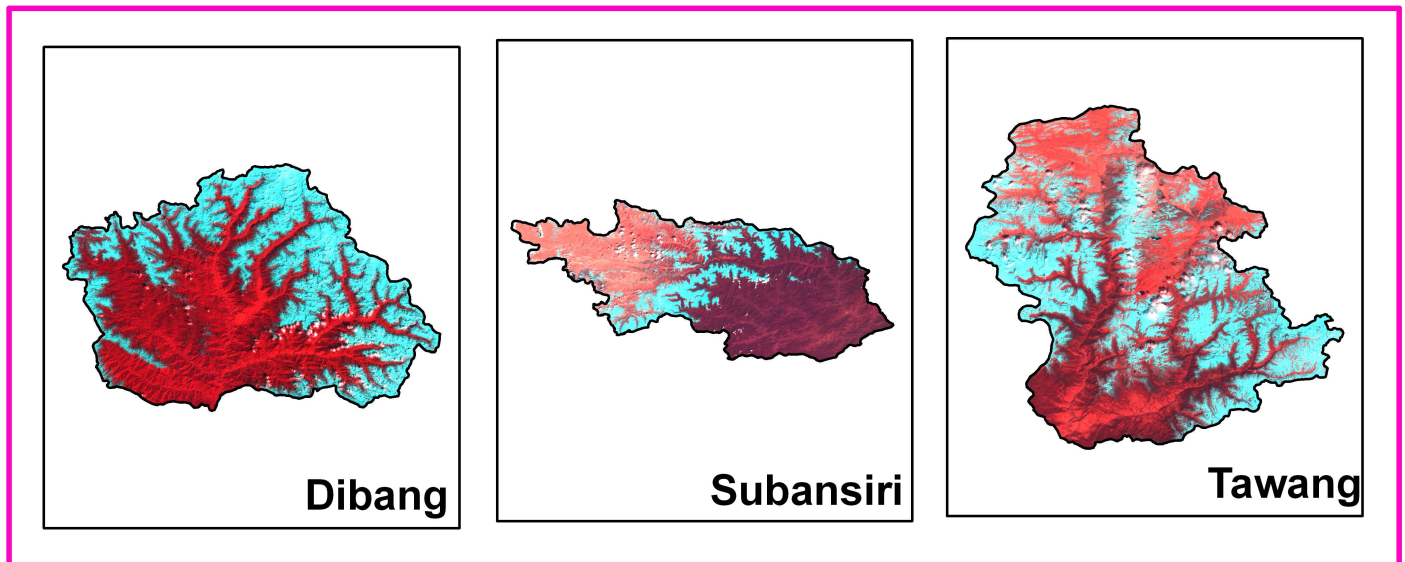


SNOW COVER ATLAS OF BRAHMAPUTRA BASIN

Sub basins: Dibang, Subansiri and Tawang

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

Year : 2012-13



State Remote Sensing Applications Centre (ISRO)
Itanagar, Arunachal Pradesh - 791113

and

Space Applications Centre (ISRO)
Ahmedabad - 380015

January 2014

SNOW COVER ATLAS OF THE BRAHMAPUTRA BASIN

Sub-basins: Dibang, Subansiri and Tawang

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

Year: 2012-13



Space Applications Centre (ISRO)

Ahmedabad-380015

And

State Remote Sensing Application Centre

Itanagar, Arunachal Pradesh 791113

January 2014

SPACE APPLICATIONS CENTRE (ISRO), AHMEDABAD - 380015

DOCUMENT CONTROL AND DATA SHEET

Report Number	SAC/EPASA/MPSG/SGP/SN/ 92 /2014
Month and year of publication	January 2014
Title	Snow cover Atlas of Brahmaputra basin
Type of Report	Scientific Report
No. of pages	76
No. of figures, Charts & Tables	56, 9 & 6
Authors	Team members
No. of References	9
Originating Unit	Geo Sciences Division, Marine, Geo and Planetary Sciences Group, Earth, Ocean, Atmosphere, Planetary Sciences and Applications area, Space Applications Centre (ISRO), Ahmedabad-15
Abstract	This atlas gives sub basin-wise distribution of snow cover in the Brahmaputra basin from October 2012 to June 2013. The sub basins included in this report are Dibhang, Subansiri and Tawang. 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, Dibhang, Subansiri and Tawang basins.
Security Classification	Unrestricted
Distribution	Among concerned

Authors (Team Members)

Space Applications centre (ISRO),

Ahmedabad - 380015

B. P. Rathore

S. K. Singh

I. Bahuguna

A. S. Rajawat

State remote Sensing Application centre

Itanagar, Arunachal Pradesh - 791113

Swapna Acharjee

Saumitra Deb

CONTENTS

	Page No.
1. INTRODUCTION	1
2. STUDY AREA	2
3. DATA USED	2
4. NORMALISED DIFFERENCE SNOW INDEX	2
5. SNOW COVER MONITORING ALGORITHM	3
6. RESULTS AND DISCUSSIONS	4
DIBANG BASIN	8
SUBANSIRI BASIN	33
TAWANG BASIN	55

1. Introduction

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

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

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

2. Study Area:

This Atlas gives distribution of snow cover in three subbasins of the Brahmaputra basin. These are Dibang, Subansiri and Tawang sub basins. Locations of these basins are shown in Figure 1.

3. Data used:

AWiFS data from October 2012 to June 2013 were used in this study.

4. Normalised Difference Snow Index (NDSI):

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

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

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

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

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

5. Snow cover monitoring algorithm

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

6. Results and discussions

In this atlas, basin-wise snow cover statistics, maps, and seasonal depletion curves have been provided from October 2012 to June 2013. Snow ablation pattern varies from basin to basin, depending on area altitude distribution in the basins. In the Tawang river basin, shows accumulation and ablation of snow throughout the winter season. For example up to February, 2013 less than 15 percent area was covered by seasonal snow. February onward accumulation starts. Ablation starts March onwards. Same pattern follow in Subansiri sub-basin. Accumulation starts early in the month of December in Dibang sub-basin. Areal extent was reaches to above 50 percent. This was reduced to 30 percent by February, 2013 again it increases to 55 percent on March, 2013. Subansiri sub-basin also shows accumulation and ablation of snow throughout the winter season but percentage areal extent snow is very less compare to Tawang and Dibang sub-basins.

Acknowledgements

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

References

Agarwal, K. G., Kumar, V. and T. Das, 1983, Melt runoff for a subcatchment of Beas basin. In Proceedings of the First National Symposium on Seasonal Snow Cover, New Delhi, India, April 28-30, 43 p.

Foster, J. L. and Chang, A. T. C., 1993, Snow cover, in Atlas of satellite observations related to global change. R. J. Gurney, C.L. Parkinson and J. L. Foster (eds.), Cambridge University Press, Cambridge, pp. 361-370.

Hall, D. K., Riggs, G. A. and Salomonson, V. V., 1995, Development of methods for mapping global snow cover using moderate resolution Image Spectroradiometer data. *Remote Sensing of Environment*, 54, pp. 127-140.

Kulkarni, A. V., Mathur, P., Rathore, B. P., Alex, S., Thakur N. and Kumar, M. 2002, Effect of global warming on snow ablation pattern in the Himalayas. *Current Science*, 83(2), pp 120-123.

Kulkarni A. V., Singh, S. K., Mathur, P. and Mishra, V. D., 2006, Algorithm to monitor snow cover using AWiFS data of RESOURCESAT for the Himalayan region. *International Journal of Remote Sensing*, 27(12), pp 2449-2457.

Kulkarni, A. V., Randhawa, S. S. and Sood, R. K., 1997, A stream flow simulation model in snow covered areas to estimate hydro-power potential: a case study of Malana nala, H.P. Proc. of the First international Conference on Renewable Energy- Small Hydro, Hyderabad, pp 761-770.

Markham, B. L. and Barker, J. L., 1987, Thematic Mapper bandpass solar exoatmospheric irradiances. *International Journal of Remote Sensing*, 8(3), pp 517-523.

Singer, F. S. and Popham, R. W., 1963. Non-meteorological observations from satellite. *Astronautics and Aerospace Engineering* 1(3), 89-92.

Srinivasulu, J. and Kulkarni, A. V., 2004, A satellite based spectral reflectance model for snow and glacier studies in the Himalayan terrain. *Proceedings of the Indian Academy of Science (Earth and Planetary Science)*, 113 (1), pp. 117-128.

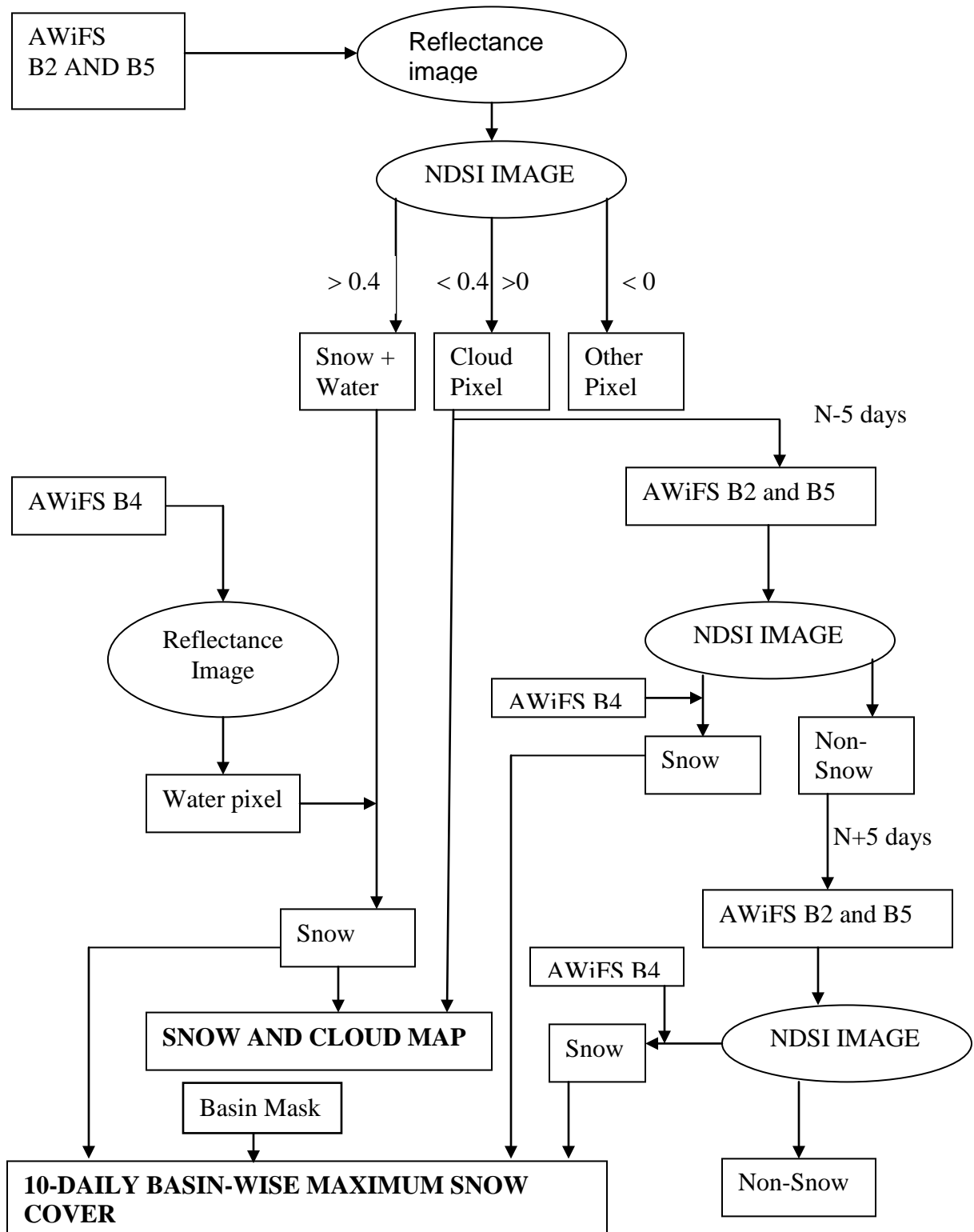


Figure 2: Algorithm for snow cover mapping using AWiFS data

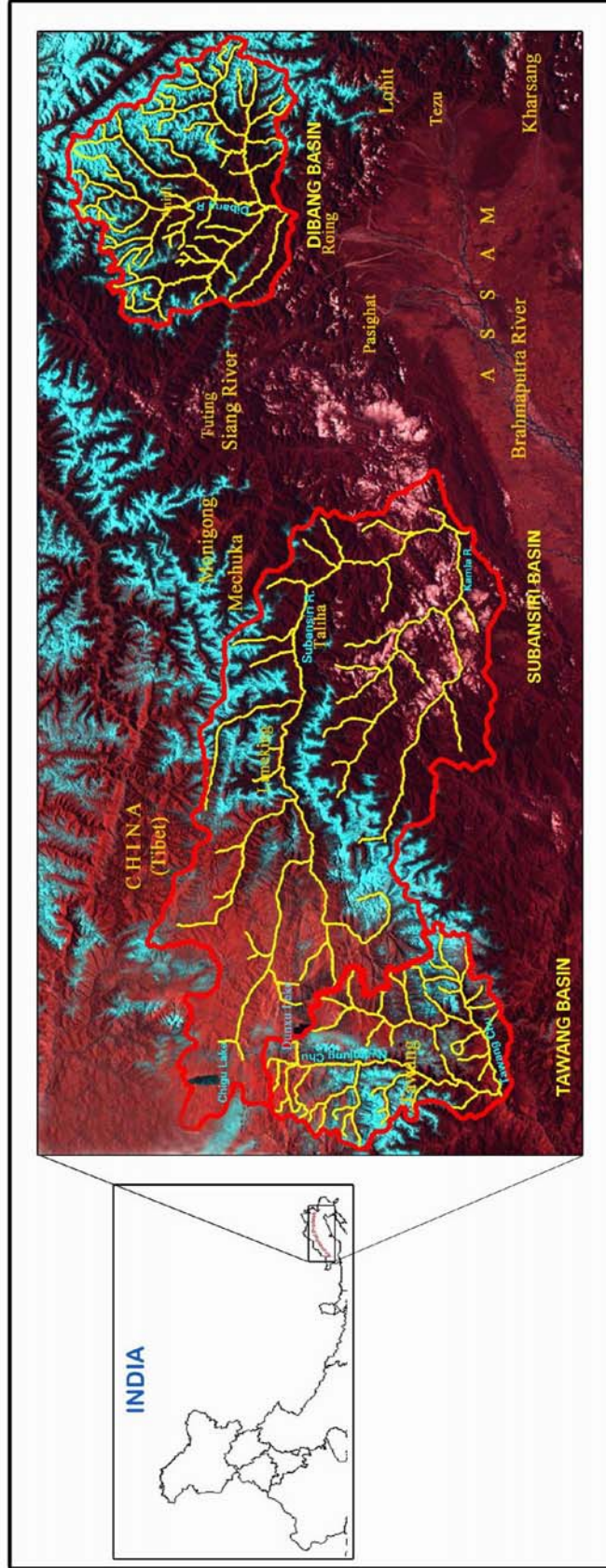


Figure 1: Location map of Dibang, Subansiri and Tawang sub-basins (Part of Brahmaputra basin)

AREAL EXTENT OF SNOW (5 DAILY)

BASIN NAME: DIBANG

BASIN AREA: 9158 sq km

S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2012							
1	8-Oct-12	1190(C)	13	2	27-Oct-12	1234	13
November 2012							
3	1-Nov-12	529	6	7	15-Nov-12	1136 (C)	12
4	3-Nov-12	381	4	8	18-Nov-12	733	8
5	6-Nov-12	456 (C)	5	9	20-Nov-12	839 (C)	9
6	10-Nov-12	2530	28	10	23-Nov-12	363 (C)	4
December 2012							
11	2-Dec-12	3418	37	14	17-Dec-12	3896	43
12	4-Dec-12	1979	22	15	24-Dec-12	4196	46
13	16-Dec-12	4830	53	16	26-Dec-12	2927 (C)	32
January 2013							
17	9-Jan-13	5972	65	21	19-Jan-13	2789	30
18	10-Jan-13	3882	42	22	22-Jan-13	3647 (C)	40
19	14-Jan-13	3243	35	23	24-Jan-13	3196	35
20	17-Jan-13	2066 (C)	23	24	31-Jan-13	2285	25
February 2013							
25	5-Feb-13	2779	30	29	15-Feb-13	1634 (C)	18
26	7-Feb-12	2468	27	30	22-Feb-13	5142	56
27	9-Feb-13	1147 (C)	13	31	24-Feb-13	3912	43
28	12-Feb-13	1419 (C)	16	32	27-Feb-13	3656	40
March 2013							
33	13-Mar-13	2551	28	34	20-Mar-13	4050	44
April 2013							
35	7-April-13	Data Not Available		36	8-April-13	Data Not Available	
May 2013							
37	21-May-13	1930 (C)	21	38	26-May-13	2067	23
June 2013							
39	12-June-12	222 (C)	2				

AREAL EXTENT OF SNOW (10 DAILY)

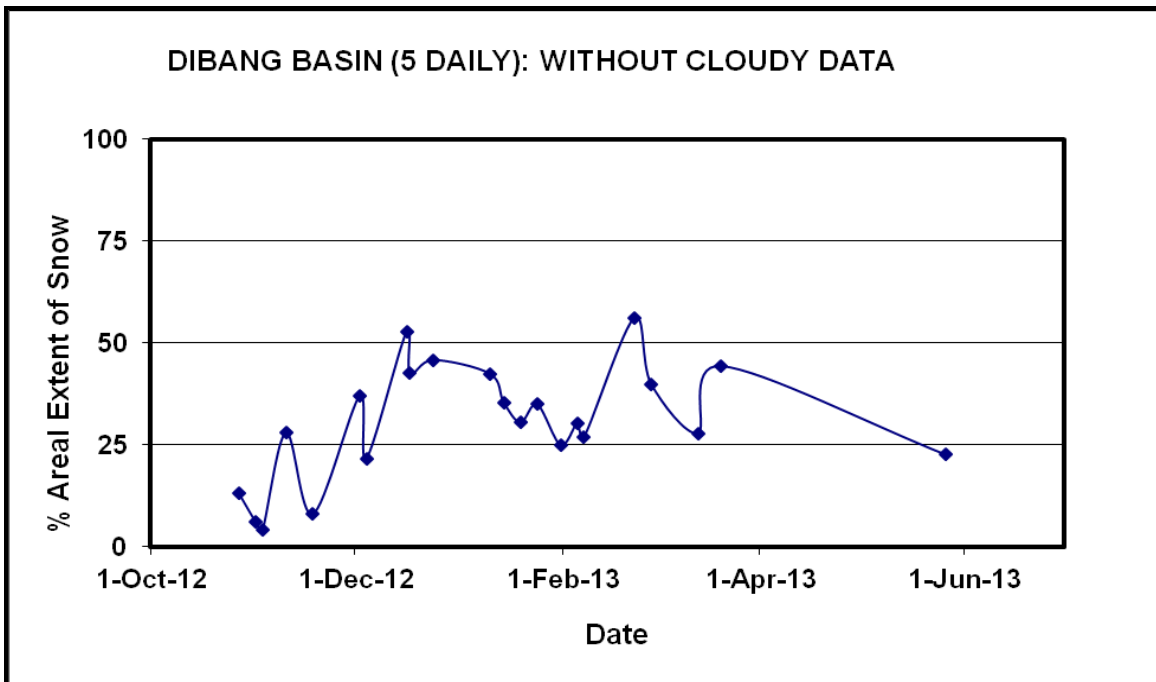
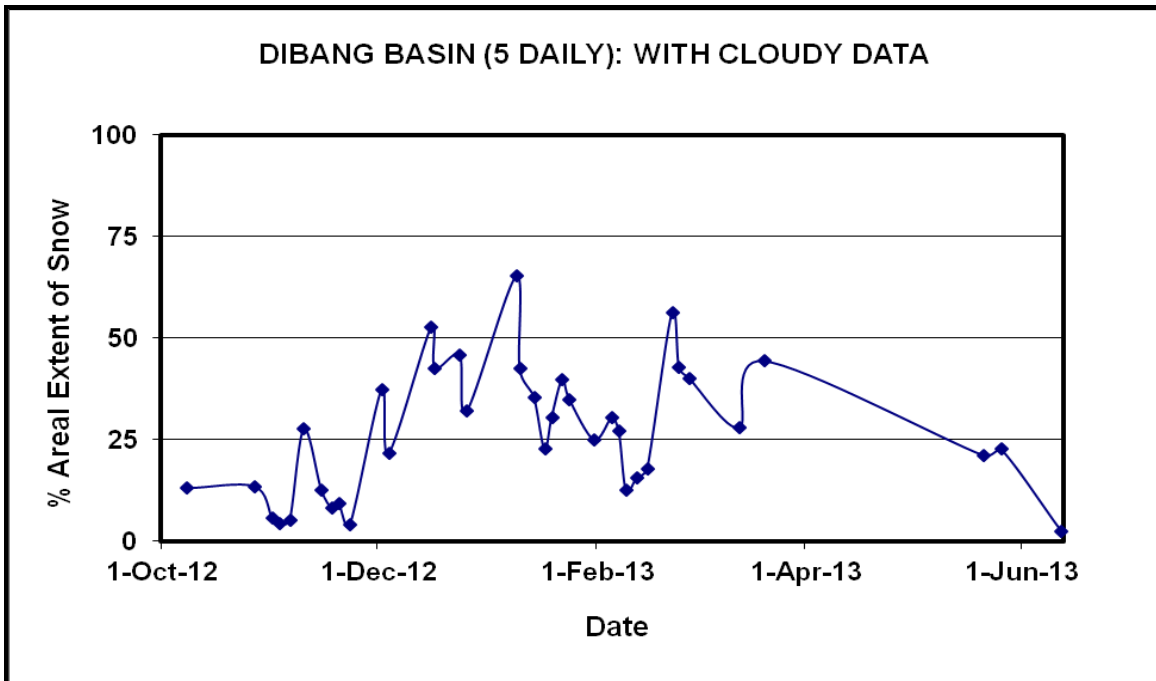
BASIN NAME: DIBANG

BASIN AREA: 9159 sq km

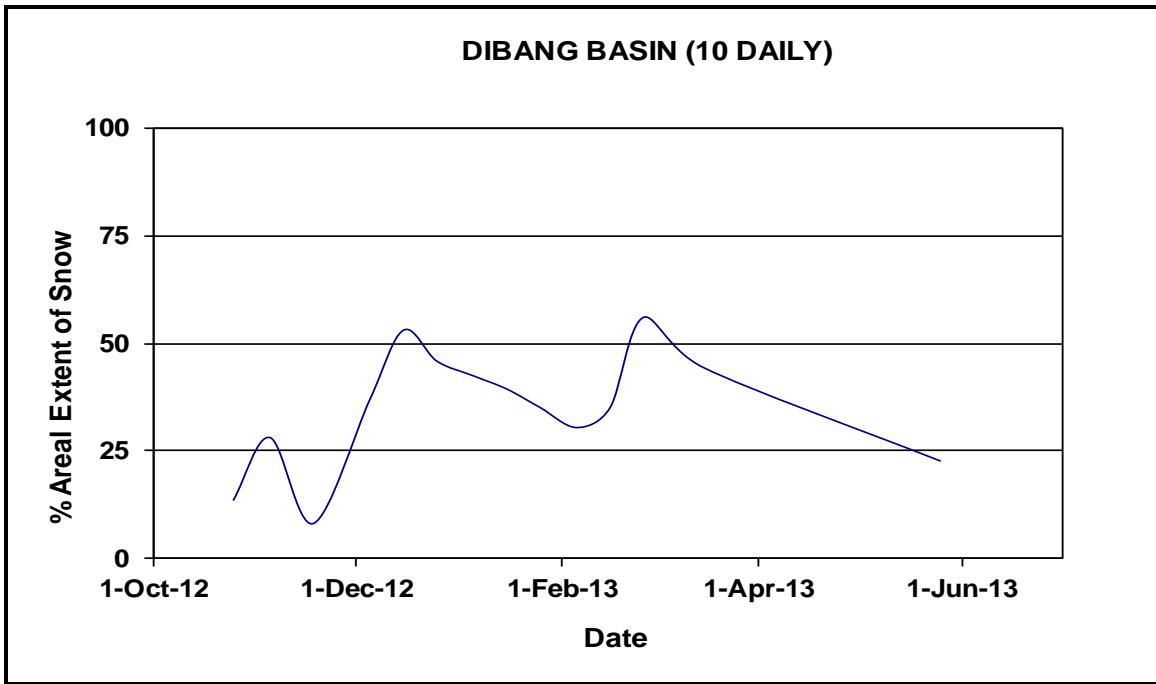
S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2012				November 2012			
1	25-Oct-12	1234	13	2	5-Nov-12	2564	28
				3	18-Nov-12	732	8
December 2012				January 2013			
4	5-Dec-12	3388	37				
5	15-Dec-12	4854	53	5	5-Jan-13	3882	42
6	25-Dec-12	4196	46	6	15-Jan-13	3600	39
				7	25-Jan-13	3205	35
February 2013				March 2013			
8	5-Feb-13	2779	30	11	15-Mar-13	4050	44
9	15-Feb-13	3205	35				
10	25-Feb-13	5128	56				
April 2013				May 2013			
				13	25-May-13	2067	23
June 2013							

