AGENZIA REGIONALE PREVENZIONE E AMBIENTE DELL'EMILIA-ROMAGNA

Servizio IdroMeteoClima

Sensitivity of “initiation of convection” respect to different boundary conditions in COSMO model at very high resolution

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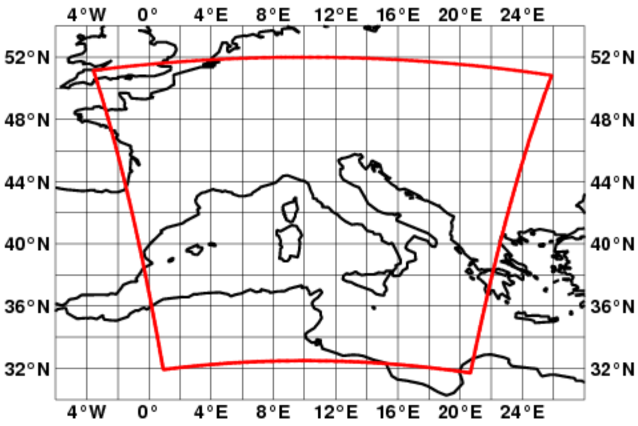
9 Th International SRNWP workshop on
Non- Hydrostatic modelling
Bad Orb 16-18 May 2011

COSMO
CONSORTIUM FOR SMALL SCALE MODELING

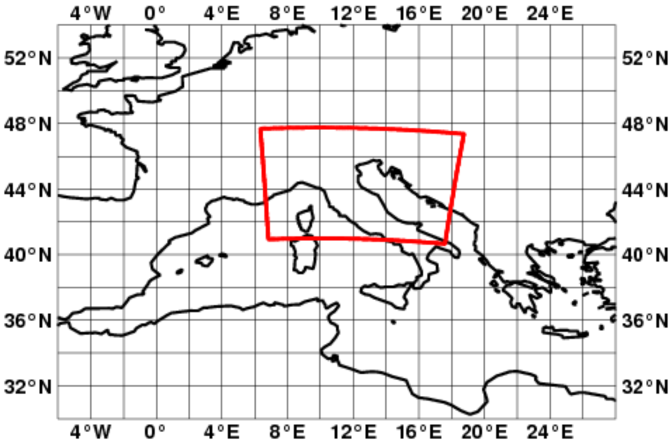
Model set up and integration area

- **COSMO I7**: v 4.13; int2lm 1.10; grid length=0.0625°; 297*313 grid points , 40 vertical levels; dt=40s.
- **COSMO I2:** v 4.13; int2lm 1.10; One way nesting on COSMO I7; grid length=0.025°; 341*300 grid points , 45 vertical levels; dt=15s.
- **COSMO I1:** v 4.13; int2lm 1.10; One way nesting on COSMO I7 or COSMOI2; grid lenght =0.01°; 551*400 grid points; 45 vertical levels; dt=5s.

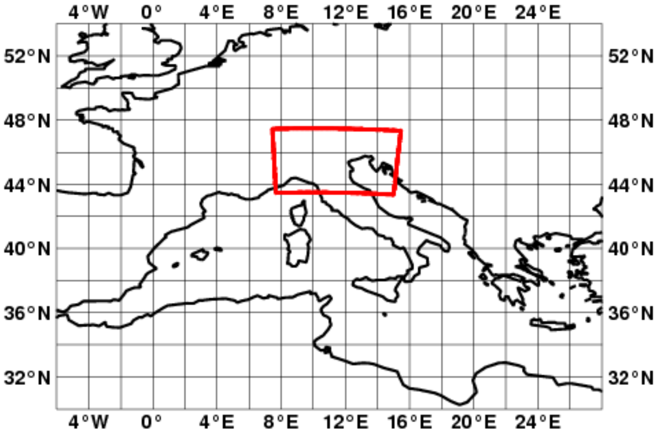
Cosmo I7



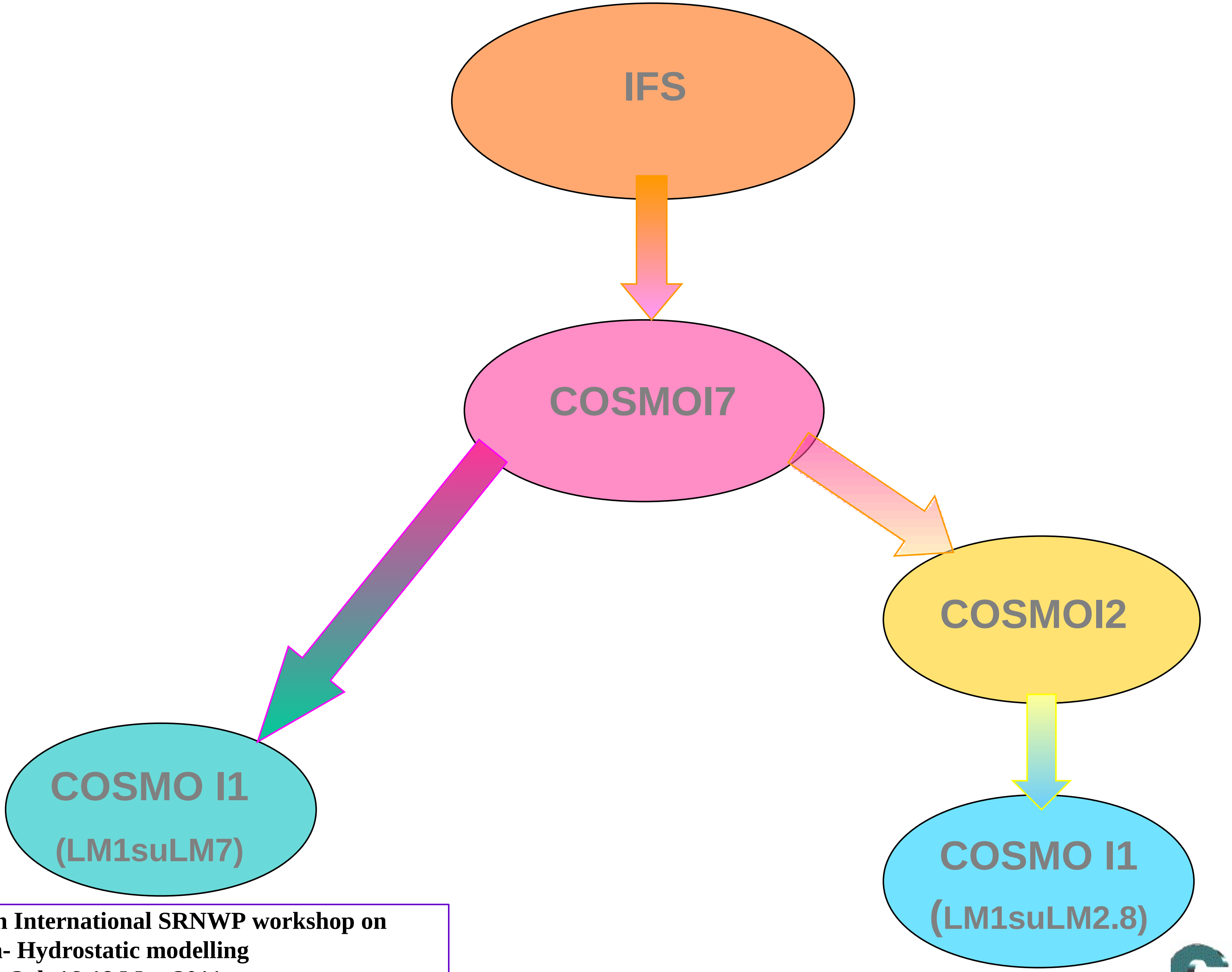
Cosmo I2



Cosmo I1



The nesting tree



IFS

COSMOI7

COSMOI2

COSMO I1
(LM1suLM7)

COSMO I1
(LM1suLM2.8)

