ΕΘΝΙΚΗ ΜΕΤΕΩΡΟΛΟΓΙΚΗ ΥΠΗΡΕΣΙΑ
HELLENIC NATIONAL METEOROLOGICAL SERVICE

CONSORTIUM FOR SMALL SCALE MODELING
COSMO

CALibration of the COSMO **MO**del
CALMO -MAX

Project participants*

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*with the contribution of Pirmin Kaufmann and Andreas Will

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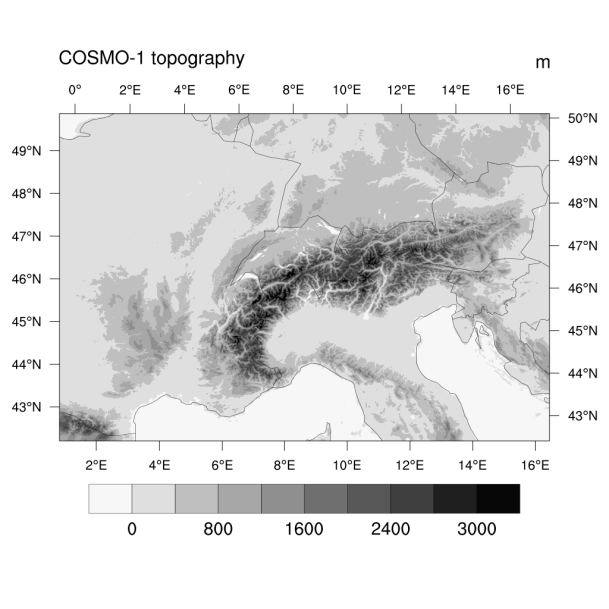
Status of the project

- The project has been **extended until December 2020** due to COVID-19
- C-MAX workshop took place in Cottbus 3-5.02.2020
- Calibration of **COSMO-1 for 5 parameters** (tkhmin, v0snow, uc1, rlam_heat, radfac) has been finalised and verification of the results is available.
- Modifications of the MM
- Attempt to reduce the computational cost by performing minimum number of simulations to fit the MM
- Simulations over the **Mediterranean Sea for 5 parameters** have been performed and calibration is pending
- Collaboration with **ETHZ** on a new **project trCLIM**
- Collaboration with the **University of Cottbus** on MM modifications to improve efficiency

