PP CALMO
CALibration of COSMO MOdel

Project Leader
Antigoni Voudouri

COSMO GM 2012 / Lugano, 10-13.09.2012

CALMO

Motivation

- Many **unconfined parameters** in the COSMO model

- **Expert tuning** during model development, but for some specific model configuration and some specific target region

- **Is this expert tuning still valid for …**
  - … a new *target region* (e.g. Alps, Greece) ?
  - … a new *model configuration* (e.g. horizontal or vertical grid refinement, new numerics, new soil module) ?

CALMO

Motivation

- Could COSMO benefits from a calibration method which is
  - **multivariate** in parameter space,
  - **objective**,
  - mainly **automatic**,
  - **practicable** in terms of computing time (but not cheap),
  - **(at least) as good as** the expert tuning ?

Too good to be true ?

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

C2SM
Center for Climate
Systems Modeling

Systematic calibration of a regional climate model and implications for expert tuning

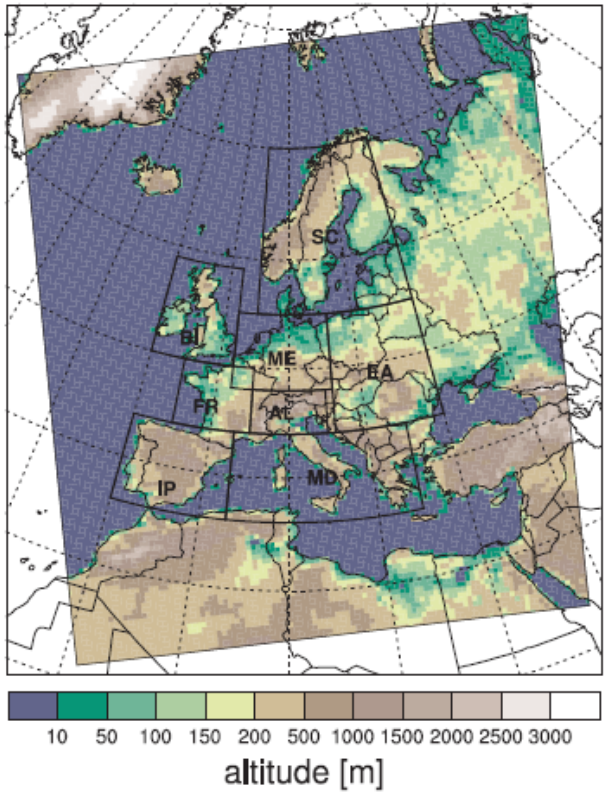
Omar Bellprat, Sven Kotlarski, Daniel Luethi, Christoph Schär

7.05.2012, Group Meeting

Performance function

Validation framework

Domain and Topography COSMO-CLM



Model performance

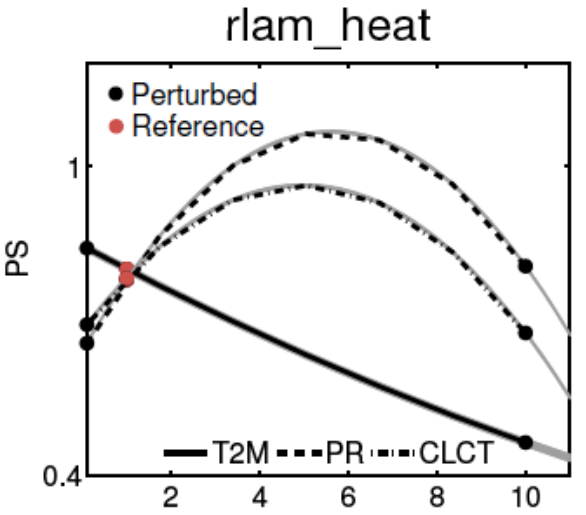
$$PI = \left\langle \frac{(m-o)^2}{(\sigma_o+\sigma_{iv}+\sigma_\epsilon)^2} \right\rangle,$$
$$PS = exp(-.5 * \sqrt{PI})$$

Least-squares error of monthly timerseries for T2M, PR and CLCT and for all PRUDENCE regions. (Normal likelyhood) m=model output, o=observations. σ_o=natural variability of observations. σ_{IV}=internal variability of CCLM, σ_{err}=uncertainty of observations.

