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# Priority Project
# CALibration of the COSMO MOdel
# CALMO

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# Outline

- Introduction
- Preliminary findings
- Sensitivity experiments
- Conclusions

# Introduction

- Started on February 2013
- Based on the work of Neelin et al. 2010, Bellprat et al. 2012
- Preliminary phase finished within COSMO year 2014-15
  - 3 parameters (tur_len, tkhmin and rlam_heat)
  - 3 variables : maximum daily temperature (Tmax), minimum daily temperature (Tmin) and 24 hours accumulated precipitation (Pr)
  - two 3-weeks periods winter (3-20/1/2008) and summer (2-20/6/2008)
- Manuscript submitted at JAMC
- Phase 2 includes
  - Calibration of COSMO GPU code in high-resolution within year 2015-16
  - Sensitivity experiments on additional parameters finished.

# The performance score (contribution of IMS)

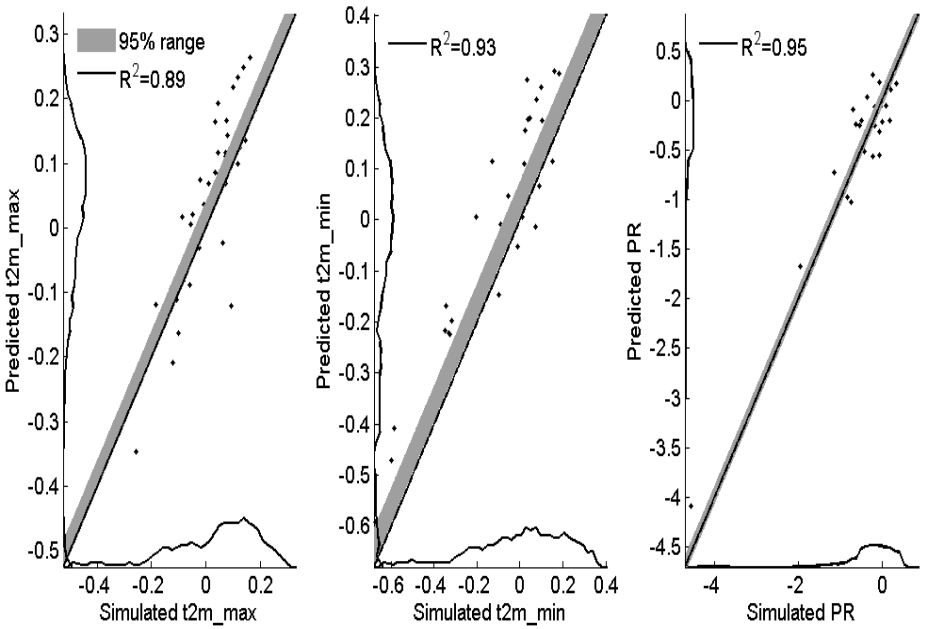
$$S_p = \sqrt{\frac{1}{N_{regs} \times N_{days}} \sum_{regions} \sum_{days} \left\{ \frac{\left(F_{Tmax,p,i,r} - O_{Tmax,i,r}\right)^2}{W_{Tmax} \times \left(\sigma_{Tmax,r}\right)^2} + \frac{\left(F_{Tmin,p,i,r} - O_{Tmin,i,r}\right)^2}{W_{Tmin} \times \left(\sigma_{Tmin,r}\right)^2} + \frac{\left(F_{Pr,p,i,r} - O_{Pr,i,r}\right)^2}{W_{Pr} \times \left(\sigma_{Pr,r}\right)^2} \right\}}$$

$$W_F = \frac{1}{N_{comb}} \sum_{p} \left\{ \frac{1}{N_{regs} \times N_{days}} \sum_{regions} \sum_{days} \frac{\left(F_{p,i,r} - O_{i,r}\right)^2}{{\sigma_r}^2} \right\}$$

