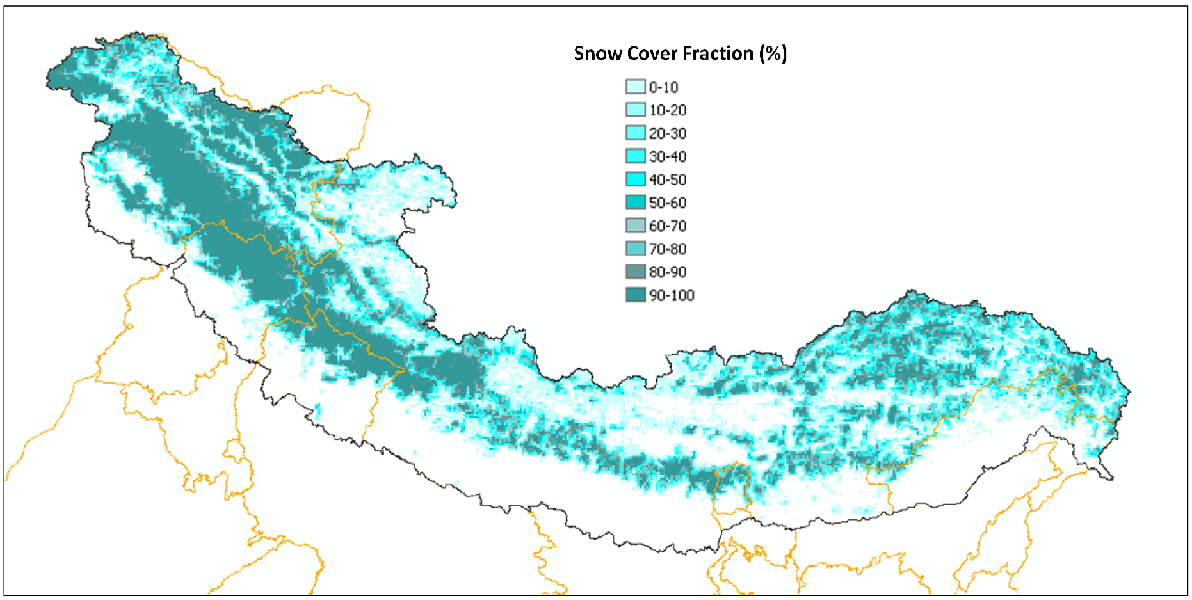
Satellite derived Information on Snow Cover Fraction (SCF)

Technical Document



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16 Abstract

A study was conducted to develop a knowledge based hierarchical automated algorithm for quick processing of Resourcesat AWiFS data and extract snow cover area. Snow cover information is used for spatial depiction of snow cover fraction (SCF). Technical document describes in brief on concept of using automated algorithm for snow cover extraction from Resourcesat-2 AWiFS sensor data. Rule based hierarchical algorithm development, accuracy, limitations, possible applications are summarized in this document .

Satellite derived Information on Snow Cover Fraction (SCF)

1. Introduction

Snow cover is dynamic in nature and melts based on local temperature variations in different time periods. Satellite sensors can provide synoptic coverage at frequent intervals which facilitates mapping, monitoring of dynamics of snow cover. All hydrological applications and land surface process monitoring models requires information on snow.

Automated Snow Cover Extraction (ASCE) Algorithm was developed by NRSC for quick processing of satellite data and extraction of Snow Cover Area (SCA) information through IMGEOS data processing chain. Further Snow Cover Fraction (SCF) as fraction of snow cover area over 3'x3' grid area was estimated.

Snow cover exists in large areas of Himalayas and is dynamic in nature. The resulting runoff from snow and glaciers. Some of the earliest applications of satellite remote sensing involved efforts to map and monitor the areal extent of snow cover. In fact, snow cover extent is the longest available environmental product provided by satellite remote sensing. In 1966 the National Oceanographic and Atmospheric Administration (NOAA) began an operational program to map Northern Hemisphere snow extent using available visible-band satellite data (Matson et al., 1986; Robinson et al., 1993). Snow cover is often easily identifiable in visible-band satellite images because it typically possesses an albedo which exceeds most all other land surface types. Snow may be identified manually by noting the magnitude of the reflectance or it may be identified automatically by the application of an algorithm which recognizes the specific spectral signature of snow. For example, at wavelengths above 1.4 µm the reflectance of snow amounts to only a few percent enabling good discrimination between snow and clouds since the reflectance of clouds remains high at that wavelength (Wiscombe and Warren, 1981).

