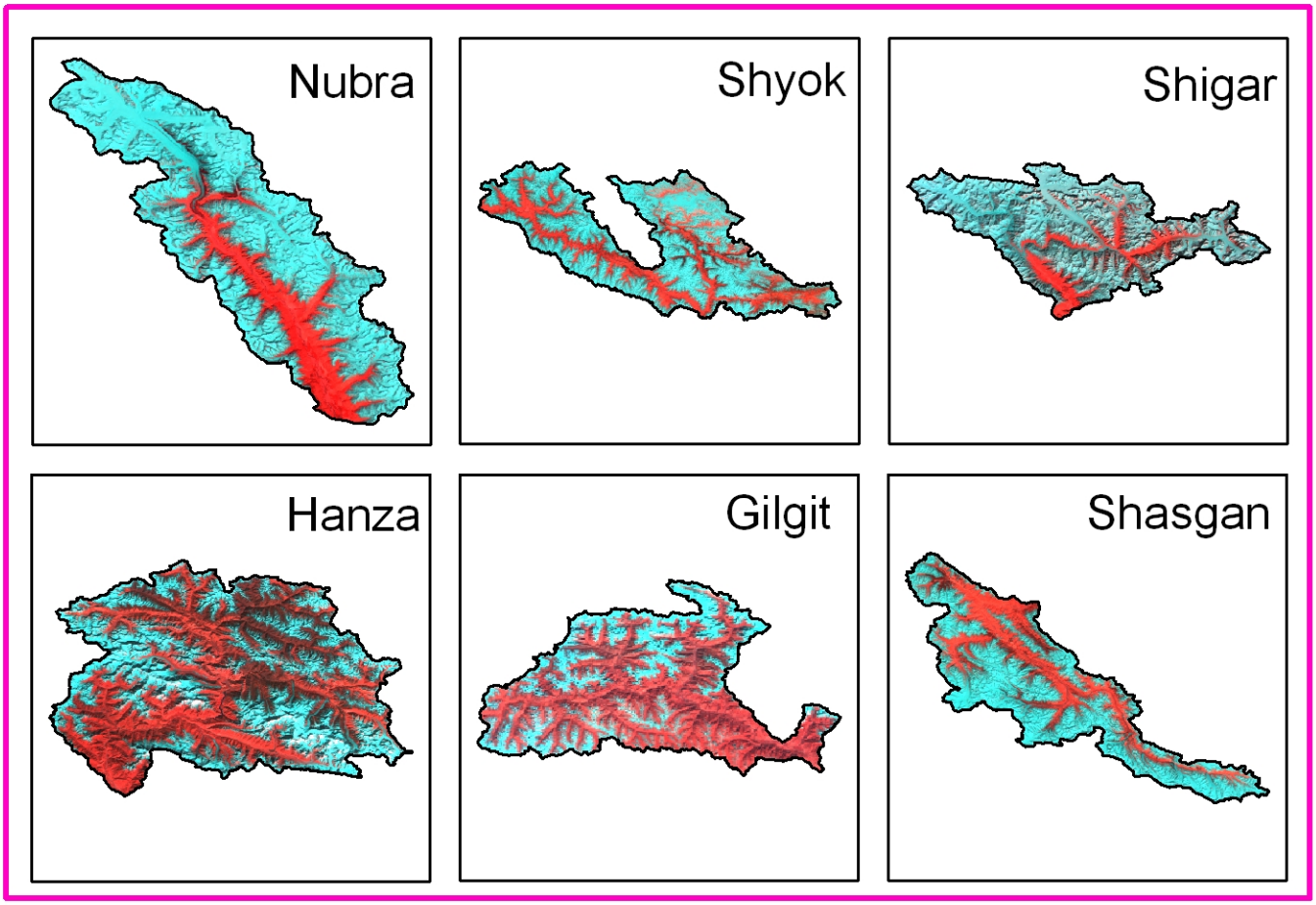
SNOW COVER ATLAS OF INDUS BASIN

Sub basins: Nubra, Shyok, Shigar, Hanza, Gilgit and Shasgan

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

Year : 2011-12



Volume II

Remote Sensing Applications Centre U. P.
Lucknow - 226021

and

Space Applications Centre (ISRO)
Ahmedabad - 380015

February, 2013

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Abstract	This atlas gives subbasin-wise distribution of snow cover in the Indus basin from October 2011 to June 2012. The subbasins included in this report are Nubra, Shyok, Shigar, Hanza, Gilgit and Shasgan. 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, Nubra, Shyok, Shigar, Hanza, Gilgit and Shasgan basins.
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Authors (Team Members)

Space Applications centre (ISRO)

Ahmedabad – 380015

B. P. Rathore

S. K. Singh

I. Bahuguna

A. S. Rajawat

Ajai

Remote Sensing Applications centre, U. P.

Lucknow - 226021

Diwakar Pandey

Rupendra Singh

S. K. S. Yadav

Ram Chandra

Anjani K. Tangri

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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 six subbasins of the Indus basin. These are Nubra, Shyok, Shigar, Hanza, Gilgit and Shasgan sub basins. Locations of these basins are shown in Figure 1.

3. Data used:

AWiFS data from October 2011 to June 2012 were used in this study.

4. Normalised Difference Snow Index (NDSI):

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

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

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

To estimate NDSI, DN numbers were converted into reflectance. This involves conversion of digital numbers into the radiance values, known as sensor calibration, and then estimation of reflectance from these radiance values. Various parameters needed for estimating spectral reflectance are maximum and minimum radiances and mean solar exo-atmospheric spectral irradiances in the satellite sensor bands, satellite data acquisition time, solar declination, solar zenith and solar azimuth angles, mean Earth-Sun distance etc. (Markham and Barker, 1987; Srinivasulu and Kulkarni, 2004).

5. Snow cover monitoring algorithm

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

season and are masked in the final products during winter. Flow diagram of the algorithm is given in Figure 2.

6. Results and discussions

In this atlas, basin-wise snow cover statistics, maps, and seasonal depletion curves have been provided from October 2011 to June 2012. Snow ablation pattern varies from basin to basin, depending on area altitude distribution in the basins. Many of these sub-basins like Gilgit, Hanza, Nubra and Shigar are highly glacierized, therefore large area under snow and glacier cover was observed even at the beginning and end of accumulation season. In case of Shyok & Shasgan sub-basin, accumulation & ablation was observed up to February.

Acknowledgements

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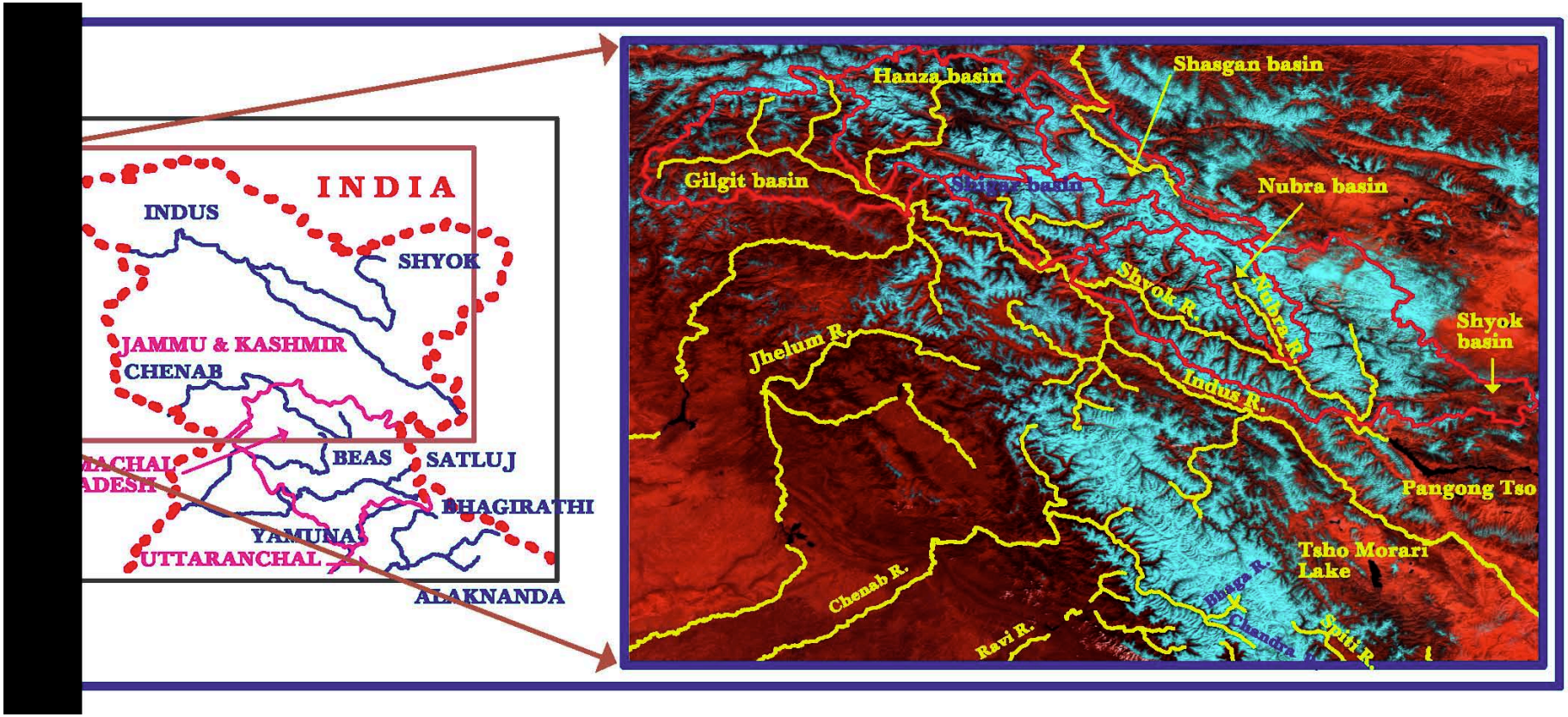


Figure 1: Location map of Nubra, Shyok, Shigar, Hanza, Gilgit and Shasgan sub-basins (Part of Indus basin)

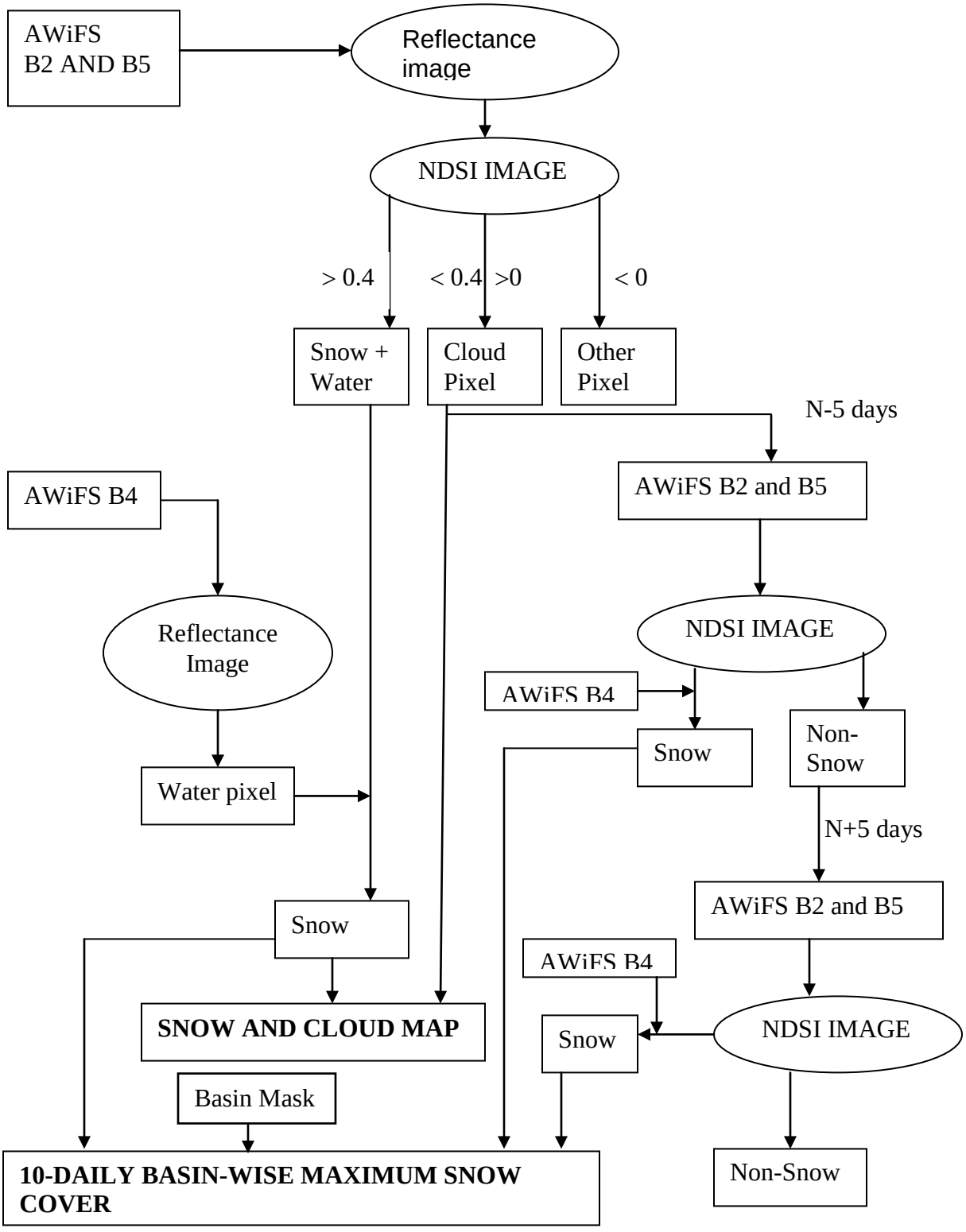


Figure 2: Algorithm for snow cover mapping using AWiFS data

NUBRA BASIN

AREAL EXTENT OF SNOW (5 DAILY)

BASIN NAME: NUBRA **BASIN AREA: 4258 sq km**

S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2011							
01	01-Oct-2011	2442	57	02	03-Oct-2011	2131	50
03	10-Oct-2011	2714	64	04	10-Oct-2011	2714	64
05	15-Oct-2011	2451	58	06	19-Oct-2011	2839	67
07	25-Oct-2011	3332	78	08	29-Oct-2011	3837	90
November 2011							
09	12-Nov-2011	3763	88	10	13-Nov-2011	3659	86
11	18-Nov-2011	4006	94	12	22-Nov-2011	3437	81
13	27-Nov-2011	3303	78	14	30-Nov-2011	2986	70
15	4-Dec-11	3321	78	16	12-Dec-11	3228	72
17	14-Dec-11	2880	68	18	16-Dec-11	318	75
19	21-Dec-11	3215	75	20	28-Dec-11	3349	79
21	31-Dec-11	3035	71				
January 2012							
22	02-Jan-12	2862	67	23	12-Jan-12	3227	76
24	21-Jan-12	2433	57	25	24-Jan-12	3944	93

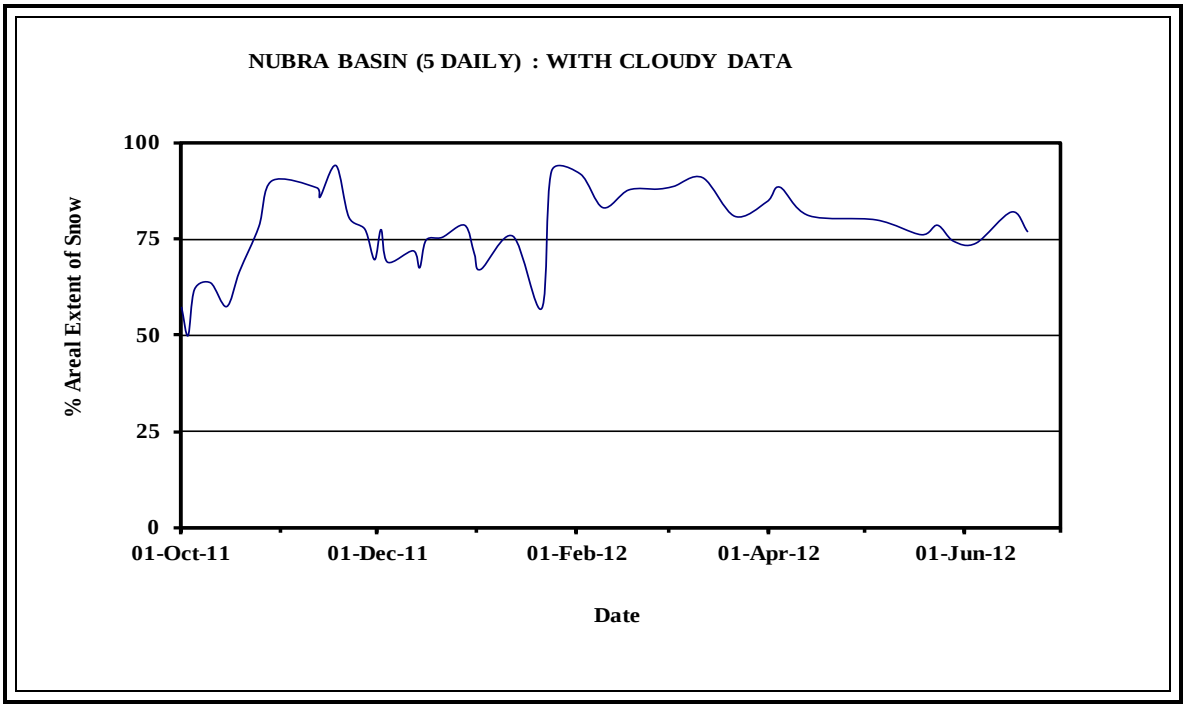
February 2012							
26	02-Feb-12	3914	92	27	09-Feb-12	3443	83
28	17-Feb-12	3738	88	29	26-Feb-12	3747	88
March 2012							
30	02-Mar-12	3777	89	31	11-Mar-12	3873	91
32	21-Mar-12	3847	81	33	31-Mar-12	3609	85
April 2012							
34	04-April-12	3769	88	35	13-April-12	3455	81
May2012							
36	04-May-12	3407	80	37	18-May-12	3244	76
38	23-May-12	3348	79	39	28-May-12	3172	74
June2012							
40	04-June-12	3163	74	41	15-June-12	3494	82
42	20-June-12	3277	77				

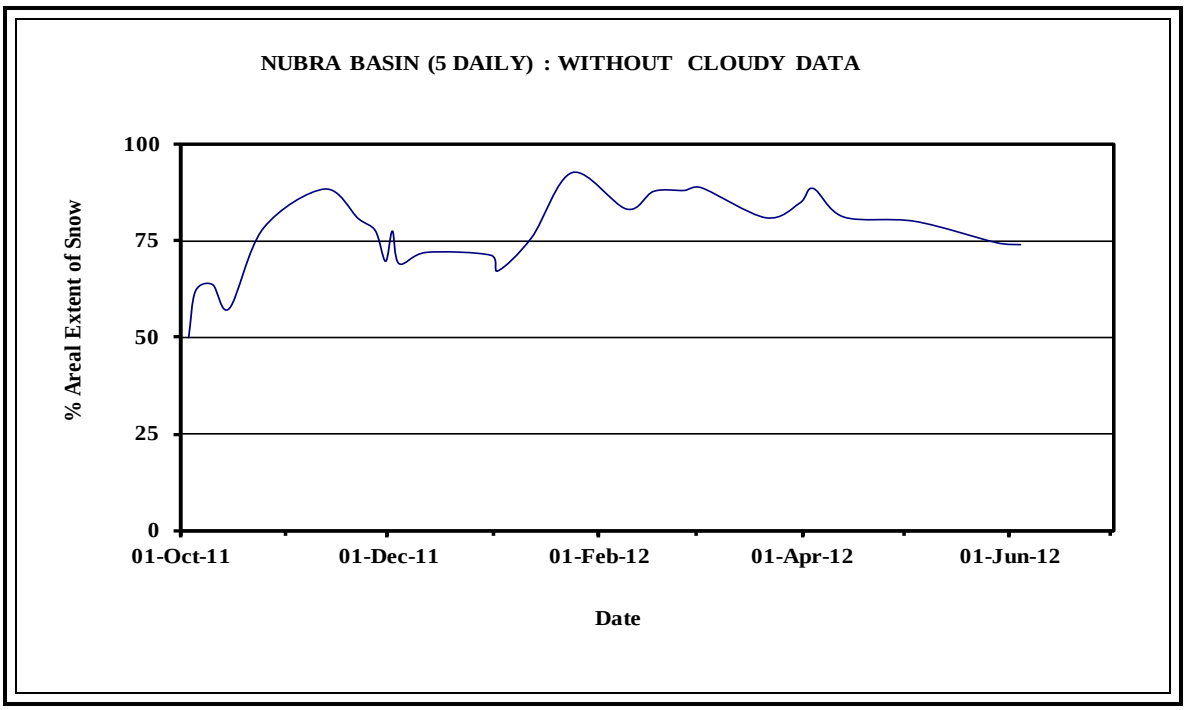
AREAL EXTENT OF SNOW (10 DAILY)

BASIN NAME: NUBRA **BASIN AREA: 4258 sq km**

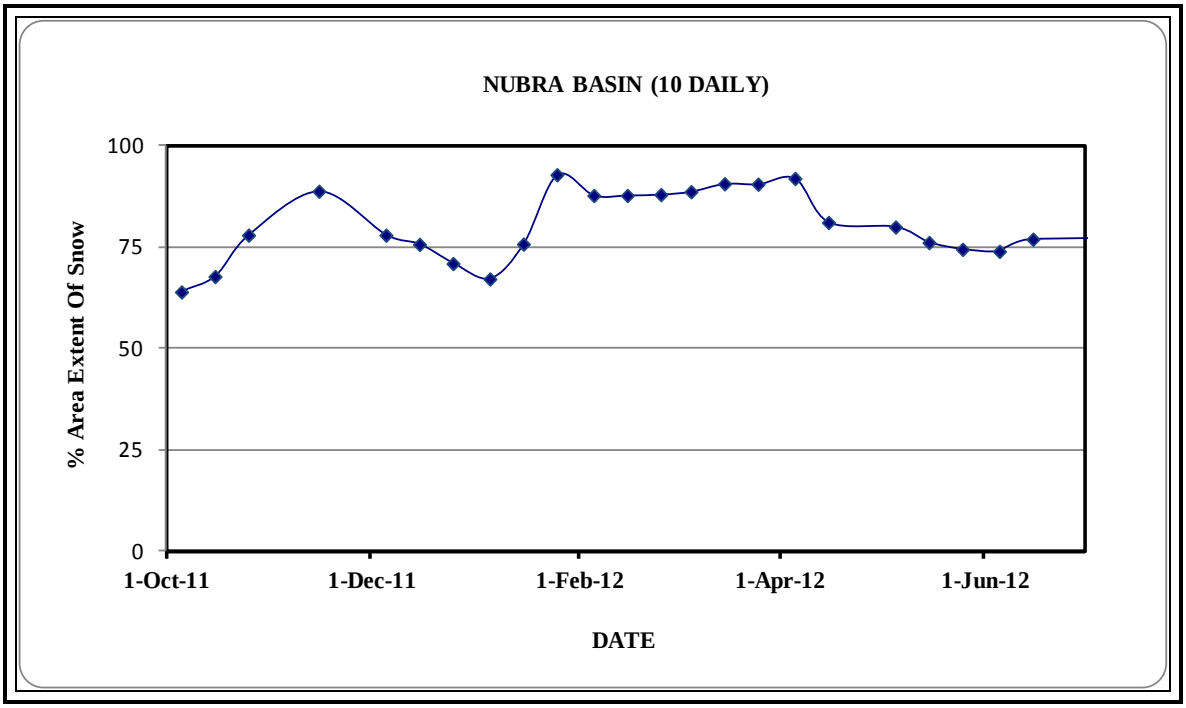
S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2011				**November 2011**			
01	10-Oct-2011	2965	63	04	12-Nov-2011	3782	88
02	15-Oct-2011	2888	68	05	22-Nov-2011	3443	81
03	25-Oct-2011	3560	84				
December 2011				**January 2012**			
06	4-Dec-11	2941	57	09	2-Jan-12	2862	67
07	15-Dec-11	3224	76	10	12-Jan-12	3227	76
08	25-Dec-11	3263	77	11	24-Jan-12	3955	93
February 2012				**March 2012**			
12	09-Feb-12	3737	88	15	02-Mar-12	3777	89
13	17-Feb-12	3738	88	16	11-Mar-12	3873	90
14	26-Feb-12	3747	88	17	21-Mar-12	3856	90
April 2012				**May 2012**			
18	04-April-12	3916	92	20	04-May-12	3406	80
19	13-April-12	3454	81	21	18-May-12	3244	76
				22	28-May-12	3172	74
June 2012							
23	04-June-12	3163	74				
24	16-June-12	3277	77				

Snow cover depletion curve



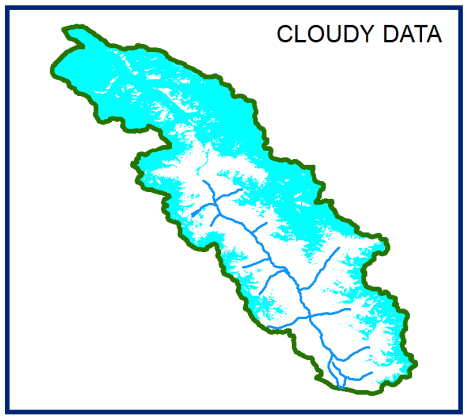


Snow cover depletion curve



SNOW COVER MAP

SNOW COVER MAP : NUBRA BASIN



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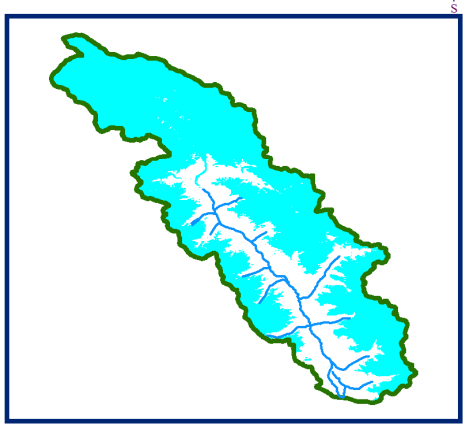

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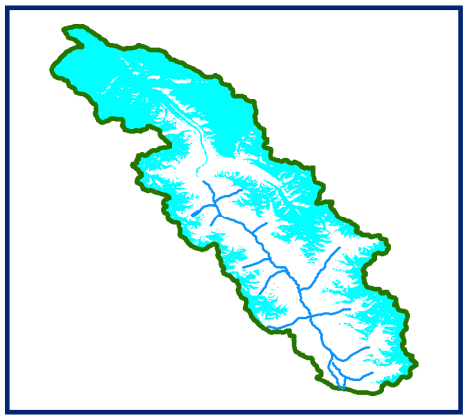

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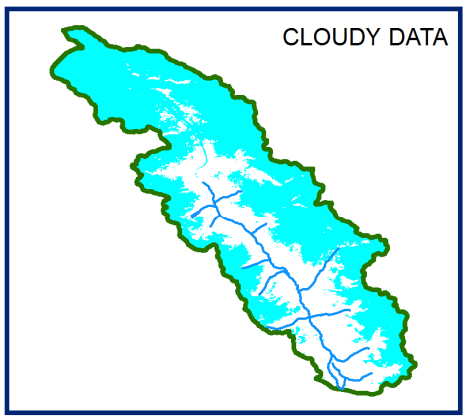

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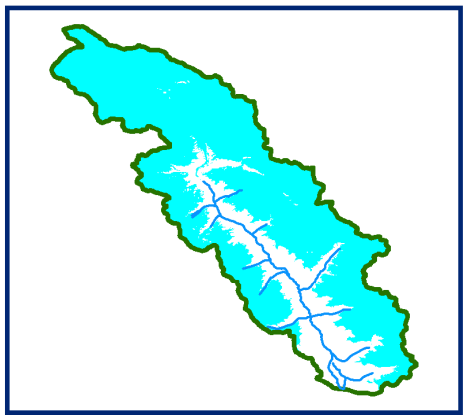

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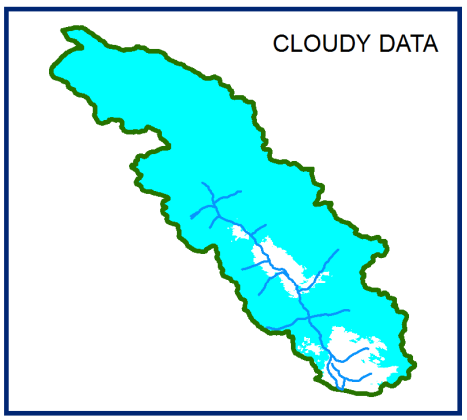


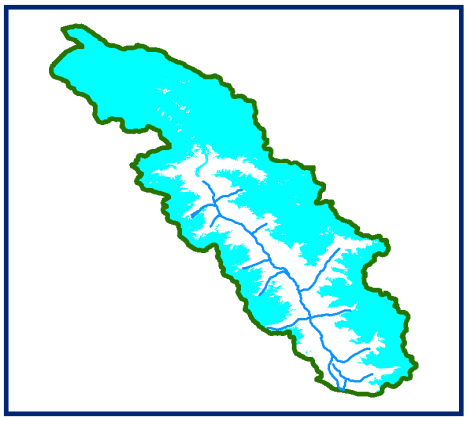
29 OCT. 2011

SNOW

0 15 30 60 90 120

Kilometers

10 DAILY SNOW COVER MAP: NUBRA BASIN



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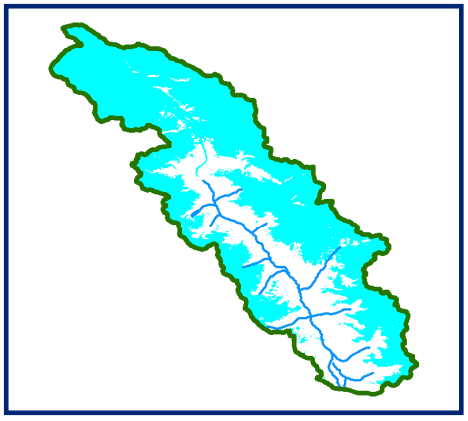

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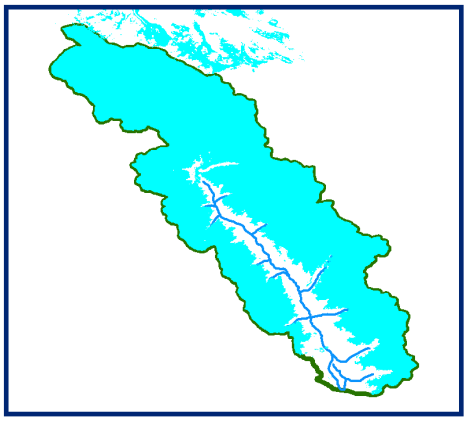

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SNOW

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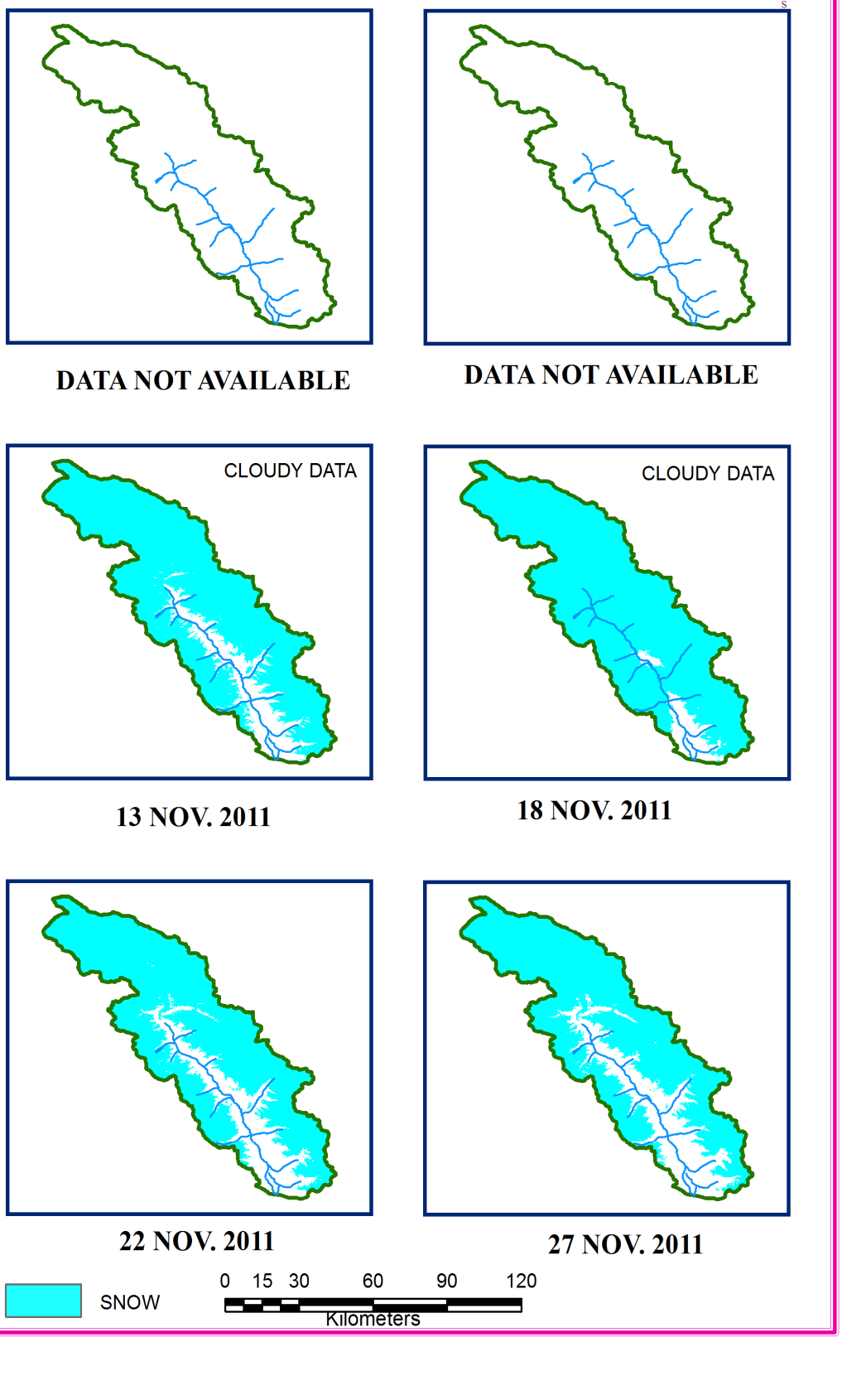
Kilometers

SNOW COVER MAP : NUBRA BASIN



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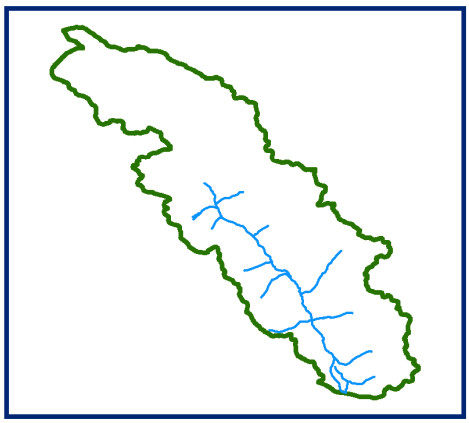
10 DAILY SNOW COVER MAP: NUBRA BASIN



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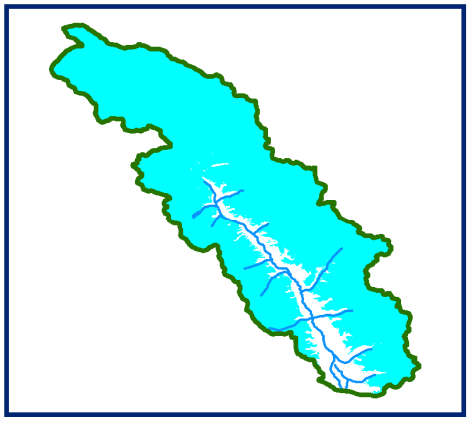

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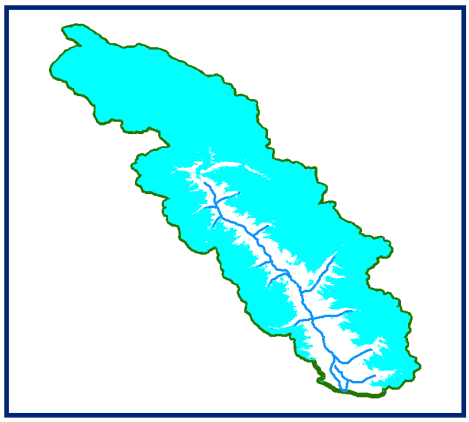

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SNOW

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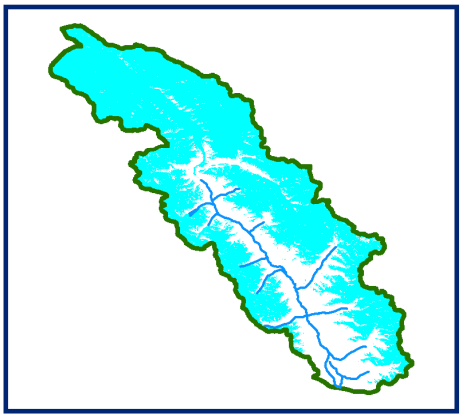
Kilometers

SNOW COVER MAP : NUBRA BASIN



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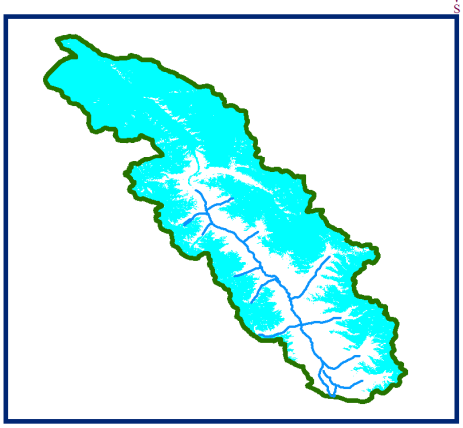

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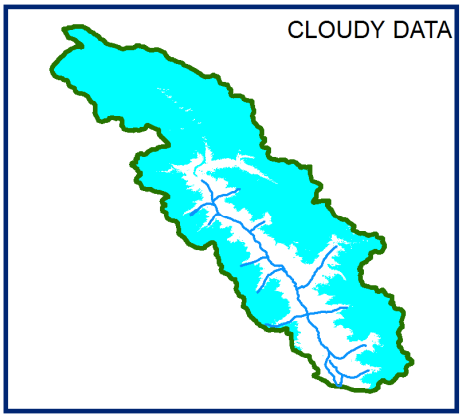

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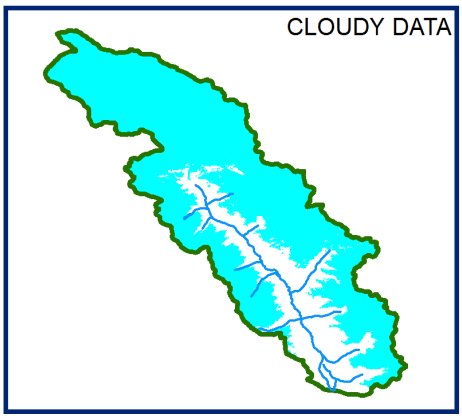

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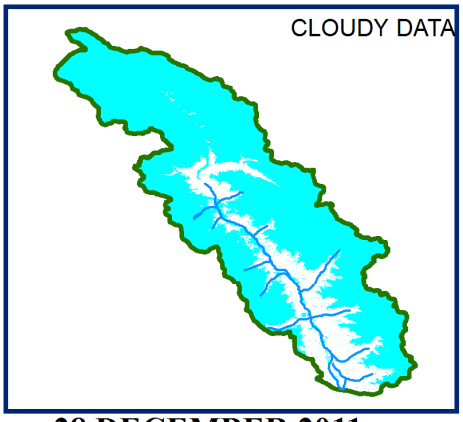

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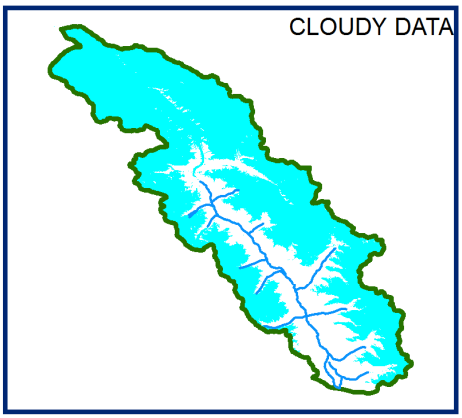


31 DECEMBER 2011

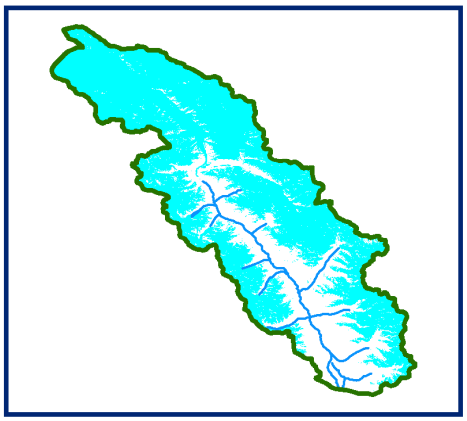
16 DECEMBER 2011

SNOW

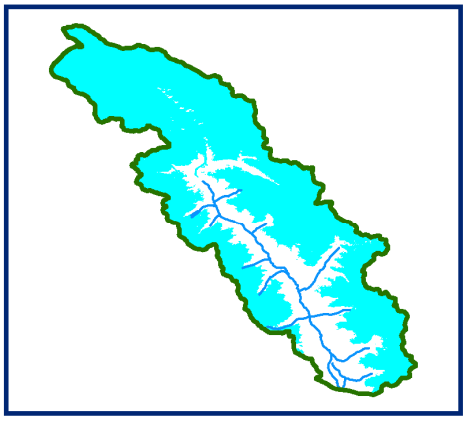
0 15 30 60 90 120

Kilometers

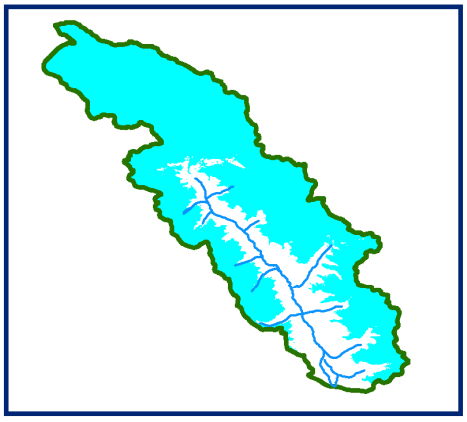
10 DAILY SNOW COVER MAP: NUBRA BASIN



DATA USED
04 DECEMBER 2011



DATA USED
15 DECEMBER 2011

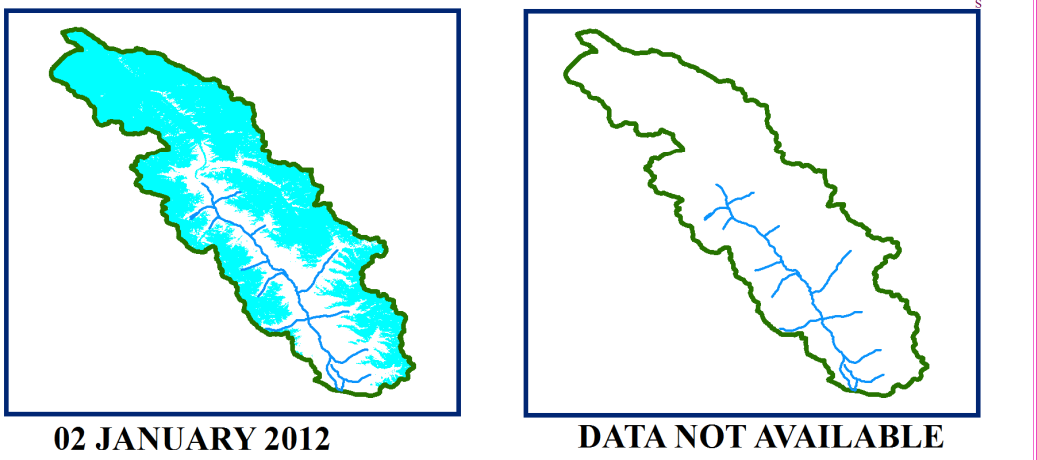


DATA USED
25 DECEMBER 2011

SNOW

0 15 30 60 90 120
Kilometers

SNOW COVER MAP : NUBRA BASIN



02 JANUARY 2012

DATA NOT AVAILABLE

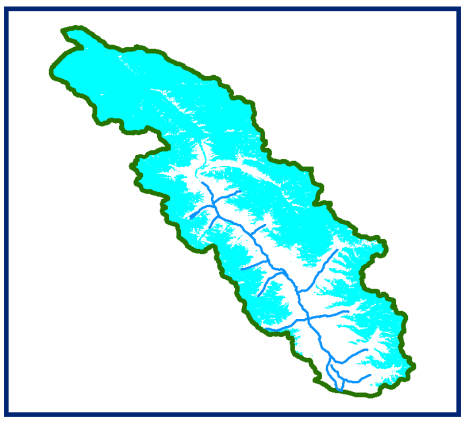
12 JANUARY 2012

DATA NOT AVAILABLE

21 JANUARY 2012

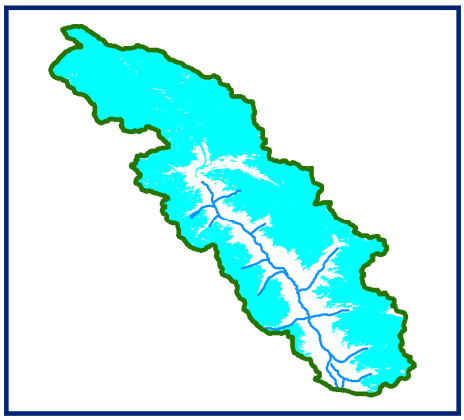
24 JANUARY 2012

10 DAILY SNOW COVER MAP: NUBRA BASIN



DATA USED

02 January 2012



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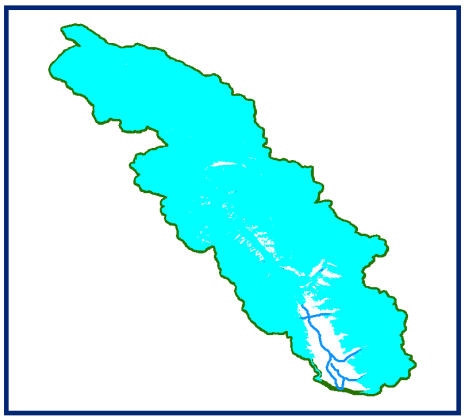
12 January 2012



DATA USED

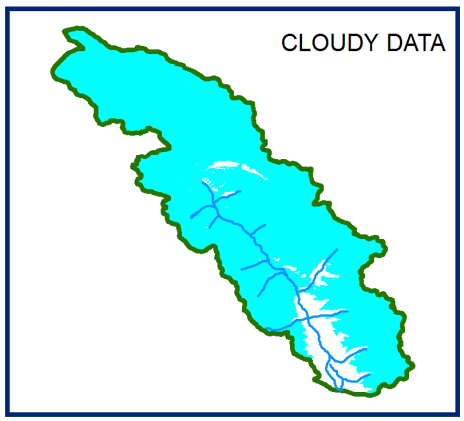
21January 2012
24 January 2012
25 January 2012

