Hydro-meteorological Analysis of Langtang Khola Catchment, Nepal

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Contents

- Introduction and Background
- Objective of the study
- Study area
- Meteorological information
- Hydrological information
- Old snow survey information
- Methodology for flow simulation by SRM
- Future work

Introduction and Background

- Water is main natural resource of Nepal, socio-economy of the country through hydro-electricity and irrigation depends on it
- The current global mean temperature is projected to rise by 0.3 to 4.8 °C by the late-21st century (IPCC, 2013)
- Due to increase of temperature water cycle is intensified causing an increase in global mean precipitation (IPCC, 2013)
- At the same time, there is redistribution causing some areas to receive more or less precipitation depending on the season (IPCC, 2013)

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- High variability in climate, lack of data, large uncertainties in climate change projection by models and uncertainty about the response of snow and glaciers

Objective

- The main objective: Impact of climate change on flow simulation specially to understand the contribution of snow melt at Langtang Khola Hydrological Station

Data collection

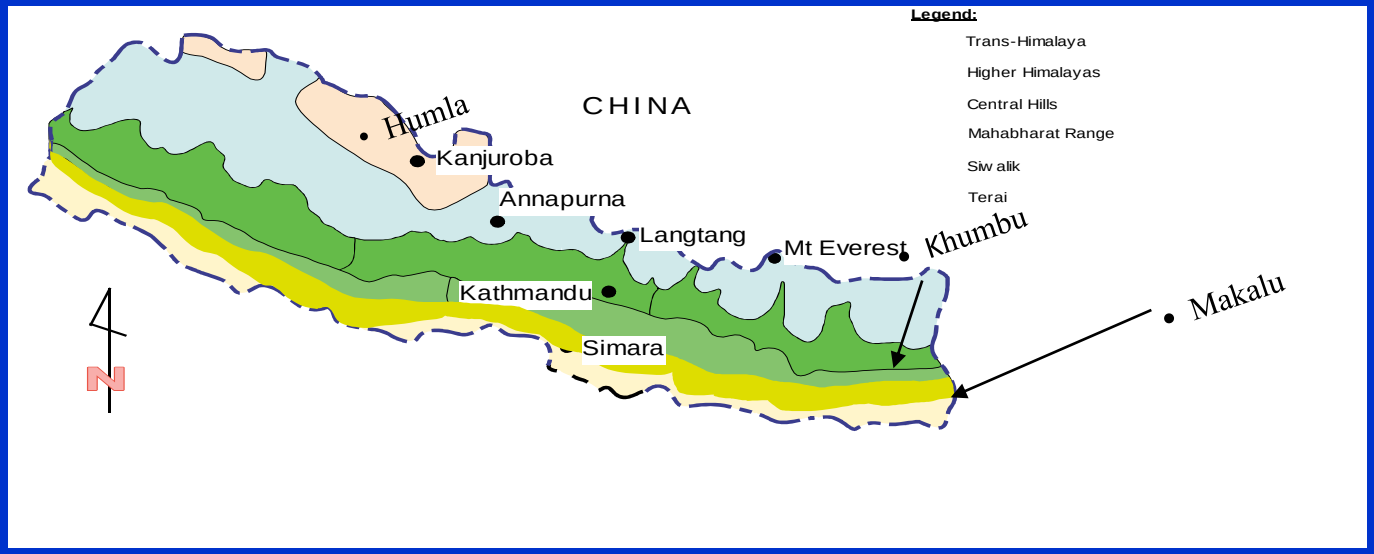
- Hydro-meteorological data are collection from DHM, government of Nepal, DHM is initiated snow and glacier hydrological activities in the year 1987 with the GTZ, Germany as a pilot project for 2 years. Full fledge project was started in the year 1990 and completed in 1997.

During the project period:

- 6 hydroclimatic stations were established in high Himalayas of Nepal
- Introduced tracer technology for determination of river discharge and Established a tracer laboratory

Location of High altitude Hydro- meteorological Stations in Nepal

• Langtang – **3800 m.**	Langtang
•Khumbu – **4335 m**	Imja
•Annapurna – **3470 m**	Modi
•Makalu – **3980 m**	Barun
•Kanjiroba – **3770 m**	Sanu Bheri
•Humla – **4220 m**	Humla Karnali

