

Observing Himalayan and Polar cryosphere through Indian satellites Ishmohan Bahuguna Scientist G & Head Cryosphere Sciences Division Space Applications Centre, ISRO, Ahmedabad-15



Cryosphere Sciences Division, GHCAG / EPSA Space Applications Centre Presentation on 30 November 2017 IN SaGHAA 2017





Snow Cover Monitoring







Snow Cover Monitoring







Glacer Inventory and Himalayan Glacier Information System (HGIS)





(Sharma et al., 2013, Nat. Acad. Sci. Lett., 497-505; Sharma et al., 2015, SAC, Tech. Rep.)



Monitoring Glacier Retreat/Advance







Glacier loss of 2.47 km² (0.15%) observed in **19 out of 196 Himalayan glaciers between** 2001 and 2016.

There is no significant retreat of debris free glaciers (approx. 0.75 % loss in area for 50 debris free glaciers) between 2001 and 2016.







SOG

Monitoring Glacier Retreat/Advance











spatial and temporal analysis of glacier facies mapped from RISAT-1, proposed RISAT-1 A and NISAR L & S band SAR data for glaciers of Indus, Ganga and Brahmaputra basins.



Energy balance modelling on snow & glaciers

Objective: To develop technique for estimating snow and ice melt based on energy balance modelling with validation in Chandra basin

$$\mathbf{Q}_{\mathrm{m}} = \mathbf{Q}_{\mathrm{n}} + \mathbf{Q}_{\mathrm{h}} + \mathbf{Q}_{\mathrm{l}}$$

Where Q_m is the energy available for melting of the snowpack; Q_n is the net radiations; Q_h is the sensible heat; Q_l is the latent heat of evaporation, condensation or sublimation.





Precipitation (10-daily) (p)

Elevation of meteorological station

✓ Rainfall

✓ snowfall

Melt factor (a)

□ Reflectance

Snow and glacier melt runoff modeling

- □ Runoff coefficients of snow and rainwater (c)
 - □ 10-Daily Discharge (For validation) (Q)
 - □ NDSI of each cell
 - Elevation of each cell
 - Density of snow
 - Basin area
 - Density of water
 - Recession coefficient (K)
 - Previous day's discharge (10-daily) (Qlast)
 - DEM (Digital Elevation Model) (Aster)



$Q = {C1 {a (T^*G)} + C2 (P^*B) + C3 {(a(T^*S))} 10000/86400} (1-K)+Qlast^*K$



- > A distributed (grid based) snow melt runoff model was developed using snow cover data from year 2004 to 2011.
- > Simulated discharge matched well with observed discharge. The coefficient of determinations (0.91 and 0.92 respectively), for Tosh watershed and Parbati subbasin respectively.

Satellite Data Based Extraction of ice velocity of Himalayan glaciers





79°0'0"E 79°10'0"E





Monitoring of glacial lakes

Mapping and monitoring of glacial and peri-glacial lakes in Indian Himalayan region and develop a model for GLOF hazard based on vulnerability Index.





Penetration in dry snow using RISAT-1 SAR data







- Detection of glacier lake buried under dry snow in winters using RISAT-1 SAR data
- Example: Samudra Tapu moraine dammed lake (H.P.)
- Penetration up to ~2 m (Singh et al., 2015, Current Science)

Monitoring of polar cryosphere using Scatterometer data



Monitoring of polar cryosphere using AltiKa Altimeter data



Surface Elevation derived using AltiKa data





Sea Ice Freeboard & thickness from AltiKa



Monitoring of polar cryosphere using SAR data

RISAT-1 mosaic (from 310 CRS data)



Monitoring of ice calving event using time series of SAR (Sentinel) data Larsen-C Calving and Iceberg Deformation



Ice Calving
Ice bergs

Wind effects on icebergs
Image: Calving of the second second

Polarimetric Analysis of FRS-1 data



Glacier Ice Velocity

200 400 600 800 1000 1200 1400 1600 1800 200



Advancement of Ice shelves around MAITRI using RISAT data

Investigations of Indian monsoon teleconnection with the polar environment processes



Data Used:

Monthly Air Temp. & Sea ice concentration data (1979-2016): NCEP/NCAR Reanalysis-II, Gaussian grid ~1.9 degree;

Monthly Precipitation at 2.5 degree grid: CMAP merged analysis (1979-2016)

Analysis:

- Normalised anomaly computed from the time-series of monthly data
- Average precipitation anomaly over Indian region correlated with the global gridded parameters with time lags from -12 to +12
- Similarly auto-correlation for Air-temperatures was also computed with time lags
- Gridded layers of Significance level and correlation coefficients generated for all lags **Findings:**

Sea ice concentration around Antarctic is having impact during time lags of -10 to -7; whereas that during -4 to -2 in Arctic has statistically significant correlation over that Indian precipitation.



