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CONSORTIUM FOR SMALL SCALE MODELING
COSMO

Soil and surface activities

(COSMO: Status Report)

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Soil & surface activities (from COSMO WG 3)

- Reformulation of land surface processes – main topics: ***implicit*** solver, ***consistency***
  Revision of TERRA ***hydrology*** [DWD & MCH, ▹ COSMO v6.0]
- Effect of ***vegetation canopy***
  - **First step*:* skin layer formulation (J.-P. Schulz)** - in operational production suite
  - Further work: resistance formulation, semi-transparent layer
- Improved vegetation ***phenology*** and ***stomatal conductance*** [PT VAINT]
- ***Urban model*** TERRA-URB [PT AEVUS2 ▹ COSMO v6.0 – **New PP**]
- Advanced ***snow model –*** multi-layer formulation [PT SAINT ▹ COSMO v6.0] New PT
- Common ***snow analysis*** [**New PP**]
- (Tool) Model ***calibration*** [**PP CALMO-MAX**, ▹ 2020Q4] [trCLIM@ETHZ, **new PP**]
- (Tool) ***TERRA standalone*** (consolidate & extend) [DWD, PT SAINT, ▹ 2020Q4]
- (COSMO software) **physiographic data *EXTPAR*** (code, land use, topography, urban parameters, soil, pollen) [ETHZ, DWD, MPI-H, ▹ running task]

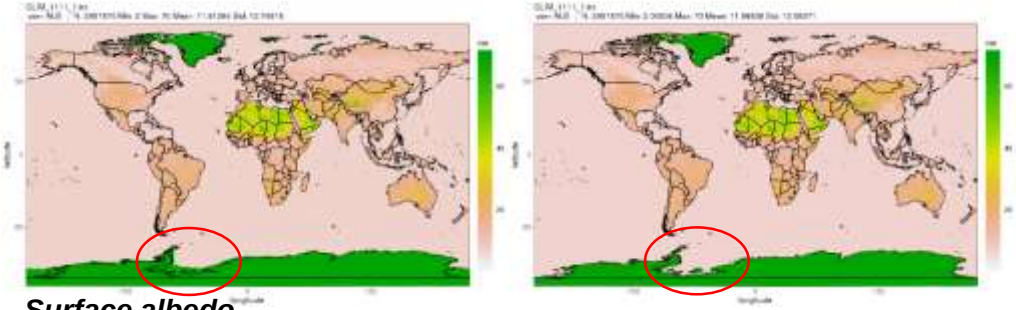
COSMO project | **more slides** | **PP - Priority Project** | PT – Priority Task

From COSMO to ICON model

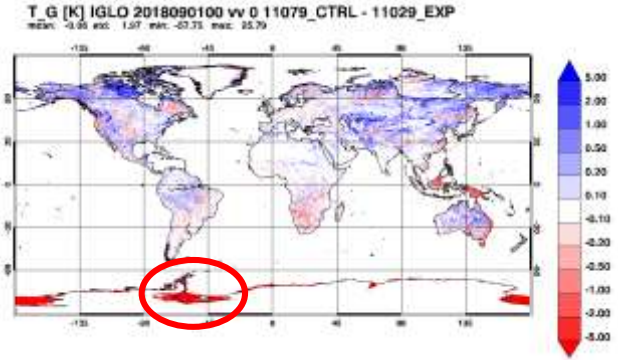
- *Turbulence Scheme*, ***soil model TERRA***, ***lake model FLake***, ***model for sea ice*** now share the same code basis between COSMO and ICON.
- COSMO and ICON will continue to differ in coupling (**tile approach),** the use of the **external parameters,** and hence the **tunings** of the models
- ***Targeted modifications on the shared code basis***
  - To better represent effects of partial snow cover and of snow under tree canopy
  - Reduction of roughness length over snow cover
  - Interception of rime
- ***External parameters***
  - Post-processing of derived physiographic data, like use of look-up tables, computation of a yearly cycle, or topo smoothing, is done in …
  - … EXTPAR and INT2LM (COSMO)
  - … the ICON model itself (ICON)

Some critical issues

- Developing / adapting a new parameterization **means more** than developing / adapting a new parameterization…
- Recent developments in WG3b have shown that the following tasks may consume a **considerable amount of resources**
  - Development of new / consolidated ***physiographic parameters*** (high resolution, global)
  - ***Tuning*** (application specific, CALMO methodology)
  - ***Testing*** (global, multiple resolutions, multiple time scales)



Surface albedo
EXTPAR GlobCover/GLCC → *EXTPAR ESA CCI*



→degraded near surface T !