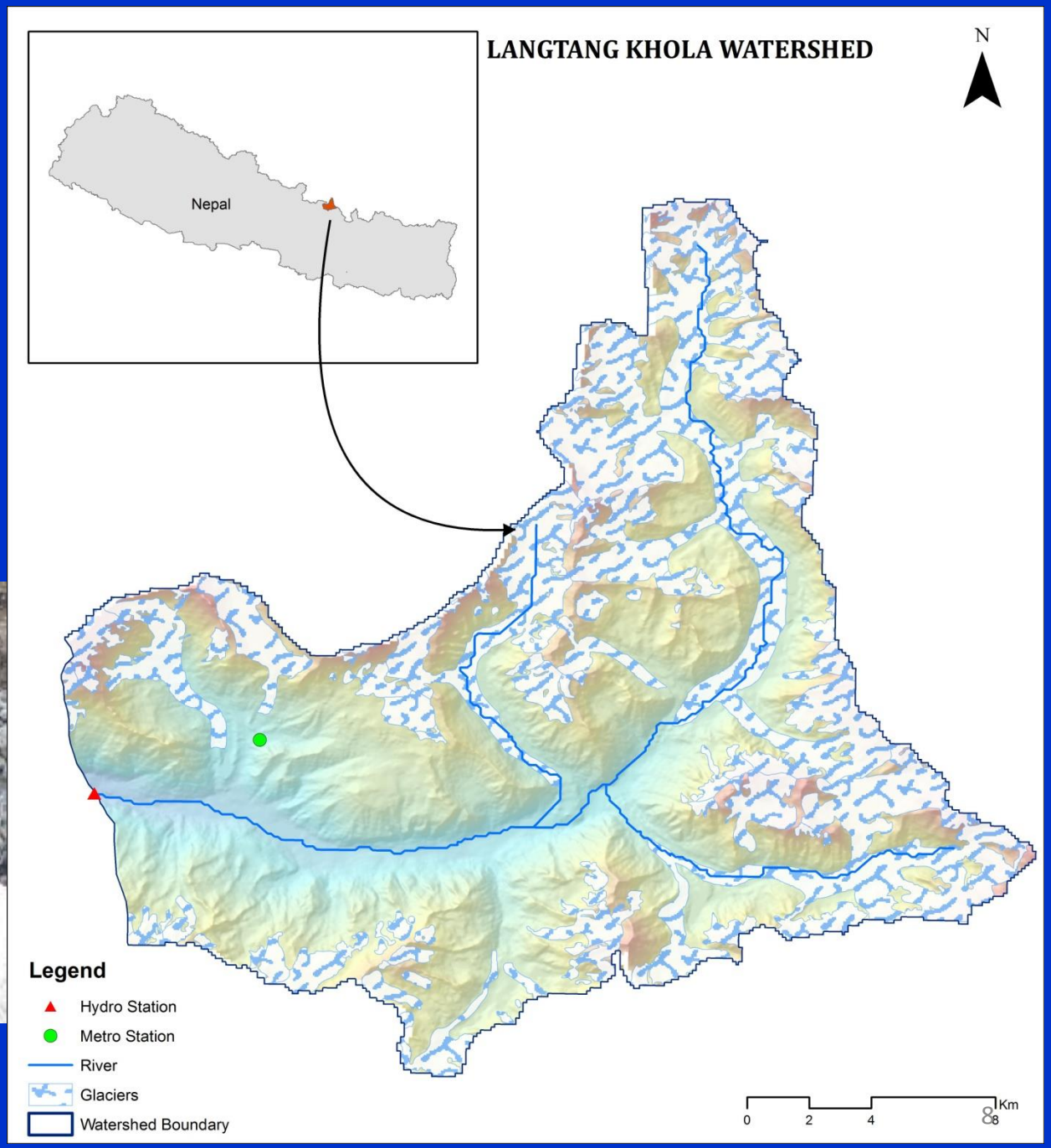


Study Area

Meteorological station:
Latitude: 28^0 12’ 43”
Longitude: 85^0 31’ 34”

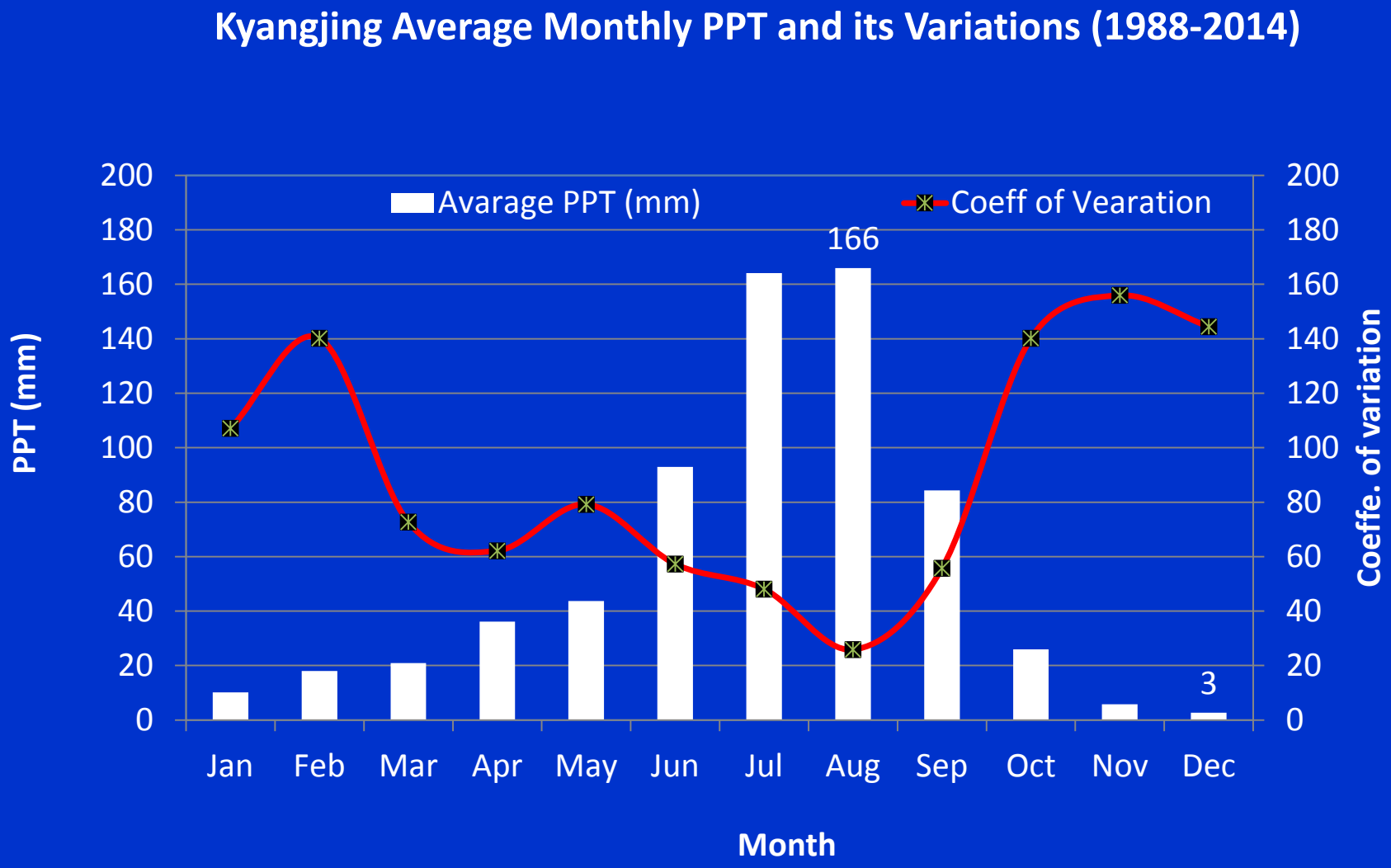
Hydrological station
Latitude: 28^0 13’ 41”
Longitude: 85^0 34’ 28”