Monitoring Polar Cryosphere



RAPID DYNAMICS OF PINE ISLAND GLACIER, WEST ANTARCTICA AND RECENT CALVING ON 25-SEP-2017









Satellite Data Based Sea Ice Studies at SAC







DGPS and Aethalometer measurements over the ablation zone of the Chhota Shigri glacier, H.P.



Sr. no.	Name of glacier	Sub-basin/Basin Glacier valley	State	Year
1	Machoi	Drass	Jammu & Kashmir	2011, 2012, 2013, 2014
2	Hoksar	Jhelum	Jammu & Kashmir	2013, 2014
3	Thajewas	Jhelum	Jammu & Kashmir	2013, 2014
4	Pensilgumpa	Zanskar	Jammu & Kashmir	2013
5	Kolahoi	Liddar	Jammu & Kashmir	2013, 2014
6	Shishram	Liddar	Jammu & Kashmir	2013, 2014
7	Chhota Shigri	Chandra	Himachal Pradesh	2011, 2012, 2013, 2014
8	Batal	Chandra	Himachal Pradesh	2013
9	Patsio	Bhaga	Himachal Pradesh	2013, 2014
10	Miyar	Miyar	Himachal Pradesh	2012, 2013
11	Menthosa	Miyar	Himachal Pradesh	2011, 2012, 2013
12	Gepang-gath	Bhaga	Himachal Pradesh	2012
13	Satopanth	Alaknanda	Uttarakhand	2011, 2012, 2014
14	Bhagirath Kharak	Alaknanda	Uttarakhand	2011, 2012, 2014
15	Chipa near Baling village	Dhauliganga	Uttarakhand	2014
16	Meola	Dhauliganga	Uttarakhand	2012
17	Lapang	Dhauliganga	Uttarakhand	2012
18	Milam	Goriganga	Uttarakhand	2012
19	Jyoling	Dhauliganga	Uttarakhand	2012
20	Naglaphu	Dhauliganga	Uttarakhand	2012
21	Lapa	Dhauliganga	Uttarakhand	2012
22	Changme Khanku	Tista	Sikkim	2012, 2013



In-situ Data Collection in Himalayan Glaciated Regions





CAP: Collaborating agencies

	Ongoing collaboration		Additional from 2018 onwards
1	G. B. Pant Institute of Himalayan Environment & Development, Almorah	14	Snow and Avalanche Studies Establishment, Chandigarh
2	Himachal Pradesh Council of Science, Technology & Environment, Shimla	15	Wadia Institute of Himalayan Geology, Dehradun
3	National Institute of Hydrology, Roorkee	16	HNB Garhwal University, Srinagar
4	Uttarakhand Space Applications Centre, Dehradun	17	Remote Sensing Applications Centre – Uttar Pradesh (RSAC-UP), Lucknow
5	Arunachal Pradesh Science and Technology	18	Indian Institute of Technology- Bombay
6	SES, JNU Delhi	19	Geological Survey of India, Lucknow
7	CSRD, JNU, Delhi	20	Institute of Mathematical Modelling, Chennai
8	Nation Centre for Antarctic and Ocean Research, Goa		
9	CEPT University		
10	M. G. Science Institute, Ahmedabad		
11	Indian Institute of Technology- Roorkee		
12	Sikkim State Science and Technology		
13	Government college, Dharamshala		





Thanks Director SAC Dr. Tapan Misra Associate Director, Sh D K Das Organisers of SaGHAA 2017 DD EPSA, Dr. Rajkumar My colleagues and research Fellows Dr A S Rajawat Shri Arun Sharma Dr Sandip Oza Dr D R Rajak Dr. Sushil Sh. B P Rathore Ms Purvee Sh Naveen Tripathy Ms Akruti

(Field Photo of Chhota Shigri glacier in Chandra basin, H.P.)