CALMOMAX project – On the Meta Model

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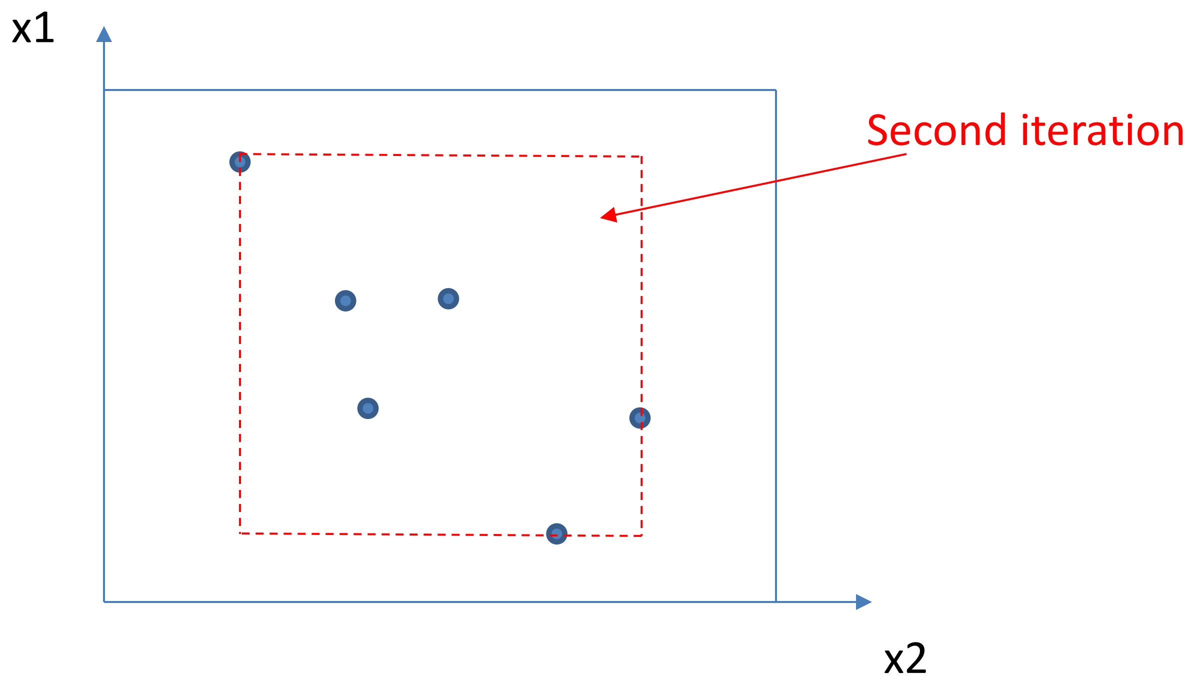
Outline

1. overview on the Convergence to the optimal parameters combination.
2. Results of Stage 2.
3. Results of Stage 3.
4. Results of Additional tests after stage 3 such as test for each month in 2013 and rainy days (only) in 2013.
5. Summary.

Convergence to the optimal parameters combination



Convergence to the optimal parameters combination

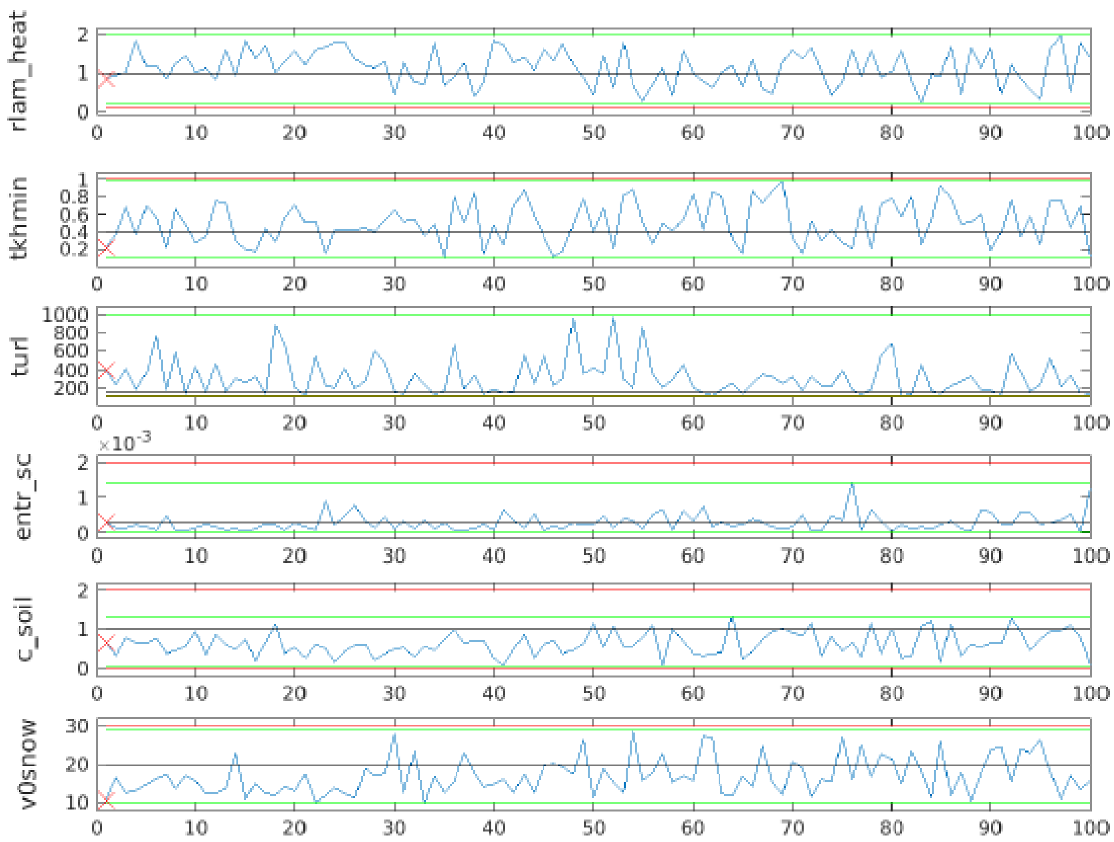


Figure 4: Example of convergence after first iteration. Each panel shows (in blue) the optimal 100 parameters values (in sorted order) among 1000 sampled combinations. The red lines represent the allowed ranges for each parameter, the green lines represent the uncertainty for each parameter after first iteration (following the optimal 100 values). Red crosses represent the best parameters combination after first iteration.

Convergence to the optimal parameters combination

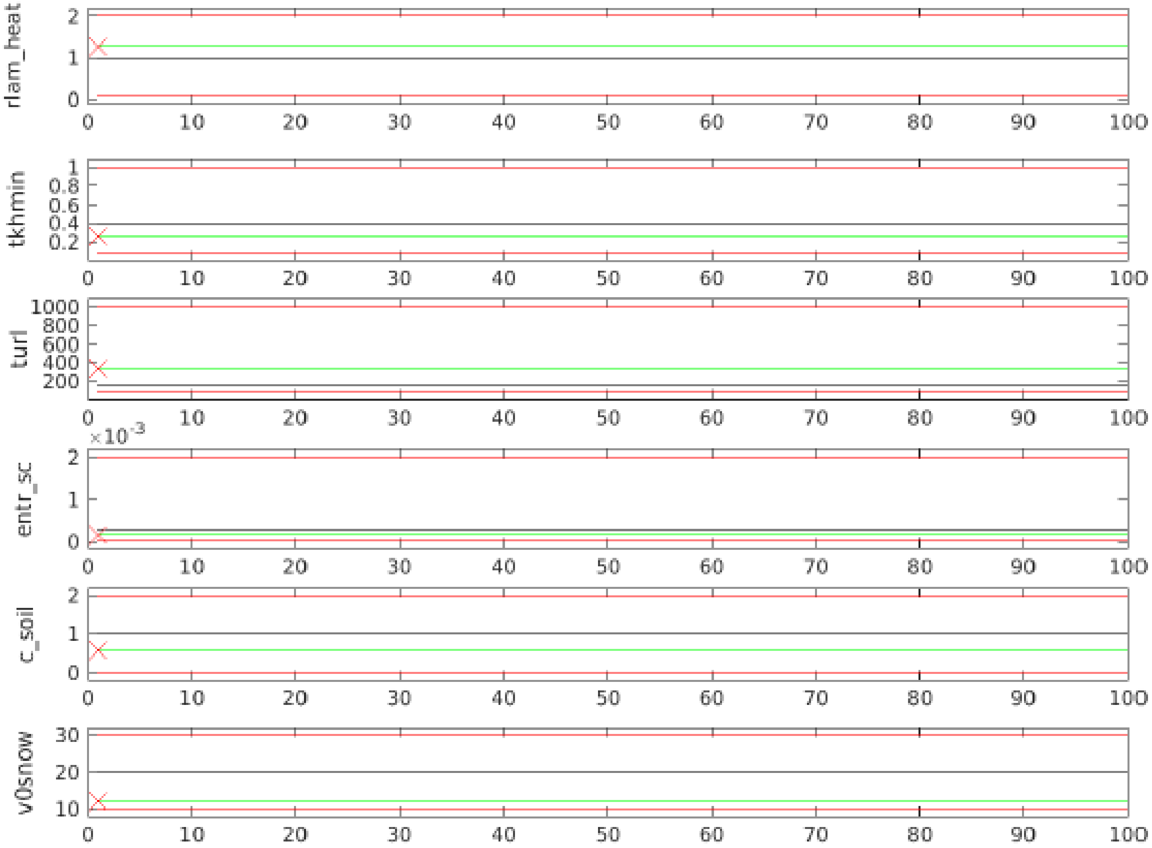


Figure 5: Example of convergence after last (35th) iteration.

Stage 2

Stage 2 is the COSMO 2.2km for all year of 2013.