The nesting tree

```
Vertical interpolation of : pp 45 46 45 45
PUNKT 18  3  UND DIE NAECHSTEN 0.101614E04 0.965324E+03 SIND IN FALSCHER REIENFOLGE
PUNKT 34  3  UND DIE NAECHSTEN 0.101614E04 0.965324E+03 SIND IN FALSCHER REIENFOLGE
PUNKT 36  3  UND DIE NAECHSTEN 0.101614E04 0.965324E+03 SIND IN FALSCHER REIENFOLGE
PUNKT 1   3  UND DIE NAECHSTEN 0.101614E04 0.965324E+03 SIND IN FALSCHER REIENFOLGE
PUNKT 31  3  UND DIE NAECHSTEN 0.101614E04 0.965324E+03 SIND IN FALSCHER REIENFOLGE
PUNKT 31  3  UND DIE NAECHSTEN 0.101614E04 0.965324E+03 SIND IN FALSCHER REIENFOLGE
PUNKT 26  3  UND DIE NAECHSTEN 0.101614E04 0.965324E+03 SIND IN FALSCHER REIENFOLGE
PUNKT 10  3  UND DIE NAECHSTEN 0.101614E04 0.965324E+03 SIND IN FALSCHER REIENFOLGE
PUNKT 21  3  UND DIE NAECHSTEN 0.101614E04 0.965324E+03 SIND IN FALSCHER REIENFOLGE
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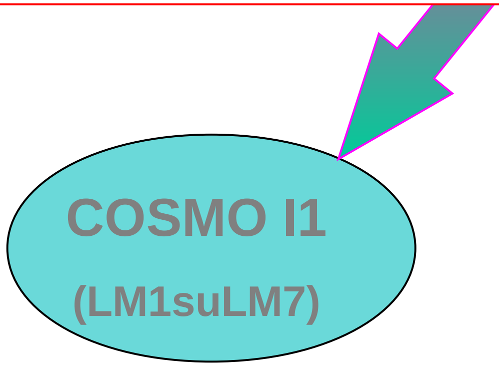

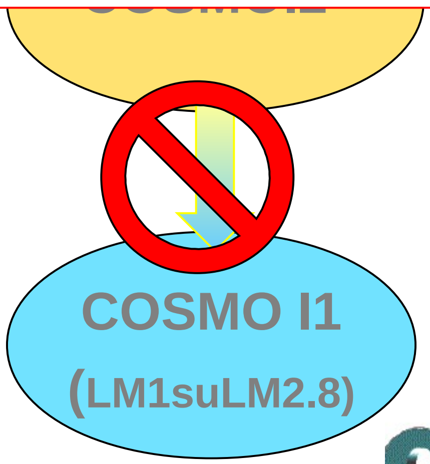

Sensitivity of "initiation of convection" respect to different resolution of COSMO model

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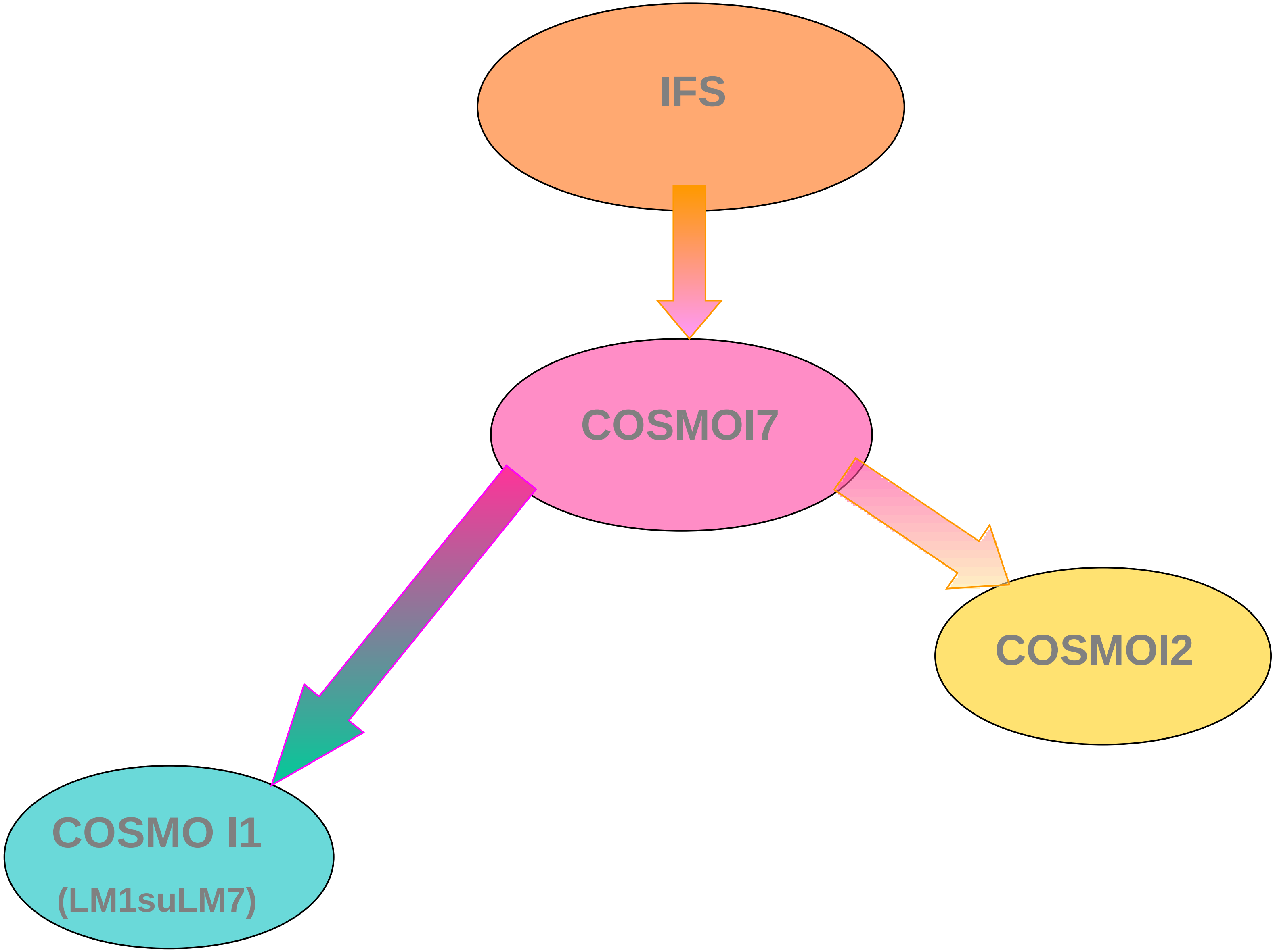
CONSORTIUM FOR SMALL SCALE MODELING
COSMO

The nesting tree



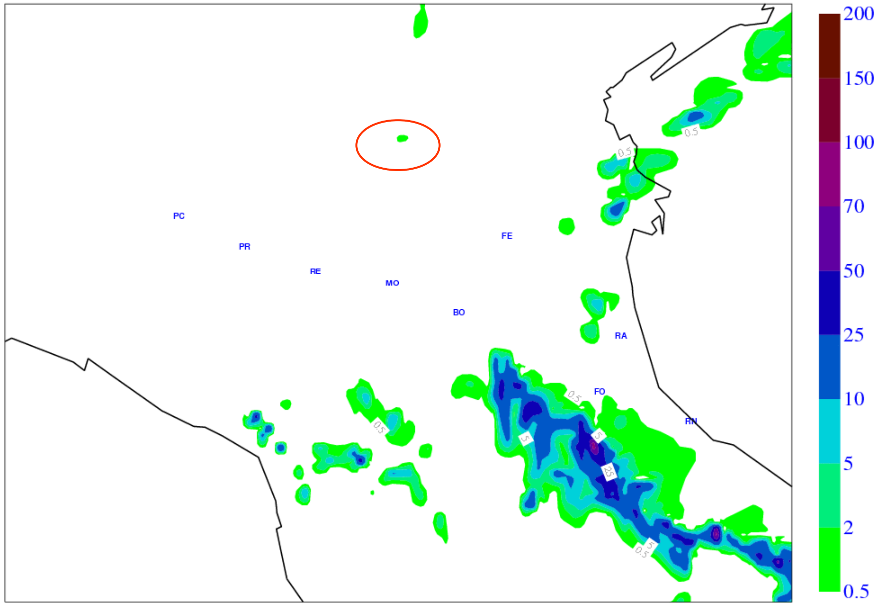
Outline

- motivations of the work
- case studies
- results

Operational CosmoI2 fc +18

27 may 2009 Parma's flood

Accumulation of 0 Forecasts VT:00UTC 27 May 2009 to 18UTC 27 May 2009 Surface: total precipitation



Observed precipitation in 15 minutes

27/05/2009 – 14:00	Colorno (PR)	21.2
27/05/2009 – 14:45	Parma T. P. (PR)	29.4
27/05/2009 – 14:45	Parma (PR)	31.4
27/05/2009 – 15:15	Casatico – Langhirano (PR)	36.8
27/05/2009 – 15:45	Collagna (RE)	20.2
27/05/2009 – 16:00	Ligonchio (RE)	30
27/05/2009 – 16:00	Collagna (RE)	25

Motivation 2

- Most of (present) high resolution model are not able to resolve explicity the deep convection; this is (maybe) because for mesh size between 3 and 7 km a convective system is partly resolved and partly still a subgrid process;

- Several studies demostrate that an increasing spatial resolution towards the 1 km spatial scale improved the rappresentation of convective phenomena (like thunderstorm, squall line and so on);

