# ASSESSING CHANGES SNOW AND GLACIER MELT RUNOFF

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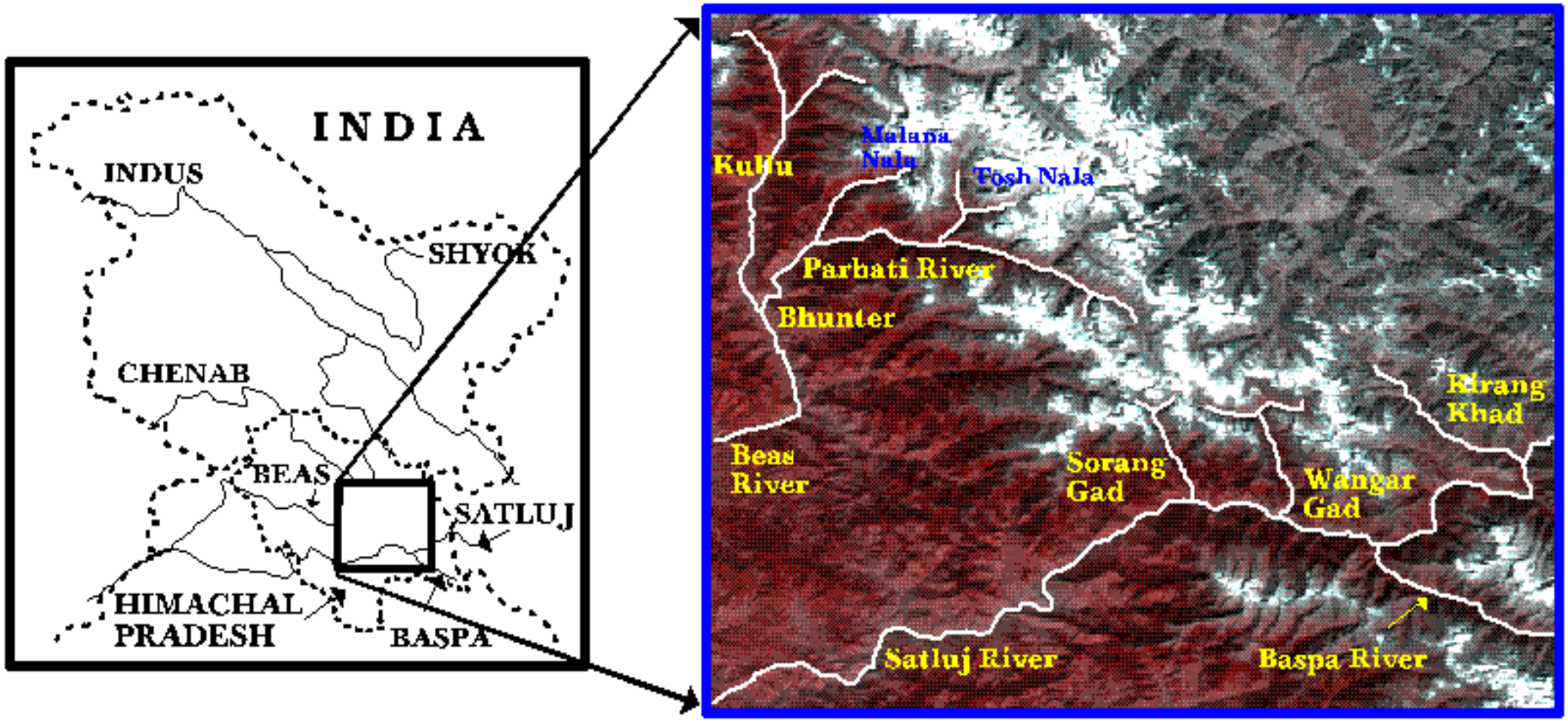


# SNOW AND GLACIER MELT RUNOFF MODELING

1. Himalayas has large number of snow and glaciated streams. Systematic assessment of hydro-power potential of each stream is needed.

