



# QPF by Finite Volume Z Discretisation

J. Steppeler, DWD, H.W. Bitzer, AGeoBW and L. Torrisi, Italian Nat.  
Met. Centre  
Langen 2006

## Plan of Lecture

- State of the project LM-z
- Some tests of Z-coordiante shaved element model
- 24 h precipitation sums
- Vertical velocities, spin up and 6 h precipitation sums

# State of the COSMO priority project LM-z Euler Version



- **Version 1.4:** Euler version, preliminary physics interface, real data forecasts possible with reduced timestep
- Extensive experimentation with Version 3.14, forecast time 30 h,  $dx=7$  km available (39 cases)
- **To be done in 2006:** Longer integrations with coarser resolutions, Cloud resolving resolutions ( 2 km)
- **To be done in 2006:** Version 1.5, improved physics interface (linear interpolation)
- **To be done in 2006:** Version 1.6: avoiding grid separation
- **To be done in 2006:** Version 1.7: Using increased (operational LM) timestep

# State of the COSMO priority project LM-z Semi Lagrangian Version



- **Current status:** One program library with Euler Version  
Planned to be available with future versions
- 3-d tests successful
- **To be done in 2006:** real data case



## Features of the LM-z - Overview

### **Dynamics and Numerics**

- Advection Form
- Prognostic Variables:  $u, v, w, T, q_v, q_c, (q_i, q_{tke}, q_r, q_s)$
- Coordinates: Rotated Lat-Lon, z-coordinate
- Arakawa C / Lorenz Grid Staggering
- 2nd Order Centred Differencing
- Semi Lagrangian option
- Leapfrog / Split explicit Time Integration (HE-VI)
- Numerical Smoothing: 4th Order Horizontal Diffusion, Rayleigh Damping, 3-D Divergence Damping

## Features of the LM-z - Overview

### **Physical Parameterization as in LM**

- Version 1.4: Interface based on cubic spline interpolation
- Version 1.5: Interface based on linear interpolation (resulting in improved surface forecasts)
- Version 1.6: Defining the physics grid to contain the z-grid as a subgrid (avoid grid separation)

## Features of the LM - Overview

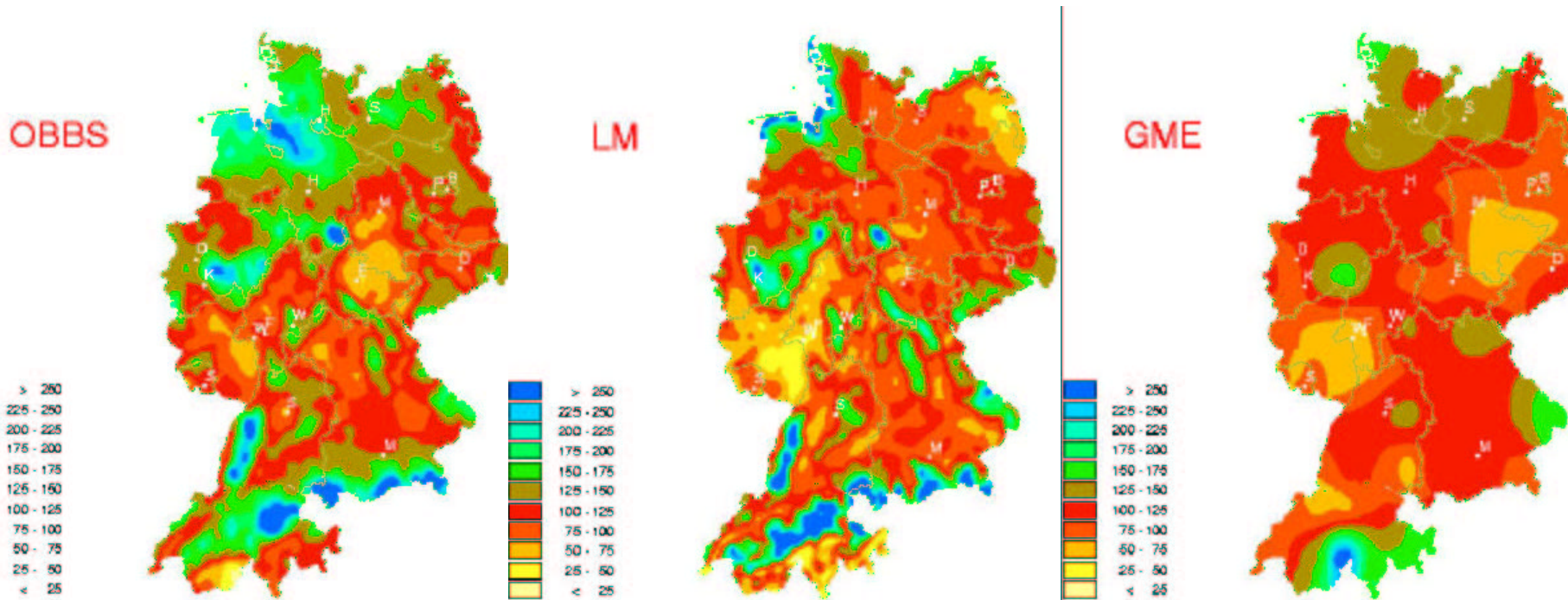
### **Boundary Conditions**

- The interpolation to the z-grid is done internally. LM-z runs from the same files as LM. However, an orography specially prepared for LM-z has to be used.

### **Initial Conditions**

- A simple nudging interface exists but is not tested currently.

# Monthly Precipitation Sum for September 2001





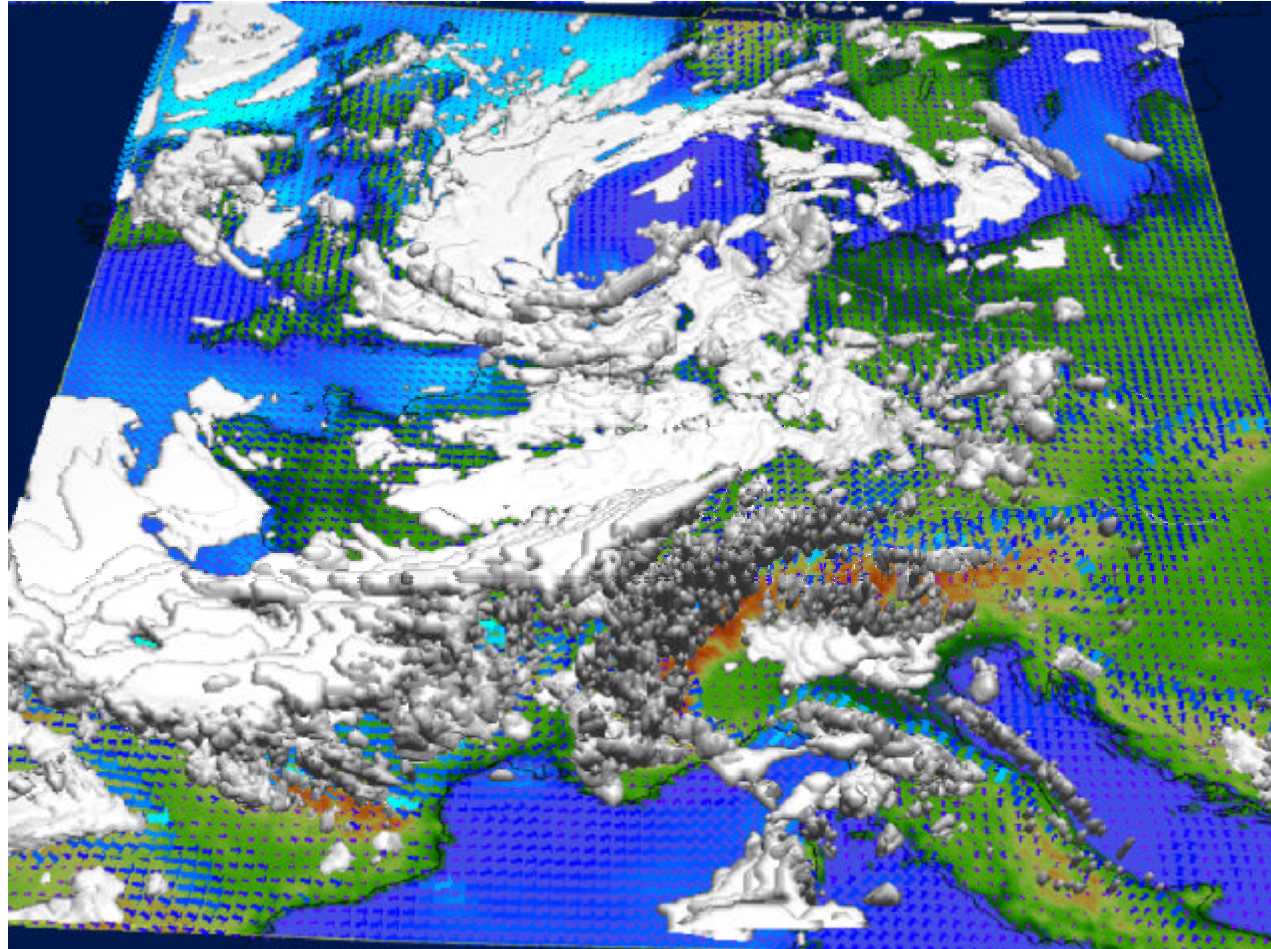
## Proposal for consideration:

- LM-tf shows more structure than supported by observations.
- Mesoscale structures may be weaker with LM-tf than observations.
- Point maxima may be higher with LM-tf than observed.

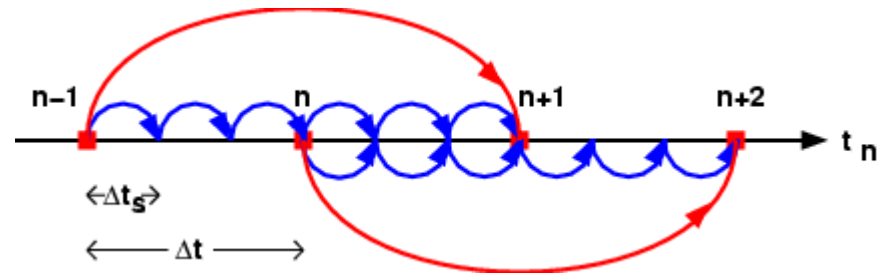
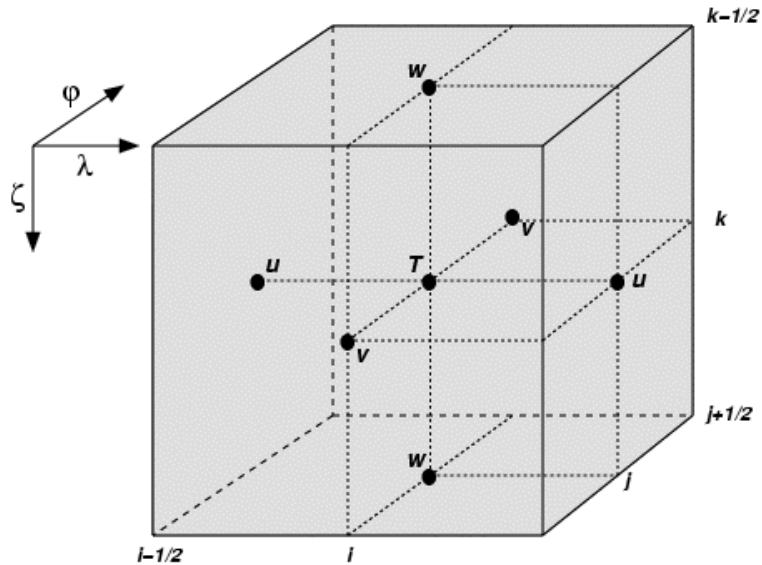
## 3-D Cloud-Picture

18 January 1998

The mountain related bias of convective clouds and precipitation is supposed to disappear with the Z-coordinate

