CzechGlobe
GLOBAL CHANGE
RESEARCH INSTITUTE CAS

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Agnieszka Wypych[3], Agnieszka Sulikowska[3]

GriSt: Daily 3-km Gridded Climate Fields for Central Europe since 1961

BudaPest, 06/05/2026

AdAgriF project – *Advanced methods of greenhouse gases emission reduction and sequestration in agriculture and forest landscape for climate change mitigation* (CZ.02.01.01/00/22_008/0004635

ACECE project (24-14581L) – *Atmospheric Circulation and weather Extremes in Central Europe and their representation in climate models*, funded by the Czech Science Foundation (GA ČR)

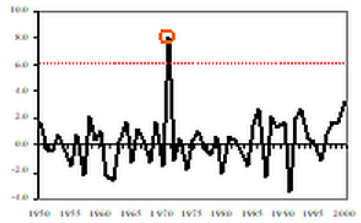
1 - Global Change Research Institute of the Czech Academy of Sciences, Brno, Czech Republic
2 - Czech Hydrometeorological Institute, Brno Regional Office, Czech Republic
3 - Jagiellonian University, Institute of Geography and Spatial Management, Department of Climatology, Kraków, Poland

Outline

- Data quality control
- Homogenization of time series
- Interpolation methods
- Products – climate services
- Example: ACECE project

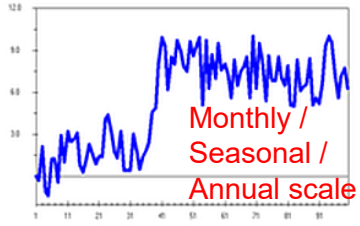
Pre-processing data

Quality control
(MetQC software)

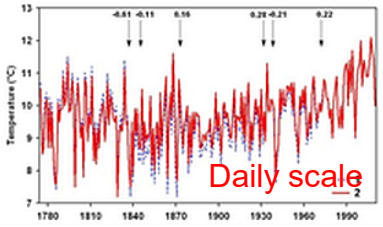


Sub-daily scale

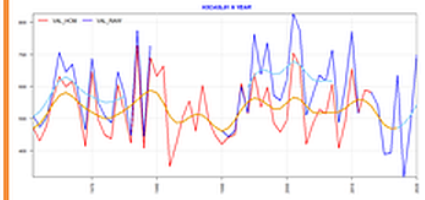
Detection of breaks
(ProClimDB/Anclim)



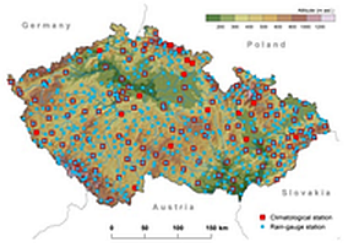
Correction of breaks
(Distribution Adjusting by Percentiles)

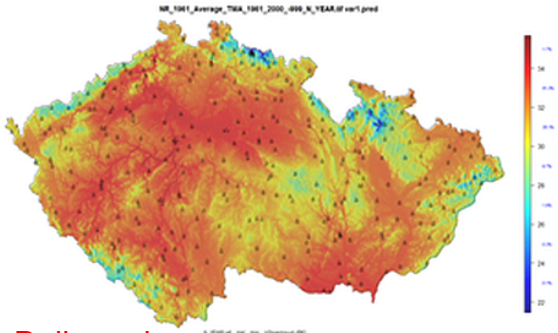


Fill the gaps
(Interpolation methods)



Gridding
(1x1 km)

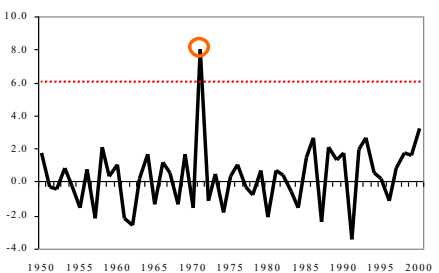


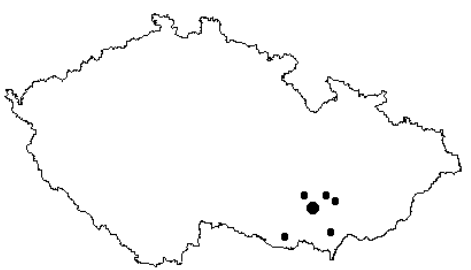


Daily scale

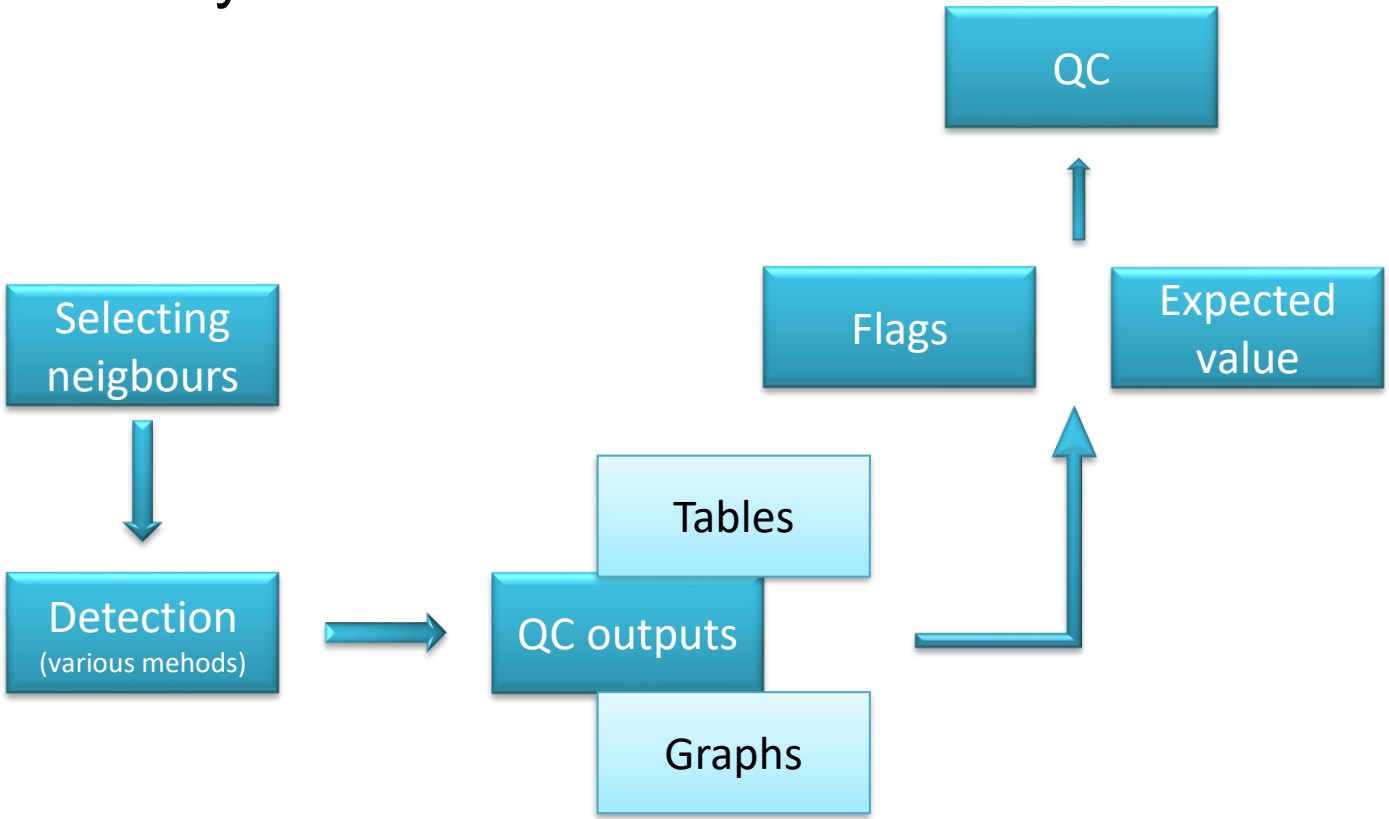
Data quality control

- Raw data may contain errors, duplicates, repeated or missing values, etc.
- The process is based on the **ProClimDB** method, reprogrammed into **R – MetQC**
- The **MetQC** software is suitable for operational use
- The quality control procedure combines several methods





Data Quality Control – MetQC



QC outputs – flags

Inspired by other softwares

<u>All checked data are flagged:</u>

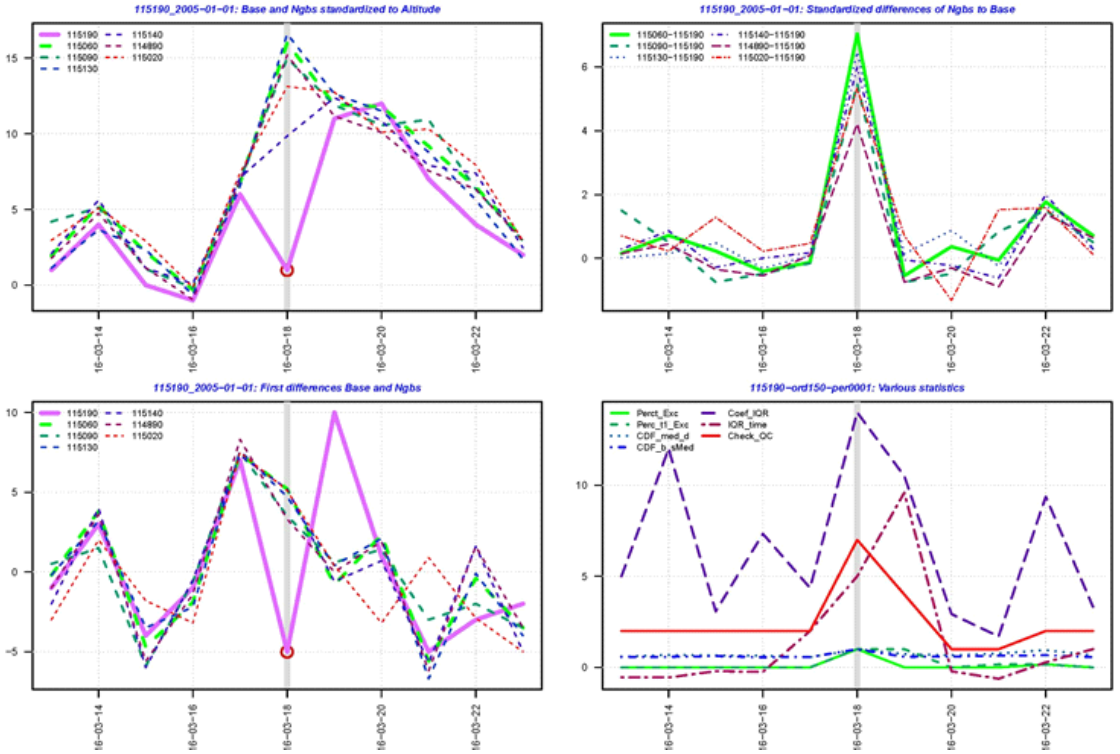
0 … valid
1 … error value (70/100% probability of error)
2 … suspect value (40/70% probability of error)
4 … repeated value (the same values repeated several times)
5 … duplicate value (same value found in neighbour station)
9 … missing value

QC outputs – tables

- Tables with errors
- Tables with suspicious values
- Tables with repeated values
- Tables with duplicate stations

	Date			Test station	Calculate value	Difference		Reference stations					
ID	YEAR	MONTH	DAY	ST_BASE	EXPECT_VAL	DIFFS	REMARK	ST_1	ST_2	ST_3	ST_4	ST_5	ST_6
							Distances	64	110	116	128	142	136
128522	TEST STATION			120.0			Altitudes,limit	110	112	169	110	450	112
122702							st_1, Correl	0.8					
100149							st_2, Correl		0.8				
132674	REFERENCE STATIONS						st_3, Correl	Correlation coef.		0.8			
123506							st_4, Correl				0.8		
126122							st_5, Correl					0.7	
100183							st_6, Correl						0.7
128522	1950	4	10	19.9	9.4	-10.5		9.6	9.0	8.0	8.4	5.3	10.0
128522	1950	11	1	12.4	4.7	-7.7		5.3	4.3	3.5	4.6	4.2	4.6
128522	1951	12	24	9.4	0.6	-8.8		-0.4	0.5	0.0	2.3	2.0	-0.8
128522	1953	11	24	-0.6	6.8	7.4		7.5	7.2	6.2	7.9	5.1	6.0
128522	1959	11	26	10.5	3.6	-6.9		2.8	4.5	2.9	4.1	5.6	2.7

