Status of Priority Project **CAL**ibration of the COSMO **MO**del **CALMO**

Antigoni Voudouri, Pavel Khain, Jean-Marie Bettems

antigoni.voudouri@hnms.gr

CALMO
Basic Idea-Steps

- The methodology used for the calibration framework from Bellprat et al. (2012) in COSMO-CLM is applied. The method is divided into the following steps:

1. Selection of important **model (unconfined) parameters** for calibration
    - Exact value is not well known
    - Model performance is sensitive to the choice of the value
2. Selection of model variables essential for NWP with existing observations to be used for validation .
3. Definition of an objective **performance function**.
4. Adjusting a **meta-model** applicable to parameter variations in a control integration (Neelin et al., 2010).
5. Sampling the parameter space to identify **optimal parameter configurations**.
6. Use optimal parameters configuration to run COSMO model.

antigoni.voudouri@hnms.gr

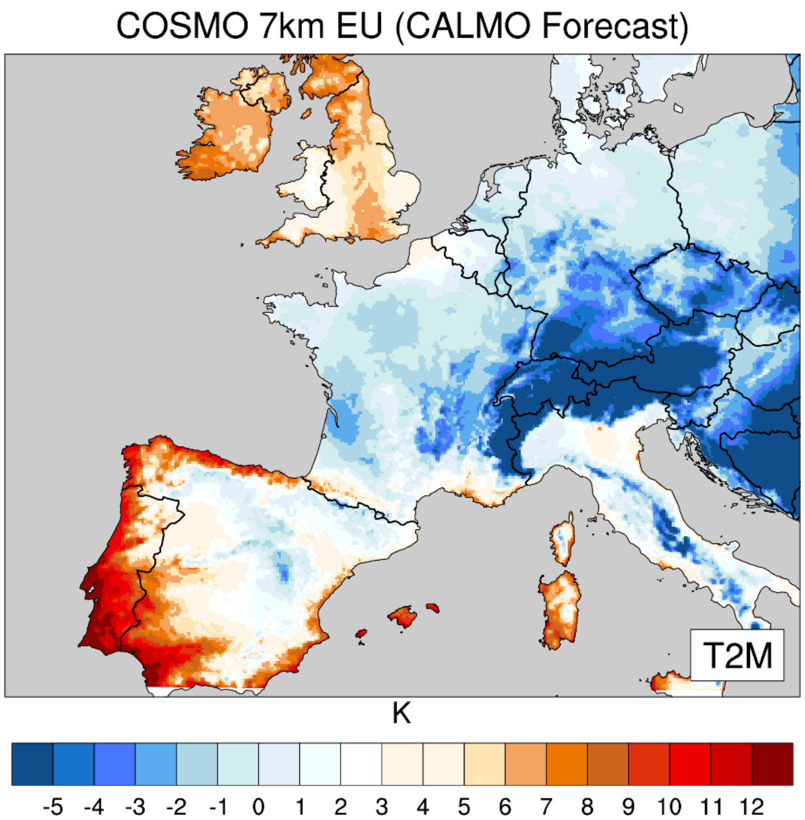
Processes	**Parameter name**	**Parameter description**	**Range***	**Main sensitivity**
Clouds-radiation feedbacks	"radfac" (no name)	Fraction of cloud qi, qs seen by radiation	[0.3,0.5,1]	Strong effect on cloud / radiation interactions
	rlam_heat	scalar for laminar boundary layer roughness	[0.1,**1**,10]	Strong effect on T2m clouds and precipitation
	rat_sea	scalar for laminar boundary layer roughness sea	[1,**20**,100]	Strong effect on T2m clouds and precipitation
Boundary and surface layer processes	tkhmin	minimal diffusion coeff. for heat (m^2/s)	[0,0.4,**1**,2]	Strong sensitivity on T2m and clouds
	tur_len	turbulent lenght	[100,250,**500**, 1000]	Moderate sensitivity on cloud and precipitation(convective)
Surface PBL feedbacks	facroot_dp	factor for the root depth for the entire field	[0.5,**1**,1.5]	Moderate sensitivity on T2m and clouds in summer)

* numbers in bold represent default values, in green setting operated ad DWD if different from default, red settings operated by MeteoSwiss if different from def.

