Implementation of the Bechtold convection scheme in COSMO: deterministic- and ensemble- mode tests

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Purpose of the work

The aim of this work, performed in the framework of a COSMO Priority Task, is to assess the sensitivity of COSMO model forecast skill to the use of different parameterisations of moist convection. The development and implementation of ensemble systems where different convection schemes can be used by the ensemble members provides an opportunity to upgrade probabilistic systems at the convection-parameterised scale and, in particular, COSMO-LEPS, the operational ensemble system of the COSMO consortium.

Model system and method

MODEL AND MOIST CONVECTION SCHEMES

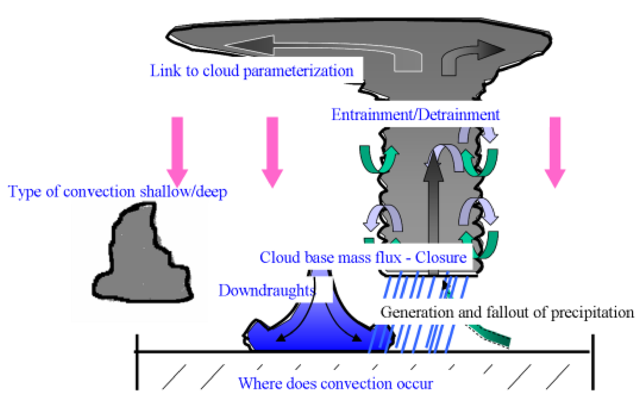
COSMO-LEPS is the operational ensemble system of the COSMO consortium:

7 km horizontal resolution; 40 ML; 20 members; 132 h forecast range; ICs&BCs from IFS ENS (RM selection), at the moment all members run with the Tiedtke scheme.

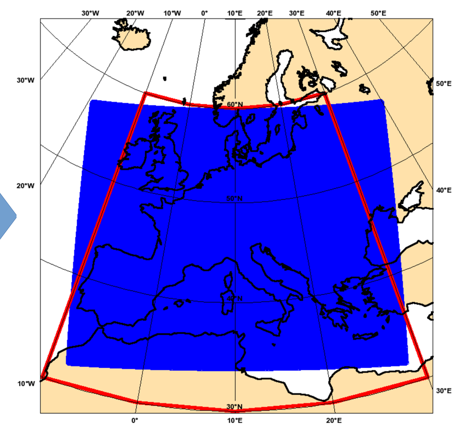
The Bechtold scheme has been implemented in ECMWF global model and has recently been adapted for COSMO.

Main features: Mass-flux schemes with different closure assumptions (moisture convergence for the Tiedtke scheme, CAPE for the Bechtold scheme).

Schematics of Mass-Flux convection schemes



COSMO-LEPS domain and clustering area



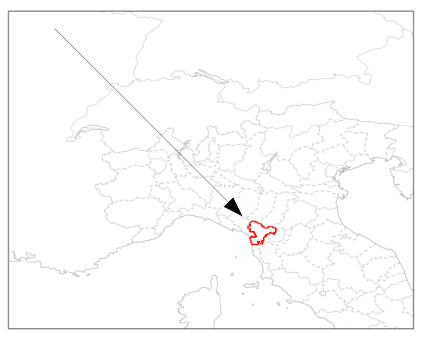
METHODOLOGY

Different runs of COSMO model are performed in both deterministic and ensemble mode

Deterministic mode

Runs of COSMO model with the Tiedtke scheme (COSMO-T) and the Bechtold scheme (COSMO-B);

Verification on a case study basis (heavy precipitation event over a river catchment in Northern Italy from 30th January to 7th February 2017)



Serchio river basin (~ 2000 km², ~ 50 obs)

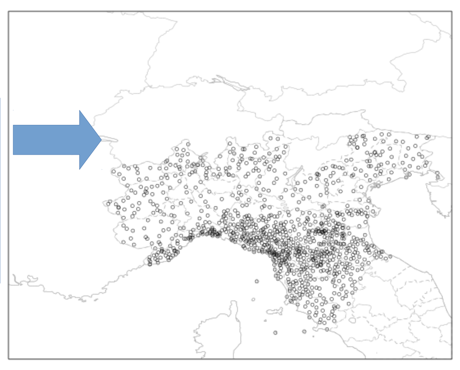
Ensemble mode

Implementation of Cleps_20bt, made of 20 members (ic&bc as in COSMO-LEPS):

