Integrated Analysis of Interferometric SAR and Radar Altimeter for Quantifying Absolute Water Level Changes and Wetland Dynamics

Wetlands cover at least 4% of Earth’s land surface and up to 20% of humid basins, but are represented poorly or not at all in most global climate models. Coastal estuaries, which connect coastal ocean, wetlands and land region, play important roles in ecosystems in terms of habitat for fish and wildlife, and flood control by absorbing and reducing the storm-water velocity. Accurate measurement or modeling of wetland-wide water level changes, its varying extent, its storage and discharge changes resulting in part from sediment loads, erosion and subsidence are fundamental to assessment of hurricane-induced flood hazards and wetland ecology, for example, in the coastal Louisiana wetland and the Florida Everglades in N. America, and in Helmand River, Afghanistan. Interferometric Synthetic Aperture Radar (InSAR) has been used to detect relative water level changes in wetlands. While representing an innovative technology to observe high-resolution (~40-m) differential water-level changes within a wetland, InSAR alone cannot measure absolute water-level because the InSAR phase value, which is ambiguously measured modulo $2\pi$, is a relative measurement. Thus, absolute (geocentric) water-level measurements at locations within the interferogram are necessary to convert the InSAR data into an absolute observation. Coherence analysis of InSAR pairs suggested that the HH polarization is preferred for this type of observation, and polarimetric analysis can help to identify double-bounce backscattering areas in the wetland. In this study, we use ENVISAT radar altimeter-measured 18-Hz (along-track resolution of 417 m) water level data processed with regional stackfile method have been used to provide vertical references for water bodies separated by levees in the wetlands. The high-resolution (~40 m) relative water changes measured from ALOS PALSAR L-band and Radarsat-1 C-band InSAR are then integrated with ENVISAT radar altimetry to obtain absolute water level in the Louisiana wetland. The resulting water level time series were validated with in situ gauge observations within the swamp forest. We demonstrate that this new technique allows retrospective reconstruction and concurrent monitoring of water conditions and flow dynamics in wetlands, especially those lacking gauge network, like the Helmand River basin, Afghanistan.

Co-Authors:
Jin-Woo Kim, C. K. Shum, Motomu Ibaraki, Hyongki Lee, Sang-Ho Baek, Faisal Hossain, John W. Jones, Zhong Lu