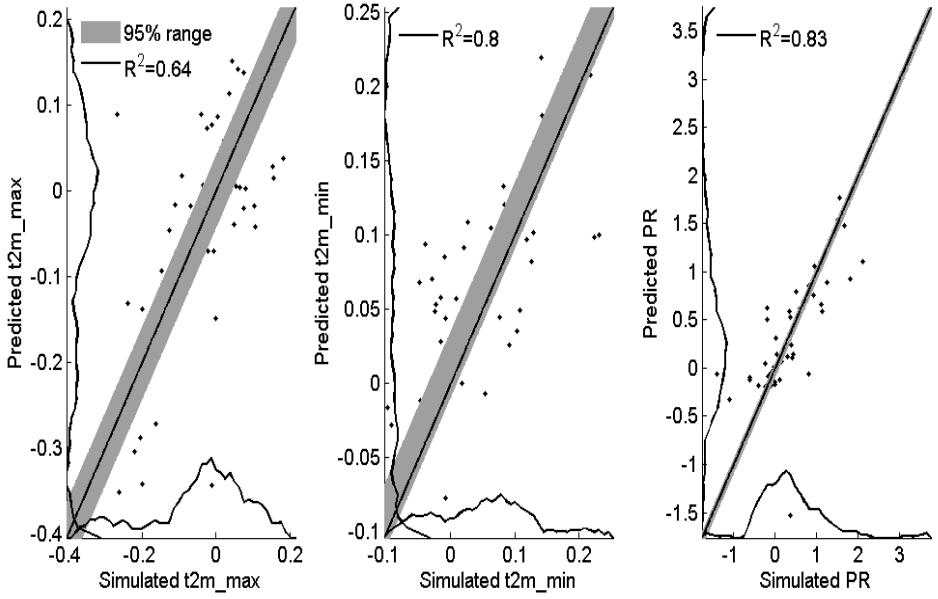
$$\sigma_r = \sqrt{\frac{1}{N_{days}} \sum_{days} (O_{i,r} - \bar{O}_{i,r})^2}$$

Note: Lower $S_p$ deviation value, stands for better score, and better the specific parameters combination.

