Deutscher Wetterdienst
Wetter und Klima aus einer Hand

BMVI Network of Experts
Knowledge Ability Action

Developing a gridded dataset of global radiation covering Germany and its neighbouring river catchment areas

Simona Höpp, Monika Rauthe, Thomas Deutschländer, Stefan Krähenmann, Stephanie Hänsel

Deutscher Wetterdienst

Contact: simona-andrea.hoepp@dwd.de

Outline

- The BMVI Network of Experts
- The HYRAS gridded dataset
- Gridding method for global radiation
- The global radiation station data basis
- The Ångström approach
- Summary
- Outlook

The BMVI Network of Experts



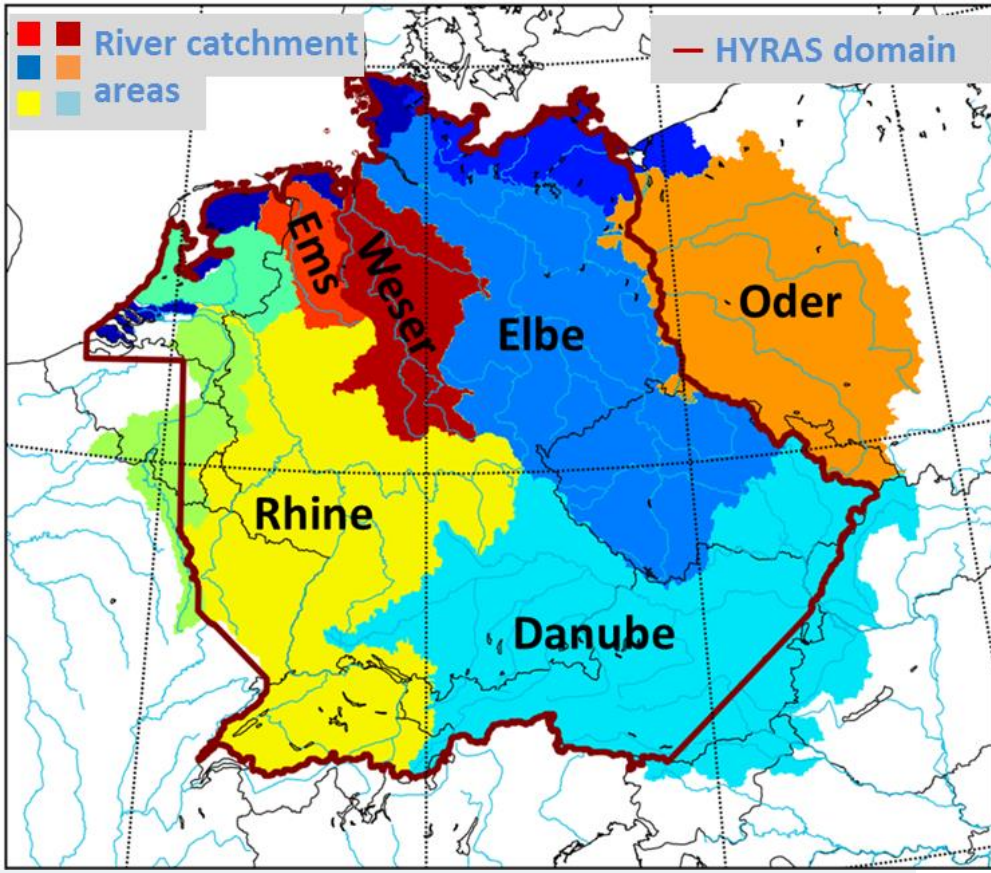
www.bmvi-expertennetzwerk.de

- **Objective:** *Enhanced resilience to adverse impacts of climate change and extreme weather events required for sustainable operation of traffic and transport infrastructure*
- Expertise and competencies of six departmental research institutes integrating perspectives of **roads**, **railways** and **waterway transport**
- **Topic 1**: ***Adapting transport and infrastructure to climate change and extreme weather events***

DWD · Eisenbahn-Bundesamt · bast · BSH Bundesamt für Seeschifffahrt und Hydrographie · bfg Bundesanstalt für Gewässerkunde · BAW