Area: 361 Km^2



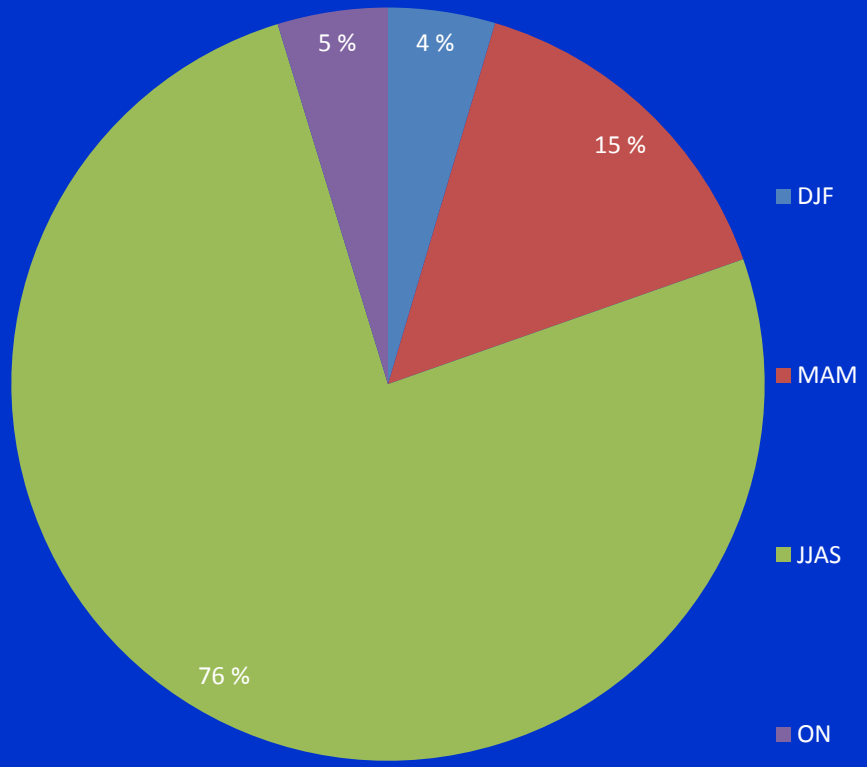
Meteorology of Langtang Khola Kyangjing

Precipitation data information

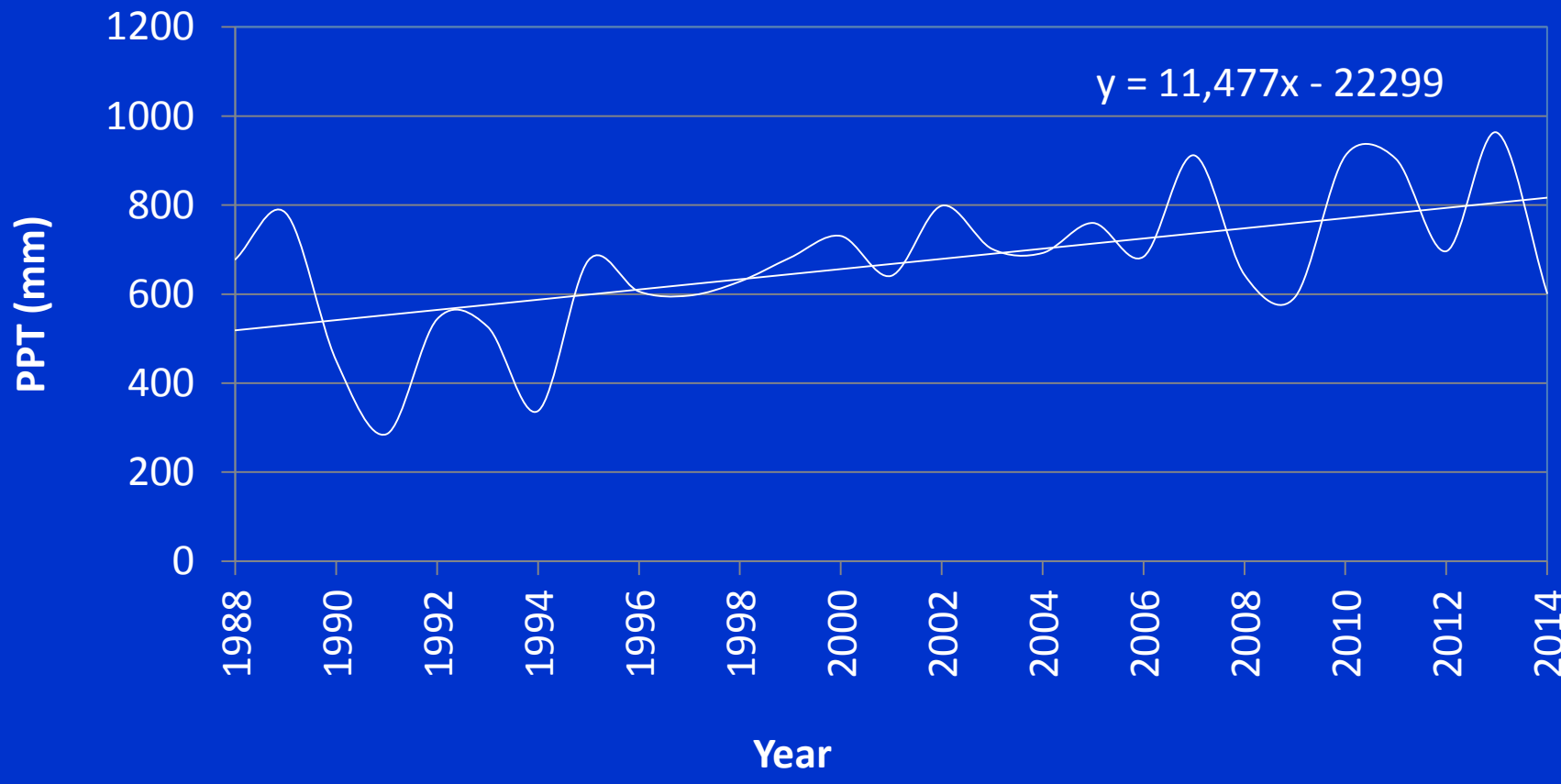


Percentage of Seasonal PPT (1988-2014)

