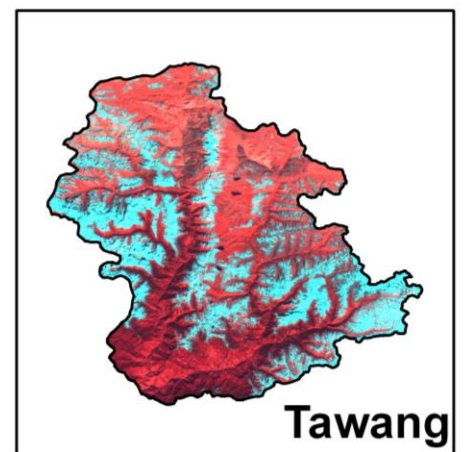
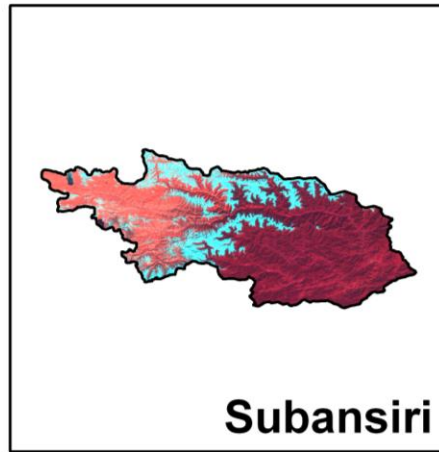
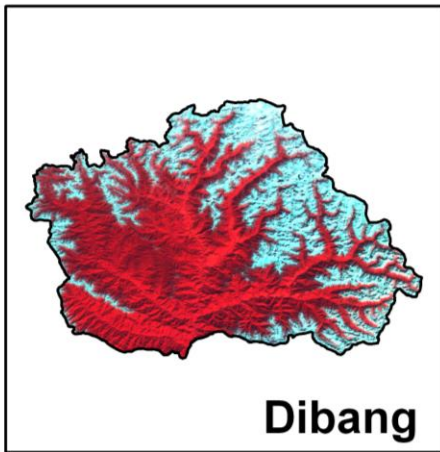


SNOW COVER ATLAS OF BRAHMAPUTRA BASIN

Sub basins: Dibang, Subansiri and Tawang

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

Year : 2013-14



State Remote Sensing Applications Centre
Itanagar, Arunachal Pradesh - 791113

and

Space Applications Centre (ISRO)
Ahmedabad - 380015

March 2015

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SPACE APPLICATIONS CENTRE (ISRO), AHMEDABAD - 380015

DOCUMENT CONTROL AND DATA SHEET

Report Number	SAC/EP SA/GSAG/GSD/SGP/SN/ 106 /2015
Month and year of publication	March 2015
Title	Snow cover Atlas of Brahmaputra basin
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No. of pages	76
No. of figures, Charts & Tables	56, 9 & 6
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Originating Unit	Geo Sciences Division, Geo Science and Applications 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 2013 to June 2014. The sub basins included in this report are Dibang, 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, Dibang, Subansiri and Tawang basins.
Security Classification	Unrestricted
Distribution	Among concerned

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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	30
TAWANG BASIN	52

1. Introduction

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

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

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

2. Study Area:

This Atlas gives distribution of snow cover in three sub-basins of the 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 2013 to June 2014 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:

$$\text{NormalizedDifferenceSnowIndex(NDSI)} = (\text{band2} - \text{band5}) / (\text{band2} + \text{band5}) \quad \dots(1)$$

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

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

5. Snow cover monitoring algorithm

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

6. Results and discussions

In this atlas, basin-wise snow cover statistics, maps, and seasonal depletion curves have been provided from October 2013 to June 2014. Snow ablation pattern varies from basin to basin, depending on area altitude distribution in the basins. Snow cover pattern in the Tawang sub-basin shows accumulation and ablation of snow throughout the winter season. Accumulation starts from January and same time ablation also starts till February first week. 55 % area is covered with snow at February 25, 2014. Ablation starts from March 15 it reaches 25% at march 25, 2014. In Subansiri basin there is not much variation in snow cover area. It varies between 5 % in the month of November and 18% in the month of February and March.. Snow cover depletion curve of Dibang sub-basin also shows accumulation & ablation throughout the season. It varies between 5% in the month of October and 57% in the month of January. It covers above 50% three times i.e. in the month of December, January & February. Overall comparison among the three sub-basins reveal that the percentage of areal extent of snow in Subansiri sub-basin is very less compared to Tawang and Dibang sub-basins. It is also found that accumulation period started early in Dibang sub-basin in mid-December and showed relative stability from 15 December to 15 February 2014 with minor fluctuation in late January and early February 2014.

Acknowledgements

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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.

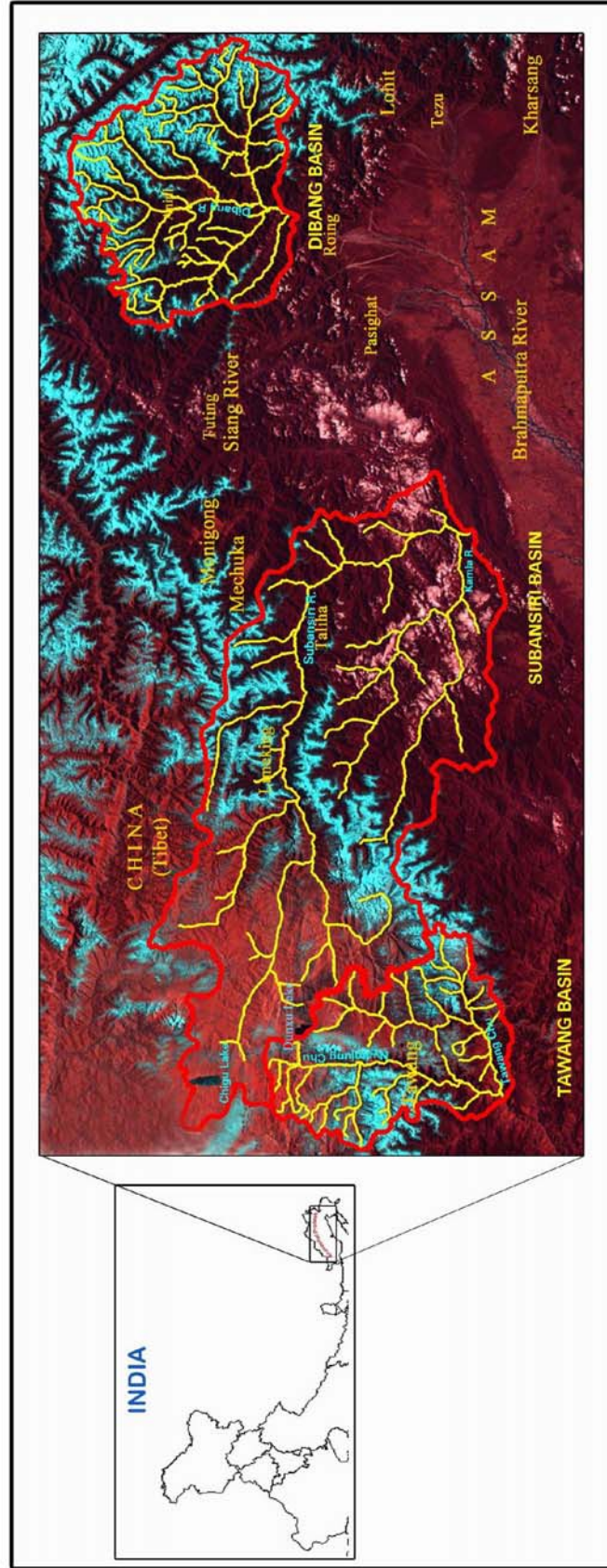


Figure 1: Location map of Dibang, Subansiri and Tawang sub-basins (Part of Brahmaputra basin)

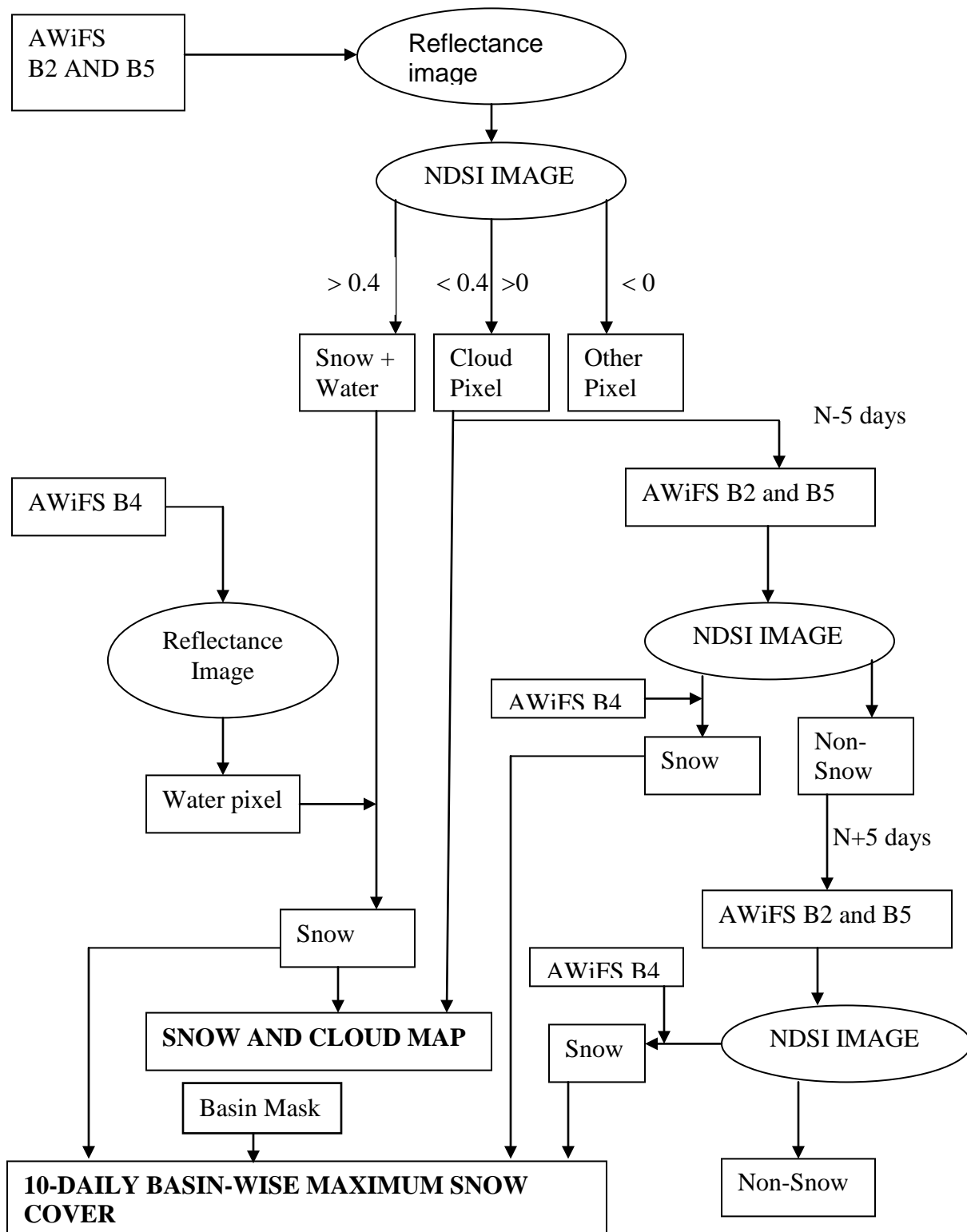


Figure 2: Algorithm for snow cover mapping using AWiFS data

DIBANG SUB-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 2013							
1	8-Oct-13	493	5	3	24-Oct-13	2264	25
2	12-Oct-13	110	1				
November 2013							
4	5-Nov-13	3919	43	7	20-Nov-13	1770	19
5	10-Nov-13	3022	33	8	25-Nov-13	1500	16
6	15-Nov-13	2295	25				
December 2013							
9	16-Dec-13	4967	54	12	28-Dec-13	6	7
10	19-Dec-13	1588	17	13	31-Dec-13	2788	30
11	21-Dec-13	3504	38				
January 2014							
14	2-Jan-14	1355	15	18	21-Jan-14	2875	31
15	4-Jan-14	2354	26	19	24-Jan-14	2937	32
16	9-Jan-14	5226	57	20	26-Jan-14	2403	26
17	17-Jan-14	3377	37				
February 2014							
21	2-Feb-14	2704	30	22	19-Feb-14	5119	56
March 2014							
23	10-Mar-14	1714	19	25	17-Mar-14	2485	27
24	15-Mar-14	3785	41	26	25-Mar-14	1475	16
April 2014							
27	22-April-14	815	9	28	30-April-14	3466	38
May 2014							
29	24-May-14	1179	13	30	31-May-14	1648	18
June 2014							
31	17-June-14	418	5				

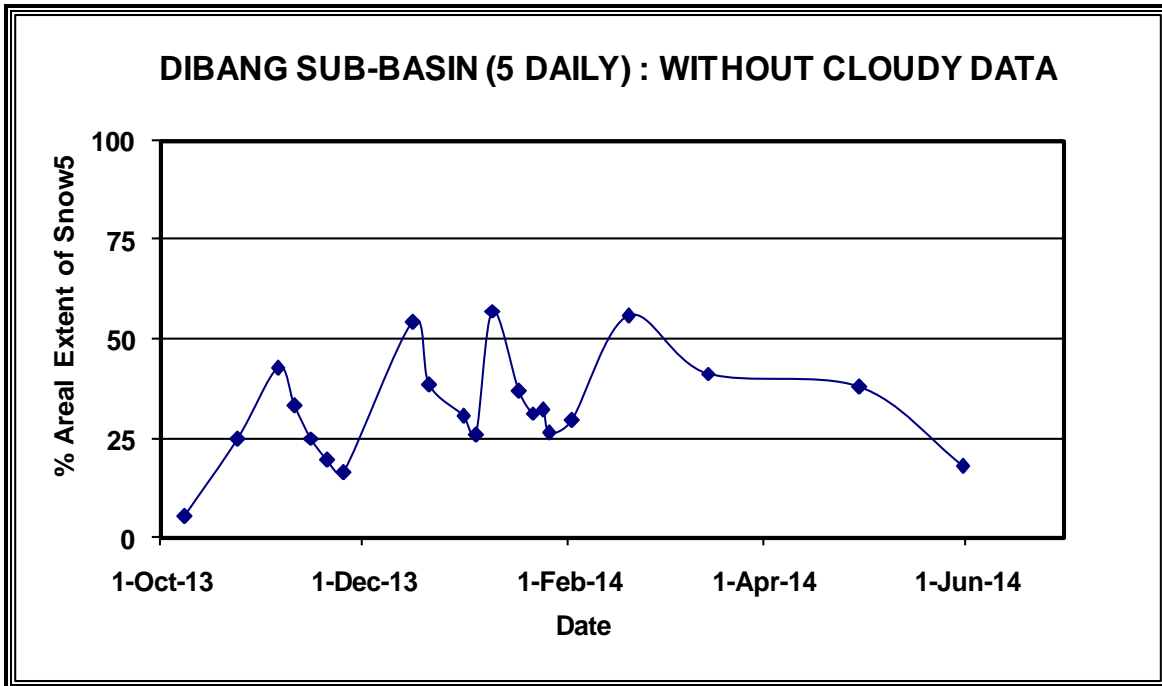
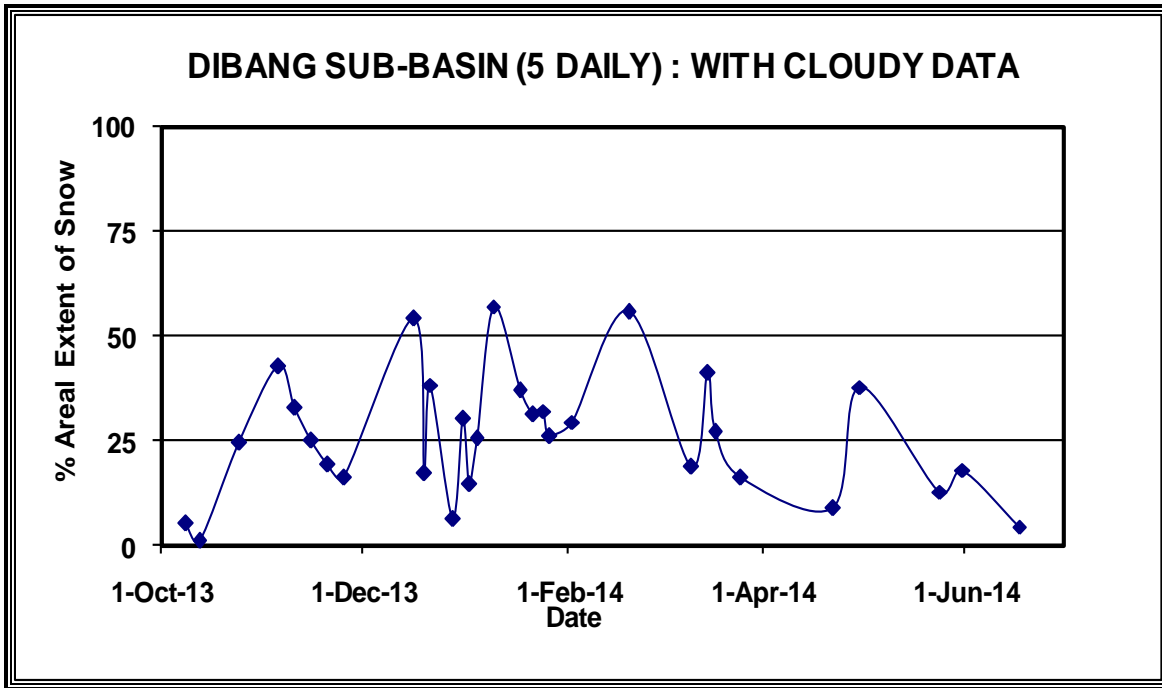
AREAL EXTENT OF SNOW (10 DAILY)

BASIN NAME: DIBANG

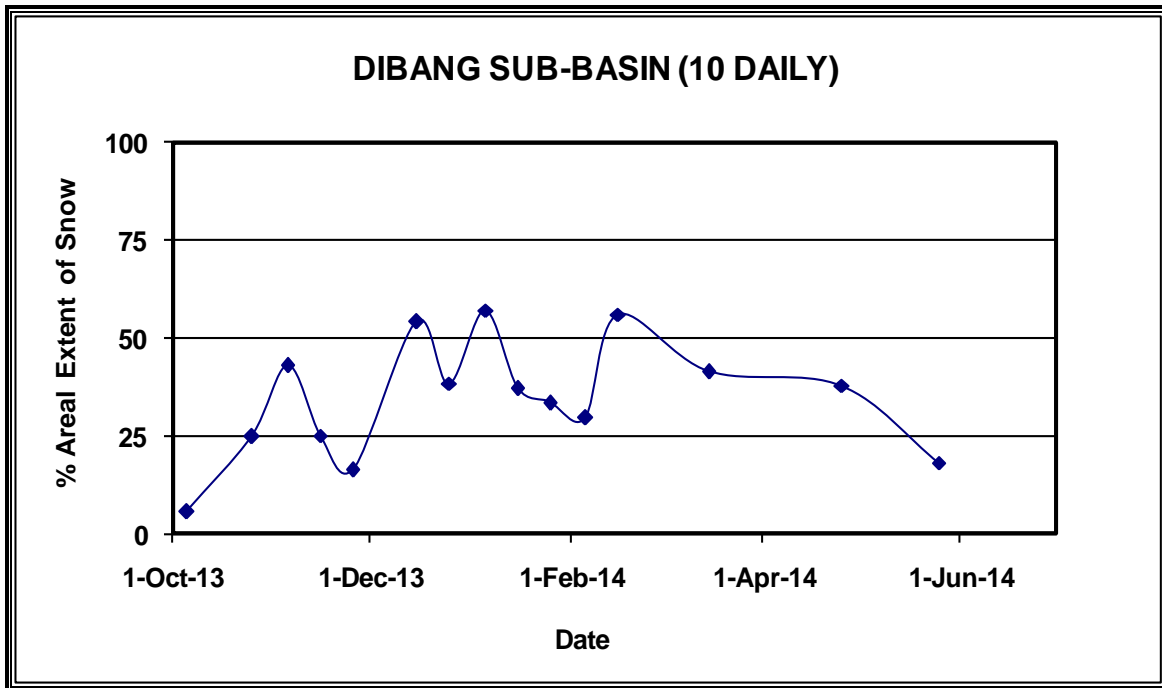
BASIN AREA: 9158 sq km

S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2013				November 2013			
1	5-Oct-13	493	5	3	5-Nov-13	3919	43
2	25-Oct-13	2264	25	4	15-Nov-13	2295	25
				5	25-Nov-13	1500	16
December 2013				January 2014			
6	15-Dec-13	4967	54	8	5-Jan-14	5226	57
7	25-Dec-13	3504	38	9	15-Jan-14	3377	37
				10	25-Jan-14	3062	33
February 2014				March 2014			
11	5-Feb-14	2704	30	13	15-Mar-14	3785	41
12	15-Feb-14	5119	56				
April 2014				May 2014			
14	25-Apr-14	3466	38	15	25-May-14	1648	18
June 2014							
16	15-June-14	CLOUDY DATA					

SNOW COVER DEPLETION CURVE

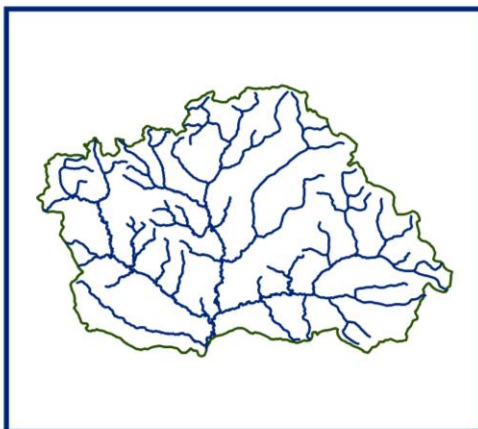


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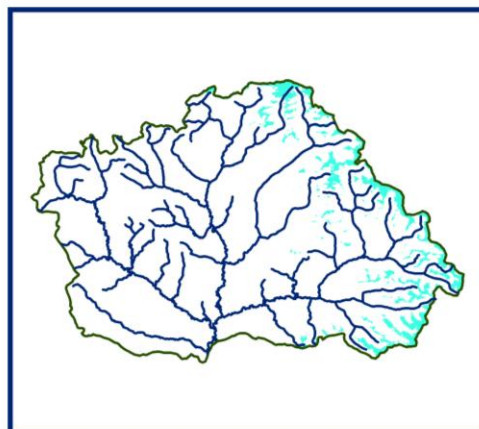


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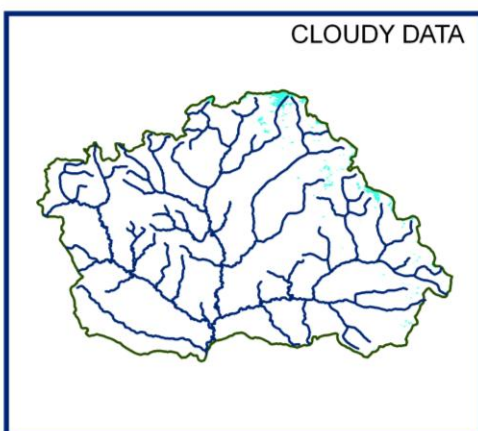
SNOW COVER MAP : DIBANG BASIN



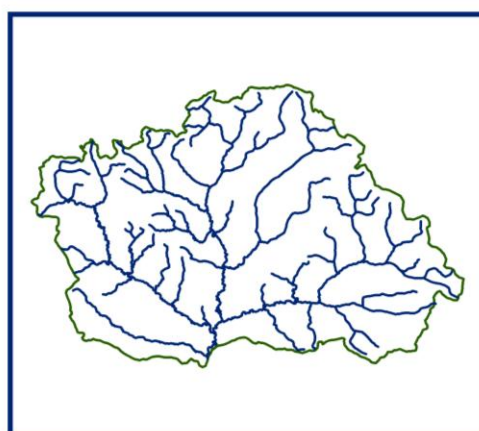
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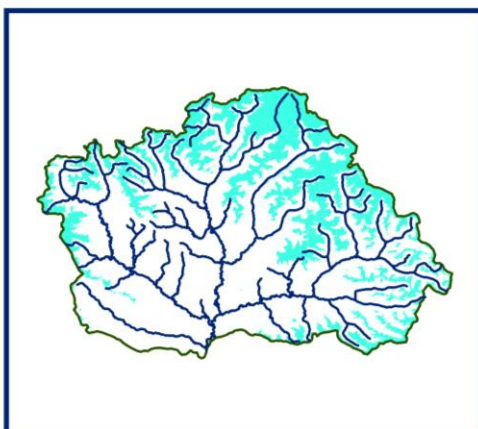
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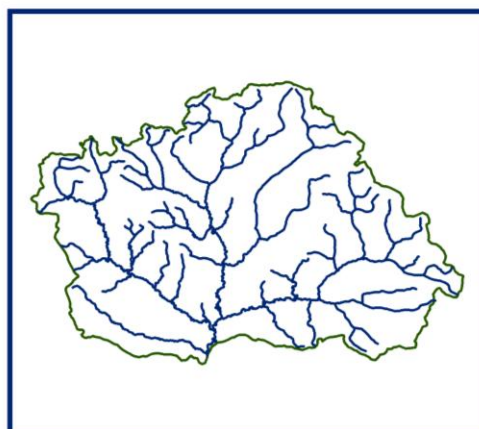
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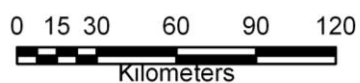
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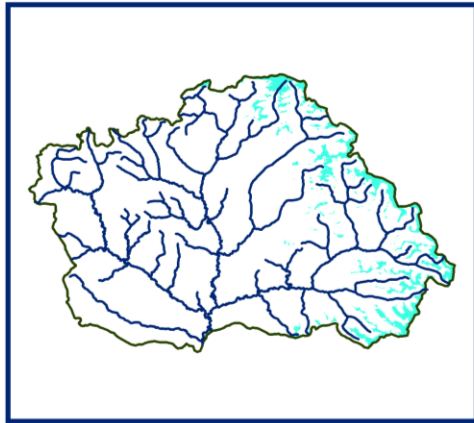
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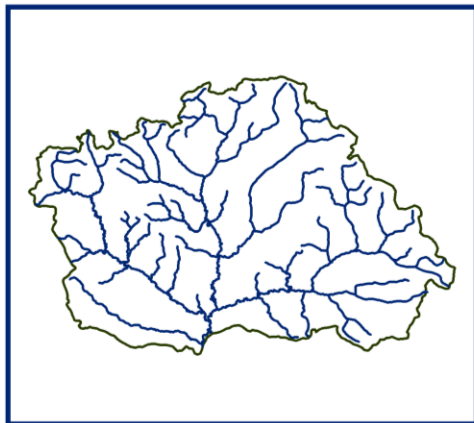
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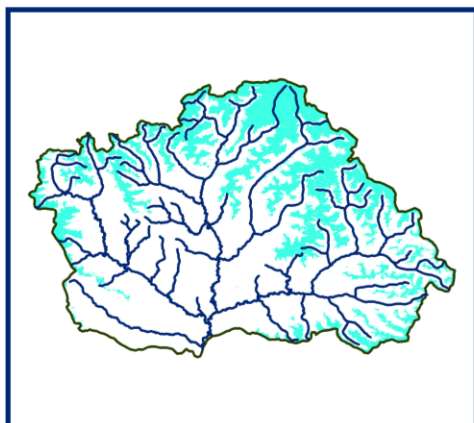
10 DAILY SNOW COVER MAP: DIBANG BASIN