2. Automated Algorithm for extraction of Snow cover Fraction

Overview of methodology : Steps involved in estimating satellite derived Snow Cover Area (SCA), Snow Cover Fraction (SCF) are : acquisition of multi-temporal satellite data, computation of Top of Atmosphere (ToA) reflectance, implementation of automated algorithm for generating snow cover layer , quality check and extraction of grid-wise (3'x3') Snow Cover Fraction (SCF).

2.1. Specifications of satellite data: Mapping and monitoring of snow cover requires satellites /sensors which are capable of having larger swath with higher Repeativity and 56 m spatial resolution. Resourcesat-1/ Resourcesat-2 AWiFS sensor having spectral data in four bands : 0.52-0.59 µm (Green), 0.62-0.68 µm (Red), 0.77-0.86 µm (NIR) and 1.55-1.70 µm (SWIR) is used for the study.

2.2. Development and implementation of automated algorithm: Normalized Difference Snow Index (NDSI) technique which generally used for automated detection of snow cover from remotely sensed data has limitations in the detection of snow under shadow and exclusion of water and cloud. A new automated snow cover estimation algorithm has been developed (Subramaniam et al., 2011) to overcome the these limitations using the spectral information available in the Red, Near Infrared and SWIR spectral bands of Resourcesat-1/2 AWiFS sensor. The automated algorithm has been implemented in hierarchical logical steps (Figure 1). The detailed methodology followed in automated algorithm is presented in the article under reference (Subramaniam et al., 2011).

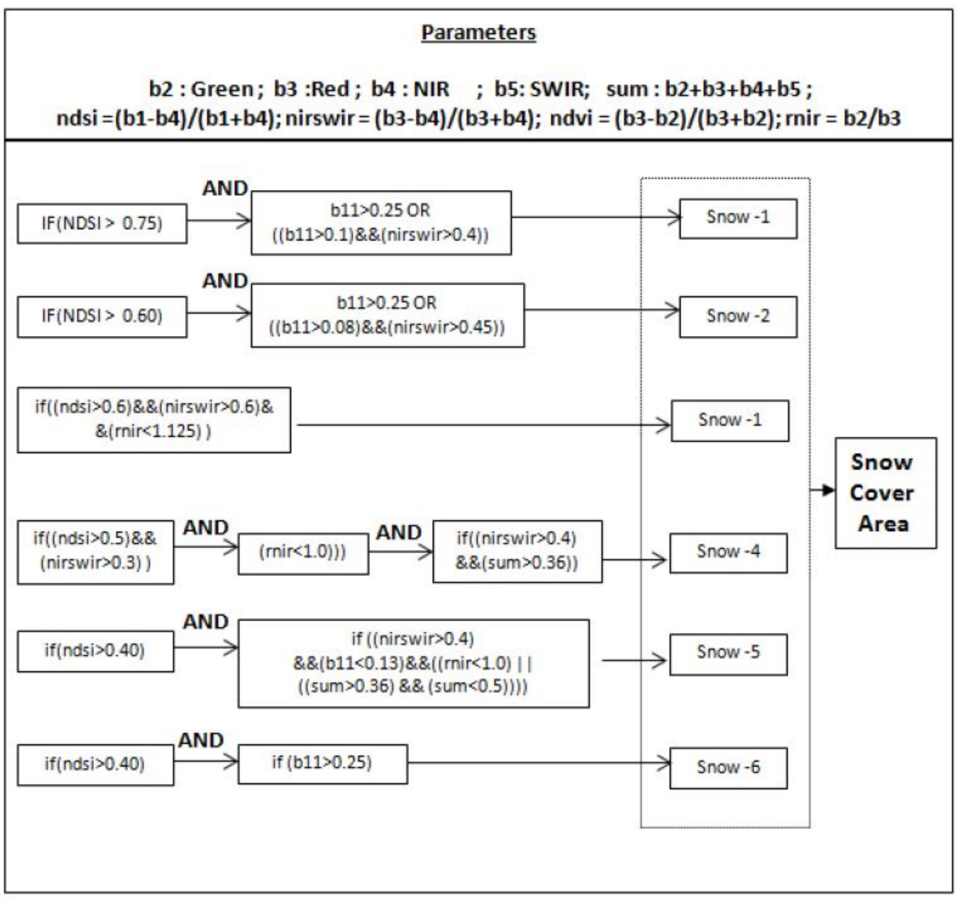

Figure.1. Flow chart for automatic extraction of snow cover area

3. Snow Cover Fraction (SCF)

Automated extraction algorithm provides a spatial snow cover layer representing snow pixels from each scene after satellite data acquisition. Scene-wise snow layers are mosaiced for generation of snow cover information over Himalayan region. Snow cover fraction is defined as fraction of geographical area covered with snow cover and total geographical area. The data base hosted in Bhuvan are spatio-temporal snow cover fraction layers at 3' x 3' Grid interval at fortnight interval . Data on snow cover fraction in IDRISI Raster format can be downloaded from Bhuvan. Cloud cover fraction information is also provided for analysis .

