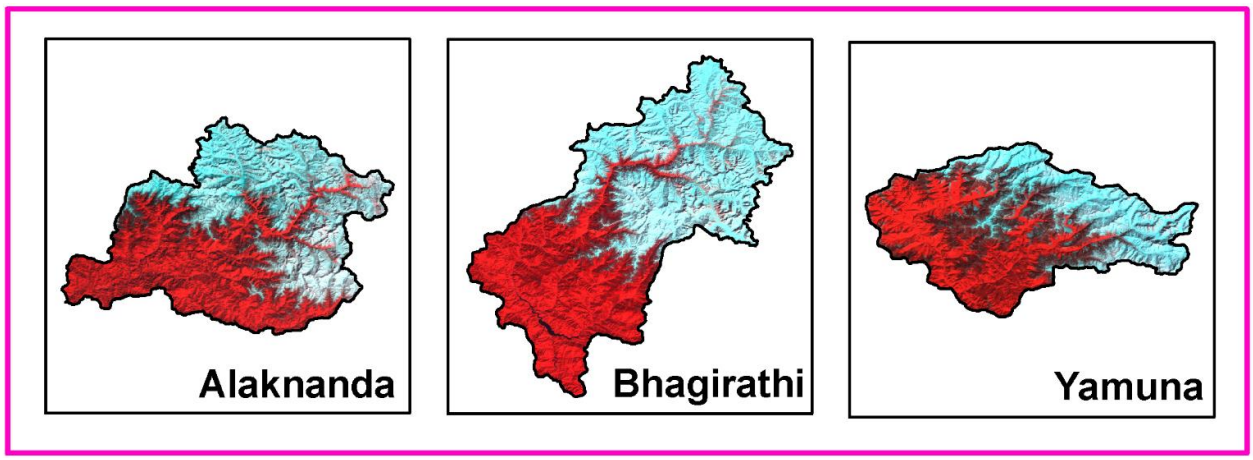
SNOW COVER ATLAS OF THE GANGA BASIN

Sub-basins: Alaknanda, Bhagirathi, and Yamuna

(Integrated *Studies of Himalayan Cryosphere*

A Project of Indian Space Research Organisation)

Year 2014 - 2015



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CEPT University- Ahmadabad 380009
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Abstract	This atlas gives sub-basin-wise distribution of snow cover in the Ganga basin from October 2014 to June 2015. The sub-basins included in this report are Alaknanda, Bhagirathi and Yamuna. The areal extent of snow cover was estimated in fully automatic mode using Normalized Difference Snow Index (NDSI) based algorithm. For this purpose, AWiFS sensor of Resourcesat satellite was used. This atlas gives snow cover products, statistics and seasonal snow depletion curve. It is expected that this data will be useful for hydrological and climatological applications.
Key words	Snow cover, NDSI, AWiFS, depletion curve, Alaknanda, Bhagirathi and Yamuna basins.
Security Classification	Unrestricted
Distribution	Among concerned

Authors (Team Members)

Space Application Centre (ISRO)

Ahmedabad-380015

B. P. Rathore

S. K. Singh

I. M. Bahuguna

A. S. Rajawat

Faculty of Geomatics and Space Application

CEPT University Ahmedabad-380009

Sowkhya Badatala

Darshna Rawal

Anjana Vyas

CONTENTS

1. **Introduction**

Snow covers almost 40 per cent of the Earth's land surface during Northern Hemisphere winter. This makes albedo and areal extent of snow as important component of the Earth's radiation balance (Foster and Chang, 1993). In addition, large areas in the Himalayas are also covered by snow during winter. Area of snow can change significantly during winter and spring. This can affect stream flow for rivers originating in the higher Himalayas. All the rivers originating from higher Himalayas receive almost 30-50 % of annual flow from snow and glacier melt run off (Agarwal et al., 1983). In addition, snow pack ablation is highly sensitive to climatic variation. Increase in atmospheric temperature can influence snowmelt and stream runoff pattern (Kulkarni et al., 2002). Therefore, mapping of the areal extent and reflectance of snow are important parameter for various climatological and hydrological applications. In addition, extent of snow cover can also be used as input for numerous other applications.

Mapping and monitoring of seasonal snow cover using field methods are normally very difficult in a mountainous terrain, like the Himalayas. Therefore, remote sensing techniques have been extensively used for snow cover monitoring. Snow cover monitoring using satellite images were started by using the TIROS-1 satellite from April 1960 (Singer and Popham 1963). Since then, the potential for operational satellite-based mapping has been enhanced by the development of higher temporal frequency and satellite sensors with higher spatial resolution. In addition, satellites with better radiometric resolutions, such as NOAA have been used successfully for snow mapping (Hall et al., 1995). This is possibly due to the distinct spectral reflectance characteristics of snow in visible and near infrared regions. India has launched series of Indian Remote Sensing satellite (IRS) to study the different earth resources. Previously launched satellites have flown with many sensors having different spatial, temporal and spectral resolutions. Recently launched RESOURCESAT-1 satellite has three different sensors namely LISS III, LISS IV & AWiFS with different spatial, temporal and spectral resolutions as desired for different applications. AWiFS (Advanced Wide Field Sensor) is an advanced version of earlier Indian satellite sensor WiFS (Wide Field Sensor) with improved spectral and spatial resolutions maintaining the same repetivity. There are a series of other polar orbiting satellites, like Landsat, NOAA and MODIS etc., which have provided information on different aspects of

snow. Geo-stationary satellites also proved their utility in mapping/monitoring the snow-covered regions. Information generated from satellite observations has been extensively used for snowmelt runoff modeling (Kulkarni et al., 1997).

2. Study Area:

This Atlas gives distribution of snow cover in three sub-basins of the Ganga basin. These are Alaknanda, Bhagirathi and Yamuna sub basins. Locations of these basins are shown in Figure 1.

3. Data used:

AWiFS data from October 2014 to June 2015 were used in this study.

4. Normalised Difference Snow Index (NDSI):

In general, the reflectance of snow is high at the red end of the visible spectrum. It tends to decline in the near-infrared region until 1090 nm, where slight gain in reflectance occurs and gives a minor peak at approximately 1090 to 1100 nm. One of the important difficulties in snow cover monitoring is the presence of cloud cover. Cloud has strong reflectivity in visible, NIR and SWIR regions while snow absorbs in SWIR, and this difference can be utilized for snow/cloud discrimination. Normalized Difference Snow Index (NDSI) utilize the normalized ratio of green and SWIR and is used as an automated approach for snow mapping addressing the shadow and cloud problems in snow bound areas.

Normalized Difference Snow Index was calculated using the ratio of green wavelength (band 2) and SWIR (band 5) of AWiFS sensor:

$$Normalized\,Difference\,Snow\,Index(NDSI) = (band2 - band5)/(band2 + band5) \quad ..(1)$$

To estimate NDSI, DN numbers were converted into reflectance. This involves conversion of digital numbers into the radiance values, known as sensor calibration, and then estimation of

reflectance from these radiance values. Various parameters needed for estimating spectral reflectance are maximum and minimum radiances and mean solar exo-atmospheric spectral irradiances in the satellite sensor bands, satellite data acquisition time, solar declination, solar zenith and solar azimuth angles, mean Earth-Sun distance etc. (Markham and Barker, 1987; Srinivasulu and Kulkarni, 2004).

5. Snow cover monitoring algorithm

An algorithm is developed to provide changes in the areal extent of snow (Kulkarni et. al., 2006). Snow extent is estimated at an interval of 5-days and 10-days, depending upon availabilities of AWiFS data. In 5-daily product, snow extent is generated scene-wise. In this product, snow and cloud extents are given. Estimate of cloud is important because, at times, snow is covered by cloud and this may be classified as non-snow area, leading to erroneous conclusions. In 10-daily product, three scenes are analyzed, if available. For example, 10 March product data of 5, 10 and 15 March was used. If any pixel is identified as snow on any one date then this pixel will be classified as snow on final product. This provides snow cover at an interval of 10 days, an important requirement in hydrological applications. Therefore, this product is generated basin-wise. Since this product is using three scenes, probability becomes high that at least in one scene, pixel may be cloud-free and this helps in overcoming problem associated with snow under cloud cover. If three consecutive scenes are not available, then all available scenes in 10 days window was used in the analysis. Differentiation between water and snow is difficult using NDSI image. In addition, separation of snow and water pixels is also difficult based on reflectance due to mountain shadow. Therefore, in the present algorithm, water bodies are marked in pre-winter season and are masked in the final products during winter. Flow diagram of the algorithm is given in Figure 2.

6. Results and discussions

In this atlas, basin-wise snow cover statistics, maps, and seasonal depletion curves have been provided from October 2014 to June 2015. Snow ablation pattern varies from basin to basin, depending on area altitude distribution in the basins. From October to December there was not much snowfall was observed, accumulation starts from October and melting was observed from until first week of December in all the three sub-basins. Again, accumulation starts from first week of January until March end. Maximum snow cover was observed in the month of February in all the three sub-basins. Yamuna sub-basin ablation starts from March. Fluctuation in snow cover was more in Yamuna sub-basin. It may be due to lower altitude.

Acknowledgements

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ALAKNANDA SUB-BASIN

AREAL EXTENT OF SNOW (5 DAILY)

BASIN NAME: ALAKNANDA **BASIN AREA: 11090 sq km**

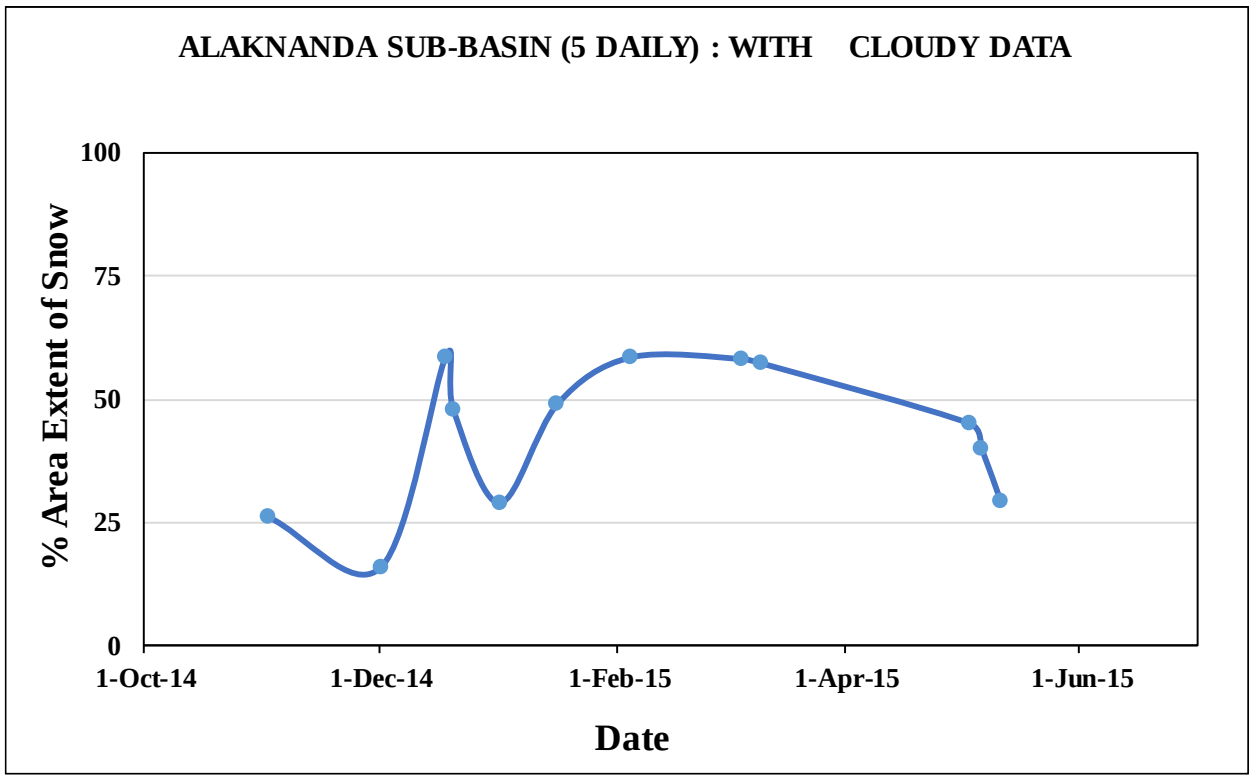
S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
November 2014							
1	02-Nov-2014	2885	26				
December 2014							
2	01-Dec-2014	1739	16	**3**	18-Dec-2014	6502	59
4	20-Dec-2014	5292	48				
January 2015							
5	01-Jan-2015	3204	29	**6**	16-Jan-2015	5434	49
February 2015							
7	04-Feb-2015	6484	58				
March 2015							
8	05-Mar-2015	6446	58	**9**	10-Mar-2015	6346	57
May 2015							
10	03-May-2015	4990	45	**11**	06-May-2015	4433	40
12	11-May-2015	3234	29				

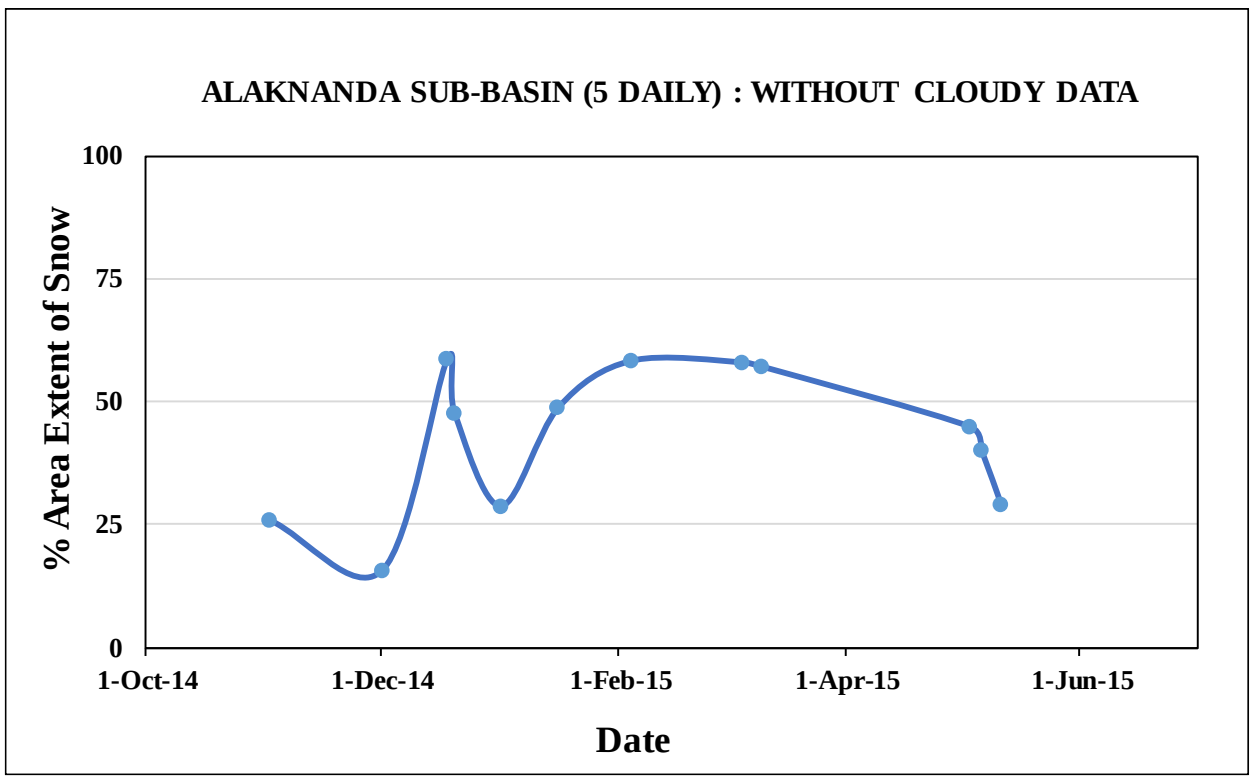
AREAL EXTENT OF SNOW (10 DAILY)

BASIN NAME: ALAKNANDA **BASIN AREA: 11090 sq km**

S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
November 2014							
1	05-Nov-2014	2885	26				
December 2014							
2	05-Dec-2014	1739	16	**3**	15-Dec-2014	6238	56
January 2015							
4	05-Jan-2015	3204	29	**5**	15-Jan-2015	5434	49
February 2015							
6	05-Feb-2015	6484	58				
March 2015							
7	05-Mar-2015	6433	58				
May 2015							
8	05-May-2015	4989	45	**9**	15-May-2015	3234	29

