

## PLANETARY LAKE LANDER: USING TECHNOLOGY RELEVANT TO TITAN'S EXPLORATION TO INVESTIGATE THE IMPACT OF DEGLACIATION ON PAST AND PRESENT PLANETARY LAKES .

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**Project Overview.** The Planetary Lake Lander project (PLL) is deploying and remotely operating a lake lander to gain operational experience that will help us better understand the technology and payload necessary, possible system constraints, and to develop solutions to overcome design issues for future lake lander missions. PLL's scientific mission in Chile is focused on the study of deglaciation. Disrupted environmental, physical, chemical, and biological cycles challenge us to identify newly emerging natural patterns and to find the most productive methods to interrogate them rapidly. In many ways, the rapidity of Earth's deglaciation confronts us with the same operational scenario as a planetary mission faced with only limited time to understand the environment and achieve its objectives. The priority for all time-, bandwidth- and often power-constrained planetary operations is to return the most informative data [1-2]. To maximize return, such missions would greatly benefit from intelligent, adaptive systems that can rapidly establish environmental baseline, track changes as they happen, adapt their data collection rate to monitor them, and prioritize data return. Such systems would be applicable to a vast array of planetary missions by improving the ability of any robots to make decisions on their own between command cycles.

Here, we will present an overview of the science and technology objectives of PLL, and a summary of the activities that accompanied the first field deployment in Laguna Negra, Central Andes of Chile, between November 26-December 16, 2011.

### **Science Goal – Planetary Environmental, Habitat, and Life Signatures of Rapid Deglaciation.**

Chile has one of the world's largest sources of glacial water mountain glaciers, ice and snow fields. Their second largest concentration is in the Central Andes south of 30°S. Due to increasing temperatures and changes in other environmental factors promoting deglaciation, most glaciers are rapidly retreating [3-12]. One of the consequences is the formation of numerous new lakes. In the current regime, precipitation is low in austral summer while runoff is at its maximum. The mechanism for this asynchronicity is water storage as snow and ice during winter, and its release through melt in summer. The sustainability of the system de-

pends on the balance between ice accumulation, ablation, and melting rate [13]. Changes in climate regime are fast altering this balance. As ice is not replenishing upstream, another consequence is the declining level of many glacial lakes where glaciers have already receded substantially, or simply disappeared.

Through a multidisciplinary approach, PLL collects critical data on how this process is affecting habitat, limnology, biodiversity, biogeochemical cycles, and ecosystems response. It seeks to identify, monitor, and characterize (a) key environmental changes and their signatures, and (b) their implications for life and habitat. Achieving this goal can provide (c) a better understanding of the magnitude and types of environmental fluctuations associated with deglaciation, (d) a quantitative and qualitative description of the response of ecosystem and habitat, and (e) elements to draw planetary analogies with Mars' and Earth's past.

Beyond Earth, the existence of ancient glaciers and lakes on Mars is now supported by multiple lines of evidence [e.g., 14-17]. It is, thus, likely that Mars experienced a similar process repeatedly throughout its history. As a result, the research carried out by PLL can also give a window in time showing the rapidity and types of physical, chemical, and possibly biological processes that could have taken place on Mars during similar climate transitions. This can inform us on life's adaptation potential, and gives us pointers on how to recognize the geological, mineralogical, and biological signatures of past deglaciation on Mars, and where to sample.

### **Technology Goal - Lake Lander and Adaptive System: A Path to Planetary Sentinel Probes.**

PLL's overarching technology mission is to deliver the first field demonstration of a planetary lake lander with complete system and analog payload. An alien seaward-bound mission [18] will be a first, with no background data. A central component is to further the science and technology productivity of such mission by: (1) providing critical background to help obtain the best science and mission performance through hands-on experience, (2) realistic simulations, and (3) the production of science operational templates for various stages of this new type of missions. The end-product will be a unique reference dataset for future mission

operations on Titan. This dataset will shed new light on the severe impact of deglaciation on Earth by simultaneously quantifying the domino effect of environmental changes from the atmosphere to the water column. Additionally, the field campaigns will enable the testing of adaptive science operations and demonstrate gain in science return using a lake lander with ever increasing decision-making capabilities.

