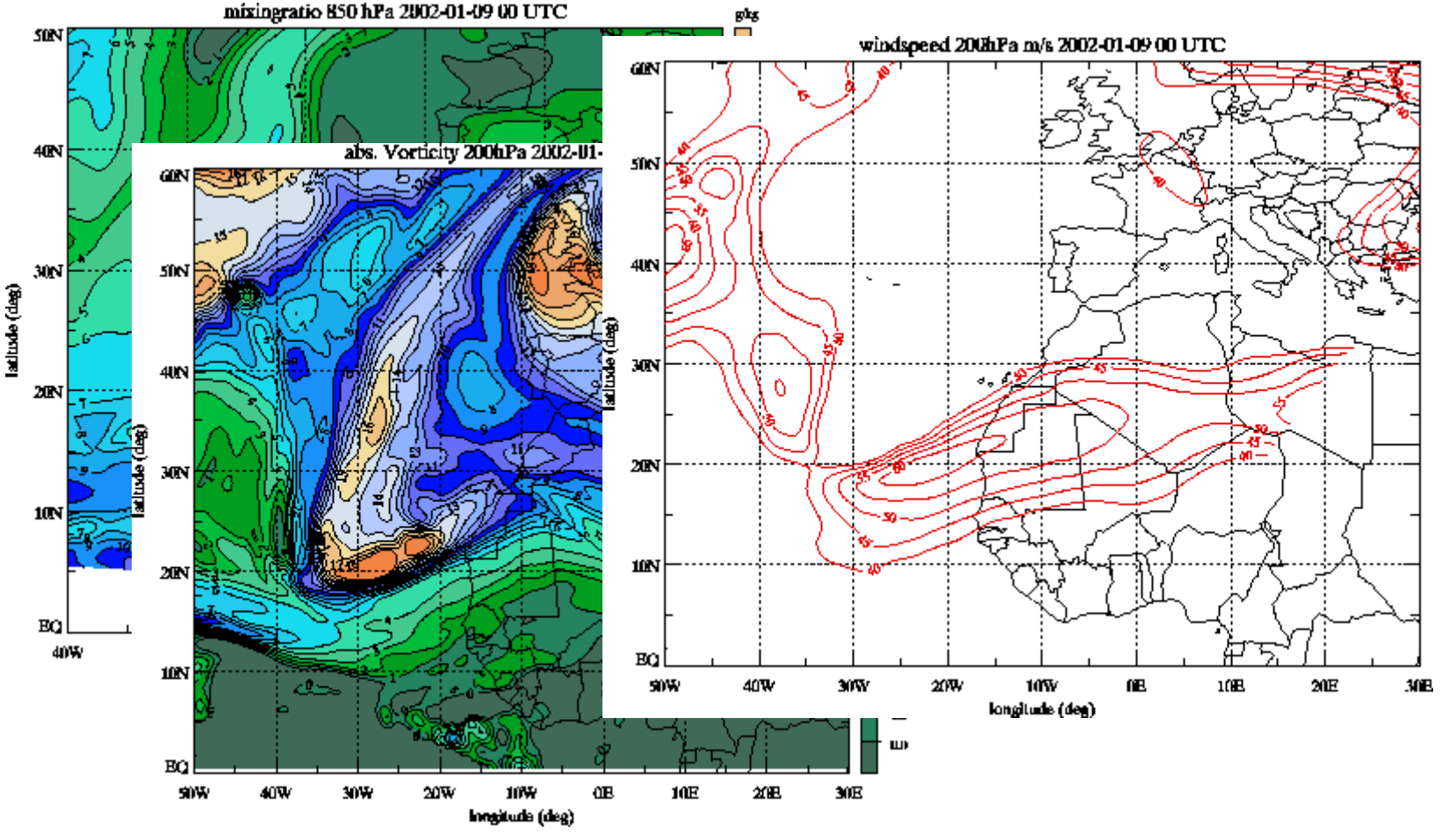
