ΕΘΝΙΚΗ
ΜΕΤΕΩΡΟΛΟΓΙΚΗ
ΥΠΗΡΕΣΙΑ
HELLENIC NATIONAL METEOROLOGICAL SERVICE

CONSORTIUM FOR SMALL SCALE MODELING
COSMO

Status of Priority Project
CALibration of the COSMO MOdel
CALMO

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Outline

- Progress within individual Tasks
- Description of simulations performed
- MM fitting
- Discussion of results
- Difficulties encountered-Open Issues
- Summary
- Presentation of the extended PP

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CALMO Tasks

- Administration and support (Task 0)
- Preliminary work (Task 1)
- Adaptation of the method (Task 2)
- Sensitivity with respect to target region (Task 3)
- Practicability of the method (Task 4)
- Documentation (Task 5)

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Progress within individual Tasks

- Task 0: Administration and support
  - 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/ProjCALM
- Task 1: Preliminary work
  - Dr Omar Bellprat, compiled a new version of the calibration code with minor changes to improve the metamodel estimation and the appropriate documentation . Now available to the users through CALMO mailing list
- Task 2: Adaptation of the method
  - **2.1: Documentation of tuning parameters and choice of parameters subspace**

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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 settings operated by MeteoSwiss if different from def.

Progress within individual Tasks

- **Task 2: Adaptation of the method**
  - **2.2: Selection of performance function(s) (still under consideration!!!)**
    - RMSE
  - **2.3: Identification of key-variables for NWP**
    - T2m, T2m_min, T2m_max, Total Precipitation,
  - **2.4: Experimental set-up**
    - The configuration of a single model run was defined: base model configuration, domain size and location, initial condition of the soil, use data assimilation or free run, simulation length
  - **2.5: Collection of data**
    - 2m-temperature daily mean observations data over Switzerland (C.Frei) transformed to a 7km grid
    - Precipitation both radar and rain gauges combined used FIELDEXTRA in order to extract daily averaged
  - **2.6: Compute experiments and analyse results**

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Progress within individual Tasks

- **Task 3: Sensitivity with respect to target region**
  - 3.1: Application of the method over different regions
    - It was found that the definition of an optimal set of coefficients can not be performed over a restricted area.
  - 3.2: Analyse results

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Progress within individual Tasks

- **Task 4: Practicability of the method**
  - The extend that the data set of full model runs can be reduced to still obtain a robust and good quality calibration result is examined (2 X 20 days)
- **Task 5: Documentation**
  - No published scientific paper regarding the results of the specific PP at the moment
  - A description of the methodology focused on steps to be followed mainly on applying the meta model is available to COSMO members.

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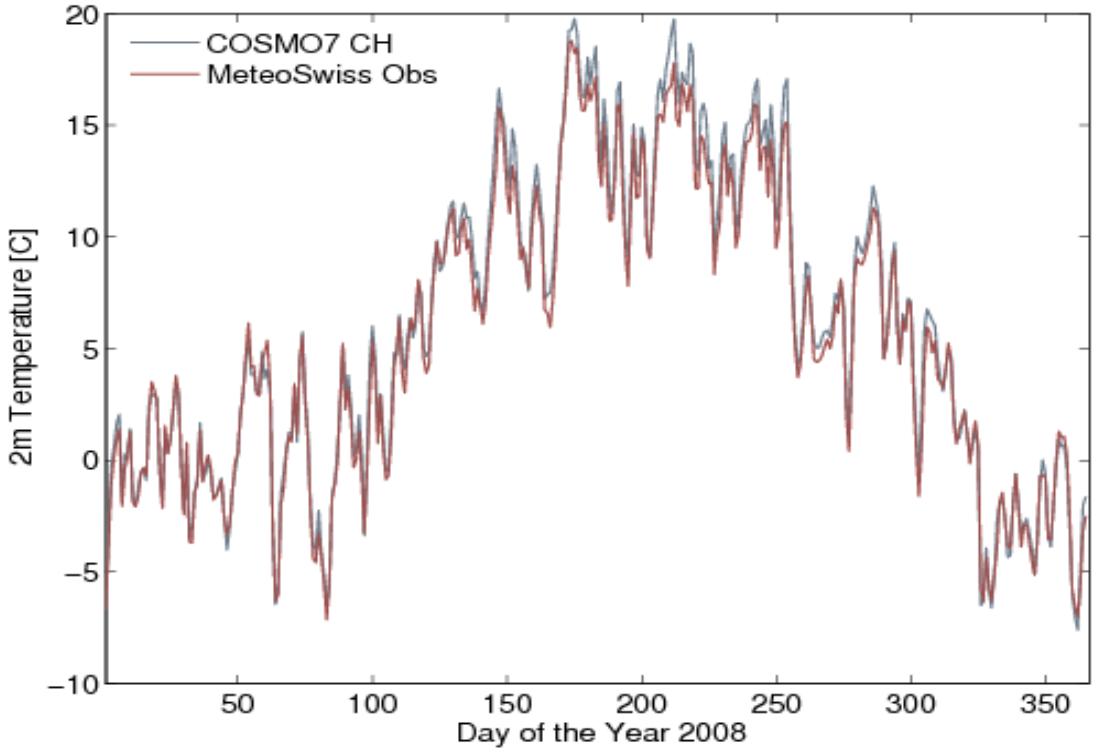
T2m verification using COSMO-7



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Model domain

- 61X41X60
- STARTLAT -1.44
- STARTLON -3.18
- Takes 2-3min/day

- 375X323X60
- STARTLAT -9.30
- STARTLON -15.78
- Takes 20 min/day

- Simulation performed with LM package at CSCS

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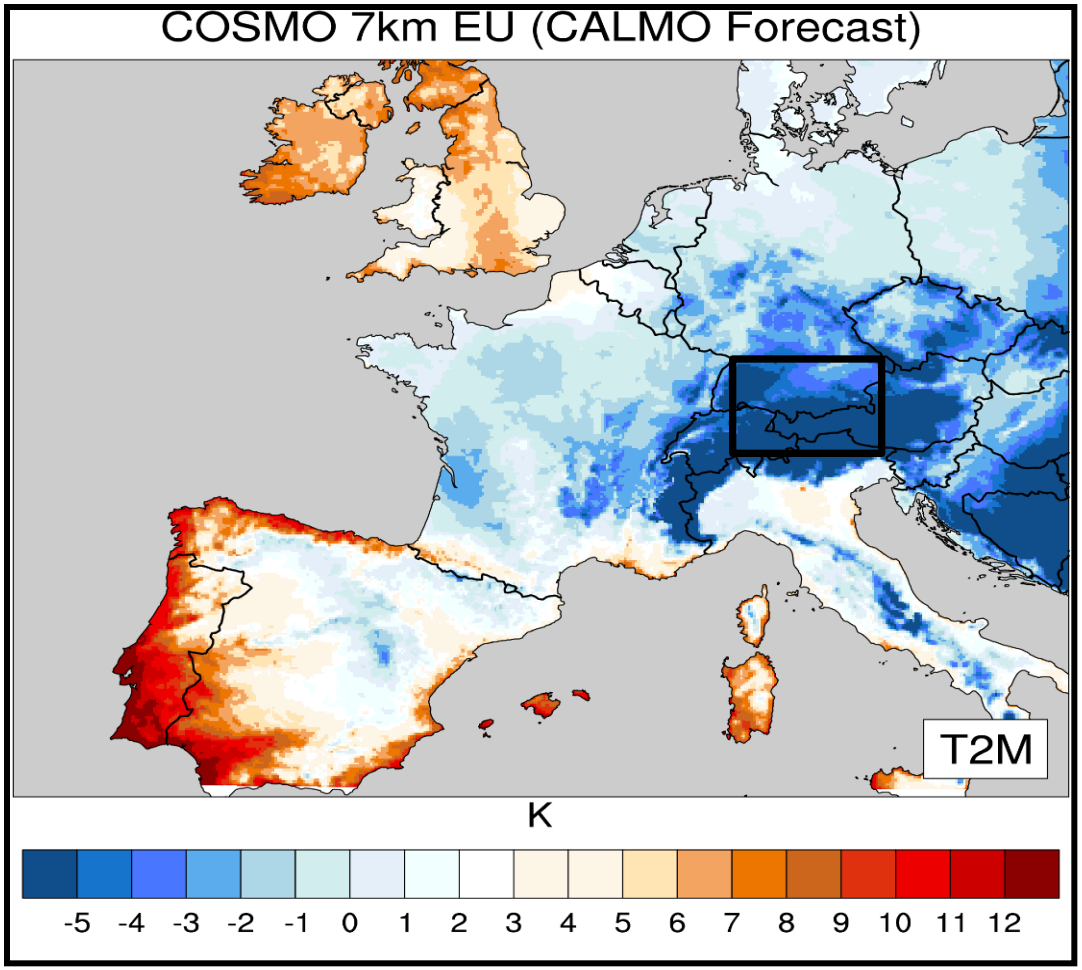
Selected Domains



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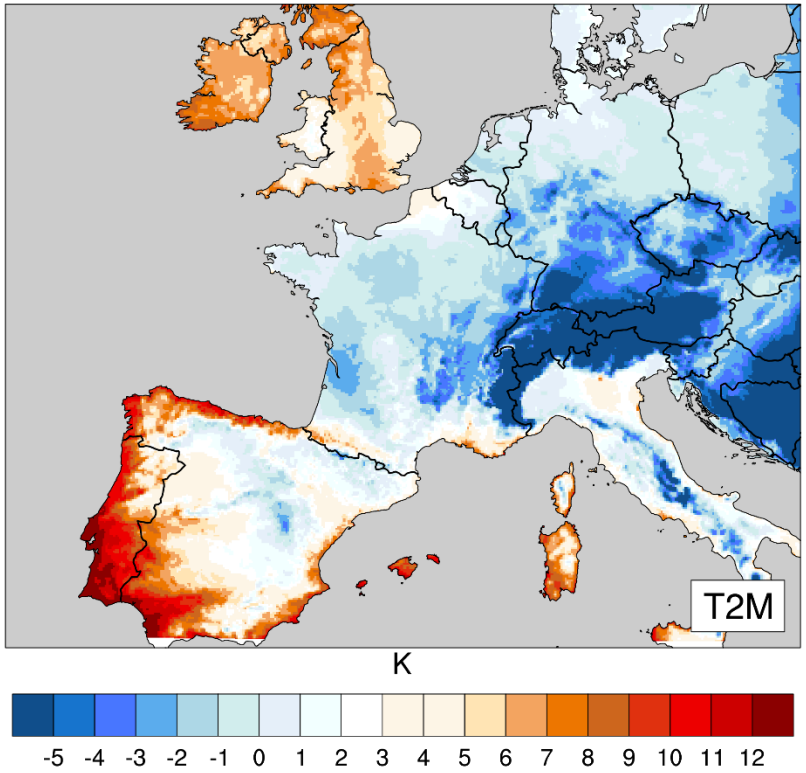
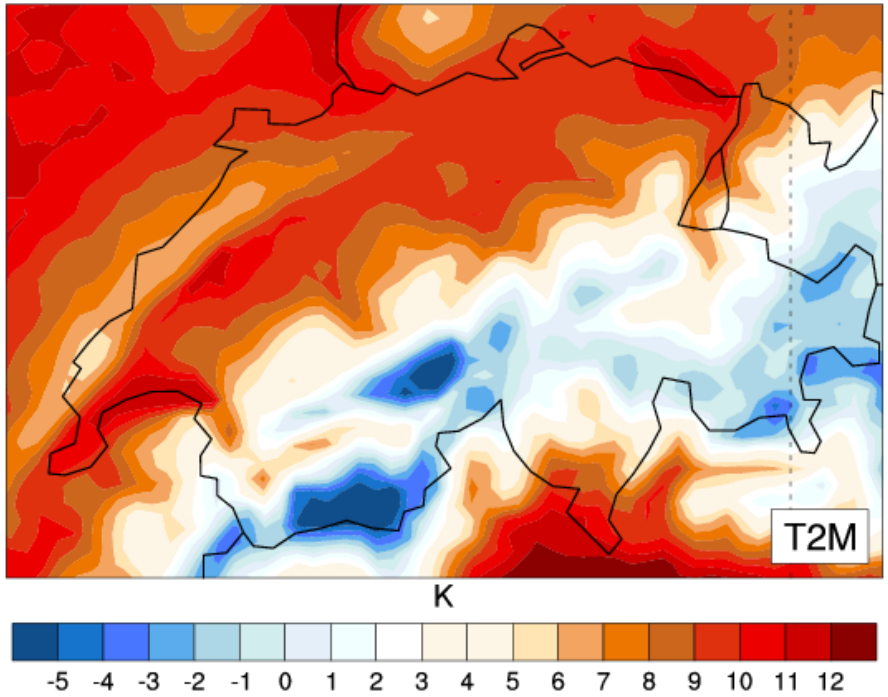
Large vs small domain
Temperature differences

