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Pipes to the earth subsurface: The role of atmospheric conditions in driving air movement along a borehole connecting land surface and an underground cavity

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Understanding air dynamics in underground cavities (e.g., caves, underground storage structures, quarries, tunnels, etc.) and different types of boreholes is of great significance for the exploration of gas transport at the earth-atmosphere interface. Here, we investigated the role of atmospheric conditions on air transport inside a borehole. Two different geometries were explored in the field: a 27-m deep shaft connected to an underground large cavity and the same shaft after being disconnected from the underground cavity. The observation setup included a standard meteorological station located above the borehole and temperature and relative humidity sensors along the borehole. Absolute humidity, calculated from the measured temperature and relative humidity, was validated as a robust marker for assessing air transport inside the two shaft geometries examined. In both cases, air inflow and outflow at depths of 12 and 27 m was found to be related to changes in barometric pressure regardless of temperature instability (thermal-induced convection) or wind velocity (wind-induced convection). In contrast, these convective fluxes were found to be significant parameters driving air flow in the upper few meters. A newly developed conceptual model is presented to examine the induced airflow in both shaft geometries with the goal of improving our understanding of gas transport and its dependence on barometric pressure changes.