High-resolution simulations of deep moist convection over the Alps – testing the COSMO-EULAG model

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Motivation and outline

- Priority Project CELO (Cosmo-Eulag Operationalization)
 of the COSMO consortium aims at preparation of fully
 operation version of the COSMO model based on
 anelastic dynamical core of the research EULAG model
- 2. The goal of current study is to test the role of increasing horizontal resolution and the influence of subgrid-scale processes (especially shallow convection) on model representation of convection over the Alpine domain
- 3. The tests use prototype Cosmo-Eulag model with Eulag dynamical core inserted into COSMO model environment and linked with basic physical parameterizations (the equivalent RK setup is downgraded comparing to operational one; no tuning intended, at the moment)





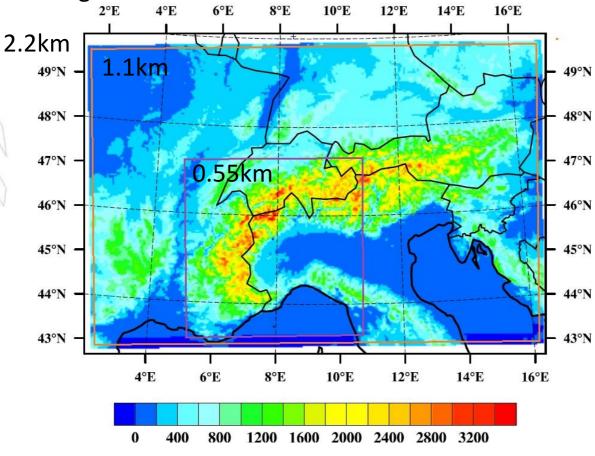




Model setup

Computational domain:

- (WE x NS) = $(520 \times 350) / (1014 \times 678) / (806 \times 806)$ (2.2km) / (1.1km) / (0.55km)
- standard operational COSMO-2 model of Meteo-Swiss vertical distribution of levels (61),
 Gal-Chen coordinate system with top at 23588.50m,
- Lateral absorber width = 45km / 23km / 11.0km
- Top sponge base height = 15km





Model setup

Dynamics:

- Saturation adjustment is on
- Numerical diffusion turned off "on" for Runge-Kutta
- Semi-Lagrangian advection of moist quantities

Microphysics:

Standard COSMO microphysics parameterization including ice, rain, snow and graupel precipitation

Radiation:

Calculated every 15 minutes (2.2km) or 6 minutes (1.1km and 0.55km) of simulation

Other parameterizations:

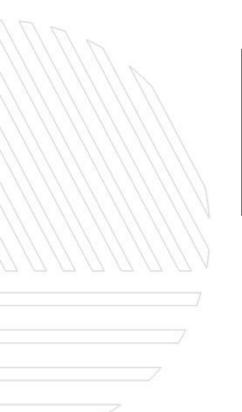
- Vertical turbulence model with surface layer fluxes
- Standard COSMO surface model

Orography:

- Operational Meteo-Swiss for 2.2 km, recalculated from SRTM for 1.1 and 0.55 km
- standard Cosmo orography filtering was applied

Initial and boundary data for all simulations are interpolated from COSMO – 7 forecast of MeteoSwiss.





Case study: role of shallow convection parameterization

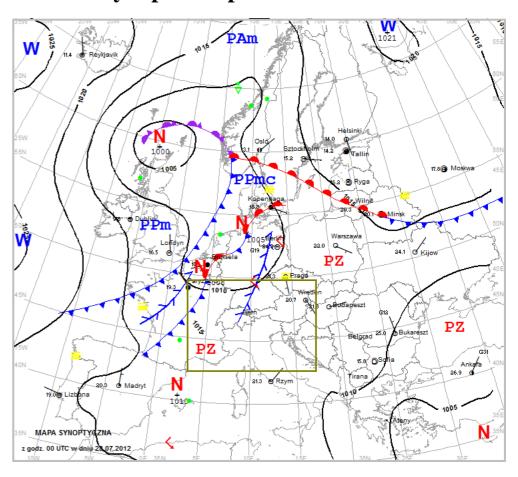


Test case

Synoptic map for 27.07.2012

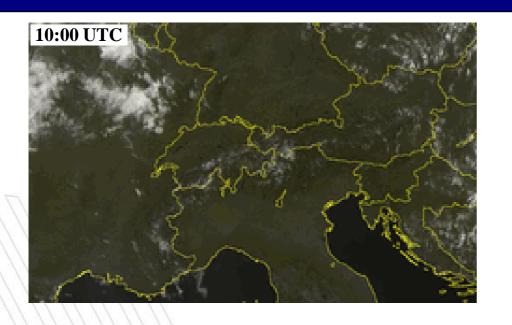
PAm' **PPms** PPm (22.6 O Kijow 21.6 🔞 Rz PZ

