Convection permitting climate experiments with ALARO over the Central Europe

Ján Mašek, Radmila Brožková, Alena Trojáková, Radim Tolasz, Adam Valík, Romana Beranová, Petr Zacharov

Czech Hydrometeorological Institute

Background

Project **PERUN**: **P**rediction, **E**valuation and **R**esearch for **U**nderstanding **N**ational sensitivity and impacts of drought and climate change for Czechia.

8 institutions are involved:

– Czech Hydrometeorological Institute is the principal leader and contractor of the project;

– There are academic, research and service institutions covering meteorology, climate, hydrology and geology.

Our role:

– Prepare the configuration of ALADIN-CLIMATE/CZ;

– Perform climate experiments including the preparation of climate scenarios.

Model configuration characteristics

Since the first results had to be provided timely, we took the operational ALARO of 2021 as basis.

– **Dynamics**: **Non-hydrostatic**

1 iteration PC NESC, SLHD diffusion, **Δt = 90 s** with **Δx = 2.3 km** and linear grid, **87 levels**;

– **Physics: ALARO-1vB**

ACRANEB2, TOUCANS with two prognostic energies TKE and TTE, 3MT;

No GWD;

– **Surface: ISBA**

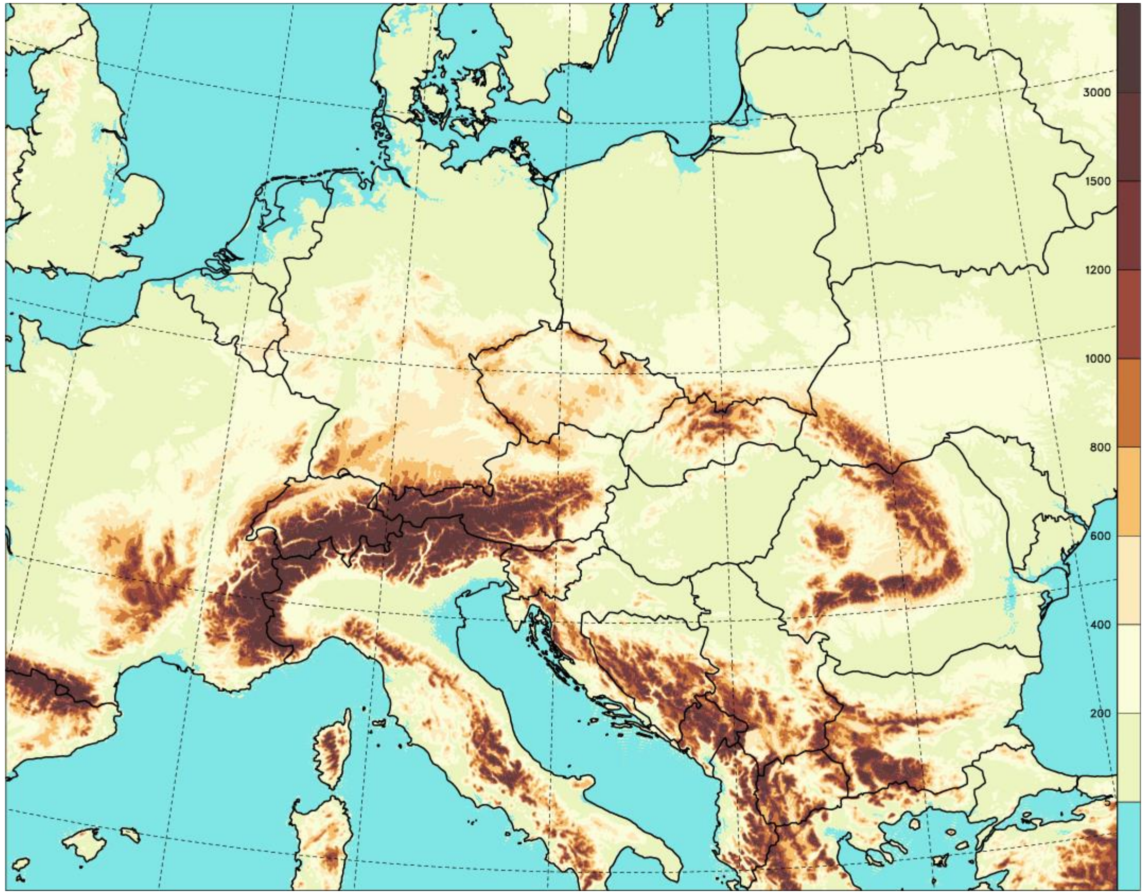
Orographic roughness taken from GMTED2010, vegetation from ECOCLIMAP II;

4 layers used in experiments with free surface evolution to capture annual cycle better.

Model domain

The size of the domain is luckily fulfilling advantageous properties:

- Large enough to ***preserve variability of small convection permitting scales*** in the domain of interest, also despite coarse resolution of the driving GCM;
- Not too large either, hence a spectral nudging to the driving GCM is not necessary.



“reanalysis“ experiment (denoted aaa)

The goal: to yield required products at high resolution over a long period and provide a kind of a testbed.

– **Set up of the assimilation:**

6 h cycle;

Surface analysis by CANARI, using observations collected from LACE partners and ECMWF;

Upper-air: blending with ERA5.

– **Associated forecast:**

Once a day from 0 h UTC a short run up to + 30 h, coupling with ERA5.

– **Covered period:** from 1989 to 2019, followed by the extension up to 2022.

“free surface“ or “evaluation” experiment (aab)

The goal: climate type of run using a ***“perfect coupling”,*** i.e. to evaluate the model.

