Technical Document

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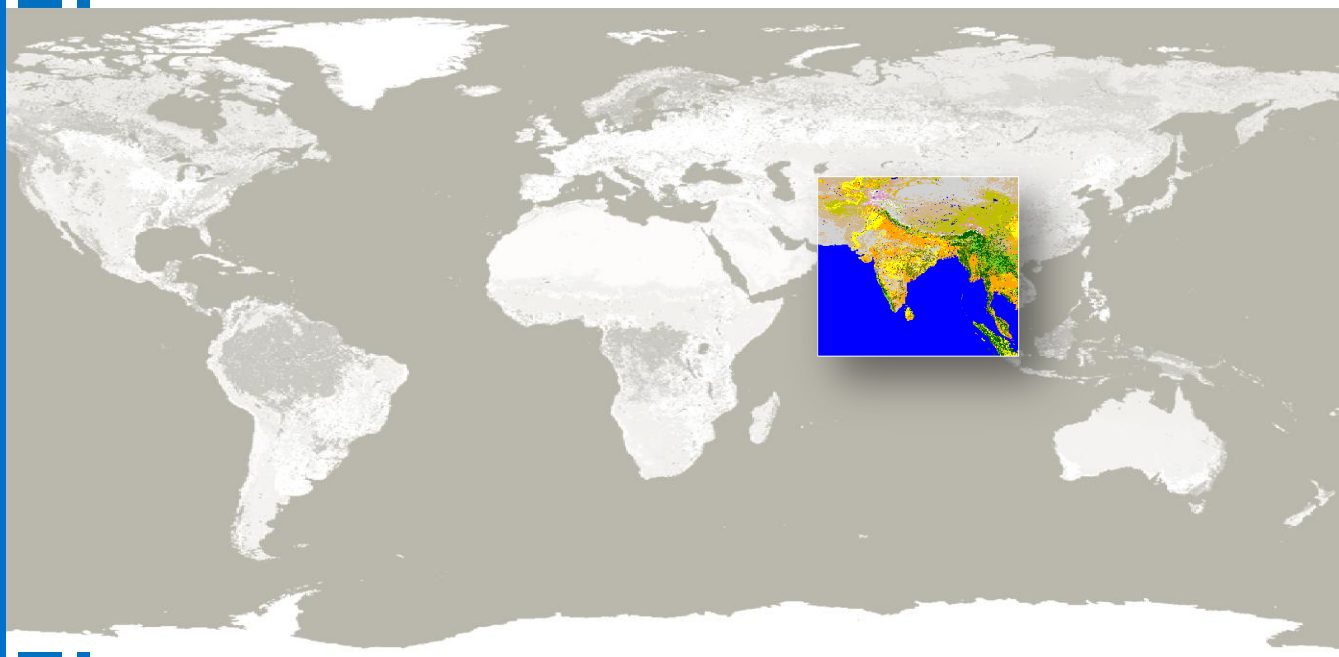
IRS-P6 AWiFS Derived Gridded Land Use/Land Cover Data Compatible to Mesoscale Models (MM5 and WRF) Over Indian Region



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15.	**Abstract:** So far 25 land use/land (LU/LC) cover categories of USGS derived global coverage with different resolution data are used to run mesoscale models. Indian satellite IRS P6, AWiFS derived LU/LC data with 56m basic resolution has been scaled to 5, 2 minute and 30 second resolutions. Indian region of USGS data is replaced with AWiFS derived data and made compatible to MM5 & WRF models. The resultant product is a global USGS LU/LC data with the Indian region replaced by the basic 56m resolution AWiFS based LU/LC adopted for mesoscale models, which is more accurate and updated at annual basis for the time period 2004-2005 to 2012-2013 (9 Cycles). **Key Words:** AWiFS derived Model compatible data, WRF, MMF.				