MeteoSwiss model improvement

Schulz & Vogel: main changes

- improved bare soil evaporation
  - less evaporation for medium-wet to wet soil conditions, thereby leading to smaller Td2m and larger T2m values as well as to a larger diurnal temperature range
  - more evaporation for medium-dry to dry soil conditions, thereby leading to larger Td2m and smaller T2m values as well as to a smaller diurnal temperature range
- skin layer temperature (new; to simulate vegetation canopy effect)
- interception reservoir activated (new)
- a few more smaller changes; *still unsatisfactory: plant transpiration*

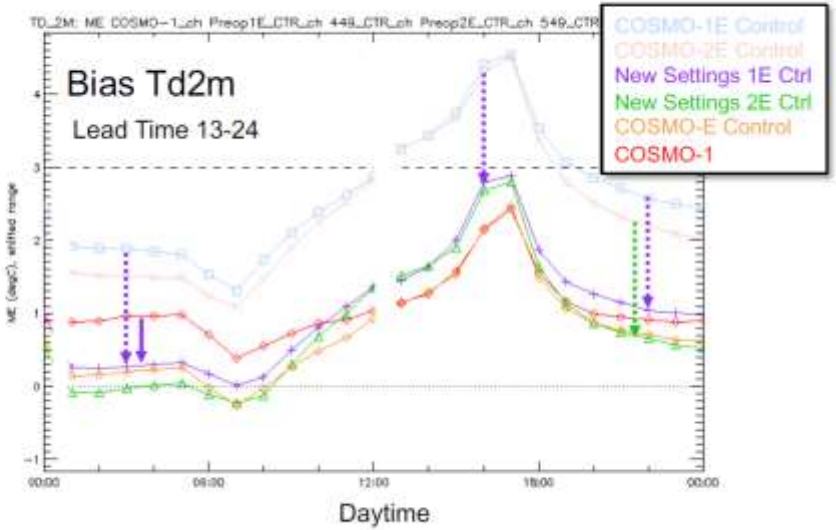
→ ***additionally needed for mitigation of poorly tuned model:***
→ ***artificially reduced evapotranspiration***

Reference: Jan-Peter Schulz and Gerd Vogel, 2020: Improving the Processes in the Land Surface Scheme TERRA: Bare Soil Evaporation and Skin Temperature, *Atmosphere*, **11**, 513

MeteoSwiss model improvement

2m Dewpoint Spring 2020 (15d)

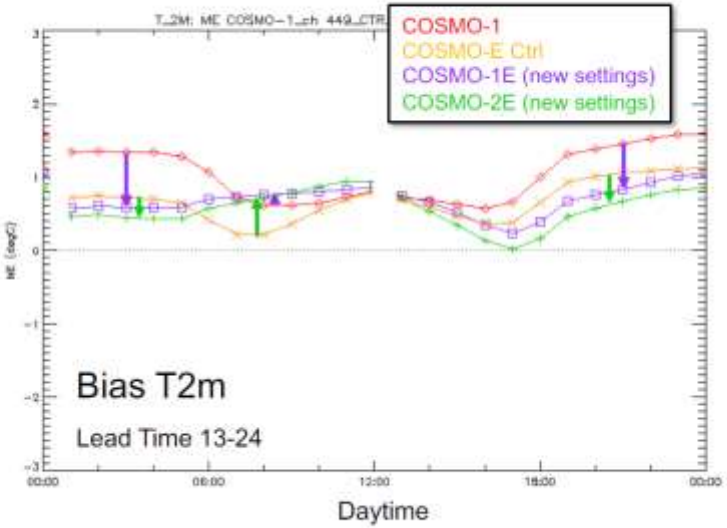
T_d bias almost back to normal (afternoon) or even improved (night, morning)



MeteoSwiss model improvement

2m Temperature Summer 2019 (15d)

Considerably smaller bias late afternoon and night ↓, some degradation during few morning hours ↑



Urban model TERRA-URB
PT_AEVUS 2

- In the framework of the research activities developed by COSMO community is currently under development the Priority task PT_AEVUS 2 (Analysis and Evaluation of TERRA_URB Scheme 2).

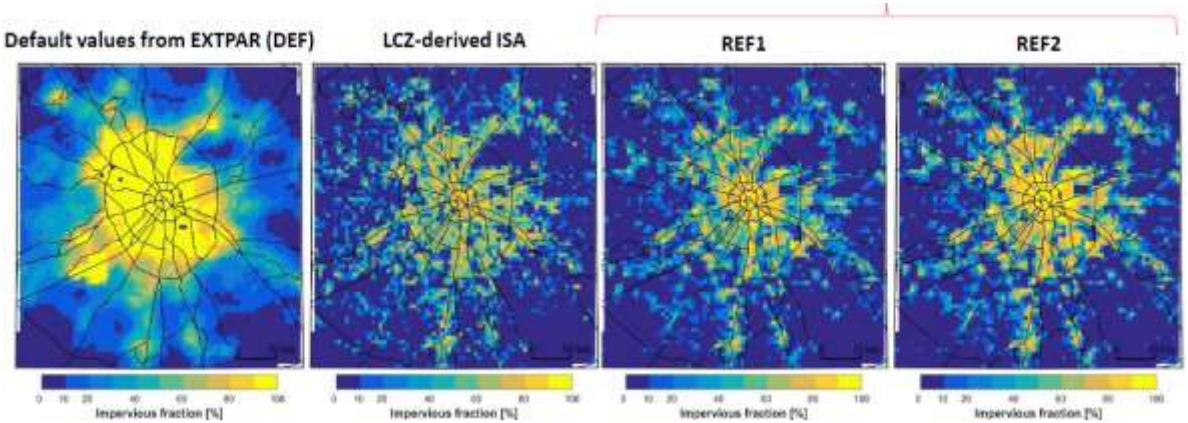
- TERRA_URB, is the urban scheme available in the COSMO model. Modelling of urban environments has gained much attention in the last years, as multiple parameterizations considering this urban dynamics became available also in COSMO model.

