Radar-driven High-resolution Hydrometeorological Forecasts of the 26 September 2007 Venice flash flood

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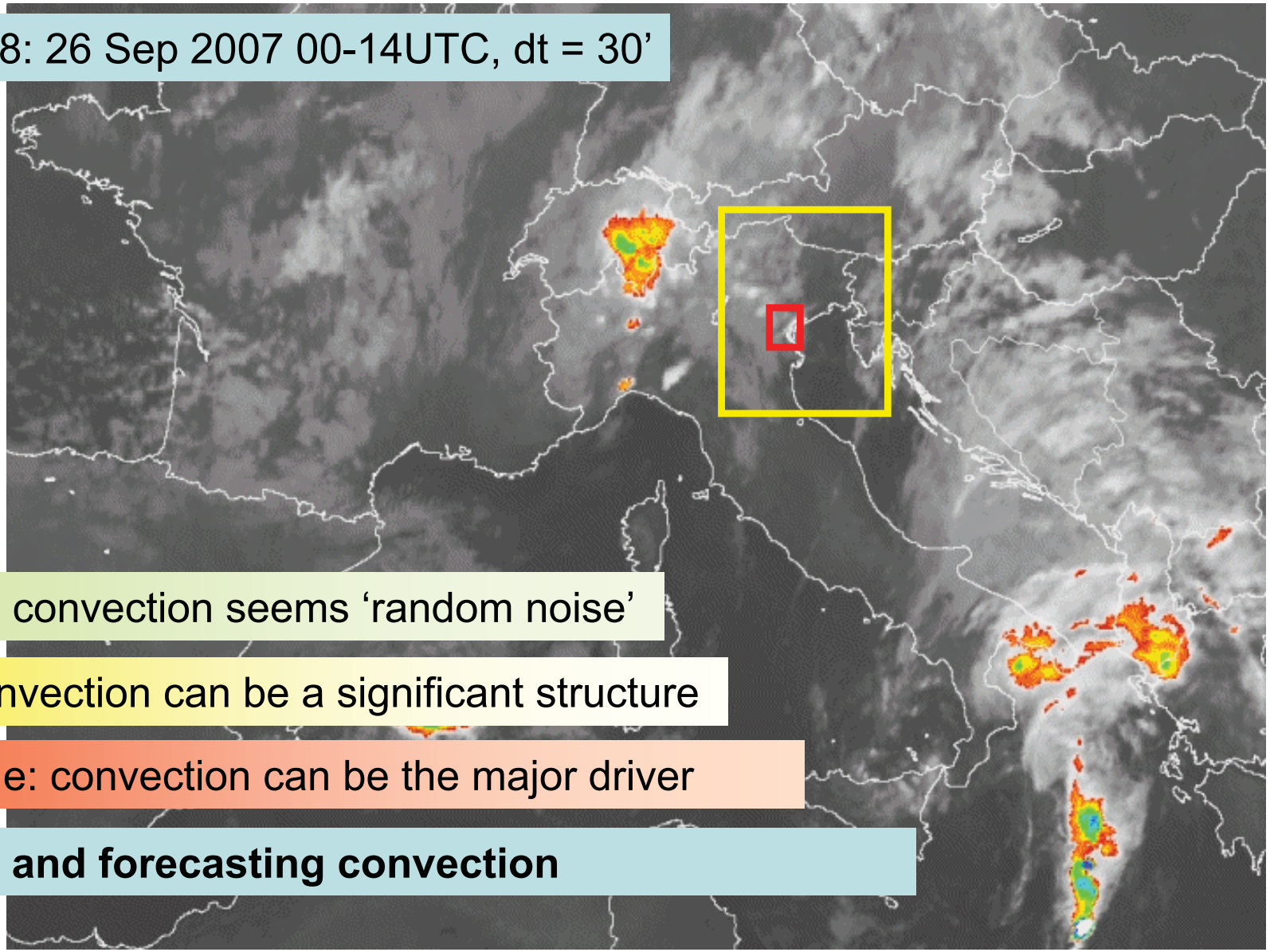
COST 731 Action: Propagation of Uncertainty
in Advanced Meteo-Hydrological Forecast Systems

Working Group F: Flash Floods and Pluvial Floods
26-28 May 2010, Cagliari, Italya

The challenge: extend flash flood warning lead time

Meteosat IR108: 26 Sep 2007 00-14UTC, dt = 30’



synoptic scale: convection seems ‘random noise’

mesoscale: convection can be a significant structure

flash flood scale: convection can be the major driver

➔ **Monitoring and forecasting convection**

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Monitoring and forecasting convection

Monitoring

- Rain gauge network: often too sparse to capture rainfall peaks, or to portray sharp gradients
- Radar: good spatial coverage, challenging QPE (e.g. attenuation in heavy precipitation → convection)

Forecasting

- Radar extrapolation techniques: limited by linearity, often not adequate for strongly non-linear convective dynamics
- Numerical weather prediction (NWP): issue of scale

Convective-scale NWP

For a convective-scale NWP to be successful need:

- **Model capable of simulating convective dynamics**
  → **Convection-permitting NWP model; dx = O(1km)**
- **Suitable initial conditions to catch a specific storm**
  → **Radar reflectivity and radial wind**

Focus this presentation

- **Realistic convective environment in which storm evolves**
  → **Mesoscale data assimilation (esp. humidity)**

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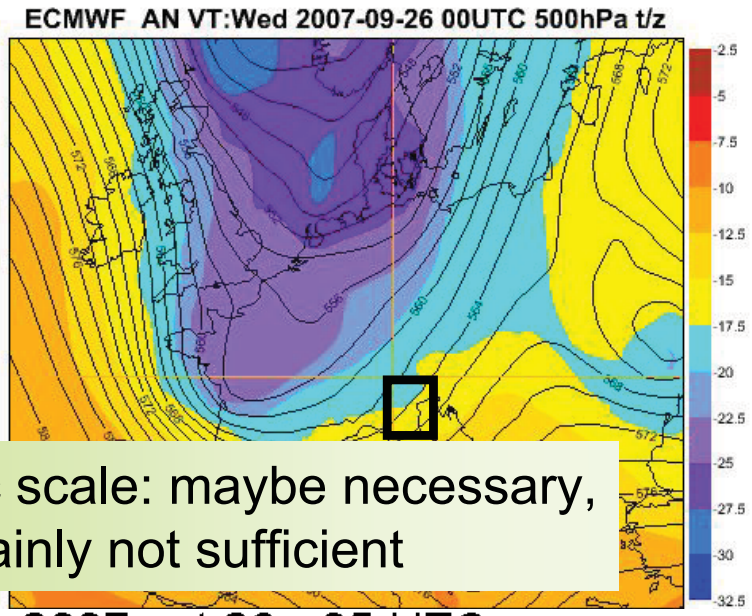
Outline

- Motivation
- Short case description
- Radar QPE analysis
- NWP experimental setup
  - Data assimilation experiments
  - Forecast experiments
  - Sensitivity experiments
- Hydrological simulations
- Summary and conclusions

Case description: 26 Sep 2007 03-09 UTC

500hPa T/Z
00UTC



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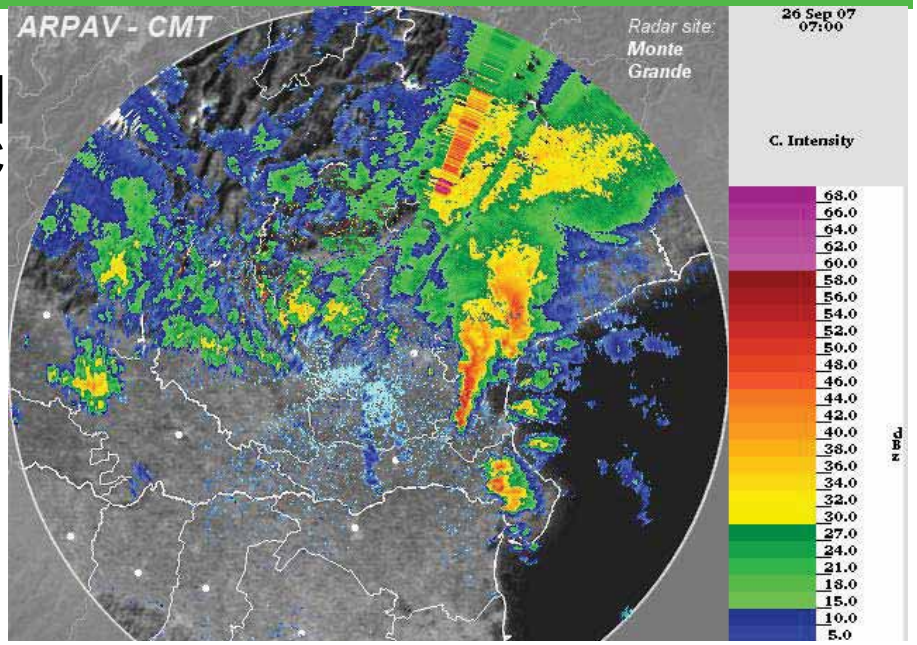
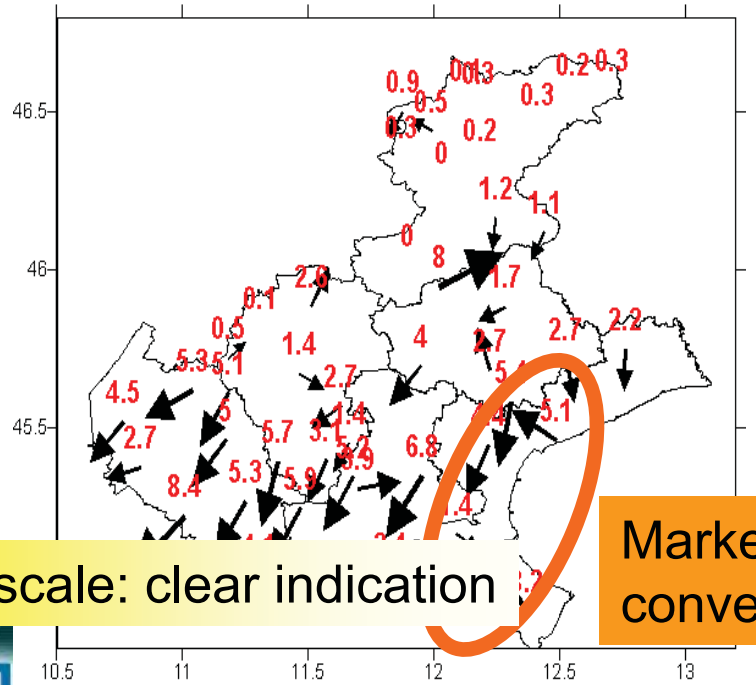
07UTC