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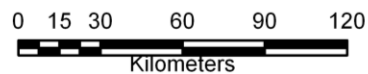
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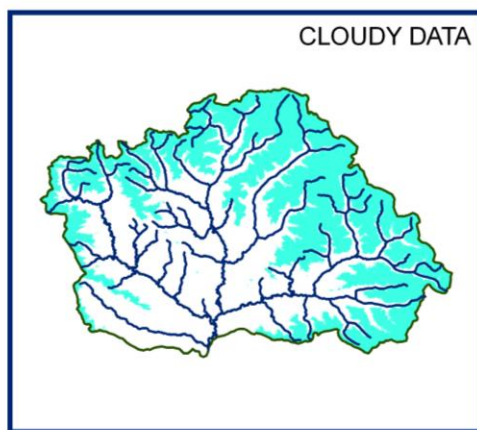
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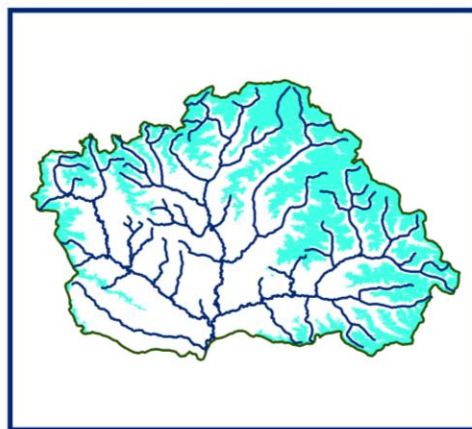
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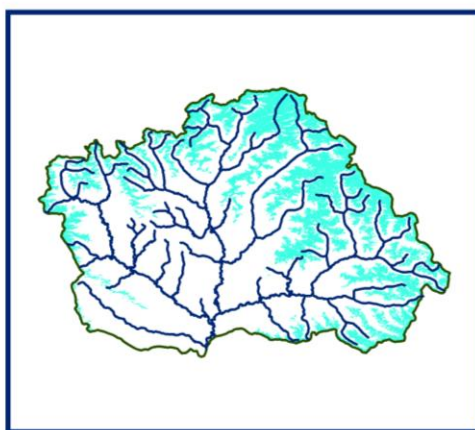
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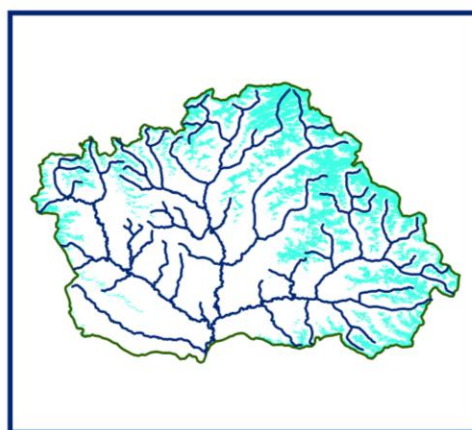
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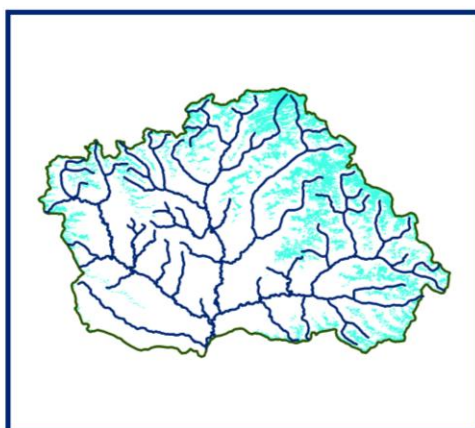
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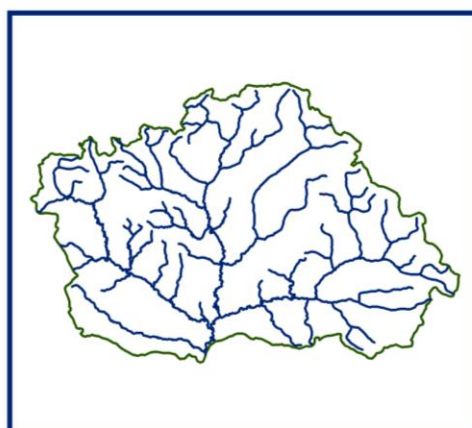
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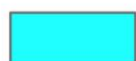
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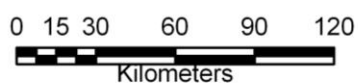
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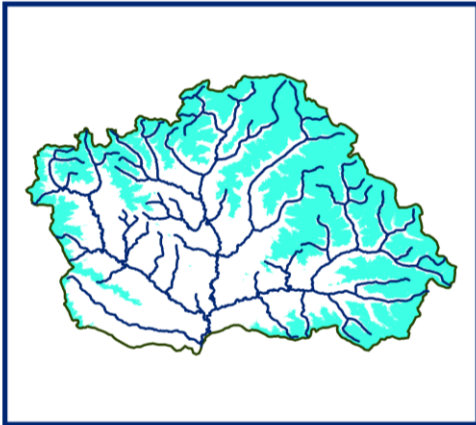
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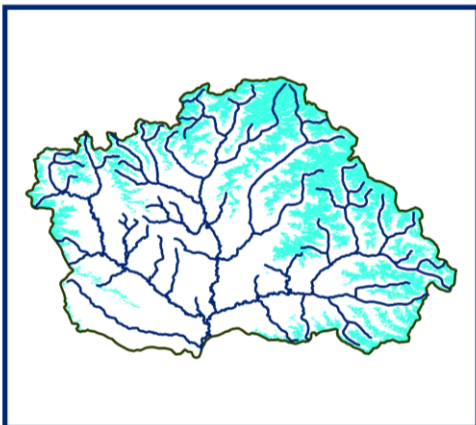
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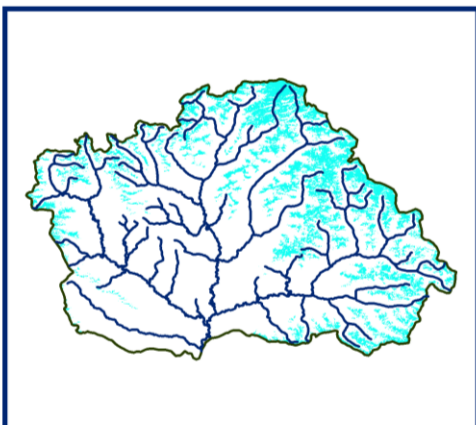
10 DAILY SNOW COVER MAP: DIBANG BASIN



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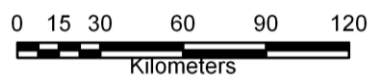
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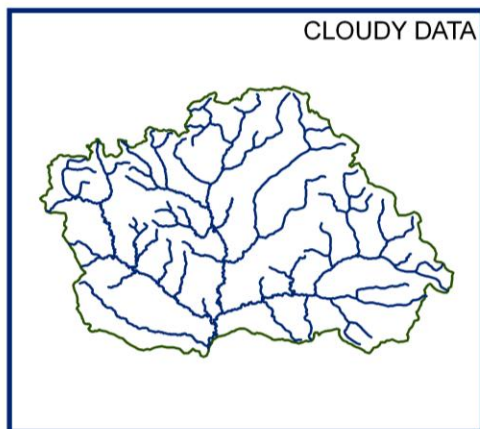
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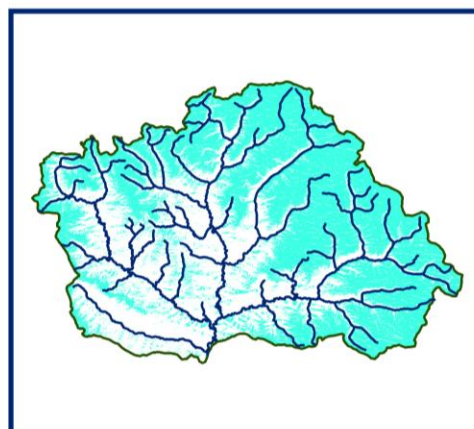
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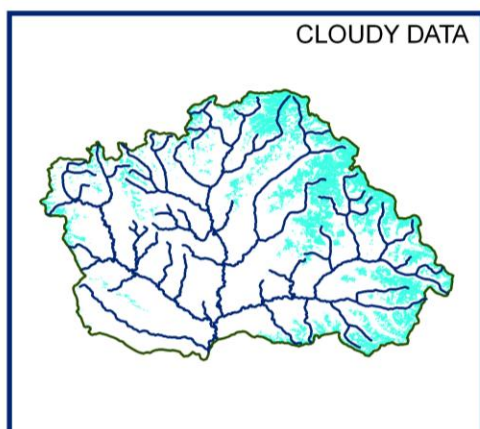
SNOW COVER MAP : DIBANG BASIN



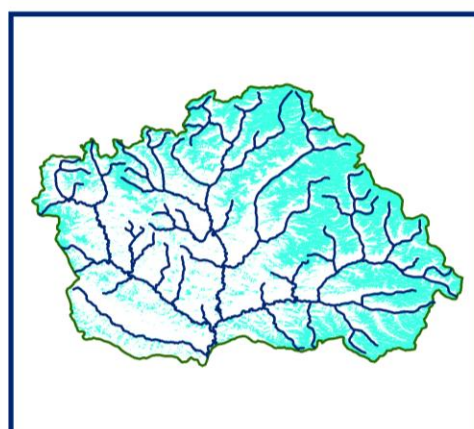
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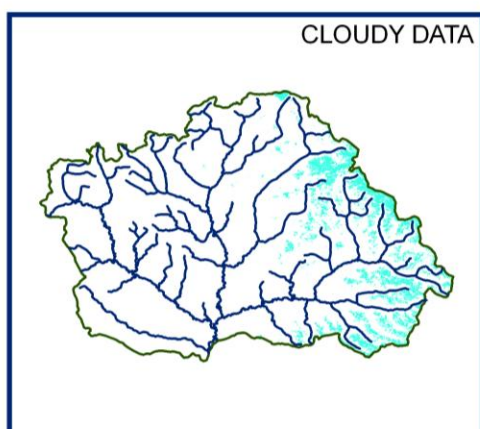
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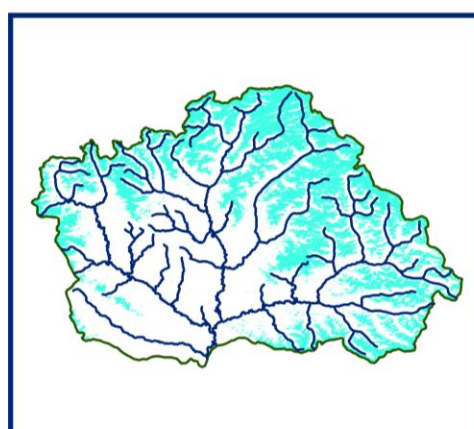
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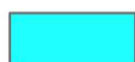
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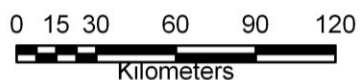
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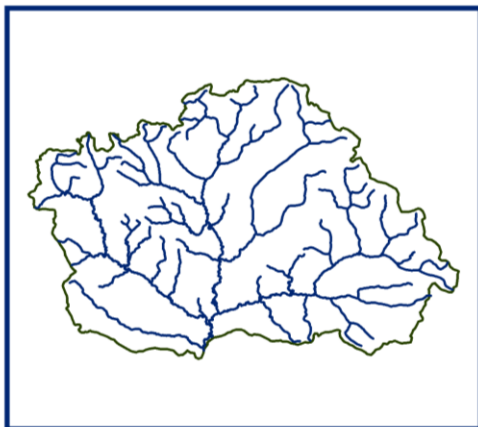
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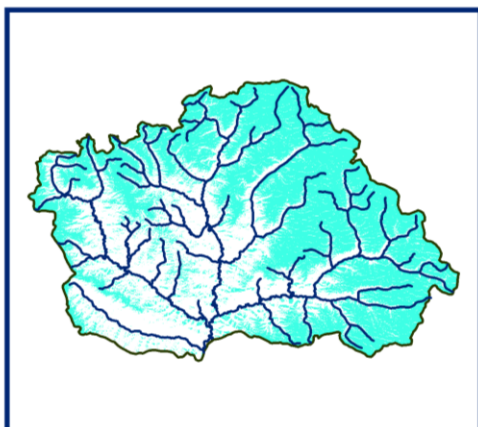
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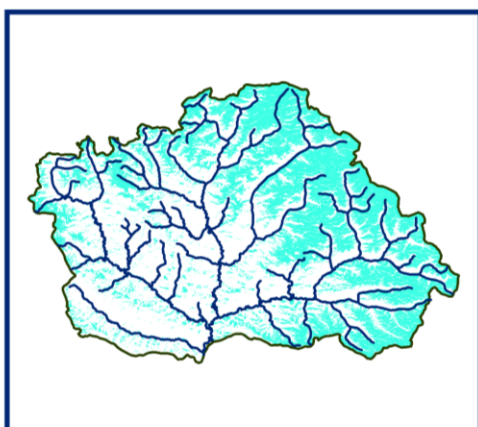
10 DAILY SNOW COVER MAP: DIBANG BASIN



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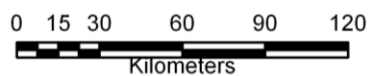
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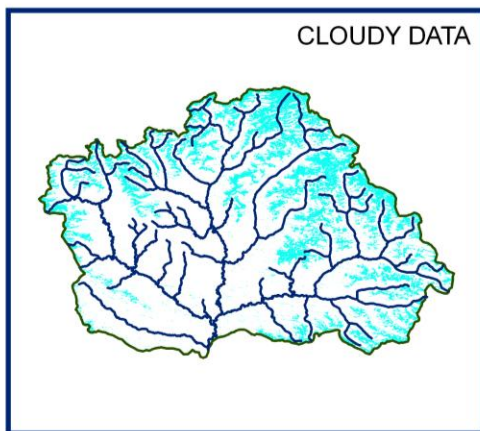
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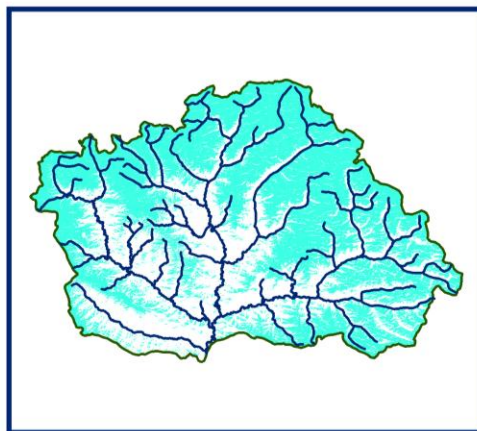
SNOW



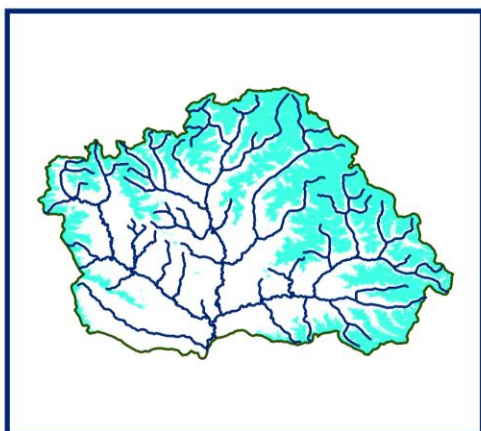
SNOW COVER MAP : DIBANG BASIN



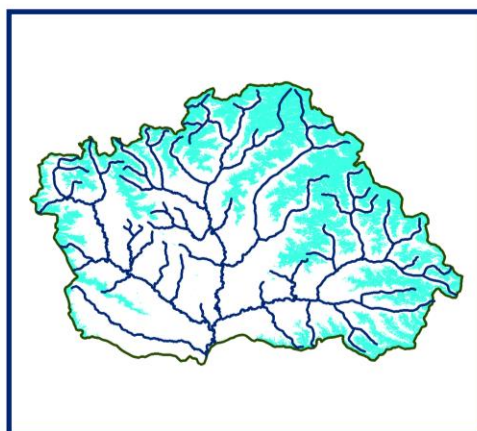
04 JANUARY 2014



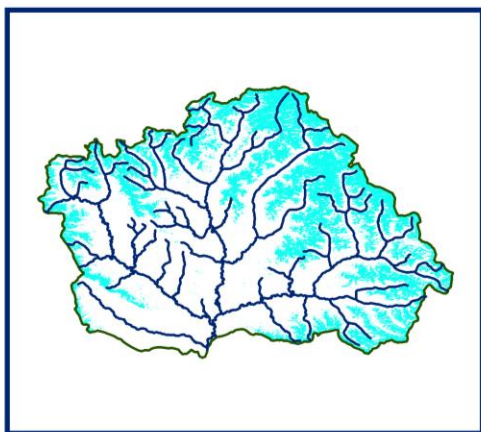
09 JANUARY 2014



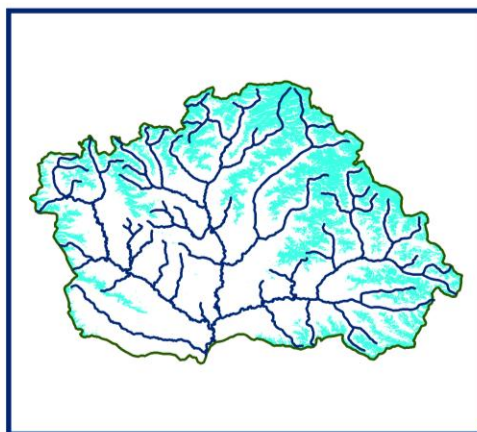
17 JANUARY 2014



21 JANUARY 2014



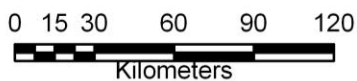
24 JANUARY 2014



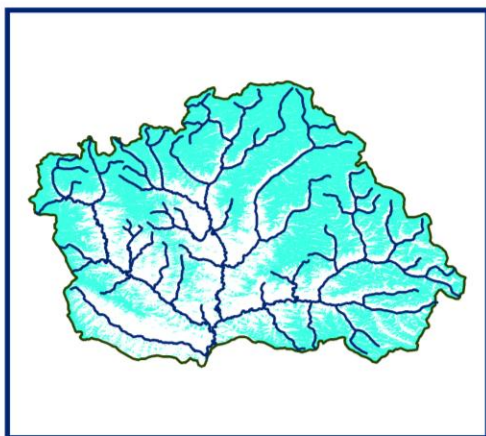
26 JANUARY 2014



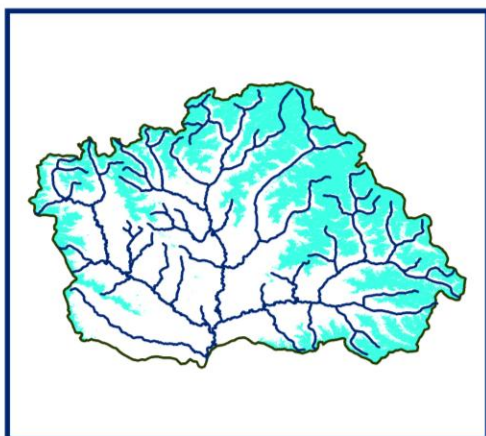
SNOW



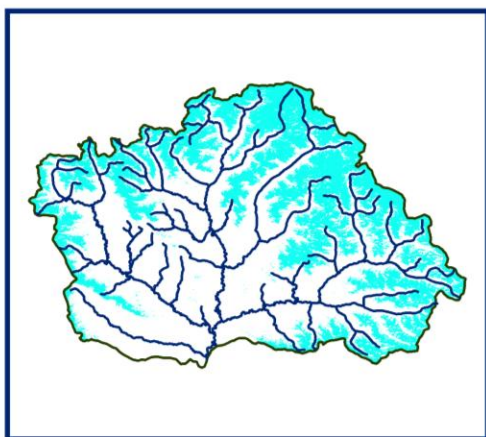
10 DAILY SNOW COVER MAP: DIBANG BASIN



DATA USED
05 JANUARY 2014



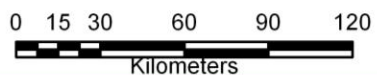
DATA USED
15 JANUARY 2014



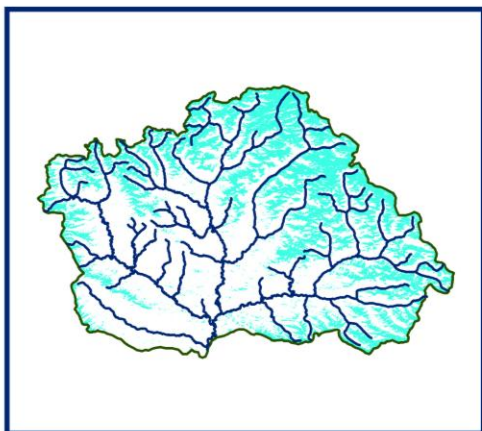
DATA USED
21 JANUARY 2014
24 JANUARY 2014
26 JANUARY 2014