SNOW

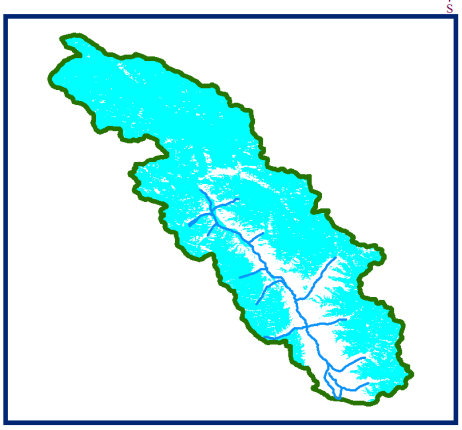
0 15 30 60 90 120

Kilometers

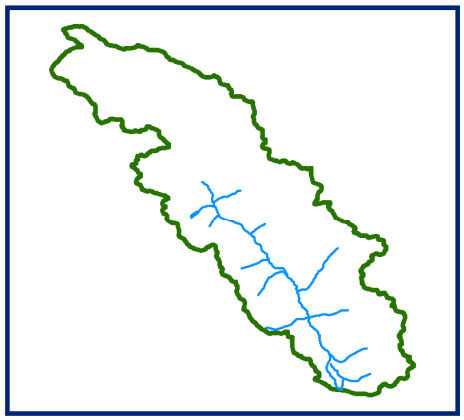
SNOW COVER MAP : NUBRA BASIN



02 FEB. 2012



09 FEB. 2012



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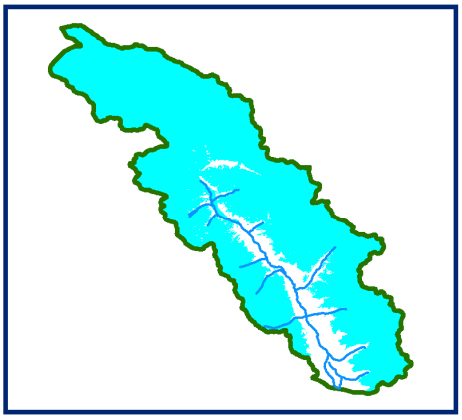
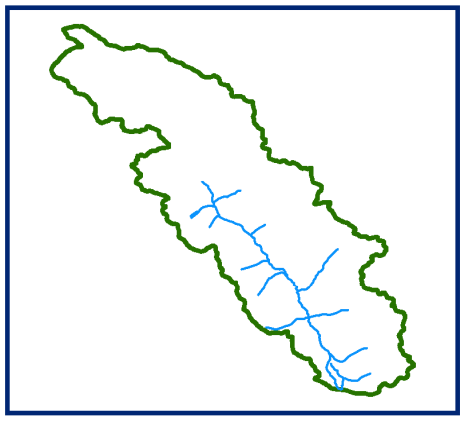


17 FEB. 2012



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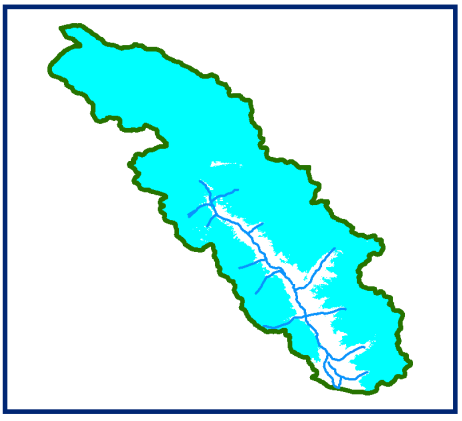


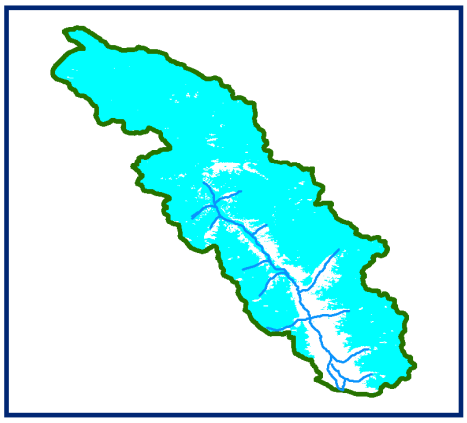
26 FEB. 2012

SNOW

0 15 30 60 90 120

Kilometers

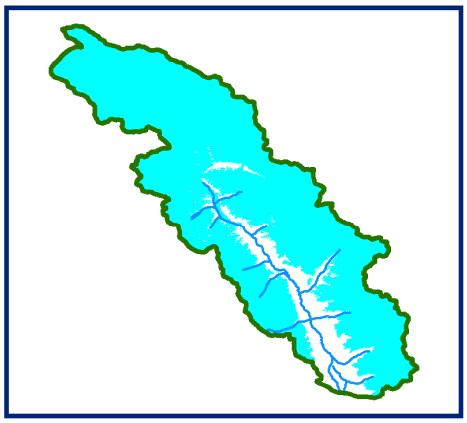
10 DAILY SNOW COVER MAP: NUBRA BASIN



DATA USED

02 FEB. 2012

09 FEB. 2012



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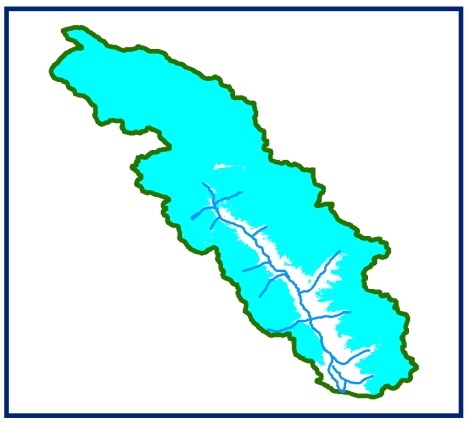
17 FEB. 2012



DATA USED

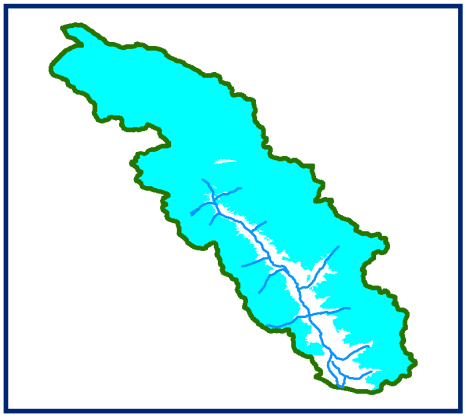
26 FEB. 2012

SNOW

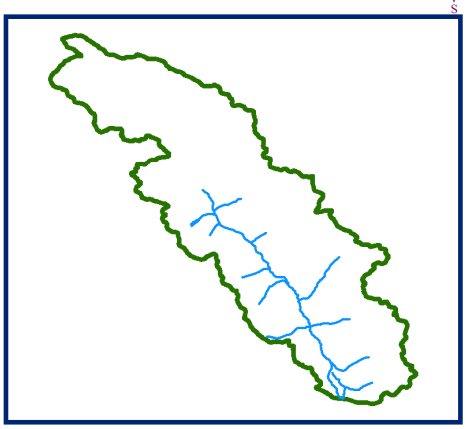
0 15 30 60 90 120

Kilometers

SNOW COVER MAP : NUBRA BASIN



02 MARCH 2012



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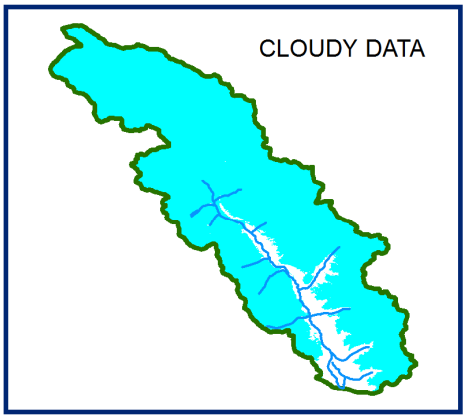

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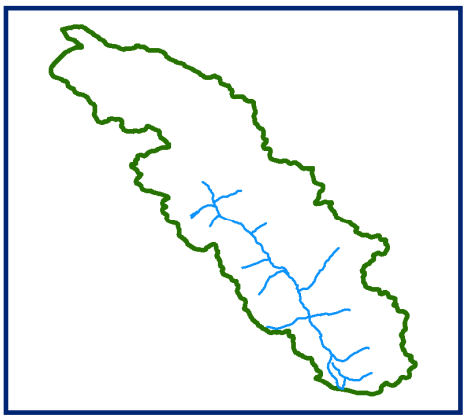

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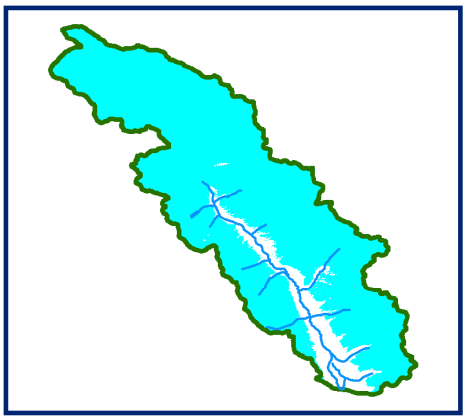
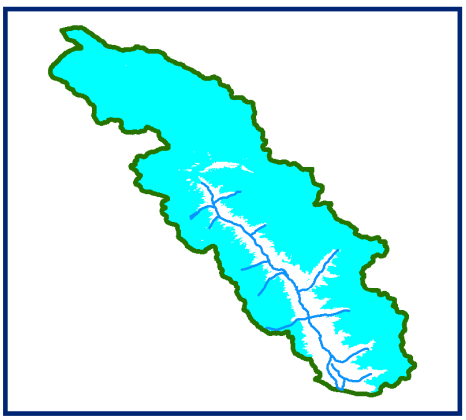


21 MARCH 2012



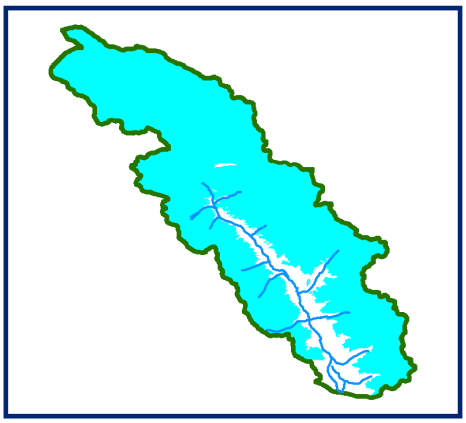
31 MARCH 2012

SNOW

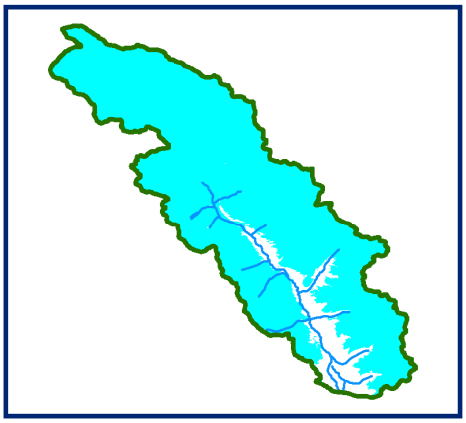
0 15 30 60 90 120

Kilometers

10 DAILY SNOW COVER MAP: NUBRA BASIN



DATA USED
02 March 2012



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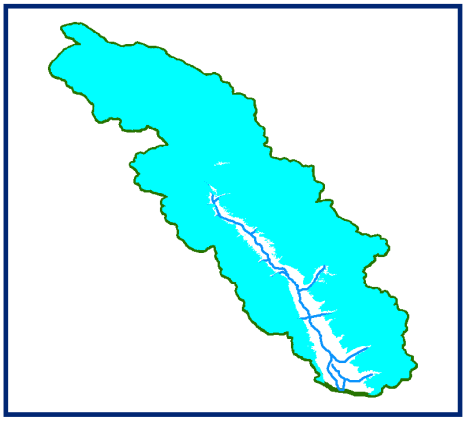
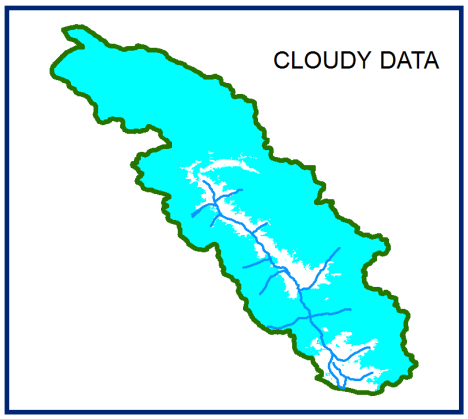


DATA USED
21 March 2012
31 March 2012

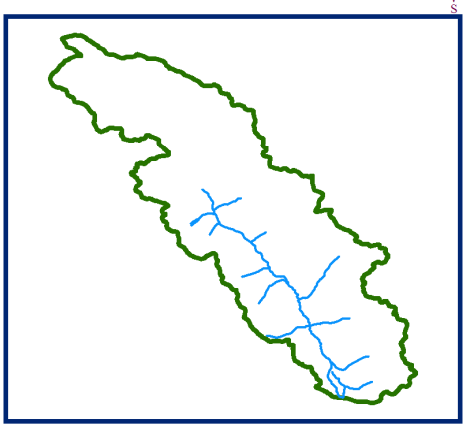
SNOW

0 15 30 60 90 120
Kilometers

SNOW COVER MAP : NUBRA BASIN



04 APRIL 2012



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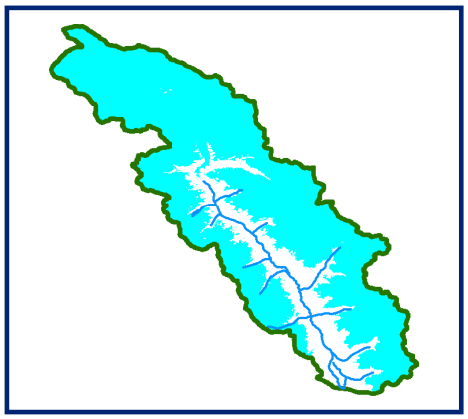
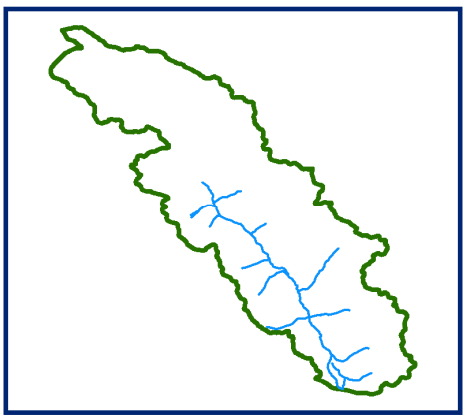


13 APRIL 2012



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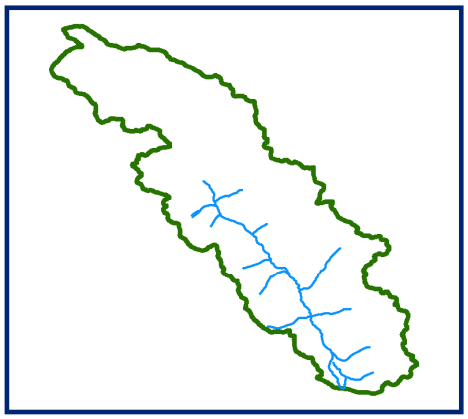

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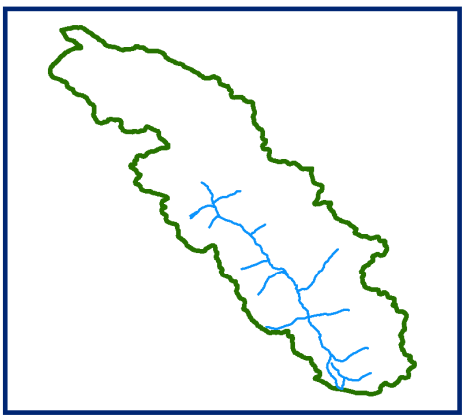


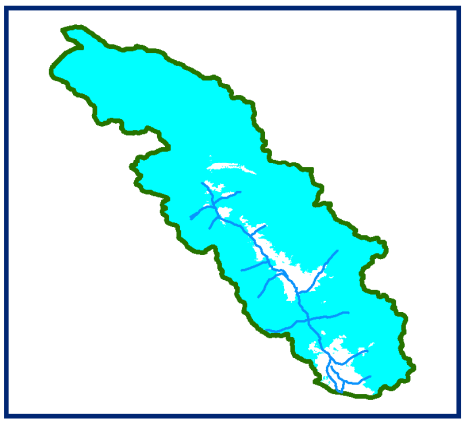
DATA NOT AVAILABLE

SNOW

0 15 30 60 90 120

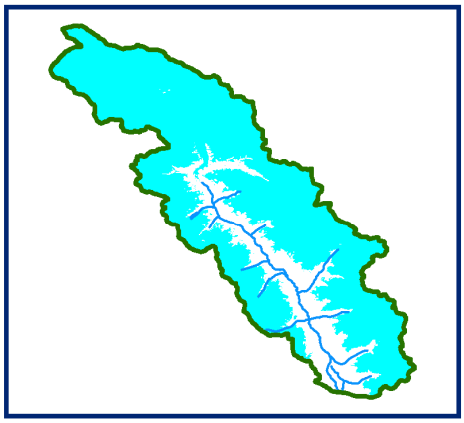
Kilometers

10 DAILY SNOW COVER MAP: NUBRA BASIN



DATA USED

04 April 2012
05 April 2012



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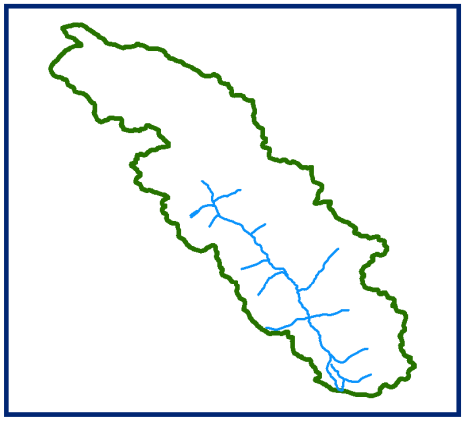


DATA USED

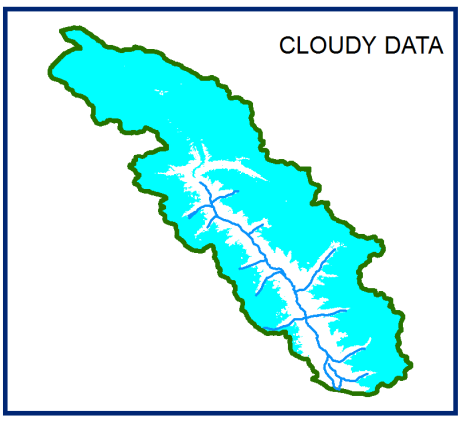
DATA NOT AVAILABLE

SNOW

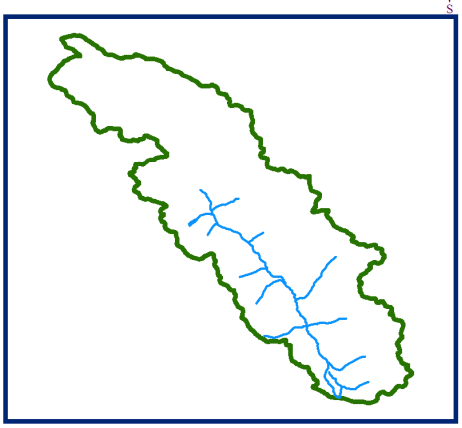
0 15 30 60 90 120

Kilometers

SNOW COVER MAP : NUBRA BASIN



04 MAY 2012



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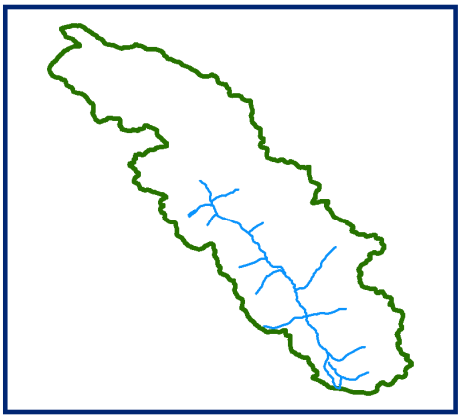

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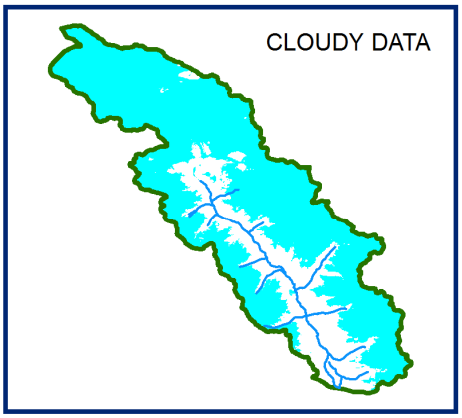
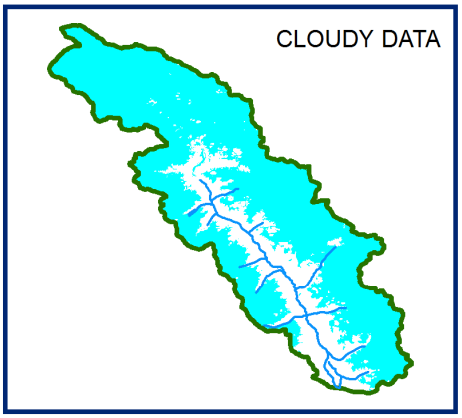
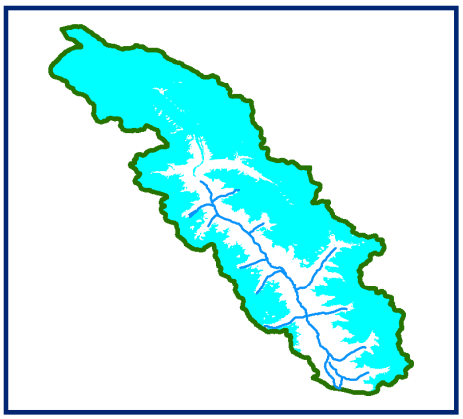


18 MAY 2012



23 MAY 2012



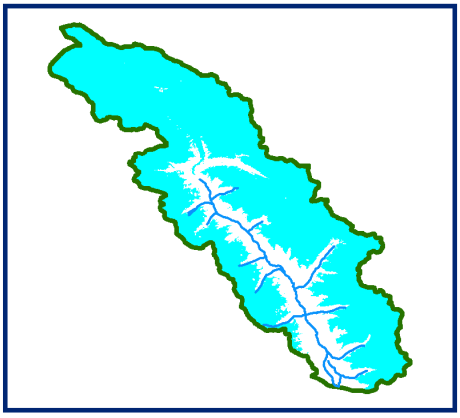
28 MAY 2012

SNOW

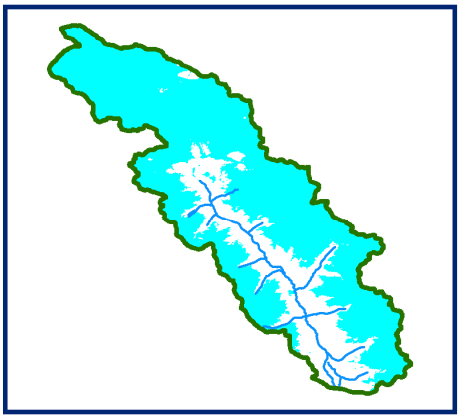
0 15 30 60 90 120

Kilometers

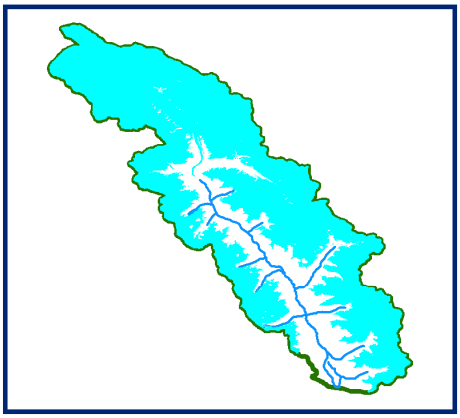
10 DAILY SNOW COVER MAP: NUBRA BASIN



DATA USED
04 May 2012



DATA USED
18 May 2012

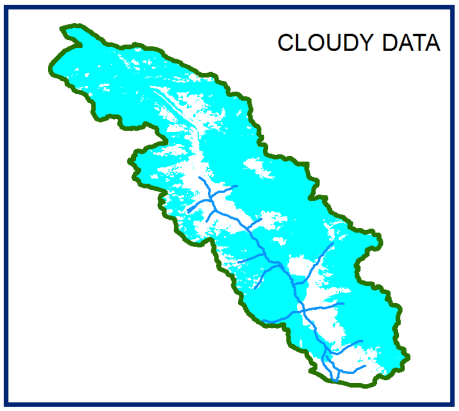


DATA USED
23 May 2012
28 May 2012

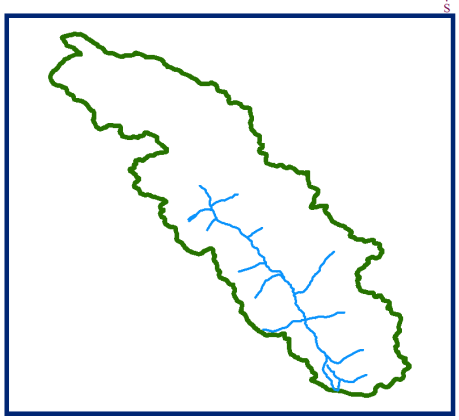
SNOW

0 15 30 60 90 120
Kilometers

SNOW COVER MAP : NUBRA BASIN



04 JUNE 2012



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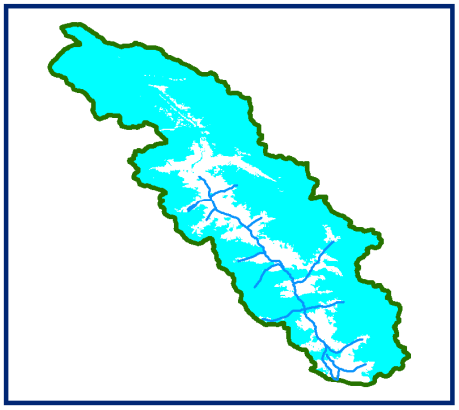
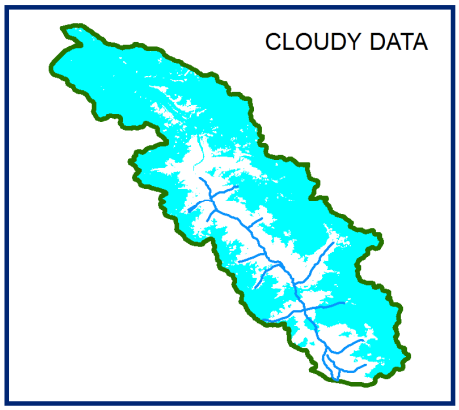
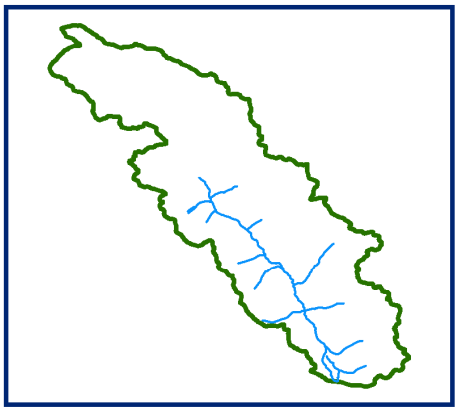


15 JUNE 2012



20 JUNE 2012



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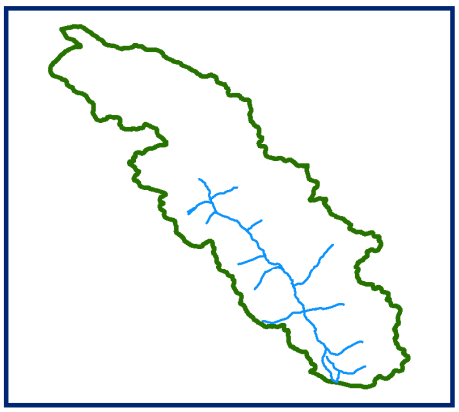


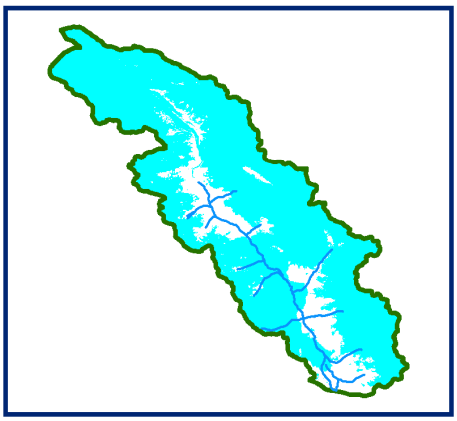
DATA NOT AVAILABLE

SNOW

0 15 30 60 90 120

Kilometers

10 DAILY SNOW COVER MAP: NUBRA BASIN



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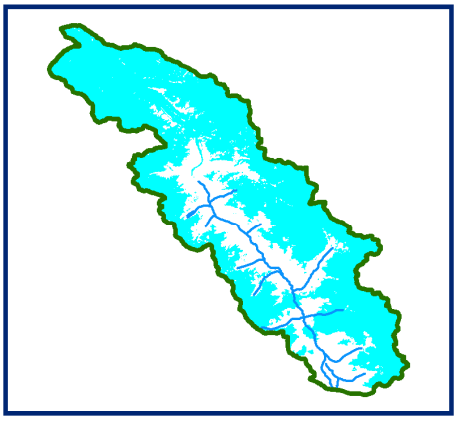
03 June 2012

04 June 2012

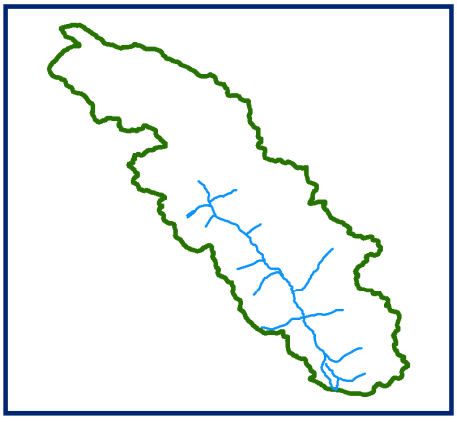


DATA USED

15 June 2012

16 June 2012

20 June 2012



DATA USED

DATA NOT AVAILABLE

SNOW

0 15 30 60 90 120

Kilometers

SHYOK BASIN

AREAL EXTENT OF SNOW (5 DAILY)

BASIN NAME: SHYOK **BASIN AREA: 27120 sq km**

S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2011							
01	01-Oct-2011	7333	27	02	03-Oct-2011	6629	23
03	10-Oct-2011	10187	38	04	15-Oct-2011	7327	27
05	25-Oct-2011	14786	54	06	29-Oct-2011	12023	44
November 2011							
07	13-Nov-2011	14837	55	08	18-Nov-2011	15850	58
09	22-Nov-2011	12890	48	10	27-Nov-2011	11408	42
December 2011							
11	4-Dec-11	9431	35	12	14-Dec-11	9694	38
13	16-Dec-11	12807	47	14	21-Dec-11	15539	57
15	28-Dec-11	9797	36	16	31-Dec-11	10463	38
January 2012							
17	2-Jan-12	9486	34	18	21-Jan-12	15411	57
19	24-Jan-12	20232	75				
February 2012							
20	02-Feb-12	18728	69	21	09-Feb-12	19623	72
22	17-Feb-12	21351	79	23	26-Feb-12	20543	76

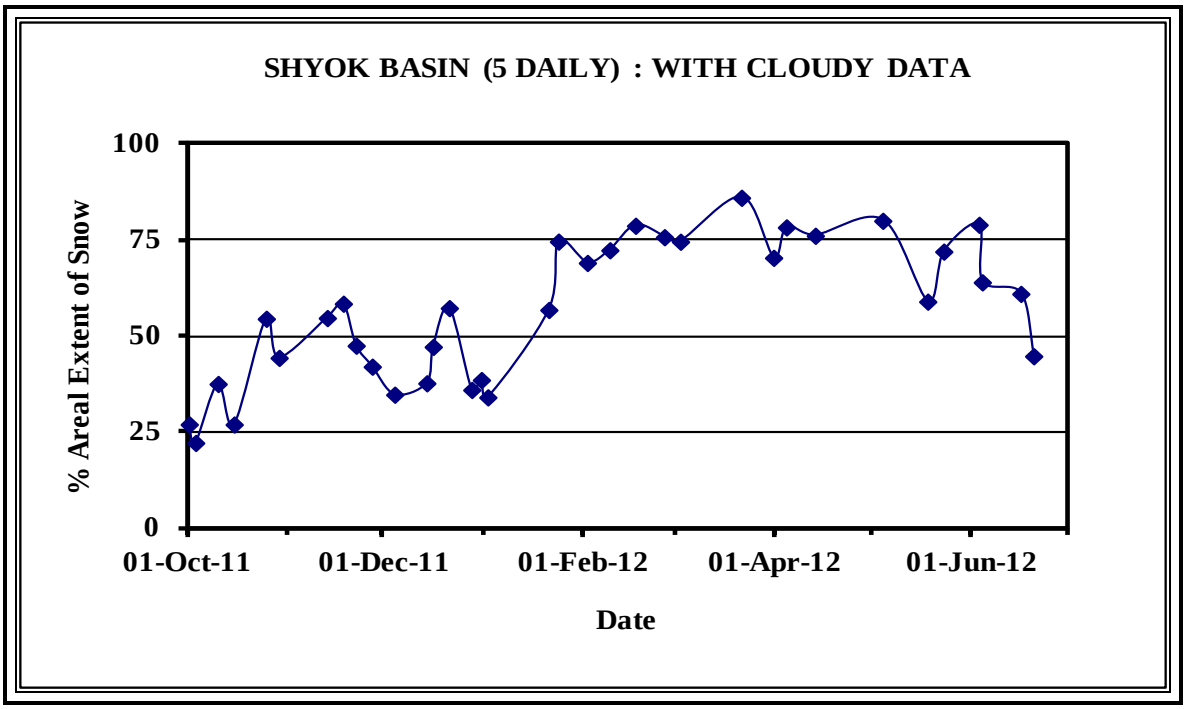
March 2012							
24	02-Mar-12	20226	75	25	21-Mar-12	23413	86
26	31-Mar-12	19087	70				
April 2012							
27	04-April-12	21235	79	28	13-April-12	20465	76
May2012							
29	18-May-12	15995	59	30	23-May-12	18209	67
June2012							
31	03-June-12	3363	79	32	04-June-12	12377.60	45.64
33	16-June-12	13014	48	34	20-June-12	12146	45

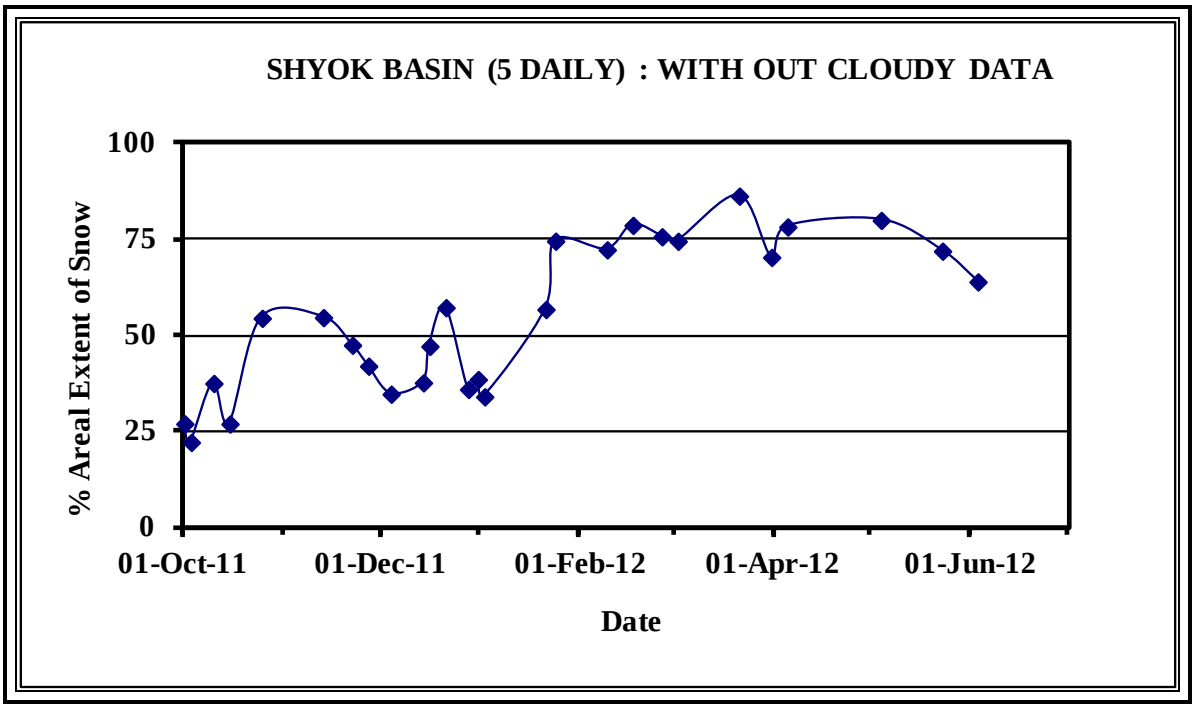
AREAL EXTENT OF SNOW (10 DAILY)

BASIN NAME: SHYOK **BASIN AREA: 27120 sq km**

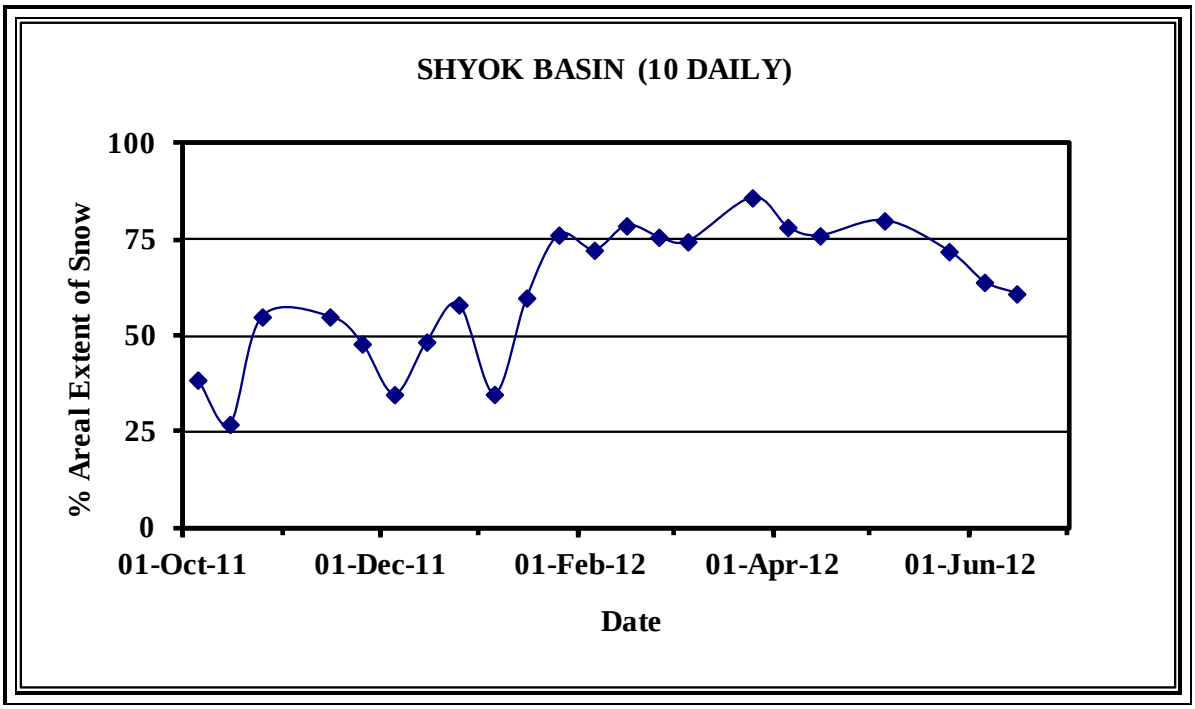
S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2011				**November 2011**			
01	10-Oct-2011	10455	39	04	13-Nov-2011	18757	70
02	15-Oct-2011	7327	27	05	22-Nov-2011	13009	48
03	25-Oct-2011	18535	68				
December 2011				**January 2012**			
06	4-Dec-11	9431	35	09	2-Jan-12	9486	35
07	15-Dec-11	13141	49	10	12-Jan-12	16255	60
08	25-Dec-11	15767	58	11	24-Jan-12	20696	76
February 2012				**March 2012**			
12	09-Feb-12	19623	72	15	02-Mar-12	20226	75
13	17-Feb-12	21351	79	16	21-Mar-12	23413	86
14	26-Feb-12	20543	76				
April 2012				**May 2012**			
17	04-April-12	21235	78	19	18-May-12	15995	59
18	13-April-12	20465	76	20	23-May-12	19412	72
June 2012							
21	04-June-12	17363	64				
22	16-June-12	16598	61				

SNOW COVER DEPLETION CURVE



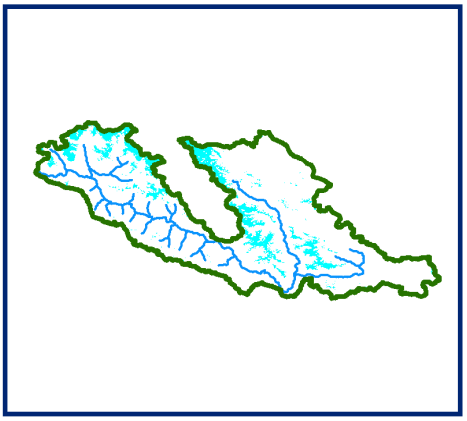


SNOW COVER DEPLETION CURVE

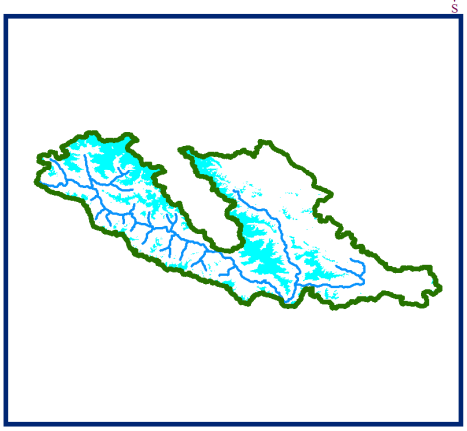


SNOW COVER MAP

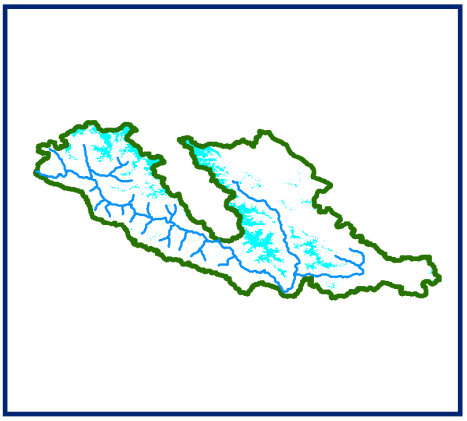
SNOW COVER MAP : SHYOK BASIN



01 OCT. 2011



10 OCT. 2011



15 OCT. 2011

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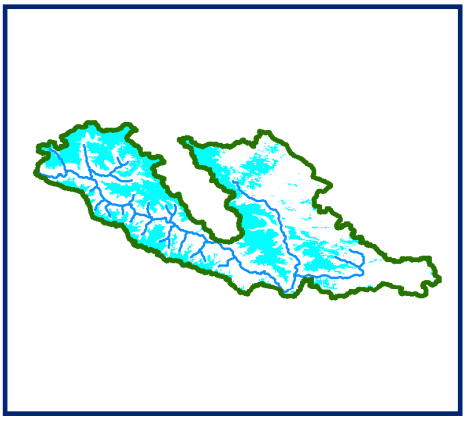
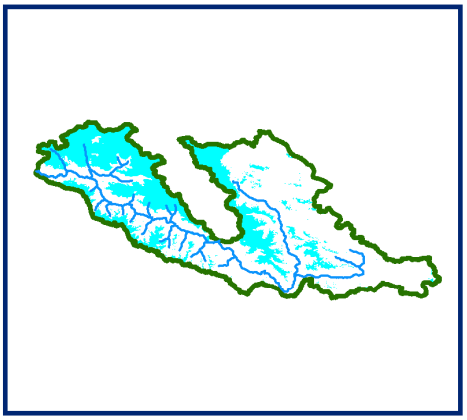


25 OCT 2011



29 OCT 2011

SNOW

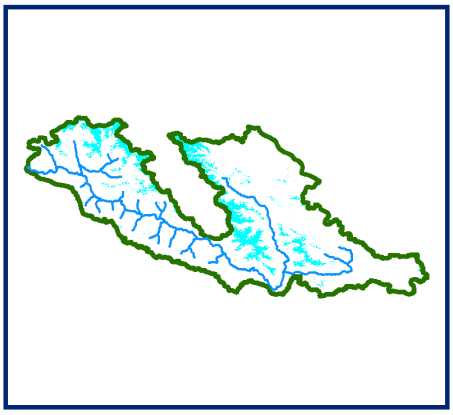
0 50 100 200 300 400

Kilometers

10 DAILY SNOW COVER MAP: SHYOK BASIN

DATA USED

01 Oct 2011
10 Oct 2011
05 Oct 2011



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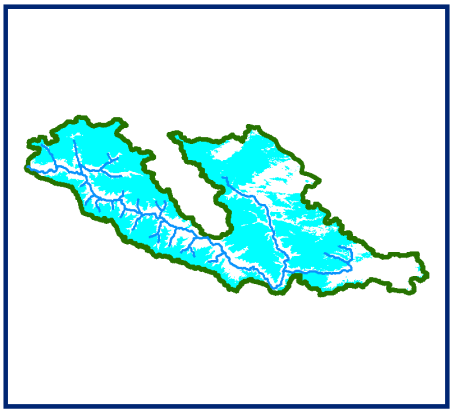


DATA USED

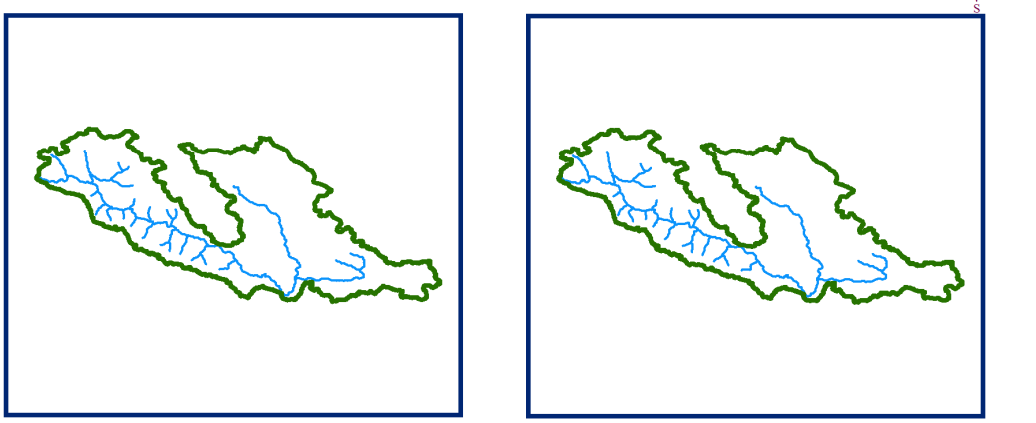
24 Oct 2011
25 Oct 2011
29 Oct 2011

SNOW

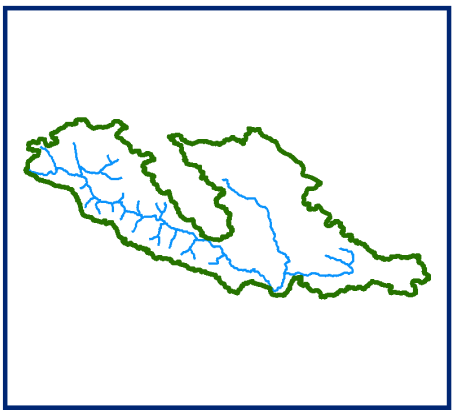
0 50 100 200 300 400

Kilometers

SNOW COVER MAP : SHYOK BASIN



10 DAILY SNOW COVER MAP: SHYOK BASIN



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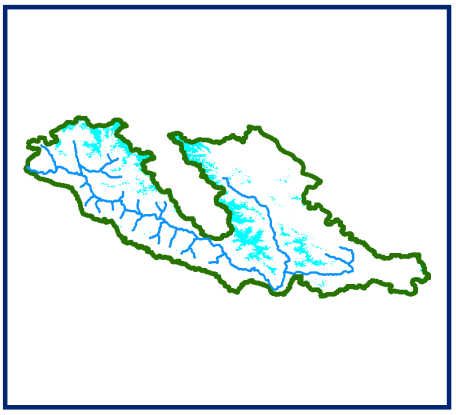

