Melting Third Pole: Driving Factors and the Consequences

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DEPARTMENT OF EARTH SCIENCES, KU

A FEW THOUGHTS…..

- INDICATORS **of** CC **are loud and clear in the UIB**
- Implications of depleting cryosphere under changing climate on **water, energy and food security** are far-reaching in the IHR having **Geopolitical consequences**
- We have lost ~ **20% of the GLACIAL MASS** during last 6 decades in the Kashmir Himalayas
- **SHIFTING hydrograph** peaks, **change** in the **FORM** of precipitation and **LOW** STORAGE CAPACITY **are a CONCERN.**
- **Water issues,** if, not understood in the right perspective have potential to **COMPLICATE THE SOUTH ASIAN SECURITY**

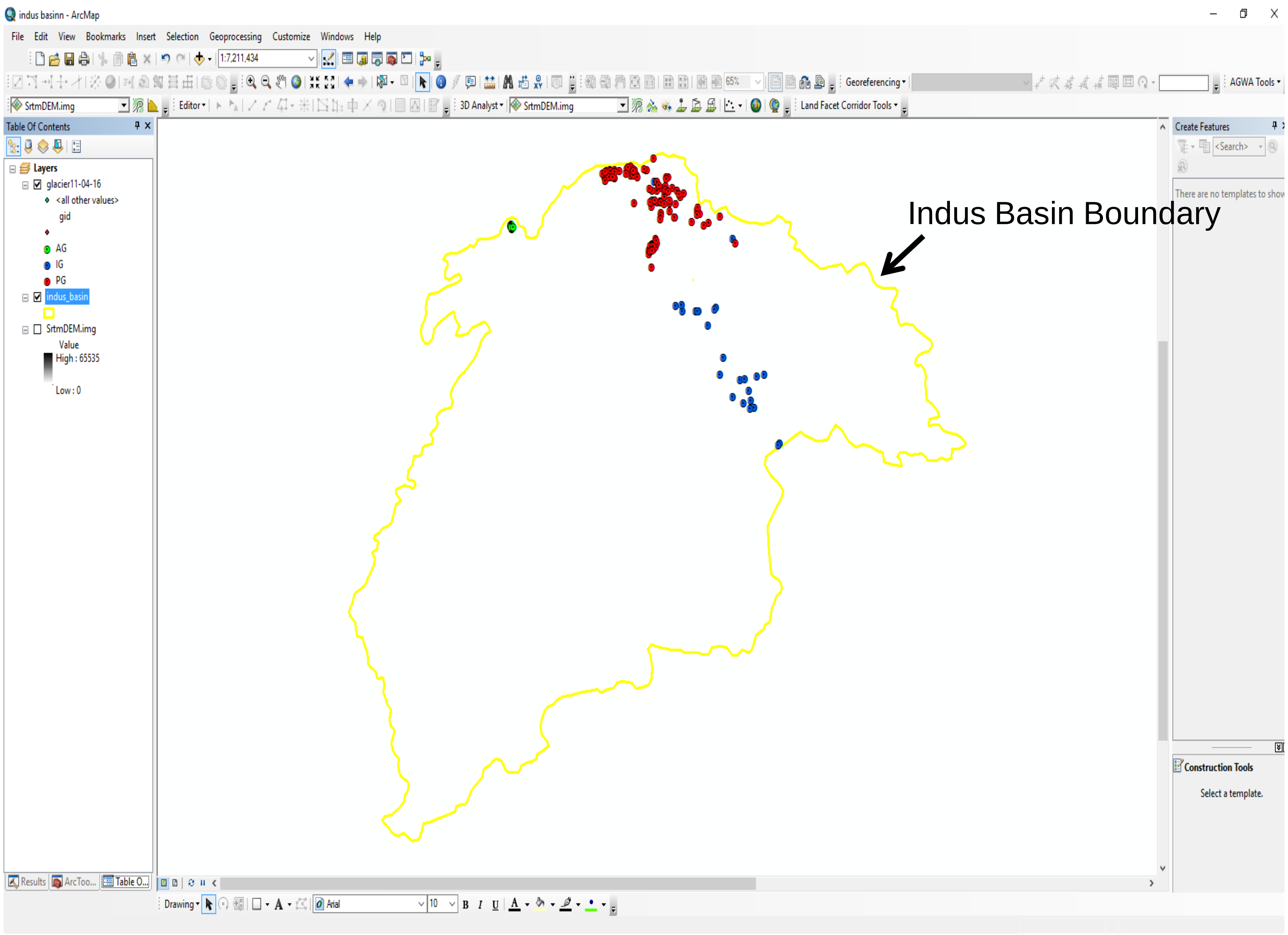
SCIENTIFIC CHALLENGES

- **How much water is stored in the Indus cryosphere?**
- **How Heterogeneous is IH Cryosphere?**
- **Have we reached the tipping point of max glacier melt in the IHR?**
- **Significant** <u>DECLINE IN THE STREAMFLOWS</u> **since 1990s due to the depletion of cryosphere** under Changing Climate
- **How Important are Glaciers for streamflow in IHR?**
- **Is BC a Significant Factor in the IHR vis-à-vis CC?**

HIMALAYAN CRYOSPHERE

Basin	Glacier area (sq. km) (1)	Mass (Gt) (2)	Mass (Gt) (3)
Alaknanda	1,036	144	110
Beas	379	53	40
Bhagirathi	883	177	143
Brahmaputra	224	21	15
Chenab	2,567	375	290
Indus	8,081	1,562	1,273
Jhelum	158	11	8
Ravi	105	11	7
Satluj	296	28	20
Sharda	772	94	71
Shyok	5,651	1,469	1,251
Siang	57	6	5
Tista	431	59	45
Yamuna	136	18	13
Shaksgam	2,198	422	338
Sulmar	340	30	22
Total	23,314	4,480	3,651

INDUS BASIN GLCIERS STUDIED IN THE PAST



Total number of glacier in the basin-18495 (ICIMOD inventory)

VOLUMER ESTIMATION APPROACHES

LUMPED APPROACH (SCALING MODELS)