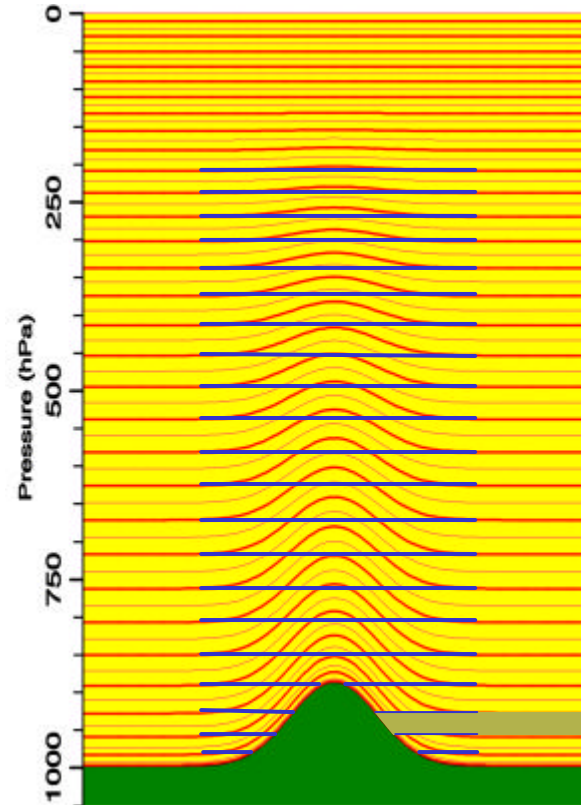
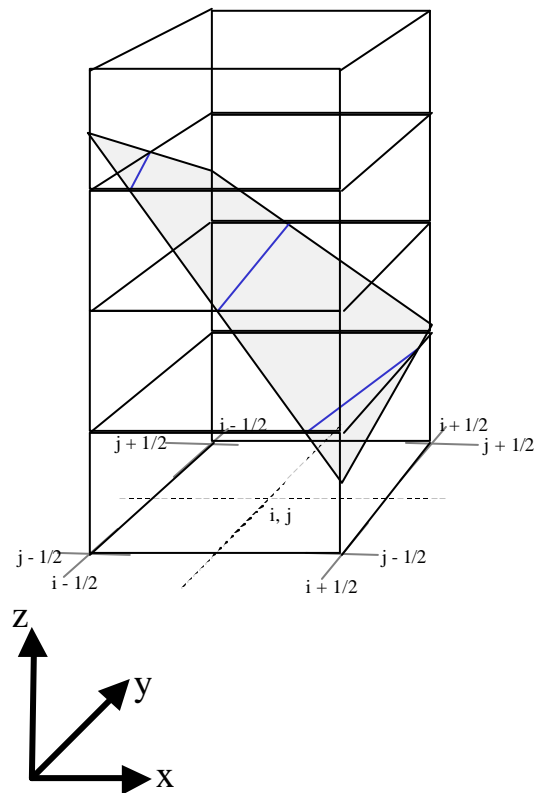


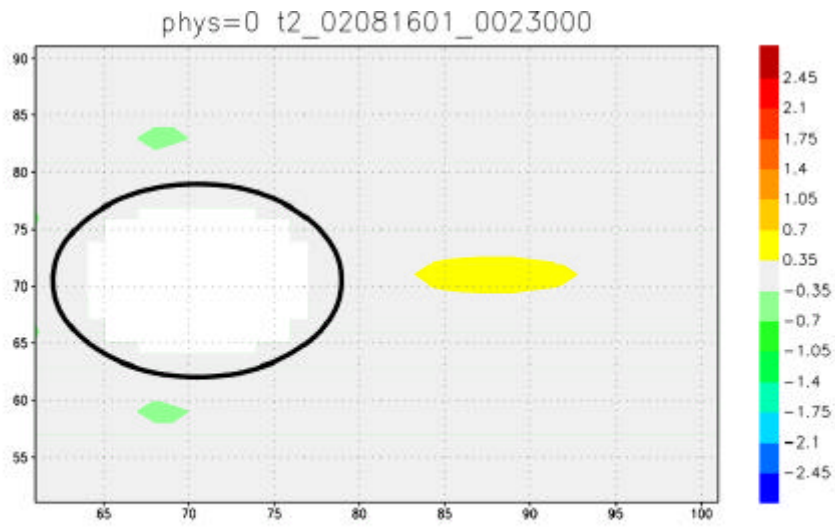
# Grid Structure and Time Integration



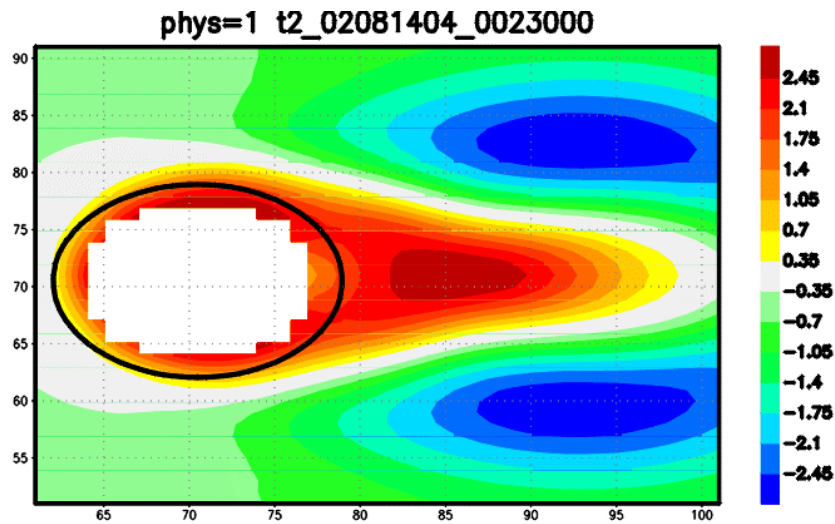
$$\frac{\partial \mathbf{f}}{\partial t} = \mathbf{F} + \mathbf{S}$$

# Cut cells in 3-d and layer structure



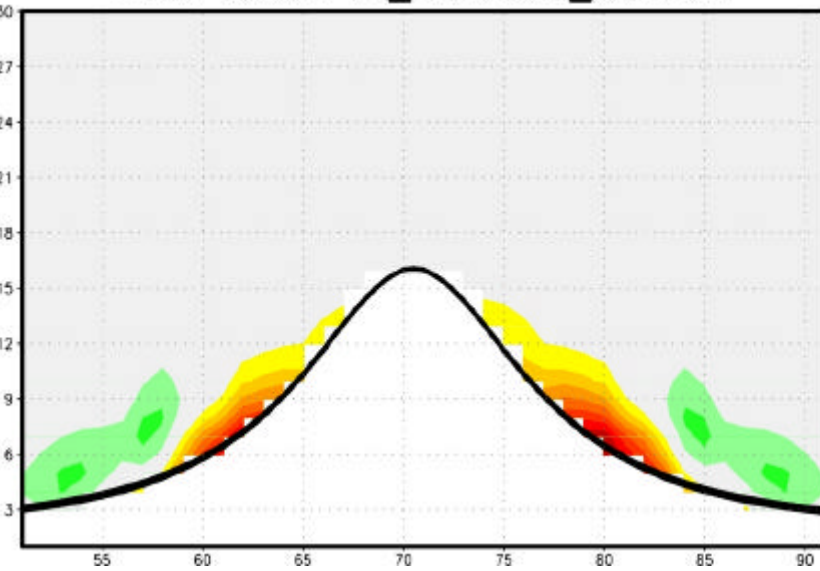


NO physics



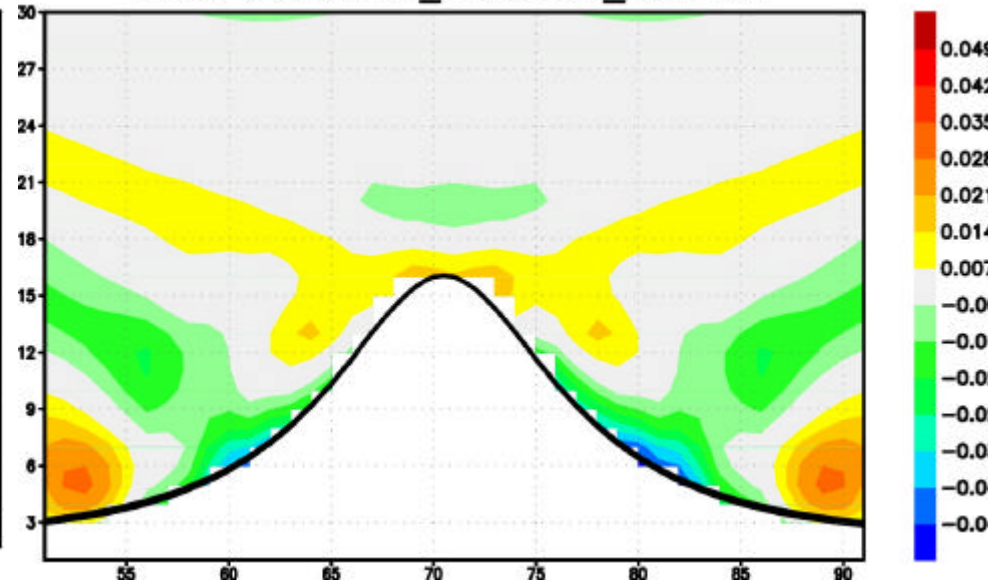
„dry“ Physics

moun 2300m w1\_02092301\_0020000



Day

moun 2300m w1\_02092302\_0020000

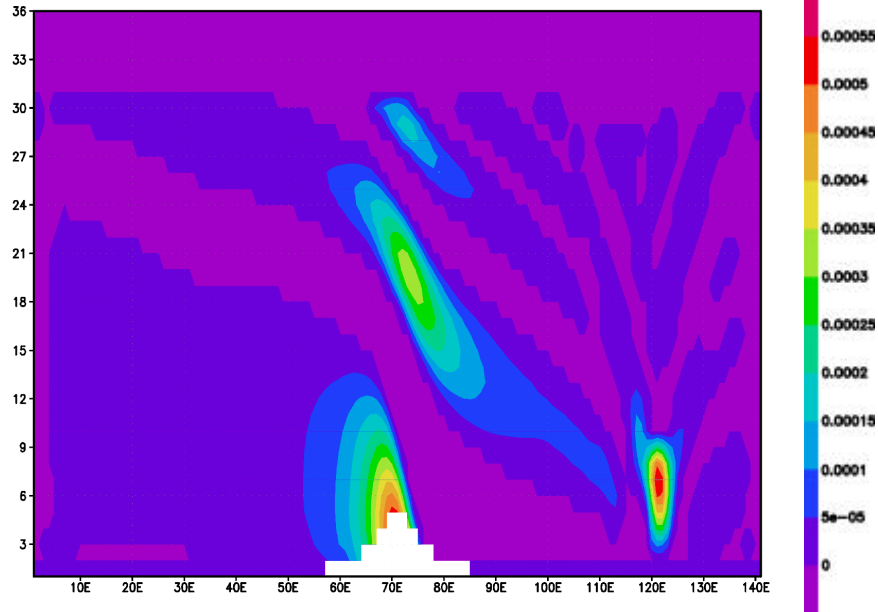


Night

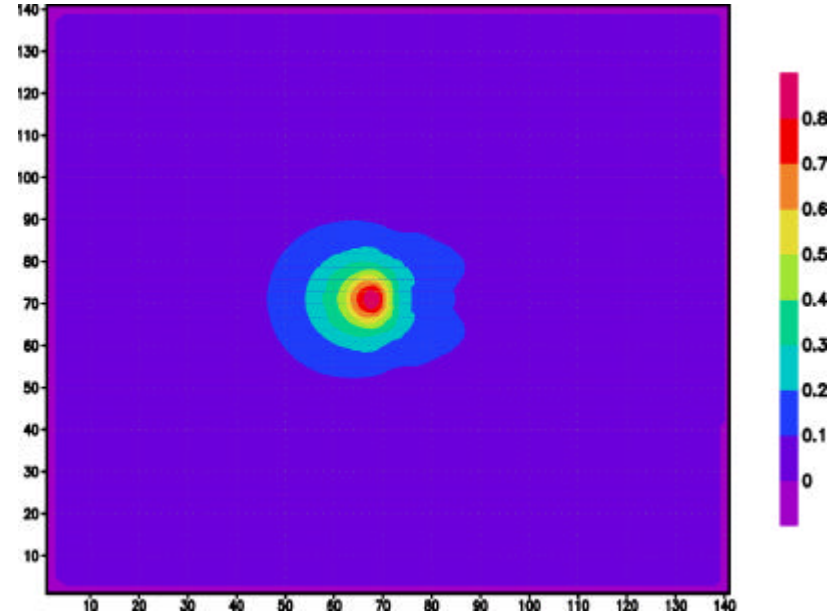
The Atmosphere at Rest Computed with the Z\_LM



