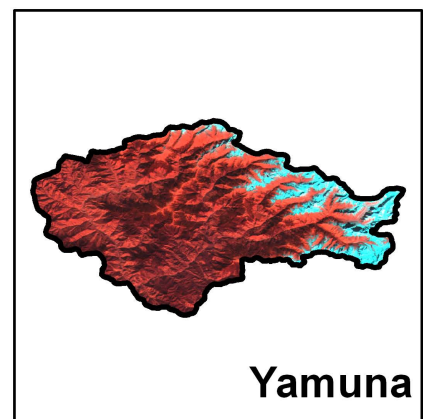
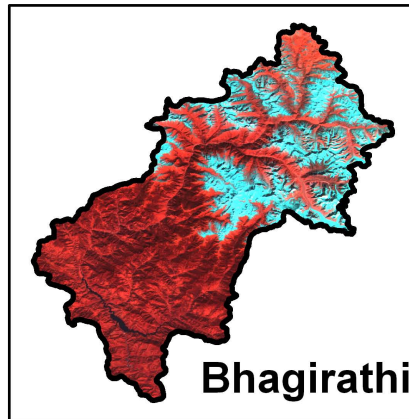


# SNOW COVER ATLAS OF GANGA BASIN

Sub basins: Alaknanda, Bhagirathi and Yamuna

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

Year : 2012-13



Uttarakhand Space Application Centre  
Dehradun - 248001

&

Space Applications Centre (ISRO)  
Ahmedabad - 380015

April 2014

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**April 2014**

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

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Month and year of publication	April 2014
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	As per list
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 2012 to June 2013. 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 sub-basins of the Ganga basin. These are Alaknanda, Bhagirathi and Yamuna sub basins. Locations of these basins are shown in Figure 1.

## **3. Data used:**

AWiFS data from October 2012 to June 2013 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:

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

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 2012 to June 2013. Snow ablation pattern varies from basin to basin, depending on area altitude distribution in the basins. In the month of October and November there is not much snow fall was observed but in Alaknanda sub-basin. Accumulation starts from December and ablation start from April end for Alaknanda and Bhagirathi sub-basins. For Yamuna sub-basin ablation starts in early March. Fluctuation in snow cover is more in Yamuna sub-basin. It may be due to lower altitude.

## **Acknowledgements**

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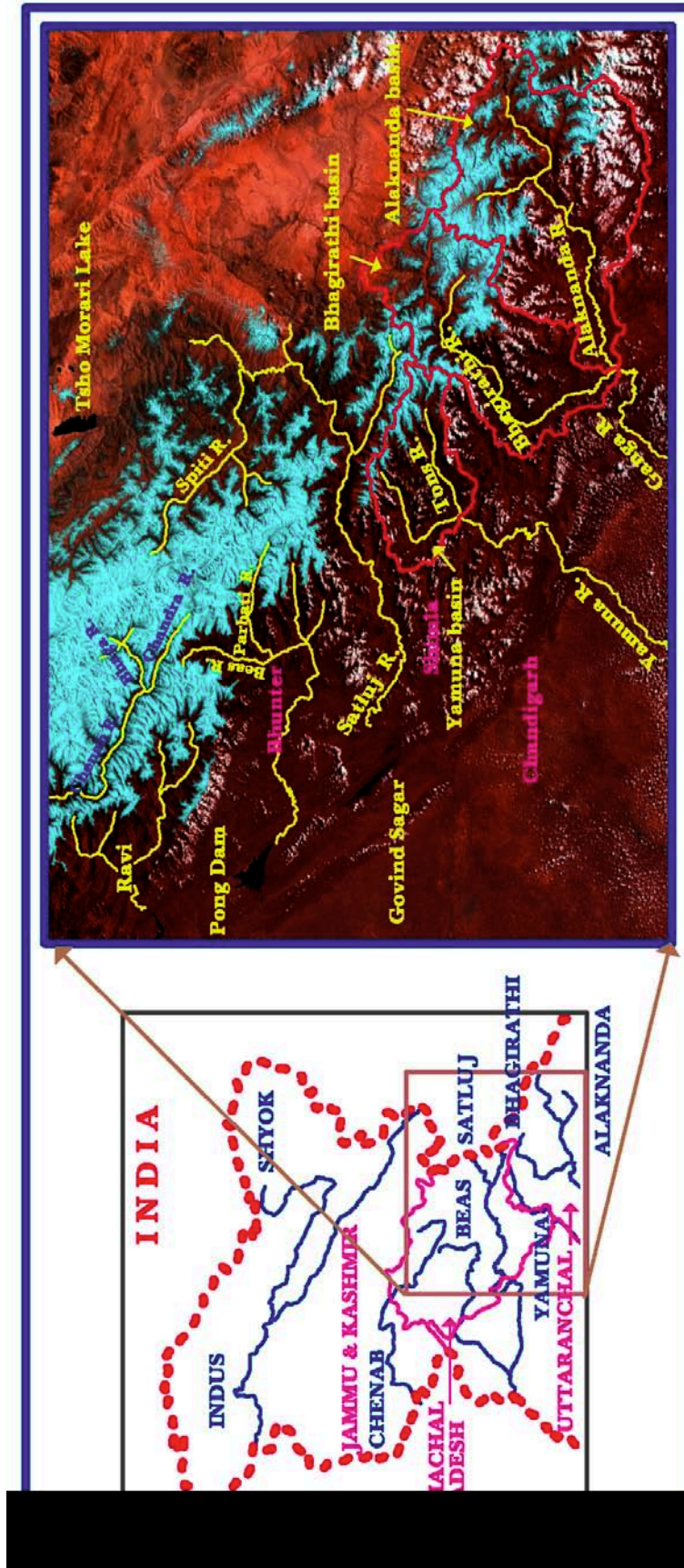
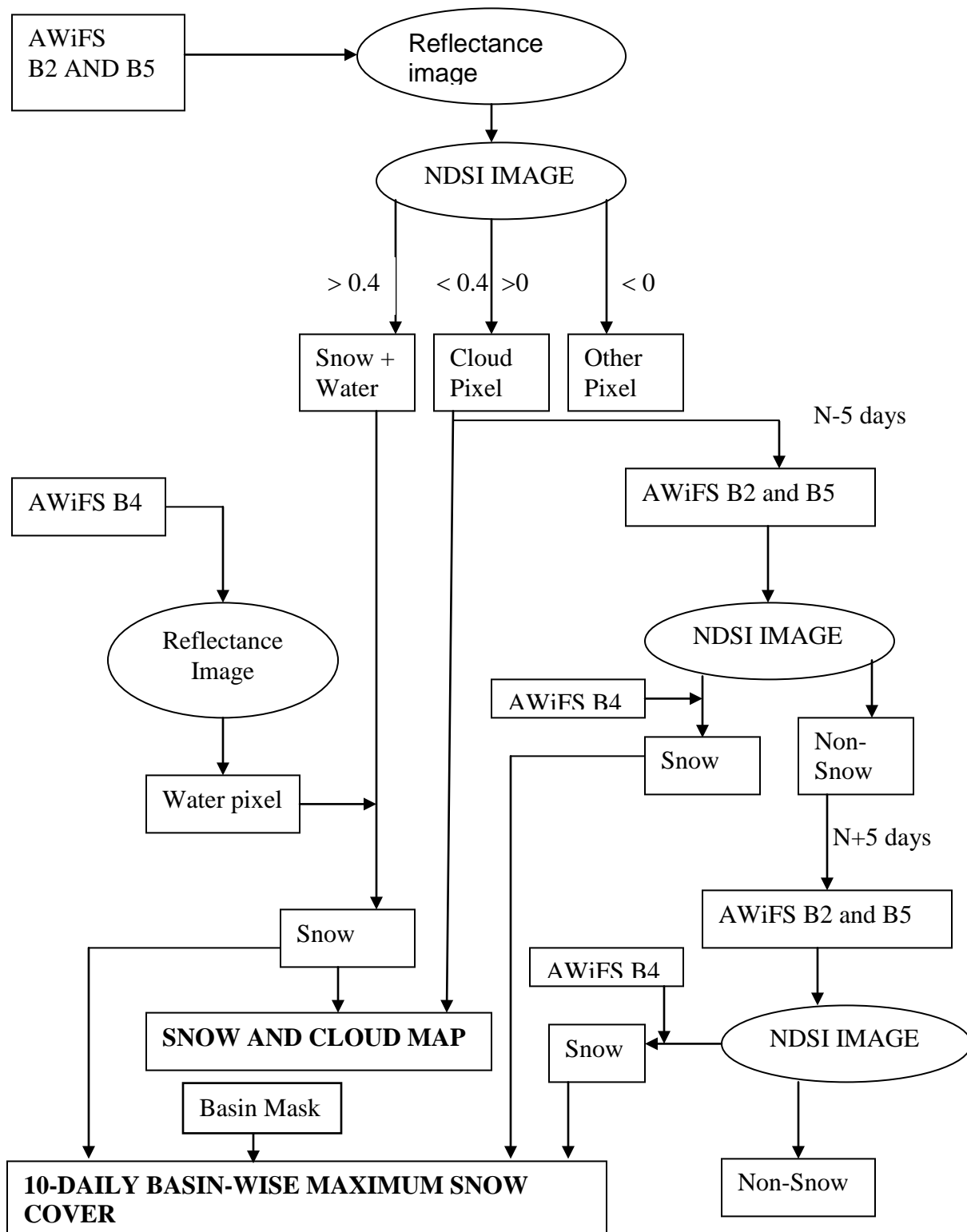


Figure 1: Location map of Alaknanda, Bhagirathi and Yamuna sub-basins (Part of Ganga basin)



**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 (%)
<b>October 2012</b>							
<b>1</b>	07-Oct-2012	1514	14	<b>5</b>	15-Oct-2012	2298	21
<b>2</b>	09-Oct-2012	4783	43	<b>6</b>	22-Oct-2012	2429	22
<b>3</b>	10-Oct-2012	3220	29	<b>7</b>	26-Oct-2012	2812	25
<b>4</b>	14-Oct-2012	2995	27	<b>8</b>	27-Oct-2012	2150	19
				<b>9</b>	31-Oct-2012	2408	22
<b>November 2012</b>							
<b>10</b>	02-Nov-2012	2912	26	<b>14</b>	12-Nov-2012	3186	29
<b>11</b>	03-Nov-2012	2716	24	<b>15</b>	15-Nov-2012	1887	17
<b>12</b>	07-Nov-2012	2661	24	<b>16</b>	17-Nov-2012	2195	20
<b>13</b>	09-Nov-2012	1058	10	<b>17</b>	26-Nov-2012	2777	25
<b>December 2012</b>							
<b>17</b>	09-Dec-2012	2247	20	<b>20</b>	25-Dec-2010	5101	46
<b>18</b>	21-Dec-2010	5113	46	<b>21</b>	26-Dec-2010	4319	39
<b>19</b>	23-Dec-2010	5113	46				
<b>January 2013</b>							
<b>22</b>	07-Jan-2013	3623	33	<b>26</b>	16-Jan-13	2781	25
<b>23</b>	11-Jan-2013	2960	27	<b>27</b>	20-Jan-13	3625	33
<b>24</b>	13-Jan-2013	4642	42	<b>28</b>	21-Jan-13	5567	50
<b>25</b>	14-Jan-2013	4510	41	<b>29</b>	25-Jan-13	4989	45
<b>February 2013</b>							
<b>32</b>	01-Feb-11	2882	45	<b>35</b>	25-Feb-2013	5545	50
<b>33</b>	09-Feb-11	5767	52				
<b>34</b>	18-Feb-11	6543	59				
<b>March 2013</b>							
<b>35</b>	05-Mar-2013	5393	49	<b>38</b>	20-Mar-2013	4385	40
<b>36</b>	17-Mar-2013	5934	54	<b>39</b>	22-Mar-2013	5174	47
<b>37</b>	19-Mar-2013	5450	49	<b>40</b>	26-Mar-2013	5790	52
<b>April 2013</b>							
<b>41</b>	12-Apr-2013	5034	45	<b>44</b>	19-Apr-2013	4874	44
<b>42</b>	15- Apr -2013	4777	43	<b>45</b>	24- Apr-2013	5006	45
<b>43</b>	17- Apr -2013	4885	44				
<b>May 2013</b>							
<b>46</b>	14-May-2013	4827	44	<b>50</b>	20-May-2013	2110	19

<b>47</b>	16-May-2013	3929	35	<b>51</b>	23-May-2013	3474	31
<b>48</b>	18-May-2013	3229	29	<b>52</b>	25-May-2013	3077	28
<b>49</b>	19-May-2013	3488	31	<b>53</b>	28-May-2013	3193	29
				<b>54</b>	31-May-2013	2362	22
<b>June 2013</b>							
<b>55</b>	01-June-2013	2354	21	<b>58</b>	21-June-2013	3413	31
<b>56</b>	04-June-2013	2755	25				
<b>57</b>	07-June-2013	2122	19				

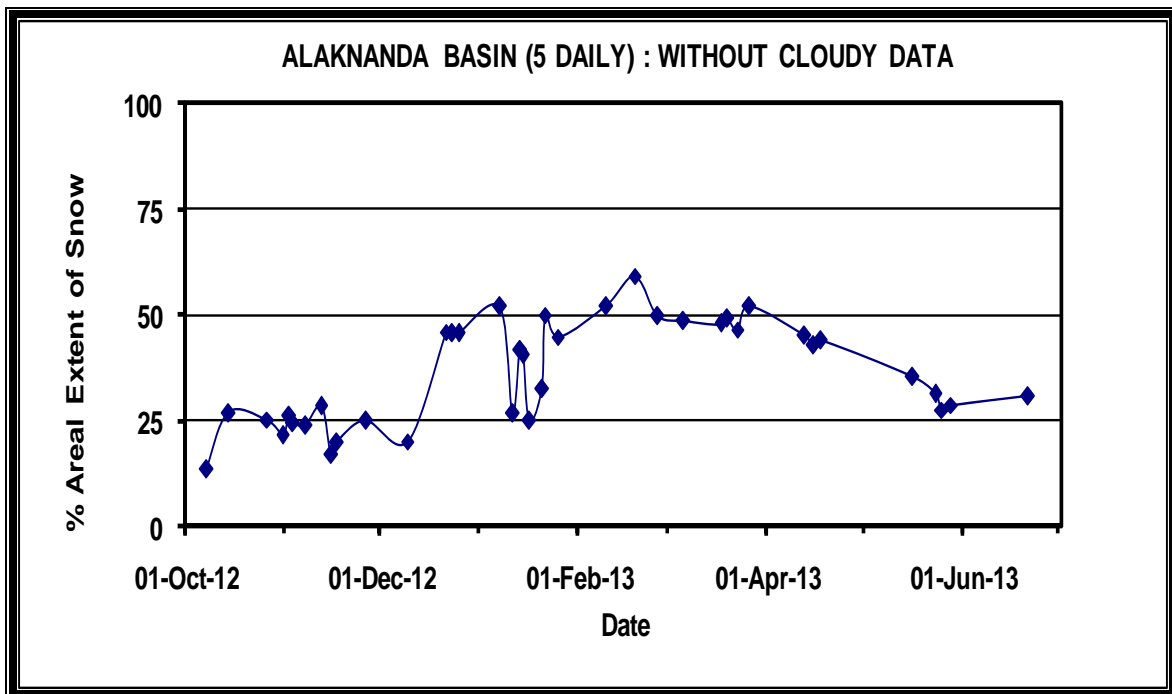
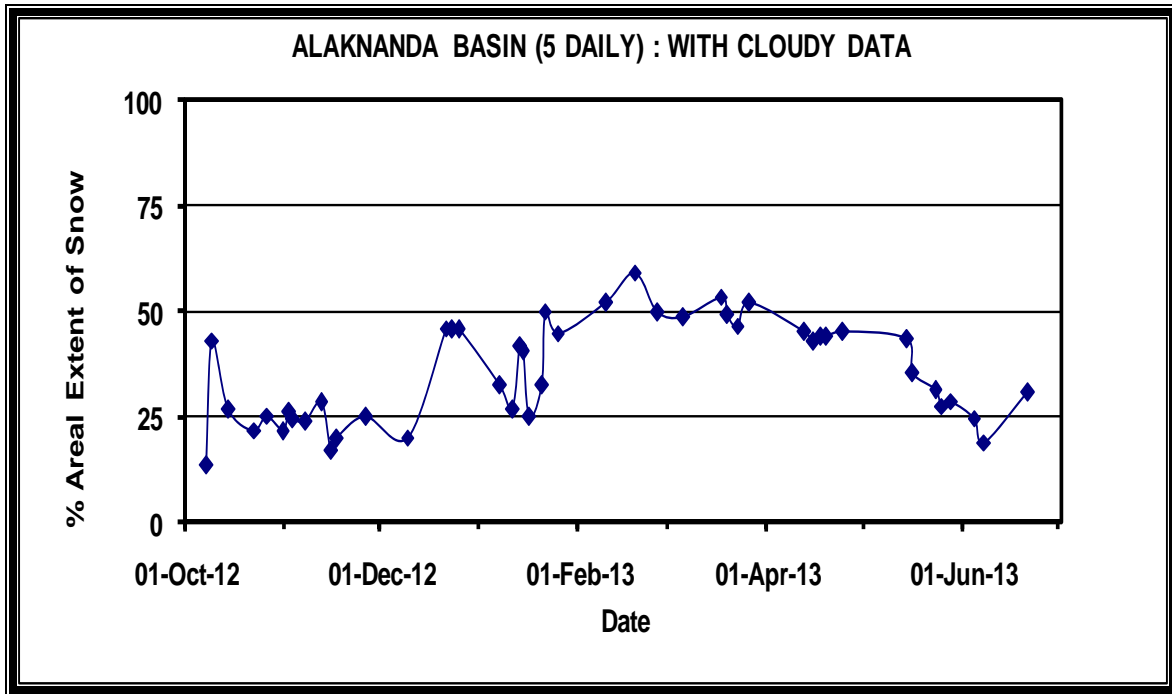
# AREAL EXTENT OF SNOW (10 DAILY)

**BASIN NAME: ALAKNANDA**

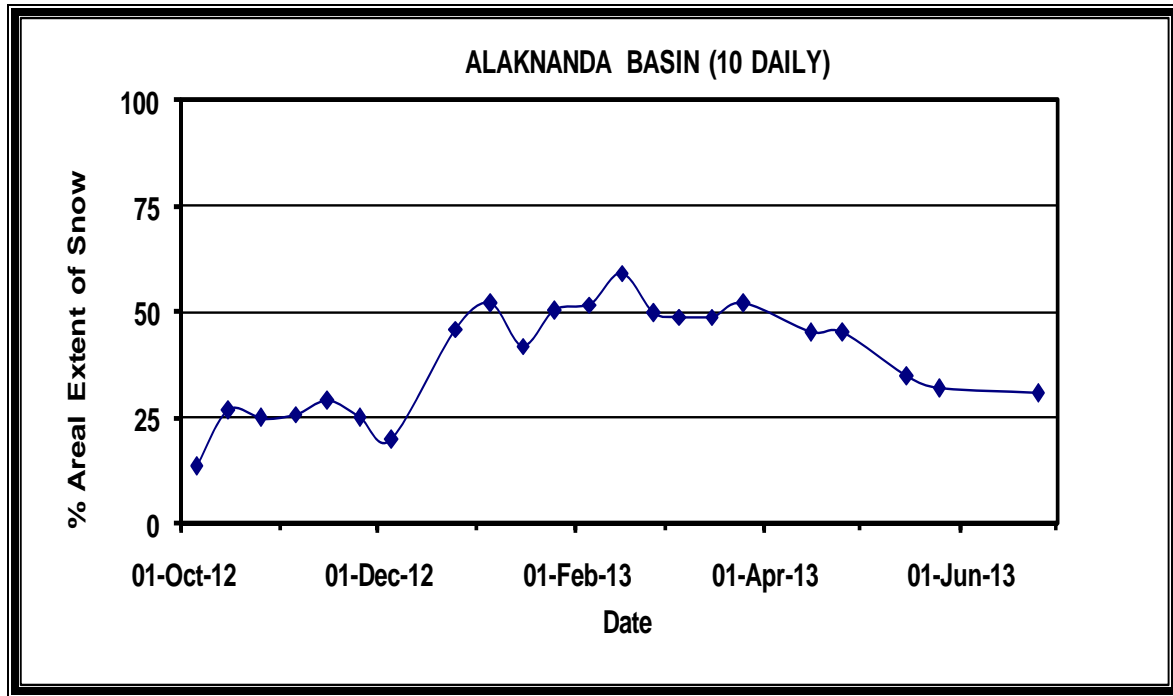
**BASIN AREA: 11090 sq km**

S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
<b>October 2012</b>							
<b>1</b>	05-Oct-2012	1514	14	<b>3</b>	25-Oct-2012	2812	25
<b>2</b>	15-Oct-2012	2995	27				
<b>November 2012</b>							
<b>4</b>	05-Nov-2012	2912	26	<b>6</b>	25-Nov-2012	2777	25
<b>5</b>	15-Nov-2012	3186	29				
<b>December 2012</b>							
<b>7</b>	05-Dec-2012	2247	20	<b>8</b>	25-Dec-2010	5101	46
<b>January 2013</b>							
<b>9</b>	05-Jan-2013	5767	52	<b>11</b>	25-Jan-13	5567	50
<b>10</b>	15-Jan-2013	4642	42				
<b>February 2013</b>							
<b>12</b>	05-Feb-11	5797	52	<b>14</b>	25-Feb-2013	5545	50
<b>13</b>	15-Feb-11	6589	59				
<b>March 2013</b>							
<b>15</b>	05-Mar-2013	5393	49	<b>17</b>	25-Mar-2013	5790	52
<b>16</b>	15-Mar-2013	5450	49				
<b>April 2013</b>							
<b>18</b>	15-Apr-2013	5034	45	<b>19</b>	25-Apr-2013	5005	45
<b>May 2013</b>							
<b>20</b>	15-May-2013	3929	35	<b>21</b>	25-May-2013	3474	31
<b>June 2013</b>							
<b>22</b>	25-June-2013	3413	31				

## Snow cover depletion curve

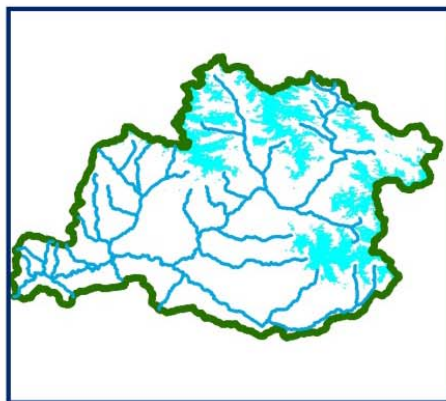


## Snow cover depletion curve

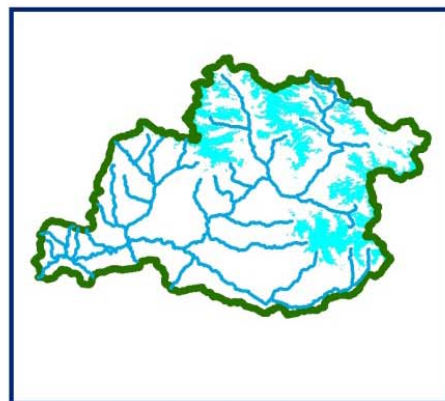


# *SNOW COVER MAP*

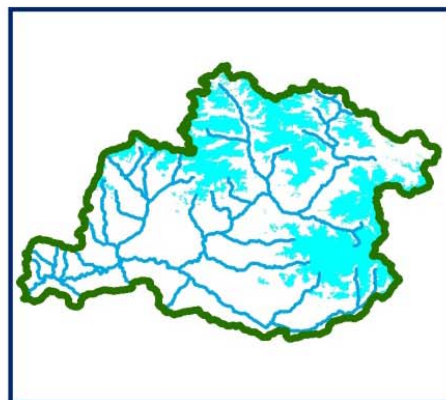
# SNOW COVER MAP : ALAKNANDA BASIN



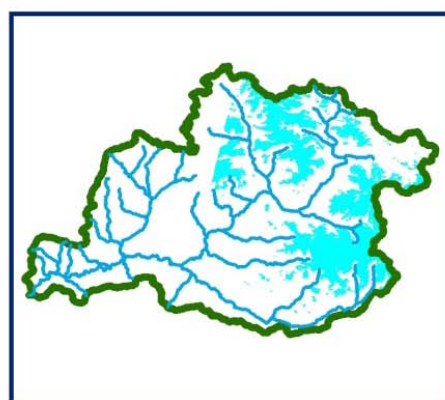
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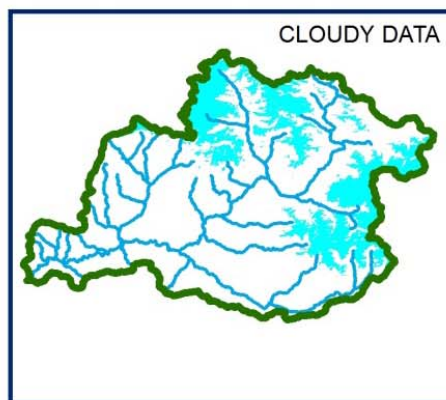
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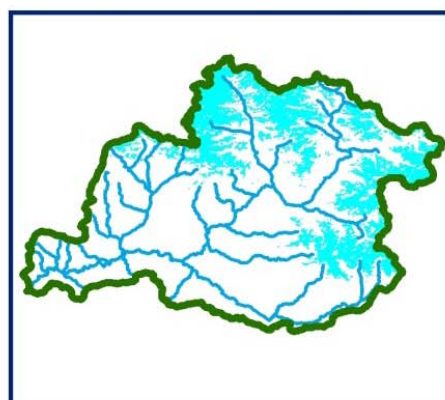
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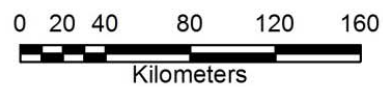
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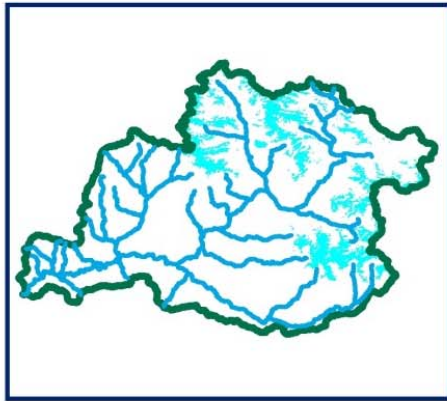


