Comparison of HD model output to river gauging observations for the Upper Indus Basin

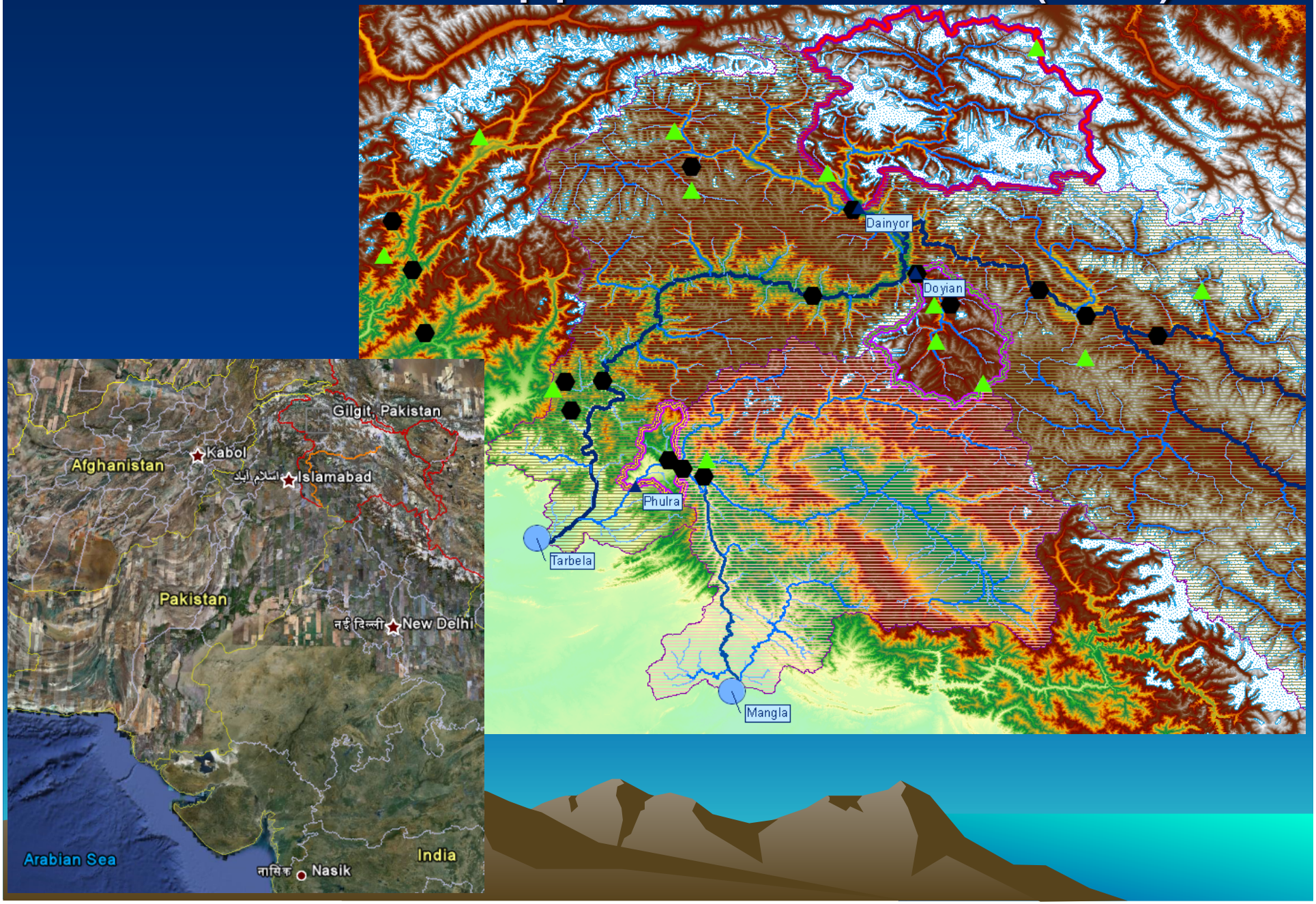
Presentation to workshop on
Water Resources in Developing Countries : Planning & Management in a Climate Change Scenario,
ICTP-Trieste -- 8 May 2009

-- by Muhammad Akhtar, Punjab University/PMD,
Amjad Massood, Global Change Impacts Studies Centre – Islamabad
And Nathan Forsythe, Newcastle University

