High-Resolution Numerical Forecast of a Hailstorm Event in the Po Valley: Sensitivity Analysis to Microphysical Parameterization Using COSMO-MODEL and MM5

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Work layout

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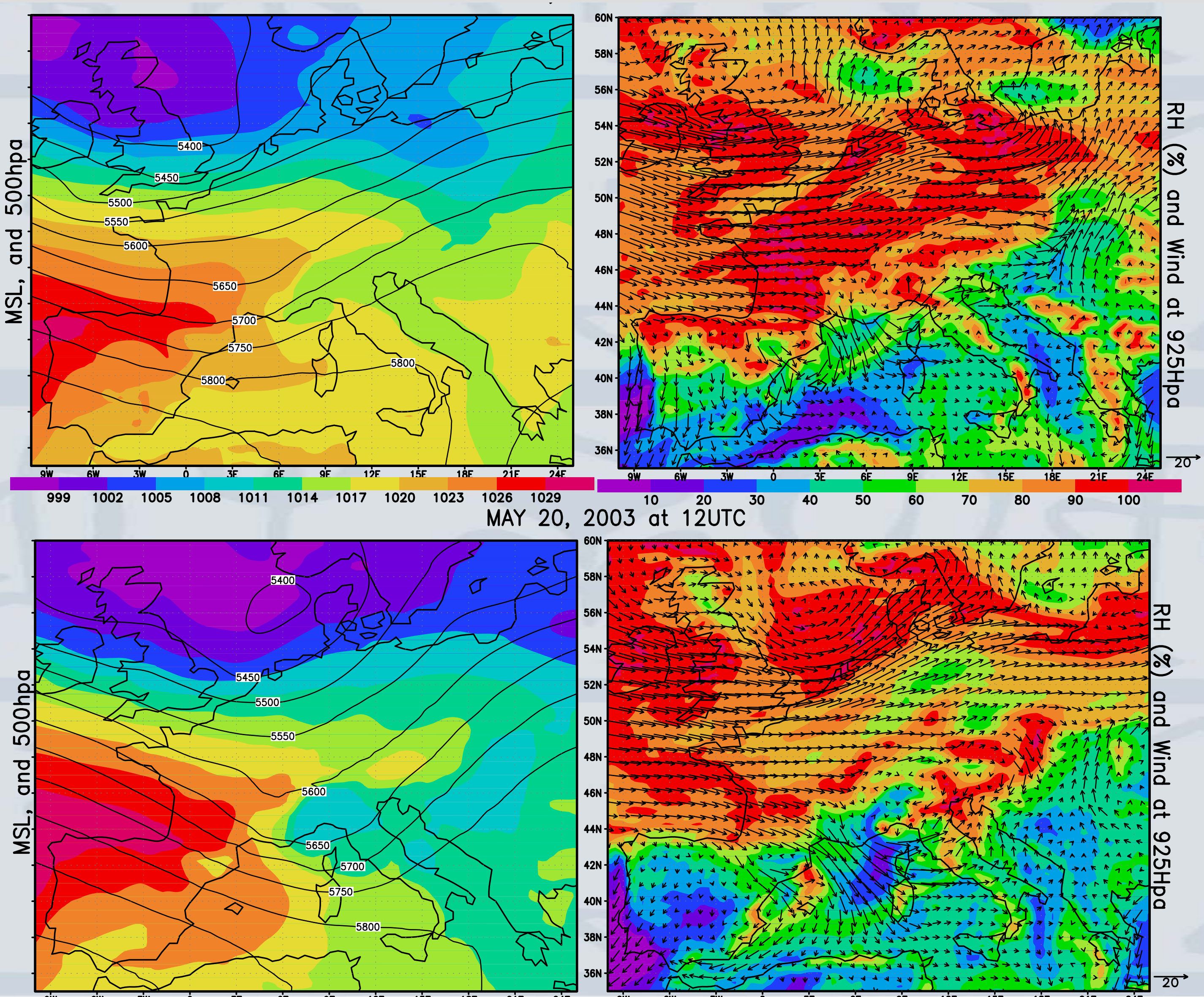
Goal of the work: providing a contribution to the current scientific debate about the usefulness and reliability of high resolution numerical modelling of deep moist convective processes

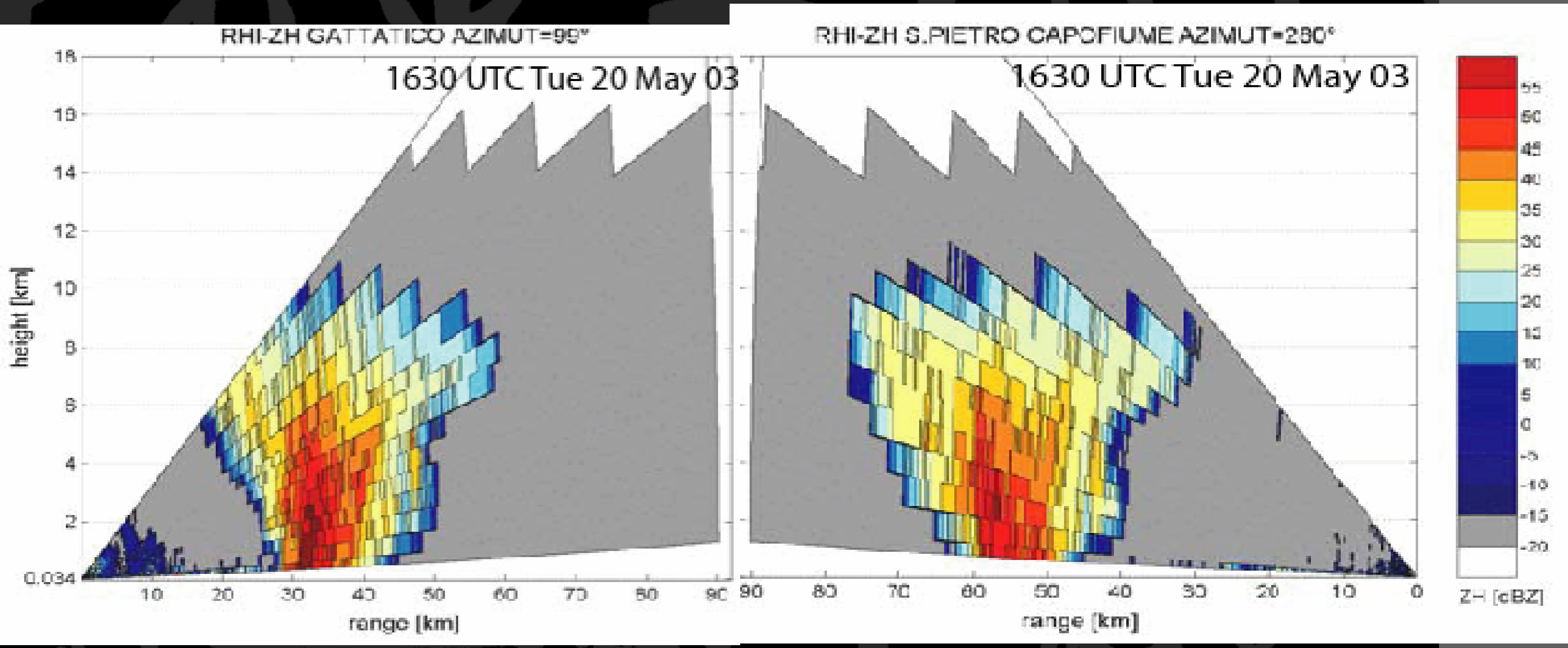
- Are NWP models (COSMO-Model, MM5) sensitive to change on their microphysical/dynamical configurations? **PART I**
- Does high resolution allow to gain a deeper insight in the physics and dynamics of deep moist convection in this case? **PART I**
- Are the simulated 3D convective structures similar to those observed by radar? **PART II**
- Is the simulated atmospheric "background" consistent with the observed convection dynamics from a data assimilation viewpoint? **PART II**