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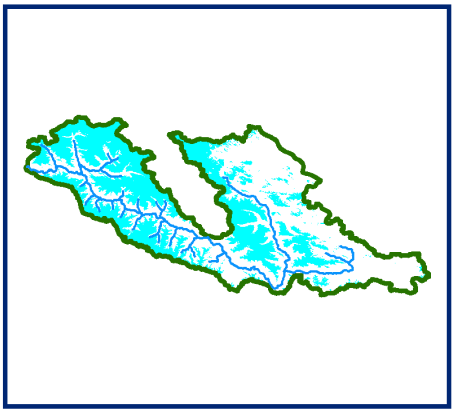
13 Nov 2011

12 Nov 2011

18 Nov 2011



DATA USED

22 Nov 2011

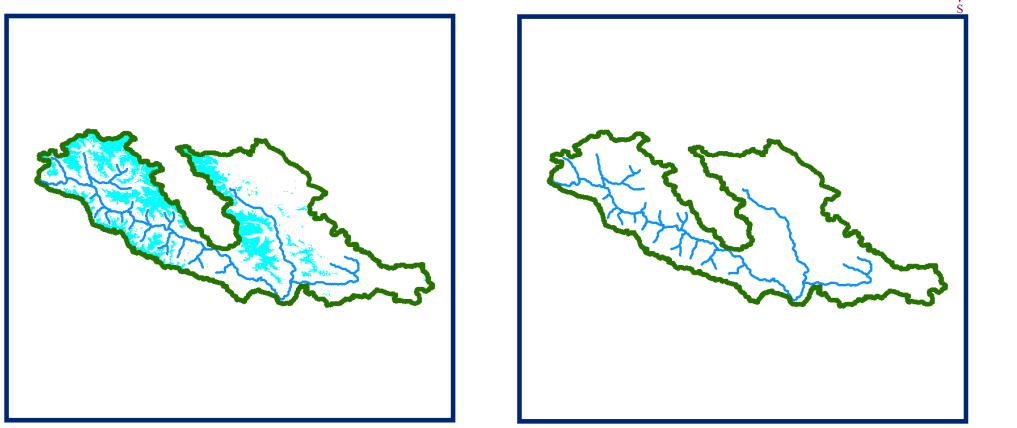
27 Nov 2011

SNOW

0 50 100 200 300 400

Kilometers

SNOW COVER MAP : SHYOK BASIN



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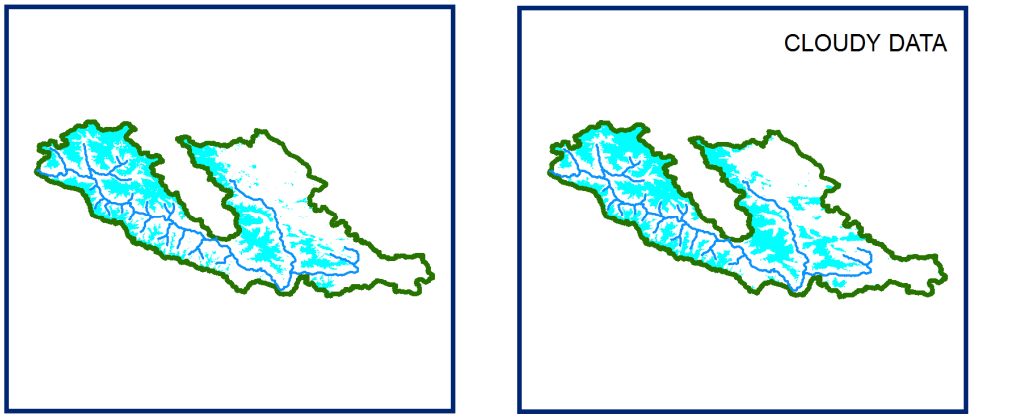
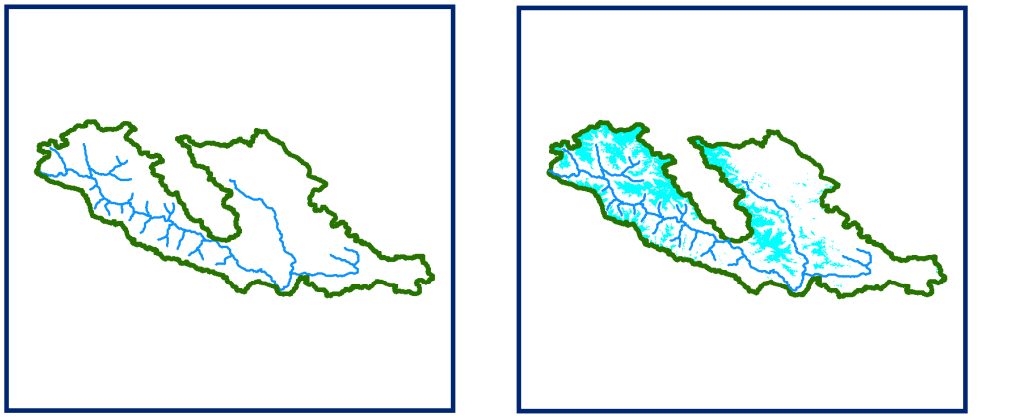


11 DEC 2011

16 DEC 2011



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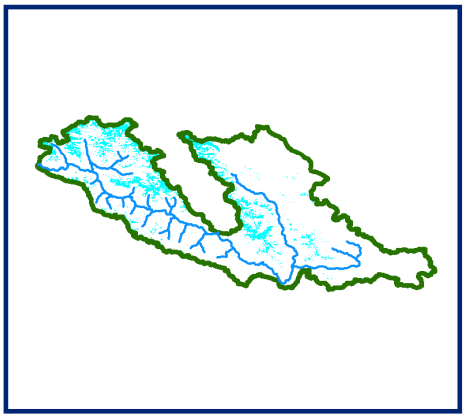
26 DEC 2011

SNOW

0 50 100 200 300 400

Kilometers

10 DAILY SNOW COVER MAP: SHYOK BASIN



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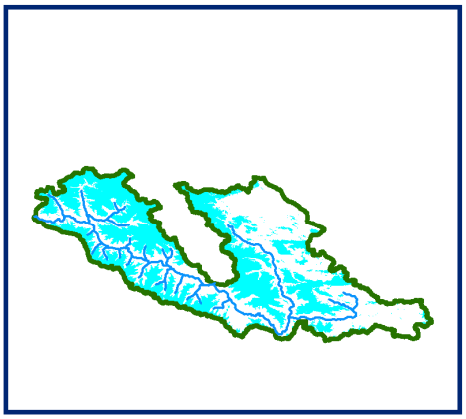

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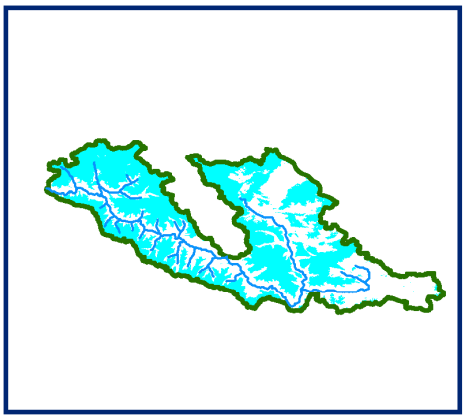


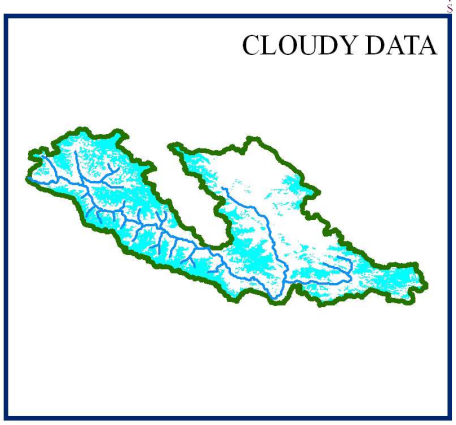
DATA USED
25 DECEMBER 2011

SNOW

0 50 100 200 300 400
Kilometers

SNOW COVER MAP : SHYOK BASIN

02 JAN 2012



12 JAN 2012

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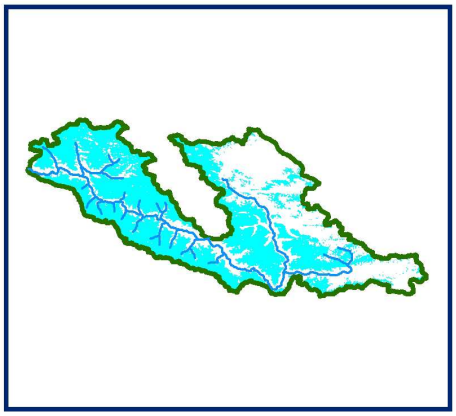
DATA NOT AVAILABLE



24 JAN 2012

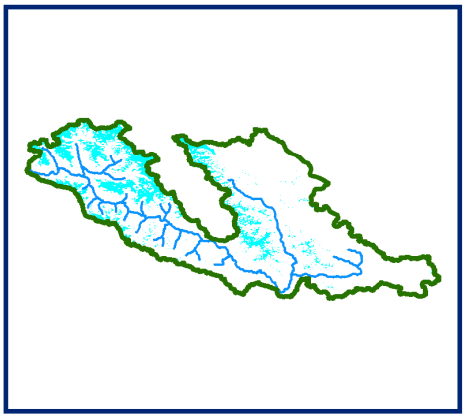
DATA NOT AVAILABLE

SNOW

0 2550 100 150 200

Kilometers

10 DAILY SNOW COVER MAP: SHYOK BASIN



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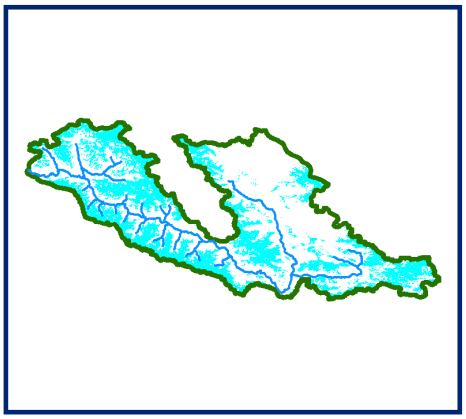

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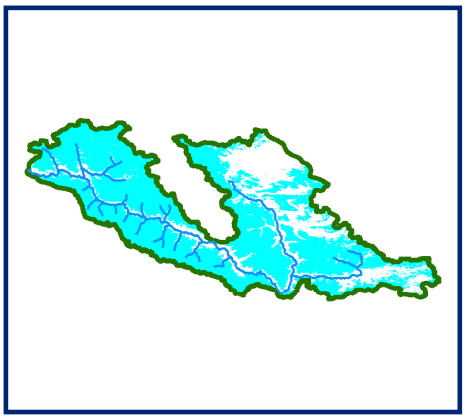


DATA USED

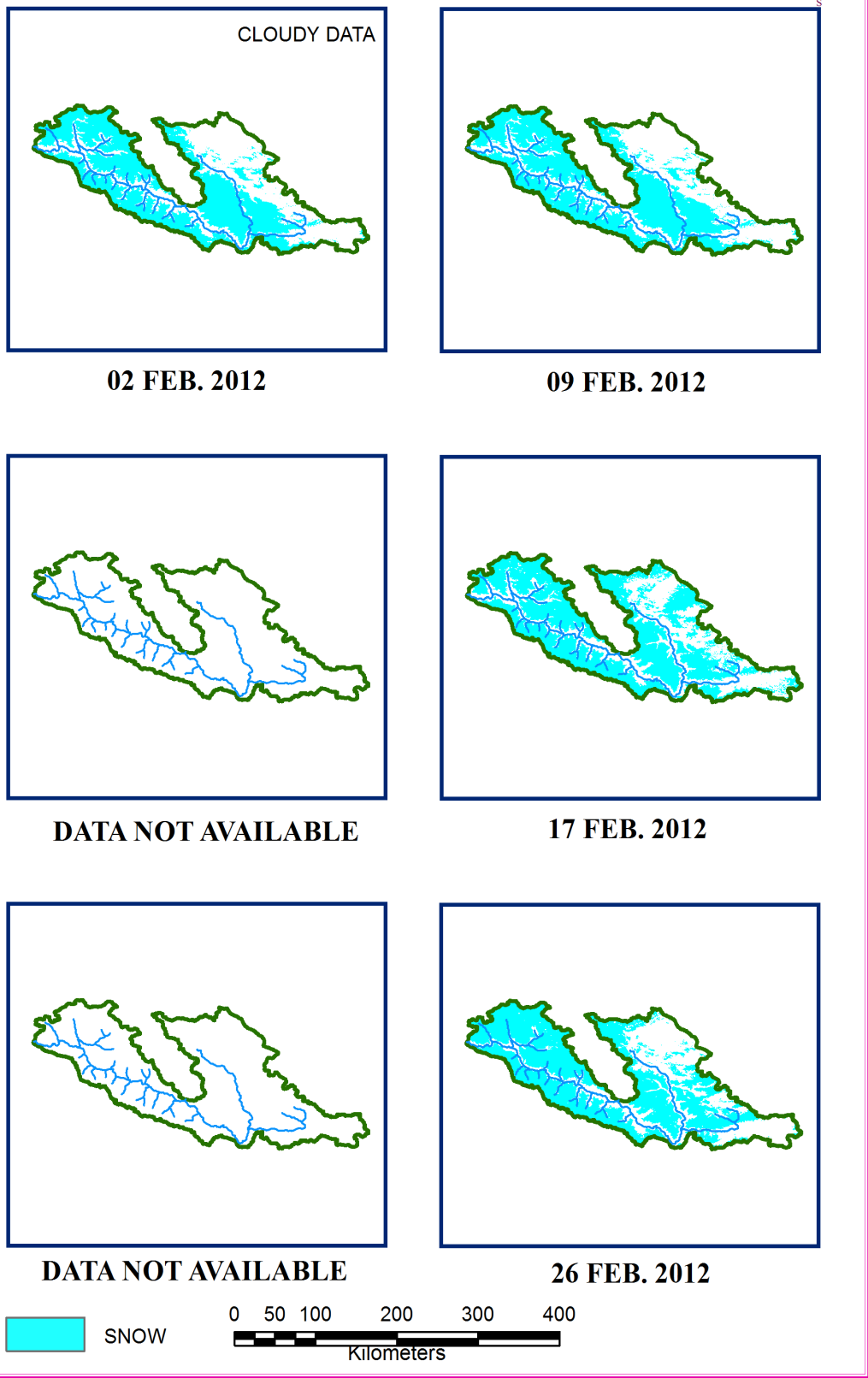
21January 2012
24 January 2012
25 January 2012

SNOW

0 50 100 200 300 400

Kilometers

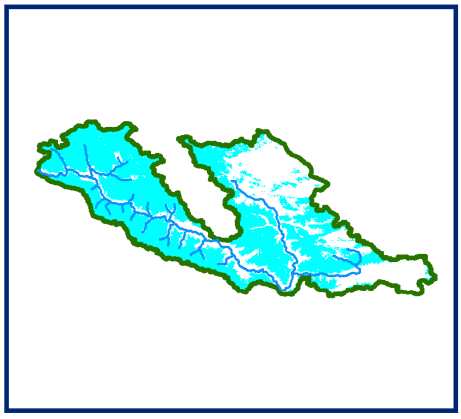
SNOW COVER MAP : SHYOK BASIN



10 DAILY SNOW COVER MAP: SHYOK BASIN

DATA USED
02 FEB. 2012
09 FEB. 2012

DATA USED
17 FEB. 2012

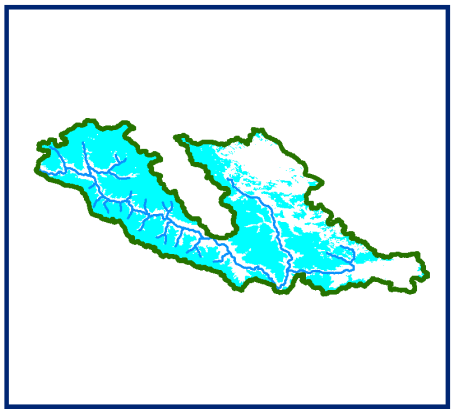


DATA USED
26 FEB. 2012

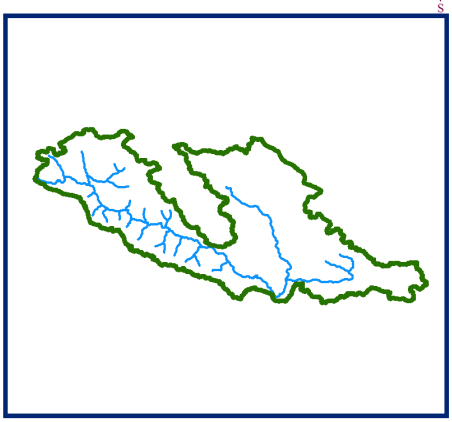
SNOW

0 50 100 200 300 400
Kilometers

SNOW COVER MAP : SHYOK BASIN



02 MARCH 2012



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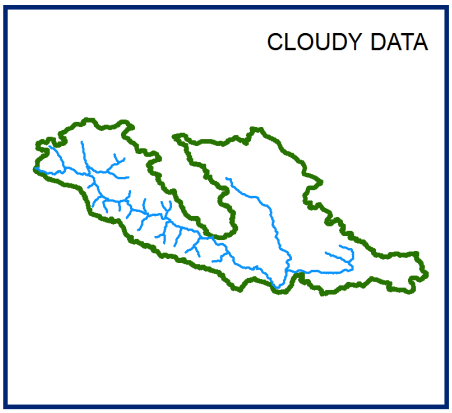

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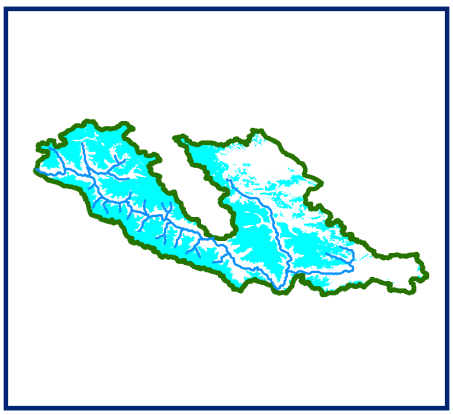


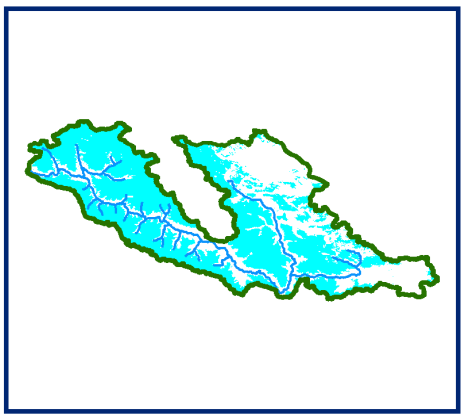
31 MARCH 2012

SNOW

0 50 100 200 300 400

Kilometers

10 DAILY SNOW COVER MAP: SHYOK BASIN



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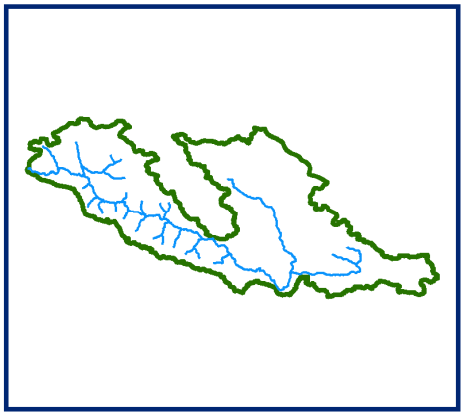
02 March 2012



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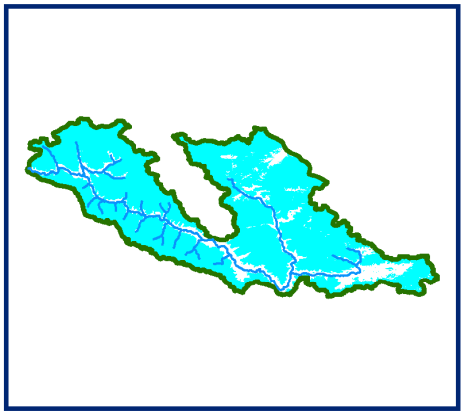

DATA USED
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31 March 2012

SNOW

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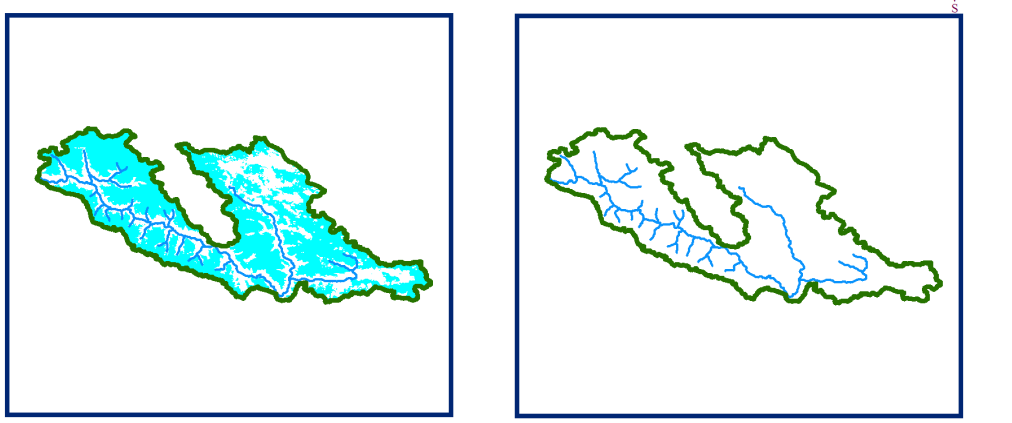
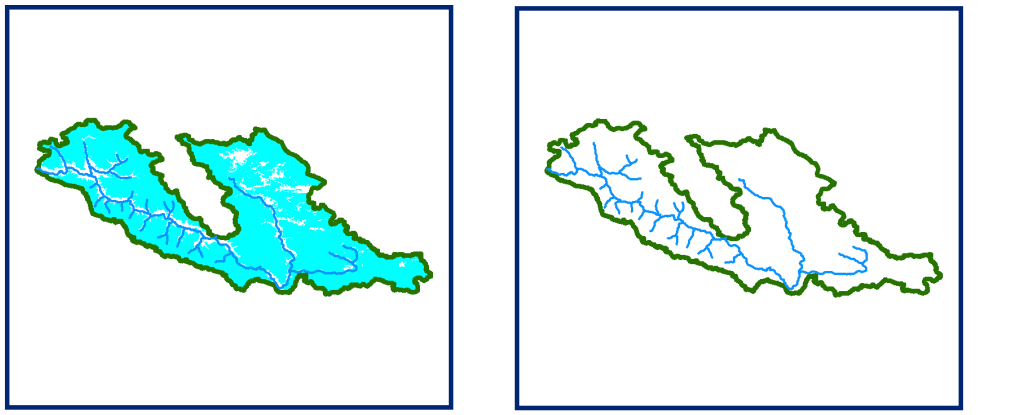
Kilometers

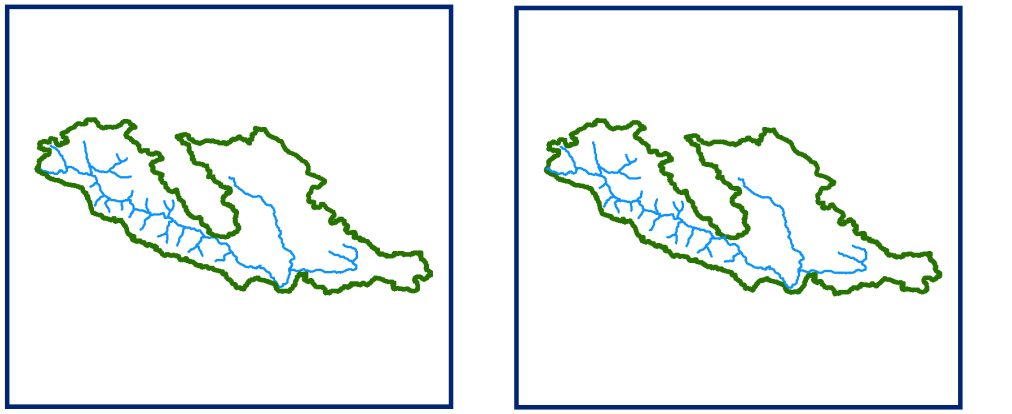
SNOW COVER MAP : SHYOK BASIN



05 APRIL 2012 | DATA NOT AVAILABLE



13 APRIL 2012 | DATA NOT AVAILABLE



DATA NOT AVAILABLE | DATA NOT AVAILABLE

SNOW

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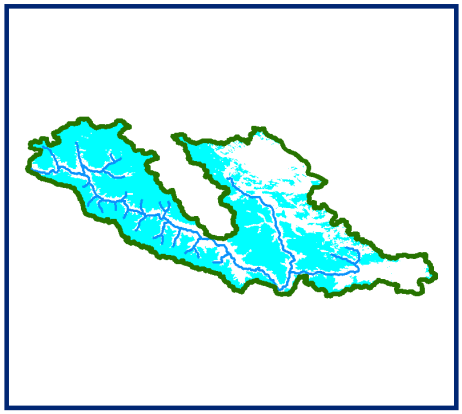
Kilometers

10 DAILY SNOW COVER MAP: SHYOK BASIN



DATA USED
04 April 2012
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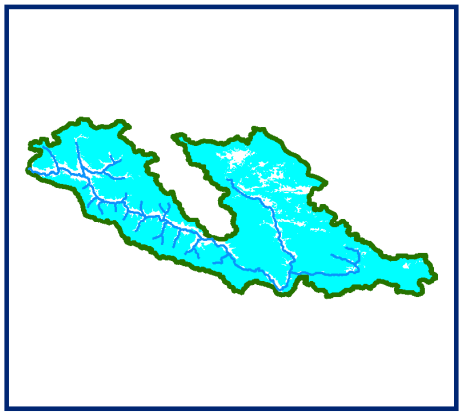

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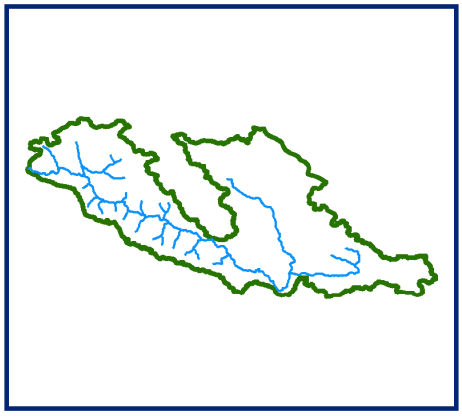
13 April 2012



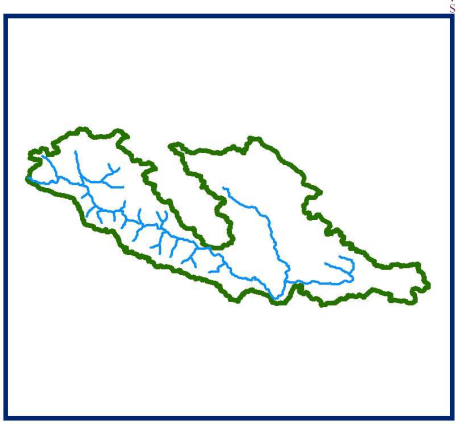
DATA USED
DATA NOT AVAILABLE

SNOW

0 50 100 200 300 400
Kilometers

SNOW COVER MAP : SHYOK BASIN

04 MAY 2012



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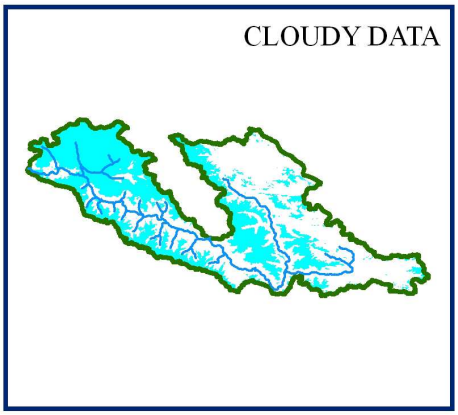
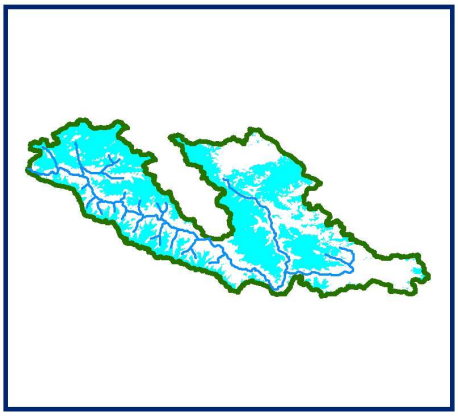


18 MAY 2012



23 MAY 2012

DATA NOT AVAILABLE

SNOW

0 25 50 100 150 200

Kilometers

10 DAILY SNOW COVER MAP: SHYOK BASIN

DATA USED
04 MAY 2012

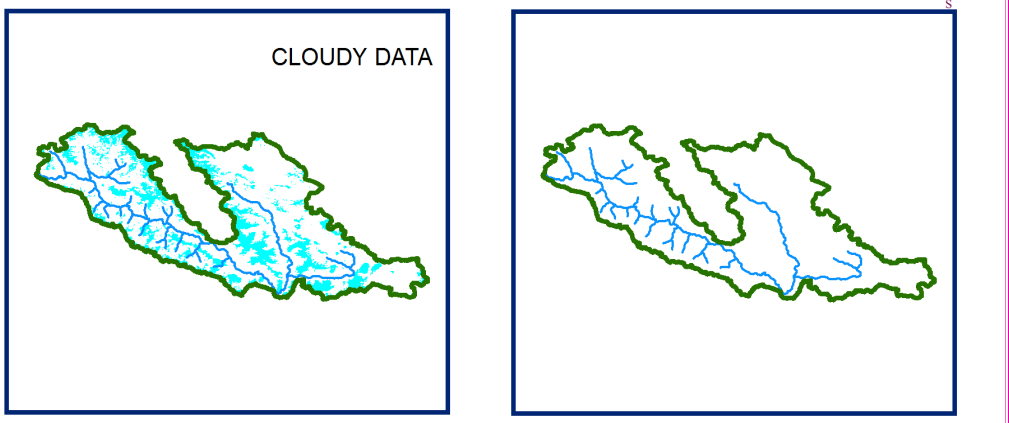
DATA USED
18 MAY 2012

DATA USED
23 MAY 2012

SNOW

0 2550 100 150 200
Kilometers

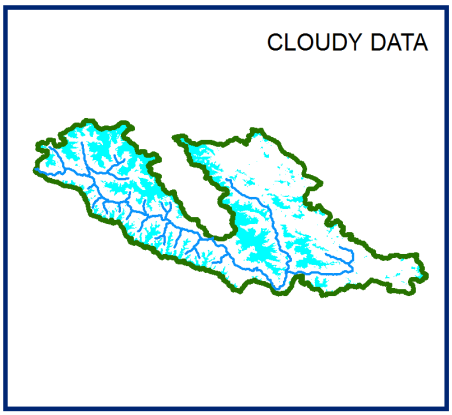
SNOW COVER MAP : SHYOK BASIN



04 JUNE 2012

DATA NOT AVAILABLE

DATA NOT AVAILABLE



20 JUNE 2012

DATA NOT AVAILABLE

DATA NOT AVAILABLE

SNOW

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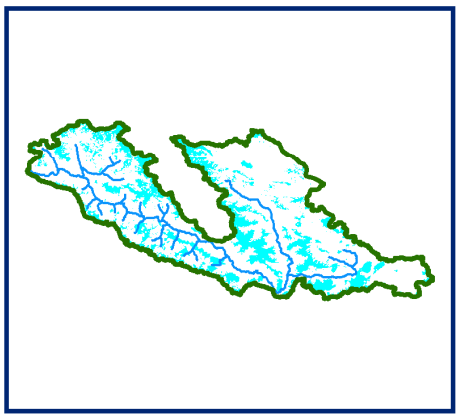
Kilometers

10 DAILY SNOW COVER MAP: SHYOK BASIN

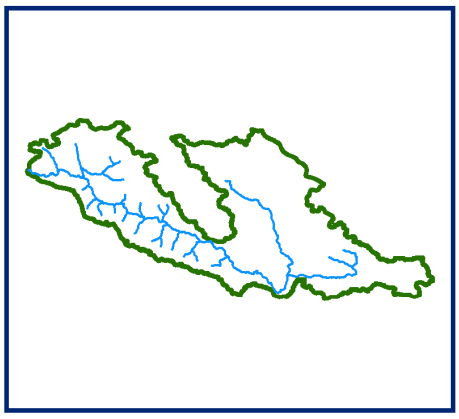


DATA USED

04 June 2012

DATA USED

15 June 2012
16 June 2012
20 June 2012



DATA USED

DATA NOT AVAILABLE

SNOW

0 50 100 200 300 400

Kilometers

SHIGAR BASIN

AREAL EXTENT OF SNOW (5 DAILY)

BASIN NAME: SHIGAR **BASIN AREA: 7050 sq km**

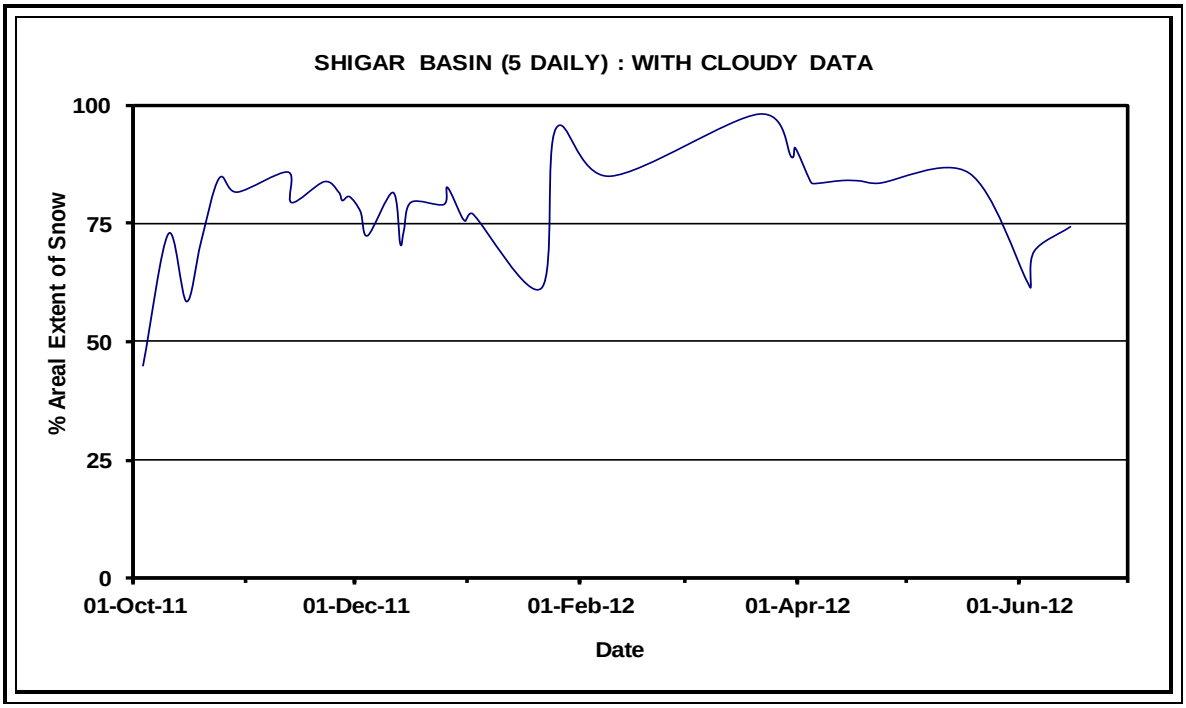
S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2011							
1	3-Oct-11	3159	45	2	10-Oct-11	5130	73
3.	15-Oct-11	4118	58	4	19-Oct-11	5008	71
5	24-Oct-11	5961	85	6	29-Oct-11	5755	82
November 2011							
7	12-Nov-11	6054	86	8	13-Nov-11	5443	77
9	22-Nov-11	5911	84	10	26-Nov-11	5755	82
11	27-Nov-11	5629	80	12	29-Nov-11	5286	81
December 2011							
13	02-Dec-11	5467	78	14	4-Dec-11	5104	72
15	11-Dec-11	5749	82	16	13-Dec-11	4980	71
17	14-Dec-11	5182	73	18	16-Dec-11	5604	79
19	25-Dec-11	5569	79	20	26-Dec-11	5826	83
21	30-Dec-11	5381	76	22	31-Dec-11	5322	75
January 2012							
23	02-Jan-12	5428	77	24	21-Jan-12	4320	61
25	24-Jan-12	6709	94				
February 2012							
26	09-Feb-12	5718	81				
March 2012							
27	2-Mar-12	6544	93	29	31-Mar-12	6418	91
27	21-Mar-12	6921	98	28	30-Mar-12	6278	89
April 2012							
30	02-Apr-12	6148	87	34	23-Apr-12	5887	84
30	04-Apr-12	5940	84	31	05-Apr-12	5882	83
32	13-Apr-12	5928	84				
May 2012							
35	18-May-12	6040	86				
June 2012							
36	03-Jun-12	4421	63	37	04-Jun-12	4325	61
38	05-Jun-12	4871	69	39	15-Jun-12	5238	74
40	16-Jun-12	4718	67	41	20-Jun-12	6619	71

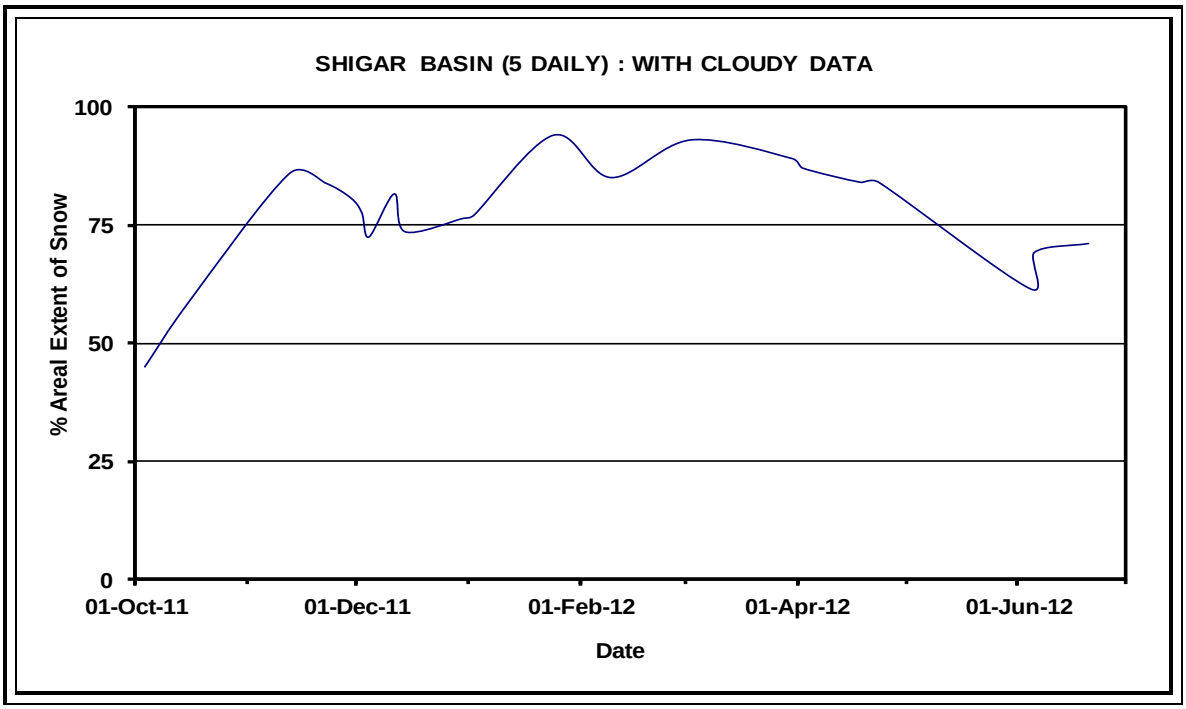
AREAL EXTENT OF SNOW (10 DAILY)

BASIN NAME: SHIGAR **BASIN AREA: 7050 sq km**

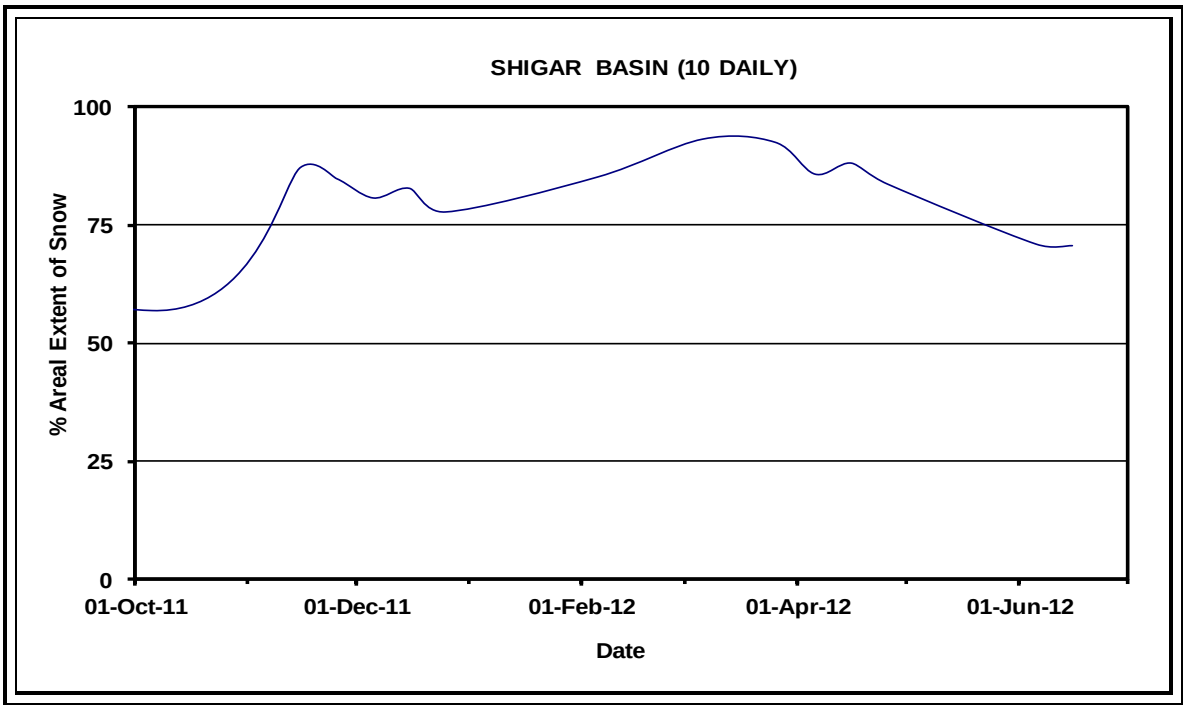
S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2011				**November 2011**			
1	5-Oct-11	4004	57	4	12-Nov-11	6136	87
				5	25-Nov-11	5966	85
December 2011				**January 2012**			
6	3-Dec-11	5681	81	9	2-Jan-11	5428	77
7	15-Dec-11	5824	83	10	22-Jan-11	6627	94
8	31-Dec-11	5472	78				
February 2012				**March 2012**			
11	09-Feb-12	5994	85	12	5-Mar-12	6544	93
				12	25-Mar-12	6510	92
April 2012				**May 2012**			
13	05-Apr-12	6035	86	16	18-May-12	6040	86
14	15-Apr-12	6199	88				
15	23-Apr-12	5887	84				
June 2012							
17	05-Jun-12	4865	69				
18	20-Jun-12	4988	71				

