GEO-A-CC-5-12-TH – Remote Sensing, GIS and GNSS

TOPIC- Landsat Image Referencing Systems

MANAS PAUL
ASSISTANT PROFESSOR
RAMMOHAN COLLEGE, KOLKATA

Landsat Image Referencing Systems

The **Worldwide Reference System (WRS)** is a global notation system for Landsat data. It enables a user to inquire about satellite imagery over any portion of the world by specifying a nominal scene centre designated by **PATH and ROW numbers**. The WRS has proven **valuable for the cataloguing, referencing, and day-to-day use of imagery** transmitted from the Landsat sensors.

The Landsat 1-3 WRS-1 notation assigns **sequential path numbers from east to west to 251 nominal satellite orbital tracks, starting with number 001 for the first track which crosses the equator at 65.48 degrees west longitude**. A specific orbital track can vary due to drift and other factors; thus, a path line is only approximate. The orbit is periodically adjusted after a specified amount of drift has occurred in order to bring the satellite back to an orbit that is nearly coincident with the initial orbit.

Row refers to the latitudinal centre line of a frame of imagery. **As the satellite moves along its path, the observatory instruments are continuously scanning the terrain below.** The instrument signals are transmitted to Earth and correlated with telemetry ephemeris data to form individual framed images. During this process, the continuous data are segmented into individual frames of data known as scenes. **Landsats 1-3 scene centers are chosen at approximately 25-second increments of spacecraft time in either direction from the equator** with each scene equal to **approximately 163 km** (101 miles) on the Earth's surface plus about 10 percent in-track overlap (5 percent for Landsat 3) added by the ground processor. **A total of 119 Landsats 1-3 daylight scenes are possible along one descending satellite path.** A complete orbit of 6196 seconds, when divided by 25 seconds, yields 247.84 intervals; **248 scenes per complete orbit (descending and ascending) were selected as the standard.**

The framing is uniform for each orbit. The adjacent east-west scenes have scene center locations at the same nominal latitude. A notation of Row numbers can, therefore, be applied to identify all scenes occurring at the same latitude. **Row 060 corresponds to latitude 0 (equator). Row 059 is immediately north of this,** and the progression continues to latitude 80 degrees, 1 minute and 12 seconds north, which is Row 001. Row 119 is at latitude 80 degrees, 1 minute and 12 seconds south.

The combination of a Path number and a Row number uniquely identifies a nominal scene center. The Path number is always given first, followed by the Row number. The notation 127-043, for example, relates to Path number 127 and Row number 043.

Landsats 1-3 orbital parameters cause **each consecutive daily track to be shifted west 25.8 degrees of longitude at the equator, corresponding to 2872 km** (1784 miles). Each succeeding day of Landsat 1-3 coverage overlapped the coverage of the preceding day. This constitutes **one complete coverage cycle, consisting of 251 orbits, taking exactly 18 days** and providing complete global coverage between 82 degrees north latitude and 82 degrees south latitude. **The consecutive day sidelap resulted in a minimum of 14 percent at the equator to nearly 85 percent at extreme latitudes.** A combination of data processing and orbital adjustment keep the error in the individual framed image centers of any geographical area on the Earth within 37 km (23 miles) in the across-track direction and 30 km (19 miles) in the along-track direction.

Landsats 4, 5, 7, 8 (and soon 9) have Earth coverage similar to Landsats 1-3. However, the lower altitude results in a different swathing pattern. Landsat 5 and 7 (and Landsat 4 prior to its decommissioning) operate in a repetitive, circular, sun-synchronous, near-polar orbit at a nominal altitude of 705.3 km (438.4 miles) measured at the equator. **The descending orbital node time is 9:45 AM +/- 15 minutes at the equator with an orbital period of 98.9 minutes, completing 14 9/16 orbits per day and viewing the entire Earth every 16 days.**

Each consecutive daily track is **spaced 2752 km (1709 miles or 24.7 degrees) west of the previous orbit at the equator.** Each succeeding day's track is shifted at the equator to the west 10.8 degrees of longitude corresponding to 1204 km (748 miles).

Coverage sidelap of adjacent orbits for the Landsat 4 and 5 MSS sensors are a minimum of 7.3 percent at the equator to nearly 84 percent at extreme latitudes. Successive orbits and framing operations are controlled to assure no more than 18 km (11 miles) variation in the across-track direction.

