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GLOSSARY

ALOS: Planned for launch in 2006, ALOS is a follow-on satellite to JERS-1. The main purposes of ALOS are to produce more accurate maps of Japan and the Asia-Pacific region, to monitor natural disasters, to survey resources and to develop new technology for Earth observation from Space. ALOS has three remote-sensing instruments, the most relevant to this report being a Phased-Array type L-band (1270 MHz) Synthetic Aperture Radar (PALSAR) for day and night and all-weather land observation. The lower frequency of PALSAR relative to RADARSAT, ENVISAT and ERS provides for increased InSAR coherence in vegetated regions, but a higher susceptibility to atmospheric phenomenon.

C-Band: The electromagnetic spectrum has been categorized into several bands for reference convenience. There are a number of different band designations defined, and in particular at radar frequencies the Letter Band designation used by the Institute of Electrical and Electronic Engineers (IEEE) includes L, S, C, X, Ku, K, Ka, V, W and mm. C-Band is defined as 4–8 GHz by the IEEE.

Coherent (or phase stable) Reflector: A coherent reflector is a simple or complex surface (such as a corner reflector) from which reflected wave components are coherent with respect to each other, and thus combine to yield larger effective power than would be observed from a diffuse scattering surface of the same area. A coherent reflector will provide phase stable returns that are useful in InSAR applications.

Corner Reflector: A corner reflector is a combination of two or more intersecting specular surfaces that combine to enhance the signal reflected back in the direction of the radar. The strongest reflection is obtained when the materials are good conductors. Corner reflectors serve several purposes; in the context of InSAR they can serve as a ground control point for georeferencing and co-registration purposes and can serve as a phase stable point target to improve InSAR coherence and act as a Point Scatterer. There are several types of corner reflectors, including (but not limited to) trihedral, dihedral and active reflectors. A trihedral reflector is a passive radar calibration device made of 3 flat surfaces arranged to form a corner with the sides intersecting at 90° – hence the term "corner reflector". A dihedral reflector is a corner reflector formed by two intersecting flat surfaces that are perpendicular to each other. An active reflector (also referred to as a transponder) is a transmitter-receiver device, the function of which is to transmit signals automatically when the proper interrogation is received. Therefore, a transponder can serve the same purpose as a corner reflector.

DEM: A Digital Elevation Model is a representation of the topography of the Earth in digital format, that is, by coordinates and numerical descriptions of altitude.

DTM: A Digital Terrain Model is a representation of a surface's topography stored in a numerical format. Each pixel is has been assigned coordinates and an altitude. Digital Elevation Model (DEM) is the preferred term.

DInSAR: Differential Interferometric Synthetic Aperture Radar is an InSAR technique used to produce a ground deformation map. DInSAR is a specific application of InSAR in which topographic phase is removed using a DEM to leave only phase contributions due to ground deformation.

DTED: Digital Terrain Elevation Data is a standard for representing raster elevation data or DEM.

Coregister: Coregistration is a process of aligning two images such that coincident pixels in the image pair are produced from the same source. In the context of satellite or aerial photography, coincident pixels would represent the exact same point on the earth. The coregistration process usually involves the selection of a finite number of GCP pixels in an image and then mathematically fitting the remainder of the pixels using a least squares technique.

EROS: Besides its meaning in Greek mythology, EROS (Earth Remote Observation Satellite) also refers to a satellite constellation owned by ImageSat International N.V. As of early 2006, the first satellite in the series, EROS-A1 is in orbit operating at an altitude of 480 kilometers, and is capable of taking high-resolution pan-chromatic (black and white) pictures of an area of 12.5 x12.5 kilometers, at a resolution of 1.8 meters.

ERS: The first and second European Remote-Sensing Satellites (ERS-1 and ERS-2) were developed by the European Space Agency as a family of multi-disciplinary Earth Observation Satellites. Respectively launched in 1991 and 1995, the ERS-1/2 satellites operate in a sun synchronous polar orbit at a height of 782–785 km. They have a number of onboard sensors, the most relevant to this report being the SAR, which operates at C-Band (5.3 GHz) and nominally offers 100 by 100 km scenes at 30-metre resolution. Shortly after ERS-2's launch in 1995, ERS-1/2 were operated in tandem to provide image pairs of nominally 1 day apart to provide good coherence for InSAR topographic measurement. The ERS-1 mission ended on March 10, 2000 by a failure of the onboard attitude control system. ERS-2 has been operating without gyroscopes since February 2001, resulting in some degradation of the data provided by the instruments. InSAR applications have been especially challenging since the ERS-2 gyroscope failure although it is possible to use scenes acquired since February 2001 by a careful selection of image acquisition parameters.

ENVISAT: The Envisat (ENVIronmental SATellite) satellite is an Earth-observing satellite built by the European Space Agency. It was launched on March 1, 2002 into a Sun synchronous polar orbit at a height of 790 km. It orbits the Earth in about 101 minutes with a repeat cycle of 35 days. Envisat carries an array of nine Earth-observation instruments that gather information about the earth (land, water, ice, and atmosphere) using a variety of measurement principles. One of ENVISAT's main instruments is the advanced SAR called ASAR. The ASAR specifications are similar to ERS-1/2, with the addition of a number of new beam modes, including an alternating polarization (AP) mode and a global monitoring mode.