SNOW COVER DEPLETION CURVE





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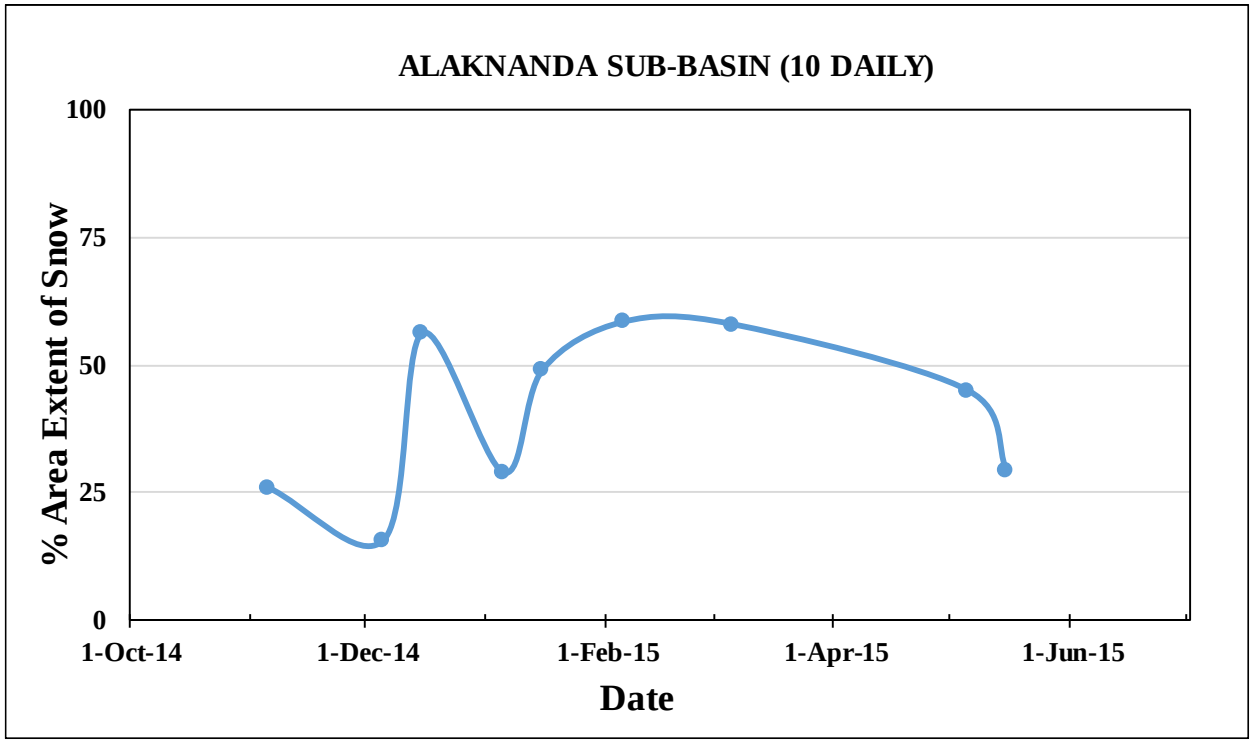
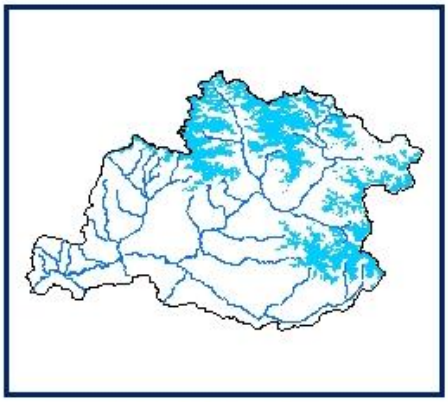


SNOW COVER MAP

SNOW COVER MAP : ALAKNANDA SUB-BASIN



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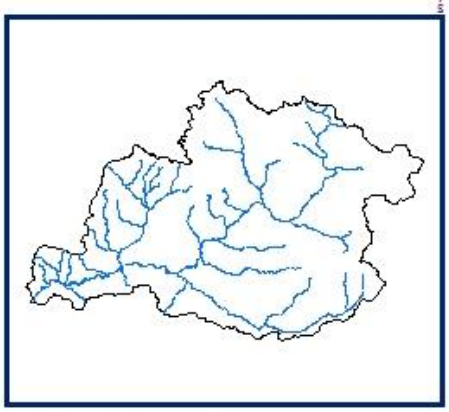

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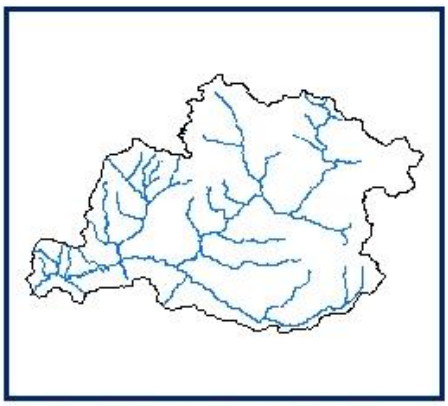

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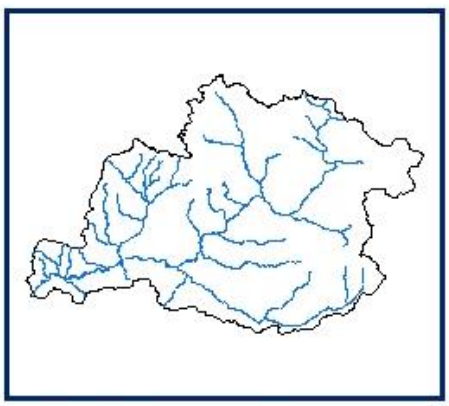

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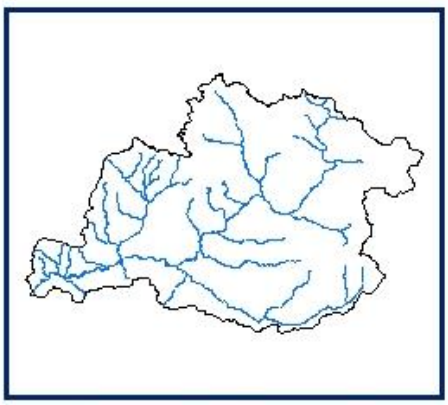

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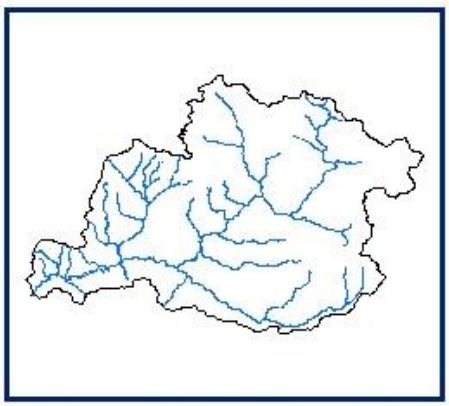

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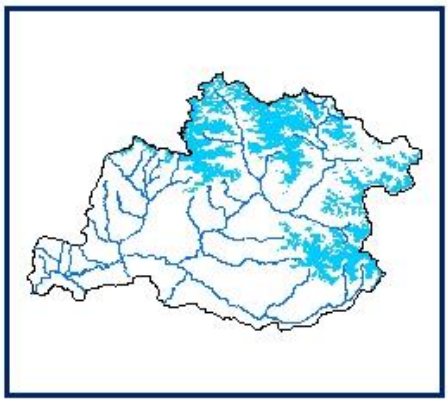
SNOW

40 20 0 40 80 120

Kilometers

10 DAILY SNOW COVER MAP : ALAKNANDA SUB-BASIN



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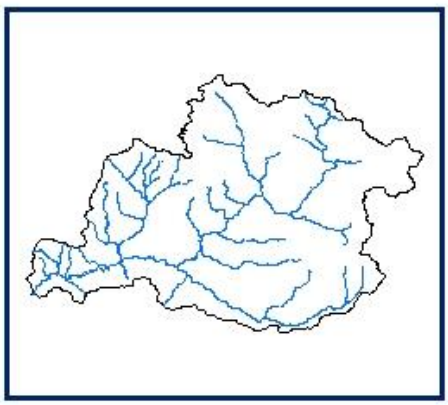

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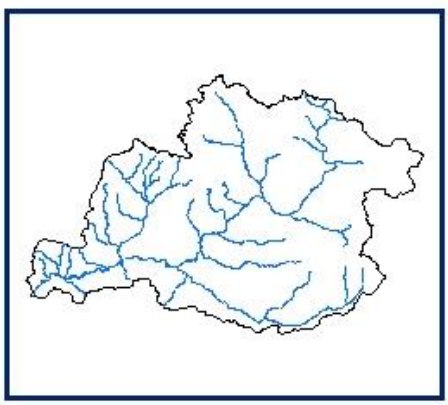

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SNOW

12.50 25 50 75

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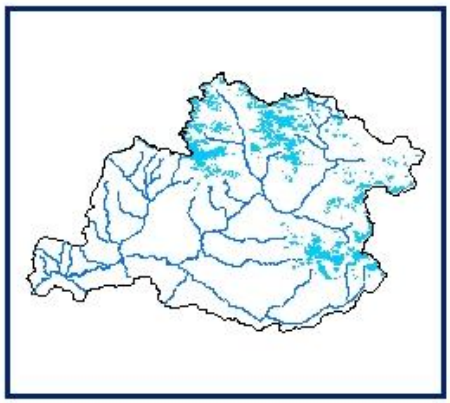
SNOW COVER MAP : ALAKNANDA SUB-BASIN



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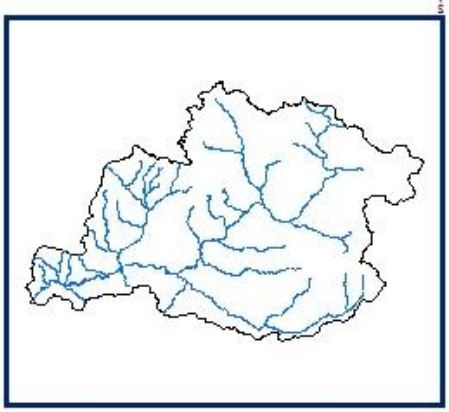

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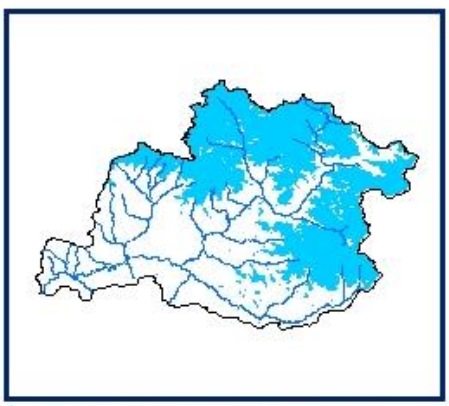

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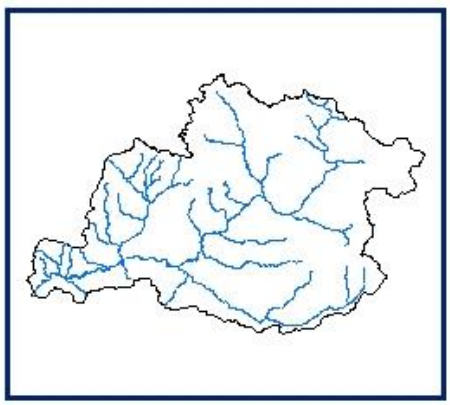

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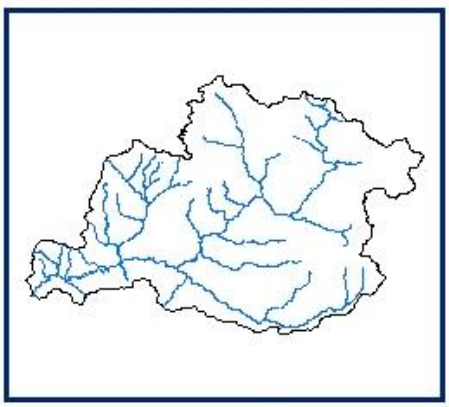

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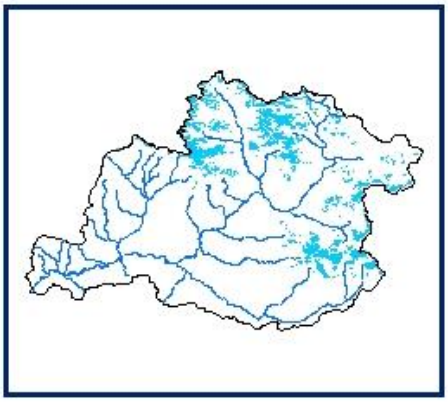
SNOW

40 20 0 40 80 120

Kilometers

10 DAILY SNOW COVER MAP : ALAKNANDA SUB-BASIN



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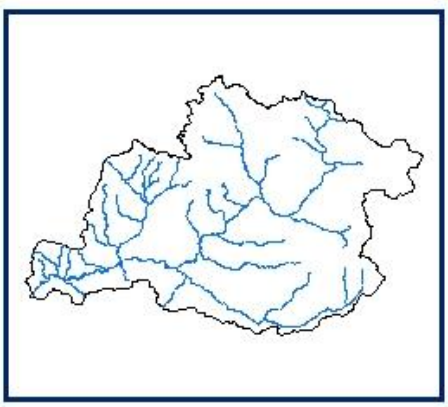

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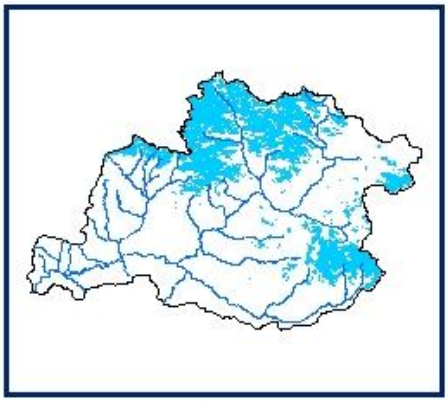
0 12.50 25 50 75
Kilometers

SNOW COVER MAP : ALAKNANDA SUB-BASIN



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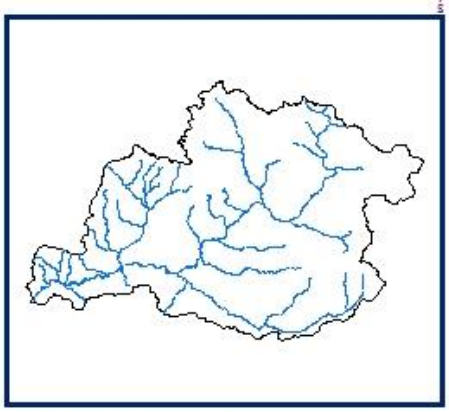

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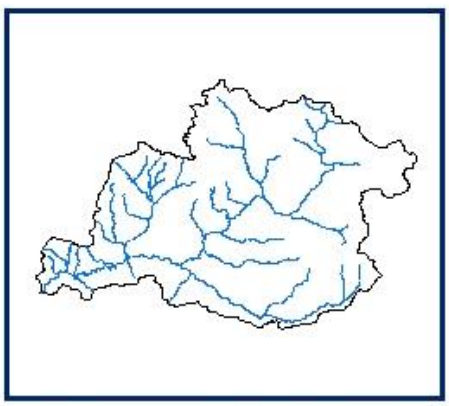

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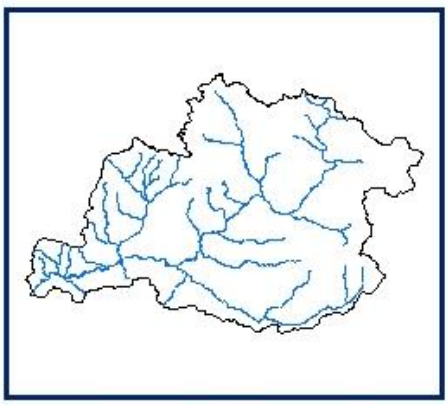

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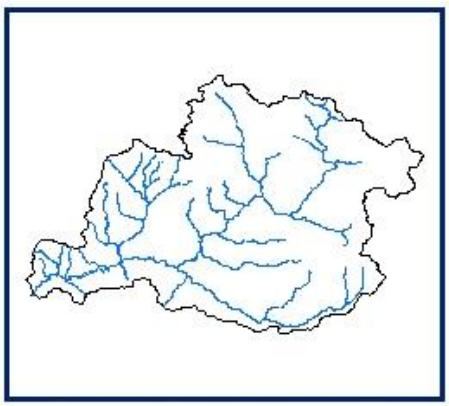

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SNOW

40 20 0 40 80 120

Kilometers

10 DAILY SNOW COVER MAP : ALAKNANDA SUB-BASIN

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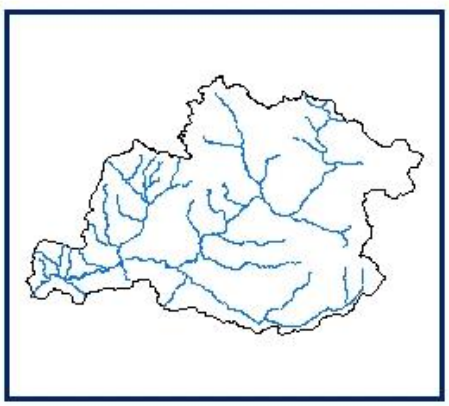