– **Set up:**

“continuous” integration;

decadal update of required surface parameters: SST, associated land-sea mask, vegetation, …;

coupling with ERA5.

– **Covered period:**

from 1989 to 2019.

“historical climate” experiment (aac)

The goal: climate type of run using a ***coupling with the same GCM as used to prepare future scenarios,*** i.e. to prepare for de-biasing.

– **Set up:**

“continuous” integration;

decadal update of required surface parameters, SST taken from NEMO;

coupling with the ESM2-1 CMIP6 version GCM system of CNRM.

– **Covered period:**

first calculated from 1989 to 2014, the second rerun is from 1975 to 2014 to cover the 30-year normal period 1981-2010. The scenario begins from 2015.

Here we get the climate and not the weather of the day!

Model verification over the past period

– **Domain and data**:

Central Europe: the so-called EOBS dataset;

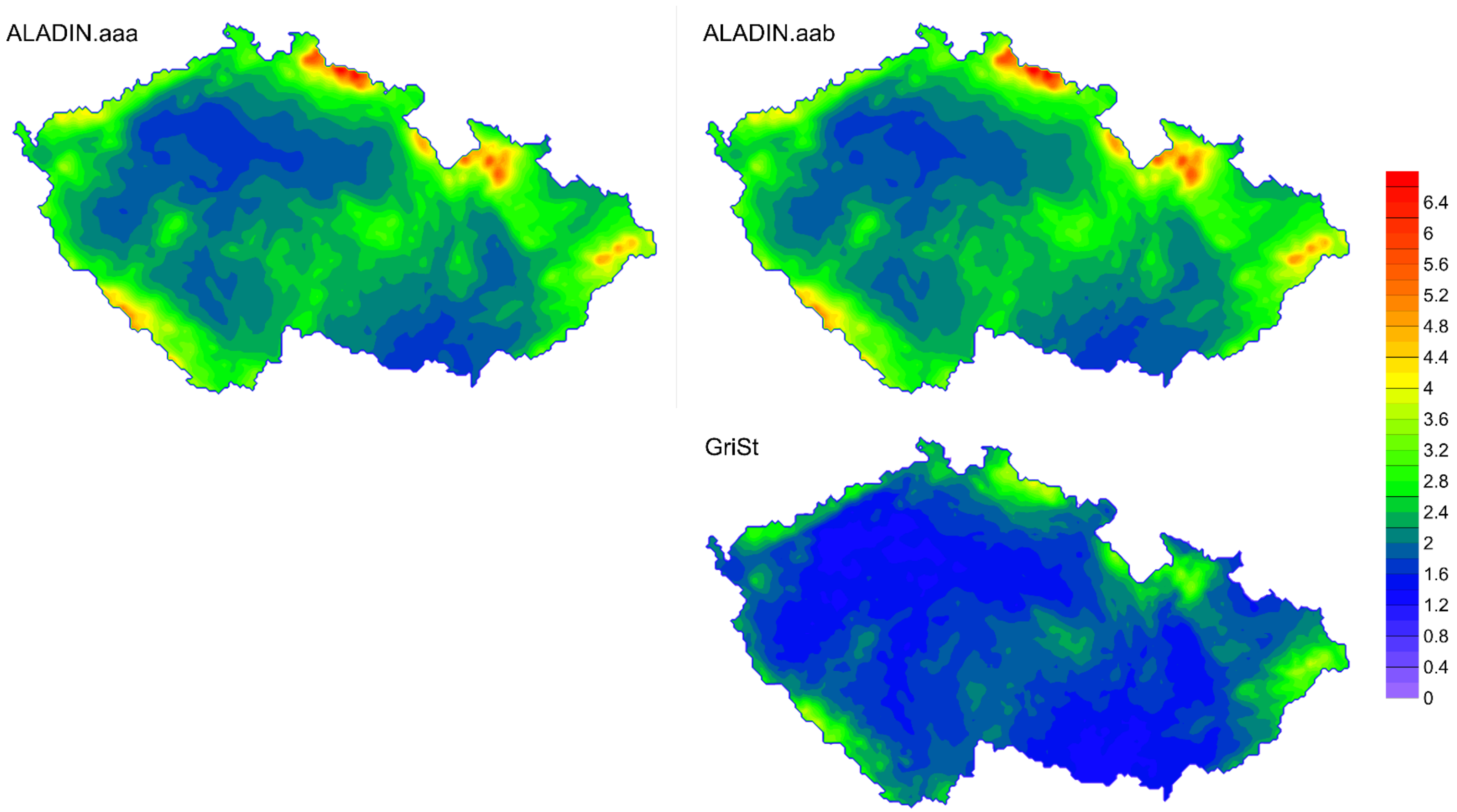
Czech Republic: the so-called **GriSt** dataset, obtained by the interpolation of stations (268 for temperature and 787 for precipitation) to the model grid of 2.3 km;

For precipitations we also get the **Merge product** of radars and stations from 2002.