COSMO 7km EU (CALMO Forecast)



COSMO 7km (CALMO Forecast)



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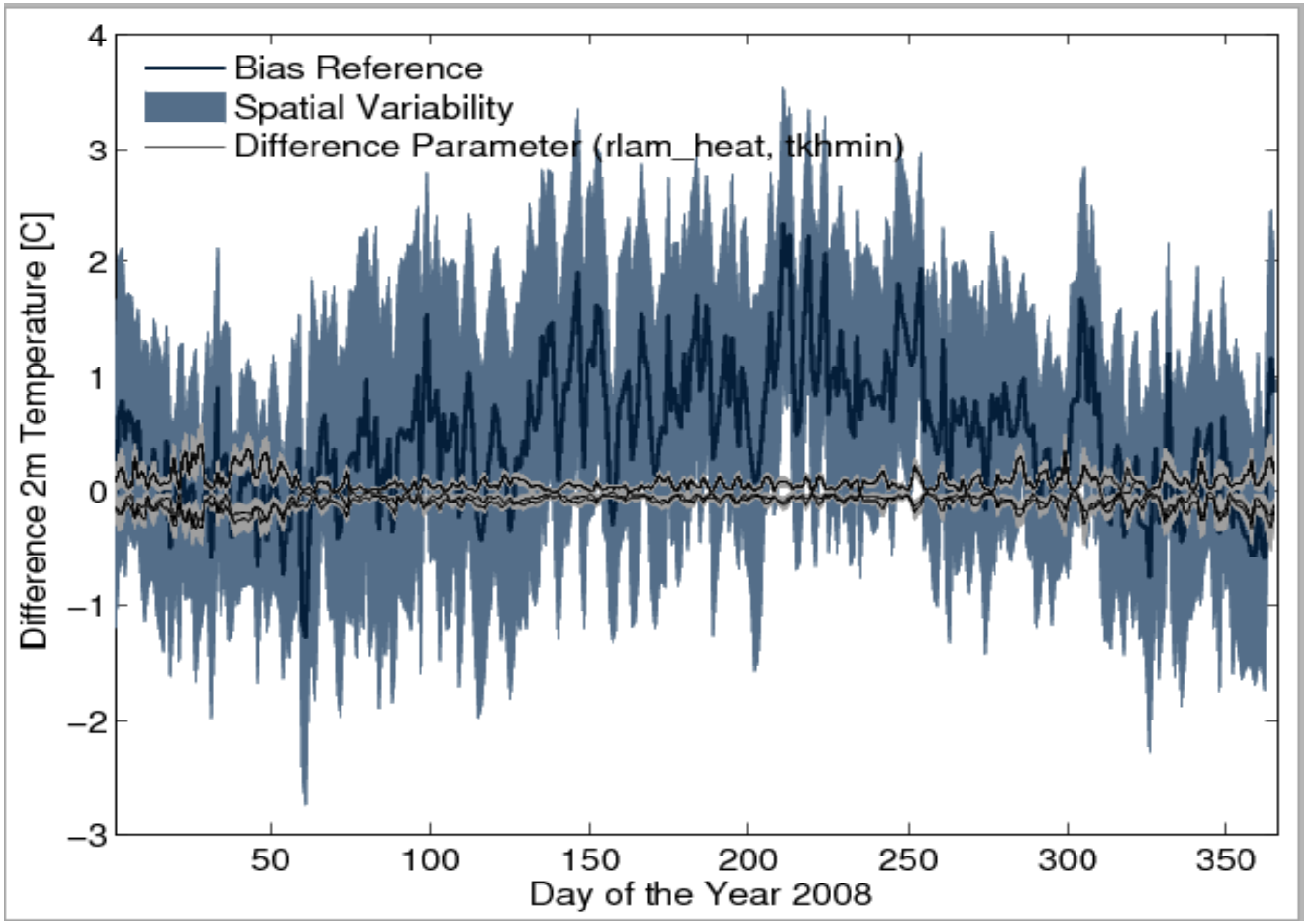
Small domain (tkhmin/rlam)



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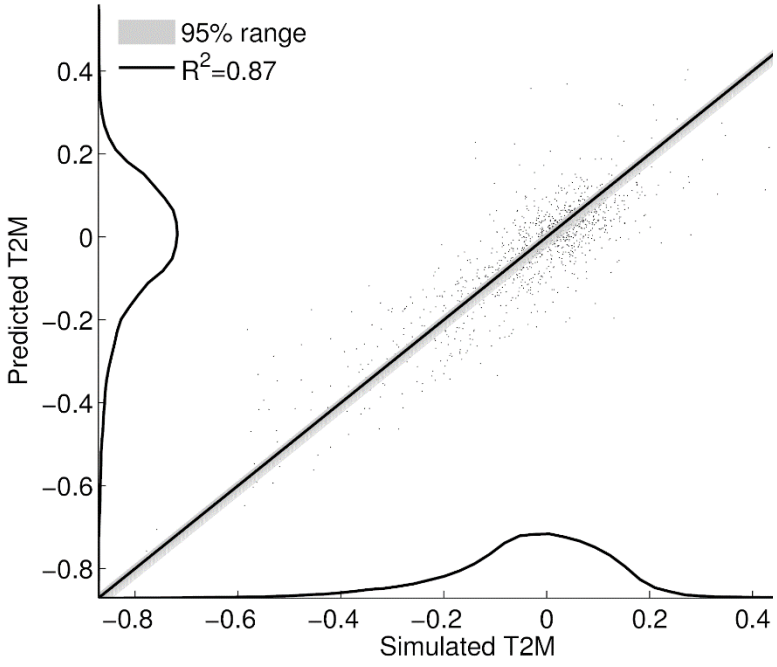
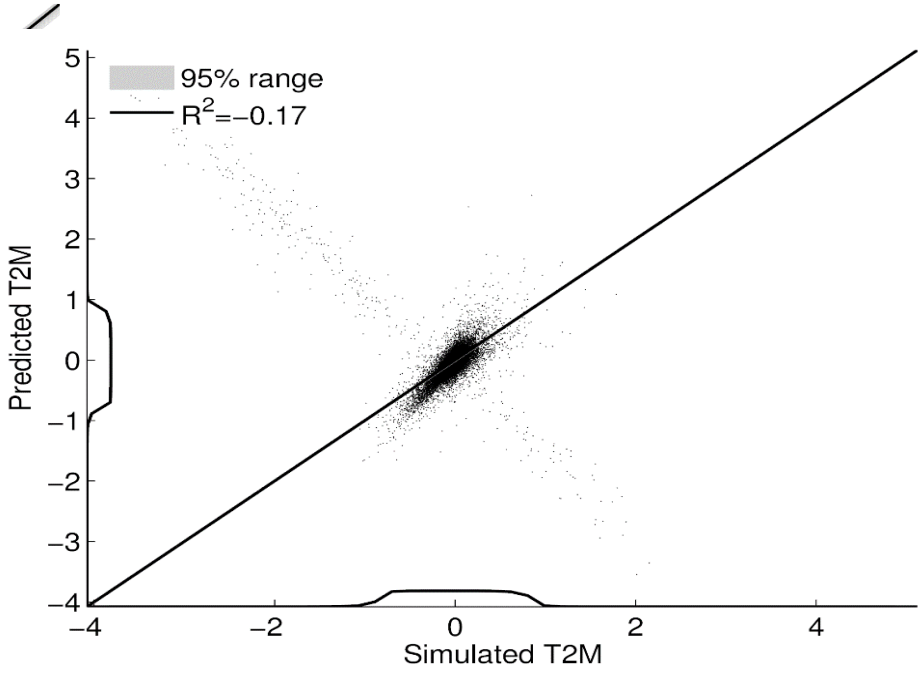
Predicting independent simulations

Large domain



Small domain



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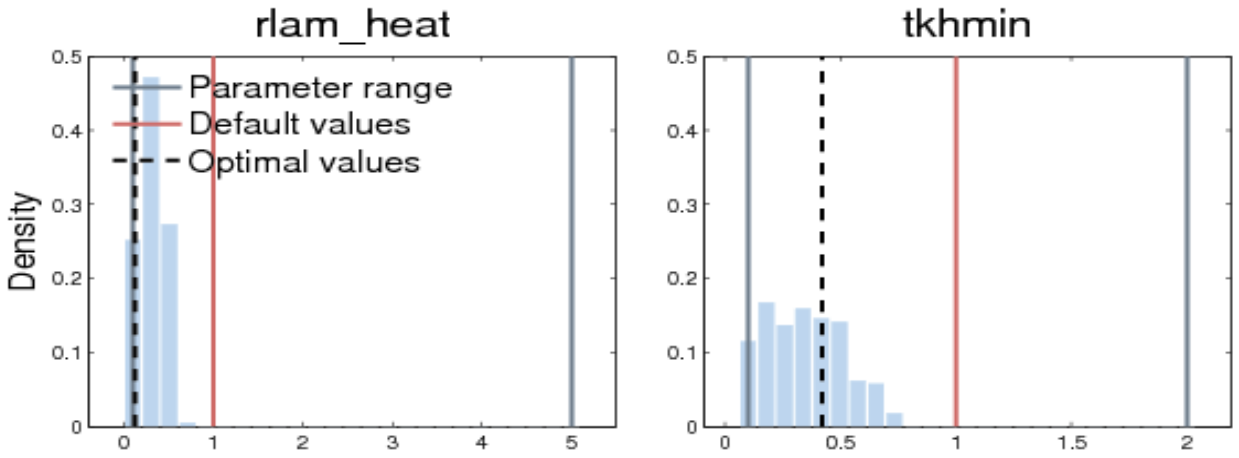
Post_cosmo_calmo7



