ΕΘΝΙΚΗ ΜΕΤΕΩΡΟΛΟΓΙΚΗ ΥΠΗΡΕΣΙΑ
HELLENIC NATIONAL METEOROLOGICAL SERVICE

CONSORTIUM FOR SMALL SCALE MODELING
COSMO

CALibration of the COSMO MOdel CALMO

Contributing Scientists

Antigoni Voudouri (HNMS), Euripides Avgoustoglou (HNMS),

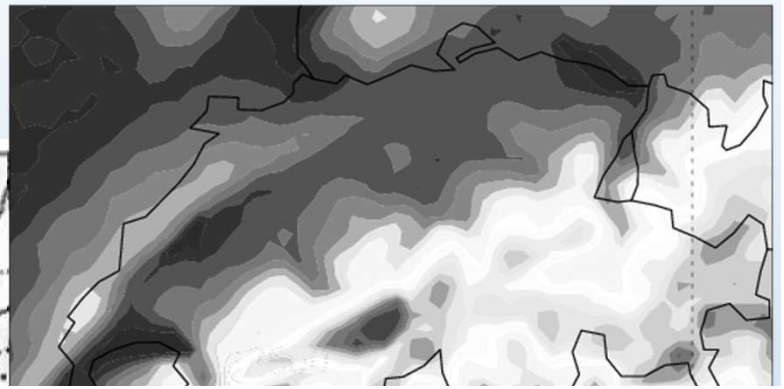
Pavel Khain (IMS), Izthak Carmona (IMS),

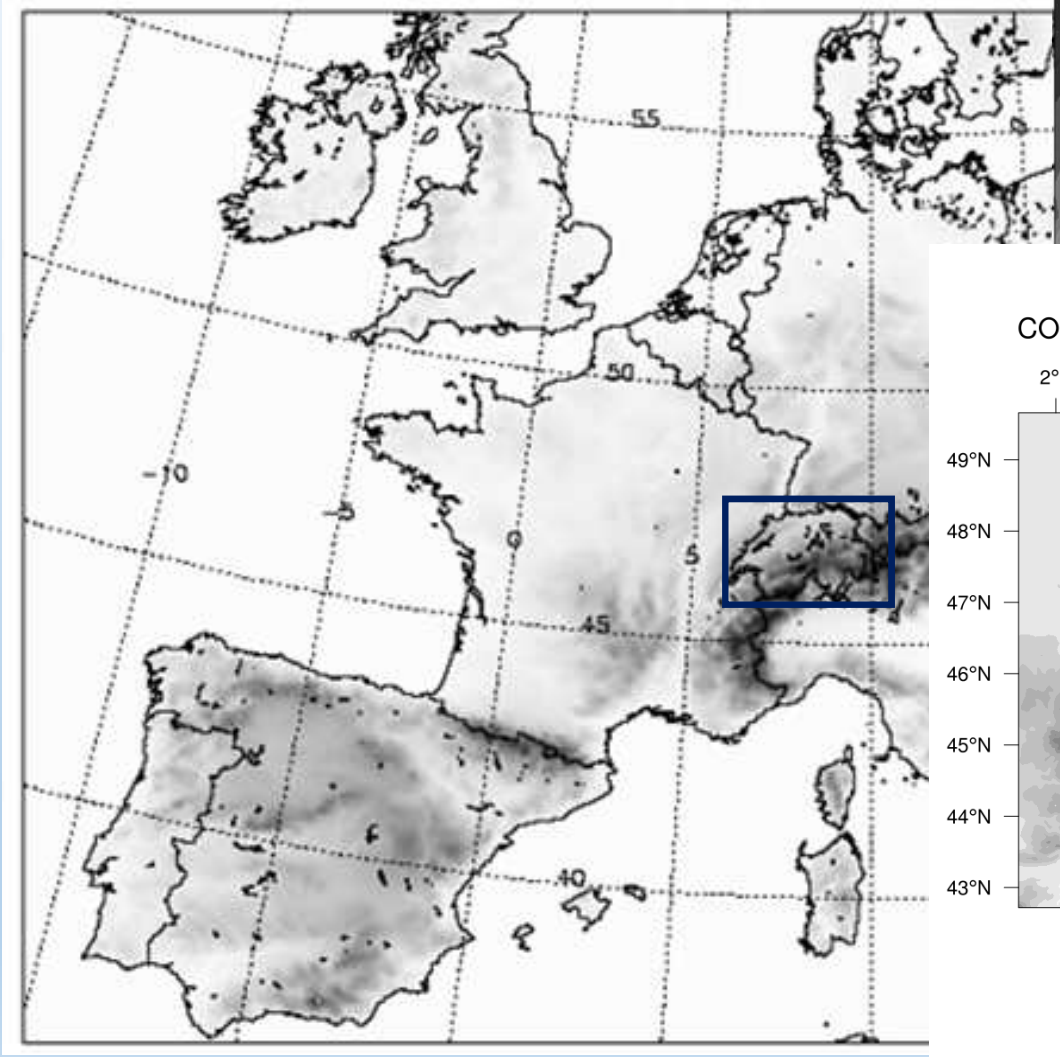
Federico Grazzini (ARPA) and Jean-Marie Bettems (MeteoSwiss)