### Goal C – Effective Field and Remote Planetary Data Collection & Distribution.

Distribute and display geospatially tagged data to a dispersed science team through a web browser with a Google Earth interface including: remotely sensed data, lake lander sensor data, ground based images, field notes, and map overlays. Goal C seeks to enable both the real time integrity evaluation of collected data, and speed up data analysis and collaboration across a geographically distributed team of investigators, including during field campaigns.

### Goal D – Education and Public Outreach (Yr1).

(1) Document the PLL deployment and the science and technology developed through Short Educational Videos (SEVs), whose overall theme is to highlight NASA’s far-reaching question of “What’s Next?”. (2) Engage the imagination of the public with through the SEVs, web-based articles, blogs (<http://pll.seti.org>, Astrobiology Magazine), and social media postings (e.g., Facebook).

### References

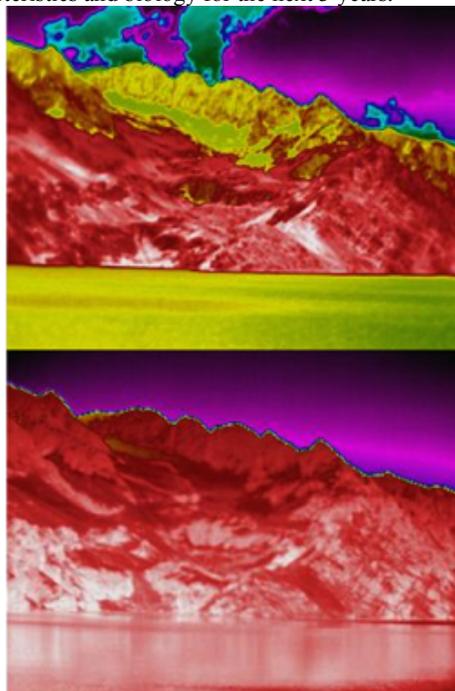
[1] Thompson et al. 2009, White Paper, for review by the Planetary Science Decadal Survey, September 15, (2009); [2] Hayden et al. 2010, *AI in Space*; [3] Haeberli et al. 2002, *WMO Bulletin* **51/1**, 18-25; [4] Diaz 2003, *Climate Change*, **59**, 33-52; [5] Favier et al. 2004, *Jour. Geophys. Res.*, **109**, D18105; [6] Coundrain et al. 2005, *Hydrological Sci. Jour.*, **50**, (6): 925-932; [7] Bradley et al. 2006, *Science*, **312**, 1755-1756; [8] Knight 2007, *Glacier Science and Environmental Change (First Edition)*, Blackwell Science Ltd; [9] Rivera et al. 2007, *Global and Planetary Change*, **59**, 126-137; [10] Schneider et al. 2007, *Global and Planetary Change*, **59**, 87-100; [11] Vuille et al. 2008, *Journ. Geophys. Res. Let.*, **108** (D6), 4147; [12] Zemp 2009, *Annals of Glaciology*, **50**, 101-111; [13] Casassa et al. 2007, *Global and Planetary Change*, **59**, 1-9; [14] Neukum et al. 2004, *Nature*, **432**, 971-979; [15] Head et al. 2005, *Nature*, **434**, 346-351; [16] Forget et al., 2006, *Science*, **20**, 311, 368-371; [17] Cabrol and Grin, Eds., 2010, *Lakes on Mars*, Elsevier, 408 p; [18] Stofan 2009, E. Titan Mare Explorer (TiME). Presentation to the NASA Decadal Survey.

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**Figure 1.** PLL towed to its position on Laguna Negra (33°39S/70°07W) in December 2011. The lake is 6 km x 2 km large and 300 m deep. PLL carries a meteorological station and a multisensor probe to monitor the lake physical characteristics and biology for the next 3 years.



**Figure 2.** Laguna Negra and the Echaurren Glacier. As part of the ground science, a FLIR thermal infrared camera observes the Echaurren glacier over 24-hr periods (Top: 15:11; Bottom: 04:11). Echaurren melting ice feeds Laguna Negra. The glacier has been receding rapidly in the past decade and is now perched on a hanging valley. The goal of this experiment is to characterize the thermophysical properties (thermal inertia and albedo) using a combination of images of diurnally collected images and visible wavelength images, then use these properties as input in thermal model of glacial stability.