CALibration of the COSMO Model Methodoly Applied on eXtremes CALMO-MAX

A. Voudouri & E. Avgoustoglou (HNMS), Y. Levi & I. Carmona (IMS), M. Milelli (ARPA-P), E. Bucchignani & P. Mercogliano (CIRA), JM. Bettems (MCH)

June 2016 – September 2019

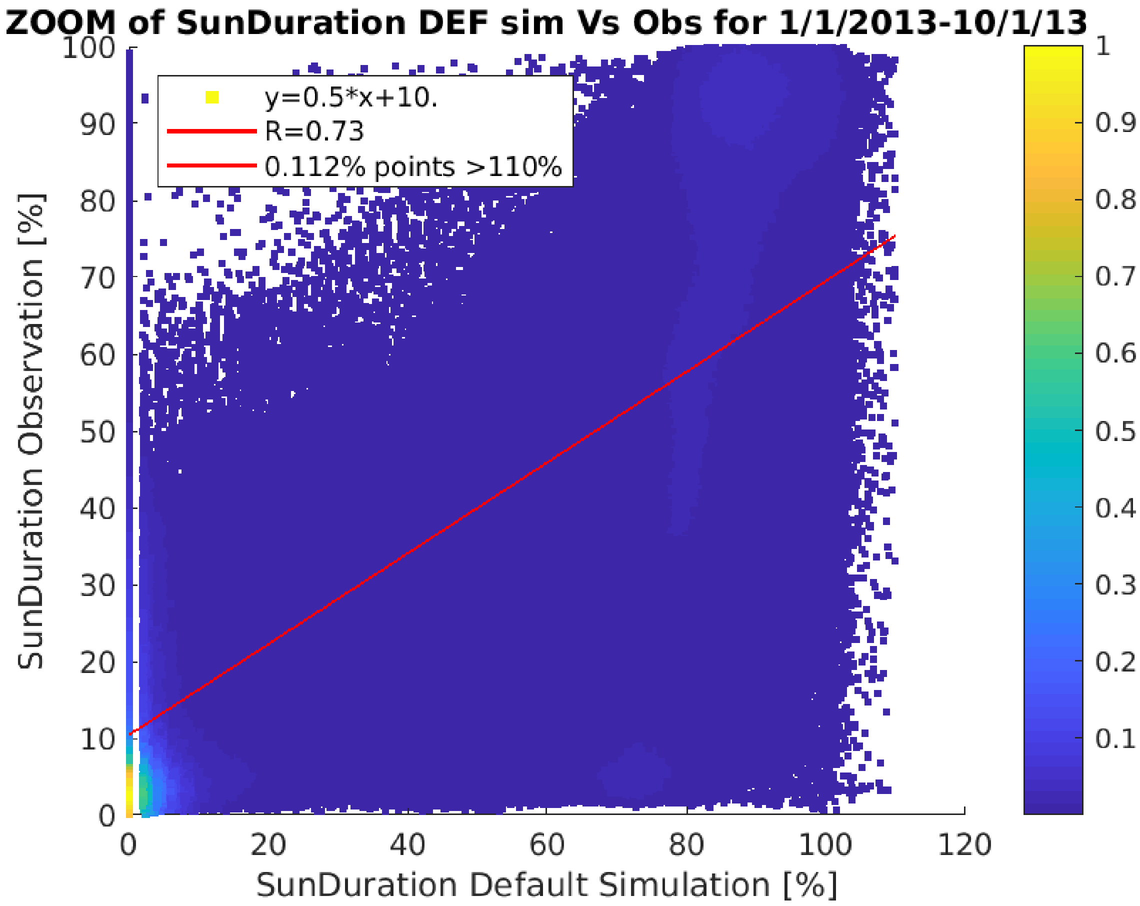
Status summary

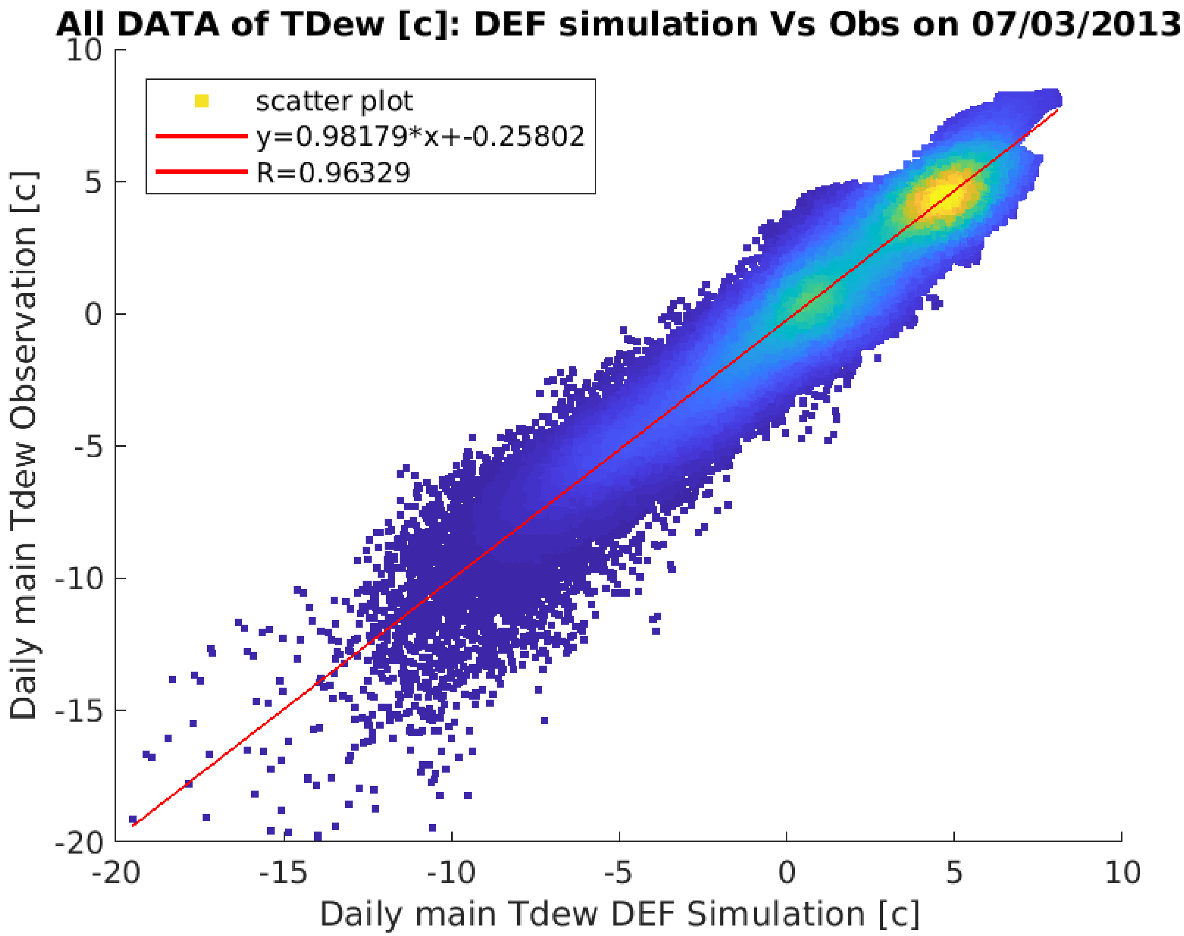
- The project is on-going at least until September 2019, in **collaboration with ETHZ calibrating COSMO-CLM.**
- Computing resources on Daint / CSCS secured (until September 2018).
- Calibration of COSMO-1 started for 5 parameters at mid December 2017, after sanity check of the proposed configuration (48TB already generated).
- A workshop took place in Athens in January 2018, a next one is scheduled for January 2019 (visitors are welcome).
- **Documents and deliverables**
  - A second paper was published in Atm. Res.
  - A manuscript submitted and accepted at COMECAP (http://comecap2018.gr/)
  - Meta model available @ https://github.com/COSMO-ORG/CALMO-MM