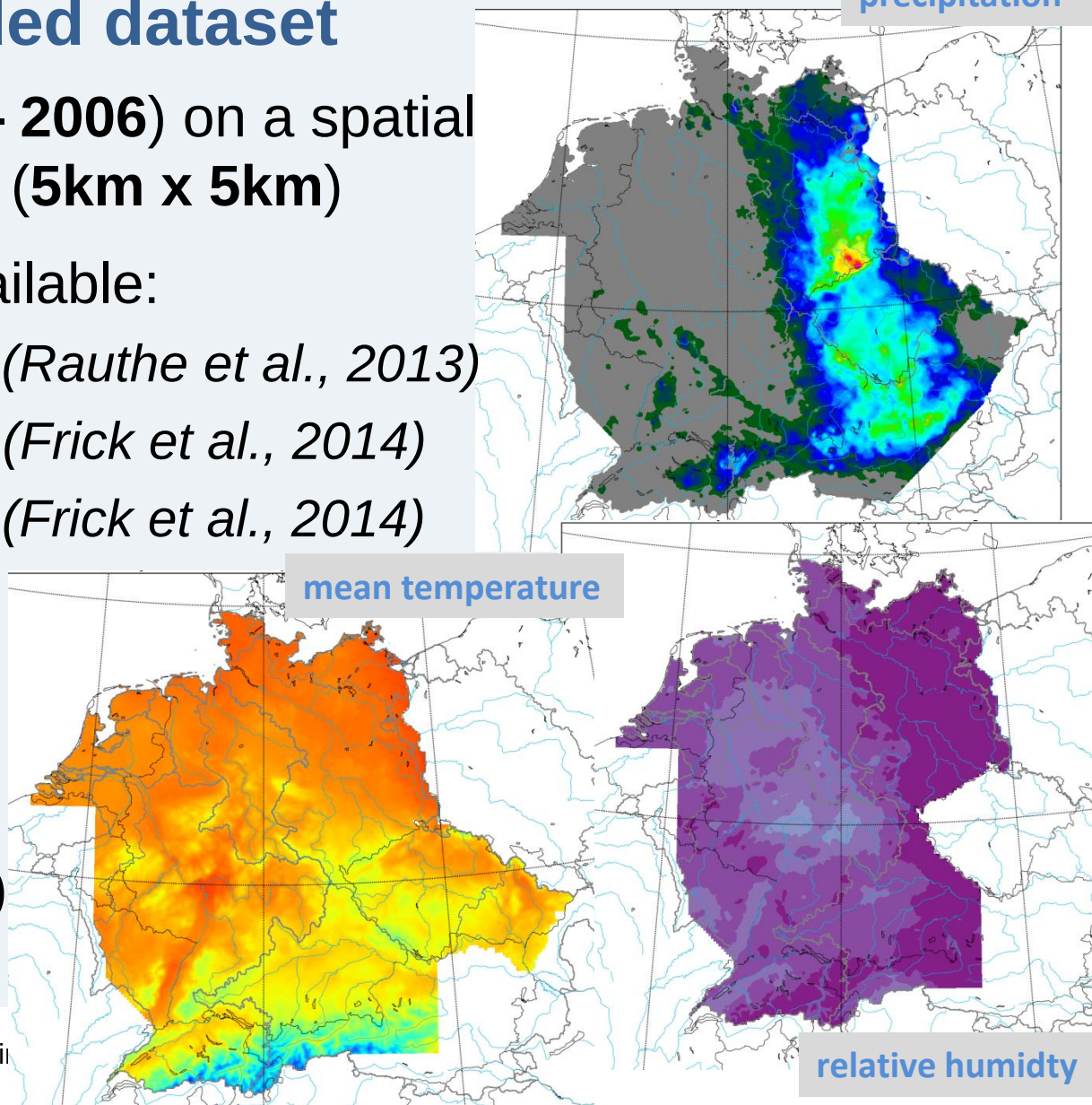
The HYRAS gridded dataset

- HYRAS: „**HY**drologische **RAS**terdaten“; hydrological gridded dataset
- **High-resolution gridded station dataset** for Germany and its river catchment areas
- Developed in German research project **KLIWAS** (2009-2013, www.kliwas.de)



The HYRAS gridded dataset

- **Daily** fields (**1951 – 2006**) on a spatial high-resolution grid (**5km x 5km**)
- Three variables available:
  - *Precipitation (Rauthe et al., 2013)*
  - *Mean temperature (Frick et al., 2014)*
  - *Relative humidity (Frick et al., 2014)*
- **Free available** for research, teaching and regulatory purposes (Contact: hydromet@dwd.de)



The HYRAS gridded dataset

- HYRAS extension needed in BMVI Network of Experts

- Intended:
  - Extension of HYRAS data set by additional variables:
    - Gridded dataset of minimum and maximum temperature
    - Gridded dataset of global radiation
    - Concept study for gridding wind variables
  - Temporal extension of HYRAS variables up until 2010/2015

Gridding method for global radiation (GS)

Optimal interpolation (Gandin, 1965):

- Operationally use in **SNOW model** of DWD (simulation and forecast of snow cover)
- Use of certain **tuning parameters** especially derived for interpolated variable
- Interpolation in 5 km x 5 km grid boxes (**moving window**)
- **Two-way interpolation** (for each time step separately):
  - Deriving the background field
  - Interpolation of the daily field

Gridding method for global radiation (GS)

