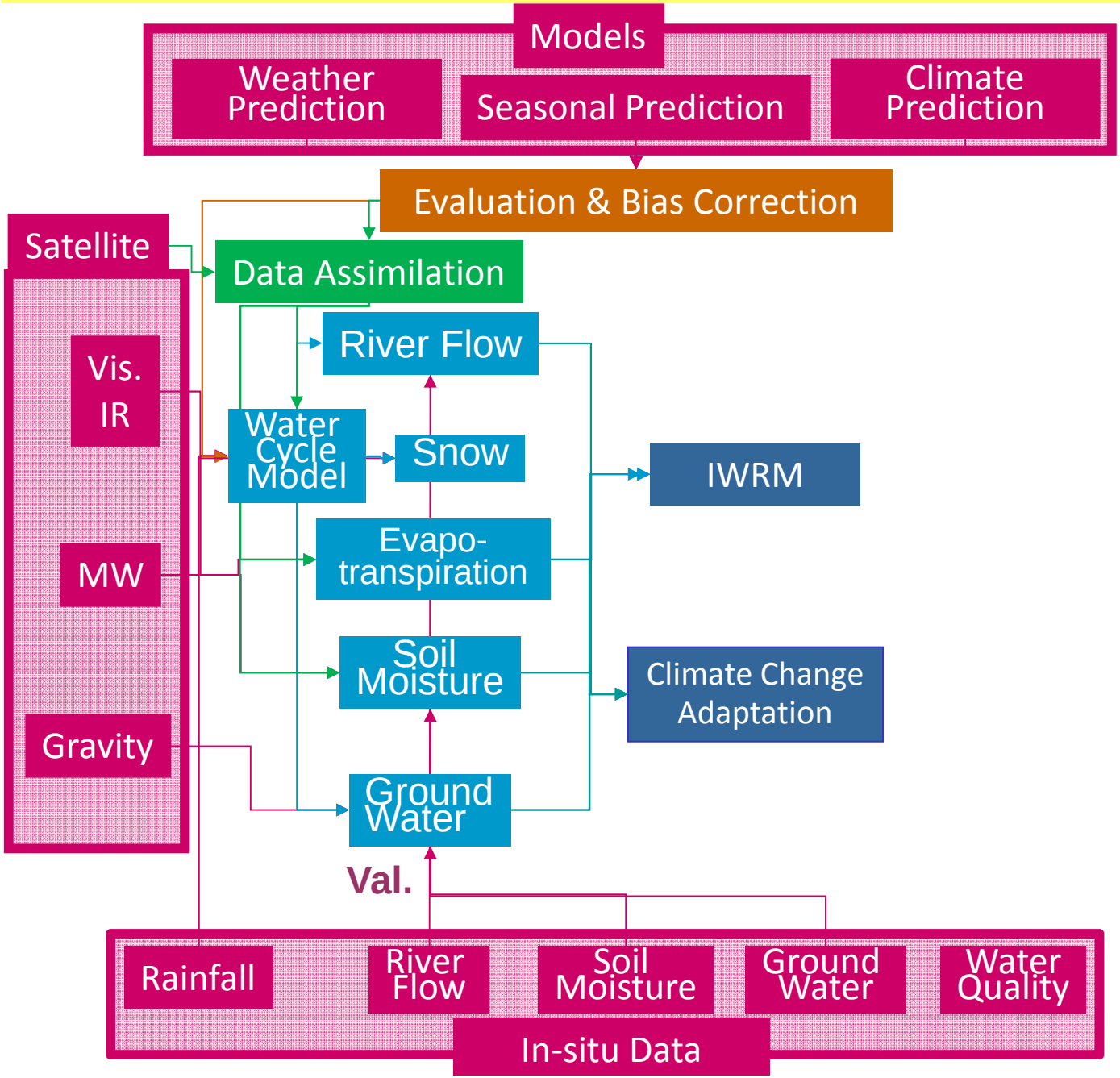
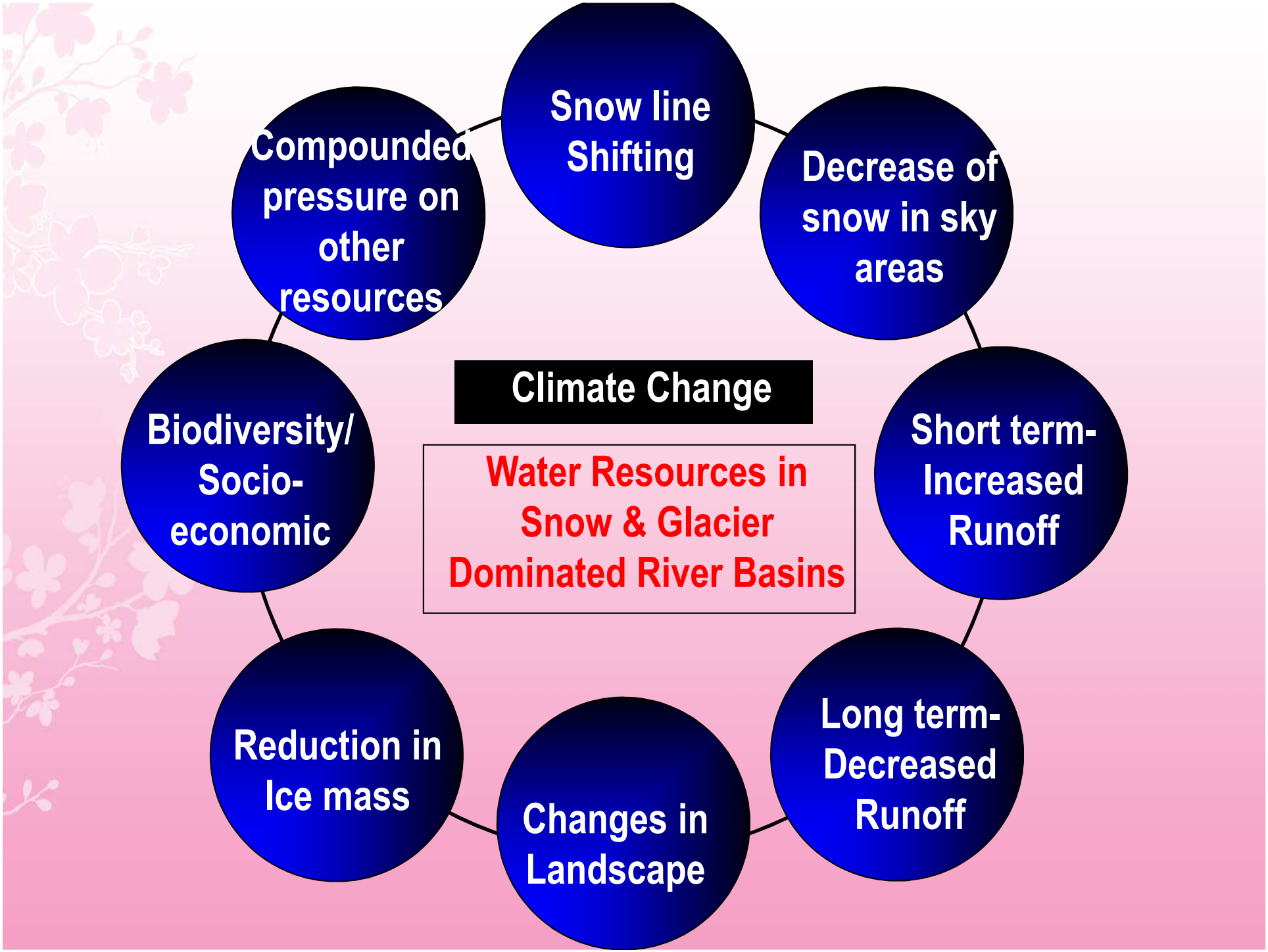
As a field scientist…. in Takaragawa Basin

The Takara River

As a field scientist….