Table.1. Products Specification: Snow Cover Fraction

Satellite data processing and Dissemination	
Satellite / Sensor	Resourcesat-2 AWiFS
DN conversion rule	Top of Atmosphere Reflectance (TOA)
Spectral Analysis	Based on TOA reflectance from all four bands of Resourcesat-2 AWiFS
Data processing Algorithm	Knowledge based rules and hierarchical algorithm for quick processing of satellite data
Data processing Chain	Through IMGEOS
Data Dissemination	Through Bhuvan
Deliverables	Snow Cover Fraction (Himalayan region)
Image File Format	Geo-TIFF
Projection	Geographic coordinates (Lat., Long.)
Datum	WGS-84
Spatial Resolution	56m
Radiometric Resolution	8 bits per pixel
Correction Level	Terrain corrected
Number of bands	1
Output Image	Snow : 1, Non snow : 0
Thematic Accuracy	Kappa Coefficient - 0.848, Overall accuracy - 92.7%
File Naming Convention	rs2aw_India_01-03-2014_15-03-2014snow.tif

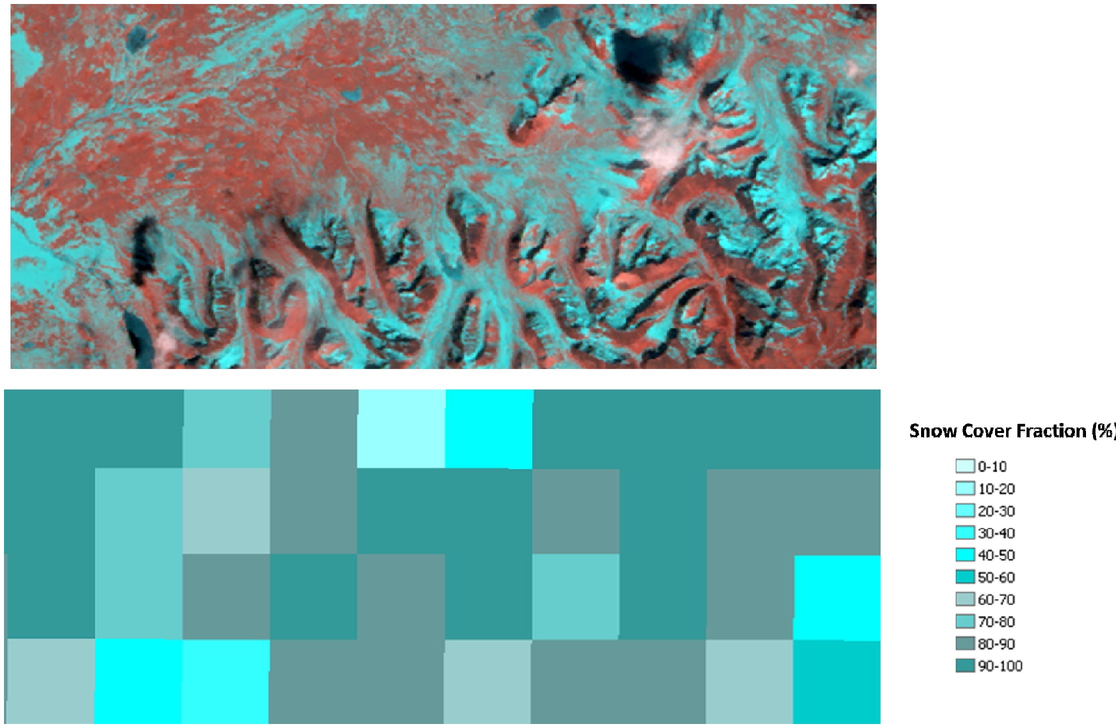

Figure.2. Satellite derived snow cover and snow cover fraction

3. Spatial Database hosted on Bhuvan

Automated Snow Cover Extraction (ASCE) algorithm was integrated into Integrated Multi-mission Ground Segment for Earth Observation Satellites (IMGEOS)- a data acquisition and processing chain . This has been facilitated for near real time satellite data processing and dissemination. This is implemented since 16th Dec, 2013. Resourcesat-2 AWIFS data is being used for this study which has Repeativity of 5 days, and hence fortnight time composite is generated from three time windows of 5 days each. Presently the following snow cover layers derived from 15 days time composite is hosted on Bhuvan and will be continued further.

