Calibration of COSMO Model over the Wider Eastern Mediterranean Area under the CALMO-MAX Priority Project

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Outline

- ❑ Domain choice
- ❑ Model version and set up
- ❑ Parameter list
- ❑ Optimization and evaluation
- ❑ Computational resources
- ❑ Conclusions

❑ Domain choice: Wider Eastern Mediterranean Area

Model version and set up

- cosmo_190418_5.06_1
- int2lm_190524_2.06
- Horizontal grid size: 0.03^0 (~3 km)
- 890x487 grid points
- 53 vertical levels (Tropopause at 33 km)
- Integration time-step: 15 secs.
- Time interval of radiation scheme call : 15 mins
- Integration period: 42 hs.
- Boundary conditions : 6hr IFS Analysis.

❑ Parameter list

PARAMETER	INTERPRETATION	RANGE	TEST VALUES (default)
rat_sea	ratio of laminar scaling factors for heat over sea	1-100	1, 10, 50
rlam_heat	scaling factor of the laminar boundary layer for heat	0.1 – 10.0	0.1, 1.0, 2.0
tkhmin tkmmin	minimal value of diffusion coefficient for heat and momentum (kept equal)	0.0-2.0	0.1, 0.40, 2.0
tur_len	asymptotic maximal turbulent length scale (m)	10 – 10000	100, 150, 1000
c_soil	surface area index of evaporative soil surfaces (dependent on surface area density of the roughness elements over land , c_lnd)	0-c_lnd(2.0)	0, 1, 2

cosmo_userguide_5.06.pdf

Also in the namelist group /TUNING/ there are some variables that are chosen differently in the ICON setup. At least compared to the settings that were used at DWD for COSMO-DE or for the former COSMO-EU. Of course the choice of these variables depend on special configurations and domains. The following table lists the variables that are now chosen at DWD for COSMO-D2 ("OLD") and for ICON ("NEW").

/TUNING/	OLD	NEW	Explanation	Default
tkhmin	0.4	0.75	Minimal diffusion coefficients [in m^2/s] for vertical scalar (heat) transport.	1
tkmmin	0.4	0.75	Minimal diffusion coefficients [in m^2/s] for vertical momentum transport.	1
rat_sea	20.0	7.0	Ratio of laminar scaling factors for heat over sea and land.	10.0
pat_len	500.0	750.0	Effective length scale of subscale surface patterns over land [in m].	100.0
tur_len	150.0	500.0	Asymptotic maximal turbulent distance [in m].	500.0
a_hshr	1.0	2.0	Length scale factor for separate horizontal shear production.	1.0
c_soil	1.0	1.75	Surface area density of the (evaporative) soil surface.	1.0

❑ Optimization and evaluation

Selection of cases, parameters and meteorological fields

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COSMO Model runs

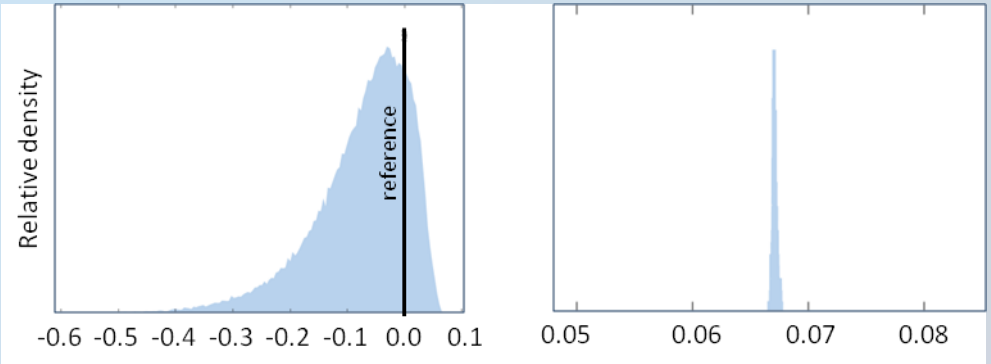
↓

Station observations from Greece and Israel
(Daily Tdry max, Tdry min, Tdew max, Tdew min and Precipitation)