Water Cycle Integrator



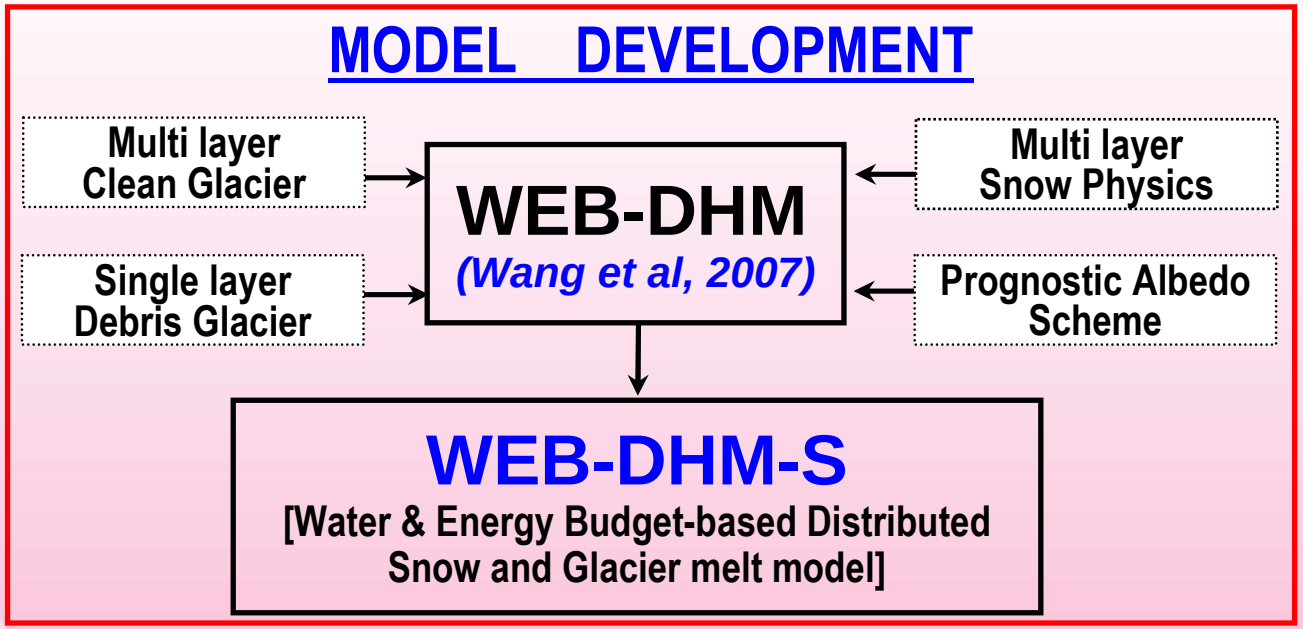

Snow line Shifting
Decrease of snow in sky areas
Short term- Increased Runoff
Long term- Decreased Runoff
Changes in Landscape
Reduction in Ice mass
Biodiversity/ Socio- economic
Compounded pressure on other resources
Climate Change
Water Resources in Snow & Glacier Dominated River Basins

Besides Distributed Hydrological Modeling,

- ✓ Dense monitoring network of hydro-meteorological variables in mountainous regions.
- ✓ Data Sharing (In situ, Satellite data, Reanalysis and Model outputs)
- ✓ Capacity Building (Human Resources)
- ✓ Knowledge management platform to exchange ideas, knowledge and experience on cryospheric issues (Cryospheric Initiatives)
- ✓ Interagency cooperation at national and regional level.

Distributed Hydrological Modeling

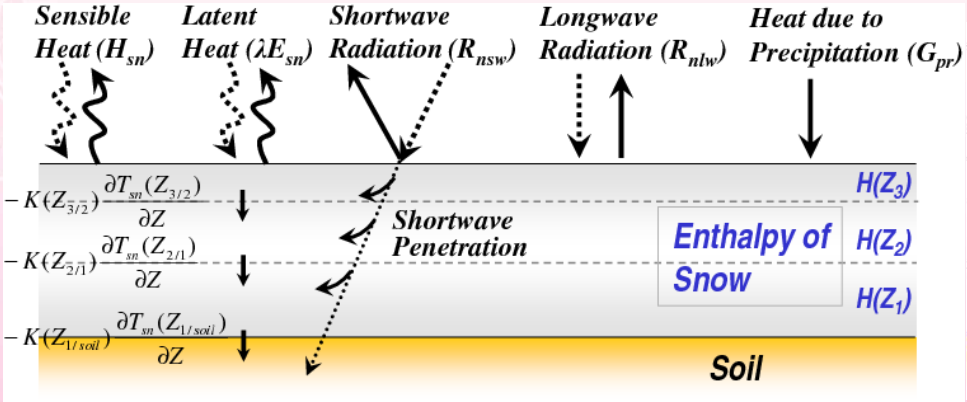
Model development: WEB-DHM-S (Shrestha et al., 2012a,b)



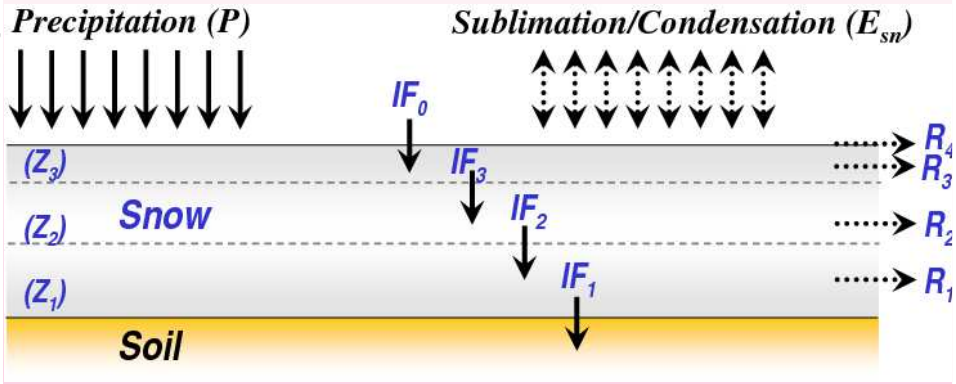
- ✓ Heavy Rainfall (Flood)
- ✓ Seasonal snow (over land)
- ✓ Snow over Glacier
- ✓ Glacier melt runoff
- ✓ Combination of either two or All