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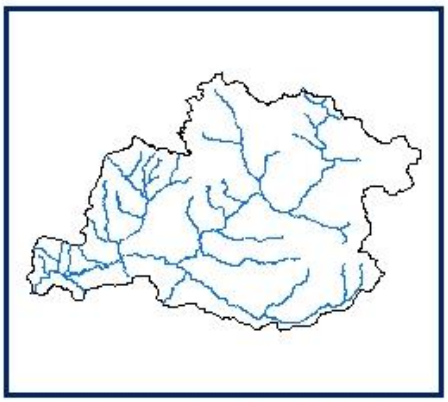
12.50 25 50 75
Kilometers

SNOW COVER MAP : ALAKNANDA SUB-BASIN



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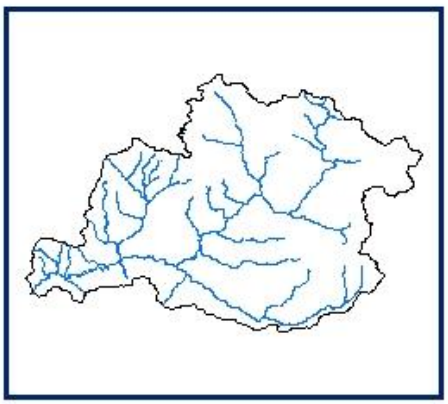

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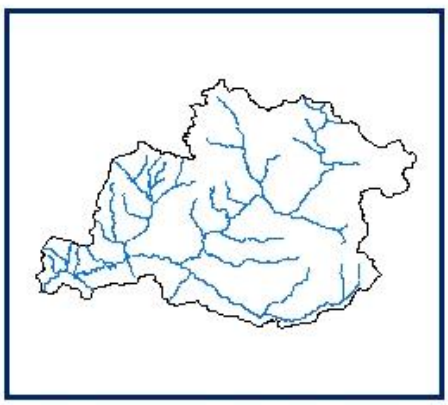

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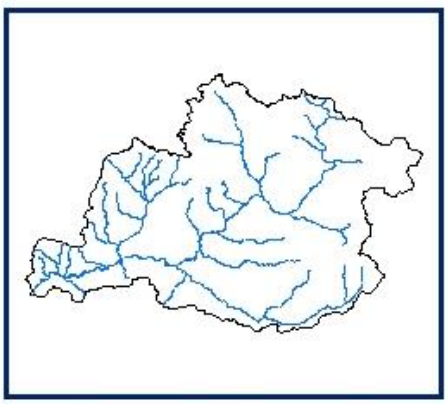

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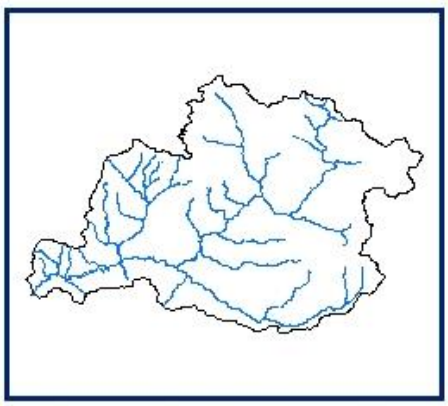

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Kilometers

10 DAILY SNOW COVER MAP : ALAKNANDA SUB-BASIN

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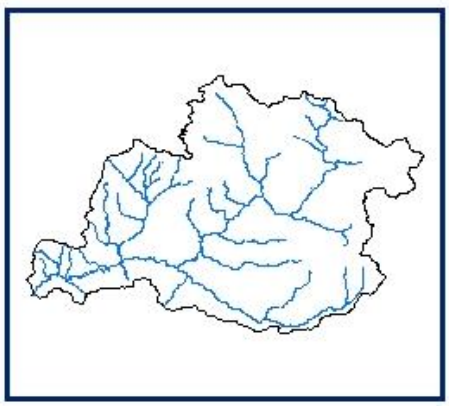

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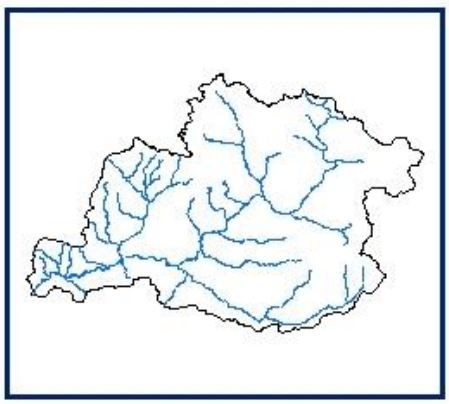


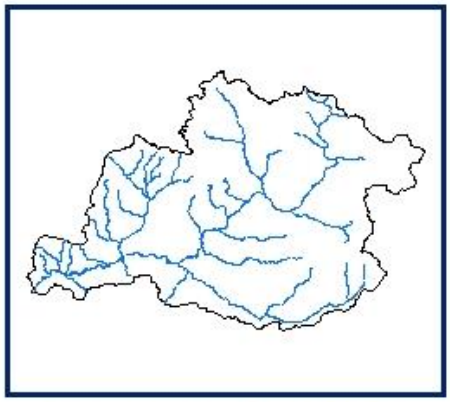
DATA NOT AVAILABLE

SNOW

0 12.50 25 50 75

Kilometers

SNOW COVER MAP : ALAKNANDA SUB-BASIN



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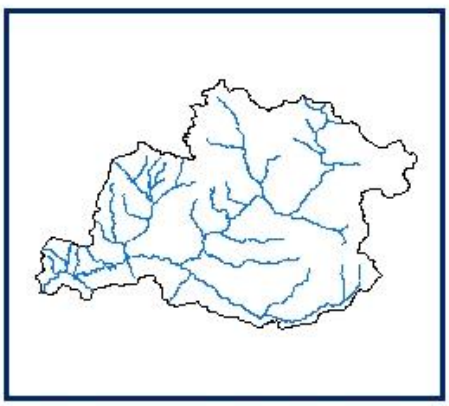
05 MARCH 2015

10 MARCH 2015



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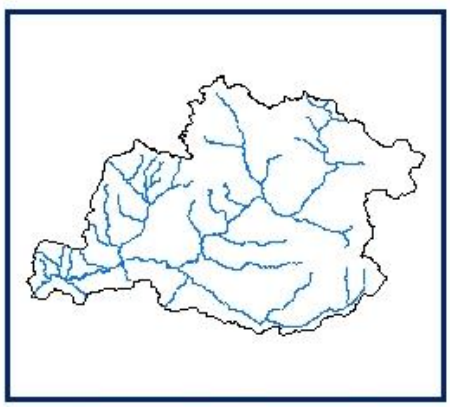

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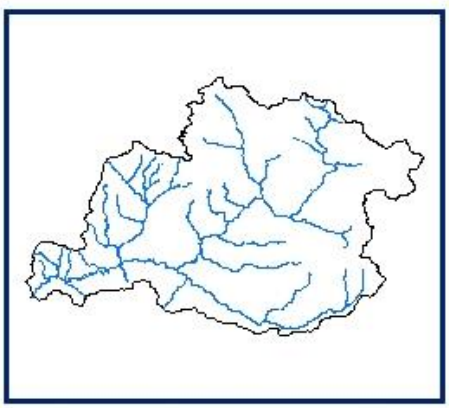


DATA NOT AVAILABLE

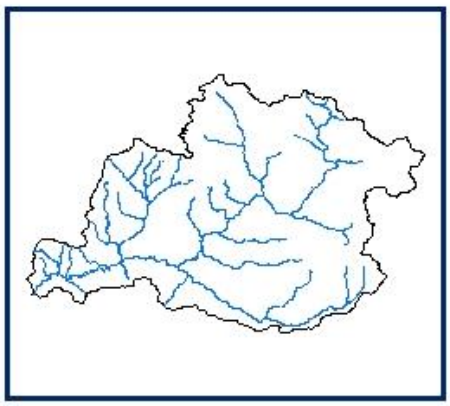
SNOW

40 20 0 40 80 120

Kilometers

10 DAILY SNOW COVER MAP : ALAKNANDA SUB-BASIN

DATA USED
05 MARCH 2015
10 MARCH 2015



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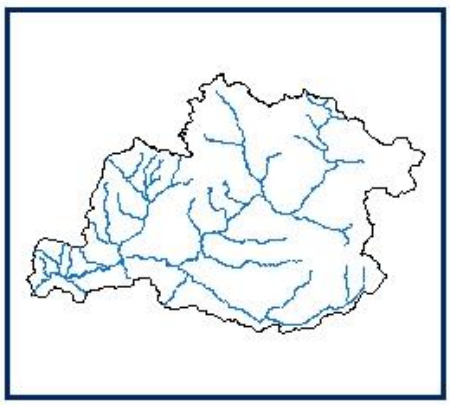


DATA NOT AVAILABLE

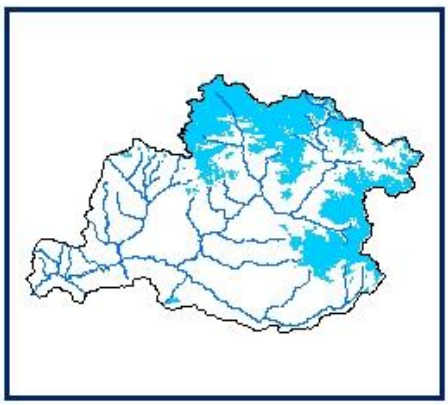
SNOW

0 12.50 25 50 75
Kilometers

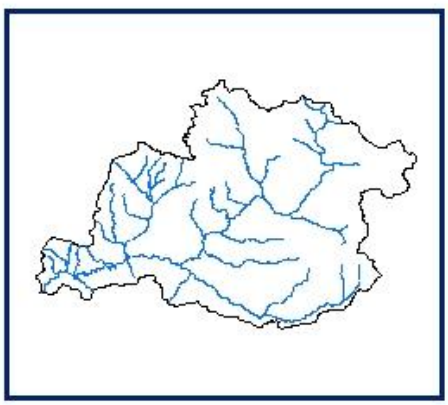
SNOW COVER MAP : ALAKNANDA SUB-BASIN

03 MAY 2015

06 MAY 2015



11 MAY 2015



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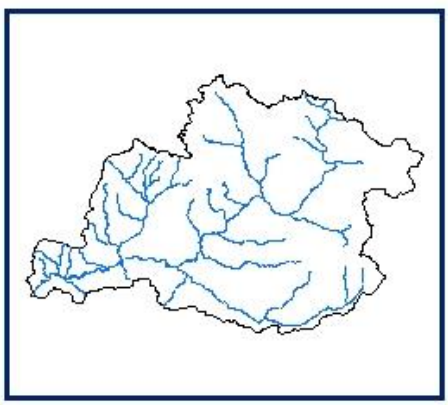

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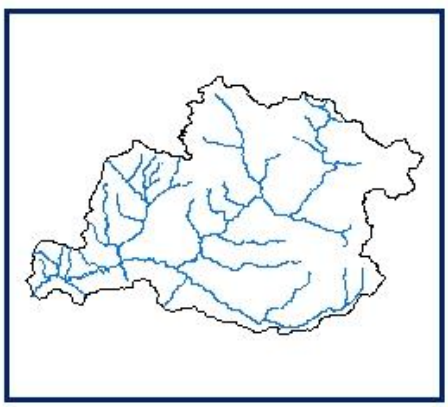


DATA NOT AVAILABLE

SNOW

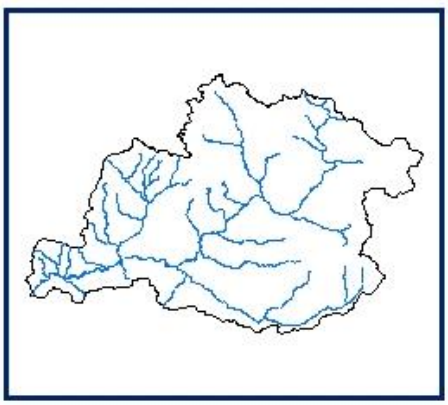
40 20 0 40 80 120

Kilometers

10 DAILY SNOW COVER MAP : ALAKNANDA SUB-BASIN

DATA USED
03 MAY 2015
06 MAY 2015

DATA USED
11 MAY 2015



DATA NOT AVAILABLE

SNOW

12.50 25 50 75
Kilometers

BHAGIRATHI SUB-BASIN

AREAL EXTENT OF SNOW (5 DAILY)

BASIN NAME: BHAGIRATHI **BASIN AREA: 7438 sq km**

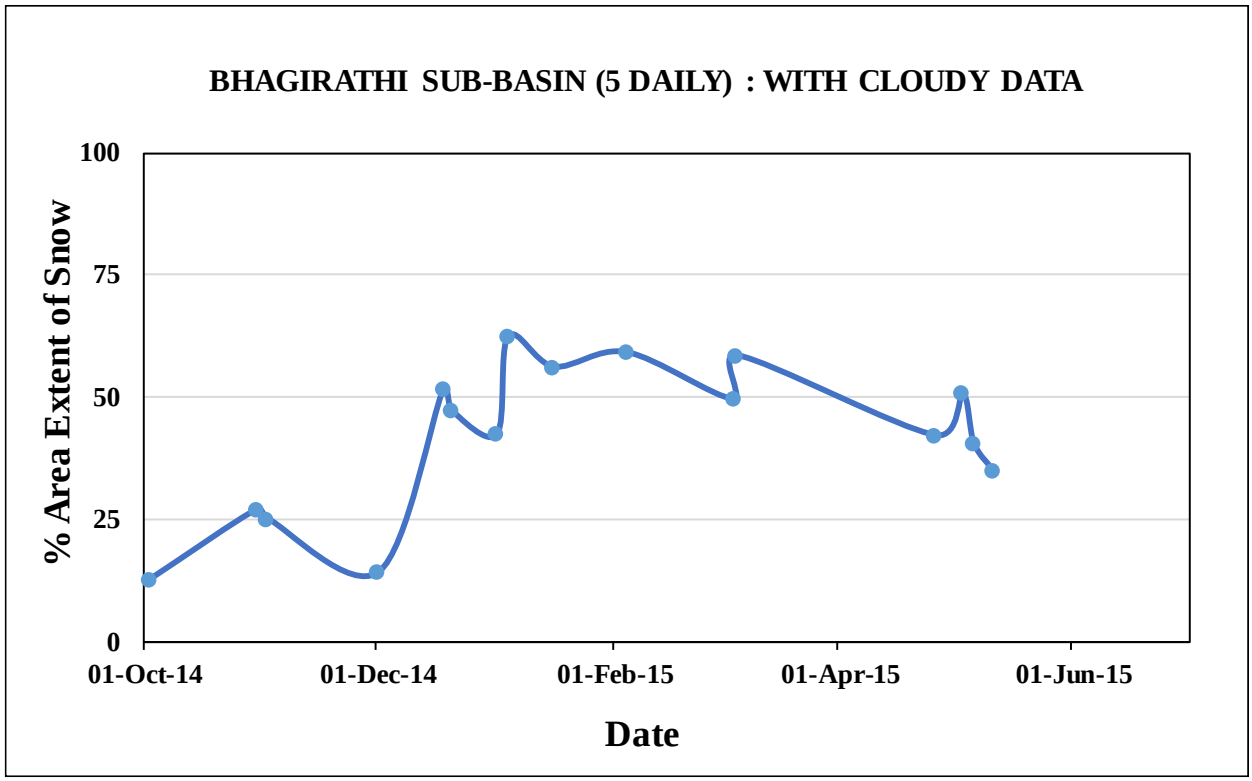
S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2014							
1	02-Oct-2014	933	13	**2**	30-Oct-2014	2001	27
November 2014							
3	02-Nov-2014	1861	25				
December 2014							
4	01-Dec-2014	1047	14	**5**	18-Dec-2014	3844	52
6	20-Dec-2014	3521	47				
January 2015							
7	01-Jan-2015	3149	42	**8**	04-Jan-2015	4646 (C)	62
9	16-Jan-2015	4182	56				
February 2015							
10	04-Feb-2015	4403	59				
March 2015							
11	04-Mar-2015	3690 (C)	50	**12**	05-Mar-2015	4356	59
April 2015							
13	26-April-2015	3134	42				
May 2015							
14	03-May-2015	3774	51	**15**	06-May-2015	3011	40
16	11-May-2015	2606	35				