MetaModel Status summary

- 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
- 2m dew point temperature (from INCA) has been introduced in the performance score to reduce the risk of over fitting the temperature.
- Included sunshine duration in the performance score, using Frei et al. (2015) km-scale gridded dataset, is under consideration
- Problem with MatLab code efficiency

Sunshine Duration for all the first 10 days (1/1/2013-10/1/2013)




All DATA of TDew [c]: DEF simulation Vs Obs on 07/03/2013
scatter plot
y=0.98179*x+-0.25802
R=0.96329
Daily main Tdew Observation [c]
Daily main Tdew DEF Simulation [c]
10
5
0
-5
-10
-15
-20
-20
-15
-10
-5
0
5
10

Cost reduction goal
Automatization of the procedure

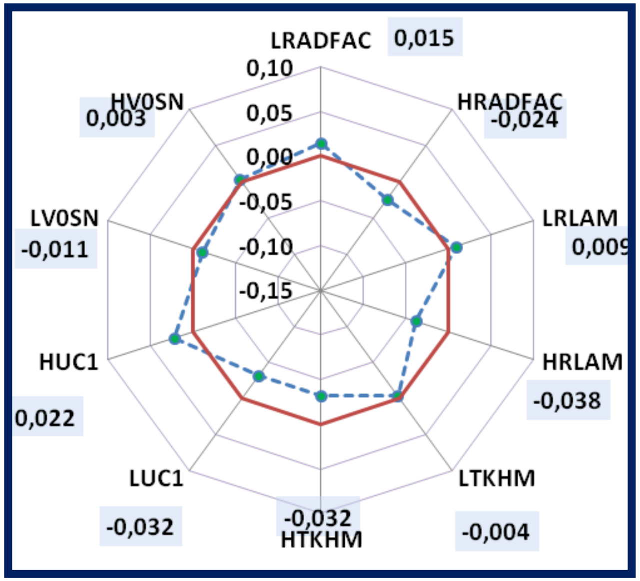
- Reduce the computational cost by performing minimum number of simulations to fit the MM
- Accuracy of the MM depends on the interaction terms used. Different methods of selection are possible :
  - Sensitivity experiments for each parameter
  - Use first guess of the MM

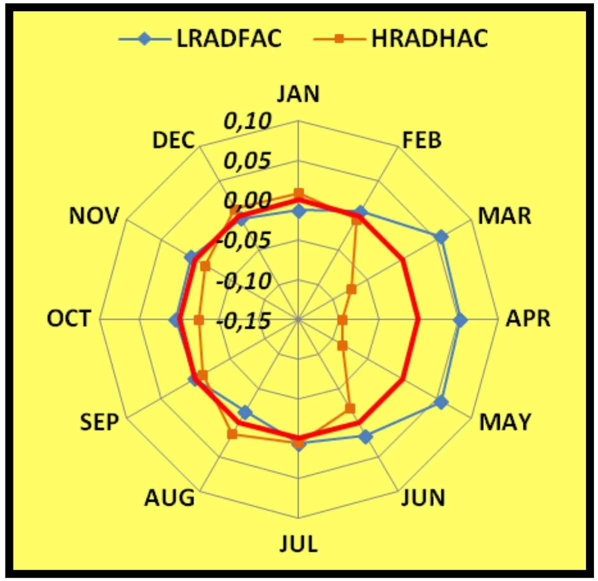
- In most cases both methods are equivalent.