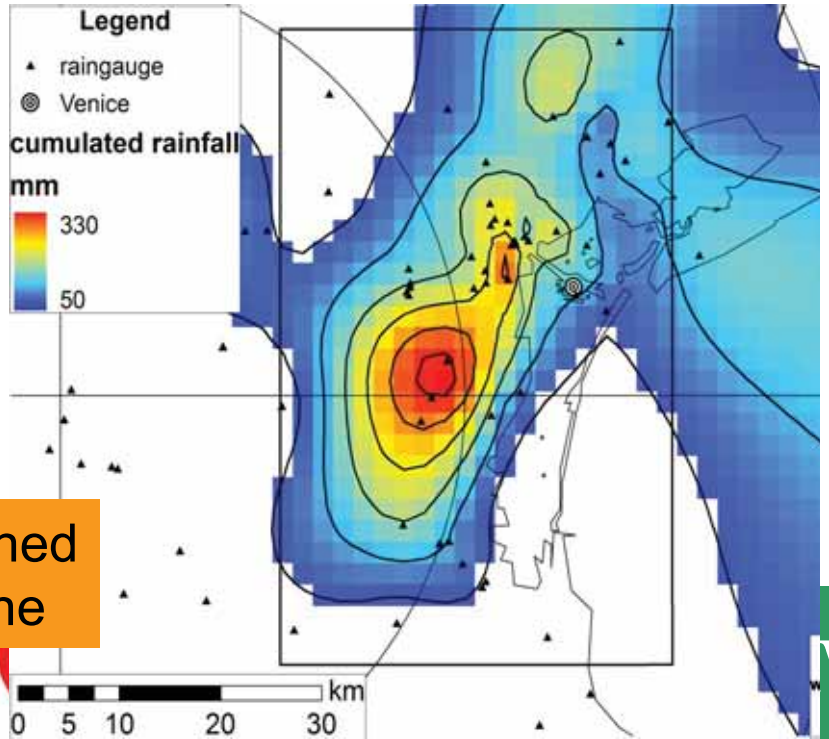


synoptic scale: maybe necessary, but certainly not sufficient

Surface Winds
05UTC



surface rainfall (event total)

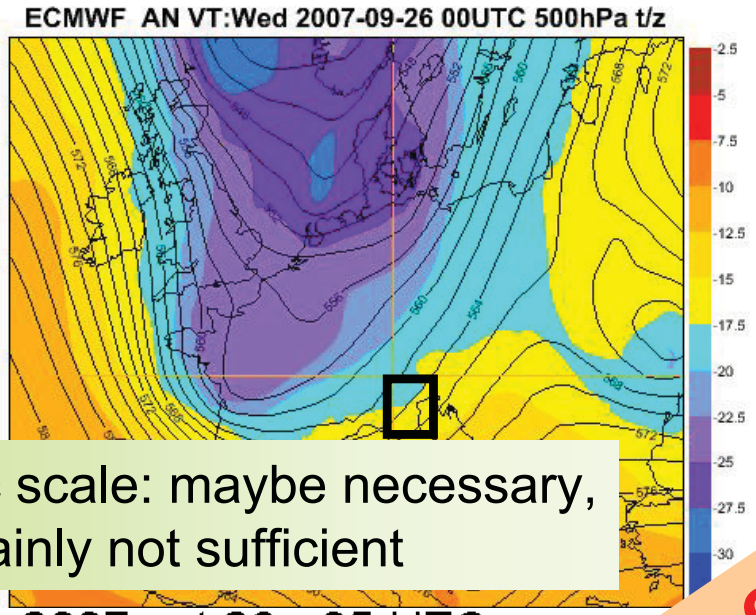


mesoscale: clear indication

Marked, sustained convergence line

Case description: 26 Sep 2007 03-09 UTC

500hPa T/Z
00UTC



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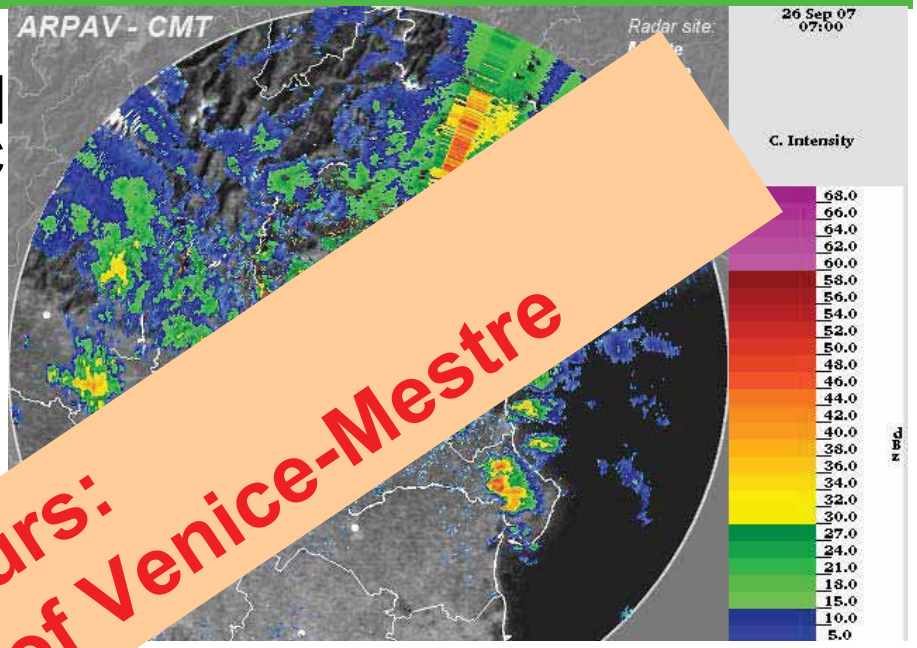
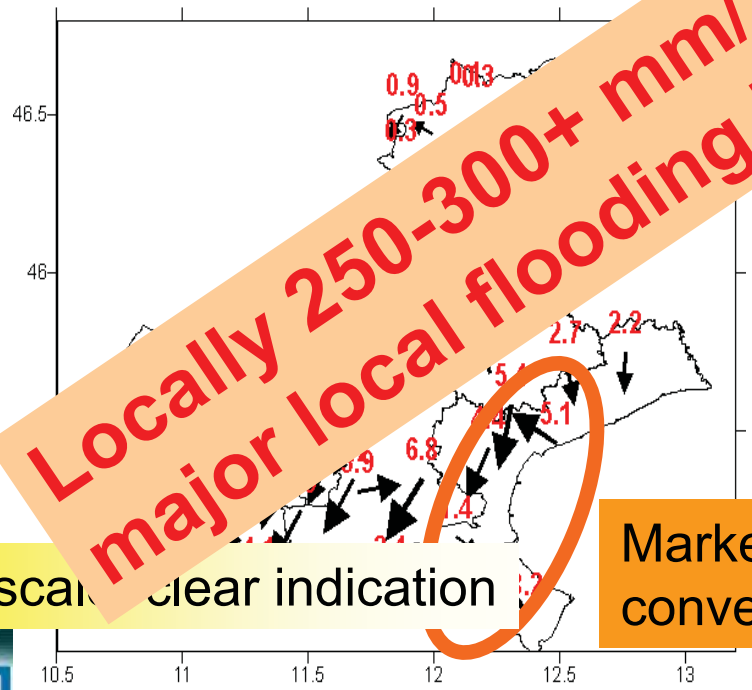


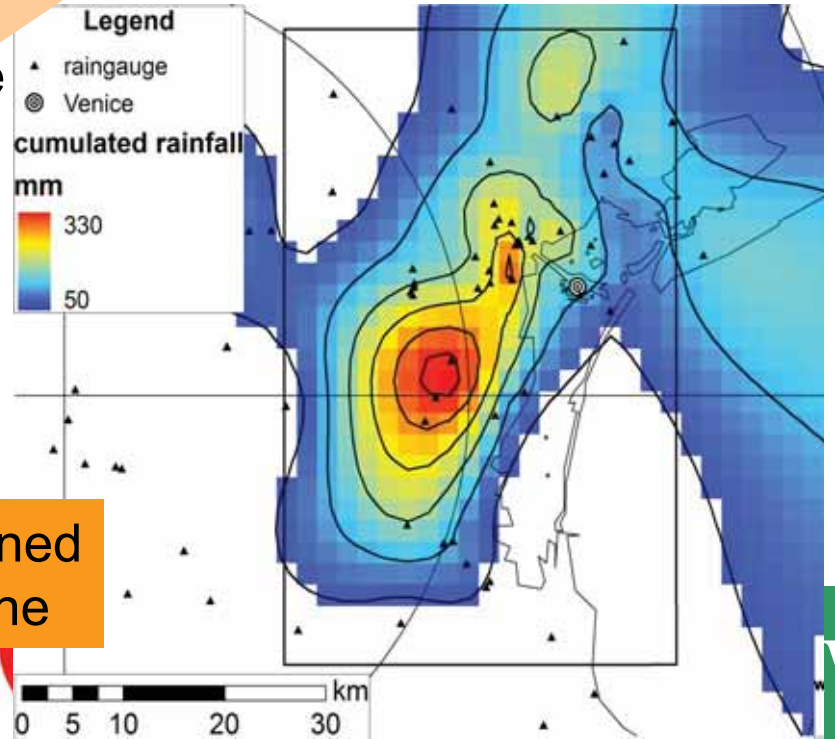
synoptic scale: maybe necessary, but certainly not sufficient