QC outputs – graphs

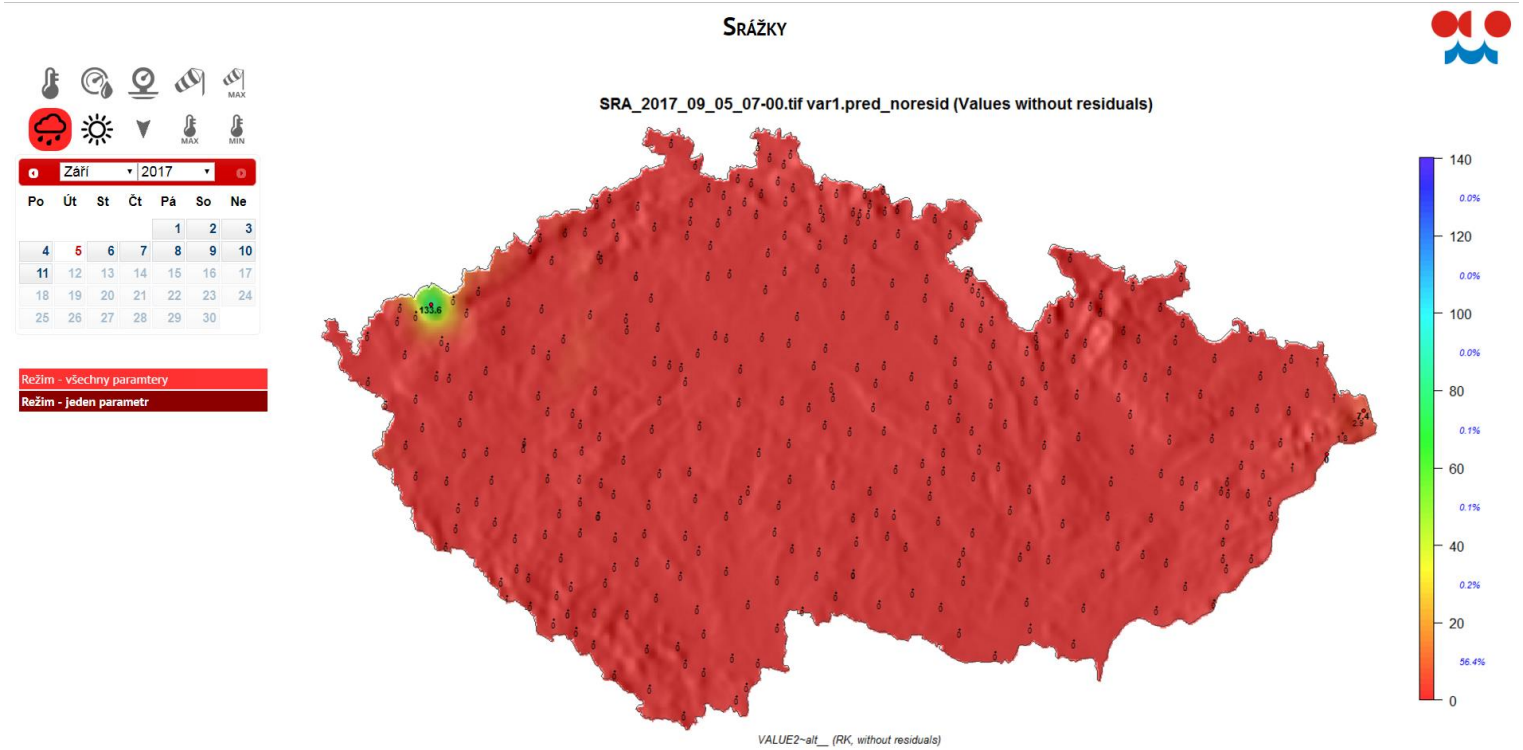


Example of Error Detection – Slovenian Regional Dataset

- Top left: Tested and neighbouring stations – values of neighbouring stations are standardized to the altitude of the tested station.
- Bottom left: First-difference series for the tested and neighbouring stations.
- Top right: Standardized differences between the tested and neighbouring series.
- Bottom right: Various statistics used for the evaluation of outliers.

QC outputs – maps

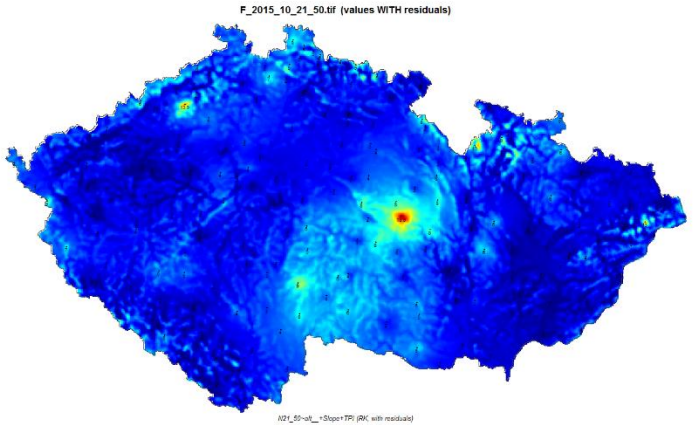
- Further optional enhancements of MetQC
- Developed and used at the Czech hydrometeorological institute
- Running in the operational mode for several years

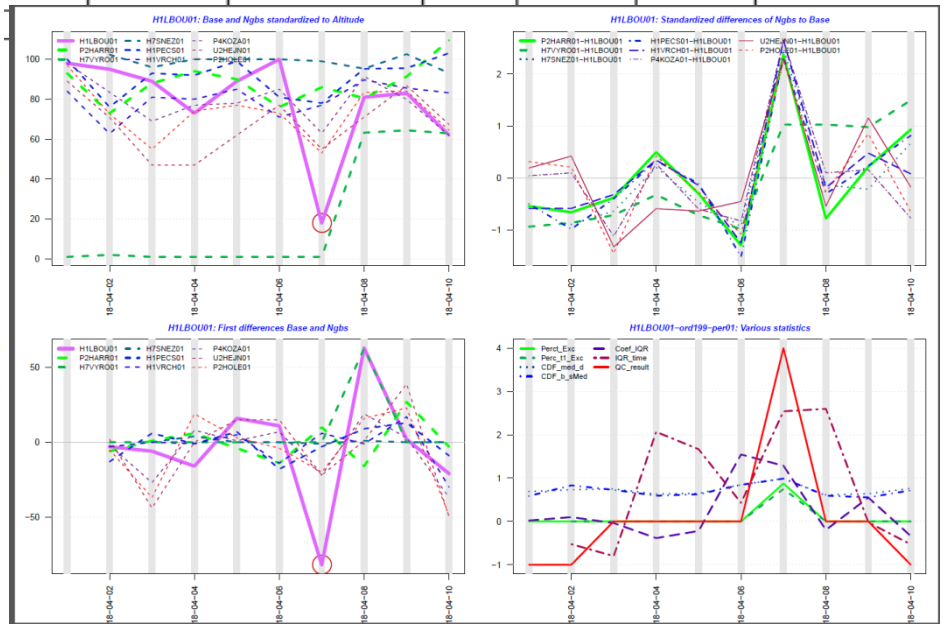


QC for 1 hour data – example

Editing d:\data\konference\cmes_2017\sra_2018_04_14_sum_outliers.dbf (5 rows)

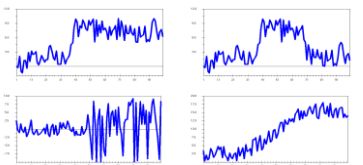
Eg_gh_id	Eg_el_abbr	Year	Month	Day	Time	Value2	Begin_date	End_date	Name	Altitude	Gauss1	Gauss2	Station_ty
P3ZDAR01	SRA	2018	04	14	07:00	4.2	01.01.2002	31.12.3999	¦Ô r nad S zavou	605	3567695	5496563	ASS
H3BROU01	SRA	2018	04	14	07:00	2.2	01.12.2000	31.12.3999	Broumov	373	3595189	5605139	AKS1
U2NBOR01	SRA	2018	04	14	07:00	0.1	01.11.2012	31.12.3999	Nově Bor	358	3468752	5624400	ASS
U2ZAND01	SRA	2018	04	14	07:00	0.1	01.06.2016	31.12.3999	¦andov	275	3457456	5620629	MSS
U2MARE01	SRA	2018	04	14	07:00	0.0	01.08.2005	31.12.3999	Maýenice	395	3477166	5630994	ASS





Homogenization of time series

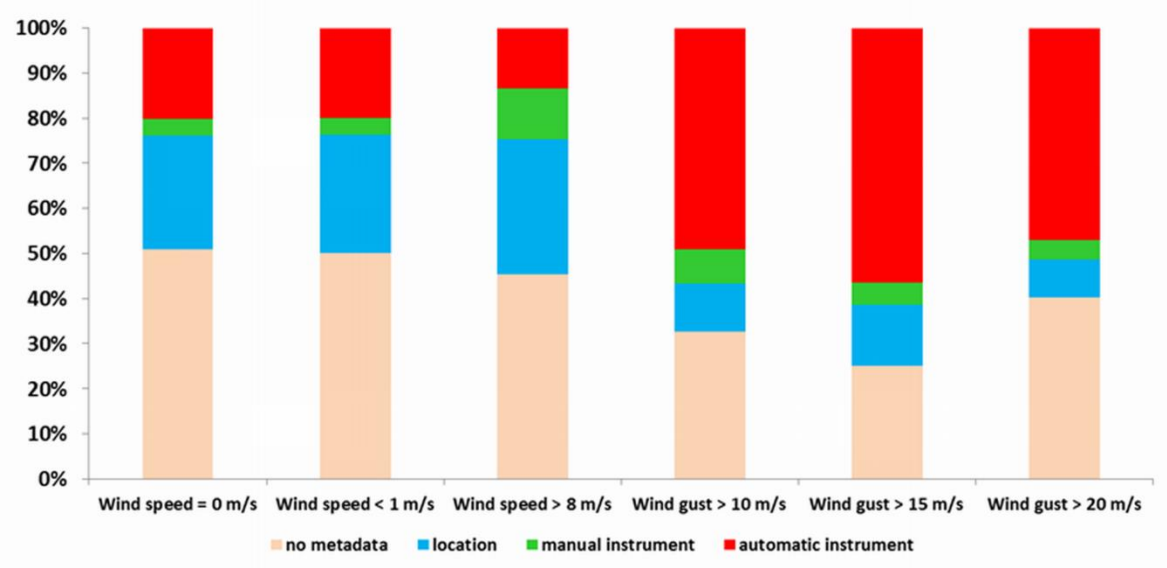
- Detection performed on **monthly, seasonal, and annual** time series
- Two types of **reference series**:
  - Single reference calculated from nearest or best-correlated neighbour stations
  - Pairwise detection – comparison with each neighbouring station individually
- Detection methods: **SNHT, Bivariate test**, and **t-test**
  - Implemented through **AnClim** (www.climahom.eu)
- **Correction**: DAP method (quantile mapping, QM) applied at **daily** time scale
  - Implemented through **ProClimDB / R** (www.climahom.eu)



Homogenization – example: results for wind speed, CZ

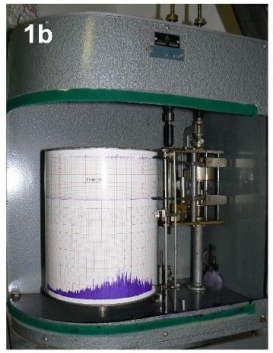
Characteristics	Nb. of stations	Nb. of inhom. stations	Percetage (%)	Nb. of breaks	breaks/station
Wind speed = 0 m/s	268	238	88.8	610	2.6
Wind speed < 1 m/s	268	264	98.5	779	3.0
Wind speed > 8 m/s	268	191	71.3	304	1.6
Wind gust > 10 m/s	71	70	98.6	159	2.3
Wind gust > 15 m/s	71	63	88.7	124	2.0
Wind gust > 12 m/s	71	63	88.7	117	1.9

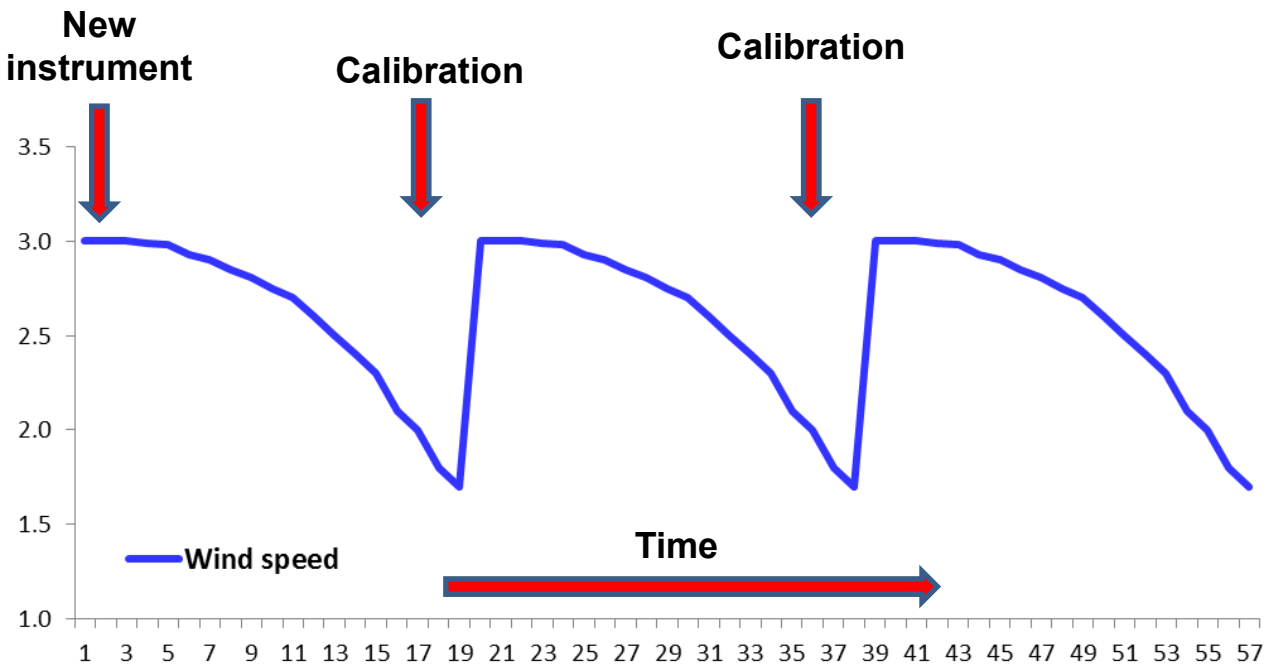
Example: number of days with wind speeds above a given threshold (since 1961)