- Additional goal of the present research activities is to transfer these developments into the ICON model permitting to correctly represent urban dynamics in high resolution configurations providing better forecast temperature, moisture and precipitation especially in urban area.

The main outcomes of the first phase of PT_AEVUS are reported in the technical report:
http://www.cosmo-model.org/content/model/documentation/techReports/docs/techReport40.pdf

Additionally on implementing and testing urban parameterization available in COSMO, in the framework of PT_AEVUS 2 also are under development activities working the on the development and upgrade of urban canopy and vegetation parameters.

ISA Urban parameter for MOSCOW



The picture underlines that the use of different dataset strongly affect the value of ISA parameter identifying urban areas

In the pictures is reported the value of ISA (impervious surface wave) parameter (one of the two parameters, together with AHF, Anthropogenic Heat Flux, identifying urban areas and related features) in the default and other 3 different values for ISA using different criteria. In particular the second one is based on the Local Climate Zone concept (*Stewart, I. D., Oke, T. R., & Krayenhoff, E. S. (2014). Evaluation of the 'local climate zone' scheme using temperature observations and model simulations. International Journal of Climatology).*

Additional details on this activity will presented during the Breakout Session on Surface Aspects

Physical processes – SNOWPOLINO

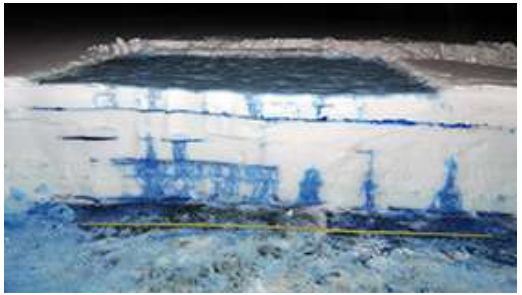
Layering

1D heat equation

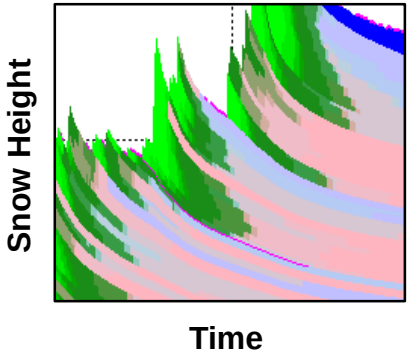
$$\frac{\partial T}{\partial t} = a\frac{\partial^2 T}{\partial x^2};\quad 0 \le x \le L;\quad t > 0$$

Phase Changes

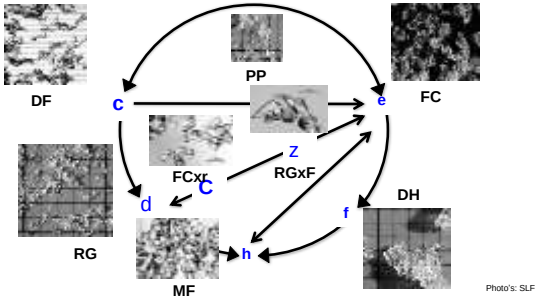
Water transport



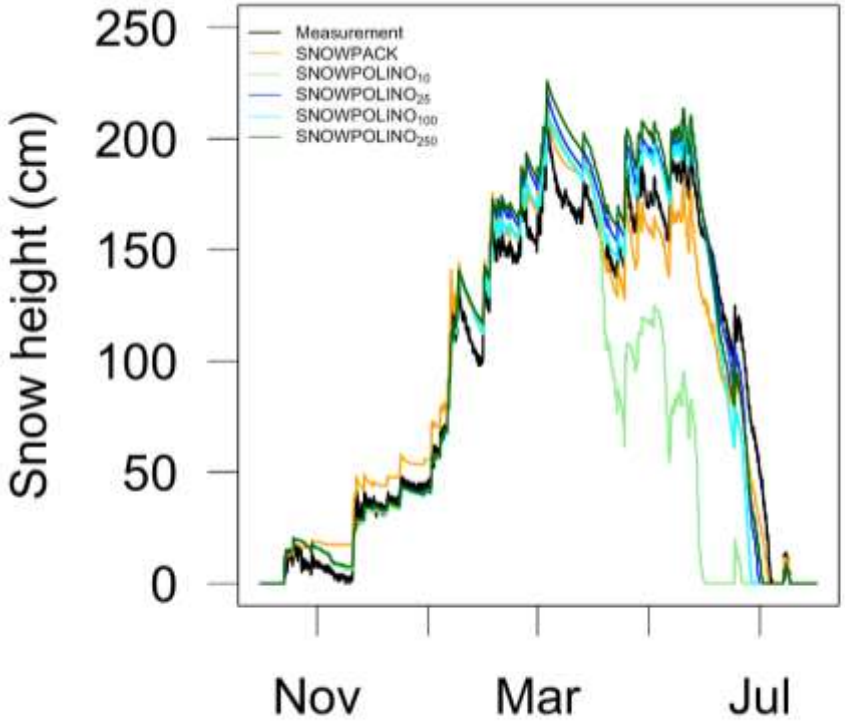
Settling/Densification



Metamorphism



Local validation – Sensitivity (# layers)



