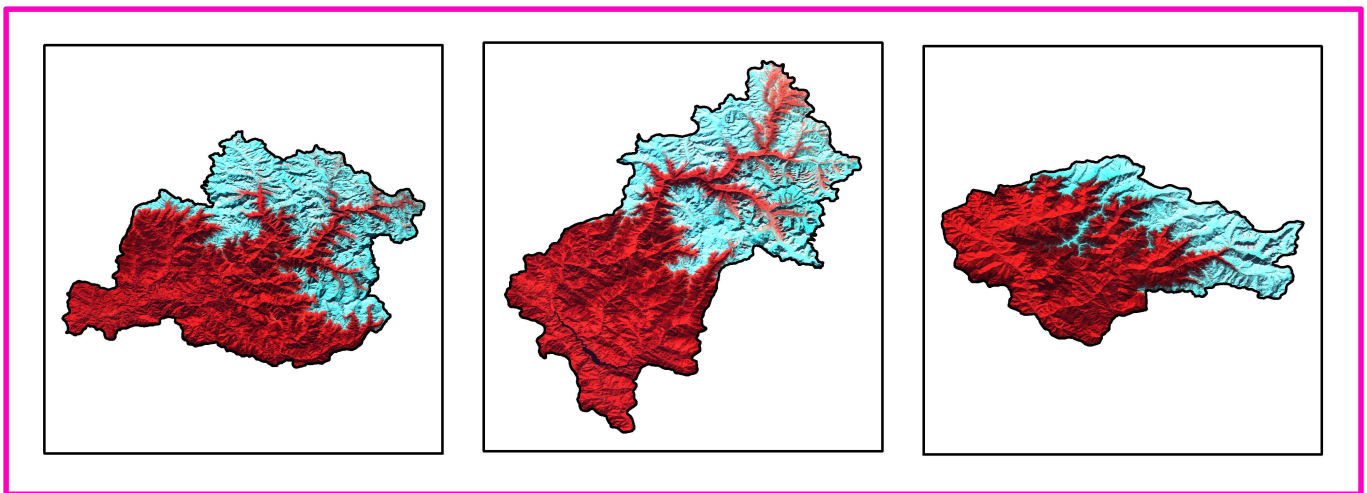


SNOW COVER ATLAS OF GANGA BASIN

Sub basins: Alaknanda, Bhagirathi and Yamuna

(A Joint Project of Indian Space Research Organisation and
Ministry of Environment and Forests, Govt. of India)

Year : 2009-10



Space Applications Centre (ISRO)
Ahmedabad - 380015

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SPACE APPLICATIONS CENTRE (ISRO), AHMEDABAD - 380015**DOCUMENT CONTROL AND DATA SHEET**

Report Number	SAC/EP SA/MP SG/GSD/SGP/SN/ 74 /2012
Month and year of publication	December 2012
Title	Snow cover Atlas of the Ganga basin
Type of Report	Scientific Report
No. of pages	76
No. of figures, Charts & Tables	56, 9 & 6
Authors	B. P. Rathore, S. K. Singh, I. Bahuguna, A. S. Rajawat and Ajai
No. of References	9
Originating Unit	Geo Sciences Division, Marine, Geo and Planetary Sciences Group, Earth, Ocean, Atmosphere, Planetary Sciences and Applications area, Space Applications Centre (ISRO), Ahmedabad-15
Abstract	This atlas gives subbasin-wise distribution of snow cover in the Ganga basin from October 2009 to June 2010. The subbasins 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

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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 subbasins 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 2009 to June 2010 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:

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

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 2009 to June 2010. Snow ablation pattern varies from basin to basin, depending on area altitude distribution in the basins. In the Yamuna river basin, this includes Tons, shows accumulation and ablation of snow throughout the winter season. For example on February 05, 2010, 81 percent area was covered by seasonal snow. This was reduced to 37 percent by March 05, 2010. Bhagirathi and the Alaknanda sub-basins also shows accumulation and ablation of snow throughout the winter season and snow depletion pattern are similar.

Acknowledgements

This investigation was carried out under Snow and Glacier Studies Project, a joint initiative of Ministry of Environment and Forest (MoEF) and Department of Space (DOS). The authors are grateful to Shri A. S. Kiran Kumar, Director, Space Applications Centre, Ahmedabad for continuous guidance and encouragement during the investigation. Authors would like to thank Dr. J. S. Parihar, Deputy Director, EPSA, SAC for their suggestions and comments on the manuscript.

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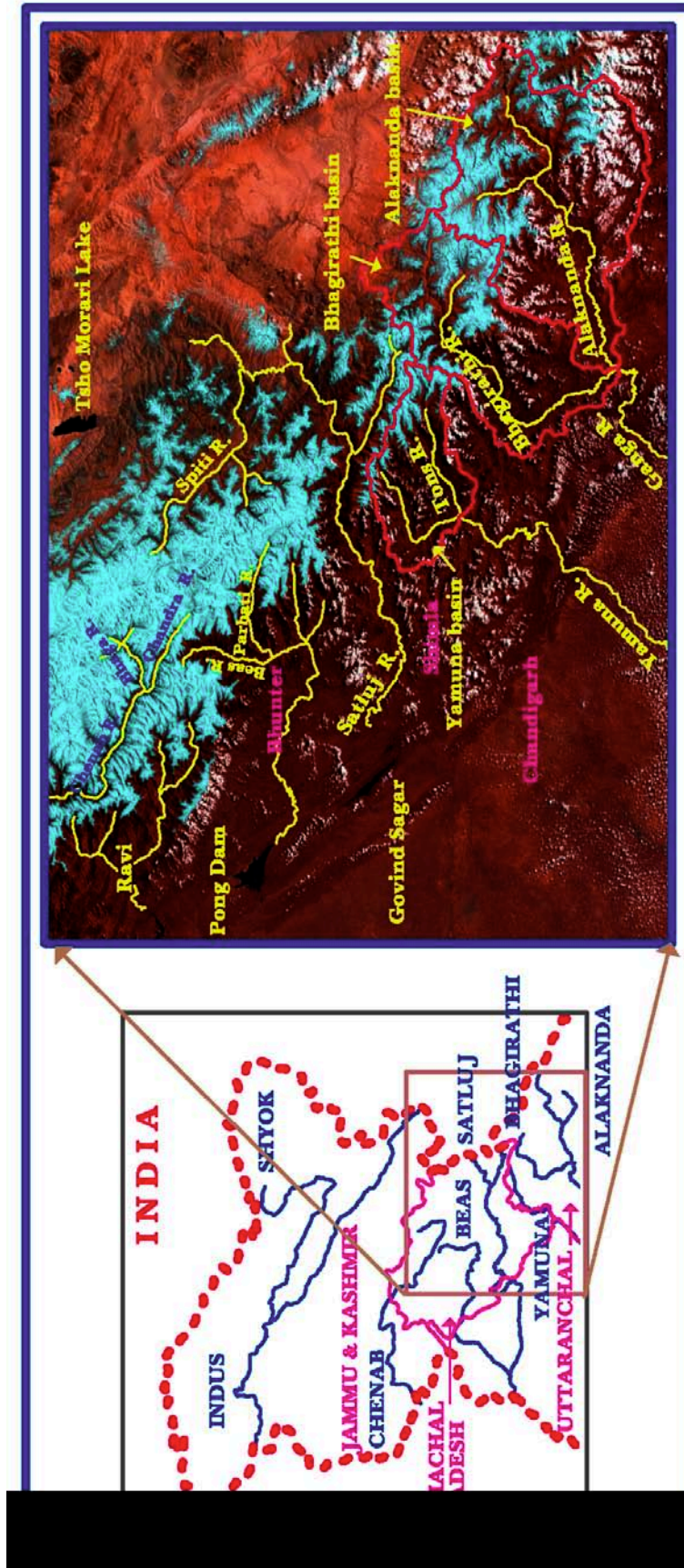


Figure 1: Location map of Alaknanda, Bhagirathi and Yamuna sub-basins (Part of Ganga basin)

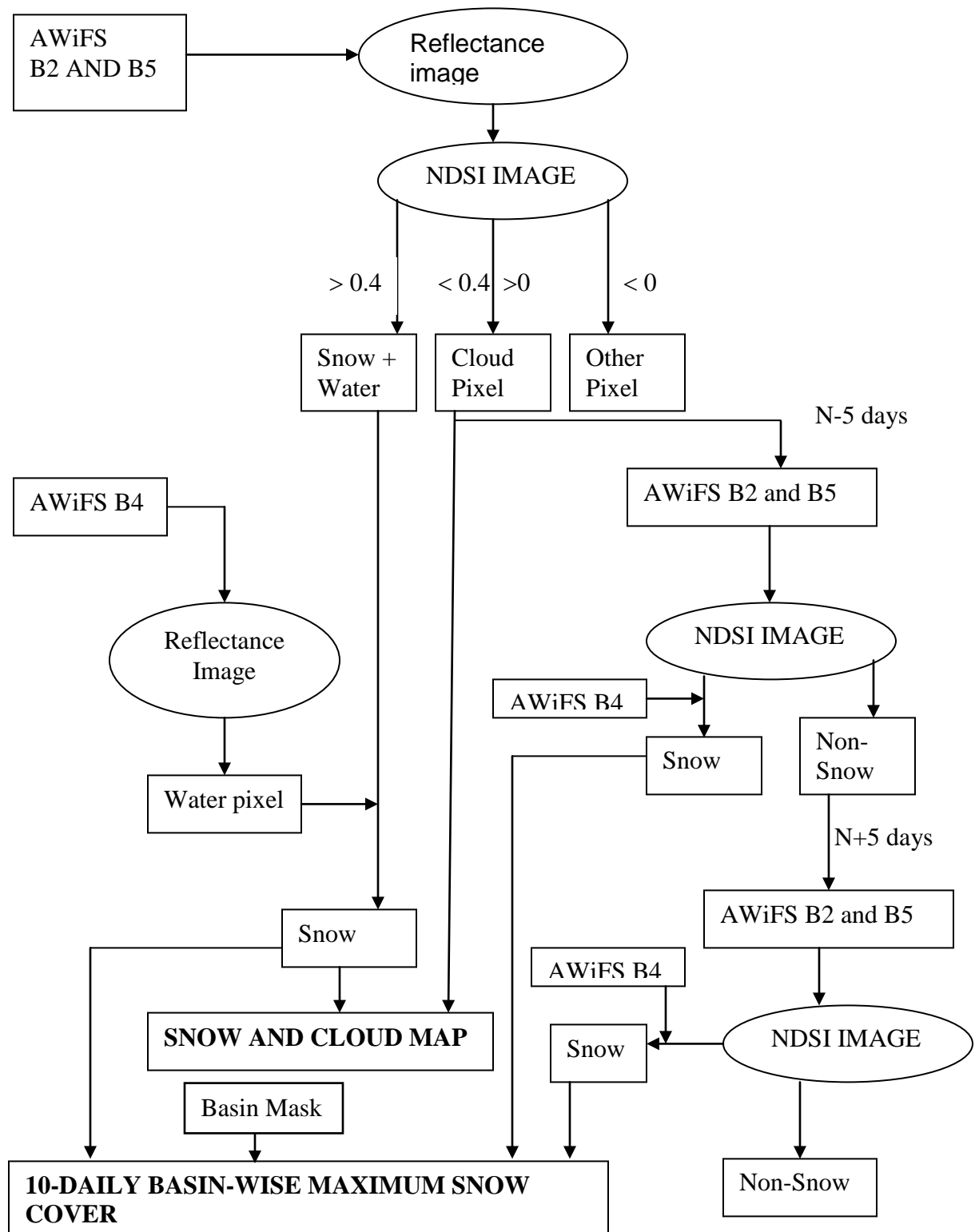


Figure 2: Algorithm for snow cover mapping using AWiFS data

ALAKNANDA 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 (%)
October 2009							
1	04-Oct-09	1362	12	3	14-Oct-09	2987	27
2	09-Oct-09	3253	29	4	28-Oct-09	2625	27
November 2009							
5	2-Nov-09	2603	23	8	16-Nov-09	4298	39
6	07-Nov-09	2573	27	9	21-Nov-09	3846	35
7	11-Nov-09	3782	34	10	26-Nov-09	3406	31
December 2009							
11	1-Dec-09	3444	31	14	20-Dec-09	3281	30
12	05-Dec-09	3073	28	15	25-Dec-09	3956	36
13	10-Dec-09	6074	55	16	29-Dec-09	3273	30
January 2010							
17	8-Jan-10	4085	37	19	27-Jan-10	3668	33
18	13-Jan-10	4219	38				
February 2010							
20	06-Feb-10	3704	33	22	11-Feb-10	4458	40
21	10-Feb-10	7167	66				
March 2010							
23	2-Mar-10	5100	46	24	6-Mar-10	4995	45
April 2010							
25	04-Apr-10	3231	33	26	19-Apr-10	5983	54
May 2010							
27	08-May-10	2894	26	28	22-May-10	2826	25
June 2010							
29	01-Jun-10	1625	15	31	11-Jun-10	2573	23
30	06-Jun-10	2148	19				

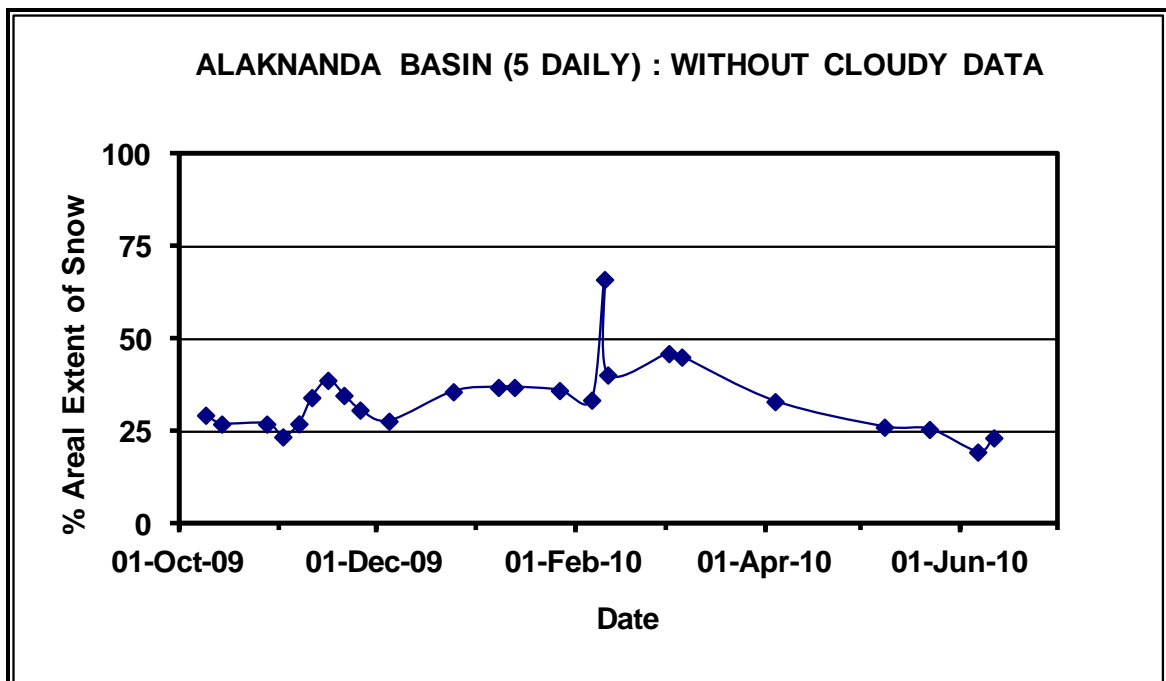
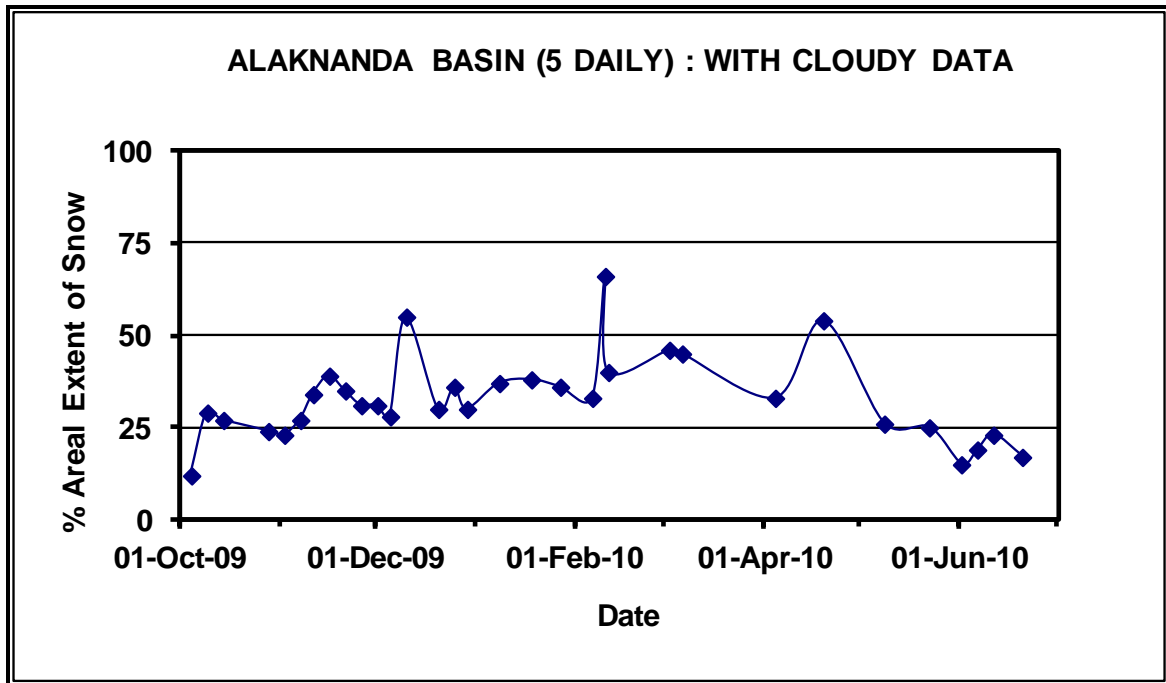
AREAL EXTENT OF SNOW (10 DAILY)

BASIN NAME: ALALNANDA

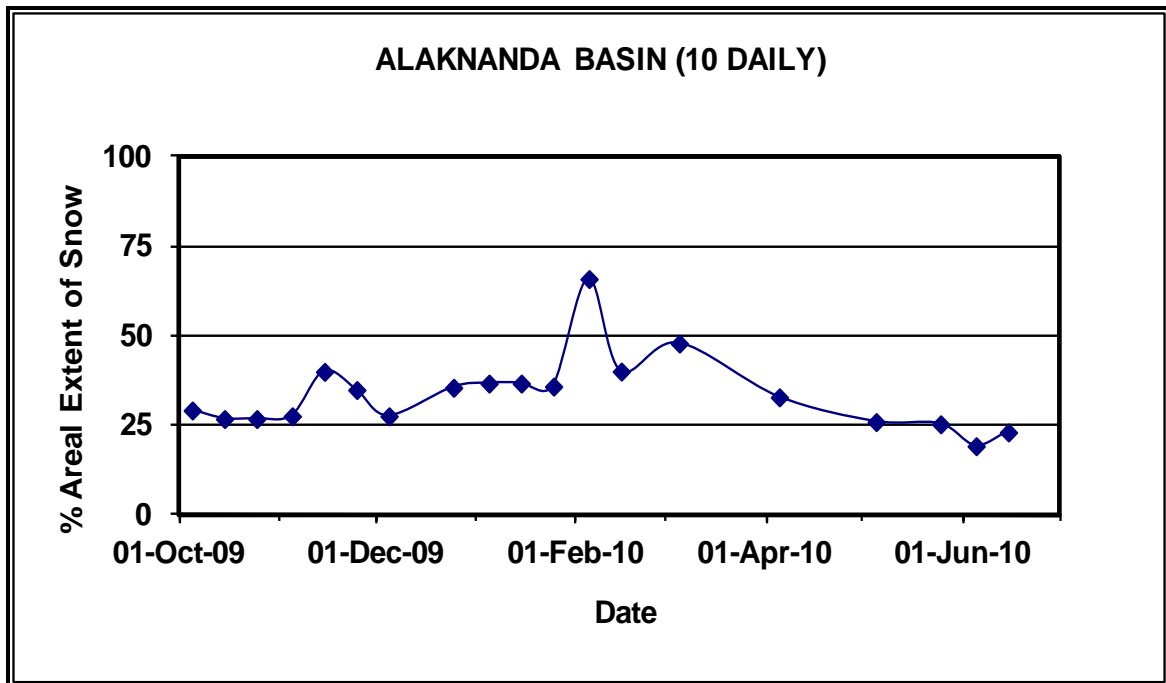
BASIN AREA: 11090 Sq km

S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2009				November 2009			
1	9-Oct-09	3253	29	3	2-Nov-09	3073	28
2	14-Oct-09	2987	27	5	11-Nov-09	4448	40
				7	21-Nov-09	3886	35
December 2009				January 2010			
9	5-Dec-09	3073	28	11	8-Jan-10	4085	37
10	25-Dec-09	3956	36				
February 2010				March 2010			
12	6-Feb-10	7319	66	14	2-Mar-10	5304	48
13	11-Feb-10	4458	40				
April 2010				May 2010			
16	4-Apr-10	3660	33	17	8-May-10	2894	26
				18	22-May-10	2826	25
June 2010							
19	6-Jun-10	2148	19				
20	11-Jun-10	2573	23				

Snow cover depletion curve

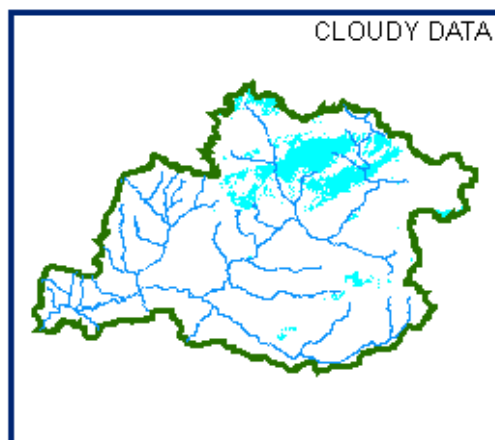


Snow cover depletion curve

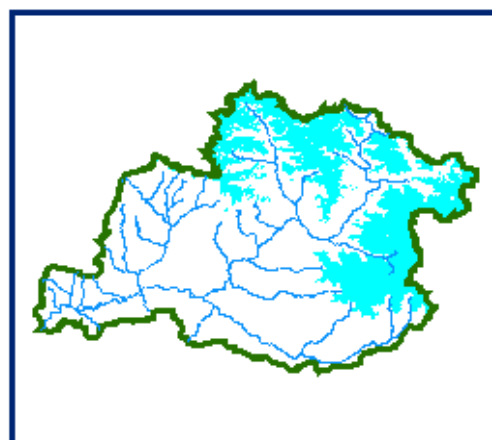


SNOW COVER MAP

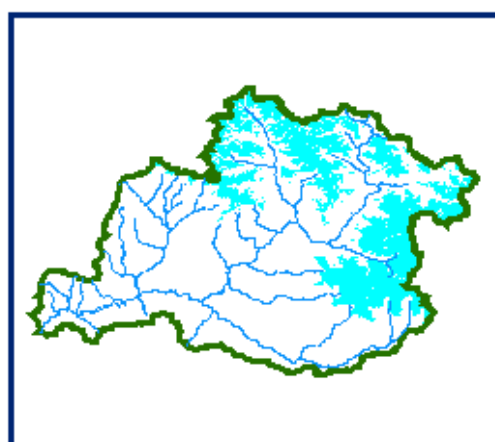
SNOW COVER MAP : ALAKNANDA BASIN



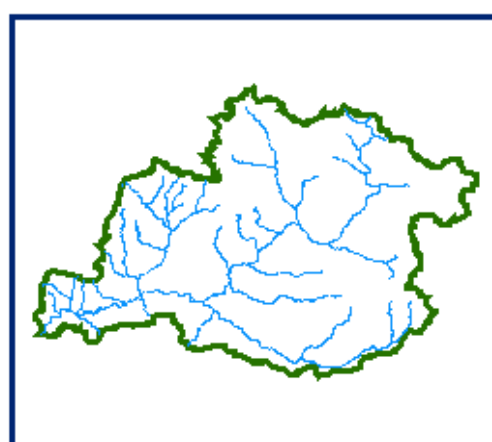
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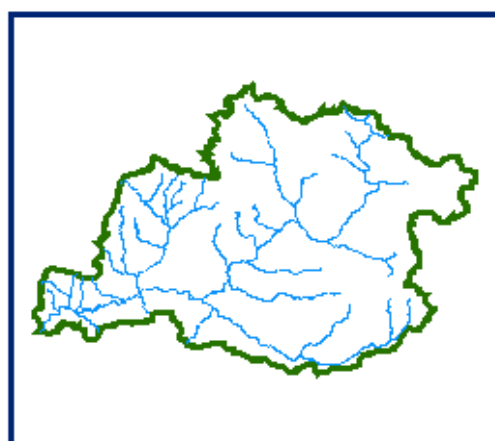
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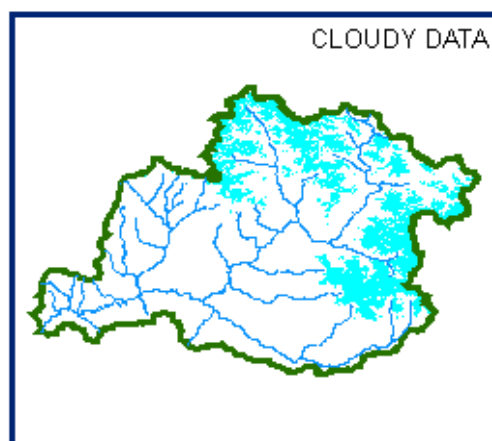
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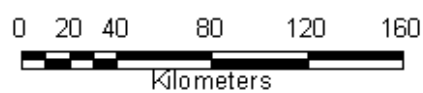
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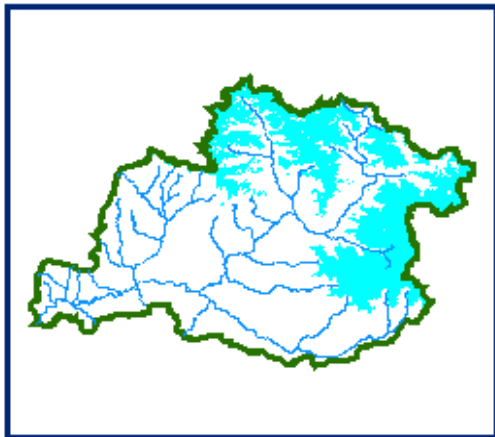
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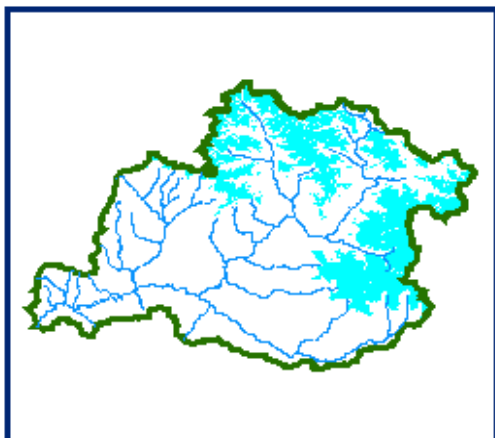
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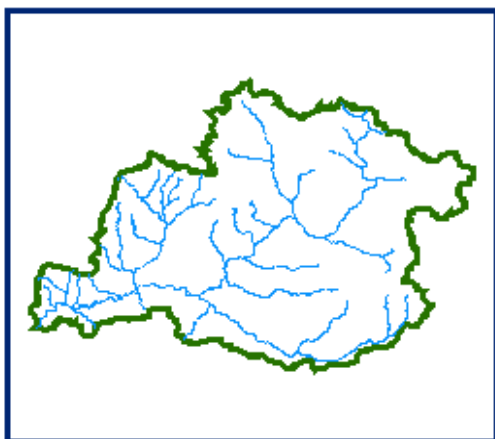
10 DAILY SNOW COVER MAP: ALAKNANDA BASIN