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Abstract

So far 25 Land Use/Land Cover (LU/LC) categories of USGS derived global coverage with different resolution data are used to run mesoscale models viz. WRF & MM5. Indian satellite IRS P6, AWiFS derived LU/LC data with 56m basic resolution has been scaled to 5, 2 minute and 30 second resolutions. Indian region of USGS data is replaced with AWiFS derived data and made compatible to MM5 & WRF models. The resultant product is a global USGS LU/LC data with the Indian region replaced by the basic 56m resolution AWiFS based LU/LC, adopted for mesoscale models, which is more accurate and updated at annual basis for the time period 2004-2005 to 2012-2013 (9 Cycles).

This document explains the methodology to generate IRS P6 AWiFS LU/LC data sets in WRF/MM5 model compatible format. Presently model compatible AWiFS derived LU/LC data are available in 30sec, 2min and 5 min resolutions for user community through NRSC/ISRO site (www.nrsc.gov.in) under Bhuvan/ NICES geospatial portal.

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IRS-P6 AWiFS Derived Gridded Land Use/Land Cover Data Compatible to Mesoscale Models (MM5 and WRF) Over Indian Region.

The variations in Land Use/Land Cover (LU/LC) influence general circulation directly through the parameters of the atmospheric model or indirectly through the hydrologic coupling. Albedo, emissivity and surface roughness are the three important parameters influenced by the LU/LC cover. Hence LU/LC changes were considered to be one of the most important factors affecting the regional climate and the concerns for changing climate. The role of the land surface is particularly important in driving boundary layer evolution and ultimately precipitation patterns. Inaccurate LU/LC information often leads to very large errors in surface energy fluxes and thus errors in boundary layer states. Vegetation-related variables like LAI, fractional vegetation cover, canopy height, emissivity, albedo, surface roughness etc. exert significant control on the surface temperature and energy balance and subsequently on boundary layer processes and states, most importantly moisture and temperature profiles.

Accurate representation of land surface is important to precisely model the effects of past, current and future land cover. Elif Sertel et al., 2009 found two types of error in WRF land cover default data (1) up to date satellite data was not used for the LU/LC layer creation and (2) LU/LC data includes misclassification. LU/LC cover is one of the dynamic features that undergo rapid changes due to anthropogenic and associated developmental activities and is amenable to satellite remote sensing. Hence there is need to include accurate and up to date satellite based LU/LC data to ingest into MM5/WRF model.

The 24-category U.S. Geological Survey (USGS) Global Land Cover Characterisation (GLCC) LU/LC dataset was derived from 1-km AVHRR data spanning April 1992 through March 1993 (Loveland et al.,2000,(modified level 2)). Modelers often use outdated USGS GLCC 30 sec (~1 Km) land cover data. With the release of the 2001 National Land Cover Data (NLCD) products at 30m cell resolution for the US and 2001 NASA MODIS land cover data at 1km cell resolution for the globe have created lot of interest among in the modeling Community. Limei Ran et al.,2010, incorporated gridded 2001 NLCD data in Weather Research Forecast (WRF) model and found improved results.

In India, national LU/LC mapping project was taken up during 2004-05 with an objective to undertake “Rapid assessment of national LU/LC on 1: 250,000 scale using multi-temporal IRS-P6 AWiFS datasets”. The study has been completed for 9 crop calendar years from 2004-05, to 9th assessment year 2012-13, 10th cycle assessment is in progress. An effort is made to generate Indian satellite IRS P6 AWiFS derived LU/LC data sets in WRF/MM5 model compatible format for numerical weather prediction/climate modeling activities. Advanced Wide Field Sensor (AWiFS) is one of the sensors onboard Resourcesat satellite (IRS P6) having four spectral bands with 56m ground resolution and five day repetivity. Multi temporal IRS-P6 AWiFS data covering Kharif (Aug –Nov), Rabi (Jan- Mar), Zaid (April- May) crop seasons were used to address spatial and temporal variability in cropping pattern and other land cover classes. The thematic classification of AWiFS data involves georeferencing of multi temporal datasets with LCC projection and WGS 84 datum. The USGS LU/LC data is derived from 1km spatial resolution MODIS data whereas the Indian effort is based on IRS P6 AWiFS 56m resolution data. It is reported in literature that mapping at high resolution and upscaling to coarser resolution brings better details than directly mapping at coarser resolution. Moreover in AWiFS classified data, use of ground truth information resulted in achieving better accuracy.

