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Saltwater intrusion and flow reversal at the submarine spring of a Mediterranean karst aquifer: observation, interpretation and modelling

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The Vise spring is the main outlet of a Jurassic karst aquifer located close to Montpellier city, South of France. The Vise spring is submarine, occurring at the bottom of the Thau lagoon at a depht of 30 m. The lagoon, made up of brachish water is connected to the Mediterranean sea. The fresh water from the karst aquifer as a whole, and especially from the spring, contributes to the qualitative state of the Thau lagoon, which is well known for shellfish farming activities.

During the last fifty years (from 1967 to 2014), six occasional saltwater intrusions (called “inversac” in French) occurred, inversing the water flow at the submarine spring during a period varying from a few weeks to a few months. This backflooding process at the spring induces a very large saltwater intrusion into the karst aquifer. Given that this aquifer provides several highly important ecosystem services (drinking water supply for the coastal villages, fresh water to the Lagoon, thermal water to Balaruc spa and health resort), a large program of groundwater monitoring has been recently launched.

An observatory has been installed over the territory since 2019. Offshore in the Thau lagoon, the submarine Vise spring was equipped with flow recording devices as well as electrical conductivity and temperature monitoring sensors. Onshore but close to the spring, three boreholes of 45 m, 168 m and 300 m deep each were drilled near an existing thermal borehole, and a new borehole including fiber-optic distributed temperature sensing (FO-DTS) is currently under completion.

Sub-hourly observations of pressure, electrical conductivity and temperature in these boreholes and in the lagoon, as well as synoptic measurement campaigns focused on groundwater chemistry, complete a monitoring network of about twenty boreholes and springs spread accross the territory.

In november 2021, a seventh backflooding event started and is observed with the new monitoring system. From an initial flow rate of about 60 l/s from the aquifer to the lagoon through the spring, the flow inverted to about 350 l/s from the lagoon to the aquifer in a few minutes on the 28th November 2020 at 9:40 AM. This sudden backflooding created a sudden water level rise of about 2.5 meters into the karst confined aquifer. A few months later, the saltwater intrusion into the aquifer is still high, equal to 150 l/s.

A physical mechanism is proposed to explain the sudden inversion of flow and its long duration after that the event has started. The propagation of a piezometric wave through the aquifer is simulated using simple analytical solutions. A preliminary meshed model of the aquifer and its interactions with the lagoon has been developed for identifying the main processes. First attempts for proposing alert indicators are also discussed.