2. Mountainous stream has lean discharge in winter and feasibility of hydropower plant depends upon winter discharge.

3. Develop a model which can assess inter seasonal variability.

# Snow and glacier melt runoff model

1. Conceptually runoff models have two components. One considers snow and glacier melt and another runoff part.

2. There could be various methods of estimation of snow and glacier melt and determination of stream runoff.

3. Models can also be developed to consider various needs and requirements.

# SEASONAL SNOW AND GLACIER MELT RUNOFF MODELING

(Pre-feasibility investigation, Autumn, winter, summer, Monsoon )

$$Q=c\{a(T*G)\}+c\{S*W)-(M*Sw)\} + (c*P*B)$$

Where,

Q = Average seasonal runoff (cu m/s)

C = Runoff coefficient

a = Melt factor (cm/degree C.d)

T = Average seasonal degree-day (degree.day)

G = Area of snow and glaciers (sq km)

S = Area of seasonal snow (sq km)

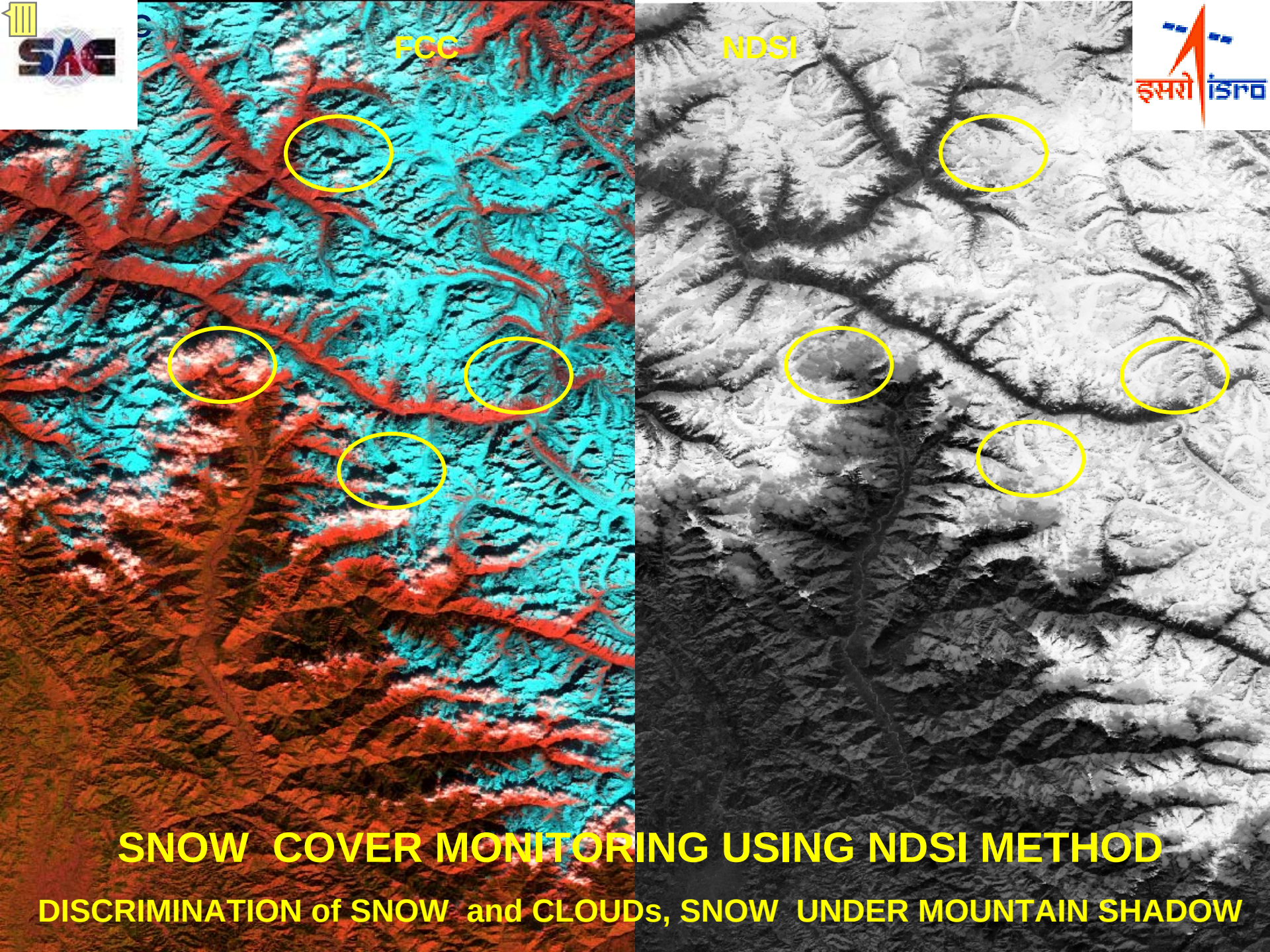
W = Water equivalent of winter snow fall (m)