# Accuracy of the MM

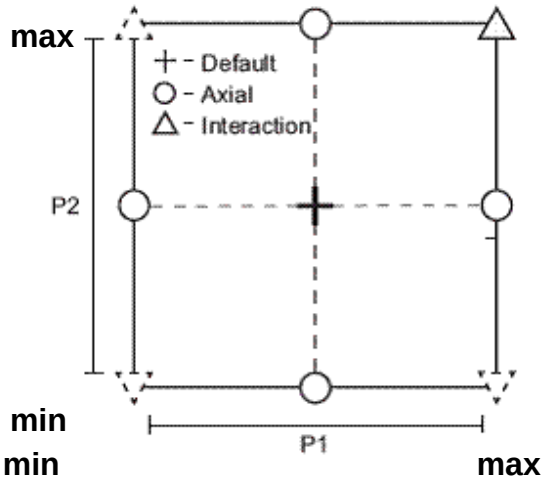


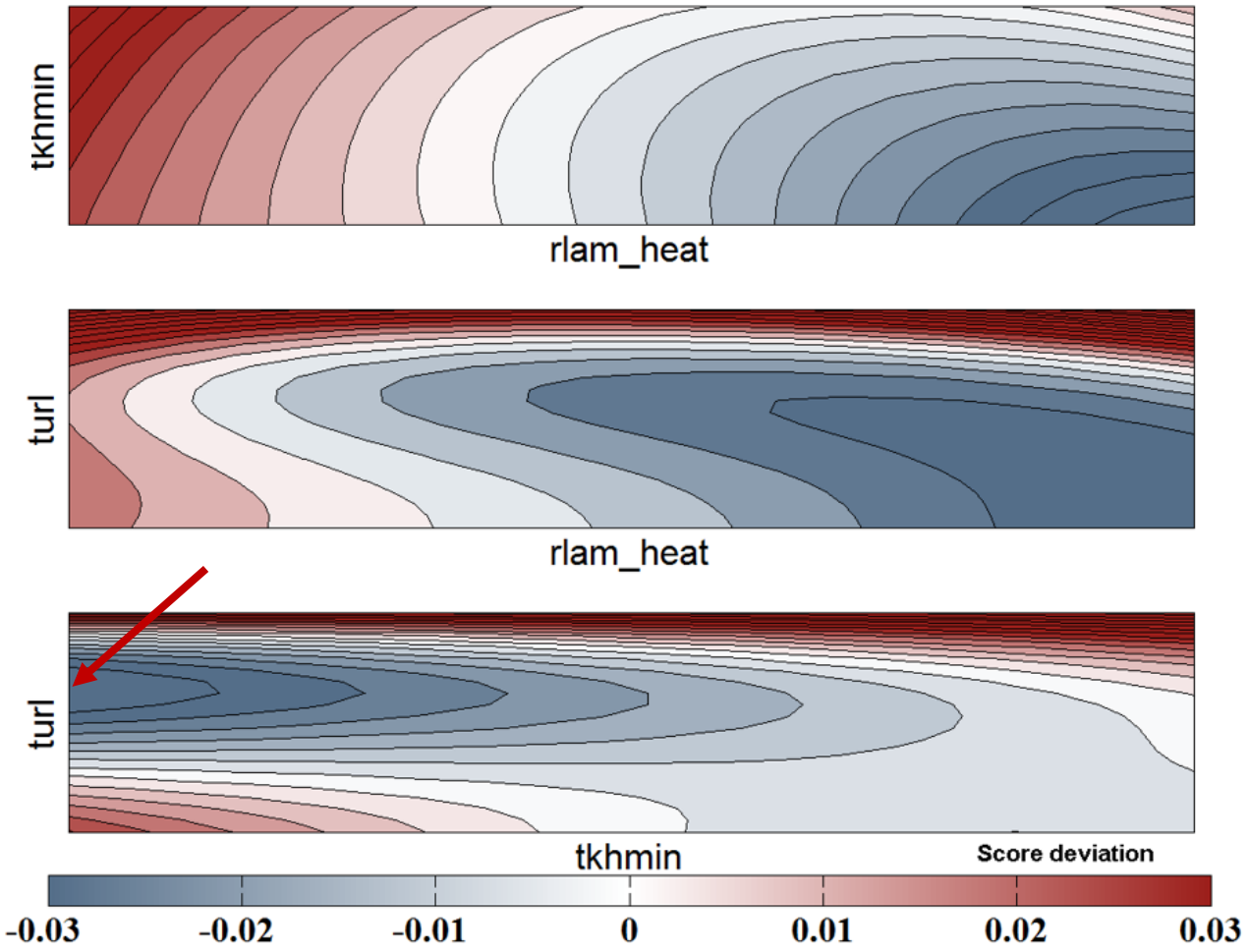

*Tmax (left panel), Tmin (centered panel) and precipitation (right panel) for the period 3-20.1.2008*



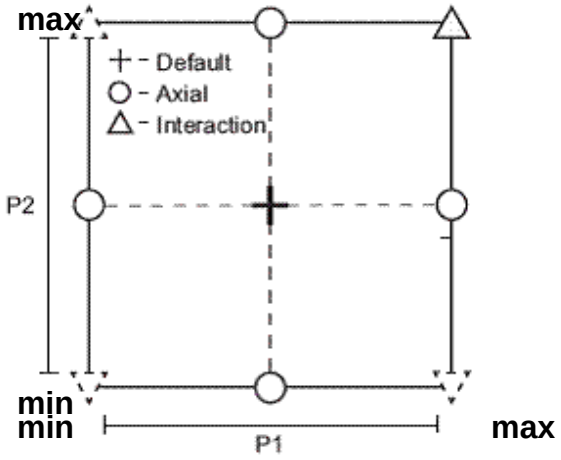

*Tmax (left panel), Tmin (centered panel) and precipitation (right panel) for the period 2-20.6.2008*