Validation of CALMO stage-2 Meta-Model using arbitrary test simulation

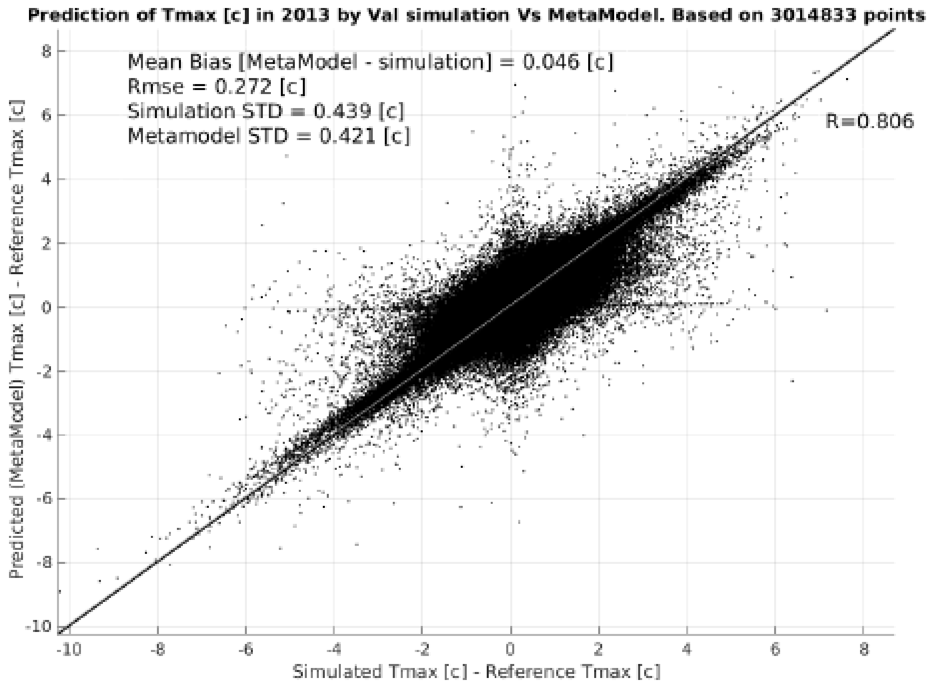


Figure 6: Tmax Meta-Model prediction for the tested parameter combination, vs COSMO simulation results during the year 2013. X axis presents the simulated Tmax minus the reference simulation. Y axis presents the Meta-Model Tmax minus the reference simulation.

Stage 2

Stage 2 is the COSMO 2.2km for all year of 2013.

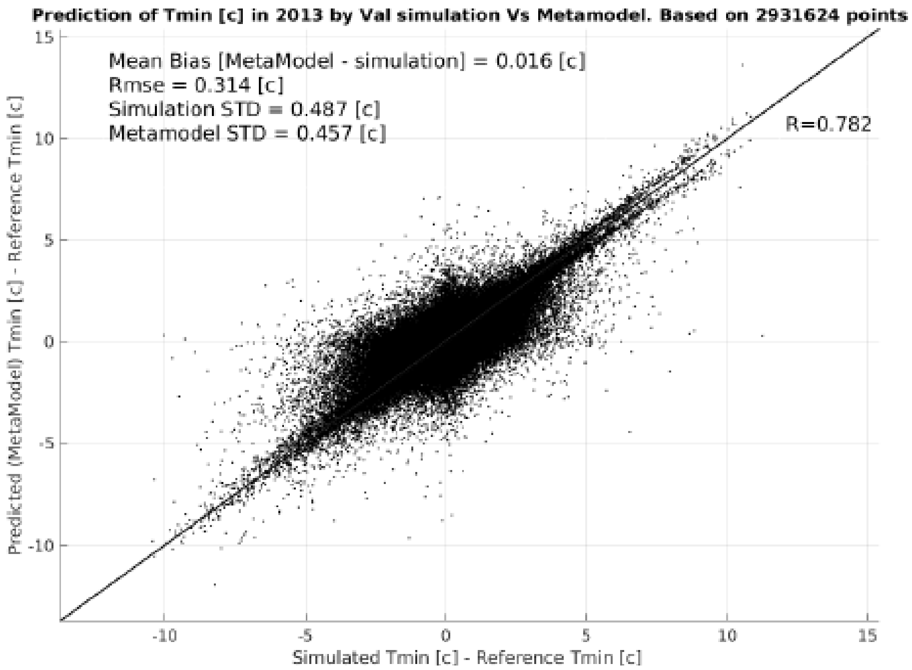


Figure 7: Tmin Meta-Model prediction for the tested parameter combination, vs COSMO simulation results during the year 2013. X axis presents the simulated Tmin minus the reference simulation. Y axis presents the Meta-Model Tmin minus the reference simulation.

Stage 2

Stage 2 is the COSMO 2.2km for all year of 2013.

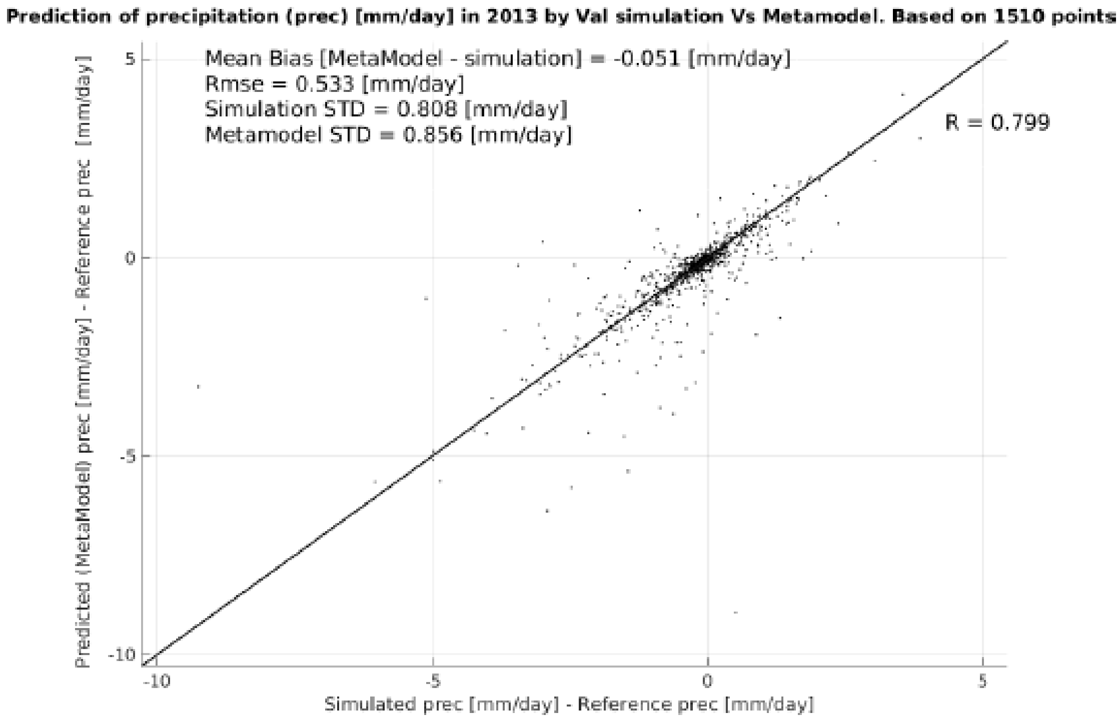


Figure 8: Pr Meta-Model prediction for the tested parameter combination, vs COSMO simulation results during the year 2013. X axis presents the simulated Pr minus the reference simulation. Y axis presents the Meta-Model Pr minus the reference simulation.

Stage 2

Stage 2 is the COSMO 2.2km for all year of 2013.

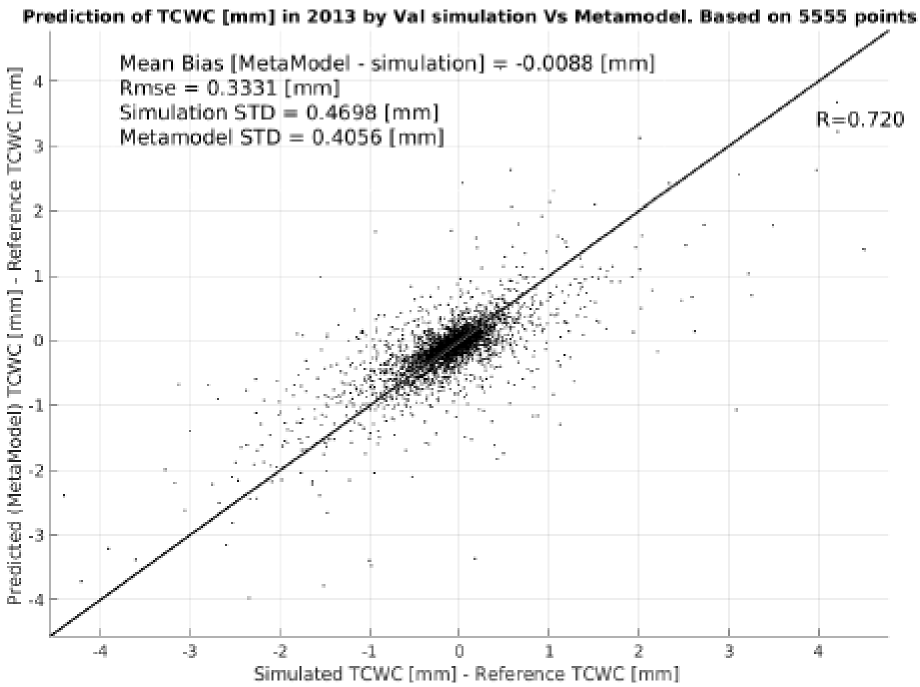


Figure 9: TCWC Meta-Model prediction for the tested parameter combination, vs COSMO simulation results during the year 2013. X axis presents the simulated TCWC minus the reference simulation. Y axis presents the Meta-Model TCWC minus the reference simulation.

Stage 2

Stage 2 is the COSMO 2.2km for all year of 2013.