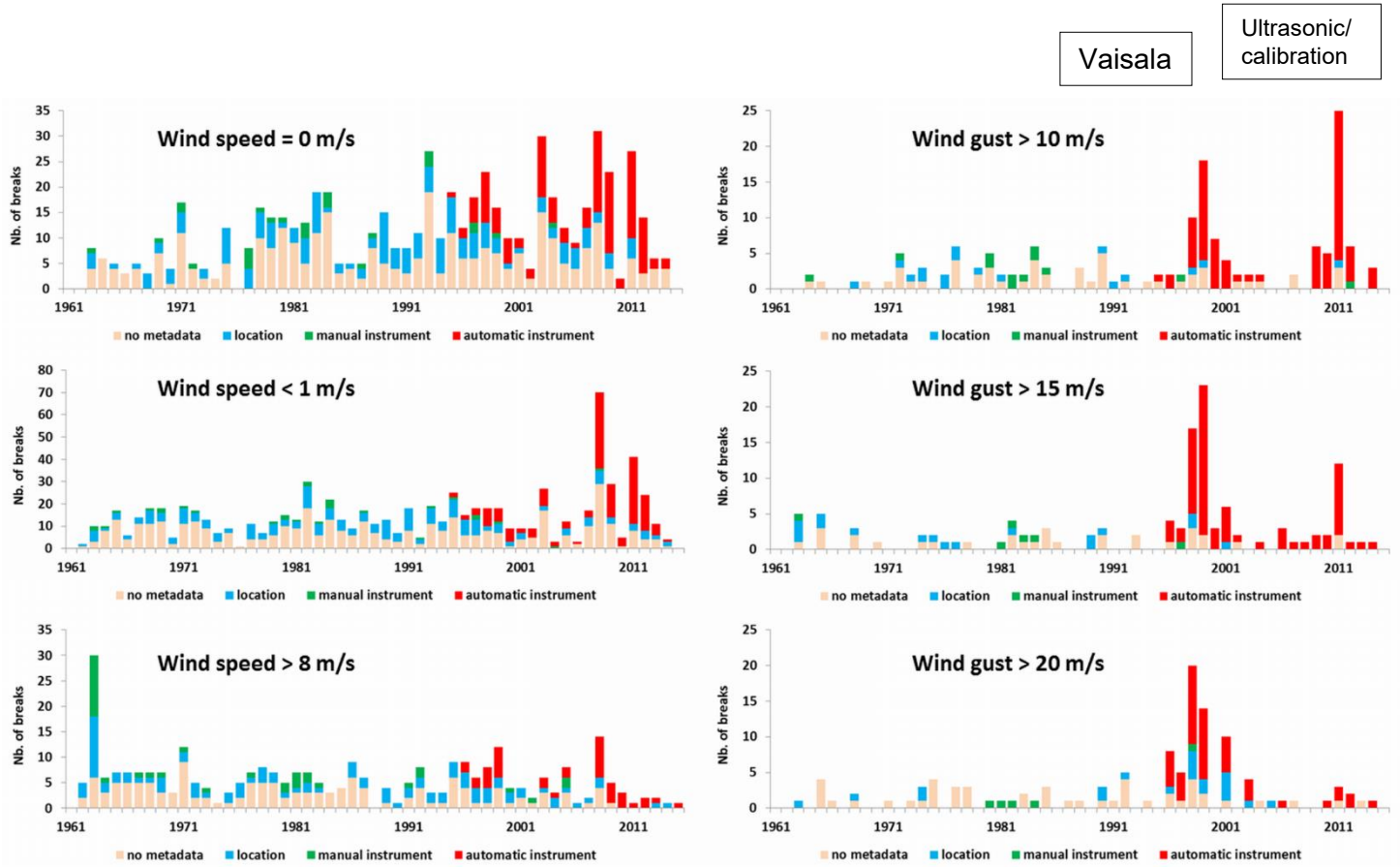
Effect of instrument change on wind speed measurements

1. Metra Anemograph
2. Vaisala anemometer
3. Ultrasonic anemometer



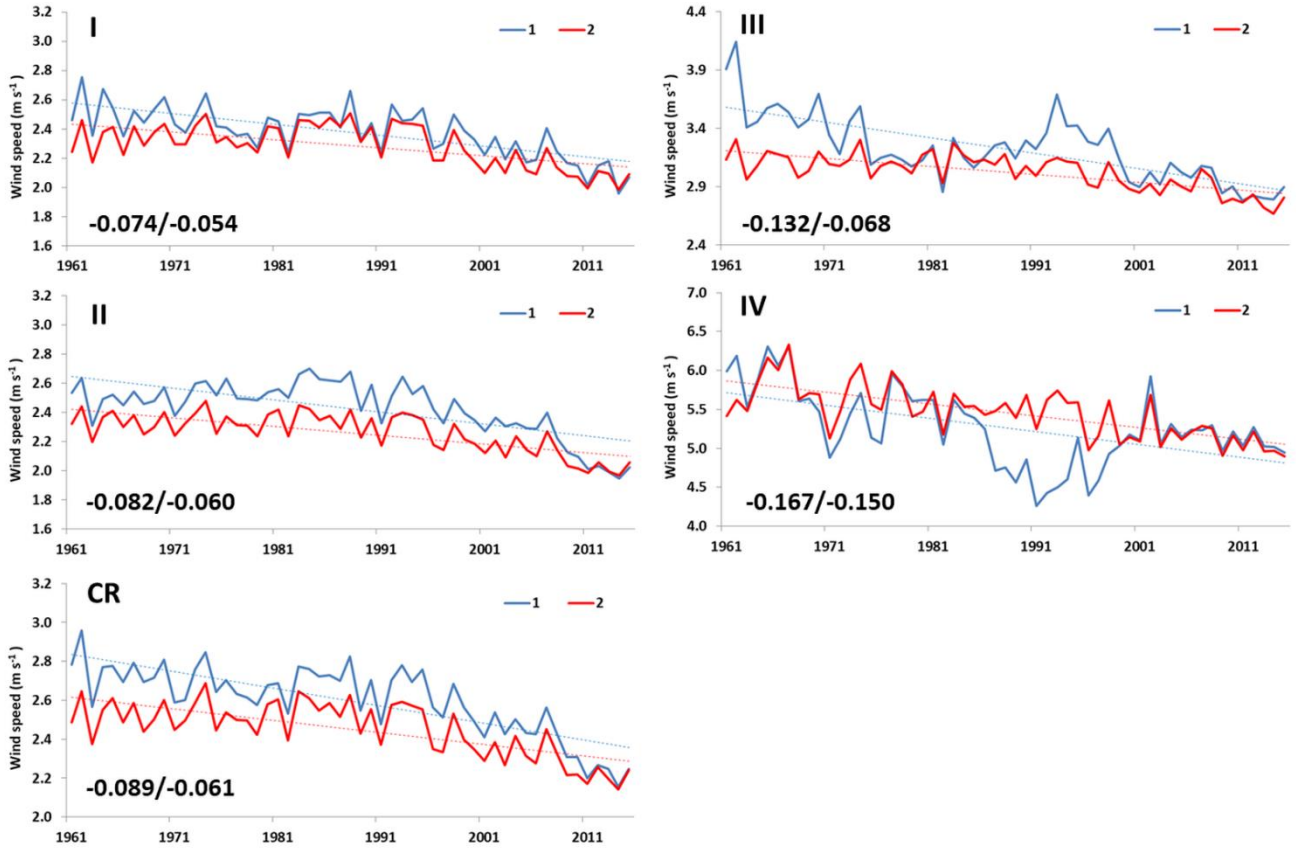


Homogenization – example: results for wind speed, CZ



Number of breaks for different counts of days with wind speeds above a given threshold (since 1961)

Homogenization – example: results for wind speed, CZ



Comparison of trends in raw (1) and homogenized (2) wind speed data for various altitudes in the Czech Republic.

After homogenization, the magnitude of decreasing wind speed trends is generally reduced.

Homogenization – example: results for precipitation, CZ

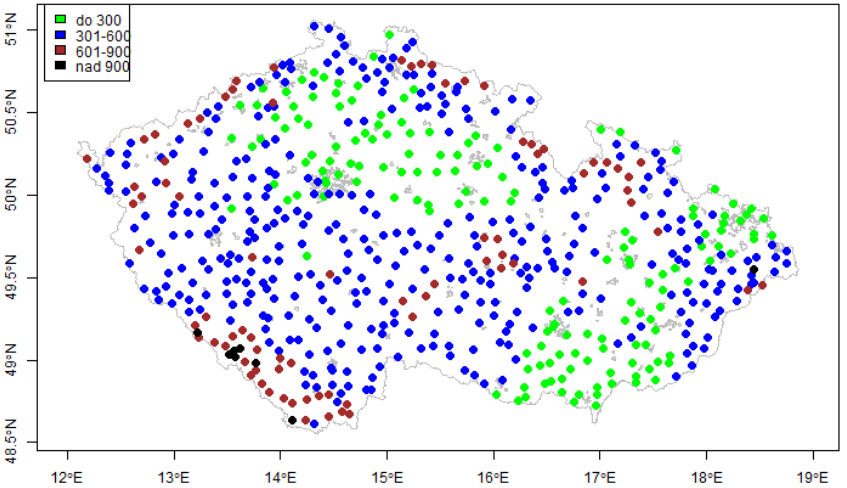
890 stations were processed, 1961-2020

786 stations were inhomogeneous (88,3 %)

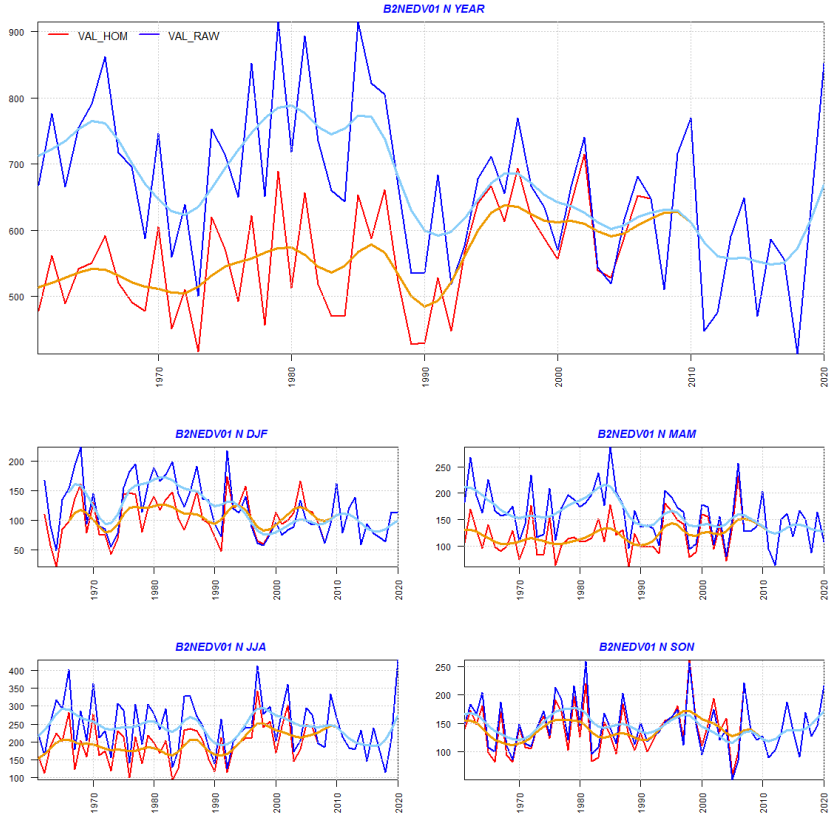
32 % of breaks explained by metadata

2398 breaks were found – 2 and 3 breaks in the series was the most common case. Maximum 9 breaks in the one series

In the end, only 600 stations could be used to calculate the normal 1991-2020



Homogenization – example: results for precipitation, CZ



The last homogeneous segment is rather short, only a few years. Can we rely on it?

To be able to continue (add) with new data, correction is done for the past.
But: which of the section is really correct?

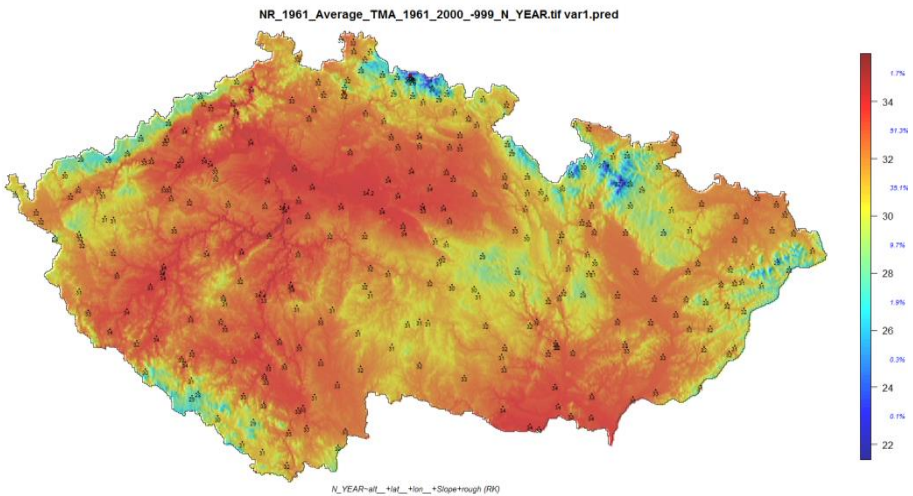
Can we really rely on newer instruments more than on old ones?