M = Winter snow melt (m)

Sw= Snow cover in winter

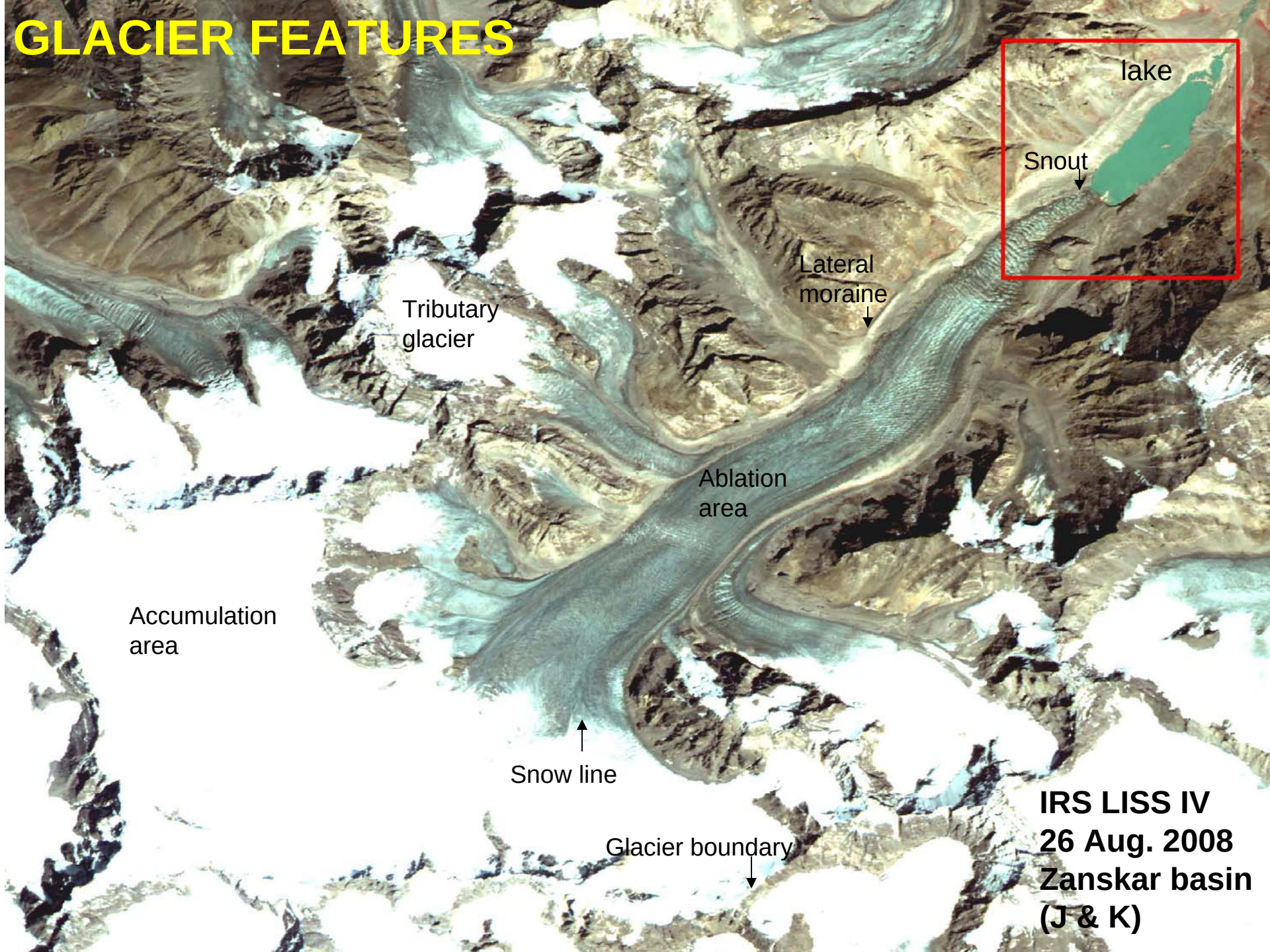
P = Average seasonal rainfall (m)

