Monitoring floods and snow cover in the Dinaric karsts (Balkans) using InSAR time-series coherence data.

Internship (M1 or M2, to be discussed) to be filled during the 2026–2027 academic year

Supervising team and host laboratory:

The internship will be supervised by Zoé Dubois (Ph.D. candidate, zoe.dubois@univ-lyon1.fr), Marianne Métois (Assistant Professor, marianne.metois@univ-lyon1.fr), and Cécile Lasserre (Research Director, cecile.lasserre@univ-lyon1.fr).
The student will have an office at the Doua campus (Lyon 1 University).

Context and objectives:

The Dinaric karsts in the Balkans are among the most iconic in the world. World-renowned for their breathtaking limestone landscapes and impressive hydrological network (including numerous caves over 1,000 m deep!), they are also extensively studied by hydrologists, particularly in relation to issues of access to water resources and hydroelectric potential in this region, which faces significant tourism pressure.

Within the karst massifs of the Dinaric Alps lie numerous poljes—vast, flat-bottomed depressions surrounded by slopes typical of karst topography—which are regularly flooded, either partially or entirely. The extent and duration of these floods serve as an excellent proxy for hydrological forcing and its timing in areas where continuous monitoring data are not readily available.

Radar interferometry (InSAR) is a satellite imaging technique based on measuring the phase difference between radar images acquired during successive satellite passes over the same area. InSAR coherence reflects the similarity (in amplitude and phase) between two radar images: high coherence thus indicates a certain similarity in ground properties and the satellite-to-ground distance between two acquisitions, whereas low coherence is a sign of change. By combining data acquired over time, it is possible to generate time-series coherence maps from InSAR measurements. Coherence is often used as a proxy for the quality of these InSAR measurements, but it can also serve as a parameter conveying more specific information. Amani et al. (2021) use it to categorize Canadian wetlands, while Nakaein et al. (2021) use it to classify land cover in São Paulo. There are also known applications for monitoring dunes (e.g., Mazoni et al., 2021), volcanoes during eruptions (e.g., Moore et al., 2019), and glaciers (e.g., Eldhuset et al., 2010). Gaudaré et al. (2026) were the first to use coherence time series to study flood pulses in the Okavango Delta (Botswana), by detecting changes in these time series.

Since 2023, the geodesy team at the Laboratoire de Géologie de Lyon has been analyzing InSAR data across the entire Balkan Peninsula, acquired by Sentinel-1 satellites and processed by the FLATSIM service of the FormaTerre Solid Earth cluster, operated by the French National Center for Space Studies (CNES) (Thollard et al., 2021). To date, we have focused on displacement time series to study the region's tectonics (Meridi et al., 2026) and interpret their seasonality, particularly in relation to hydrological processes (Zoé Dubois's PhD thesis). Since these processes closely affect temporal coherence, a study of coherence time series (notably the periods and spatial extents of polje flooding and snow cover) appears to be complementary and shows great potential for deepening our understanding of the specific hydrogeology of the Dinaric karsts.

Data :

The coherence time series to be analyzed are derived from the processing of Sentinel-1 radar image time series provided by the FLATSIM service (Thollard et al. 2021). They are among the ancillary products provided by the service, whose primary objective is to produce displacement time series over large geographic areas. The temporal coverage of these data extends from 2014 to 2025.

These time series can be compared with the displacement time series processed by FLATSIM as well as with meteorological data from the Croatian Meteorological and Hydrological Institute (https://meteo.hr/index_en.php). Cross-referencing with elevation or land cover data (both Copernicus products) or snow masks will also be relevant.

Suggested tasks:

Depending on the student's progress, interests, and initial results, several areas of focus will be addressed:

- Study area: Initially, the student will focus on one InSAR track, and within that track, on an area where known floods have been recorded and mapped.
- Methodology: Extraction of temporal coherence time series using the code by Louis Gaudaré (2026). Visualization and cartographic representation of these time series. Students may choose to represent them as a "cube"—that is, a sequence of coherence maps at each time step—or to represent trends (phase, amplitude) based on the approach of Gaudaré et al., 2026.
- Hydrogeology: Identify temporally flooded areas based on temporal coherence and map them. Estimate the duration and extent of these floods. Interpret them in relation to karst processes and/or human-made structures (dams, water pipelines, etc.).
- Snow cover: As with floods, identify snow cover based on temporal consistency data and, if possible, map it (start and end dates, duration of snow cover).

Tools and skills:

The student will work primarily in Python. The code developed by Louis Gaudaré to process coherence time series can serve as a foundation. The use of cartographic visualization tools (QGIS, Python, or others) will be required (QGIS is an easy-to-use software for simple tasks; training in its use can take place during the internship).

An interest in geophysical data processing and interpretation is, of course, required. Autonomy and the ability to take initiative are valued.

References:

Gaudaré et al. 2025. https://doi.org/10.1016/j.rse.2025.115173

Meridi, A., et al. 2026 https://doi.org/10.1029/2026JB033831

Thollard, F., et al. (2021). https://doi.org/10.3390/rs13183734

Amani, M. et al. 2021. https://doi.org/10.3390/rs13163315

Eldhuset, K., et al. 2003. doi:10.1080/01431160210153039.

Manzoni, M et al. 2021. https://doi.org/10.3390/rs13071362

Moore, C. et al. 2019. https://doi.org/10.1029/2019GC008692

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