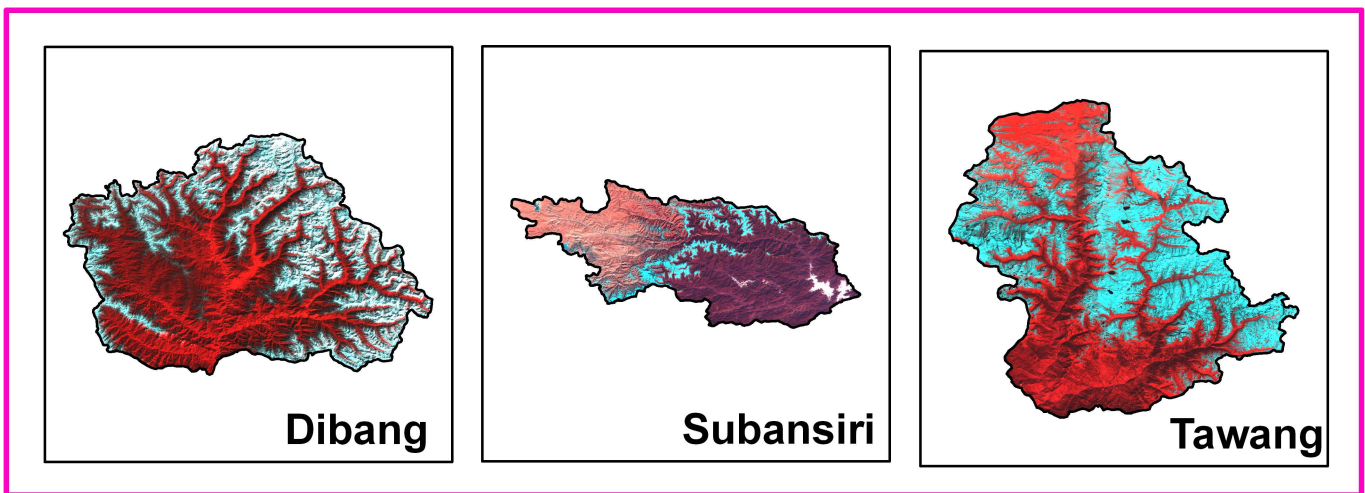


SNOW COVER ATLAS OF BRAHMAPUTRA BASIN

Sub basins: Dibang, Subansiri and Tawang

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

Year : 2010-11



State Remote Sensing Application Centre
Itanagar, Arunachal Pradesh - 791113

&

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SPACE APPLICATIONS CENTRE (ISRO), AHMEDABAD - 380015

DOCUMENT CONTROL AND DATA SHEET

Report Number	SAC/RESA/MESG/SGP/SN/ 67 /2012
Month and year of publication	May 2012
Title	Snow cover Atlas of Brahmaputra basin
Type of Report	Scientific Report
No. of pages	76
No. of figures, Charts & Tables	56, 9 & 6
Authors	Team members
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Originating Unit	Geo Sciences Division, Marine, Geo and Planetary Sciences Group, Earth, Ocean, Atmosphere, Planetary Sciences and Applications area, Space Applications Centre (ISRO), Ahmedabad-15
Abstract	This atlas gives sub basin-wise distribution of snow cover in the Brahmaputra basin from October 2010 to June 2011. The sub basins included in this report are Dibhang, Subansiri and Tawang. The areal extent of snow cover was estimated in fully automatic mode using Normalized Difference Snow Index (NDSI) based algorithm. For this purpose AWiFS sensor of Resourcesat satellite was used. This atlas gives snow cover products, statistics and seasonal snow depletion curve. It is expected that this data will be useful for hydrological and climatological applications.
Key words	Snow cover, NDSI, AWiFS, depletion curve, Dibhang, Subansiri and Tawang basins.
Security Classification	Unrestricted
Distribution	Among concerned

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1. Introduction

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

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

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

2. Study Area:

This Atlas gives distribution of snow cover in three subbasins of the 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 2010 to June 2011 were used in this study.

4. Normalised Difference Snow Index (NDSI):

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

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

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

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

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

5. Snow cover monitoring algorithm

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

6. Results and discussions

In this atlas, basin-wise snow cover statistics, maps, and seasonal depletion curves have been provided from October 2010 to June 2011. Snow ablation pattern varies from basin to basin, depending on area altitude distribution in the basins. In the Tawang river basin, shows accumulation and ablation of snow throughout the winter season. For example on November 15, 2010, 26 percent area was covered by seasonal snow. This was reduced to 16 percent by December 25, 2010 again it increases to 71 percent on February 15, 2011. Dibang sub-basin also shows accumulation and ablation of snow throughout the winter season and snow depletion pattern is similar. Subansiri sub-basin also shows accumulation and ablation of snow throughout the winter season but percentage areal extent snow is very less compare to Tawang and Dibang sub-basins.

Acknowledgements

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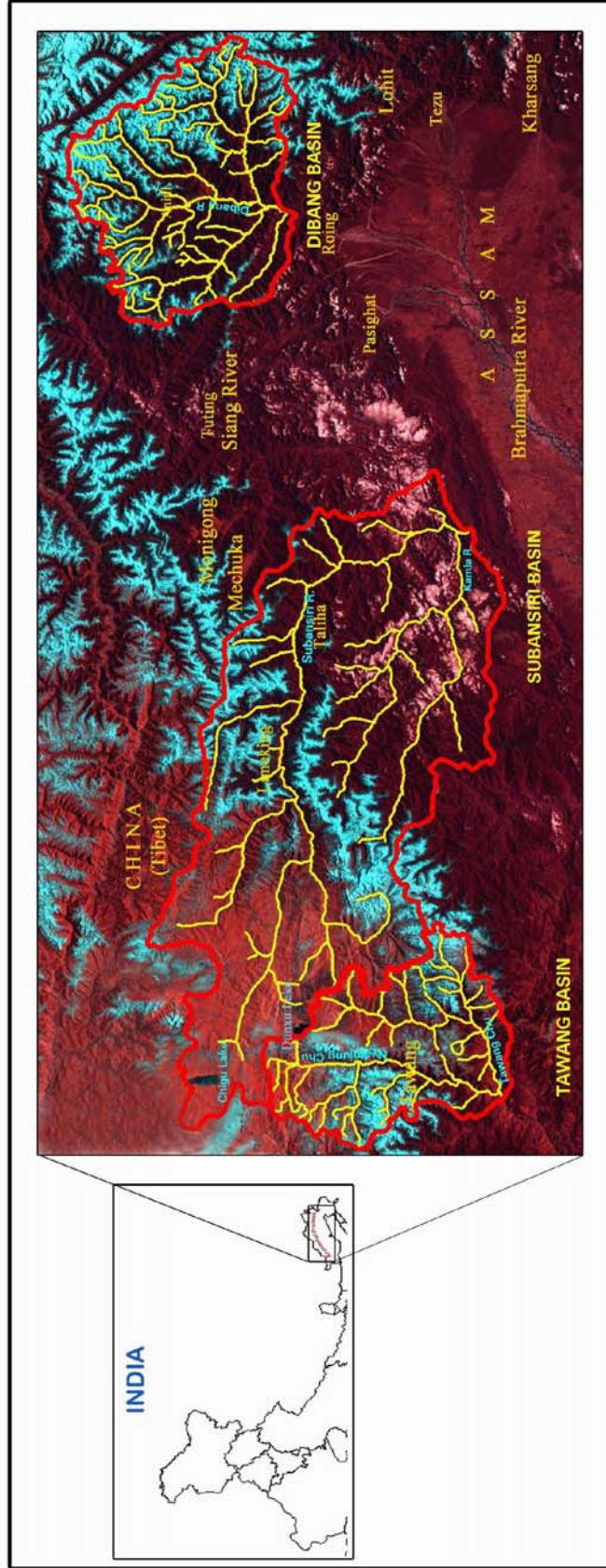


Figure 1: Location map of Dibang, Subansiri and Tawang sub-basins (Part of Brahmaputra basin)

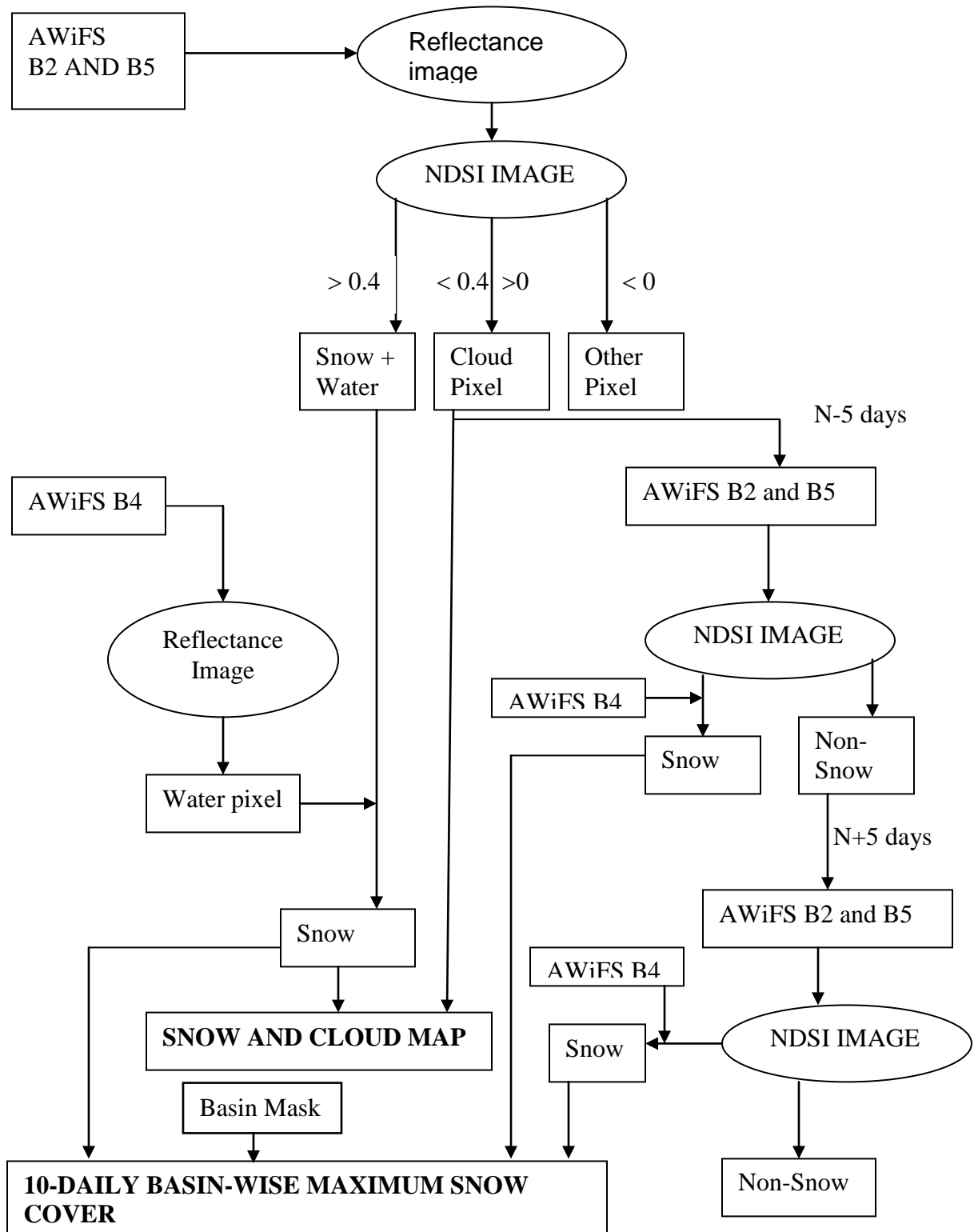


Figure 2: Algorithm for snow cover mapping using AWiFS data

DIBHANG BASIN

AREAL EXTENT OF SNOW (5 DAILY)

BASIN NAME: DIBANG

BASIN AREA: 9158.08sq km

S. No	Date	Snow cover (sq km)	Snow cover (%)	S.No	Date	Snow cover (sq km)	Snow cover (%)
October 2010							
1	1-Oct-10	DNA		5	26-Oct-10	320.58	4
2	7-Oct-10	CLOUDYDATA		6	27-Oct-10	DNC	
3	12-Oct-10	640.19	7	7	30-Oct-10	DNA	
4	16-Oct-10	CLOUDYDATA		8	31-Oct-10	CLOUDYDATA	
November 2010							
9	4-Nov-10	DNA		14	18-Nov-10	DNA	
10	5-Nov-10	705.62	8	15	23-Nov-10	DNA	
11	9-Nov-10	436.27	5	16	24-Nov-10	3134.73	34
12	10-Nov-10	437.90	5	17	28-Nov-10	DNA	
13	14-Nov-10	CLOUDYDATA					
December 2010							
18	3-Dec-10	2981.85	33	23	14-Dec-10	DNA	
19	4-Dec-10	2759.31	30	24	18-Dec-10	2432.35	27
20	8-Dec-10	2696.36	29	25	22-Dec-10	DNA	
21	9-Dec-10	CLOUDYDATA		26	23-Dec-10	1410.62	15
22	13-Dec-10	4309.41	47	27	27-Dec-10	2243.33	25
January 2011							
28	2-Jan-11	DNA		32	11-Jan-11	3974.46	43
29	6-Jan-11	3570.22	39	33	21-Jan-11	5138.81	56
30	7-Jan-11	DNA		34	26-Jan-11	DNA	
31	10-Jan-11	DNA		35	30-Jan-11	4940.38	54
February 2011							
36	3-Feb-11	DNA		40	18-Feb-11	DNA	
37	4-Feb-11	4438.19	48	41	23-Feb-11	5295.65	58
38	8-Feb-11	DNA		42	27-Feb-11	DNA	
39	9-Feb-11	CLOUDYDATA		43	28-Feb-11	CLOUDYDATA	
March 2011							
44	4-Mar-11	CLOUDYDATA		45	14-Mar-11	DNC	
46	15-Mar-11	DNA		47	19-Mar-11	CLOUDYDATA	
April 2011							
48	2-April-11	CLOUDYDATA		49	7-apr-11	CLOUDYDATA	
50	12-April-11	2976.04	33	51	17-Apr-11	3851.15	42

52	21-Apr-11	CLOUDYDATA		53	26-Apr-11	4177.05	46
54	27-Apr-11	3911.61	43				
May 2011							
55	6-May-11	3058.17	33	56	11-May-11	CLOUDYDATA	
57	15-May-11	CLOUDYDATA		58	25-May-11	1866.39	20
June 2011							
59	8-June-11	CLOUDYDATA		60	13-June-11	CLOUDYDATA	
61	23-June-11	CLOUDYDATA		62	28-June-11	CLOUDYDATA	

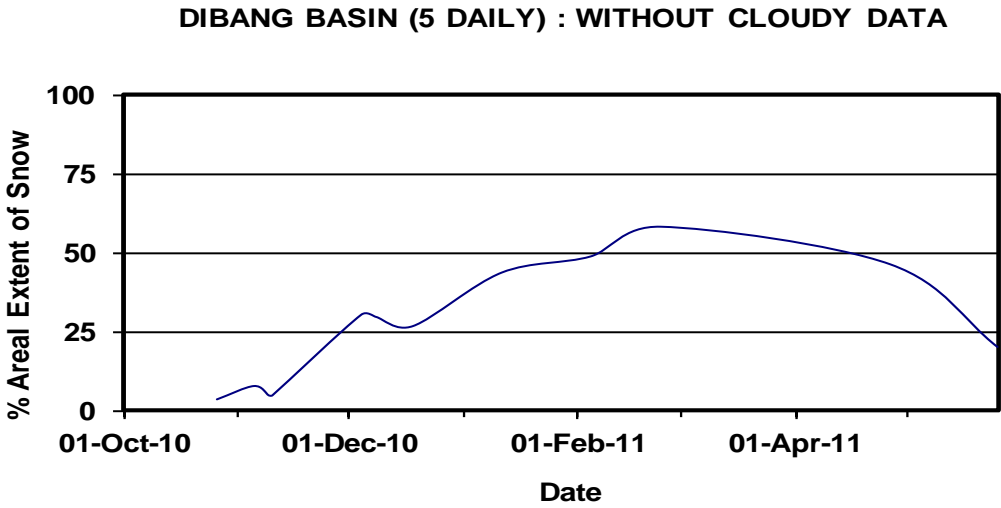
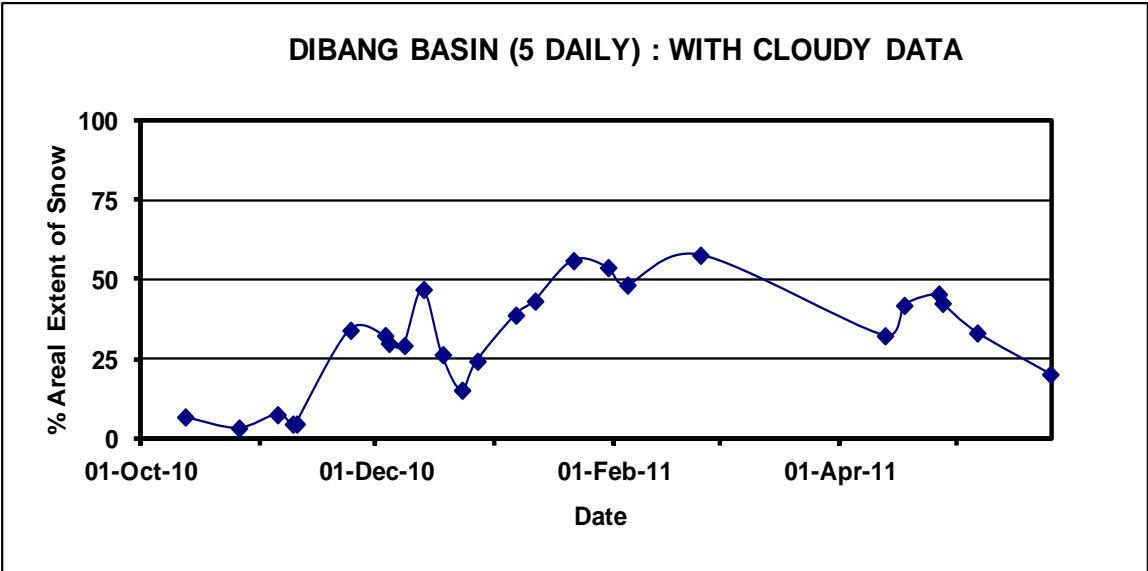
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AREAL EXTENT OF SNOW (10 DAILY)

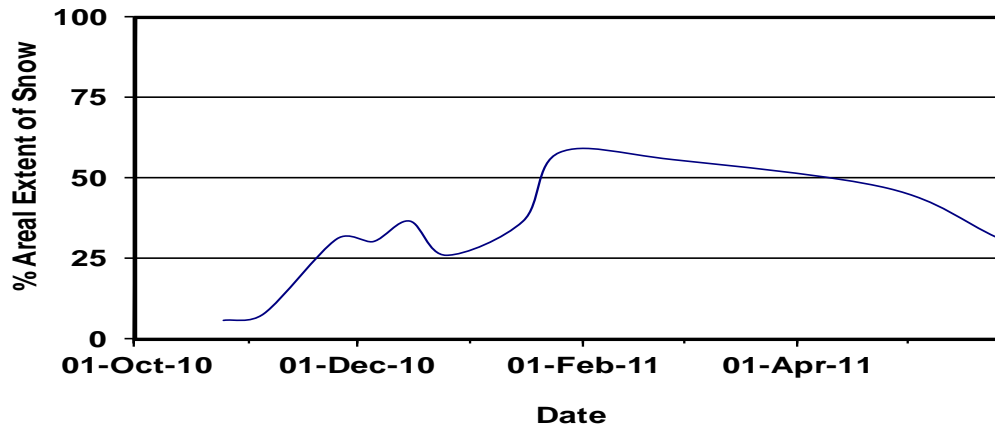
BASIN NAME: DIBANG

BASIN AREA: 9158.08 sq km

S. No	Date	Snow cover (sq km)	Snow cover (%)	S.No	Date	Snow cover (sq km)	Snow cover (%)
October 2010				November 2010			
1	26-Oct-10	546.62	6	2	10-Nov-10	437.34	5
				3	24-Nov-10	2857.03	31
December 2010				January 2011			
4	3-Dec-10	2783.39	30	7	11-Jan-11	3360.12	37
5	13-Dec-10	3364.93	37	8	21-Jan-11	4827.53	53
6	23-Dec-10	2394.74	26	9	30-Jan-11	5310.92	58
February 2011				March 2011			
10	23-Feb-11	5111.00	56	11	14-Mar-11	CLOUDY DATA	
April 2011				May 2011			
12	27-Apr-11	4295.03	47	13	25-May-11	2891.98	32
June 2011							
14	13-June-11	CLOUDY DATA		15	23-June-11	CLOUDY DATA	

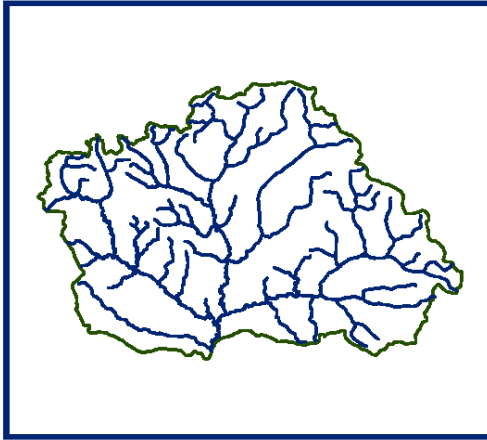


DIBANG BASIN (10 DAILY)