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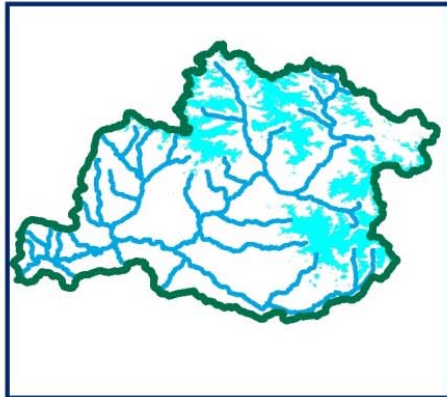




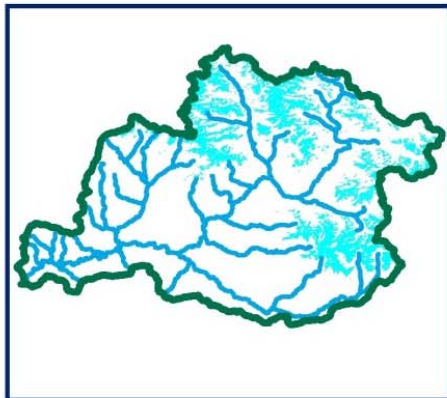
**10 DAILY SNOW COVER MAP: ALAKNANDA BASIN**



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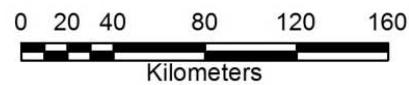
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DATA USED  
**31 OCTOBER 2012**



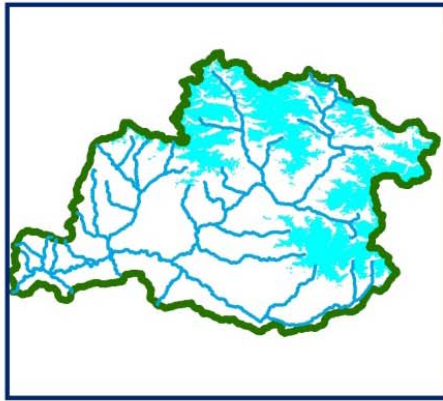
SNOW



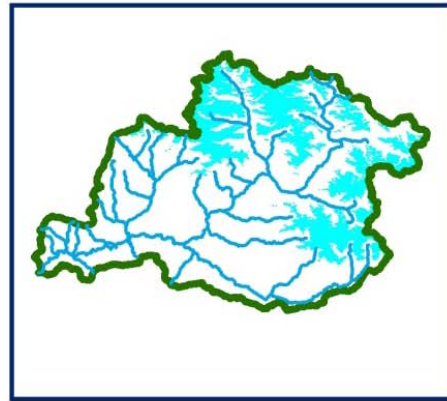
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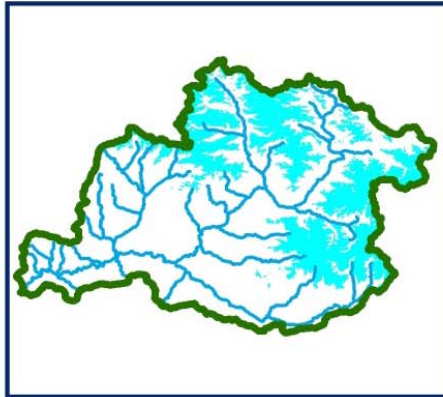
# ALAKNANDA BASIN



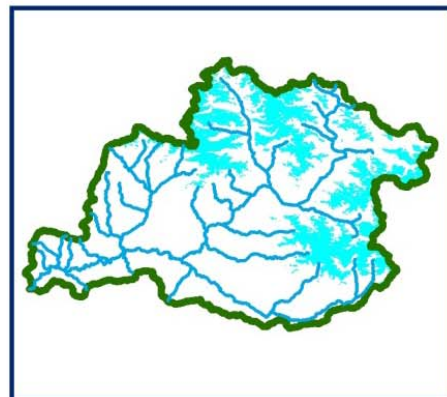
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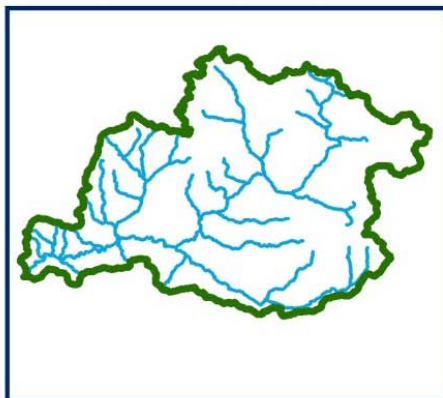
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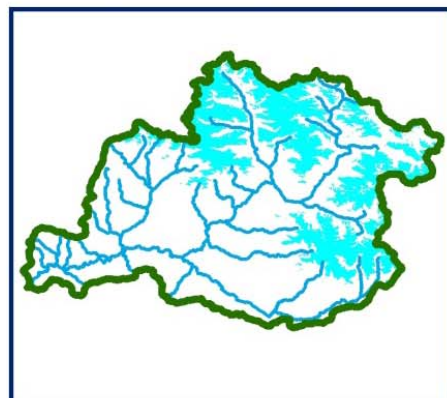
12 NOVEMBER 2012



17 NOVEMBER 2012



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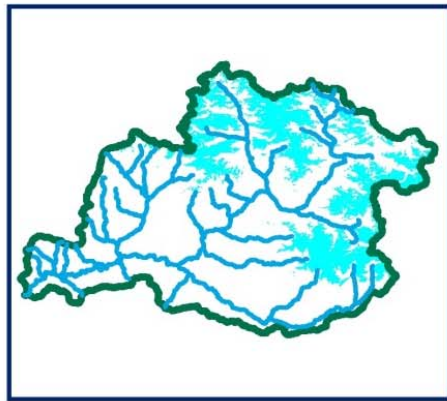
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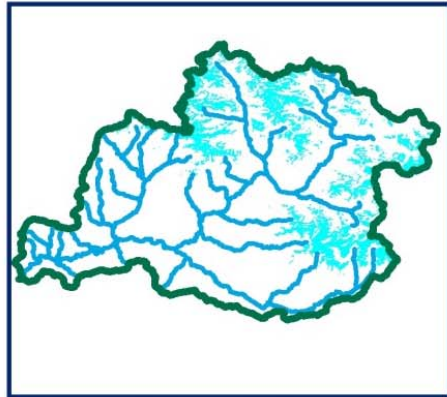
SNOW



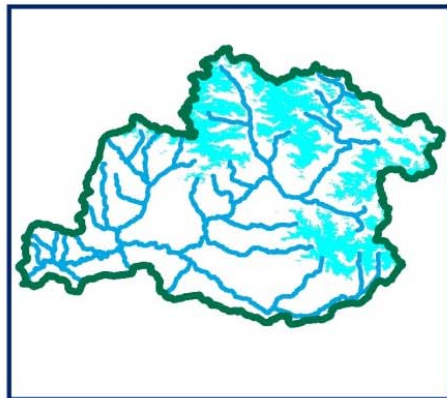
**10 DAILY SNOW COVER MAP: ALAKNANDA BASIN**



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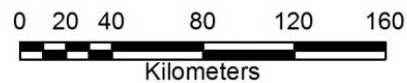
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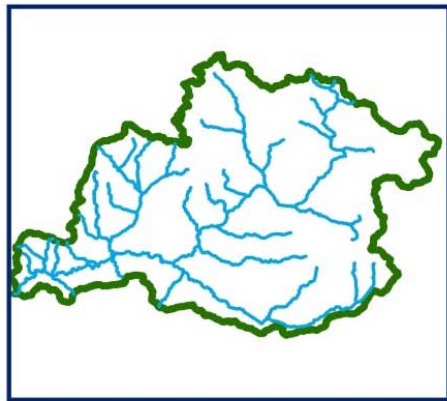
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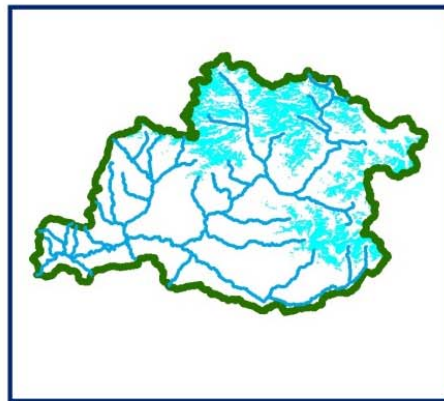
SNOW



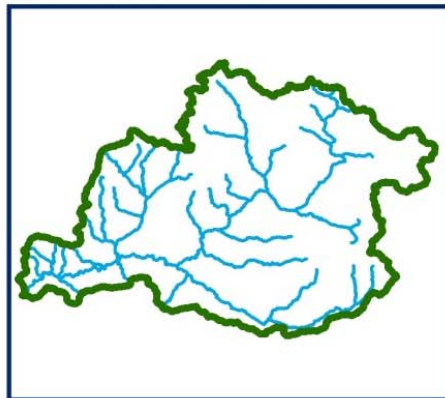
**SNOW COVER MAP : ALAKNANDA BASIN**



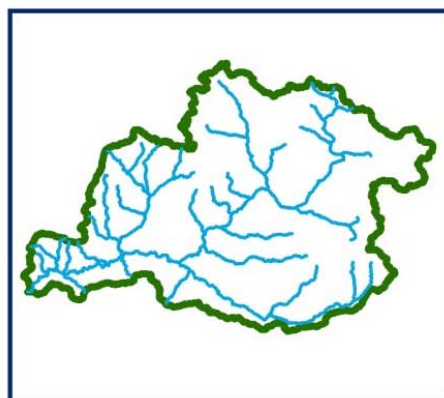
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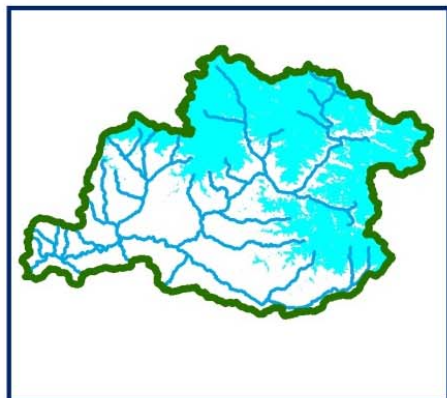
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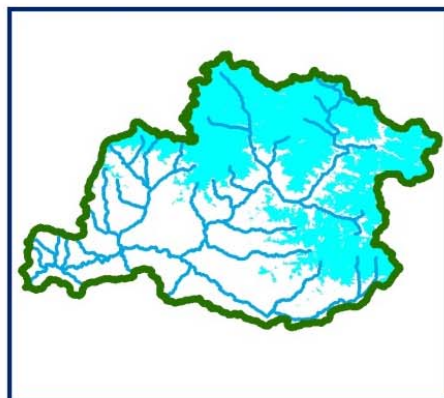
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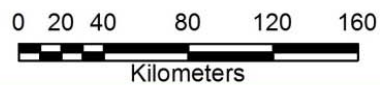
**21 DECEMBER 2012**



**26 DECEMBER 2012**

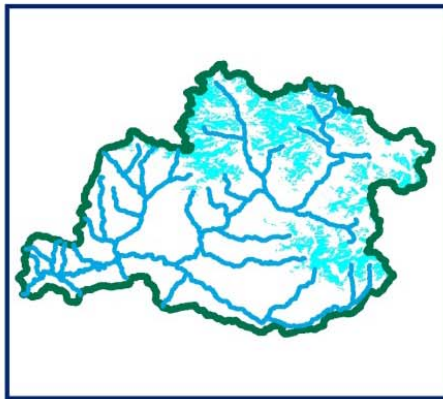


**SNOW**

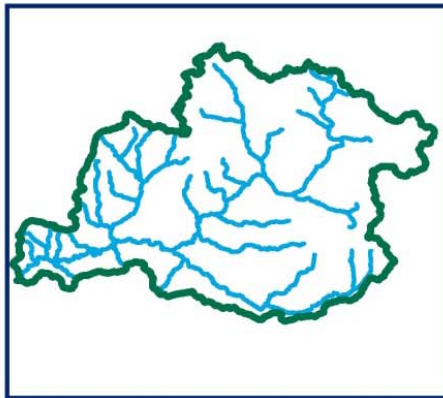




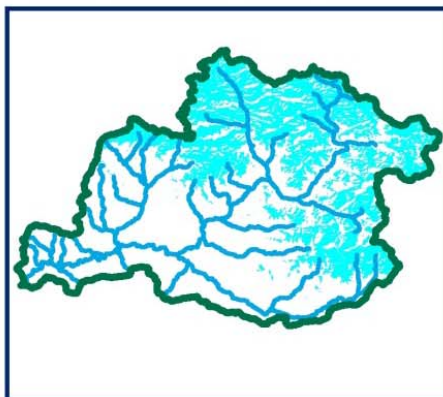
**10 DAILY SNOW COVER MAP: ALAKNANDA BASIN**



DATA USED  
**9 DECEMBER 2012**



DATA USED  
**DATA NOT AVAILABLE**



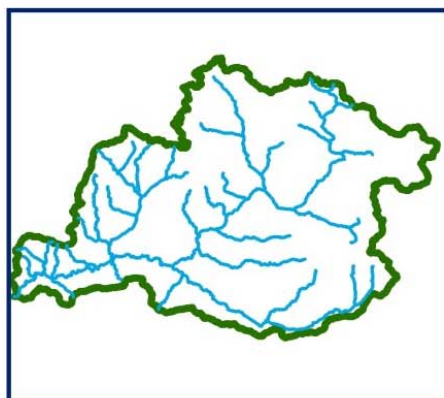
DATA USED  
**23 DECEMBER 2012**



SNOW



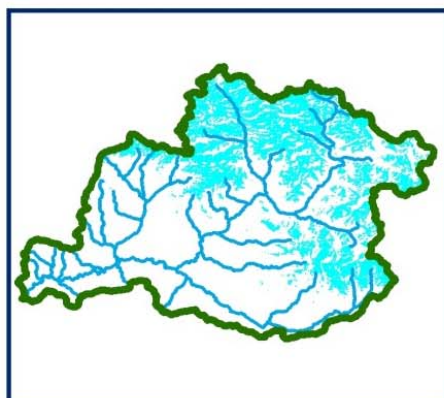
# SNOW COVER MAP : ALAKNANDA BASIN



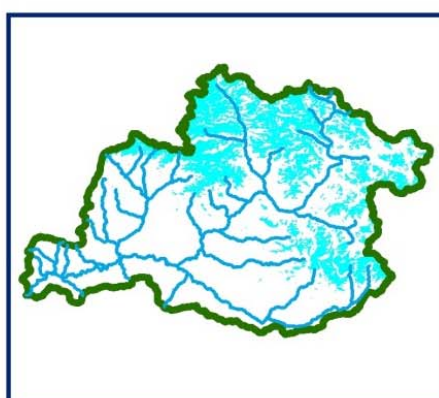
DATA NOT AVAILABLE



07 JANUARY 2013



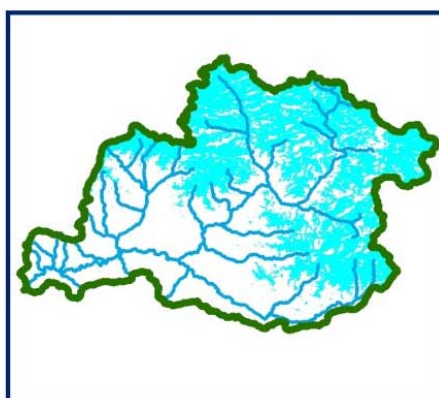
11 JANUARY 2013



16 JANUARY 2013



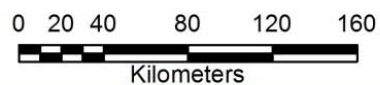
21 JANUARY 2013



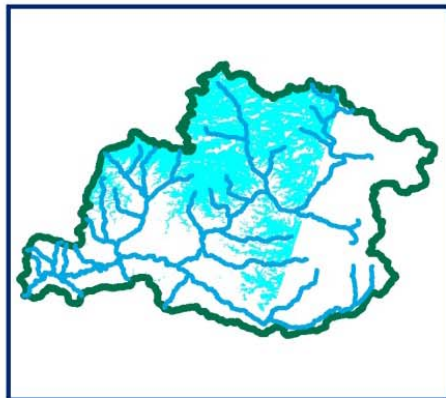
25 JANUARY 2013



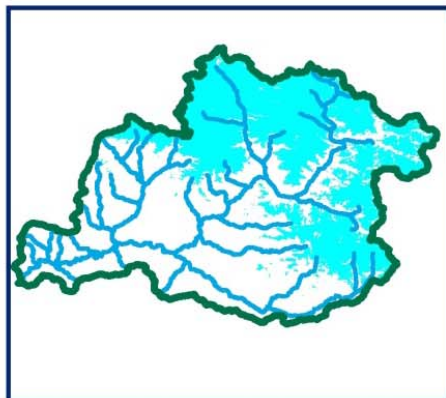
SNOW



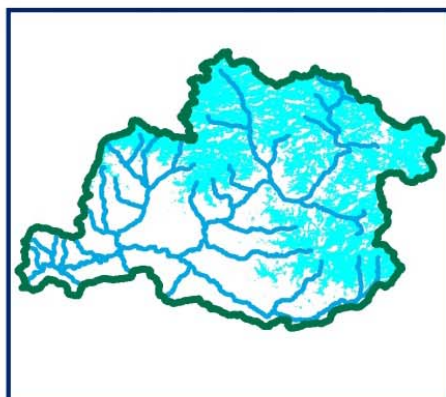
**10 DAILY SNOW COVER MAP: ALAKNANDA BASIN**



DATA USED  
**7 JANUARY 2013**



DATA USED  
**13 JANUARY 2013**



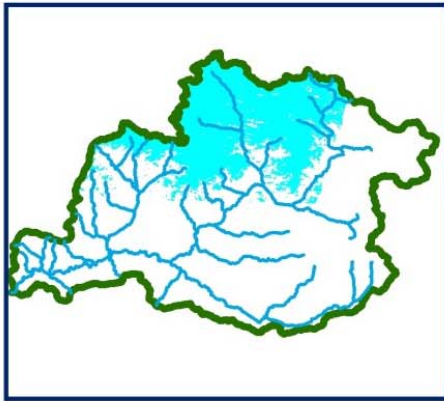
DATA USED  
**25 JANUARY 2013**



SNOW



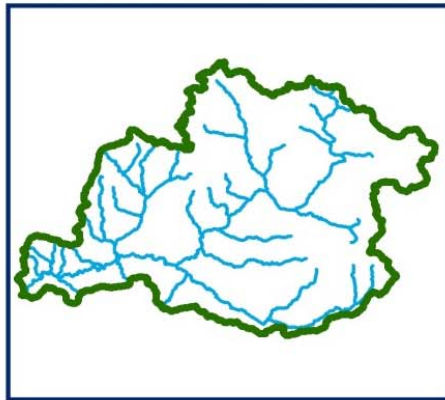
**SNOW COVER MAP : ALAKNANDA BASIN**



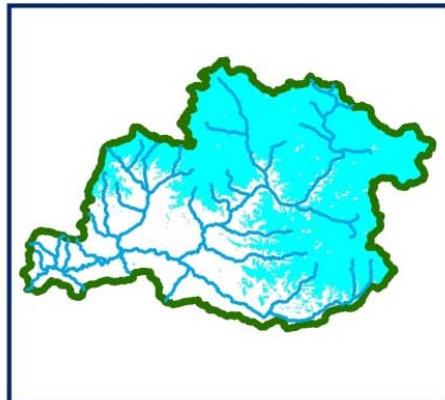
**01 FEBRUARY 2013**



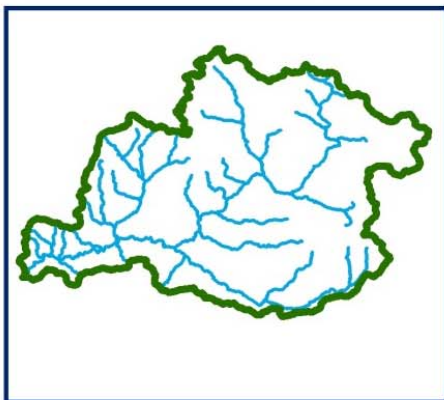
**09 FEBRUARY 2013**



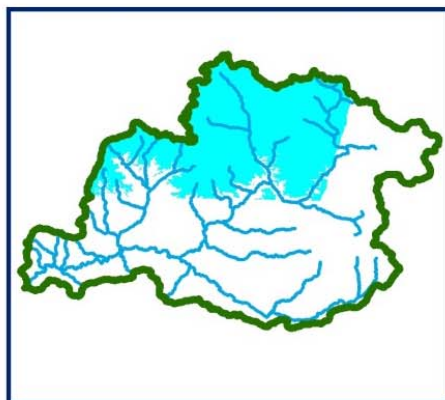
**DATA NOT AVAILABLE**



**18 FEBRUARY 2013**



**DATA NOT AVAILABLE**



**25 FEBRUARY 2013**

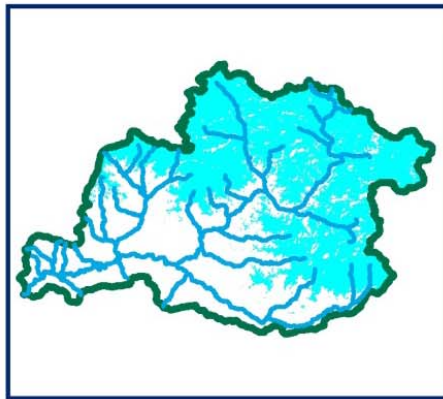


**SNOW**

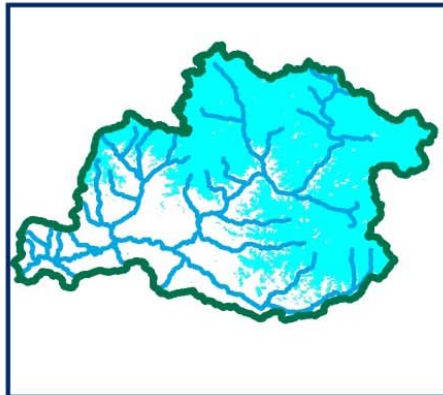




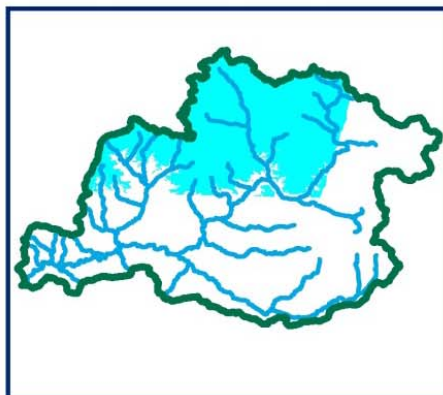
**10 DAILY SNOW COVER MAP: ALAKNANDA BASIN**