Snow accumulation and melting Processes

Energy Balance



Mass Balance

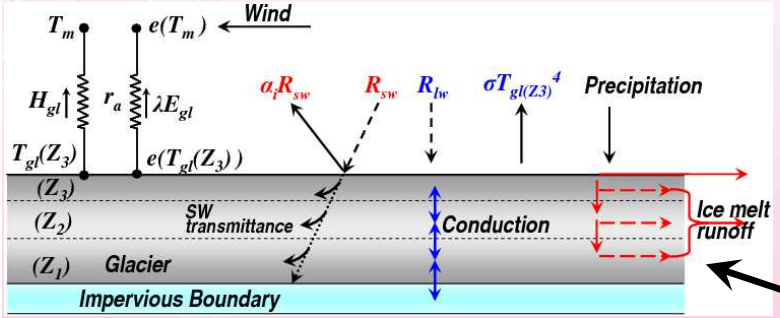


- Surface energy balance – Top layer, Conductive flux – Underlying layer
- Enthalpy – Cold content and Phase Change – Refreezing/ Melting- Ice and Water content
- Compaction (destructive metamorphism, overburden and melt)
- Density of fresh snow – Parameterized from air temperature and wind speed
- Snow Albedo – BATS albedo Scheme (Dickinson et al, 1993) – VIS and NIR albedos

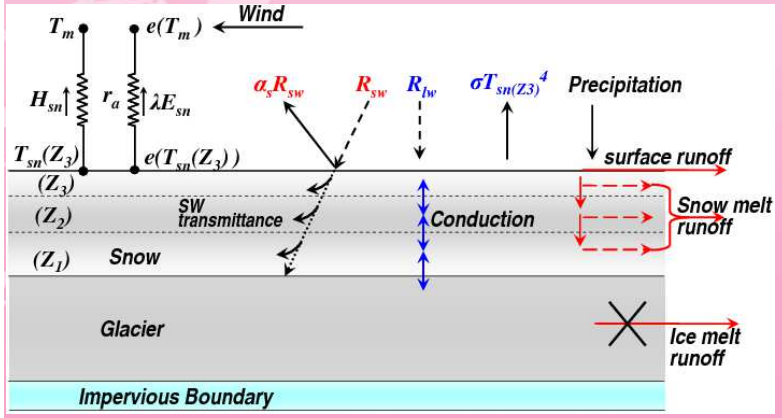
(Glaciated region)

Clean Glacier

- ✓ 3 Layer scheme
- ✓ Ice albedo = 0.4 (Time invariant)



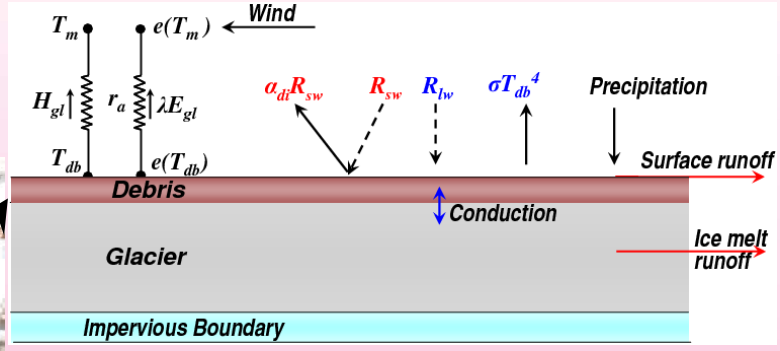
After snowfall



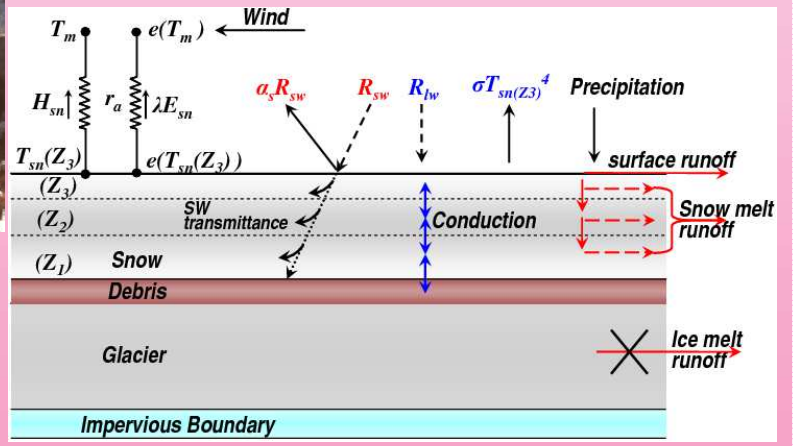
Clean Glacier covered with fresh snow

Debris covered glacier

- ✓ 1 Layer scheme
- ✓ Debris albedo = 0.15 (Time invariant)