MM5/WRF mesoscale models use USGS generated regular latitude/longitude inputs on vegetation (LU/LC), terrain elevation, land-water mask, soil types, vegetation fraction and deep soil temperature. USGS data contains 24- categories, land use/land cover features at different resolutions of 1-degree, 30, 10, 5, 2-minutes and 30-seconds.

Figure 1 shows the methodology to generate AWiFS LU/LC data sets in WRF/MM5 model compatible format. USGS LU/LC data has 24 categories (plus one no data category) whereas LU/LC data derived from Indian satellite IRS P6 AWiFS has 19 categories. Since the current objective is to make AWiFS data compatible to USGS global data for a wider use by the modelers, Indian AWiFS data was first regrouped to USGS 24 categories based on Table 1. In this table, 2nd column corresponds to USG 24 LU/LC classes and 4th column represents AWiFS derived 19 classes; seventh column shows the different classes ID of AWiFS classes (from column 3) need to recode for the purpose of matching with USGS LU/LC data as given in column 6 (Recoded AWiFS classes). Then recoded AWiFS data in ERDAS imagine format (*.img) exported to BIP (Band Interleaved by Pixel) format for further processing.

The USGS LU/LC global data are assumed to be valid at the center of a grid box. Hence there are 360X180 data points for 1 degree data; (360X2) X (180X2) for 30 minute data; (360x120) X (180X120) data points for the 30 second data and so on as given in Table 2. As given in the table, higher resolution 30sec data is equivalent to 0.925(~1 Km) and coarse resolution data of 2, 5, 10, 30 minutes are respectively equivalent to 3.7, 9.25, 18.5,55.5km and 1degree is equivalent to 111km spatial resolution.

30 Second MM5 compatible data creation (derived from AWiFS).

For the 30 seconds compatible data creation, majority classes are calculated based on a new fixed grid accommodating 17X17 AWiFS pixels and then replacing the Indian region of global USGS LU/LC data (of 24 classes) by AWiFS derived data. Then export the above data in BIP format to produce MM5 compatible output equivalent to 30 seconds **(veg-usgs.30s)** .

