



DEVELOPMENT AND VALIDATION OF SNOW COVER MONITORING ALGORITHM FOR HIMALAYAN REGION



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CHARACTERISTICS OF AWiFS SENSOR OF IRS P-6 (From Kiran Kumar, 2003)



Sr. No.	Parameter	Value			
1	Ground sampling distance (meter) Across track Along track	56 (nadir), 70(off-nadir) 66 for an integration time of 9.96 msec			
2	Swath (w/o earth curvature effect)	740 km			
3	Bands (μm)	B2	B3	B4	B5
		0.52-0.59	0.62-0.68	0.77-0.86	1.55-1.7
4.	Quantization (Bits)	10			
5	Signal to noise ration @ saturation radiance	>512 (for all bands)			
6	Radiance setting ($\text{mw}/\text{cm}^2/\text{Sr}/\mu\text{m}$) @ 100 % albedo	B2	B3	B4	B5
		53	47	31.5	7.5
8	Band to band registration (pixel)	$\leq \pm 0.25$			



SNOW COVER MONITORING

NORMALISED DIFFERENCE SNOW INDEX

(Reflectance AWiFS B2- Reflectance AWiFS B5)

NDSI =

(Reflectance AWiFS B2+Reflectance AWiFS B5)



FIELD VALIDATION OF NDSI FOR DIFFERENT HIMALAYAN FEATURES

(From: Kulkarni et al, 2006)



Target	Radiance (mW-cm ⁻² -sr ⁻¹ -μm ⁻¹)		Reflectance (%)		NDSI
	B2	B5	B2	B5	
Fresh moist snow	38.45	0.48	97.02	11.29	0.791
Refrozen fresh snow	20.92	0.09	82.13	2.30	0.945
High wet snow	29.00	0.10	76.02	1.63	0.958
Wet snow at Southern facing slope	36.70	0.10	78.86	1.35	0.966
Clean snow under shadow	0.83	0.009	83.8	4.0	0.91
Moist soil mixed with leaves	2.80	2.03	6.99	3.51	0.331
Moist Soil under shadow	0.41	0.020	21.8	33.0	-0.21
Pine	1.65	0.60	4.91	13.30	-0.460
Deciduous leaves	2.06	1.66	4.10	24.79	-0.716
Standing Water	1.53	0.005	5.2	0.1	0.96
Water under shadow	0.10	0.005	4.2	0.8	0.67