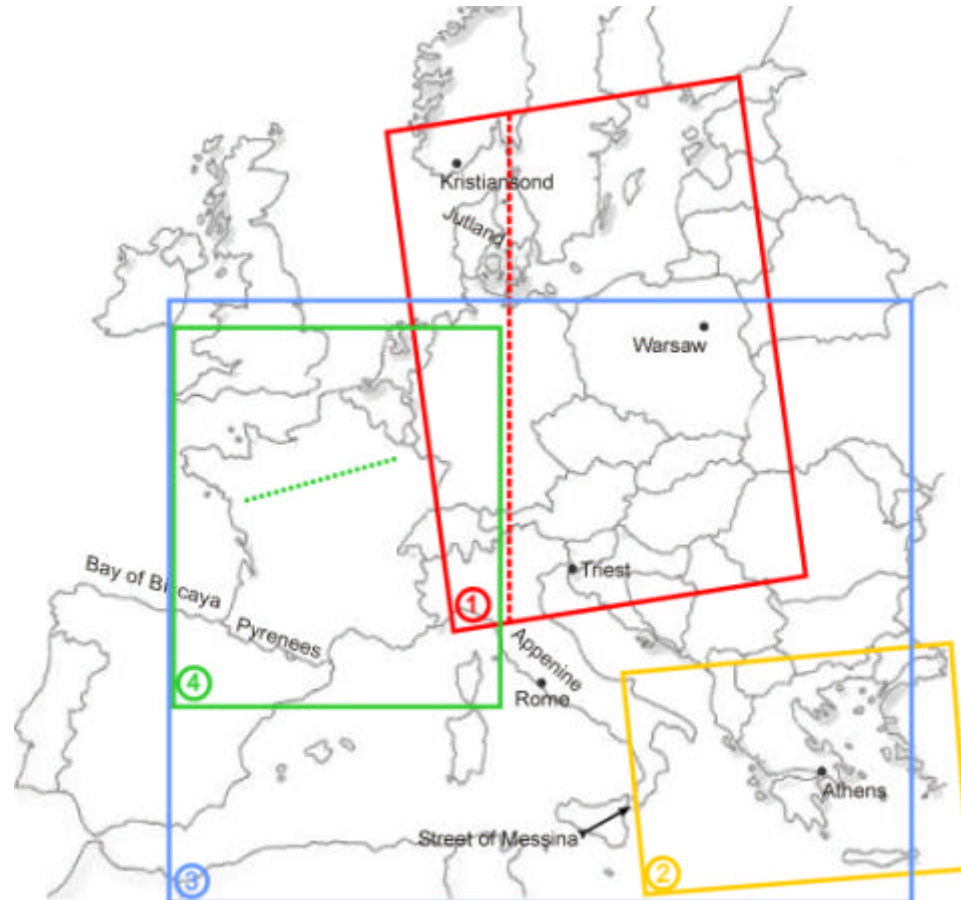
## Cloud water



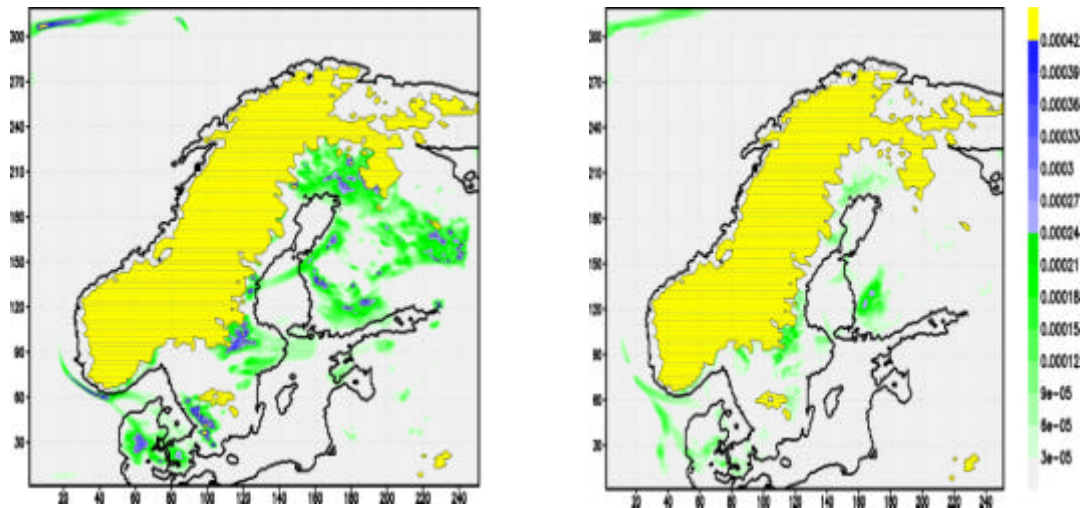
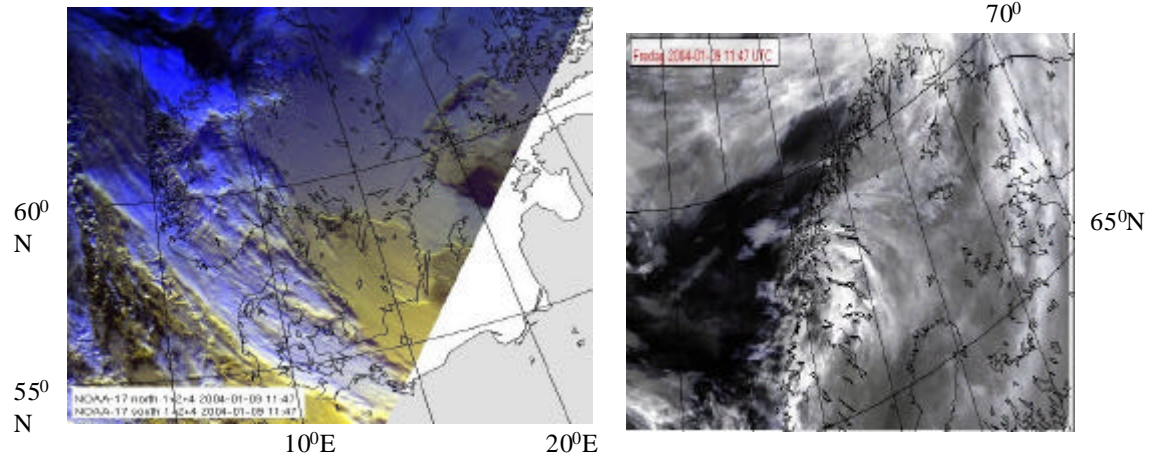
## Precipitation



# Test areas



# The Scandinavia case



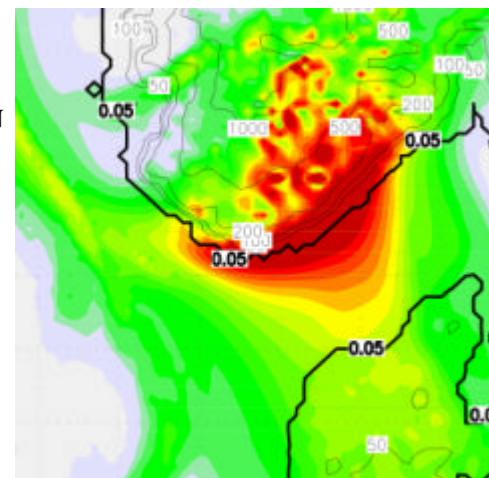
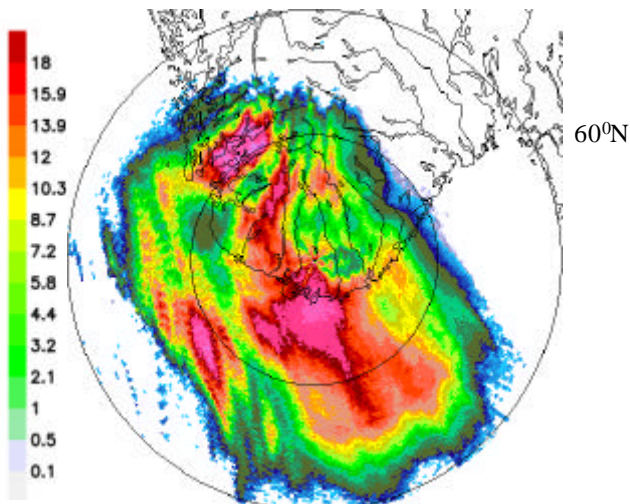
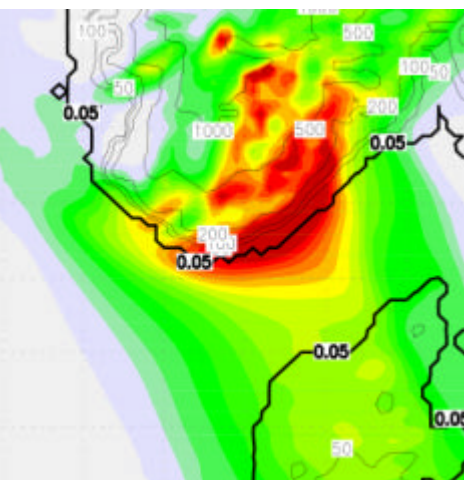
# Precipitation 9 January 2004