Locally 250-300+ mm/3-6 hours: major local flooding in city of Venice-Mestre

Surface
Winds
05UTC



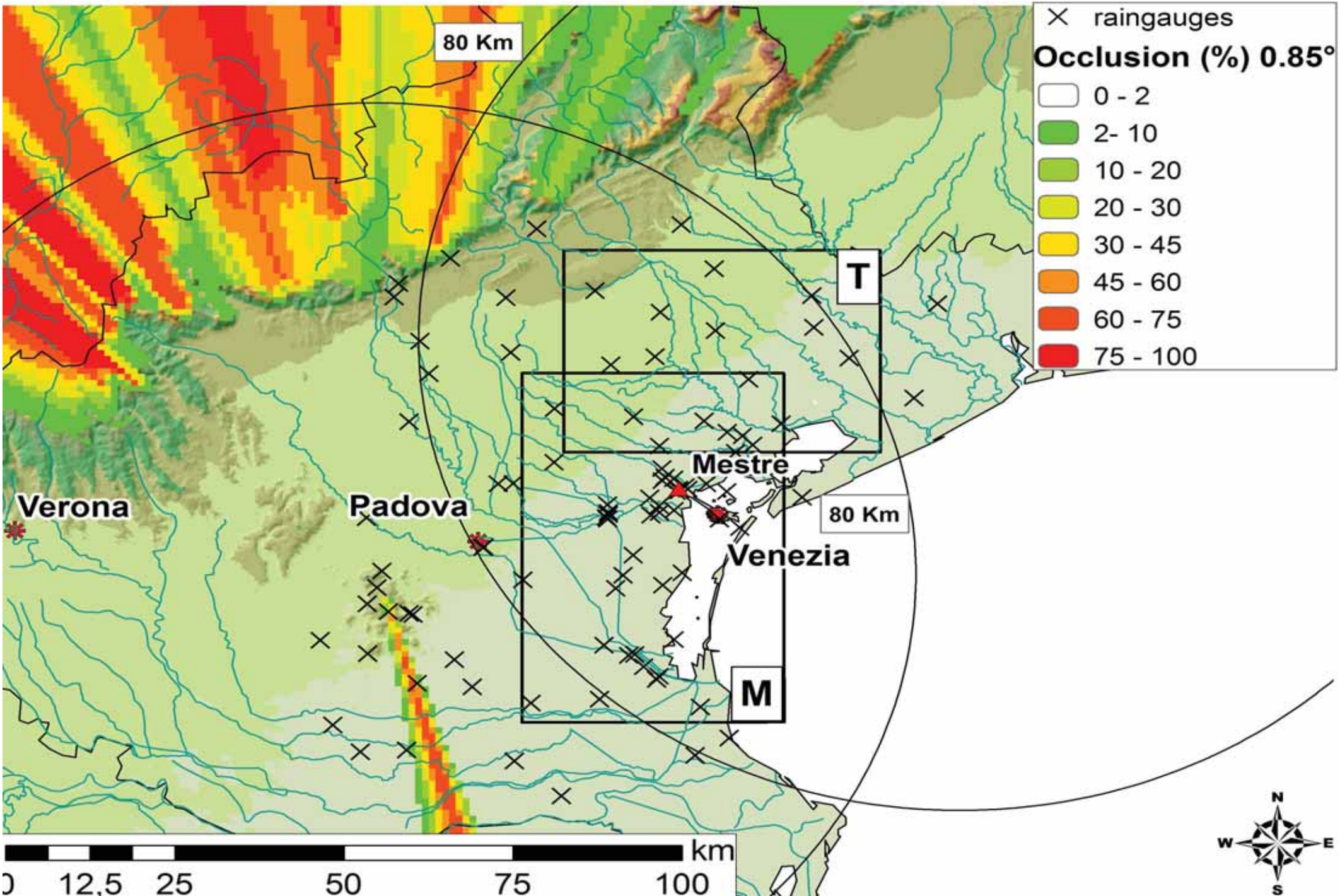
ainfall
(event
total)



mesoscal clear indication

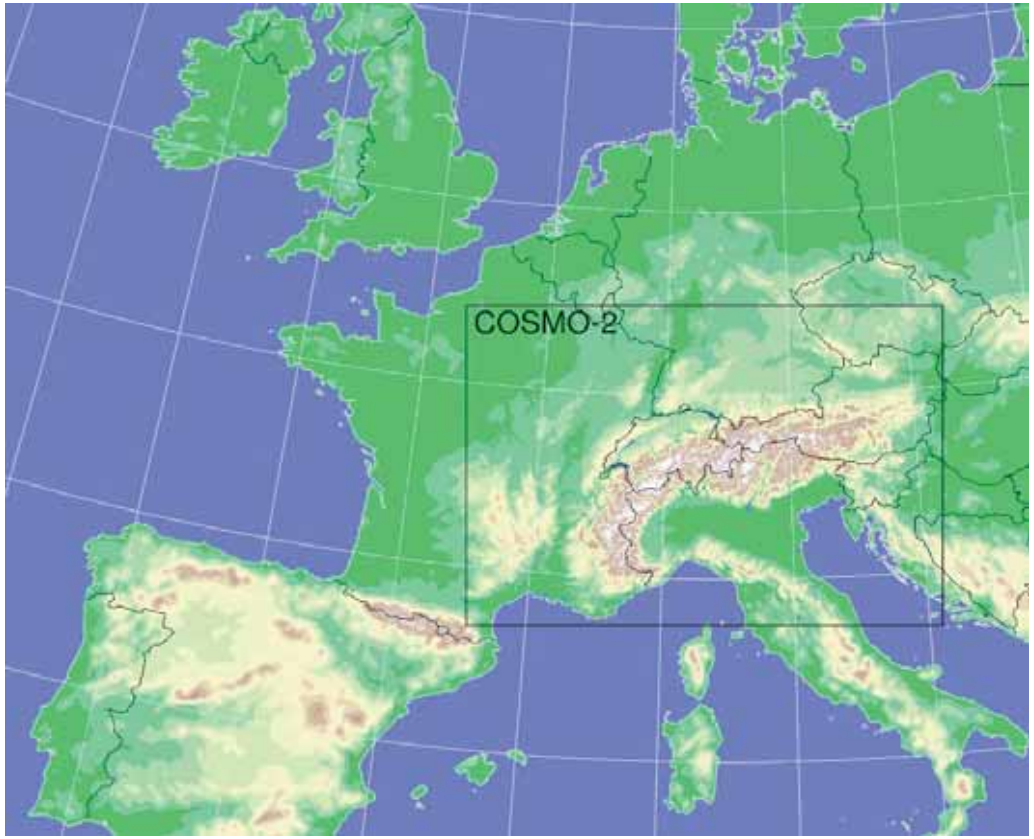
Marked, sustained convergence line

Study area: North-eastern Italy



Atmospheric, hydrological and hydraulic models

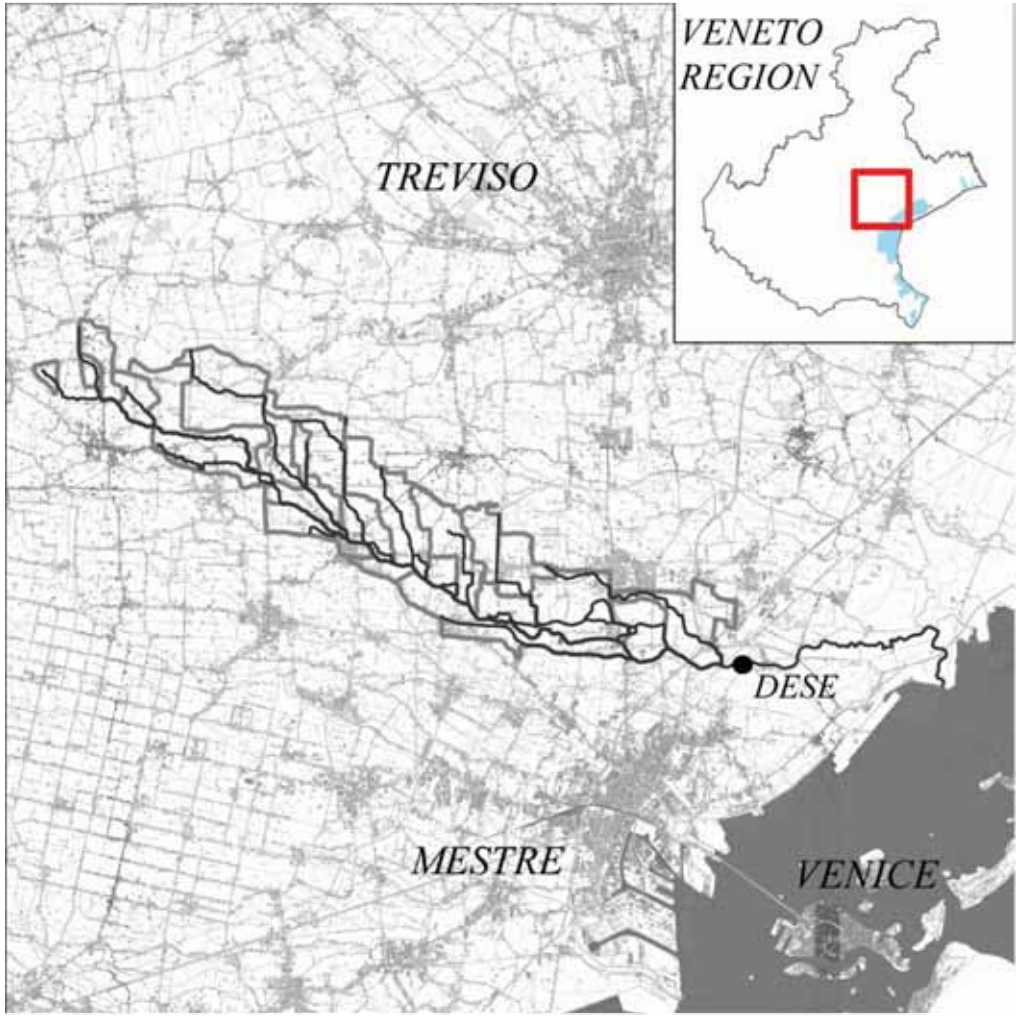
NWP: COSMO-2



Convection-permitting (dx=2.2km)