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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

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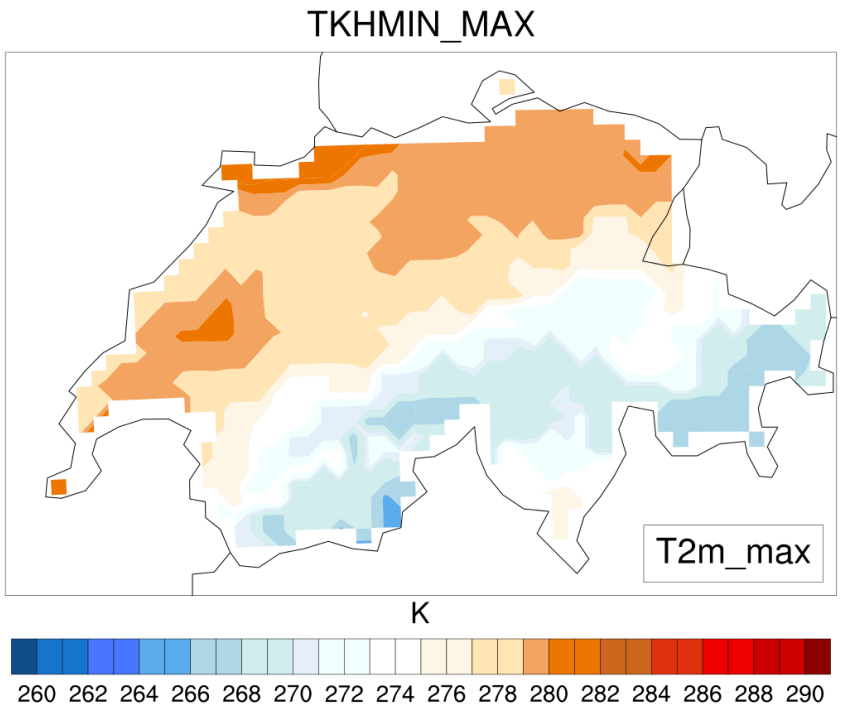
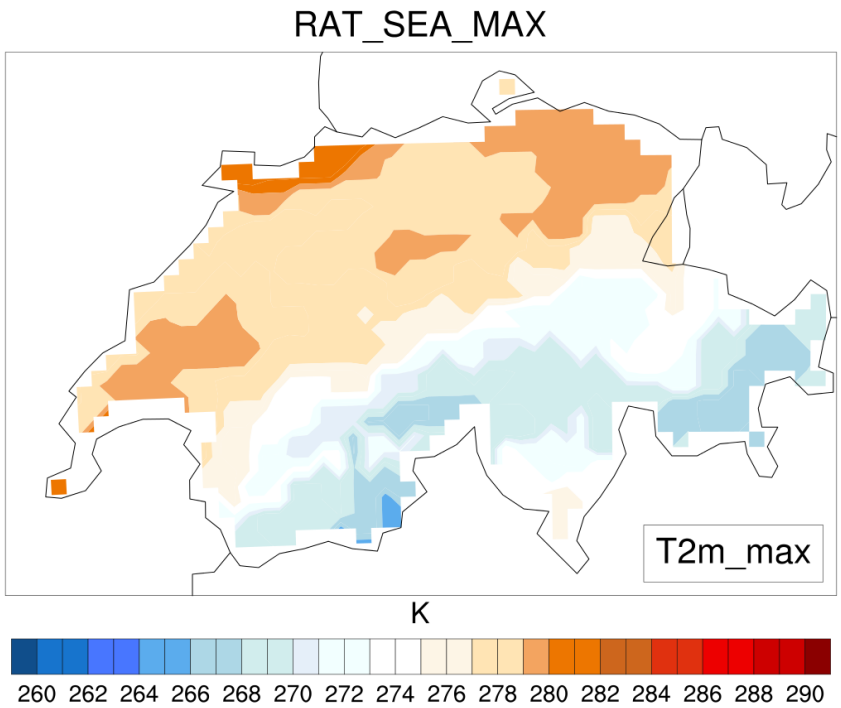
Perturbed simulations 10.01.08





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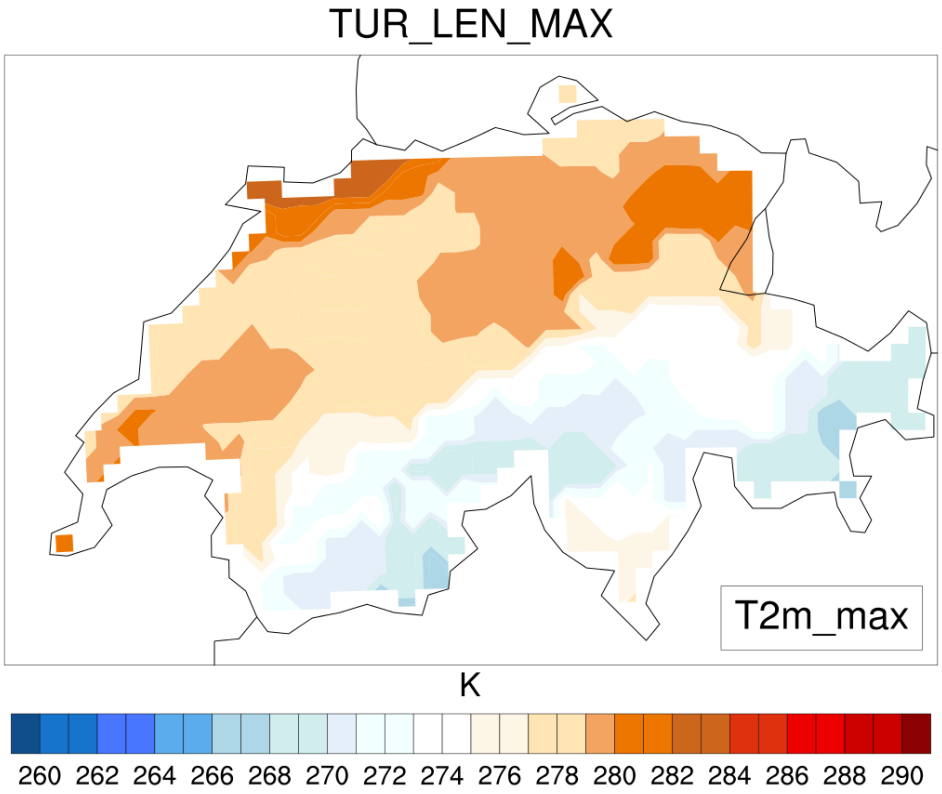
Perturbed simulations 10.01.08



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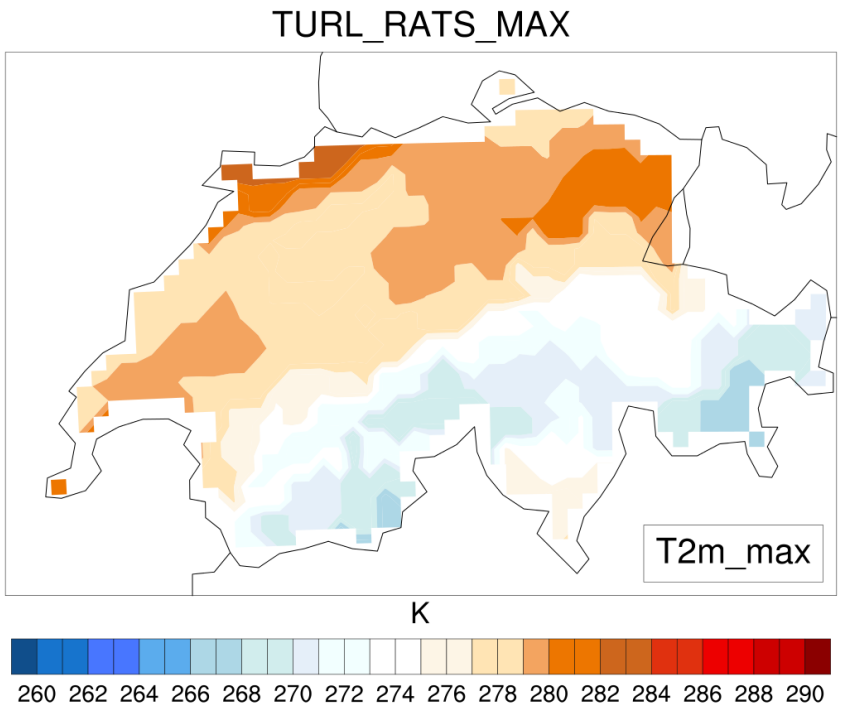
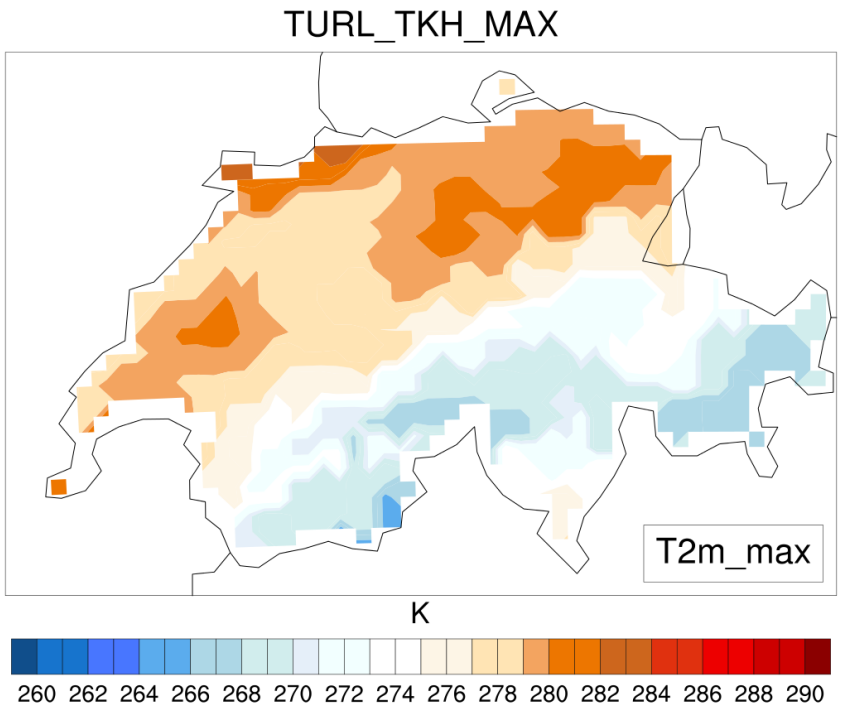
Perturbed simulations 10.01.08