$$V = cA^{\gamma}$$

V= volume of glacier

A = area of the glacier

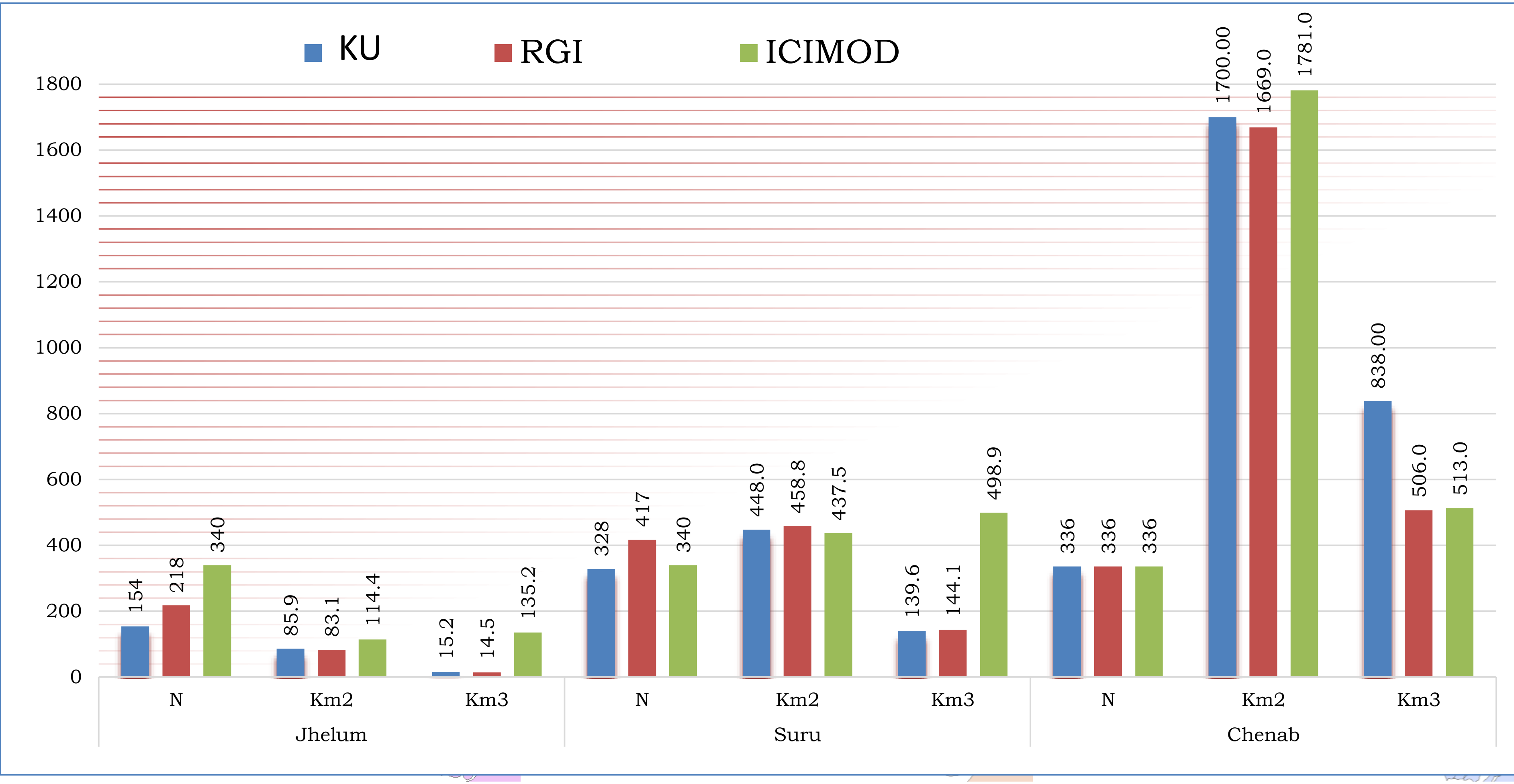
Source	*Parameter*	*Formulae*
Chen and Ohmura,1990	*area*	$V = 0.191 \times A^{1.375}$
Bahr, 1997	*area*	$V = 0.03 \times A^{1.36}$
Bahr et al, 1997	*area*	$V = 0.2055 \times A^{1.36}$
Arendt et al., 2006	*area*	$V = 0.28 \times A^{1.375}$
Haeberli and Hoelzle, 1995	*Slope*	$h = \tau / f\rho g \sin\alpha$
LIGG et al.,	*area*	*H=-11.32+ 0.8433x* $A^{1.3}$

VOLUMER ESTIMES

	Area (km^2)	Volume (km^3) based on (*81*), adjusted	Volume (km^3) based on scaling parameters by			Mean elevation (m a.s.l.)
			(*86*)	(*85*)	(*87*)	
Karakoram	**17,946**	**1259**	**2235**	**2745**	**4024**	**5326**
Western Himalaya	8943	415	515	610	895	5155
Central Himalaya	9940	484	647	770	1128	5600
Eastern Himalaya	3946	172	235	279	408	5395
Himalaya total	**22,829**	**1071**	**1397**	**1659**	**2431**	**5390**
Total	**40,775**	**2330**	**3632**	**4403**	**6455**	**5362**

Bolch et al., 2012, State and Fate of Himalayan Glaciers, Science

RS BASED GLACIER INVENTORIES



KU (OWN) **RGI** **ICIMOD**

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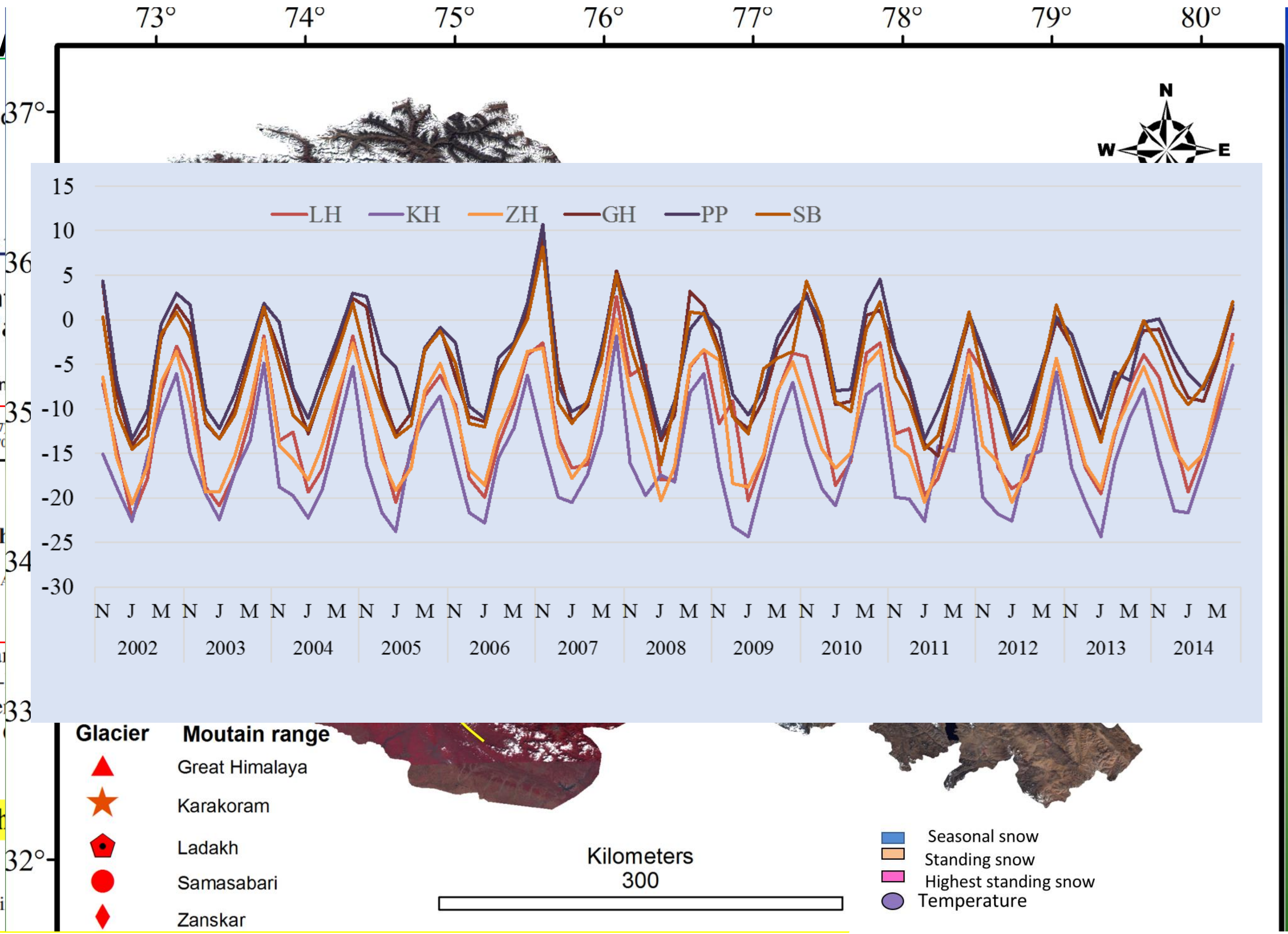
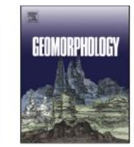
Shakil Romshoo
University of Kashmi





