The WegenerNet 3D Open-Air Laboratory for Climate Change Research: A unique facility for high-resolution weather and climate studies

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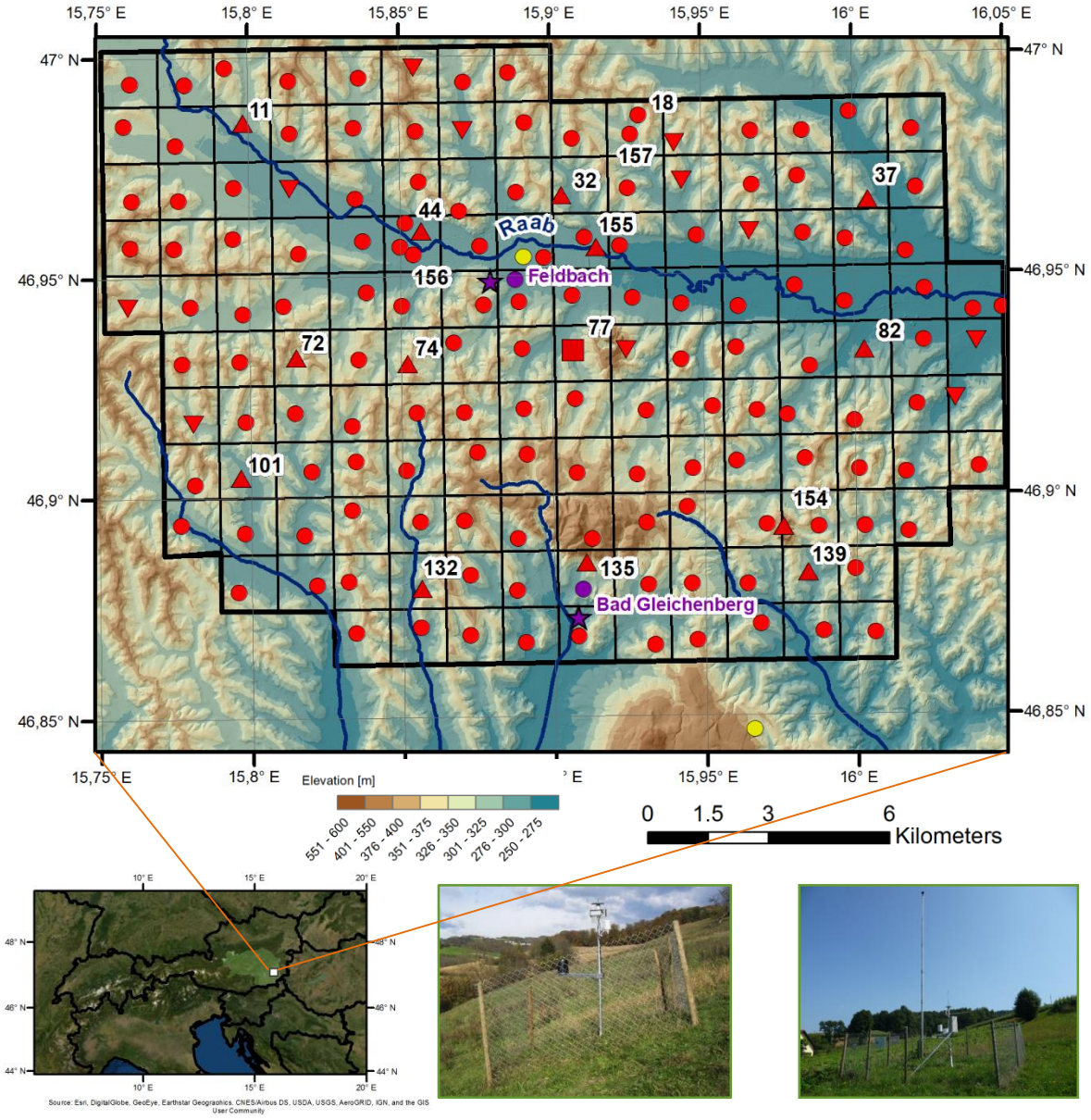
Further info on sponsors and funding: www.wegenernet.org

WegenerNet Feldbach Region climate station network (WEGN 2D part)