B = Basin area without snow/glacier (sq m)

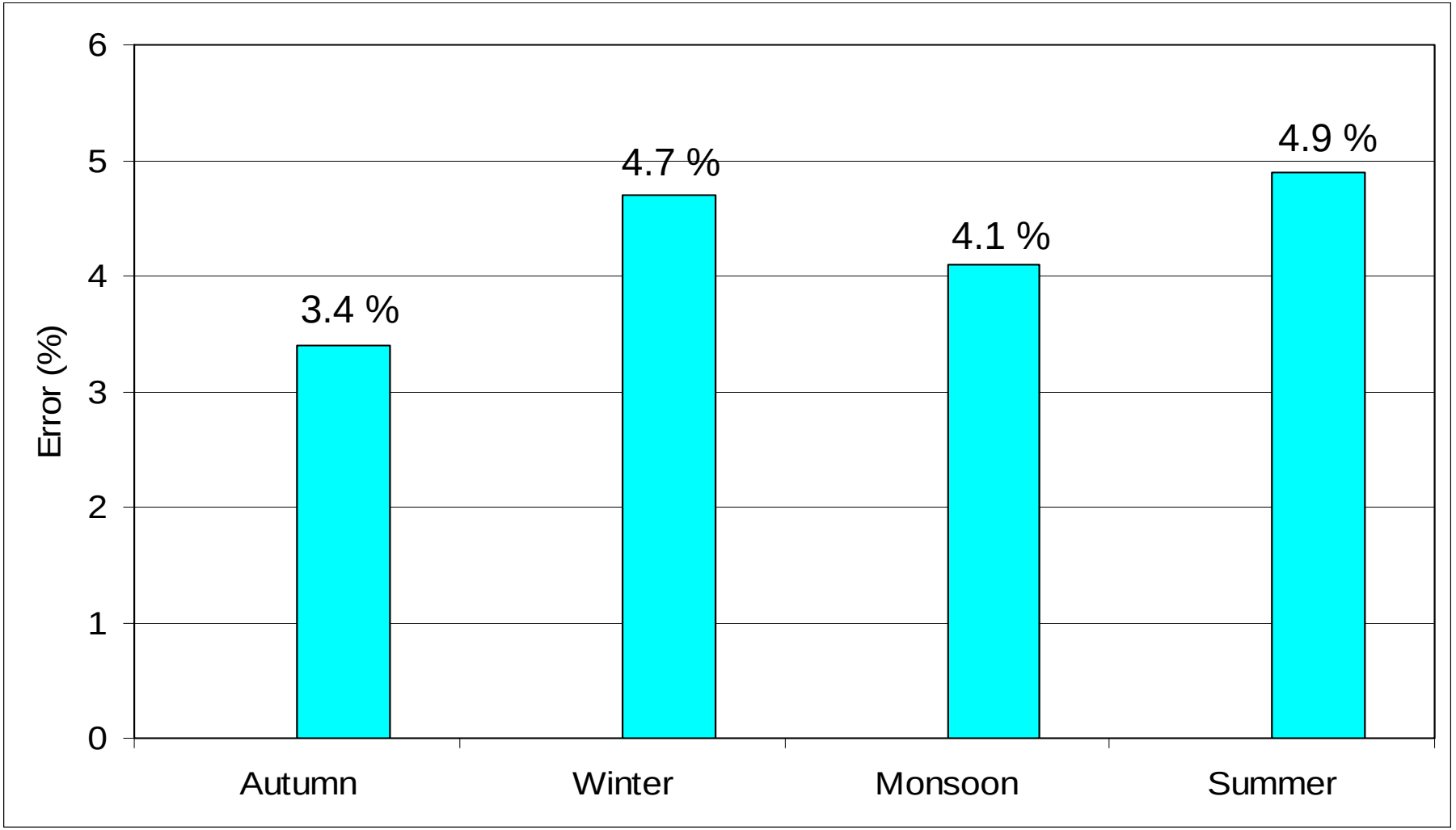



# SNOW COVER MONITORING USING NDSI METHOD

## DISCRIMINATION of SNOW and CLOUDs, SNOW UNDER MOUNTAIN SHADOW