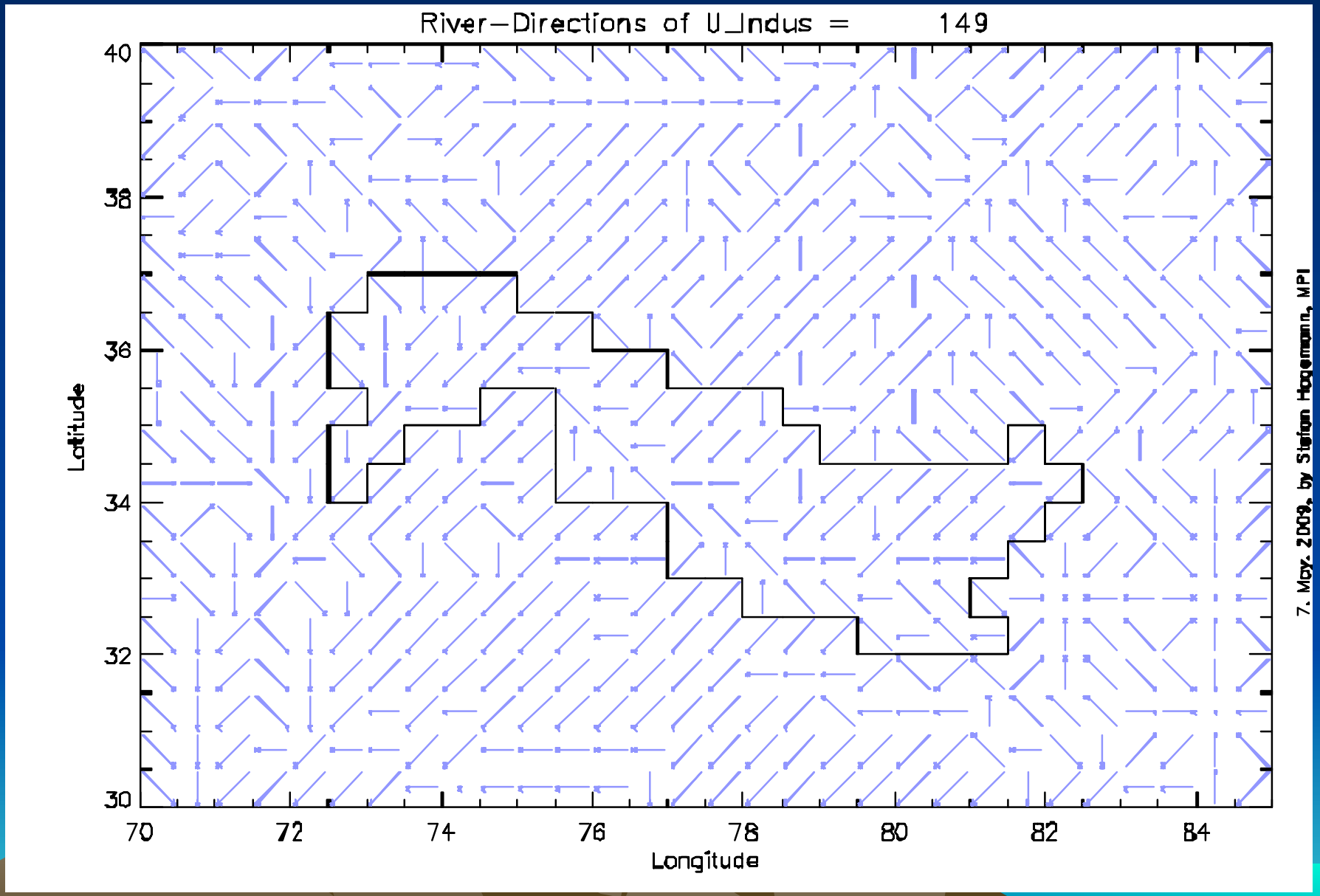
Overview of presentation

- Upper Indus Basin (UIB) location & context
- Comparison of HD-simulated & observed hydrographs & cumulative runoff
- Subcatchment scale comparison
- Comparison of ERA40 input climatology and spatial estimations from gridded datasets
- Insights from local observations

Location of the Upper Indus Basin (UIB)