Snow cover depletion curve



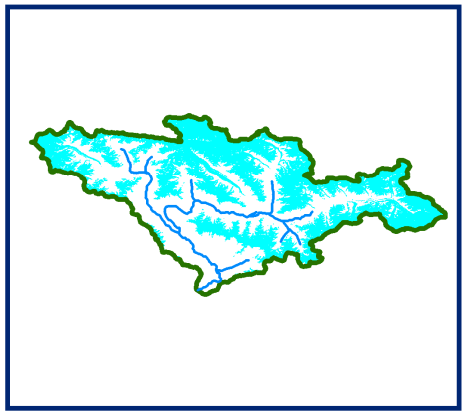


Snow cover depletion curve

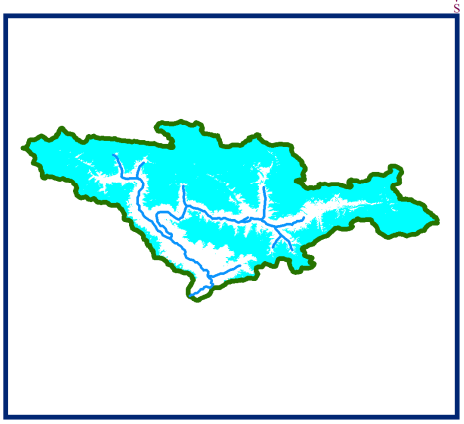


SNOW COVER MAP

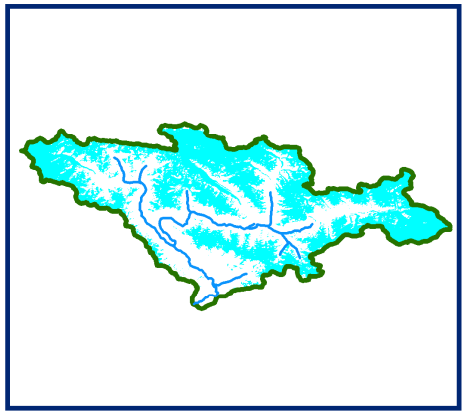
SNOW COVER MAP : SHIGAR BASIN



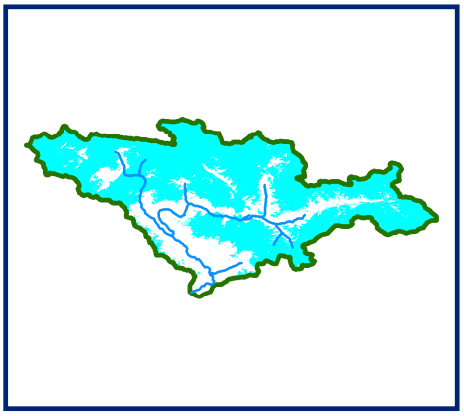
03 OCTOBER 2011



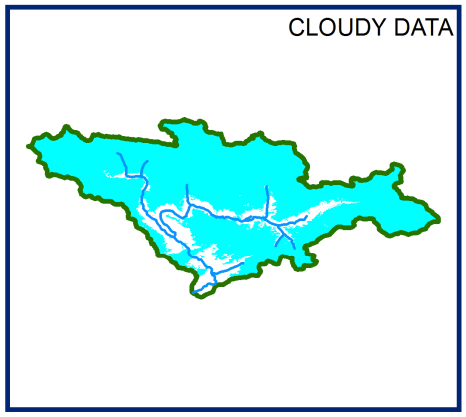
10 OCTOBER 2011



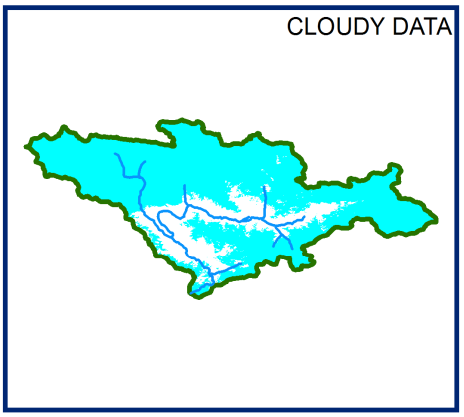
15 OCTOBER 2011
10 OCTOBER 2011



19 OCTOBER 2011

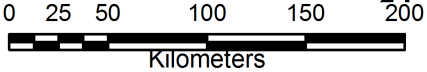


24 OCTOBER 2011

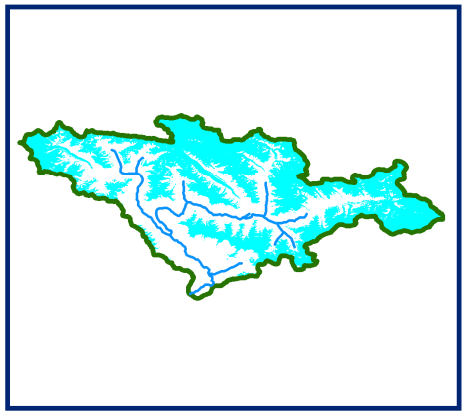


29 OCTOBER 2011
24 OCTOBER 2011

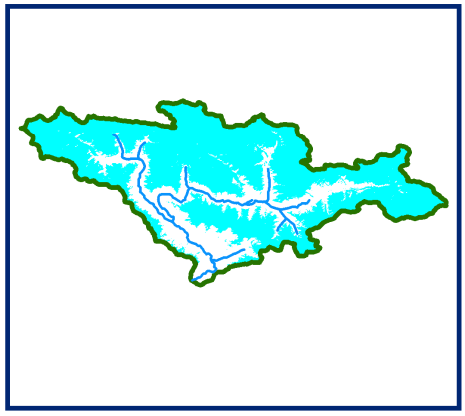
SNOW



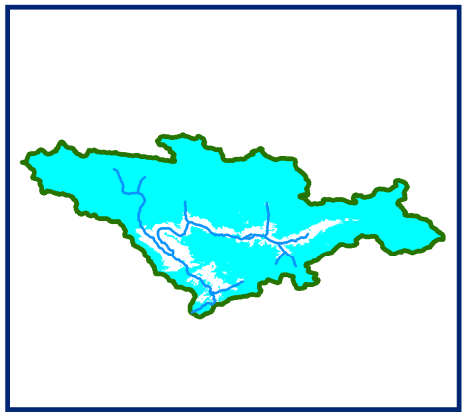
10 DAILY SNOW COVER MAP: SHIGAR BASIN



DATA USED
03 OCTOBER 2011
10 OCTOBER 2011



DATA USED
15 OCTOBER 2011
19 OCTOBER 2011

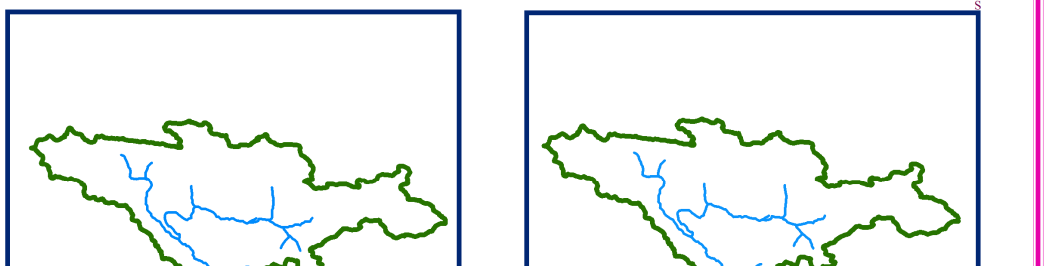


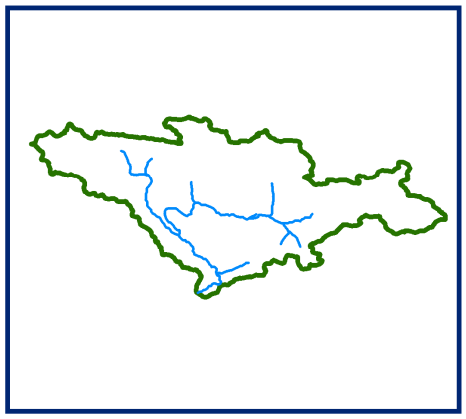
DATA USED
25 OCTOBER 2011

SNOW

0 25 50 100 150 200
Kilometers

SNOW COVER MAP : SHIGAR BASIN





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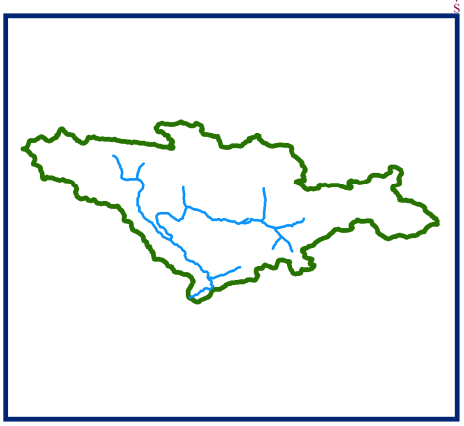

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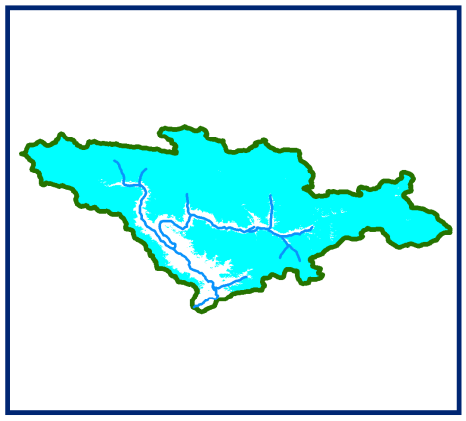
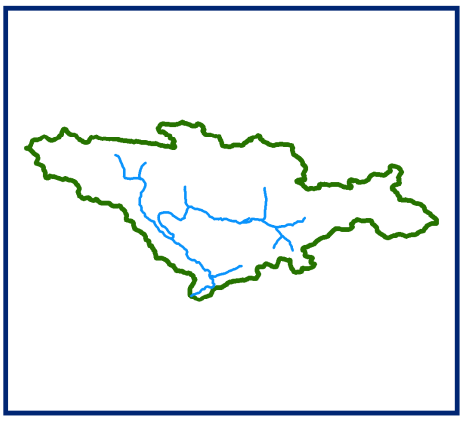


12 NOVEMBER 2011



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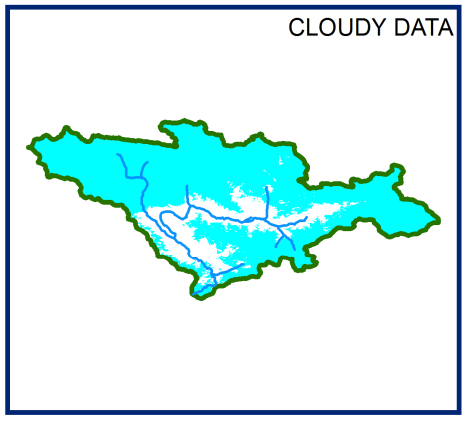
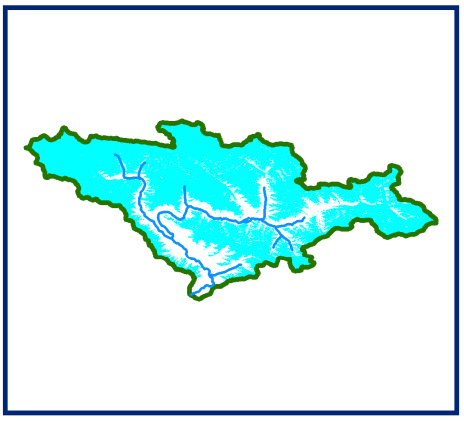
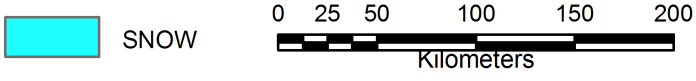


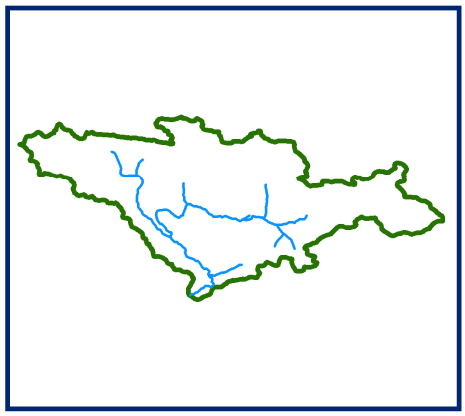
22 NOVEMBER 2011



29 NOVEMBER 2011



10 DAILY SNOW COVER MAP: SHIGAR BASIN



DATA USED
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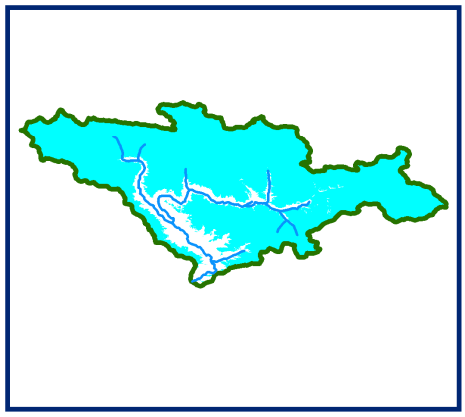
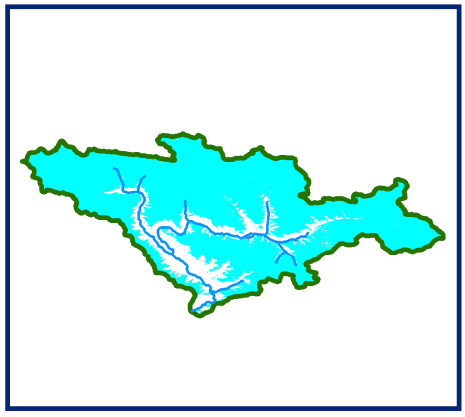


DATA USED
12 NOVEMBER 2011
13 NOVEMBER 2011

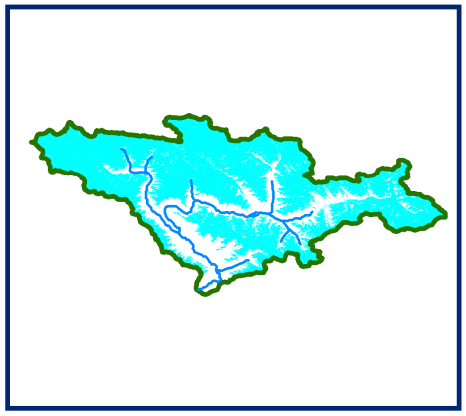


DATA USED
22 NOVEMBER 2011
26 NOVEMBER 2011
27 NOVEMBER 2011

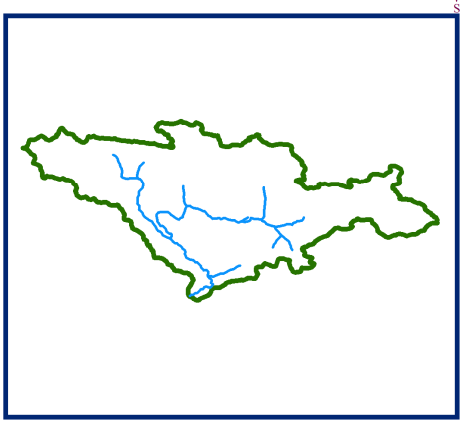
SNOW

0 25 50 100 150 200
Kilometers

SNOW COVER MAP : SHIGAR BASIN



04 DECEMBER 2011



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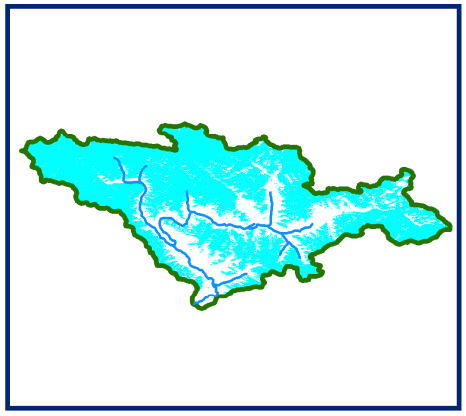
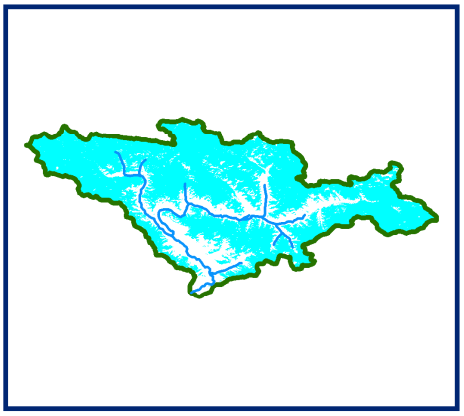
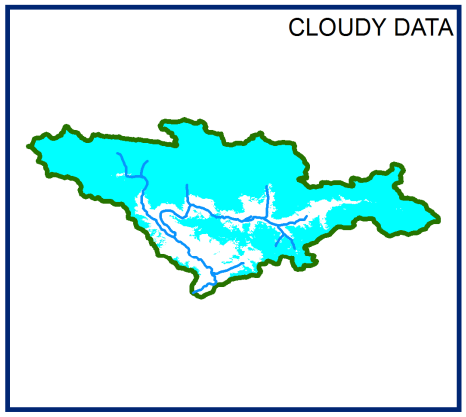


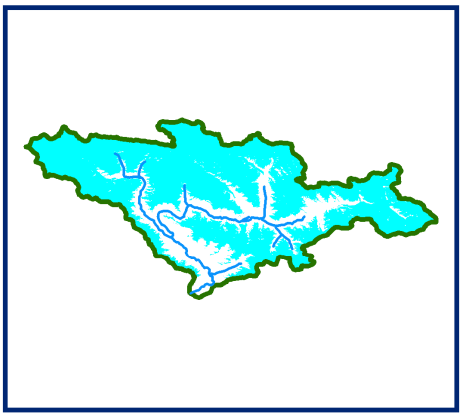
13 DECEMBER 2011



16 DECEMBER 2011
13 DECEMBER 2011



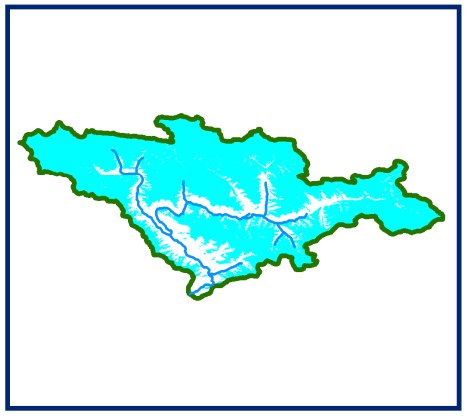
25 DECEMBER 2011



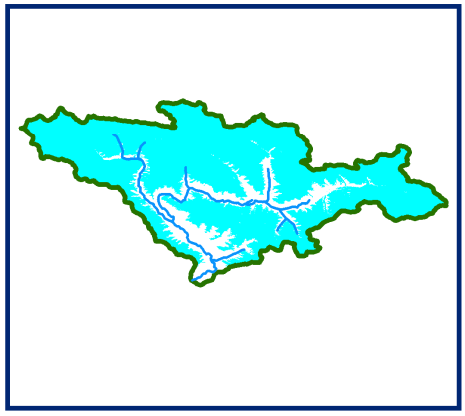
30 DECEMBER 2011

SNOW

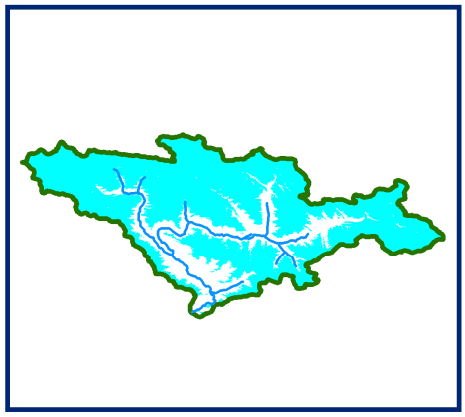
10 DAILY SNOW COVER MAP: SHIGAR BASIN



DATA USED
02 DECMBER 2011
04 DECMBER 2011



DATA USED
11 DECMBER 2011
14 DECMBER 2011
16 DECMBER 2011

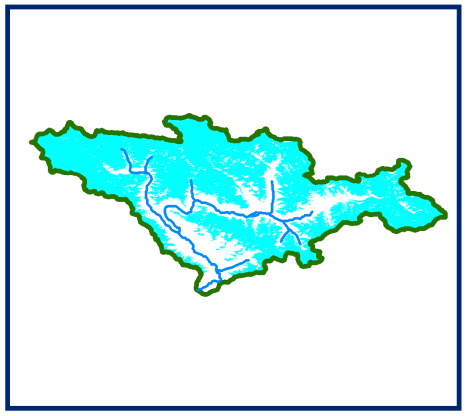


DATA USED
26 DECMBER 2011
30 DECMBER 2011
31 DECMBER 2011

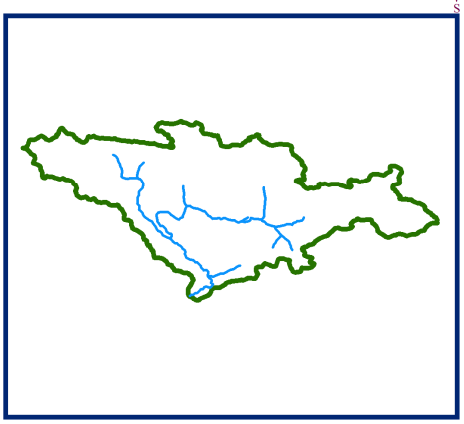
SNOW

0 25 50 100 150 200
Kilometers

SNOW COVER MAP : SHIGAR BASIN



02 JANUARY 2012



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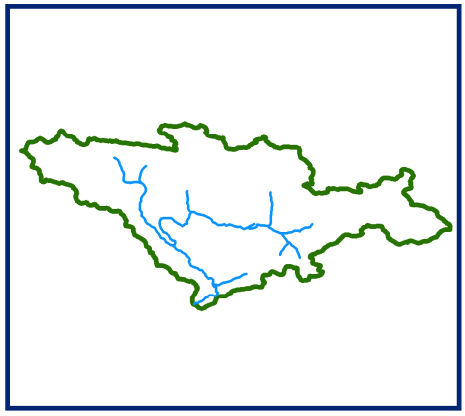

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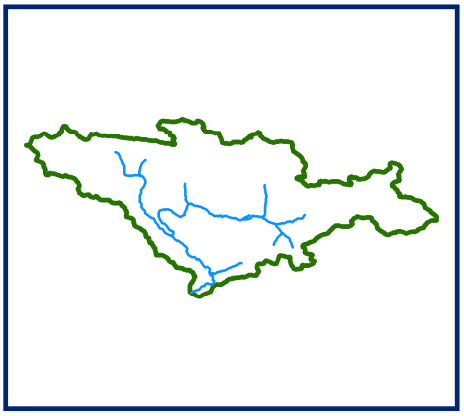

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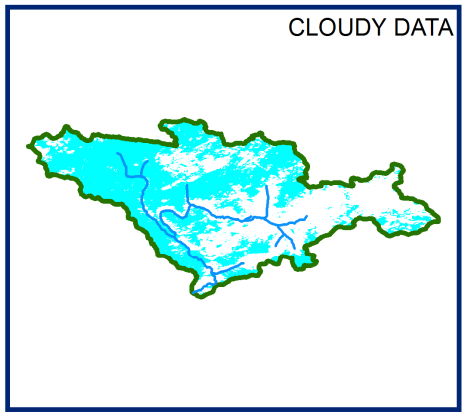
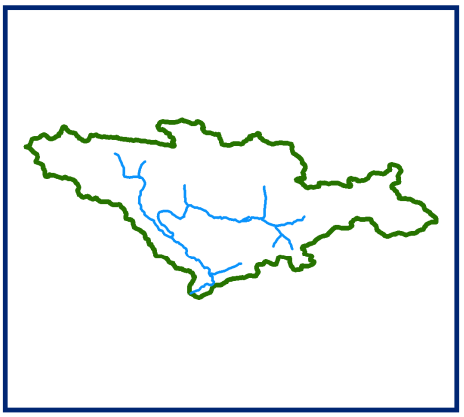


21 JANUARY 2012



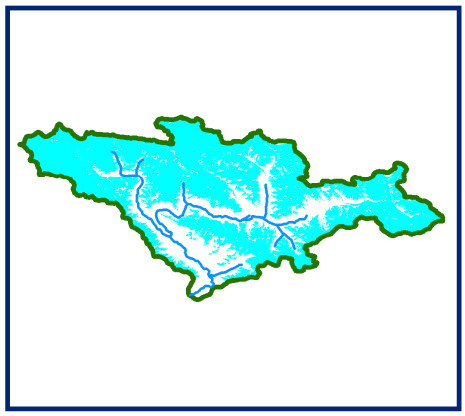
DATA NOT AVAILABLE

SNOW

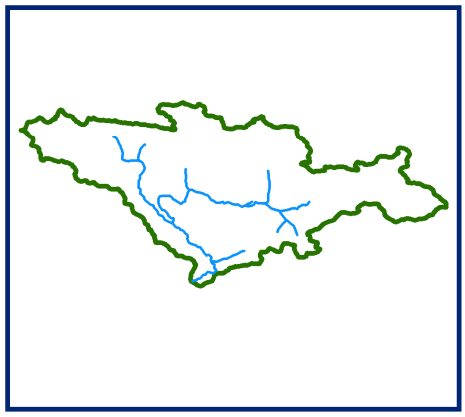
0 25 50 100 150 200

Kilometers

10 DAILY SNOW COVER MAP: SHIGAR BASIN



DATA USED
02 JANUARY 2012



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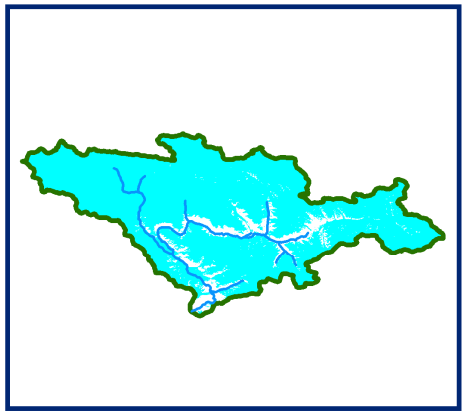
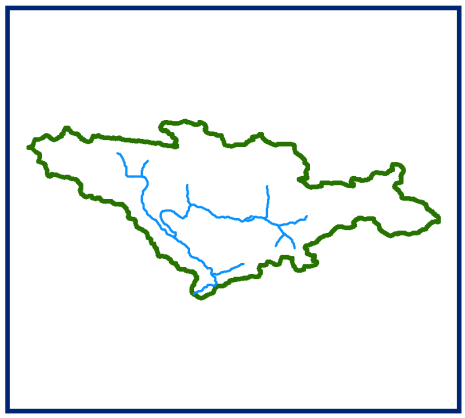


DATA USED
21 JANUARY 2012
22 JANUARY 2012

SNOW

0 25 50 100 150 200
Kilometers

SNOW COVER MAP : SHIGAR BASIN



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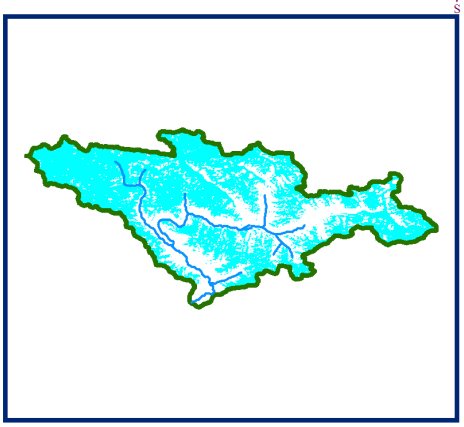
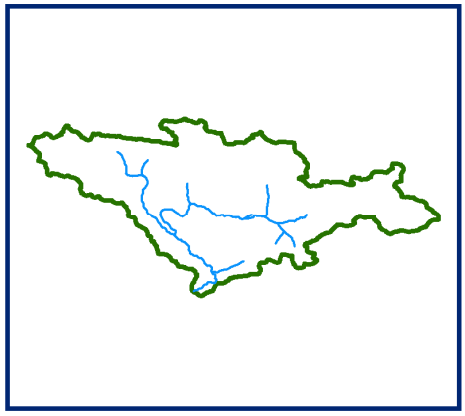


09 FEB. 2012



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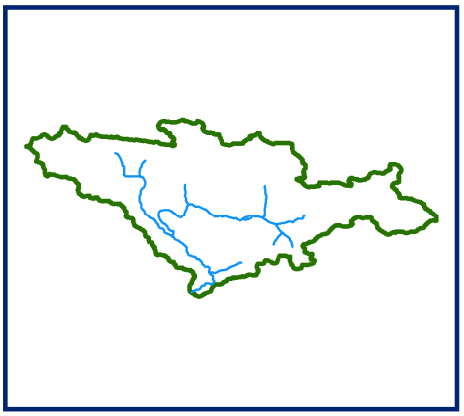

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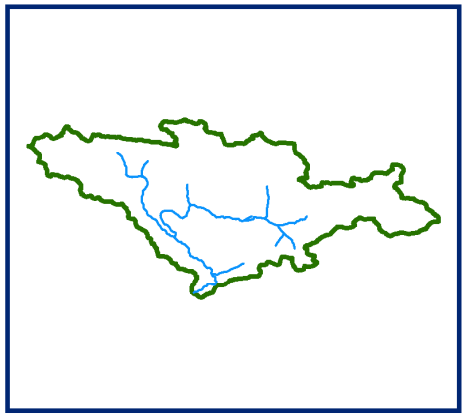

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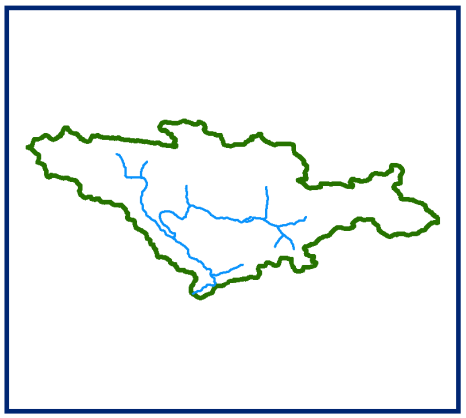


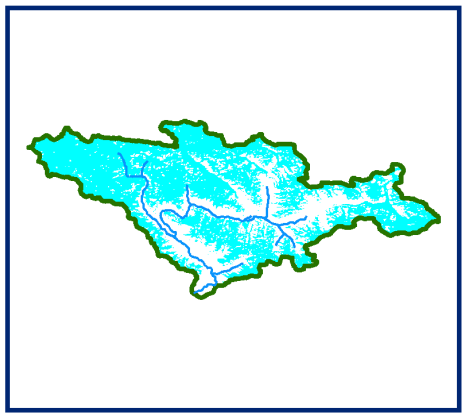
DATA NOT AVAILABLE

SNOW

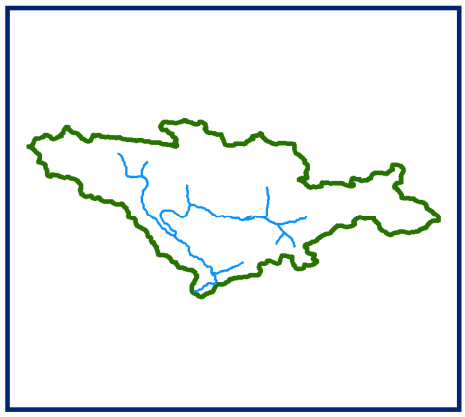
0 25 50 100 150 200

Kilometers

10 DAILY SNOW COVER MAP: SHIGAR BASIN



DATA USED
09 FEB. 2012



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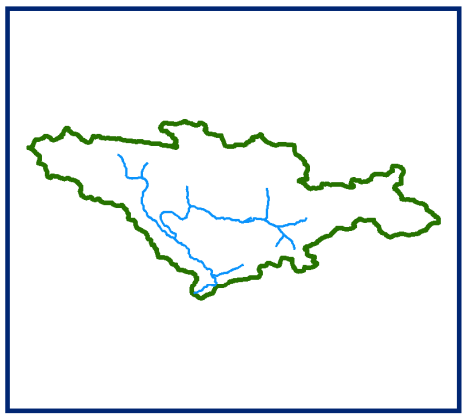

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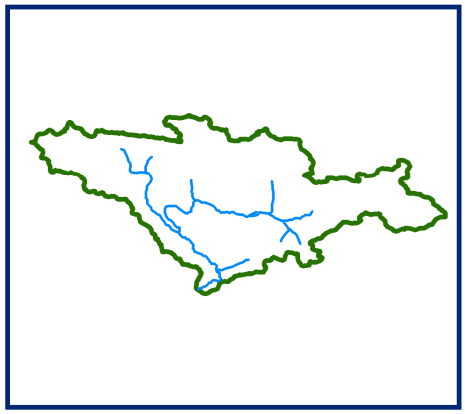
DATA NOT AVAILABLE

SNOW

0 25 50 100 150 200
Kilometers

SNOW COVER MAP : SHIGAR BASIN



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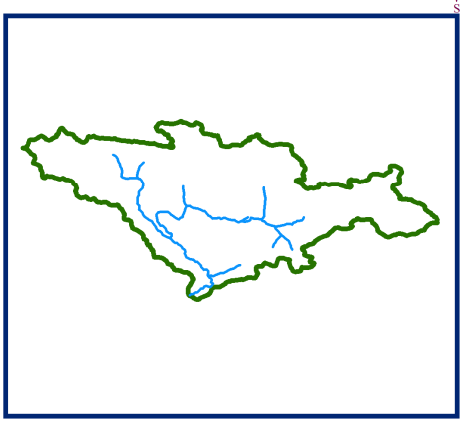

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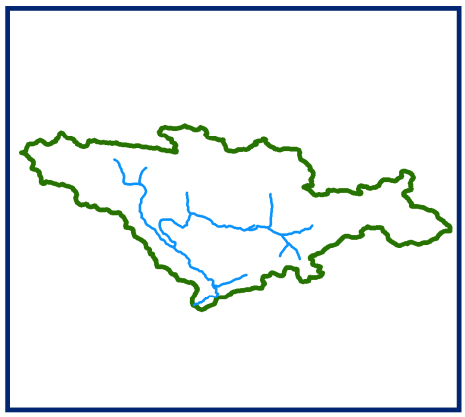

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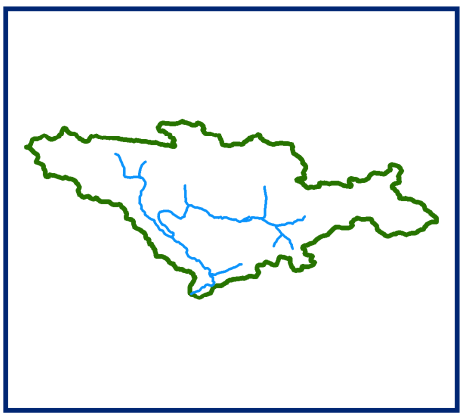

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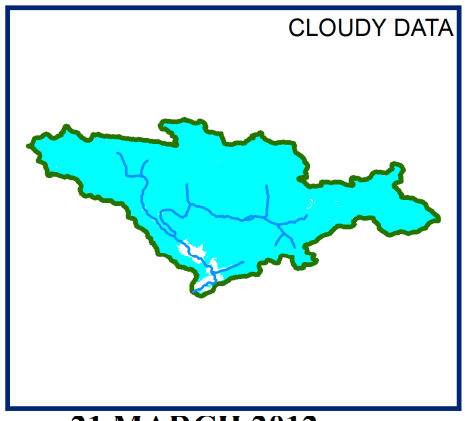
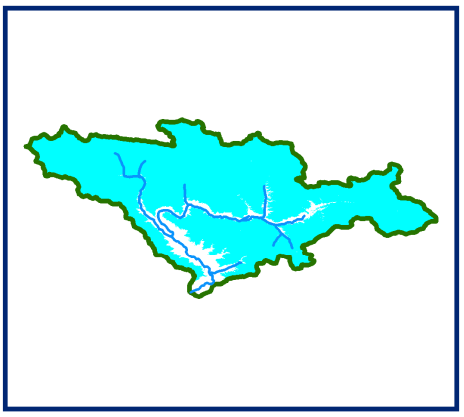


21 MARCH 2012



30 MARCH 2012

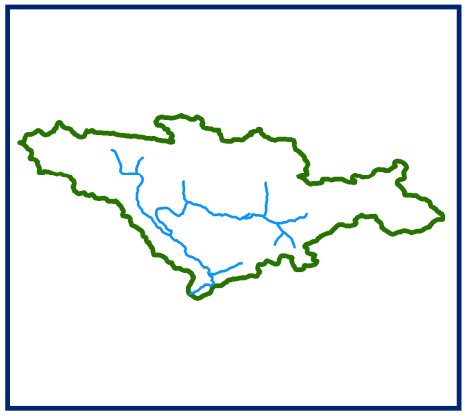
30 MARCH 2012

SNOW

0 25 50 100 150 200

Kilometers

10 DAILY SNOW COVER MAP: SHIGAR BASIN



DATA USED
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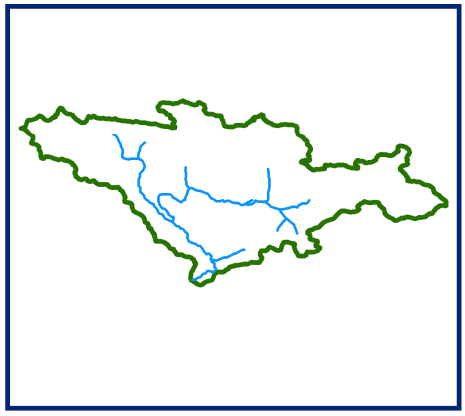

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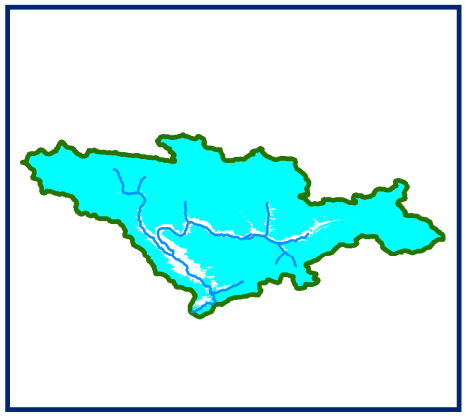
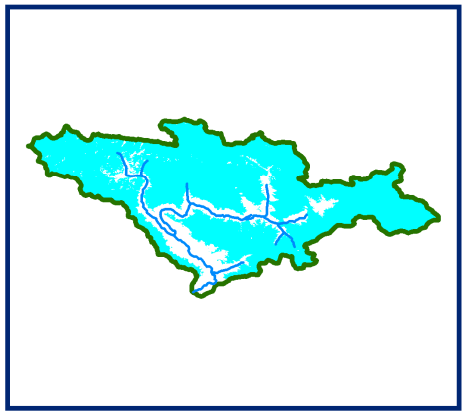


DATA USED
21 MARCH 2012
30 MARCH 2012
31 MARCH 2012

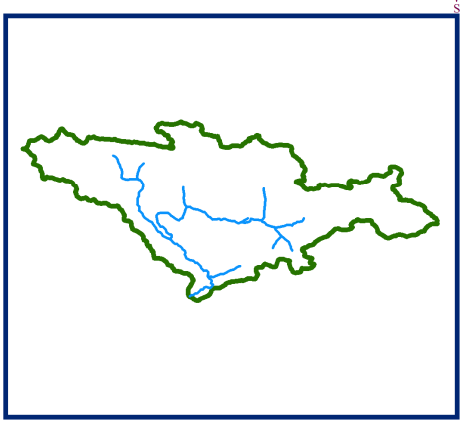
SNOW

0 25 50 100 150 200
Kilometers

SNOW COVER MAP : SHIGAR BASIN



05 APRIL 2012



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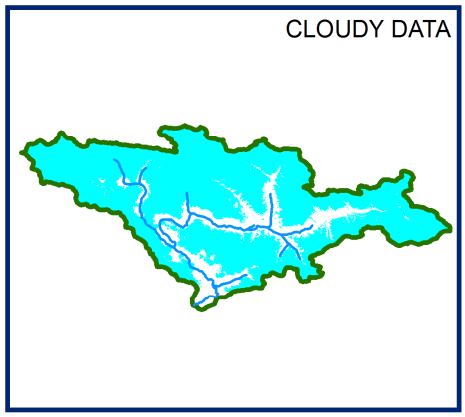
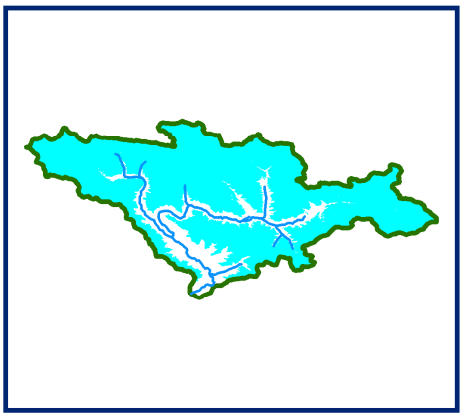
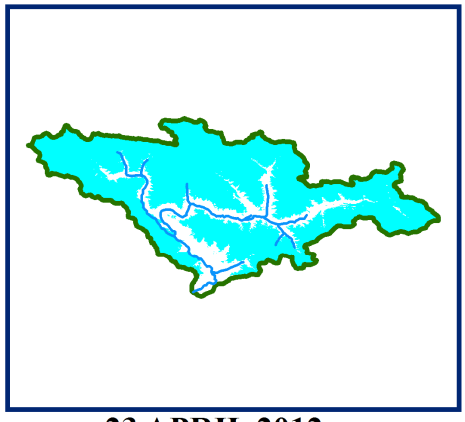


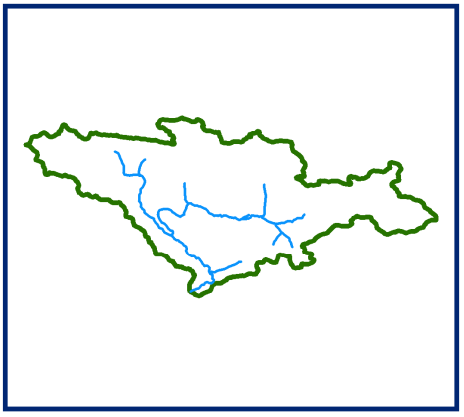
13 APRIL 2012



18 APRIL 2012
30 MARCH 2012



23 APRIL 2012

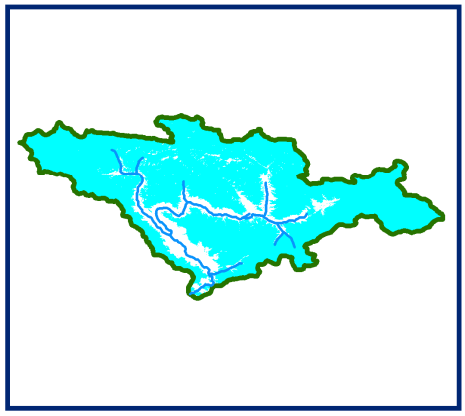


DATA NOT AVAILABLE

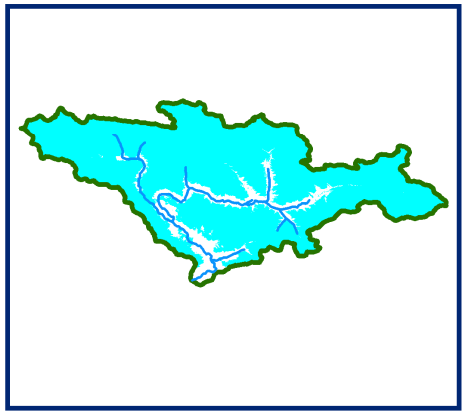
SNOW

0 25 50 100 150 200
Kilometers

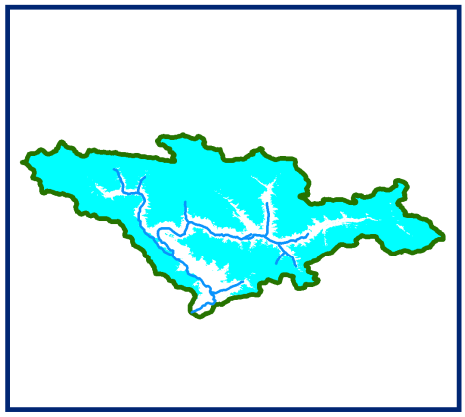
10 DAILY SNOW COVER MAP: SHIGAR BASIN



DATA USED
04 APRIL 2012
05 APRIL 2012



DATA USED
13 APRIL 2012
18 APRIL 2012

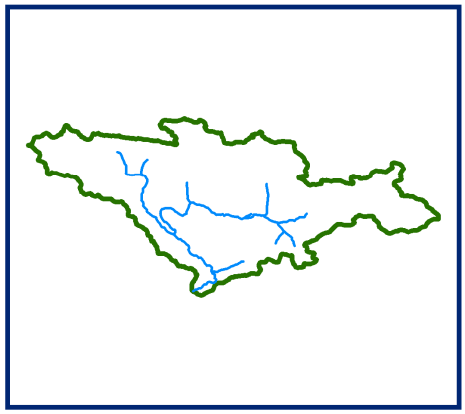


DATA USED
23 APRIL 2012

SNOW

0 25 50 100 150 200
Kilometers

SNOW COVER MAP : SHIGAR BASIN



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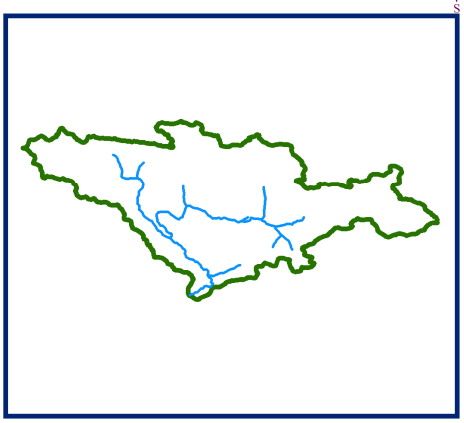

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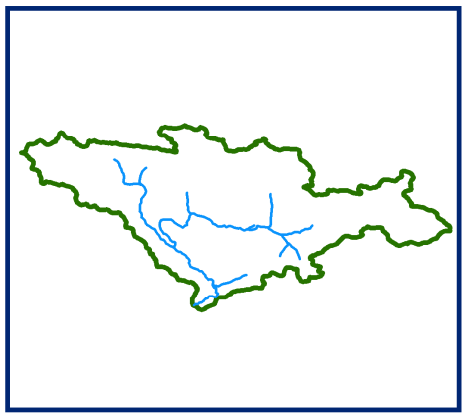

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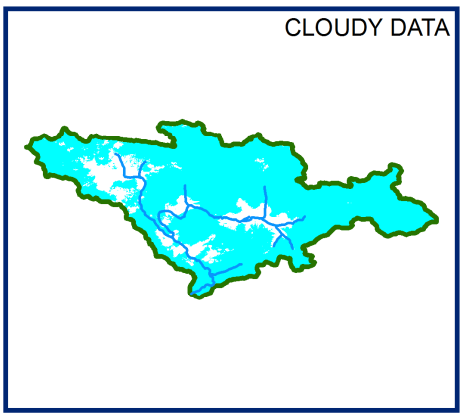
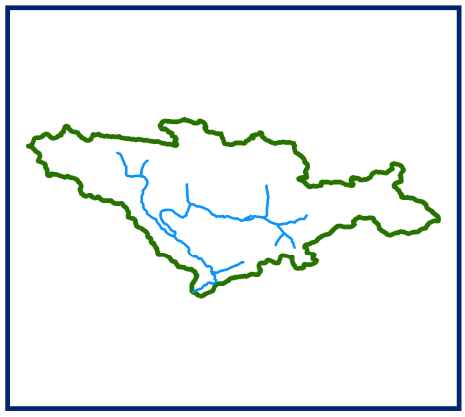


18 MAY 2012
03 JUNE 2012



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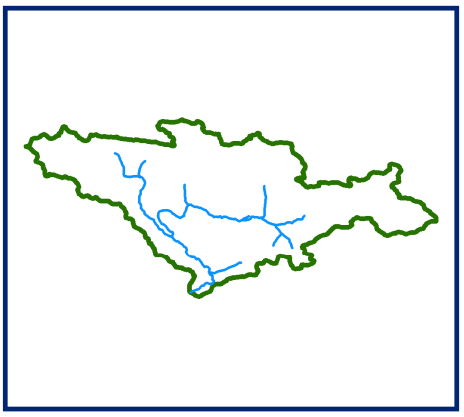
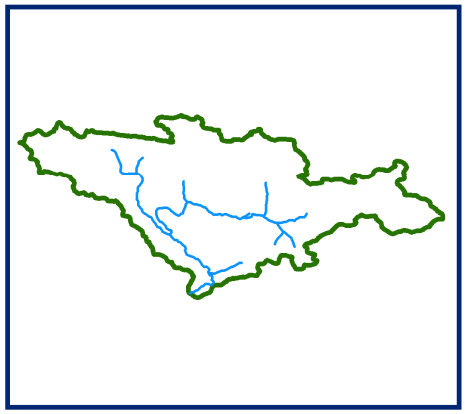