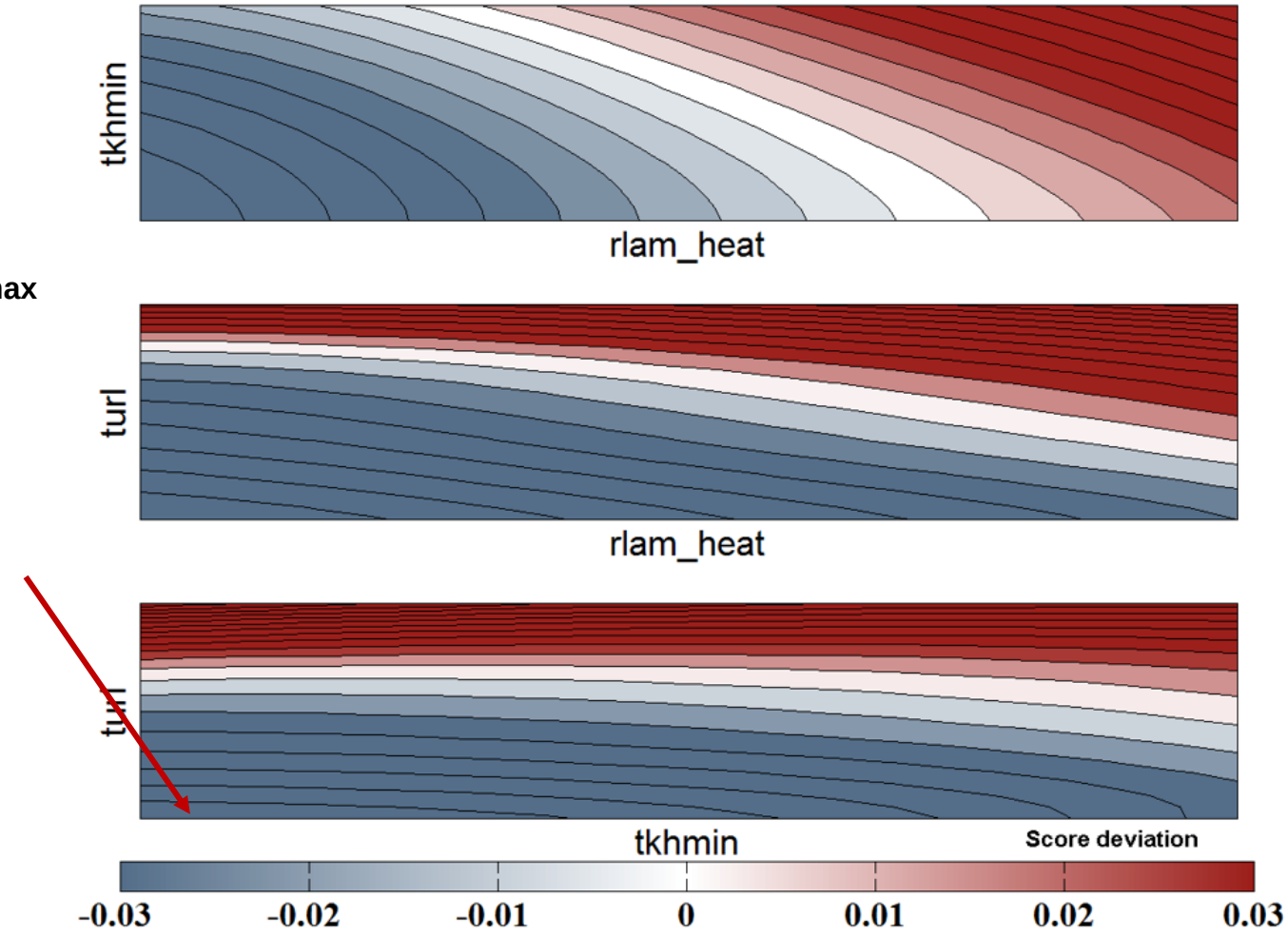
# 3-20.01.2008


max
Default
Axial
Interaction
P2
min
min
P1
max

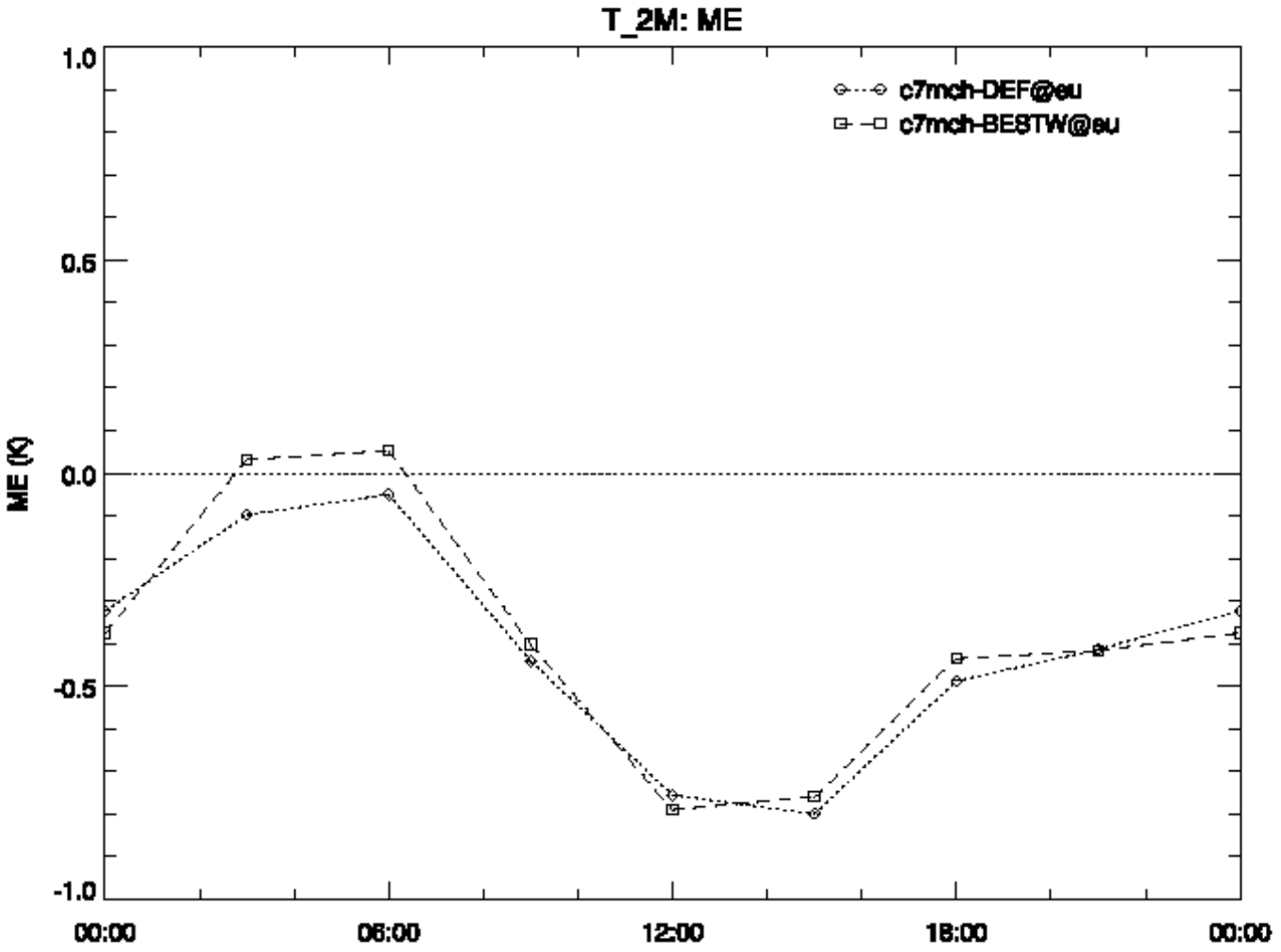

tkhmin
rlam_heat
turl
rlam_heat
turl
tkhmin
Score deviation
-0.03
-0.02
-0.01
0
0.01
0.02
0.03

# 2-20.06.2008


max
Default
Axial
Interaction
P2
min
min
P1
max


tkhmin
rlam_heat
turl
rlam_heat
turl
tkhmin
Score deviation
-0.03
-0.02
-0.01
0
0.01
0.02
0.03

# Verification Results (thanks to P. Kaufmann)



# What have we learned?

- Selection of parameters requires:
  - Detailed definition of parameter ranges.
  - Sensitivity experiments within allowed ranges
- Minimum number of experiments required to fit the MM is not 2N+N(N-1)/2, should follow a Box Behnken experiment design (sufficient to fit a quadratic model )
- Observations to fit the MM
- The performance score to be used requires:
  - observation errors,
  - weighting factors,
  - Variables compination
- Methodology CAN be transferred to NWP

A detailed technical report (No 25) summarizing results of the first stage of CALMO is now available to COSMO though:

**http://www.cosmo-model.org/content/model/documentation/techReports/docs/techReport25.pdf**

# Sensitivity experiments (contribution of E. Avgoustoglou)

**13 parameters were considered.**

⊗

**3 values/parameter including default.**

⊗

**The evaluation period consisted of 62 days from year 2013, i.e.:**
**February 1-20, June 1-20, December 10-31.**

⇓

**2418 runs based on COSMO.v5.0**

- **Horizontal grid size: $0.0625^0$ (~7km).**
- **649x393 grid points (wider mediterranean area), 60 levels.**
- **Integration time-step: 30 secs.**
- **Integration period: 48 hs.**
- **Boundary conditions : 6hr IFS Analysis.**
- **Computational Cost ~ $10^7$ b.u. on Cray X C30 of ECMWF (gratis HNMS).**

# DEFINITION OF SENSITIVITIES (S)

$$S_{<P>}(\%) = \frac{< P >_{TEST} - < P >_{DEFAULT}}{< P >_{DEFAULT}} \bullet 100$$

$< P >$ stands for $< SNOWGSP >$ *or* $< TOTPREC >$ *or* $< CLCL >$ *or* $< CLCM >$ *or* $< CLCH >$ *or* $< CLCT >$

$$S_{\{\langle \mathrm{TOTPREC} \rangle, \langle \mathrm{SNOWGSP} \rangle, \langle \mathrm{CLCH} \rangle, \langle \mathrm{CLCM} \rangle, \langle \mathrm{CLCL} \rangle\}} = \left|S_{\langle \mathrm{TOTPREC} \rangle}\right| + \left|S_{\langle \mathrm{SNOWGSP} \rangle}\right| + \left|S_{\langle \mathrm{CLCH} \rangle}\right| + \left|S_{\langle \mathrm{CLCM} \rangle}\right| + \left|S_{\langle \mathrm{CLCL} \rangle}\right|$$

$$S_{\begin{bmatrix} TMIN\,2m \\ TMAX\,2m \end{bmatrix}} = \begin{bmatrix} < TMIN\,2m > \\ < TMAX\,2m > \end{bmatrix}_{TEST} - \begin{bmatrix} < TMIN\,2m > \\ < TMAX\,2m > \end{bmatrix}_{DEFAULT}$$