- members 1-10 run with the Bechtold scheme (Cleps-10B);
- members 11-20 run with the Tiedtke scheme

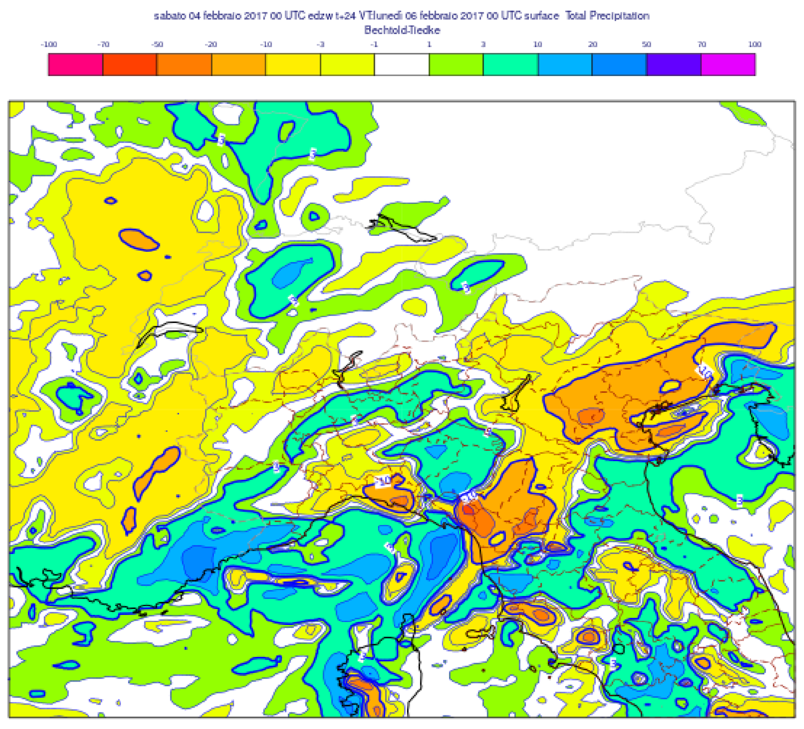
Verification period from 28th March to 31th May 2017

Verification network ~ 1000 obs (non GTS stations, regional network)

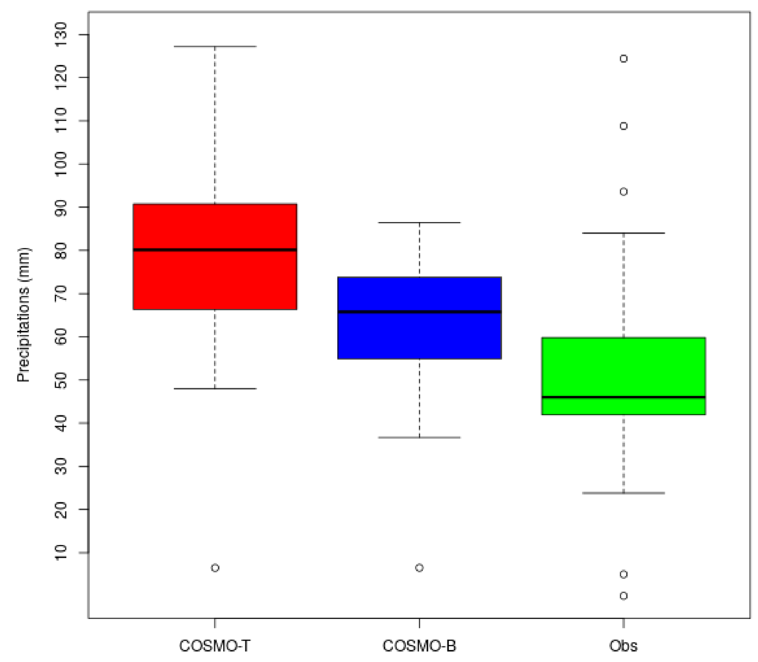


Tests in deterministic mode (case study)