Flattening: In the context of an InSAR derived movement map, flattening is the process by which an interferogram is processed after phase unwrapping to remove trends in the data that are not due to ground movement. The process generally involves the a priori identification of regions or monumentation that have zero or measured movement (either through regional knowledge or site surveys) movement. Sometime trends through an image can be visually identified and removed without a priori regional knowledge.

GCPs: Ground Control Points are geographical features of known location that are recognizable on images and can be used to determine geometrical correction.

Geocoding or Georegistration: Geocoding is a geographic correction of image data to conform to a map projection. Ground control points are often used to increase the accuracy of the geocoding process. The finished product is resampled to a standard square pixel size.

GIS: Geographic Information System is a computer-based system designed to input, store, manipulate, and output geographically referenced data.

Interferogram: An interferogram is a phase image or signal produced by combining two complex and co-registered images or signals. For InSAR, two SAR images that include both magnitude and phase information are used as the basis of an interferogram.

InSAR: Interferometric Synthetic Aperture Radar is a technique involving phase measurements from successive SAR images to infer differential range and range changes for the purpose of detecting very subtle changes on or of the earth's surface with unprecedented scale, accuracy and reliability. The InSAR technique combines two complex SAR images to produce an interferogram. The phase fringes in the interferogram can be interpreted as topography or alternately as ground deformation if the topographic phase is removed from the interferogram.

Interferometric Point Target Analysis: See PS-InSAR. Point target and point scatterer can be used interchangeably in the context of InSAR.

JERS: Japanese Earth Resources Satellite is an Earth Observation Satellite used to image the global land area for national land survey, agriculture, forestry, and fishery, environmental protection, disaster protection, and coastal monitoring, etc. focusing on observation around the world and resource exploitation. It was launched into a sun-synchronous orbit in 1992 at an altitude of 568 km with a repeat cycle of 44 days. The SAR instrument on board operated at L-Band (1.275 GHz). The lower frequency of JERS relative to RADARSAT, ENVISAT and ERS provides for increased InSAR coherence in vegetated regions, but a higher susceptibility to atmospheric phenomenon. This satellite operated until 1998, and re-entered the Earth's atmosphere in 2000.

L-Band: The electromagnetic spectrum has been categorized into several bands for reference convenience. There are a number of different band designations defined, and in particular at radar frequencies the Letter Band designation used by the Institute of Electrical and Electronic Engineers (IEEE) includes L, S, C, X, Ku, K, Ka, V, W and mm. L-Band is defined as 1–2 GHz by the IEEE.

LIDAR: Light Detection and Ranging (LIDAR) is an active remote sensing system that uses a LASER light beam (instead of a microwave beam as used in RADAR) to measure vertical distance.

LCCP: The Lambert Conformal Conical Projection is a commonly used projection for large countries in the mid-latitudes having an east-west orientation. It was presented by Lambert in 1772. The Earth's surface is visualized as being a cone that has been unfolded.

Map Projection: A map projection is a systematic representation of a round body such as the Earth on a flat (plane) surface. Map projections are usually defined by a set of mathematical equations that specify for each point on the globe, one and only one corresponding point on a flat map.

NAD: There are two North American Datums (NAD) – North American Datum of 1927 (NAD 27) and North American Datum of 1983 (NAD 83). Both are geodetic reference systems, but each is based on different measurements. NAD 27 incorporated all horizontal geodetic surveys completed up to 1927. NAD 83 updated NAD 27 with current measurements using radio astronomy and satellite observations. NAD 83 positions are consistent with satellite location systems.

PALSAR: PALSAR is the SAR instrument on board the ALOS satellite. It is a Phased-Array type L-band (1270 MHz) SAR for day and night and all-weather land observation. The lower frequency of PALSAR relative to RADARSAT, ENVISAT and ERS provides for increased InSAR coherence in vegetated regions, but a higher susceptibility to atmospheric phenomenon.

Phase Ambiguity: In interferometry, phase ambiguities arise from the fact that phase is a cyclic measure that is only described from 0° to 360° and the true phase may in fact be ±*n*360°, where *n* is an integer. The movement or topography that produces the phase information in an interferogram is not cyclic, and therefore a single-phase value may describe an infinite number of different movement measurements or elevation changes. For example, in the context of C-Band SAR (5.3 GHz), 0 degrees in phase may refer to ±2.7*n* cm of movement (i.e., the movement could be 0 cm or 2.7cm or 5.4cm, etc.). Phase ambiguities are resolved using a number of strategies depending on the application. For general InSAR, interferograms are spatially 'unwrapped' in phase to resolve the ambiguities by examining where the phase changes from 0 to 360 degrees or vice versa. For Point Scattering InSAR or Interferometric Point Target Analysis, phase ambiguities are 'unwrapped' for each point target by applying a movement model (for example, linear progression of movement over time) to the phase measured at each target over the series of satellite images.