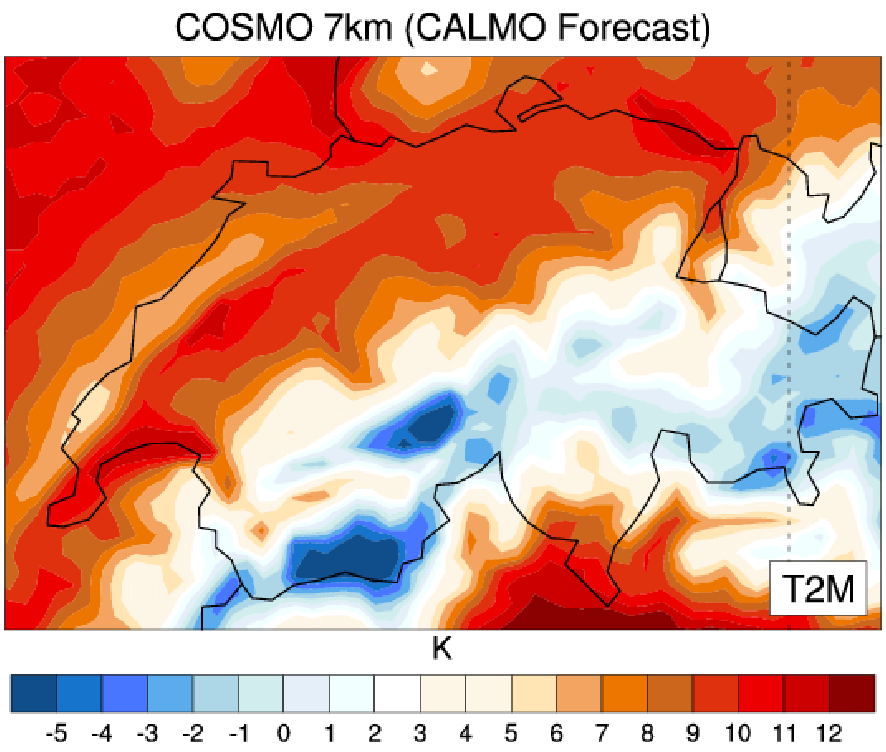
antigoni.voudouri@hnms.gr

Large vs small domain Temperature differences

Takes 20 min/day

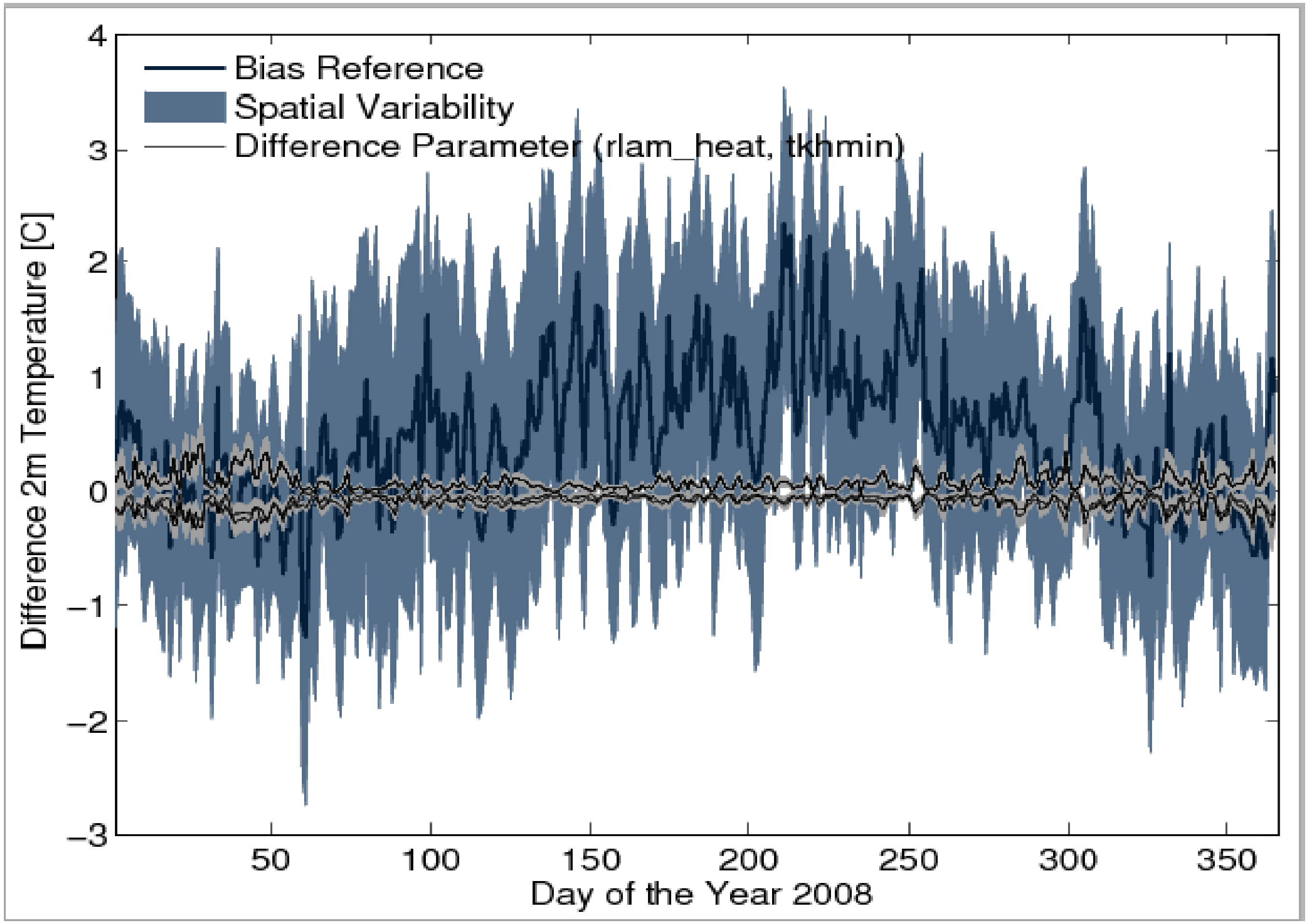


Takes 2-3min/day



antigoni.voudouri@hnms.gr

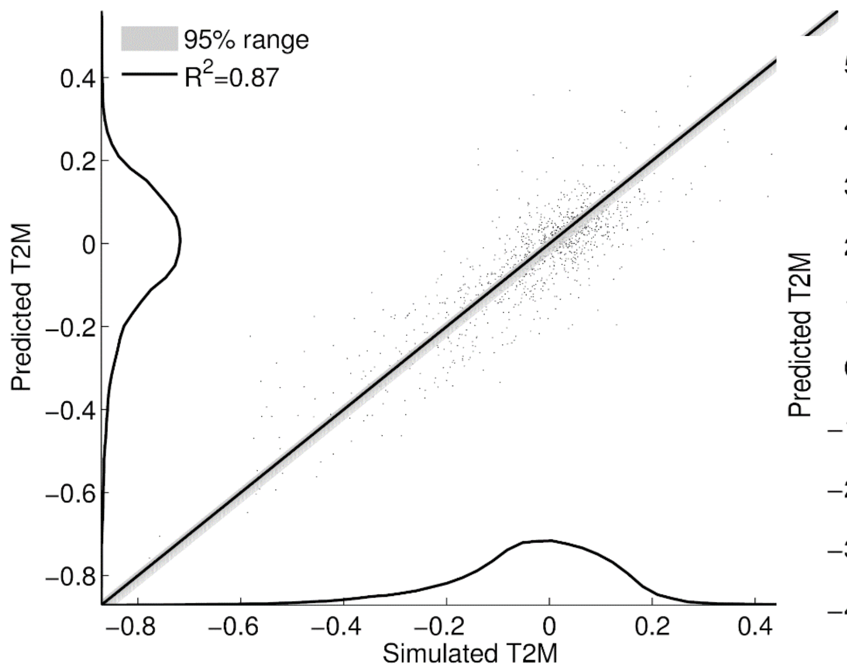
Small domain (tkhmin/rlam)