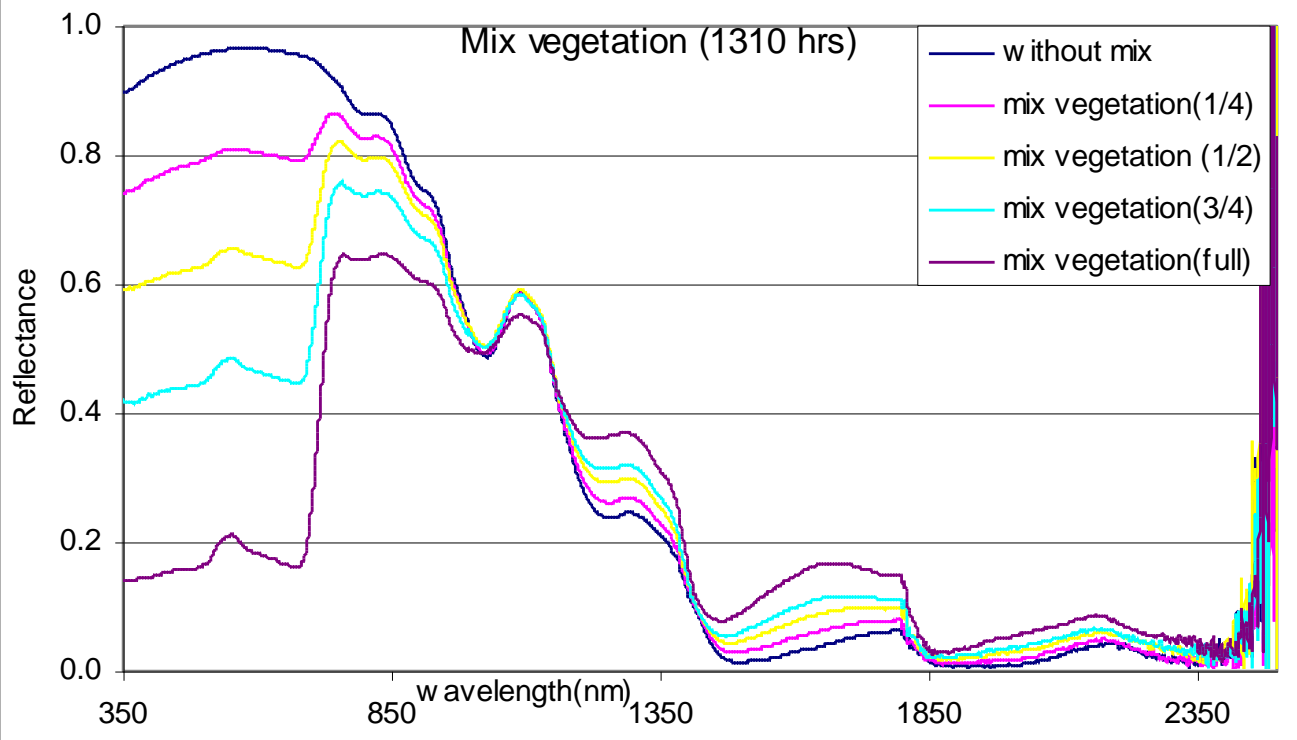


FIELD VALIDATION OF NDSI FOR DIFFERENT HIMALAYAN FEATURES (From: Kulkarni et al, 2010)