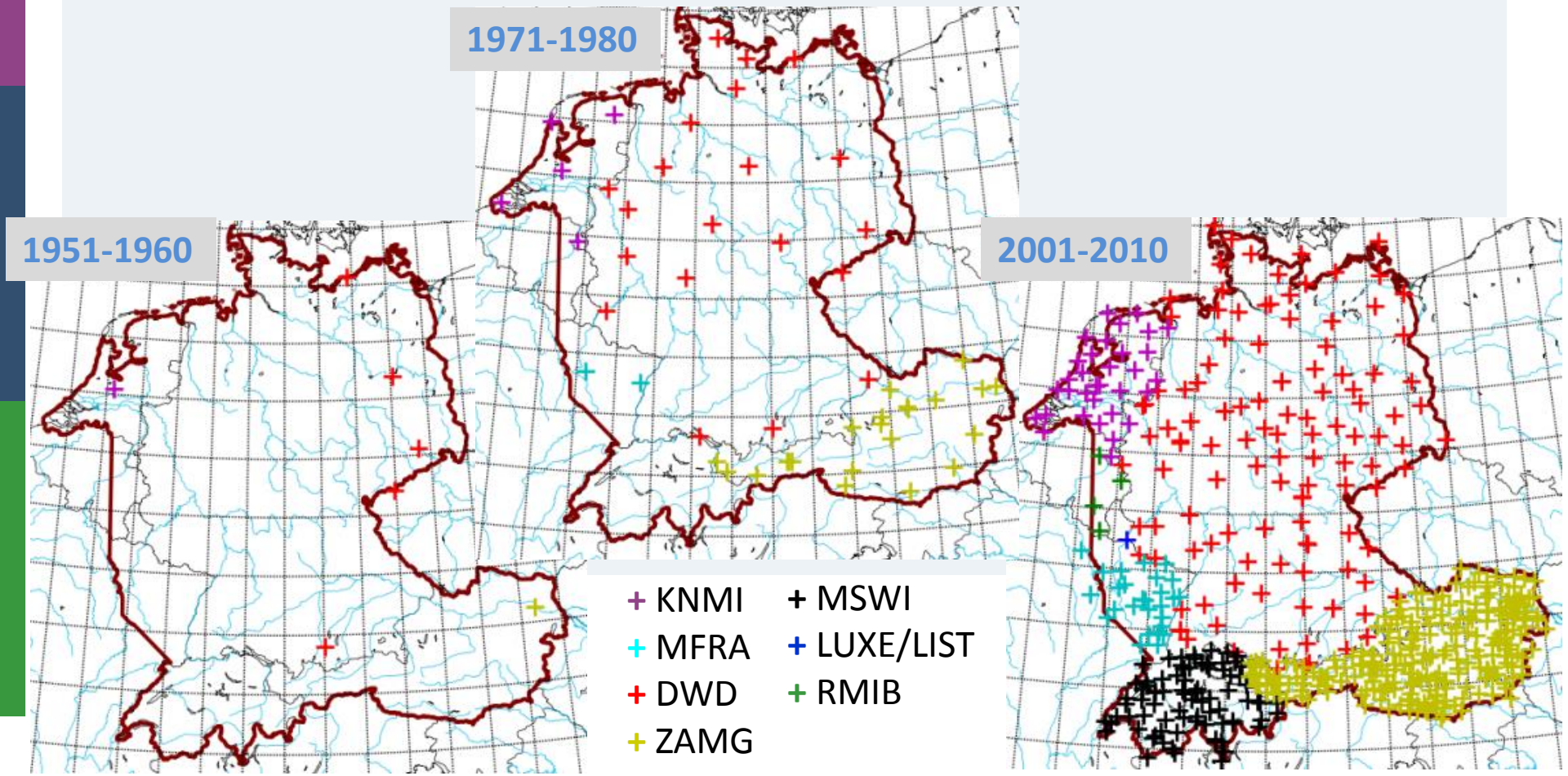
Optimal interpolation (Gandin, 1965):

- Find 15-30 stations influencing the grid point
- Splitting station values into background and anomaly values: $z = z_b(x, y, h) + z_a$
- Calculation of **background values** for grid points by trend analysis and multiple linear regression
- Computation of **interpolation weights** for stations by the determined spatial correlation function
- Interpolation of station **anomaly values** to the grid with interpolation weights

➢ Adding background and anomaly for **grid point values**

The global radiation station data basis

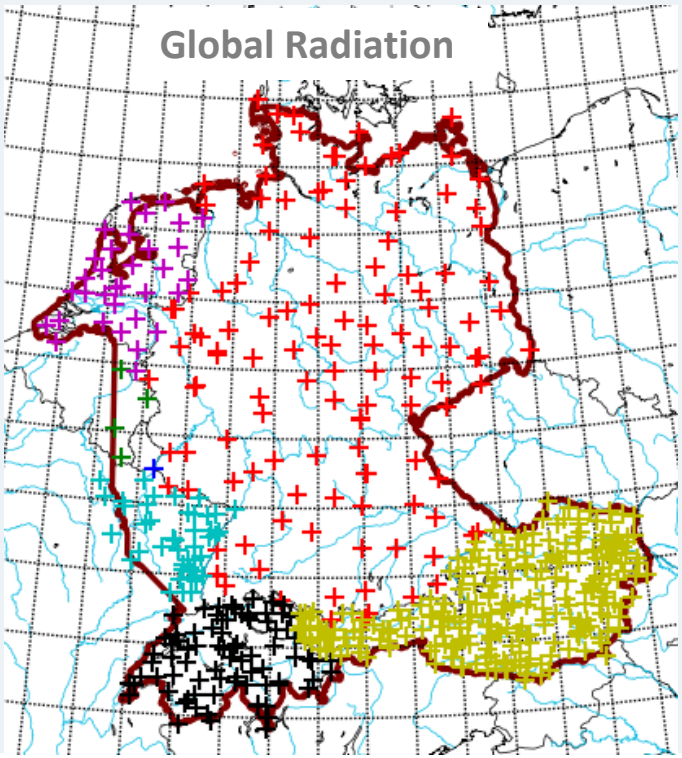
- Poor data coverage of global radiation messurements in HYRAS domain (especially before 1981)



