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

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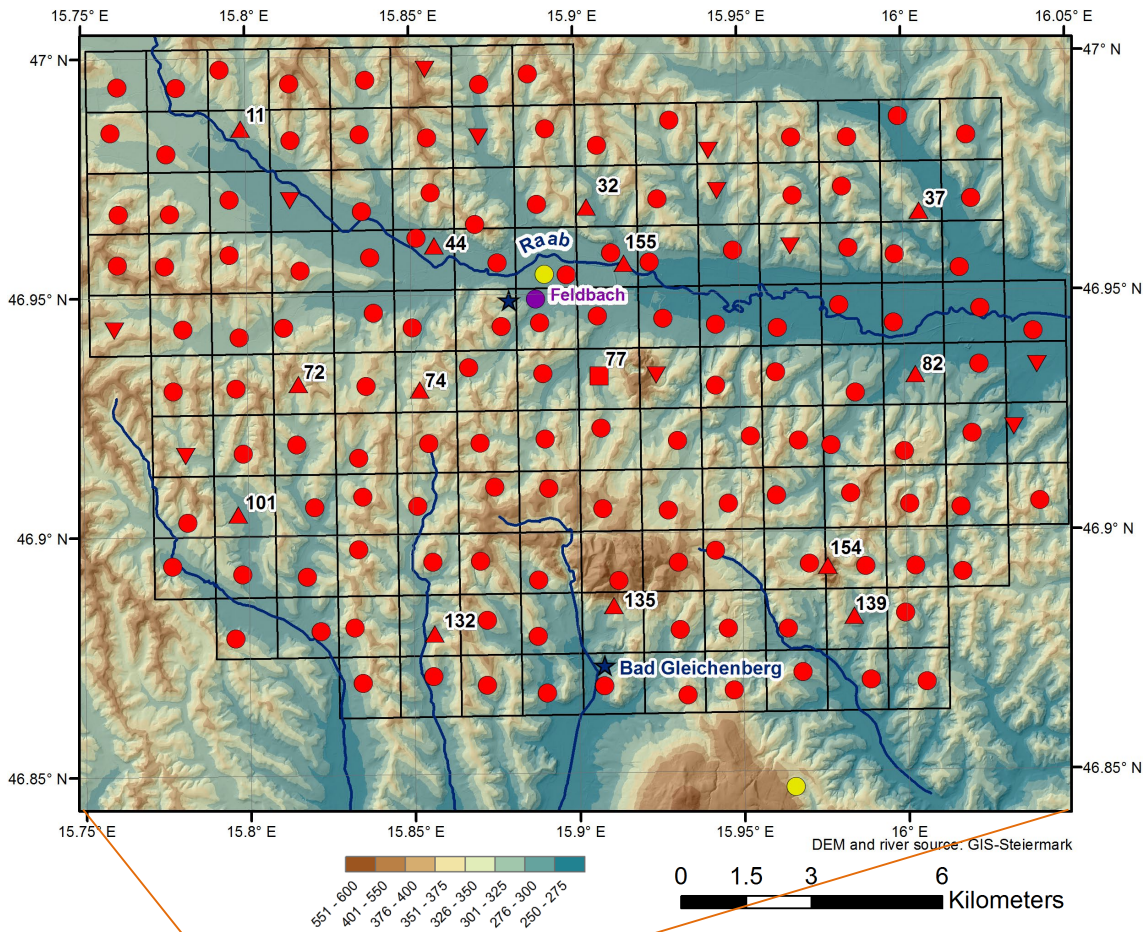**Online presentation@ EMS Annual Meeting 2021, 9 September 2021**

Das Land Steiermark

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Further info on partners & sponsors: www.wegcenter.at/wegenernet

The WegenerNet 3D Open-Air Laboratory for Climate Change Research (WEGN 3D) – Ground Station Network (WEGN 2D part)


Key features of the WegenerNet ground station network:

- Pioneering high-resolution network for long-term monitoring of weather and climate

- **156 climate stations** (red symbols in map) located in the southeastern Alpine forelands in Austria

- **~22 km x 16 km region**

- Station grid with a station every about 2 km²

- Elevation range ~250 m to 600 m,

- Highest station elevation: 520 m

- Almost 15 years of data (start: 1st January 2007)

- Main parameters: **Temperature, relative humidity, and precipitation**, measured at all stations

- At 13 main stations additional measurements of wind and solid precipitation (heated rain gauges)

- At 12 Stations soil moisture and soil temperature measurements

- Reference station additionally measures air pressure and net radiation balance

- Measurement **sampling rate 5 min** (at main stations 1 min)

