Towards optimization of the COSMO-2 model for quantitative precipitation forecasts

Felix Ament[1], Marcel Koller[2]

felix.ament@meteoswiss.ch

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Department of Home Affairs FDHA
Federal Office of Meteorology and Climatology MeteoSwiss

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

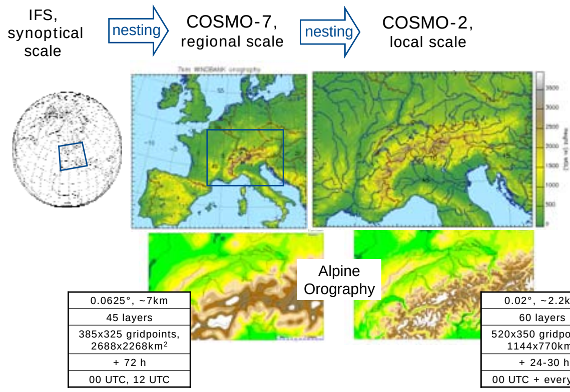
1 Federal Office of Meteorology and Climatology MeteoSwiss, Zürich, Switzerland
2 Institute for Atmospheric and Climate Science, ETH Zürich, Switzerland

COSMO-2

COSMO-2 is the Swiss high resolution (Δx=2.2km) version of the weather prediction model COSMO (formerly known as Lokal-Modell, LM), which will become operationally at the beginning of next year. Expected benefits of this model are

- better representation of small scale features above complex topography
- direct simulation of deep convection
- improved simulation of local extreme events

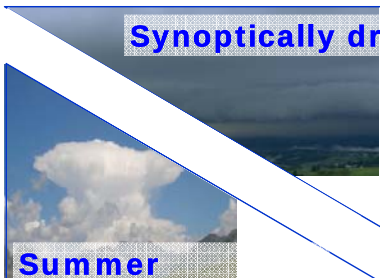
This may lead to improved forecast of near surface parameters (like 2m-temperature and 10m-wind) and precipitation. The evaluation of precipitation forecasts is the focus of this poster



COSMO-7
0.0625°, ~7km
45 layers
385x325 gridpoints, 2688x2268km²
+ 72 h
00 UTC, 12 UTC

COSMO-2
0.02°, ~2.2km
60 layers
520x350 gridpoints, 1144x770km²
+ 24-30 h
00 UTC + every 3 h

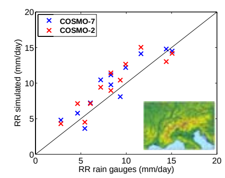
	COSMO-7 Operational version	Model enhancements for high resolution
Dynamics	Split explicit leap frog time integration (three time levels)	Runge Kutta two time level integration; higher order advection schemes
Physics	Bulk microphysics (cloud water and ice; rain; snow) Δ-two stream-radiative transfer scheme 1.5 order turbulence closure Tiedtke massflux convection scheme Multilayer soil module	Graupel added as third precipitation type Higher update frequency of radiation calculation (15min) No parameterization of deep convection; only shallow condition still needs to be parameterized
Data assimilation	Newtonian relaxation (nudging) of in situ surface and upper air observation	Near future: Latent heat nudging of radar data



Synoptically driven situations

As examples of synoptically driven situations, 12 hindcasts of special observing periods during the MAP 1999 (Mesoscale Alpine Program) campaign have been performed. The analysis (see right) reveals the following main aspects:

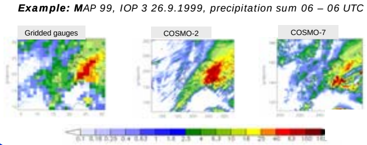
- COSMO-2 and COSMO-7 are very similar ...
- ... and perform well on coarse scale ...
- ... but still exhibit both large local errors.

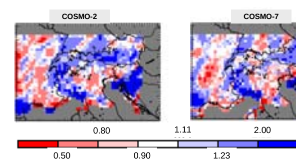


(24 h accumulations; averaged over 12 cases, 20km scale)	COSMO-7	COSMO-2
BIAS (mm/day)	1.12	1.26
STD (mm/day)	11.4	13.6
Pattern correlation	0.63	0.65
ETS (1mm)	0.35	0.36
ETS (10mm)	0.36	0.42

Left: Alpine domain averaged precipitation. For all twelve considered cases. Top: Corresponding classical scores against gridded rain gauge data. Bottom: Mean relative error of all twelve cases at 20km resolution against gridded rain gauge data.