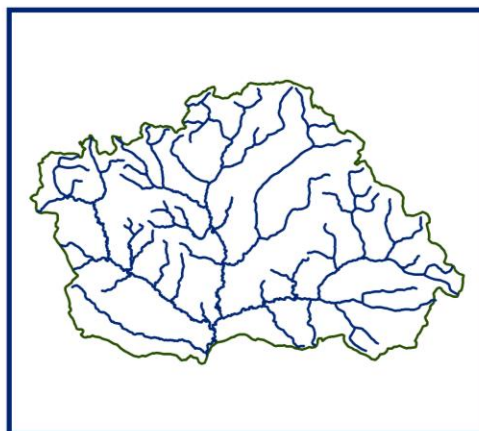
SNOW



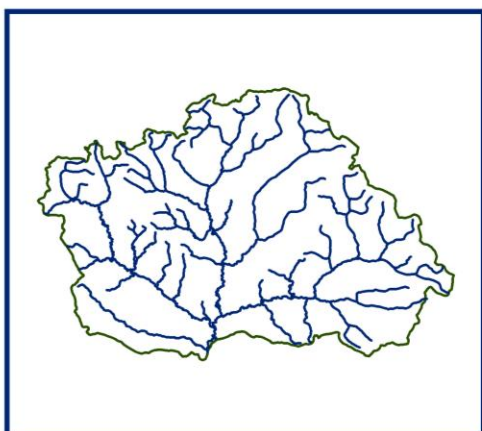
SNOW COVER MAP : DIBANG BASIN



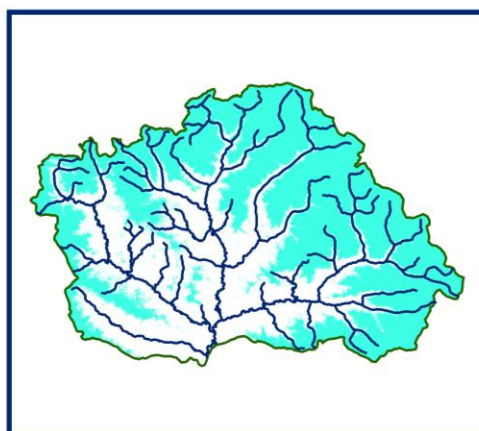
02 FEBRUARY 2014



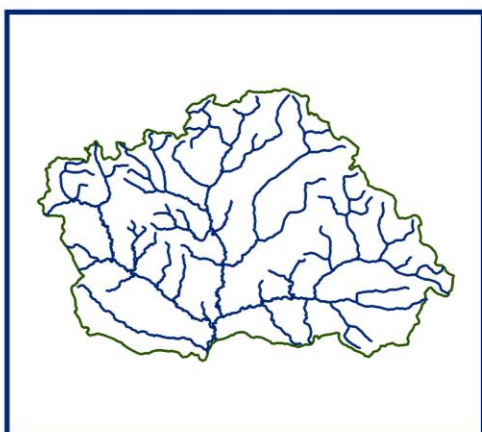
DATA NOT AVAILABLE



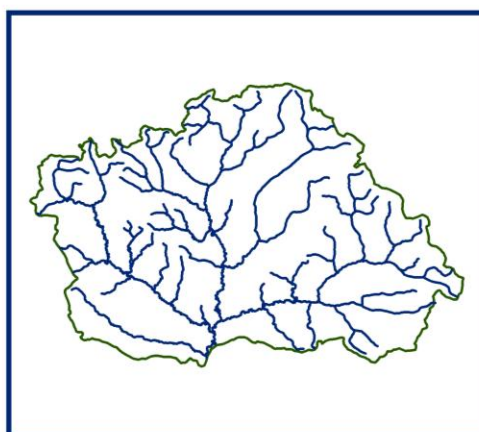
DATA NOT AVAILABLE



19 FEBRUARY 2014



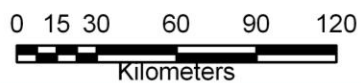
DATA NOT AVAILABLE



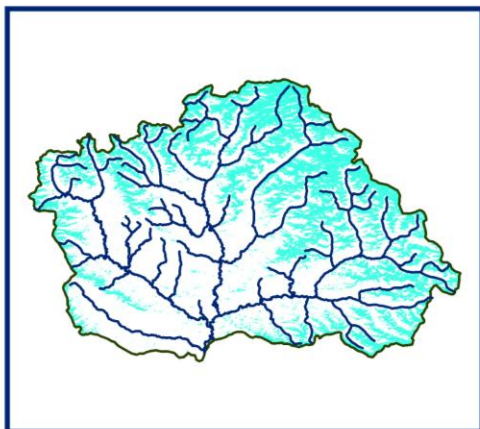
DATA NOT AVAILABLE



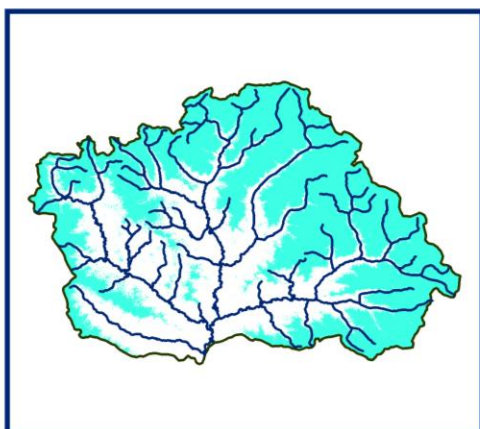
SNOW



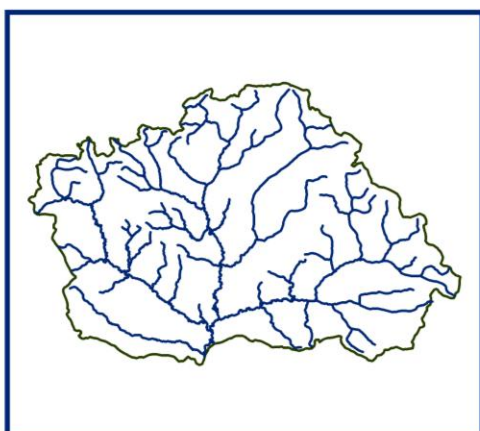
10 DAILY SNOW COVER MAP: DIBANG BASIN



DATA USED
05 FEBRUARY 2014



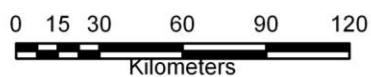
DATA USED
15 FEBRUARY 2014



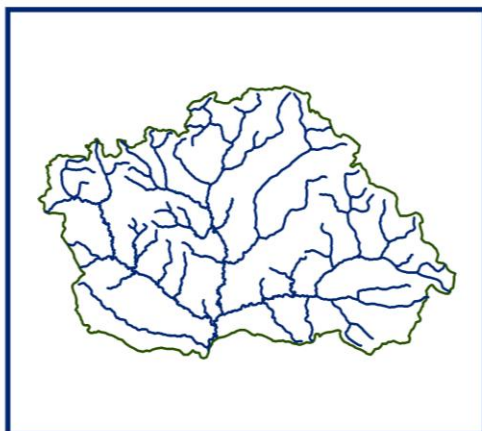
DATA USED
DATA NOT AVAILABLE



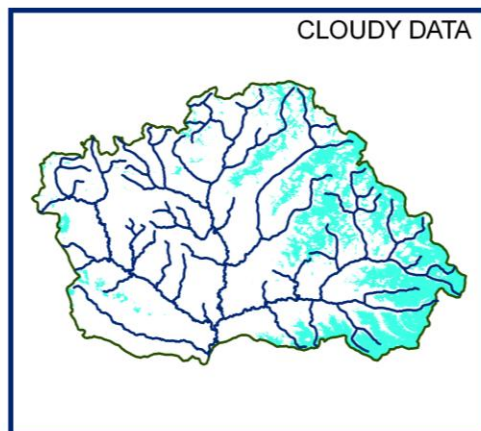
SNOW



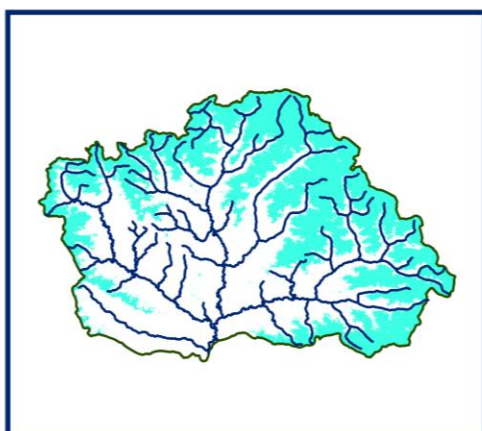
SNOW COVER MAP : DIBANG BASIN



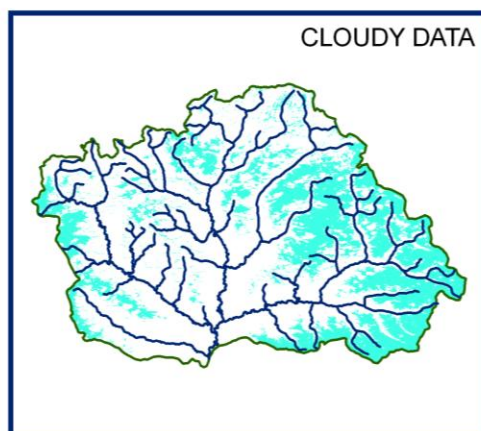
DATA NOT AVAILABLE



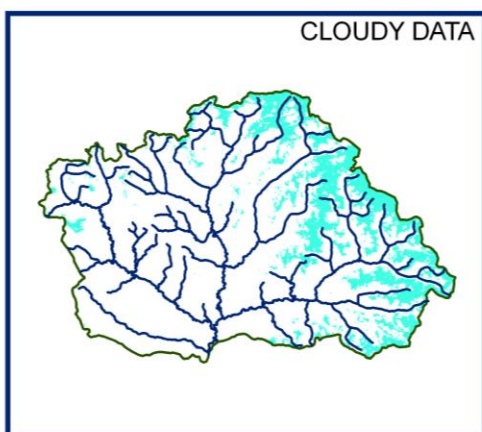
10 MARCH 2014



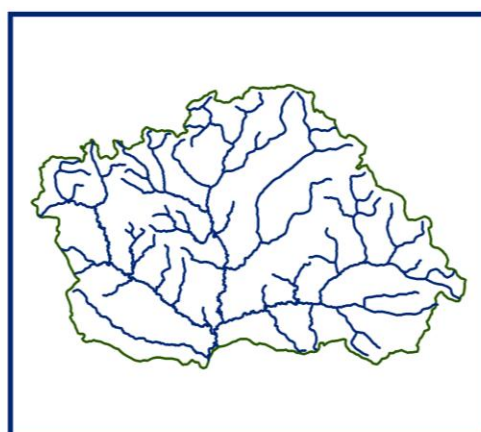
15 MARCH 2014



17 MARCH 2014



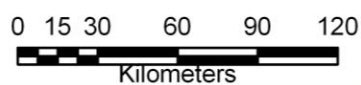
25 MARCH 2014



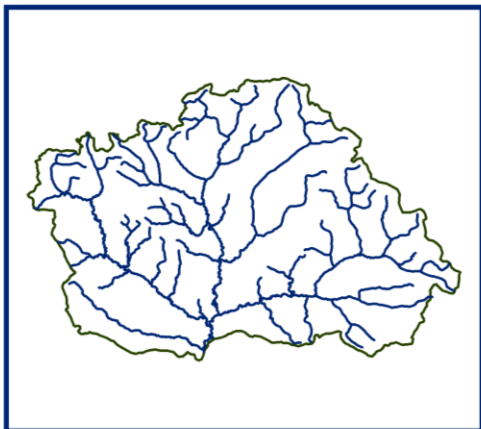
DATA NOT AVAILABLE



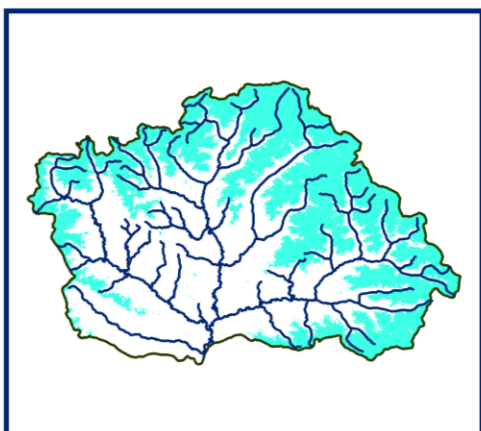
SNOW



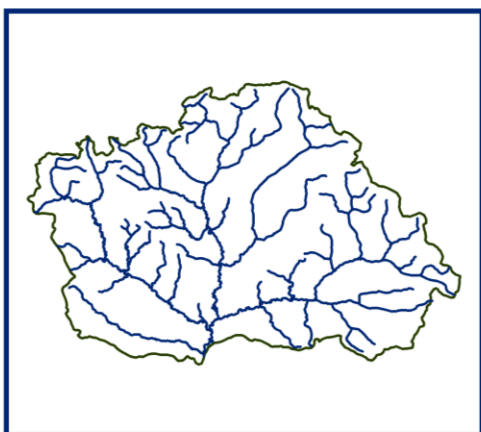
10 DAILY SNOW COVER MAP: DIBANG BASIN



DATA USED
DATA NOT AVAILABLE



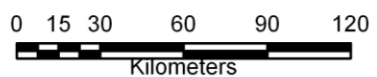
DATA USED
15 MARCH 2014



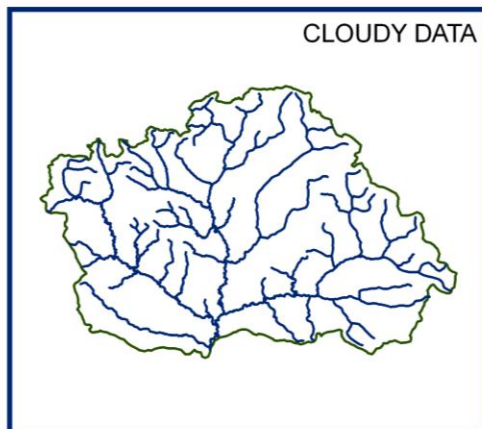
DATA USED
DATA NOT AVAILABLE



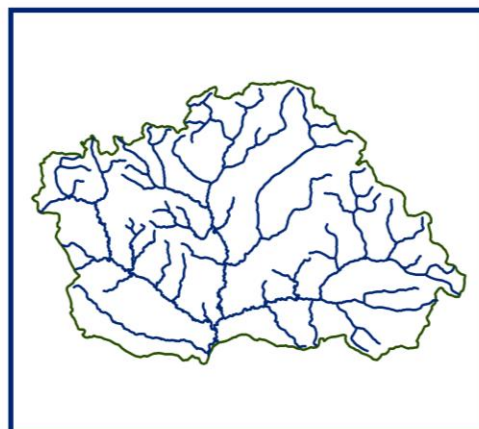
SNOW



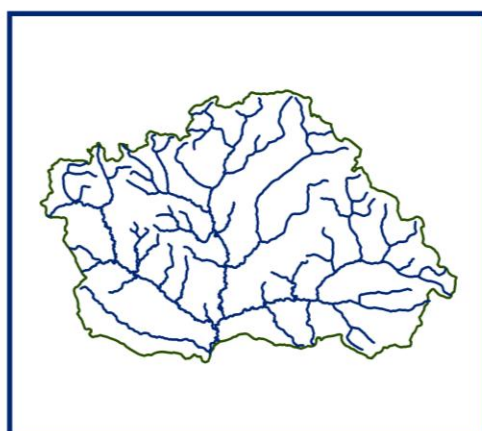
SNOW COVER MAP : DIBANG BASIN



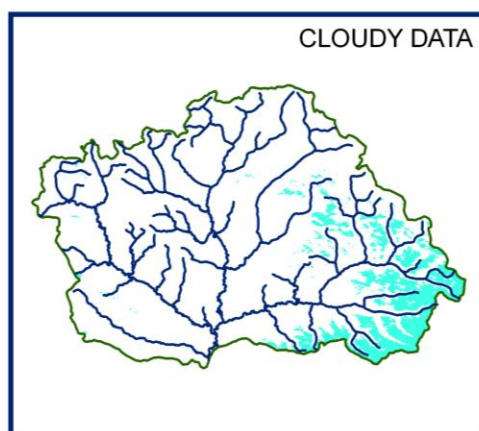
03 APRIL 2014



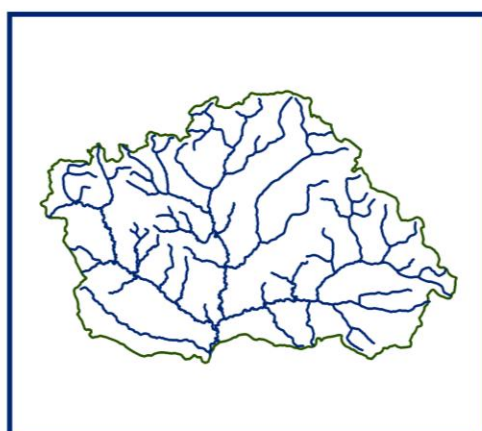
DATA NOT AVAILABLE



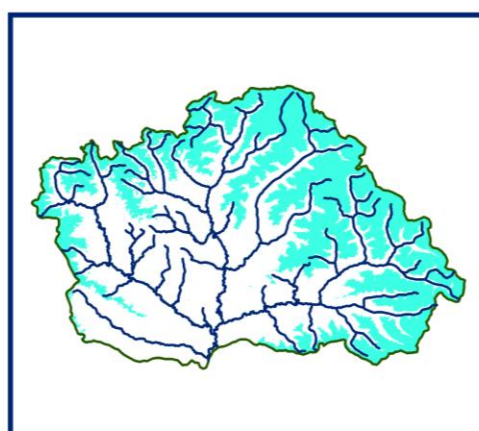
DATA NOT AVAILABLE



22 APRIL 2014



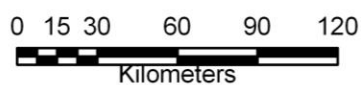
DATA NOT AVAILABLE



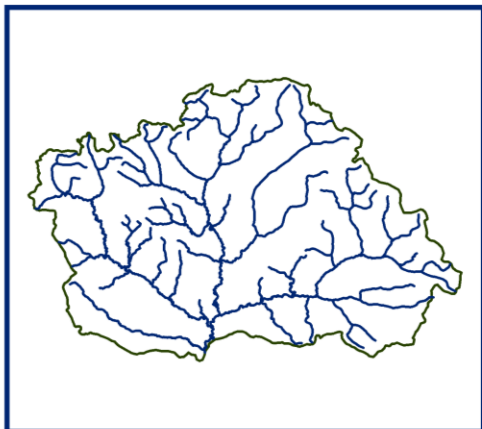
30 APRIL 2014



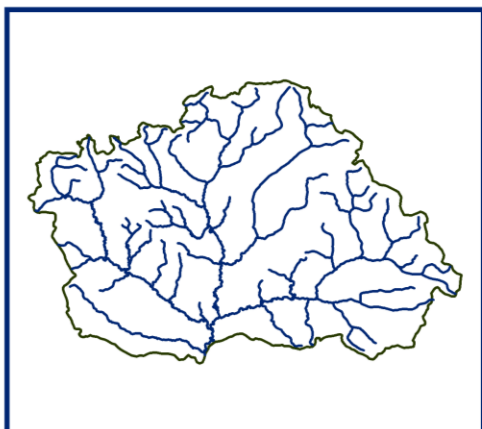
SNOW



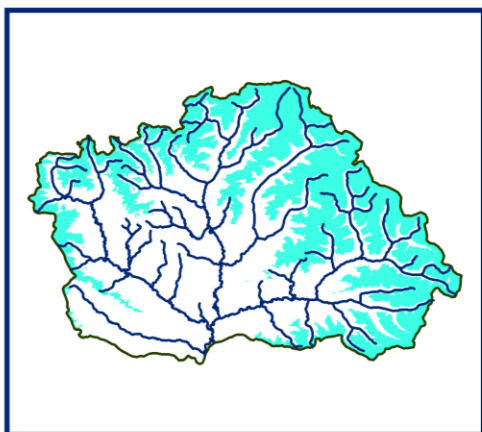
10 DAILY SNOW COVER MAP: DIBANG BASIN



DATA USED
DATA NOT AVAILABLE



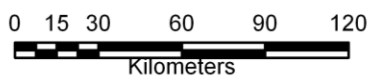
DATA USED
DATA NOT AVAILABLE



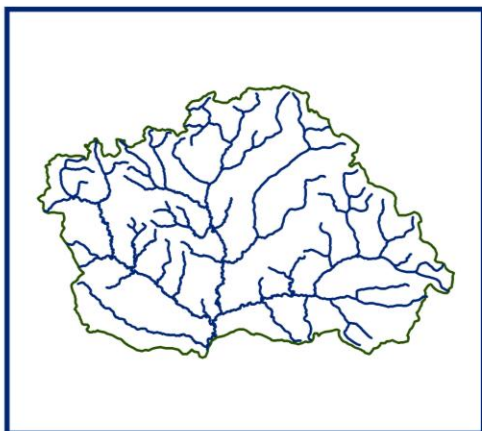
DATA USED
25 APRIL 2014



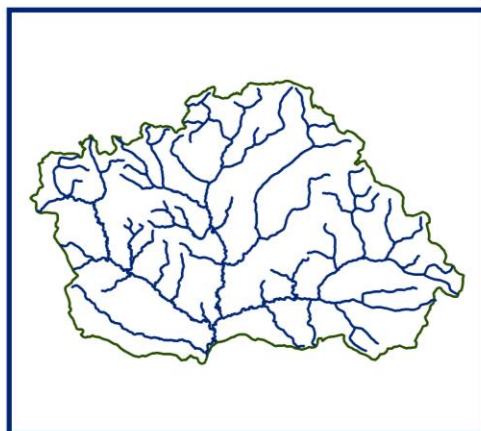
SNOW



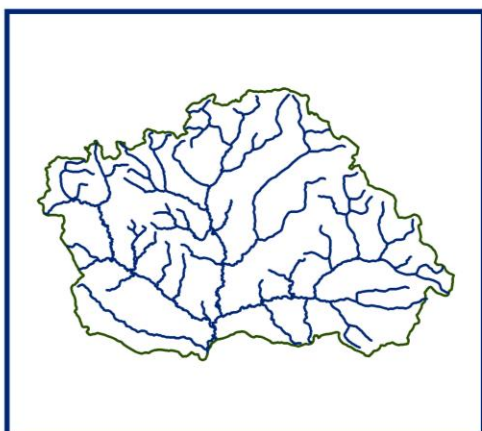
SNOW COVER MAP : DIBANG BASIN



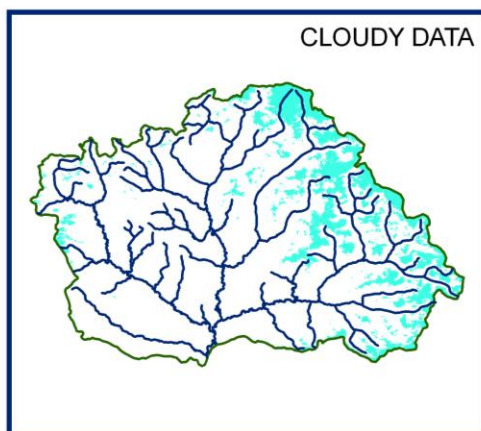
DATA NOT AVAILABLE



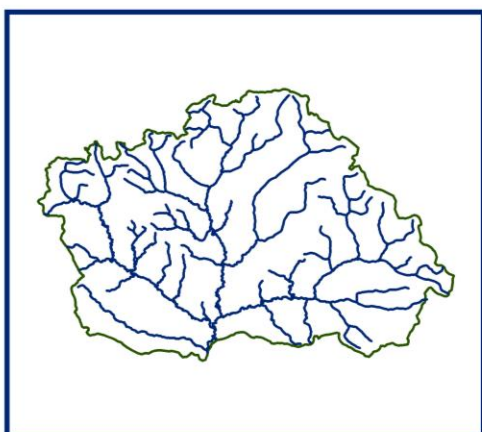
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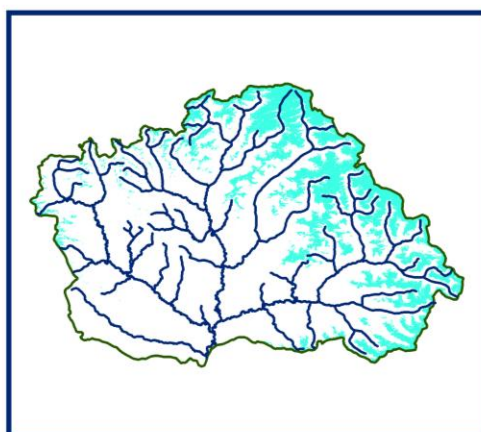
DATA NOT AVAILABLE



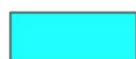
24 MAY 2014



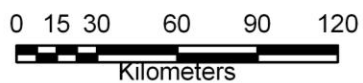
DATA NOT AVAILABLE



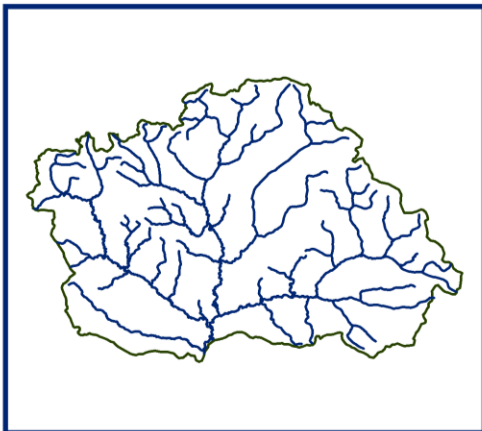
31 MAY 2014



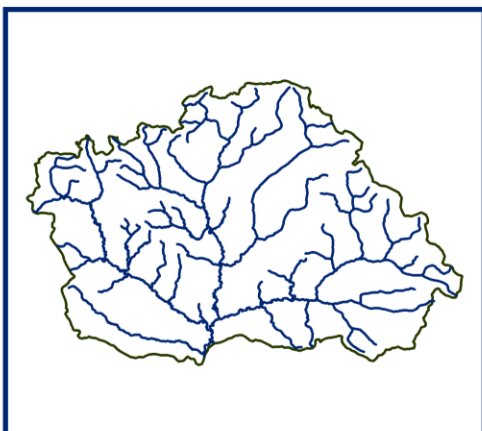
SNOW



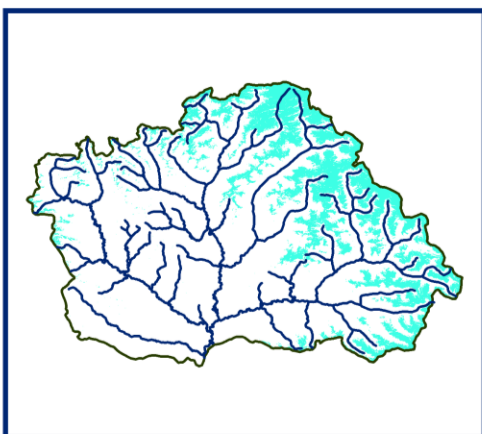
10 DAILY SNOW COVER MAP: DIBANG BASIN



DATA USED
DATA NOT AVAILABLE



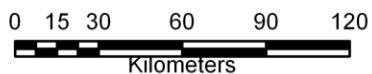
DATA USED
DATA NOT AVAILABLE



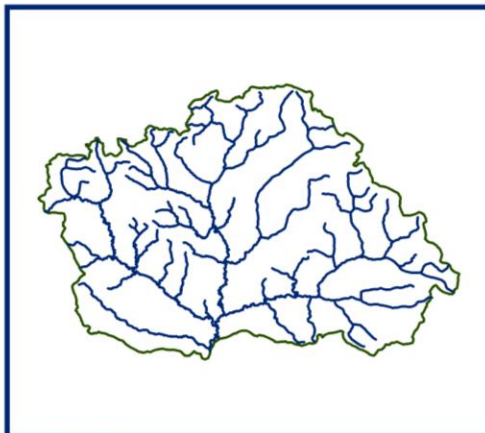
DATA USED
25 MAY 2014



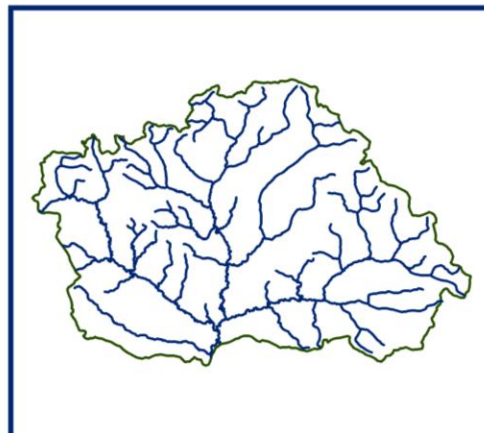
SNOW



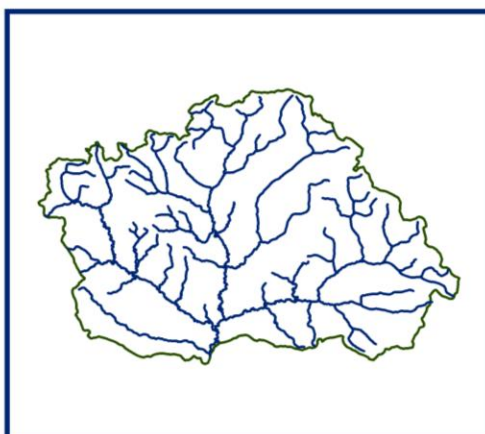
SNOW COVER MAP : DIBANG BASIN



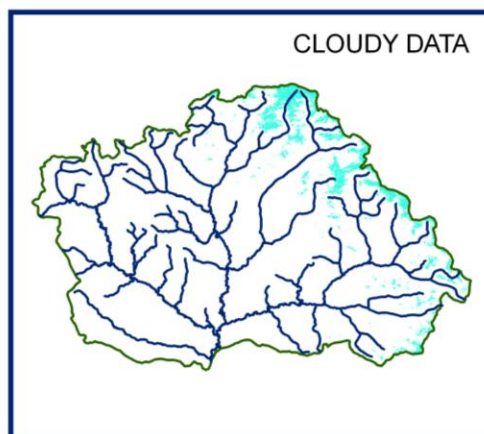
DATA NOT AVAILABLE



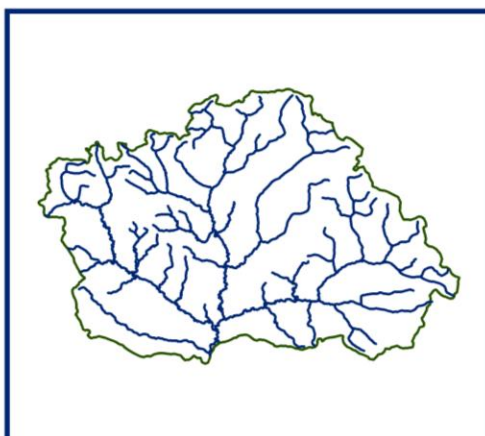
DATA NOT AVAILABLE



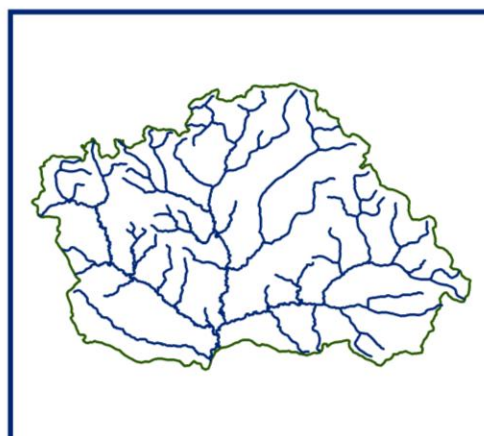
DATA NOT AVAILABLE



17 JUNE 2014



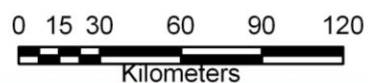
DATA NOT AVAILABLE



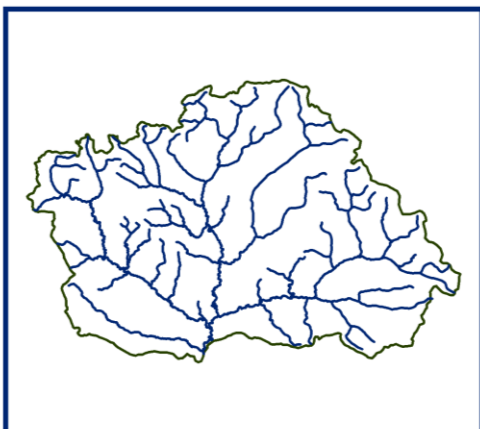
DATA NOT AVAILABLE



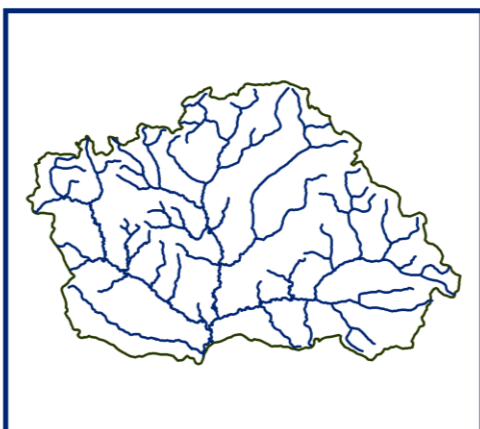
SNOW



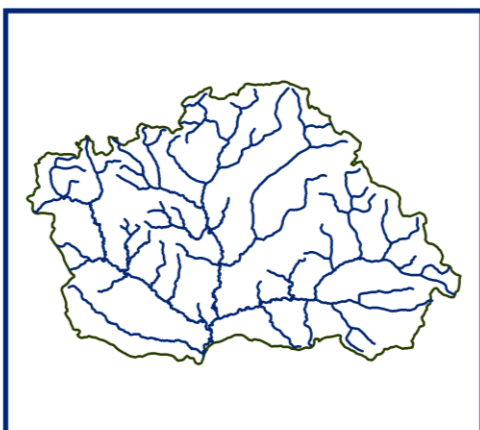
10 DAILY SNOW COVER MAP: DIBANG BASIN



DATA USED
DATA NOT AVAILABLE



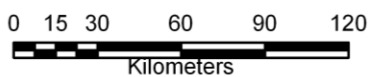
DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE



SNOW



SUBANSIRI SUB-BASIN

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 2013							
1	12-Oct-13	1684	7	2	26-Oct-13	758	3
November 2013							
3	5-Nov-13	2690	11	6	19-Nov-13	1313	5
4	10-Nov-13	1949	8	7	24-Nov-13	1407	6
5	15-Nov-13	1265	5	8	29-Nov-13	728	3
December 2013							
9	9-Dec-13	590	2	12	25-Dec-13	1944	8
10	16-Dec-13	4473	18	13	28-Dec-13	523	2
11	18-Dec-13	2369	9	14	30-Dec-13	1796.18	7
January 2014							
15	2-Jan-14	802	3	18	23-Jan-14	1807	7
16	9-Jan-14	3860	15	19	26-Jan-14	1678	7
17	21-Jan-14	1961	8	20	30-Jan-14	1479	6
February 2014							
21	4-Feb-14	493	2	22	19-Feb-14	4458	18
March 2014							
23	10-Mar-14	1770	7	26	24-Mar-14	3162	12
24	15-Mar-14	4604	18	27	29-Mar-14	1310	5
25	17-Mar-14	1566	6				
April 2014							
28	3-April-14	481	2	29	22-apr-14	676	3
May 2014							
30	11-May-14	1517	6				
June 2014							
31	1-June-14	CLOUDYDATA					

