ΕΘΝΙΚΗ ΜΕΤΕΩΡΟΛΟΓΙΚΗ ΥΠΗΡΕΣΙΑ
HELLENIC NATIONAL METEOROLOGICAL SERVICE

CONSORTIUM FOR SMALL SCALE MODELING
COSMO

CALibration of the COSMO MOdel
CALMO -MAX

Rome, 21st General Meeting

9-12.09.2019

CALMO-MAX Agenda

Monday, 09.09.2019		
09:00 – 09:05	J.M. Bettems	Opening
09:05 – 09:25	A.Voudouri	CALMO-MAX progress and roadmap
09:25 – 09:45	E. Avgoustoglou	Experimental design
09:45 – 10:05	I. Carmona	Web Conference: Progress on the MM
10:05 – 10:20	P. Mercogliano	CALMO-MAX @ CIRA
10:20 – 10:35	A.Will	CALMO-MAX @ COTTBUS
10:35 – 10:45	A.Voudouri / S.Soerland	Joint effort with ETHZ
10:45 – 11:00		Discussion on similar calibration techniques
11:00 – 11:30	All	COFFEE and REGISTRATION
11:30 – 12:15		Optimization of CALMO-MAX methodology
12:15 – 13:00		CALMO-NExtI (New Extension to ICON)
13:00 – 14:30	All	LUNCH

Status summary

- The project is on-going **extension until September 2020 approved**
- Computing resources **available on** University of Cottbus, MeteoSwiss and ECMWF (+ apply for Special project)
- Calibration of COSMO-1 for 5 parameters. Verification is pending……..
- Collaboration with ETHZ (presentation of S. Soerland)
- Collaboration with BTU Cottbus (A. Will)
- The CLM community on-line namelist tool for parameters is now available to COSMO members to be used through

https://tools.clm-community.eu/NLT_v2/portal/index.php

Meta Model Status summary (IMS contribution talk of I. Carmona)

- A perturbed initial condition run was made to estimate the internal model variability. This is used to screen out cases where internal model variability is larger that parameter dependency.
- Spatial verification for precipitation (FSS) has been included in the performance score
- Delays due the efficiency of MM running at IMS computer resources
- 2m dew point temperature (from INCA) has been introduced in the performance score to reduce the risk of over fitting the temperature.
- Significant differences in the values of the optimum parameters for some of the decades in 2013 are detected
- Included sunshine duration in the performance score, using Frei et al. (2015) km-scale gridded dataset, is still under consideration

Modifying from ETS to FSS

$$S_{COSI-p} = \frac{1}{N_m \sum_{\Psi=1}^{N_\Psi} \omega_\Psi} \left\{ \sum_{\substack{\Psi=1\\ \Psi\neq 3}}^{N_\Psi} \omega_\Psi \sum_{m=1}^{N_m} \left[1 - \frac{\sum_{r=1}^{N_r} \sum_{d_m=1}^{N_{d_m}} \left(F_{p,\Psi,r,m,d_m} - O_{\Psi,r,m,d_m} \right)^2}{\sum_{r=1}^{N_r} \sum_{d_m=1}^{N_{d_m}} \left(O_{\Psi,r,m,d_m-1} - O_{\Psi,r,m,d_m} \right)^2} \right] + \omega_3 \frac{\sum_{m=1}^{N_m} \sum_{r=1}^{N_r} \sum_{t=1}^{N_t} ETS_{p,r,m,t}}{N_m N_r N_t} \right\}$$

$$S_{COSI-p-new} = \frac{1}{N_m \sum_{\Psi=1}^{N_\Psi} \omega_\Psi} \left\{ \sum_{\substack{\Psi=1\\ \Psi\neq 3}}^{N_\Psi} \omega_\Psi \sum_{m=1}^{N_m} \left[1 - \frac{\sum_{r=1}^{N_r} \sum_{d_m=1}^{N_{d_m}} \left(F_{p,\Psi,r,m,d_m} - O_{\Psi,r,m,d_m} \right)^2}{\sum_{r=1}^{N_r} \sum_{d_m=1}^{N_{d_m}} \left(O_{\Psi,r,m,d_m-1} - O_{\Psi,r,m,d_m} \right)^2} \right] + \omega_3 \frac{\sum_{m=1}^{N_m} \sum_{r=1}^{N_r} \sum_{t=1}^{N_t} FSS_{p,r,m,t}}{N_m N_r N_t} \right\}$$

