SCATSAT-1 DATA PRODUCTS GENERATION AND DISSEMINATION

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ABSTRACT: The Scatsat-1 satellite was launched by Indian Space Research Organization (ISRO) on September 26, 2016. Scatsat-1 is a continuity mission for OSCAT (oceansat scatterometer) on board oceansat-2 satellite which provides back scatter coefficients (sigma – 0) over entire globe and wind vectors i.e. wind speed and direction over the global oceans. The sigma – 0 products are very much useful for various land and oceanographic applications. The wind vector products are being used for weather forecasting, cyclogenesis prediction, cyclone detection and tracking services by different national and international users. The satellite covers the entire globe over a period of two days.

The most important point in this mission is to provide data products within 180 minutes of data acquisition by satellite for all 14/15 orbits for Indian / international users. For this purpose, facilities have been established at polar ground stations i.e., in north and south poles to receive data from satellite for all orbits. Facilities have been established for transfer of data from polar ground stations to NRSC (National Remote Sensing Center) shadnagar, generation of data products and dissemination of products to users with in specified turnaround time. The products are being supplied to users in operational mode from 24th April, 2017 onwards. This paper describes details of entire facility, types of products and dissemination methods. A web portal and FTP server are also established for down loading data products by users.

1. INTRODUCTION

Weather forecasting is the process of forecasting the future state of the weather using currently available observations. It plays a major role in different applications like climate change studies, prediction of monsoon onset, ships navigation, air traffic control, disasters, floods and many others. It is a continuous activity to forecast the future state of the weather for short range, medium range and long range periods. Data from many ground and space based instruments is being used for this activity. Satellites are playing a major role in this activity because of their spatial and temporal coverage characteristics over ground based observations. Satellite sensors operating in different frequencies i.e. optical, infrared and microwave regions of the electromagnetic spectrum are being used in different weather forecasting systems. Scatterometer is one of the important microwave sensors used for this purpose.

Weather forecasting is carried out at different meteorological organizations world-wide using NWP (Numerical weather prediction) models. Wind vectors over global oceans are one of the major inputs for them and must be assimilated into the models within 180 minutes of data acquisition by the sensor. The total process of data acquisition by the sensor, data dumping, data processing, data products generation, dissemination to the forecasting centers and assimilation into NWP models must be carried out within 180 minutes from the time of data acquisition. For weather forecasting models, data assimilation within 180 minutes is acceptable because there assumed to be no reasonable variation in winds for this period of time.

Cyclones are formed over different oceans and they severely affect the human lives and property. These cyclones need to be monitored effectively from the formation stage to the landfall stage to reduce the loss as much as possible. Most of the cyclones are formed over open oceans where land based monitoring instruments are generally not available. Remote sensing satellites based observations plays a crucial role in this regard. Satellite based observations are being used for quite a long time for monitoring of cyclones. It is a very cost-effective and efficient technique to predict, detect, track and monitor cyclones. Different optical, infrared and microwave satellites data are being used for these purposes and scatterometer, a microwave sensor plays a major role in this activity. The early prediction and detection of cyclone formation is very much crucial for taking all necessary precautions. Scatterometer derived wind vectors are useful for prediction, detection and tracking of cyclones. Cyclones are predicted based on the wind patterns generated over the ocean surface. ISRO has been using scatterometer generated winds for cyclones monitoring since OSCAT time frame i.e. from 2010 onwards. It was able to capture cyclones namely Thane, Nilam and Phailin over India, typhoon kabayan over Philippines, hurricanes Irene and sandy over USA using OSCAT data. India is more prone to tropical cyclones over the Arabian sea and Bay of Bengal. Every year cyclones over India cause torrential rains and floods and severely affects large number of people. So, it is very much critical to predict the cyclones well in advance.