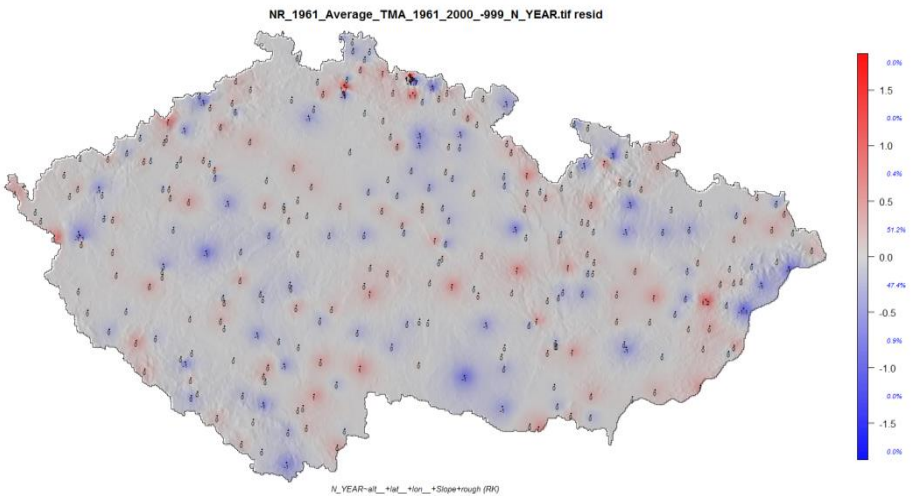
Large difference between measured and homogenized data up to 250 mm (in annual sum).

Although the correction is right, how to explain it to the customer that the total precipitation in his area has changed so much …

Interpolation

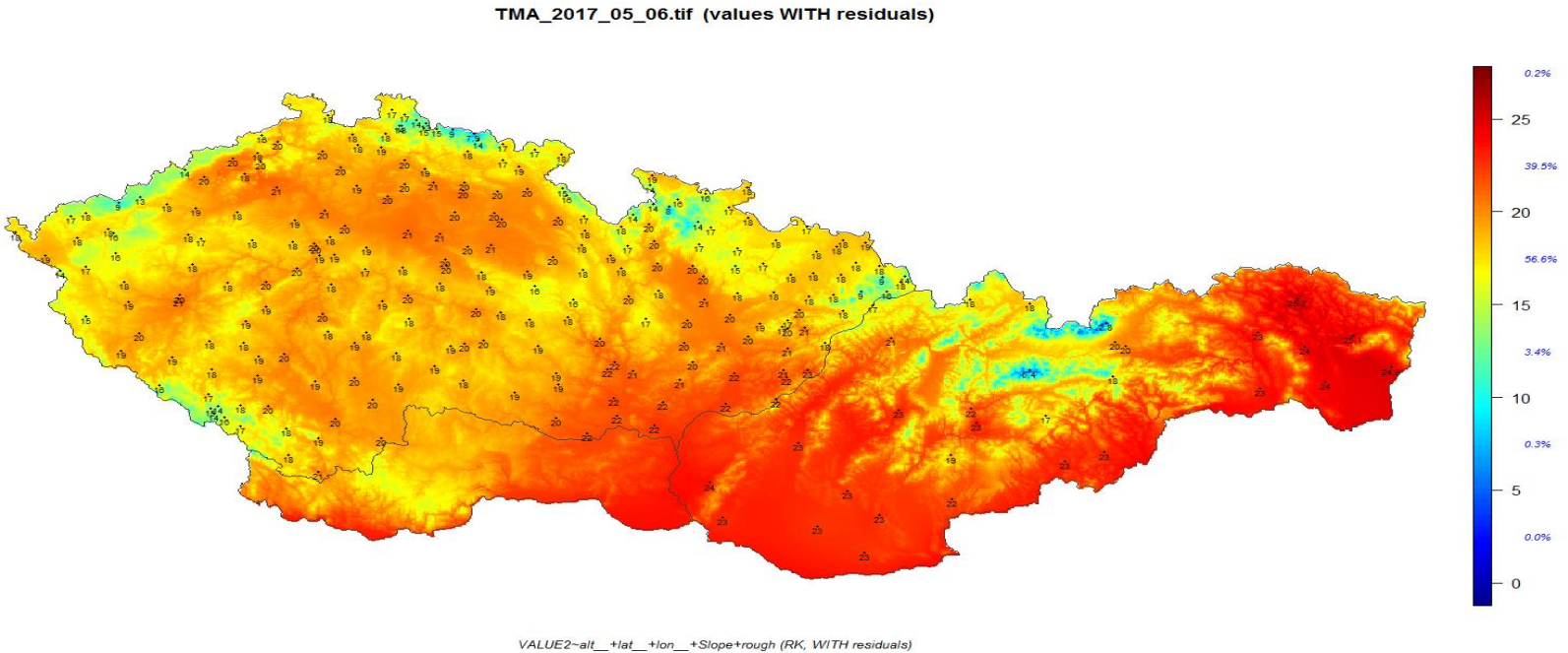
- Method based on regression kriging (dependence on altitude, latitude, longitude, etc.)
- Particular attention is paid to semivariogram construction
- Method for residual interpolation – standard approaches (IDW, kriging, TPS, …) do not always perform well in all situations (e.g. precipiation over large areas) - DDA (Delaunay–Diffuse Anchoring) method applied





Interpolation – Example: GriSt for CzechoSlovakia

- Daily maps of major meteorological elements (1941–present) at 500 m resolution
- Based on technical series (quality-controlled and homogenized observations)
- Also operates in eal-time mode, e.g. for www.intersucho.cz

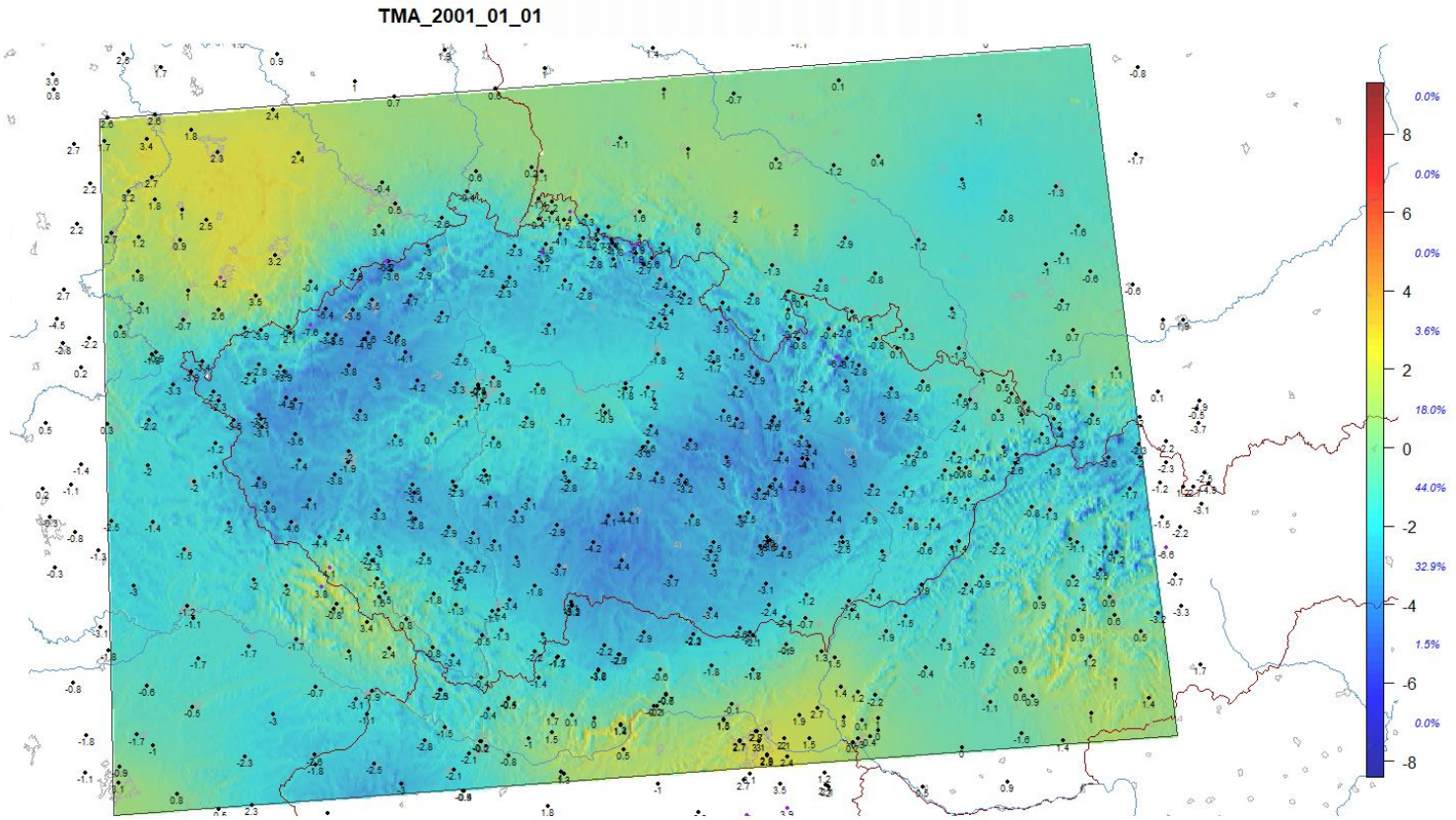


Interpolation – examples – GriSt extended

Air temperature
(Tavg, Tmax, Tmin)