4. Accuracy Assessment

Accuracy assessment was carried out with random grid sampling (75 x 75 pixels) representing different geographical regions spread across the study area in different time periods. The overall accuracy is found to be 93.5% with kappa coefficient of 0.821

5. Limitations

Cloud clover persisting will limit the satellite data acquisition. Presence of hazy cloud, cloud shadows may introduce errors in the results. Knowledge based automated algorithm and such inaccuracies observed will be considered for updating the knowledge base and improve the automated snow cover extraction algorithm . Cloud cover fraction at grid interval is also provided for analysis.

6. Productization in IMGEOS

IMGEOS is a ground segment infrastructure designed as a multi layer architecture having User Services, Data reception & Processing systems and Storage along with Security and Monitoring components to meet the increasing demand of varied types of satellite data products acquired from all IRS Earth Observation missions.

In IMGEOS the data product generation chain is triggered by work-orders from User order processing system (UOPS). The chain comprising of dedicated processing systems controlled by Data product work-flow manager (DPWFM) ,generates products as per the defined processing level .

The Information product generation system (IPGS) is a newly added work-flow in IMGEOS to automatically generate Snow layers from standard products of Resourcesat-2 AWIFS sensor in near real time .

Every day 1-2 real time passes of AWIFS data covering Himalayan region are processed in near real time to generate scene based snow layers. These scene based layers are used to generate fifteen day composite mosaic of Himalayan region and the Snow Fraction of the same .