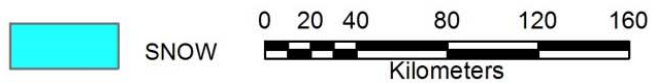
DATA USED  
**9 FEBRUARY 2013**



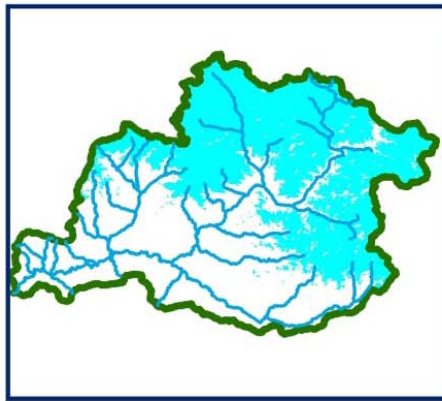
DATA USED  
**18 FEBRUARY 2013**



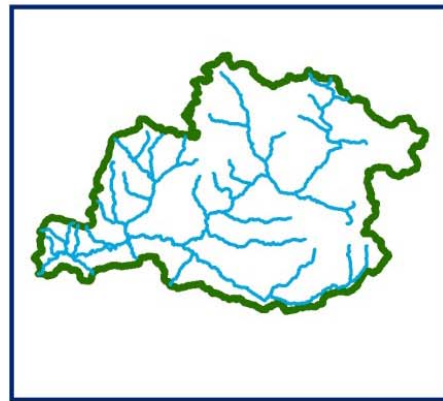
DATA USED  
**25 FEBRUARY 2013**



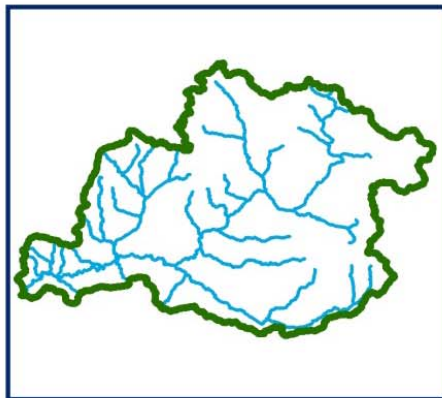
# SNOW COVER MAP : ALAKNANDA BASIN



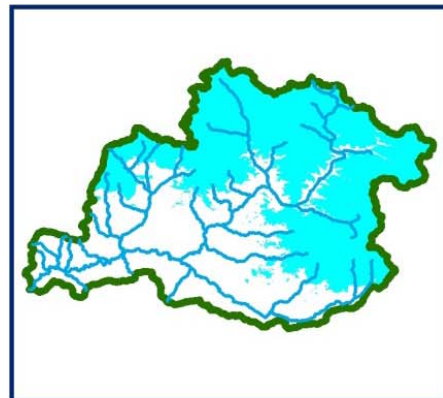
05 MARCH 2013



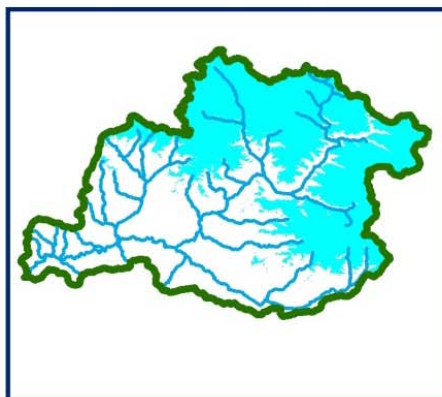
DATA NOT AVAILABLE



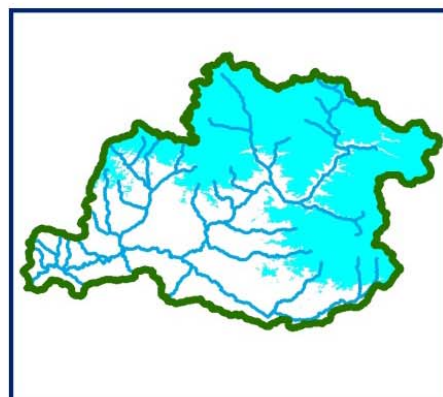
DATA NOT AVAILABLE



17 MARCH 2013



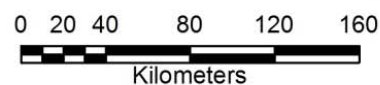
22 MARCH 2013



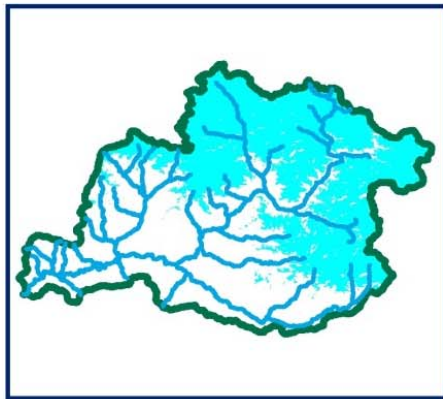
26 MARCH 2013



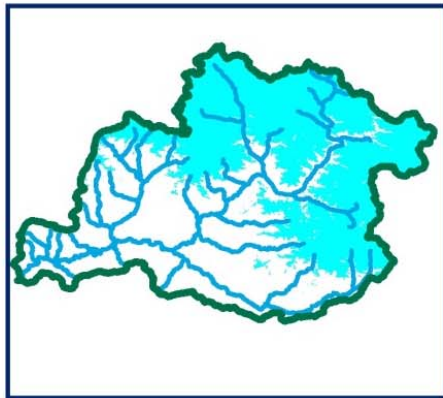
SNOW



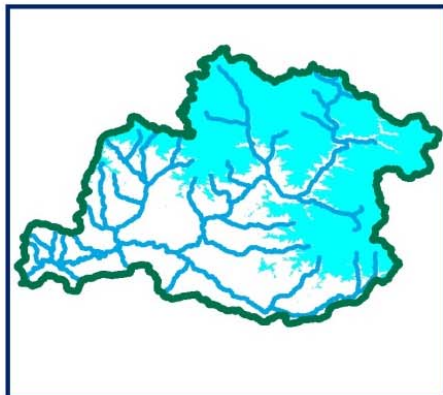
**10 DAILY SNOW COVER MAP: ALAKNANDA BASIN**



DATA USED  
**5 MARCH 2013**



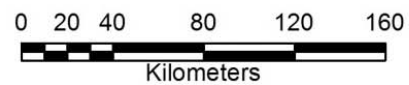
DATA USED  
**19 MARCH 2013**



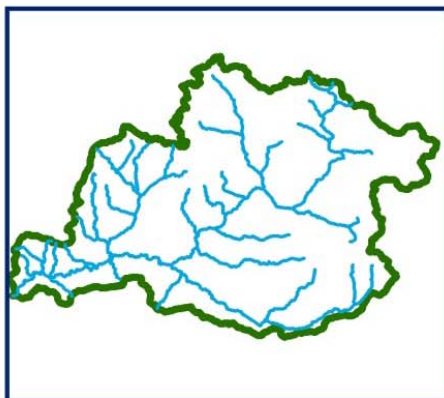
DATA USED  
**26 MARCH 2013**



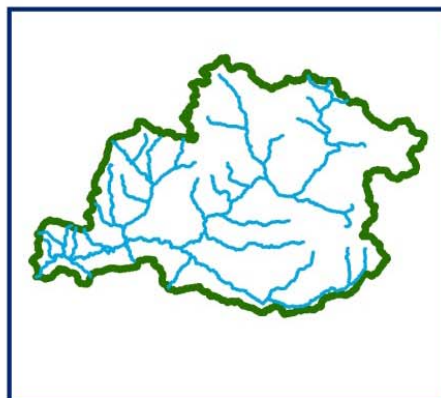
SNOW



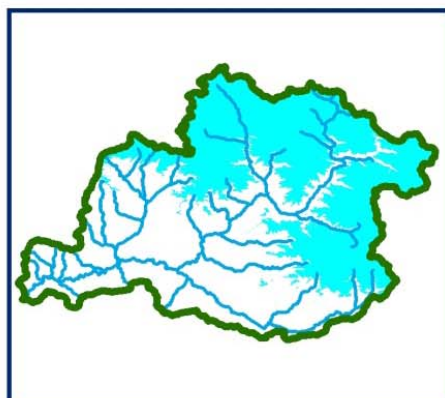
# SNOW COVER MAP : ALAKNANDA BASIN



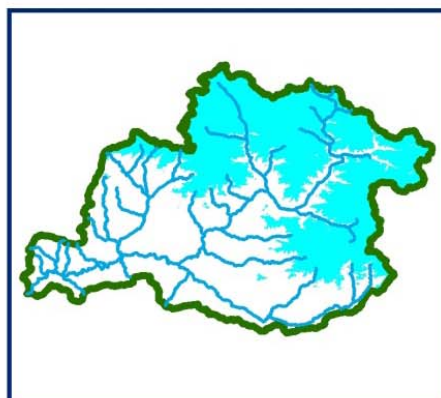
DATA NOT AVAILABLE



DATA NOT AVAILABLE



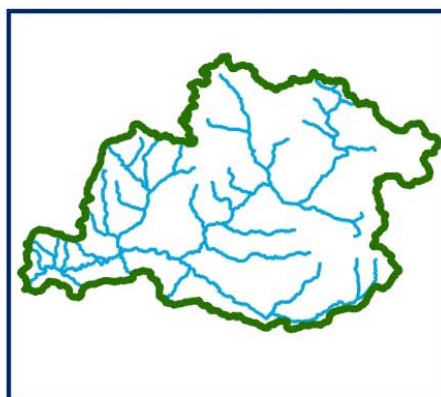
12 APRIL 2013



17 APRIL 2013



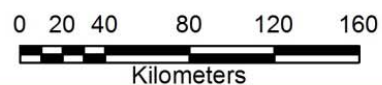
24 APRIL 2013



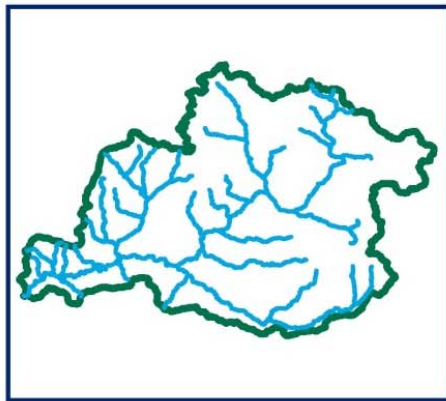
DATA NOT AVAILABLE



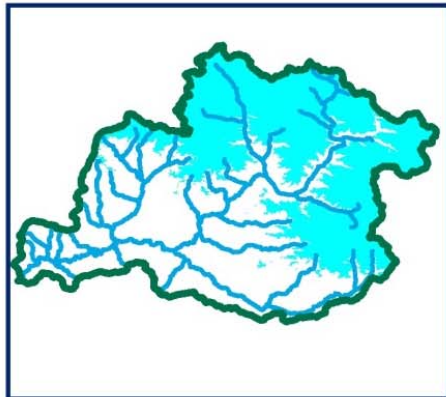
SNOW



**10 DAILY SNOW COVER MAP: ALAKNANDA BASIN**



DATA USED



DATA USED  
**12 APRIL 2013**



DATA USED  
**24 APRIL 2013**



SNOW

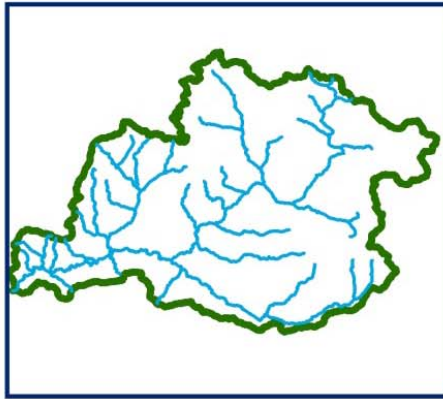




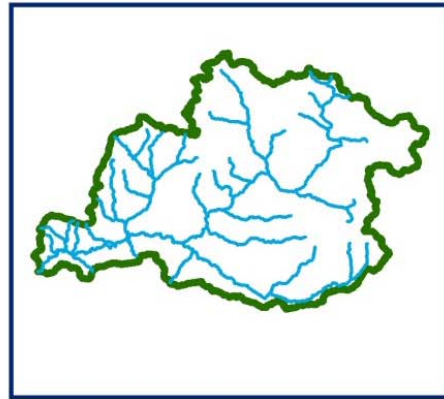
# SNOW COVER MAP

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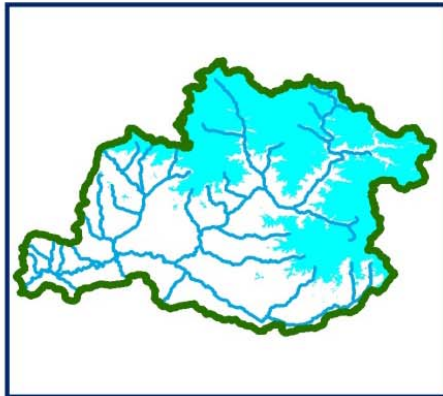
# ALAKNANDA BASIN



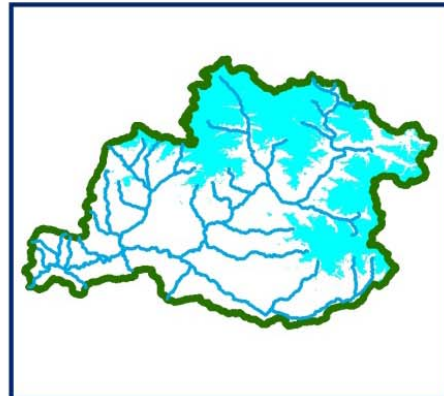
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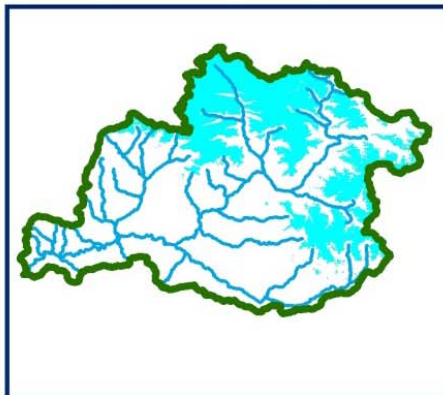
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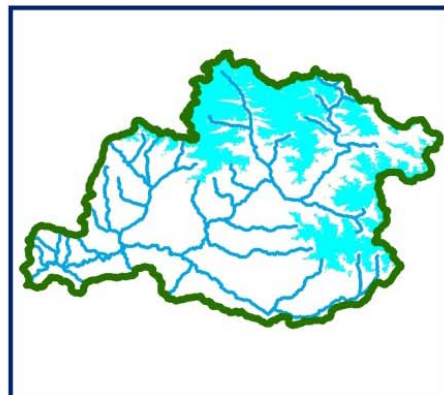
14 MAY 2013



16 MAY 2013



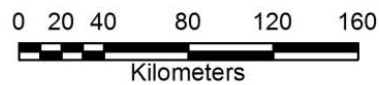
23 MAY 2013



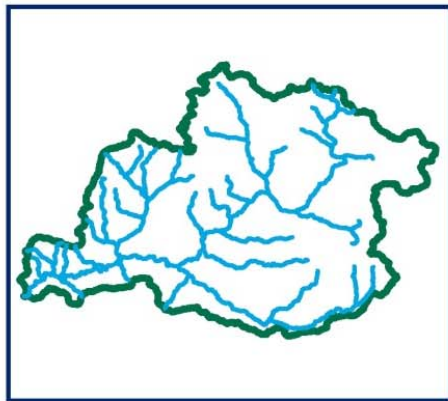
28 MAY 2013



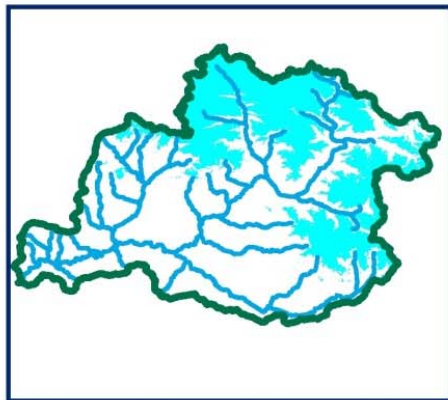
SNOW



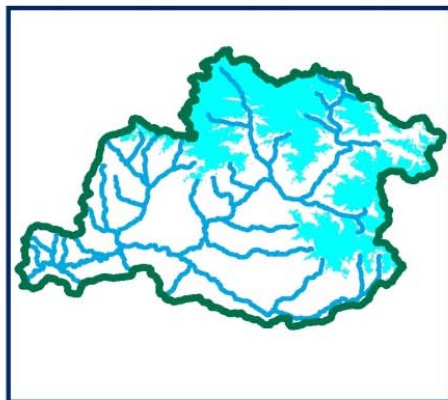
**10 DAILY SNOW COVER MAP: ALAKNANDA BASIN**



DATA USED  
DATA NOT AVAILABLE



DATA USED  
16 MAY 2013



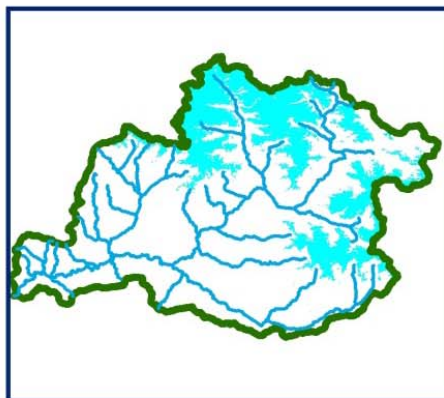
DATA USED  
18 MAY 2013



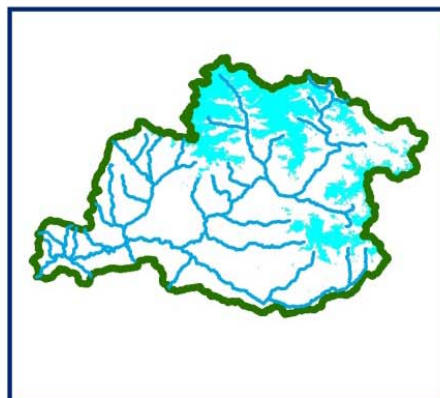
SNOW



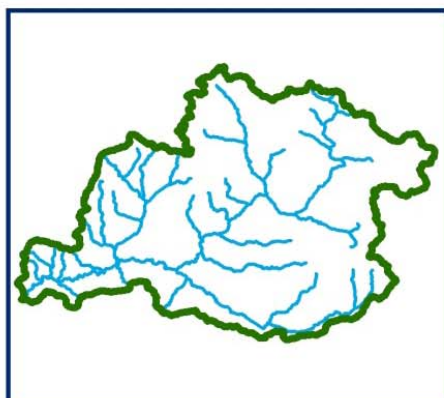
# SNOW COVER MAP : ALAKNANDA BASIN



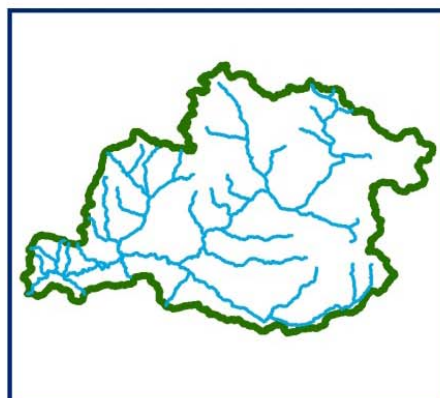
4 JUNE 2013



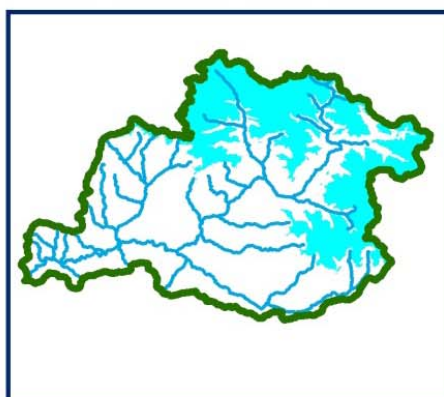
7 JUNE 2013



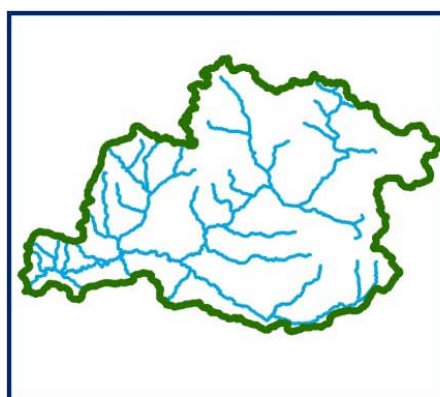
DATA NOT AVAILABLE



DATA NOT AVAILABLE



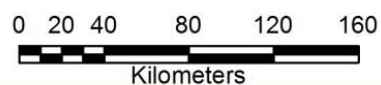
21 JUNE 2013



DATA NOT AVAILABLE

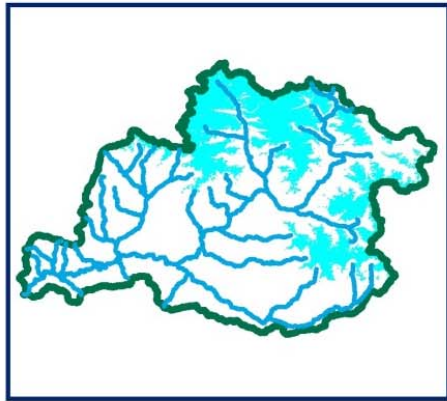


SNOW

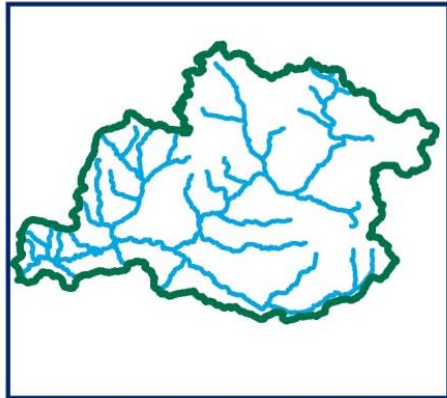




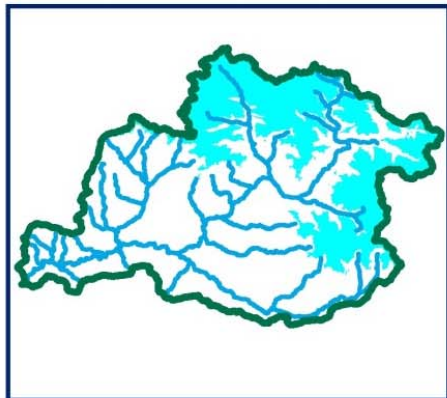
**10 DAILY SNOW COVER MAP: ALAKNANDA BASIN**