Synoptic map for 28.07.2012

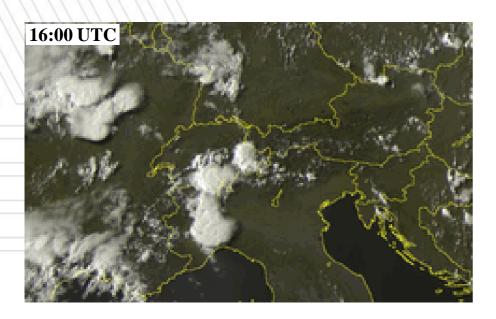


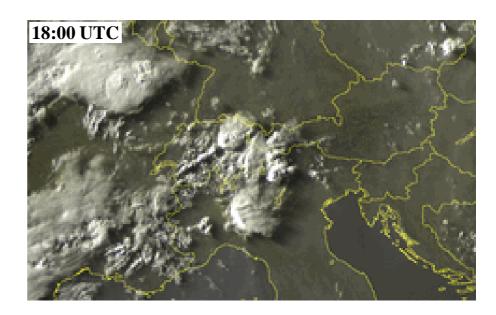
- Surface weak and shallow low-pressure system
- Some (rather weak) upper-air forcing

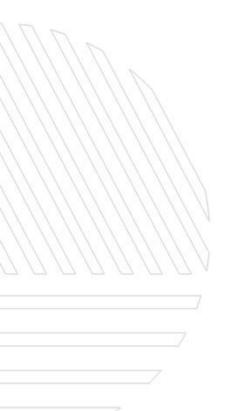
Test case: MSG High Resolution Visible (HRV) channel