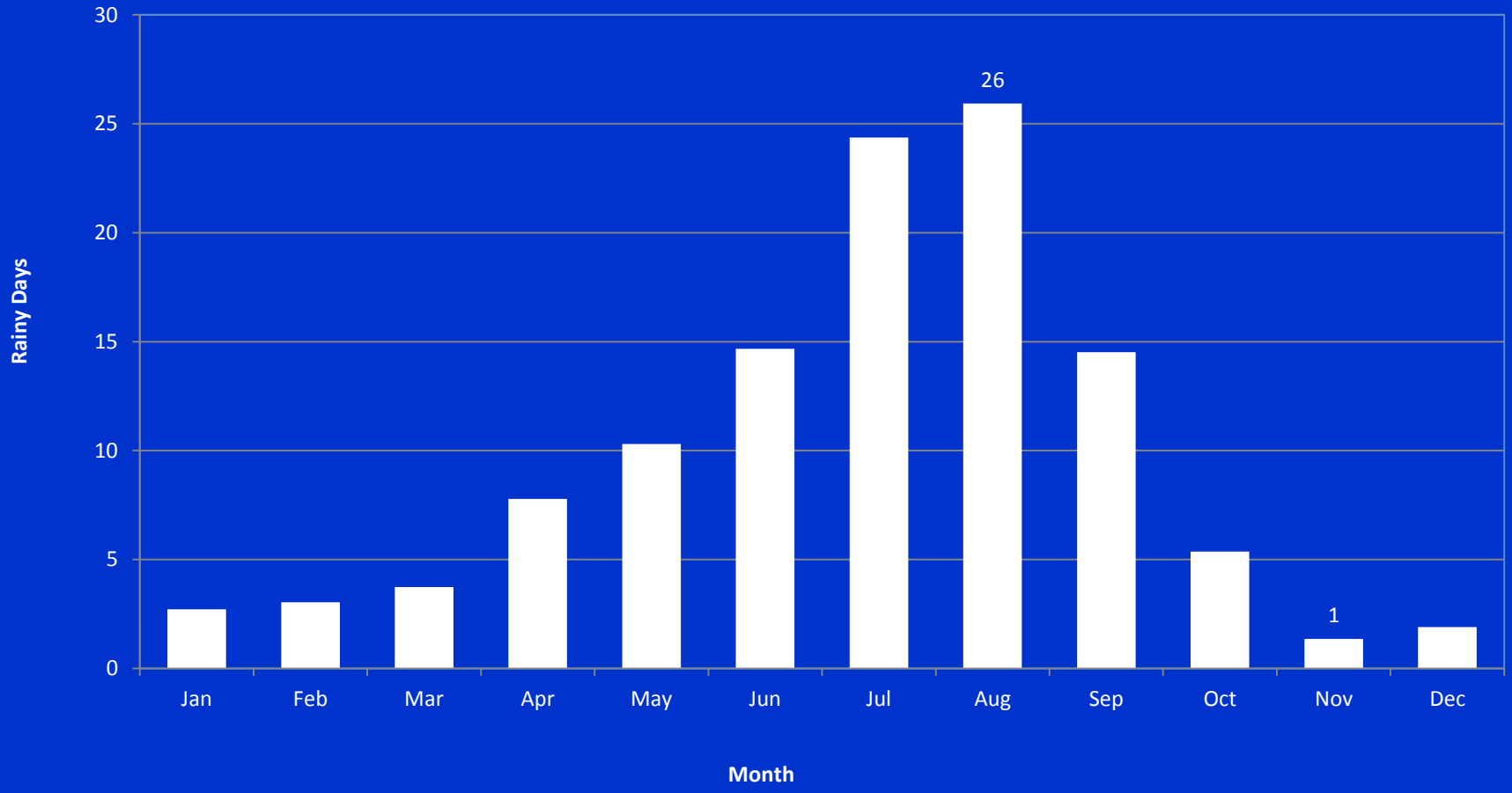
- 76 % of PPT occurs in monsoon season
- 5% of PPT occurs in winter season



Kyangjing Annual PPT (mm) (1988-2014)



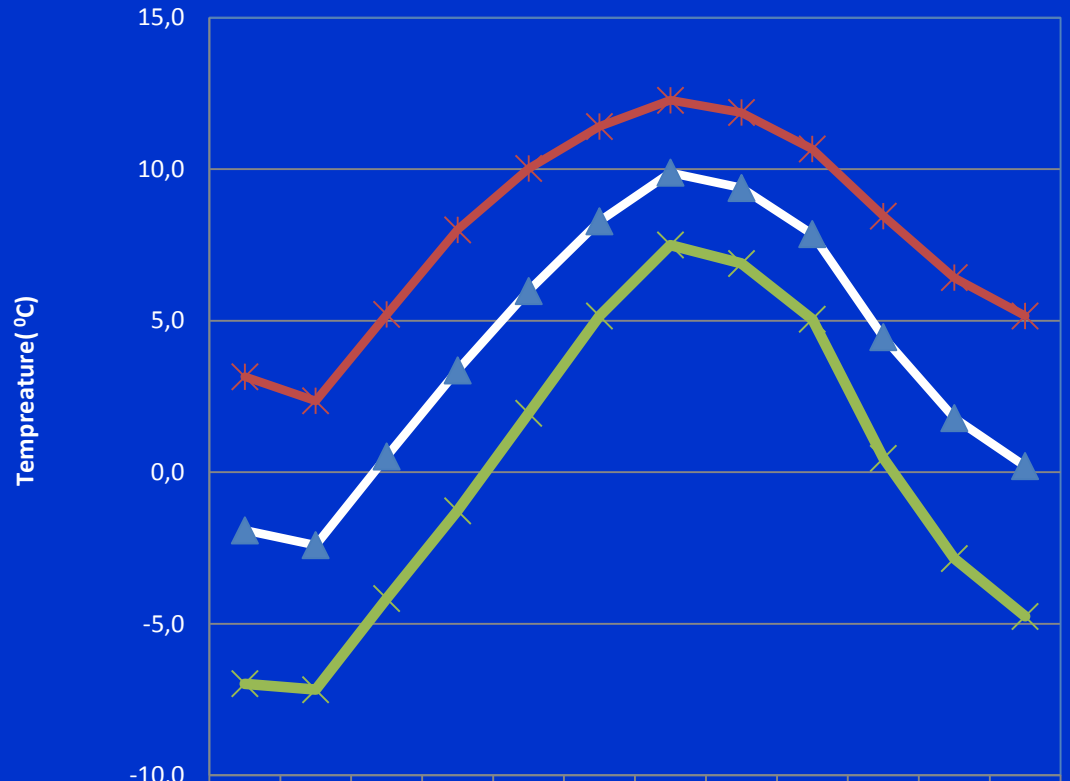
Monthly Average Rainy Days (1988-2014)



Kyagjing Annual Rainy Days (1988-2014)

Monthly Average Temperature (1988-2008)

