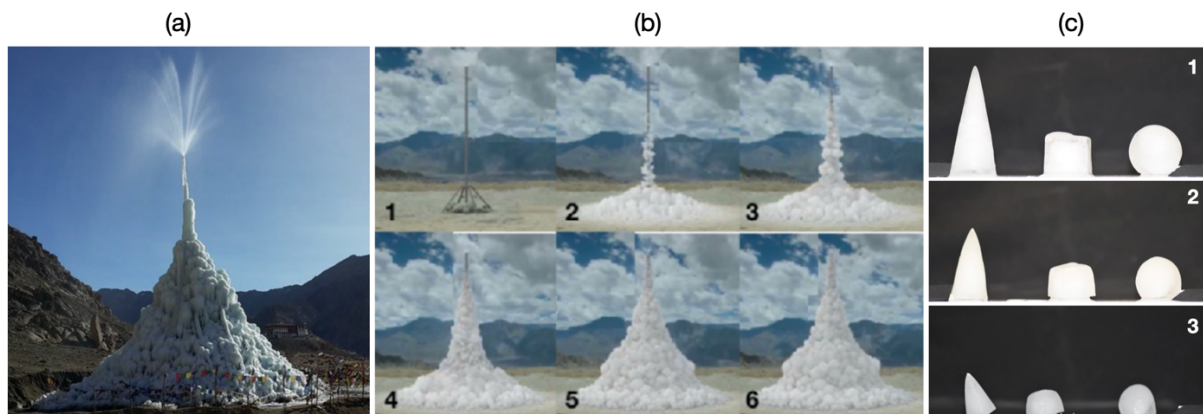


M2 Internship 2024-2025:  
**Ice stupa formation and melting**  
LadHyX, Ecole Polytechnique, IPParis

**Context:** Ice stupas illustrated in Figure 1(a) are artificial glaciers defined by their inventors (the Ice Stupa Project) as “economical reservoirs of water for desert lands”. Their structure resembles a huge pyramid of ice (typically 40 m high and 20 m large), obtained by freezing small droplets of water. Their design allows a slow melting during spring and summer, ensuring a sustained water supply for agricultural purposes.



**Figure 1:** (a) Photograph of an ice stupa in Ladakh. (b) Snapshots of the growth of an ice stupa. (c) Three snapshots of experiments showing the melting of ice objects a few centimeters in size and a variety of shapes (cone, cube, sphere) over time.

**Goals:** During the internship, the first objective will be to produce experimental meter-size ice stupas in the cold chamber of the lab by spraying water droplets vertically onto a cold substrate in a cold atmosphere. The shapes obtained will be monitored over time, and the effect of various parameters such as flow rate, temperature, and size of droplets will be studied. A phase diagram of the observed ice structures will be constructed, and the processes by which these ice structures form will be studied theoretically. By alternating cold and warmer periods, certain melting patterns such as those shown in Figure 1 (a) at the centimetre scale will be reproduced and studied. In the second stage, the optimal shape for delaying the melting of an ice object will be investigated. The melting time and the successive shapes of an initial object will be explored both experimentally and theoretically, taking into account thermal convection, diffusion, and radiations.

**Profile:** Candidates should have a good background in fluid mechanics and phase transitions. A strong interest in both experiments and theoretical analysis will be welcome. Depending on the candidate, the internship may be followed by a PhD thesis on the morphogenesis of ice structures.

**Contact:** Caroline Cohen, LadHyX, [caroline.cohen@polytechnique.edu](mailto:caroline.cohen@polytechnique.edu)