LM-z

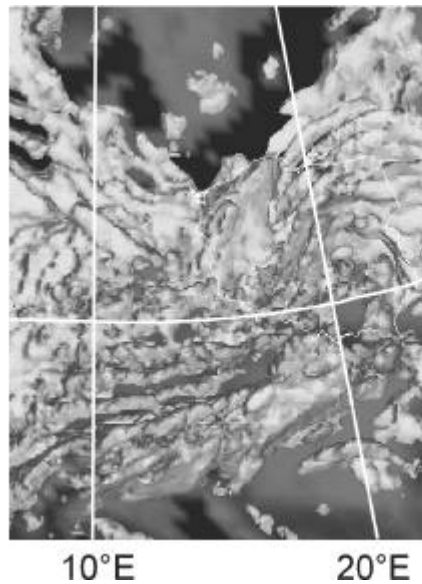
OBS

LM-tf

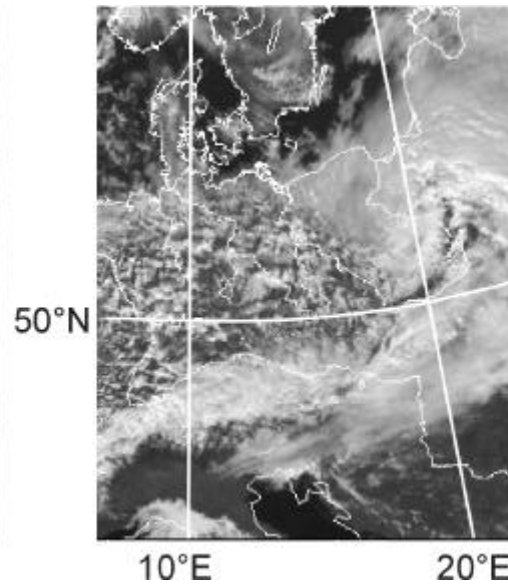


10°E

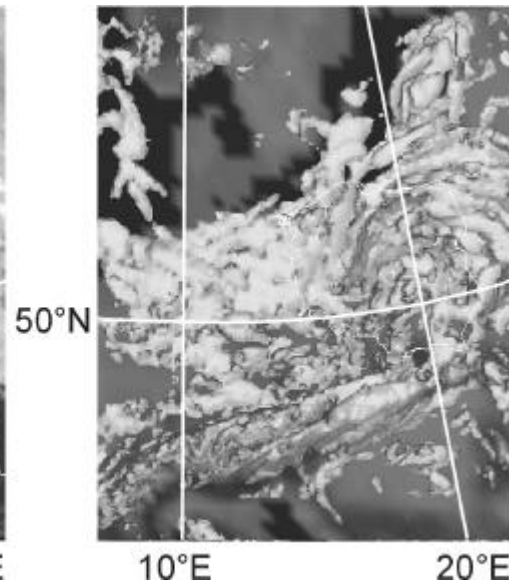
# 12 h Cloud forecasts 28 March 1997



LM-Z

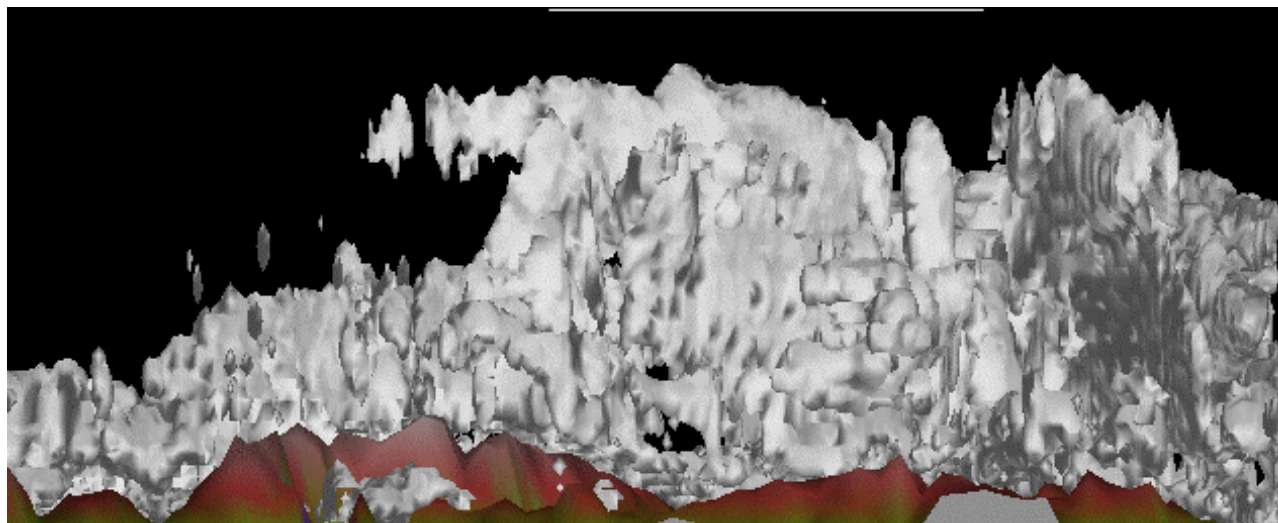


OBS

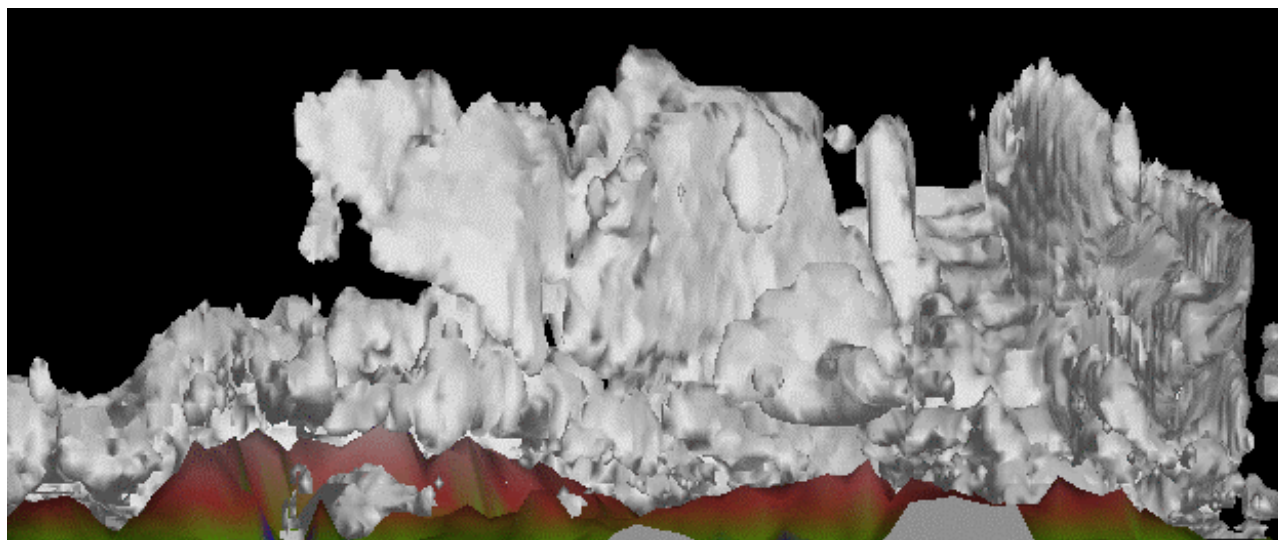


LM-tf

# 12 hr cloud forecasts seen from south, 28 March 1997

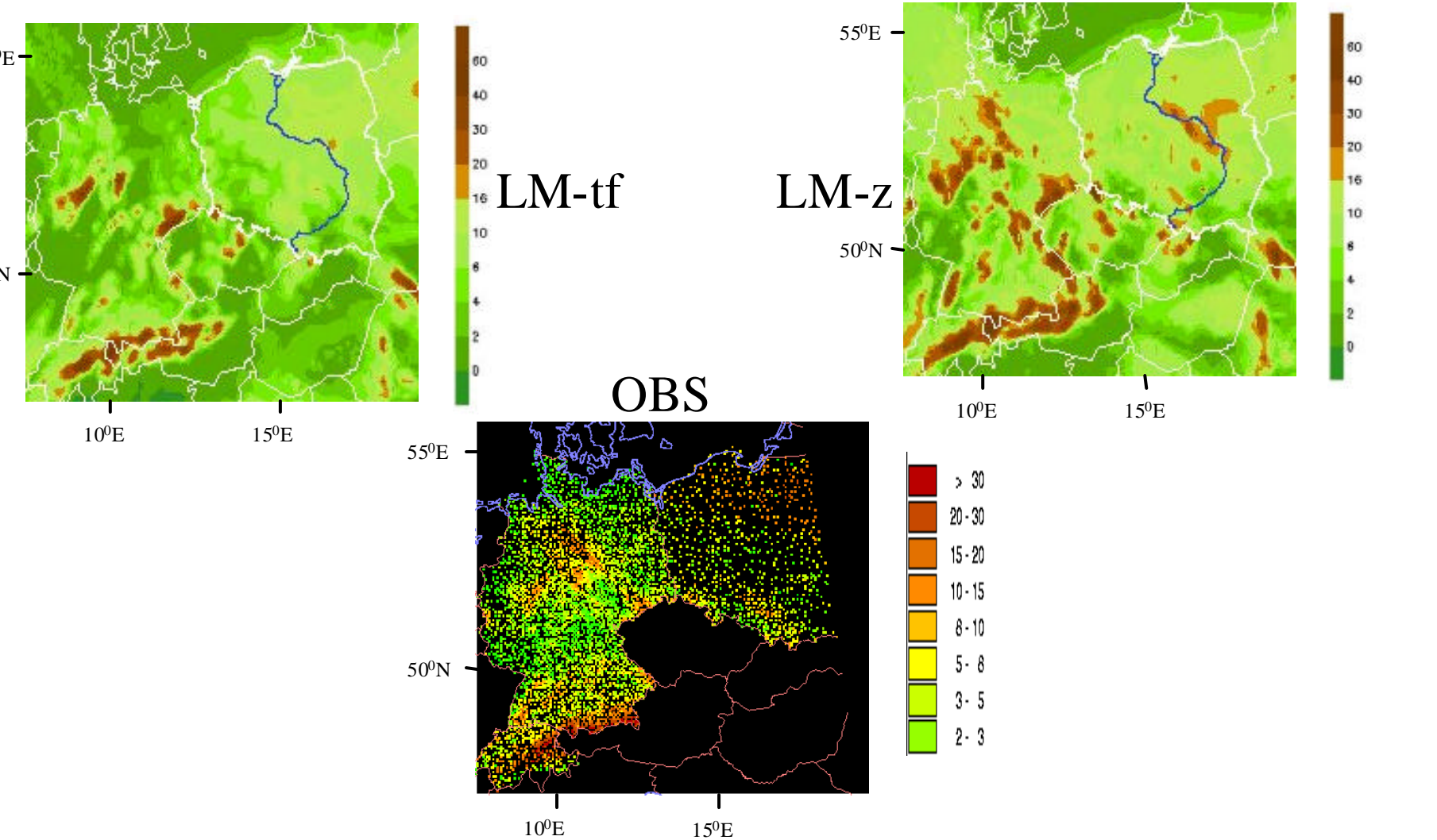


LM-tf



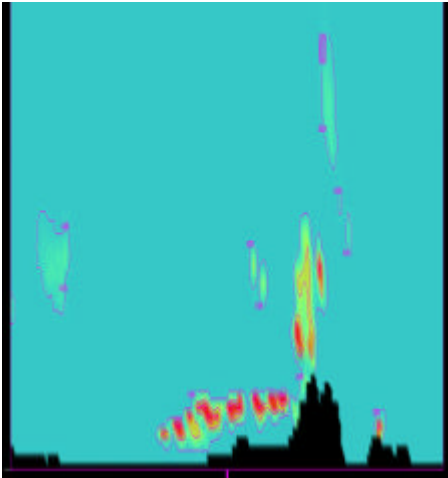
LM-z

# Precipitation 29 March 1997 06 - 28 March 1997 06

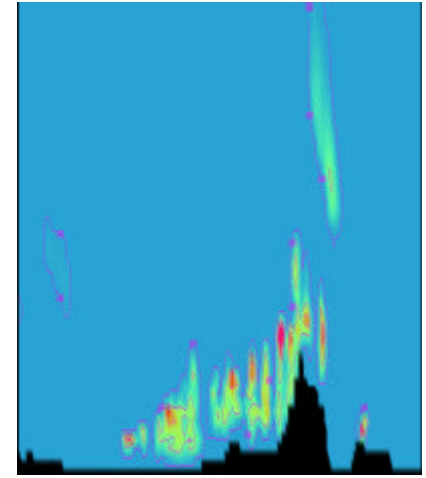




# 12 h forecast 28 March 1997, North South cross section for cloud water



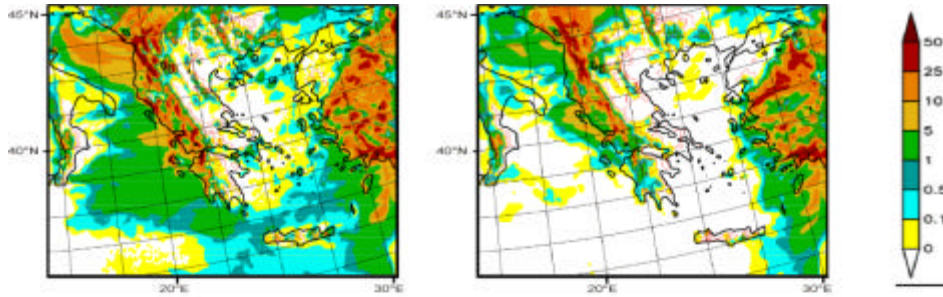
LM-tf



LM-z

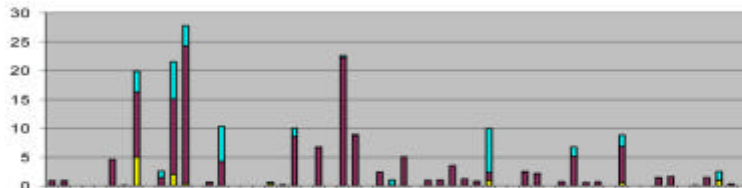


# Forecasts of the Athens area

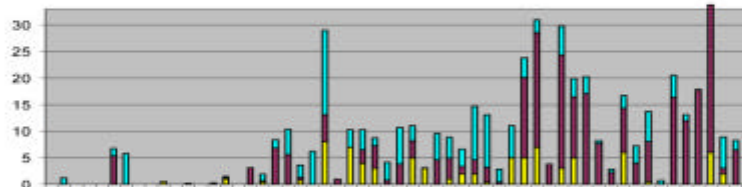


6 March 2005 12 h accumulated precipitation

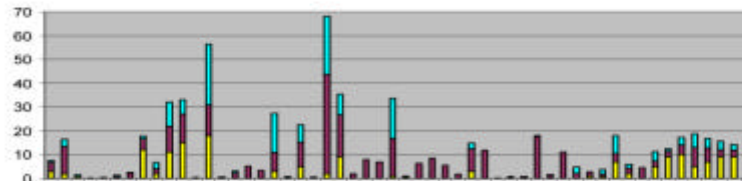
left: LM-tf, right: LM-z



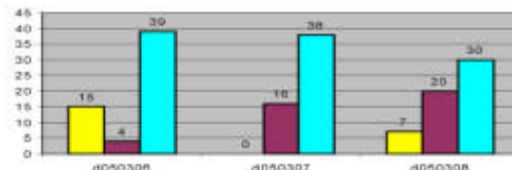
6 March 2005



7 March 2005



8 March 2005



Number of cases where LM-tf (red) or LM-z (blue) has better precipitation forecast

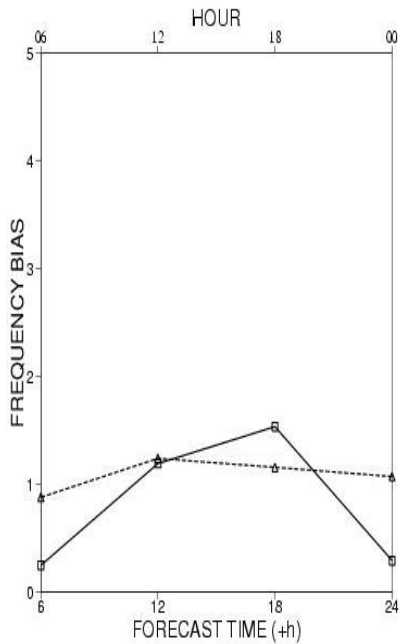
Observations (yellow) and forecasts of 12 h precipitation sums with LM-tf (red) and LM-z (blue)



## Cases using the Rome model area

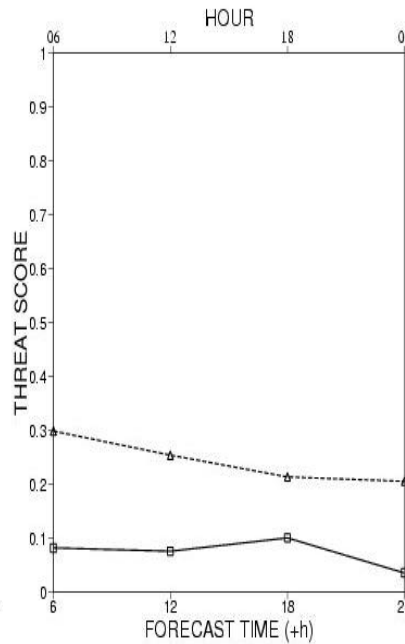
- 35 cases: 25 March 2005 to 29 March 2005 and 23 April 2005 to 22 May 2005
- $D_x = 7$  km
- Initial and boundary values from IfS