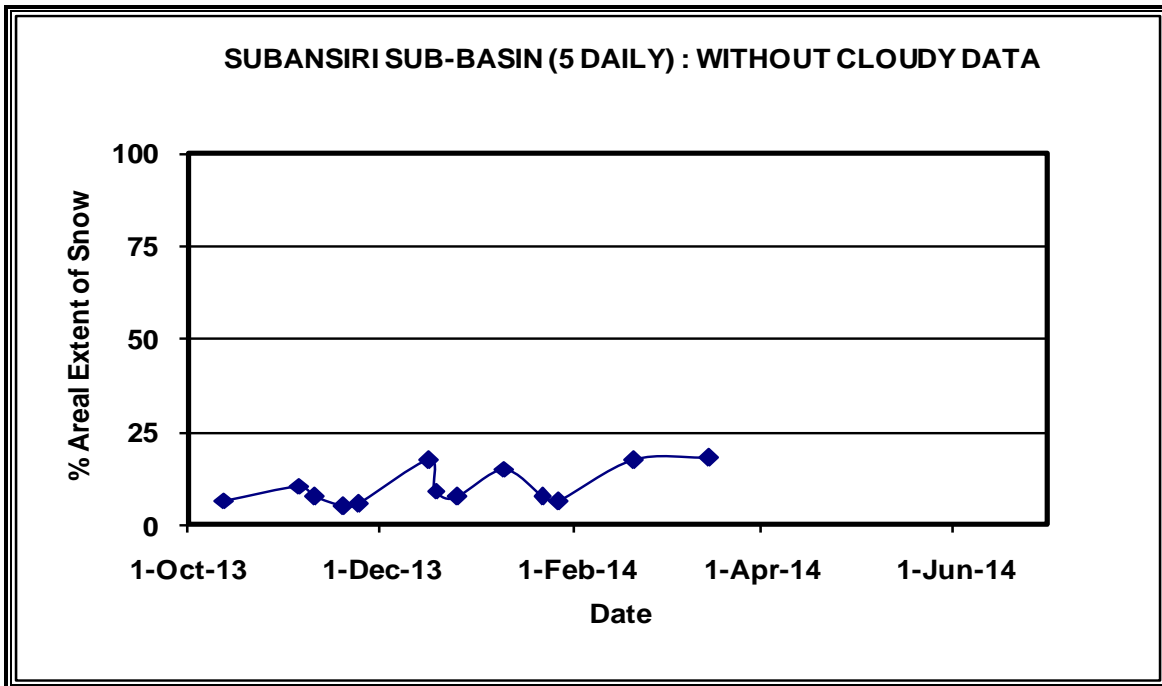
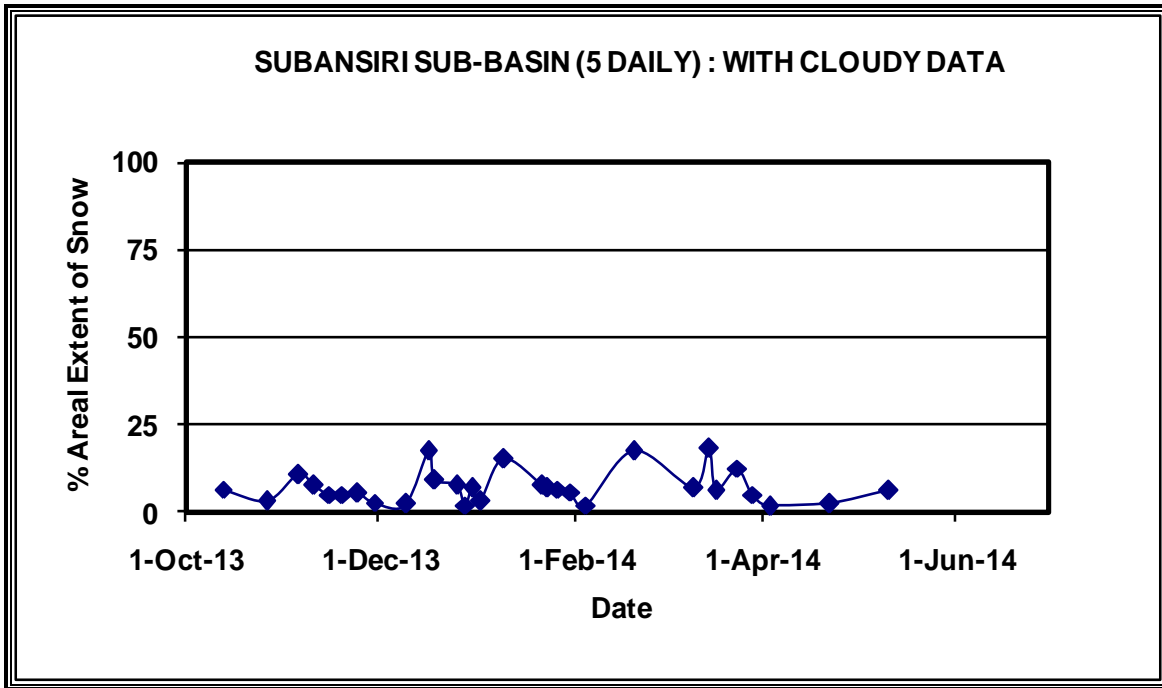
AREAL EXTENT OF SNOW (10 DAILY)

BASIN NAME: SUBANSIRI

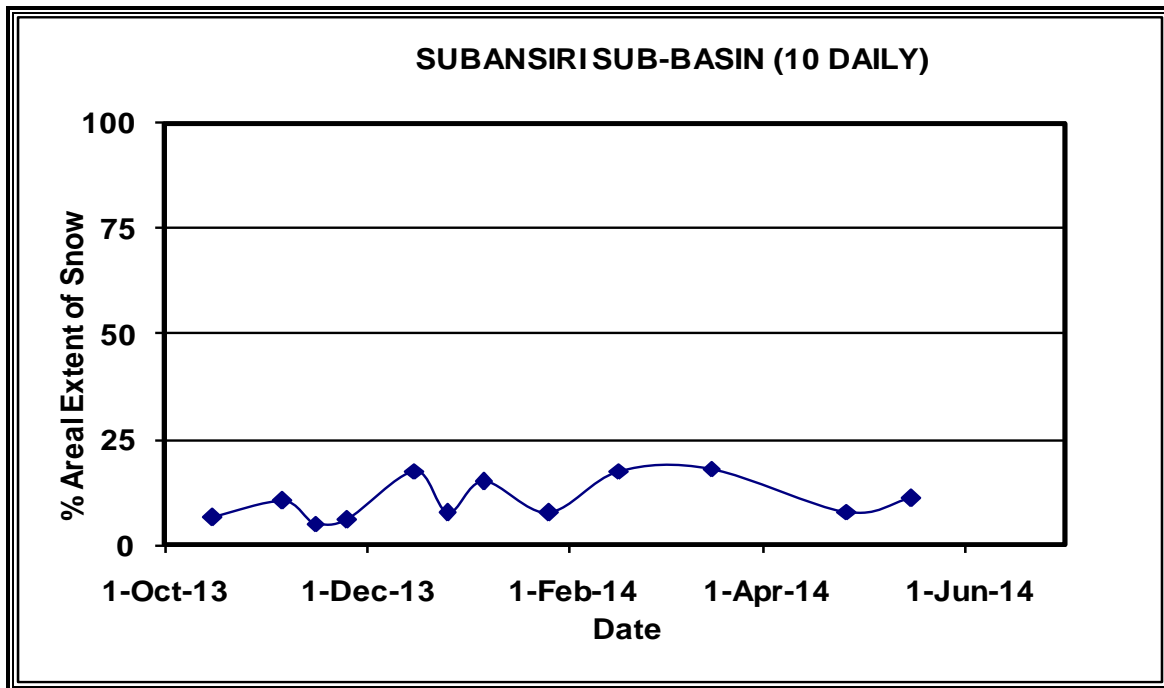
BASIN AREA: 25345 sq km

S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2013				November 2013			
1	15-Oct-13	1684	7	2	5-Nov-13	2690	11
				3	15-Nov-13	1313	5
				4	25-Nov-13	1516	6
December 2013				January 2014			
5	16-Dec-13	4473	18	7	5-Jan-14	3860	15
6	25-Dec-13	1944	8	8	25-Jan-14	1961	8
February 2014				March 2014			
9	15-Feb-14	4458	18	10	15-Mar-14	4604	18
April 2014				May 2014			
11	25-Apr-14	2097	8	12	15-May-14	2770	11
June 2014							
13	5-June-14	NO DATA					

SNOW COVER DEPLETION CURVE

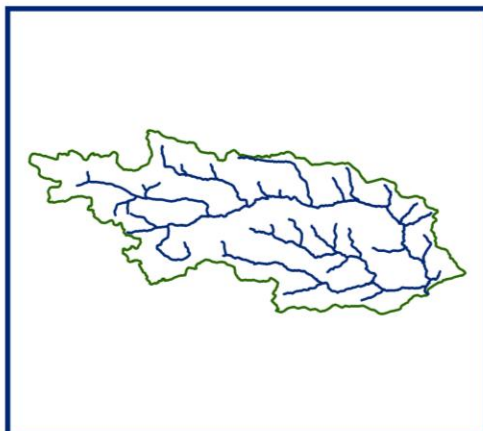


SNOW COVER DEPLETION CURVE

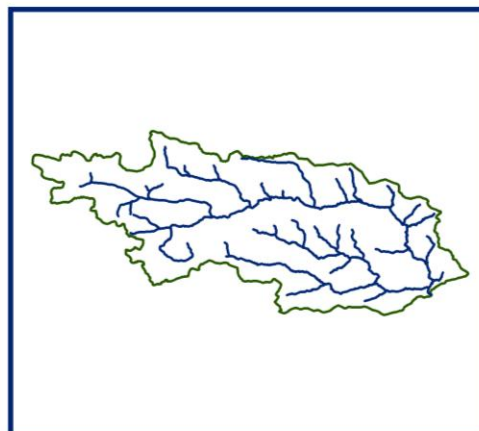


SNOW COVER MAP

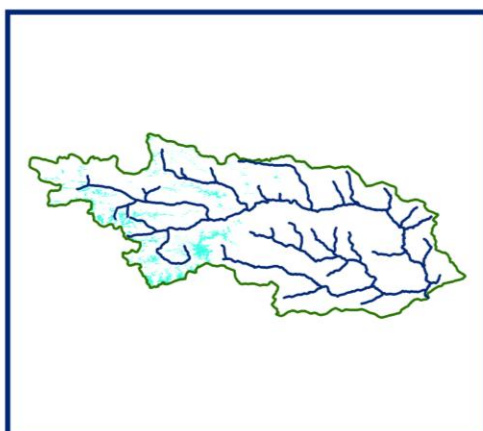
SNOW COVER MAP : SUBANSIRI BASIN



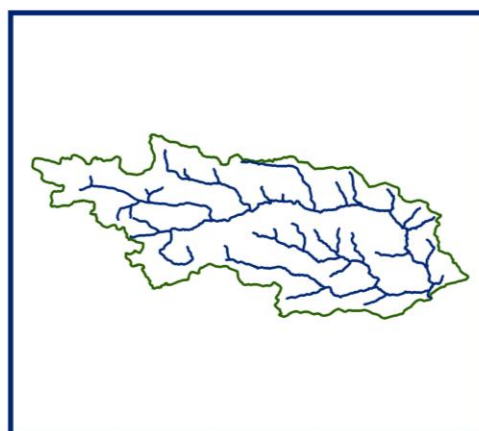
DATA NOT AVAILABLE



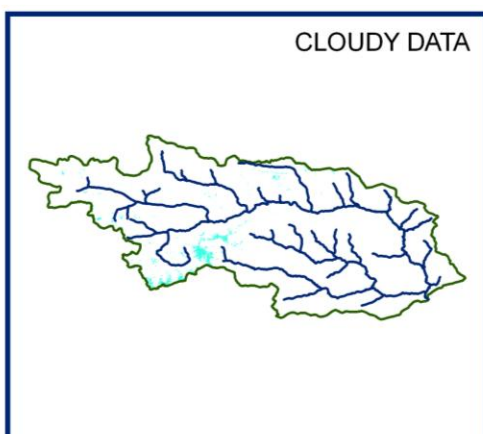
DATA NOT AVAILABLE



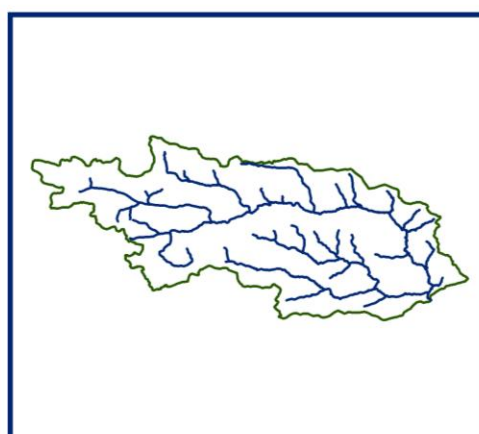
12 OCTOBER 2013



DATA NOT AVAILABLE



26 OCTOBER 2013



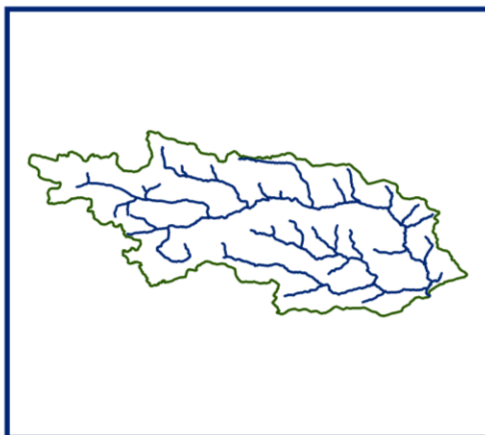
DATA NOT AVAILABLE



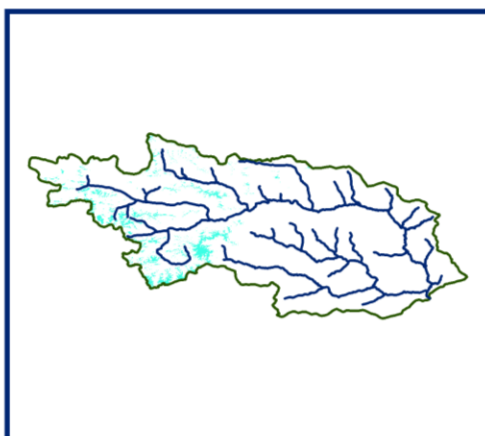
SNOW



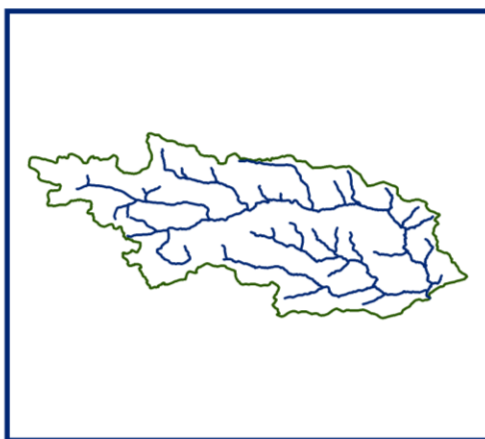
10 DAILY SNOW COVER MAP: SUBANSIRI BASIN



DATA USED
DATA NOT AVAILABLE



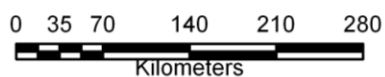
DATA USED
15 OCTOBER 2013



DATA USED
DATA NOT AVAILABLE



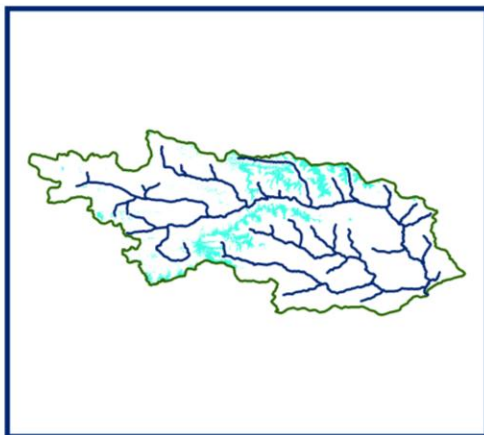
SNOW



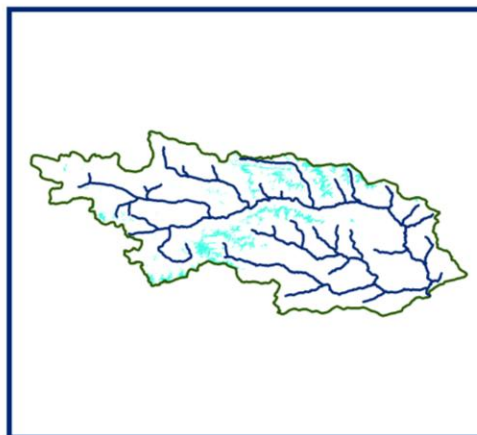
SNOW COVER MAP

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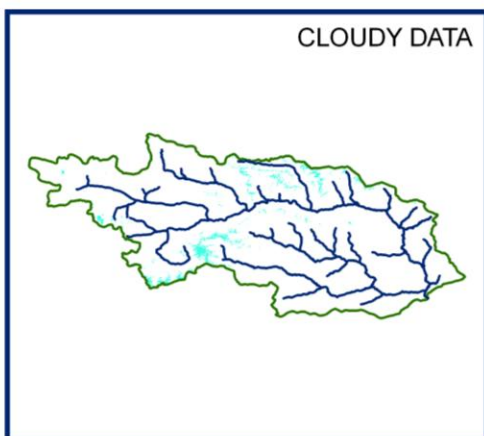
SUBANSIRI BASIN



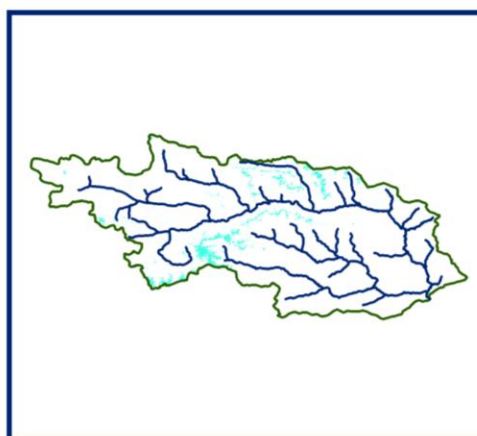
05 NOVEMBER 2013



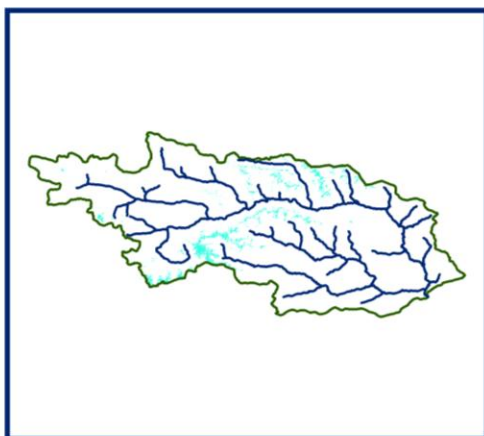
10 NOVEMBER 2013



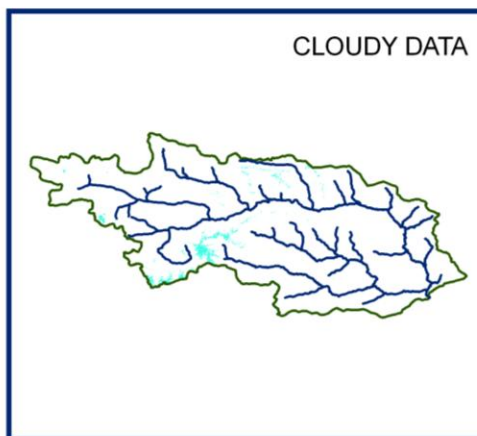
15 NOVEMBER 2013



19 NOVEMBER 2013



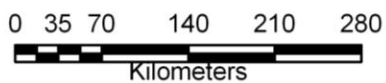
24 NOVEMBER 2013



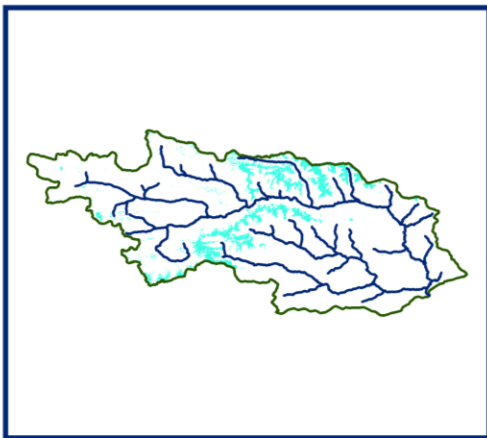
29 NOVEMBER 2013



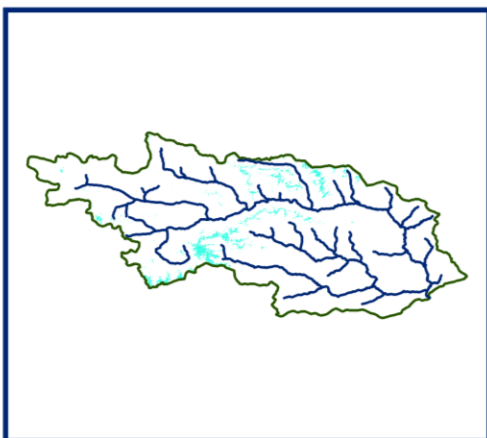
SNOW



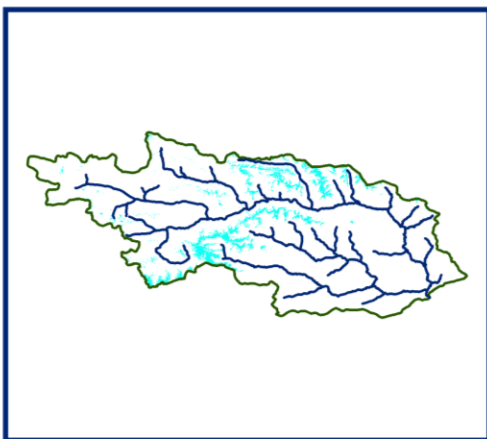
10 DAILY SNOW COVER MAP: SUBANSIRI BASIN



DATA USED
05 NOVEMBER 2013



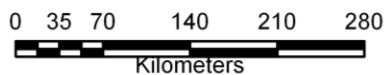
DATA USED
15 NOVEMBER 2013



DATA USED
24 NOVEMBER 2013
29 NOVEMBER 2013



SNOW



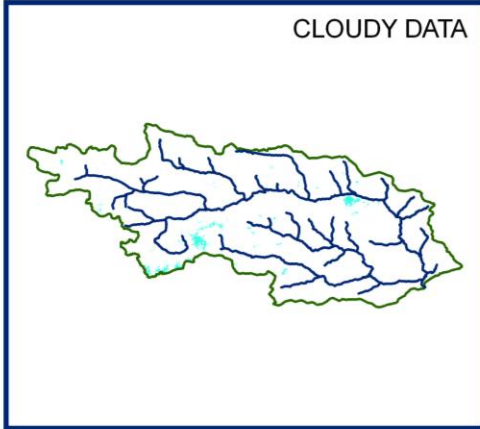
SNOW COVER MAP

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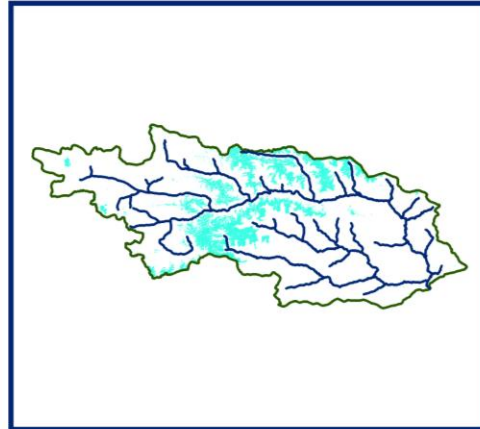
SUBANSIRI BASIN



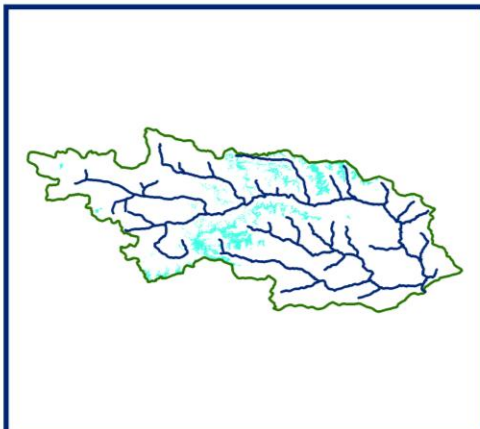
CLOUDY DATA



09 DECEMBER 2013

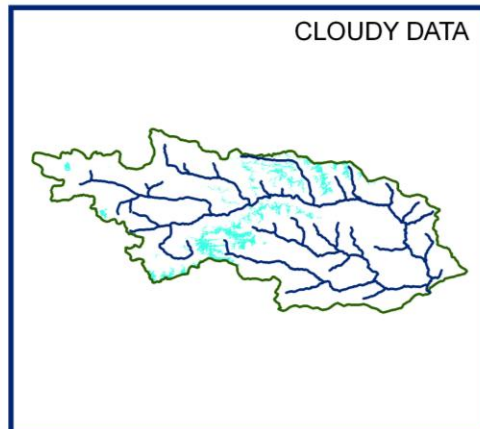


16 DECEMBER 2013



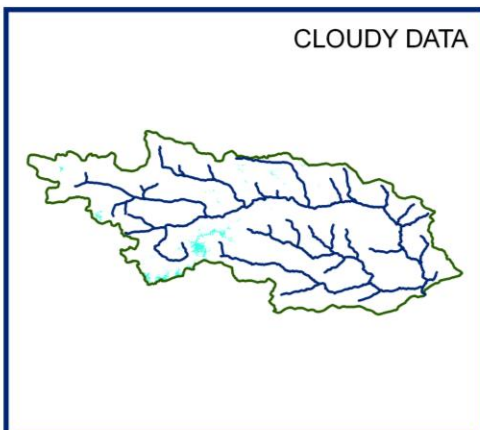
18 DECEMBER 2013

CLOUDY DATA



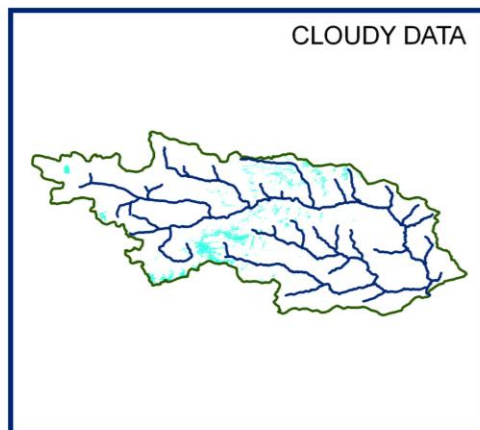
25 DECEMBER 2013

CLOUDY DATA



28 DECEMBER 2013

CLOUDY DATA



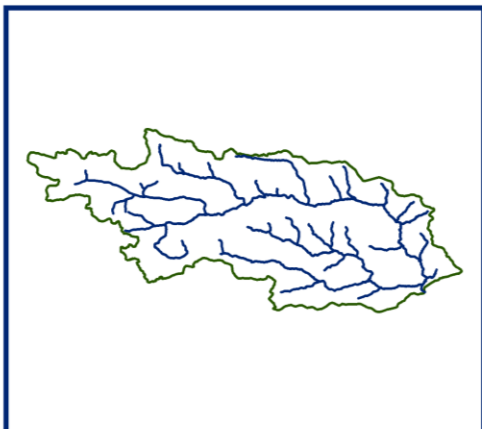
30 DECEMBER 2013



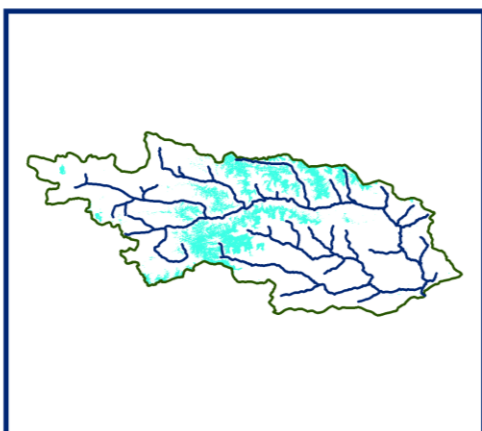
SNOW



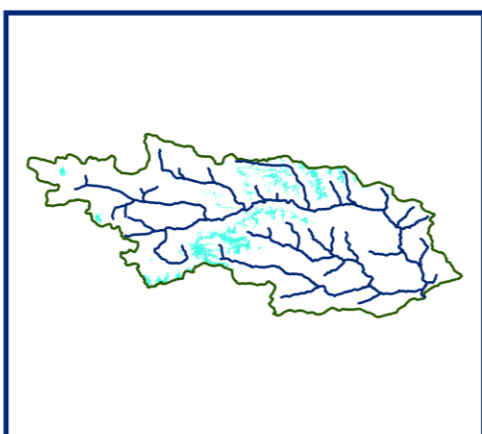
10 DAILY SNOW COVER MAP: SUBANSIRI BASIN