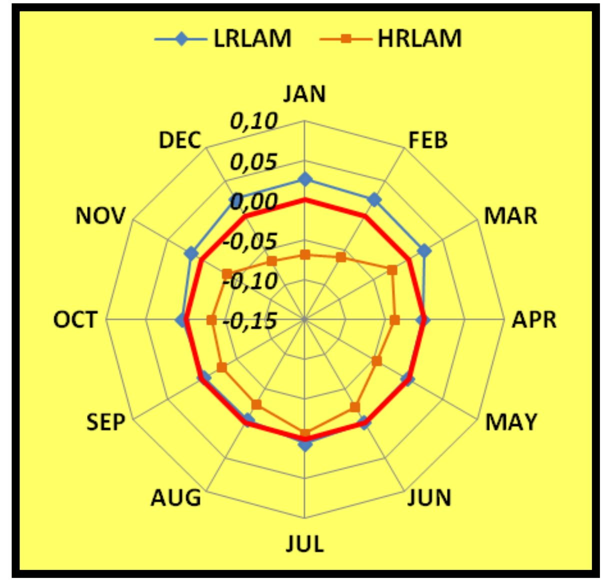
Parameter list

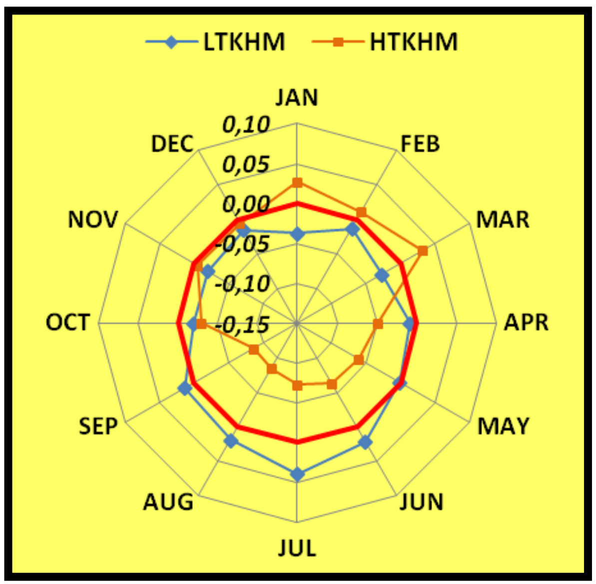
Acronym	Parameter	Value
Minimal diffusion coefficient for heat	tkhmin	[0. 1 ,**0.4**,1]
Factor for laminar resistance for heat	rlam_heat	[0.1,**1**,2]
Parameter controlling the vertical variation of critical relative humidity for sub-grid cloud formation	uc1	[0,0.8,1]
Uniform factor for root depth field	root_dp (fac_root_dp)	[0.5,**1**,1.5] [0.1 ….in src_soil.f90)
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]
Factor for hydraulic conductivity	kexpdec** Replace with gamma	[**1, 2**]