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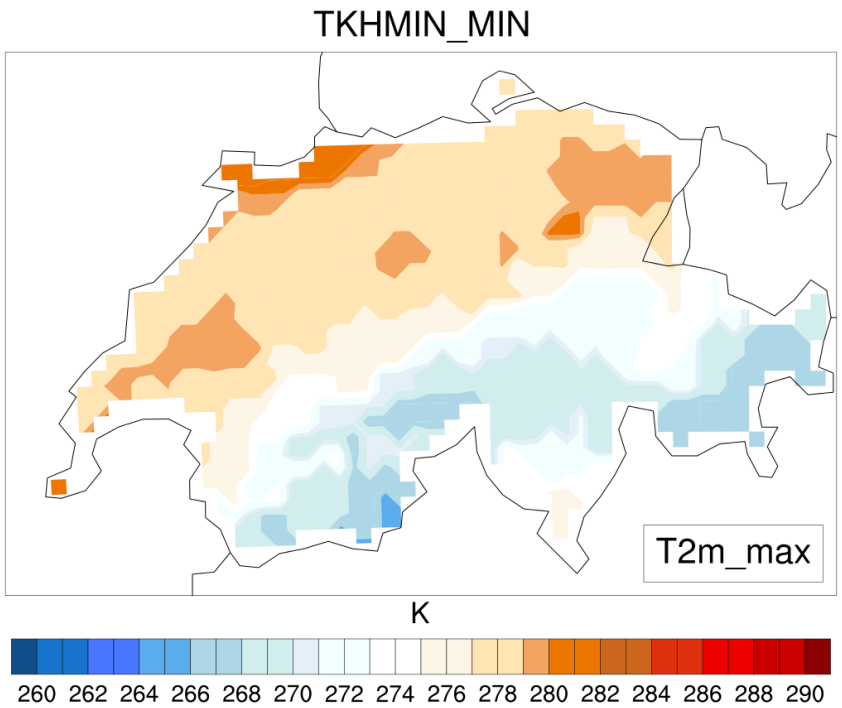
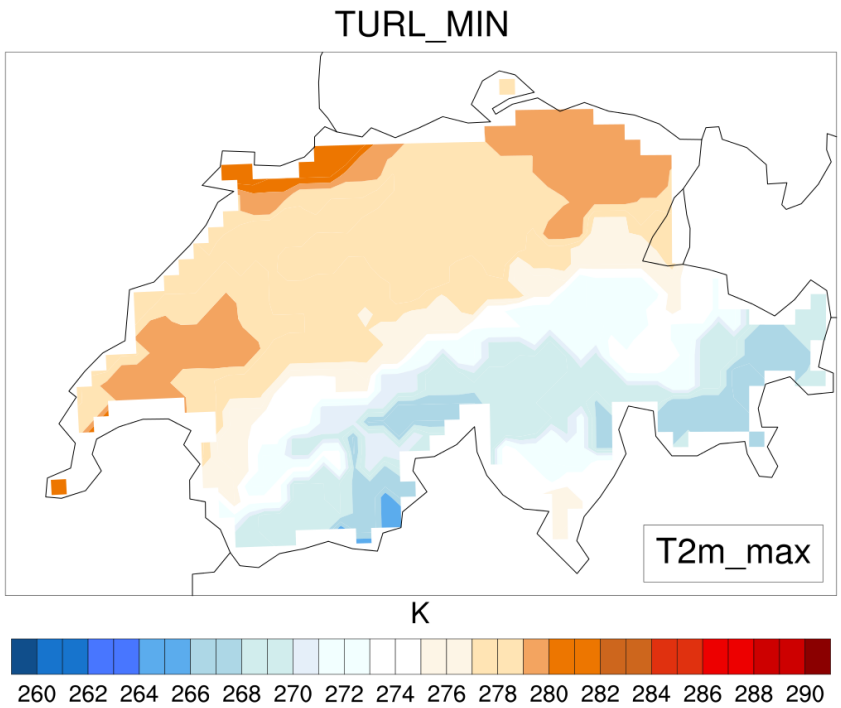
Perturbed simulations 10.01.08





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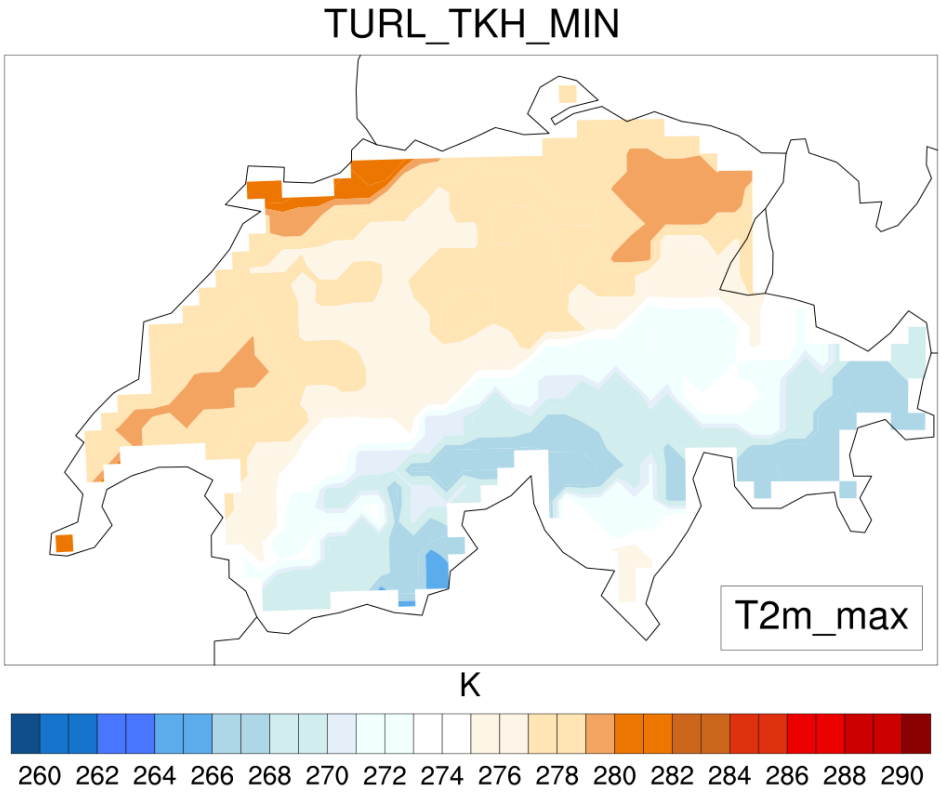
Perturbed simulations 10.01.08



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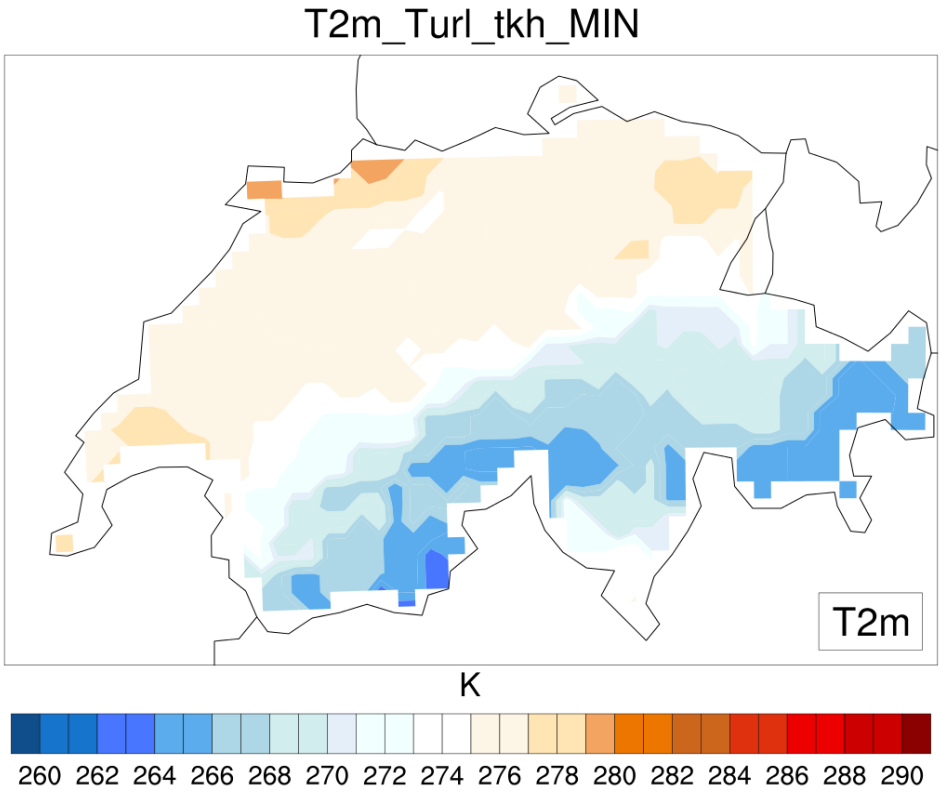
10.01.08 (average 2m T)



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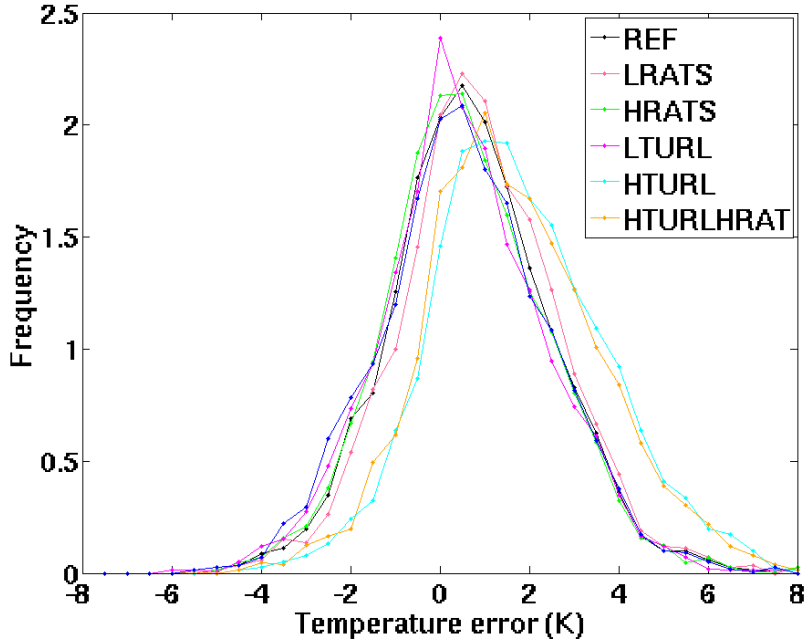
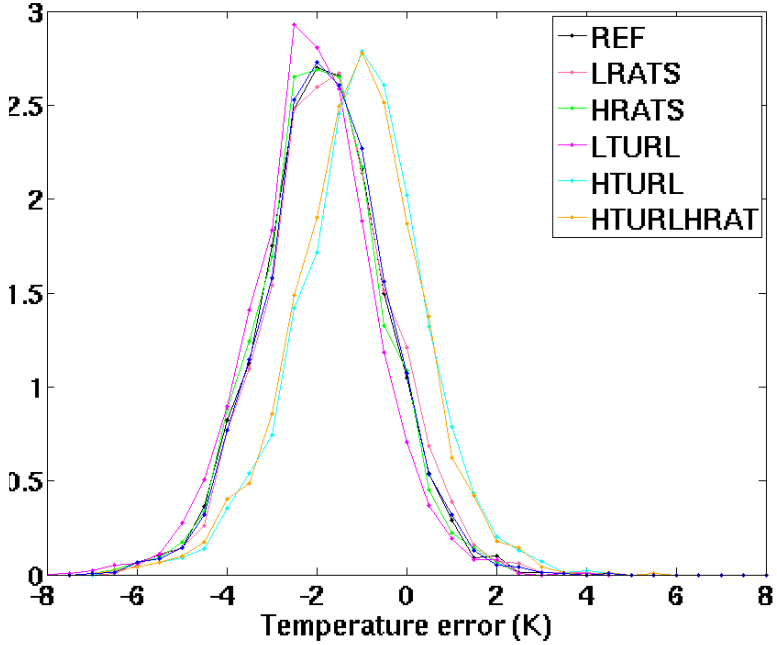
Distribution function of errors