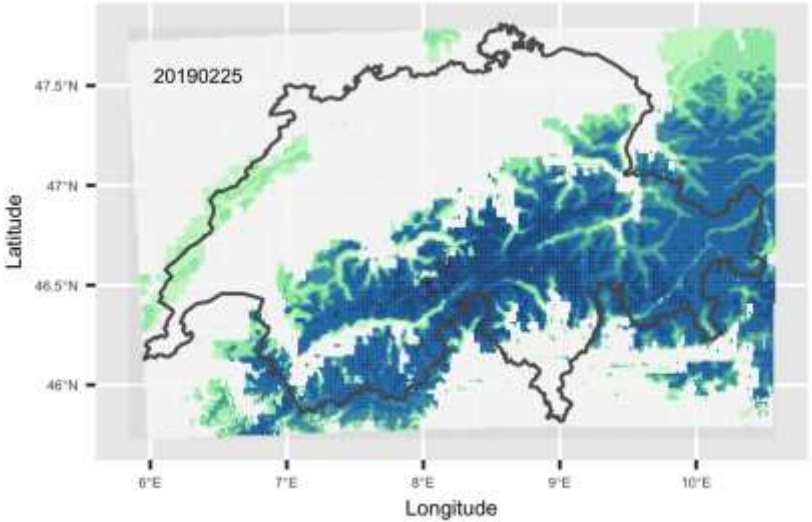
Runtime

# Layers	Time	Percent
-	s	%
10	4.6	69
25	**6.6**	**100**
100	16.9	256
250	43.2	655

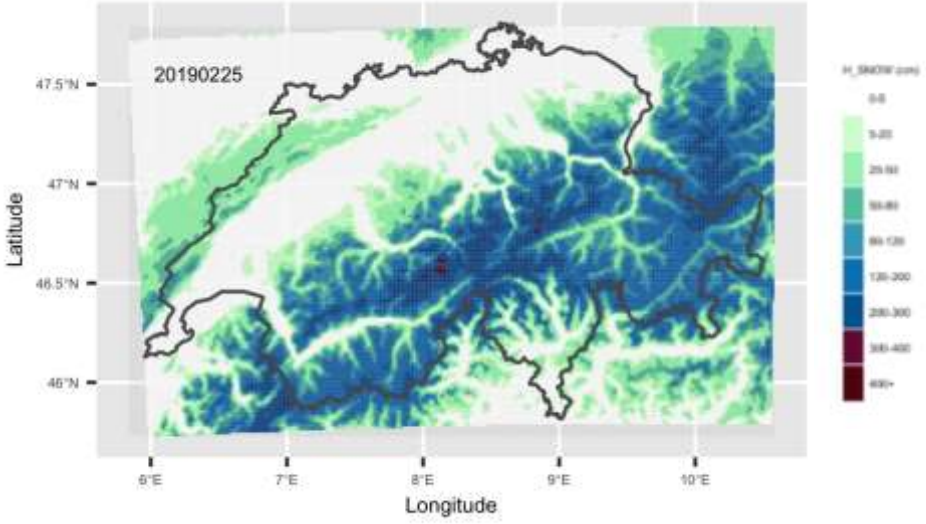
Weissfluhjoch – Winter 2015-16

Regional verification – Snow mask products

COSMO-1 (Analysis)