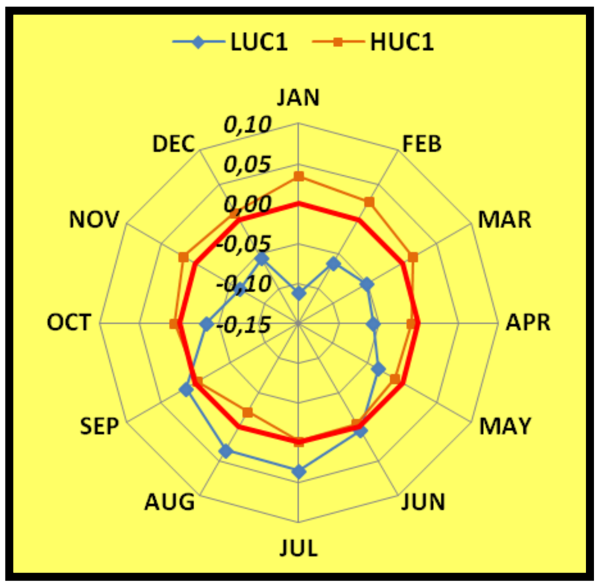
Td (Yearly vs Monthly Sensitivities

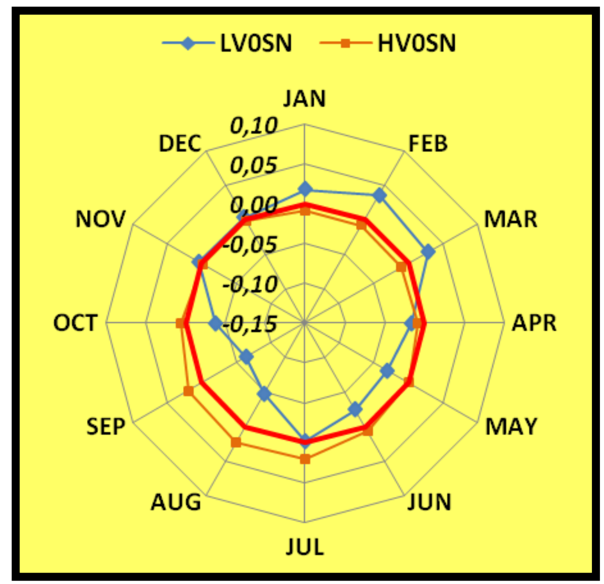




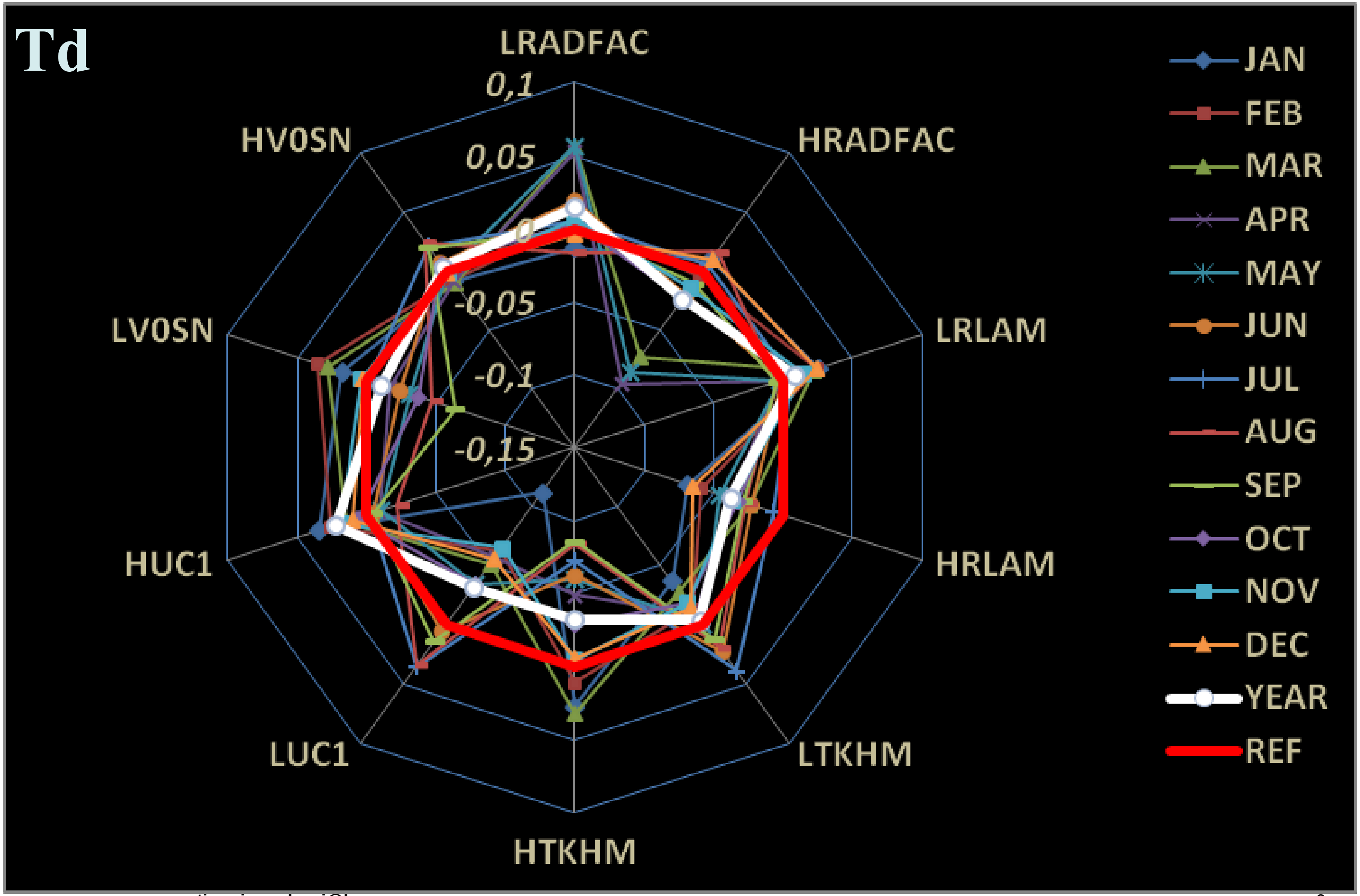






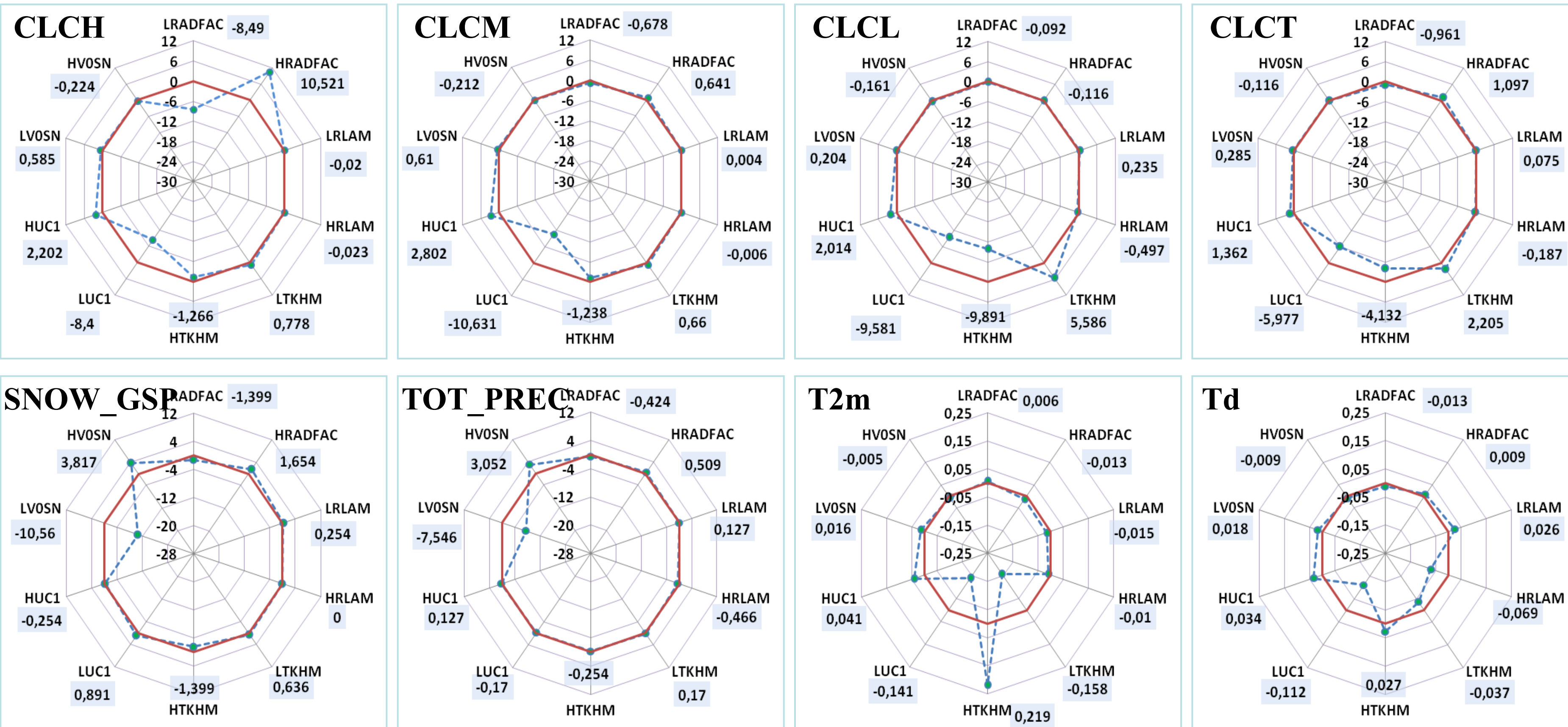


Yearly and Monthly Sensitivities combined



PANORAMA OF MONTHLY SENSITIVITIES FOR 2013

JANUARY



$$S_{COSI-p} = \frac{1}{N_m \sum_{\Psi=1}^{N\Psi} \omega_\Psi} \left\{ \sum_{\substack{\Psi=1 \\ \Psi \neq 3}}^{N\Psi} \omega_\Psi \sum_{m=1}^{N_m} \left[1 - \frac{\sum_{r=1}^{N_r} \sum_{d_m=1}^{Nd_m} (F_{p,\Psi,r,m,d_m} - O_{\Psi,r,m,d_m})^2}{\sum_{r=1}^{N_r} \sum_{d_m=1}^{Nd_m} (O_{\Psi,r,m,d_m-1} - O_{\Psi,r,m,d_m})^2} \right] + \omega_3 \frac{\sum_{m=1}^{N_m} \sum_{r=1}^{N_r} \sum_{t=1}^{N_t} ETS_{p,r,m,t}}{N_m N_r N_t} \right\} \quad (4)$$