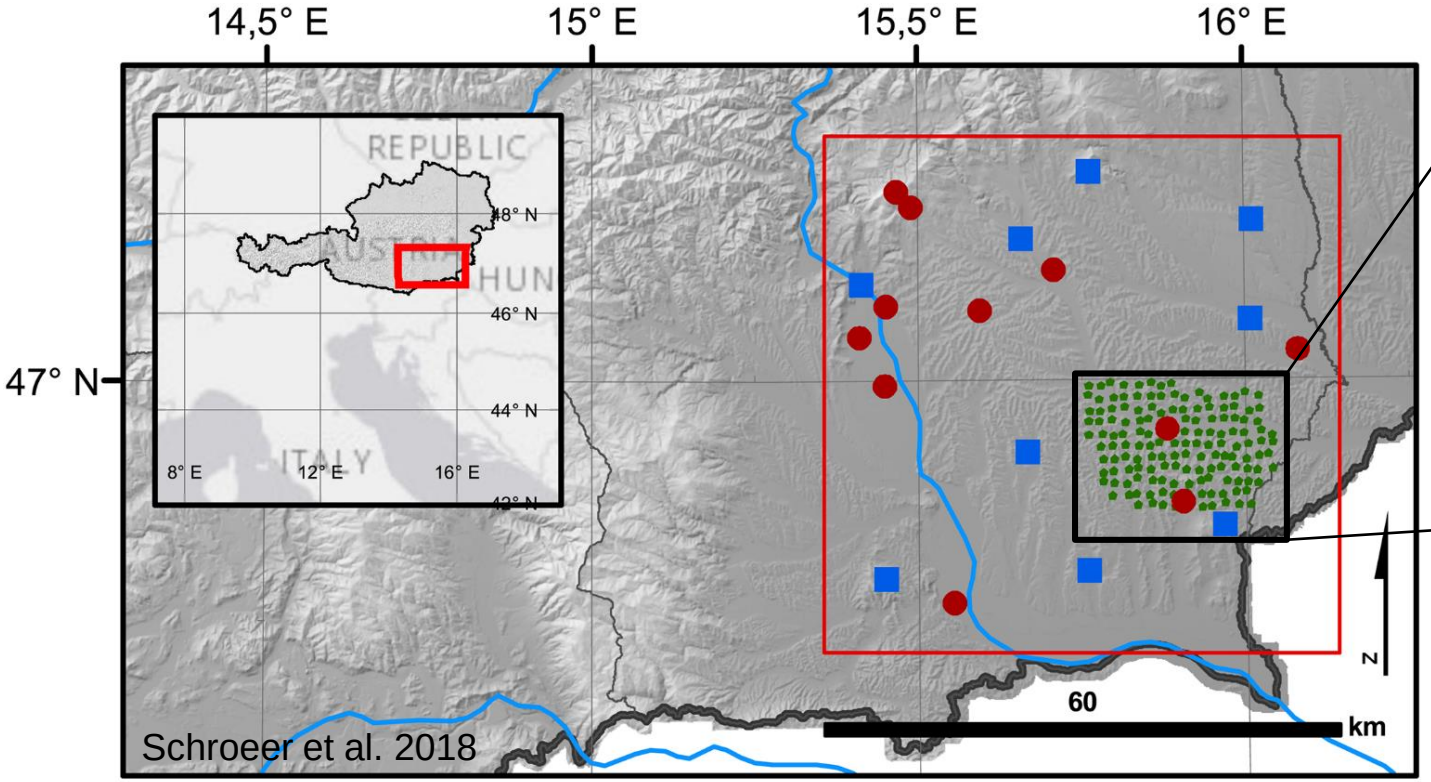


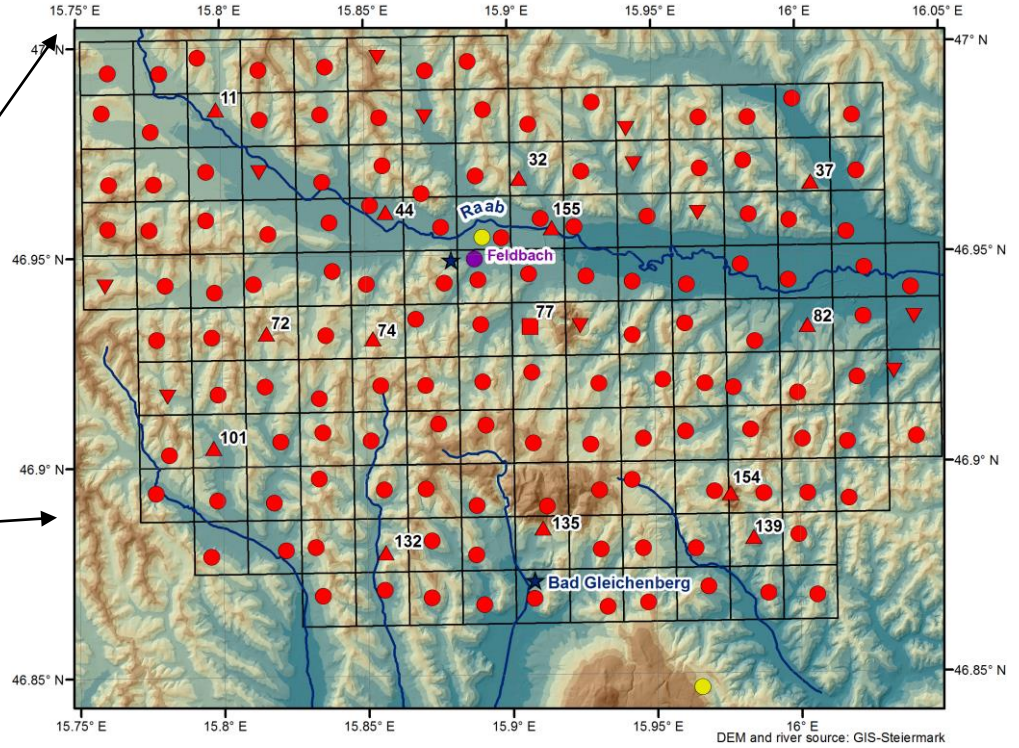
Key features of the WegenerNet 2D:

- **156 climate stations** located in SE Styria
- **~22 km x 16 km region (about 350 km²)**
- Station grid with **one station every about 2 km²**
- Main parameters: **Temperature, relative humidity, and precipitation**, measured at all stations
- Wind- and soil-parameters measured at selected stations
- Measurement **sampling rate 5 min**
- Data available at wegenernet.org

  (since 2007, currently 16 year record)

Comparison of station densities (ZAMG and AHYD stations)





● ZAMG station ■ AHYD station ⬟ WEGN station ▭ Focus area

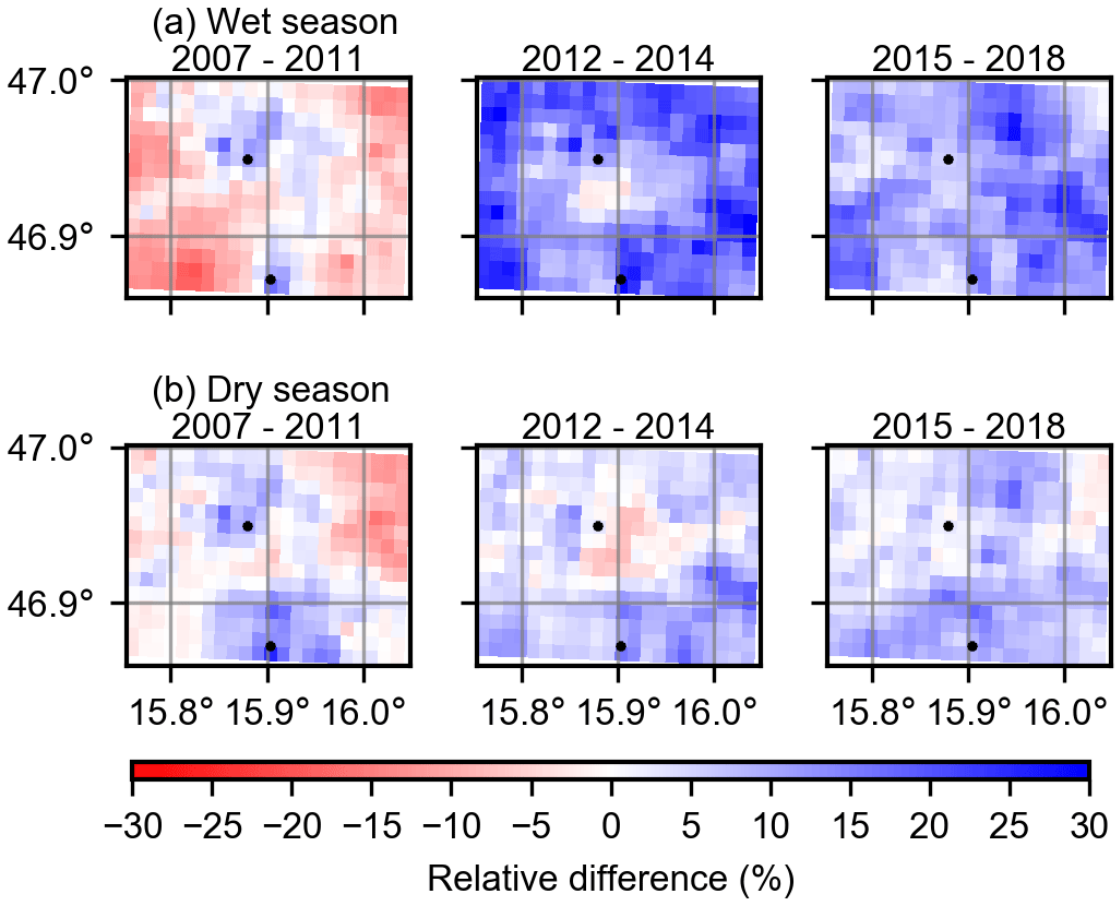
- 154 WEGN, 11 ZAMG, 9 AHYD stations

Scientific results so far (1)

Evaluation of gridded data products and satellite data:

- **INCA**:
  - Kann et al., WAF, 2011
  - Ghaemi et al., HESS, 2021
- **SPARTACUS**:
  - Hiebl and Frei, Theor. Appl. Climatol., 2018
- **Global Precipitation Mission (GPM):**
  - O, et al., HESS, 2017
  - Tan et al., J. Hydrometeorol., 2018
  - Lasser, et al., AMT, 2019
- **GPM IMERG, GSMaP, CMORPH, MSWEP:**
  - Hu et al., J. Hydrol., 2020
- **Soil Moisture Data (SMAP, Sentinel, SoMo.ml-EU):**
  - Suman et al., Remote. Sens., 2020
  - Hegazi et al., Remote. Sens., 2021
  - Hegazi et al., Agronomy, 2023
  - O et al., Sci. Data, 2022

Ghaemi et al., 2021 – INCA precip relative bias



Scientific results (2)

Analyses of high-res precipitation variability, and error dependence on gauge density:

- Schroeer et al., GRL, 2018
- Frei and Isotta, JGR-Atmo., 2019
- O et al., J. Hydrol., 2018
- O and Foelsche, HESS, 2019
- Hohmann et al, Water, 2021
- Lau and Behrangi, Remote Sens. 2022

Generation and evaluation of high-resolution wind fields:

- Schlager et al., WAF, 2017, AMT, 2018, GMD, 2019

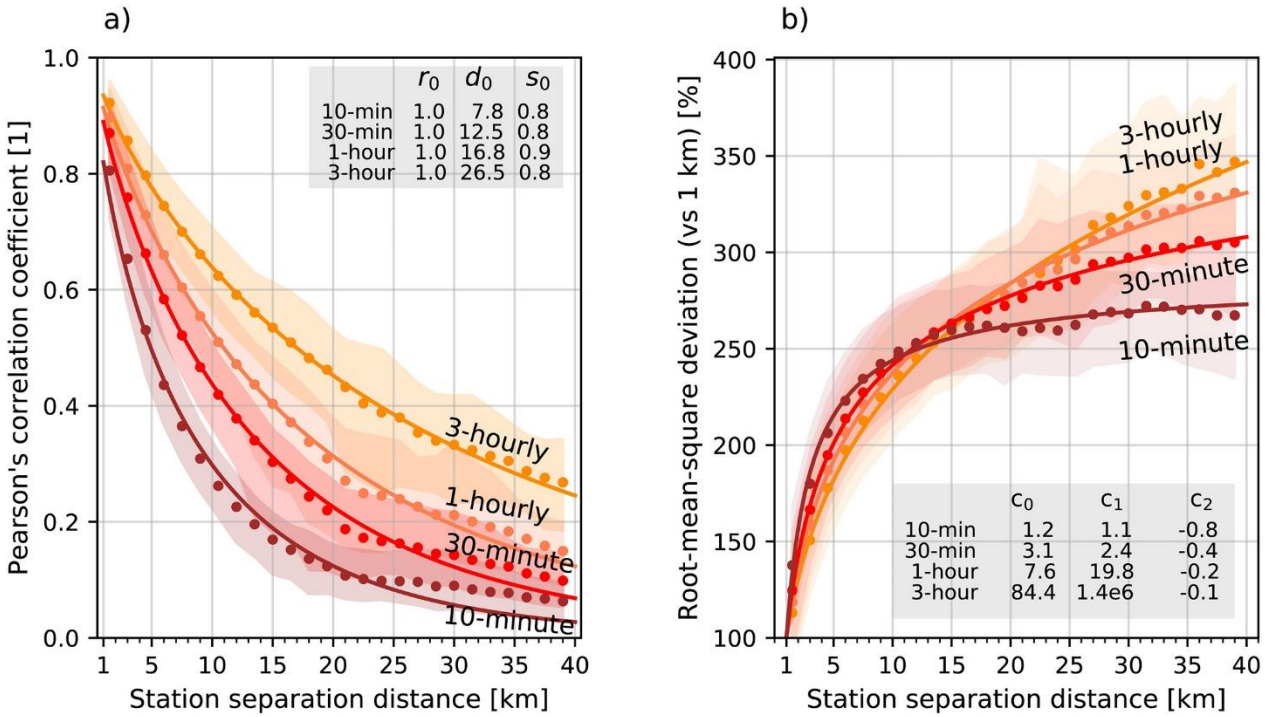
Regional climate influence on plant communities:

- Denk and Berg, Tuexenia, 2014

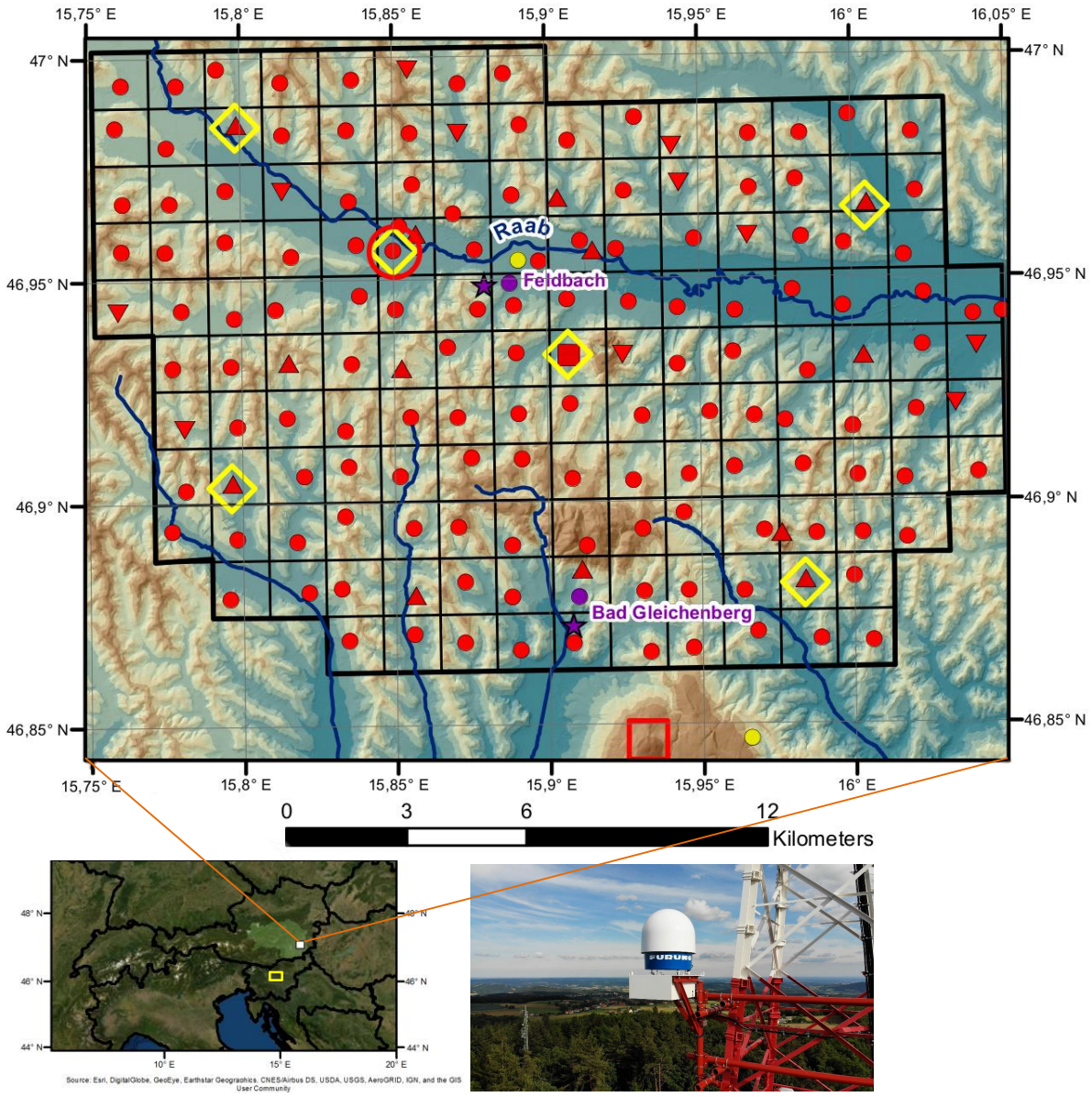
Full list of publications:

www.wegcenter.at/wegenernet --> publications

Schroeer et al., 2018 – spatial decorrelation of precipitation



The WegenerNet 3D Open-Air Laboratory for Climate Change Research (WEGN 3D): Atmospheric sounding components



WegenerNet 3D observing components:

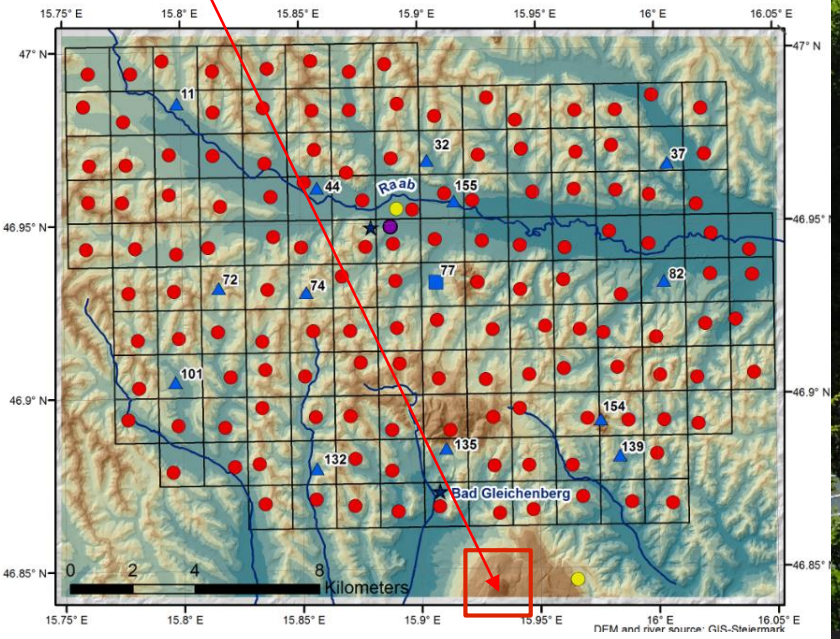
- A polarimetric Doppler **X-Band precipitation radar**
- An azimuth-steerable **MW/IR atmospheric profiling radiometer**
- An azimuth-steerable **IR cloud structure radiometer**
- A water vapor mapping high-resolution **Global Navigation Satellite System** (GNSS) six-station **network** (“**GNSS-StarNet**”)