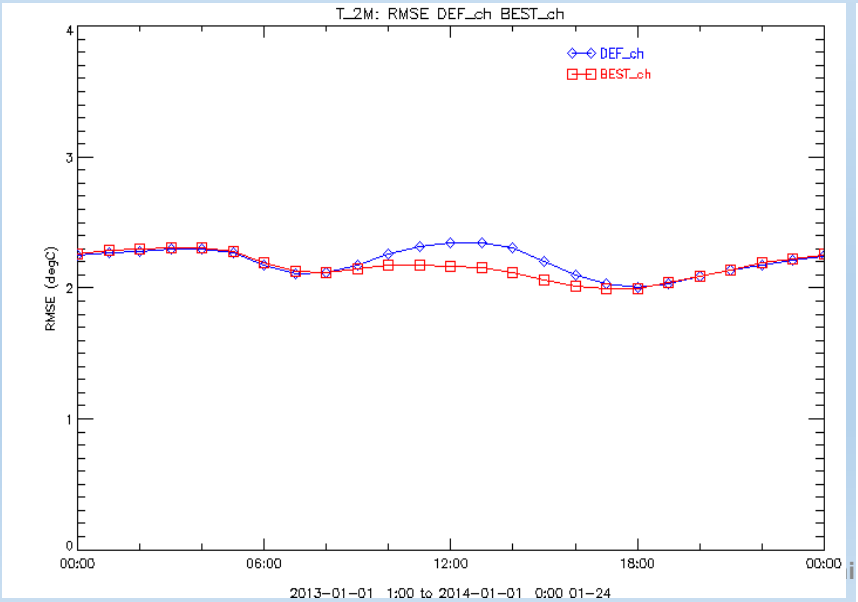
Calibration of COSMO-1

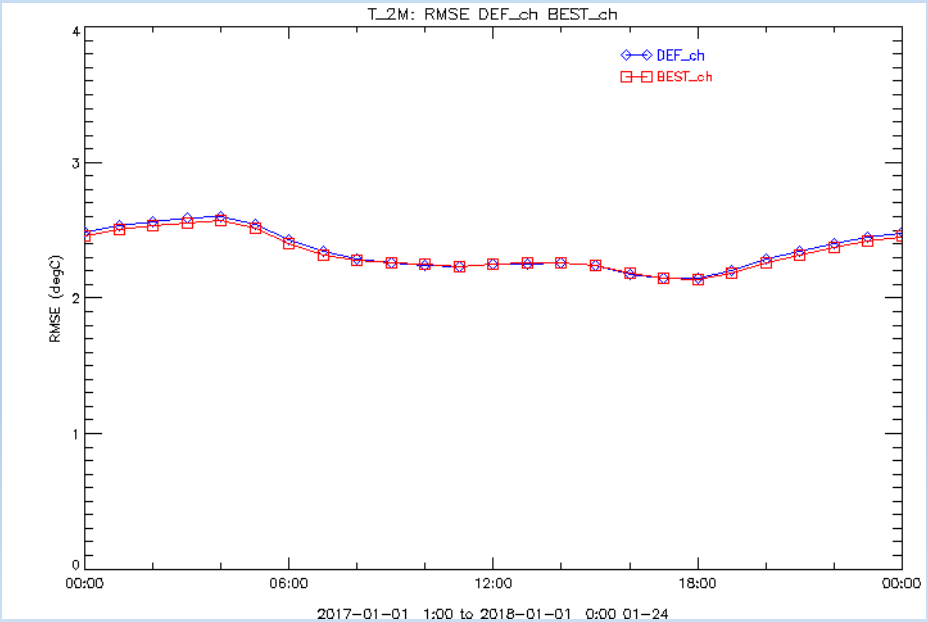


Acronym	Parameter	Parameter Range *	Optimum value	ETHZ Value
Minimal diffusion coefficient for heat	tkhmin	[0. 1 ,0.4,1]	0.279	1.37
Factor for laminar resistance for heat	rlam_heat	[0.1,1,2]	0.9296	0.72
Parameter controlling the vertical variation of critical relative humidity for sub-grid cloud formation	uc1	[0,0.8,1]	0.7686	0.75
Factor for vertical velocity of snow	v0snow	[10,20,30]	18.95	25.6
Fraction of cloud water and ice considered by the radiation scheme	radfac	[0.3,0.6,0.9]	0.6775	0.59

Table 1: Statistics of 2m temperature for years 2013 and 2017

Year	2013		2017	
Measure T2m	DEF	BEST	DEF	BEST
ME	0.043	0.128	0.236	0.143
RMSE	2.2	2.162	2.35	2.33
MINMOD	-28.67	-28.67	-29.64	-28.77
MINOBS	-28.7		-29.5	
MAXMOD	38.43	37.41	40.0	40.0
MAXOBS	37.1	37.1	36.9	





Equitable threat score (Gilbert skill score)-

$$ETS = \frac{hits - hits_{random}}{hits + misses + false\ alarms - hits_{random}}$$

where $$hits_{random} = \frac{(hits + misses)(hits + false\ alarms)}{total}$$

Answers the question: How well did the forecast "yes" events correspond to the observed "yes" events (accounting for hits due to chance)?
Range: -1/3 to 1, 0 indicates no skill. **Perfect score:** 1.

Probability of detection (hit rate) -

$$POD = \frac{hits}{hits + misses}$$

Answers the question: What fraction of the observed "yes" events were correctly forecast?
Range: 0 to 1. **Perfect score:** 1