- in the future: 1km scale are able to make use of higher resolution input data (data assimilation from radar or high resolution gauge rain network) in the assimilation cycle;

Model set up:

- Versions: Int2lm 1.10 - Cosmo 4.13;
- Cosmo I7: IC from a 12h previous assimilation cycle (from IFS analisys); BC from IFS forecast; FC run +24;
- Cosmo I2 and Cosmo I1; IC and BC from CosmoI7 forecast;

MODEL	SPATIAL RESOLUTION	BC & IC	NAMESTIS
COSMO I7	0.625° x 0.625°	BC da IFS	Graupel, Tiedke, sso on, dt = 40s
COSMO I2	0.025°x 0.025°	BC from cosmo I7	Graupel, Runge Kutta, sso off, shallow convection only, dt = 15s
COSMO I1	0.01° x 0.01°	BC from I7	Graupel, Runge Kutta, sso off, Shallow convection , dt = 5s

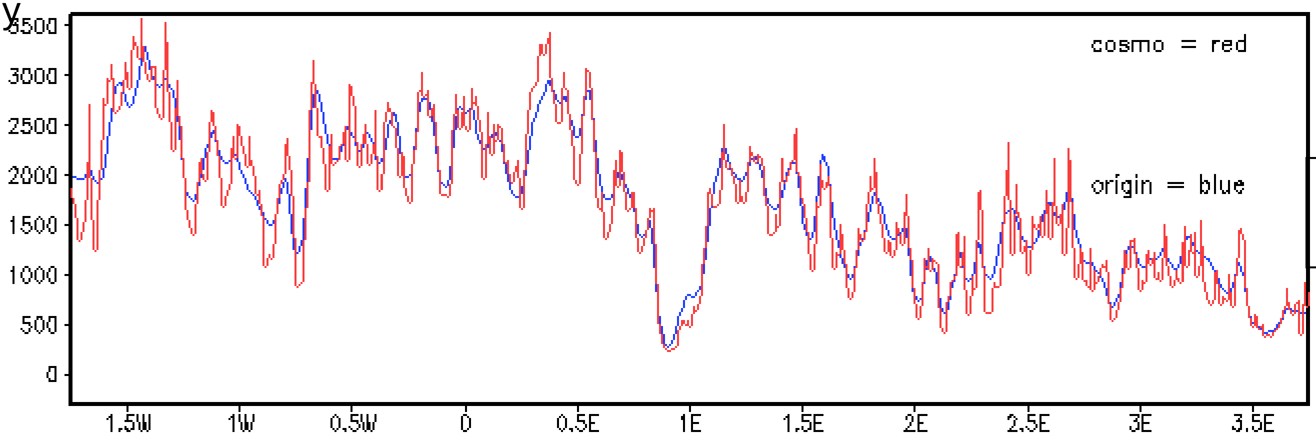
PROBLEMS on steep orography: CFL errors

If the integration area covered only the Po Valley there is any problem, but as the integration included the Alps .... a CFL violation error occorred; The model isn't able to handle a steep orography like this one in the photo without a smoothing.

Photo by D. Cesari

A smoothing of the original orography is a necessary at least at this stage of implementation...

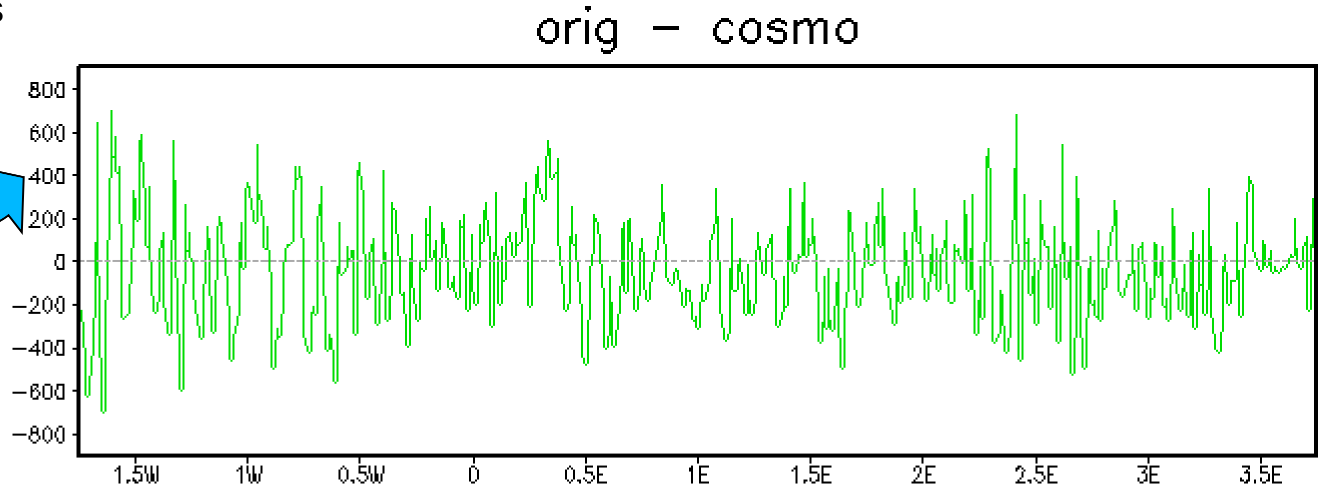
The original orography vs the Cosmo smoothed orography



☐ **original = RED**

☐ **Smoothed = BLUE**

The differences



What we look at?

- we take a glance to precipitation because we are interested to the convective activity with and without a synoptic forcing;

- first of all because we are interested to the possibility of a very high resolution model (at this stage of development) to create by himself the deep convection;

- secondly because it is simple to compare our model precipitation forecast with the radar's network (they have more or less the same resolution) or the gauge network;

- using the radar data we want to compare the localization and the growth of convective cells and the initiation of convection;

- It's unlikely that the model can predict exactly in the space and in the time every showers and this has to be borne in mind when we'll look to the maps.
- Neverthless the structure predicted by the model give us some usefull information about what will happen in the next few hours (usefull for a civil protection warning in an operational use);

