The Coordinated Parameter Testing 2 (COPAT2) initiative of the CLM-Community: towards a recommended configuration of COSMO-CLM and ICON-CLM new model versions

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General info on COSMO-CLM 6.0

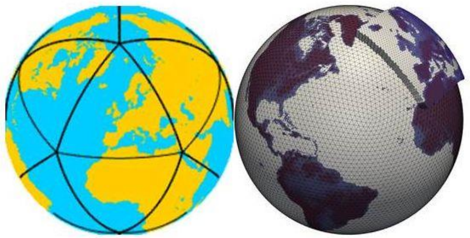
CONSORTIUM FOR SMALL SCALE MODELING COSMO

Climate Limited-area Modelling Community

- COSMO(-CLM) 6.0 released on 14 December 2021: last release of the COSMO model
- The CLM-Community used the COSMO model in **Cl**imate **m**ode (COSMO-CLM) for regional climate modelling over 20 years

- **Main changes between COSMO 5.0 and COSMO 6.0:**
    - Unification with CLM (new diagnostics, new tuning variables, new hydrology scheme, …)
    - Implementation of snow model SNOWPOLINO
    - Modifications of NetCDF I/O (prefetching, asynchronous output, online compression, restart in single precision, …)
    - Modifications for TERRA-URB (urban-canopy land-surface scheme)
    - New diagnostics for soil water budget and fix for computation of subsurface runoff
    - Additional Greenhouse-Gas Emission Scenarios (Shared Socioeconomic Pathways)
    - Changes in Data Assimilation (observation handling, single precision)
    - Implementation of radar forward operator EMVORADO
    - EULAG dynamical core added
    - Revised Cloud Radiation Coupling
    - Unification of Soil and Surface Modules with ICON
    - Implementation of skin temperature formulation in TERRA
    - Running COSMO in single precision

General info on ICON / ICON-CLM



- The ICON modelling framework is a joint project aimed at developing a unified next-generation global numerical weather prediction and climate modelling system

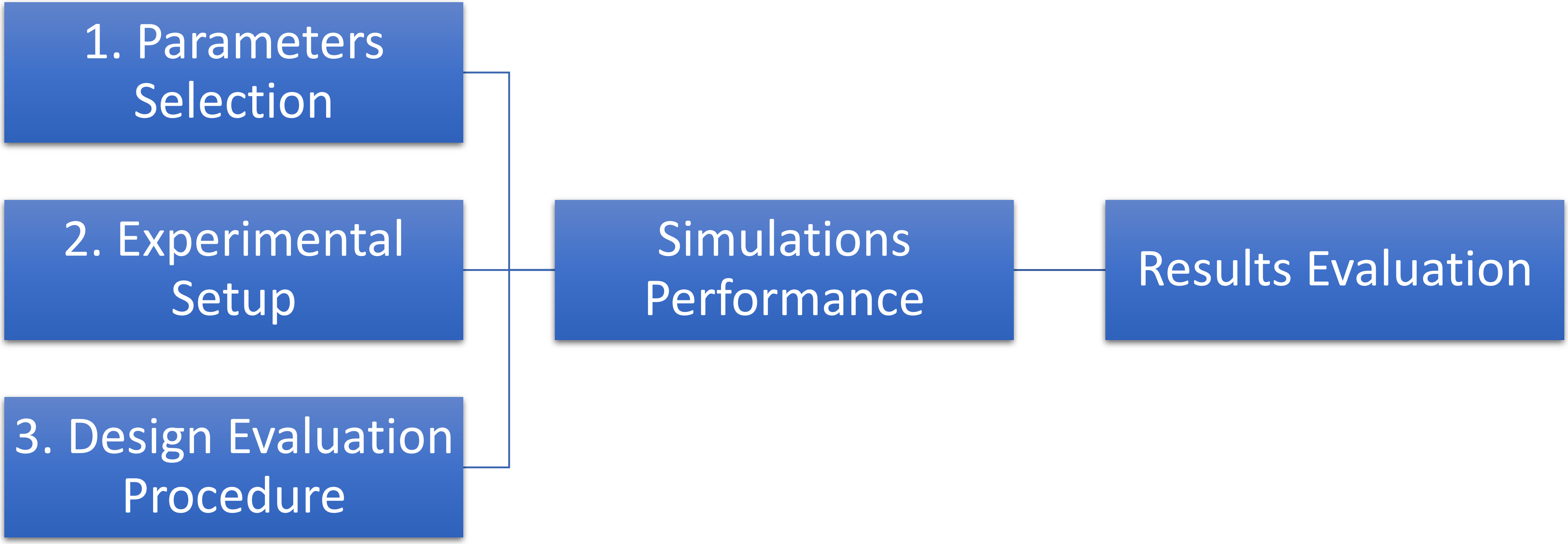
DWD KIT Karlsruher Institut für Technologie DKRZ DEUTSCHES KLIMARECHENZENTRUM MAX-PLANCK-INSTITUT FÜR METEOROLOGIE CSCS