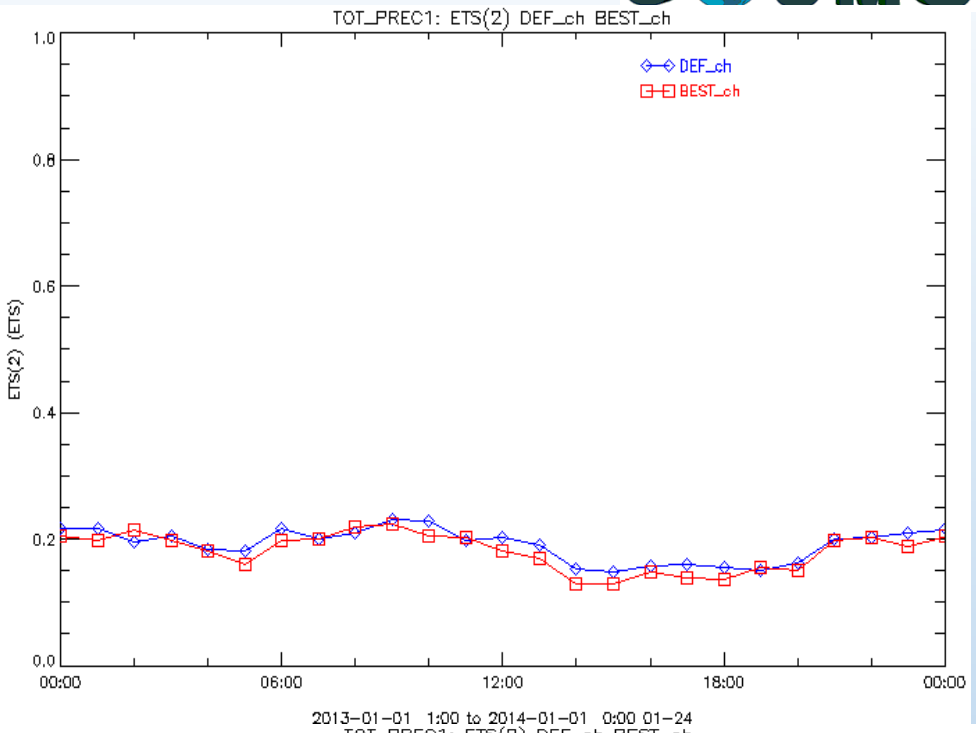
False alarm ratio -

$$FAR = \frac{false\ alarms}{hits + false\ alarms}$$

Answers the question: What fraction of the predicted "yes" events actually did not occur (i.e., were false alarms)?
Range: 0 to 1. **Perfect score:** 0.

Table 2: Statistics on the hourly accumulated precipitation for years 2013 and 2017

Hourly precipitation	2013		2017	
2013	DEF	BEST	DEF	BEST
ME	0.032	0.029	0.027	0.025
RMSE	0.771	0.771	0.8	0.8
MAXMOD	56.07	47.17	48.59	58.24
MAXOBS	48.5		60.8	
ETS(0.1)	0.355	0.334	0.35	0.35
FAR(0.1)	0.441	0.459	0.45	0.45
POD(0.1)	0.643	0.622	0.63	0.63