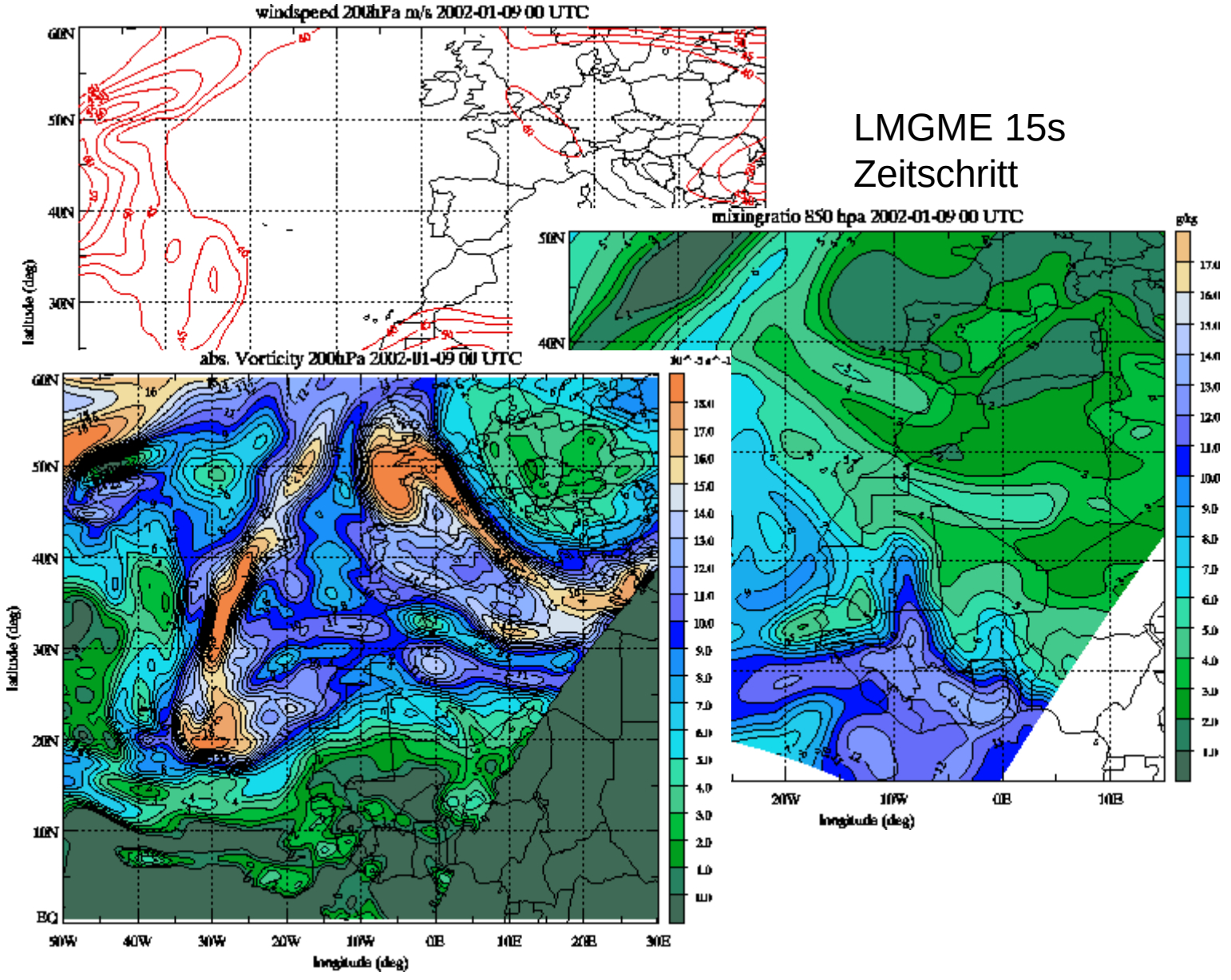
0E
10E
latitude (deg)
longitude (deg)