# Rome are cases: Surface verification, 35 cases



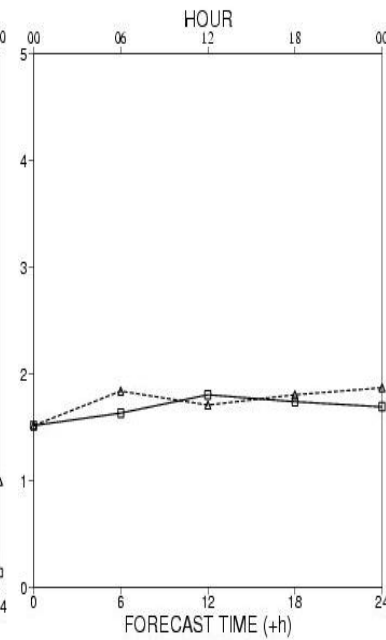
Frequency

Bias



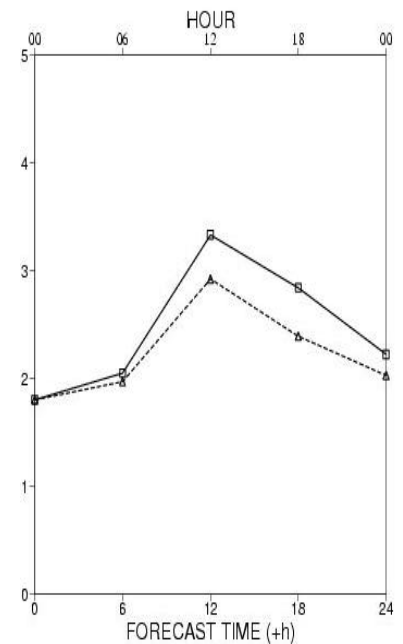
Threat score

2 mm



RMS

10 m wind

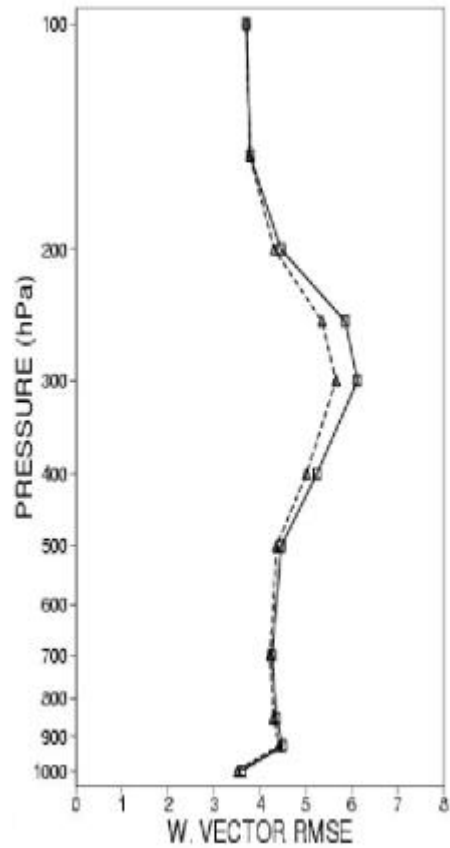


RMS

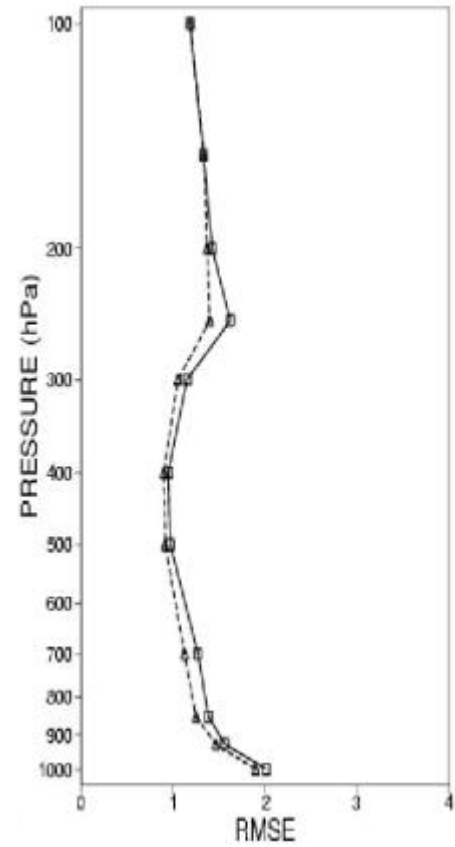
2 m Temperature



# RMS against Radiosondes



Wind



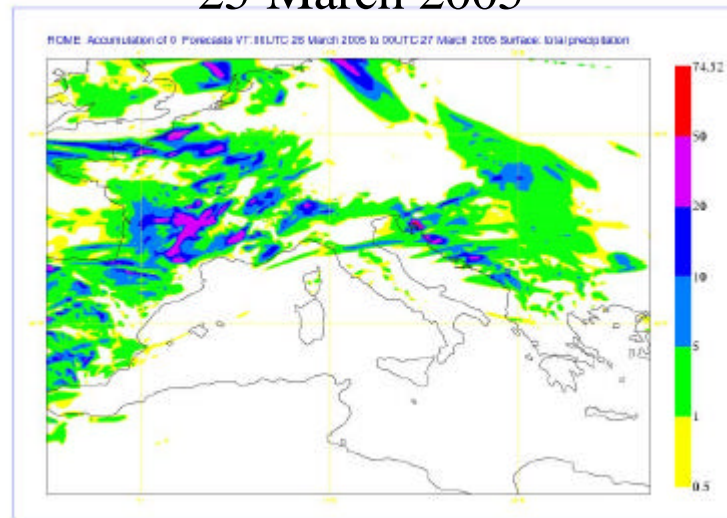
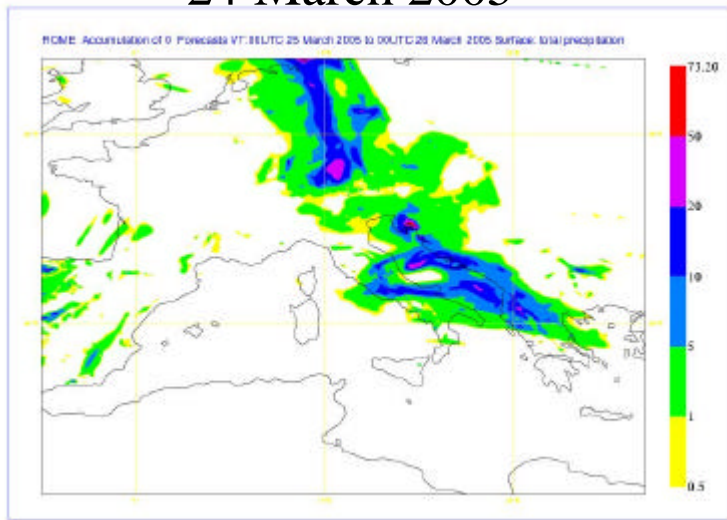
Temperature

# 24 h precipitation sums

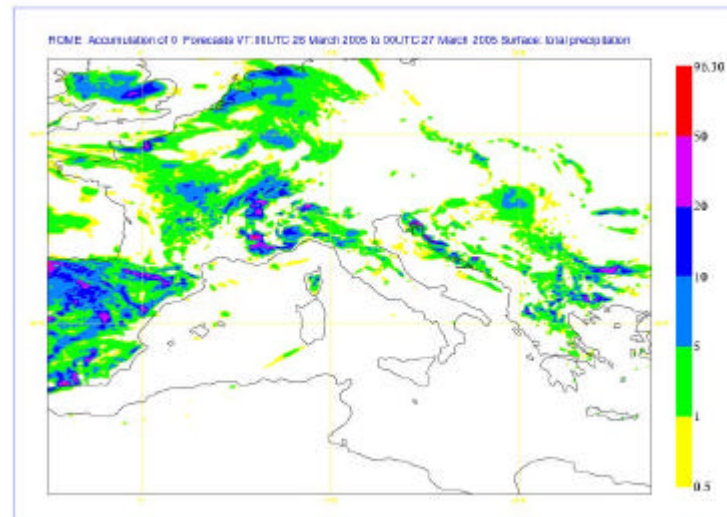
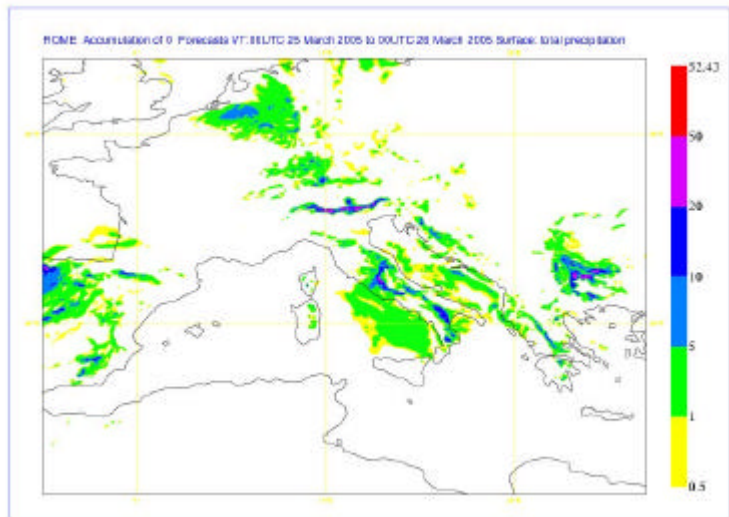


24 March 2005

25 March 2005



LM-z



LM

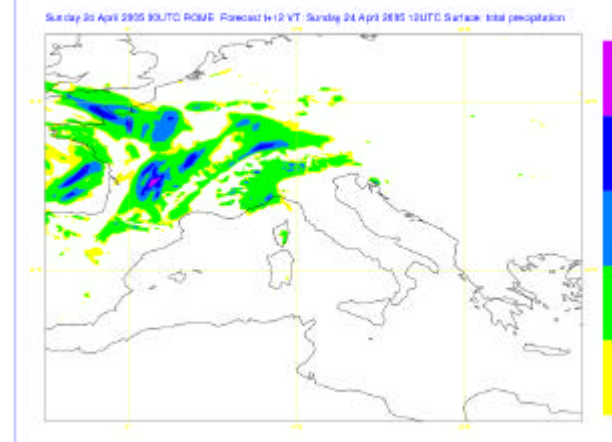
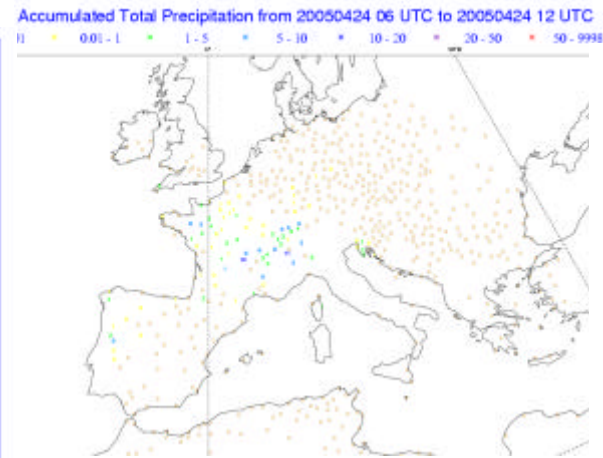
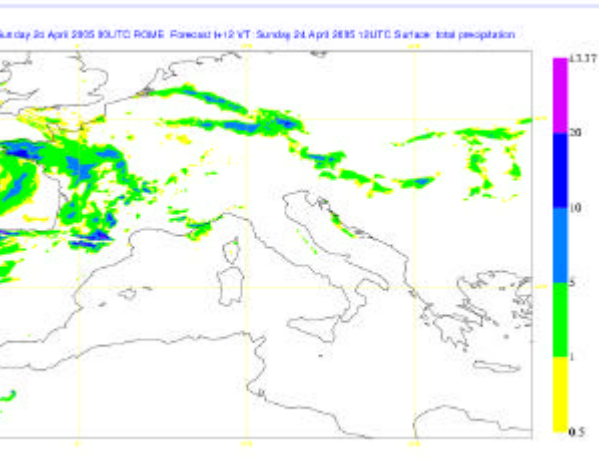
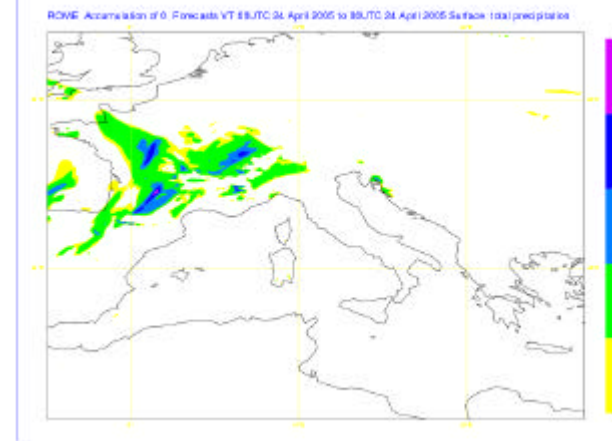
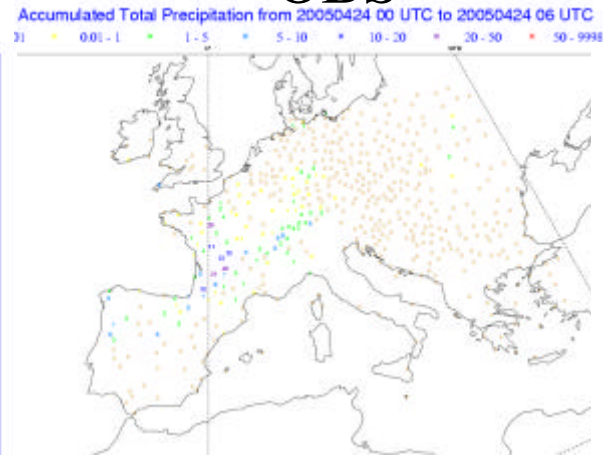
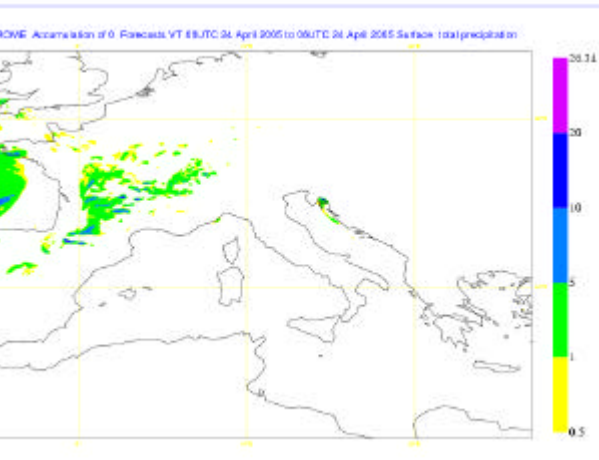
# 6 h precipitation sums 24 April 2005