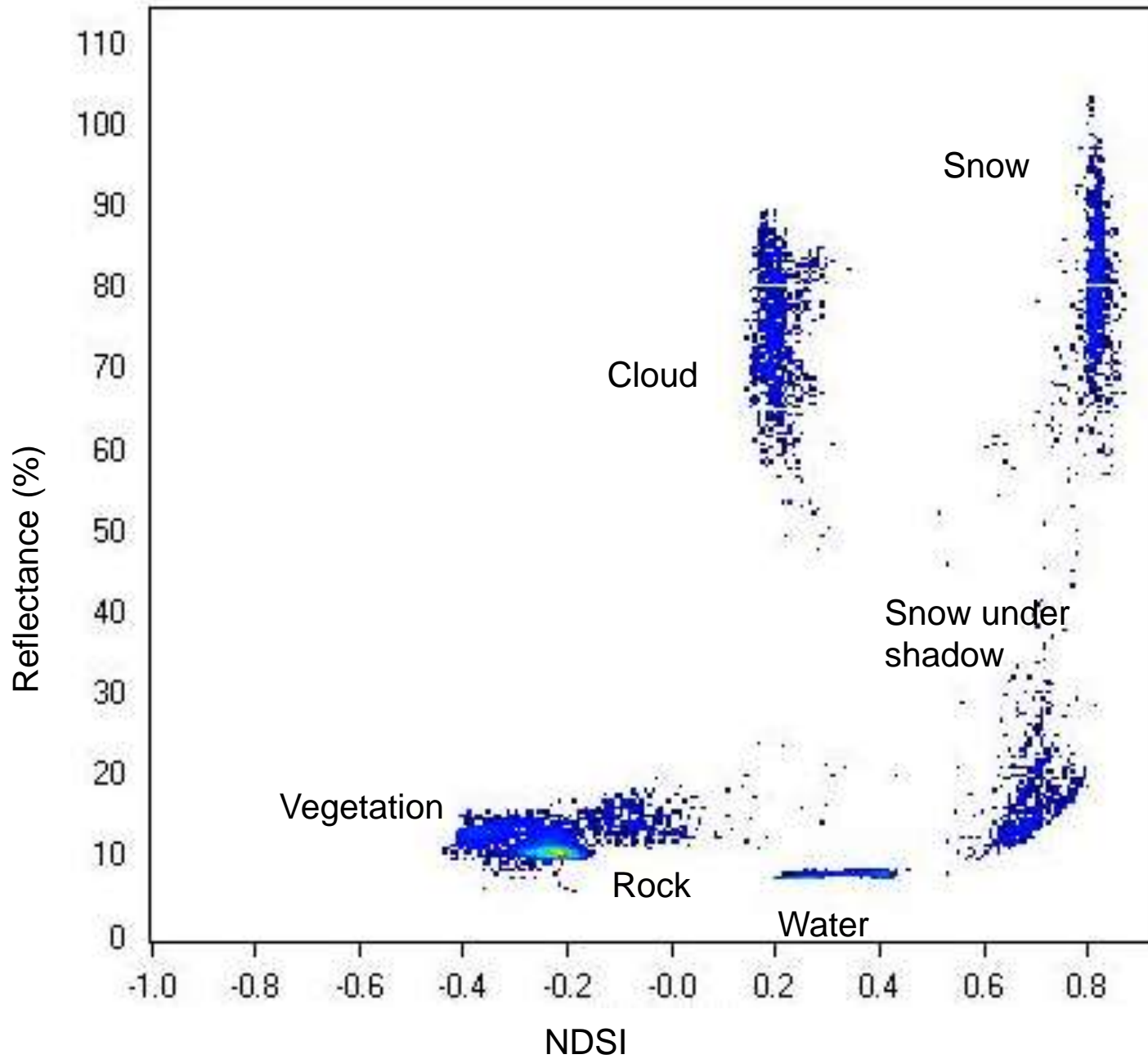


Slope angle	Orientation	AWiFS Band 2 (reflectance)	AWiFS Band 5 (reflectance)	NDSI
10 ⁰	North	0.5988	0.0117	0.96
	South	0.8501	0.0165	0.96
	East	0.7919	0.0117	0.97
	West	0.6212	0.0110	0.97
20 ⁰	North	0.4182	0.0101	0.95
	South	0.9440	0.0171	0.96
	East	0.9732	0.0159	0.97
	West	0.5359	0.0110	0.96
30 ⁰	North	0.3820	0.0086	0.96
	South	1.0356	0.0155	0.97
	East	1.0591	0.0185	0.97
	West	0.4498	0.0077	0.97
40 ⁰	North	0.2900	0.0067	0.95
	South	1.1736	0.0215	0.96
	East	1.1366	0.0242	0.96
	West	0.3185	0.0044	0.97