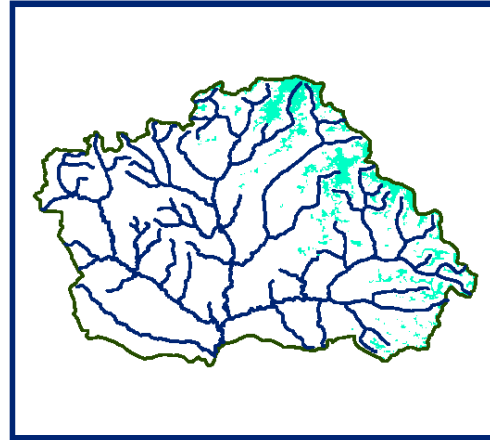


SNOW COVER MAPS

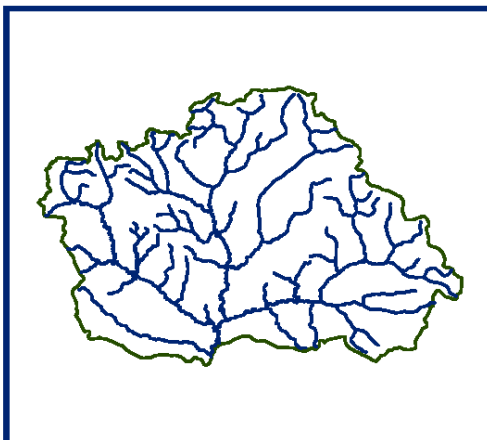
SNOW COVER MAP : DIBANG BASIN



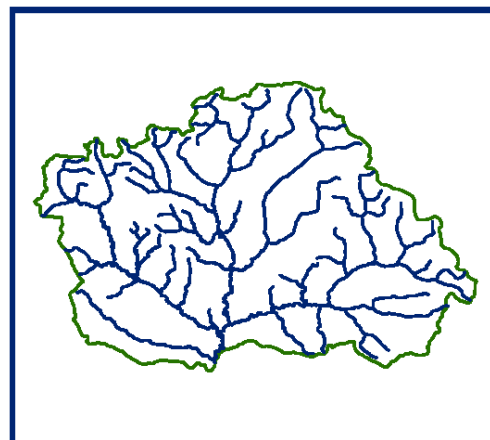
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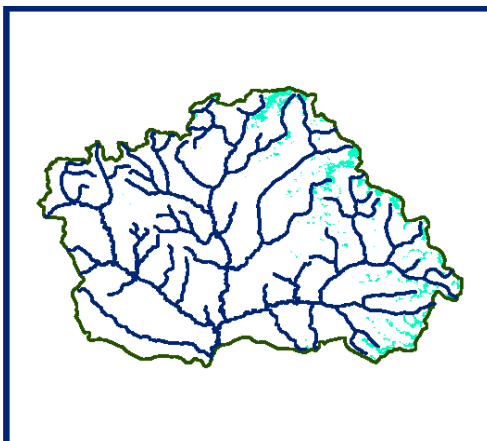
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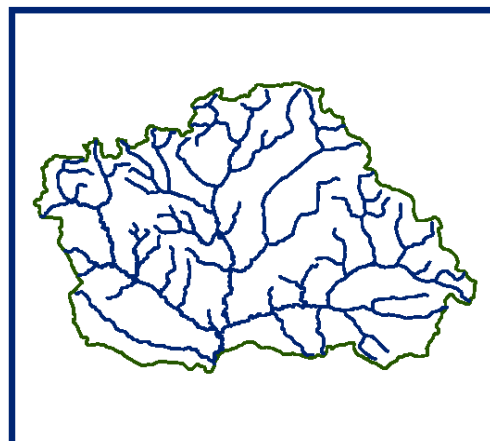
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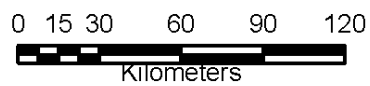
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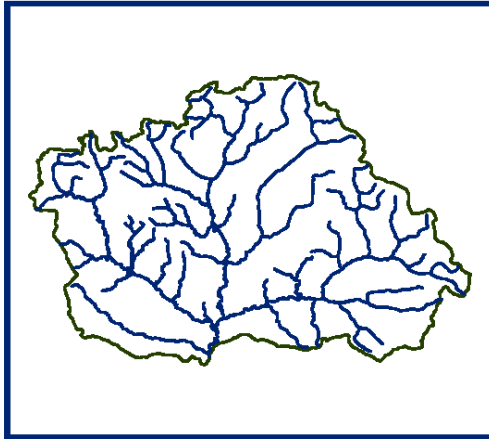
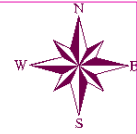
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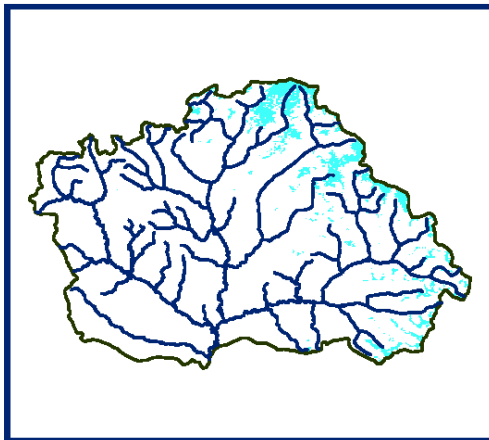
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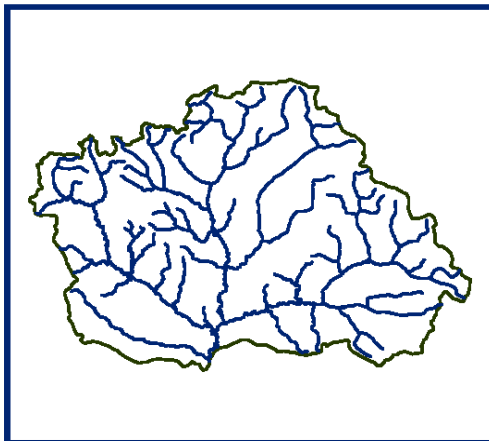
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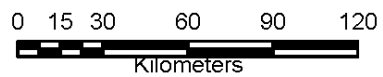
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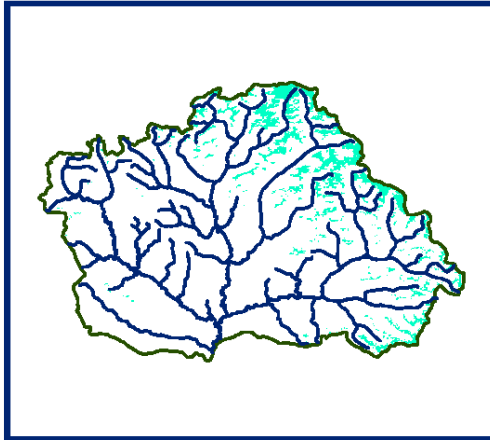
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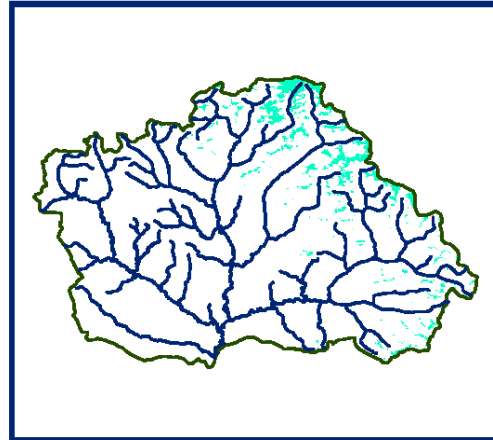
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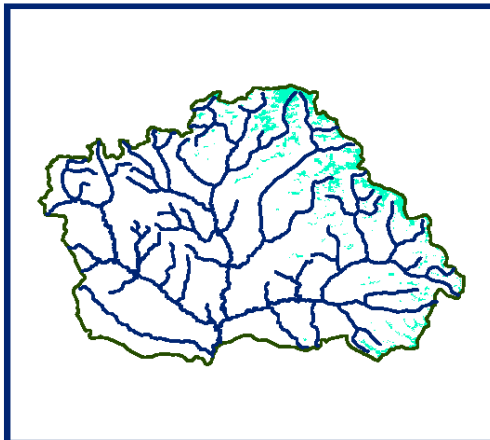
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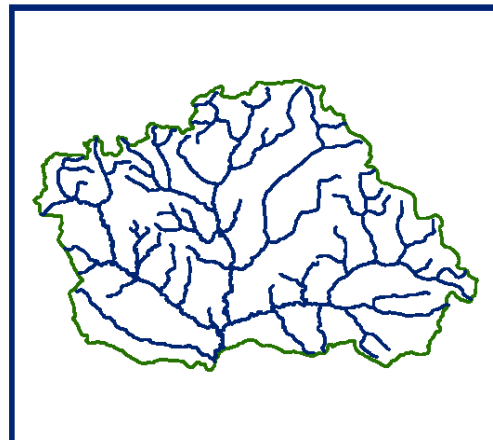
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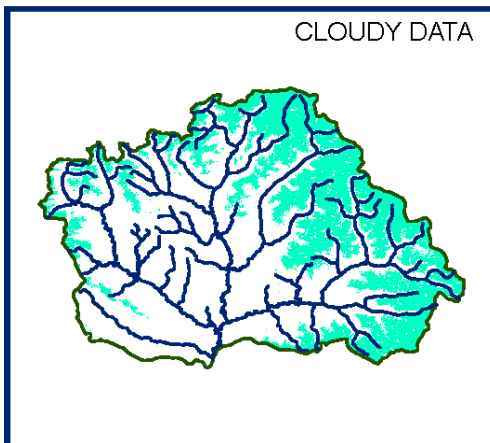
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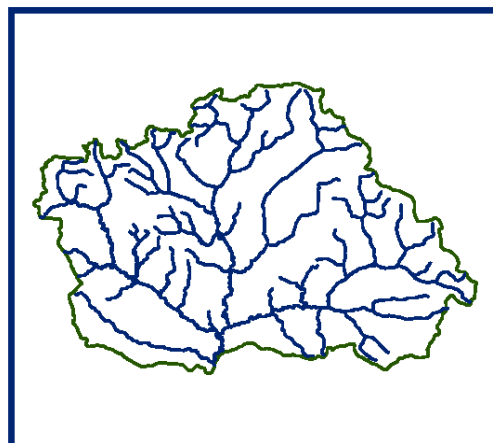
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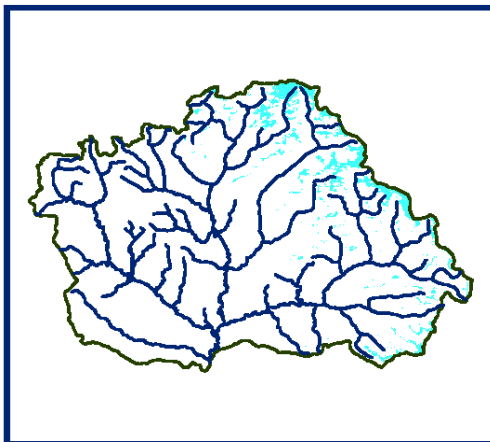
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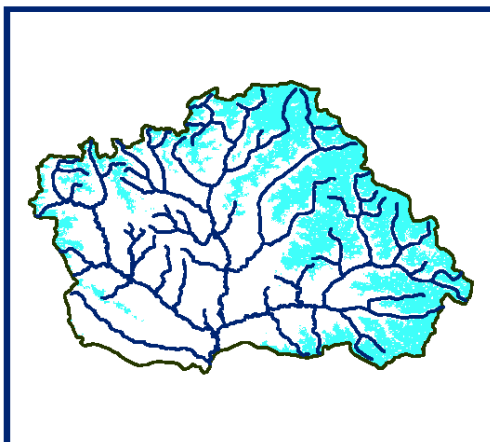
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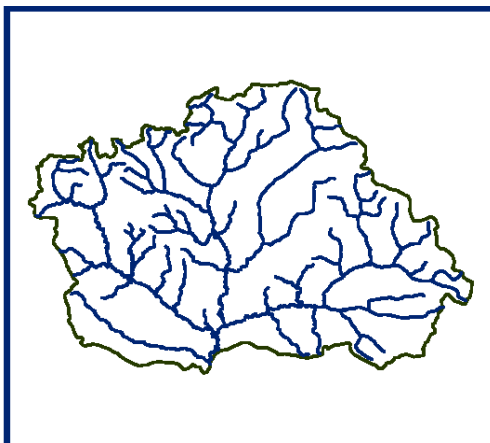
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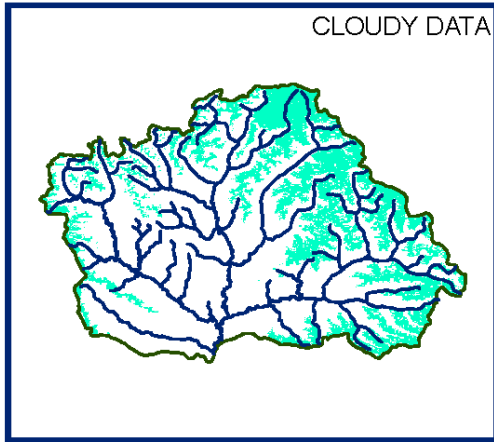
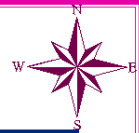
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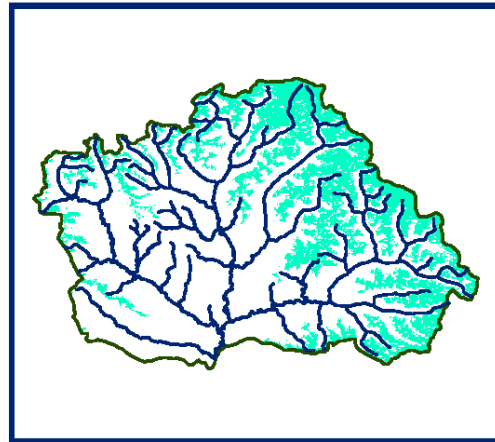
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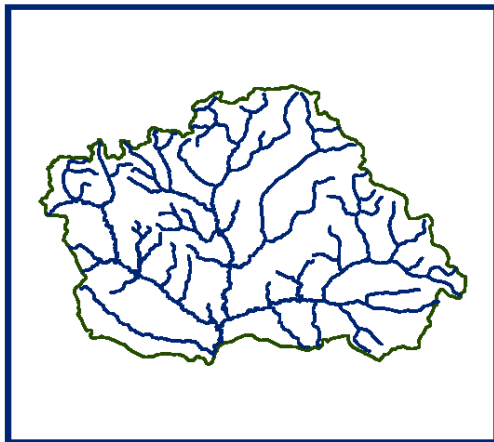
SNOW COVER MAP : DIBANG BASIN



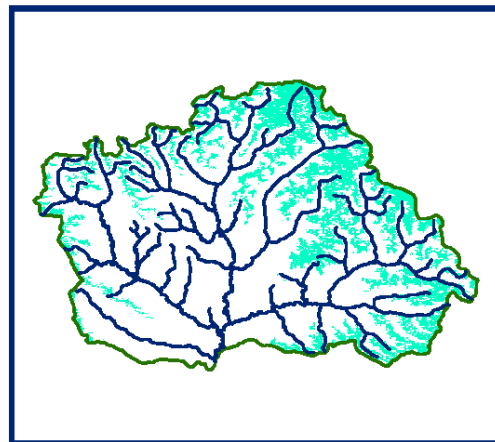
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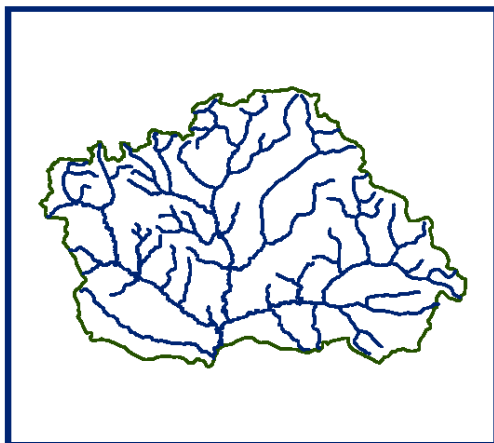
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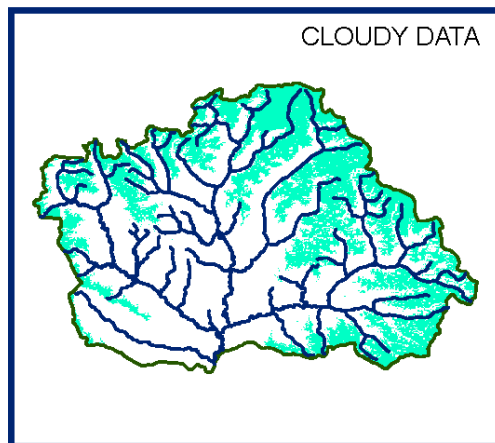
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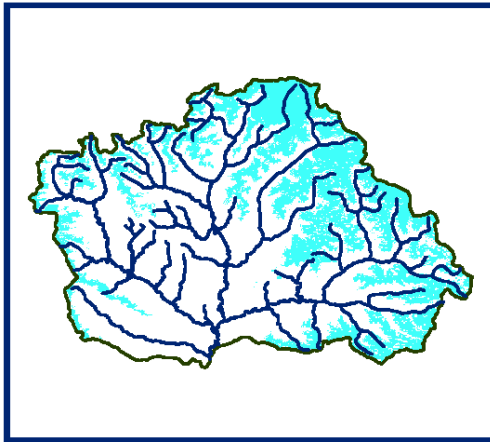
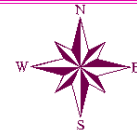
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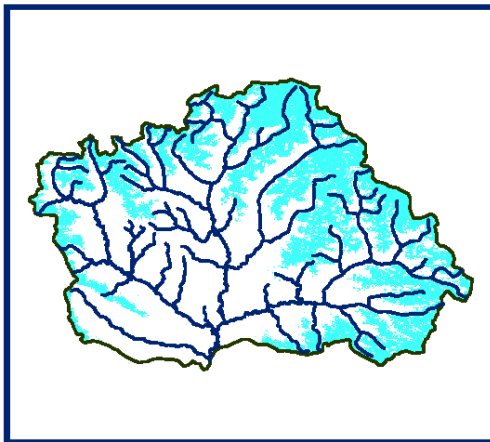
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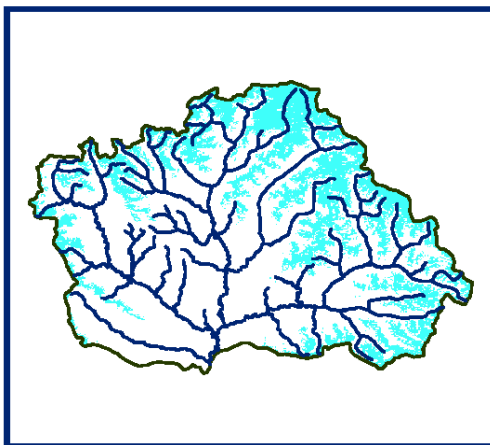
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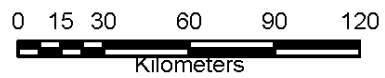
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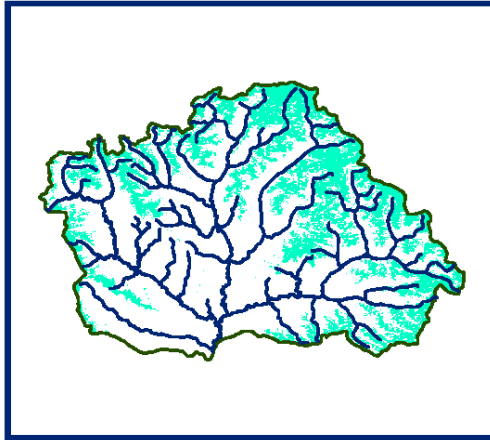
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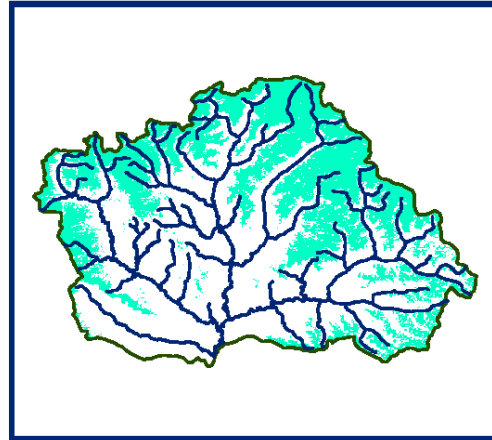
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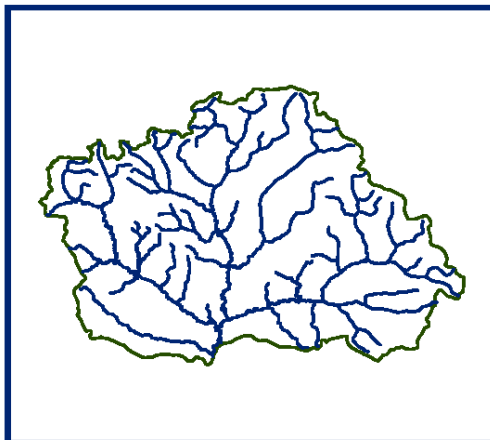
SNOW COVER MAP : DIBANG BASIN



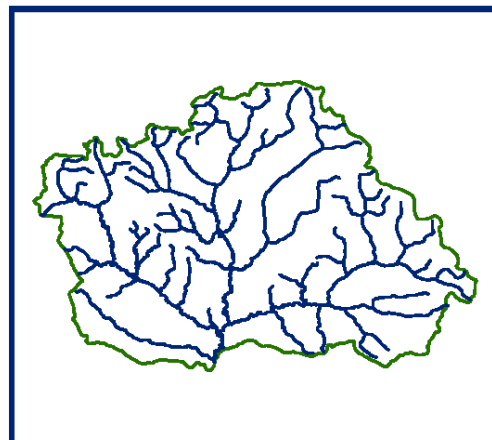
06 JANUARY 2011



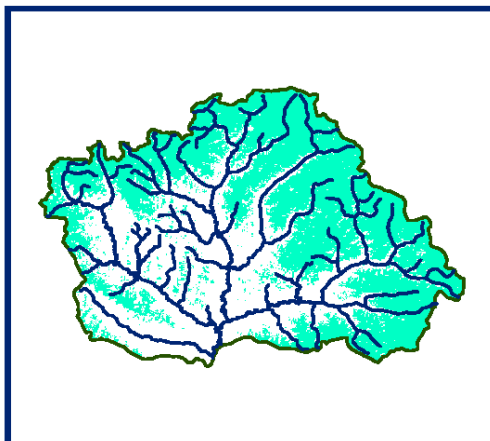
11 JANUARY 2011



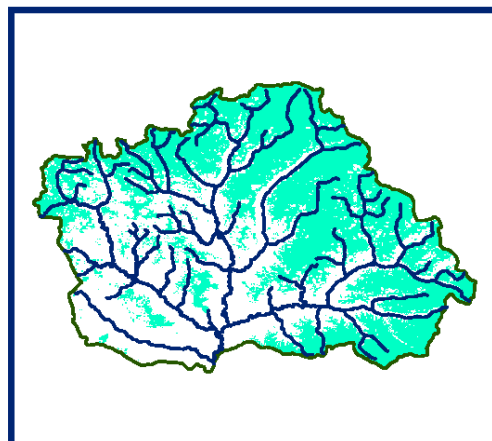
DATA NOT AVAILABLE



DATA NOT AVAILABLE



21 JANUARY 2011



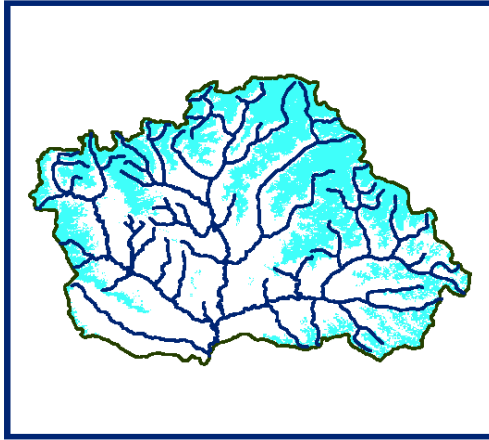
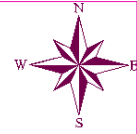
30 JANUARY 2011



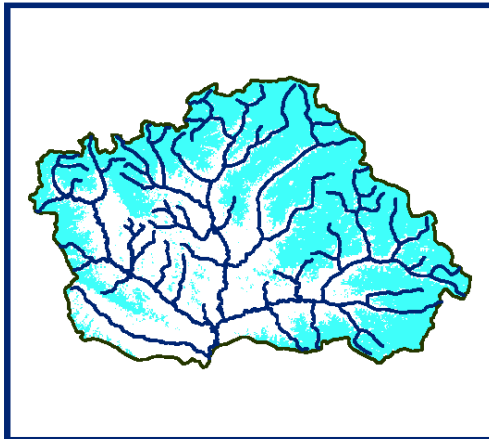
SNOW



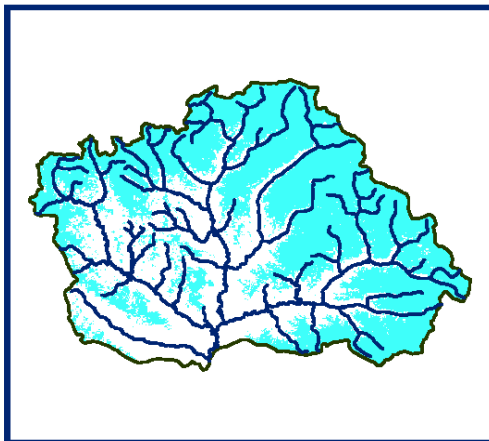
10 DAILY SNOW COVER MAP: DIBANG BASIN



DATA USED
11 JANUARY 2011



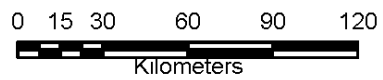
DATA USED
21 JANUARY 2011



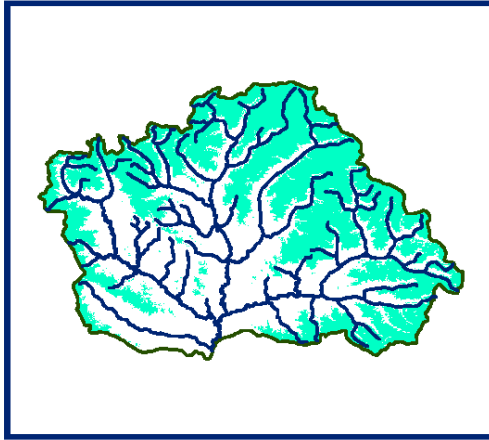
DATA USED
30 JANUARY 2011



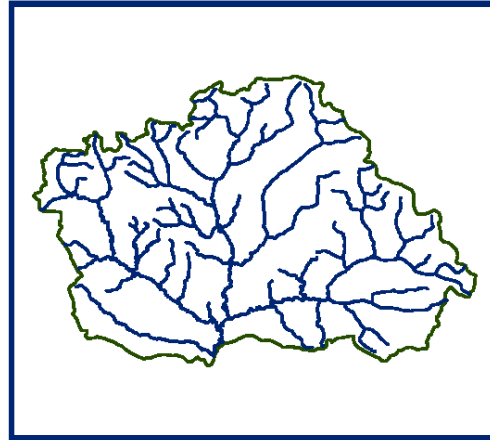
SNOW



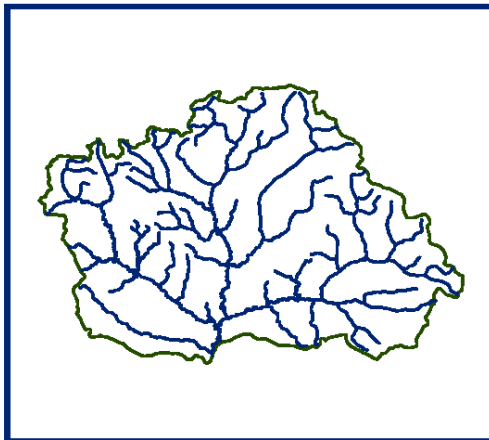
SNOW COVER MAP : DIBANG BASIN



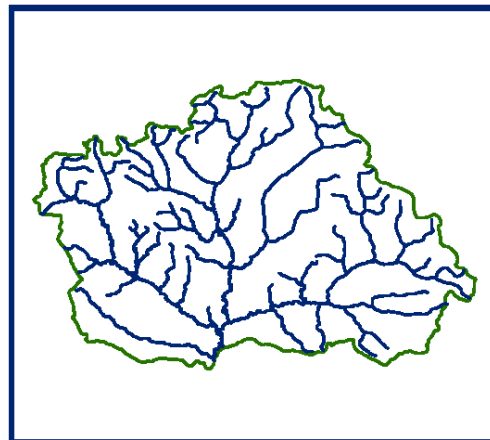
04 FEBRUARY 2011



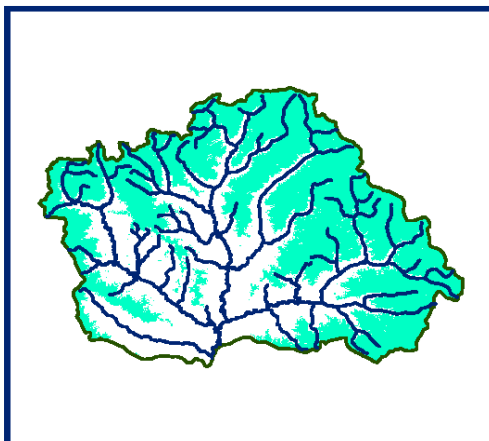
DATA NOT AVAILABLE



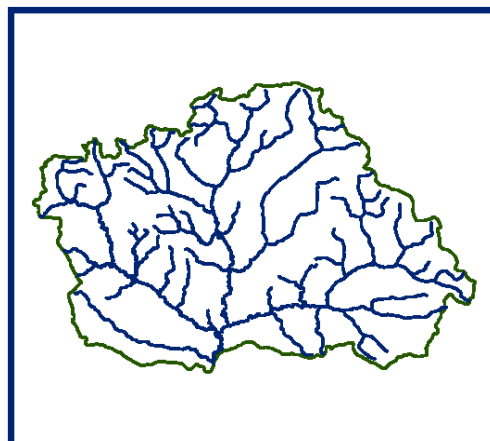
DATA NOT AVAILABLE



DATA NOT AVAILABLE



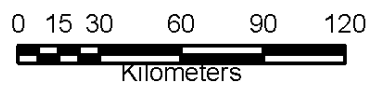
23 FEBRUARY 2011



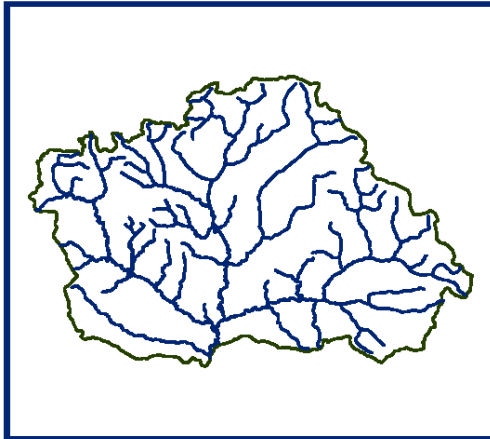
DATA NOT AVAILABLE



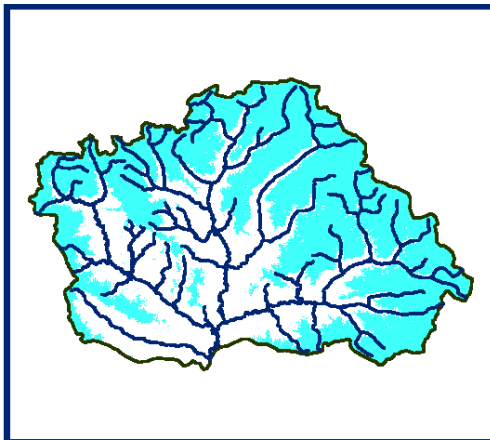
SNOW



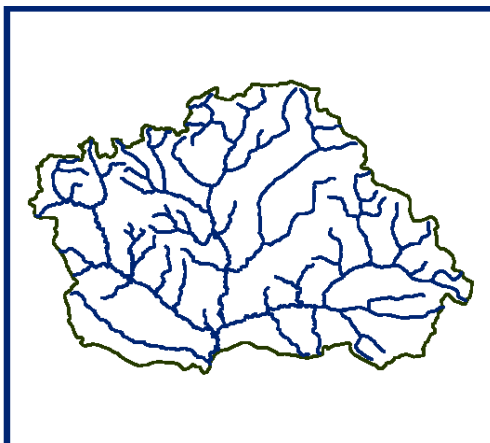
10 DAILY SNOW COVER MAP: DIBANG BASIN



DATA USED
DATA NOT AVAILABLE



DATA USED
23 FEBRUARY 2011



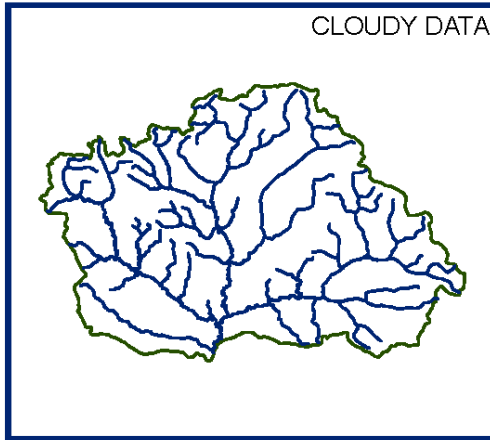
DATA USED
DATA NOT AVAILABLE



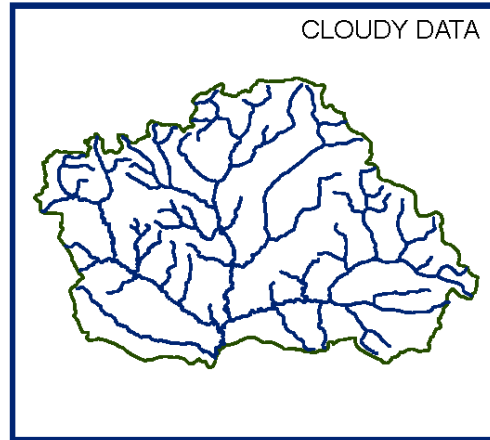
SNOW



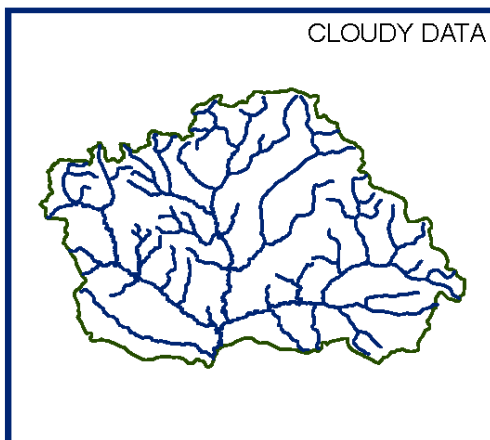
SNOW COVER MAP : DIBANG BASIN



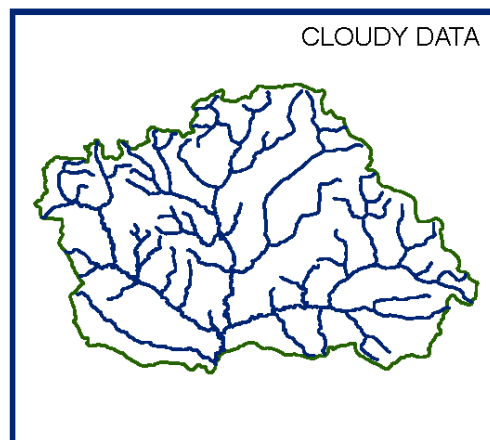
04 MARCH 2011



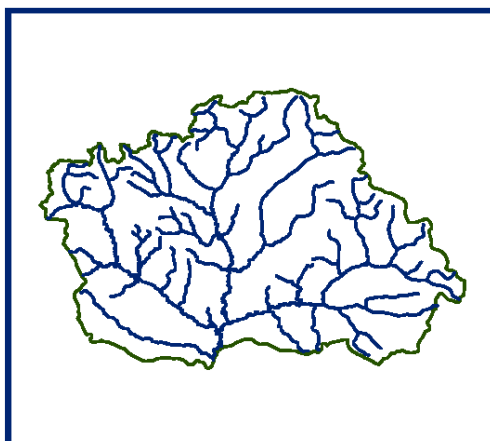
14 MARCH 2011



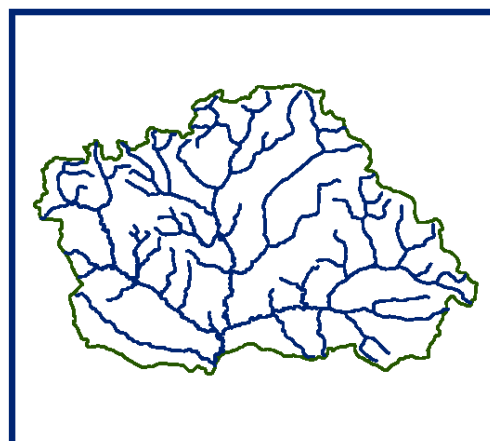
15 MARCH 2011



19 MARCH 2011



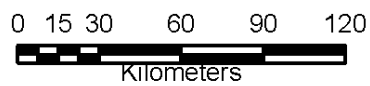
DATA NOT AVAILABLE



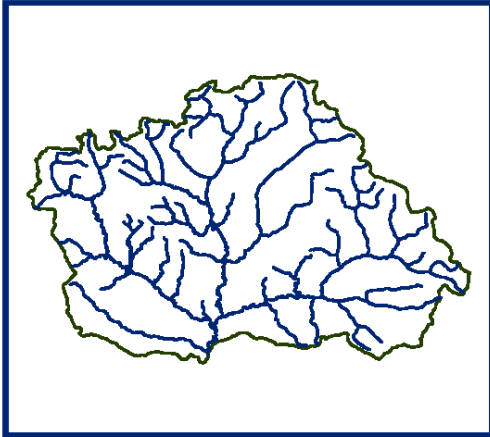
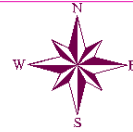
DATA NOT AVAILABLE