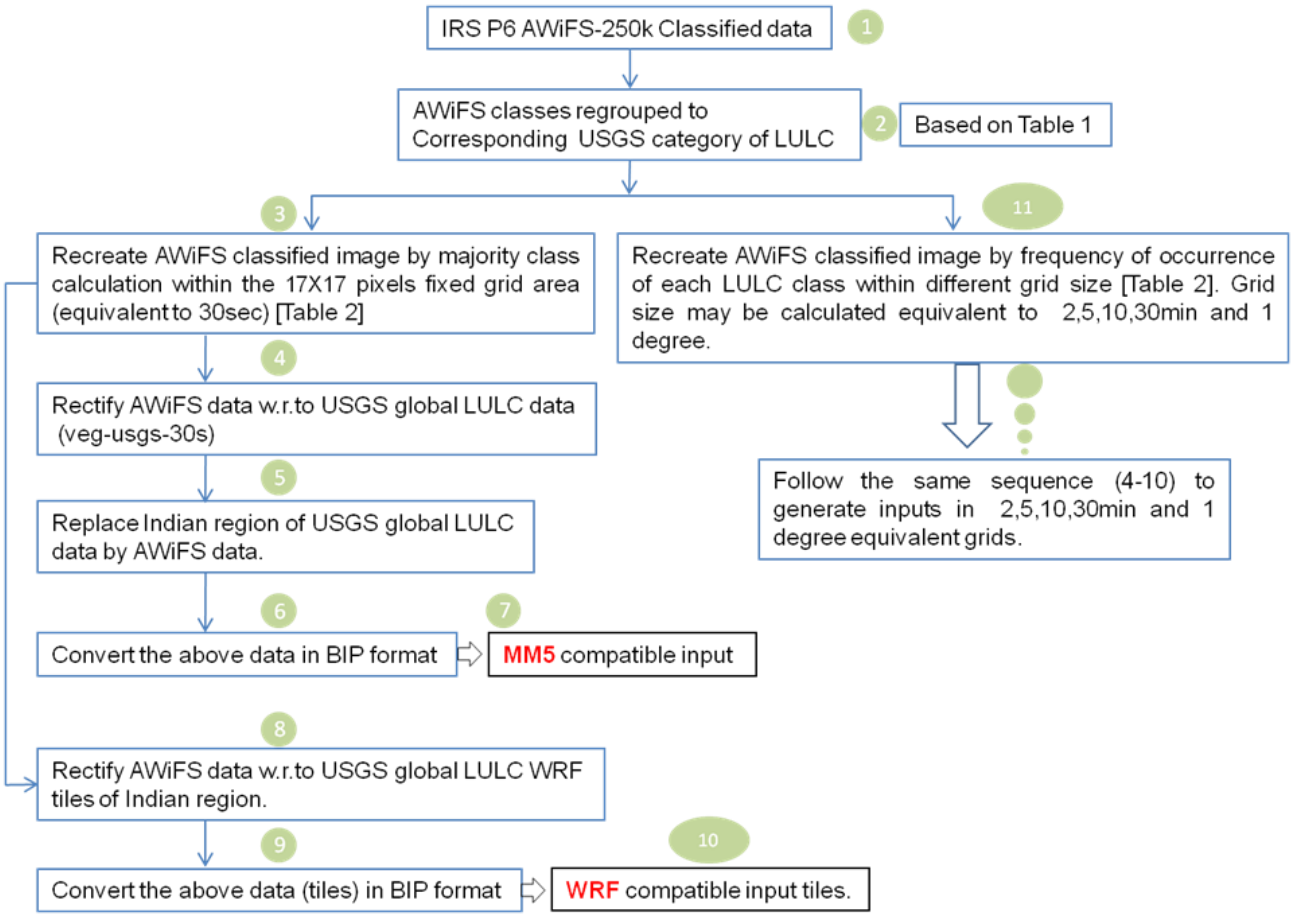
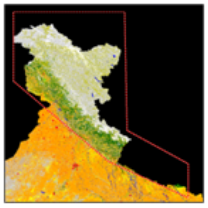


Figure 1: Methodology flow to generate IRS P6 AWiFS LU/LC data sets in WRF/MM5 model compatible format

1	2	3	4	5	6	7
CLS-ID	USGS	CLS-ID	Actual AWiFS Class	CLS-ID	Recoded - AWiFS	Recode AWiFS
1	Urban and Built-Up La	1	Build up	1	Settlement	1
2	Dryland crop.Past.	2	Kharif only	2	Kharif Crop only	2
3	Irrg.Crop.Past.	3	Rabi only	3	Rabi crop / zaid/double/triple Crop	3+4+5
4	Mixed Dryland/Irrigat	4	Zaid only	4		
5	Crop/Grs.Mosaic	5	Double / tripple	5	Current Fallow	6
6	Crop/Wood Mosaic	6	Current fallow	6		
7	Grassland	7	Plantation/orchard	7	Grassland	12
8	Shrubland	8	Evergreen forest	8	Scrub/Deg.Forest/Scrubland	10+15
9	Mix Shrub/Grs.	9	Deciduous forest	9		
10	Savana	10	Scrub/Deg. forest	10		
11	Deciduous Broadleaf Forest	11	Littoral swamp	11	Deciduous Forest	9
12	Deciduous Needleleaf	12	Grassland	12		
13	Evergreen Broadleaf Forest	13	Other wasteland	13	Evergreen Forest	8
14	Evergreen Needleleaf	14	Gullied	14	Evergreen Forest (Himalayan region)	8 after recode
15	Mixed Forest	15	Scrubland	15	Plantations/orchard/shifting Cultivation	7+18
16	Water Bodies	16	Water bodies	16	Water bodies	16
17	Herbaceous Wetland	17	Snow covered	17		
18	Wooded Wetland	18	Shifting Cultivation	18	Littoral Swamp (Mangrove)	11
19	Barren or Sparsely Veg.	19	Rann	19	Other Wasteland/Gullied/Rann	13+14+19
20	Herbaceous Tundra			20		
21	Wooded Tundra			21		
22	Mixed Tundra			22		
23	Bare Ground Tundra			23		
24	Snow or Ice			24	Snow cover	17
25	No data			25		