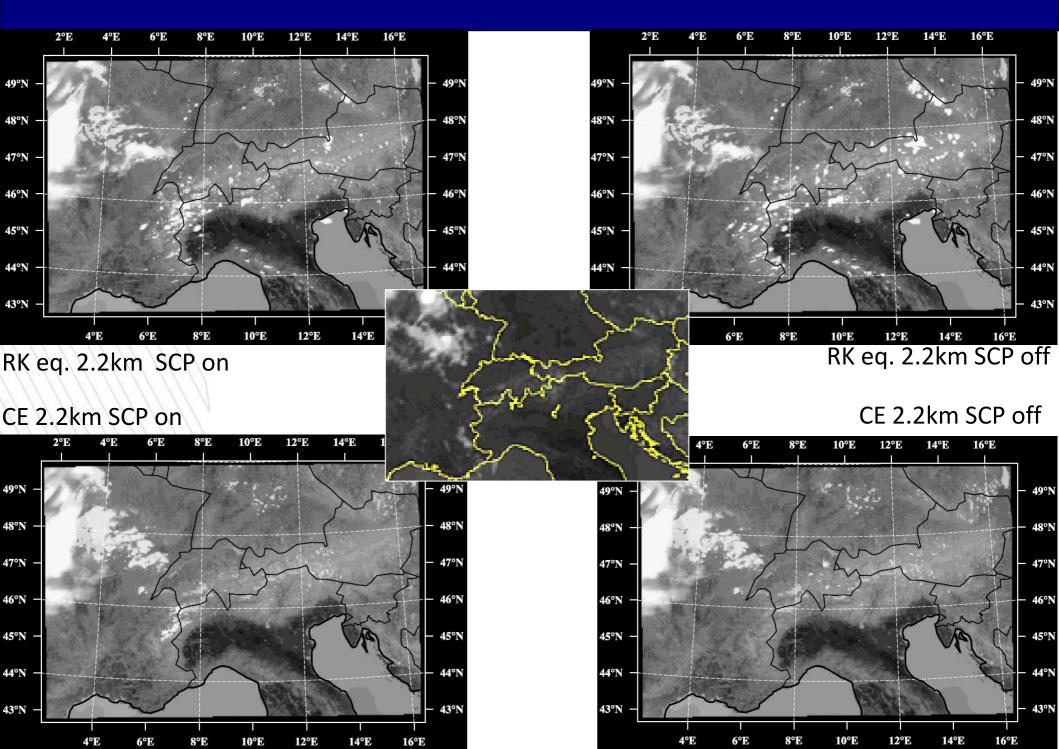


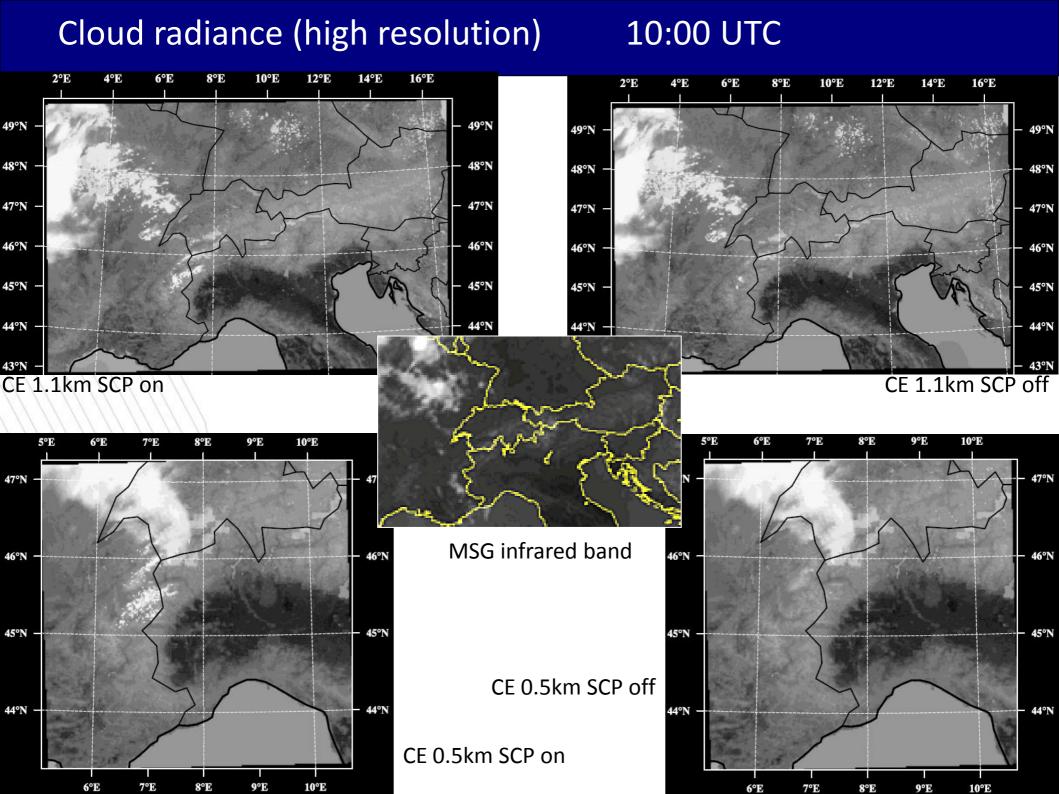
Spatial structure of convection



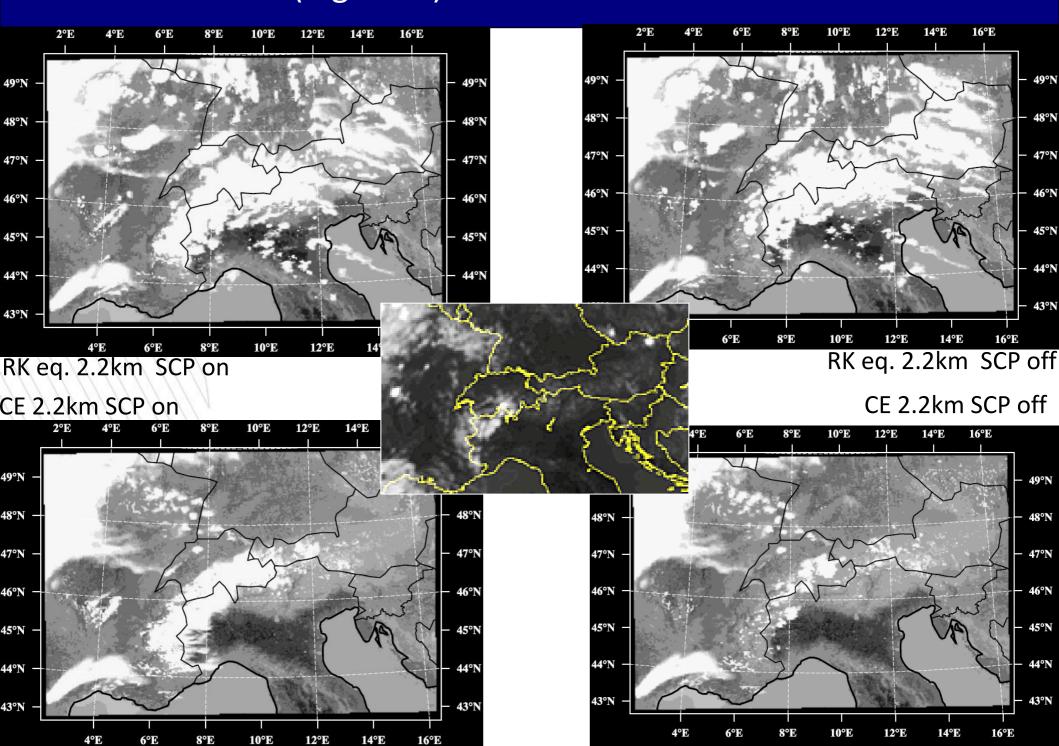