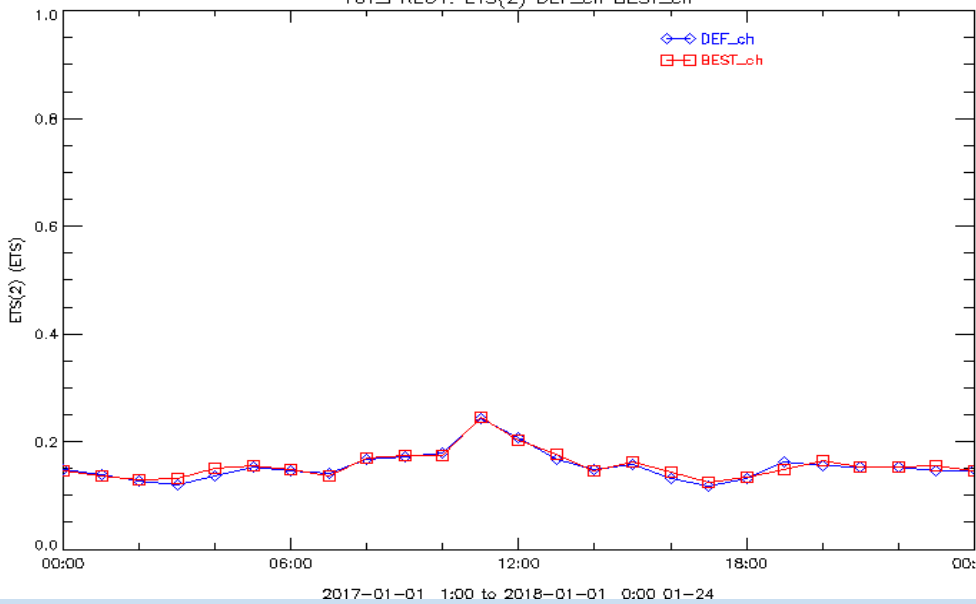
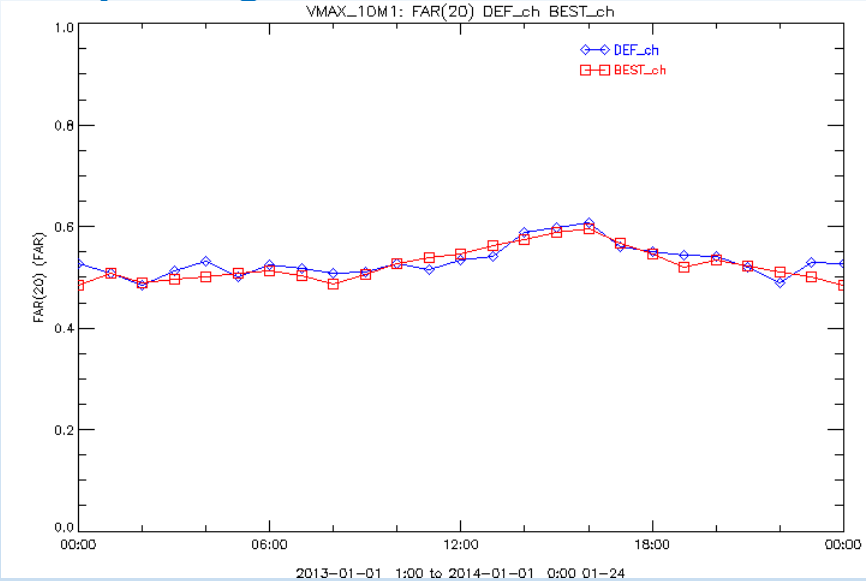
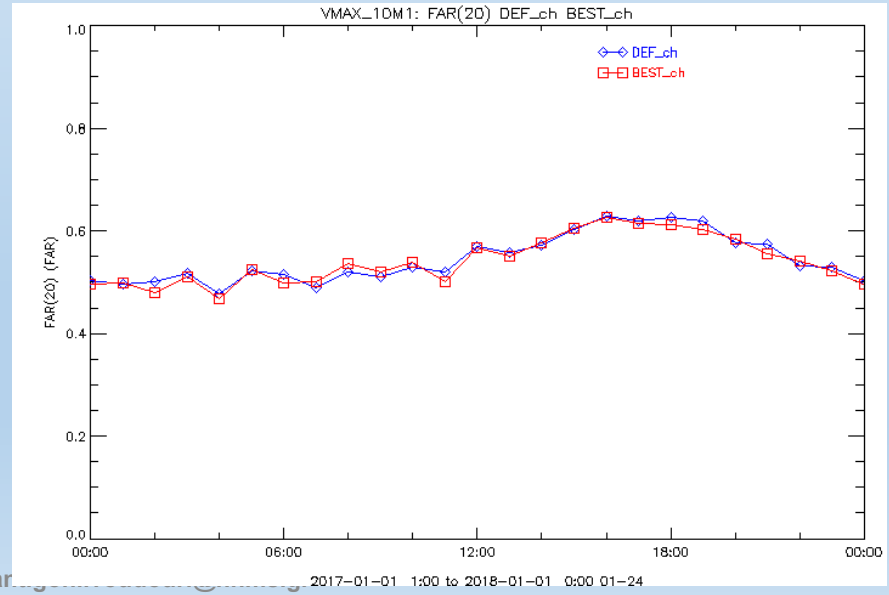


Table 3: Statistics of the hourly wind gust for years 2013 and 2017

1h wind gust	2013		2017	
ME	0.515	0.442	0.46	0.45
RMSE	3.158	3.173	3.24	3.23
MAXMOD	54.55	50.58	57.9	54.5
MAXOBS	57.9		54.4	

Hourly wind gust





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Meta Model Status summary (IMS contribution)