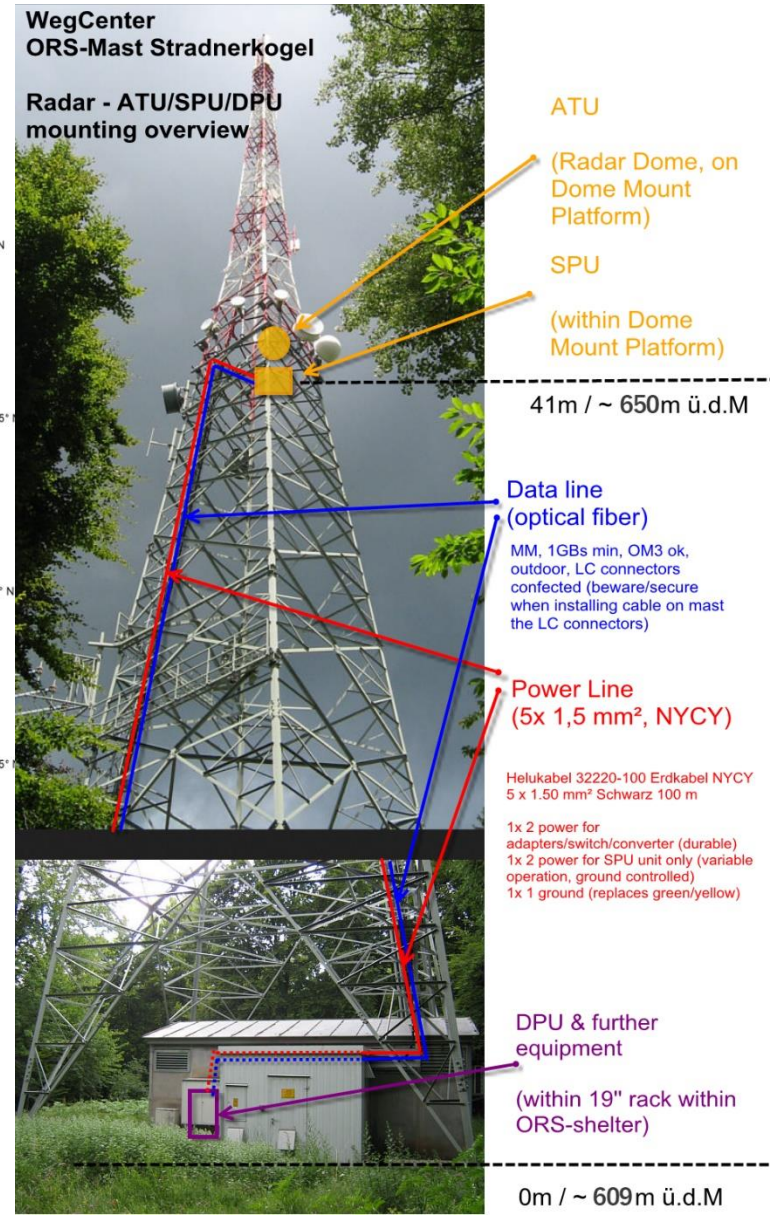
The three components are marked by these symbols in the map:

- X-Band precipitation radar Stradnerkogel
- GNSS-StarNet (six GNSS water vapor sensors)
- Tropospheric profiling and cloud structure radiometers

WegenerNet 3D: X-Band precipitation radar Stradnerkogel

Location: Mount Stradnerkogel at 609 m above mean sea level.





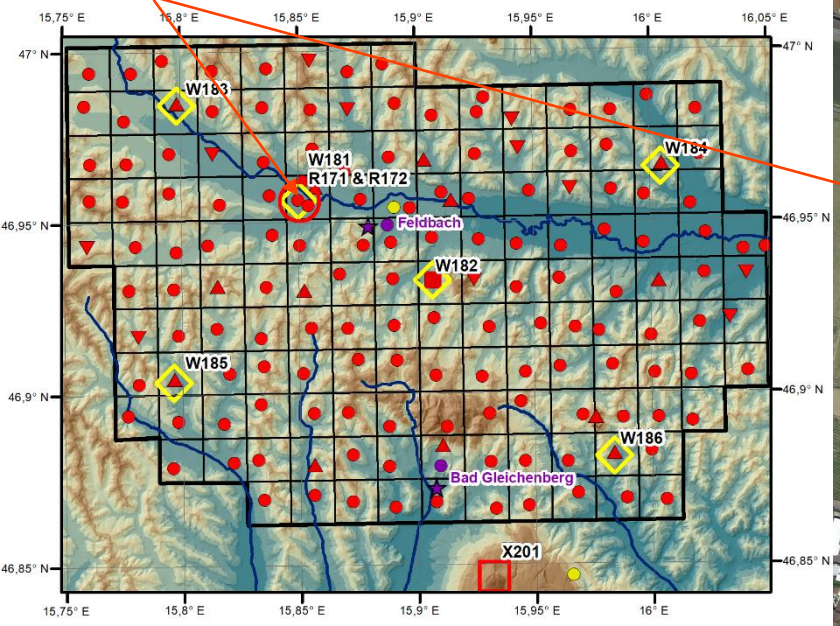
- Output products: **Rainfall intensity R** (mm/h), **Reflectivity Zh, Zv** (dBZ), differential Reflectivity ZDR (dB), Differential Phase Shift ΦDP (°), Specific Differential Phase KDP (°/km), Doppler velocity V (m/s), and Doppler spectral width W (m/s)
- **500 m horizontal and vertical resolution**
- **2.5-min time sampling**

  Mounted on a 81 m tall radio mast, about half-level, at 41 m height.

WegenerNet 3D: X-Band precipitation radar Stradnerkogel - view in northern direction

WEGN 3D: MW/IR tropospheric profiling and cloud structure radiometers

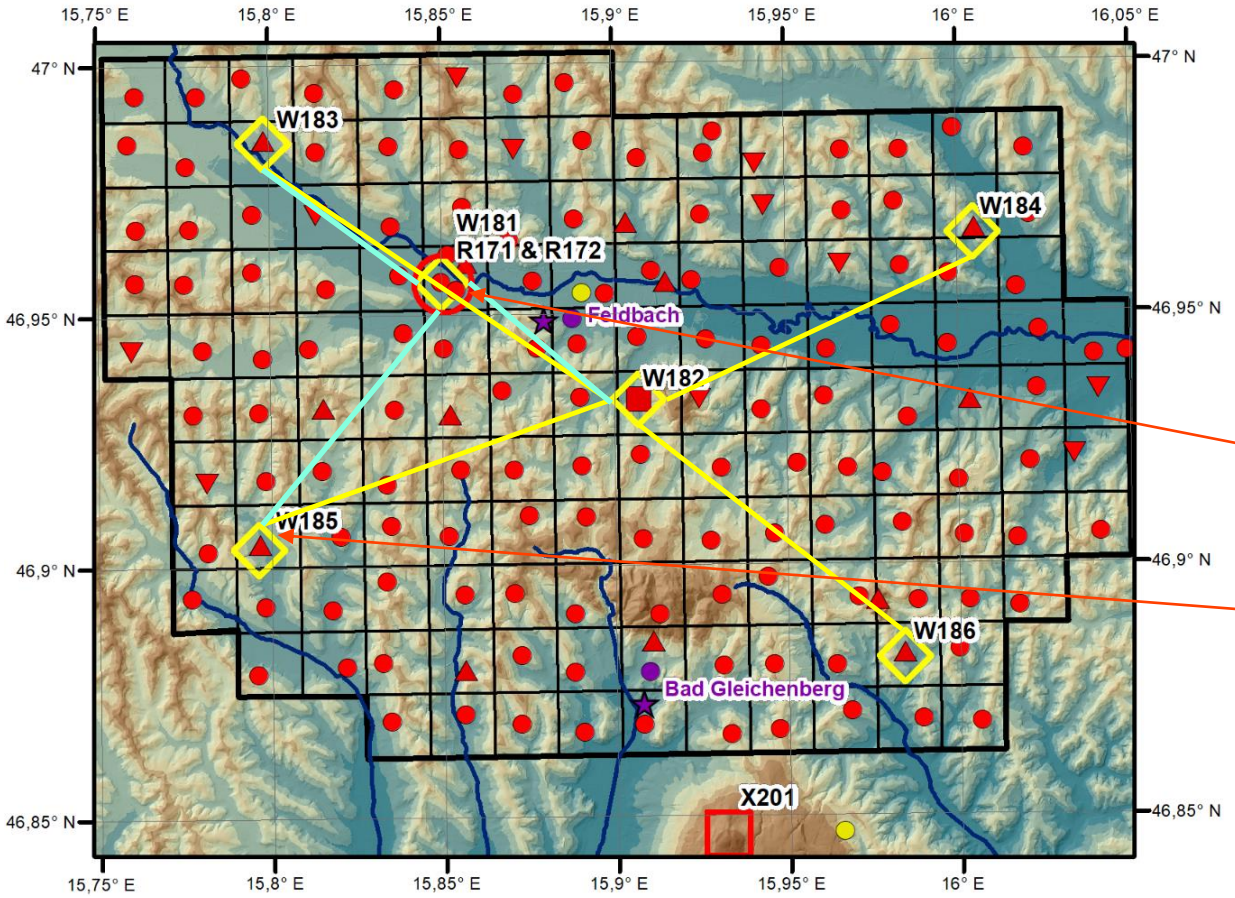
Location “Central Station Raabtal” (156): Rooftop (~27 m above ground) of an office building in the central valley of the region