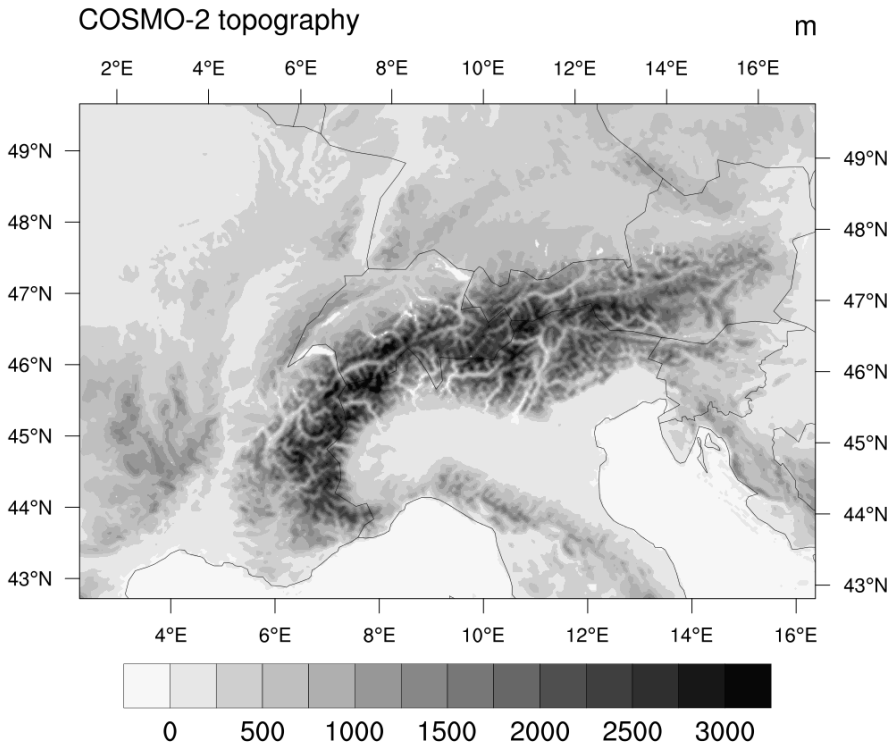
Motivation

- Substitute expert tuning with objective calibration any time new unconfined parameters are induced in COSMO model
- Provide a useful tool for model re-calibration on any standard production system used by National Weather Services
- Transfer expertise gained through the implementation of the calibration methodology from Stage 1 (coarse resolution) to Stage 2 (fine resolution)

Steps from CALMO Stage 1 to Stage 2
Increased resolution from 7km







.....to 2.2km (Stage 2)