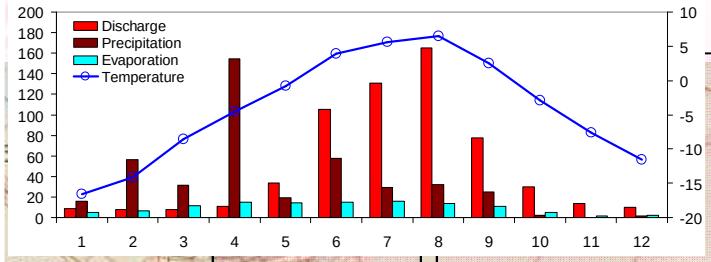


After snowfall



Debris covered with fresh snow

Basin-wide Model development & Validation



Hunza

Narayani

PunatShang

Dudhkoshi

SHIBUTO

TONE

Image Source: ICIMOD

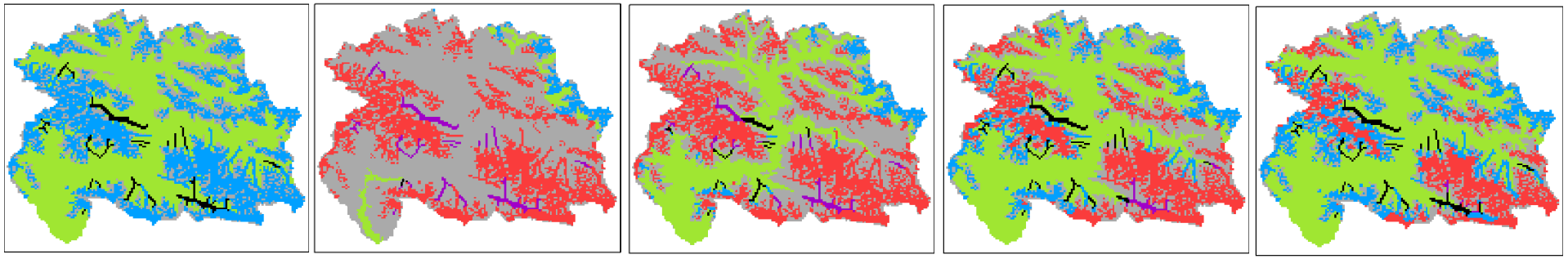
Snow & Glaciermelt Dominant

Snow+Glacier But Monsoon Dominant

Seasonal Snow cover

Snow and Glacier Cover @ Hunza Basin, Upper Indus

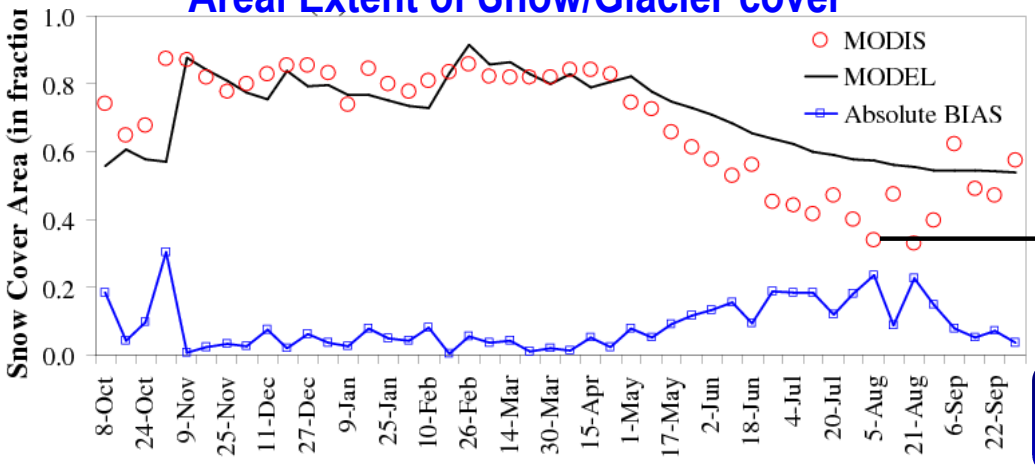
Model Output (Year 2002)



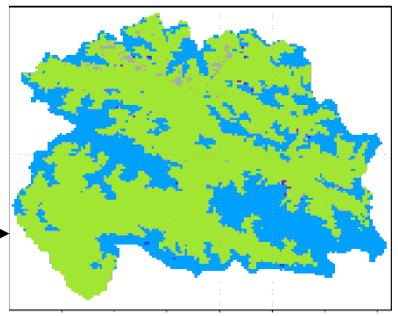
Initial Condition (Inventory-ICIMOD) | **Feb. 24** | **May 18** | **Jul. 12** | **Sep. 30**

Land
Snow over Land
Clean glacier
Snow over clean glacier
Debris covered glacier
Snow over debris glacier

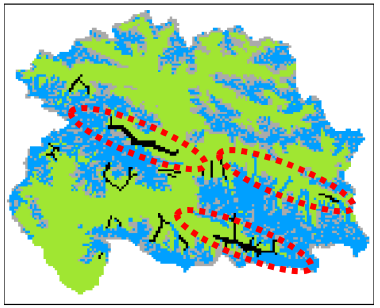
Areal Extent of Snow/Glacier cover



MODIS

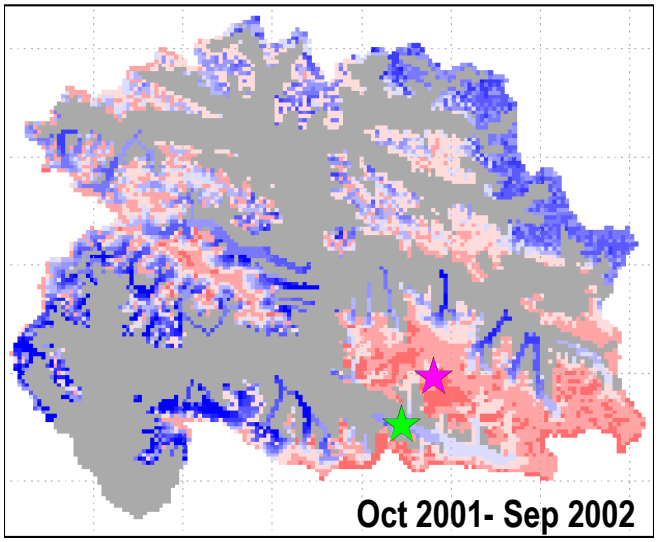


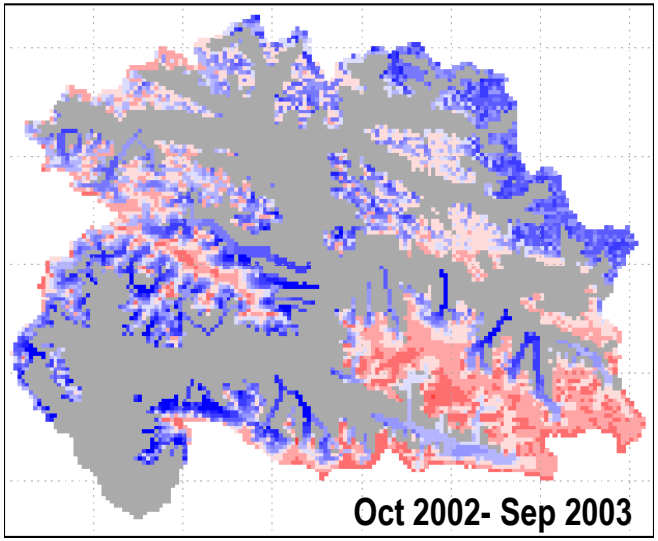
Inventory (ICIMOD)

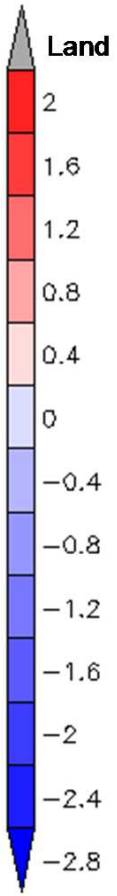


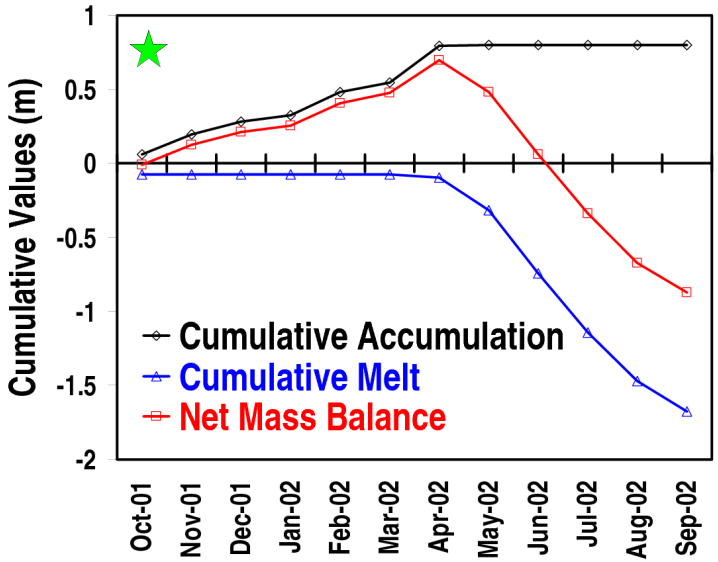
MODIS was unable to capture debris covered glaciers and low altitude clean glaciers.

