ΕΘΝΙΚΗ
ΜΕΤΕΩΡΟΛΟΓΙΚΗ
ΥΠΗΡΕΣΙΑ
HELLENIC NATIONAL METEOROLOGICAL SERVICE

CONSORTIUM FOR SMALL SCALE MODELING
COSMO

CALibration of the COSMO MOdel CALMO

Contributing Scientists

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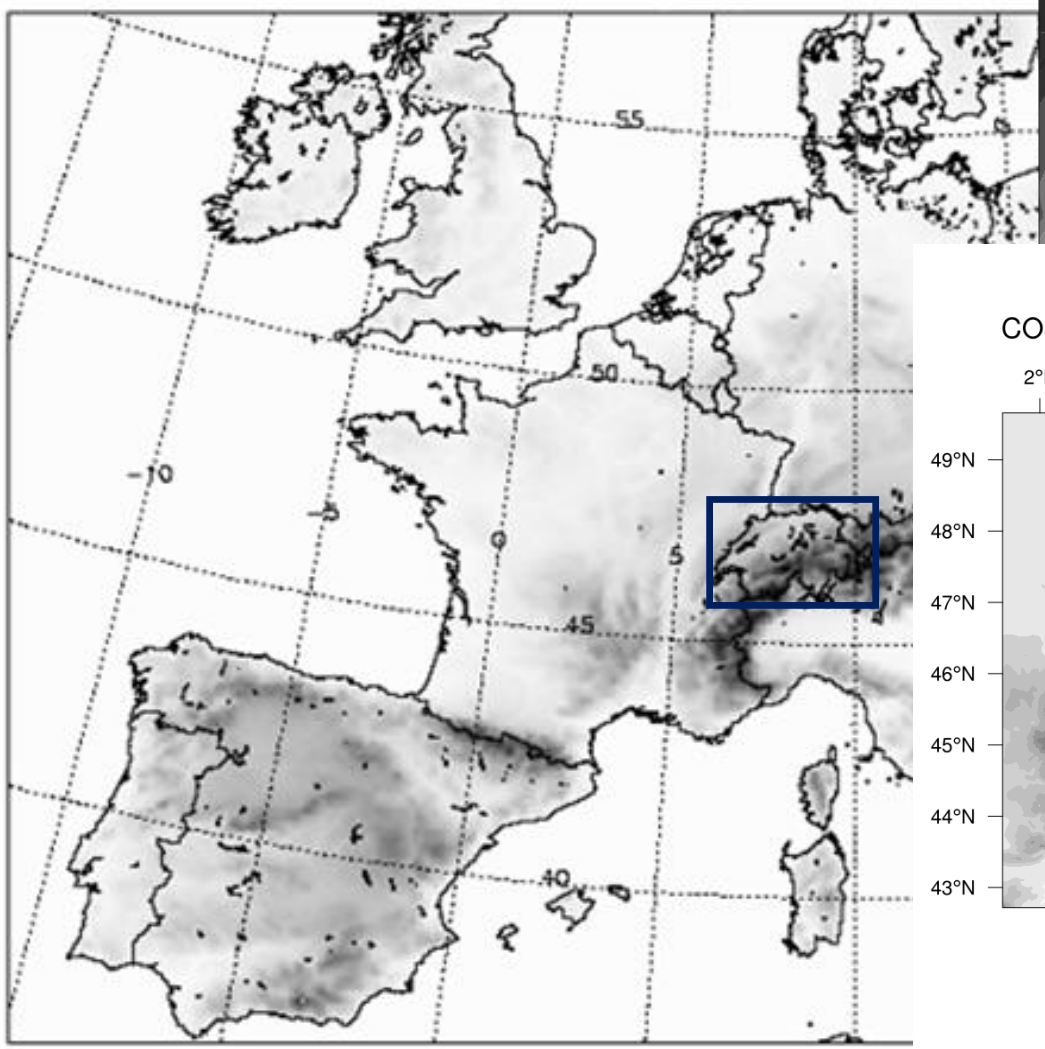
Motivation

- Substitute expert tuning with objective calibration any time new unconfined parameters are induced in COSMO model