INFLUENCE OF MIXED PIXELS ON SPECTRAL REFLECTANCE AND NDSI

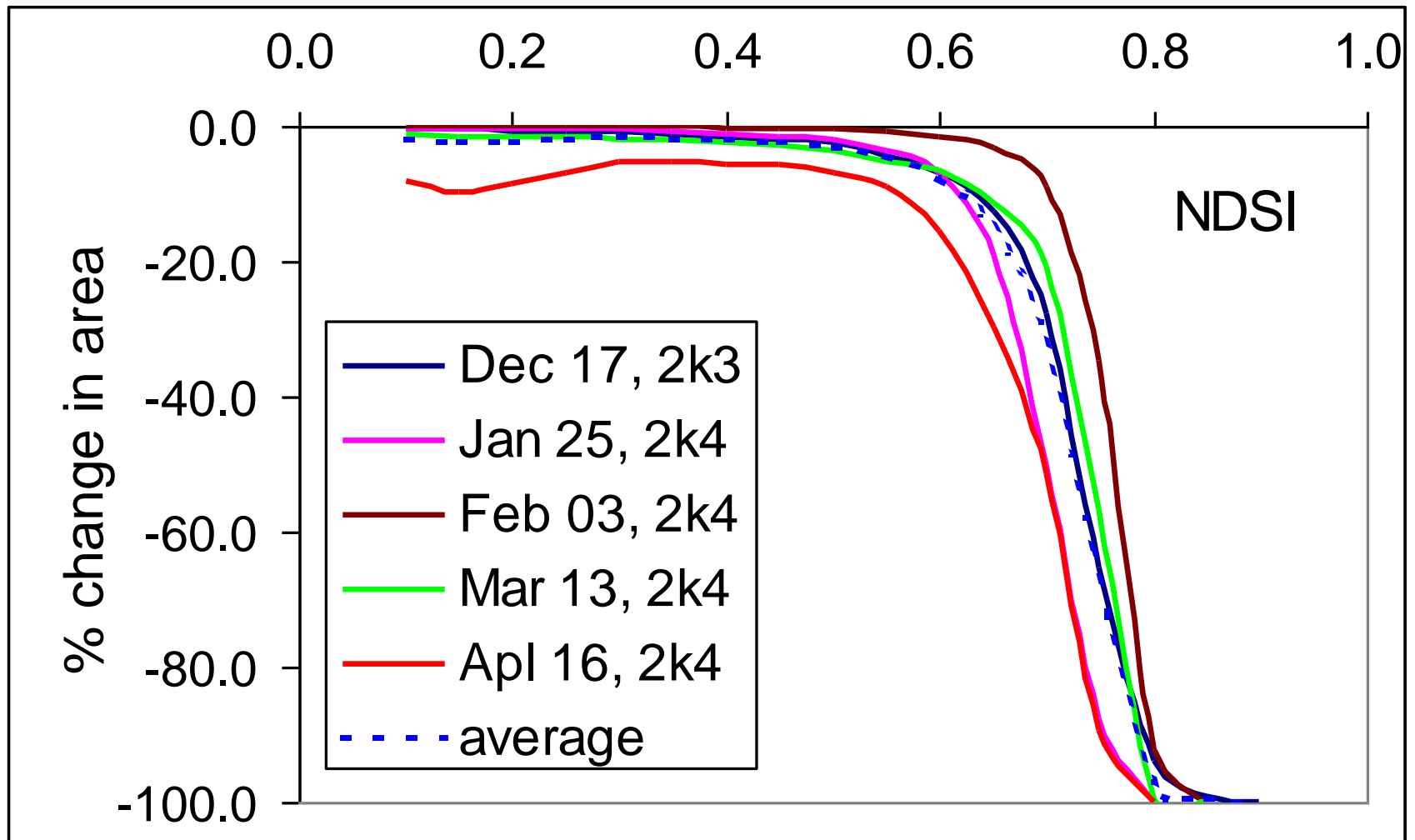


	B2	B3	B4	B5	NDSI
Without vegetation	0.964	0.959	0.861	0.033	0.93
Mix vegetation 1/4	0.807	0.795	0.824	0.056	0.87
Mix vegetation 1/2	0.650	0.631	0.793	0.081	0.77
Mix vegetation 3/4	0.475	0.451	0.739	0.103	0.64
Vegetation full	0.199	0.167	0.640	0.152	0.13