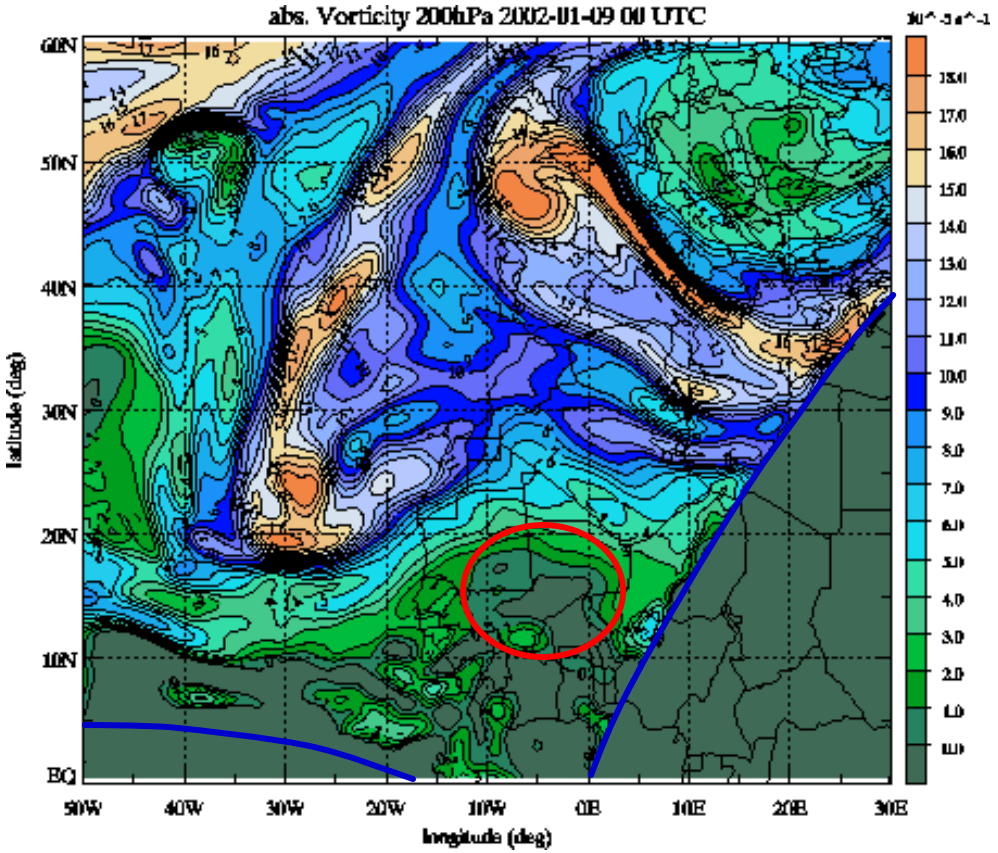
gmedefault



ecmwfdefault



LMGME 15s Zeitschritt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60N
50N
40N
30N
20N
10N
EQ
50W
40W
30W
20W
10W
0E
10E
20E
30E
latitude (deg)