Case study: hailstorm over Nor. Italy, 20 May 2003

During the night between 19 and 20 May 2003, a cold front coming from the North-West crossed the Alps causing a series of severe hailstorms over Emilia-Romagna and southern Veneto

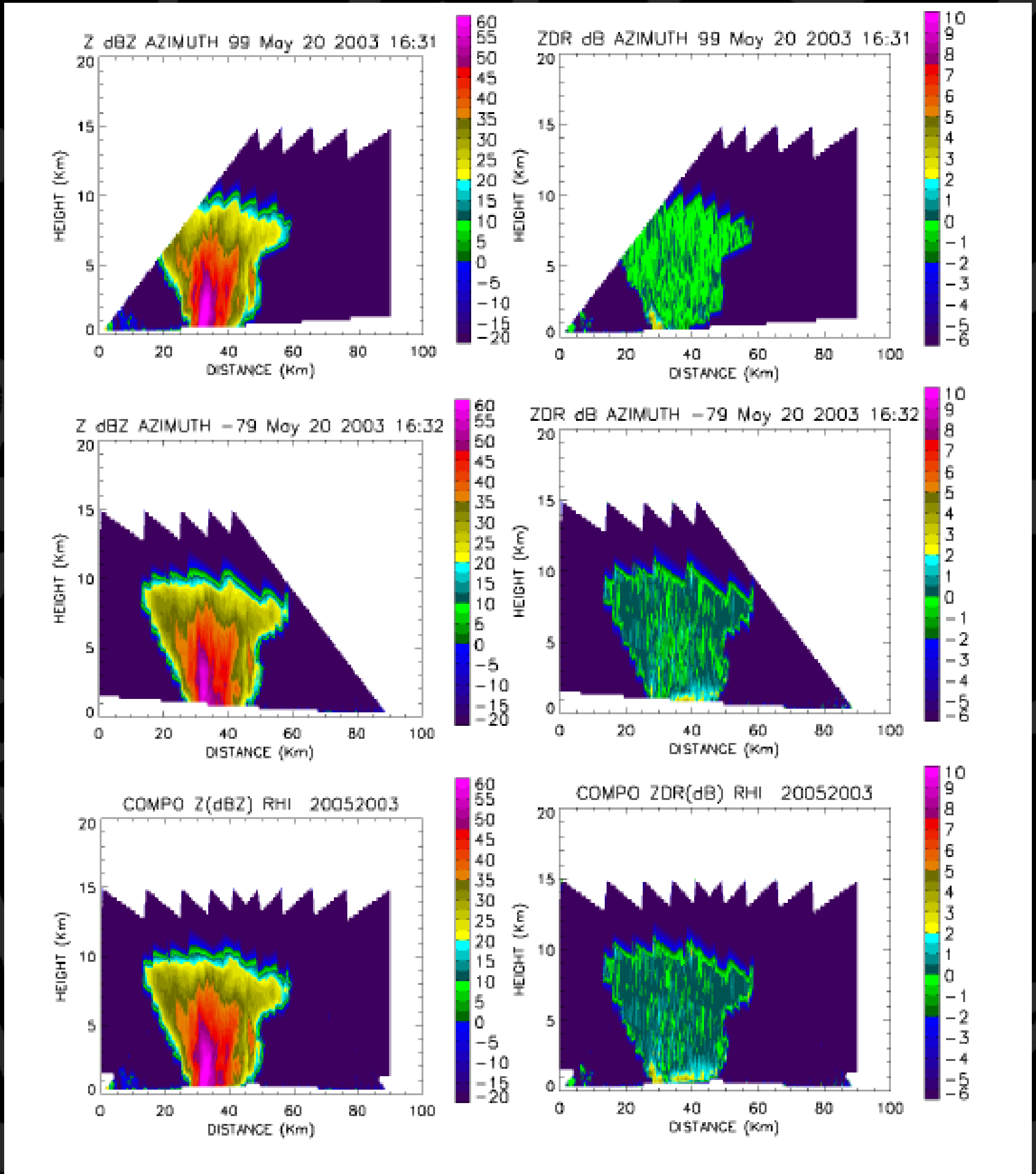


Radar observations (courtesy of ARPA-SIM)



Vertical section (RHI) of copolar reflectivity Z_{HH} with respect to the line of sight between the two C-band radar systems in Italy on May 20, 2003 at 16:30.

Radar observations (courtesy of ARPA-SIM)



20 May 2003; RHI of Z and ZDR for the GAT radar (a), (b), the SPC radar (c), (d) and the composite (e), (f) along the reference line connecting the two radars.

NWP Model setup

COSMO-LAMI	MM5
Non-hydrostatic	Non-hydrostatic
1-way nesting	2-way nesting
Max horizontal resolution: 1km (3 domains)	Max horizontal resolution: 1km (4 domains)
50 vertical levels ("terrain following")	33 vertical levels (sigma levels)
Turbulence: Mellor-Yamada (order 1.5)	Turbulence: MRF (order 1.5)
Convective closure: Kain-Fritsch (only for the 7-km domain)	Convective closure : Kain-Fritsch (only for 27 and 9-km domains)
Microphysics: 3-category ice scheme (cloud ice, graupel/hail, snow)	Microphysics: 3-category ice scheme (cloud ice, graupel/hail, snow)

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Sensitivity to graupel particle properties

(density, number density intercept, velocity/size and mass/size distribution)

in COSMO-LAMI and MM5 simulations with a 3-category ice scheme with a 1 km resolution

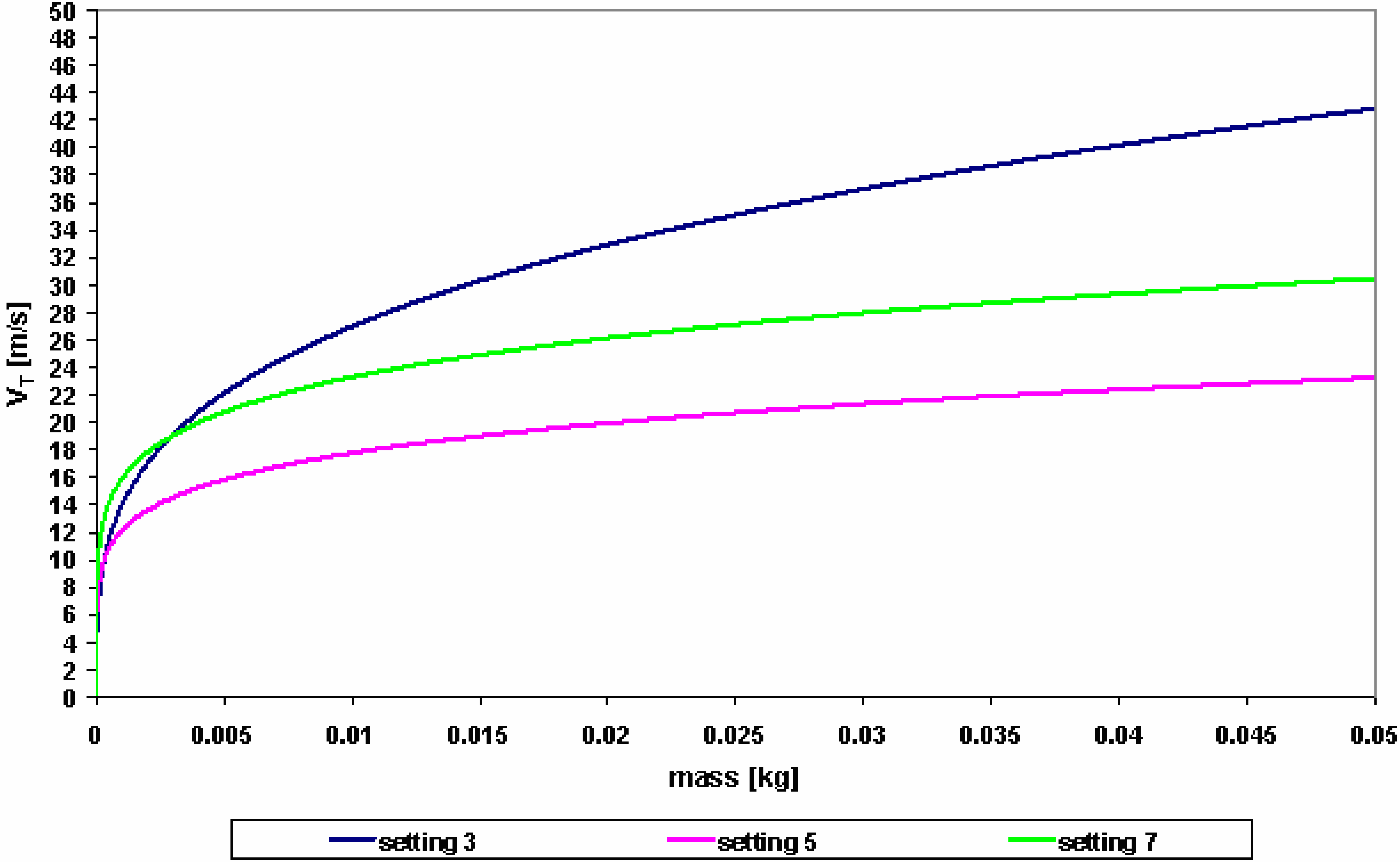
Setting	ρ_G (g/cm^3)	N_G^0 (m^{-4})	a[m$^{(1-b)}$*s^{-1}]	b	c[kg*m$^{(-e)}$]	e
1	0.2	$4*10^4$	442	0.89	169.6	3.1
2	0.2	$4*10^5$	442	0.89	169.6	3.1
3	0.2	$4*10^6$	442	0.89	169.6	3.1
4	0.4	$4*10^4$	93.35	0.50	209.44	3.0
5	0.4	$4*10^5$	93.35	0.50	209.44	3.0
6	0.4	$4*10^6$	93.35	0.50	209.44	3.0
7	0.9	$4*10^4$	140.03	0.50	471.24	3.0
8	0.9	$4*10^5$	140.03	0.50	471.24	3.0
9	0.9	$4*10^6$	140.03	0.50	471.24	3.0