- we look to the model capacity to reproduce the right "initiation of convection" (where we define the "initiation of convection" as the time when the radar accumulated precipitation is over 0.1 mm/h)

- and to the model capability to reproduce the right cycle of precipitation rate

Let's start: Case studies

- 27 may 2009 – flood over Parma city – Isolated but intense convective activity over North Italy associated with a weak cold advection at upper level and a cold pool from previous systems over Veneto.
- 07 July 2009 – Pre-frontal organized thunderstorm over North Italy with growth of a lot of intense multi-cell thunderstorms over the Emilia Romagna.
- 29 may 2010 – Very weak synoptic forcing due to cold advection over the eastern Alps. Heavy thunderstorms in the North Italy and a strong organized thunderstorm along the Po river (about 70mm/2h recorded by the rain gauge of Copparo station - Ferrara)
- 07 - 08 sep 2010 – mixed event due to a through over the France associated with a cold front over the North Italy. Thunderstorm and extended precipitation over Italy.
- 09 sep sep 2010 – Post frontal convective organized activity over the North Italy and Emilia Romagna region.

Case study of 09 september 2010

Post frontal convective organized activity over the North Italy and Emilia Romagna region.

ALE PREVENZIONE E AMBIENTE DELL'EMILIA-ROMAGNA

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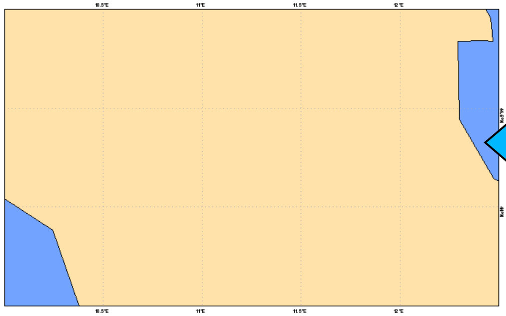


Integration area
Lat = 43.5°N to 45°N
Lon = 10°E to 12.5°E

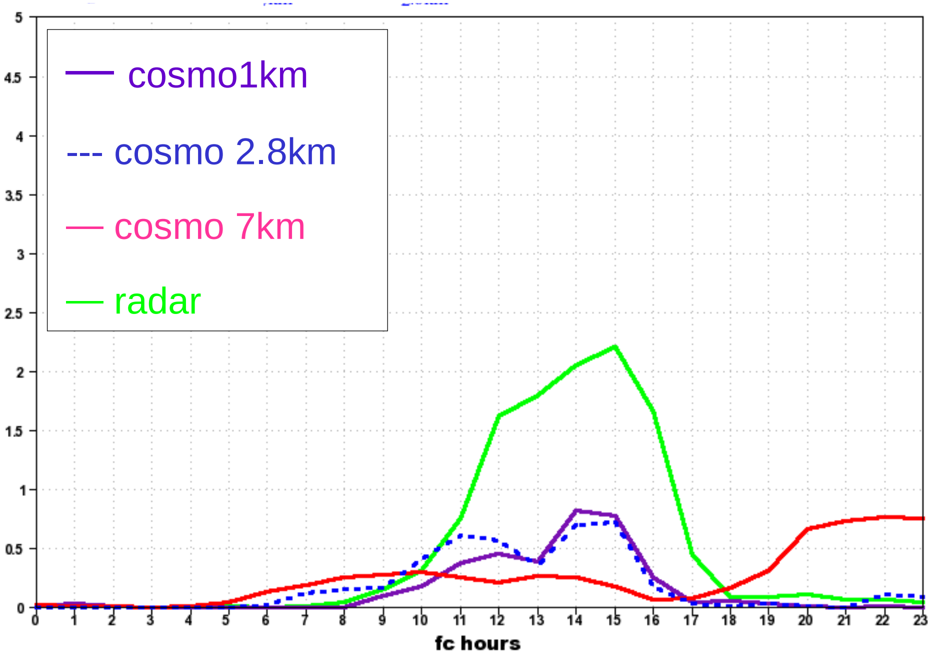
<u>1) The precipitation cycle is captured by both of HR model</u> (the max is in the exact hour,and the cycle is similar to the radar's one), but they underestimate both the maximum and the 24h precipitation;

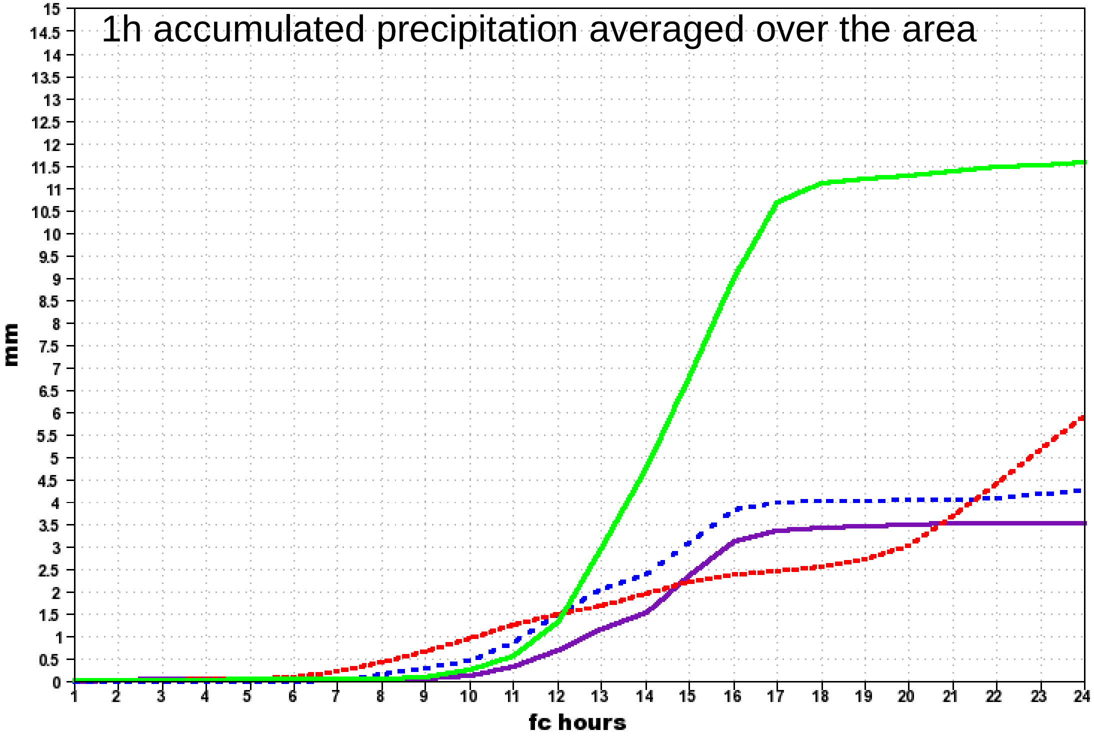
<u>2) The 1km has the right time of "intiation of convection"</u> rather than the other models (CosmoI7 anticipates while CosmoI2 postpones the beginning).

- 3) Cosmo I7 has an incorrect precipitation cycle (2 peak of precipitation)

4) All the 3 model underestimate the total 24h precipitation

Mean rain rate over the area (mm/h)





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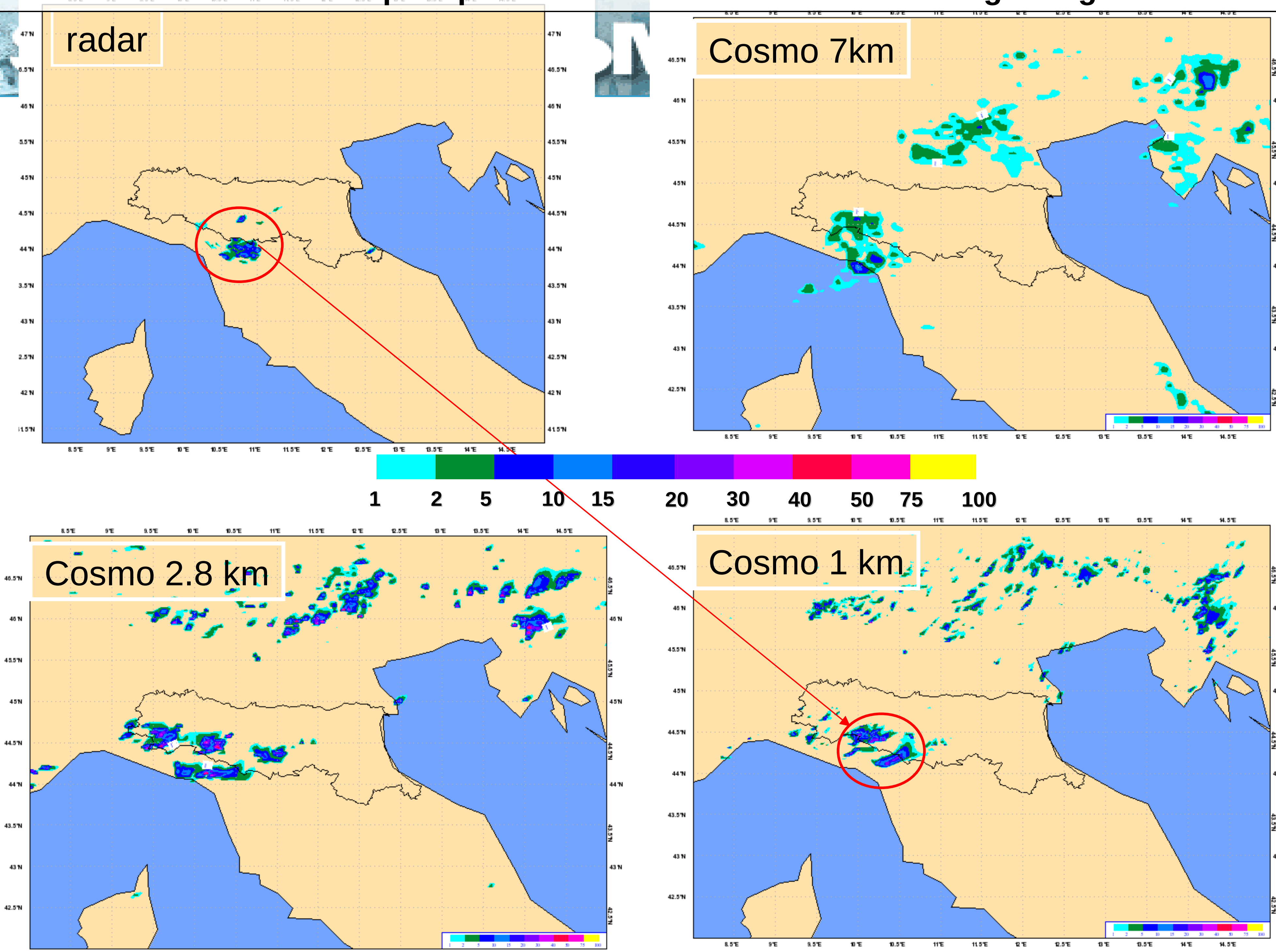
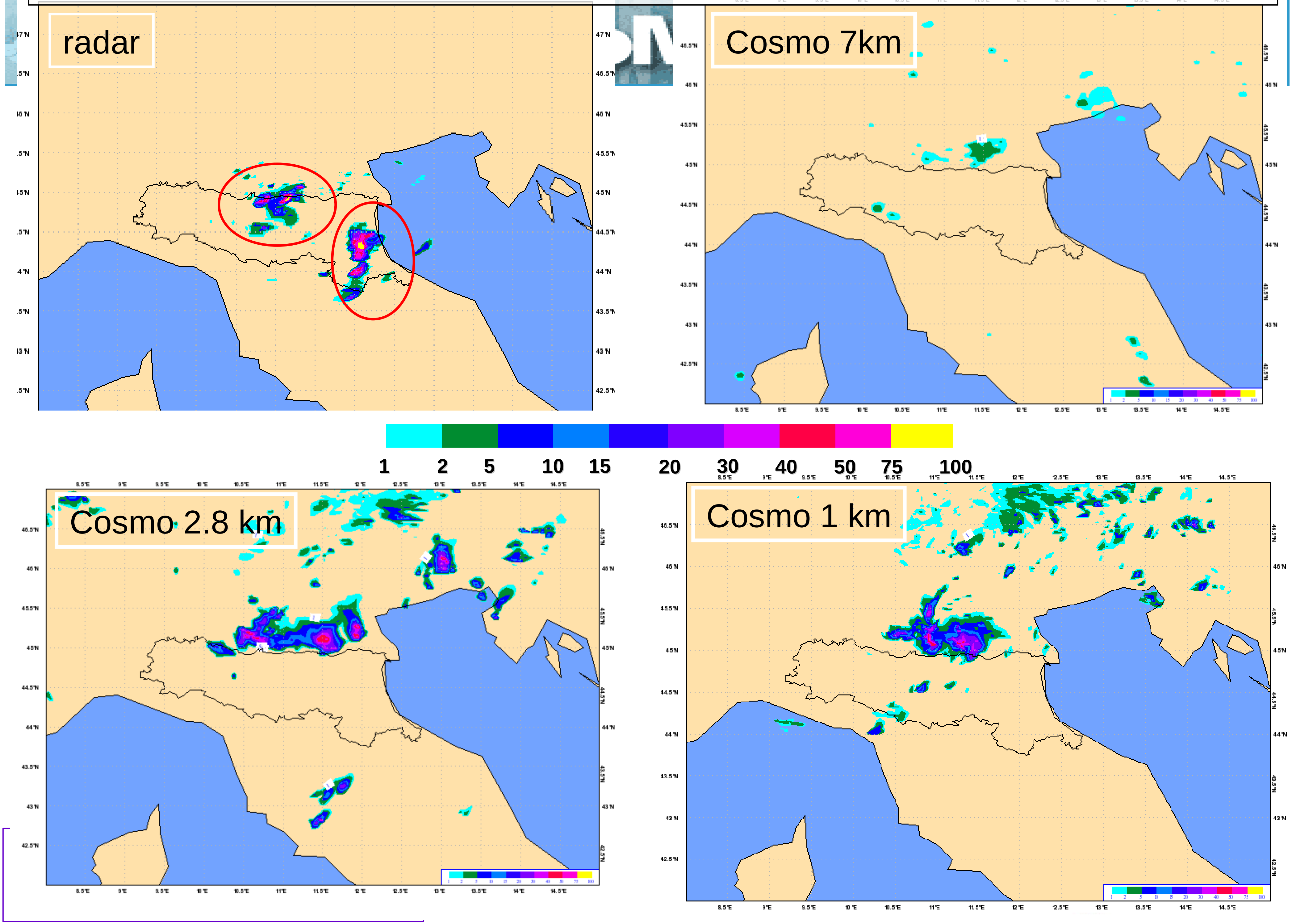