The **Landsat 4, 5, 7, 8, and 9 Worldwide Reference System-2 (WRS-2)** is an extension of the global Landsat 1 through 3 WRS-1 and utilizes an orderly Path/Row system in a similar fashion. There are, however, major differences in repeat cycles, coverage, swathing patterns and Path/Row designators due to the large orbital differences of Landsats 4 and 5 compared to Landsats 1 through 3.The 16-day ground coverage cycle for Landsats 4–9 was accomplished in 233 orbits. **Thus, for Landsats 4–9, the WRS-2 system is made up of 233 paths numbered 001 to 233, east to west, with Path 001 crossing the equator at 64.60 degrees west longitude.**

Landsat 4–9 scenes are chosen at 23.92-second increments of spacecraft time in both directions calculated from the equator in order to create 248 Row intervals per complete orbit. Note that this is the same as the Landsat 1 through 3 WRS-1 system. The Rows have been positioned in such a way that Row 60 coincides with the equator during the descending node on the day side part of the orbit and Row 184 during the ascending node. Row one of each Path starts at 80 degrees, 47 minutes north latitude and the numbering increases southward to a maximum latitude 81 degrees, 51 minutes south (Row 122) and then turns northward, crosses the equator (Row 184), and continues to a maximum latitude of 81 degrees, 51 minutes north (Row 246). Row 248 is located at latitude 81 degrees 22 minutes north whereupon another Path begins.

IRS Image Referencing Systems

Referencing scheme, which is unique for each satellite mission, is a means of conveniently identifying the geographic location of points on the earth. This scheme is designated by Paths and Rows. The Path-Row concept is based on the nominal orbital characteristics.

Path

An orbit is the course of motion taken by the satellite, in space and the *descending* ground trace of the orbit is called a 'Path'. The orbit being similar to IRS-1C, the satellite completes 341 orbits in 24 days with an orbital period of 101.35 minutes. This way, the satellite completes approximately 14 orbits per day.

On day one (D1), the satellite covers orbit numbers 1 to 14, which as per the referencing scheme will be path numbers 1, 318, 294, 270, 246, 222, 198, 174, 150, 126, 102, 78, 54 and 30 assuming that the cycle starts with path 1. So orbit 1 corresponds to path 1 , orbit 2 to path 318, orbit 3 to path 294 etc., The fifteenth orbit or first orbit of day two (D2), is path 6 which will be to the east of path 1 and is separated from path 1 by 5 paths. Path number one is assigned to the track which is at 29.7 deg West longitude. The gap between successive paths is 1.055 deg. All subsequent orbits fall westward. Path 1 is so chosen, that, the pass with a maximum elevation greater than deg for the data reception station of NRSA at Shadnagar can be avoided. The orbit is adjusted periodically, after a certain amount of drift, to bring the satellite into the specified orbit. The path pattern is controlled within ±1 Km about the nominal path pattern.

Row

Along a path, the continuous stream of data is segmented into a number of scenes of convenient size. As in case of IRS-1C, LISS-III is the primary payload and the scene centres of LISS-III are considered for defining rows. In case of IRS-P6, the scene centres of LISS-III are fixed to be same as that of IRS-1C as the orbit is same and the primary payload, LISS-III, is very much similar to that of IRS-1C. With respect to each scene centre, a **LISSIII scene consisting of 6420 lines is framed** so that the selected scene centre is the centre of the scene. The uniformly separated scene centres are, such that, same rows of different paths fall at the same latitude. **The lines joining the corresponding scene centres of different paths are parallel to the equator and are called Rows. The row number 1 falls around 81 deg North latitude, row number 41 will be near 40 deg North and row number of the scene lying on the equator is 75. The Indian region is covered by row numbers 30 to 90 and path numbers 65 to 130.**

Use of referencing scheme

The Path-Row referencing scheme eliminates the usage of latitude and longitudes and facilitates convenient and unique identification of a geographic location. It is useful in preparing accession and product catalogues and reduces the complexity of data products generation. Using the referencing scheme, the user can arrive at the number of scenes that covers his area of interest.

LISS-III referencing scheme and scene coverage

The swath of LISS-III is 141 Km in all the four bands. Since the swath of LISS-III in all the four bands is greater than the inter orbit distance (117.5 Km), the sensor scans the entire globe once in every cycle without gaps. The referencing scheme of LISS-III consists of 341 paths numbered from west to east. Each path consists of 149 rows. Consecutive paths are covered with a separation of five days. If Path 1 is covered on day one, Path 2 will be covered on day six.

Each LISS-III scene covers an area of 142 Km x 141 Km. The side lap between two LISS-III scenes is 23.5 Km at the equator. The overlap between successive scenes in a path is 7 Km.

There are four LISS-IV mono scenes A, B, C and D within one LISS-III scene, like PAN scenes of IRS-1C. But the overlap between the A / C scenes and B / D scenes is increased to 5 Km as compared to 1 Km of IRS-1C. The overlap between A (or B) and C (or D) is increased to 2.5 Km as compared to 1 Km of IRS-1C.