Verification

For each threshold Tr and radius R the FSS score is calculated as follows

Brier score:

$$FBS(Tr,R) = \frac{1}{N}\sum_{i,j}\left(M_{i,j} - O_{i,j}\right)^2$$

Worst Brier score:

$$FBS_{worst}(Tr,R) = \frac{1}{N}\sum_{i,j}\left({M_{i,j}}^2 + {O_{i,j}}^2\right)$$

Fractional Skill Score:

$$FSS(Tr,R) = 1 - \frac{FBS(Tr,R)}{FBS_{worst}(Tr,R)}$$

BEST → $FSS(Tr,R)$**=1**

WORST → $FSS(Tr,R)$**=0**

Roberts et al. (2008), Ebert (2009), Mittermaier et al. (2010,2013)

Parameter list

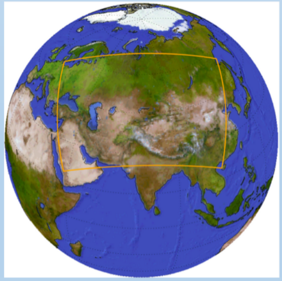
Acronym	**Parameter**	**Value**
Minimal diffusion coefficient for heat	tkhmin (m2/s)	[0. 1 ,**0.4**,1]
Factor for laminar resistance for heat	rlam_heat	[0.1,**1**,2]
Parameter controlling the vertical variation of critical relative humidity for sub-grid cloud formation	uc1	[0,0.8,1]
Factor for vertical velocity of snow	v0snow	[10,20,30]
Fraction of cloud water and ice considered by the radiation scheme	radfac	[0.3,**0.6**,0.9]

Objective Calibration activities with the regional climate model COSMO-CLM

Currently within the CLM-Community there is activity with the calibration method over two different domains:

Over Europe:
Work done at ETH: Silje Lund Sørland, Omar Bellprat, Katherine Osterried, Linda Schlemmer, Nikolina Ban, Marie-Estelle Demory and Christoph Schär

Over Central Asia:
Work done at University of Bern/Freie University: Emmanuele Russo, Silje Lund Sørland, Ingo Kirchner, Martijn Schaap, Christoph C. Raible and Ulrich Cubasch



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Europe:
Objective Calibration of COSMO-crCLIMv1-1 (EUR-44)

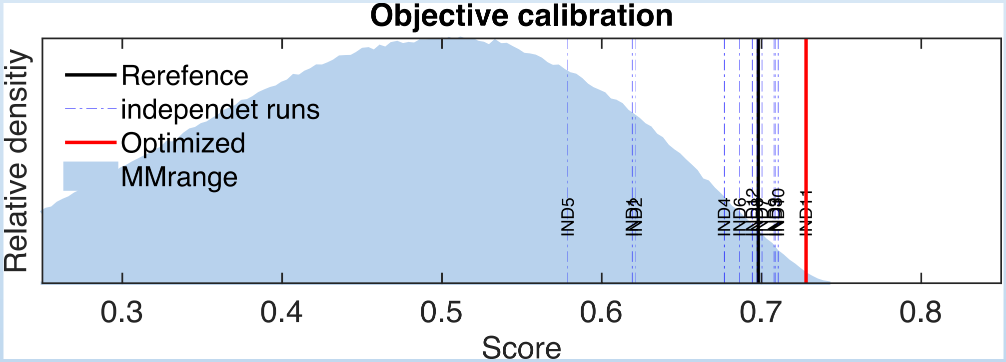
Work done at ETH: Silje Lund Sørland, Omar Bellprat, Katherine Osterried, Linda Schlemmer, Nikolina Ban, Marie-Estelle Demory and Christoph Schär

1. Calibration framework

Calibration method:	Bellprat et al. (2012, 2016).
Model version	COSMO-crCLIM (the GPU version of the COSMO-model).
Model domain/resolution	EURO-CORDEX domain with the 50km horizontal resolution.
Calibration time	The simulations are from 2000-2009, where only the last 5 years (2005-2009) is used for the calibration.
Tuning parameters	8 tuning parameters (decided based on previous calibration done by Lüthi et al. and Bellprat et al. Coordinated with CALMO-MAX.)
Number of simulations	8 different tuning parameters, this gives in total 128 simulations + 1 reference simulations. Additional independent runs are also performed.
Performance score (PS)	Same as in Bellprat et al. E-OBS for t2m and pr. CRU for cloud-cover data.

