Measuring Water Level Fluctuations of Two Connected Wetlands in the Dominican Republic Using InSAR

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Introduction

Wetlands are ecosystems of high endemism and great biodiversity. InSAR can provide the high spatial resolution of ground deformation over a large area that more traditional terrestrial-based methods lack.

In this research, we applied InSAR to study the seasonal variations in water level of the wetlands near two lakes in the southwest of the Dominican Republic: Lake Enriquillo, a highly saline lake designated as a Wetland of International Importance under the Ramsar Convention in 2002, and Laguna del Limon (Fig. 1).

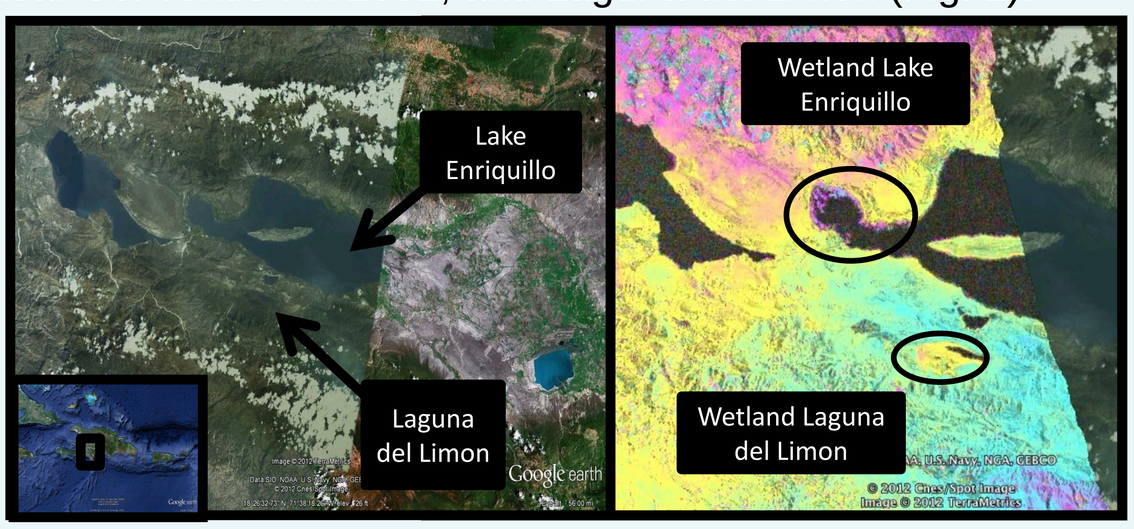

Fig. 1 Google Earth image showing area of study and an example of an interferogram showing the lake level change in the wetlands.

Methods

Using the double-reflected radar waves off the water surface and trunks of inundated vegetation, Interferometric Synthetic Aperture Radar (InSAR) is capable of measuring water level fluctuations from space at a cm-level accuracy in these ecosystems with emergent vegetation (Fig. 2).

We used the data acquired by the Phased Array type L-band Synthetic Aperture Radar (PALSAR) sensor on board of the Japanese Advanced Land Observation Satellite (ALOS) from October 2008 to January 2011. We used two different satellite paths overlapping the region of interest to minimize errors and confirm our measurements (Fig. 3).

Wave phase is wrapped into intervals (-π,+π), so a necessary step is phase unwrapping which means adding the correct number of cycles to get the real deformation. The small number of pixels from which we can estimate lake level in the Enriquillo Lake makes this data prone to error when applying the unwrapping algorithm. Assuming that there are two cycles error in the data obtained from the big lake, and after subtracting this phase difference from the data we get a time series mimicking the lake level estimate made by Luna and Poteau [2] as shown in figure 4.

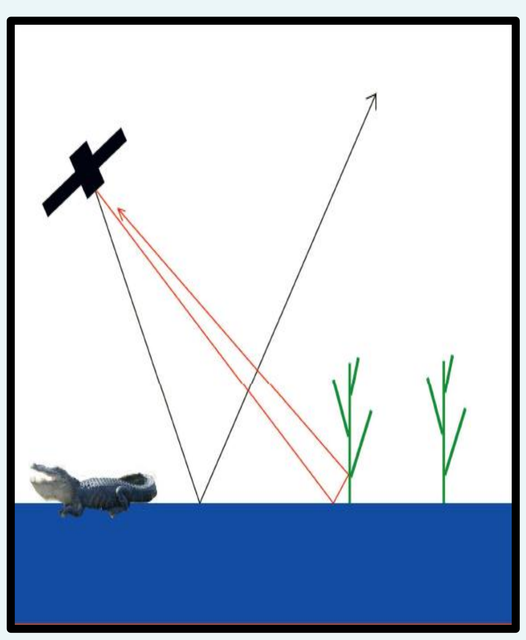

Fig. 2 shows the double bounce effect [1,3]