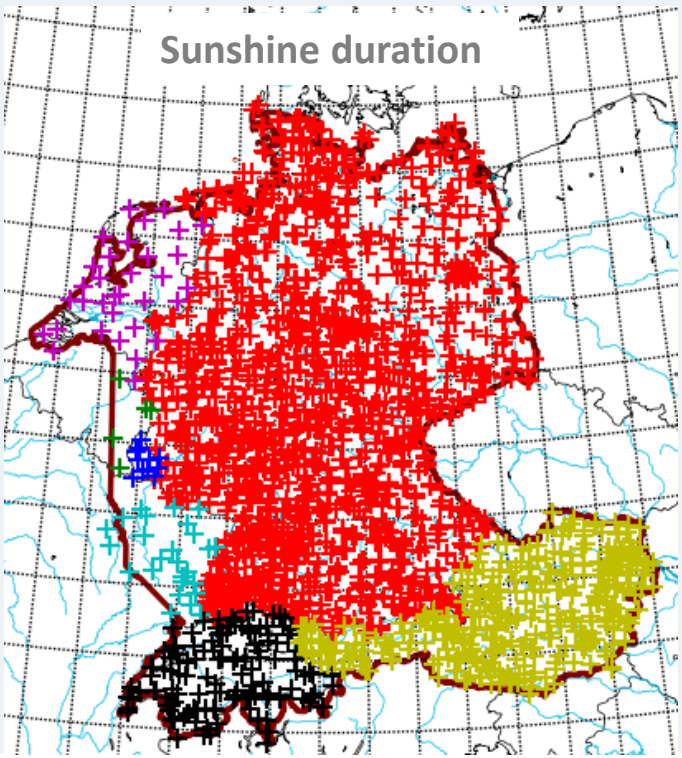
The Ångström approach

- Additional usage of sunshine duration measurements (SD)
- Ångström approach:

$$\frac{GS}{GS_0} = (a + b\frac{SD}{SD_0})$$



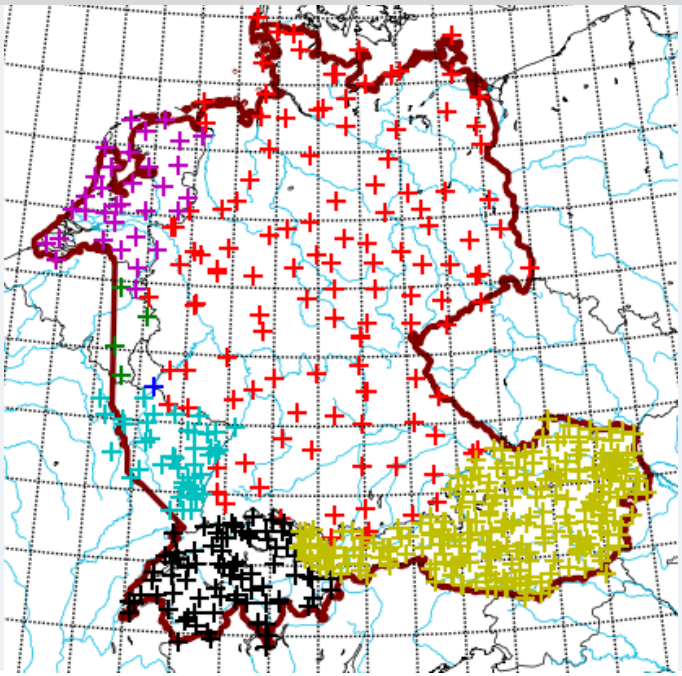
+



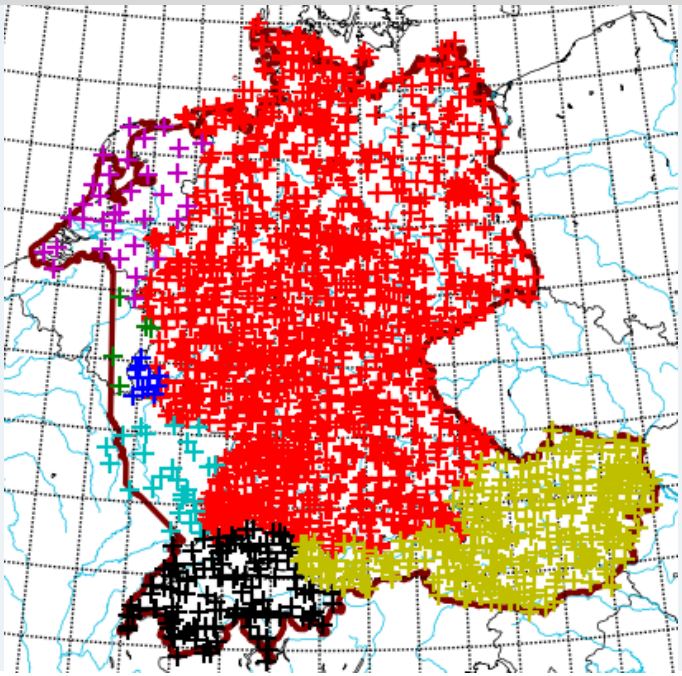
The Ångström approach

- Additional usage of sunshine duration measurements (SD)
- Ångström approach: $$\frac{GS}{GS_0} = (a + b\frac{SD}{SD_0})$$