Calibration results for entire year 2013

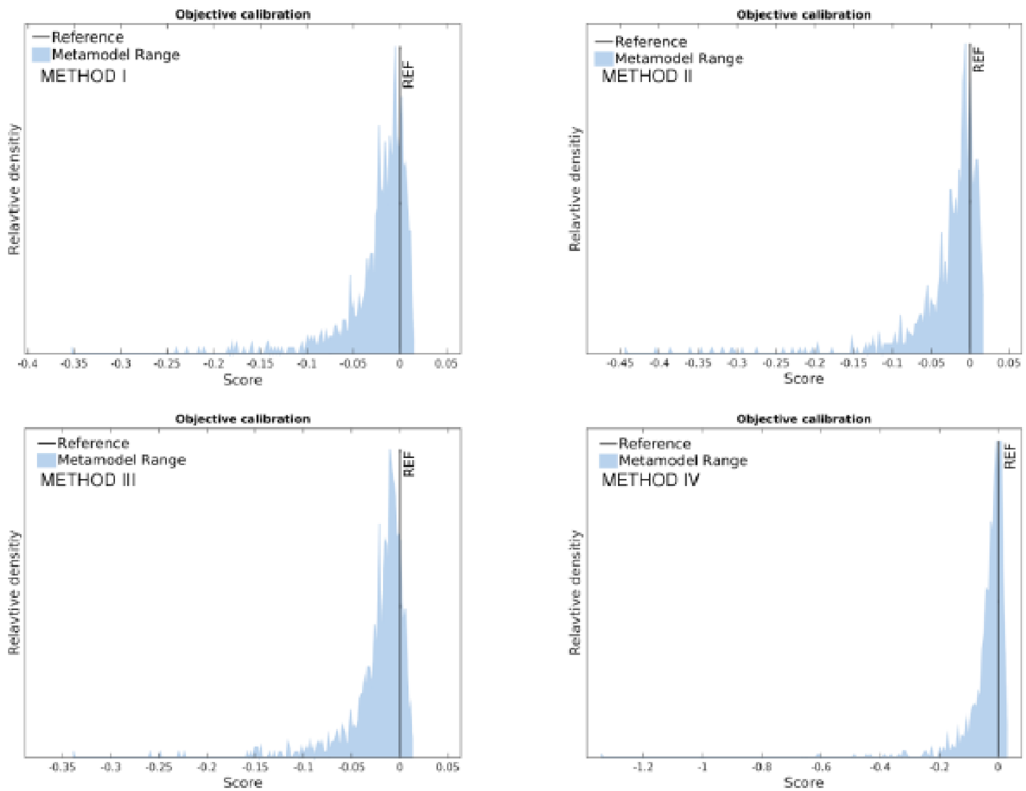


Figure 14: S_p scores distributions after **first** iteration, together with the score of the reference (REF) simulation, for methods I-IV. For convenience, the distributions are presented as function of $\widetilde{S}_p = 1 - S_p/S_{p,REF}$ for methods I, II and as function of $\widetilde{S}_p = S_p/S_{p,REF} - 1$ for methods III, IV. Therefore higher $\widetilde{S}_p > 0$ means better score with respect to the REF simulation.

Stage 2

Stage 2 is the COSMO 2.2km for all year of 2013.

The four methods

1. Averaging Tmax and Tmin over region, using RMSE-type score (Matlab parmeter ‘pr_only’=0).

2. Not Averaging Tmax and Tmin over region, using RMSE-type score (Matlab parameter ‘pr_only’=1).

3. Averaging Tmax and Tmin over region, using COSI-type score (Matlab parameter ‘pr_only’=0).

4. Not Averaging Tmax and Tmin over region, using COSI-type score (Matlab parameter ‘pr_only’=1).

Stage 2

Stage 2 is the COSMO 2.2km for all year of 2013.

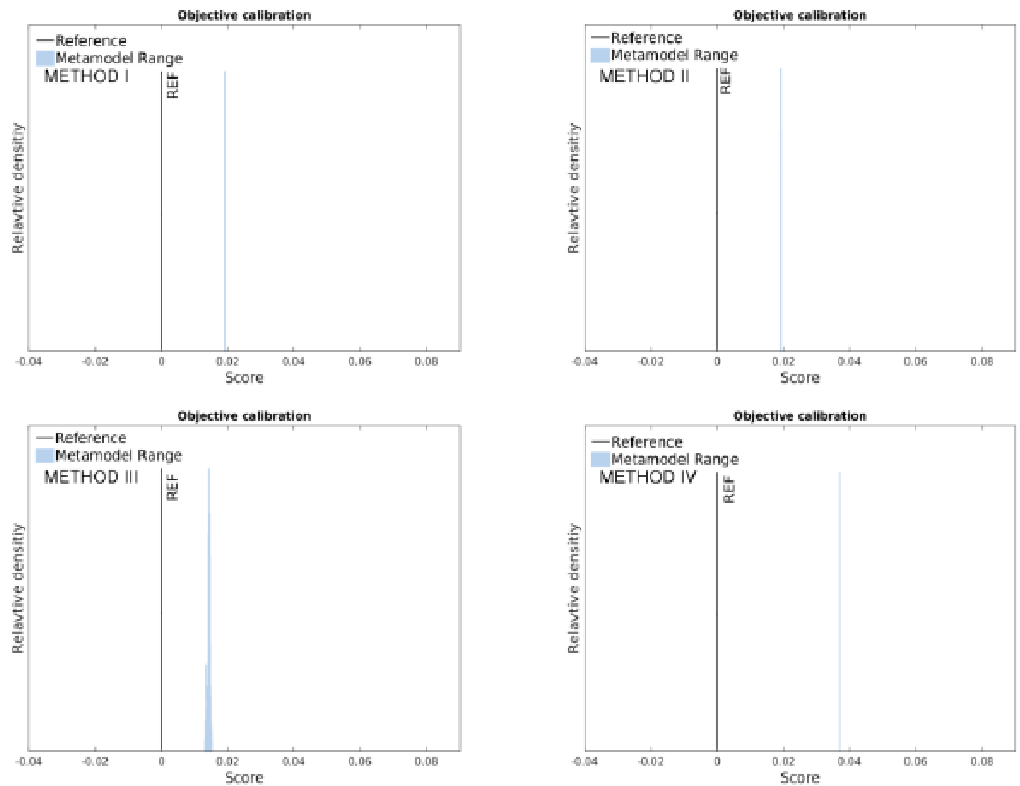


Figure 15: S_p scores distributions after **last** iteration, together with the score of the reference (REF) simulation, for methods I-IV. For convenience, the distributions are presented as function of $\widetilde{S}_p = 1 - S_p/S_{p,REF}$ for methods I, II and as function of $\widetilde{S}_p = S_p/S_{p,REF} - 1$ for methods III, IV. Therefore higher $\widetilde{S}_p > 0$ means better score with respect to the REF simulation.

Stage 2

Stage 2 is the COSMO 2.2km for all year of 2013.

Optimal parameters For Method IV.

Assuming method IV as the most reasonable, the final optimal parameters combination with its uncertainty is:

- rlam_heat=1.273 instead of the default 1.0. Uncertainty: [1.149 1.390];
- tkhmin=0.266 instead of the default 0.4; Uncertainty: [0.205 0.351];
- tur_len=346.5 instead of the default 150; Uncertainty: [294.6 409.9];
- entr_sc=0.0001607 instead of the default 0.003; Uncertainty: [0.0001261 0.0002104];
- c_soil=0.588 instead of the default 1.0; Uncertainty: [0.515 0.664];
- v0snow=12.3 instead of the default 20; Uncertainty: [11.6 13.3].

Stage 2

Calibration results - seasonal dependence

Cases	rlam_heat	Tkhmin	tur_len
Entire 2013	1.149 **1.273** 1.390 [-6.5% +6.2%]	0.205 **0.266** 0.351 [-6.8% +9.4%]	294.6 **346.5** 409.9 [-5.8% +7.0%]
Summer 2013	0.954 **1.071** 1.164 [-6.2% +4.9%]	0.186 **0.221** 0.270 [-3.9% +5.4%]	352.2 **357.5** 398.9 [-0.6% +4.6%]
Winter 2013	0.982 **1.112** 1.232 [-6.8% +6.3%]	0.791 **0.891** 0.929 [-11.1% +4.2%]	109.8 **117.2** 127.9 [-0.8% +1.2%]

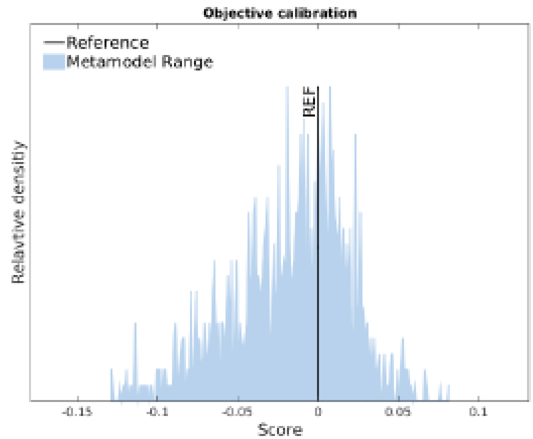
Table 5: CALMO stage-2 optimal parameters combinations, as well as their uncertainties for method IV for the following cases: all months in 2013, summer 2013 (Jul, Aug and Sep) and winter 2013 (Jan, Feb and Mar).

Cases	entr_sc (10^{-4})	c_soil	v0snow
Entire 2013	1.261 **1.607** 2.104 [-1.8% +2.5%]	0.515 **0.588** 0.664 [-3.7% +3.8%]	11.6 **12.3** 13.3 [-3.5% +5.0%]
Summer 2013	4.439 **4.890** 5.495 [-2.3% +3.1%]	1.090 **1.150** 1.205 [-3.0% +2.8%]	20.2 **21.2** 22.3 [-5.5% +5.0%]
Winter 2013	1.387 **1.714** 2.076 [-1.7% +1.9%]	0.0 **0.041** 0.134 [-2.1% +4.7%]	29.2 **30.0** 30.0 [-4.0% +0.0%]

Table 6: CALMO stage-2 optimal parameters combinations, as well as their uncertainties for method IV for the following cases: all months in 2013, summer 2013 (Jul, Aug and Sep) and winter 2013 (Jan, Feb and Mar).

Stage 3

Calibration results for January 2013



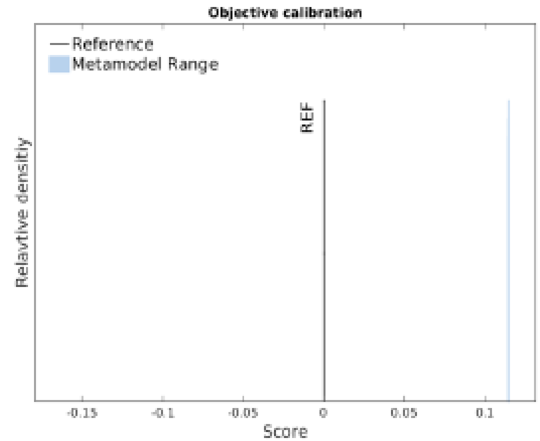


Figure 22: S_p scores distributions after **first** iteration (left) and **last** iteration (right), together with the scores of the reference (REF) simulation. For convenience, the distributions are presented as function of $\widetilde{S}_p = S_p/S_{p,REF} - 1$. Higher $\widetilde{S}_p > 0$ means better score with respect to the REF simulation.

