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Improving COSMO by using CAMS aerosols

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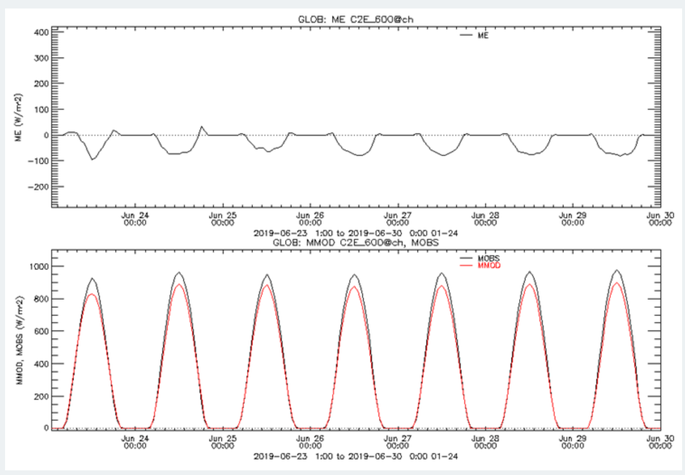
The Problem And The Target

- Strong negative bias of **global radiation (GLOB)** for clear-sky conditions
- Compensation of negative bias with positive bias for cloudy-sky conditions
- Limited understanding of customers for this clear-sky bias

Global radiation Mean Error [W/m^2]



OBS

MODEL

Test and Use CLOUDRAD for our COSMO domains

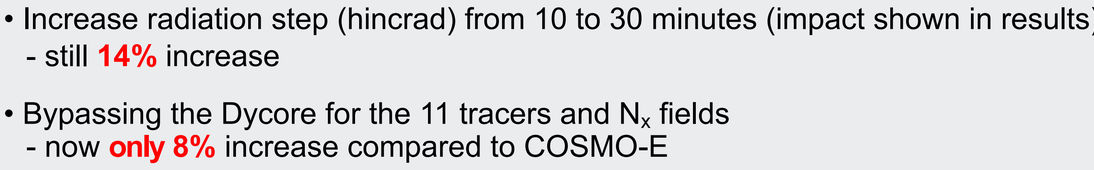
CLOUDRAD is an extension of the current radiation-scheme developed in the T^2(RC)^2 project mainly by the Israel Meteorological Service (IMS)

- Use of prognostic aerosol-fields from Copernicus Atmospheric Monitoring System (CAMS) from ECMWF instead of Tanre,1984 climatology
  - sea salt, mineral dust, black carbon, sulphate, …
  - in total 11 aerosol-species
  - integration into COSMO via analysis and boundary conditions
- Dozens of new parametrizations for processes influencing radiative transfer
  - by including snow (q_s), graupel (q_g), and rain (q_r)
  - by estimating number concentration N_x of hydrophilic aerosols from CAMS data and by estimating local subgrid-scale updraft velocity (w_{eff})
  - combining N_x and w_{eff} to compute the number concentration of nucleated cloud droplets (N_{CCN}) using the Segal-Khain parametrization, ...

→ **all together should improve clear-sky** and **cloudy-sky radiation**

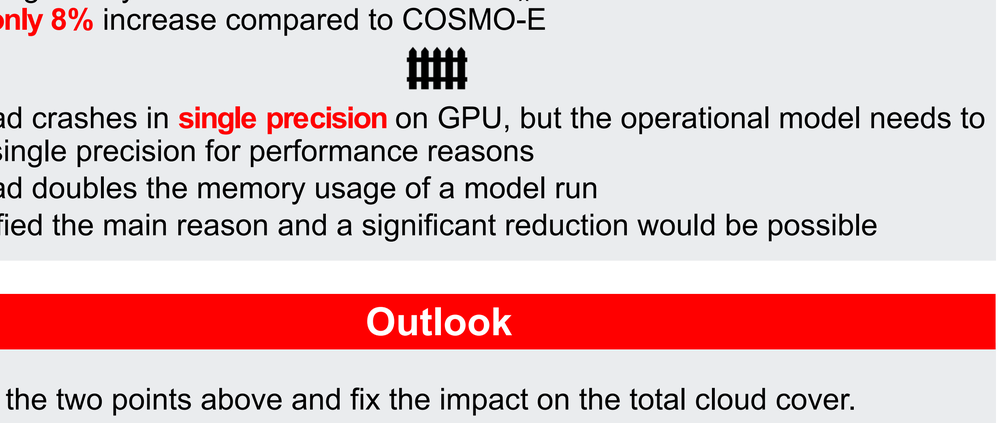
Verification approach for the Alpine region

- Four 1-week periods with only clear-sky or cloudy-sky in winter and in summer
- **2.2 km** COSMO-E member instead of expensive 1km runs



We need a True-True verification: consider ONLY "observation-model" pairs with Total Cloud Cover (CLCT) >= 2.5 octas

all: **GLOB** only **True-True** Daily **M**ean **E**rror



GPU porting and GPU-Timings

- Initial Configuration:
  25% increase compared to COSMO-E with double precision
  - not possible for operational use
- Switch off expensive Segal-Khain parametrization for grid-scale precipitation
  - still **18%** increase
- Increase radiation step (hincrad) from 10 to 30 minutes (impact shown in results)
  - still **14%** increase
- Bypassing the Dycore for the 11 tracers and N_x fields
  - now **only 8%** increase compared to COSMO-E

- Cloudrad crashes in **single precision** on GPU, but the operational model needs to run in single precision for performance reasons
- Cloudrad doubles the memory usage of a model run
  - identified the main reason and a significant reduction would be possible

Outlook

Work on the two points above and fix the impact on the total cloud cover.