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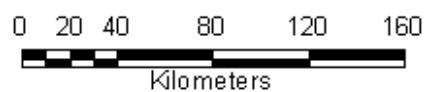
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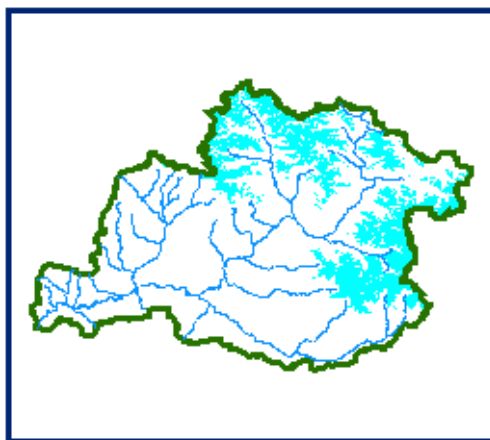
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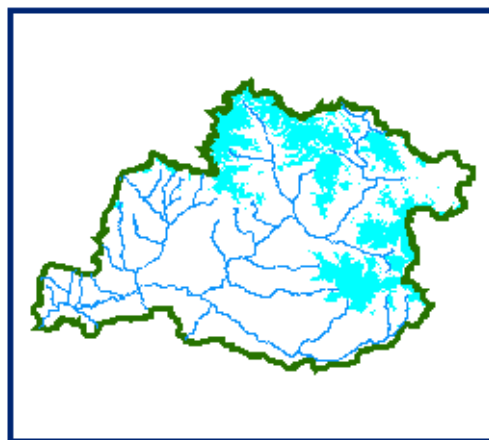
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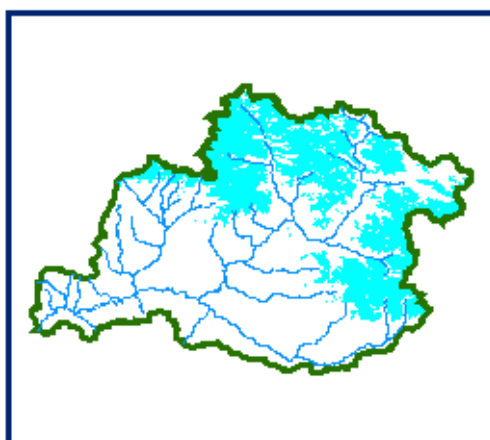
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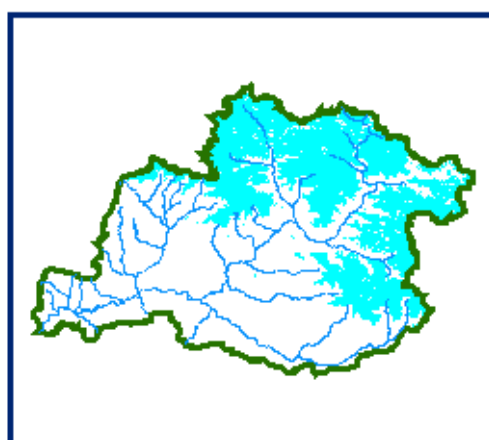
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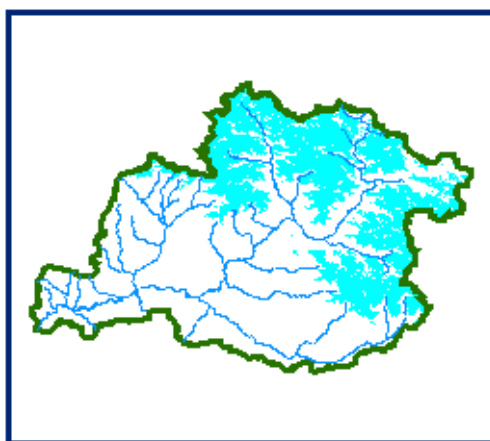
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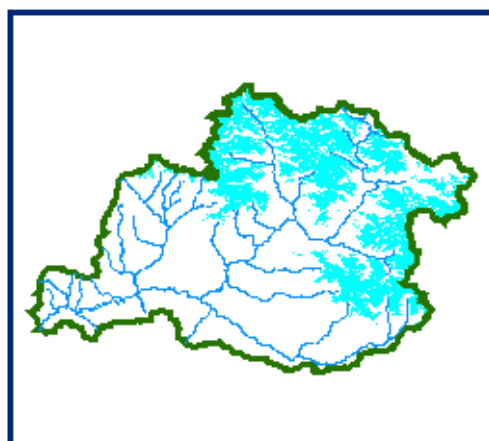
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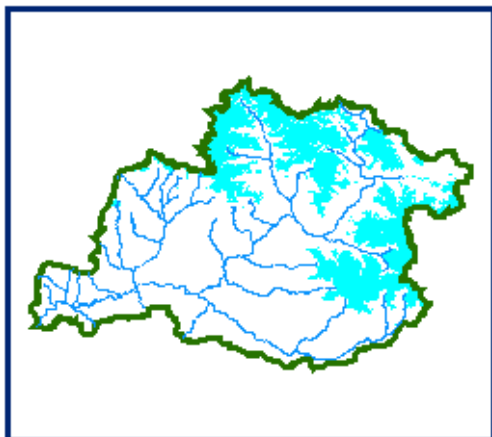
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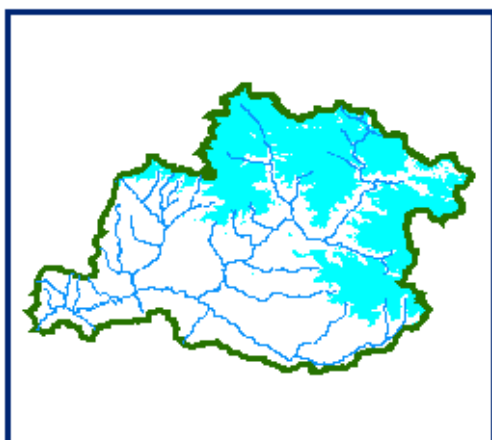
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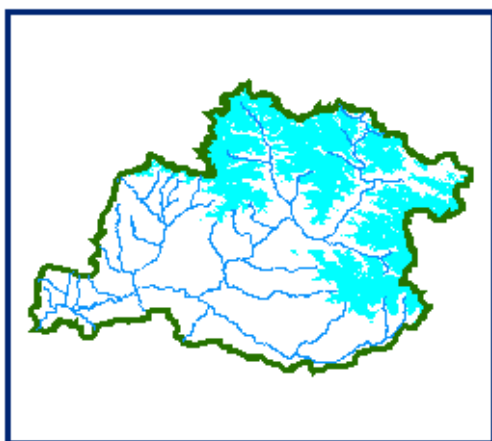
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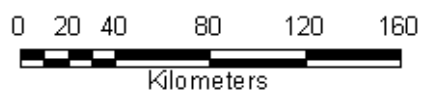
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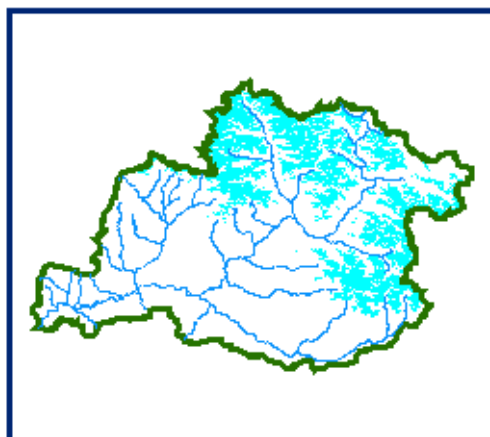
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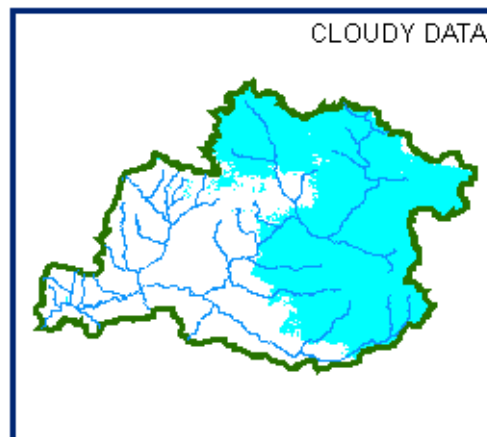
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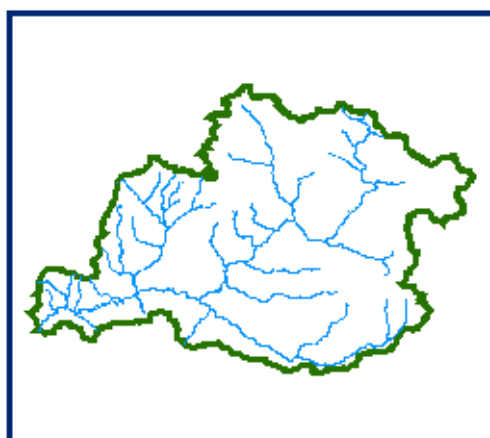
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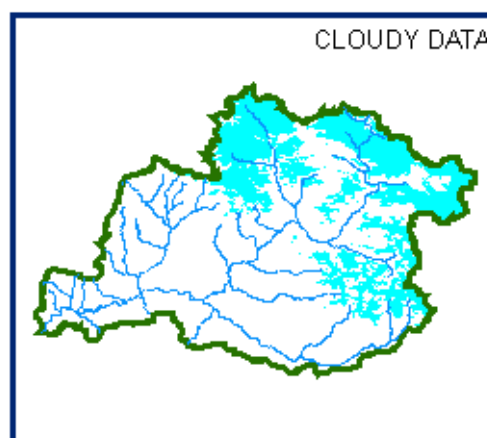
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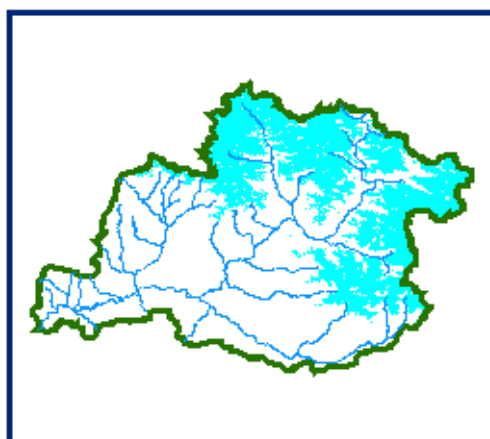
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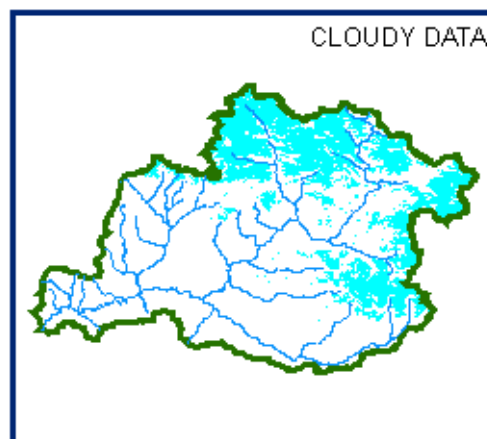
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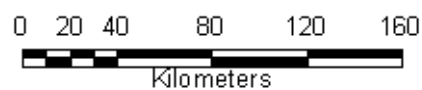
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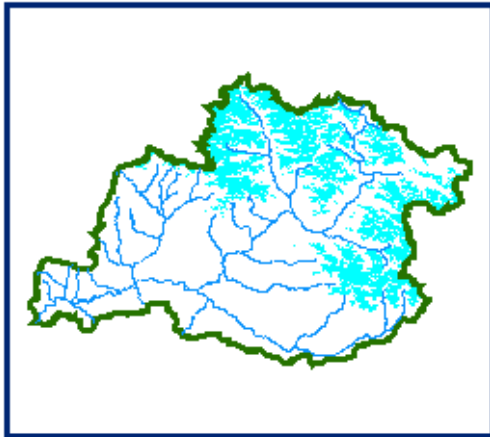
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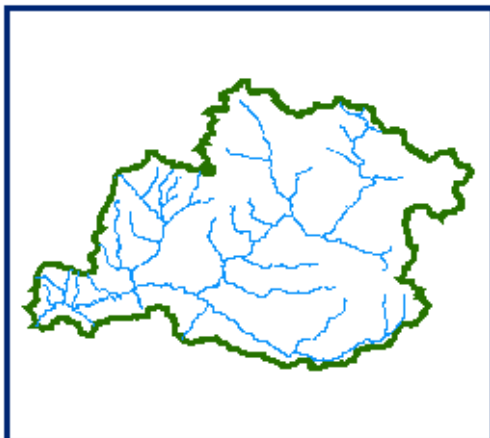
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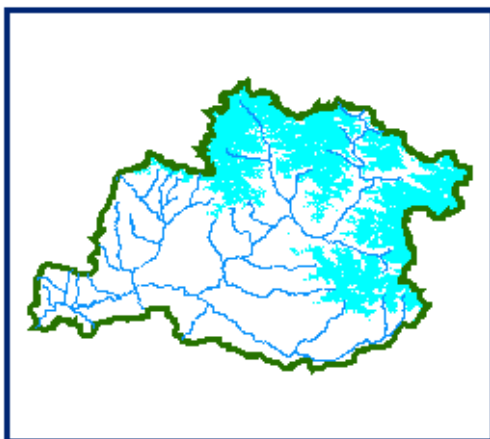
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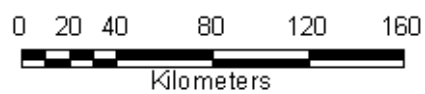
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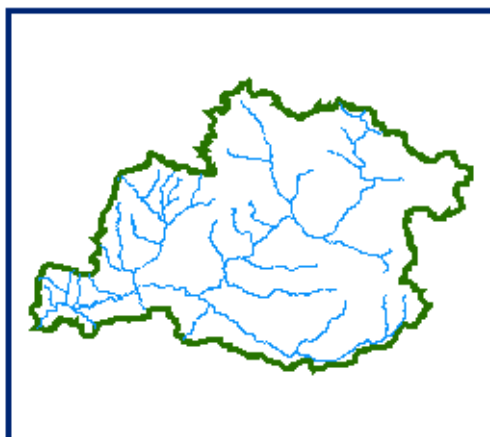
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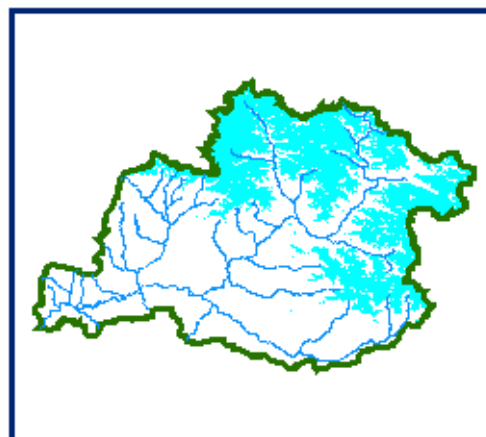
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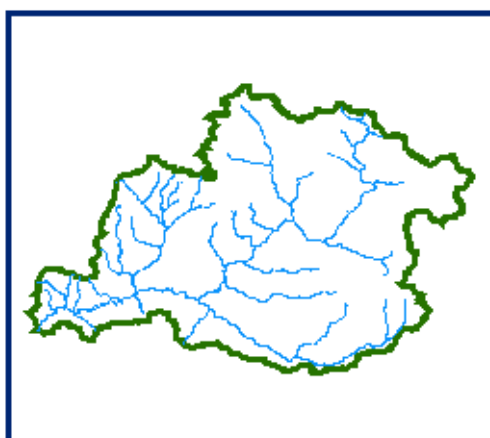
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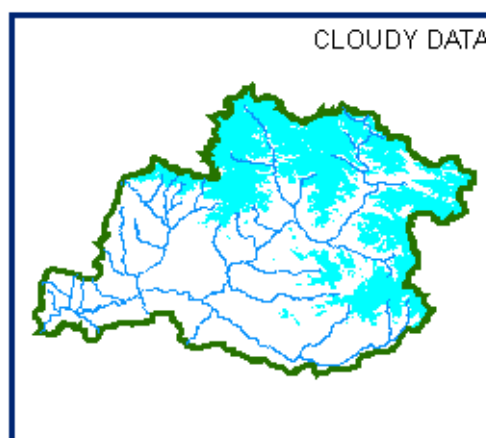
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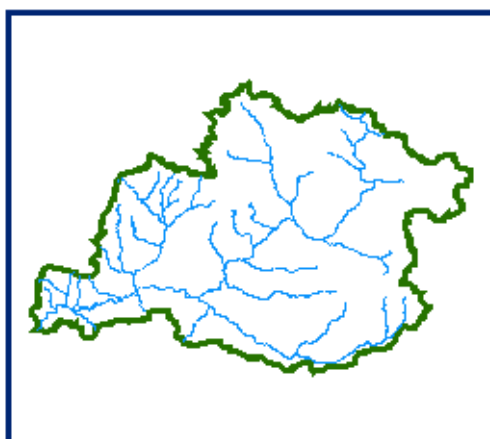
8 JANUARY 2010



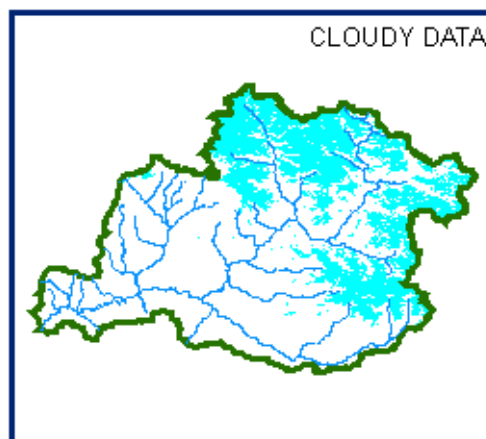
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18 JANUARY 2010



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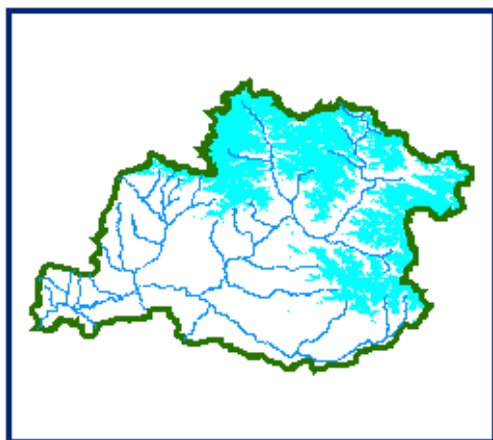
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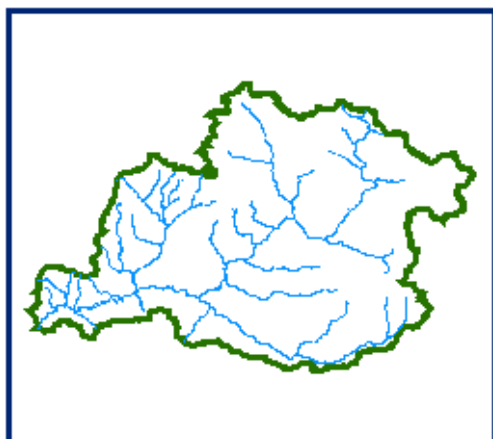
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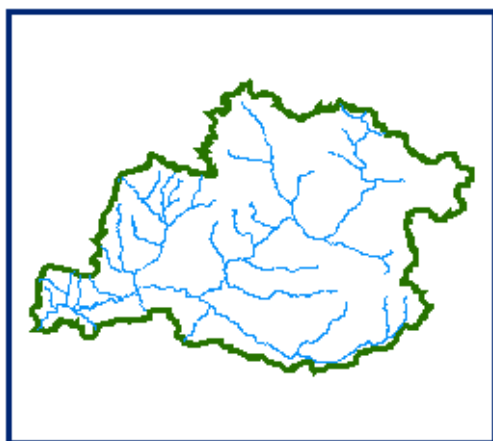
10 DAILY SNOW COVER MAP: ZASKER BASIN



DATA USED
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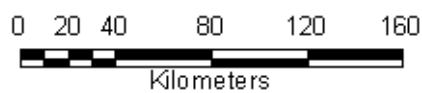
DATA USED
DATA NOT AVAILABLE



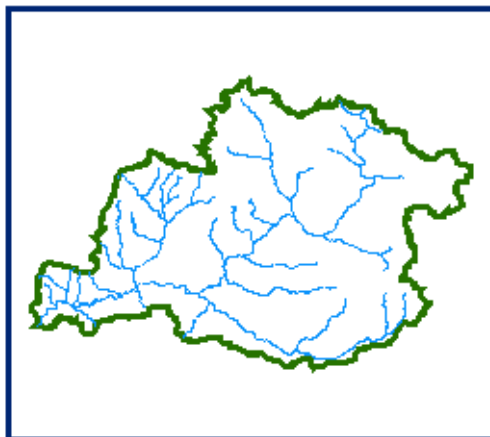
DATA USED
DATA NOT AVAILABLE



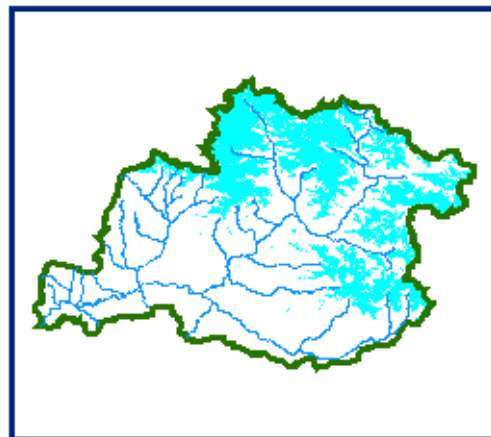
SNOW



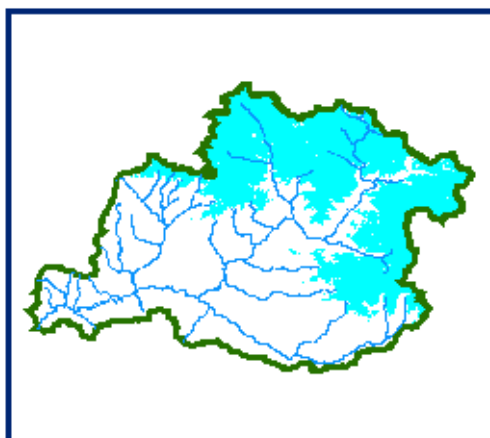
SNOW COVER MAP : ALAKNANDA BASIN



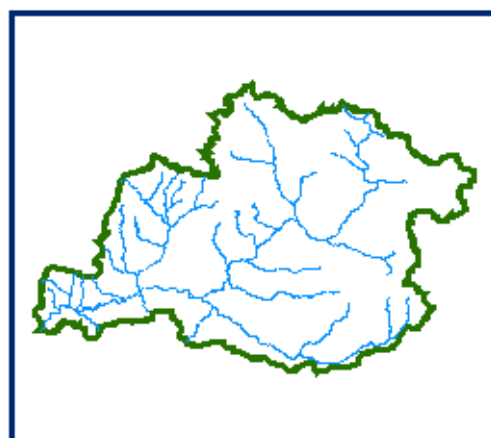
DATA NOT AVAILABLE



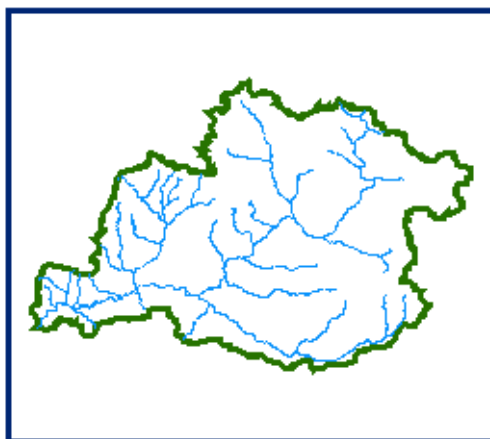
6 FEBRUARY 2010



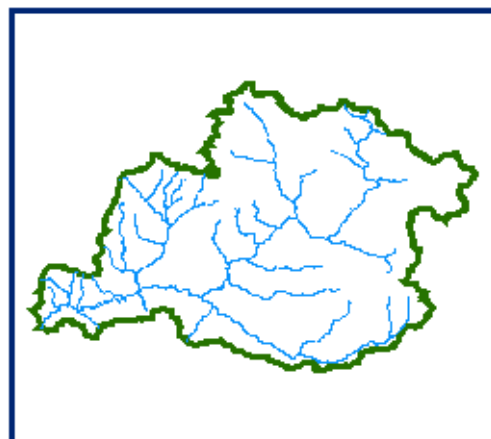
11 FEBRUARY 2010



DATA NOT AVAILABLE



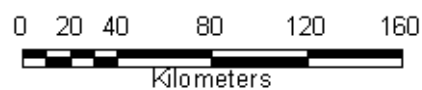
DATA NOT AVAILABLE



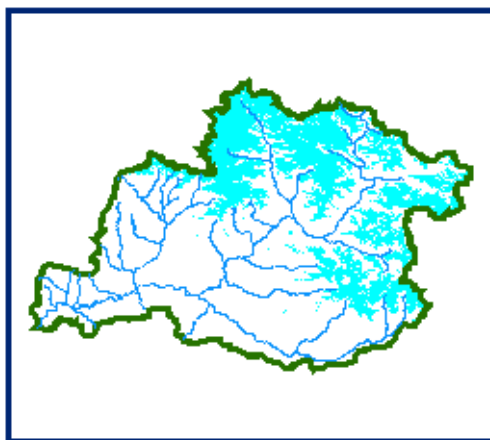
DATA NOT AVAILABLE



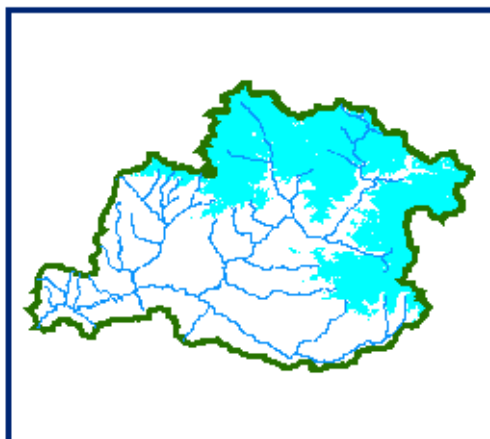
SNOW



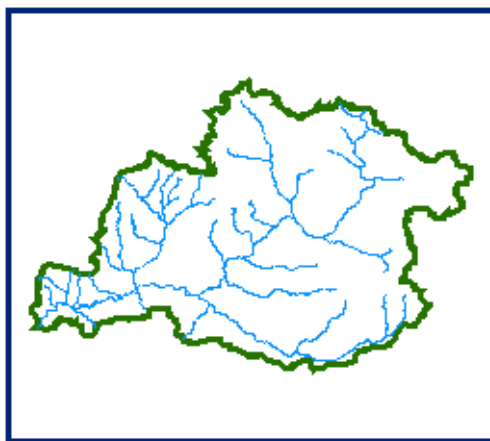
10 DAILY SNOW COVER MAP: ALAKNANDA BASIN