Steps from CALMO Stage 1 to Stage 2
Increased simulations period

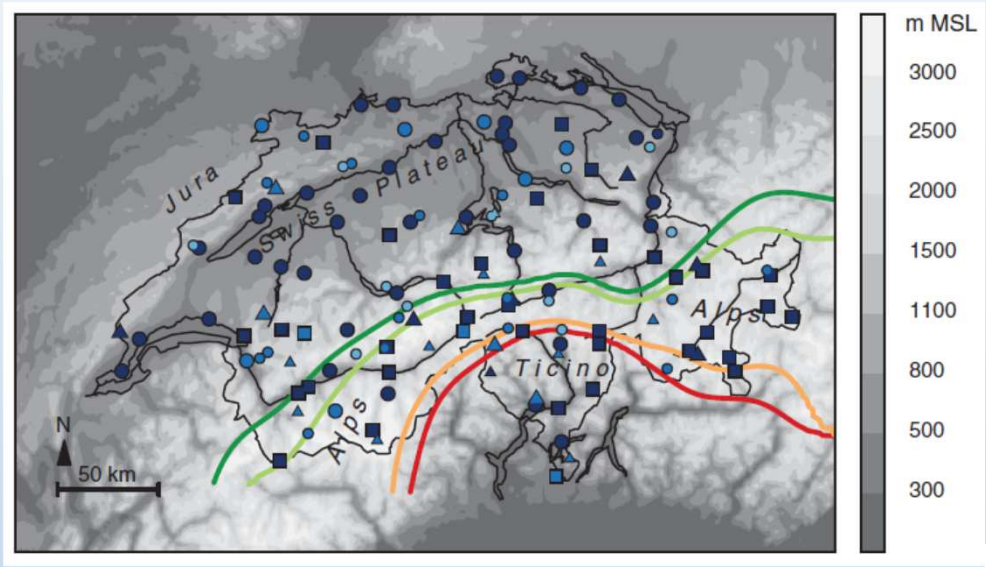
Stage-1

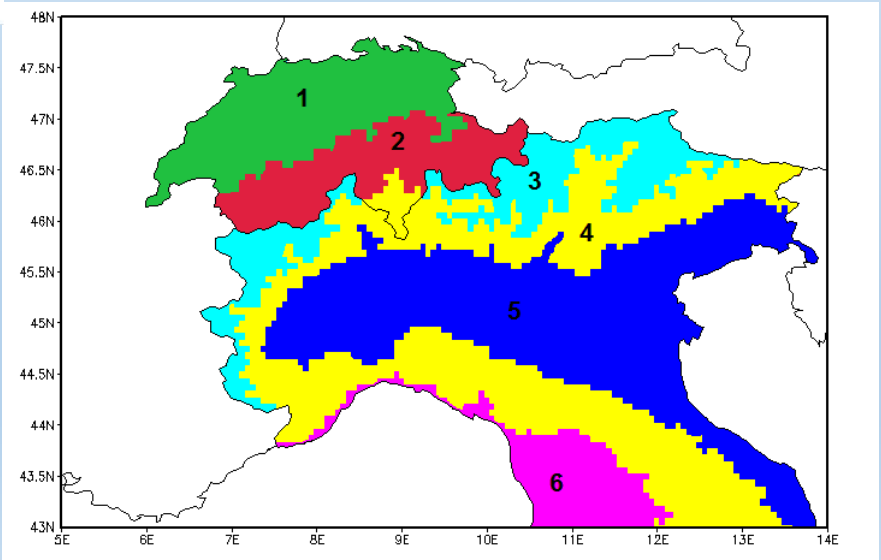
- Two 3-weeks periods (from 40 days of 2008)
  - winter (3-20/1/2008) and
  - summer (2-20/6/2008)

Stage-2

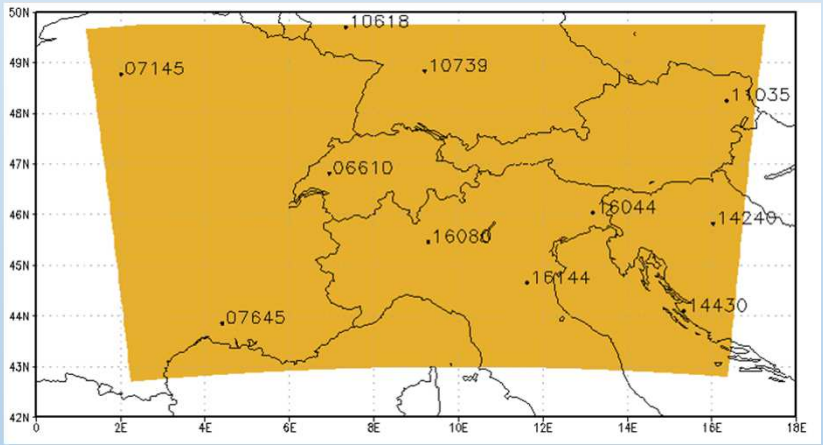
- Entire year 2013

Steps from CALMO Stage 1 to Stage 2
Increased verification area to include also north of Italy





Steps from CALMO Stage 1 to Stage 2
Added soundings profiles to include more fields



Stage-1

- Daily maximum 2m temperature
- Daily minimum 2m temperature
- 24h accumulated precipitation

Stage-2 (Stage-1 & New)

- Total column water vapor
- Relative humidity, temperatures, East-West wind component and South-North wind component at 500mb ,700mb and 850mb
- Vector wind shear between the levels of 1000mb-850mb, 850mb -700mb and 700mb- 500mb
- *Convective available potential energy*
- *Convective inhibition*

Steps from CALMO Stage 1 to Stage 2
Increased number of free parameters tested for calibration

Surface layer		
Name	range	comment
rlam_heat (and rat_sea)	[0.1,1*,2] *([1,20*,100]*	*changes in rlam_heat must be compensated by an inverse change of rat_sea in order to maintain (at least approximately) rlam_heat*rat_sea. [0,20*, 200*)* *This in principle also applies to COSMO model unless we intend to change the evaporation over water.*

turbulence		
Name	range	comment
tur_len	[100,150*, 1000]	L_scal=MIN(0.5*l_hori, tur_len
tkhmin (and tkmmin)	[0.1, 0.4*, 1]	*Should be equal!* *Increasing values does not keep low clouds, decreasing values better scores*

Steps from CALMO Stage 1 to Stage 2
Increased number of free parameters tested for calibration

Surface layer		
Name	range	comment
c_soil	[0,1*, **0.5,** c_lnd]	c_lnd=2
rlam_heat (and rat_sea)	[0.1, **0.2**,1*,2] *([1,20*,100]*	*changes in rlam_heat must be compensated by an inverse change of rat_sea in order to maintain (at least approximately) rlam_heat*rat_sea. [0,20*, 200)* *This in principle also applies to COSMO model unless we intend to change the evaporation over water.*