Cloud radiance

10:00 UTC

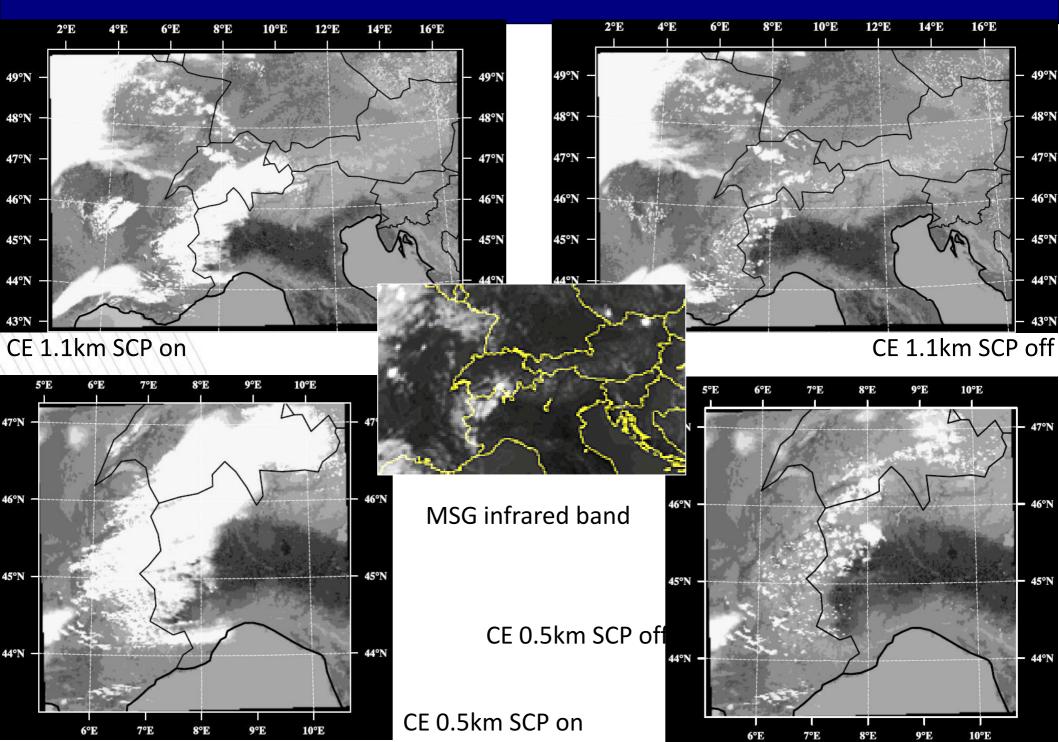




Cloud radiance (high res.) 14:00 UTC

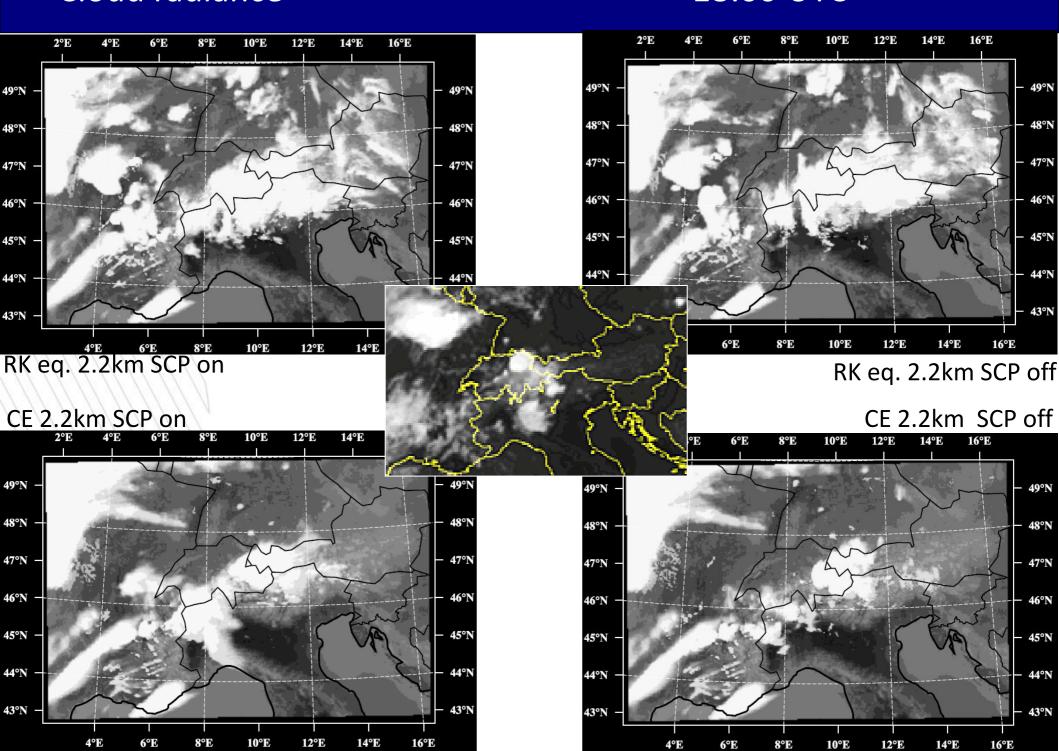