DATA USED  
**7 JUNE 2013**



DATA USED  
**DATA NOT AVAILABLE**



DATA USED  
**21 JUNE 2013**



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 (%)
<b>October 2012</b>							
<b>1</b>	04-Oct-2012	1392	19	<b>7</b>	22-Oct-2012	2349	32
<b>2</b>	05-Oct-2012	1717	23	<b>8</b>	24-Oct-2012	2152	29
<b>3</b>	07-Oct-2012	1061	14	<b>9</b>	26-Oct-2012	2469	33
<b>4</b>	09-Oct-2012	3278	44	<b>10</b>	28-Oct-2012	3445	46
<b>5</b>	10-Oct-2012	2008	27	<b>11</b>	29-Oct-2012	2470	33
<b>6</b>	11-Oct-2012	1710	23	<b>12</b>	31-Oct-2012	2158	29
<b>November 2012</b>							
<b>10</b>	02-Nov-2012	2328	31	<b>15</b>	10-Nov-2012	1085	15
<b>11</b>	03-Nov-2012	2242	30	<b>16</b>	12-Nov-2012	2343	32
<b>12</b>	05-Nov-2012	1737	24	<b>17</b>	15-Nov-2012	1520	20
<b>13</b>	07-Nov-2012	2080	28	<b>18</b>	17-Nov-2012	1628	22
<b>14</b>	09-Nov-2012	1503	20	<b>19</b>	26-Nov-2012	2010	27
				<b>20</b>	27-Nov-2012	1942	26
<b>December 2012</b>							
<b>21</b>	09-Dec-2012	1844	25	<b>23</b>	25-Dec-2012	2989	40
<b>22</b>	23-Dec-2012	2410	32				
<b>January 2013</b>							
<b>24</b>	09-Jan-2013	2468	33	<b>27</b>	14-Jan-2013	2824	38
<b>25</b>	11-Jan-2013	1642	22	<b>26</b>	20-Jan-2013	4719	63
<b>26</b>	13-Jan-2013	3155	42	<b>27</b>	30-Jan-2013	4196	56
<b>February 2013</b>							
<b>32</b>	01-Feb-13	4172	56	<b>34</b>	25-Feb-13	4439	60
<b>33</b>	11-Feb-13	4420	59	<b>35</b>	28-Feb-2013	4289	58
<b>March 2013</b>							
<b>35</b>	05-Mar-2013	3886	52	<b>37</b>	19-Mar-2013	4033	54
<b>36</b>	17-Mar-2013	4381	59	<b>38</b>	26-Mar-2013	3912	52.59
<b>April 2013</b>							
<b>39</b>	12-Apr-2013	3757	51				

<b>40</b>	15- Apr -2013	3640	49				
<b>41</b>	17- Apr -2013	4463	60				
<b>May 2013</b>							
<b>42</b>	01-May-2013	3365	45	<b>46</b>	18-May-2013	3082	41
<b>43</b>	09-May-2013	2657	36	<b>47</b>	20-May-2013	2690	36
<b>44</b>	14-May-2013	3095	42	<b>48</b>	23-May-2013	2960	39
<b>45</b>	16-May-2013	2974	40	<b>49</b>	25-May-2013	2681	36
<b>June 2013</b>							
<b>50</b>	01-June-2013	2473	33	<b>53</b>	21-June-2013	2993	40
<b>51</b>	04-June-2013	2163	29	<b>54</b>	30-June-2013	2935	39
<b>52</b>	07-June-2013	2280	31				

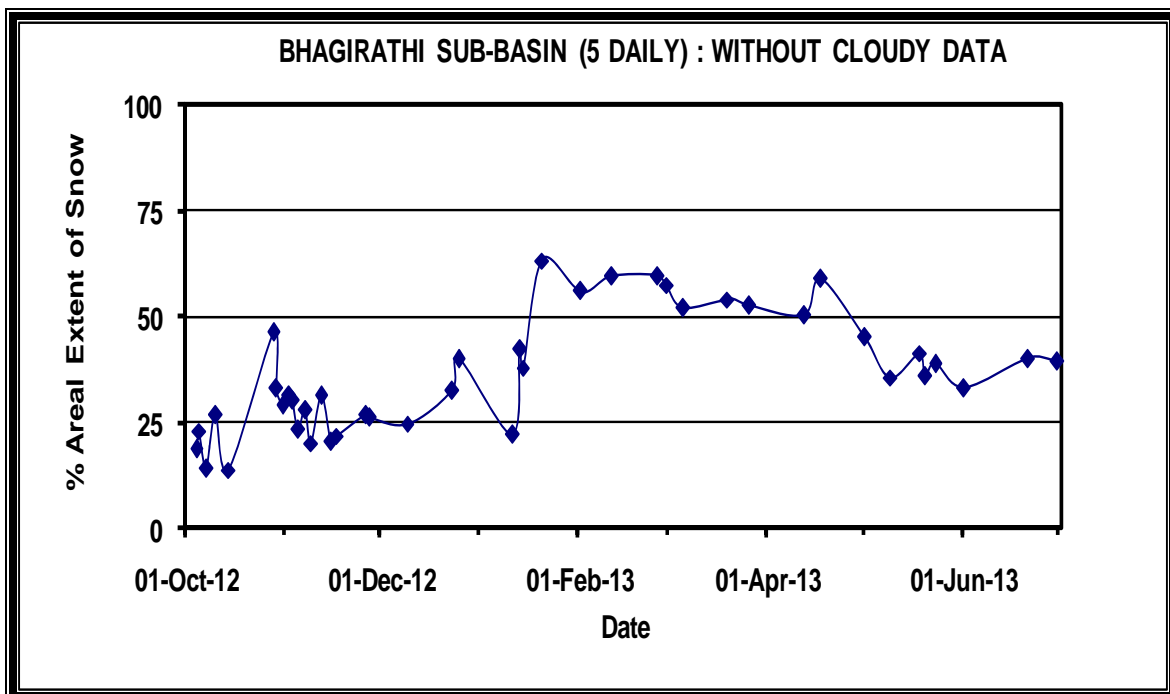
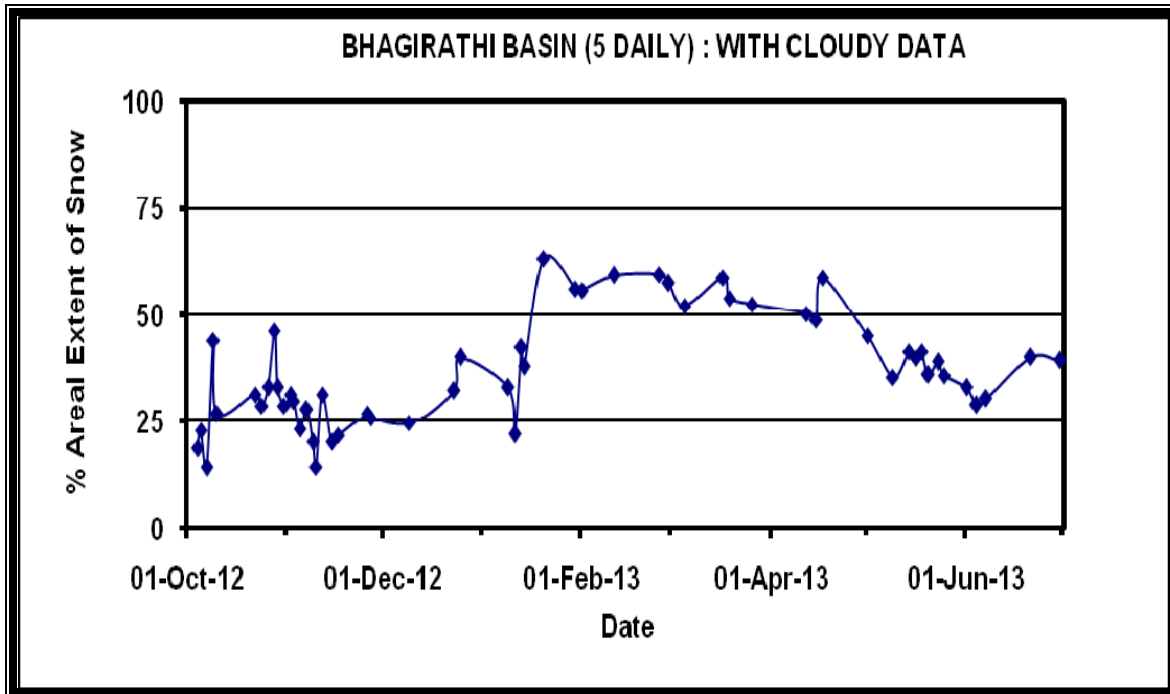
### AREAL EXTENT OF SNOW (10 DAILY)

**BASIN NAME: BHAGIRATHI**

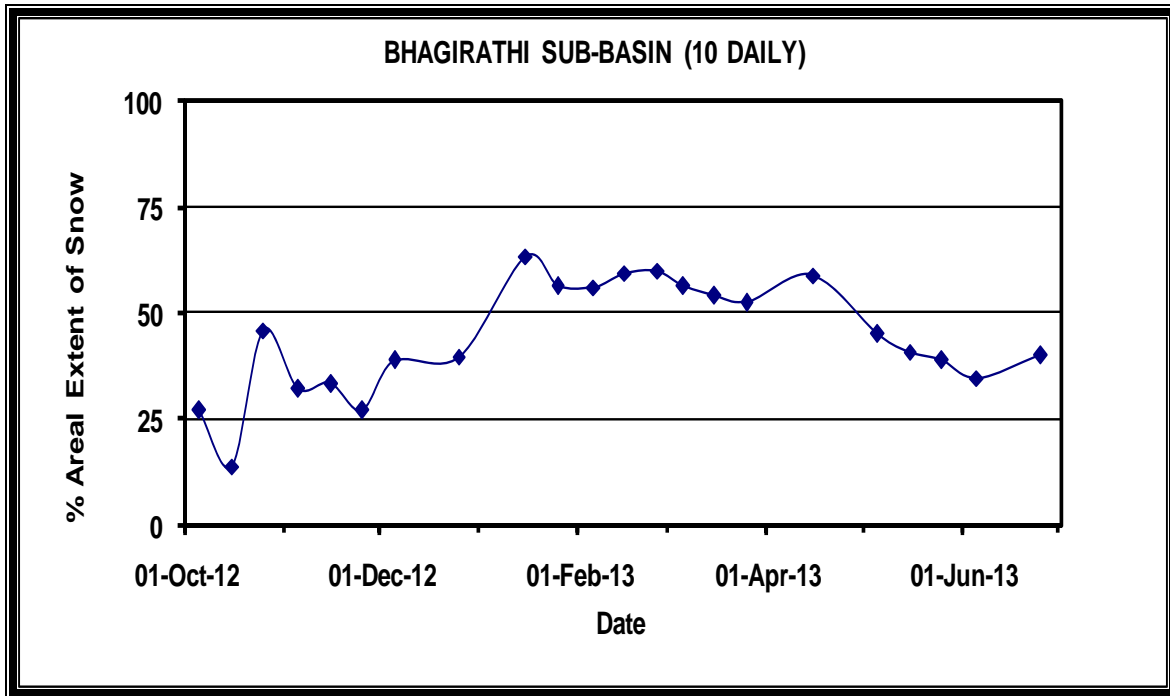
**BASIN AREA: 7438 sq km**

S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
<b>October 2012</b>							
<b>1</b>	05-Oct-2012	2028	27	<b>3</b>	25-Oct-2012	3421	46
<b>2</b>	15-Oct-2012	1041	14				
<b>November 2012</b>							
<b>10</b>	05-Nov-2012	2396	32	<b>12</b>	25-Nov-2012	2008	27
<b>11</b>	15-Nov-2012	2488	33				
<b>December 2012</b>							
<b>13</b>	05-Dec-2012	2889	39	<b>15</b>	25-Dec-2012	2966	40
<b>January 2013</b>							
<b>16</b>	15-Jan-13	4713	63	<b>18</b>	25-Jan-13	4195	56
<b>February 2013</b>							
<b>25</b>	05-Feb-2013	4172	56	<b>27</b>	25-Feb-2013	4463	60
<b>26</b>	15-Feb-2013	4420	59				
<b>March 2013</b>							
<b>29</b>	05-Mar-2013	4206	57	<b>31</b>	25-Mar-2013	3912	53
<b>30</b>	15-Mar-2013	4016	54				
<b>April 2013</b>							
<b>32</b>	15-Apr-2013	4388	59				
<b>May 2013</b>							
<b>46</b>	05-May-2013	3347	45	<b>48</b>	25-May-2013	2887	39
<b>47</b>	15-May-2013	3050	41				
<b>June 2013</b>							
<b>55</b>	05-June-2013	2588	35	<b>56</b>	25-June-2013	2993	40

## Snow cover depletion curve



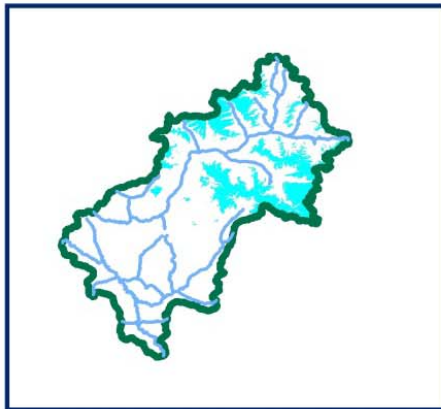
## Snow cover depletion curve



# *SNOW COVER MAP*



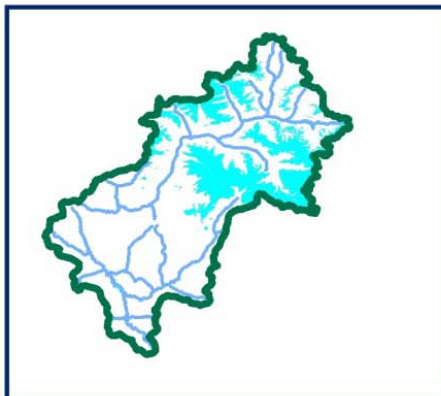
# SNOW COVER MAP : BHAGIRATHI BASIN



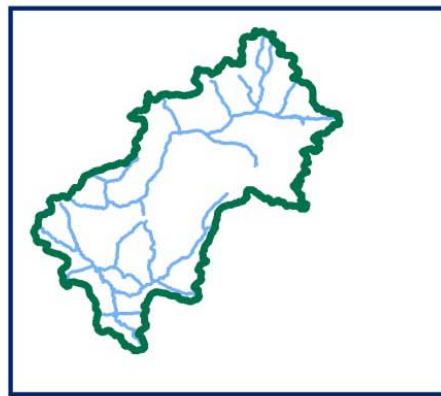
4 OCTOBER 2012



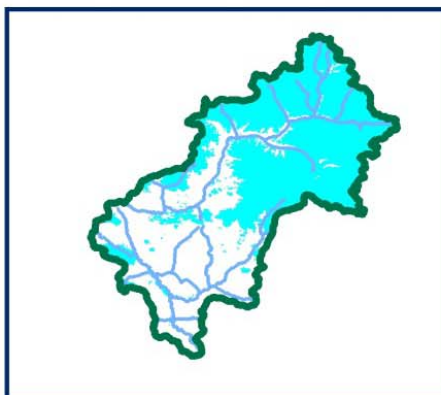
10 OCTOBER 2012



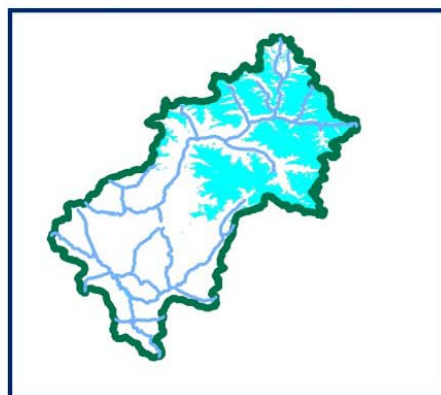
11 OCTOBER 2012



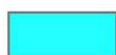
DATA NOT AVAILABLE



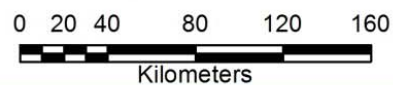
24 OCTOBER 2012



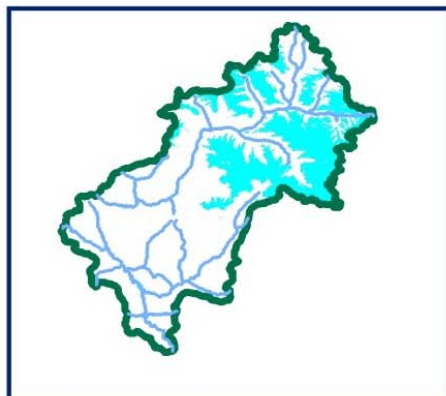
29 OCTOBER 2012



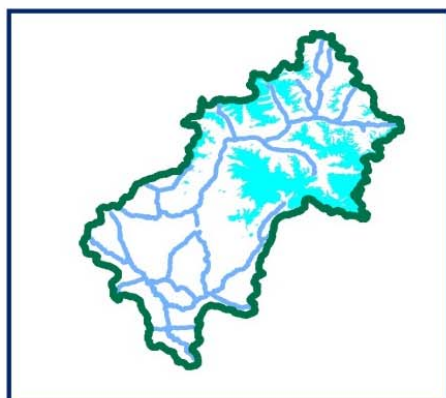
SNOW



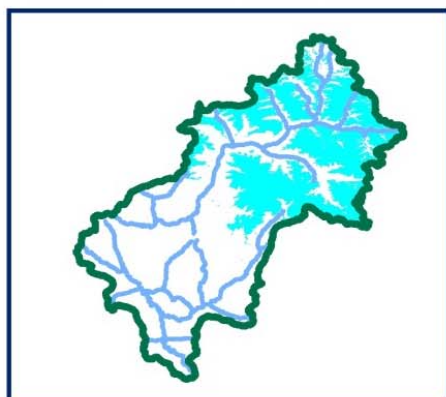
**10 DAILY SNOW COVER MAP: BHAGIRATHI BASIN**



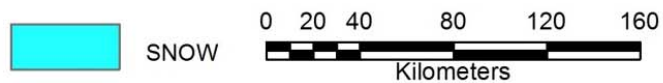
DATA USED  
**5 OCTOBER 2012**



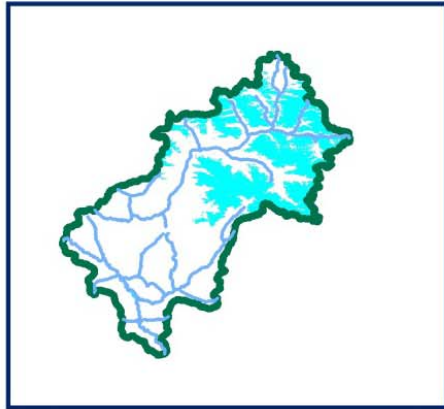
DATA USED  
**14 OCTOBER 2012**



DATA USED  
**28 OCTOBER 2012**



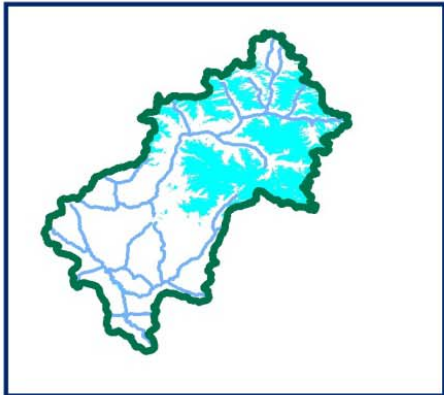
# SNOW COVER MAP : BHAGIRATHI BASIN



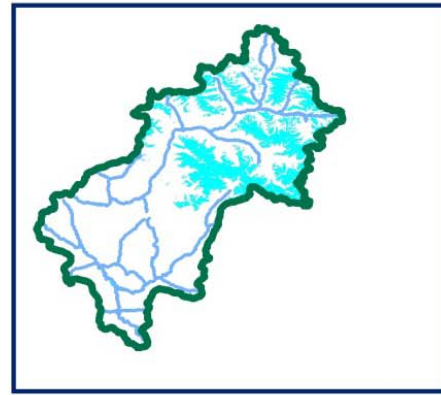
3 NOVEMBER 2012



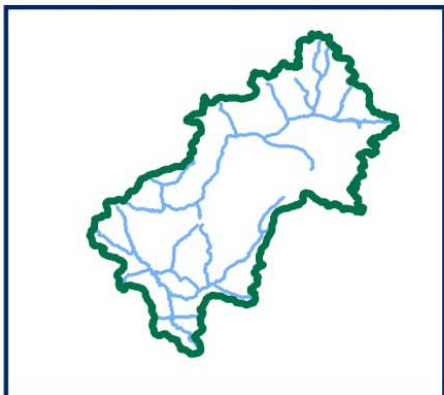
7 NOVEMBER 2012



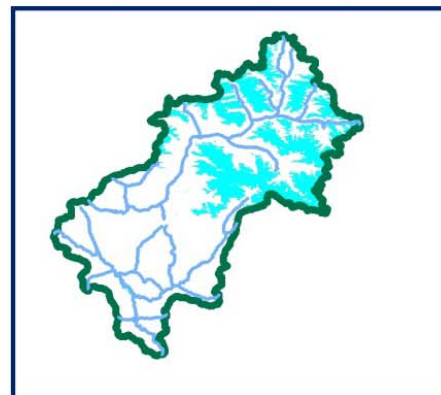
12 NOVEMBER 2012



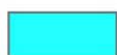
17 NOVEMBER 2012



DATA NOT AVAILABLE



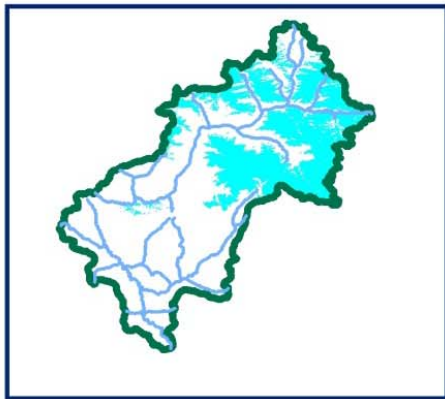
27 NOVEMBER 2012



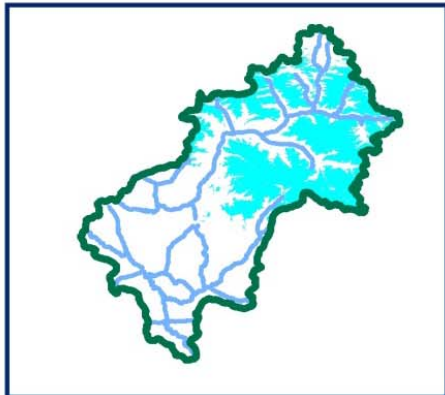
SNOW



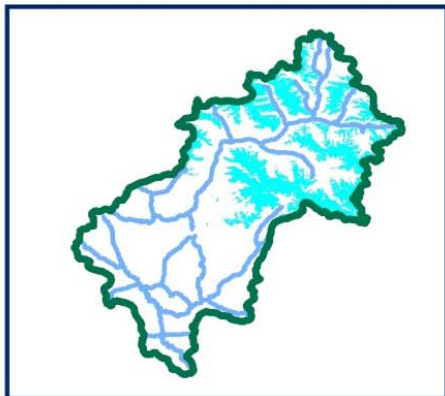
**10 DAILY SNOW COVER MAP: BHAGIRATHI BASIN**



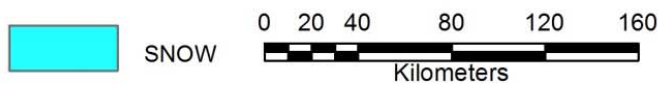
DATA USED  
**2 NOVEMBER 2012**



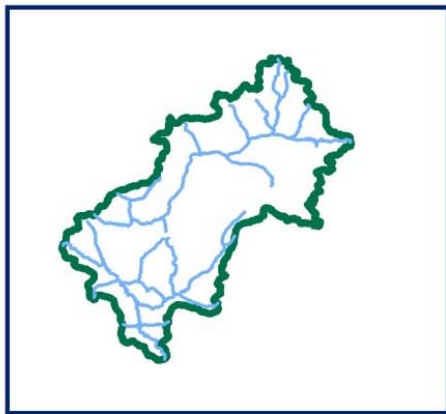
DATA USED  
**12 NOVEMBER 2012**



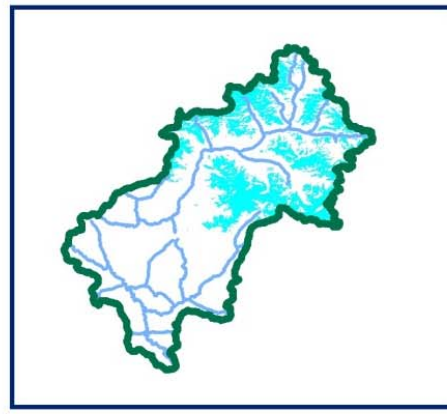
DATA USED  
**26 NOVEMBER 2012**



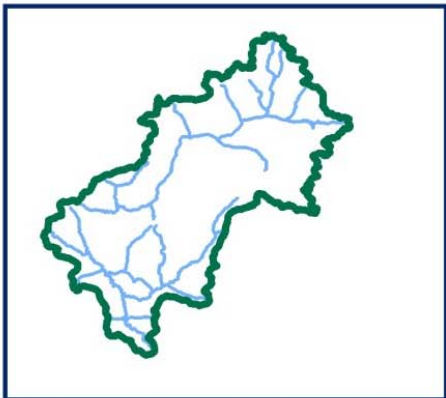
# SNOW COVER MAP : BHAGIRATHI BASIN



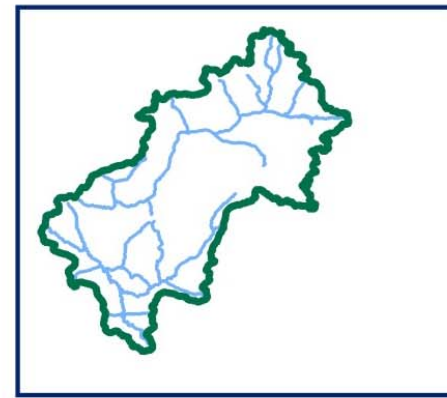
DATA NOT AVAILABLE



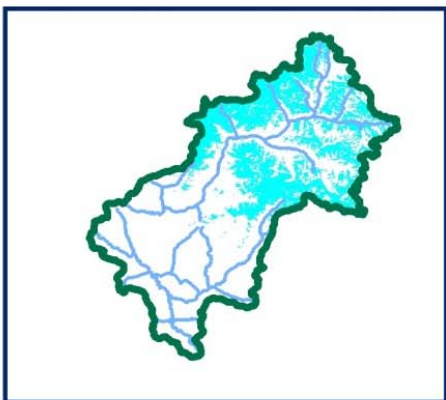
9 DECEMBER 2012



DATA NOT AVAILABLE



DATA NOT AVAILABLE



23 DECEMBER 2012



25 DECEMBER 2012

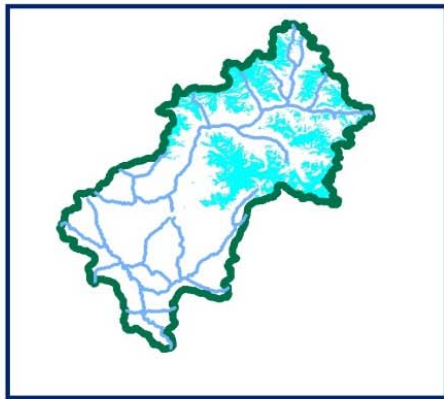


SNOW

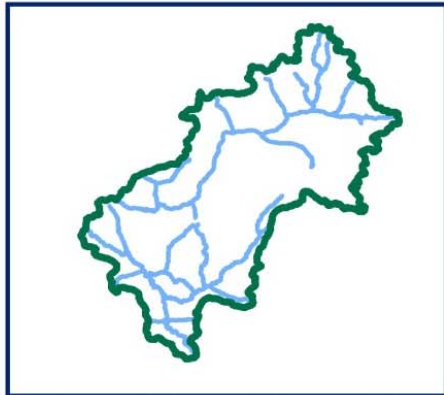




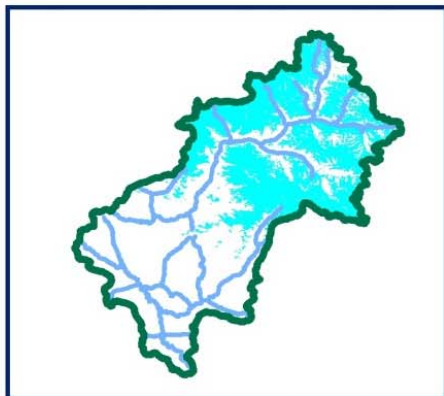
**10 DAILY SNOW COVER MAP: BHAGIRATHI BASIN**