Additional partners CONSORTIUM FOR SMALL SCALE MODELING COSMO Climate Limited-area Modelling Community

- The Climate Limited-area Mode of ICON (**ICON-CLM**) developed by the CLM-Community.
  It is based on the limited-area mode of ICON, including further developments and adjustments that are necessary for regional climate simulations

- The CLM-Community also provides a runtime environment (SPICE) for regional climate simulations with ICON-CLM, including pre- and postprocessing functionalities

General Strategy COPAT2



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1. Parameters selection

1st Phase **Test single configuration options → determine potential parameters improving model performances**

COSMO-CLM 6.0

Dynamics

e.g.: Bott advection with deformal correction, fast-waves solver

C202,C203,C204,C205

Physics

e.g.: explicit calculation of skin surface energy budget, ground water table, mass-flux scheme

C210,C212,C213,C214

Turbulence

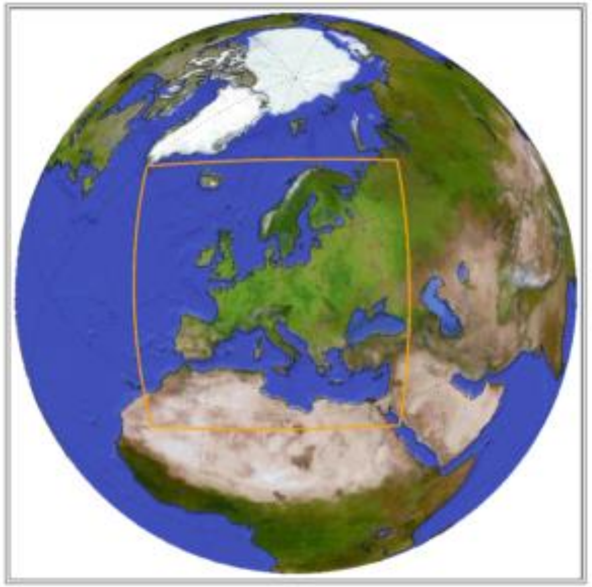
e.g.: new ICON Turbulence scheme

C220,C221,C222,C223, C224, C225

2nd Phase **Test Combined configuration changes**

2. Experimental Design COSMO-CLM 6.0

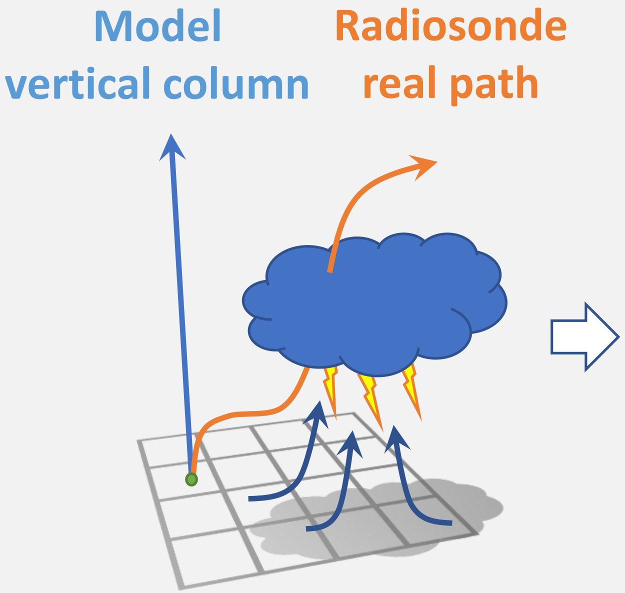
- Target domain: CORDEX Europe
- Target resolution: ~12 km
- Reference simulation for period 1979-2000
  with configuration based on NWP configuration
- 1st set of simulation over period 1979-1985
- 2nd set of extended simulations over period 1979-1990
- Additional test simulations for more recent period
- All simulations are performed on the systems of the German Climate Computing Center (DKRZ):
  -- MISTRAL (decommissioned)
  -- LEVANTE