Table 1: Regrouping criteria to match IRS P6 AWiFS based LU/LC data with USGS LU/LC classes

Class ID=14: “Evergreen Needle leaf” of Table 1



SL #	GRID (LONGXLAT wise)	Total no of GRIDs	GRID Resolution in	GRID Resolution in Km	~ No of AWiFS Pixel in each GRID
1	360X180	64800	1 Degree	111	1982
2	360X2X180X2	259200	30 min	55.5	991
3	360X6X180X6	2332800	10 min	18.5	330
4	360X12X180X12	9331200	5 min	9.25	165
5	360X30X180X30	58320000	2 min	3.7	66
6	360X120X180X120	933120000	30 sec	0.925	17

Table 2: Different Grid sizes and number of AWiFS pixels occupied by each grid.

30 Second WRF compatible data creation (derived from AWiFS)

In the similar way, 30 second AWiFS majority filtered data has been geo-corrected w.r.to USGS WRF tiles (24 class) and then geo-corrected data are used to replace USGS global WRF tiles of Indian region and export these tiles to BIP format to generate WRF compatible tiles of Indian region. Total numbers of 30 second WRF tiles are 16 as shown in Table 3.

For coarse resolution data of 2,5,10,30 minutes and 1degree, new grid sizes are created respectively accommodating 66,165,330,991 and 1982 AWiFS pixels (Table 2). Then frequency of occurrence of each of the LU/LC cover classes in IRS-P6 AWiFS data at different resolutions mentioned above were calculated.

2 minute MM5 compatible input (derived from AWiFS)

AWiFS derived 2 minute frequency image created by above mentioned method has 24 classes. With the same dimension, a single layer having value zero is stacked to the frequency image to have a frequency image of 25 classes. Then AWiFS derived LU/LC (25 class) image is geo-corrected w.r.to the global USGS LU/LC 2 minute LU/LC data. USGS global LU/LC (2minute) of Indian region is then replaced with geo corrected AWiFS LU/LC 2 minute data and export this generic file to BIP format to produce MM5 input (veg-usgs.02).

2minute WRF compatible input (derived from AWiFS)

Geo-correct the AWiFS LU/LC frequency data (24 classes) w.r.to USGS 2 minute resolution WRF LU/LC tiles mosaic data and the global USGS LU/LC (2 minute) of Indian region is replaced by geo-corrected AWiFS data. The USGS 2minute WRF LU/LC individual tiles of Indian region (nine numbers) are used to extract tiles wise AWiFS replaced 2 minutes data. Then nine individual AWiFS replaced tiles are exported to BSQ format to produce nine WRF AWiFS compatible AWiFS data (Table 3).

In the similar way all other resolution AWiFS derived data can be made compatible to MM5 and WRF model. AWiFS replaced 30 second data is shown in Figure 2 and the frequency image of 2 minutes resolution is shown in Figure 3. MM5/WRF compatible file names conventions are given in Table 3. Figure 4 shows the comparative display of USGS and AWiFS LU/LC data for 30 sec resolutions, where many classes are misrepresented in USGS LU/LC.