– **Evaluated screen level parameters:**

Tmean, Tmin, Tmax, RH, Wspeed, RR

Precipitation results (1)

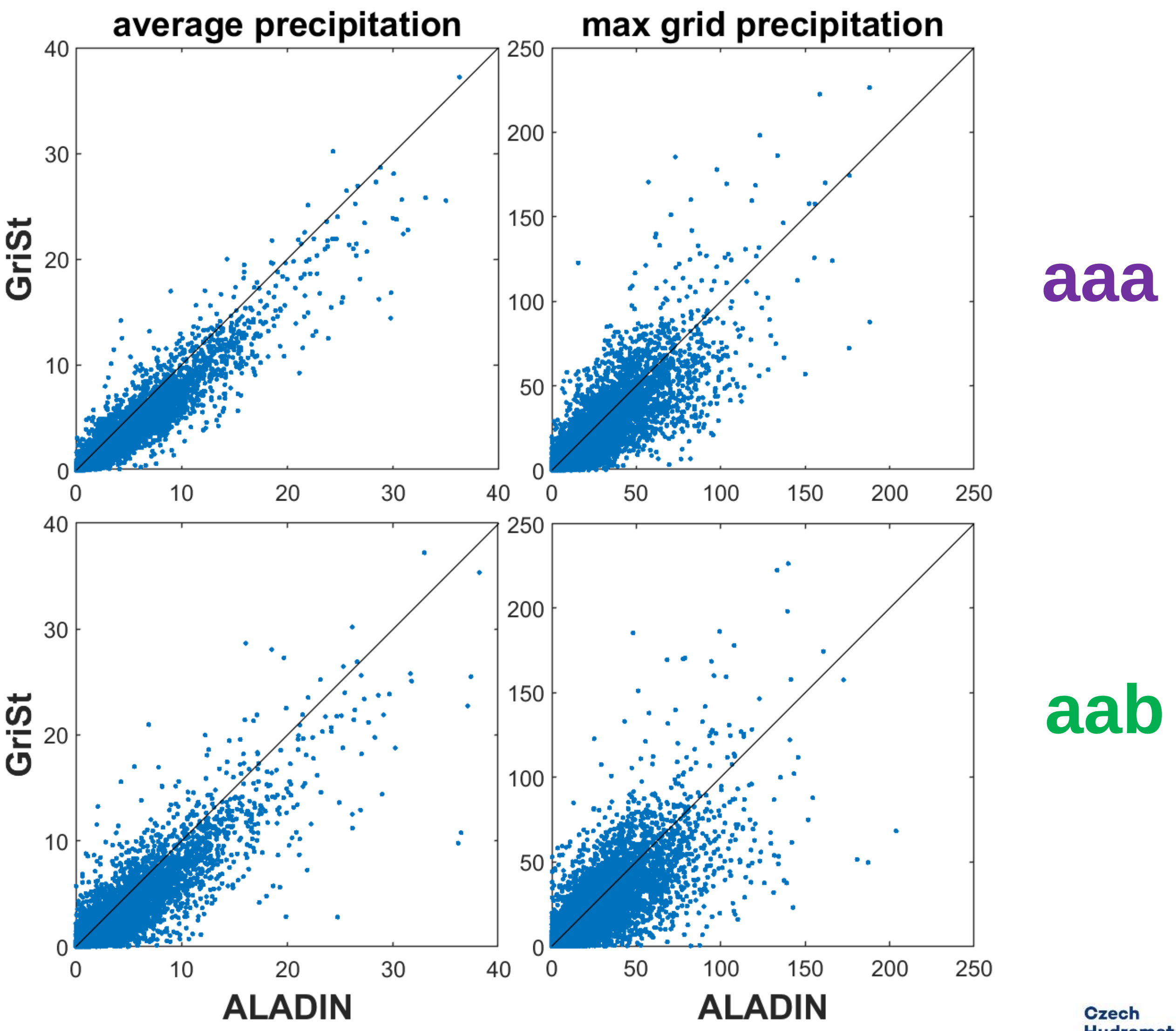


Mean daily precipitation [mm] from the "reanalysis aaa" short runs (from +6 h to +30 h starting from 0 h UTC) and from the free surface "evaluation run aab" coupled with ERA5. In both cases we get a positive bias, more pronounced in mountains. ***Period: 1990-2019***.

Precipitation results (2)

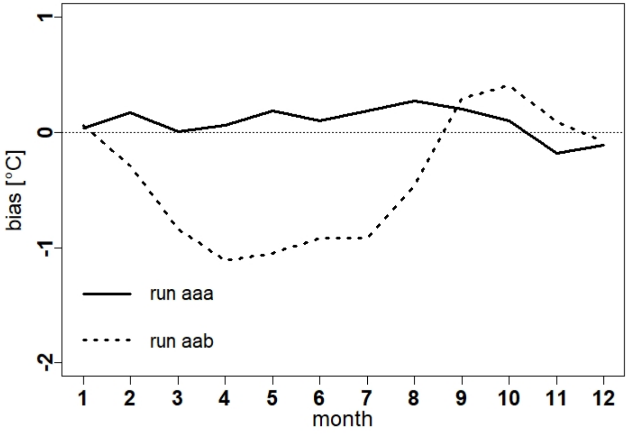
Daily precipitation sums correlation for experiments “aaa” and “aab”