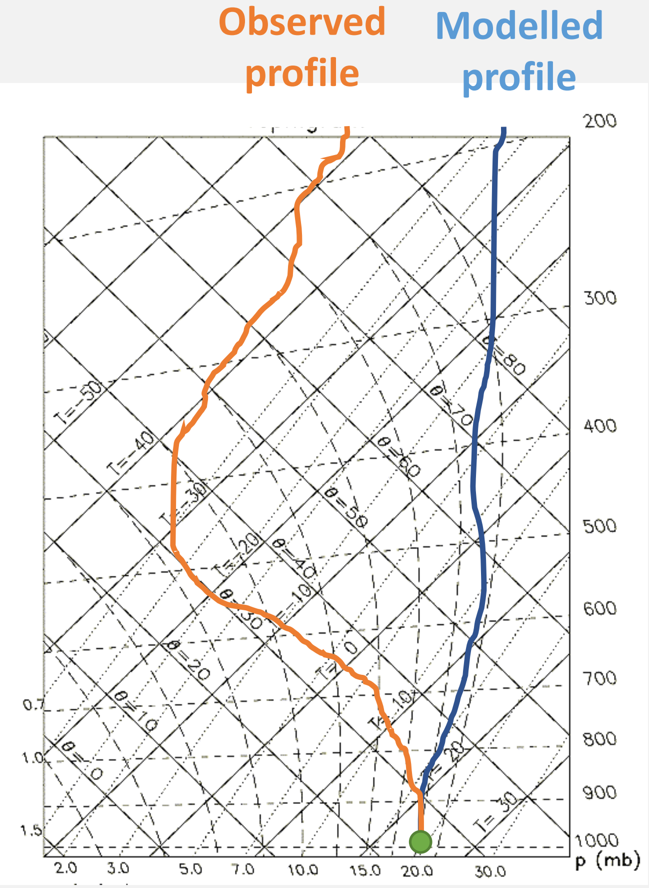


Source: *ht tps://cordex.org/domains/cordex-region-euro-cordex/*

3. Details of Evaluation Procedure

Reference Datasets: gridded in-situ products (Eobs) + gridded reanalysis products (ERA5) + station data (BSRN) + radiosondes (contribution by U. Voggenberger (UniWien) and Heimo Truehetz (Uni Graz))





3. Details of Evaluation Procedure

Metrics

Need of simplified approach, minimize the number of metrics for ranking the experiments

Discussion is still ongoing

- Consideration of **Standardized RMSE:** coarse-grain the data first over pre-defined regions

→ 1- Variables become quasi-gaussians

→ 2- Reduce uncertainty related to chaotic nature of the system

- **Transformation from metrics to ranking bye score points of evidence**: for a given metric (e.g. BIAS), ratio of points with significant improvement/worsening

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Workflow for selecting best performing model, Step 1