longitude (deg)
10^-5 s^-1
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
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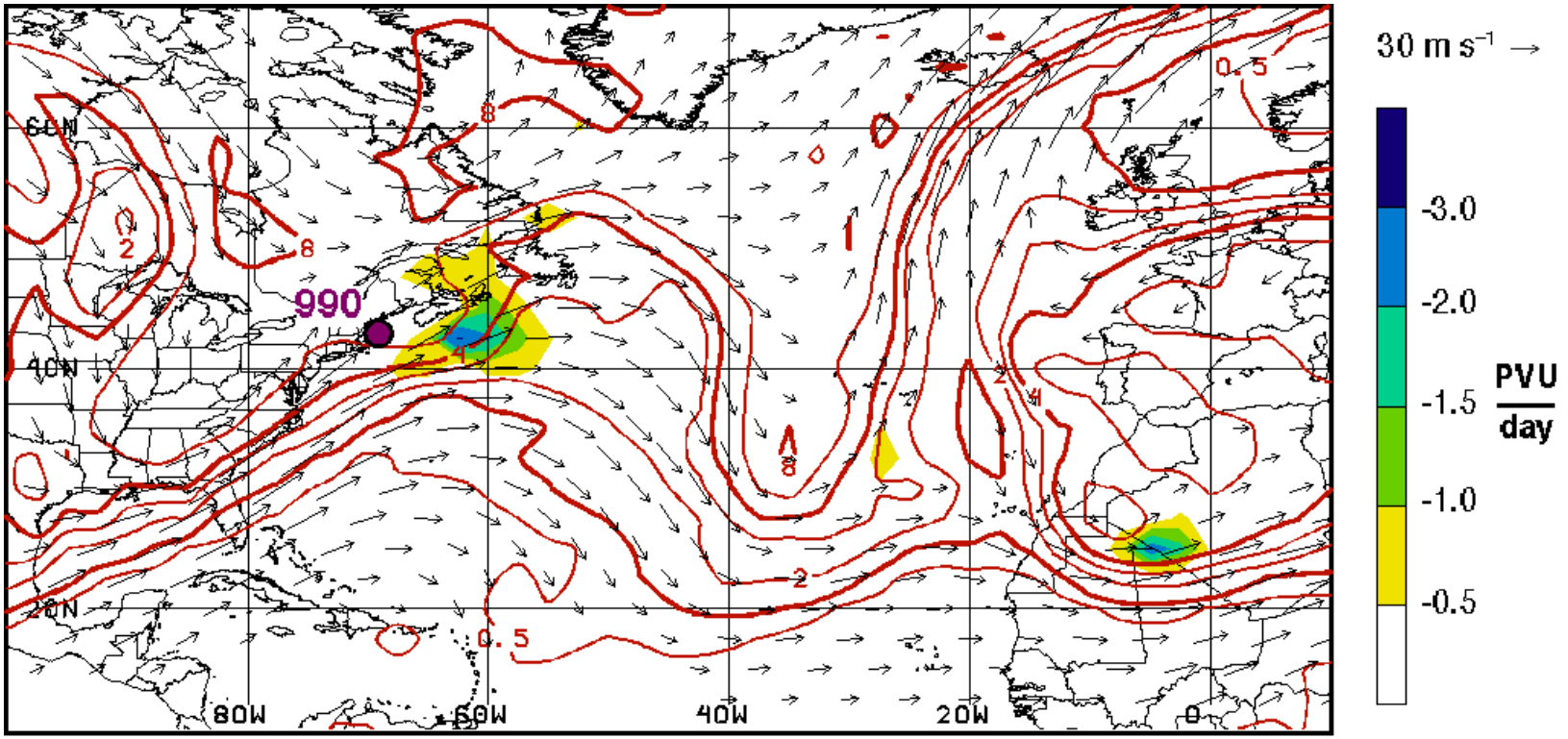
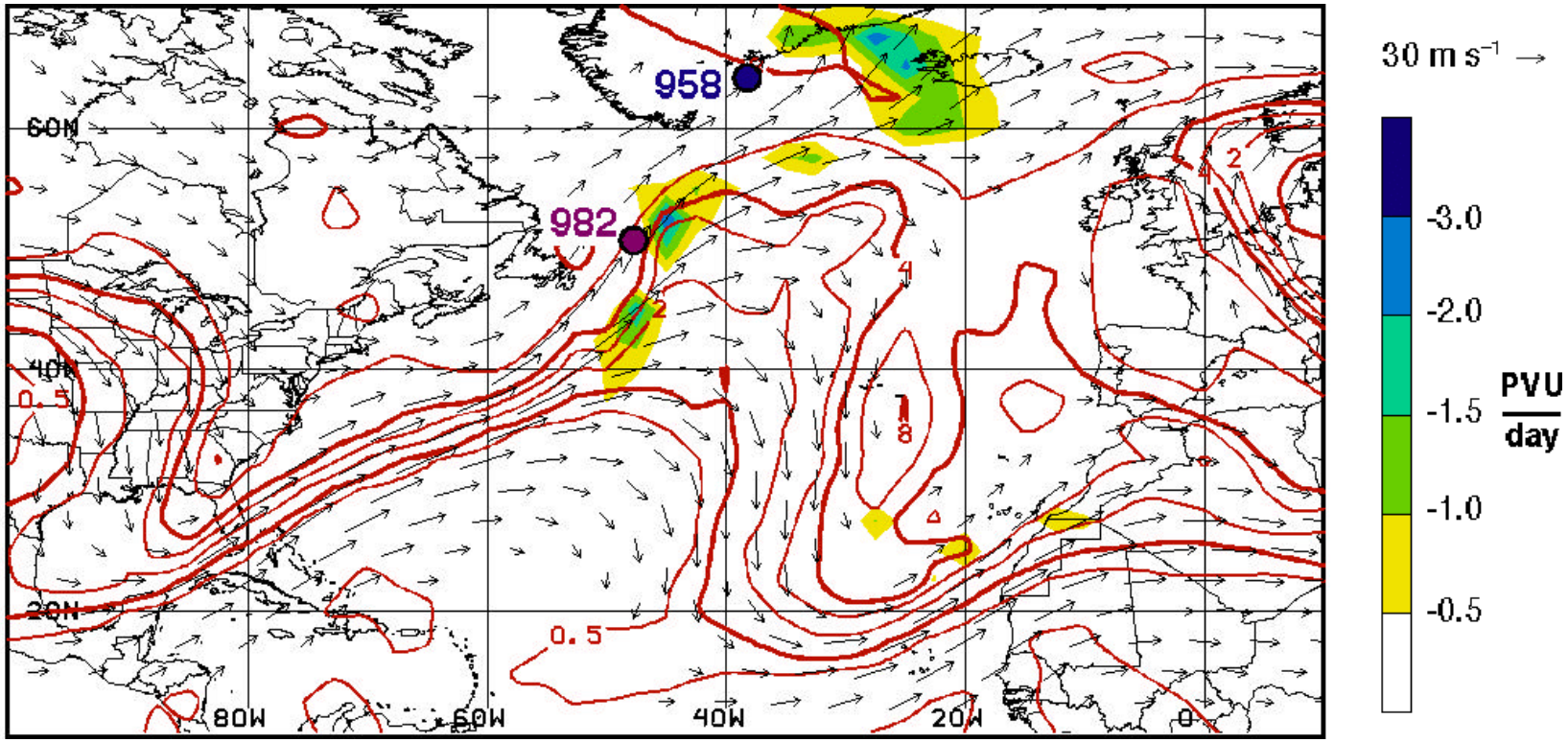
1.0
0.0