avg aaa = 0,95
max aaa = 0,85
avg aab = 0,90
max aab = 0,79



Courtesy of Petr Zacharov

Temperature results

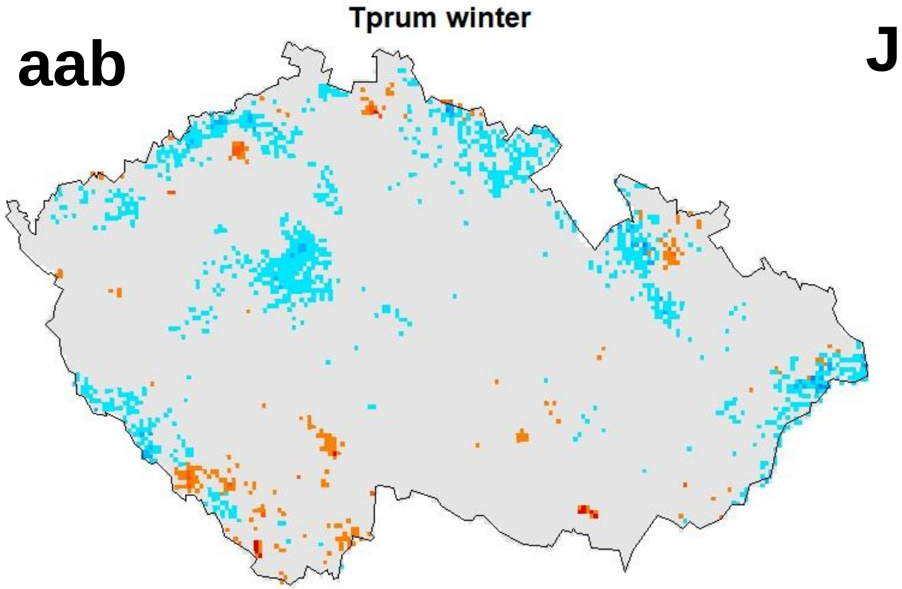


Average daily temperatures: annual cycle comparing "reanalysis aaa" short runs and "free surface aab".

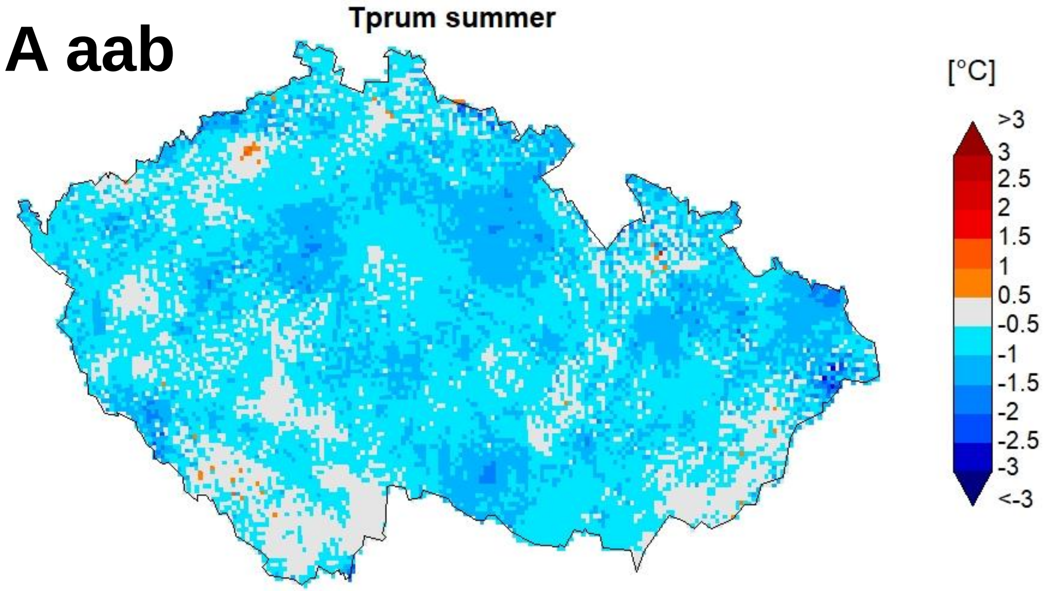
Period: 1990-1999.