Sensitive model parameters

Selected model parameters

- **rlam_heat**: Controls restistance of the laminar surface fluxes for heat.
- **qi0**: Threshold for auto-conversion from ice to snow.
- **entr_sc**: Entrainment rate of shallow convection.
- **uc1**: Controls relative humidity criterion in sub-grid cloud formation.
- **rootdp**: Uniform factor of the root depth field.



Minimum and maximum paramter value for rlam_heat

Meta-model in parameter space

Non-linear regression

Fit a multivariate quadratic model in the parameter space (Neelin, 2010)

Meta-model

$$\Phi' = \vec{\mu} \cdot \vec{a} + \vec{\mu}^T \cdot B \vec{\mu} + \Phi_s$$

Φ: Model field (e.g. T2M,PR,CLCT), $\vec{\mu}$: Parameter vector, a, B: Coefficient matrices

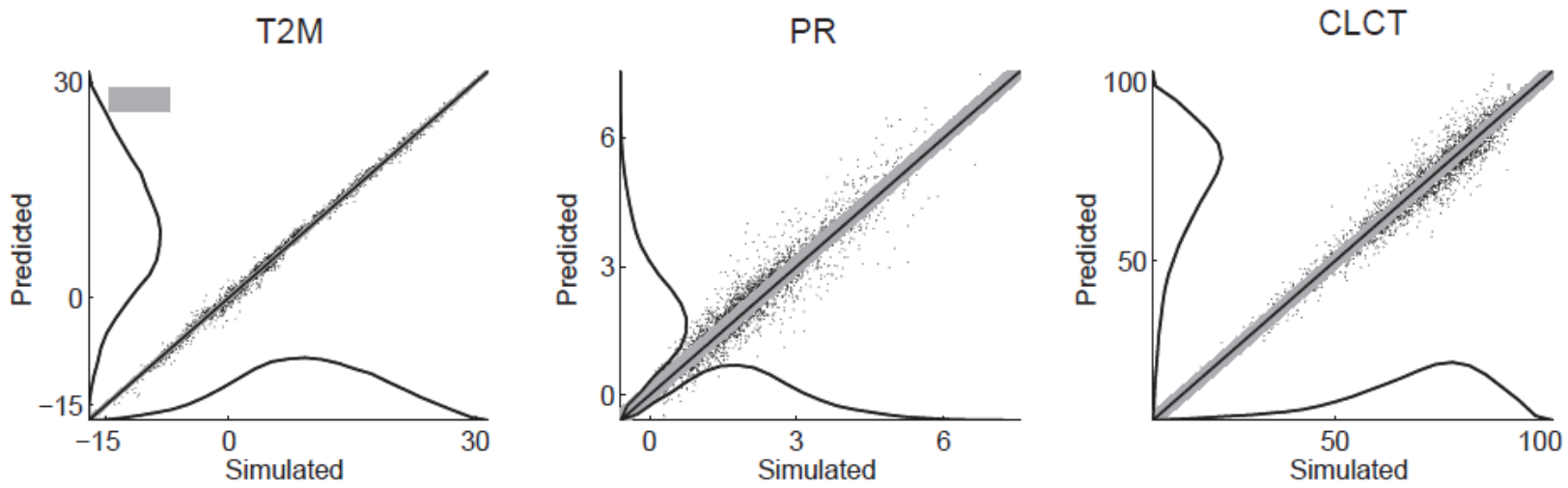
e.g. for 2 parameters: $\Phi' = \Phi_s + a_1\mu_1 + a_2\mu_2 + b_1\mu_1^2 + b_2\mu_2^2 + 2\mu_1\mu_2$

Number of simulations for analytical solution $= N * 2 + N(N-1)/2$.
For 5 parameters 20 simulations needed.

The Meta-model works!