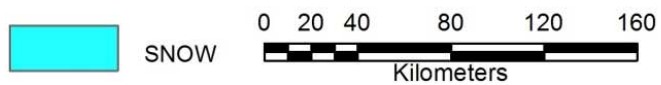
DATA USED  
**09 DECEMBER 2012**



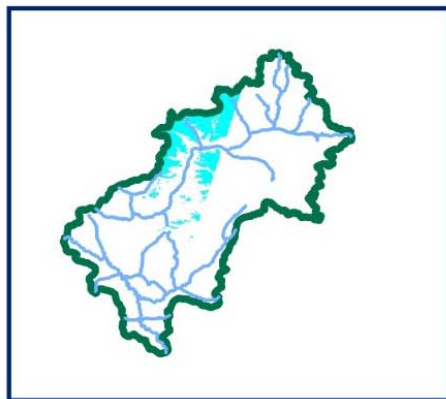
DATA USED  
**DATA NOT AVAILABLE**



DATA USED  
**25 DECEMBER 2012**



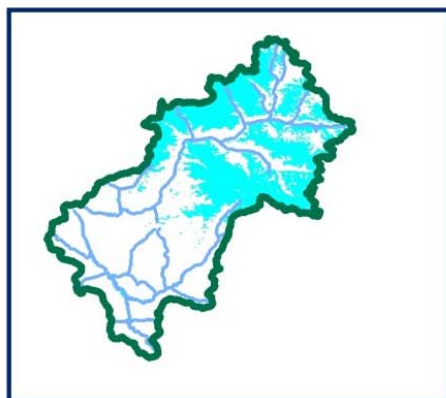
# SNOW COVER MAP : BHAGIRATHI BASIN



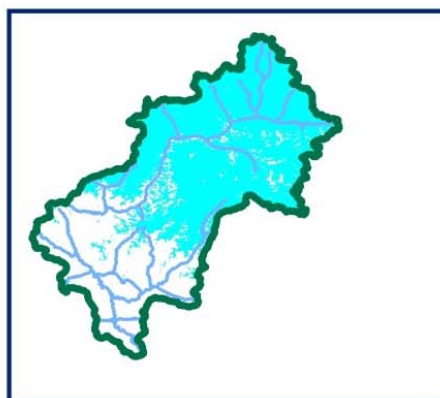
3 JANUARY 2013



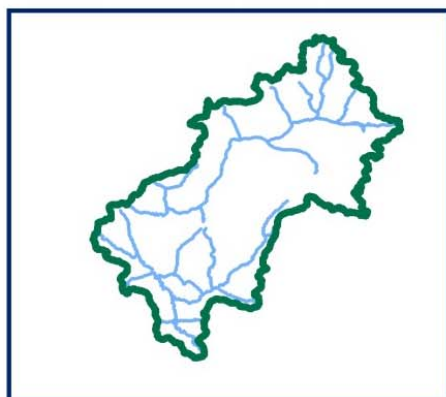
9 JANUARY 2013



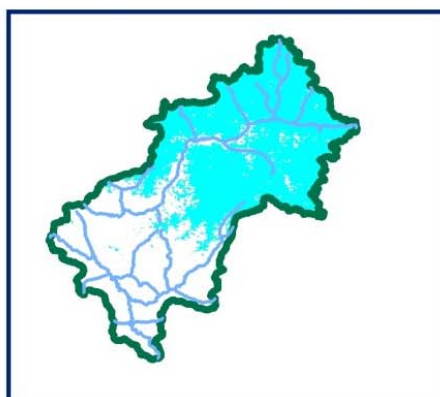
14 JANUARY 2013



20 JANUARY 2013



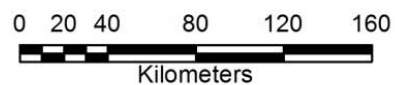
DATA NOT AVAILABLE



30 JANUARY 2013



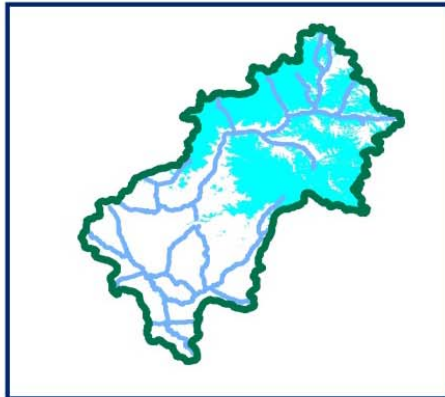
SNOW



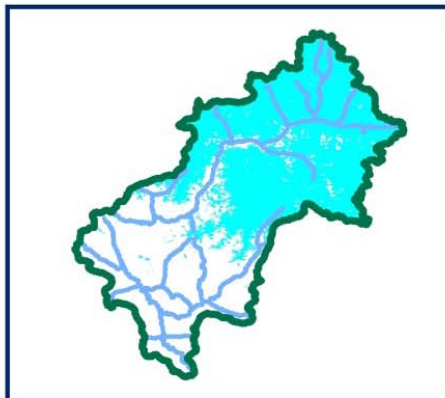
**10 DAILY SNOW COVER MAP: BHAGIRATHI BASIN**



DATA USED  
**9 JANUARY 2013**



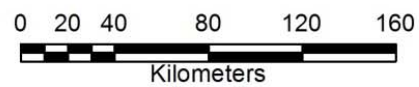
DATA USED  
**13 JANUARY 2013**



DATA USED  
**30 JANUARY 2013**



SNOW

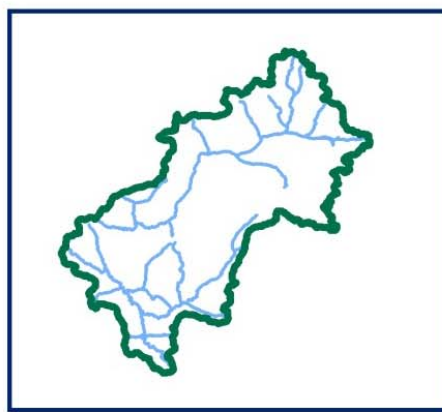




# SNOW COVER MAP : BHAGIRATHI BASIN



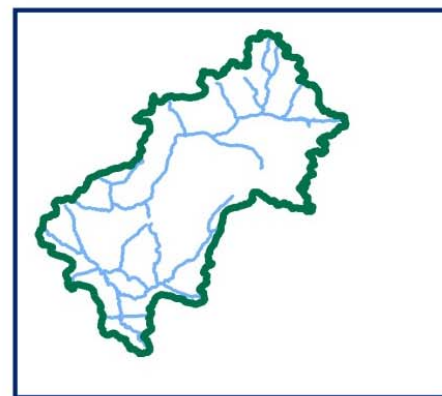
**1 FEBRURY 2013**



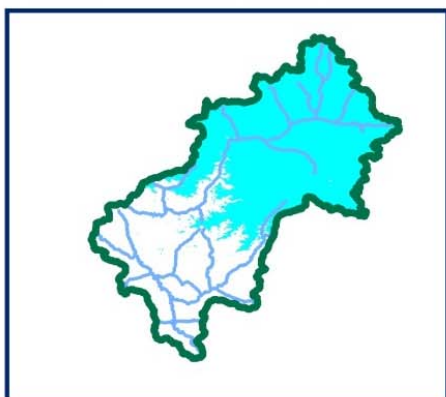
**DATA NOT AVAILABLE**



**11 FEBRURY 2013**



**DATA NOT AVAILABLE**



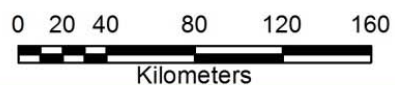
**25 FEBRURY 2013**



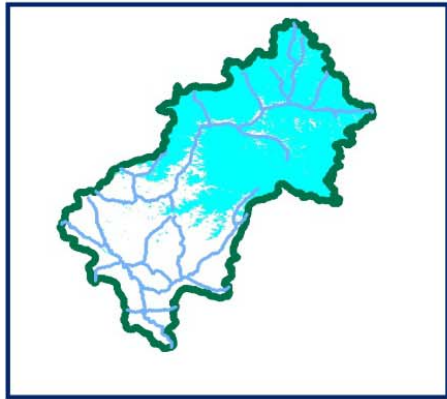
**28 FEBRURY 2013**



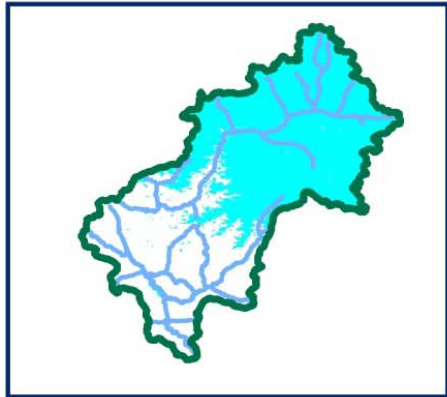
**SNOW**



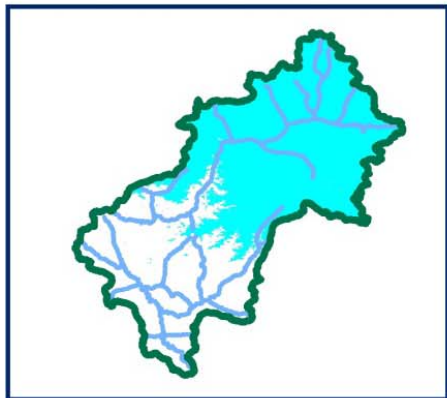
**10 DAILY SNOW COVER MAP: BHAGIRATHI BASIN**



DATA USED  
**1 FEBRUARY 2013**



DATA USED  
**11 FEBRUARY 2013**



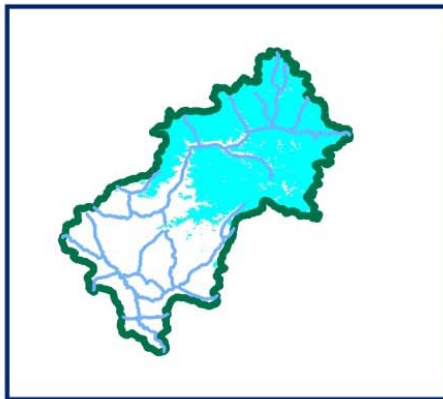
DATA USED  
**25 FEBRUARY 2013**



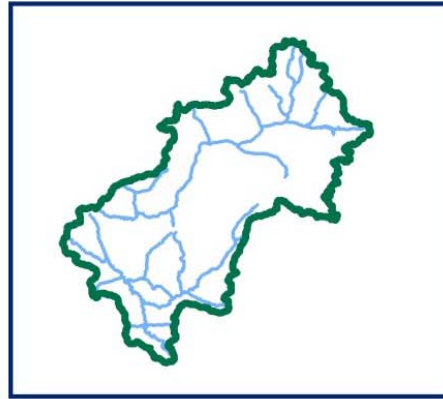
SNOW



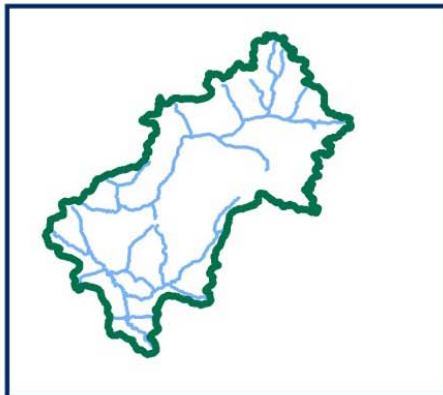
# SNOW COVER MAP : BHAGIRATHI BASIN



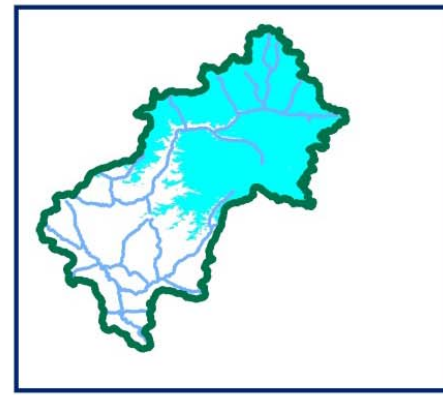
4 MARCH 2013



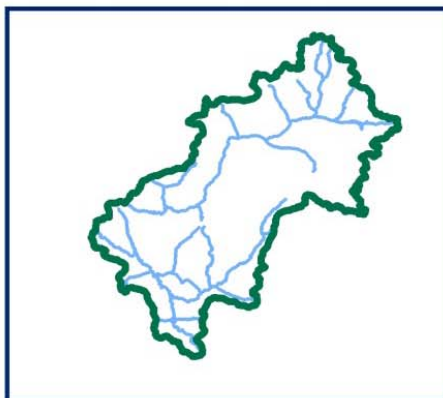
DATA NOT AVAILABLE



DATA NOT AVAILABLE



19 MARCH 2013



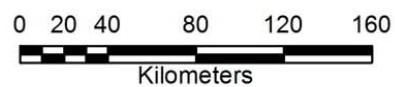
DATA NOT AVAILABLE



26 MARCH 2013



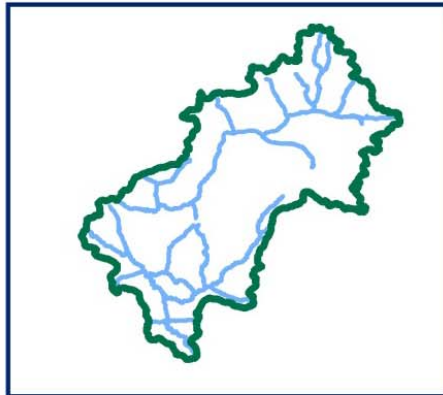
SNOW



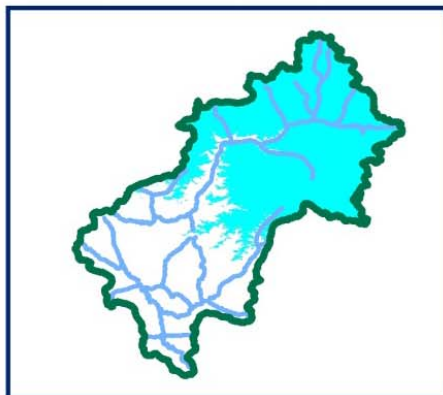
**10 DAILY SNOW COVER MAP: BHAGIRATHI BASIN**



DATA USED  
**5 MARCH 2013**



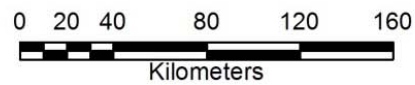
DATA USED  
**DATA NOT AVAILABLE**



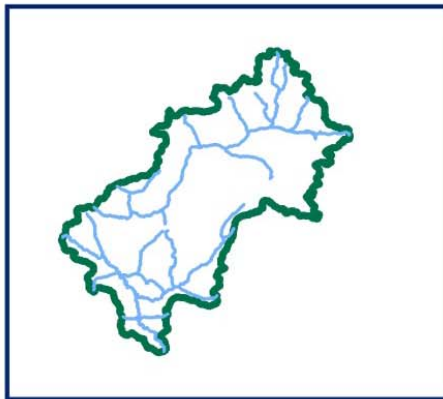
DATA USED  
**19 MARCH 2013**



SNOW



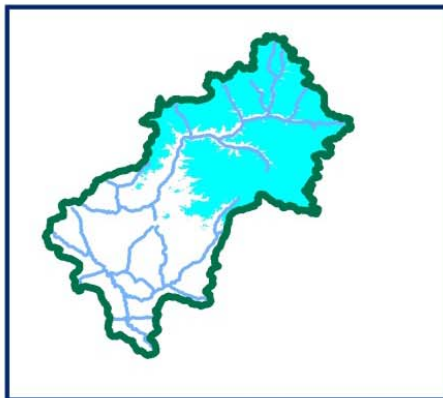
# SNOW COVER MAP : BHAGIRATHI BASIN



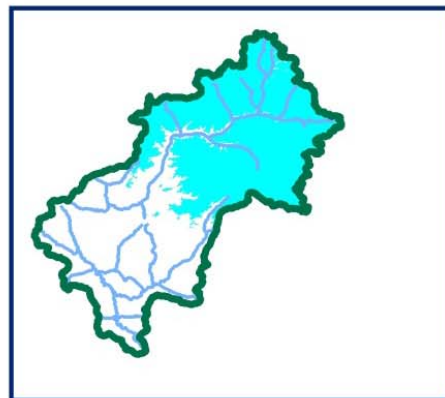
DATA NOT AVAILABLE



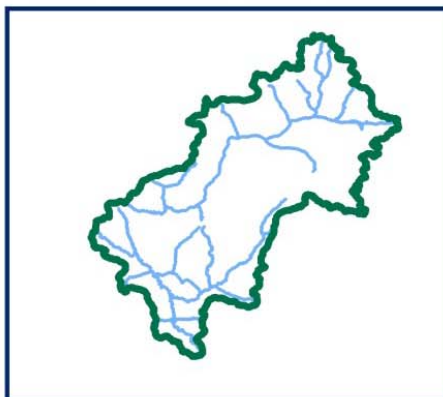
10 APRIL 2013



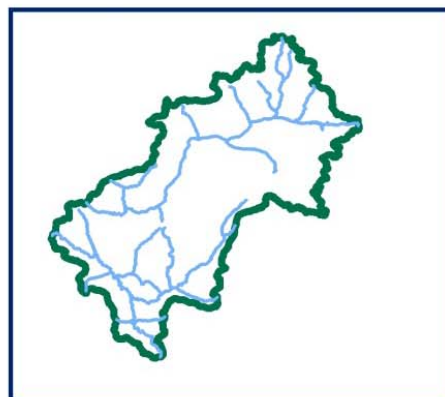
15 APRIL 2013



17 APRIL 2013



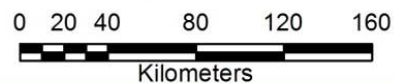
DATA NOT AVAILABLE



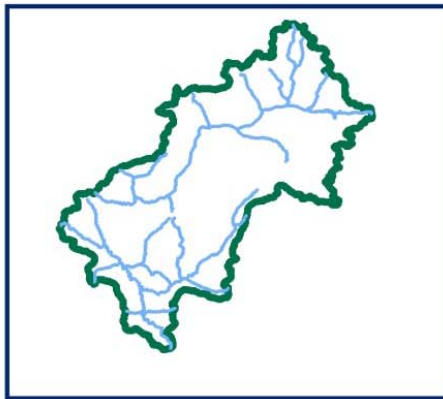
DATA NOT AVAILABLE



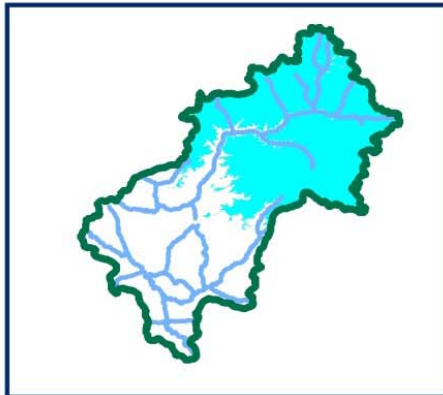
SNOW



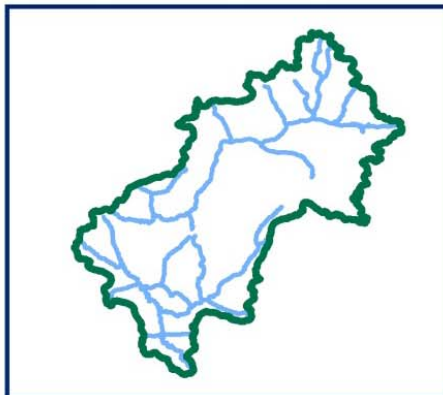
**10 DAILY SNOW COVER MAP: BHAGIRATHI BASIN**