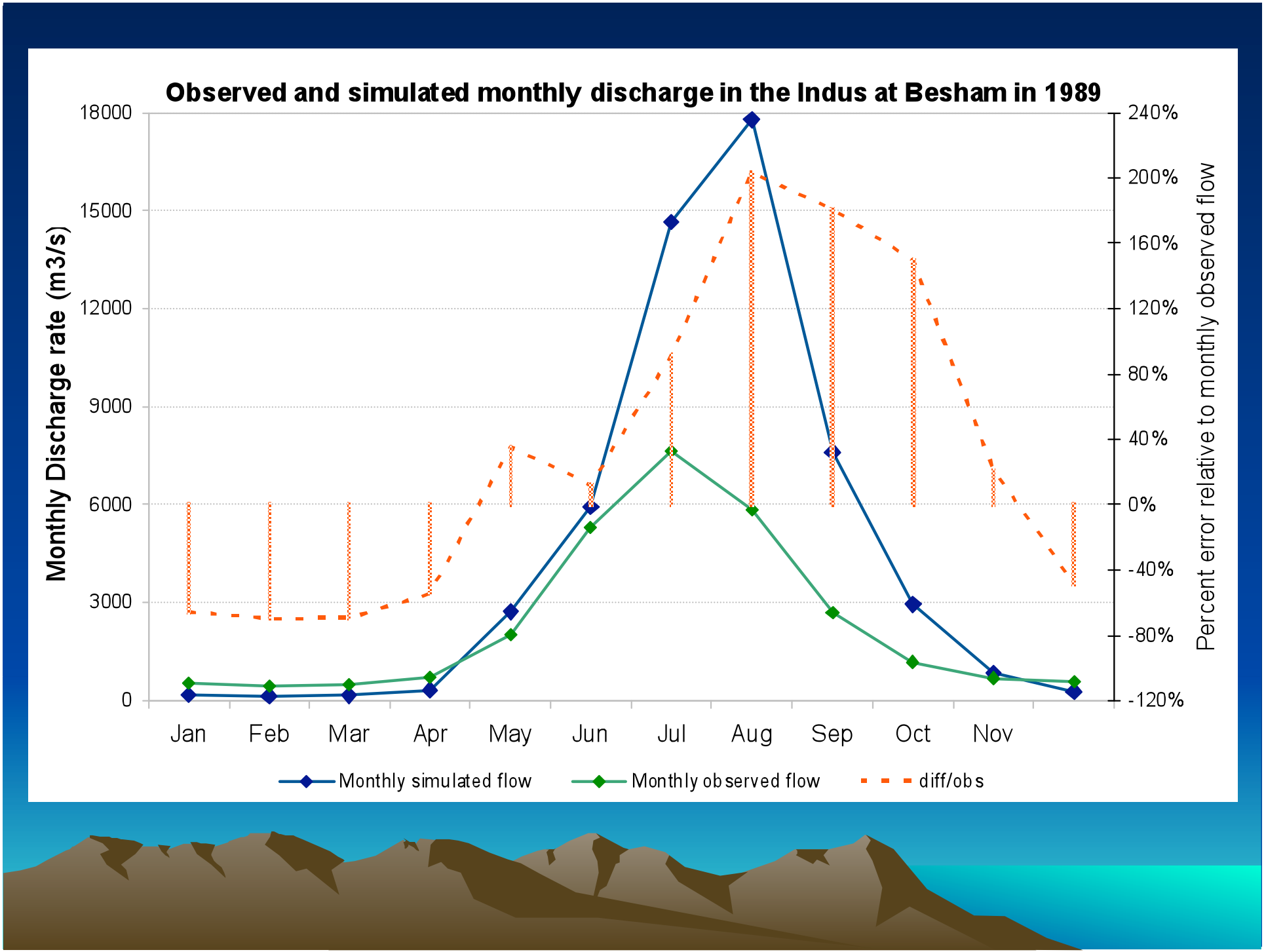


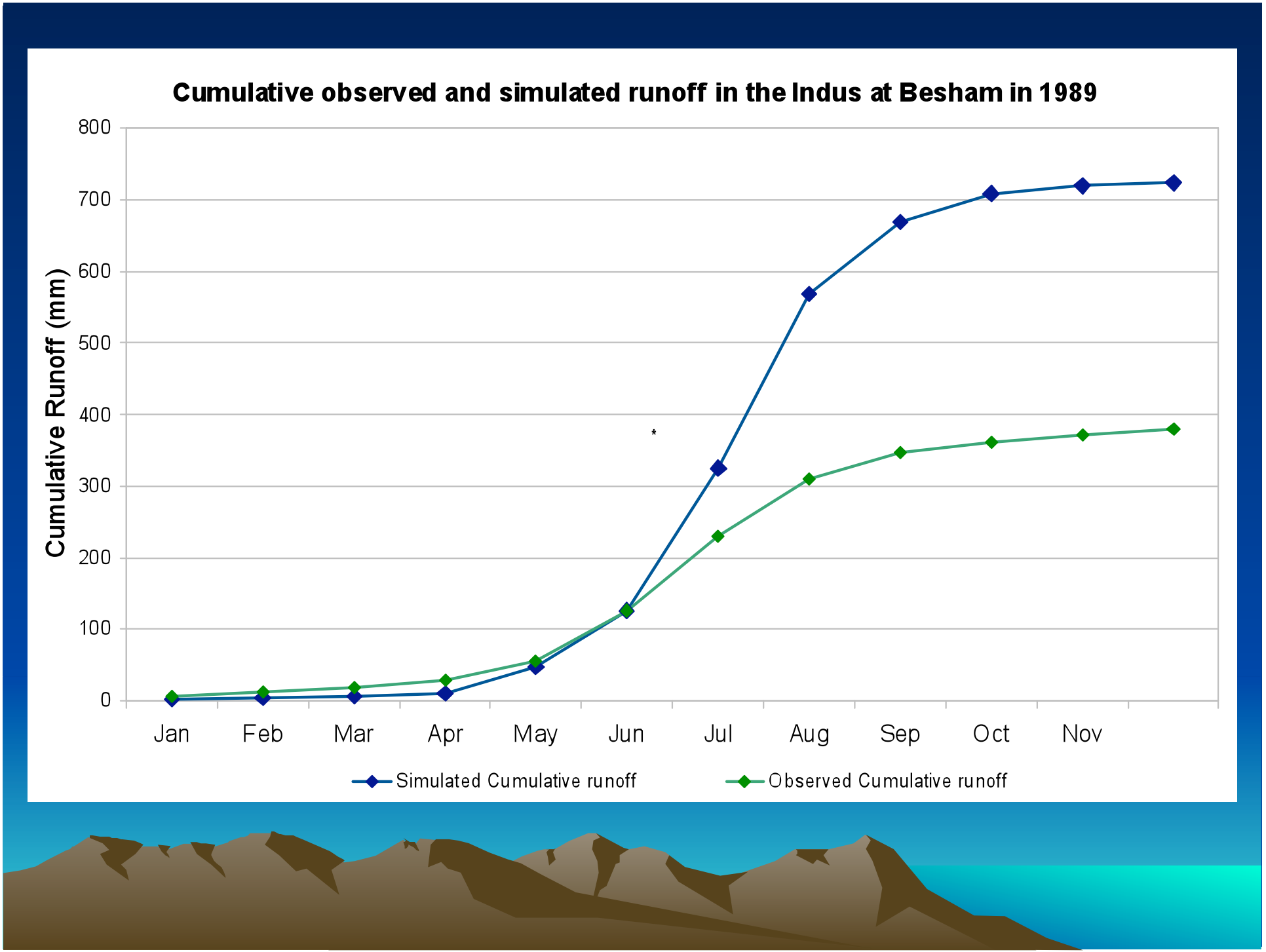
Model discretisation of UIB

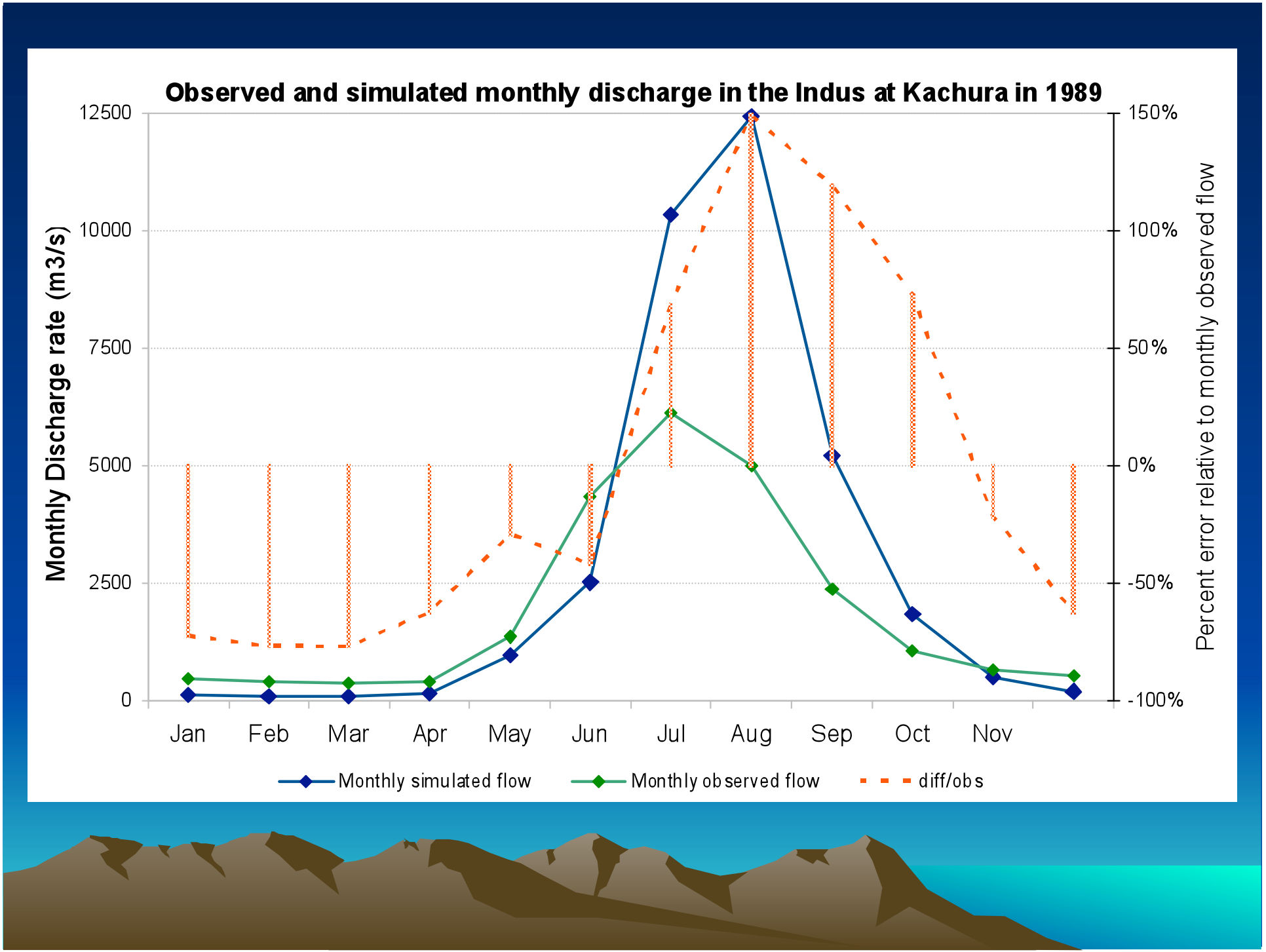