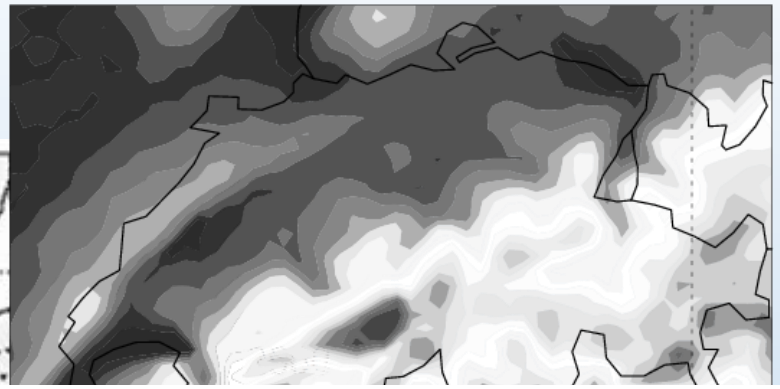
- Provide a useful tool for model re-calibration on any standard production system used by National Weather Services

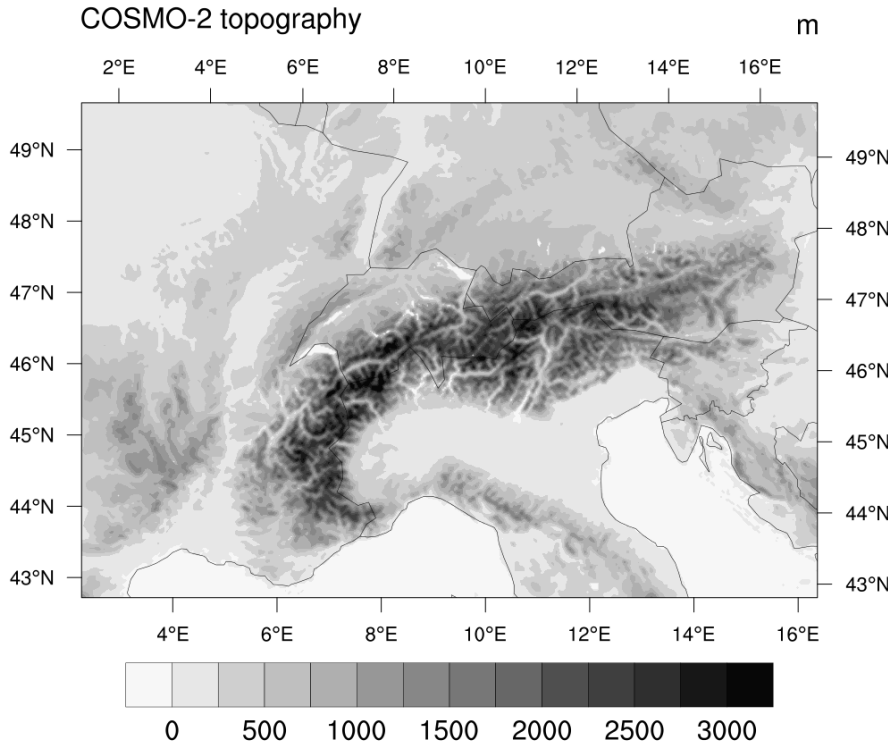
- Transfer expertise gained through the implementation of the calibration methodology from Stage 1 (coarse resolution) to Stage 2 (fine resolution)

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



COSMO 7km (CALMO Forecast)