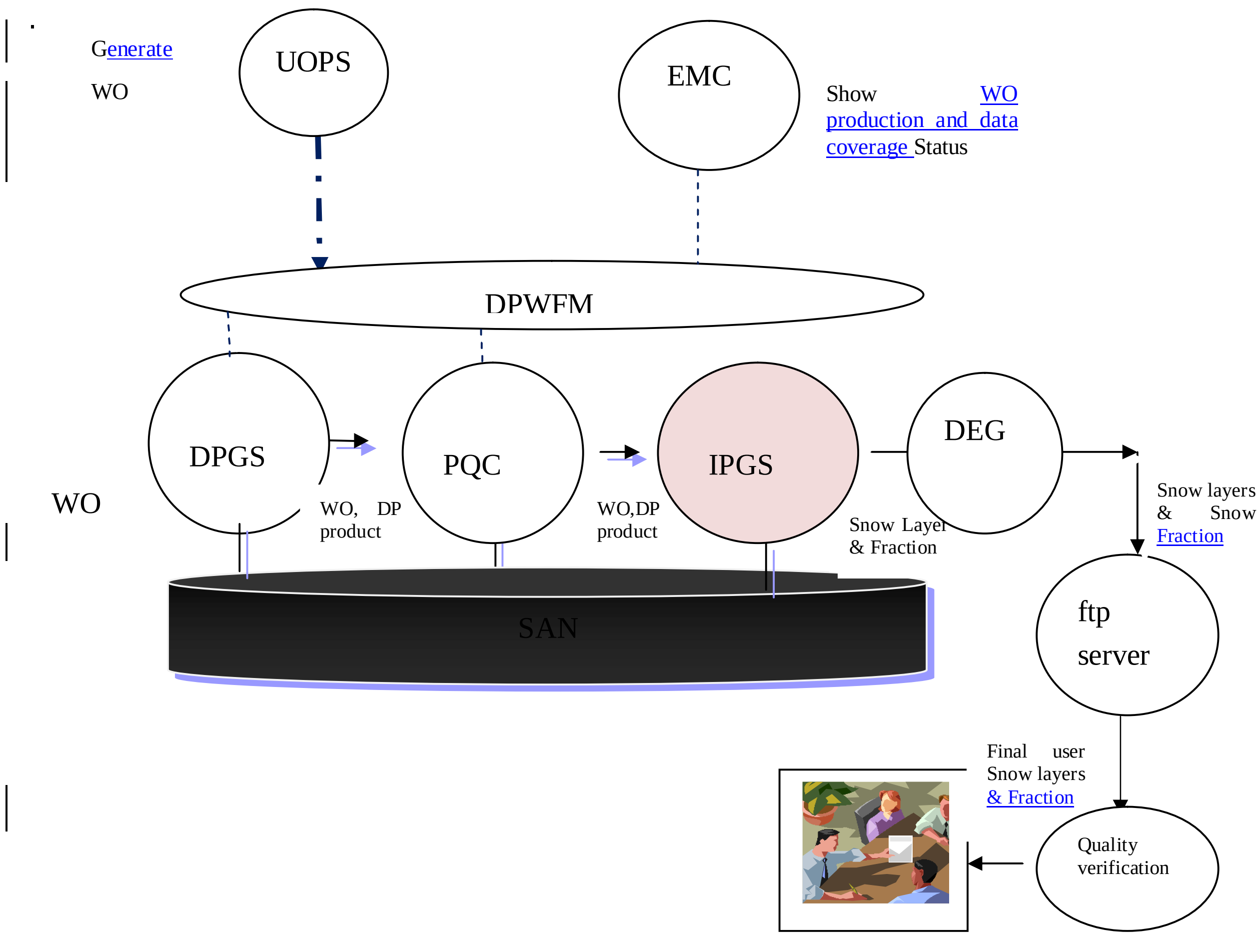

Fig.3 major elements under IPGS production chain

The major elements under IPGS production chain are:

- Product generation Initiation through Work Order generation:
  IPGS Data processing Chain is initiated with IPGS Work Order generated at User Ordering system. DPWFM routes this work-order to DPGS work-centre to generate terrain corrected products
- Information Product Generation System :
  IPGS Scheduler at IPGS work-centre processes the scene wise work-orders , invokes and manages the IPGS Layer Generation Software to generate scene wise Snow layer. Once all scene based Snow layers of the path are generated the path wise Mosaic generation is initiated. Once in five days all the path wise mosaics are used to generate 5-Day Himalayan region mosaic. Time Composite of three 5-day Himalayan region snow mosaics is generated and used for 15-Day Snow Fraction Product generation.
- Product Dissemination to FTP:
  The generated Snow mosaic layer and Fraction are then transferred to FTP Server via Data Exchange (DEG) system which are downloadable from FTP Server through a FTP user-account.

- Chain Monitoring and Routing through DPWFM and EMC:
  DPWFM generates status messages of processing done at each work-centre in the chain for the use by EMC software to allow graphical monitoring of progress done in IPGS Chain.

IPGS System and Software architecture:

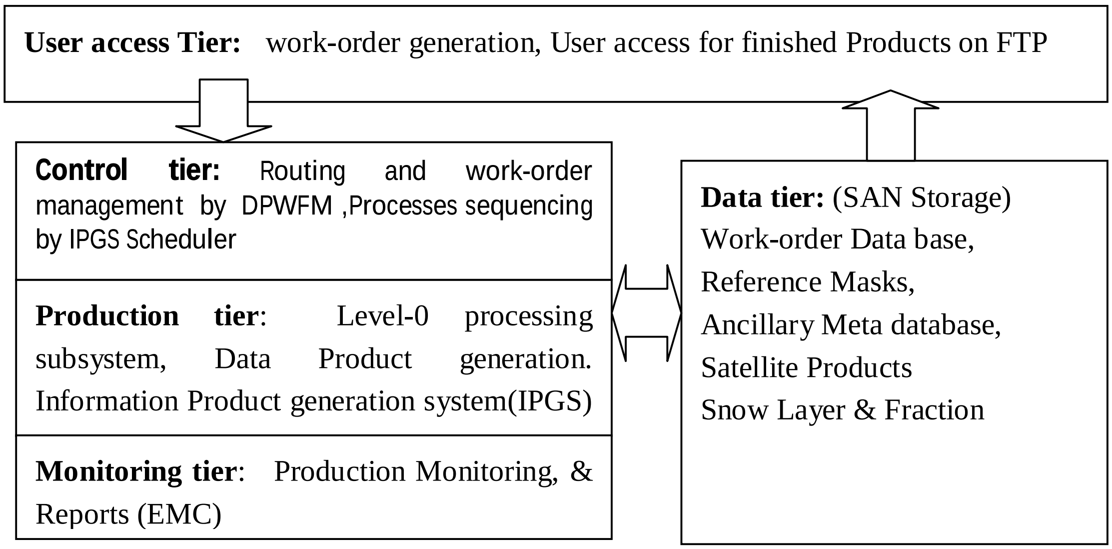

Fig.4. **IPGS System and Software architecture**

IPGS software is a new component in IMGEOS for generation of Information Layers , Mosaic generation and distributed scheduling . The layer and Mosaic generation software is developed and optimized in IMGEOS framework with standardized interfaces for automation and error handling in production chain using open source tools. The synchronization of Mosaic generation and time composition are achieved using system level daemon services. The IPGS scheduler is capable of distributed scheduling to take advantage of available processing nodes.

7.Possible Applications

- Studies on snow cover dynamics and as input for land surface processes modeling.
- Information on snow cover fraction for 3’ x 3’ grids will be useful for hydrological and climate models
- Source of information for the development of alert mechanism for existence / non existence of snow cover

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