120 compute nodes for 200 hours in parallel

15 times ¼ shared nodes for 6 hours in parallel

Simulation 1

Simulation 2

Simulation 3

Simulation 4

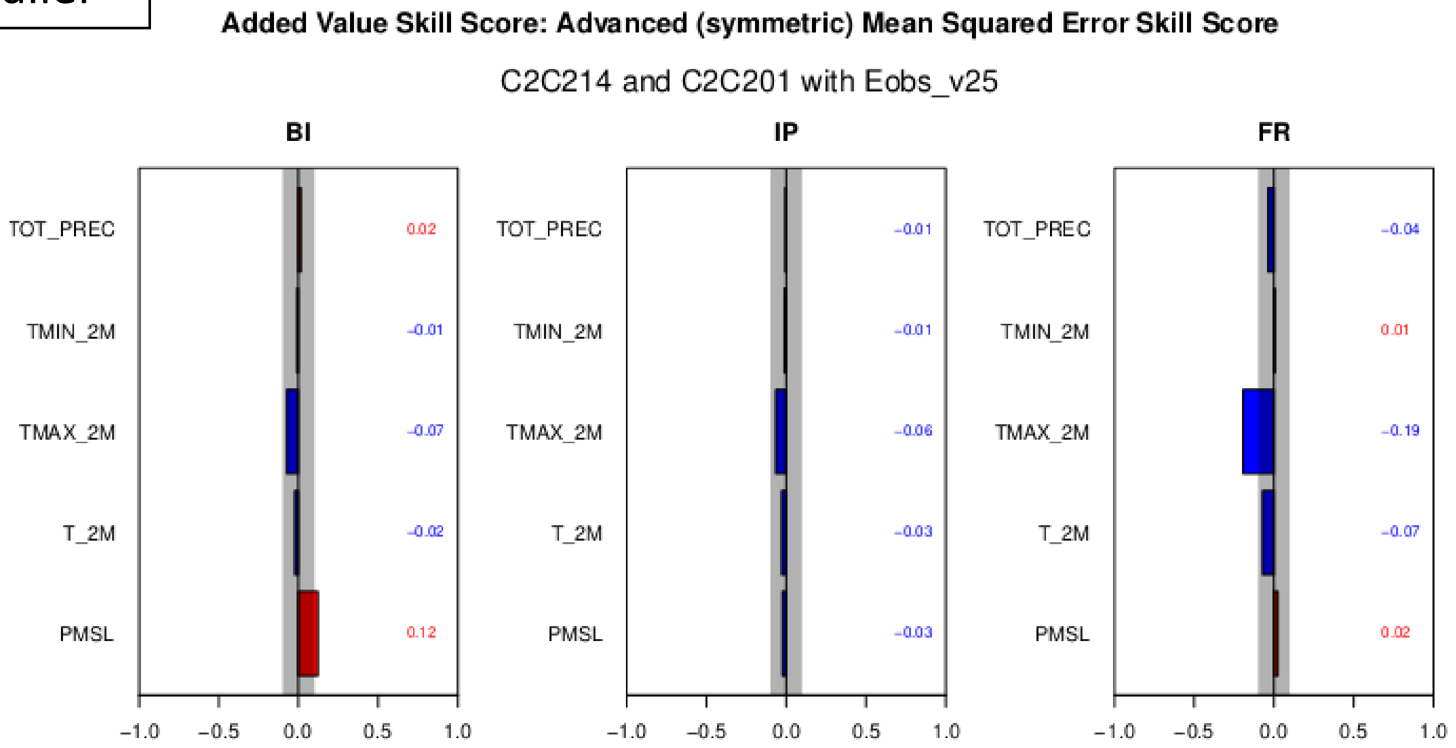
Simulation 5

Simulation 6

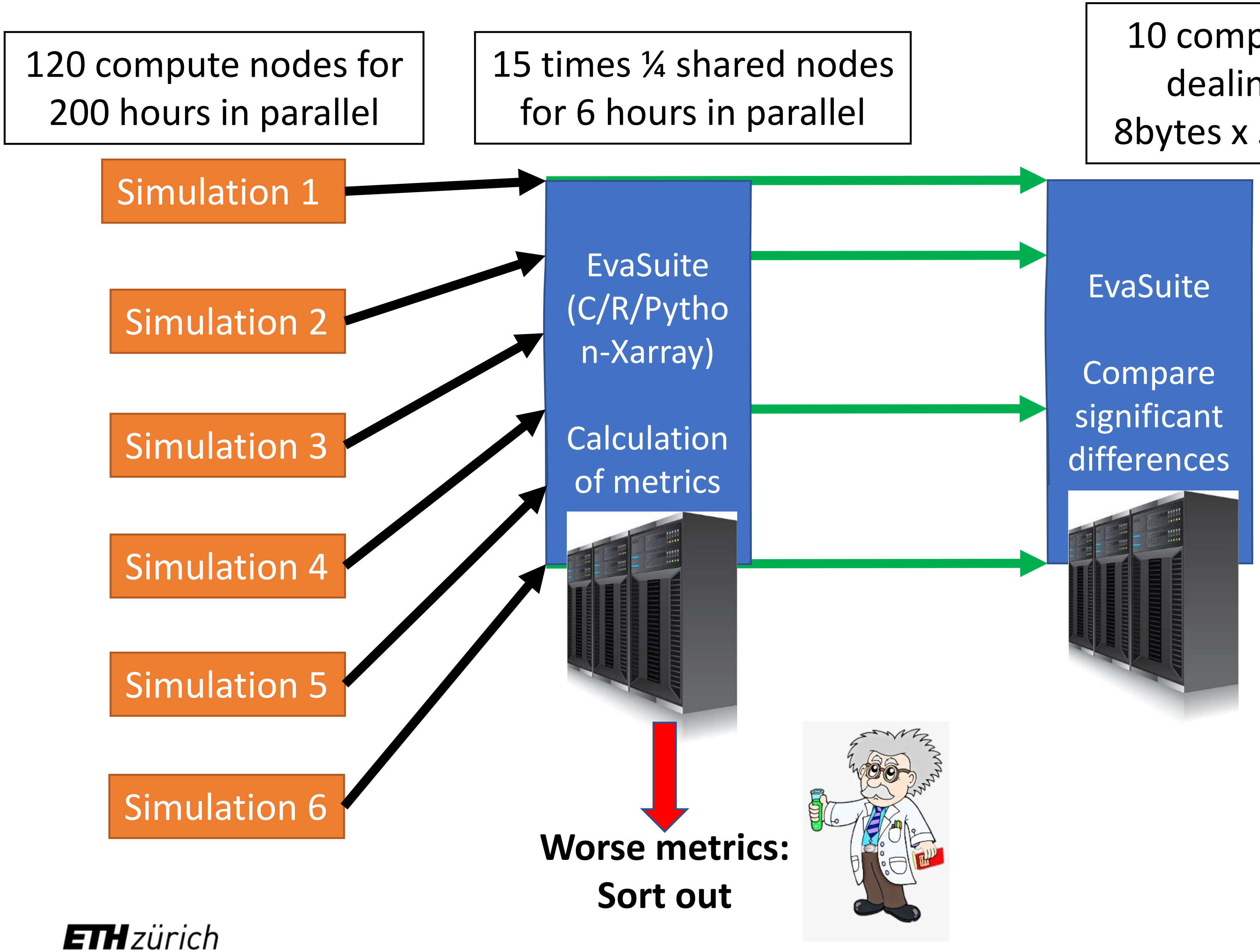
....