Minimum Temperature (K)



Maximum Temperature (K)



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Meta-model description

According to Neelin et al. (2010)

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

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

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

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

2N+N(N-1)/2

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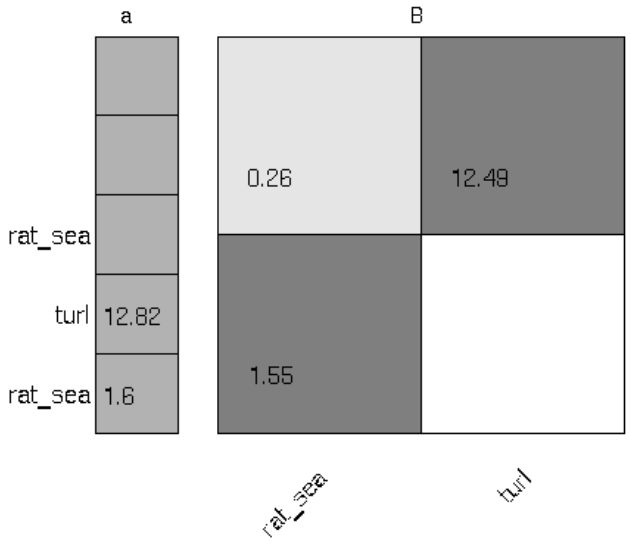
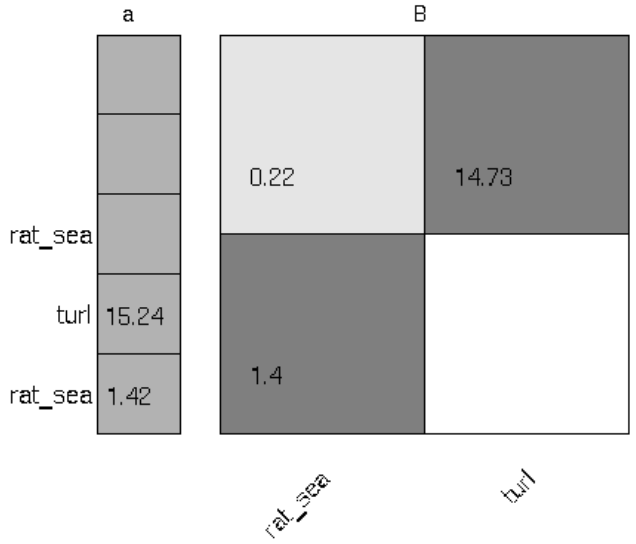
Linear, quadratic and interaction terms

Minimum Temperature (K)



Maximum Temperature (K)



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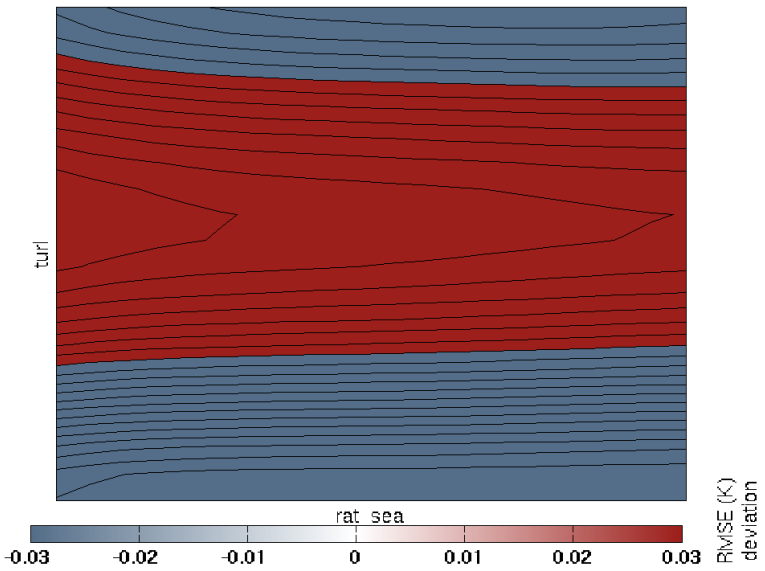
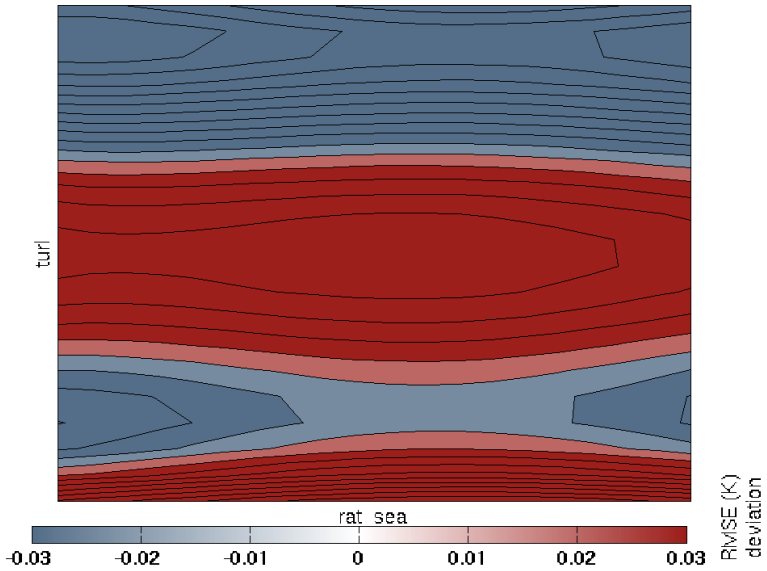
Pairwise planes of a two-dimensional parameter space

Minimum Temperature (K)



Maximum Temperature (K)



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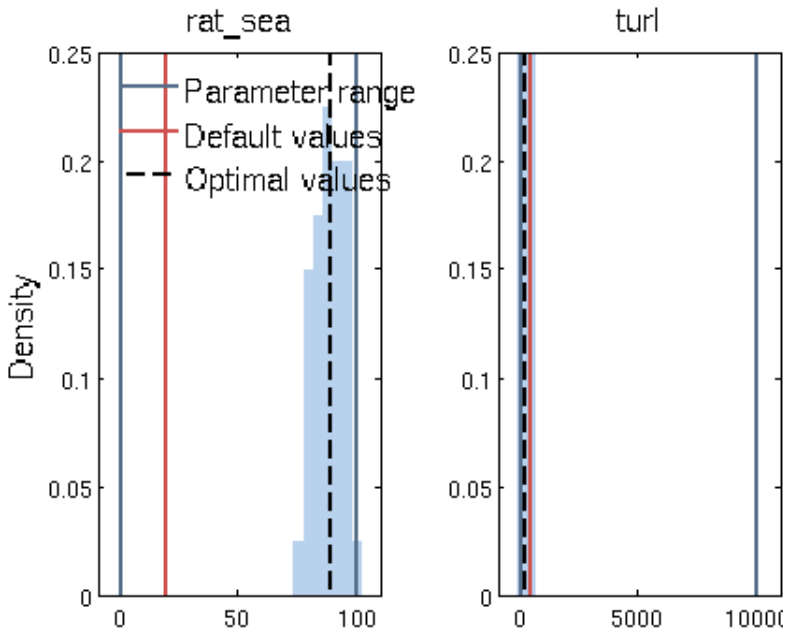
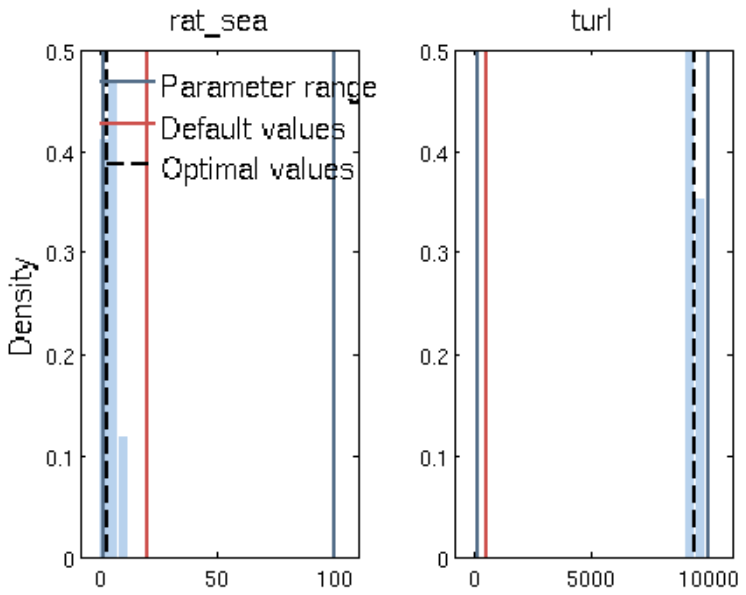
Density of parameter values

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)