- Data available at www.wegenernet.org

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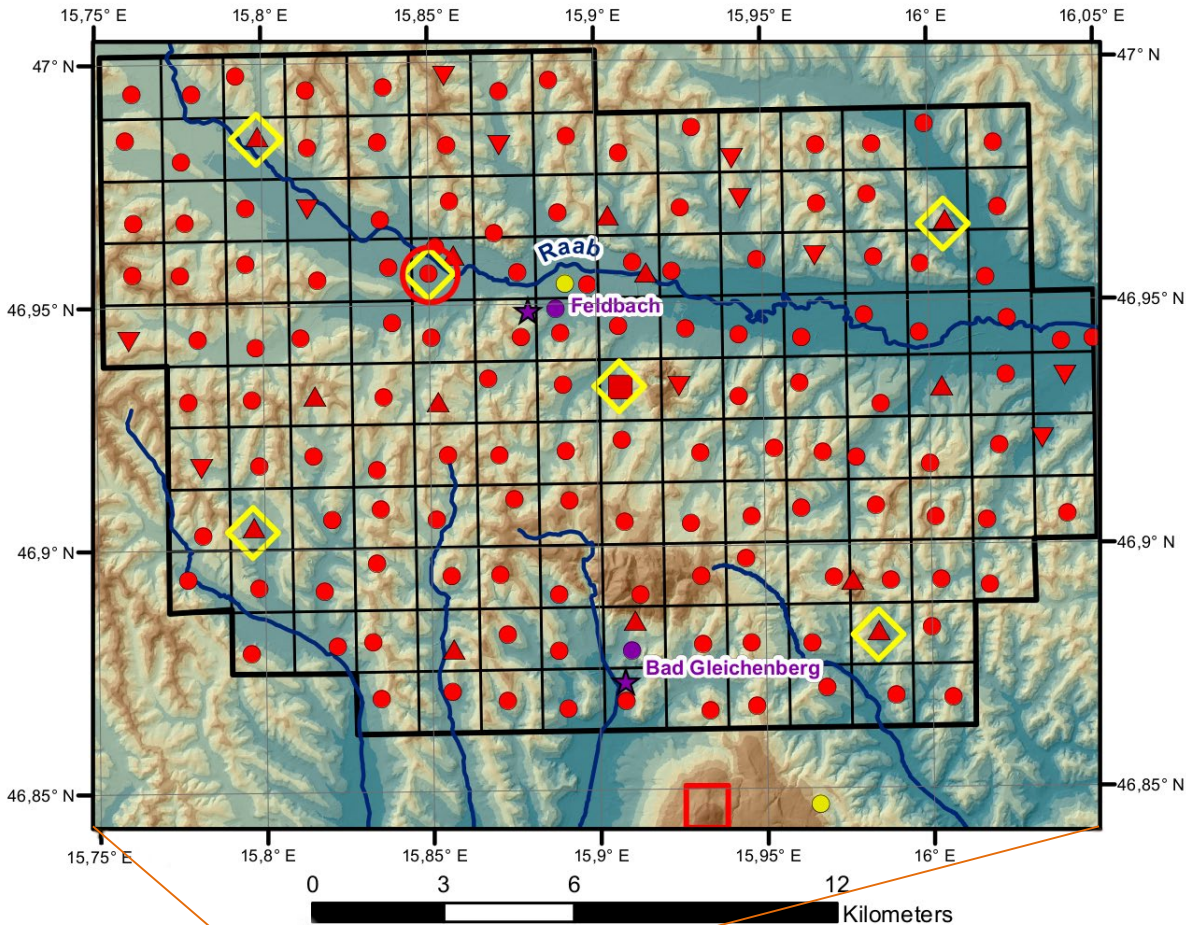

WegenerNet 3D observing components:

- 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**")
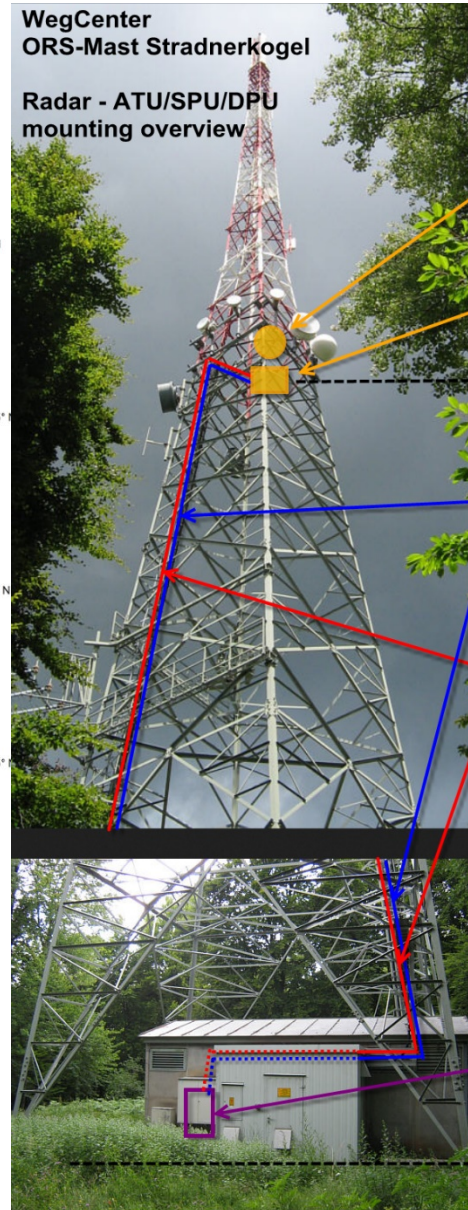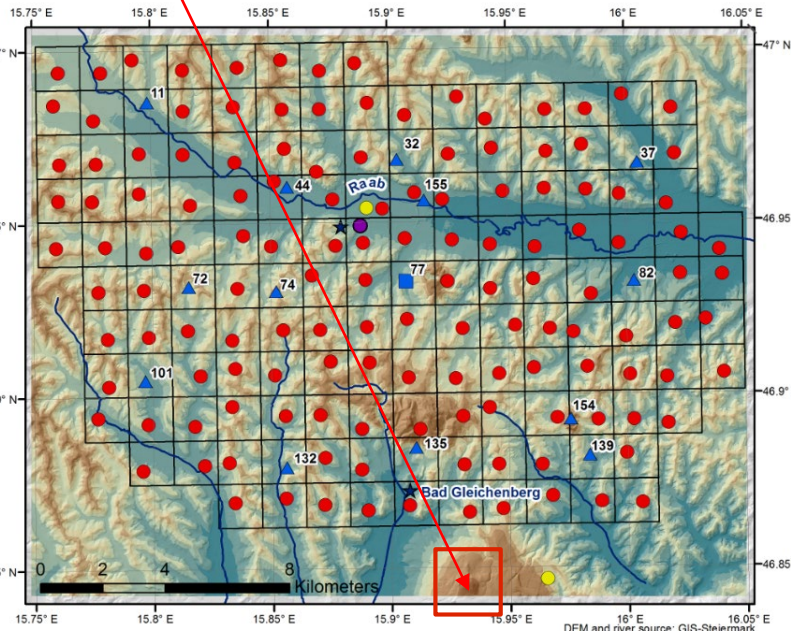
The three components are marked by these symbols in the map:

☐ X-Band precipitation radar Stradnerkogel

◇ GNSS-StarNet (six GNSS water vapor sensors)

◯ Tropospheric profiling and cloud structure radiometers
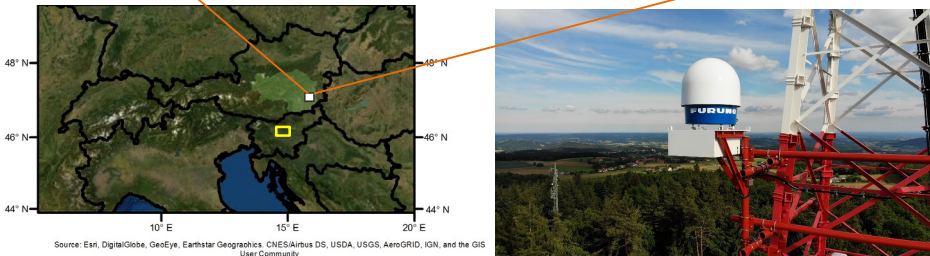
WEGN 3D: Polarimetric X-Band precipitation radar Stradnerkogel

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

WegCenter
ORS-Mast Stradnerkogel

Radar - ATU/SPU/DPU
mounting overview

ATU
(Radar Dome, on Dome Mount Platform)

SPU
(within Dome Mount Platform)

41m / ~ 650m ü.d.M

Data line (optical fiber)
MM, 1GBs min, OM3 ok, outdoor, LC connectors confected (beware/secure when installing cable on mast the LC connectors)

Power Line (5x 1,5 mm², NYCY)
Helukabel 32220-100 Erdkabel NYCY 5 x 1.50 mm² Schwarz 100 m

1x 2 power for adapters/switch/converter (durable)
1x 2 power for SPU unit only (variable operation, ground controlled)
1x 1 ground (replaces green/yellow)

DPU & further equipment
(within 19" rack within ORS-shelter)

0m / ~ 609 m ü.d.M

- Output products: **Rainfall intensity R** (mm/h), **Reflectivity Zh and Zv** (dBZ), etc.
- **1 km x 1 km horizontal, 500 m vertical**
- **2.5-min time sampling**