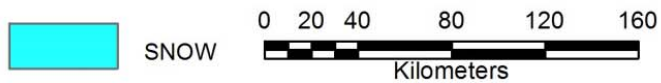
DATA USED  
**DATA NOT AVAILABLE**



DATA USED  
**17 April 2013**

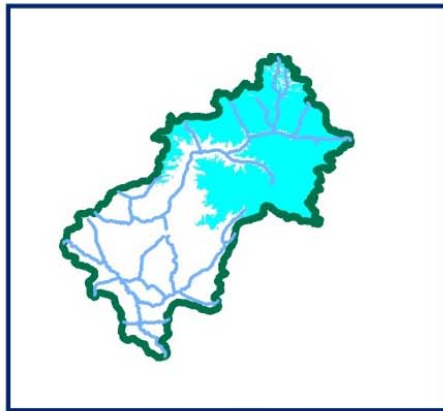


DATA USED  
**DATA NOT AVAILABLE**

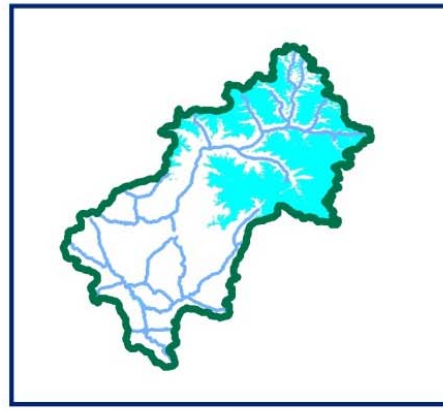




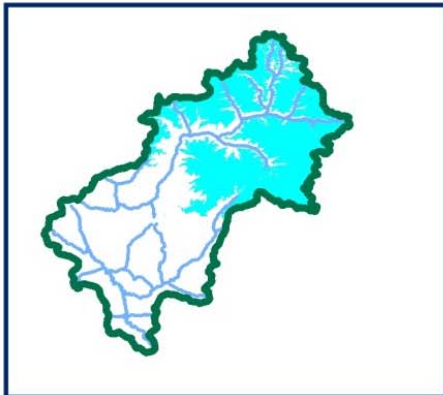
# SNOW COVER MAP : BHAGIRATHI BASIN



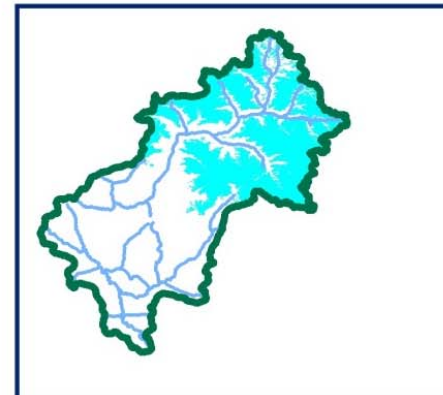
1 MAY 2013



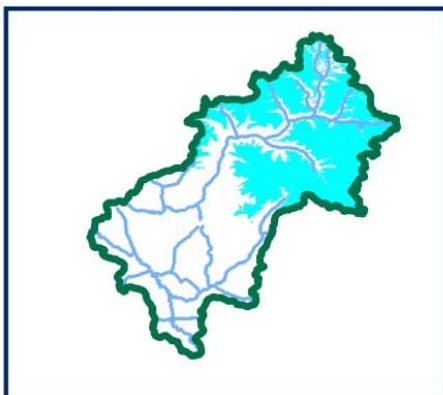
9 MAY 2013



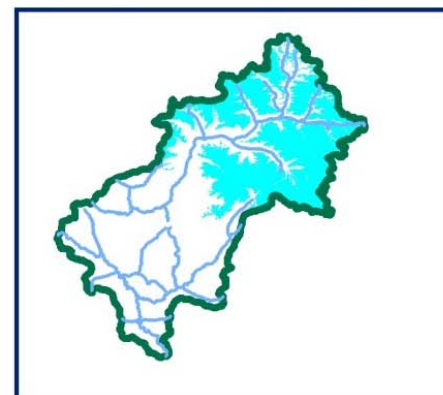
14 MAY 2013



20 MAY 2013



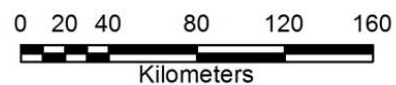
23 MAY 2013



25 MAY 2013



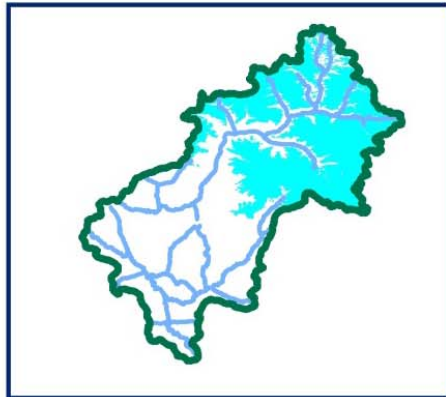
SNOW



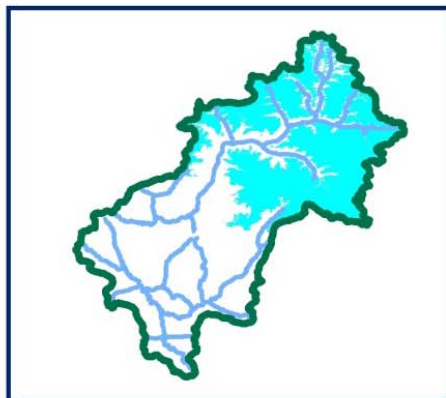
**10 DAILY SNOW COVER MAP: BHAGIRATHI BASIN**



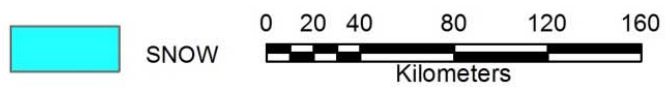
DATA USED  
**9 MAY 2013**



DATA USED  
**20 MAY 2013**

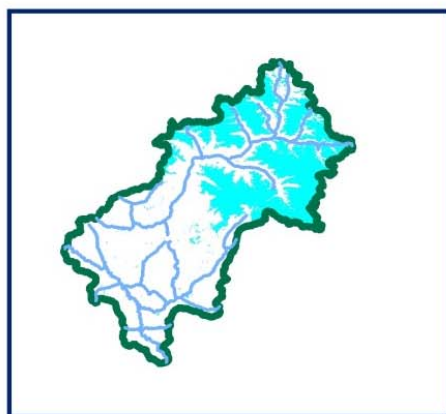


DATA USED  
**23 MAY 2013**





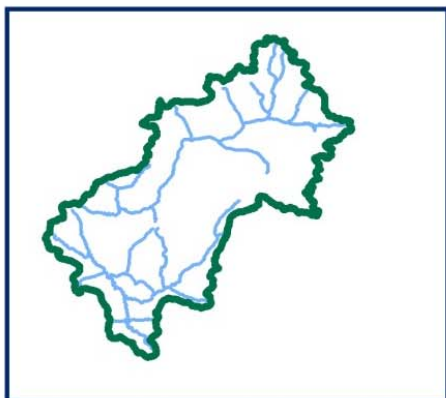
# SNOW COVER MAP : BHAGIRATHI BASIN



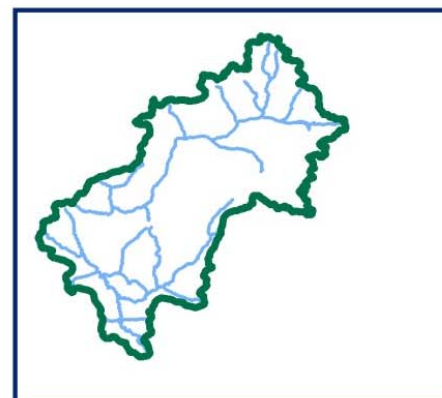
1 JUNE 2013



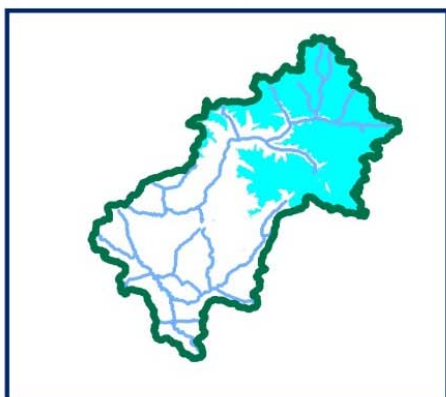
7 JUNE 2013



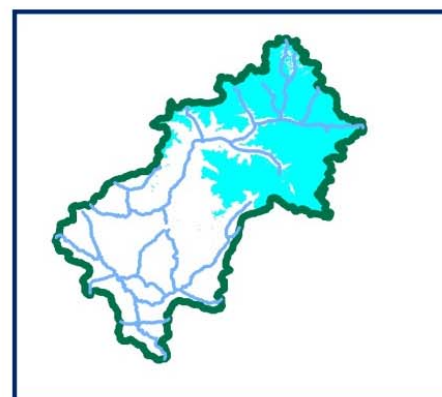
DATA NOT AVAILABLE



DATA NOT AVAILABLE



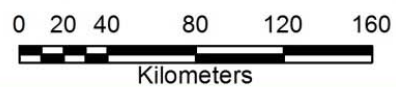
21 JUNE 2013



30 JUNE 2013



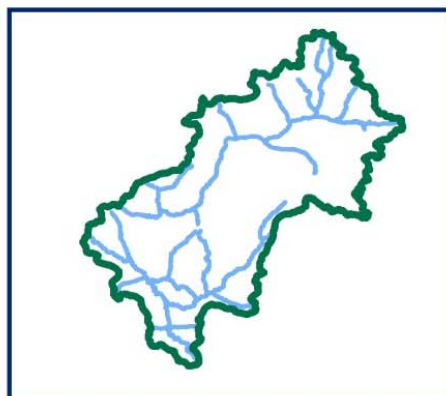
SNOW



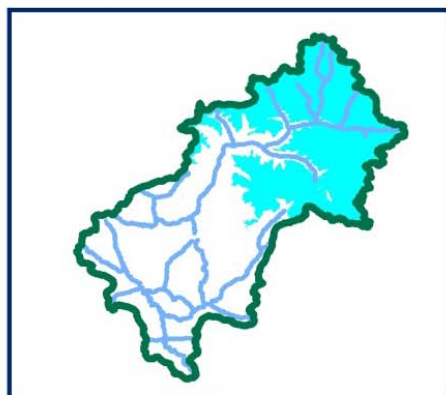
# 10 DAILY SNOW COVER MAP: BHAGIRATHI BASIN



DATA USED  
**1 JUNE 2013**



DATA USED  
**DATA NOT AVAILABLE**



DATA USED  
**21 JUNE 2013**



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 (%)
<b>October 2012</b>							
<b>1</b>	07-Oct-2012	242	7	<b>6</b>	26-Oct-2012	359	10
<b>2</b>	11-Oct-2012	509	14	<b>7</b>	28-Oct-2012	575	16
<b>3</b>	14-Oct-2012	409	14	<b>8</b>	29-Oct-2012	525	15
<b>4</b>	17-Oct-2012	649	18	<b>9</b>	31-Oct-2012	436	12
<b>5</b>	24-Oct-2012	963	27				
<b>November 2012</b>							
<b>10</b>	02-Nov-2012	512	15	<b>14</b>	10-Nov-2012	2755	78
<b>11</b>	04-Nov-2012	357	10	<b>15</b>	12-Nov-2012	682	19
<b>12</b>	07-Nov-2012	458	13	<b>16</b>	17-Nov-2012	425	12
<b>13</b>	09-Nov-2012	277	8	<b>14</b>	26-Nov-2012	479	14
<b>December 2012</b>							
<b>21</b>	01-Dec-2012	1152	33	<b>23</b>	23-Dec-2012	881	25
<b>22</b>	22-Dec-2012	875	25				
<b>January 2013</b>							
<b>24</b>	03-Jan-2013	1131	32	<b>26</b>	13-Jan-2013	1352	38
<b>25</b>	08-Jan-2013	1084	31	<b>27</b>	16-Jan-2013	837	24
<b>26</b>	09-Jan-2013	981	28	<b>28</b>	20-Jan-2013	2514	71
<b>27</b>	11-Jan-2013	734	21	<b>29</b>	27-Jan-2013	2974	84
				<b>30</b>	30-Jan-2013	2088	59
<b>February 2013</b>							
<b>32</b>	01-Feb-13	2498	71	<b>36</b>	18-Feb-2013	2558	73
<b>33</b>	08-Feb-13	2411	68	<b>37</b>	25-Feb-2013	2590	73
<b>34</b>	09-Feb-13	2336	66	<b>38</b>	28-Feb-2013	2050	58
<b>35</b>	11-Feb-13	2912	83	<b>40</b>			
<b>March 2013</b>							
<b>35</b>	04-Mar-2013	1742	49	<b>38</b>	17-Mar-2013	2147	61
<b>36</b>	05-Mar-2013	1699	48	<b>39</b>	19-Mar-2013	1691	48
<b>37</b>	12-Mar-2013	2294	65	<b>40</b>	26-Mar-2013	1516	43
<b>April 2013</b>							
<b>39</b>	12-Apr-2013	1382	39	<b>41</b>	17-Apr-2013	1276	36
<b>40</b>	15-Apr-2013	1237	35	<b>42</b>	19-Apr-2013	1210	34
<b>May 2013</b>							

<b>43</b>	09-May-2013	1093	31	<b>46</b>	23-May-2013	801	23
<b>44</b>	15-May-2013	968	27	<b>47</b>	25-May-2013	721	20
<b>45</b>	16-May-2013	879	25	<b>48</b>	28-May-2013	687	19
<b>46</b>	20-May-2013	798	23				
<b>June 2013</b>							
<b>49</b>	01-June-2013	671	19	<b>51</b>	21-June-2013	706	20

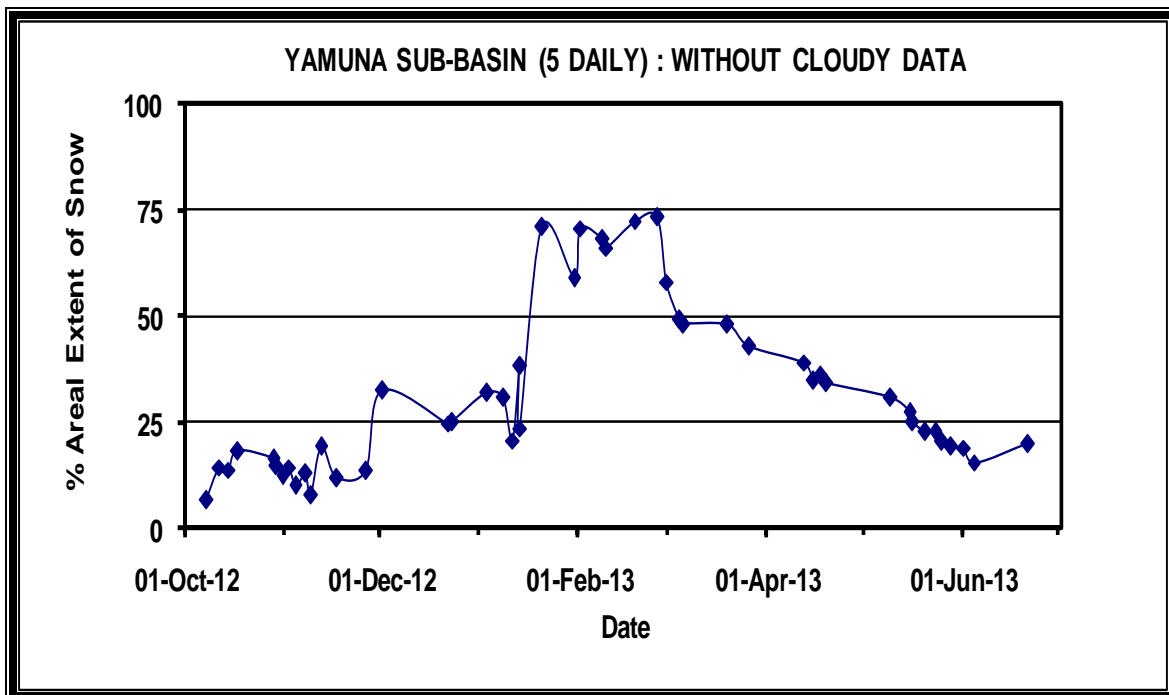
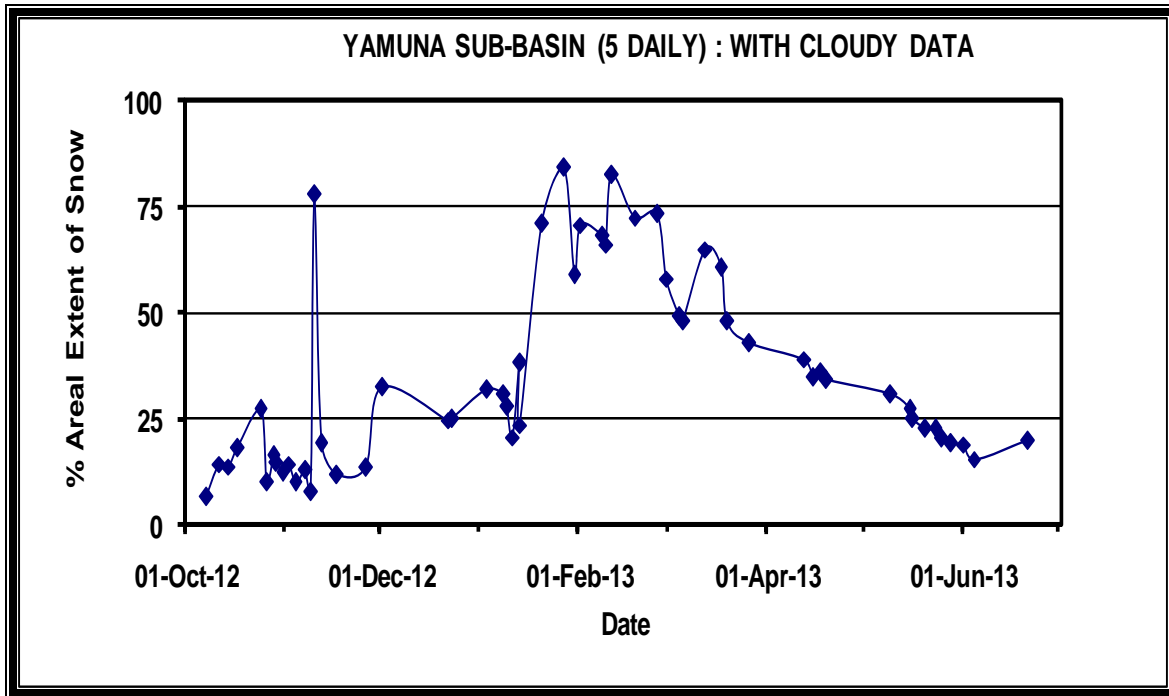
# AREAL EXTENT OF SNOW (10 DAILY)

**BASIN NAME: Yamuna**

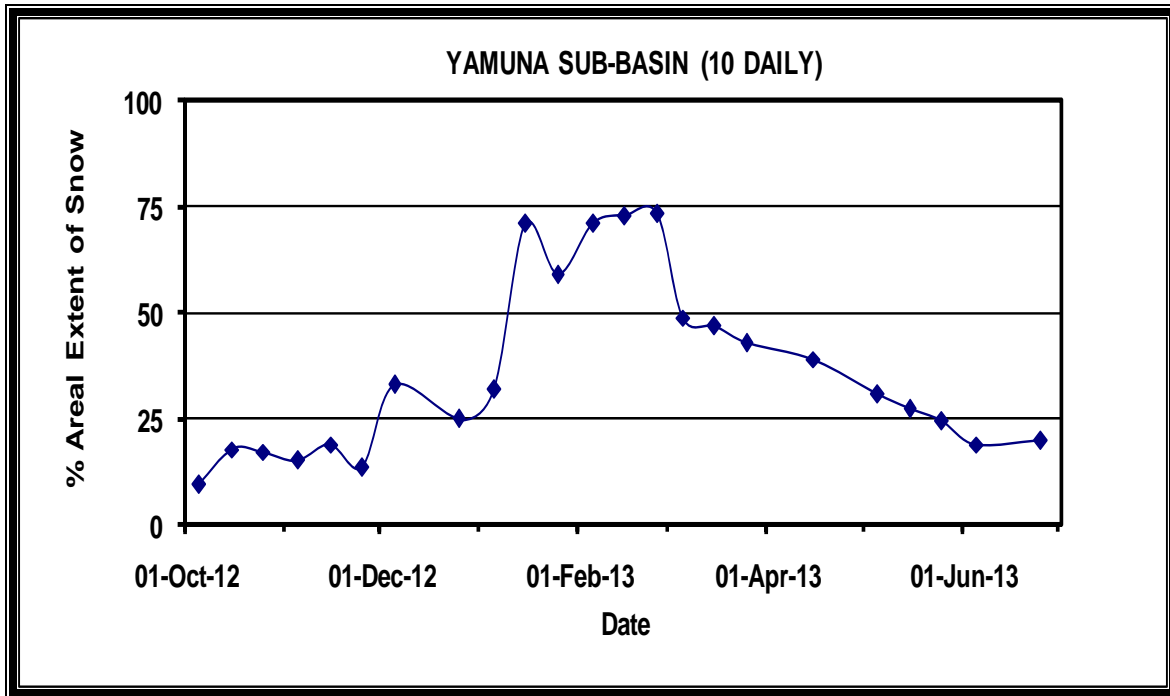
**BASIN AREA: 3527 sq km**

S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
<b>October 2012</b>							
<b>1</b>	05-Oct-2012	338	10	<b>3</b>	25-Oct-2012	612	17
<b>2</b>	15-Oct-2012	635	18				
<b>November 2012</b>							
<b>10</b>	05-Nov-2012	543	15	<b>12</b>	25-Nov-2012	479	14
<b>11</b>	15-Nov-2012	670	19				
<b>December 2012</b>							
<b>13</b>	05-Dec-2012	1163	33	<b>14</b>	25-Dec-2012	881	25
<b>January 2013</b>							
<b>16</b>	05-Jan-13	1128	32	<b>18</b>	25-Jan-13	2081	59
<b>17</b>	15-Jan-13	2504	71				
<b>February 2013</b>							
<b>25</b>	05-Feb-2013	2504	71	<b>27</b>	25-Feb-2013	2590	73
<b>26</b>	15-Feb-2013	2575	73				
<b>March 2013</b>							
<b>29</b>	05-Mar-2013	1728	49	<b>31</b>	25-Mar-2013	1516	43
<b>30</b>	15-Mar-2013	1658	47				
<b>April 2013</b>							
<b>32</b>	15-Apr-2013	1381	39				
<b>May 2013</b>							
<b>46</b>	05-May-2013	1093	31	<b>48</b>	25-May-2013	870	25
<b>47</b>	15-May-2013	968	27				
<b>June 2013</b>							
<b>55</b>	05-June-2013	670	19	<b>56</b>	25-June-2013	715	20