DATA NOT AVAILABLE

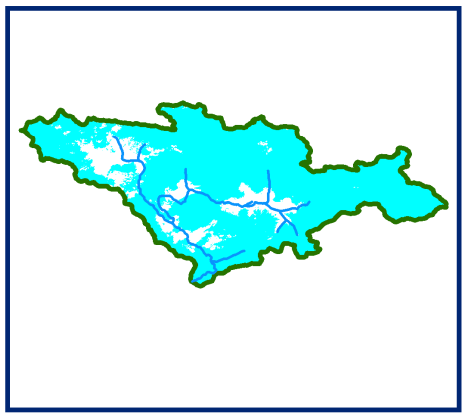
SNOW

0 25 50 100 150 200
Kilometers

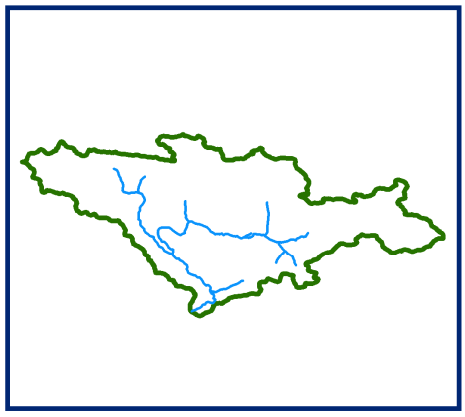
10 DAILY SNOW COVER MAP: SHIGAR BASIN



DATA USED
DATA NOT AVAILABLE



DATA USED
18 MAY 2012

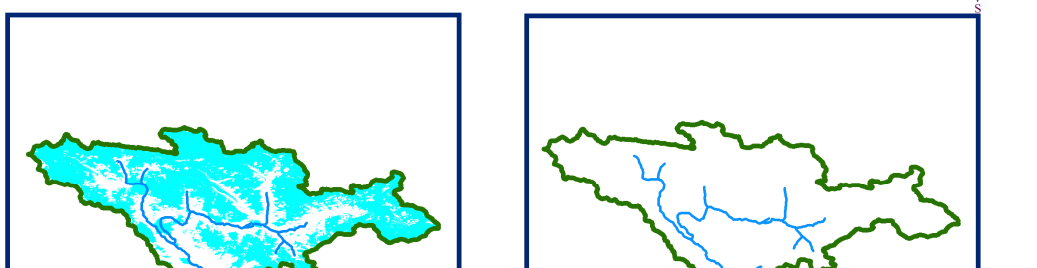


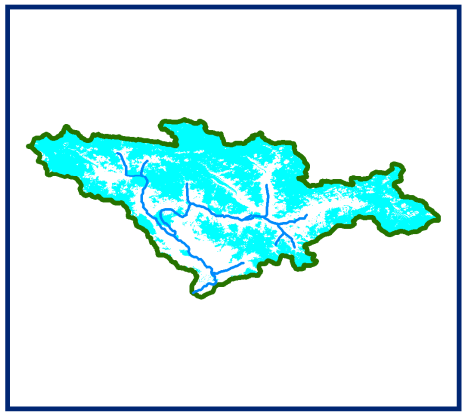
DATA USED
DATA NOT AVAILABLE

SNOW

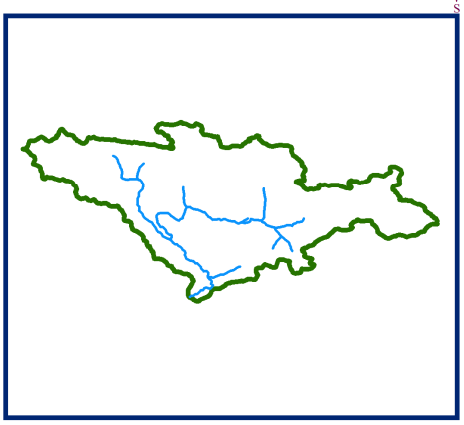
0 25 50 100 150 200
Kilometers

SNOW COVER MAP : SHIGAR BASIN





03 JUNE 2012



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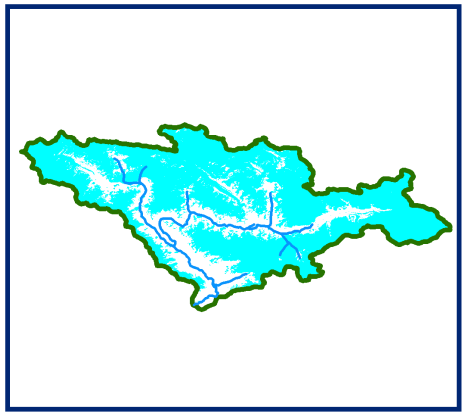
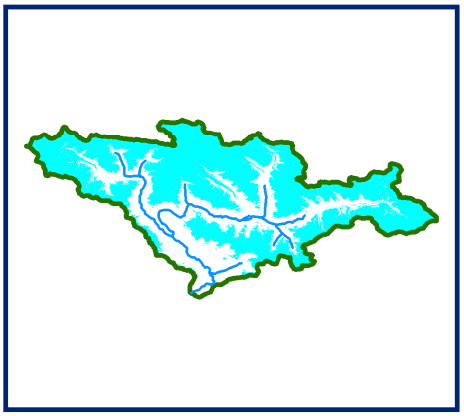
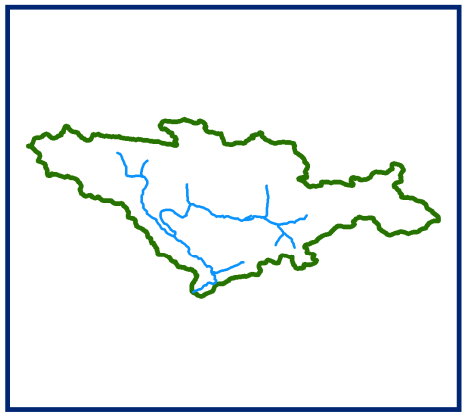


15 JUNE 2012
20 JUNE 2012



20 JUNE 2012



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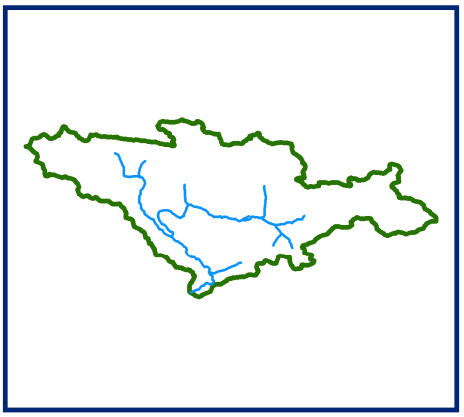

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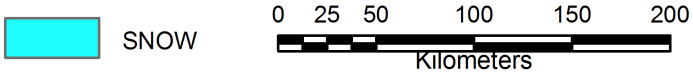
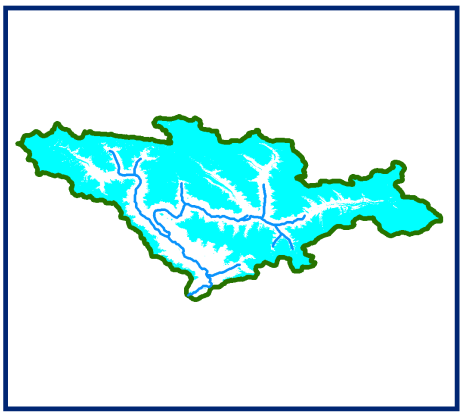
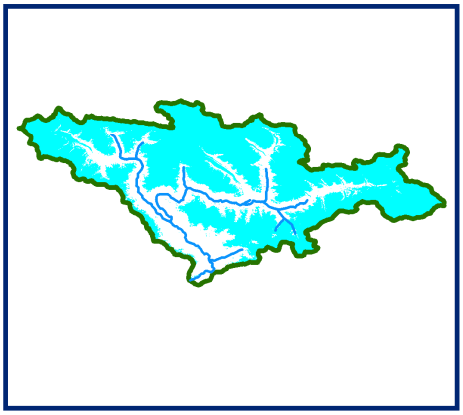


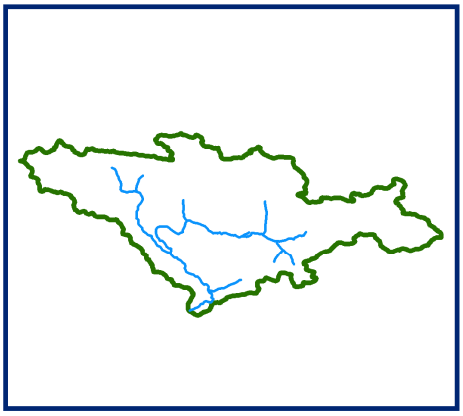
10 DAILY SNOW COVER MAP: SHIGAR BASIN



DATA USED
03 JUNE 2012
04 JUNE 2012
05 JUNE 2012



DATA USED
15 JUNE 2012
16 JUNE 2012
20 JUNE 2012



DATA USED
DATA NOT AVAILABLE

SNOW

0 25 50 100 150 200
Kilometers

HANZA BASIN

AREAL EXTENT OF SNOW (5 DAILY)

BASIN NAME: HANZA **BASIN AREA: 13711 sq km**

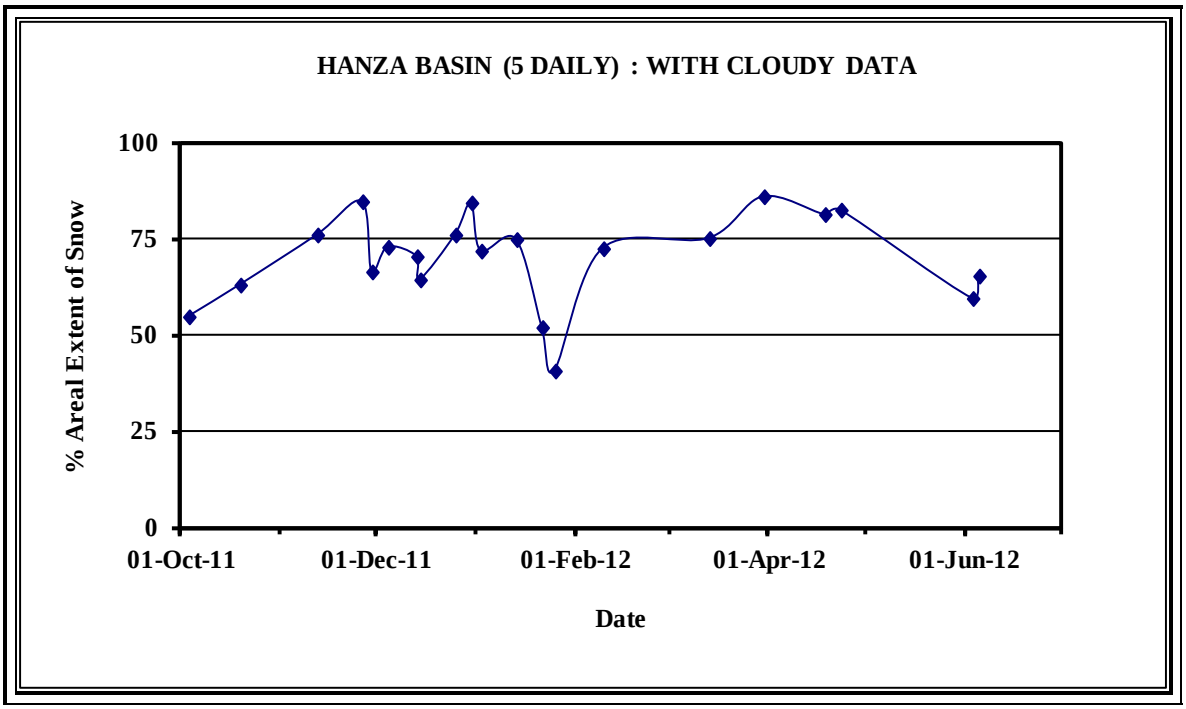
S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2011							
1	3-Oct-11	7530	55	2	19-Oct-11	8662	63
November 2011							
3	12-Nov-11	10448	76	4	26-Nov-11	11633	85
5	29-Nov-11	9131	67				
December 2011							
6	04-Dec-11	10031	73	7	14-Dec-11	8847	65
8	13-Dec-11	9673	71	9	25-Dec-11	10446	76
10	30-Dec-11	11589	85				
January 2012							
11	2-Jan-12	9868	72	12	21-Jan-12	7148	52
13	13-Jan-12	10283	75	14	25-Jan-12	5599	41
February 2012							
15	09-Feb-12	9957	73				
March 2012							
16	13-Mar-12	10321	75	17	30-Mar-12	11812	86
April 2012							
18	18-Apr-12	11176	82	19	23-Apr-12	11335	83
May 2012							
June 2012							
20	03-Jun-12	8183	60	21	05-Jun-12	8983	66

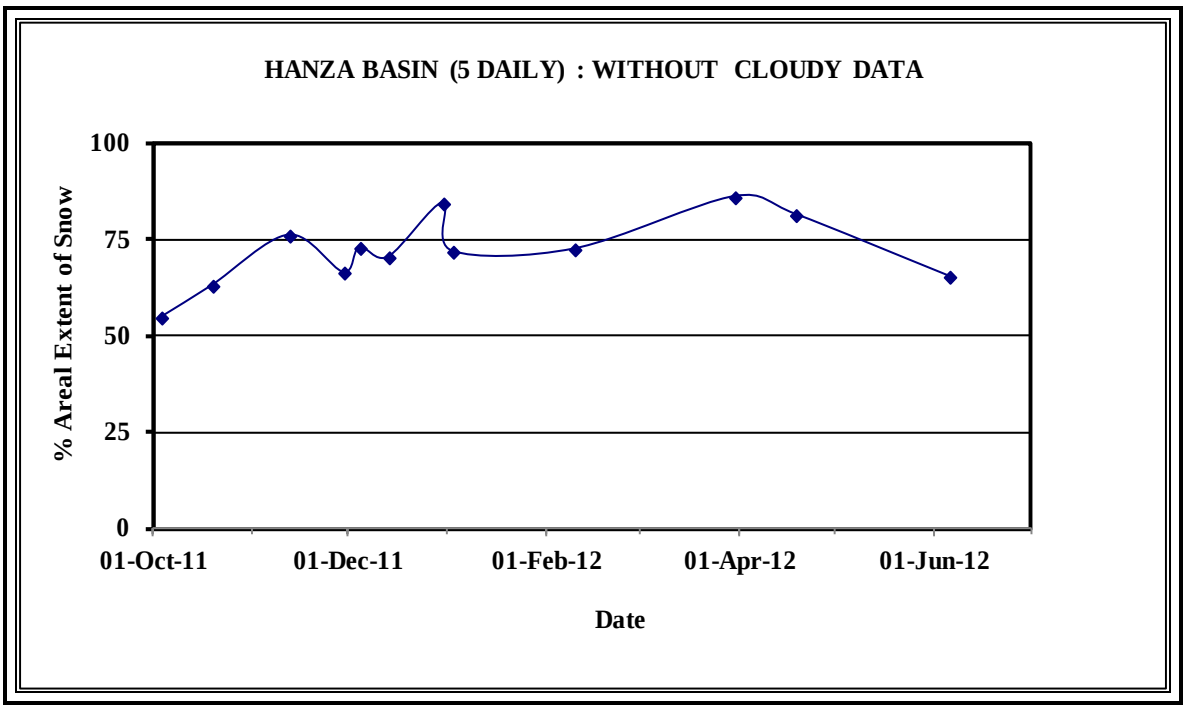
AREAL EXTENT OF SNOW (10 DAILY)

BASIN NAME: HANZA **BASIN AREA: 13711 sq km**

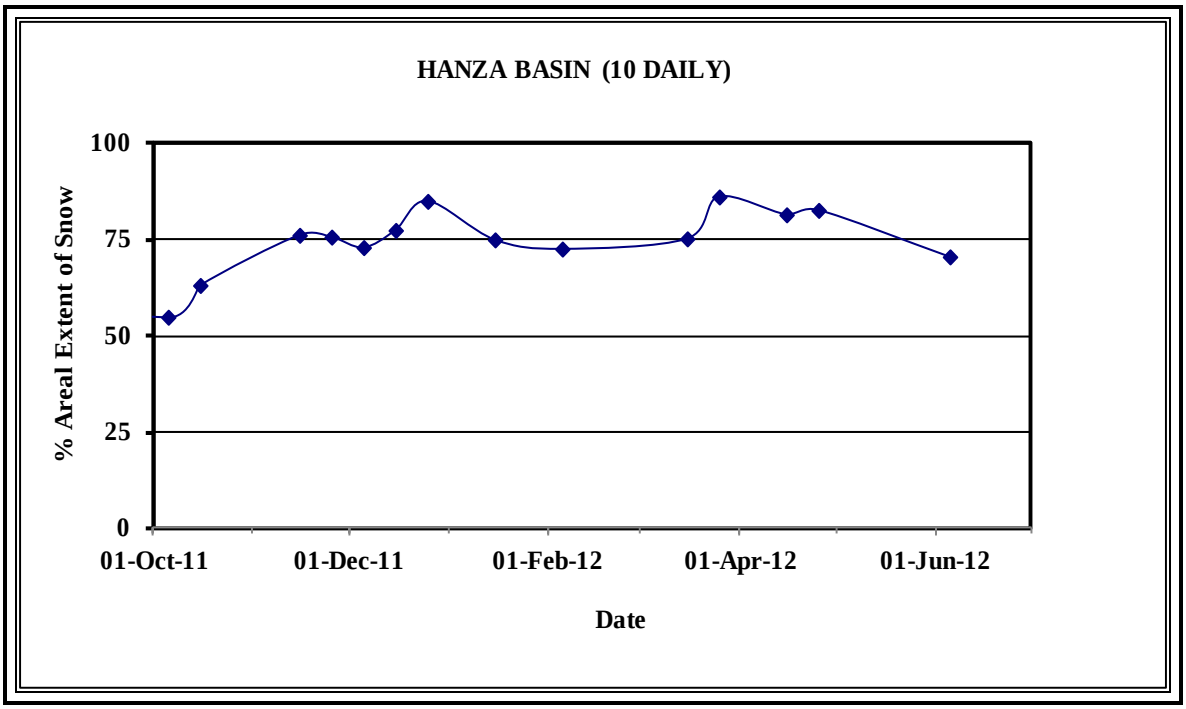
S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2011				**November 2011**			
1	3-Oct-11	7530	55	3	12-Nov-11	10448	76
2	19-Oct-11	8662	63	4	27-Nov-11	10382	76
December 2011				**January 2012**			
5	4-Dec-11	10031	73	8	2-Jan-11	9868	72
6	15-Dec-11	10622	77	9	13-Jan-12	10283	75
7	27-Dec-11	10770	79	10	23-Jan-12	8305	61
February 2012				**March 2012**			
11	09-Feb-12	9957	73	12	13-Mar-12	10321	75
				13	30-Mar-12	11812	86
April 2012				**May 2012**			
14	18-Apr-12	11176	82				
15	23-Apr-12	11335	83				
June 2012							
16	04-Jun-12	9679	71				

Snow cover depletion curve



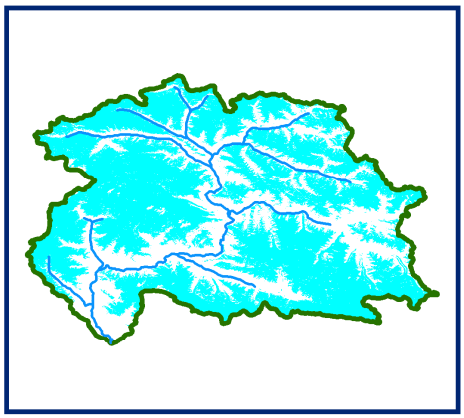


Snow cover depletion curve

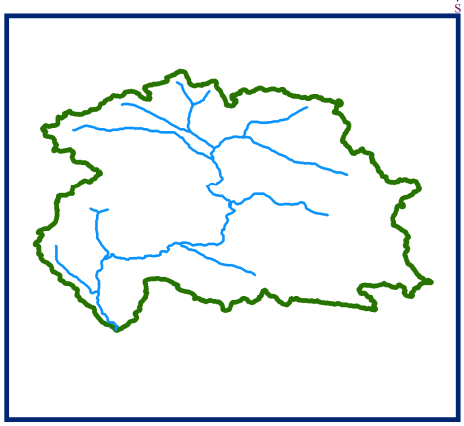


SNOW COVER MAP

SNOW COVER MAP : HANZA BASIN



03 OCTOBER 2011
04 DECEMBER 2011



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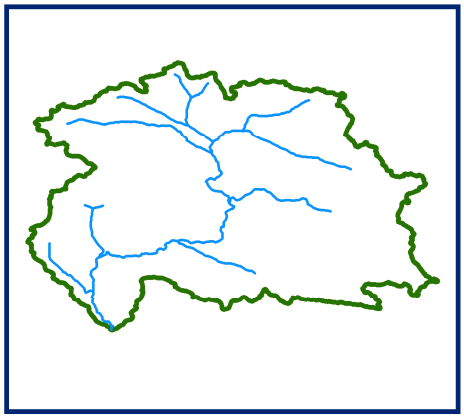

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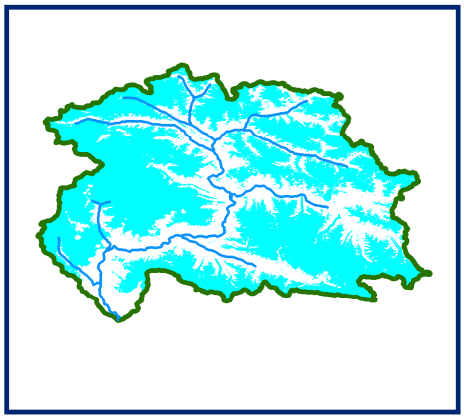
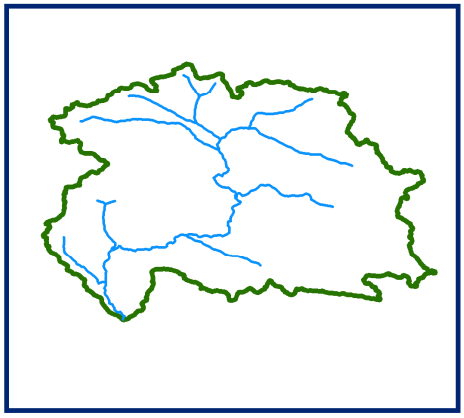


19 OCTOBER 2011



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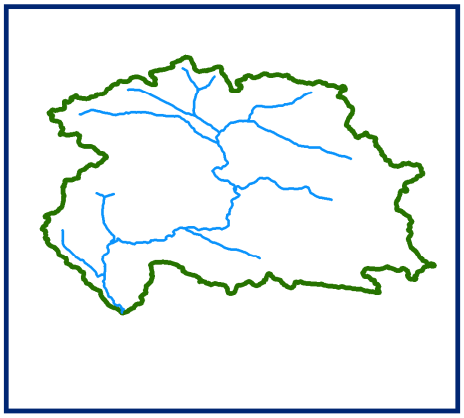


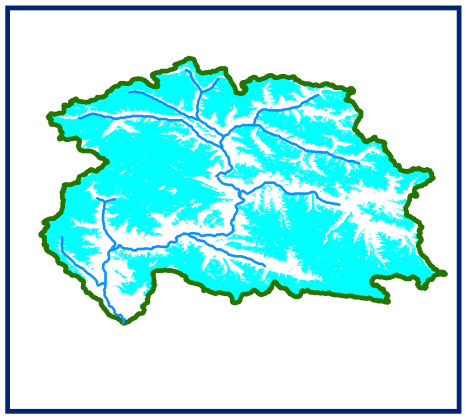
DATA NOT AVAILABLE

SNOW

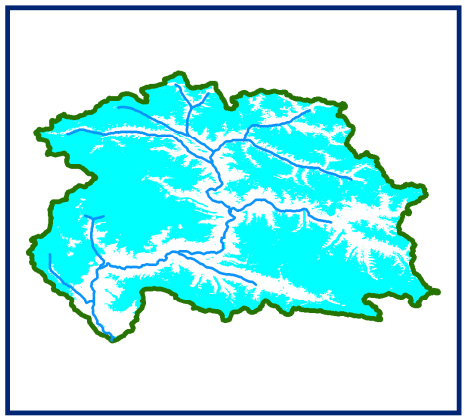
0 25 50 100 150 200

Kilometers

10 DAILY SNOW COVER MAP: HANZA BASIN



DATA USED
03 OCTOBER 2011



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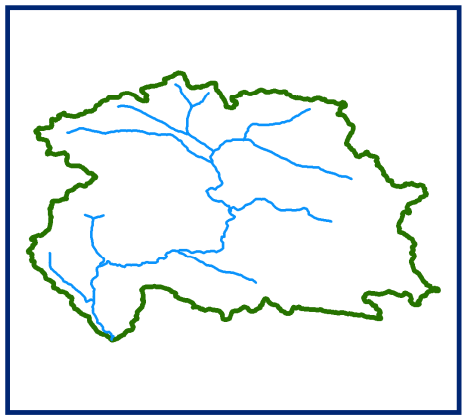
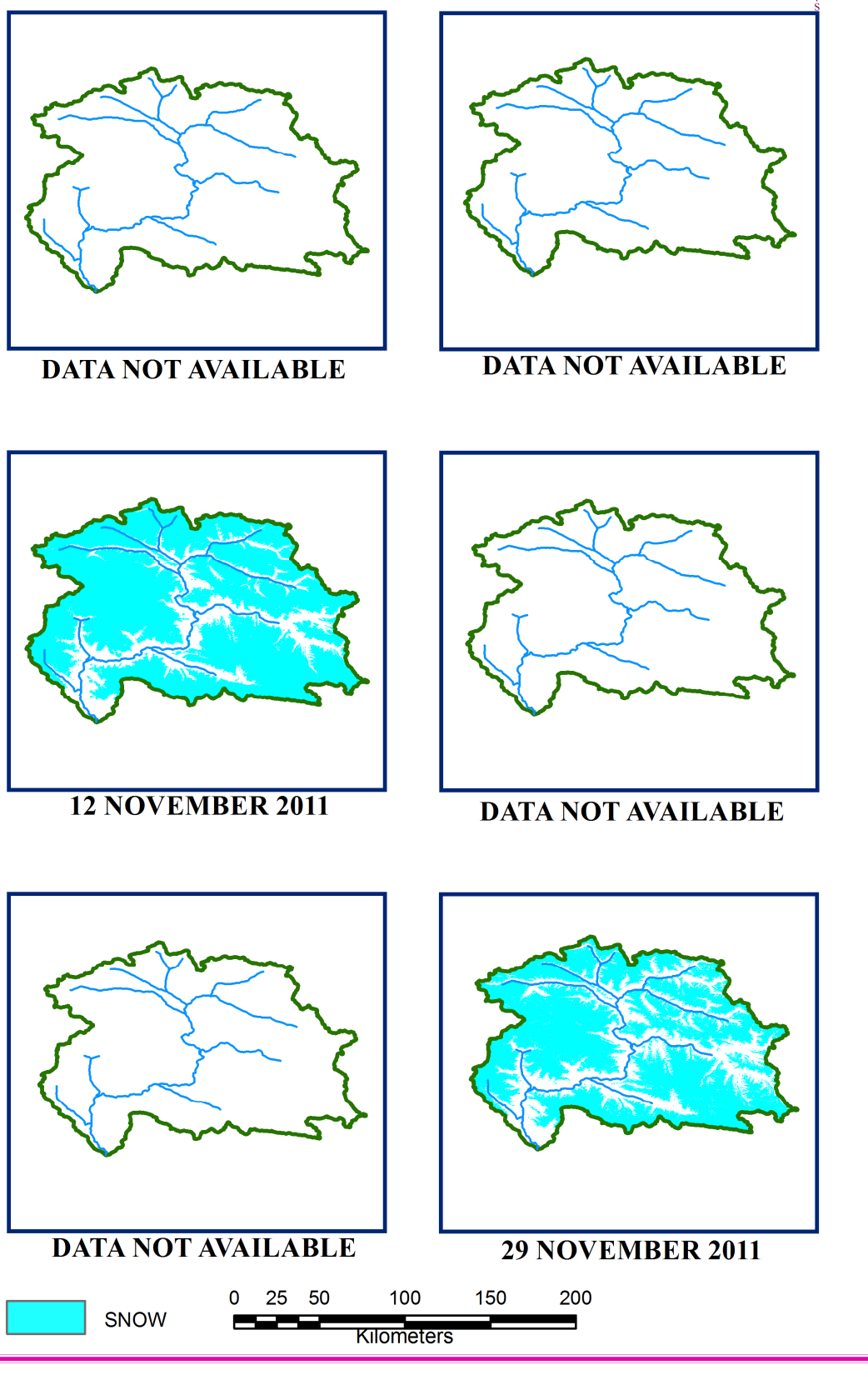


DATA USED
DATA NOT AVAILABLE

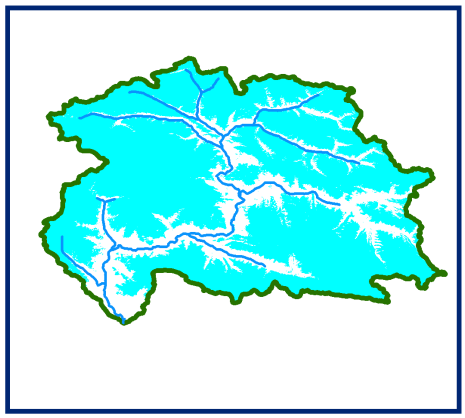
SNOW

0 25 50 100 150 200
Kilometers

SNOW COVER MAP : HANZA BASIN



10 DAILY SNOW COVER MAP: HANZA BASIN



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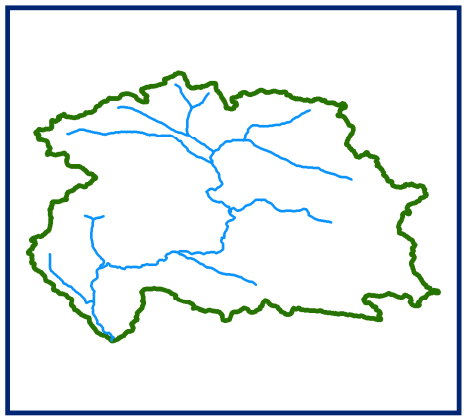
12 NOVEMBER 2011



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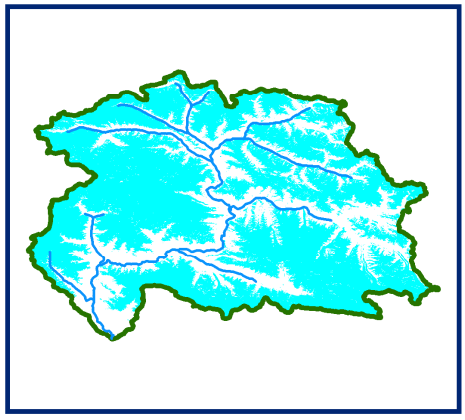
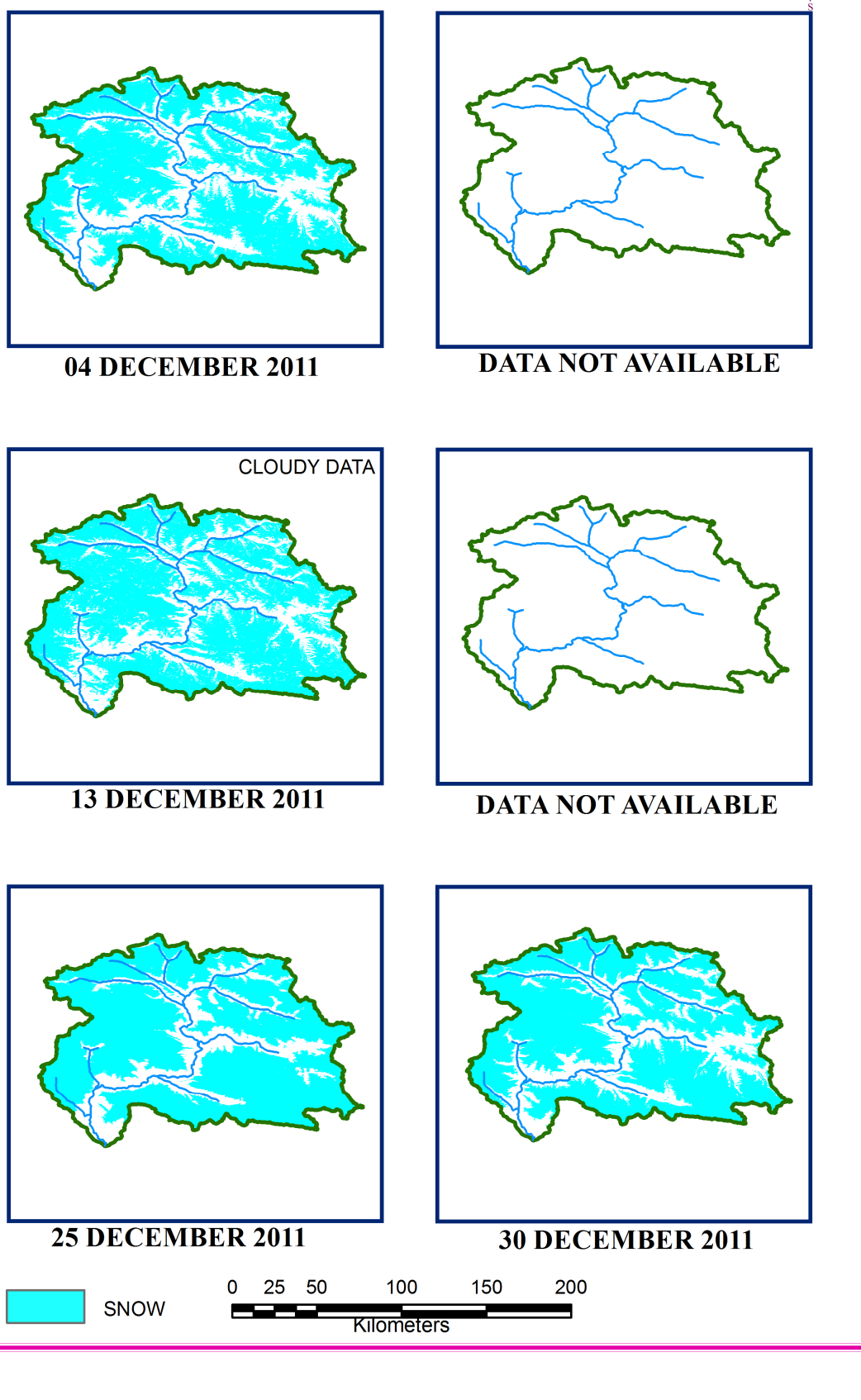


DATA USED
26 NOVEMBER 2011
29 NOVEMBER 2011

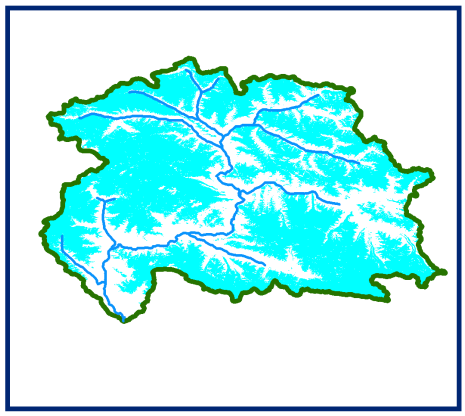
SNOW

0 25 50 100 150 200
Kilometers

SNOW COVER MAP : HANZA BASIN



10 DAILY SNOW COVER MAP: HANZA BASIN



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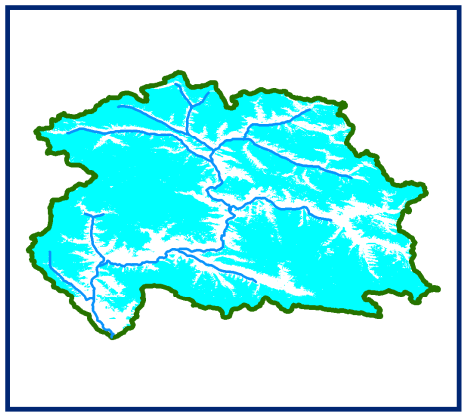
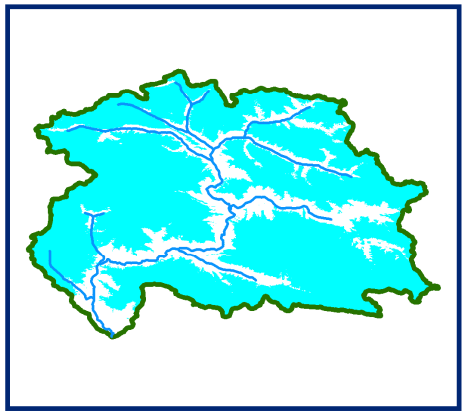
04 DECEMBER 2011



DATA USED
13 DECEMBER 2011
14 DECEMBER 2011

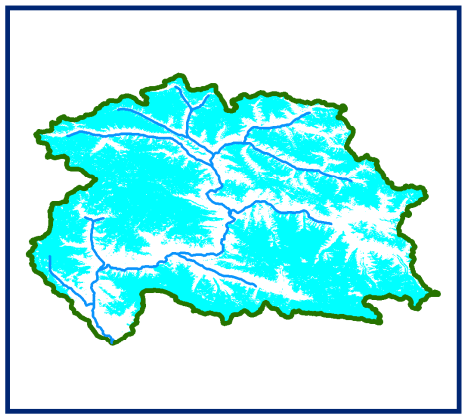


DATA USED
25 DECEMBER 2011
30 DECEMBER 2011

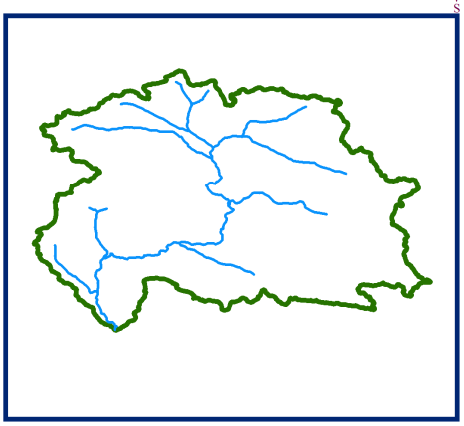
SNOW

0 25 50 100 150 200
Kilometers

SNOW COVER MAP : HANZA BASIN



02 JANUARY 2012



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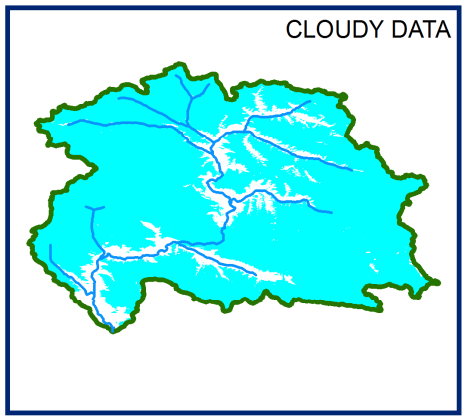
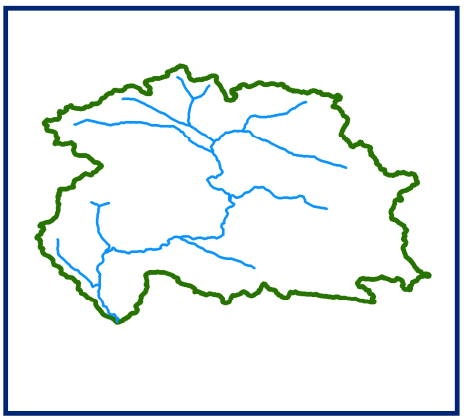


13 JANUARY 2012



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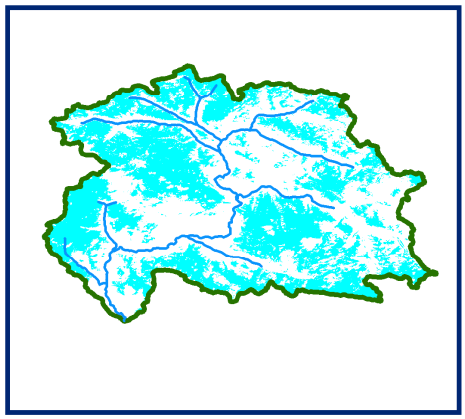

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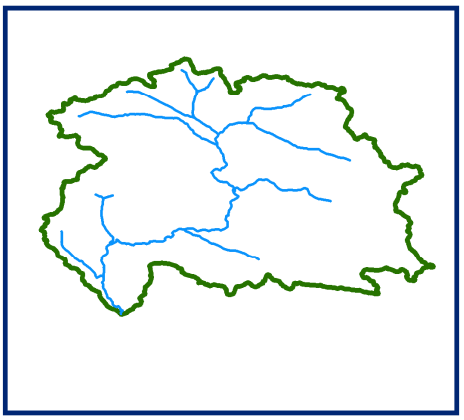


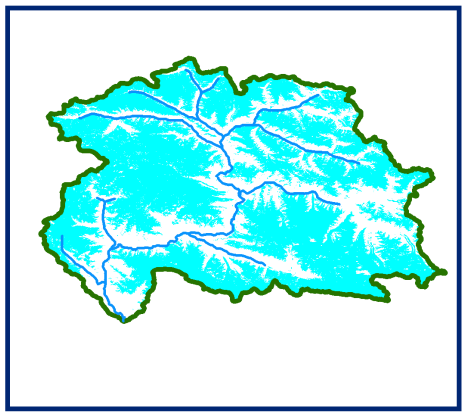
DATA NOT AVAILABLE

SNOW

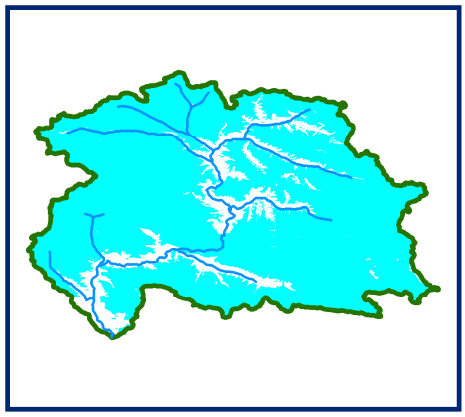
0 25 50 100 150 200

Kilometers

10 DAILY SNOW COVER MAP: HANZA BASIN



DATA USED
02 JANUARY 2012



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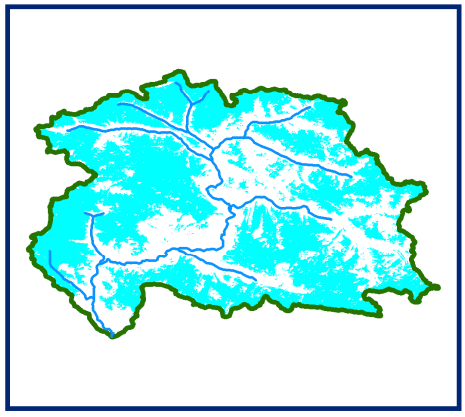
13 JANUARY 2012

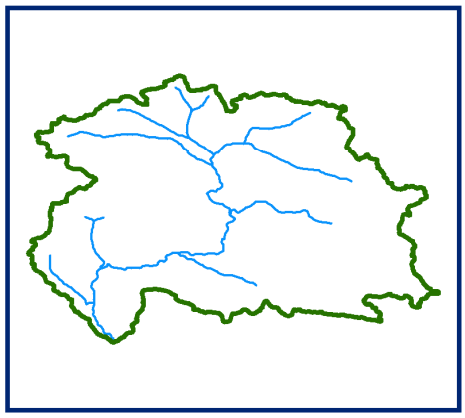


DATA USED
21 JANUARY 2012
25 JANUARY 2012

SNOW

0 25 50 100 150 200
Kilometers

SNOW COVER MAP : HANZA BASIN



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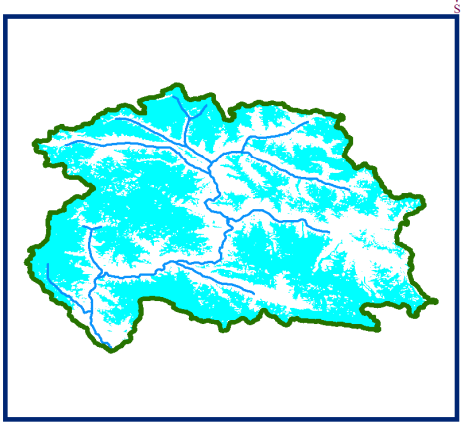
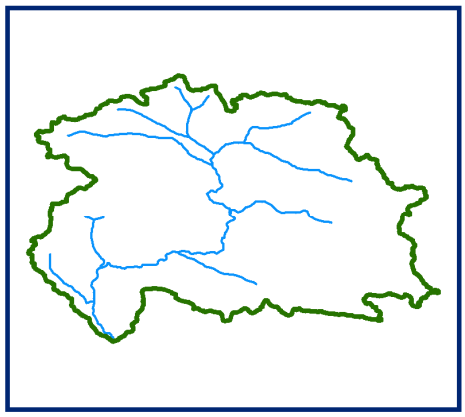


09 FEB. 2012



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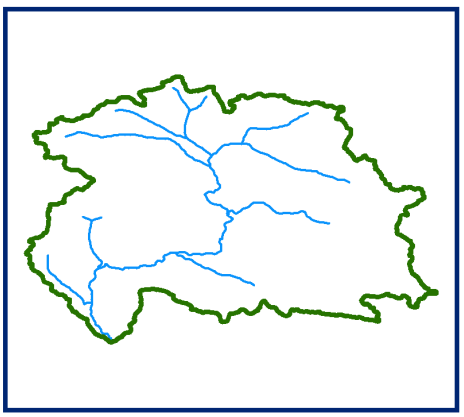

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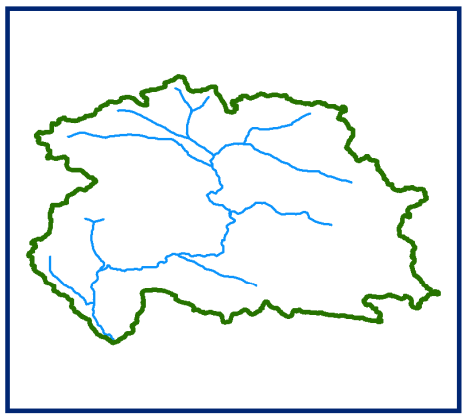

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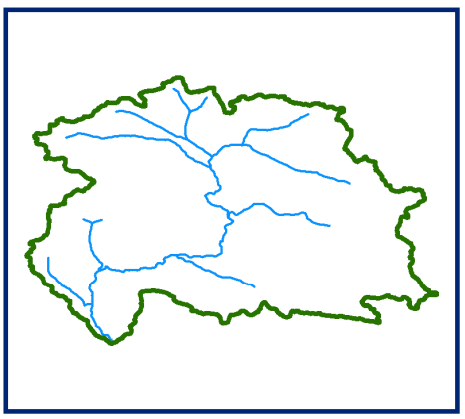


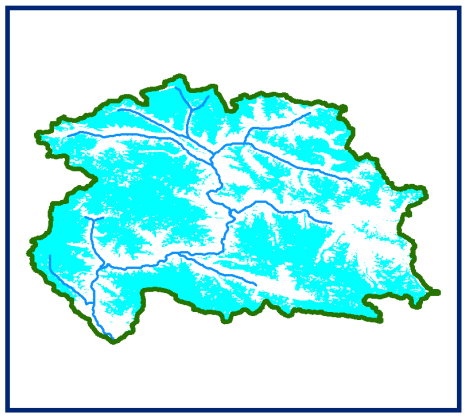
DATA NOT AVAILABLE

SNOW

0 25 50 100 150 200

Kilometers

10 DAILY SNOW COVER MAP: HANZA BASIN



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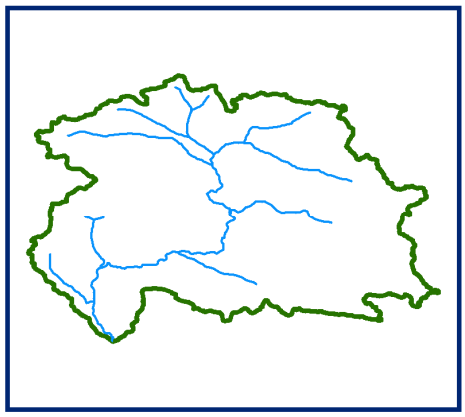
09 FEB. 2012



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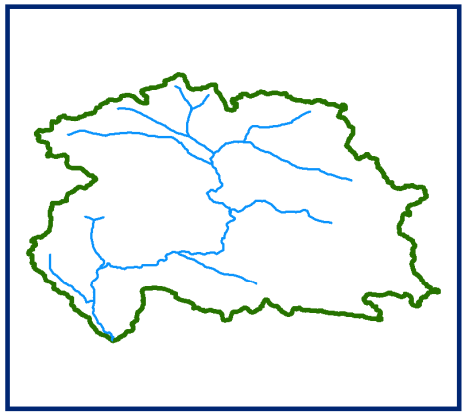

DATA USED

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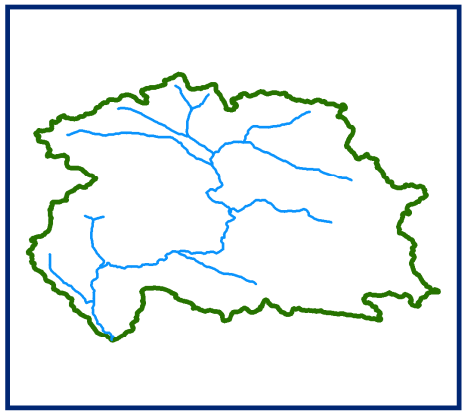
SNOW

0 25 50 100 150 200

Kilometers

SNOW COVER MAP : HANZA BASIN



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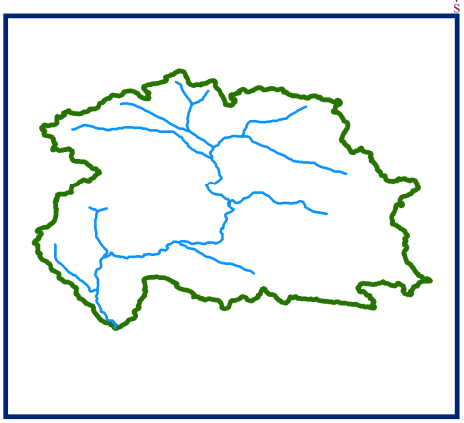