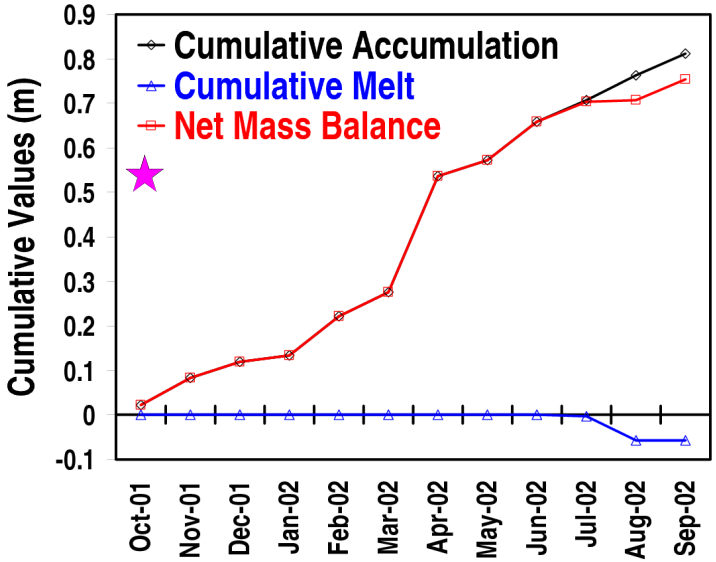
Net mass balance (m water equivalent)