PV, diabatic PV tendencies & wind at 335 K

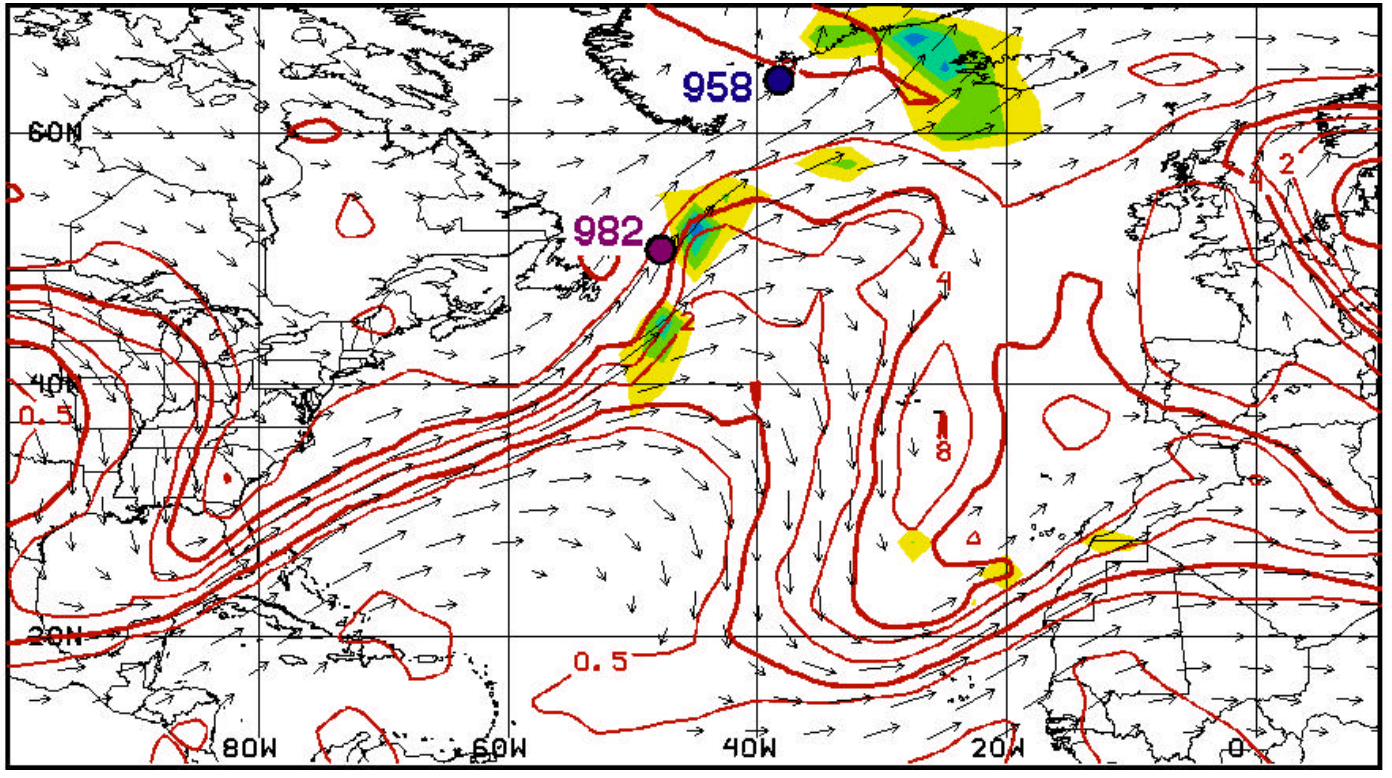


12 UTC, January 07, 2002

PV, diabatic PV tendencies & wind at 335 K



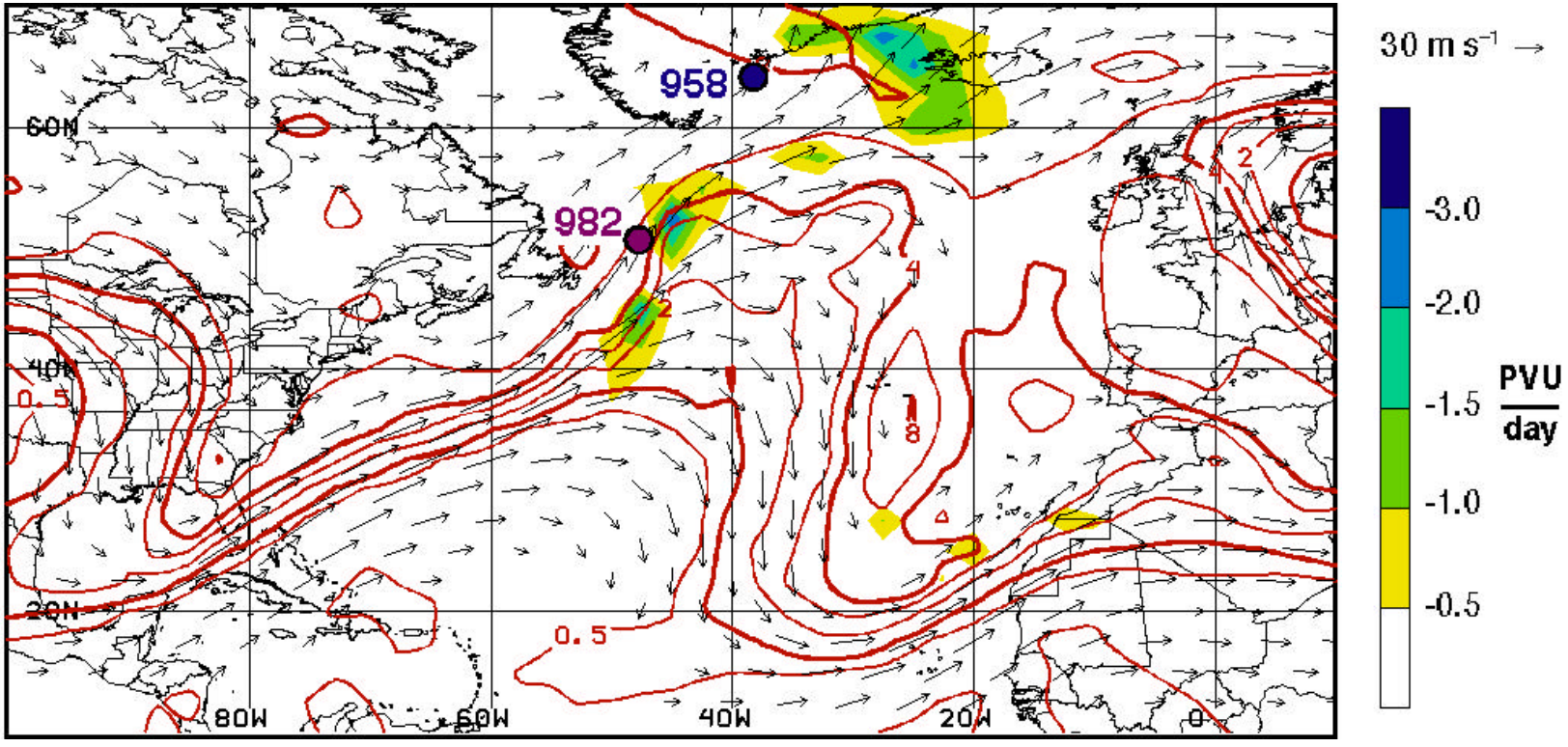