Shallow convection		
Name	range	comment
entr_sc	[0.5 ,3*,**7.95,** 20]E-04	

turbulence		
Name	range	comment
tur_len	[100,150*, **316,** 1000]	L_scal=MIN(0.5*l_hori, tur_len
tkhmin (and tkmmin)	[0.1, 0.4*, **0.7,** 1]	*Should be equal!* *Increasing values does not keep low clouds, decreasing values better scores*

Grid scale precipitation		
Name	range	comment
v0snow	[10,**15,** 20*,30]	25 in COSMO-EU In (data_gscp.f90)

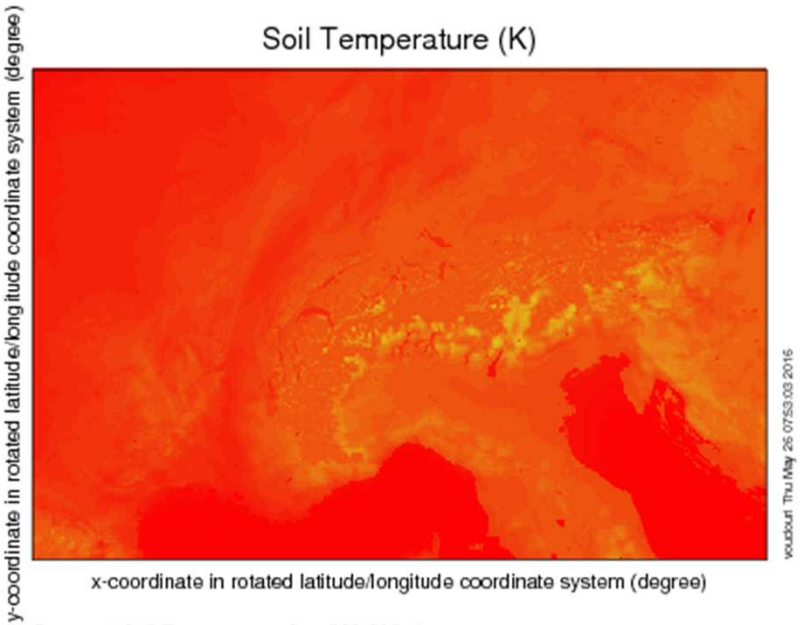
Vegetation and soil		
Name	range	comment
crsmin	[50,150*,200]	

ΕΘΝΙΚΗ ΜΕΤΕΩΡΟΛΟΓΙΚΗ ΥΠΗΡΕΣΙΑ
HELLENIC NATIONAL METEOROLOGICAL SERVICE

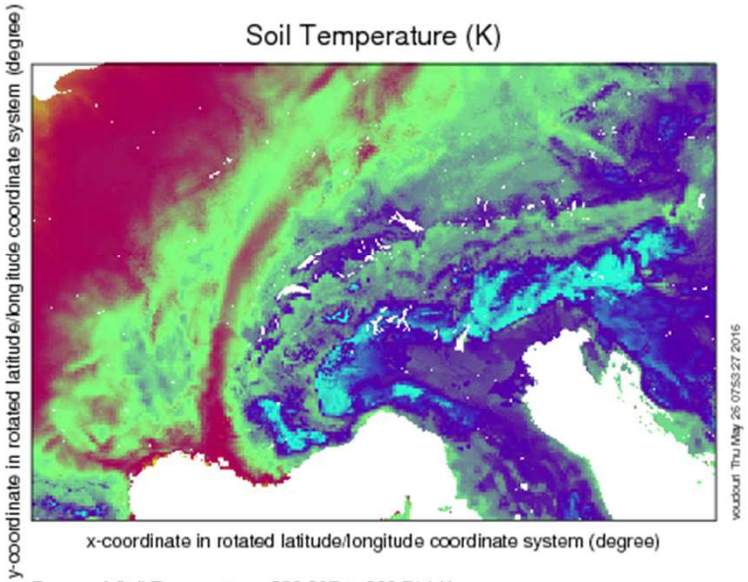
CONSORTIUM FOR SMALL SCALE MODELING
COSMO

Steps from CALMO Stage 1 to Stage 2

Initial data for soil temperature and soil water content extracted from the updated version of TERRA standalone (TSA).