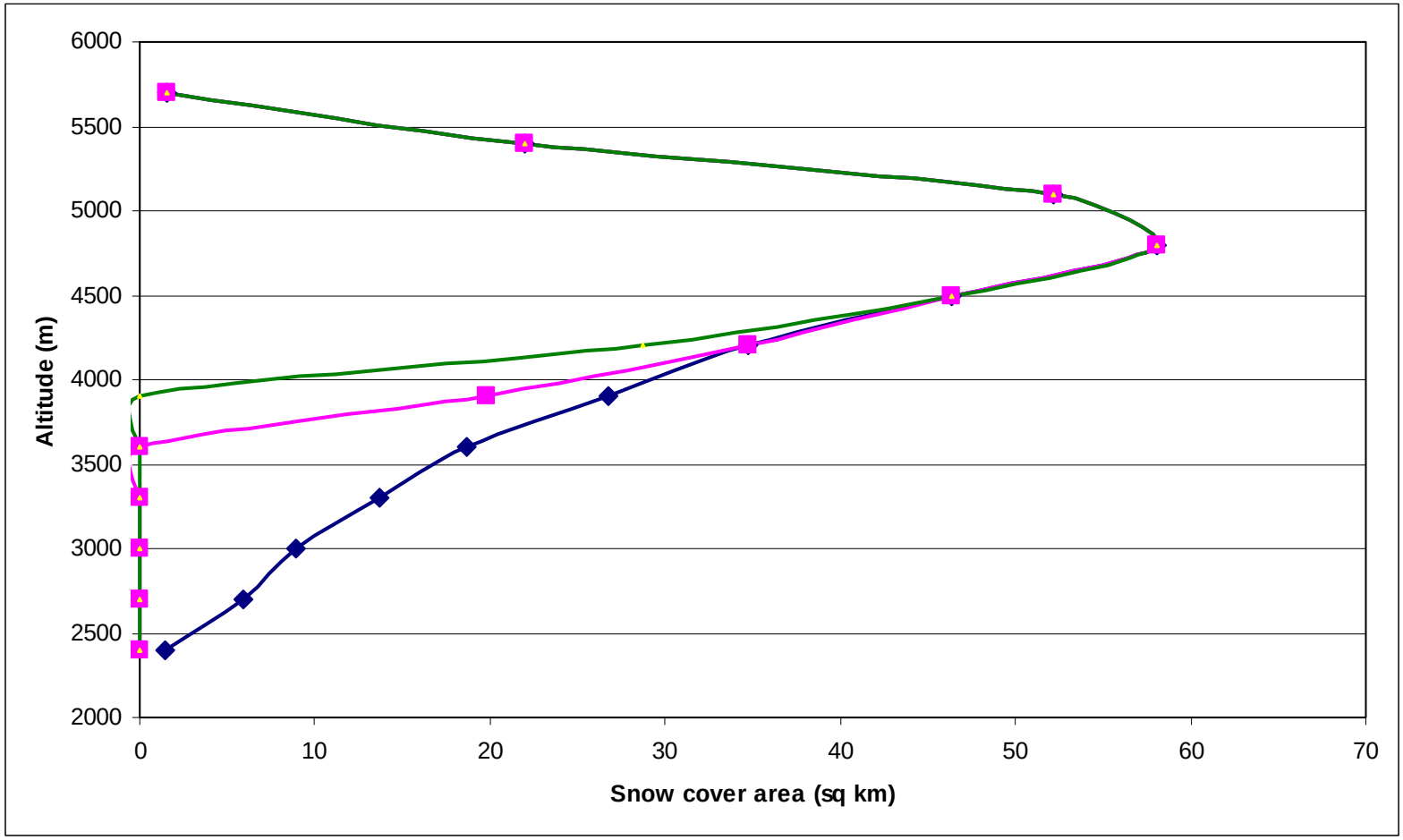

GLACIER FEATURES
lake
Snout
Lateral moraine
Tributary glacier
Ablation area
Accumulation area
Snow line
Glacier boundary
IRS LISS IV
26 Aug. 2008
Zanskar basin
(J & K)