Velocity-size relationship: $V_T=aD^b$

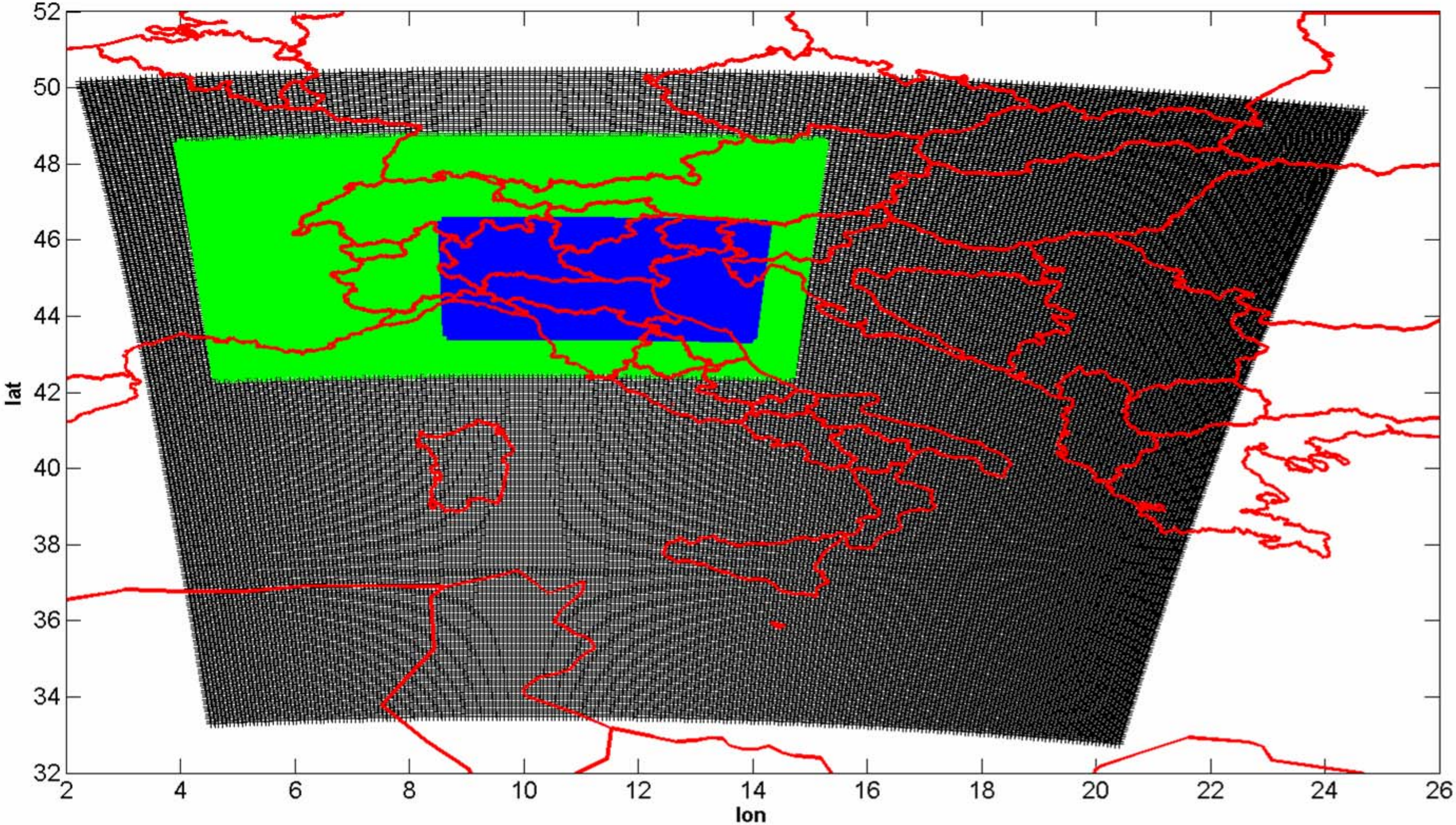
Mass-size relationship: $M=cD^e$

Heymsfield & Kajikawa, 1986
Lin et al, 1983
Reinhardt and Seifter, 2005

Velocity-size and velocity-mass relationships

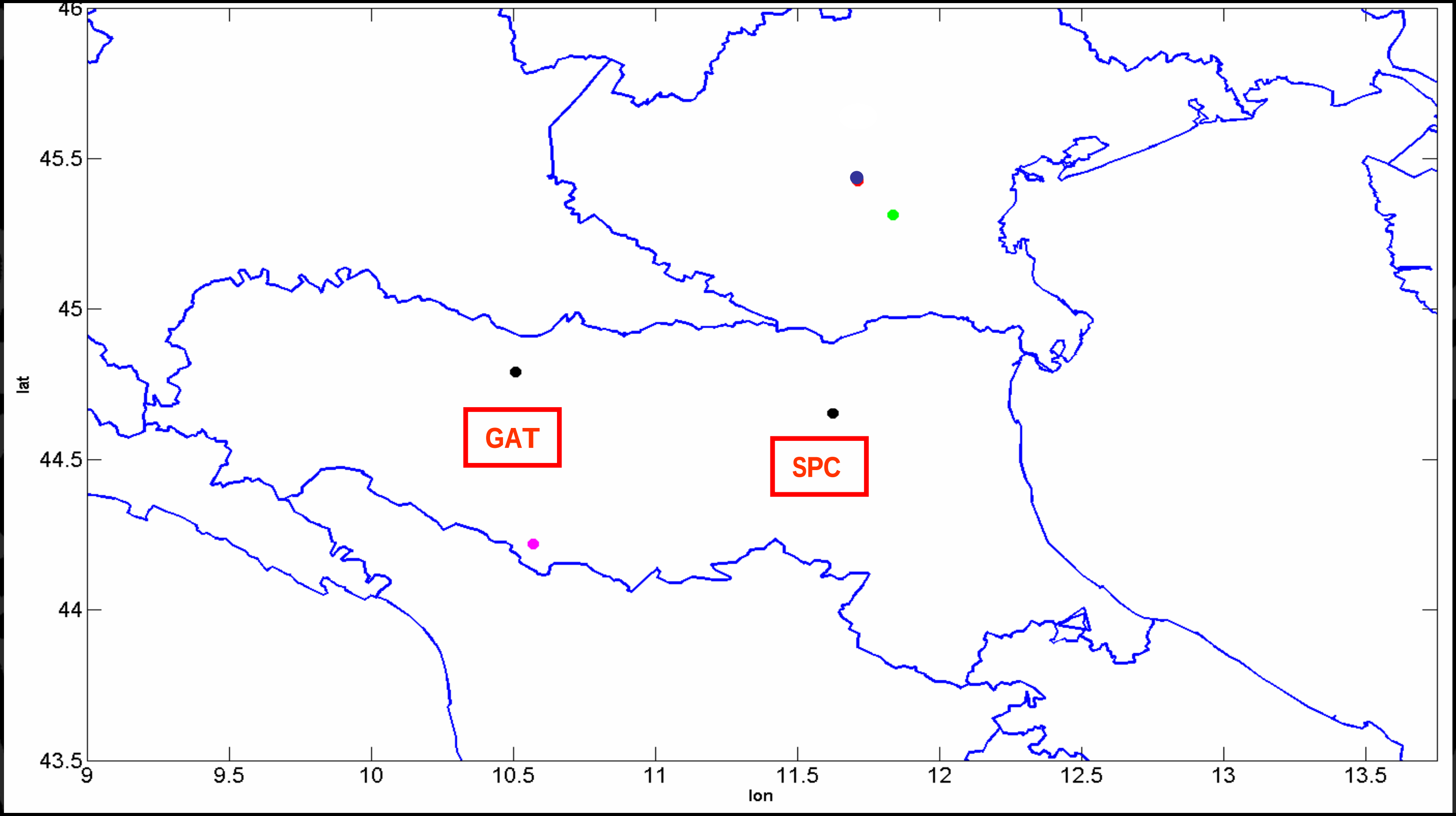


COSMO-LAMI Computational domains (7 km, 2.8 km and 1 km)



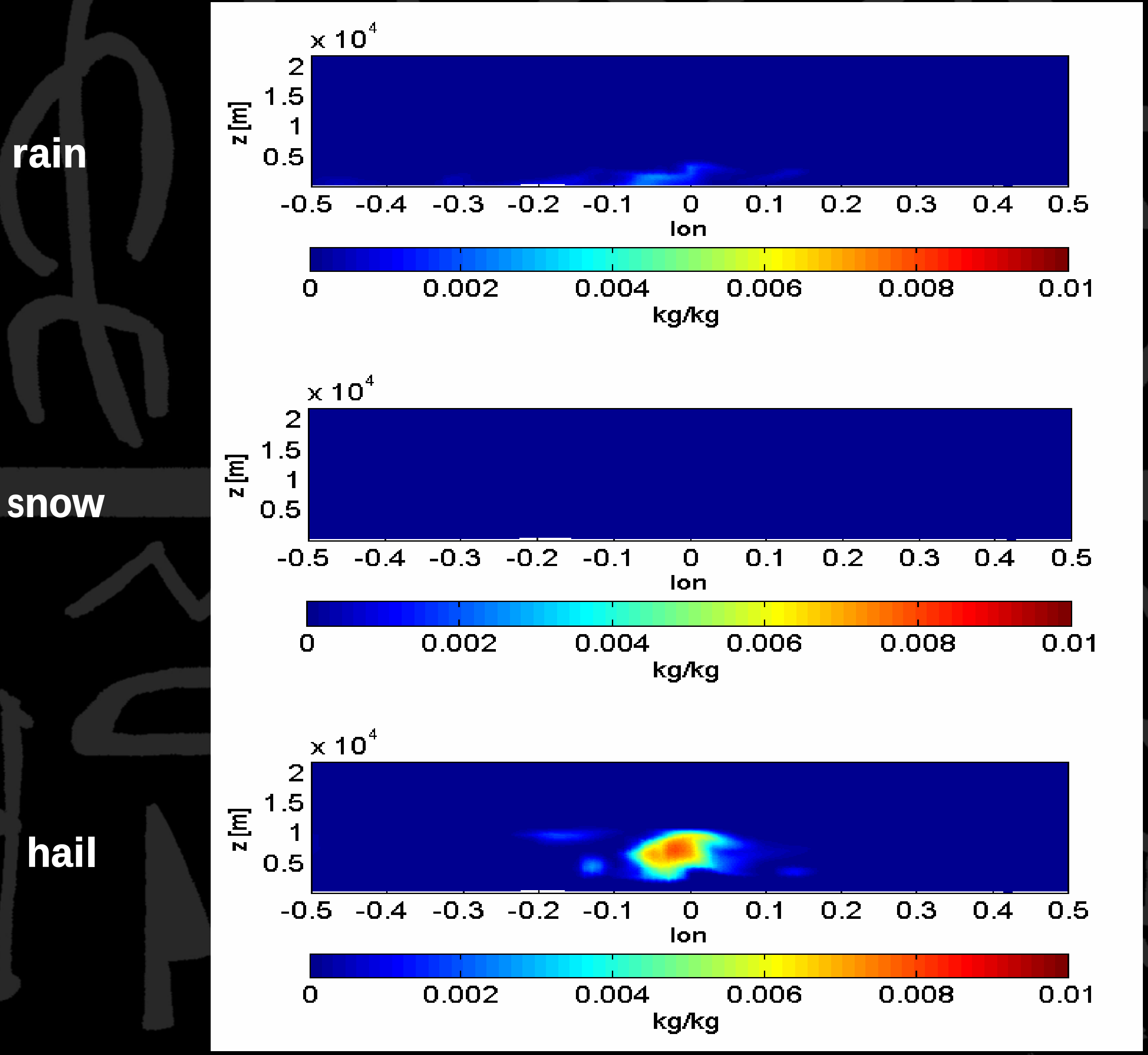
Results

In order to compare the physical results provided by these experiments the convective cell characterized by the maximum vertical velocity at z=5000 m in the time period 1600-1800 UTC and belonging to the area common to the two radars, has been identified.



experiment 3 (blue circle, at 1645 UTC)
experiment 5 (magenta circle, at 1730 UTC)
experiment 7 (green circle, at 1700 UTC)

SETTING 3: vertical cross section of the mass fraction at 1645 UTC, for the maximum convective cell (aspect ratio of figure 1:5).