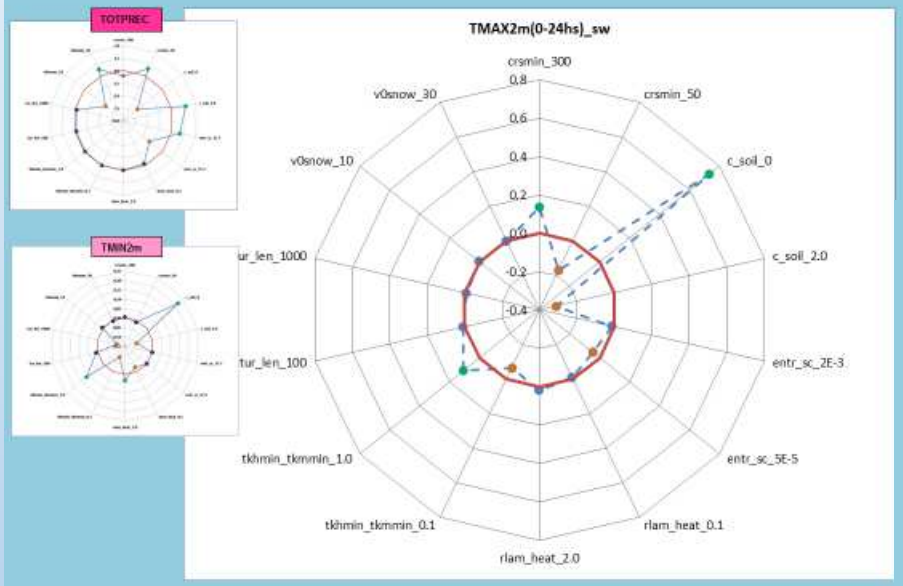
Range of Soil Temperature: 0 to 290.039 K
Range of x-coordinate in rotated latitude/longitude coordinate system: -6.8 to 4.77 degree
Range of y-coordinate in rotated latitude/longitude coordinate system: -4.4 to 3.33 degree
Current time: 0 seconds since 2013-01-01 00:00:00
Current Depth below land surface: 0 cm
Frame 1 in File laf2013010100_noTSA.nc



Range of Soil Temperature: 258.867 to 289.714 K
Range of x-coordinate in rotated latitude/longitude coordinate system: -6.8 to 4.77 degre
Range of y-coordinate in rotated latitude/longitude coordinate system: -4.4 to 3.33 degre
Current time: 0 seconds since 2013-01-01 00:00:00
Current Depth below land surface: 0 cm
Frame 1 in File laf2013010100.nc

Steps from CALMO Stage 1 to Stage 2

Proposed a new methodology for the selection of additional interaction simulations other than min-max-default



Steps from CALMO Stage 1 to Stage 2 Induced several modification to MM

- Tmax/Tmin are now optionally averaged over regions
- MM gives vertical profiles characteristics
- New regions for averaging the 24h accumulated precipitation (optional also for Tmax, Tmin) are defined
- Induced new performance scores (from RMSE to COSI)
- Logarithmic transformation for some of the parameters
- Convergence to the optimal parameters combination