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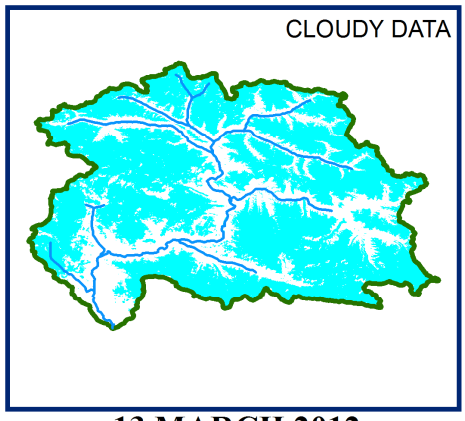
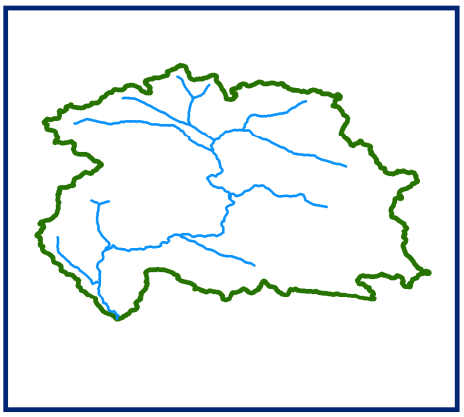


13 MARCH 2012



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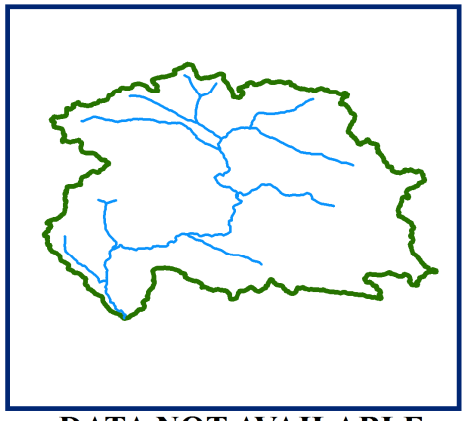

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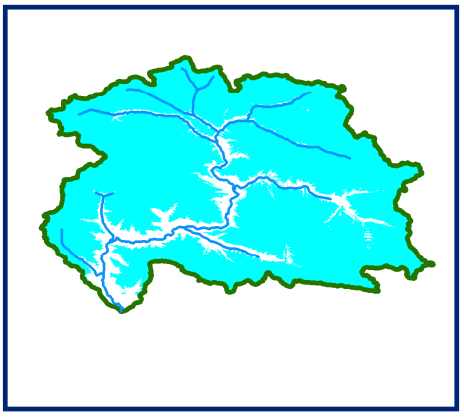


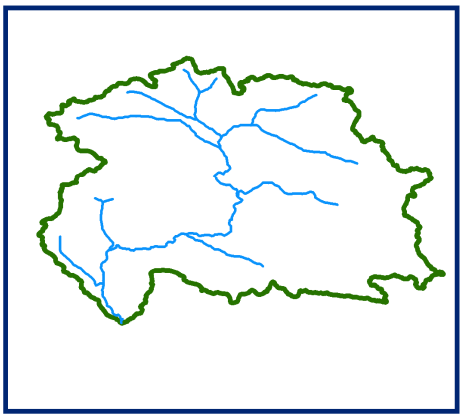
30 MARCH 2012

SNOW

0 25 50 100 150 200

Kilometers

10 DAILY SNOW COVER MAP: HANZA BASIN



DATA USED
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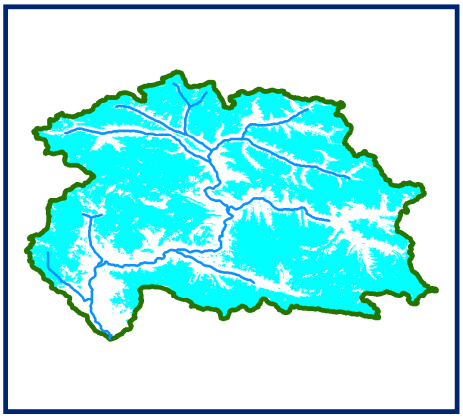
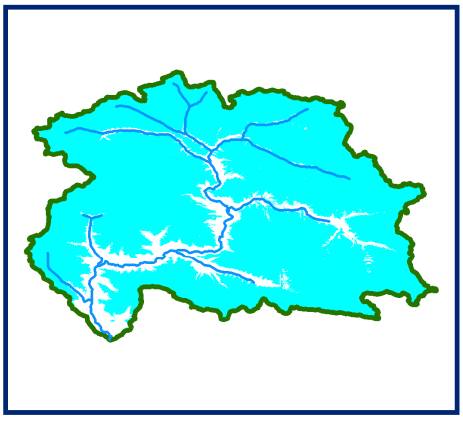


DATA USED
13 MARCH 2012

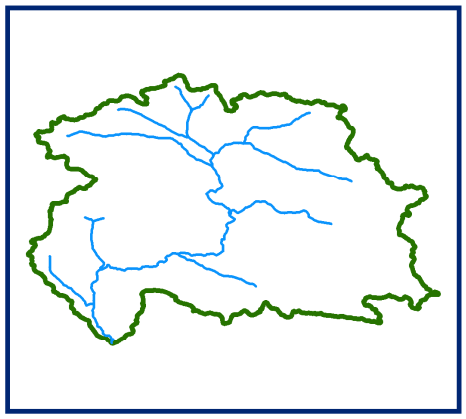


DATA USED
30 MARCH 2012

SNOW

0 25 50 100 150 200
Kilometers

SNOW COVER MAP : HANZA BASIN



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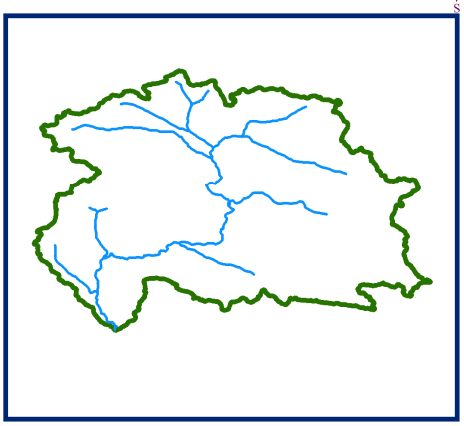

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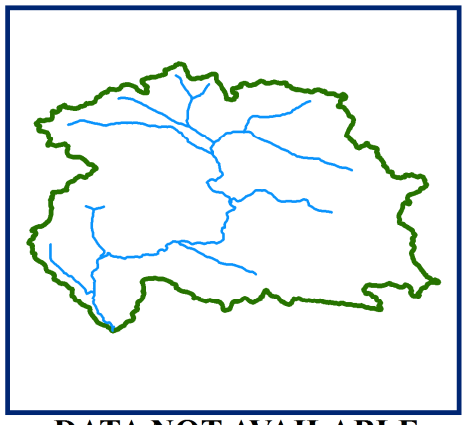

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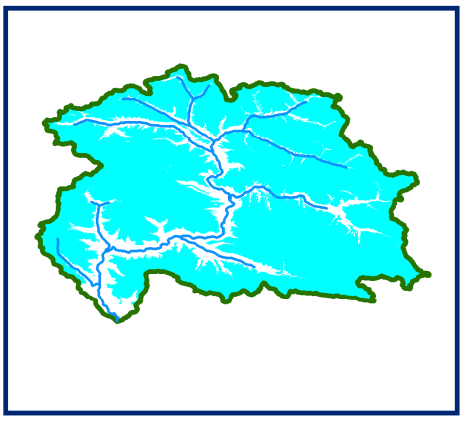
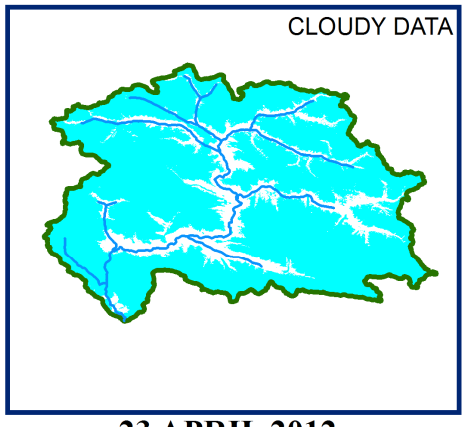
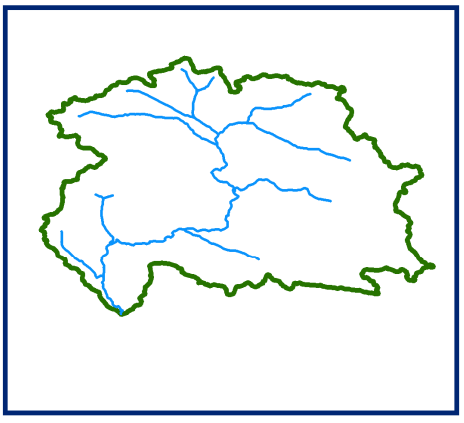


18 APRIL 2012



23 APRIL 2012



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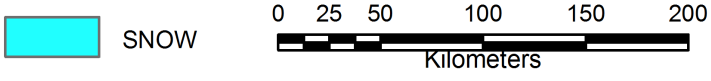
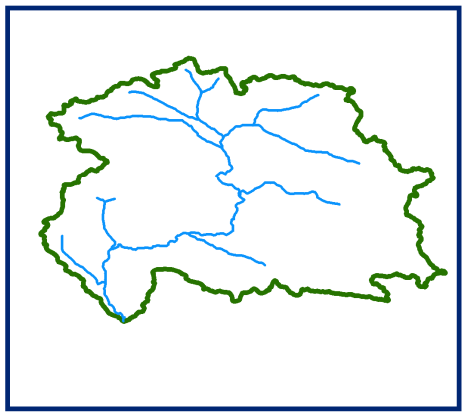


10 DAILY SNOW COVER MAP: HANZA BASIN



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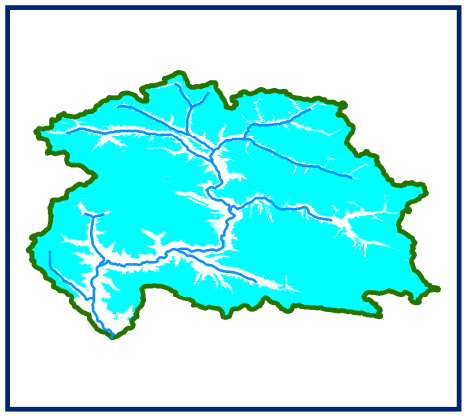

DATA USED
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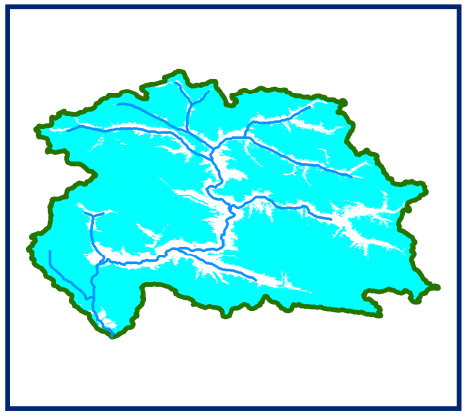
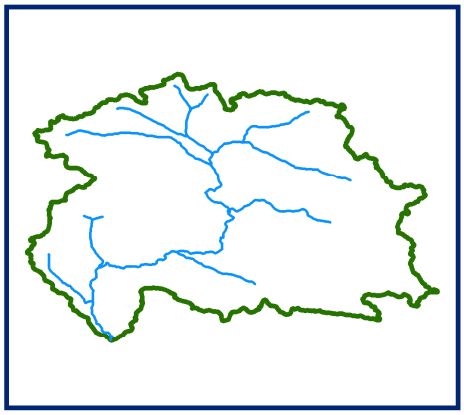


DATA USED
23 APRIL 2012

SNOW

0 25 50 100 150 200
Kilometers

SNOW COVER MAP : HANZA BASIN



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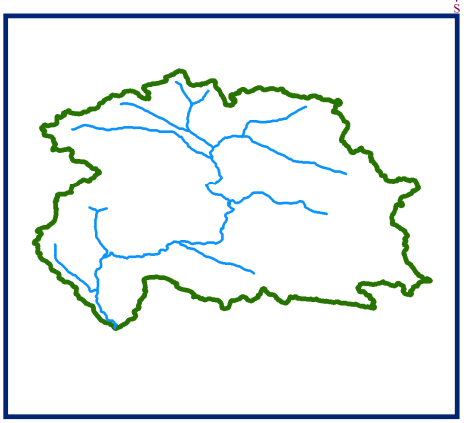

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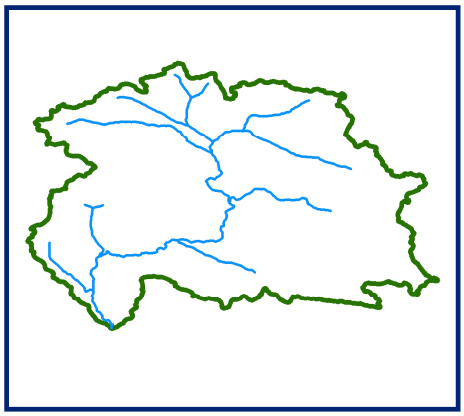

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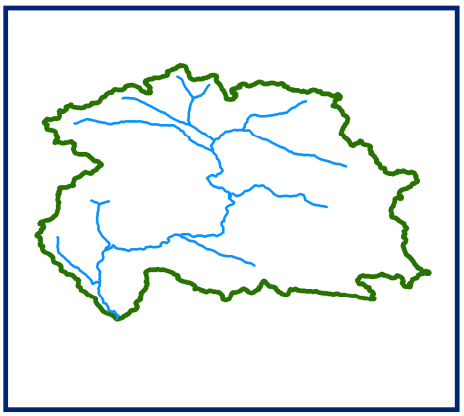

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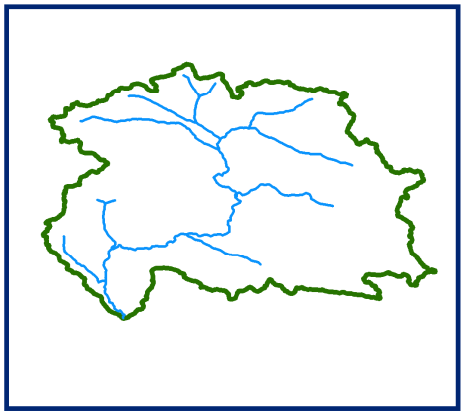

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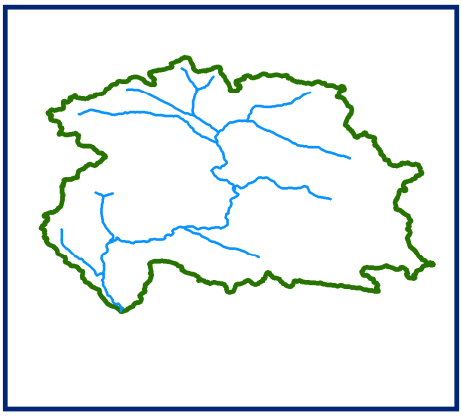


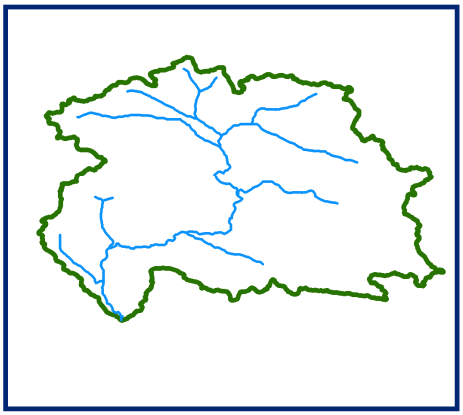
DATA NOT AVAILABLE

SNOW

0 25 50 100 150 200

Kilometers

10 DAILY SNOW COVER MAP: HANZA BASIN



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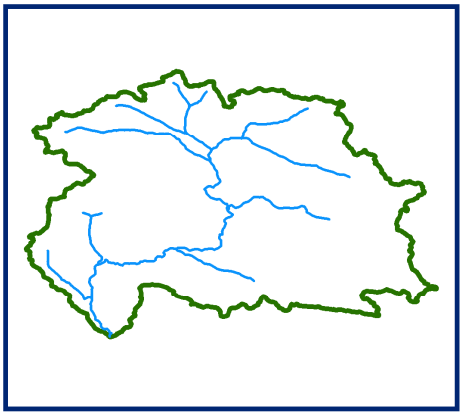

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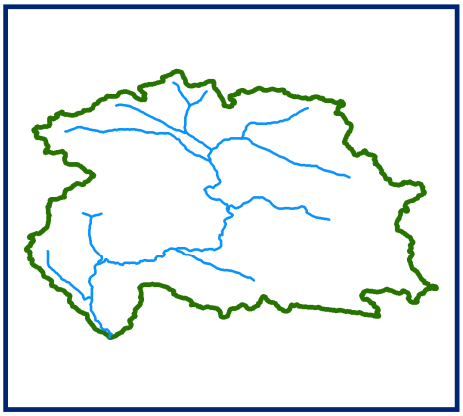

DATA USED
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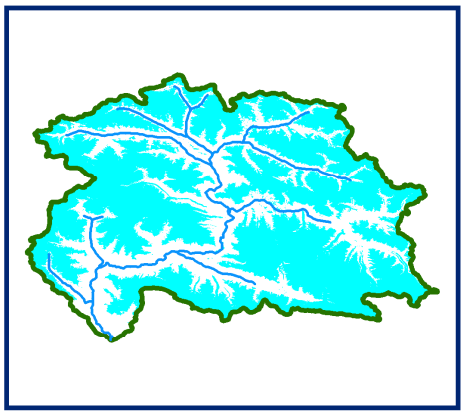
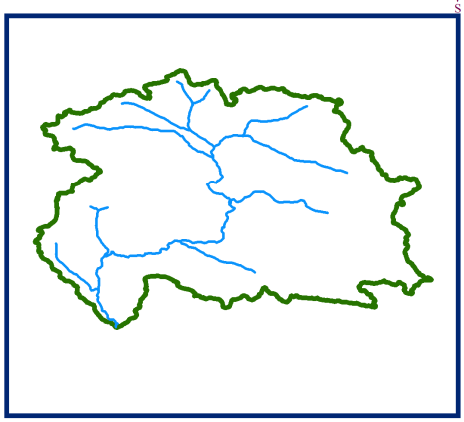
SNOW

0 25 50 100 150 200
Kilometers

SNOW COVER MAP : HANZA BASIN



05 JUNE 2012



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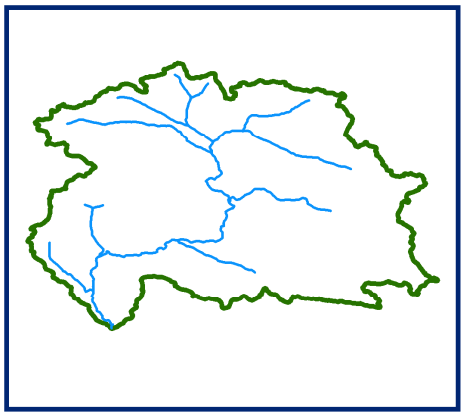

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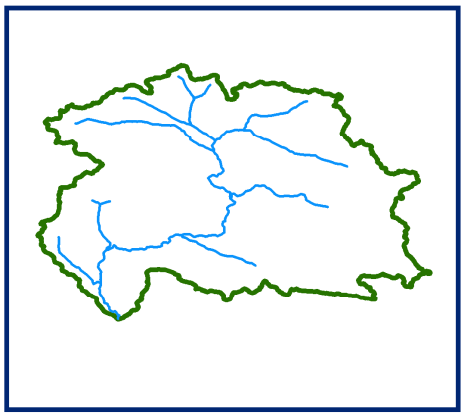

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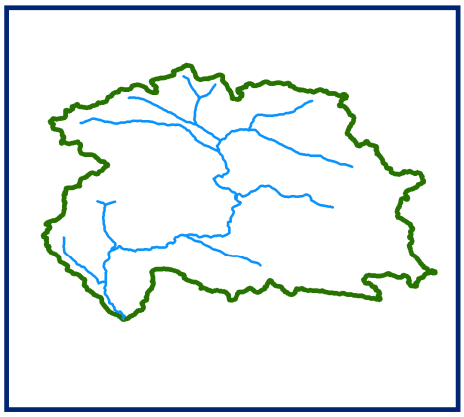

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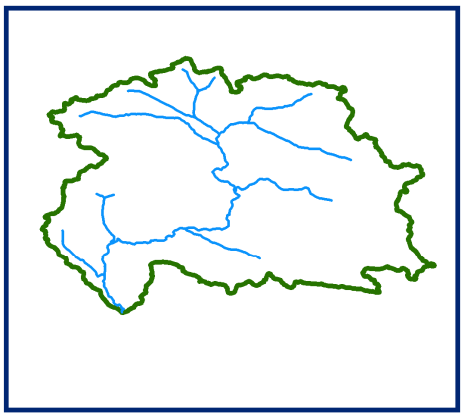


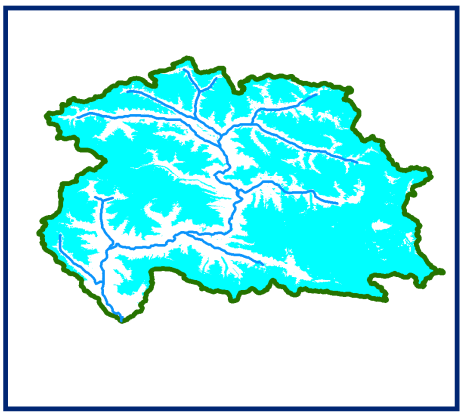
DATA NOT AVAILABLE

SNOW

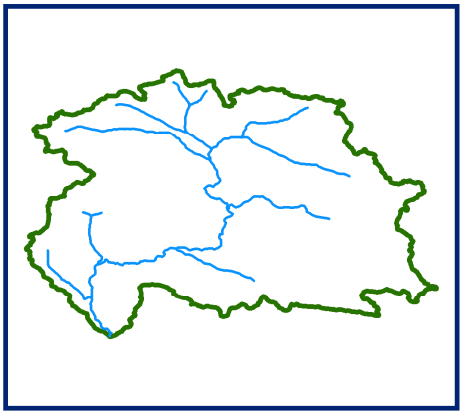
0 25 50 100 150 200

Kilometers

10 DAILY SNOW COVER MAP: HANZA BASIN



DATA USED
03 JUNE 2012
05 JUNE 2012



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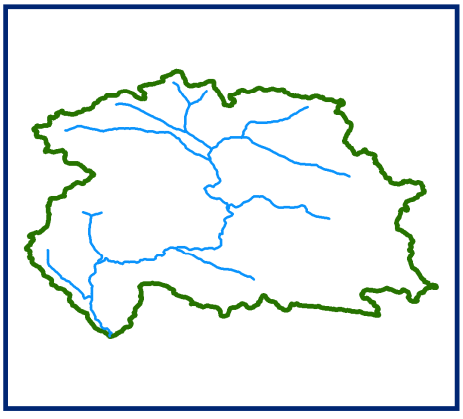


DATA USED
DATA NOT AVAILABLE

SNOW

0 25 50 100 150 200
Kilometers

GILGIT BASIN

AREAL EXTENT OF SNOW (5 DAILY)

BASIN NAME: GILGIT **BASIN AREA: 13615 sq km**

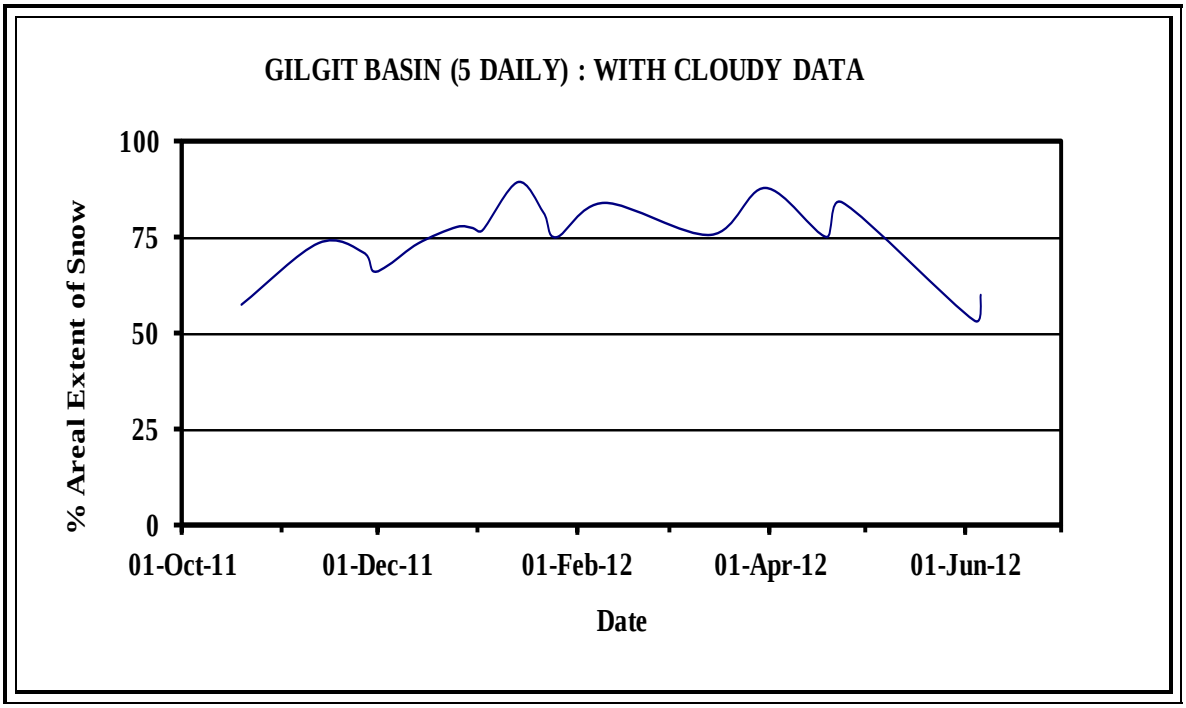
S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2011							
1	19-Oct-11	7823	57				
November 2011							
2	12-Nov-11	10026	74	3	26-Nov-11	9686	71
4	29-Nov-11	9019	66				
December 2011							
5	4-Dec-11	9300	68	6	13-Dec-11	10016	74
7	25-Dec-11	10603	78	8	30-Dec-11	10563	78
January 2012							
9	02-Jan-11	10498	77	10	13-Jan-12	11111	90
11	21-Jan-12	12206	82	12	25-Jan-12	10235	75
February 2012							
13	09-Feb-12	11465	84				
March 2012							
14	13-Mar-12	10320	76	15	30-Mar-12	11998	88
April 2012							
16	18-Apr-12	10243	75	17	23-Apr-12	11475	84
May 2012							
June 2012							
18	03-Jun-12	7257	53	19	05-Jun-12	8173	60

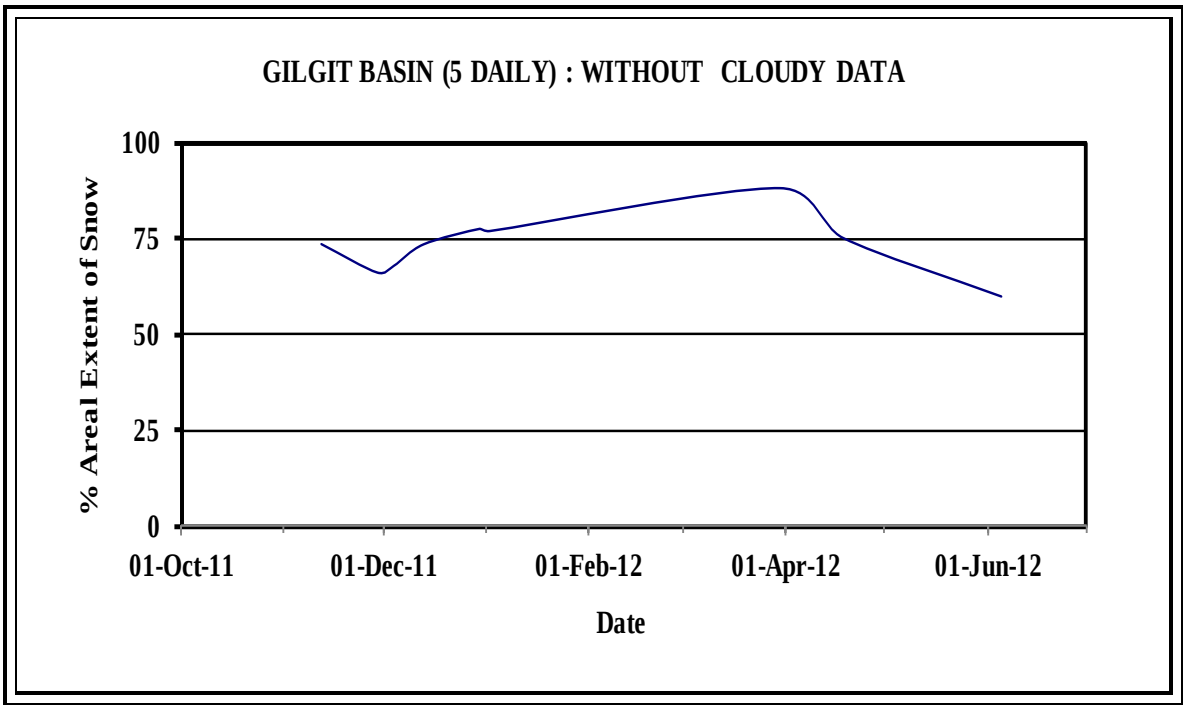
AREAL EXTENT OF SNOW (10 DAILY)

BASIN NAME: GILGIT **BASIN AREA: 13615 sq km**

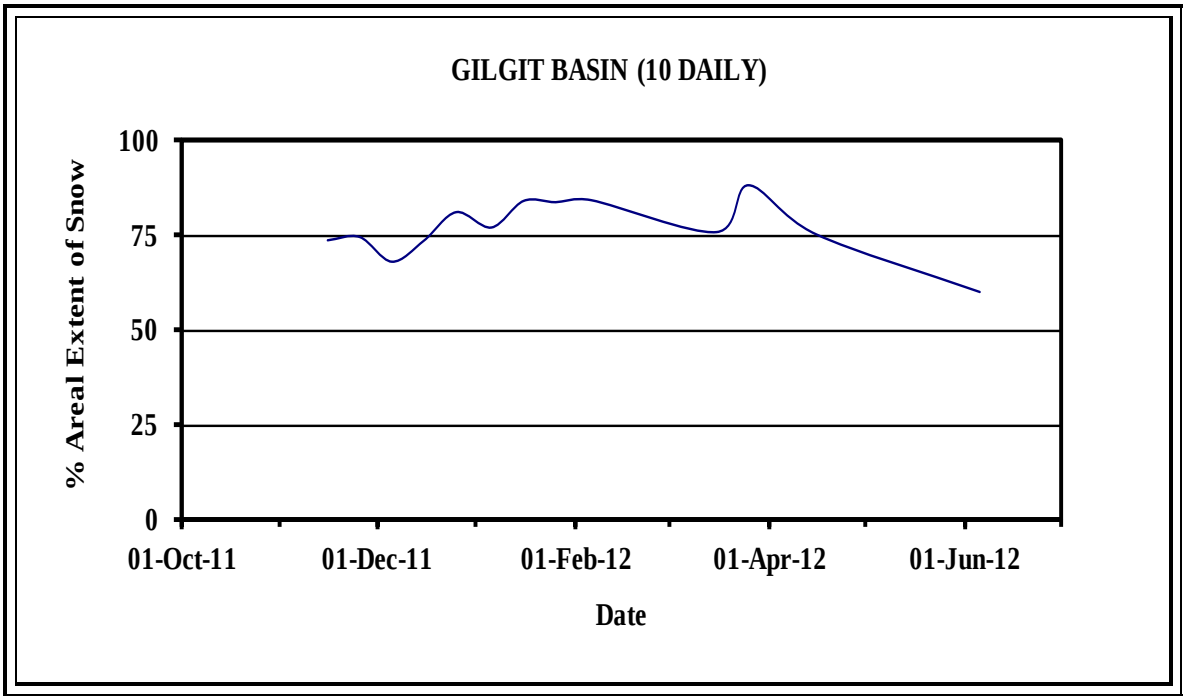
S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2011				**November 2011**			
1	19-Oct-11	7823	57	2	12-Nov-11	10026	74
				3	28-Nov-11	10144	75
December 2011				**January 2012**			
4	4-Dec-12	9300	68	7	02-Jan-11	10498	77
5	13-Dec-11	10016	74	8	13-Jan-12	12206	90
6	27-Dec-11	11035	81	9	21-Jan-12	11390	84
February 2012				**March 2012**			
10	09-Feb-12	11465	84	11	13-Mar-12	10320	76
				12	30-Mar-12	11998	88
April 2012				**May 2012**			
13	18-Apr-12	10243	75				
14	23-Apr-12	11475	84				
June 2012							
15	04-Jun-2012	8603	63				

Snow cover depletion curve



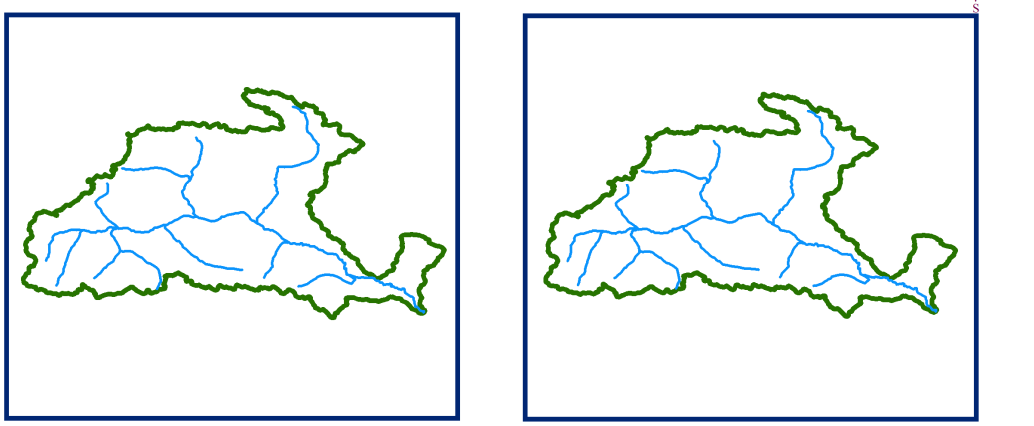


Snow cover depletion curve



SNOW COVER MAP

SNOW COVER MAP : GILGIT BASIN



DATA NOT AVAILABLE | DATA NOT AVAILABLE

DATA NOT AVAILABLE | 19 OCTOBER 2011

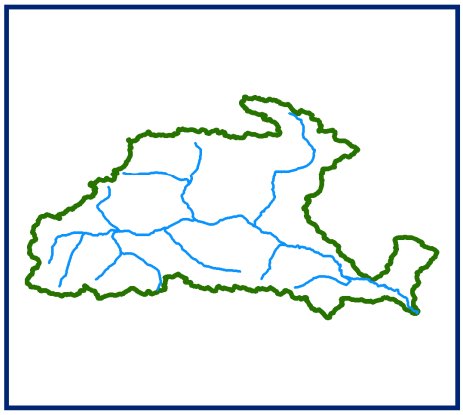
DATA NOT AVAILABLE | DATA NOT AVAILABLE

SNOW

0 30 60 120 180 240

Kilometers

10 DAILY SNOW COVER MAP: GILGIT BASIN



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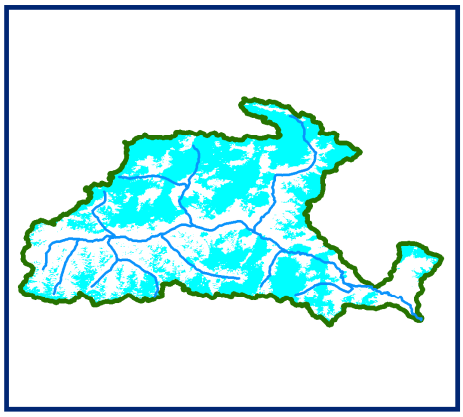

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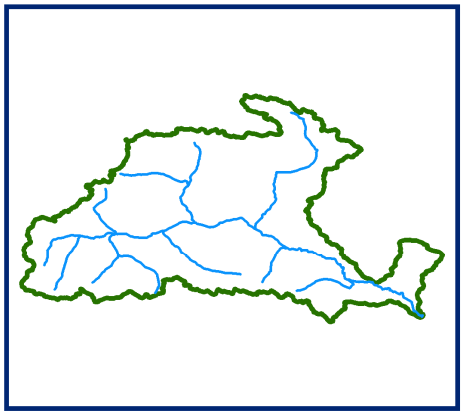
19 OCTOBER 2011

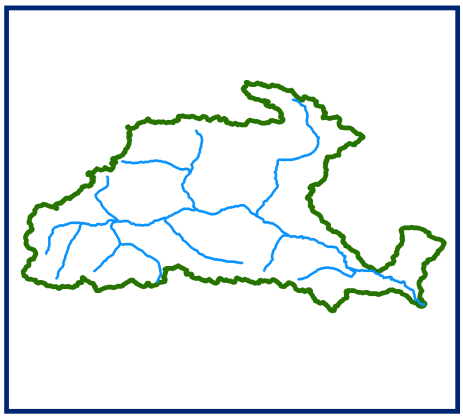


DATA USED
DATA NOT AVAILABLE

SNOW

0 30 60 120 180 240
Kilometers

SNOW COVER MAP : GILGIT BASIN



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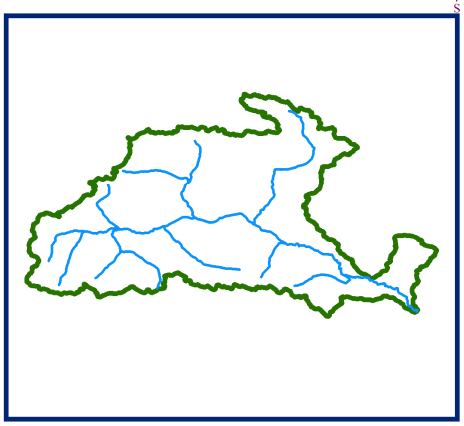

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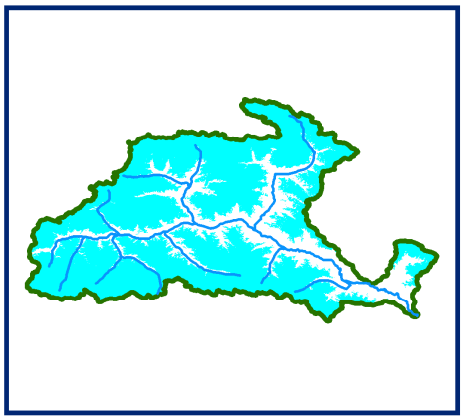
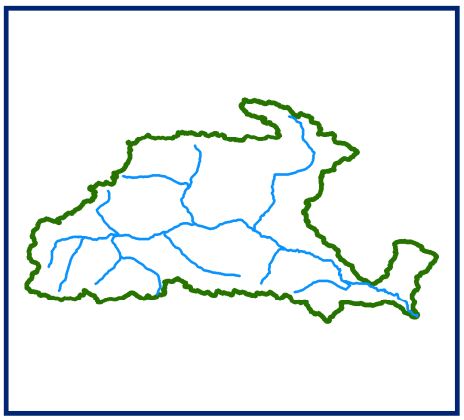


12 NOVEMBER 2011



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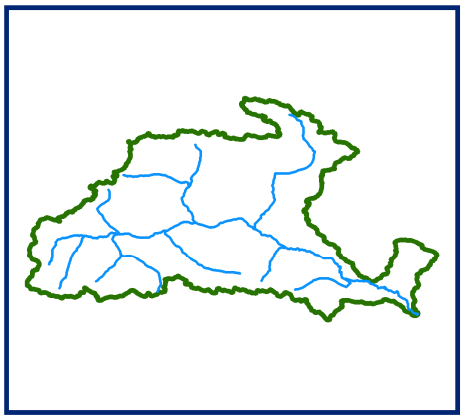

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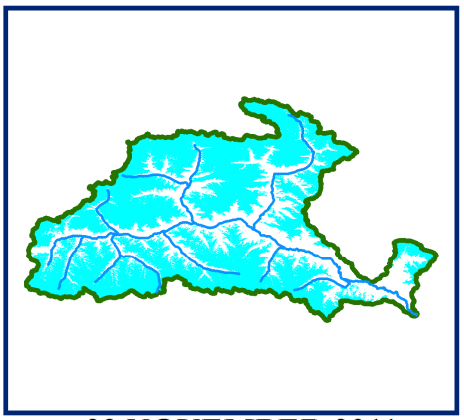
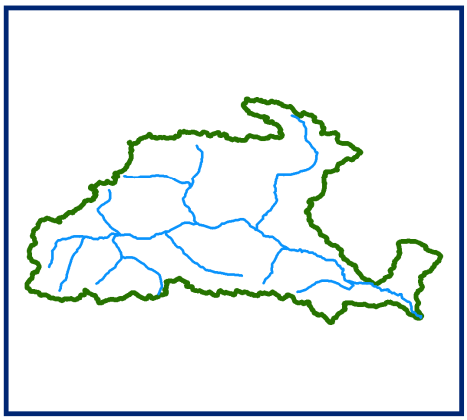


29 NOVEMBER 2011
04 DECEMBER 2011

SNOW

0 30 60 120 180 240
Kilometers

10 DAILY SNOW COVER MAP: GILGIT BASIN



DATA USED
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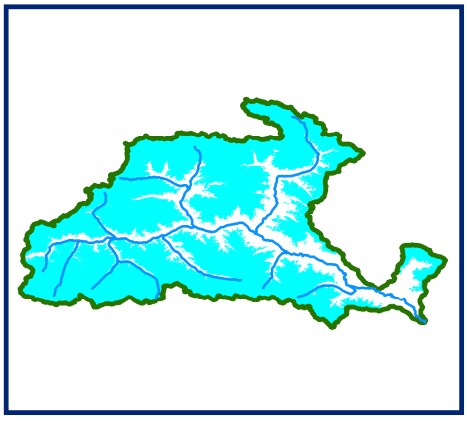
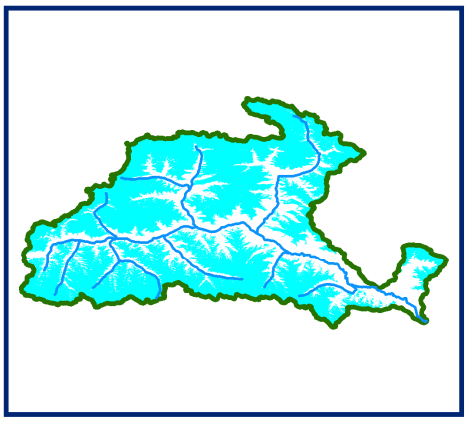


DATA USED
12 NOVEMBER 2011

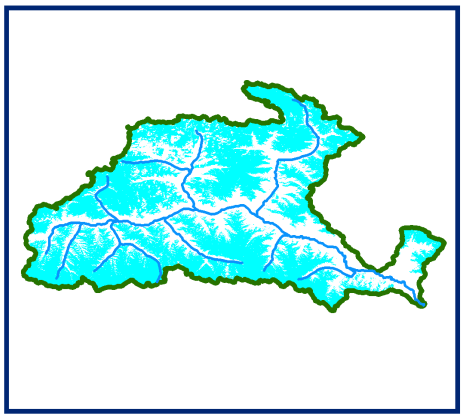


DATA USED
26 NOVEMBER 2011
29 NOVEMBER 2011

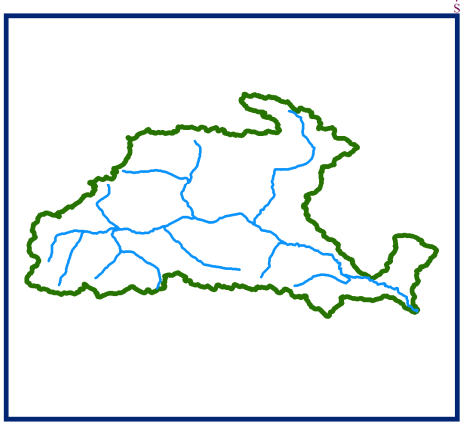
SNOW

0 30 60 120 180 240
Kilometers

SNOW COVER MAP : GILGIT BASIN



04 DECEMBER 2011



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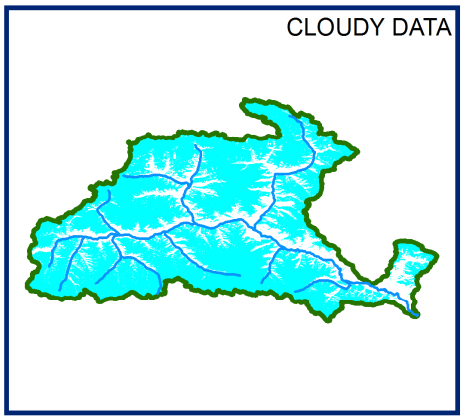
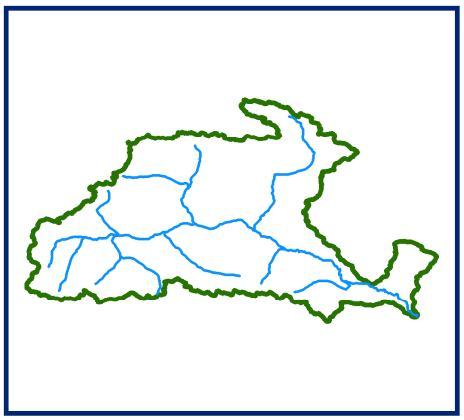


13 DECEMBER 2011



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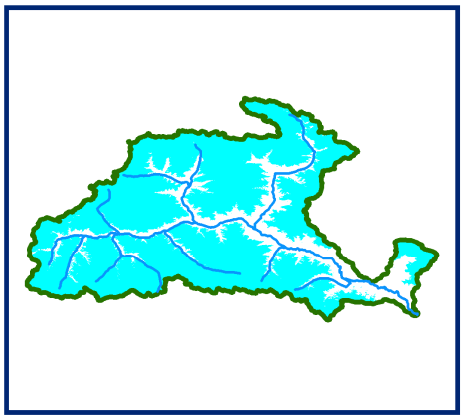
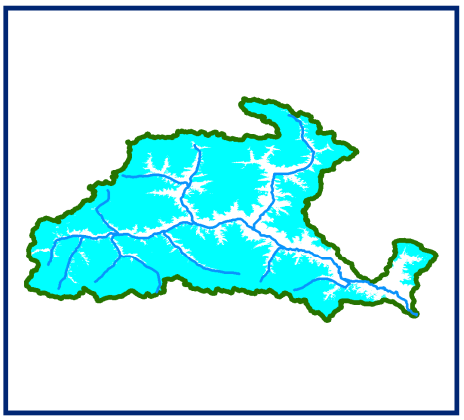