LM

OBS

LM-z



# 6 h precipitation sums 24 April 2005

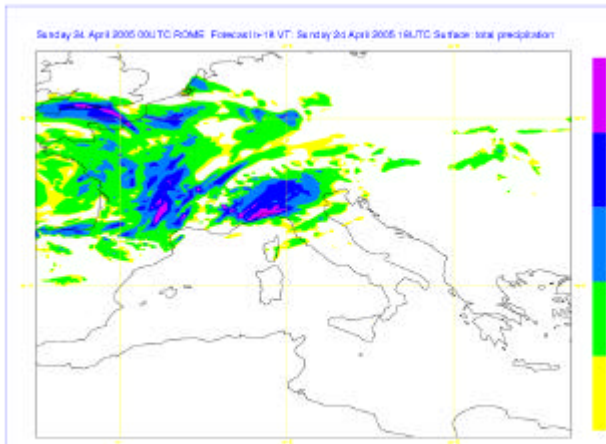
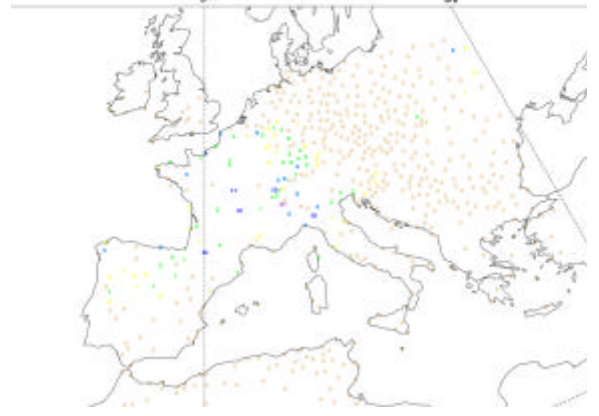
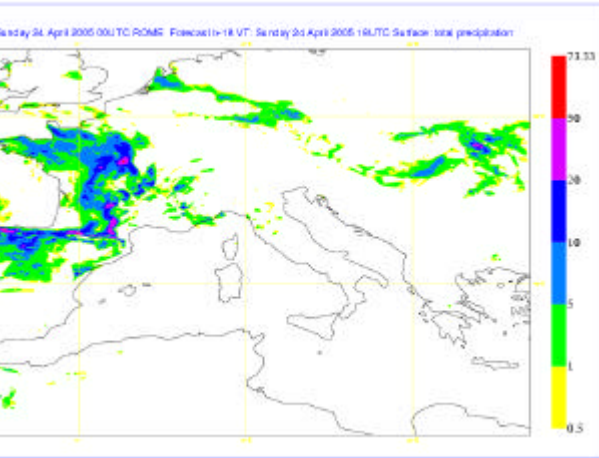
LM

OBS

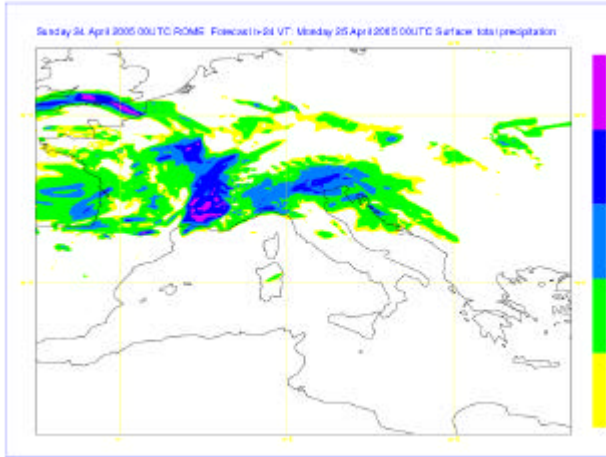
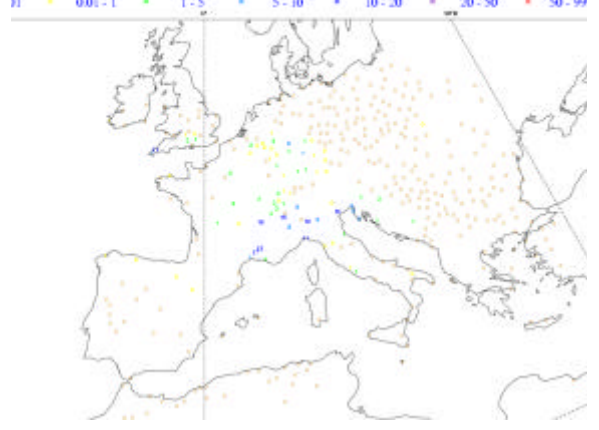
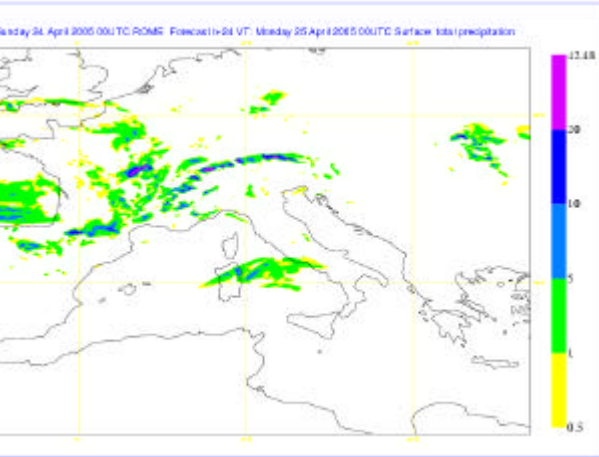
LM-z



Accumulated Total Precipitation from 20050424 12 UTC to 20050424 18 UTC



Accumulated Total Precipitation from 20050424 18 UTC to 20050425 00 UTC

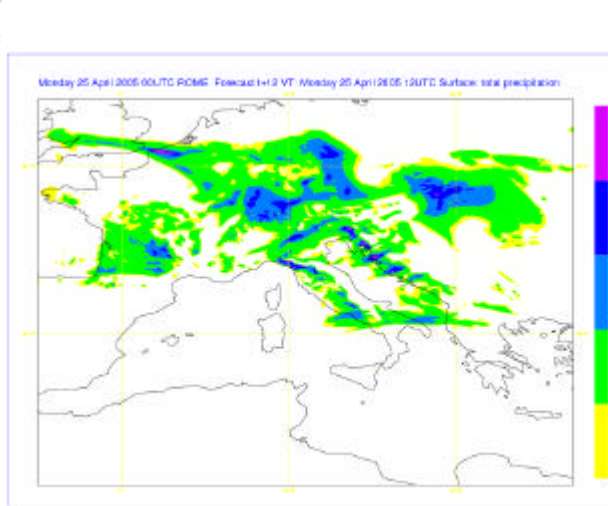
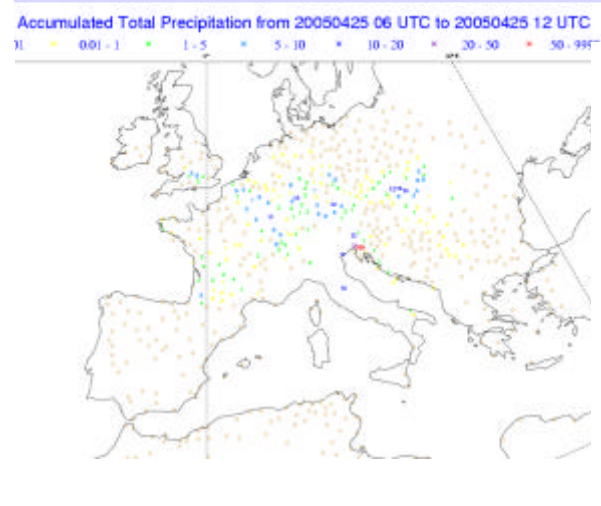
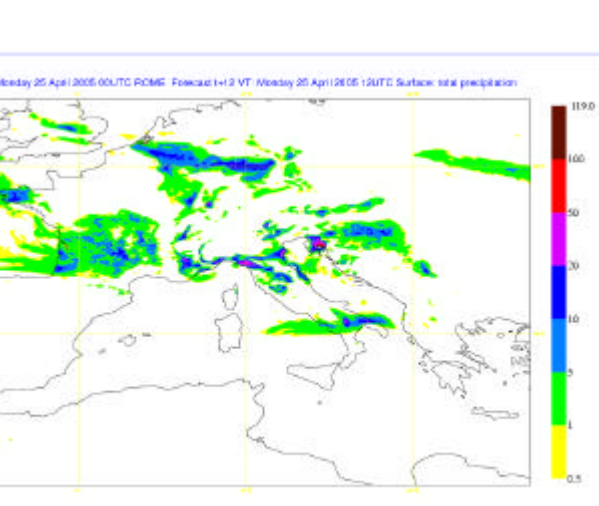
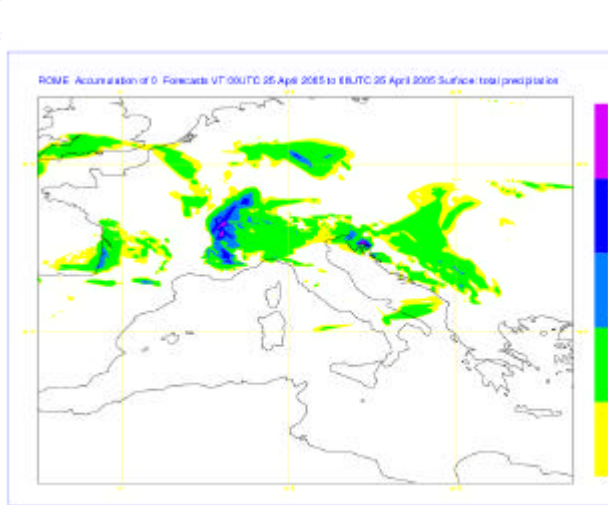
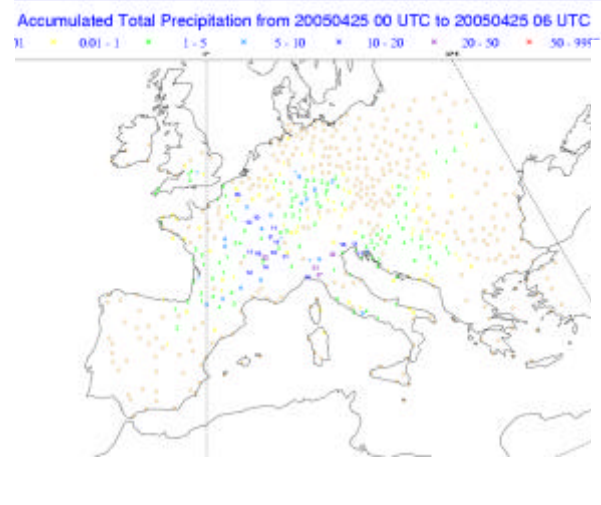
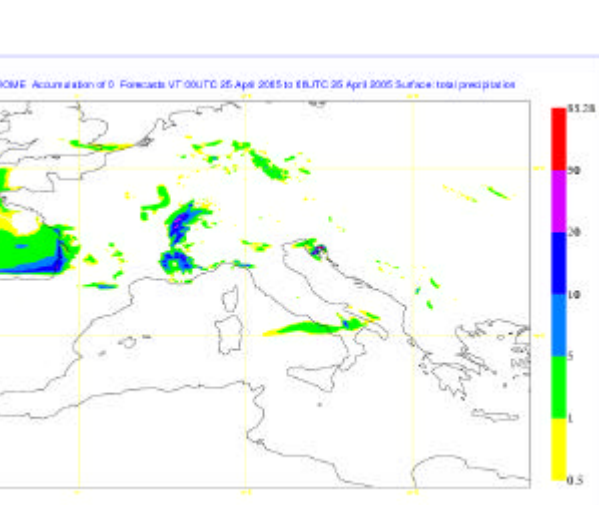