Steps from CALMO Stage 1 to Stage 2
Modification to MM induced Cosi type score

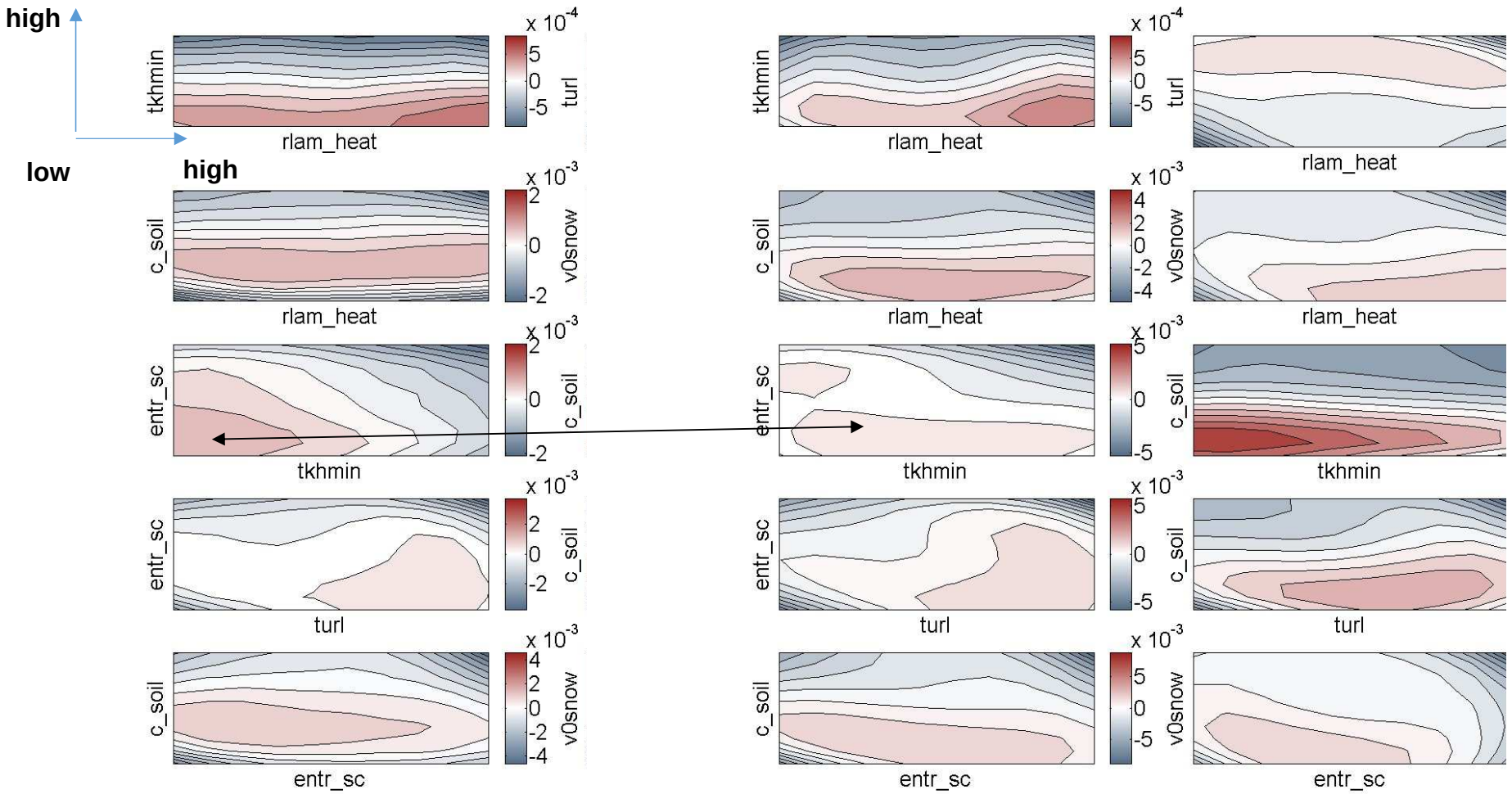
$$S_p = \frac{1}{12\sum_{\Psi=1}^{18}\omega_\Psi}\left\{\sum_{\Psi\neq 3}\omega_\Psi\sum_{mon=1}^{12}\left[1-\frac{\sum_{\Psi regs}\sum_{\Psi days}\left(F_{\Psi,p,d,r,mon}-O_{\Psi,d,r,mon}\right)^2}{\sum_{\Psi regs}\sum_{\Psi days}\left(O_{\Psi,d-1,r,mon}-O_{\Psi,d,r,mon}\right)^2}\right]+\omega_3\frac{\sum_{mon=1}^{12}\sum_{\Psi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