Global warming is affecting the entire world in many ways. Due to raise in global warming recently, sea ice is melting very fast over Polar Regions i.e. Arctic and Antarctica. Himalayan Glaciers are retreating very fast and Greenland ice sheets are also shrinking in size. The melting of sea-ice, glaciers and ice sheets causes the raise in the sea levels and it adversely impacts coastal regions. Himalayan glaciers are the major sources of water for many rivers in India like Ganga and Brahmaputra. If these glaciers recede at a faster rate, causes severe floods and impacts millions of people. So, a careful monitoring of sea-ice and glaciers is very much required and it is only possible to do these efficiently using remote sensing satellites data. Optical sensors cannot be used for sea ice monitoring because of low level of illumination in Polar Regions and frequent cloud cover in other areas. Microwave sensors like scatterometer are very much useful for these studies. Scatterometer derived sigma-0 data is useful in sea-ice and glaciers monitoring studies over the Arctic, Antarctic, Greenland, Himalayas and other snow/ice covered regions. This data is useful to estimate the extent of ice spread and age.

ISRO (Indian space research organization) has started launching scatterometer payloads on-board IRS (Indian remote sensing) satellites starting with Oceansat-2 satellite (OSCAT) in 2009. It continued with another scatterometer payload on-board SCATSAT-1 in 2016. SCATSAT-1 scatterometer is an active microwave sensor operating at 13.515 GHz Ku band frequency. It is an all-weather sensor capable to operate continuously throughout the day. It measures the back scattered signals from the surface of the earth and generates sigma-0 values over the entire globe and near-surface wind vectors i.e. wind speed and wind direction over the global oceans.

NRSC has started acquiring remote sensing satellites data since 1978 using the ground station established at Earth station complex, shadnagar. The state of the art facility, IMGEOS (Integrated Multi-mission Ground segment for Earth Observation Satellites) is setup at this ground station to acquire process and disseminate remote sensing satellites data from the IRS and few foreign satellites in a complete automated manner. This ground station can acquire all polar remote sensing satellites data four times in a day i.e. two during day time and two during night time during ascending and descending orbits. But, all polar remote sensing satellites including SCATSAT-1 satellite rotates around the earth 14/15 times per day. So, it is not possible to collect all the orbits data in near real time using this ground station alone. To overcome this limitation, NRSC/ISRO has started using its own ground station AGEOS (Antarctica ground station for earth observation satellites) established at Antarctica, Bharati located in South Pole and another ground station at SVALBARD located in North Pole. These two stations being located near north and south poles respectively can have satellite visibility for more number of orbits. All the 14/15 orbits of SCATSAT-1 data are being acquired in near real time using these two ground stations is transferred to shadnagar ground station using dedicated network links (satellite and terrestrial) and is processed to meet the stringent timeline requirements. The products generated at this facility are hosted on FTP (File transfer protocol) server and SAGAR (Satellite Application based Global Archive) web portal. The products are being used by different national and international users like NCMWRF (National center for medium range weather forecasting), ECMWF (European center for medium range weather forecasting), NOAA (National oceanic and avionics administration), KNMI (Royal Netherlands meteorological institute) etc.

2. BRIEF DESCRIPTION ABOUT SCATTEROMETER

Scatterometer flown on Oceansat-2 and SCATSAT-1 satellites are both pencil beam scatterometers [5]. The sensor conically scans the surface of the earth in two polarizations i.e. one vertical VV (outer beam) and one horizontal HH (inner beam) polarizations at two different incidence angles. The sensor measures each point on the surface of the earth from four view angles i.e. Inner Fore, Inner Aft, Outer Fore and Outer Aft. The satellite scanning geometry is shown in the figure 1.

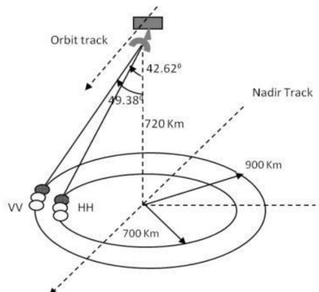


Figure 1: Satellite scanning geometry

It covers 90% of the globe in single day and entire globe in two days. The specifications of the scatterometer sensor are as follows.