EvaSuite (C/R/Python-Xarray)

Calculation of metrics



Workflow for selecting best performing model, Step 2



Score board with Eobs-v25lr_and_ERA5, model: C2C305,refmod: C2C301, region: P_France

season metric	Summer BIASsk	Winter BIASsk	Spring BIASsk	Autumn BIASsk
tas				
tasmin	▲		△	
tasmax	▲	▲	▲	▲
dtr	▲	▲	▲	▲
psl_eobs	▲	▼	▲	▽
rsds_eobs				
psl_era5	▲	▼	▲	▼
rsds_era5				
clt				
prw				

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Workflow for selecting best performing model, Step 3

120 compute nodes for 200 hours in parallel

15 times ¼ shared nodes for 6 hours in parallel

10 compute nodes for 24 hours dealing with arrays of size: 8bytes x 500 x 500 x 3000 x 1000

Simulation 1

Simulation 2

Simulation 3

Simulation 4

Simulation 5

Simulation 6

EvaSuite (C/R/Python-Xarray)

Calculation of metrics

EvaSuite

Compare significant differences

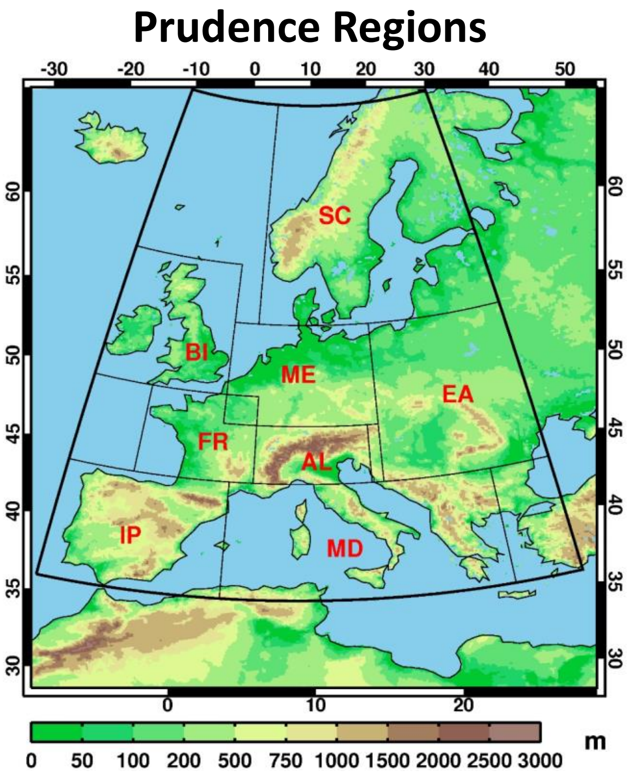
Score board with Eobs-v25lr_and_ERA5, model: C2C305,refmod: C2C301, region: P_France