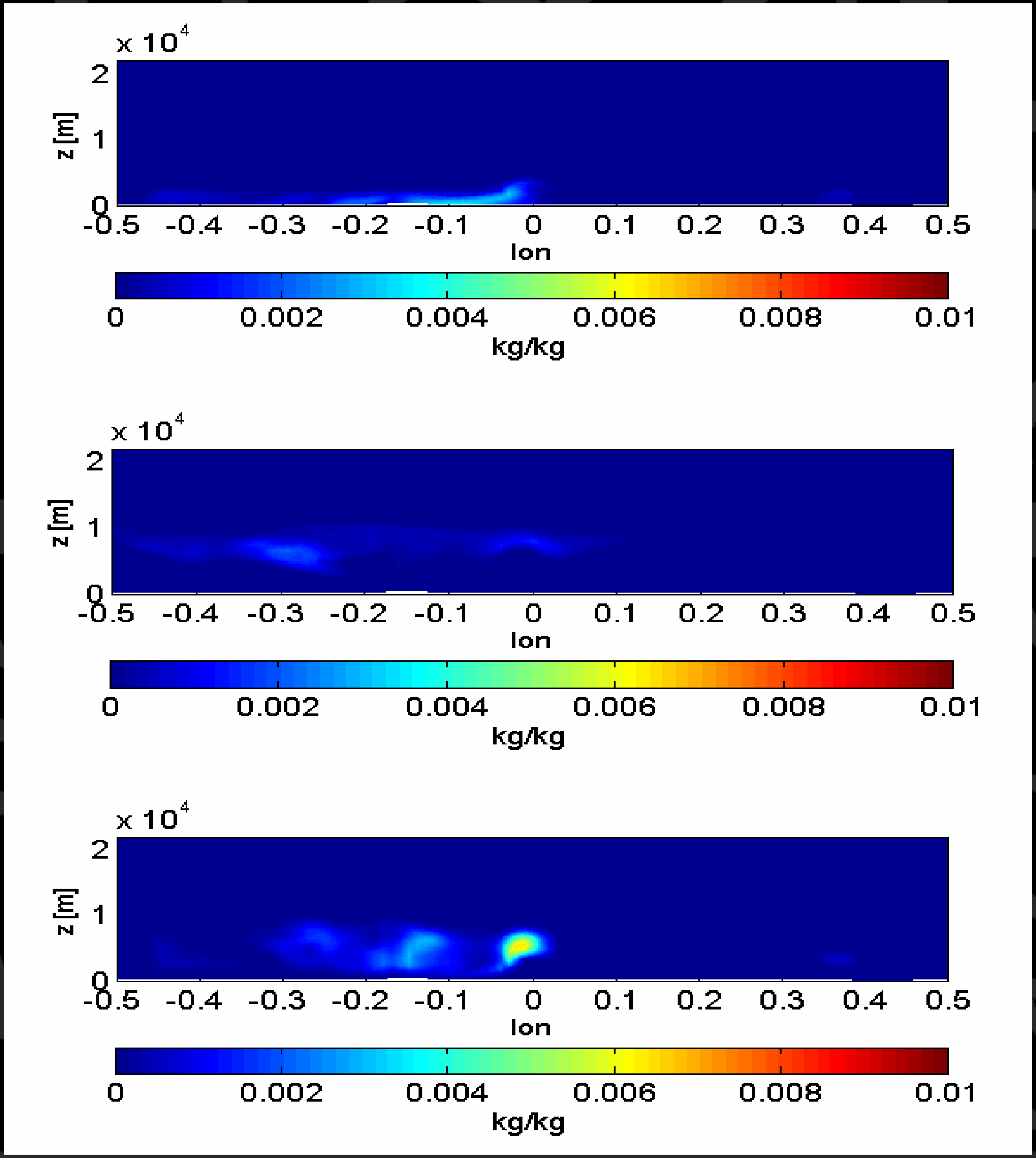


SETTING 5: vertical cross section of the mass fraction at 1645 UTC, for the maximum convective cell (aspect ratio of figure 1:5).

rain

snow

hail



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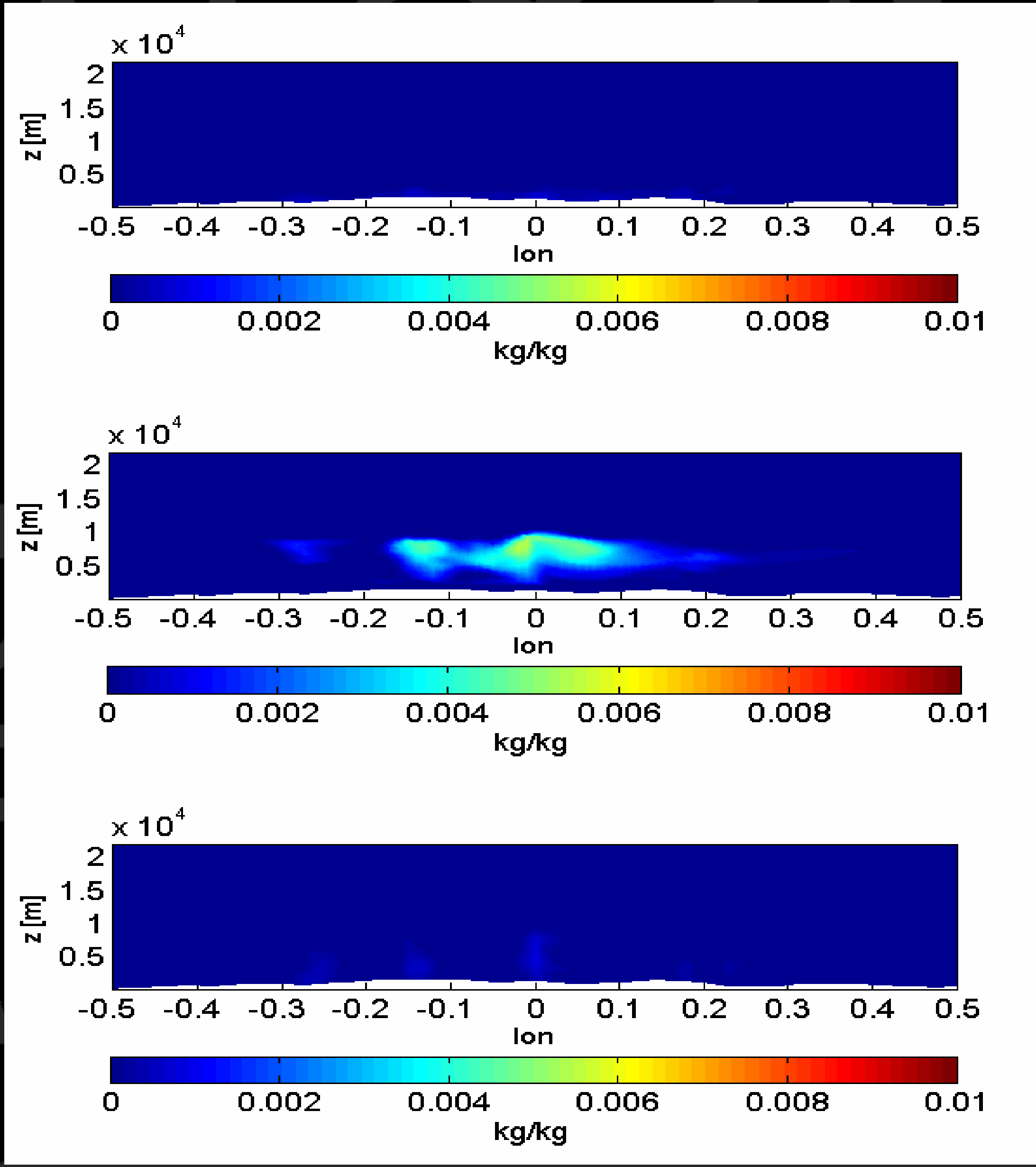
SETTING 5: vertical cross section of the mass fraction at 1645 UTC, for the maximum convective cell (aspect ratio of figure 1:5).

rain

snow

hail



SETTING 3: vertical cross section of the sedimentation flux at 1645 UTC, for the maximum convective cell (aspect ratio of figure 1:5).