Table 1: SCATSAT-1 scatterometer sensor specifications

Parameter	**Specification**	
Altitude	720km	
Frequency	13.515 GHz	
Scanning rate	20.5 rpm	
Nominal PRF	193 Hz	
	Inner beam	**Outer beam**
Polarization	HH	VV
Swath	1400 km	1800 km
Beam width (Az x El)	1.47^0 x 1.63^0	1.39^0 x 1.72^0
Footprint	27km x 46 km	30 km x 70 km
Wind vector cell size	50 km x 50 km, 25 km x 25 km	
Wind speed range	3 to 30 m/s	
Wind direction range	0^0 to 360^0	
Wind speed accuracy	1.8 m/s or 10% whichever is higher	
Wind direction accuracy	20^0 rms.	

Scatterometer works on the principle of back scattering. It actively transmits electromagnetic pulses to the earth's surface and measures back scattered response. Sigma-0 is derived from the back scattered response using radar equation. The intensity of the back scatter response depends on the roughness and dielectric properties of the target. The ocean surface roughness changes according to wind velocity and correspondingly the received back scattered power. The back scattered power is measured from different azimuth angles and it is four in this case. The wind speed and direction are estimated with these observations using GMF (Geo physical model function) [2] that relates back scatter and wind vector. The wind vector retrieval process uses model winds derived from ECMWF.

3. DATA PROCESSING FACILITY SETUP

SCATSAT-1 data of all 14/15 orbits is being acquired daily in near real time using Shadnagar, Antarctica, Svalbard and Tromso ground stations. Only data acquisition facilities are established at these ground stations. The data acquired at Antarctica, Svalbard and Tromso stations are transferred to IMGEOS facility at shadnagar using dedicated 36 Mbps satellite link and 10 Mbps terrestrial link respectively. The pass schedule files that are required for data acquisition and the raw data acquired are transferred using these links. Shadnagar ground station is used for backup purposes and to play back recorded data.

Once the raw data is received at shadnagar ground station, it is processed using ADP (Ancillary data processing) system to generated level-0 products. Then these products are transferred to DPGS (Data products generation system) system to generate different types of data products. Currently sigma-0 and wind vector data products are generated over two grids of sizes 25 km and 50 km respectively. To meet the TAT (Turnaround time) requirements, these products are generated using two separate DPGS systems. Another DPGS system is used for reprocessing whenever software version is changed. The products are evaluated for quality purposes using separate DQE (Data Quality Evaluation) software. Different networks are connected using secure DEG (Data Exchange Gateway) systems for security purposes. Data products generated are hosted on the web portal and FTP server. The FTP server hosts specific set of products for specific users. The web portal hosts data products for all the users.

The total process from data acquisition to products dissemination takes place using IMGEOS framework [4] defined work flows in a complete automated manner. Currently data products are generated within the nominal TAT of 50 minutes from the time of data acquisition at ground station. Software's are designed to monitor total chain continuously and raise alarms whenever there are some events like problem in data acquisition or exceeding of TAT to take corrective actions before the next orbit data is acquired. The total activity is monitored on 24/7 basis as data is available for every 100 minutes. The total data acquisition, processing and dissemination setup is depicted in the figure 2.