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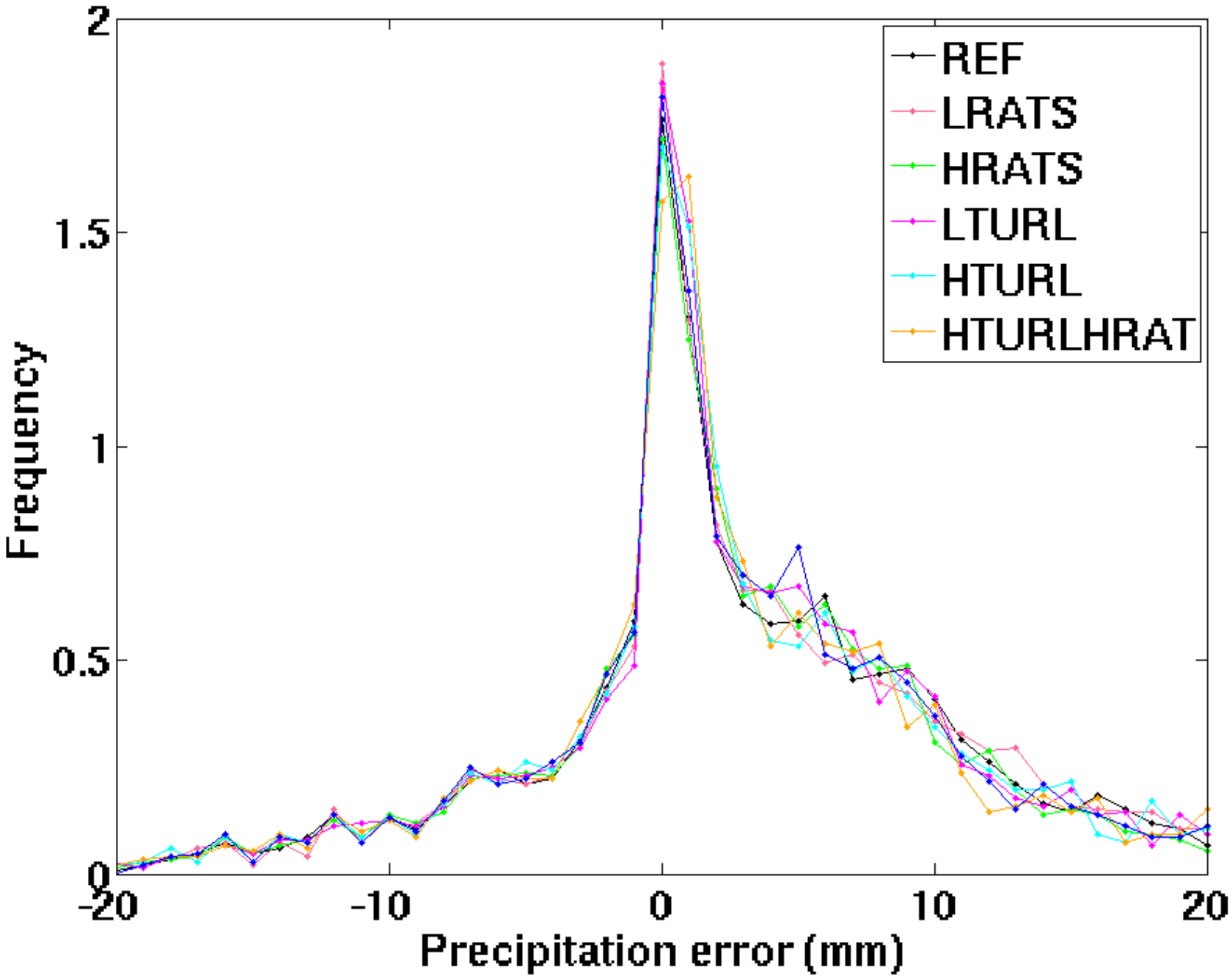
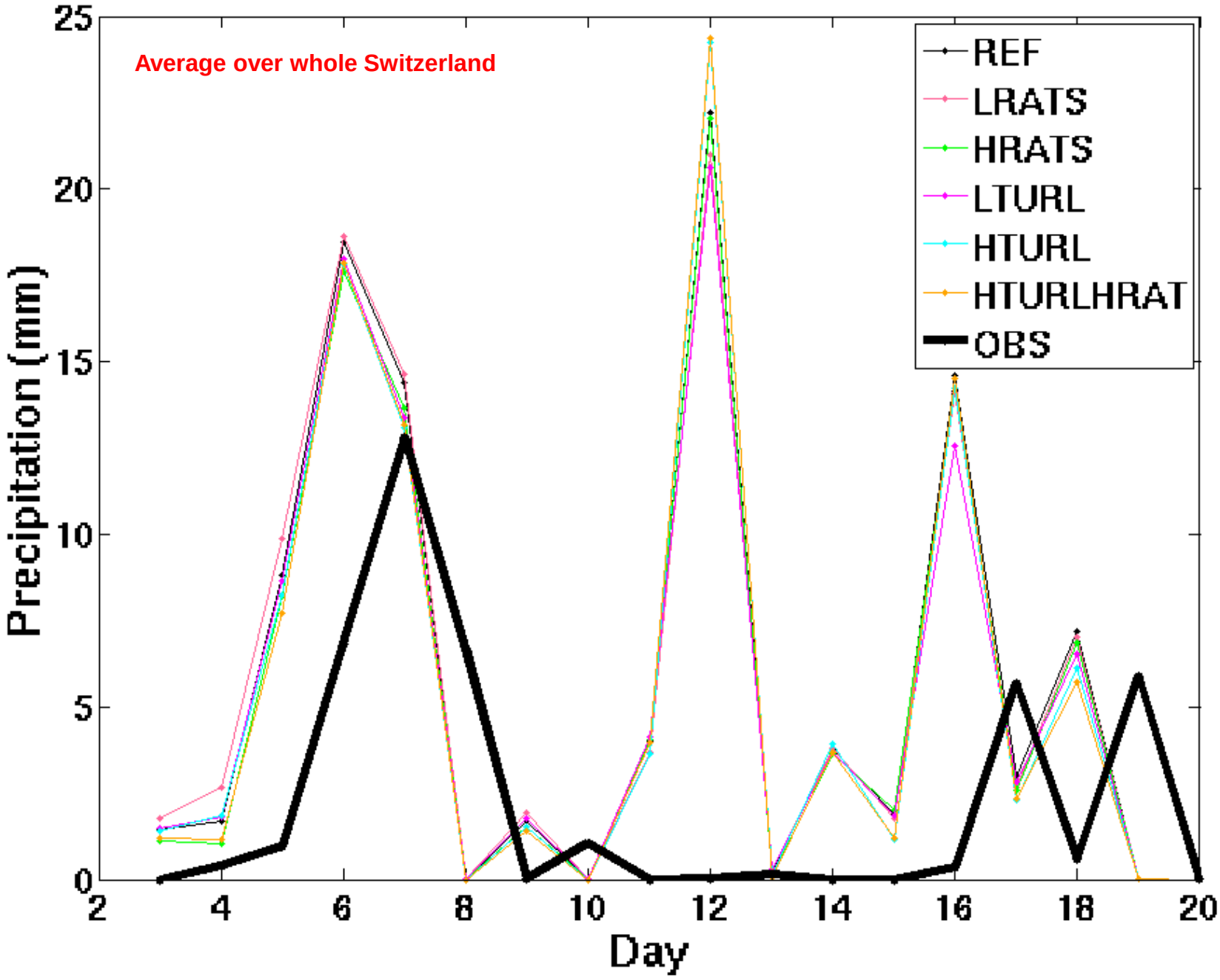
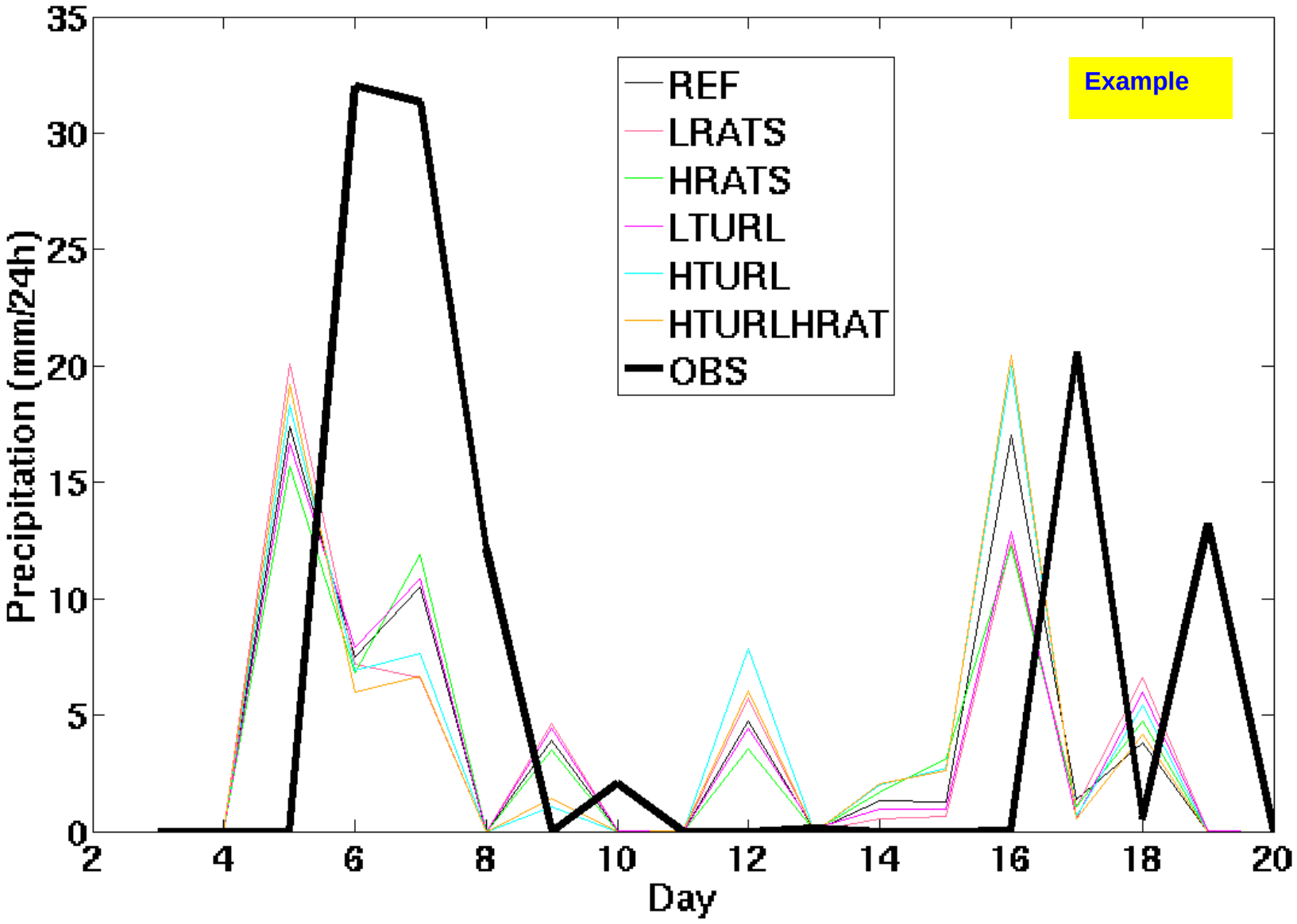
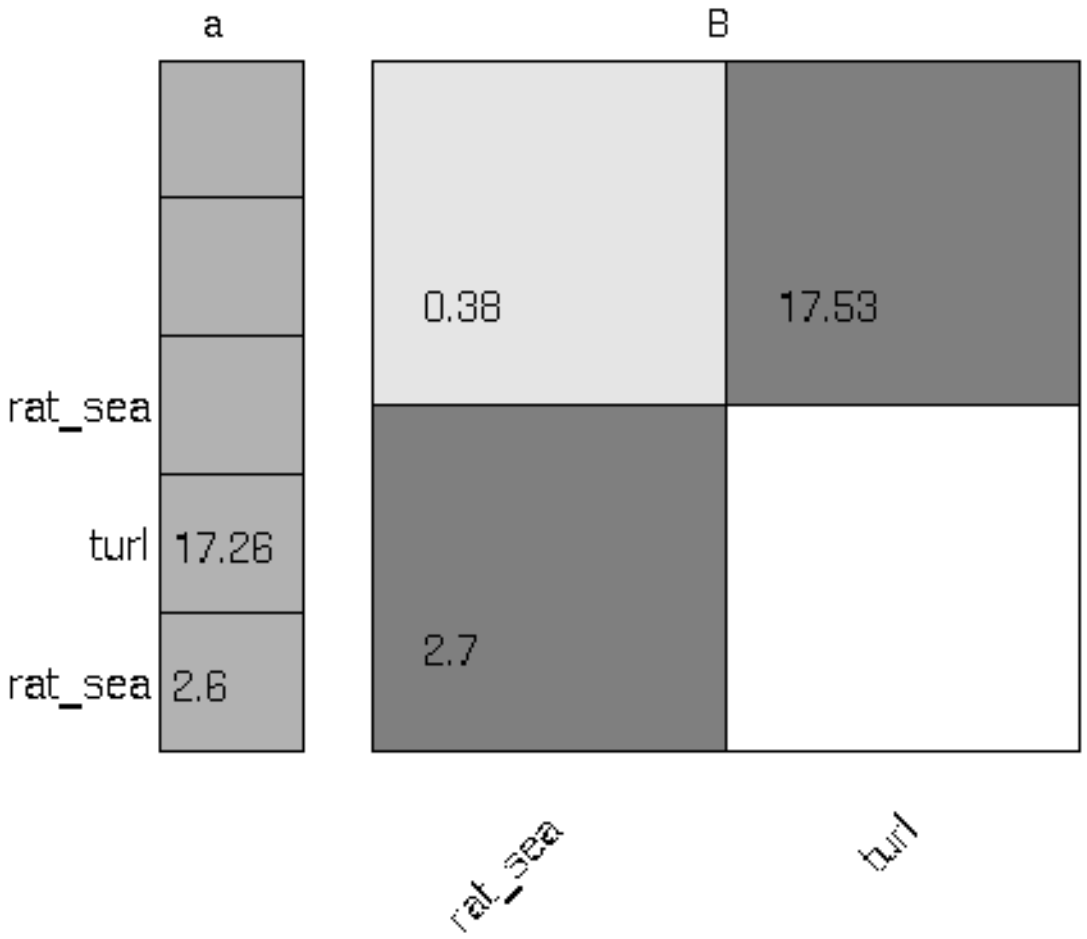
3. Accumulated Precipitation (mm/24h)