DATA USED
6 FEBRUARY 2010



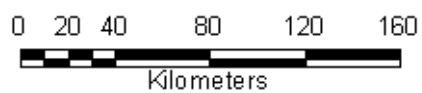
DATA USED
11 FEBRUARY 2010



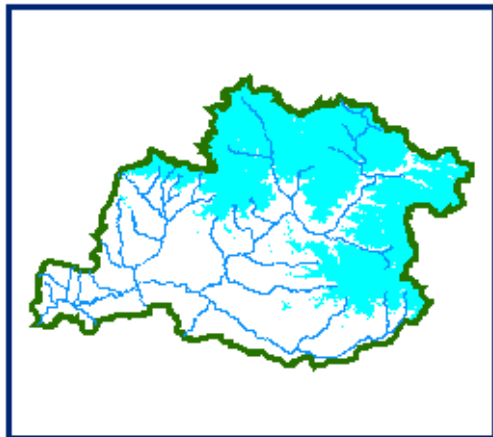
DATA USED
DATA NOT AVAILABLE



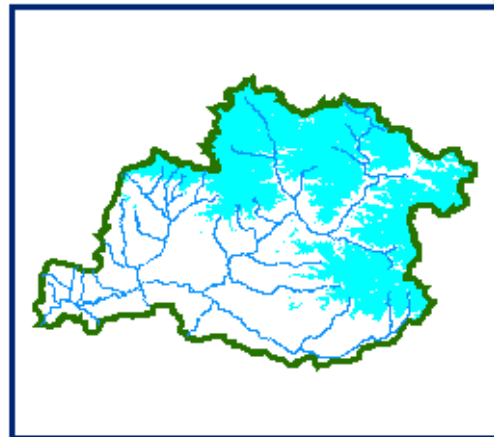
SNOW



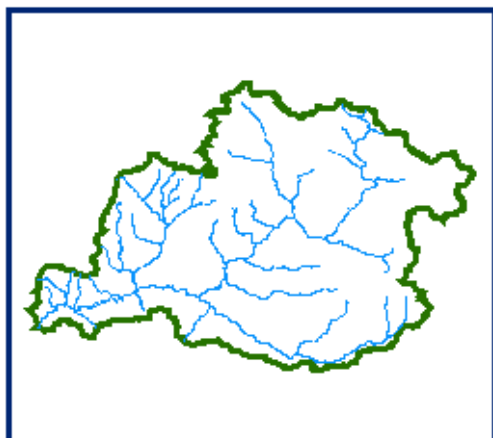
SNOW COVER MAP : ALAKNANDA BASIN



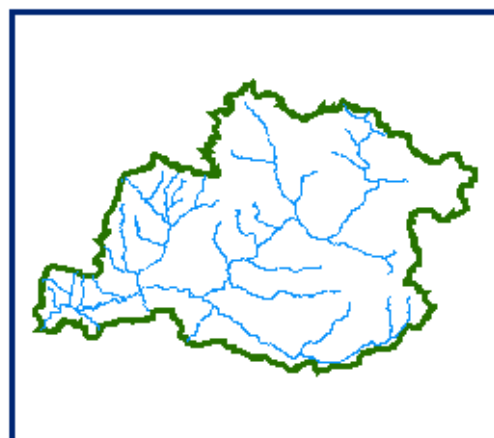
2 MARCH 2010



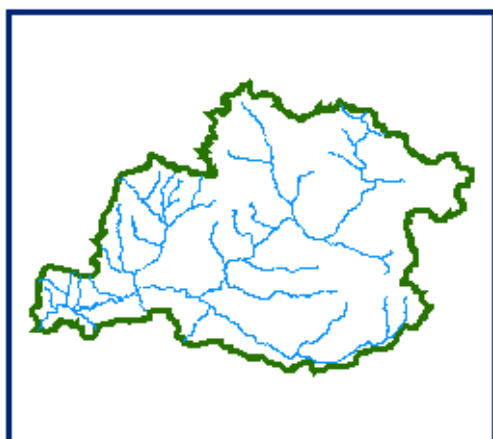
6 MARCH 2010



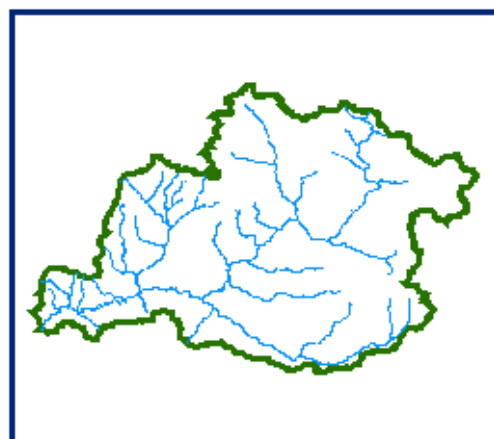
DATA NOT AVAILABLE



DATA NOT AVAILABLE



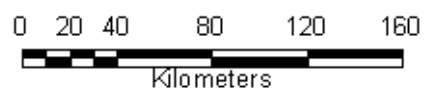
DATA NOT AVAILABLE



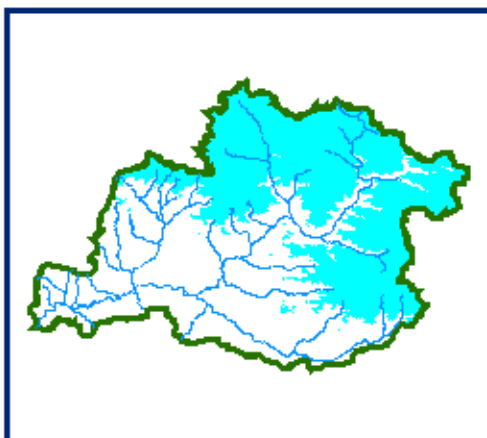
DATA NOT AVAILABLE



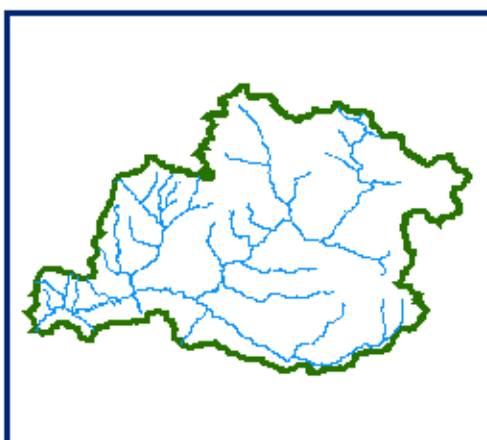
SNOW



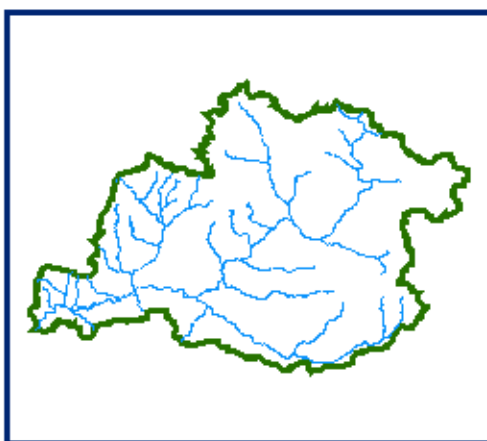
10 DAILY SNOW COVER MAP: ZASKER BASIN



DATA USED
2 MARCH 2010
6 MARCH 2010



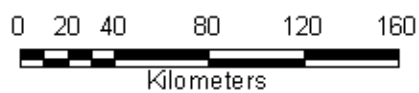
DATA USED
DATA NOT AVAILABLE



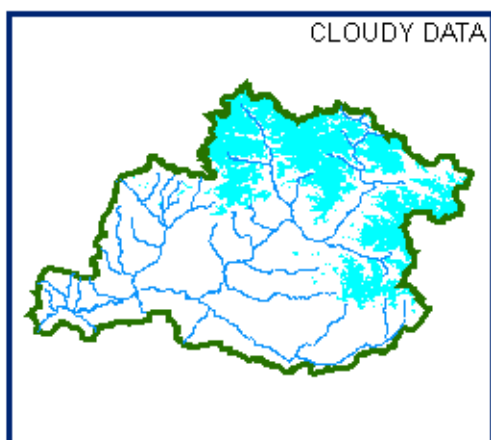
DATA USED
DATA NOT AVAILABLE



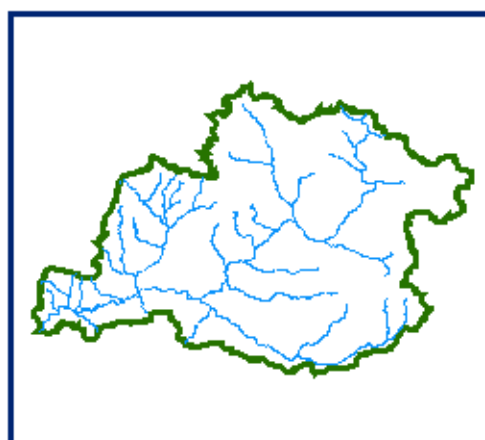
SNOW



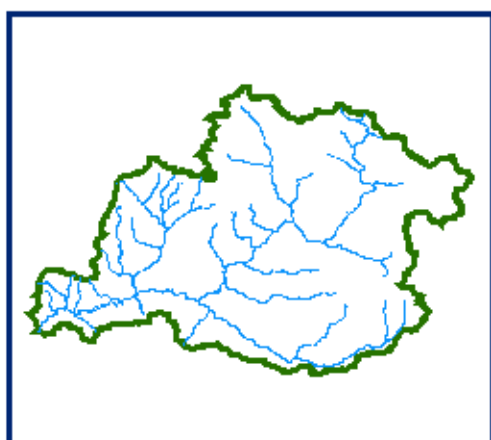
SNOW COVER MAP : ALAKNANDA BASIN



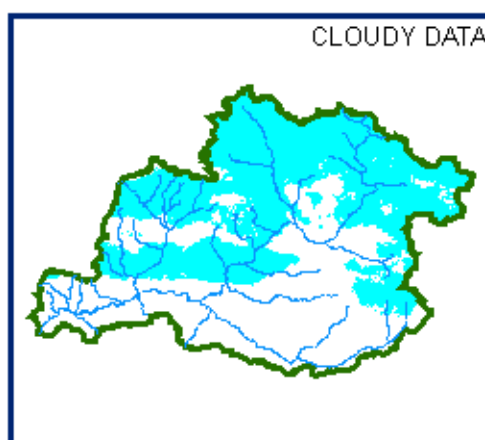
4 APRIL 2010



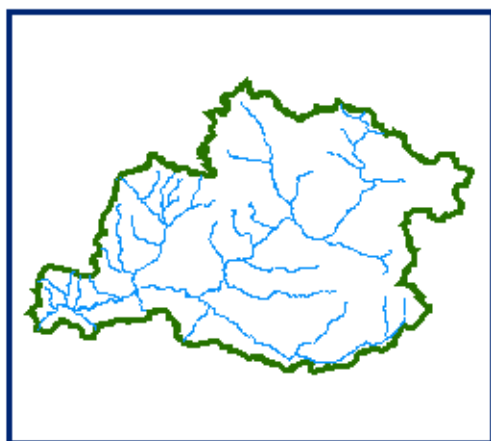
DATA NOT AVAILABLE



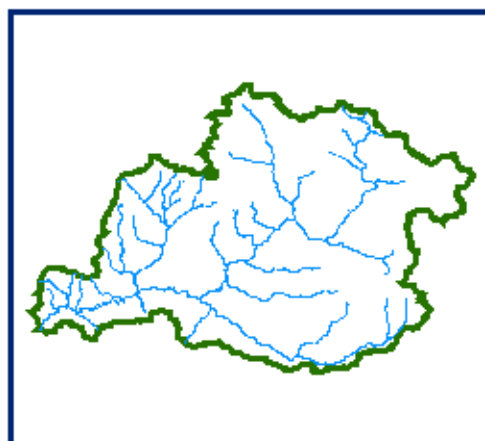
DATA NOT AVAILABLE



19 APRIL 2010



DATA NOT AVAILABLE



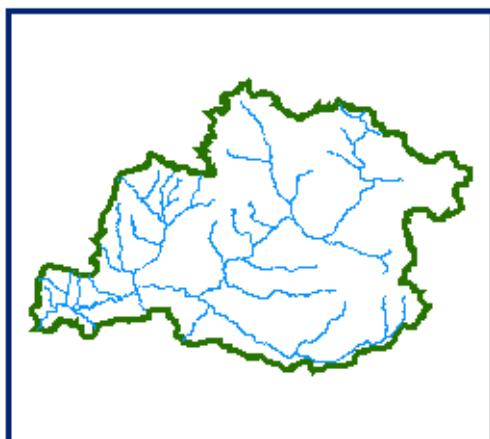
DATA NOT AVAILABLE



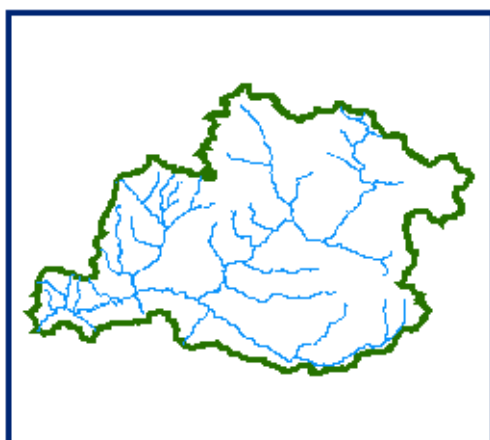
SNOW



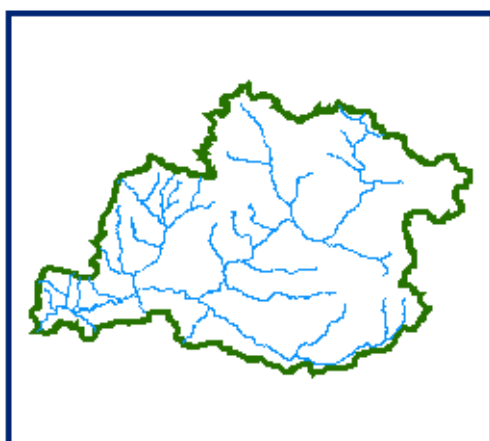
10 DAILY SNOW COVER MAP: ALAKNANDA BASIN



DATA USED
DATA NOT AVAILABLE



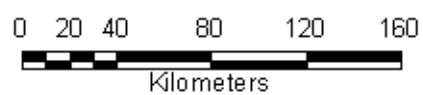
DATA USED
DATA NOT AVAILABLE



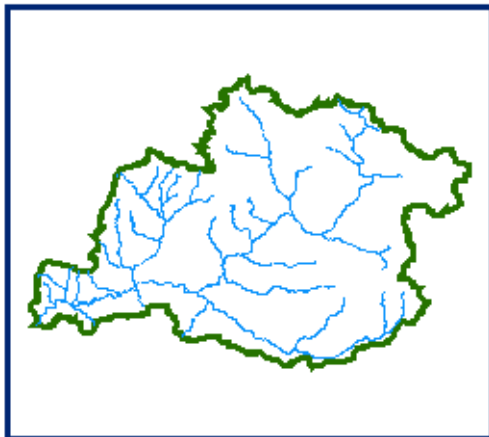
DATA USED
DATA NOT AVAILABLE



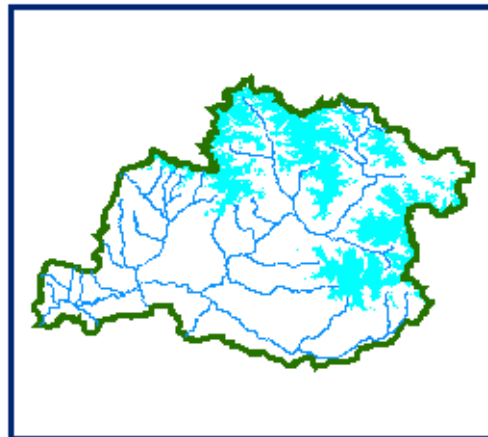
SNOW



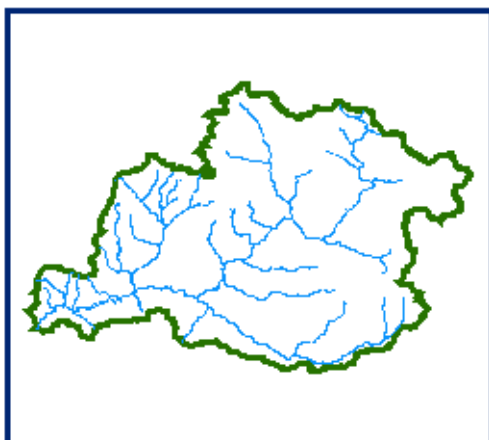
SNOW COVER MAP : ALAKNANDA BASIN



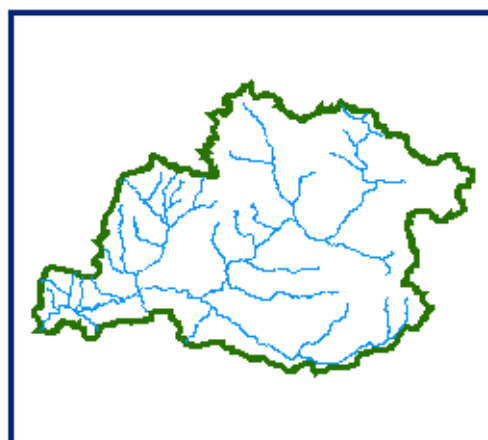
DATA NOT AVAILABLE



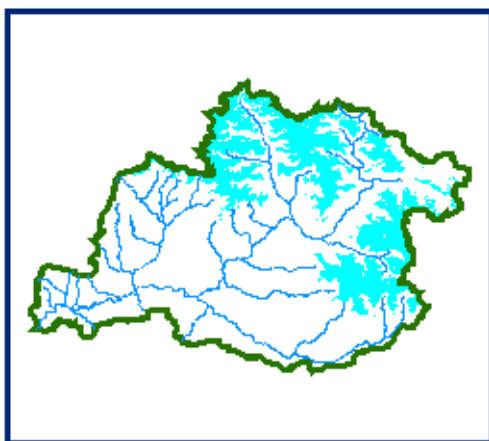
8 MAY 2010



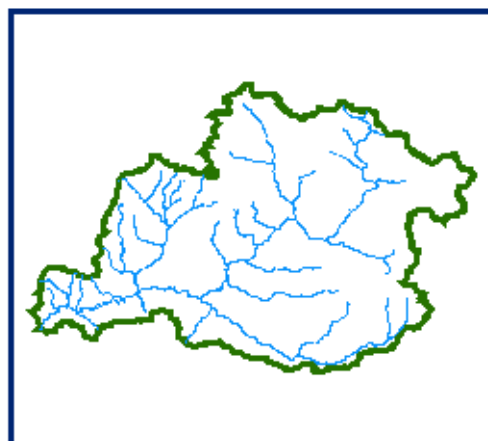
DATA NOT AVAILABLE



DATA NOT AVAILABLE



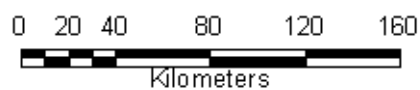
22 MAY 2010



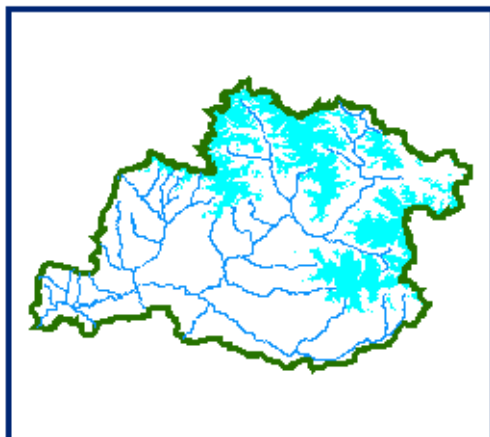
DATA NOT AVAILABLE



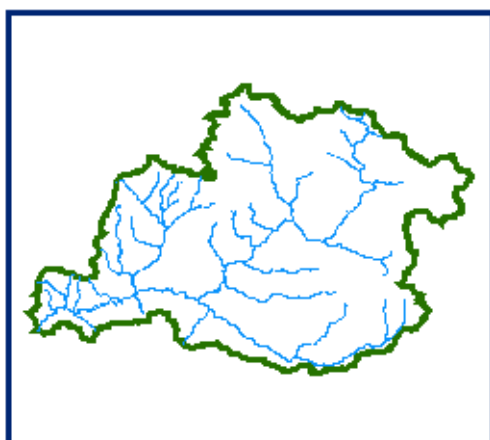
SNOW



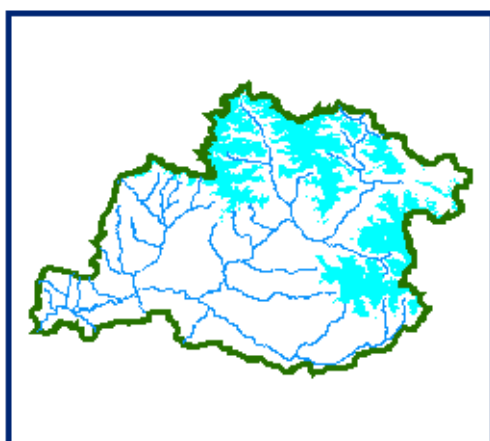
10 DAILY SNOW COVER MAP: ALAKNANDA BASIN



DATA USED
8 MAY 2010



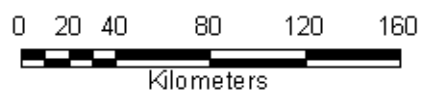
DATA USED
DATA NOT AVAILABLE



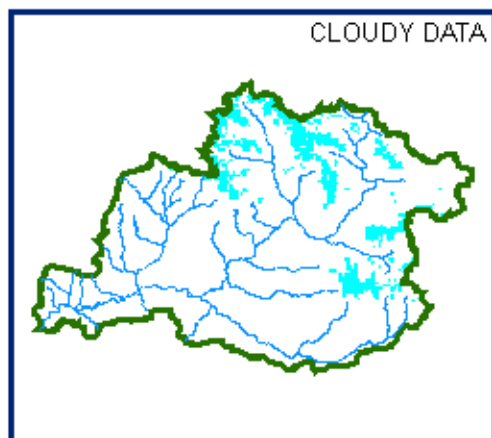
DATA USED
22 MAY 2010



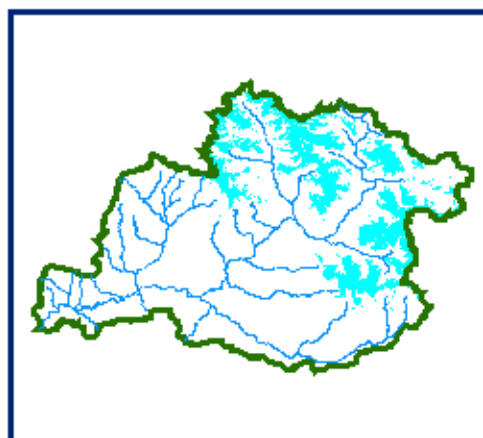
SNOW



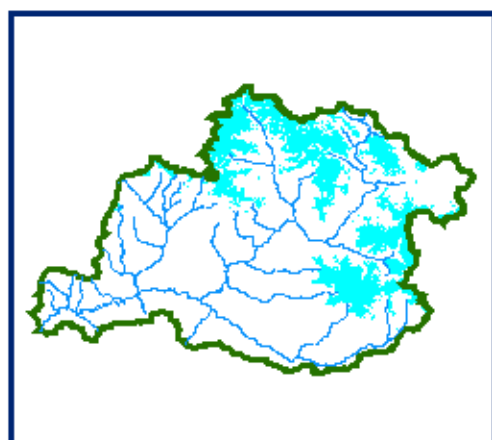
SNOW COVER MAP : ALAKNANDA BASIN



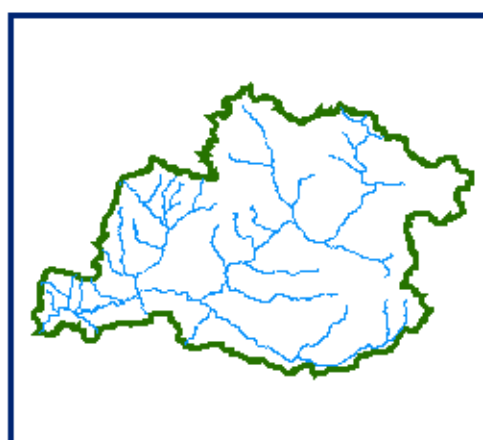
1 JUN 2010



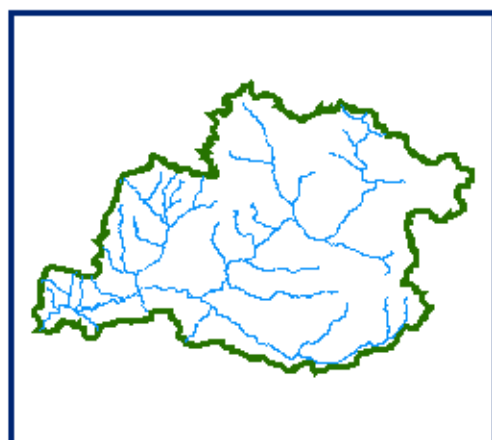
6 JUN 2010



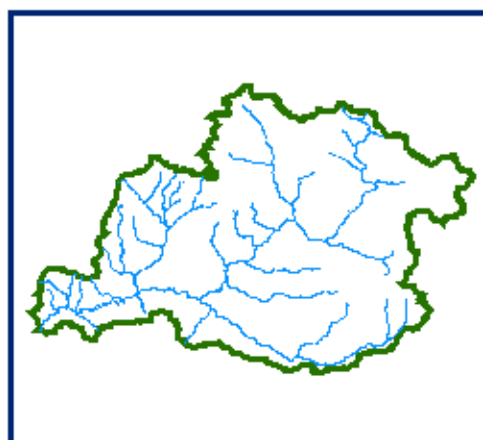
11 JUN 2010



DATA NOT AVAILABLE



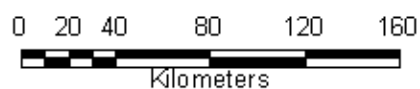
DATA NOT AVAILABLE



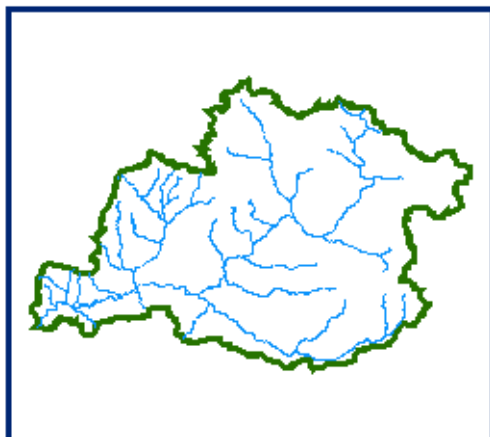
DATA NOT AVAILABLE



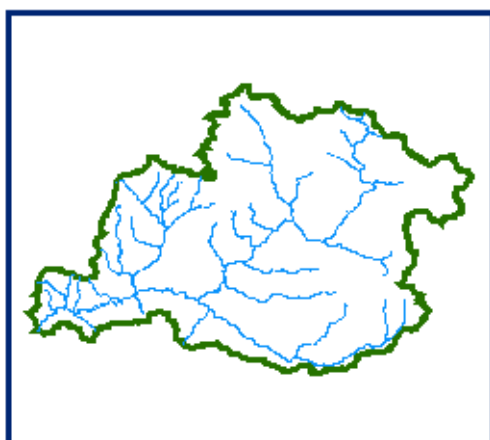
SNOW



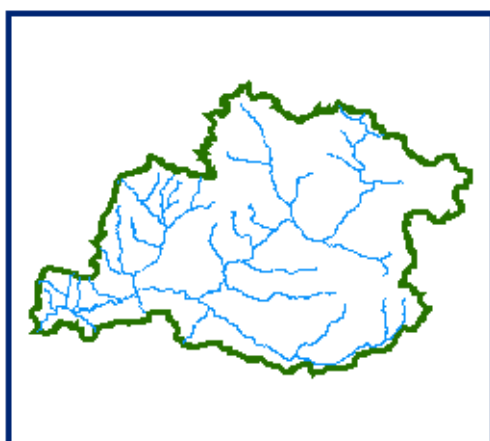
10 DAILY SNOW COVER MAP: ALAKNANDA BASIN



DATA USED
DATA NOT AVAILABLE



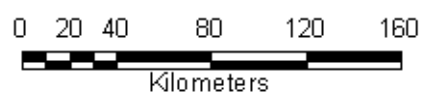
DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE



SNOW



BHAGIRATHI BASIN

AREAL EXTENT OF SNOW (5 DAILY)