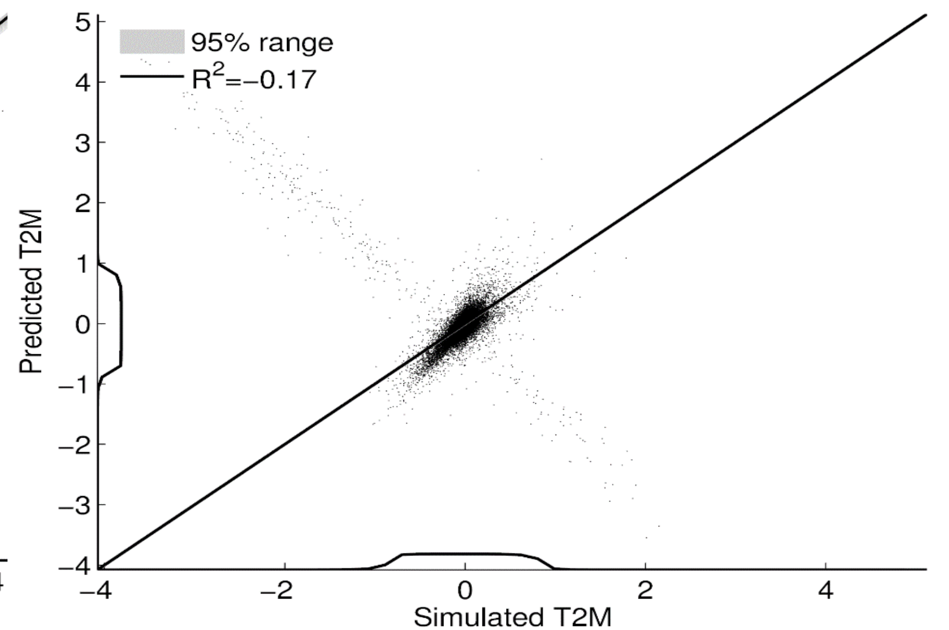
antigoni.voudouri@hnms.gr

Predicting independent simulations

Large domain



Small domain



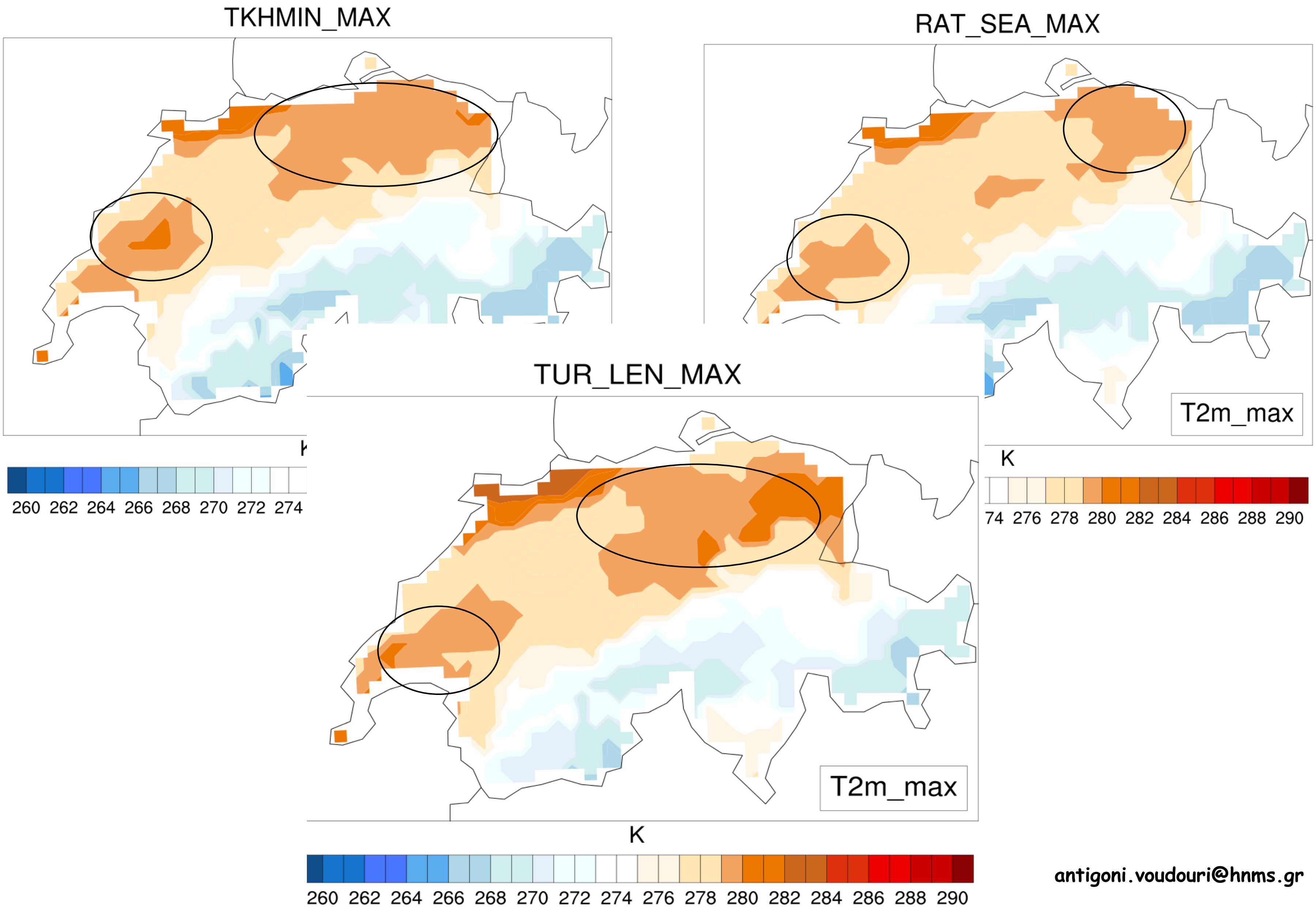
antigoni.voudouri@hnms.gr

CALMO simulations

	tkhmin [0,2] def. 1	rlam_heat [0.1,10] def. 1	rat_sea [1,100] def. 20	tur_len[0,10000] def. 500.0
LF_RING	1	1	20	500
LF_RING_HRATS	1	5	100	500
LF_RING_HRATS1	1	1	100	500
LF_RING_HRLAM	1	10	20	500
LF_RING_HTKH	2	1	20	500
LF_RING_HTURL	1	1	20	10000
LF_RING_HTURLHRAT	1	1	100	10000
LF_RING_HTURLHRLAM	1	10	20	10000
LF_RING_HTURLHRLAM1	1	5	20	10000
LF_RING_HTURLHTKH	2	1	20	10000
LF_RING_LRATS	1	5	1	500
LF_RING_LRATS1	1	1	1	500
LF_RING_LRATSLRLAM	1	0.1	1	500
LF_RING_LRATSLTKH	0.1	5	1	500
LF_RING_LRATSLTKH1	0.1	1	1	500
LF_RING_LRLAM	1	0.1	20	500
LF_RING_LTKH	0	1	20	500
LF_RING_LTKHLRLAM	0.1	0.1	20	500
LF_RING_LTURL	1	1	20	100
LF_RING_LTURLTKH	0	1	20	100
LF_RING_LTURLTKH1	0.1	1	20	100
LF_RING_R	0.5	3	20	500
LF_RING_VAR3	0.5	3	50	500
LF_RING_VAR3TURL	0.5	3	20	750
LF_RING_VAR4	0.5	3	50	750