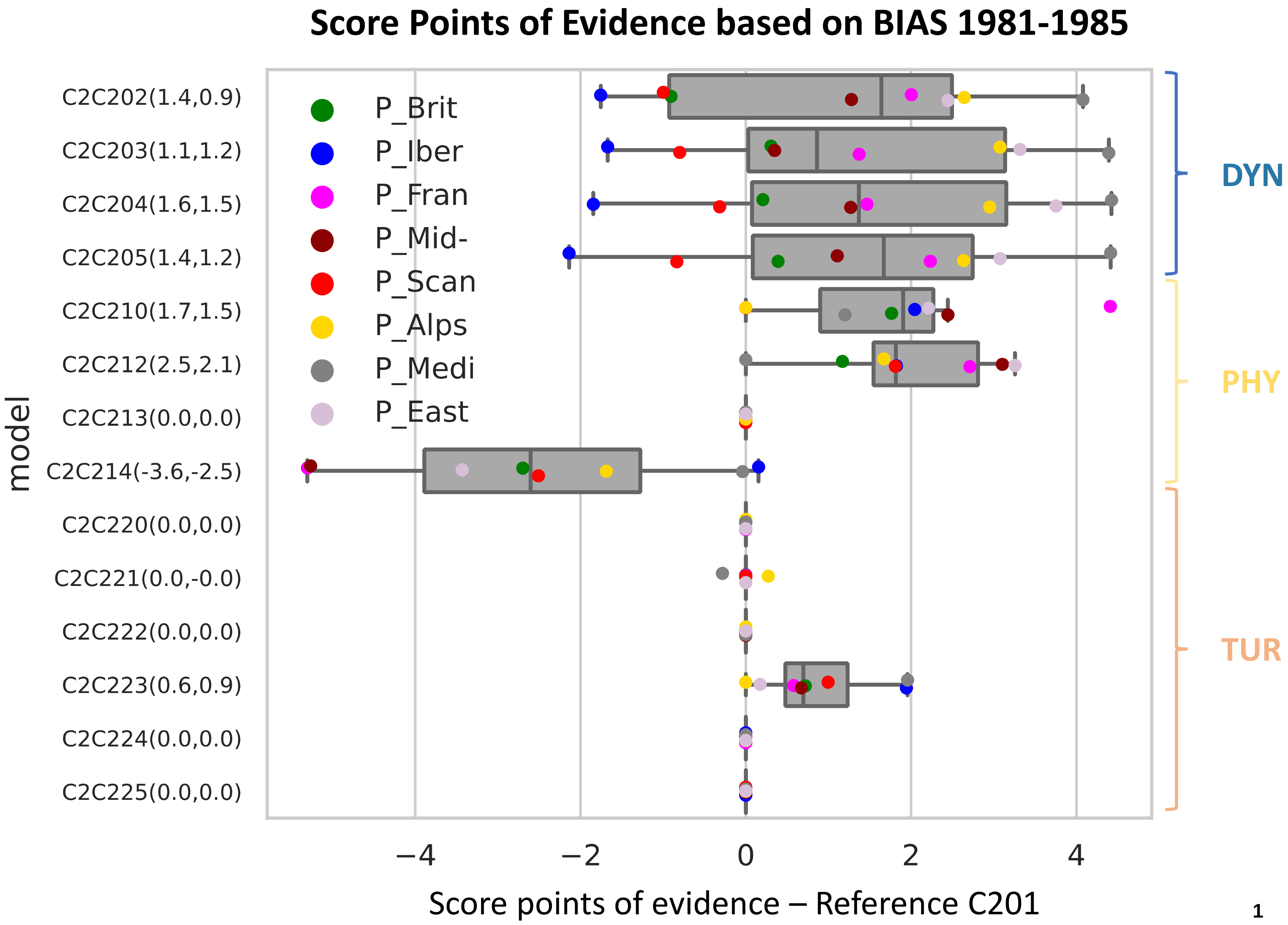
season metric	Summer BIASsk	Winter BIASsk	Spring BIASsk	Autumn BIASsk
tas				
tasmin	▲		△	
tasmax	▲	▲	▲	▲
dtr	▲	▲	▲	▲
psl_eobs	▲	▼	▲	▽
rsds_eobs				
psl_era5	▲	▼	▲	▼
rsds_era5				
clt				
prw				

Worse metrics: Sort out

Decision for best performing simulation

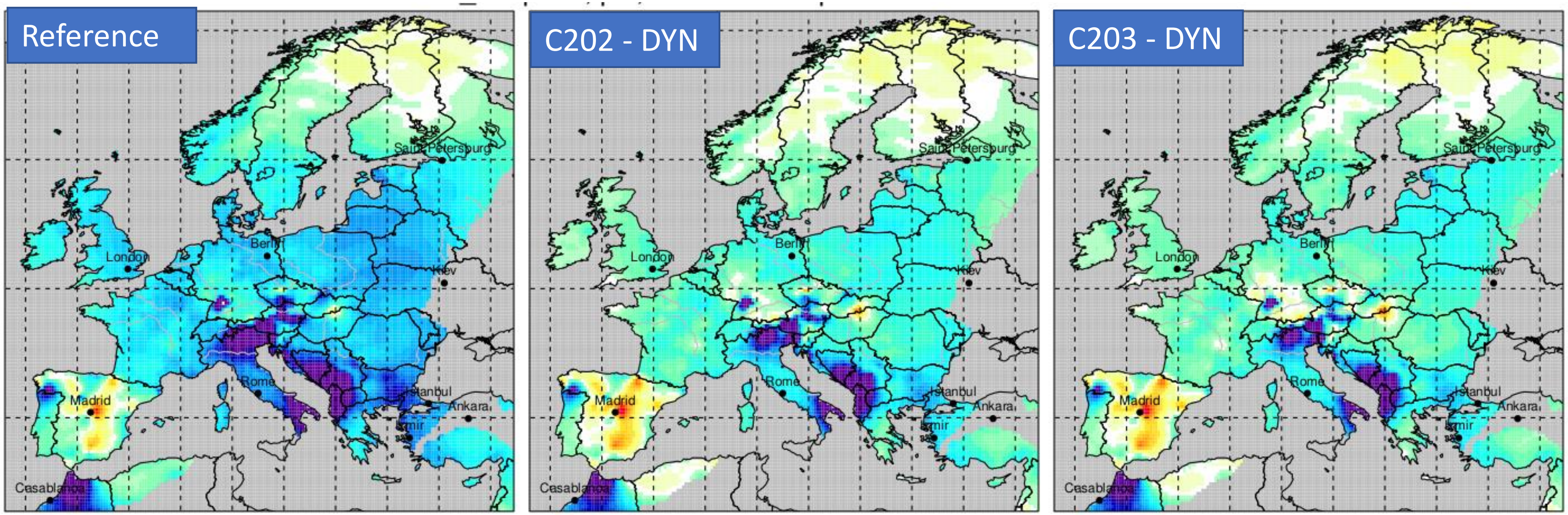
Decision for best performing model – Results from the first phase of COPAT2