Differences in 24-h cumulated precipitation between COSMO-B runs and COSMO-T runs

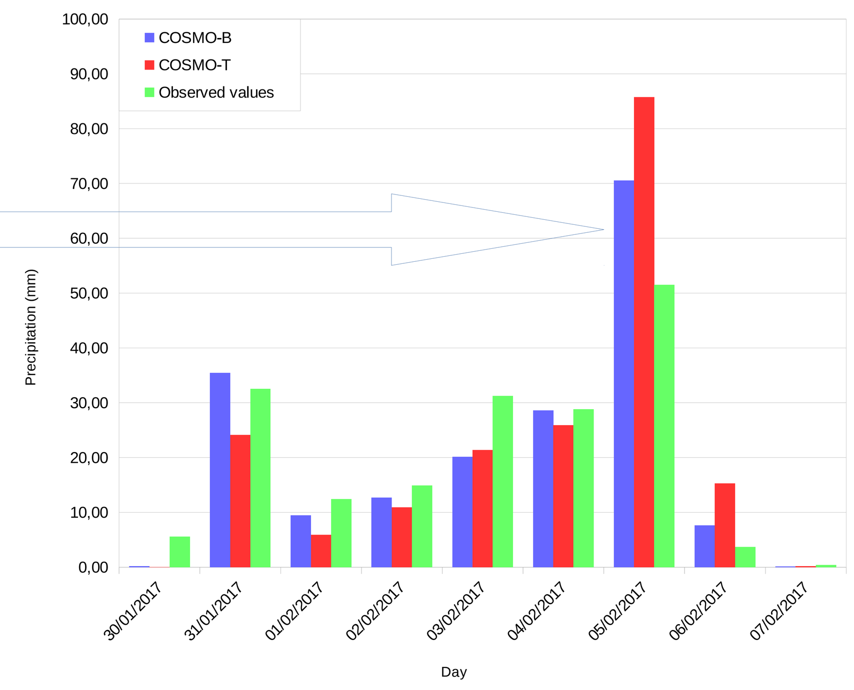


Run valid for 5 February 2017 initialised at 00 UTC of 4 February 2017 (fc +24-48 h)



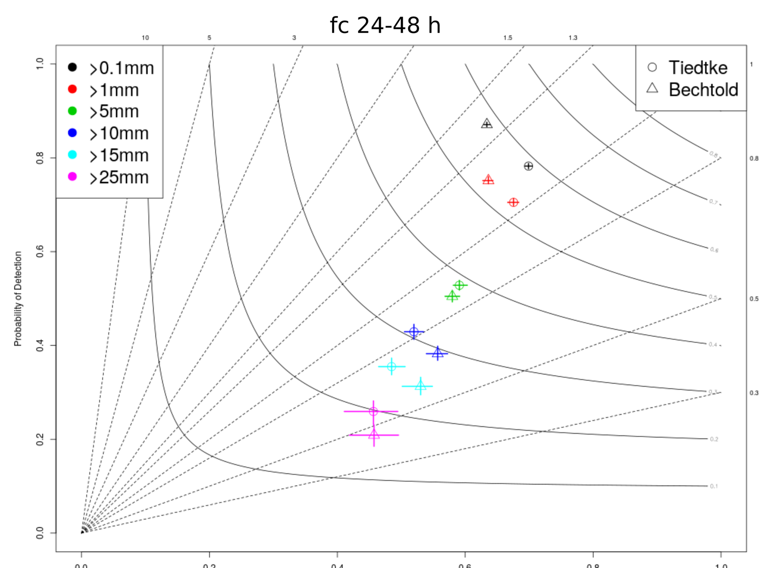
Boxplot for 5 February predicted and observed total precipitation distribution over the Serchio basin (fc +24-48 h)