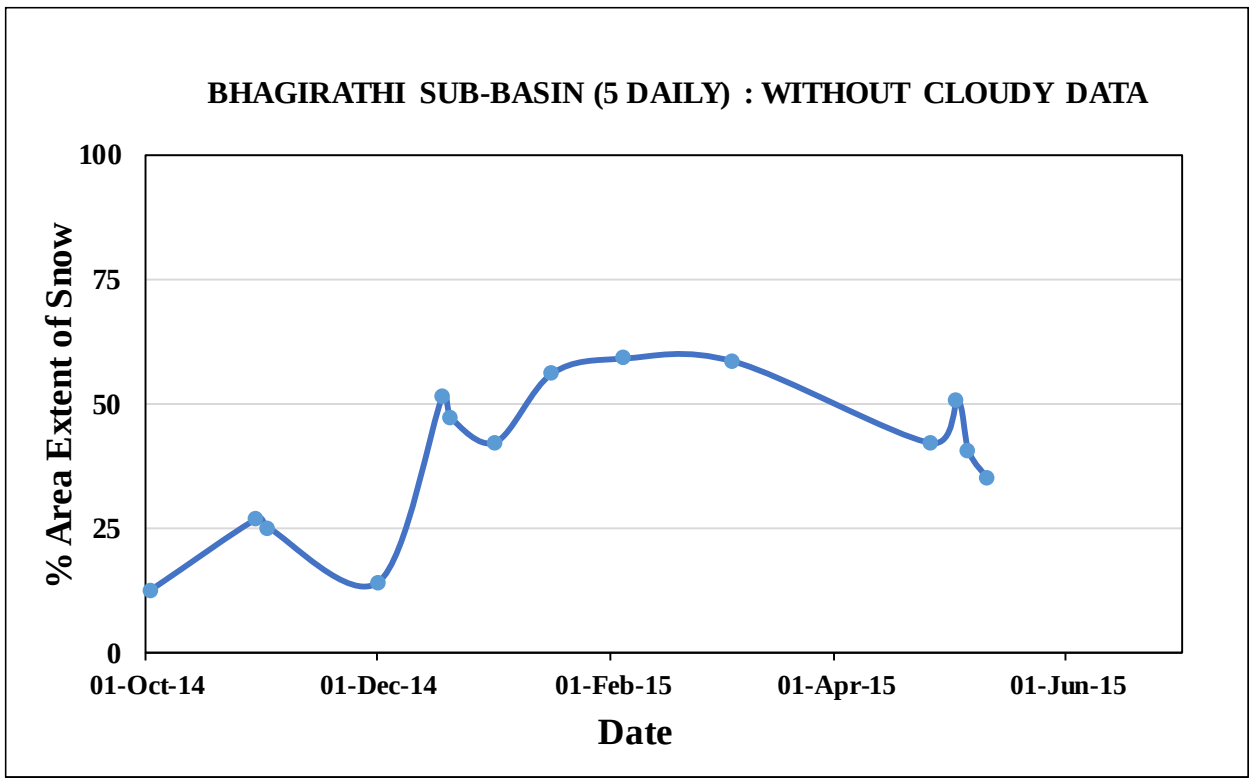
AREAL EXTENT OF SNOW (10 DAILY)

BASIN NAME: BHAGIRATHI **BASIN AREA: 7438 sq km**

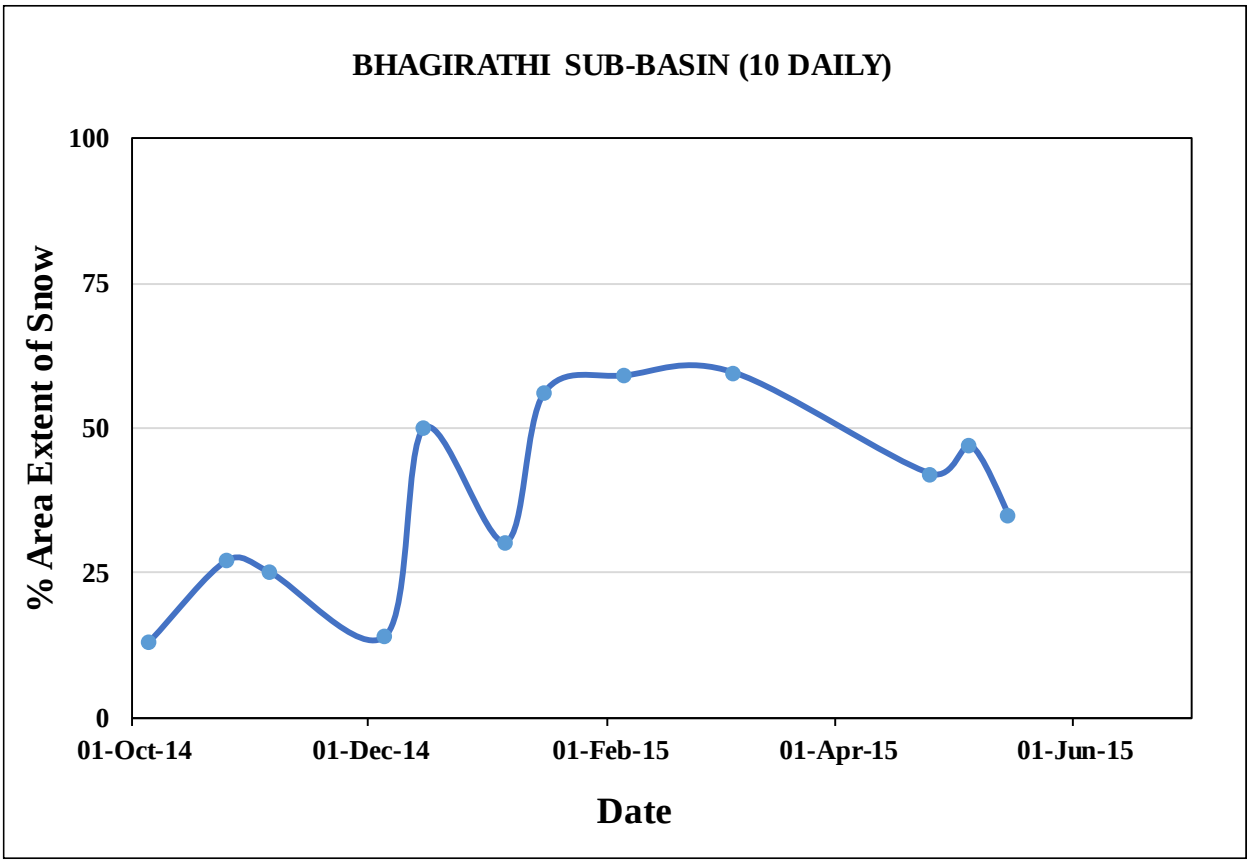
S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2014							
1	05-Oct-2014	933	13	**2**	25-Oct-2014	2001	27
November 2014							
3	05-Nov-2014	1861	25				
December 2014							
4	05-Dec-2014	1047	14	**5**	15-Dec-2014	3713	50
January 2015							
6	05-Jan-2015	2247	30	**7**	16-Jan-2015	4182	56
February 2015							
8	05-Feb-2015	4403	59				
March 2015							
9	05-Mar-2015	4425	59				
April 2015							
10	25-April-2015	3134	42				
May 2015							
11	05-May-2015	3498	47	**12**	15-May-2015	2606	35

SNOW COVER DEPLETION CURVE





SNOW COVER DEPLETION CURVE

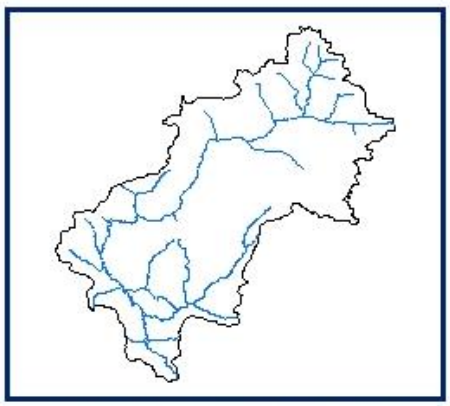


SNOW COVER MAP

SNOW COVER MAP : BHAGIRATHI SUB-BASIN

DATA NOT AVAILABLE

02 OCTOBER 2014



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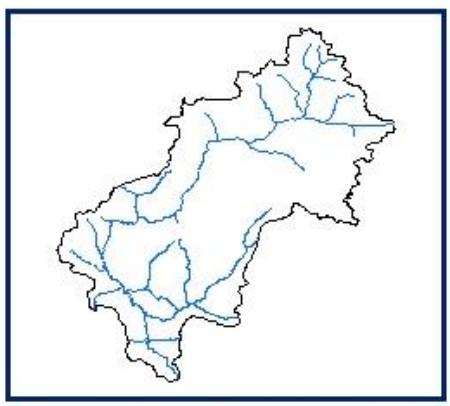

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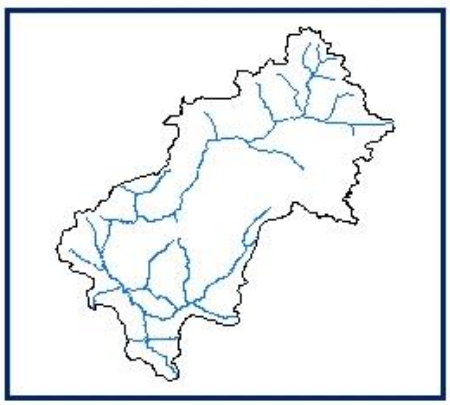

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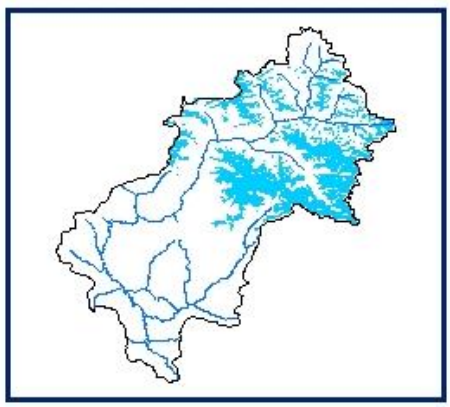


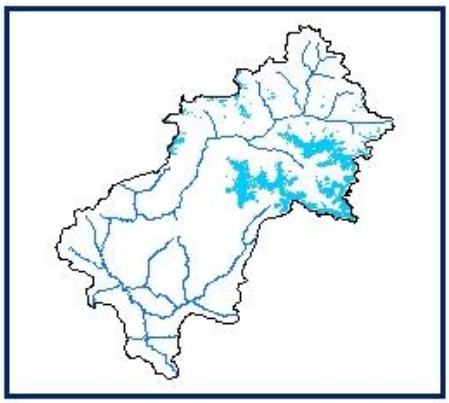
30 OCTOBER 2014

SNOW

40 20 0 40 80 120

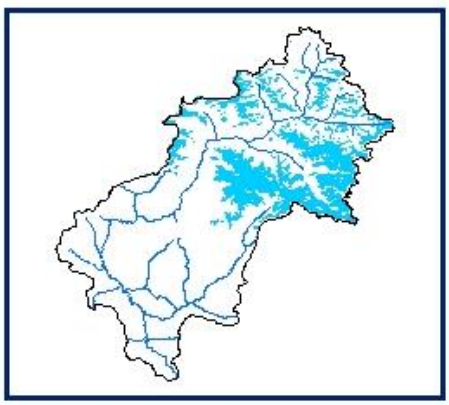
Kilometers

10 DAILY SNOW COVER MAP : BHAGIRATHI SUB-BASIN



DATA USED
02 OCTOBER 2014

DATA NOT AVAILABLE

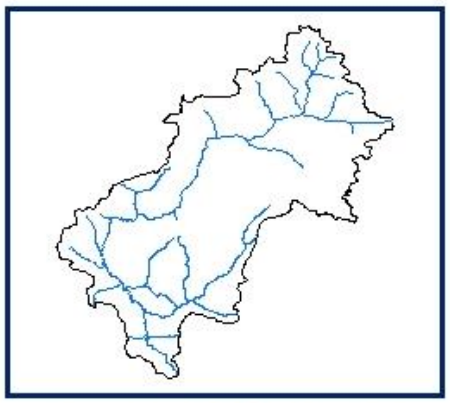


DATA USED
30 OCTOBER 2014

SNOW

2512.5 0 25 50 75
Kilometers

SNOW COVER MAP : BHAGIRATHI SUB-BASIN



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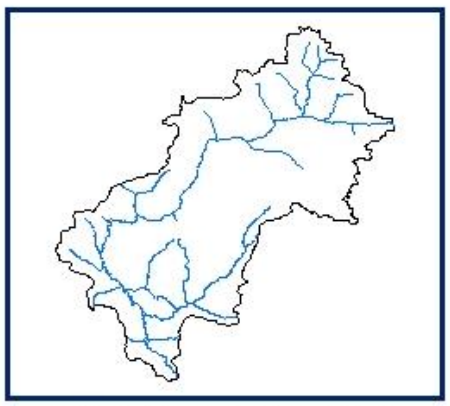

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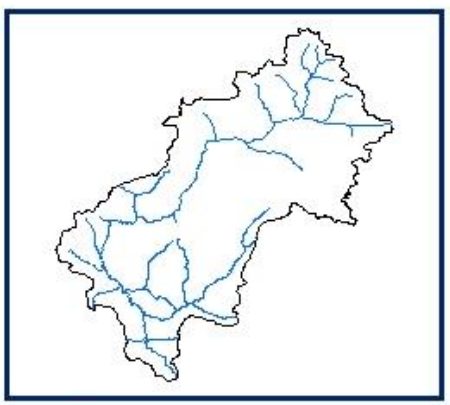

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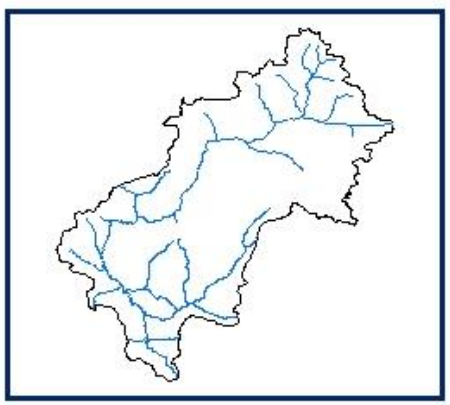

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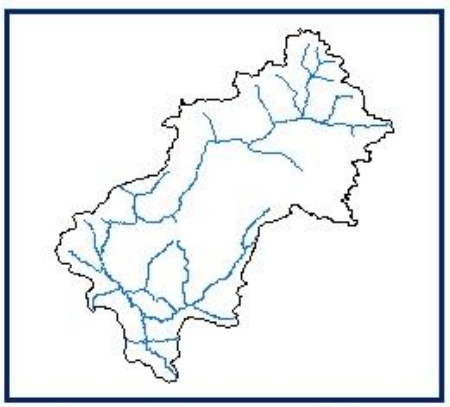


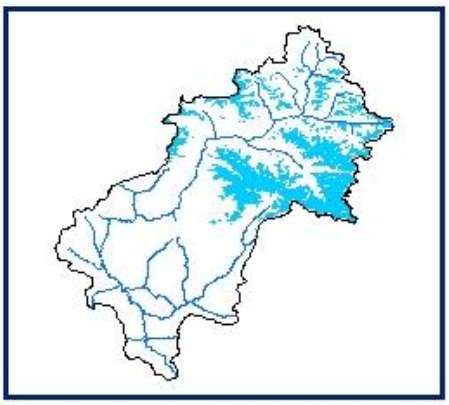
DATA NOT AVAILABLE

SNOW

40 20 0 40 80 120

Kilometers

10 DAILY SNOW COVER MAP : BHAGIRATHI SUB-BASIN



DATA USED
02 NOVEMBER 2014

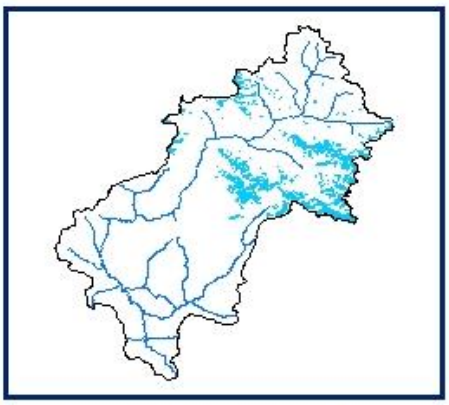
DATA NOT AVAILABLE

DATA NOT AVAILABLE

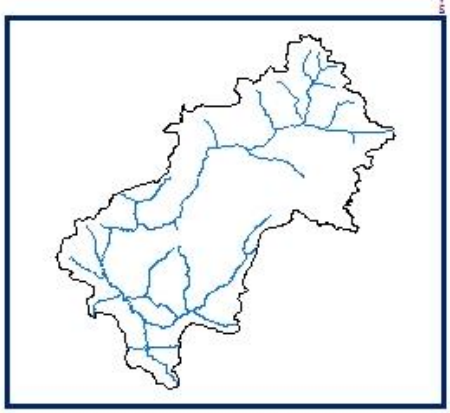
SNOW

2512.5 0 25 50 75
Kilometers

SNOW COVER MAP : BHAGIRATHI SUB-BASIN



01 DECEMBER 2014



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18 DECEMBER 2014

20 DECEMBER 2014

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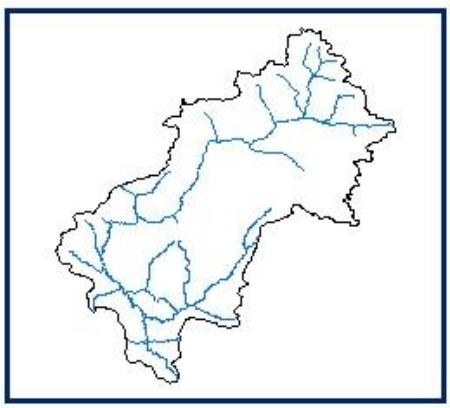