- A perturbed initial condition run was made to estimate the internal model variability. Screen out cases where internal model variability is larger that parameter dependency.
- Spatial verification for precipitation (FSS) has been included in the performance score.
- 2m dew point temperature (from INCA) has been introduced in the performance score to reduce the risk of over fitting the temperature.
- MatLab code efficiency has been examined. MM optimization - now the computation time is 10% from original!
- Build functions to calculate the skill score using FSS and weights given to fields included.
- Matlab to Octave: the translation of the MM to Octave, technical issues at ECMWF machines have been addressed
- Has bias been used instead of real value when completing the MM correlation check (as performed by ETH)???
- Implementation of a program for choosing a given number of days relatively similar synoptically by objective cluster analysis

COSI-FSS score

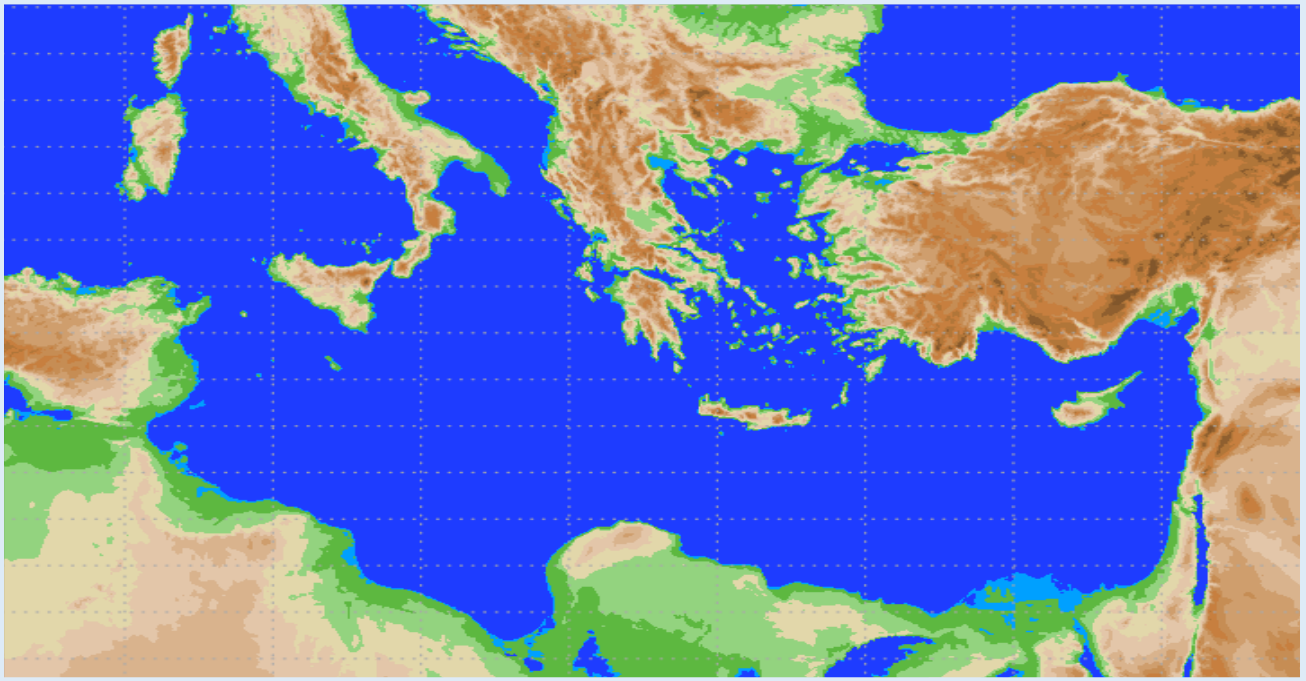
$$S_p = \frac{1}{12 \sum_{\Psi=1}^{18} \omega_\Psi} \left\{ \sum_{\Psi \neq 3} \omega_\Psi \sum_{mon=1}^{12} \left[1 - \frac{\sum_{\Psi regs} \sum_{\Psi days} (F_{\Psi,p,d,r,mon} - O_{\Psi,d,r,mon})^2}{\sum_{\Psi regs} \sum_{\Psi days} (O_{\Psi,d-1,r,mon} - O_{\Psi,d,r,mon})^2} \right] + \omega_3 \frac{\sum_{mon=1}^{12}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