## Snow cover depletion curve



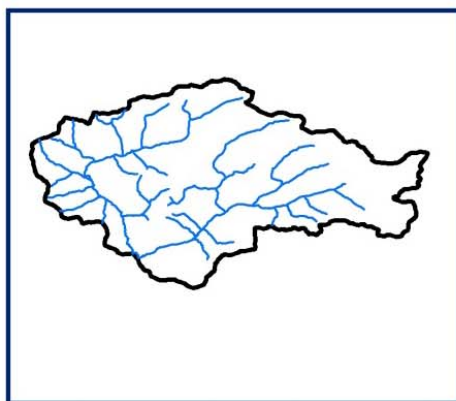
## Snow cover depletion curve



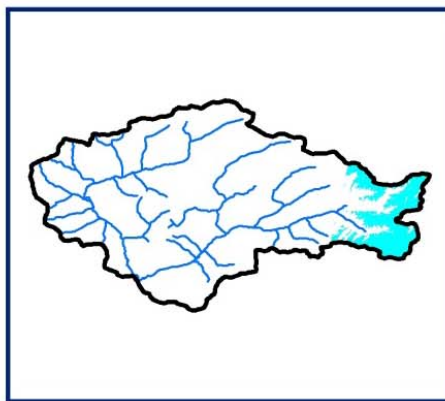


# *SNOW COVER MAP*

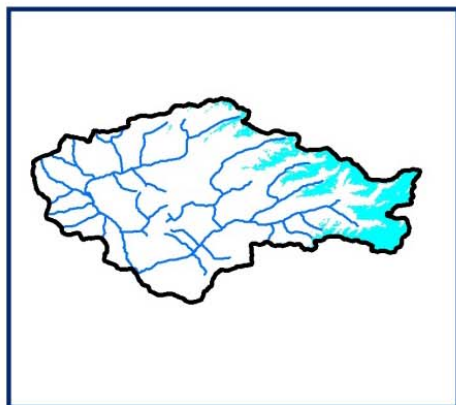
# SNOW COVER MAP : YAMUNA BASIN



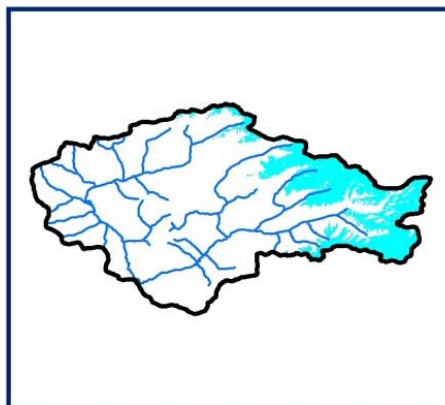
DATA NOT AVAILABLE



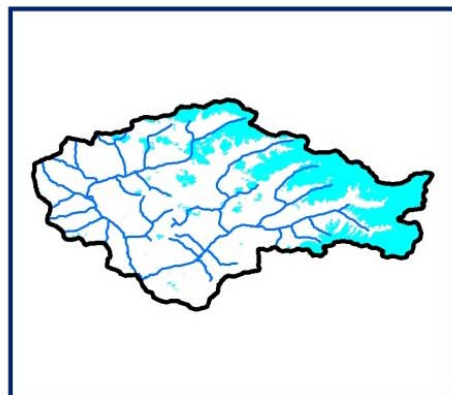
10 OCTOBER 2012



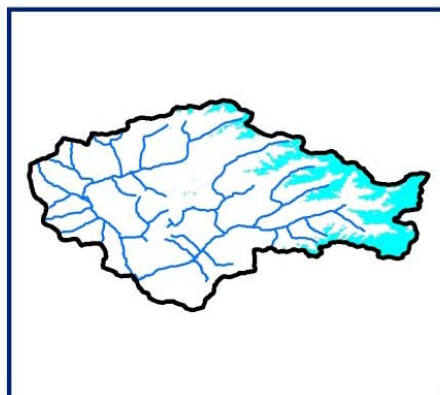
14 OCTOBER 2012



17 OCTOBER 2012



24 OCTOBER 2012



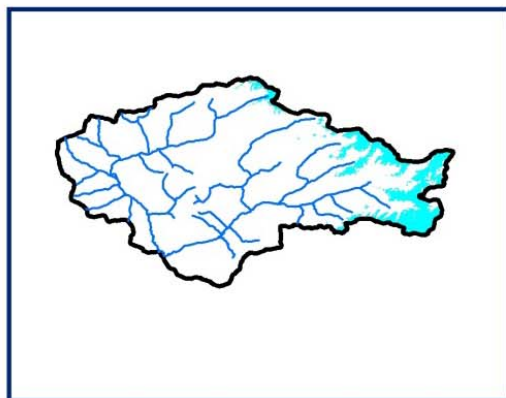
29 OCTOBER 2012



SNOW

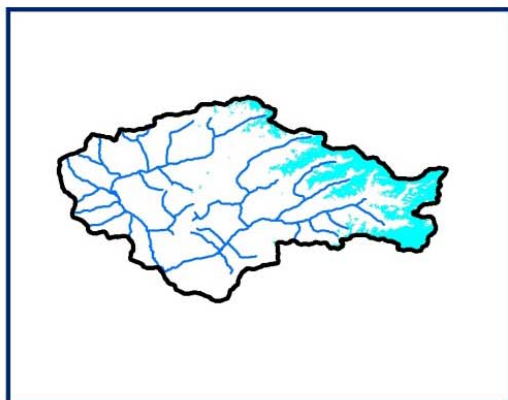


## 10 DAILY SNOW COVER MAP: YAMUNA BASIN

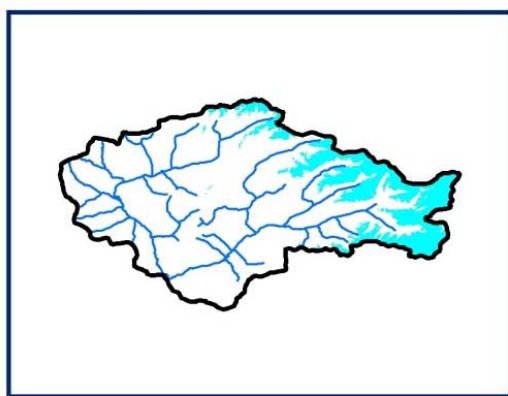


**DATA USED**

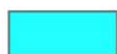
**05 OCTOBER 2012**



**11 OCTOBER 2012**



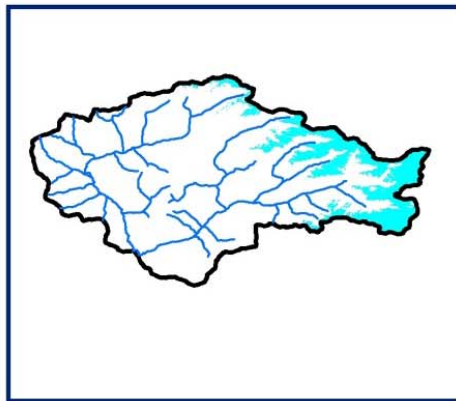
**28 OCTOBER 2012**



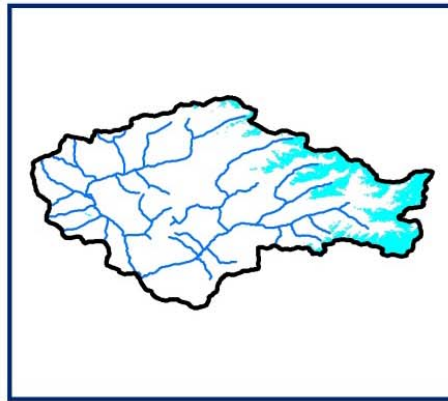
**SNOW**

0 12.5 25 50 75 100  
Kilometers

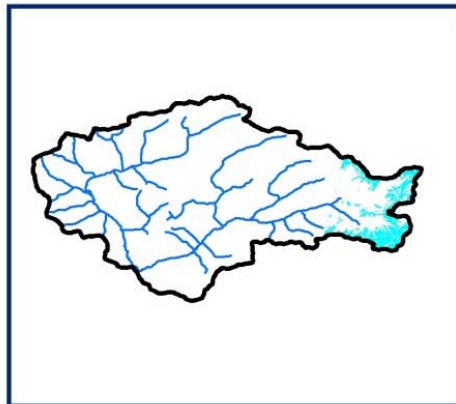
# SNOW COVER MAP : YAMUNA BASIN



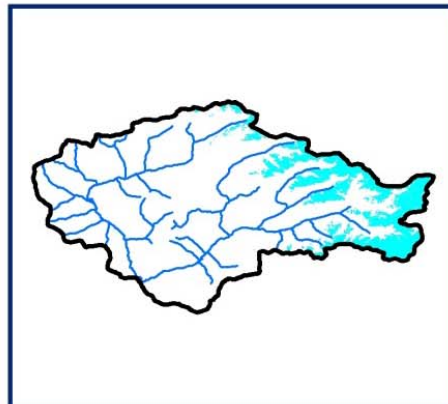
02 NOVEMBER 2012



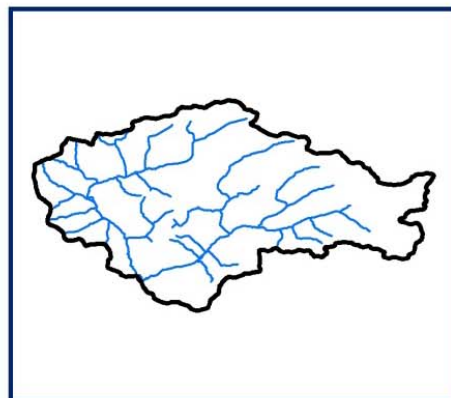
07 NOVEMBER 2012



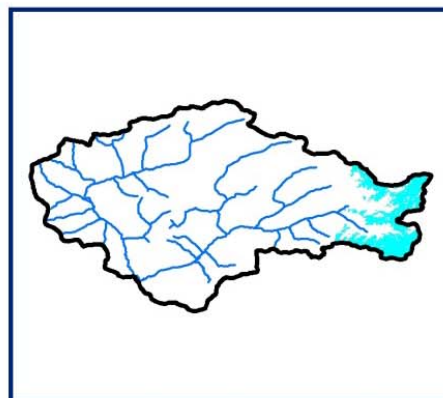
15 NOVEMBER 2012



17 NOVEMBER 2012



DATA NOT AVAILABLE



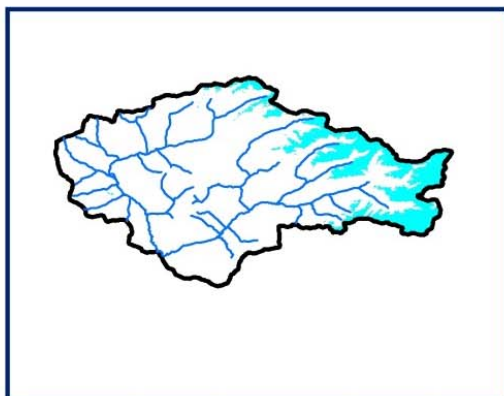
27 NOVEMBER 2012



SNOW

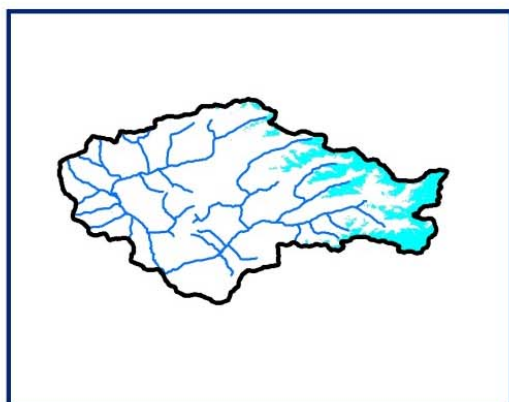


## 10 DAILY SNOW COVER MAP: YAMUNA BASIN

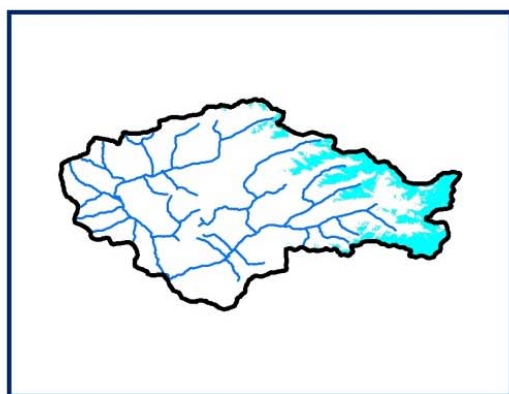


**DATA USED**

**07 NOVEMBER 2012**



**17 NOVEMBER 2012**



**26 NOVEMBER 2012**



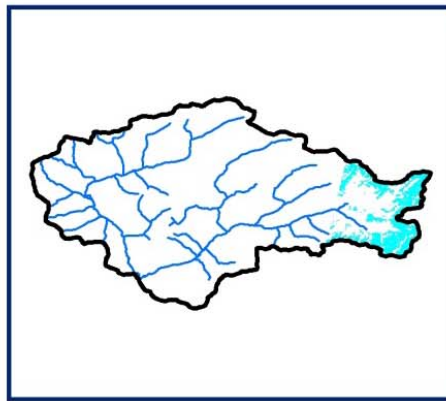
**SNOW**

0 12.5 25 50 75 100  
Kilometers

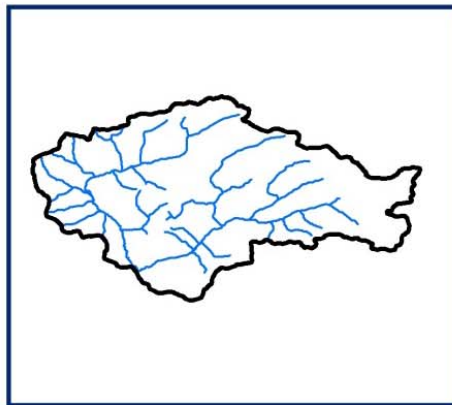
# SNOW COVER MAP : YAMUNA BASIN



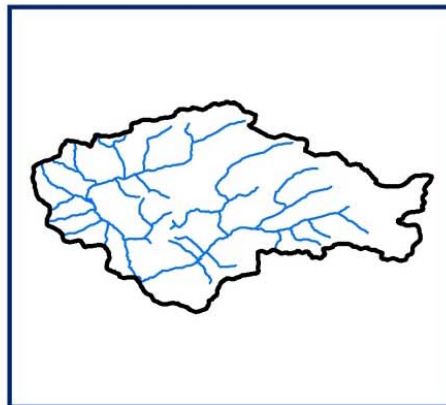
01 DECEMBER 2012



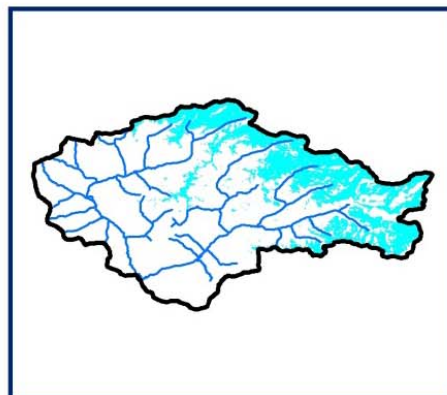
09 DECEMBER 2012



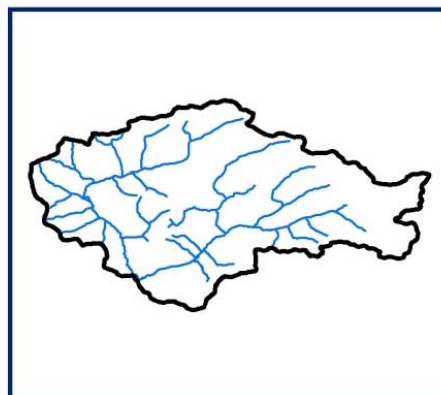
DATA NOT AVAILABLE



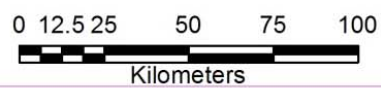
DATA NOT AVAILABLE



22 DECEMBER 2012



DATA NOT AVAILABLE

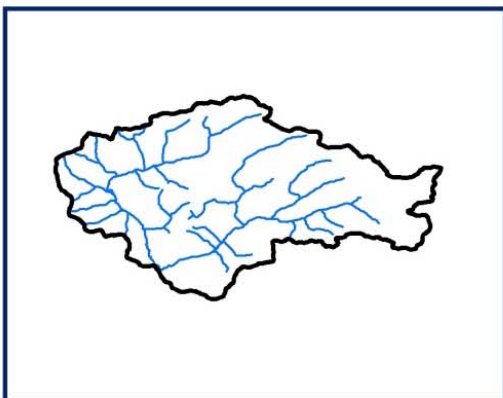


## 10 DAILY SNOW COVER MAP: YAMUNA BASIN

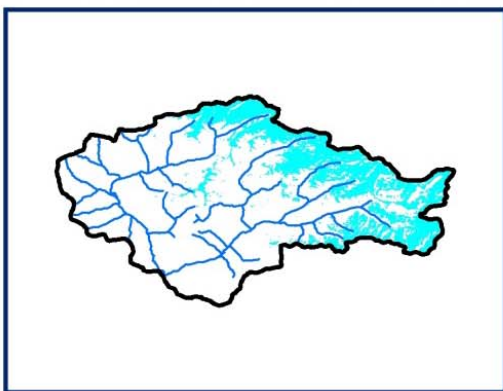


**DATA USED**

**01 DECEMBER 2012**



**DATA NOT AVILABLE**



**23 DECEMBER 2012**

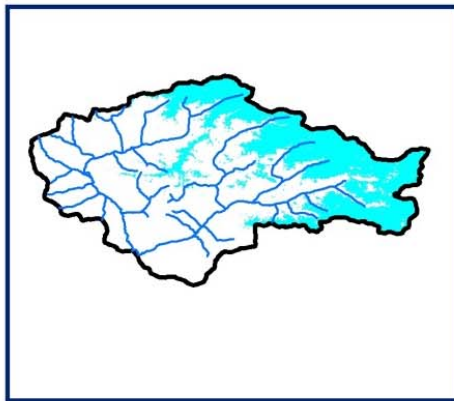


**SNOW**

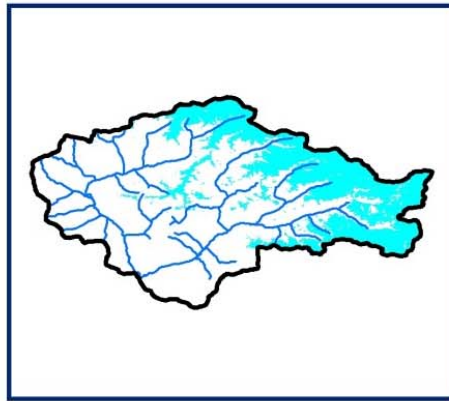
0 12.5 25 50 75 100  
Kilometers



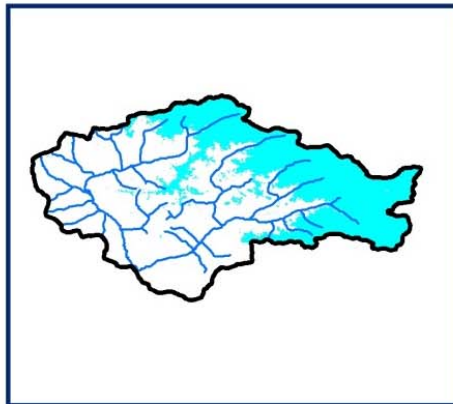
# SNOW COVER MAP : YAMUNA BASIN



03 JANUARY 2013



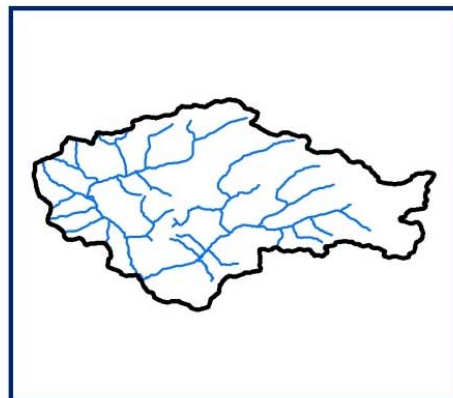
08 JANUARY 2013



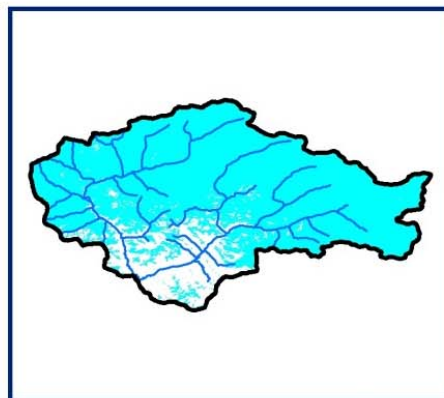
13 JANUARY 2013



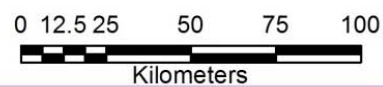
20 JANUARY 2013



DATA NOT AVAILABLE



27 JANUARY 2013



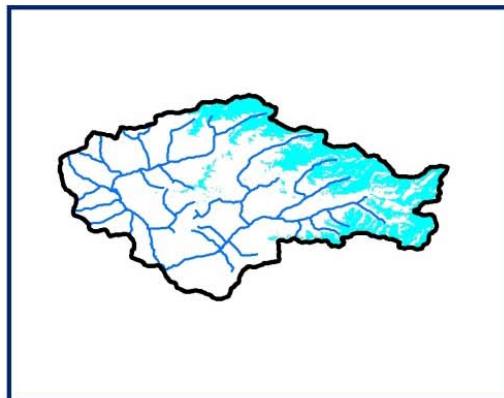


## 10 DAILY SNOW COVER MAP: YAMUNA BASIN

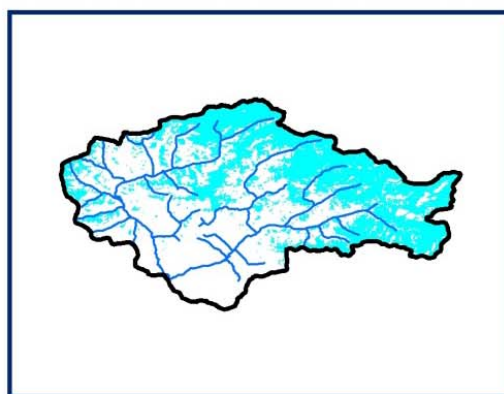


**DATA USED**

**08 JANUARY 2013**



**16 JANUARY 2013**



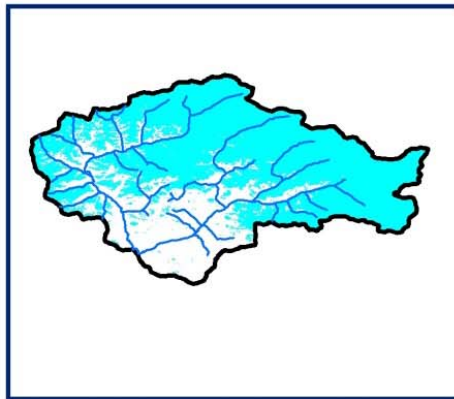
**30 JANUARY 2013**



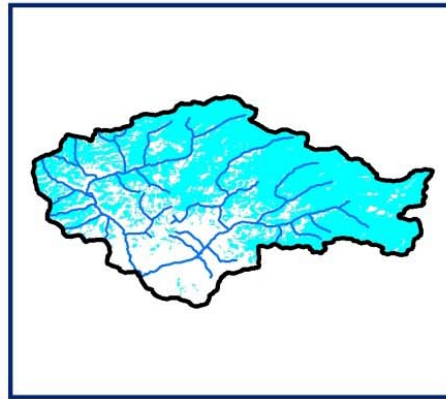
**SNOW**

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Kilometers

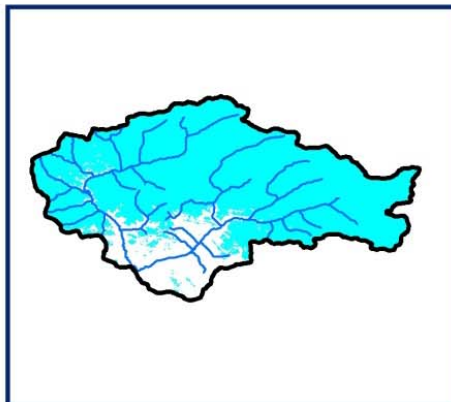
# SNOW COVER MAP : YAMUNA BASIN



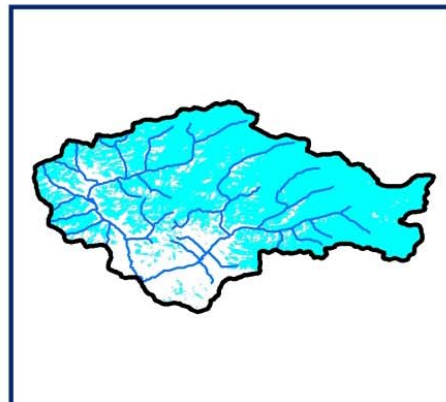
**01 FEBRUARY 2013**



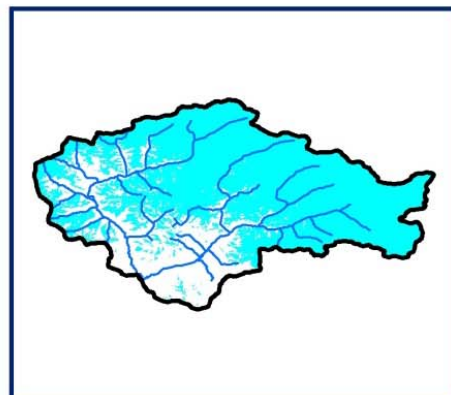
**09 FEBRUARY 2013**



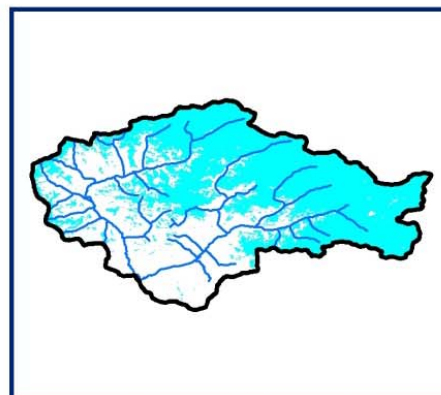
**11 FEBRUARY 2013**



**18 FEBRUARY 2013**



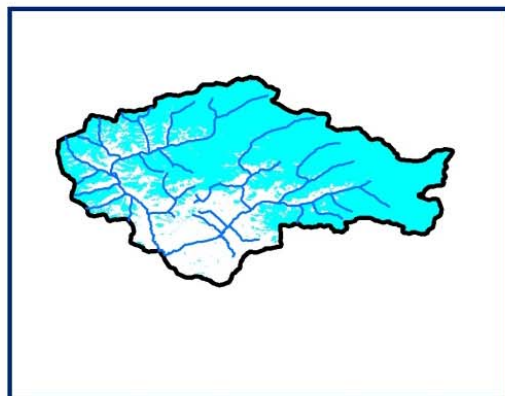