→ Metamodel calibration

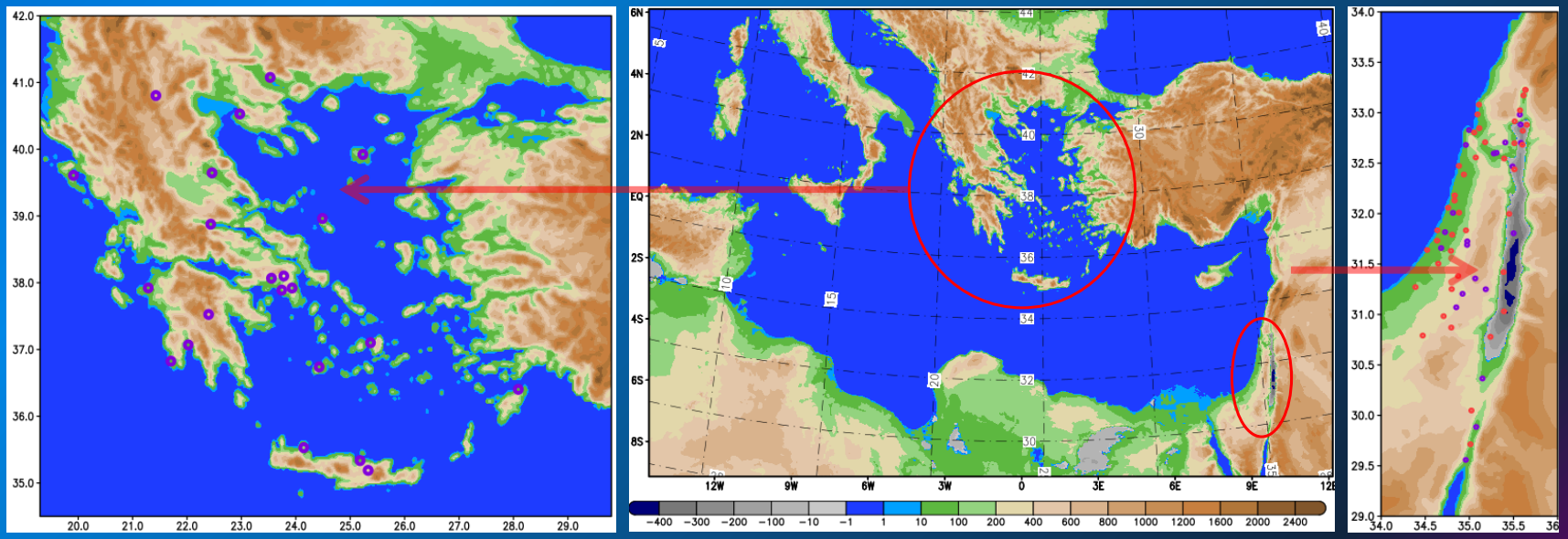
↓

Derivation of optimum parameter values in reference to the default runs



MM performance score distribution difference range from the default performance score over the representative cases for the first iteration (left) and the corresponding optimum parameter distribution at the end of the iteration process right). The positive (negative) values refer to a better (worse) performance score with respect to the reference simulation with the default parameter values.

Station observations from Greece and Israel



The domain topography (m) of model runs over the Central-Eastern Mediterranean area along with the approximate areas of station locations encircled in red. Right: The positions of the 22 Greek meteorological stations under consideration. Left: The positions of the 65 Israeli meteorological stations taken into consideration. Highlighted in purple color, the 22 stations selected for additional examinations with the Greek ones.

Case choice for optimization and model runs

60 cases were chosen from the year 2019, 5cases/month

22 runs per case according to parameter default, min/max, cross and optimum values

PARAMETER	INTERPRETATION	TEST VALUES min,def,max	OPTIMUM VALUES
c_soil	surface area index of evaporative soil	0, 1, 2	0.825
rat_sea	ratio of laminar scaling factors for heat over sea	1, 10, 50	5.288
rlam_heat	scaling factor of the laminar boundary layer for heat	0.1, 1.0, 2.0	1.049
tkhmin tkmmin	minimum value of diffusion coefficients for heat and momentum (both are kept equal)	0.1, 0.4, 2.0	1.356
tur_len	asymptotic maximum turbulent length scale (m)	100, 150, 1000	524.66

Case choice for evaluation

60 different cases were chosen from the year 2019, 5cases/month

❑ Optimization and Evaluation

Selection of a new set of cases

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COSMO Model runs (default and optimum parameter values)

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Station observations from Greece and Israel
(Daily Tdry max, Tdry min, Tdew max, Tdew min and Precipitation)