DNA- DATA NOT AVAILABLE

SNOW COVER DEPLETION CURVE

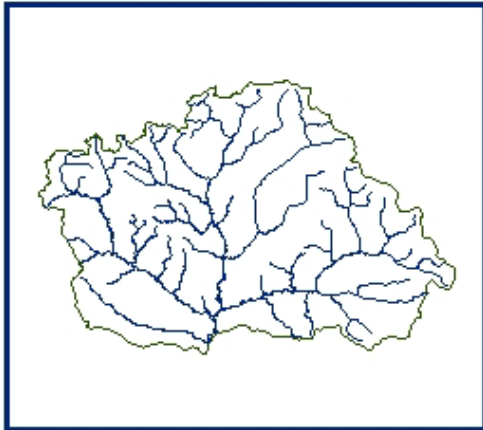


SNOW COVER DEPLETION CURVE

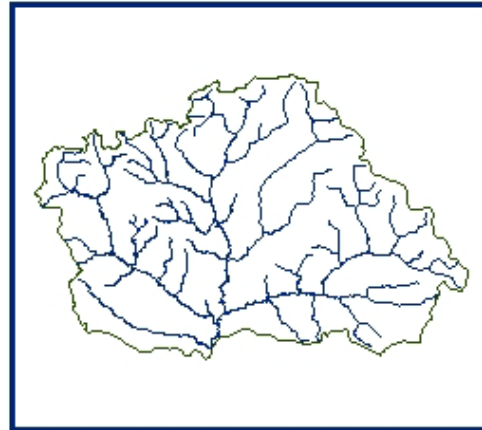


SNOW COVER MAP

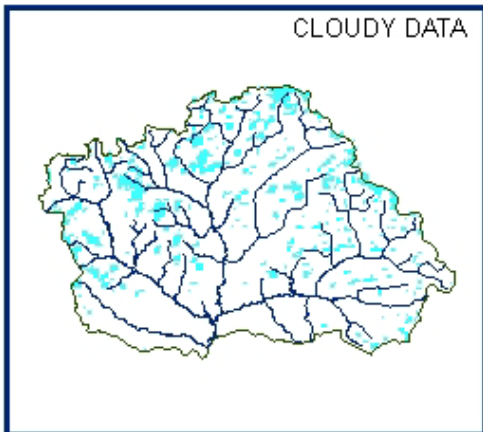
SNOW COVER MAP : DIBANG BASIN



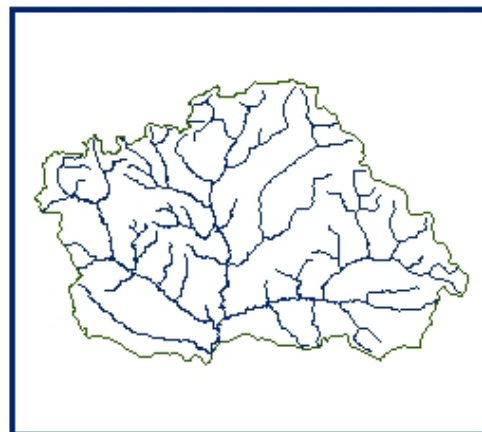
DATA NOT AVAILABLE



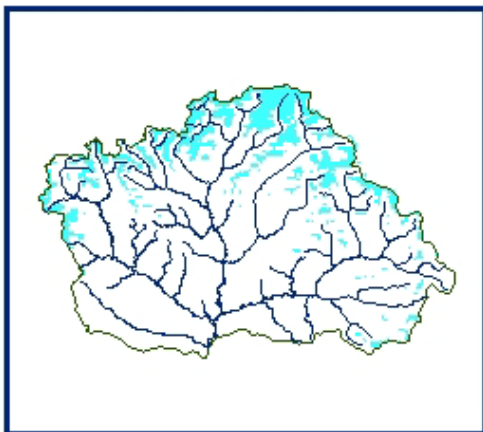
DATA NOT AVAILABLE



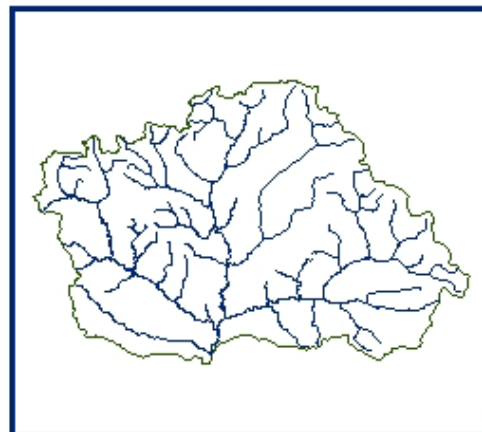
08 OCTOBER 2012



DATA NOT AVAILABLE



27 OCTOBER 2012



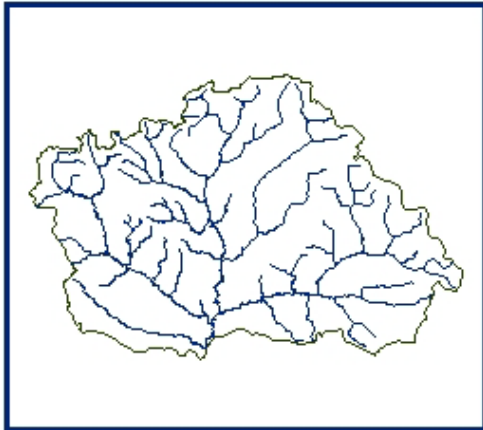
DATA NOT AVAILABLE



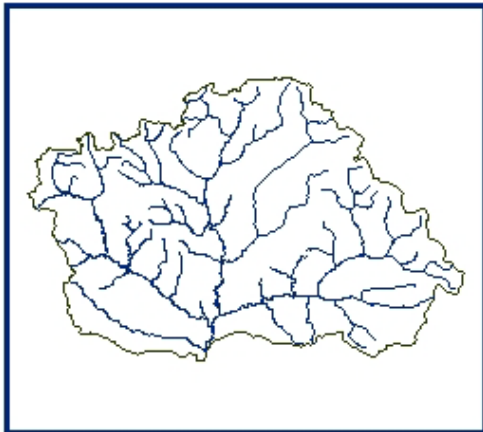
SNOW



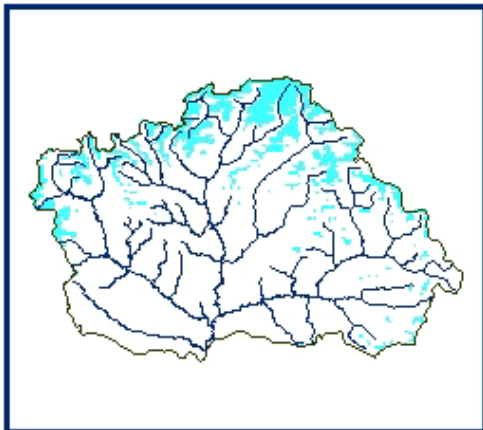
10 DAILY SNOW COVER MAP: DIBANG BASIN



DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE



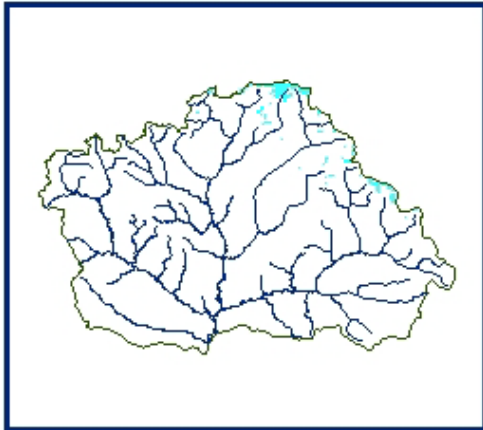
DATA USED
25 OCTOBER 2013



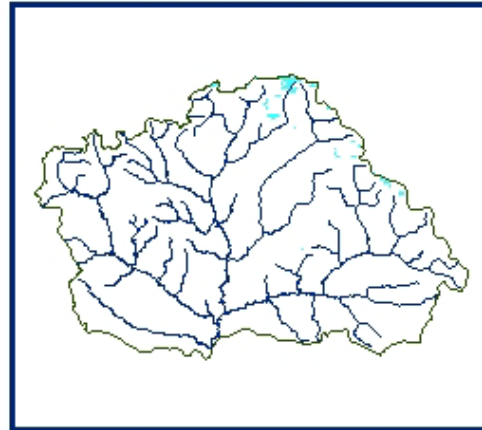
SNOW



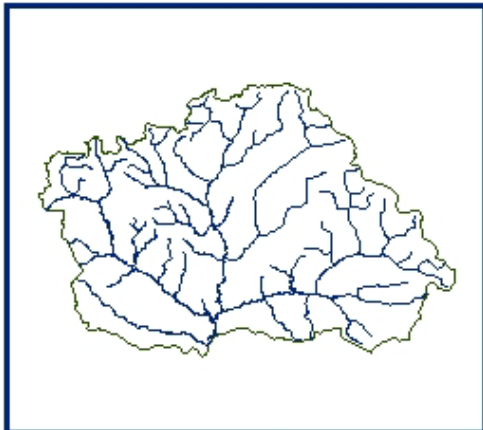
SNOW COVER MAP : DIBANG BASIN



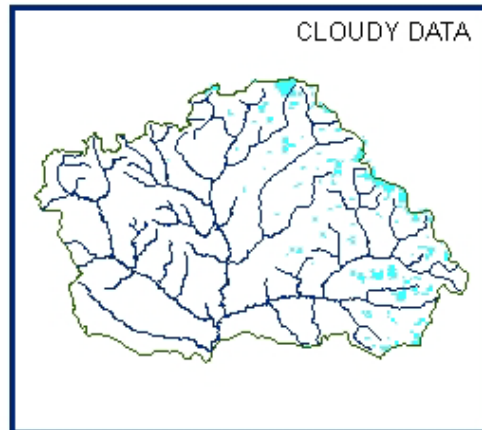
01 NOVEMBER 2012



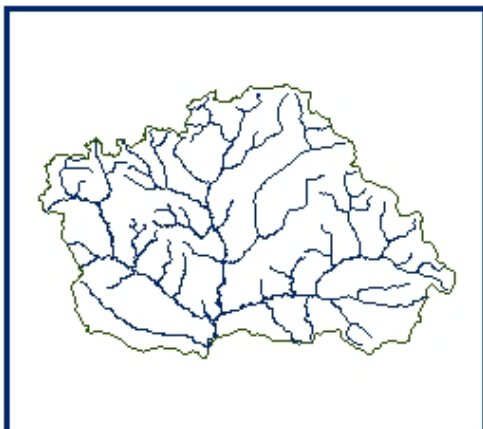
03 NOVEMBER 2012



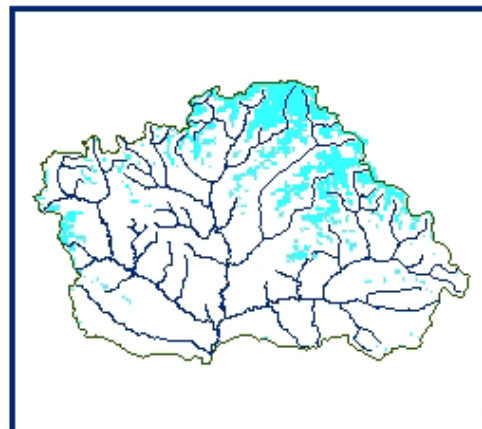
DATA NOT AVAILABLE



06 NOVEMBER 2012



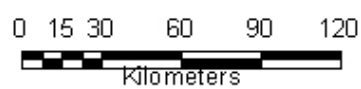
DATA NOT AVAILABLE



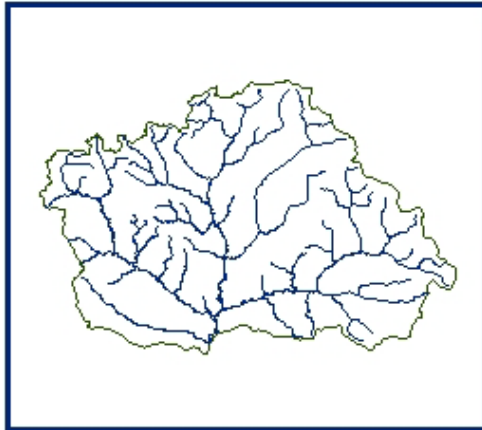
10 NOVEMBER 2012



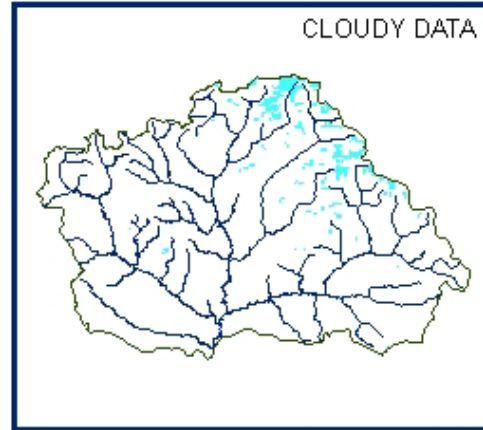
SNOW



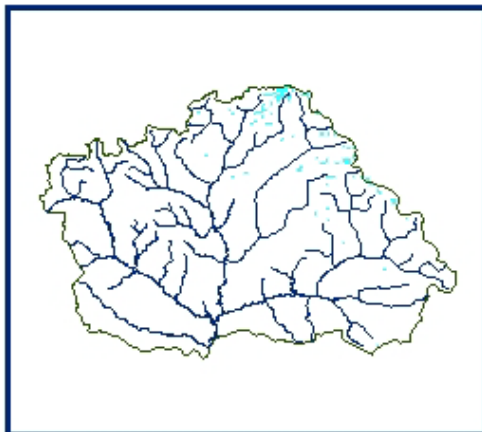
SNOW COVER MAP : DIBANG BASIN



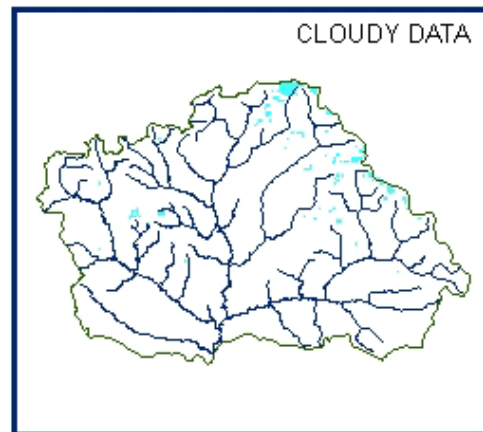
DATA NOT AVAILABLE



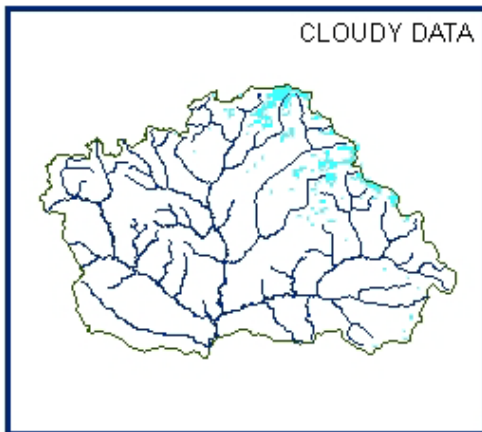
15 NOVEMBER 2012



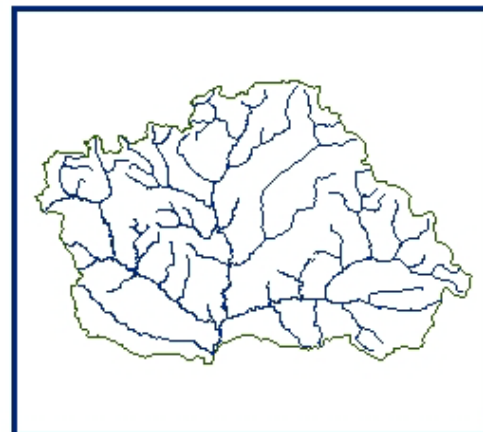
18 NOVEMBER 2012



20 NOVEMBER 2012



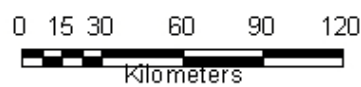
23 NOVEMBER 2012



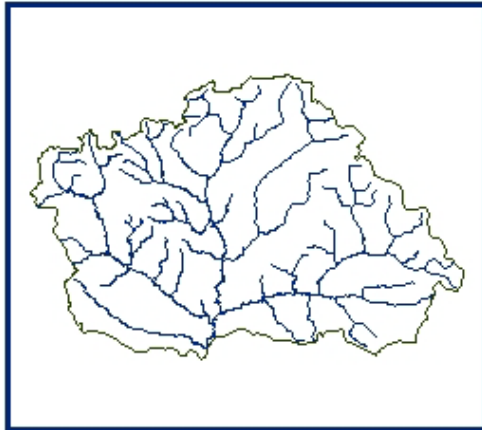
DATA NOT AVAILABLE



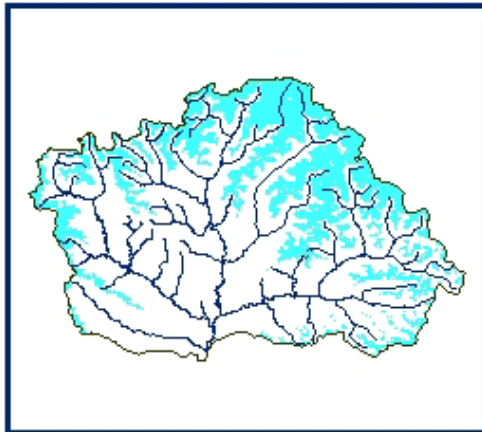
SNOW



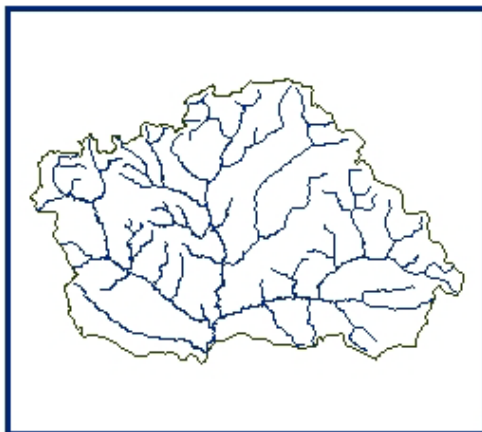
10 DAILY SNOW COVER MAP: DIBANG BASIN



DATA USED
DATA NOT AVAILABLE



DATA USED
05 NOVEMBER 2012



DATA USED
DATA NOT AVAILABLE



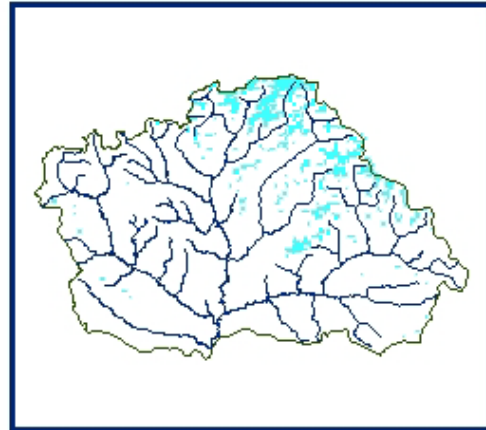
SNOW



SNOW COVER MAP : DIBANG BASIN



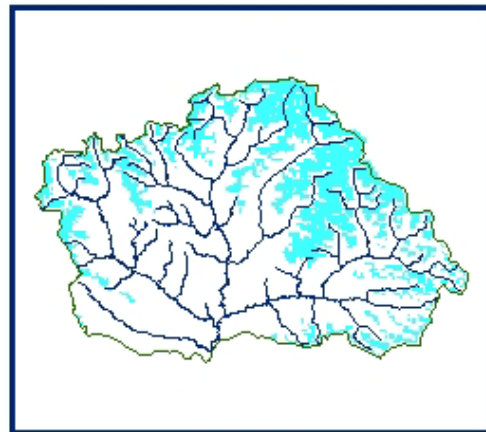
02 DECEMBER 2012



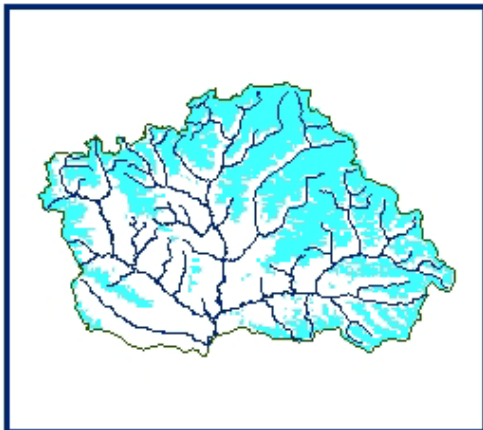
04 DECEMBER 2012



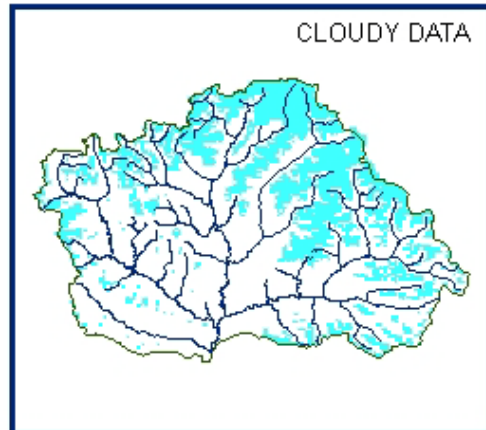
16 DECEMBER 2012



17 DECEMBER 2012



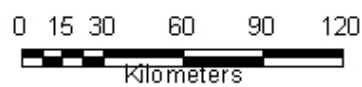
24 DECEMBER 2012



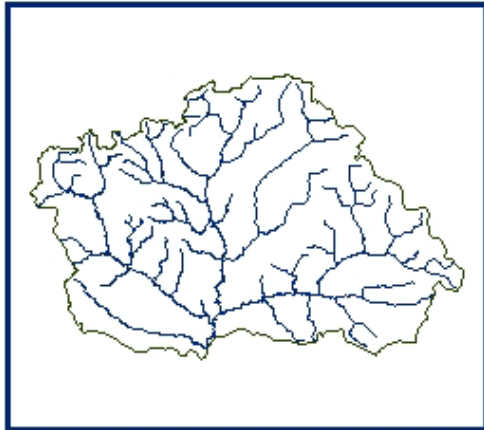
26 DECEMBER 2012



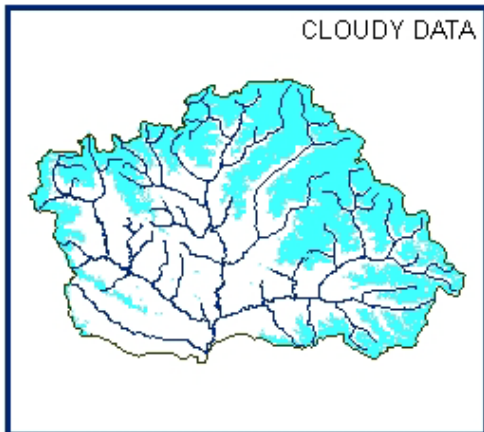
SNOW



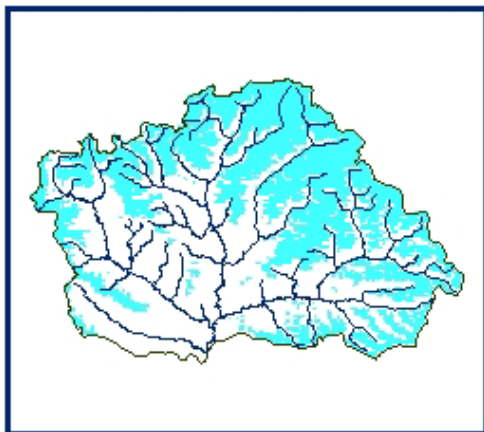
10 DAILY SNOW COVER MAP: DIBANG BASIN



DATA USED
DATA NOT AVAILABLE



DATA USED
15 DECEMBER 2012



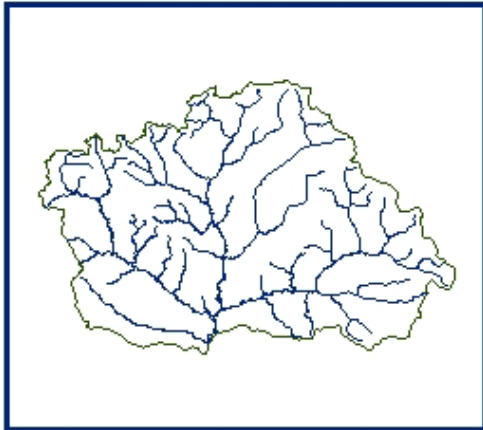
DATA USED
25 DECEMBER 2012



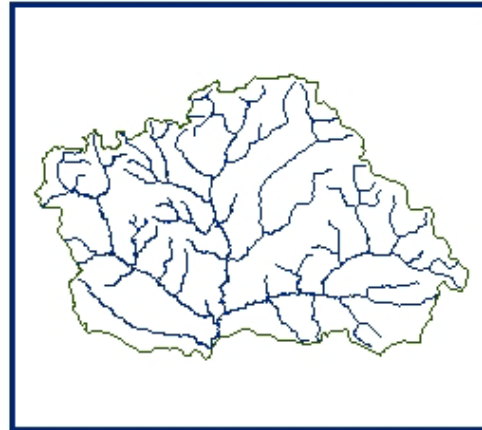
SNOW



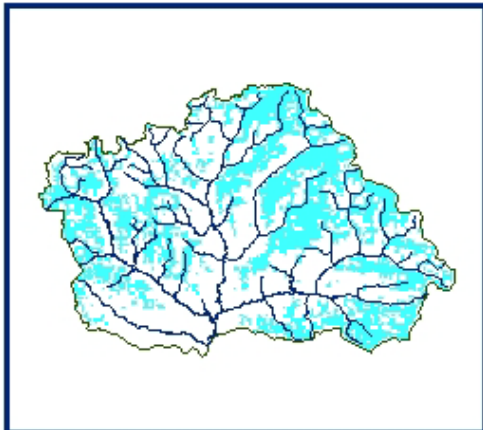
SNOW COVER MAP : DIBANG BASIN



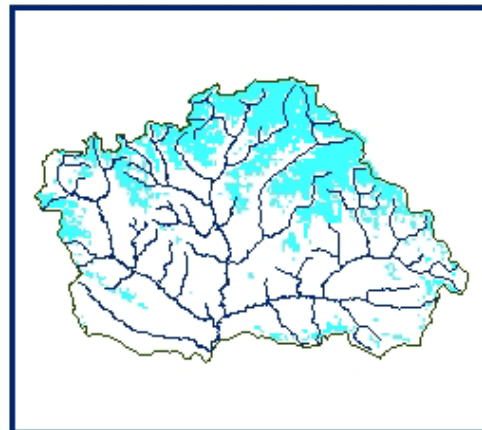
DATA NOT AVAILABLE



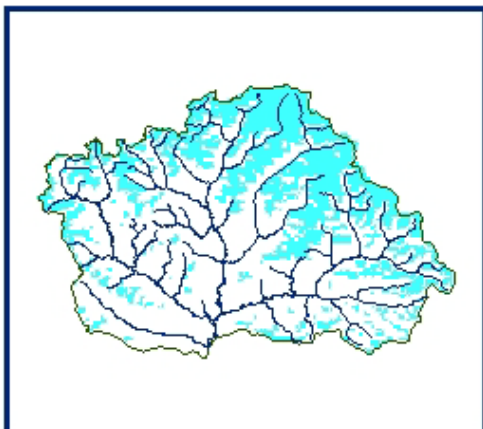
DATA NOT AVAILABLE



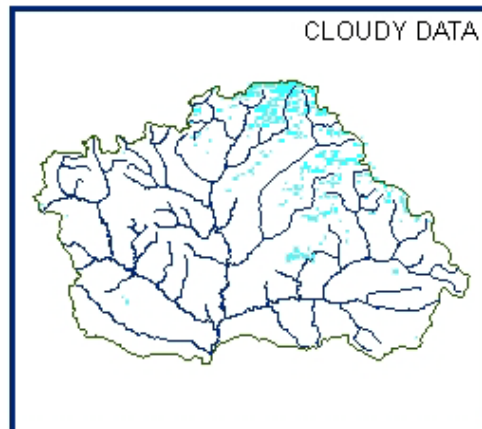
09 JANUARY 2013



10 JANUARY 2013



14 JANUARY 2013



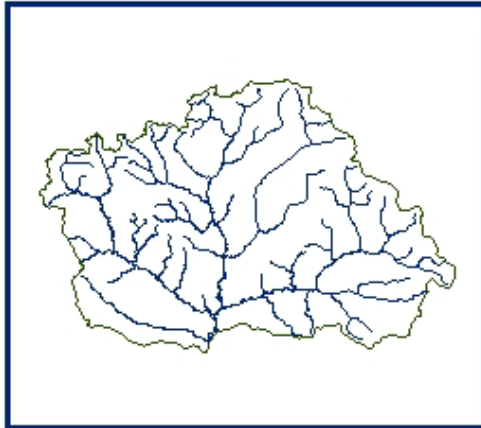
17 JANUARY 2013



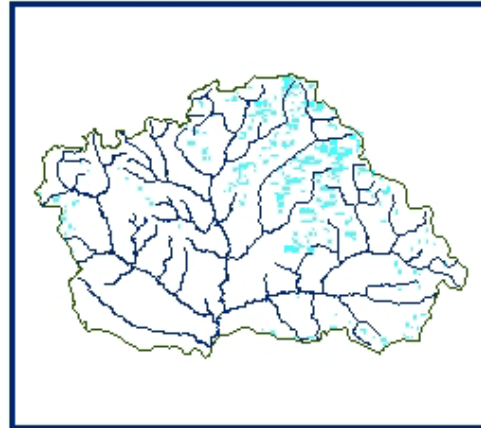
SNOW



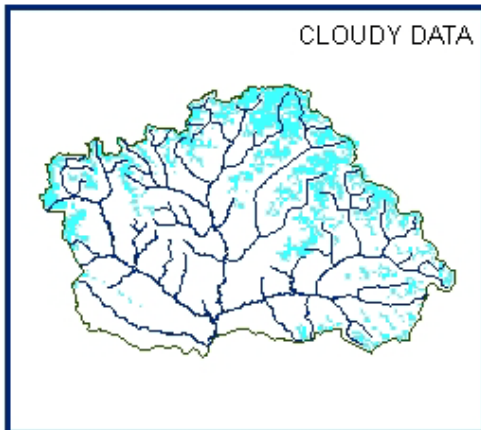
SNOW COVER MAP : DIBANG BASIN



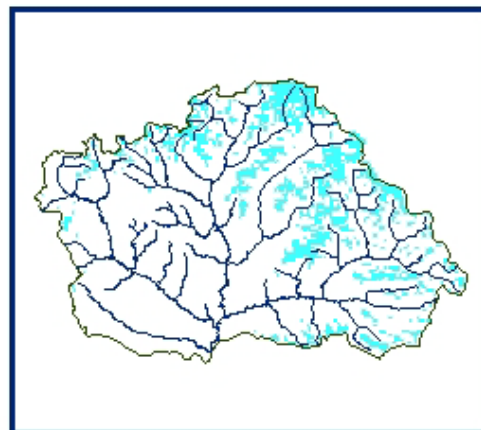
DATA NOT AVAILABLE



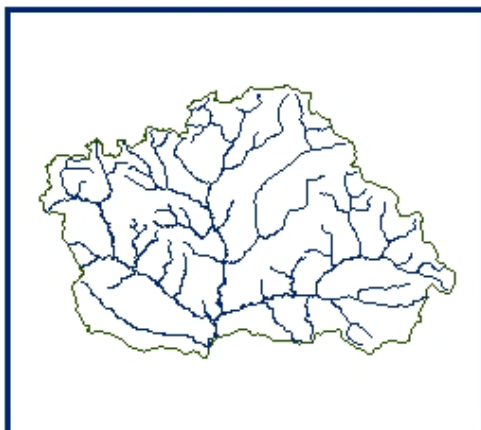
19 JANUARY 2013



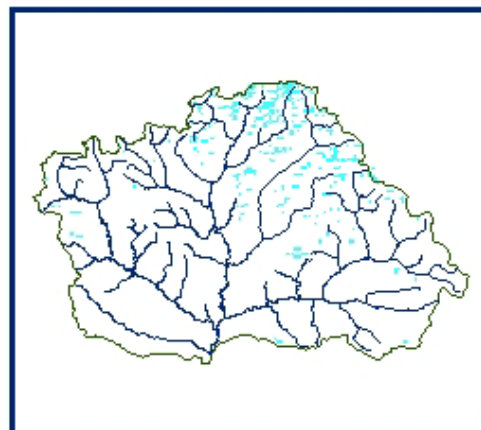
22 JANUARY 2013



24 JANUARY 2013



DATA NOT AVAILABLE



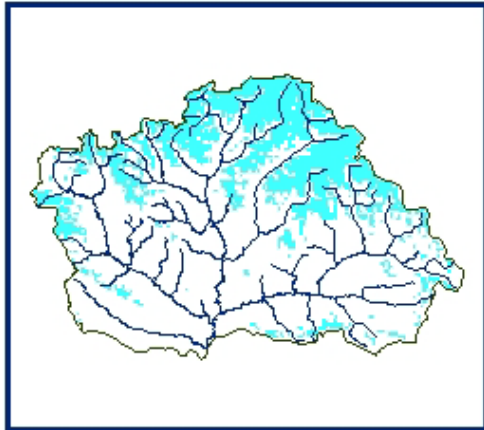
31 JANUARY 2013



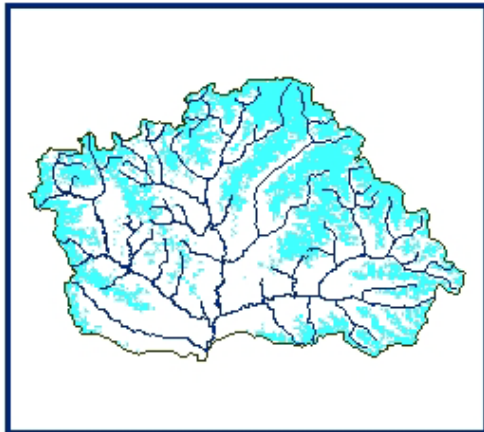
SNOW



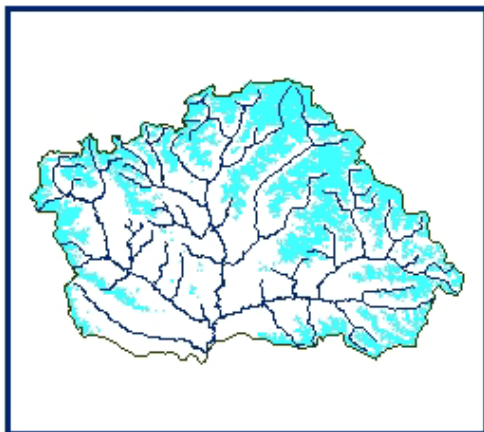
10 DAILY SNOW COVER MAP: DIBANG BASIN



DATA USED
05 JANUARY 2013



DATA USED
15 JANUARY 2013



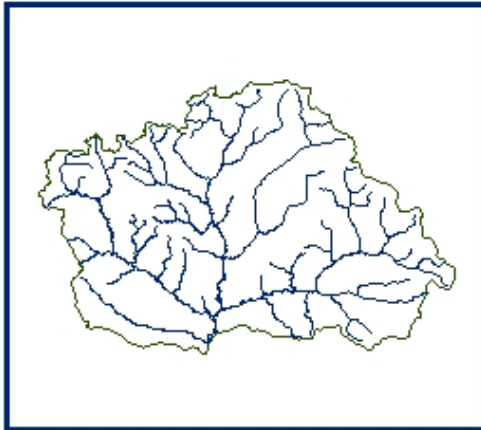
DATA USED
25 JANUARY 2013



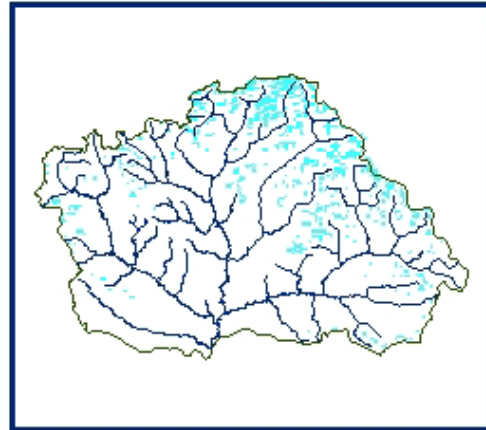
SNOW



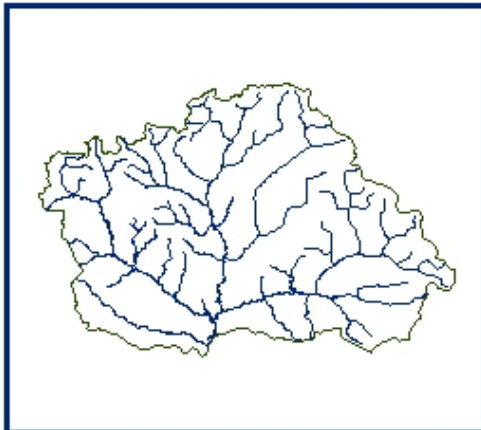
SNOW COVER MAP : DIBANG BASIN



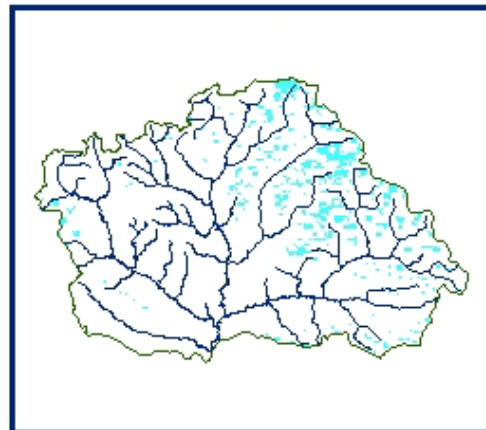