1h cumulated precipitation at 12 utc 09 09 2011- the beginning



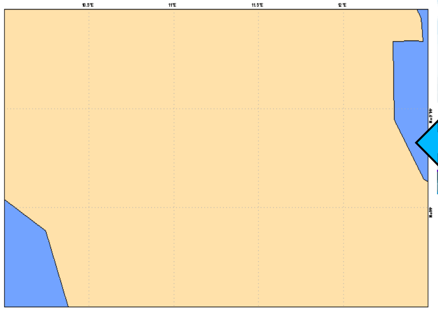
1h cumulated precipitation at 17 utc 09 09 2011- the maximum



Case study of 07- 08 september 2010

mixed event due to a through over the France associated with a cold front over the North Italy. Thunderstorm and extended precipitation over Italy. Beginning very early in the night of 08.

Run of 08/09 at 00 utc



Integration area
Lat = 43.5°N to 45°N
Lon = 10°E to 12.5°E

The 1nd max is capturated by CosmoI2 because of large scale forcing) .

CosmI1km doesn't have the rigth beginning of convection and also the 1nd maimum (maybe the event is too close the beginning of run?)

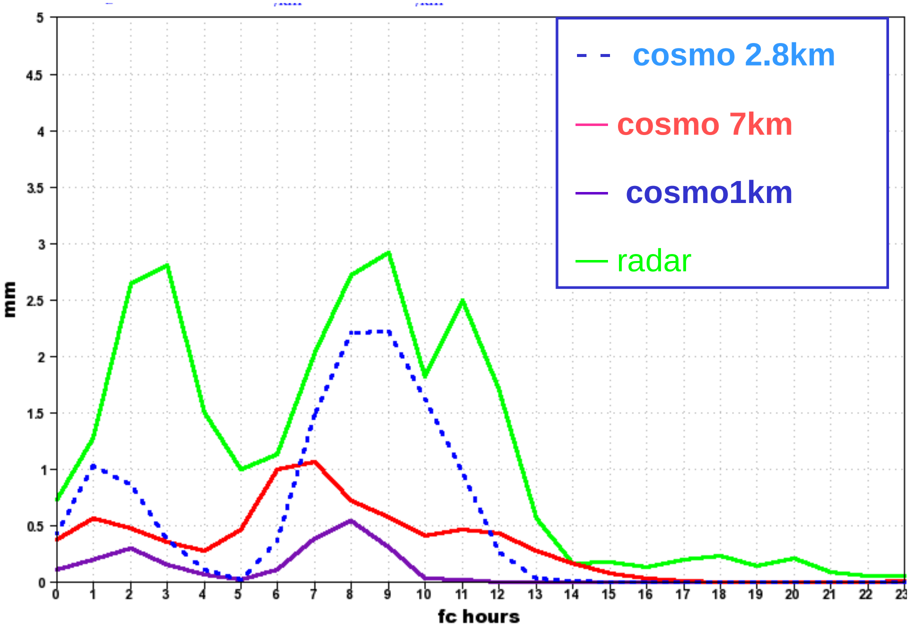
Both HR models captured the 2nd peak of precipitation and the cycle;

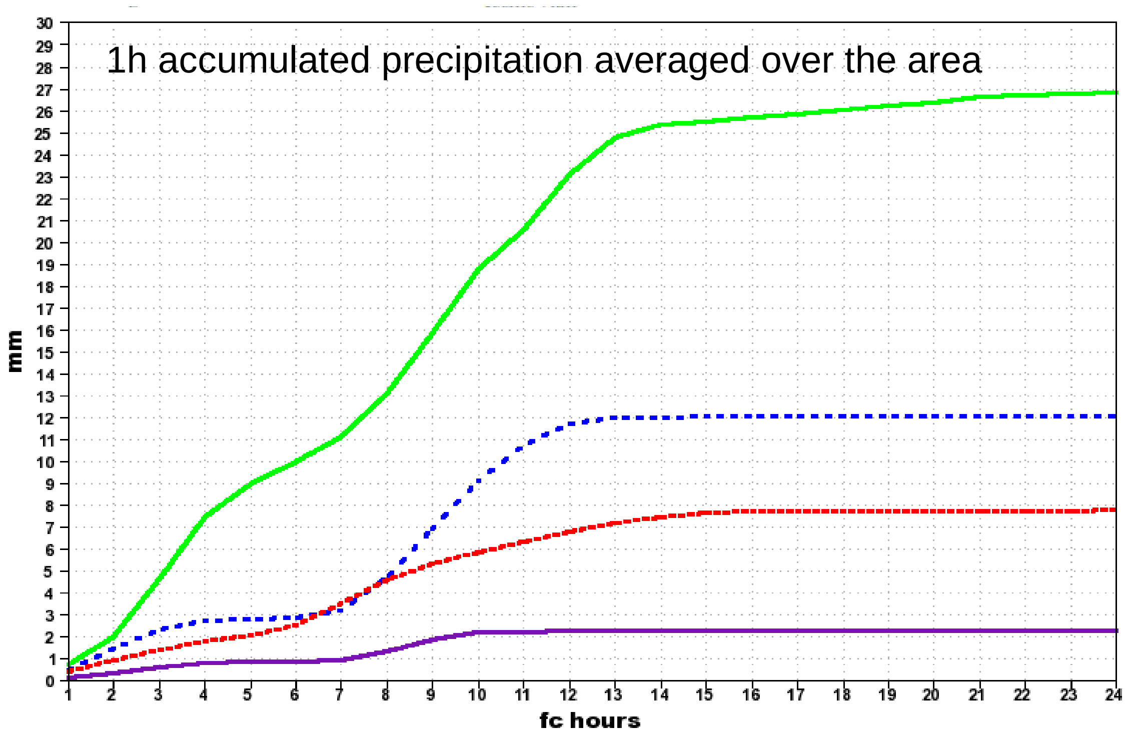
CosmoI2 performs better than CosmoI1 (maybe because there is a large scale forcing) that totally underestimates both the maximum;

Cosmo I7 doesn' have the right cycle It anticipate of about 3hours the 2nd peak);

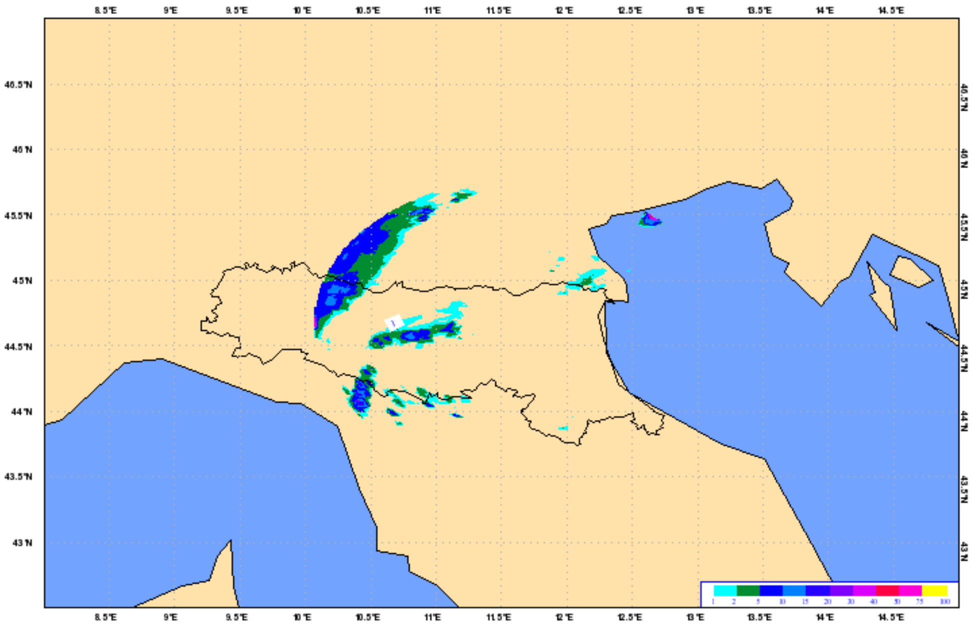
All models underestimate the 24htotal precipitation.

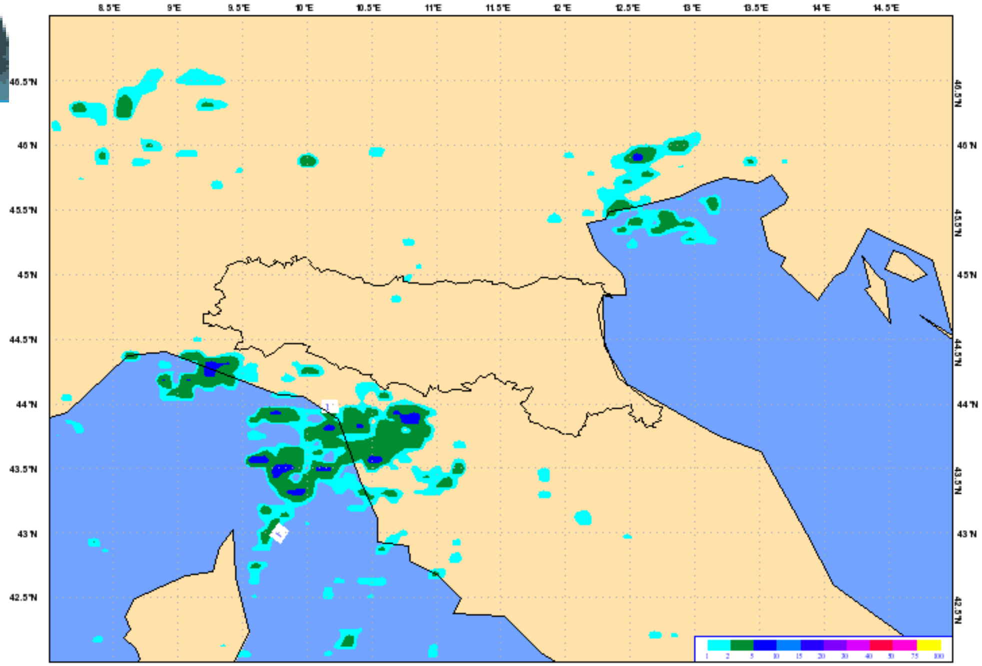
Mean rain rate over the area (mm/h)

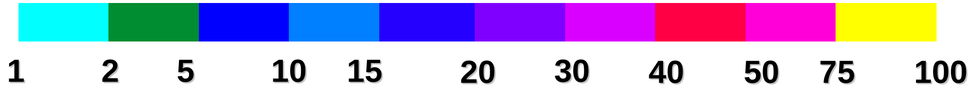


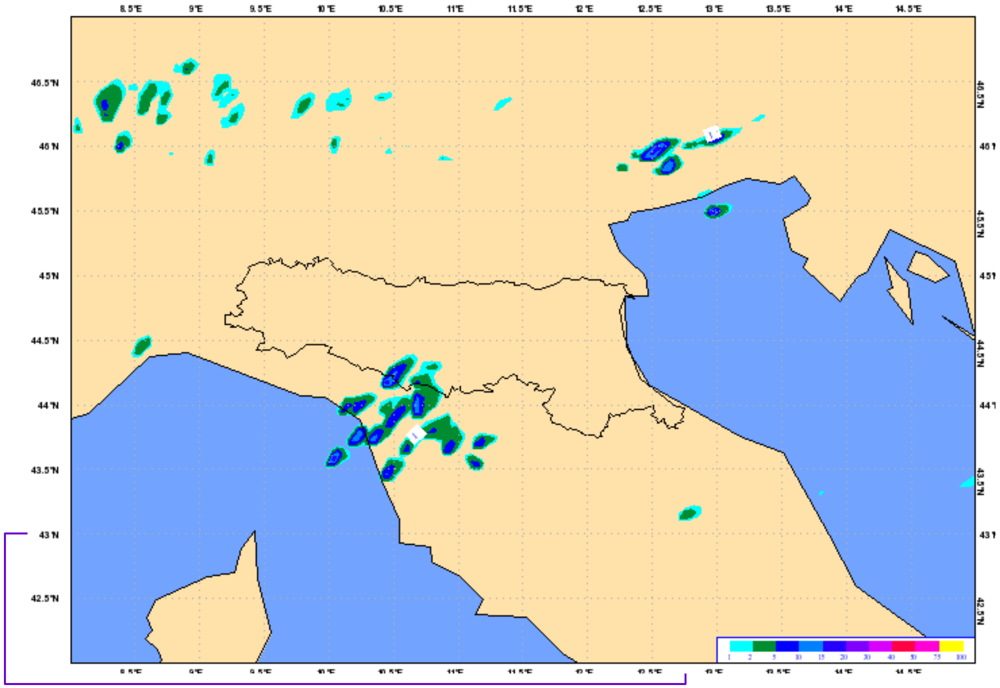

1h accumulated precipitation averaged over the area

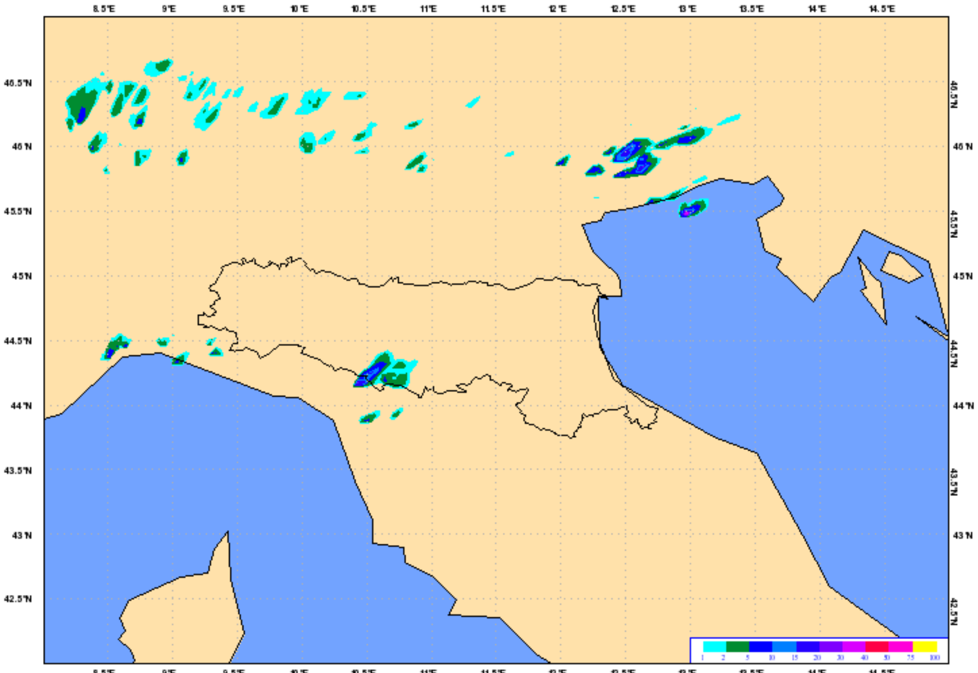
1h cumulated precipitation at 01 utc 08 09 2011- the beginning



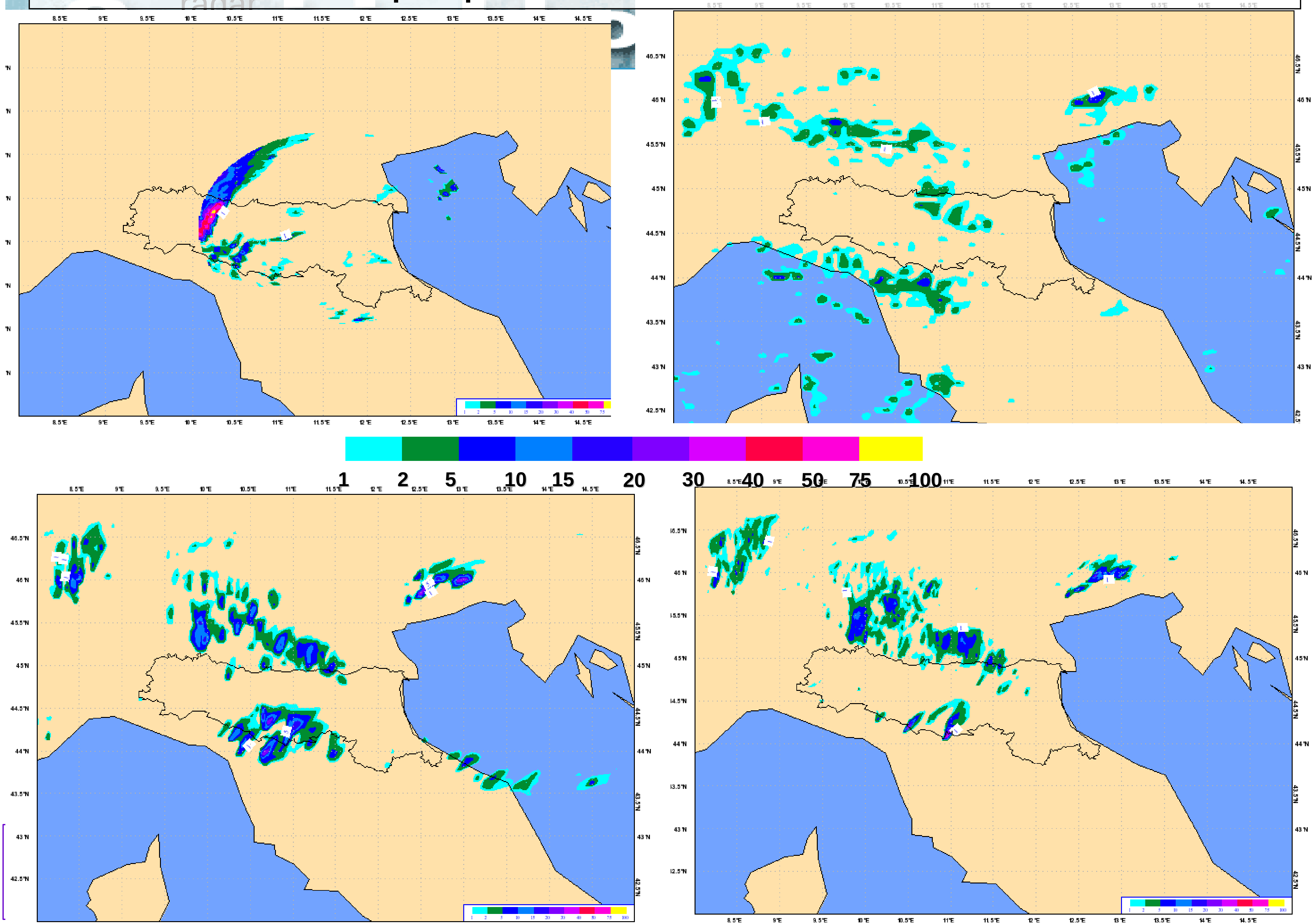






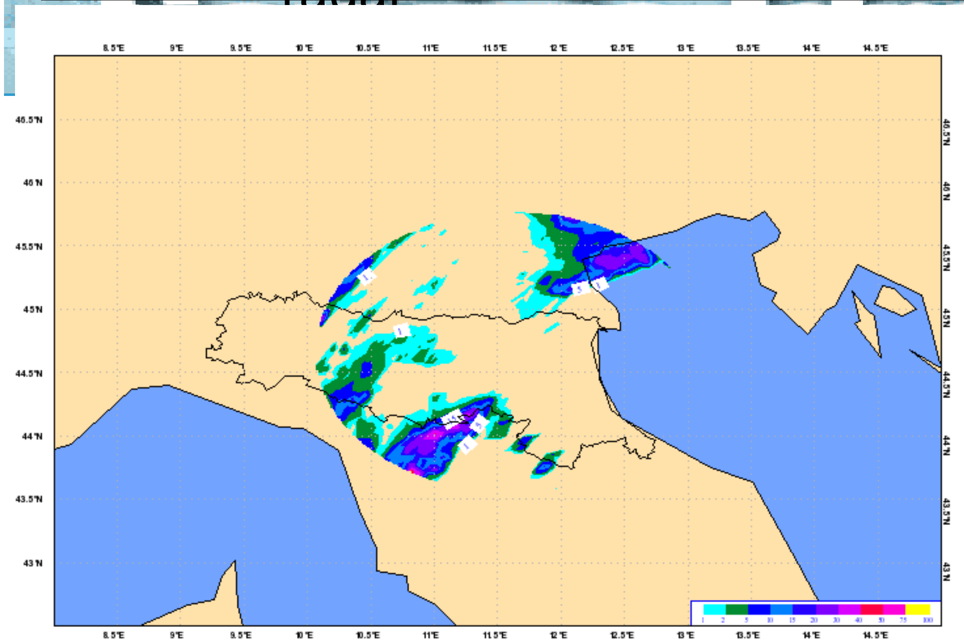


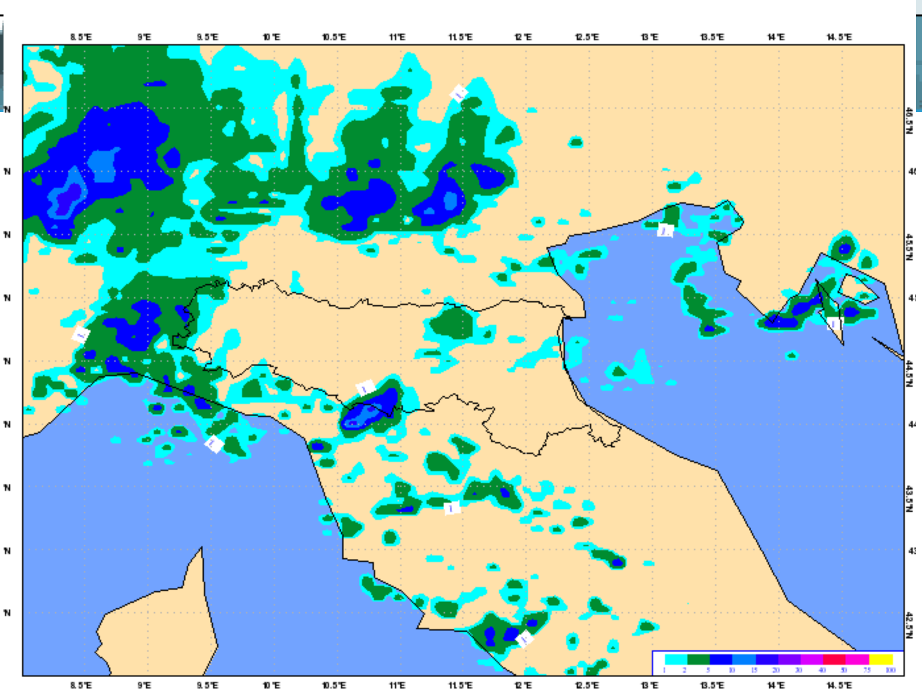
1h cumulated precipitation at 03 utc 08 09 2011- the first maximum



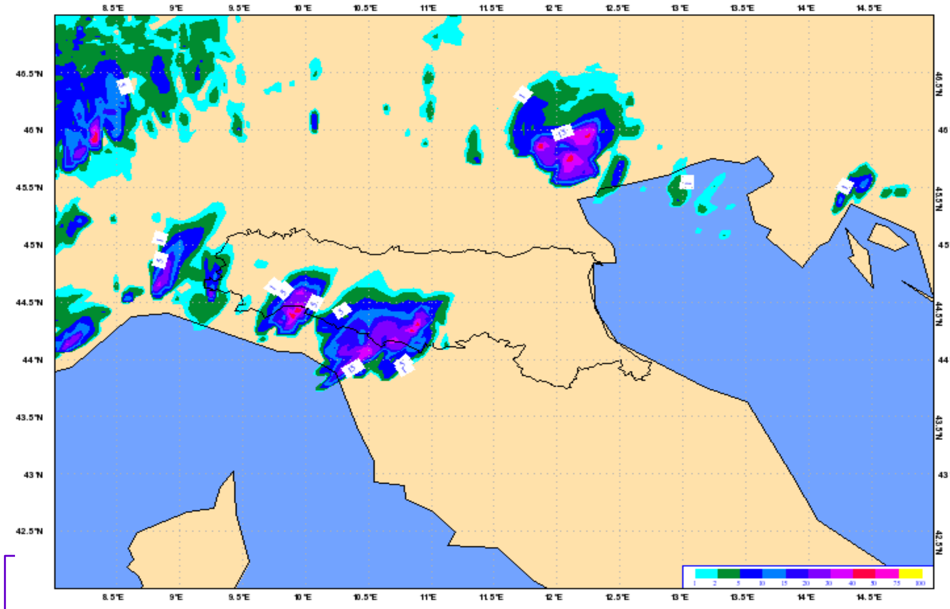
1h cumulated precipitation at 09 utc 08 09 2011- the second maximum

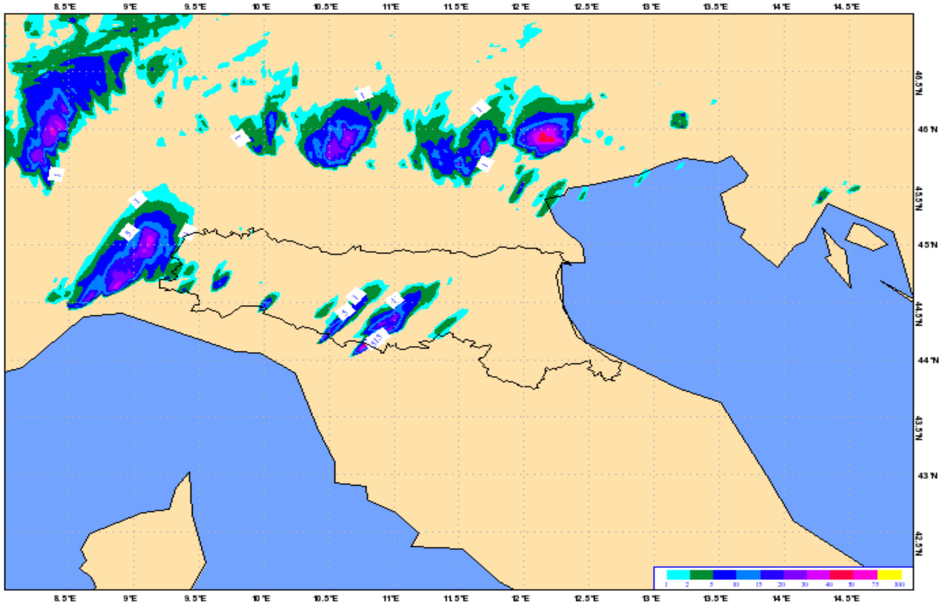
radar





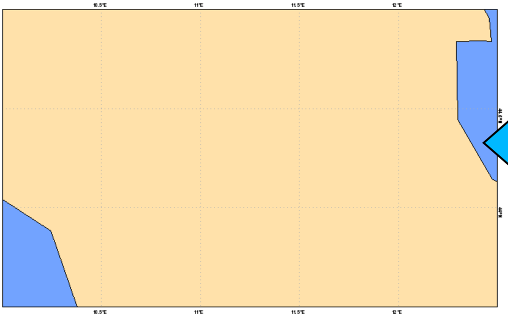
20 3





Too close to the beginning? Let's start 12 hours earlier
Run of 07 sept 2010 at 12 UTC fc +24

Precipitation of 08 sept; run of 07/sept at 12 utc

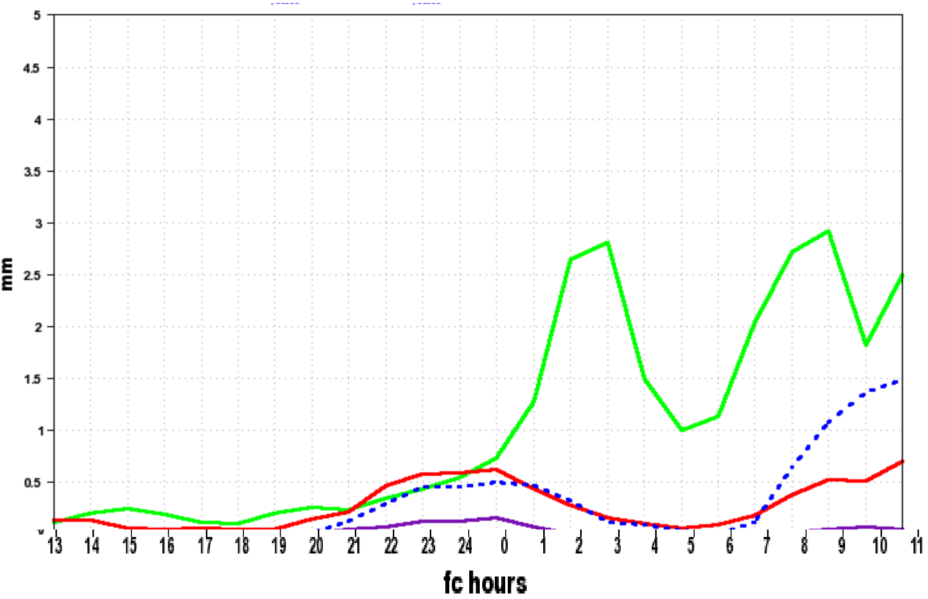


Integration area
Lat = 43.5°N to 45°N
Lon = 10°E to 12.5°E

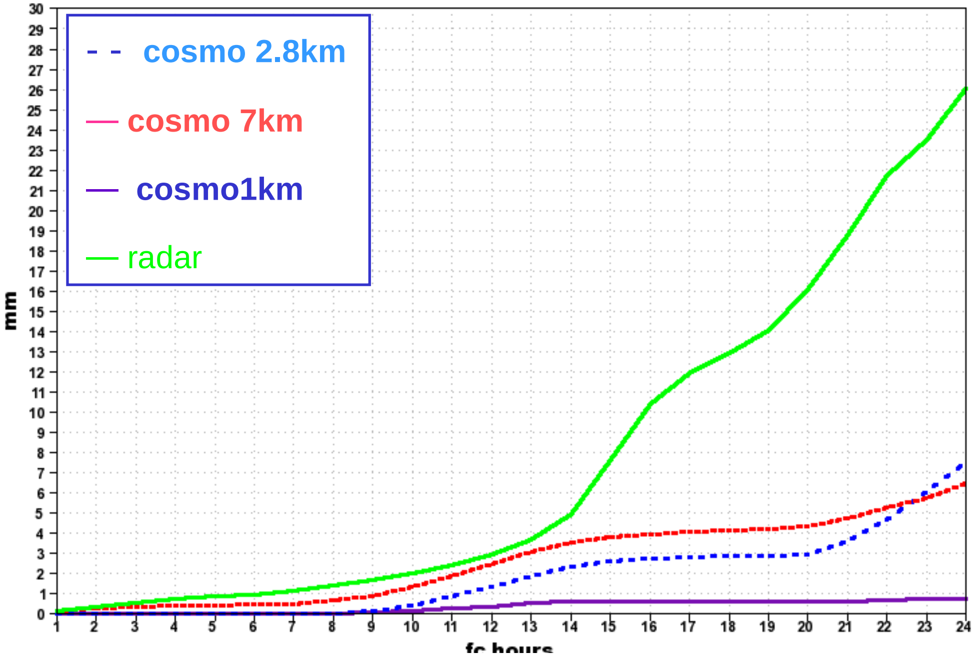
- The 1st peak is anticipated and understimated by all the 3 model;