Acronym	Range	OPT
rlam_heat	[0.1;1; 2]	0.72
v0snow	[10;20;30]	25.6
tkhmin (and tkmmin)	[0.1;1; 2]	1.37
tur_len	[60;500; 1000]	563
uc1	[0;0.8; 1.6]	0.75
radfac	[0.3;0.6; 0.9]	0.59
fac_rootdp2	[0.5;1; 1.5]	0.96
l_g	[0.25; 1.59; 10]	3.57

2. Results

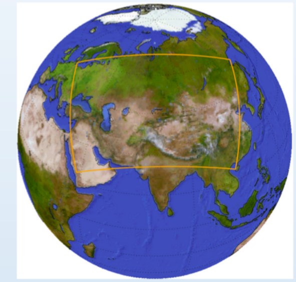


Future work:

- The goal is to perform the calibration on both EUR-11 and EUR-44 (until now only EUR-44).
- In the next months, the plan is to do test with different configurations (e.g. turn of the deep convection at 12km; include transient aerosol description etc.) and this also require a new calibration.

Central Asia: Evaluating the performance of COSMO-CLM for the CORDEX Central Asia domain

Work done at University of Bern/Freie University: Emmanuele Russo, Silje Lund Sørland, Ingo Kirchner, Martijn Schaap, Christoph C. Raible and Ulrich Cubasch



1. Objectives

The performance of COSMO-CLM 5.0 for the CORDEX Central Asia domain is evaluated.

Goal: Investigating main model uncertainties and limitations, determining at the same time an optimal model configuration

Challenges: Large biases in the reference run. Warm bias up to 15-20 degrees in winter!

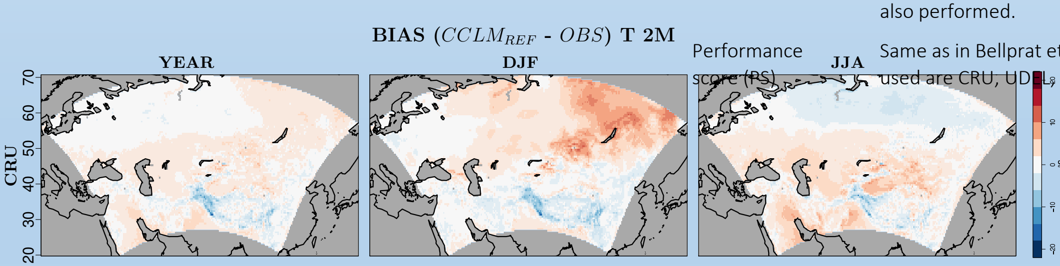
2. framework

Calibration method:	Bellprat et al. (2012, 2016).
Model version	COSMO-CLM5.0
Model domain/resolution	CORDEX Central Asia domain with the 25km horizontal resolution.
Calibration time	The simulations are from 2000-2005.
Tuning parameters	Performed perturbed physics experiment as in Bellprat et al. (2012) to decide the most relevant parameters to calibrate. Decided to perform the calibration on 9 different tuning parameters.
Number of simulations	9 different tuning parameters, this gives in total 169 simulations + 1 reference simulations. Additional independent runs are also performed.
Performance score (PS)	Same as in Bellprat et al. C used are CRU, UDEL, GPCC

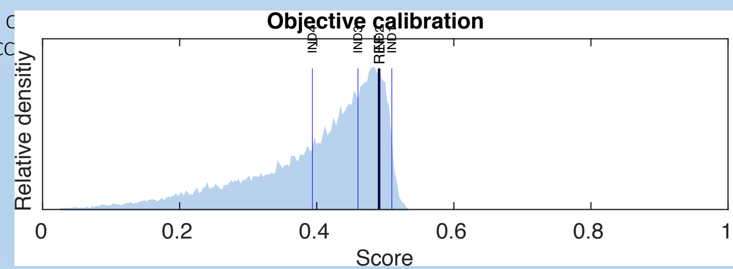
3. Status/Preliminary results

The simulations are done, and are currently being analyzed.

The results with the new optimized tuning parameters show some improvement in the model performance, but some of the bias is due to model deficiencies that cannot be removed with an objective calibration.



Reference COSMO-CLM simulation 25km resolution 1995-2005



ETHZ	1.37	0.72	25.6	0.59	0.75

For 36 decades in 2013 The optimum parameters	Tkhmin	Rlam_heat	V0snow	Radfac	UC1
default	0.4	1	20	0.6	0.8
New Mean	0.3530	1.0128	18.41	0.6843	0.4638
Median	**0.2791**	**0.9296**	**18.95**	**0.6775**	**0.7686**
STD	0.2451	0.3481	3.00	0.1219	0.4166
Max	0.9999	1.7265	25.29	0.8880	0.9990
Min	0.1004	0.3689	12.44	0.3685	$3.9597*10^{-5}$