where the equitable threat score (Gilbert skill score) $ETS_{p,r,m,t}$ for a particular parameter combination p, region r, month m and threshold index (with N_t standing for the number of selected thresholds) is defined as

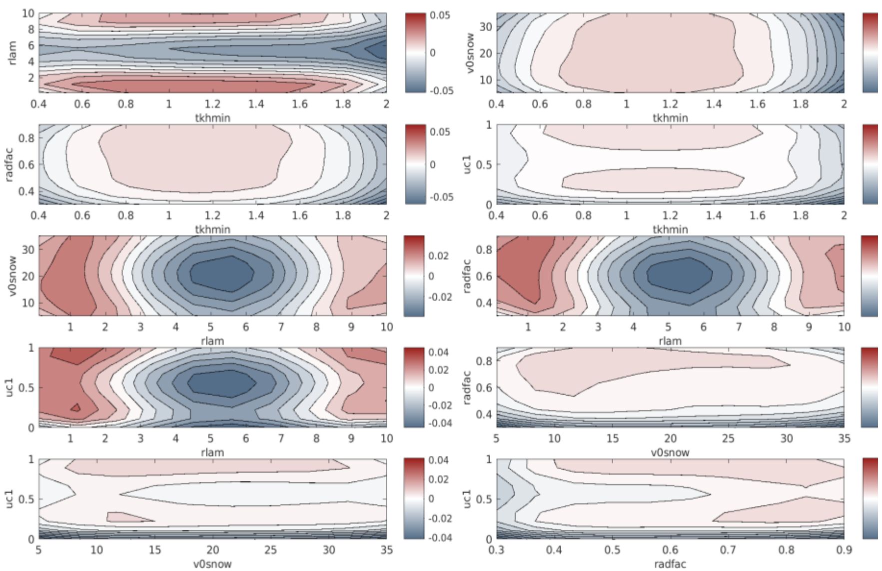
$$ETS_{p,r,m,t} = \frac{H - \frac{(H+F)(H+M)}{Nd_m}}{H + M + F - \frac{(H+F)(H+M)}{Nd_m}} \quad (5)$$