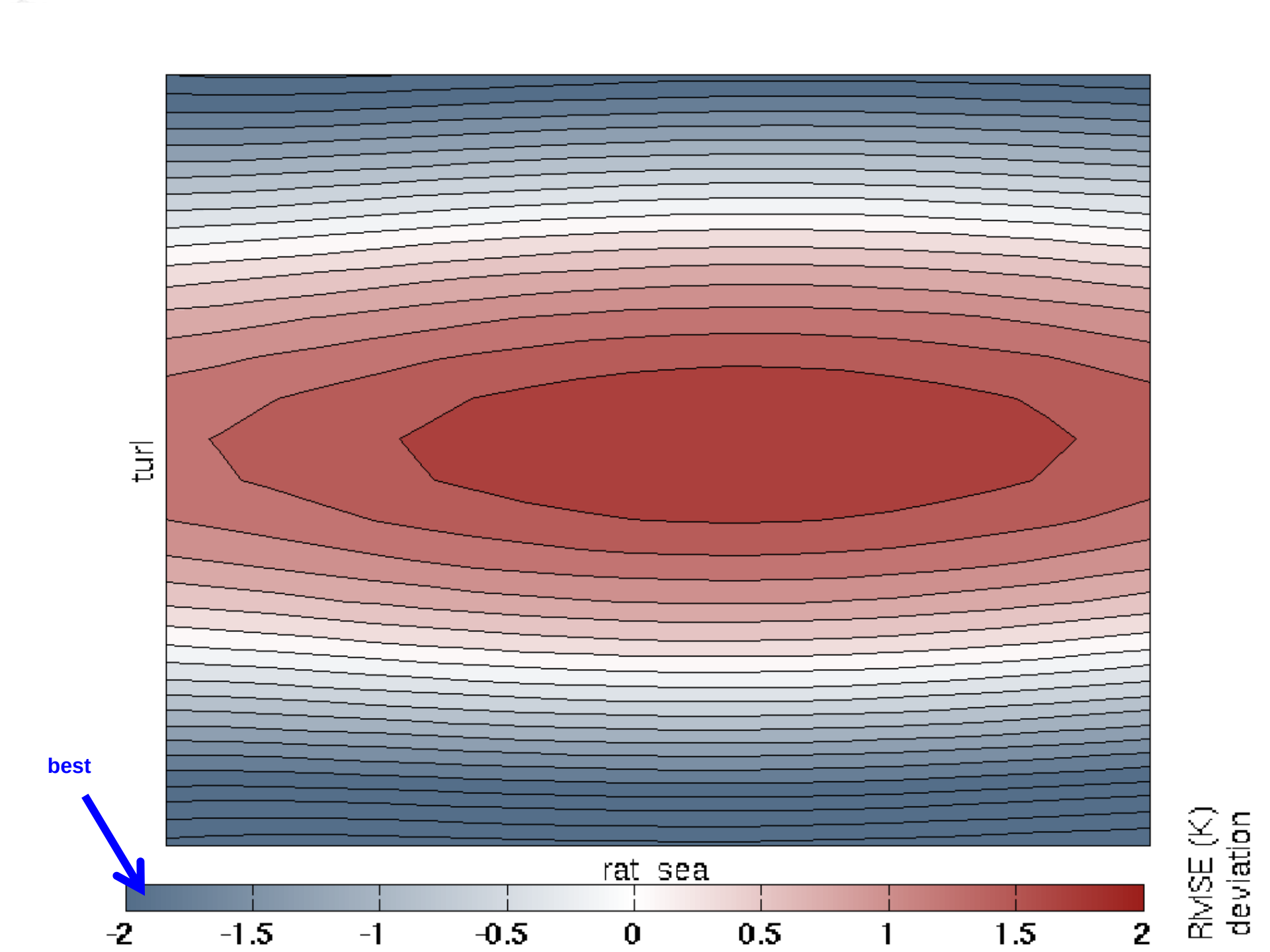

REF
LRATS
HRATS
LTURL
HTURL
HTURLHRAT
Frequency
Precipitation error (mm)
2
1.5
1
0.5
0
-20
-10
0
10
20

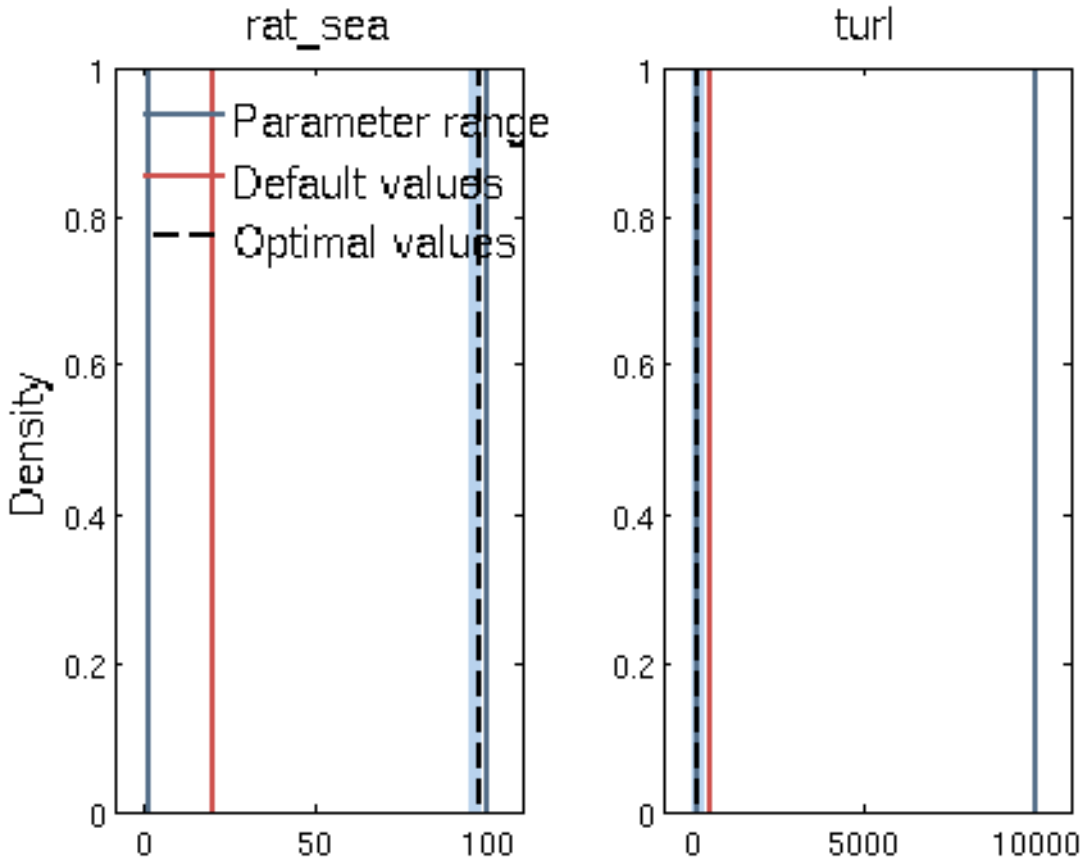

Average over whole Switzerland
REF
LRATS
HRATS
LTURL
HTURL
HTURLHRAT
OBS
Precipitation (mm)
Day
0
5
10
15
20
25
2
4
6
8
10
12
14
16
18
20

Precipitation (mm/24h) time series at region-103




a
B
rat_sea
turl
rat_sea
17.26
2.6
0.38
17.53
2.7
rat_sea
turl


turl
rat sea
best
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
RMSE (K)
deviation

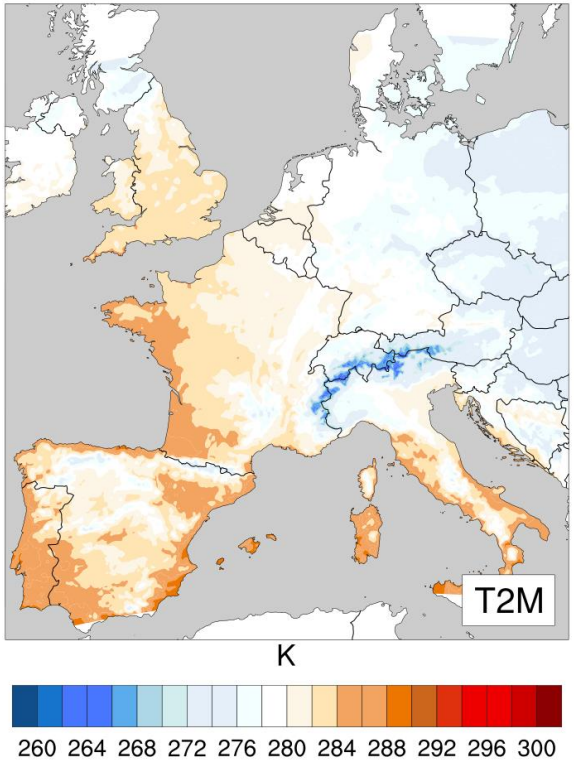

rat_sea
turl
Parameter range
Default values
Optimal values
Density
1
0.8
0.6
0.4
0.2
0
0
50
100
5000
10000

