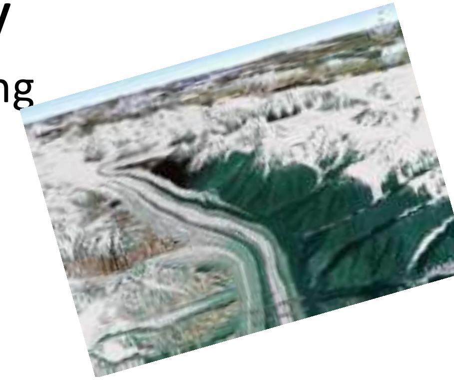
Jain University

School of Engineering & Technology

Department of Electronics & Communication Engineering

JAIN UNIVERSITY

Estd. u/s 3 of UGC Act, 1956



Presentation on

90 GHz RADIOMETER FOR MEASURING/MONITORING SNOW/ICE PROPERTIES IN HIMALAYAS

Presented By

Vasudha .MP

Jain University

International Workshop on Small Satellite and Sensor Technology for Disaster Management, IISc, Bangalore, India, 31st March – 2nd April 2014

Contents

Background

(i) Himalayas 'abode of snow' is the world's third largest region of glaciers. It includes the **Siachen Glacier and the Biafo Glacier** and 46 notable glaciers in four different states of Indian Nation.

(ii) Himalayan glaciers feed major south-asian rivers like the Indus, the Brahmaputra and the Ganges.

(iii) Since 70's, there is (a). Serious decrease in accumulation and/or mass balance (b). drastically increasing ablation of glaciers [1]

(iv) The major hazards caused by melting Himalayan glaciers are catastrophic events like – Floods, Dangerous Sea Conditions and the like.

(v) Due to (a). Inaccuracy in ground-based observations and

(b). Paucity of consistent and reliable data airborne observations is necessary

(vi) Our project **proposes to secure the most** consistent and reliable data from remote sensing method using ***airborne 90 GHz millimeter-wave radiometer with special reference to*** **glaciers in Himalaya.**

Geo-Physical Parameters

The parameters to be measured and/or monitored includes:

(A) Geographic regions: India (northeast), Pakistan, Afghanistan, China, Bhutan, Nepal and the oceans around the Indian sub-continent.

(B) Geo-Physical Parameters: Evaluation of accumulation ablation of glaciers and its variables on time scale: daily/monthly/seasonal/annual.

(C) Additional parameters:

- (i) Observing related atmospheric and climatic variations.
- (ii) Mapping of Glacier areas and relative variables after comparing with data obtained from other (EOS) and/or in situ field observations.

Project Objectives

1) Development of an airborne 90 GHz millimeter-wave radiometer for collecting data in airborne missions.
2) To provide field-testing on stationary towers.
3) Establishing stations with auxiliary sensors for providing data (in-situ data) in Himalayas.

Preliminary Functional Block Diagram

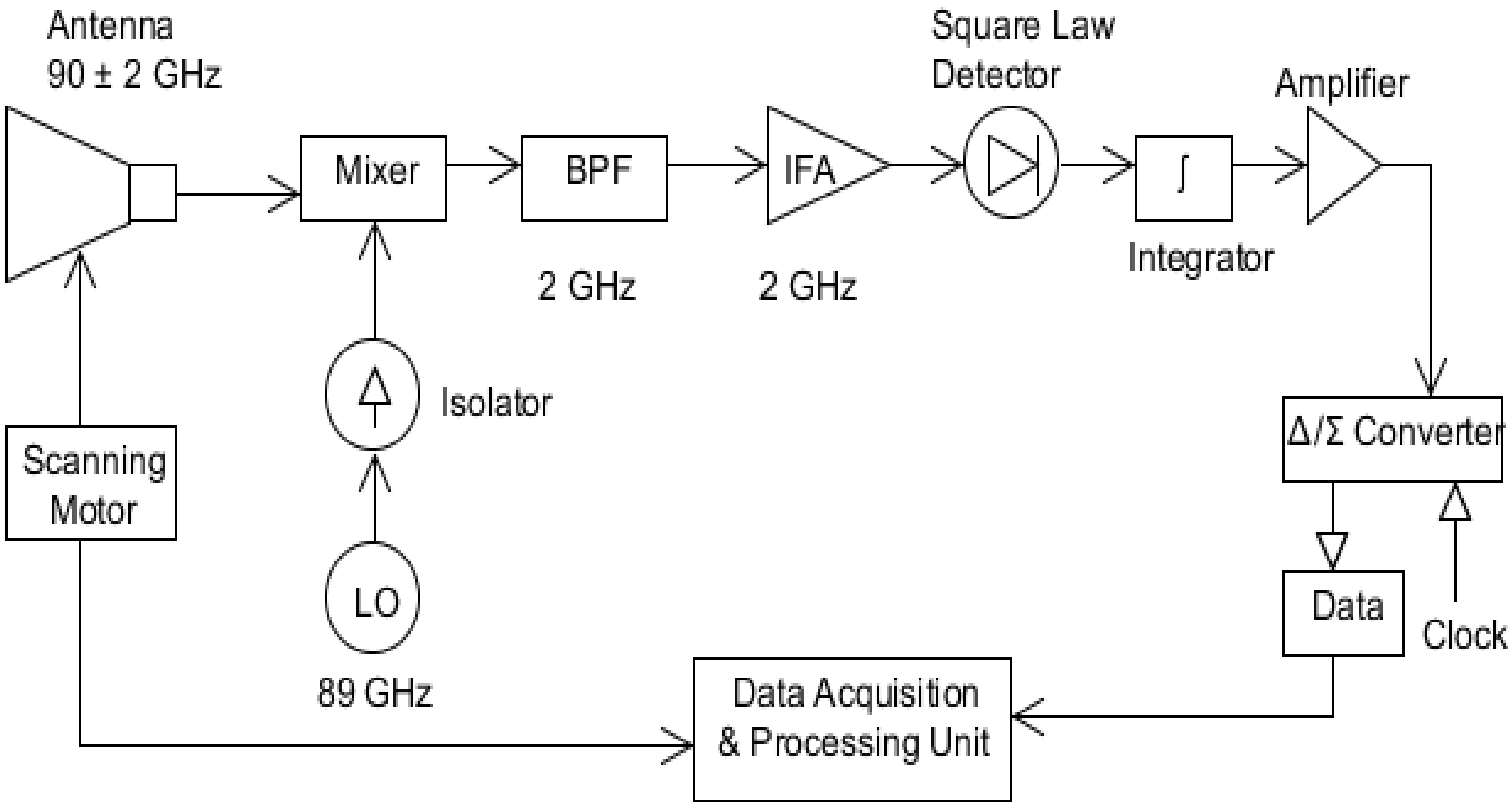


Fig:1 - 90 GHz Radiometer Preliminary Block Diagram

Sub System: Antenna

Antenna proposed to develop indigenously

- 90 GHz Horn Feed.
- Mechanical Conical Scan.
- Dual Linear Polarization (H and V)(initially performing single polarization).
- Offset Parabolic Reflector.
- 30 cm Antenna Size.
- 3 km Altitude.
- 6 km Swath Width.

Table: 1 - Variation of Footprint (FP) based on Antenna Size and Altitude

	Antenna size (d)				
	20 cm	30 cm	40 cm	50 cm	60 cm
Altitude 1 km	FP:19.8m	FP:13.2 m	FP:9.9 m	FP:7.92 m	FP:6.6 m
Altitude 2 km	FP:39.6 m	FP:26.4 m	FP:19.8 m	FP:15.84 m	FP:13.2 m
Altitude 3 km	FP:59.4 m	FP:39.6 m	FP:29.7 m	FP:23.76 m	FP:19.8 m
Altitude 4 km	FP:79.2 m	FP:52.8 m	FP:39.6 m	FP:31.68 m	FP:26.4 m
Altitude 5 km	FP:99.0 m	FP:66.0 m	FP:49.5 m	FP:39.60 m	FP:33.0 m
Altitude 6 km	FP:118.8 m	FP:79.2 m	FP:59.4 m	FP:47.52 m	FP:39.6 m
Altitude 7 km	FP:138.6 m	FP:92.4 m	FP:69.3 m	FP:55.44 m	FP:46.2 m
Altitude 8 km	FP:158.4 m	FP:105.6 m	FP:79.2 m	FP:63.36 m	FP:52.8 m