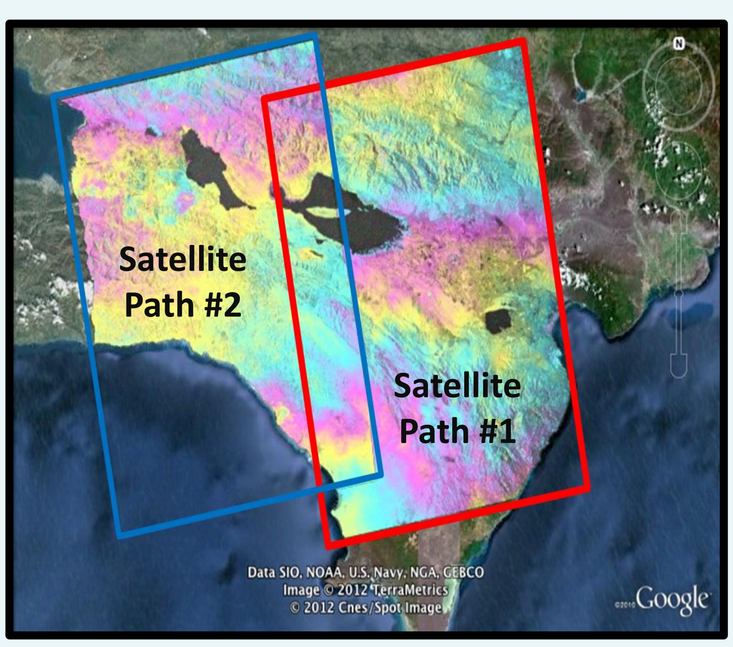

Fig. 3 shows the interferograms from the two different Path overlapping in the desired region

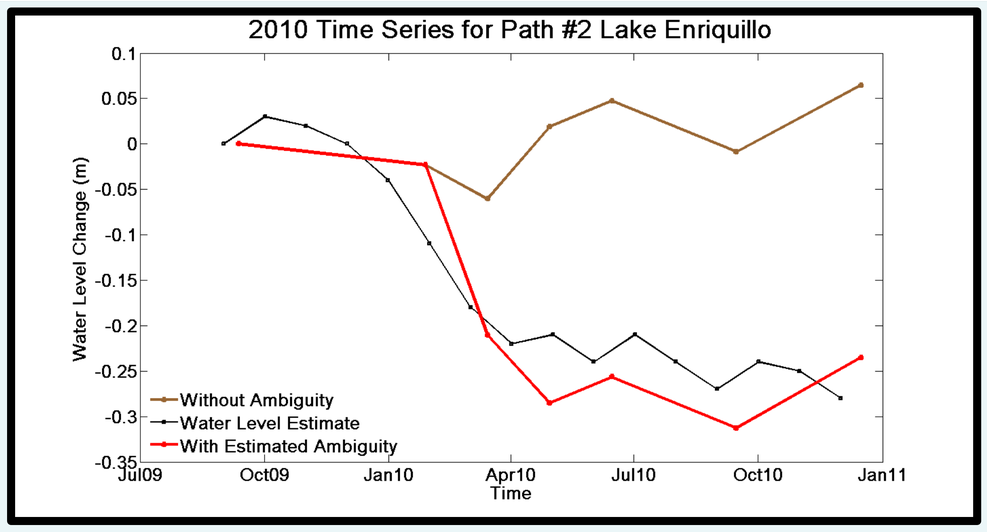

Fig. 4 shows Lake Enriquillo data before (brown) and after (red) subtracting the cycles due to estimated unwrapping error in the measurements