Cloud radiance (high res.) 14:00 UTC



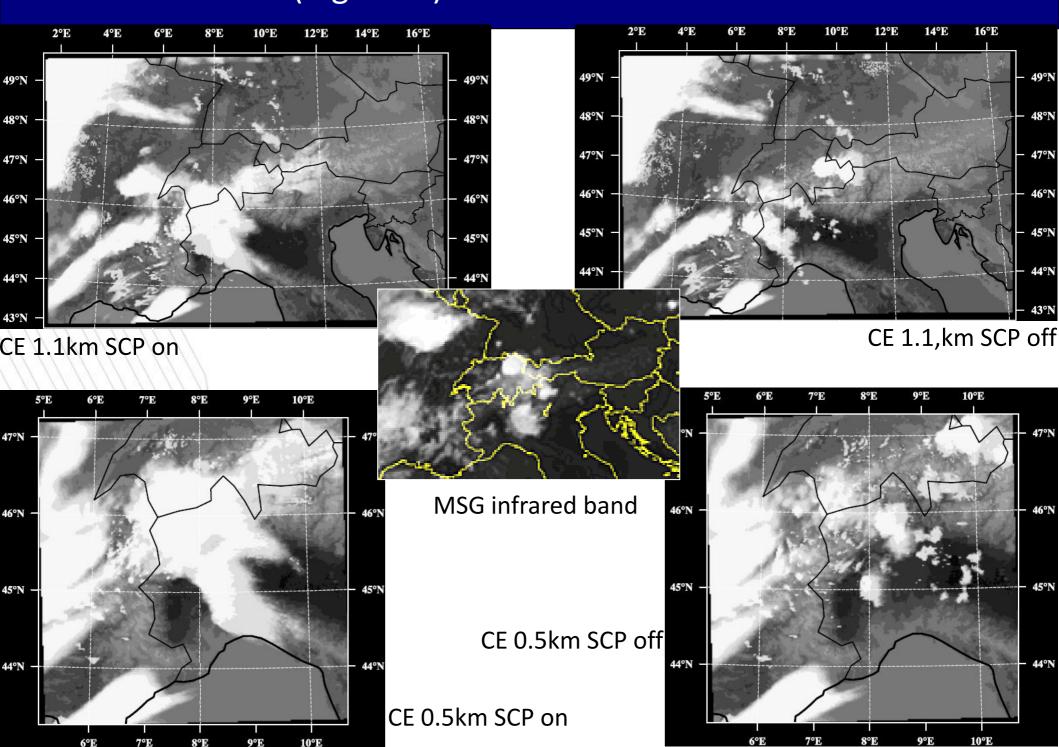
Cloud radiance

18:00 UTC



Cloud radiance (high res.)