➢ **How get a and b for SD stations without GS values?**



+



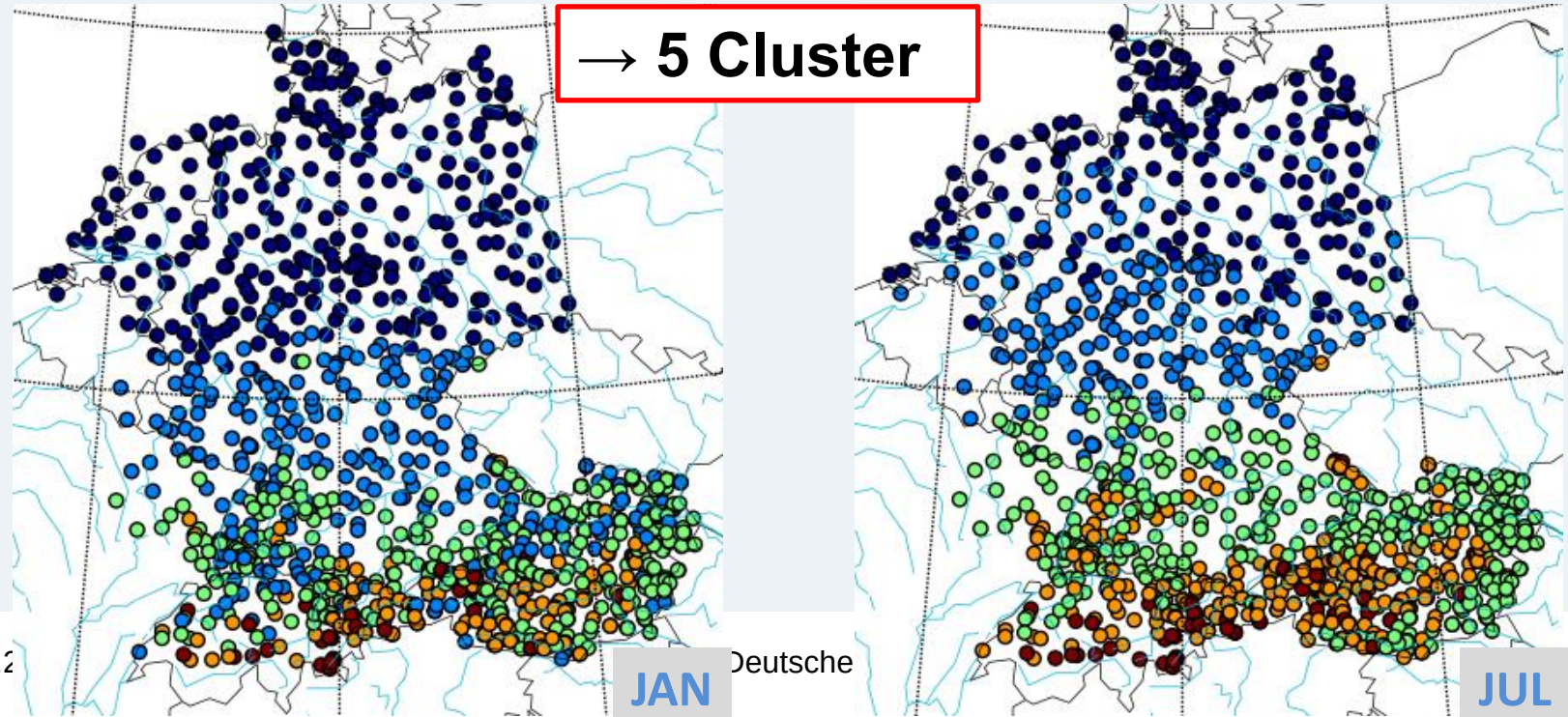
+ KNMI + MFRA + DWD + ZAMG + MSWI + LUXE/LIST + RMIB

The Ångström approach

$$\frac{GS}{GS_0} = (a + b\frac{SD}{SD_0})$$

1) Classification of subregions for monthly mean of sunshine duration (1981-2010)
   - Cluster analysis (Ward method with subsequent k-means)
   - Each Cluster with at least one station with SD *and* GS measurement (SDGS stations)