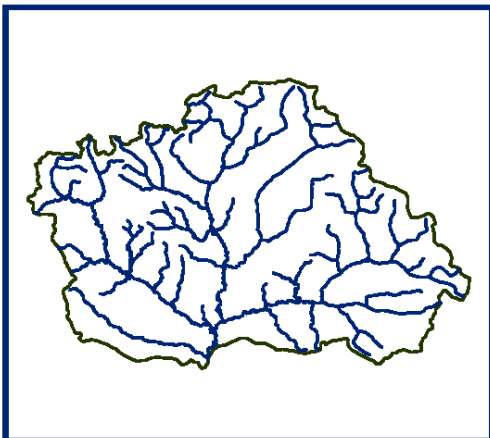
SNOW



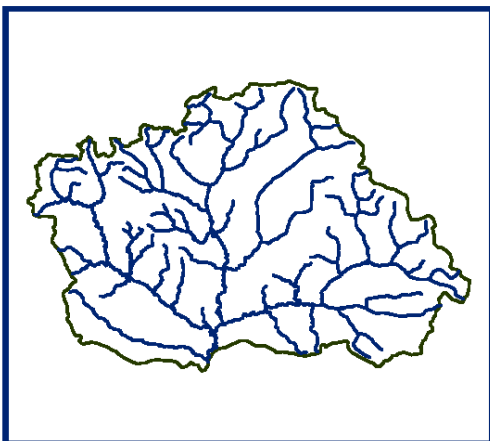
10 DAILY SNOW COVER MAP: DIBANG BASIN



DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE



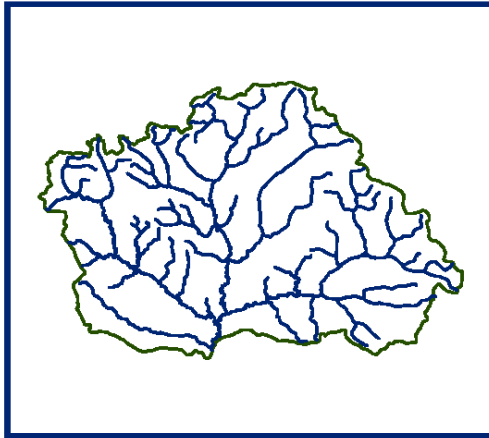
DATA USED
DATA NOT AVAILABLE



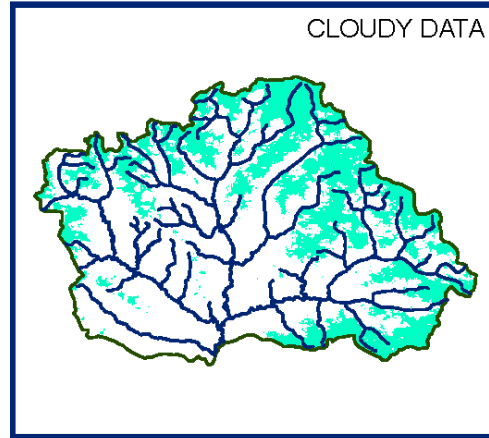
SNOW



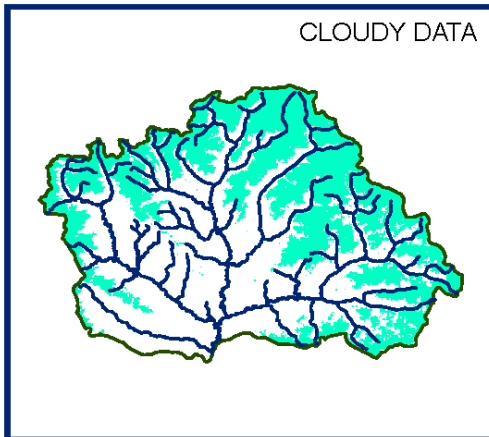
SNOW COVER MAP : DIBANG BASIN



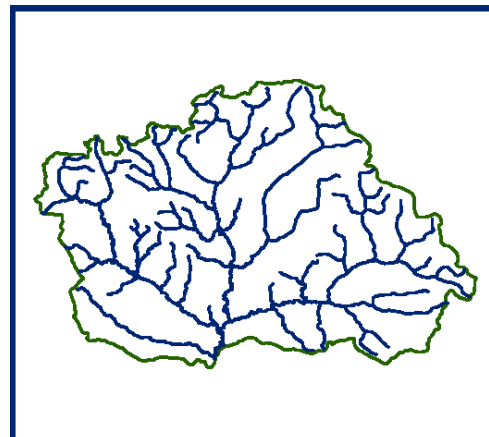
DATA NOT AVAILABLE



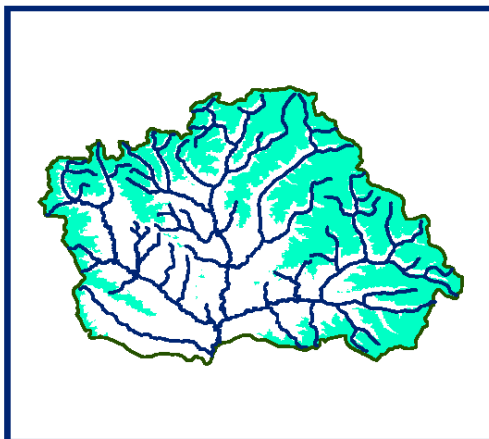
12 APRIL 2011



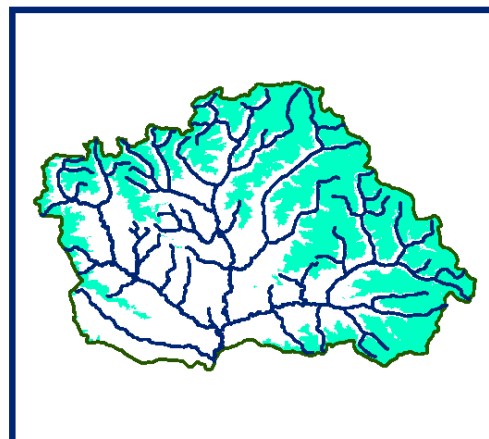
17 APRIL 2011



DATA NOT AVAILABLE



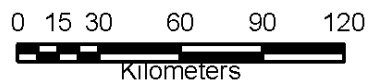
26 APRIL 2011



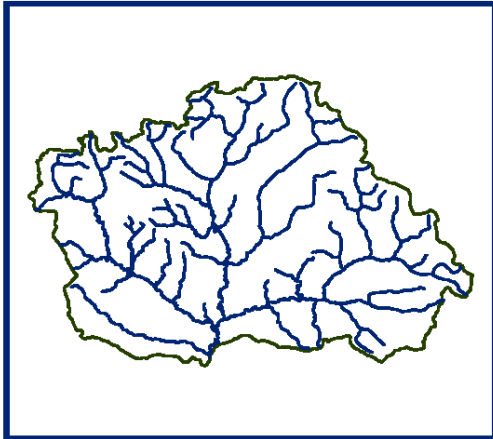
27 APRIL 2011



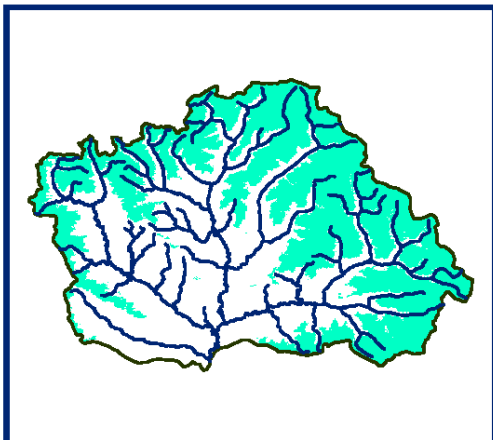
SNOW



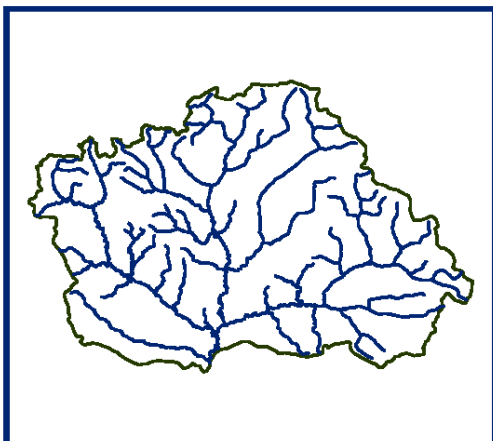
10 DAILY SNOW COVER MAP: DIBANG BASIN



DATA USED
DATA NOT AVAILABLE



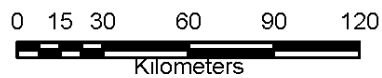
DATA USED
27 APRIL 2011



DATA USED
DATA NOT AVAILABLE



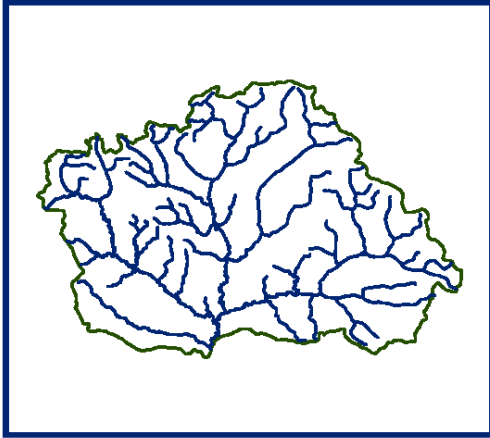
SNOW



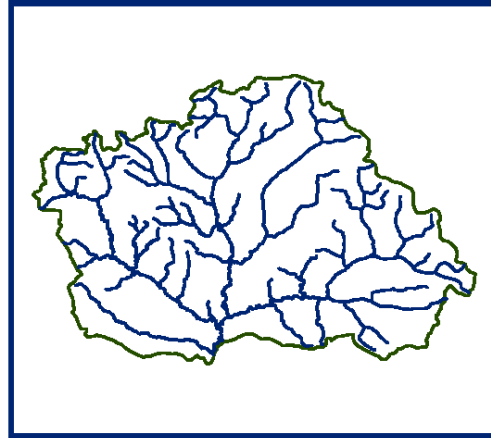
SNOW COVER MAP

:

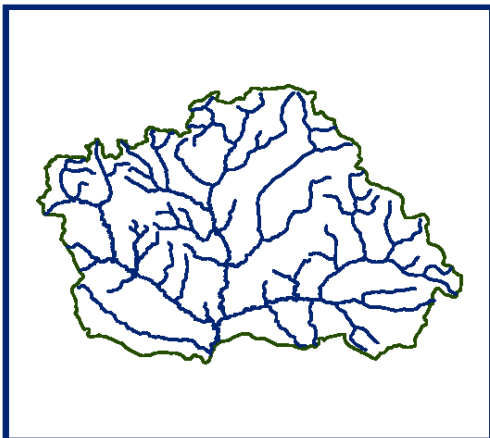
DIBANG BASIN



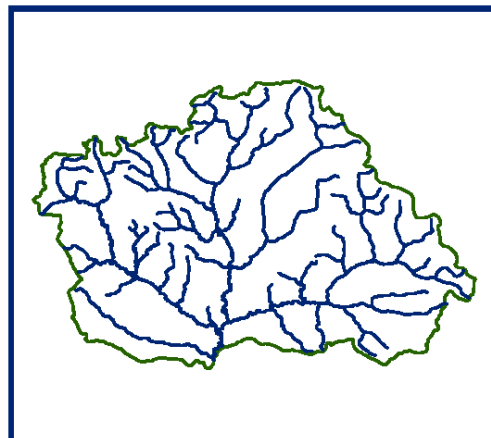
DATA NOT AVAILABLE



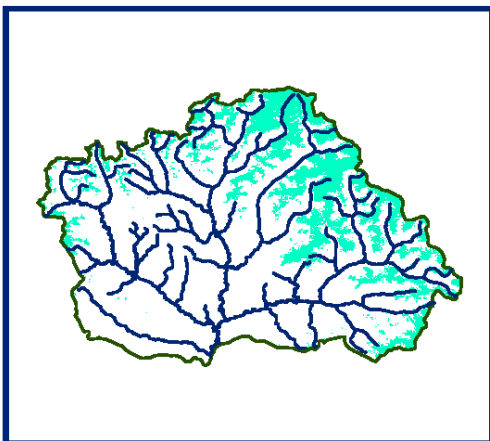
DATA NOT AVAILABLE



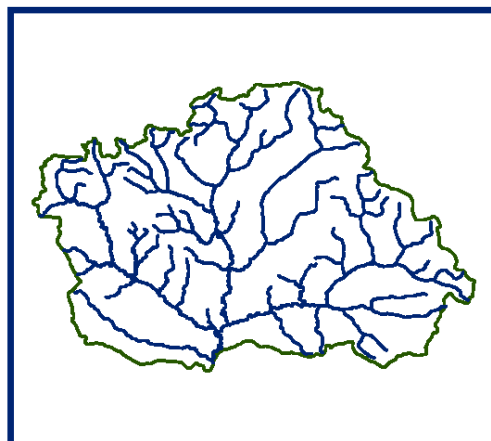
DATA NOT AVAILABLE



DATA NOT AVAILABLE



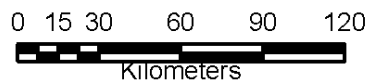
25 MAY 2011



DATA NOT AVAILABLE

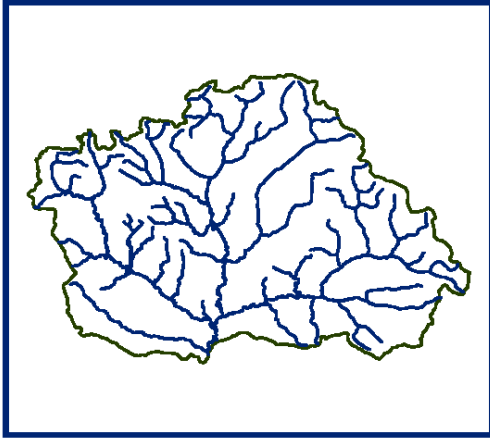
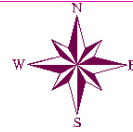


SNOW

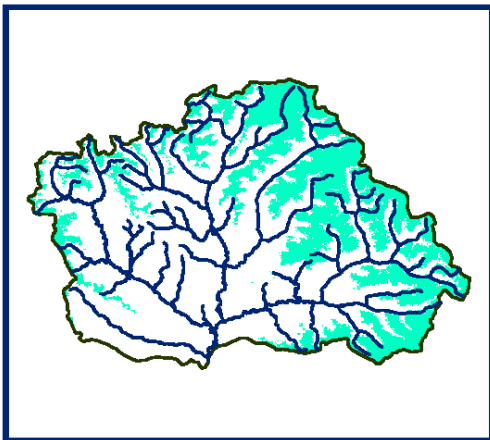


Kilometers

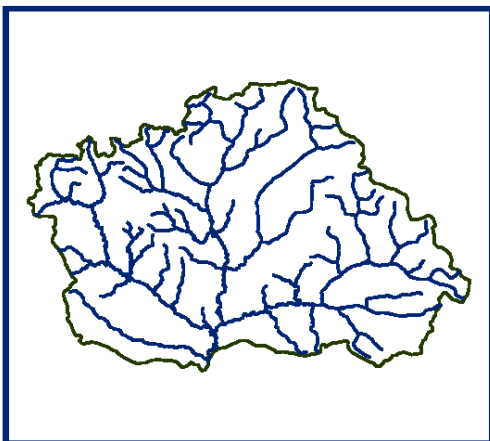
10 DAILY SNOW COVER MAP: DIBANG BASIN



DATA USED
DATA NOT AVAILABLE



DATA USED
25 MAY 2011



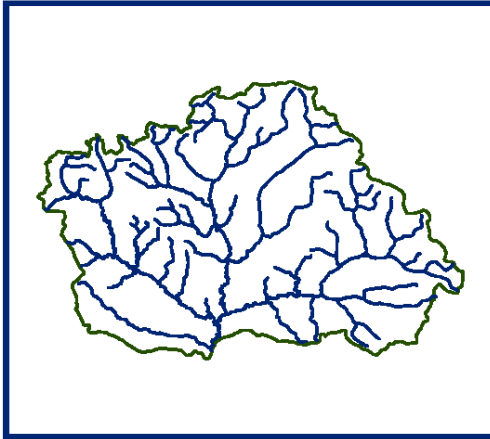
DATA USED
DATA NOT AVAILABLE



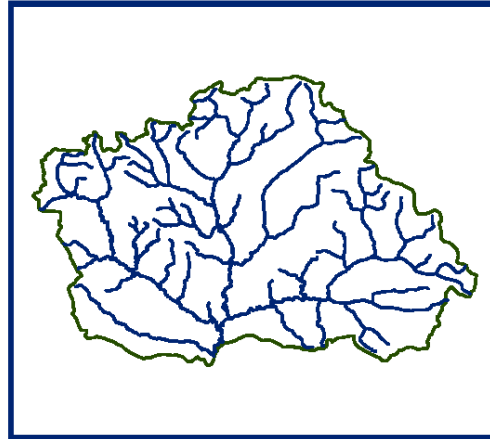
SNOW



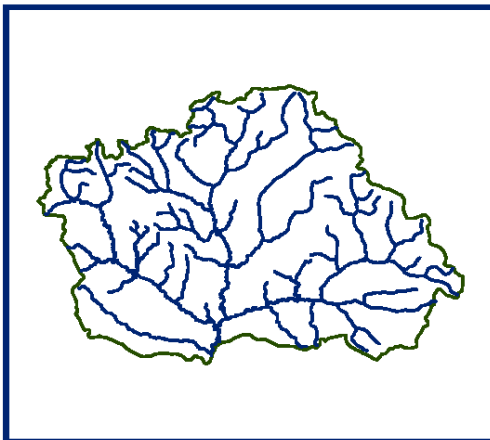
SNOW COVER MAP : DIBANG BASIN



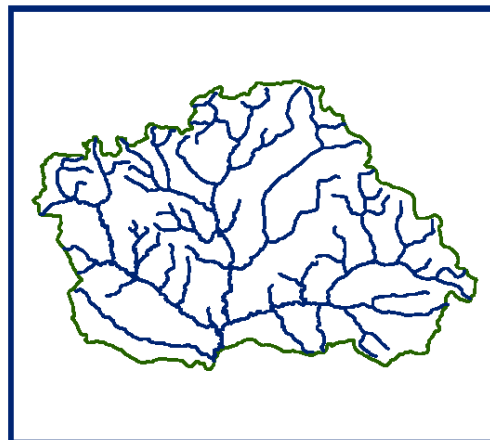
DATA NOT AVAILABLE



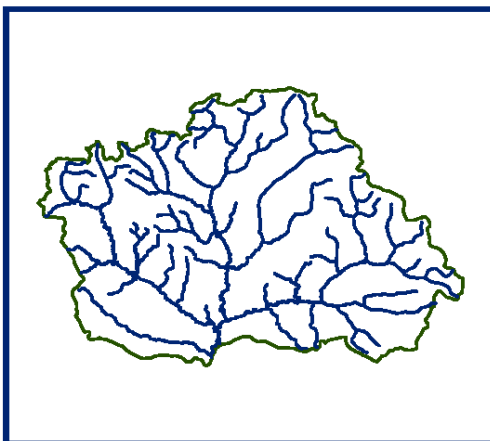
DATA NOT AVAILABLE



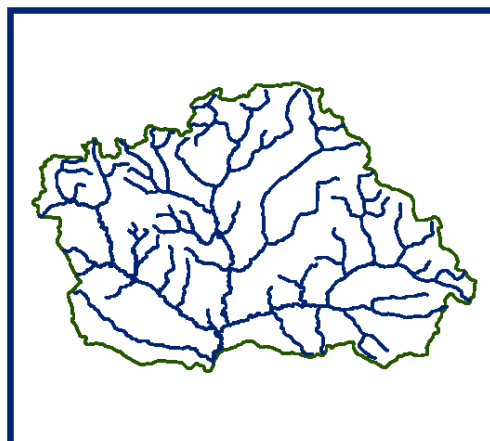
DATA NOT AVAILABLE



DATA NOT AVAILABLE



DATA NOT AVAILABLE



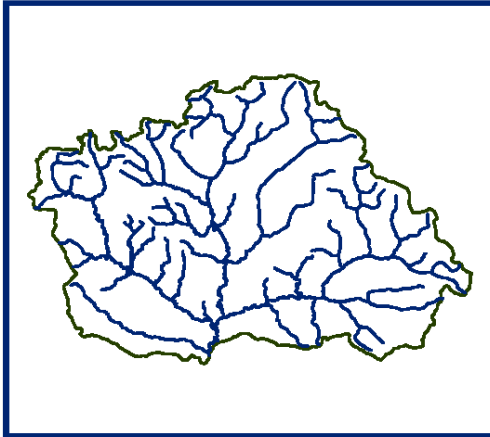
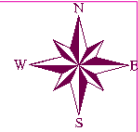
DATA NOT AVAILABLE



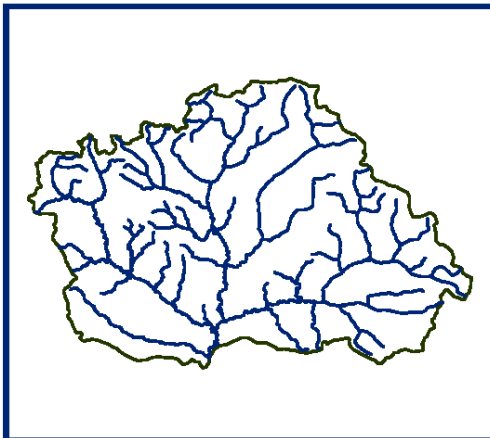
SNOW



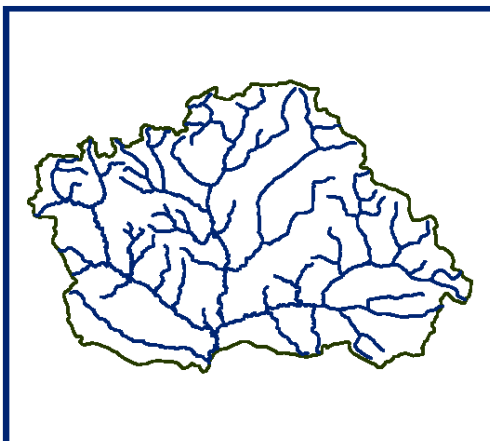
10 DAILY SNOW COVER MAP: DIBANG BASIN



DATA USED
DATA NOT AVAILABLE



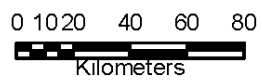
DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE



SNOW



SUBANSIRI BASIN

AREAL EXTENT OF SNOW (5 DAILY)

BASIN NAME: SUBANSIRI

BASIN AREA: 25344.62sq km

S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2010							
1	1-Oct-10	CLOUDYDATA		5	26-Oct-10	2389.50	10
2	7-Oct-10	CLOUDYDATA		6	27-Oct-10	DNC	
3	12-Oct-10	DNA		7	30-Oct-10	2523.25	9
4	16-Oct-10	CLOUDYDATA		8	31-Oct-10	CLOUDYDATA	
November 2010							
9	4-Nov-10	2740.75	10.81	14	18-Nov-10	DNA	
10	5-Nov-10	DNA		15	23-Nov-10	1943.94	8
11	9-Nov-10	2133.70	8.42	16	24-Nov-10	DNA	
12	10-Nov-10	DNA		17	28-Nov-10	1664.36	7
13	14-Nov-10	1784.20	7.04				
December 2010							
18	3-Dec-10	2365.17	9.33	23	14-Dec-10	DNA	
19	4-Dec-10	DNA		24	17-Dec-10	2587.76	10
20	8-Dec-10	2260.55	8.92	25	22-Dec-10	2285.43	9
21	9-Dec-10	CLOUDYDATA		26	23-Dec-10	CLOUDYDATA	
22	13-Dec-10	2795.83	11.03	27	27-Dec-10	2598.48	10
January 2011							
28	2-Jan-11	DNA		32	11-Jan-11	DNC	
29	6-Jan-11	1028.67	4.06	33	15-Jan-11	1128.23	4
30	7-Jan-11	DNA		34	21-Jan-11	DNA	
31	10-Jan-11	2372.13	9.36	35	26-Jan-11	DNC	
				36	30-Jan-11	1693.74	7
February 2011							
37	3-Feb-11	3351.81	13.22	41	18-Feb-11	4804.66	19
38	4-Feb-11	DNA		42	23-Feb-11	4412.49	17
39	8-Feb-11	809.93	3.19	43	27-Feb-11	1079.02	4
40	9-Feb-11	CLOUDYDATA		44	28-Feb-11	CLOUDYDATA	
March 2011							
45	4-Mar-11	1674.11	6.61	46	14-Mar-11	CLOUDYDATA	
47	15-Mar-11	DNC		48	19-Mar-11	1825.42	7

April 2011							
49	2-April-11	2716.74	11	50	7-apr-11	1384.52	5
51	12-April-11	1349.88	5	52	17-Apr-11	DNC	
53	21-Apr-11	1922.19	8	54	26-Apr-11	5832.87	23
55	27-Apr-11	DNC					
May 2011							
56	6-May-11	2241.50	9	57	11-May-11	CLOUDYDATA	
58	15-May-11	CLOUDYDATA		59	25-May-11	2494.77	10
June 2011							
60	8-June-11	CLOUDYDATA		61	13-June-11	326.46	1
62	23-June-11	CLOUDYDATA		63	28-June-11	CLOUDYDATA	

