Rice mapping using multi-temporal imagery in Monsoon Asia

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A newly launched satellite provides good-quality cloud-free radar imagery useful for mapping rice-crop areas with an accuracy of 80%.

Rice is a major food staple in Monsoon Asia, a region covering south, southeast, and east Asia. However, with rapid increases in population and urbanization, the demand for rice production in ever decreasing areas of arable land is becoming critical. Up-to-date information about rice-planting areas is therefore important for sustainable development in this region. Because of frequent cloud cover and heavy precipitation in the rice-growing season, rice mapping on the basis of optical remote sensing is often a challenge. Synthetic-aperture radar (SAR) is a potential alternative because of its all-weather, day-and-night imaging capabilities. SAR sensors frequently acquire images at multiple frequencies and polarizations that are ideal for mapping rice-crop areas based on the dynamics of rice backscatter at different stages of growth.

In January 2006, the Advanced Land Observing Satellite (ALOS) was launched successfully by the Japan Aerospace Exploration Agency (JAXA). The onboard Phased Array-type L-band Synthetic Aperture Radar (PALSAR) acquires SAR images at a wavelength of 23.5cm, in a revisit cycle of 46 days. PALSAR operates in several modes—including fine-beam single and dual polarization, polarimetric, and scanning SAR—enabling data acquisition at spatial resolutions ranging from 6.25 to 50m, with swath widths from 70 to 360km. Because of their longer wavelength, PALSAR signals can penetrate rice canopies and provide structural information for rice and other land cover types. These features, coupled with the regional observation strategy, make PALSAR very attractive for rice mapping.

We tested the feasibility of this approach using PALSAR imagery of southeast China. Rice is often planted in paddy fields and grows in distinct stages, including transplanting, tillering, ear differentiation, heading, and maturing. Rice backscatter in SAR imagery displays higher temporal variation than other types of land cover. For example, rice in the transplanting stage exhibits low backscatter from flooded water when the rice plant is short and sparse. On the other hand, in the tillering stage the backscatter increases rapidly when more tillers emerge and develop into a denser canopy. It is slightly decreased in the late heading stage when the leaves start to dry up. Temporal variation of radar backscatter is key to mapping rice with PALSAR images.

Figure 1 shows an example PALSAR observation of Fuyang City in Zhejiang province (China). It is composed of PALSAR images (with 6.25m pixel size) acquired in three rice-growth stages, taken on 18 June (transplanting), 3 August (tillering), and 18 September 2006 (heading). Rice grows in lowland plains

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Figure 2. Class map derived from multi-temporal PALSAR images. Upland forests in mountainous areas are masked out.

and its fields are often small and fragmented by dryland crops, orchards, and human residences, a typical land-use pattern in southeast China.

Rice and other types of land cover (except upland forests) can be extracted from the PALSAR images. To reduce intrinsic speckle noise in SAR imagery, we adopted a support-vector-machine (SVM) classifier to separate rice from other classes based on their backscatter variation in the spatial and temporal dimensions. The SVM identifies a linear hyperplane that maximizes the distance between rice and any other type of land cover. Noisy pixels in the training data are not used in the process and speckle effects are therefore reduced. The PALSAR-derived land-cover map in Figure 2 reaches an overall accuracy of 80%.

Our results demonstrate that ALOS provides a good characterization of rice mapping in Monsoon Asia. Further study will concentrate on regional mapping of rice-crop areas and monitoring of rice growth, the focus of ongoing research through the ALOS Kyoto and Carbon Initiative of JAXA.

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References