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

Steps from CALMO Stage 1 to Stage 2
Increased simulations period

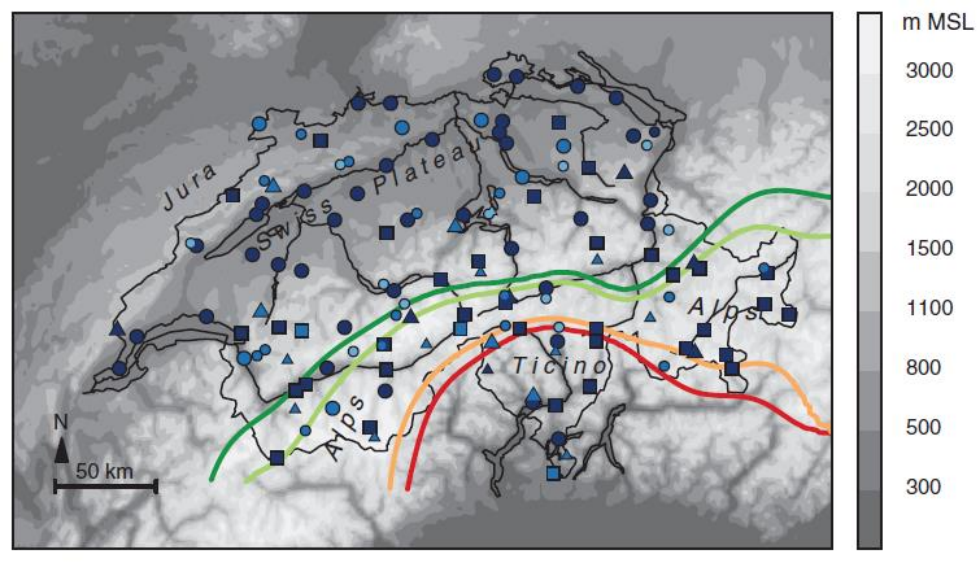
Stage-1

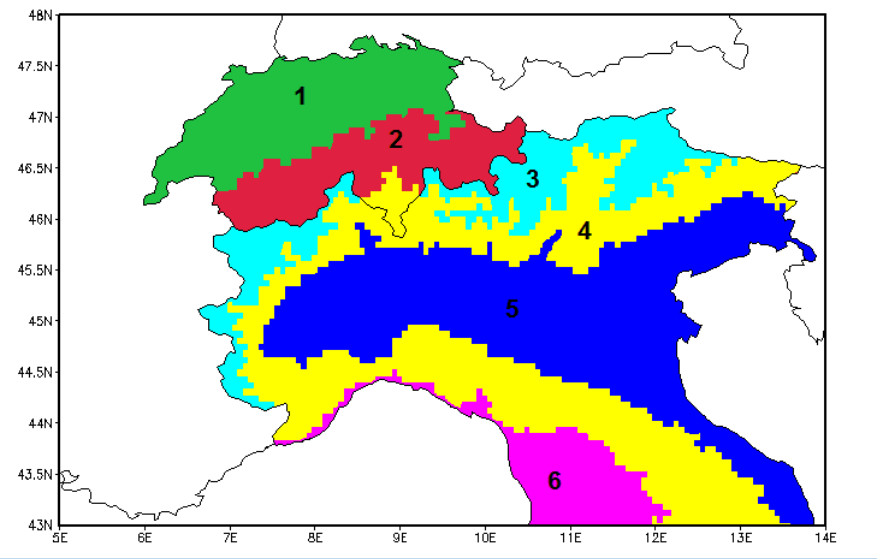
- Two 3-weeks periods (from 40 days of 2008)
  - winter (3-20/1/2008) and
  - summer (2-20/6/2008)