FP = Footprint
d = Antenna size and
H = Altitude

λ = 3.3mm
FP = 1.2 x H x (λ/d) m

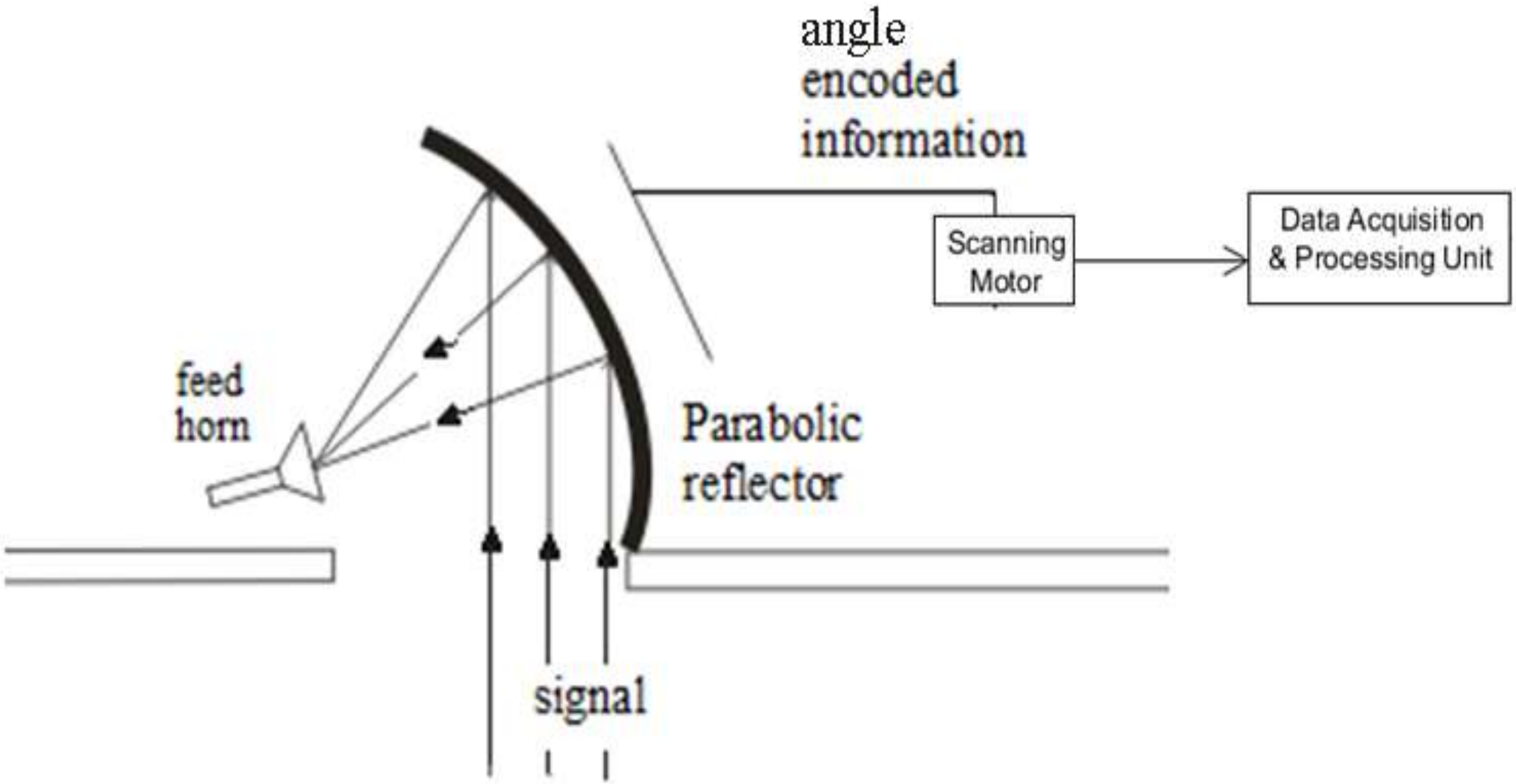


Fig:2 – Mounting System of Antenna

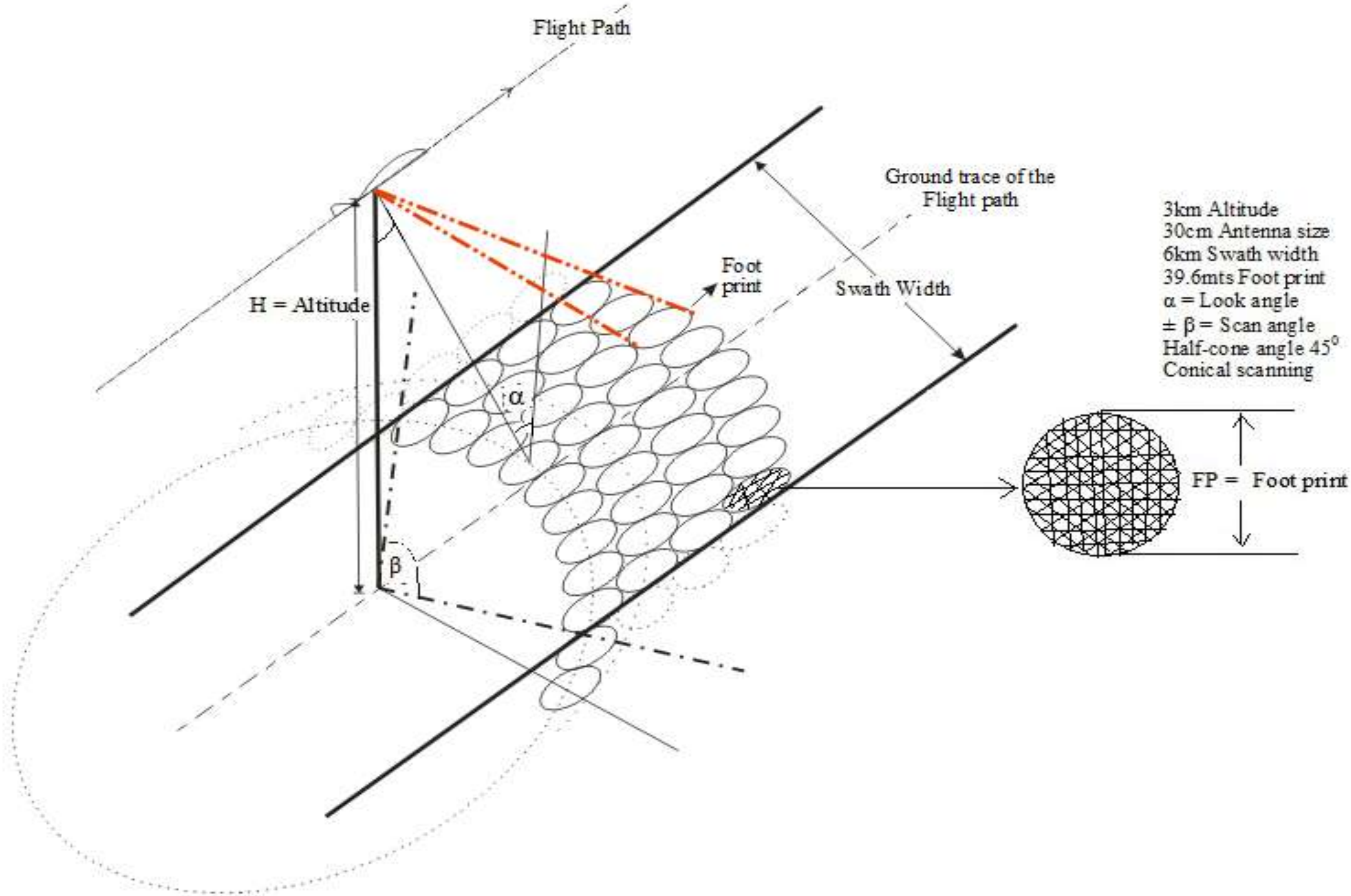


Fig:3 – Shows Conical Scanning

