Journal of Geomatics Vol 11 No. 1 April 2017

Automated snow data processing tool for Natural Resource Data Base (NRDB)

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(Received: Jan 03, 2017; in final form: Mar 28, 2017)

Abstract: Geographic Information System (GIS) tool was developed within ArcGIS for automation of snow data processing. This utility was developed using Visual Basic for Applications (VBA) language based on Arc Objects technology offered by the Environmental Systems Research Institute (ESRI). Tool provides an integrated solution for snow data processing which involve tasks i.e. raster to vector conversion, projection transformation, clipping operation and attribute addition. Datasets contain snow information about 33 basins of Himalayan regions. Further, non-spatial information was added to finally generated vector layers like basin name, code etc. These vector layers were organized in Natural Resources Database (NRDB) and available as OGC (Open Geospatial Consortium) compliant WMS (Web Map Service) service through NNRMS (National Natural Resources Management System) portal (www.nnrms.gov.in).

Keywords: Snow, ArcObjects, VBA, GIS, ArcGIS, WMS, NRDB, NNRMS

1. Introduction

India has a unique geographical location and is endowed with abundant natural resources. It comprises of rivers, fertile soil, forests, mineral deposits, mountains etc. To meet the increasing demand of food and fuel, optimal utilization of natural resources is required. To achieve this, the Department of Space, Government of India has initiated a programme titled National Natural Resources Repository (NRR) for creating and maintaining a systematic archive of all the digital spatial database of thematic and base maps generated using remote sensing data and promote / encourage its usage. The NRR programme consists of three elements, namely (i) data generation, (ii) database organization, and (iii) spatial data services. Data generation is being addressed through Natural Resources Census (NRC) project, database organization through Natural Resources Data Base (NRDB), and spatial data services through NNRMS portal which houses the GIS repository of natural resources for entire country in a secured environment (Anon., 2005). NNRMS supports optimal utilization of country's natural resources by providing systematic inventory of natural resources available using remote sensing data in conjunction with conventional data / techniques. Under NNRMS (www.nnrms.gov.in), the NRDB was established as a repository of all thematic data sets generated within ISRO-DOS. NRDB is collection of data sets on natural resources including the datasets collected over past several years under NNRMS. Access to these databases can be done through NNRMS portal. NRDB repository is regularly updated with new spatial data, especially for the projects like Monitoring snow and glaciers, wetland, NRC. Updation requires several stages of processes starting from metadata generation, database organization to map generation. This paper addresses the development of methodology for automatic processing and organizing snow data in NRDB on regular basis.

2. Study area and data

Himalayan region falls in to different geographical locations which belong to states of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Arunachal Pradesh and Sikkim. Himalayas possess one of the largest resources of snow and ice outside the polar regions. There are increasing concerns by scientific community that global warming caused by increase in concentration of greenhouse gases in atmosphere can cause dramatic impact on the snow melt runoff in the river systems. Sensitivity of snow and glaciers to variations in temperature makes them a key indicator of climate change. In order to study climate change, inventory of snow cover is required.

Under project Snow and Glacier Studies, snow cover monitoring was done (every 5 days and 10 days) by Space Applications Centre (SAC) along with 13 concerned Central / State government Departments and Academic Institutes during year 2008 to 2014 of Himalayan region covering Indus, Ganga and Brahmaputra river basins using IRS (Resourcesat 1 and 2) AWiFS data (SAC, 2016).

Snow cover data of Himalayan region with respect to different basins was generated as classified images for the months from October to June. This data is generated in raster format representing snow and no snow, respectively. In this study, six basins of Ganga, Brahmaputra, Indus, Chenab, Satluj and Tista and 33 sub-basins was taken up for snow cover monitoring (SAC 2016). The list of study sub-basins is given in Table 1.

Table 1: List of study sub-basins

Sr. No.	Sub-basin	Sr. No.	Sub-basin
1	Alaknanda	18	Parbati
2	Astor	19	Pin
3	Baspa	20	Rangit
4	Beas	21	Ravi
5	Bhaga	22	Shasgan
6	Bhagirathi	23	Shigar
7	Bhut	24	Shigo
8	chandra	25	Shyok
9	Dibang	26	Spiti
10	Dras	27	Subansiri
11	Gilgit	28	Suru
12	Hanza	29	Tawang
13	Jhelum	30	Tista
14	Jiwa	31	Warwan
15	Kisanganga	32	Yamuna
16	Miyar	33	Zaskar
17	Nubra		

Snow cover datasets (every 10 days) from year 2008 to 2014 in raster format were provided to NRDB for organization into geo database and serving the data as OGC (Open Geospatial Consortium) compliant Web Map Service (WMS). Data was required to be processed and organized as per NNRMS standards before database insertion (Anon. 2005). Tasks associated with processing i.e. raster to vector conversion, projection transformation, clipping for state wise separation and inserting feature attributes for large volume of data was tedious, repetitive, and time consuming. So the objective was to convert manual processing of snow cover data into automatic one.

