ThermoKarst project: Summary

Caves represent fragile ecosystems where biogeochemical processes largely depend on cave temperature. Caves also host unique environmental records whose interpretation closely depends on temperature as well. In the recent years, much interest has been dedicated to speleothems, secondary carbonate formations such as stalagmites and flowstones found in caves, for their potential to archive accurately datable paleoenvironmental information over the last ca. 0.5 Ma. Several mechanisms, including heat diffusion through the bedrock and advection from air and water fluxes, transfer energy from the surface to the cave. Depending on the relative importance of these fluxes, subsurface temperatures will be more or less attenuated and out-of-phased with respect to temperature fluctuations in the external atmosphere. Achieving a good understanding of the thermal response of karst to climate change is thus central to quantify dissolution/precipitation rates, interpret geochemical partitioning and determine impacts on organisms living in karst.

From existing studies, we formulated three hypotheses to be tested within the proposed project:

1. Air ventilation represents a dominant mechanism for heat transfer in karst massifs;
2. Thermal reaction time in caves depends primarily on advective fluxes (water and air) rather than heat conduction;
3. Heat exchanges are sufficient to produce a significant amount of condensation water in karst, at least in some circumstances.

The aim of this project is therefore to produce a founded assessment of heat and mass transfers in karst systems in order to address these questions. In particular, we want to test how climate changes propagate into the subsurface and determine the thermal response of a cave system at different spatial and temporal scales. A simplified global model of karst massifs will be set up in which the karst system will be divided into sub-systems (bedrock, conduits, epikarst...). Heat transfer by conduction and advection (water and air) in matrix rock and conduits will be fully coupled. However, the effect of 1) forced air ventilation through cave passages, or 2) through epikarst, are not well constrained by field data, making their modelling very uncertain. Field and modelling investigations will thus focus on these two aspects in this project.

To achieve this objective SISKA, specialist of karst environments, will benefit of the support of the FAST laboratory, specialized in modelling heat and mass transfer. Two work packages will be worked out in parallel, one on the modelling aspects and the other one on field data. At the beginning a parametric study ("*initial model*") will be carried out with simplified analytical models in order to assess orders of magnitude of the respective processes under various conditions. This will be used for refining the setup of a numerical global model (WP1) and the field data acquisition (WP2). Both work-packages will be iteratively synthesized all along the project in order to be able to discuss the three hypotheses at the end of the project. Two main sites will be instrumented including the Milandre Cave Laboratory (MCL), where a large set of data is already available. The sites will be instrumented for temperature monitoring along with control parameters for mass transfers including air, water, CO_2 and radon fluxes.

A team of two PhD-students is needed for setting up the monitoring in the field and developing the modelling skills and tools necessary for this project. Senior researchers from ISSKA and FAST will actively support them for establishing procedures and make pragmatic decisions to solve challenges along the project.

The project will thus bring new information about the time-response of karst to climate change, about the intensity of the ventilation of karst massifs, and about the significance of condensation water to aquifer recharge.

Results anticipated from this research will also provide essential data for several further domains: **Freshwater supply** (temperature variations at karst springs), **Public health** (radon exhaled in houses), **Speleogenesis** (condensation corrosion), **Permafrost** (ice caves), **Geothermal heat abstraction and storage** (effect of conduits on heat exchange), **Tunnelling and mining** (prediction of voids and water inrushes in underground constructions), **Remote sensing**: (interpretation of thermal anomalies), **Cave conservation** (protection of archaeological and show caves), **Carbon cycle**: (carbonate dissolution and precipitation is controlled by pCO_2, un turn by ventilation), **Cave biology** (conditions for underground habitats)…

Results of the proposed project will thus become a milestone in the understanding of heat transfer in carbonate rocks.