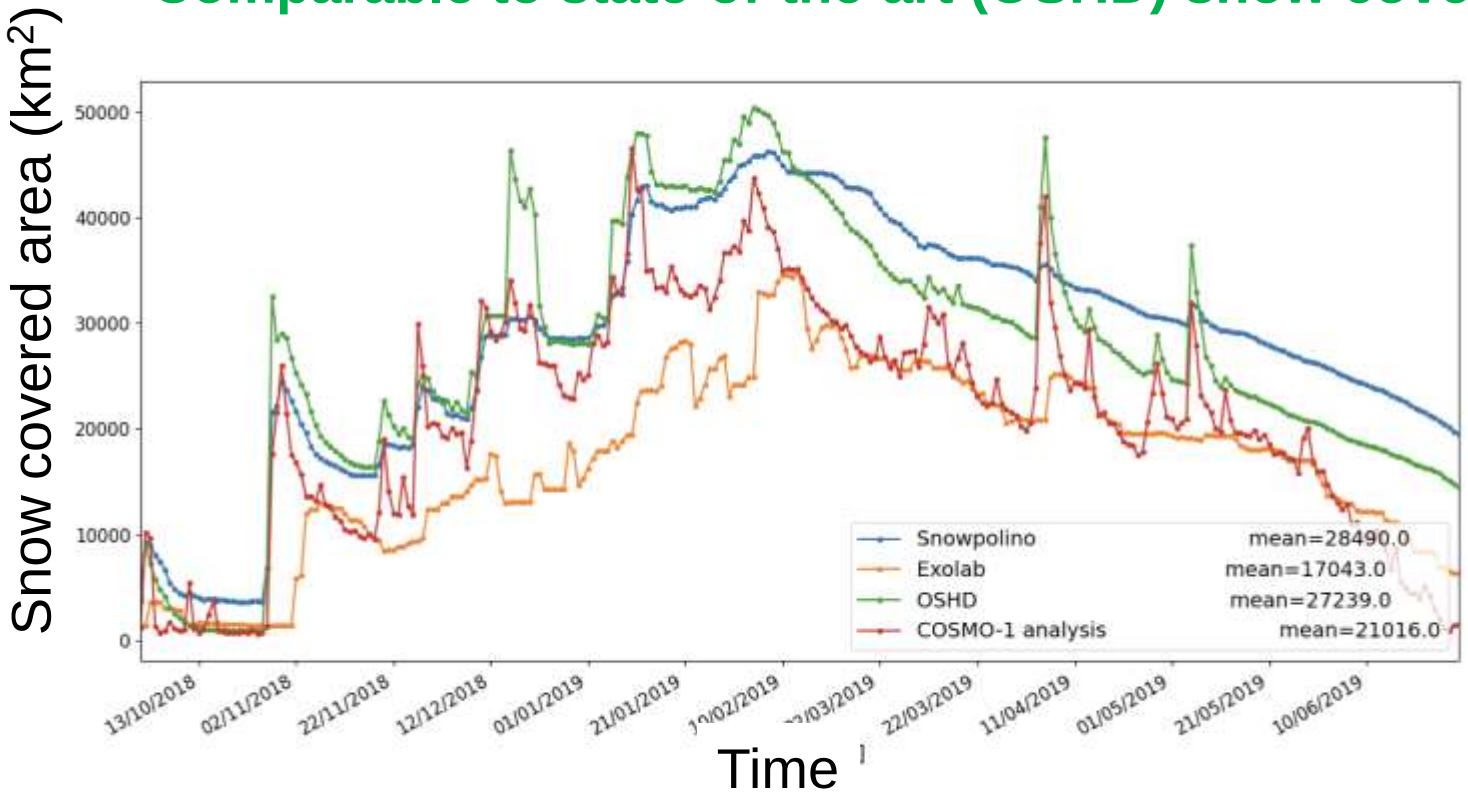


SNOWPOLINO



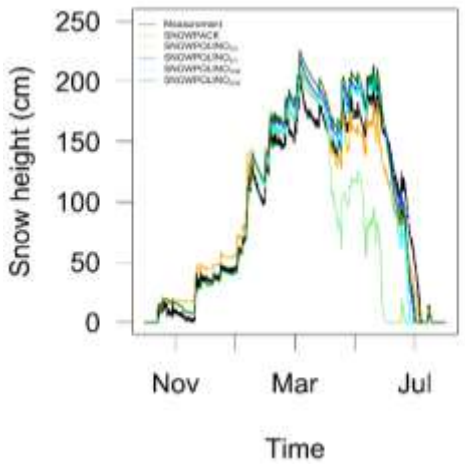
Regional verification – Snow masks

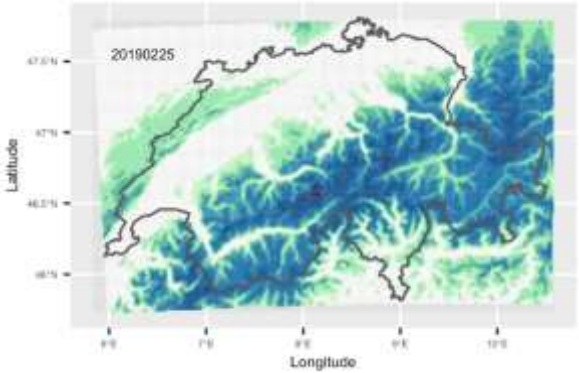
Comparable to state-of-the-art (OSHD) snow cover product



Summary & Conclusion

- ‘New’ (**GPU capable**) multi-layer snow cover scheme (SNOWPOLINO) was implemented into COSMO - **v6.0 ready**!
- Minor to major adaptations; e.g. implementation, tuning, switches – v6.1
- Main physical parametrizations (i.e. phase change, water transport) were taken or adapted mainly from the sophisticated snow cover model SNOWPACK.
- Scheme is switchable (**namelist option; lsnow**) and no. of layers can be chosen (default currently n=25).
- Local (offline) validations of SNOWPOLINO shows **comparable results to SNOWPACK**.
- Spatial validation (online) shows **good promising results.**
- **Operational implementation (MCH) – Winter 2020/2021**