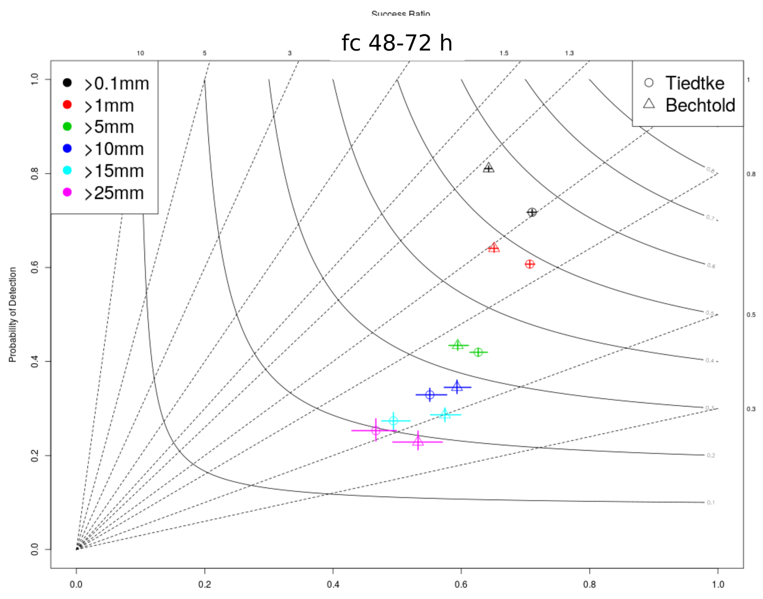
Comparison between COSMO-B and COSMO-T runs (1 per day at 00 UTC) for predicted and observed areal means of 24-h cumulated precipitation over the Serchio river catchment area (fc +24-48 h)



Tests in ensemble mode (April/May 2017)

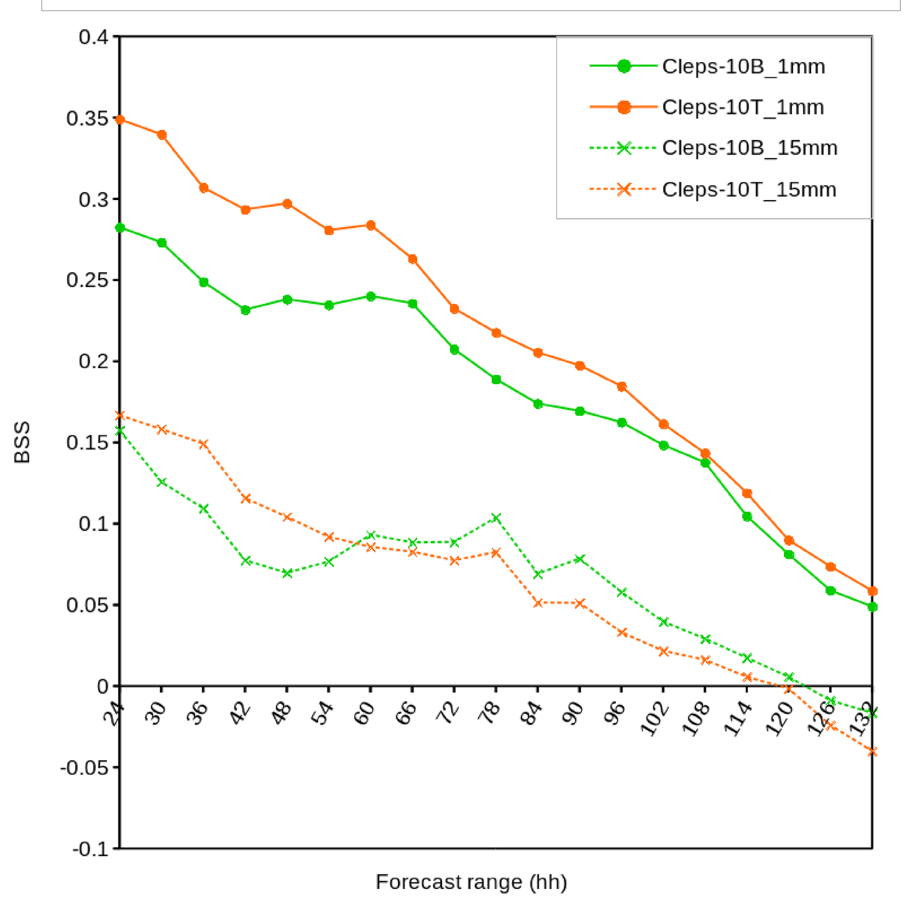
Forecast skill in terms of cumulated precipitation over Northern Italy regional network (nearest gridpoint)