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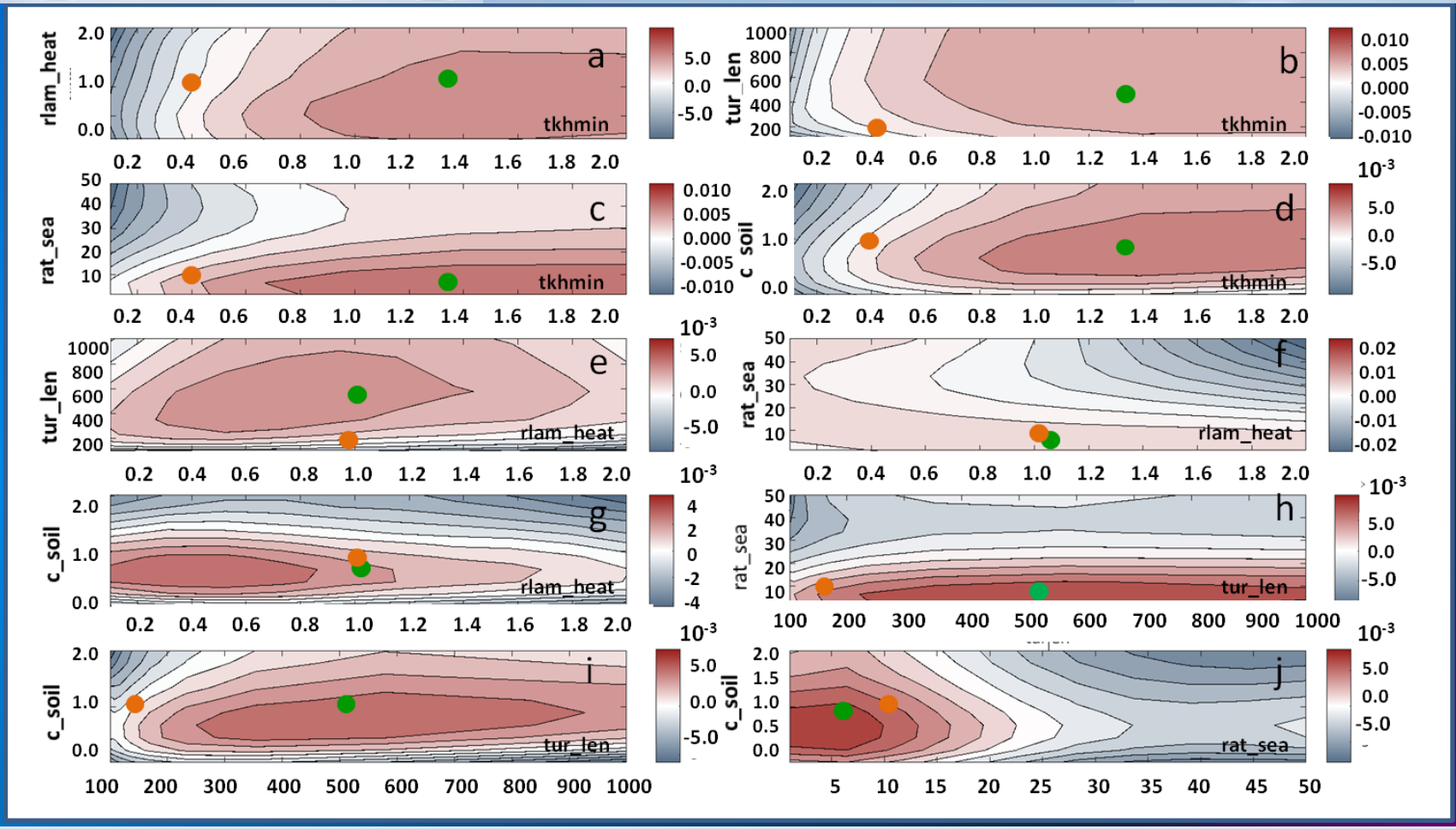
Evaluation of model performance scores for optimum parameter values in reference to the default runs