Converting the classified snow cover raster images to vector format and projection transformation were the primary objectives. Additionally, clipping of the data as per respective basin and adding attribute along with respective attribute values i.e. names, area, code were also required so as to put the snow cover mapping layers into the pre-defined geo database of NRDB.

3. Conceptualization and methodology

Before development of automated snow data processing tool for NRDB, sample snow dataset was taken and processed manually using ArcGIS to develop methodology and required product generation. Initially, the user interface in ArcGIS used to identify objects, properties, and methods to be integrated in code. Then to convert manual process to automatic, ArcObjects library was examined and studied. ArcObjects is the development environment of the desktop ArcGIS applications and it is used to customize and extend ArcGIS using the embedded Visual Basic for Applications (VBA). VBA is COM (Component Object Model) compliant and is supported by the ArcObjects technology of ESRI, which are available in higher software versions of ArcGIS (at http://www.esri.com). ArcObjects can actually mitigate the amount of repetitive work, streamline the workflow and even produce functionalities that are not easily available in ArcGIS (Wunderlich, 2009; Chang Kang-Tsung, 2008). ArcObjects includes APIs (Application Programming Interface) that support the built-in functionalities like reprojection and other raster and vector operations (Xu and Gao, 2008). The steps involved in processing data are shown in figure 1. During the initial phase of development, semi-automated process was prepared to accomplish the requirement. Subsequently it was converted into the fully automated tool.