ΕΘΝΙΚΗ ΜΕΤΕΩΡΟΛΟΓΙΚΗ ΥΠΗΡΕΣΙΑ
HELLENIC NATIONAL METEOROLOGICAL SERVICE

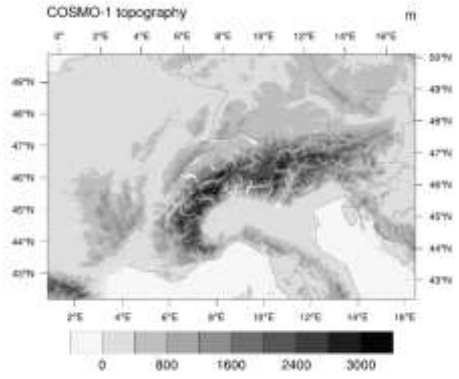
CALibration of the COSMO MOdel
CALMO -MAX

Project participants*

Antigoni Voudouri, Euripides Avgoustoglou, Yoav Levi, Izthak Carmona, Eduardo Bucchignani and Jean-Marie Bettems

*with the contribution of Pirmin Kaufmann, Silje Soerland (ETHZ) and Andreas Will (BTU)

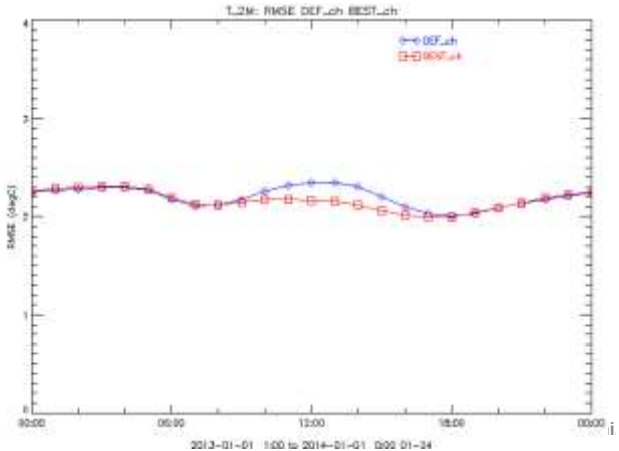
Calibration of COSMO-1

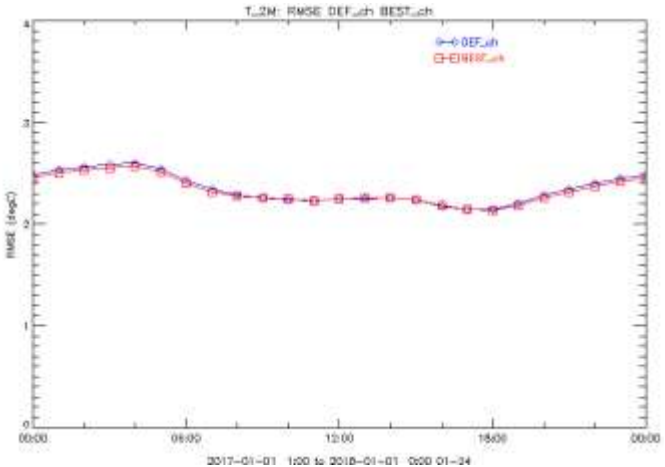


Acronym	Parameter	Parameter Range	**Optimum value**	ETHZ Value
Minimal diffusion coefficient for heat	tkhmin	[0. 1 ,**0.4**,1]	**0.279**	1.37
Factor for laminar resistance for heat	rlam_heat	[0.1,**1**,2]	**0.9296**	0.72
Parameter controlling the vertical variation of critical relative humidity for sub-grid 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

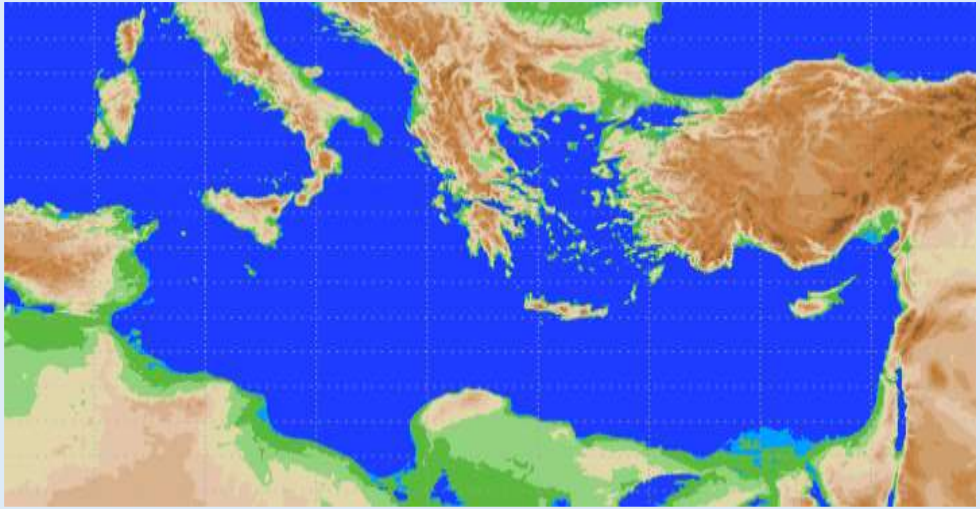
2m temperature for years 2013 and 2017

Year	2013		2017	
Measure T2m	DEF	BEST	DEF	BEST
ME	0.043	0.128	0.236	0.143
RMSE	2.2	2.1	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	