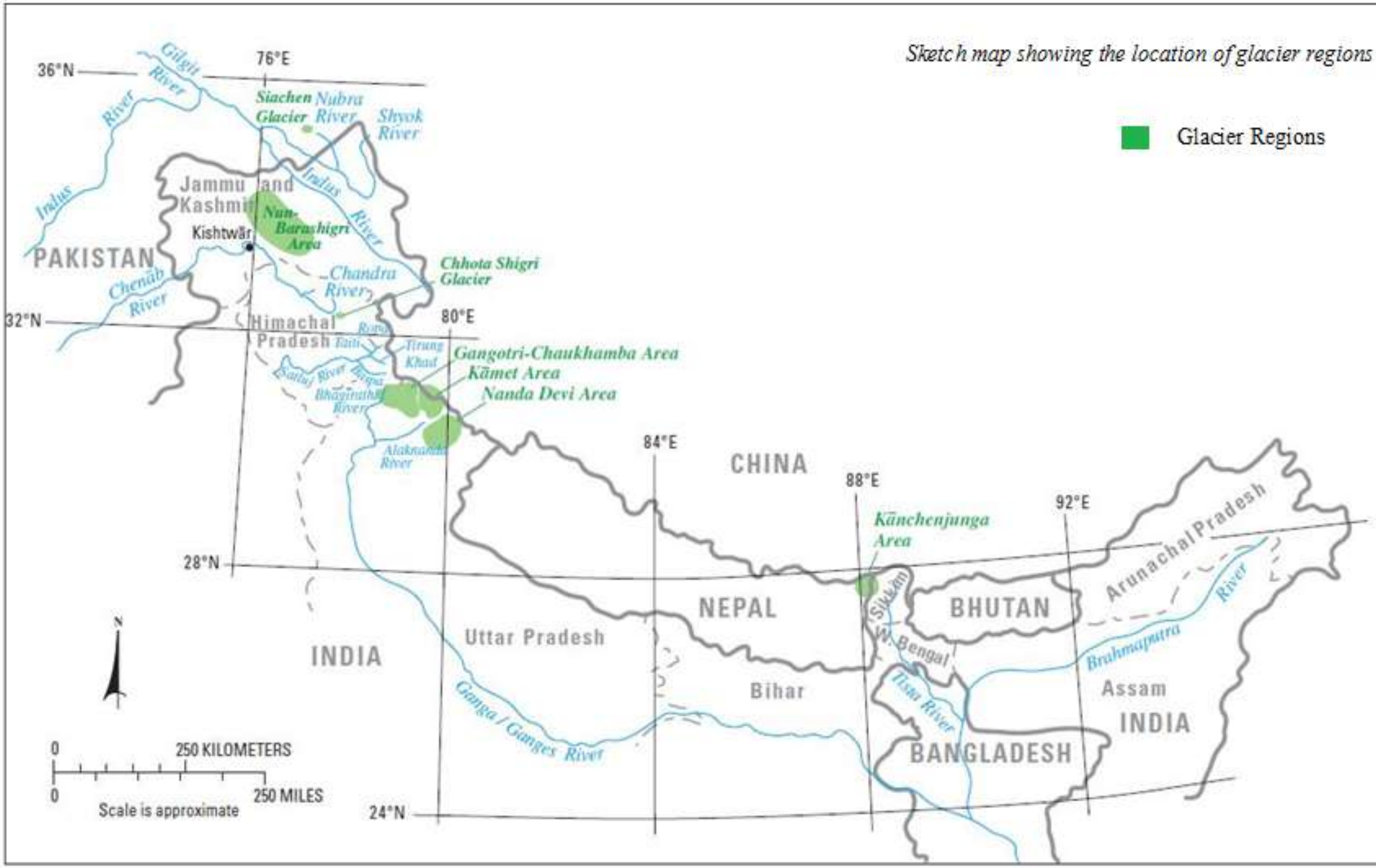


Fig: 4 - Sketch Map Showing Glacier Regions

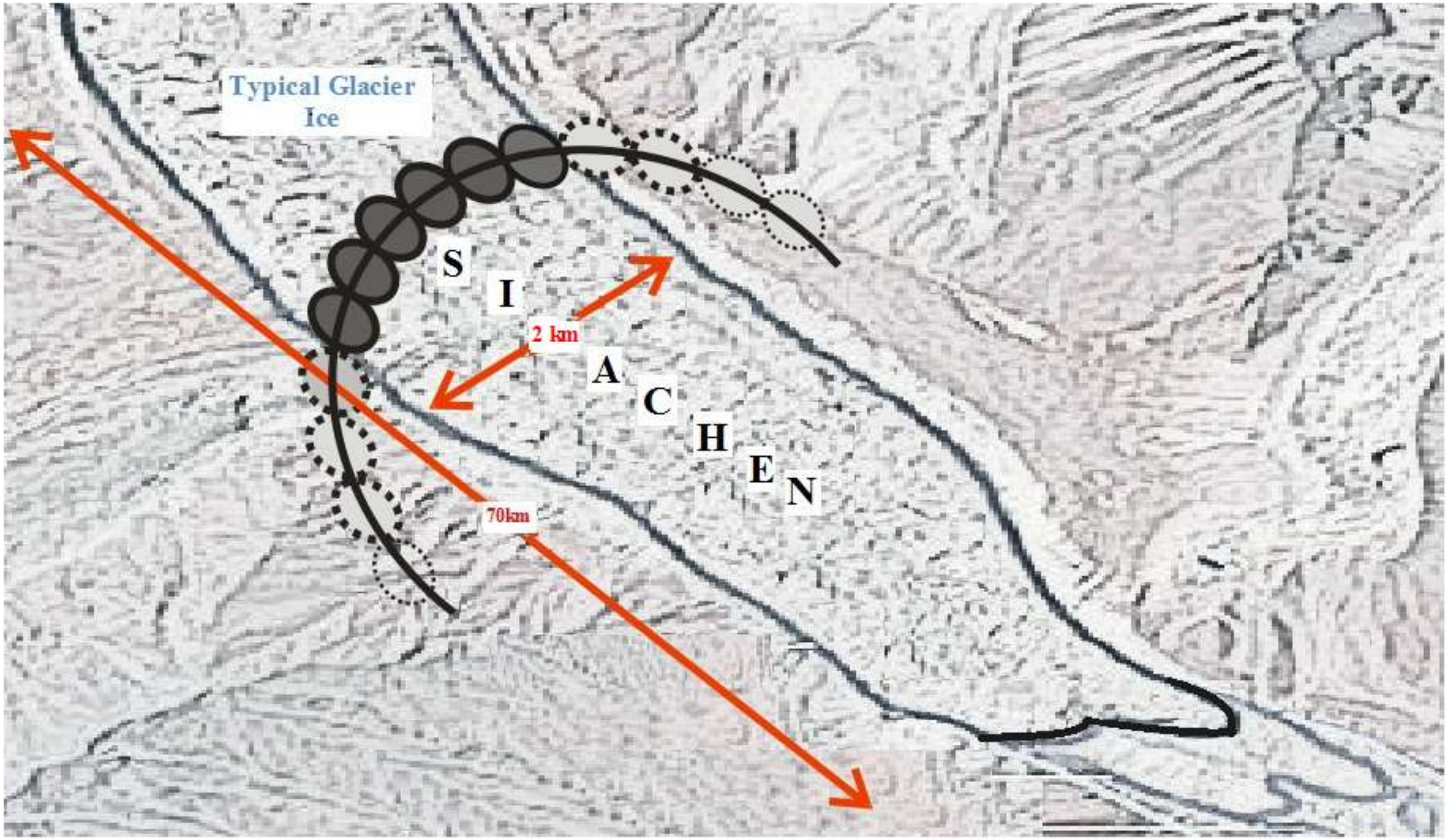
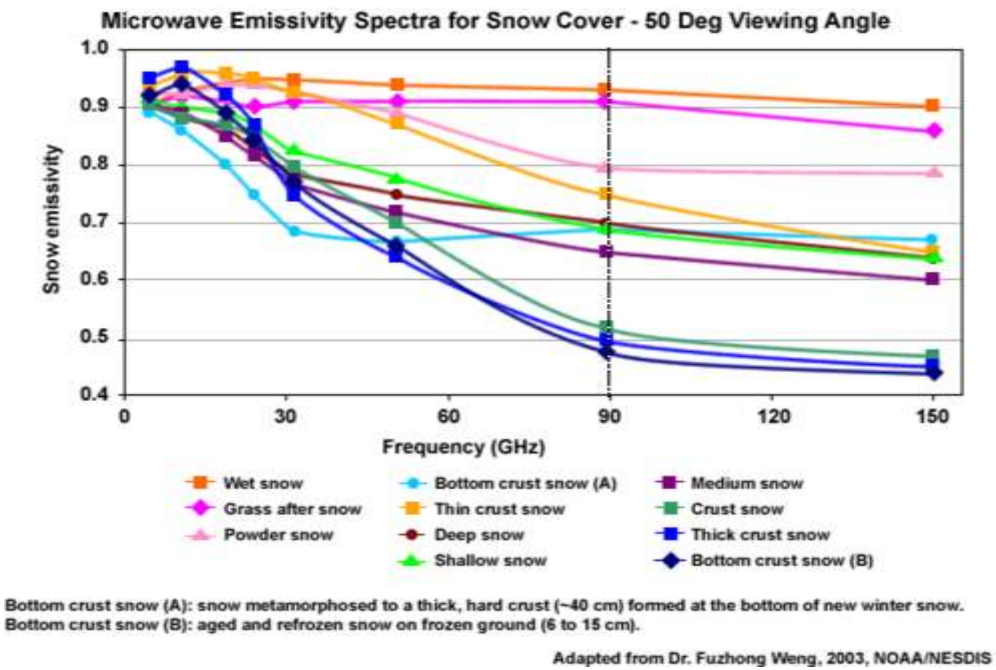
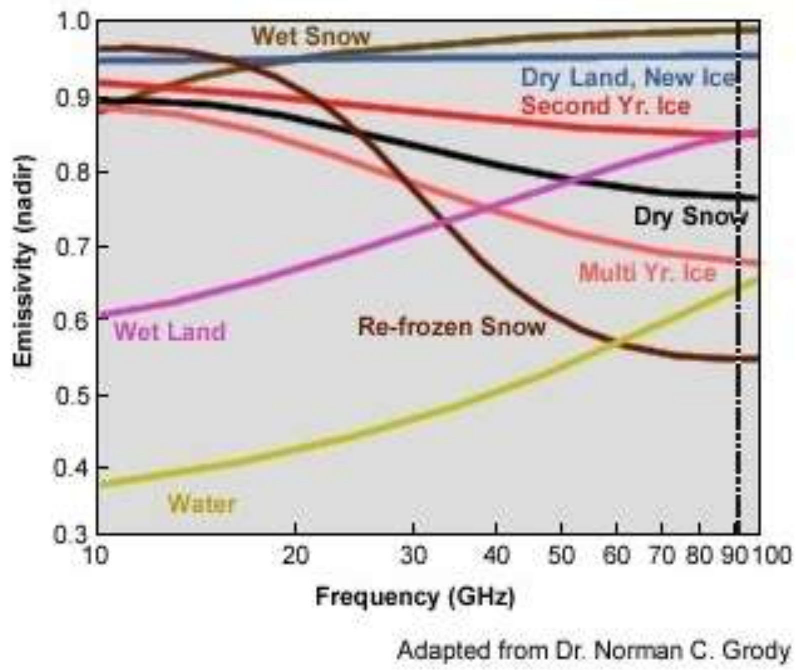