- The cycle is completely wrong for both 7km and 1km, while the CosmoI2 performs better at the end of forecast (maybe it is slightly late reaching the maximum)
- The initiaton of convection is capturated only by CosmoI7, the other 2 HR models missing the rising of precipitation of the early morning;
- Tthe 2 nested model follows the cycle of the parent model;

The CosmoI1 miss the precipitation at all

Mean rain rate over the area (mm/h)



1h accumulated precipitation averaged over the area



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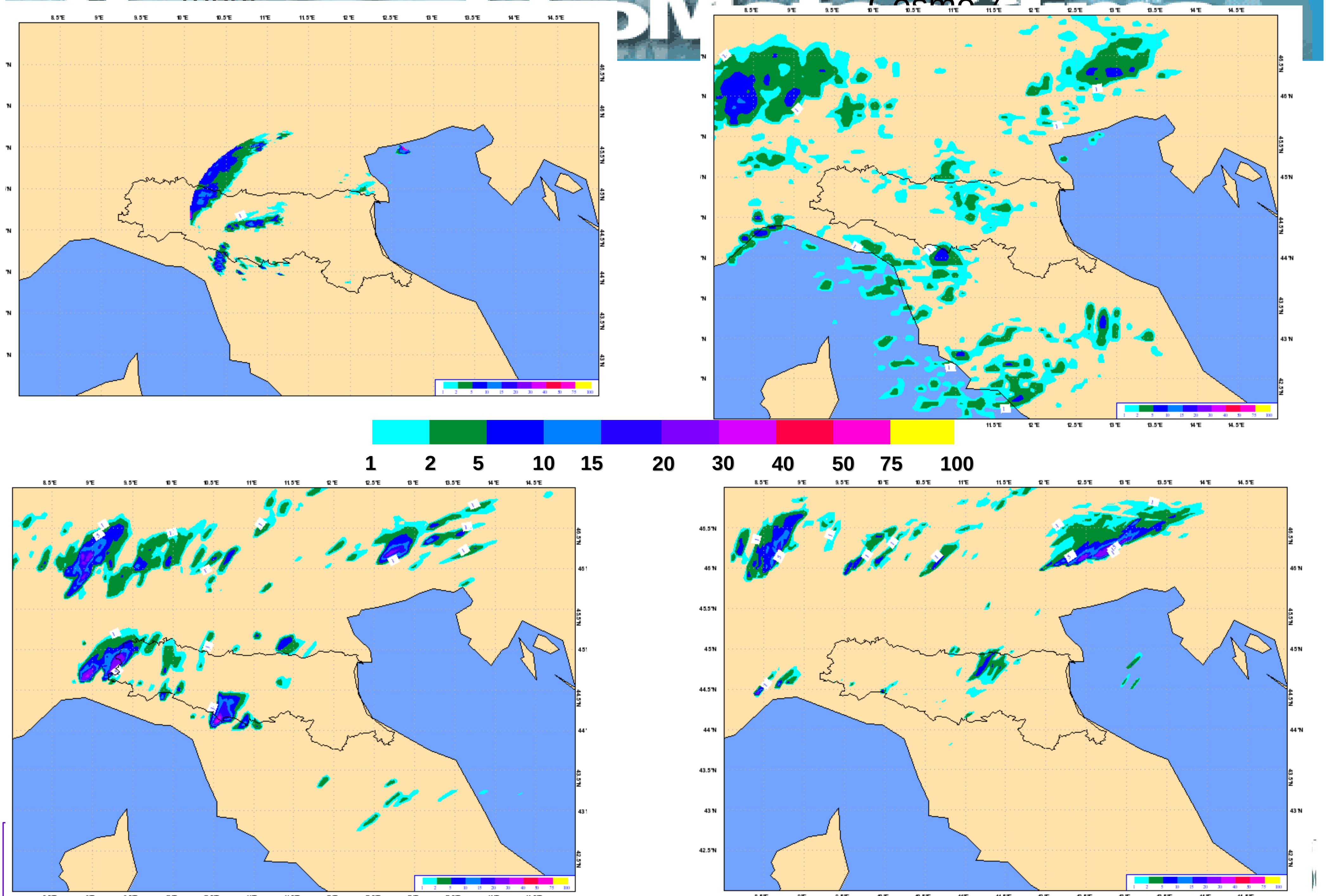
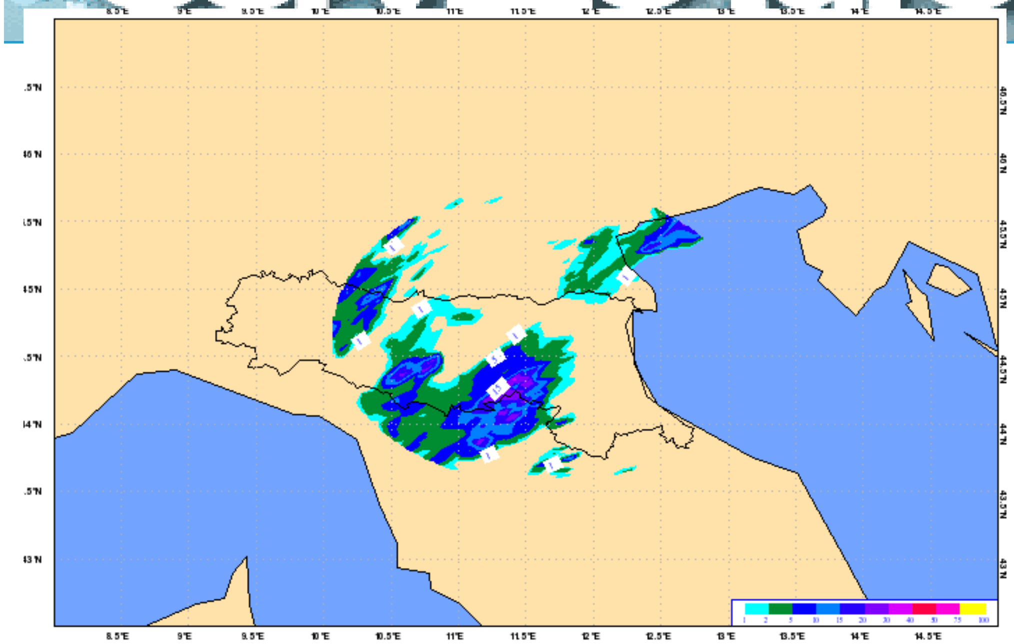
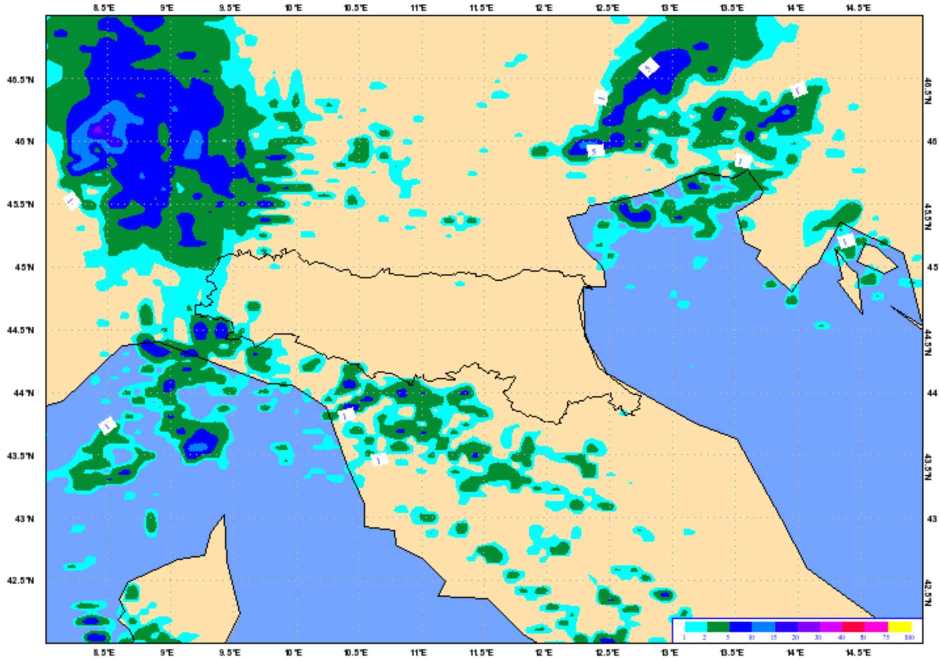
1h cumulated precipitation at 01 utc 08 09 2011- the beginning



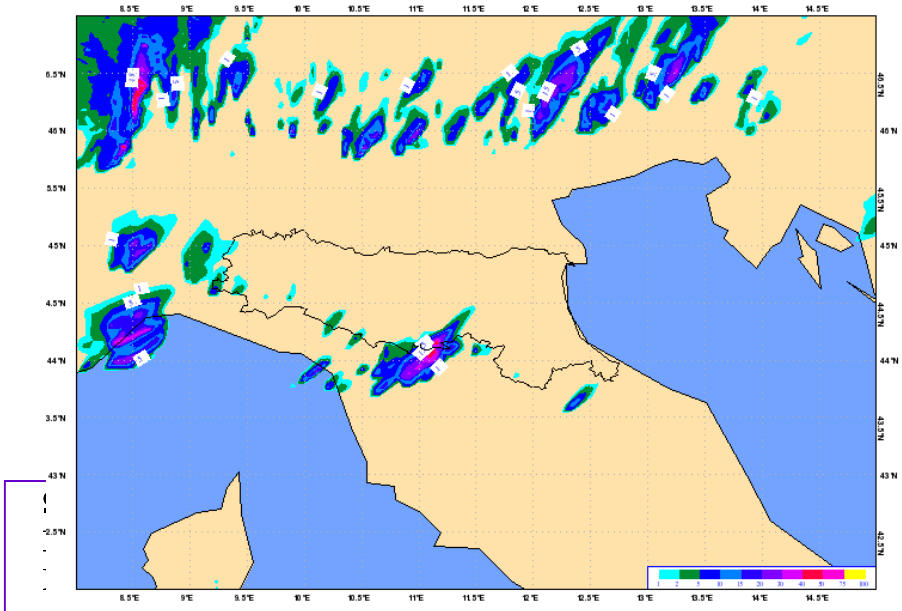
1h cumulated precipitation at 03 utc 08 09 2011- the first maximum

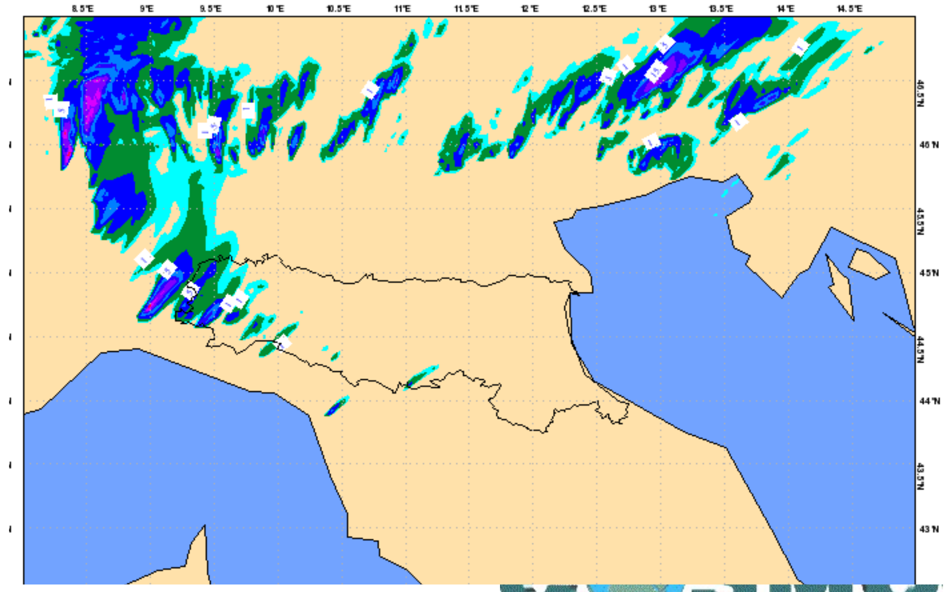
radar



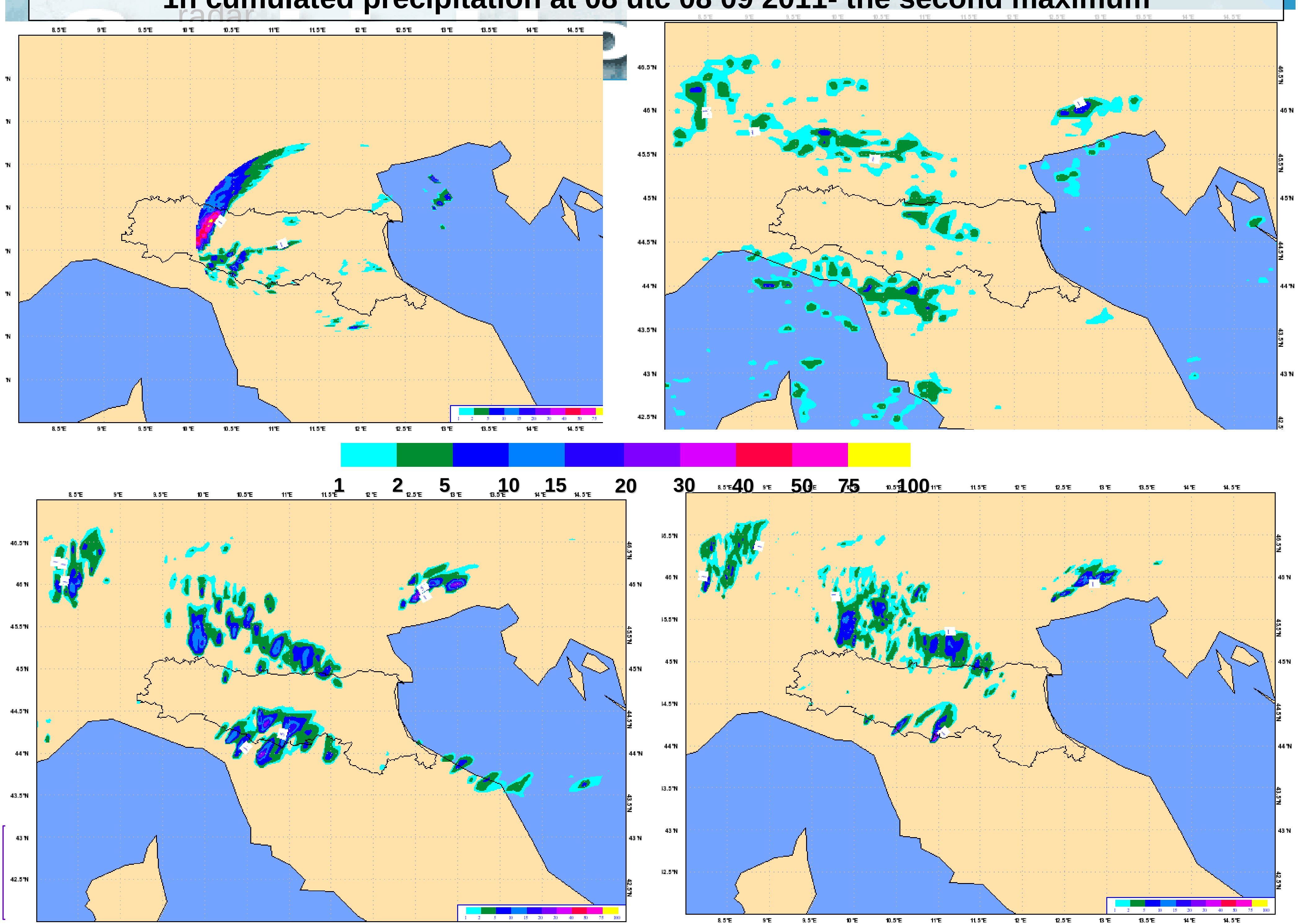


1 2 5 10 15 20 30 40 50 75 100



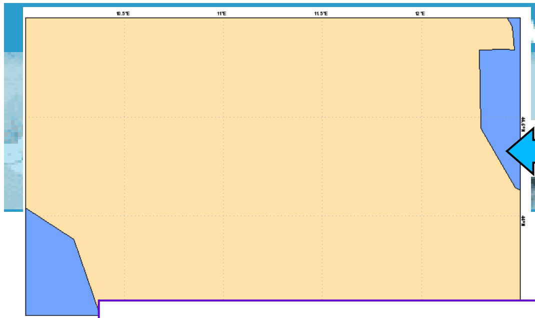


1h cumulated precipitation at 08 utc 08 09 2011- the second maximum



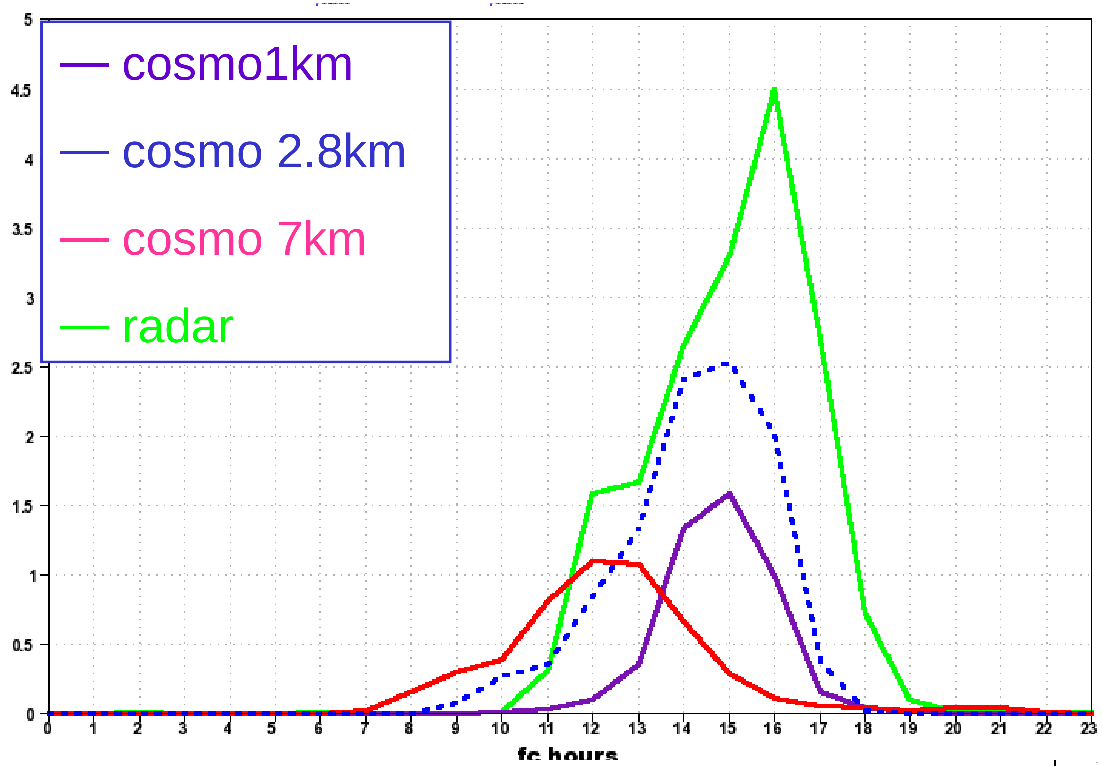
Case study of 27 may 2009

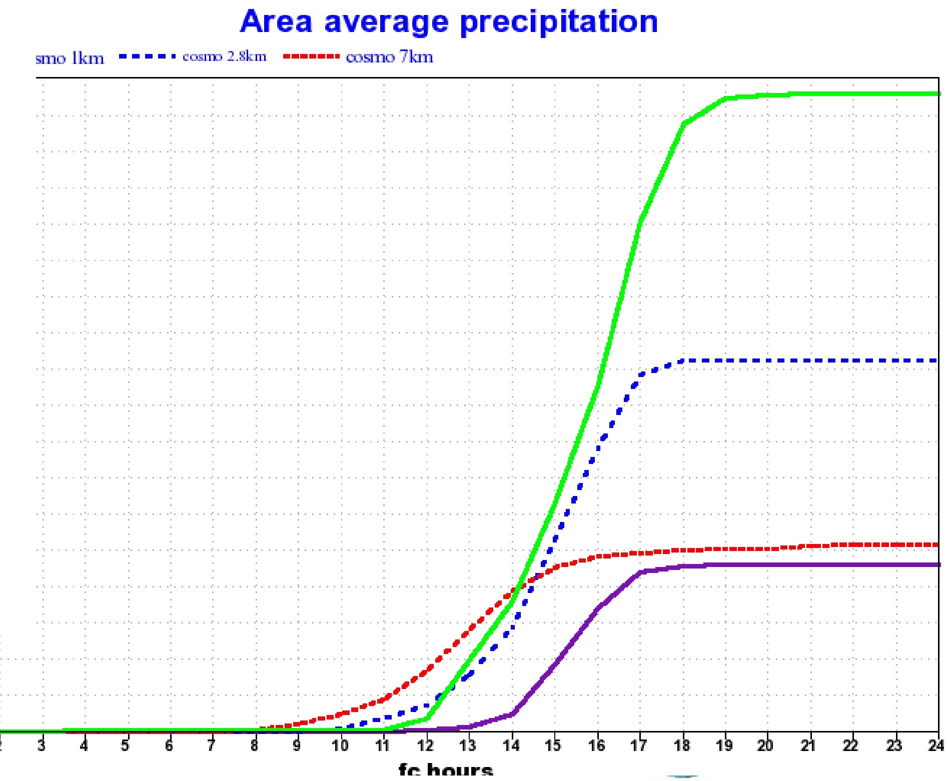
flood over Parma city – Isolated but intense convective activity over North Italy associated with a weak cold advection at upper level and a cold pool from previous systems over Veneto.



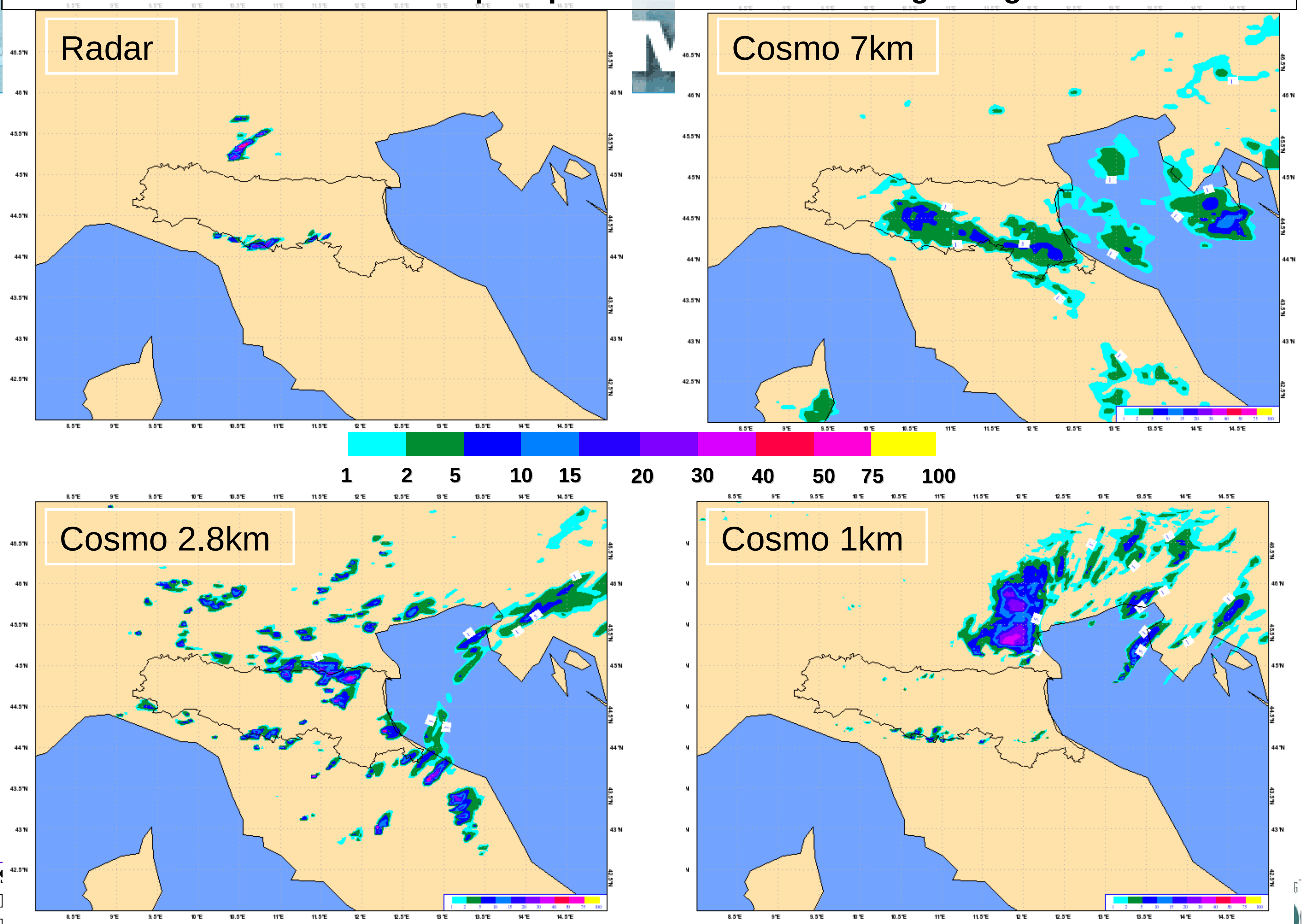
Integration area
Lat = 43.5°N to 45°N
Lon = 10°E to 12.5°E

- Both the HR models have (more or less) the right cycle of the precipitation;
- The CosmoI2 and the CosmoI1 anticipate of fews hours the maximum;
- CosmoI7 has a quite smoothed cycle driving maybe by the convection scheme (the peak of precipitation is at noon). It anticipates the cycle of about 4 hours;
- All the 3 models underestimate the peak of the precipitation.
- CosmoI7 anticipates the initiation of convection of about 4 hours;
- Cosmo 2.8 km anticipates of about 1 hour the peak;
- Cosmo1km posticipates the initiation of convection of about 1 hour;

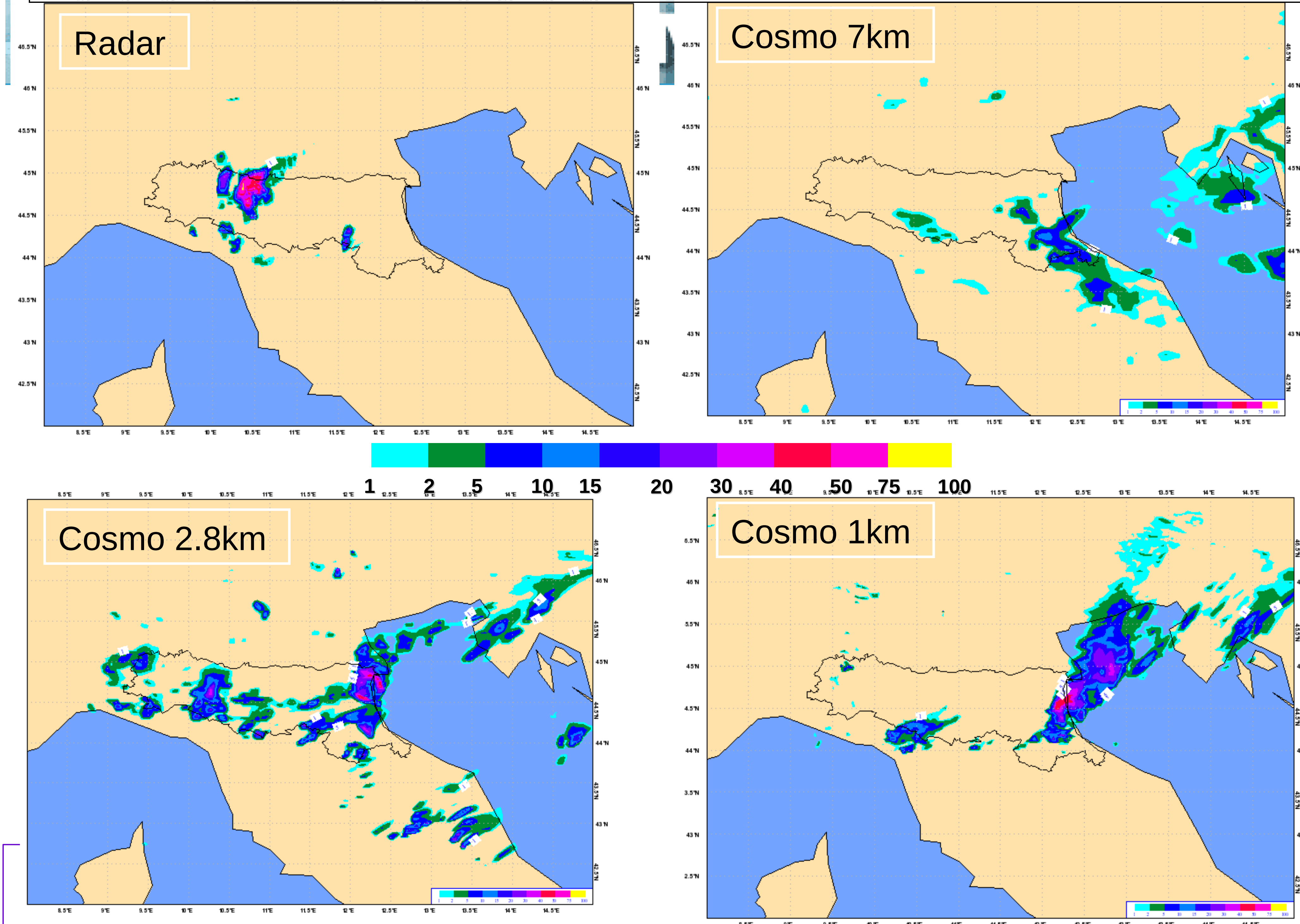




1h cumulated precipitation at 13 utc - the beginning



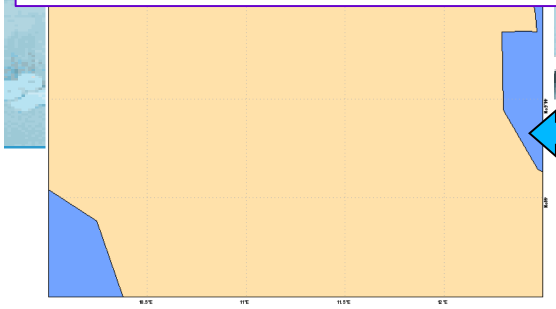
1h cumulated precipitation at 16 utc - the maximum