18:00 UTC

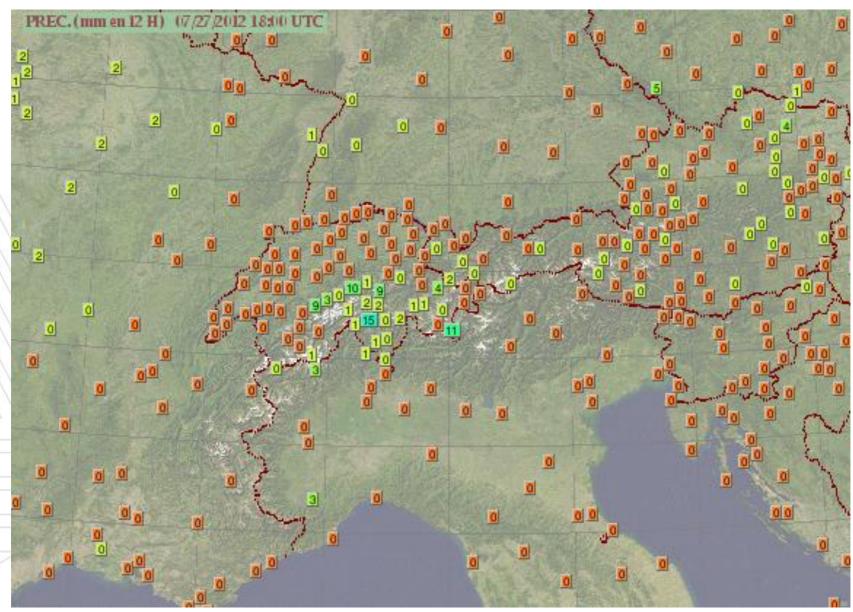


Summary: convective cloud pattern

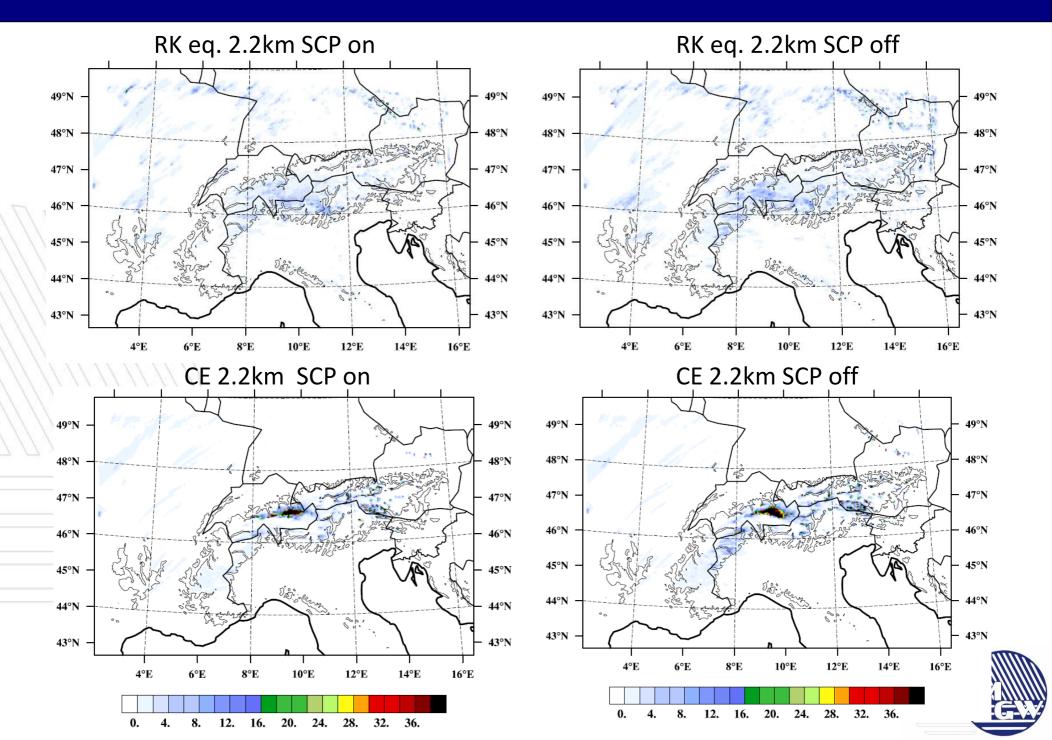
- Qualitatively, while the SCP have minor impact on RK 2.2 km spatial pattern
 of convective clouds, it significantly influences the pattern of the CE
 convective clouds, for all resolutions tested (from 2.2 to 0.55 km)
- In CE, the forecasts without SCP result in less extensive spread of convective clusters which is also more in agreement with observations, for the analyzed case
- In CE with SCP, the spatial pattern of convective clouds is similar across tested resolutions, during the day
- In CE without SCP, the spatial pattern of convective clouds is similar across resolutions for early stages of the convection, for later stages the pattern differs between resolutions