Fig: 5 – Siachen Glacier Scanning

Emissivity of Snow/Ice





Graph: 1 (a)

Graph: 1(b)

Graph:- 1(a) Shows Emissivity of Snow; 1(b) Shows Emissivity of Snow and Water

Sub Systems Cont..

1. Antenna to be developed indigenously
2. Feed system to be developed indigenously
3. Balanced mixer/pre-amplifier to be developed/procured
   - ❖ 90 GHz preamplifier, NF- 8to 10 dB to be procured
   - ❖ 90 GHz local oscillator require 10 mw power to be procured (gunn diode oscillator).
4. IF amplifier frequency 0.1 to 2 GHz, gain 25 to 30 dB min, NF <3dB to be procured.
5. A/D convertor – 12 bits, 0 to 10 vts.
6. Integrator, IF detector and data processing unit are to be developed indigenously/ procured.

Overall General Specifications of the Airborne Radiometer

- Estimated payload mass is 30 kg.
- Nominal Altitude: 3km to 8km (above ground level to be worked out after discussions with aircraft operators).
- Total Payload Power Required: 10 to 15W.
- Mechanically scanning antenna.
- Antenna Diameter: 30 – 40 cm.
- Antenna: dual linear polarization (V & H) (initially performing single polarization).
- Spatial Resolution: < 20m – 40m
- Sensitivity: less than 1 K
- Scan angle: 30 – 45 degrees
- Swath: 4 – 10 km (depends on height of flight, scan angle and antenna diameter)

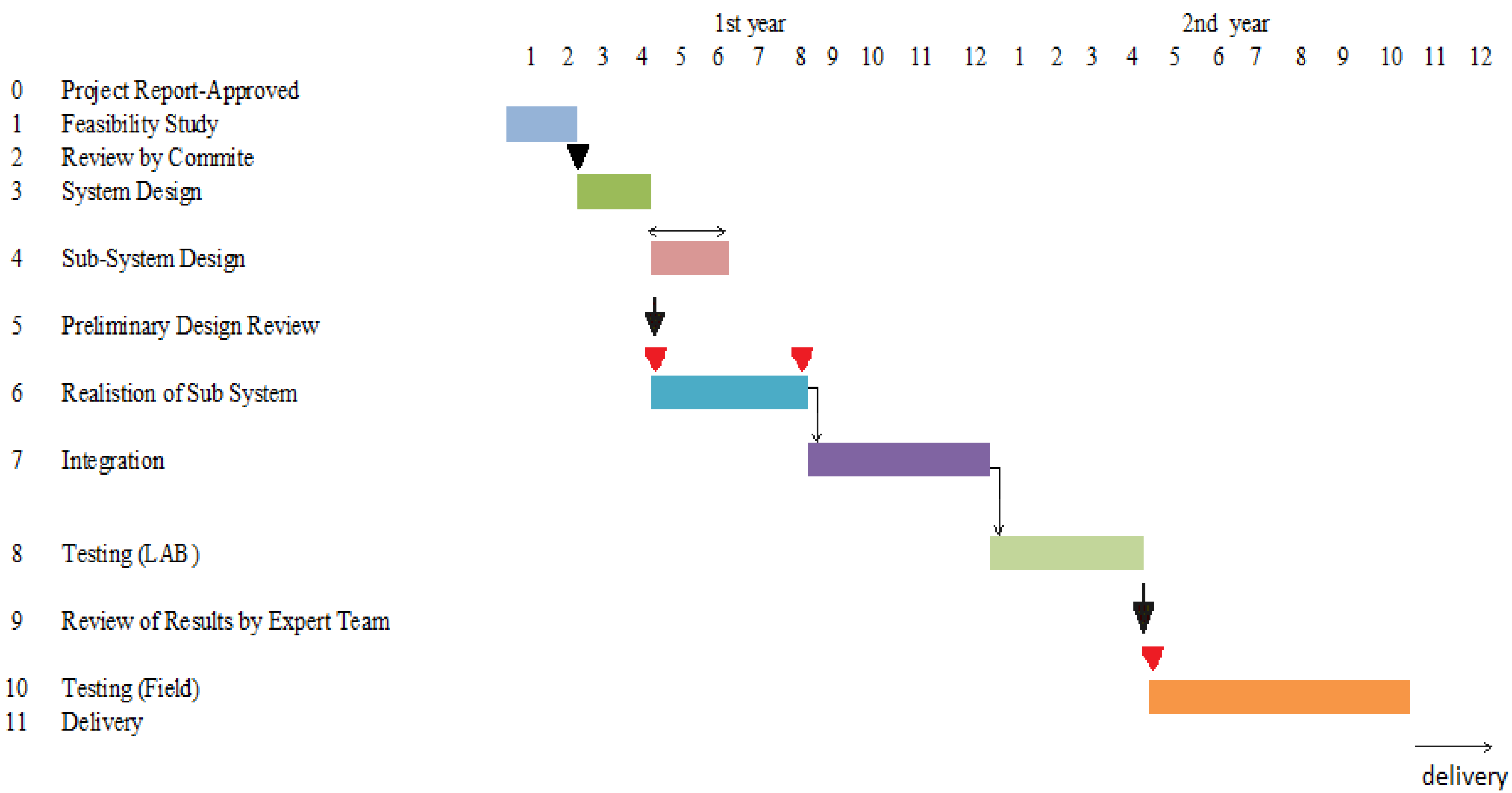
Procuring Sub-System Equipments

Present manufacturers/vendors/dealers/distributors:

1. MITEQ
2. Mini-circuits
3. Millitech (millimeter-wave technology and solutions)
4. Texas Instruments
5. Microsemi Corporation (Nasdaq: MSCC)
6. M/A-COM Technology Solutions Holdings (MACOM)

Positive response from the above in technical field is obtained, feasibility study is under discussion.

Project Time Schedule



Implementation Highlights

1) Development of radiometer:

a. Development and implementation period is estimated as: two to three years.

b. Manpower: one faculty with 4-6 students.

c. Estimated cost Rs: 50 lakhs which includes expenditure towards:

i) Mechanically Scanning Antenna

ii) RF components (front end- receiver part)

iii) IF components and recording

iv) Airborne operations

v) Auxiliary / supporting scientific sensors for ground-based measurements

Cont…

2) Project Collaboration:

- Passive millimeter wave sub-systems are procured under support by US (LMCO) collaboration.
- Fabrication of antenna and feed by local industry and Jain university.
- Scanning mechanism and low frequency components by Jain university and local industries.
- Standard lab equipment/components setup
  - a) Liquid nitrogen load at 90 GHz
  - b) Variable attenuator
  - c) Standard gain horn (for pattern measurement)
  - d) Coaxial cable, connectors, bends (L shape) etc.
  - e) Mounting and testing inside campus.
- Indigenously development of sub-systems by Jain University and/or Indian industry.
- Based on the time schedule and budget the sub- systems will be developed/procured.

Cont…

3) Proposed Collaboration Agencies:

The Jain University will collaborate for the synergistic benefits of the proposed project/s with the following agencies:

(i) Lockheed Martin Company (LMCO), USA.

(ii) Indian Institute of Science (IISc), Bangalore, India.

4) Project Management and Implementation:

Jain University, Bangalore, Karnataka State India.