From Scoring points back to details: Experiments with changes in Dynamics

spring mean bias MSLP COSMO-CLM – 1980-1985



reduced spring BIAS with new DYN → Why it is not in all season?

What is the cause of errors in reference data? → use ERA5 as backup

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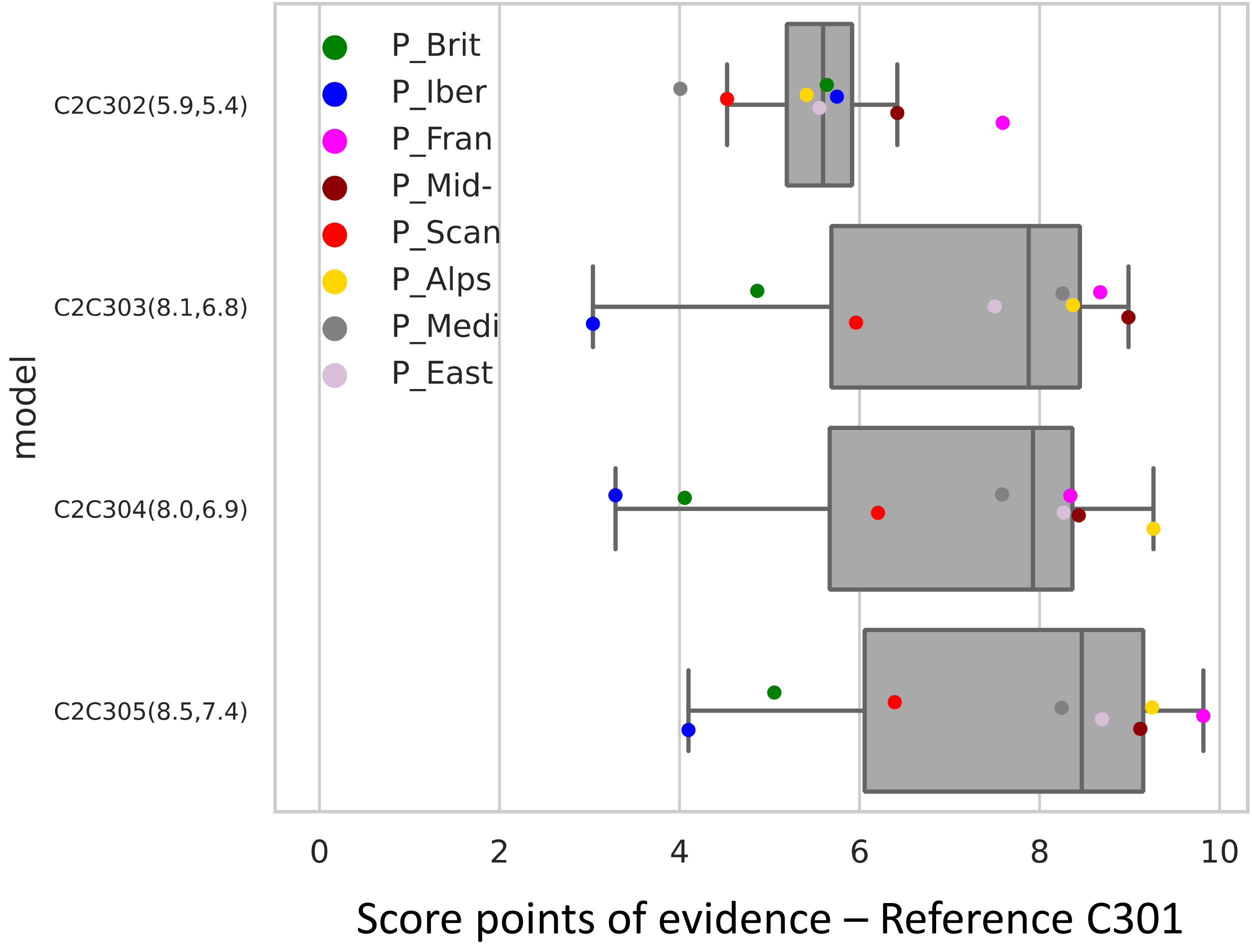
Second phase of COPAT 2 – Combined configuration experiments (Experiments C2C3…)