BASIN NAME: BHAGIRATHI

BASIN AREA: 7438 sq km

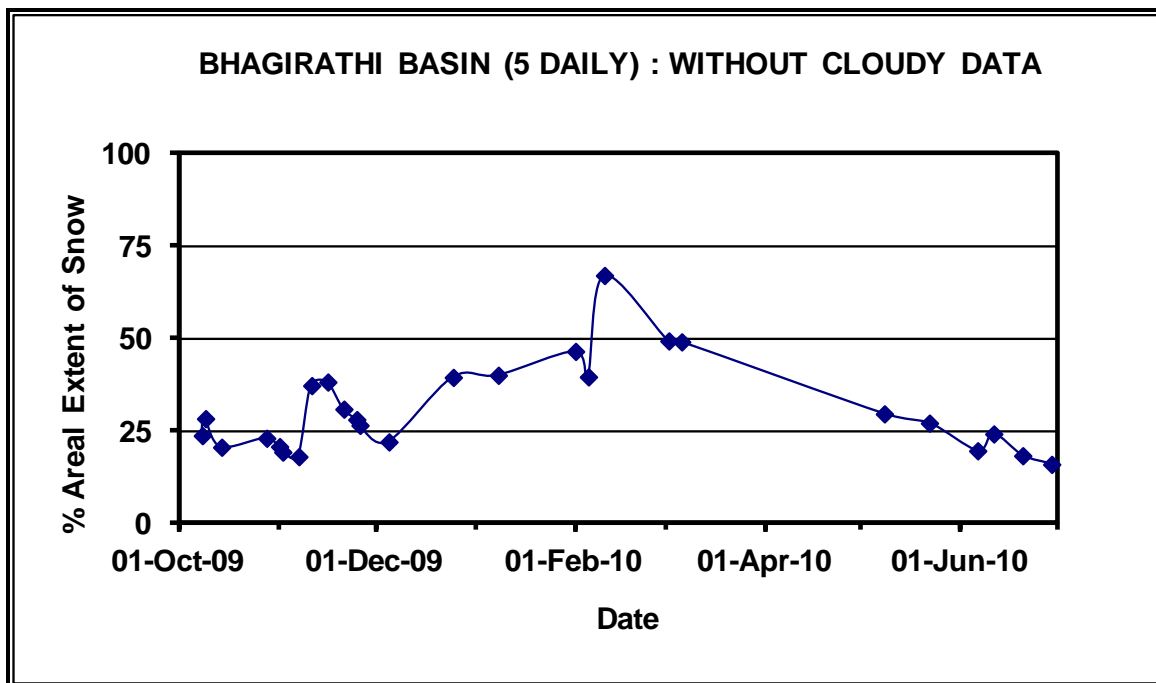
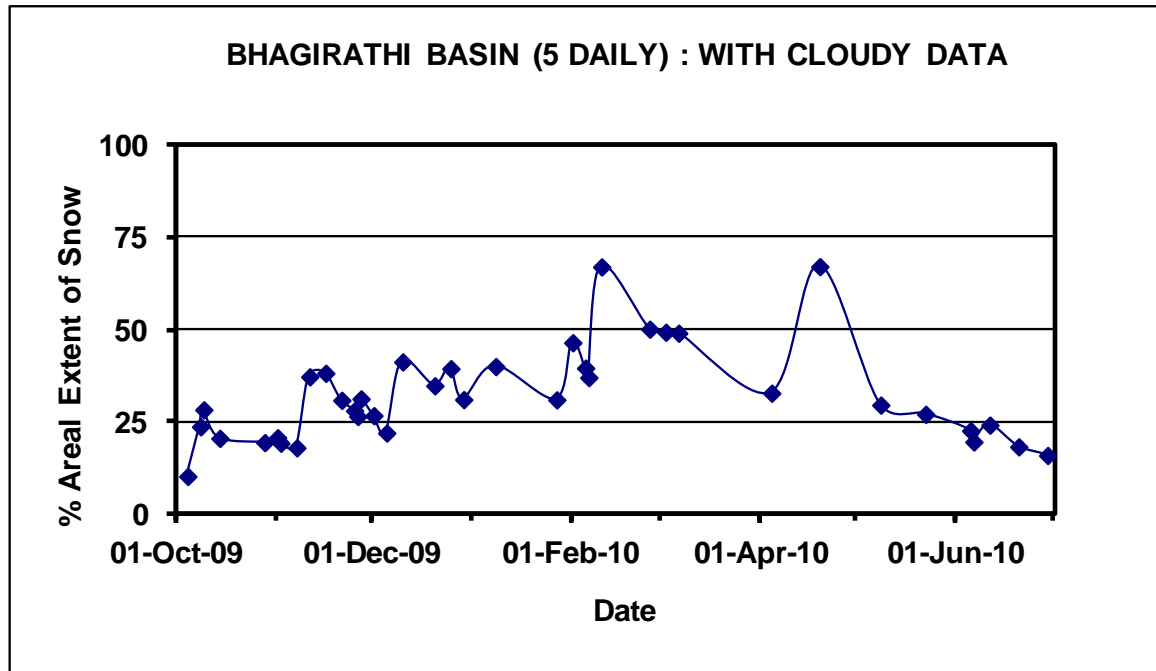
S. No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2009							
1	04-Oct-09	763	10	4	14-Oct-09	1530	21
2	8-Oct-09	1764	24	5	28-Oct-09	1444	19
3	09-Oct-09	2105	28				
November 2009							
6	01-Nov-09	1543	21	11	21-Nov-09	2296	31
7	02-Nov-09	1432	19	12	25-Nov-09	2086	28
8	07-Nov-09	1340	18	13	26-Nov-09	1971	26
9	11-Nov-09	2769	37	14	27-Nov-10	2325	31
10	16-Nov-09	2841	38				
December 2009							
15	1-Dec-09	1988	27	18	20-Dec-09	2590	35
16	05-Dec-09	1637	22	19	25-Dec-09	2934	39
17	10-Dec-09	3069	41	20	29-Dec-09	2311	31
January 2010							
21	08-Jan-10	2976	40				
February 2010							
22	01-Feb-11	3457	46	25	10-Feb-10	4393	59
23	5-Feb-10	2945	40	26	25-Feb11	3729	50
24	6-Feb101	2755	37				
March 2010							
27	02-Mar-10	3667	49	28	06-Mar-10	3648	49
April 2010							
29	04-Apr-10	2440	33	30	19-Apr-10	4989	67
May 2010							
31	08-May-10	2201	30				
32	22-May-10	2015	27				
June 2010							
33	5-Jun-10	1685	23	37	20-Jun-10	1360	18
34	06-Jun-10	1459	20	38	29-Jun-10	1185	16
35	11-Jun-10	1797	24				

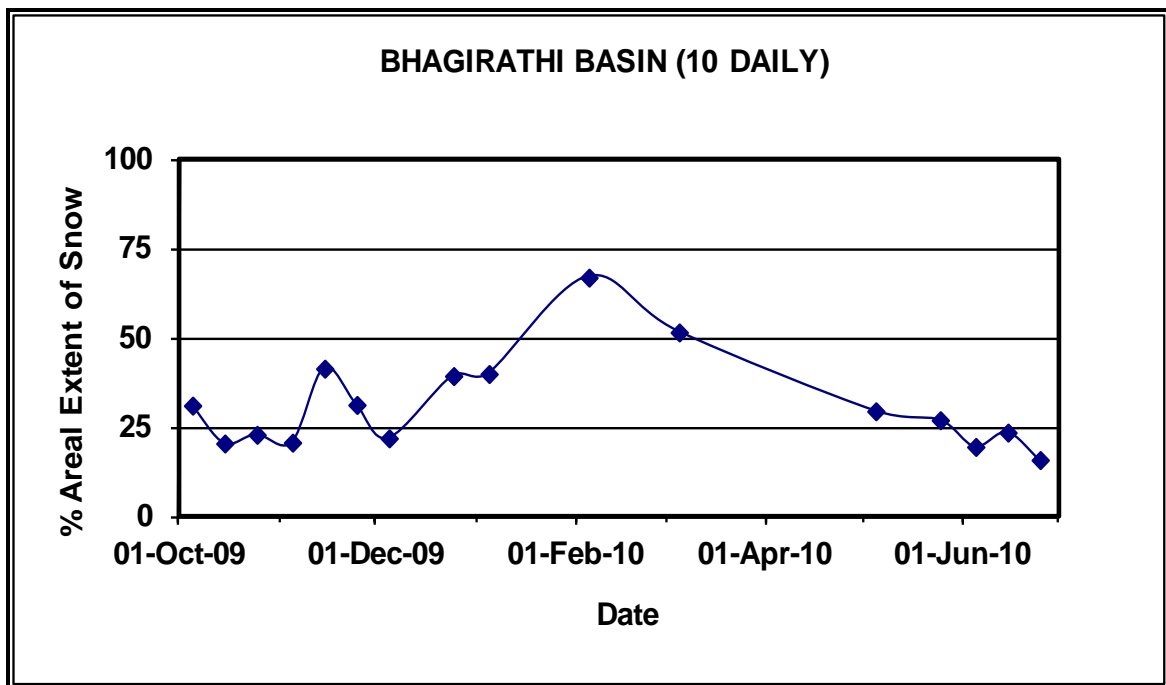
AREAL EXTENT OF SNOW (10 DAILY)

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 2009				November 2009			
1	9-Oct-09	2319	31	3	7-Nov-09	1547.68	21
2	14-Oct-09	1530	21	4	16-Nov-09	3087.92	42
				5	25-Nov-09	2332.68	31
December 2009				January 2010			
6	5-Dec-09	1637	22	8	8-Jan-10	2976	40
7	25-Dec-09	2934	39				
February 2010				March 2010			
9	5-Feb-10	2944.87	40	10	2-Mar-10	3842	52
April 2010				May 2010			
				11	8-May-10	2200.61	30
				12	22-May-10	2014.50	27
June 2010							
13	6-Jun-10	1458.62	20	14	11-Jun-10	1756.77	24



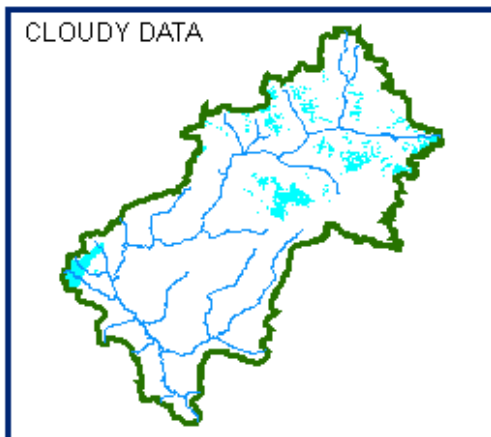


SNOW COVER MAP

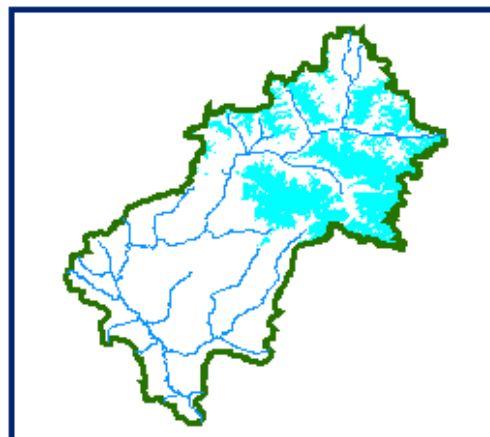
SNOW COVER MAP : BAGIRATHI BASIN



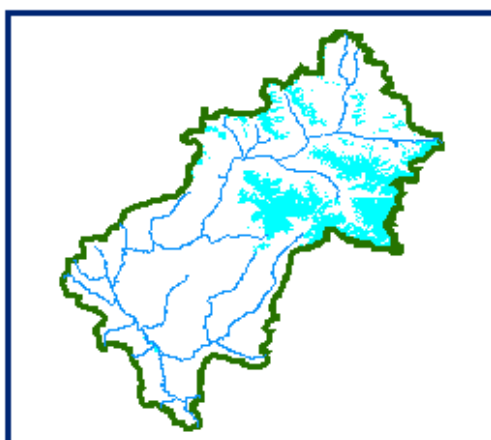
CLOUDY DATA



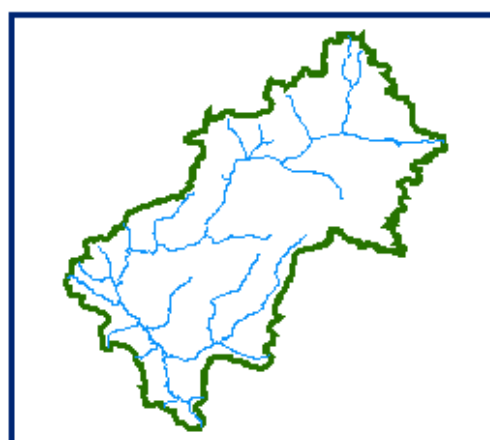
4 OCTOBER 2009



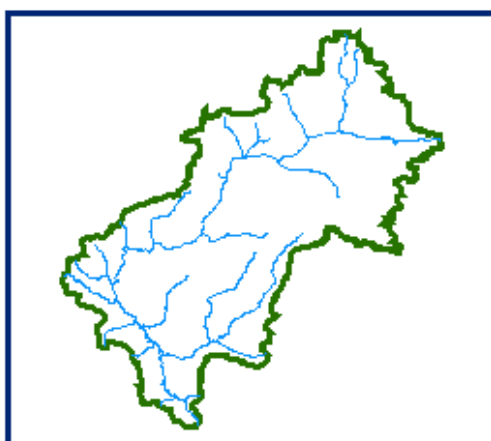
9 OCTOBER 2009



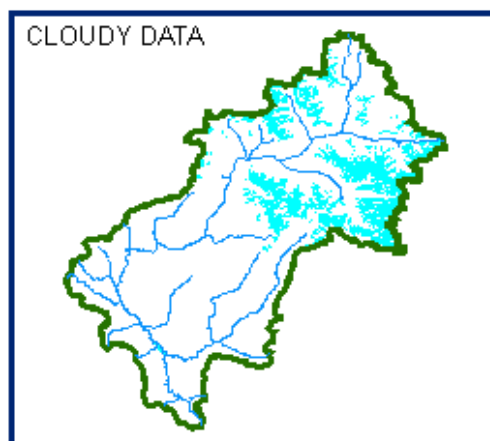
14 OCTOBER 2009



DATA NOT AVAILABLE



DATA NOT AVAILABLE



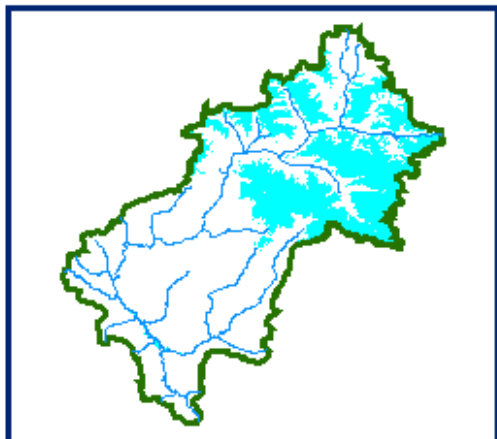
28 OCTOBER 2009



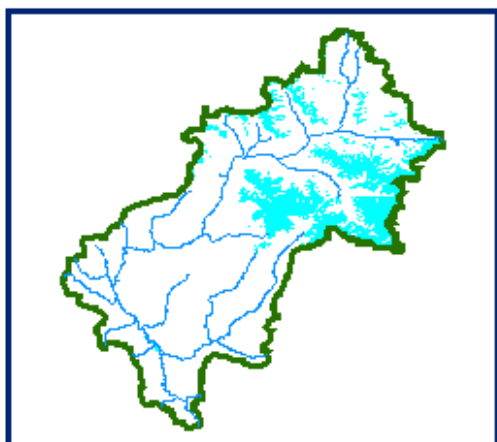
SNOW



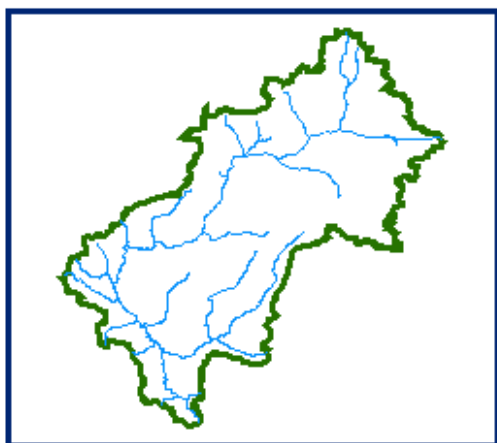
10 DAILY SNOW COVER MAP: ZASKER BASIN



DATA USED
8 OCTOBER 2009
9 OCTOBER 2009



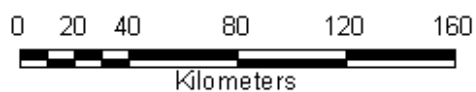
DATA USED
14 OCTOBER 2009



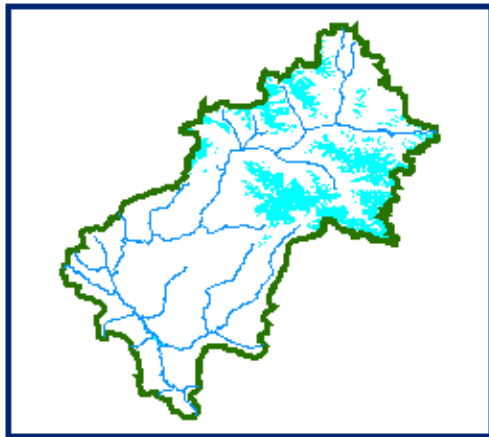
DATA USED
DATA NOT AVAILABLE



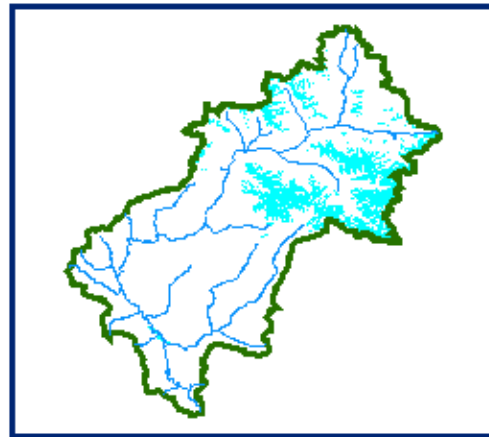
SNOW



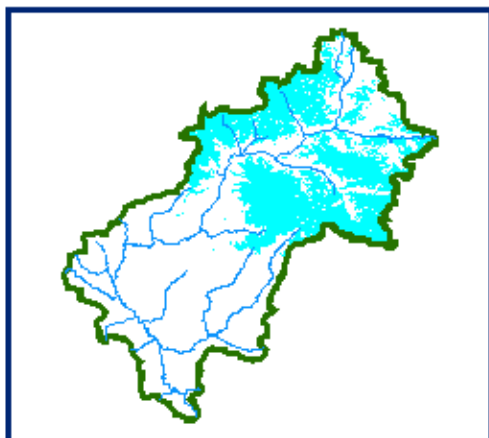
SNOW COVER MAP : BAGIRATHI BASIN



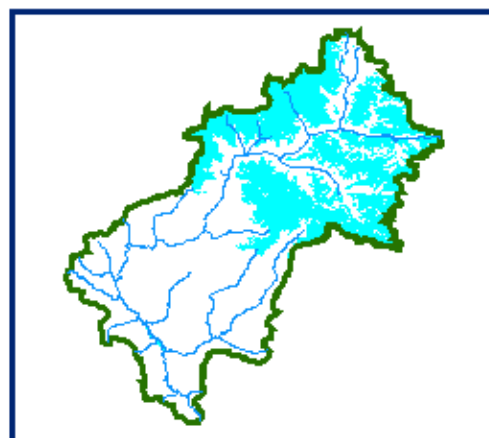
1 NOVEMBER 2009



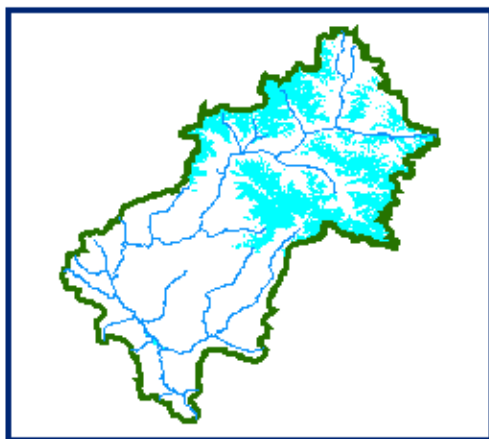
7 NOVEMBER 2009



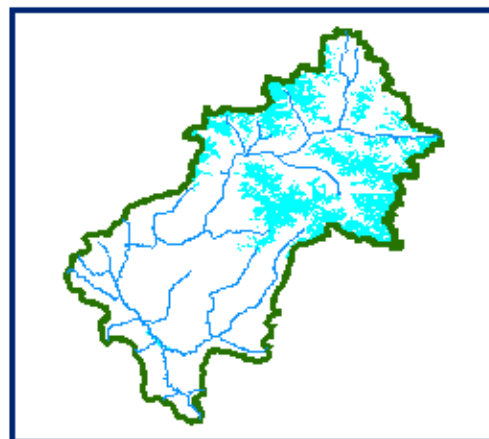
11 NOVEMBER 2009



16 NOVEMBER 2009



21 NOVEMBER 2009



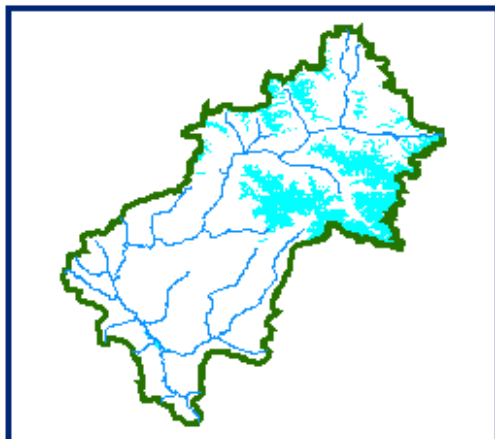
26 NOVEMBER 2009



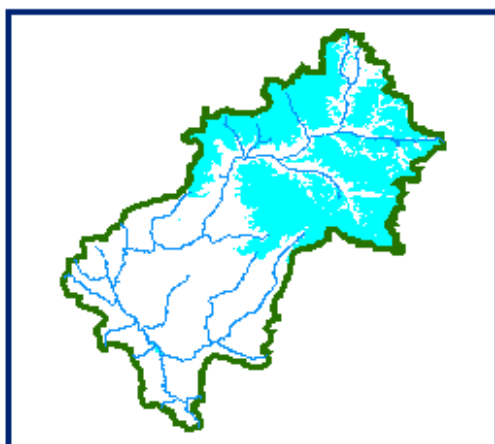
SNOW



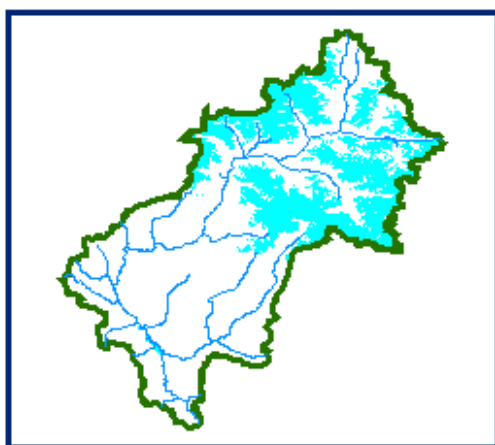
10 DAILY SNOW COVER MAP: ZASKER BASIN



DATA USED
1 NOVEMBER 2009
2 NOVEMBER 2009
7 NOVEMBER 2009



DATA USED
11 NOVEMBER 2009
16 NOVEMBER 2009



DATA USED
21 NOVEMBER 2009
25 NOVEMBER 2009
26 NOVEMBER 2009



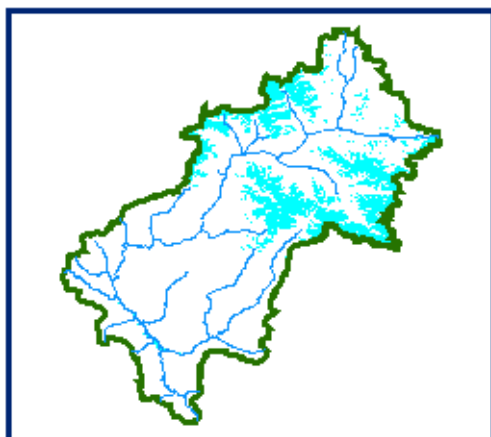
SNOW



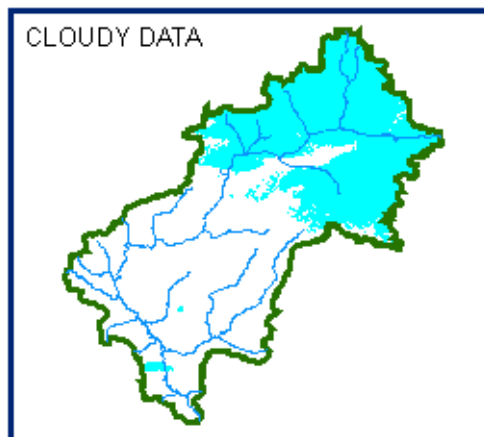
SNOW COVER MAP

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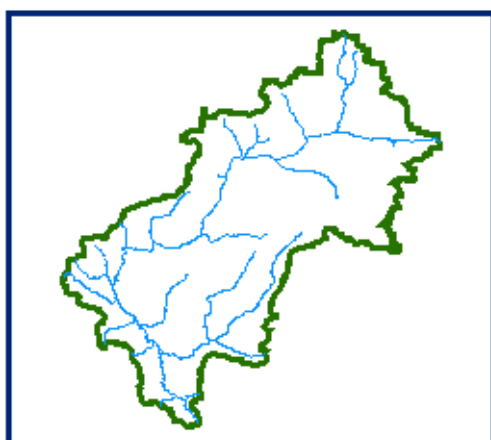
BAGIRATHI BASIN



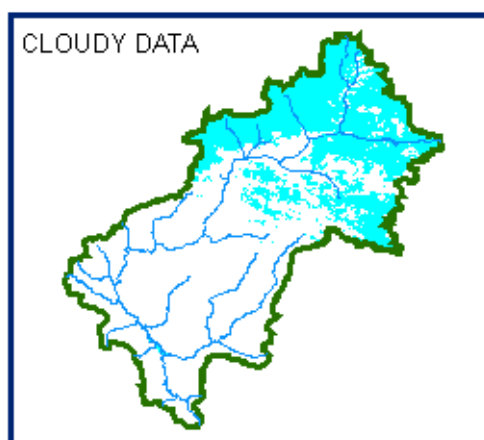
5 DECEMBER 2009



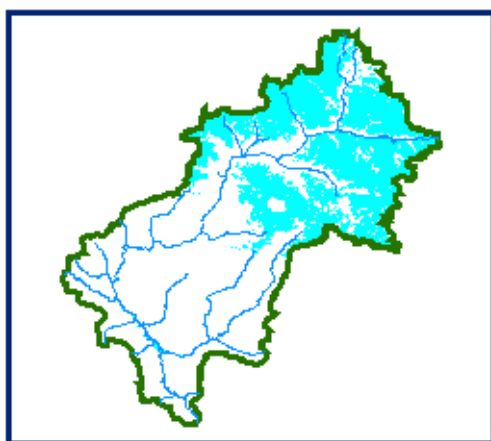
10 DECEMBER 2009



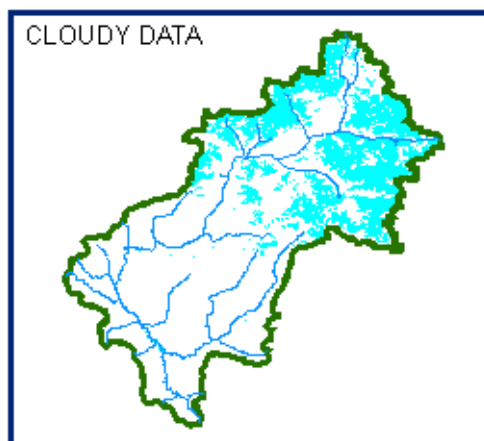
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20 DECEMBER 2009



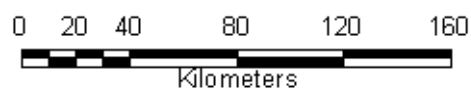
25 DECEMBER 2009



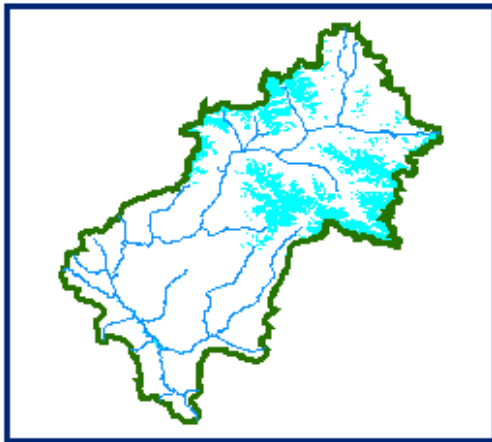
29 DECEMBER 2009



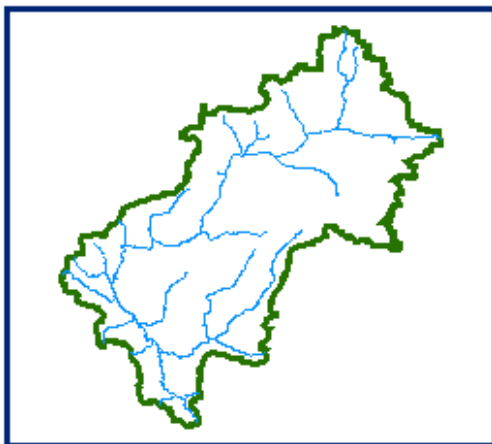
SNOW



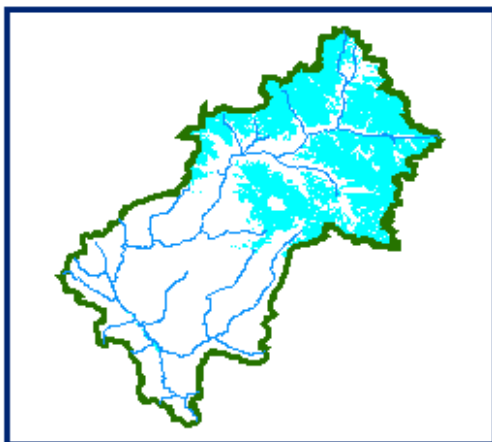
10 DAILY SNOW COVER MAP: BAGIRATHI BASIN