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Category:Multi Cap
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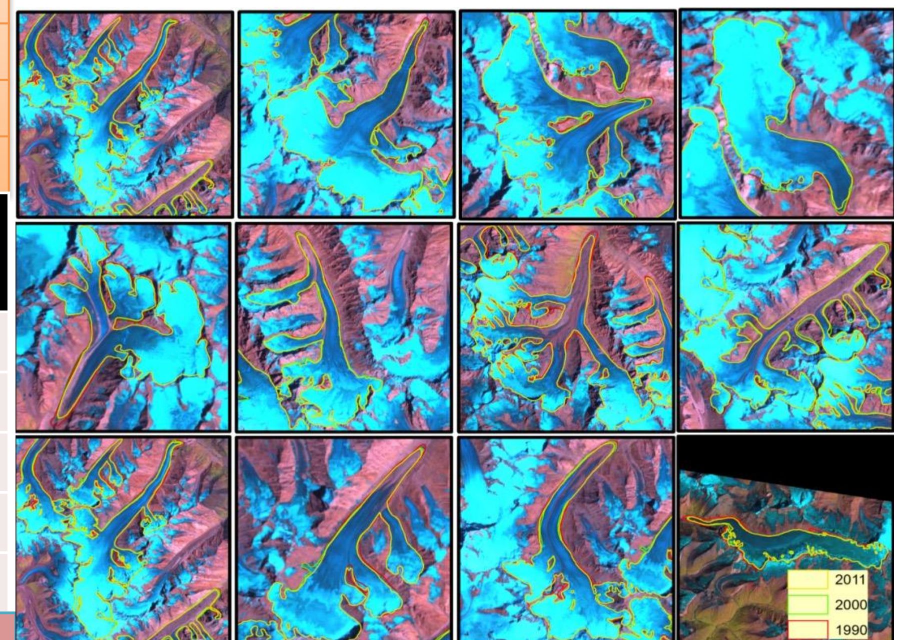
Remote Sensing of Glaciers

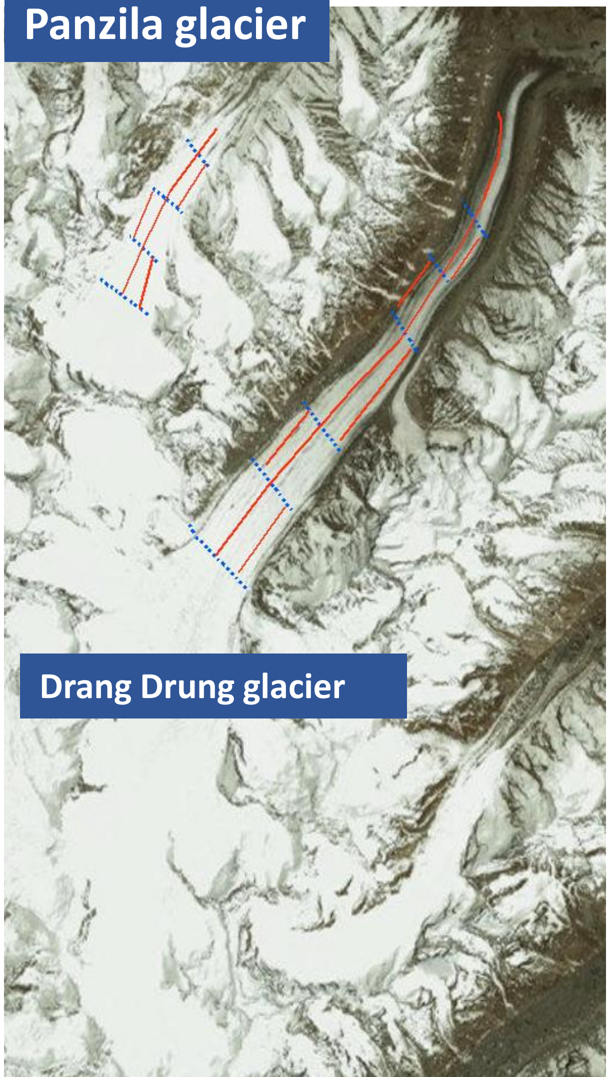
Mountain Range	GH	SB	ZH	LH	KK
	Changes in area, ELA, volume and snout				
Temp. (°C)	-5.49	-6.10	-11.92	-11.55	-15.56
Area (%)	-8.05	-6.32	-5.42	-5.65	1.6%
ELA (m)	-45	-32	-63	-22	-18
Volume(%)	-11.5	-8.5	-7.37	7.65	-0.99
Snout (m)	176	257	226	162	136

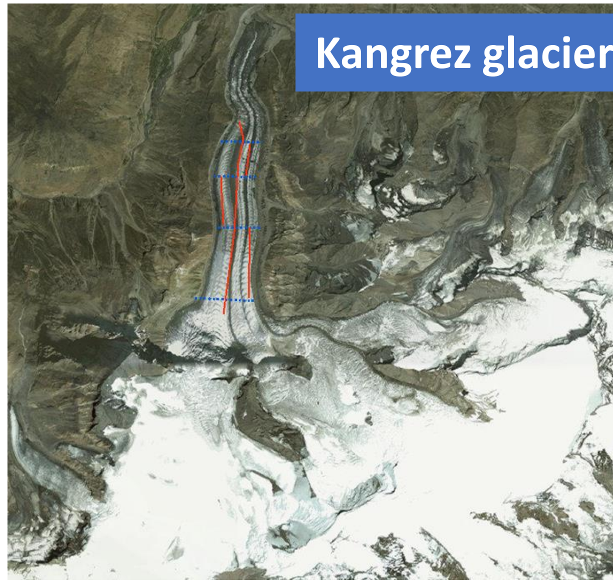
Elevation (m)	Area (%)	Snout(m)	ELA (m)	Vol. (%)
<4500	-8.25	182.86	-43.79	-11.30
4500-5000	-4.70	170.00	-89.50	-6.39
5000-5500	-4.07	265.21	-37.22	-5.51
5500-6000	-4.00	140.07	-22.57	-5.42
>6000	-2.72	112.67	-4.33	-1.77

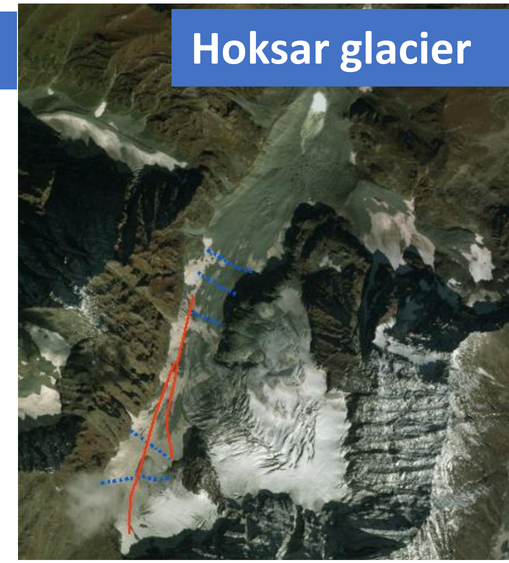
Mountain ranges	Min. Thickness change (m)	Max. Thickness change (m)	Avg. Thickness change (m)
ZH	-0.13	-8.06	-2.81
LH	-1.52	-3.14	-2.33
KH	2.61	-4.38	-0.57
SB	-3.36	-6.35	-5.44
GH	-2.7	-3.4	-3.05