FSS score is instead of ETS score

Optimum parameter values for COSMO 1km using COSI-FSS, Variables: daily T2max, T2min, Rain

IMS matlab	*Best iteration number*	Tkhmin [0.1-1]	Rlam [0.1-2]	V0snow [10-30]	Radfac [0.3-0.9]	Uc1 [0-1]
29/8/2013-07/9/2013	19	0.2323	0.7146	20.65	0.6541	0.007403
8-17/9/2013	40 (there is almost convergence)	0.3696	0.8629	23.54	***0.6747***	0.8461
18-27/9/2013	17	0. 1009	0.8263	19.27	0.4935	0.1348
28/9/2013-7/10/2013	37	0.2493	0.8214	20.89	0.6500	0.000158
8-17/10/2013	40 (there is convergence)	***0.2804***	0.6589	12.44	0.5782	0.8303
18-27/10/2013	23	0.2590	0.7872	18.78	0.5757	0.00005158
28/10/2013-6/11/2013	40 (there is convergence)	0.4649	1.1094	14.78	0.537995	0.005773
7-16/11/2013	23	0.4276	1.190	18.33	0.3685	0.79922
17-26/11/2013	37	0.3907	0.6993	21.96	0.6661	0.8355
27/11/2013-6/12/2013	22	0.3082	1.677	17.99	0.8832	0.8724
7-16/12/2013	24	0.1004	1.6995	16.36	0.8302	0.7379
17-26/12/2013	38	0.9874	0.3689	19.85	0.5914	0.8817
1-31/12/2013		**0.279**	**0.9296**	**18.95**	**0.6775**	**0.7686**

Simulations over the Mediterranean



PARAMETER	INTERPRETATION	RANGE	TEST VALUES (default)
rat_sea	ratio of laminar scaling factors for heat over sea	1-100	1, 10, 50
rlam_heat	scaling factor of the laminar boundary layer for heat	0.1 – 10.0	0.1, 1.0, 2.0
tkhmin tkmmin	minimal value of diffusion coefficient for heat and momentum (kept equal)	0.0-2.0	0.1, 0.40, 2.0
tur_len	asymptotic maximal turbulent length scale (m)	10 – 10000	100, 150, 1000
c_soil	surface area index of evaporative soil surfaces (dependent on surface area density of the roughness elements over land , c_lnd)	0-c_lnd(2.0)	0, 1, 2

Remarks

- Strong **dependency** of parameters optimum on the **time** of the year
- Significant optimum value differences, large intra-annual fluctuations
- Variation of the optimum reflects **dependency on the atmospheric flow** or weather pattern (check with observed atmospheric fields)
- **Implicit** dependency of some tuning parameters to model variables
- Methodology is "**model independent**" and can be applied to any NWP or climate model.

Deliverables

- Calibration results over Mediterranean
- IMS consolidated MM code and uploaded at ECMWF
- Well-documented list of model parameters tested for calibration
- Meta model available @ https://github.com/COSMO-ORG/CALMO-MM (pending)
- Schedule a web conference for a training with a full package (pending)
- Networking with other groups IRSN (suspended), ETH (trClim project-on going)
- Detailed description of the optimization method (parameters convergence)
- Cottbus department of mathematics to: (a) propose a new approach on MM (b) perform calibration on the new dynamical core
- Common MM with COSMO-CLM/ Updated user guide on MM
- Workshop with COSMO-NWP and COSMO-CLM (Zurich) on MM
- **Documents and deliverables**
  - Technical report No 42
  - Contribution to the 20th COSMO Newsletter

Future work - CALMO based next PP

- Cost reduction goal and estimate computational cost with respect to model performance improvement
- Synchronize the COSMO and the ETHZ developments
- Provide a unified, consolidated, portable (Octave or Python) and well documented (user guide) meta-model code and an automatized procedure

- Use calibration to check robustness of parameterization schemes e.g. do similar optimum parameter values define confidence interval of the parameterization scheme?
- Idea of cluster analysis (based on ensemble members) is valid only in cases of similar results for optimum parameter values per member
- List of unconfined parameters correlated to model variables is needed