DATA USED
5 DECEMBER 2009



DATA USED
DATA NOT AVAILABLE



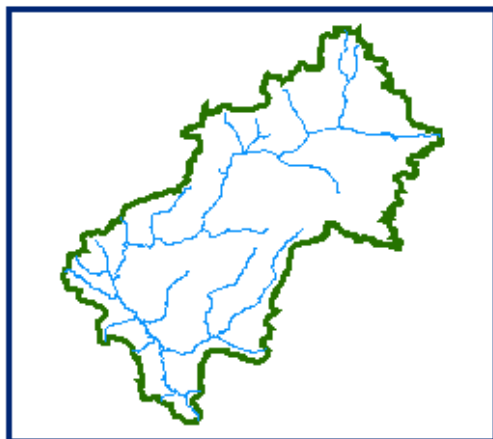
DATA USED
25 DECEMBER 2009



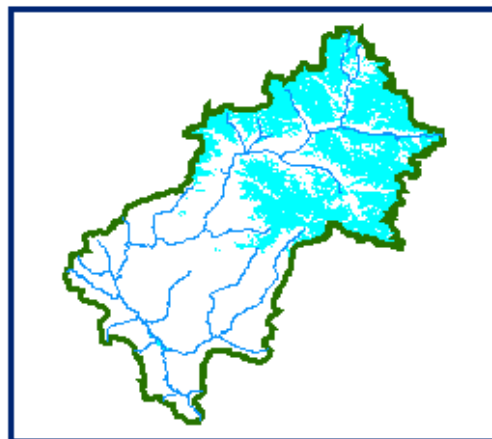
SNOW



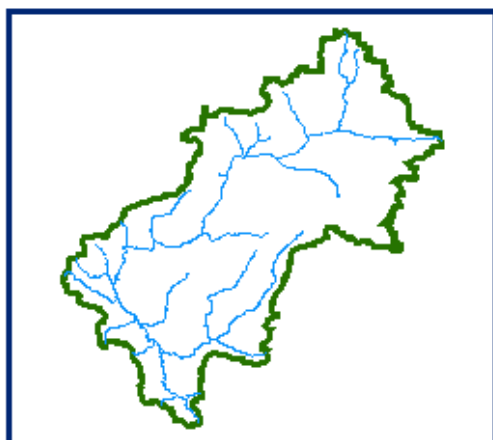
SNOW COVER MAP : BAGIRATHI BASIN



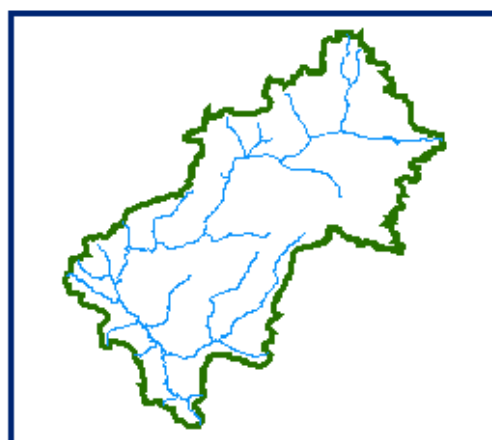
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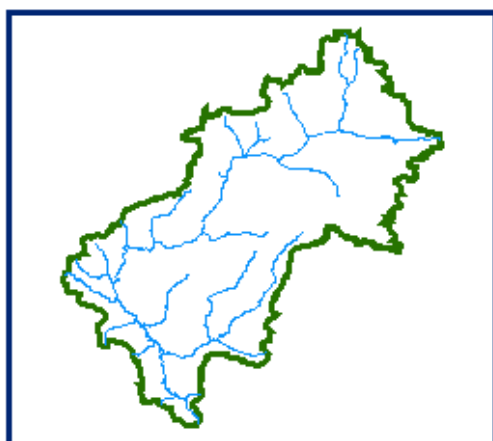
8 JANUARY 2010



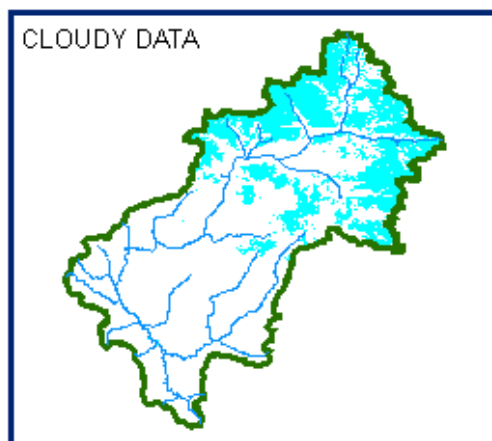
DATA NOT AVAILABLE



DATA NOT AVAILABLE



DATA NOT AVAILABLE



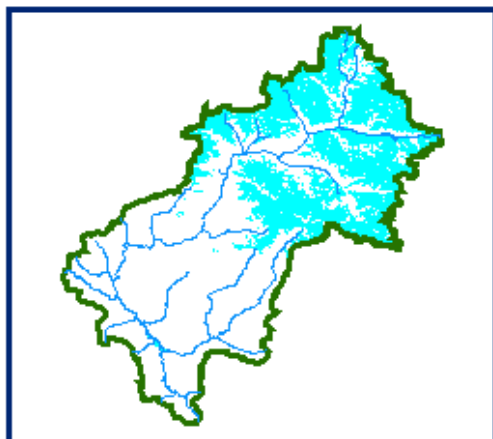
27 JANUARY 2010



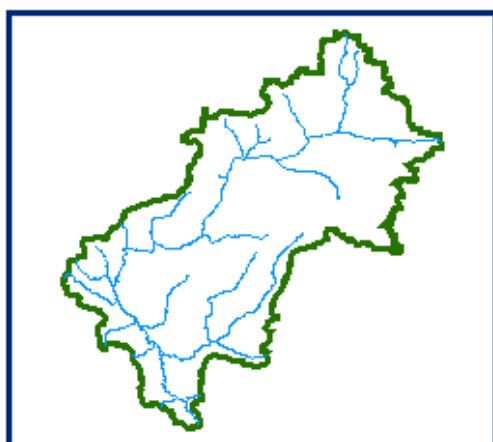
SNOW



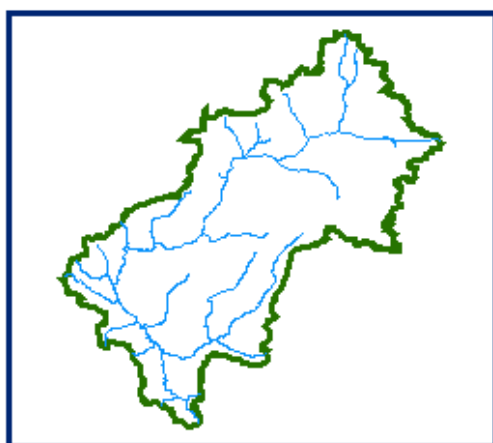
10 DAILY SNOW COVER MAP: BAGIRATHI BASIN



DATA USED
8 JANUARY 2010



DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE



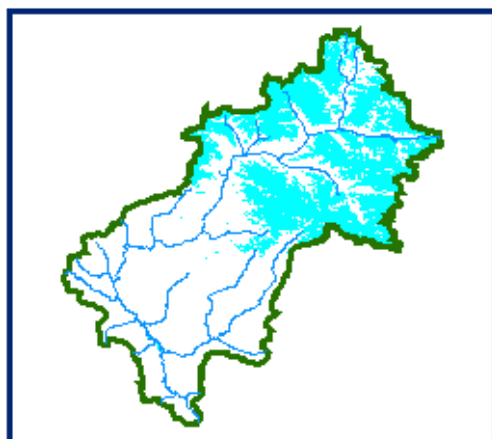
SNOW



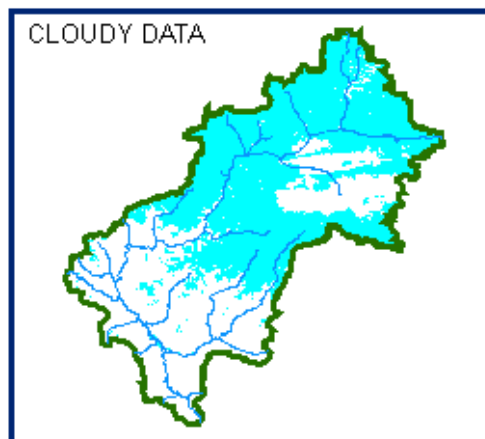
SNOW COVER MAP

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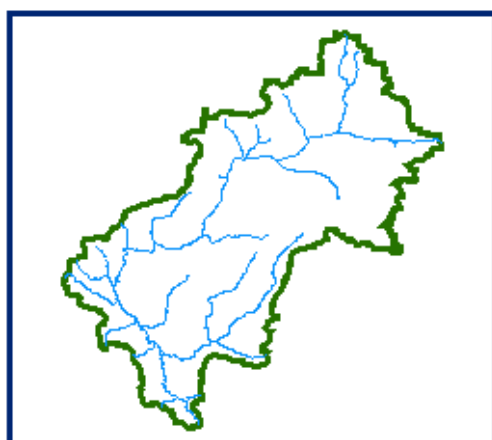
BAGIRATHI BASIN



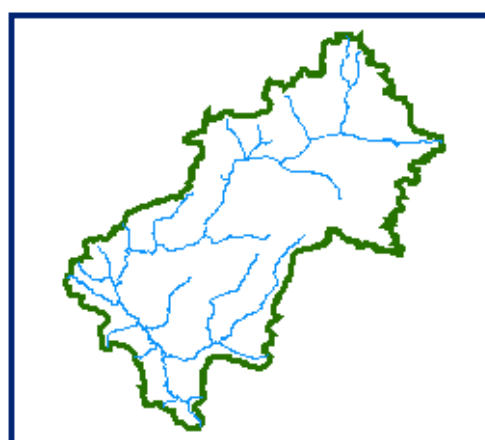
5 FEBRUARY 2010



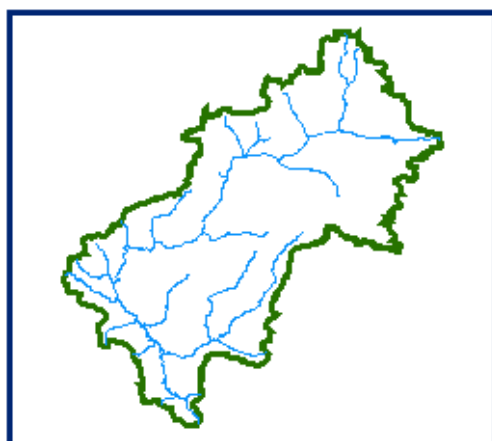
10 FEBRUARY 2010



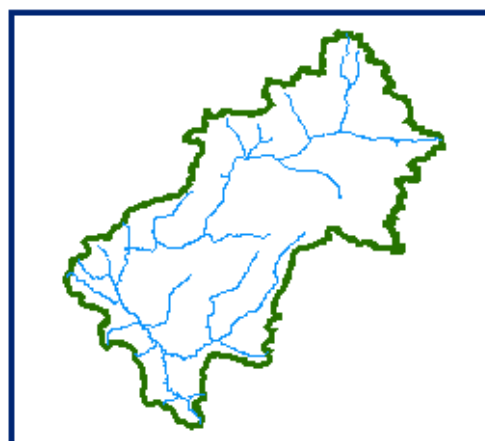
DATA NOT AVAILABLE



DATA NOT AVAILABLE



DATA NOT AVAILABLE



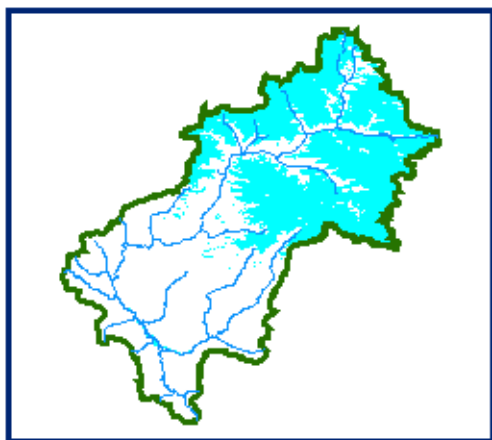
DATA NOT AVAILABLE



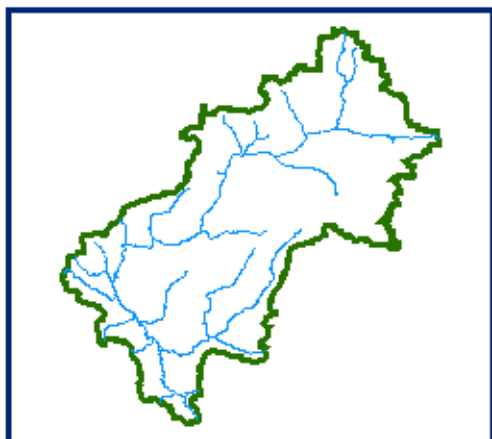
SNOW



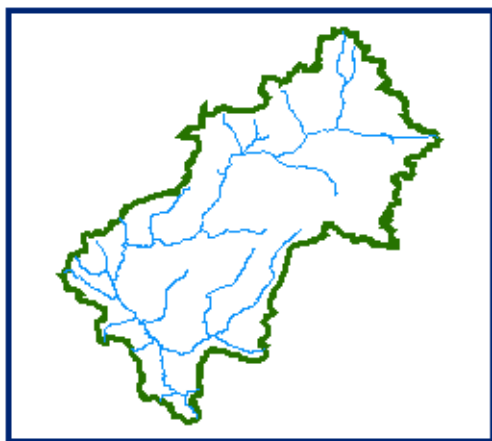
10 DAILY SNOW COVER MAP: BAGIRATHI BASIN



DATA USED
1 FEBRUARY 2010
5 FEBRUARY 2010



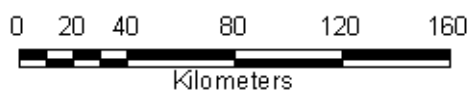
DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE



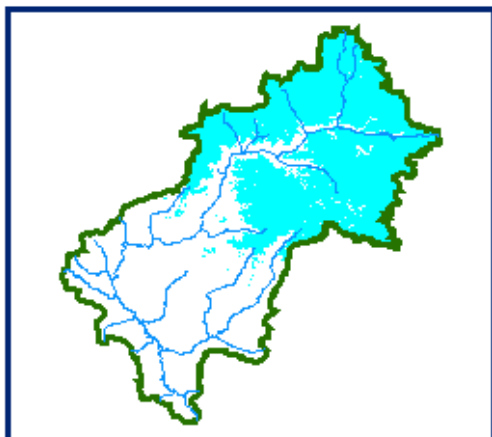
SNOW



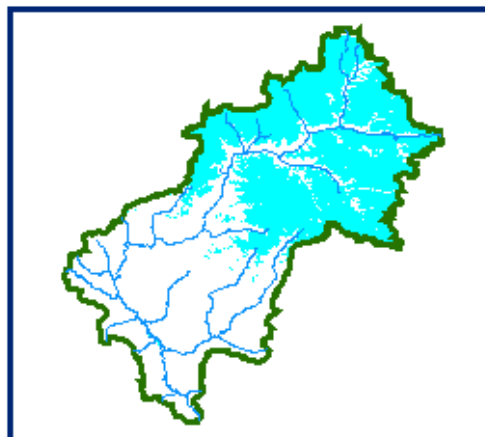
SNOW COVER MAP

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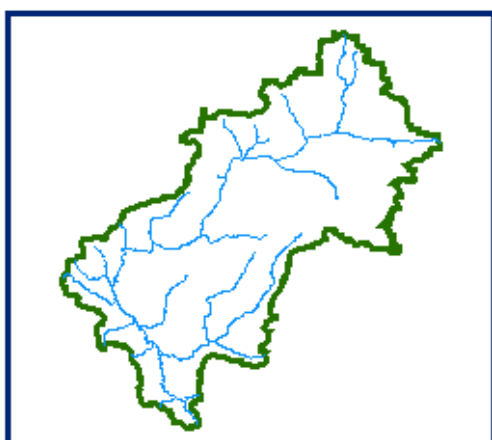
BAGIRATHI BASIN



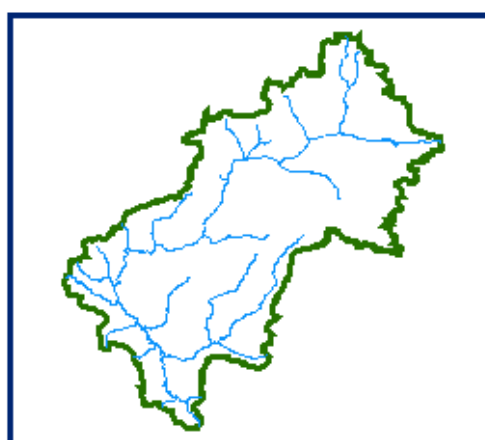
2 MARCH 2009



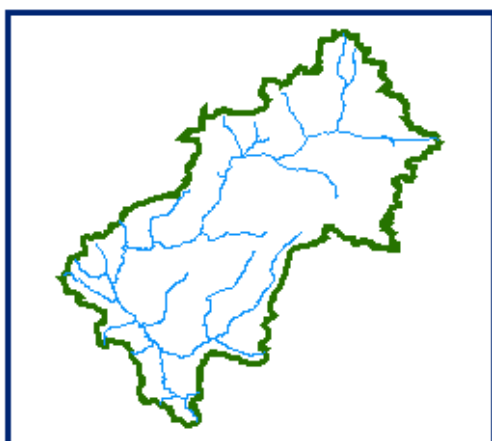
6 MARCH 2009



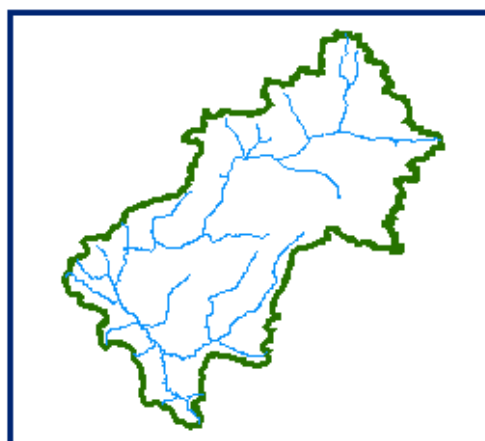
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DATA NOT AVAILABLE



DATA NOT AVAILABLE



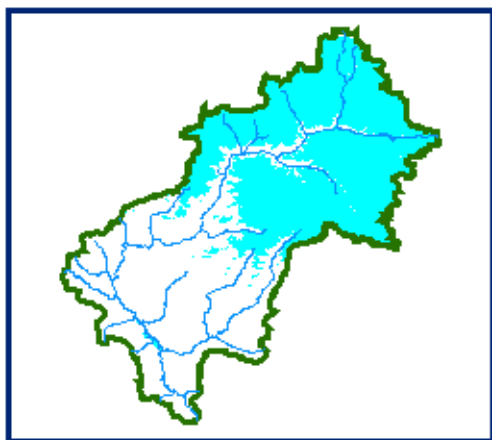
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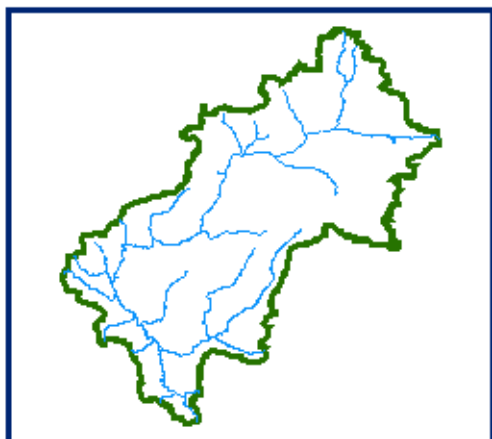
SNOW



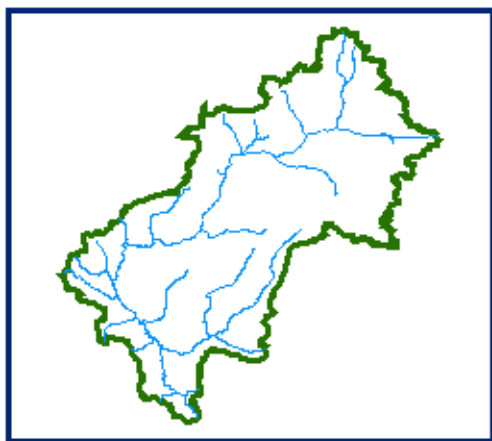
10 DAILY SNOW COVER MAP: BAGIRATHI BASIN



DATA USED
2 MARCH 2010
6 MARCH 2010



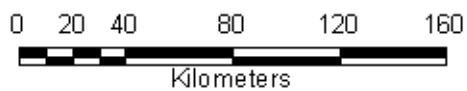
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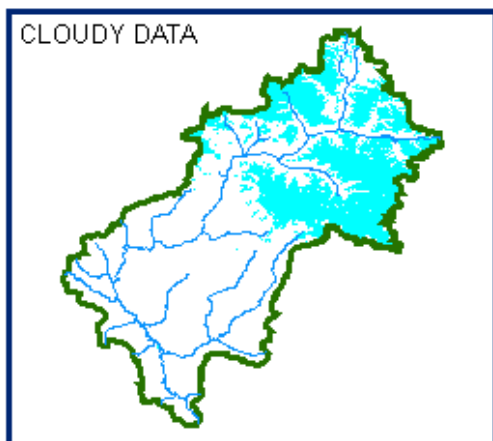
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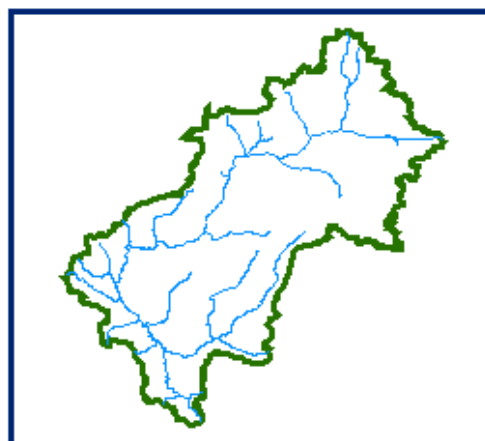
SNOW



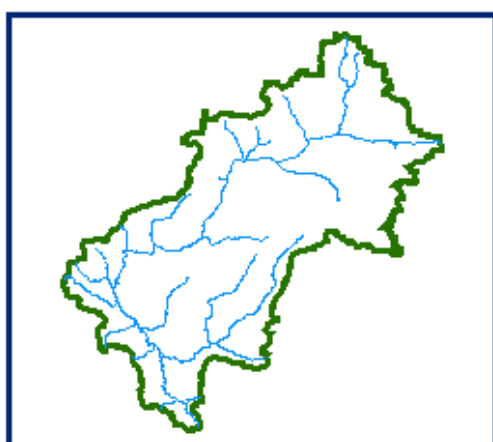
SNOW COVER MAP : BAGIRATHI BASIN



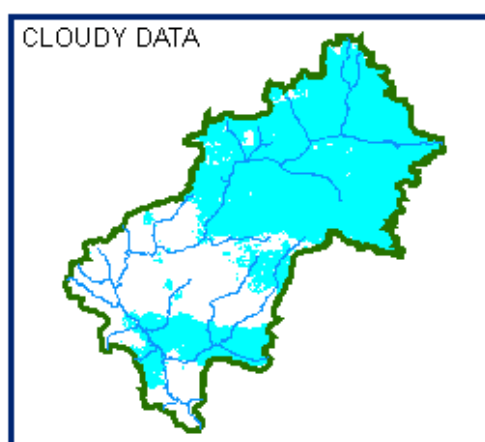
4 APRIL 2009



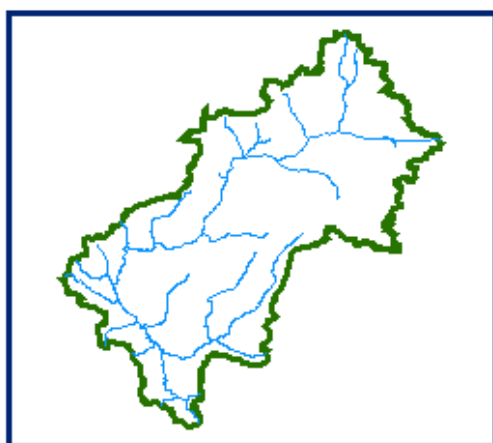
DATA NOT AVAILABLE



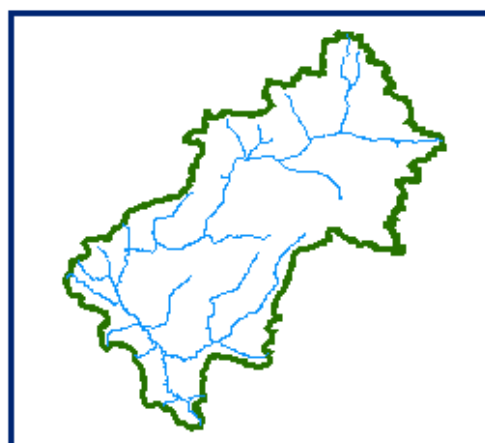
DATA NOT AVAILABLE



19 APRIL 2009



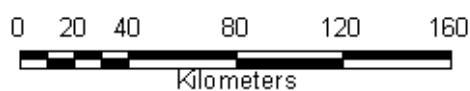
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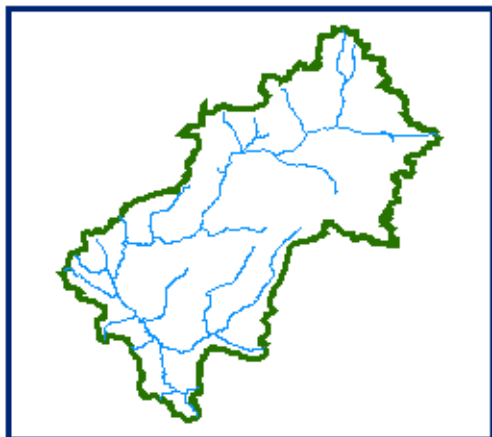
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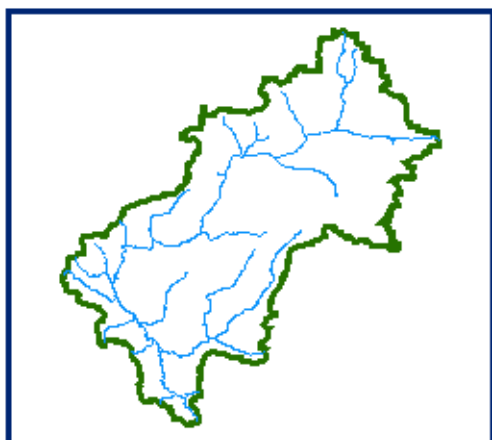
SNOW



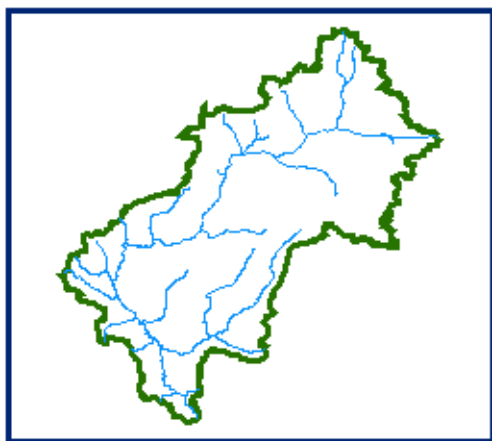
10 DAILY SNOW COVER MAP: BAGIRATHI BASIN



DATA USED
DATA NOT AVAILABLE



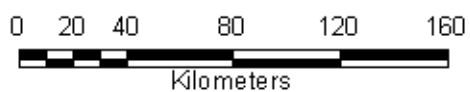
DATA USED
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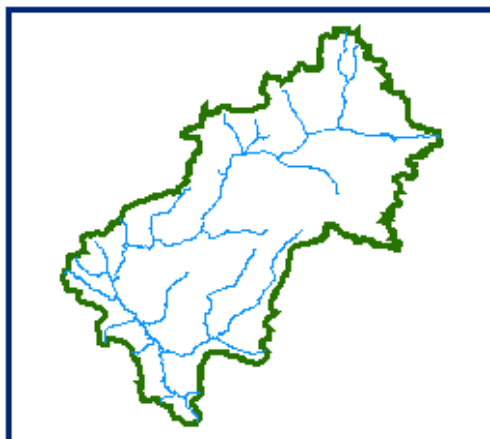
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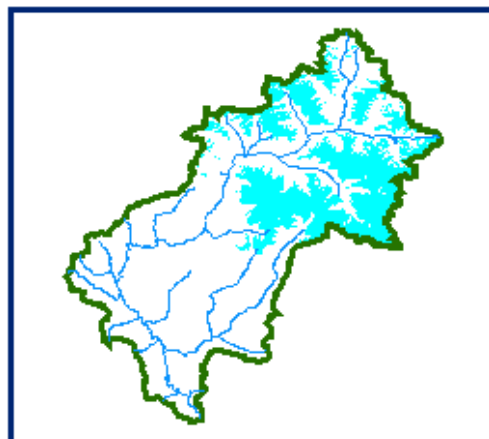
SNOW



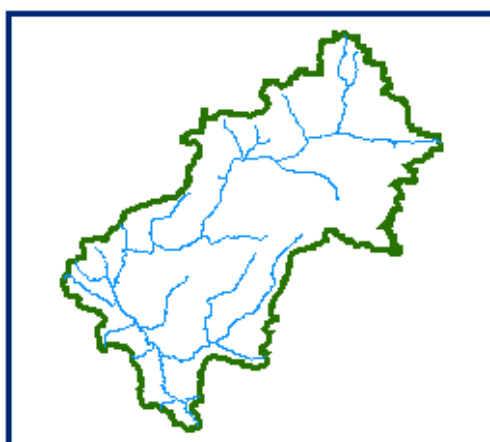
SNOW COVER MAP : BAGIRATHI BASIN



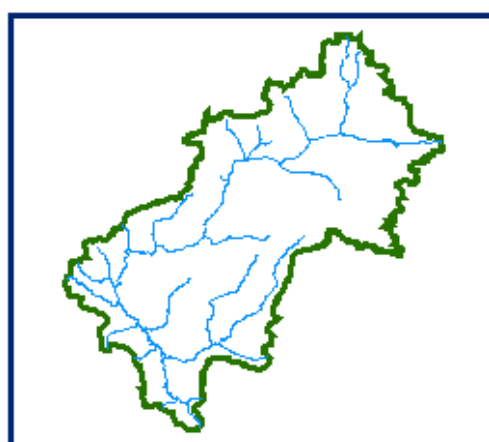
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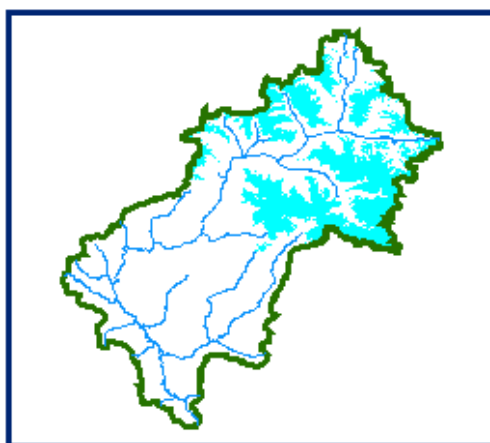
8 MAY 2010