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

WEGN 3D: MW/IR atmospheric 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
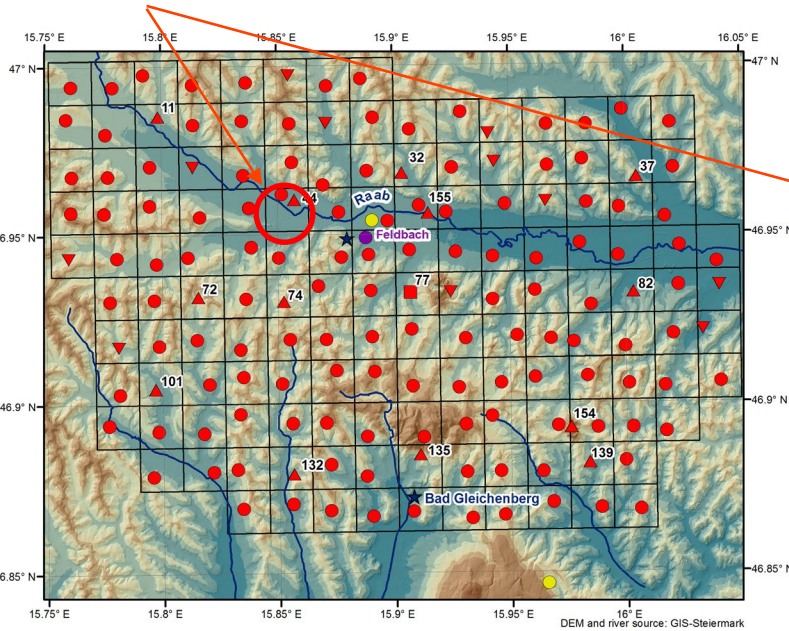
- Output products: temperature, humidity, and **cloud liquid water** profiles; integrated water vapor, **liquid water path**, **cloud base height**, for full sky above the radiometer pair (angular resolution: 10° elev., 20° azim.)

- **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:

DEM and river source: GIS-Steiermark
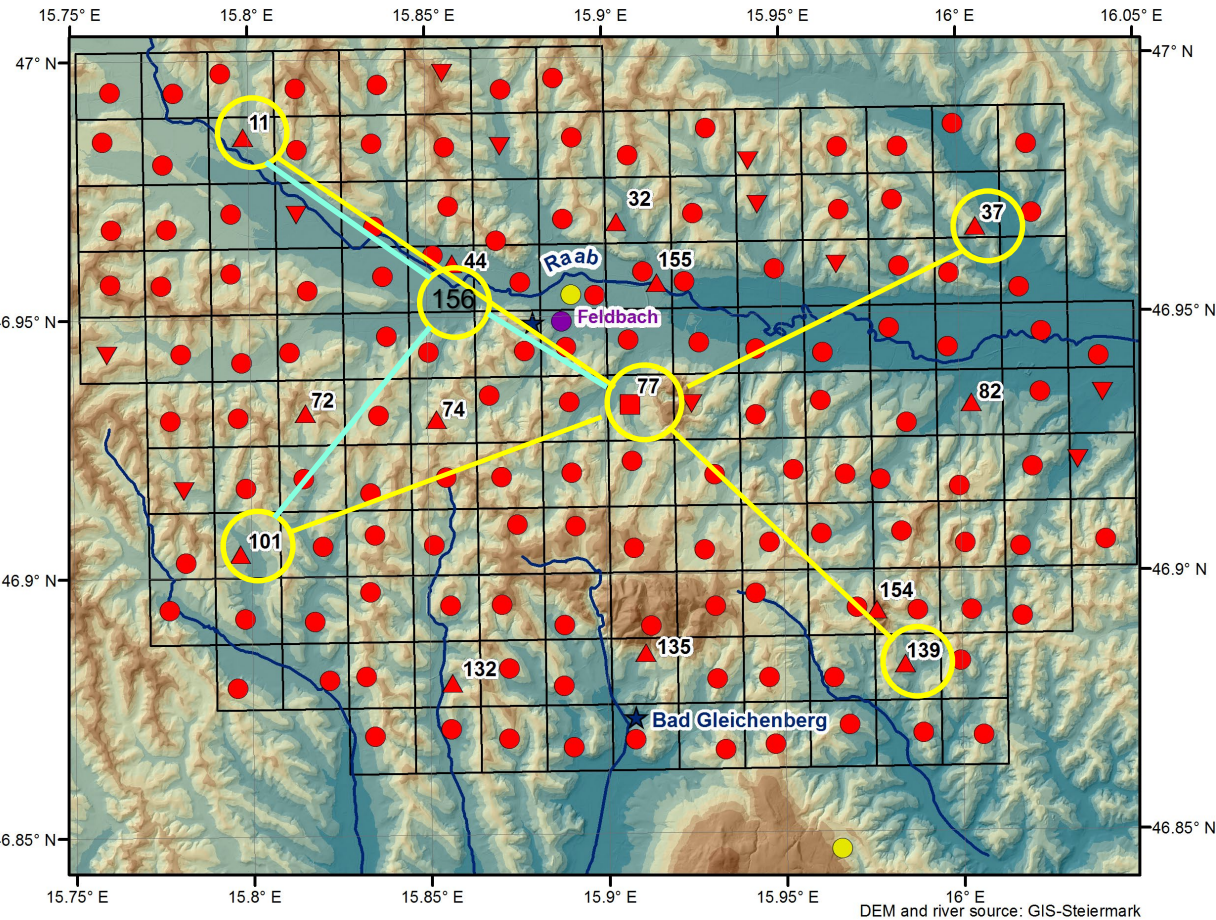
——— GNSS-StarNet "Main Star"