DNC- BASIN NOT IN SCENE/HALF IN SCENE

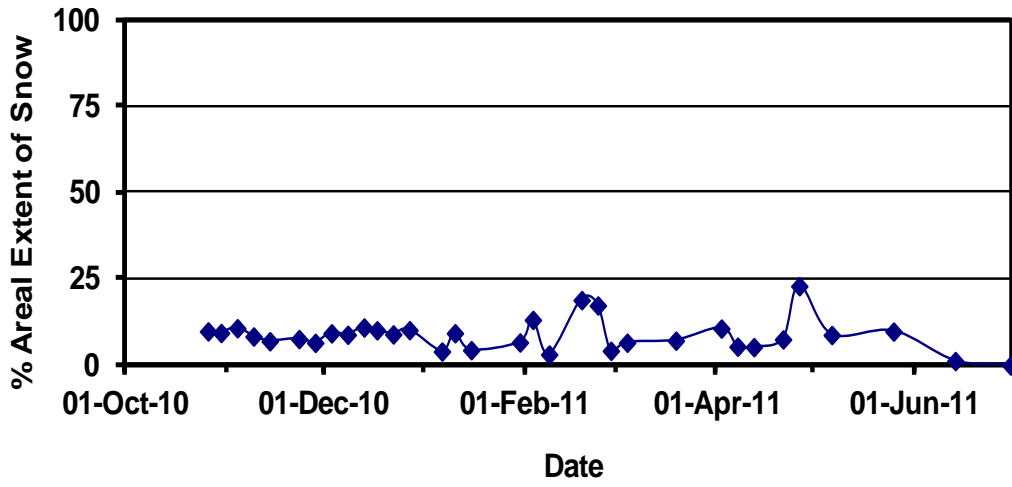
AREAL EXTENT OF SNOW (10 DAILY)

BASIN NAME:SUBANSIRI

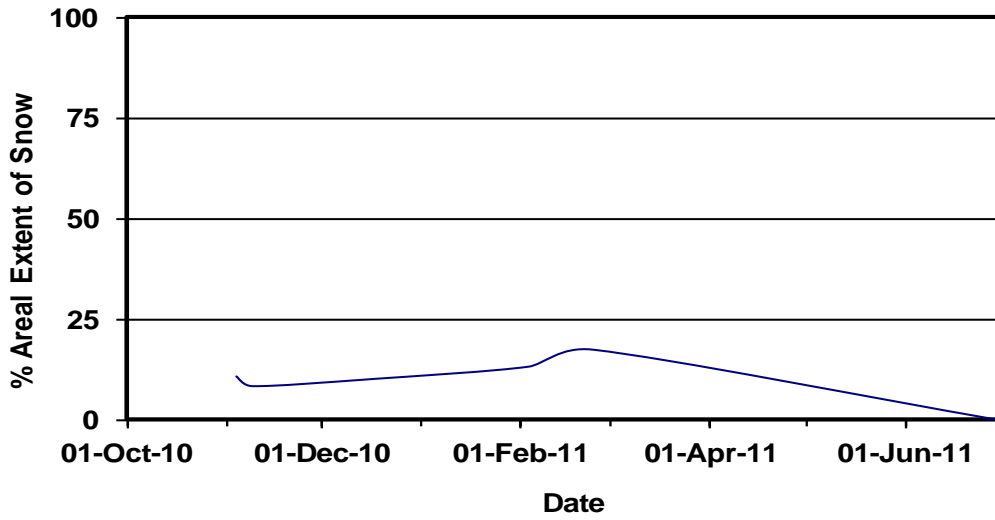
BASIN AREA: 25344.62sq km

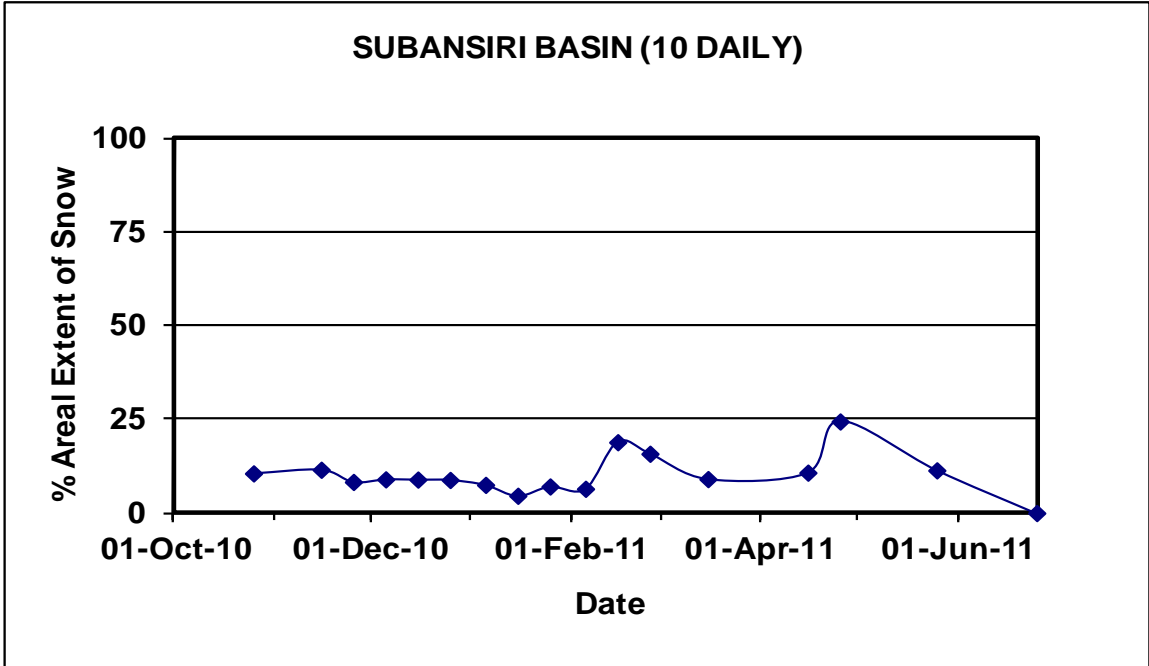
S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2010				November 2010			
1	30-Oct-10	2682.04	11	2	14-Nov-10	2927.60	12
				3	23-Nov-10	2105.35	8
December 2010				January 2011			
4	8-Dec-10	2279.57	9	7	6-Jan-11	1906.19	8
5	17-Dec-10	2265.38	9	8	15-Jan-11	1169.45	5
6	27-Dec-10	2238.68	9	9	30-Jan-11	1798.75	7
February 2011				March 2011			
10	8-Feb-11	1641.19	6	13	14-Mar-11	CLOUDY DATA	
11	18-Feb-11	4790.99	19	14	19-Mar-11	2298.20	9
12	27-Feb-11	4011.99	16				
April 2011				May 2011			
15	12-Apr-11	2732.65	11	17	25-May-11	2887.29	11
16	26-Apr-11	6192.81	24				
June 2011							
18	13-June-11	CLOUDY DATA		19	23-June-11	CLOUDY DATA	

SUBANSIRI BASIN (5 DAILY) : WITH CLOUDY DATA



SUBANSIRI BASIN (5 DAILY) : WITHOUT CLOUDY DATA



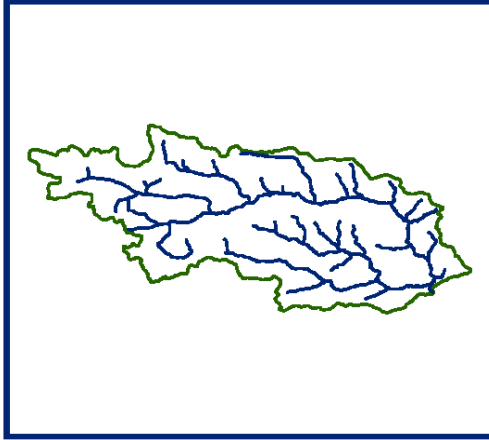


SNOW COVER MAPS

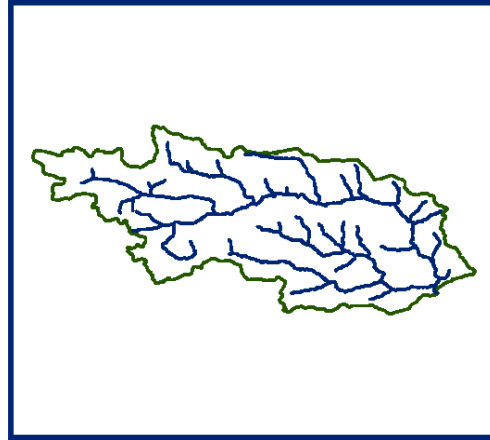
SNOW COVER MAP

:

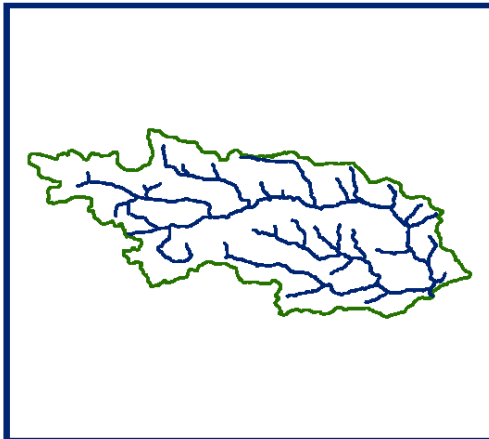
SUBANSIRI BASIN



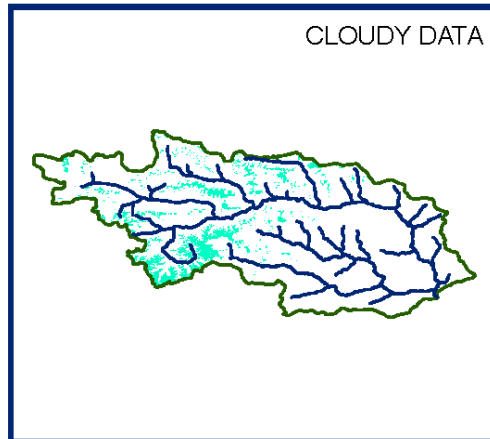
DATA NOT AVAILABLE



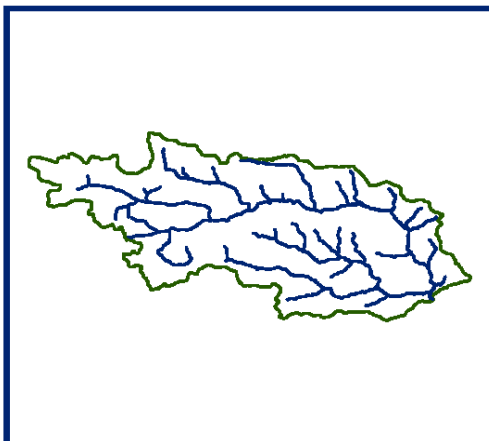
DATA NOT AVAILABLE



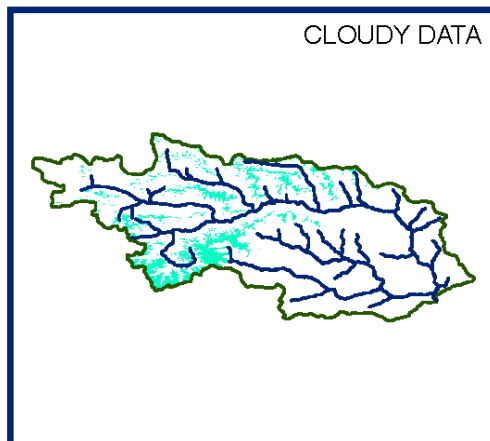
DATA NOT AVAILABLE



26 OCTOBER 2010



DATA NOT AVAILABLE



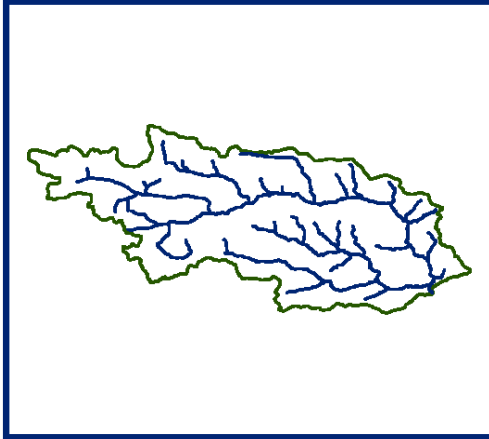
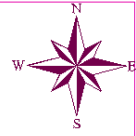
30 OCTOBER 2010



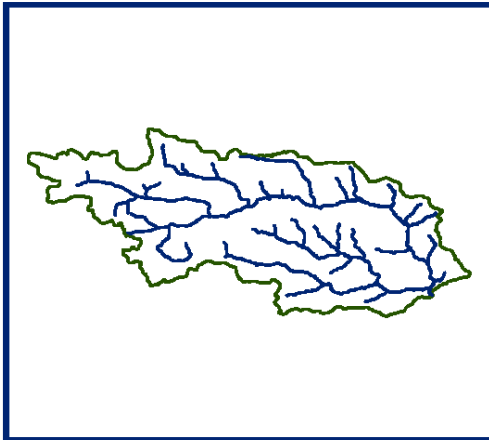
SNOW



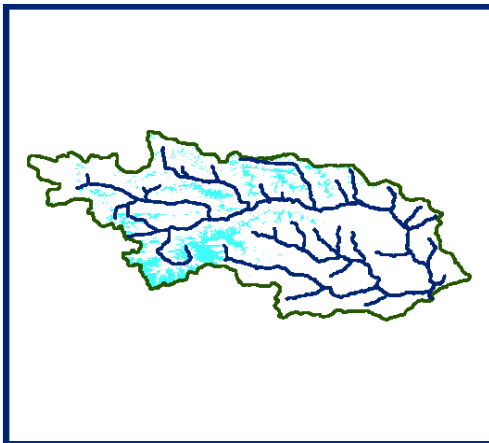
10 DAILY SNOW COVER MAP: SUBANSIRI BASIN



DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE



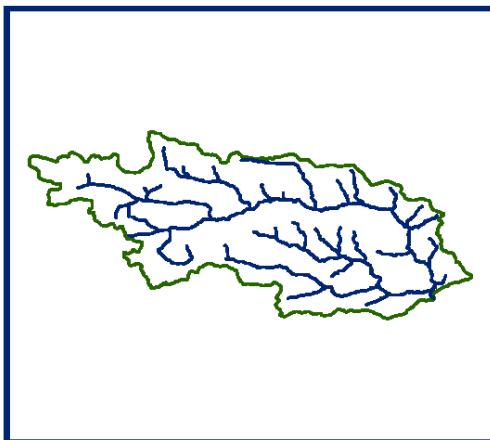
DATA USED
30 OCTOBER 2010



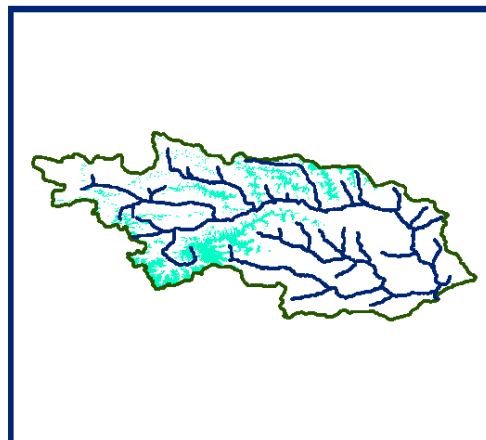
SNOW



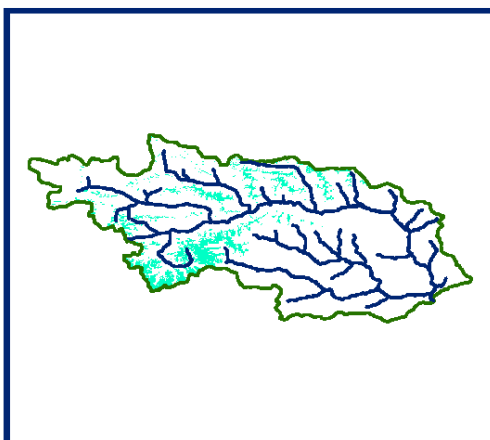
SNOW COVER MAP : SUBANSIRI BASIN



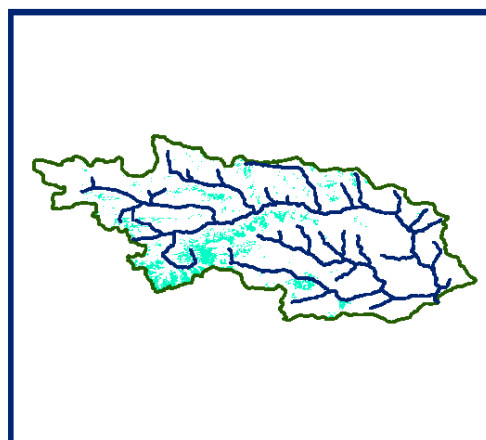
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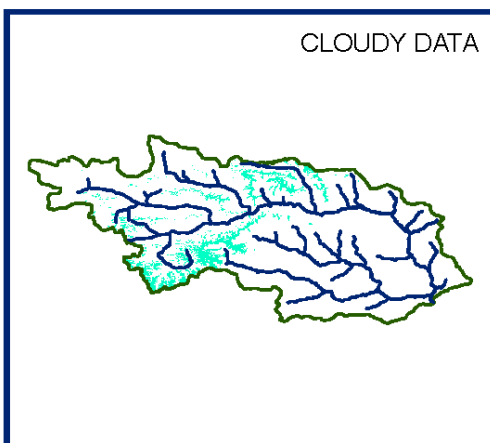
04 NOVEMBER 2010



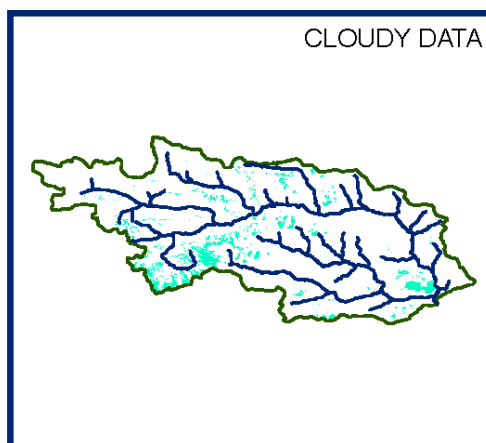
09 NOVEMBER 2010



14 NOVEMBER 2010



23 NOVEMBER 2010



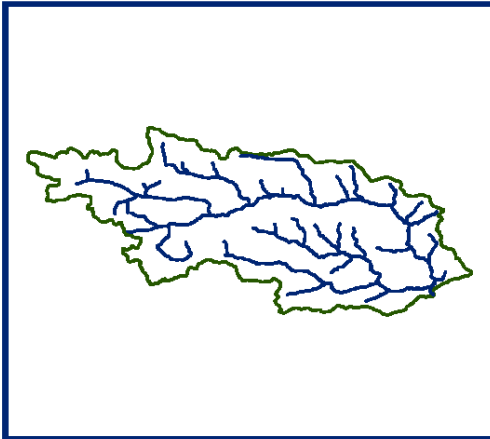
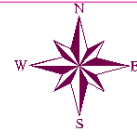
28 NOVEMBER 2010



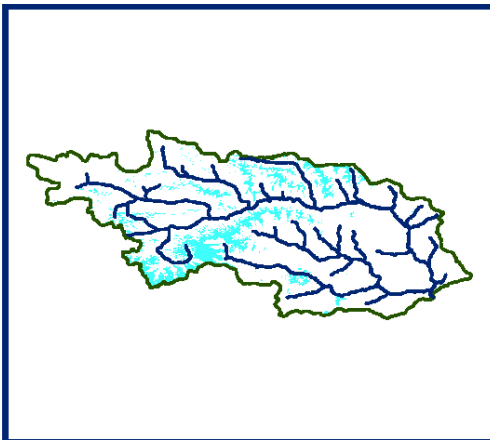
SNOW



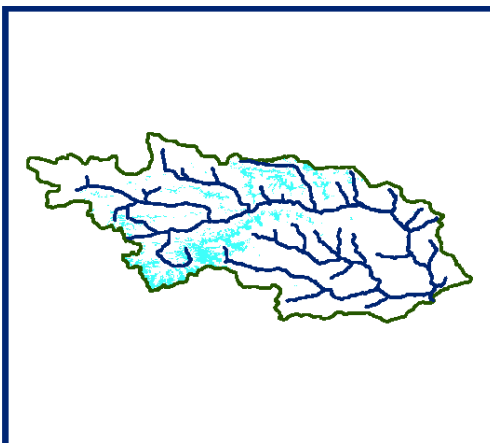
10 DAILY SNOW COVER MAP: SUBANSIRI BASIN



DATA USED
DATA NOT AVAILABLE



DATA USED
14 NOVEMBER 2010



DATA USED
23 NOVEMBER 2010



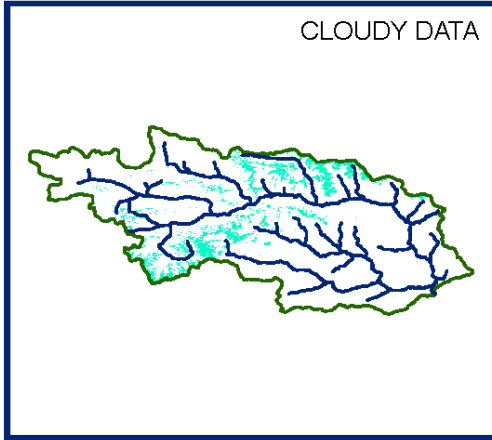
SNOW



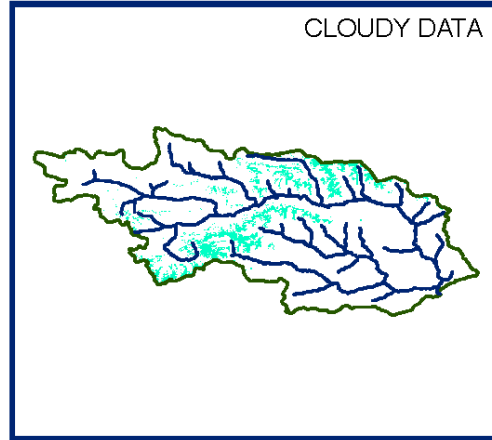
SNOW COVER MAP

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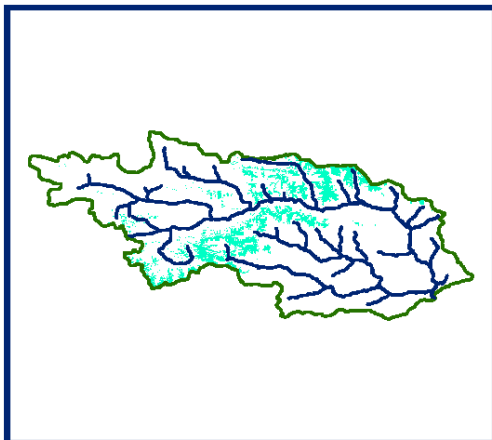
SUBANSIRI BASIN



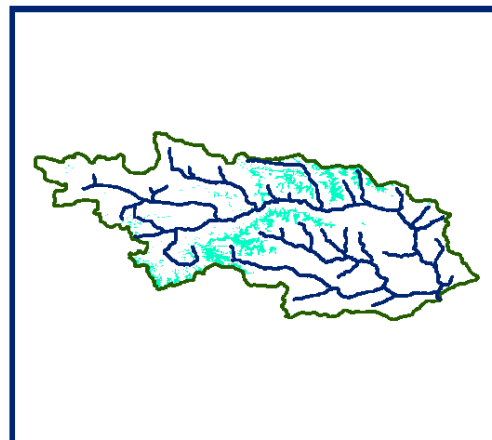
03 DECEMBER 2010



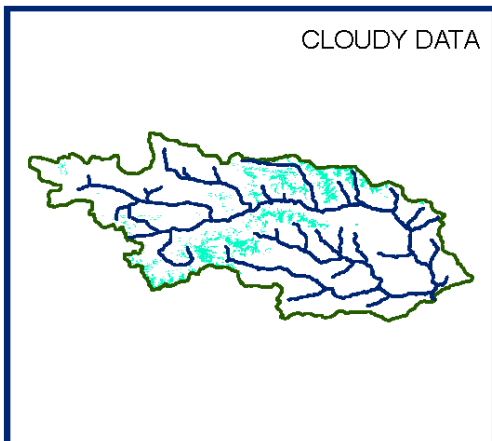
08 DECEMBER 2010



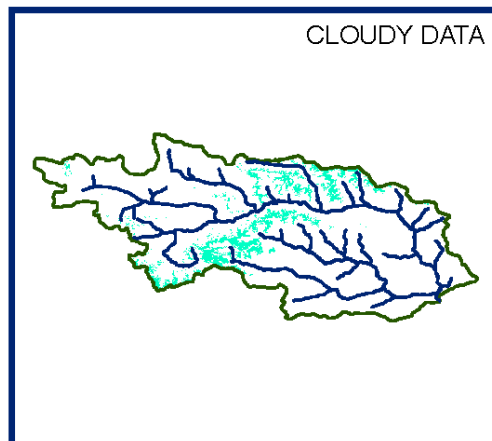
13 DECEMBER 2010



17 DECEMBER 2010



22 DECEMBER 2010



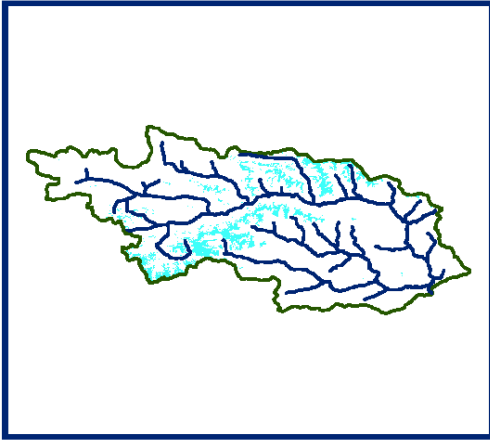
27 DECEMBER 2010



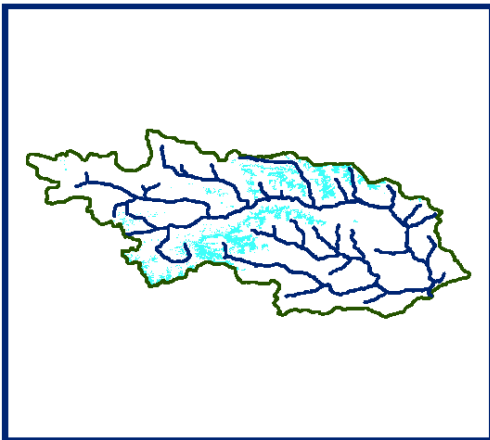
SNOW



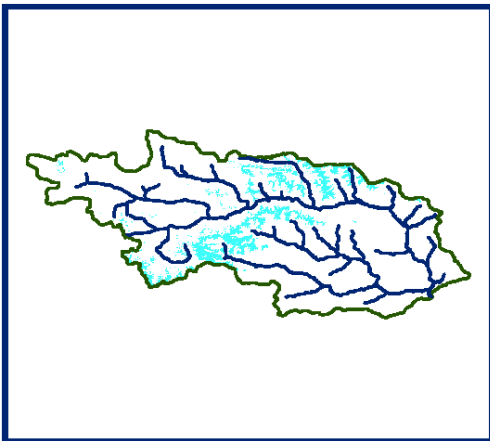
10 DAILY SNOW COVER MAP: SUBANSIRI BASIN