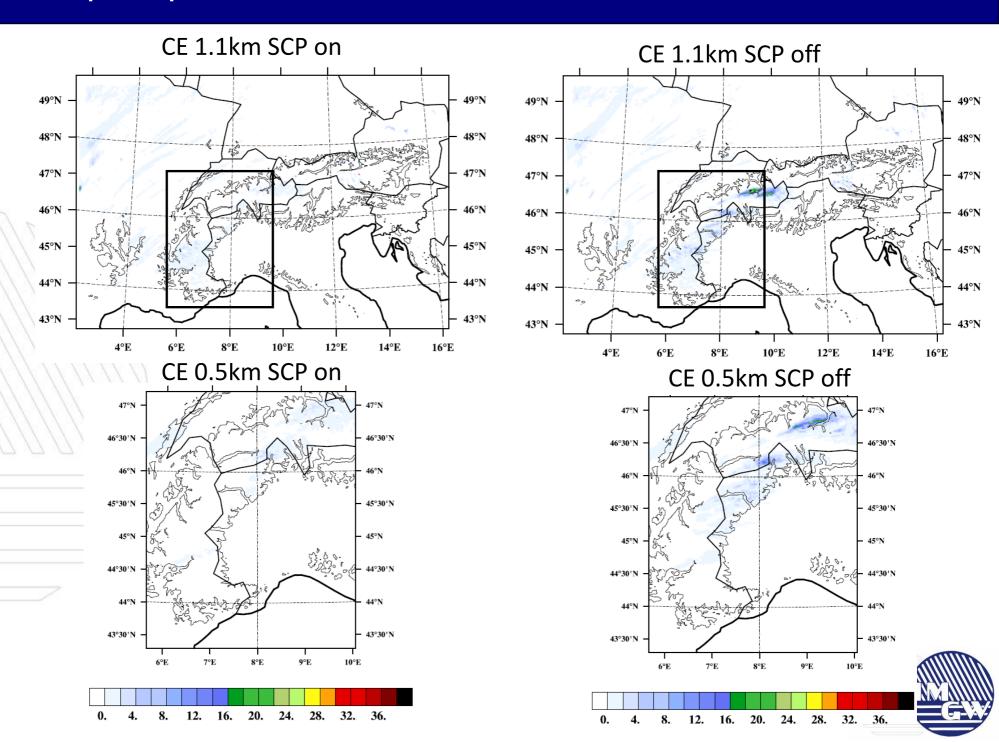
Precipitation field



Total precipitation till 18:00 UTC



Total precipitation till 18:00 UTC



Domain-averaged rainfall at 24:00 UTC

Domain-averaged precipitation sum [mm] for 24 h simulation

Cosmo - Eulag						
SCP ON			SCP OFF			
2.2 km	1.1 km	0.55 km	2.2 km	1.1 km	0.55 km	
1.42	1.02	0.07	1.60	1.20	0.33	

Runge – Kutta				
SCP ON	SCP OFF			
2.2 km	2.2 km			
1.83	1.65			



Summary: precipitation

- CE forecast gives strong local maxima (overestimations) of precipitation in mountain regions, especially for lower resolutions (2.2 km grid)
- With increasing resolutions, the CE precipitation maxima diminish and for 0.55 km grid attain values closed to observed (at least station-based)
- While the 2.2 km RK precipitation maxima are lower comparing to CE, the precipitation area is more extensive comparing to CE and total precipitation sum is higher
- For RK, an application of SCP increases the total precipitation amount, for CE it decreases it, for all resolutions applied
- For CE, application of SCP decreases values of precipitation maxima

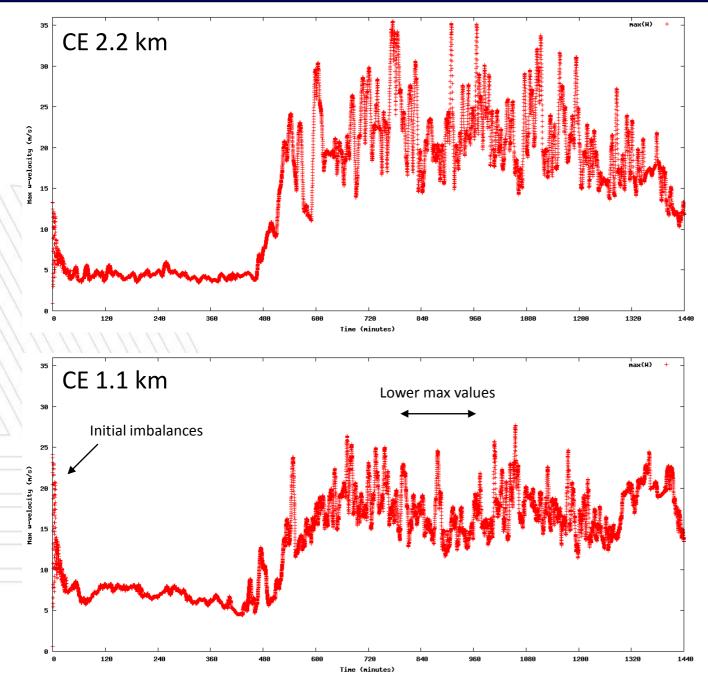




Diurnal cycles



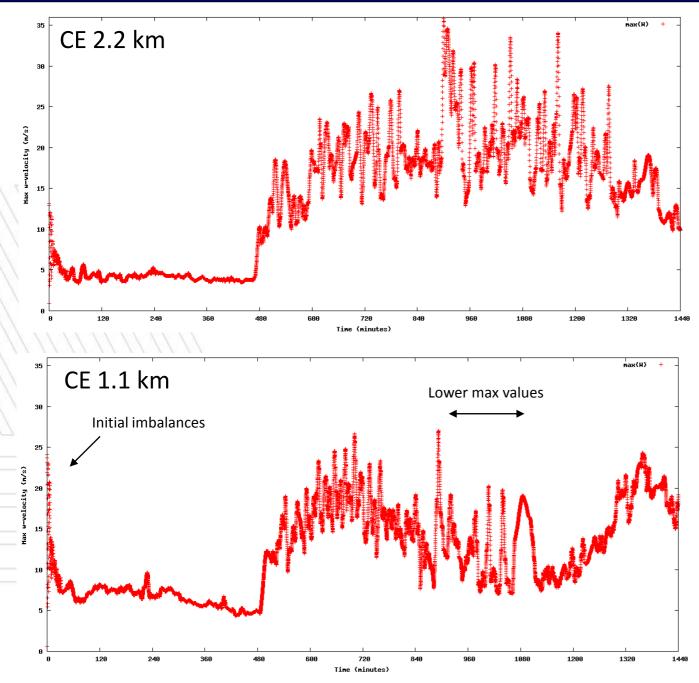
Maximum vertical velocity (W): SCP off





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Maximum vertical velocity (W): SCP on