# 6 h precipitation sums 25 April 2005

LM

OBS

LM-z



# 6 h precipitation sums 25 April 2005

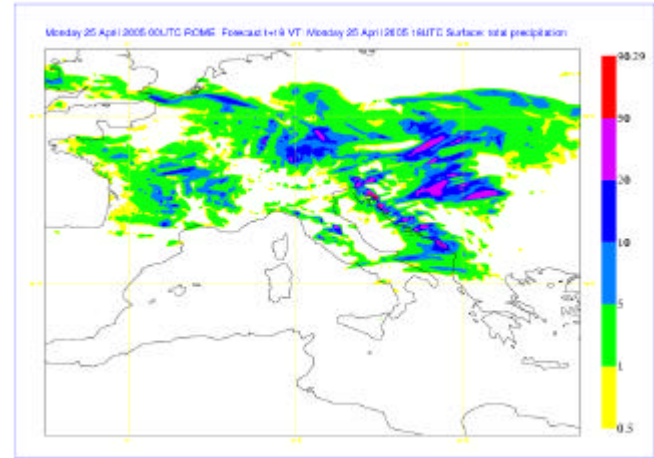
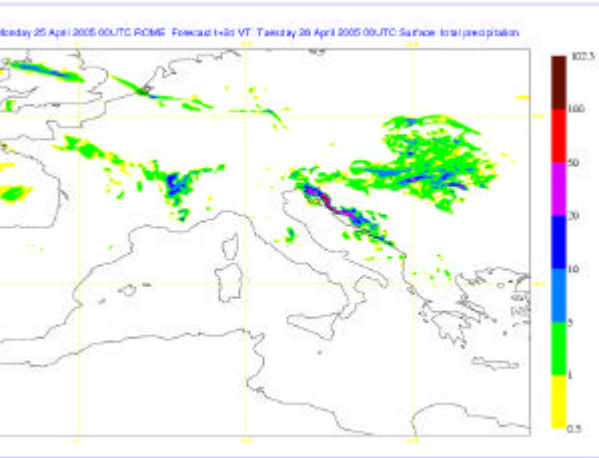
LM

OBS

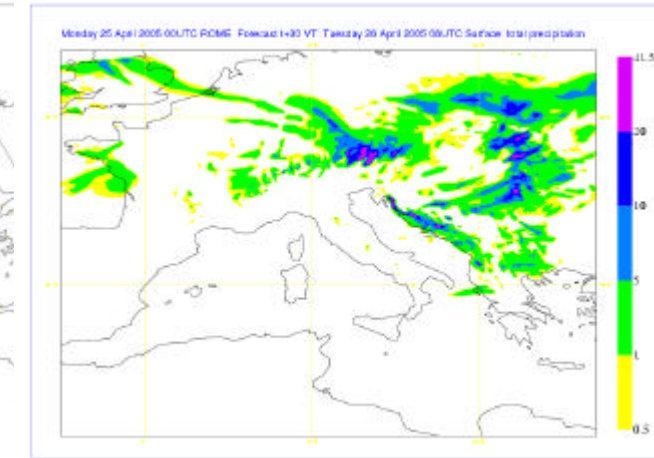
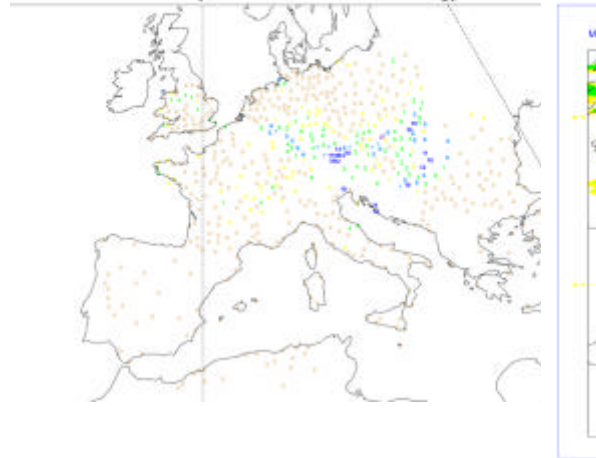
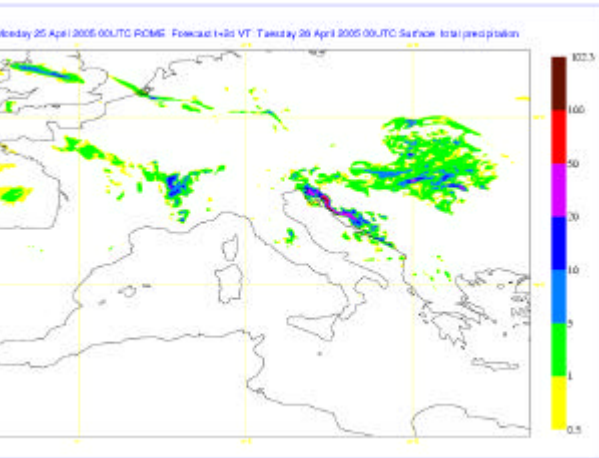
LM-z



Accumulated Total Precipitation from 20050425 12 UTC to 20050425 18 UTC



Accumulated Total Precipitation from 20050425 18 UTC to 20050426 00 UTC





# 6 h precipitation sums, 5 May 2005

LM

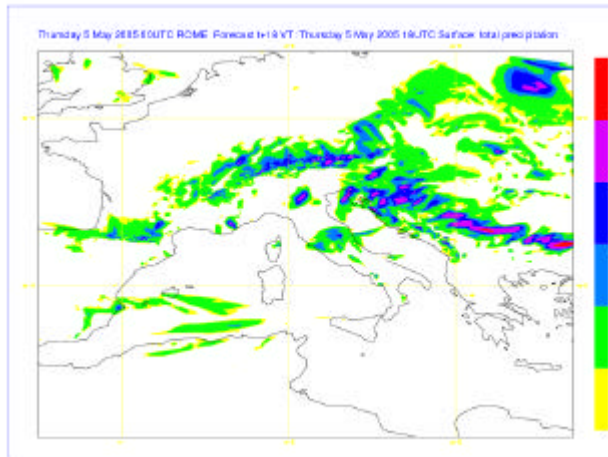
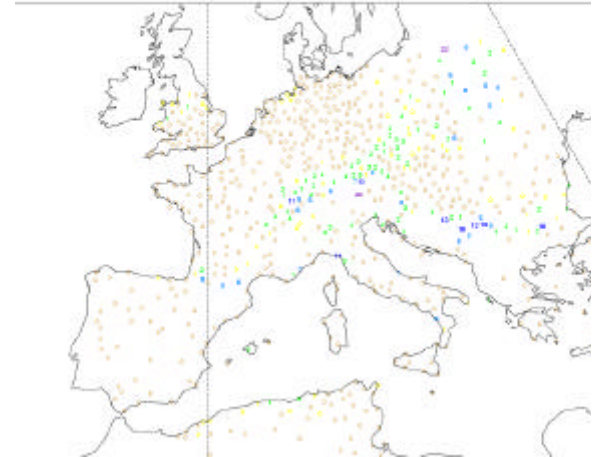
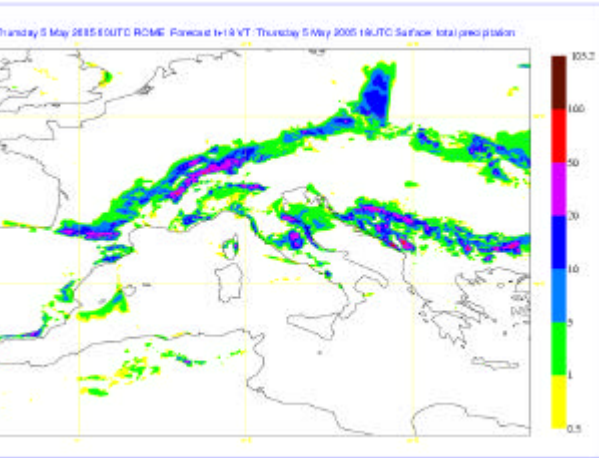
OBS

LM-z



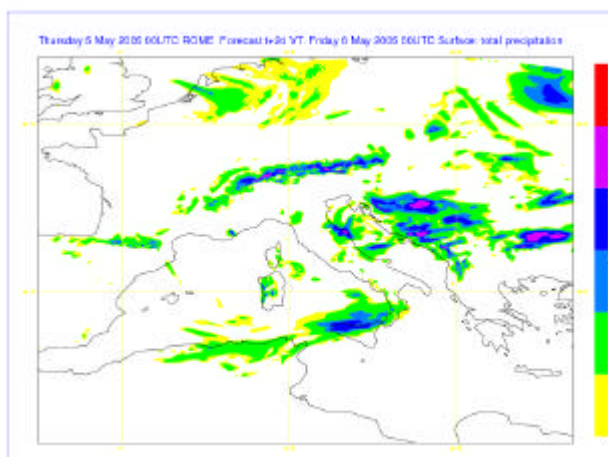
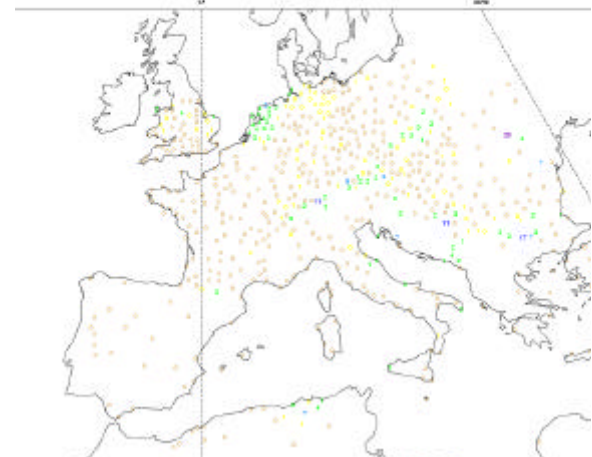
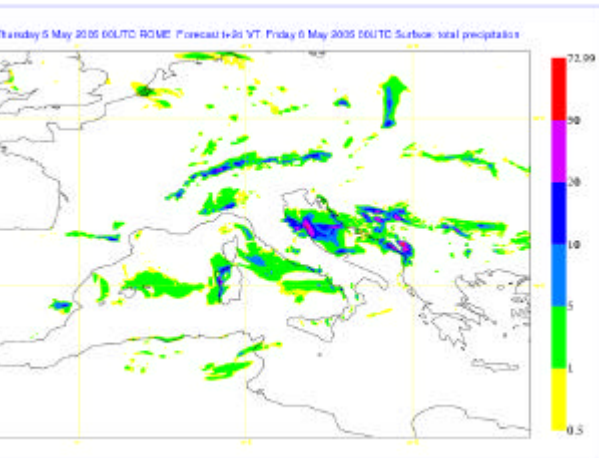
Accumulated Total Precipitation from 20050505 12 UTC to 20050505 18 UTC

0.1 0.01 - 1 1 - 5 5 - 10 10 - 20 20 - 50 50 - 9998



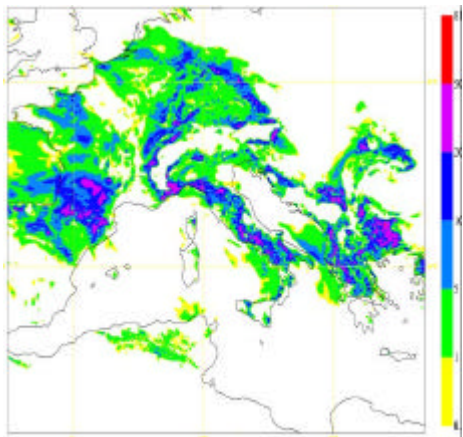
Accumulated Total Precipitation from 20050505 18 UTC to 20050506 00 UTC