Case study of 07 July 2009

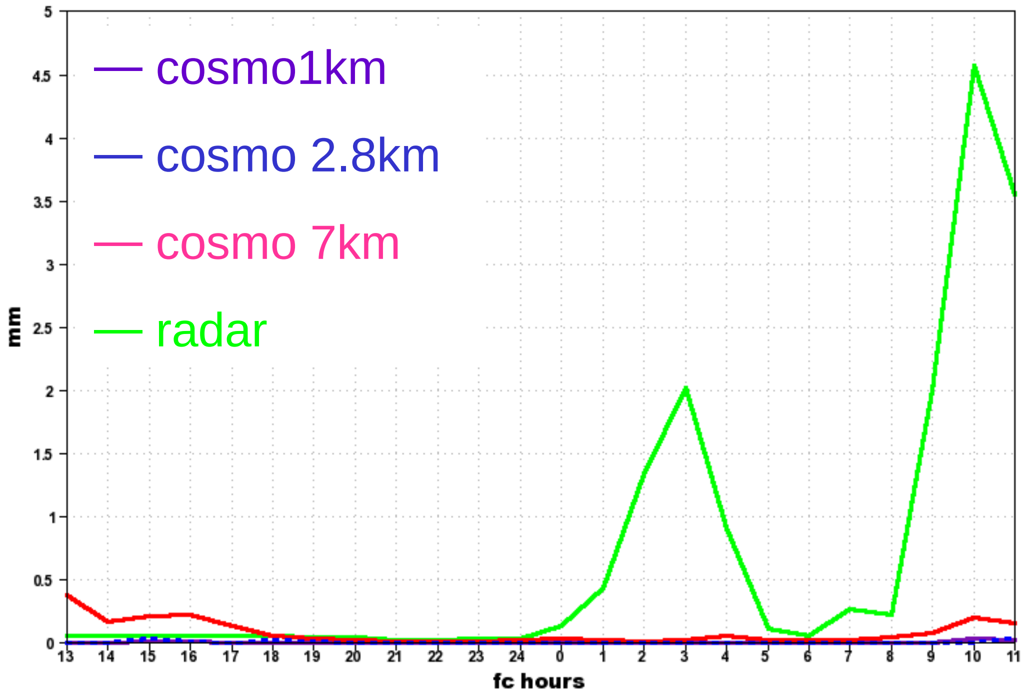
Pre-frontal organized thunderstorm over North Italy with growth of a lot of intense multi-cell thunderstorms over the Emilia Romagna.

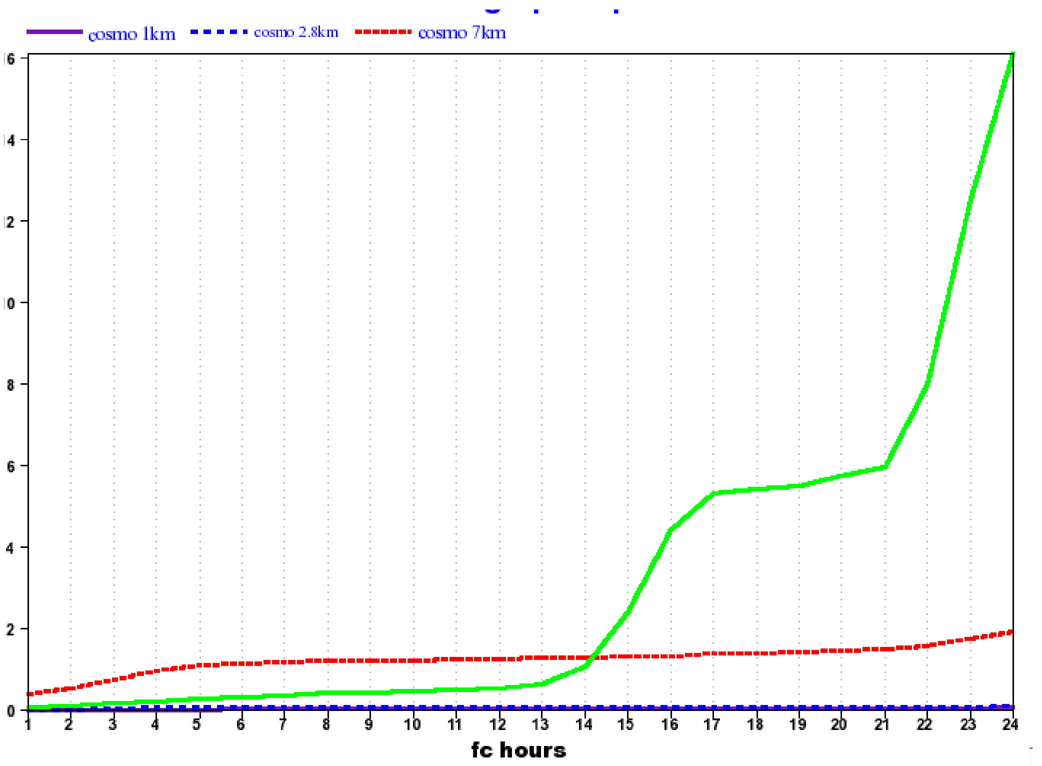
Case study of 07/07/2009



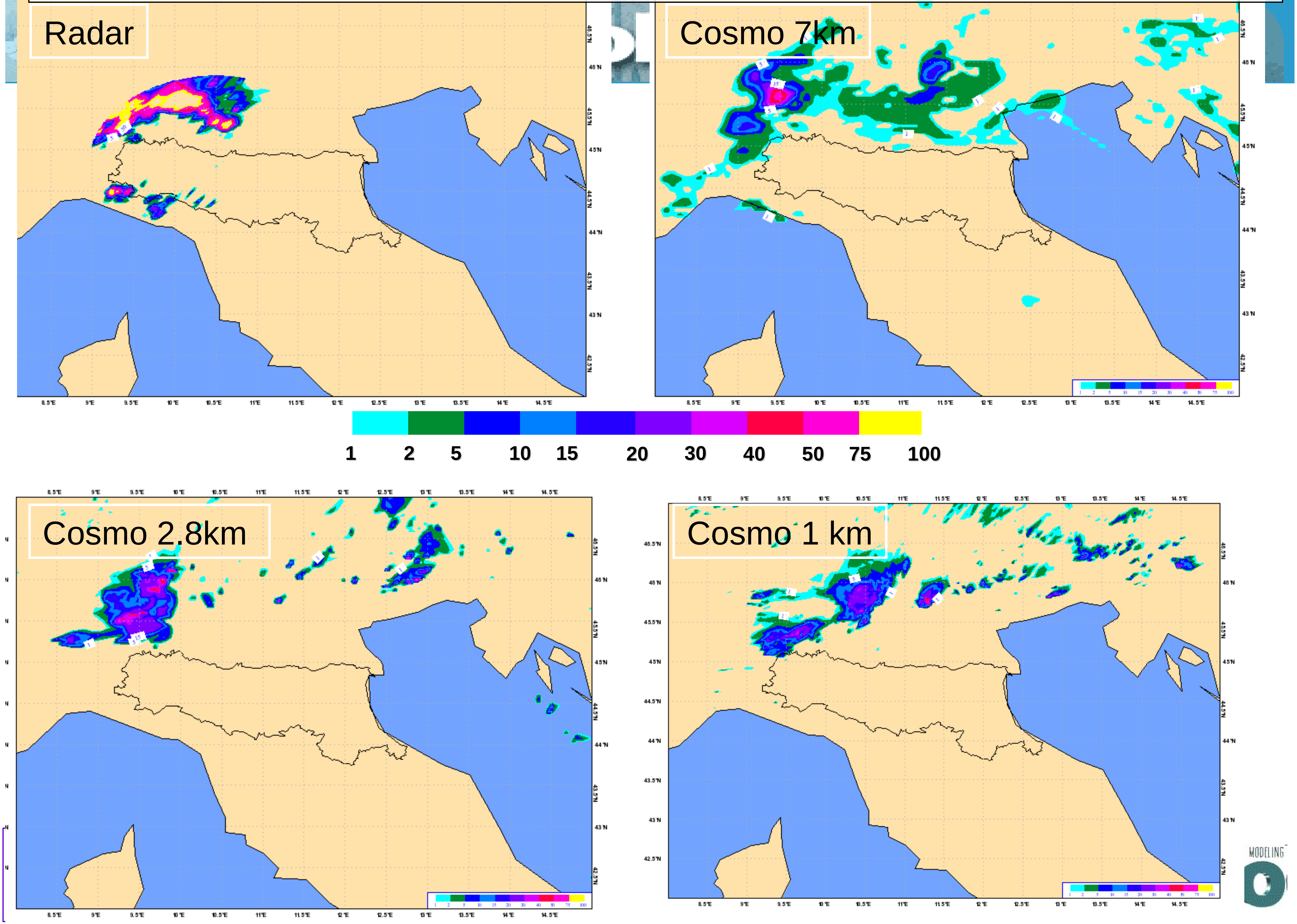
Integration area
Lat = 43.5°N to 45°N
Lon = 10°E to 12.5°E

- Cosmo 7km performs better than the other models. The “initiation of convection” has no particular delay;
- Cosmo 2.8km and Cosmo 1km definitely underestimates the precipitation,they miss totally the precipitation;

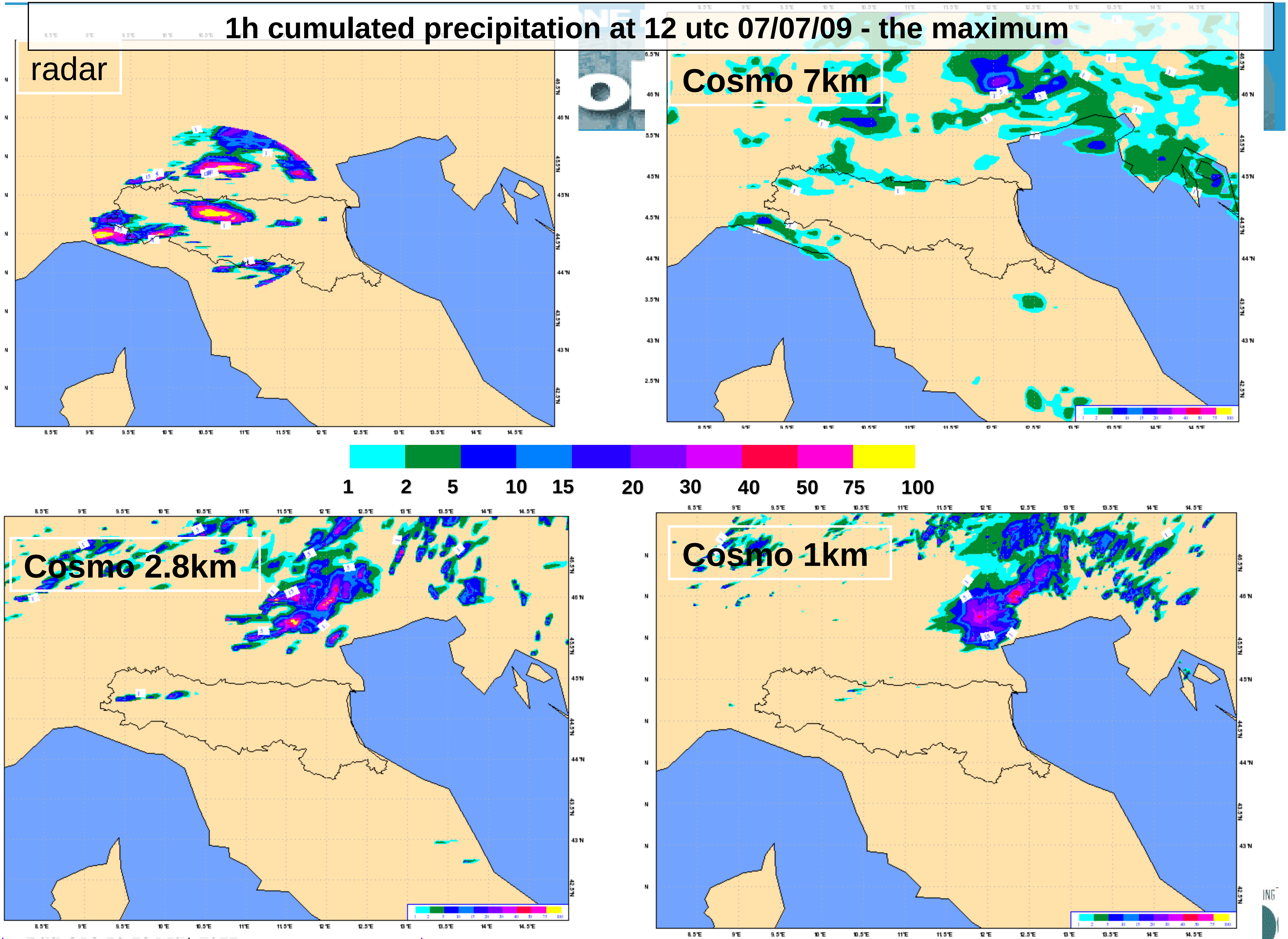




1h cumulated precipitation at 08 utc 07/07/09 - the beginning



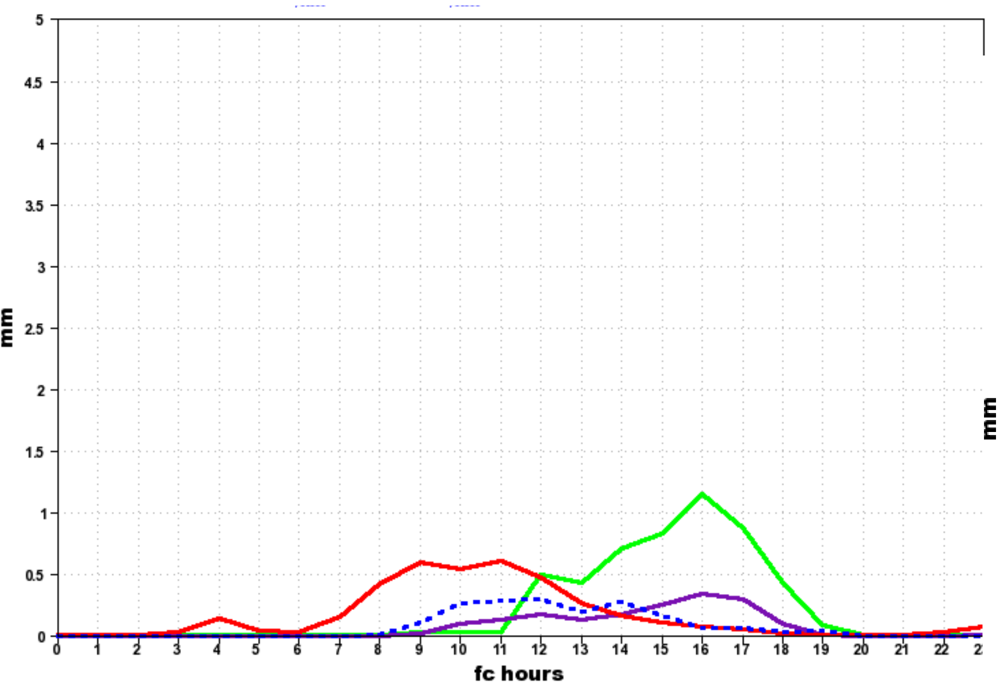
1h cumulated precipitation at 12 utc 07/07/09 - the maximum

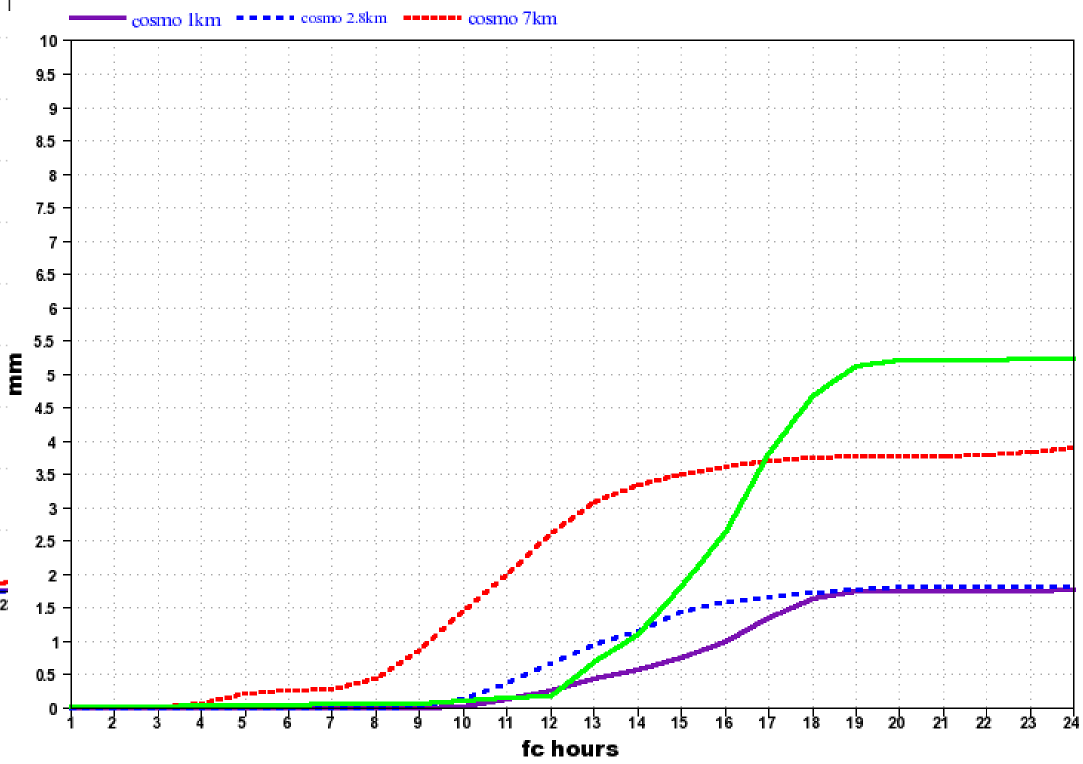


Case study of 29 May 2010

Very weak synoptic forcing due to cold advection over the eastern Alps. Heavy thunderstorms in the North Italy and a strong organized thunderstorm along the Po river (about 70mm/2h recorded by the rain gauge of Copparo station - Ferrara)

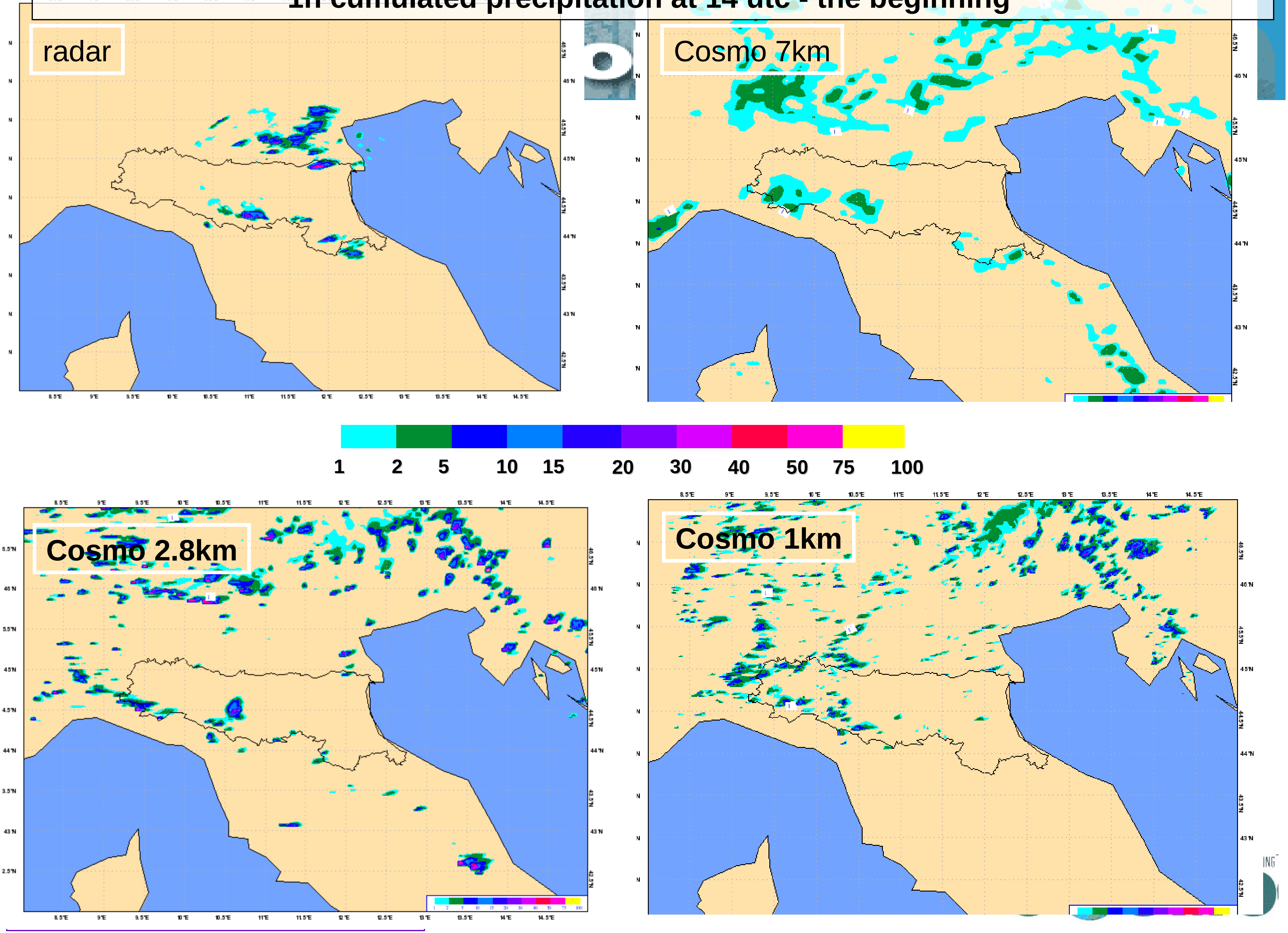
- The best performance; Cosmo1km has the same cycle with the right peak,unfortunately it underestimates the maximum;It's initiation of convection is the same of the radar's one;
- Cosmo 7km anticipates of about 6 hours the maximum, even if the 24h total precipitation is sligtly underestimated;
- Cosmo 2.8km; the “initiation of convection” is of about 3 hour earlier and it underestimates the total averaged precipitation; itseems to follows the parent cycle instead of his own convection;



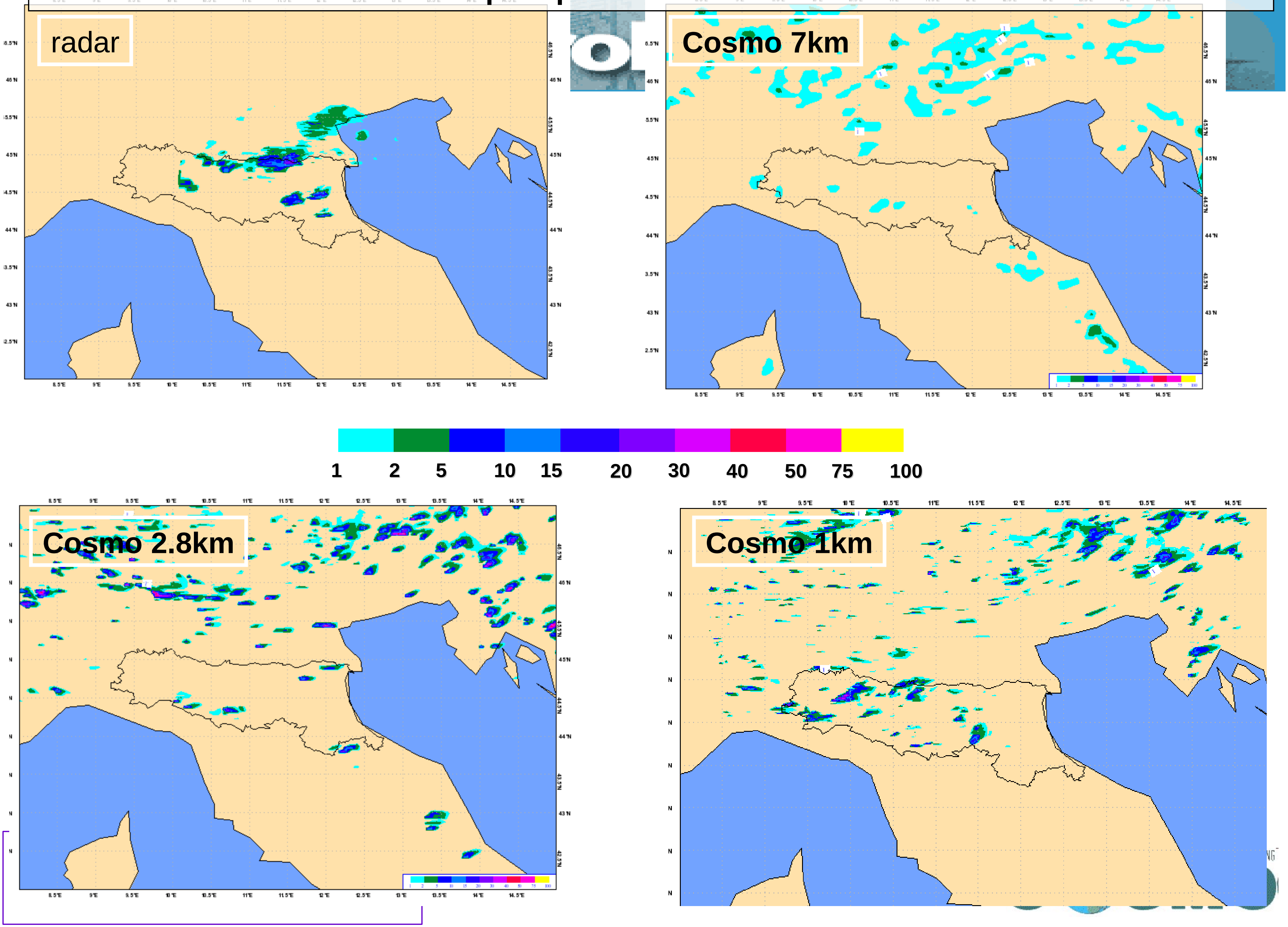


9 Th International SRNWP workshop on
Non- Hydrostatic modelling
Bad Orb 16-18 May 2011

1h cumulated precipitation at 14 utc - the beginning



1h cumulated precipitation at 16 utc - the maximum



summarizing ….

Delay in the “Initiation convection” relative to the radar expressed in hours (the minus sign means the model anticiates the beginning

Case study	Radar (h UTC)	Cosmo 7km	Cosmo 2km	Cosmo 1km
09/09/10	10	-2	-1	+1
08/09/10	01	+2	+1	--
27/05/09	12	-4	-1	+1
07/07/09	01	-	-	-
29/05/10	13	-5	-2	0

Model capability to reproduce the exact time of the maximum of precipitation.