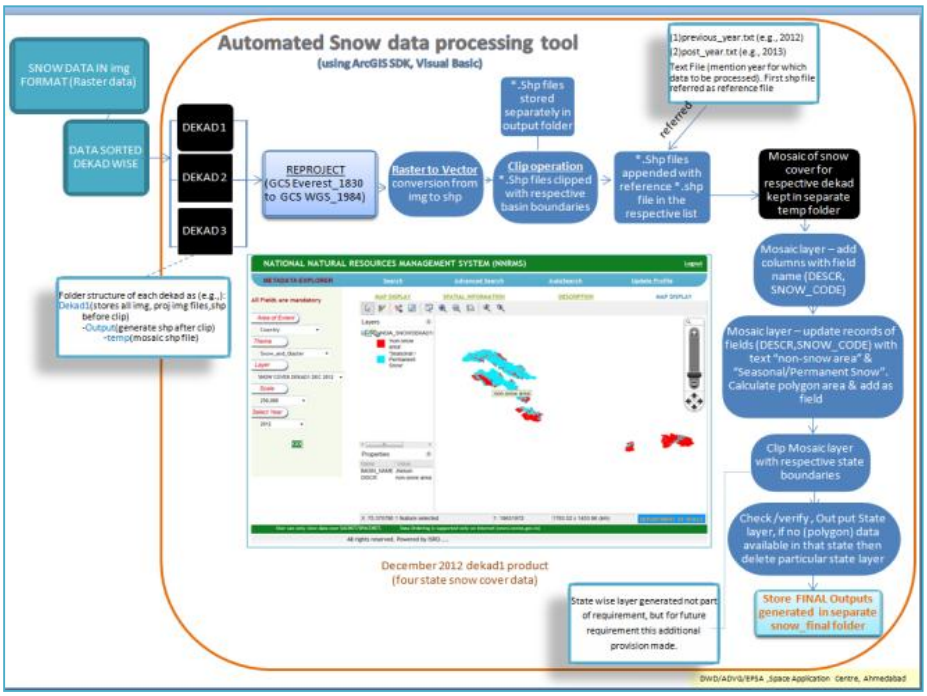


Figure 1: Steps for processing data

First step in the processing was the projection of raster file. Initially, snow raster datasets submitted to NRDB were in GCS Everest-1830 (also called Indian Datum). All data in NRDB organized is in geographic projection. According to NNRMS standards for GIS database, the recommended system is Geographic Coordinates. This is to allow flexibility for seamlessness and also for providing outputs in any desired Map projection of choice of user (Anon., 2005). So, module for automatic reprojection of raster datasets was developed in VBA using ArcObjects library (Song et al., 2013). Next step in automated process was to perform clipping operation with respective basin boundaries. A separate clip function is referred using ARCGIS SDK library. After clipping operation, first shape file of respective basin is taken as reference file and rest of the shape files were appended accordingly, this work was carried out by using append function provided in ArcObjects library. Next process was the attribute insertion into mosaic/appended file, it is carried out using additional function of add field in the library. After field insertion, all attributes information gets added against the code generated during raster to vector conversion. Using area calculation method, Respective polygon area was calculated and added to attribute table of the shape file generated. Algorithm has been developed in such a way that final product generated from mosaic after clipping will be checked for the existence of the unnecessary polygons. During processing name of respective polygon is added with basin name of the area it belongs.

These generated vector layers were organized in NRDB and available as OGC compliant WMS service through NNRMS portal. NNRMS is WebGIS based portal which disseminates natural resources datasets archived from various national projects as WMS Service. AutoDesk software is used for publishing all snow layers as WMS Service which can be displayed in a browser application i.e. NNRMS. The WMS defines the interface for accessing geospatial data uniformly from remote servers in a standard format, such as Portable Network Graphics (PNG) and Graphics Interchange Format (GIF), through HTTP (Mishra and Sharma, 2016).

4. Results and discussion

Following outputs shown in Figures describe the product generated using automated tool and snow layers as WMS Service in NNRMS portal. Figure 2 shows raster classified image of snow data for Alaknanada basin for the year 2012 of the first dekad of month December.

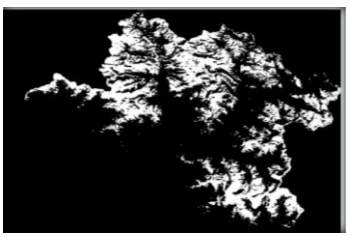


Figure 2: Snow cover area of Alaknanda basin

Figure 3 shows the shape file of Alaknanda basin utilized for clipping operation.

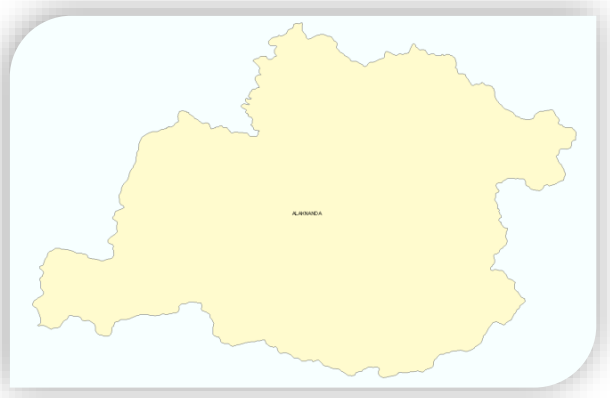
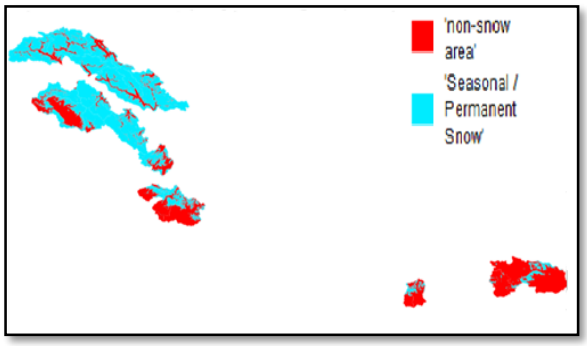


Figure 3: Shapefile of Alaknanda basin

Figure 4 (a) shows the final output layer generated for first dekad of December along with its attributes table as shown in Figure 4 (b), showing added columns i.e. “BASIN NAME”, “SNOW_CODE, DISCR (description)” and “F_AREA (area)”.