Radar rainfall assimilation: LHN

Hydro: geomorphological model



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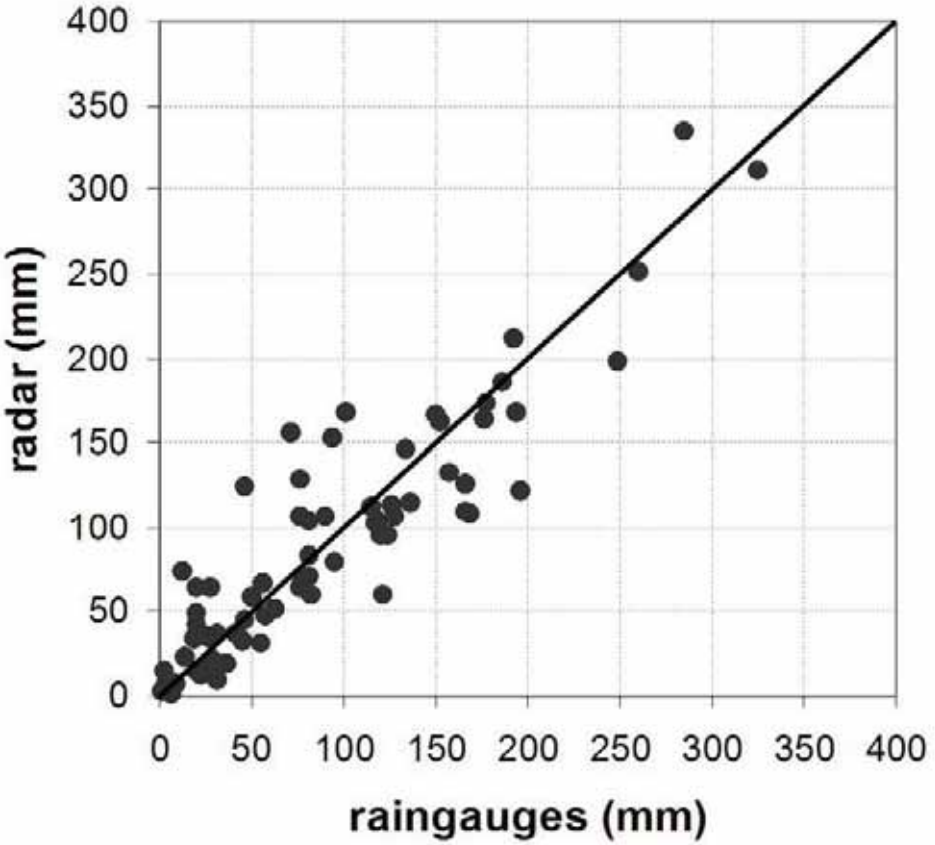
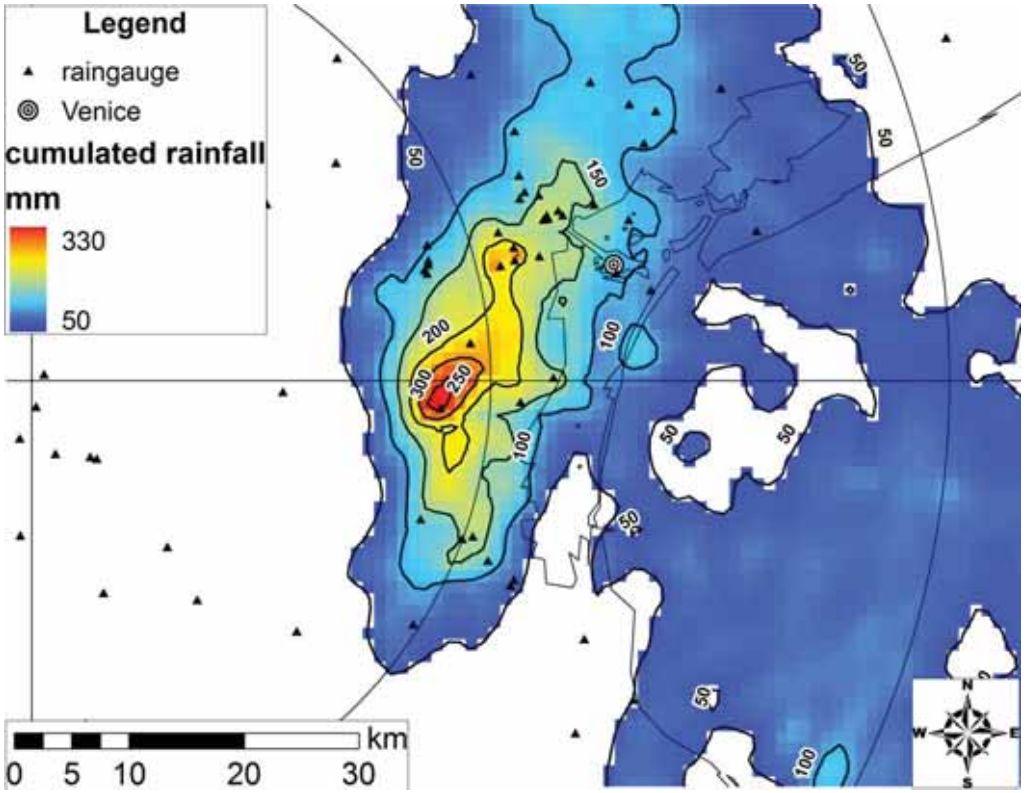
Radar QPE analysis: 24h accumulation

Radar vs. Rain gauge network (82)



Radar QPE accumulation



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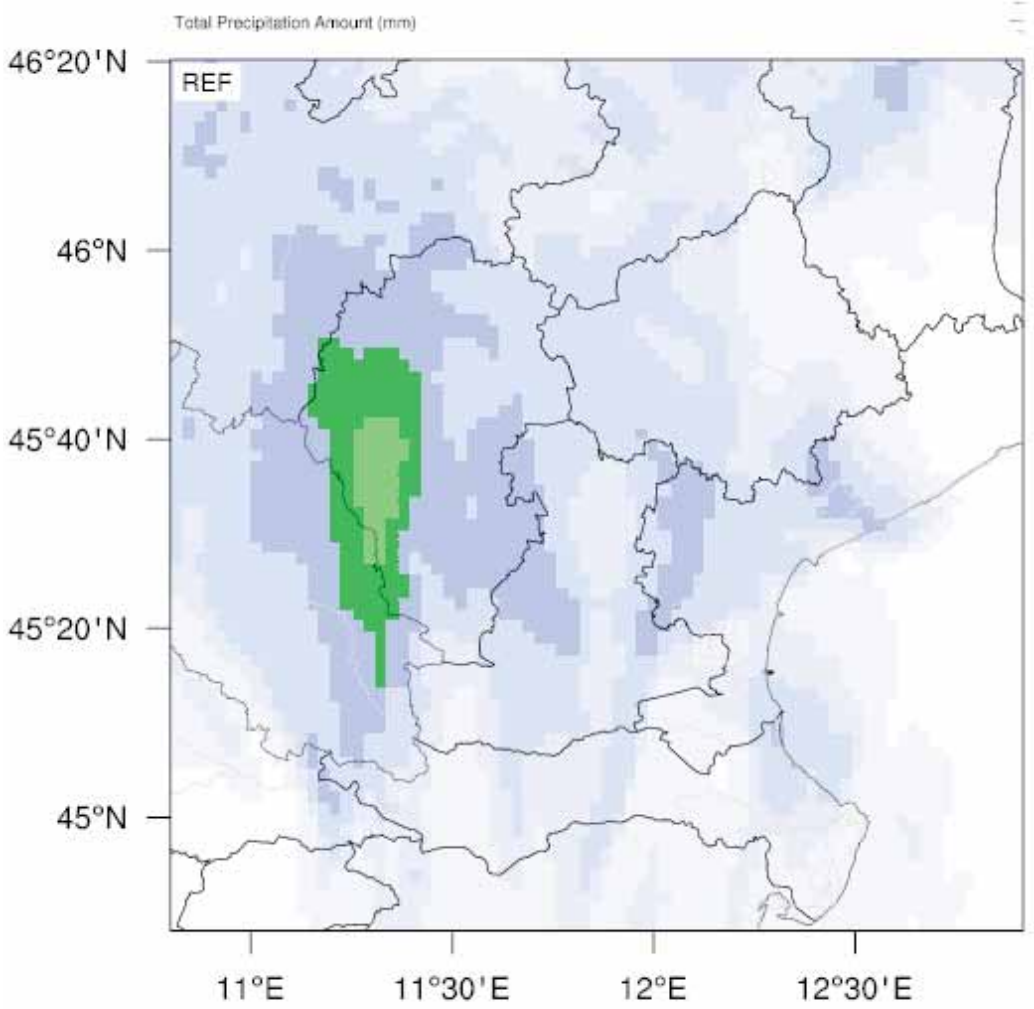
Radar rainfall assimilation exps: storm total precip