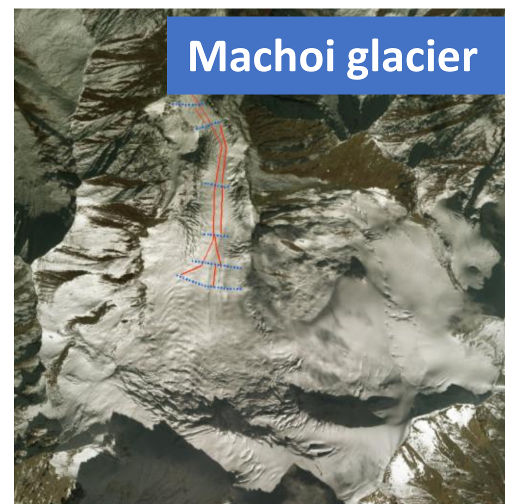


BENCHMARK GLACIERS FOR DETAILED FIELD STUDIES

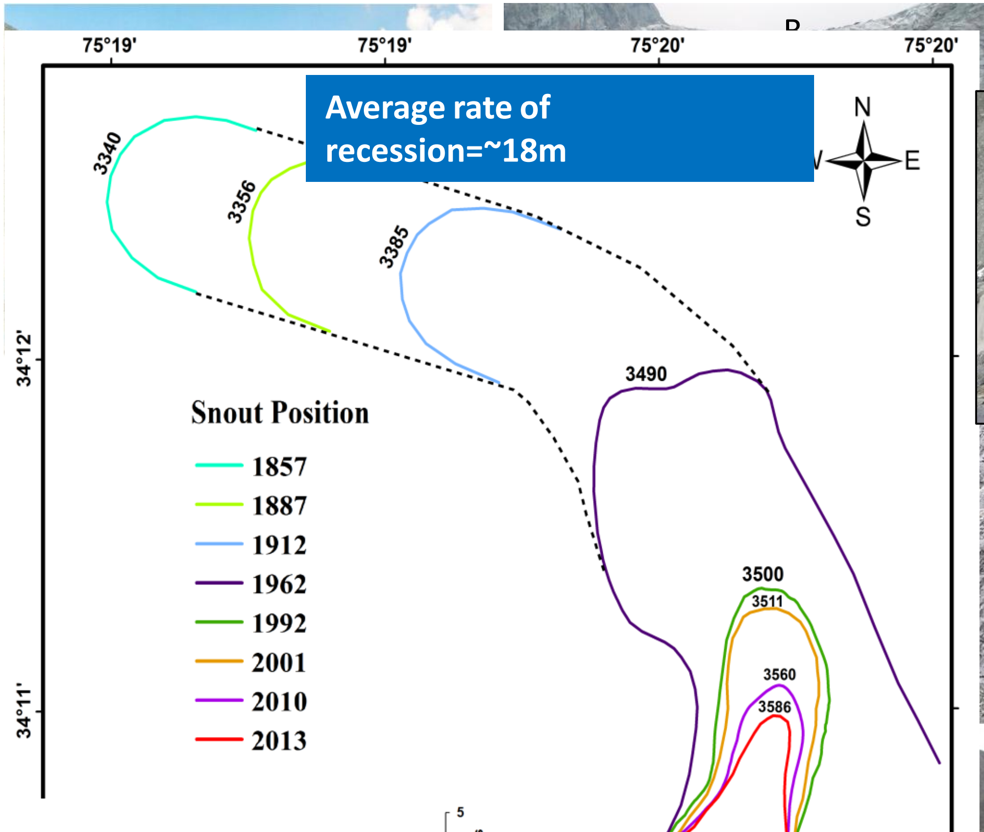






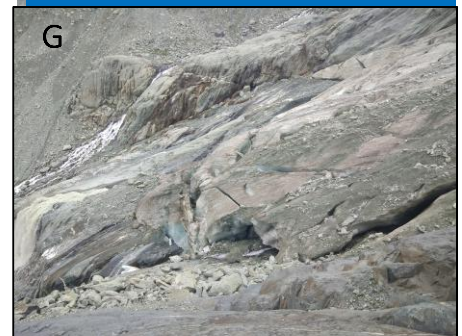


KOLOHAI GLACIER SNOUT MONITORING

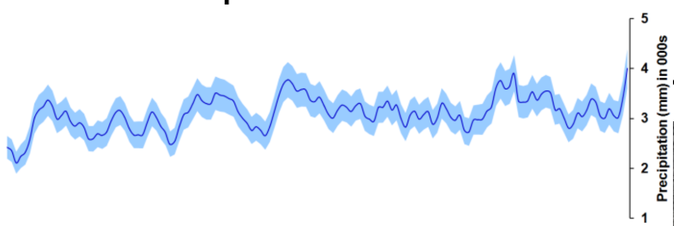


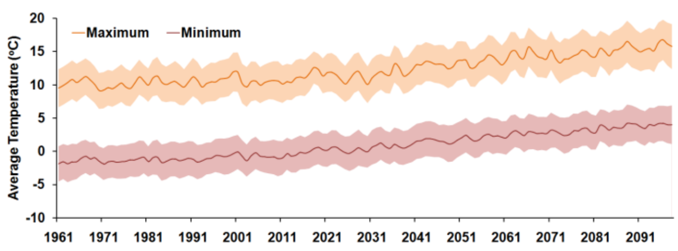
Average rate of recession=~18m

SNOUT



A= 2007
B=2009
C=2011
D=2013
E=2014
F=2015
G=2017





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ELSEVIER

Full length Article

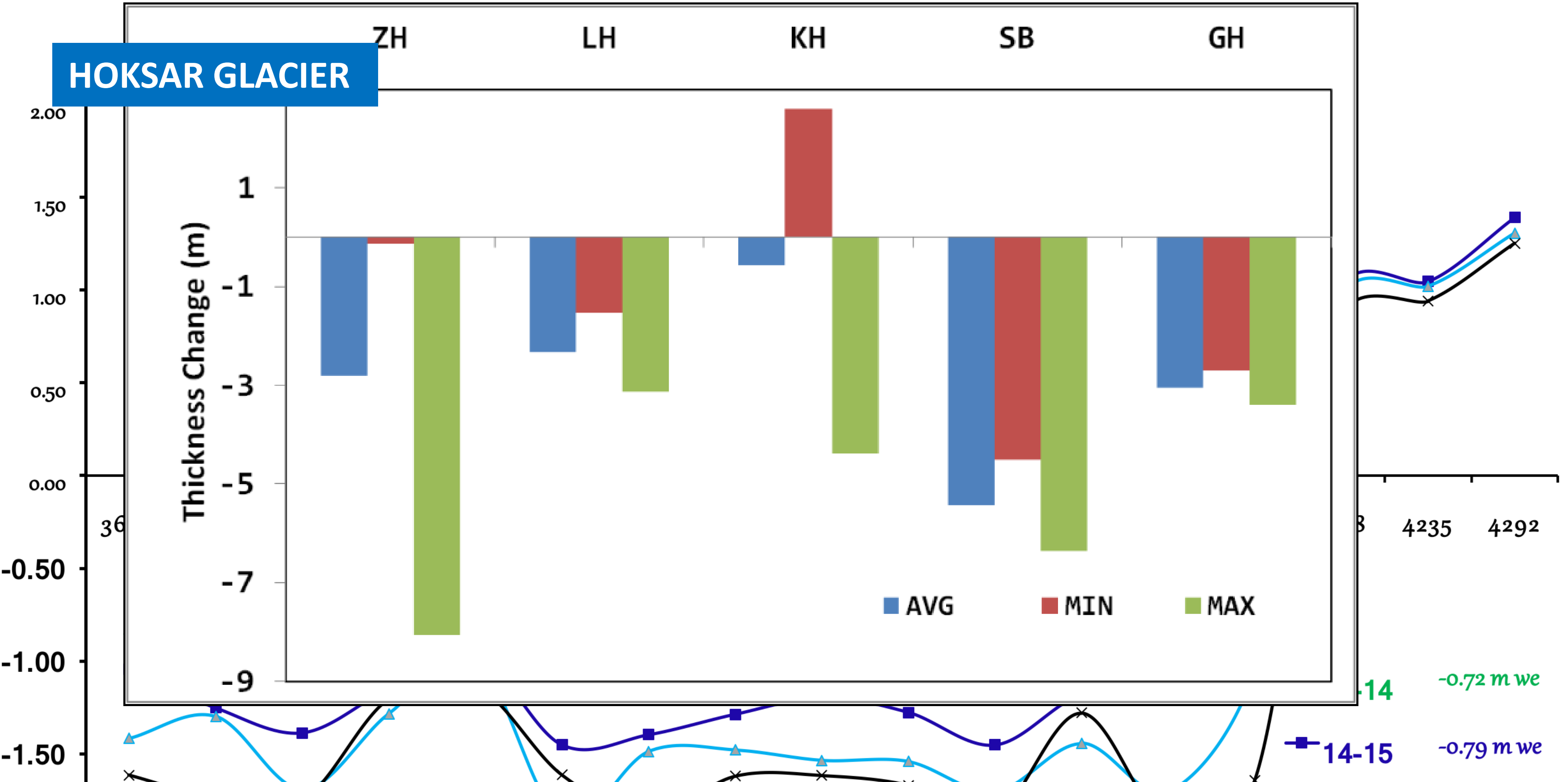
The recent deglaciation of Kolahoi valley in Kashmir Himalaya, India in response to the changing climate