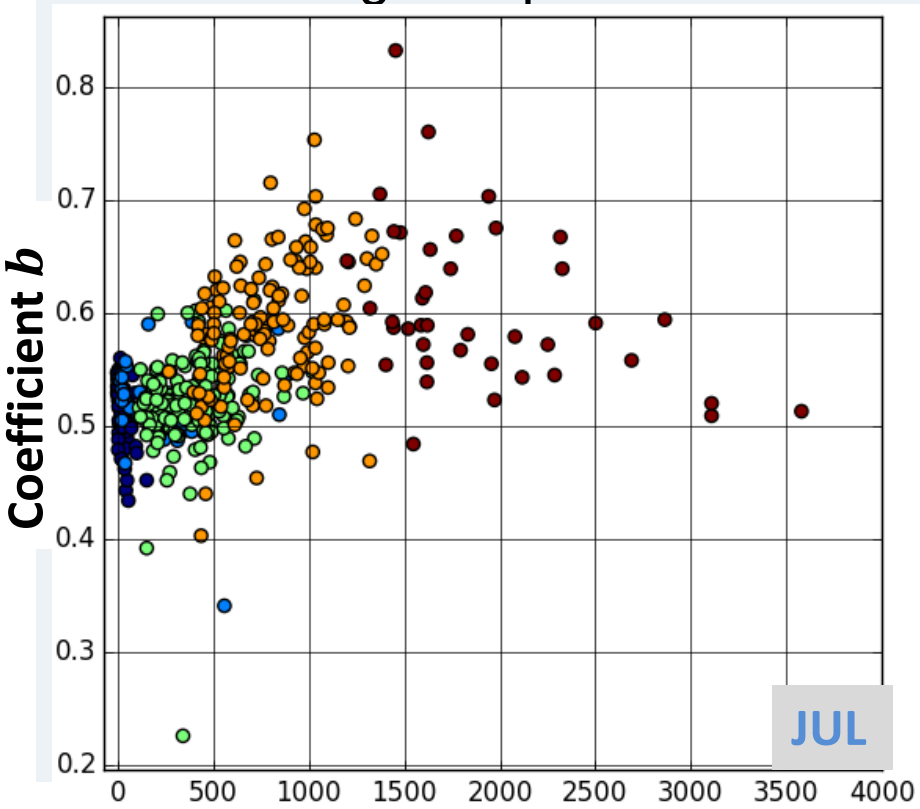
→ 5 Cluster

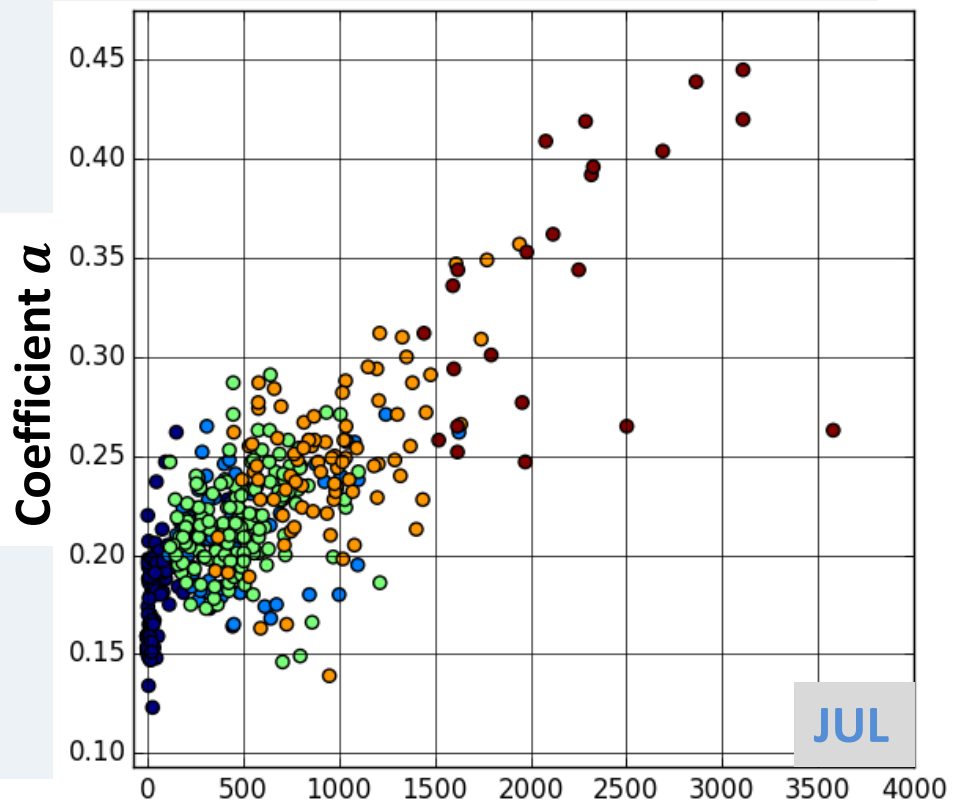


The Ångström approach

$$\frac{GS}{GS_0} = (a + b\frac{SD}{SD_0})$$

2) Computation of Ångström coefficients for each cluster
   - b: no height dependence in any cluster
   - a: height dependence