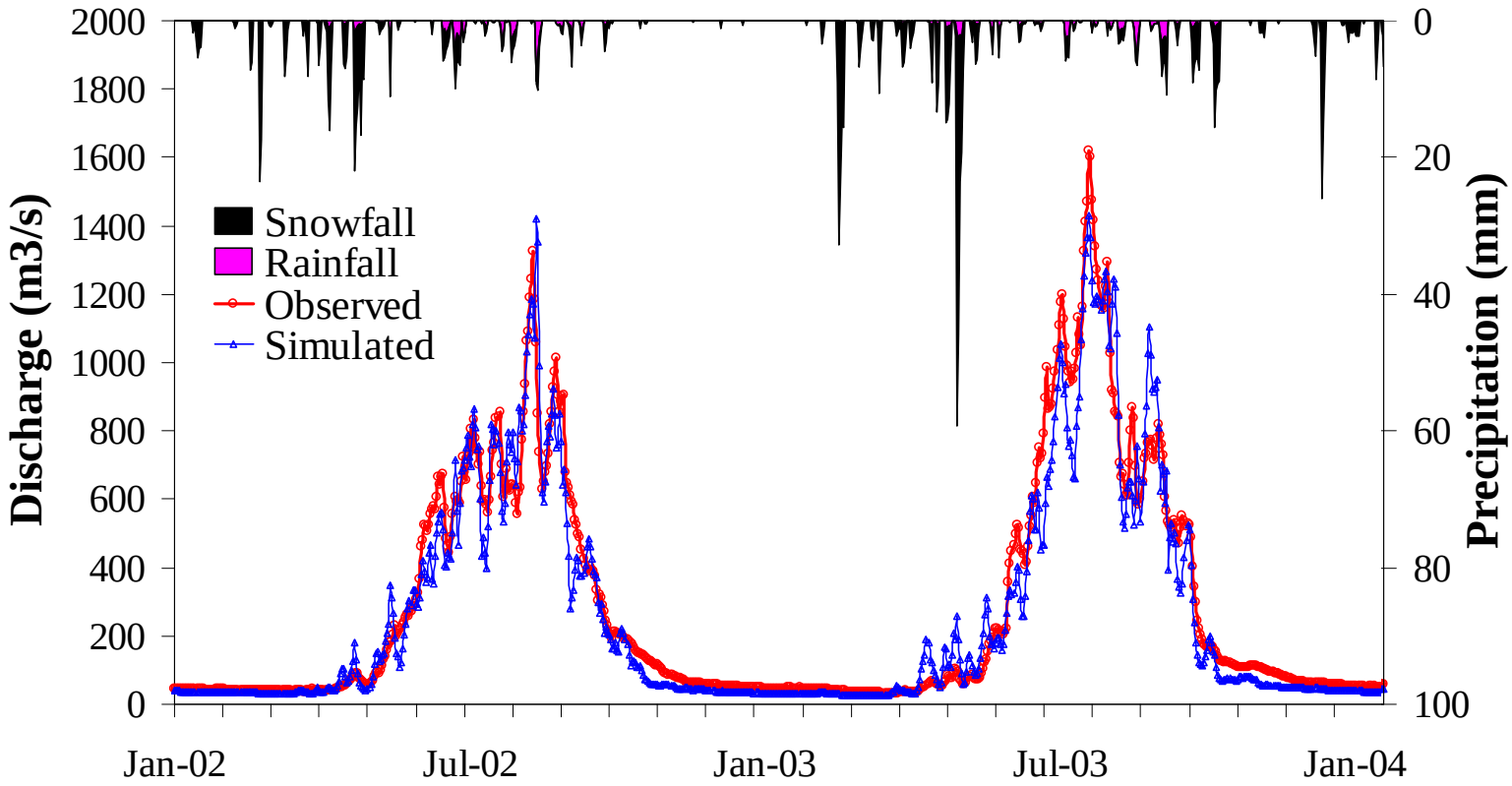








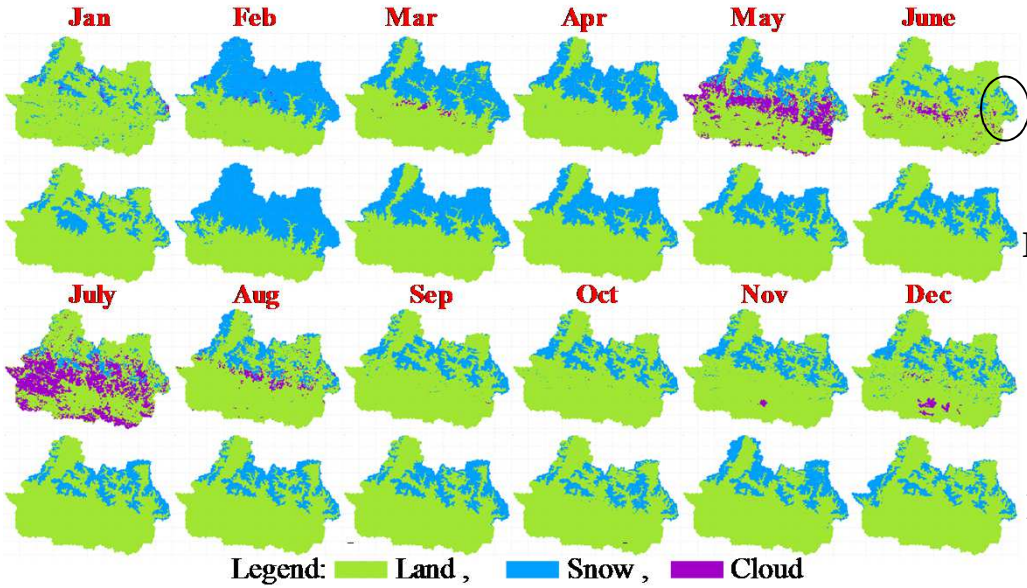
Discharge at basin outlet



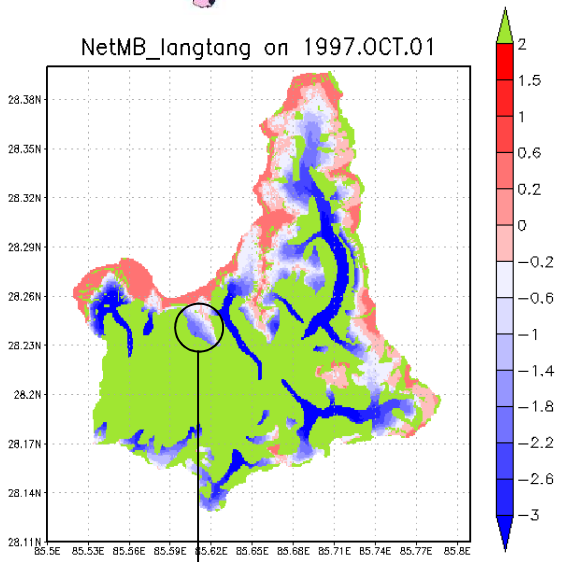
	Contribution to Discharge			Statistics		
Year	Rainfall	Snow melt	Glacier melt	NSE	MBE	R^2
2002	12%	35%	53%	0.92	+4.56%	0.97
2003	10%	40%	50%	0.94	+3.65%	0.97

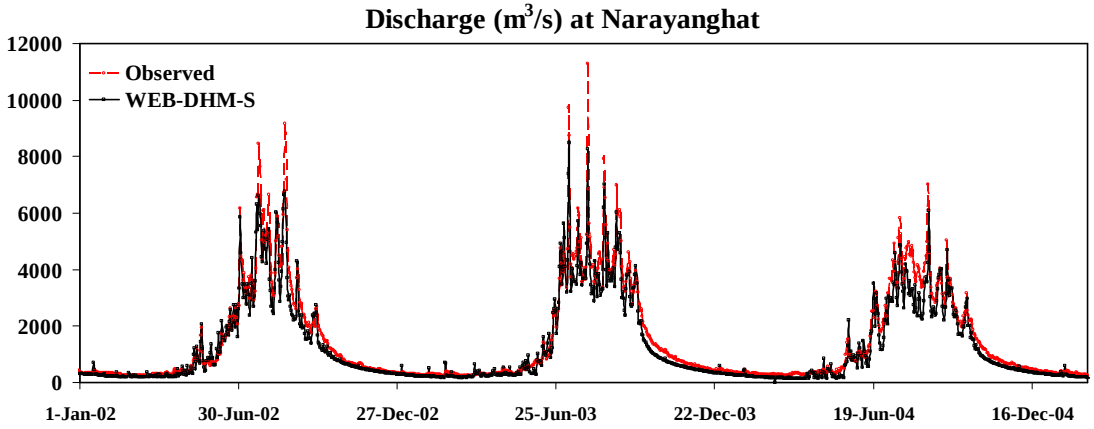
River Basin at Nepal Himalaya (Monsoon Dominant)

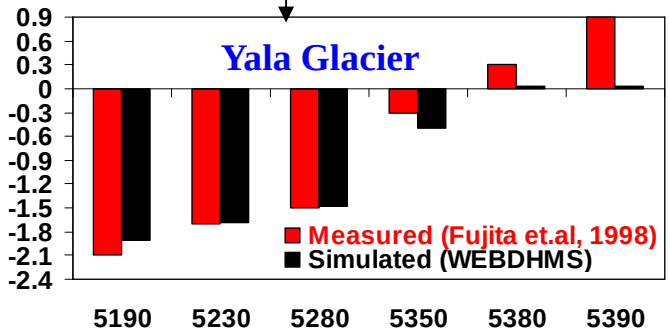
Narayani Basin
(AWCI CCAA Basin)
32000 km^2



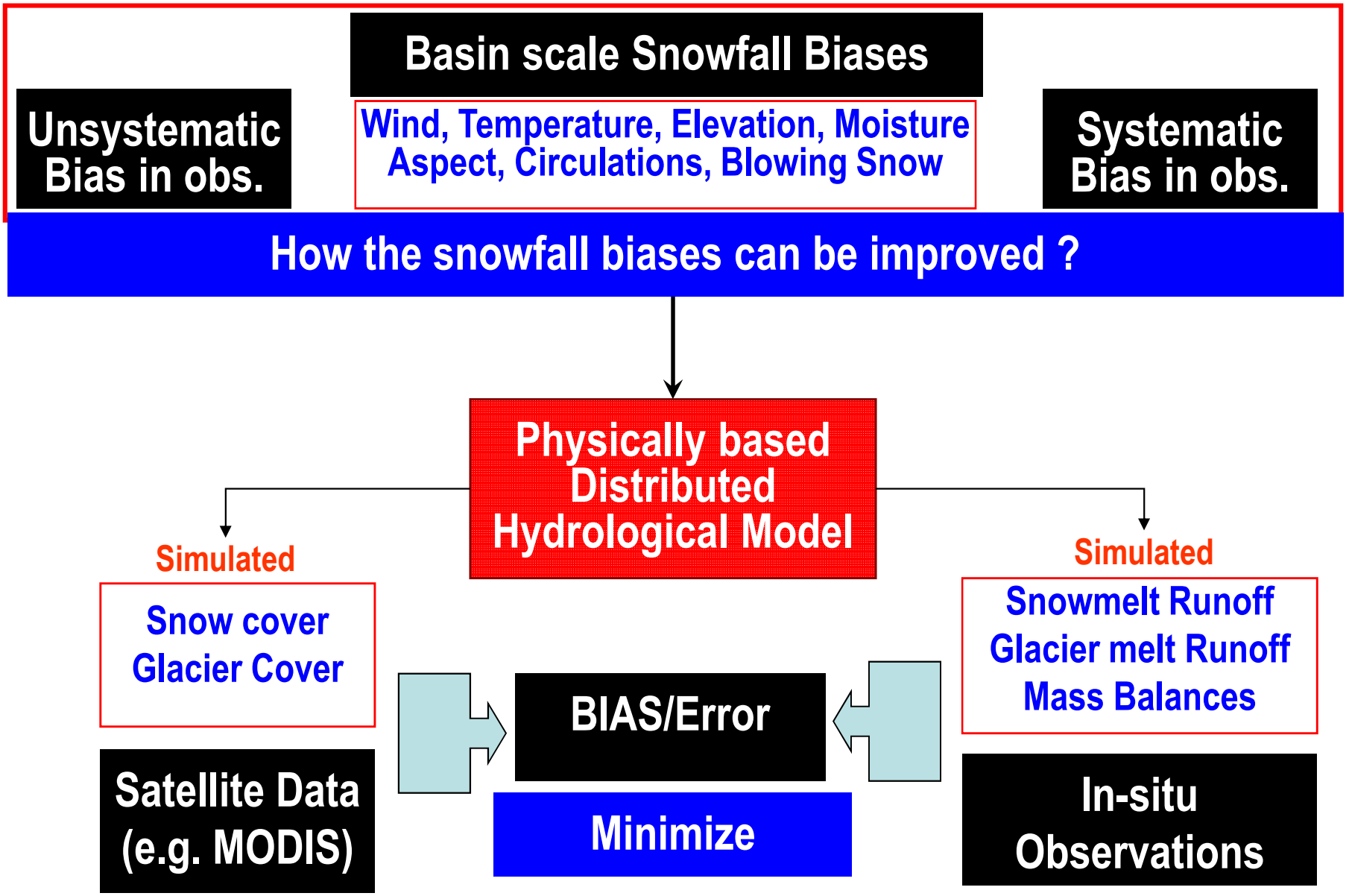
Langtang Basin (340 km^2)