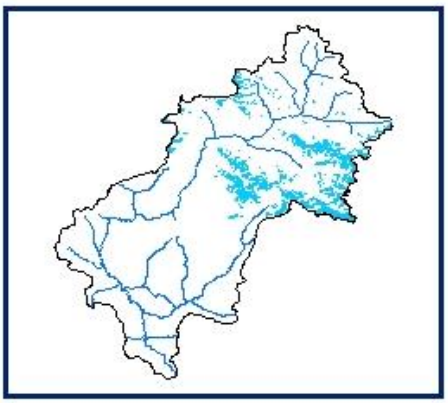
DATA NOT AVAILABLE

SNOW

40 20 0 40 80 120

Kilometers

10 DAILY SNOW COVER MAP : BHAGIRATHI SUB-BASIN



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01 DECEMBER 2014

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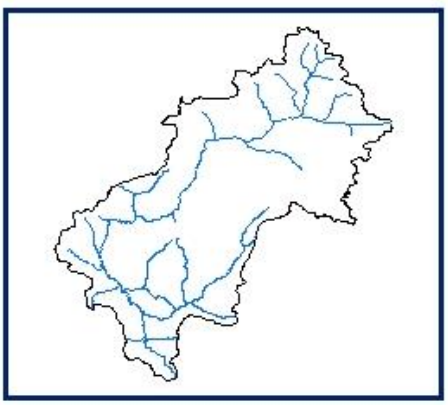


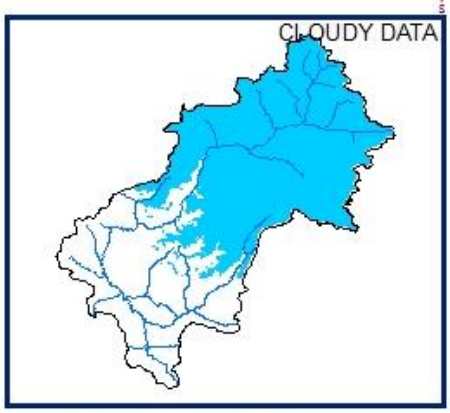
DATA NOT AVAILABLE

SNOW

2512.5 0 25 50 75
Kilometers

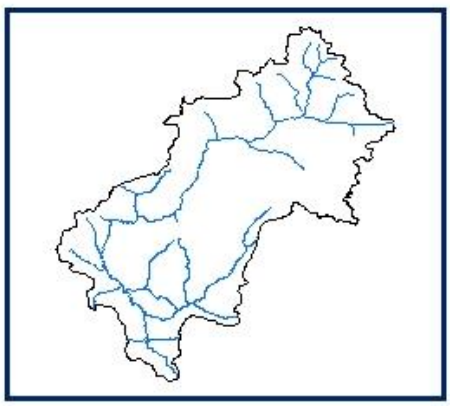
SNOW COVER MAP : BHAGIRATHI SUB-BASIN

01 JANUARY 2015



04 JANUARY 2015

16 JANUARY 2015



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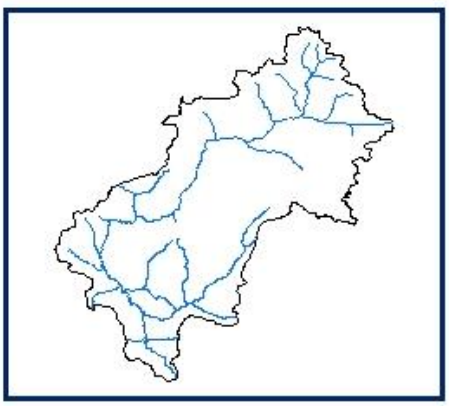

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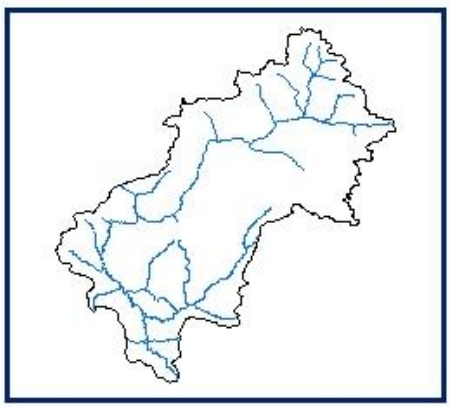


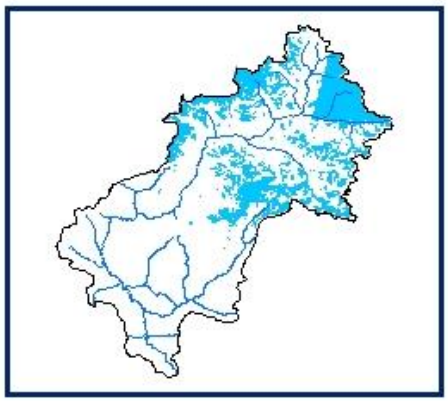
DATA NOT AVAILABLE

SNOW

40 20 0 40 80 120

Kilometers

10 DAILY SNOW COVER MAP : BHAGIRATHI SUB-BASIN



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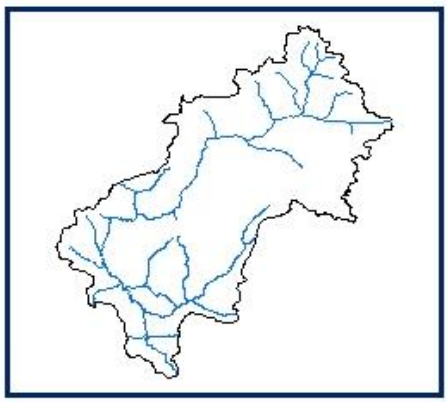
01 JANUARY 2015
04 JANUARY 2015

DATA USED
16 JANUARY 2015

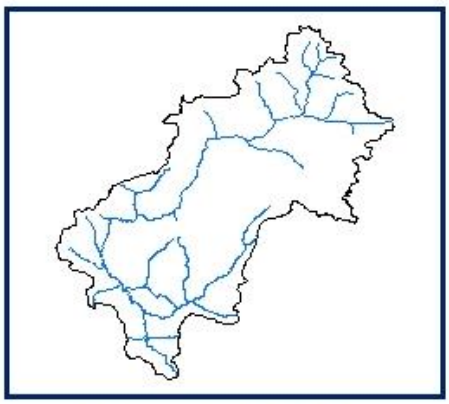


DATA NOT AVAILABLE

SNOW

25 12.5 0 25 50 75
Kilometers

SNOW COVER MAP : BHAGIRATHI SUB-BASIN



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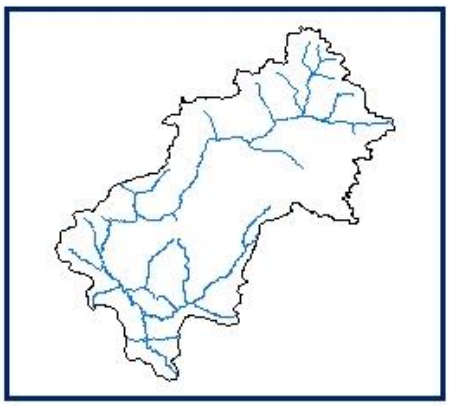

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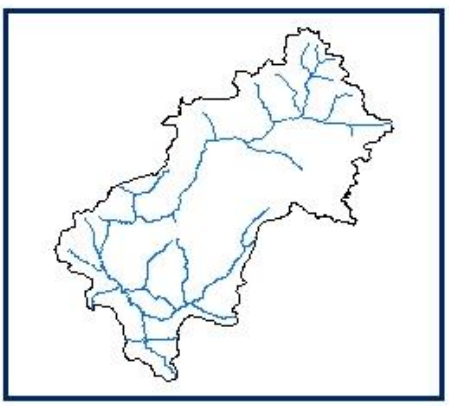

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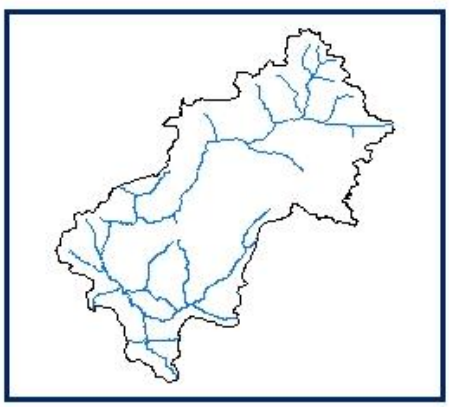

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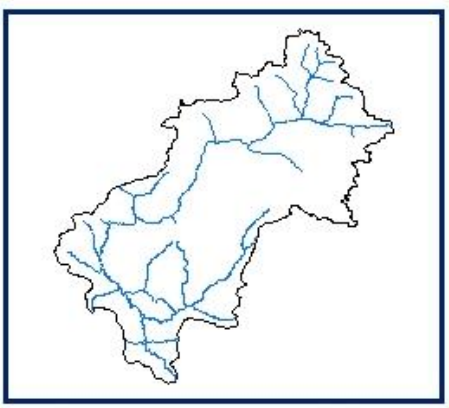


DATA NOT AVAILABLE

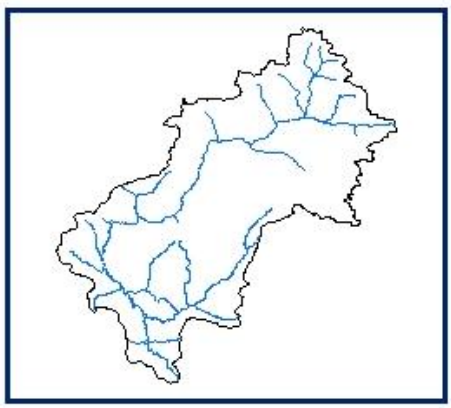
SNOW

40 20 0 40 80 120

Kilometers

10 DAILY SNOW COVER MAP : BHAGIRATHI SUB-BASIN

DATA USED
04 FEBRUARY 2015



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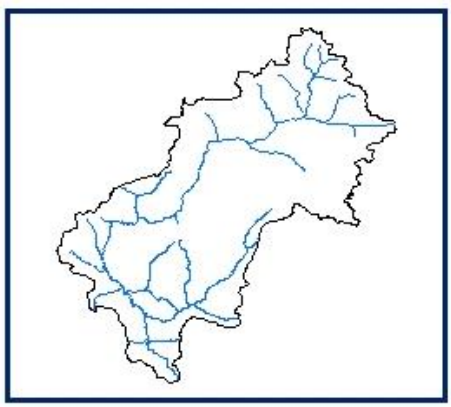
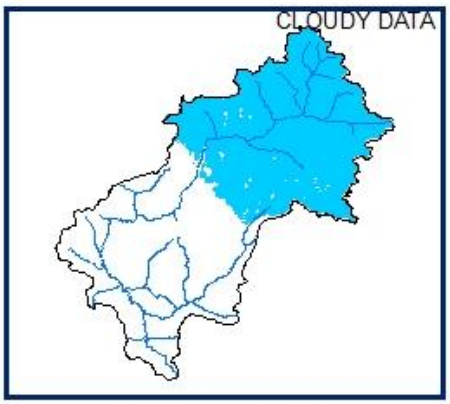


DATA NOT AVAILABLE

SNOW

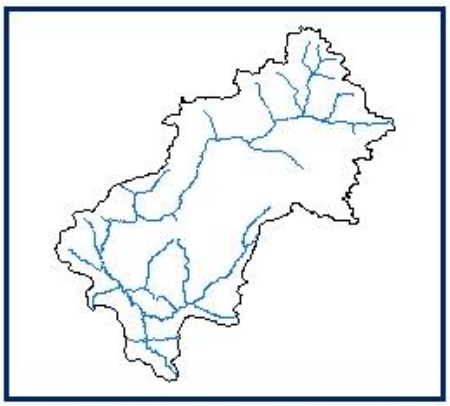
2512.5 0 25 50 75
Kilometers

SNOW COVER MAP : BHAGIRATHI SUB-BASIN



04 MARCH 2015

05 MARCH 2015



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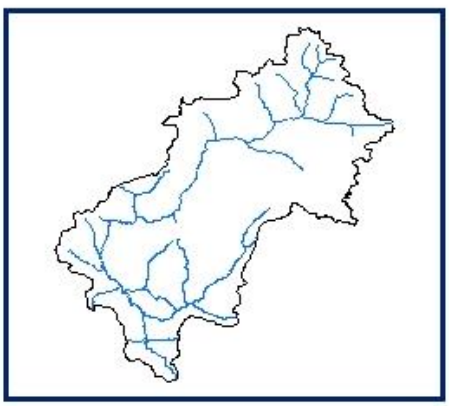

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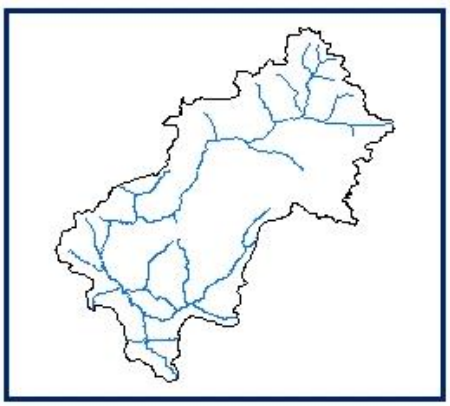

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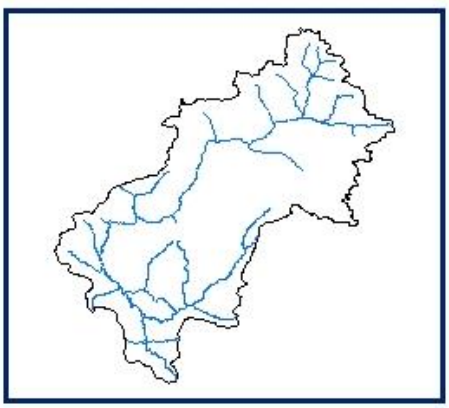


DATA NOT AVAILABLE

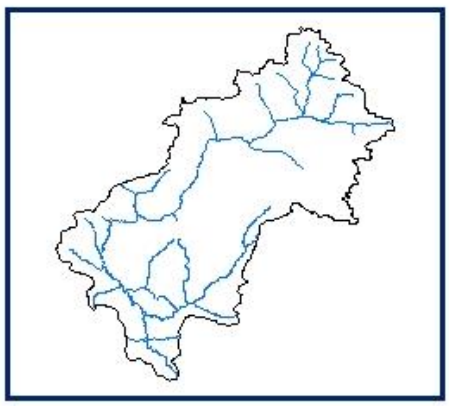
SNOW

40 20 0 40 80 120

Kilometers

10 DAILY SNOW COVER MAP : BHAGIRATHI SUB-BASIN

DATA USED
04 MARCH 2015
05 MARCH 2015



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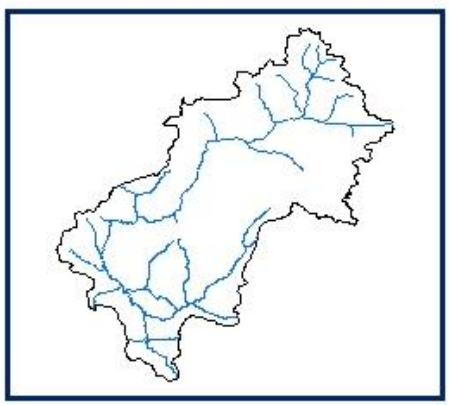

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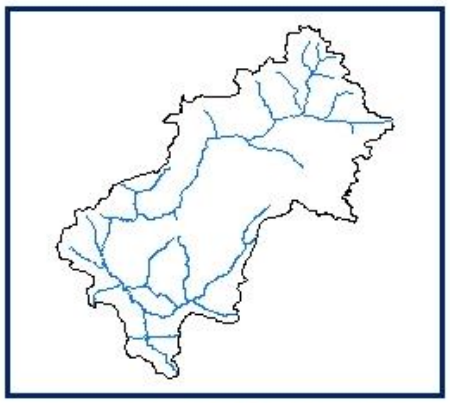
SNOW