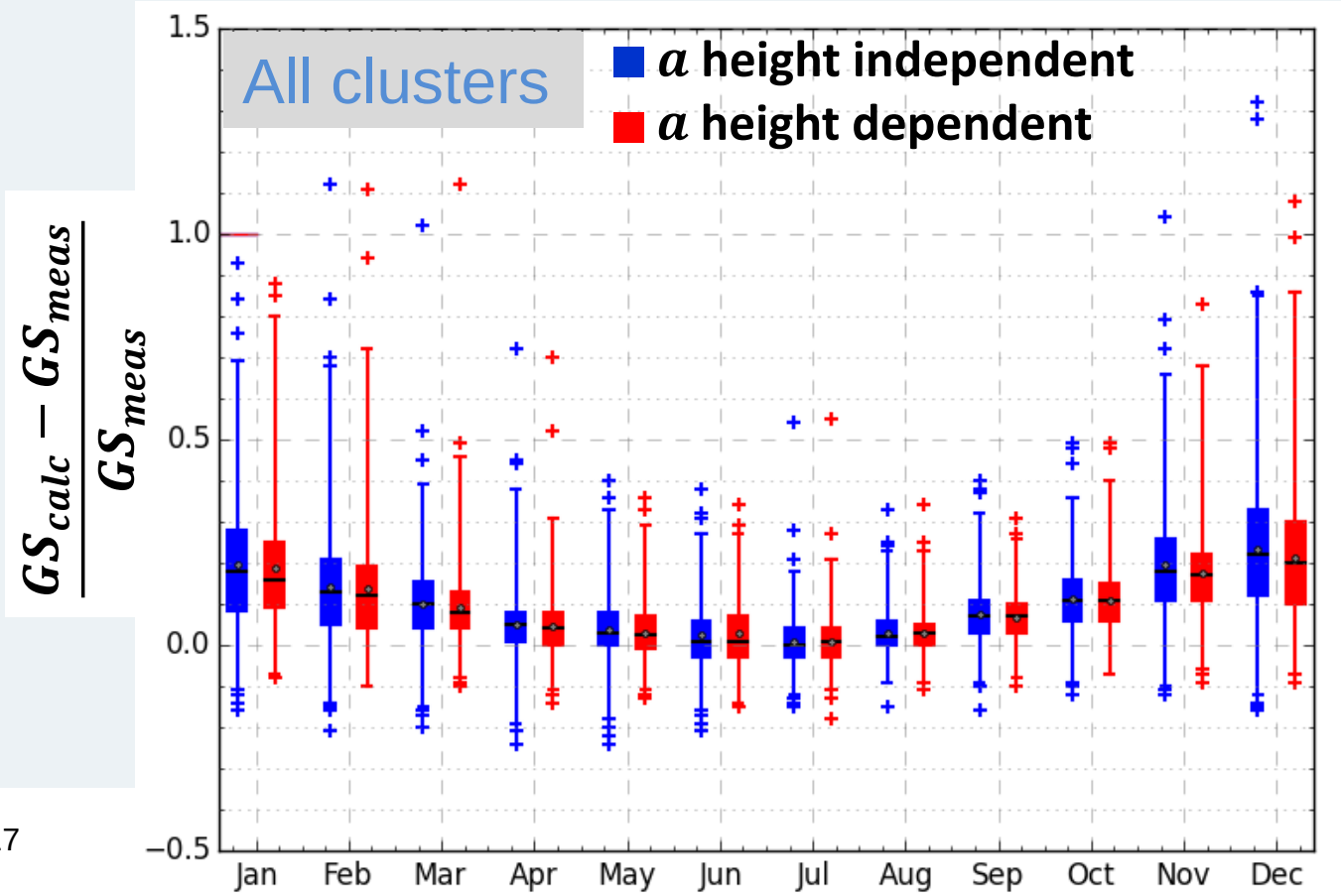




The Ångström approach

$$\frac{GS}{GS_0} = (a + b\frac{SD}{SD_0})$$

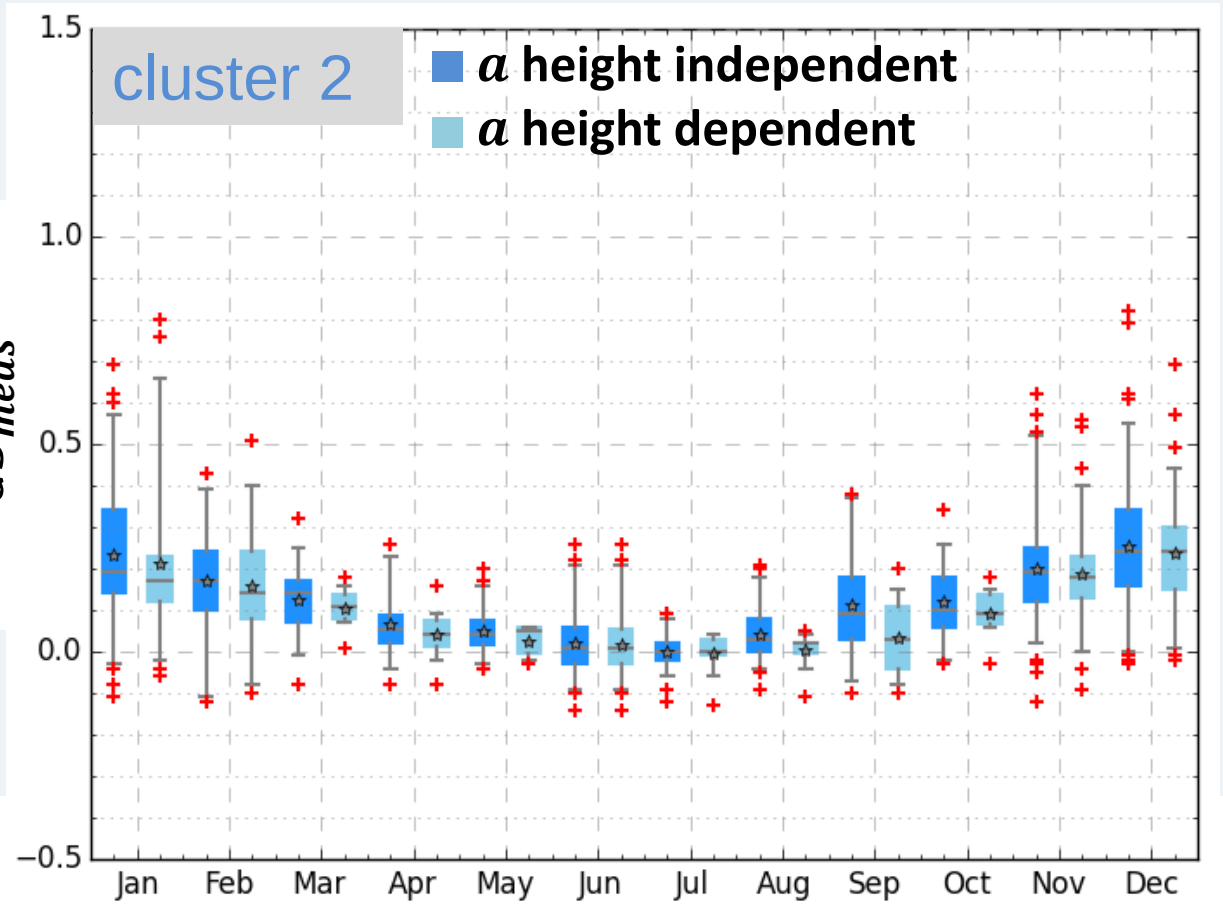
3) Calculation of GS with a height dependent and with a height independent:
   - For all SDGS stations

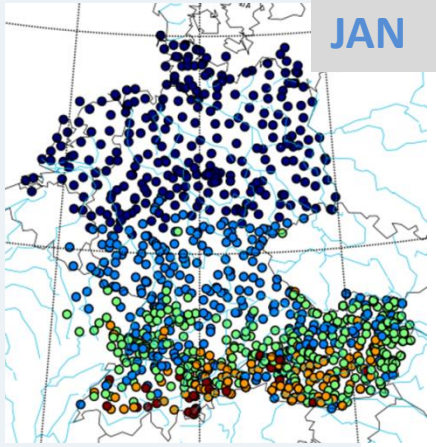


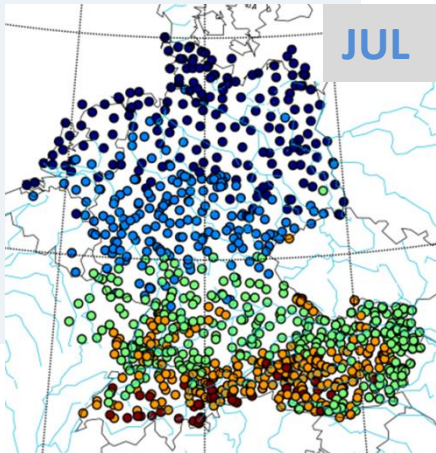
The Ångström approach

$$\frac{GS}{GS_0} = (a + b\frac{SD}{SD_0})$$

3) Calculation of GS with a height dependent and with a height independent:
   - For each cluster







Summary

Developing the HYRAS global radiation dataset since 1951:

- Poor data coverage of global radiation measurements
  - Additional use of sunshine duration data
- Using the Ångström approach:
  - Clustering of SD stations
  - No height dependence of Ångström coefficient b
  - Height dependence of Ångström coefficient a
- Computation of GS with Ångström approach per cluster
  - Improvement of difference between calculated and measured GS with $\boldsymbol{a}$ height dependent than with $\boldsymbol{a}$ height independent

Outlook

- Alternate classification of climatological areas with fixed/ only slightly changing cluster distributions per month (overlapping areas)
  - Easier adding of new station data
  - Better comparison of monthly variation of computed GS per cluster
- Application of height dependent a to selected clusters/ months
  - Finding criterion for automated process
- Interpolate GS station values to first gridded data set
  - Validation of the new dataset
  - Comparison with other datasets (e.g. satellite data)

Thank you for your attention!
Köszönöm szépen!

Outlook

- Alternate classification of climatological areas with fixed/ only slightly changing cluster distributions per month (overlapping areas)
  - Easier adding of new station data
  - Better comparison of monthly variation of computed GS per cluster
- Application of height dependent a to selected clusters/ months
  - Finding criterion for automated process
- Interpolate GS station values to first gridded data set
  - Validation of the new dataset
  - Comparison with other datasets (e.g. satellite data)

Contact: simona-andrea.hoepp@dwd.de