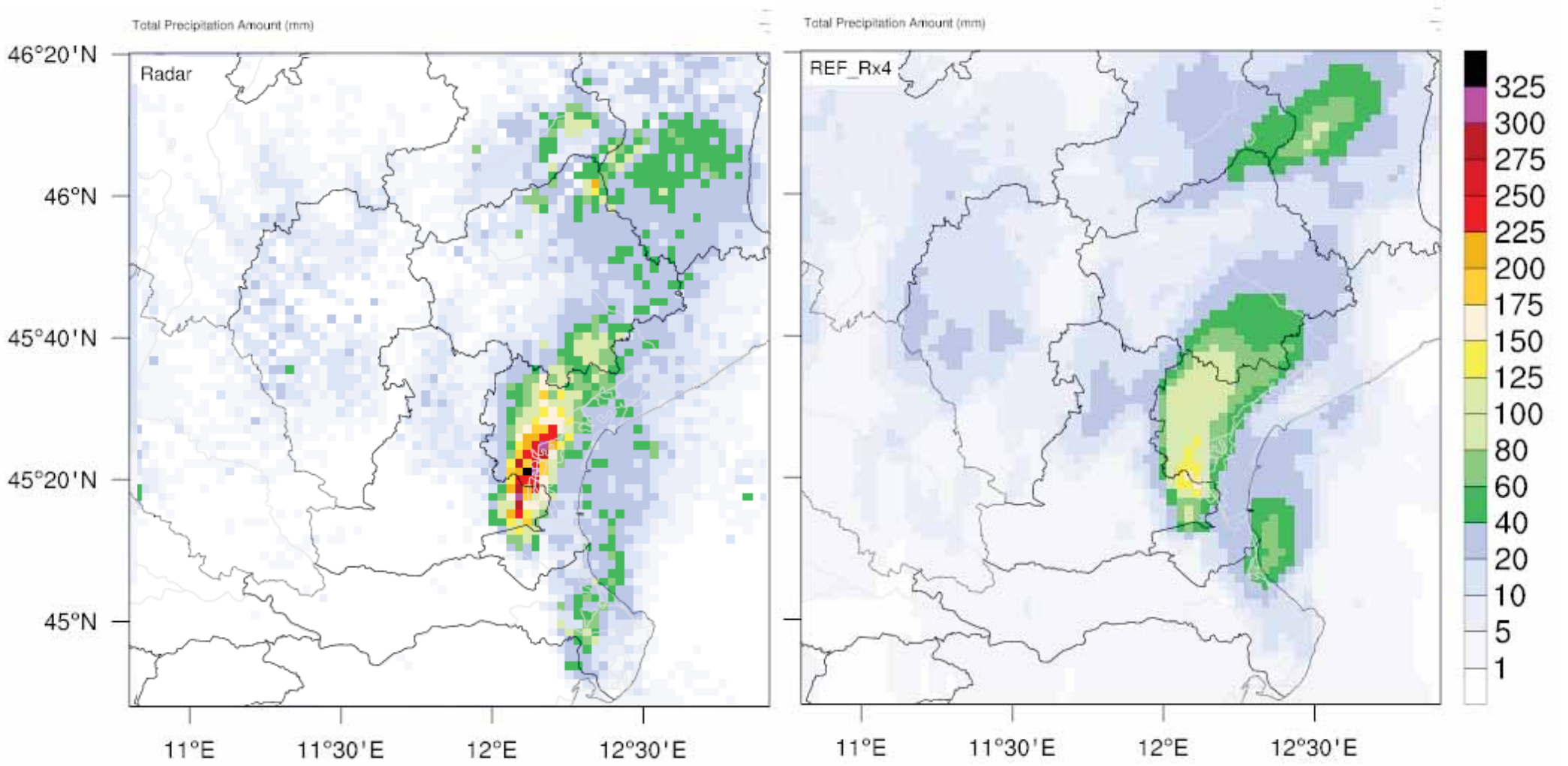
Without radar data assimilation



Radar rainfall assimilation exps: storm total precip

Radar QPE accumulation

With radar data assimilation



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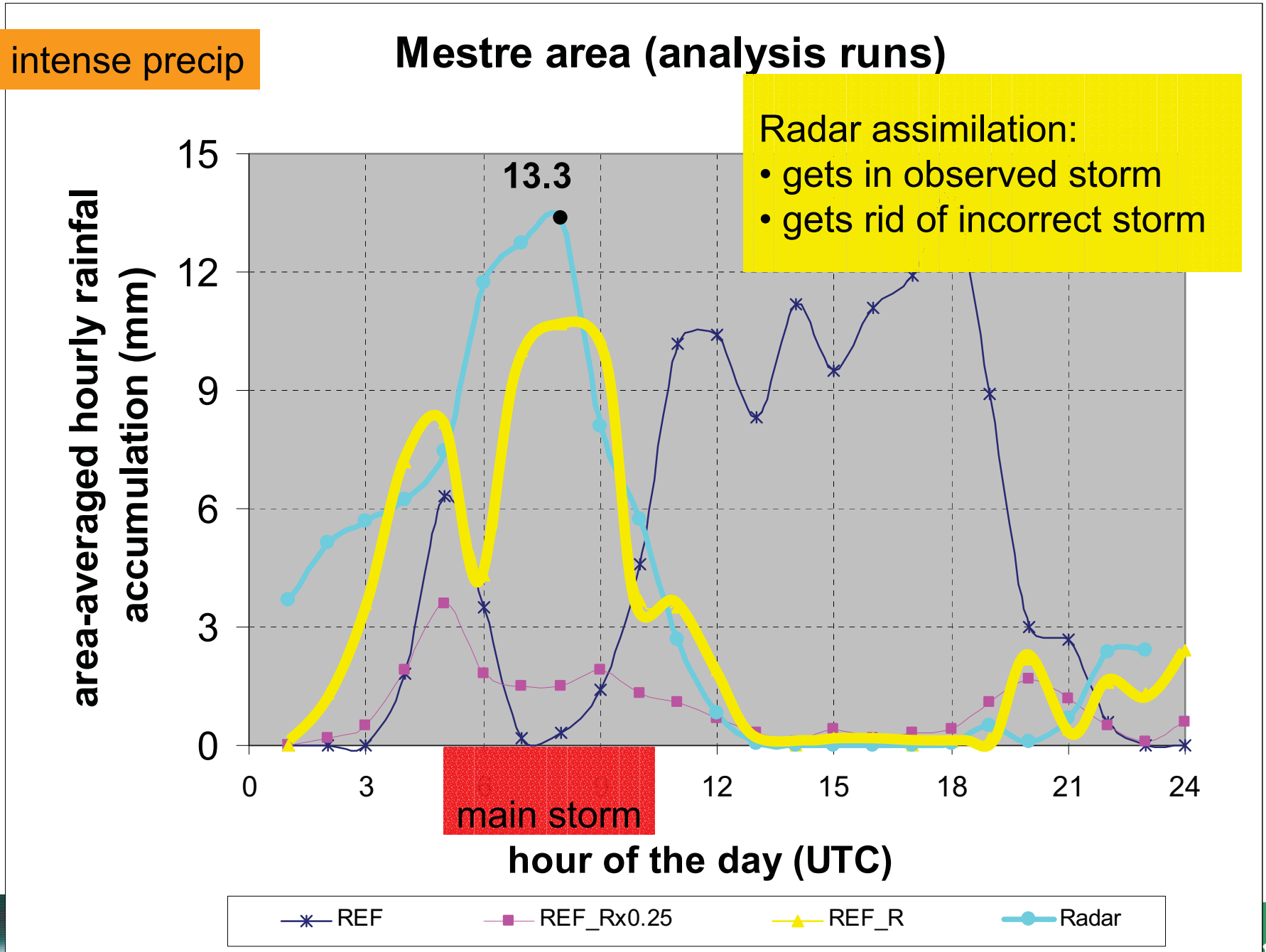
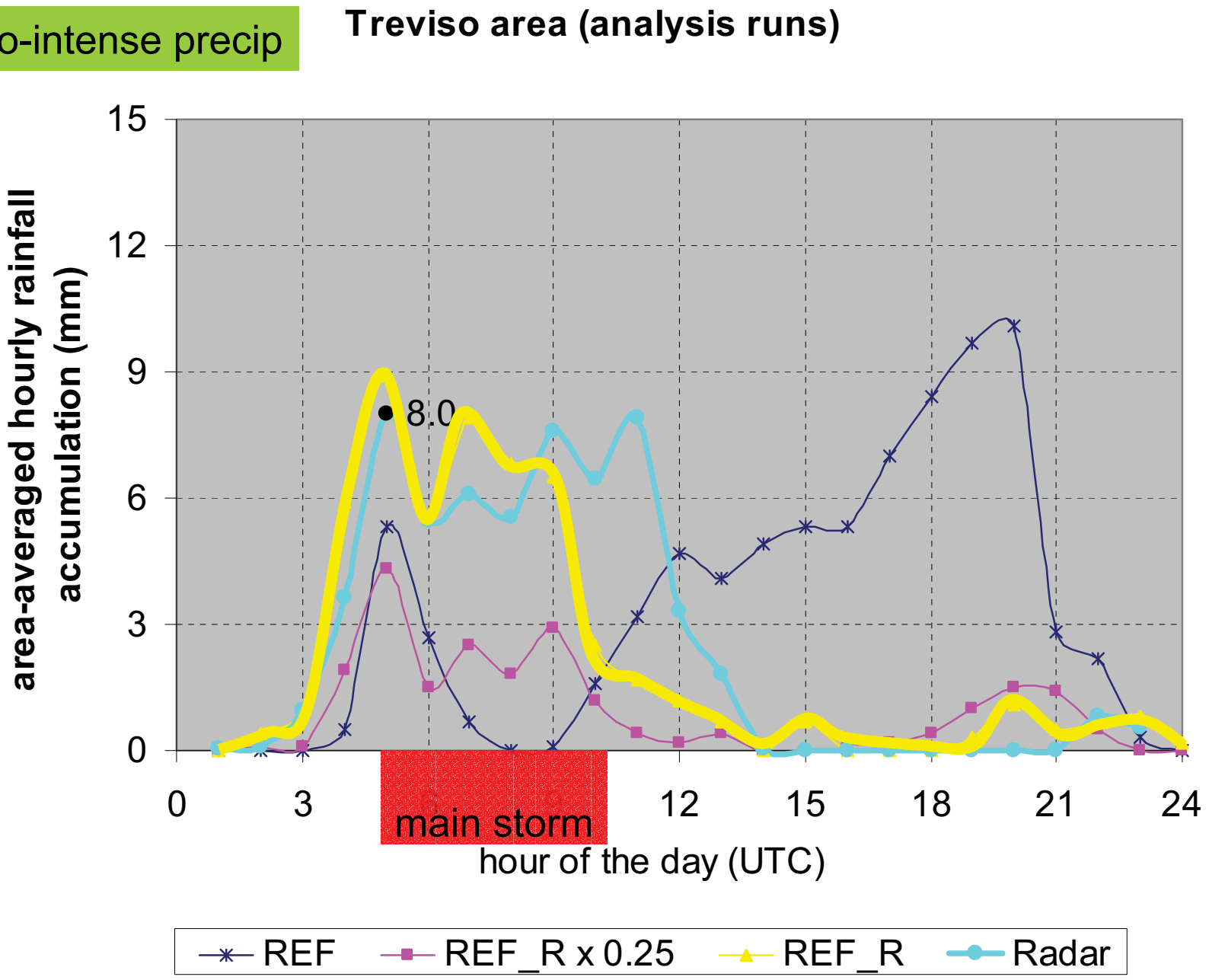
Hourly area-averaged precipitation: Mestre-Analysis

very intense precip



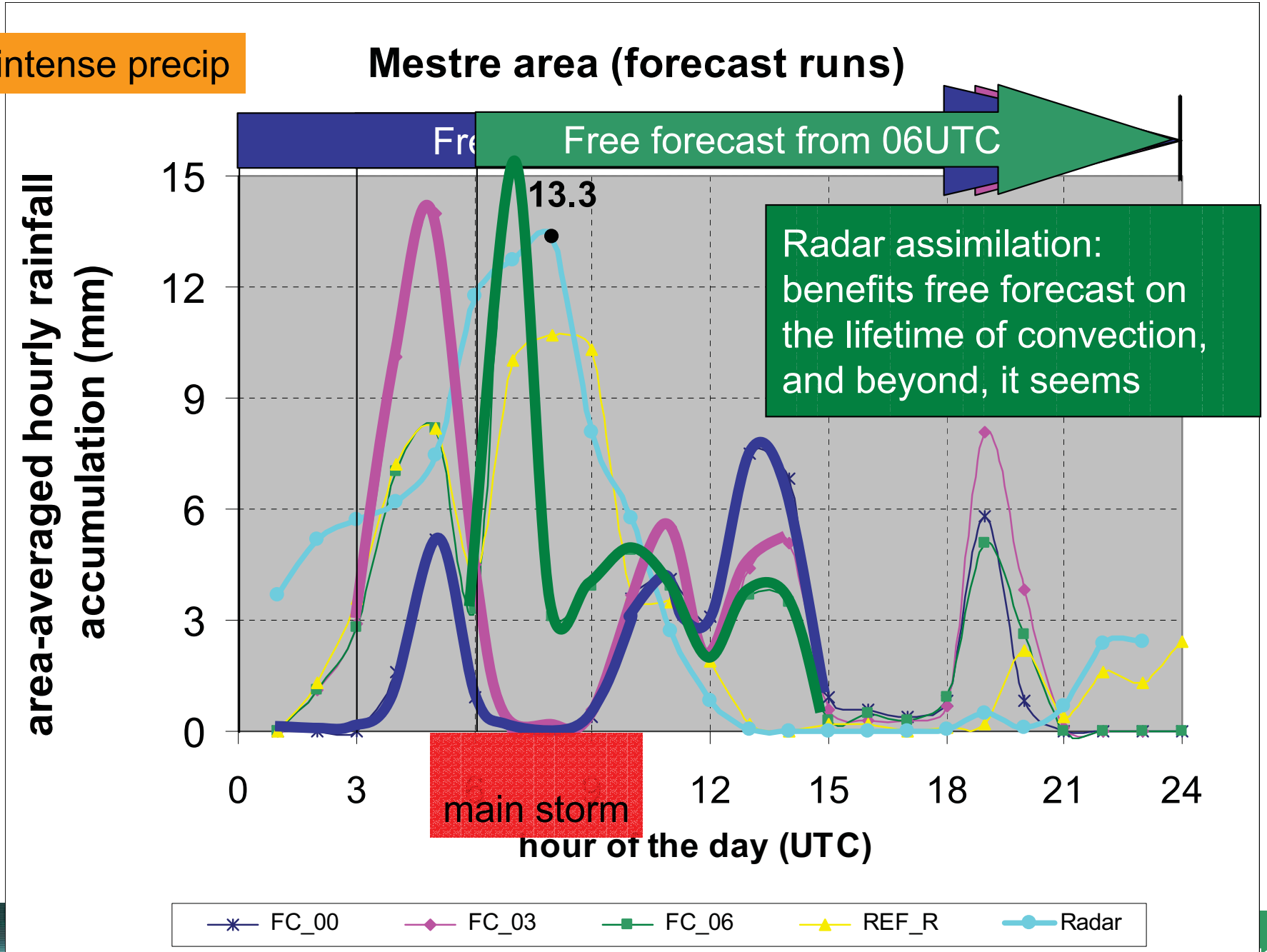
Hourly area-averaged precipitation: Treviso-Analysis