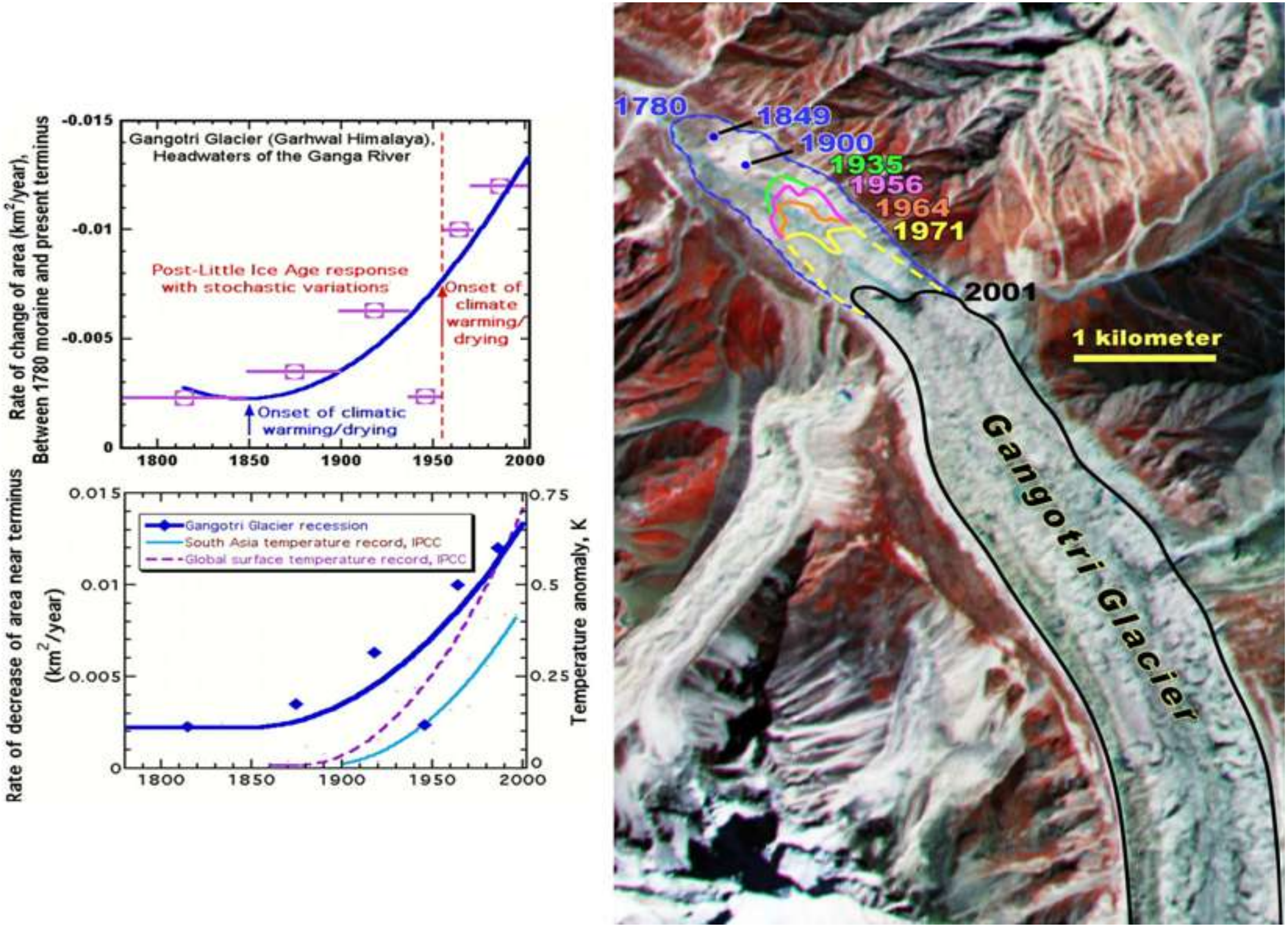


Fig: 6(a) - Gangotri Glacier retreated with 1 km width form year 1780 -2001

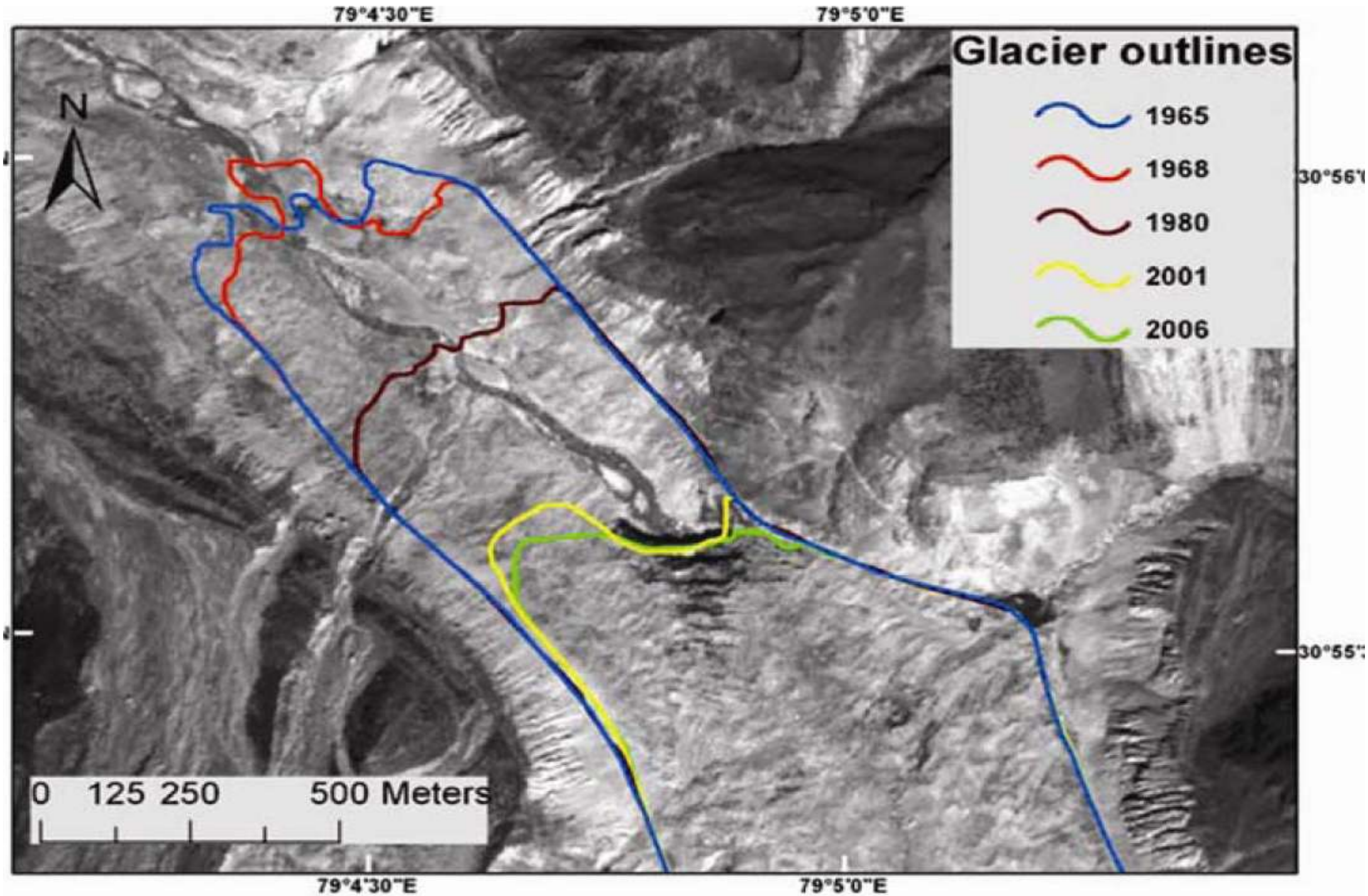


Fig:6(b) - Gangotri Glacier retreated 26.5 meters per year form 1968-2006

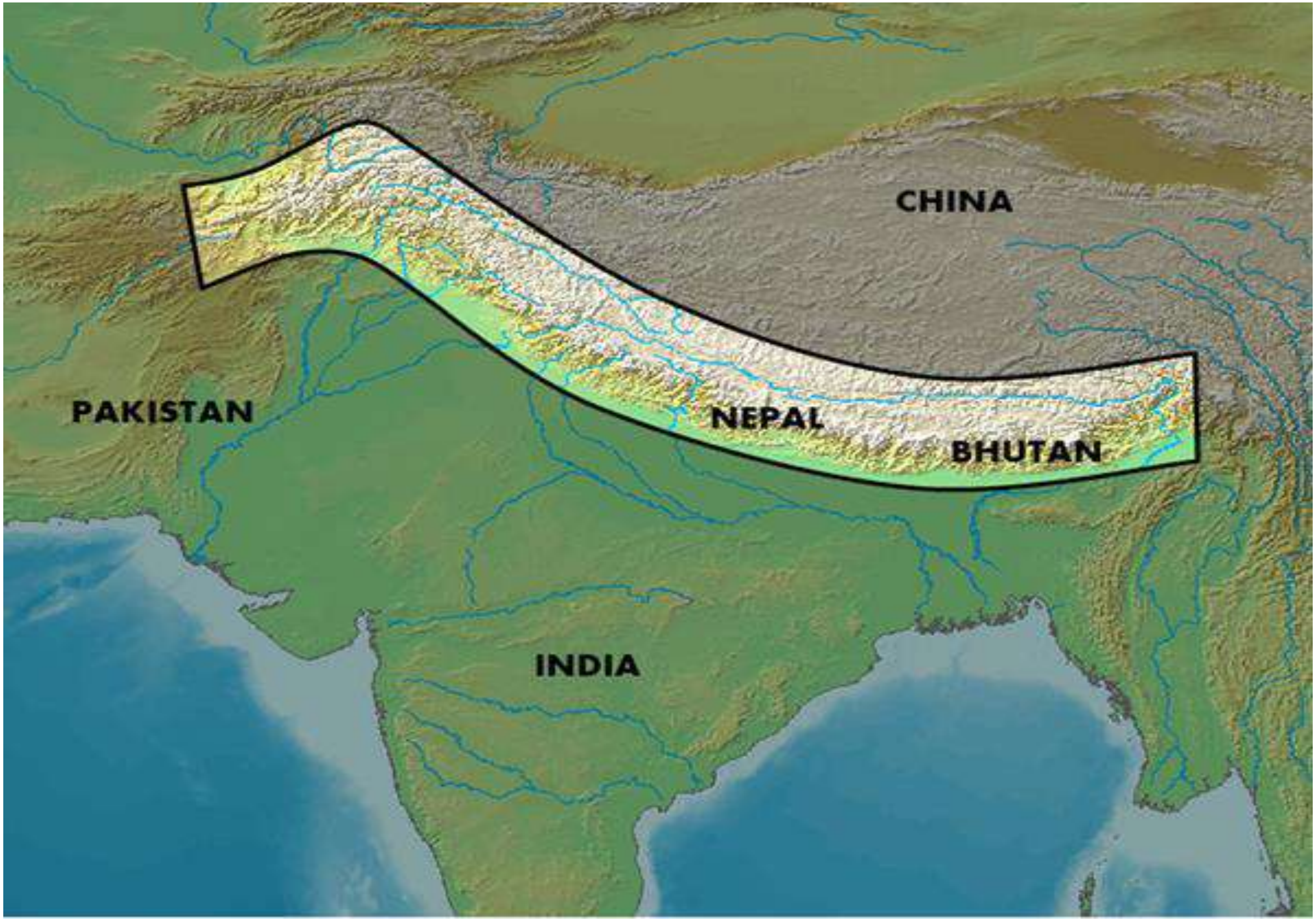


Fig:7 - Shows Glacier Region

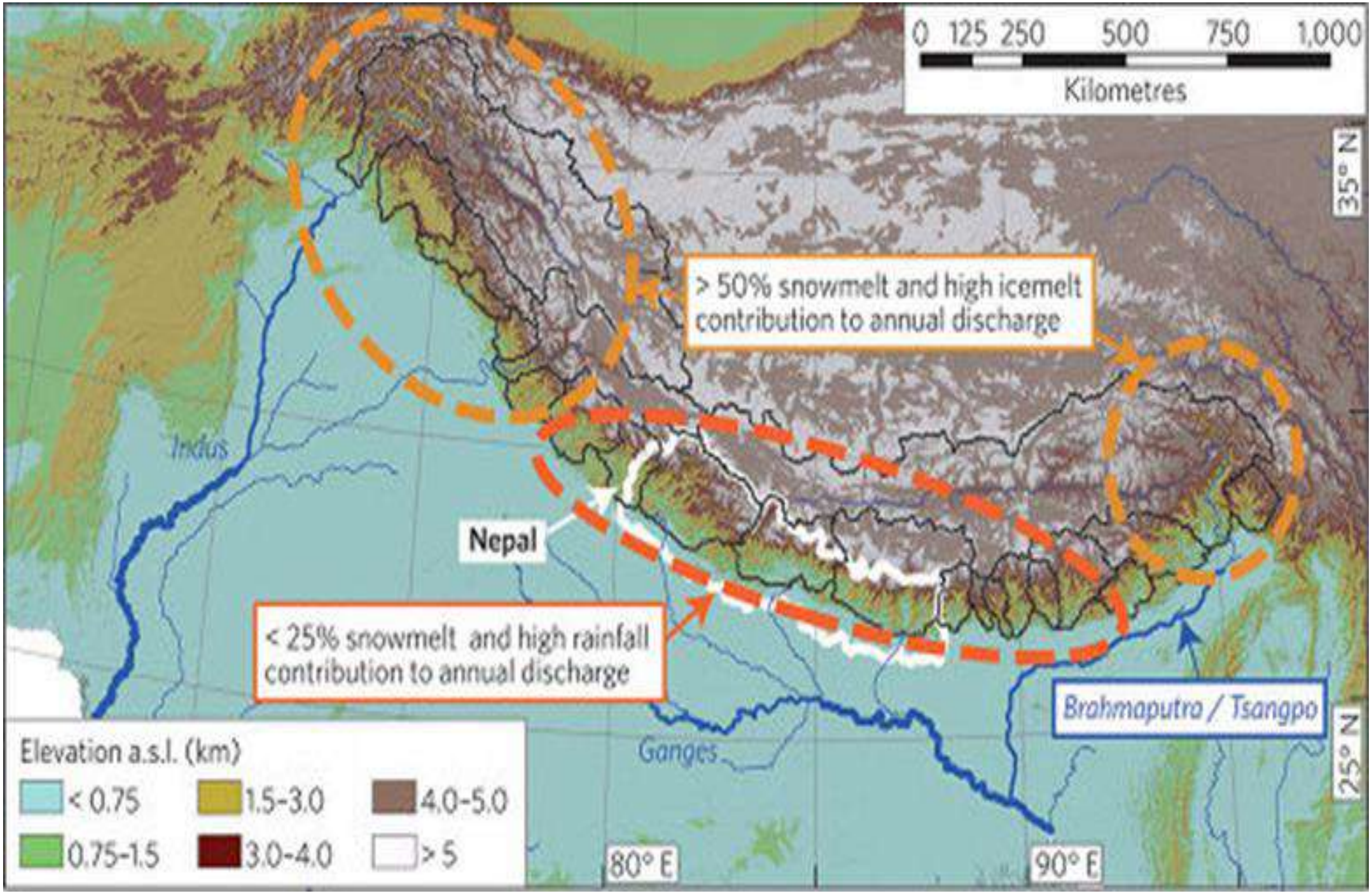


Fig:8 - Shows Glacier Properties

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[1] SR Bajracharya, PK Mool and BR Shrestha, "Global Climate Change and Melting of Himalayan Glaciers," in proceedings of ICIMOD publications, the Icfai's University Press, India; page: 28 – 46, 2008.

[2] KK Singh V.D Mishra Dhiraj Kumar Singh and A Ganju, "Estimation of Snow Surface temparature for NW Himalayan Regions using Passive microwave Satellite Data" Indian Journal of Radio and Space physics Vol:42: Page: 27-33, February 2013

[3] R.Jilani, M Haq, A Naseer, " A Study of Glaciers in North Pakistan" In Pakistan Space & Upper Atsmosphere Research Commission (SUPRCO) 2010.

[4] Richard S. Williams, Jr., and Jane G. Ferrigno, "Satellite Image Atlas Of Glaciers Of The World - GLACIERS OF INDIA," in preceding of U.S. Geological Survey Professional, PAPER 1386–F.-5, -259,2010 Page:F-159- F-191