Courtesy of Romana Beranová

DJF aab

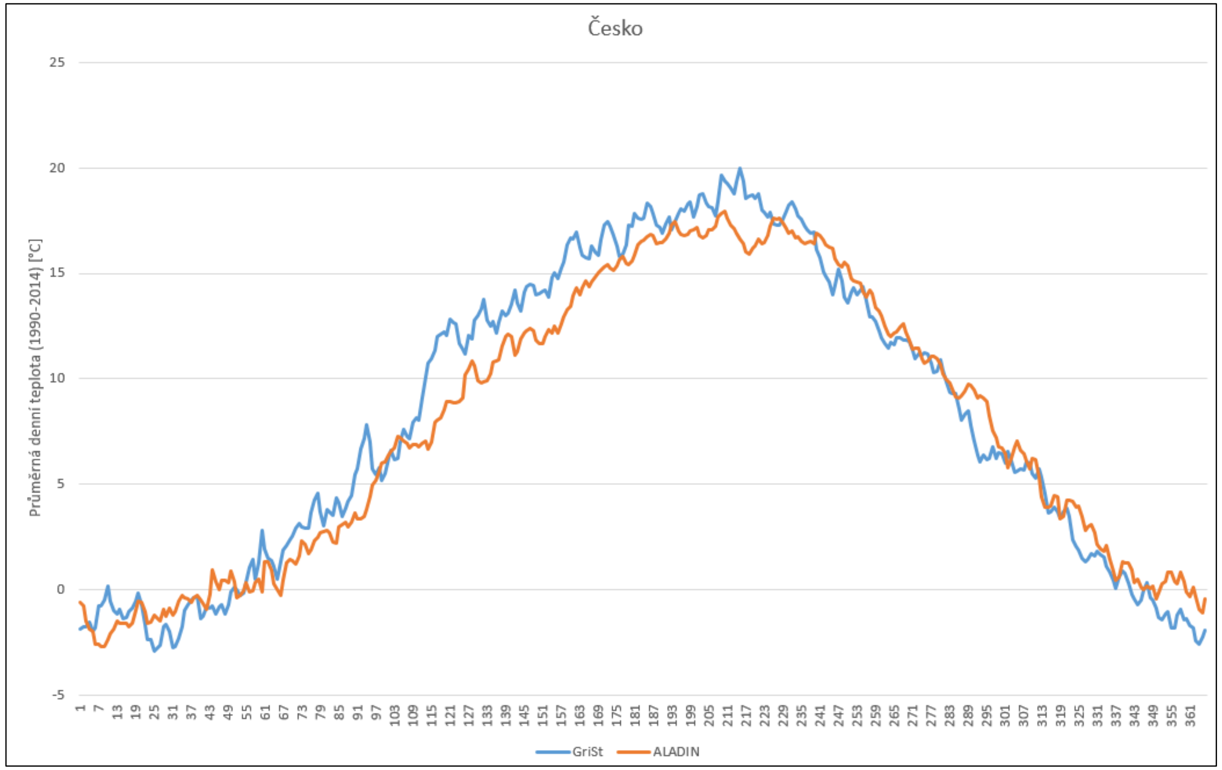


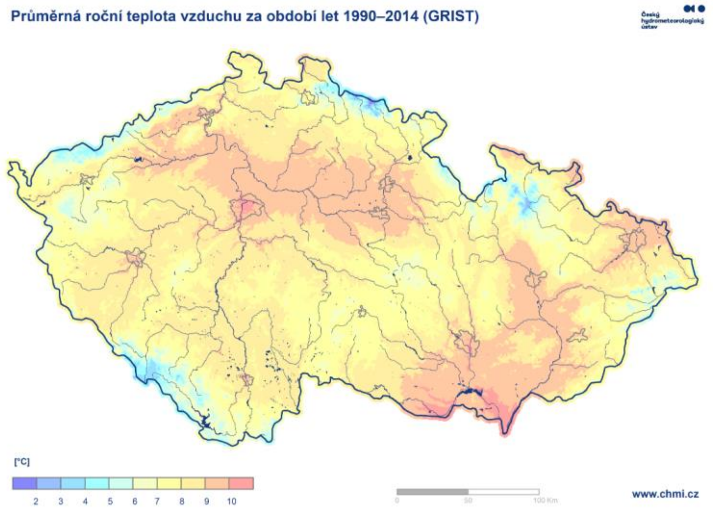
JJA aab



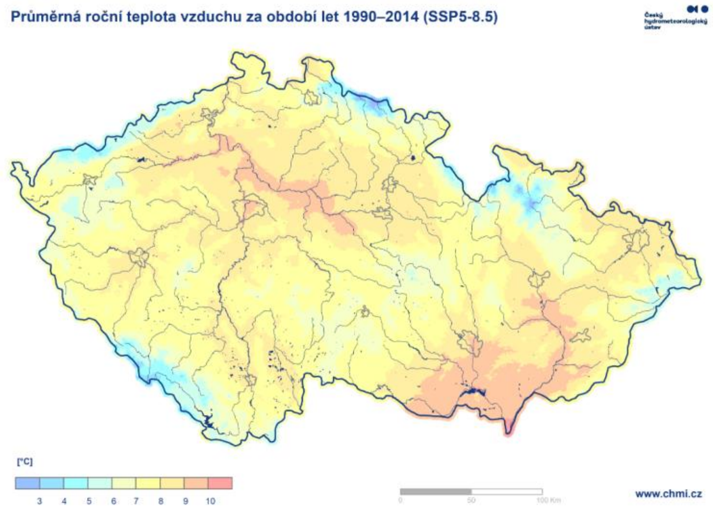
Czech Hydrometeorological Institute