DATA USED
DATA NOT AVAILABLE



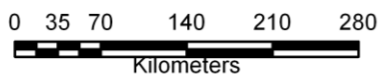
DATA USED
15 DECEMBER 2013



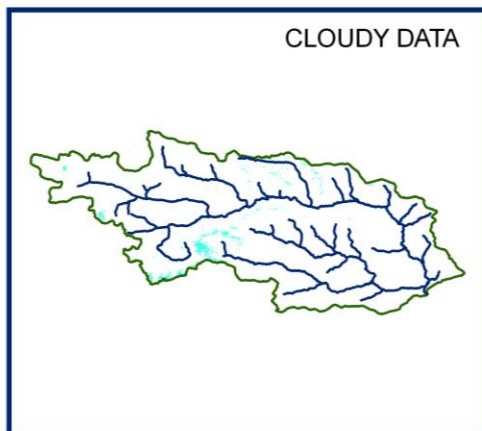
DATA USED
25 DECEMBER 2013



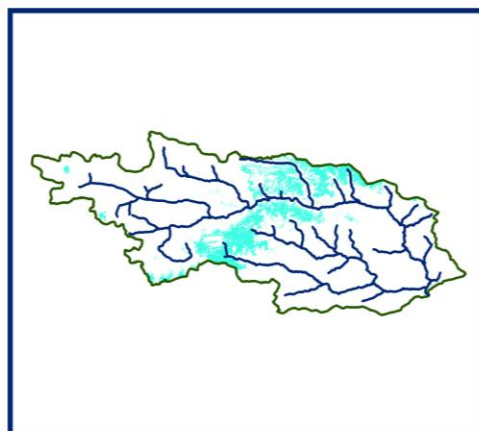
SNOW



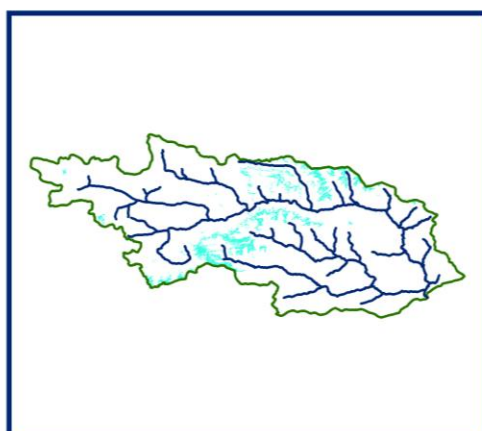
SNOW COVER MAP : SUBANSIRI BASIN



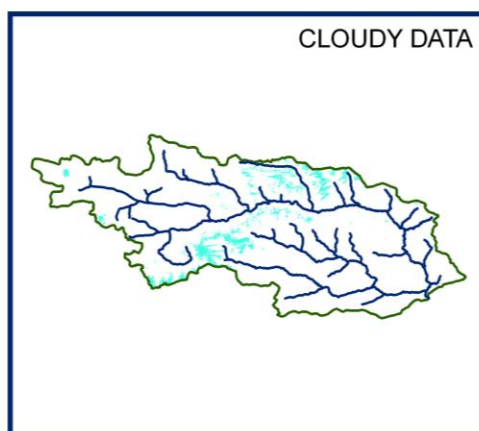
02 JANUARY 2014



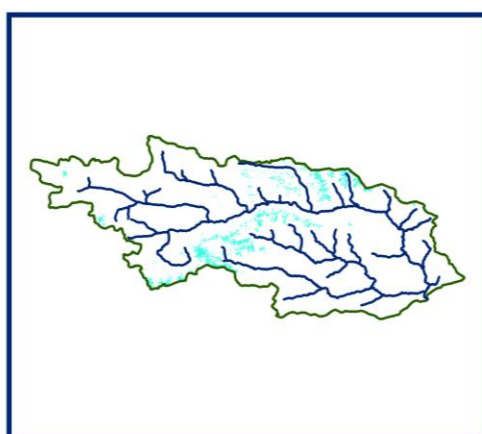
09 JANUARY 2014



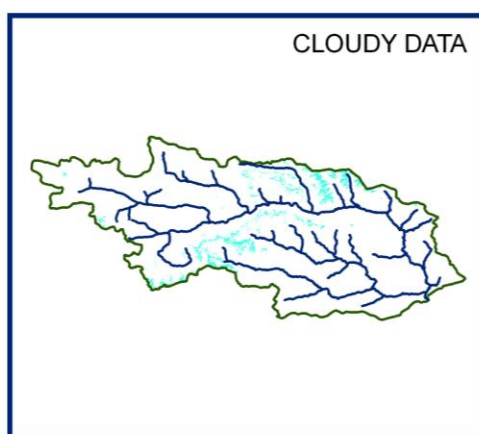
21 JANUARY 2014



23 JANUARY 2014



26 JANUARY 2014



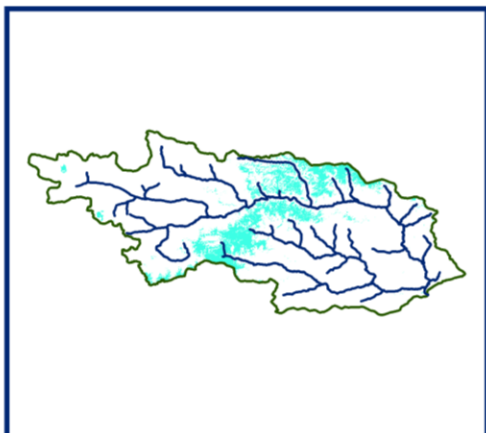
30 JANUARY 2014



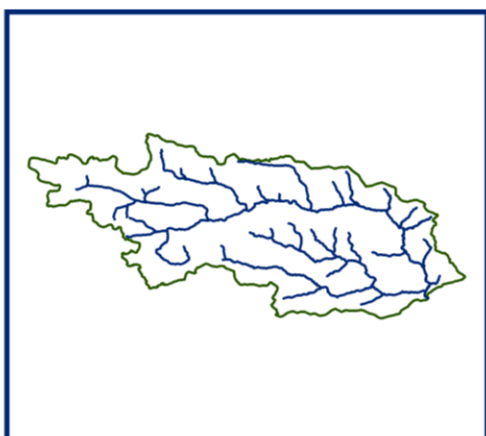
SNOW



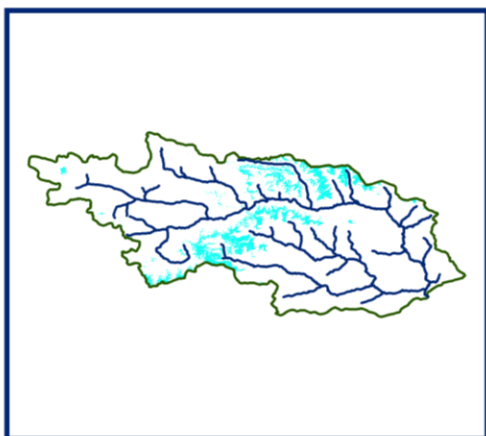
10 DAILY SNOW COVER MAP: SUBANSIRI BASIN



DATA USED
05 JANUARY 2014



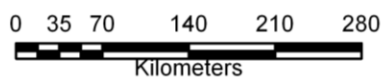
DATA USED
DATA NOT AVAILABLE



DATA USED
26 JANUARY 2014
30 JANUARY 2014



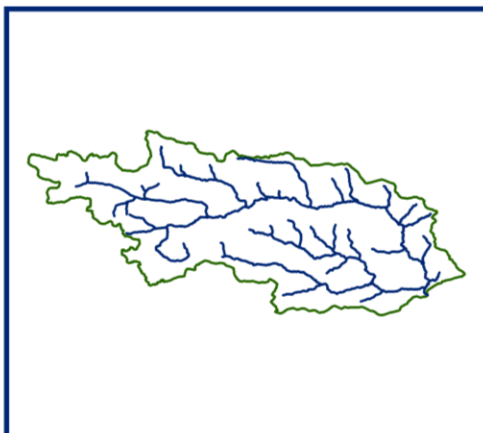
SNOW



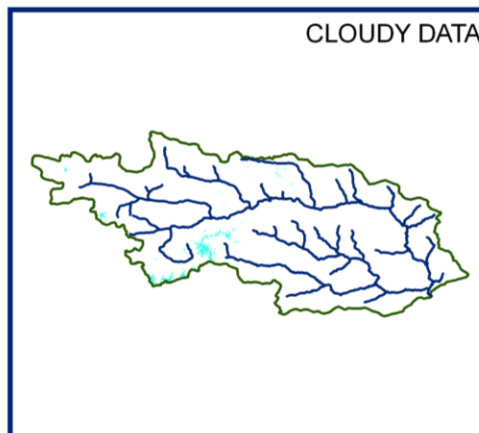
SNOW COVER MAP

:

SUBANSIRI BASIN

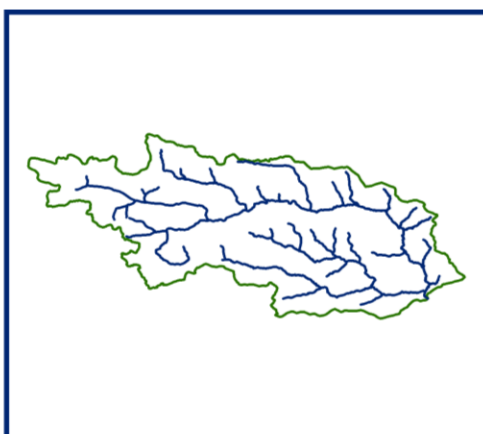


DATA NOT AVAILABLE

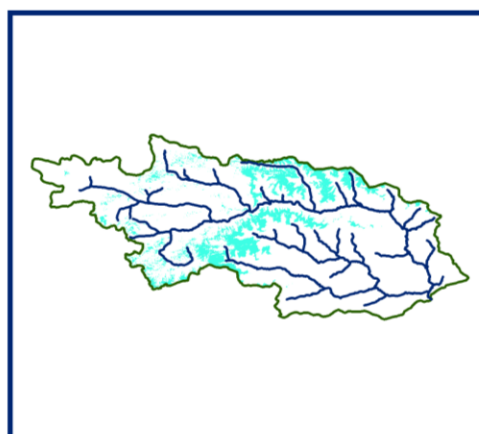


CLOUDY DATA

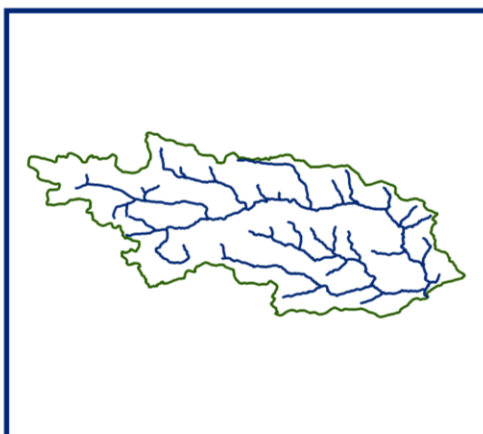
04 FEBRUARY 2014



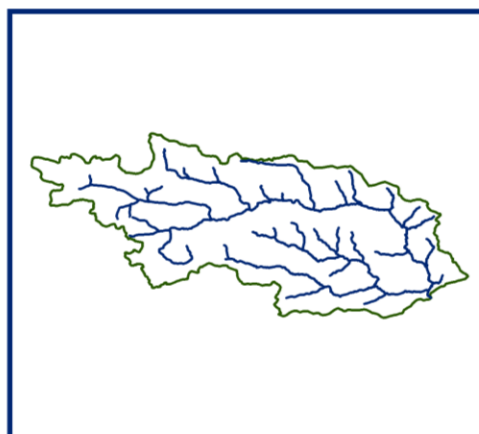
DATA NOT AVAILABLE



19 FEBRUARY 2014



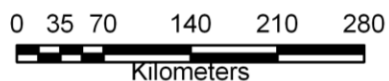
DATA NOT AVAILABLE



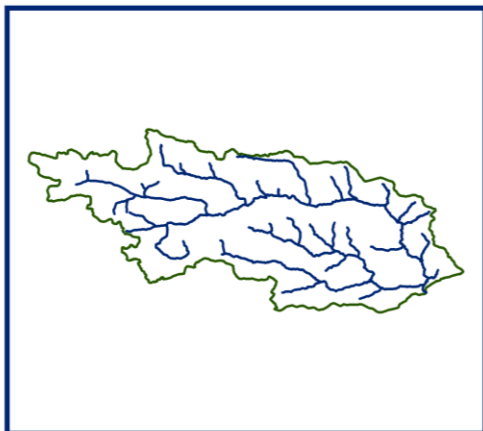
DATA NOT AVAILABLE



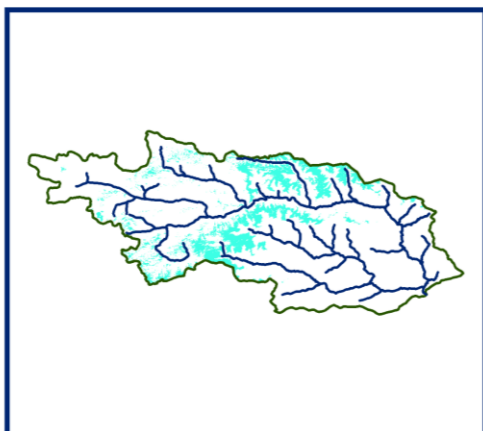
SNOW



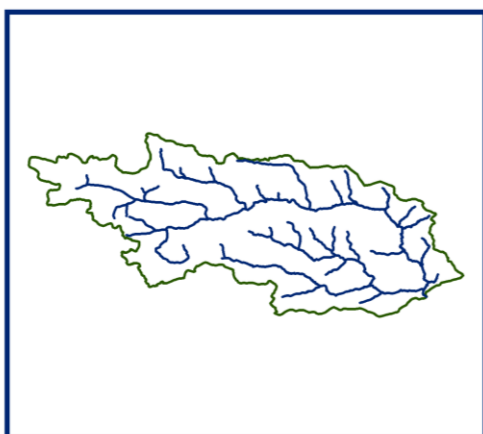
10 DAILY SNOW COVER MAP: SUBANSIRI BASIN



DATA USED
DATA NOT AVAILABLE



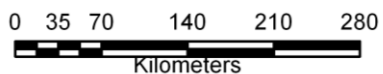
DATA USED
15 FEBRUARY 2014



DATA USED
DATA NOT AVAILABLE



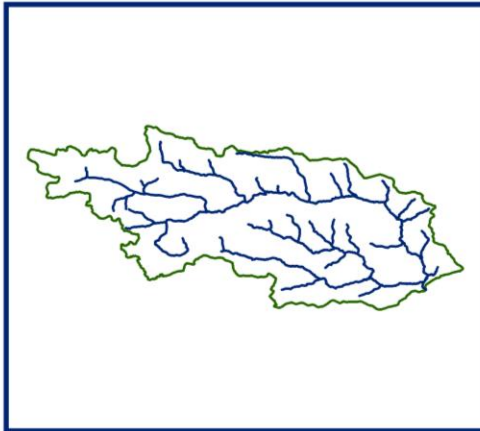
SNOW



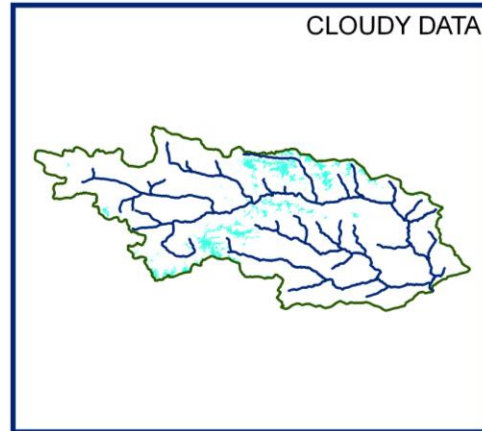
SNOW COVER MAP

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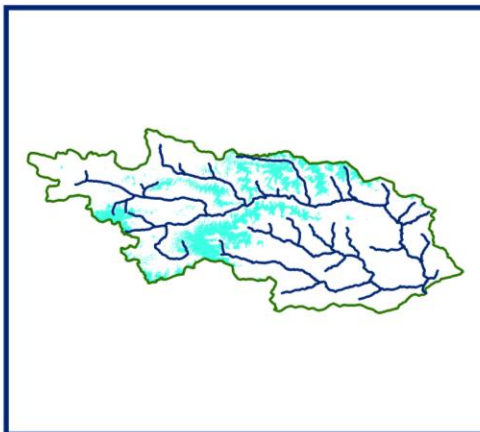
SUBANSIRI BASIN



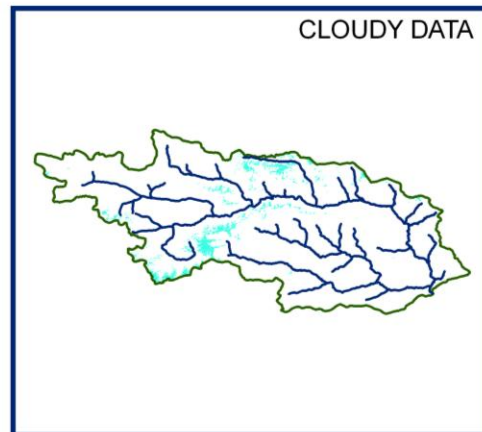
DATA NOT AVAILABLE



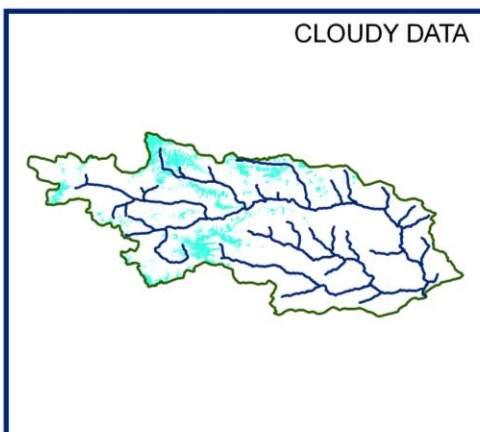
10 MARCH 2014



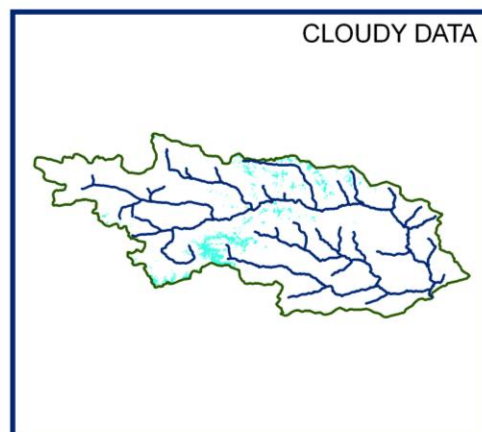
15 MARCH 2014



17 MARCH 2014



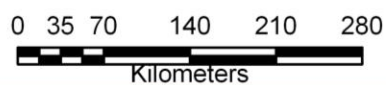
24 MARCH 2014



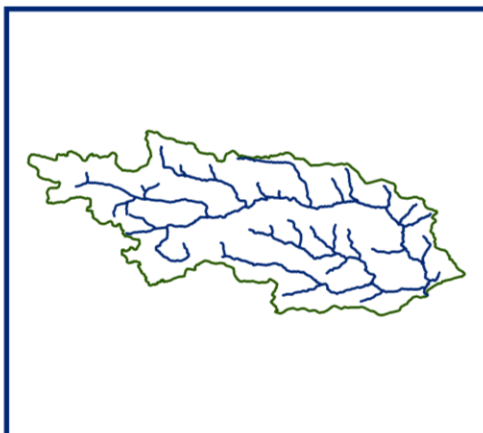
29 MARCH 2014



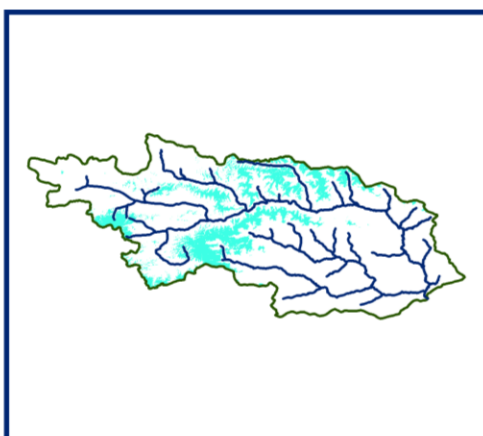
SNOW



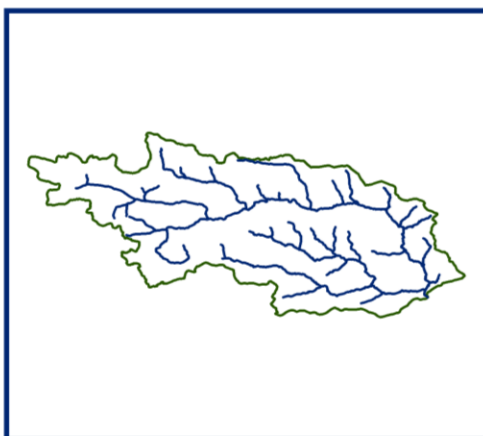
10 DAILY SNOW COVER MAP: SUBANSIRI BASIN



DATA USED
DATA NOT AVAILABLE



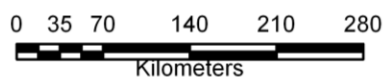
DATA USED
15 MARCH 2014



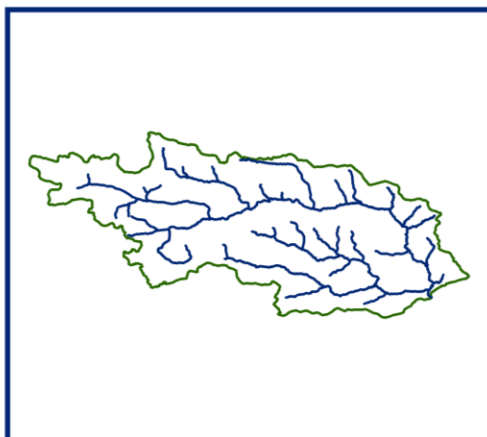
DATA USED
DATA NOT AVAILABLE



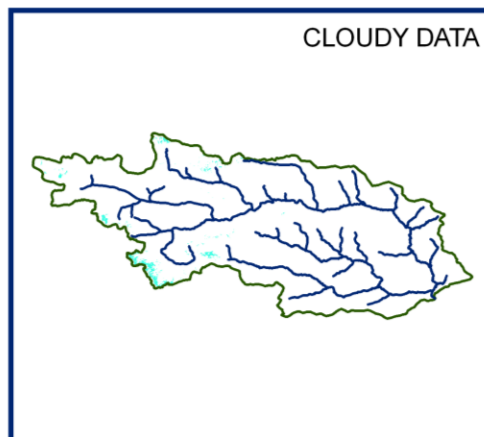
SNOW



SNOW COVER MAP : SUBANSIRI BASIN

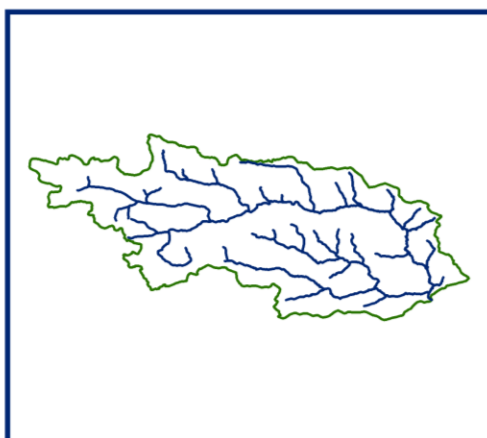


DATA NOT AVAILABLE

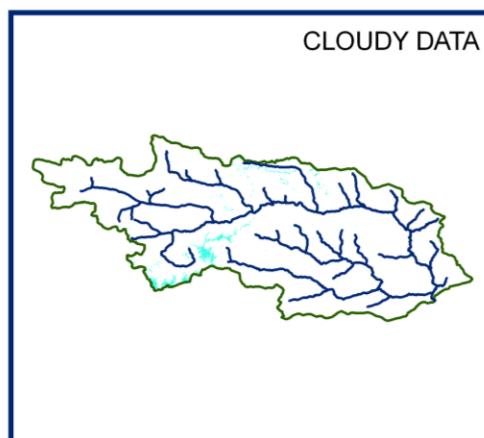


CLOUDY DATA

03 APRIL 2014

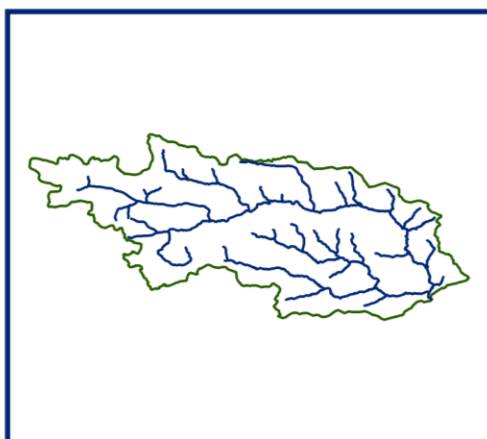


DATA NOT AVAILABLE

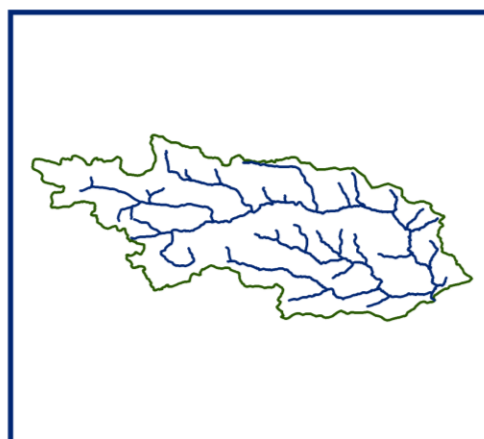


CLOUDY DATA

22 APRIL 2014



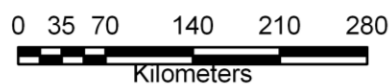
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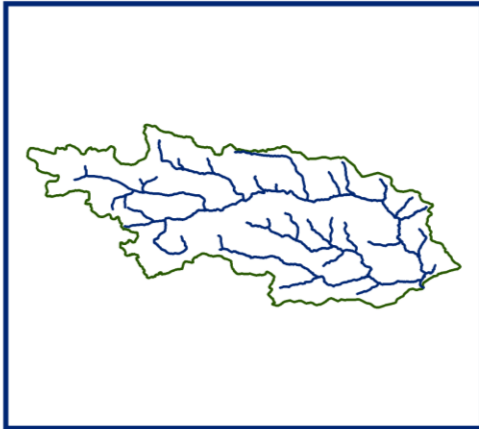
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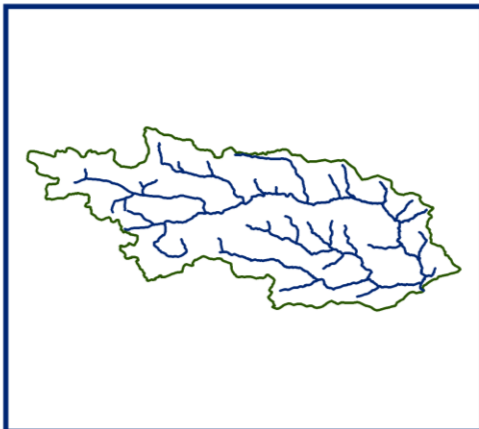
SNOW



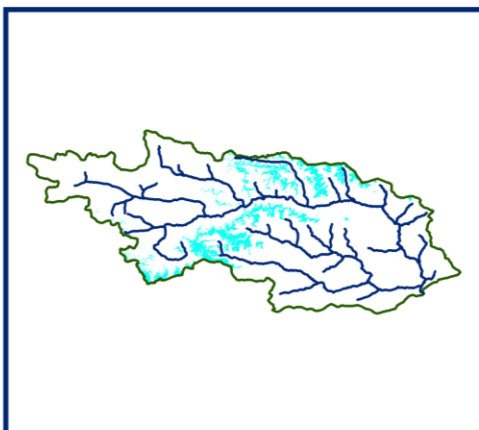
10 DAILY SNOW COVER MAP: SUBANSIRI BASIN