Irfan Rashid, Shakil Ahmad Romshoo*, Tariq Abdullah

Department of Earth Sciences, University of Kashmir, Hazratbal, Srinagar, Jammu and Kashmir 190006, India

Range-wise Ice Thickness Estimates from ICESAT (2002-08)

HOKSAR GLACIER



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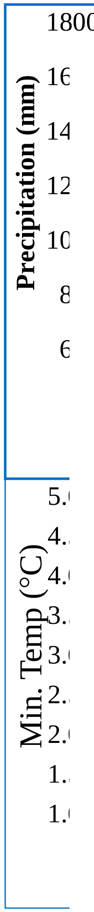
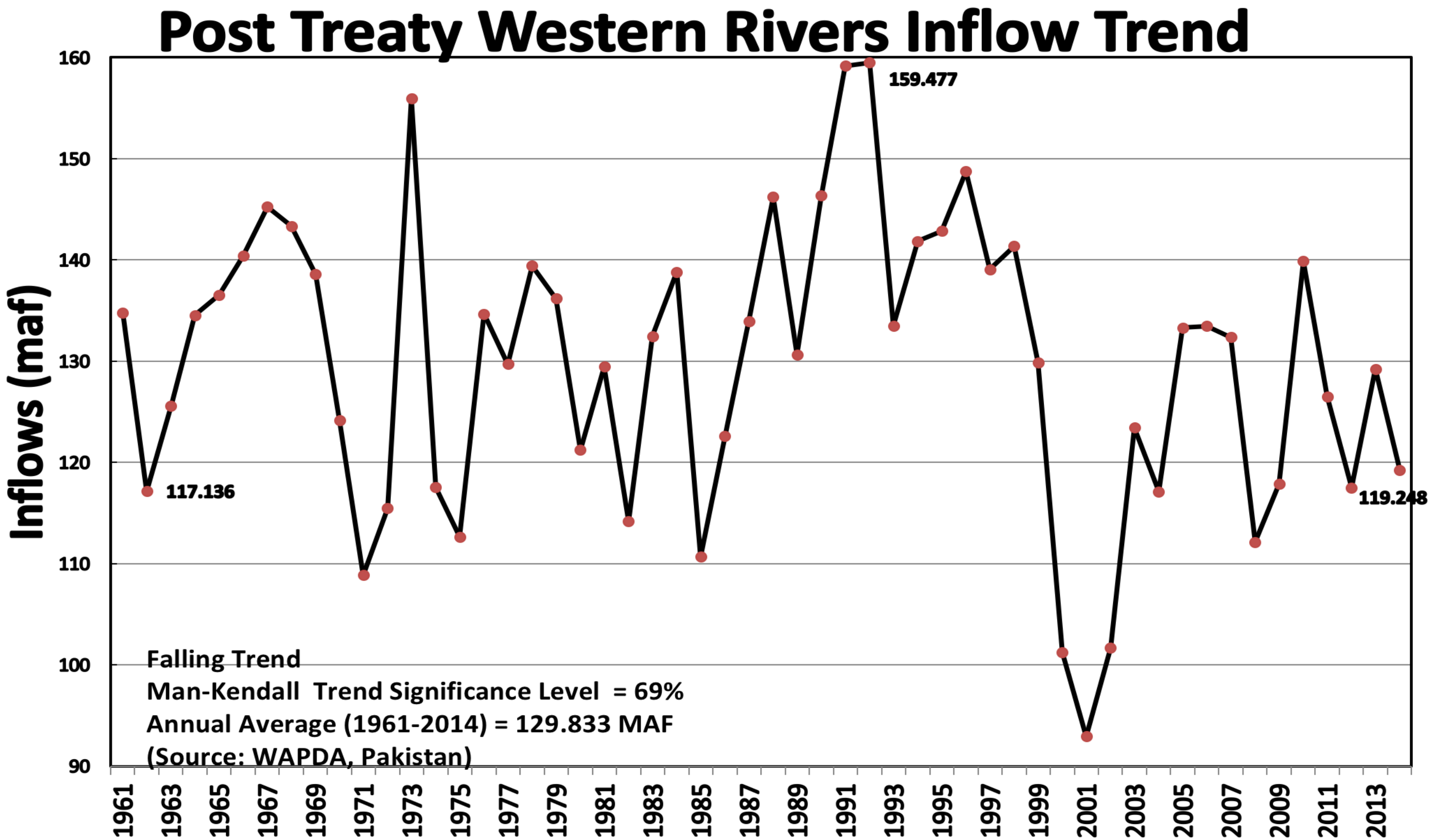
Linkages Climate Change, Shrinking Cryosphere & streamflows





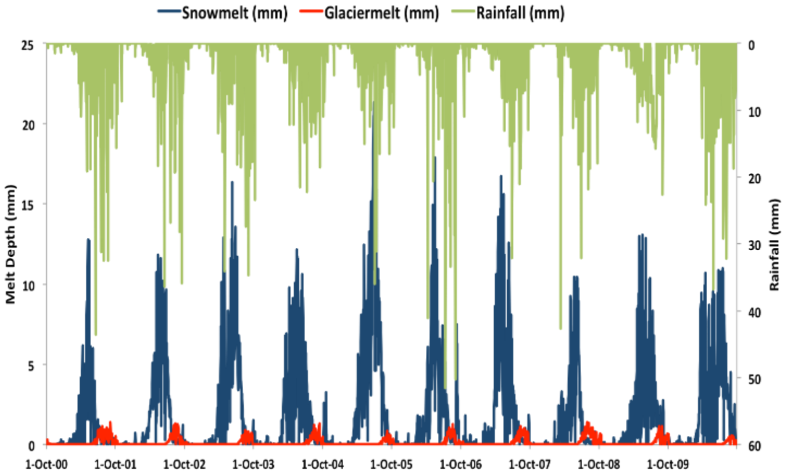
Streamflows in the Lidder Catchment in the Upper Indus Basin, India

Author(s): Shakil Ahmad Romshoo, Reyaz A. Dar, Irfan Rashid, Asif Marazi, Nahida Ali and Sumira N. Zaz

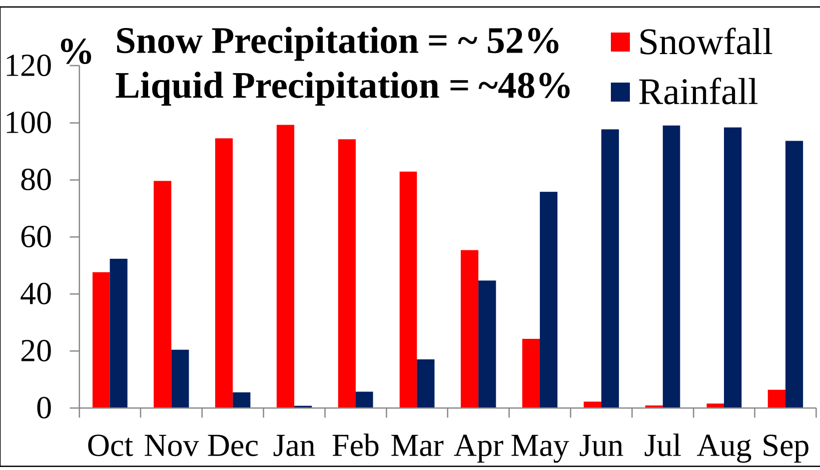
Source: Arctic, Antarctic, and Alpine Research, 47(4):627-644.