Temperature – coupling with ESM2-1





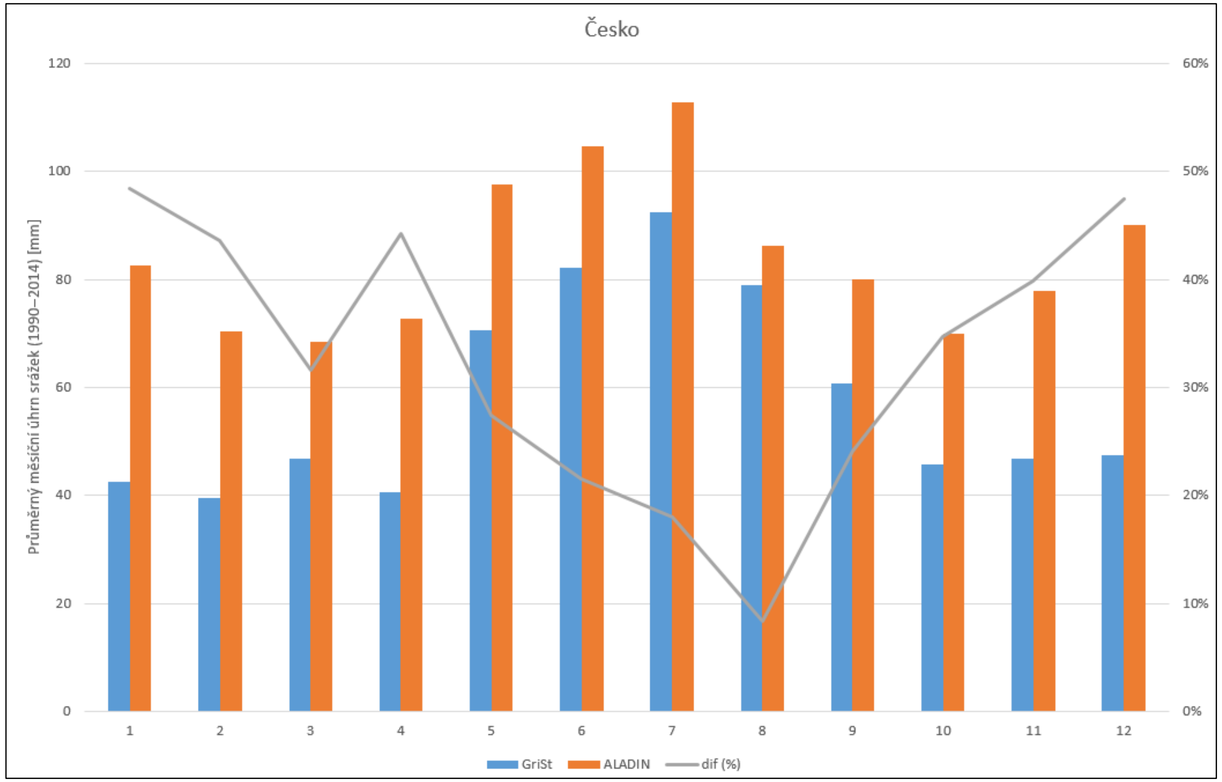
GriST

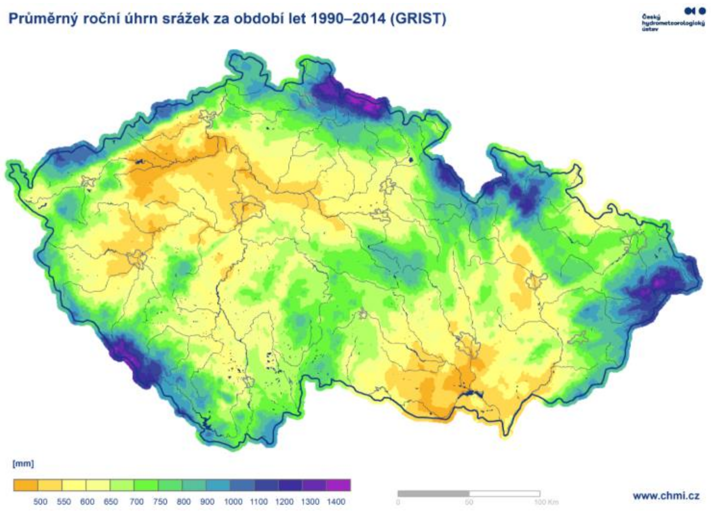


aac

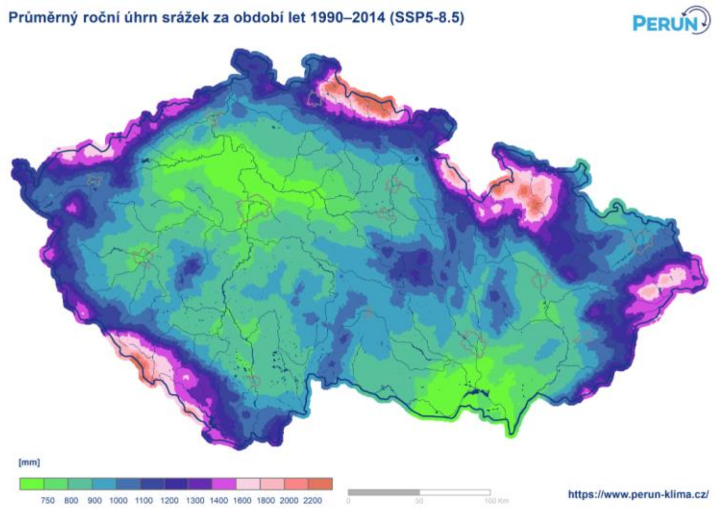
Mean annual temperature. ***Period: 1990-2014***.

