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The analysis of temperature-related parameters in air, vadose zone and groundwater: the Mezzi Po test site (NW Italy)

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The shallow subsurface temperature (<20 m b.g.l., below ground surface) can undergo significant spatial and seasonal variations due to the large number of factors affecting it, such as climate and land use. The most direct relation occurs with air temperatures, that propagate into the subsurface by conduction mechanisms. Besides, it is known that the advective heat transport, due to the groundwater flow in aquifers, the rainfall-related temperature variations and the soil thermal properties play an important role.

To reach a deeper understanding of the phenomena affecting the subsurface temperature distribution site-specific, multi-temporal thermal investigations were carried out. The novelty of this study consists in the integrated monitoring array, which includes temperature-related parameters (air temperature, groundwater and vadose zone temperatures, soil moisture, precipitation, groundwater depth), joined to a detailed site-scale geological and hydrogeological characterization. The experimental site (named Mezzi Po test site) was implemented in the rural surroundings of Turin city, in the alluvial plain of Po River (NW Italy). The test site currently provides almost 3 years of measures.

The test site is characterized by an unconfined aquifer (8 to 18 m thick) hosted in the late Pleistocene and Holocene fluvial deposits, mainly consisting of coarse gravels with sands, except for the shallowest 2.5 m b.g.l. (silts and sands). Below, pre-Pliocene marine units constitute an impermeable bedrock.

The monitoring results show that the water table is pretty shallow and ranges between 3.5 and 5.3 m b.g.l., predisposing the aquifer to undergo significant temperature oscillations due to the groundwater proximity with the ground surface. Furthermore, the aquifer flow direction is fairly constant at site scale, WSW-ENE oriented, confirming the regional draining role of the Po River.

The relationships between air temperature and subsoil temperature, estimated by cross correlation functions, is strong but at the same time they reveal a damping and a delay of the atmospheric signal on the unsaturated (UZ) and saturated (SZ) zones. Along the monitoring period, an increased moisture in response to rainfall was recorded up to 1.50 m b.g.l.; at 3.60 m b.g.l. the moisture remains nearly constant throughout the year and is affected only by the fluctuations of the water table.

The daily average temperatures fluctuate between -3 °C and +30 °C in air, while in the UZ at 0.60 m b.g.l. the oscillations are reduced in the range 1.5-27.0 °C and the delay is some days. At 1.80 m b.g.l. the daily average temperatures range between 8.0 °C and 18.5 °C and the delay reaches 2 months. At 3.80 m b.g.l. the daily average temperatures range between 11.5 °C and 15.5 °C.

In the saturated zone (SZ) the temperature varies between 13 °C and 15 °C at 9.5 m b.g.l., with a damping of temperature fluctuations equal to 94% and a delay of around 4 months, compared to air temperatures. The trend is almost the same at 7 m b.g.l., with <1 °C variations due to different types of sensors.