**25 FEBRUARY 2013**



**28 FEBRUARY 2013**



## 10 DAILY SNOW COVER MAP: YAMUNA BASIN

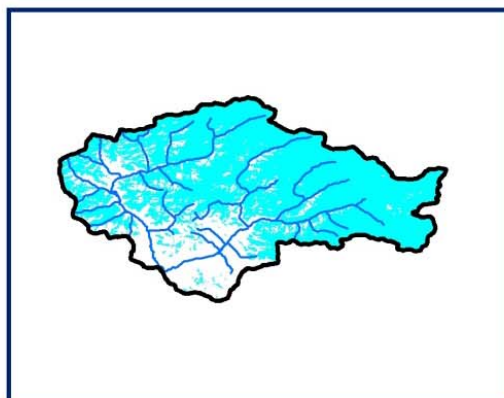


### DATA USED

01 FEBRURY 2013

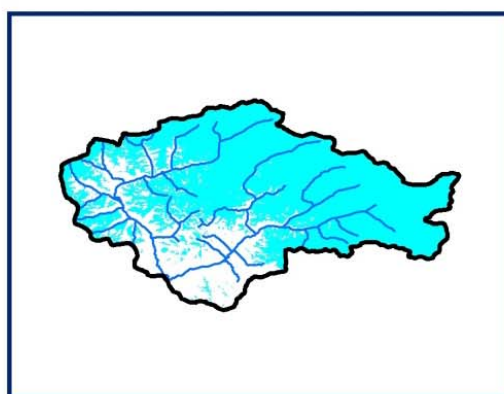
08 FEBRURY 2013

09 FEBRURY 2013



11 FEBRUARY 2013

18 FEBRUARY 2013



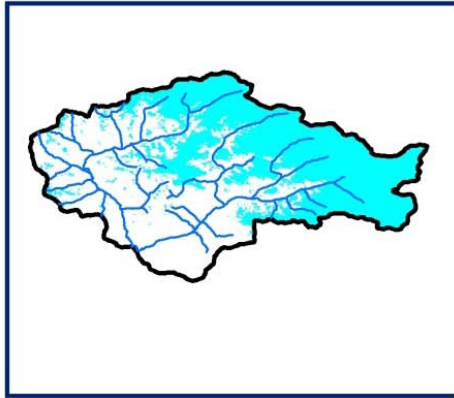
25 FEBRUARY 2013

28 FEBRUARY 2013

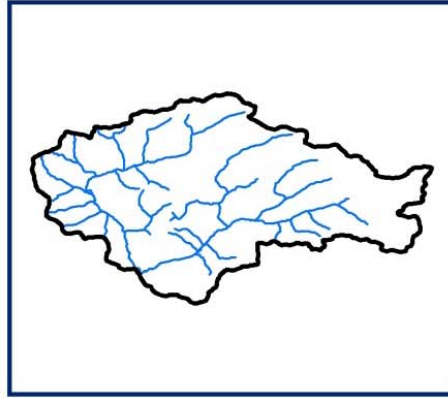


0 12.5 25 50 75 100  
Kilometers

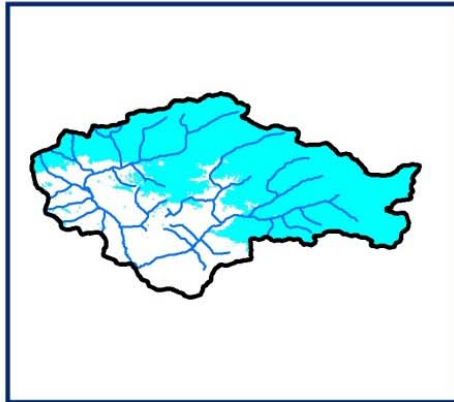
# SNOW COVER MAP : YAMUNA BASIN



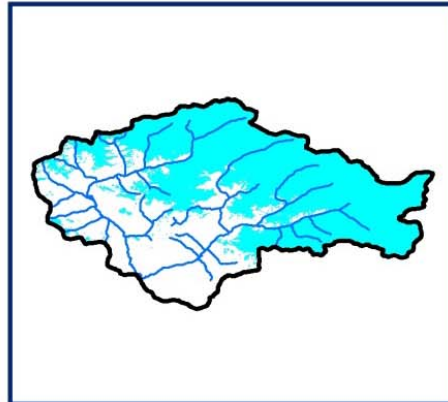
04 MARCH 2013



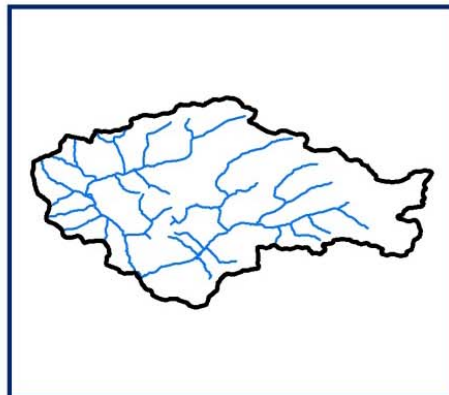
DATA NOT AVAILABLE



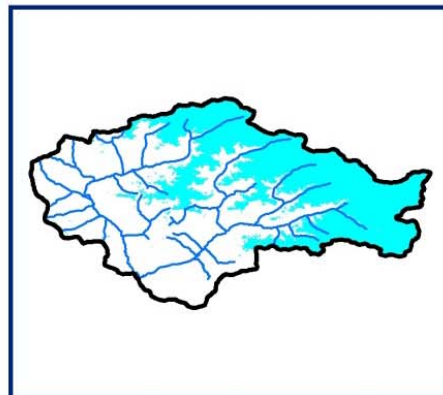
12 MARCH 2013



17 MARCH 2013



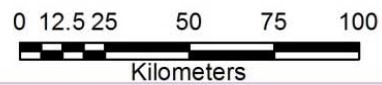
DATA NOT AVAILABLE



26 MARCH 2013



SNOW

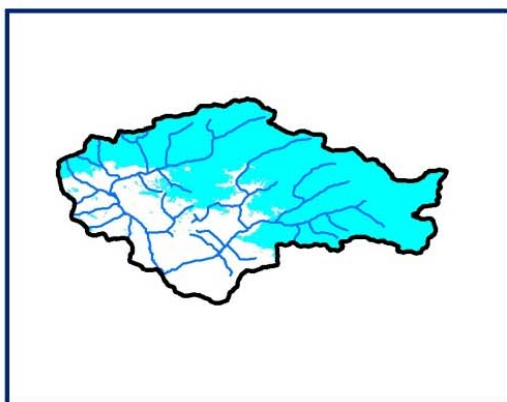


## 10 DAILY SNOW COVER MAP: YAMUNA BASIN

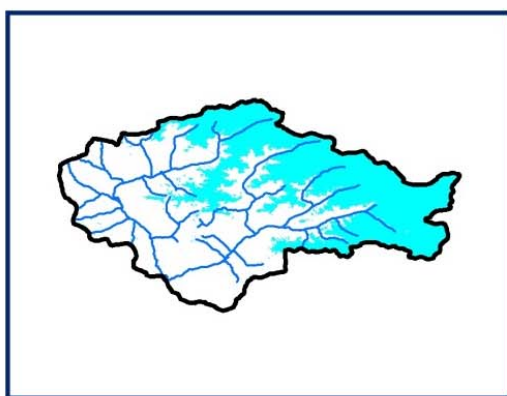


**DATA USED**

**04 MARCH 2013**



**19 MARCH 2013**



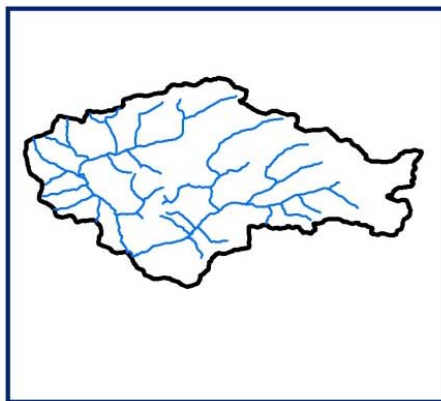
**26 MARCH 2013**

 SNOW

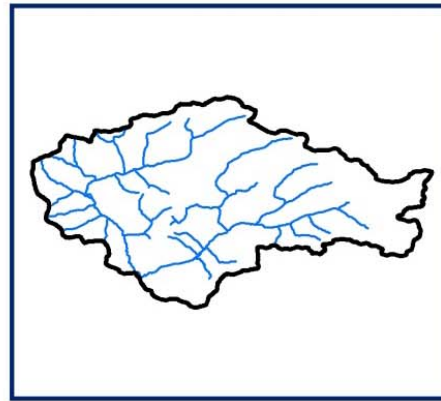
0 12.5 25 50 75 100  
Kilometers



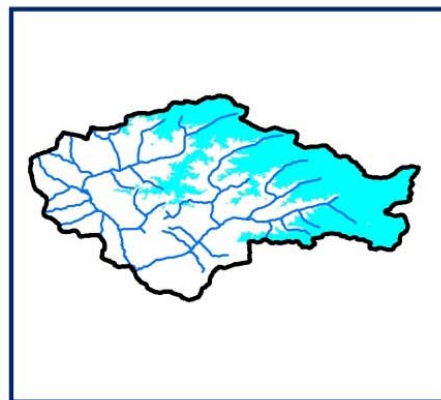
# SNOW COVER MAP : YAMUNA BASIN



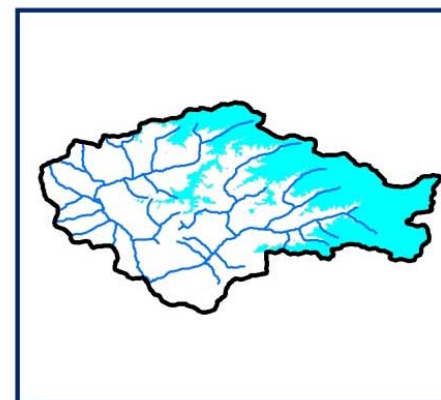
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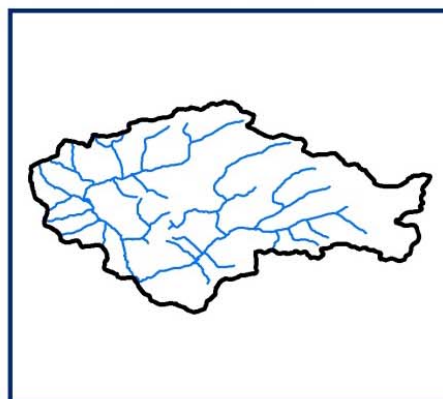
DATA NOT AVAILABLE



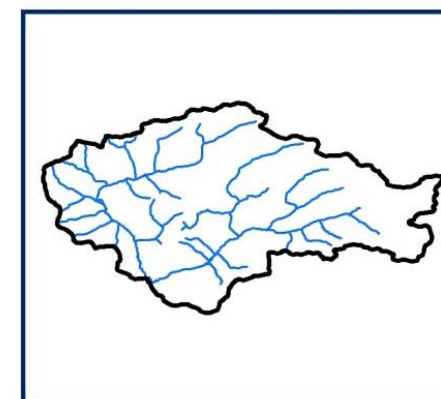
12 APRIL 2013



17 APRIL 2013



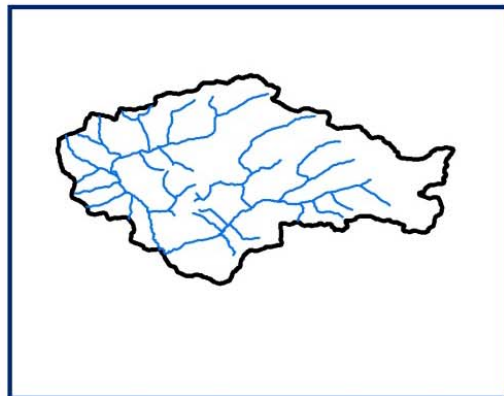
DATA NOT AVAILABLE



DATA NOT AVAILABLE

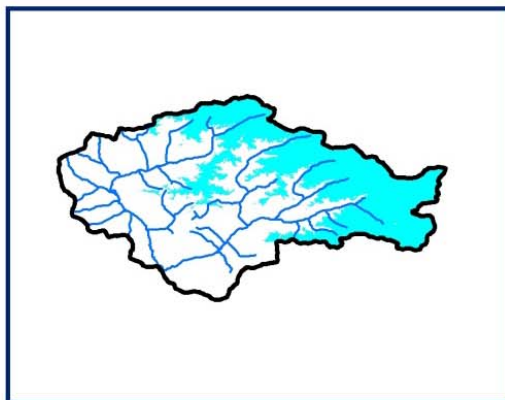


# 10 DAILY SNOW COVER MAP: YAMUNA BASIN

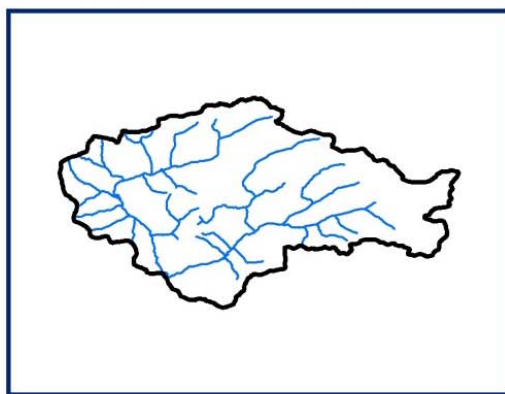


DATA USED

DATA NOT AVILABLE



12 APRIL 2013

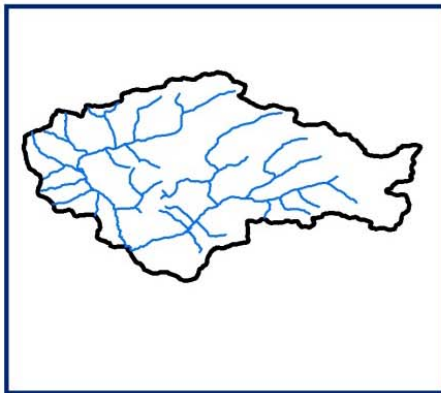


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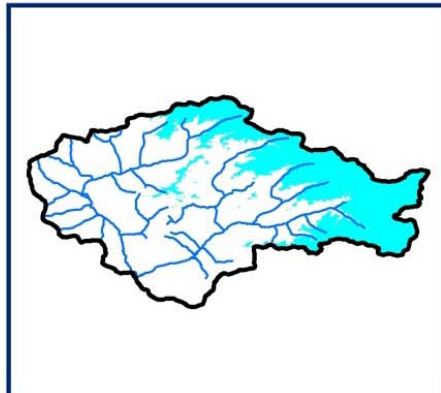


0 12.5 25 50 75 100  
Kilometers

# SNOW COVER MAP : YAMUNA BASIN



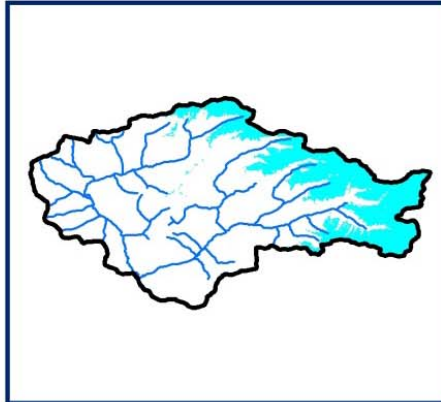
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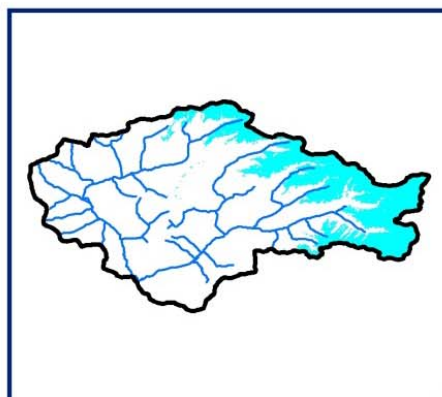
09 MAY 2013



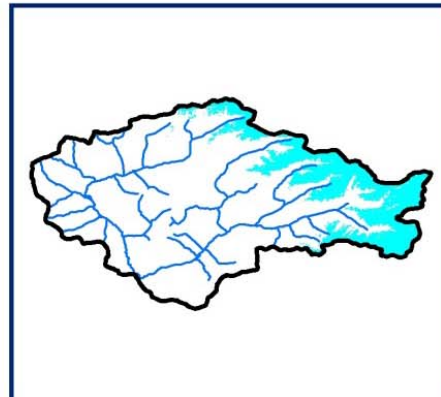
15 MAY 2013



20 MAY 2013



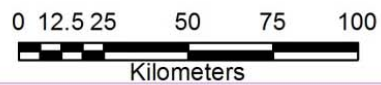
23 MAY 2013



28 MAY 2013



SNOW



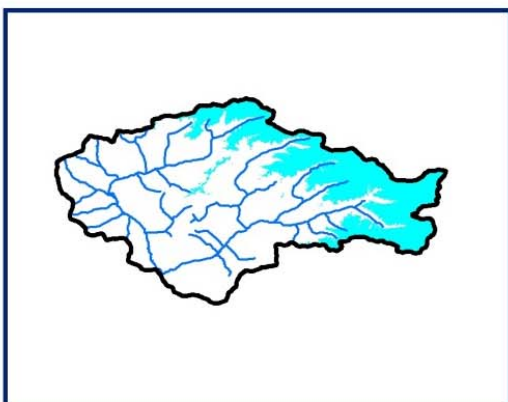


## 10 DAILY SNOW COVER MAP: YAMUNA BASIN

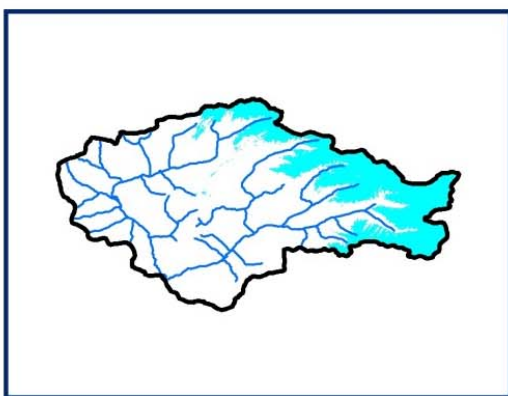


**DATA USED**

**09 MAY 2013**



**15 MAY 2013**



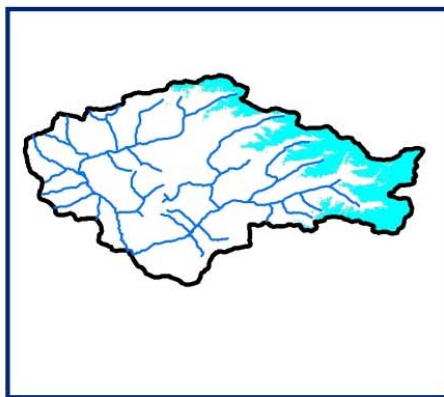
**23 MAY 2013**



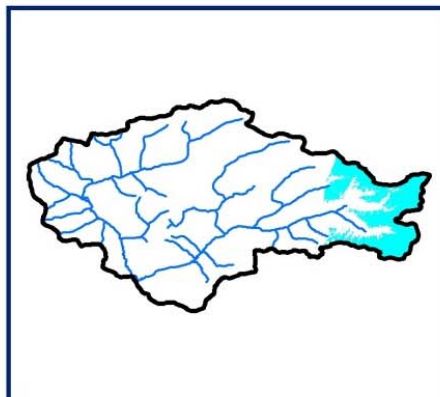
**SNOW**

0 12.5 25 50 75 100  
Kilometers

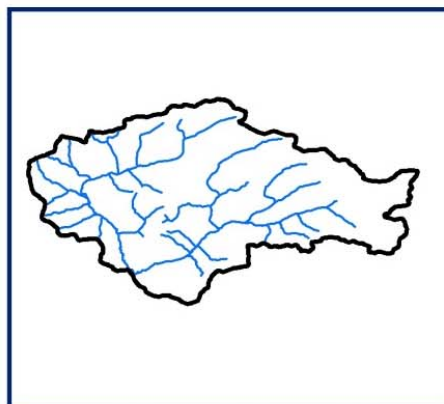
**SNOW COVER MAP : YAMUNA BASIN**



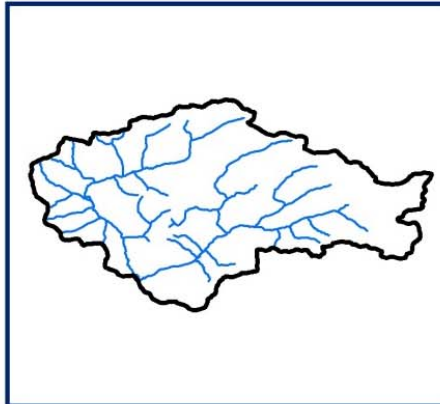
**01 JUNE 2013**



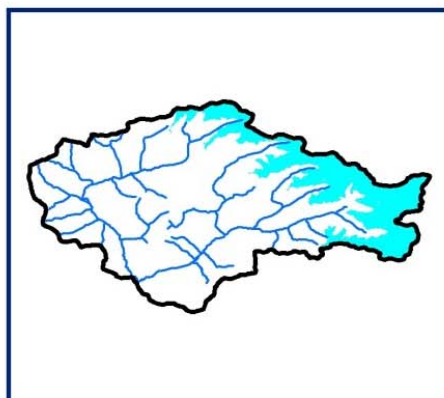
**07 JUNE 2013**



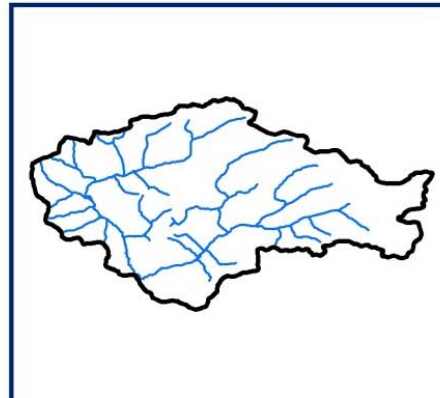
**DATA NOT AVAILABLE**



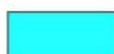
**DATA NOT AVAILABLE**



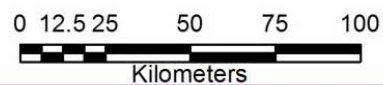
**21 JUNE 2013**



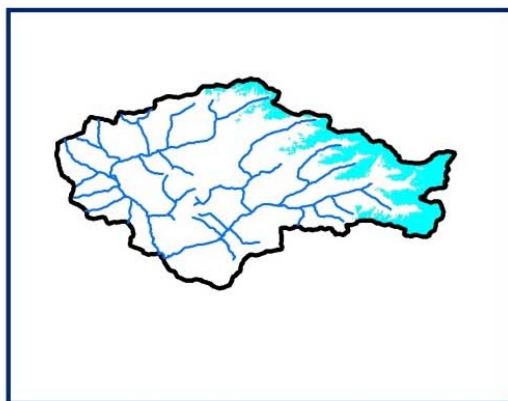
**DATA NOT AVAILABLE**



**SNOW**

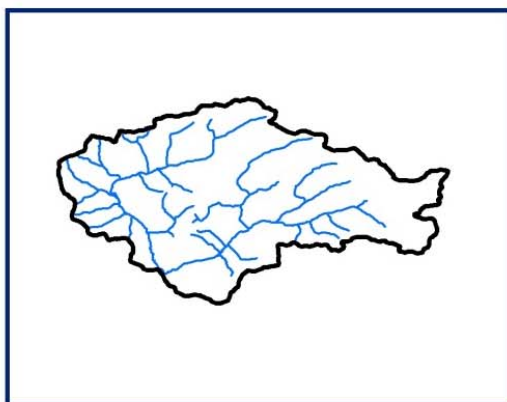


## 10 DAILY SNOW COVER MAP: YAMUNA BASIN

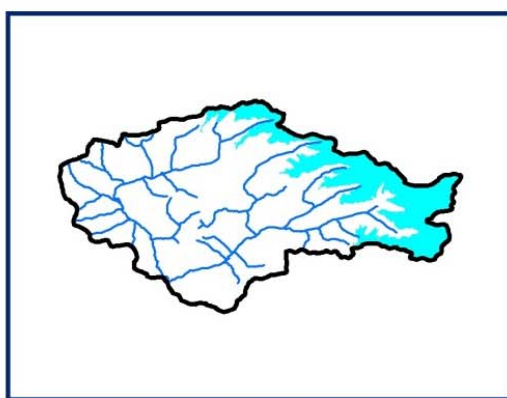


**DATA USED**

**04 JUNE 2013**



**DATA NOT AVAILABLE**



**21 JUNE 2013**



**SNOW**

0 12.5 25 50 75 100  
Kilometers