Number of stations
CZ – 268 technical series
SK – 94
AT – 28
DE – 79
PL – 56

500*500 m spatial resolution,
daily time step,
1961-2025

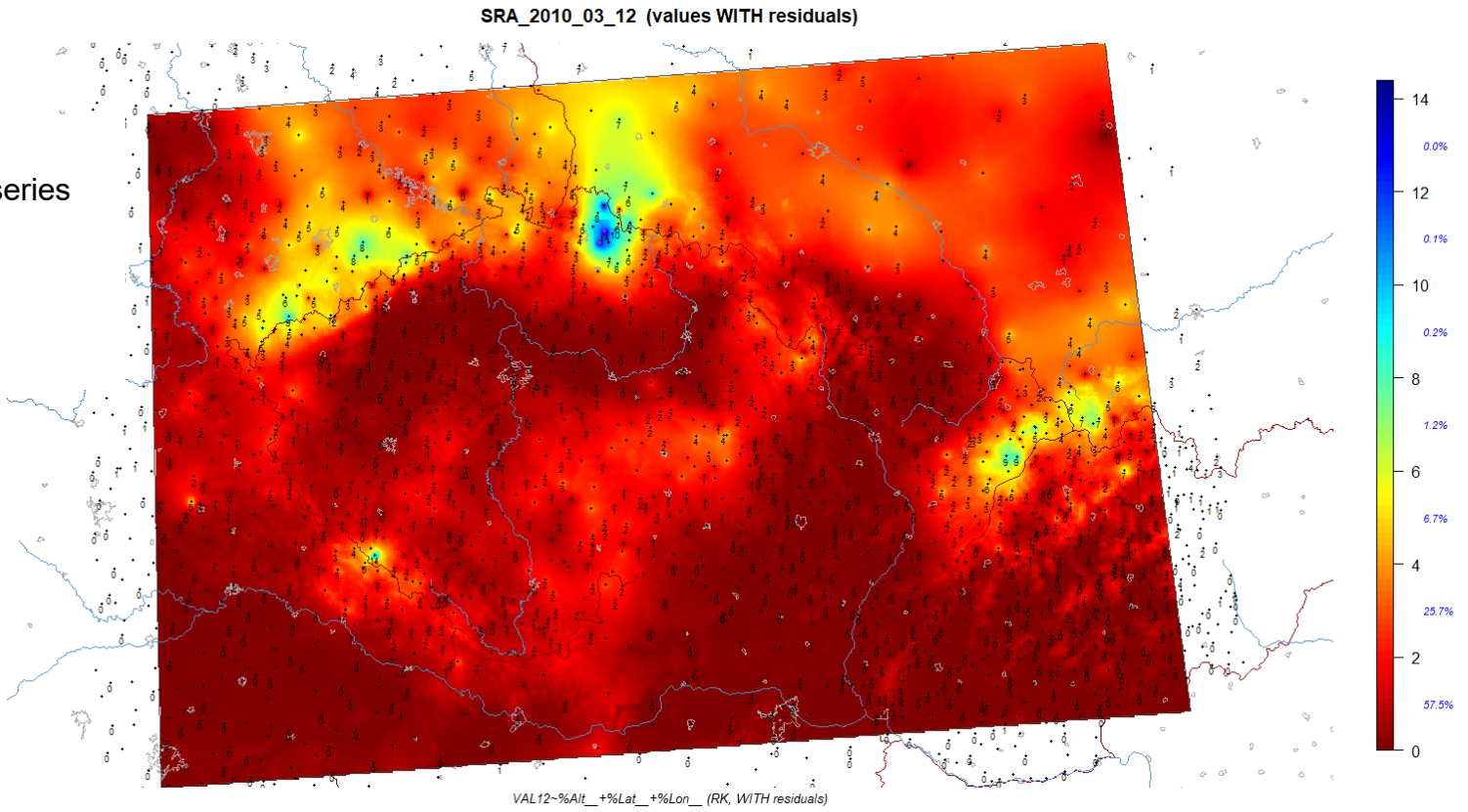


Interpolation – examples – GriSt extended

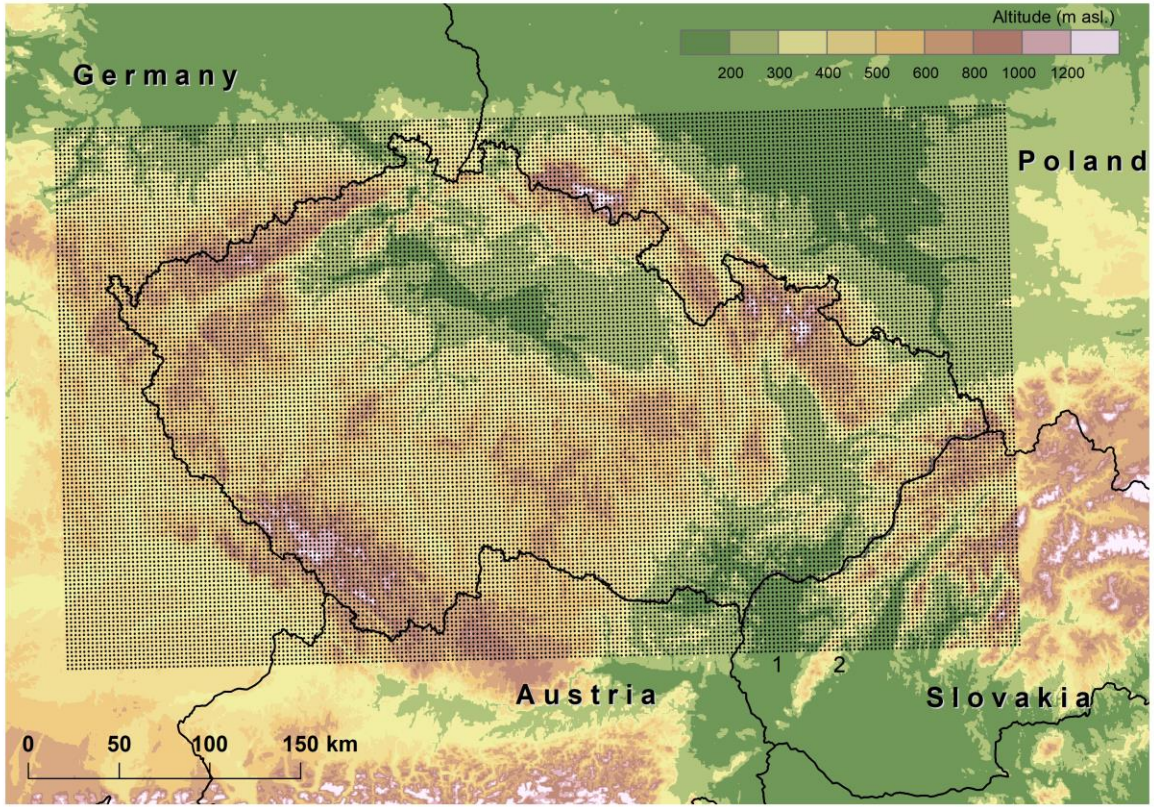
Precipitation

Number of stations
CZ – 787 technical series
SK – 478
AT- 114
DE – 1231
PL – 169

0.5 km spatial resolution,
daily time step,
1961-2025



Interpolation – examples



Grid points of ALADIN-Climate/CZ (RCM - CPM),
read from maps (29 154 points),

Background for bias correction
DAP method (QM)

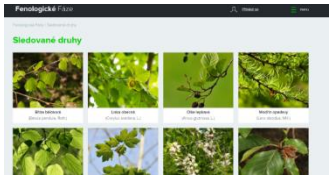
Products / climate services

- Our web platforms (AgroRisk.cz, FireRisk.cz, ClimRisk.cz, Intersucho.cz, etc.), created in cooperation with partner institutions, offer climate information and decision-support tools.
- They are based on quality-controlled, homogenized, and spatially interpolated data
- The long-term monitoring record (1961–2025) provides the foundation for accurate forecasting and climate projections.