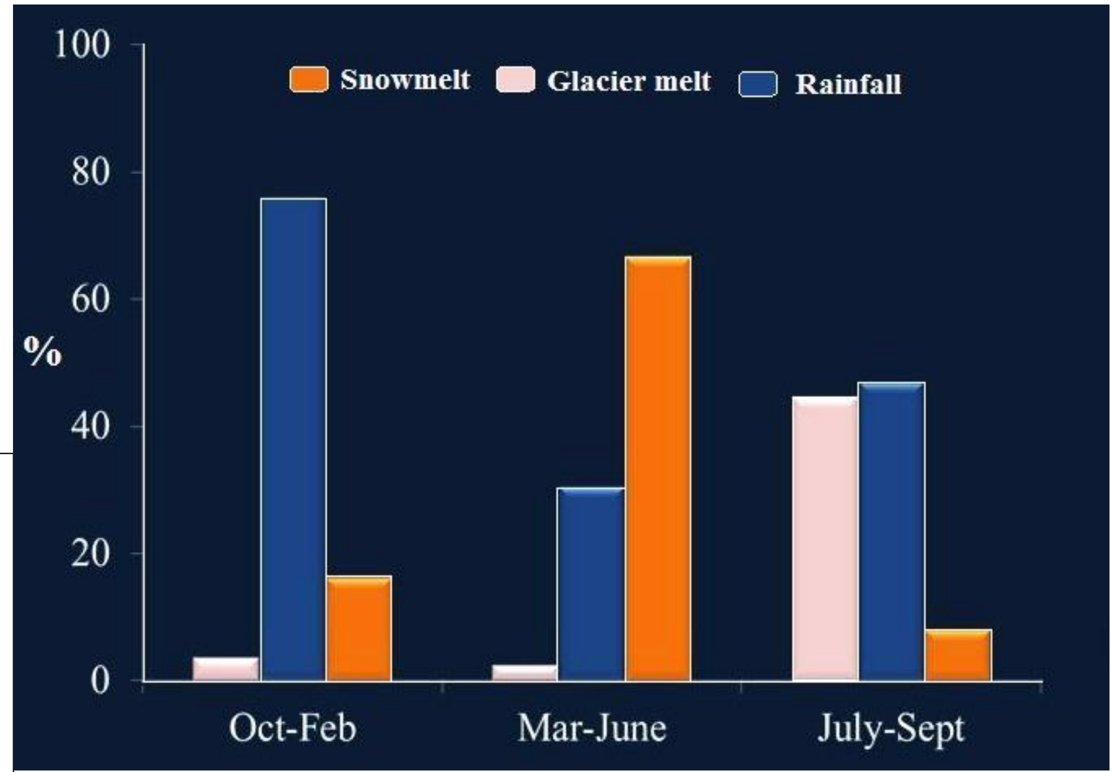
Published By: Institute of Arctic and Alpine Research (INSTAAR), University of Colorado

STREAMFLOW PARTITIONING



Snow melt 54.83% **Glacier melt** 6.14% **Rainfall** 38.03%

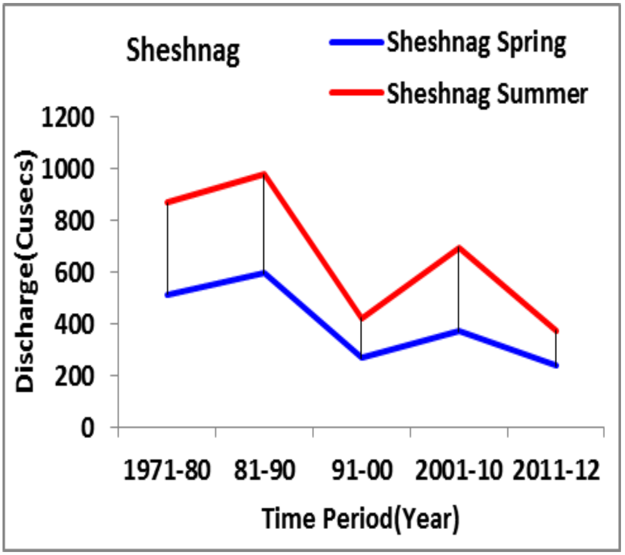


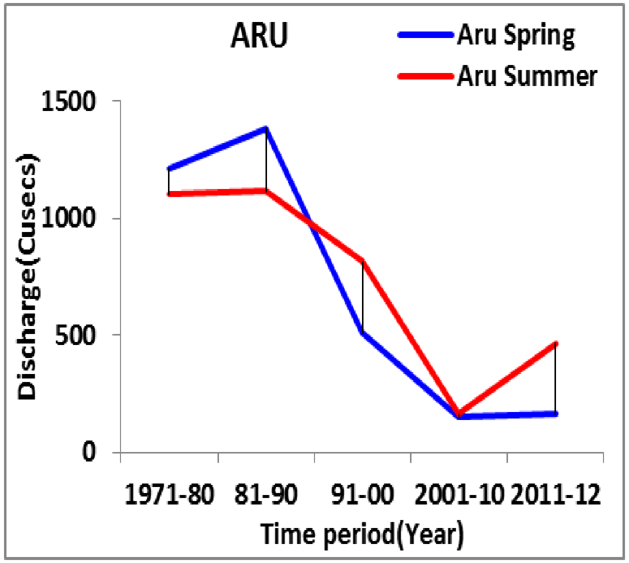


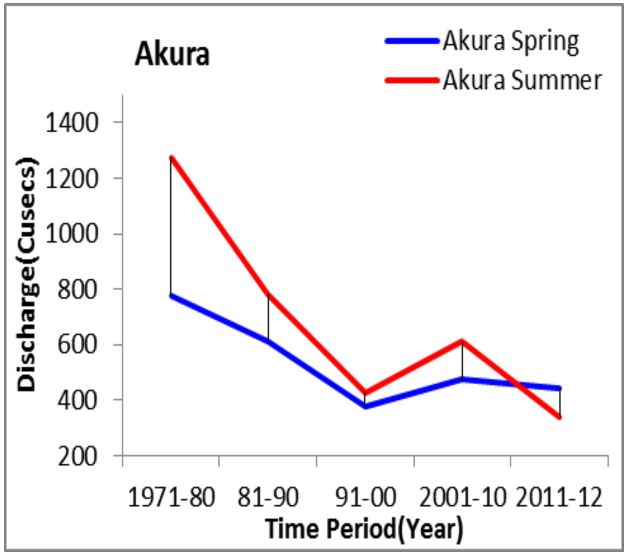
Contribution of Snow and Ice

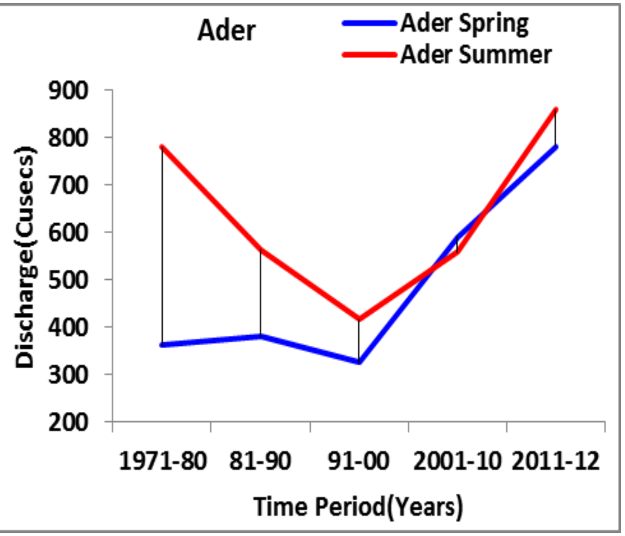
Western River Stations	Approximate Contribution of Snow and Ice	Period	Annual Inflows (MAF)	Ice and Snow Contrib. (MAF)
Indus at Tarbela	85%	1961-2013	60.72	51.6
Kabul at Nowshera	75%	1961-2013	21.65	16.2
Jhelum at Mangla	65%	1961-2013	22.20	14.4
Chenab at Marala	50%	1961-2013	25.36	12.7
Western Rivers Average Inflows	129.93 MAF			
Total Western Rivers Snow and Ice Contribution	95.0 MAF			
Total Contribution of Snow and Ice in Western Rivers	73.1 %			