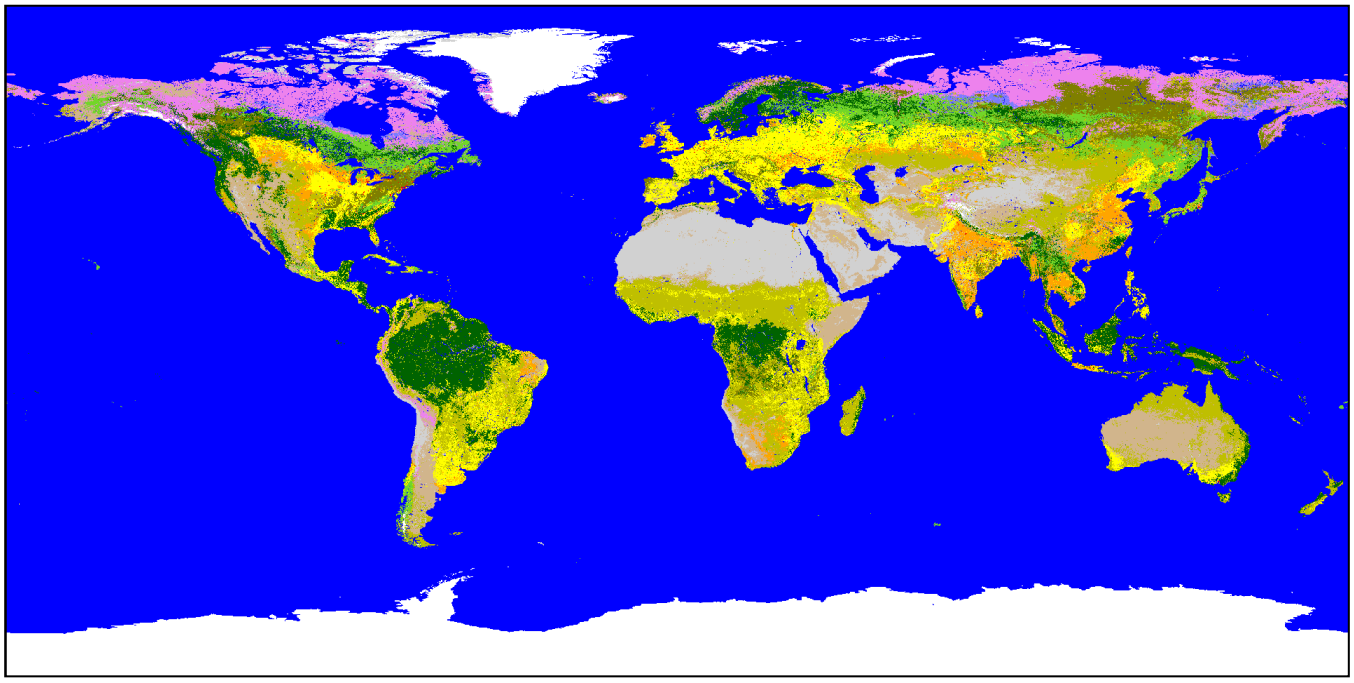


Figure 2: USGS LU/LC data (30sec) with the Indian region replaced by the IRS P6 AWiFS based LU/LC data.