**DATA USED
08 DECEMBER 2010**



**DATA USED
17 DECEMBER 2010**



**DATA USED
27 DECEMBER 2010**



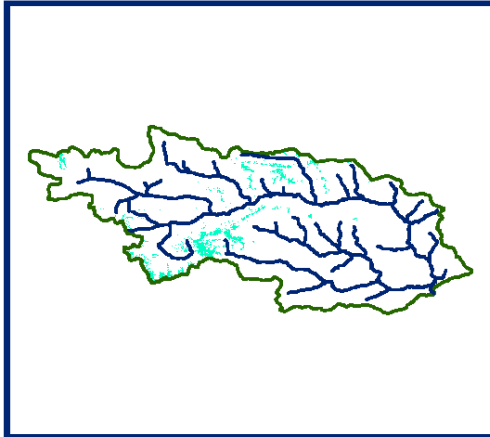
SNOW



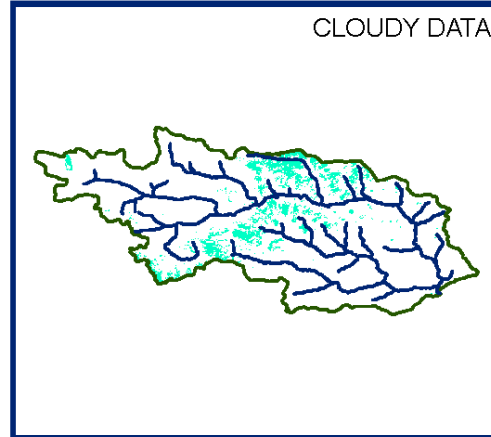
SNOW COVER MAP

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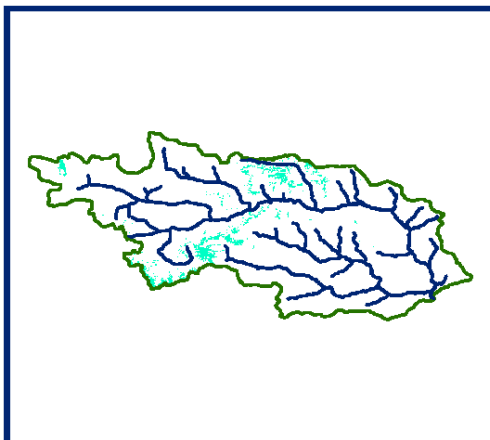
SUBANSIRI BASIN



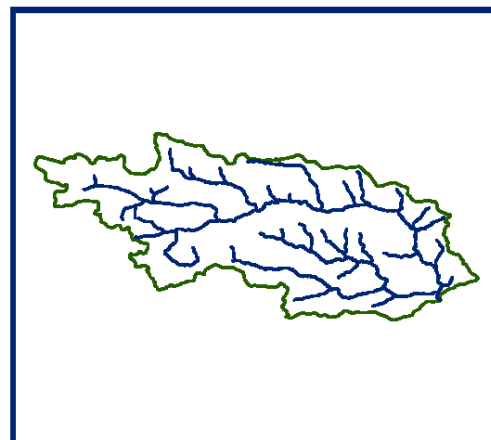
06 JANUARY 2011



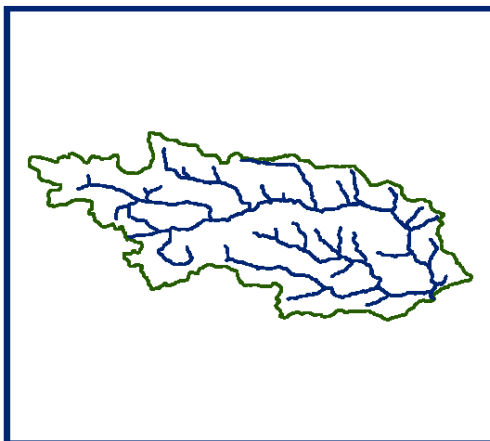
10 JANUARY 2011



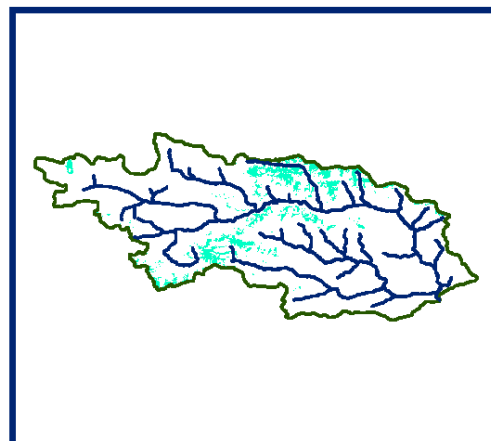
15 JANUARY 2011



DATA NOT AVAILABLE



DATA NOT AVAILABLE



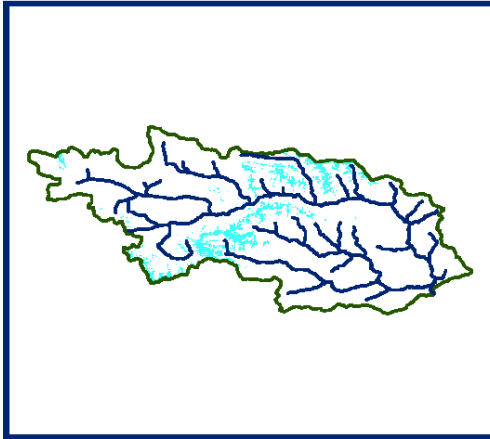
30 JANUARY 2011



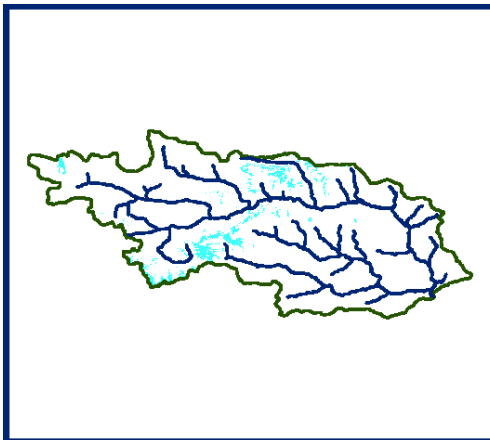
SNOW



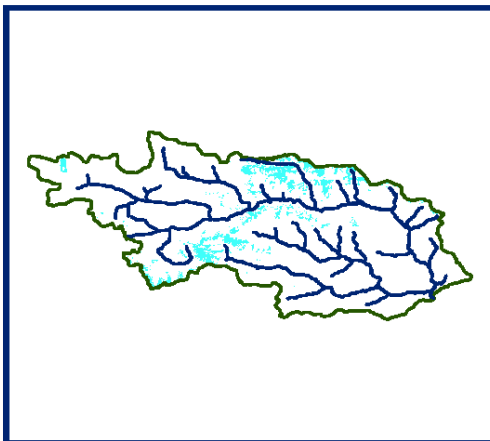
10 DAILY SNOW COVER MAP: SUBANSIRI BASIN



**DATA USED
06 JANUARY 2011**



**DATA USED
15 JANUARY 2011**



**DATA USED
30 JANUARY 2011**



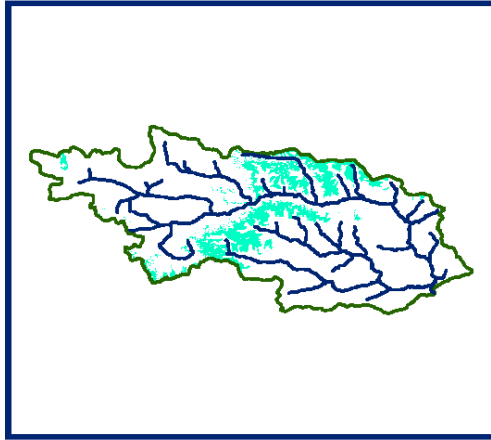
SNOW



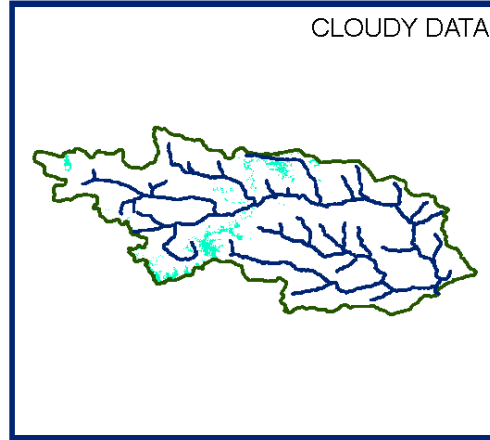
SNOW COVER MAP

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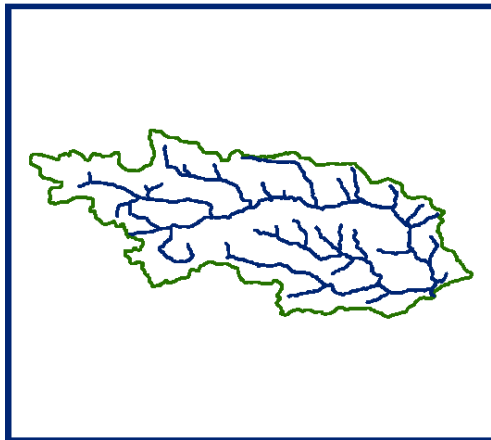
SUBANSIRI BASIN



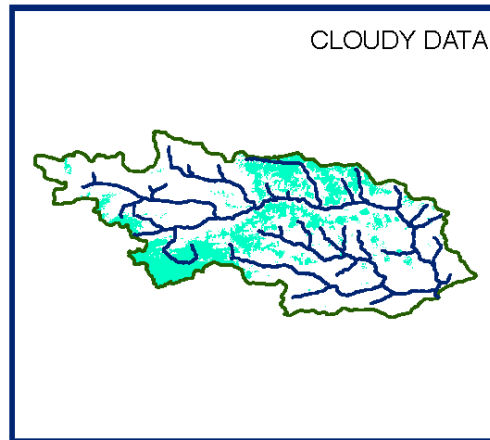
03 FEBRUARY 2011



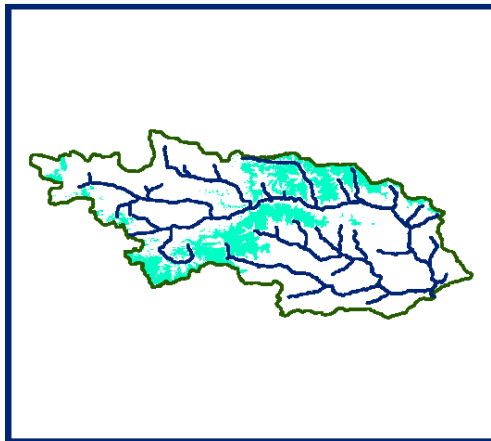
08 FEBRUARY 2011



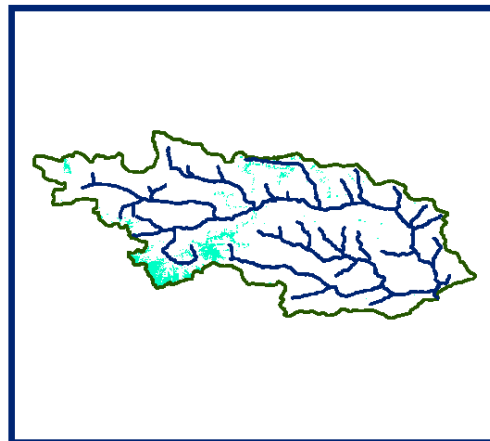
DATA NOT AVAILABLE



18 FEBRUARY 2011



23 FEBRUARY 2011



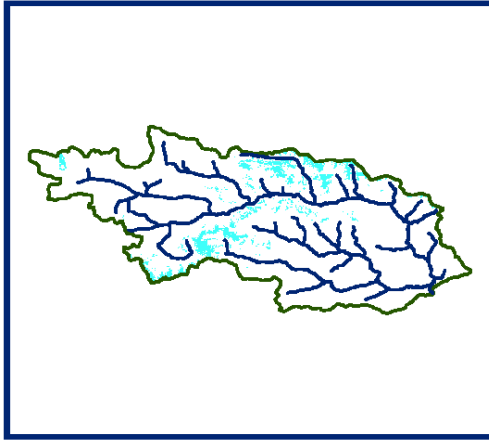
27 FEBRUARY 2011



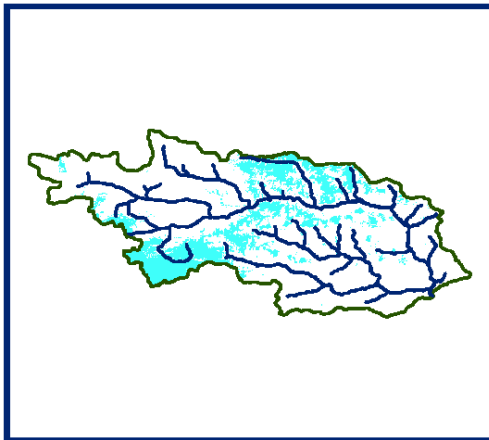
SNOW



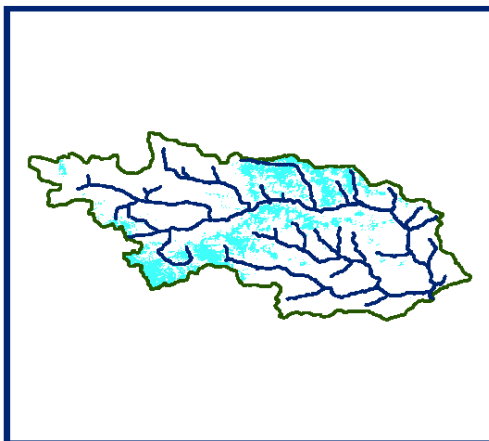
10 DAILY SNOW COVER MAP: SUBANSIRI BASIN



**DATA USED
8 FEBRUARY 2011**



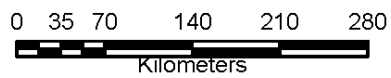
**DATA USED
18 FEBRUARY 2011**



**DATA USED
27 FEBRUARY 2011**



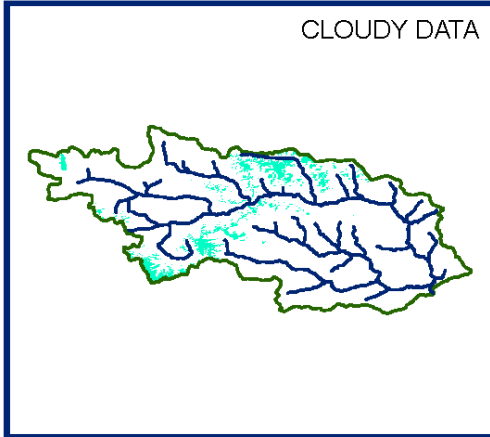
SNOW



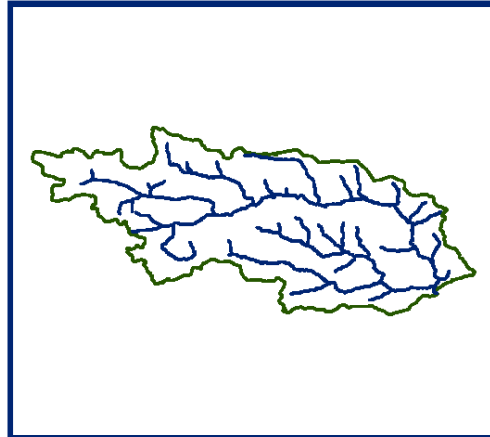
SNOW COVER MAP

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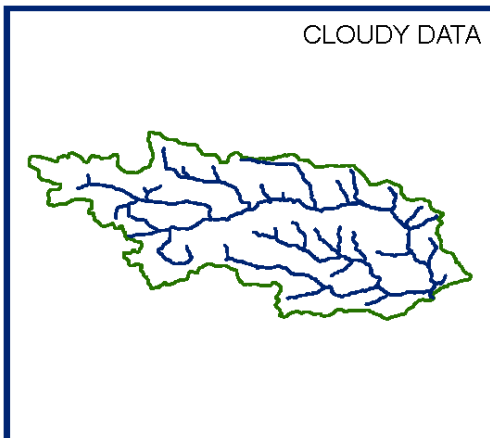
SUBANSIRI BASIN



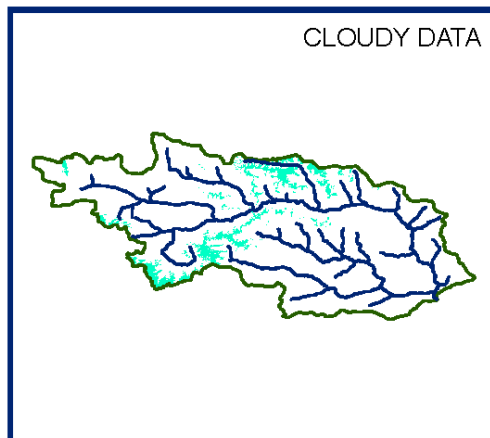
04 MARCH 2011



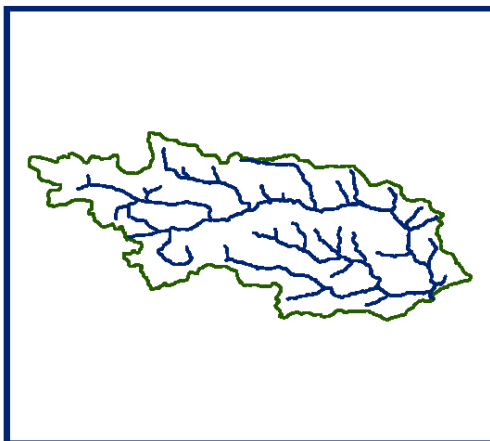
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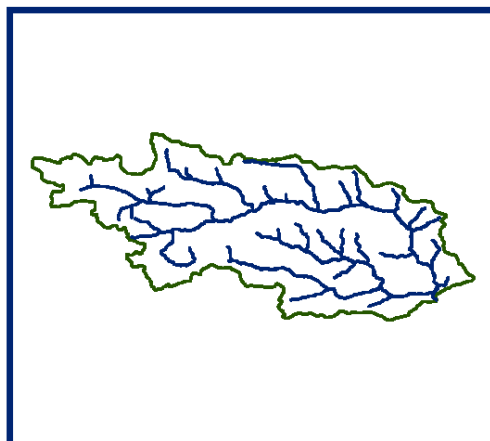
14 MARCH 2011



19 MARCH 2011



DATA NOT AVAILABLE



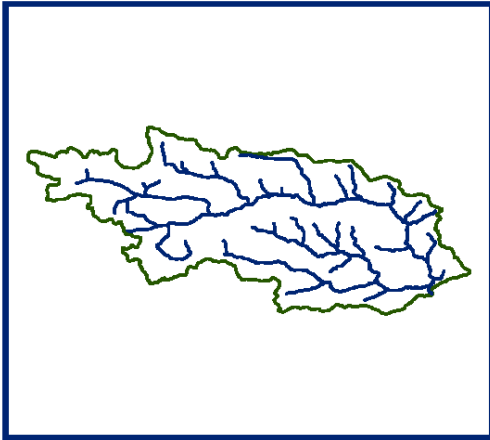
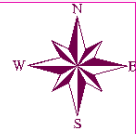
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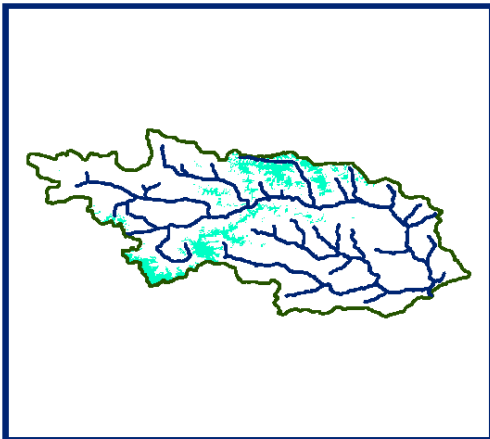
SNOW



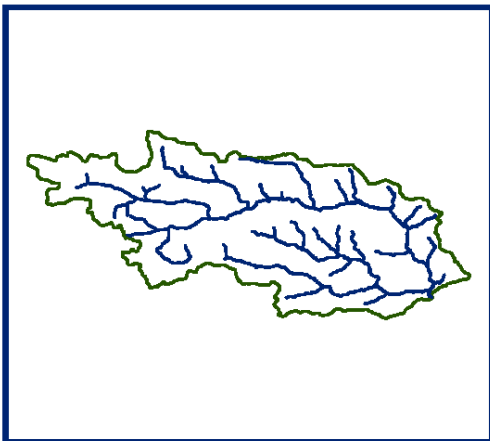
10 DAILY SNOW COVER MAP: SUBANSIRI BASIN



DATA USED
DATA NOT AVAILABLE



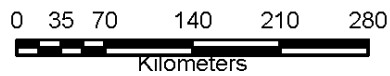
DATA USED
19 MARCH 2011



DATA USED
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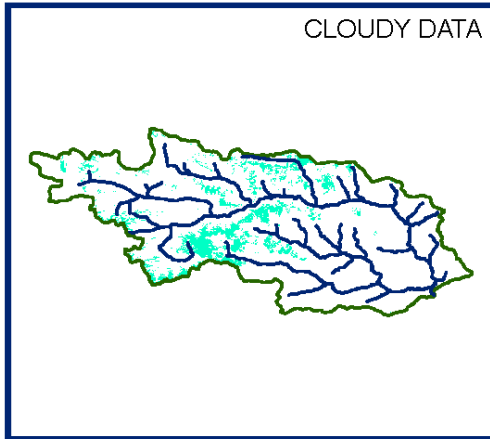
SNOW



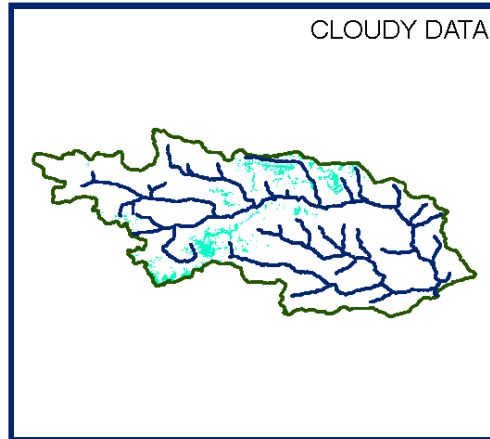
SNOW COVER MAP

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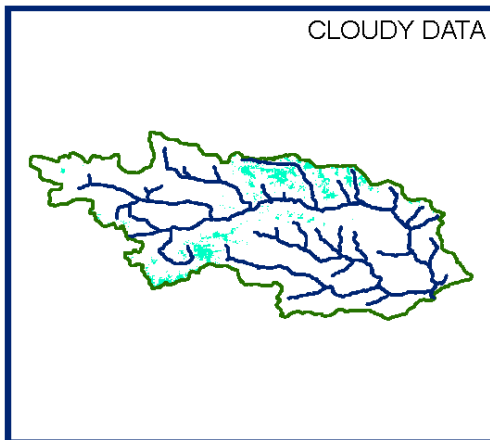
SUBANSIRI BASIN



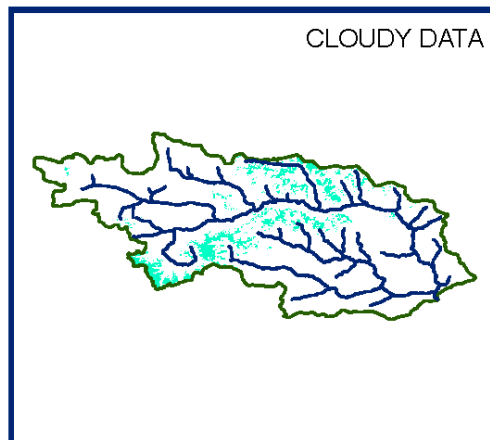
02 APRIL 2011



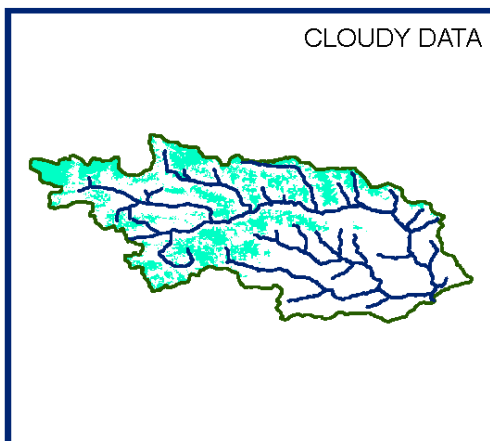
07 APRIL 2011



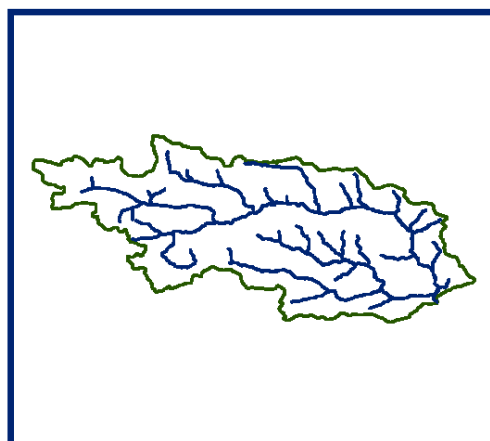
12 APRIL 2011



21 APRIL 2011



26 APRIL 2011



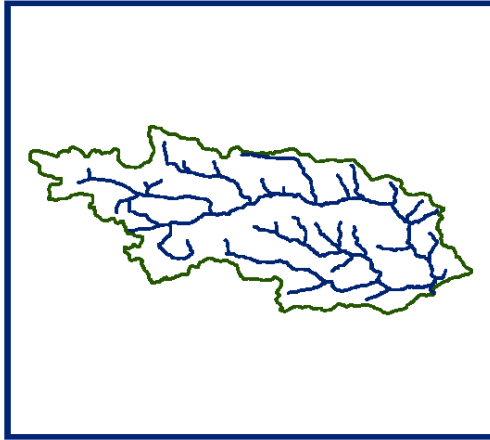
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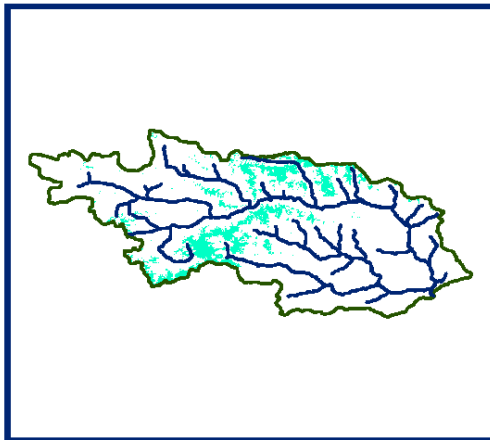
SNOW



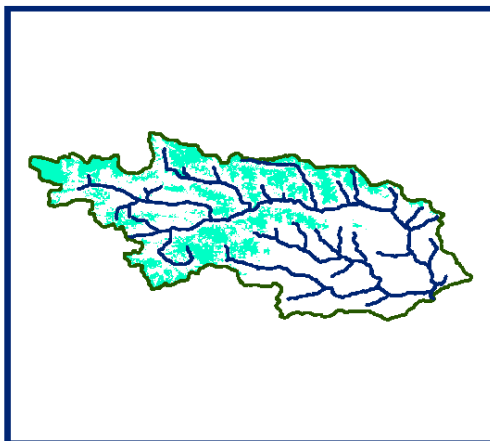
10 DAILY SNOW COVER MAP: SUBANSIRI BASIN



DATA USED
DATA NOT AVAILABLE



DATA USED
12 APRIL 2011



DATA USED
26 APRIL 2011



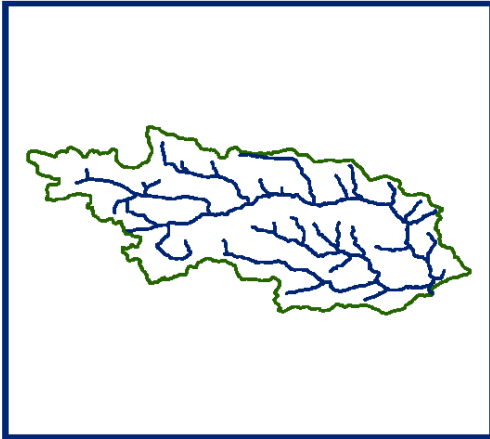
SNOW



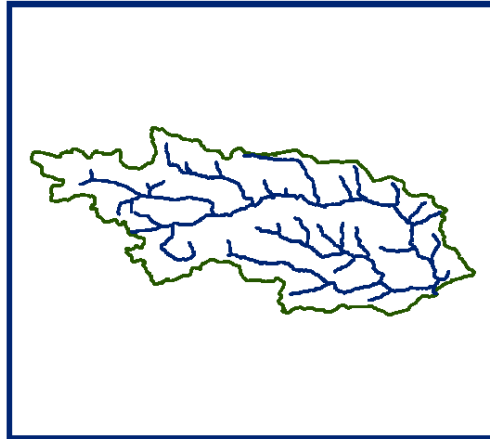
SNOW COVER MAP

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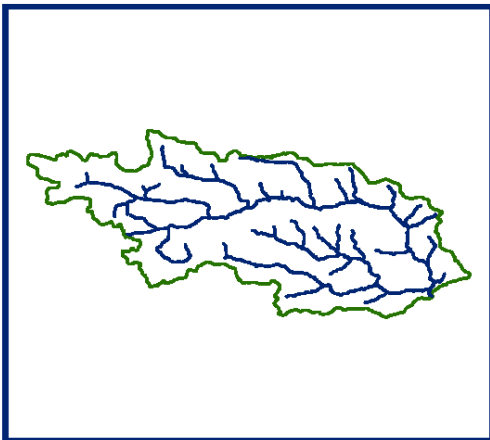
SUBANSIRI BASIN