Work in progress

- **Parameter sensitivity evaluation**
  - permanent COSMO task, workshop at HNMS
- **MetaModel modifications**
  - MatLab code optimization
  - ✓MM code in parallel
- **Minimize computational cost**
  - ✓Selection of one interaction term needed to fit the MM
  - ✓Run model over a limited area
  - Quantify the final cost of the method
- **Costs/benefits of the methodology**
  - ✓Is Parameters optimum clearly a function of weather and season????
  - A yearly independent verification for COSMO-1 is needed to consolidate benefits
- **COSMO platform**
  - Establish a demonstration platform at ECMWF
  - Apply method over a Mediterranean domain (talk of E. Avgoustoglou)

References

The list of manuscripts prepared and presented within this COSMO year is as follows:

1. **Bucchignani Edoardo, Antigoni Voudouri, Paola Mercogliano. 2019. *A sensitivity analysis with COSMO-LM at 1 km resolution over South-Italy*. Submitted in Atmospheric Research**
2. **Voudouri A., Carmona I., Avgoustoglou E., Levi Y., Bettems J.M and Bucchignani E. 2018. *Impacts on model performance score from CALMO and CALMO-MAX.* To be published in COSMO Newsletter No19**
3. **Avgoustoglou E., Voudouri A., Carmona I., Bucchignani E., Levy Y. and Bettems J.M. 2019. *A methodology towards the hierarchy of model calibration tests via the domain sensitivity of COSMO Model over the Mediterranean area*. Submitted in Atmospheric Research**
4. **Voudouri A., Carmona I., Avgoustoglou E., Levi Y. and Bettems J.M., 2018, *Optimization of COSMO model interannual variability*. Presented at 14th International Conference on Meteorology, Climatology and Atmospheric Physics, October 15-17, 2018, Alexandroupolis, Greece http://comecap2018.gr/**
5. **A final report delivered at CSCS**

Additional information
Please visit

http://www.cosmo-model.org/content/tasks/priorityProjects/calmoMax/default.htm
http://mail.cosmo-model.org/mailman/listinfo/cosmo-calmo

The Meta model is also available @ https://github.com/COSMO-ORG/CALMO-MM

Maximum per Special Project per year

The amount of resources requested by each project for each year cannot exceed more than 8% of the total amount of resources available for that year.

The maximum amount of 66.0 million billing units is equivalent to 4096834 hours elapsed time for a serial job or e.g. to running a parallel job on two nodes for 56878 hours.

High Performance Computing Facility	66.0	million units
Accumulated data storage (total archive volume)	352.0	terabytes

Large Special Project requests

Requests asking in any year for these resources or more will receive a detailed review by members of the Scientific Advisory Committee.

High Performance Computing Facility	10.0	million units
Accumulated data storage (total archive volume)	60.0	terabytes

Task	Contributing Scientist	Date of delivery
IMS to run MM to find optimum using existing simulations	Izthak Carmona	**28.02.2019**
Use kesch resources to compute OPT for 2013 and OPT and REF for a different year	Antigoni Voudouri	**31.03.2019**
Use bias instead of real value when completing the MM correlation check (as performed by ETH)	Izthak Carmona	**30.04.2019**
Compare results with ETH and proceed on submitting a manuscript at a peer reviewed international journal	Antigoni Voudouri	**30.04.2019**
MM code translated to Octave to be compatible with ECMWF platform	Izthak Carmona Euripides Avgoustoglou	**30.4.2019**
CALMO methodology applied at COTTBUS for the 5 parameters as in CALMO-MAX , using COTTBUS computer resources	Andreas Will	**31.05.2019**
Use on-line namelist tool available for CLM.		**30.06.2019**
Infrastructure at ECMWF	Euripides Avgoustoglou Antigoni Voudouri	**30.06.2019**
Use kesch resources to compute OPT and REF for year 2017	Antigoni Voudouri	**30.06.2019**
Methods to reduce computational cost	All	**30.09.2019**
Calibration of COSMO of the parameters associated with the new dynamical core at COTTBUS	Andreas Will	**30.09.2019**
CIRA will provide output data to IMS for fitting the MM.	Izthak Carmona Eduardo Bucchignanni	**After the end of COSMO-1 calibration**

CALMO-MAX next phase

- Performing sensitivity tests (DPS) to find the parameter to tune. Domain Parameter Sensitivity DPS itself is not normalized in an optimal way as it is influenced by the average values themselves
- For each parameter find a model variable that best correlates with the parameter variability
- Run dates that will include all possible weather conditions on the globe
- Find a relation between each tuning parameter and a model variables or combinations.
- Sensitivity of the interactions between parameters and try to adjust.