Scores with ETS and FSS for precipitation

Best Score (in Red Color) 1/1/2018-10/1/2018

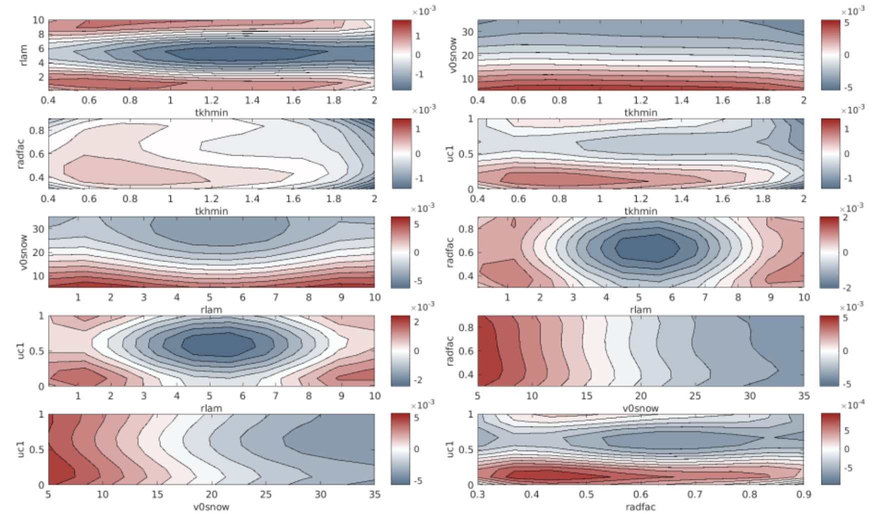
Score with FSS

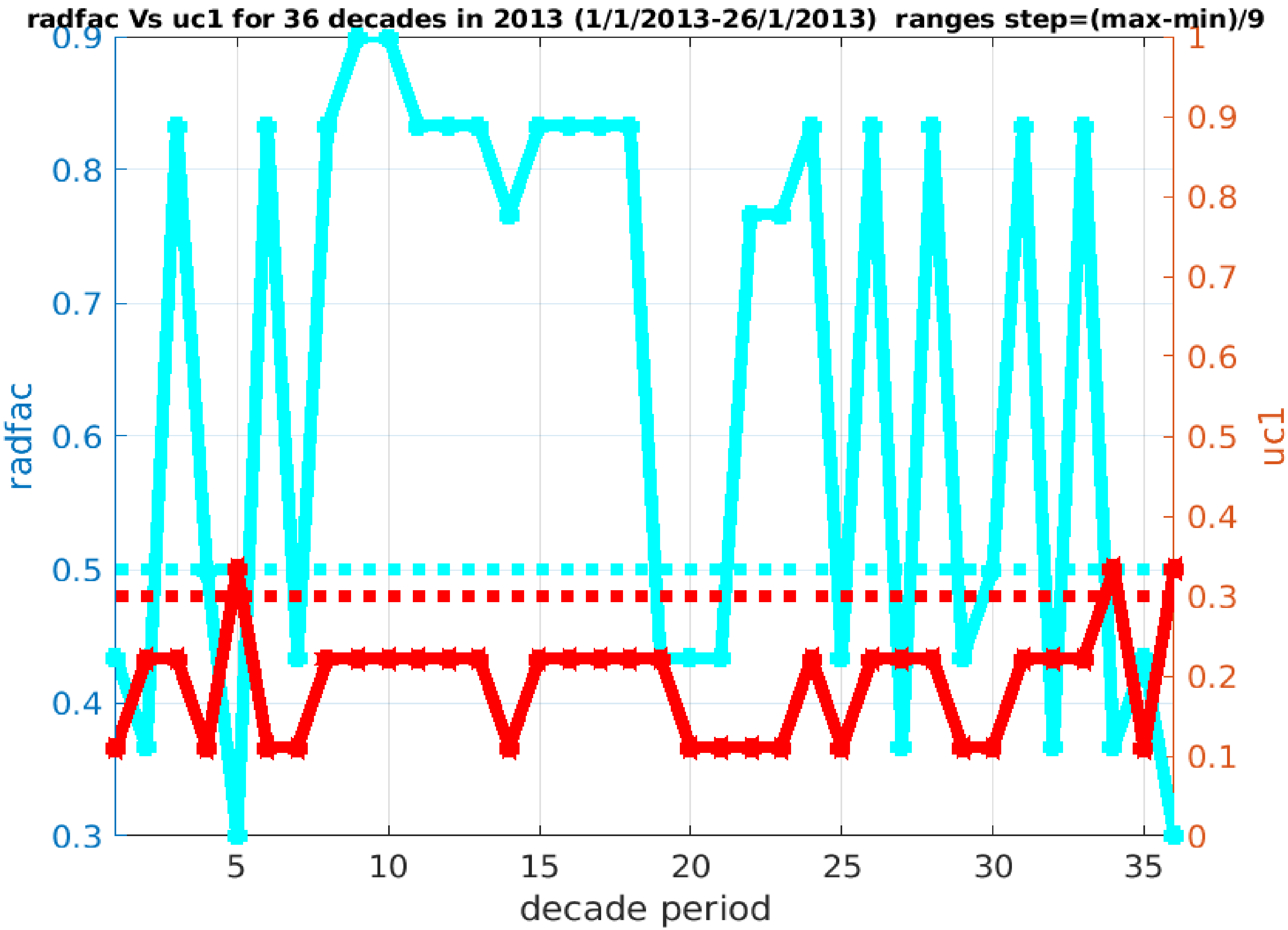
(COSI score in CALMO, 1 threshold)



Score with ETS

(COSI score in CALMO, 5 thresholds)




radfac Vs uc1 for 36 decades in 2013 (1/1/2013-26/1/2013) ranges step=(max-min)/9
radfac
uc1
decade period
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
5
10
15
20
25
30
35

Preliminary results from the objective calibration of the COSMO-crCLIM model

Silje Lund Sørland[1], Omar Bellprat[1], Katherine Osterried[2], Linda Schlemmer[1], Nikolina Ban[1] and Christoph Schär[1]
1. Institute for Atmospheric and Climate Science, ETH Zürich
2. Center for Climate System Modelling, ETH Zürich

- Based on the method of Bellprat et al. (2012, 2016).
- The simulation necessary for the calibration is done on the EURO-CORDEX domain with the 50km horizontal resolution by using the GPU version of the COSMO-model (COSMO-crCLIM).
- The simulations are from 2000-2009, where only the last 5 years (2005-2009) are used for the calibration.
- All the simulations are finished, and the final work is related to performing the calibration to sample the parameter space so that the best optimal set of tuning parameters can be found. The following results are thus only preliminary.