——— GNSS-StarNet "Embedded Star"

- 6 Multi-GNSS stations within WegenerNet region (at WegenerNet station no.s 11, 37, 77, 101, 139, 156), built and operated jointly with the GFZ Potsdam (Prof. J. Wickert & Team)

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

WegenerNet references and further information

Data portal: www.wegenernet.org

Homepage: www.wegcenter.at/wegenernet

Selected Key Publications:

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.
https://doi.org/10.5194/essd-13-1307-2021
Brief description of WEGN 3D components therein:
https://essd.copernicus.org/articles/13/1307/2021/#section7

O, S., U. Foelsche, G. Kirchengast, J. Fuchsberger, J. Tan, and W. A. Petersen (2017):
Evaluation of GPM IMERG Early, Late, and Final rainfall estimates using WegenerNet gauge data in southeastern Austria, *Hydrol. Earth Syst. Sci.*, 21, 6559–6572
https://doi.org/10.5194/hess-21-6559-2017

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.
https://doi.org/10.1175/BAMS-D-11-00161.1

WegenerNet Data DOI:

Fuchsberger J., G. Kirchengast, C. Bichler, A. Leuprecht, and T. Kabas (2021):
WegenerNet climate station network Level 2 data version 7.1 (2007–2020), University of Graz, Wegener Center for Climate and Global Change, Graz, Austria.
https://doi.org/10.25364/WEGC/WPS7.1:2021.1

Instrument provider information:
Precipitation radar: https://furuno-weather-radar.com

MW/IR Radiometer: https://www.radiometer-physics.de

IR Cloud Structure Radiometer: http://www.nubiscope.de

GNSS-StarNet infrastructure ops: https://www.gfz-potsdam.de/en/section/space-geodetic-techniques/projects/gnss-infrastructure/