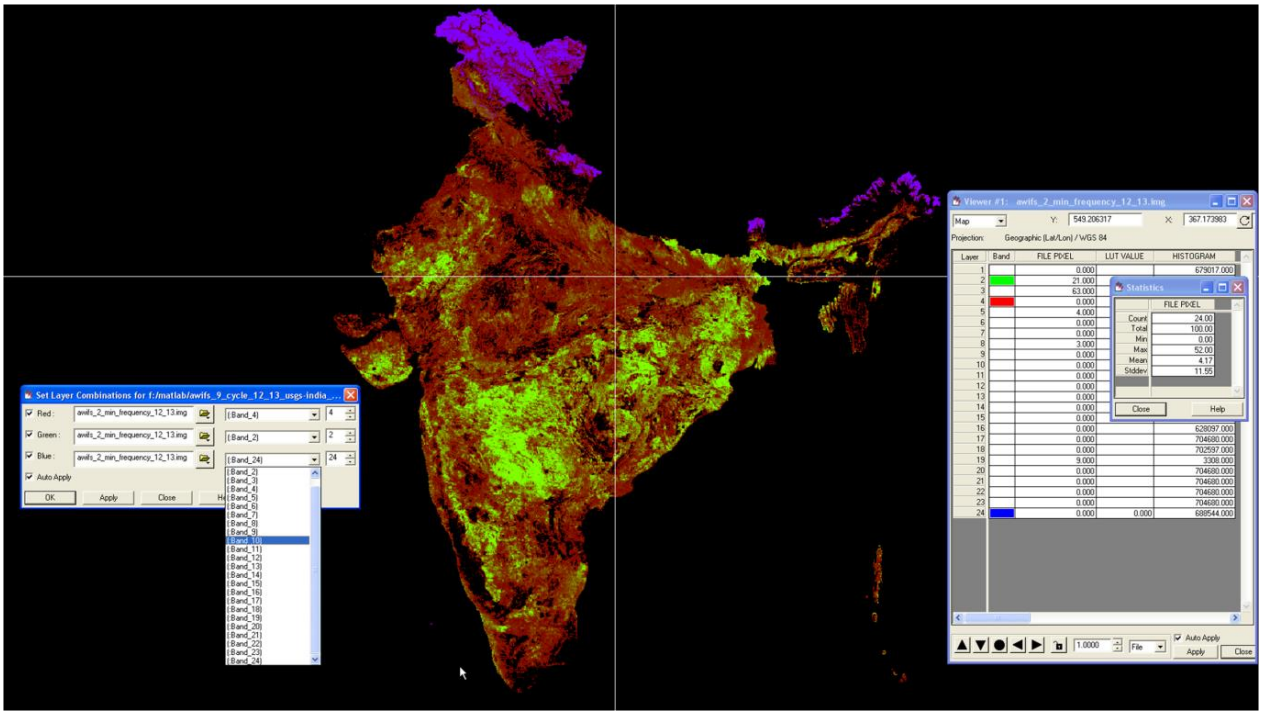


Figure 3: IRS P6 AWiFS based LU/LC frequency data in 2 minute resolution.

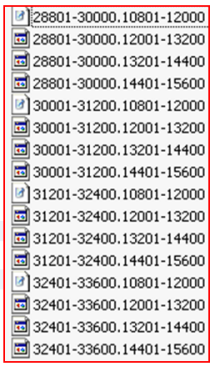
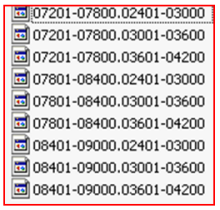
Resoln. _MM5_Sen_format	File name (.Resolution)	Resoln._Sen_WRF_format	File name
30sec_MM5_AWiFS_BIP	veg-usgs.30s	30sec_AWiFS_WRF_BIP	
2min_MM5_AWiFS_BIP	veg-usgs.02	2min_AWiFS_WRF_BSQ	
5min_MM5_AWiFS_BIP	veg-usgs.05	5min_AWiFS_WRF_BSQ	

Table 3: MM5 and WRF model compatible file names convention adopted for Indian region.

At every stage of geo correction **“ *.gcc"** files are saved and used for different cycle’s output generation. Each time after producing BIP/BSQ format compatible to MM5/WRF, it is required to check the data by importing into **"*.img"** format for visualization (Example: for MM5 2 minute input **"veg-usgs.02",** we import the data with BIP option, Row=5400, Column=10800 and 25 classes and display in imagine).

Presently model compatible AWiFS data are available in 30sec, 2min and 5 min resolutions for users through NRSC/ISRO site (www.nrsc.gov.in) under Bhuvan/ NICES geospatial portal.