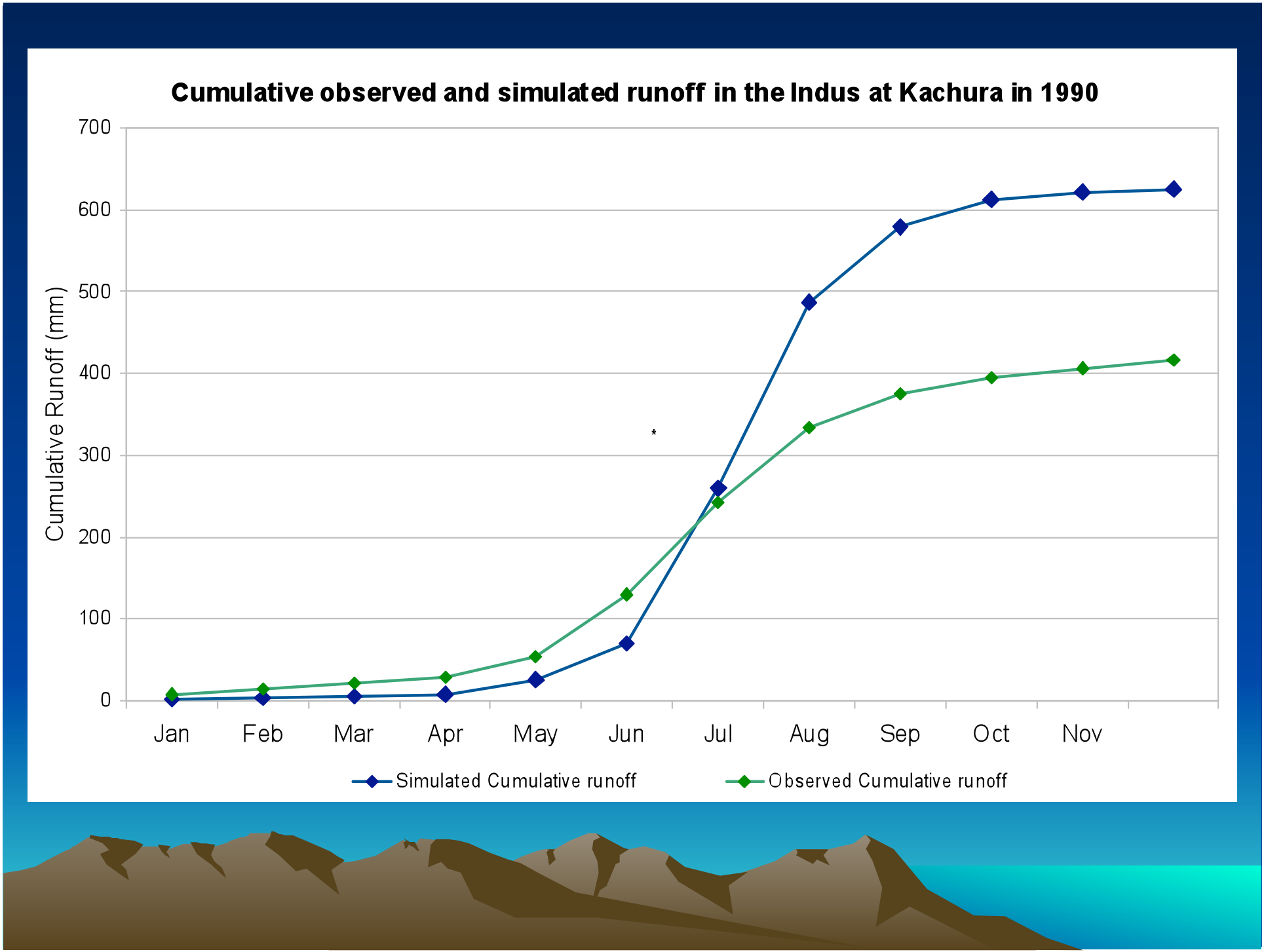
Comparison of HD-simulated and observed hydrographs & cumulative runoff