Stage 3

Taking into account the uncertainties using also cases 1-5, the final optimal parameters combination (with its uncertainty) is:

- tkhmin=**1** instead of the default 0.4; Uncertainty: [0.983 1];
- tur_len=**109.3** instead of the default 150; Uncertainty: [104.3 117.2];
- entr_sc=**0.002** instead of the default 0.003; Uncertainty: [0.0018 0.002];
- c_soil=**2** instead of the default 1.0; Uncertainty: [1.937 2];
- crsmin=**200** instead of the default 150; Uncertainty: [186.3 200].

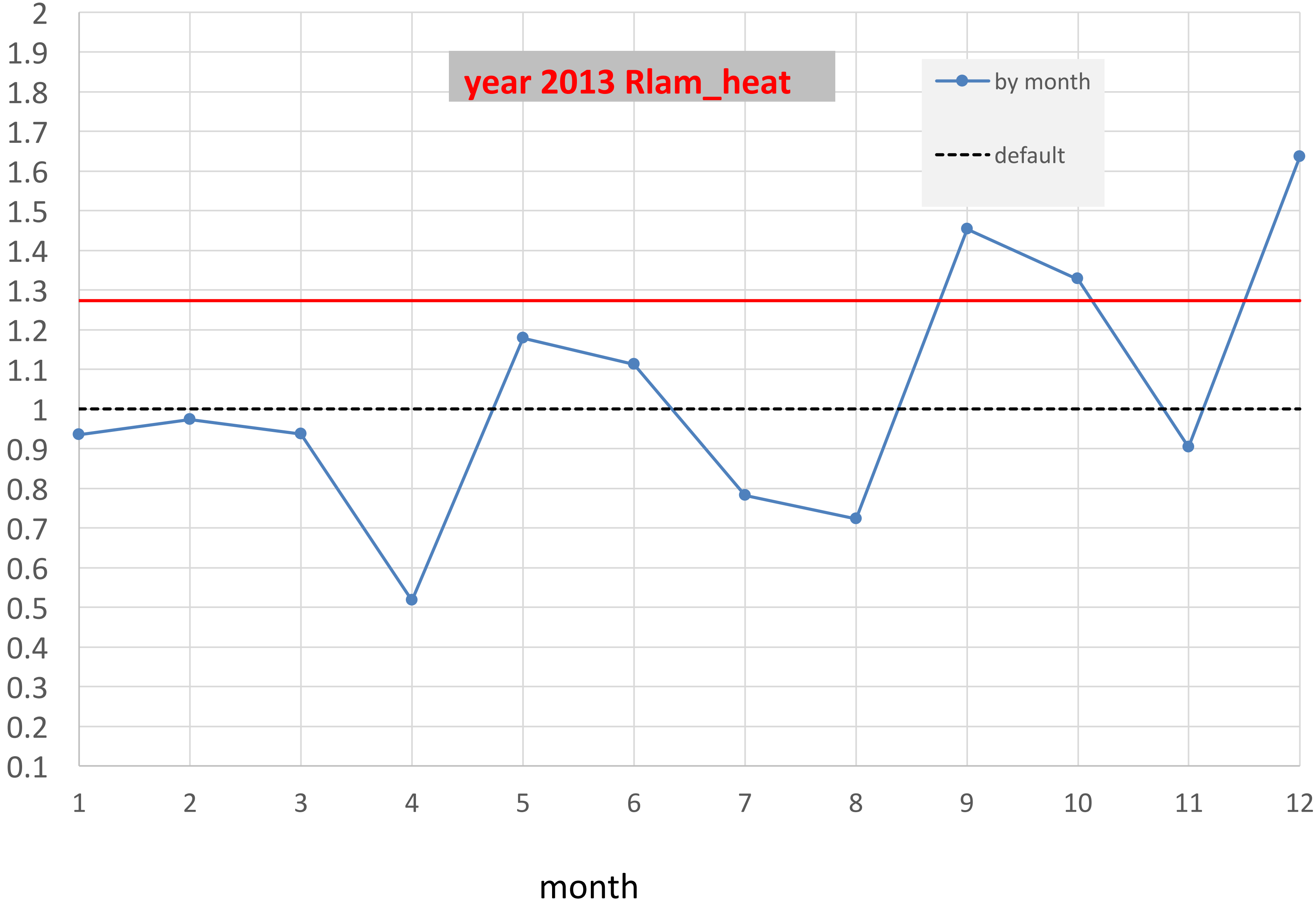
Summary of Stage 2 and Stage 3 where the values in tables are referred to method IV.

CALMO Stage	rlam_heat	Tkhmin	tur_len
Stage-2 Entire 2013	1.149 1.273 1.390 [-6.5% +6.2%]	0.205 0.266 0.351 [-6.8% +9.4%]	294.6 346.5 409.9 [-5.8% +7.0%]
Stage-2 Jan 2013	0.845 0.935 1.002 [-4.7% +3.5%]	0.191 0.220 0.262 [-3.2% +4.7%]	559.8 653.3 753.0 [-10.4% +11.1%]
Stage-3 Jan 2013	Default value*	0.983 1.000 1.000 [-1.9% +0.0%]	104.3 109.3 117.2 [-0.6% +0.9%]

CALMO Stage	entr_sc (10^{-4})	c_soil	v0snow
Stage-2 Entire 2013	1.261 1.607 2.104 [-1.8% +2.5%]	0.515 0.588 0.664 [-3.7% +3.8%]	11.6 12.3 13.3 [-3.5% +5.0%]
Stage-2 Jan 2013	2.346 2.764 3.242 [-2.1% +2.5%]	0.653 0.756 0.841 [-5.2% +4.3%]	11.2 11.8 12.3 [-3.0% +2.5%]
Stage-3 Jan 2013	18.0 20.0 20.0 [-10.3% +0.0%]	1.937 2.000 2.000 [-3.2% +0.0%]	Default value*

New Results Beyond Stage 3:

The optimal parameters for Method 4 at COSMO 2.2km (Method 4 = Score by COSI method and pr_only=1 (only area average on rain, not on Daily Tmin and Tmax)



New Results Beyond Stage 3:

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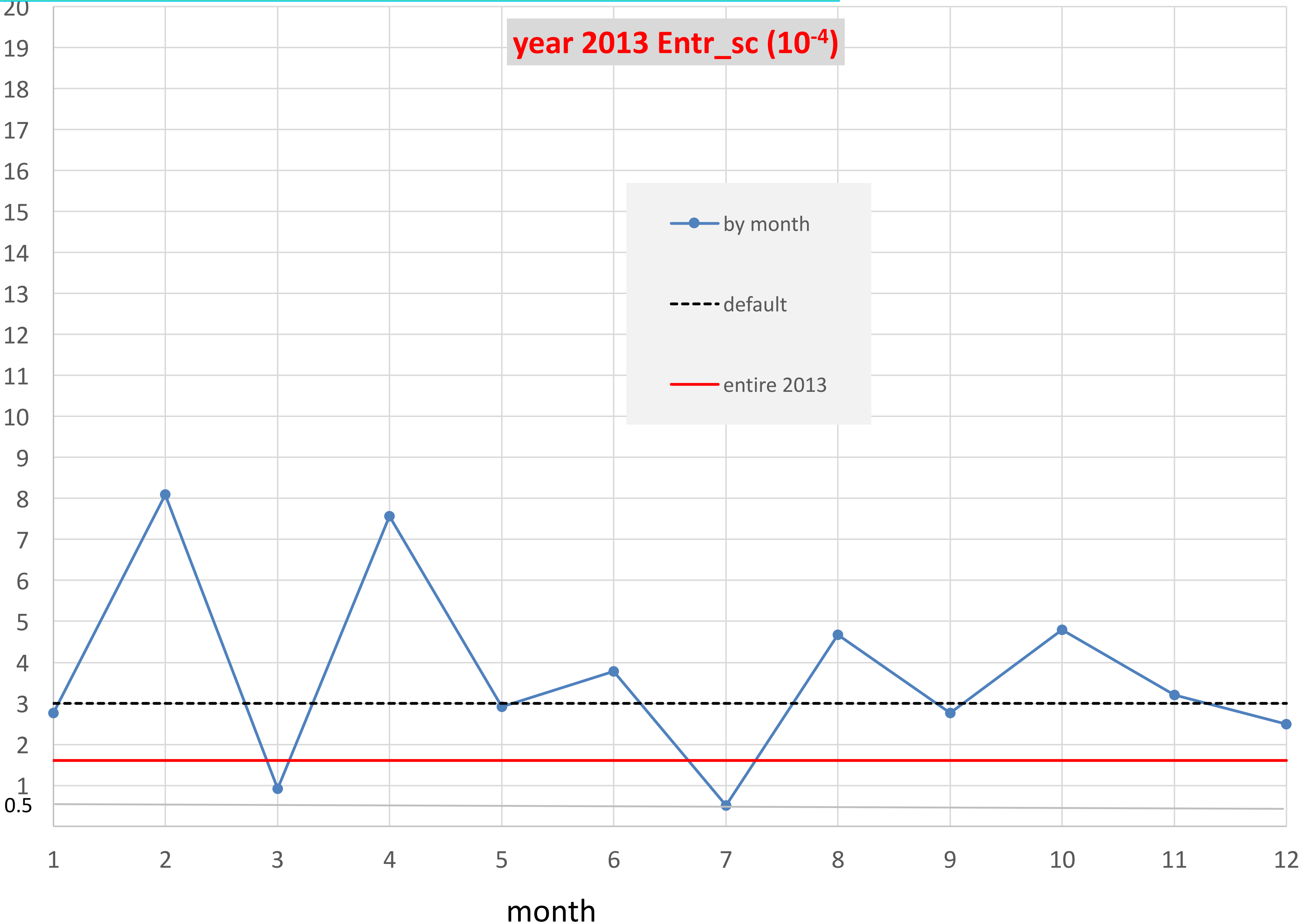
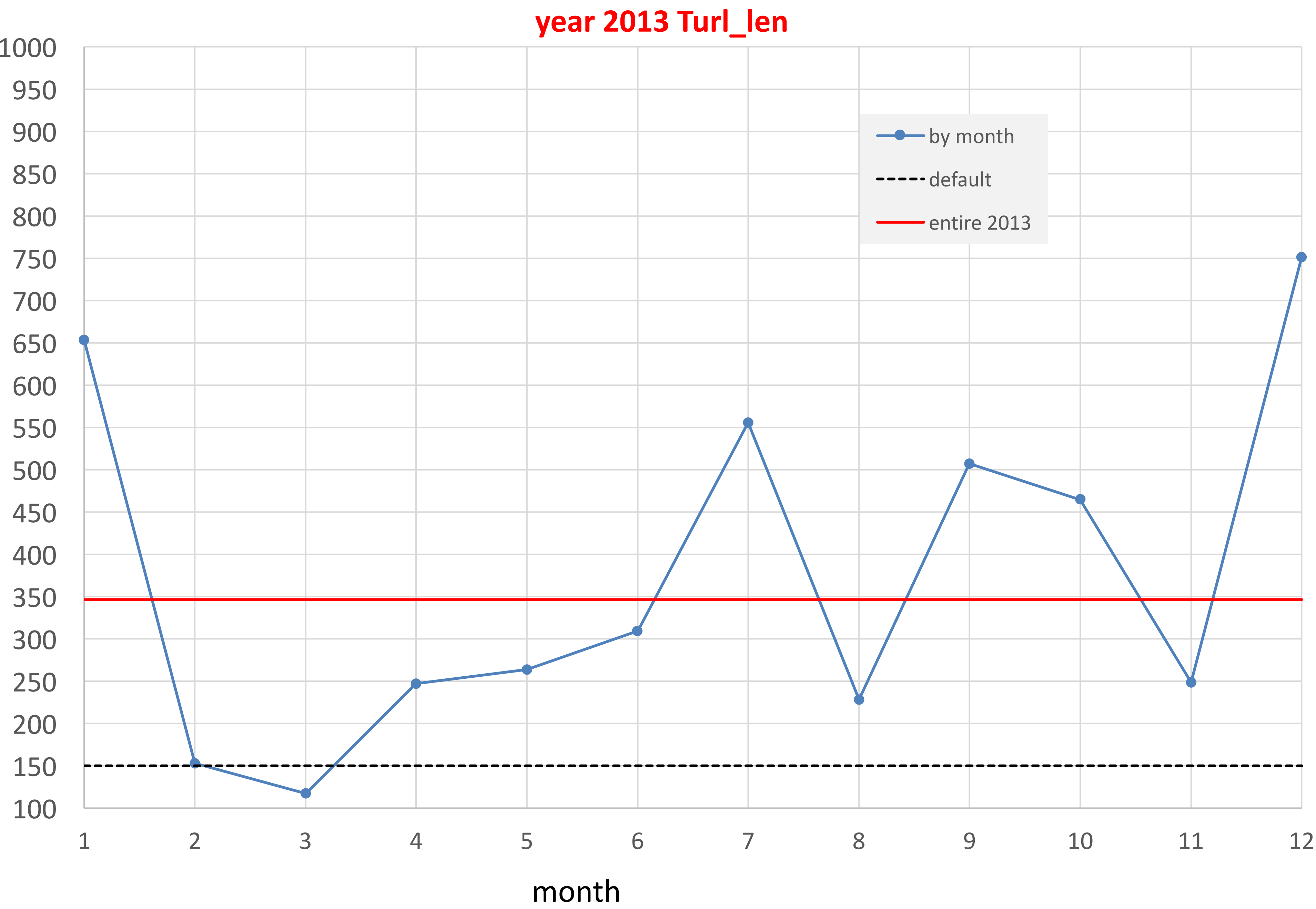
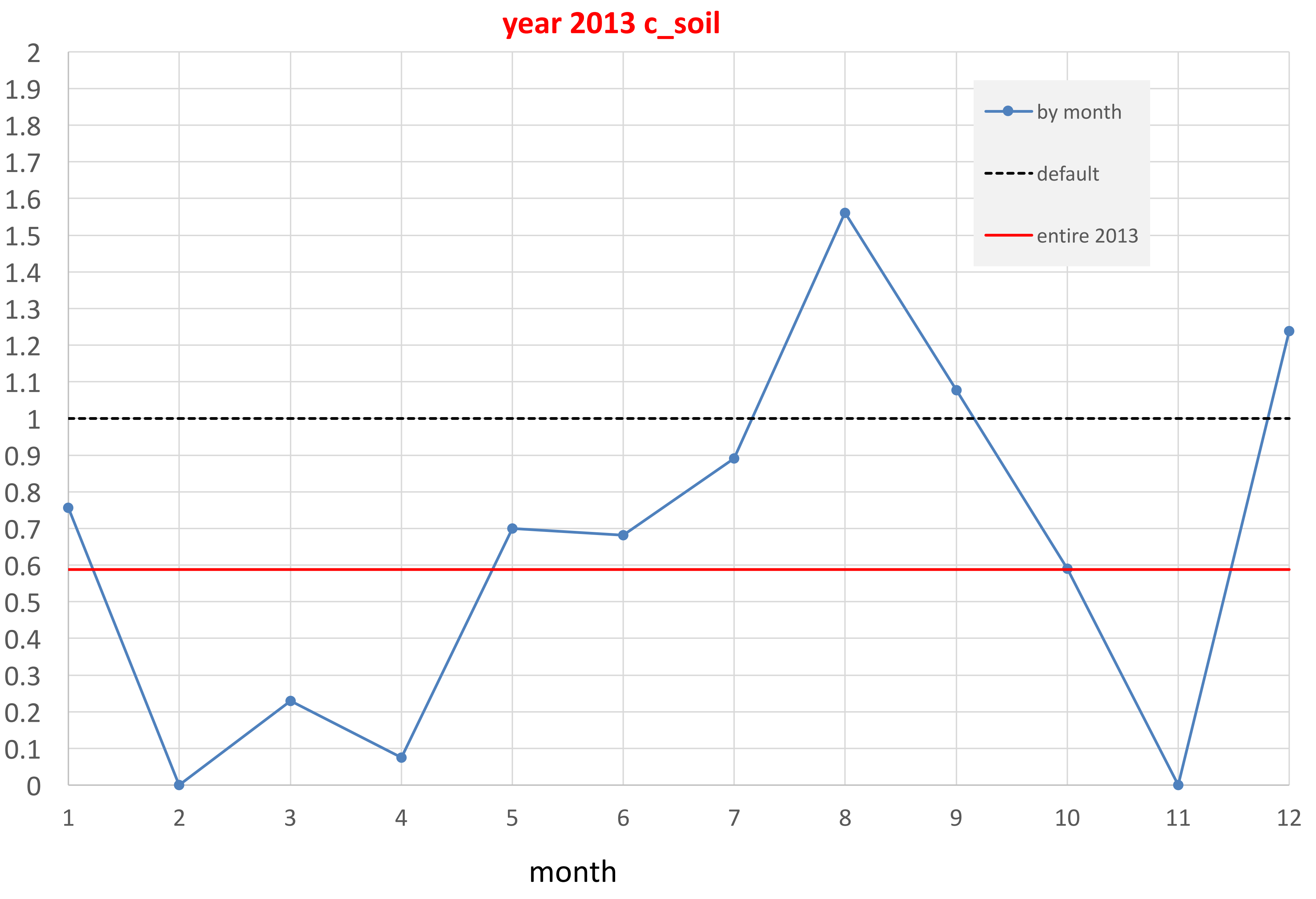


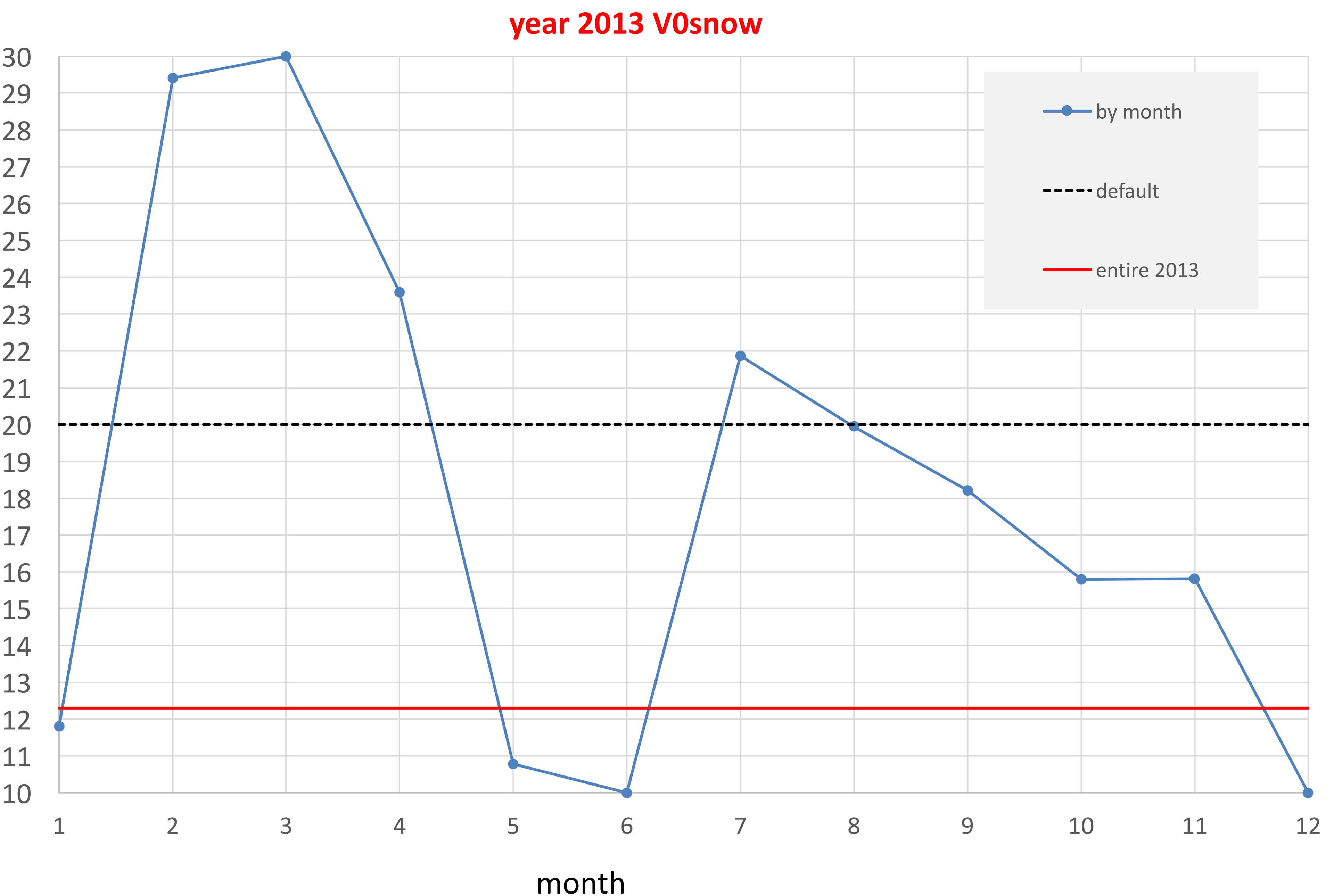
New Results Beyond Stage 3:



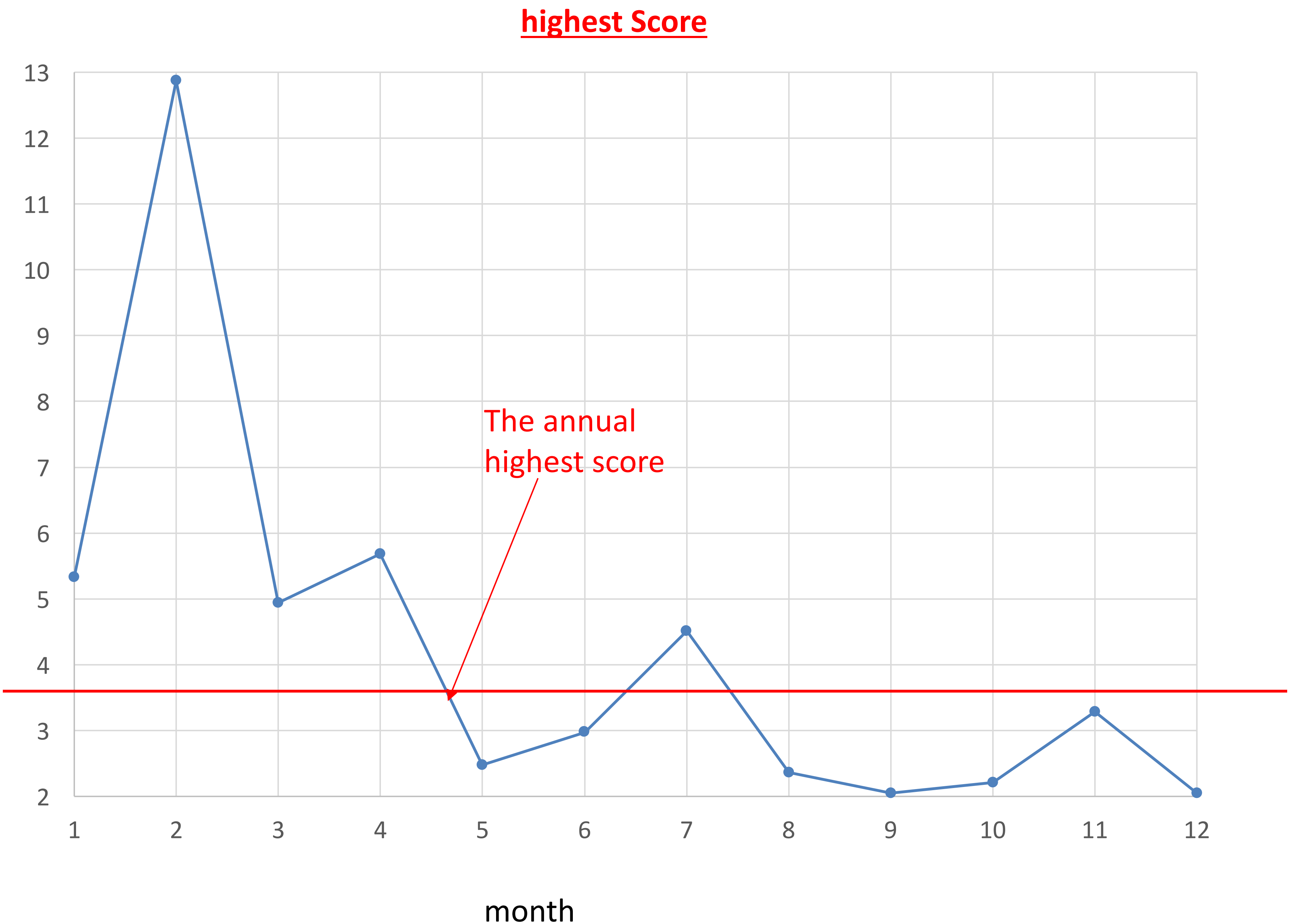
New Results Beyond Stage 3:



New Results Beyond Stage 3:



New Results Boyhood Stage 3:



New Results Beyond Stage 3:

Rainy Day Optimal parameters for 2013

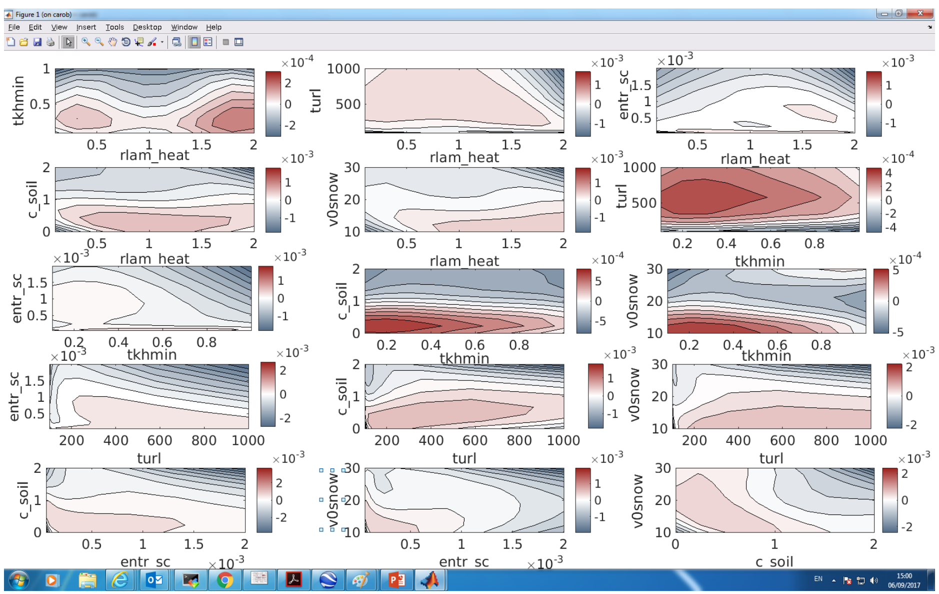
- The test of CALMO Rainy days is for Method 4 (COSI and pr_only=1) and COSMO 2.2km and year 2013.
- Only days with observed precipitation average area above or equal 0.05 mm/day.
- Approximately , 60% of the observed days in 2013 has above or equal 0.05 mm/days (for area average, there are 7 areas).
- We did not choose the threshold of rainy days to be 0.1mm because 0.01 mm is one of the five thresholds for calculating ETS of precipitation (see COSI method).

New Results Beyond Stage 3:

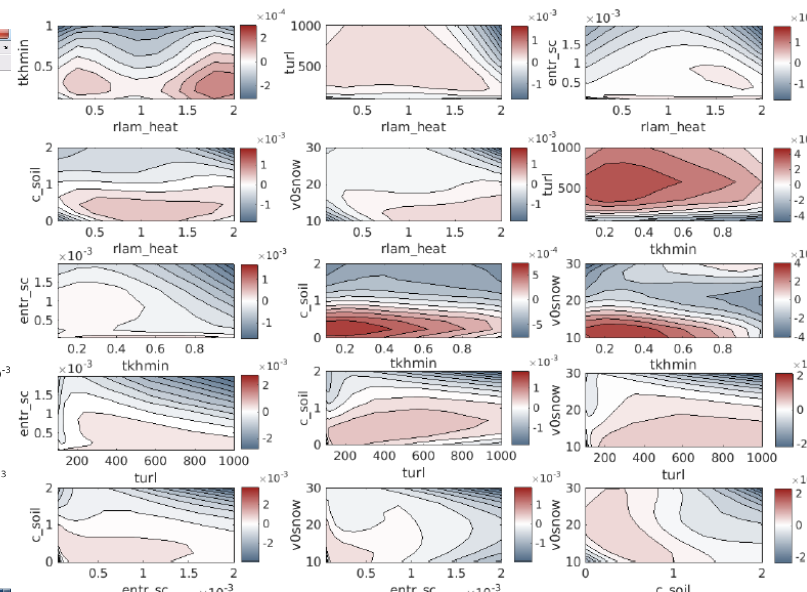
Planes Figure

CALMO with observed Rainy days compared to all days in 2013 (all available observation). The score is by COSI method

Only for daily Rain above or equal 0.05mm in 2013



All available observed days in 2013

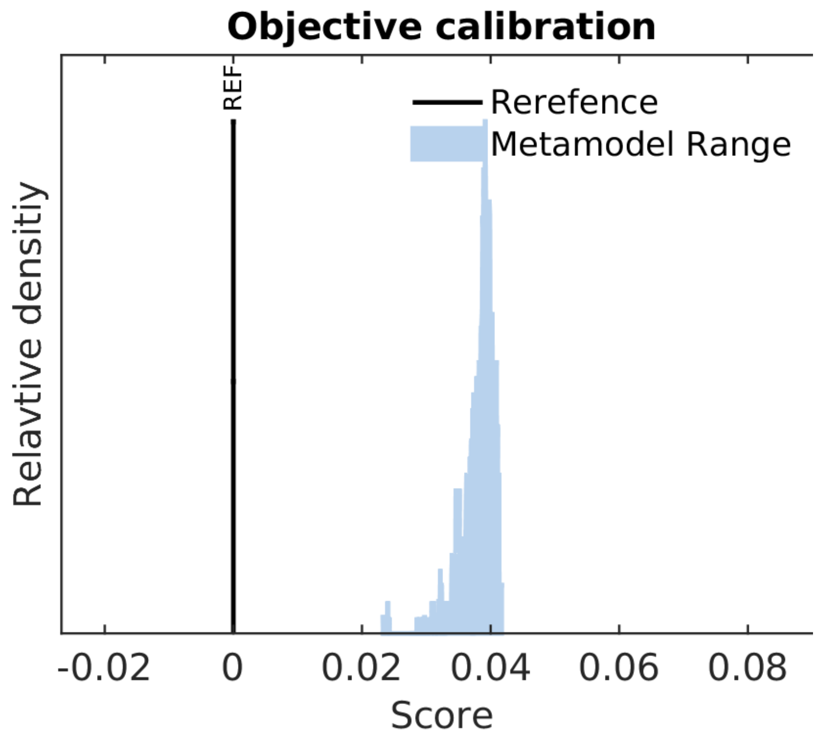


New Results Beyond Stage 3:

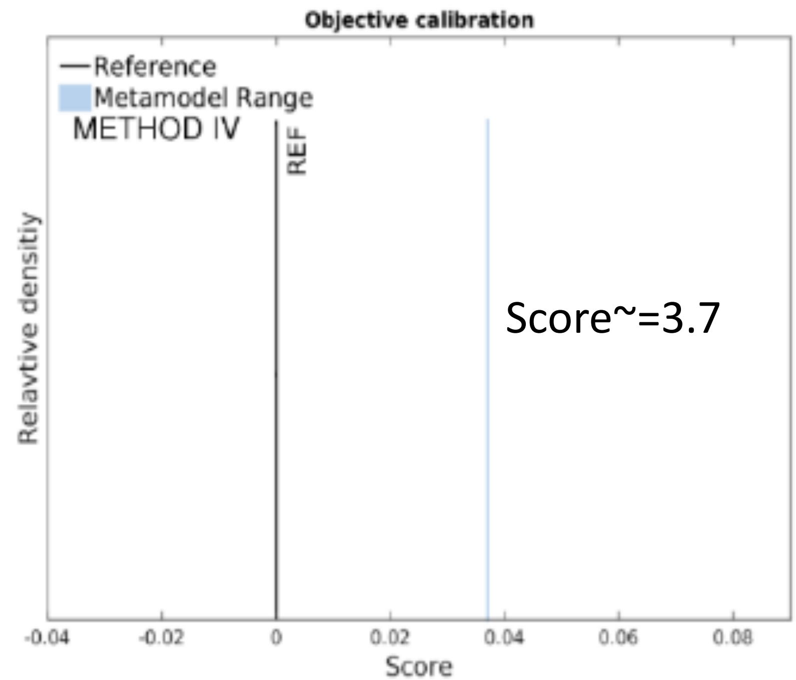
COSI Score

CALMO with observed Rainy days compared to all days in 2013 (all available observation). The score is by COSI method

CALMO Rainy days for iteration 10.



CALMO all days (for iteration 40)



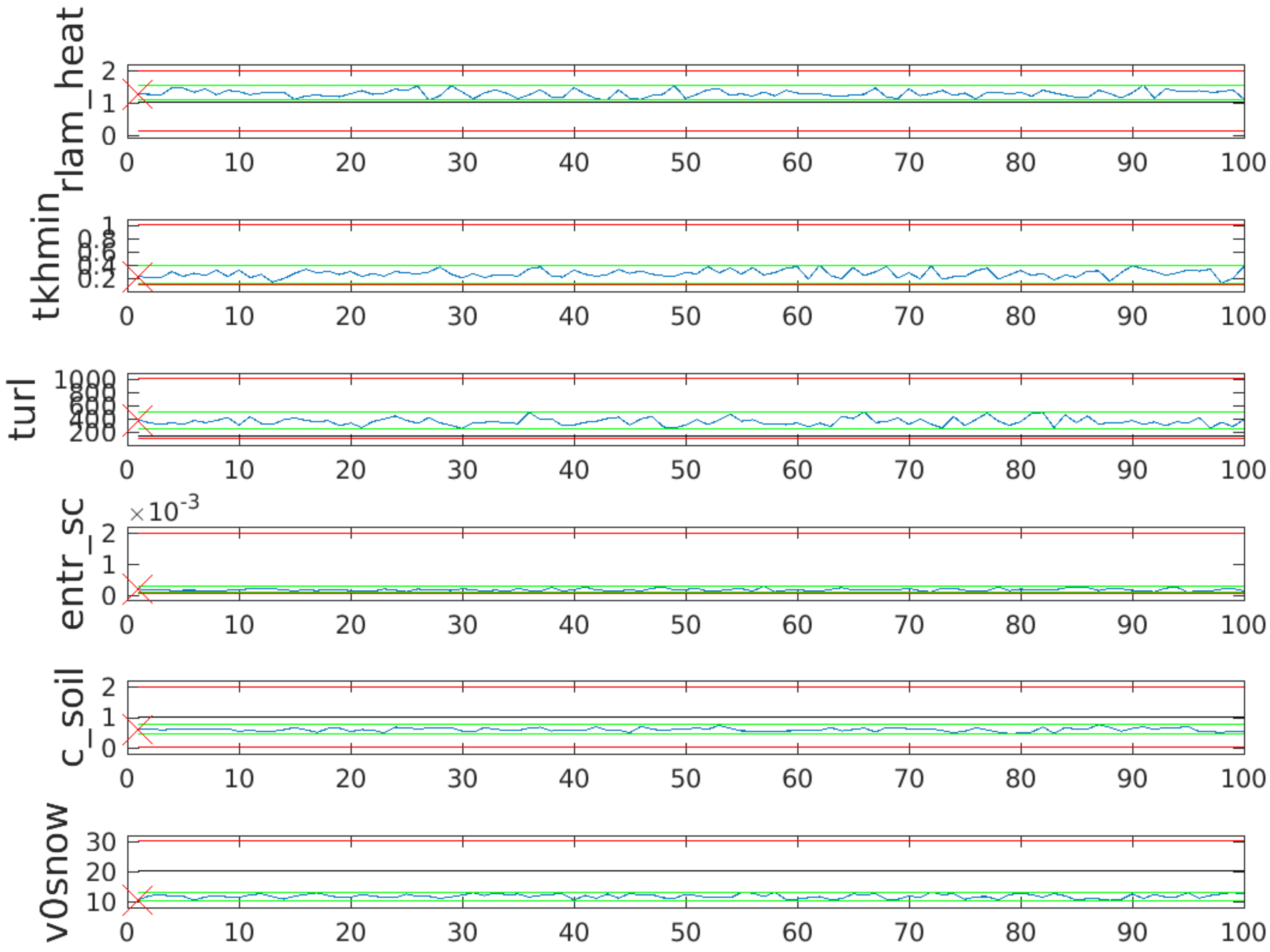
- Meanwhile, Matlab reached only integration 10 out of 40.
- Meanwhile there is no convergence.
- The goal is to reach iteration number 40 (or less if there is convergence before).

New Results Boyhood Stage 3:

The best optimal parameters:

CALMO with observed Rainy days compared to all days in 2013 (all available observation).

For iteration 10.



New Results Boyhood Stage 3:

The best optimal parameters
CALMO with observed Rainy days compared to all days in 2013 (all available observation). For iteration 10.

Optimal Parameter/test	Ralm_Heat	Tkhminn	Tur_len	Entr_c	C_soil	V0snow
Rainy days (iteration 10)	1.263	0.236	386.8	2.071	0.620	10.5
All days (iteration 40)	1.273	0.266	346.5	1.607	0.588	12.3

Summary

Conclusions

- There is a need to increase the number of iterations in order to be sure about the optimal parameters for Rainy days (precipitation area average of daily rain 0.05mm and above).

- It seems that the monthly behavior of the optimal parameters is not totally random.

- In the planes graph, there are some differences in the optimal parameters, especially, where the ‘Ralm_heat’ parameter is involved.

The End

Outline

1. Overview
2. Meta-Model
3. Performance score
4. Convergence to the optimal parameters combination
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Back up Presentation

Overview: stages of the CALMO project

	Stage-1	Stage-2	Stage-3
Resolution	7km	2.2km	1.1km
Simulations domain	[17W-22E, 35N-57N]	[0E-17E,42N-50N]	[0E-17E, 42N-50N]
Calibration area	Switzerland	Switzerland and north Italy	Switzerland and north Italy
Calibrated atmospheric fields	T2m-max; T2m-min; 24h-precipitation	T2m-max; T2m-min; 24h-precipitation; sounding profiles diagnostics: CAPE; CIN; total column water vapor; vector wind shears between the levels 500-700mb/700-850mb/850-1000mb; temperature, relative humidity and wind components at 850, 700 and 500mb	T2m-max; T2m-min; 24h-precipitation; sounding profiles diagnostics: CAPE; CIN; total column water vapor; vector wind shears between the levels 500-700mb/700-850mb/850-1000mb; temperature, relative humidity and wind components at 850, 700 and 500mb
Simulations period	1-20/1/2008, 1-20/6/2008	1/1/2013-31/12/2013	1/1/2013-1/2/2013
Tuning parameters	rlam_heat, tkhmin, tur_len	rlam_heat, tkhmin, tur_len, entr_sc, c_soil, v0snow	tkhmin, tur_len, entr_sc, c_soil, crsmin

Table 1: Overview: different stages of the CALMO project

Overview: tuned parameters

	Used at stages:	Brief physical meaning:	Min	Default	Max
rlam_heat	1,2	rlam_heat $[no-units]$ is the parameter which linearly determines the heat resistance length of laminar layer; so that the higher is rlam_heat the higher is the resistance of laminar layer for heat transfer, and consequently, the lower is the heat transfer between the surface and the lower atmosphere	0.1	1	2
tkhmin	1,2,3	tkhmin $[m^2/s]$ and tkmmin $[m^2/s]$ determine the minimum limits for the turbulence coefficients. tkhmin presence is evident when the turbulent diffusion coefficients (then the mixing) are small, which occurs in stable conditions, mainly at night near the surface	0.1	0.4	1
tur_len	1,2,3	tur_len $[m]$ is l_∞ in Blackadar formula (Blackadar, 1962) for the turbulence length. The higher is tur_len, the higher are the turbulent coefficients (both vertical and horizontal) in the middle-upper atmospheric levels, and consequently the higher are the turbulent fluxes (mixing) for all the variables and tracers	100	150	1000
entr_sc	2,3	entr_sc $[m^{-1}]$ is the mean entrainment rate of boundary layer humidity into the shallow convection clouds. The higher is entr_sc, the more effective is the shallow convection vertical mixing	0.05e-3	0.3e-3	2e-3
c_soil	2,3	c_soil $[no-units]$ is the surface-area index of the evaporating fraction of gridpoints over land: c_soil $\in$ [0, c_lnd=2]. The higher is c_soil, the higher is the surface evaporation	0	1	2
v0snow	2	v0snow $[no-units]$ is the factor in the terminal velocity for snow	10	20	30
crsmin	3	crsmin $[s/m]$ is the minimum value of stomatal resistance used by the BATS approach for vegetation transpiration	50	150	200