25 DECEMBER 2011



30 DECEMBER 2011

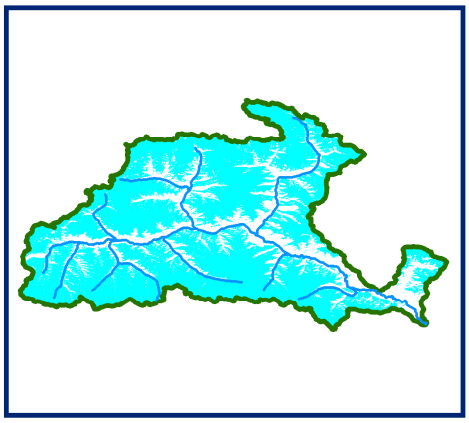
SNOW

0 30 60 120 180 240

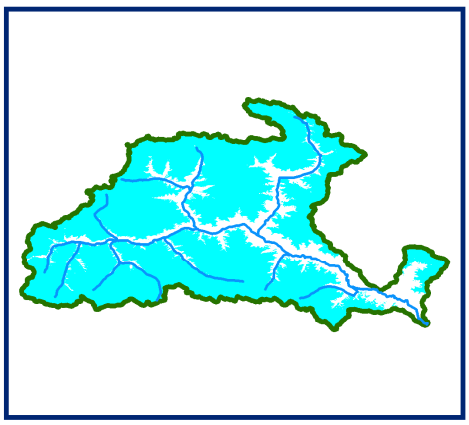
Kilometers

10 DAILY SNOW COVER MAP: GILGIT BASIN

DATA USED
04 DECEMBER 2011



DATA USED
13 DECEMBER 2011

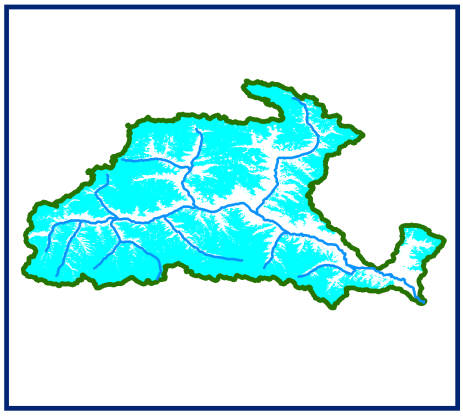


DATA USED
25 DECEMBER 2011
30 DECEMBER 2011

SNOW

0 30 60 120 180 240
Kilometers

SNOW COVER MAP : GILGIT BASIN



02 JANUARY 2012
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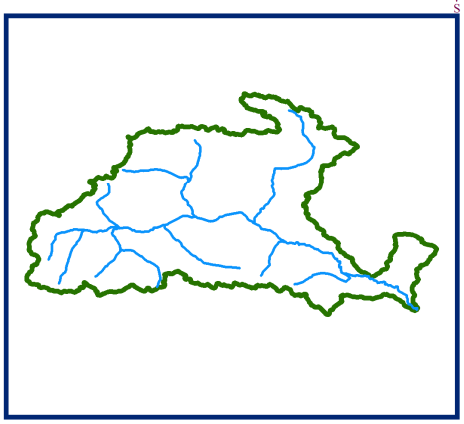

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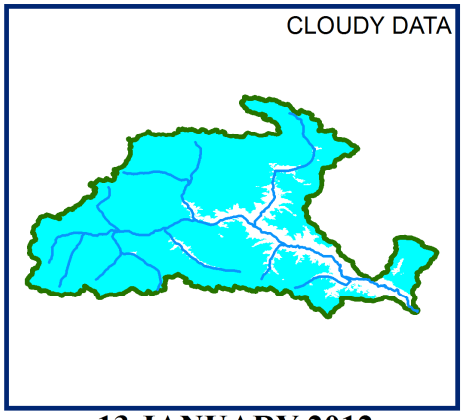
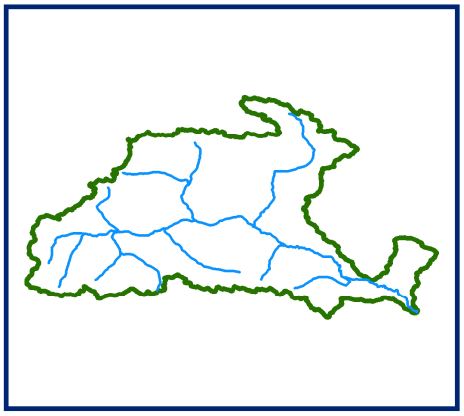


13 JANUARY 2012



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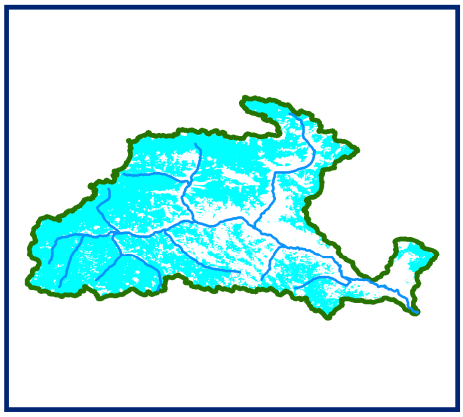

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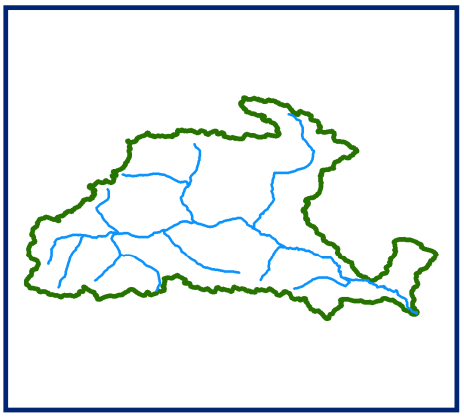


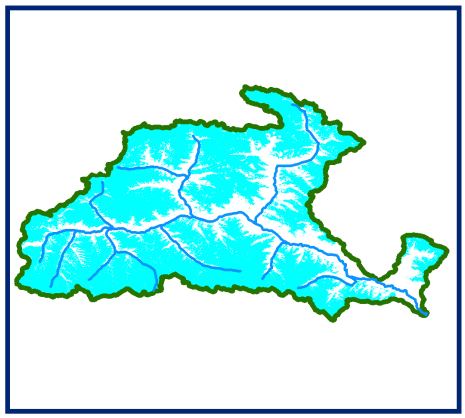
DATA NOT AVAILABLE

SNOW

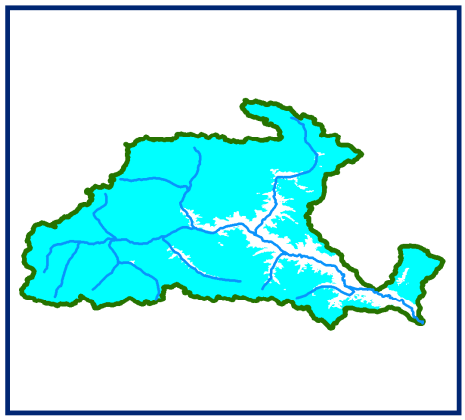
0 30 60 120 180 240

Kilometers

10 DAILY SNOW COVER MAP: GILGIT BASIN



DATA USED
02 JANUARY 2012



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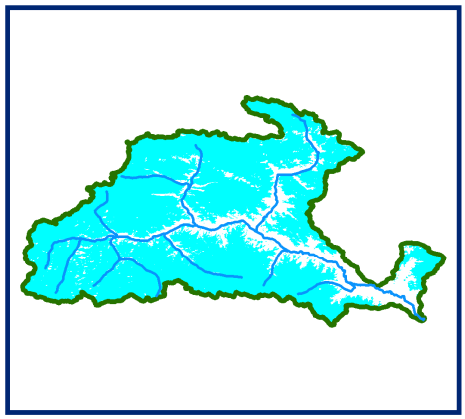
13 JANUARY 2012

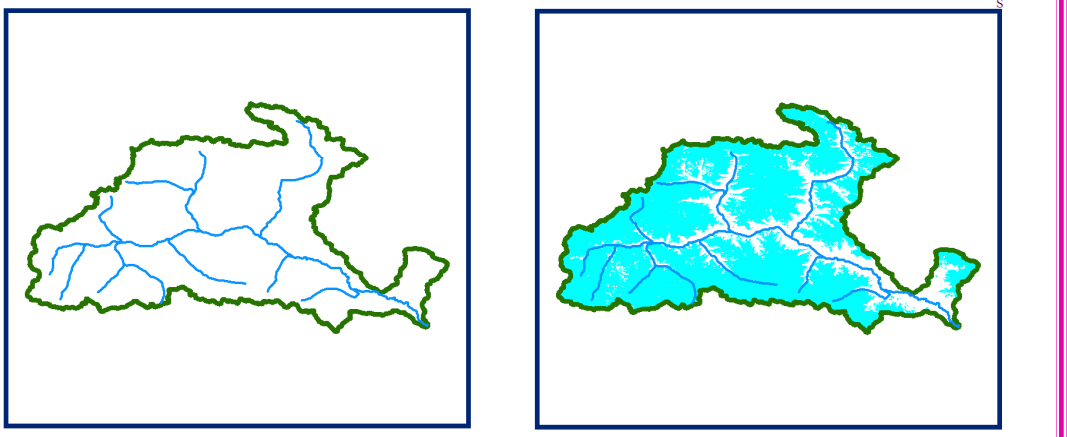


DATA USED
21 JANUARY 2012
25 JANUARY 2012

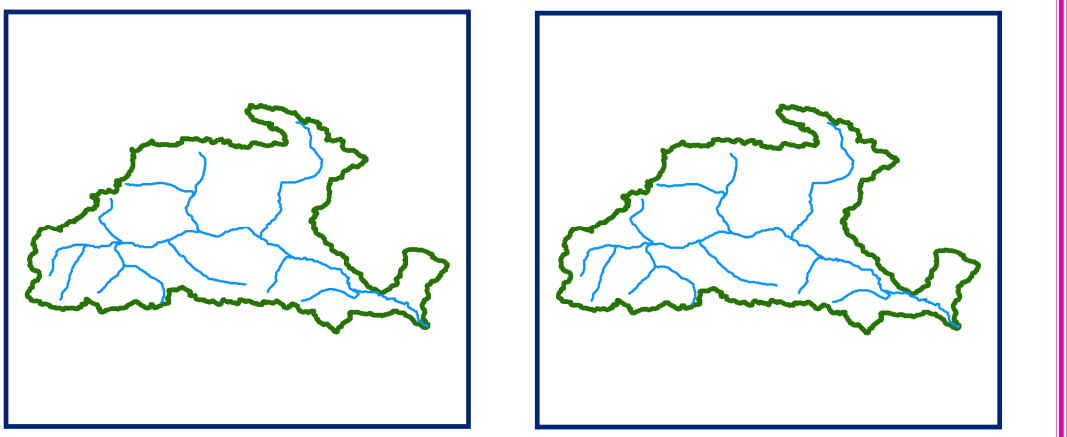
SNOW

0 30 60 120 180 240
Kilometers

SNOW COVER MAP : GILGIT BASIN



DATA NOT AVAILABLE | 09 FEB 2012



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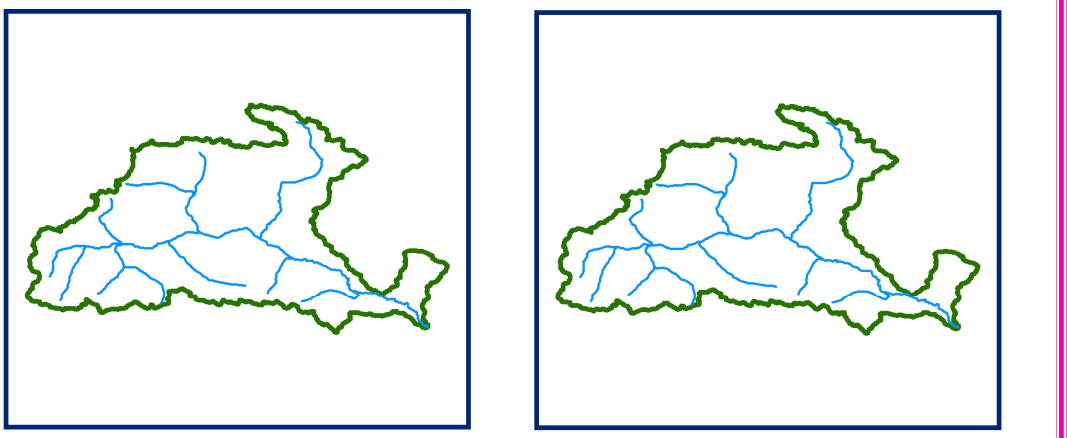


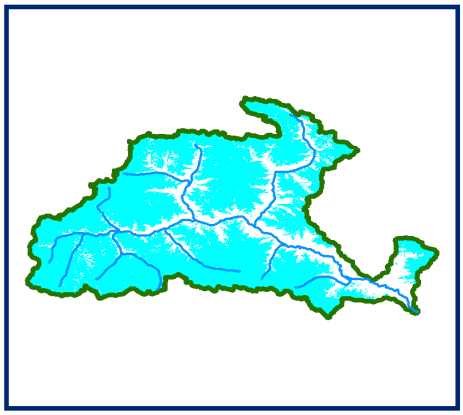
DATA NOT AVAILABLE | DATA NOT AVAILABLE

SNOW

0 30 60 120 180 240

Kilometers

10 DAILY SNOW COVER MAP: GILGIT BASIN



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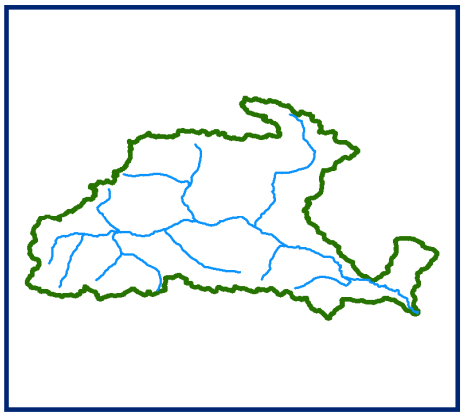

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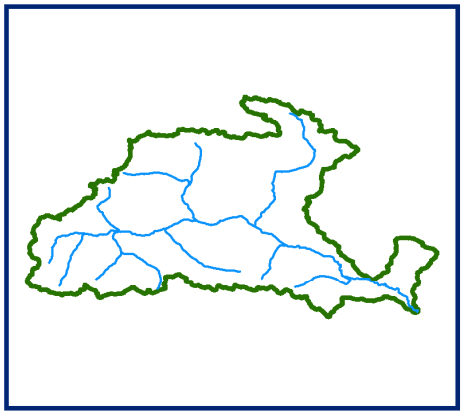


DATA USED

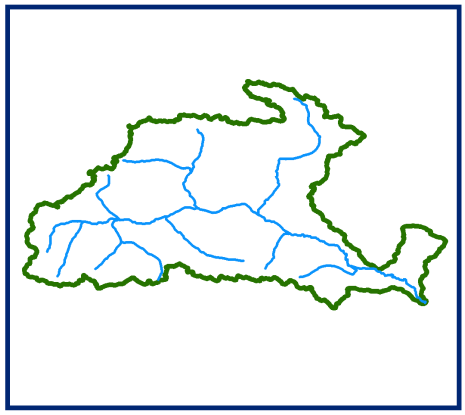
DATA NOT AVAILABLE

SNOW

0 30 60 120 180 240

Kilometers

SNOW COVER MAP : GILGIT BASIN



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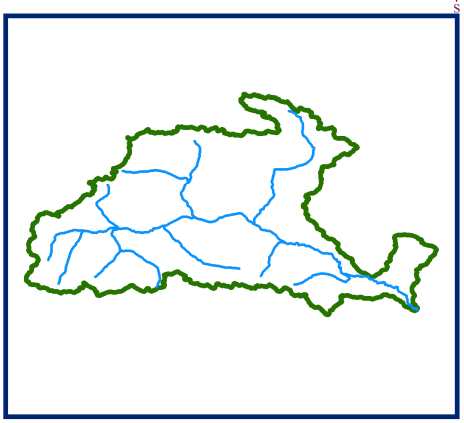

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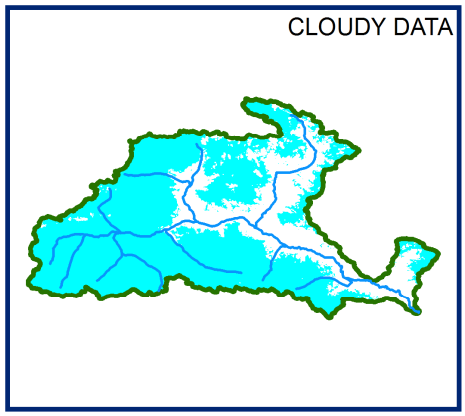
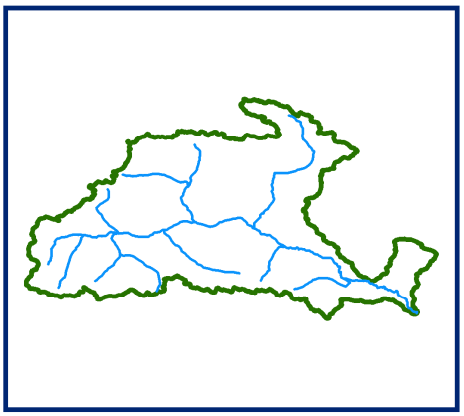


13 MARCH 2012



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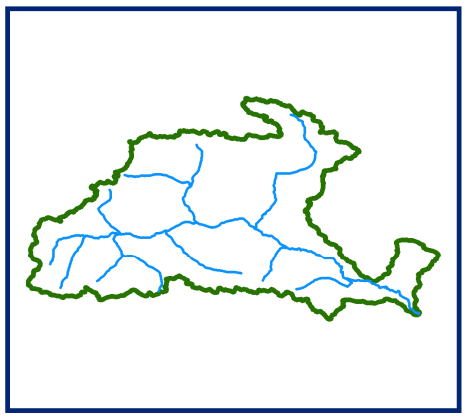

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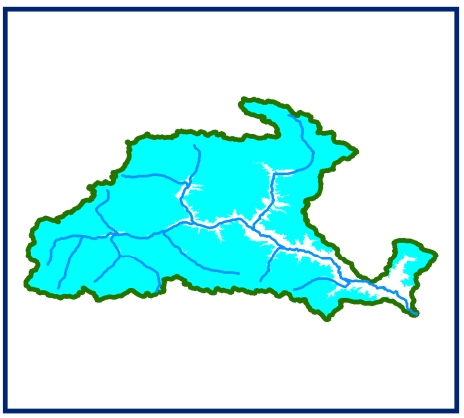


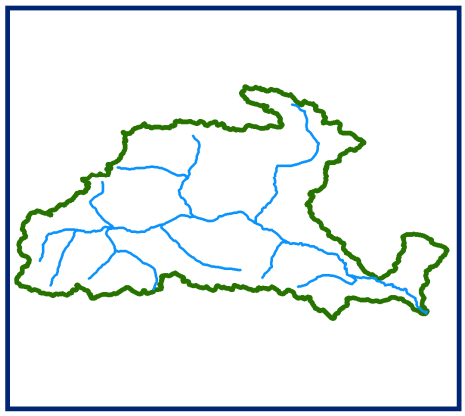
30 MARCH 2012

SNOW

0 30 60 120 180 240

Kilometers

10 DAILY SNOW COVER MAP: GILGIT BASIN



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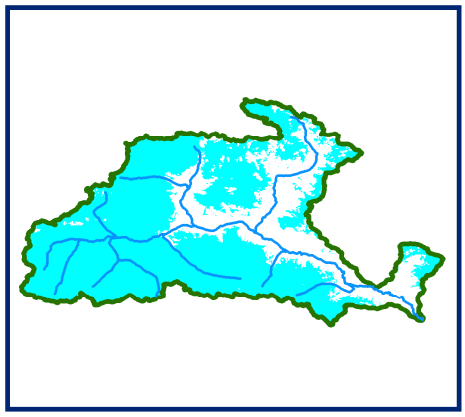

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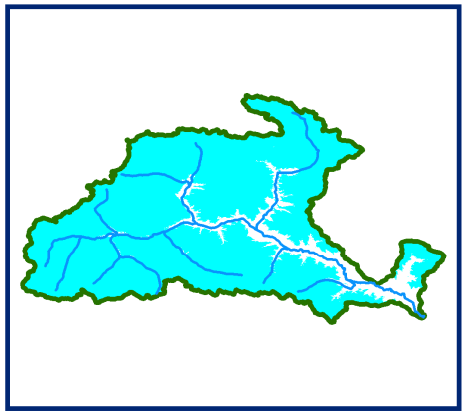
13 MARCH 2012

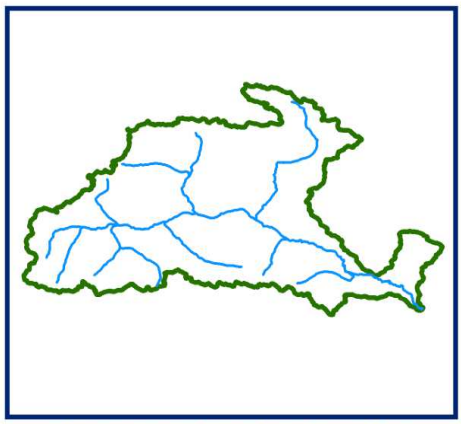


DATA USED
30 MARCH 2012

SNOW

0 30 60 120 180 240
Kilometers

SNOW COVER MAP : GILGIT BASIN



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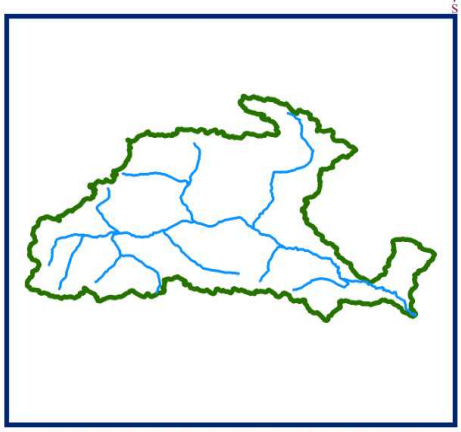

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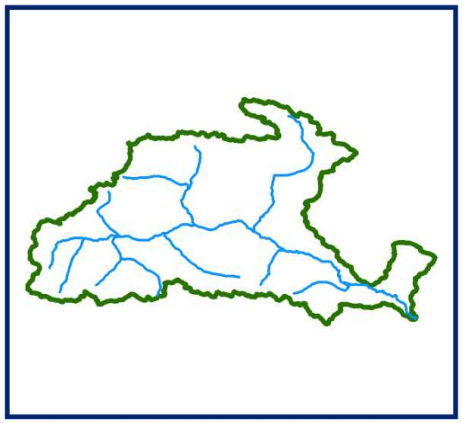

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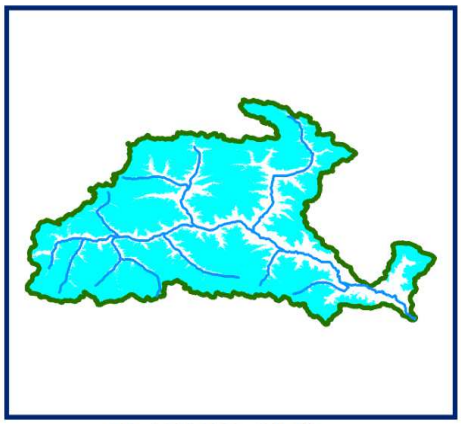
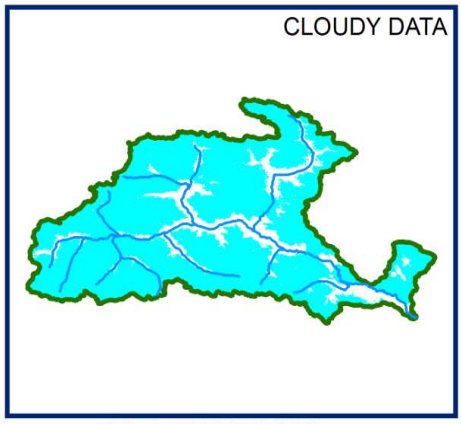
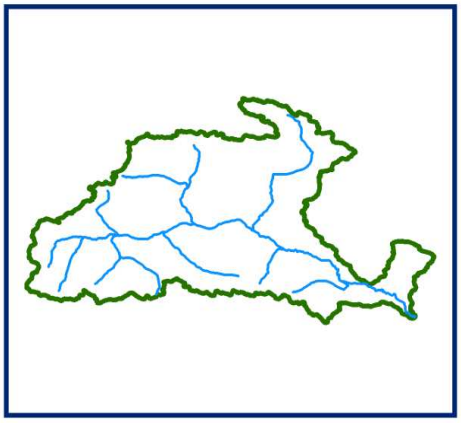


18 APRIL 2012



23 APRIL 2012



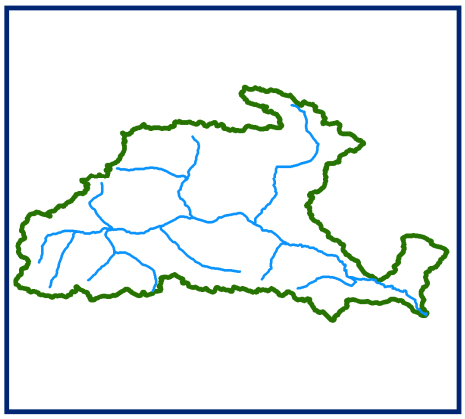
DATA NOT AVAILABLE

SNOW

0 30 60 120 180 240

Kilometers

10 DAILY SNOW COVER MAP: GILGIT BASIN



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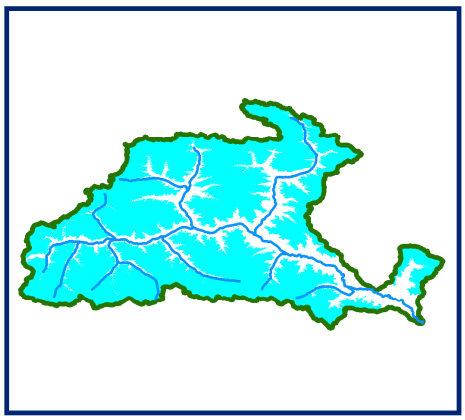

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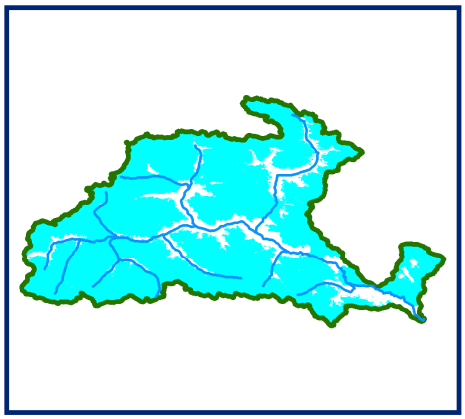
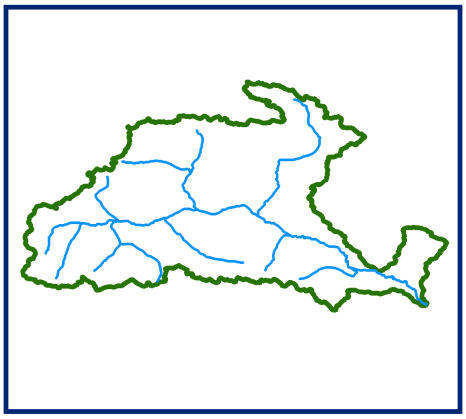


DATA USED
23 APRIL 2012

SNOW

0 30 60 120 180 240
Kilometers

SNOW COVER MAP : GILGIT BASIN



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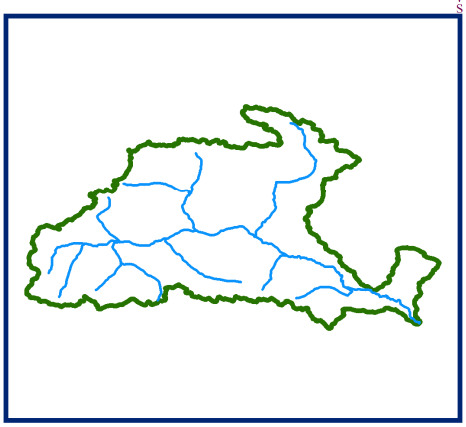

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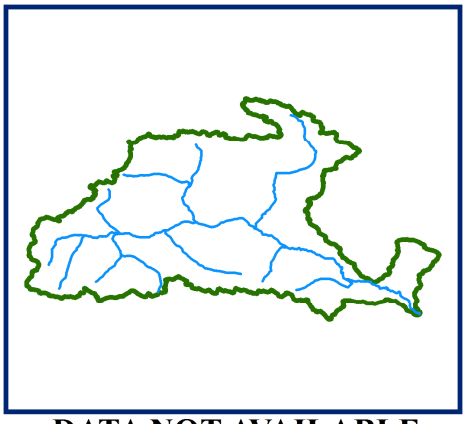

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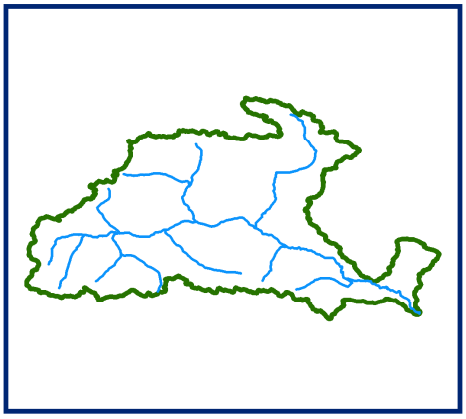

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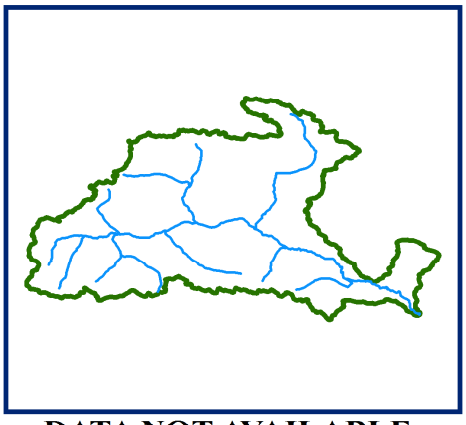

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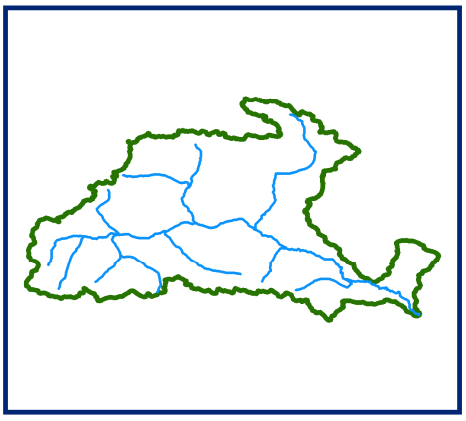


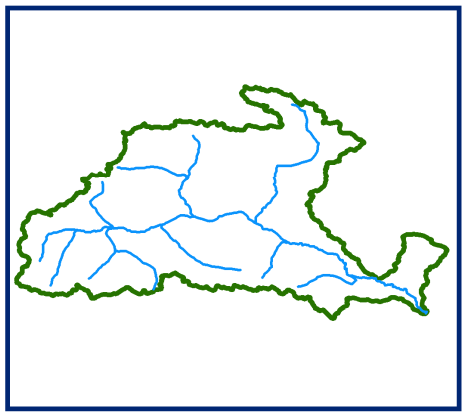
DATA NOT AVAILABLE

SNOW

0 30 60 120 180 240

Kilometers

10 DAILY SNOW COVER MAP: GILGIT BASIN



DATA USED
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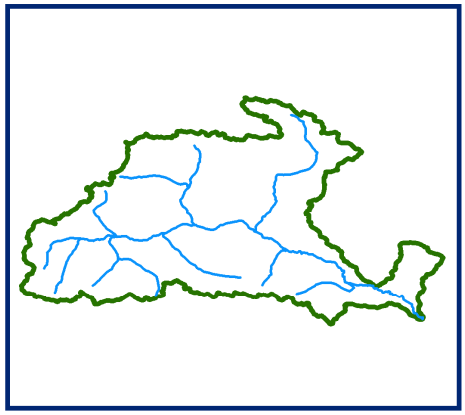

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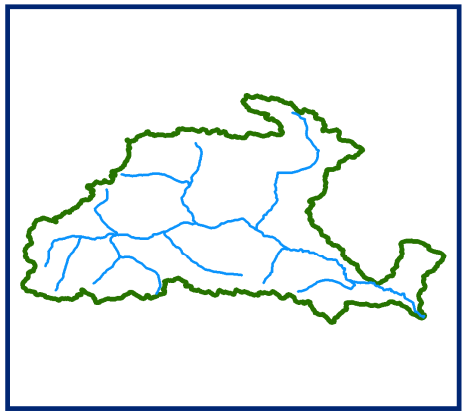
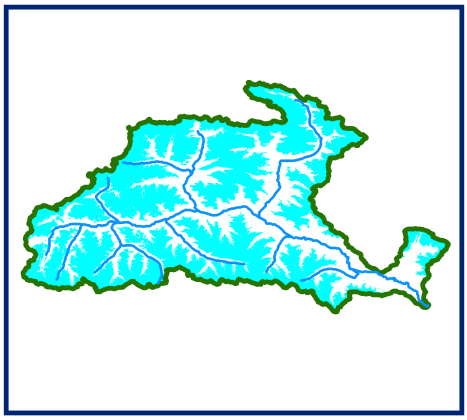


DATA USED
DATA NOT AVAILABLE

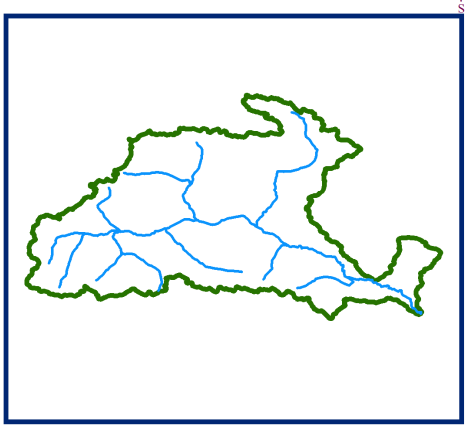
SNOW

0 30 60 120 180 240
Kilometers

SNOW COVER MAP : GILGIT BASIN



05 JUNE 2012



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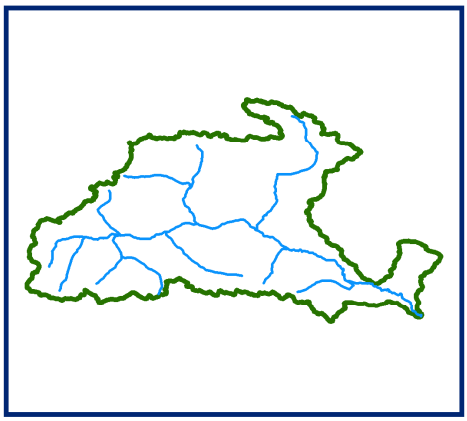

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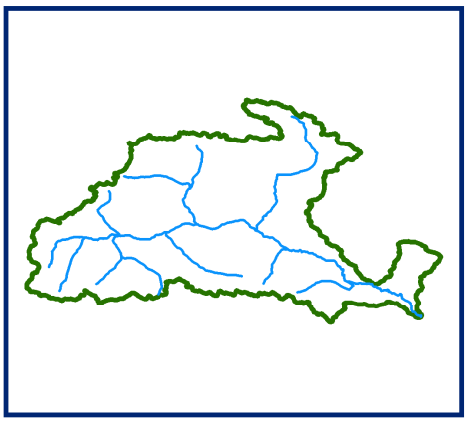

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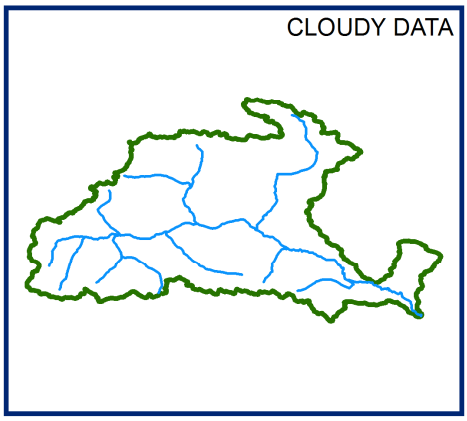

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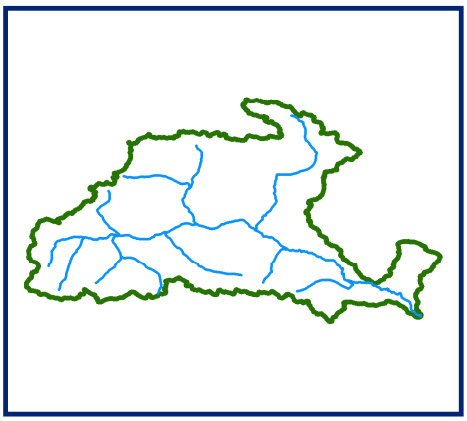


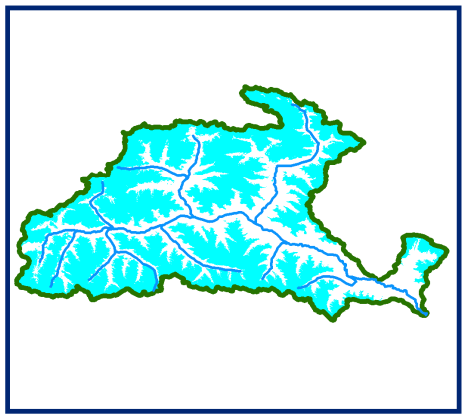
DATA NOT AVAILABLE

SNOW

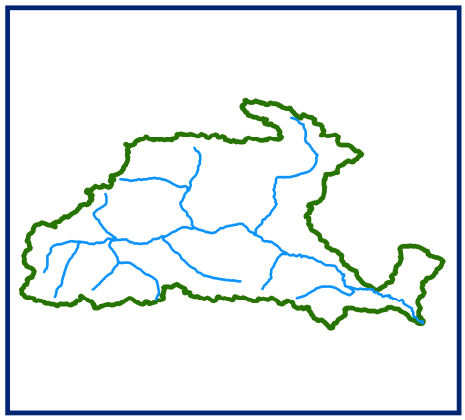
0 30 60 120 180 240

Kilometers

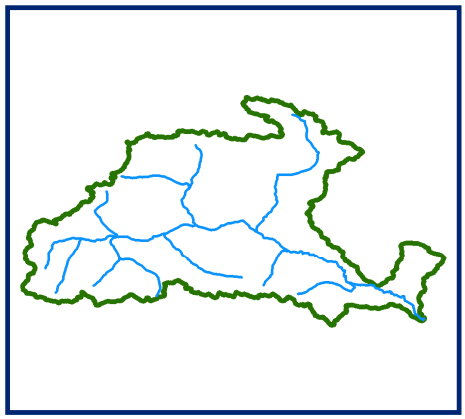
10 DAILY SNOW COVER MAP: GILGIT BASIN



DATA USED
03 JUNE 2012
05 JUNE 2012



DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE

SNOW

0 30 60 120 180 240
Kilometers

SHASGAN BASIN

AREAL EXTENT OF SNOW (5 DAILY)

BASIN NAME: SHASGAN **BASIN AREA: 7613 sq km**

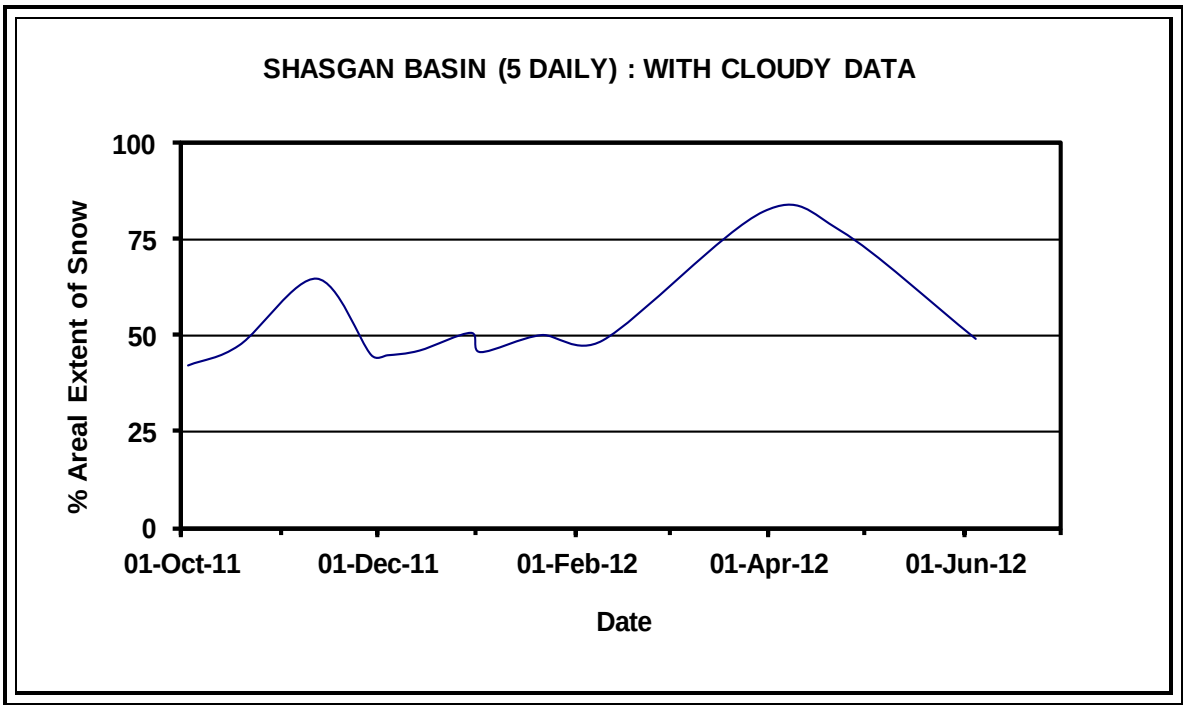
S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2011							
01	03-OCT-2011	3207	42	02	19-OCT-2011	3608	47
November 2011							
03	11-Nov-11	4919	65	04	29-Nov-11	3412	45
December 2011							
05	4-Dec-11	3407	45	06	14-Dec-11	3500	46
07	13-Dec-11	3566	47	08	30-Dec-11	3850	51
January 2012							
09	2-Jan-11	3470	46	10	21-Jan-12	2240	29
February 2012							
11	09-Feb-12	3702	49				
March 2012							
12	30-March-2012	6266	82				
April 2012							
13	23-April-2012	5899	77				
June 2012							
14	04-June-2012	3732	49				

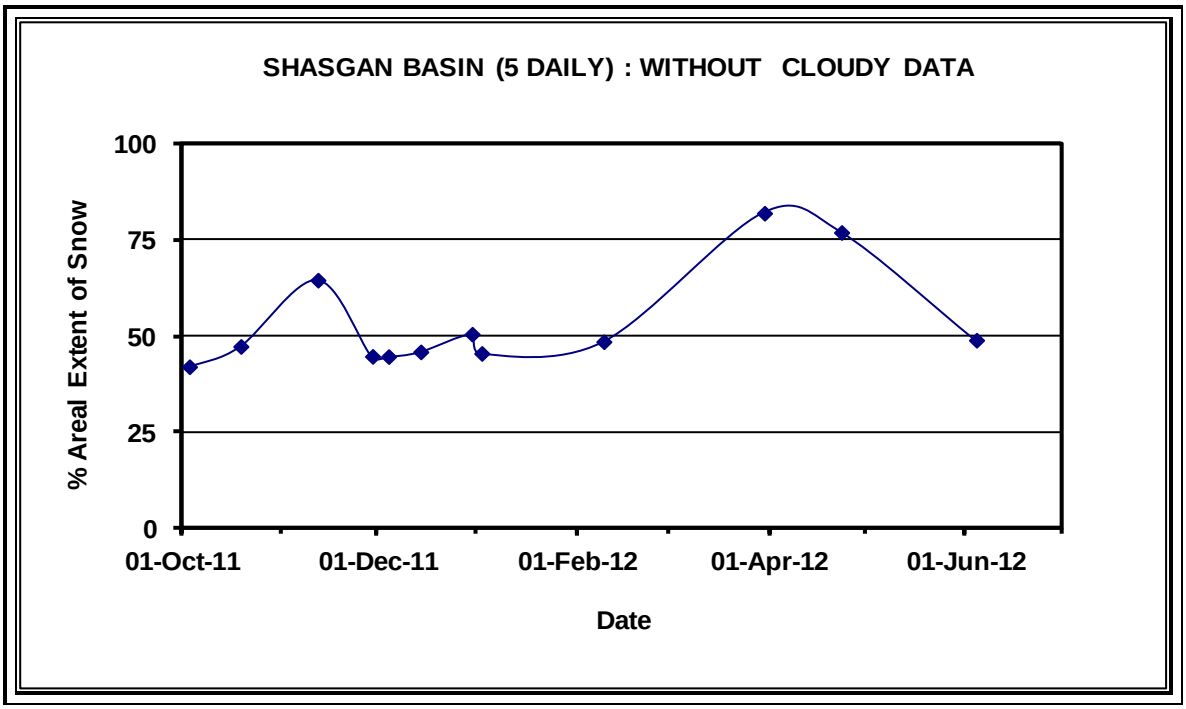
AREAL EXTENT OF SNOW (10 DAILY)

BASIN NAME: SHASGAN **BASIN AREA: 7613 sq km**

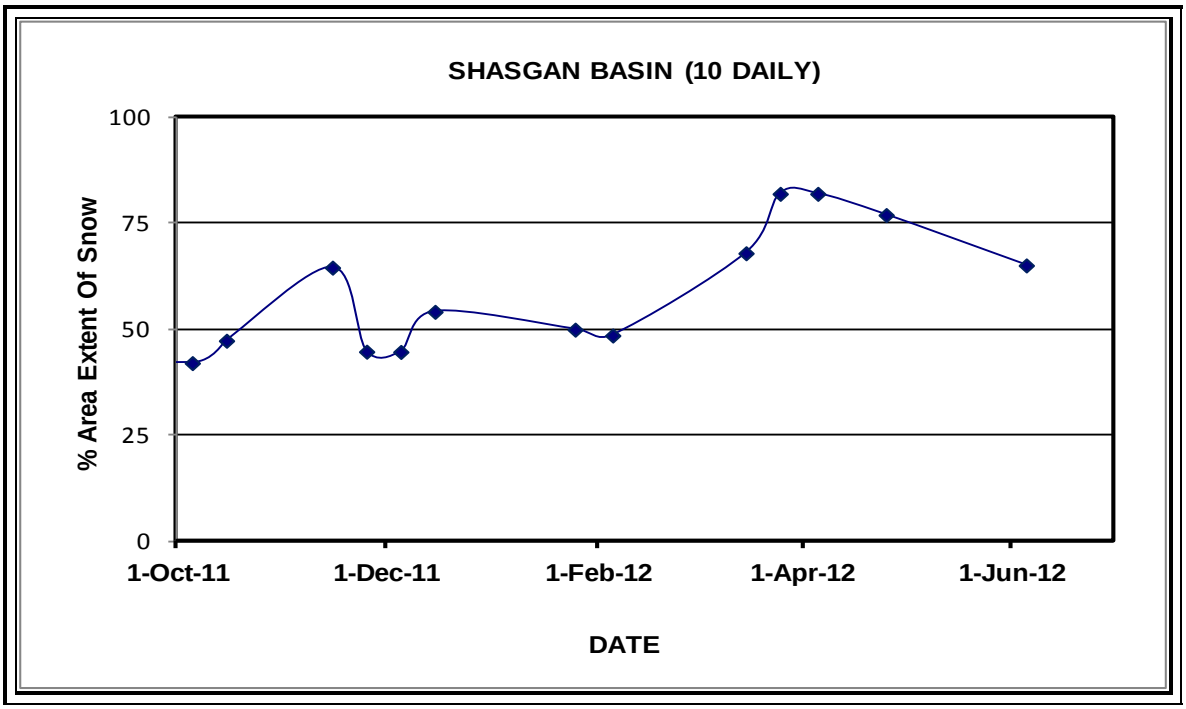
S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2011				**November 2011**			
01	3-Oct-11	3207	42	03	11-Nov-11	4919	65
02	19-OCT-2011	3608	47	04	29-Nov-11	3412	45
December 2011				**January 2012**			
05	4-Dec-11	3407	45	07	2-Jan-11	3470	46
06	15-Dec-11	4127	54	08	21-Jan-12	2240	29
February 2012				**March 2012**			
09	09-Feb-12	3702	49	10	30-March-2012	6266	82
April 2012				**June 2012**			
11	23-April-2012	5899	77	12	03-June-2012	4958	65

Snow cover depletion curve



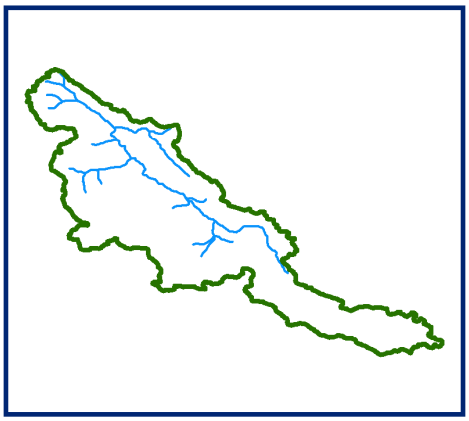


Snow cover depletion curve



SNOW COVER MAP

SNOW COVER MAP : SHASHGAN BASIN



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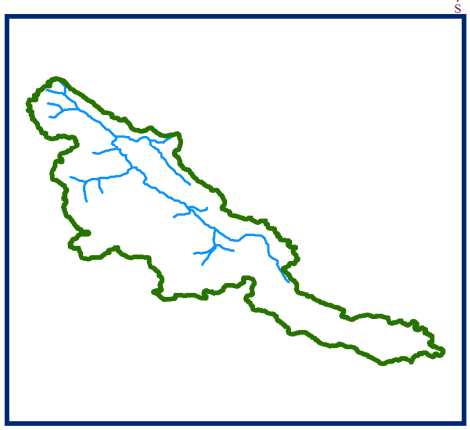