Results

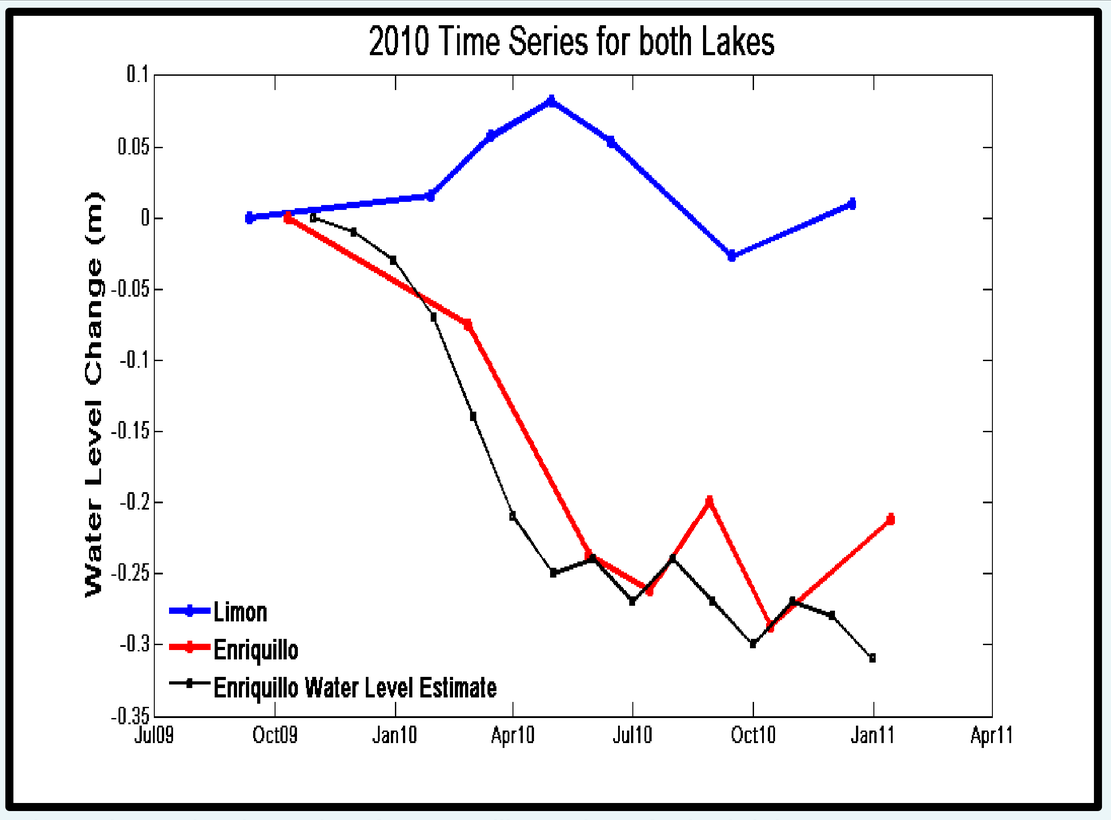

Fig. 5 shows the data taken from satellite path #1 for both lakes

- For Laguna del Limon: Seasonal variation of 10-15 centimeters. Confirmed using two different satellite paths (Fig. 5).
- For Lake Enriquillo: Decrease in water level of about 20 centimeters in the water level from September 2009 to January 2011. This result agrees with an independent estimation based on lake hydrodynamics model predictions (Fig. 5).
- Our InSAR-based time series of lake level fluctuations revealed distinct behaviors of the two wetlands. For example, opposite behavior during summer months.

Conclusion

The results obtained in the study mainly demonstrate that InSAR is an effective way to measure water level fluctuations at wetlands in this region. The same method could be applied to other wetlands in the area to fully understand the complex hydrology of the connected wetland systems and the impacts of the hydrological changes on the environment and local human community.

Acknowledgments

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References

[1] Alsdorf, D. E., J. M. Melack, T. Dunne, L. A. K. Mertes, L. L. Hess, and L. C. Smith (2000), Interferometric radar measurements of water level changes on the Amazon floodplain, Nature, 404, 174–177.

[2] E. Romero Luna and D. Poteau, 'Water Level Fluctuations of Lake Enriquillo and Lake Saumatre in Response to Environmental Changes", MA thesis. Cornell University, 2011.

[3] S. Wdowinski, S.-W. Kim, F. Amelung, and T. Dixon, "Wetland InSAR: A new space-based hydrological monitoring tool of wetlands surface water level changes," in *Proc. GlobWetland Symp.*, 2006