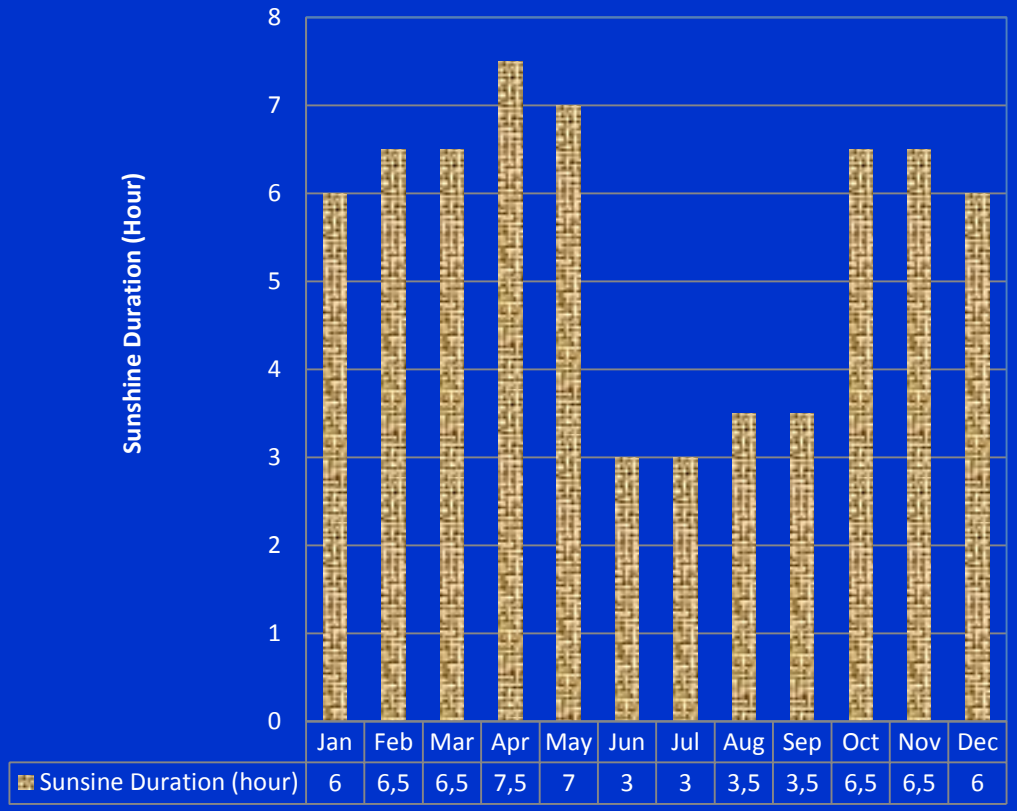
- Warmest is July, the average TMAX is 12.3 ^{0}C
- Coldest is Feb, the average TMIN is 7.2 ^{0}C



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Temp. 0C	-1,9	-2,4	0,5	3,4	6,0	8,3	9,9	9,4	7,9	4,5	1,8	0,2
Maximum Temp. 0C	3,1	2,4	5,2	8,0	10,0	11,4	12,3	11,9	10,7	8,5	6,4	5,2
Minimum Temp. 0C	-7,0	-7,2	-4,2	-1,3	1,9	5,2	7,5	6,9	5,0	0,5	-2,8	-4,8

Monthly Average Sunshine duration situation (1988-2008)

- Lowest sunshine duration Jun and July due to monsoon cloud activity
- Highest sunshine duration occurs in April



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sunsine Duration (hour)	6	6,5	6,5	7,5	7	3	3	3,5	3,5	6,5	6,5	6

Historical Snow Measurements in Langtang valley

Snow measurements work in Feb,1991
Department of Hydrology and Meteorology, Governments of Nepal

Historical Snow Measurement Data

Date: 25 Feb 1991

Height 4980 m

Exposition SE

Slope Gentile

Plce Tsergo-Ri Langtang

Time15 PM

Air Temperature -8^{0}C

Weather Cloudy

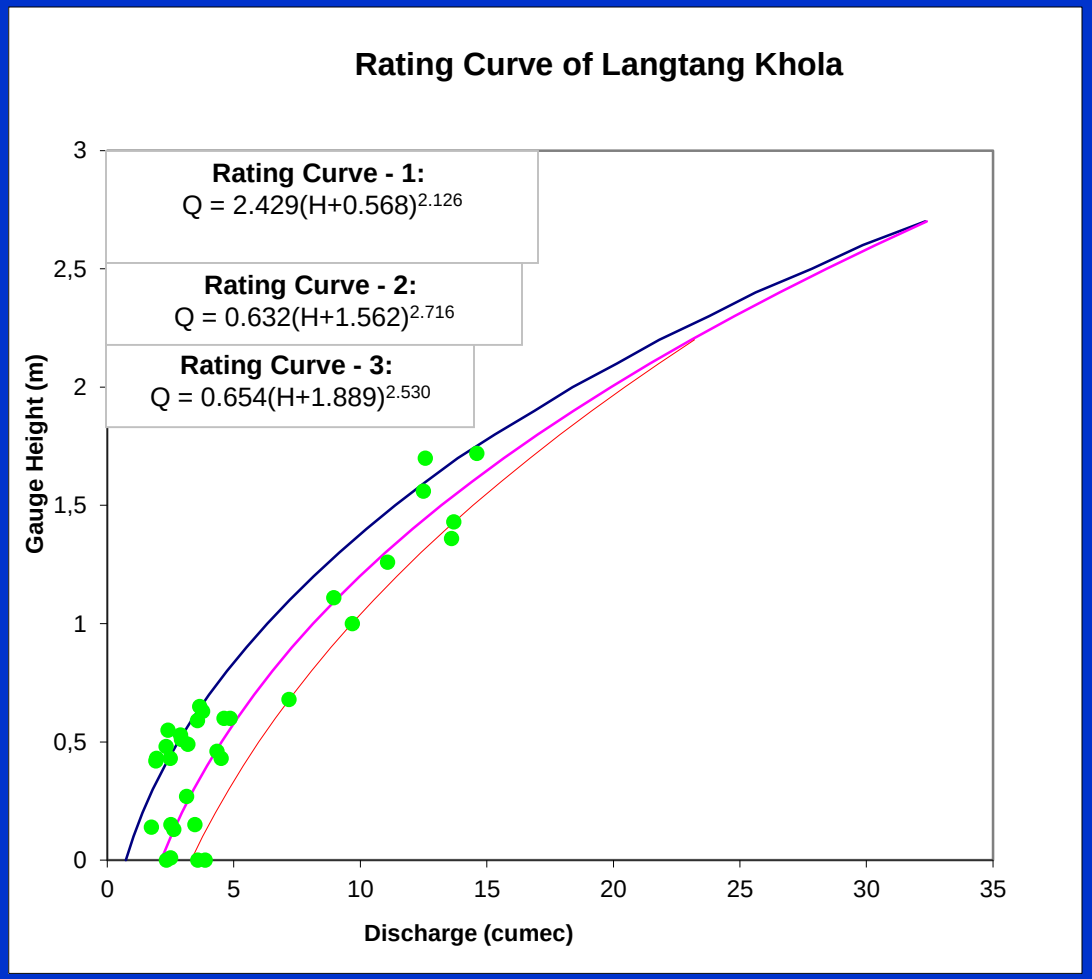
Level	1 Height cm	1 WE (mm)	2 Height (cm)	2 WE (mm)	2 Height (cm)	3 WE (mm)	4 Mean density (g/cm^3)
1	28	59	29	62	29	60	0.21
2	47	198	47	202	47	194	0.42
3	40	170	42	180	40	172	0.42
Sum	115	427	118	444	116	426	0.37