00 UTC, January 09, 2002



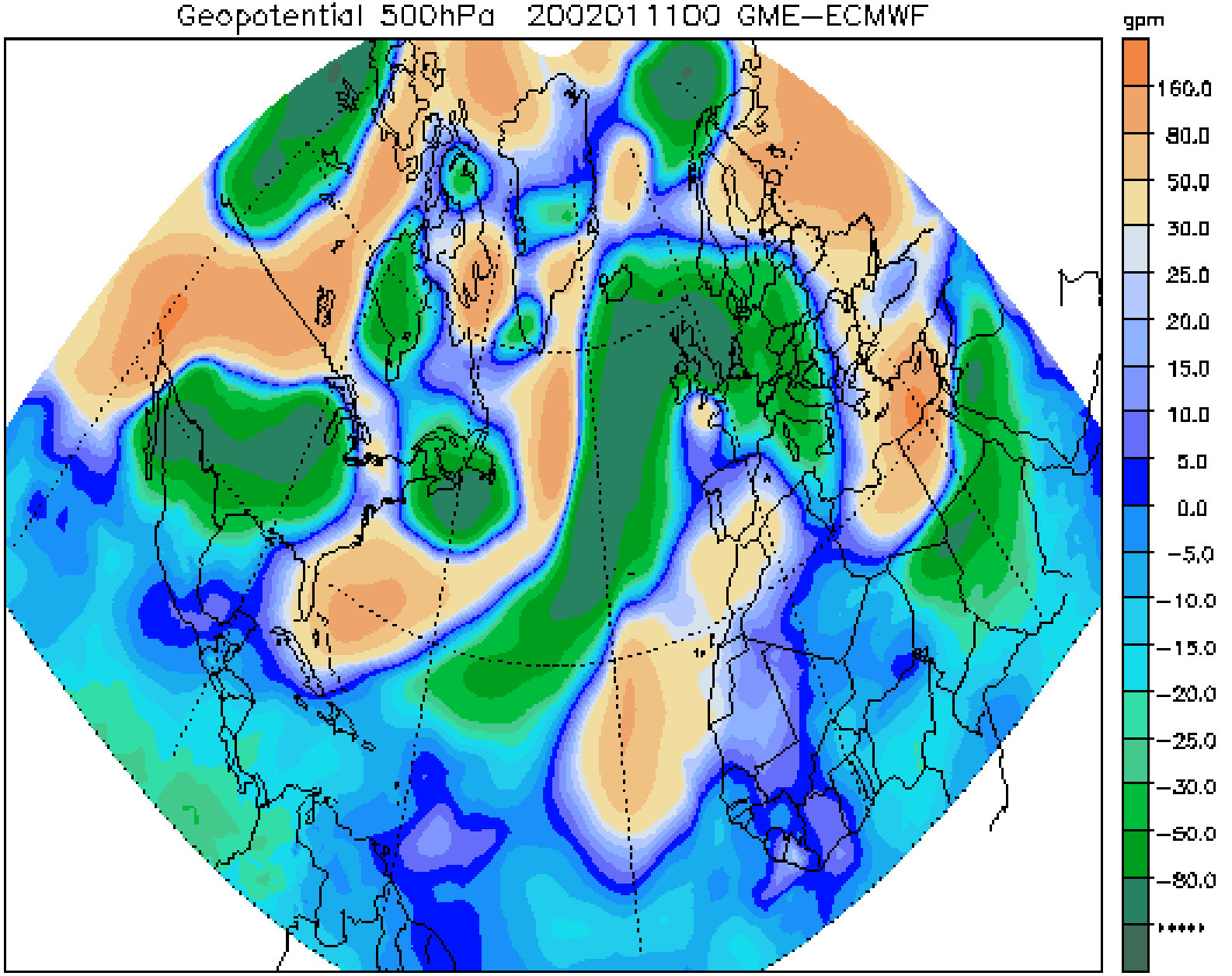
00 UTC, January 09, 2002

Trough 2 - PV Evolution

PV, diabatic PV tendencies & wind at 335 K



00 UTC, January 09, 2002


Geopotential 500hPa 2002011100 GME–ECMWF
gpm
160.0
80.0
50.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
–5.0
–10.0
–15.0
–20.0
–25.0
–30.0
–50.0
–80.0