Products – examples

www.intersucho.cz

www.klimatickazmena.cz

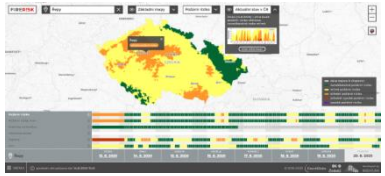


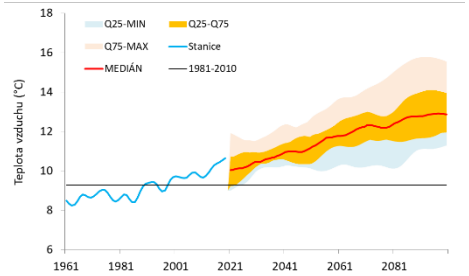
www.vynosy-plodin.cz

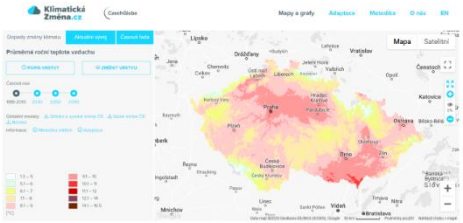
www.fenofaze.cz

www.agrorisk.cz

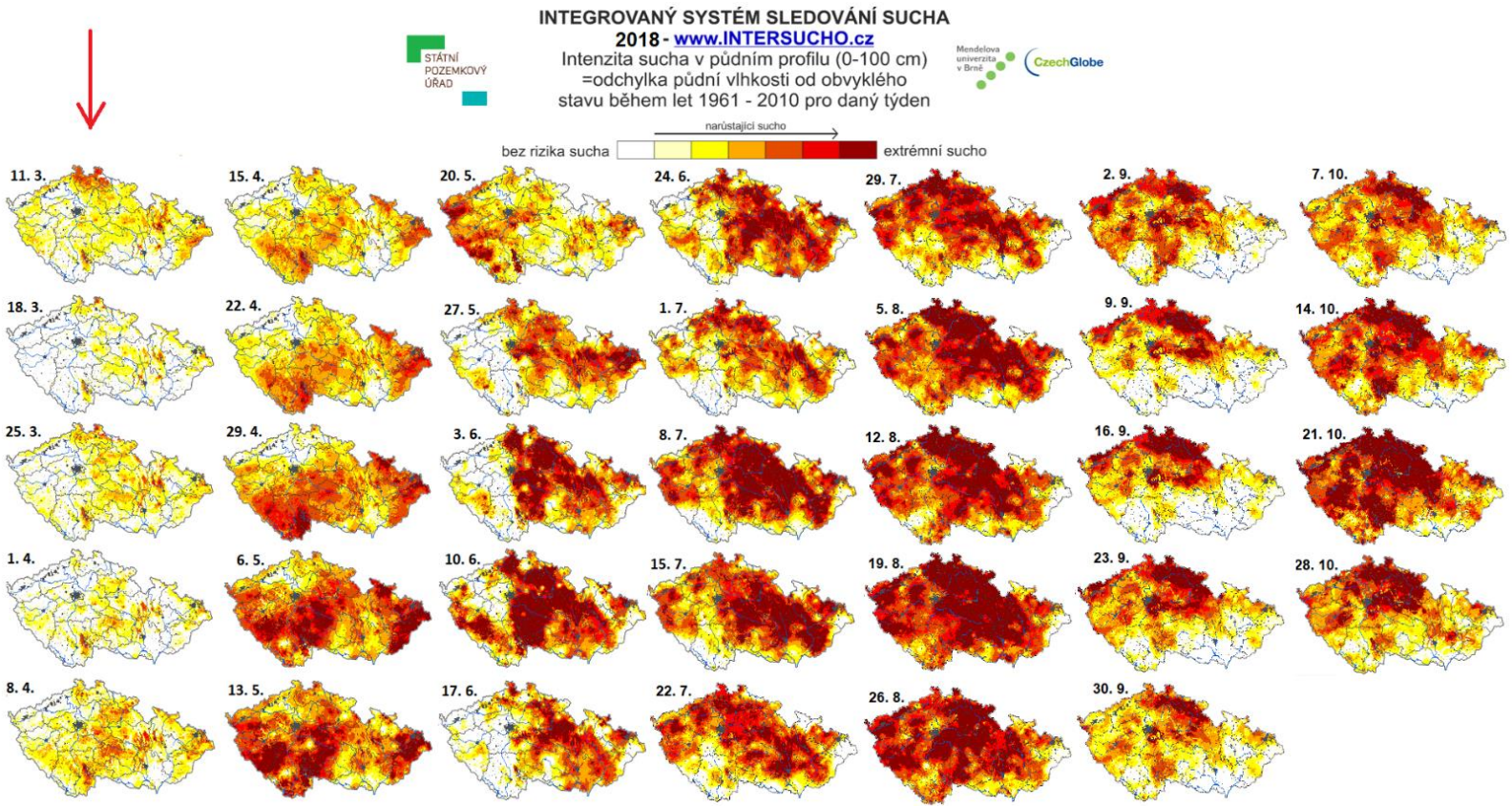
www.firerisk.cz







Drought monitoring and forecast, CZ



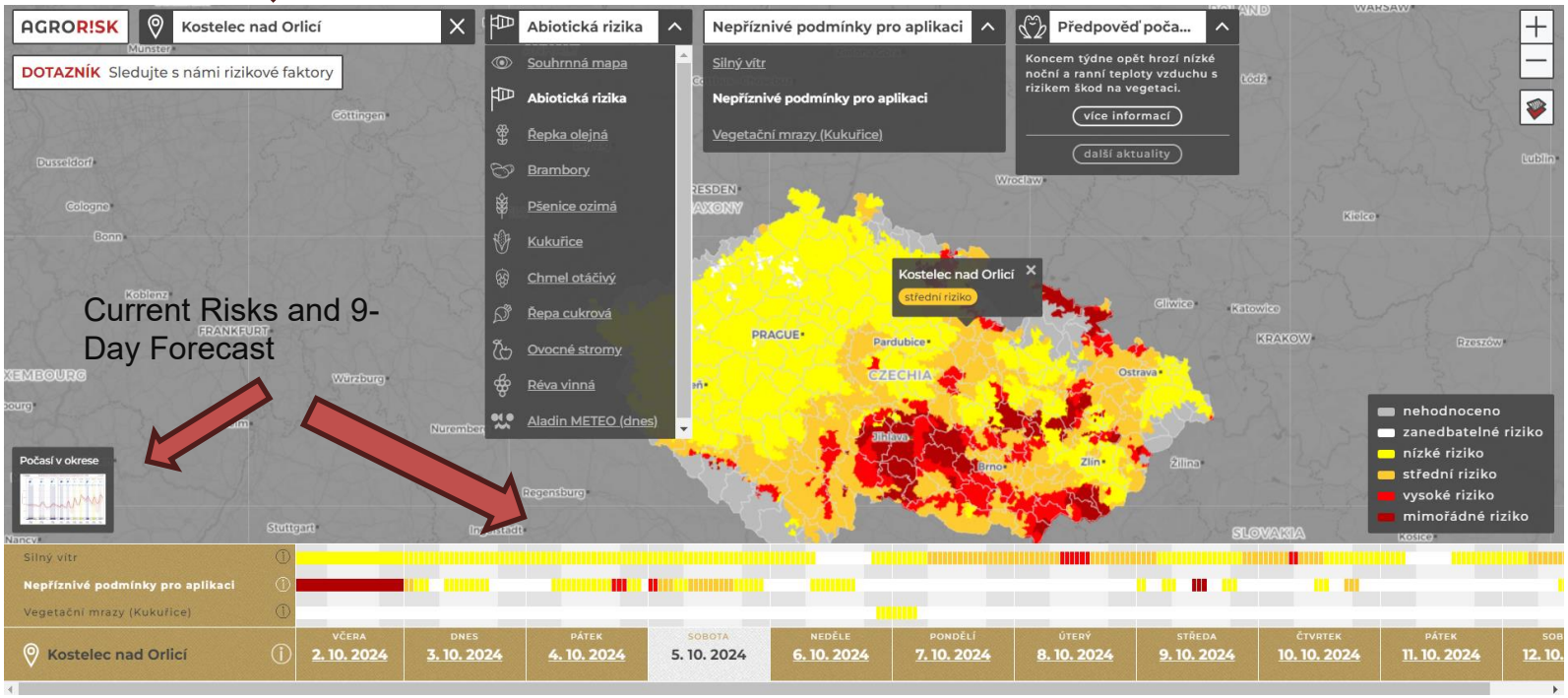
www.intersucho.cz

An early warning system against abiotic and biotic risks

Cadastre

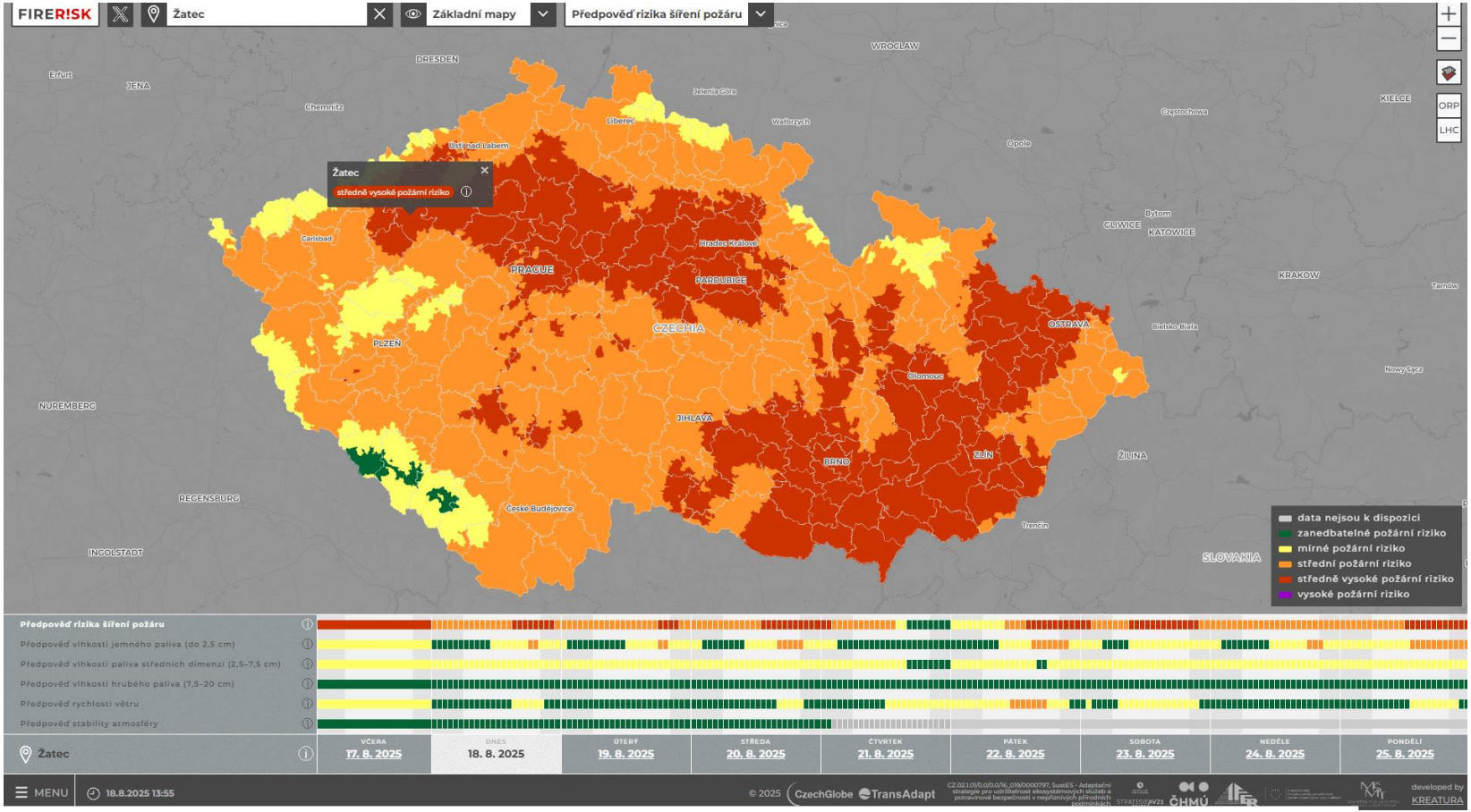
Crop

Current Risks



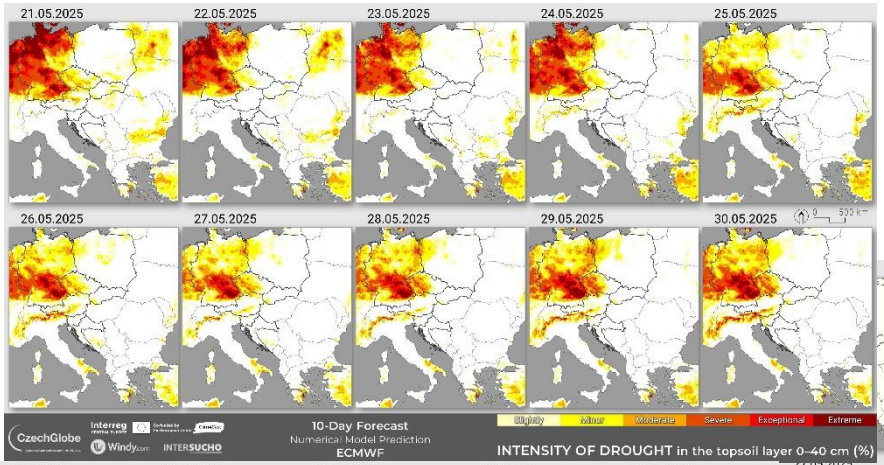
www.agrorisk.cz

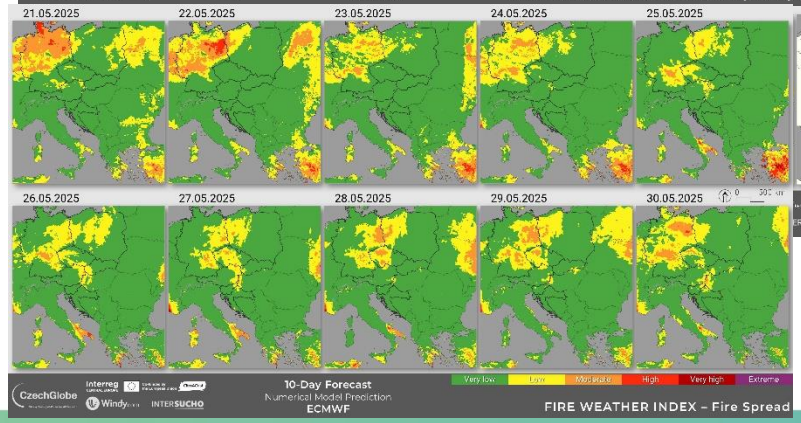
Wild fire forecast

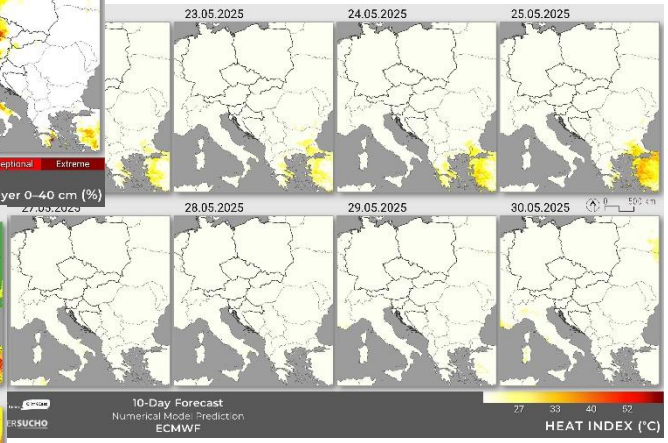


www.firerisk.cz

Monitoring and prediction of changing climate conditions (drought, wildfire, heat) in real time clim4cast.czechglobe.cz



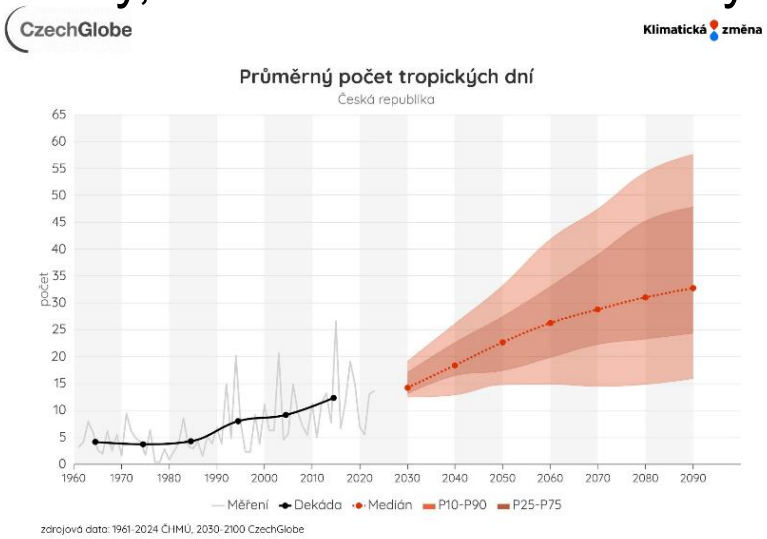


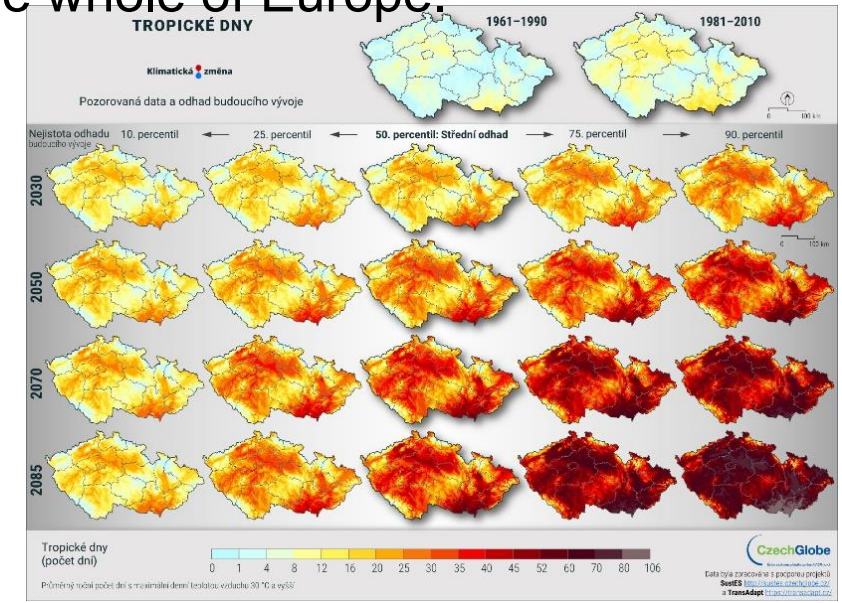


Reference dataset: ERA5-Land

Climate change data for CZ (www.klimatickazmena.cz)

Currently, similar work is underway for the whole of Europe.



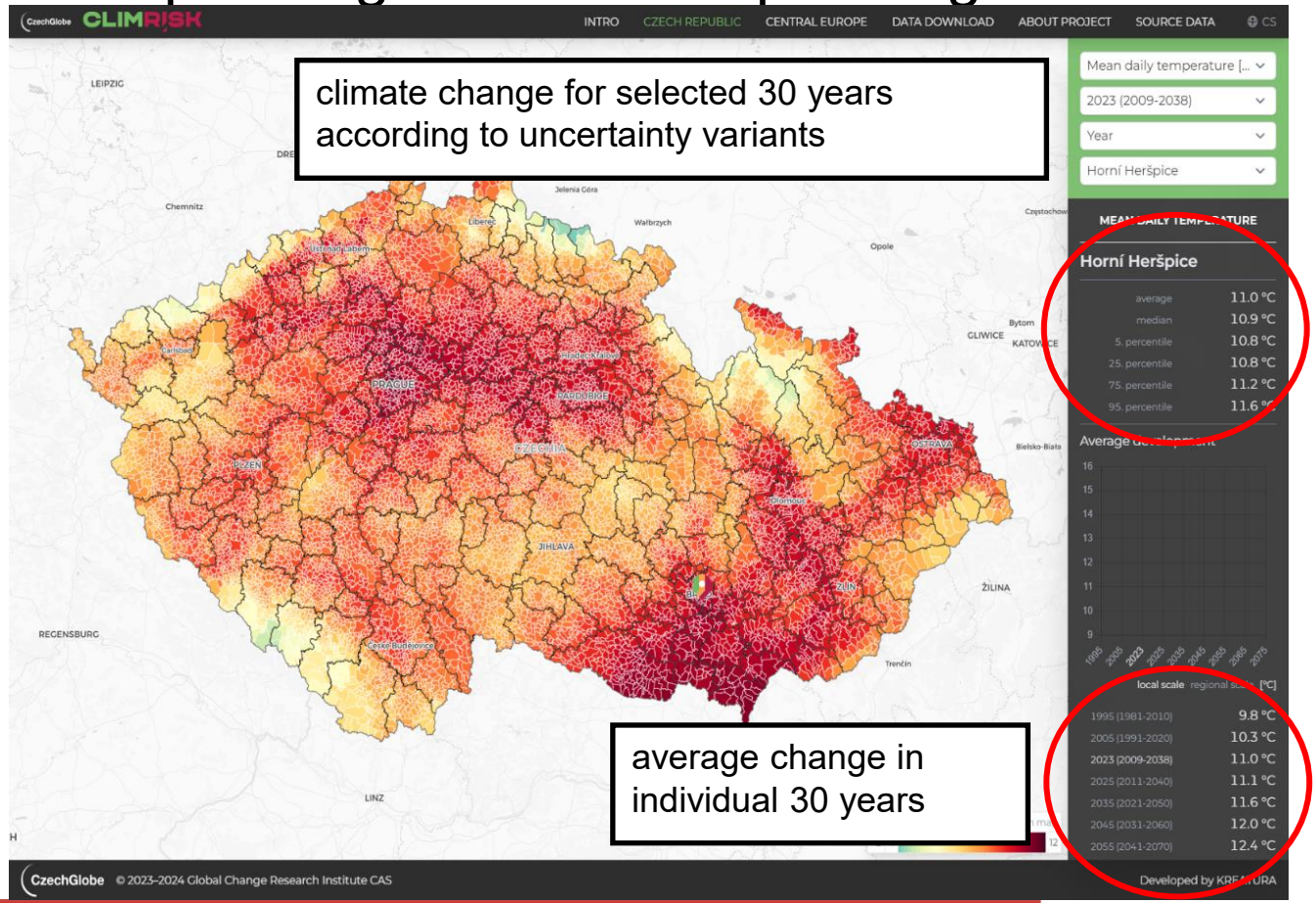


- www.klimatickazmena.cz
- Technical time series are applied for bias correction.
- Derived from a robust ensemble of more than 30 global climate models rather than EURO-CORDEX regional models; this decision is based on extensive testing.
- Only new-generation convection-permitting regional models (e.g. ALADIN-Climate/CZ) are included. Climate change estimates are therefore both state-of-the-art and grounded in a thorough analysis of historical climate trends.