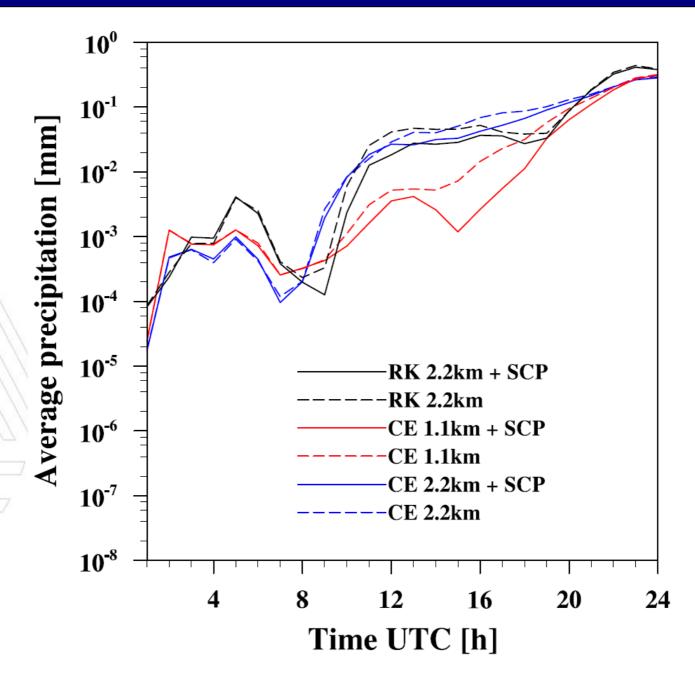
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Summary: vertical velocity cycle

- CE simulations well represent onset of day-time convection
- CE simulation with higher resolution (1.1 km grid) give lower maximum vertical velocities (in agreement with precipitation estimations), and give increased intensity of late nocturnal convection (comparing to 2.2 km grid)
- Implementation of SCP resulted in less intensive early convection for 2.2 km grid but less intensive late convection for 1.1 km grid

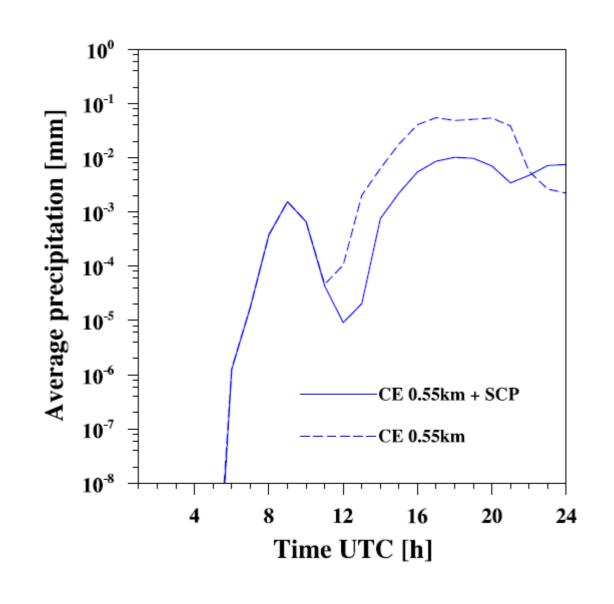


Diurnal domain-averaged precipitation cycle (hourly data)





Diurnal domain-averaged precipitation cycle (hourly data)





Summary: precipitation diurnal cycle

- For 2.2 km grid RK simulation the precipitation diurnal cycle is weakly influenced by the SCP
- It concerns also 2.2 km grid CE simulations, which are close to the RK results, apart from weaker evening precipitation minimum and weaker night-time maximum
- 1.1 km CE simulations give smaller precipitation except late-night phase (comparing to 2.2 km grid)
- 1.1 km CE simulation with SCP shows early-afternoon precipitation maximum suggesting 2-phase convection cycle involving generation and decay of first-generation convection cells, followed by development of second-generation cells
- In smaller mountainous domain simulations using 0.55 km grid there is evidence of such "double" convection cycle (the primary precipitation maximum appears to early)

Outlook

Further work will include:

- Implementation to the CE of the Eulerian transport of moist variables (MPDATA), in agreement with the transport of the dynamic variables
- Testing CE in 0.28 km resolution
- Further evaluation, including verification, spectral analysis, etc...



Thank you!

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