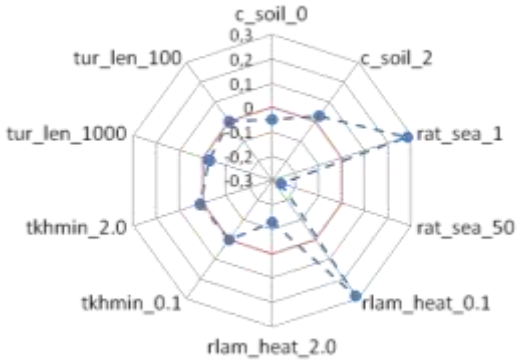




Calibration over the Mediterranean



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



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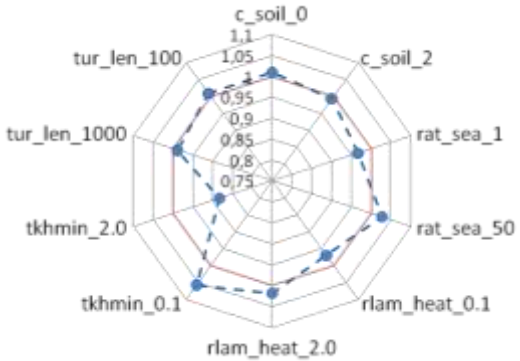
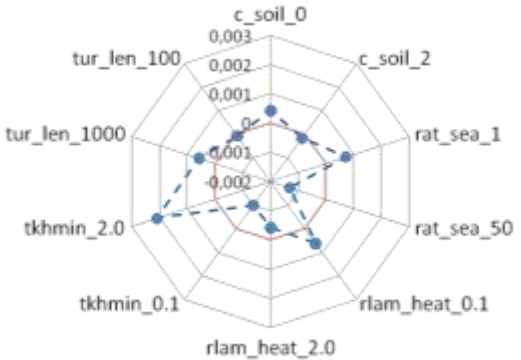


<TMAX_2M-TMIN_2M>TEST / <TMAX_2M-TMIN_2M>DEFAULT



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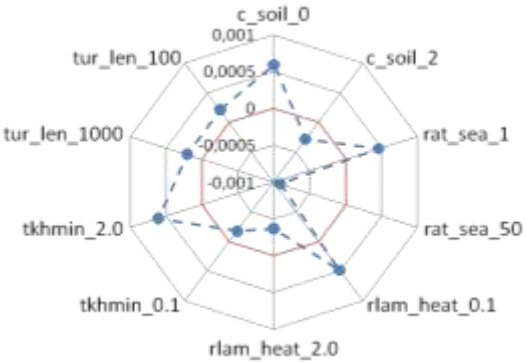


(<TMAX_2M>TEST-<TMAX_2M>DEFAULT) / <TMAX_2M>DEFAULT

Remarks– CALMO based next PP

- **Improvement** on diurnal cycle of T2m even for a well-tuned configuration
- Strong **dependency** of parameters **optimum** on **the time** of the year
- **Variation** of the optimum **reflects dependency** on the atmospheric flow or weather pattern
- Methodology is **"model independent"** and can be applied to any NWP or climate model.

CALMO-Next……..

- Cost reduction in terms of **computational cost** with respect to **model performance** improvement
- **Synchronize** the COSMO and the ETHZ **developments**.
- **Cottbus** department of mathematics to: (a) propose a **new approach on MM** (b) perform **calibration on the new dynamical core**
- Use calibration to check **robustness of parameterization schemes** e.g. do similar optimum parameter values define confidence interval of the parameterization scheme?
- List of **unconfined and 'tuned' parameters** correlated to model variables is **needed**

EXTPAR (WG3b)

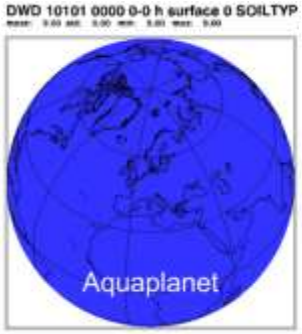
COSMO software, physiographic data retrieval

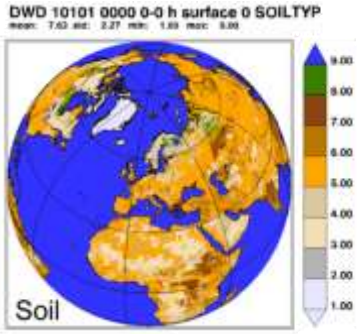
Source Code Administrator: Katie Osterried / ETHZ