- Output products: **temperature, humidity**, and **cloud liquid water profiles**; **integrated water vapor**, **liquid water path**, **cloud layer heights**, and **cloud cover** for full sky above the radiometer pair (angular resolution: 10° elev., 20° azim.)
- **10 min time sampling**
- Vertical grid resolution of <= 60 m in boundary layer (at < 1.5 km altitude) and <= 300 m in free troposphere (1.5 km to 10 km)

WEGN 3D: GNSS six-station network “GNSS-StarNet”

Station locations:

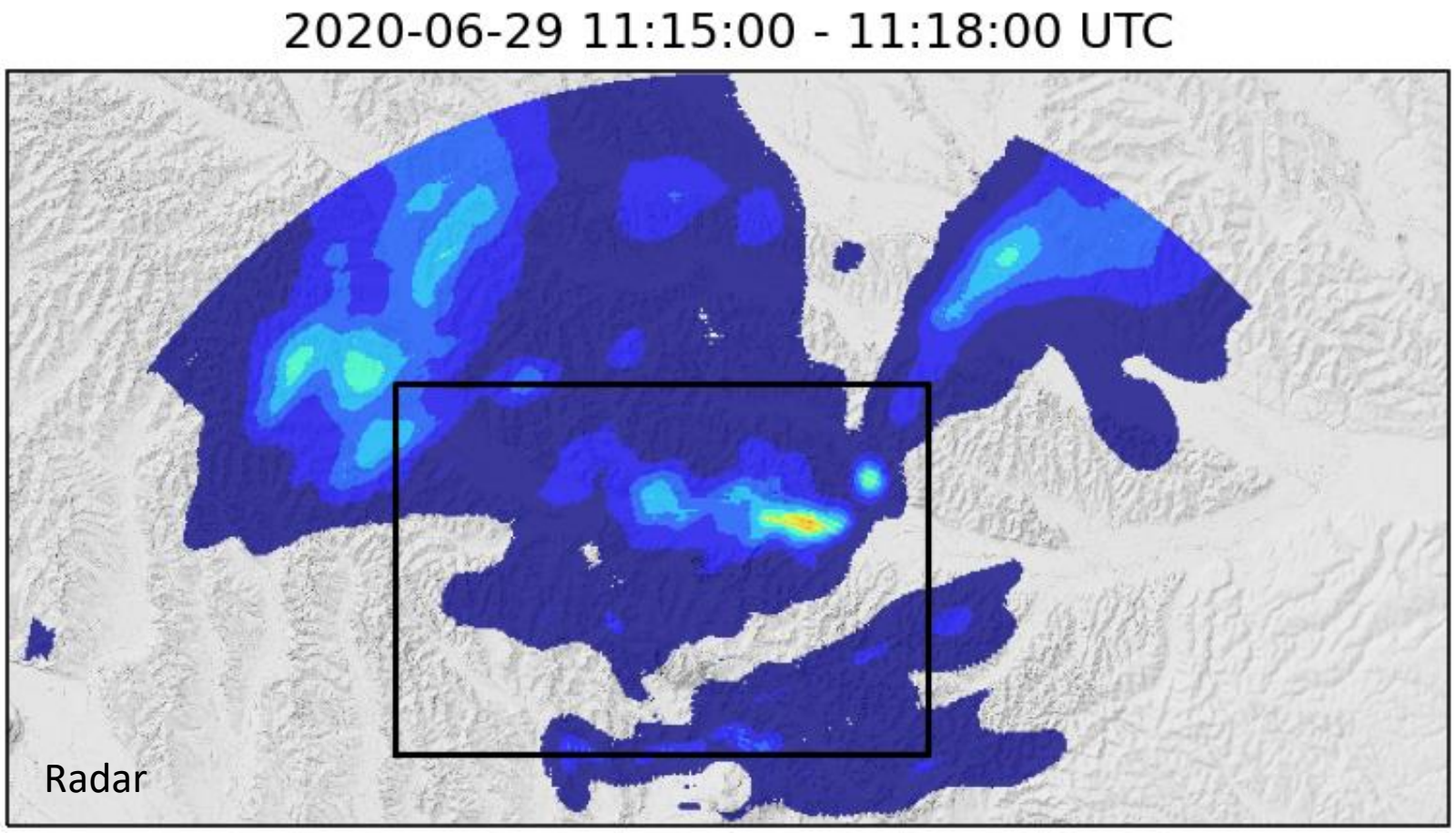


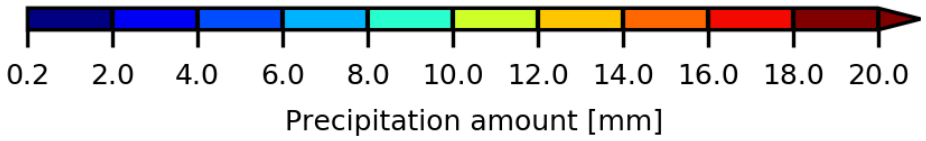
GNSS-StarNet “Main Star“

GNSS-StarNet “Embedded Star“

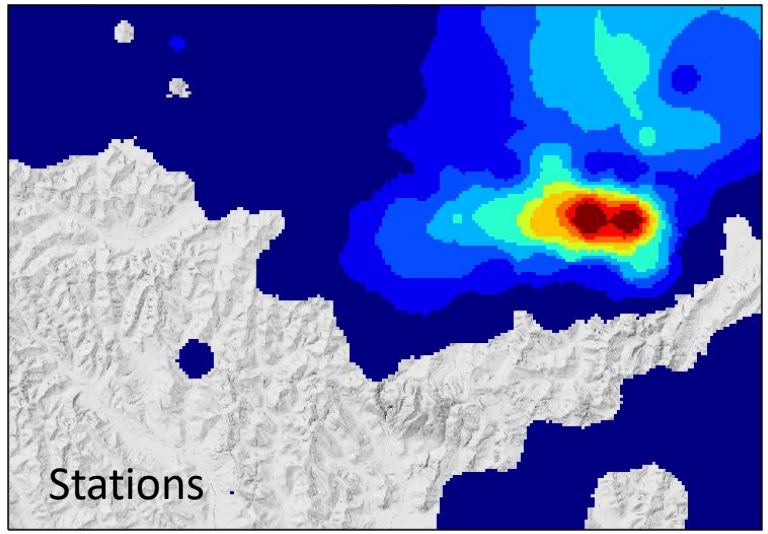
- **6 Multi-GNSS stations** within WegenerNet
- Measuring slant and vertically **integrated water vapor (IWV) columns** above the WegenerNet area, with 2.5 min to 15 min time resolution

X-Band precipitation radar: Case study of heavy precipitation on 29 June 2020 (1)

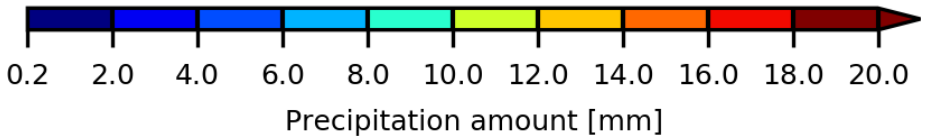




- **Highest 5-min precipitation rate on WegenerNet record (since 2007):**
- **20.6 mm/5 min** at Station 66
- 42.0 mm/30 min, 58.2 mm/60 min, and 76.8 mm/day