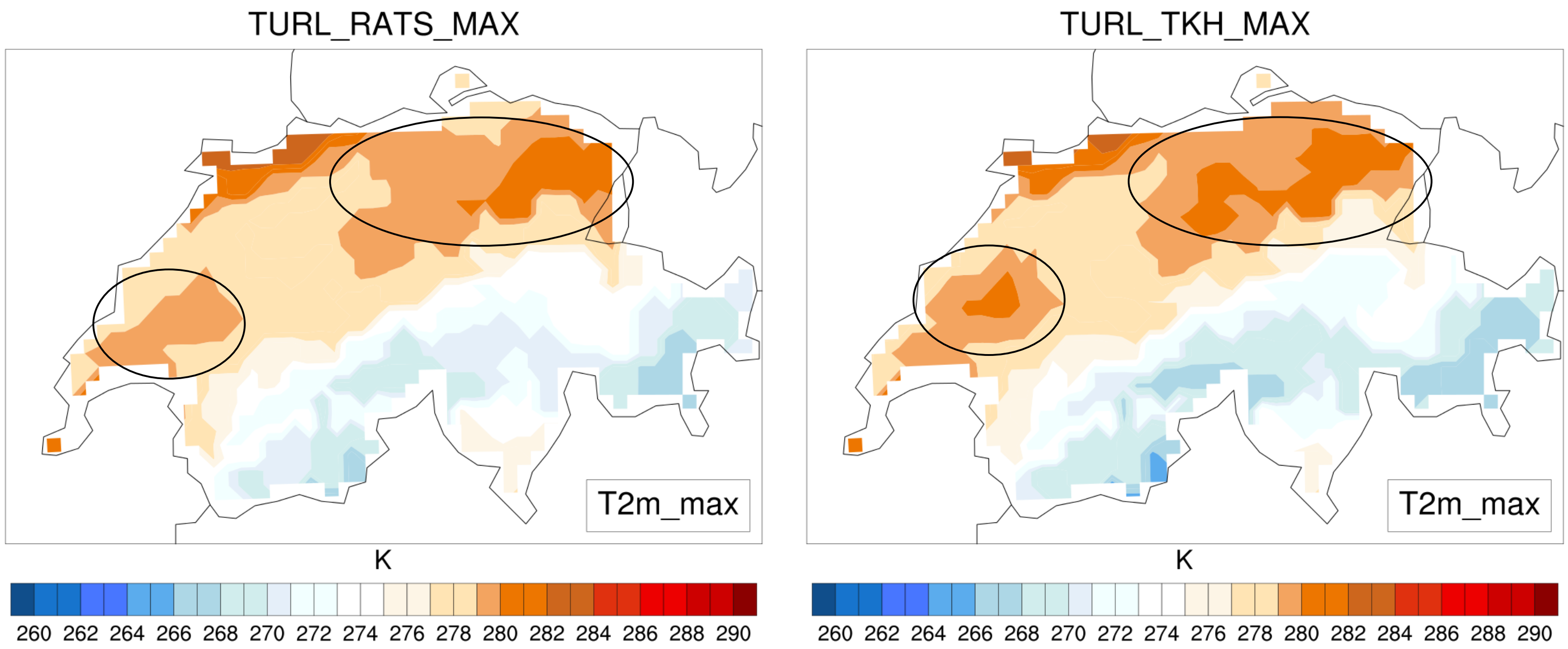
 antigoni.voudouri@hnms.gr

Perturbed simulations 10.01.08



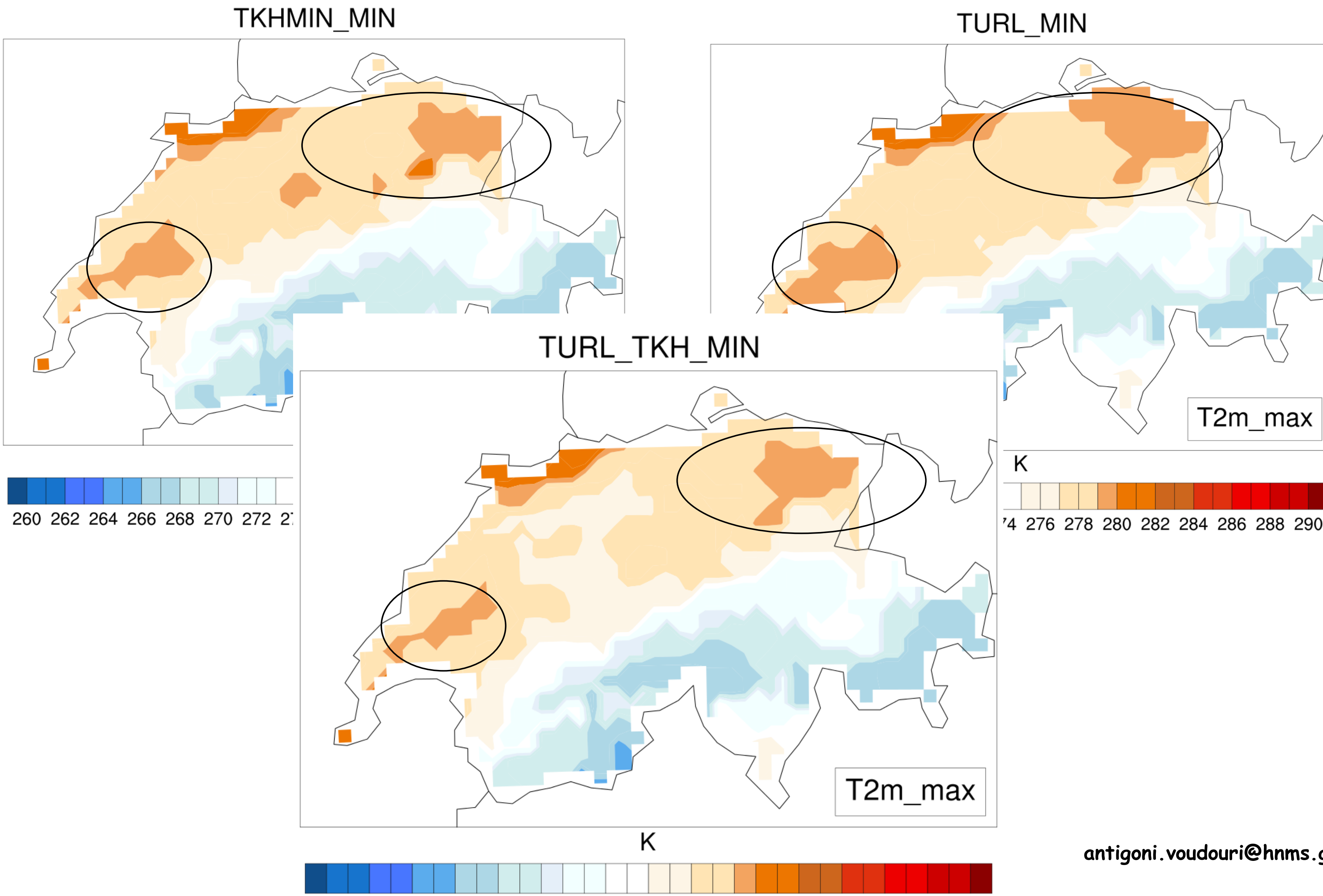
antigoni.voudouri@hnms.gr

Perturbed simulations 10.01.08



antigoni.voudouri@hnms.gr

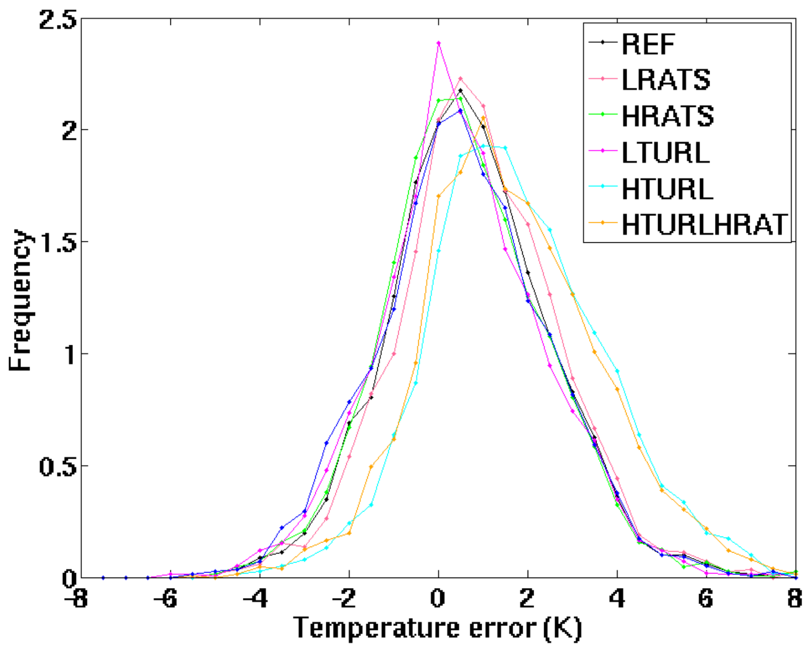
Perturbed simulations 10.01.08



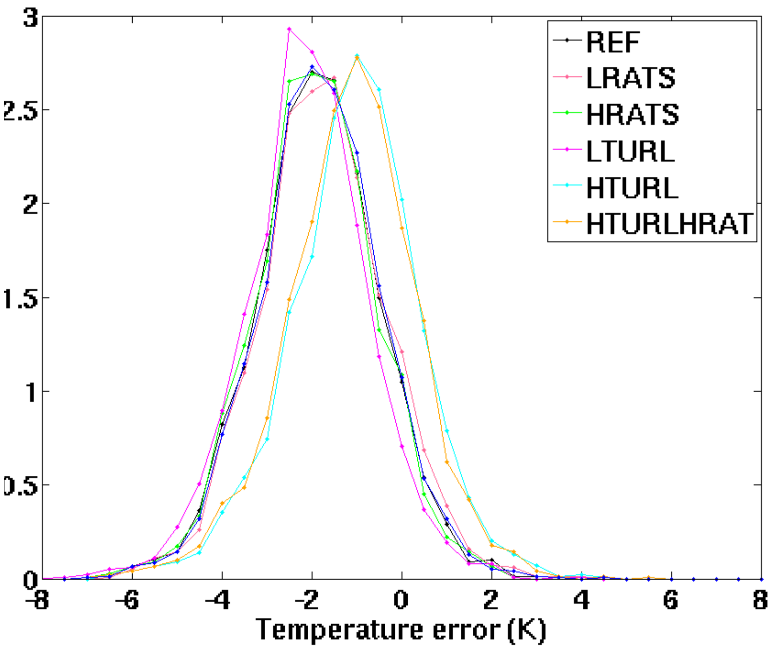
antigoni.voudouri@hnms.gr

Distribution function of errors

Minimum Temperature (K)



Maximum Temperature (K)



antigoni.voudouri@hnms.gr

Meta-model description

According to Neelin et al. (2010)

$$\Phi' = \Phi_{std} + \mu^T a + \mu^T \mathbf{b}\mu \quad (1)$$

where