Precipitation – coupling with ESM2-1





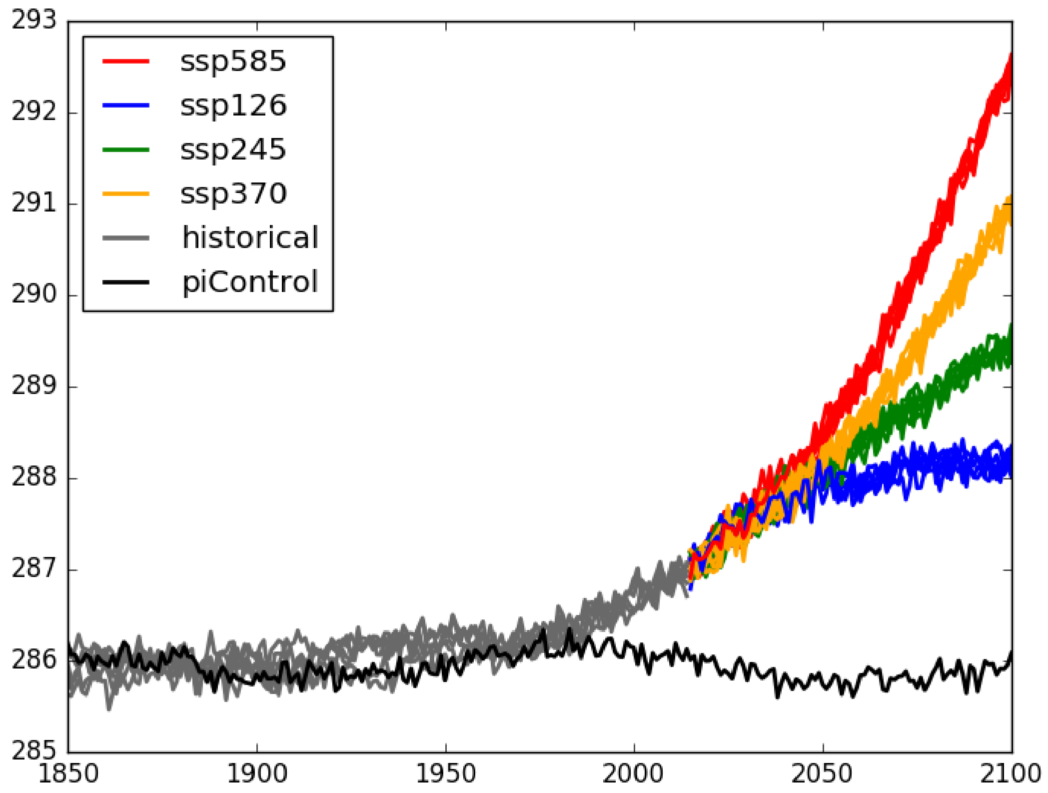
GriST

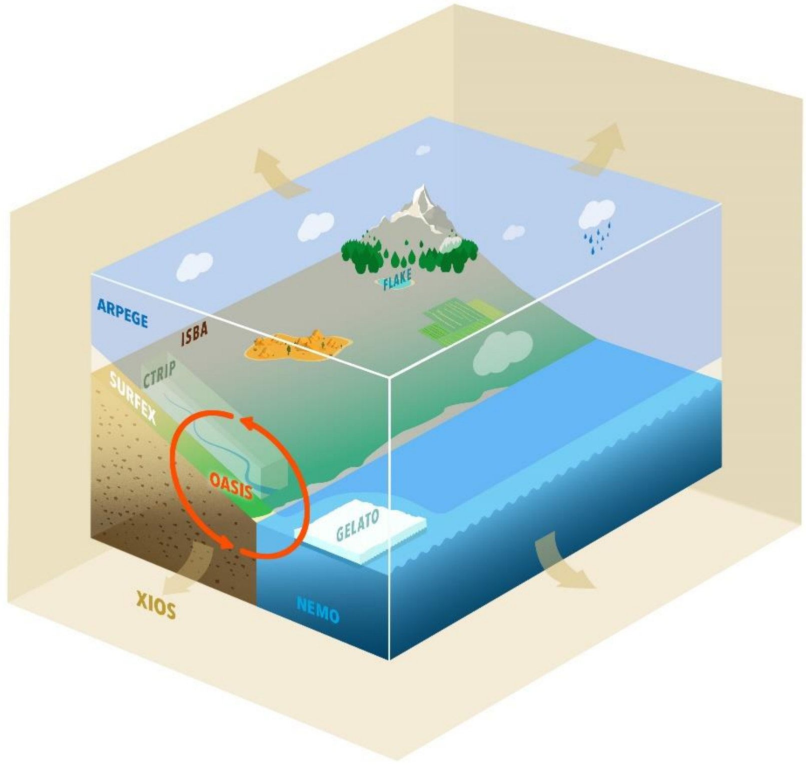


aac

Mean annual temperature. ***Period: 1990-2014***.

CMIP6 scenario by the system ESM2-1

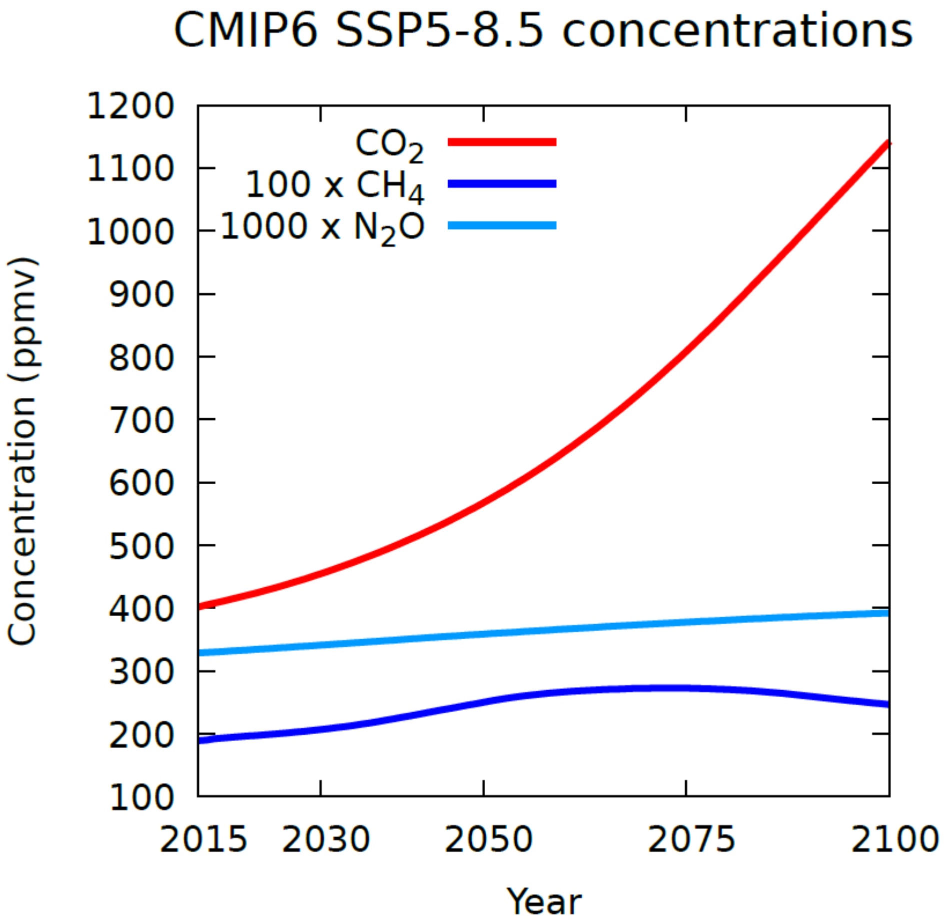




CNRM-CM

CMIP6: Coupled Model Intercomparison Project Phase 6, World Climate Research Program