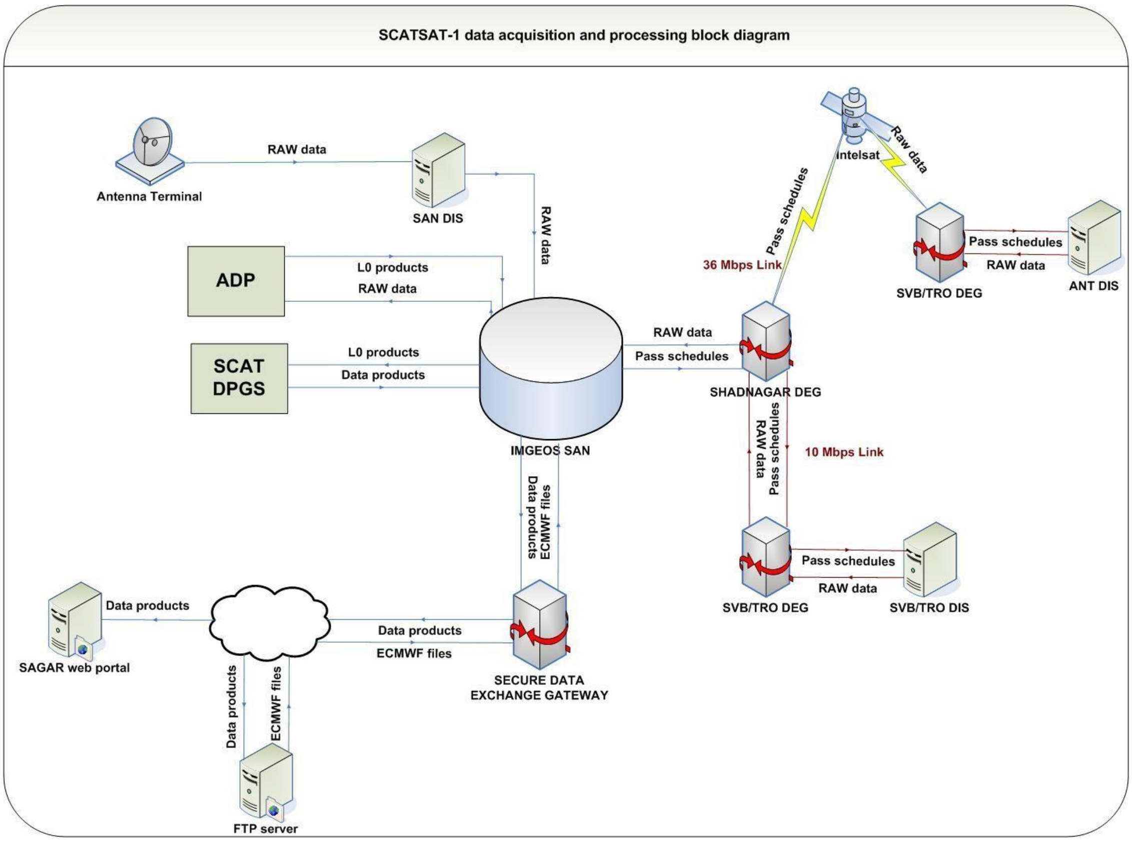


Figure 2: SCATSAT-1 data acquisition and processing setup block diagram

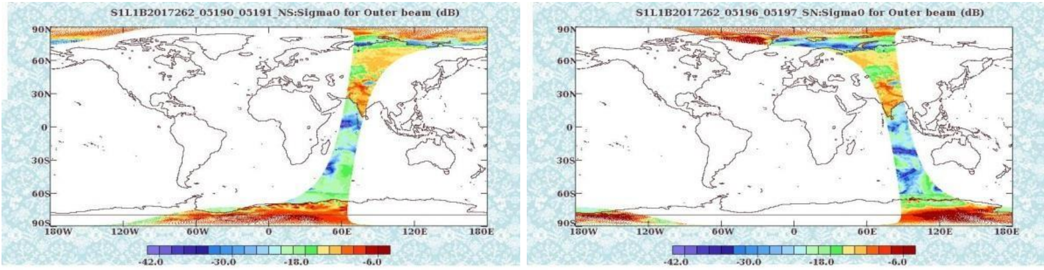
4. DATA PRODUCTS

SCATSAT-1 data is acquired at four ground stations. There will be switching over between different ground stations during 14/15 orbits of data acquisition i.e. from SVALBARD to Antarctica and vice versa. The products are to be disseminated within the specified timelines. So, it is not possible to define products for entire orbit similar to OSCAT because sometimes entire orbit data is not available during switching over from one station to another. So, half-orbit products are defined for SCATSAT-1. The two products are designated as S-N and N-S to represent South Pole to North Pole and North Pole to South Pole during ascending and descending phases of the orbit [7]. The products are generated over two grid sizes of 25km and 50 km respectively. Experimental products are generated at higher resolutions also. Different types of products and their descriptions are mentioned in table 2.