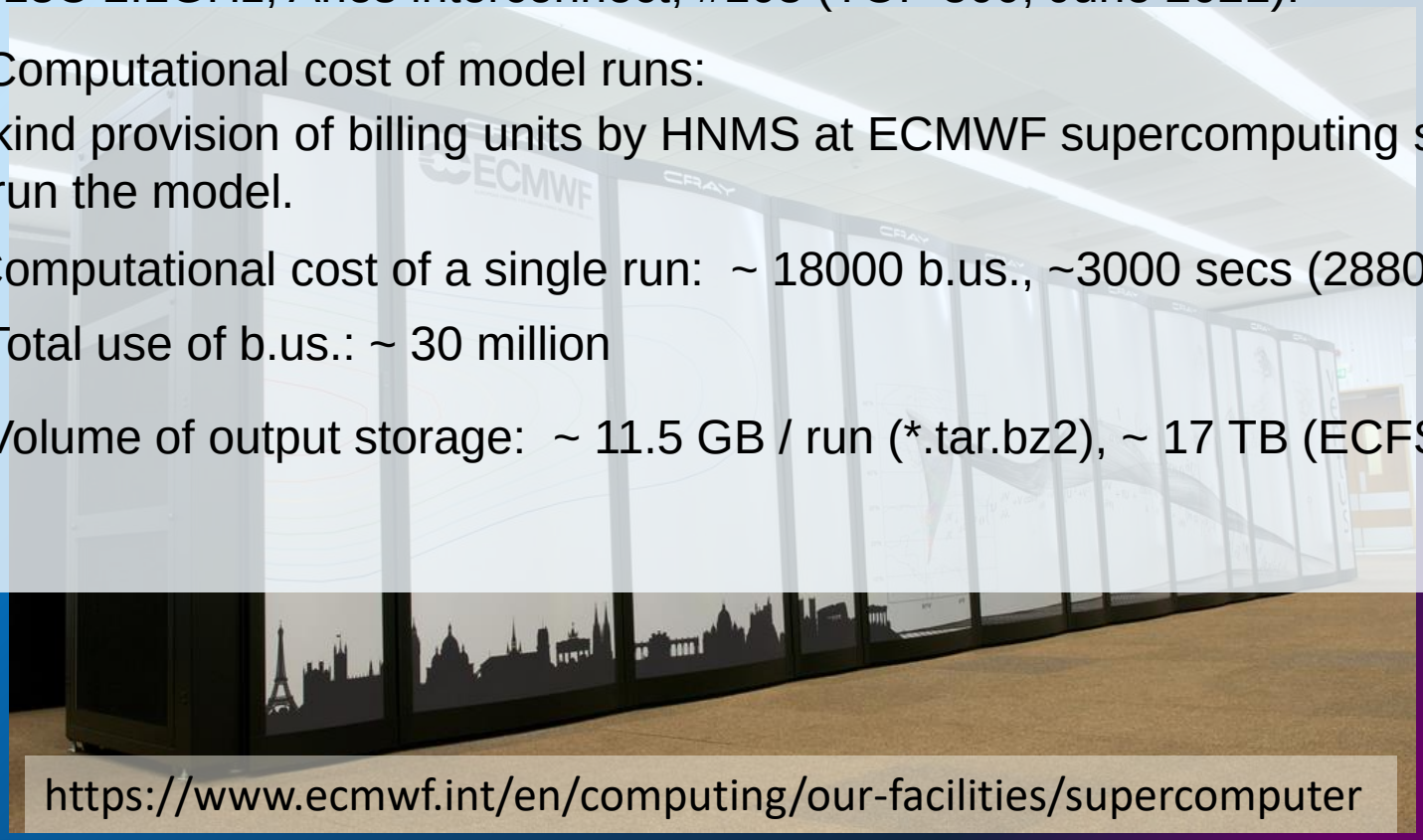
Contours of the deviation of the COSI skill score from the domain average ($s_P - \overline{s_P}$) for the ten parameter pairs. The red areas represent the above-average skill of the parameters pairs and the blue areas represent below-average skill. The green bullets display the optimum parameter values while the orange ones have their corresponding default values. In all the graphs the other parameters keep their default values.

Computational resources

- Computer system : ECMWF Cray XC40, Xeon E5-2695v4 18C 2.1GHz, Aries interconnect, #103 (TOP 500, June 2021).
- Computational cost of model runs:

In kind provision of billing units by HNMS at ECMWF supercomputing system to run the model.

- Computational cost of a single run: ~ 18000 b.us., ~3000 secs (2880 cpus).
- Total use of b.us.: ~ 30 million
- Volume of output storage: ~ 11.5 GB / run (*.tar.bz2), ~ 17 TB (ECFS).



https://www.ecmwf.int/en/computing/our-facilities/supercomputer

CONCLUSIONS

- Calibration of COSMO model using CALMO technology over the wider Eastern Mediterranean area should be considered a succesfull endeavor towards the benefit of COSMO, ICON and CCLM as well as the meteorological and climatological communities in general.
- This work nicely completed the CALMO works over Switzerland and Northern Italy, especially under the fact that COSMO model was optimized using rather sparse station observations instead of gridded data.
- Although this work was computationally expensive, it should be considered computationally quite affordable for smaller domains as well as quite adequate regarding local meteorological features.

MAIN REFERENCE:

E. Avgoustoglou , I. Carmona, A. Voudouri, Y. Levi, A. Will, J.M. Bettems: Calibration of COSMO Model in the Central-Eastern Mediterranean area adjusted over the domains of Greece and Israel, Atmospheric Research, Volume 279, 1 December 2022, 106362.