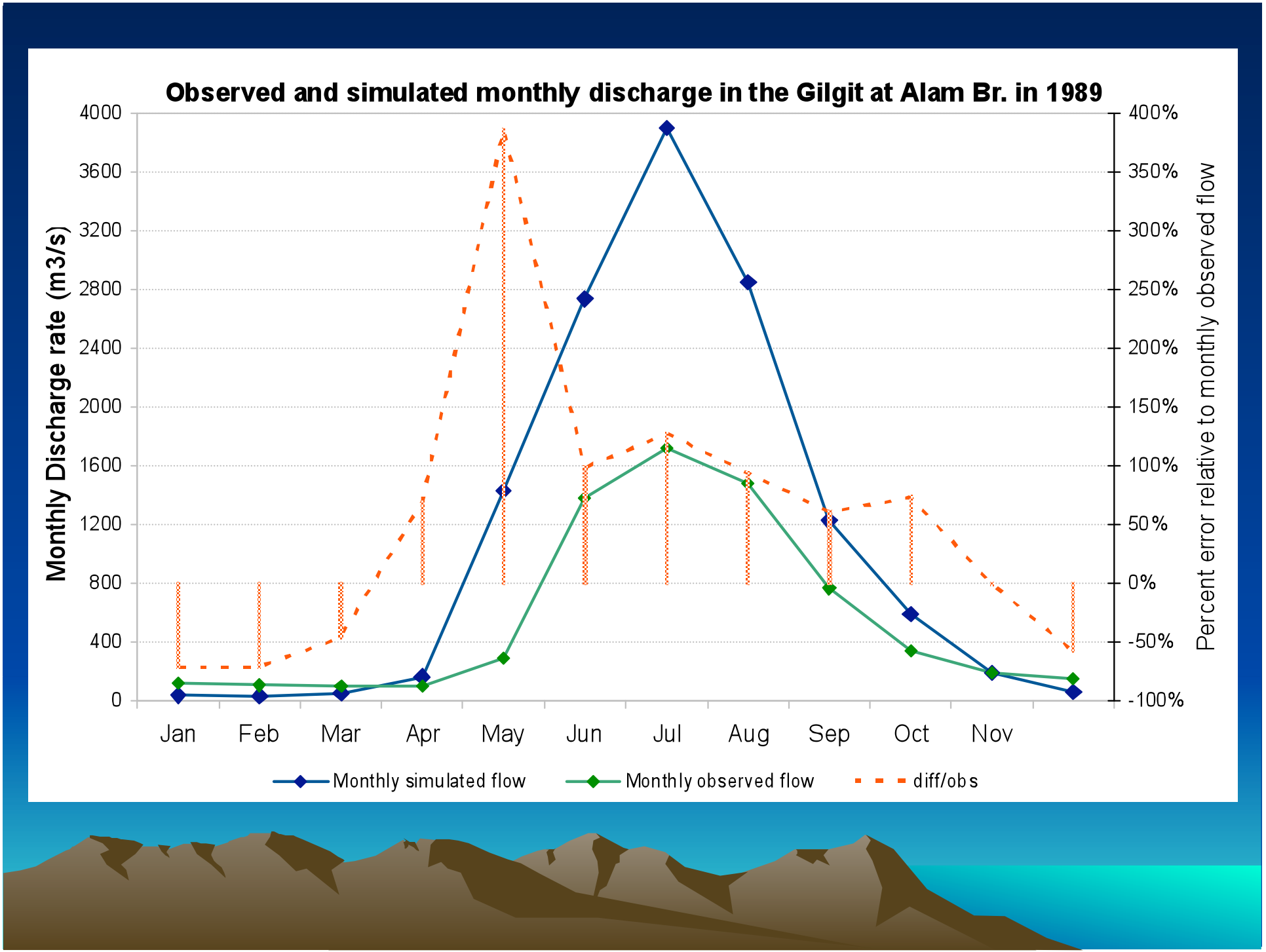
with consideration of subcatchment scale