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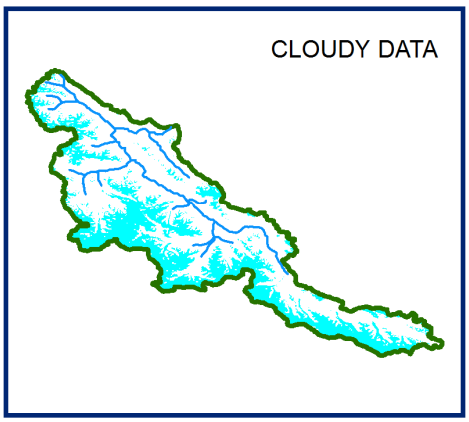
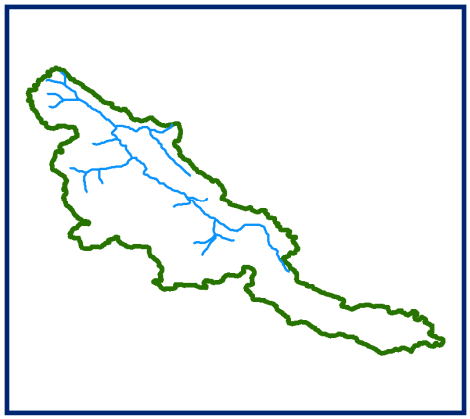


19 OCT. 2011



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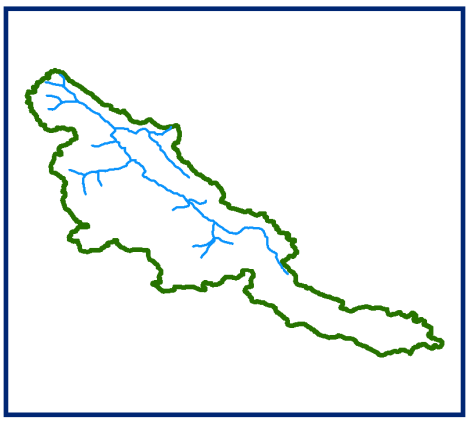

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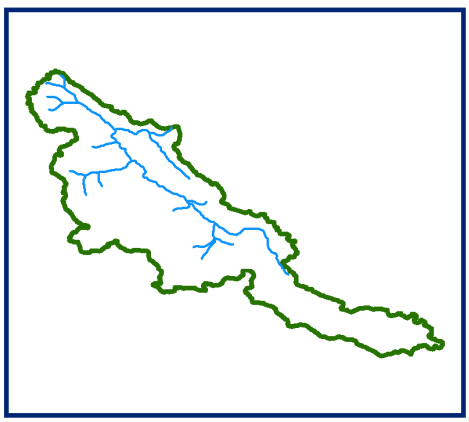


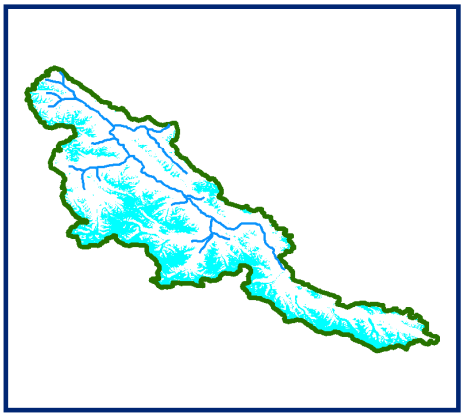
DATA NOT AVAILABLE

SNOW

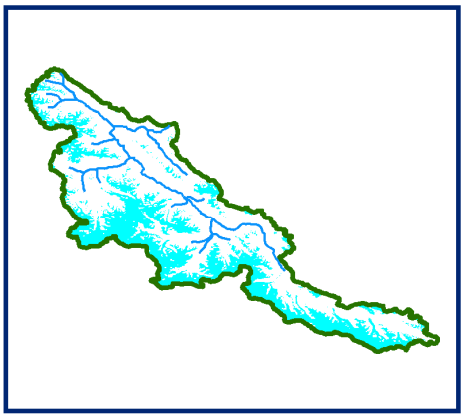
0 25 50 100 150 200

Kilometers

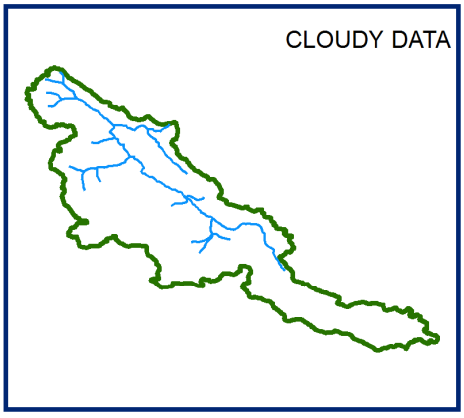
10 DAILY SNOW COVER MAP: SHASHGAN BASIN



DATA USED
03 Oct 2011



DATA USED
19 Oct 2011

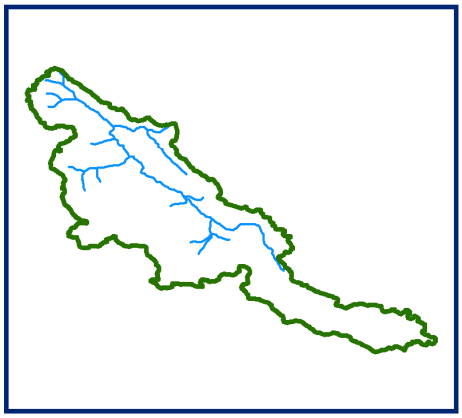


DATA USED
DATA NOT AVAILABLE

SNOW

0 25 50 100 150 200
Kilometers

SNOW COVER MAP : SHASHGAN BASIN



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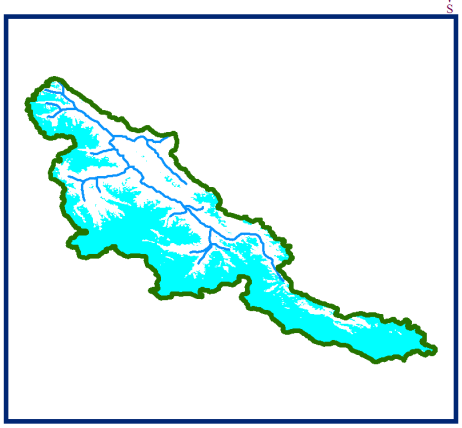
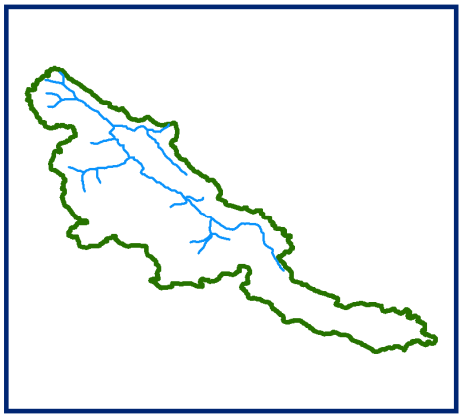


12 NOV. 2011



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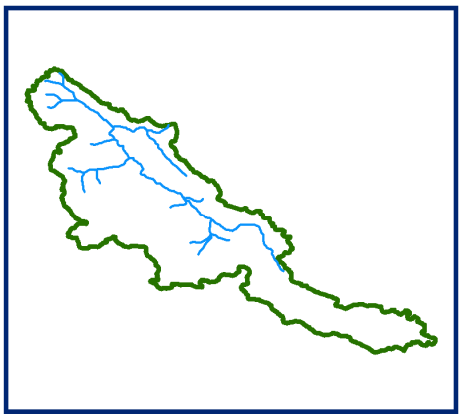

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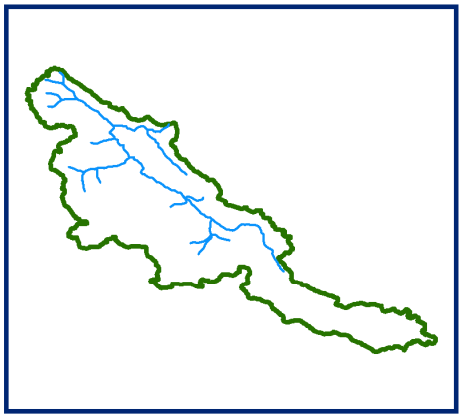

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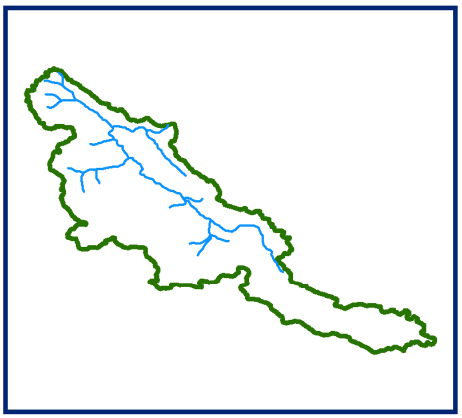


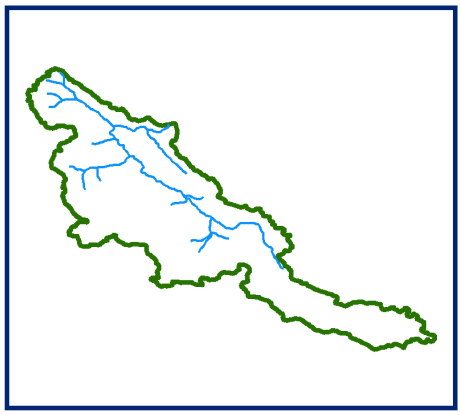
DATA NOT AVAILABLE

SNOW

0 25 50 100 150 200

Kilometers

10 DAILY SNOW COVER MAP: SHASHGAN BASIN



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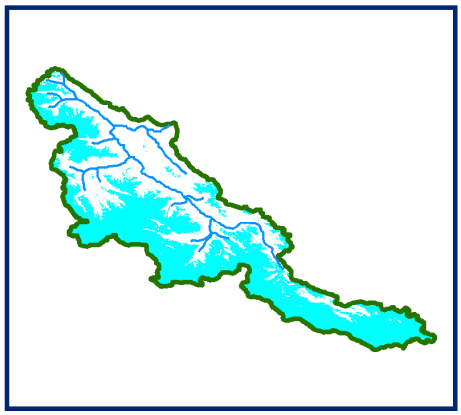

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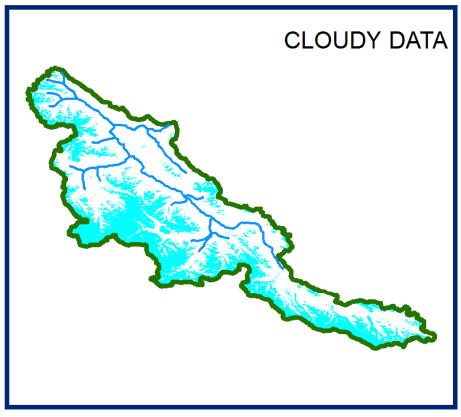
12 Nov 2011



DATA USED

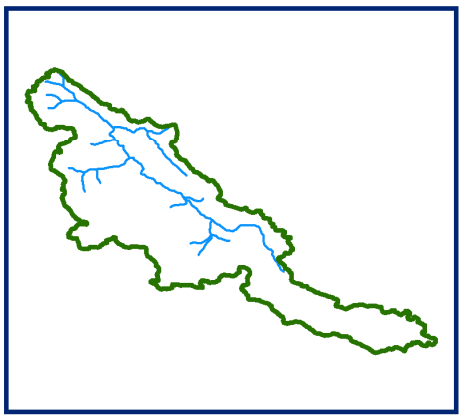
29 Nov 2011

SNOW

0 25 50 100 150 200

Kilometers

SNOW COVER MAP : SHASHGAN BASIN



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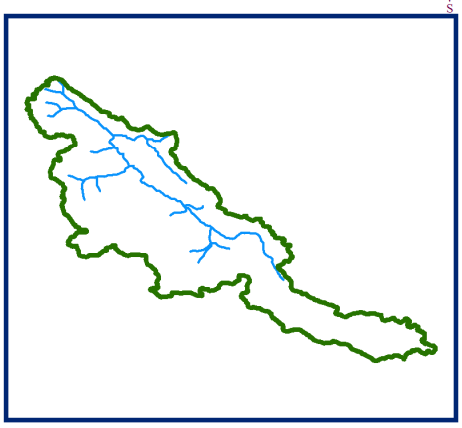

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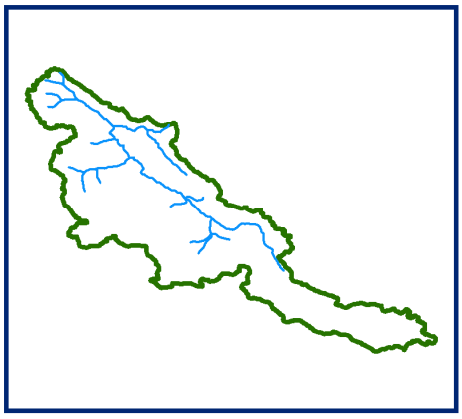

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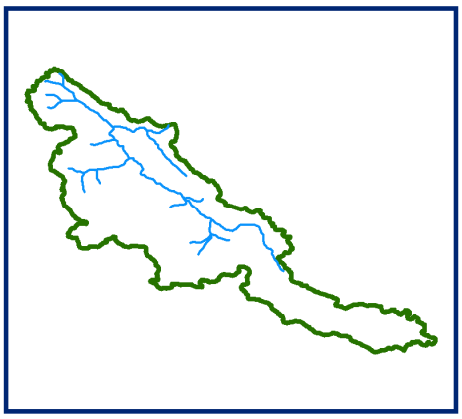

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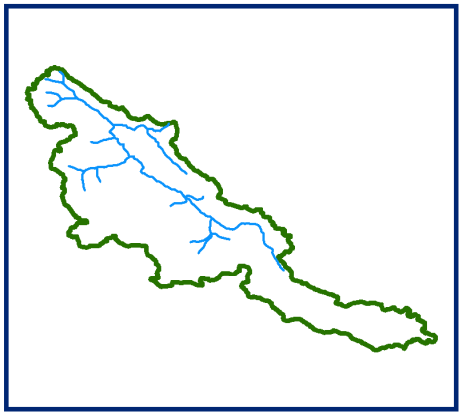

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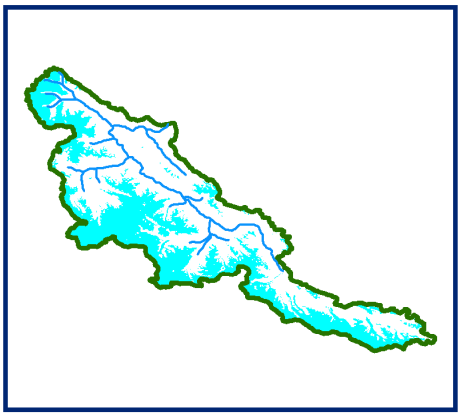


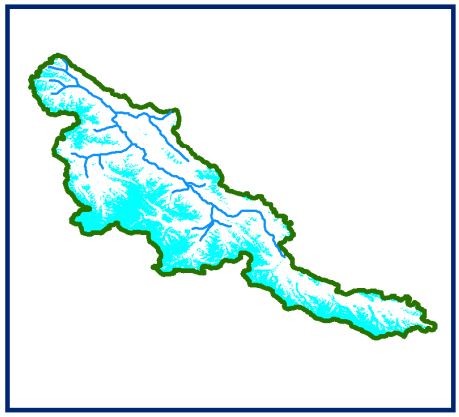
30 DEC. 2011

SNOW

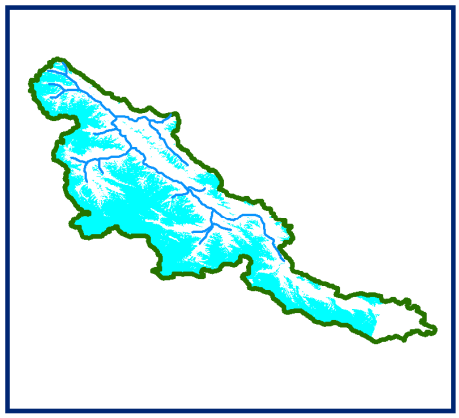
0 25 50 100 150 200

Kilometers

10 DAILY SNOW COVER MAP: SHASGAN BASIN



DATA USED
04 DECEMBER 2011



DATA USED
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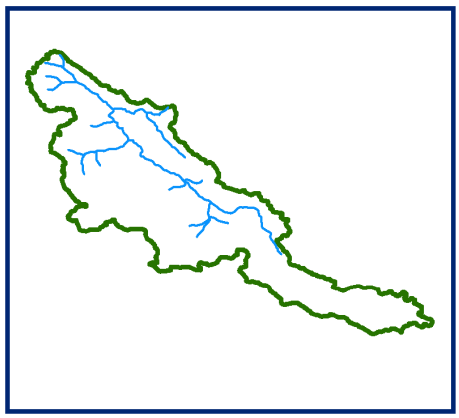
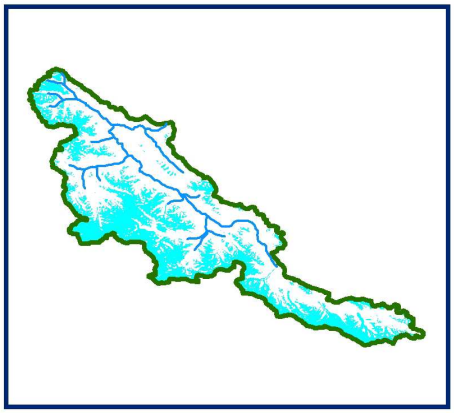


DATA USED
DATA NOT AVAILABLE

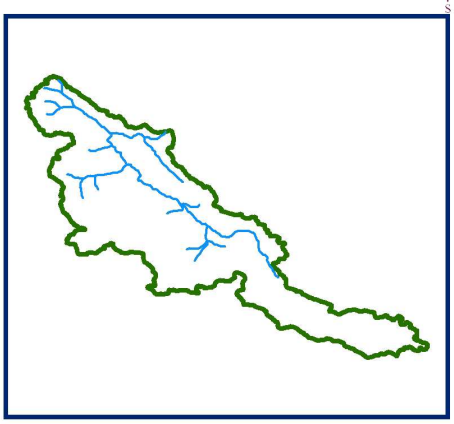
SNOW

0 25 50 100 150 200
Kilometers

SNOW COVER MAP : SHYOK BASIN



02 JAN 2012



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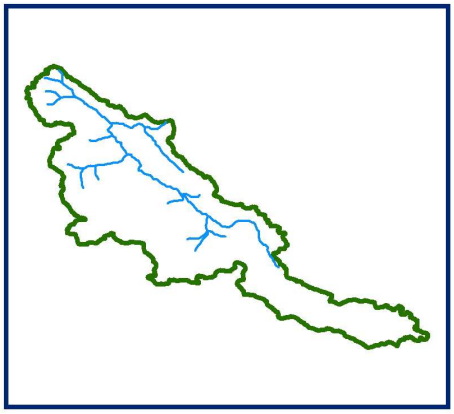

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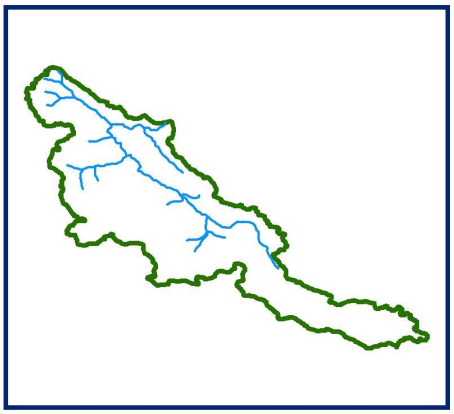

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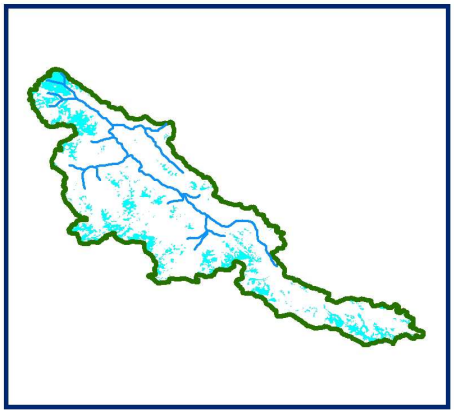
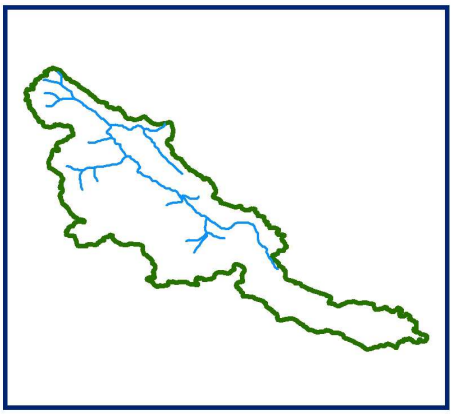


21 JAN 2012



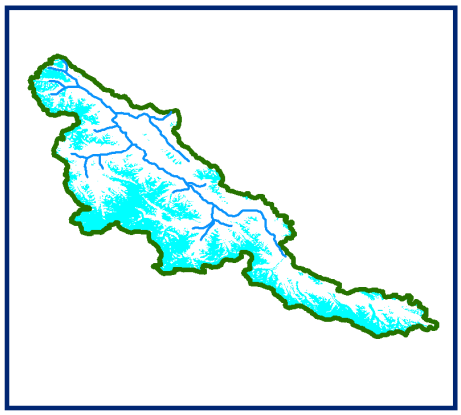
DATA NOT AVAILABLE

SNOW

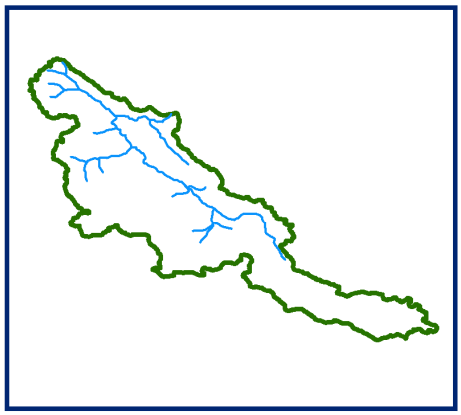
0 1530 60 90 120

Kilometers

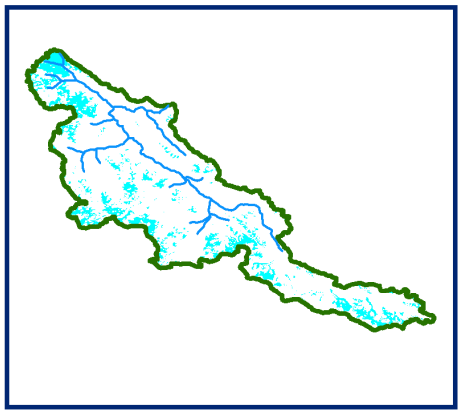
10 DAILY SNOW COVER MAP: SHASGAN BASIN



DATA USED
02 JANUARY 2011



DATA USED
DATA NOT AVAILABLE

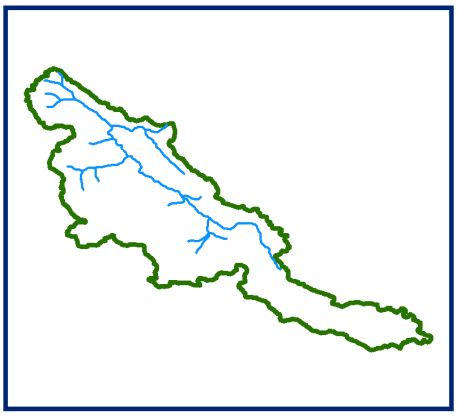


DATA USED
21 JANUARY 2011

SNOW

0 25 50 100 150 200
Kilometers

SNOW COVER MAP : SHASHGAN BASIN



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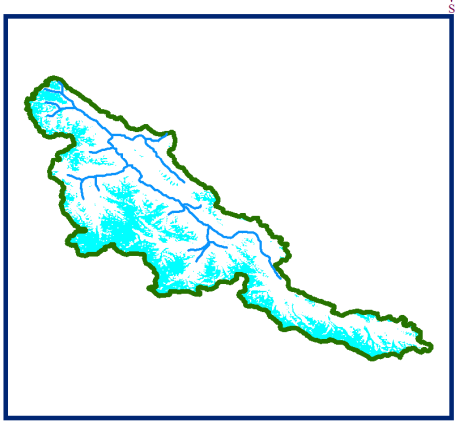
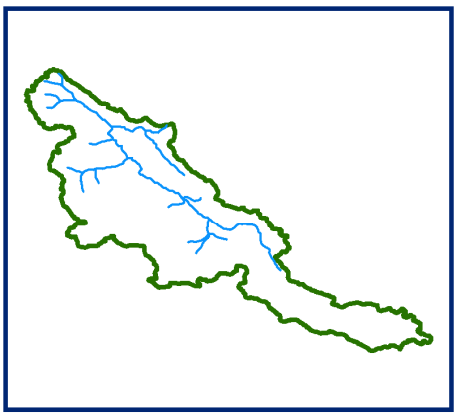


09 FEB. 2012



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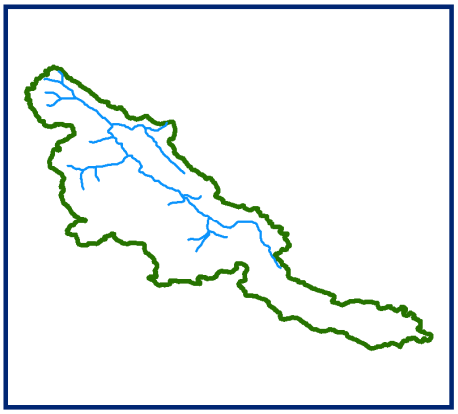

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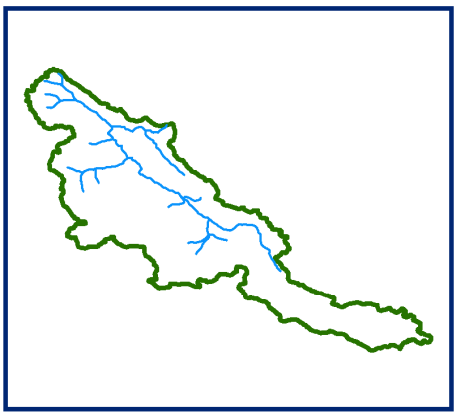

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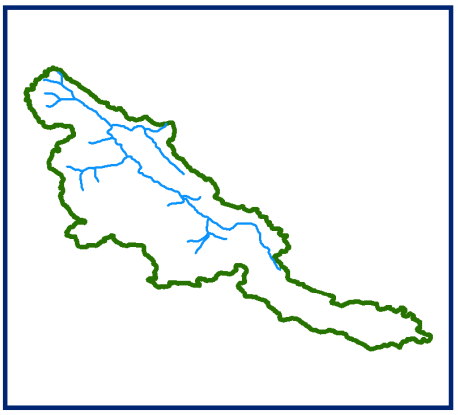


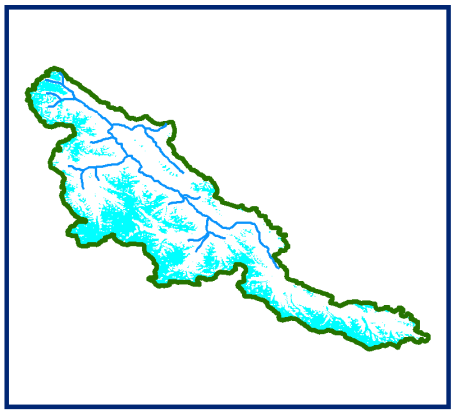
DATA NOT AVAILABLE

SNOW

0 25 50 100 150 200

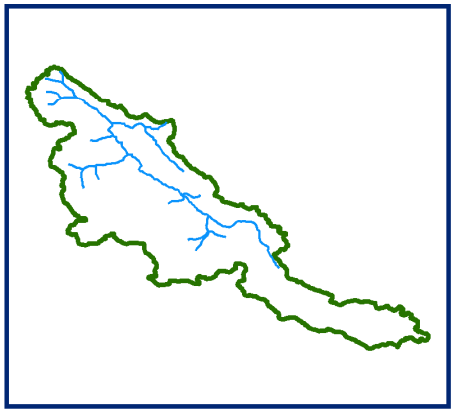
Kilometers

10 DAILY SNOW COVER MAP: SHASHGAN BASIN



DATA USED

09 FEB. 2012



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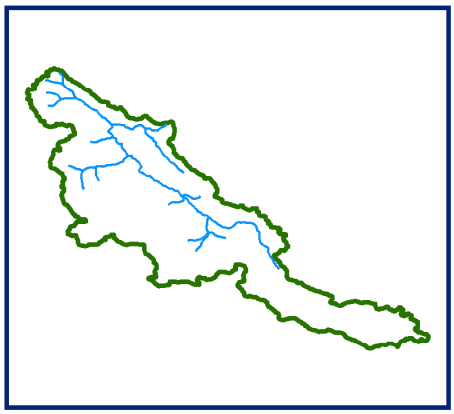


DATA USED

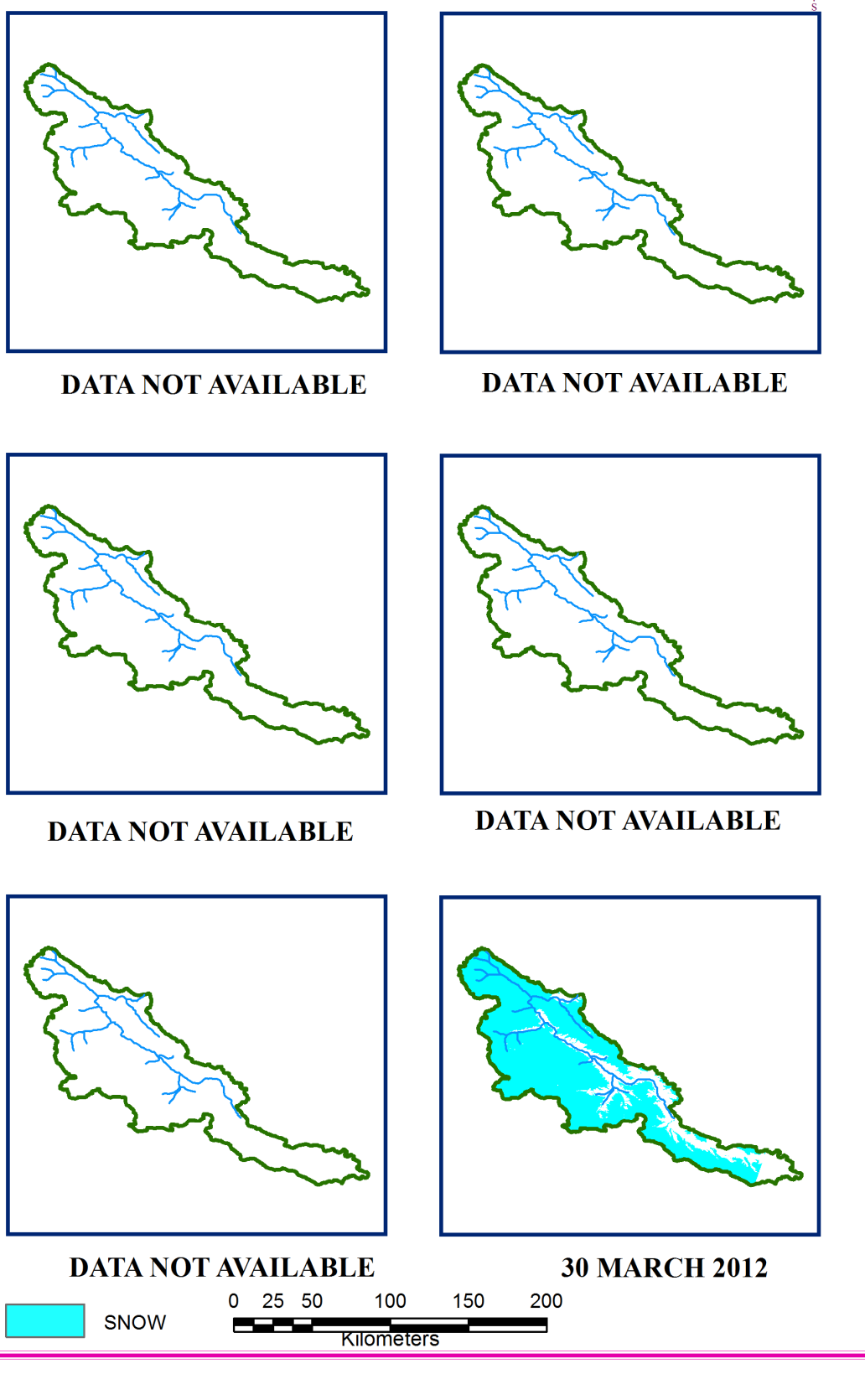
DATA NOT AVAILABLE

SNOW

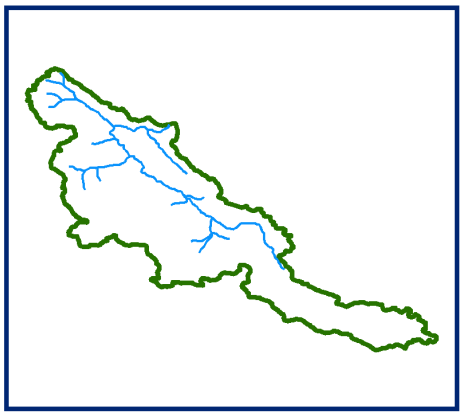
0 25 50 100 150 200

Kilometers

SNOW COVER MAP : SHASHGAN BASIN



10 DAILY SNOW COVER MAP: SHASHGAN BASIN



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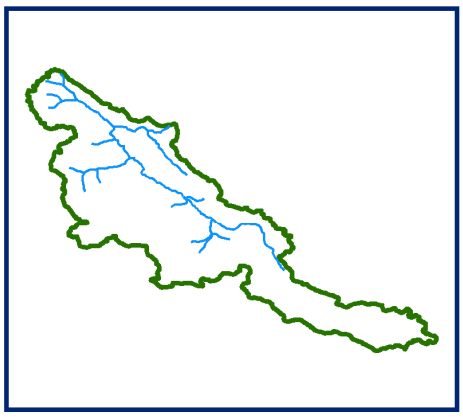

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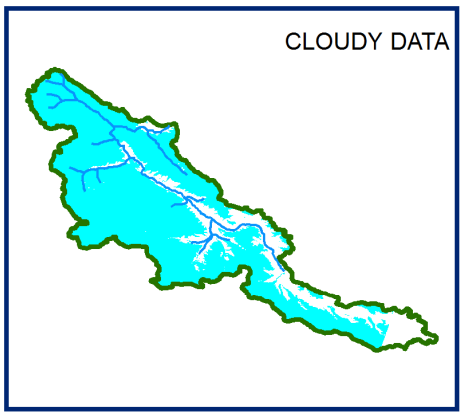


DATA USED

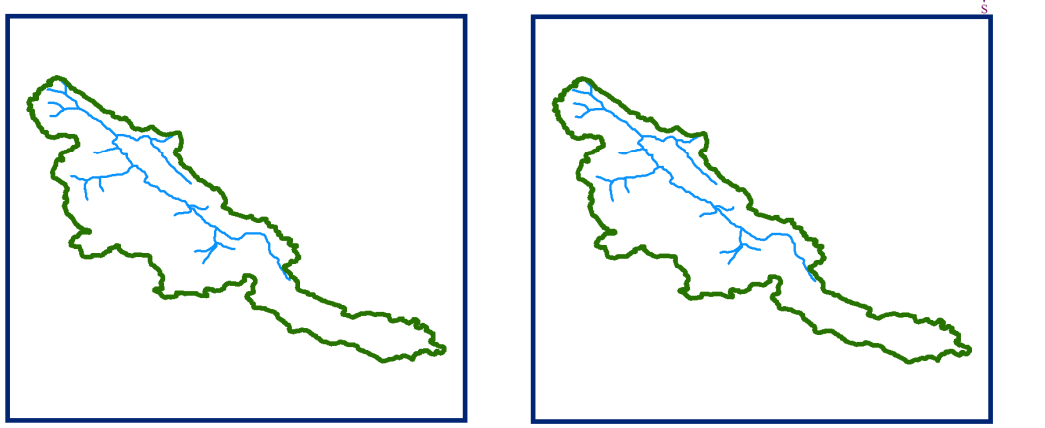
30 March 2012

SNOW

0 25 50 100 150 200

Kilometers

SNOW COVER MAP : SHASHGAN BASIN



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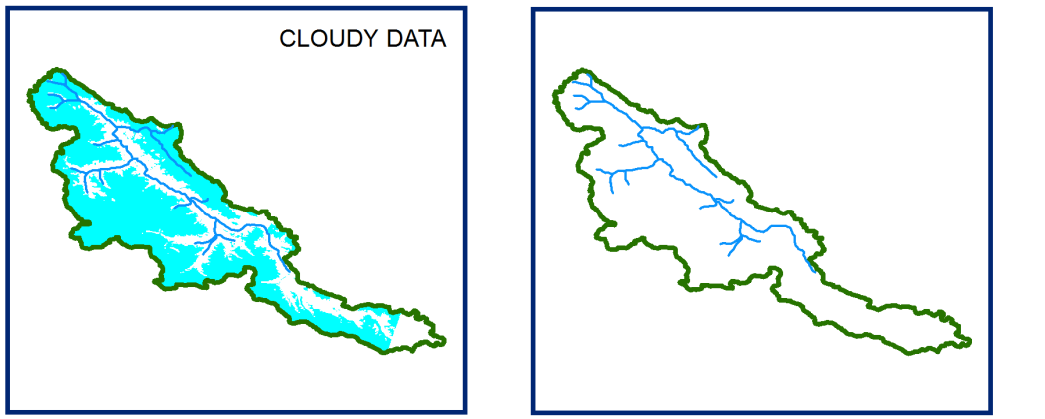
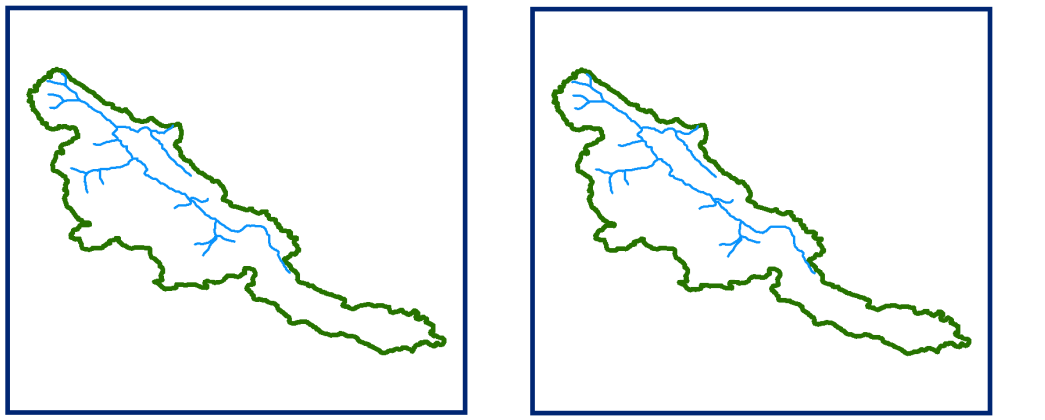


13 APRIL 2012 | DATA NOT AVAILABLE



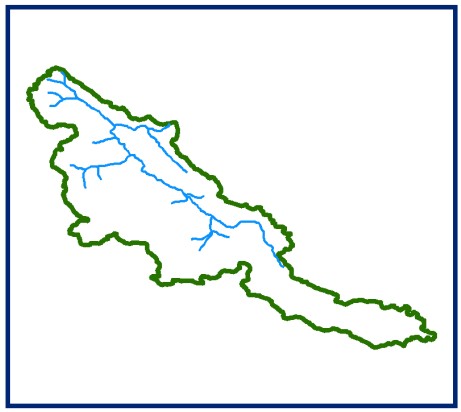
DATA NOT AVAILABLE | DATA NOT AVAILABLE

SNOW

0 25 50 100 150 200

Kilometers

10 DAILY SNOW COVER MAP: SHASHGAN BASIN



DATA USED

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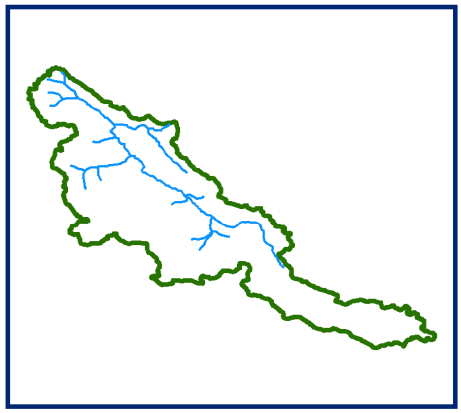

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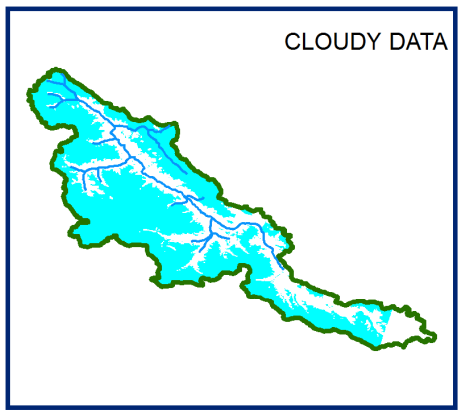


DATA USED

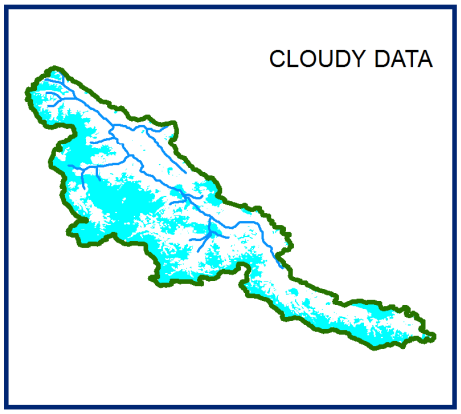
23 April 2012

SNOW

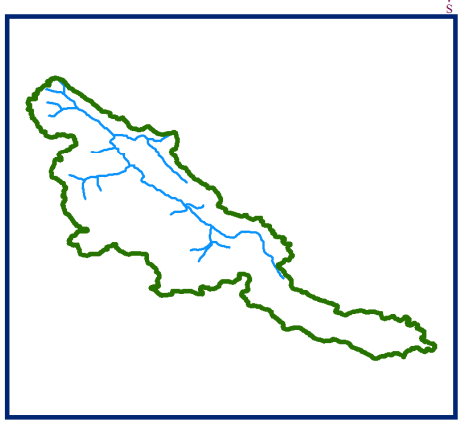
0 25 50 100 150 200

Kilometers

SNOW COVER MAP : SHASHGAN BASIN



04 JUNE 2012



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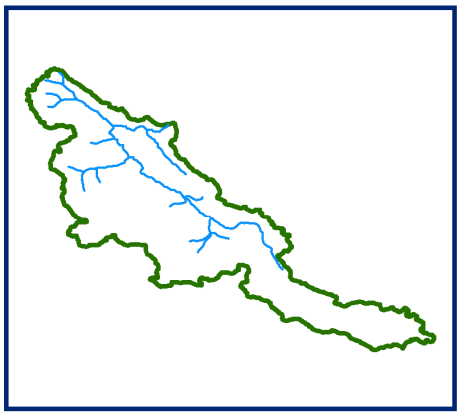

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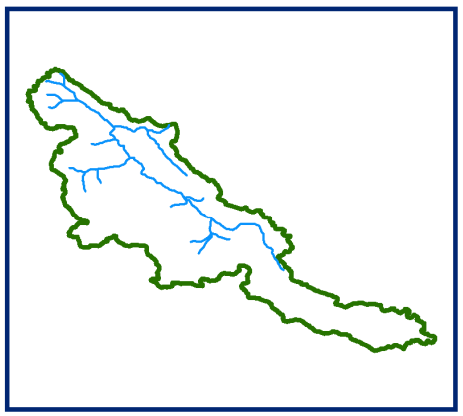

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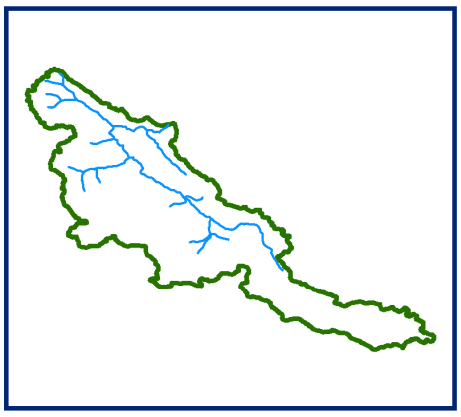

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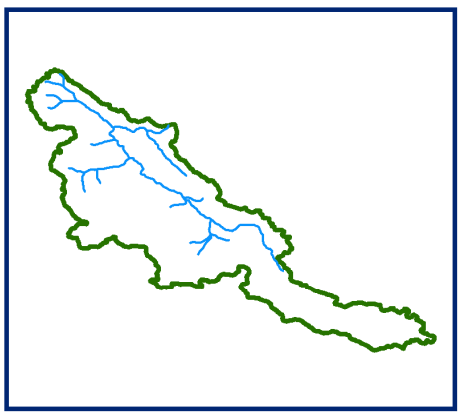

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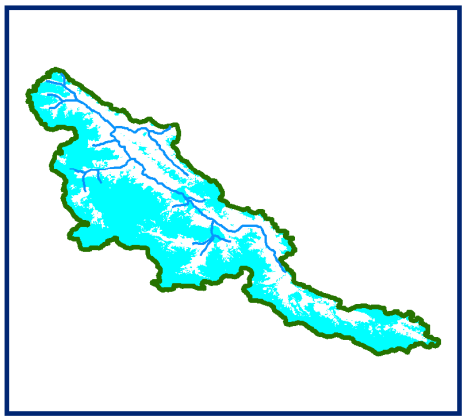
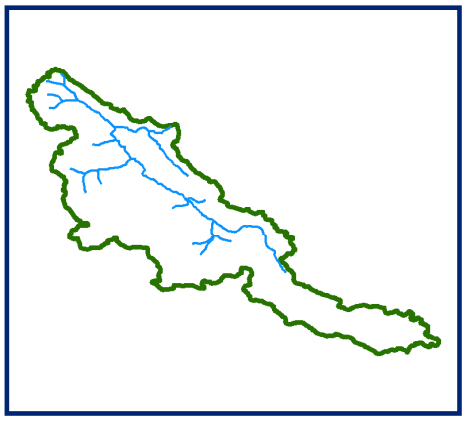
SNOW

10 DAILY SNOW COVER MAP: SHASHGAN BASIN



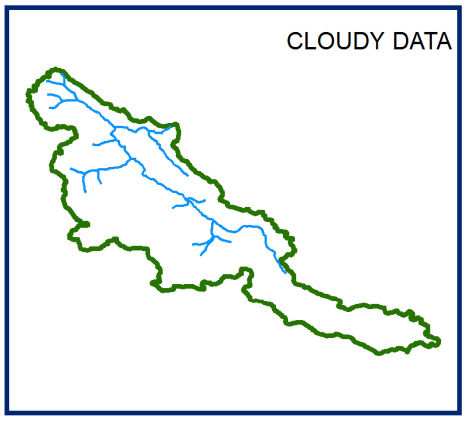
DATA USED

03 June 2012
04 June 2012



DATA USED

12 Nov 2011



DATA USED

DATA NOT AVAILABLE

SNOW

0 25 50 100 150 200

Kilometers