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

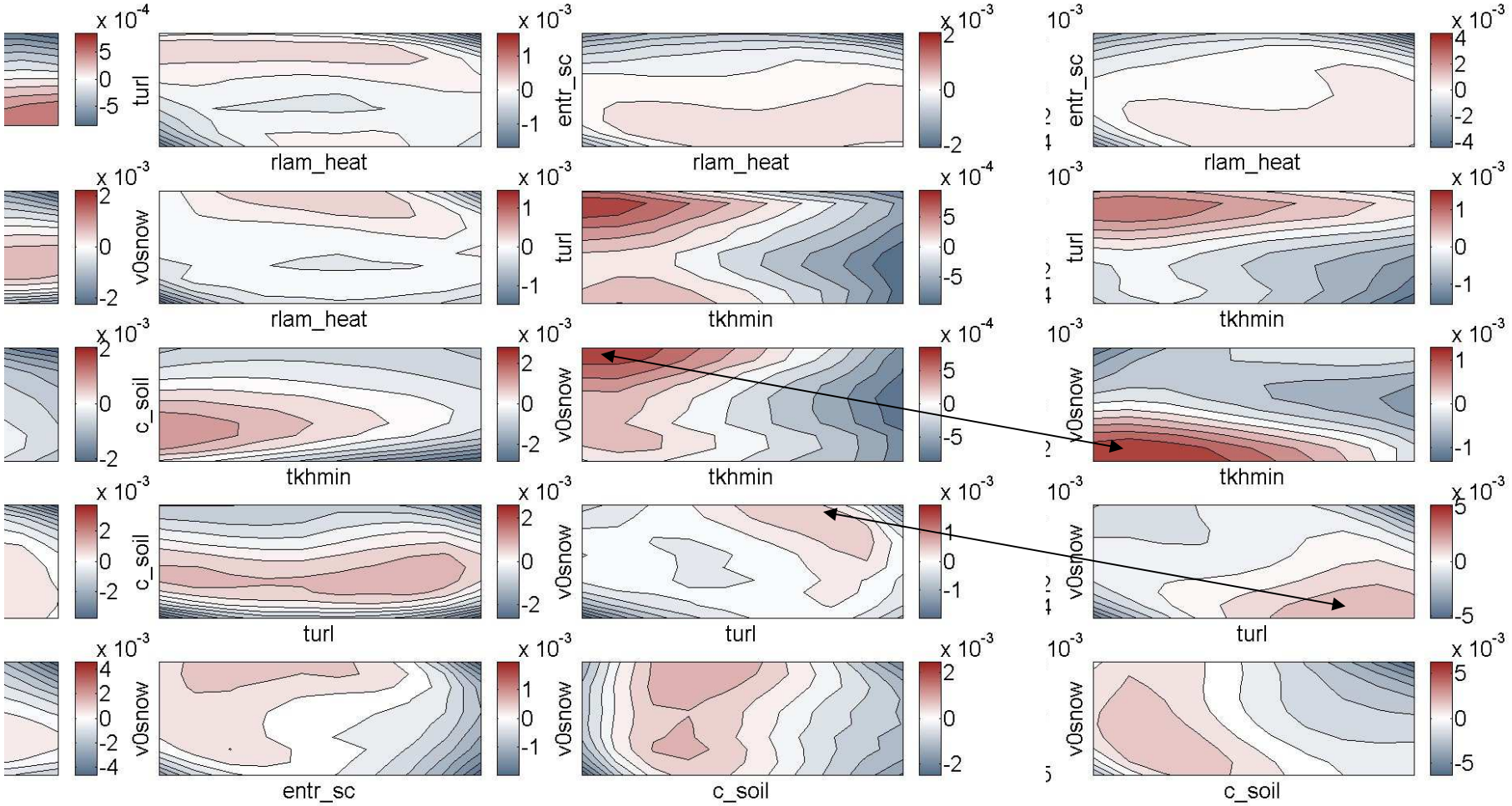
Calibration results

- Calibration was performed using 4 different methods:
  - Averaging Tmax and Tmin over regions, using RMSE-type score;
  - Not averaging Tmax and Tmin over regions, using RMSE-type score;
  - Averaging Tmax and Tmin over regions, using or the COSI score;
  - Not averaging Tmax and Tmin over regions, using the COSI score.

Method 3 :Averaging Tmax and Tmin over regions, using or the COSI score



Method 4 : Not Averaging Tmax and Tmin over regions, using the COSI score



Optimal parameters combinations according 4 different methods

	METHOD I	METHOD II	METHOD III	METHOD IV
	rlam_heat=0.763 tkhmin=0.209 tur_len=312.7 entr_sc=0.000101 csoil=0.626 v0snow=17.9	rlam_heat=1.105 tkhmin=0.390 tur_len=475.6 entr_sc=0.000077 csoil=0.761 v0snow=18.2	rlam_heat=0.740 tkhmin=0.176 tur_len=368.8 entr_sc=0.000114 csoil=0.663 v0snow=17.8	rlam_heat=1.240 tkhmin=0.233 tur_len=363.9 entr_sc=0.000267 csoil=0.492 v0snow=12.1
METHOD I	1.828 %	1.557 %	1.801 %	1.329 %
METHOD II	1.647 %	1.880 %	1.685 %	1.556 %
METHOD III	1.481 %	1.217 %	1.587 %	0.980 %
METHOD IV	2.980 %	2.966 %	2.916 %	**3.951 %**
Average score:	**1.984 %**	**1.905 %**	**1.997 %**	**1.954 %**

Optimum parameters set using method 3

Surface layer		
Name	range	comment
c_soil	[0, **0.663**, 1*, c_lnd]	c_lnd=2
rlam_heat (and rat_sea)	[0.1, **0.74**, 1*, 2] *([1,20*,100]*	*changes in rlam_heat must be compensated by an inverse change of rat_sea in order to maintain (at least approximately) rlam_heat*rat_sea. [0,20*, 200)* *This in principle also applies to COSMO model unless we intend to change the evaporation over water.*

Shallow convection		
Name	range	comment
entr_sc	[0.5 , **1.14**, 3*, 20]E-04	

turbulence		
Name	range	comment
tur_len	[100,150*, **368.8**, 1000]	L_scal=MIN(0.5*l_hori, tur_len
tkhmin (and tkmmin)	[0.1, **0.176**, 0.4*, 1]	*Should be equal!* *Increasing values does not keep low clouds, decreasing values better scores*

Grid scale precipitation		
Name	range	comment
v0snow	[10, **17.8**, 20*, 30]	25 in COSMO-EU In (data_gscp.f90)