2512.5 0 25 50 75
Kilometers

SNOW COVER MAP : BHAGIRATHI SUB-BASIN



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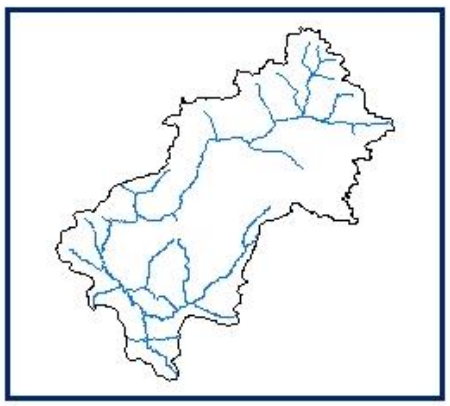

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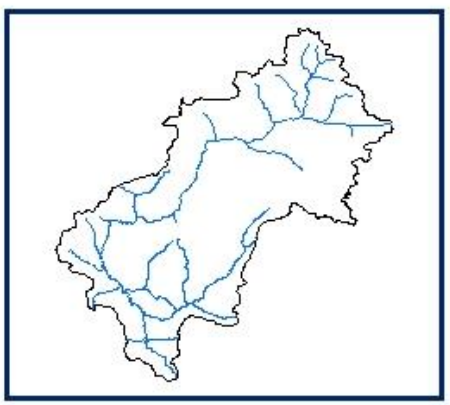

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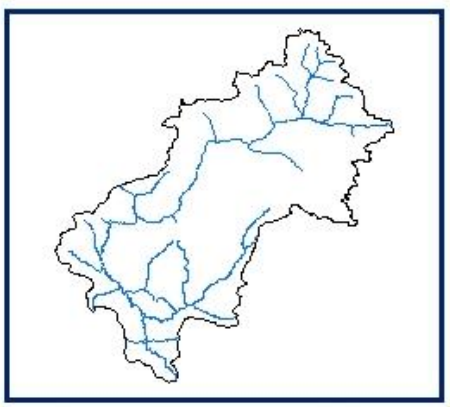
26 APRIL 2015



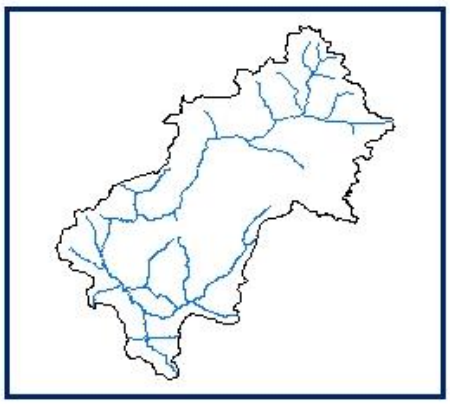
DATA NOT AVAILABLE

SNOW

40 20 0 40 80 120

Kilometers

10 DAILY SNOW COVER MAP : BHAGIRATHI SUB-BASIN



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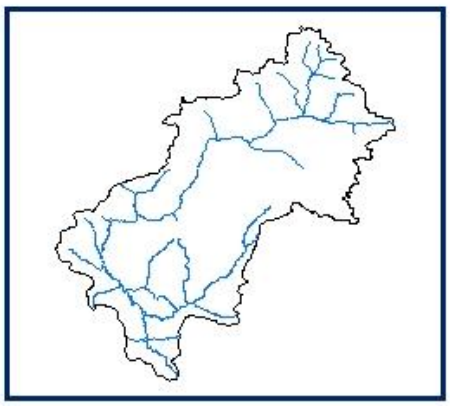

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DATA USED
26 APRIL 2015

SNOW

2512.5 0 25 50 75
Kilometers

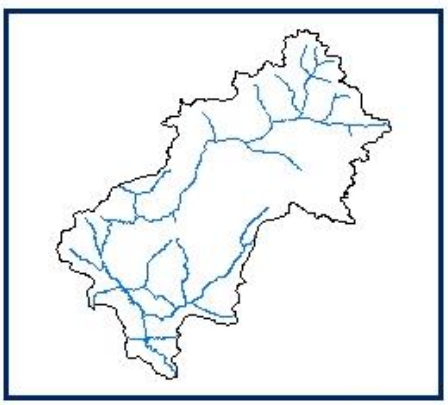
SNOW COVER MAP : BHAGIRATHI SUB-BASIN

03 MAY 2015

06 MAY 2015

11 MAY 2015

DATA NOT AVAILABLE



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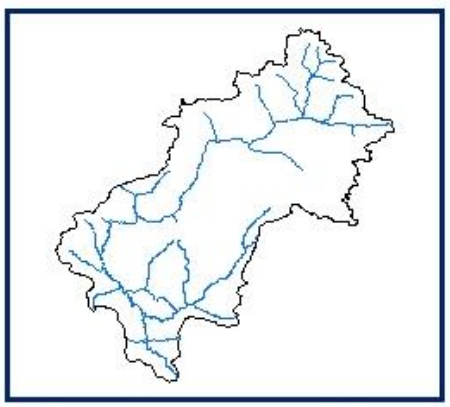


DATA NOT AVAILABLE

SNOW

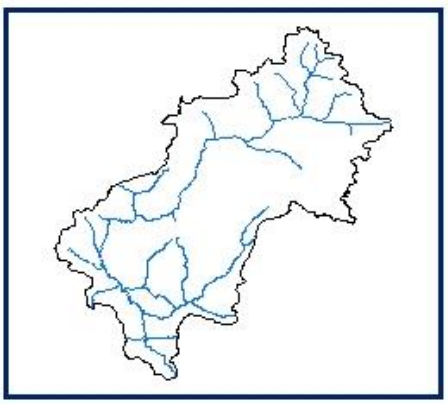
40 20 0 40 80 120

Kilometers

10 DAILY SNOW COVER MAP : BHAGIRATHI SUB-BASIN

DATA USED
03 MAY 2015
06 MAY 2015

DATA USED
11 MAY 2015



DATA NOT AVAILABLE

2512.5 0 25 50 75
Kilometers

SNOW

YAMMUNA SUB-BASIN

AREAL EXTENT OF SNOW (5 DAILY)

BASIN NAME: YAMMUNA **BASIN AREA: 3527 sq km**

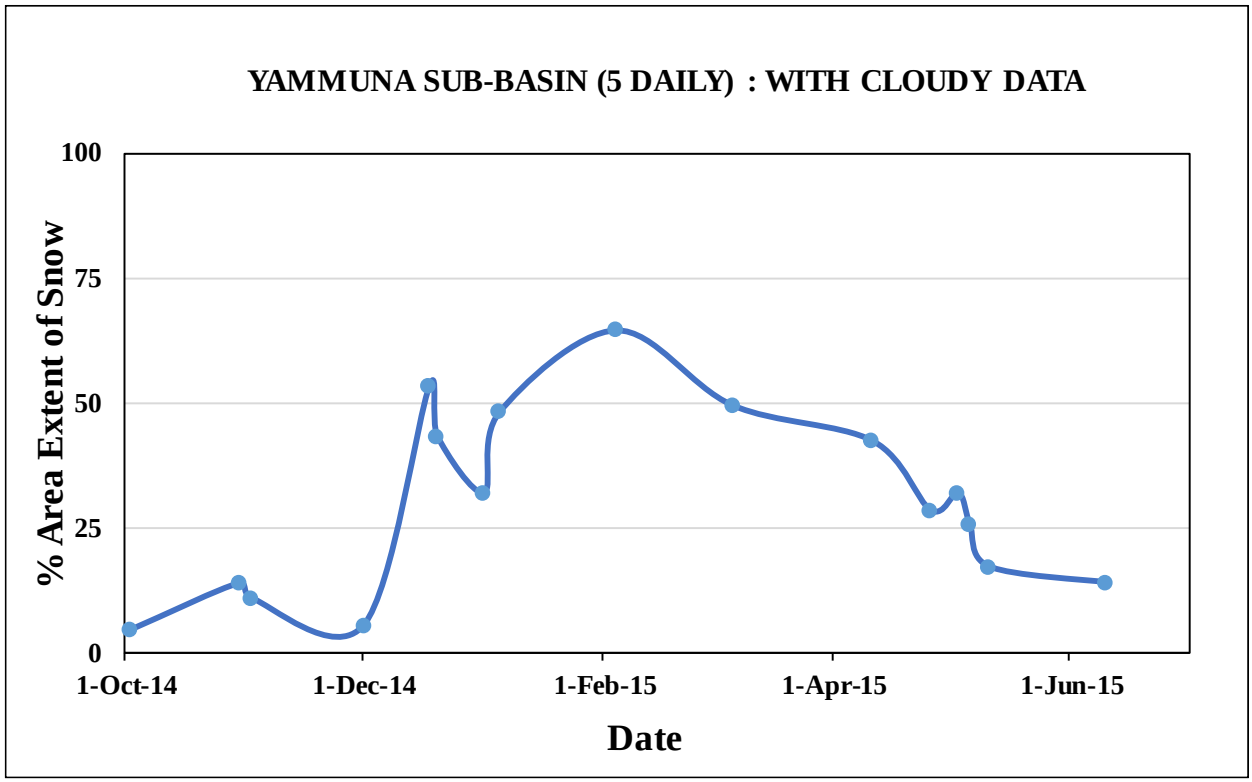
S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2014							
1	02-Oct-2014	162	5	**2**	30-Oct-2014	492	14
November 2014							
3	02-Nov-2014	388	11				
December 2014							
4	01-Dec-2014	193	5	**5**	18-Dec-2014	1890	54
6	20-Dec-2014	1532	43				
January 2015							
7	01-Jan-2015	1133	32	**8**	05-Jan-2015	1701	48
February 2015							
9	04-Feb-2015	2280	65				
March 2015							
10	06-Mar-2015	1750	50				
April 2015							
11	11-April-2015	2926	42	**12**	26-April-2015	1008	29
May 2015							
13	03-May-2015	1132	32	**14**	06-May-2015	912	26
15	11-May-2015	610 (C)	17				
June 2015							
16	10-June-2015	498 (C)	14				

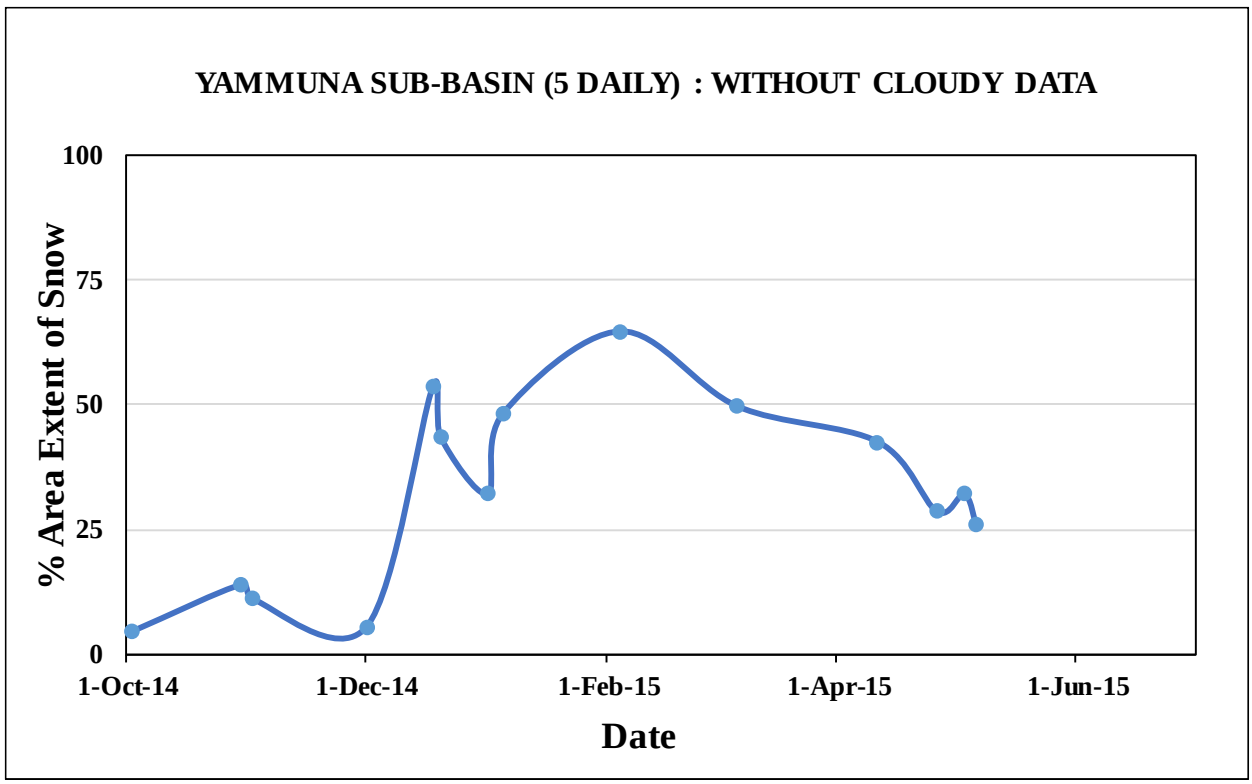
AREAL EXTENT OF SNOW (10 DAILY)

BASIN NAME: YAMMUNA **BASIN AREA: 3527 sq km**

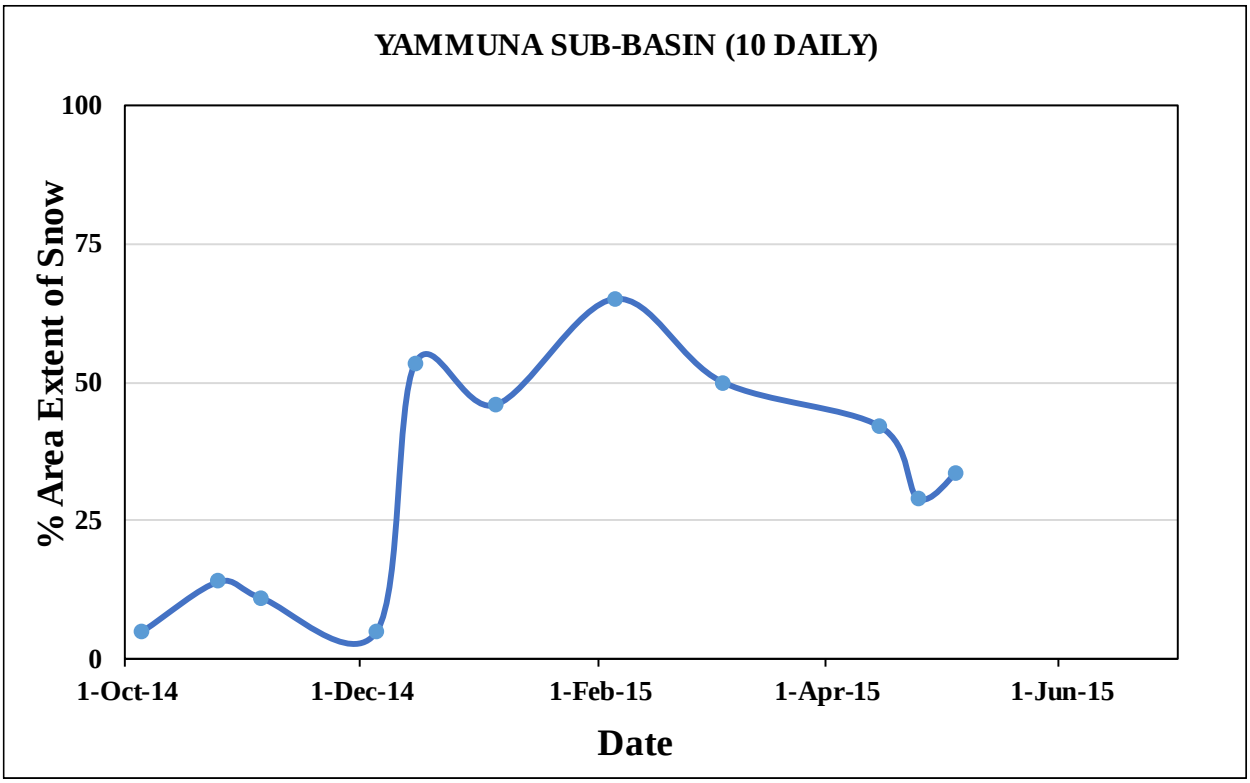
S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2014							
1	05-Oct-2014	162	5	**2**	25-Oct-2014	492	14
November 2014							
3	05-Nov-2014	388	11				
December 2014							
4	05-Dec-2014	193	5	**5**	15-Dec-2014	1883	53
January 2015							
6	05-Jan-2015	1618	46				
February 2015							
7	05-Feb-2015	2280	65				
March 2015							
8	05-Mar-2015	1750	50				
April 2015							
9	15-April-2015	1499	42	**10**	25-April-2015	1008	29
May 2015							
11	05-May-2015	1188	34				

