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Greta **Near-surface Geothermal Resources in the Territory of the Alpine space**

POTENTIAL ASSESSMENT FOR THE USE OF NEAR SURFACE GEOTHERMAL ENERGY IN THE ALPINE REGION

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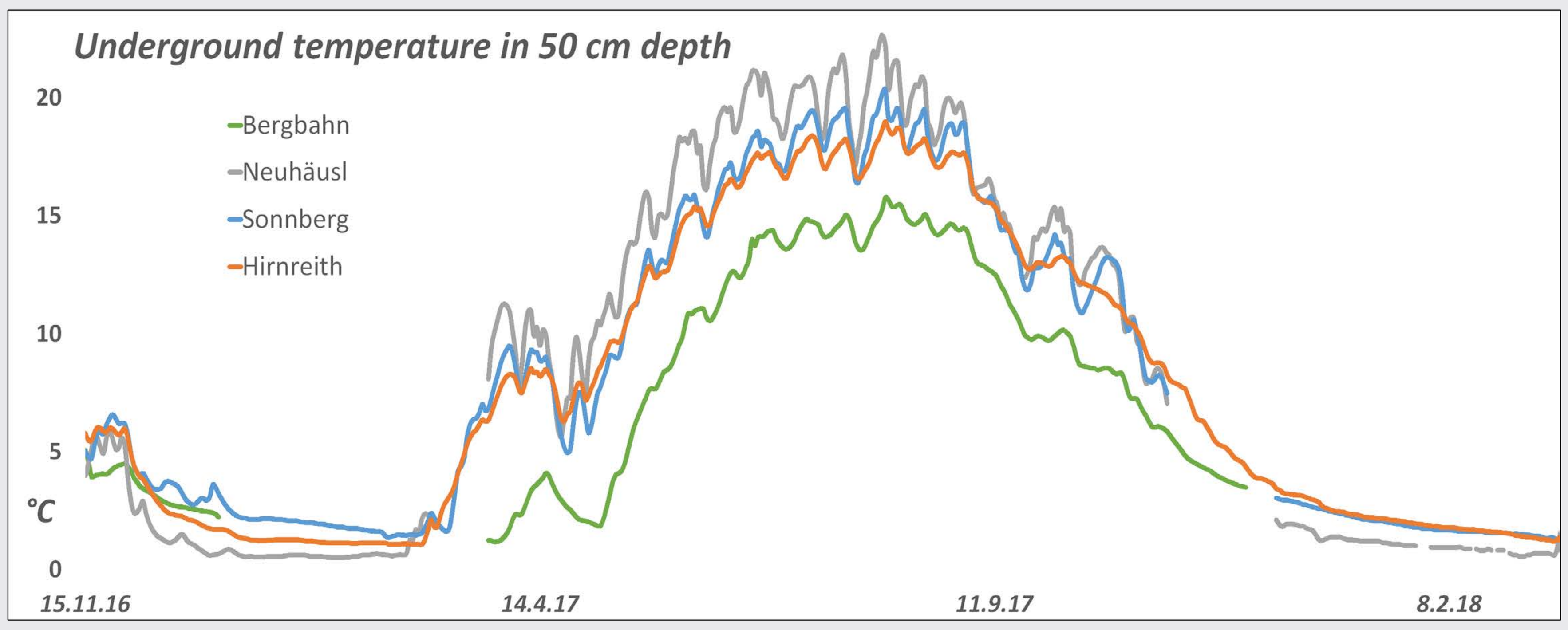
The project GRETA aims to **foster Near-Surface Geothermal Energy** (NSGE) in the territory of the Alpine Space. Main goals are to **assess potentials** of NSGE, **exchange knowledge and best practices** on a transnational basis and to **integrate NSGE into policy instruments.** Besides these overall objectives, each of the participating countries (Austria, France, Germany, Italy, Slovenia, Switzerland) is carrying out detailed analysis in their case study area. In Austria, the **focus** within the project is set on **the potential in high altitude regions**. The focus region comprise the communities Leogang and Saalbach-Hinterglemm where settlements are located in altitudes of about 800 – 1.000 m. For a sustainable use of NSGE in heating and cooling, it is important to know the potential in its spatial extent. Therefore, potential maps for groundwater heat pump systems and for borehole heat exchangers were calculated. These maps shall serve as tools for spatial energy planning.