ClimRisk.cz / climateproofing.cz – climate proofing tool for CZ

The tool is intended for

- Agricultural
- Forestry
- Energy sector
- Construction
- Finance
- Government
- Media
- Public



www.climrisk.eu

ClimRisk.eu – climate data for CZ / Central Europe

26 meteorological characteristics

- Mean daily temperature [°C]
- Minimum daily temperature [°C]
- Maximum daily temperature [°C]
- Precipitation sum [mm]
- Mean wind speed [m/s]
- Relative humidity [%]
- Sunshine duration [h]
- Global radiation [MJ/m²]
- Number of hot days
- Number of tropical nights
- Number of extremely hot days
- Number of days in heat wave
- Number of frost days
- Number of ice days
- Number of days in cold wave
- Number of days in very cold wave
- Number of days with precipitation
- Number of days with daily precipitation ≥ 10 mm
- Number of days with daily precipitation ≥ 20 mm
- Number of days with low soil humidity in 40 cm
- Number of days with very low soil humidity in 100 cm
- Number of days with snow cover ≥ 3 cm
- Number of days with snow cover ≥ 10 cm
- Number of days with snow cover ≥ 30 cm

30-year periods

- 1995 (1981-2010)
- 2005 (1991-2020)
- 2023 (2009-2038)
- 2025 (2011-2040)
- 2035 (2021-2050)
- 2045 (2031-2060)
- 2055 (2041-2070)
- 2065 (2051-2080)
- 2075 (2061-2090)

Monthly, seasonal and annual data

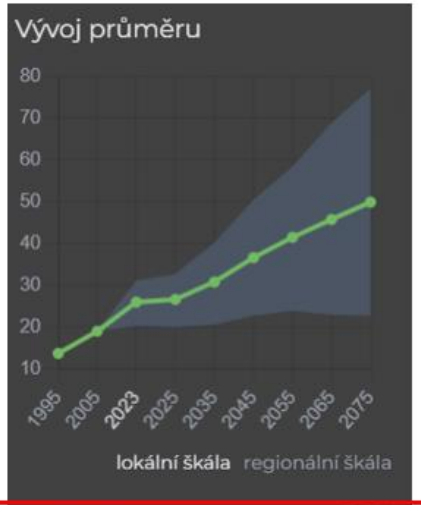
- January
- February
- March
- April
- May
- June
- July
- August
- September
- October
- November
- December
- Spring (MAM)
- Summer (JJA)
- Autumn (SON)
- Winter (DJF)
- Summer half year (April to September)
- Winter half year (October to March)
- Year

ClimRisk.eu – climate data for CZ / Central Europe

Temperature

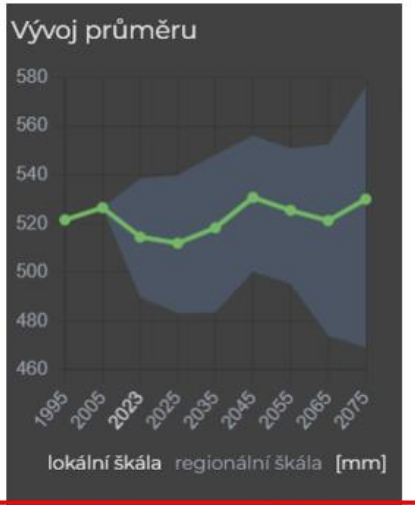
1995 (1981-2010)	9.6 °C	
2005 (1991-2020)	10.1 °C	
2023 (2009-2038)	10.9 °C	
2025 (2011-2040)	11.0 °C	
2035 (2021-2050)	11.5 °C	
2045 (2031-2060)	12.0 °C	+2,4°C
2055 (2041-2070)	12.4 °C	
2065 (2051-2080)	12.7 °C	
2075 (2061-2090)	13.1 °C	+3,5°C

Tropical days



1995 (1981-2010)	13.8	
2005 (1991-2020)	19.1	
2023 (2009-2038)	26.1	
2025 (2011-2040)	26.7	
2035 (2021-2050)	30.9	
2045 (2031-2060)	36.7	+23 days
2055 (2041-2070)	41.6	
2065 (2051-2080)	45.8	
2075 (2061-2090)	50.0	+36 days

Precipitation

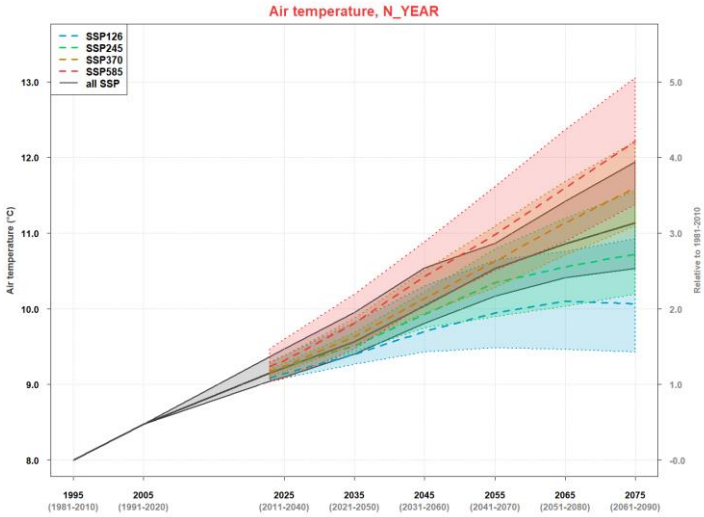


1995 (1981-2010)	521.5 mm	
2005 (1991-2020)	526.6 mm	
2023 (2009-2038)	514.5 mm	
2025 (2011-2040)	512.0 mm	
2035 (2021-2050)	518.3 mm	
2045 (2031-2060)	530.7 mm	+ 9 mm
2055 (2041-2070)	525.5 mm	
2065 (2051-2080)	521.2 mm	
2075 (2061-2090)	530.1 mm	+ 9 mm

climateproofing.cz

CzechGlobe
Ústav výzkumu globální změny AV ČR

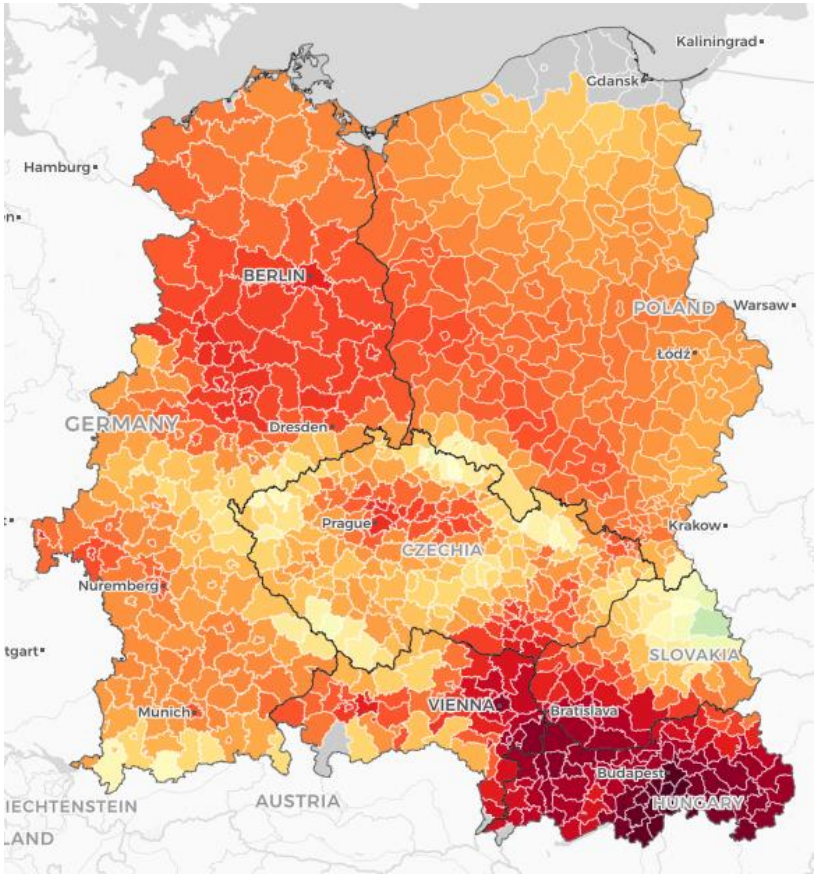
- Official application of the Ministry of the Environment (CZ)
- Focused on the climate proofing process.
- The website www.climateproofing.cz was created to guide applicants for structural funds through the climate proofing process for their investment plans.
- Climate data developed for climate proofing purposes (ClimRisk/PERUN) will be certified and valid for the Czech Republic.
- "Traffic light" system – the user simply enters the location of interest and the building type, and the application evaluates the level of climate-related risk/exposure.



CzechGlobe · Český hydrometeorologický ústav · Sust/ES · AdAgriF · CLIMRISK · PERUN

Nový nástroj pro klimatické prověřování pro střední Evropu

ClimRisk.eu – climate data for Central Europe



ClimRisk background data are available in two spatial domains:

- CZ: 0.5 km resolution
- CE/EU: 10 km resolution based on the E-OBS dataset

On the web, information is provided in the form of cadasters and NUTS 3 regions.

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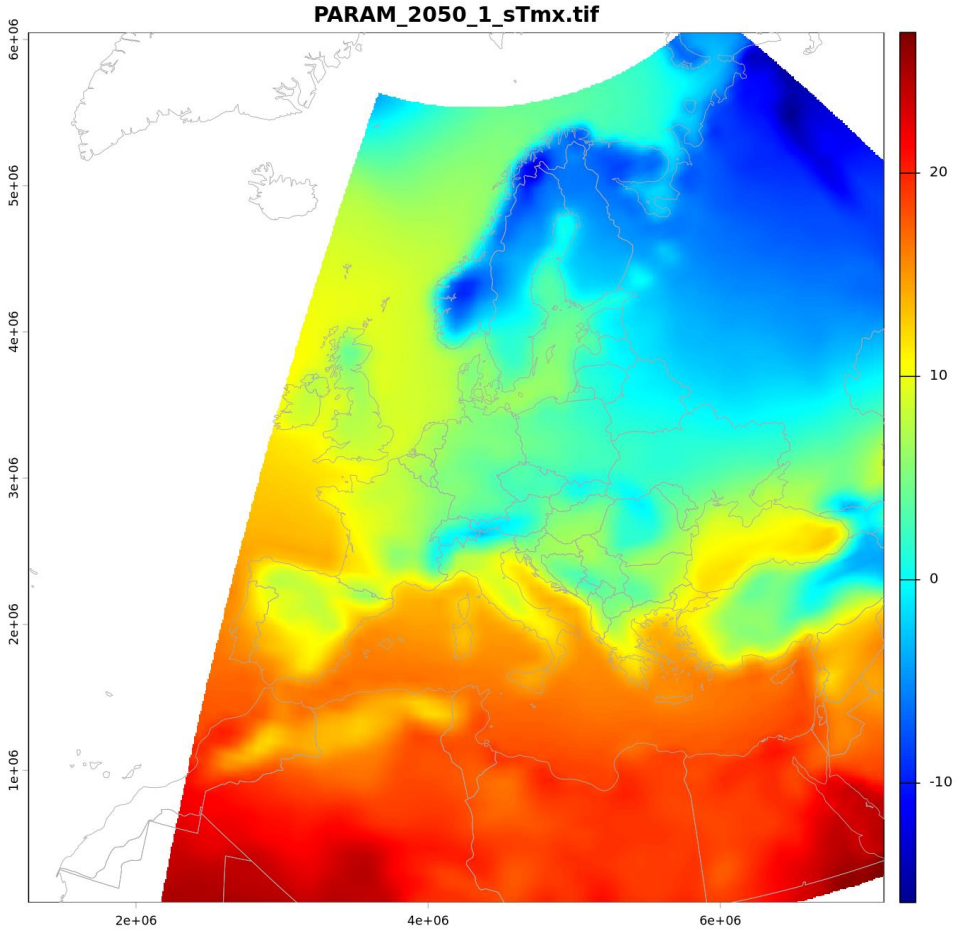
ClimRisk for the whole of Europe – calculations are in the final phase (7 GCMs, 1 CP-RCM, 4 scenarios).



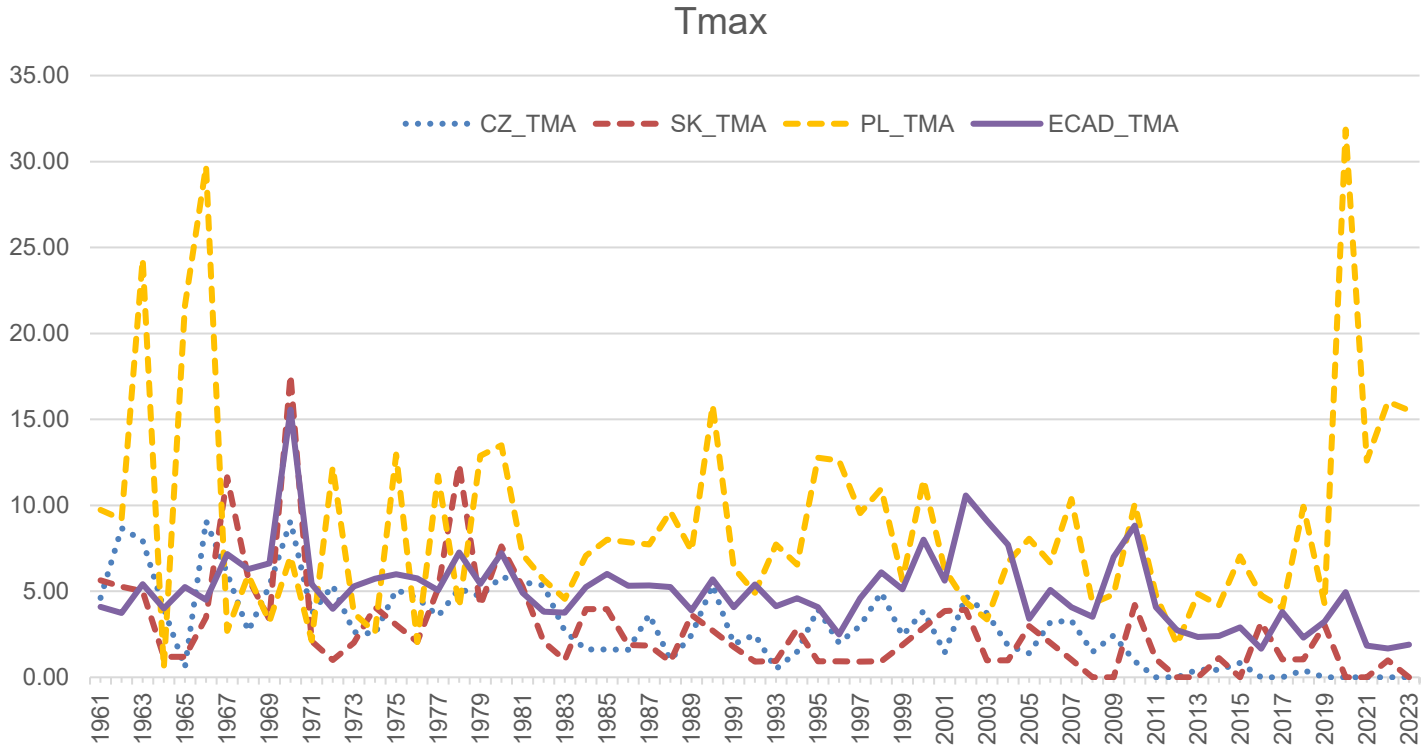
5.5 km spatial resolution, daily data

ACECE project

- ACECE – Atmospheric Circulation and weather Extremes in Central Europe and their representation in climate models (CZ and PL partners)
- Data source: CZ, SK, PL – from meteorological services (CHMI, SHMI, IMGW), and ECA&D (European Climate Assessment & Datase, https://www.ecad.eu/)
- ECA&D – publicly available dataset;