moderate-to-intense precip



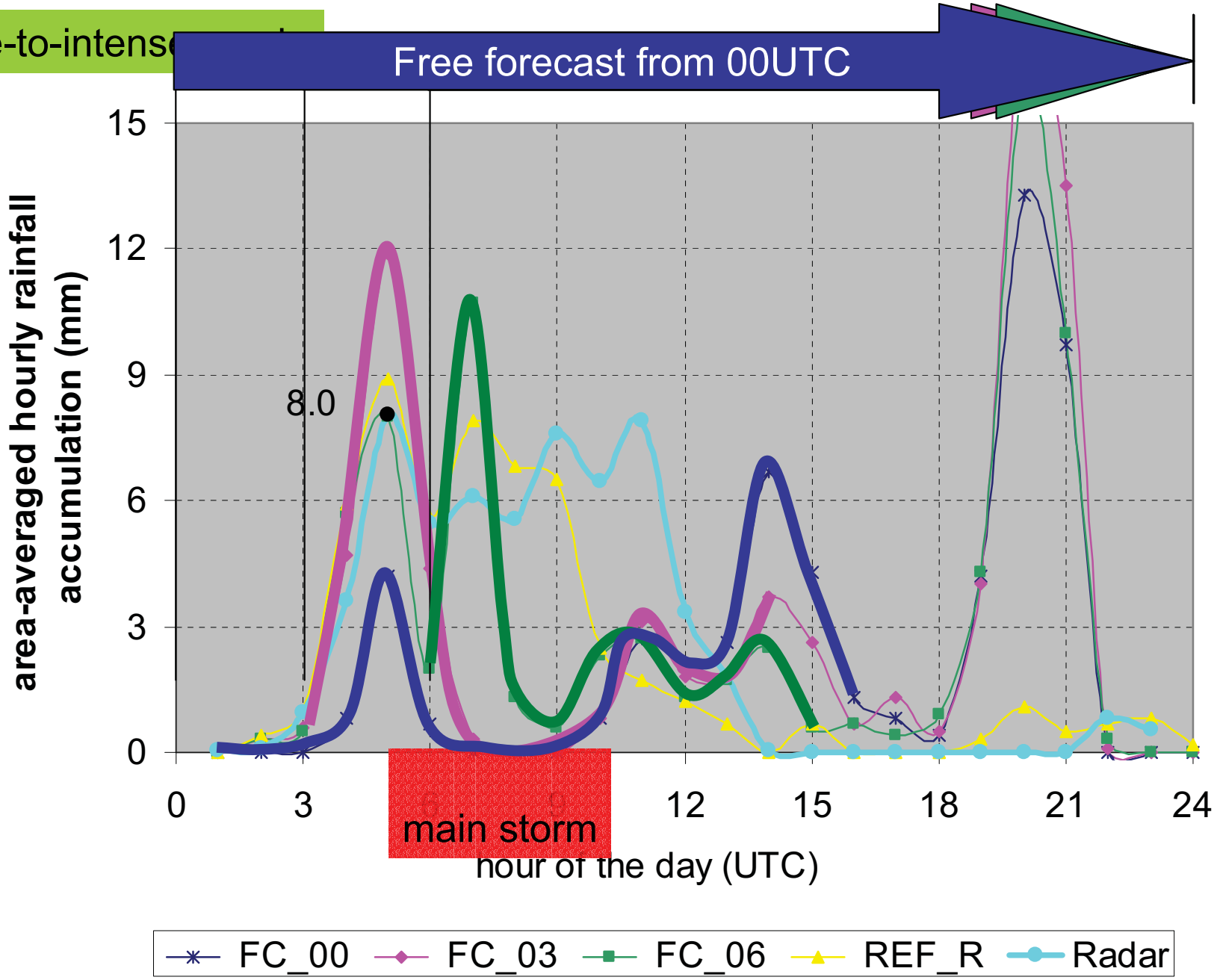
Hourly area-averaged precipitation: Mestre-Forecast

very intense precip

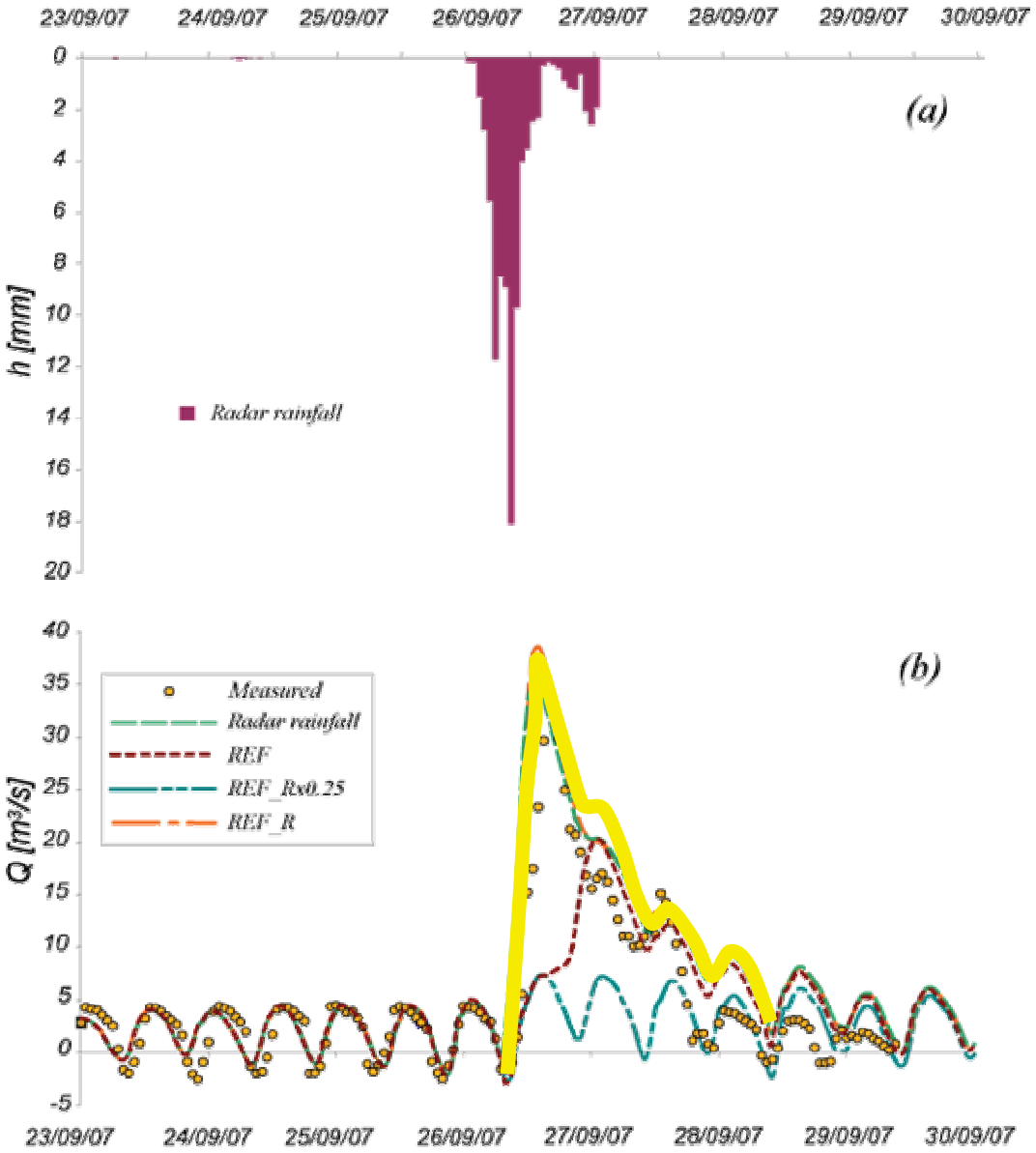


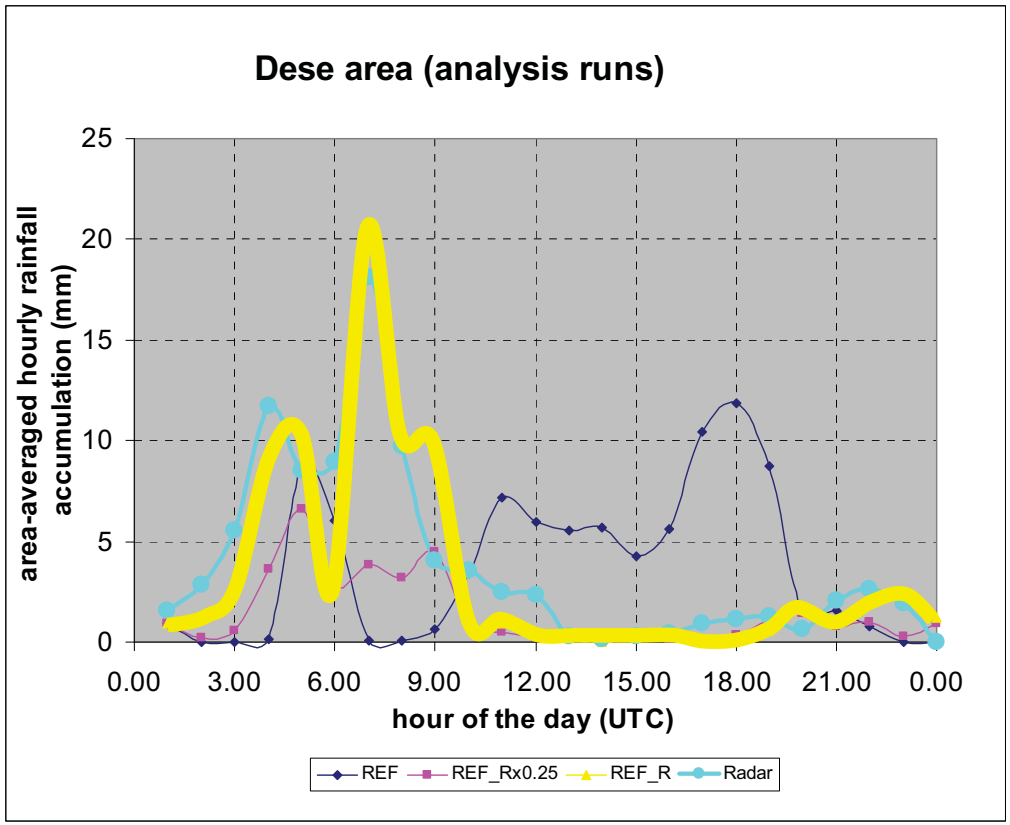
Hourly area-averaged precipitation: Treviso-Forecast