Scatterplot of March 13, 2004 of AWiFS

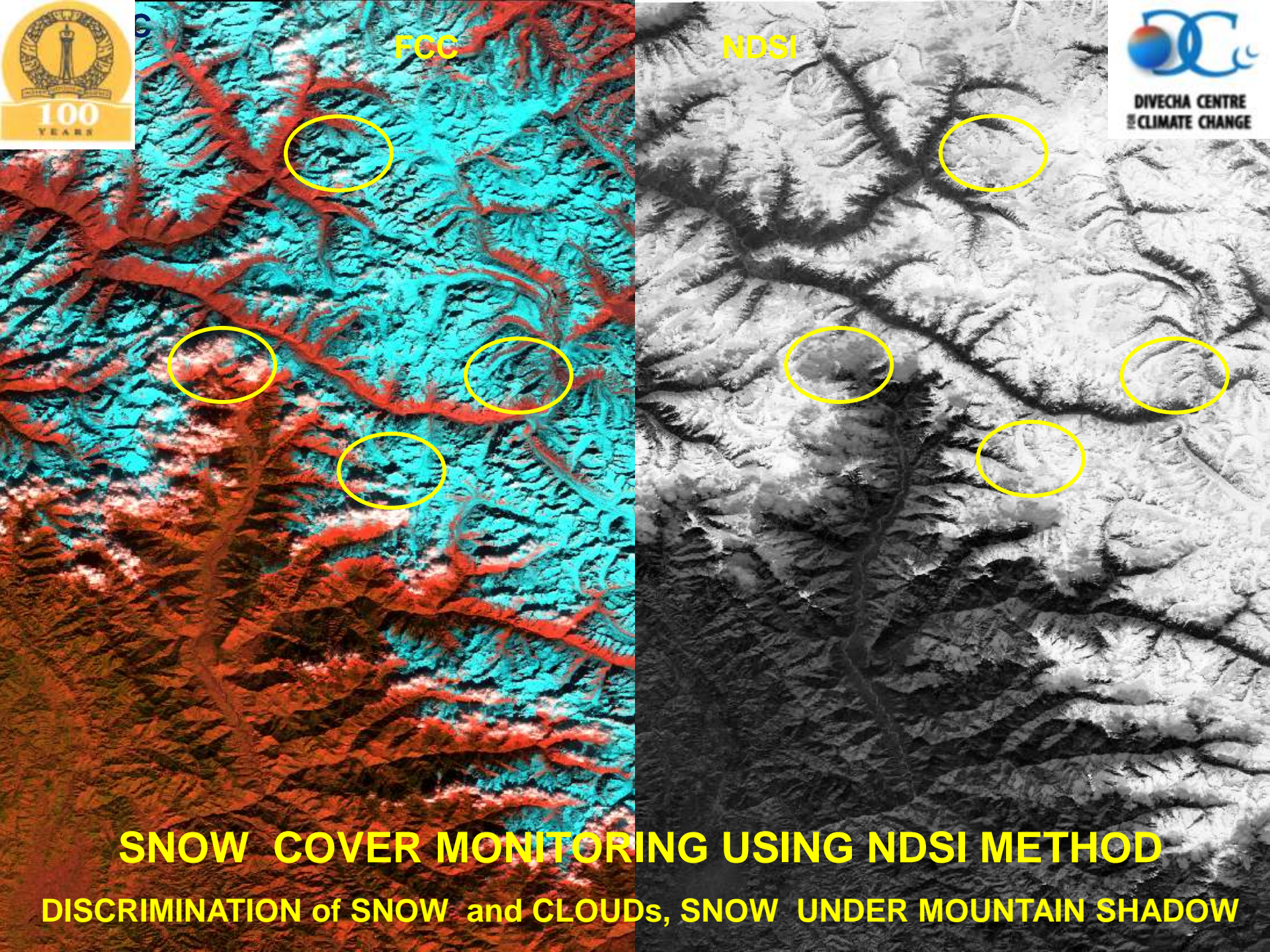
SENSITIVITY ANALYSIS





FCC

NDSI



SNOW COVER MONITORING USING NDSI METHOD

DISCRIMINATION of SNOW and CLOUDs, SNOW UNDER MOUNTAIN SHADOW

AWiFS
B2 AND B5

Reflectance image

NDSI IMAGE

> 0.4

< 0.4 > 0

< 0

Snow +
Water

Cloud
Pixel

Other
Pixel

N-5 days

AWiFS B4

Reflectance
Image

Water pixel

AWiFS B2 and B5

NDSI IMAGE

AWiFS B4

Snow

Non-Snow

N+5 days

Snow

SNOW AND CLOUD MAP

Basin Mask

AWiFS B4