$\mu = (\mu_1, \ldots \mu_N)^T$ and $a = (a_1, \ldots a_N)^T$ are vectors over the parameter set

b is an *N* by *N* matrix with elements *bij*

Note that each element *ai, bij* is itself a high dimensional vector over space and season.

For 2 parameters (1) becomes

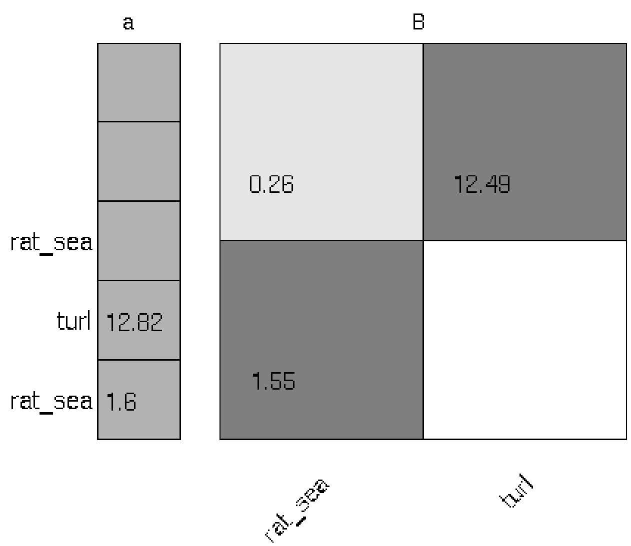
$$\Phi' = \Phi_{std} + \mu_1 a_1 + \mu_2 a_2 + \mu_1^2 b_{11} + \mu_2^2 b_{22} + 2\mu_1 \mu_2 b_{12}$$

depending on the number of parameters to be optimized the minimum number of model runs required is

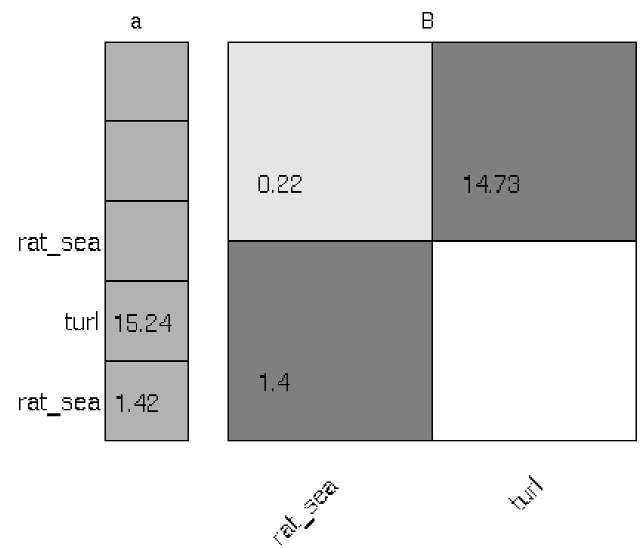
2N+N(N-1)/2

Linear, quadratic and interaction terms

Minimum Temperature (K)