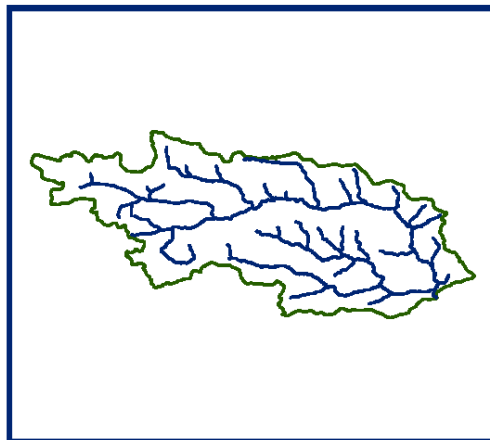
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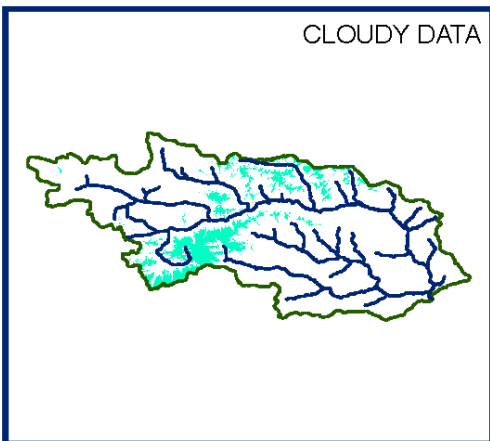
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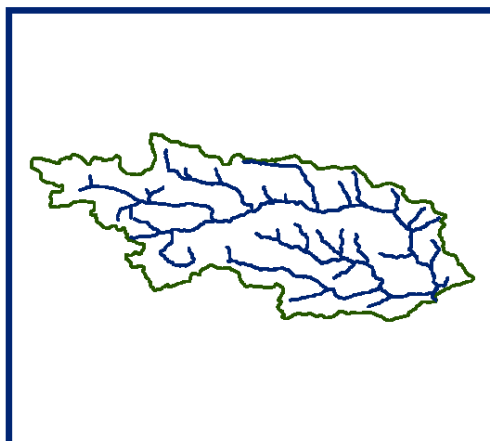
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DATA NOT AVAILABLE



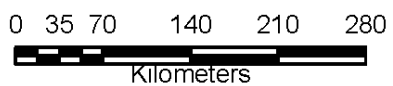
25 MAY 2011



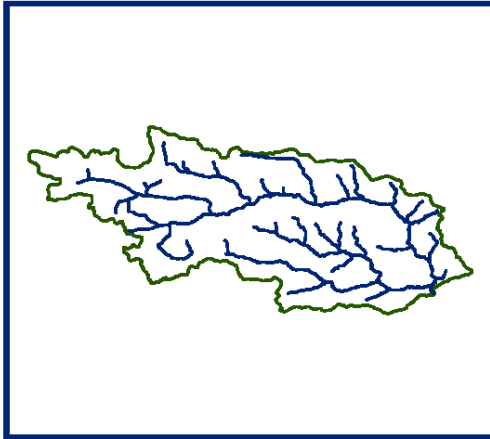
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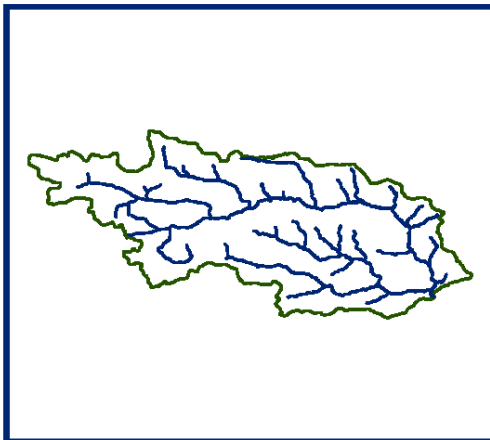
SNOW



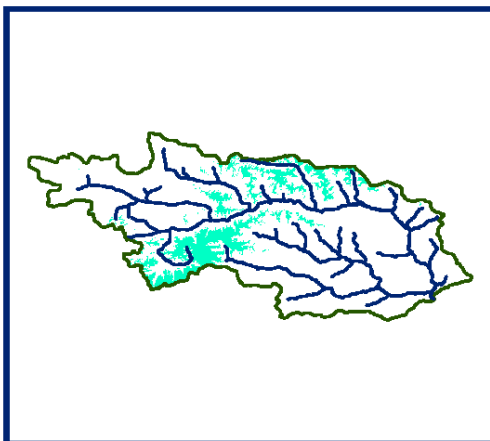
10 DAILY SNOW COVER MAP: SUBANSIRI BASIN



**DATA USED
DATA NOT AVAILABLE**



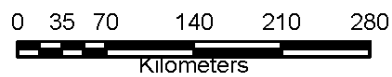
**DATA USED
DATA NOT AVAILABLE**



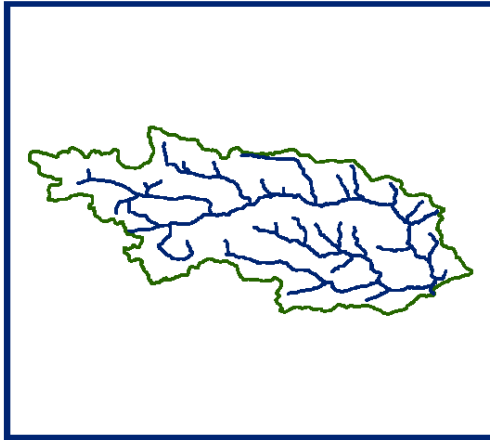
**DATA USED
25 MAY 2011**



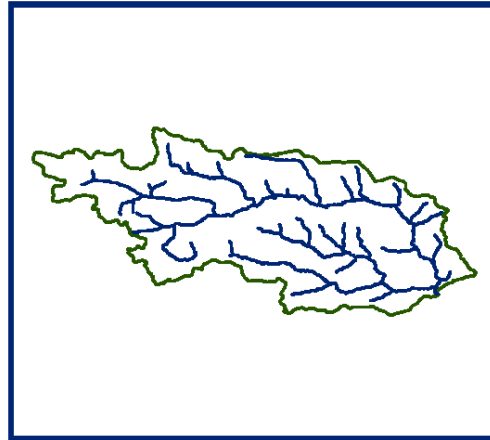
SNOW



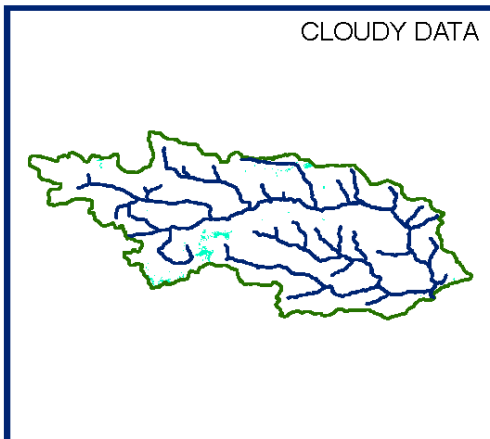
SNOW COVER MAP : SUBANSIRI BASIN



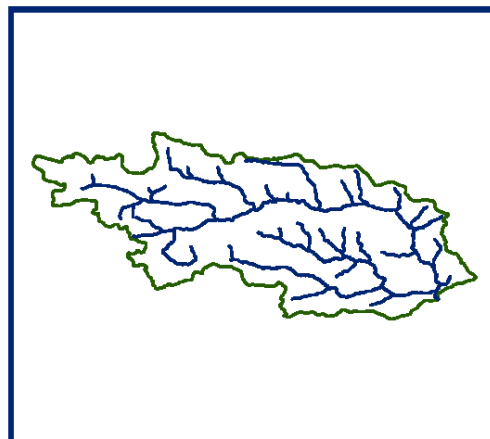
DATA NOT AVAILABLE



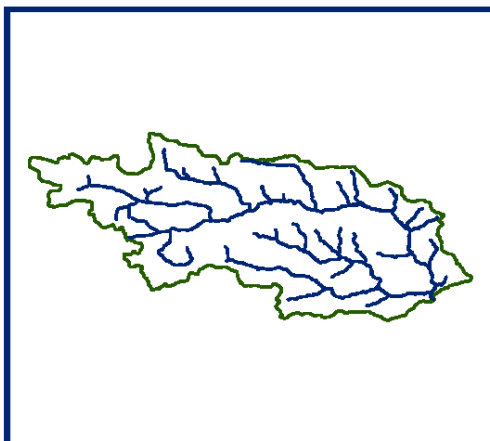
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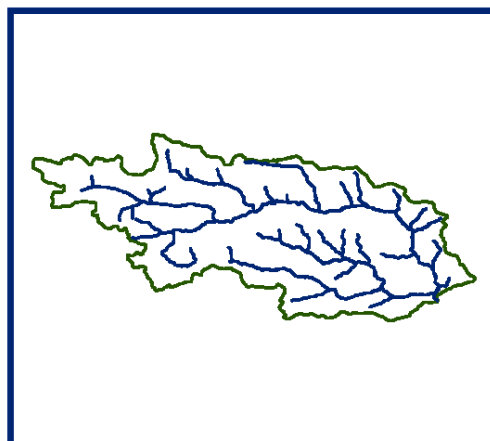
13 JUNE 2011



DATA NOT AVAILABLE



DATA NOT AVAILABLE



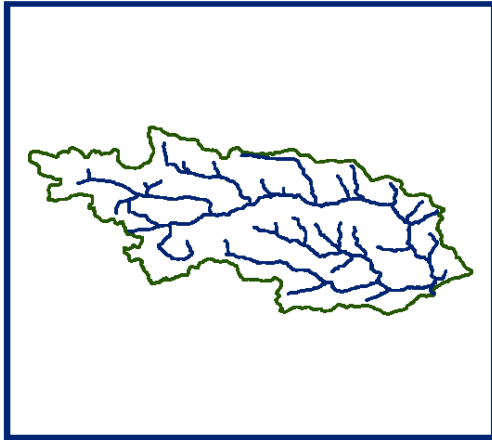
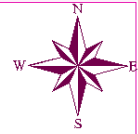
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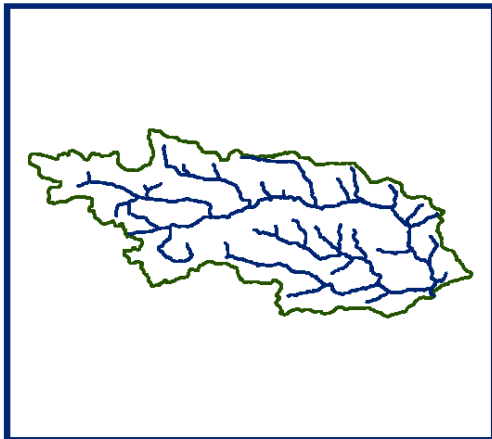
SNOW



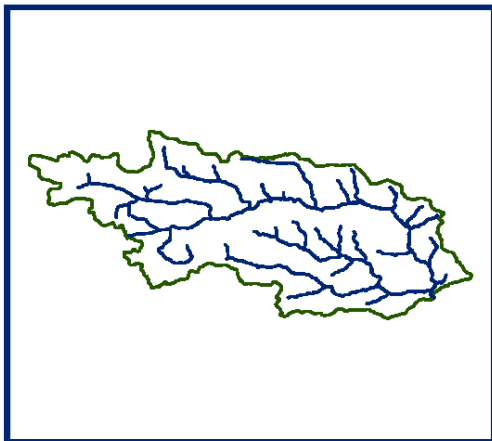
10 DAILY SNOW COVER MAP: SUBANSIRI BASIN



DATA USED
DATA NOT AVAILABLE



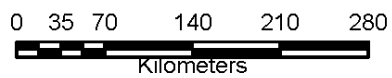
DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE



SNOW



TAWANG BASIN

AREAL EXTENT OF SNOW (5 DAILY)

BASIN NAME: TAWANG

BASIN AREA: 6720.57 sq km

S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2010							
1	1-Oct-10	222.40	3	5	26-Oct-10	1715.55	26
2	7-Oct-10	CLOUDYDATA		6	27-Oct-10	DNC	
3	12-Oct-10	DNA		7	30-Oct-10	1556.85	23
4	16-Oct-10	CLOUDYDATA		8	31-Oct-10	CLOUDYDATA	
November 2010							
9	4-Nov-10	1552.95	23	14	18-Nov-10	1252.72	19
10	5-Nov-10	DNA		15	23-Nov-10	1537.21	23
11	9-Nov-10	1374.37	20	16	24-Nov-10	DNA	
12	10-Nov-10	DNA		17	28-Nov-10	1239.58	18
13	14-Nov-10	910.51	14				
December 2010							
18	3-Dec-10	1223.50	18	24	13-Dec-10	1061.90	16
19	4-Dec-10	DNC		25	14-Dec-10	DNC	
20	7-Dec-10	1155.10	17	26	17-Dec-10	1117.41	17
21	8-Dec-10	1035.69	15	27	22-Dec-10	1083.42	16
22	9-Dec-10	CLOUDYDATA		28	27-Dec-10	1003.42	15
23	12-Dec-10	1072.22	16				
January 2011							
29	2-Jan-11	DNA		35	15-Jan-11	1101.35	16
30	5-Jan-11	1638.84	24	36	21-Jan-11	DNA	
31	6-Jan-11	1424.36	21	37	26-Jan-11	DNA	
32	7-Jan-11	DNA		38	29-Jan-11	1272.28	19
33	10-Jan-11	1420.14	21	39	30-Jan-11	996.32	15
34	11-Jan-11	DNC					
February 2011							
40	3-Feb-11	1479.90	22	44	18-Feb-11	4766.17	71
41	4-Feb-11	DNA		45	22-Feb-11	4263.97	63
42	8-Feb-11	1086.57	16	46	27-Feb-11	3346.53	50
43	9-Feb-11	CLOUDYDATA		47	28-Feb-11	CLOUDYDATA	
March 2011							
48	4-Mar-11	2231.41	33	49	14-Mar-11	CLOUDY DATA	
50	15-Mar-11	DNC		51	19-Mar-11	2146.64	32

April 2011							
48	2-April-11	1154.24	17	49	7-apr-11	1685.31	25
50	12-April-11	1314.52	20	51	17-Apr-11	DNC	
52	21-Apr-11	3026.81	45	53	26-Apr-11	2127.23	32
54	27-Apr-11	DNC					
May 2011							
55	6-May-11	1794.20	27	56	11-May-11	CLOUDYDATA	
57	15-May-11	CLOUDYDATA		58	25-May-11	1159.54	17
June 2011							
59	8-June-11	CLOUDYDATA		60	13-June-11	303.89	5
61	23-June-11	CLOUDYDATA		62	28-June-11	CLOUDYDATA	

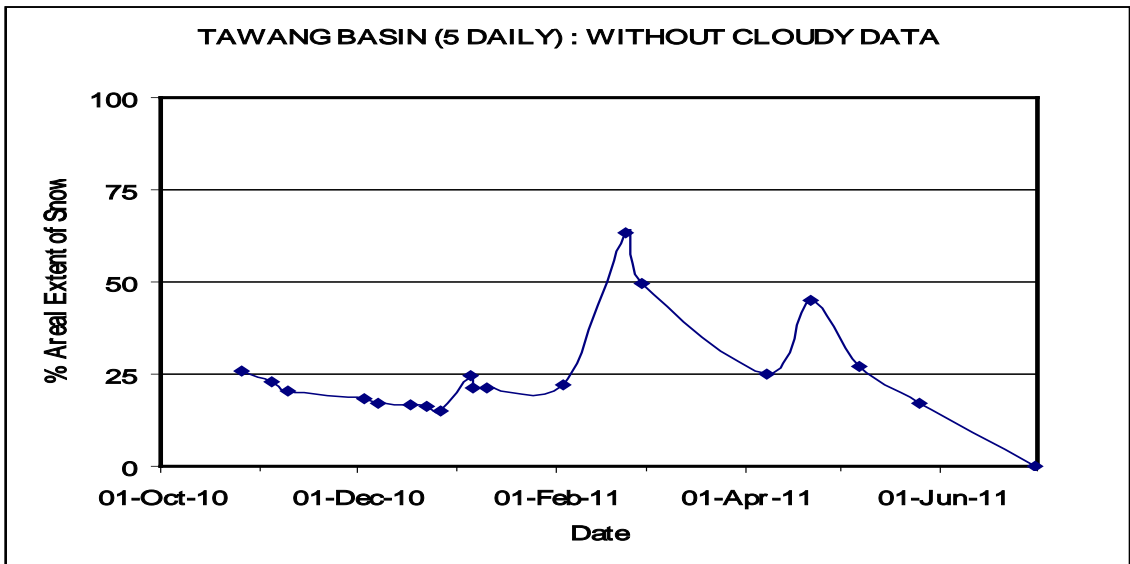
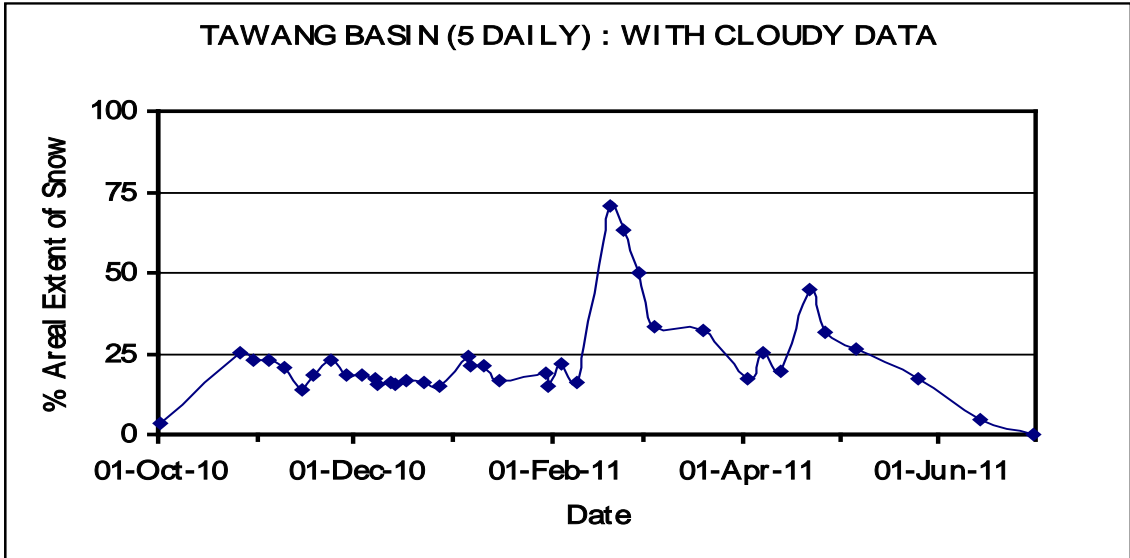
DNC-BASINS NOT IN SCENE/HALF IN SCENE

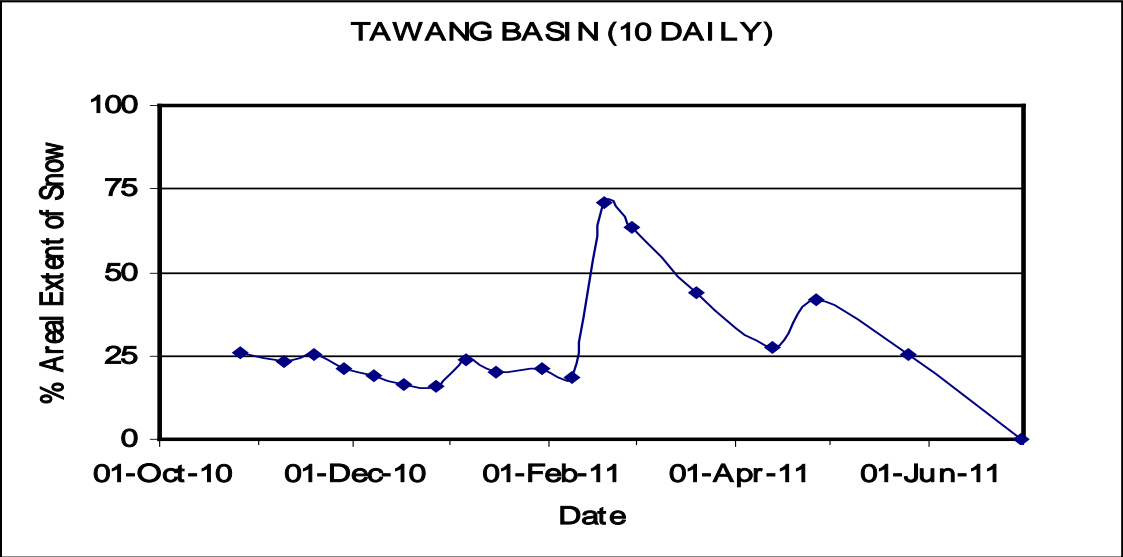
AREAL EXTENT OF SNOW (10 DAILY)

BASIN NAME: TAWANG

BASIN AREA: 6720.57 sq km

S No	Date	Snow cover (sq km)	Snow cover (%)	S No	Date	Snow cover (sq km)	Snow cover (%)
October 2010				November 2010			
1	26-Oct-10	1725.86	26	2	9-Nov-10	1571.02	23
				3	18-Nov-10	1717.25	26
				4	28-Nov-10	1407.18	21
December 2010				January 2011			
5	7-Dec-10	1272.93	19	8	5-Jan-11	1587.40	24
6	17-Dec-10	1116.67	17	9	15-Jan-11	1359.09	20
7	27-Dec-10	1073.95	16	10	29-Jan-11	1424.59	21
February 2011				March 2011			
11	8-Feb-11	1234.61	18	14	14-Mar-11	CLOUDY DATA	
12	18-Feb-11	4780.90	71	15	19-Mar-11	2945.94	44
13	27-Feb-11	4263.36	63				
April 2011				May 2011			
16	12-Apr-11	1834.26	27	18	25-May-11	1717.61	26
17	26-Apr-11	2799.52	42				
June 2011							
18	13-June-11	CLOUDY DATA		19	23-June-11	CLOUDY DATA	



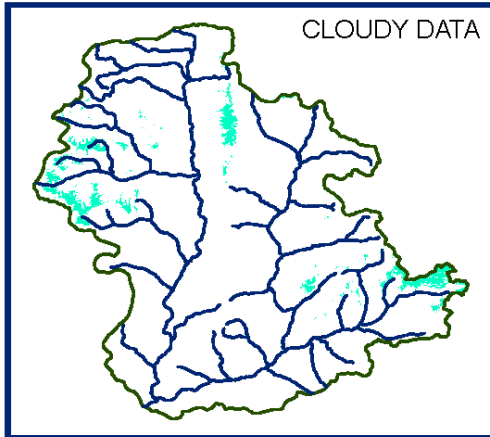


SNOW COVER MAPS

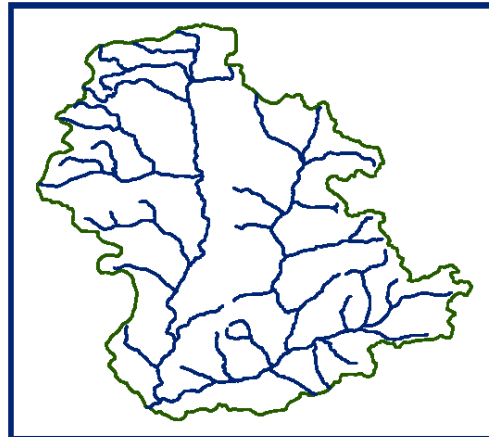
SNOW COVER MAP

:

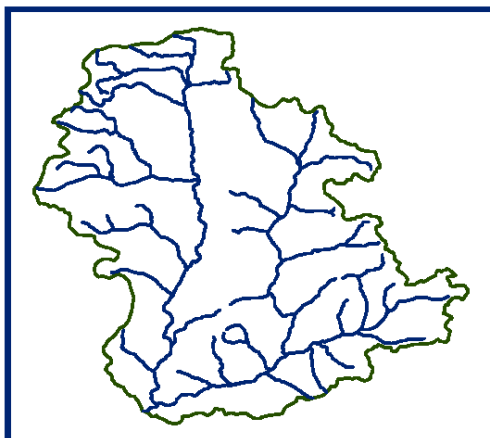
TAWANG BASIN



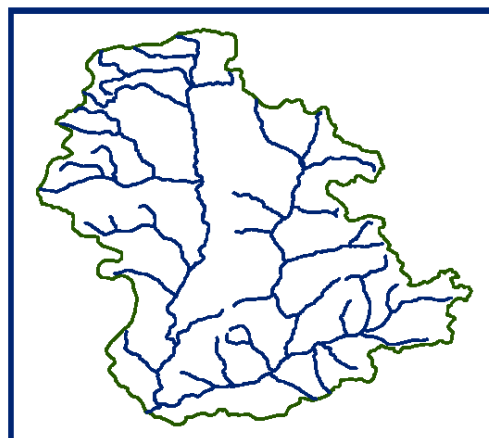
01 OCTOBER 2010



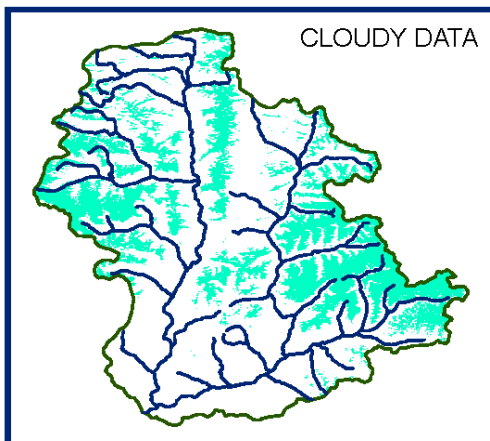
DATA NOT AVAILABLE



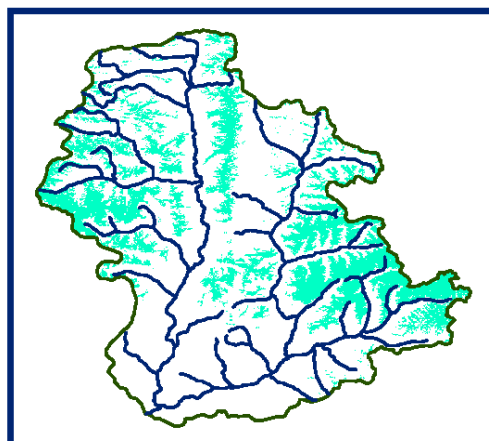
DATA NOT AVAILABLE



DATA NOT AVAILABLE



26 OCTOBER 2010



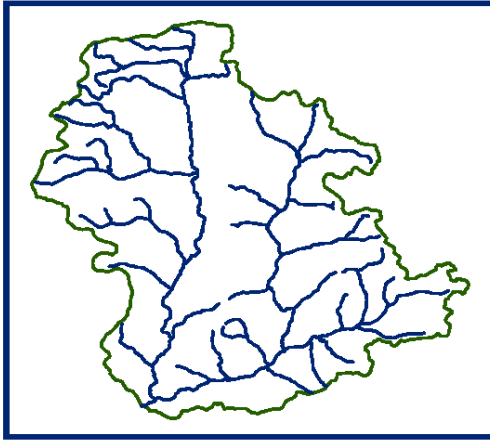
30 OCTOBER 2010



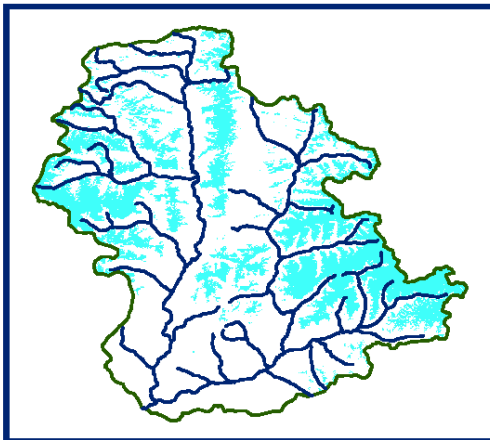
SNOW



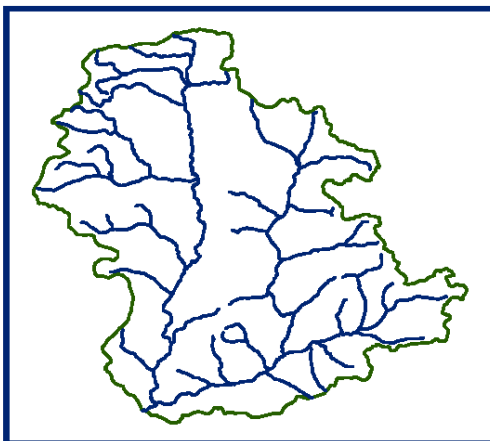
10 DAILY SNOW COVER MAP: TAWANG BASIN



DATA USED
DATA NOT AVAILABLE



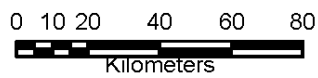
DATA USED
26 OCTOBER 2010



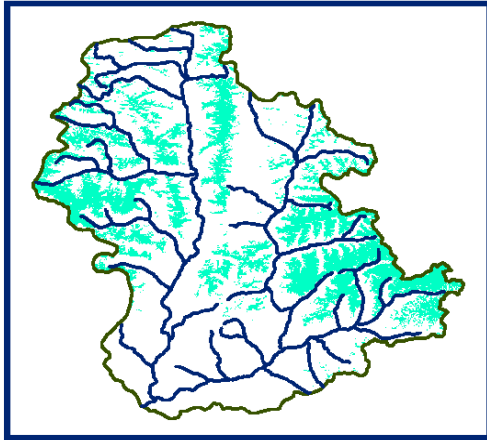
DATA USED
DATA NOT AVAILABLE



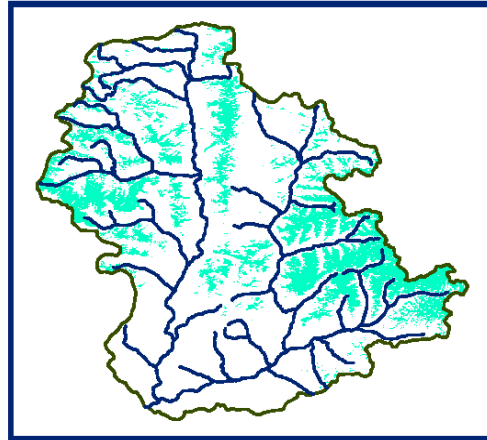
SNOW



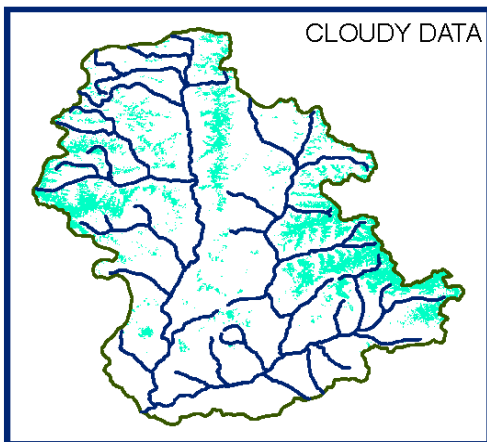
SNOW COVER MAP : TAWANG BASIN



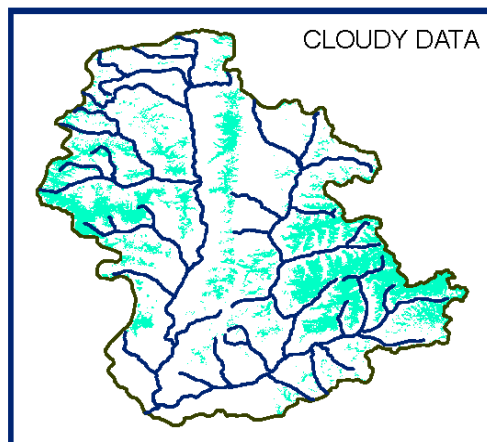
04 NOVEMBER 2010



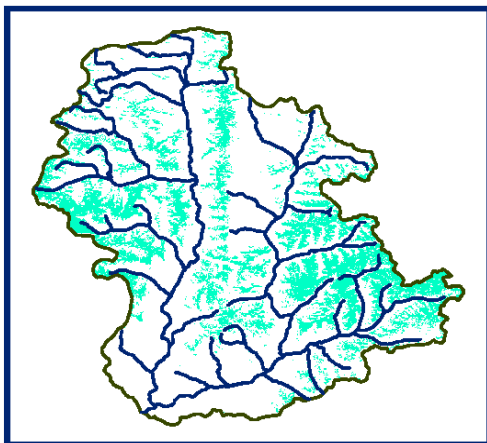
09 NOVEMBER 2010



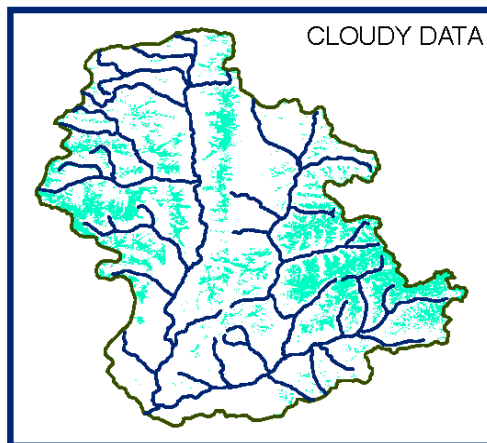
14 NOVEMBER 2010



18 NOVEMBER 2010



23 NOVEMBER 2010



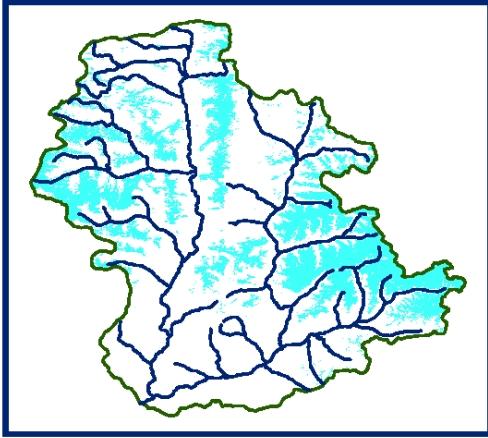
28 NOVEMBER 2010



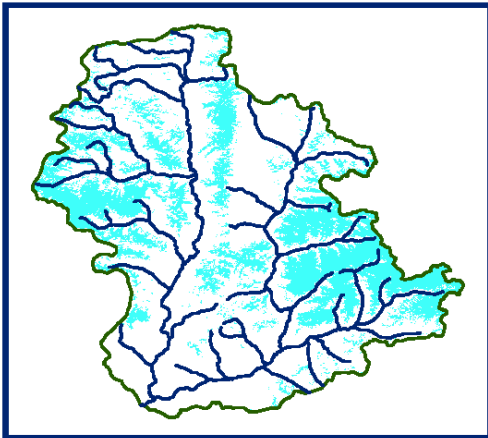
SNOW



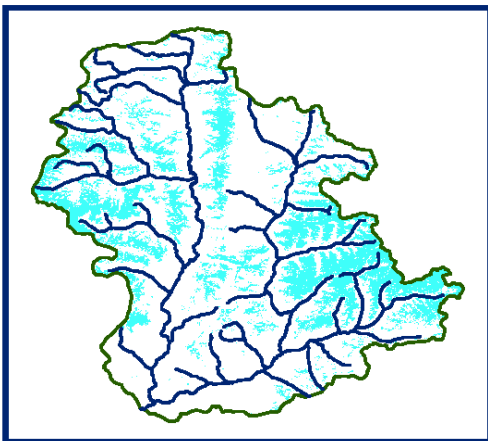
10 DAILY SNOW COVER MAP: TAWANG BASIN



**DATA USED
09 NOVEMBER 2010**



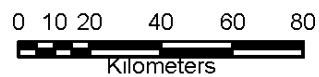
**DATA USED
18 NOVEMBER 2010**



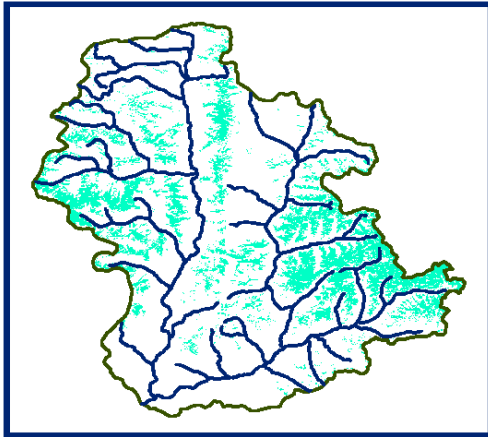
**DATA USED
28 NOVEMBER 2010**



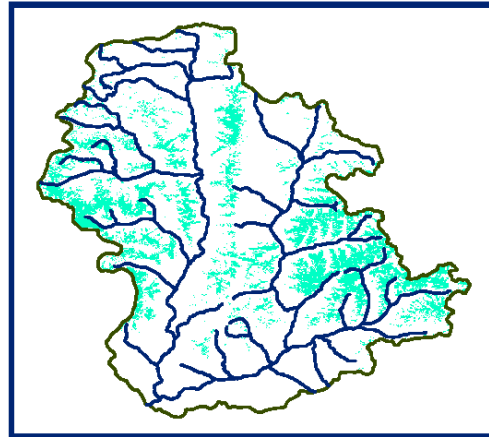
SNOW



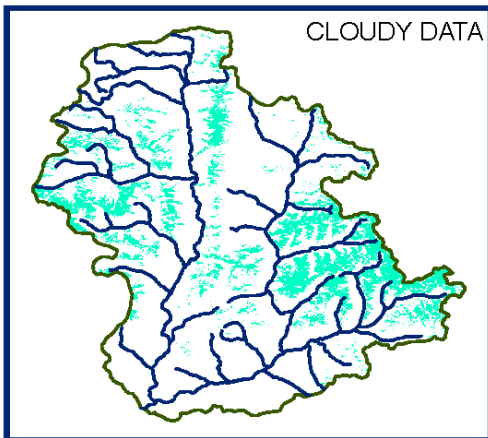
SNOW COVER MAP : TAWANG BASIN



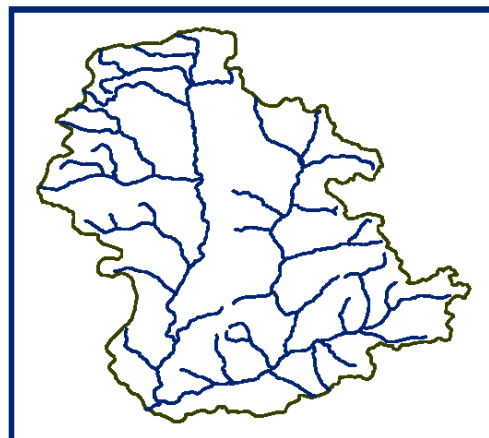
03 DECEMBER 2010



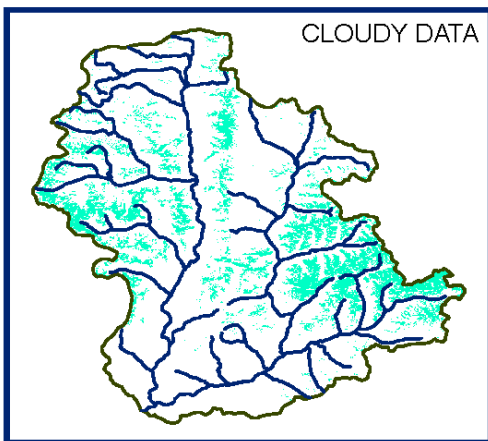
07 DECEMBER 2010



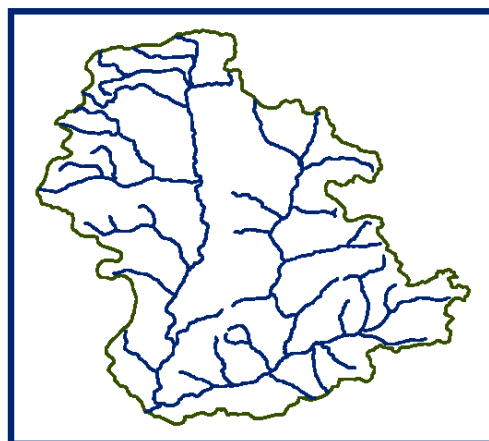
08 DECEMBER 2010



DATA NOT AVAILABLE



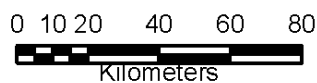
12 DECEMBER 2010



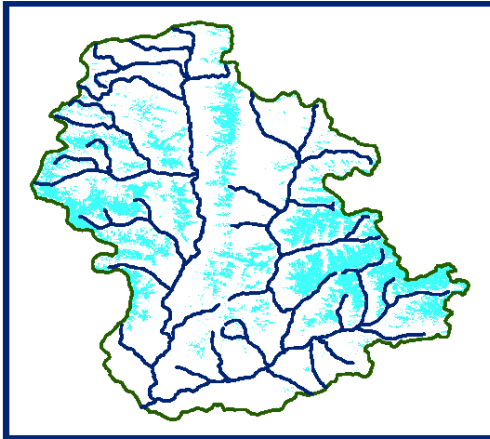
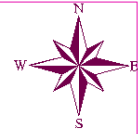
DATA NOT AVAILABLE



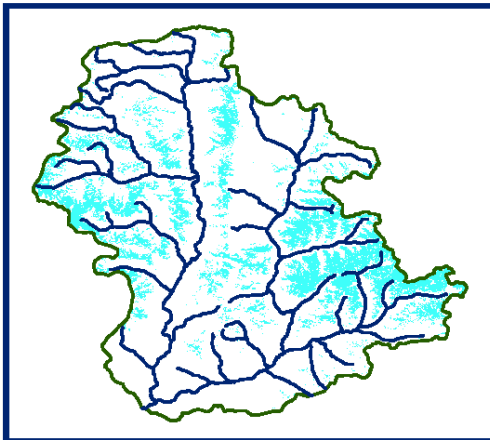
SNOW



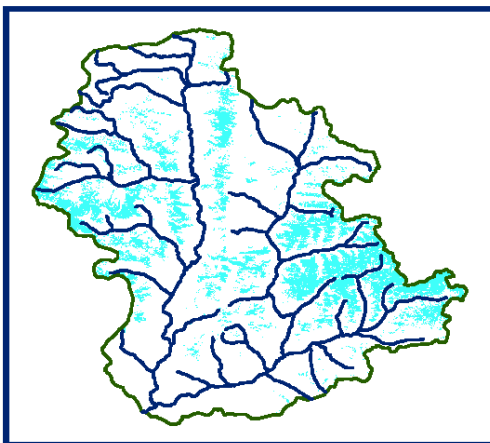
10 DAILY SNOW COVER MAP: TAWANG BASIN



DATA USED
07 DECEMBER 2010



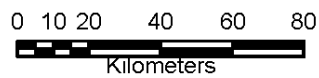
DATA USED
17 DECEMBER 2010



DATA USED
27 DECEMBER 2010



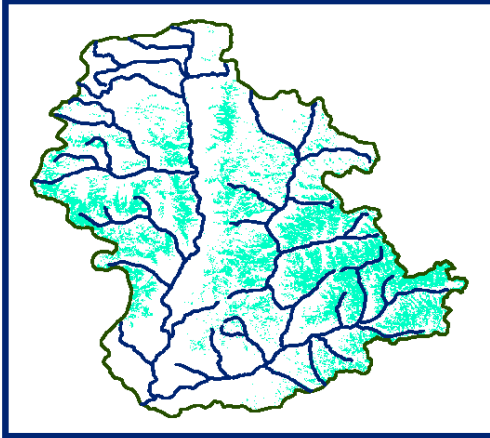
SNOW



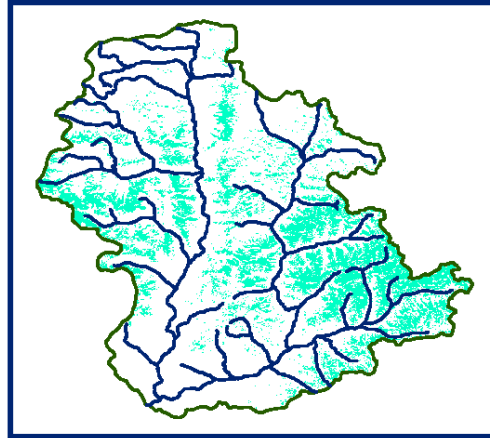
SNOW COVER MAP

:

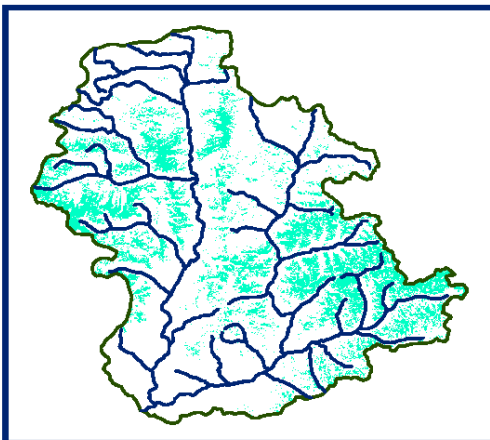
TAWANG BASIN



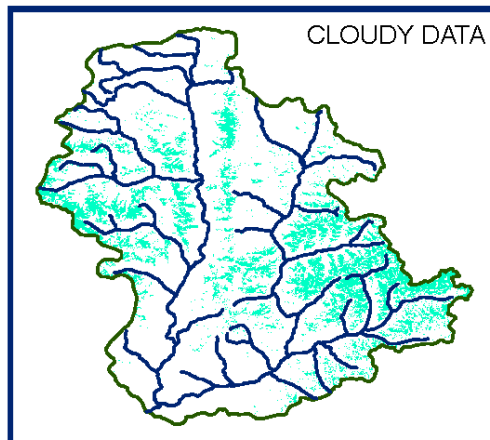
05 JANUARY 2011



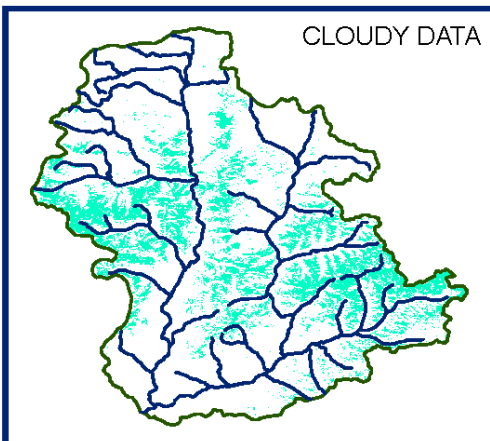
06 JANUARY 2011



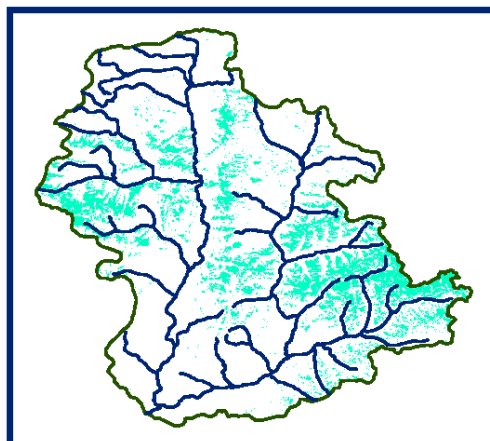
10 JANUARY 2011



15 JANUARY 2011



29 JANUARY 2011



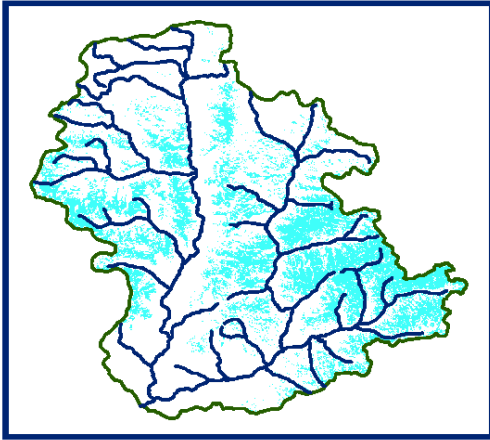
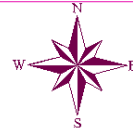
30 JANUARY 2011



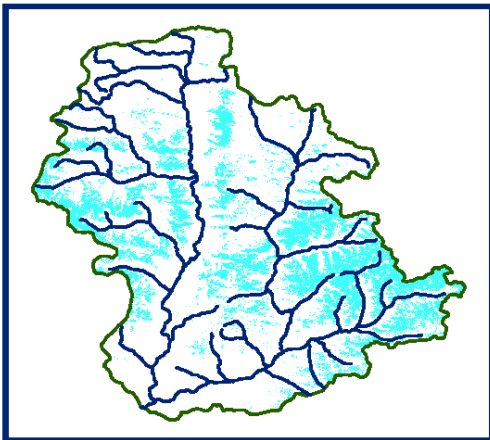
SNOW



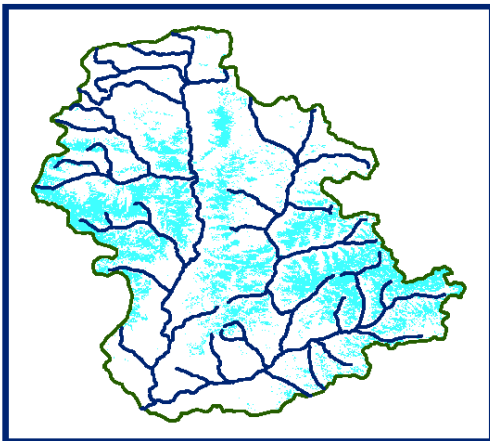
10 DAILY SNOW COVER MAP: TAWANG BASIN



**DATA USED
05 JANUARY 2011**



**DATA USED
15 JANUARY 2011**



**DATA USED
29 JANUARY 2011**



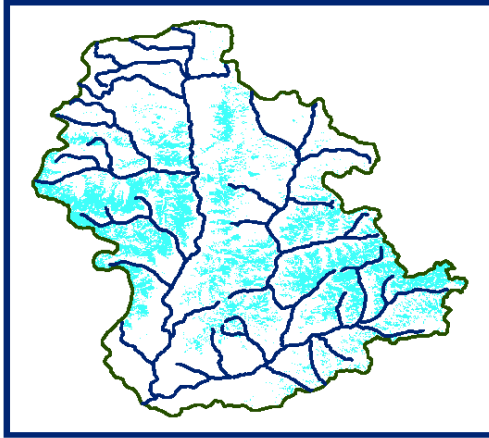
SNOW



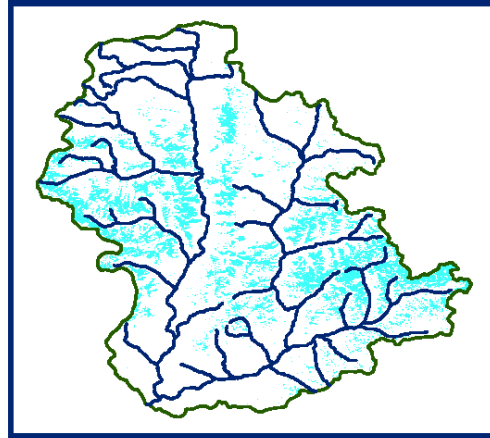
SNOW COVER MAP

:

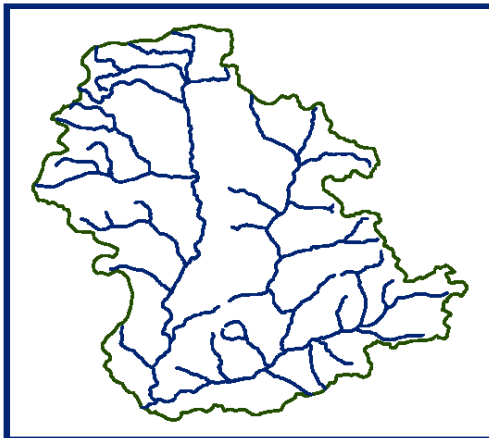
TAWANG BASIN



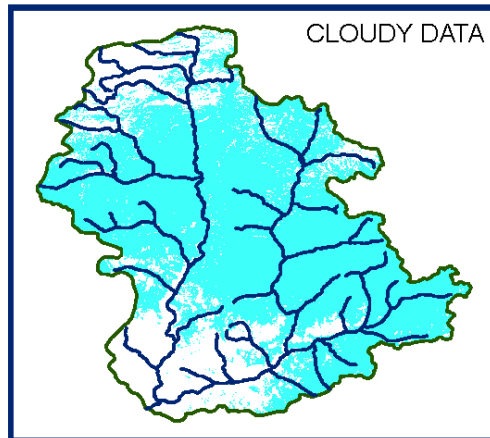
03 FEBRUARY 2011



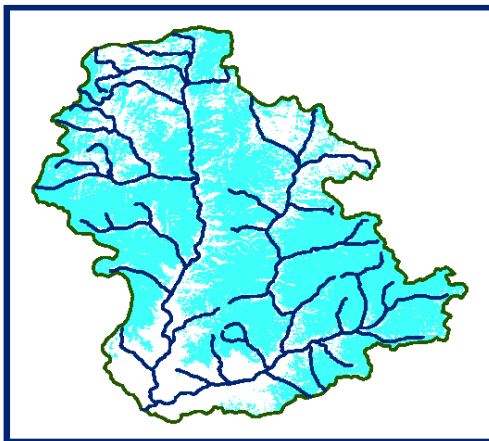
08 FEBRUARY 2011



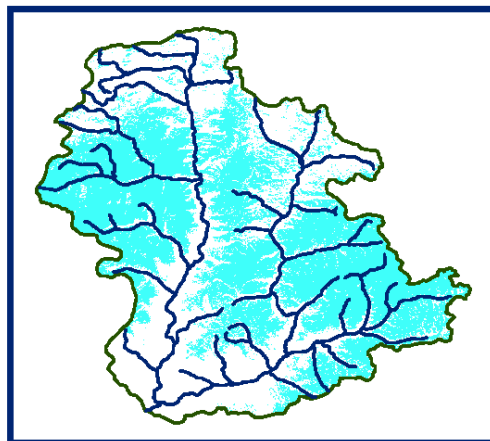
DATA NOT AVAILABLE



18 FEBRUARY 2011



22 FEBRUARY 2011



27 FEBRUARY 2011

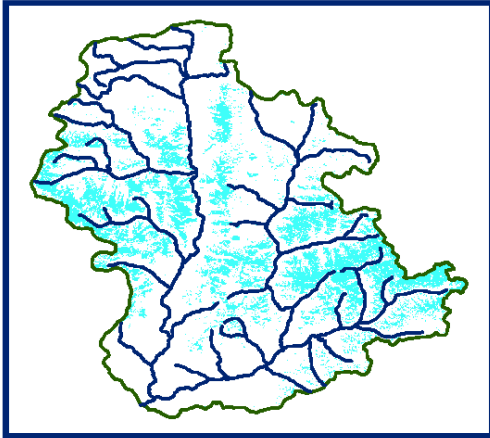
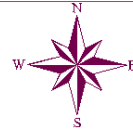