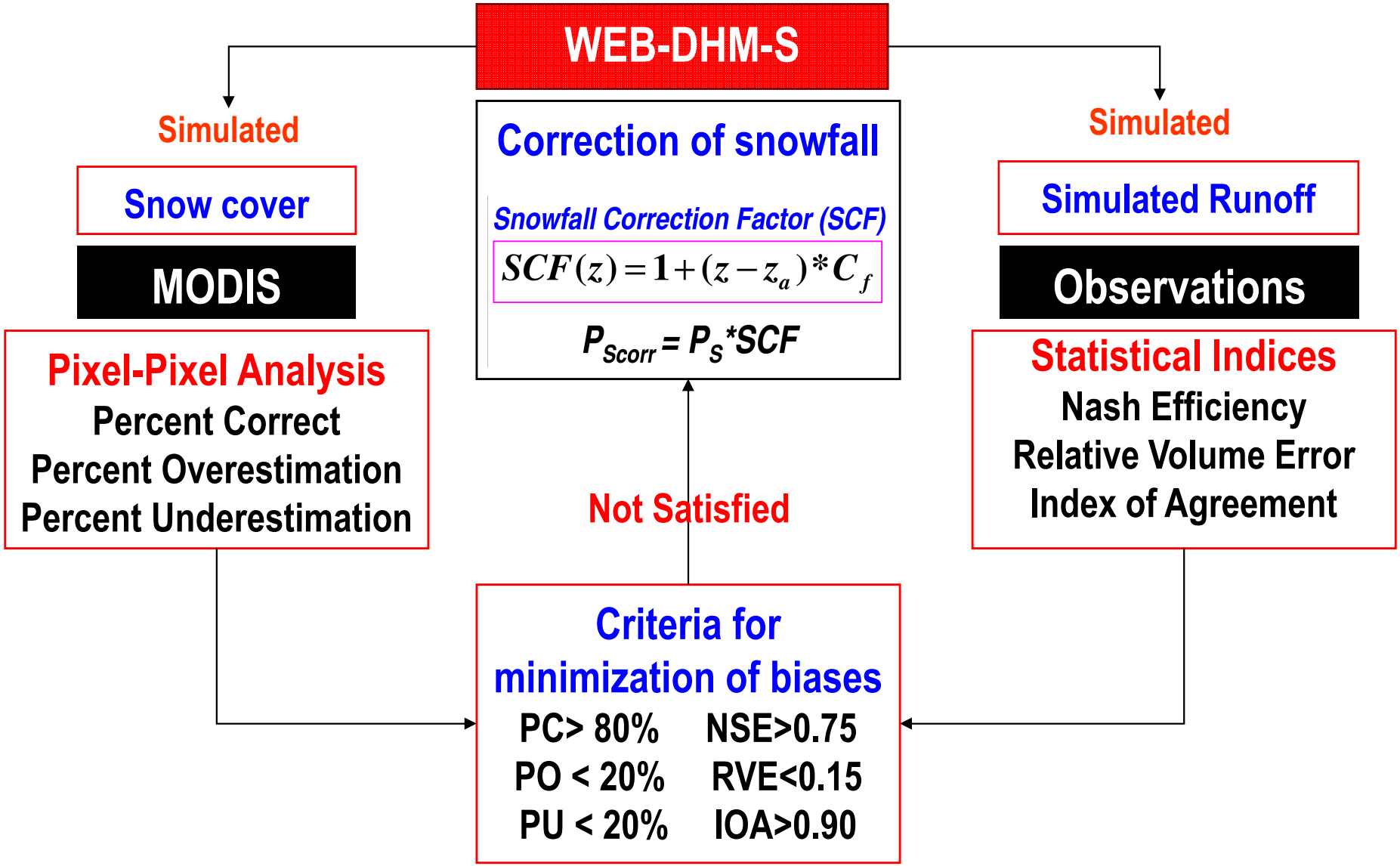




In many cases, basin scale winter precipitation (Snowfall) variability is utmost important



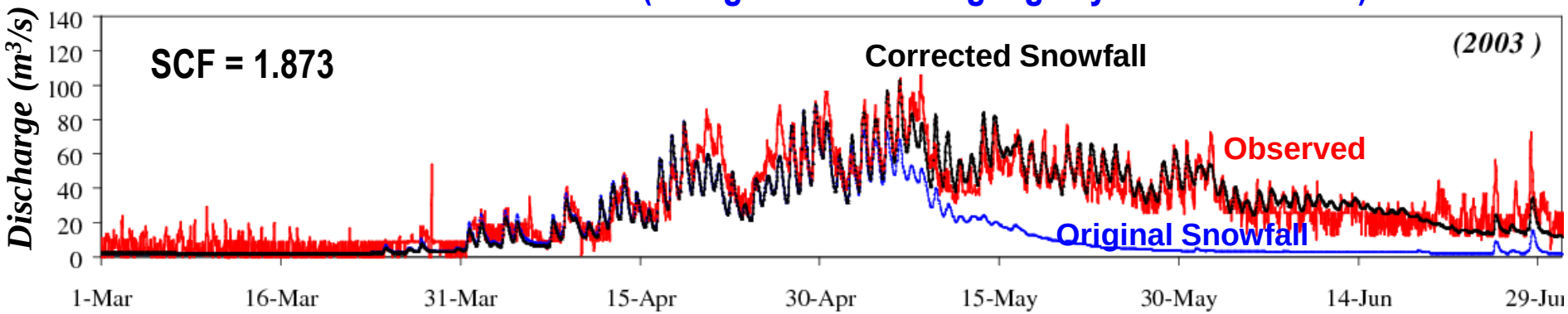
Methodology : Snowfall Correction in basin-scale