DATA NOT AVAILABLE



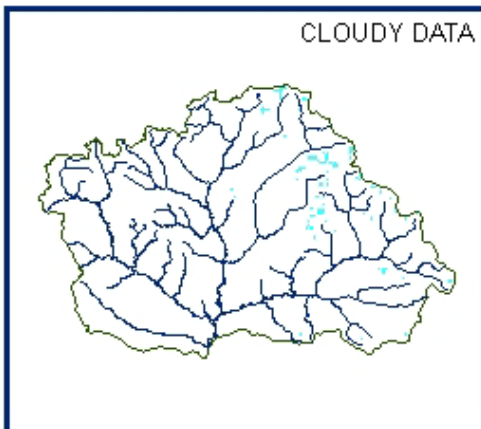
05 FEBRUARY 2013



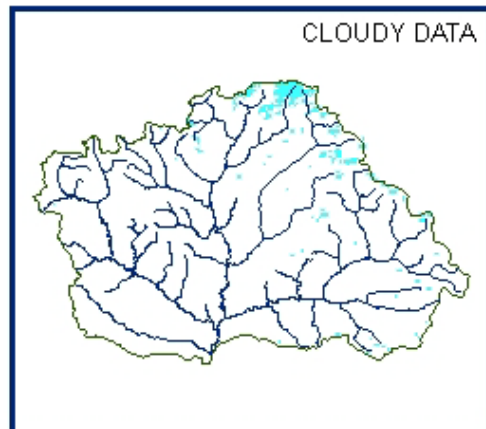
DATA NOT AVAILABLE



07 FEBRUARY 2013



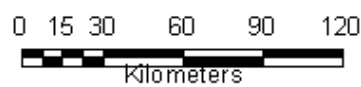
09 FEBRUARY 2013



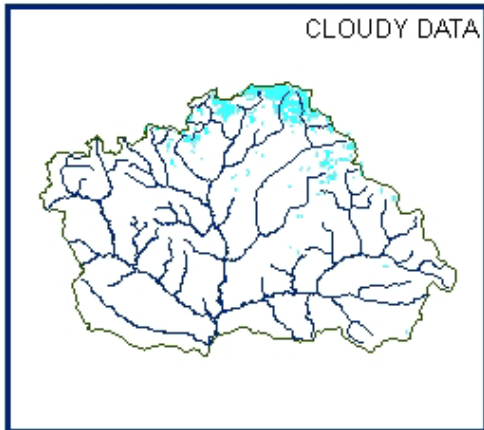
12 FEBRUARY 2013



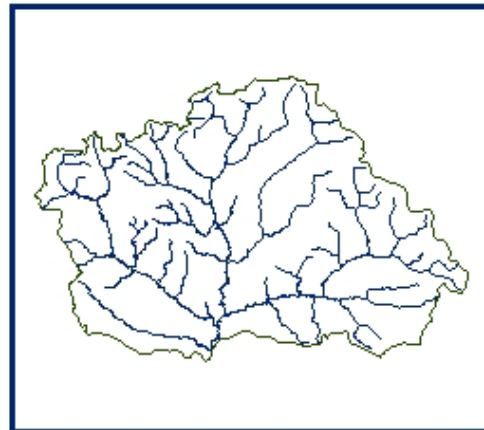
SNOW



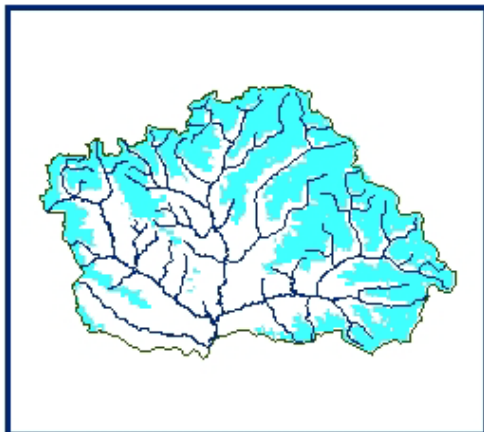
SNOW COVER MAP : DIBANG BASIN



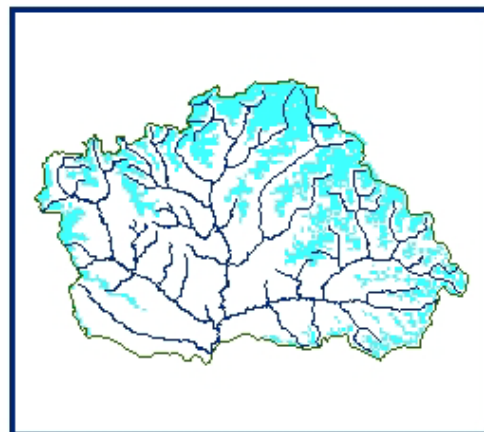
15 FEBRUARY 2013



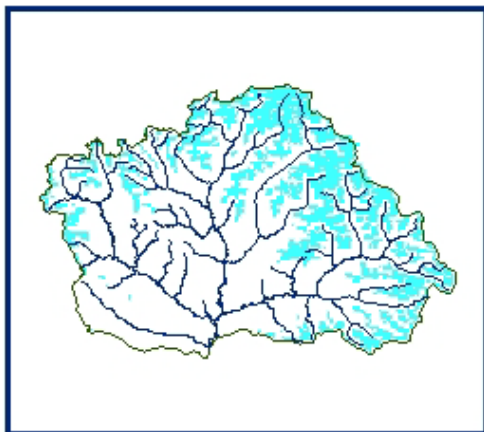
DATA NOT AVAILABLE



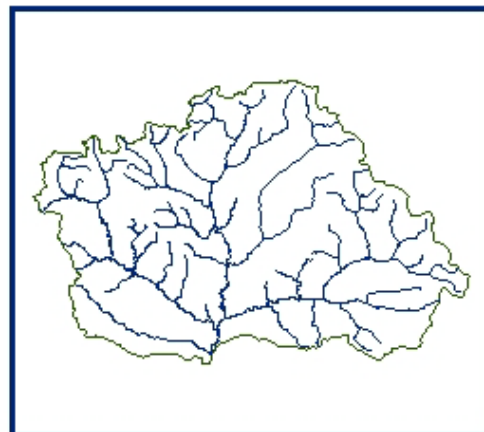
22 FEBRUARY 2013



24 FEBRUARY 2013



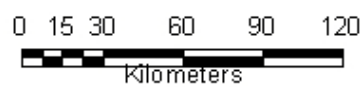
27 FEBRUARY 2013



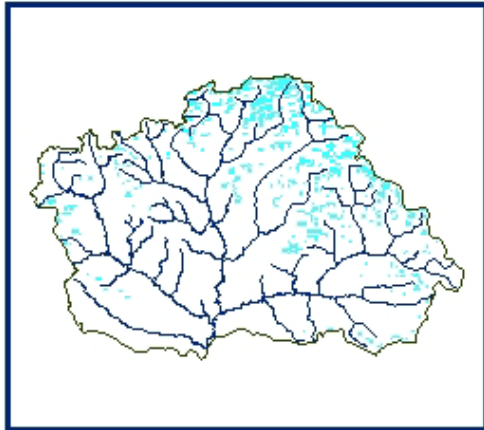
DATA NOT AVAILABLE



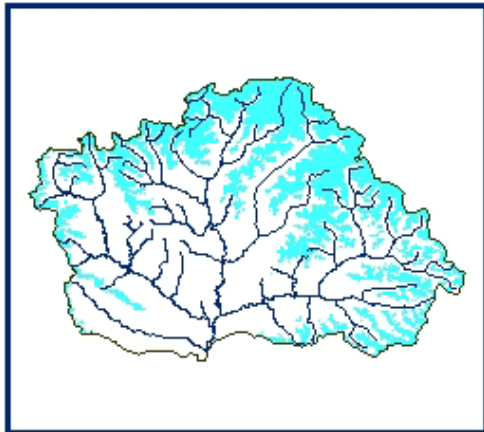
SNOW



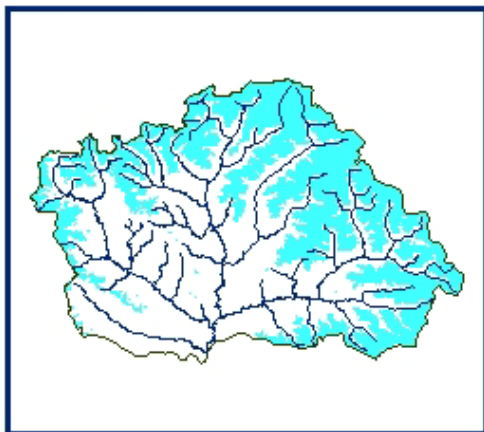
10 DAILY SNOW COVER MAP: DIBANG BASIN



DATA USED
05 FEBRUARY 2013



DATA USED
15 FEBRUARY 2013



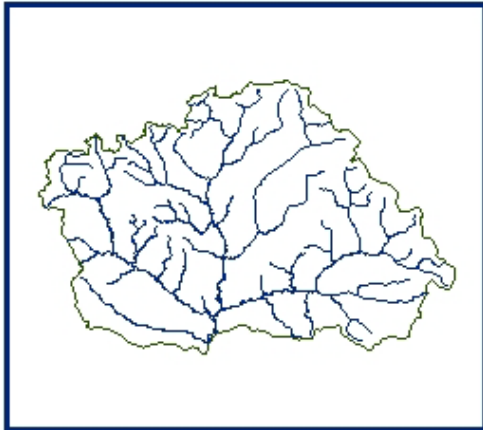
DATA USED
25 FEBRUARY 2013



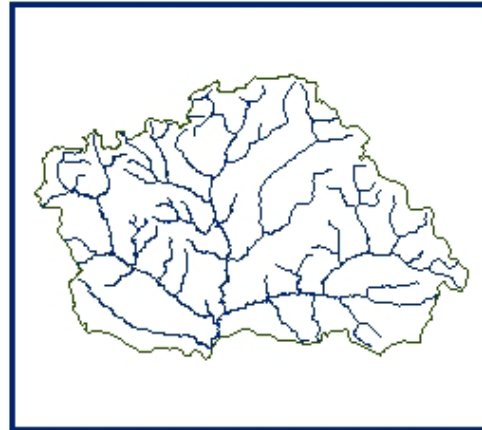
SNOW



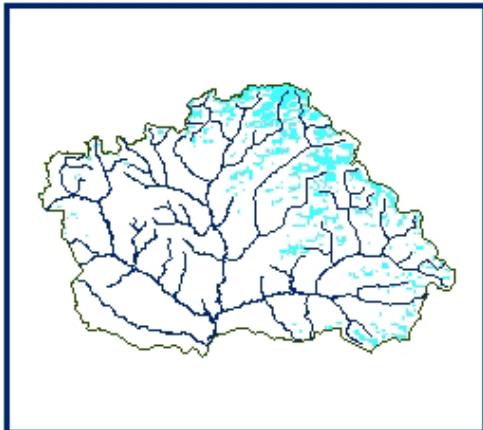
SNOW COVER MAP : DIBANG BASIN



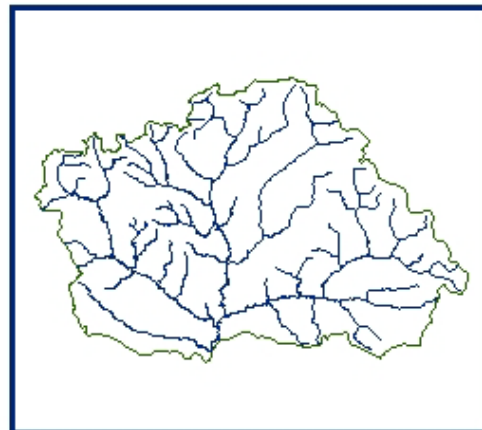
DATA NOT AVAILABLE



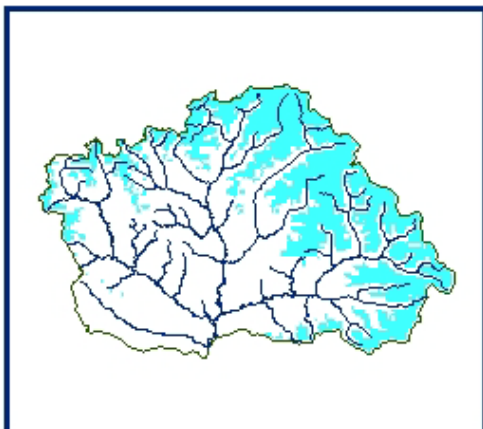
DATA NOT AVAILABLE



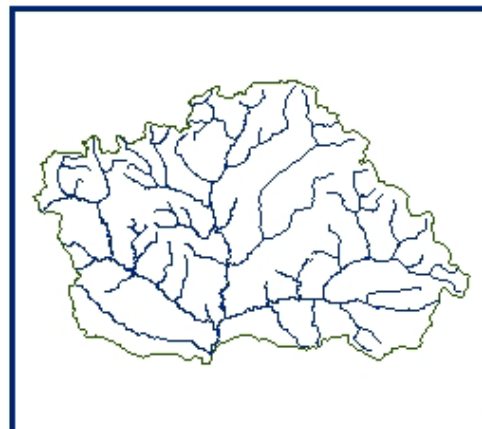
13 MARCH 2013



DATA NOT AVAILABLE



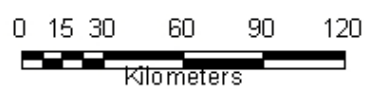
20 MARCH 2013



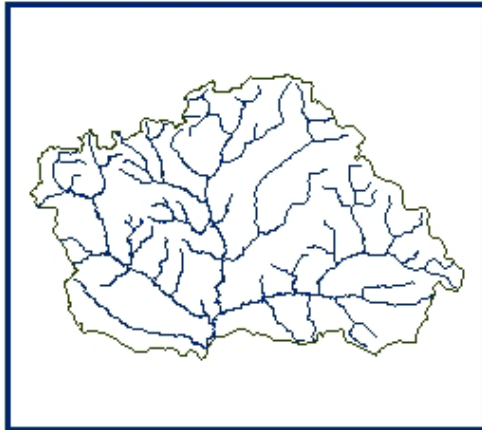
DATA NOT AVAILABLE



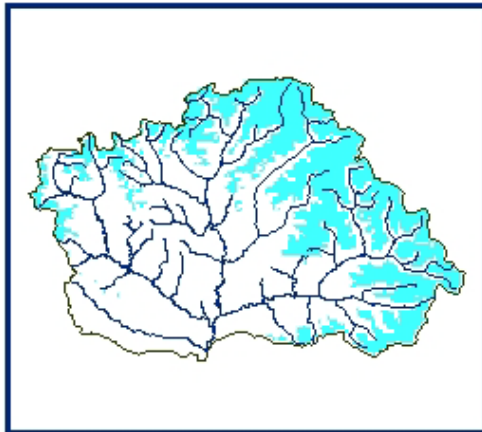
SNOW



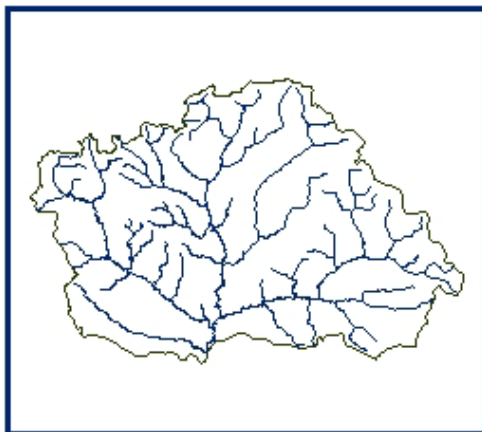
10 DAILY SNOW COVER MAP: DIBANG BASIN



DATA USED
DATA NOT AVAILABLE



DATA USED
15 MARCH 2013



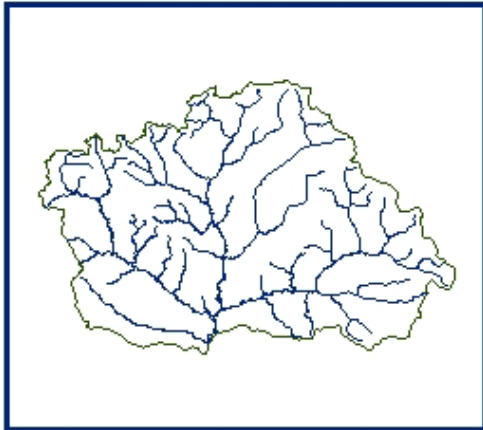
DATA USED
DATA NOT AVAILABLE



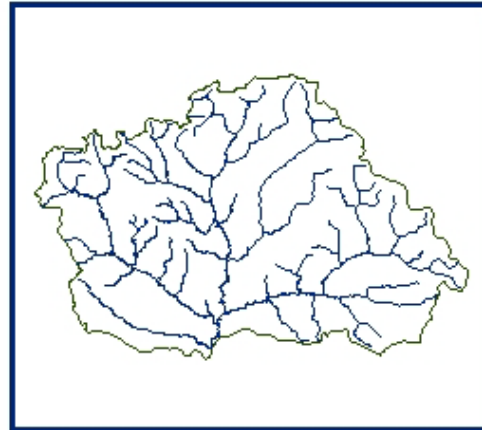
SNOW



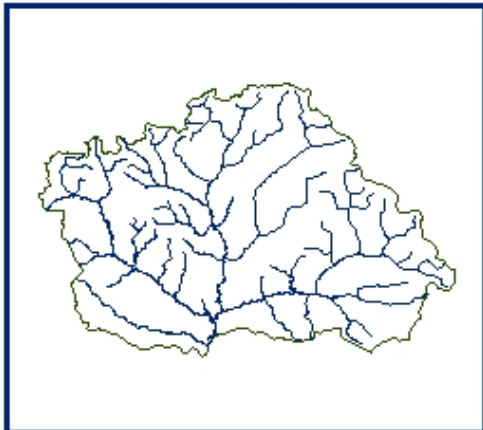
SNOW COVER MAP : DIBANG BASIN



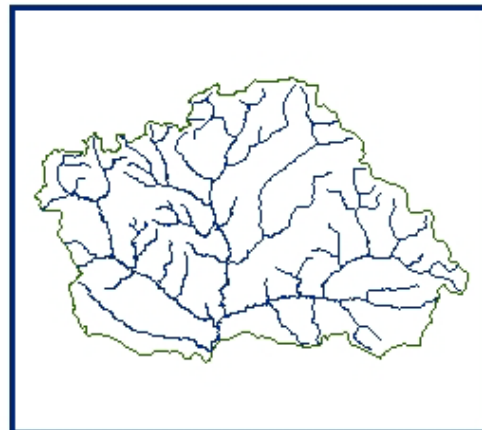
DATA NOT AVAILABLE



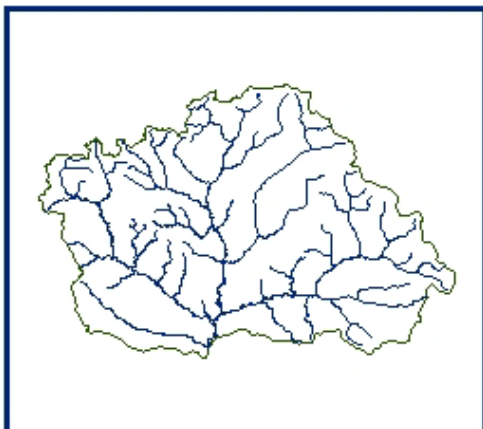
DATA NOT AVAILABLE



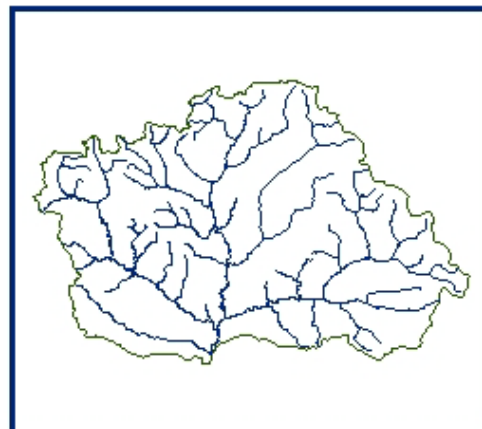
DATA NOT AVAILABLE



DATA NOT AVAILABLE



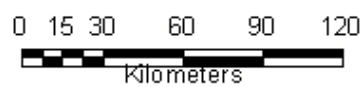
DATA NOT AVAILABLE



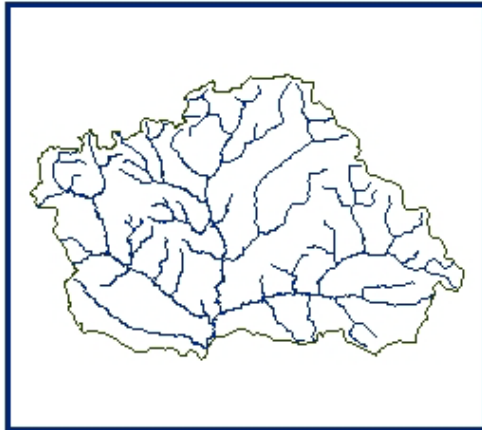
DATA NOT AVAILABLE



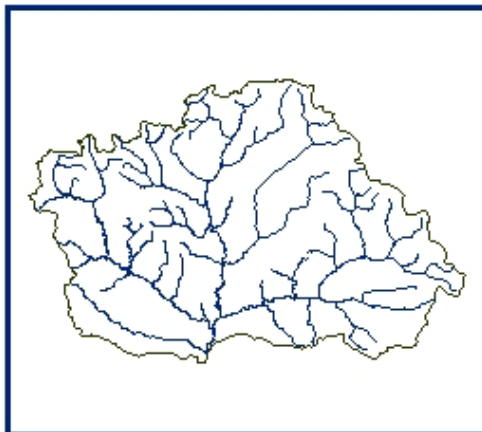
SNOW



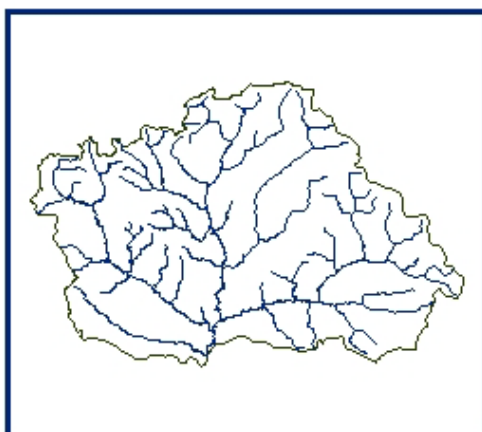
10 DAILY SNOW COVER MAP: DIBANG BASIN



DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE



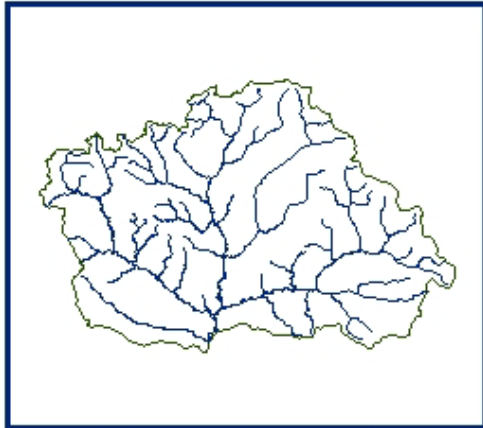
DATA USED
DATA NOT AVAILABLE



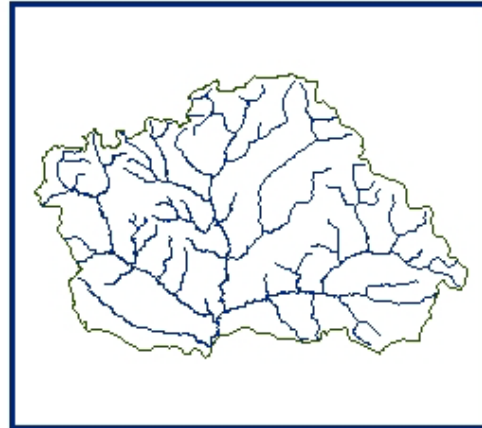
SNOW



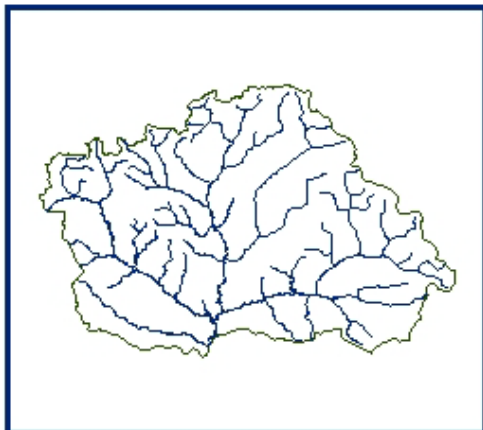
SNOW COVER MAP : DIBANG BASIN



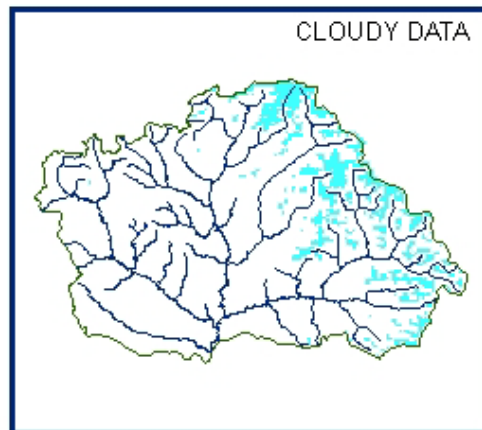
DATA NOT AVAILABLE



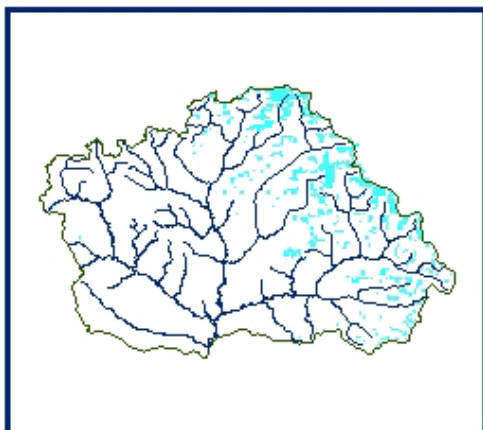
DATA NOT AVAILABLE



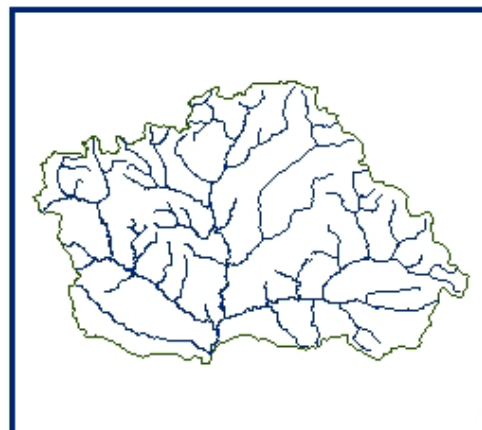
DATA NOT AVAILABLE



21 MAY 2013



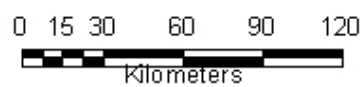
26 MAY 2013



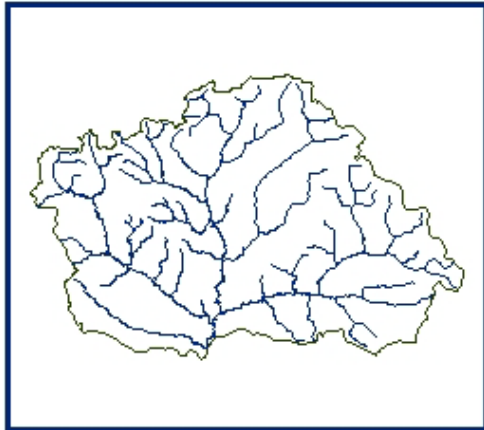
DATA NOT AVAILABLE



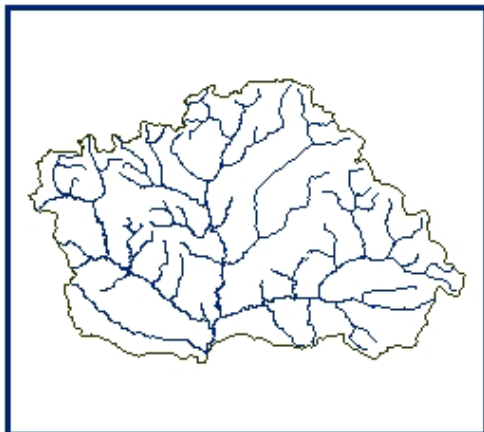
SNOW



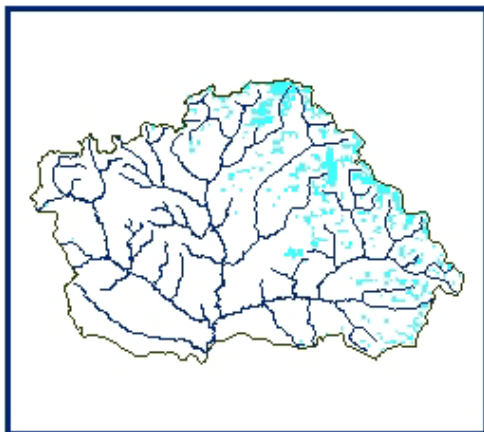
10 DAILY SNOW COVER MAP: DIBANG BASIN



DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE



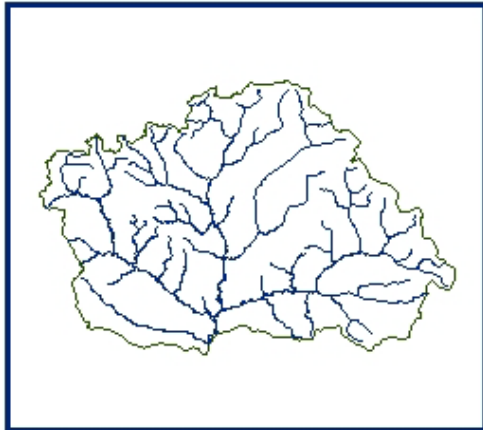
DATA USED
25 MAY 2013



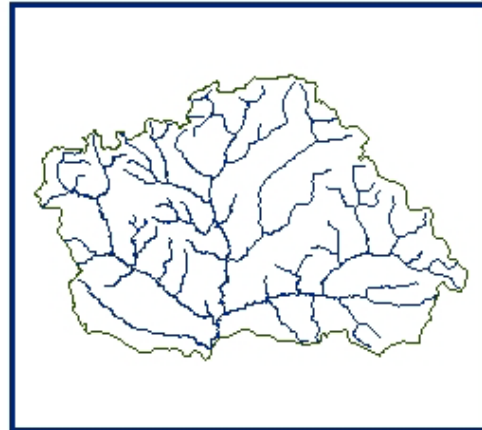
SNOW



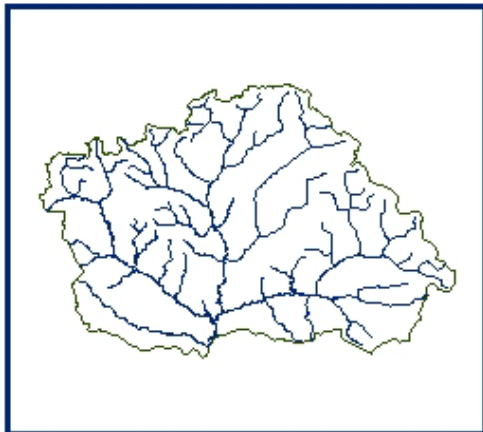
SNOW COVER MAP : DIBANG BASIN



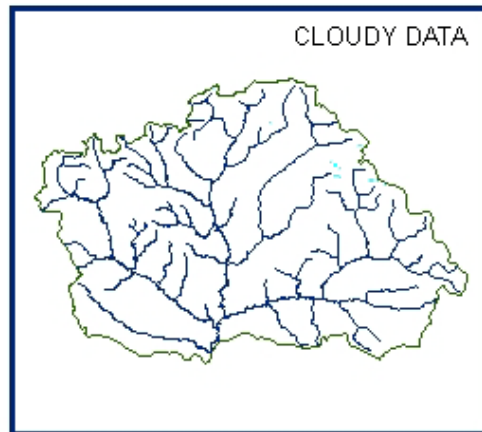
DATA NOT AVAILABLE



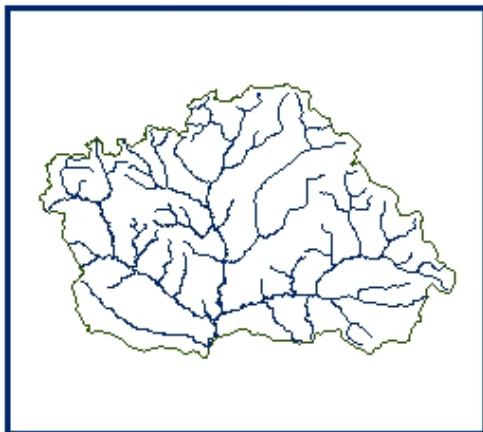
DATA NOT AVAILABLE



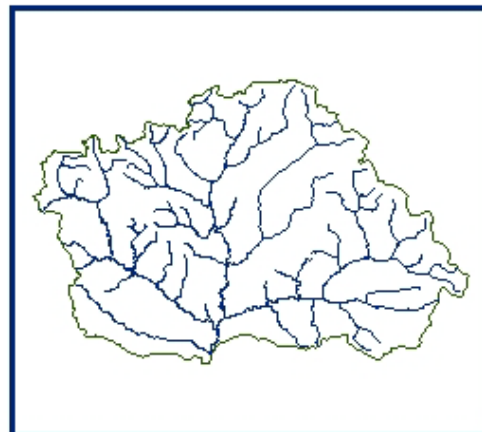
DATA NOT AVAILABLE



12 JUNE 2013



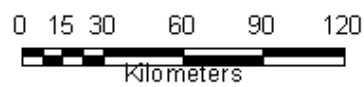
DATA NOT AVAILABLE



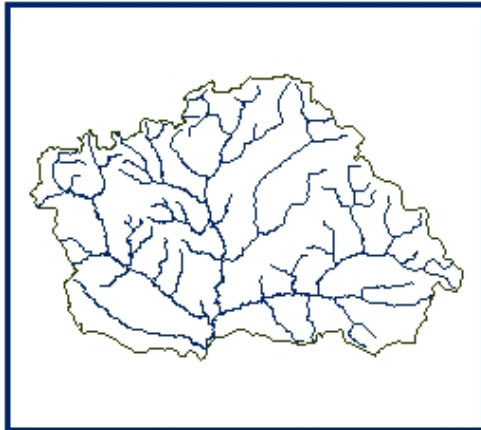
DATA NOT AVAILABLE



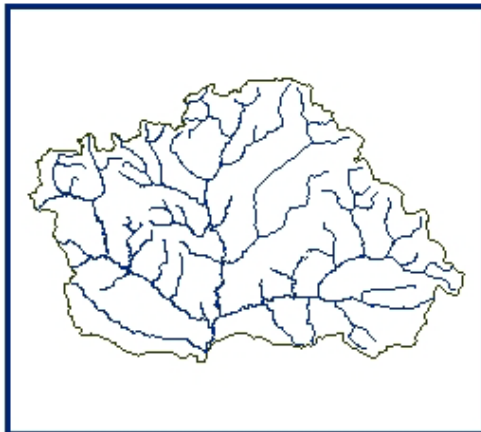
SNOW



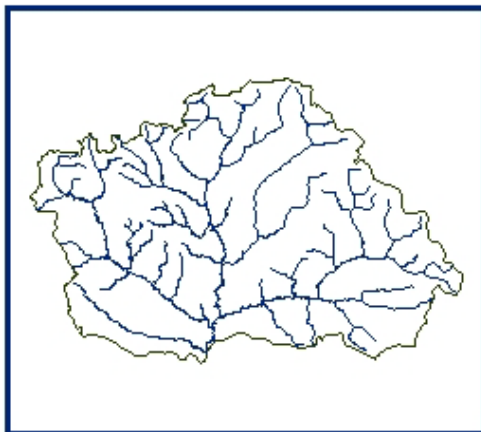
10 DAILY SNOW COVER MAP: DIBANG BASIN



DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE



SNOW



AREAL EXTENT OF SNOW (5 DAILY)