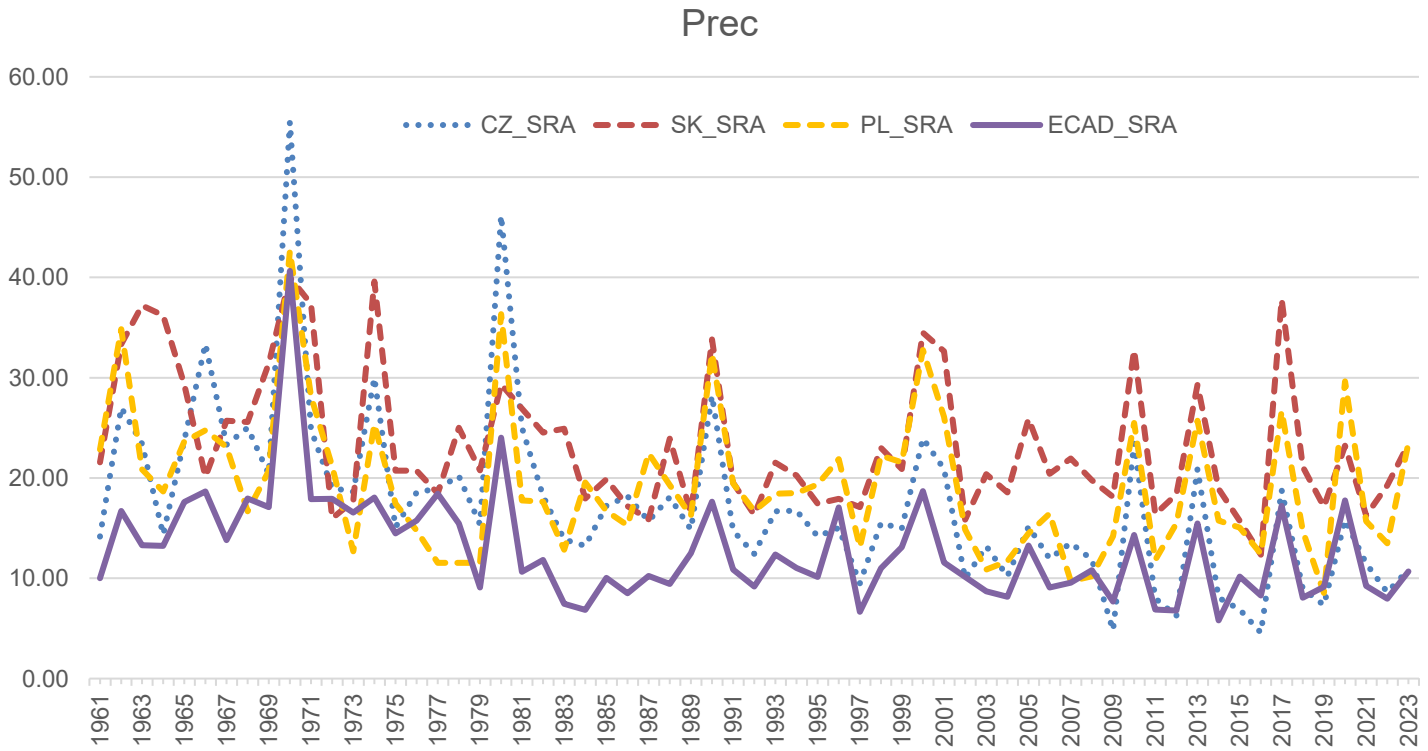
ACECE project – data quality control

Number of detected errors relative to the total number of available stations in a given year



ACECE project – data quality control

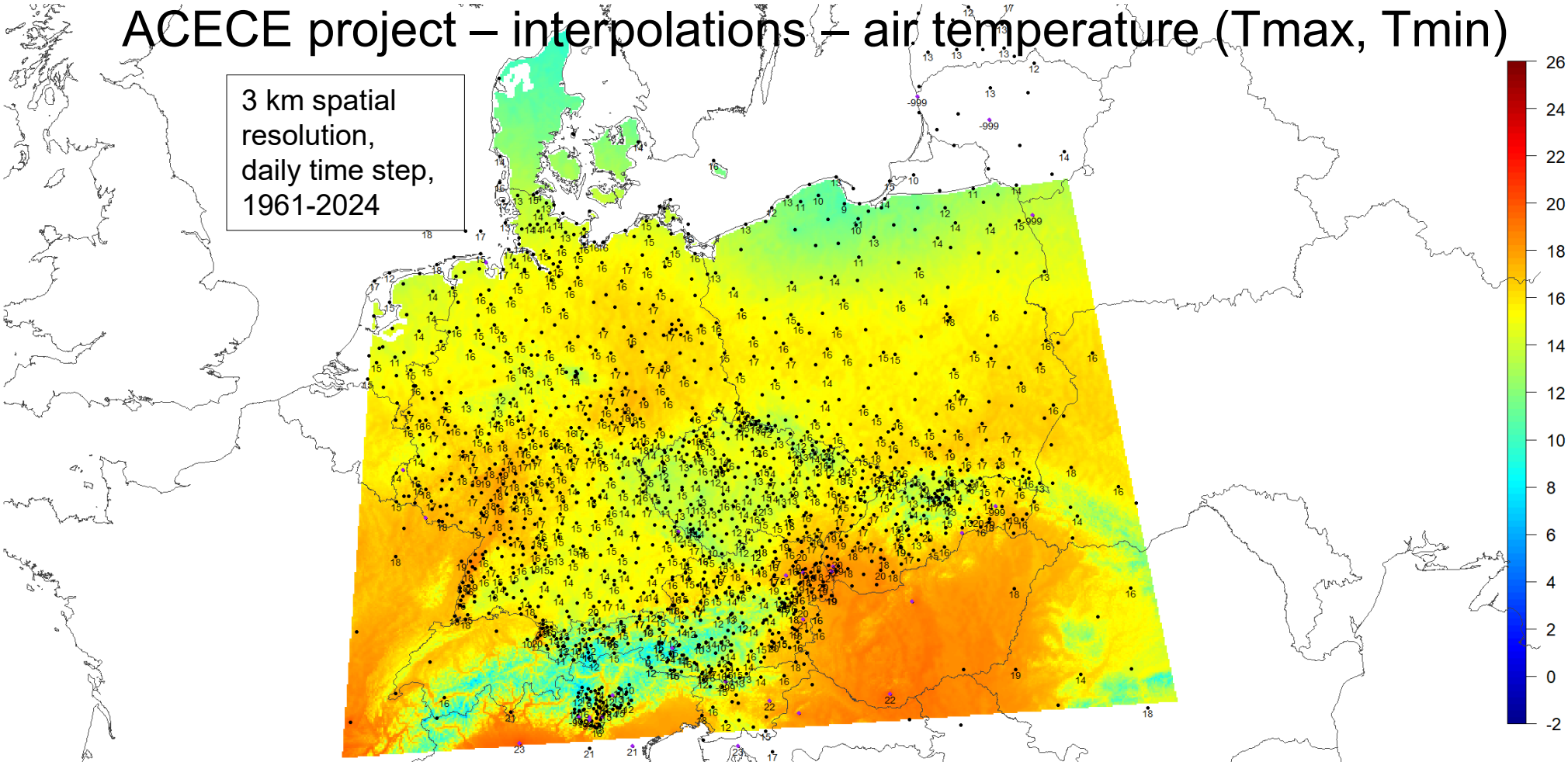
Number of detected errors relative to the total number of available stations in a given year



TMIN_2000_08_19

ACECE project – interpolations – air temperature (Tmax, Tmin)

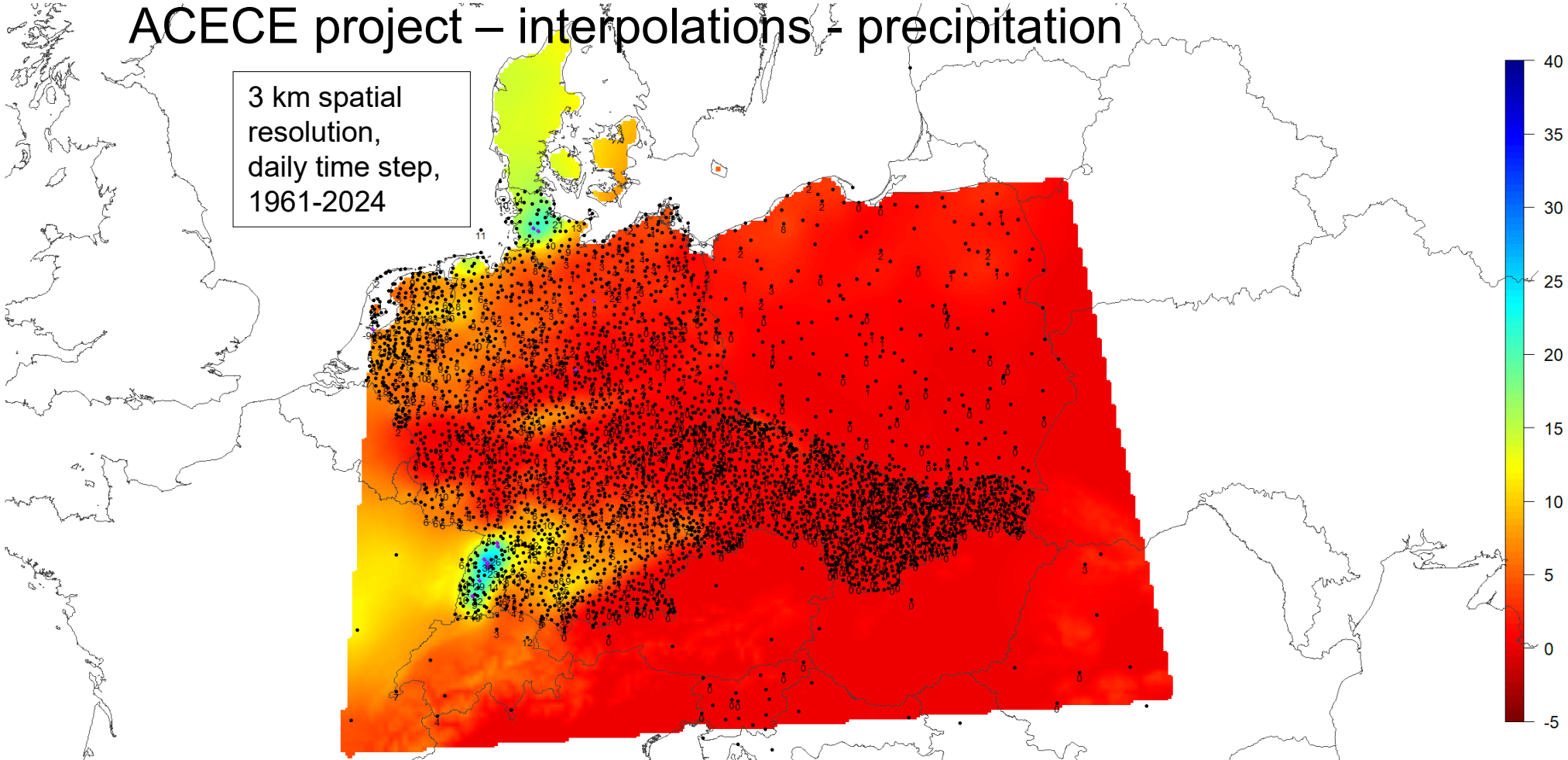
3 km spatial resolution,
daily time step,
1961-2024



SRA_2021_05_04

ACECE project – interpolations - precipitation

3 km spatial resolution, daily time step, 1961-2024



ACECE project – currently working on

- Homogenization in progress
- Including additional variables:
  - global radiation (sunshine duration),
  - wind speed,
  - relative humidity
- Climate scenarios (ClimRisk – GCMs + RCMs)

Conclusions

- Combining quality-controlled station records, homogenized time series, and high-resolution spatial interpolations provides a strong foundation for climate service products — especially when supported by a long historical record.
- This approach works best at national or regional scales.
- Global products (e.g. drought monitoring, fire risk, or heatwave assessments on Windy.com) rely on other data sources, such as reanalyses provided through C3S.
- However, tuning and validating products first at the **national level** using station data is an excellent starting point. This is particularly important when working with **derived variables** (from basic meteorological elements), such as **evapotranspiration** and **soil moisture**.

Publicly available information

www.windy.com (contribution to global products)
clim4cast.czechglobe.cz
www.climrisk.eu
www.climrisk.cz
www.firerisk.cz
www.agrorisk.cz
www.fenofaze.cz
www.dendronet.cz
www.intersucho.cz
www.vynosy-plodin.cz
vlny-veder.czechglobe.cz
www.klimatickazmena.cz