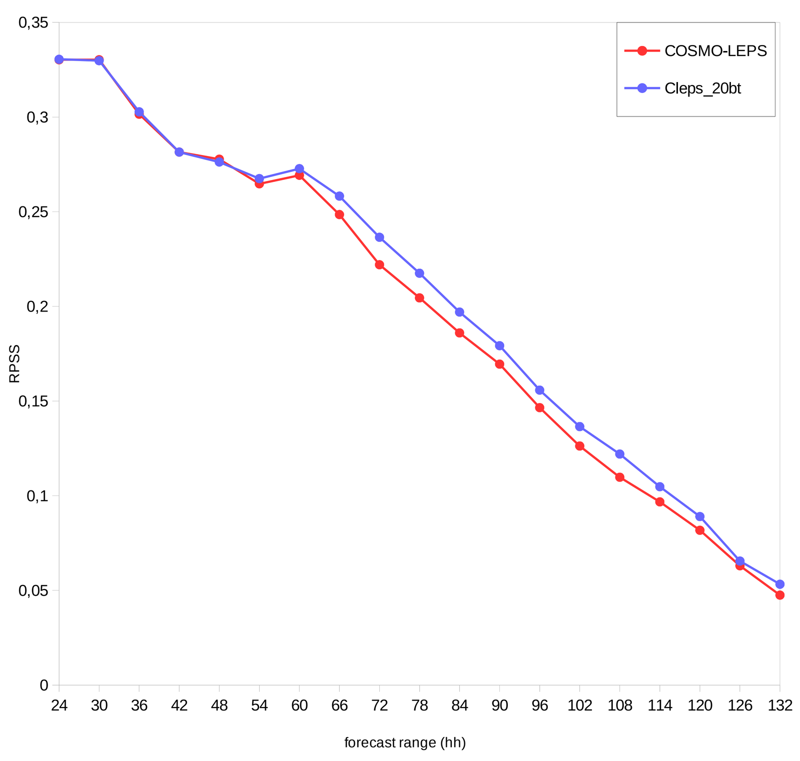
Performance diagrams for 24h cumulated precipitation: member 2 of Cleps-10T vs member 2 of Cleps-10B

Comparison between Cleps-10B and Cleps-10T (made of members 1-10 of COSMO-LEPS)



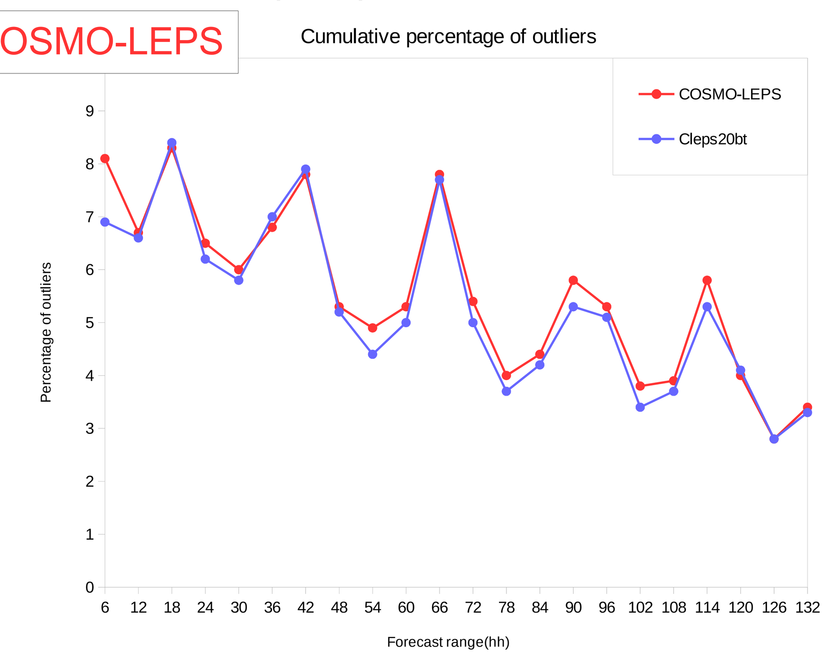
BSS for 1mm/6h and 15 mm/6h cumulated precipitation: the higher the better