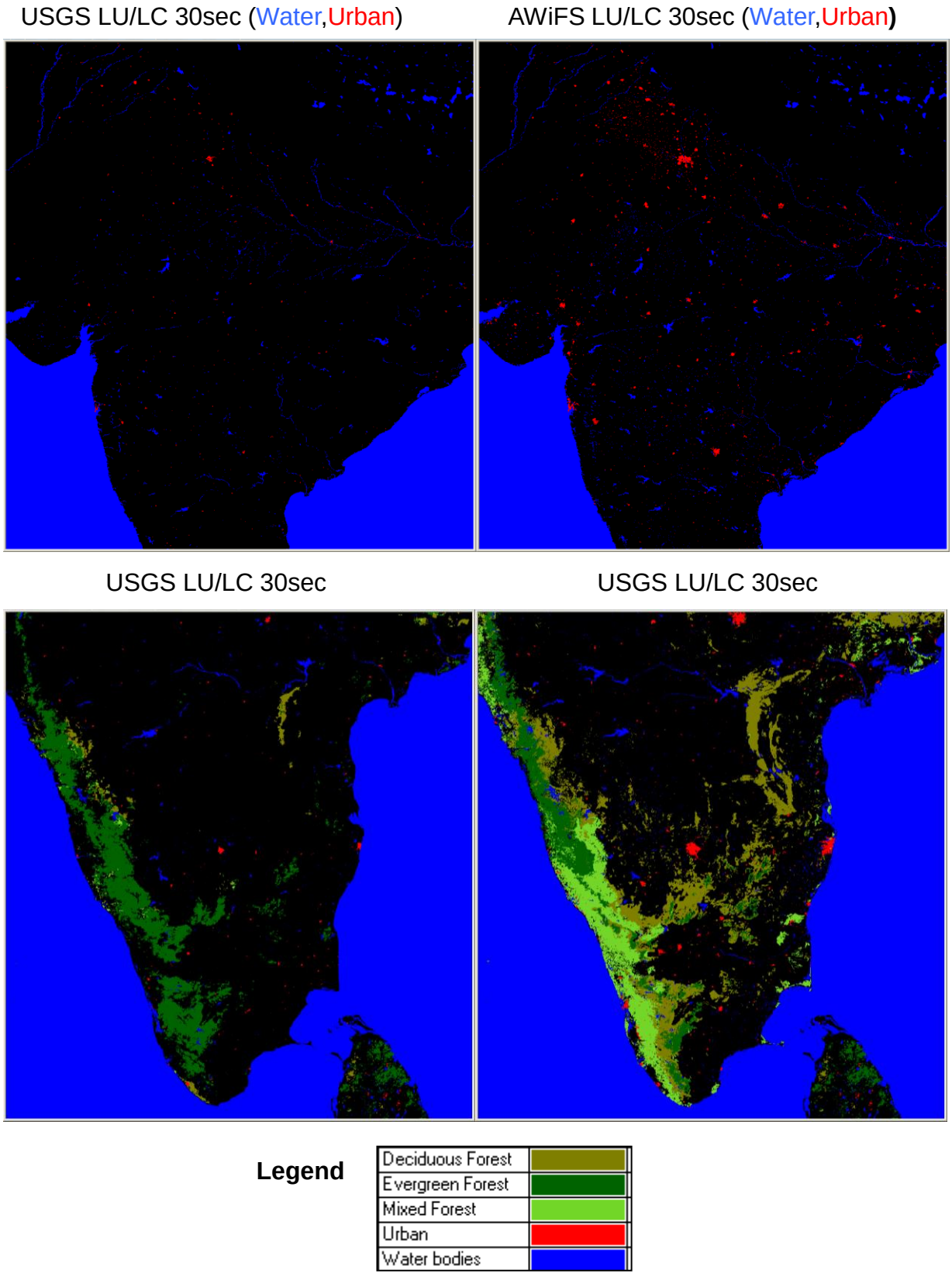


Figure 4: Comparative display of USGS and AWiFS LU/LC data for 30 sec resolutions, where many classes are misrepresented in USGS LU/LC

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