Summary of Stage 2

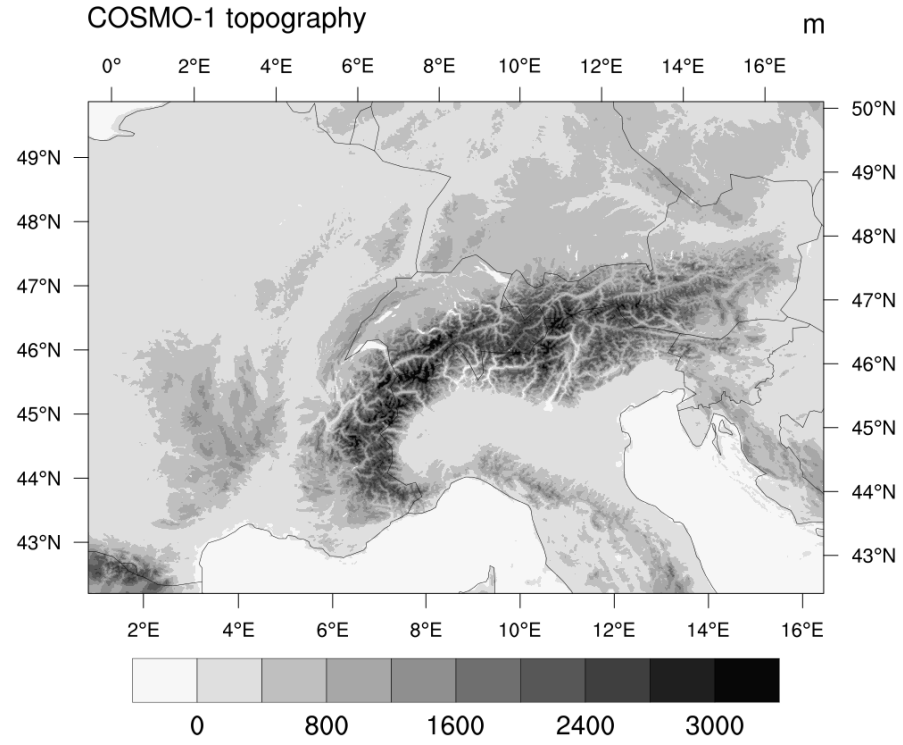
- Further optimization of a well tuned NWP model is feasible
- A maximum of about 4% improvement is achieved for COSMO-2 using CALMO methodology
- Optimum values of the 5 out of 6 parameters used are less than the default ones
- Differences on the optimum set of parameter are evident when averaging (NOT suggested for NWP model) variables such as temperatures over simulation domain
- As the performance score used for calibration changes the values of optimum set, it could be selected according the end user's needs
- Thus CALMO methodology could be a useful tool for running a calibrated COSMO model over different simulation areas
- Minimize computational cost of methodology is still missing……..

References

- Avgoustoglou Euripides, Antigoni Voudouri, Pavel Khain, Federico Grazzini and Jean-Marie Bettems, 2016. Design and Evaluation of Sensitivity Tests of COSMO Model over the Mediterranean:13th International Conference on Meteorology, Climatology and Atmospheric Physics (COMECAP 2016),Thessaloniki, 19-21 September 2016. Springer International Publisher AG : "Perspectives on Atmospheric Sciences"
- Khain P., I. Carmona, A. Voudouri, E. Avgoustoglou, J.-M. Bettems, F. Grazzini (2016). Progress report on CALMO - stage 2
- Voudouri A., Khain P., Carmona I. Bellprar O., Grazzini F., Avgoustoglou E., Bettems J. M. and Kaufmann P. 2016: Objective calibration of numerical weather prediction models, Atm. Res. Under revision
- Voudouri Antigoni, Euripides Avgoustoglou and Pirmin Kaufmann, 2016. Impacts of observational data assimilation on operational forecasts. 13th International Conference on Meteorology, Climatology and Atmospheric Physics (COMECAP 2016),Thessaloniki, 19-21 September 2016. Springer International Publisher AG : "Perspectives on Atmospheric Sciences"

- Under preparation:
  - A second manuscript summarizing the work using COSMO 2km
  - Final project report
  - A cookbook and the latest version of the MM

Steps from CALMO Stage 2 to Stage 3
Started COSMO-1 calibration using GPU COSMO (STELLA 1.04.12)



Steps from CALMO Stage 2 to Stage 3
5 free parameters used for calibration

Surface layer		
Name	range	comment
c_soil	[0,1*, c_lnd]	c_lnd=2
rlam_heat (and rat_sea)	[0.1, 1*,2] *([1,20*,100]*	*changes in rlam_heat must be compensated by an inverse change of rat_sea in order to maintain (at least approximately) rlam_heat*rat_sea. [0,20*, 200)* *This in principle also applies to COSMO model unless we intend to change the evaporation over water.*

Shallow convection		
Name	range	comment
entr_sc	[0.5 ,3, 20]E-04	

turbulence		
Name	range	comment
tur_len	[100,150*, 1000]	L_scal=MIN(0.5*l_hori, tur_len
tkhmin (and tkmmin)	[0.1, 0.4*, 1]	*Should be equal!* *Increasing values does not keep low clouds, decreasing values better scores*

Vegetation and soil		
Name	range	comment
crsmin	[50,150*,200]	

CALMO Methodology Applied on eXtremes (C-MAX), associated with calibration during extreme events, use of 'extremely' low resources as well 'extremely' new model parameterization

C-MAX is coming……

Thank you for the attention