# Validation of snow and glacier melt runoff model: Wangar Gad basin
## (Rathore and Kulkarni, Current Science, 2009)

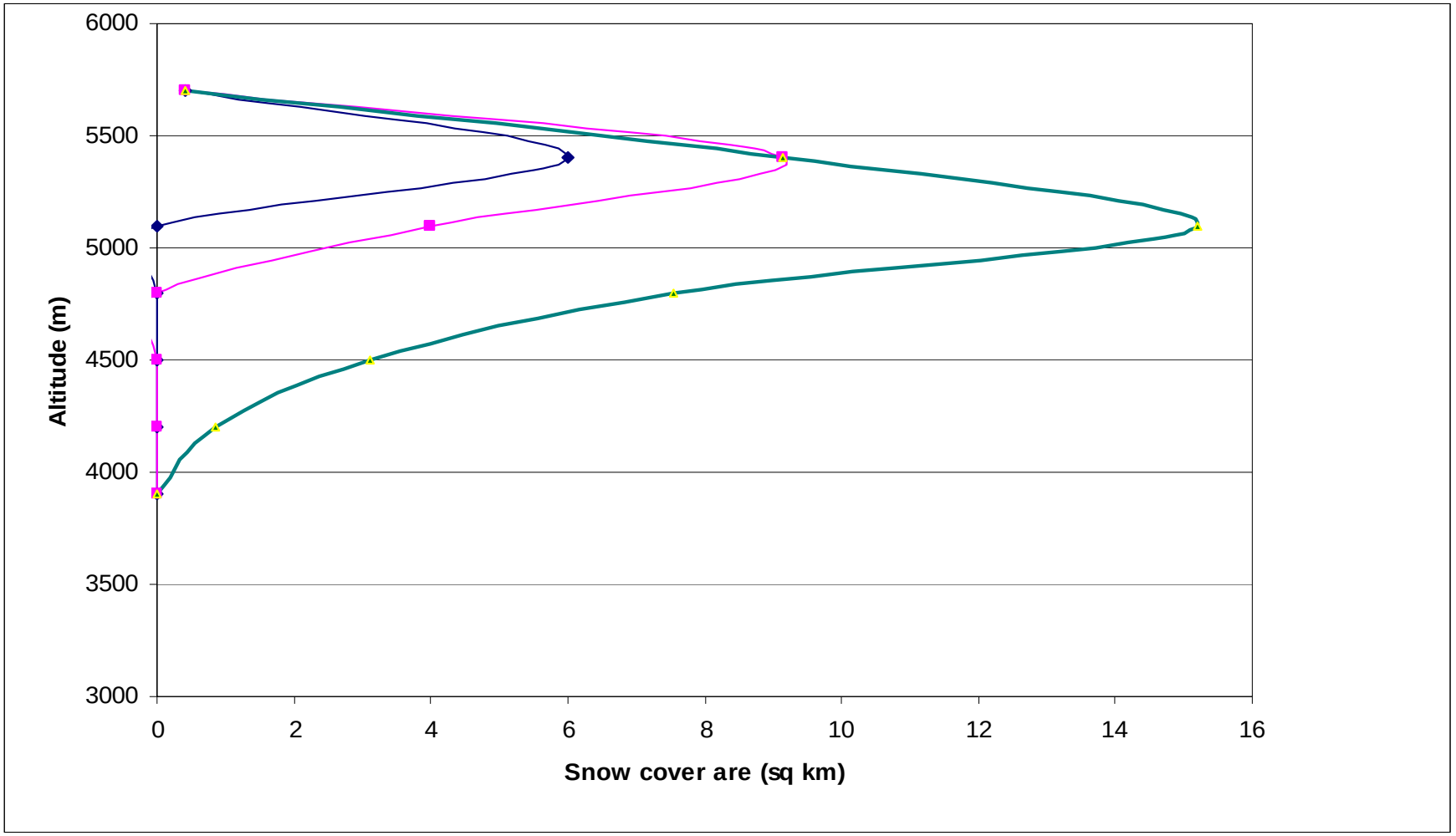


# ESTIMATION OF FUTURE CHANGES IN SNOW AND GLACIER EXTENT

# CHANGES IN SNOW COVER DUE TO RISE IN TEMP BY 1 DEG C



# CHANGES IN GLACIER AAR DUE TO RISE IN TEMP BY 1 DEG C

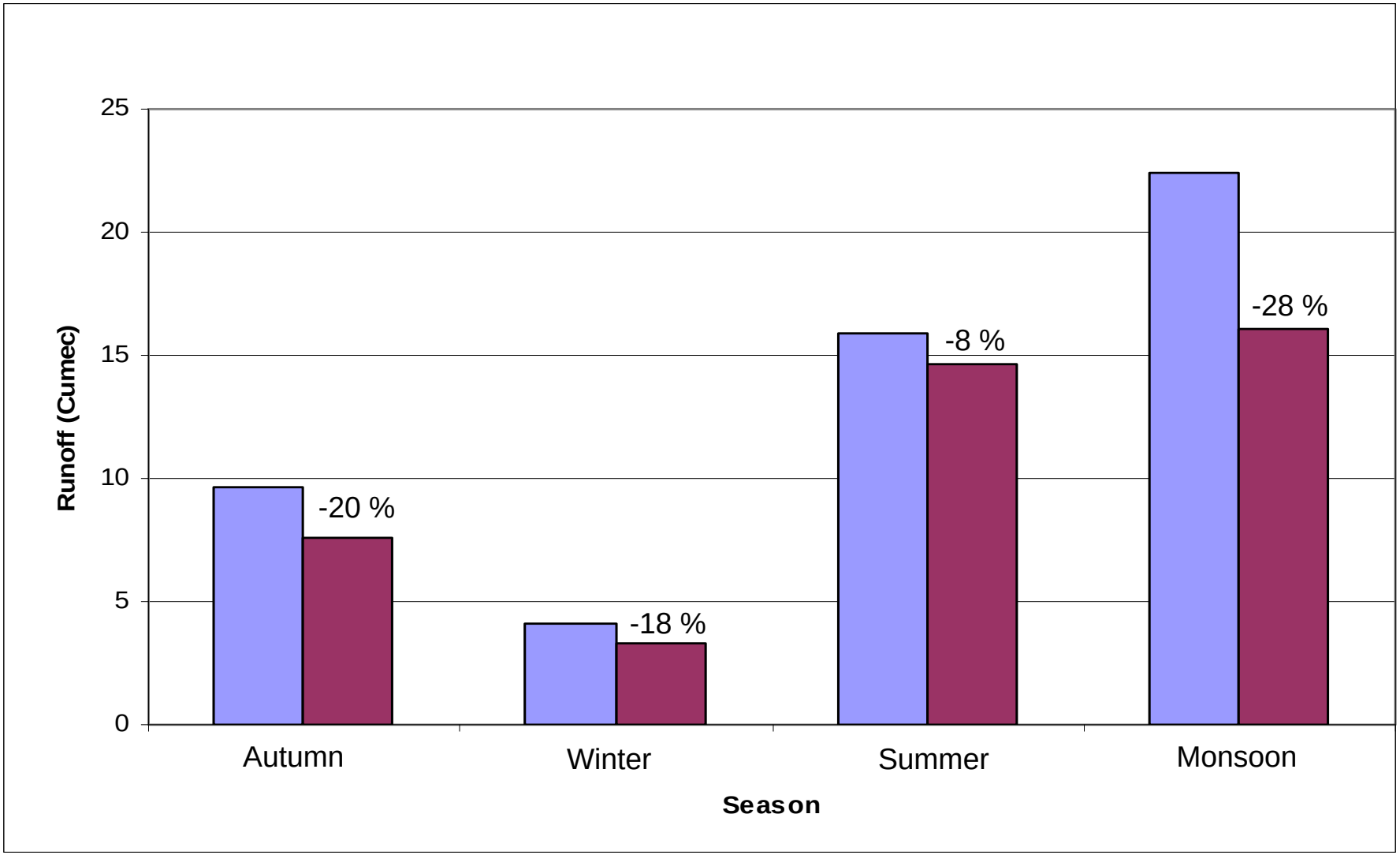



AAR WILL CHANGE FROM 0.37 TO 0.17 DUE TO 1 DEG RISE IN TEMP

# CHANGES IN INPUT PARAMETERS DUE TO RISE IN 1 DEG C TEMPERATURE

| | Winter | | Summer | | Autumn | | Monsoon | |