Ground temperature as key parameter for a sustainable use of NSGE

Underground temperature is a key parameter for NSGE potential assessment and is usually calculated based on outside air temperature under consideration of elevation**. It can be assessed more precise under consideration of e.g. solar radiation, snow cover and underground properties.** This method is not used as a standard because multiple parameters are needed which are not easily available and calculations tend to get more complex.

For validation reasons, measurement stations are necessary – those were missing in the Austrian case study area. That is why monitoring stations were installed in the municipality of Leogang. Two stations were realized in the valley at about 800 m, two were installed further up the mountain at 1250 m (south-slope) and 1400 m (north-slope). The measurement chains are in-house developments and consist of single digital thermometers (Ds18b20) measuring the underground temperature in depths of 10 cm, 20 cm, 50 cm, 1 m, 1.5 m and 3 m below surface. The data loggers connected to the measurement chains are based on an Arduino Micro controller. Lead accumulators and a solar panel supply power and data is transmitted on a daily basis via SMS protocol.

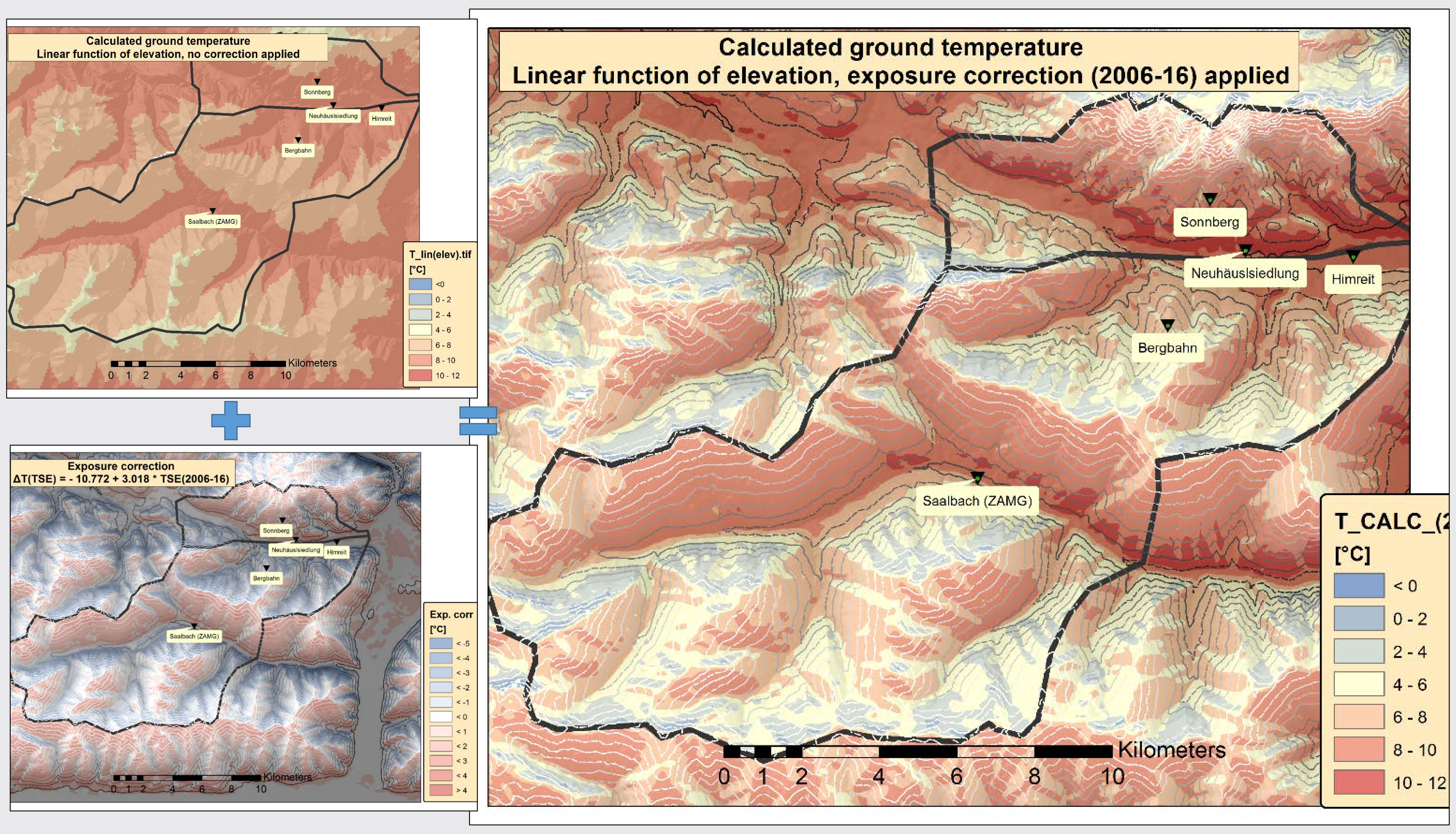
Interesting results. Different than expected, the sensors in the valley (~800 m altitude) do not continuously show the highest underground temperatures. The southwards heading station Sonnberg, located at an altitude of 1250 m, shows the highest temperature in spring (might be due to an early snow cover acting as thermal insulation) and second highest temperatures in summer. The earliest and thickest snow cover is at the north-facing station "Bergbahn". Here, the temperature drop is the least significant. These first results show, how much influence parameters like the snow cover or the exposition do have on the underground temperature and that altitude as such is not reliable to predict underground temperatures.