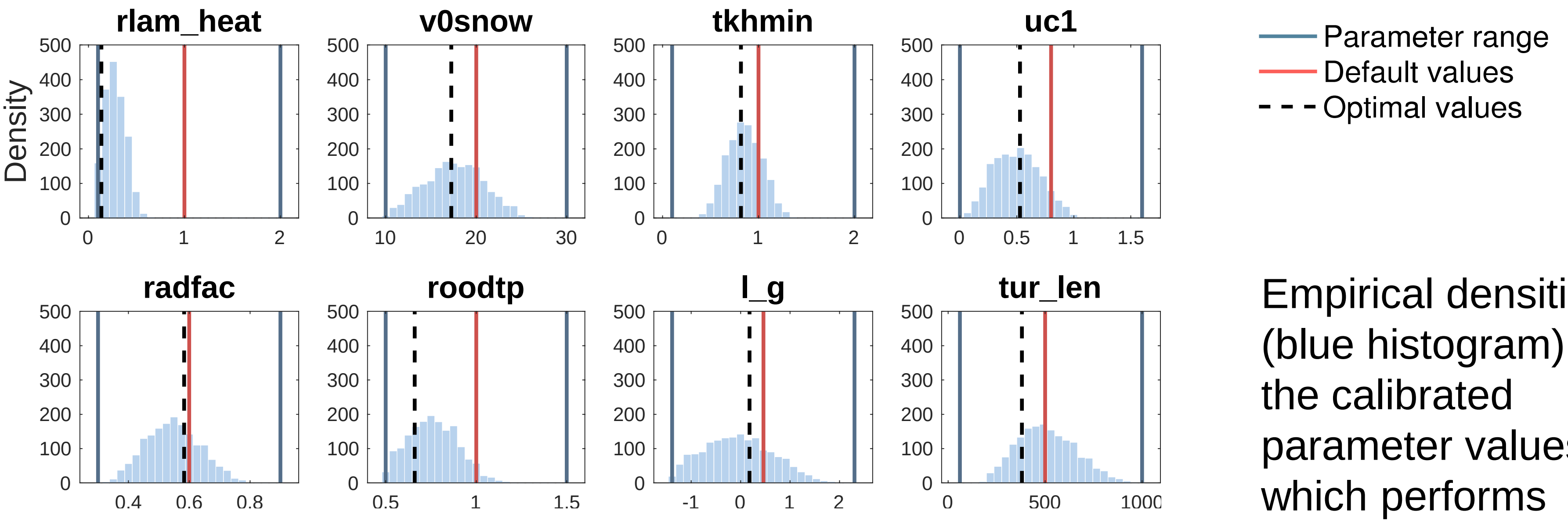
Tuning parameters

Acronym	Description of the parameter	Range
rlam_heat	Scalar resistance for sensible and latent heat fluxes in the laminar surface layer (TURBULENCE - scheme)	[0.1;1; 2]
v0snow	Factor in the terminal velocity for snow (Microphysics - scheme)	[10;20;30]
tkhmin (and tkmmin)	Minimal vertical turbulent diffusion rate [m^2s^{-1}] (TURBULENCE – scheme)	[0.1;1; 2]
tur_len	Maximal turbulent length scale (m) (TURBULENCE - scheme)	[60;500; 1000]
uc1	Parameter controlling the vertical variation of critical relative humidity for sub-grid cloud formation (RADIATION - scheme)	[0;0.8; 1.6]
radfac	Fraction of cloud water and ice considered by radiation scheme (RADIATION - scheme)	[0.3;0.6; 0.9]
fac_rootdp2	Uniform factor for root depth field (Soil-model)	[0.5;1; 1.5]
l_g	Tuning parameter for ground-water runoff (Soil-model)	[0.25; 1.59; 10]

With 8 different tuning parameters, this gives in total 128 simulations + 1 reference simulations.

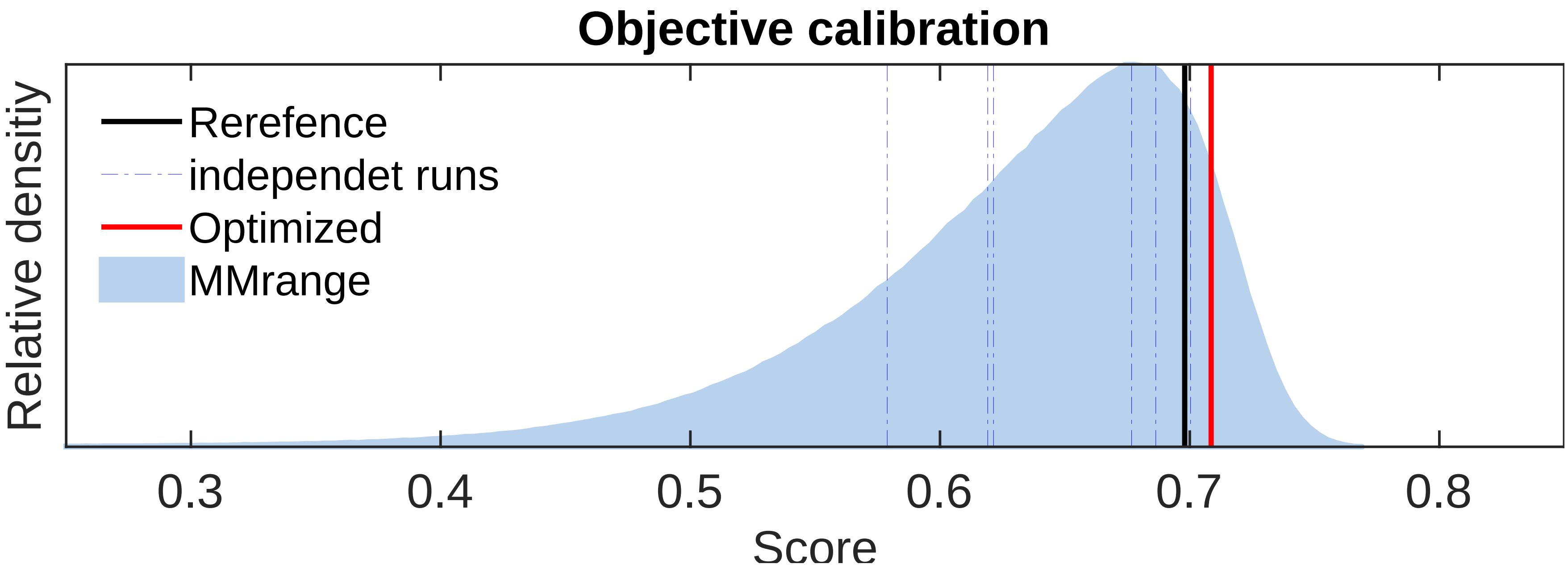
7 independent simulations is performed in addition, so the skill of the metamodel can be evaluated

Results with optimal set of tuning parameter



Empirical densities (blue histogram) of the calibrated parameter values, which performs equally well, given the uncertainty of the metamodel in predicting the model performance

The distribution of the model performance



Calibration range estimated with the metamodel (MM) when computing one million parameter combinations from a Latin hypercube experiment.

Sensitivity with COSMO-1 over South Italy for CALMO-MAX

Edoardo Bucchignani[1,2], Paola Mercogliano[1,2] , Myriam Montesarchio[1,2] Alessandra Lucia Zollo[1,2]

1 CIRA Centro Italiano Ricerche Aerospaziali – Capua (Italy)

2 CMCC Foundation - Centro Euro-Mediterraneo sui Cambiamenti Climatici – Capua (Italy)

Simple tests

TEST	Parameter
0	Default
1	tkhmin at minimum
2	tkhmin at maximum
3	rlam_heat at minimum
4	rlam_heat at maximum
5	v0snow at minimum
6	v0snow at maximum
7	uc1 at minimum
8	uc1 at maximum
9	radfac at minimum
10	radfac at maximum
11	fac_root_dp at minimum
12	fac_root_dp at maximum
13	kexpdec at 0.
14	kexpdec at 1.

Interaction tests

TEST	Parameter
15	rlam_heat (min) , uc1 (min)
16	rlam_heat (min), tkhmin (min)
17	uc1 (min), v0snow (max)
18	rlam_heat (min), v0snow (max)

The analysis of results shows that radfac, fac_root_dp and kexpdec produce very slight (or no) modifications, so they will be neglected.

The four interaction simulations were performed considering max (min) values of rlam_heat, uc1, tkhmin, v0snow.