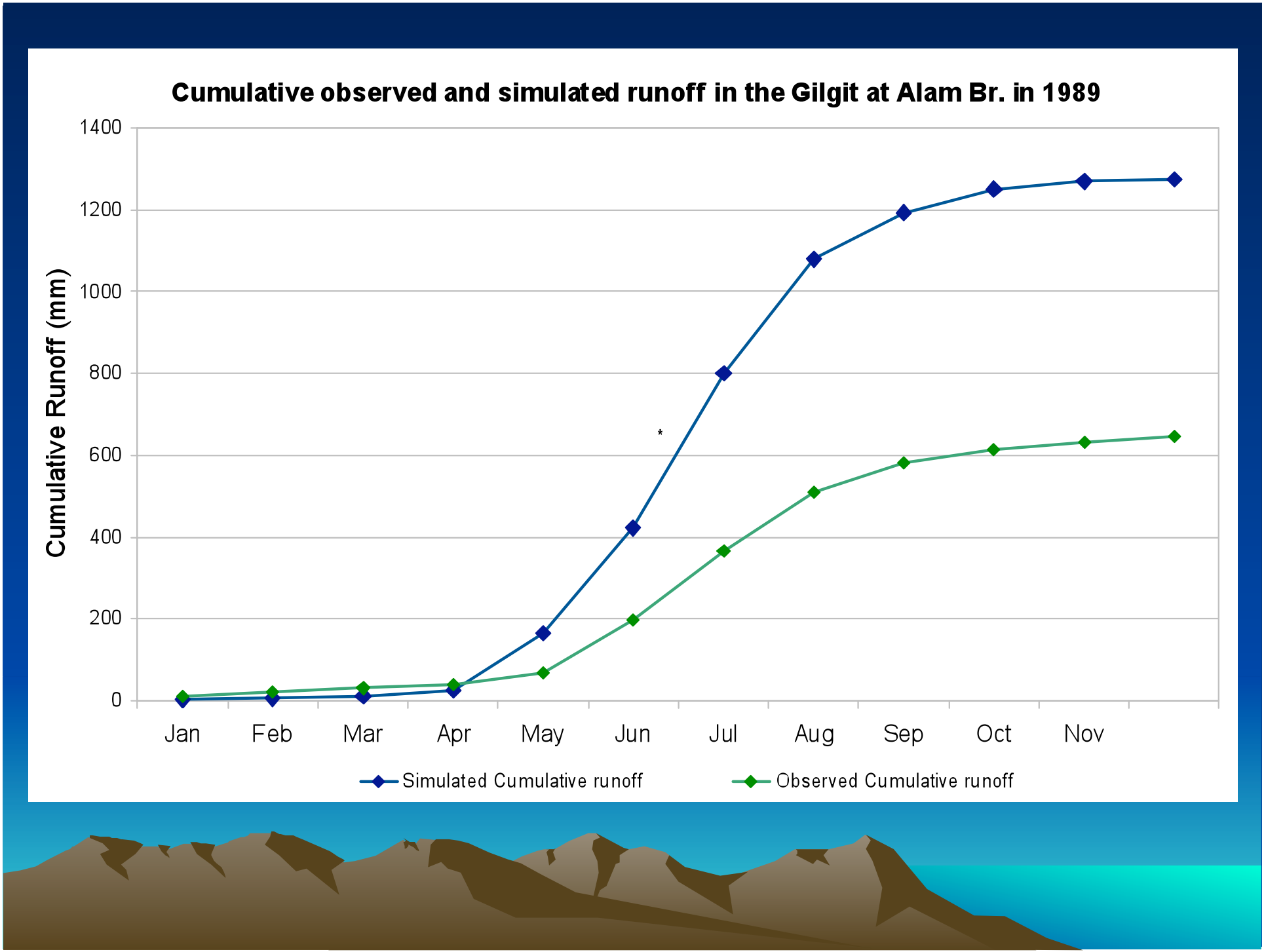

Observed and simulated monthly discharge in the Indus at Besham in 1989
Monthly Discharge rate (m3/s)
Percent error relative to monthly observed flow
18000
15000
12000
9000
6000
3000
0
240%
200%
160%
120%
80%
40%
0%
-40%
-80%
-120%
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Monthly simulated flow
Monthly observed flow
diff/obs


Cumulative observed and simulated runoff in the Indus at Besham in 1989
Cumulative Runoff (mm)
800
700
600
500
400
300
200
100
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Simulated Cumulative runoff
Observed Cumulative runoff

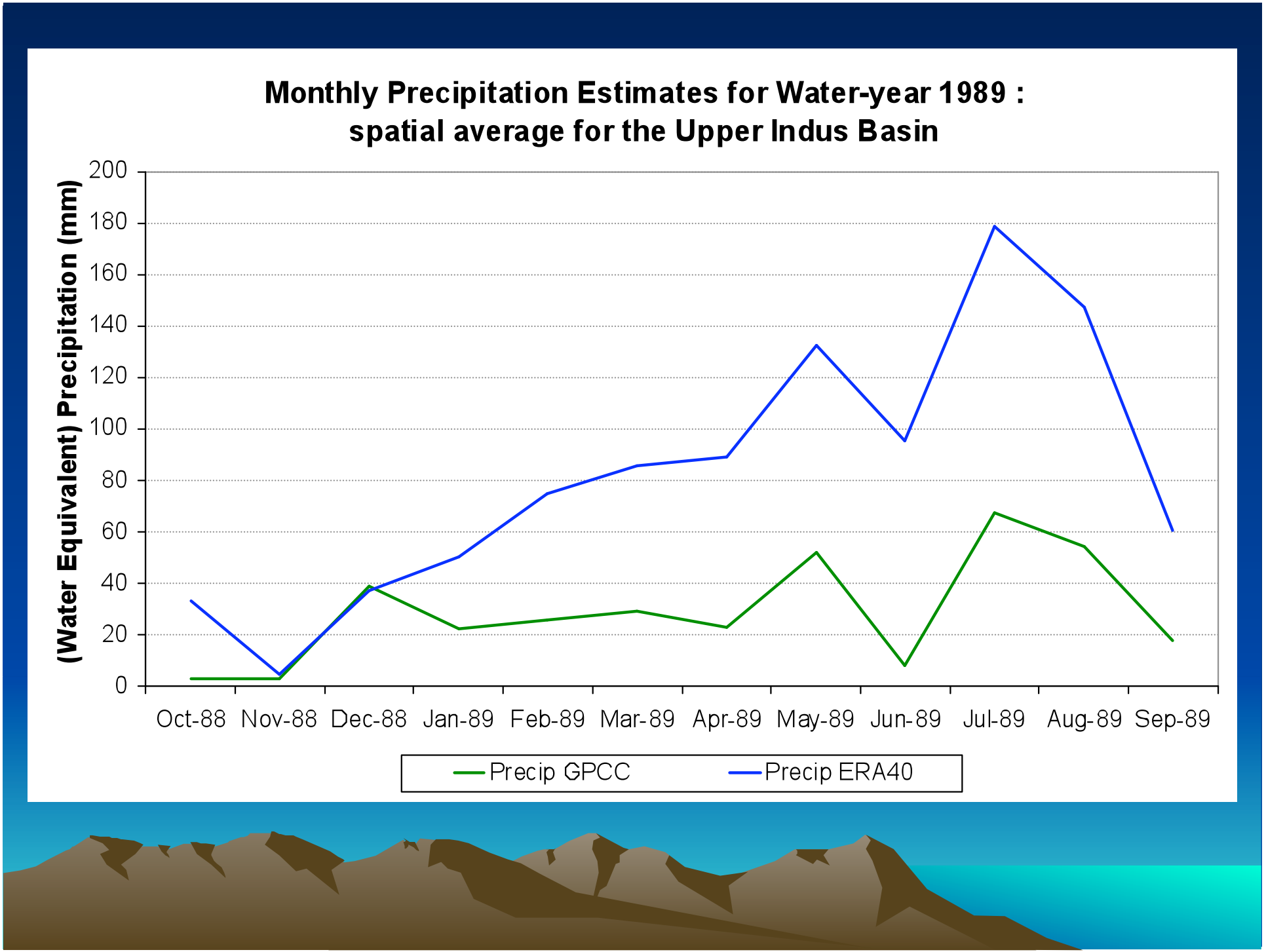

Observed and simulated monthly discharge in the Indus at Kachura in 1989
Monthly Discharge rate (m3/s)
Percent error relative to monthly observed flow
12500
10000
7500
5000
2500
0
150%
100%
50%
0%
-50%
-100%
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Monthly simulated flow
Monthly observed flow
diff/obs

