Space-borne Synthetic Aperture Radar (SAR) and Geophysical Applications: Polarimetric Imaging and Monitoring of Earth's Surface Processes

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The focus of Earth Science research has recently been shifting from the traditional and classical geology and geophysics disciplines because of increasing concerns about Earth's rapidly changing environment, which is in part believed to be closely linked to anthropogenic origins. One of the effective tools for continuously monitoring the changes in global scale is the space-borne remote sensing technique. In particular, microwave remote sensing systems have become very effective and sought after tools, because of their continuous imaging and monitoring capabilities of Earth, without sun light under increasing cloud covers and unpredictable weather conditions globally.

The Synthetic Aperture Radar (SAR), or microwave imaging radar, is becoming a more sophisticated, powerful and cost effective tool for continuously monitoring changes in various Earth's surface processes, without the dependency on solar illumination or on weather conditions. The signal wavelength of SAR systems is sufficiently long, compared to the visible bands of the electromagnetic spectrum, that the phase information from backscattered SAR signal can be accurately resolved for various interferometric applications. The phase and wave number information from SAR data can be effectively resolved in both cross-track and along-track geometries, making it a unique space-borne sensor that can monitor and measure very small changes and deformation at the surface of Earth. The space-borne SAR systems can thus continuously observe the Earth's surface with very high spatial resolution independent of solar illumination or of weather conditions. These advantages have been and can be widely utilized in various Earth system science applications.

The new generation of space-borne SAR systems, including RADARSAT-2 (launched in Dec. 2007), TerraSAR-X (launched in July 2007) and ALOS (PALSAR) (launched in January, 2006), now all operate in the fully polarimetric mode. These space-borne fully polarimetric SAR systems in C-, X-, and L-bands now make it possible for us to observe the Earth's surface processes in multiple frequencies and in fully polarimetric mode simultaneously.

This paper will discuss the new space-borne SAR applications on land, tidal flats between the land mass and ocean and ocean applications, including monitoring of active volcanoes, using differential InSAR techniques, land subsidence mapping using PS-InSAR, coastal wind measurements from co-pol SAR data, soil moisture mapping, ocean current and wave imaging and measurements using ATI (Along Track Interferometry) and polarimetric decomposition theory and applications of fully polarimetric SAR data.

RADARSAT-2 (CSA, Canada), along with TerraSAR-X (DLR, Germany), and ALOS (JAXA, Japan), all provide us with a new research tool. All weather capabilities of these satellites without sun light also make them ideal tools for monitoring natural disasters such as volcanic eruptions, earthquakes and landslides, in addition to the biomass estimation and Earth's surface cover classification. A full range of new application capabilities of these new satellites in Earth system science and geophysics in general will be discussed and explored.