C_f = Calibration factor, z = Elevation of the grid, z_a = Avg inverse distance weight Elevation of the rain gauges used in Interpolation

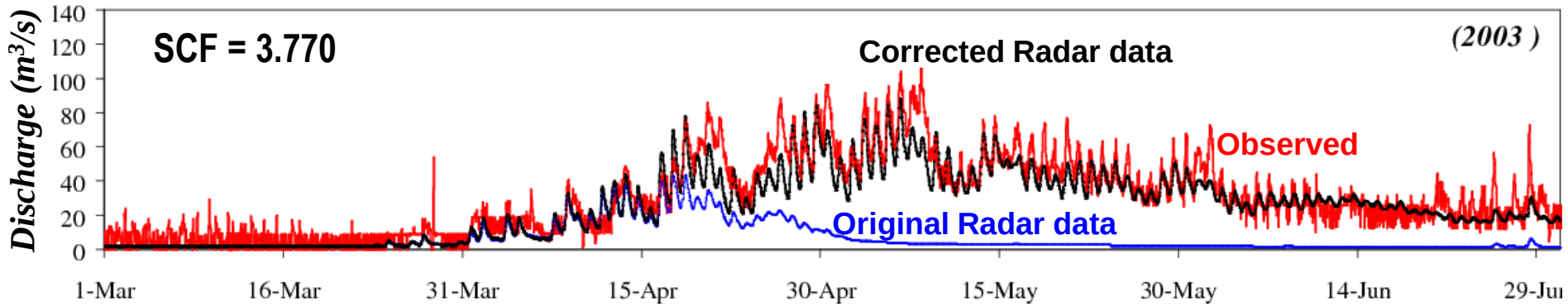
Application at Yagisawa Basin, Japan

Snowmelt Runoff (Using observed raingauge system – AMeDAS)



Statistics	NSE	RE	IOA
AMeDAS	0.20	-50	0.71
Corrected AMeDAS	0.89	-3	0.98

Snowmelt Runoff (Using Radar dataset)



Radar-AMeDAS	-0.40	-80	0.14
Corrected Radar	0.89	-14	0.97

These Corrected Snowfall values can be used to correct Reanalysis dataset for Long-term simulation.

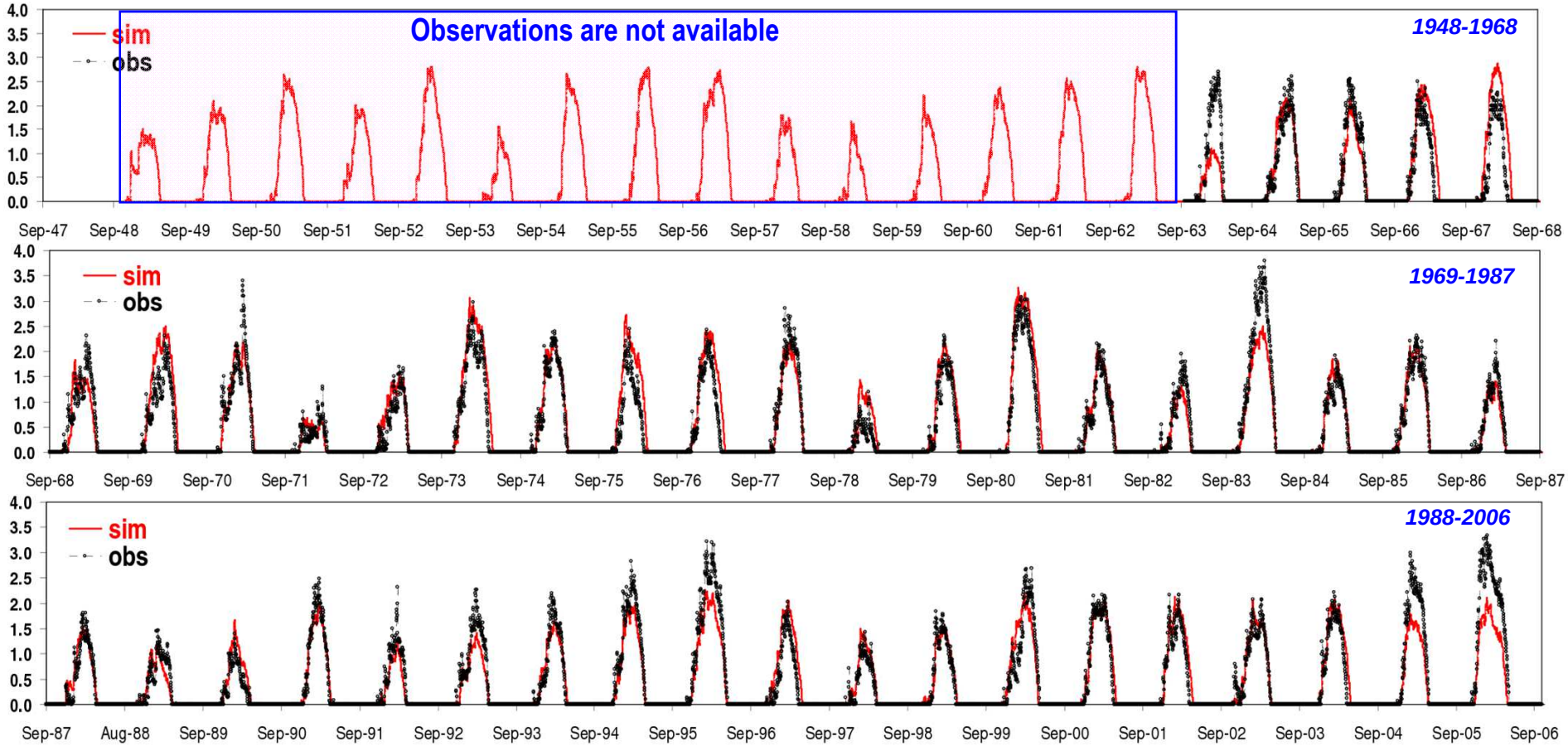
JP10 Reanalysis data (1948-12006) at Yagisawa

Monthly Correction Factor

$$\frac{\text{JP10 raw}}{\text{AMeDAS-Corr}} \rightarrow$$

Correction Factor for JP10 (4 year Average)

Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
1.32.	1.01	0.92	1.40	1.51	2.12	1.30



Interannual Variation of Snow Depth was simulated fairly well

Research Contribution

a) The Model which can simulate the snow processes (depth, water equivalent, density, temperature, albedo, Runoff), Glacier processes and Forest snow processes simultaneously in a basin scale – applicable at wide region.

b) Provides distributed glacier mass balances

c) Successful applicable at HKH river basins.

d) Method for correction of snowfall in basin-scale

e) Response of cold region hydrology to climate change

Thank you !

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