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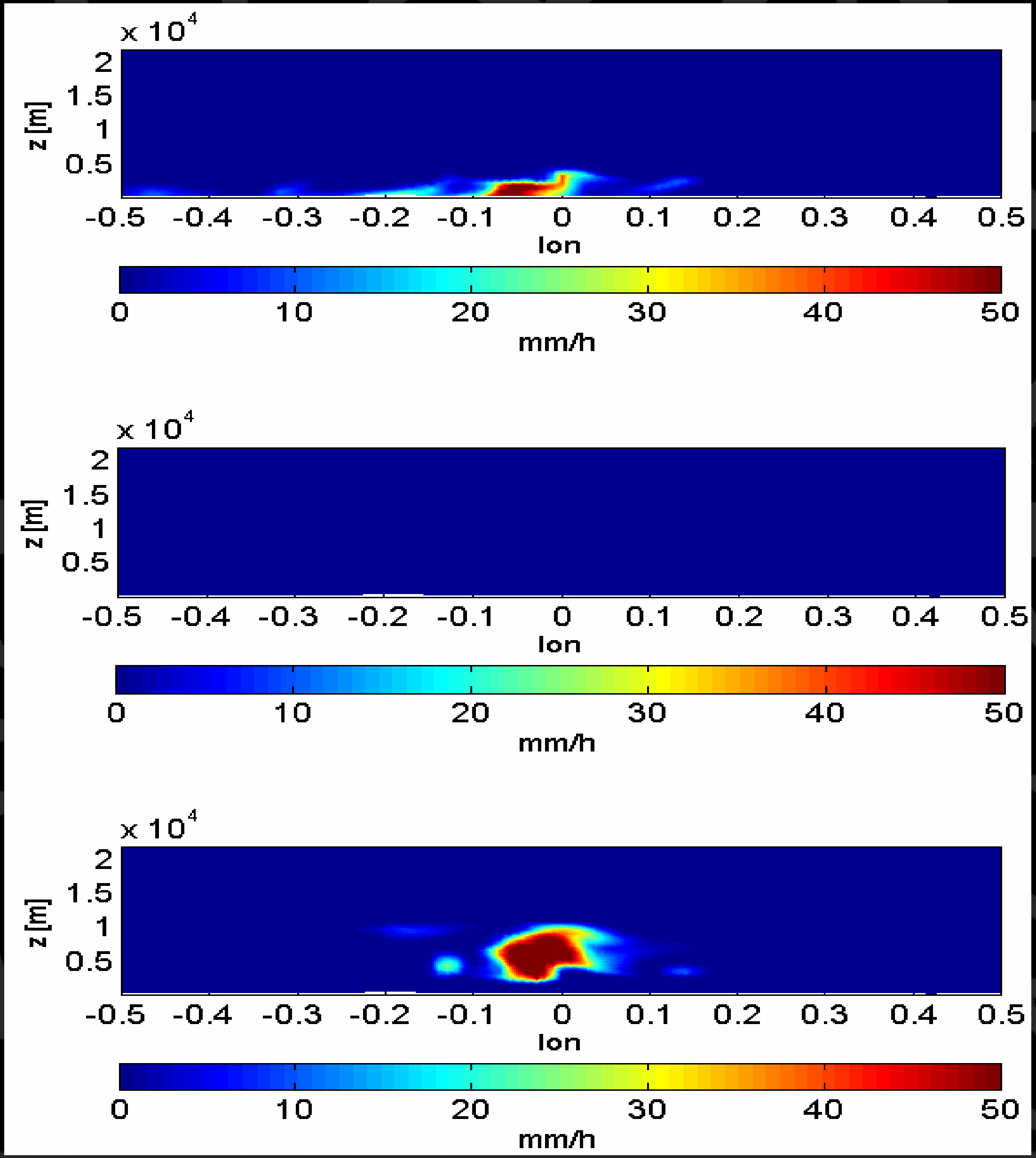
rain

snow

hail

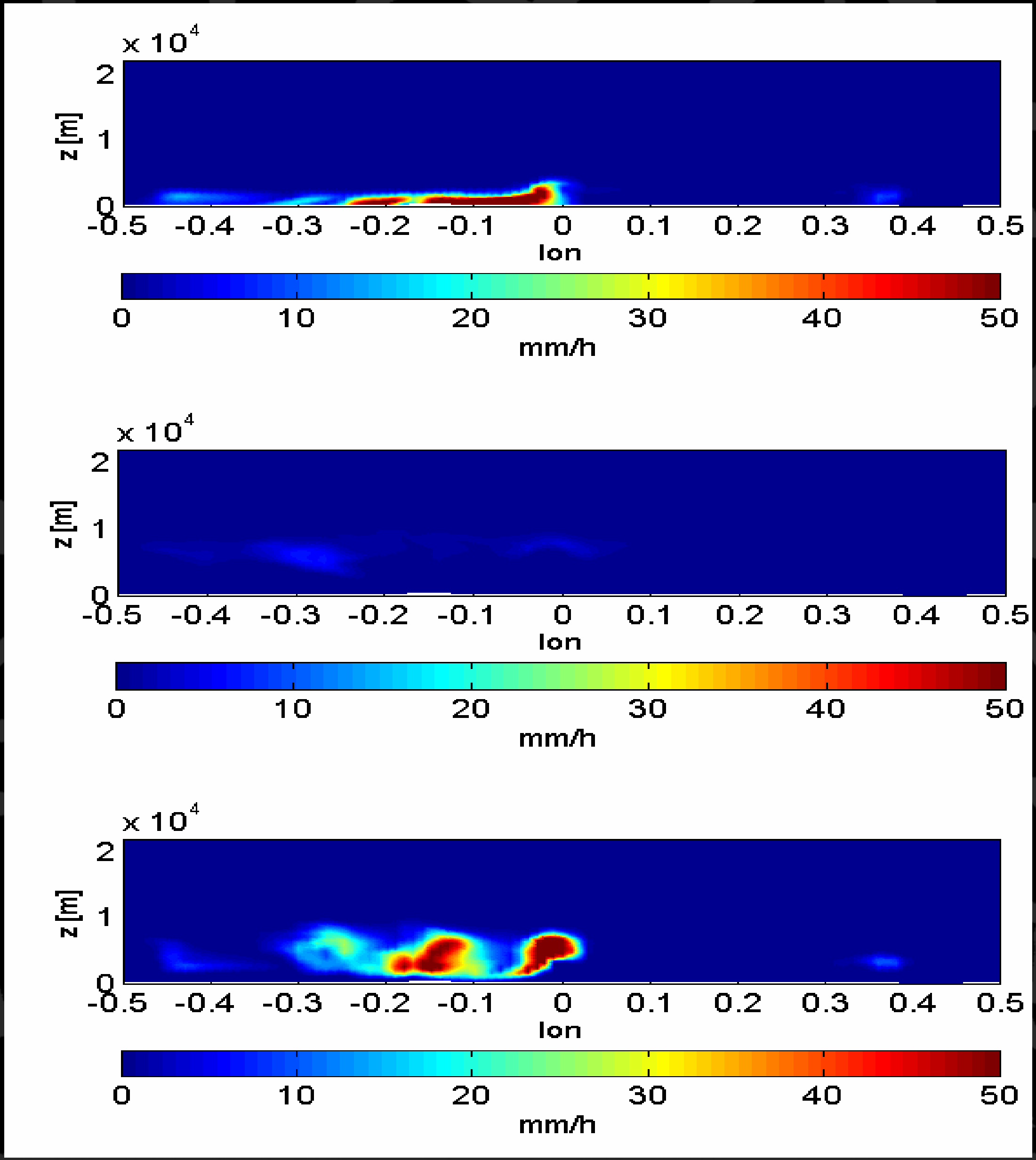


SETTING 5: vertical cross section of the sedimentation flux at 1730 UTC, for the maximum convective cell (aspect ratio of figure 1:5).