Table 2: Data products and their specifications

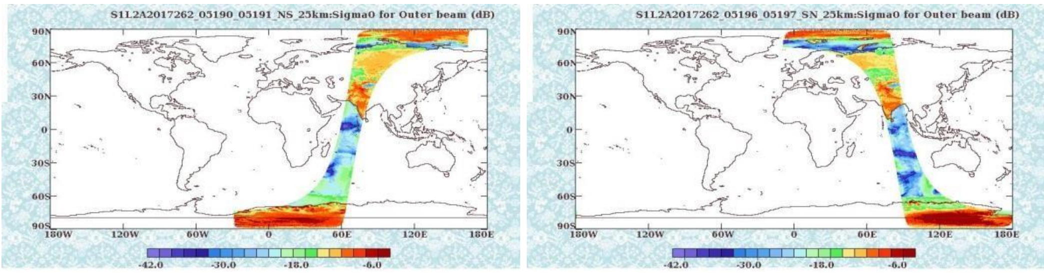
Product Type	Product Level	Swath	Cell size	Format
Slice level sigma-0	L1B	1800 km	-	HDF5
Half-orbit wise grid level sigma-0	L2A	1800 km	25 x 25 km, 50 x 50 km	HDF5
Half-orbit wise grid level winds	L2B	1800 km	25 x 25 km, 50 x 50 km	HDF5
Global sigma-0	L3SH, L3SH	Global	0.5^0 x 0.5^0, 0.25^0 x 0.25^0	HDF5
Global winds	L3WW	Global	0.5^0 x 0.5^0, 0.25^0 x 0.25^0	HDF5

The slice level L1B sigma-0 products are generated using back scattered power using radar equation. The L2A products are gridded products with geo location information attached to each grid cell. These products are generated using slice level sigma-0 products by combining slices falling in the same grid. The L2B wind products are generated from L2A products using GMF's. L3 global simga-0 and wind products are generated using all the available L2A and L2B products of the given day. L3SH and L3SV products are horizontal and vertical polarization sigma-0 products respectively. All the L1B, L2A and L2B products are generated half-orbit wise and L3 products are generated one for each day. Two day global time composite products are also generated using day-wise L3 products. L1B and L2A products are available for specific users. L2B and L3 products are available to all the users. L2B and L3 products are available on both SAGAR web portal and FTP server. The jpeg chips of the different types of products are shown in the following figures.



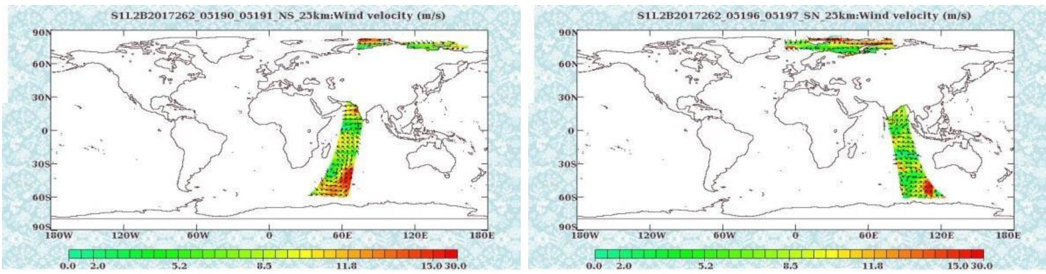
(a) (b)