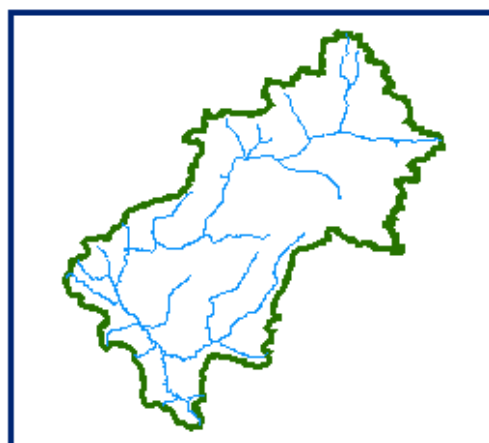
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DATA NOT AVAILABLE



22 MAY 2010



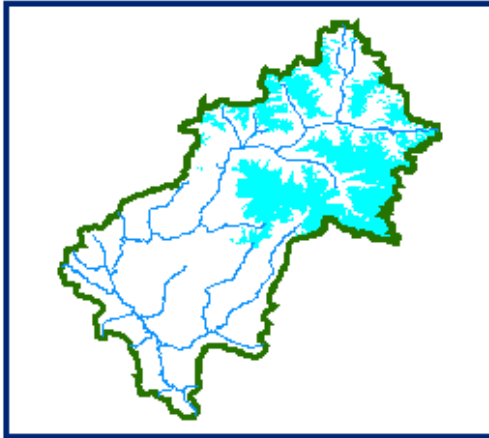
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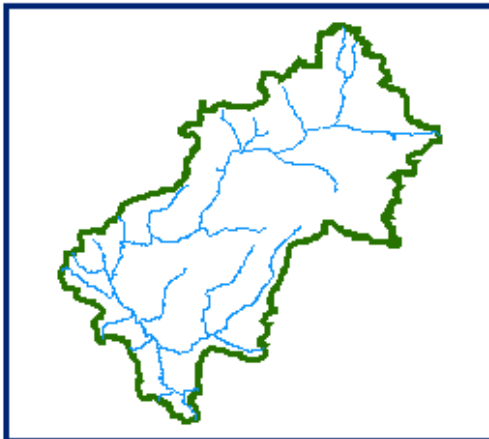
SNOW



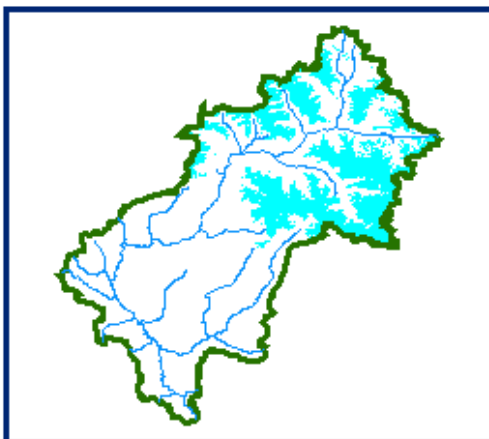
10 DAILY SNOW COVER MAP: BAGIRATHI BASIN



DATA USED
8 MAY 2010



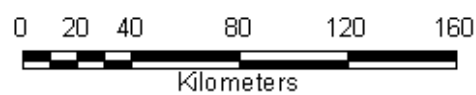
DATA USED
DATA NOT AVAILABLE



DATA USED
22 MAY 2010



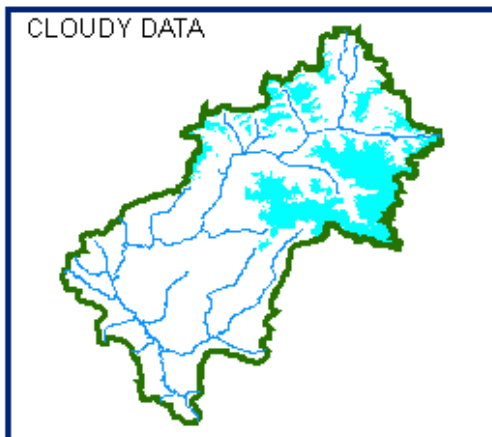
SNOW



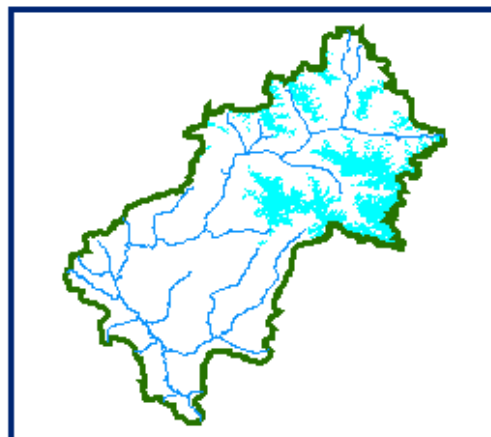
SNOW COVER MAP : BAGIRATHI BASIN



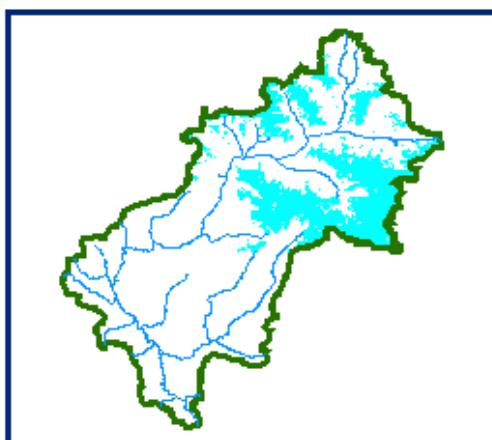
CLOUDY DATA



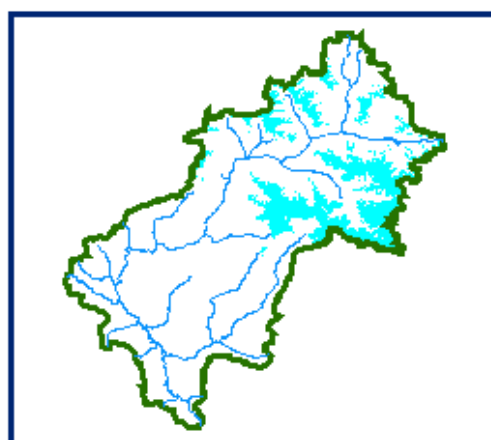
5 JUN 2010



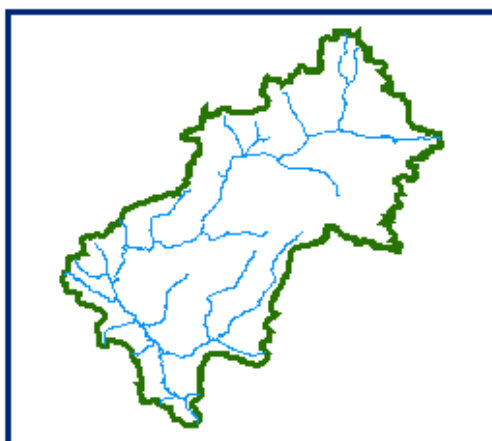
6 JUN 2010



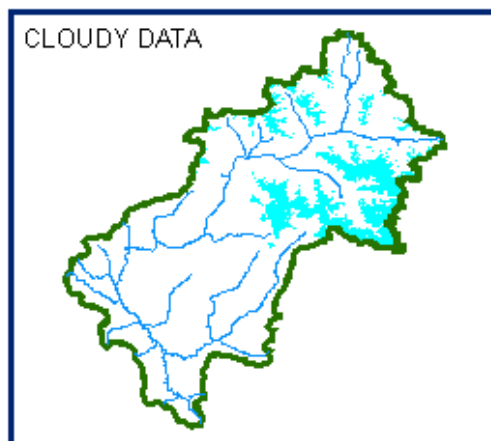
11 JUN 2010



20 JUN 2010



DATA NOT AVAILABLE



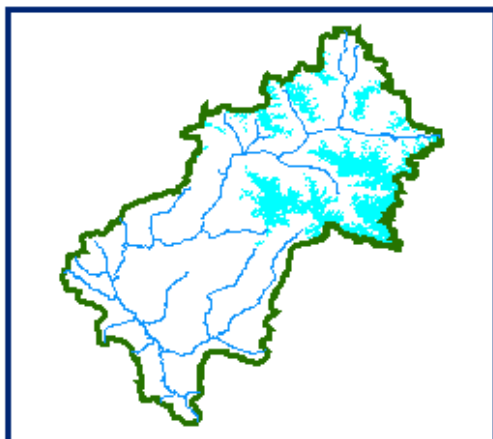
29 JUN 2010



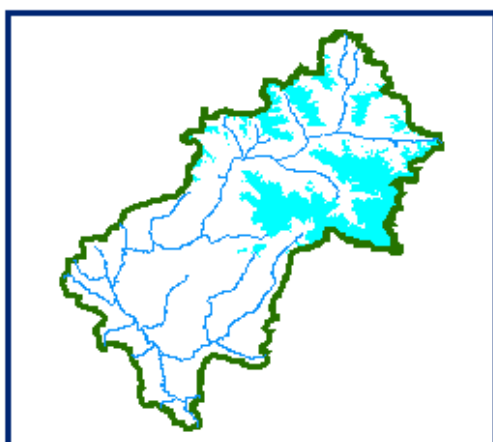
SNOW



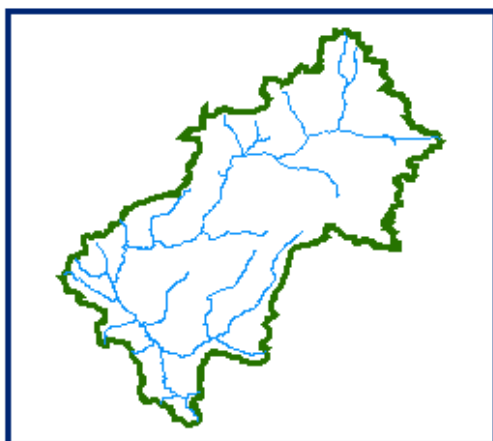
10 DAILY SNOW COVER MAP: BAGIRATHI BASIN



DATA USED
6 JUN 2010



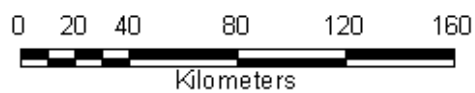
DATA USED
11 JUN 2010
20 JUN 2010



DATA USED
DATA NOT AVAILABLE



SNOW



YAMUNA BASIN

AREAL EXTENT OF SNOW (5 DAILY)

BASIN NAME: YAMUNA

BASIN AREA: 3527 Sq km

S. No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2009							
1	03-Oct-09	144.53	4	4	13-Oct-09	392.28	11
2	04-Oct-09	236.14	7	5	27-Oct-09	329.22	9
3	09-Oct-09	681.14	19	6	28-Oct-09	324.09	9
November 2009							
7	01-Nov-09	346.73	10	12	20-Nov-09	1061.46	30
8	02-Nov-09	343.23	10	13	21-Nov-09	1011.57	29
9	06-Nov-09	324.75	9	14	25-Nov-09	916.07	26
10	11-Nov-09	1481.76	42	15	26-Nov-09	894.19	25
11	16-Nov-09	1261.53	36	16	30-Nov-09	843.47	24
December 2009							
17	05-Dec-09	770.00	22	21	20-Dec-09	1626.91	46
18	10-Dec-09	154.65	4	22	24-Dec-09	1047.80	30
19	14-Dec-09	143.51	4	23	29-Dec-09	312.15	9
20	19-Dec-09	1051.39	30				
January 2010							
24	08-Jan-10	1006.49	29	25	27-Jan-10	875.57	25
February 2010							
26	05-Feb-10	959.90	27	28	10-Feb-10	2847.81	81
27	06-Feb-10	651.14	18				
March 2010							
29	02-Mar-10	1236.90	35	30	06-Mar-10	1295.85	37
April 2010							
31	04-Apr-10	787.41	22	32	09-Apr-10	213.90	6
May 2010							
33	08-May-10	543.33	15	35	22-May-10	509.68	14
34	12-May-10	514.32	15	36	31-May-10	463.45	13
June 2010							
37	01-Jun-10	341.59	10	40	20-Jun-10	316.92	9
38	05-Jun-10	428.51	12	41	24-Jun-10	202.24	6
39	06-Jun-10	378.65	11	42	29-Jun-10	244.48	7

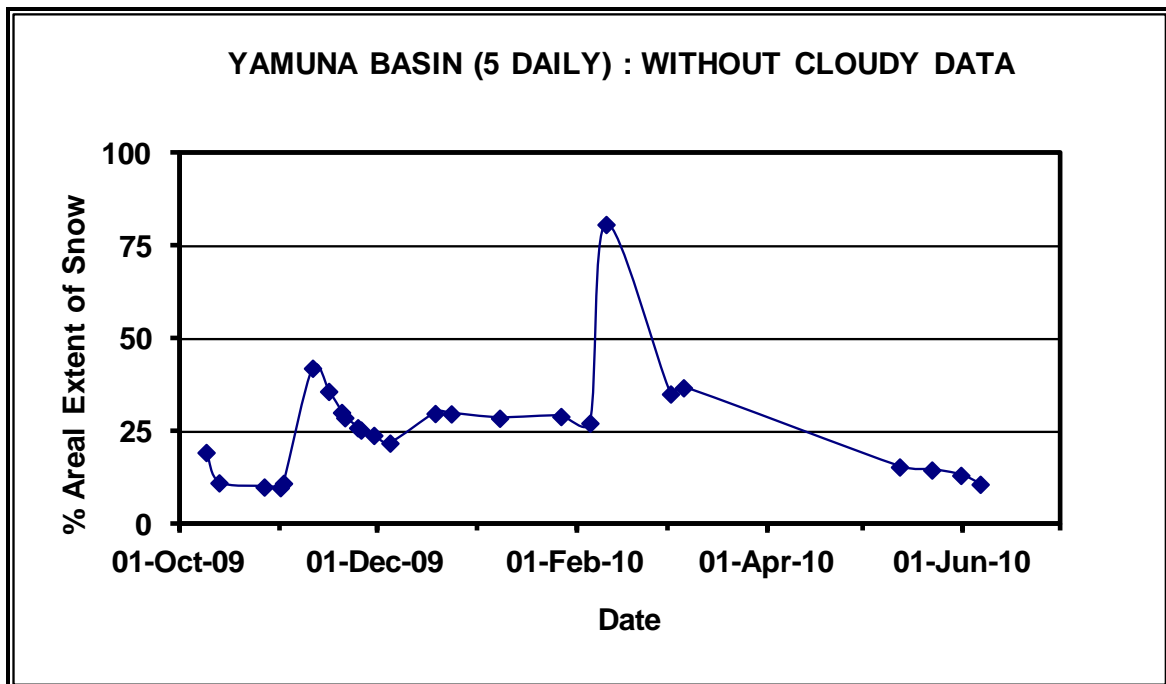
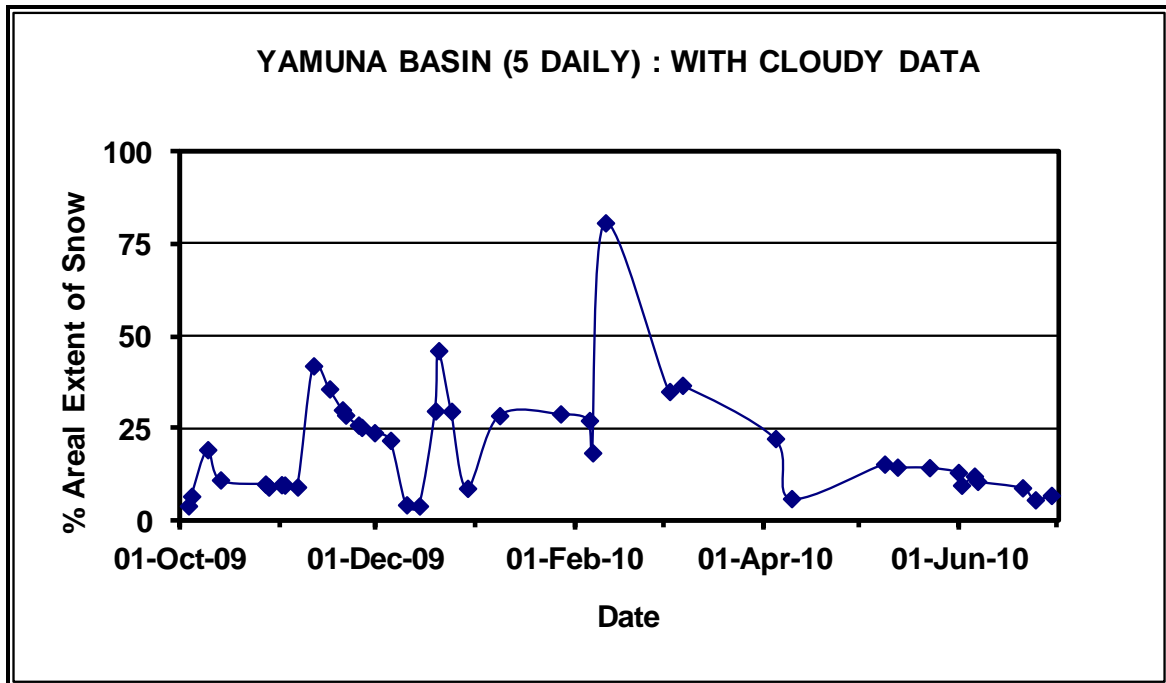
AREAL EXTENT OF SNOW (10 DAILY)

BASIN NAME: YAMUNA

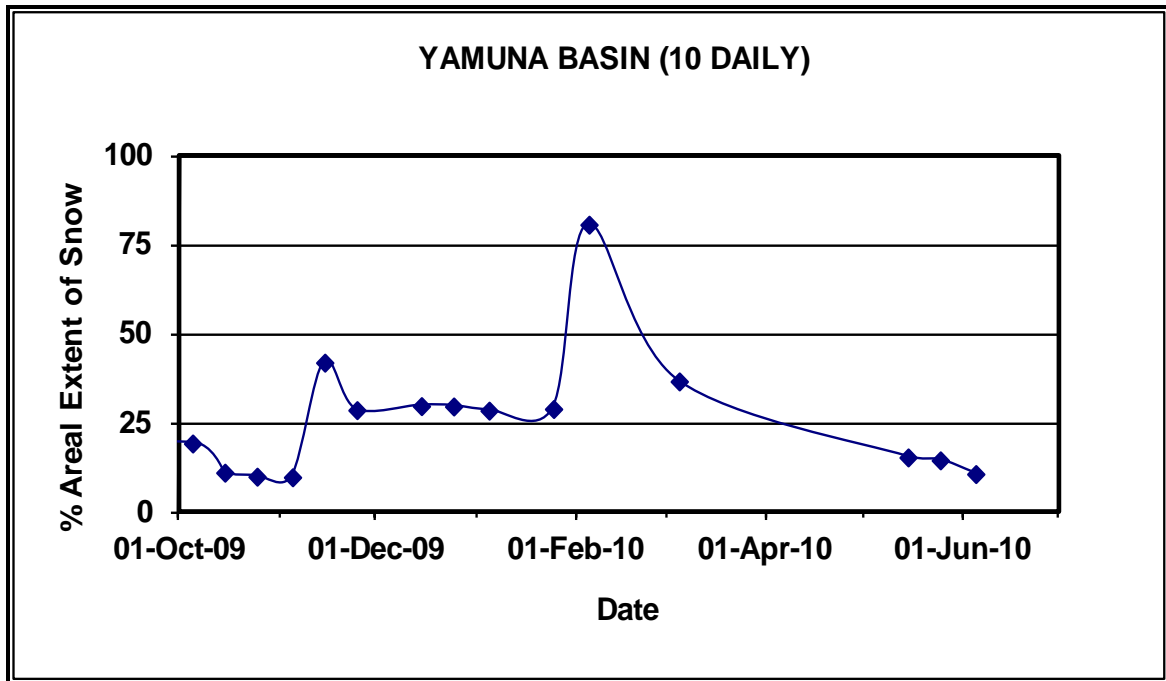
BASIN AREA: 3527 Sq km

S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2009				November 2009			
1	5-Oct-09	681	19	4	2-Nov-09	392.26	10
2	15-Oct-09	392	11	5	16-Nov-09	1216.90	42
3	25-Oct-09	353	10	6	25-Nov-09	987.30	29
December 2009				January 2010			
7	5-Dec-09	770	22	10	5-Jan-10	1006.49	29
8	15-Dec-09	1051	30		25-Jan-10		29
9	25-Dec-09	1048	30				
February 2010				March 2010			
11	5-Feb-10		81	12	5-Mar-10	1207.84	37
April 2010				May 2010			
				13	15-May-10	543	15
				14	25-May-10	529	15
June 2010							
15	5-Jun-10	378.65	11				