Example: MAP 99, IOP 3 26.9.1999, precipitation sum 06 – 06 UTC

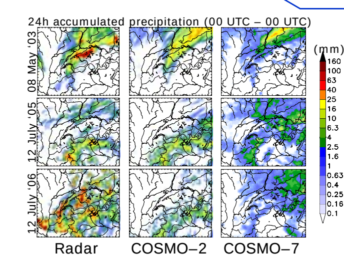




Summer convection

Precipitation forecasts of summer convection differ significantly between COSMO-7 and COSMO-2 (see right): The convection scheme of COSMO-7 results in unrealistically widespread precipitation patterns. COSMO-2 produces reasonable structures, but tends to initiate too little convection.

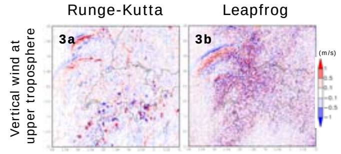
Sensitivity experiments were performed in COSMO-2 to find model components which can remedy the deficiency of missing convection: Tests on shallow convection, microphysics and surface fluxes should minor impact, in contrast to changes in the numerics and the turbulence scheme (see right and bottom).

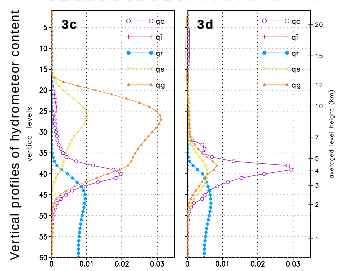


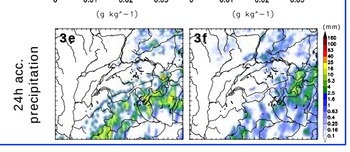
Impact of numerical time integration schemes

A sensitivity study shows the influence of numerical time integration on explicit computation of convective precipitation

- 2-time-level Runge-Kutta scheme is able to predict up- and downdraft systems in convective cells *(see Fig. 3a)*
- 3-time-level Leapfrog computes a noisy vertical wind pattern in upper troposphere where hardly any cells can be identified *(see Fig. 3b)*
- deep convective clouds consisting of mainly snow and graupel can develop with Runge-Kutta scheme but not with Leapfrog scheme *(see Fig. 3c, 3d)*
- Runge-Kutta scheme computes higher intensities of convective precipitation compared to Leapfrog scheme *(see Fig. 3e, 3f)*
- Leapfrog scheme is not suitable for explicit computation of convection in COSMO-2. Runge-Kutta scheme should be used instead



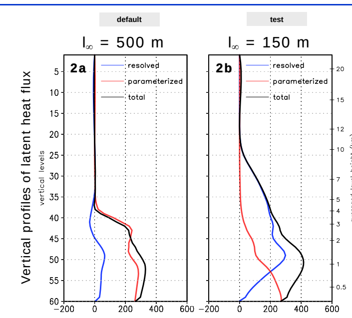


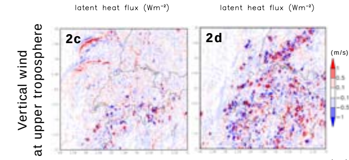


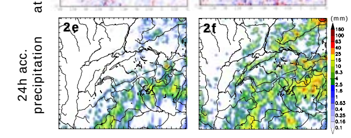
Impact of turbulence parameterization

Asymptotic turbulent length scale l_∞ is a measure for the maximal extent of parameterized turbulent eddies

- Parameterized turbulent fluxes are lowered *(Fig. 2a, 2b)*
- Resolved turbulent fluxes compensate for the reduced parameterized fluxes *(Fig. 2a, 2b)*
- Vertical motion is triggered by increased resolved fluxes
- Number and intensity of explicit convective cells is considerably increased *(see Fig. 2c, 2d)*
- Convective precipitation in COSMO-2 is clearly intensified by reduction of asymptotic turbulent length scale l_∞ *(see Fig. 2e, 2f)*
- Simple reduction of l_∞ does not lead to better precipitation forecasts
- Future adaptation of turbulence parameterization is needed to take into account that explicit computation of convection strongly depends on the balance between parameterized and resolved turbulent motion.







Conclusions

- Under synoptically driven situations COSMO-7 and COSMO-2 show a similar QPF performance.
- COSMO-2 can in principle predict convective precipitation more realistically than COMSO-7
- Prediction of convection in COSMO-2 suffers from missing of convective cells, in particular in region with low orographic forcing.
- Future adaptation of the turbulence parameterization scheme can potentially remedy this effect.