rain

snow

hail

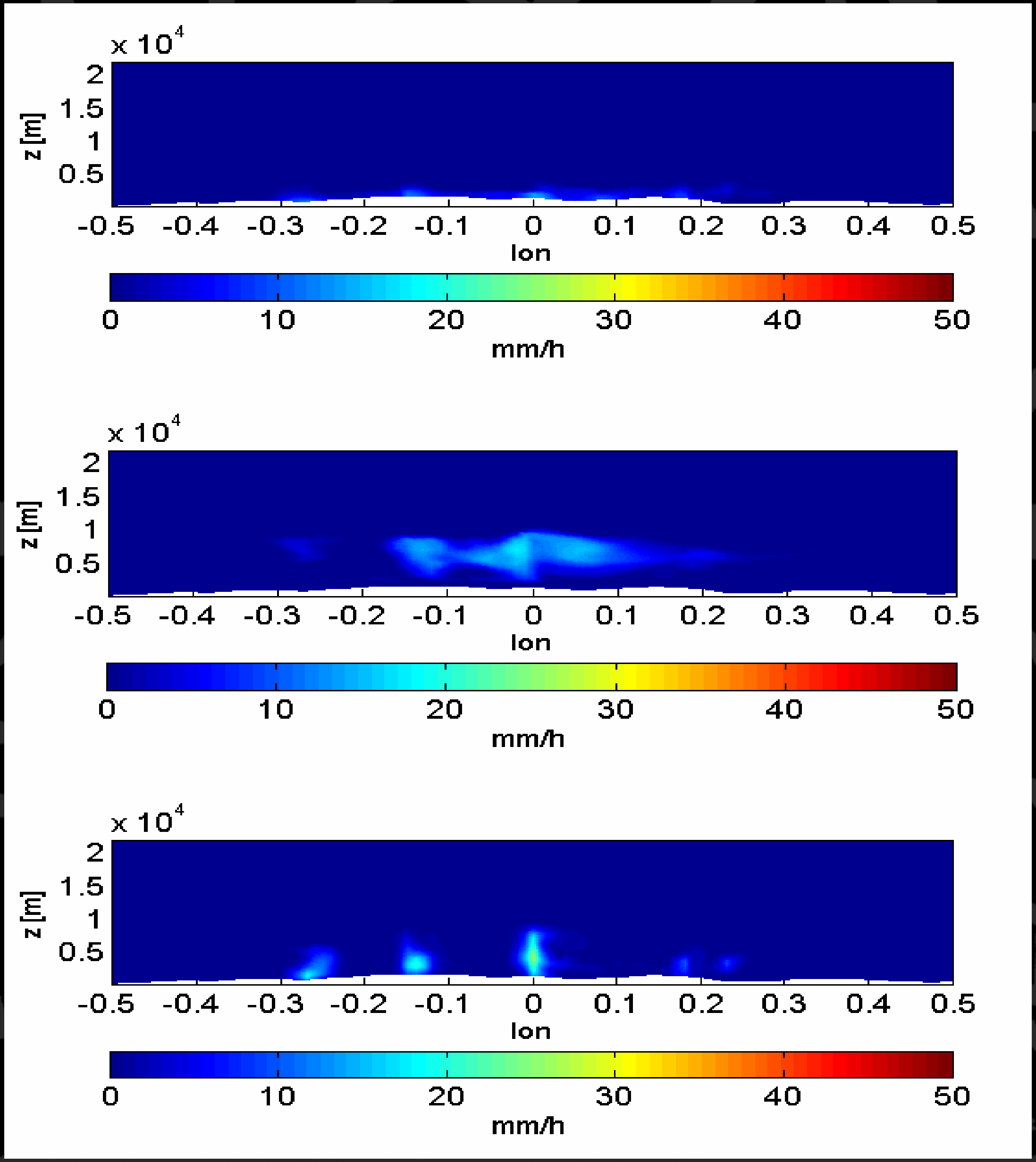


SETTING 7: vertical cross section of the sedimentation flux at 1700 UTC, for the maximum convective cell (aspect ratio of figure 1:5).

rain

snow

hail



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EXPERIMENT 3: 16-18 UTC rainfall intensity at ground level (COSMO-LAMI)

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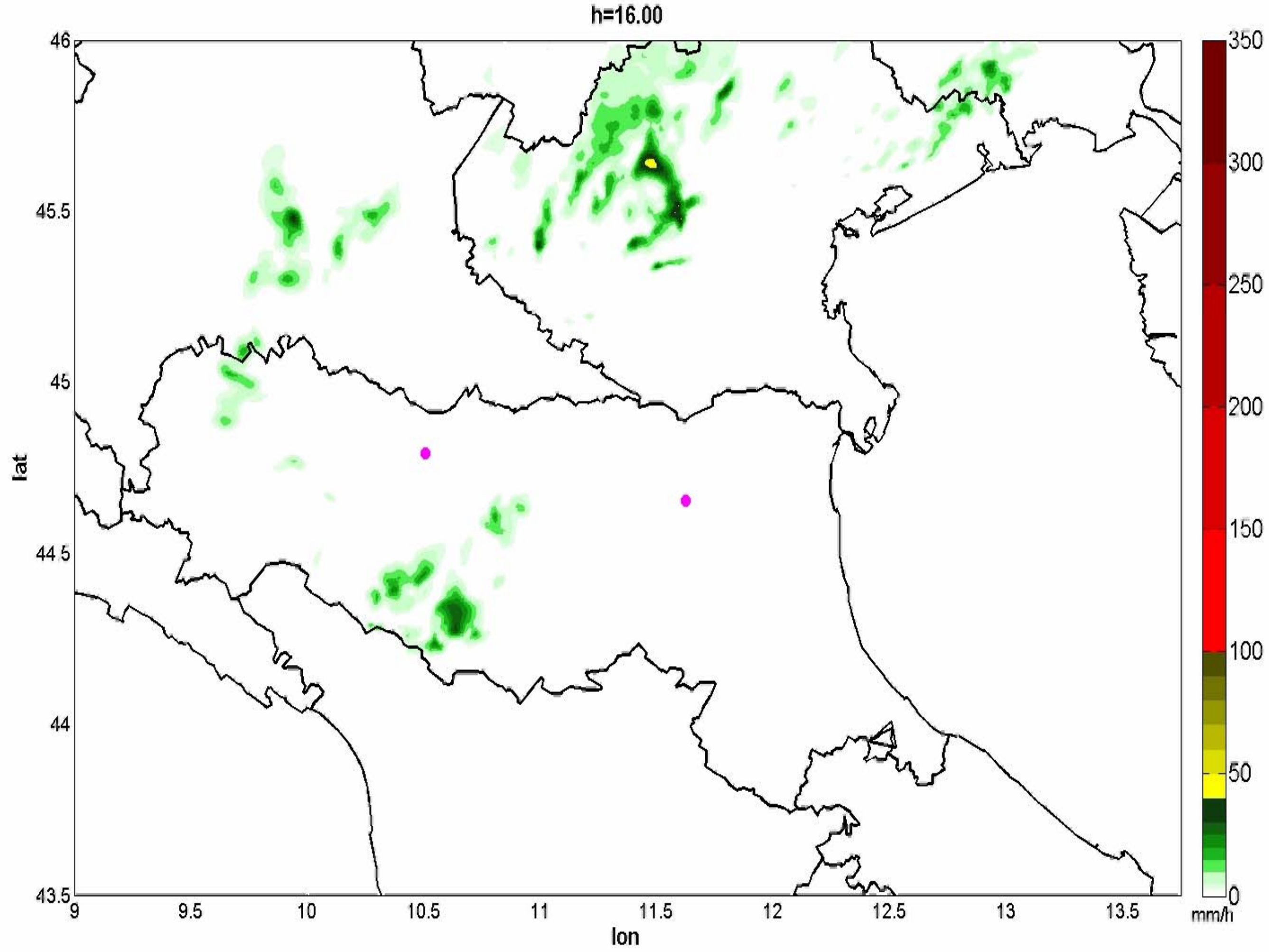

EXPERIMENT 5: 16-18 UTC rainfall intensity at ground level (COSMO-LAMI)