Snow cover depletion curve

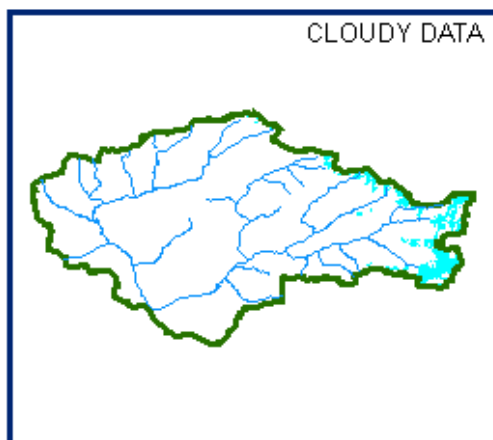


Snow cover depletion curve

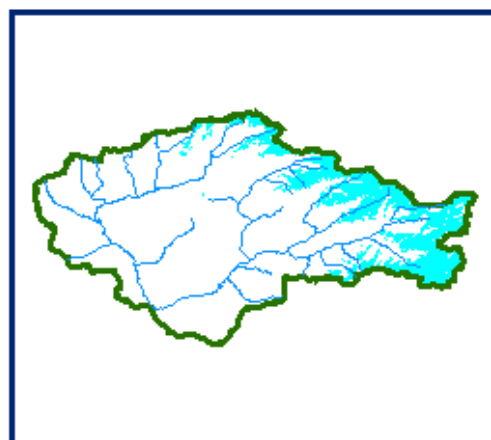


SNOW COVER MAP

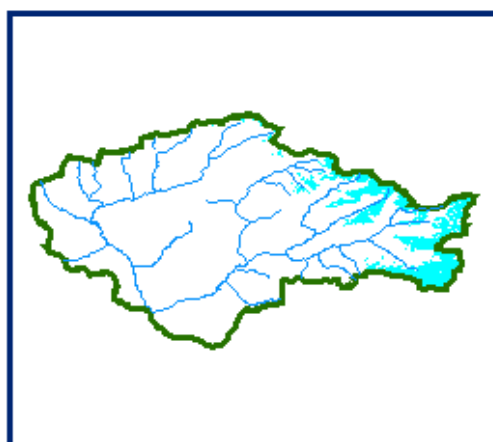
SNOW COVER MAP : YAMUNA BASIN



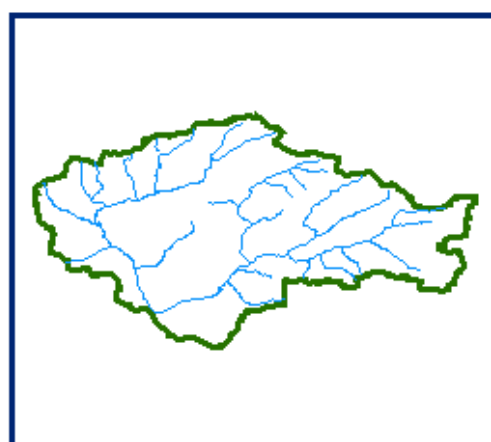
4 OCTOBER 2009



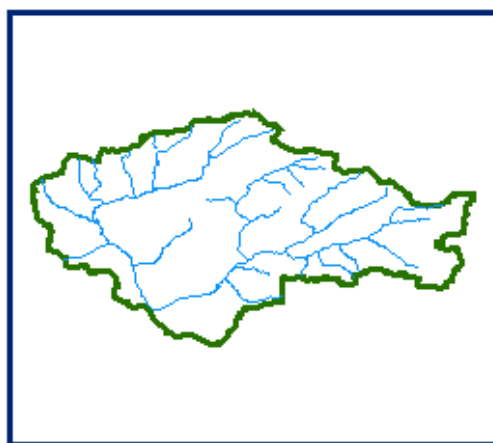
9 OCTOBER 2009



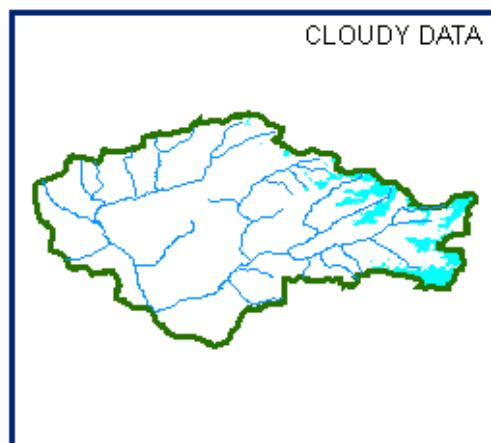
13 OCTOBER 2009



DATA NOT AVAILABLE



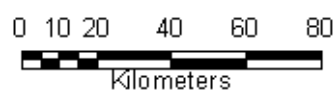
DATA NOT AVAILABLE



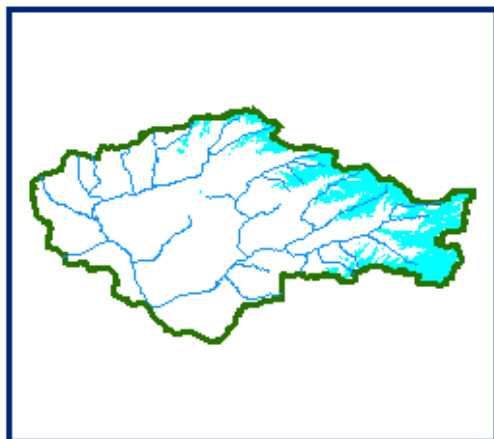
27 OCTOBER 2009



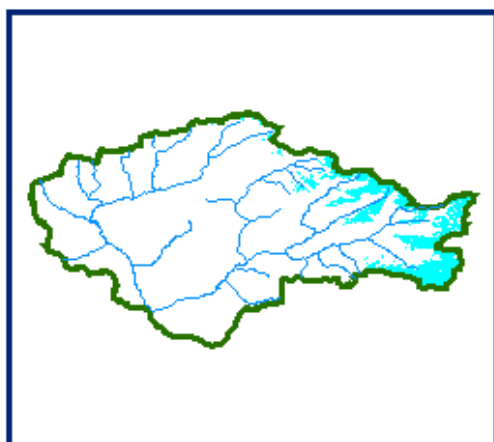
SNOW



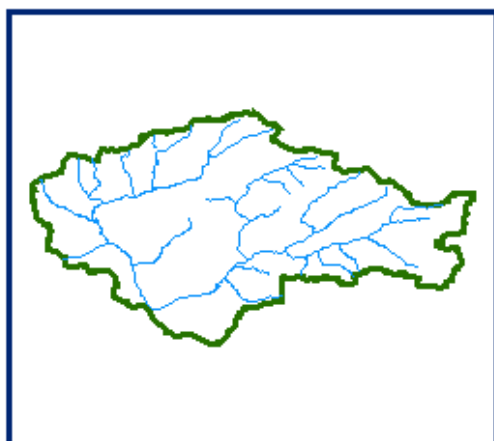
10 DAILY SNOW COVER MAP: YAMUNA BASIN



DATA USED
9 OCTOBER 2009



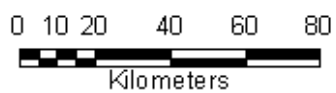
DATA USED
13 OCTOBER 2009



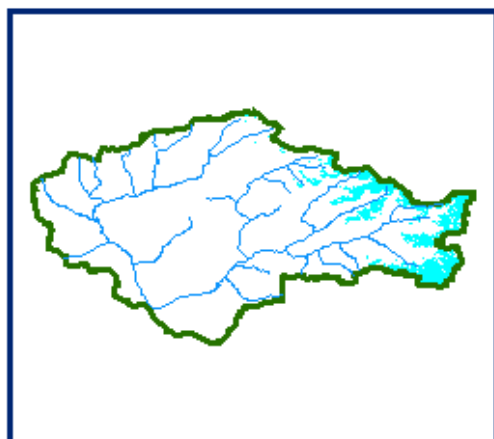
DATA USED
DATA NOT AVAILABLE



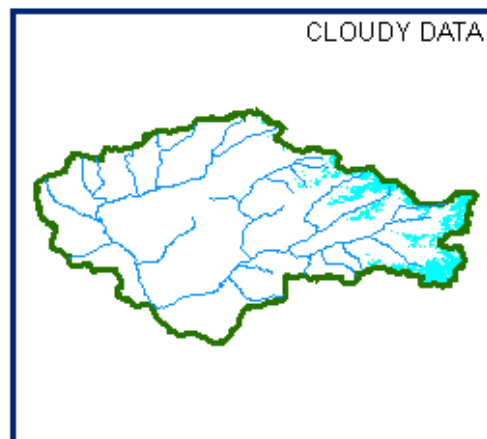
SNOW



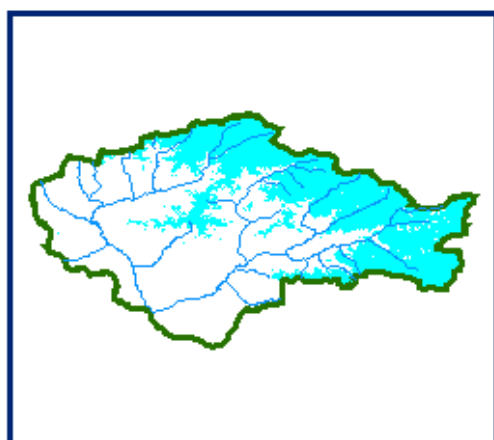
SNOW COVER MAP : YAMUNA BASIN



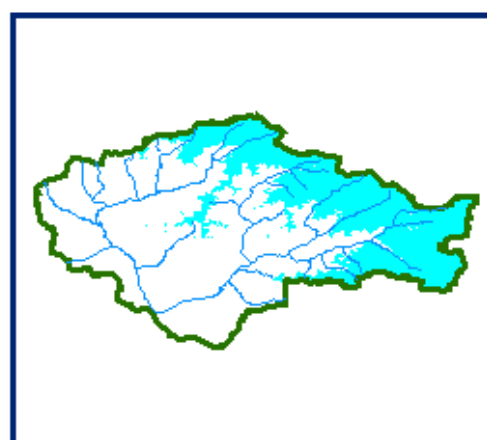
1 NOVEMBER 2009



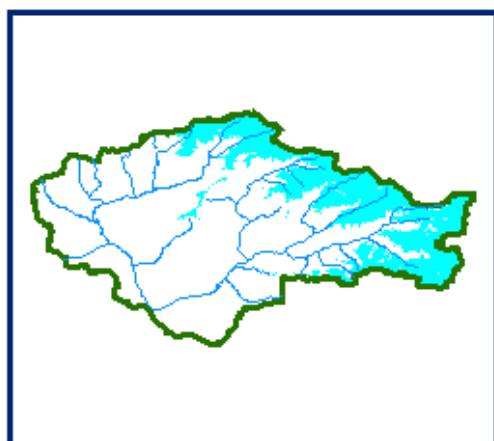
6 NOVEMBER 2009



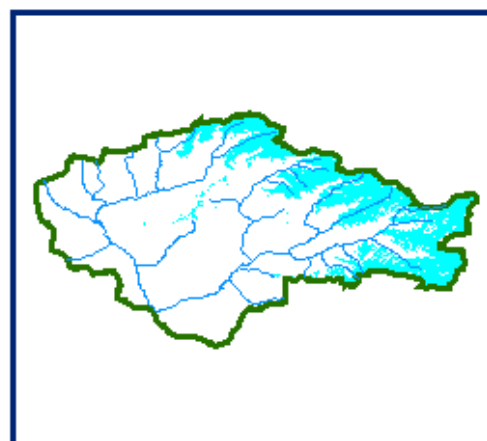
11 NOVEMBER 2009



16 NOVEMBER 2009



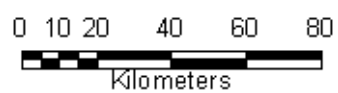
21 NOVEMBER 2009



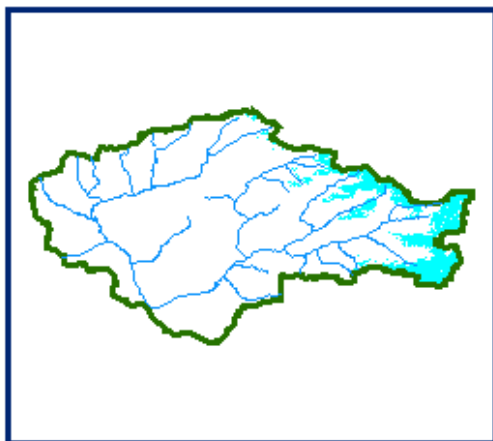
26 NOVEMBER 2009



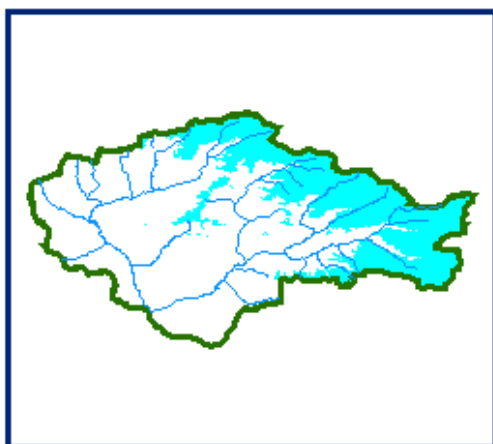
SNOW



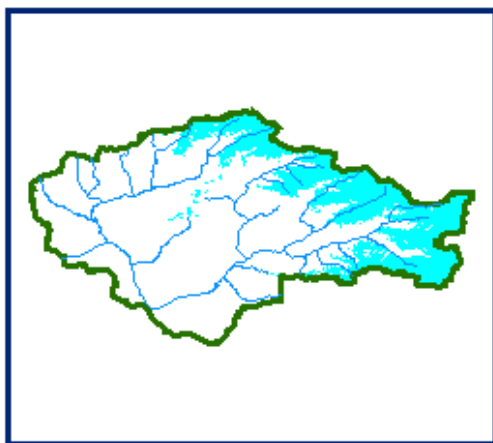
10 DAILY SNOW COVER MAP: YAMUNA BASIN



DATA USED
1 NOVEMBER 2009
2 NOVEMBER 2009



DATA USED
11 NOVEMBER 2009
16 NOVEMBER 2009
20 NOVEMBER 2009



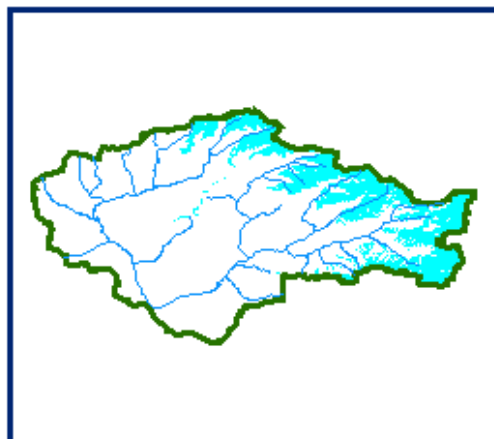
DATA USED
21 NOVEMBER 2009
25 NOVEMBER 2009
26 NOVEMBER 2009



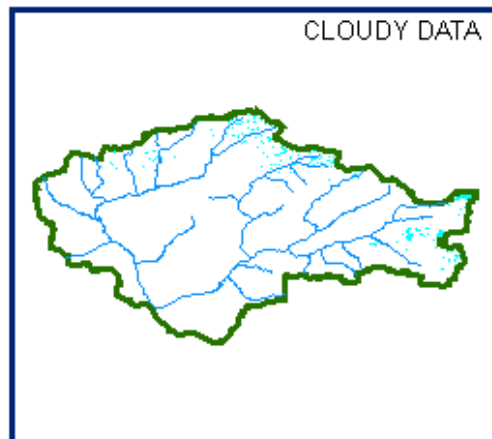
SNOW

0 10 20 40 60 80
Kilometers

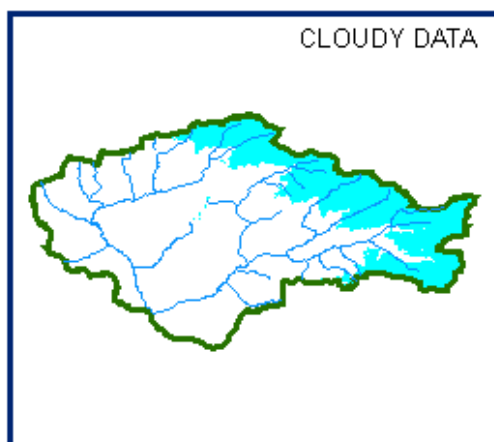
SNOW COVER MAP : YAMUNA BASIN



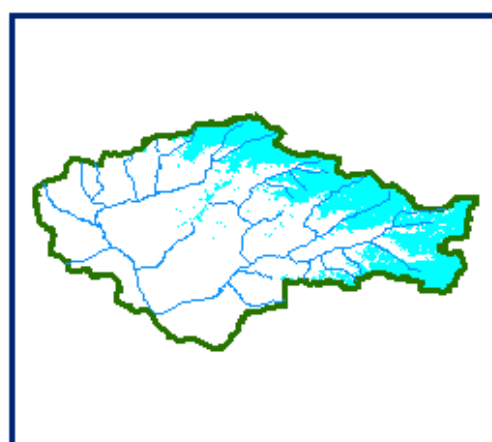
5 DECEMBER 2009



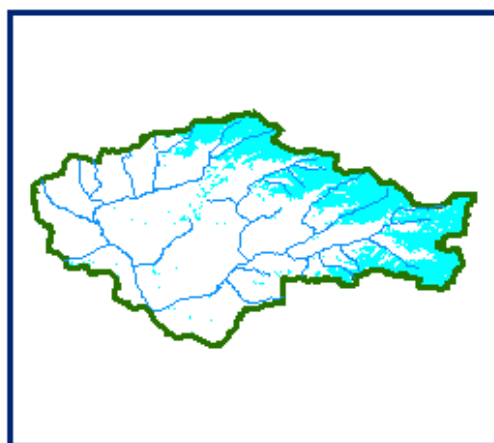
10 DECEMBER 2009



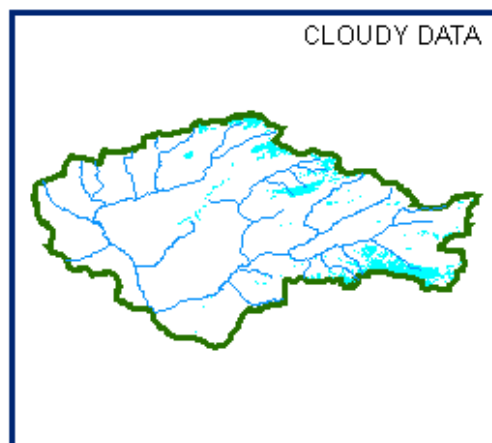
14 DECEMBER 2009



19 DECEMBER 2009



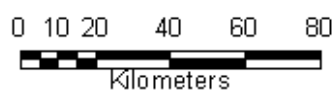
24 DECEMBER 2009



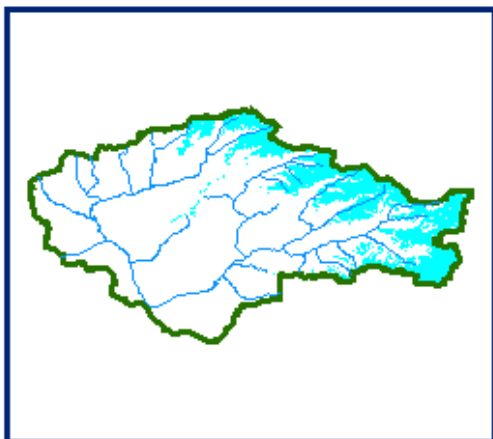
29 DECEMBER 2009



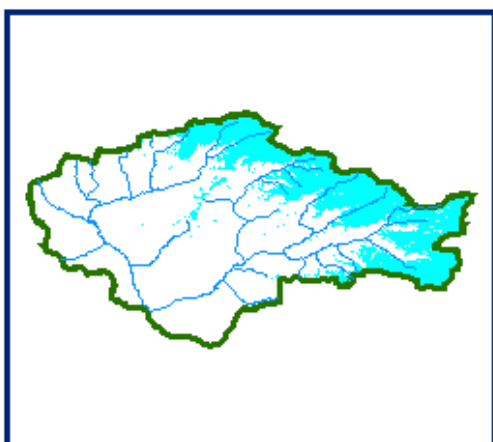
SNOW



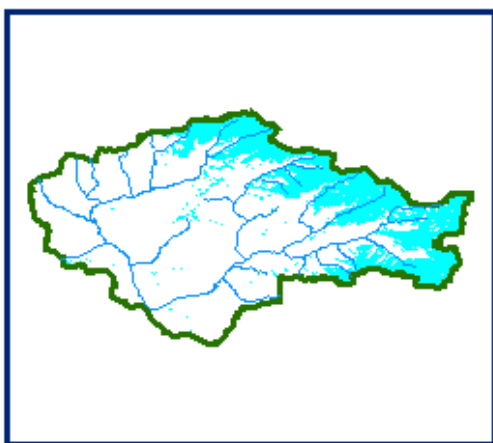
10 DAILY SNOW COVER MAP: YAMUNA BASIN



DATA USED
5 DECEMBER 2009



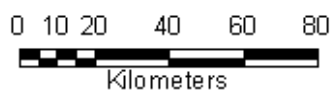
DATA USED
19 DECEMBER 2009



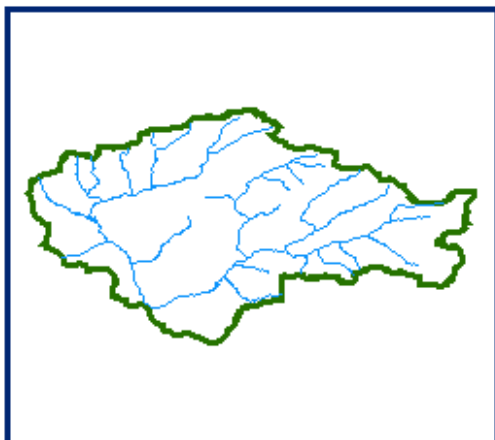
DATA USED
24 DECEMBER 2009



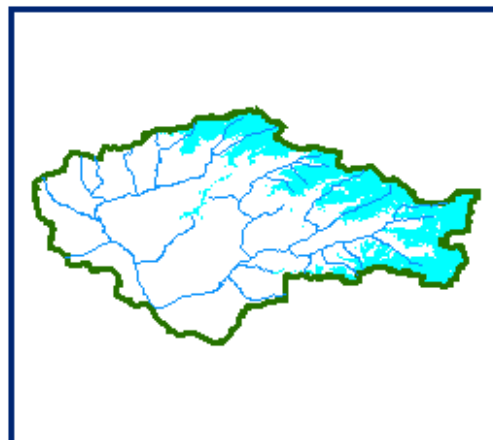
SNOW



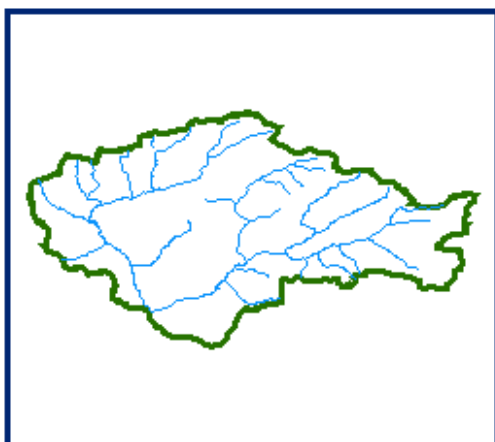
SNOW COVER MAP : YAMUNA BASIN



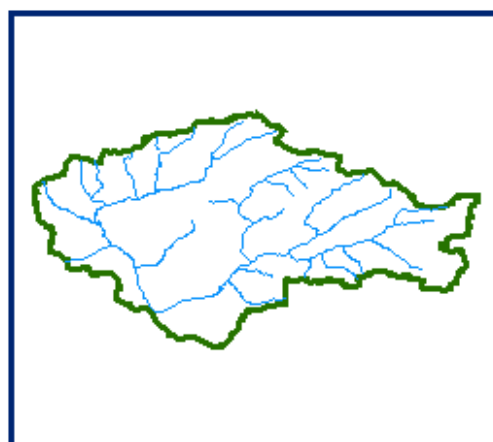
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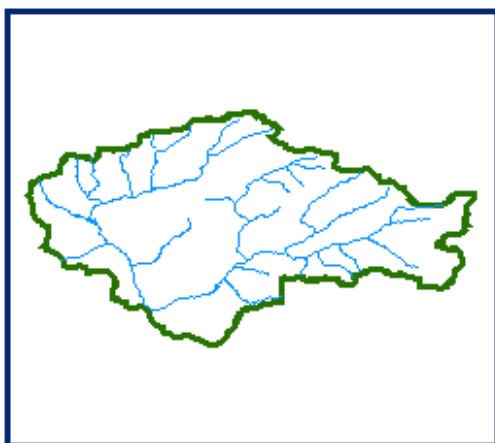
8 JANUARY 2010



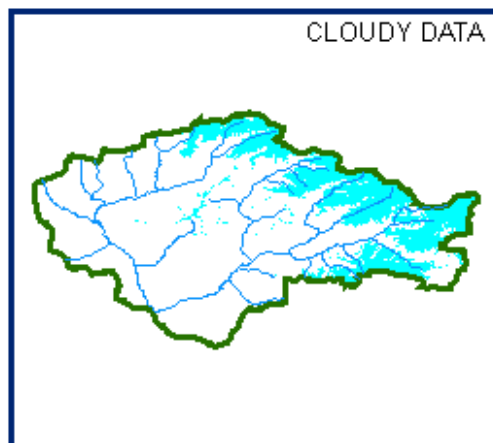
DATA NOT AVAILABLE



DATA NOT AVAILABLE



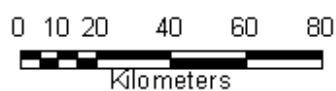
DATA NOT AVAILABLE



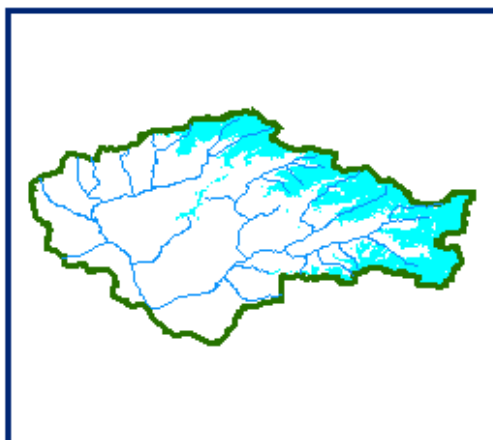
27 JANUARY 2010



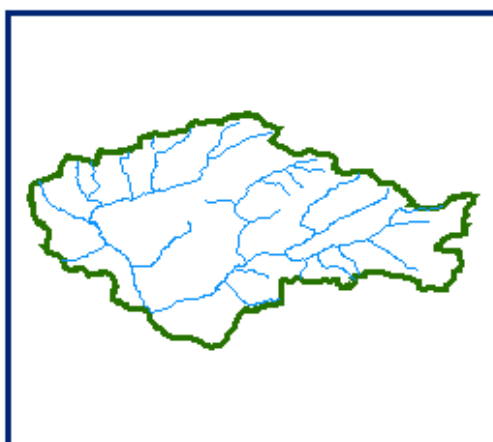
SNOW



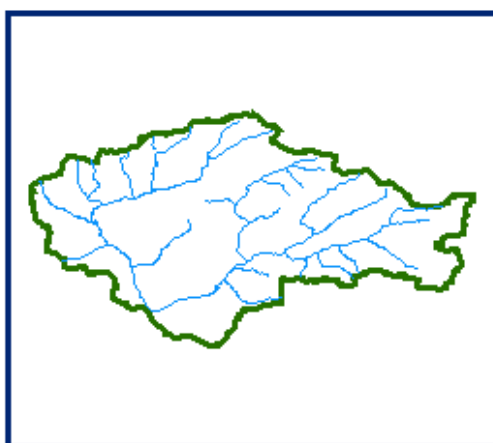
10 DAILY SNOW COVER MAP: YAMUNA BASIN



DATA USED
8 JANUARY 2010



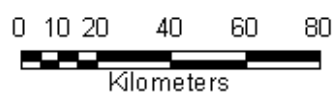
DATA USED
DATA NOT AVAILABLE



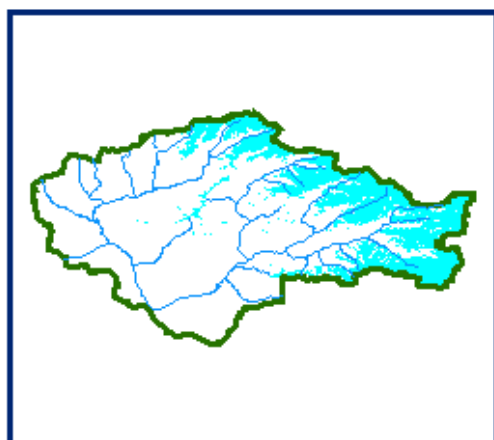
DATA USED
DATA NOT AVAILABLE



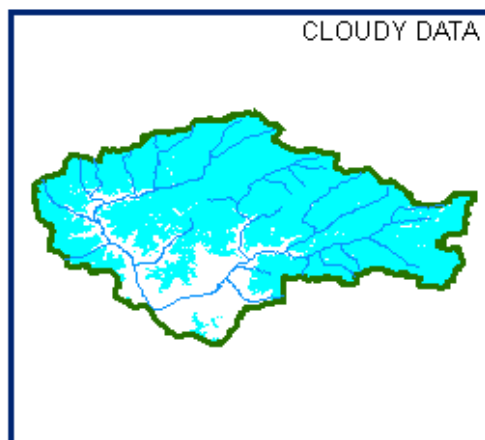
SNOW



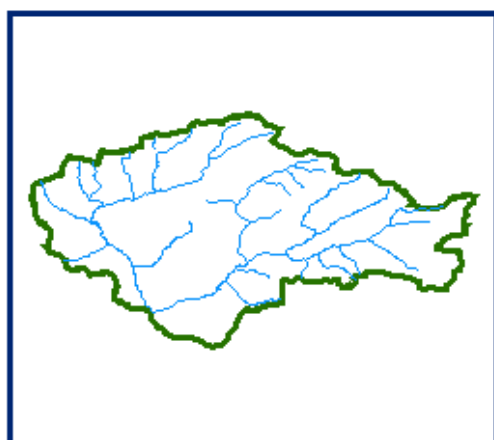
SNOW COVER MAP : YAMUNA BASIN



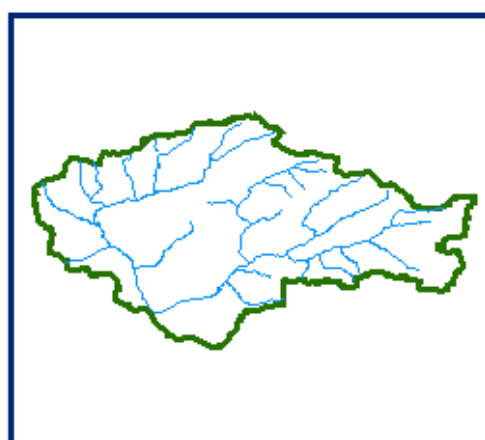
5 FEBRUARY 2010



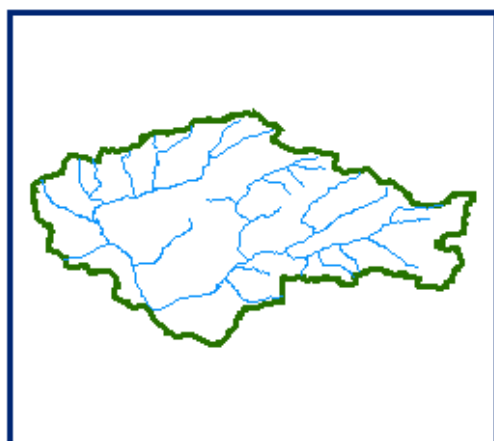
10 FEBRUARY 2010



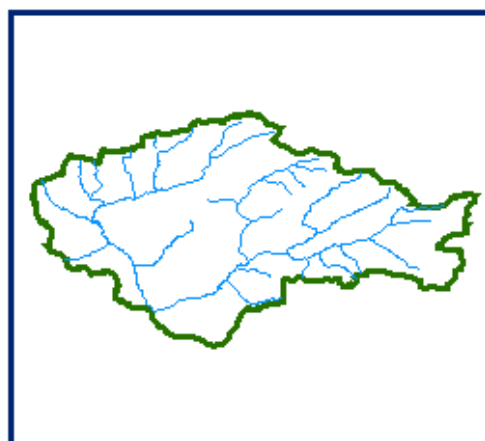
DATA NOT AVAILABLE



DATA NOT AVAILABLE



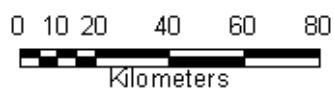
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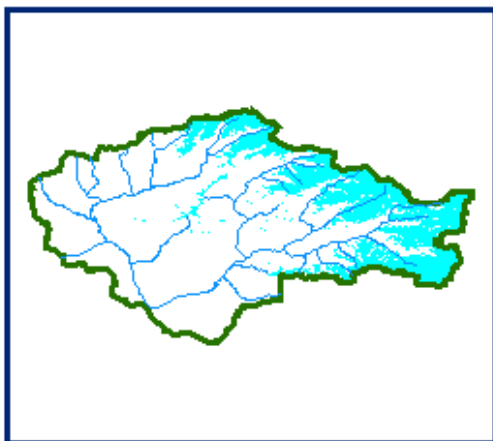
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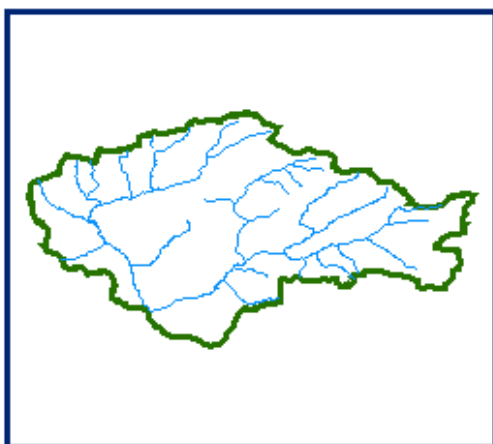
SNOW