Stage-2

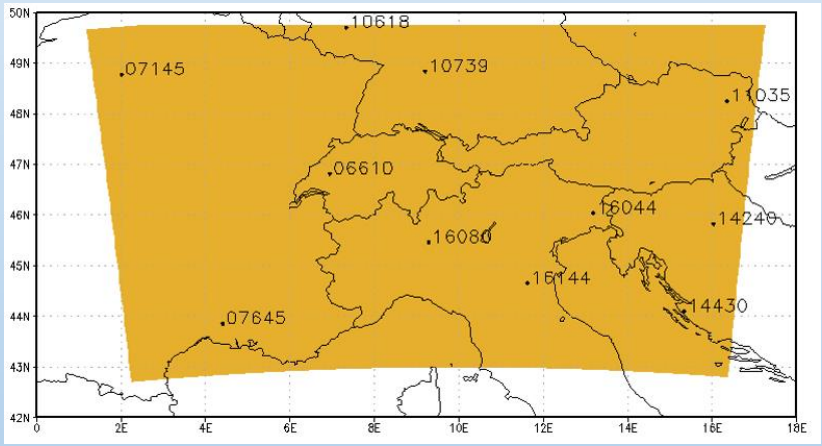
- Entire year 2013

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	

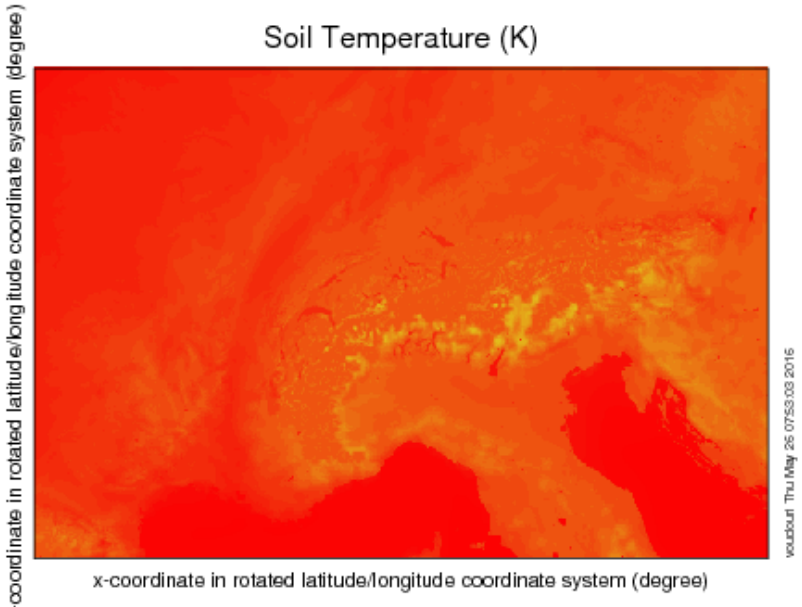
turbulence		
Name	range	comment
tur_len	[100,150*, **316,** 1000]	L_scal=MIN(0.5*l_hori, tur_len
tkhmin (and tkmmin)	[0.1, 0.4*, **0.7,** 1]	*Should be equal!* *Increasing values does not keep low clouds, decreasing values better scores*

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

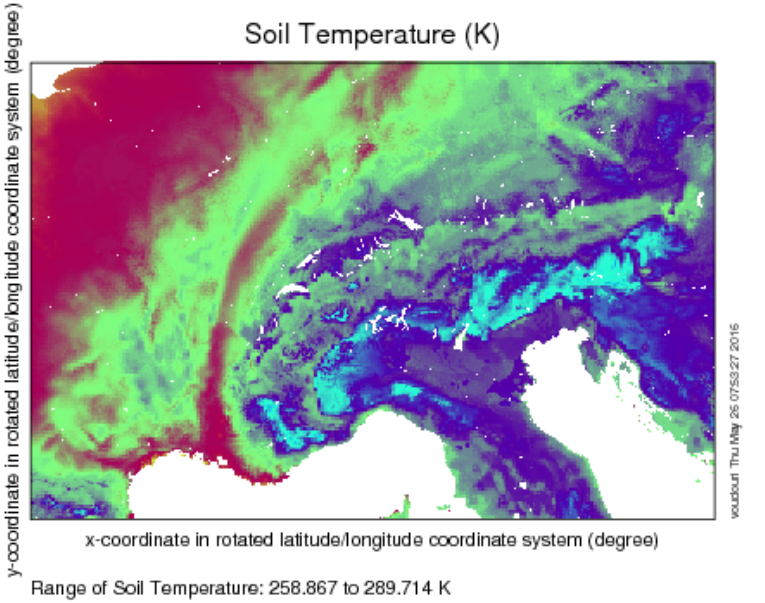
Vegetation and soil		
Name	range	comment
crsmin	[50,150*,200]	

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).



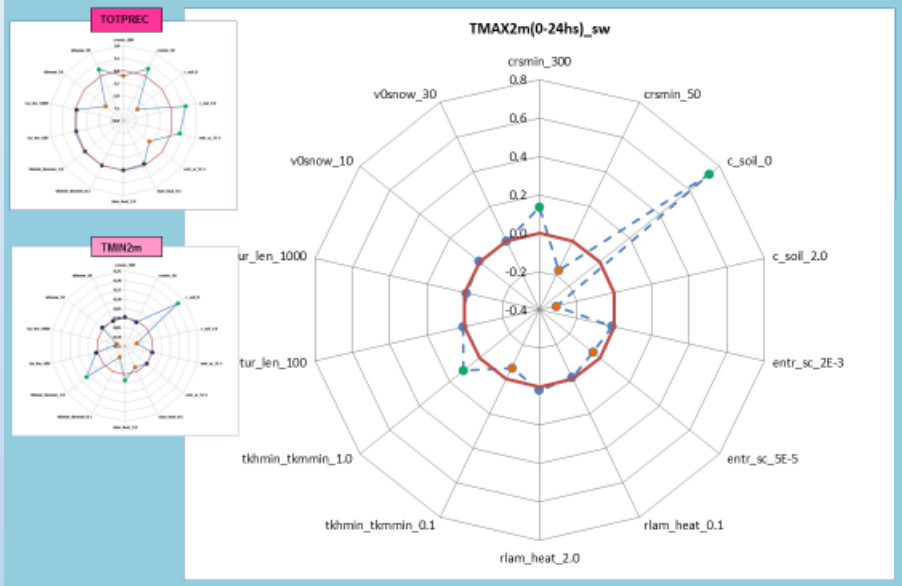
Range of Soil Temperature: 0 to 290.039 K
Range of x-coordinate in rotated latitude/longitude coordinate system: -6.8 to 4.77 degree
Range of y-coordinate in rotated latitude/longitude coordinate system: -4.4 to 3.33 degree
Current time: 0 seconds since 2013-01-01 00:00:00
Current Depth below land surface: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