DATA USED
DATA NOT AVAILABLE



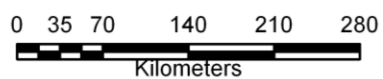
DATA USED
DATA NOT AVAILABLE



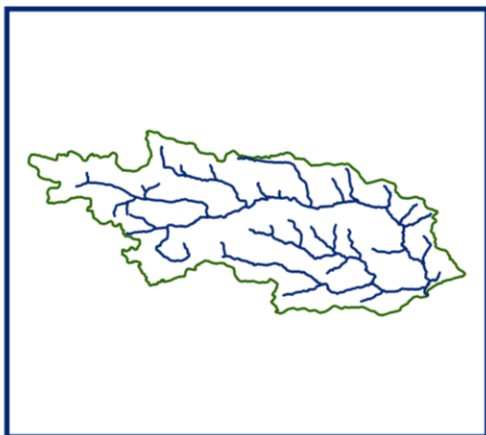
DATA USED
21 JANUARY 2014
22 APRIL 2014



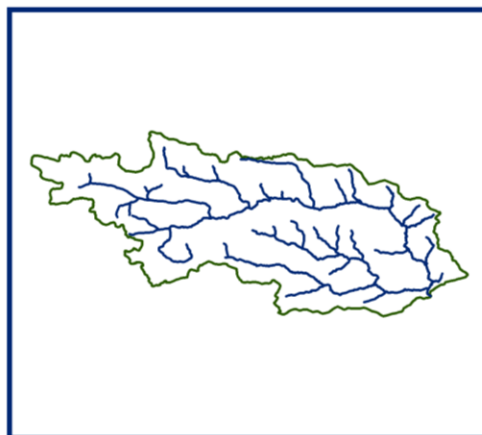
SNOW



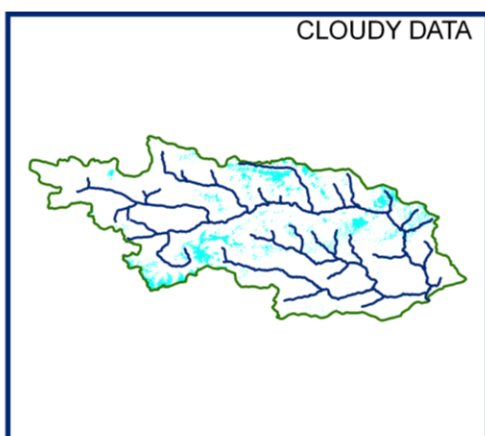
SNOW COVER MAP : SUBANSIRI BASIN



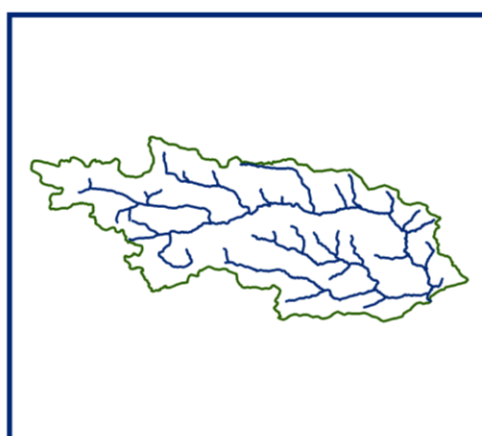
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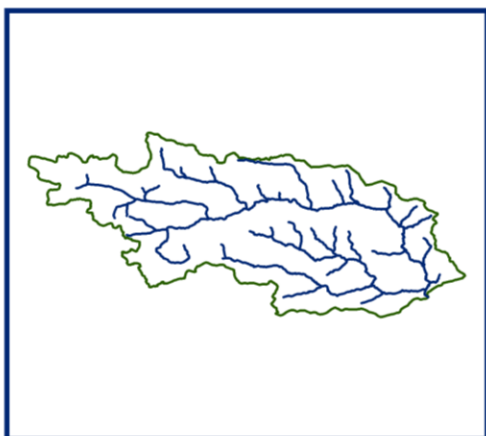
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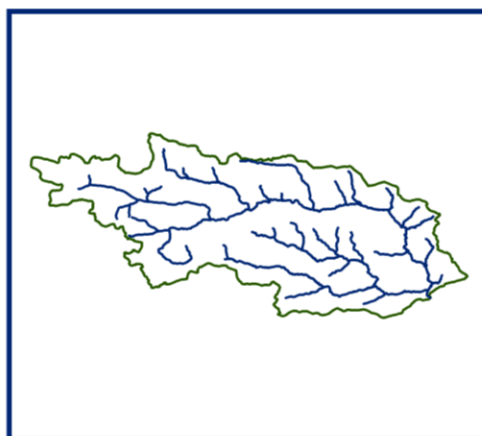
11 MAY 2014



DATA NOT AVAILABLE



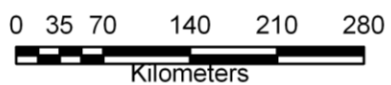
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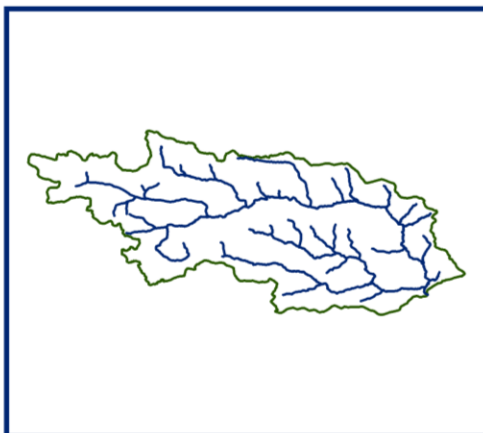
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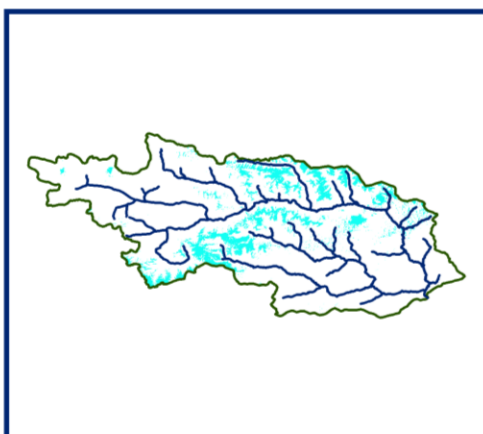
SNOW



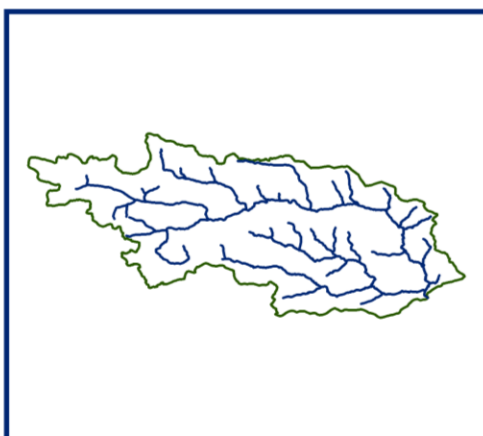
10 DAILY SNOW COVER MAP: SUBANSIRI BASIN



DATA USED
DATA NOT AVAILABLE



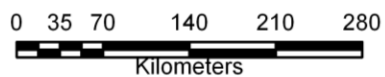
DATA USED
21 JANUARY 2014
11 MAY 2014



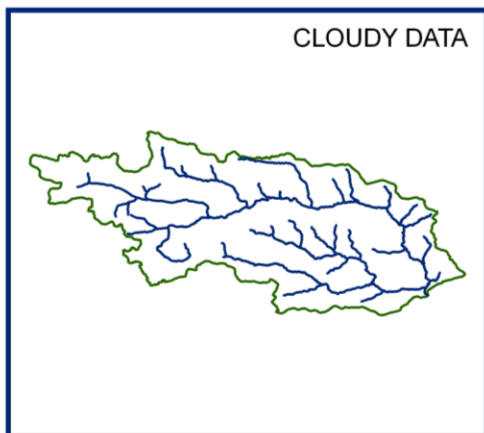
DATA USED
DATA NOT AVAILABLE



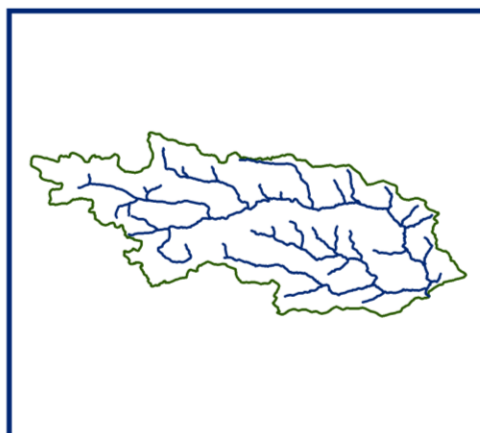
SNOW



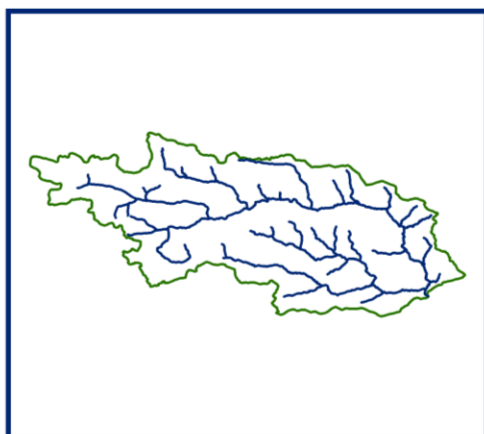
SNOW COVER MAP : SUBANSIRI BASIN



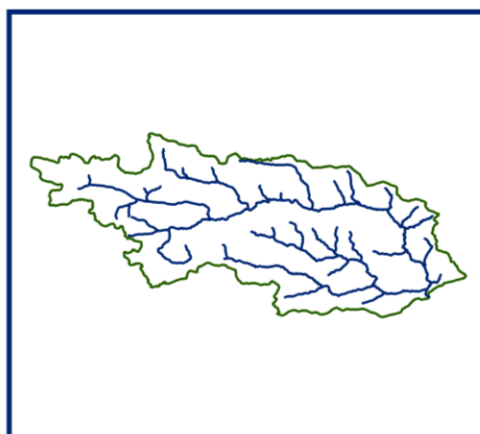
01 JUNE 2014



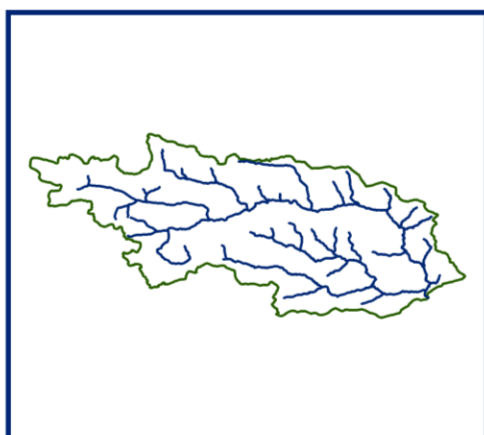
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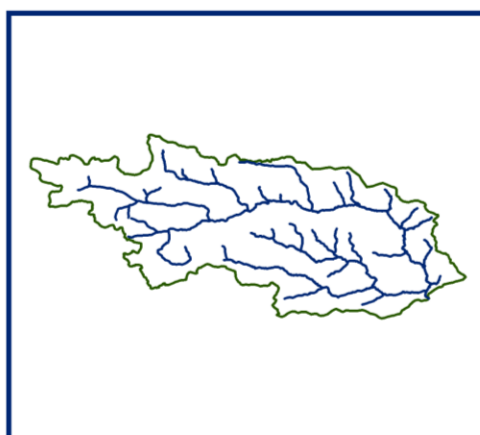
DATA NOT AVAILABLE



DATA NOT AVAILABLE



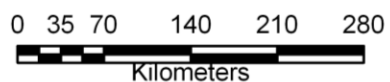
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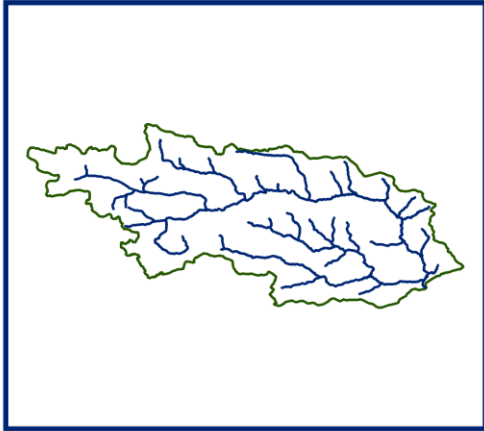
DATA NOT AVAILABLE



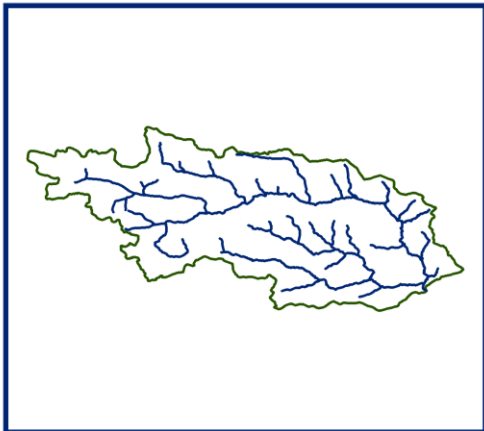
SNOW



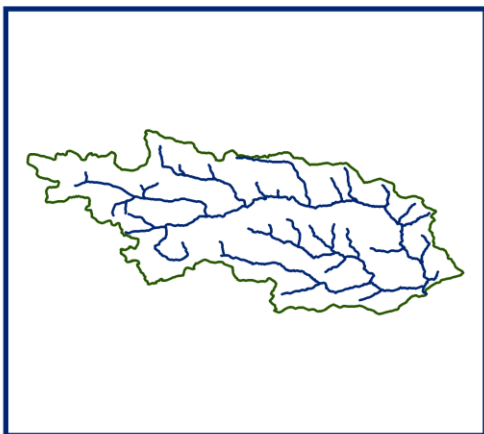
10 DAILY SNOW COVER MAP: SUBANSIRI BASIN



DATA USED
DATA NOT AVAILABLE



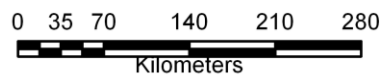
DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE



SNOW



TAWANG SUB-BASIN

AREAL EXTENT OF SNOW (5 DAILY)

BASIN NAME: TAWANG

BASIN AREA: 6721 sq km

S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2013							
1	9-Oct-13	1831	27	4	21-Oct-13	498	7
2	12-Oct-13	798	12	5	26-Oct-13	444	7
3	16-Oct-13	1688	25				
November 2013							
6	5-Nov-13	1616	24	10	19-Nov-13	806	12
7	10-Nov-13	1049	16	11	24-Nov-13	704	10
8	14-Nov-13	948	14	12	29-Nov-13	570	8
9	15-Nov-13	896	13				
December 2013							
13	3-Dec-13	538	8	18	25-Dec-13	842	13
14	8-Dec-13	474	7	19	27-Dec-13	515	8
15	9-Dec-13	442	7	20	28-Dec-13	462	7
16	16-Dec-13	1103	16	21	30-Dec-13	731	11
17	18-Dec-13	533	8				
January 2014							
22	1-Jan-14	437	7	28	21-Jan-14	654	10
23	2-Jan-14	433	6	29	23-Jan-14	855	13
24	8-Jan-14	1134	17	30	25-Jan-14	495	7
25	9-Jan-14	848	13	31	26-Jan-14	532	8
26	13-Jan-14	2180	32	32	30-Jan-14	498	7
27	20-Jan-14	848	13				
February 2014							
33	1-Feb-14	699	10	36	18-Feb-14	3665	55
34	4-Feb-14	473	7	37	19-Feb-14	2961	44
35	13-Feb-14	1406	21	38	21-Feb-14	2575	38
March 2014							
39	3-Mar-14	2442	36	43	21-Mar-14	3708	55
40	10-Mar-14	1514	23	44	24-Mar-14	2643	39
41	15-Mar-14	3491	52	45	29-Mar-14	1666	25
42	17-Mar-14	1783	27				

April 2014							
46	3-April-14	1164	17	47	22-April-14	1787	27
May 2014							
48	11-May-14	1023	15	49	25-May-14	269	4
June 2014							
50	1-June-14	588	9				

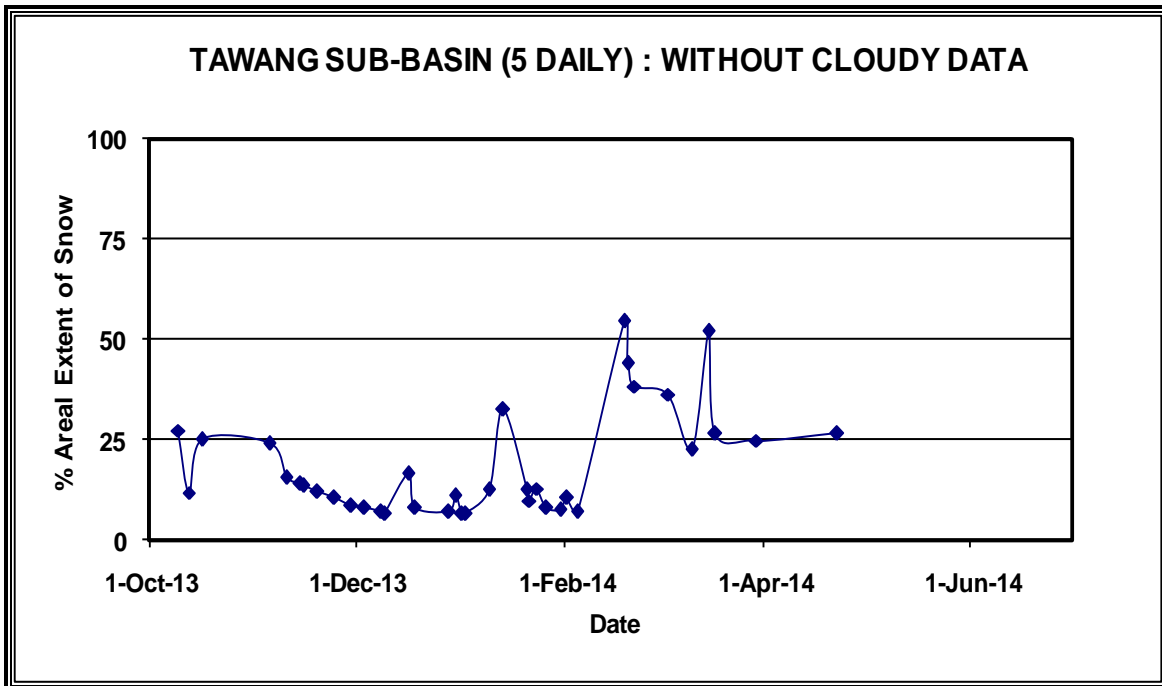
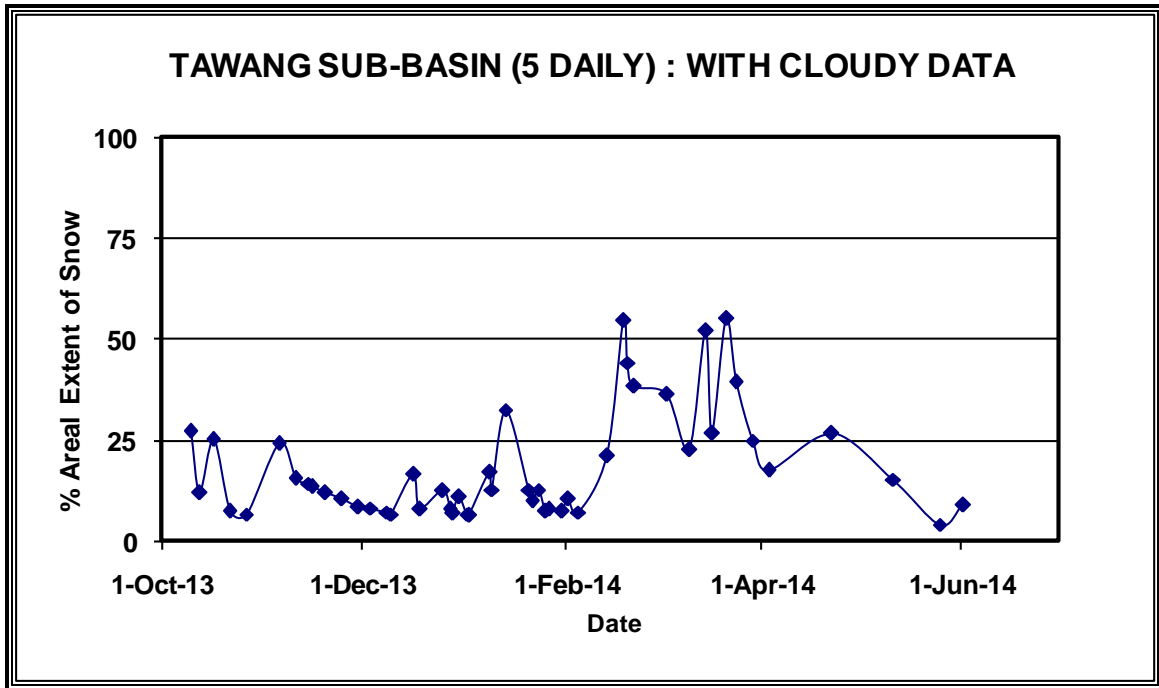
AREAL EXTENT OF SNOW (10 DAILY)

BASIN NAME: TAWANG

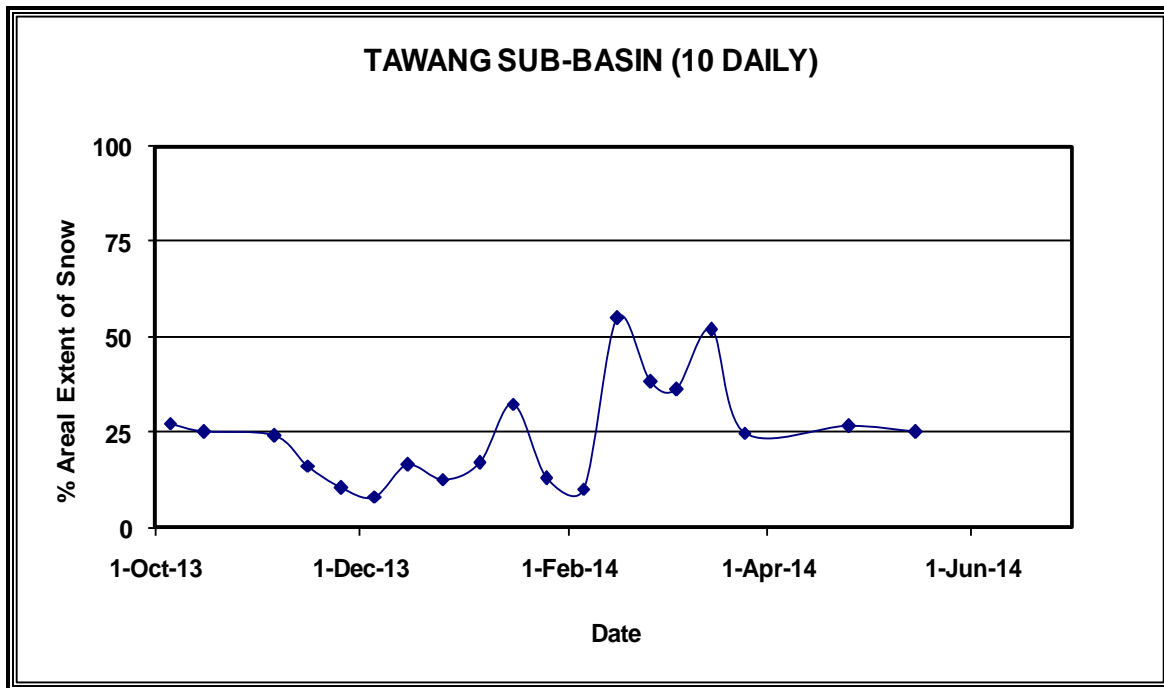
BASIN AREA: 6721sq km

S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2013				November 2013			
1	5-Oct-13	1831	27	3	5-Nov-13	1616	24
2	15-Oct-13	1688	25	4	15-Nov-13	1090	16
				5	25-Nov-13	704	10
December 2013				January 2014			
6	5-Dec-13	538	8	9	5-Jan-14	1134	17
7	15-Dec-13	1103	16	10	15-Jan-14	2180	32
8	25-Dec-13	842	13	11	25-Jan-14	855	13
February 2014				March 2014			
12	5-Feb-14	699	10	15	5-Mar-14	2442	36
13	15-Feb-14	3699	55	16	15-Mar-14	3491	52
14	25-Feb-14	2575	38	17	25-Mar-14	1666	25
April 2014				May 2014			
18	25-Apr-14	1787	27	19	15-May-14	1680	25
June 2014							
20	5-June-14	CLOUDY DATA					

SNOW COVER DEPLETION CURVE

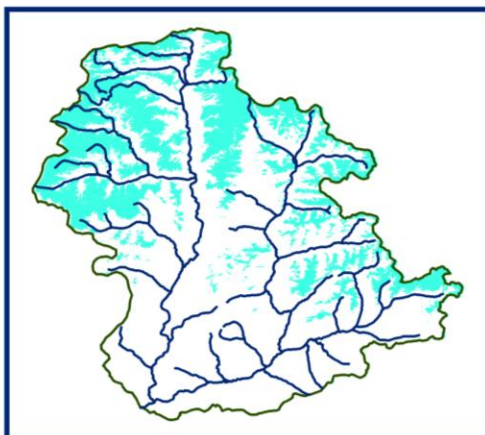


SNOW COVER DEPLETION CURVE

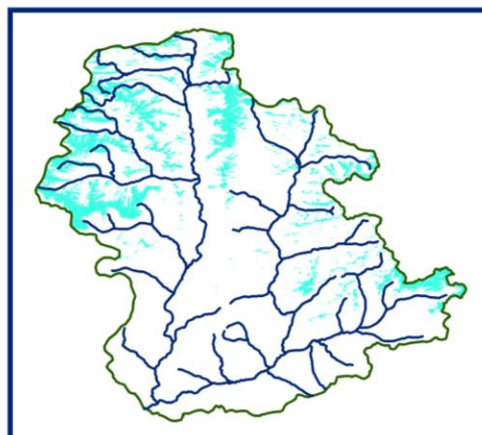


SNOW COVER MAP

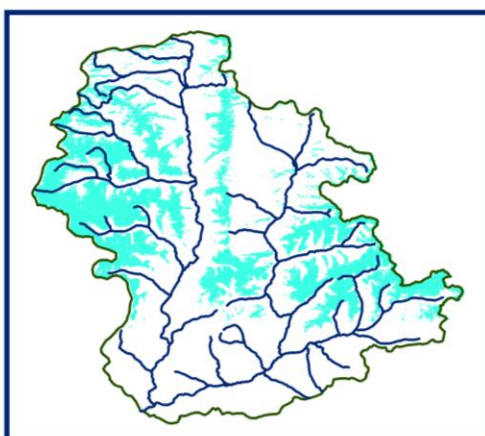
SNOW COVER MAP : TAWANG BASIN



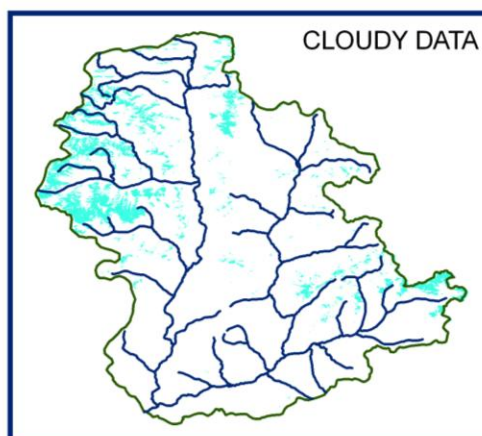
09 OCTOBER 2013



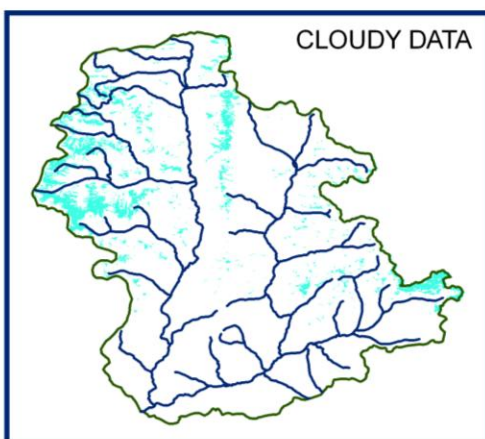
12 OCTOBER 2013



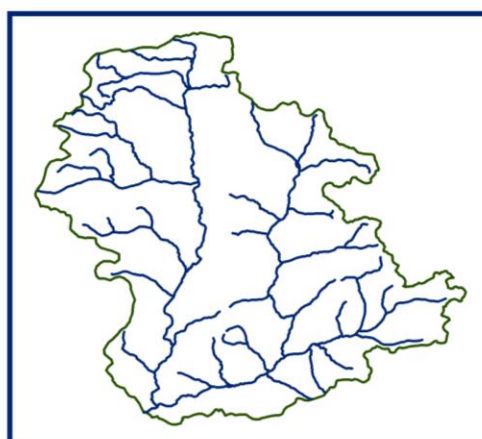
16 OCTOBER 2013



21 OCTOBER 2013



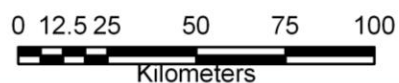
26 OCTOBER 2013



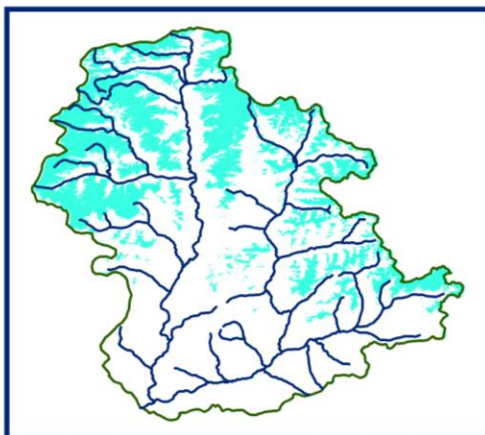
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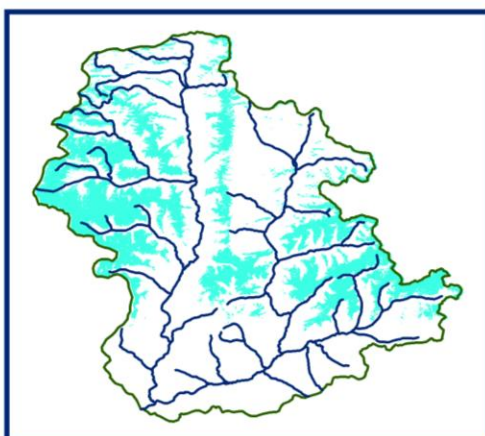
SNOW