0.1 0.01 - 1 1 - 5 5 - 10 10 - 20 20 - 50 50 - 9998

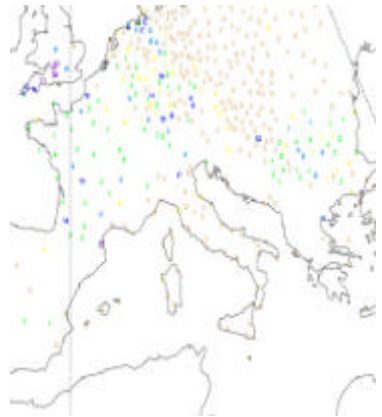


# 24 hr precipitation sums 29 march 2005

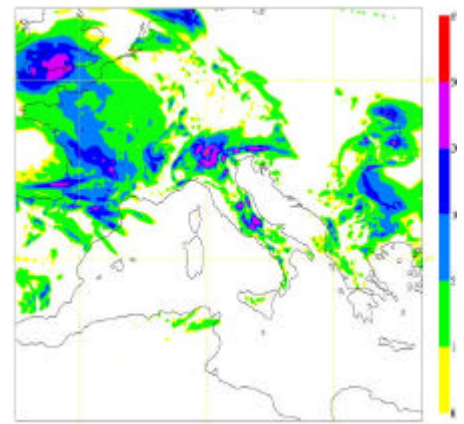
LM



OBS



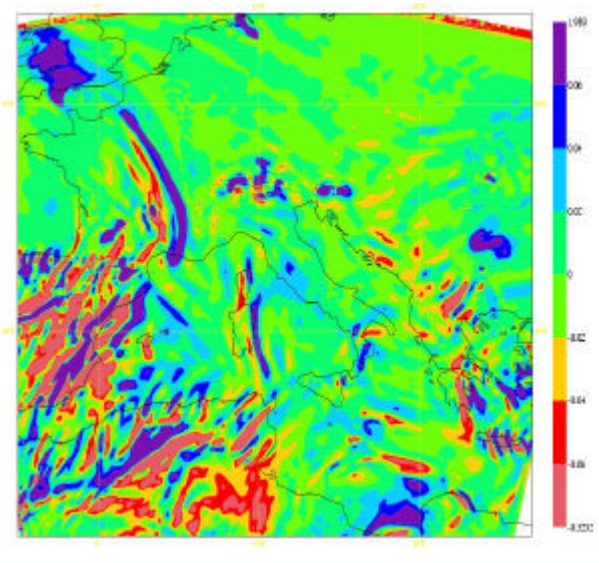
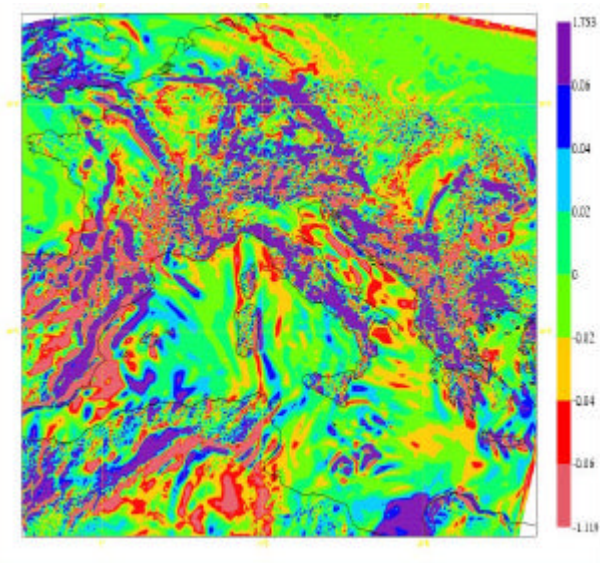
LM-z



# 12 h forecasts of $w$ (5000 m)

LM

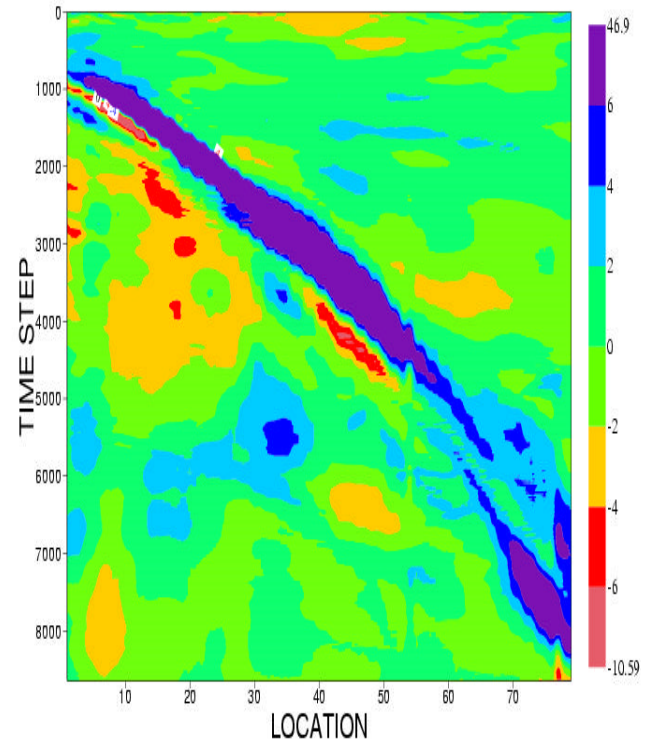
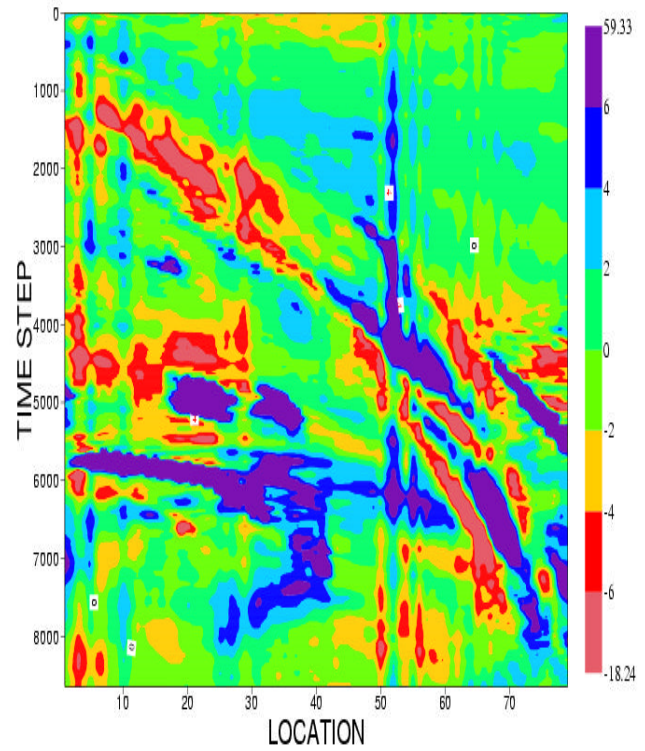
LM-z



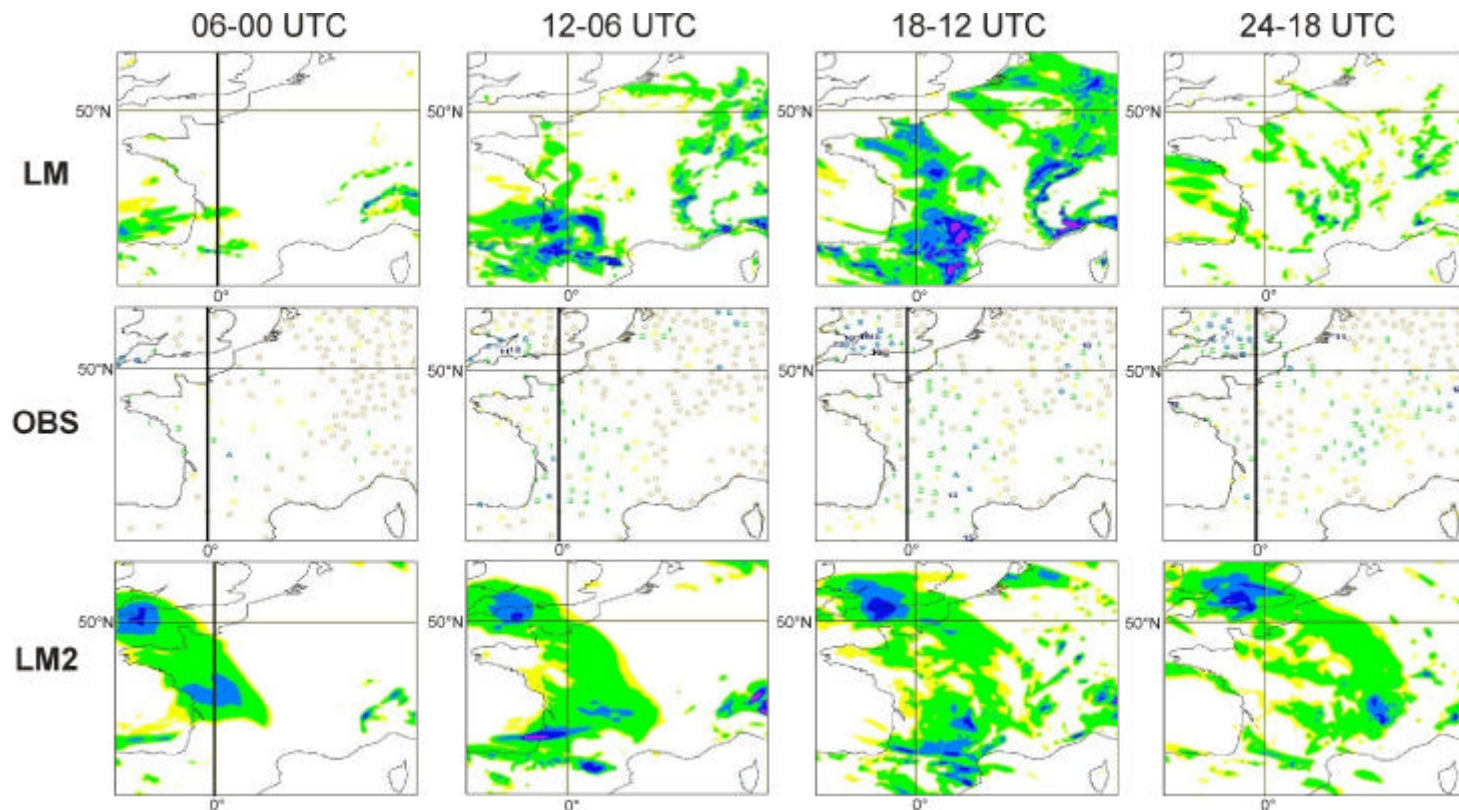
# Space time cross section for height 5000 m on the line Nantes Luxembourg

LM

LM-z

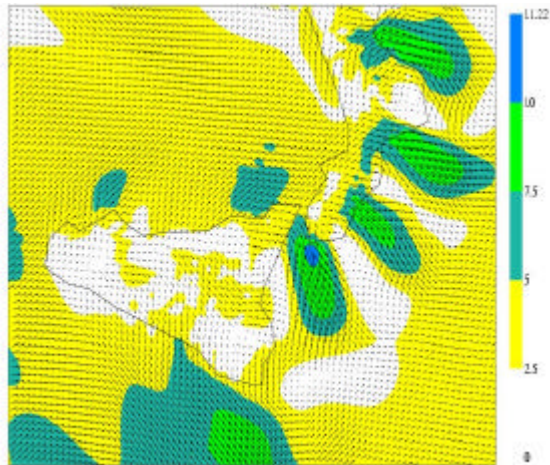


# 6 h precipitation sums 29 March 2005



# Lee winds in the South of Italy

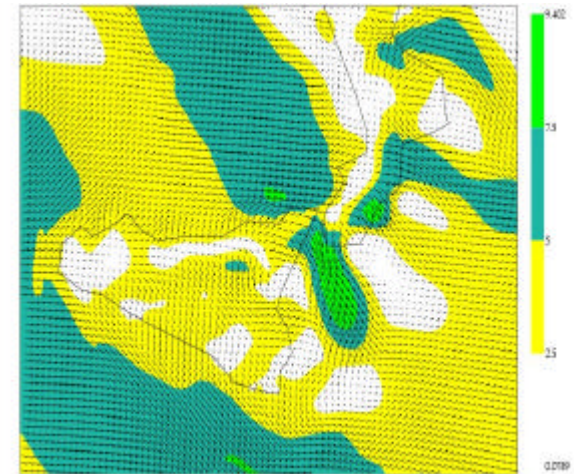
LM-z



OBS



LM



## Conclusions: LM-z / LM-tf

- Forecast skill for Precip, T and V considerably improved
- Precipitation less noisy, point maxima reduced more mesoscale structures
- Much less spinup, Precipitation more continuous in time
- w appears more reasonable