SNOW COVER DEPLETION CURVE



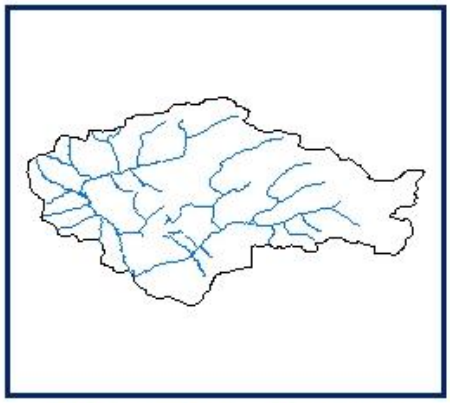


SNOW COVER DEPLETION CURVE



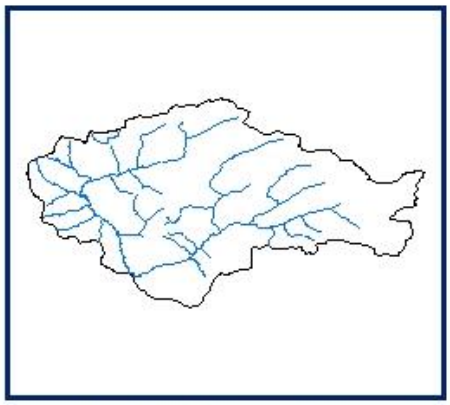
SNOW COVER MAP

SNOW COVER MAP : YAMMUNA SUB-BASIN



DATA NOT AVAILABLE

02 OCTOBER 2014



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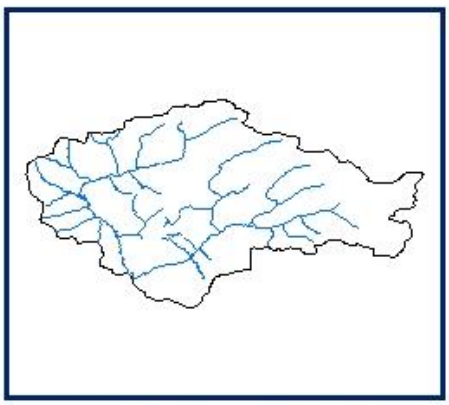

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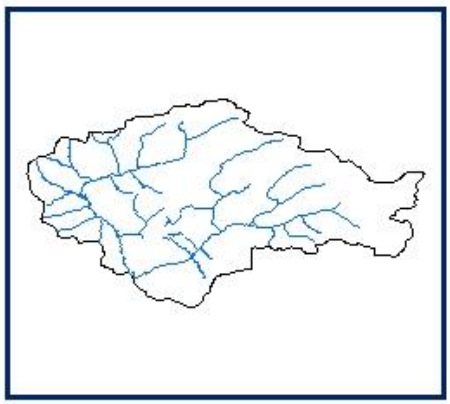


DATA NOT AVAILABLE

30 OCTOBER 2014

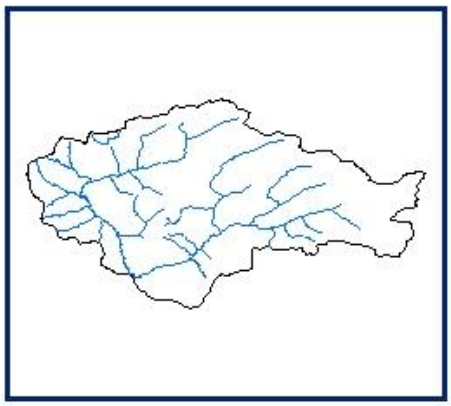
SNOW

30 15 0 30 60 90

Kilometers

10 DAILY SNOW COVER MAP : YAMMUNA SUB-BASIN

DATA USED
02 OCTOBER 2014



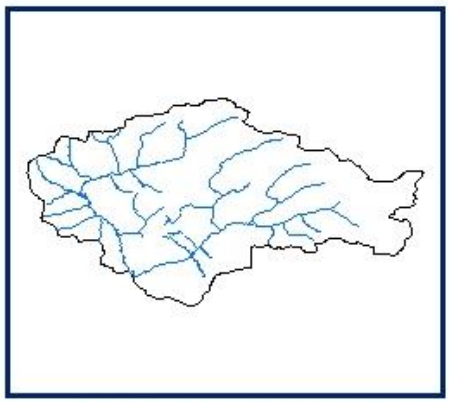
DATA NOT AVAILABLE

DATA USED
30 OCTOBER 2014

SNOW

105 0 10 20 30
Kilometers

SNOW COVER MAP : YAMMUNA SUB-BASIN



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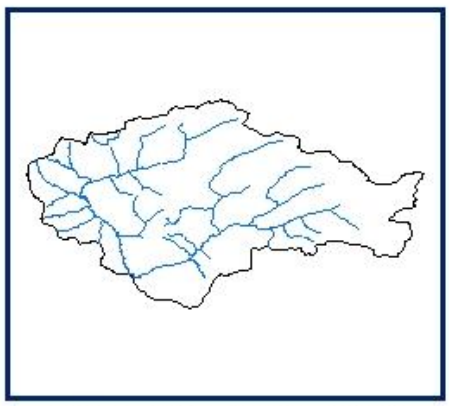

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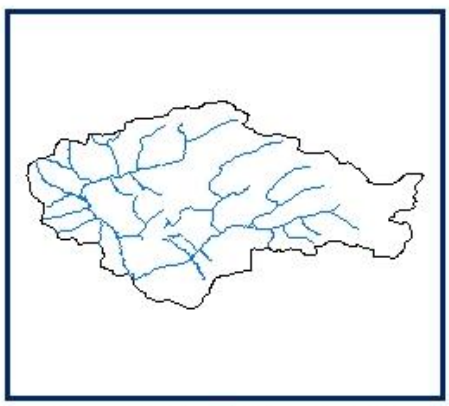

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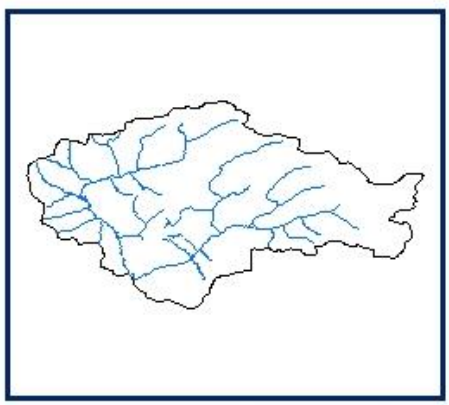

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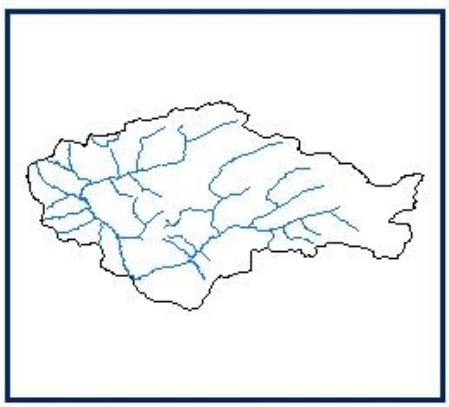


DATA NOT AVAILABLE

SNOW

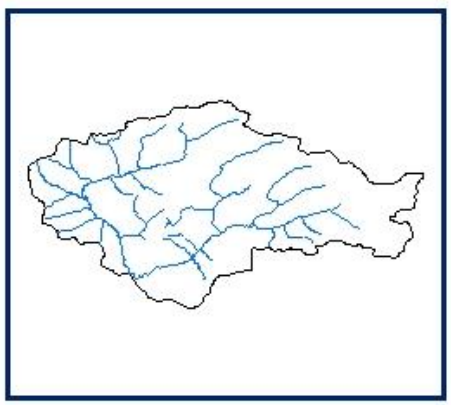
30 15 0 30 60 90

Kilometers

10 DAILY SNOW COVER MAP : YAMMUNA SUB-BASIN

DATA USED
02 NOVEMBER 2014

DATA NOT AVAILABLE



DATA NOT AVAILABLE

SNOW

105 0 10 20 30
Kilometers

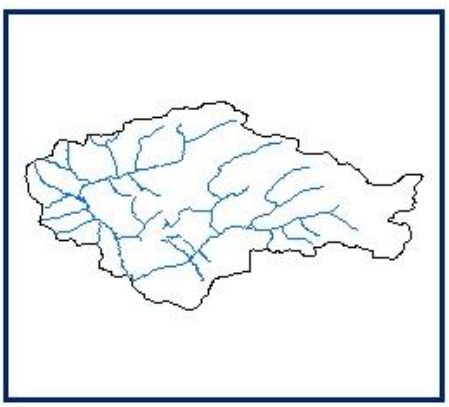
SNOW COVER MAP : YAMMUNA SUB-BASIN

01 DECEMBER 2014

DATA NOT AVAILABLE

18 DECEMBER 2014

20 DECEMBER 2014



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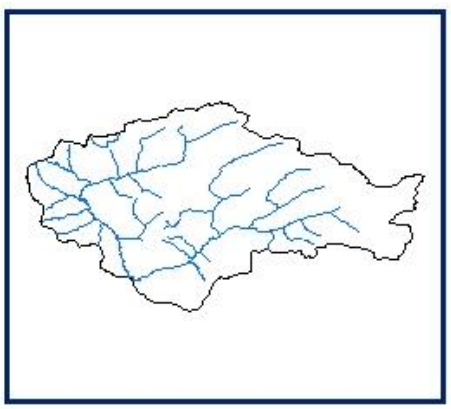


DATA NOT AVAILABLE

SNOW

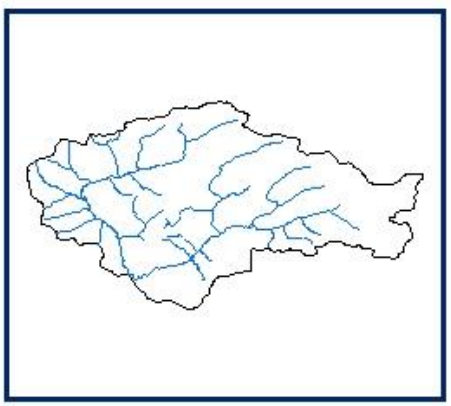
30 15 0 30 60 90

Kilometers

10 DAILY SNOW COVER MAP : YAMMUNA SUB-BASIN

DATA USED
01 DECEMBER 2014

DATA USED
18 DECEMBER 2014
20 DECEMBER 2014



DATA NOT AVAILABLE

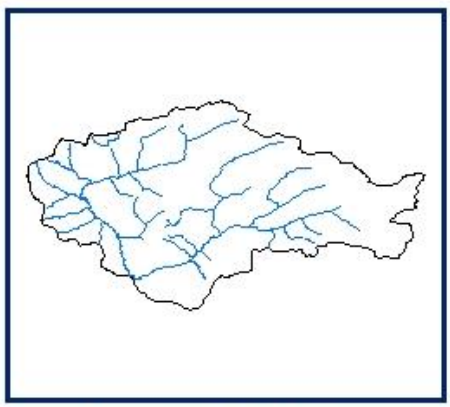
SNOW

105 0 10 20 30
Kilometers

SNOW COVER MAP : YAMMUNA SUB-BASIN

01 JANUARY 2015

05 JANUARY 2015



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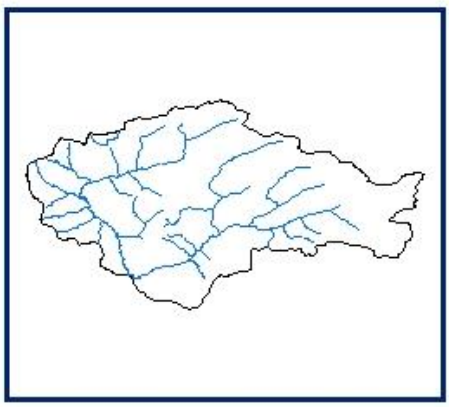

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SNOW

30 15 0 30 60 90

Kilometers

10 DAILY SNOW COVER MAP : YAMMUNA SUB-BASIN

DATA USED
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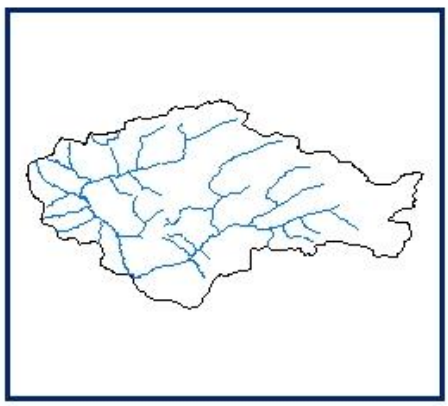
05 JANUARY 2015



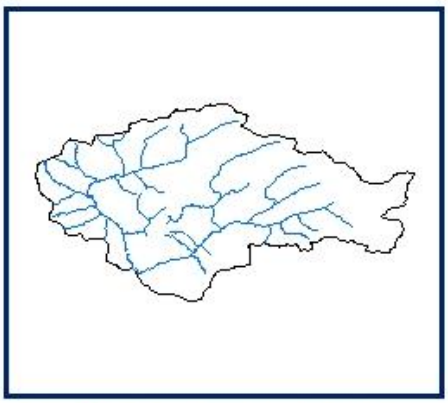
DATA NOT AVAILABLE

DATA NOT AVAILABLE

SNOW

105 0 10 20 30
Kilometers

SNOW COVER MAP : YAMMUNA SUB-BASIN



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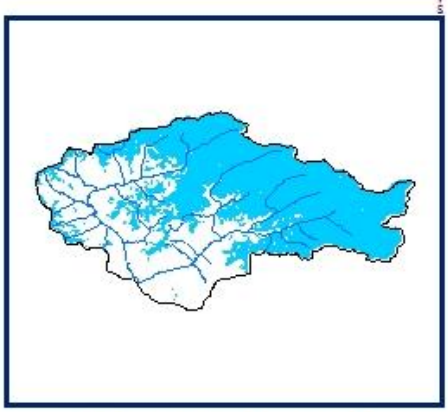
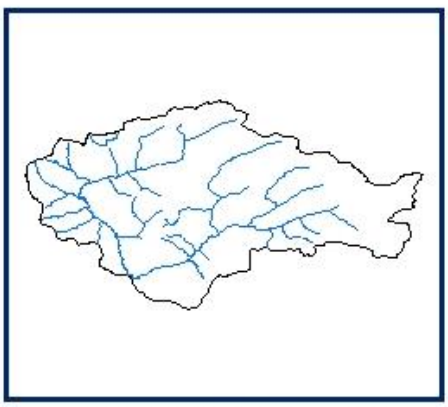


04 FEBRUARY 2015



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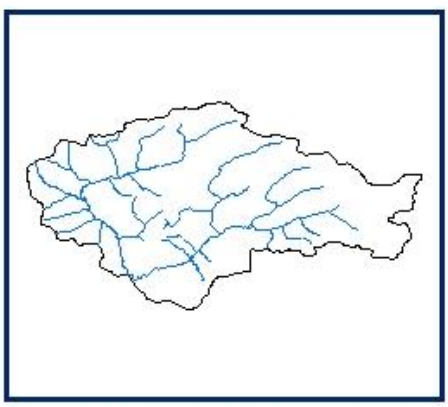

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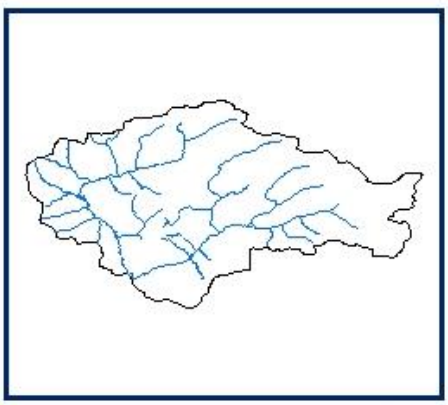

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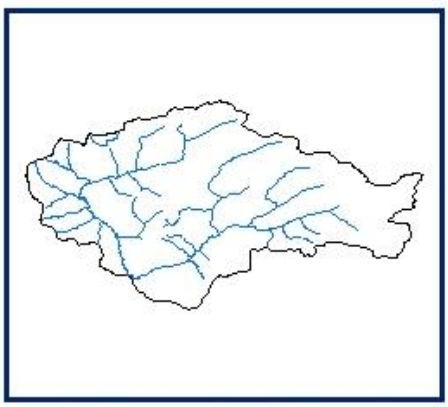


