R

RADARSAT-2

RADARSAT-2, the second in a series of Canadian spaceborne Synthetic Aperture Radar (SAR) satellites, was built by MacDonald Dettwiler, Richmond, Canada. RADARSAT-2, jointly funded by the Canadian Space Agency and MacDonald Dettwiler, represents a good example of public–private partnerships. RADARSAT-2 builds on the heritage of the RADARSAT-1 SAR satellite, which was launched in 1995. RADARSAT-2 will be a single-sensor polarimetric C-band SAR (5.405 GHz).

RADARSAT-2 retains the same capability as RADARSAT-1. Morena et al., 2004 For example, the RADARSAT-2 has the same imaging modes as RADARSAT-1, and as well, the orbit parameters will be the same thus allowing co-registration of RADARSAT-1 and RADARSAT-2 images. Furthermore, radiometric and geometric calibration is maintained thus permitting correlation of time series data for applications such as long-term change detection (Luscombe and Thomson, 2001).

The following features of the RADARSAT-2 system are thought to be the most significant in terms of their impact on existing and new applications.

Polarization modes. Three polarization modes: Selective, Polarimetry, Selective Single.

Resolution. 3 m ultra-fine mode and a 10-m Multi-Look Fine mode.

Programming lead time. Programming is defined as the minimum time between receiving a request to program the satellite and the actual image acquisition. Routine image acquisition planning is base-lined at 12–24 h, and emergency acquisition planning is base-lined at 4–12 h.

Processing. Routine processing is base-lined at 4 h; emergency processing is base-lined at 3 h; and 20 min for processing a single scene.

Re-visit. Re-visit is defined as the capability of the satellite to image the same geographic region. Re-visit is improved through the use of left- and right-looking capability.

Georeference. Image location knowledge of <300 m at down-link and <100 m post-processing.

RADARSAT-2 polarimetry modes

The RADARSAT-2 polarimetric capability is considered to be the most significant in terms of increasing the information content of the SAR imagery, and is subsequently discussed in more detail. To date, SAR data have been widely available from single channel (single frequency and polarization) spaceborne radars including ERS-1 and 2, JERS-1, and RADARSAT-1. RADARSAT-2 provides polarized data, and is the first spaceborne commercial SAR to offer polarimetry data.

The intent here is not to outline polarimetry theory, but to present the concepts in an intuitive manner so that those not familiar with polarimetry can understand the benefits of polarimetry and the information available in polarimetry data. Many articles are available that discuss polarimetry theory, applications, and provide excellent background information (Ulaby and Elachi, 1990; Touzi *et al*. 2004). Notwithstanding the inherent complexity of polarimetry, polarimetry in its simplest terms refers to the orientation of the radar wave relative to the earth's surface and the phase information between polarization configurations.

RADARSAT-1 is horizontally polarized meaning the radar wave (the electric component of the radar wave) is horizontal to the earth's surface (Figure R1). In contrast, the ERS SAR sensor was vertically polarized, implying the radar wave was vertical to the earth's surface. Spaceborne SAR sensors such as RADARSAT-2, ENVISAT, and the Shuttle Imaging Radar have the capability to send and receive data in both horizontal (HH) and vertical (VV) polarizations. Both the HH and VV polarization configurations are referred to as co-polarized modes. A second mode, the cross-polarized mode, combines horizontal send with vertical receive (HV) or vice versa (VH). As a rule, the law of reciprocity applies and HV ≅ VH (Ulaby and Elachi, 1990).

A unique feature of RADARSAT-2 is the availability of polarimetry data, meaning that both the amplitude and the phase information are available. The amplitude information is familiar to SAR users, but the phase information is likely new and rather nonintuitive. In its simplest term, phase can be thought of as the travel time for the SAR signal: the travel time is the two-way time between the sensor and the earth, and includes any propagation delays as a result of surface or volume scattering. It is the propagation delays and the scattering properties of the HH and VV polarization configurations that make polarimetry data so powerful.

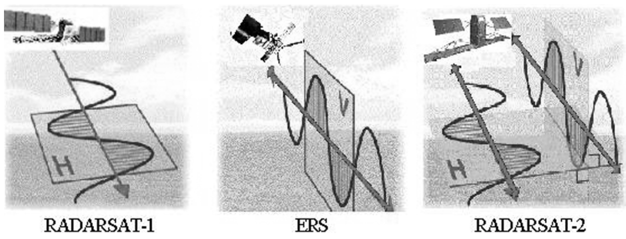

Figure R1 Orientation of horizontal (H) and vertical (V) polarization. Typical transmit and receive polarizations are HH, VV, and HV (adapted from the CCRS website).