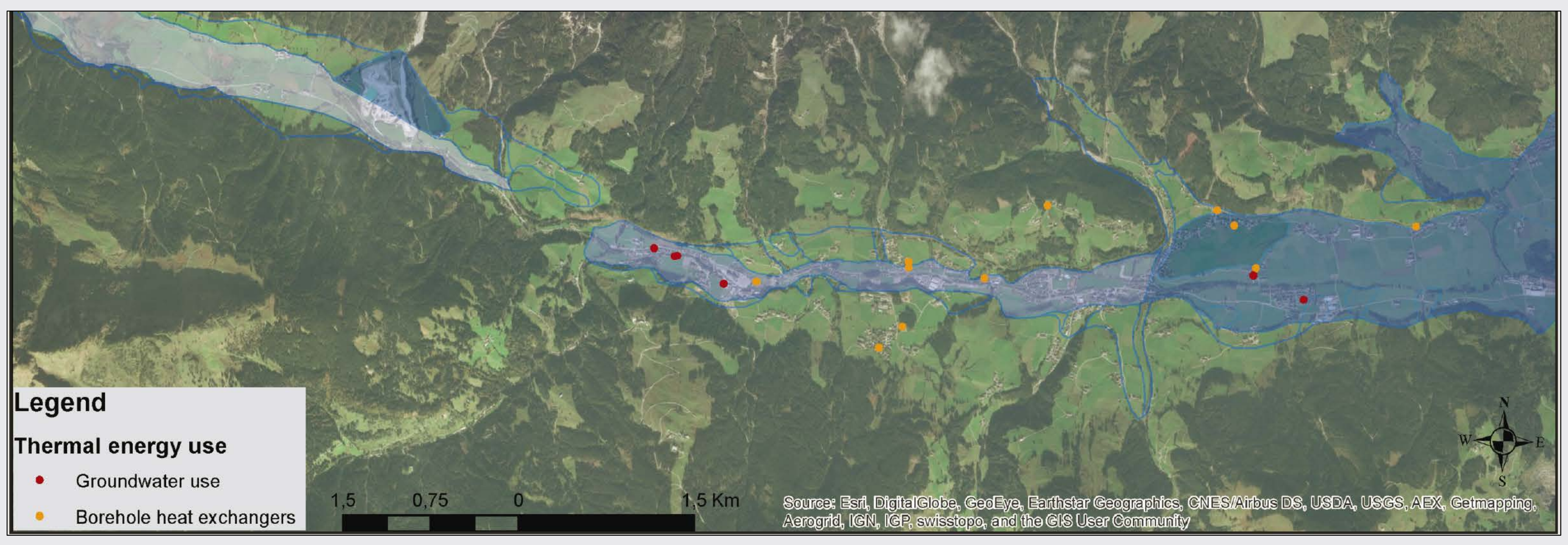
Spatial data as input for potential assessment

The input data for the calculation of potential maps for NSGE utilization needs to be available spatially distributed. Main input datasets are the **ground temperature**, the **thermal rock properties** and the **properties of available aquifers**.