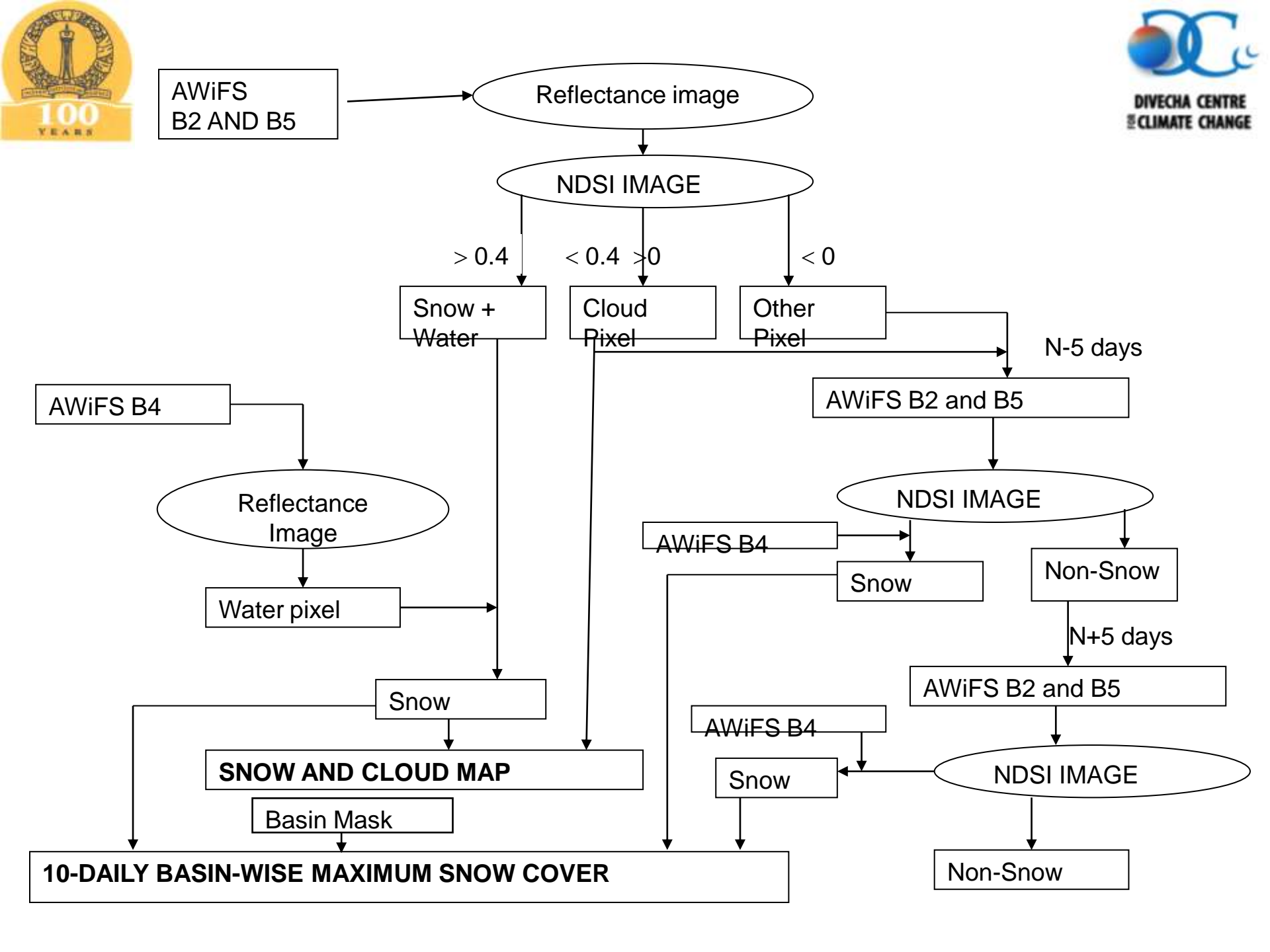
Snow

AWiFS B2 and B5

NDSI IMAGE

Non-Snow

10-DAILY BASIN-WISE MAXIMUM SNOW COVER



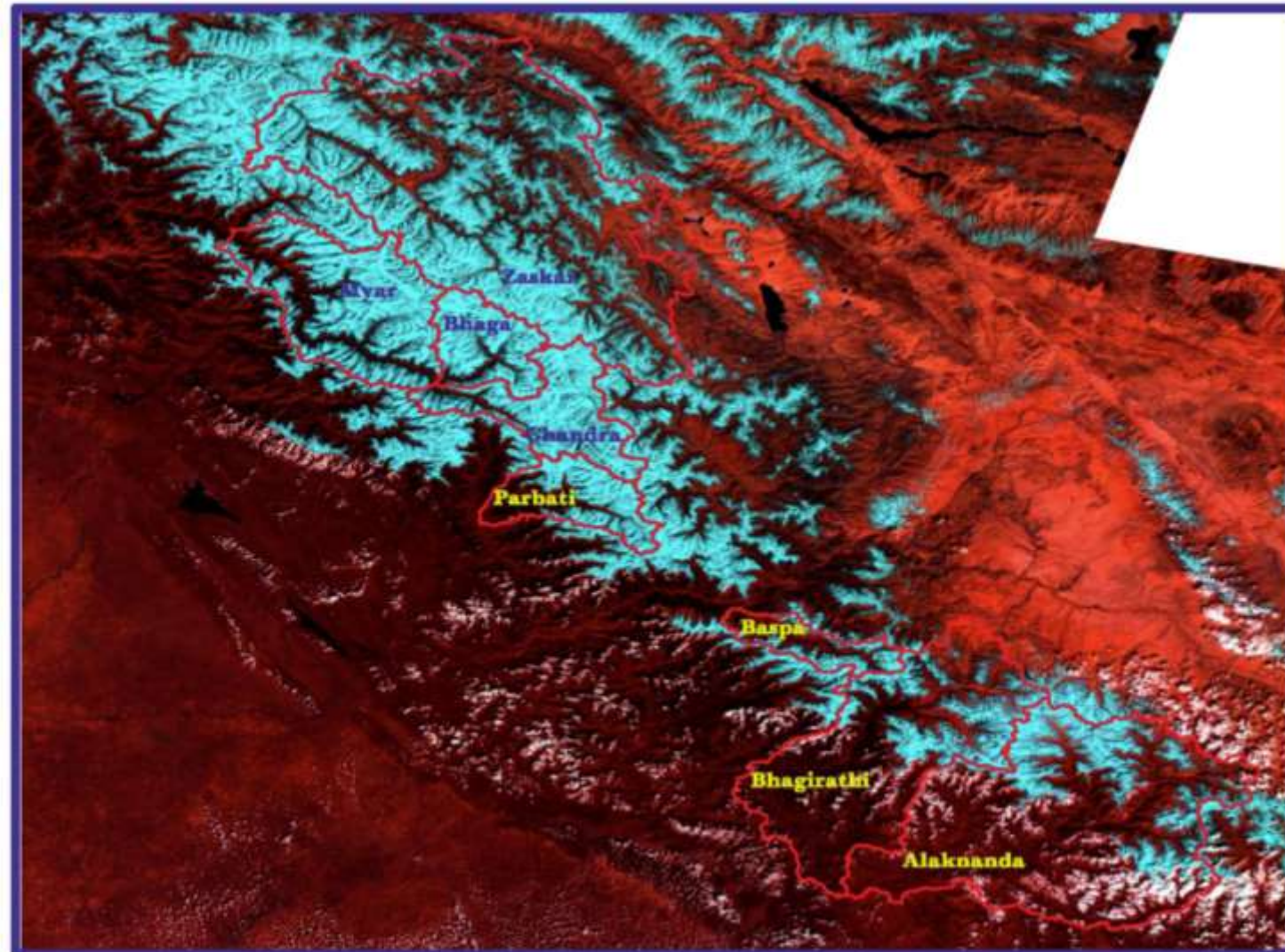


MONITORING OF SEASONAL SNOW USING AWiFS DATA



Snow cover mapping in selected sub basins from October to June (2005 - 2009).

Basin	Sub-basins
Ganga	Alaknanda, Bhagirathi, Yamuna
Satluj	Spiti, Pin, Baspa, Jiwa, Parbati, Beas
Chenab	Ravi, Bhaga, Chandra, Miyar, Bhut, Warwan