Table 2: COSMO parameters tuned at different stages of the CALMO project

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Meta-Model: recent changes

Option not to average Tmax/Tmin over regions

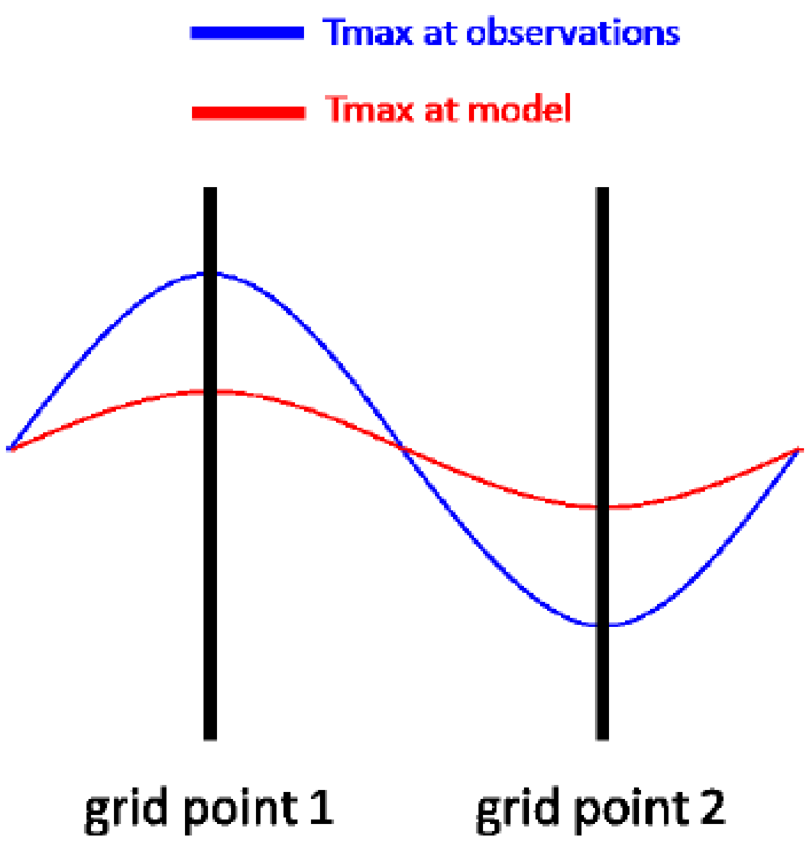

Figure 1: Schematic example for the reason not to average Tmax/Tmin over regions.

Meta-Model: recent changes

Defining new regions for averaging the 24h accumulated precipitation (optional also for Tmax, Tmin)

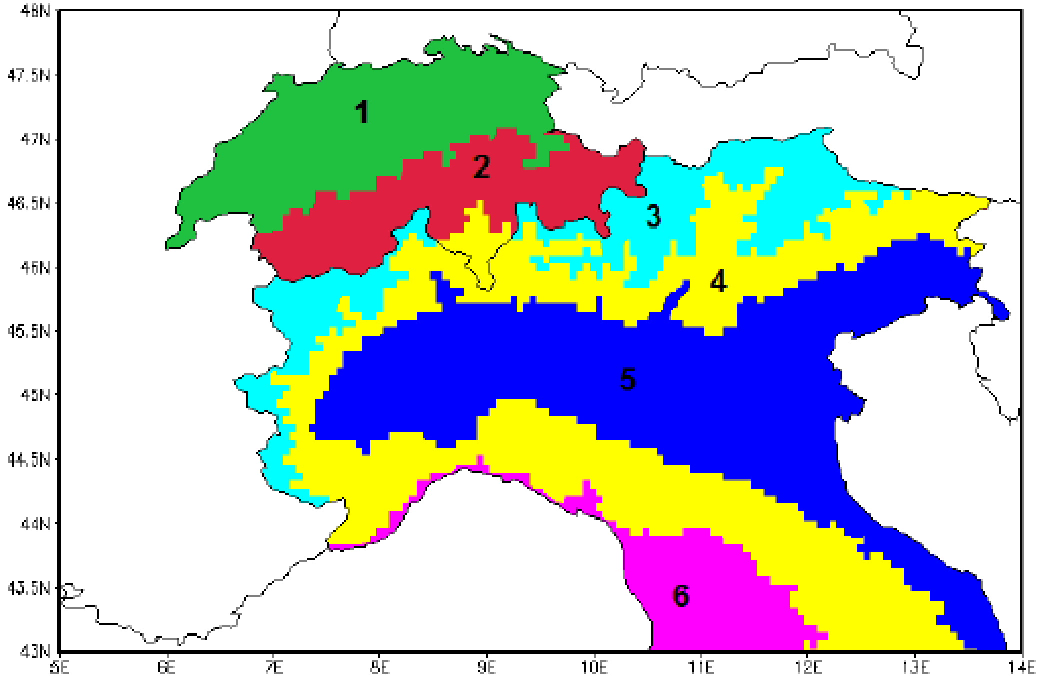

Figure 2: Geographically unique regions for precipitation averaging: 1-green: Swiss plateau (300m<h<1500m); 2-red: Swiss Alps (1500m<h); 3-cyan: Italian Alps (1500m<h); 4-yellow: Italian hills and Ticino (300m<h<1500m); 5-blue: Po Valley (h<300m); 6-magenta: Italian north-west coast (mainly h<300m).

Meta-Model: recent changes

Meta-Model predicts profiles characteristics

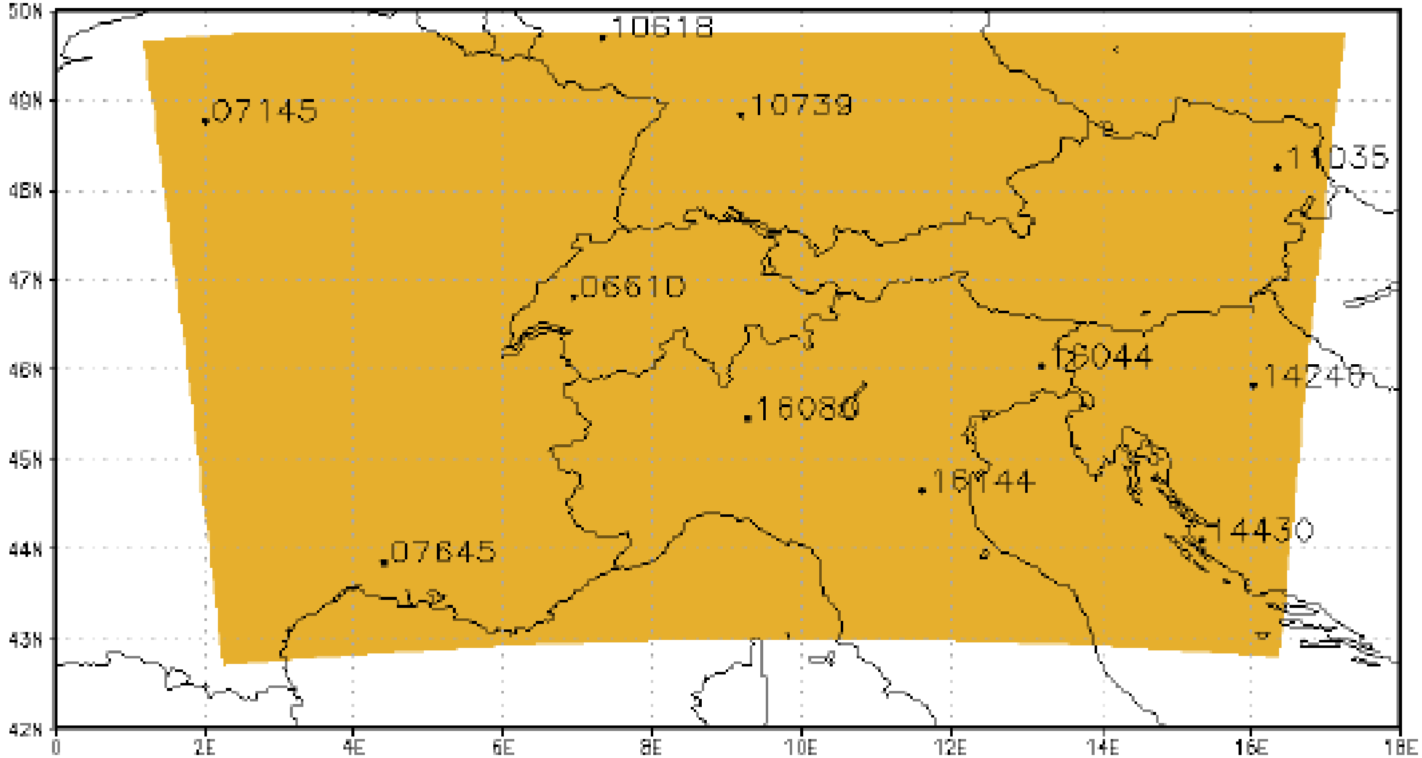

Figure 3: Available soundings inside CALMO-stages 2 and 3 domains.

Meta-Model: recent changes

Logarithmic transformation for some of the parameters

$$x \to \hat{x} \equiv log(\alpha \frac{x - x_{min}}{x_{max} - x_{min}} + \beta).$$

$$\hat{x}_{max} - \hat{x}_d \stackrel{!}{=} \hat{x}_d - \hat{x}_{min} \text{ defines } \alpha \text{ and } \beta.$$

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Performance score: COSI-type score

$$S_p = \frac{1}{12\sum_{\Psi=1}^{18}\omega_\Psi}\left\{\sum_{\Psi\neq 3}\omega_\Psi\sum_{mon=1}^{12}\left[1-\frac{\sum_{\Psi regs}\sum_{\Psi days}(F_{\Psi,p,d,r,mon}-O_{\Psi,d,r,mon})^2}{\sum_{\Psi regs}\sum_{\Psi days}(O_{\Psi,d-1,r,mon}-O_{\Psi,d,r,mon})^2}\right]+\omega_3\frac{\sum_{mon=1}^{12}\sum_{\Psi regs}\sum_{\Psi thr}ETS_{p,r,mon,thr}}{N_{\Psi days,mon}N_{\Psi regs,mon}}\right\}$$

$$ETS_{p,r,mon,thresh} = \frac{H-\frac{(H+F)(H+M)}{N_{\Psi regs,mon}}}{H+M+F-\frac{(H+F)(H+M)}{N_{\Psi regs,mon}}}$$

$$-1/3 < ETS < 1$$