moderate-to-intens



Hydrological simulation: Dese basin-Analysis





Analysis with radar rainfall assimilation

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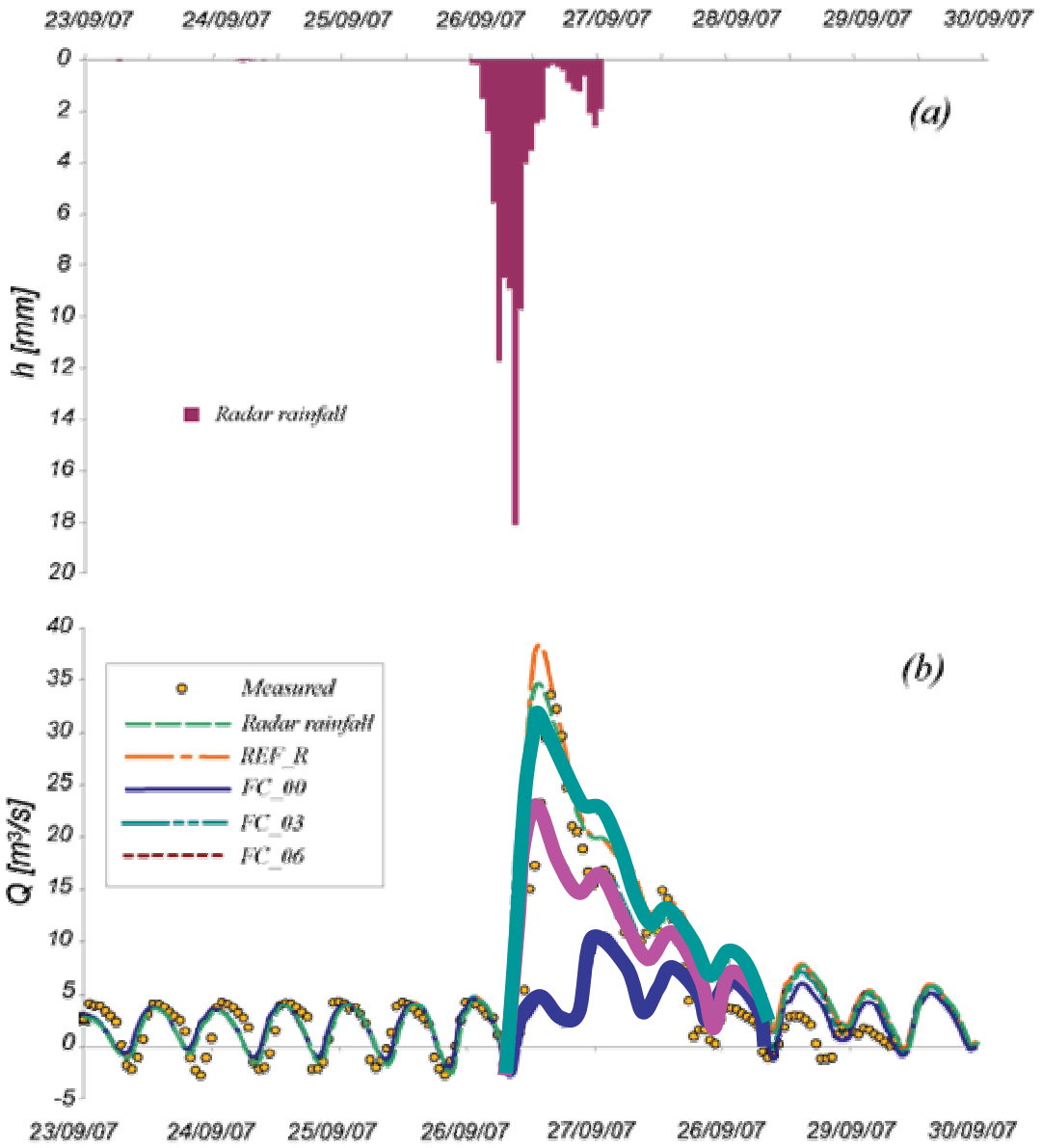
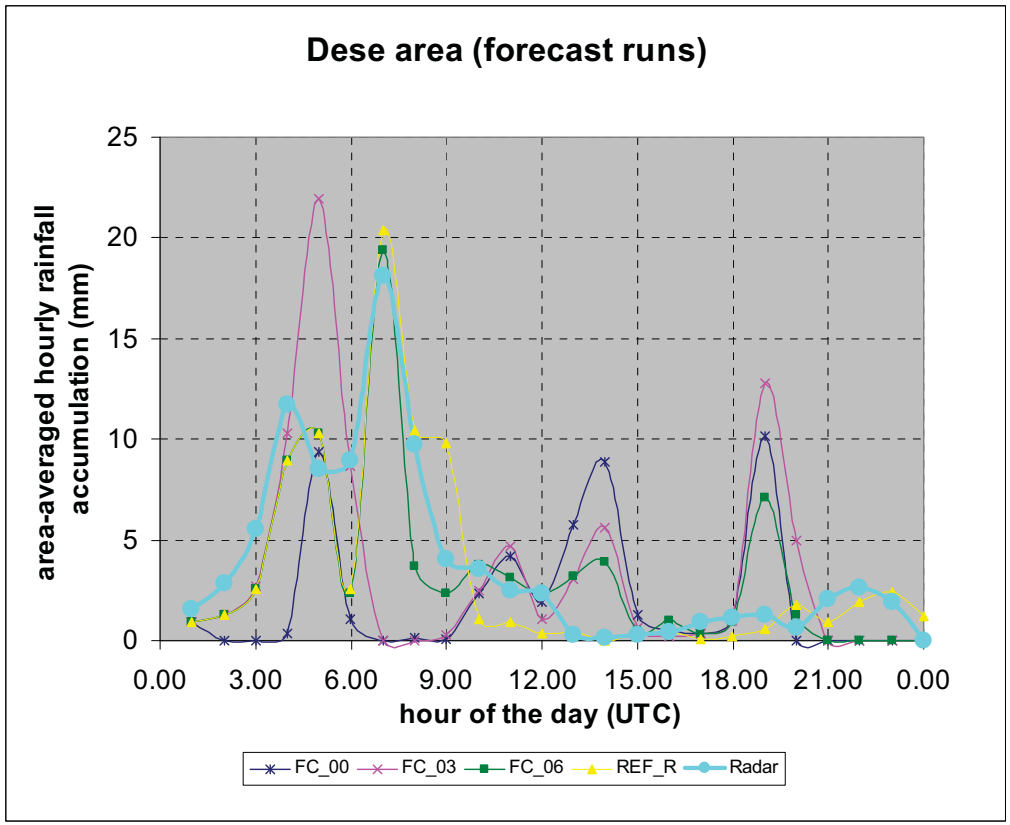
Hydrological simulation: Dese basin-Forecast





Free FC from 06 UTC

Free FC from 03 UTC

Free FC from 00 UTC

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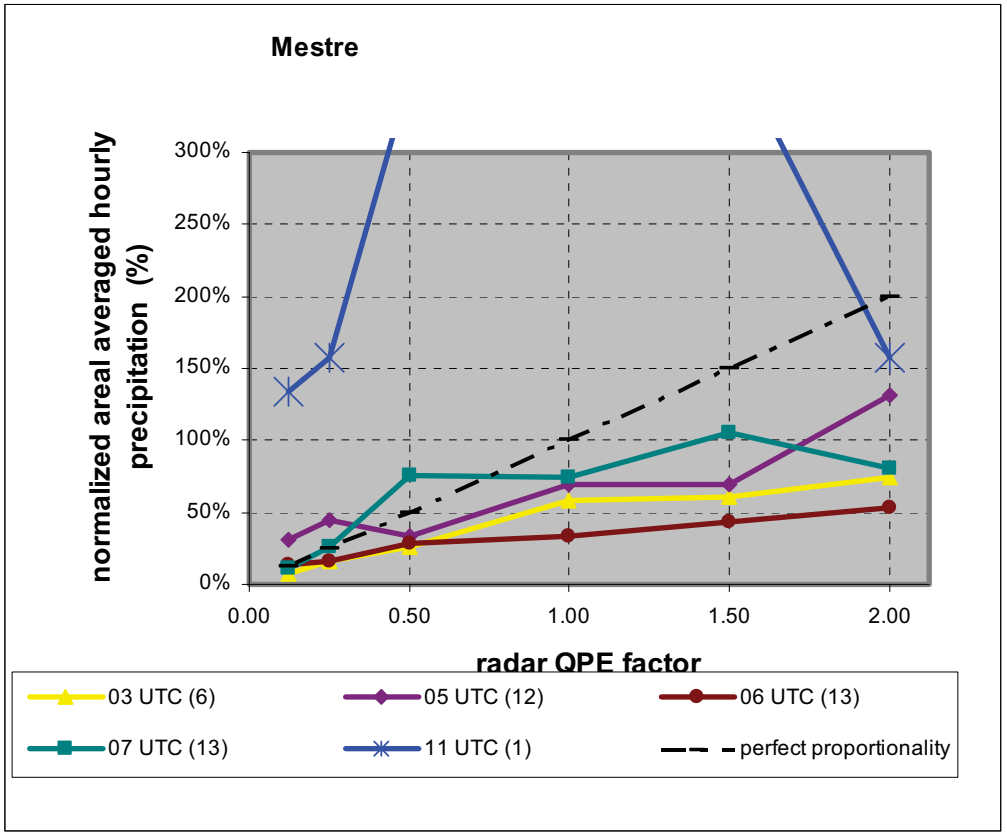
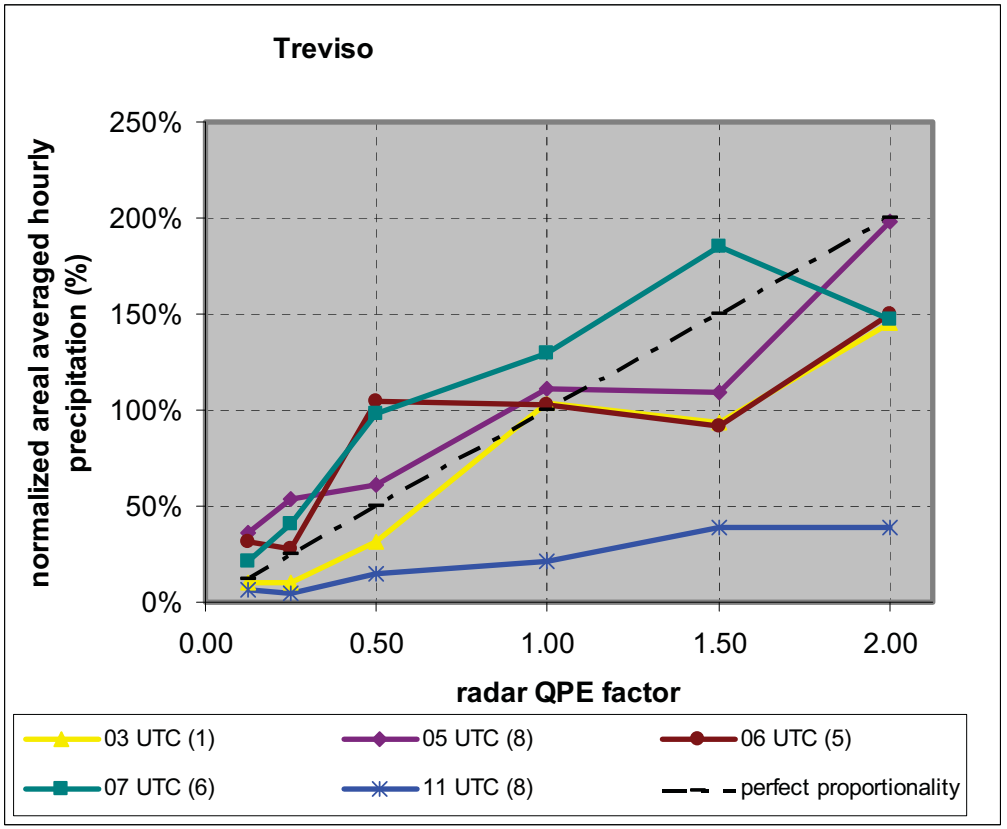
Sensitivity experiments to radar QPE amplitude

very intense precipitation



moderate-to-intense precipitation



Apparent limitations of the model in producing extreme rainfall intensities?!