Score Points of Evidence based on BIAS 1981-1985



New bare soil evaporation formulation +
Explicit treatment of skin surface energy budget

C302 +
Changes in dynamics (as in C202)

C303 +
lhor_pgrad_Mahrer=T

C304 +
itype_outflow_qrsg=2

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First Evaluation Results: Combined tests

Mean Bias Experiment C305 Vs C301

season	Summer	Winter	Spring	Autumn
metric	BIASsk	BIASsk	BIASsk	BIASsk
tas	0.11	-0.27	0.14	-0.17
tasmin	0.11	0.50	0.38	1.00
tasmax	-0.11	0.44	1.12	0.36
dtr	-0.05	1.32	1.25	1.22
psl_eobs	-0.40	-1.31	0.23	-1.28
rsds_eobs	0.12	-0.04	0.32	-0.03
psl_era5	1.17	-1.49	1.31	-1.43
rsds_era5	0.11	-0.05	0.29	-0.03
clt	-0.03	-0.01	0.06	-0.17
prw	0.10	0.00	0.01	-0.01

Conclusions & Outlook

- Designed calibration procedure for COSMO-CLM 6.0 and ICON-CLM
- First set of experiments performed with COSMO-CLM 6.0
- 1st phase outcome: some parameters of COSMO-CLM 6.0 showed potential for test in 2nd phase
- 2nd phase outcome: further improvement over reference run detected
- Next tasks: promising configurations from 2nd phase tested for longer periods and recent day climate
- Next tasks: use of radiosondes measurements for evaluating the levels above 10 meter
- ICON-CLM: parameter sensitivity experiments defined and first experiments start in November 2022
- Ongoing discussion on evaluation metrics
- Final results will be made publicly available

Thank you for your attention!

General Strategy: Parameters Selection

C2C201	Reference			
C2C202	DYNUM_group	y_scalar_advect = BOTTDC2, itype_fast_waves = 2, l_3D_div_damping = .TRUE., ldyn_bbc = .FALSE., itype_bbc_w = 114, l_diff_Smag = .TRUE.	Bott Advection with deformal correction; improved fast waves stability; fully 3-D Isotropic divergence damping	
C2C203	DYNUM_GROUP + DYNUM_SINGLE	DYNUM_GROUP + lhor_pgrad_Mahrer = .TRUE.	Better geostrophic gradient than in standard discretization	
C2C204	DYNUM_GROUP + DYNUM_SINGLE	DYNUM_GROUP + itype_outflow_qrsg = 2	no relaxation of qr, qs, qg is done at outflow boundary points	
C2C205	DYNUM_GROUP + DYNUM_SINGLE	DYNUM_GROUP + hd_corr_u_bd = 0.75, hd_corr_t_bd = 0.75, hd_corr_p_bd = 0.75	Diffusion in wind components	
C2C210	Physics	itype_canopy=2, cskinc=-1	Explicit calculation of skin surface energy budget (Schulz and Vogel 2017)	
C2C212	Physics	itype_evsl = 4, c_soil=1.25	Improved bare soil evaporation	
C2C213	Physics	Cwimax_ml = 0,0005		
C2C214	Physics	iitype_hydmod = 1	Ground water formulation allowing ground water build up Soil Heat conductivity based on vegetation and not on soil moisture	
C2C220	Turbulence	ltkesso = .TRUE.	SSO-wake turbulence production for TKE	
C2C221	Turbulence	ltkeshs = .TRUE.	Consider horizontal shear production for TKE	
C2C222	Turbulence	icldm_turb = 2, icldm_tran = 2	Clouds sub-grid scale condensation considering water clouds	
C2C223	Turbulence ICON	loldtur=.FALSE., itype_vdif = 1	New ICON turbulence scheme	
C2C224	Turbulence ICON	pat_len=750.0, imode_pat_len=2 (turbdata.f90)		
C2C225	Turbulence ICON	ltkeshs=True, a_hshr=2.0, imode_shshear=2 (turbdata.f90)		