WE = D* h* 10

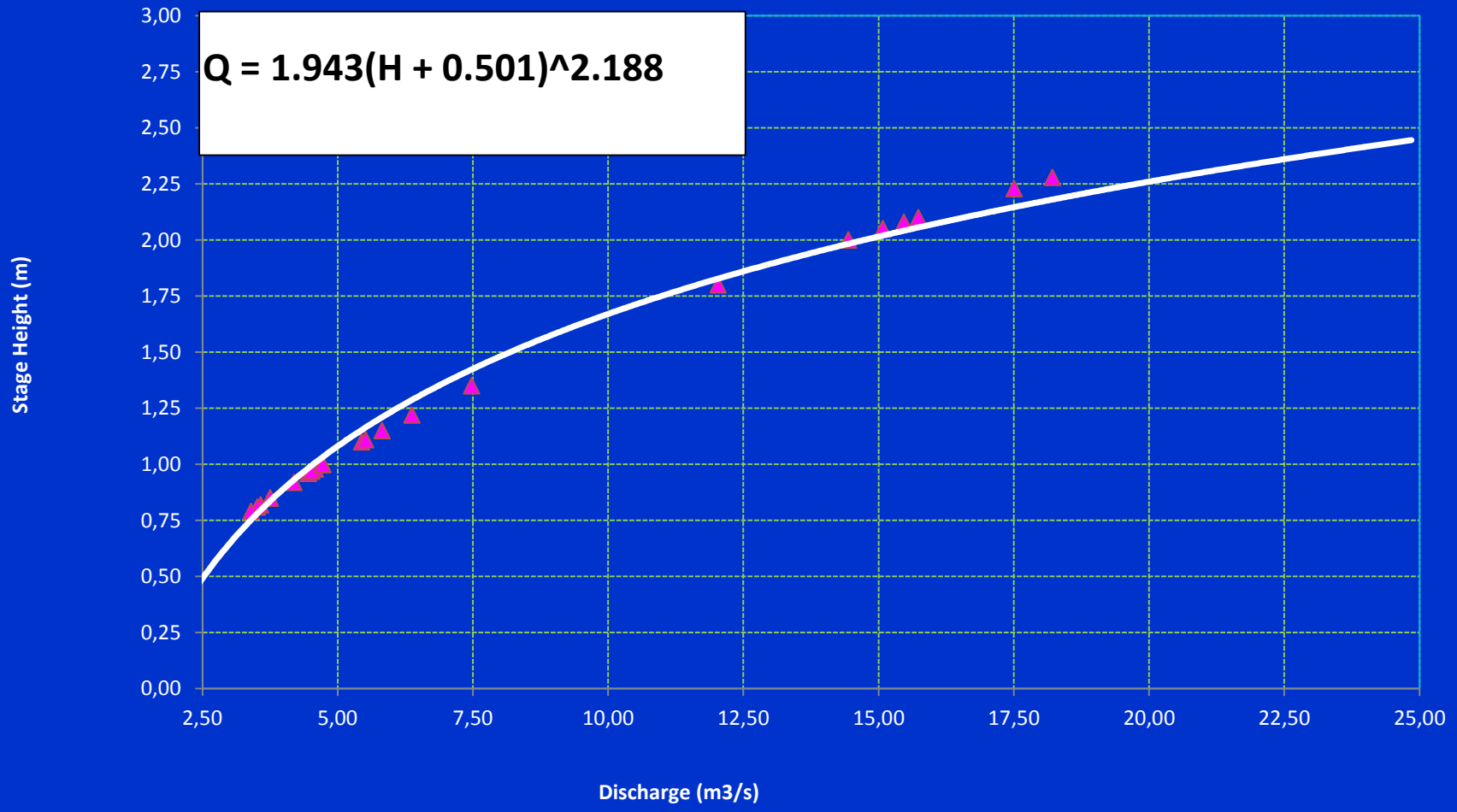
Density = WE/(h*10)

Hydrology of Langtang Khola

Validity Rating Curve No.	From	To
1	01.01.1991	13.06.1993
2	14.06.1993	08.10.1993
1	09.10.1993	29.04.1997
2	30.04.1997	05.04.1999
1	06.04.1999	04.06.2002
3	05.06.2002	13.09.2002
2	14.09.2002	31.12.2006