Indus	Jhelum, Dras, Kishanganga, Astor, Suru, Shigo, Hanza, Zaskar, Nubra, Shyok, Hanza, Gilgit, Shingar, Shasgan, .
Tista	Tista, Rangit
Brahmaputra	Tawang, Dibang, Subansiri





VALIDATION OF ALGORITHM

Sr. No.	Validation points	Nos.
1	Match	132
2	Unmatched	2
3	Excluded due to cloud	73
	Total	207



VALIDATION OF ALGORITHM

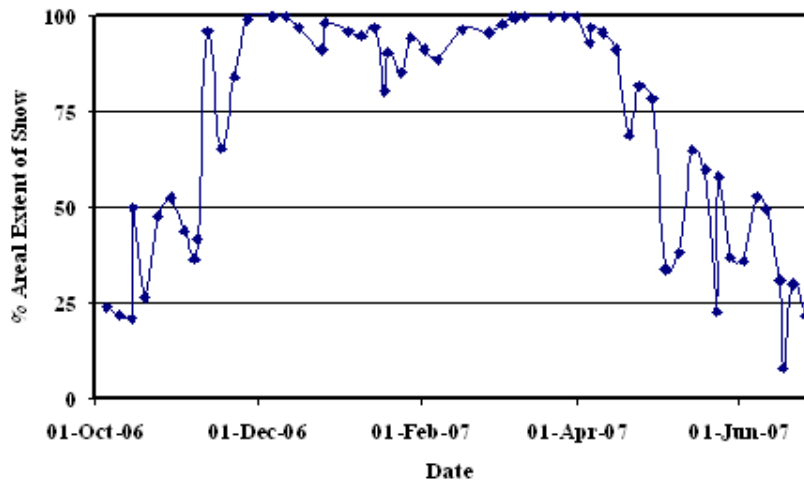


Class	Total pixels	Snow identified pixels	Accuracy
Snow/ice	431713	429975	99.6
Barren land	1038658	1020150	98.2
Sparse vegetation	517275	506821	97.9
Dense vegetation	133425	128132	95.8