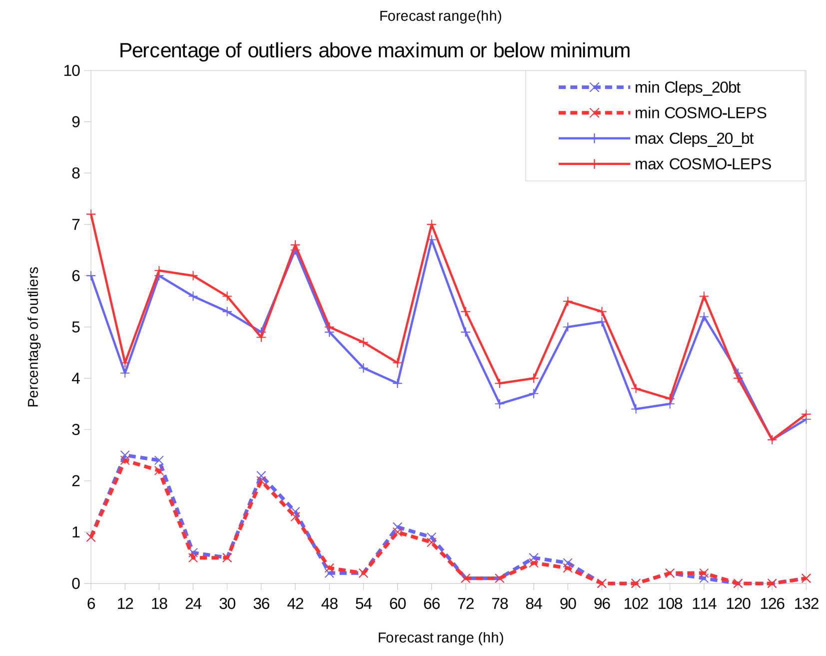
Comparison between Cleps_20bt and COSMO-LEPS



24-h running mean of RPSS for 6-h cumulated precipitation: RPSS is a cumulative BSS, the higher the score, the better the forecast

Percentage of outliers for 6-h cumulated precipitation: the lower the better





Conclusions

- ✔ Case-study verification: deterministic runs perform better with the Bechtold scheme for most of the investigated days in terms of precipitation averaged over a small river basin.
- ✔ Long-term verification: COSMO runs with the Bechtold scheme tend to overestimate the occurrence of light-precipitation events ("drizzle" problem).
- ✔ Cleps_20bt (using either the Tiedtke or the Bechtold convection scheme) has higher skill than COSMO-LEPS (using the Tiedtke scheme only) for different thresholds of 6-h cumulated precipitation, more evident from +48 hours onwards.
- ✔ Cleps_20bt shows a reduction in the Percentage of Outliers compared to COSMO-LEPS, especially by limiting the fraction of observations lying above the maximum forecast value.
- ✔ The use of the Bechtold scheme is proposed as a perturbation to the COSMO-LEPS ensemble, so as to have a more comprehensive description of the uncertainties linked to the model representation of cumulus convection.

Future plans

- ✔ Perform runs in ensemble mode for other seasons and at 5 km of horizontal resolution.
- ✔ Assess the Cleps_20bt forecast skill in terms of other variables (2m temperature, 10m wind speed, humidity..).
- ✔ If results are satisfactory, the operational implementation of Cleps_20bt is envisaged.
- ✔ Investigate the possibility of parameter tuning to address the drizzle issue.

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