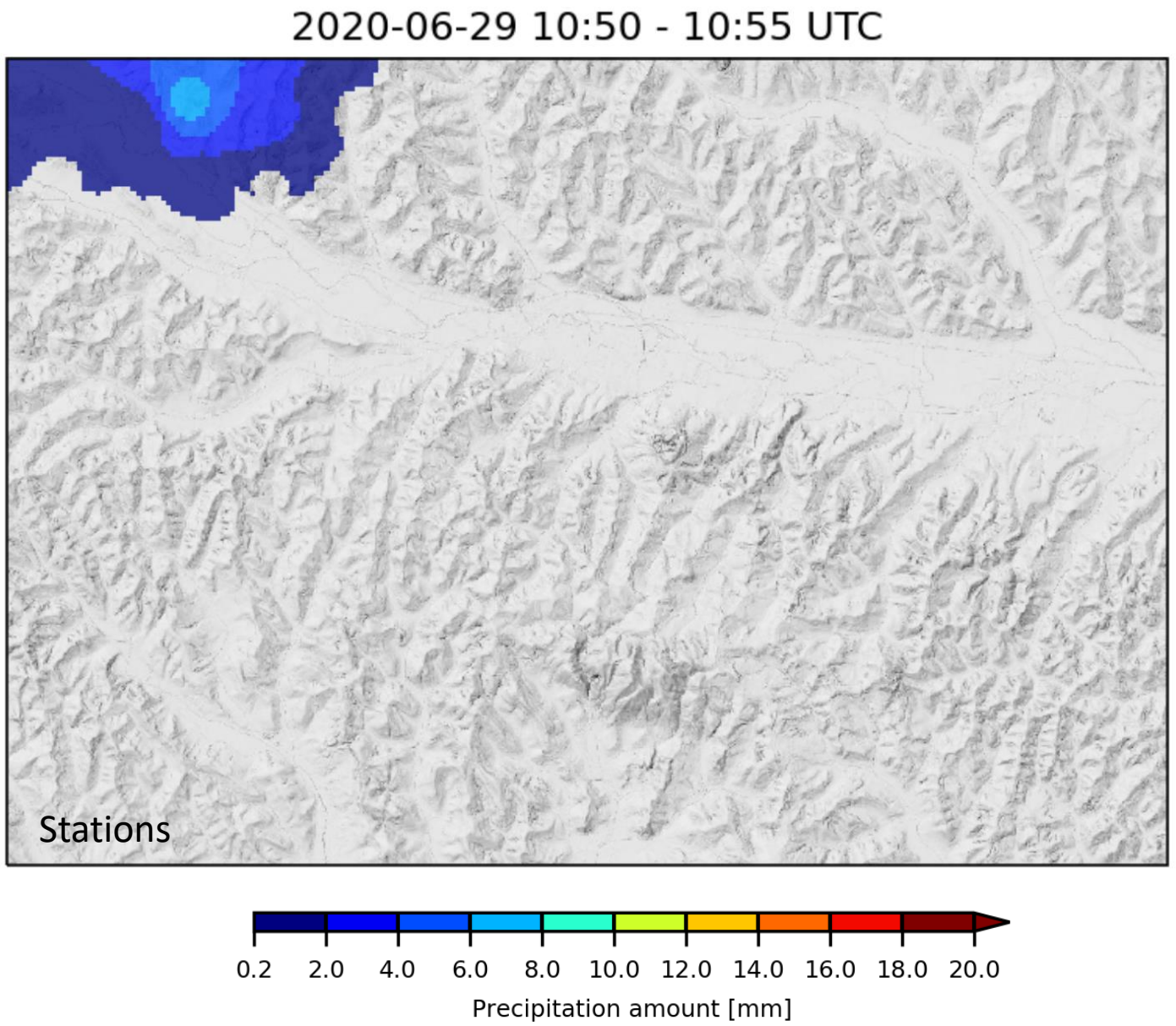


X-Band precipitation radar: Case study of heavy precipitation on 29 June 2020 (2)



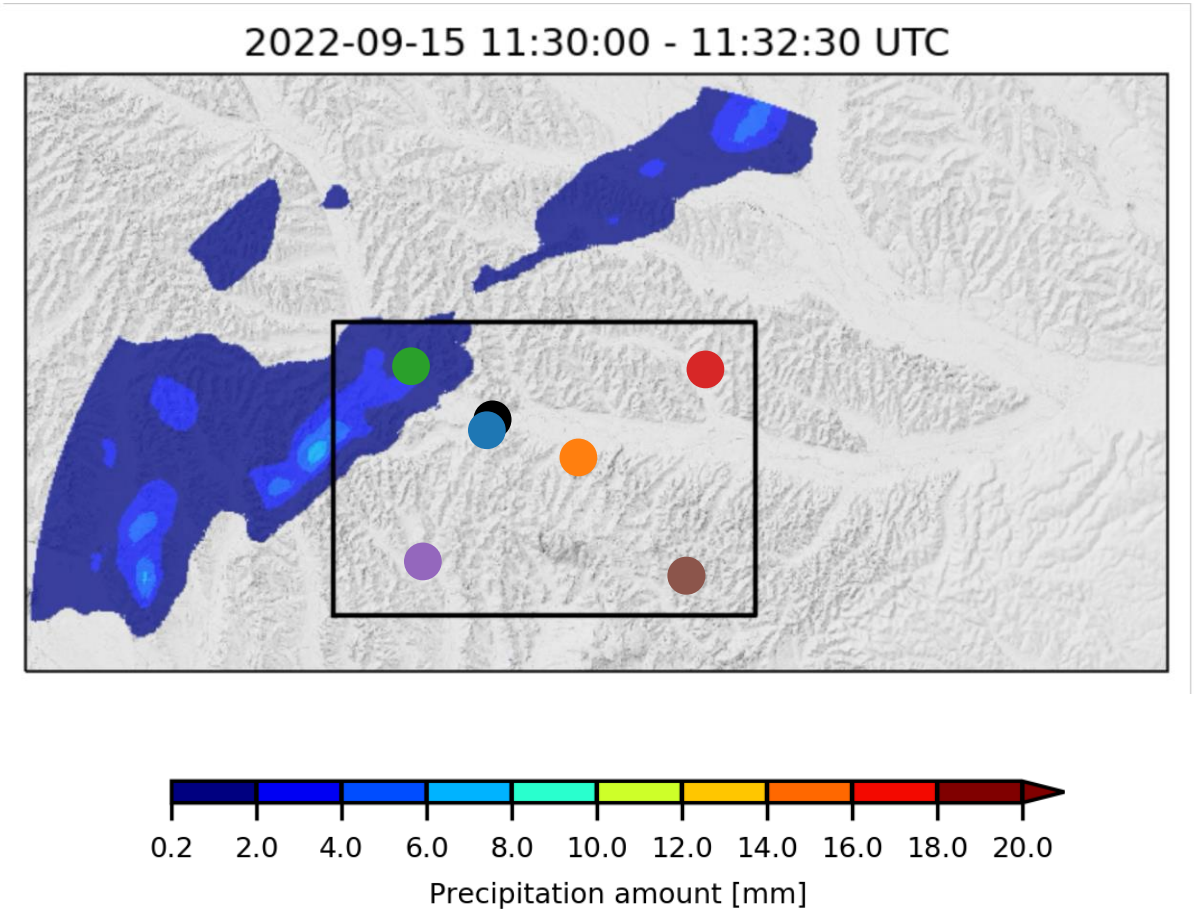
- Animation of radar images (2020-06-29 10:39 – 11:51 UTC)

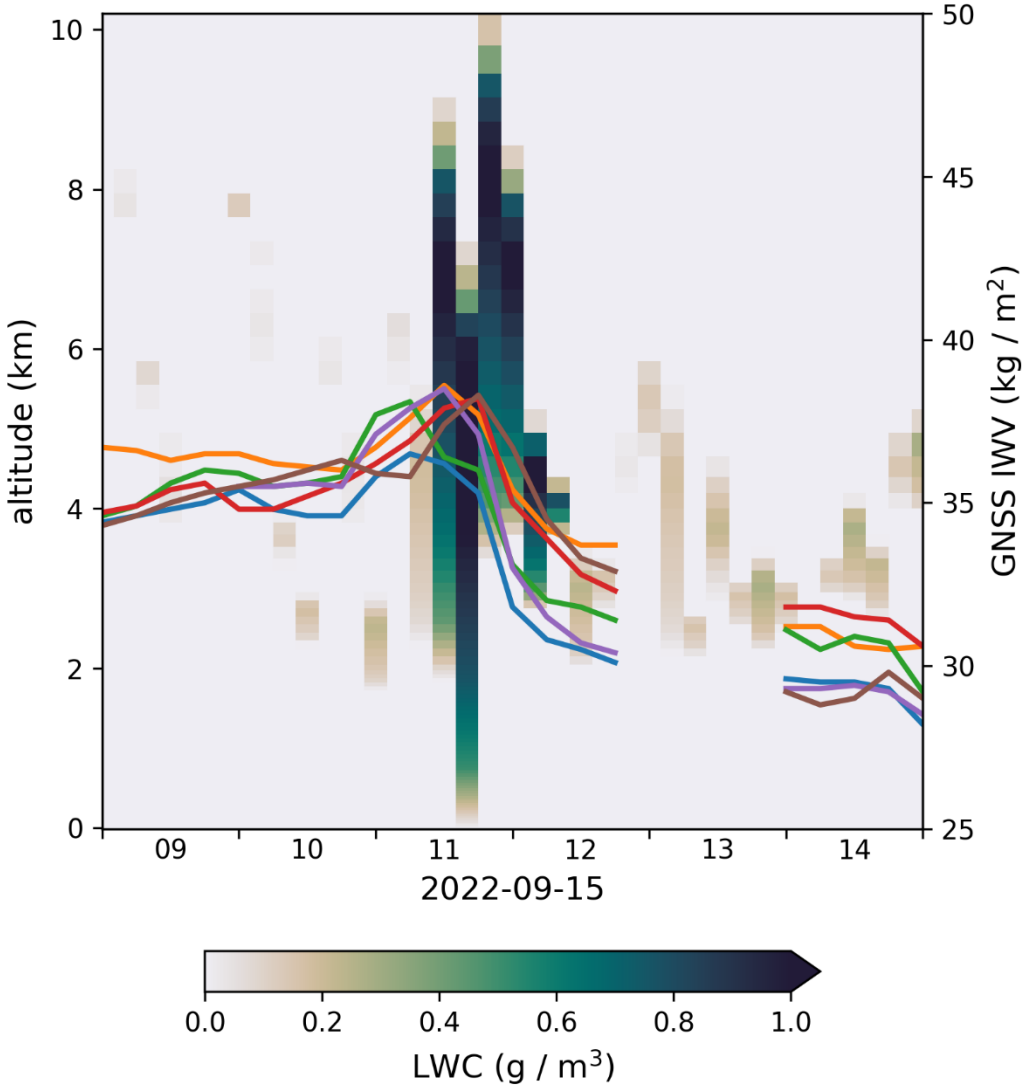
X-Band precipitation radar: Case study of heavy precipitation on 29 June 2020 (3)