Table R1 RADARSAT-2 modes. Beam mode name, swath width, swath coverage, and nominal resolution

	Beam mode	Nominal swath width (km)	Swath coverage to left or right of ground track (km)	Approximate resolution Rng × Az (m^2)
Selective Polarization	Standard	100	250–750	25 × 28
	Wide	150	250–650	25 × 28
Transmit H or V	Low incidence	170	125–300	40 × 28
Receive H or V or (H and V)	High incidence	70	750–1000	20 × 28
	Fine	50	525–750	10 × 9
	ScanSAR wide	500	250–750	100 × 100
	ScanSAR narrow	300	300–720	50 × 50
Polarimetry				
Transmit H and V on alternate pulses	Standard QP	25	250–600	25 × 28
Receive H and V on every pulse	Fine QP	25	400–600	11 × 9
Selective Single Polarization				
Transmit H or V	Multiple fine	50	400–750	11 × 9
Receive H or V	Ultra-fine wide	20	400–550	3 × 3

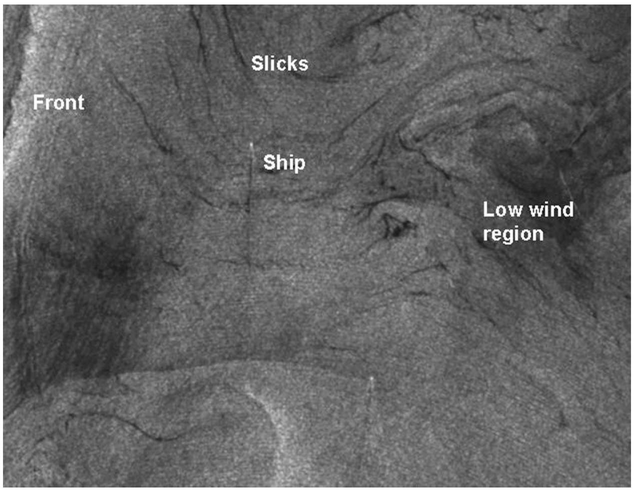

Figure R2 RADARSAT-1 SAR image acquired September, 1998 off the coast of Alaska. Typical ocean features and targets are shown. (Canadian Space Agency, 1998).

The RADARSAT-2 program has adopted the following terms to define the polarization modes (Table R1): Selective Polarization, Polarimetry, and Selective Single Polarization. Selective Polarization and Selective Single Polarization modes imply the availability of amplitude data, but no interchannel phase data. For example, amplitude data may be HH, VV, or HV imagery. In contrast, the polarimetry mode (also called quad-polarized) implies the availability of both amplitude and interchannel phase information. The amplitude information is the same as the Selective Polarization and Selective Single Polarization modes, but adds phase information, such as the co-polarized phase difference.

Marine applications

Marine applications of SAR data can be divided into three main categories: atmospheric phenomena, ship detection, and ocean features (Figure R2).

Atmospheric phenomena include the effect of large-scale atmospheric features such as hurricanes on the ocean surface. Although SAR images through the hurricane cloud-structure, the variability of the hurricane wind speed produces changes in the ocean surface-roughness that the radar detects. For example, the low-wind regime at the eye of the hurricane looks very different than the outer high-wind edges. The radar sensitivity to wind-induced roughness can also be used to map ocean-surface wind speed and direction. The use of VV polarization will be the preferred polarization configuration, largely due to a better radar response relative to HH or HV configurations.

Ship detection is optimal under low wind conditions, HH polarization, and large incidence angles. When co-polarized data and small incidence angles are used, there is increased radar return from the ocean surface, thus reducing the contrast between the ocean and the ship. The use of cross-polarized data (e.g., HV), however, enhances ship detection at small incidence angles due to the weaker return from the ocean surface, but similar return from the ship. Through the application of target decomposition algorithms, quad-polarized data can be used for ship detection and classification (Yeremy *et al*., 2001).

Ocean features include the detection of eddies, fronts, slicks, currents, surface waves, and internal waves. Radar return from the ocean surface is due to Bragg scattering. Bragg scattering is stronger for VV polarization, thus VV polarization is predominantly used versus HH or HV. The use of quad-polarized data will add significantly to the information content of the SAR imagery.

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Cross-references

Remote Sensing of Coastal Environments
Synthetic Aperture Radar Systems

RATING BEACHES

Introduction

Beaches are the number one recreational destination for Americans and Europeans, and a beach culture has developed worldwide. Nothing restores the body and soul like a stay at the beach. We are naturally drawn to the rhythmic pounding of the waves as if returning to our primordial beginnings. Recreational opportunities abound, and everyone, but perhaps children most of all, loves sand.

People are flocking to the shore in ever-increasing numbers for sun and fun. But most want much more from a beach experience—people are searching for real getaway places where they can escape from urban confinement and everyday pressures. The shore offers freedom from the

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