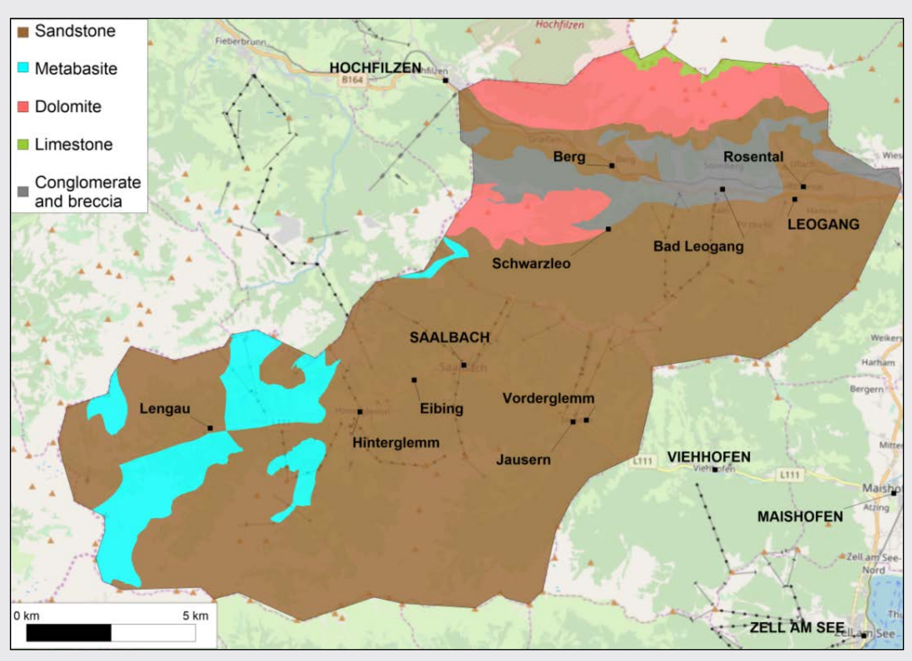
Based on the **GROUND TEMPERATURE** studies in the focus region, a workflow for an improved ground temperature map for the region was elaborated.
The calculation is based on multiregression analysis. In the first attempt, the measured annual mean underground temperatures are plotted vs. elevation and the first linear regression is calculated. The second step is the linear regression of the temperature deviation vs the mean solar exposure of the particular site. Using this approach, the mean underground temperature can be reproduced within satisfactory limits and further be calculated using gridded data. The resulting map serves as key input for the potential calculation for borehole heat exchangers.



The characterization of the defined **AQUIFERS** in the valleys have shown that large parts are suitable for the thermal use via groundwater heat pumps. Ten suitable aquifer bodies characterized by fine- to coarse grained Quaternary gravels were identified. They show thicknesses between 10 and 20 m with hydraulic heads of maximum 20 m. Their hydraulic conductivity values range between 0,0001 to 0,0025 m/s. Red dots in the figure below indicate the locations groundwater uses, from where mean annual aquifer temperatures of about 8 °C were derived.



A simplified geological map reporting bedrock lithologies was compiled for the spatial distribution of **THERMAL ROCK PROPERTIES**. This map represents a compilation of available geological and lithological information from maps of the region with scales between 1:200.000 (geol. map of Salzburg) and 1:50.000 (geol. map of Zell am See and Kitzbühel). Units representing lithologies with similar thermal rock properties were grouped to receive a simplified but realistic distribution of thermal conductivity values.