For Those with Immediate Deeper Interest: complementary slides with further information follow below (slides 8 to 15).
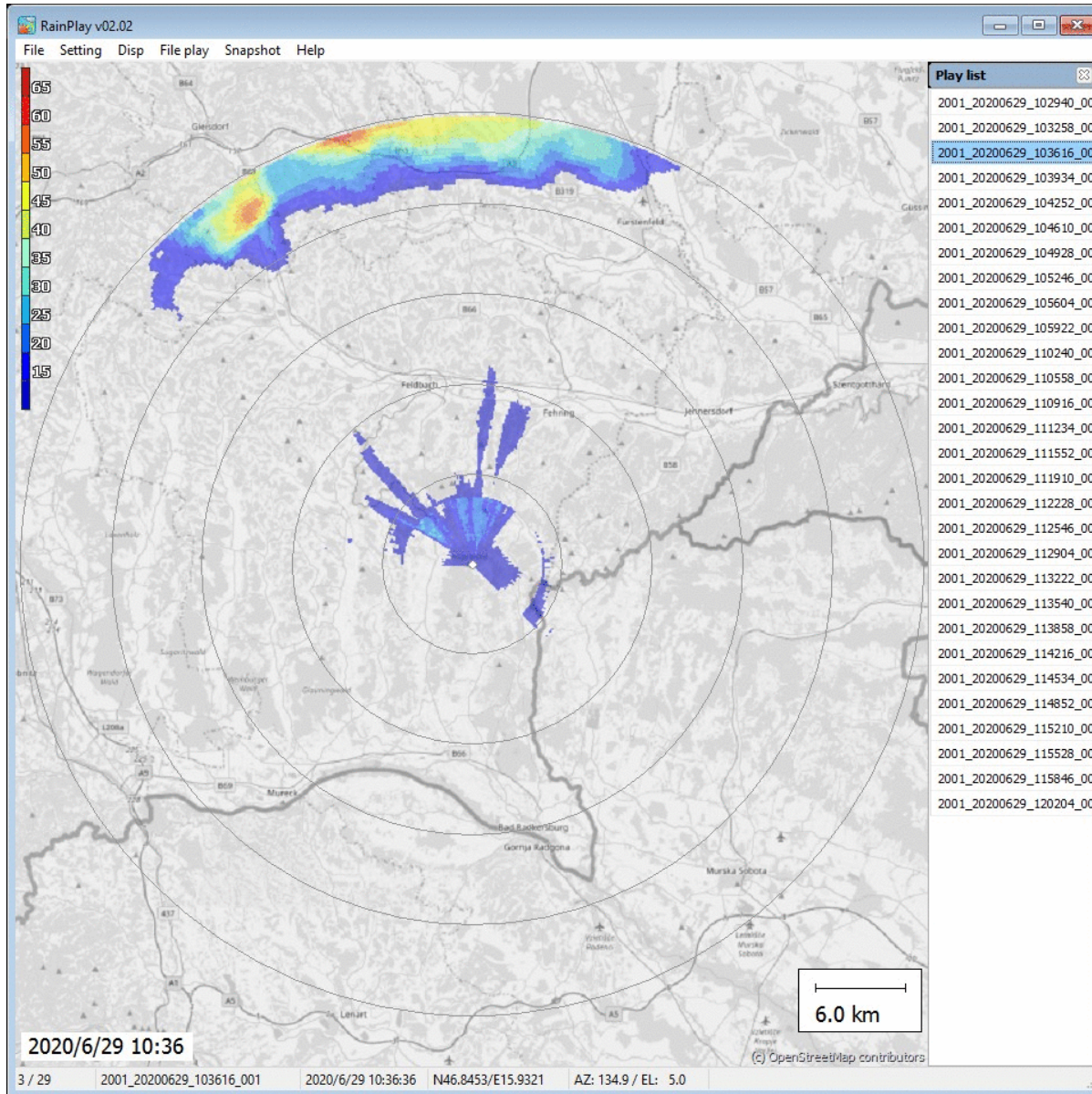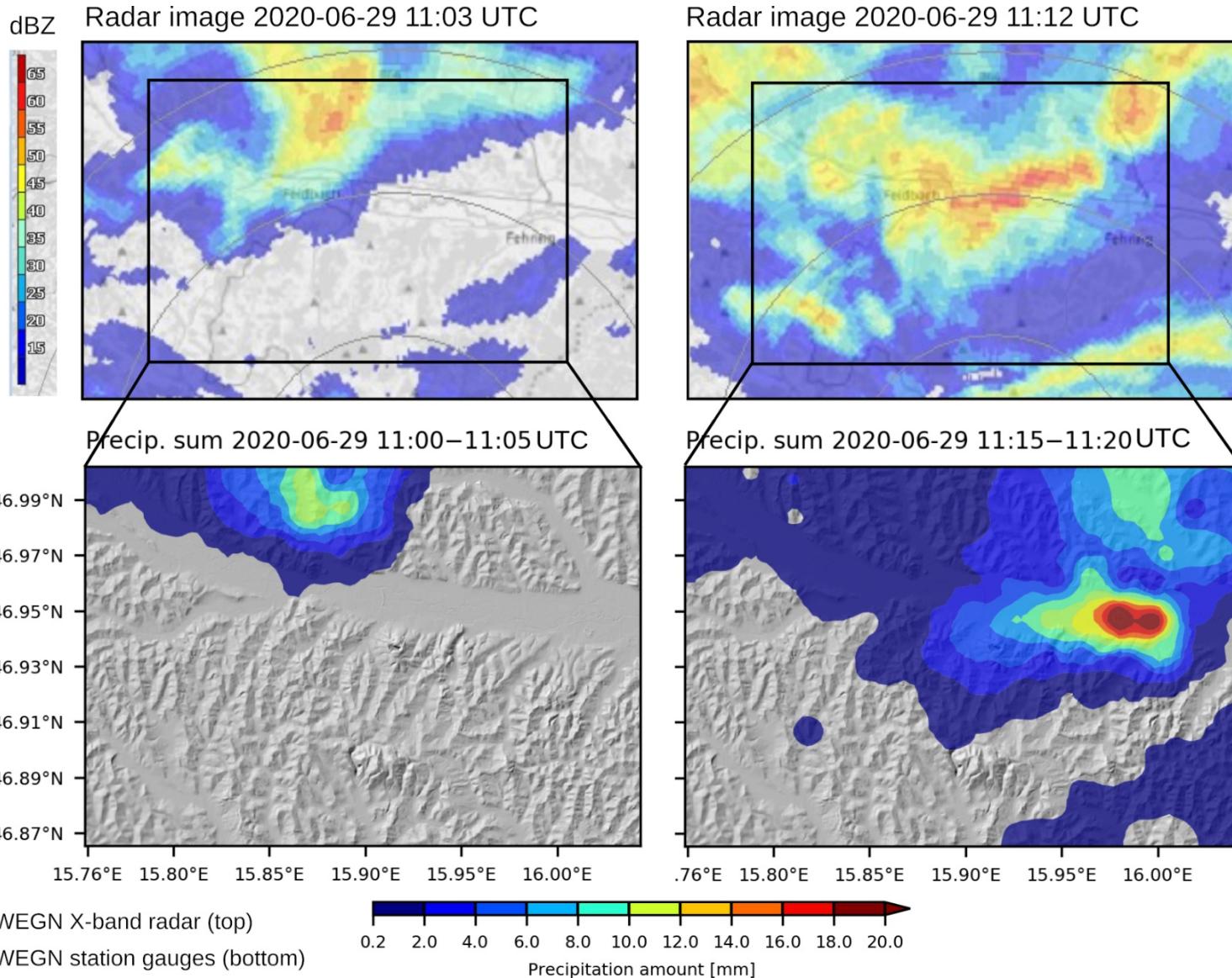
- Animation of radar images (2020-06-29 10:29 – 12:02 UTC)