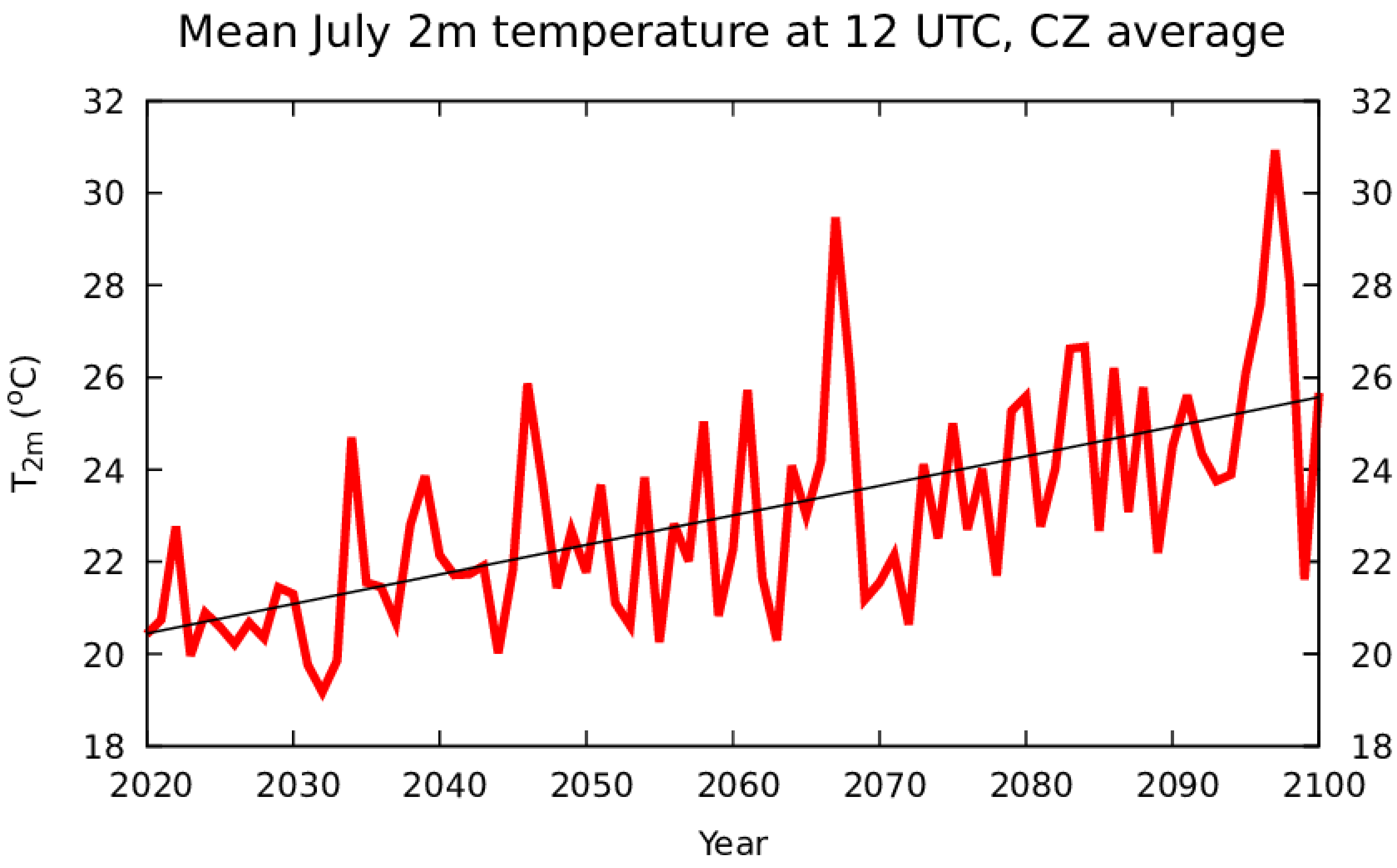
Prescribed green house gas concentrations SSP5-85



SSP5-8.5 greenhouse gas concentrations (ppmv)					
gas \ year	2015	2030	2050	2075	2100
CO_2	401.7	454.3	567.2	808.5	1142.3
CH_4	1.890	2.067	2.499	2.725	2.465
N_2O	0.328	0.341	0.358	0.377	0.392

Optical properties for ACRANEB2 (CO2+ composite) are scaled so that the radiative balance for the Earth-troposphere system is kept. It is cheap and precise.

Temperature evolution in scenario SSP5-8.5



Summary

– Results obtained so far show a good model skill comparable to other RCMs, including the need of de-biasing;

– Model validation in climate experiments gives additional useful information;

– Future plans:

  prepare the next climate version based on CY46T1;

  improvements in the microphysics and turbulence;

  using SURFEX.

Thank you for your attention

Radmila Brožková and Ján Mašek

🖂*jan.masek@chmi.cz, radmila.brozkova@chmi.cz*

Czech Hydrometeorological Institute