TOTPREC class 1
TMIN2m class 2
TMAX2m class 3

	c_soil min	c_soil max	v0_sn min	v0_sn max	crsmin min	crsmin max	entr min	entr max	tkhm min	tkhm max	tur_l min	tur_l max	rlam_h min	rlam_h max
c_soil min			14	2	1	16	13	3	26	35		25	27	34
c_soil max			5	19	21	10	4	20	41	29		39	40	32
v0_sn min					6	18	15	7						
v0_sn max					22	11	8	23						
crsmin min							9	24	45	44				47
crsmin max							17	12	43	46				48
entr min														
entr max														
tkhm min												38	42	33
tkhm max												28	30	36
tur_l min														
tur_l max													37	31
rlam_h min														
rlam_h max														

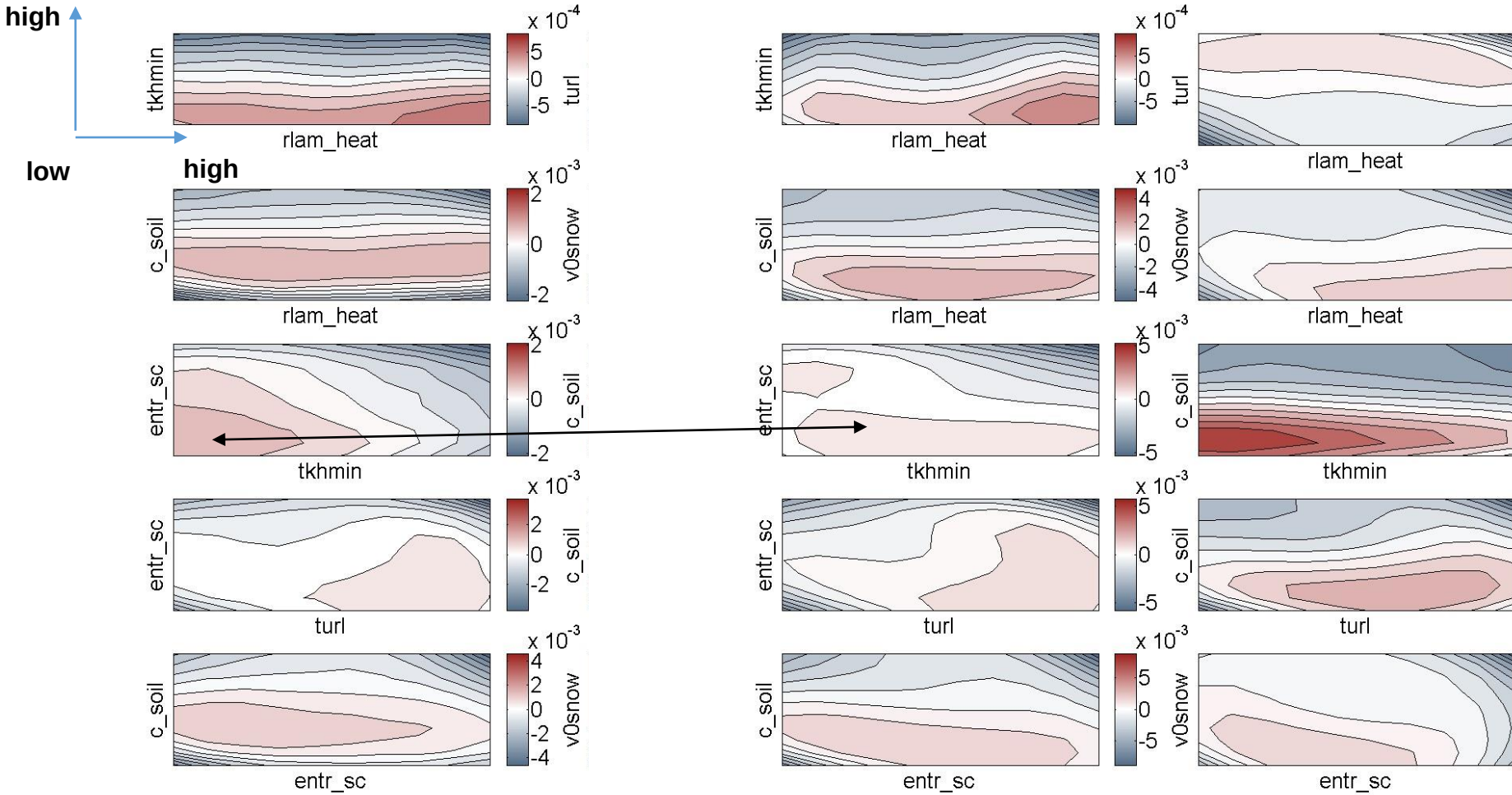
Steps from CALMO Stage 1 to Stage 2
Induced several modification to MM