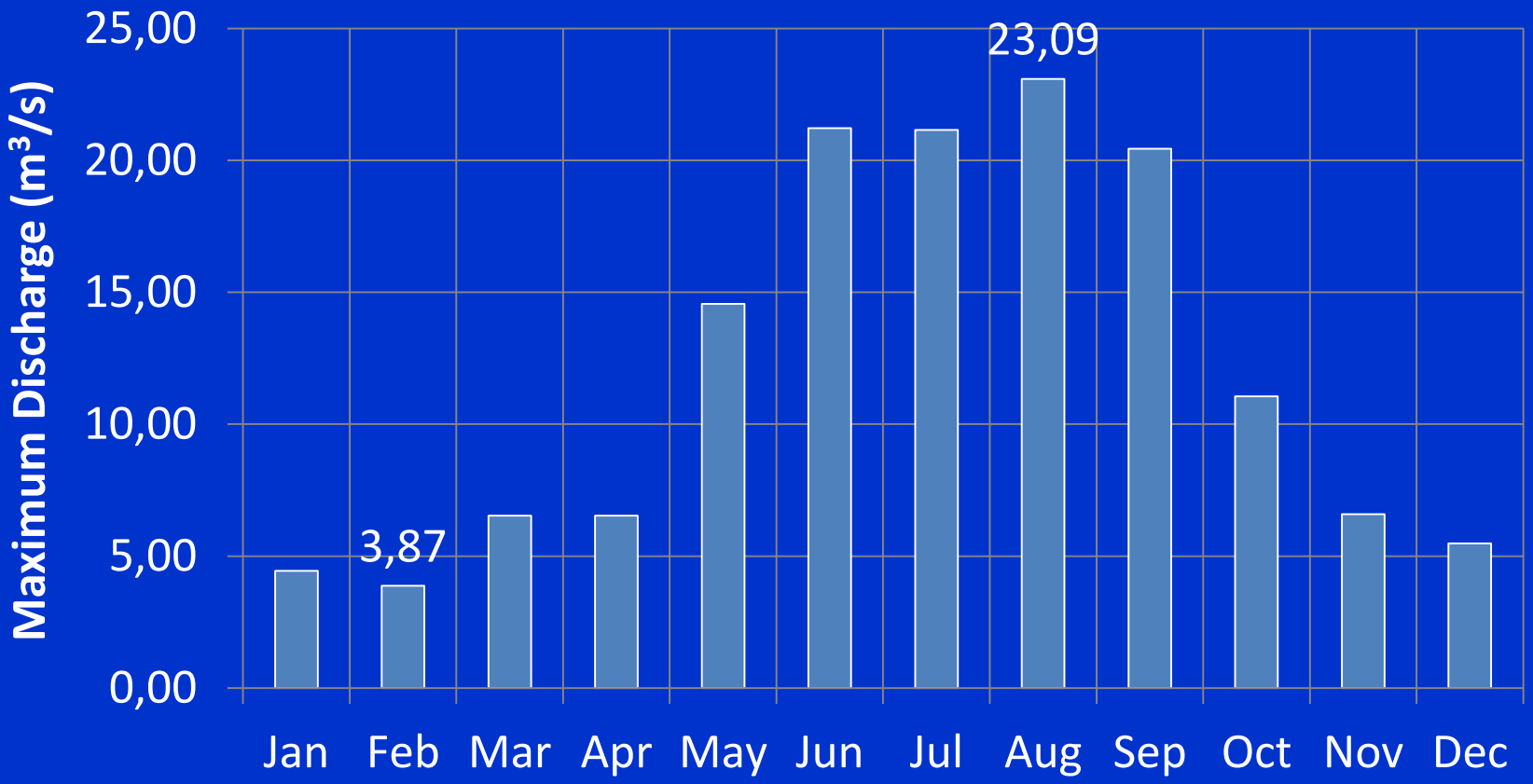


Rating Curve of Langtang Khola (2006 - 2013)



Langtang Khola Stage Height (m)_2013

Monthly Maximum Discharge in Langtang Kola



Annual Observed Discharge Trend (1988-2014)

Methodology for flow simulation by Snowmelt Runoff Model (SRM)

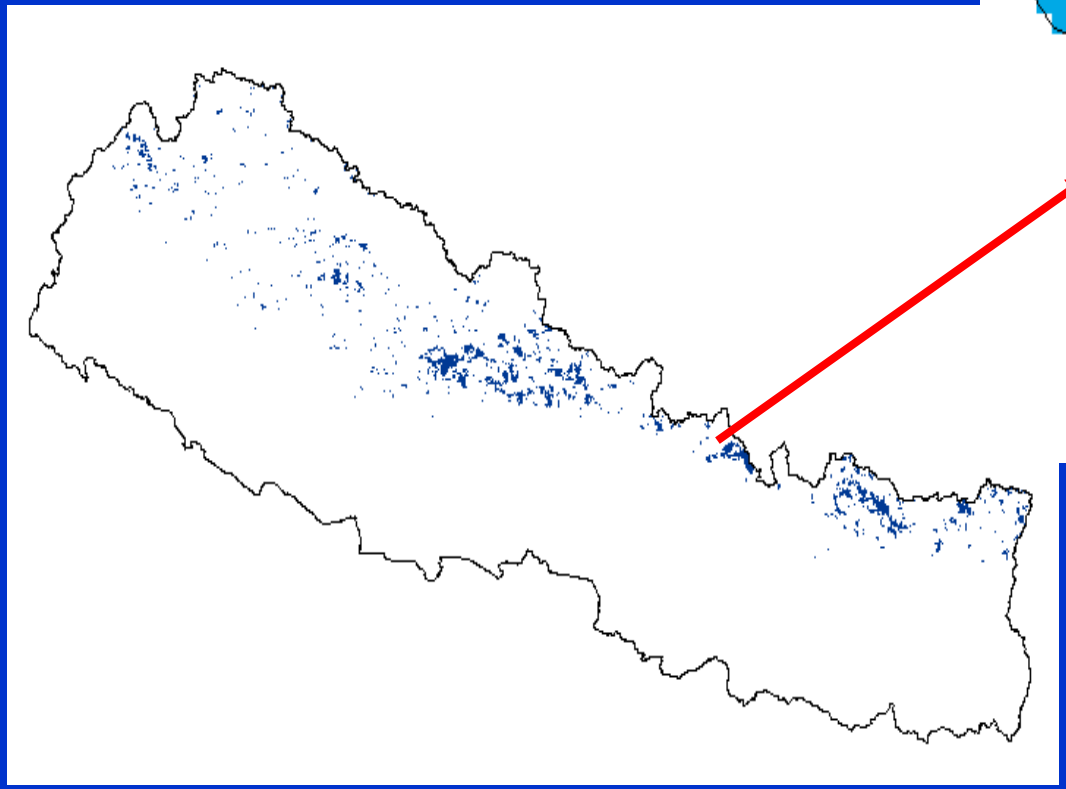
Flow simulation year

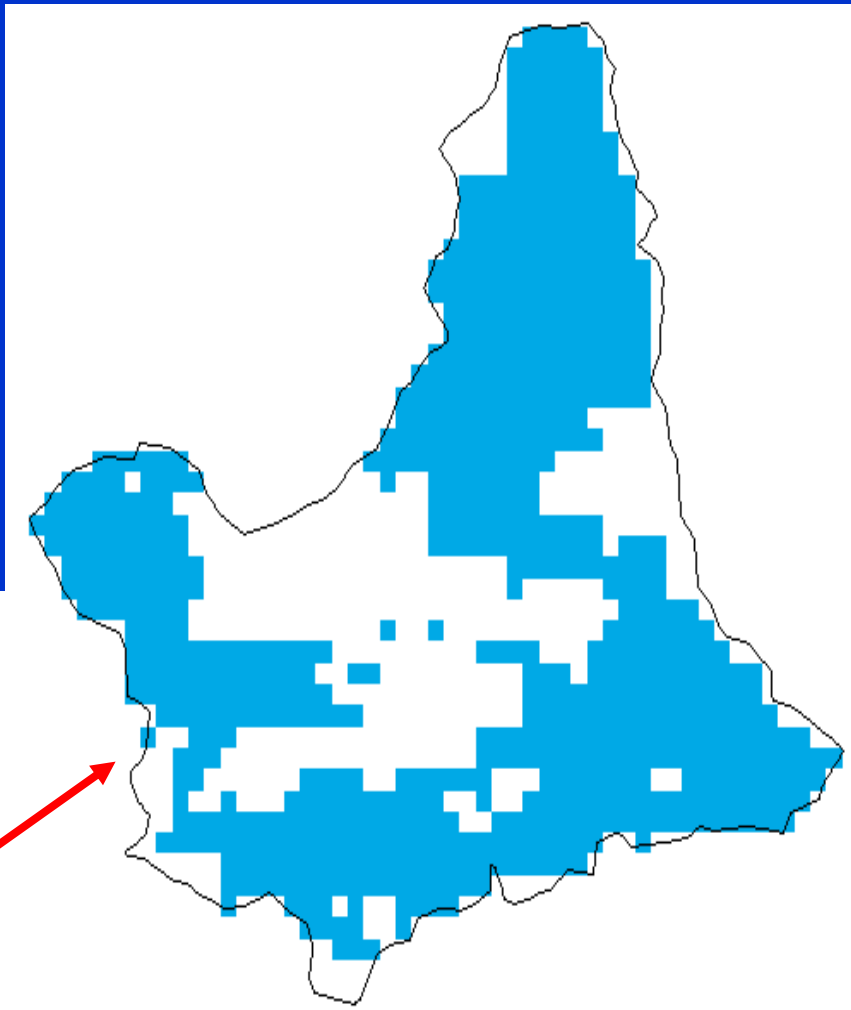
- After pre-processing and analyzing the hydro-meteorological data of Kyangjing
- 2000 - 2006 will be taken as parameter calibration year
- 2007 - 2013 will be taken as validation year