|---|---|---|---|---|---|---|---|---|
| | 2004 | 2040 | 2004 | 2040 | 2004 | 2040 | 2004 | 2040 |
| Snow extent (sq km) | 234 | 209 | 117 | 111 | 147 | 128 | 26 | 21 |
| Glacier extent (sq km) | 40 | 16.4 | 40 | 16.4 | 40 | 16.4 | 40 | 16.4 |
| Avg. snow line altitude (m) | 3979 | 4140 | 4419 | 4588 | 4320 | 4488 | 4610 | 4778 |
| Temp. index | 0.0026 | 0.0023 | 0.016 | 0.016 | 0.0094 | 0.0088 | 0.028 | 0.027 |

# Estimated seasonal runoff (cumecs) in Wangar Gad basin due to rise in temperature by 1oC (Rathore and Kulkarni, Current Science, 2009)



# IMPORTANT OBSERVATIONS

- Maximum reduction is observed in monsoon, even though amount of rainfall was not changed, suggesting influence of latent heat transfer due to rain on ice.

- Model suggest significant reduction in glacier area. Possibly due to lower area altitude distribution of glaciers.

- In summer, i.e. between April and June, contribution of glacier melt into runoff is not high and most of the runoff is generated from seasonal snow melt. Small reduction in snow area was observed in winter, affecting small reduction in runoff.