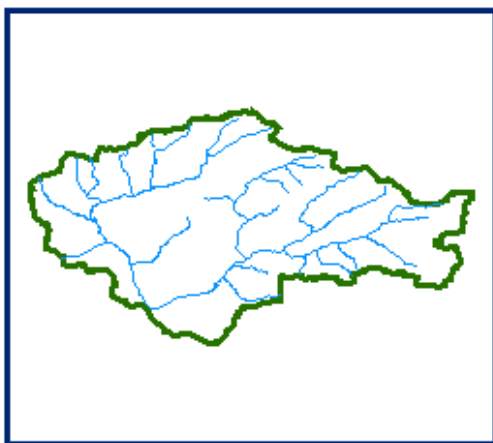
10 DAILY SNOW COVER MAP: YAMUNA BASIN



DATA USED
5 FEBRUARY 2010



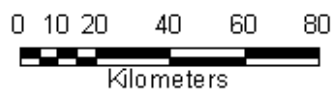
DATA USED
DATA NOT AVAILABLE



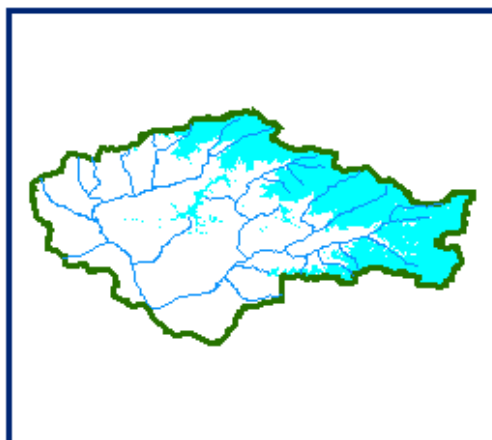
DATA USED
DATA NOT AVAILABLE



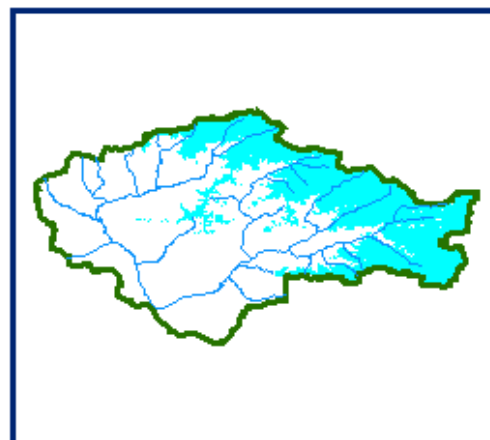
SNOW



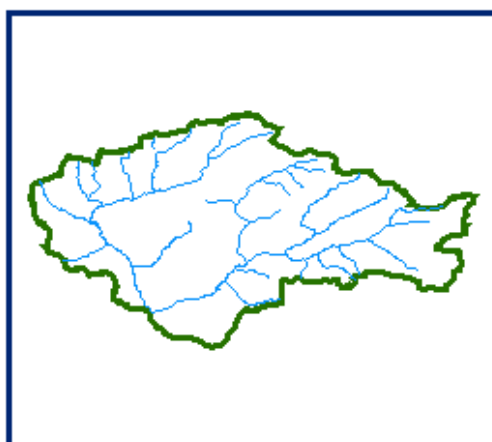
SNOW COVER MAP : YAMUNA BASIN



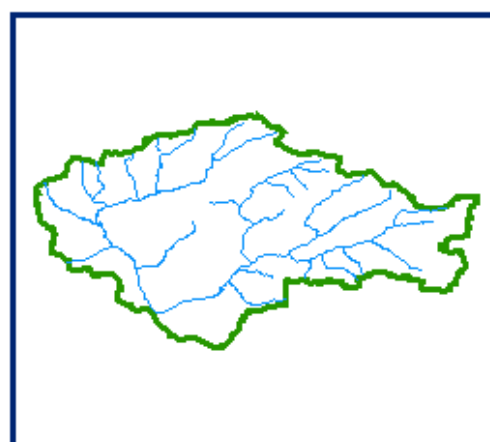
2 MARCH 2010



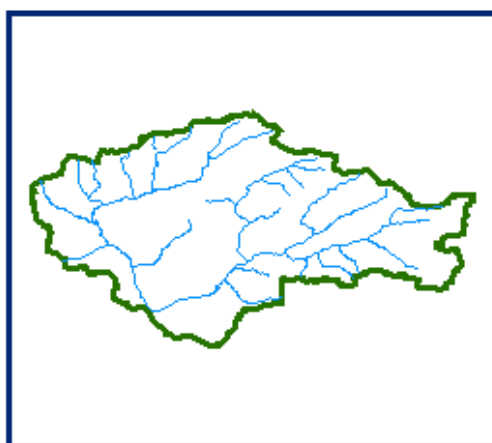
6 MARCH 2010



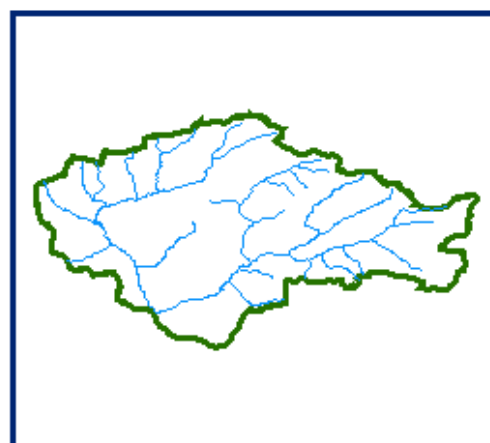
DATA NOT AVAILABLE



DATA NOT AVAILABLE



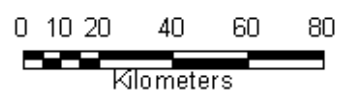
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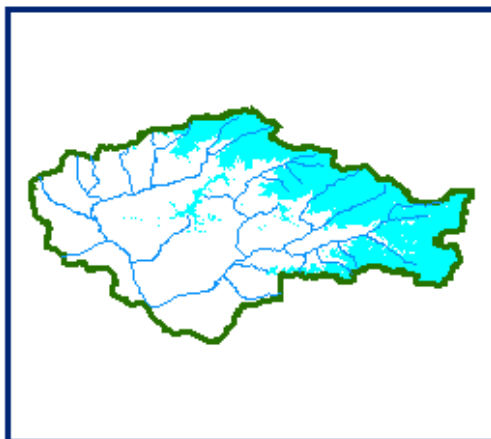
DATA NOT AVAILABLE



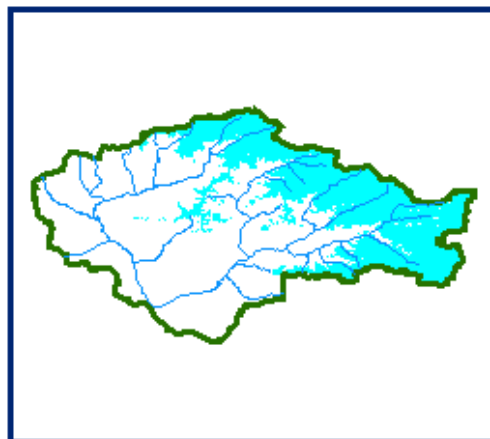
SNOW



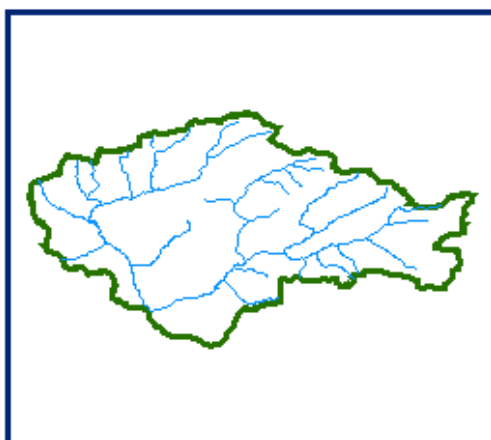
SNOW COVER MAP : YAMUNA BASIN



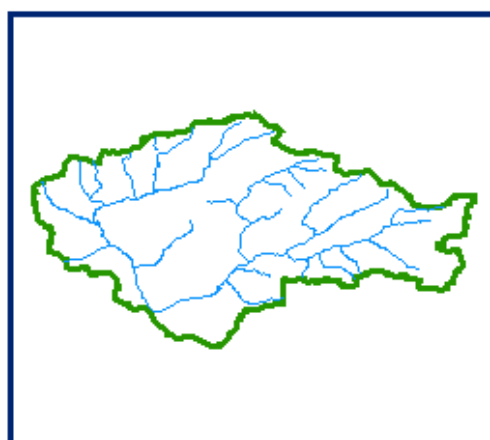
2 MARCH 2010



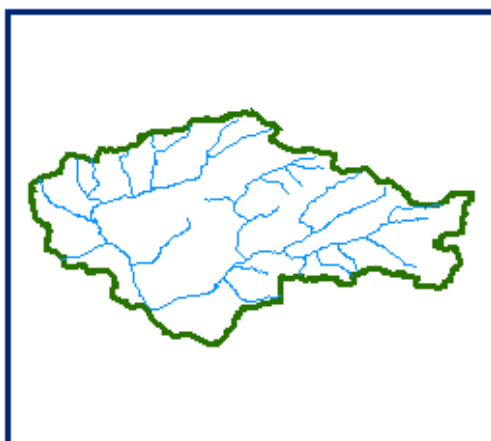
6 MARCH 2010



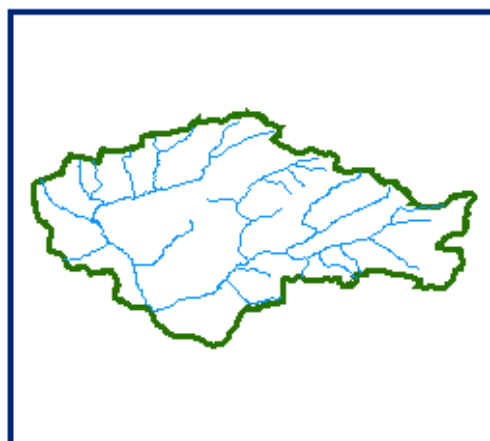
DATA NOT AVAILABLE



DATA NOT AVAILABLE



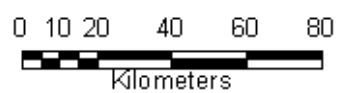
DATA NOT AVAILABLE



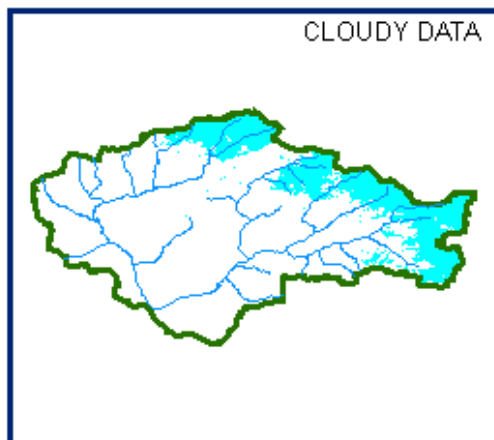
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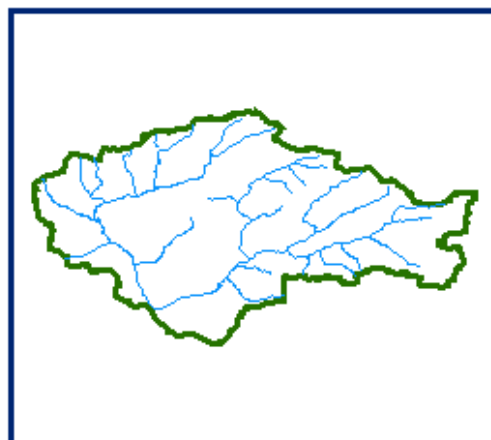
SNOW



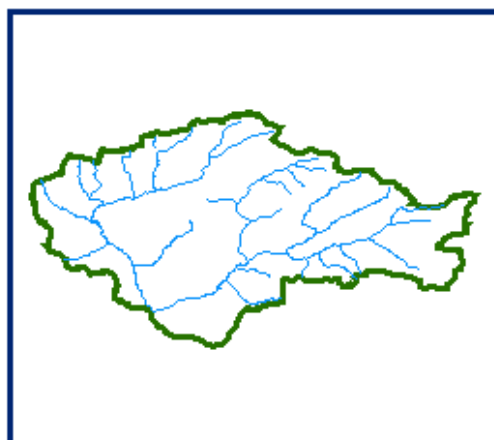
SNOW COVER MAP : YAMUNA BASIN



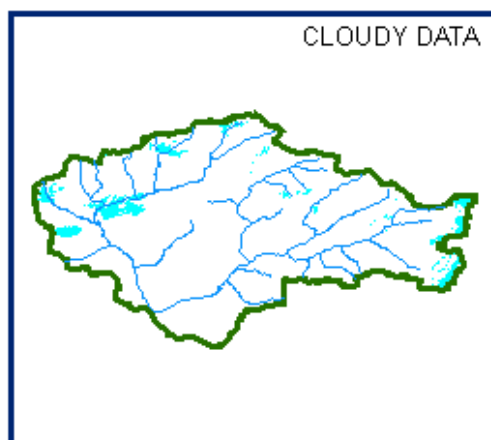
4 APRIL 2010



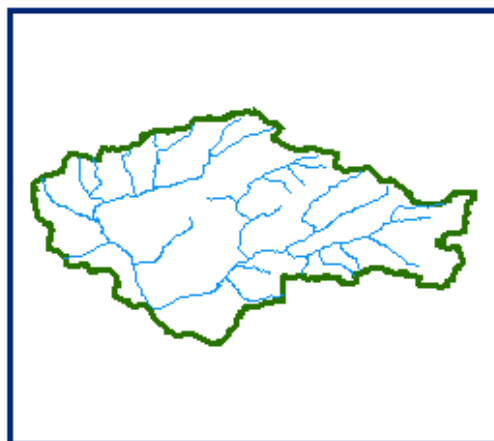
DATA NOT AVAILABLE



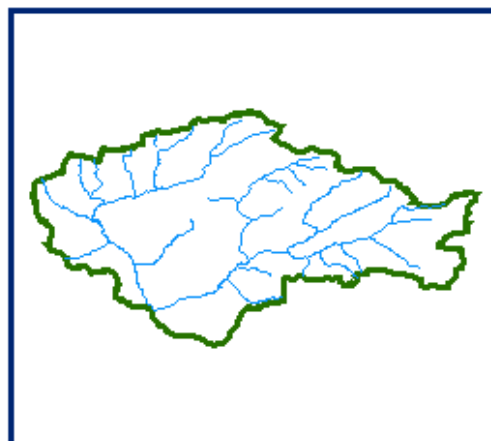
DATA NOT AVAILABLE



19 APRIL 2010



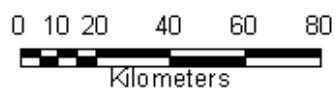
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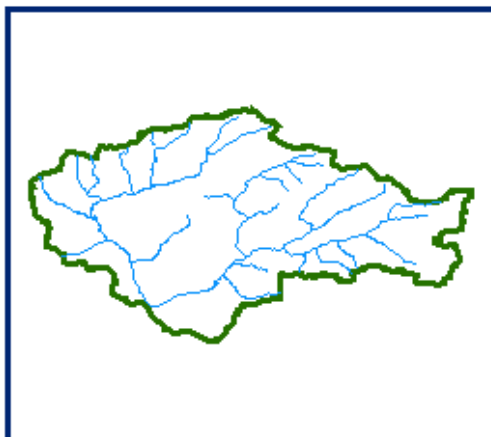
DATA NOT AVAILABLE



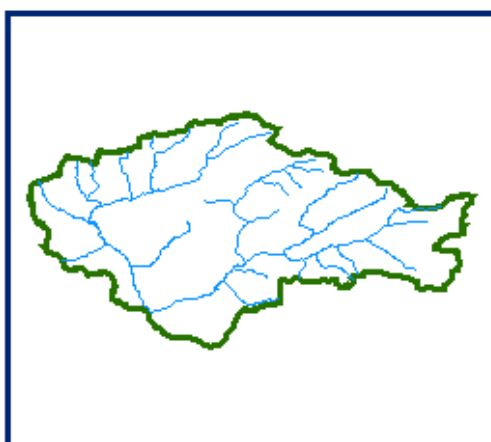
SNOW



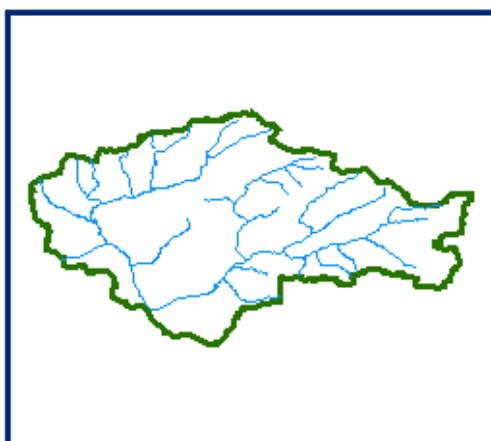
10 DAILY SNOW COVER MAP: YAMUNA BASIN



DATA USED
DATA NOT AVAILABLE



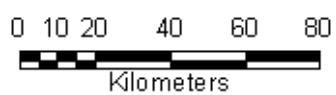
DATA USED
DATA NOT AVAILABLE



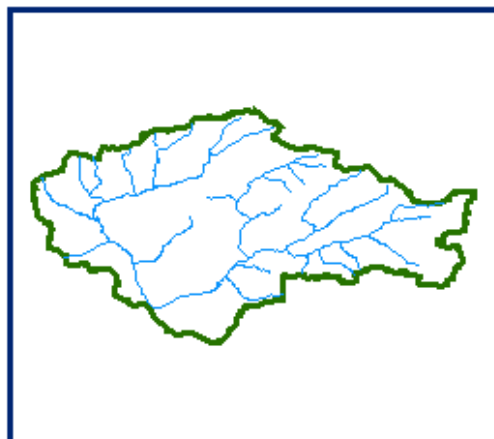
DATA USED
DATA NOT AVAILABLE



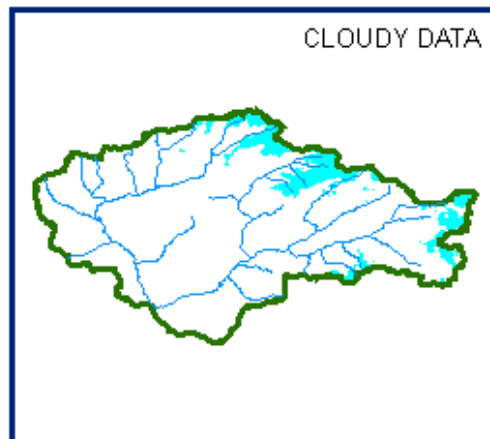
SNOW



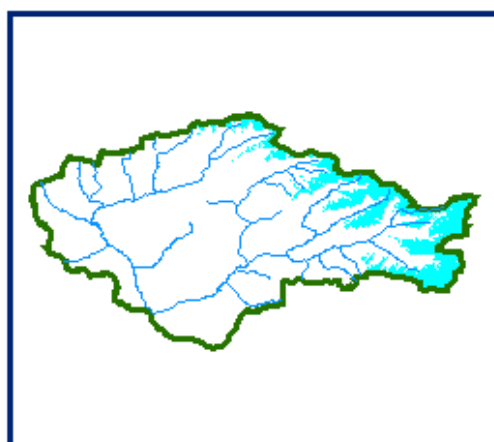
SNOW COVER MAP : YAMUNA BASIN



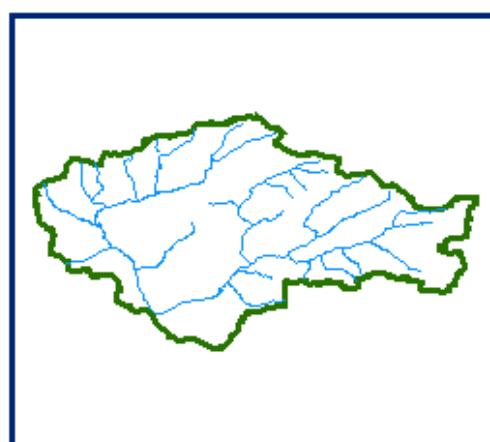
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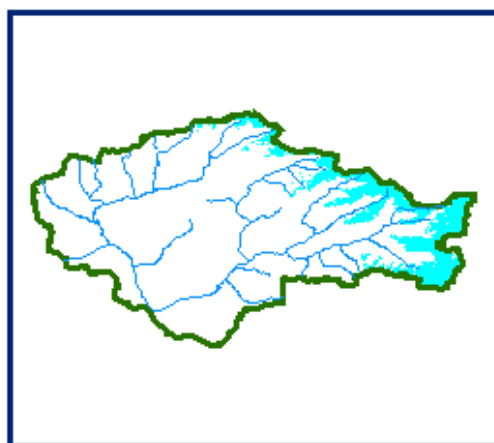
8 MAY 2010



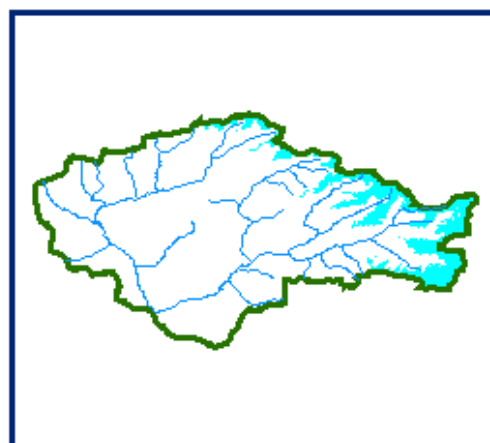
12 MAY 2010



DATA NOT AVAILABLE



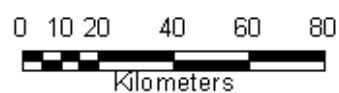
22 MAY 2010



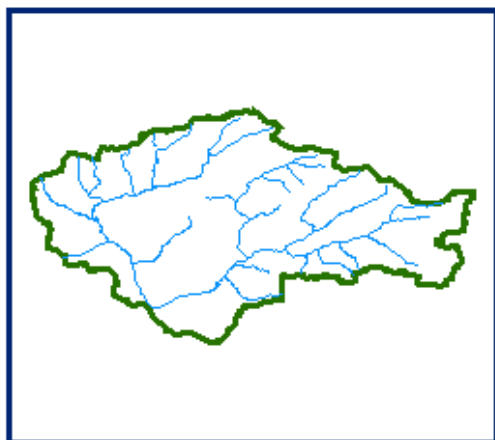
31 MAY 2010



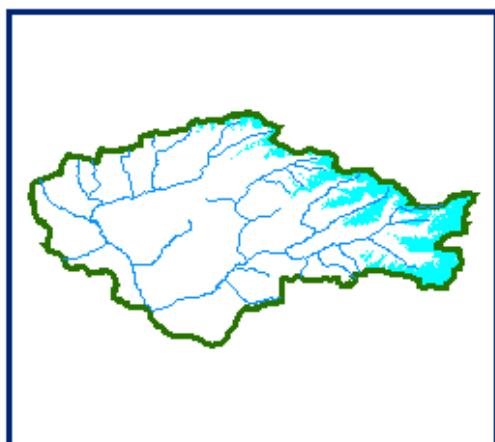
SNOW



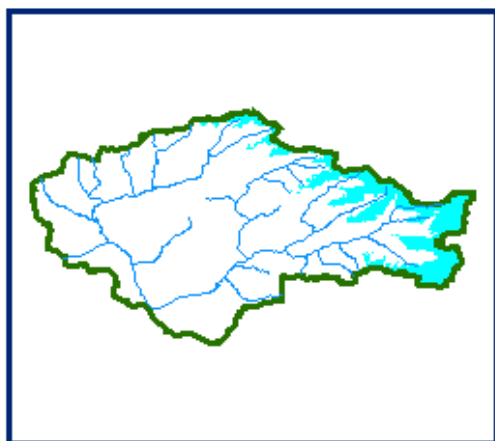
10 DAILY SNOW COVER MAP: YAMUNA BASIN



DATA USED
DATA NOT AVAILABLE



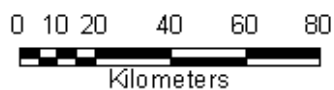
DATA USED
12 MAY 2010



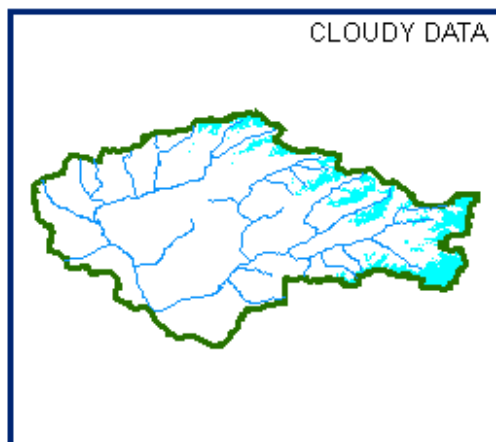
DATA USED
22 MAY 2010
31 MAY 2010



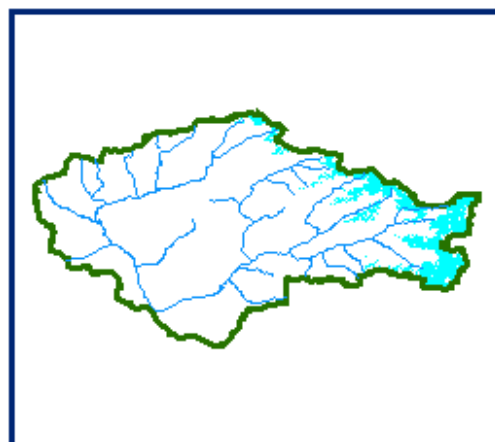
SNOW



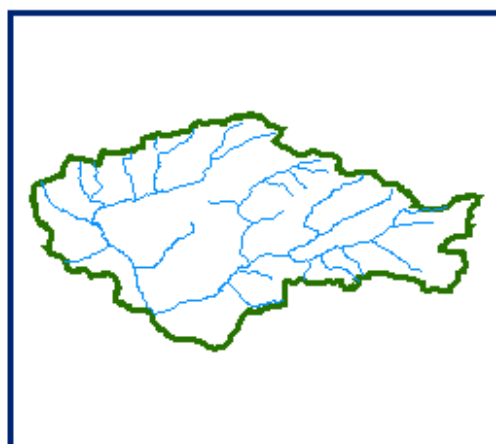
SNOW COVER MAP : YAMUNA BASIN



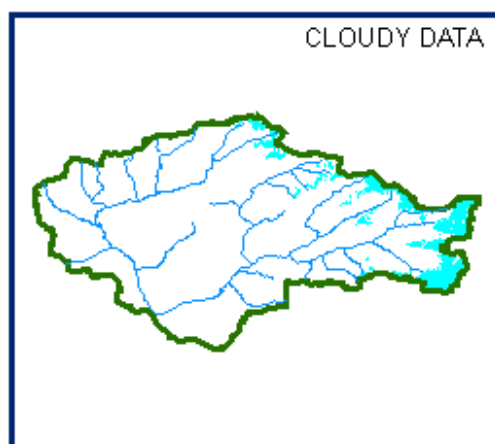
5 JUN 2010



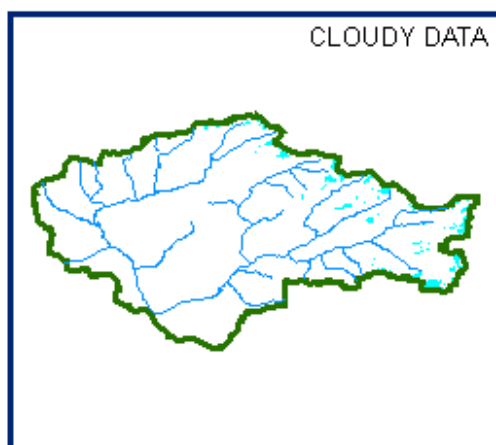
6 JUN 2010



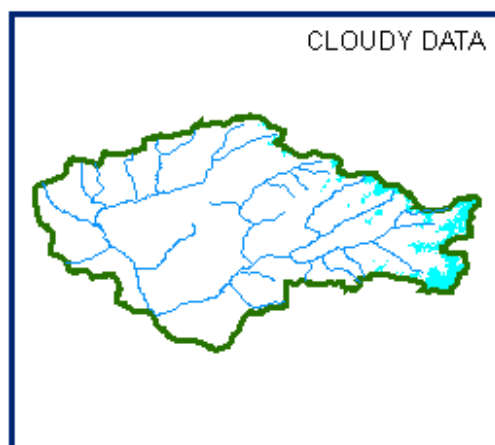
DATA NOT AVAILABLE



20 JUN 2010



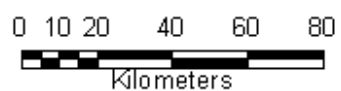
24 JUN 2010



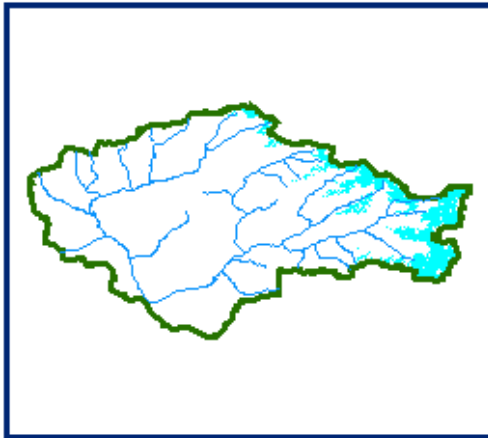
29 JUN 2010



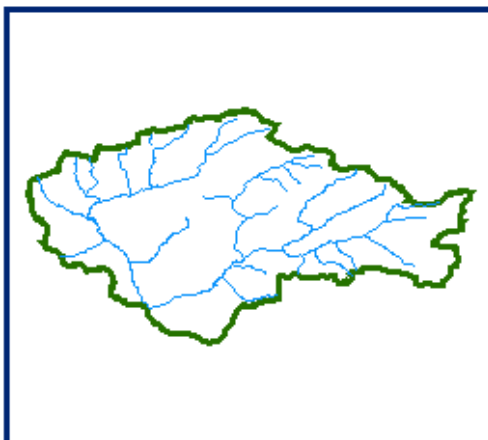
SNOW



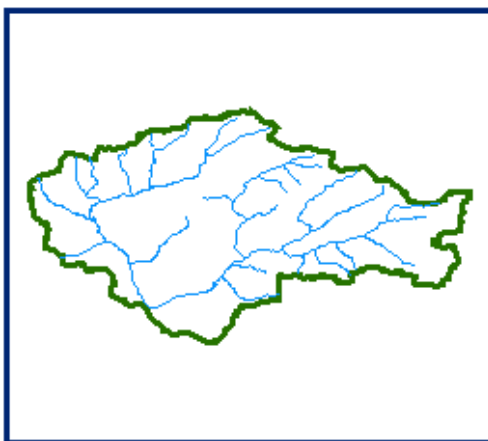
10 DAILY SNOW COVER MAP: YAMUNA BASIN



DATA USED
6 JUN 2010



DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE



SNOW