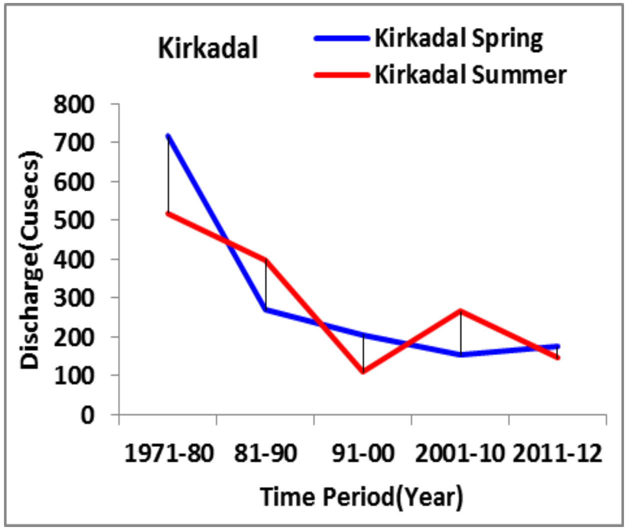
STREAMFLOW PEAK SHIFTS: SUMMER TO SPRING (OBSERVATIONS)

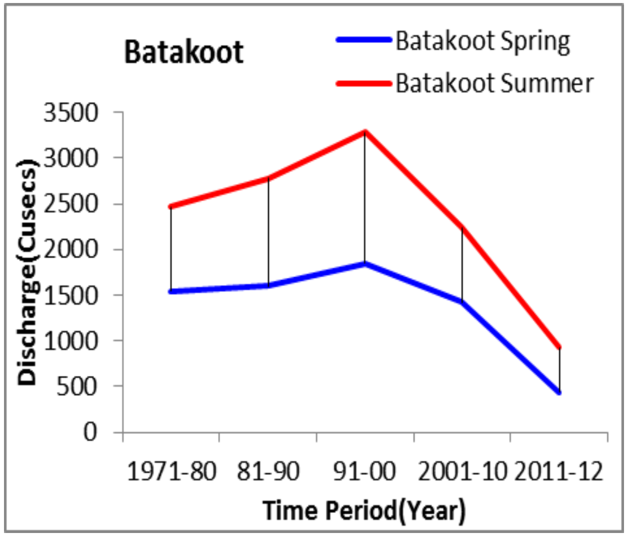




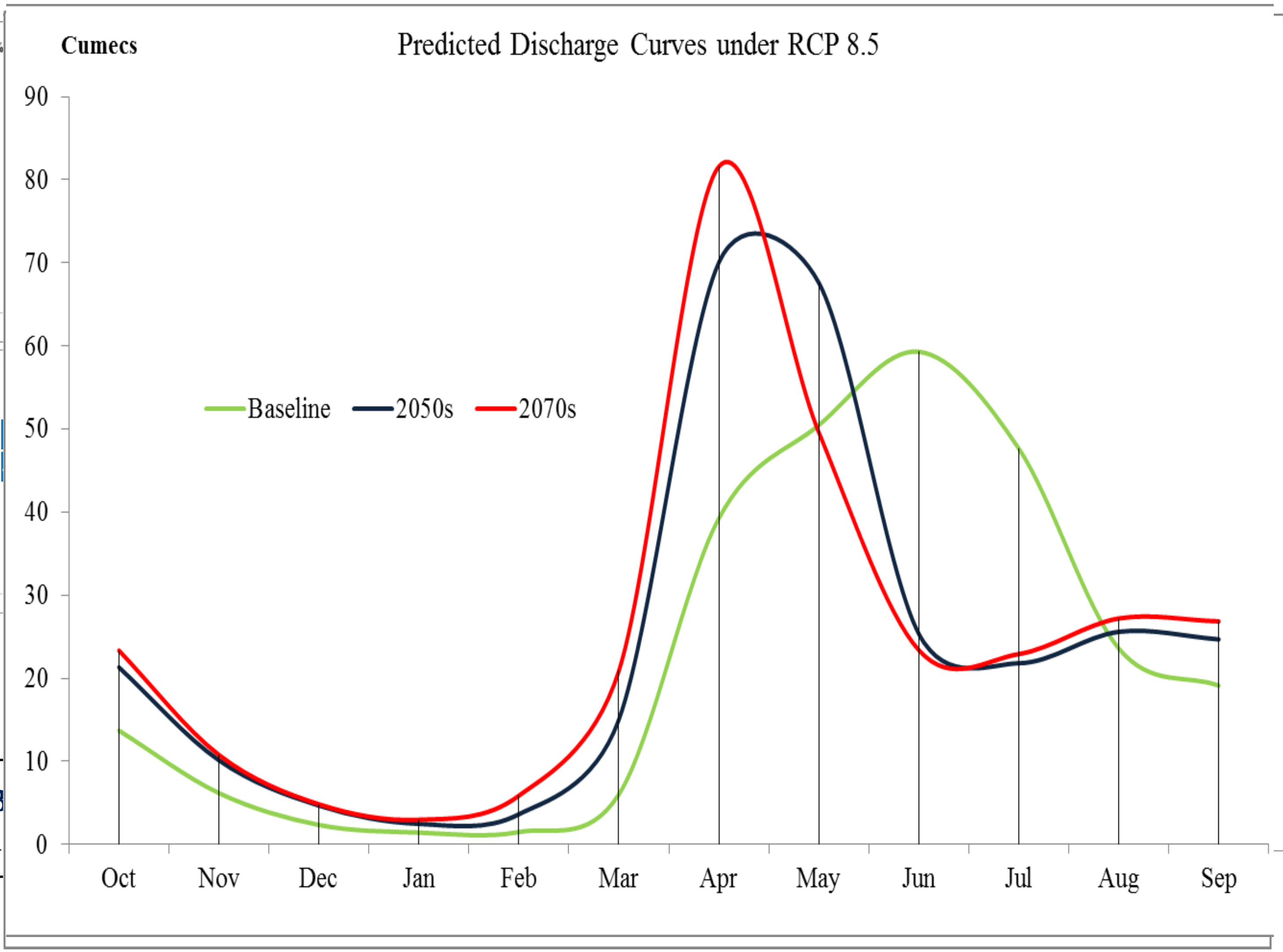


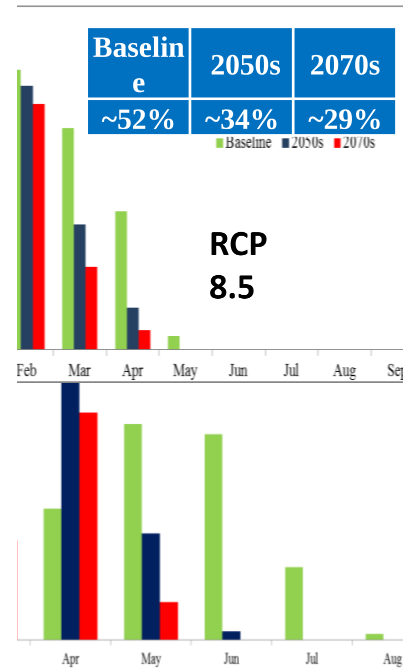






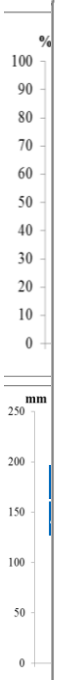
Modelling streamflows under Changing Climate