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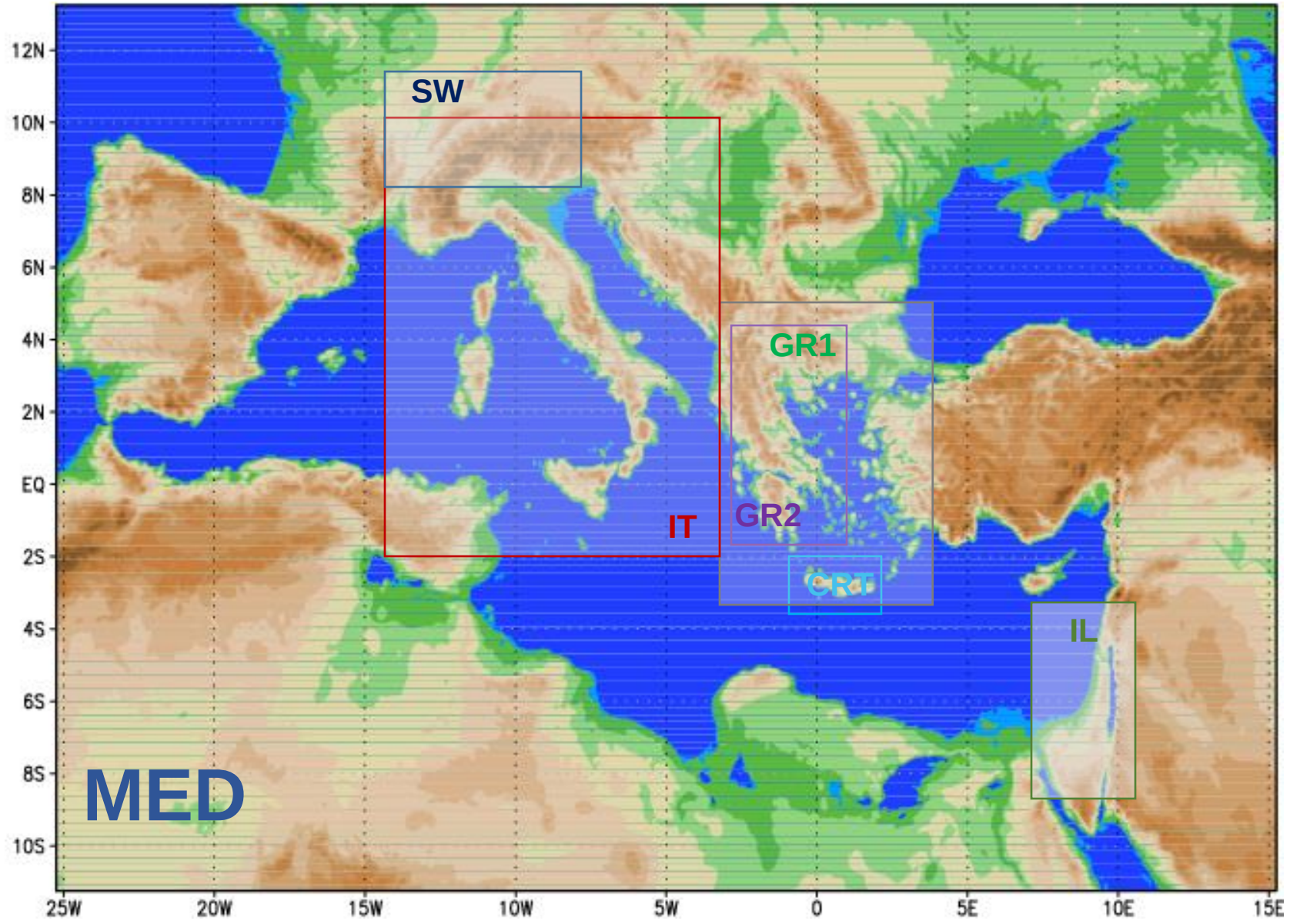
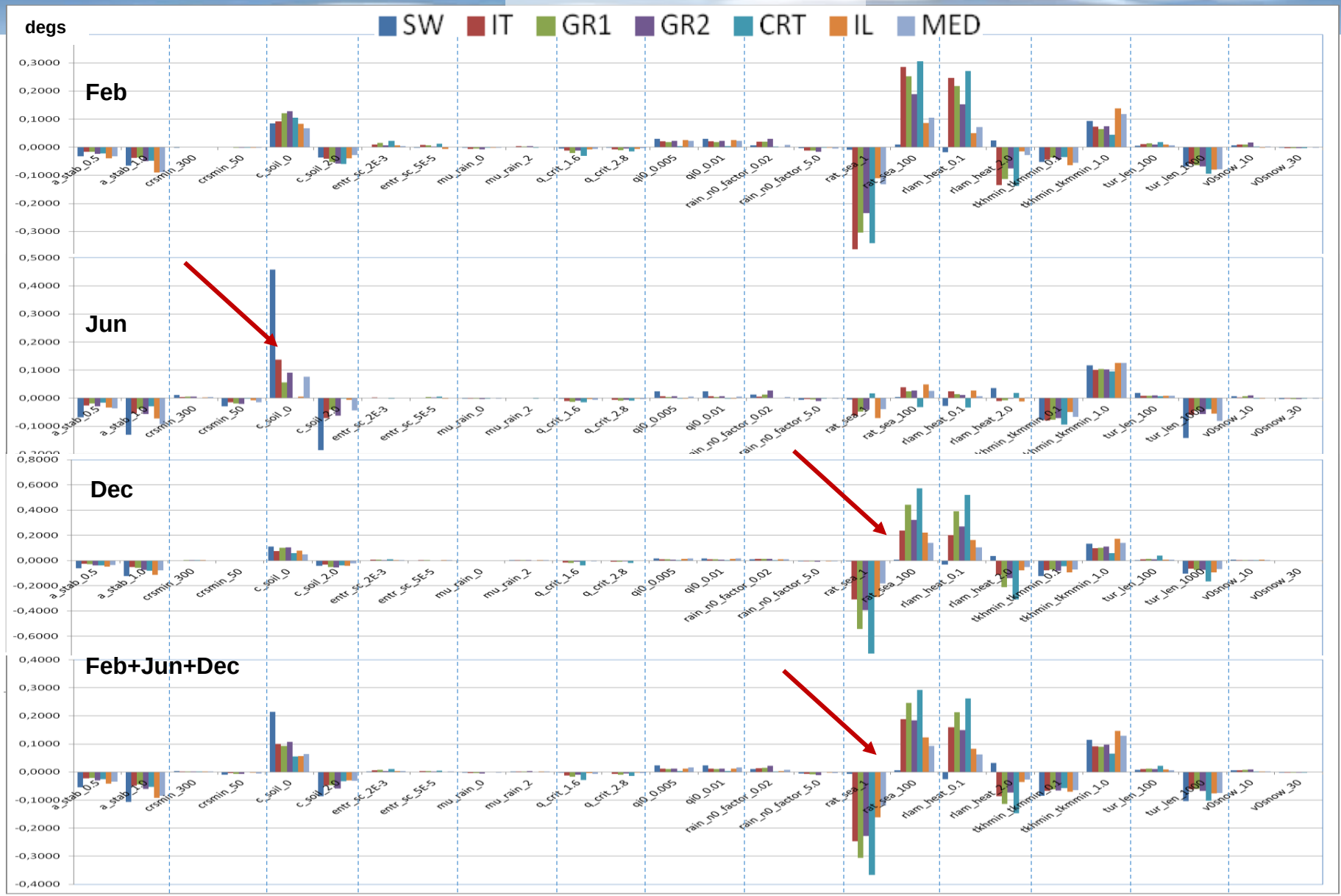