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Summary and conclusions - 1

- **Radar rainfall assimilation with convection-permitting NWP model COSMO-2 of the Venice-Mestre flash flood 2007**
- **Clear benefit of radar information in analysis mode**
- **In forecast mode this benefit is on the order of the lifetime of the convective systems, i.e. 2-3 hours, and more**

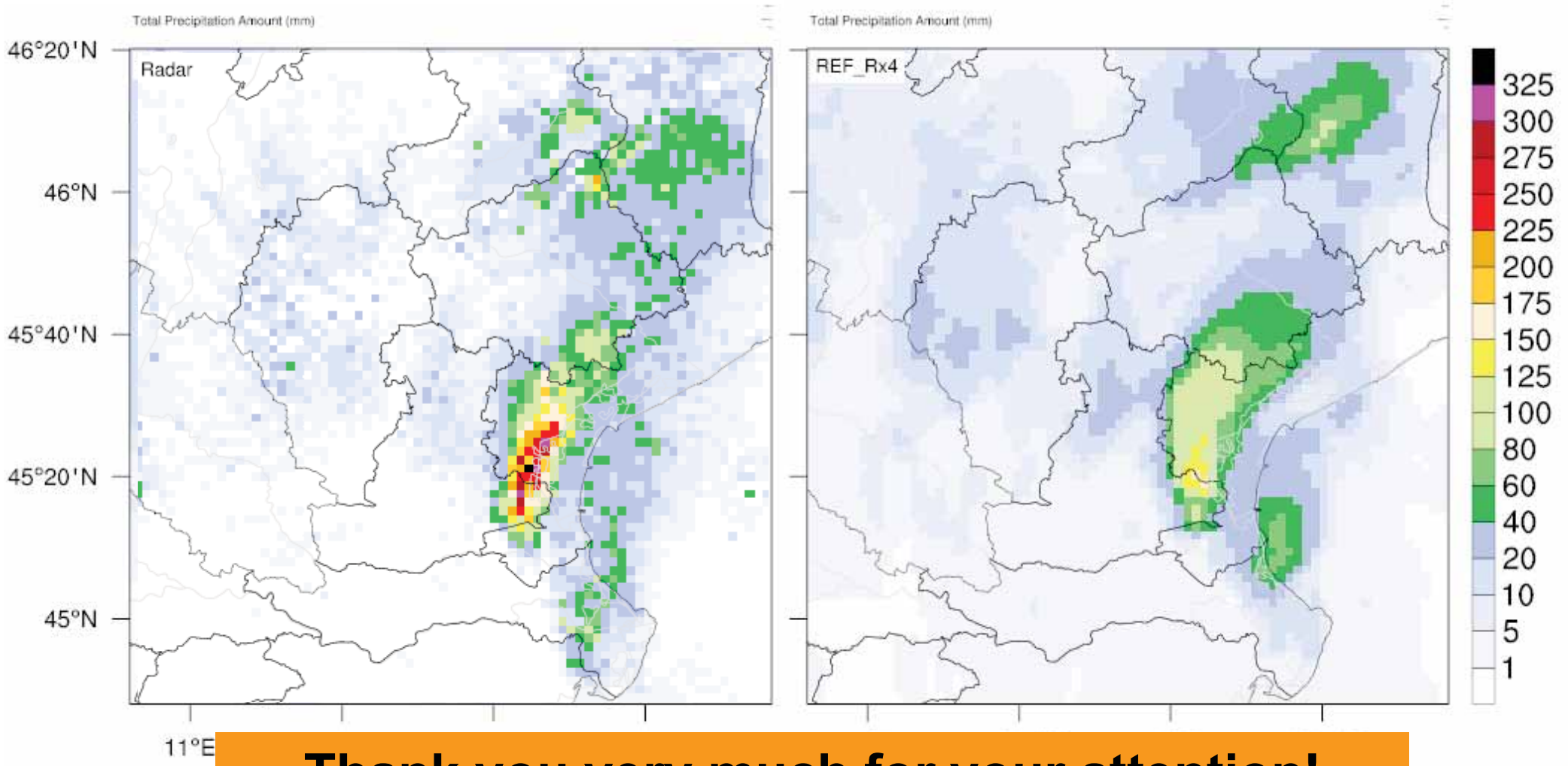
Summary and conclusions - 2

- **Hydrological simulations confirm benefit of radar:**
  - **Direct assimilation of radar QPE yields similar results as rain gauges**
  - **Radar-driven NWP QPF clearly show increased leadtime, in this case of some 3 hours**
- **Limits of the NWP model in producing very high rainfall rates emerged in this case, yet area-averaged values are ok**

Radar rainfall assimilation is promising!

Radar QPE accumulation

With radar data assimilation



Thank you very much for your attention!

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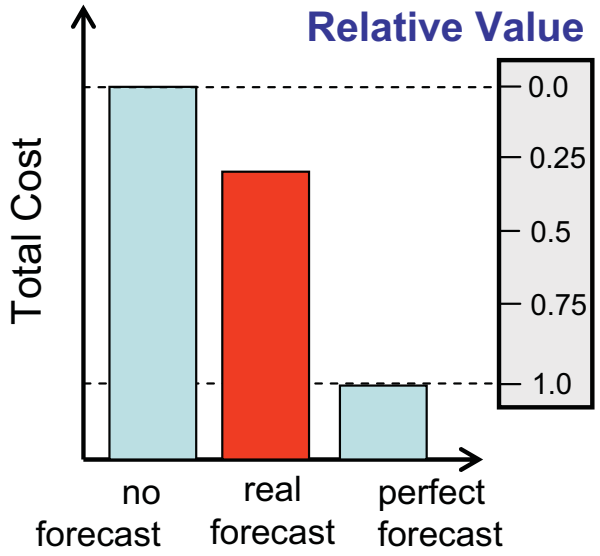
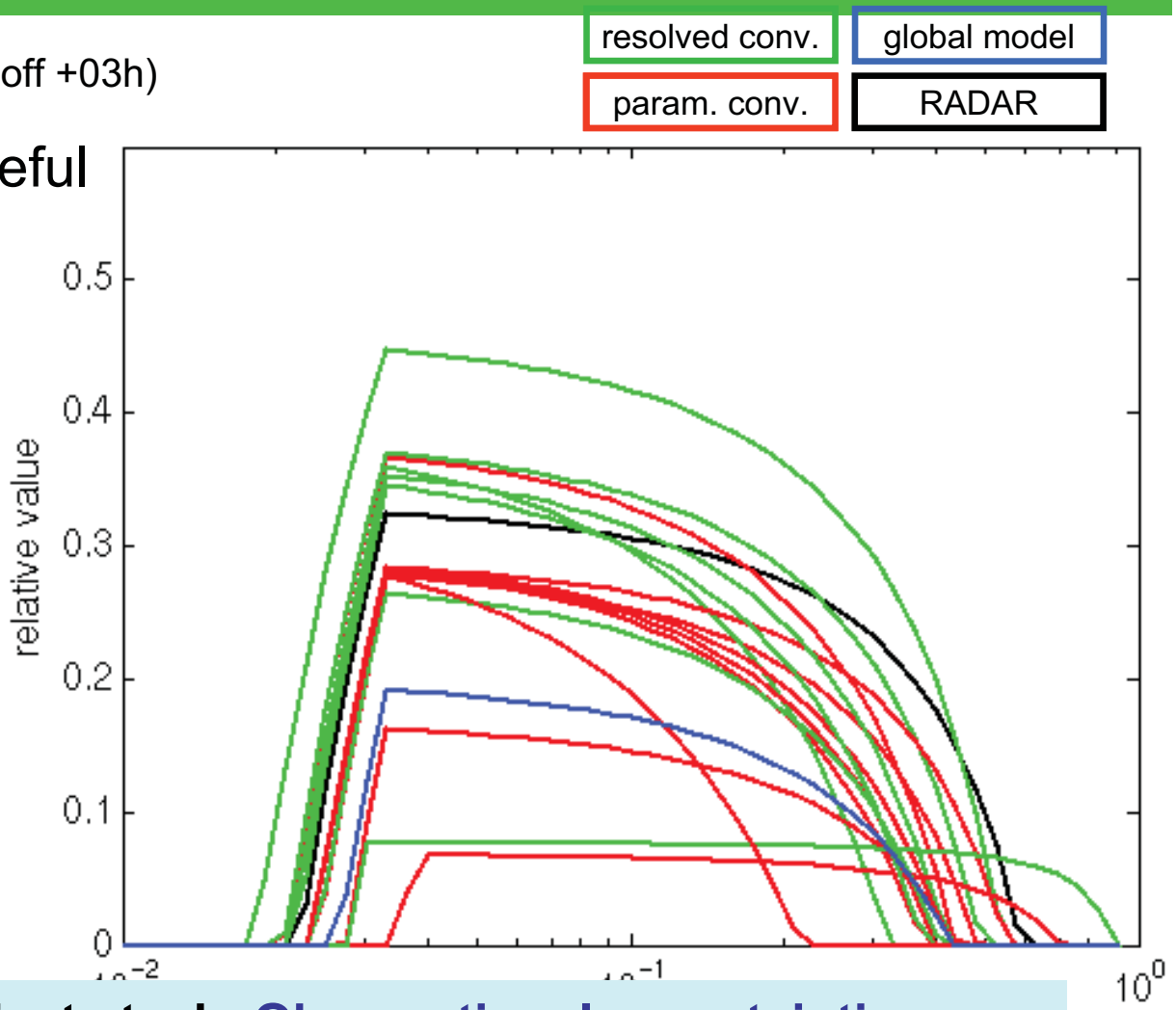
MAP D-PHASE: Relative value – Alert level „yellow“ (10/a)

(03h, 06h and 12h accumulations, cut-off +03h)



+ useful



Precipitation verification is a delicate task: Observational uncertainties are not significantly smaller than forecast errors!

e …

high-resolution models tend to give better results. In particular, better statistical representation at coarser scales.