Baseline	2050s	2070s
~52%	~34%	~29%

RCP 8.5



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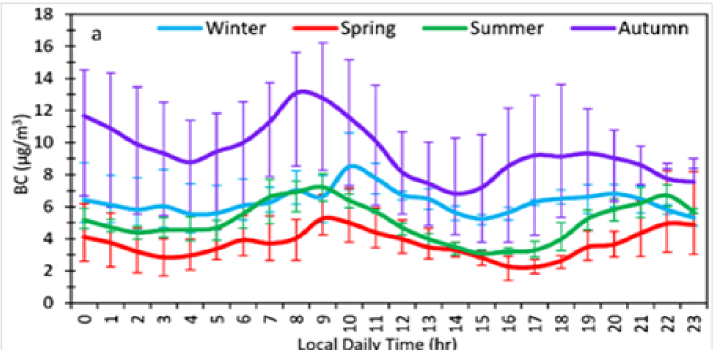
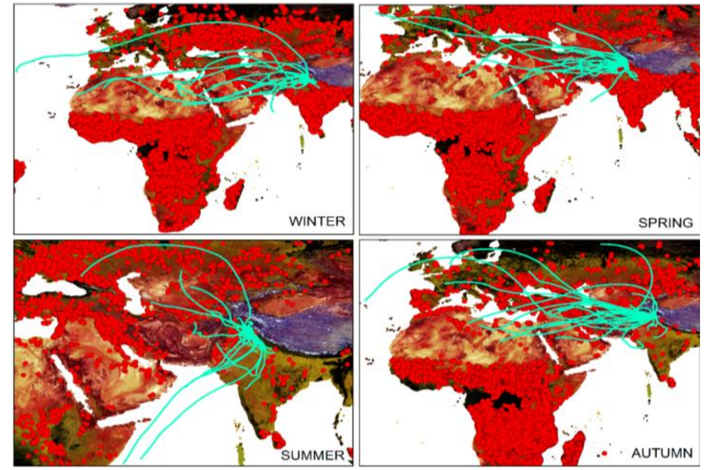
UNPUBLISHED WORK

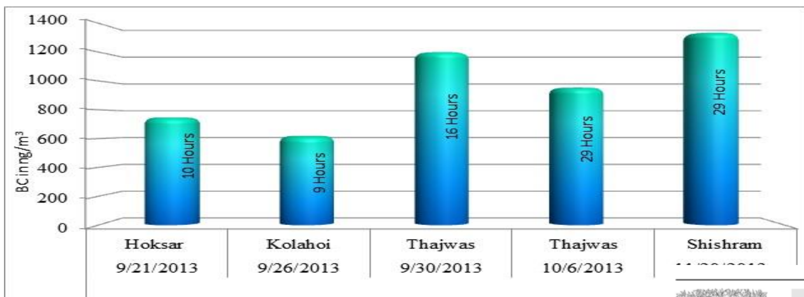
BC STUDIES IN KASHMIR HIMALAYA

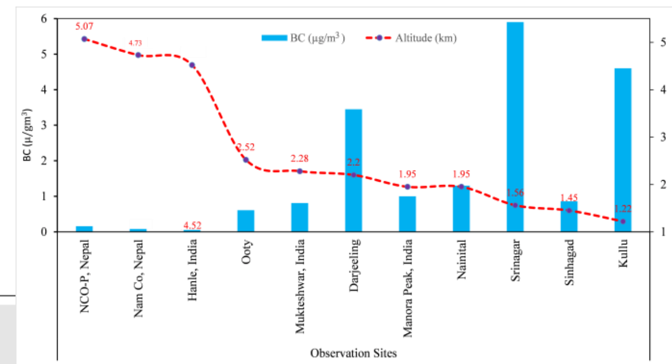


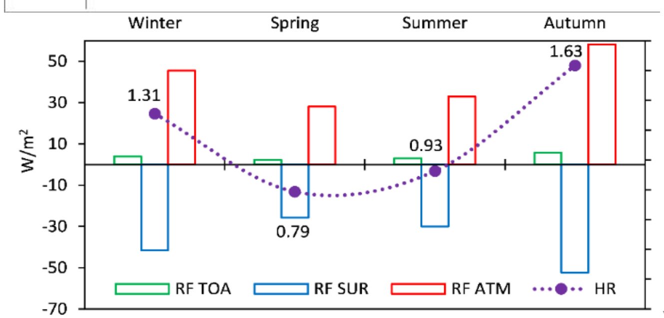
Seasonal variations of BC mass concentration

BC sampling at Hoksar Glacier in Lidder valley.









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Aerosol black carbon at an urban site-Srinagar, Northwestern Himalaya, India: Seasonality, sources, meteorology and radiative forcing

Mudasir Ahmad Bhat [a], Shakil Ahmad Romshoo [a,*], Gufran Beig [b]

[a] Department of Earth Sciences, University of Kashmir, India
[b] Indian Institute of Tropical Meteorology (IITM), India

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Wednesday, October 4th 2017

Reel The Field Magazine Pulse In Pictures Bookshop Trending Sections

CHOKING CITIES

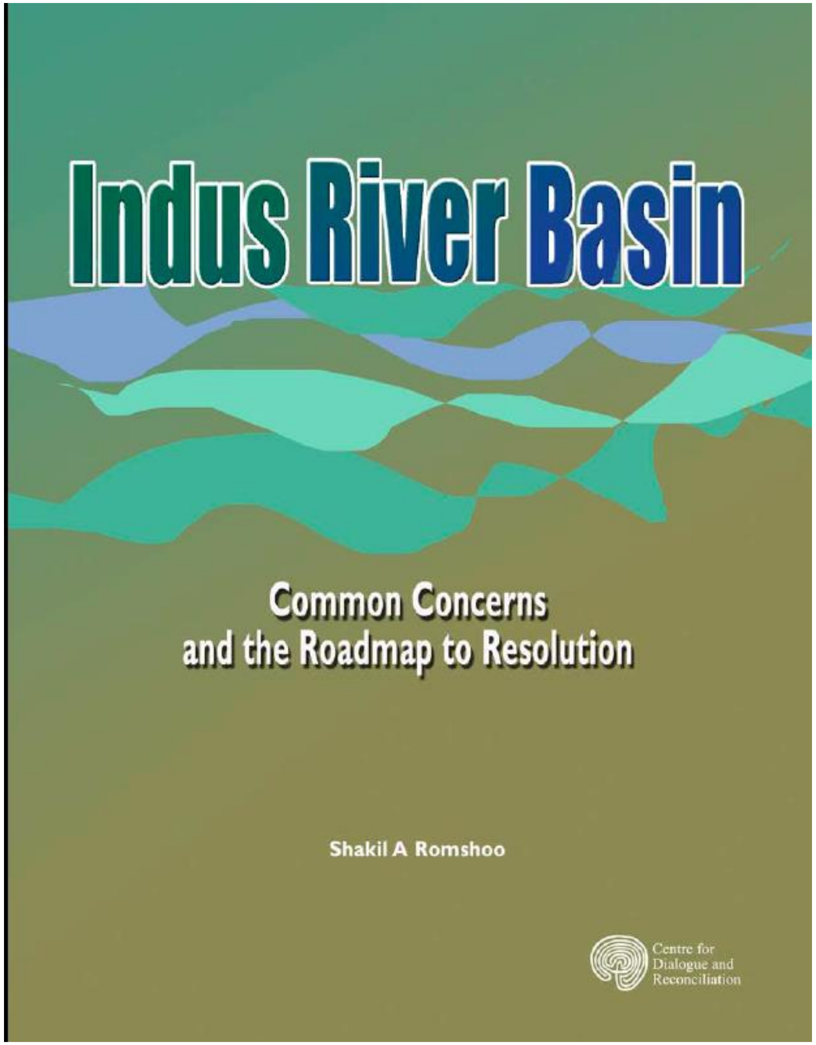
Kashmir's air is pristine, right? Wrong

On certain days the air quality in Srinagar can be as bad as that in Delhi or Kolkata.

Concerns on Indus Water Sharing

GEOPOLITICAL CONSEQUENCES

- INDUS WATER TREATY IS CC BLIND
- DEPLETION OF STREAMFLOWS
- CHANGE OF HYDROGRAPH
- VOICES FOR GW TREATY
- SECURITIZATION OF WATER SHARING
- RELIGIOUS & NATIONALIST POSTURES
- NEED FOR WATER STORAGE/FLOOD INFRASTRUCTURE
- DATA SHARING/TELEMETRY/JOINT STUDIES TO BE ENCOURAGED
- BC VS CC DEBATE



SCIENCE should guide public policy & water sharing diplomacy


Thank you