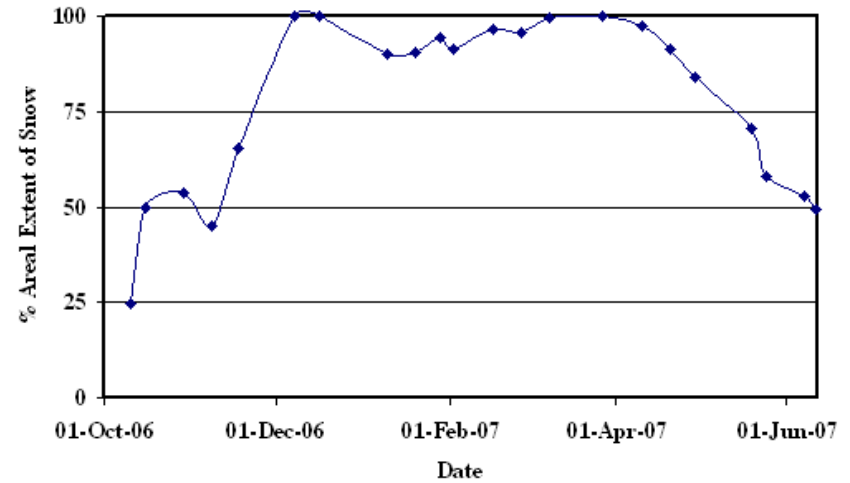


INFLUENCE OF CLOUD ON SNOW COVER ESTIMATIC

BHAGA BASIN (5 DAILY) : WITH CLOUDY DATA

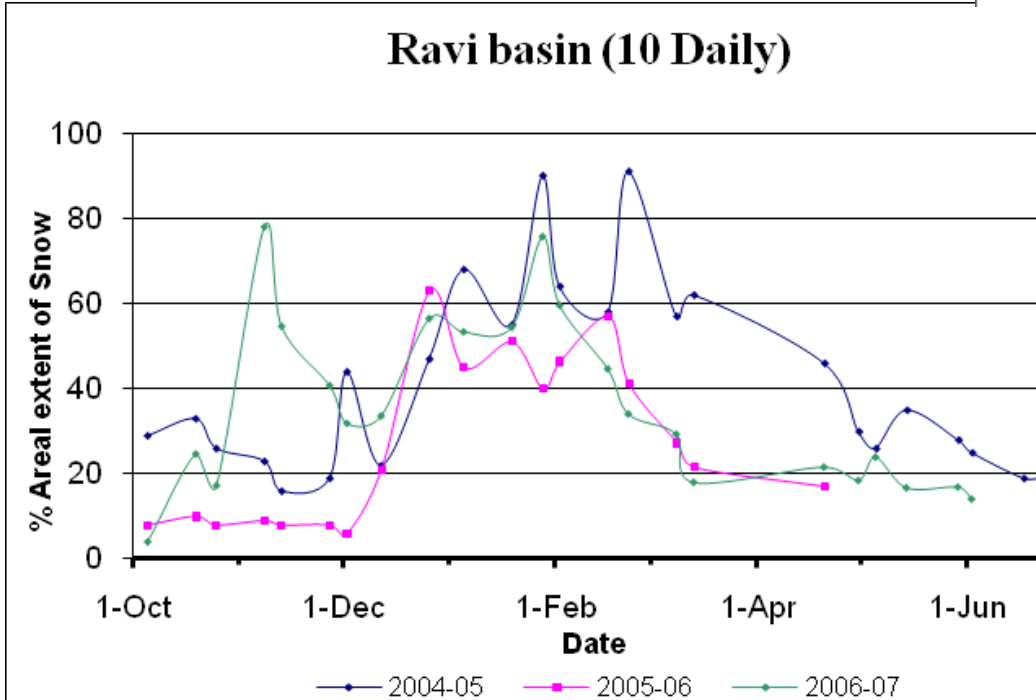
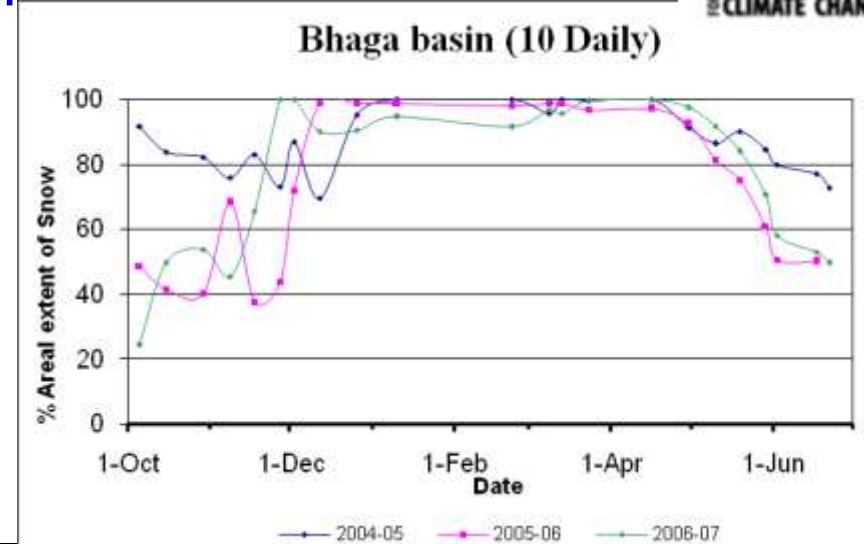


BHAGA BASIN (10 DAILY)





Snow accumulation and ablation pattern in basins located in different parts of Himalaya



Mean snow fall Western Himalaya: 2004-5: 739 cm; 2005-6: 606 cm; 2006-7: 596 cm



THANKS



11 7 2004