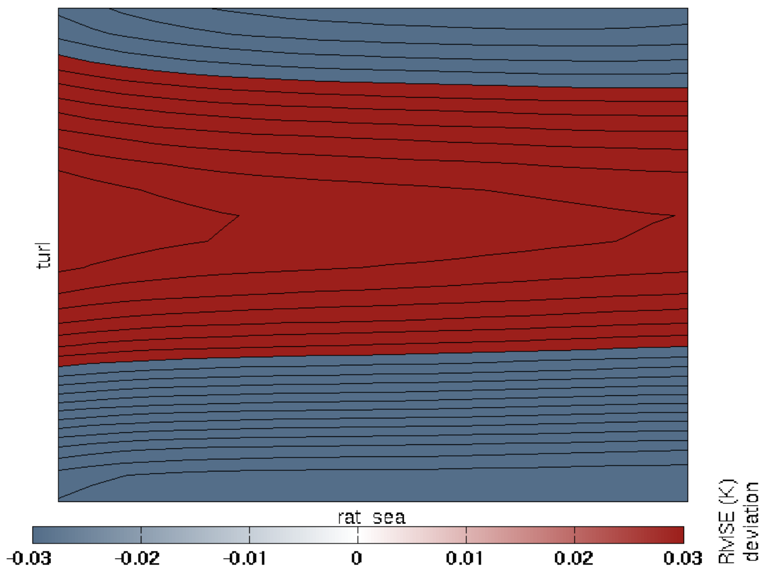
Maximum Temperature (K)



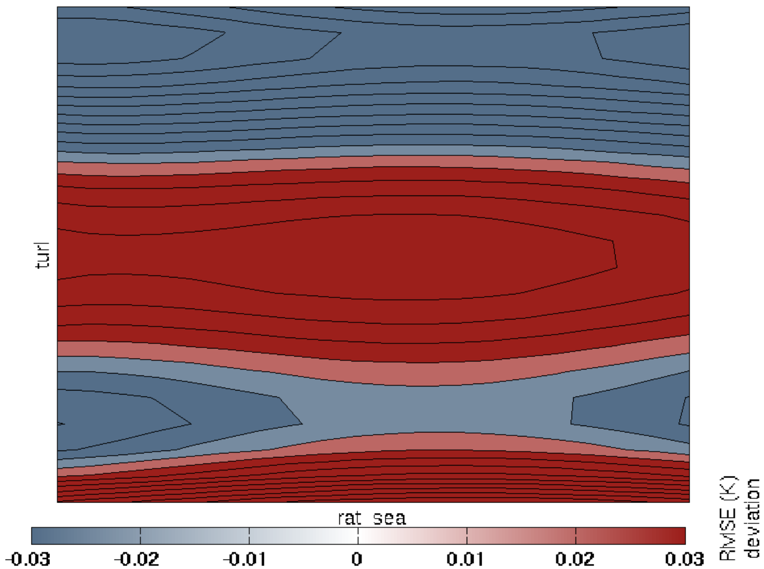
antigoni.voudouri@hnms.gr

Pairwise planes of a two-dimensional parameter space

Minimum Temperature (K)



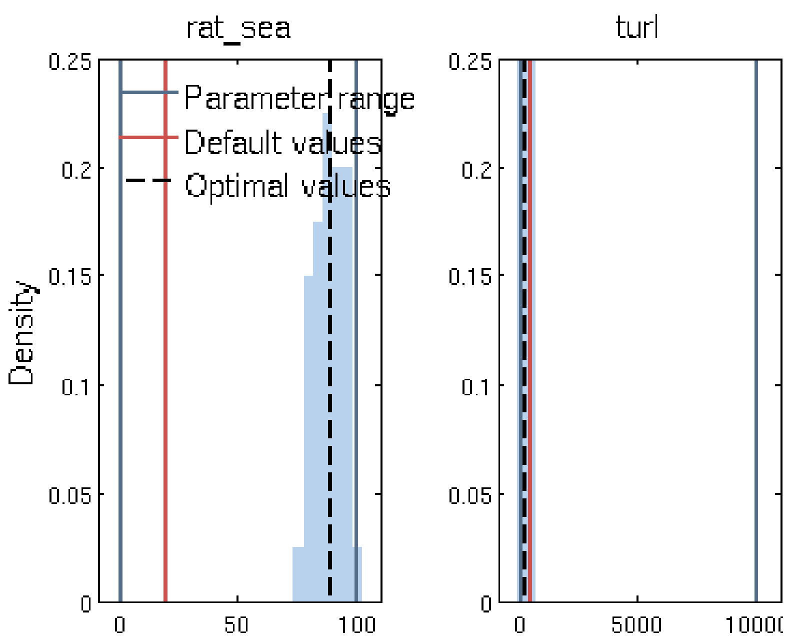
Maximum Temperature (K)



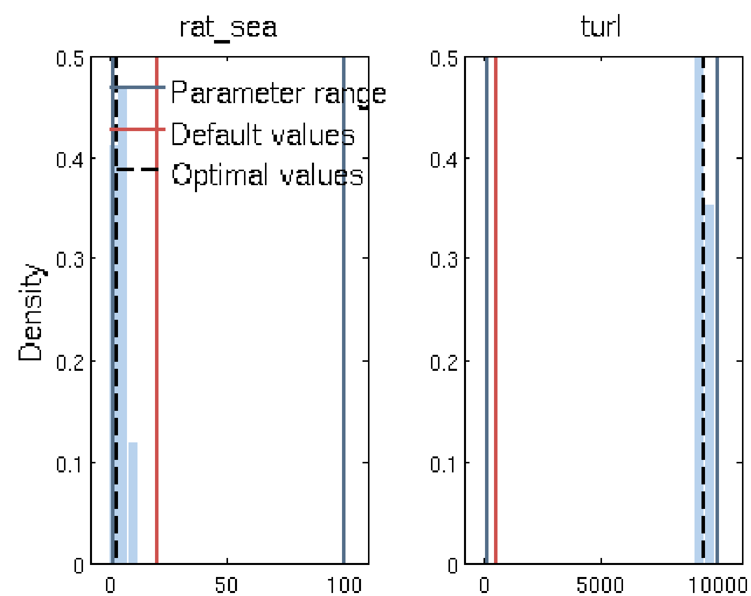
Density of parameter values

The red line in each panel shows the default parameter value and the black line shows the parameter combination of the best performing simulation