Radar image 2020-06-29 11:03 UTC

Radar image 2020-06-29 11:12 UTC

Precip. sum 2020-06-29 11:00−11:05 UTC

Precip. sum 2020-06-29 11:15−11:20 UTC

WEGN X-band radar (top)
WEGN station gauges (bottom)

Precipitation amount [mm]

- **2nd 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

Precip. sum 2020-06-29 10:45−10:50

Precipitation amount [mm]
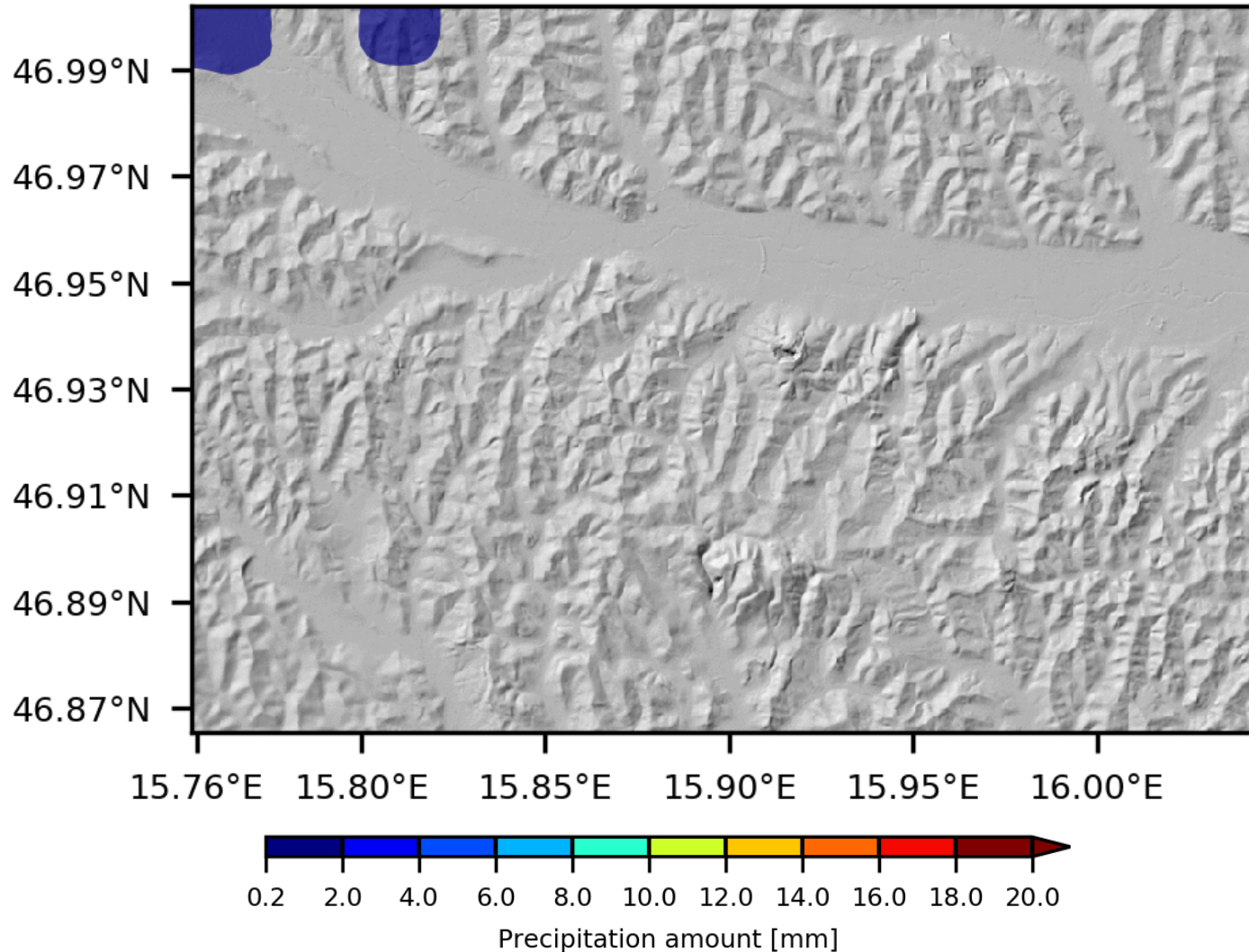
- Animation of WegenerNet gridded precipitation data:
  June 29, 2020 10:45 – 12:00 UTC
  (*Note:* actually animated in the pptx version only)