Figure 3: (a), (b) Level 1B slice level sigma-0 products



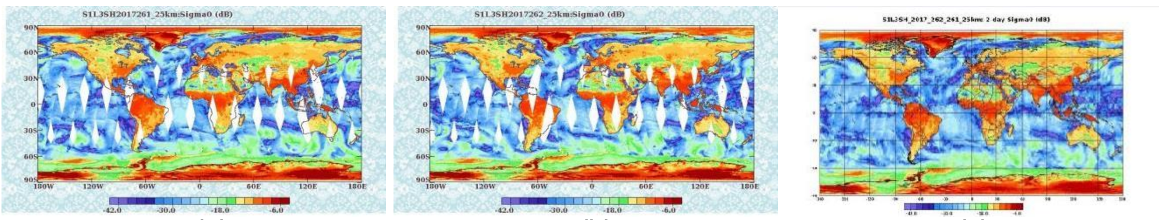
(a) (b)

Figure 4: (a), (b) Level 2Agrid level sigma-0 products



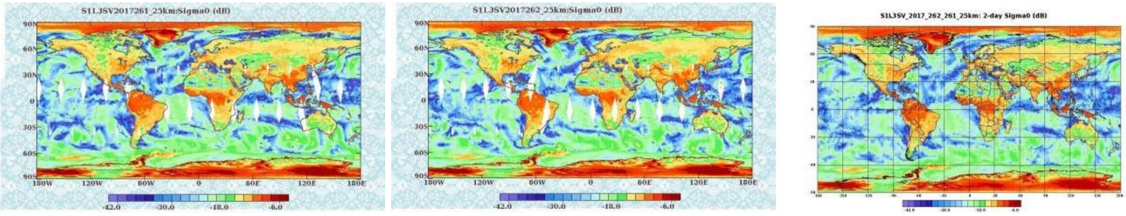
(a) (b)

Figure 5: (a), (b) Level 2B grid level wind vector products



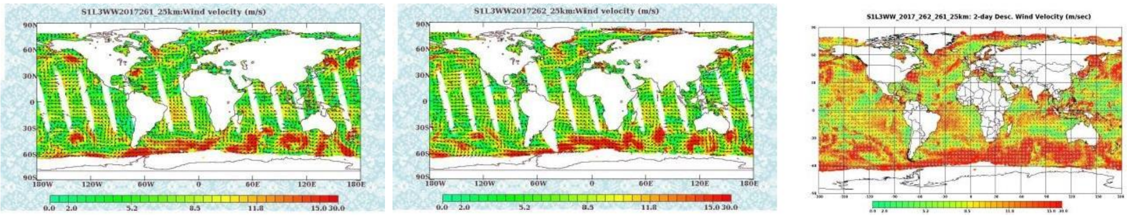
(a) (b) (c)

Figure 6: (a), (b) Level 3 day-wise global HH sigma-0 products, (c) Two-day time composite global HH sigma-0 product



(a) (b) (c)

Figure 7: (a), (b) Level 3 day-wise global VV sigma-0 products, (c) Two-day time composite global VV sigma-0 product



(a) (b) (c)

Figure 8: (a), (b) Level 3 day-wise global wind vector products, (c) Two-day time composite global wind vectorproduct

5. DATA AVAILABILITY

SCATSAT-1 data products are available from both FTP server and SAGAR web portal. The screenshots of web portal and FTP server are shown in the following figures.