[5] Jianchu Xu Grumbine RE, Shrestha A, Eriksson M, Yang X, Wang Y Wilkes A, "The Melting Himalayas: Cascading Effects of Climate Change on Water, Biodiversity, and Livelihoods" Conservation Biology Volume 23, No. 3, 2009

Table 1:- Variation of sensitivity at

NF = 6 dB T_A= 300 K T_N= 900 K

B= Bandwidth τ = Integration time

$$\text{Sensitivity} = \Delta T = \frac{T_A + T_N}{\sqrt{B\tau}} k$$

Sl. No	Integration time τ (msec)	At B = 500MHz ΔT is (k)	At B = 1000MHz ΔT is (k)	At B = 1.5GHz ΔT is (k)	At B = 2GHz ΔT is (k)
1	10ms	0.536 K	0.379 K	0.309 K	0.268 K
2	20ms	0.379 K	0.268 K	0.219 K	0.189 K
3	30ms	0.309 K	0.219 K	0.178 K	0.155 K
4	40ms	0.268 K	0.189 K	0.155 K	0.134 K
5	50ms	0.240 K	0.169 K	0.138 K	0.120 K
6	60ms	0.219 K	0.155 K	0.126 K	0.109 K
7	70ms	0.202 K	0.143 K	0.117 K	0.101 K
8	80ms	0.189 K	0.134 K	0.109 K	0.095 K
9	90ms	0.178 K	0.126 K	0.103 K	0.089 K
10	100ms	0.169 K	0.120 K	0.098 K	0.085 K
11	200ms	0.120 K	0.084 K	0.069 K	0.060 K
12	300ms	0.098 K	0.069 K	0.056 K	0.049 K
13	400ms	0.085 K	0.060 K	0.048 K	0.042 K
14	500ms	0.076 K	0.054 K	0.043 K	0.038 K
15	600ms	0.069 K	0.049 K	0.040 K	0.034 K
16	700ms	0.064 K	0.045 K	0.037 K	0.032 K
17	800ms	0.060 K	0.042 K	0.034 K	0.030 K
18	900ms	0.056 K	0.040 K	0.032 K	0.028 K
19	1000ms	0.054 K	0.038 K	0.030 K	0.027 K