- Animation of WegenerNet gridded precipitation data:
  June 29, 2020 10:45 – 11:50 UTC

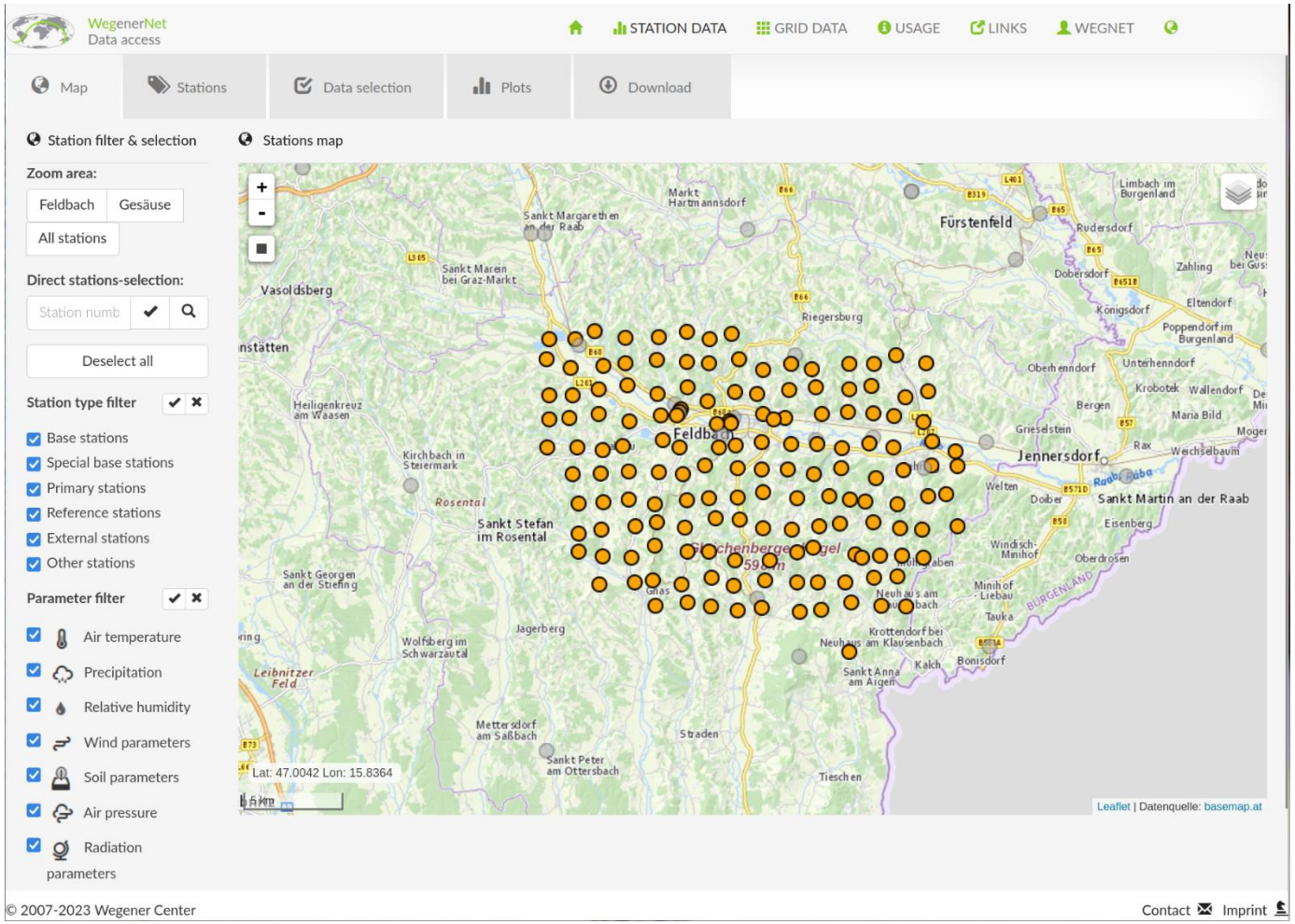
WEGN 3D: Case study of heavy precipitation event on 15 Sep. 2022





WEGN Station data: 17.7 mm/5 min @12:05 UTC, St. 114

WegenerNet data portal - wegenernet.org



- Free access for non-commercial users
- Quality-controlled data
- Easy registration and data access
- Interactive plots
- Time-series data and gridded data
- Data download: .csv for time-series data, NetCDF for gridded data
- For downloading large amounts of data via FTP see the latest data-DOI page: https://doi.org/10.25364/WEGC/WPS8.0:2023.1

Perspectives 2023+

- Validation of Geosphere Austrian Reanalysis (ARA) product using WegenerNet 2D+3D data
- Build data processing chain for WEGN 3D data
- Build the WegenerNet Open Data & Science Laboratory Region Southeast Austria (WEGN2OPEN) Open Data Store & Science Services
- Validation of ESA Earth Cloud Aerosol and Radiation Explorer (EarthCARE) satellite data (launch 2024)

WegenerNet references and further information

Full list of publications: www.wegcenter.at/wegenernet -> publications

Data portal: www.wegenernet.org

Fuchsberger, J. and G. Kirchengast (2022):
Release Notes for Version 8.0 of the WegenerNet Processing System (WPS Level 2 data v8). https://wegenernet.org/downloads/Fuchsberger-etal_2023_WPSv8-release-notes.pdf