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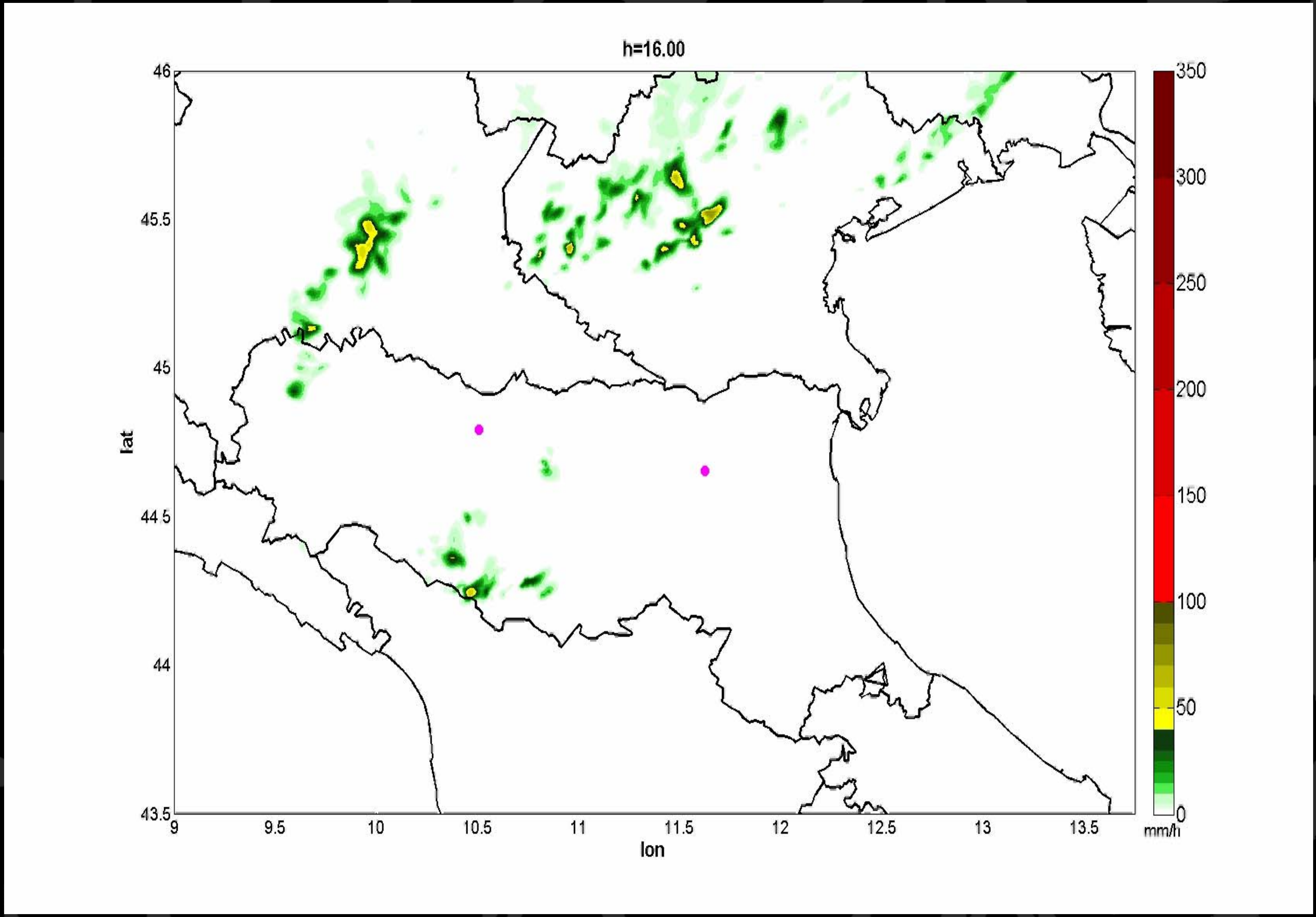
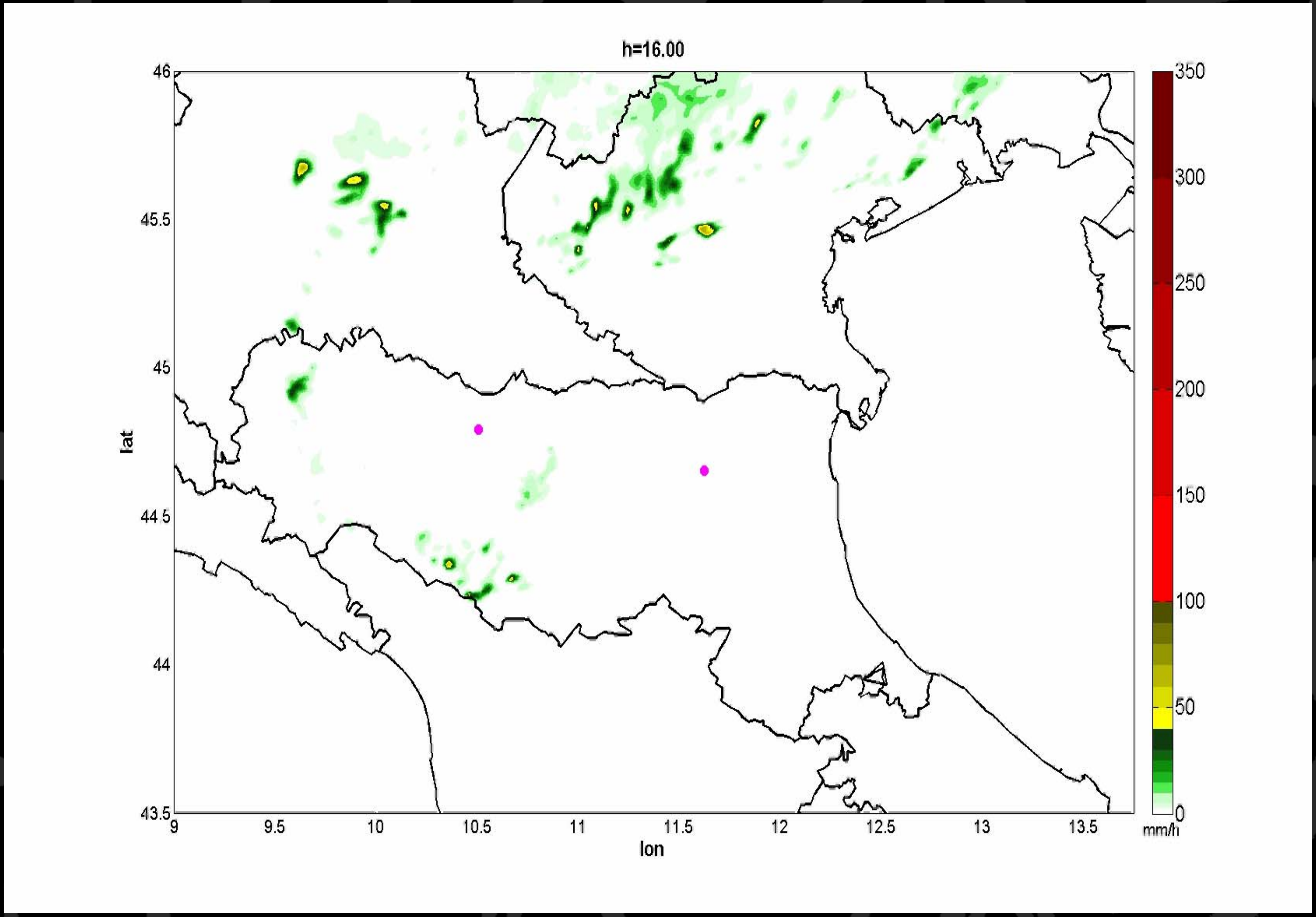


EXPERIMENT 7: 16-18 UTC rainfall intensity at ground level (COSMO-LAMI)



Mean population and diameter of rain cells

(based on Von Hardenberg et al, 2003)

RUN	Mean cell's diameter (threshold: 20 mm/h)	Cells mean population (threshold: 20 mm/h)	Mean cell's diameter (threshold: 30 mm/h)	Cells mean population (threshold: 30 mm/h)
3	18	31	25	13
5	16	33	18	21
7	14	39	17	24

Conclusions

both COSMO-LAMI and MM5 simulated cells exhibit a relevant sensitivity to changes in the graupel particle properties with remarkable effects on

Spatial organization

Convective motion field

Ground effects

Number of cells

Cell's mean diameter

Open issue

Since both models, whatever it was their configuration, are able to provide realistic and plausible results, what is their forecast skill? Do the modelled scenarios agree with observations? Can the tuning of microphysics upgrade forecast's performance? Can we find a best configuration?

…….Part II of this work

(tomorrow, 9.40)

will answer the question

Thank you!