Exploring Planetary Lakes

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1. Project Overview – The Planetary Lake Lander project (PLL) is funded by the NASA (ASTEP) Program. It deploys an adaptive robotic lake lander in the Central Andes of Chile where ice is melting at an accelerated rate. Deglaciation subjects lakes to interannual variability and impacts metabolic activity and biogeochemical cycles, lake habitat, ecosystem, and biodiversity. Documenting the deglaciation process contributes to a better understanding of the changes affecting Earth's glacial lake ecosystems here and now, and may shed light on how life adapted during past deglaciations. From an astrobiological perspective, it brings new insights into the evolution of Mars habitability during comparable geological periods, and into its remote and *in situ* signatures. Further, the robotic exploration of lakes confronts us with challenges analogous to those faced by future planetary missions to Titan's lakes and seas.

2. Astrobiology Science – The Impact of Deglaciation on Planetary Lake Habitats. During the 2011 and 2012 field campaigns, PLL characterized the physical, geological, and biological environment of Laguna Negra (33.65S - 70.13W) a 6-km large, 1.7 km long, and 300 m deep glacial lake. Time series show changes in precipitation, temperature, and relative humidity over the past decades. Meteorological stations and stream gauge track daily and seasonal changes at high resolution. Data are correlated to daily vertical profiles performed by the lake lander to monitor physicochemical changes, and show the impact of melting ice on microbial organisms type, abundance, and migration over the water column. Bathymetric surveys reveal the bottom topography, and isolated habitats. Light profiles show exceptional transparency: Damaging UV reaches down to 15 m below the surface; Video exploration down to ~200 m depth shows that complete light extinction does not occur before ~100 m. Critical thermal transitions as well as turbididy and light changes occur between 15-25 m. Changes in archea and bacteria populations are observed from 0-20 m. Water column and sediment samples collected are analyzed by sandwich microarray immunoassays, and by cloning and sequencing bacterial and archaeal 16SrRNA gene. Biomarker and microbial profiles are obtained by using a Life Detector Chip (LDChip450), extracellular polymers, exopolysaccharides, universal biomarkers like DNA, amino acids, and other biomolecules.

3. Remote Sensing Signatures of Deglaciation – Most dominant spectral units around the lake have been defined in ASTER near- and thermal infrared orbital imagery, and their texture defined using ground FLIR thermal imagery. Twenty-four time-lapse thermal videos show changing surface temperature conditions around the lake, which are controlled by solar radiation, surface moisture content, grain size, slope, and/or geology. Regular monitoring of changes in these signatures provides a method to remotely survey the impact of deglaciation on habitats, and provides a regional perspective to changes in the lake ecosystem.

4. Technology Pathways to Planetary Lake Exploration. PLL ultimate goal is to develop and field test operational scenarios relevant to future missions to Titan. It carries a science payload comparable to that of the Titan Mare Explorer (TiME) mission project. During the first two field campaigns, we generated an environmental database to baseline the adaptive system that will be used in 2013 by the lake lander to autonomously explore the lake. The results will help us obtain the first quantification of science return and operational constraints of such mission. It will provide critical information on where adaptive science and system can maximize mission productivity. Adaptive science is currently being designed and developed for onboard and off-board operations, and data analysis and management. Adaptive sampling capabilities should allow the lake lander to make decision on its own about the nature of changes it observes in the lake (e.g., temperature and turbidity), and to decide what sampling templates and data rates to utilize to document these changes. Ultimately, PLL aims at producing a new generation of robots that can accumulate knowledge about their environment; understand mission priorities, and the concepts of nominal and off-nominal environmental conditions; and make and evaluate observations as events happen *in situ*, and not only when receiving commands from Earth. PLL is a first step toward planetary robot awareness and decision-making without constant human oversight. Finally, PLL uses an Exploration Ground Data Systems (xGDS) developed at NASA Ames to handle science data.