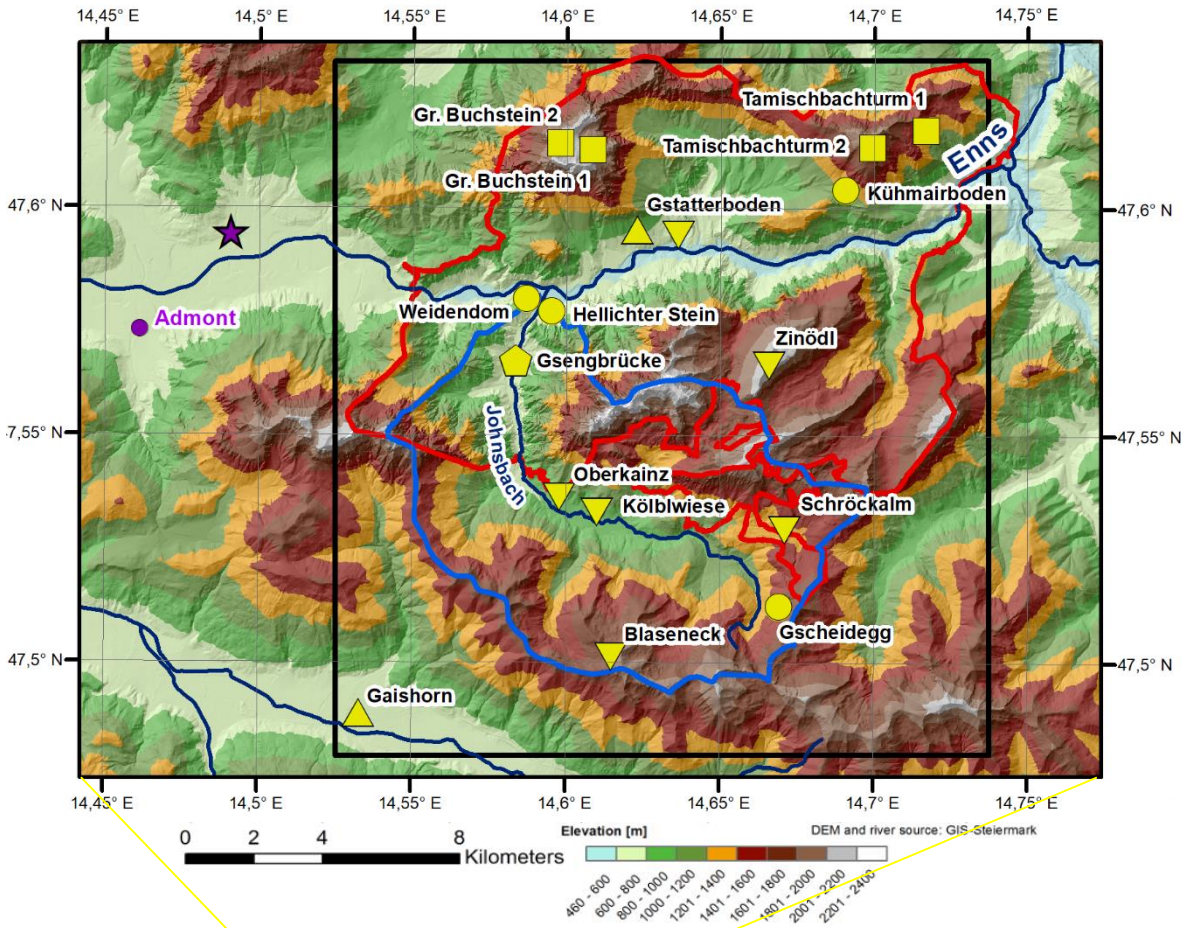
Fuchsberger, J., G. Kirchengast, and T. Kabas (2021):
WegenerNet high-resolution weather and climate data from 2007 to 2020, *Earth Syst. Sci. Data*, 13, 1307–1334. doi:10.5194/essd-13-1307-2021

Kirchengast, G., T. Kabas, A. Leuprecht, C. Bichler, and H. Truhetz (2014): WegenerNet: A pioneering high-resolution network for monitoring weather and climate. *Bull. Amer. Meteor. Soc.*, 95, 227-242, doi:10.1175/BAMS-D-11-00161.1

WegenerNet Data:

Fuchsberger J., G. Kirchengast, C. Bichler, A. Leuprecht, and T. Kabas (2023):
WegenerNet climate station network Level 2 data version 8 (2007–2022), University of Graz, Wegener Center for Climate and Global Change, Graz, Austria. https://doi.org/10.25364/WEGC/WPS8.0:2023.1

WegenerNet Gesäuse Region



WegenerNet Gesäuse Region:

- **15 climate stations** in an alpine setting ~16 km x 17 km
- 2 hydrographic stations
- Station altitudes from ca. **600 m to 2200 m**
- Measured parameters: Temperature, relative humidity, precipitation, snow depth, wind, radiation and air pressure
- **10-min** measurement interval
- Operating since 2007; stations were successively added

Station operators:

WegenerNet Gesäuse Region

Station Kölblwiese (860 m)

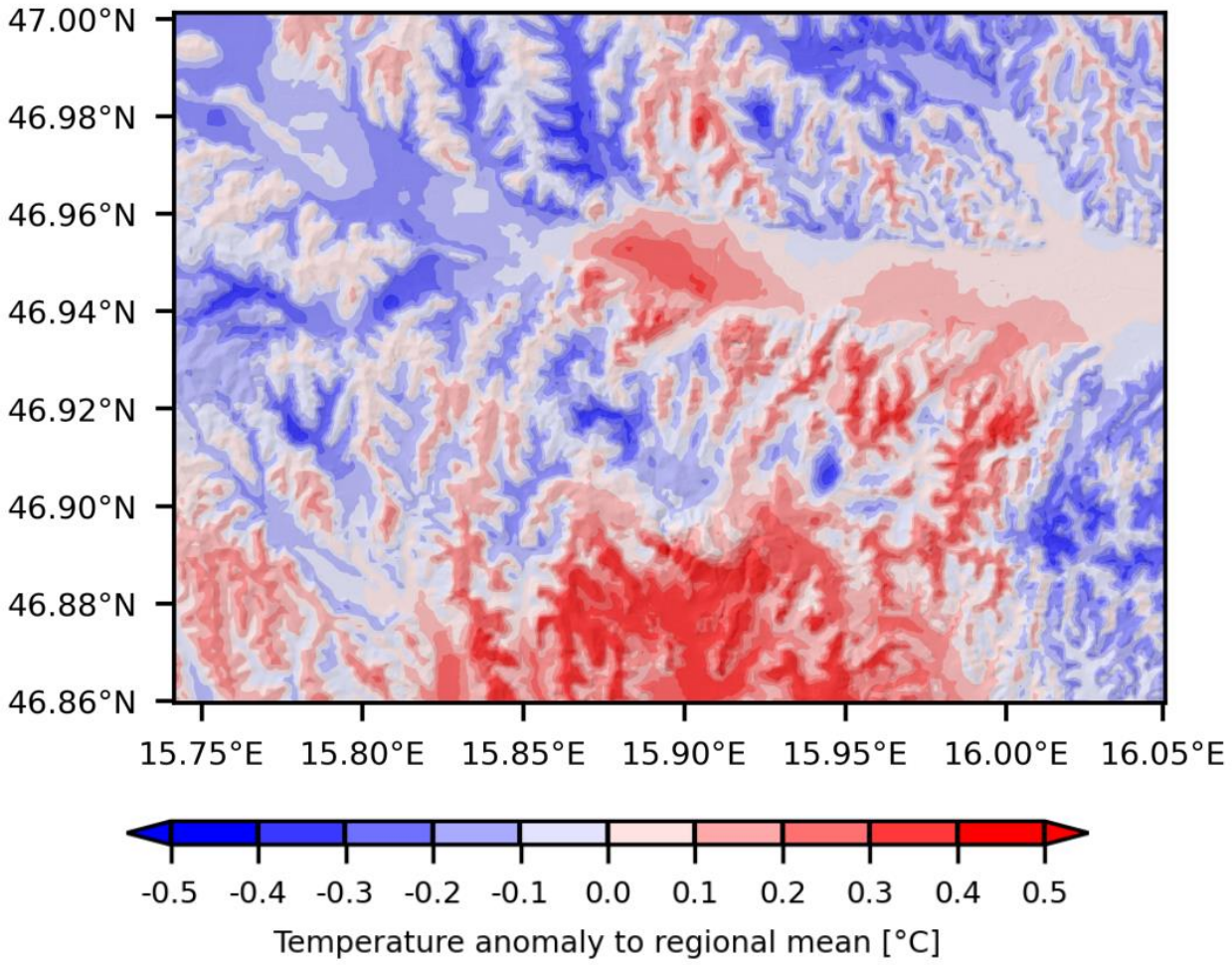
Fotos: A. Pilz

WegenerNet Processing System (WPS) version 8

WPS v8 improvements:

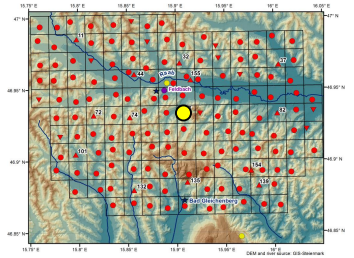
- Improvements of Quality Control System:
  - daily checks for detection of blocked gauges and snow melt events (in addition to hourly checks)
- Improvements of Data Product Generator:
  - generation of terrain-following temperature gradients (needed for the interpolation of temperature data)
  - Homogenization of precipitation data
  - Homogenization of temperature data
  - Increased resolution of grid data to 100 m
  - Generation of decadal data

Decadal mean Summer temperature data 2011-2020
(T_mean = 20.05 °C)



Installed sensors (at the reference station no. 77)

Wind (Speed and direction): 10 m above ground



Radiation balance: 2 m

Air temperature und relative humidity: 2 m

Precipitation: 1.5 m

Air pressure

Soil moisture and temperature: -20 cm