Attributes of INDIA_SNOWDEKAD1DEC2505CM2012

FID	Shape *	ID	GRIDCODE	BASIN_NAME	SNOW_CODE	DISCR	F_AREA
0	Polygon	13	10	Alaknanda	1	non-snow area	0
1	Polygon	17	10	Alaknanda	1	non-snow area	0.000002
2	Polygon	18	10	Alaknanda	1	non-snow area	0.000001
3	Polygon	27	10	Alaknanda	1	non-snow area	0
4	Polygon	28	10	Alaknanda	1	non-snow area	0
5	Polygon	29	10	Alaknanda	1	non-snow area	0.000003
6	Polygon	30	10	Alaknanda	1	non-snow area	0.000002
7	Polygon	31	10	Alaknanda	1	non-snow area	0.000006
8	Polygon	33	10	Alaknanda	1	non-snow area	0.000001
9	Polygon	35	10	Alaknanda	1	non-snow area	0.000001
10	Polygon	36	10	Alaknanda	1	non-snow area	0.000009
11	Polygon	37	10	Alaknanda	1	non-snow area	0.000001
12	Polygon	38	10	Alaknanda	1	non-snow area	0.00001
13	Polygon	39	10	Alaknanda	1	non-snow area	0
14	Polygon	41	10	Alaknanda	1	non-snow area	0.000006
15	Polygon	44	10	Alaknanda	1	non-snow area	0.000002
16	Polygon	46	10	Alaknanda	1	non-snow area	0.000001
17	Polygon	47	10	Alaknanda	1	non-snow area	0.000001
18	Polygon	48	10	Alaknanda	1	non-snow area	0
19	Polygon	49	10	Alaknanda	1	non-snow area	0
20	Polygon	51	10	Alaknanda	1	non-snow area	0.000001
21	Polygon	52	10	Alaknanda	1	non-snow area	0.000005

Record: 1 Show: All Selected Records (0 out of 64256

Figure 4: (a) Vector layer as WMS Service; and (b) Attribute table of vector layer in ArcGIS

As described in the methodology a separate state wise vector layers showing availability of snow were also generated using state boundary vector layer. Indian State Boundary layer used for generating state wise layers are

already available in NRDB have been generated under National GIS (NATGIS) project. Figure-5 to 9 shows screen shots of generated snow cover WMS Service using automated tool for the Indian states of Jammu& Kashmir, Uttarakhand, Himachal Pradesh, Arunachal Pradesh and Sikkim.