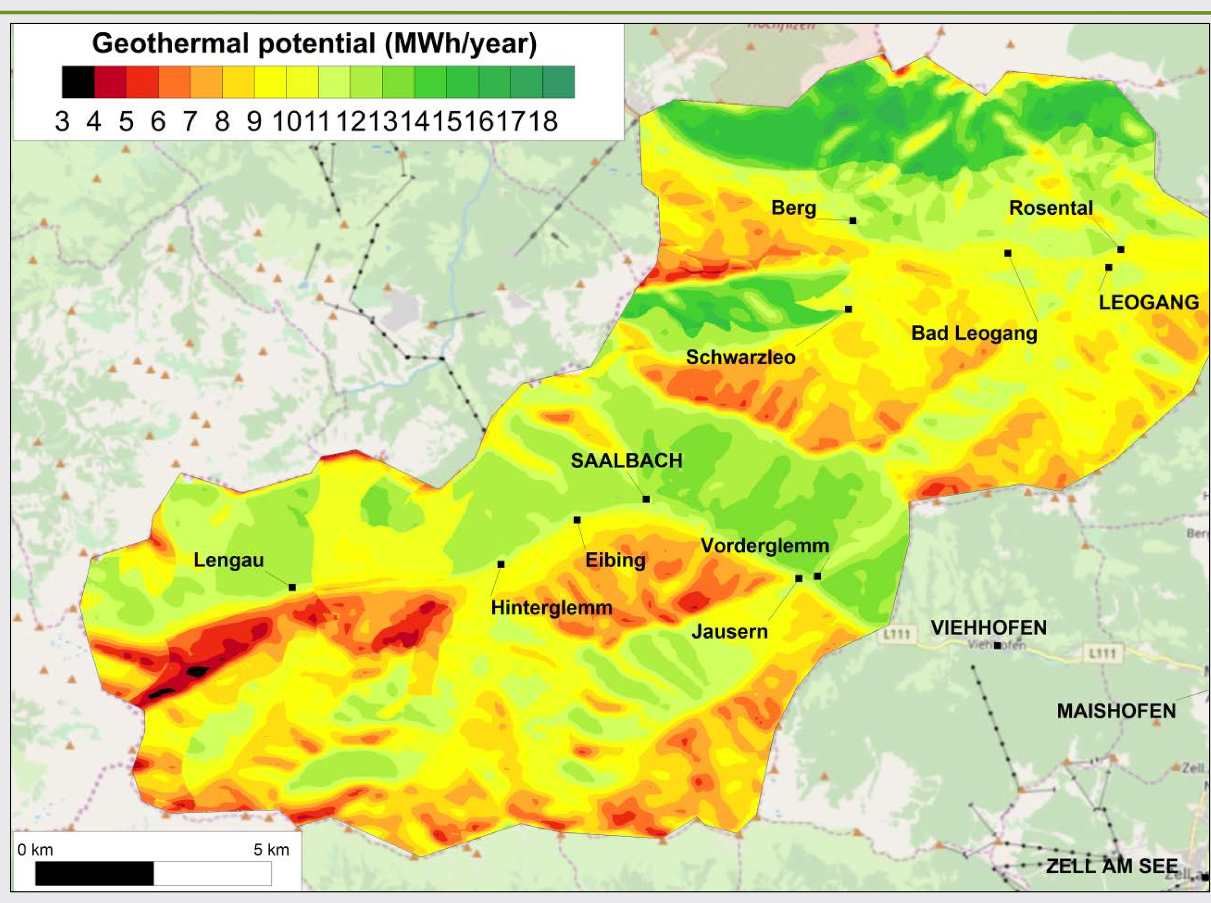


RESULTS – GEOTHERMAL POTENTIAL MAPS

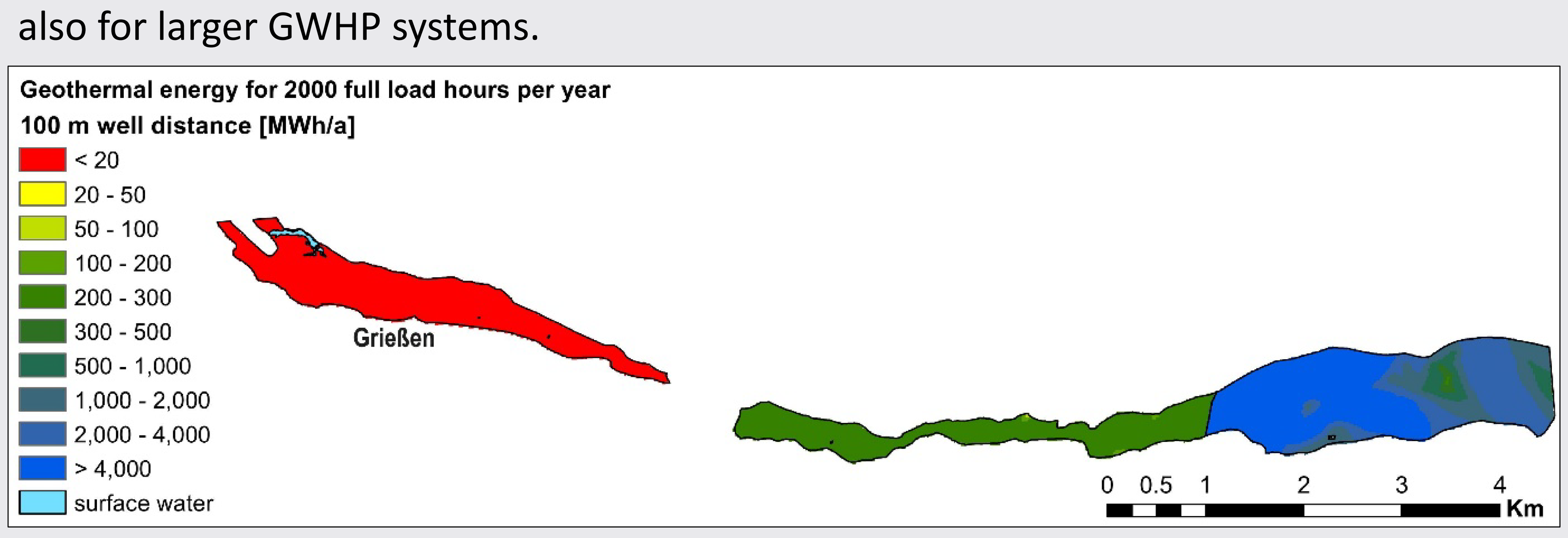
All maps are downloadable via https://areeweb.polito.it/ricerca/groundwater/zip/GRETA_NSGE_potential

The main results of this study are two maps, indicating the **potential for closed- and for open-loop installations**. The calculations were carried out by TUM (Technical University of Munich) and POLITO (Politecnico di Torino) using the G.POT method for closed-loop and a method developed by TUM in collaboration with POLITO & ARPA VdA for open-loop. The common outputs are maps of geothermal potential expressed in MWh/y.

Spatial distribution of closed-loop potential
The effect of ground temperature is quite clear, as southward-oriented slopes exhibit ground temperatures of about 8-10°C, while northward-oriented slopes are much colder (about 2-7°C). On the other hand, the thermal conductivity exhibit a much lower spatial variability, with most of the surface lying in the range 2-2.8 W/(mK).
For this reason, the highest values of geothermal potentials are found in the lower, southward-oriented side of the valleys of Saalbach (12-13 MWh/y) and of Leogang (9-12 MWy). Much lower values are found in the northward-oriented slopes, ranging between 4 and 9 MWh/y.



Spatial distribution of open-loop potential (Leogang): The W part offers low suitability for thermal use due to low aquifer thickness (3 m) and a hydraulic conductivity of only $1 \cdot 10^{-4}$ m/s. The middle part offers moderate conditions. Especially larger systems would be limited by the significant drawdown in the 7 m thick aquifer. The W part offers high aquifer thickness of 20 m and good hydraulic conductivity of $2 \cdot 10^{-3}$ m/s and is combined with a high hydraulic gradient, and therefore offers quite suitable conditions also for larger GWHP systems.



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