Fitting the MM- Finding the optimal set

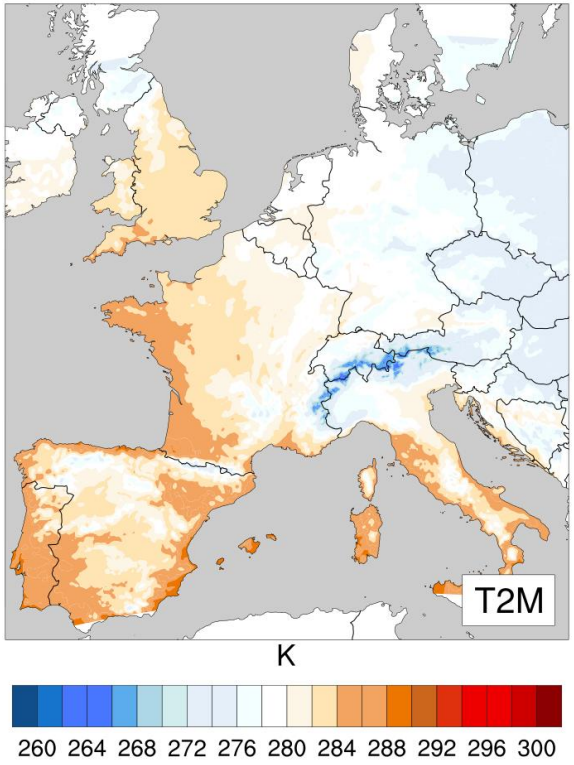
	Tmin	Tmax	Precipitation
Best rat_sea [1,20,100]	89.4	3	97.4
Best tur_len [100,500,10000]	265	9397	104.5

10.01.08 12 UTC

REF



OPT



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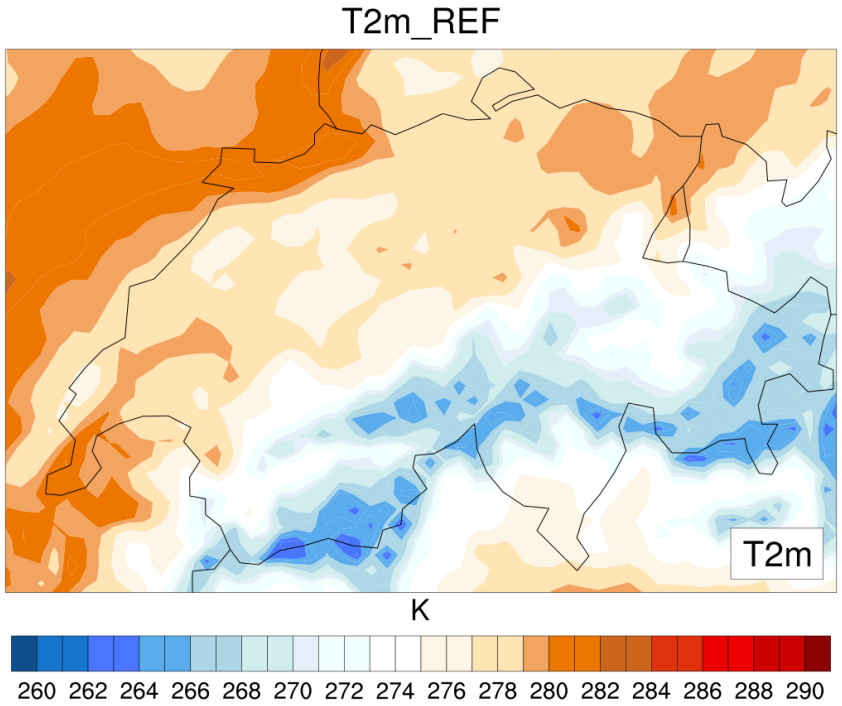
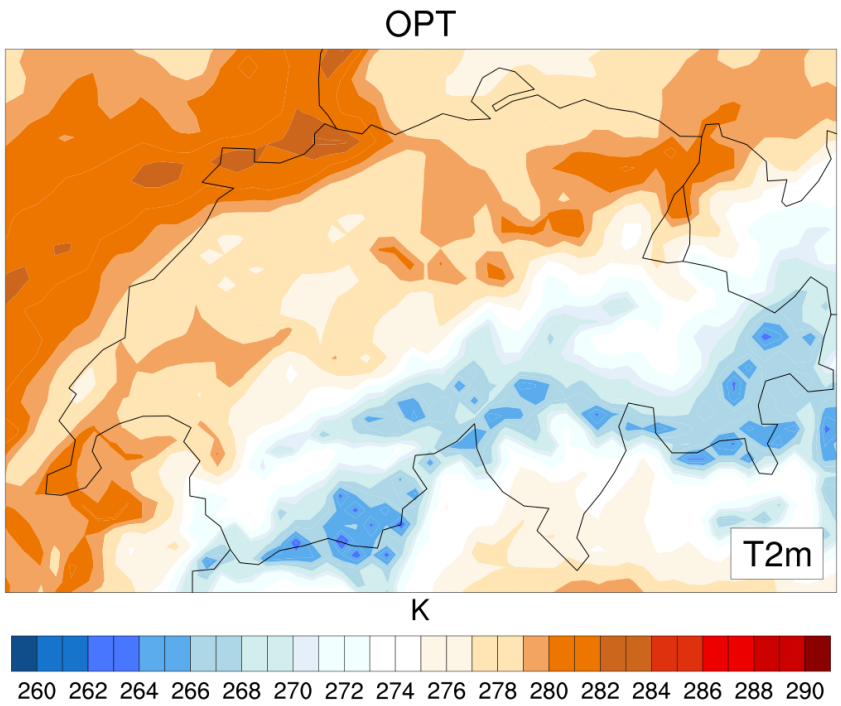
10.01.08 12 UTC





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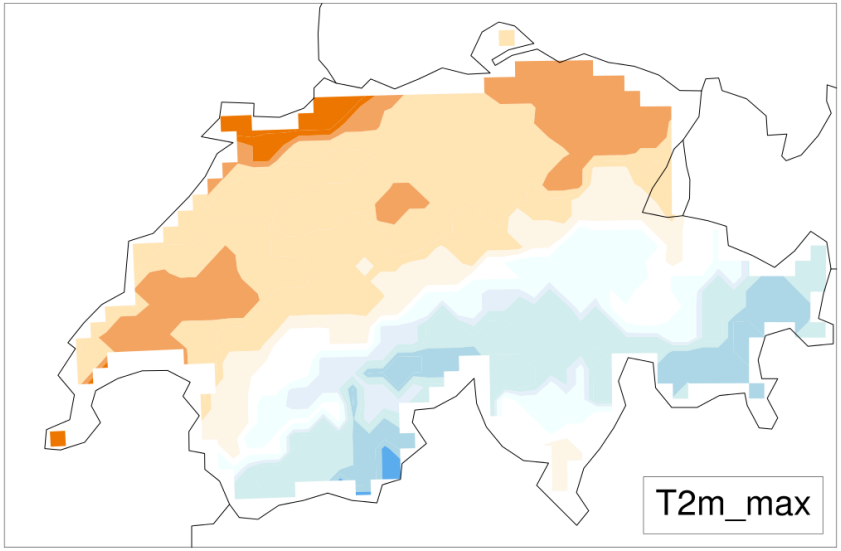
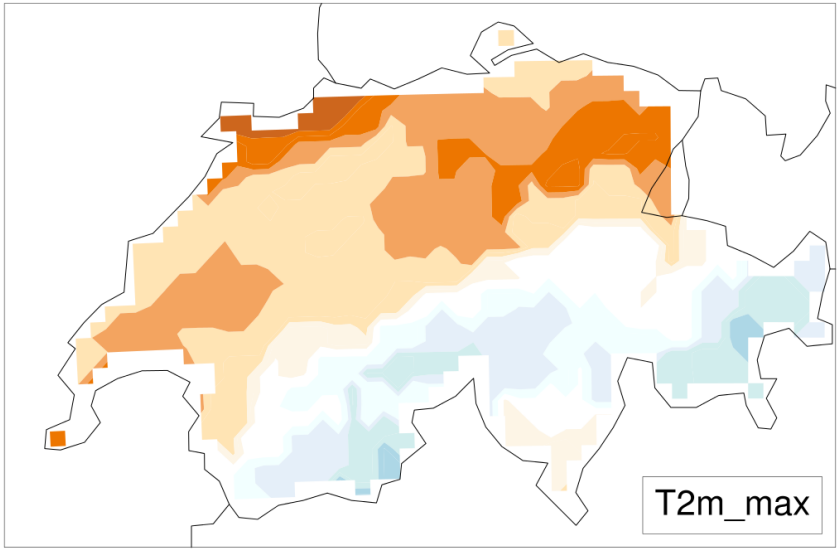
10.01.08

T2M_MAX_REF



T2M_MAX_OPT



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Difficulties- Open Issues

1. Definition of an objective **performance function:** Score selection other than RMSEv**(PS ????)**.
2. Important for NWP **model parameters** to be identified 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…….

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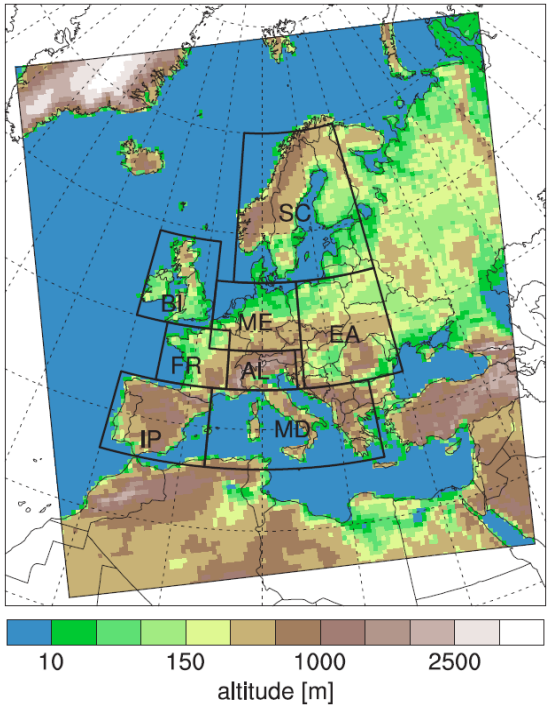
Method: Performance score

RCM Calibration

Multiobjective performance measure for climate applications

Used to select 5 important model parameters



Performance Score (PS)

$$PS = exp\left(-0.5\sqrt{\left\langle \frac{(m-o)^2}{(\sigma_{err}+\sigma_{iv}+\sigma_{inter})^2} \right\rangle}\right)$$

Least-squares error of monthly timerseries for T2M, PR and CLCT and for all PRUDENCE regions. (4DVar)

m=model output, o=observations

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Summary

- Primary goal of CALMO is to demonstrate the applicability of the approach using a computationally cost-effective framework.
- Due to the small domain (Switzerland) used initially a clear overview on the advantages of the methodology used was not evident.
- 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.
- CALMO gain: Delevopment of an automatised tool to re-calibrated COSMO for new model developments/target domains

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Any suggestions, comments, remarks?

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