Predicting independent simulations

In order to assess to error the meta-model independent simulations have been simulated (10 Simulations)



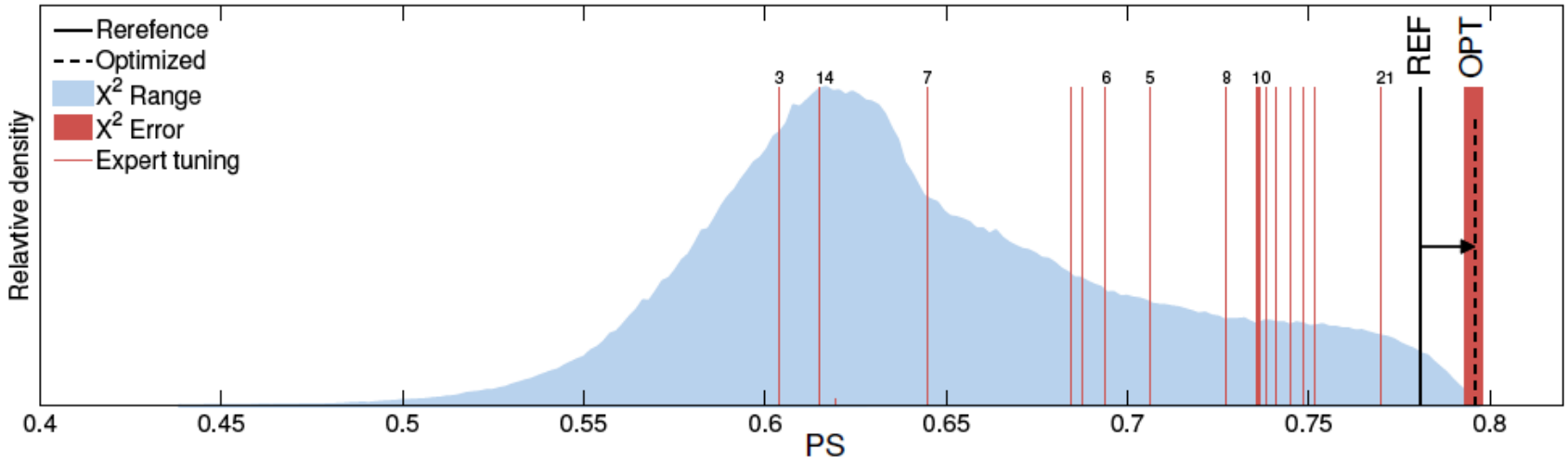
Predicting independent simulations 10000 spatial means

The meta-model predicts the RCM with high accuracy - optimal parameters can be determined with any procedure.

Objective calibration beats expert tuning!

Systematic calibration versus expert tuning

Full performance range for the selected parameter ranges and expert tuning for CORDEX setup.



1 Mio. parameter combinations from a latin hyper-cube.

Much more efficient procedure and additional reduction of 10% of the error.

CALMO

Goal

- Goal is to answer the two following questions:
  1. How **practicable** is the calibration framework developed at ETHZ for NWP applications ? Which adaptations are necessary ?
  2. How **sensitive** is the optimal parameters set with respect to the **model domain** (e.g. N. Europe, Alps, Mediterranean) ? Any **gain in model quality** observed with respect to the default configuration ?

CALMO

Basic information

- Accepted by COSMO StC.
- Duration 12/2012-12/2014 -Approximately 2 FTEs
- Supported by ETHZ (Prof. C.Schaer).
- Responsibility in WG3b.
- A. Voudouri will participate with 0.7 FTE
- F.Grazzini will participate at the level of 0.1 FTE in 2013.
- Participation of Omar Bellprat in 2013 (resources to be consolidated).

CALMO

Tasks

- Task 1 : Preliminary work (e.g. acquire computing resources)
- Task 2 : Adaptation of the existing method for NWP applications
- Task 3 : Sensitivity of optimal parameters to the choice of the target region
- Task 4 : Define optimal methodology in terms of computing time and quality gain
- Task 5 : Documentation, incl. scientific paper


THANK YOU FOR THE ATTENTION