Case study	Radar (h UTC)	Cosmo 7km	Cosmo 2km	Cosmo 1km
09/09/10	15	+5	-1	-1
08/09/10	03 08	-2 -2	-1 0	0 0
27/05/09	16	-4	-1	-1
07/07/09	02 12	-	-	-
29/05/10	13	-6	-5	0

Conclusions

The model performance depends strongly from the type of weather.

For the 2 case with a strong synoptic forcing (08 sept 2010 and 27 May 2009) CosmoI2 has the best performance, even if the cycle of precipitation is captured by all the models.

For the 2 case with a weak synoptic forcing (09 sept 2010 - post-frontal event and 07 July 2009 pre-frontal event) in the first all the 2 HR models perform better than the parent model CosmoI7 and the cycle is well capturated, while in the second case all the 3 model fail the forecast.

In the absence of any synoptic forcing (case study of 29 may 2010) CosmoI1 is the best model and it is able to create the convective activity on our target area (the Emilia Romagna region)

Future work

Sensitivity to the nesting on the CosmoI2 and comparison between the different boundary condition;

Sensitivity to the increased vertical level;

Take a look to other variables (like for example the winds for the air quality)

Thanks for the attention

And many thanks to Davide Cesari (ARPA-SIMC)

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Vertical interpolation of : pp 45 46 45 45
PUNKT 18  3  UND DIE NAECHSTEN 0.101614E04 0.965324E+03 S          ALSCHER REIENFOLGE
PUNKT 34  3  UND DIE NAECHSTEN 0.101614E04 0.965324E          D IN FALSCHER REIENFOLGE
PUNKT 36  3  UND DIE NAECHSTEN 0.101614E04 0.965          3 SIND IN FALSCHER REIENFOLGE
PUNKT 1   3  UND DIE NAECHSTEN 0.101614E04          4E+03 SIND IN FALSCHER REIENFOLGE
PUNKT 31  3  UND DIE NAECHSTEN 0.1016          965324E+03 SIND IN FALSCHER REIENFOLGE
PUNKT 31  3  UND DIE NAECHSTEN 0          04 0.965324E+03 SIND IN FALSCHER REIENFOLGE
PUNKT 26  3  UND DIE NAECHST          1614E04 0.965324E+03 SIND IN FALSCHER REIENFOLGE
PUNKT 10  3  UND DIE NAE          0.101614E04 0.965324E+03 SIND IN FALSCHER REIENFOLGE
PUNKT 21  3  UND DI          STEN 0.101614E04 0.965324E+03 SIND IN FALSCHER REIENFOLGE
……………………          ………………………………………………………………………………………
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Do you rembeber the error ? Any suggestions?