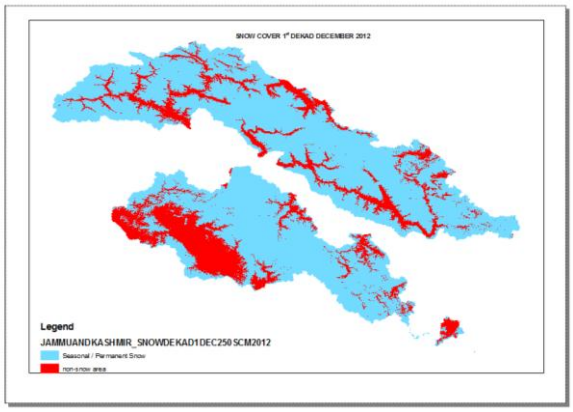


Figure 5: Snow cover WMS of Jammu & Kashmir

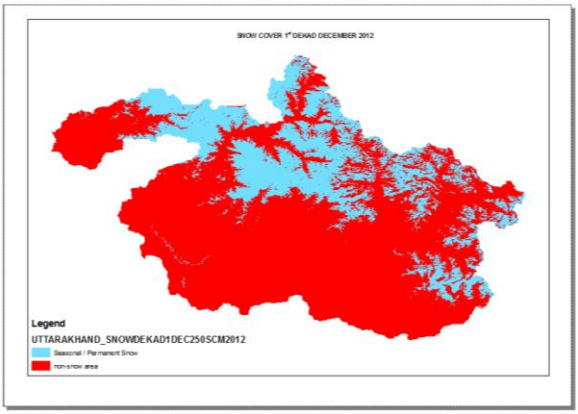


Figure 6: Snow cover WMS of Uttarakhand

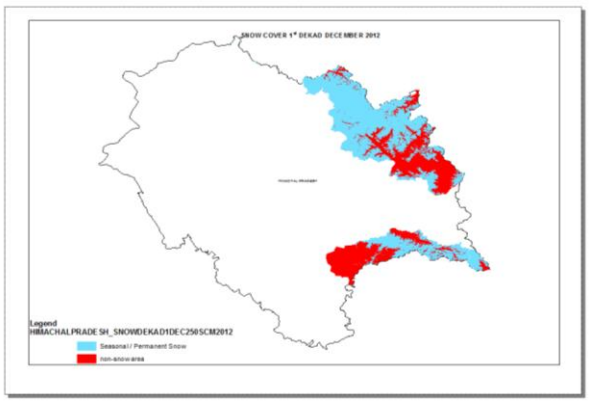


Figure 7: Snow cover WMS of Himachal Pradesh

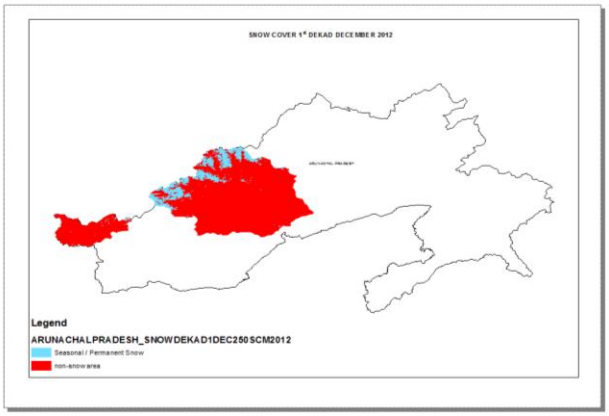


Figure 8: Snow cover WMS of Arunachal Pradesh

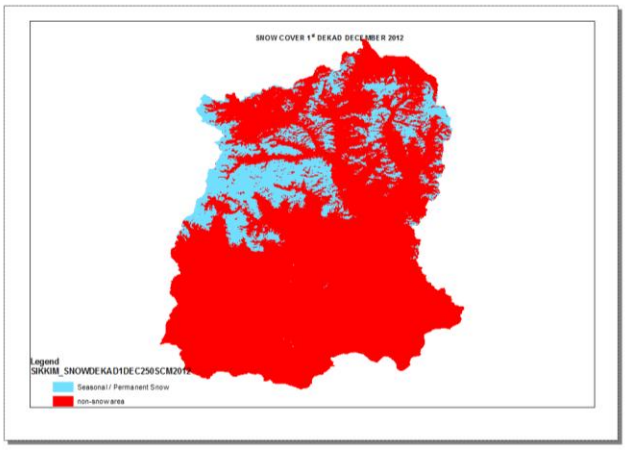


Figure 9: Snow cover WMS of Sikkim

The combined snow product is published as WMS and disseminated in NNRMS portal as shown in Figure 10. Related metadata generated is shown in Figure 11 (a) and (b).

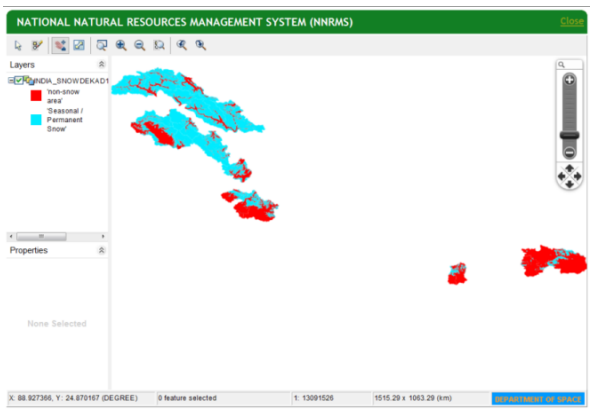


Figure 10: Snow cover WMS service of all basins in NNRMS Portal

Figure 11: (a) Spatial information of combined snow cover layer in English and Hindi respectively; and (b) Description of combined snow cover layer English and Hindi respectively

5. Conclusion

The development of automated snow data processing tool fastens the processing of voluminous spatial datasets like snow cover. It saves time and avoids processing errors if performed manually. This developed automated tool fulfils all requirements for generation of vector layers to be organized into Natural Resources Data Base according to its predefined standards. This also endorses the use of advanced computer assisted technology applied to the management of natural resources i.e. snow. Any novice user can process the snow data using this tool without having any detail knowledge of GIS. The VBA programming language and the ArcObjects used for developing this tool are an emerging technology in GIS based applications. The flexibility of the tool for further modification and updation is an added advantage with developed one.

Acknowledgements

The authors would like to thank Shri Tapan Misra, Director, Space Applications Centre, Dr. Raj Kumar, Deputy Director and Shri Shashikant A. Sharma, Group Head for providing all required infrastructure and encouragement to conduct this work. We also express our thanks to Shri B.P. Rathod, Scientist, Dr. A S Rajawat and Dr. I M Bahuguna for fruitful discussions. We also thank Shri Prateek Mathur and Shri Purnesh Jani for providing development support.

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