Minimum Temperature (K)



Maximum Temperature (K)

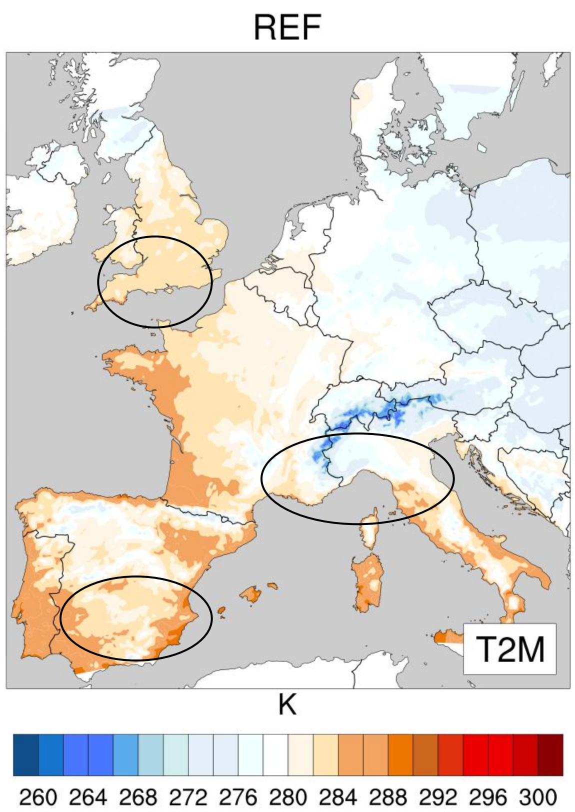


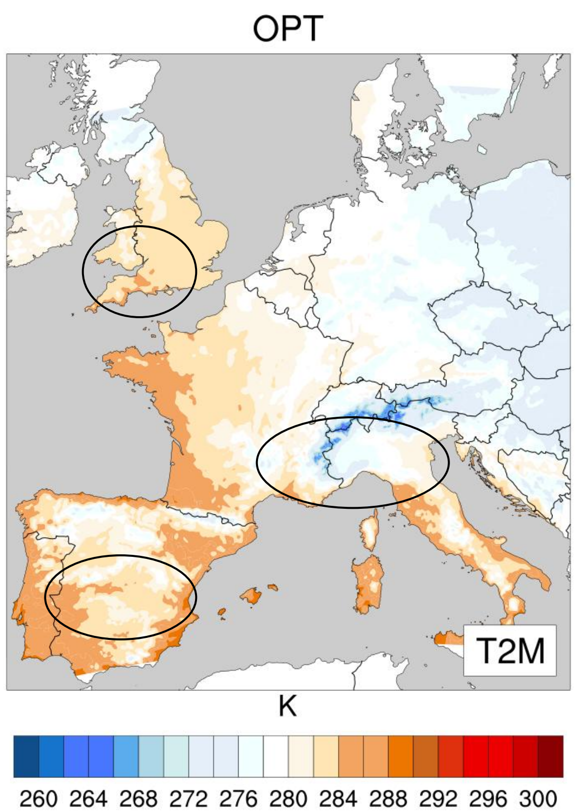
antigoni.voudouri@hnms.gr

Fitting the MM- Finding the optimal set

	Tmin	Tmax	Precipitation
Best rat_sea [1,20,100]	89.4	3	97.4
Best tur_len [100,500,10000]	265	9397	104.5