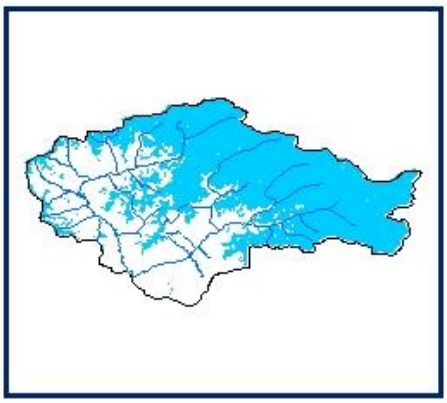
DATA NOT AVAILABLE

SNOW

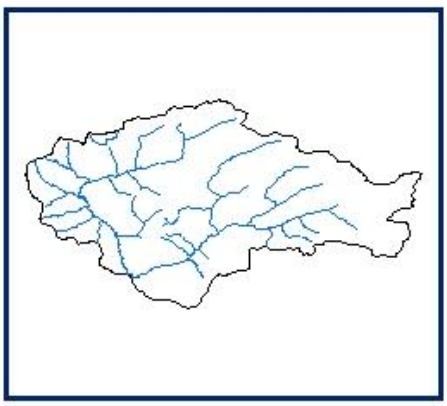
30 15 0 30 60 90

Kilometers

10 DAILY SNOW COVER MAP : YAMMUNA SUB-BASIN



DATA USED
04 FEBRUARY 2015



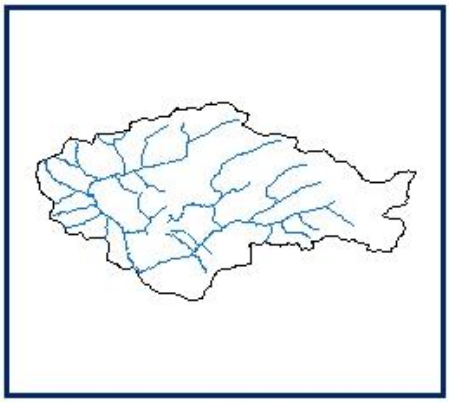
DATA NOT AVAILABLE

DATA NOT AVAILABLE

105 0 10 20 30
Kilometers

SNOW

SNOW COVER MAP : YAMMUNA SUB-BASIN



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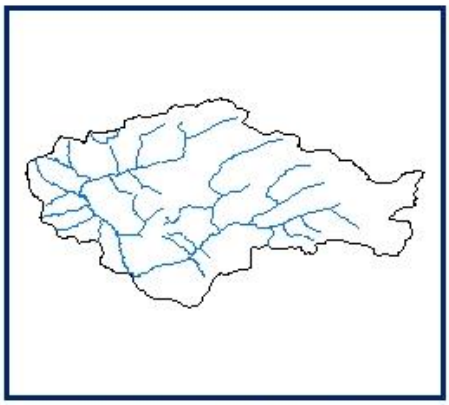
06 MARCH 2015



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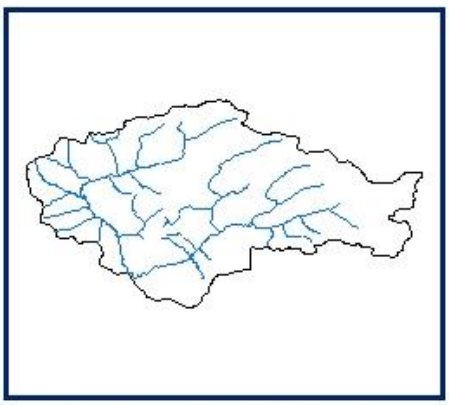

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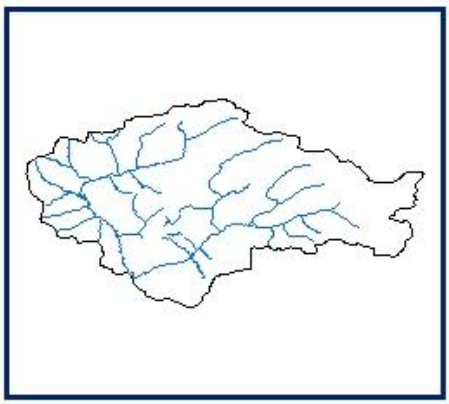

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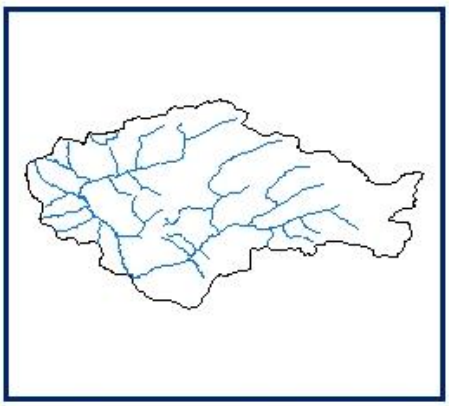


DATA NOT AVAILABLE

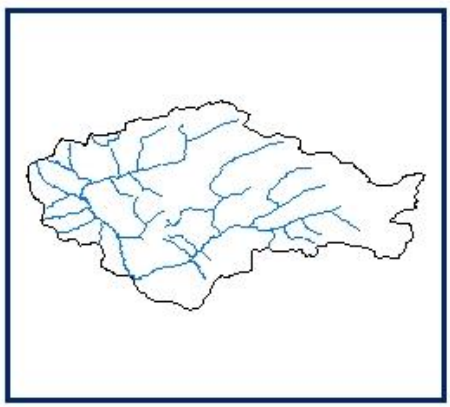
SNOW

30 15 0 30 60 90

Kilometers

10 DAILY SNOW COVER MAP : YAMMUNA SUB-BASIN

DATA USED
06 MARCH 2015



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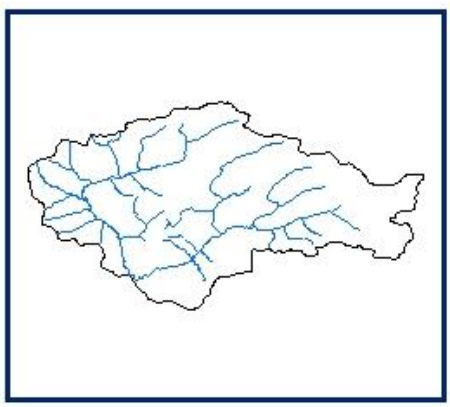
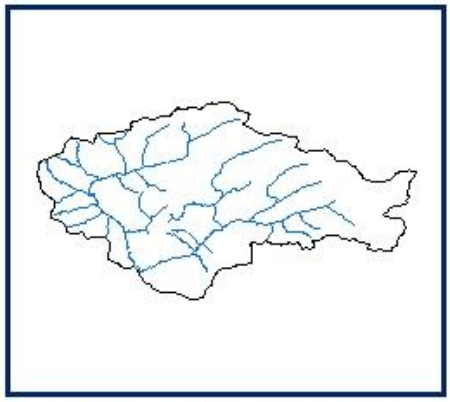


DATA NOT AVAILABLE

SNOW

105 0 10 20 30
Kilometers

SNOW COVER MAP : YAMMUNA SUB-BASIN



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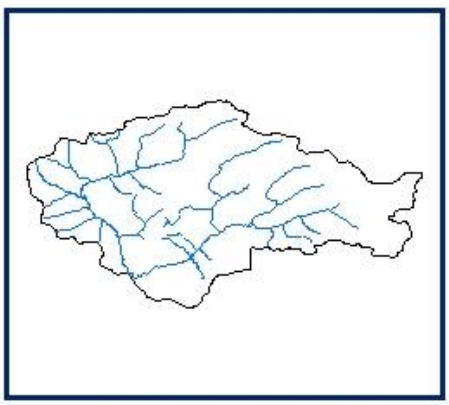

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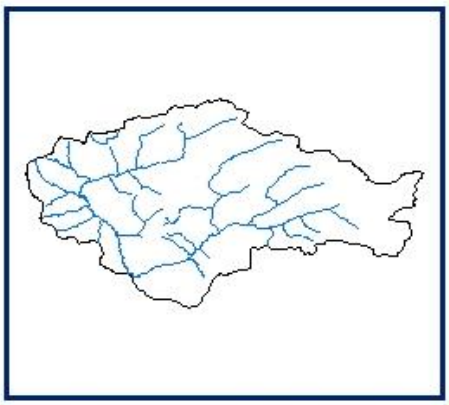


DATA NOT AVAILABLE

SNOW

30 15 0 30 60 90

Kilometers

10 DAILY SNOW COVER MAP : YAMMUNA SUB-BASIN

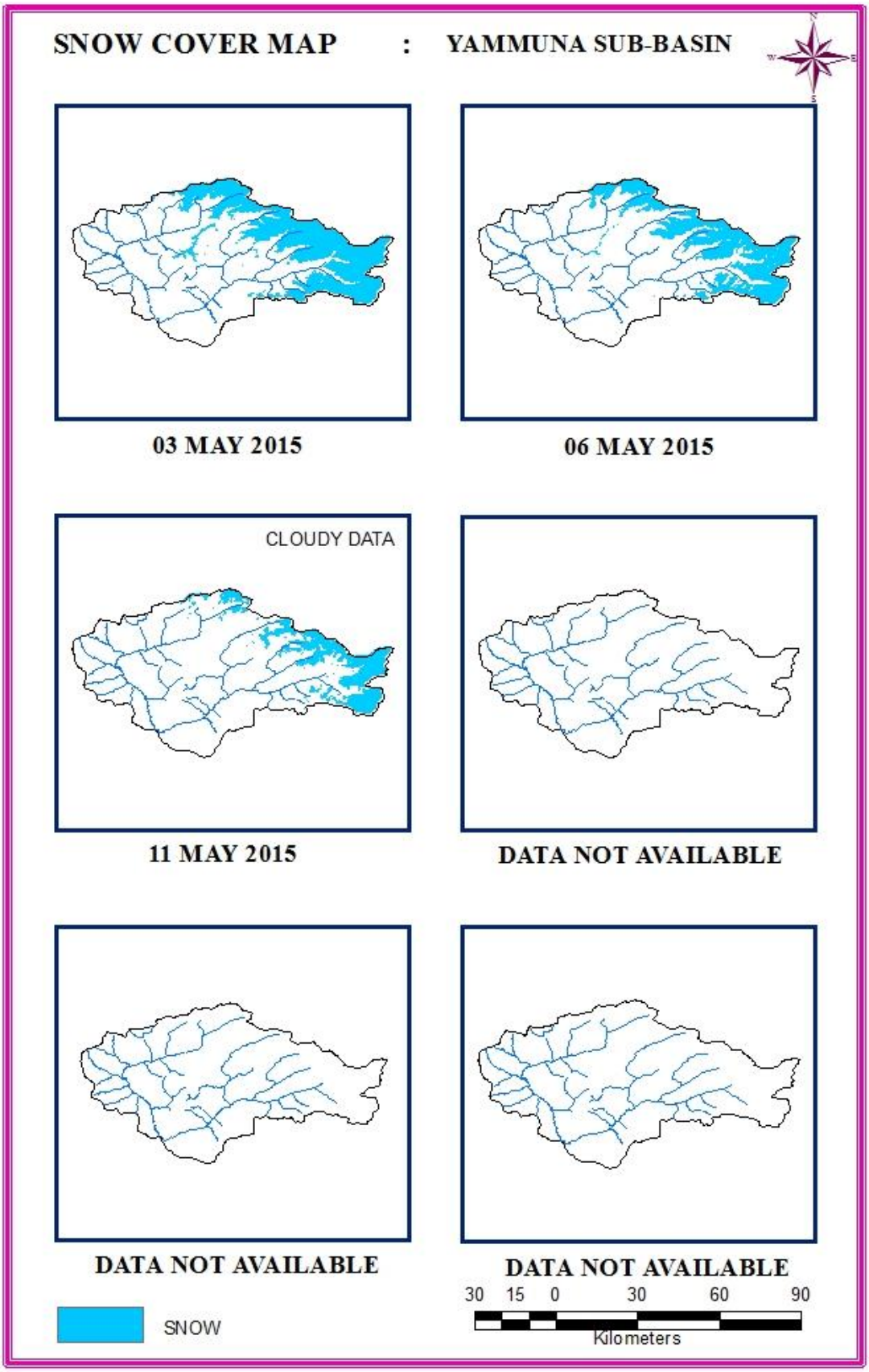
DATA NOT AVAILABLE

DATA USED
11 APRIL 2015

DATA USED
26 APRIL 2015

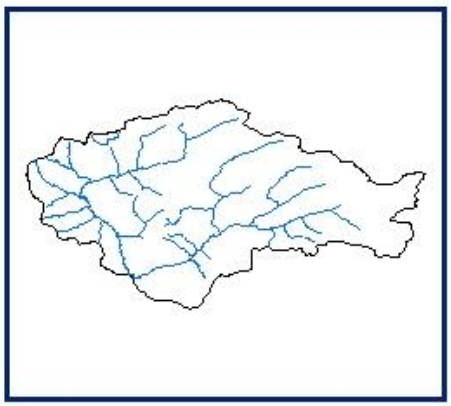
SNOW

105 0 10 20 30
Kilometers


SNOW COVER MAP : YAMMUNA SUB-BASIN
03 MAY 2015
06 MAY 2015
CLOUDY DATA
11 MAY 2015
DATA NOT AVAILABLE
DATA NOT AVAILABLE
DATA NOT AVAILABLE
SNOW
30 15 0 30 60 90
Kilometers

10 DAILY SNOW COVER MAP : YAMMUNA SUB-BASIN

DATA USED
03 MAY 2015
06 MAY 2015



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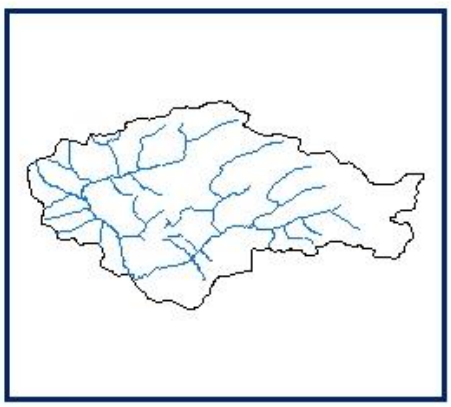

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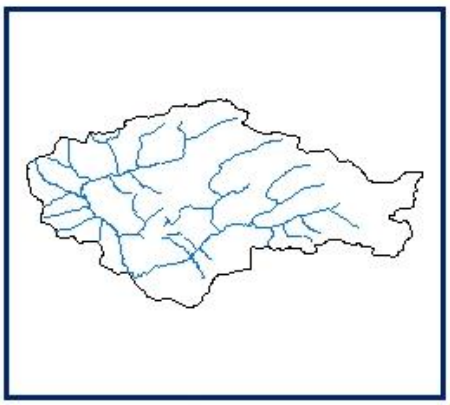
SNOW

105 0 10 20 30
Kilometers

SNOW COVER MAP : YAMMUNA SUB-BASIN



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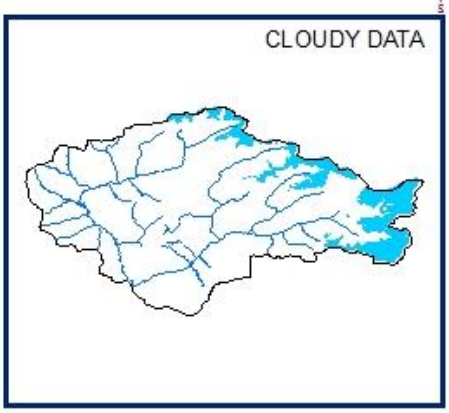

10 JUNE 2015

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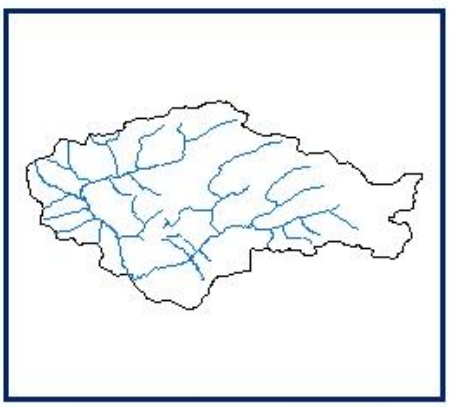

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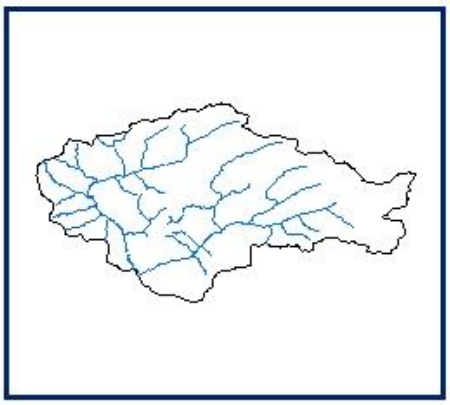

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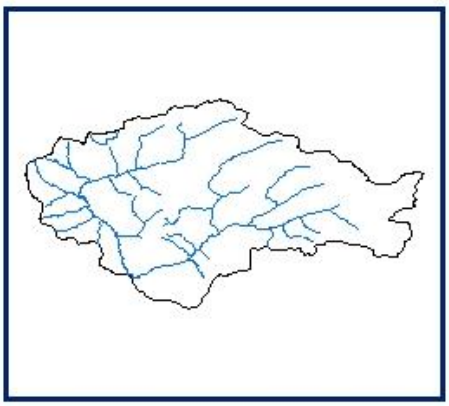

DATA NOT AVAILABLE

SNOW

30 15 0 30 60 90

Kilometers