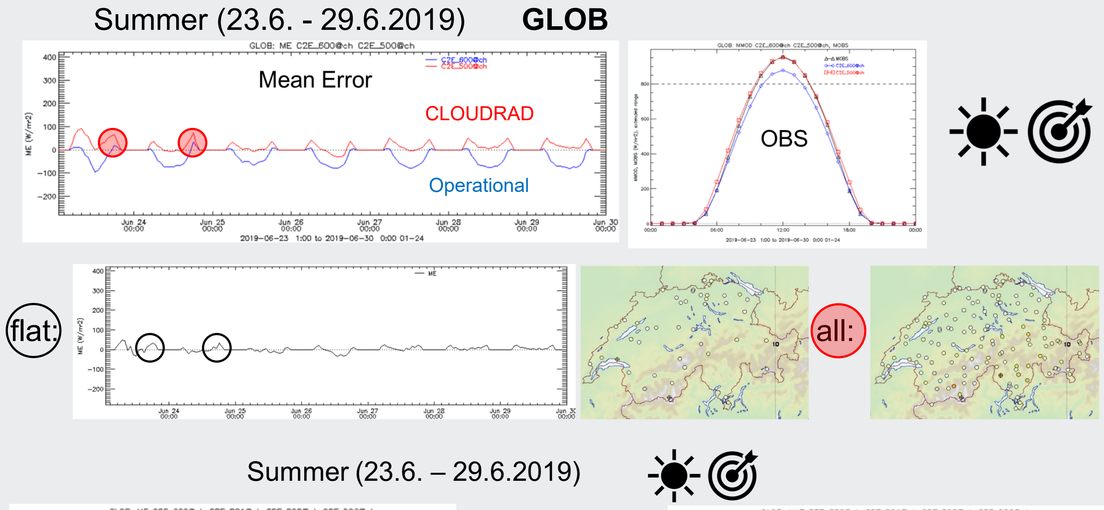
References

Pavel Khain, Harel Muskatel, Ulrich Blahak (2019): *Implementation of the new cloud-radiation scheme in COSMO,* COSMO News Letter No. 18*,* 9 pages, http://www.cosmo-model.org

Tanre, D., J.-F. Geleyn, and J. Slingo (1984): *First results of the introduction of an advanced aerosol-radiation interaction in the ECMWF low resolution global model.* In Proc. of the Meetings of Experts on Aerosols and their Climatic Effects, Williamsburg, VA, pp. 133–177, WMO and IAMAP.

Final Results with GPU-otpimizations

Summer (23.6. - 29.6.2019) **GLOB**

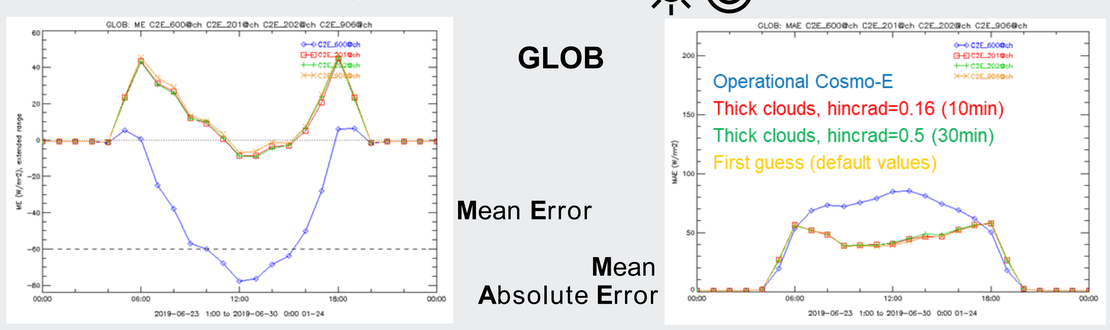


Summer (23.6. – 29.6.2019)

GLOB

Mean **E**rror

Mean **A**bsolute **E**rror

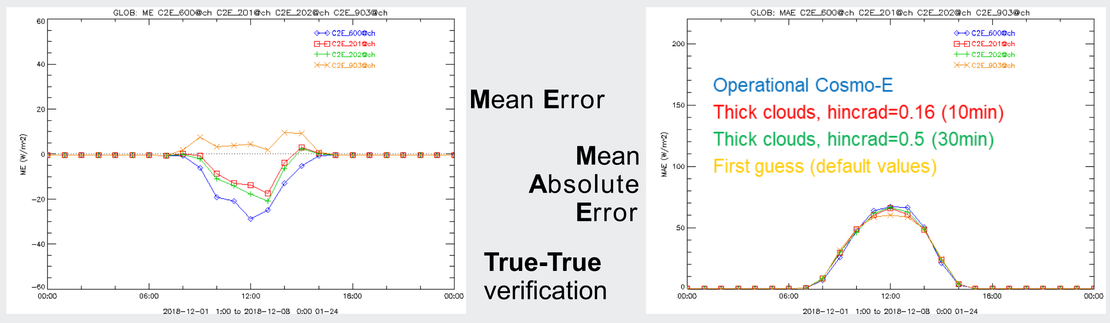


Winter (1.12. – 7.12.2018)

Mean **E**rror

Mean **A**bsolute **E**rror

True-True verification



Conclusions

- **Major** improvement for clear-sky
- Same skill for cloudy-sky as operational COSMO-E
- Reasonable impact on 2m temperature and humidity (not shown)
- **Need:** thicker clouds in summer
  thinner clouds in winter

- **Overestimation** of Total Cloud Cover (CLCT) with CLOUDRAD (not shown)
- Need a built-in switch to improve output of CLCT only
- Still about 50 W/m^2 mean absolute error for global radiation

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