- 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

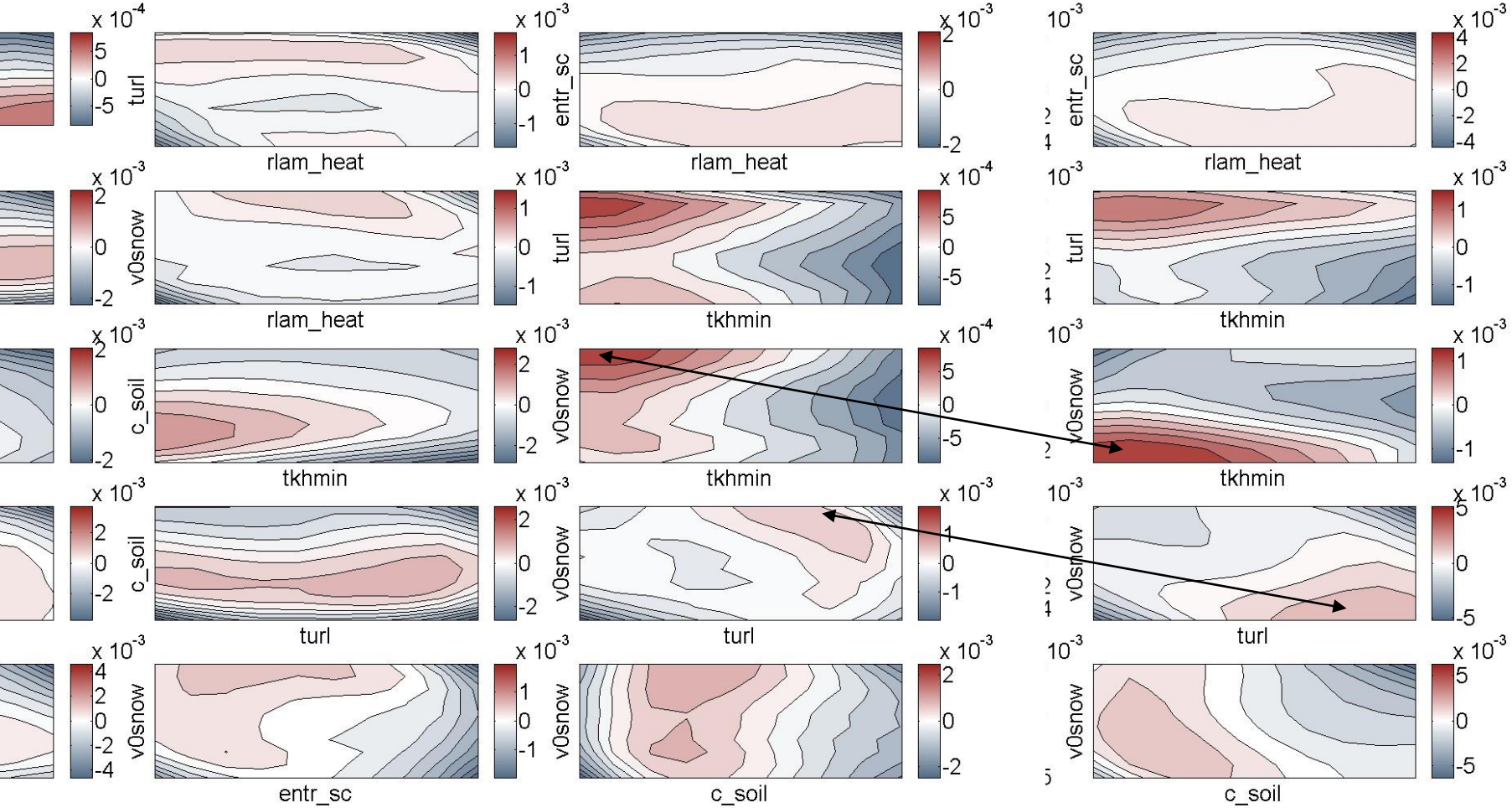
Calibration results

- 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 %**

Summary of Stage 2

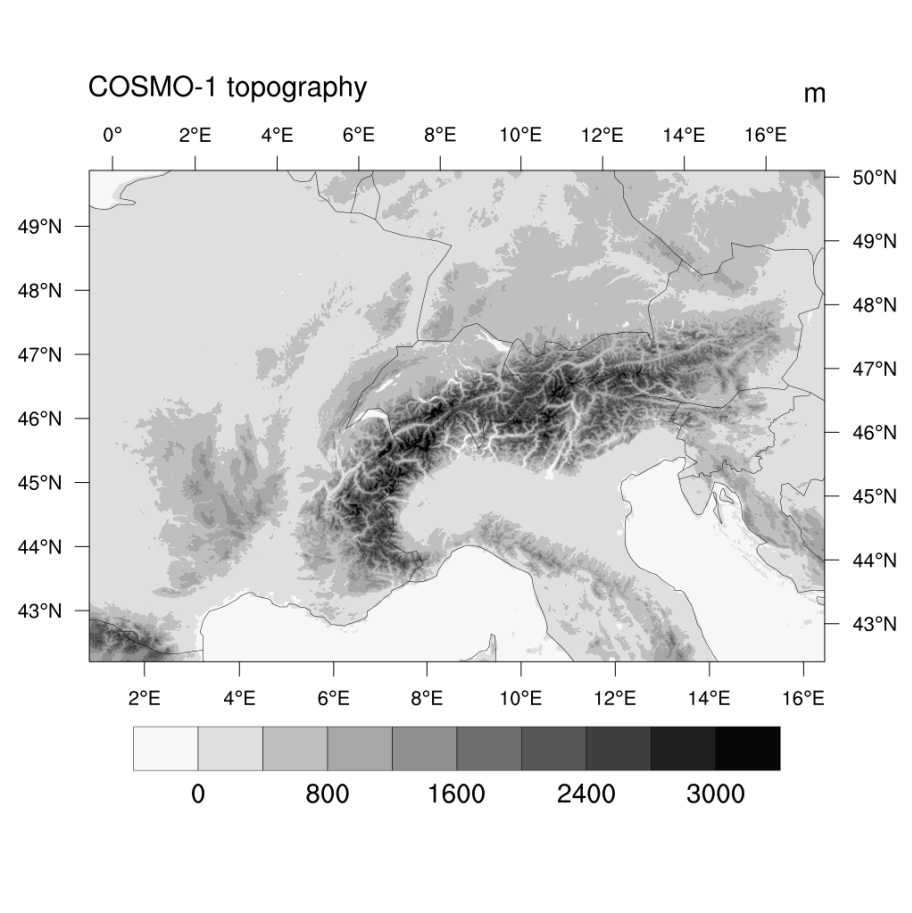
- Further optimization of a well tuned NWP model is feasible
- A maximum of about 4% improvement is achieved for COSMO-2 using CALMO methodology
- Optimum values of the 5 out of 6 parameters used are less than the default ones
- Differences on the optimum set of parameter are evident when averaging (NOT 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