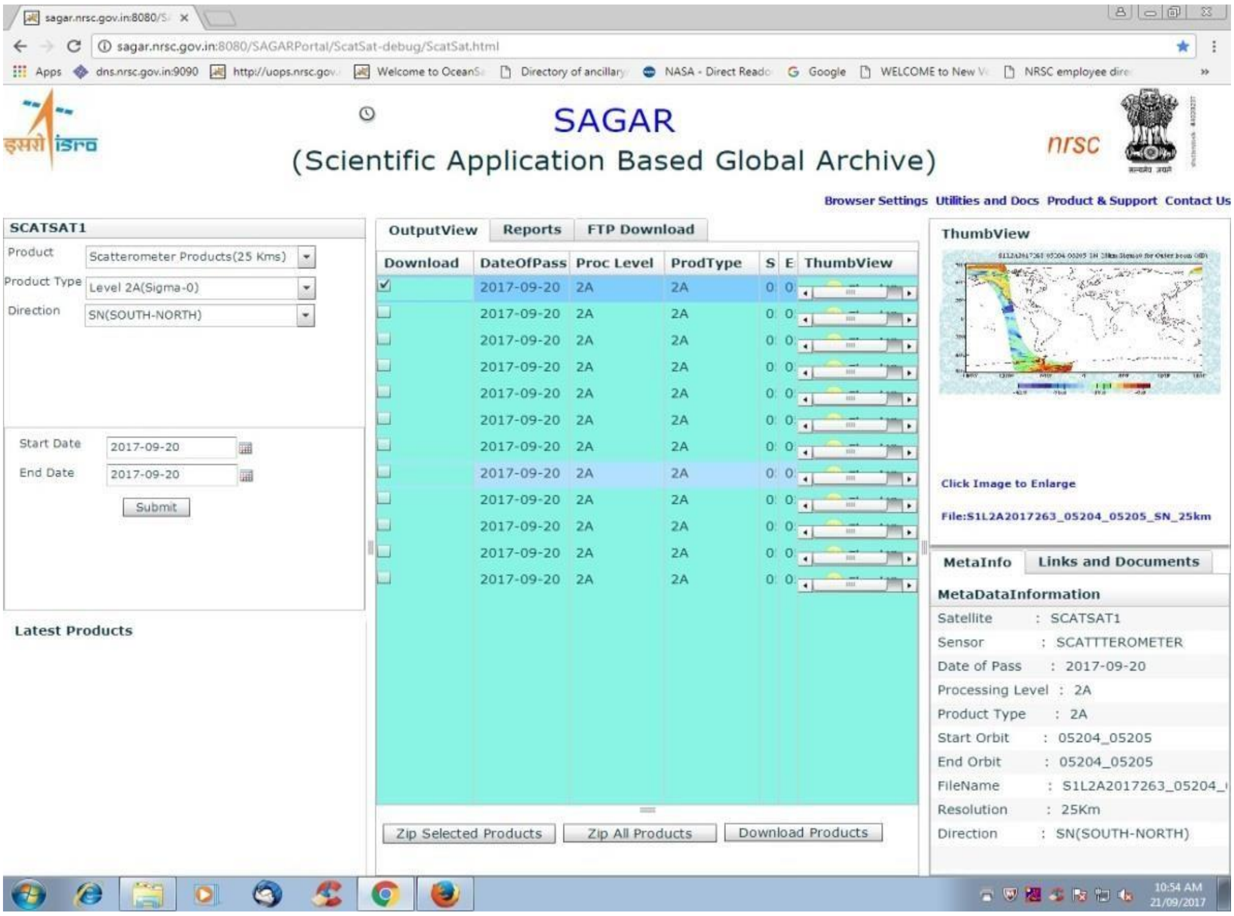


Figure 9: SAGAR web portal

SAGAR web portal can be accessed from NRSC website ***www.nrsc.gov.in***

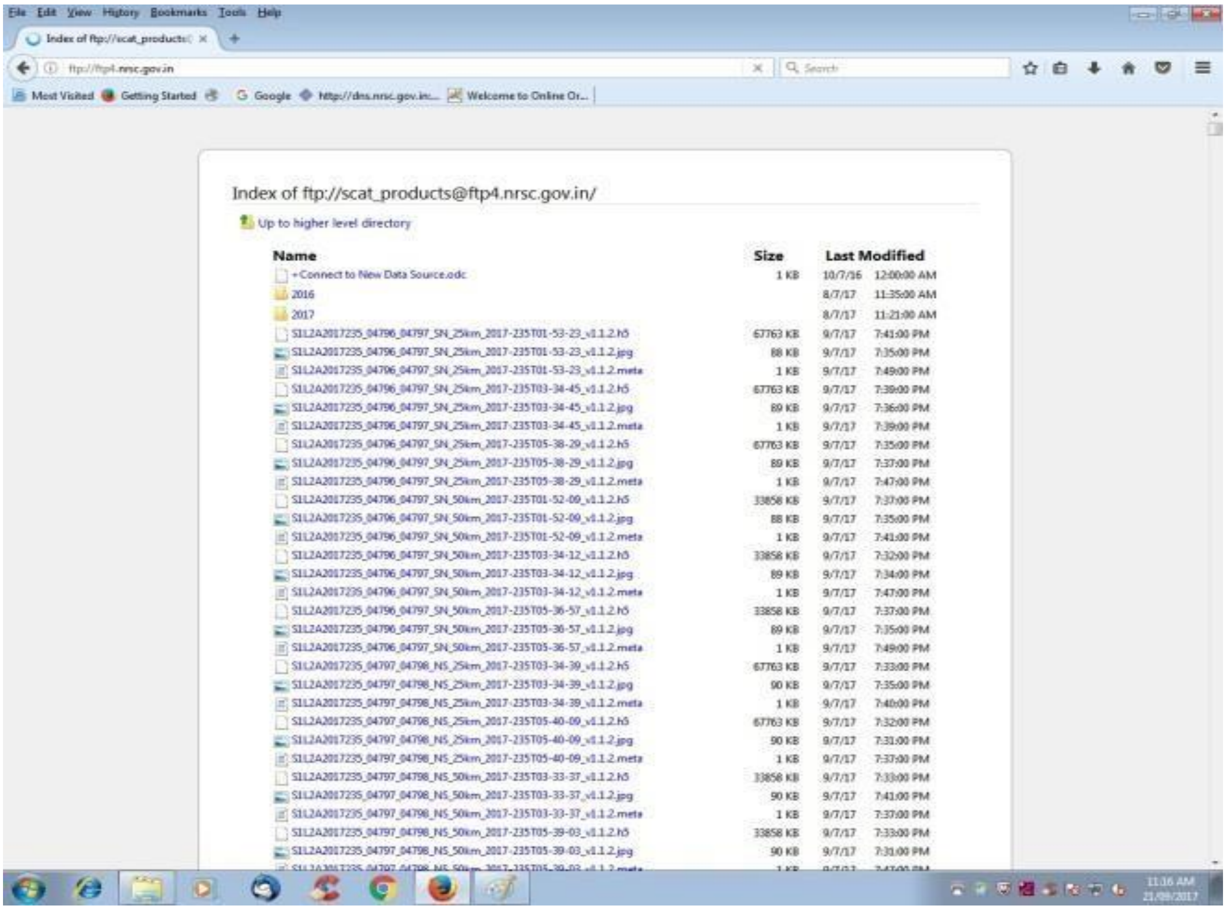


Figure 10: FTP server

The statistics of the SCATSAT-1 products downloaded using web portal and FTP server after its operationalization in April 2017 are given in the following table.

Table 3: SCATSAT-1 data products statistics downloaded by different users

	May 2017	**June 2017**	**July 2017**	**Aug 2017**
MOSDAC	41,735	23,004	24,367	42,832
EUMETSAT	5,451	12,751	15,806	11,429
NCMRWF	10,621	10,144	10,342	6,513
Oceanweather, Inc USA	2,058	1,978	2,229	1,289
IFFREMER, France	5,232	4,587	8,024	6,919
Japan Met. Agency	0	2,484	3,566	2,348
Others	0	0	1,232	9,592
Total	65,097	54,768	65,566	80,902

6. CONCLUSIONS

This paper explains the requirement of processing of the data within 180 minutes from the time of the data acquisition by the sensor. It explains the specifications of the scatterometer sensor followed by the facilities established for data acquisition, data transfer, products generation and dissemination of the data products for different national and international users. It gives details of different types of data products generated and the platform for dissemination to the users. This kind of processing facility can be extended for any other satellite that requires stringent time line requirements and for future scatterometer missions also.

7. REFERENCES

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