SNOW

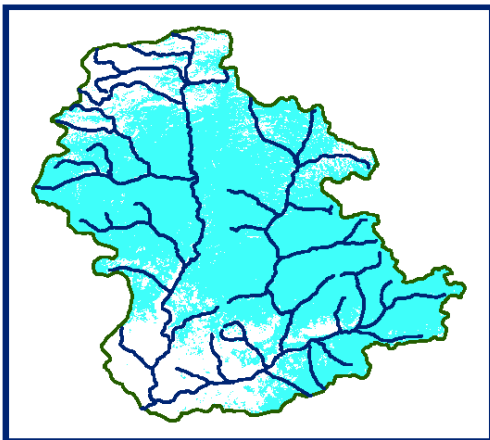


Kilometers

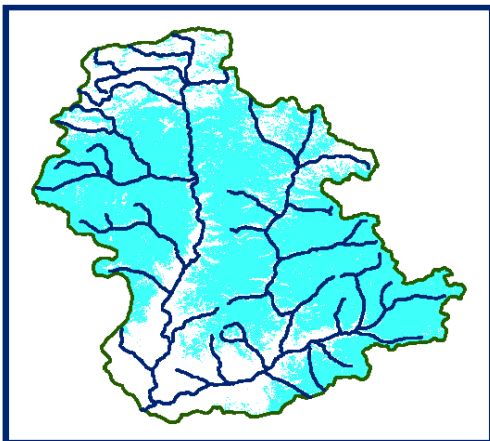
10 DAILY SNOW COVER MAP: TAWANG BASIN



**DATA USED
08 FEBRUARY 2011**



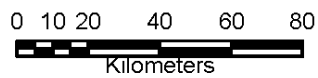
**DATA USED
18 FEBRUARY 2011**



**DATA USED
27 FEBRUARY 2011**



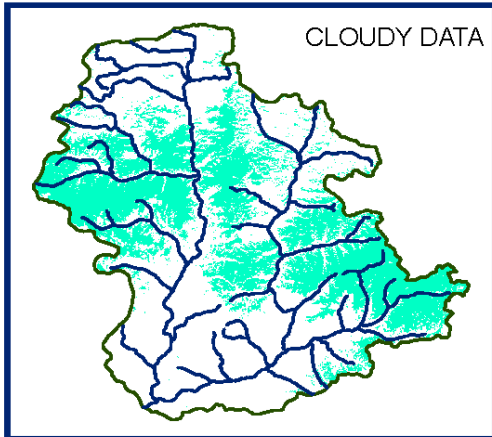
SNOW



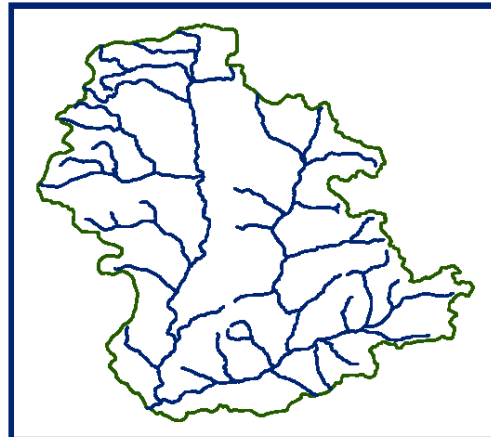
SNOW COVER MAP

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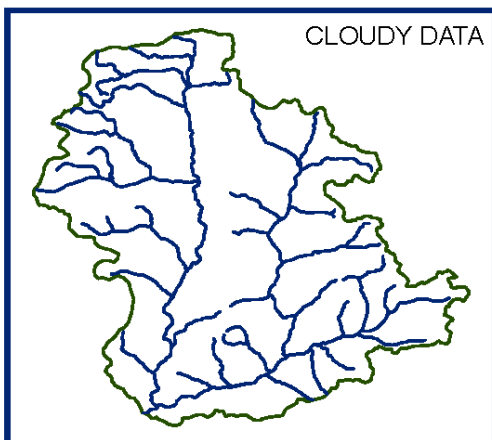
TAWANG BASIN



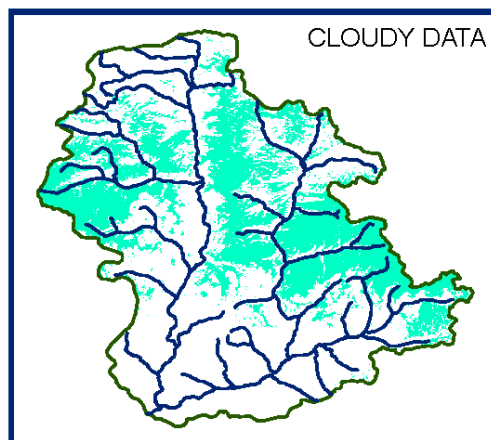
04 MARCH 2011



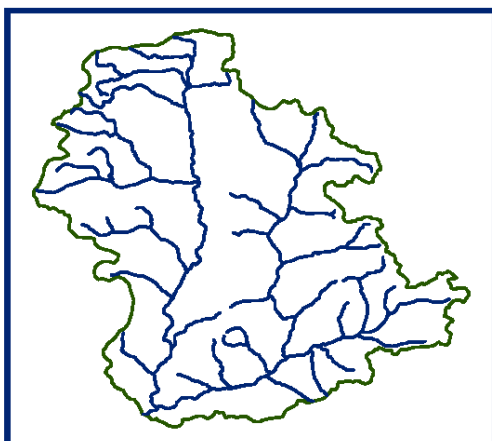
DATA NOT AVAILABLE



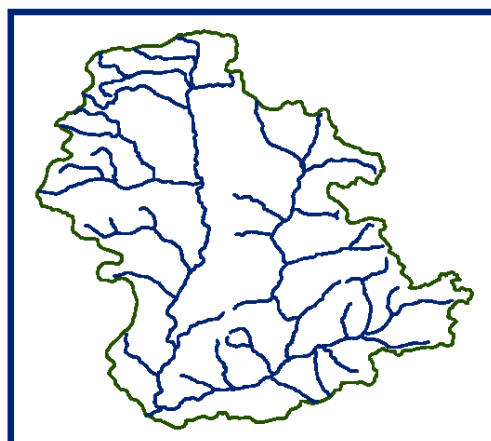
14 MARCH 2011



19 MARCH 2011



DATA NOT AVAILABLE



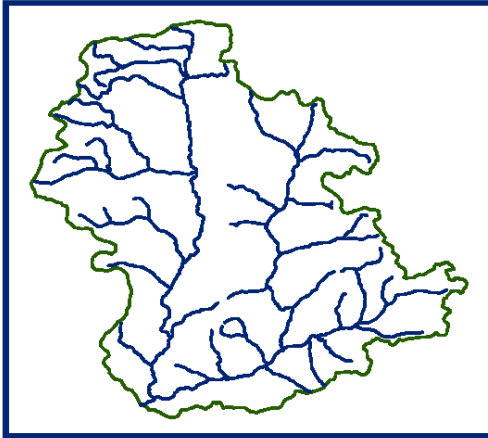
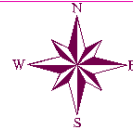
DATA NOT AVAILABLE



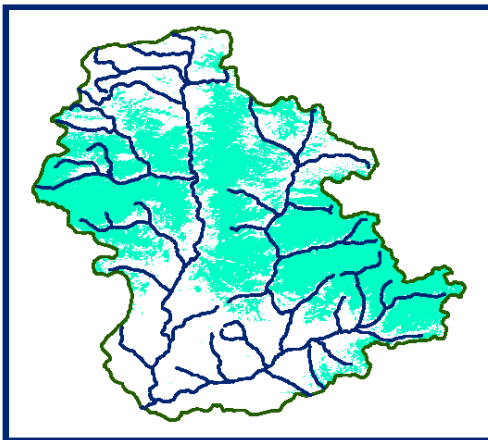
SNOW



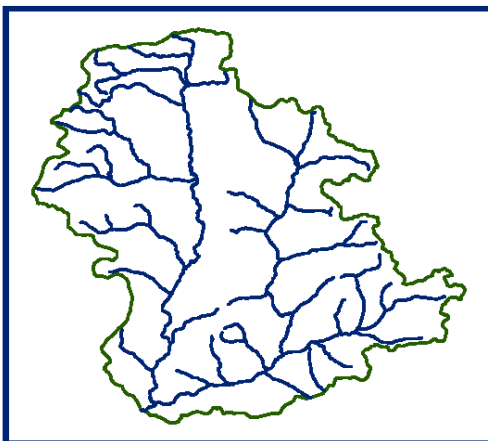
10 DAILY SNOW COVER MAP: TAWANG BASIN



DATA USED
DATA NOT AVAILABLE



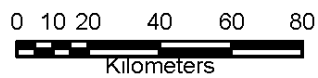
DATA USED
19 MARCH 2011



DATA USED
DATA NOT AVAILABLE



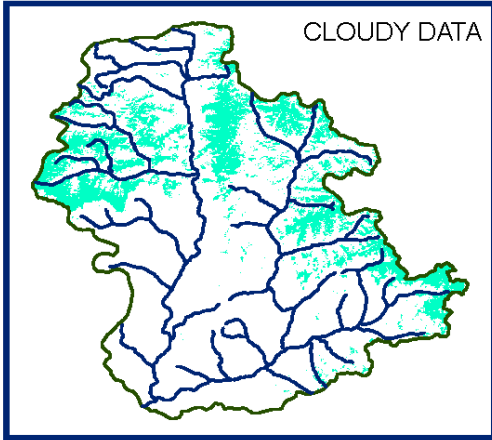
SNOW



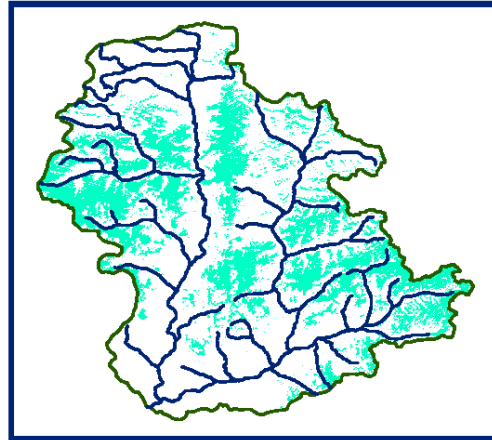
SNOW COVER MAP

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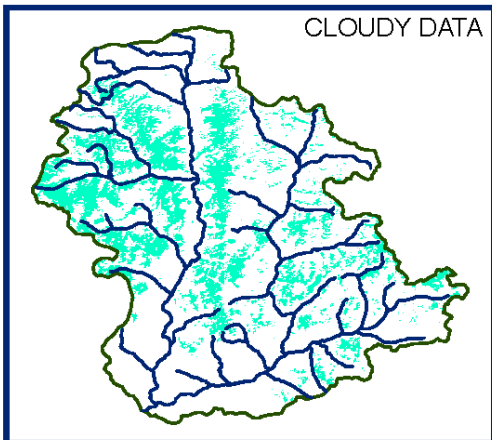
TAWANG BASIN



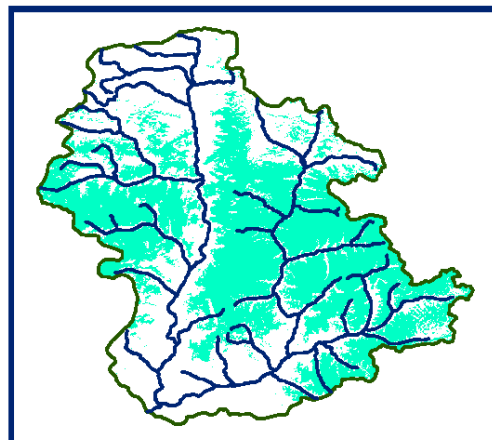
02 APRIL 2011



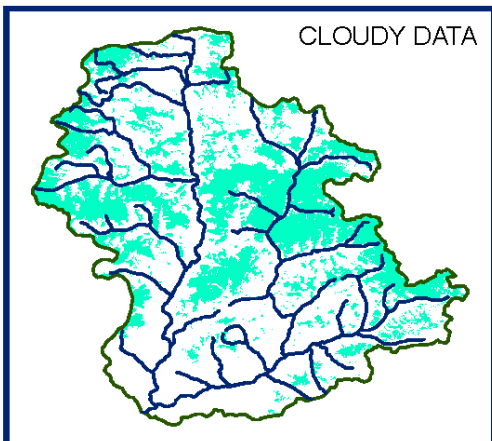
07 APRIL 2011



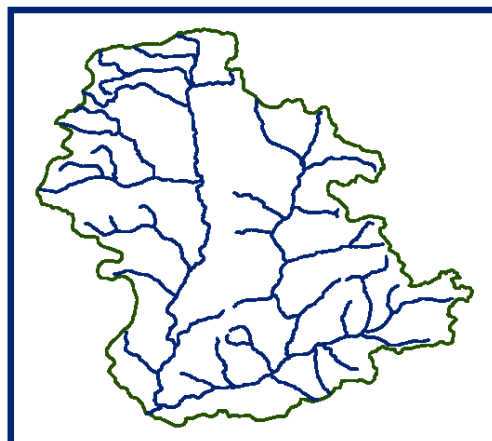
12 APRIL 2011



21 APRIL 2011



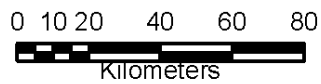
26 APRIL 2011



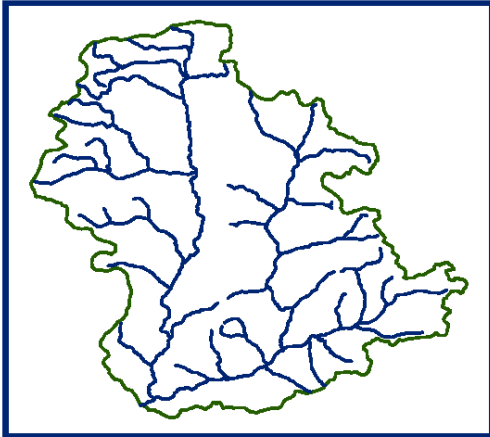
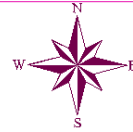
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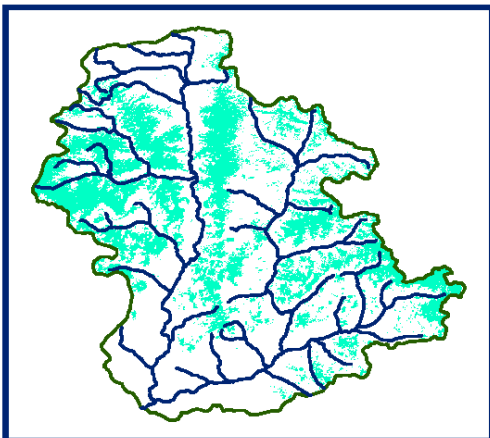
SNOW



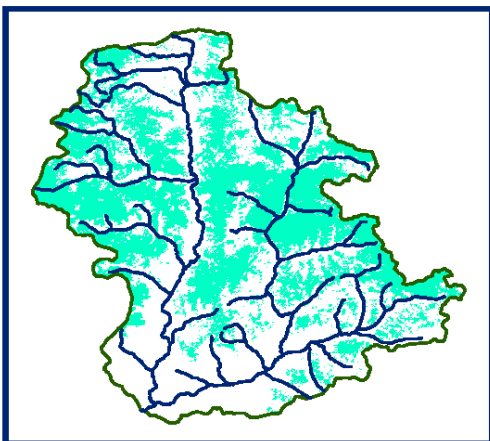
10 DAILY SNOW COVER MAP: TAWANG BASIN



**DATA USED
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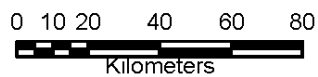
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12 APRIL 2011**



**DATA USED
26 APRIL 2011**



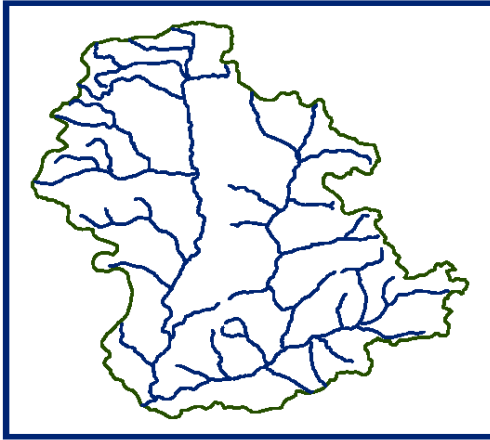
SNOW



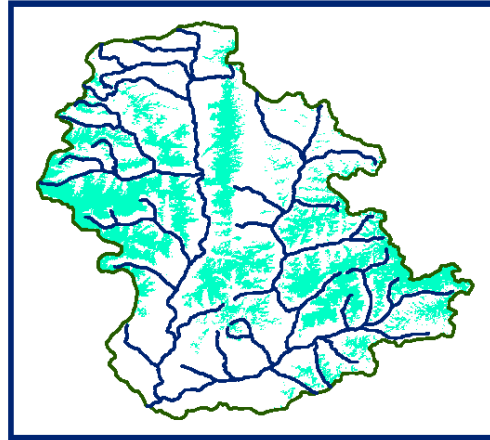
SNOW COVER MAP

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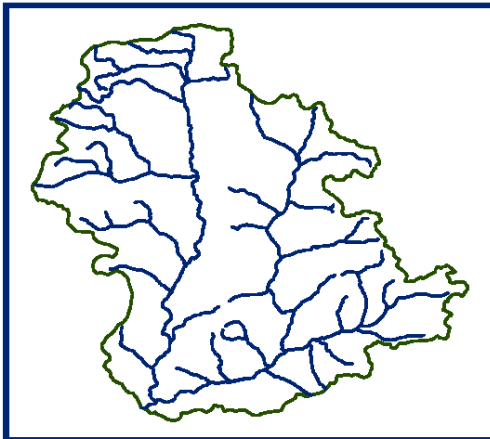
TAWANG BASIN



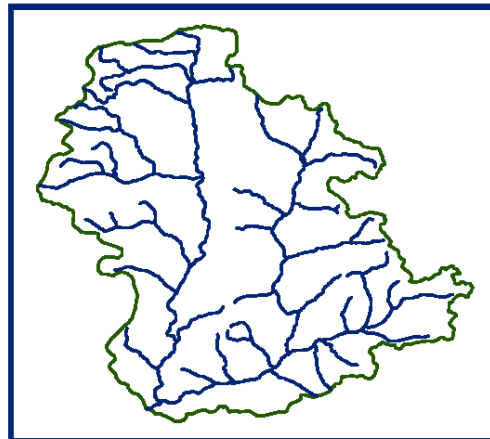
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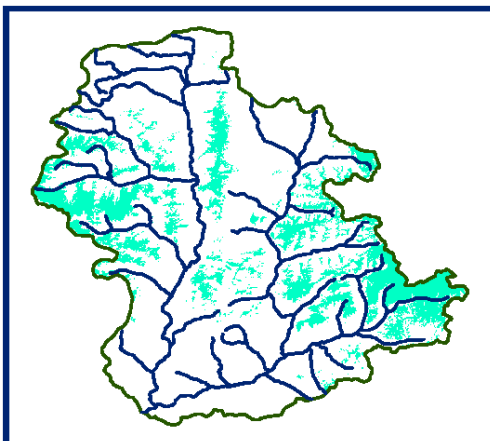
06 MAY 2011



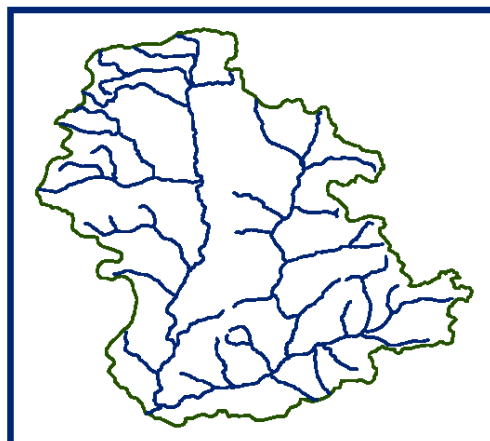
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DATA NOT AVAILABLE



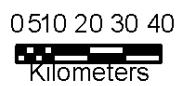
25 MAY 2011



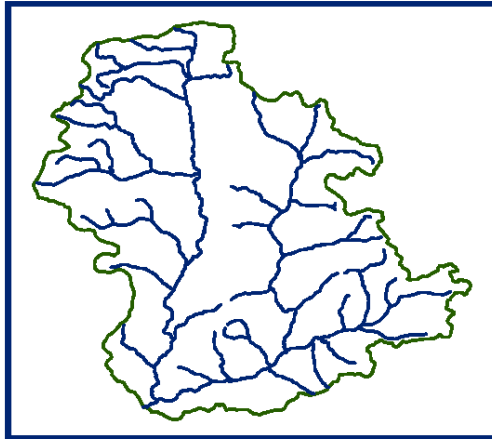
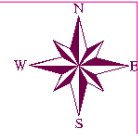
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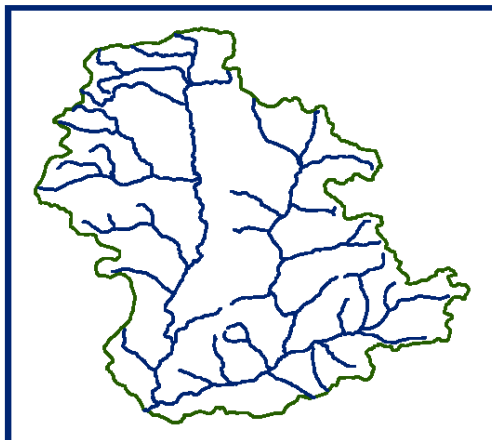
SNOW



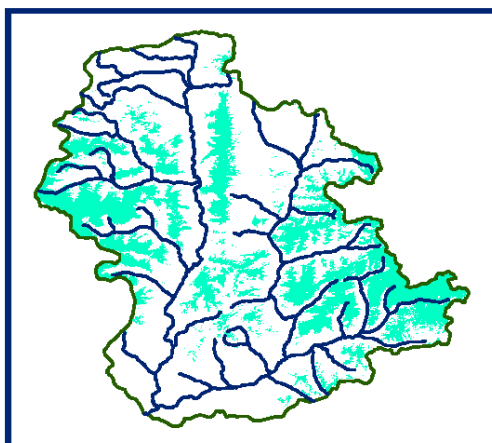
10 DAILY SNOW COVER MAP: TAWANG BASIN



DATA USED
DATA NOT AVAILABLE



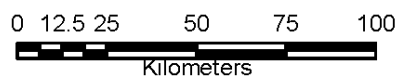
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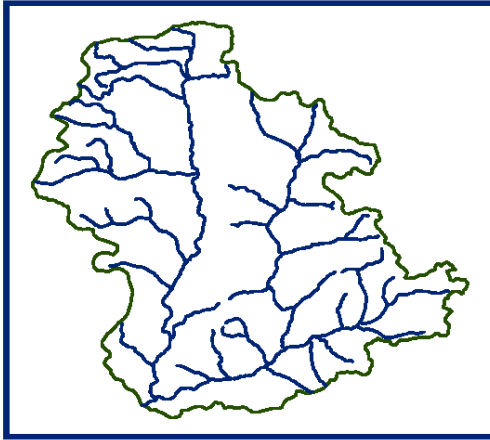
SNOW



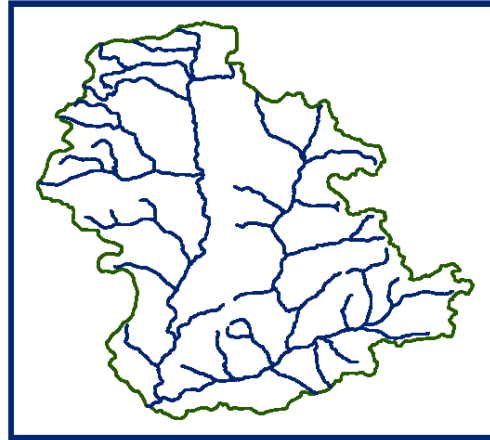
SNOW COVER MAP

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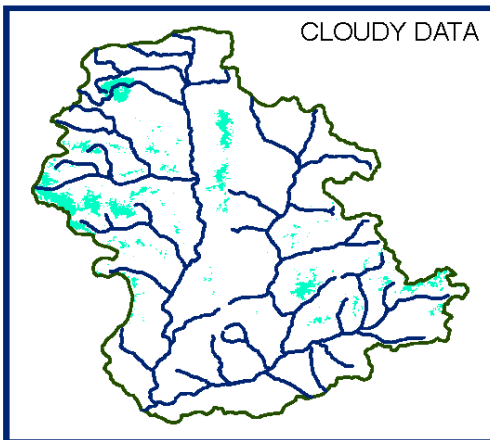
TAWANG BASIN



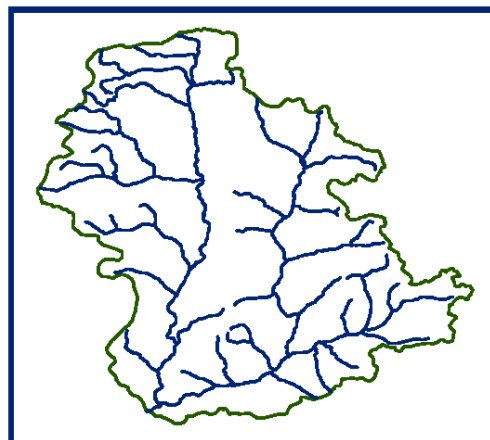
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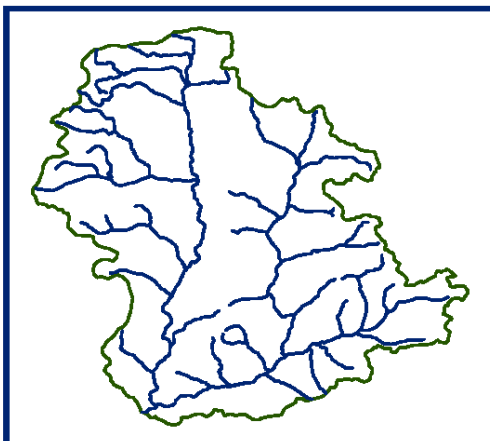
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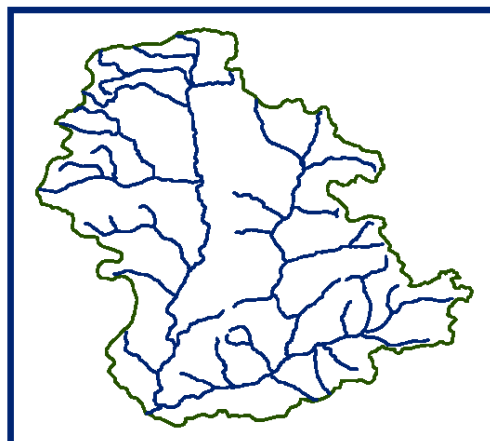
13 JUNE 2011



DATA NOT AVAILABLE



DATA NOT AVAILABLE



DATA NOT AVAILABLE

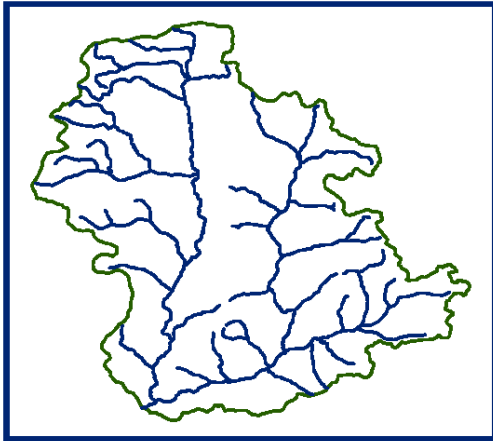
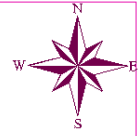


SNOW

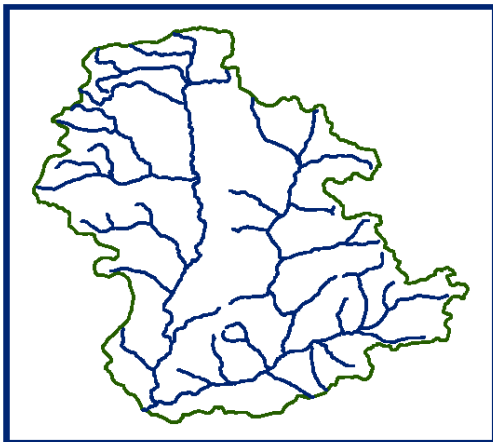


Kilometers

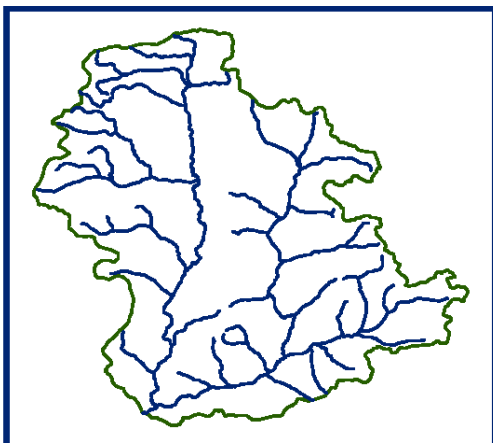
10 DAILY SNOW COVER MAP: TAWANG BASIN



DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE



DATA USED
DATA NOT AVAILABLE



SNOW

