Monitoring the Hydrosphere and Cryosphere Using Distributed Acoustic Sensing

Yan Yang
Seismological Laboratory, Caltech

Distributed Acoustic Sensing (DAS) is an emerging technology that can repurpose existing fiber-optic cables into dense arrays of seismic sensors. With dense spatial sampling and continuous long-term recordings, DAS enables detailed studies of the near surface at unprecedented spatiotemporal resolution. This technology can address challenges in studying the environmental processes in the hydrosphere (soil moisture, groundwater) and cryosphere (glaciers, permafrost) such as deploying and maintaining observational systems with adequate coverage, duration, and sensor density. In this talk, I will show how DAS can be applied to environmental monitoring through two examples. The first example uses a telecommunication fiber-optic cable in Indian Wells Valley, California, to monitor soil moisture dynamics in the vadose zone under varied climatic conditions. We show that DAS effectively captures responses to precipitation and droughts, aligning well with in-situ soil moisture sensors and hydrological models. The second example uses a fiber-optic cable at the Amundsen–Scott South Pole Station to characterize the firn structure, a critical factor in accurately estimating ice sheet mass balance. We also show that year-round DAS data can precisely track firn density changes at the South Pole. These results highlight the vast research potential at the intersection of fiber-optic seismology, hydrology, and glaciology, demonstrating how DAS is paving new paths for enhanced understanding and monitoring of diverse environmental phenomena.