BASIN NAME: SUBANSIRI

BASIN AREA: 25345 sq km

S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2012							
1	7-Oct-12	4823 (C)	19	3	27-Oct-12	2118 (C)	8
2	19-Oct-12	1239 (C)	5				
November 2012							
4	3-Nov-12	1240	5	8	15-Nov-12	1592 (C)	6
5	5-Nov-12	2428 (C)	10	9	17-Nov-12	1371	5
6	10-Nov-12	1813	7	10	20-Nov-12	1128	4
7	12-Nov-12	1281	5				
December 2012							
11	2-Dec-12	1873	7	15	18-Dec-12	2890	11
12	4-Dec-12	1529	6	16	23-Dec-12	2935	12
13	6-Dec-12	1701	7	17	26-Dec-12	2224	9
14	16-Dec-12	3345	13	18	30-Dec-12	716 (C)	3
January 2013							
19	9-Jan-13	4709	19	22	28-Jan-13	1815	7
20	14-Jan-13	2442	10	23	31-Jan-13	1437	6
21	16-Jan-13	942 (C)	4				
February 2013							
24	4-Feb-13	4929	19	27	14-Feb-13	680 (C)	3
25	7-Feb-13	1031 (C)	4	28	19-Feb-13	7488 (C)	30
26	12-Feb-13	977	4	29	24-Feb-13	4464	18
March 2013							
30	5-Mar-13	2778	11	32	20-Mar-13	2833	11
31	15-Mar-13	1451 (C)	6				
April 2013							
33	8-April-13	1541 (C)	6				
May 2013							
34	21-May-13	832 (C)	3	35	26-May-13	1292 (C)	5
June 2013							
36	12-June-13	333 (C)	1				

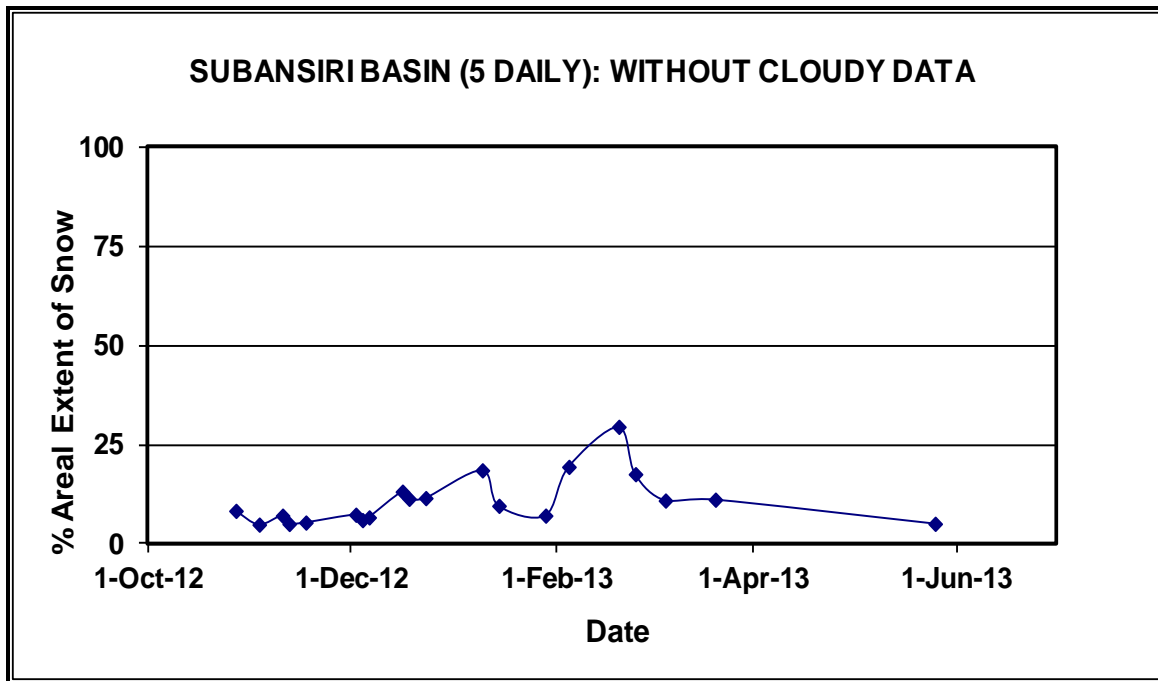
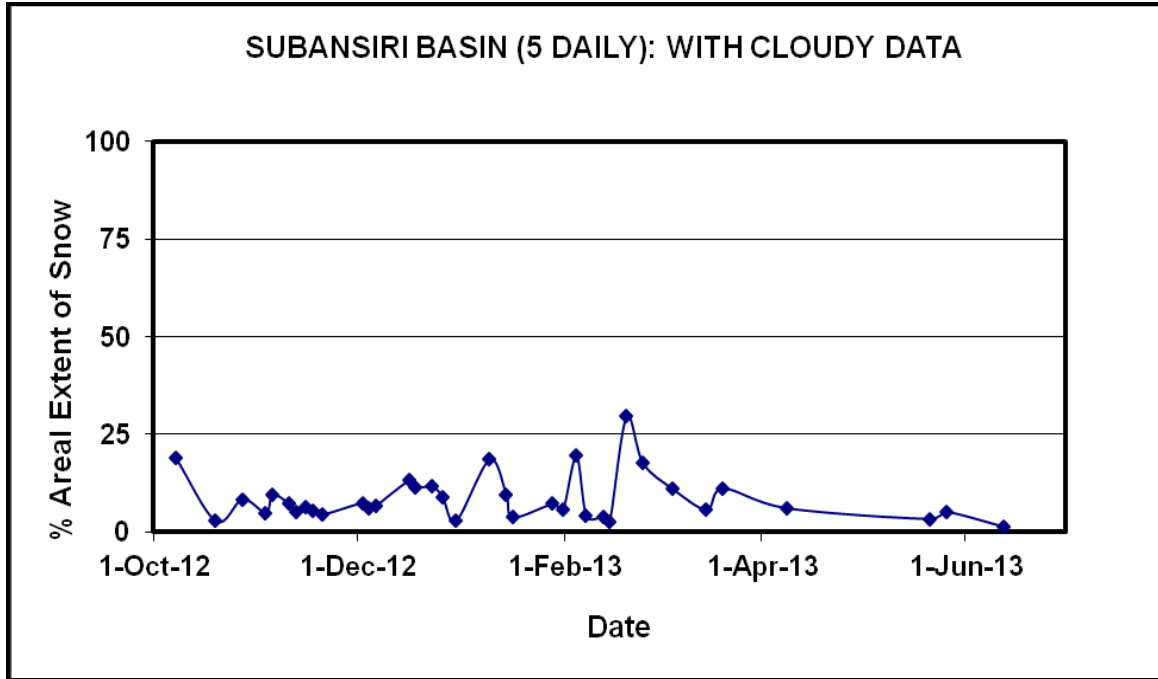
AREAL EXTENT OF SNOW (10 DAILY)

BASIN NAME: SUBANSIRI

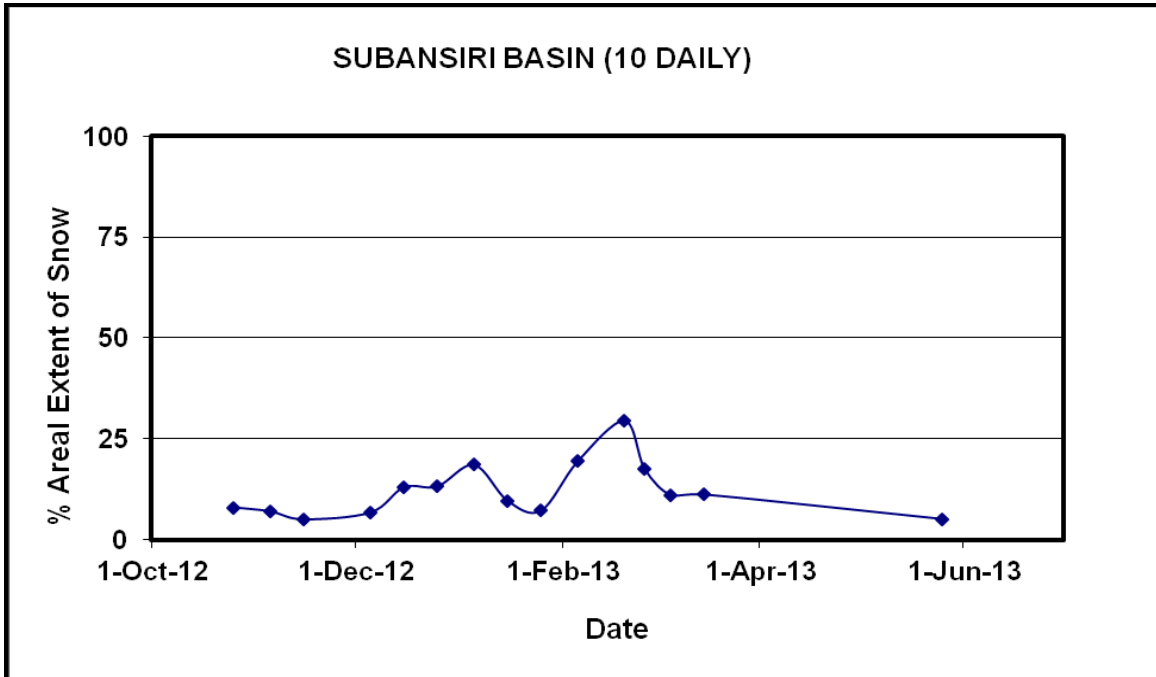
BASIN AREA: 25345 sq km

S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2012				November 2012			
1	25-Oct-12	1239	8	2	5-Nov-12	1774	7
				3	15-Nov-12	1281	5
December 2012				January 2013			
4	5-Dec-12	1701	7	7	5-Jan-13	4816	19
5	15-Dec-12	3295	13	8	15-Jan-13	2442	10
6	25-Dec-12	3295	13	9	25-Jan-13	1815	7
February 2013				March 2013			
10	5-Feb-13	4929	19	13	5-Mar-13	2778	11
11	15-Feb-13	7604	30	14	15-Mar-13	2788	11
12	25-Feb-13	4562	18				
April 2013				May 2013			
15	8-April-13	DNA		16	25-May-13	1292	5
June 2013							
17	12-June-13	DNA					

SNOW COVER DEPLETION CURVE

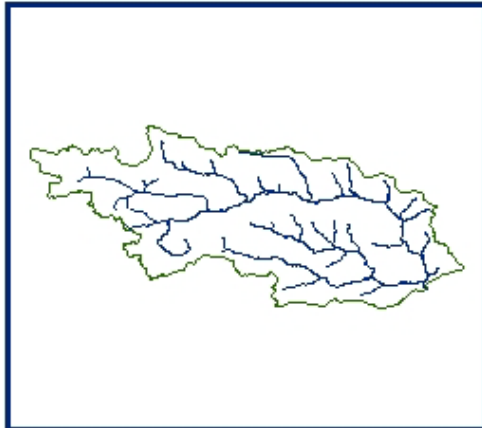


SNOW COVER DEPLETION CURVE

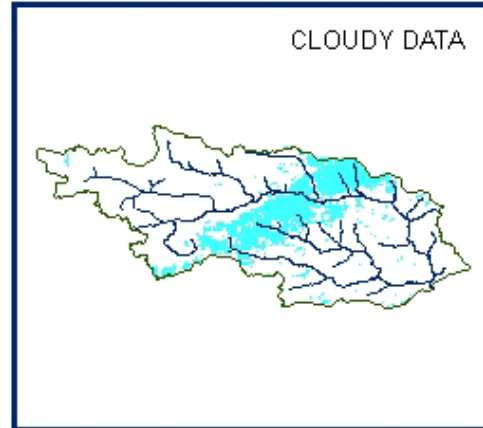


SNOW COVER MAP

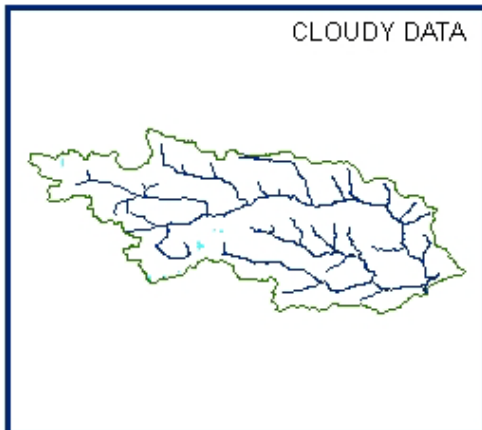
SNOW COVER MAP : SUBANSIRI BASIN



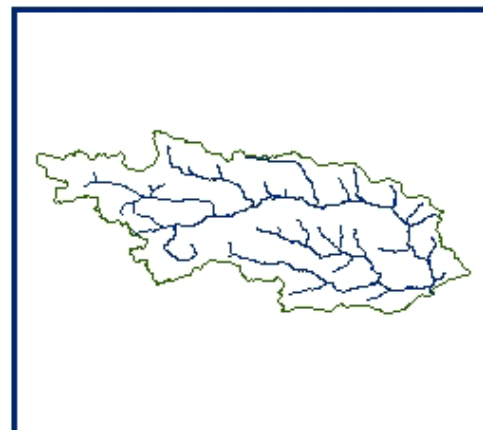
DATA NOT AVAILABLE



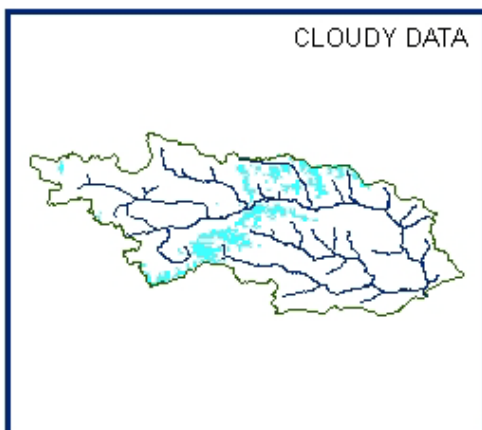
07 OCTOBER 2012



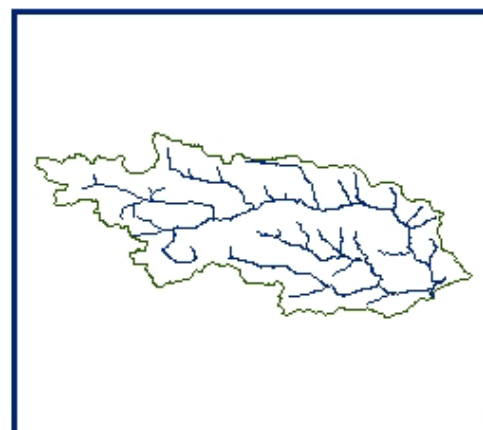
19 OCTOBER 2012



DATA NOT AVAILABLE



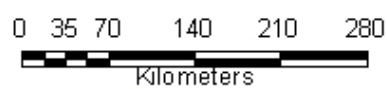
27 OCTOBER 2012



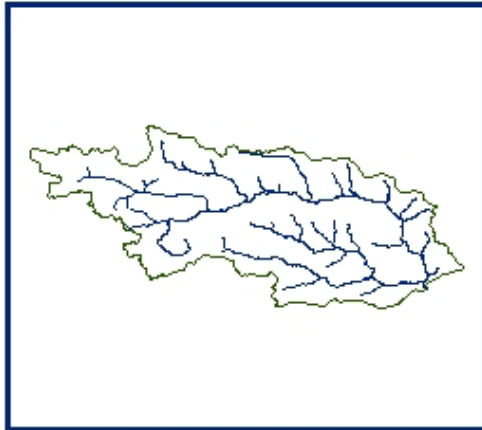
DATA NOT AVAILABLE



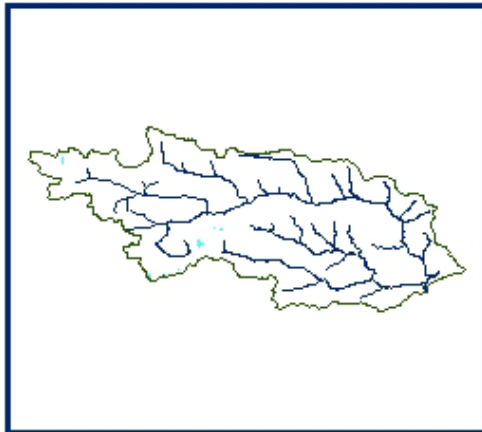
SNOW



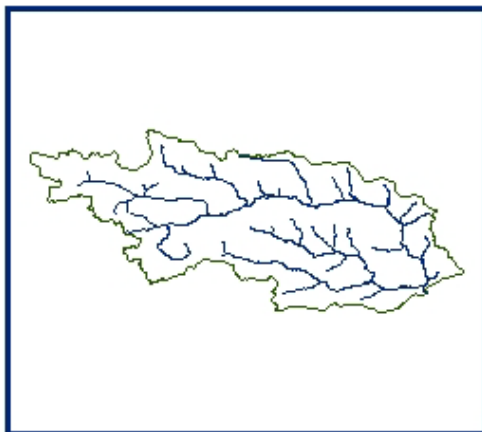
10 DAILY SNOW COVER MAP: SUBANSIRI BASIN



DATA USED
DATA NOT AVAILABLE



DATA USED
15 OCTOBER 2012



DATA USED
DATA NOT AVAILABLE



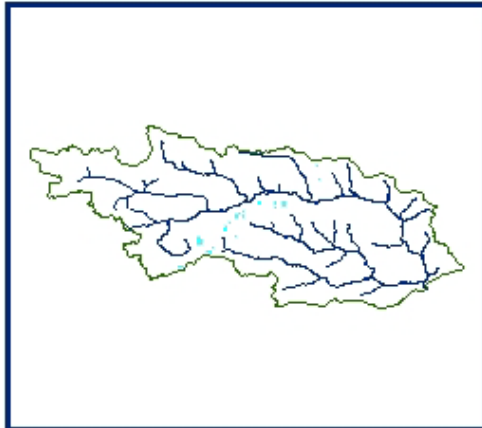
SNOW



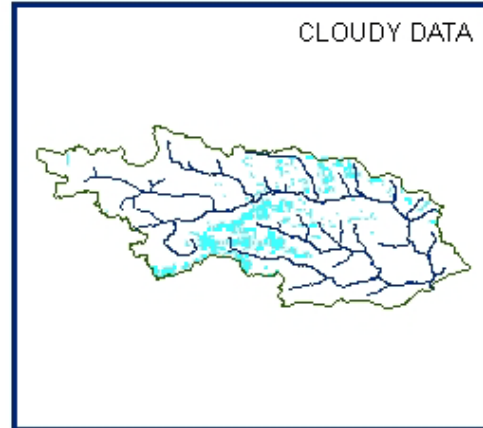
SNOW COVER MAP

:

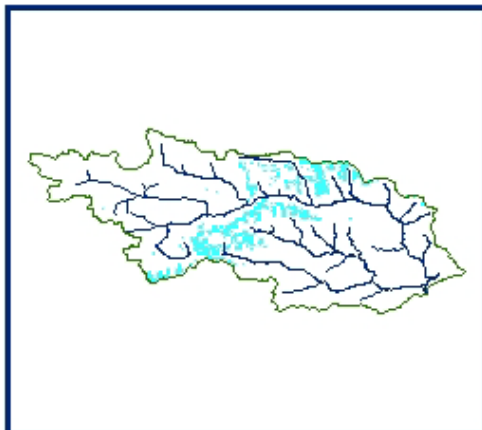
SUBANSIRI BASIN



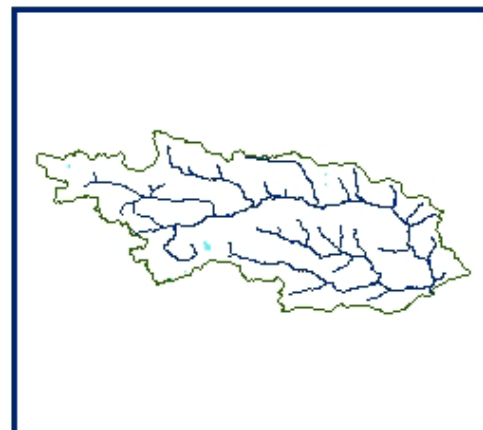
03 NOVEMBER 2012



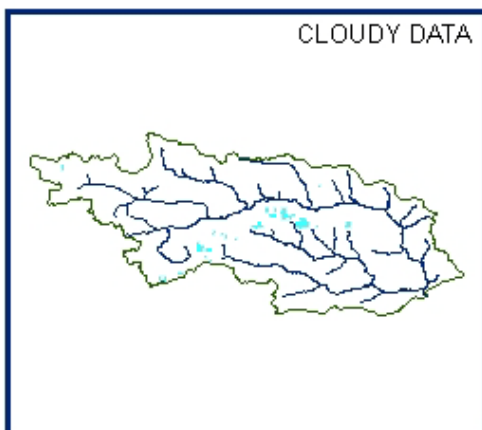
05 NOVEMBER 2012



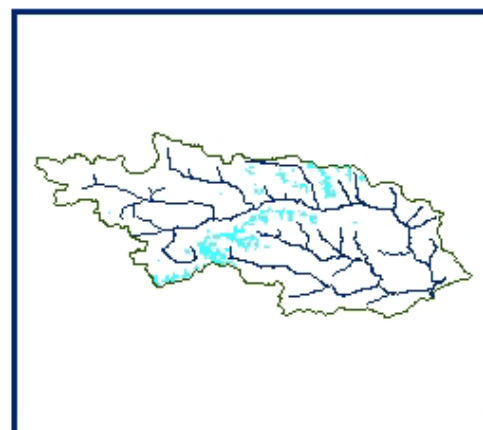
10 NOVEMBER 2012



12 NOVEMBER 2012



15 NOVEMBER 2012



17 NOVEMBER 2012



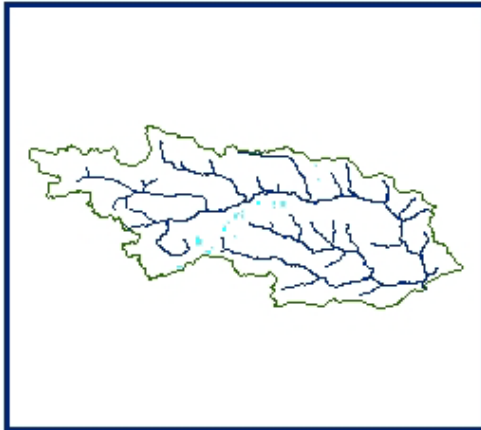
SNOW



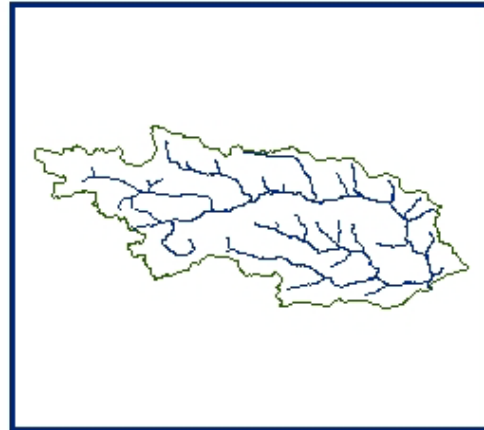
SNOW COVER MAP

:

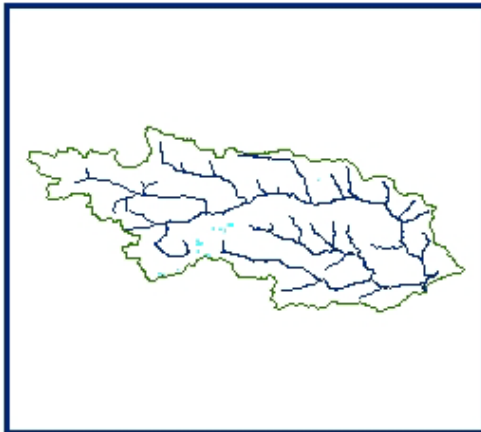
SUBANSIRI BASIN



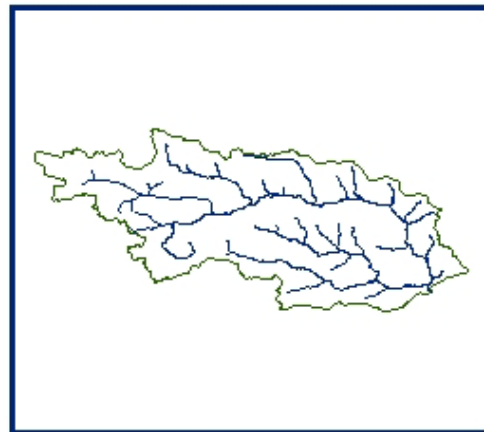
DATA NOT AVAILABLE



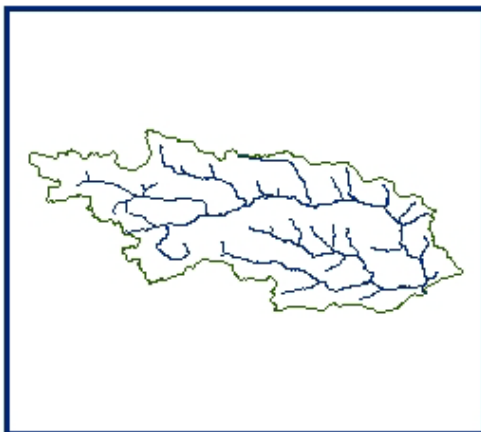
DATA NOT AVAILABLE



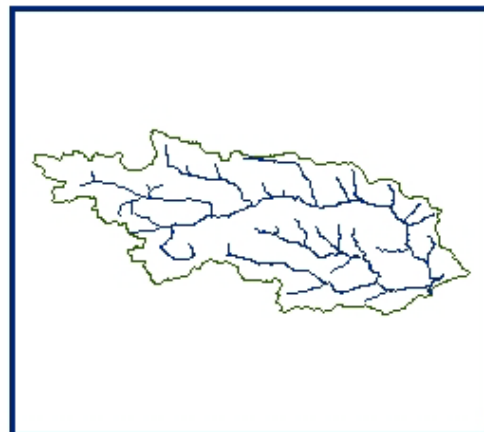
20 NOVEMBER 2012



DATA NOT AVAILABLE



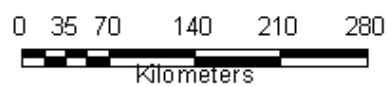
DATA NOT AVAILABLE



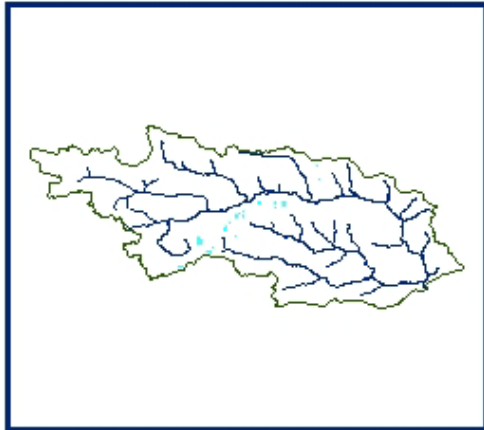
DATA NOT AVAILABLE



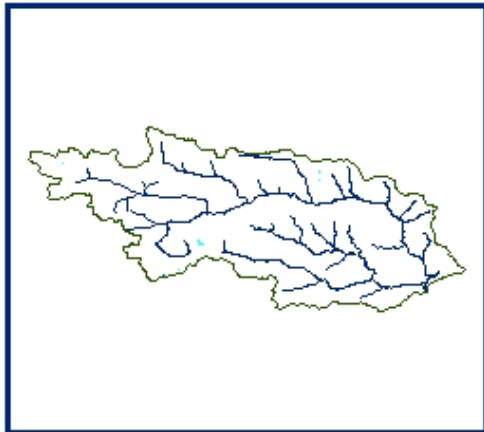
SNOW



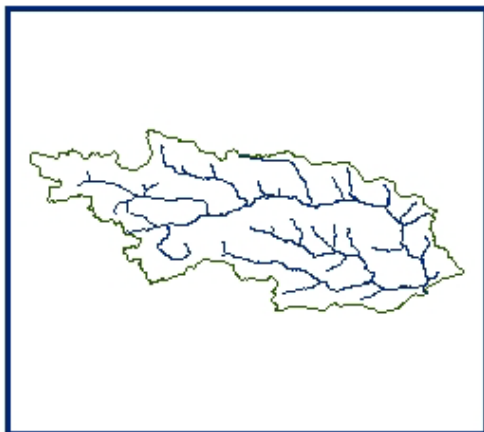
10 DAILY SNOW COVER MAP: SUBANSIRI BASIN