Table 2:- Variation of sensitivity at

$NF = 9$ dB $T_A = 300$ K $T_N = 2100$ K

B= Bandwidth τ = Integration time

$$\text{Sensitivity} = \Delta T = \frac{T_A + T_N}{\sqrt{B\tau}} k$$

Sl. No	Integration time τ (msec)	At B = 500MHz ΔT is (k)	At B = 1000MHz ΔT is (k)	At B = 1.5GHz ΔT is (k)	At B = 2GHz ΔT is (k)
1	10ms	1.073K	0.759 K	0.619 K	0.536 K
2	20ms	0.759 K	0.536 K	0.438 K	0.380 K
3	30ms	0.619 K	0.438 K	0.357 K	0.309 K
4	40ms	0.536 K	0.379 K	0.309 K	0.268 K
5	50ms	0.480 K	0.339 K	0.277 K	0.240 K
6	60ms	0.438 K	0.309 K	0.253 K	0.220 K
7	70ms	0.405 K	0.286 K	0.234 K	0.202 K
8	80ms	0.379 K	0.268 K	0.220 K	0.190 K
9	90ms	0.357 K	0.253 K	0.206 K	0.178 K
10	100ms	0.339 K	0.240 K	0.196 K	0.169 K
11	200ms	0.240 K	0.169 K	0.138 K	0.120 K
12	300ms	0.196 K	0.138 K	0.113 K	0.098 K
13	400ms	0.169 K	0.120 K	0.098 K	0.084 K
14	500ms	0.151 K	0.107 K	0.087 K	0.075 K
15	600ms	0.138 K	0.098 K	0.080 K	0.069 K
16	700ms	0.128 K	0.090 K	0.074 K	0.064 K
17	800ms	0.120 K	0.084 K	0.069 K	0.060 K
18	900ms	0.113 K	0.080 K	0.065 K	0.056 K
19	1000ms	0.107 K	0.075 K	0.062 K	0.053 K

Table 3:- Variation of sensitivity at

NF = 12 dB T_A= 300 K T_N= 4500 K

B= Bandwidth τ = Integration time

$$\text{Sensitivity} = \Delta T = \frac{T_A + T_N}{\sqrt{B\tau}} k$$

Sl. No	Integration time τ (msec)	At B = 500MHz ΔT is (k)	At B = 1000MHz ΔT is (k)	At B = 1.5GHz ΔT is (k)	At B = 2GHz ΔT is (k)
1	10ms	2.146 K	1.518 K	1.239 K	1.073 K
2	20ms	1.158 K	1.073 K	0.876 K	0.759 K
3	30ms	1.240 K	0.876 K	0.715 K	0.619 K
4	40ms	1.073 K	0.759 K	0.619 K	0.536 K
5	50ms	0.960 K	0.678 K	0.554 K	0.480 K
6	60ms	0.876 K	0.619 K	0.506 K	0.438 K
7	70ms	0.811 K	0.573 K	0.468 K	0.405 K
8	80ms	0.759 K	0.536 K	0.438 K	0.379 K
9	90ms	0.715 K	0.506 K	0.413 K	0.357 K
10	100ms	0.678 K	0.480 K	0.392 K	0.339 K
11	200ms	0.480 K	0.339 K	0.277 K	0.240 K
12	300ms	0.392 K	0.277 K	0.226 K	0.196 K
13	400ms	0.339 K	0.240 K	0.196 K	0.169 K
14	500ms	0.303 K	0.214 K	0.175 K	0.151 K
15	600ms	0.277 K	0.196 K	0.160 K	0.138 K
16	700ms	0.256 K	0.181 K	0.148 K	0.128 K
17	800ms	0.240 K	0.169 K	0.138 K	0.120 K
18	900ms	0.226 K	0.160 K	0.130 K	0.113 K
19	1000ms	0.214 K	0.151 K	0.124 K	0.107 K

Table 4:-

Altitude = H; Scan angle = 45 degree; Swath width = SW;

Altitude (H)	Swath width (SW)
1 km	2 km
2 km	4 km
3 km	6 km
4 km	8 km
5 km	10 km
6 km	12 km
7 km	14 km
8 km	16 km

Table 5:-

Beam width Ψ; Number of Footprints = FP_N

Antenna size (D)	Beam width Ψ (degrees)	FP_N
20 cm	1.155	311.6 ≅ 312
30 cm	0.770	467.5 ≅ 468
40 cm	0.5775	623.3 ≅ 623
50 cm	0.462	779.2 ≅ 779
60 cm	0.385	935.06 ≅ 935

Table 6:- Emissivity at 50^0 for Multiyear Ice:

	37 GHz (H)	37 GHz (V)	90 GHz (H)	90 GHz (V)
AIMR	0.90	0.93	0.73	0.76
Carsey (dry)	0.706	0.764	0.650	0.680

Table 7:- Emissivity at 50^0 for Summer Melt Conditions:

	37 GHz (H)	37 GHz (V)	90 GHz (H)	90 GHz (V)
AIMR	0.92	0.96	0.89	0.93
Carsey (summer melt)	0.93	0.97	0.92	0.95

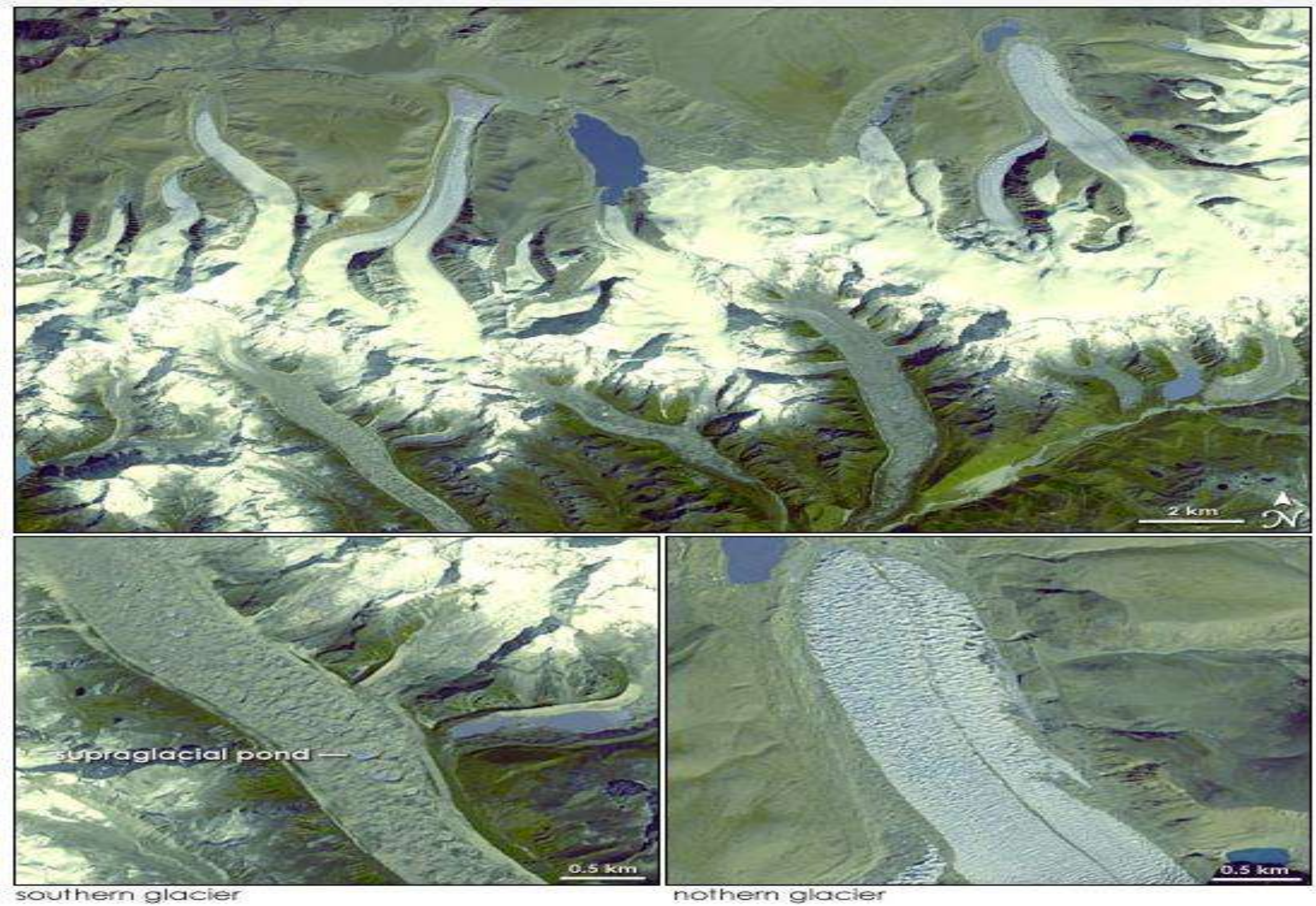

Fig:9 – Surface Features of Glaciers of Bhutan /Himalayas

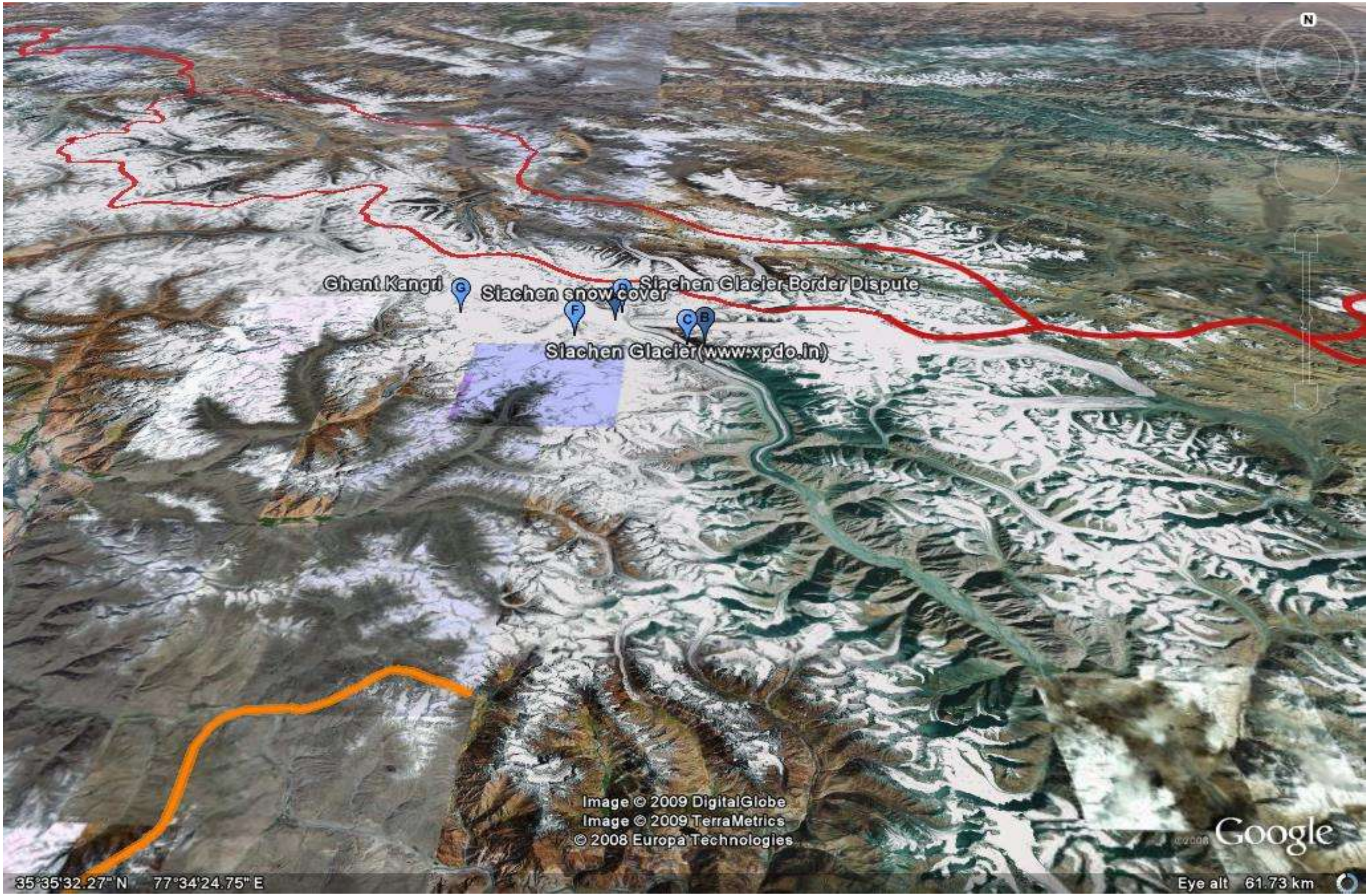

Fig: 10 - Siachen Glacier is located in the eastern Karakoram range in the Himalaya Mountains at about 35°25′16″N 77°06′34″E / 35.421226°N 77.109540°E

Fig:11 - Image showing valley glaciers in the Karakorum Shan (Range) along the border of western China (P.R.C.), India, and Pakistan, on 18 Jul 1978

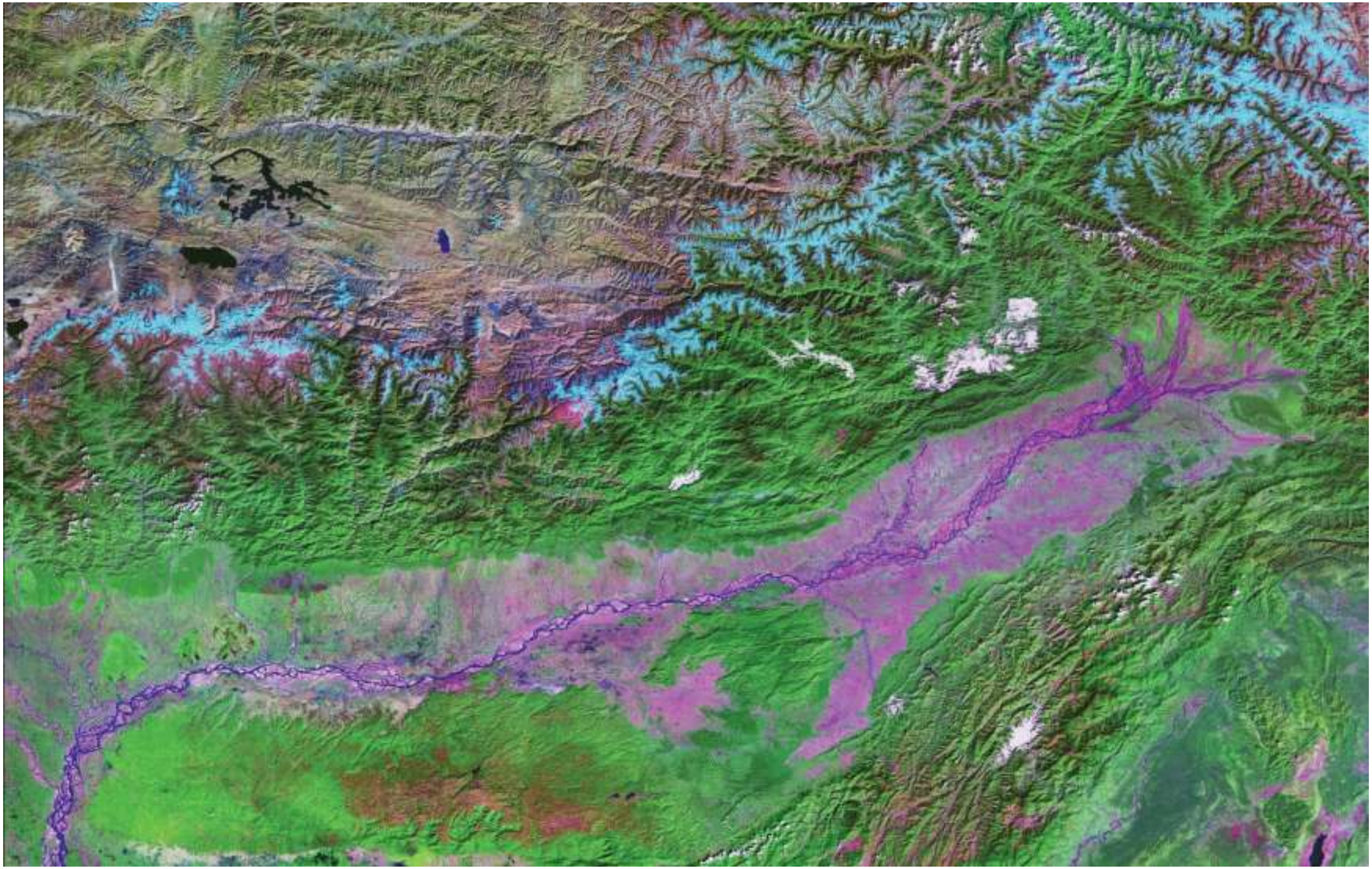

Fig:12 - image showing glaciers of the Himalaya Mountain Range (light blue)

THANK YOU