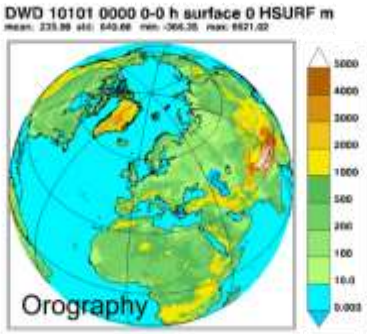
Latest release 5.4 (29.05.2020)

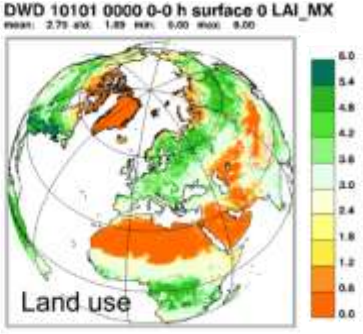
https://github.com/C2SM-RCM/extpar

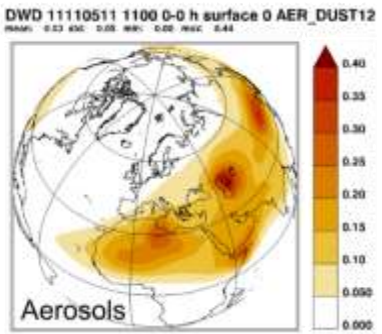
EXTPAR - Background











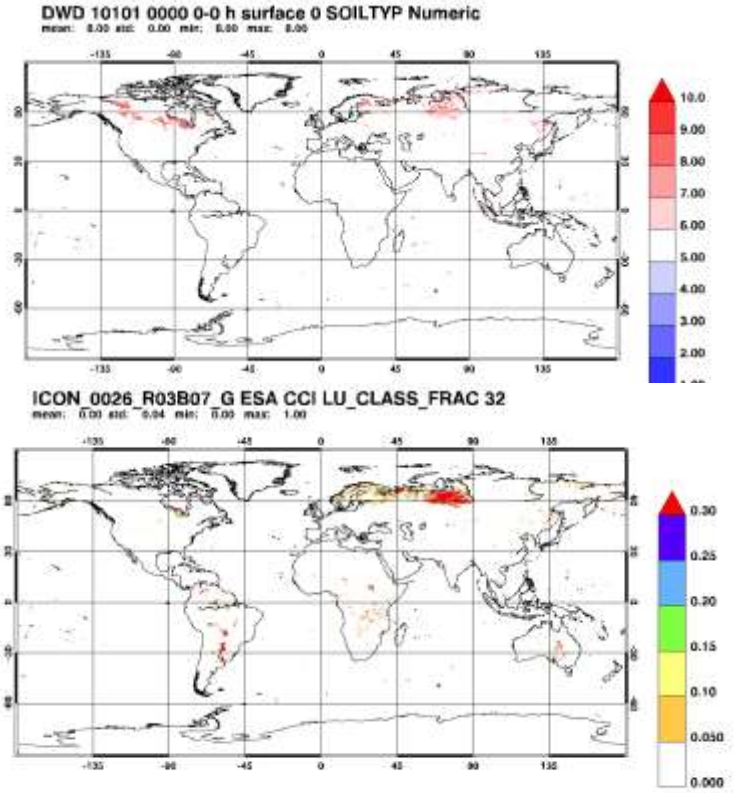
- Geospatial data are retrieved from high-resolution satellite information or land registers and are aggregated to the model's global or limited-area grid.
- In a final processing step all available data are cross-checked for consistency (e.g., to exclude vegetation on glaciers).
- The required model parameters are very similar for NWP models, but the used data sources and the applied tools vary between different models – i.e. different mapping of geospatial information (Onvlee et al, 2014).

EXTPAR Status

- *Active* development team (ETHZ, MPI-M and DWD).
- One week *hackathon* organized yearly to accelerate development.
- Code *unification* and major code *consolidation* performed these last 3 years.
- Clean-up and unify *raw data sets*, now all available under Git-LFS repository (https://gitlab.dkrz.de/extpar-data/extpar-input-data/-/tree/master).
- Comprehensive *regression suite* (different platforms, both COSMO and ICON models).
- Up to date *documentation* (“User and Implementation manual”).
- *Raw data sets* recently added
  - CAMEL Emissivity (NASA, global)
  - ESA CCI land cover (ESA, global)
  - Corine land cover (Copernicus, Europe)
- *Output fields* recently added
  - Skin conductivity (SKC)

Example: ESA CCI* Land-use data

*climate change initiative



- New land-use data (ESA CCI) can provide improved representation of active mires compared to FAO

- **Advantages of ESA CCI**:
  - Higher resolution (compared to FAO soil)
  - Higher granularity compared to GlobCover2009 (38 vs. 23 land-use classes and full global coverage)
  - Periodic updates (advantage in reanalysis projects)

EXTPAR – Work 2020/21