DATA USED
05 NOVEMBER 2012



DATA USED
15 NOVEMBER 2012



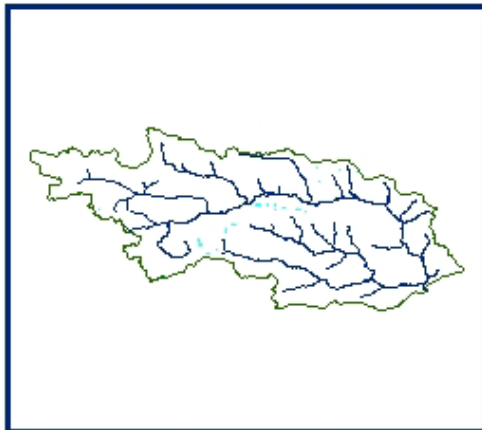
DATA USED
DATA NOT AVAILABLE



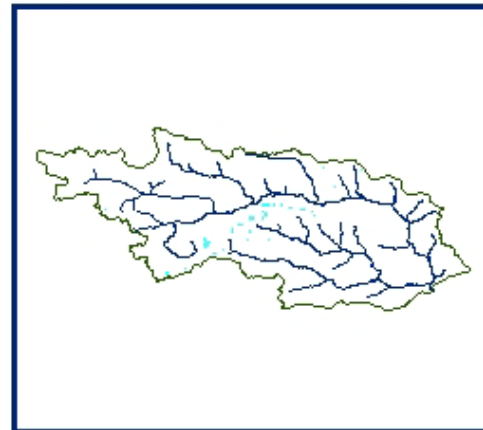
SNOW



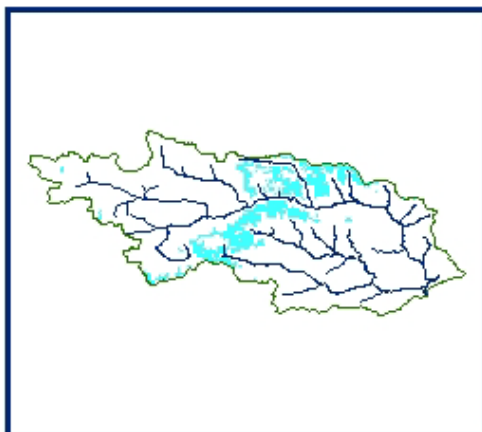
SNOW COVER MAP : SUBANSIRI BASIN



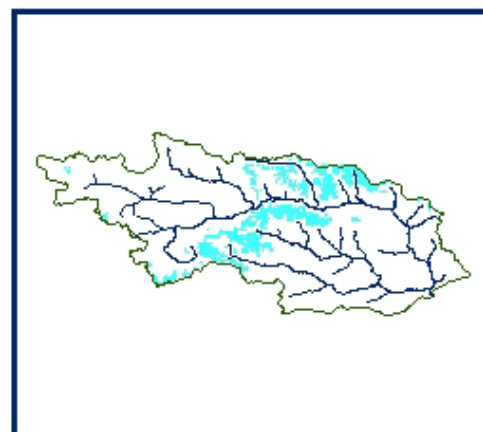
04 DECEMBER 2012



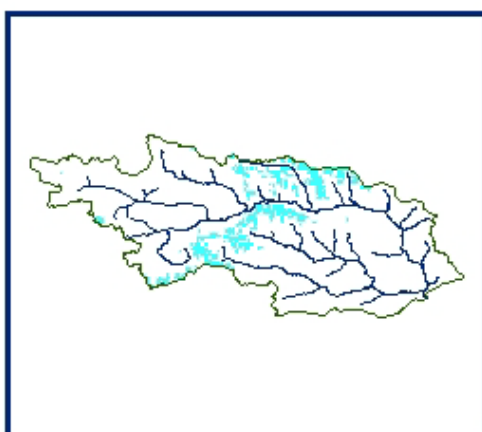
06 DECEMBER 2012



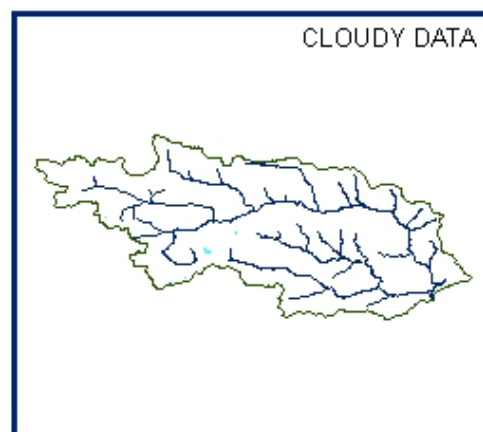
16 DECEMBER 2012



18 DECEMBER 2012



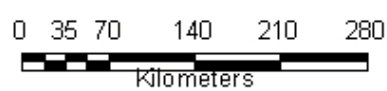
23 DECEMBER 2012



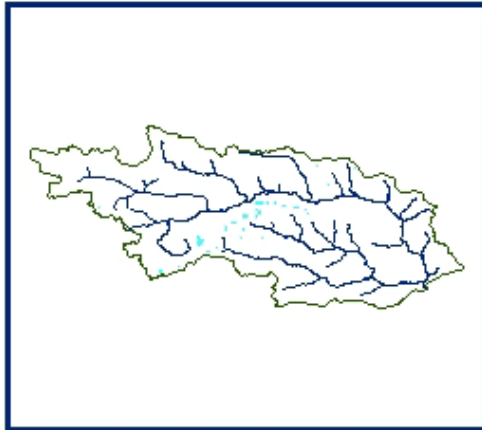
30 DECEMBER 2012



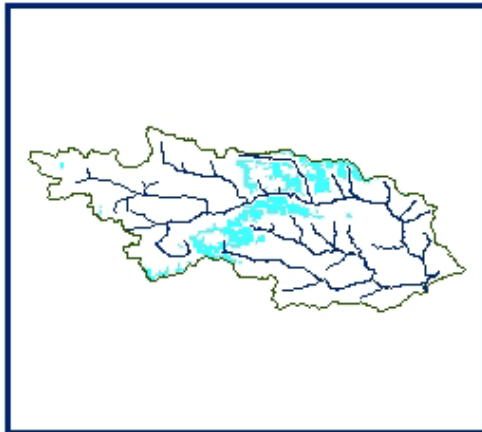
SNOW



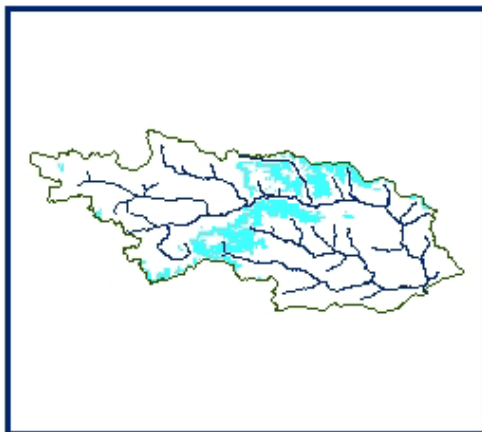
10 DAILY SNOW COVER MAP: SUBANSIRI BASIN



DATA USED
05 DECEMBER 2012



DATA USED
15 DECEMBER 2012



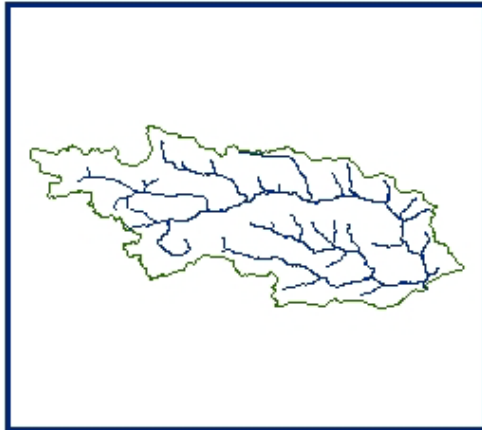
DATA USED
25 DECEMBER 2012



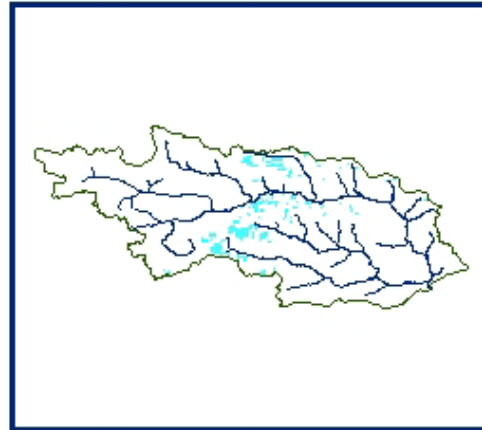
SNOW



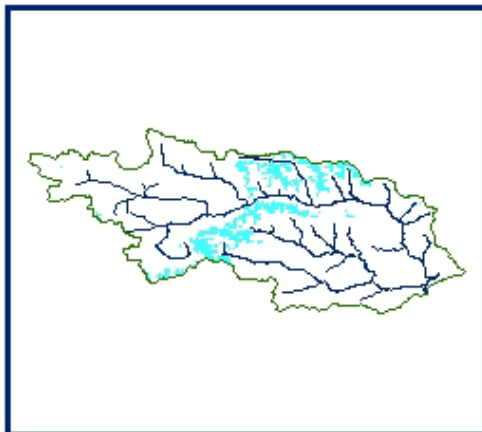
SNOW COVER MAP : SUBANSIRI BASIN



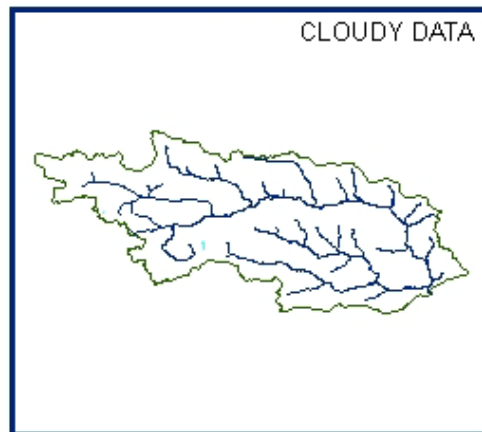
DATA NOT AVAILABLE



09 JANUARY 2013

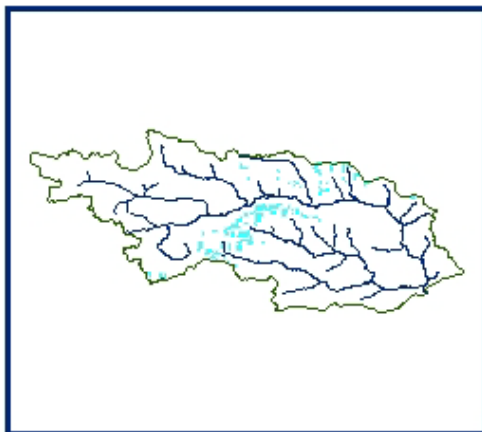


14 JANUARY 2013

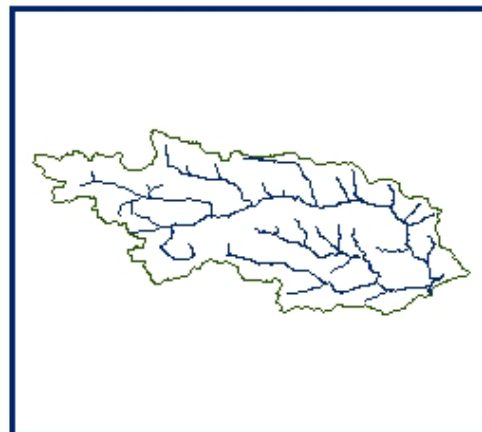


CLOUDY DATA

16 JANUARY 2013



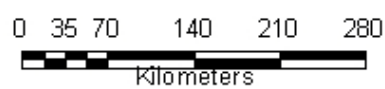
28 JANUARY 2013



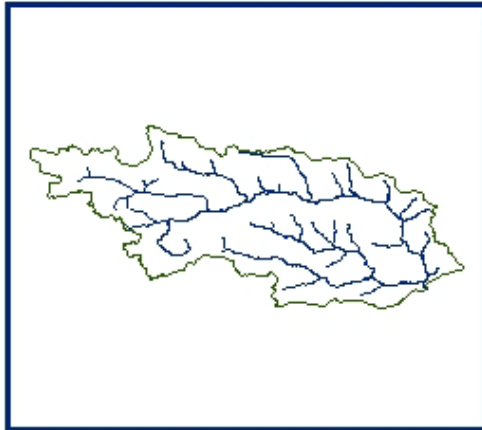
DATA NOT AVAILABLE



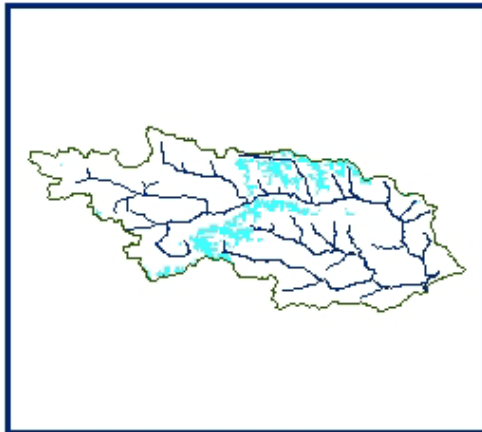
SNOW



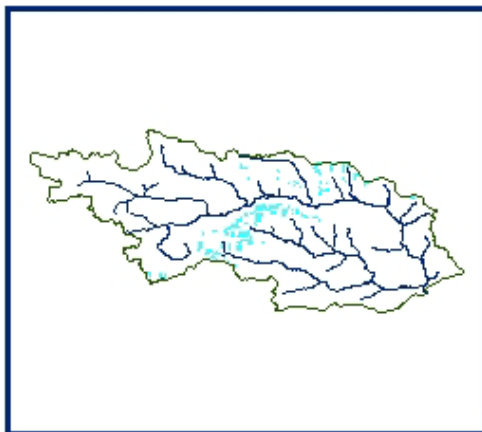
10 DAILY SNOW COVER MAP: SUBANSIRI BASIN



DATA USED
DATA NOT AVAILABLE



DATA USED
15 JANUARY 2013



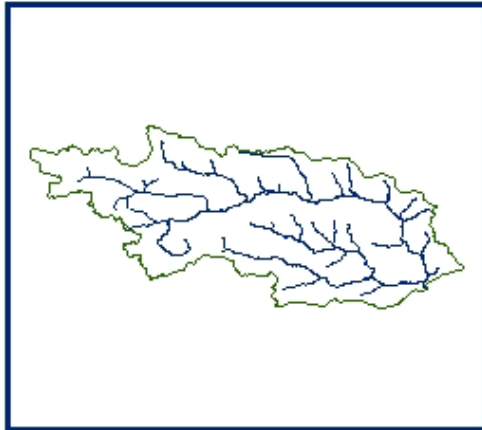
DATA USED
25 JANUARY 2013



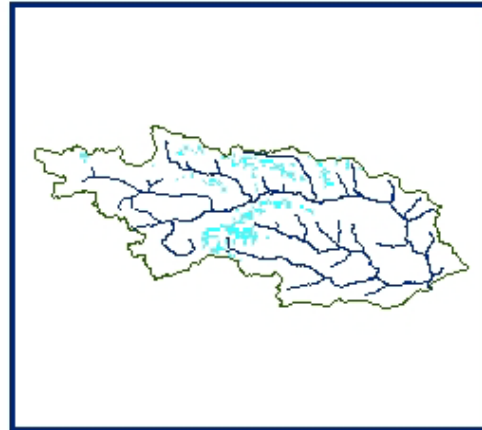
SNOW



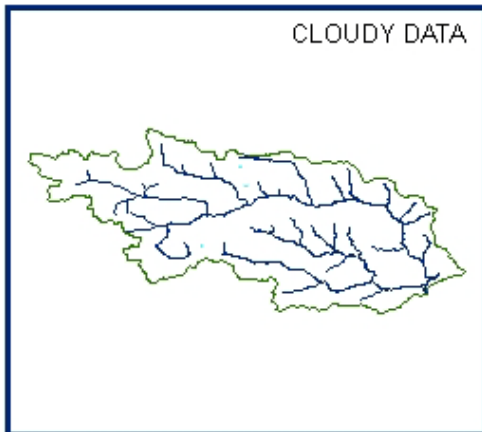
SNOW COVER MAP : SUBANSIRI BASIN



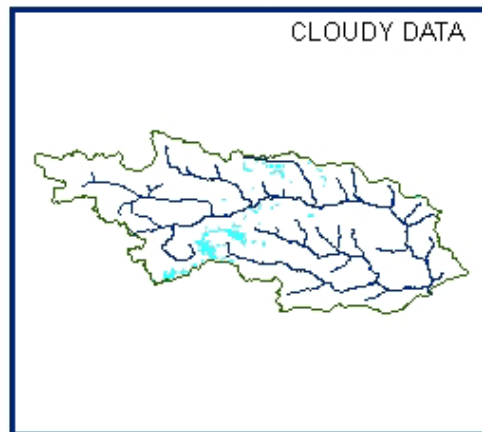
DATA NOT AVAILABLE



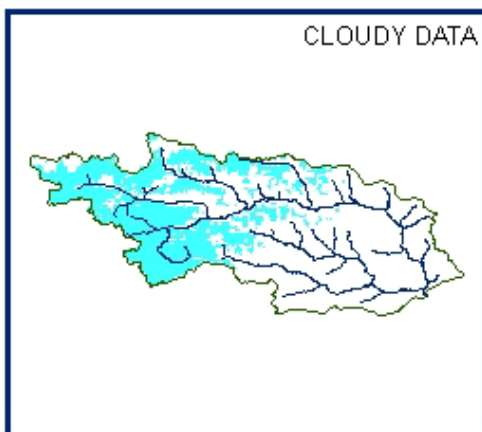
04 FEBRUARY 2013



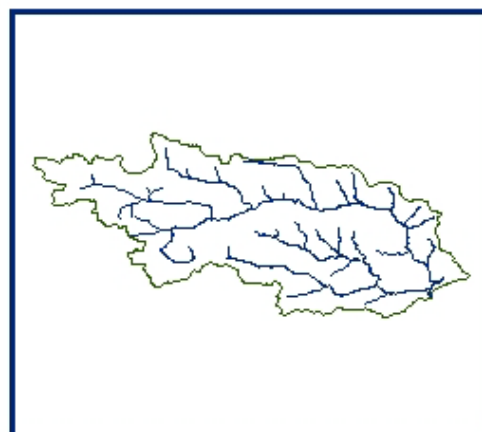
07 FEBRUARY 2013



14 FEBRUARY 2013



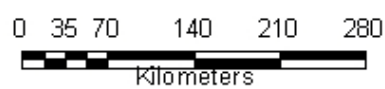
19 FEBRUARY 2013



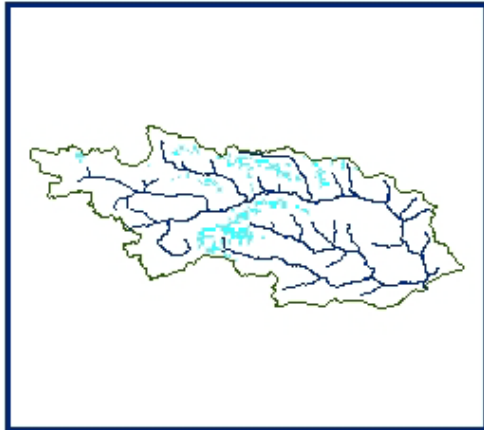
DATA NOT AVAILABLE



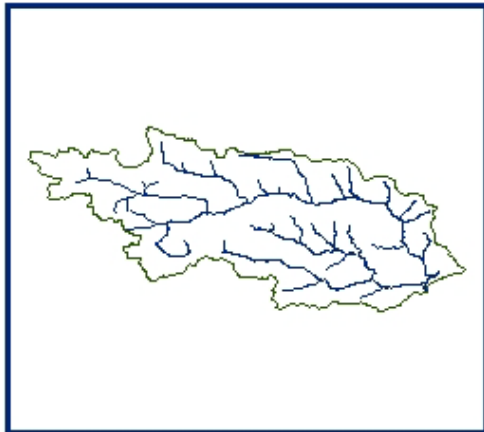
SNOW



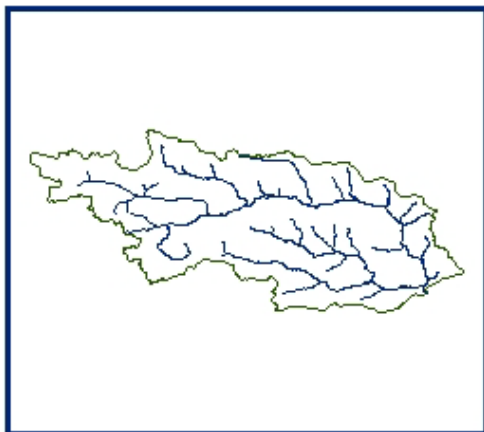
10 DAILY SNOW COVER MAP: SUBANSIRI BASIN



DATA USED
05 FEBRUARY 2013



DATA USED
DATA NOT AVAILABLE



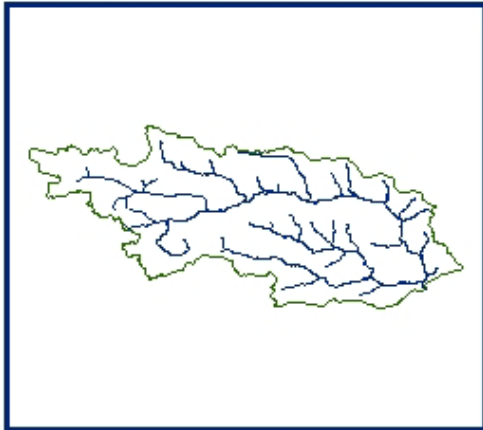
DATA USED
DATA NOT AVAILABLE



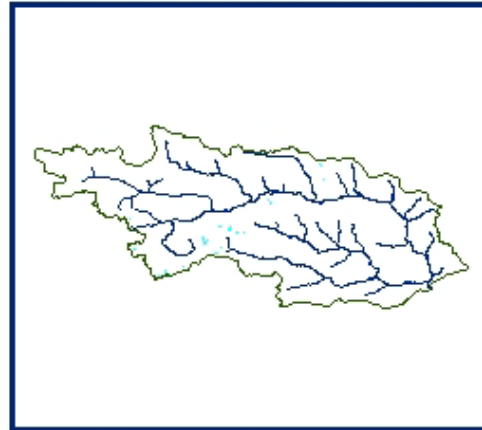
SNOW



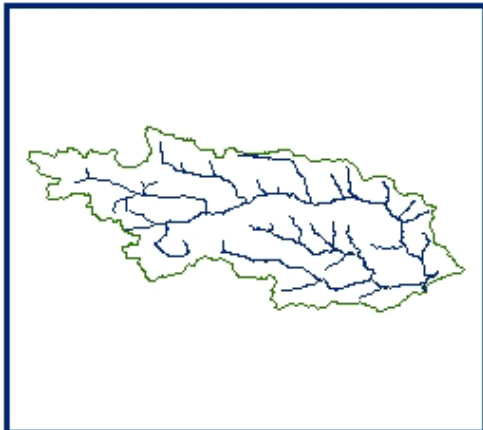
SNOW COVER MAP : SUBANSIRI BASIN



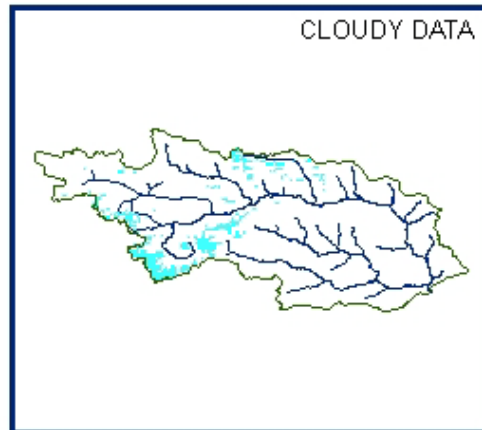
DATA NOT AVAILABLE



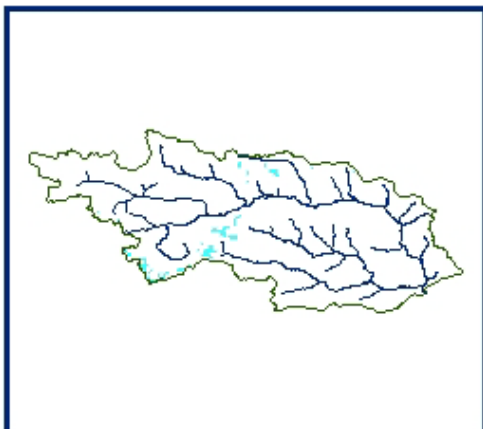
05 MARCH 2013



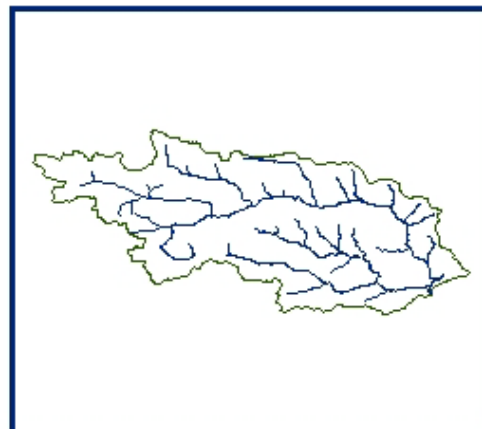
DATA NOT AVAILABLE



15 MARCH 2013



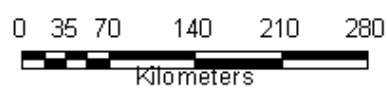
20 MARCH 2013



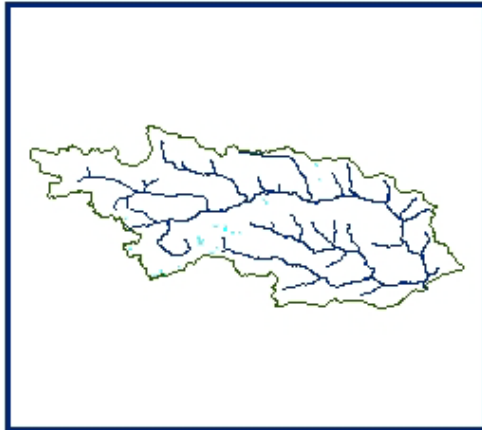
DATA NOT AVAILABLE



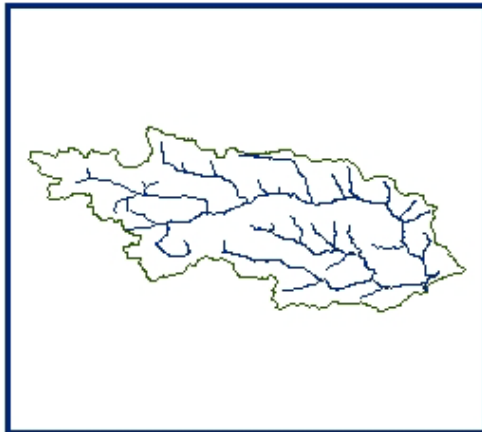
SNOW



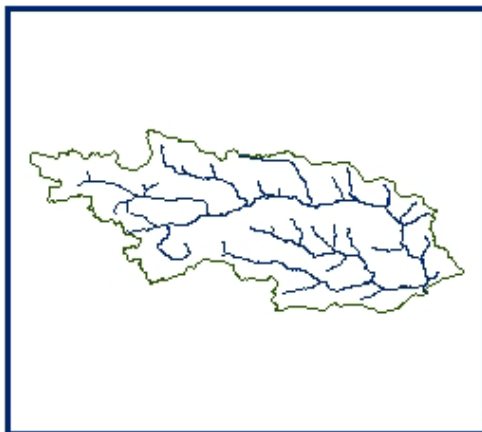
10 DAILY SNOW COVER MAP: SUBANSIRI BASIN



DATA USED
05 MARCH 2013



DATA USED
DATA NOT AVAILABLE



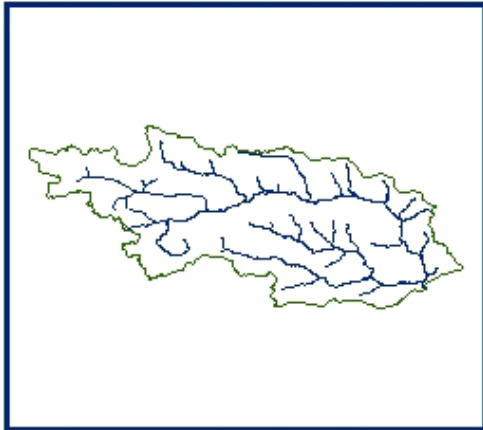
DATA USED
DATA NOT AVAILABLE



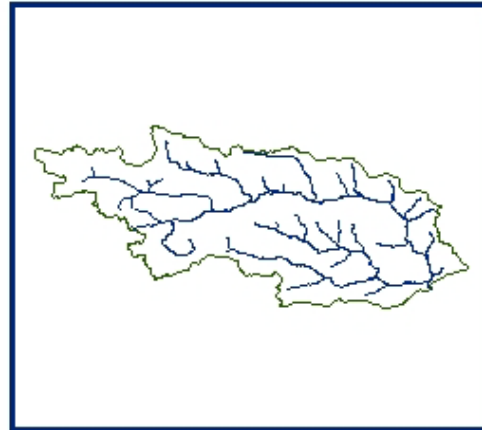
SNOW



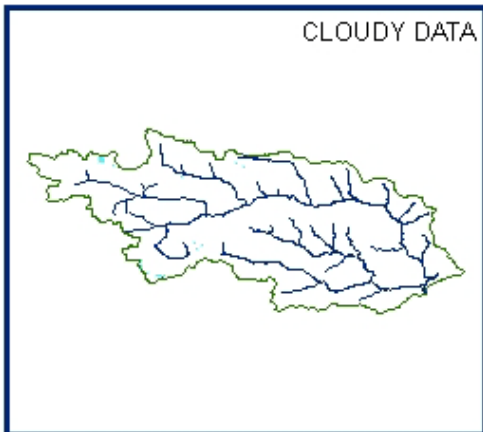
SNOW COVER MAP : SUBANSIRI BASIN



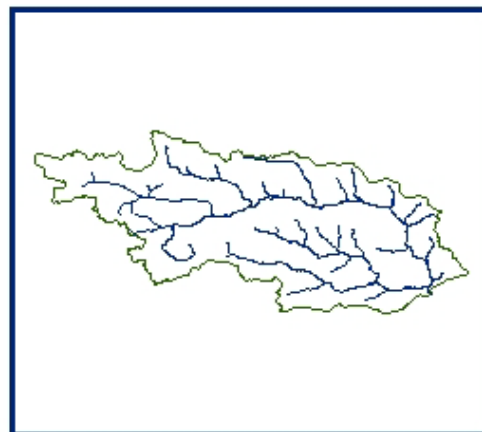
DATA NOT AVAILABLE



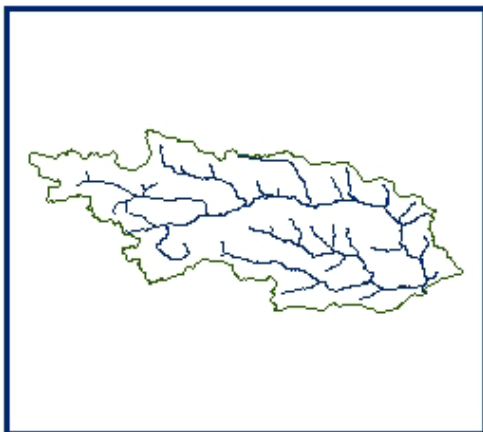
DATA NOT AVAILABLE



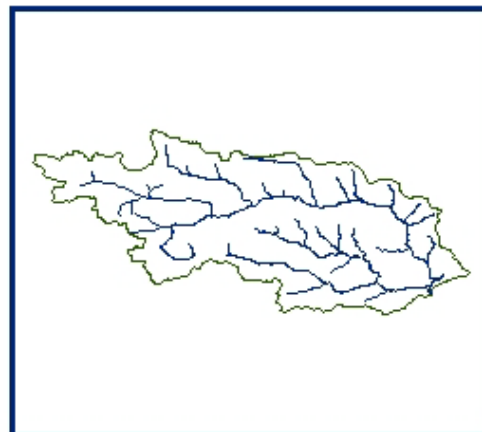
08 APRIL 2013



DATA NOT AVAILABLE



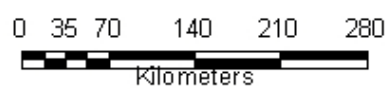
DATA NOT AVAILABLE



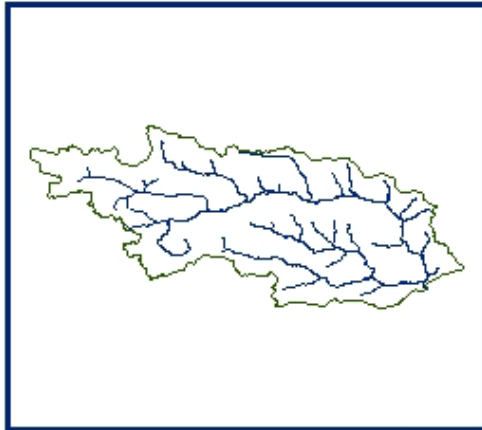
DATA NOT AVAILABLE



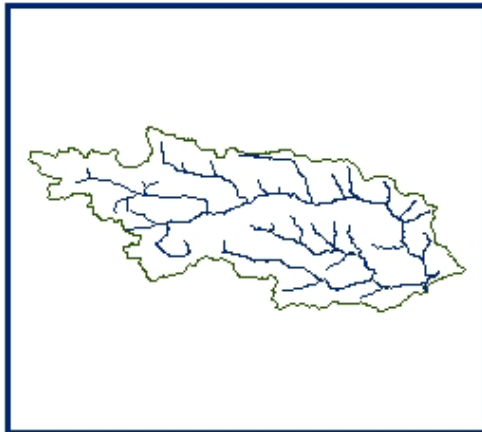
SNOW



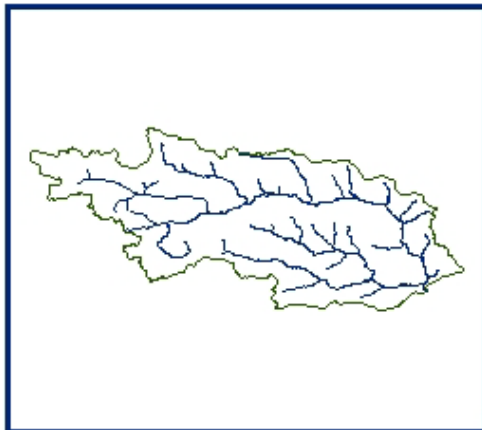
10 DAILY SNOW COVER MAP: SUBANSIRI BASIN



DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE



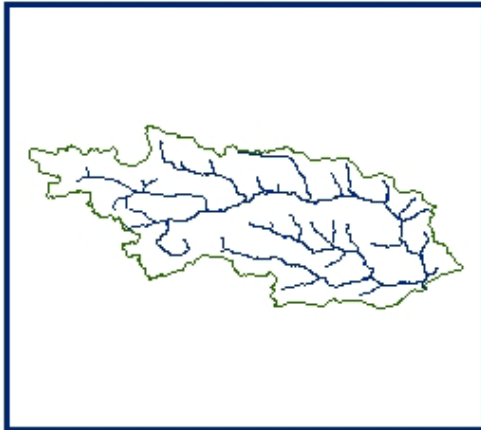
SNOW



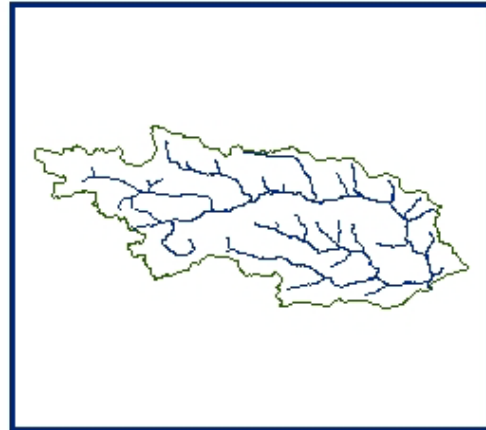
SNOW COVER MAP

:

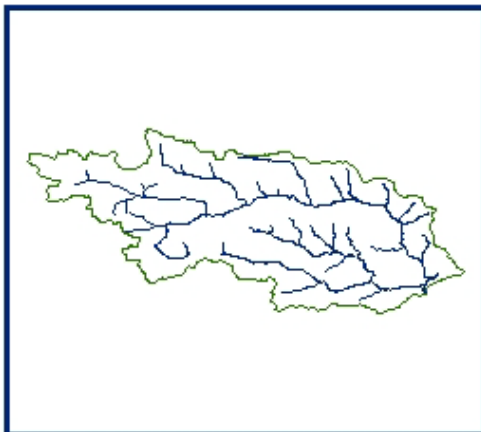
SUBANSIRI BASIN



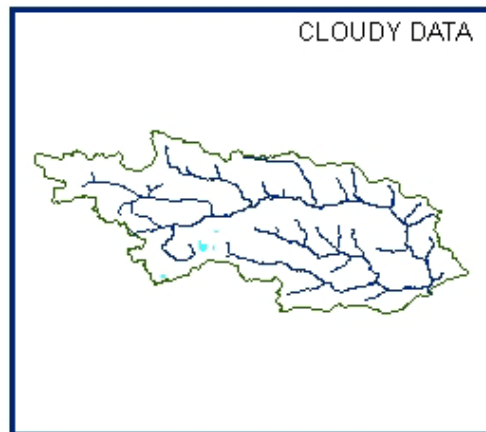
DATA NOT AVAILABLE



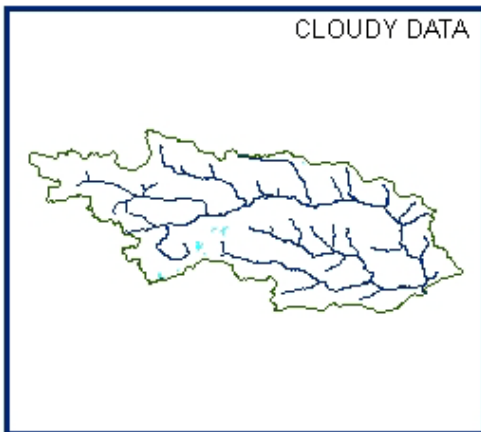
DATA NOT AVAILABLE



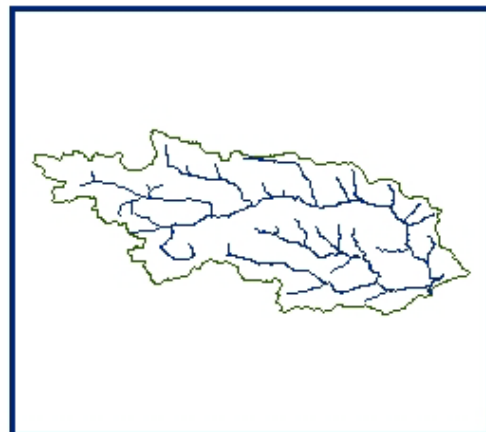
DATA NOT AVAILABLE



21 MAY 2013



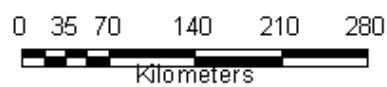
26 MAY 2013



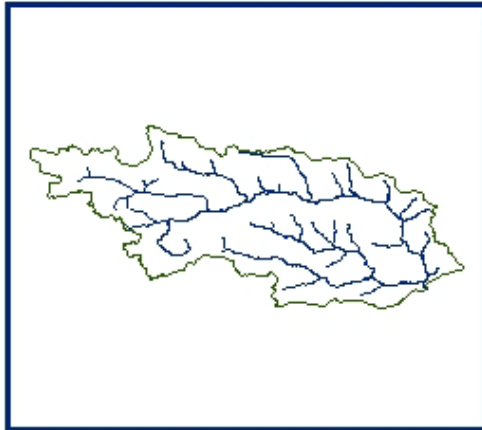
DATA NOT AVAILABLE



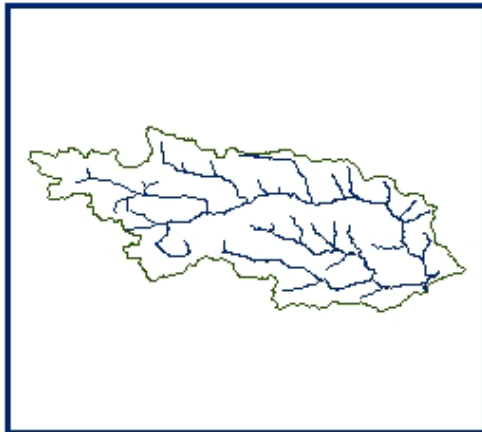
SNOW



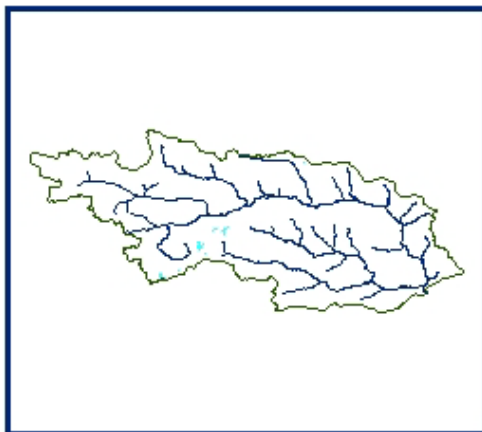
10 DAILY SNOW COVER MAP: SUBANSIRI BASIN



DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE



DATA USED
25 MAY 2013



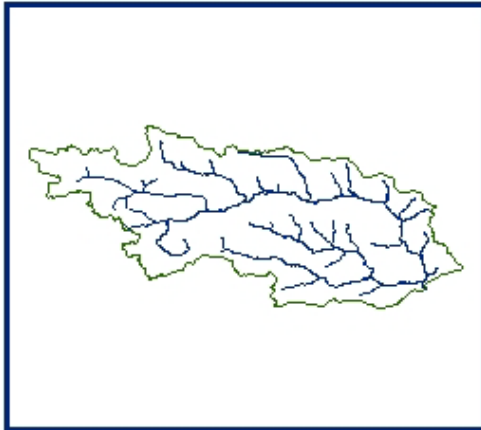
SNOW



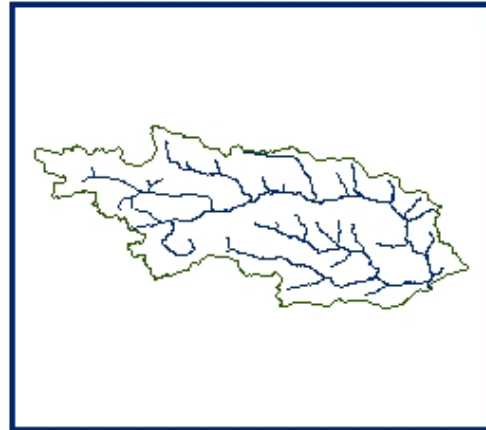
SNOW COVER MAP

:

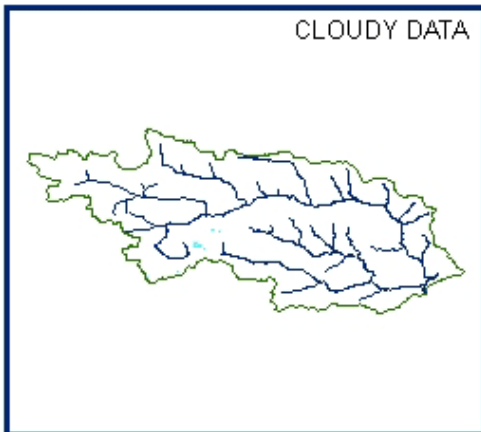
SUBANSIRI BASIN



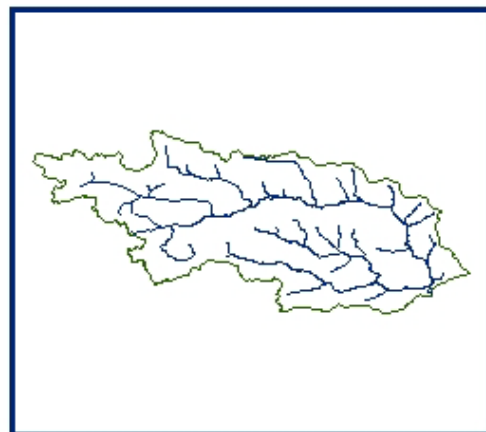
DATA NOT AVAILABLE



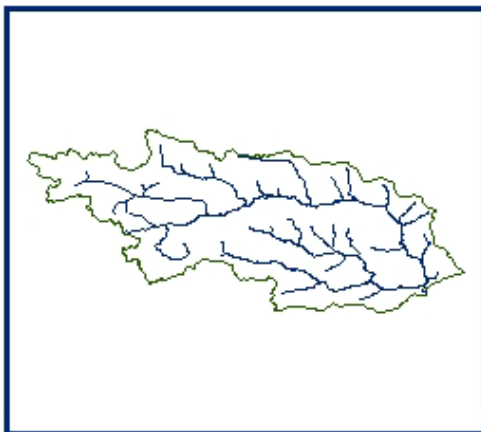
DATA NOT AVAILABLE



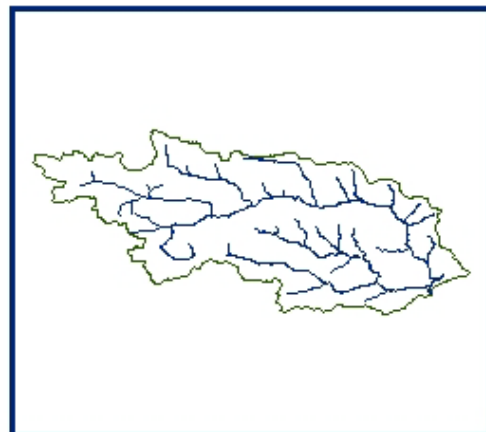
12 JUNE 2013



DATA NOT AVAILABLE



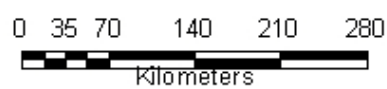
DATA NOT AVAILABLE



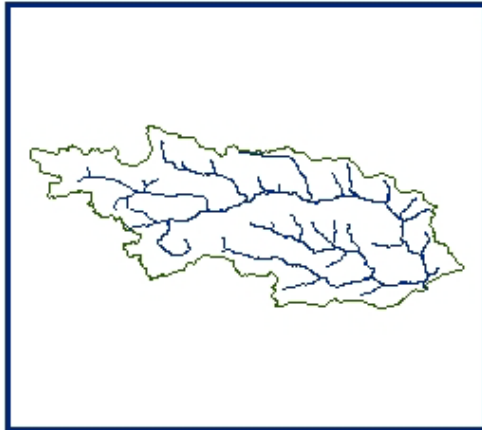
DATA NOT AVAILABLE



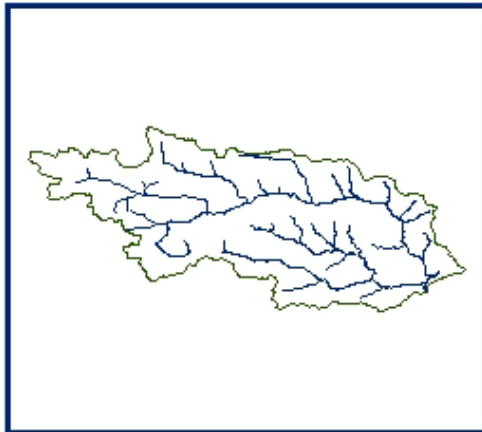
SNOW



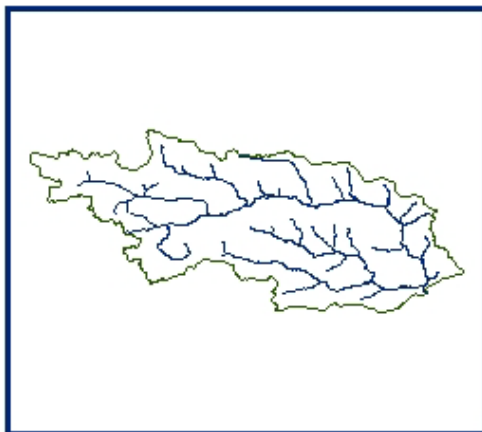
10 DAILY SNOW COVER MAP: SUBANSIRI BASIN



DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE



SNOW



AREAL EXTENT OF SNOW (5 DAILY)

BASIN NAME: TAWANG

BASIN AREA: 6725 sq km

S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2012							
1	7-Oct-12	329	5	3	26-Oct-12	755	11
2	19-Oct-12	653	10	4	27-Oct-12	627 (C)	9
November 2012							
5	3-Nov-12	452 (C)	7	9	15-Nov-12	486	7
6	5-Nov-12	613	9	10	17-Nov-12	402	6
7	10-Nov-12	350	5	11	19-Nov-12	473	7
8	12-Nov-12	426	6	12	26-Nov-12	341	5
December 2012							
13	1-Dec-12	329	5	19	20-Dec-12	510 (C)	8
14	2-Dec-12	287	47	20	23-Dec-12	647	10
15	4-Dec-12	267	4	21	25-Dec-12	465	7
16	6-Dec-12	313 (C)	5	22	26-Dec-12	404	6
17	16-Dec-12	1058	16	23	30-Dec-12	452	7
18	18-Dec-12	906	13				
January 2013							
24	6-Jan-13	491	7	29	18-Jan-13	442	7
25	9-Jan-13	753	11	30	21-Jan-13	683	10
26	13-Jan-13	508	8	31	28-Jan-13	330	5
27	14-Jan-13	414	6	32	30-Jan-13	321	5
28	16-Jan-13	321	5	33	31-Jan-13	269 (C)	4
February 2013							
34	4-Feb-13	1751	26	39	18-Feb-13	5595	83
35	6-Feb-13	635	9	40	19-Feb-13	5171	77
36	7-Feb-13	192 (C)	3	41	23-Feb-13	4982	74
37	12-Feb-13	162 (C)	2	42	24-Feb-13	4875	73
38	14-Feb-13	315 (C)	5	43	28-Feb-13	4214	63
March 2013							
44	3-Mar-13	3994	59	47	15-Mar-13	1996 (C)	30
45	5-Mar-13	3198	48	48	20-Mar-13	3842 (C)	57
46	14-Mar-13	2636	39				
April 2013							
49	7-April-13	3026	45	50	8-April-13	2152	32
May 2013							
51	13-May-13	1440 (C)	21	53	21-May-13	669 (C)	10
52	16-May-13	15919 (C)	24	54	26-May-13	1100	16
June 2013							
55	11-June-13	577(C)	9	56	12-June-13	673(C)	10

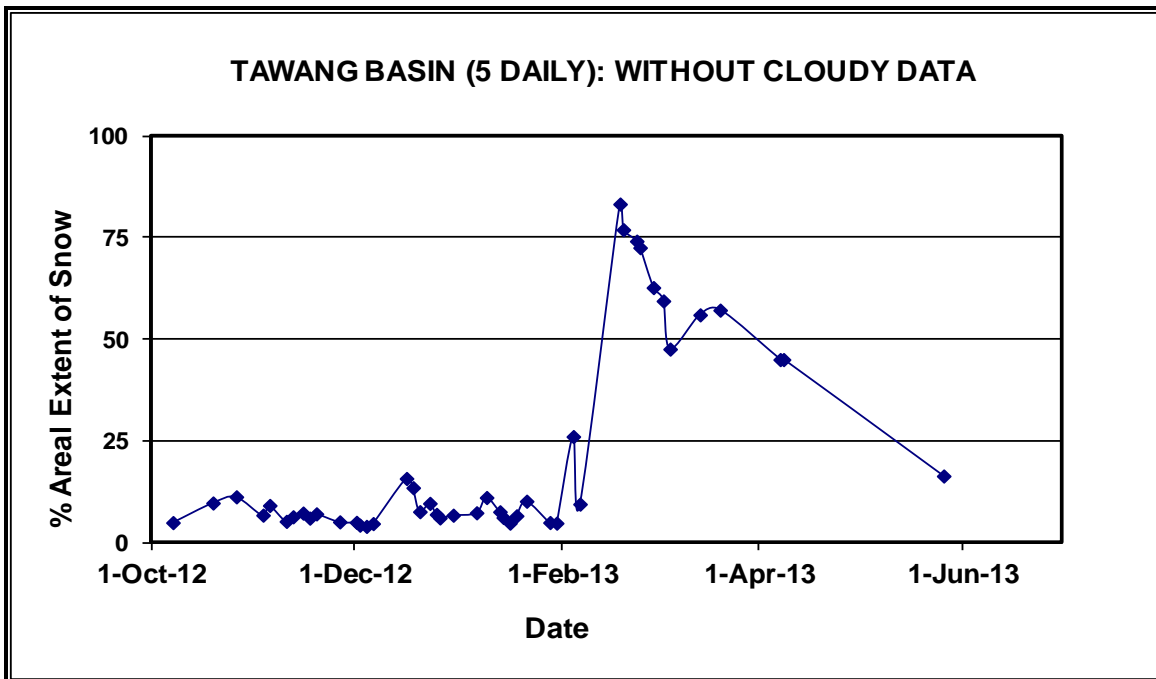
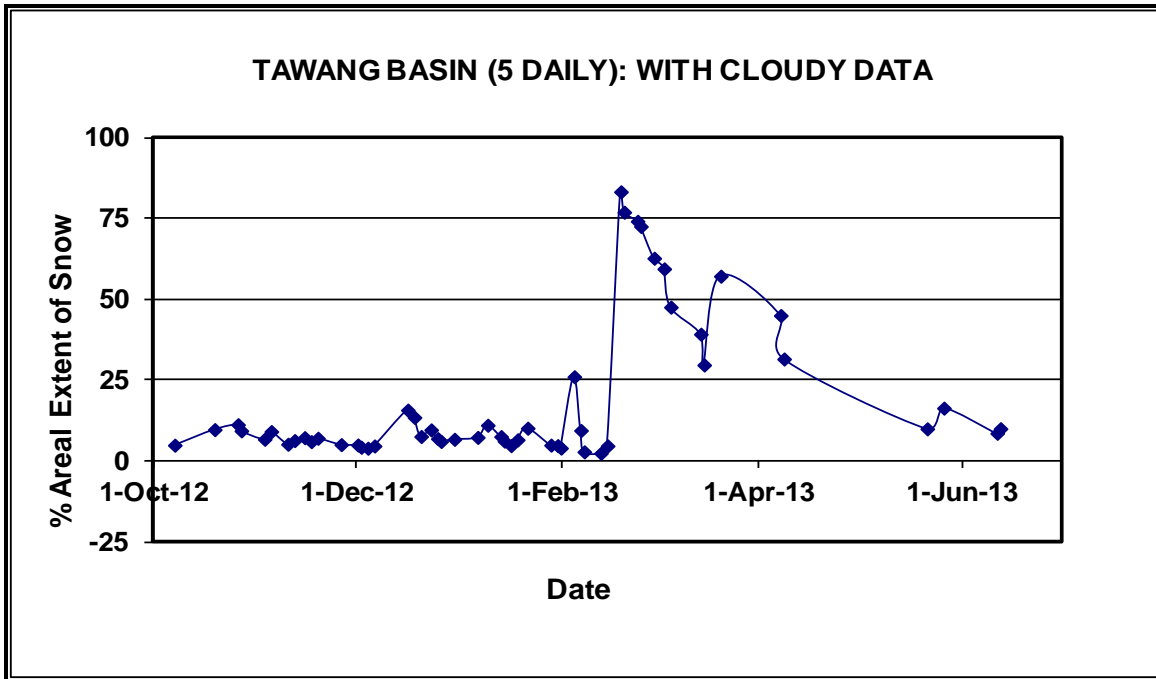
AREAL EXTENT OF SNOW (10 DAILY)

BASIN NAME: TAWANG

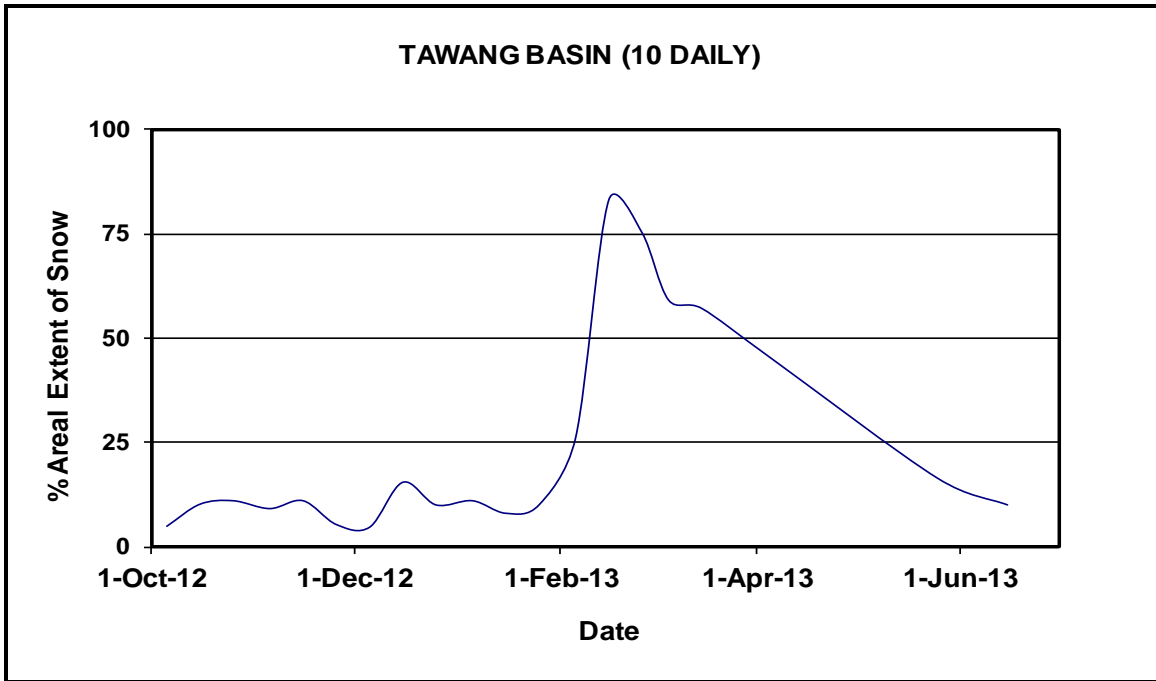
BASIN AREA: 6725 sq km

S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2012				November 2012			
1	5-Oct-12	336	5	3	5-Nov-12	613	9
1	15-Oct-12	653	10	4	15-Nov-12	741	11
2	25-Oct-12	755	11	5	25-Nov-12	341	5
December 2012				January 2013			
6	5-Dec-12	313	5	9	5-Jan-13	740	11
7	15-Dec-12	1036	15	10	15-Jan-13	538	8
8	25-Dec-12	611	9	11	25-Jan-13	673	10
February 2013				March 2013			
12	5-Feb-13	1749	26	15	5-Mar-13	3968	59
13	15-Feb-13	5575	83	16	15-Mar-13	3833	57
14	25-Feb-13	5049	75				
April 2013				May 2013			
17	8-April-13	3026	45	18	25-May-13	1100	16
June 2013							
19	12-June-13	673	10				

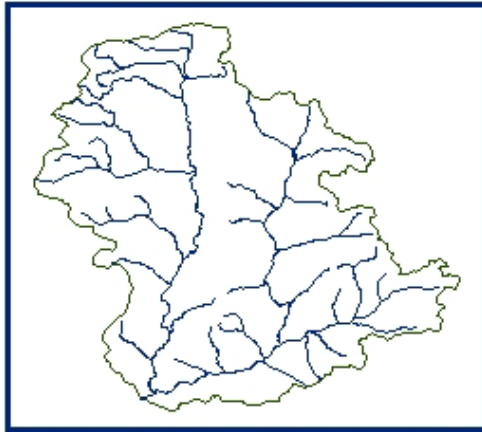
SNOW COVER DEPLETION CURVE



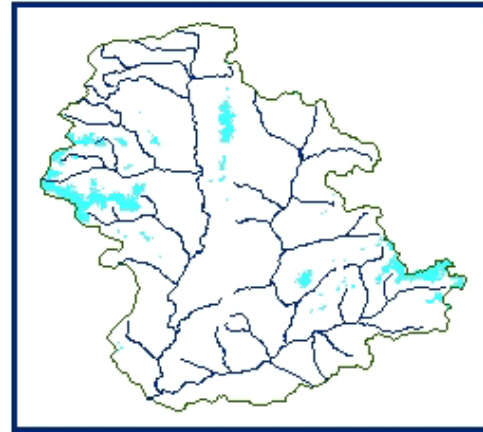
SNOW COVER DEPLETION CURVE



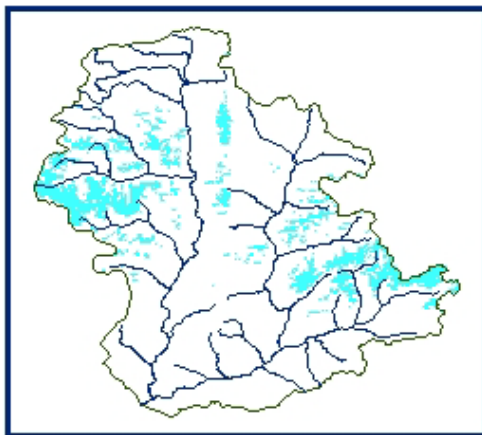
SNOW COVER MAP



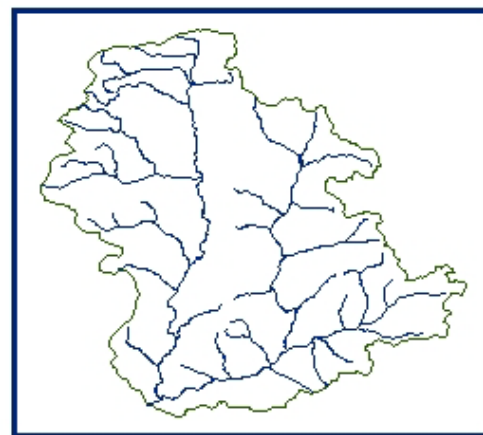
DATA NOT AVAILABLE



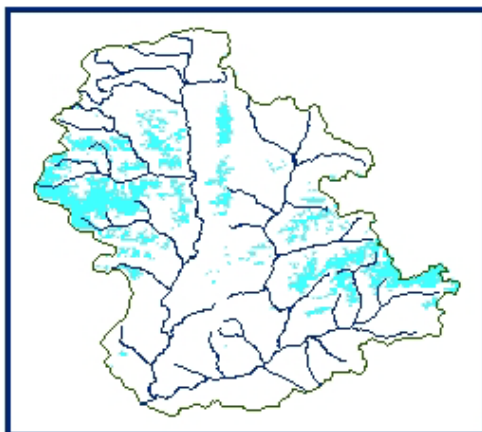
07 OCTOBER 2012



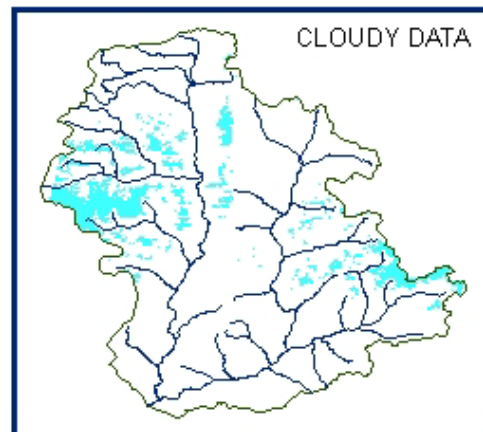
19 OCTOBER 2012



DATA NOT AVAILABLE



26 OCTOBER 2012



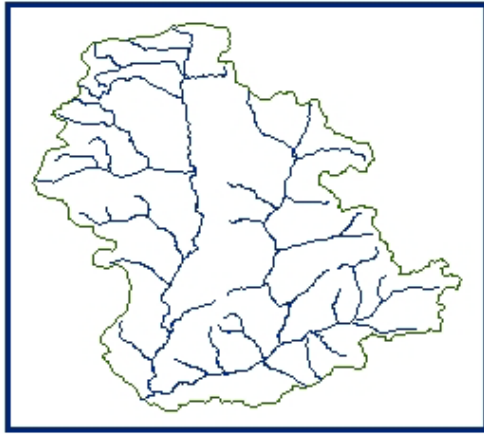
27 OCTOBER 2012



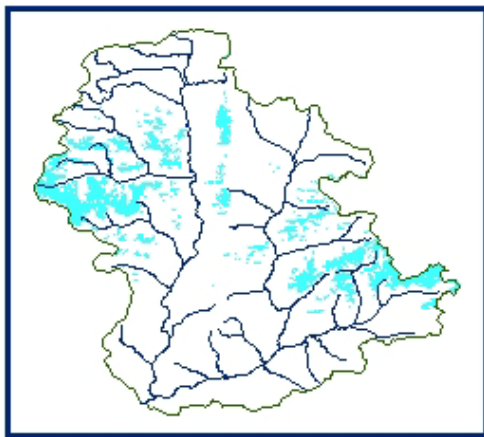
SNOW



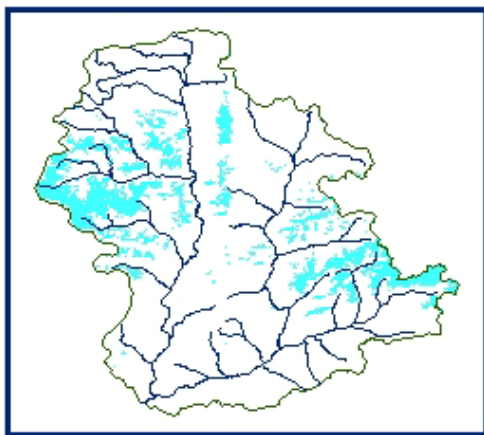
10 DAILY SNOW COVER MAP: TAWANG BASIN



DATA USED
DATA NOT AVAILABLE



DATA USED
15 OCTOBER 2012



DATA USED
25 OCTOBER 2012



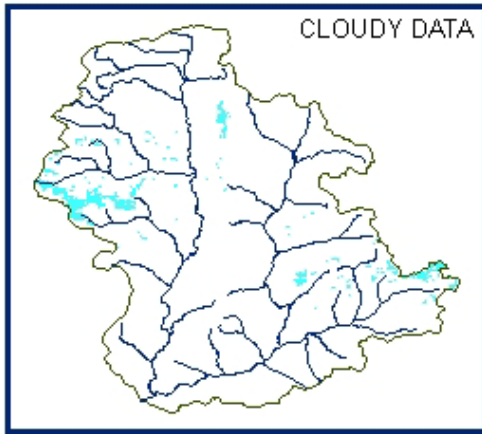
SNOW



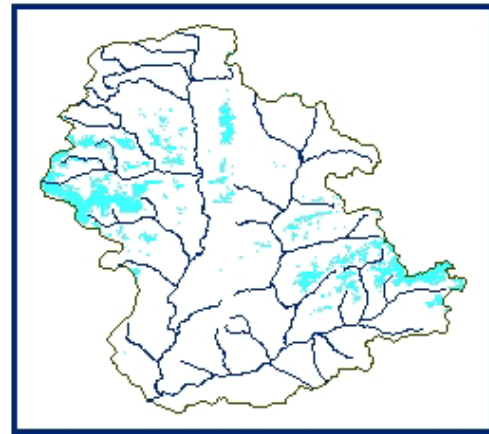
SNOW COVER MAP

:

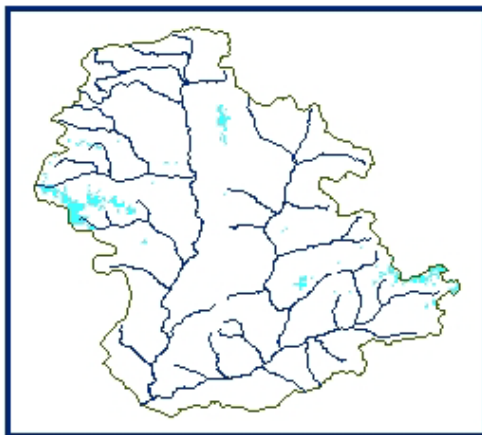
TAWANG BASIN



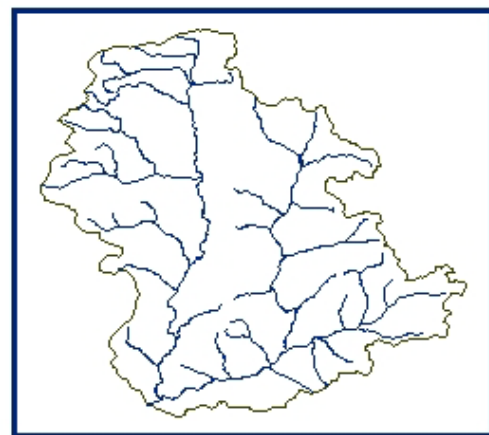
03 NOVEMBER 2012



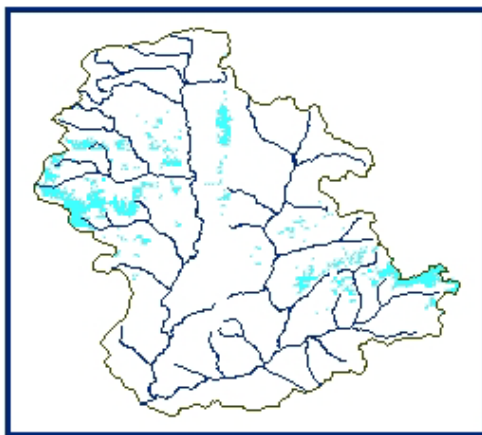
05 NOVEMBER 2012



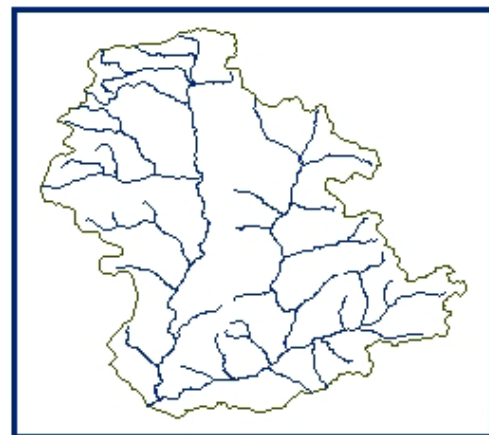
10 NOVEMBER 2012



DATA NOT AVAILABLE



12 NOVEMBER 2012

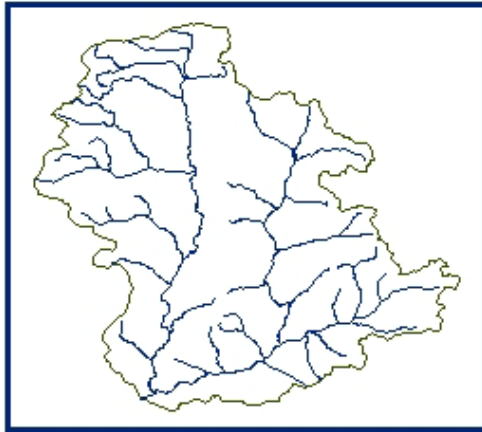


DATA NOT AVAILABLE

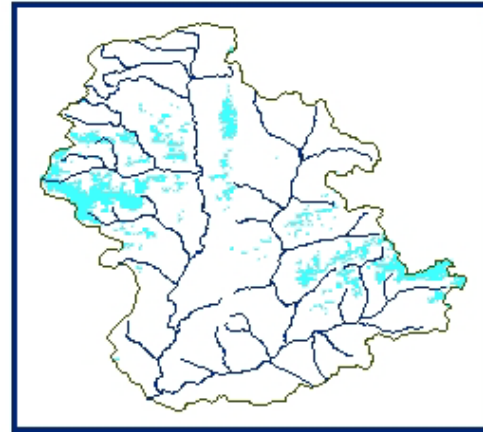


SNOW

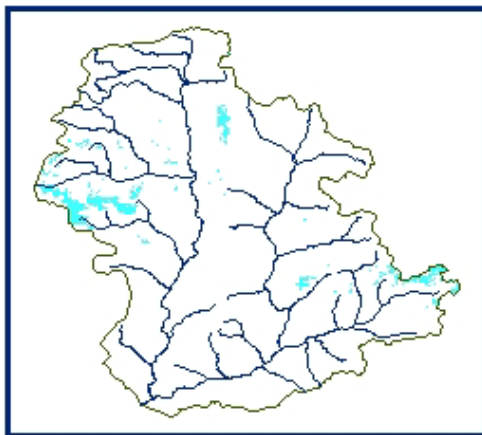




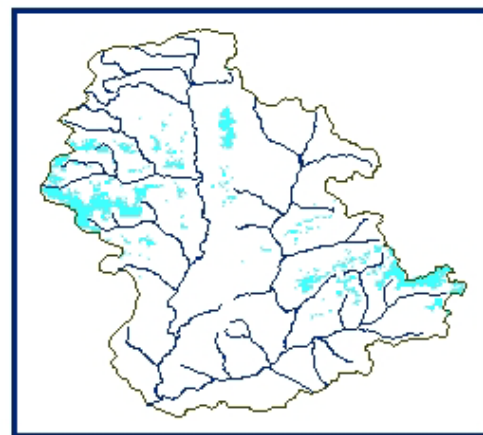
DATA NOT AVAILABLE



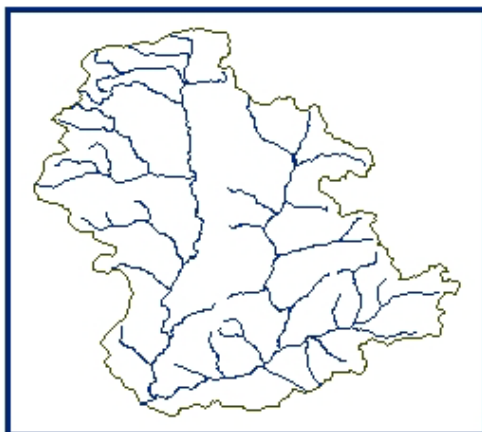
15 NOVEMBER 2012



17 NOVEMBER 2012



19 NOVEMBER 2012



DATA NOT AVAILABLE



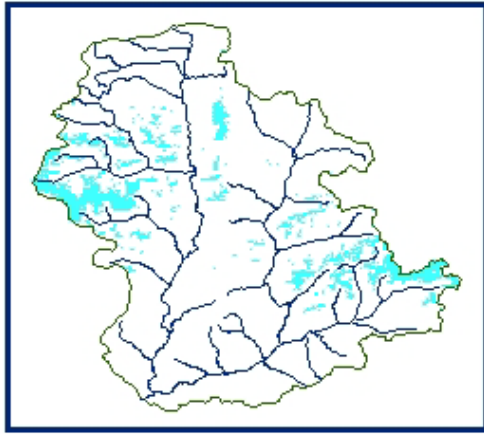
26 NOVEMBER 2012



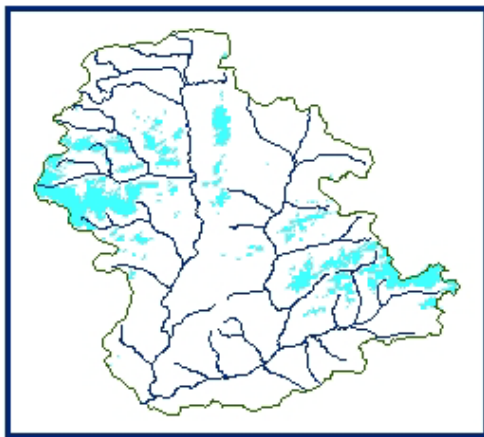
SNOW



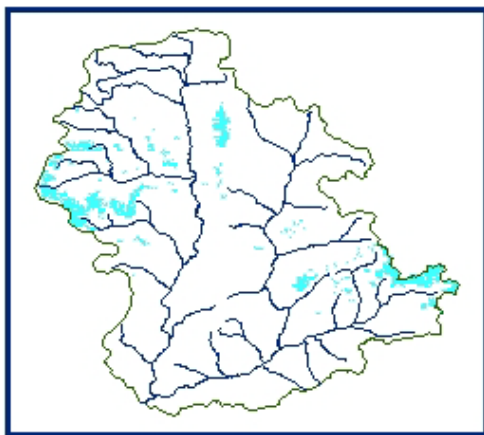
10 DAILY SNOW COVER MAP: TAWANG BASIN



DATA USED
05 NOVEMBER 2012



DATA USED
15 NOVEMBER 2012



DATA USED
25 NOVEMBER 2012

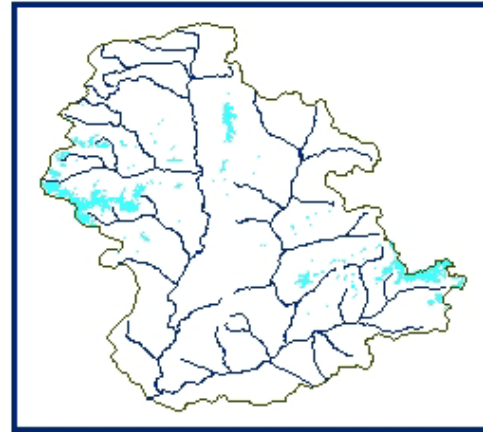


SNOW

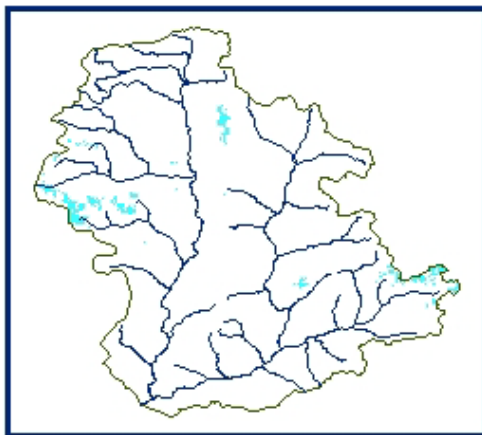




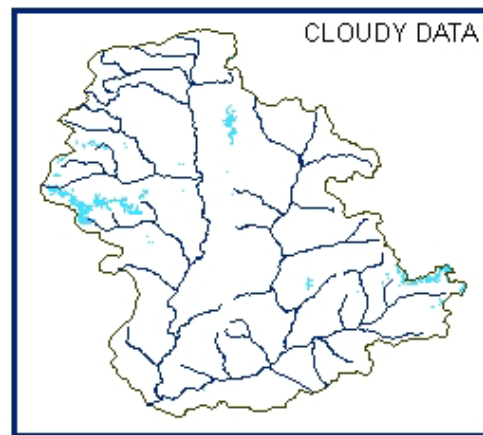
01 DECEMBER 2012



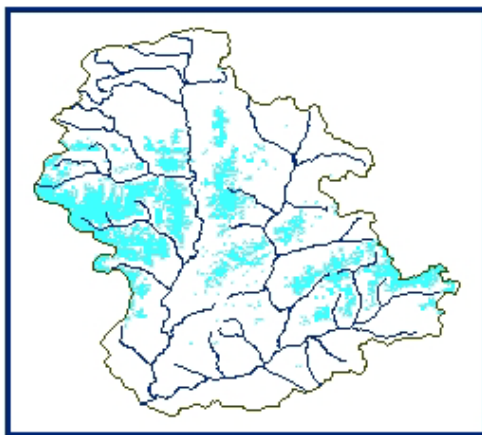
02 DECEMBER 2012



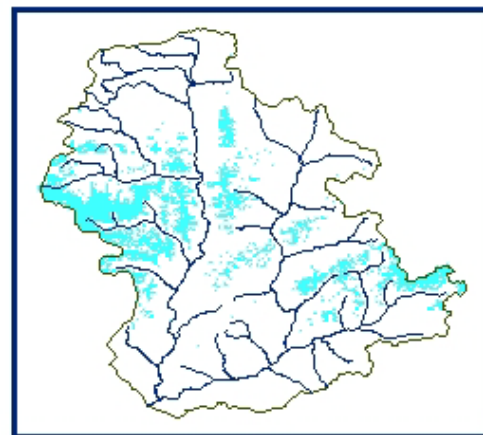
04 DECEMBER 2012



06 DECEMBER 2012



16 DECEMBER 2012



18 DECEMBER 2012



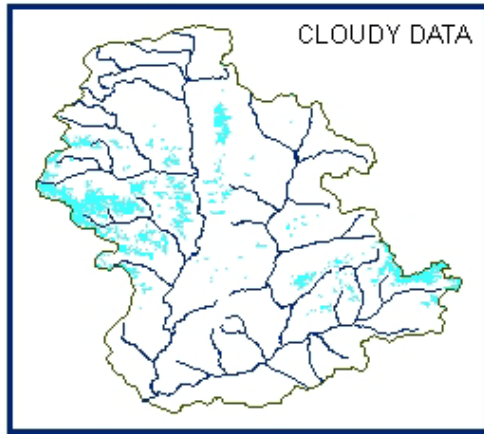
SNOW



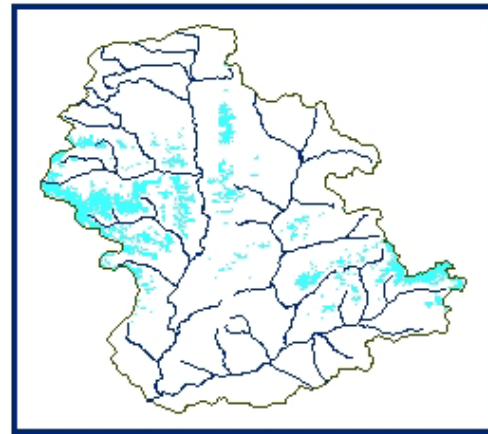
SNOW COVER MAP

:

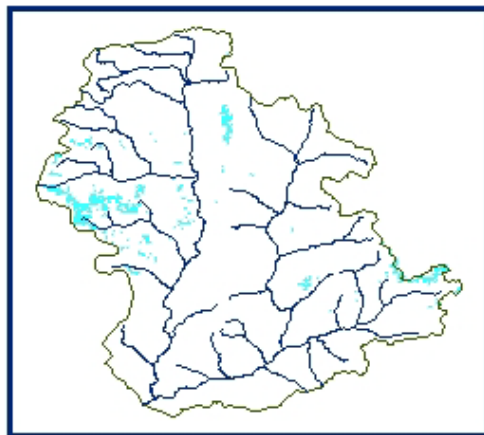
TAWANG BASIN



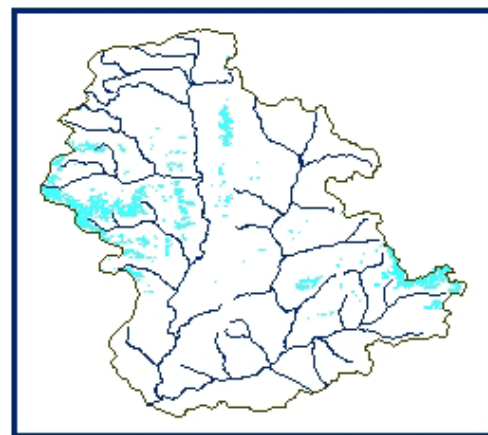
20 DECEMBER 2012



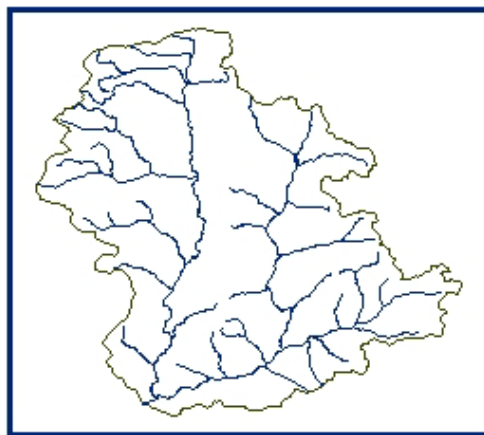
23 DECEMBER 2012



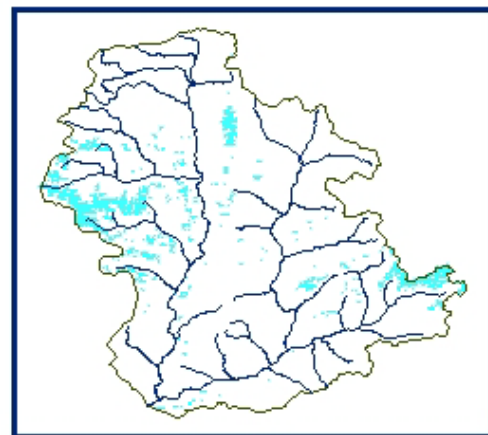
25 DECEMBER 2012



26 DECEMBER 2012



DATA NOT AVAILABLE



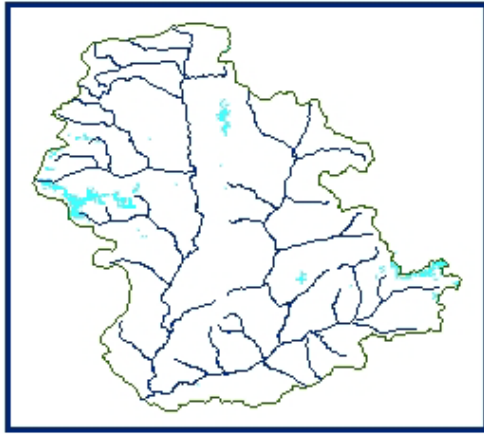
30 DECEMBER 2012



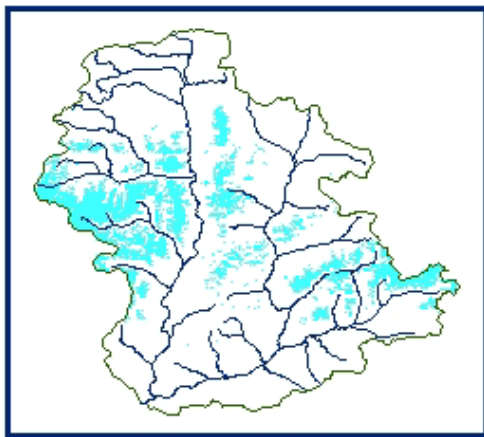
SNOW



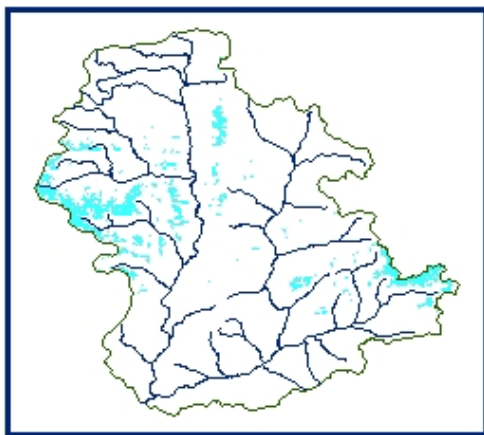
10 DAILY SNOW COVER MAP: TAWANG BASIN



DATA USED
05 DECEMBER 2012



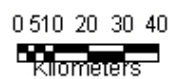
DATA USED
15 DECEMBER 2012

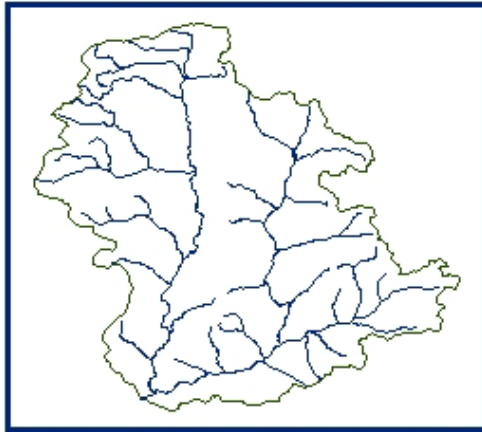


DATA USED
25 DECEMBER 2012

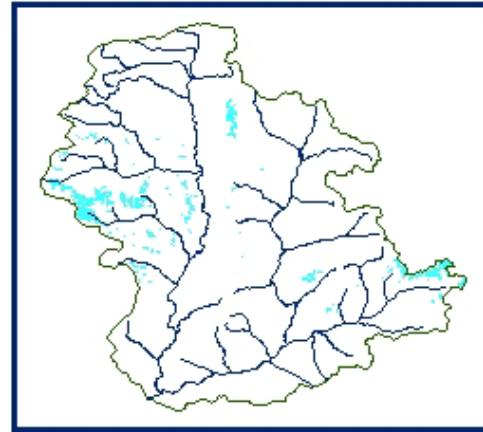


SNOW

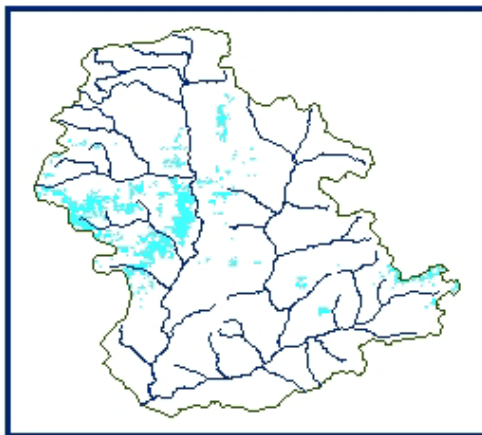




DATA NOT AVAILABLE



06 JANUARY 2013



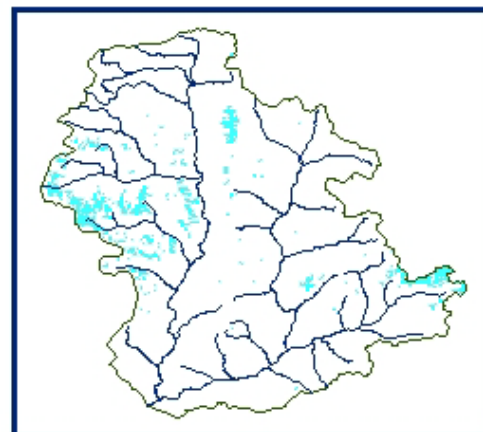
09 JANUARY 2013



13 JANUARY 2013



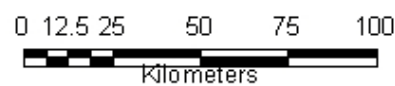
14 JANUARY 2013



16 JANUARY 2013



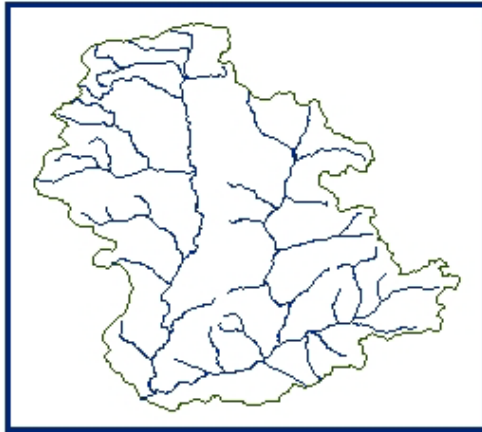
SNOW



SNOW COVER MAP

:

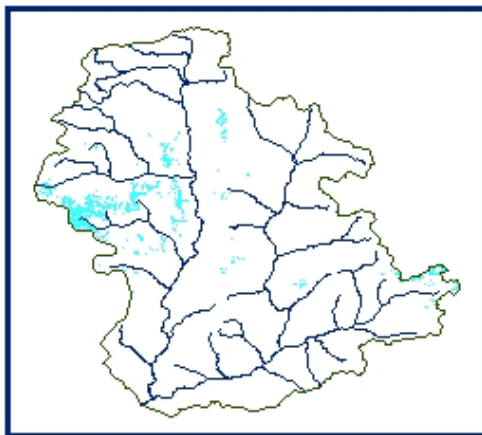
TAWANG BASIN



DATA NOT AVAILABLE



18 JANUARY 2013



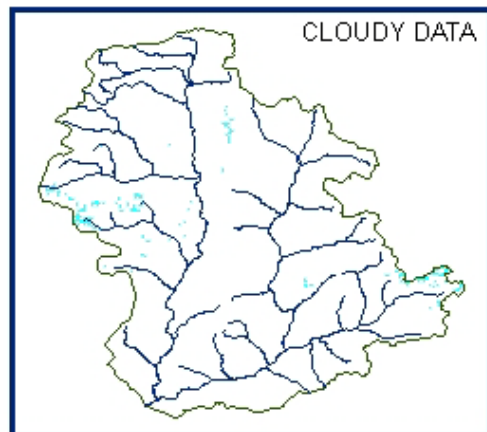
21 JANUARY 2013



28 JANUARY 2013



30 JANUARY 2013



31 JANUARY 2013



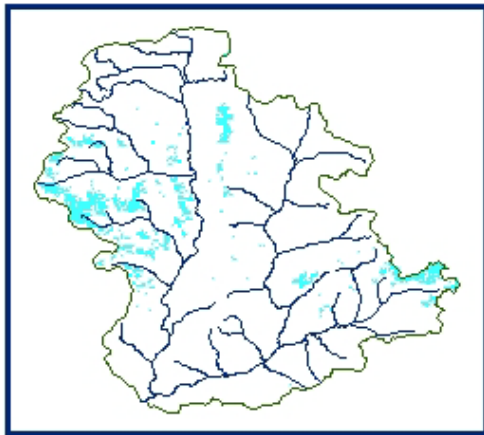
SNOW



10 DAILY SNOW COVER MAP: TAWANG BASIN



DATA USED
05 JANUARY 2013



DATA USED
15 JANUARY 2013



DATA USED
25 JANUARY 2013



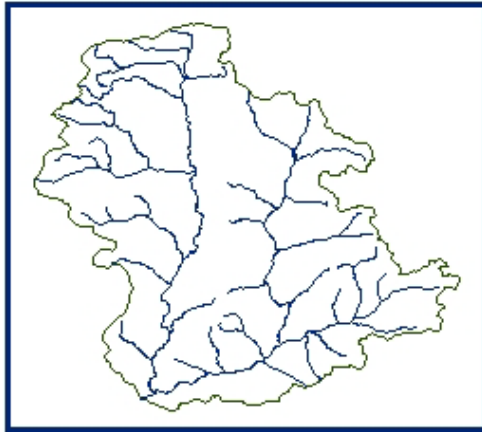
SNOW



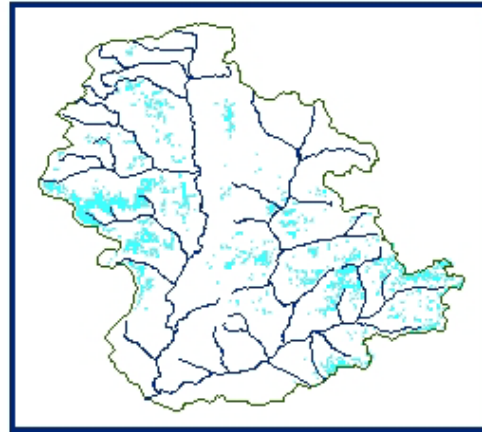
SNOW COVER MAP

:

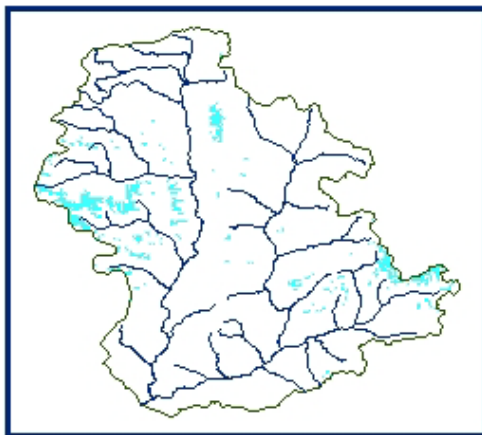
TAWANG BASIN



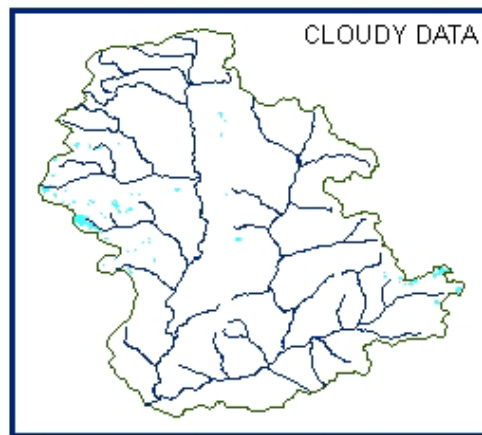
DATA NOT AVAILABLE



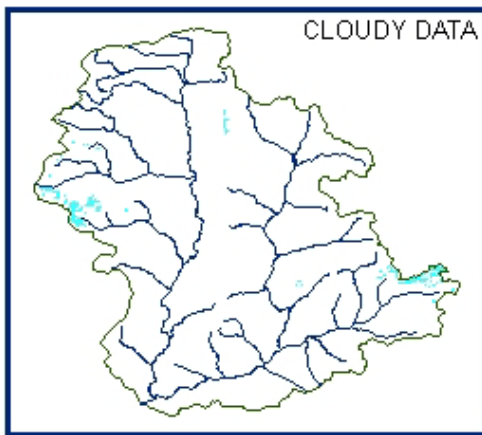
04 FEBRUARY 2013



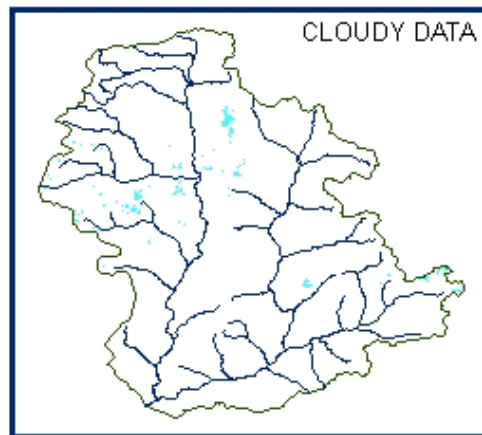
06 FEBRUARY 2013



07 FEBRUARY 2013



12 FEBRUARY 2013

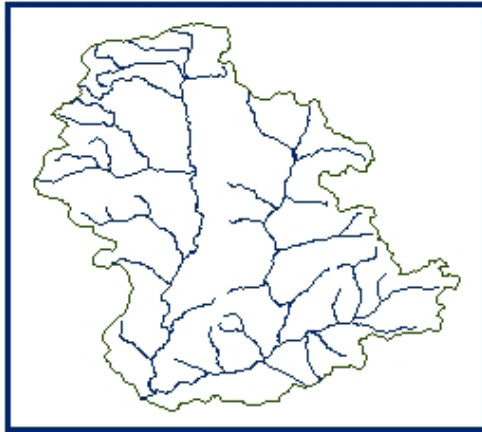


14 FEBRUARY 2013

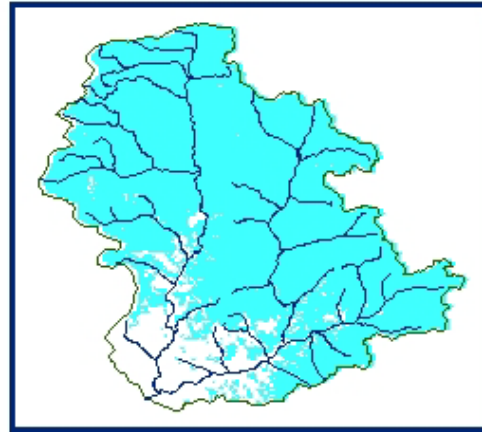


SNOW

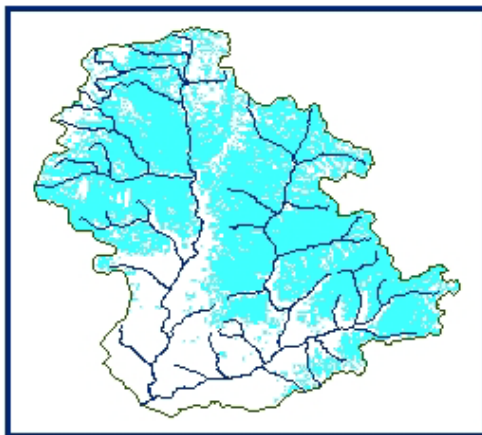




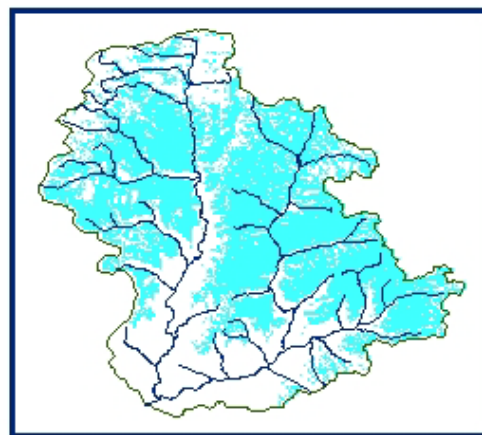
DATA NOT AVAILABLE



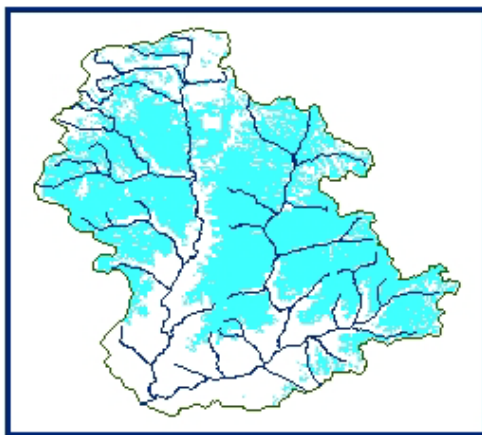
18 FEBRUARY 2013



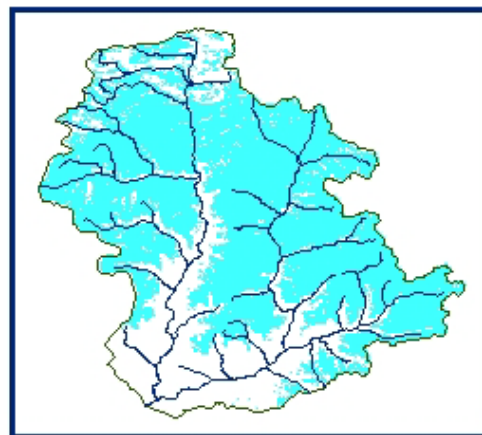
19 FEBRUARY 2013



23 FEBRUARY 2013



24 FEBRUARY 2013



28 FEBRUARY 2013



SNOW



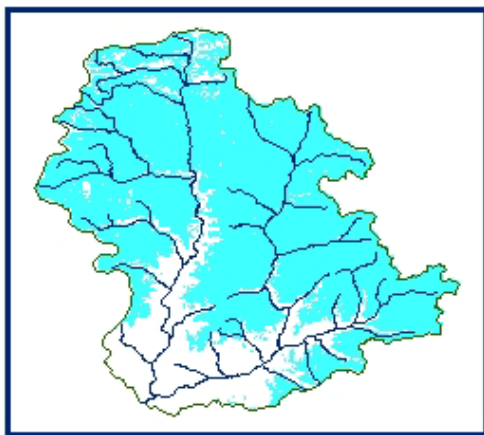
10 DAILY SNOW COVER MAP: TAWANG BASIN



DATA USED
05 FEBRUARY 2013



DATA USED
15 FEBRUARY 2013



DATA USED
25 FEBRUARY 2013



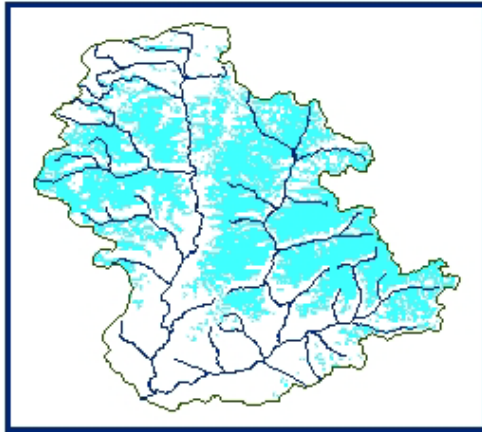
SNOW



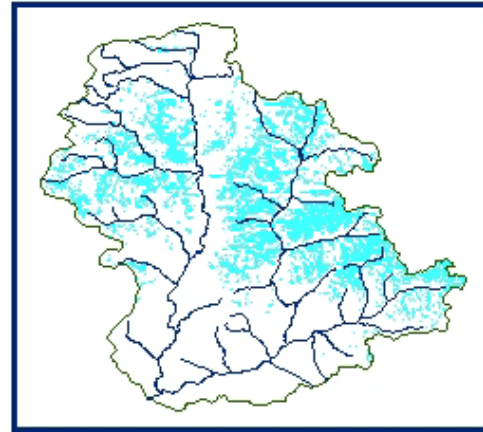
SNOW COVER MAP

:

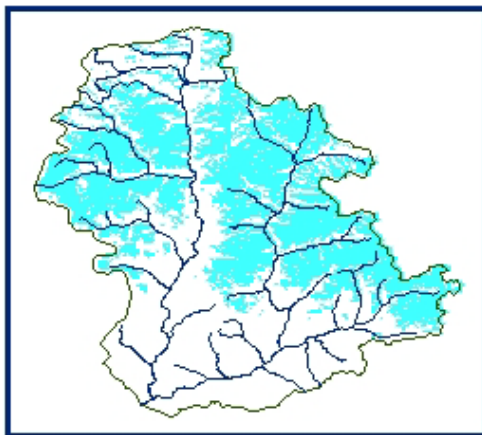
TAWANG BASIN



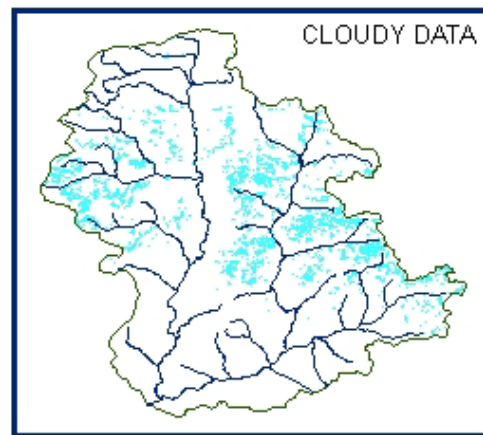
03 MARCH 2013



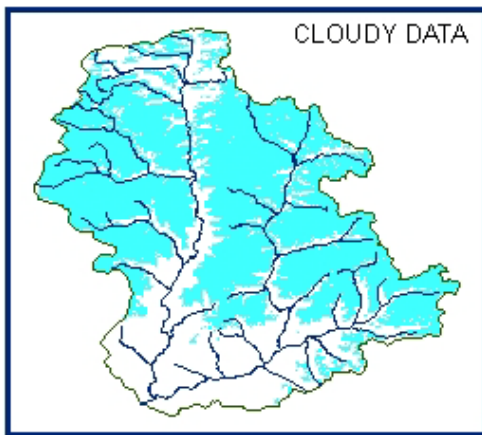
05 MARCH 2013



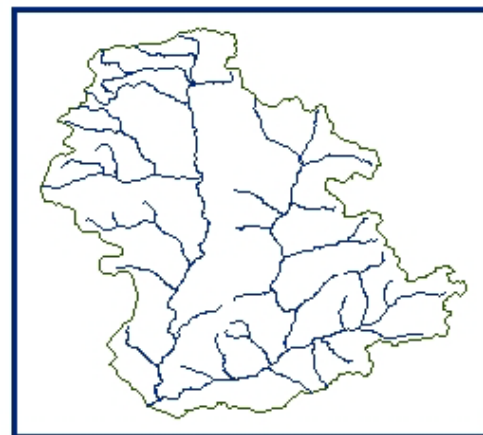
14 MARCH 2013



15 MARCH 2013



20 MARCH 2013



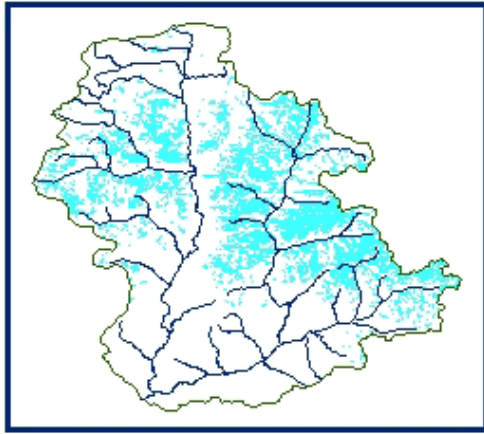
DATA NOT AVAILABLE



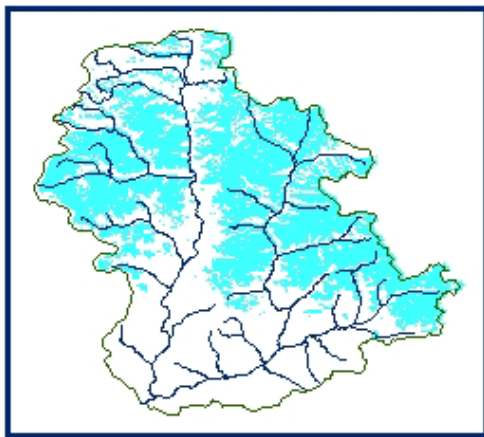
SNOW



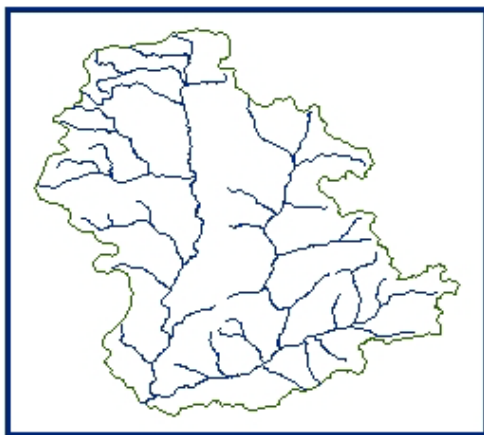
10 DAILY SNOW COVER MAP: TAWANG BASIN



DATA USED
05 MARCH 2013



DATA USED
15 MARCH 2013

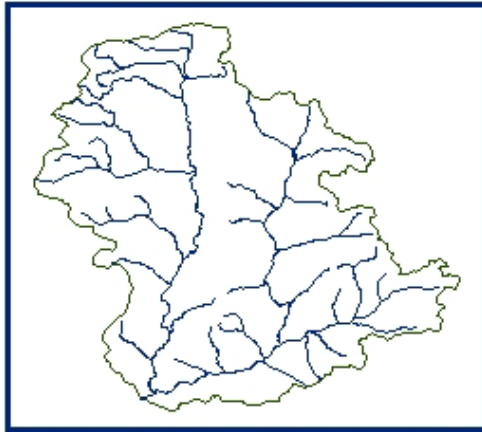


DATA USED
DATA NOT AVAILABLE

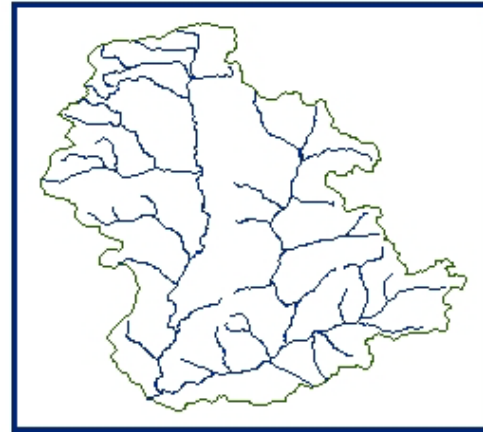


SNOW

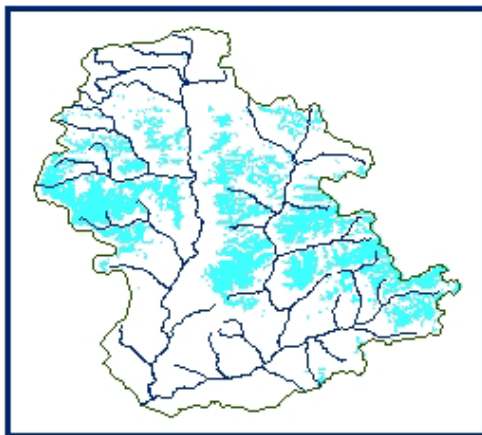




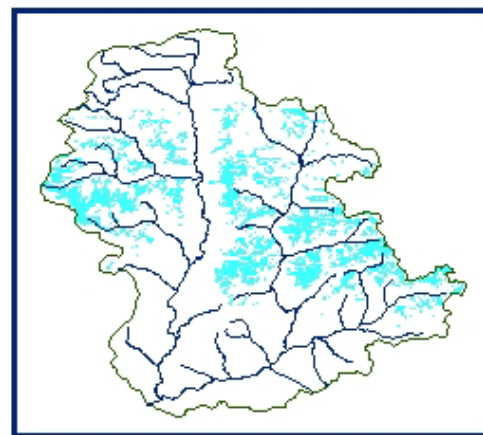
DATA NOT AVAILABLE



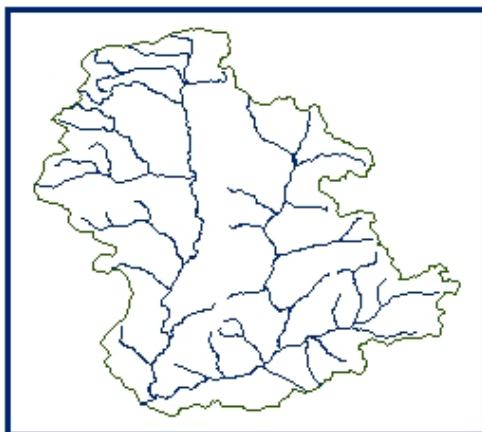
DATA NOT AVAILABLE



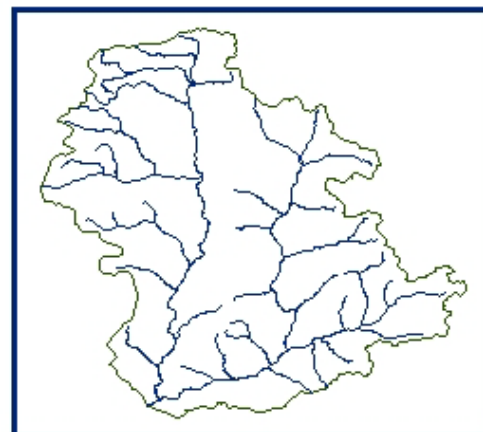
07 APRIL 2013



08 APRIL 2013



DATA NOT AVAILABLE



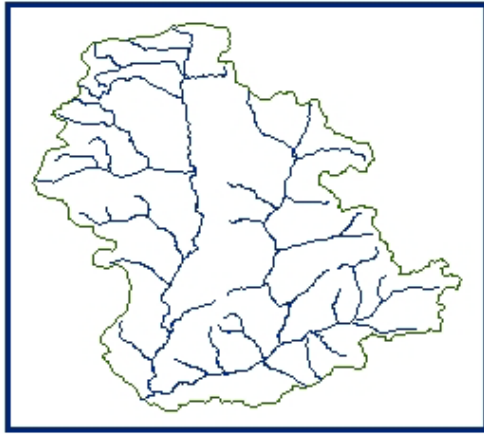
DATA NOT AVAILABLE



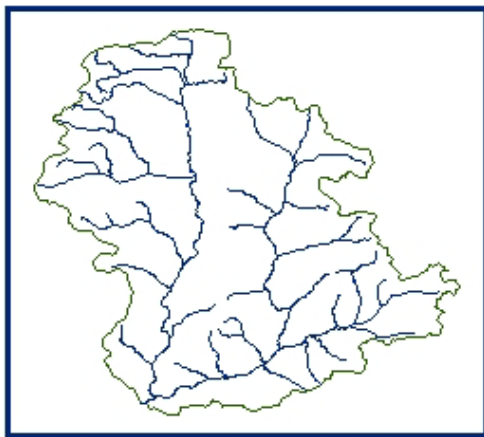
SNOW



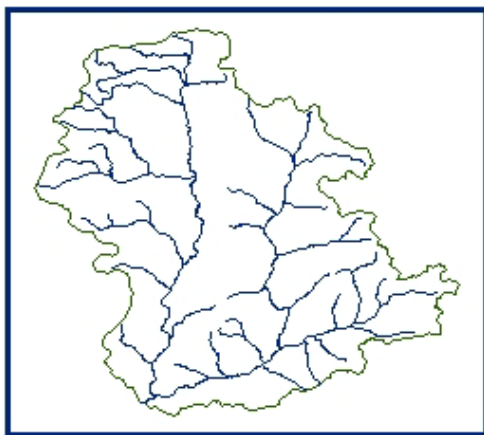
10 DAILY SNOW COVER MAP: TAWANG BASIN



DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE

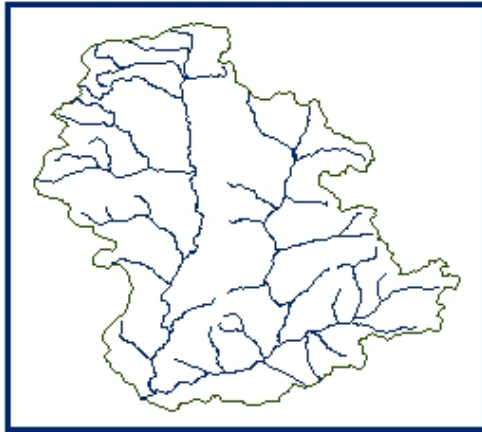


DATA USED
DATA NOT AVAILABLE

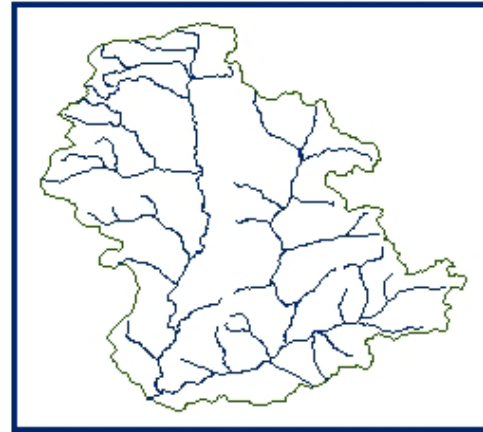


SNOW

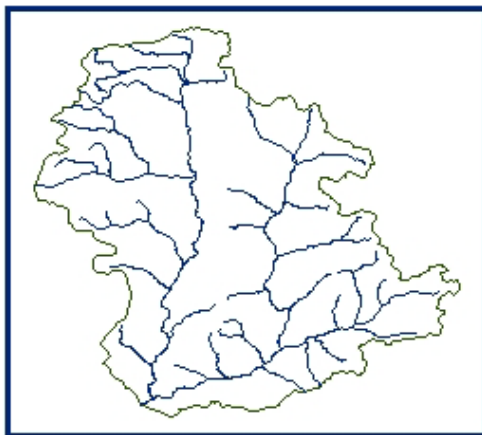




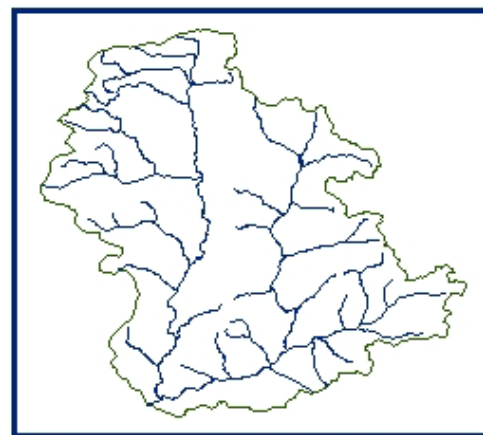
DATA NOT AVAILABLE



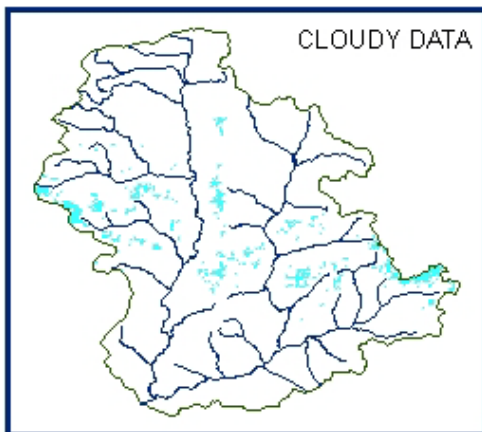
DATA NOT AVAILABLE



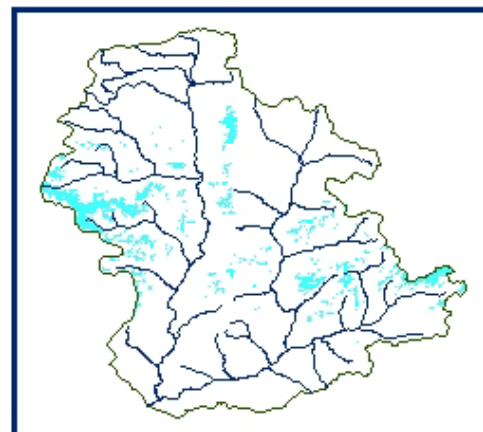
DATA NOT AVAILABLE



DATA NOT AVAILABLE



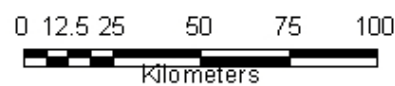
21 MAY 2013



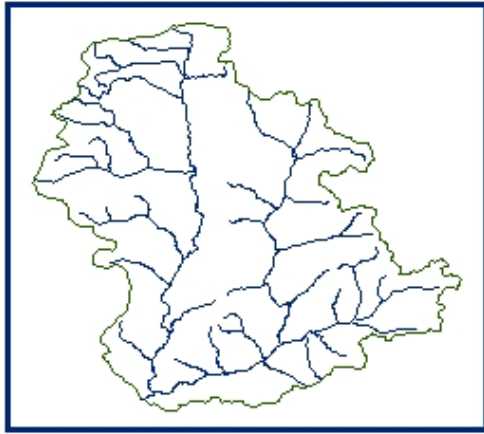
26 MAY 2013



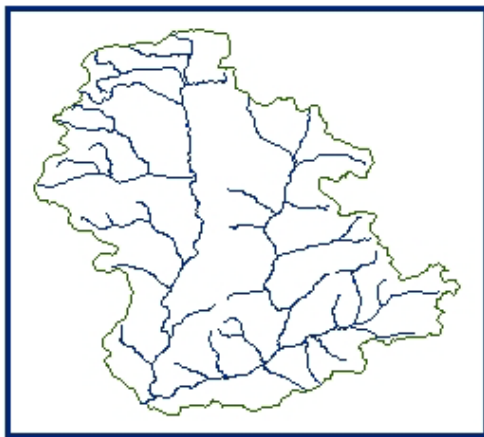
SNOW



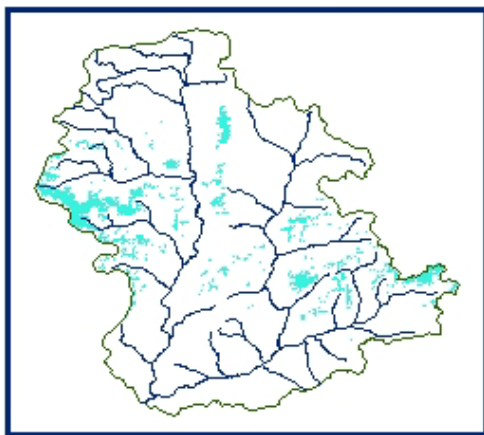
10 DAILY SNOW COVER MAP: TAWANG BASIN



DATA USED
DATA NOT AVAILABLE



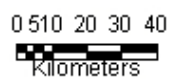
DATA USED
DATA NOT AVAILABLE

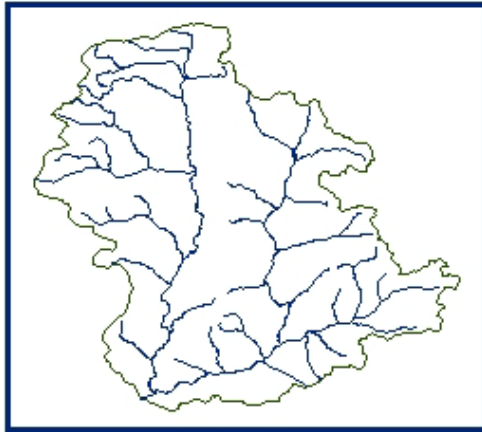


DATA USED
25 MAY 2013

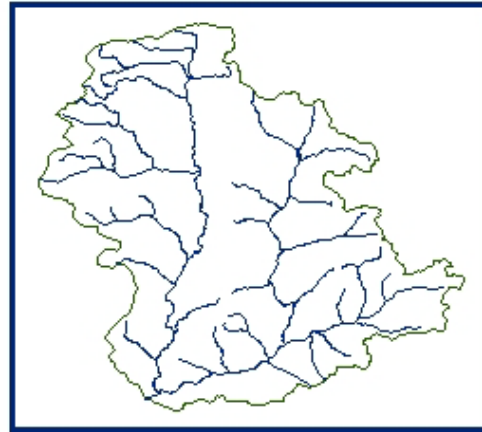


SNOW

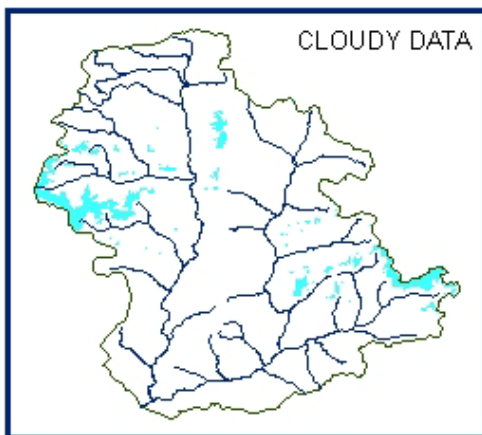




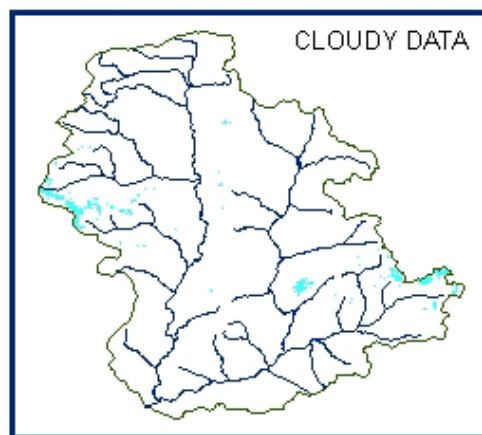
DATA NOT AVAILABLE



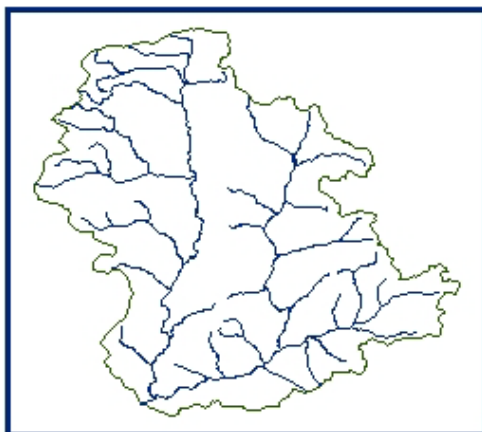
DATA NOT AVAILABLE



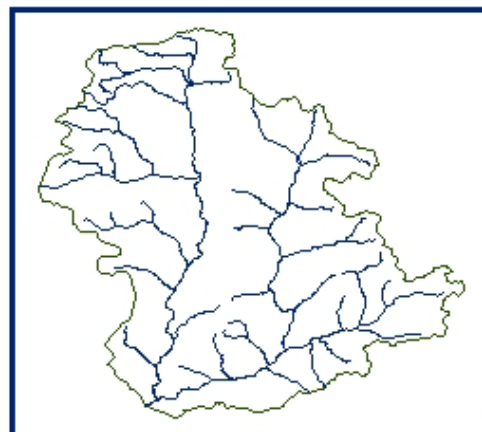
11 JUNE 2013



12 JUNE 2013



DATA NOT AVAILABLE



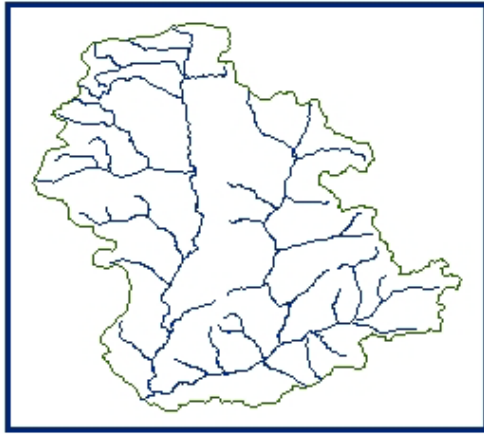
DATA NOT AVAILABLE



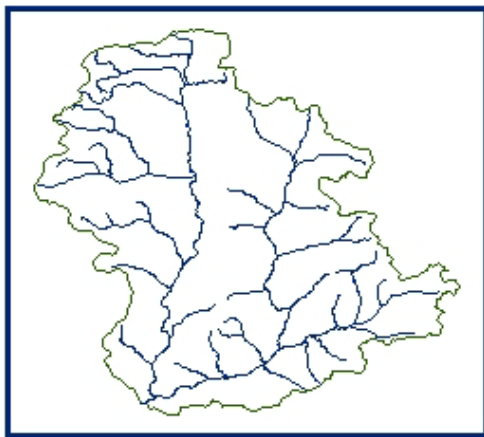
SNOW



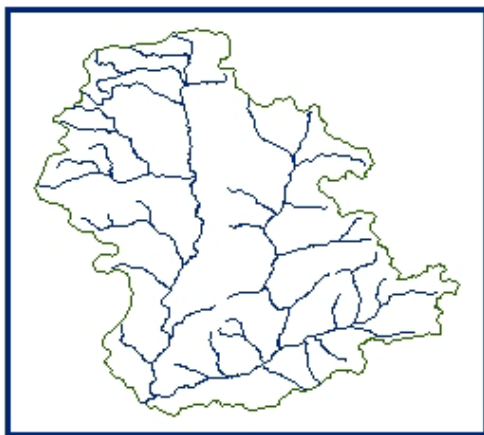
10 DAILY SNOW COVER MAP: TAWANG BASIN



DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE



SNOW