- Type Furuno WR-2120

- Polarimetric X-band weather radar operating at ~9.4 GHz

- Output products: **Rainfall intensity R** (mm/h), **Reflectivity Zh and Zv** (dBZ), Doppler velocity V (m/s), Doppler velocity width W (m/s), Cross polarization difference phase φdp (deg), Specific differential phase KDP (deg/km), Correlation coefficient between the two polarizations, Horizontal and Vertical Differential reflectivity ZDR (dB)

- Further derived products: Hydrometeor classification, drop size distribution

- Native resolution: 2.7° angular, 300 m radial

- Resolution of processed 3D volume data: **1 km x 1 km horizontal, 500 m vertical**

- Observation range: 30 km (up to 70 km for case studies)

- **2.5-min time sampling** (180° 3D volume; down to 30 s for case studies)

- Peak output power: 100 W

- Advanced pulse compression techniques

- Operating since May 2020

MW/IR atmospheric profiling radiometer: Specifications and data products

- Type: RPG-HATPRO-G5
- **Relative humidity and temperature profiling** microwave/IR radiometer
- Multi-directional azimuth and elevation scanning
- Output products: temperature, humidity, and cloud liquid water profiles; integrated water vapor, **liquid water path**, **cloud base height**
- 14 microwave channels (22 GHz to 31 GHz and 51 GHz to 58 GHz)
- IR radiometer at 9.6-11.5 μm band
- **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)**
- Observation range: 0 m to 10000 m
- **10-min time sampling** (for full 3D scene for chosen ops mode)
- Capable of GNSS satellite tracking for GNSS-line-of-sight integrated water vapor (IWV) observations
- temperature profiling with an accuracy of ~0.5 K or better in boundary layer and ~1 K or better in free troposphere
- relative humidity profiling with an accuracy of ~5 % or better in the lower troposphere (< 5 km altitude);

# IR cloud structure radiometer: Specifications and data products

- Type: NubiScope infrared cloud scanning radiometer
- Enabling multi-layer cloud-field reconstruction over the WegenerNet area
- Multi-directional azimuth and elevation scanning
- IR radiometer at 8-14 µm band
- Output products: **IR temperature of cloudless sky, cloud cover percentage, cloud type, cloud base height and temperature**
- **10-min time sampling** (for full 3D scene)

GNSS-StarNet: Specifications and data products

- Receiver type: Septentrio PolaRx5 FULL

- Mapping of **water vapor columns**

- **15-min time sampling** (slant total delays 2.5 min)

- Main data products: Vertically **Integrated Water Vapor** [kg m^2], Zenith Wet Delay [mm], Zenith Total Delay [mm], Slant Total Delay [mm]

- Operated in cooperation with GFZ Potsdam, providing station monitoring and processing towards the main data products
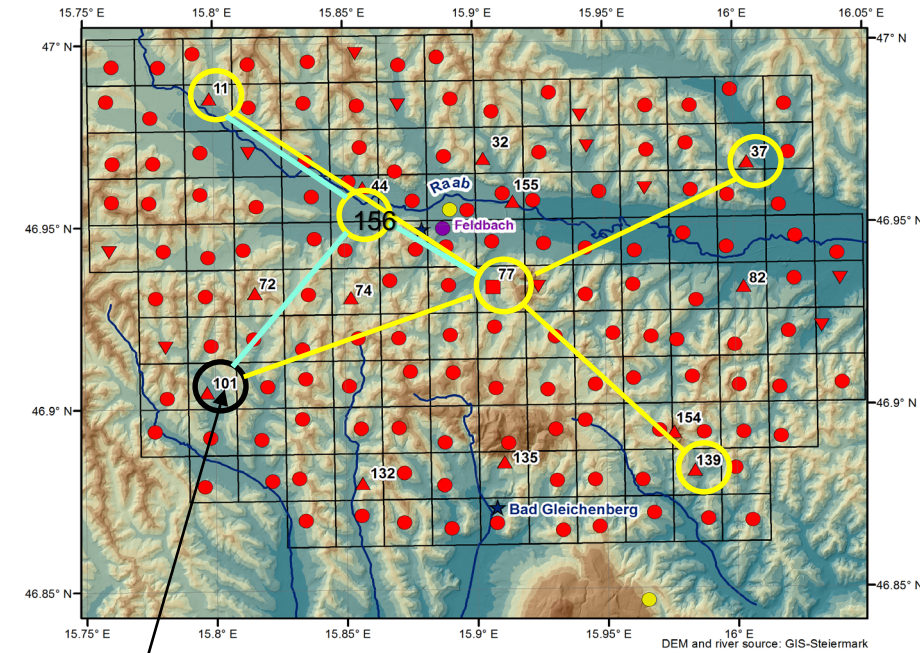
- GNSS-StarNet station installed on 1st October 2020 at the location of WEGN Station No. 101