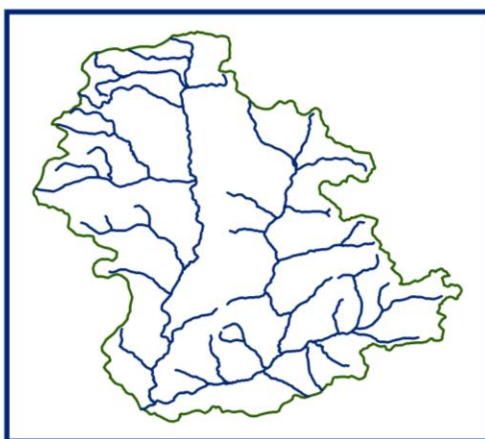
10 DAILY SNOW COVER MAP: TAWANG BASIN



DATA USED
05 OCTOBER 2013



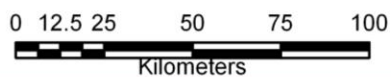
DATA USED
15 OCTOBER 2013



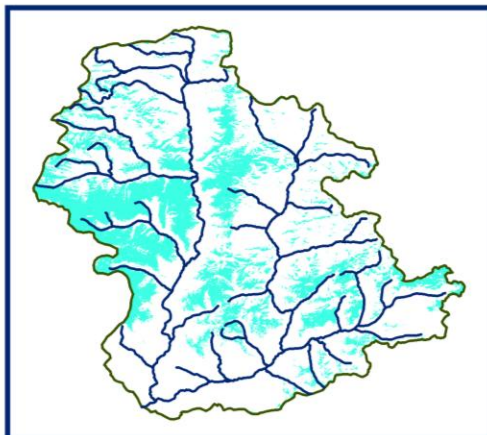
DATA USED
DATA NOT AVAILABLE



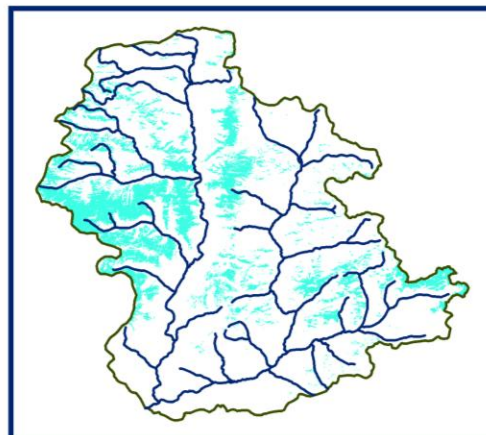
SNOW



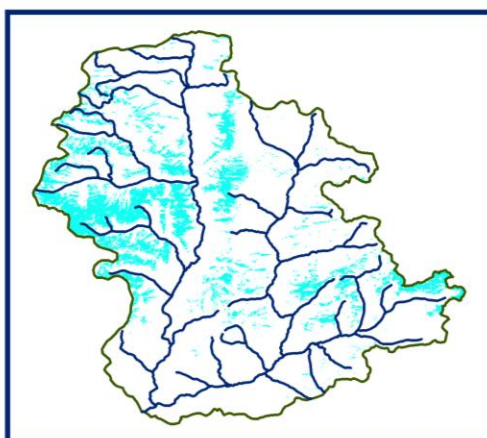
SNOW COVER MAP : TAWANG BASIN



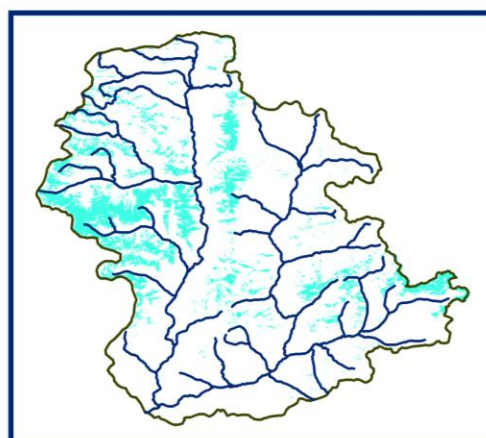
05 NOVEMBER 2013



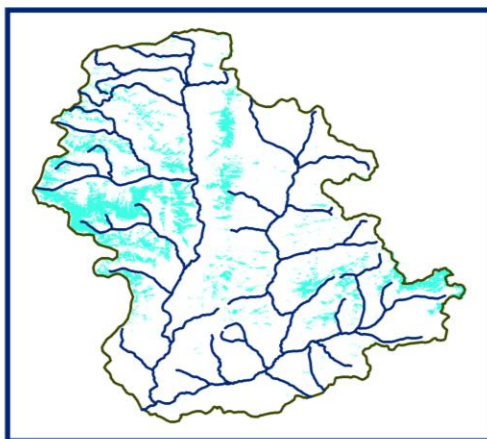
10 NOVEMBER 2013



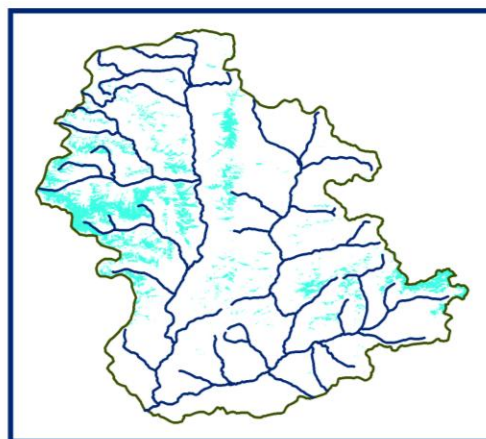
15 NOVEMBER 2013



19 NOVEMBER 2013



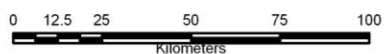
24 NOVEMBER 2013



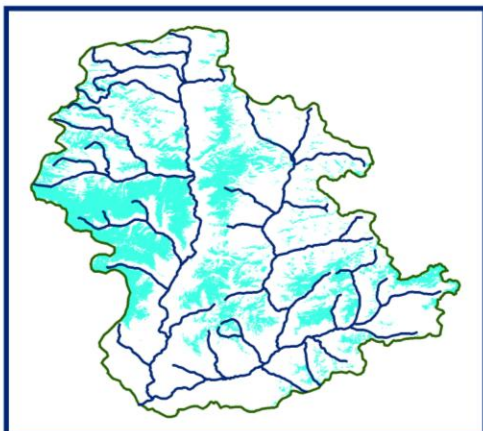
29 NOVEMBER 2013



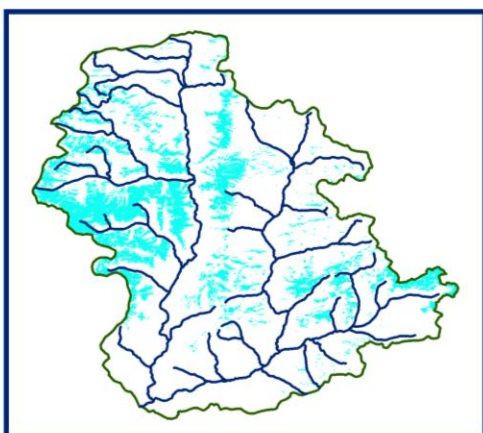
SNOW



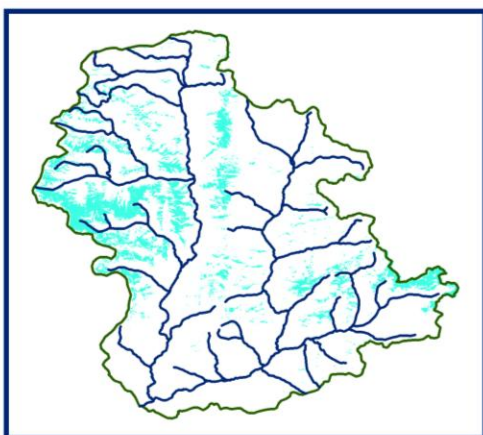
10 DAILY SNOW COVER MAP: TAWANG BASIN



DATA USED
05 NOVEMBER 2013



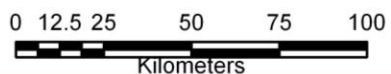
DATA USED
15 NOVEMBER 2013
19 NOVEMBER 2013



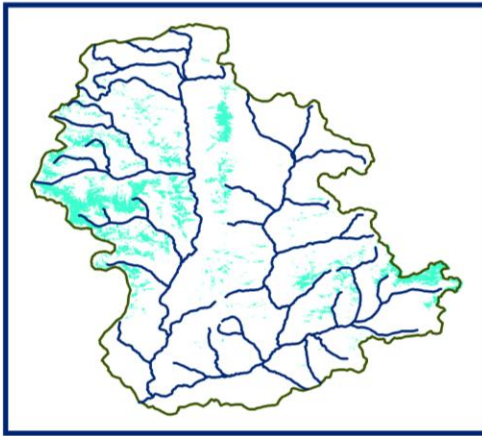
DATA USED
25 NOVEMBER 2013



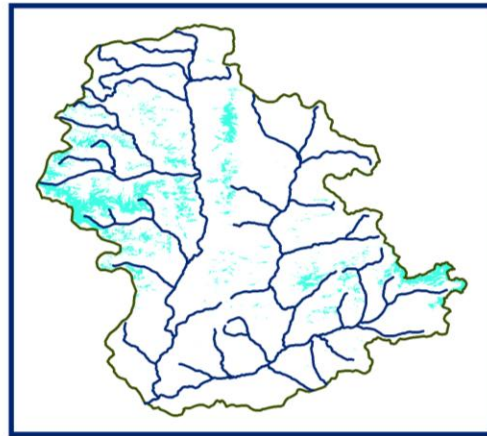
SNOW



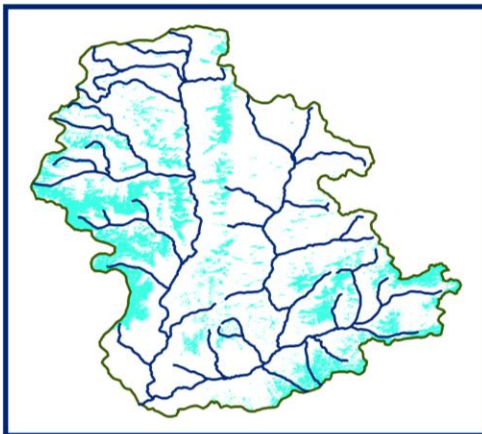
SNOW COVER MAP : TAWANG BASIN



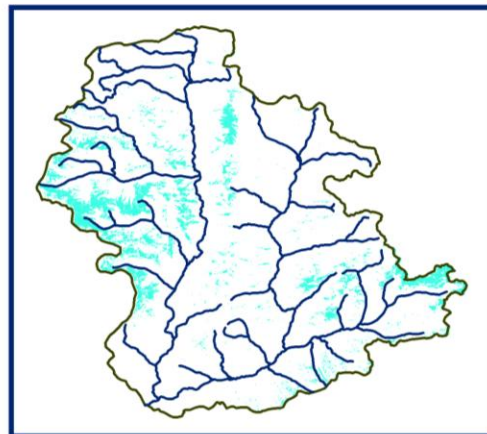
03 DECEMBER 2013



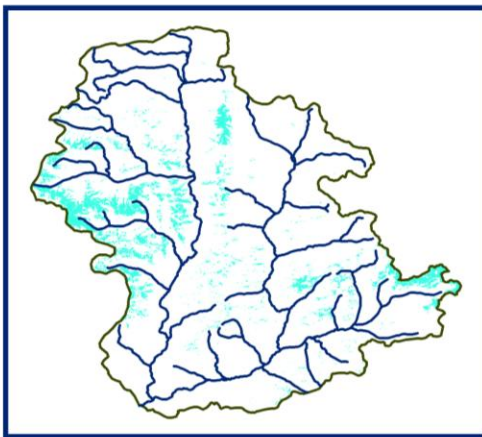
09 DECEMBER 2013



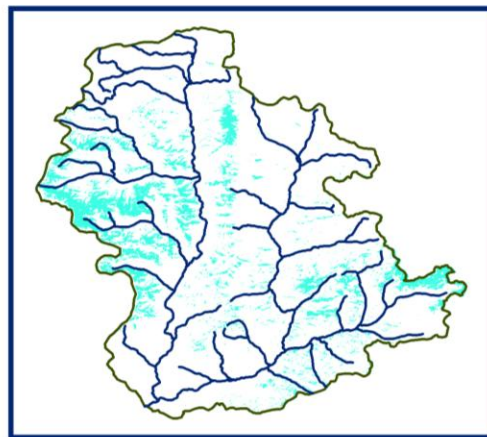
16 DECEMBER 2013



18 DECEMBER 2013



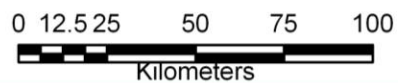
28 DECEMBER 2013



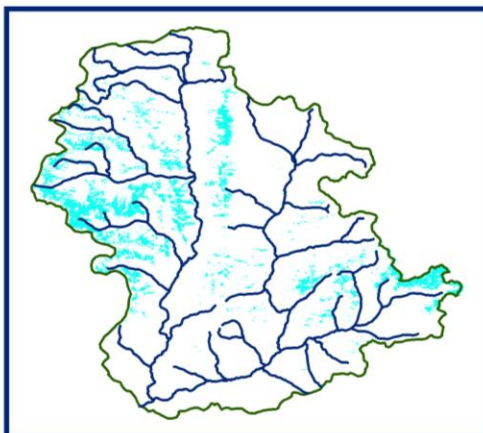
30 DECEMBER 2013



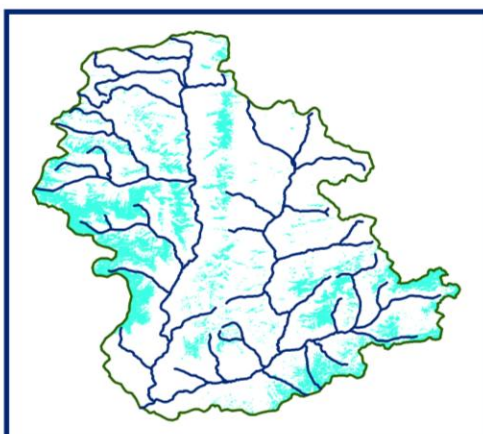
SNOW



10 DAILY SNOW COVER MAP: TAWANG BASIN



DATA USED
03 DECEMBER 2013
08 DECEMBER 2013
09 DECEMBER 2013



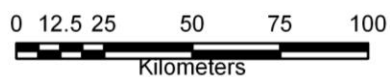
DATA USED
15 DECEMBER 2013



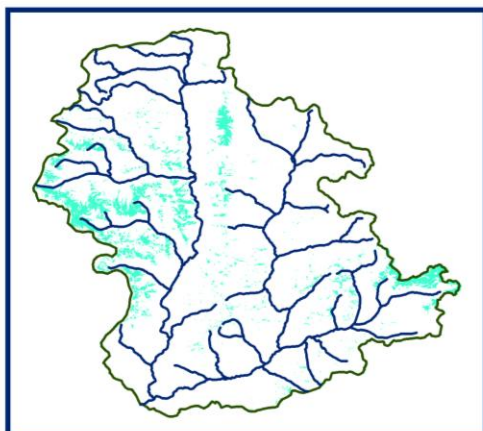
DATA USED
25 DECEMBER 2013



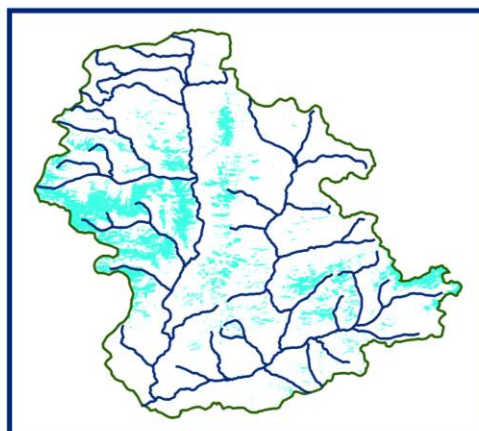
SNOW



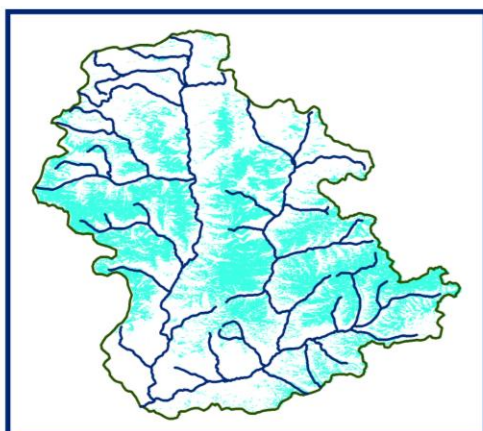
SNOW COVER MAP : TAWANG BASIN



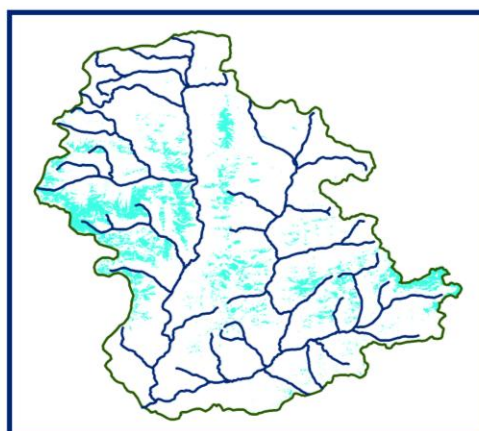
01 JANUARY 2014



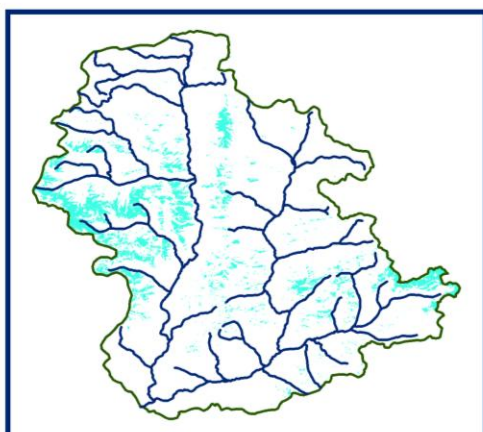
09 JANUARY 2014



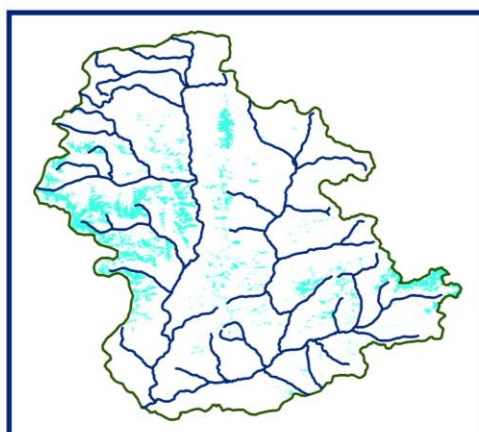
13 JANUARY 2014



21 JANUARY 2014



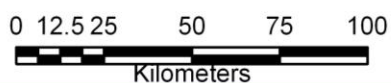
26 JANUARY 2014



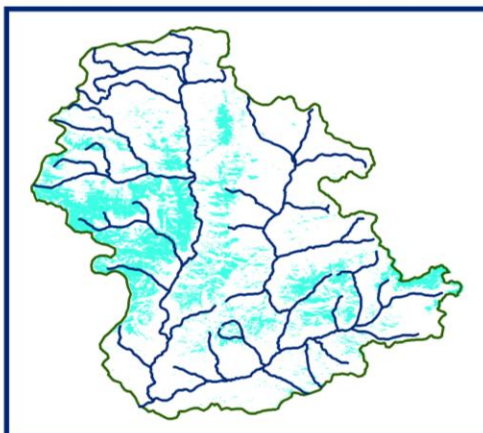
30 JANUARY 2014



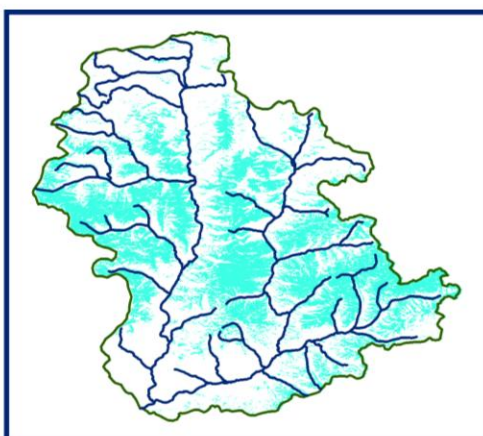
SNOW



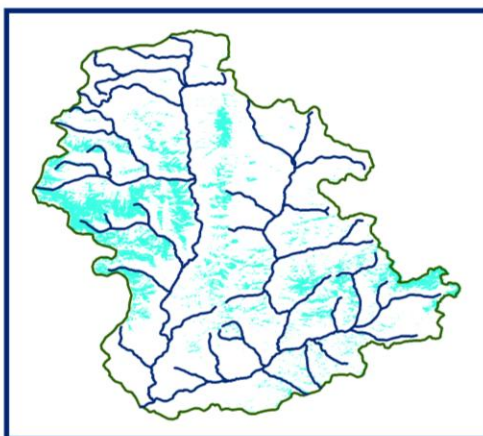
10 DAILY SNOW COVER MAP: TAWANG BASIN



DATA USED
05 JANUARY 2014



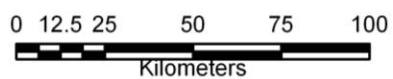
DATA USED
15 JANUARY 2014



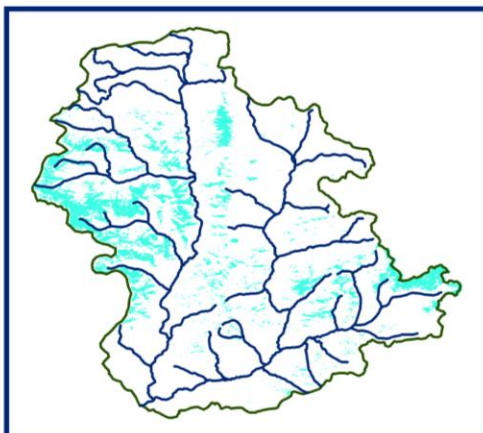
DATA USED
25 JANUARY 2014



SNOW



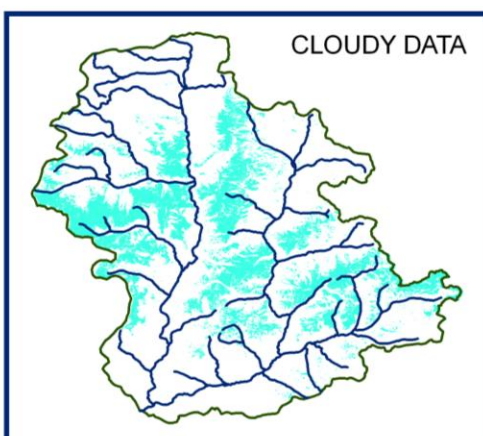
SNOW COVER MAP : TAWANG BASIN



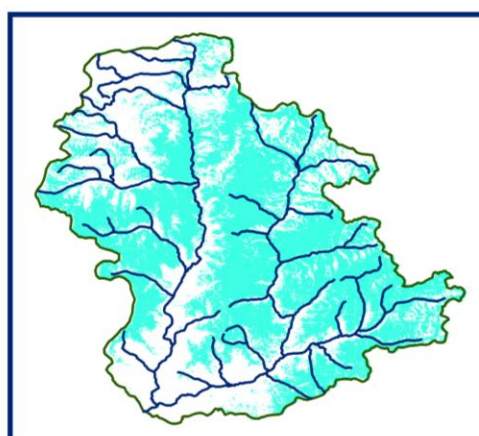
01 FEBRUARY 2014



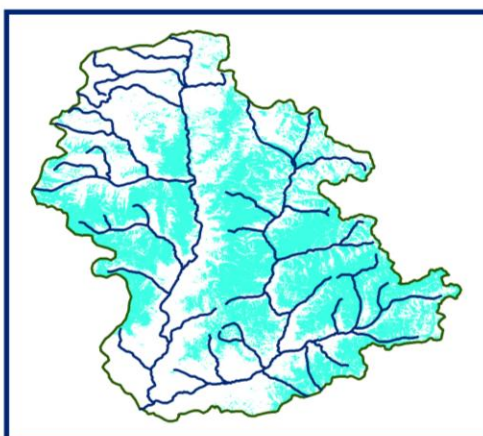
04 FEBRUARY 2014



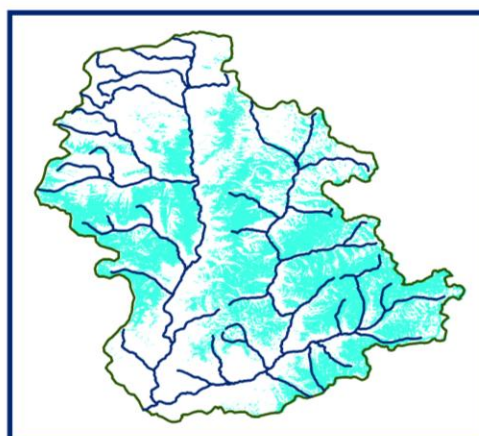
13 FEBRUARY 2014



18 FEBRUARY 2014



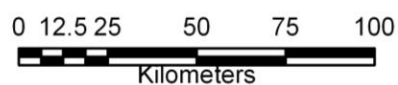
19 FEBRUARY 2014



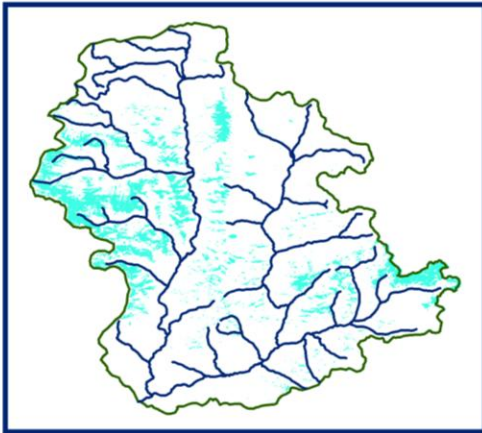
21 FEBRUARY 2014



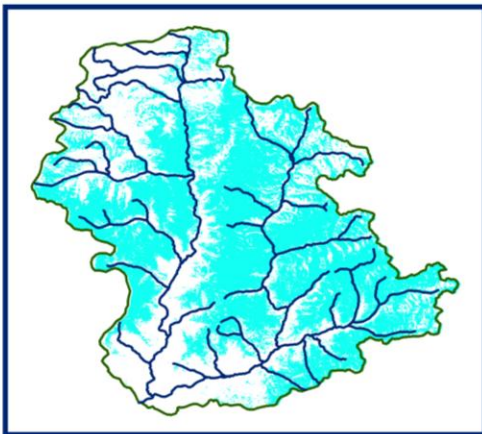
SNOW



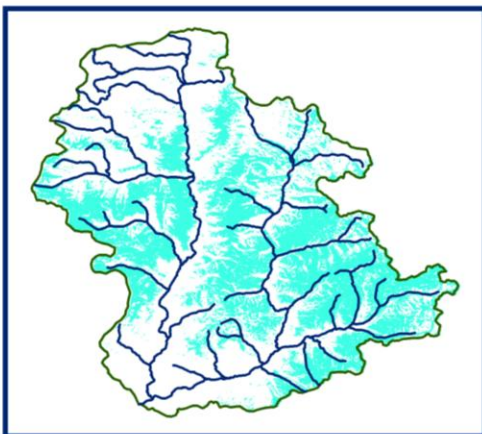
10 DAILY SNOW COVER MAP: TAWANG BASIN



DATA USED
05 FEBRUARY 2014



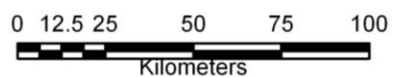
DATA USED
13 FEBRUARY 2014
18 FEBRUARY 2014