# Sensitivity for TMIN2m




| Pars: | a_stab | crsmin | c_soil | entr_sc | mu_rain | q_crit | qi0 | rain_n0_factor | rat_sea | rlam_heat | tkhmin_tkmmin | tur_len | v0snow |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lims: | 0.0, 1.0 | 50, 300 | 0, 2 | 5E-5, 2E-3 | 0, 2 | 1.6, 2.8 | 0, 0.01 | 0.02, 5.0 | 10, 100 | 0.1, 2.0 | 0.1, 1.0 | 100, 1000 | 10, 30 |
| Def : | 0.5 | 150 | 1 | 3E-4 | 1 | 4.0 | 0.005 | 1.0 | 20 | 1.0 | 0.4 | 150 | 20 |

# Sensitivity for {TOTPREC,SNOWGSP,CLCH,CLCM,CLCL}


| Pars: | a_stab | crsmin | c_soil | entr_sc | mu_rain | q_crit | qi0 | rain_n0_factor | rat_sea | rlam_heat | tkhmin_tkmmin | tur_len | v0snow |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lims: | 0.0, 1.0 | 50, 300 | 0, 2 | 5E-5, 2E-3 | 0, 2 | 1.6, 2.8 | 0, 0.01 | 0.02, 5.0 | 10, 100 | 0.1, 2.0 | 0.1, 1.0 | 100, 1000 | 10, 30 |
| Def : | 0.5 | 150 | 1 | 3E-4 | 1 | 4.0 | 0.005 | 1.0 | 20 | 1.0 | 0.4 | 150 | 20 |

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# Parameters selection

| Surface layer | | |
|---|---|---|
| Name | range | comment |
| c_soil | [0,1*,c_lnd] | c_lnd=2 |
| rlam_heat (and rat_sea) | [0.1,1*,2]<br>*([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)*<br>*This in principle also applies to COSMO model unless we intend to change the evaporation over water.* |

7(-8) parameters = 57(113) instead of 36 (45) simulation to fit the MM according to rule

| 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!*<br>*Increasing values does not keep low clouds, decreasing values better scores* |

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

| Vegetation and soil | | |
|---|---|---|
| Name | range | comment |
| crsmin | [50,150*,300] | |
| kexpdec | [0, 2* , 2] | *f=2 in Decharme et al. 2006, parameter for hydraulic conductivity induced in Tuning namelist by G.Morsier* |

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

# Conclusions

- Objective calibration is possible for NWP models and has several advantages: transparent, efficient, effective.
- Calibration methodology can be a useful tool for ensemble predictions.
- Selection of model parameters/performance score is a crucial but also user-depended step
- Additional parameterization development and new model implementations is always needed but…
- Calibration is also then meaningful in order to substitute expert tuning!

- http://mail.cosmo-model.org/mailman/listinfo/cosmo-calmo

# Stay tuned…….