Max daily T2m values

		DEF	TKHMIN		RLAM_HEAT		V0snow		UC1		RADFAC		FAC ROOTDP		KEXPDEC		INT1	INT2	INT3	INT4
	OBS	cosmo0	cosmo1	cosmo2	cosmo3	cosmo4	cosmo5	cosmo6	cosmo7	cosmo8	cosmo9	cosmo10	cosmo11	cosmo12	cosmo13	cosmo14	cosmo15	cosmo16	cosmo17	cosmo18
03-nov	19.3	19.5	19.4	19.8	19.8	19.5	19.5	19.5	19.9	19.4	19.5	19.5	19.5	19.5	19.5	19.5	20.0	19.9	20.0	19.8
04-nov	24.0	20.8	20.5	21.0	20.8	20.7	20.7	20.7	20.7	20.6	20.6	20.7	20.8	20.8	20.7	20.7	20.9	21.0	20.7	20.9
05-nov	20.2	19.5	19.5	19.6	19.5	19.5	19.5	19.5	19.7	19.4	19.5	19.5	19.5	19.5	19.5	19.5	19.8	19.6	19.7	19.5
06-nov	18.2	17.8	17.7	17.9	18.2	17.6	17.8	17.8	18.2	17.7	17.8	17.8	17.8	17.8	17.8	17.8	18.6	18.3	18.2	18.3

Max T2m average bias values

03-nov	19.3	0.2	**0.1**	0.5	0.5	0.2	0.2	0.2	0.6	**0.1**	0.2	0.2	0.2	0.2	0.2	0.2	0.7	0.6	0.7	0.5
04-nov	24.0	-3.2	-3.5	**-3.0**	-3.2	-3.3	-3.3	-3.3	-3.3	-3.4	-3.4	-3.3	-3.2	-3.2	-3.3	-3.3	-3.1	-3.0	-3.3	-3.1
05-nov	20.2	-0.7	-0.7	-0.6	-0.7	-0.7	-0.7	-0.7	-0.5	-0.8	-0.7	-0.7	-0.7	-0.7	-0.7	-0.7	**-0.4**	-0.6	-0.5	-0.7
06-nov	18.2	-0.4	-0.5	-0.3	**0.0**	-0.6	-0.4	-0.4	**0.0**	-0.5	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	0.4	0.1	**0.0**	0.1

Min daily T2m values

	OBS	cosmo0	cosmo1	cosmo2	cosmo3	cosmo4	cosmo5	cosmo6	cosmo7	cosmo8	cosmo9	cosmo10	cosmo11	cosmo12	cosmo13	cosmo14	cosmo15	cosmo16	cosmo17	cosmo18
03-nov	10.5	12.5	12.3	13.5	12.4	12.6	12.5	12.5	12.2	12.6	12.5	12.5	12.5	12.5	12.5	12.5	11.6	13.3	12.2	12.4
04-nov	10.0	12.4	12.4	12.9	12.5	12.4	12.4	12.4	12.3	12.5	12.4	12.4	12.4	12.4	12.5	12.5	12.3	12.9	12.3	12.5
05-nov	9.5	11.2	10.5	12.6	11.2	11.3	11.2	11.2	10.9	11.5	11.2	11.2	11.2	11.2	11.2	11.2	11.0	12.6	11.0	11.2
06-nov	9.7	12.2	12.2	12.4	12.4	12.2	12.4	12.2	12.2	12.3	12.2	12.2	12.2	12.2	12.2	12.3	12.3	12.7	12.0	12.4

Min T2m average bias values

03-nov	10.5	2.0	1.8	3.0	1.9	2.1	2.0	2.0	1.7	2.1	2.0	2.0	2.0	2.0	2.0	2.0	**1.1**	2.8	1.7	1.9
04-nov	10.0	2.4	2.4	2.9	2.5	2.4	2.4	2.4	**2.3**	2.5	2.4	2.4	2.4	2.4	2.5	2.5	**2.3**	2.9	**2.3**	2.5
05-nov	9.5	1.7	**1.0**	3.1	1.7	1.8	1.7	1.7	1.4	2.0	1.7	1.7	1.7	1.7	1.7	1.7	1.5	3.1	1.5	1.7
06-nov	9.7	2.5	2.5	2.7	2.7	2.5	2.7	2.5	2.5	2.6	2.5	2.5	2.5	2.5	2.5	2.6	2.6	3.0	**2.3**	2.7

Minimum **rlam_heat** and **uc1** at provide an improvement for Max T2m, while minimum **tkhmin** and **uc1** slight improvement for Min T2m,

Conclusions

- **Parameter sensitivity evaluation**
  - ✓ compact representation with spider graphs
  - ➢ permanent COSMO task, workshop at HNMS
- **MetaModel modifications**
  - ✓ FSS score for precipitation added in performance score
  - ✓ More than 20 meteorological fields are now used
  - ➢ MatLab to Octave, code optimization
- **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**
  - ✓ Preliminary results of work in progress at ETHZ are encouraging
  - ✓ Only the ranges of unconfined parameters need to be defined
  - ✓ Parameters optimum is 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

ΕΘΝΙΚΗ ΜΕΤΕΩΡΟΛΟΓΙΚΗ ΥΠΗΡΕΣΙΑ
HELLENIC NATIONAL METEOR

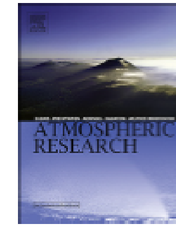
Atmospheric Research 213 (2018) 70–85

Contents lists available at ScienceDirect

Atmospheric Research

journal homepage: www.elsevier.com/locate/atmosres

ELSEVIER



Check for updates

Optimization of high resolution COSMO model performance over Switzerland and Northern Italy

Voudouri A.[a], Khain P.[b], Carmona I.[b], Avgoustoglou E.[a,*], Kaufmann P.[c], Grazzini F.[d], Bettems J.M.[c]

[a] Hellenic National Meteorological Service, Hellinikon 16777, Greece
[b] Israel Meteorological Service, Bet Dagan 5025001, Israel
[c] Federal Office of Meteorology and Climatology, Zurich, Switzerland
[d] ARPA-SIMC, Bologna, Italy

Thank you for your attention

build on a
s had been
re standard,
he model on
in order to
zerland and
ted to daily
itation. The
meta-model
mproved by
pitation and
imum set of
rrently, the
s it remains
expensive for a regular usage of the calibration procedure.

Спасибо