Phase Unwrapping: Phase unwrapping is the process of spatially or temporally removing phase ambiguities by examining locations of phase discontinuities. If the phase information is changing too quickly to resolve the phase ambiguities (e.g., in the case of IPTA where movement jumps by more than ±*n*360° in phase from one sample to the next), then a phase model (e.g., linear progression) must be applied to the phase samples to properly resolve the ambiguities.

Point Scatterer: In the context of satellite interferometry, a point scatterer is an object or collection of tightly packed objects on the ground that produces consistent microwave echoes back to the SAR instrument. The echoes of a point scatterer are defined to be relatively strong and statistically consistent (i.e., having a low variance of intensity) from one SAR image to the next. Point scatterers are also defined as being point targets whereby the source of the echoes originate from one distinct point in space rather than from multiple points such as in the case of a tree canopy or ocean surface where scattering is complex and spatially distributed in nature.

PS InSAR: Point Scatterer InSAR is an interferometric technique that identifies point scatterers in a series of SAR images and calculates movement from the phase variation of each point scatterer. The identification of point scatterers requires the use of a large number of SAR images in order to identify consistent scatterers.

RADARSAT-1: RADARSAT-1 is an advanced Earth observation satellite project developed by Canada to monitor environmental change and to support resource sustainability. With a planned lifetime of five years, RADARSAT-1 is equipped with a Synthetic Aperture Radar (SAR). The

SAR is a powerful microwave instrument that can transmit and receive signals to "see" through clouds, haze, smoke, and darkness, and obtain high quality images of the Earth in all weather at any time. This provides significant advantages in viewing under conditions that preclude observation by aircraft and optical satellites. Using a single frequency, C-Band, the RADARSAT-1 SAR has the unique ability to shape and steer its radar beam over a 500-km range. Users have access to a variety of beam selections that can image a swath from 50 km to 500 km with resolutions from 10 metres to 100 metres respectively. Incidence angles range from 10 degrees to 60 degrees.

RADARSAT-2: RADARSAT-2 is a Canadian C-Band (5.405 GHz) satellite SAR currently being built to provide data continuity to RADARSAT-1. In addition to providing data continuity with RADARSAT-1 by including the same modes of operation, RADARSAT-2 will include a number of improved capabilities compared to its predecessor. Some of the enhancements include:

- a resolution as fine as 3 m;
- a rotating capability so that the antenna points either right or left, providing more versatile and timely coverage;
- a variety of polarization options, including dual polarization and full quadrature polarization;
- GPS positioning for better orbit knowledge and control, which will improve InSAR applications; and
- provision for possible future tandem operation with RADARSAT-3.

The system is jointly funded by the Canadian Government and MacDonald Dettwiler Associates (MDA). The launch is planned for 2006 for operation by mid 2007. The RADARSAT orbit has a nominal altitude of 798 km, with a period of 100.7 minutes and an inclination of 98.6°. The orbit is sun-synchronous to maximize the power intake of the solar panels.

SAR: A synthetic aperture radar, or SAR, is a coherent radar system that generates high-resolution remote sensing imagery. Typically, SARs operate at microwave frequencies, typically C-Band at 5.3 GHz (for comparison, a microwave oven operates at 2.4 GHz); however, there are L-Band (JERS and PALSAR) and X-Band SARs (TerraSAR-X). The image produced by a SAR is composed of the intensity of the echoes from objects on the ground, thus producing a 'black and white' image. SAR data also includes phase information that is a result of the complex reflectivity of the 'scattering objects' on the ground. The phase information is also used by InSAR to produce topography or ground movement.

SRTM: The Shuttle Radar Topography Mission Shuttle was a C-Band interferometric SAR mission performed by a US Space Shuttle in 2000. SRTM data are available as raster elevation data rather than the raw SAR/InSAR pairs.

Topographic Phase: Topographic phase is phase information present in an interferogram that is due to topography or elevation differences on the earth. For the DInSAR process, topographic phase is removed from the interferogram using an elevation model. If that elevation model is inaccurate or has not been properly co-registered with a SAR image pair, the left over phase in an interferogram that is not attributed to ground movement or atmospheric effects is usually referred to as residual topographic phase. Residual topographic phase generally correlates well with elevation.

UTM: Universal Transverse Mercator Projection is a projection of the Earth's ellipsoid upon a surface of transversal cylinders (axes on the equatorial plane) enveloping the Earth at 6-degree intervals of longitude.

WGS-84: The World Geodetic System (WGS-84) Ellipsoid is a mathematical model representing the shape of the Earth. It is a very simple model, just an ellipsoid of revolution, so it is often the preferred model for satellite positioning systems. The standard units for WGS-84 are in degrees latitude and longitude. Other geodic models exist that more accurately describe the earth, but which are quite complex.

X-Band: The electromagnetic spectrum has been categorized into several bands for reference convenience. There are a number of different band designations defined, and in particular at radar frequencies the Letter Band designation used by the Institute of Electrical and Electronic Engineers (IEEE) includes L, S, C, X, Ku, K, Ka, V, W and mm. X-Band is defined as 8–12 GHz by the IEEE.