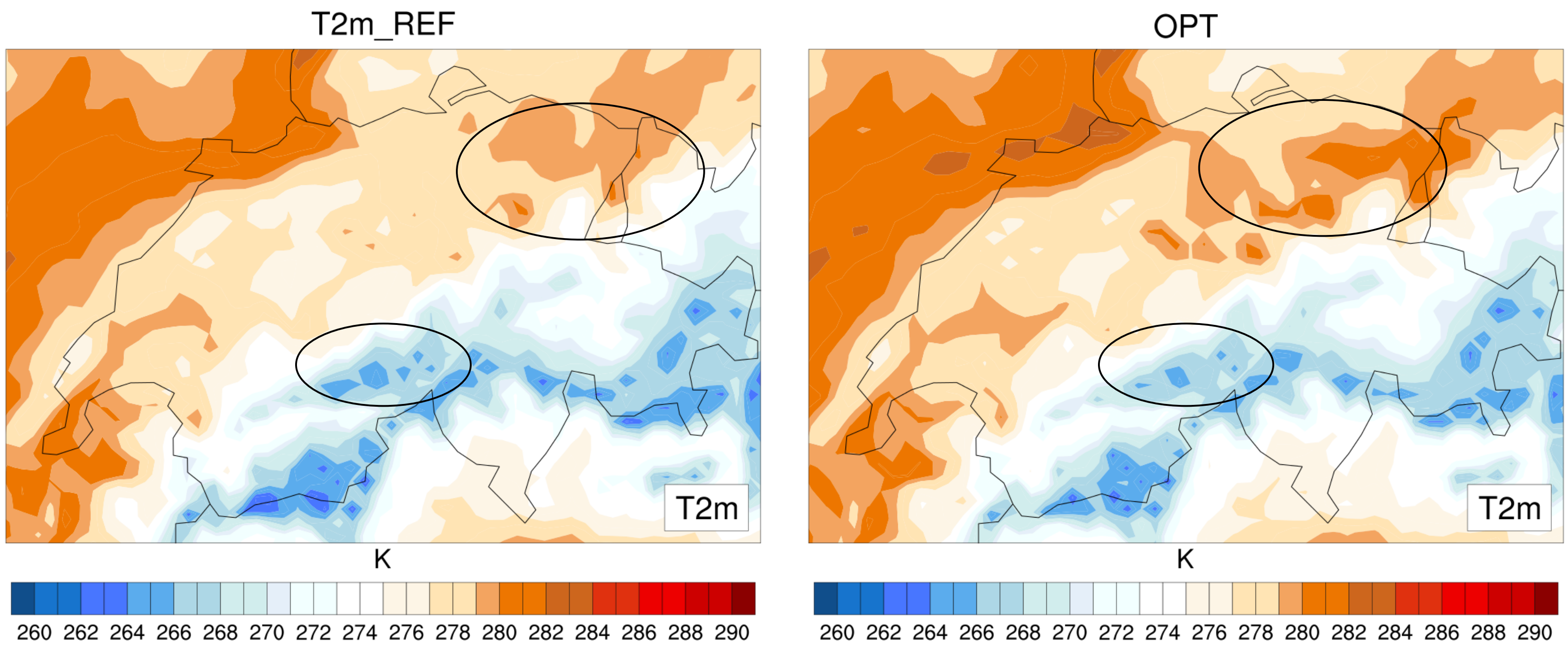
10.01.08 12 UTC





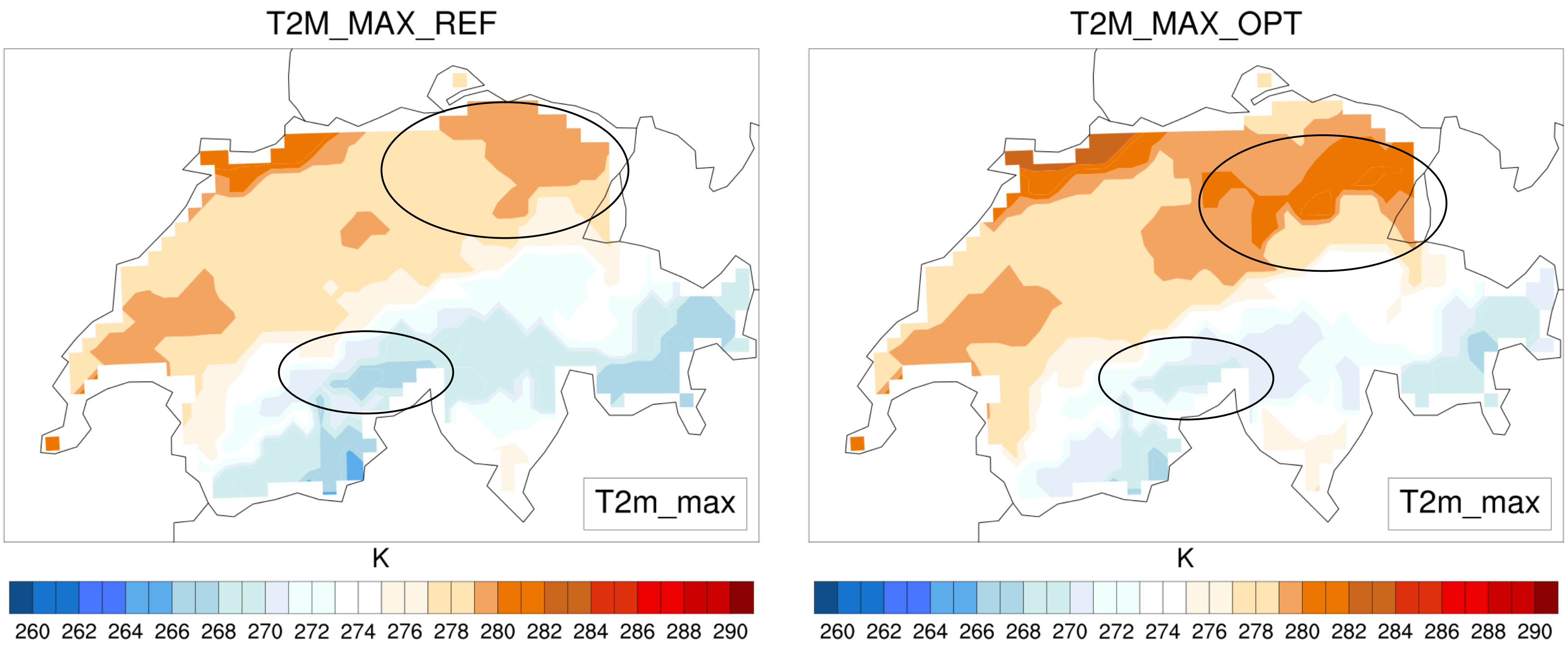
antigoni.voudouri@hnms.gr

10.01.08 12 UTC



antigoni.voudouri@hnms.gr

10.01.08



antigoni.voudouri@hnms.gr

Difficulties- Open Issues

1. Definition of an objective **performance function:** Score selection other than RMSE **(PS ????)**.
2. Important NWP **model free parameters** to be tested other than the 4 already used (tkhmin, rlam_heat, tur_len, rat_sea)
3. Minor modification used for the **meta-model** applicable to parameter variations (currently in MATLAB, other language) .
4. Determine the **optimal parameter configurations**.
5. **Technical** Issues : Storage capacity, available computer resources proposal at CSCS!

antigoni.voudouri@hnms.gr

Project extension

Project ends in 09.2015, instead of 12.2014

- Many research groups and operational centers are moving towards (convection-permitting) kilometric resolutions, thus there is a particular interest for re-calibrating a high-resolution configurations.
- The use of an objective method such as the one applied in Bellprat et al. (2012b) is highly attractive due to its efficiency, wide calibration range and transparency.
- The focus is on the COSMO-1 calibration to show the benefit of the method for calibrating COSMO-NWP. In a second step, once the benefit of the method has been assessed, the focus is on the optimization of the method.
- An objective and practicable methodology, incl. tools, that can substitute expert tuning for calibrating NWP models.
- Technical and scientific documentation.
- Understand the sensitivity of the NWP model quality with respect to the unconfined model parameters.

 antigoni.voudouri@hnms.gr

CALMO Tasks

- Task 0: Administration and support *(continues….)*
- Task 1: Preliminary work *(1 new sub Task added)*
  - 1.4: Consolidation of CALMO methodology
- Task 2: Adaptation of the method *(2 new subTasks added)*
  - 2.6: Modifications on the meta-model
  - 2.8 Data thinning policy and application
- Task 3: Assessing the usefulness of the calibration method *(subTasks modified)*
  - 3.1: Application of the method using COSMO-1
  - 3.2: Analyse results

- Task 4: Practicability of the method
- Task 5: Documentation

antigoni.voudouri@hnms.gr

Contributing Scientists

A.Voudouri / HNMS	0.8 FTE
P. Khain /IMS	0.35 FTE
I. Carmona /IMS	0.3 FTE
E. Avgoustoglou /HNMS	0.25 FTE
JM. Bettems / MeteoSwiss	0.06 FTE

(in addition, support from MeteoSwiss will be provided as needed)

Summary

- Primary goal of CALMO was to demonstrate the applicability of the approach using a computationally cost-effective framework.
- The calibration procedure is still under process, but it is evident from that the method should be applied over a large domain.
- Performance score and available observations are essential for calibration.
- Systematic errors can not be resolved with the method but the large effort devoted for expert tuning can be restrained.
- CALMO gain: Delevopment of an automatised tool to re-calibrated COSMO for new model developments/target domains

Any suggestions, comments, remarks?

- CALMO mailing list
  http://mail.cosmo-model.org/mailman/listinfo/cosmo-calmo
- WiKi page similar to the one used at MeteoSwiss
  https://wiki.c2sm.ethz.ch/Wiki/ProjCALMO

antigoni.voudouri@hnms.gr