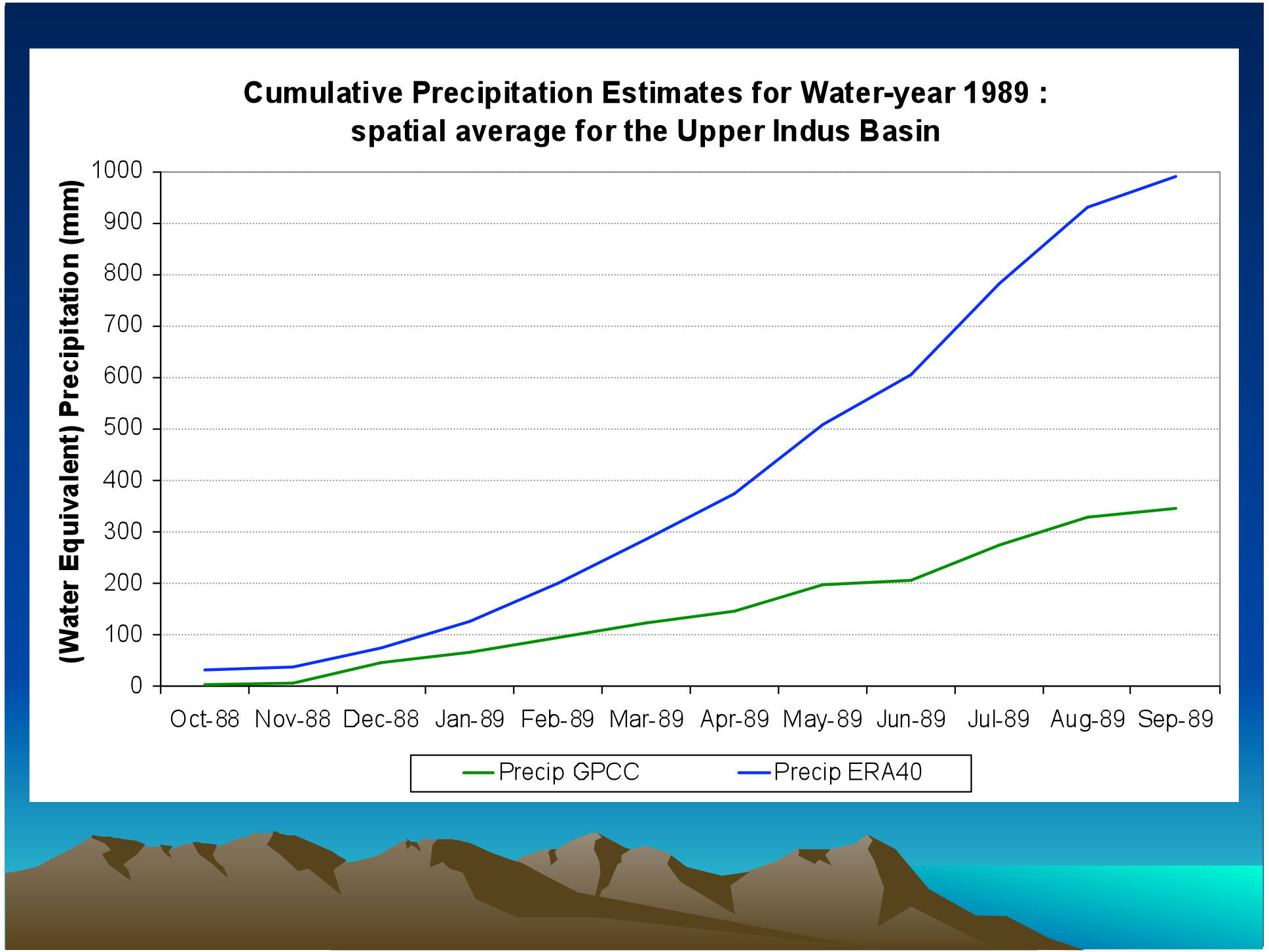

Cumulative observed and simulated runoff in the Indus at Kachura in 1990
Cumulative Runoff (mm)
700
600
500
400
300
200
100
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Simulated Cumulative runoff
Observed Cumulative runoff