Introduction to Snowmelt Runoff Model (SRM)

- Developed by Martinec in 1975 in Swiss Snow and Avalanche Research Institute
- Estimation of daily stream flow in Mountain basins
- Based on degree day method, can be used to simulate/forecast
- Simple and Efficient

Snow cover map of Langtang Catchment 25 Feb 2015





Snow Cover Mapping of Langtang

- MODIS Daily Snow products
- Preprocessing and processing of MODIS snow products using : MODIS Reprojection tool
- Which includes;
  - Mosaicking
  - Spatial and temporal filtering

Generation of daily snow cover area of Langtang Catchment

Basic snowmelt runoff model

$$Q_{n+1} = [c_{Sn} \cdot a_n (T_n + \Delta T_n) S_n + c_{Rn} \cdot P_n] (A.10000/86400) (1-k_{n+1}) + Q_n k_{n+1}$$

Snow melt

Rainfall

Flow Recession

Q : Basin discharge

n : Day indicator

T : Air temperature

P : Precipitation falling as rain

S : Snow covered area

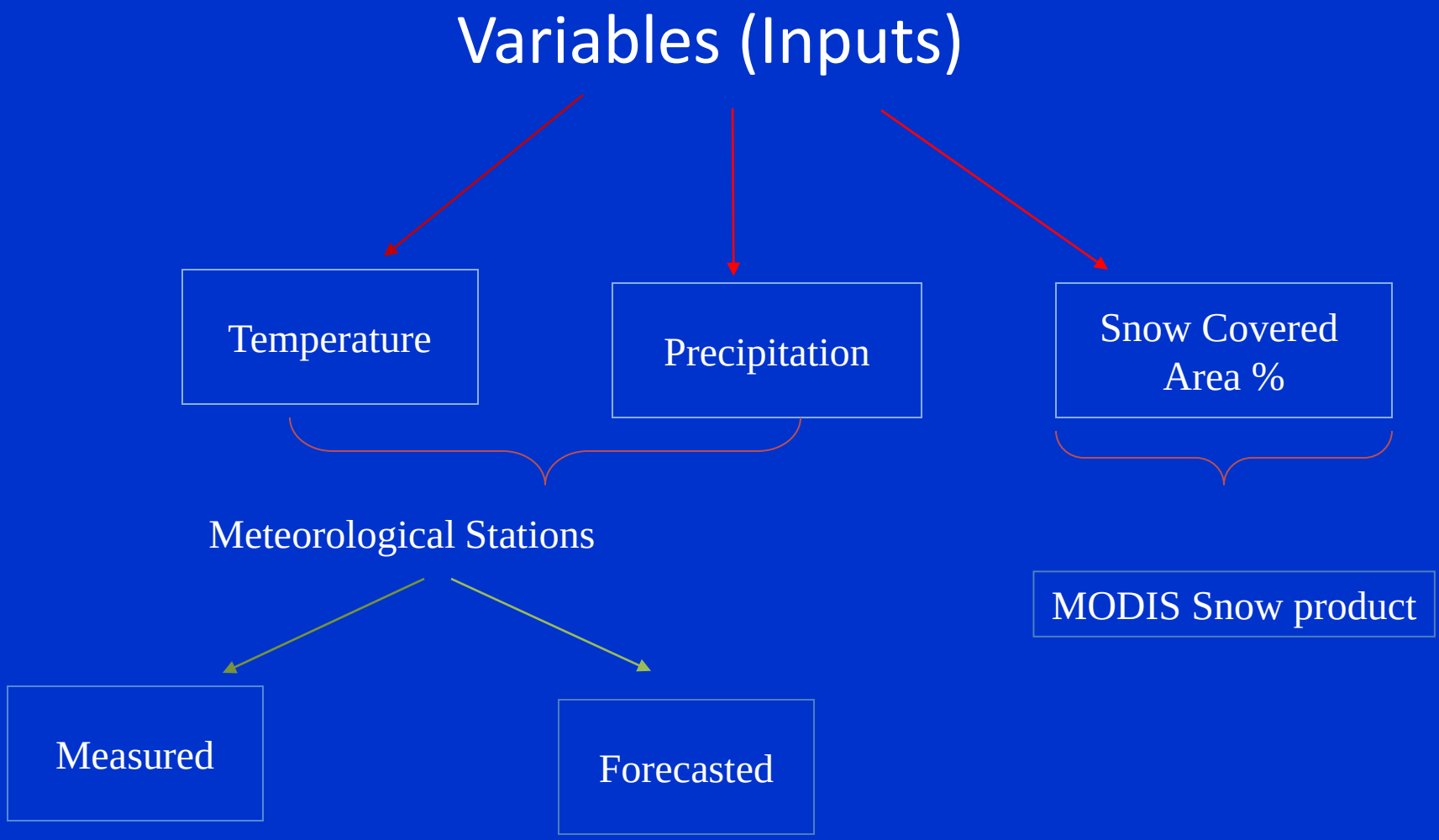
A : Zonal area

k_{n+1}: Recession coefficient

a_n : Degree day factor

c_{sn},c_{rn} : correction for losses due to snowmelt and rainfall

Cont….


Variables (Inputs)
Temperature
Precipitation
Snow Covered Area %
Meteorological Stations
MODIS Snow product
Measured
Forecasted

Cont…

7Parameters

- Runoff Coefficients (c_s,c_r)
- Degree Day Factor (a)
- Temperature Lapse Rate (γ)
- Critical Temperature (T_{crit})
- Rainfall Contributing Area
- Time Lag (L)
- Recession Coefficient

Future work

- Calibration and Validation of SRM
- Simulate daily discharge
- Calculating runoff components in Langtang Catchment
- The research is still going on

Thank You