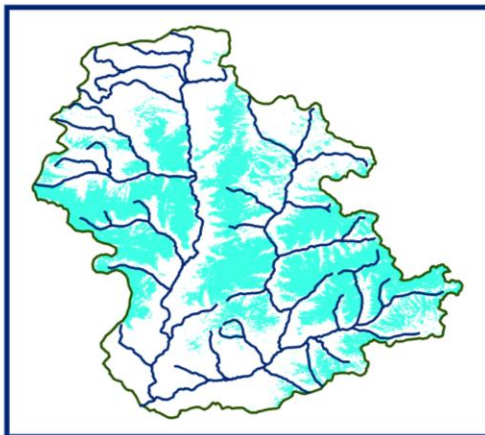
DATA USED
25 FEBRUARY 2014



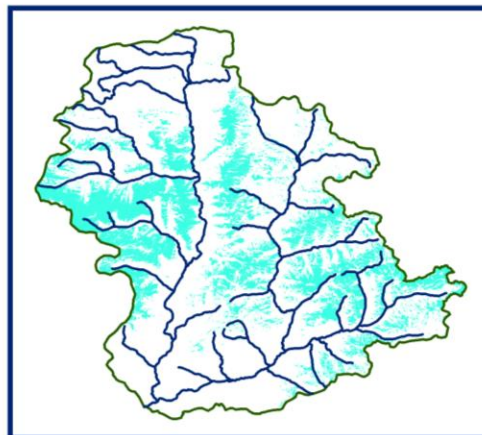
SNOW



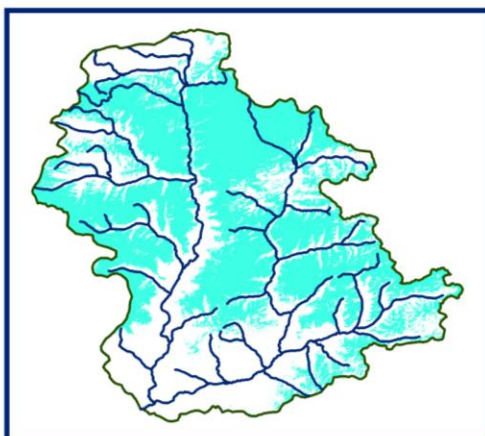
SNOW COVER MAP : TAWANG BASIN



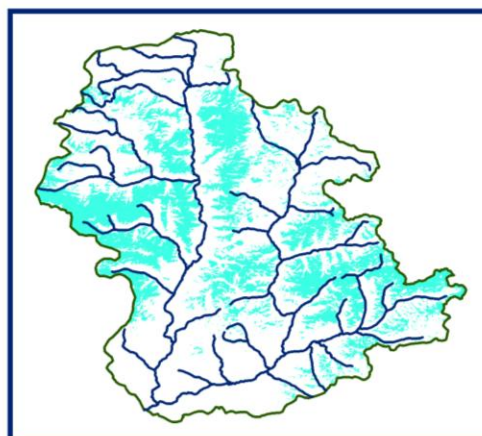
03 MARCH 2014



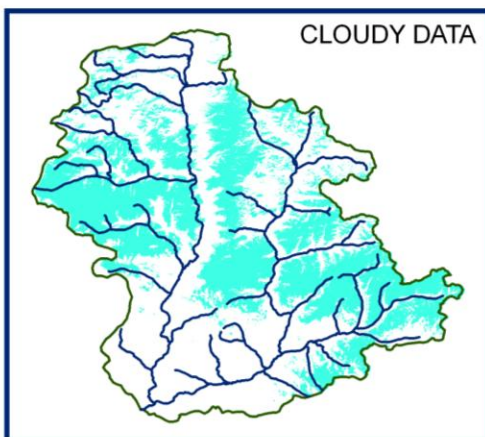
10 MARCH 2014



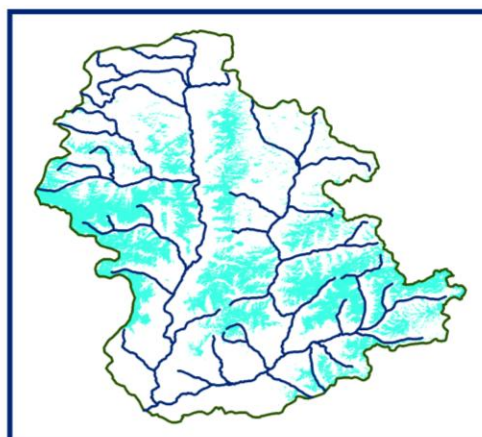
15 MARCH 2014



17 MARCH 2014



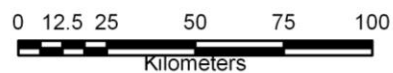
24 MARCH 2014



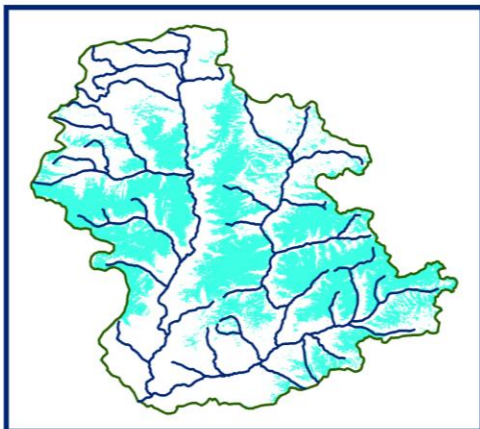
29 MARCH 2014



SNOW



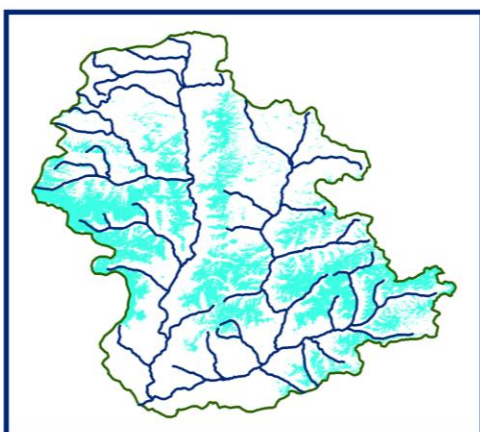
10 DAILY SNOW COVER MAP: TAWANG BASIN



DATA USED
05 MARCH 2014



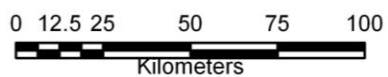
DATA USED
15 MARCH 2014



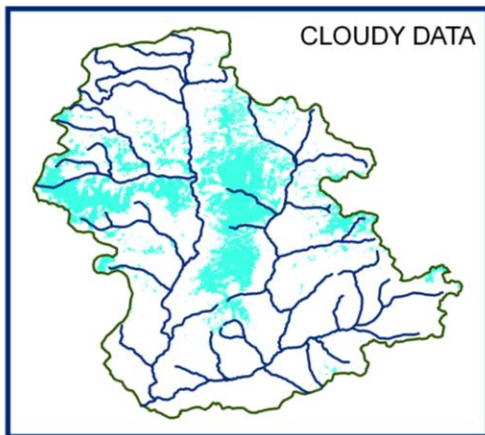
DATA USED
25 MARCH 2014



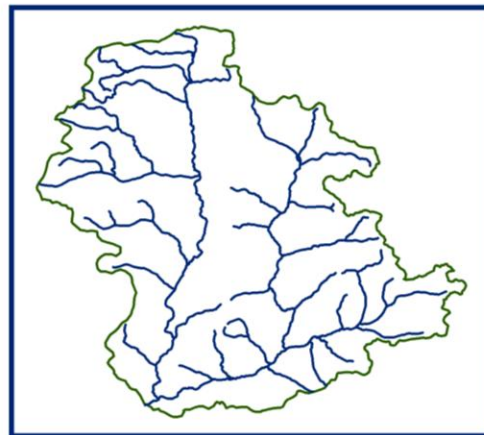
SNOW



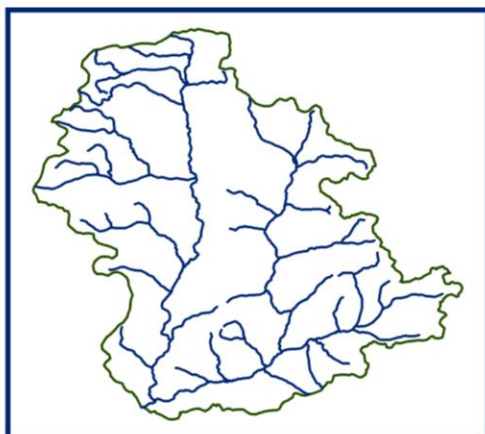
SNOW COVER MAP : TAWANG BASIN



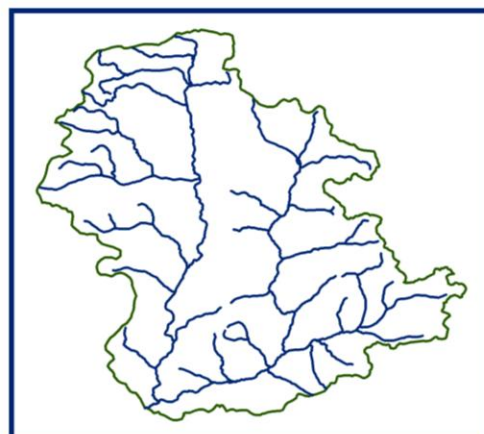
03 APRIL 2014



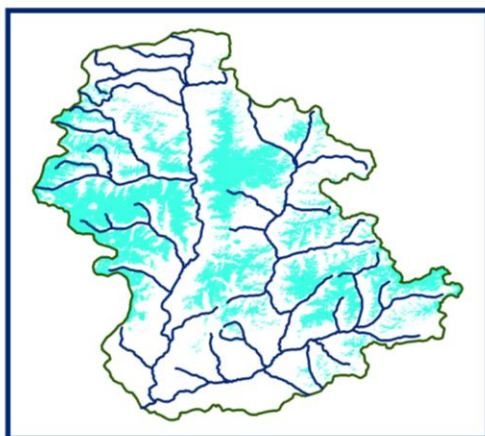
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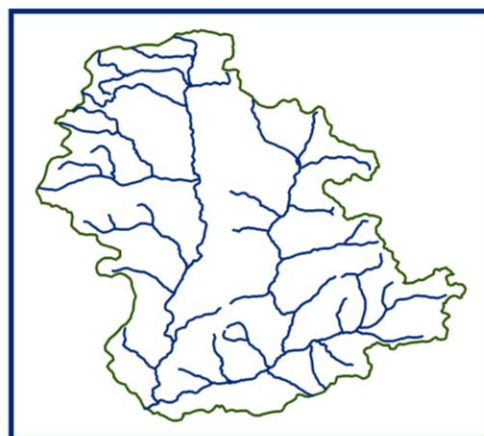
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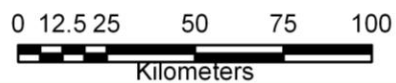
22 APRIL 2014



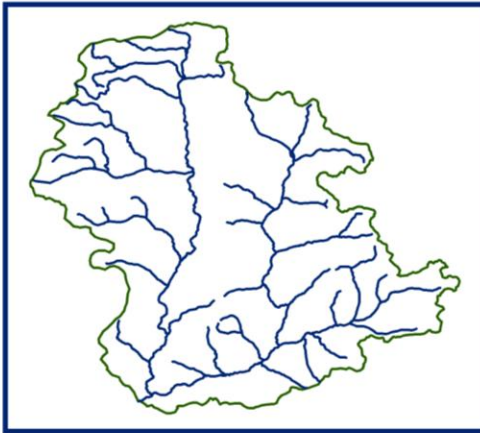
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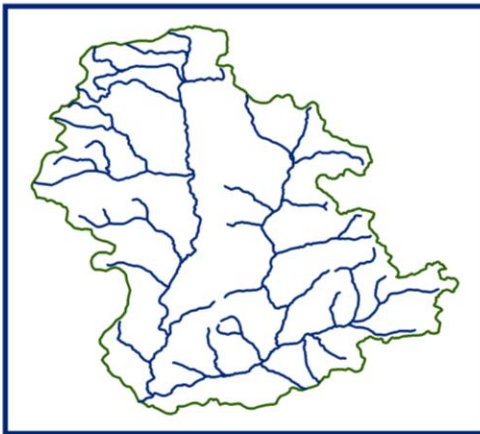
SNOW



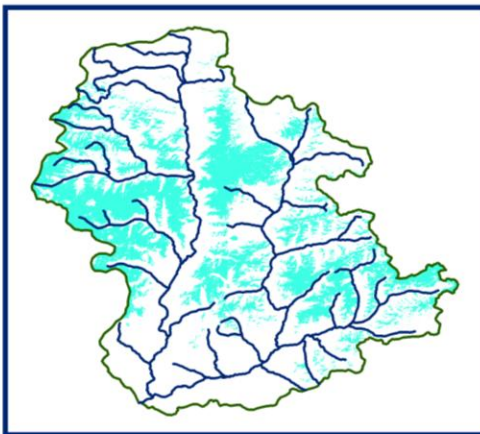
10 DAILY SNOW COVER MAP: TAWANG BASIN



DATA USED
DATA NOT AVAILABLE



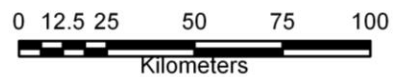
DATA USED
DATA NOT AVAILABLE



DATA USED
25 APRIL 2014



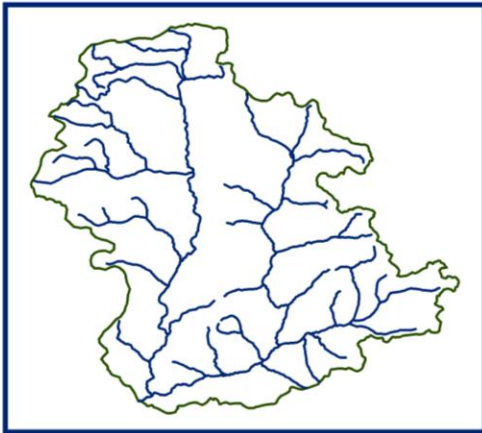
SNOW



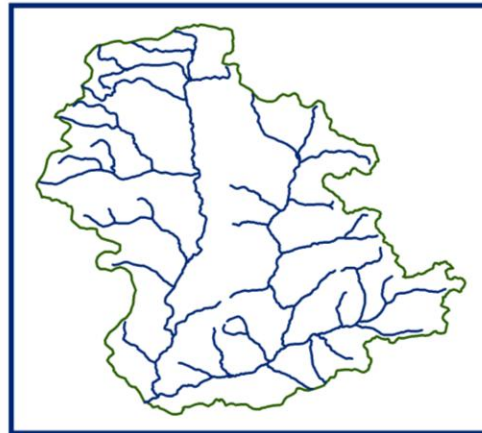
SNOW COVER MAP

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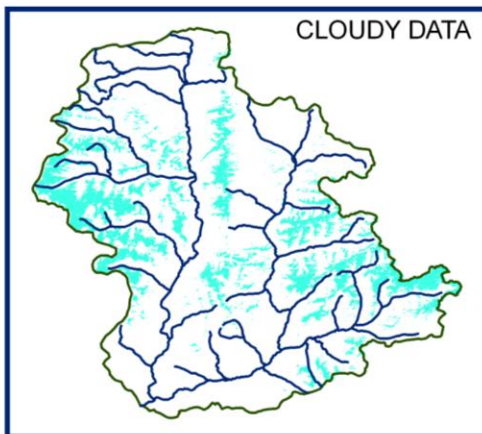
TAWANG BASIN



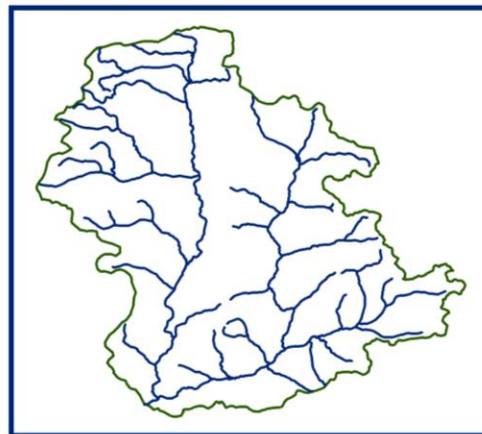
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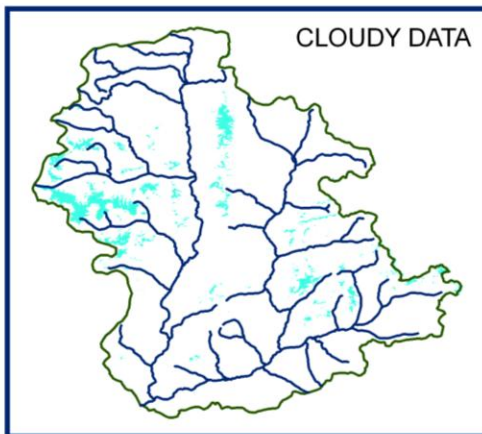
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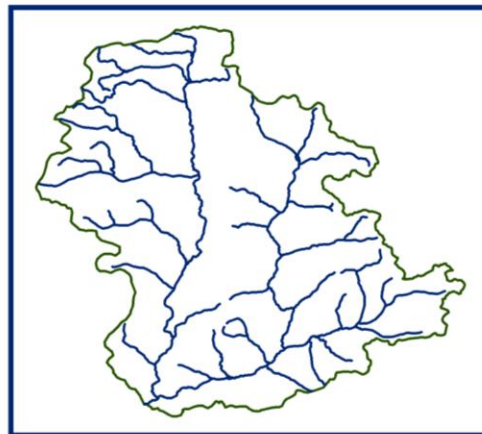
11 MAY 2014



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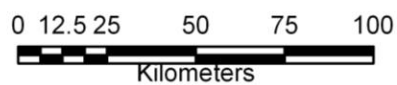
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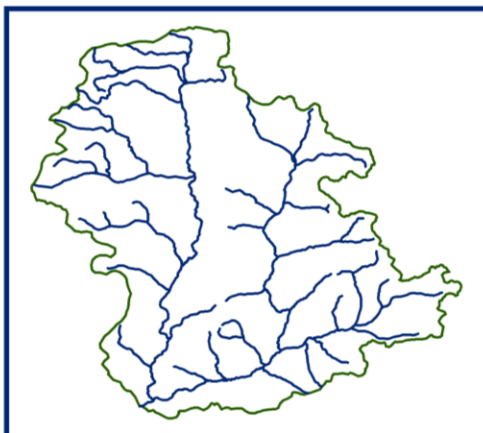
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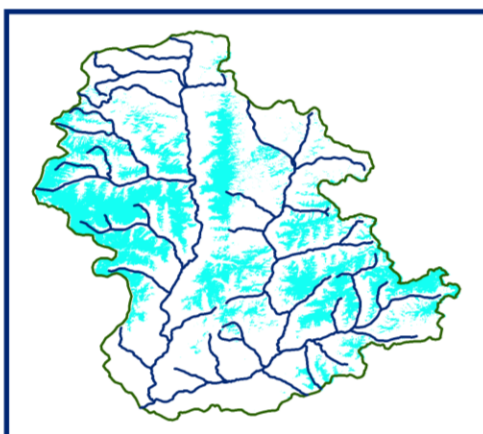
SNOW



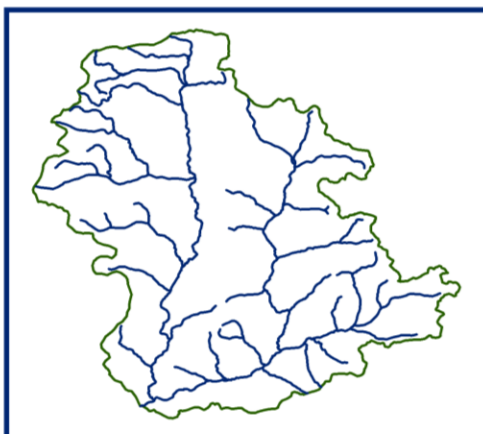
10 DAILY SNOW COVER MAP: TAWANG BASIN



DATA USED
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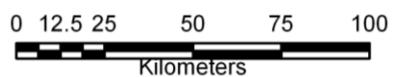
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22 APRIL 2014



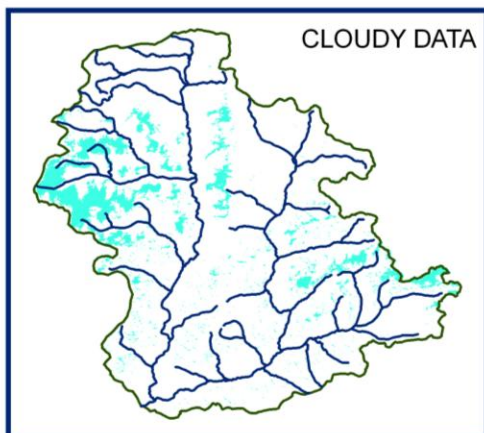
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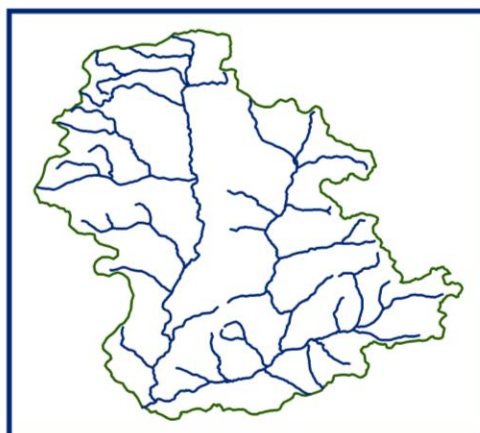
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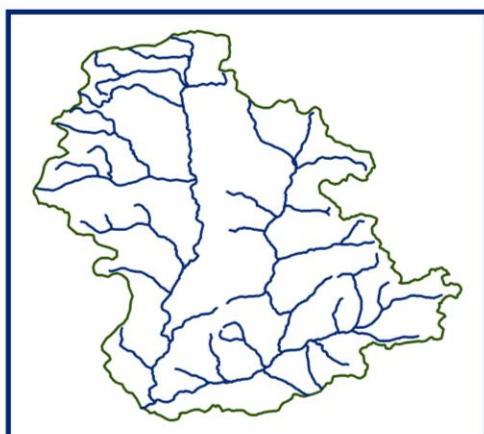
SNOW COVER MAP : TAWANG BASIN



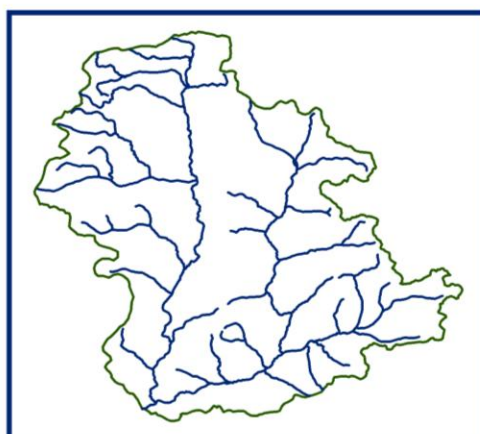
01 JUNE 2014



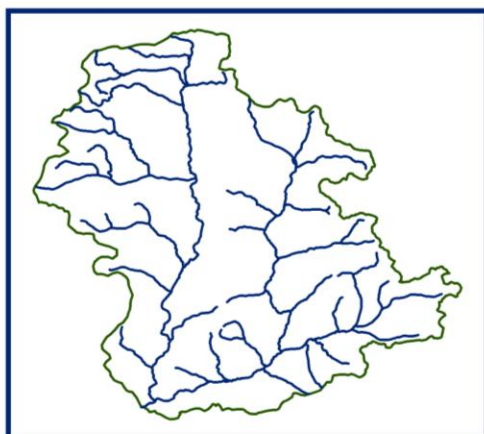
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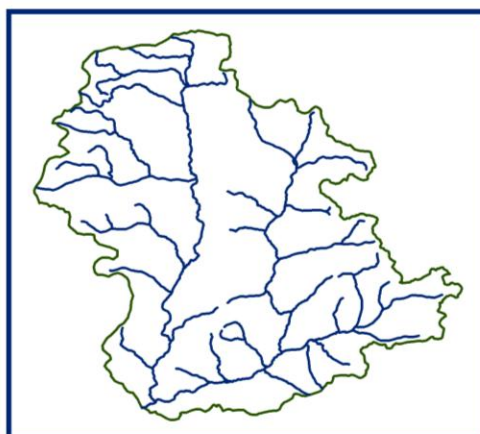
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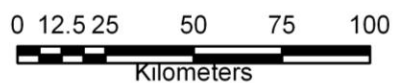
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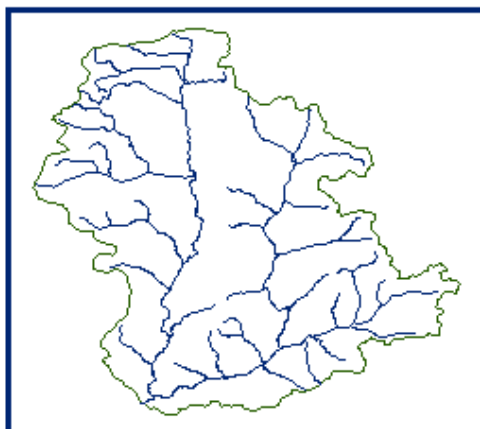
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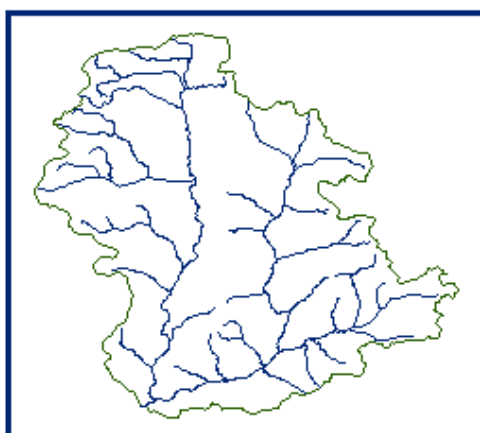
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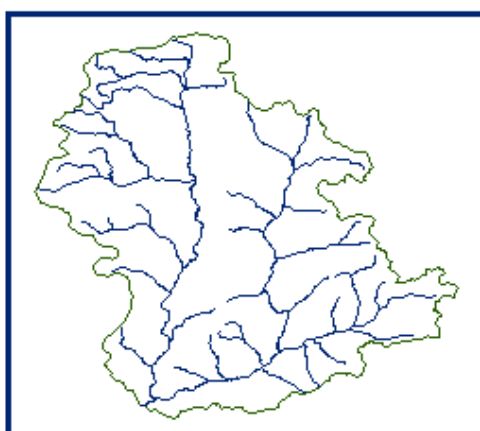
10 DAILY SNOW COVER MAP: TAWANG BASIN



DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE



SNOW