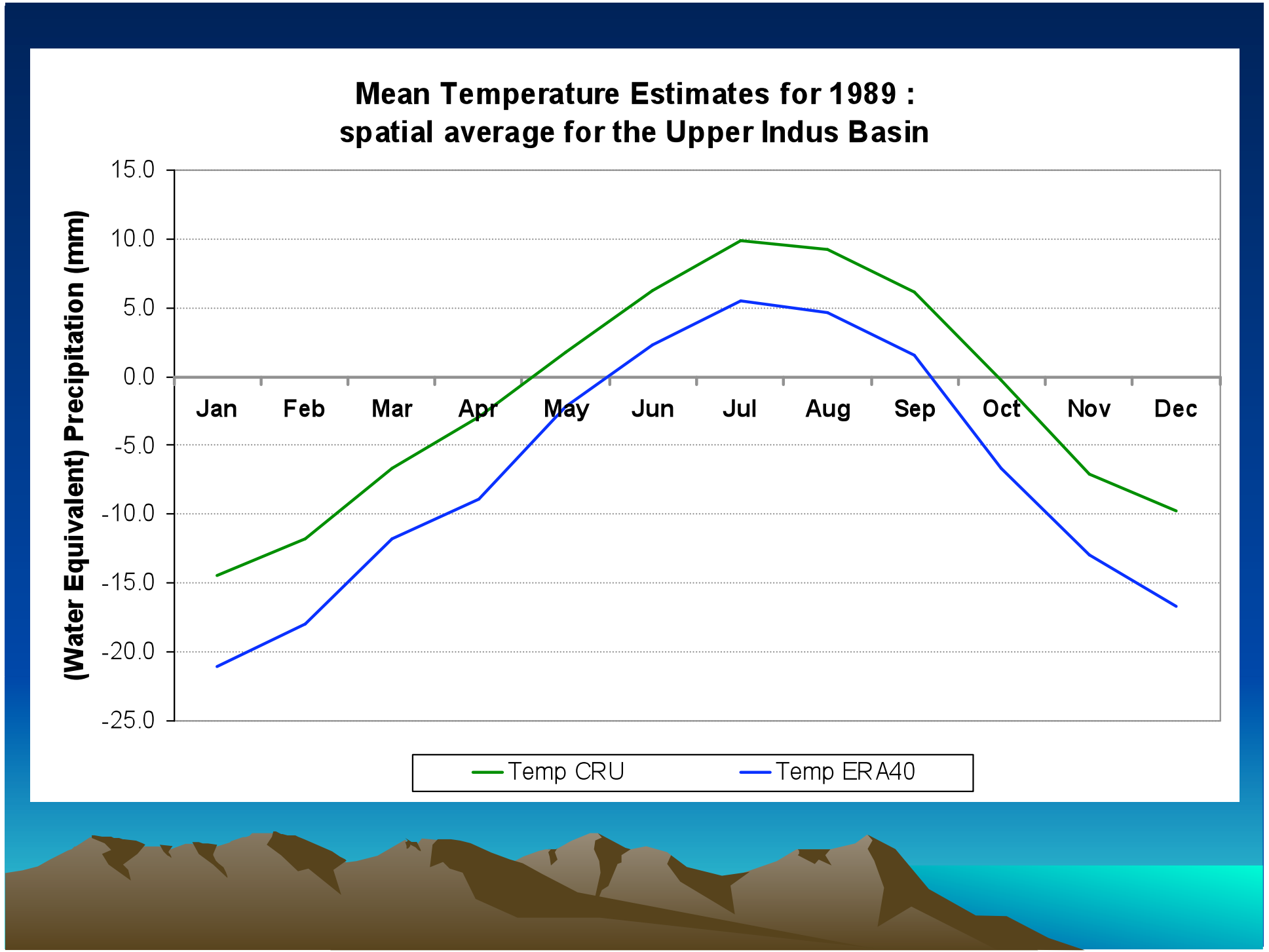

Observed and simulated monthly discharge in the Gilgit at Alam Br. in 1989
Monthly Discharge rate (m3/s)
Percent error relative to monthly observed flow
4000
3600
3200
2800
2400
2000
1600
1200
800
400
0
400%
350%
300%
250%
200%
150%
100%
50%
0%
-50%
-100%
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Monthly simulated flow
Monthly observed flow
diff/obs


Cumulative observed and simulated runoff in the Gilgit at Alam Br. in 1989
Cumulative Runoff (mm)
1400
1200
1000
800
600
400
200
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Simulated Cumulative runoff
Observed Cumulative runoff

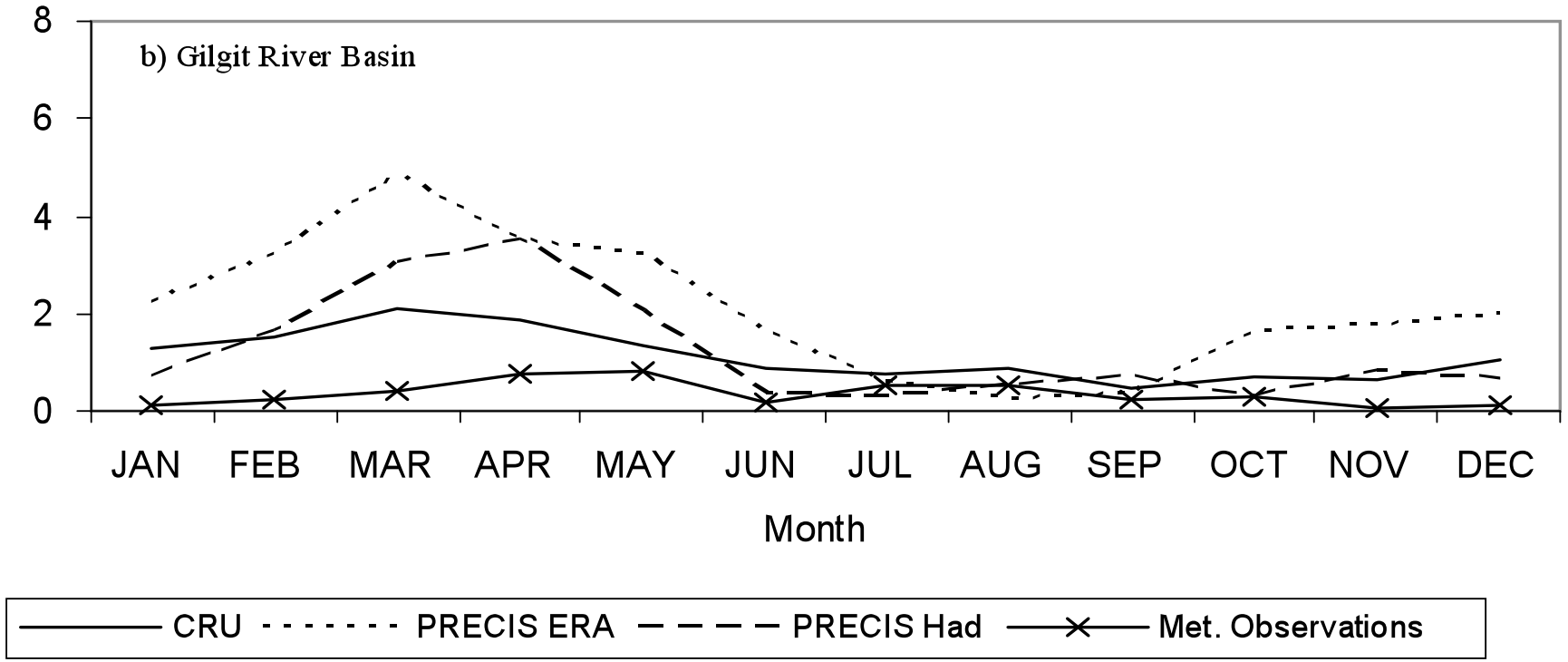
Comparison of ERA40 (model input) climatology and spatial estimations from gridded datasets


Monthly Precipitation Estimates for Water-year 1989 :
spatial average for the Upper Indus Basin
(Water Equivalent) Precipitation (mm)
200
180
160
140
120
100
80
60
40
20
0
Oct-88
Nov-88
Dec-88
Jan-89
Feb-89
Mar-89
Apr-89
May-89
Jun-89
Jul-89
Aug-89
Sep-89
Precip GPCC
Precip ERA40

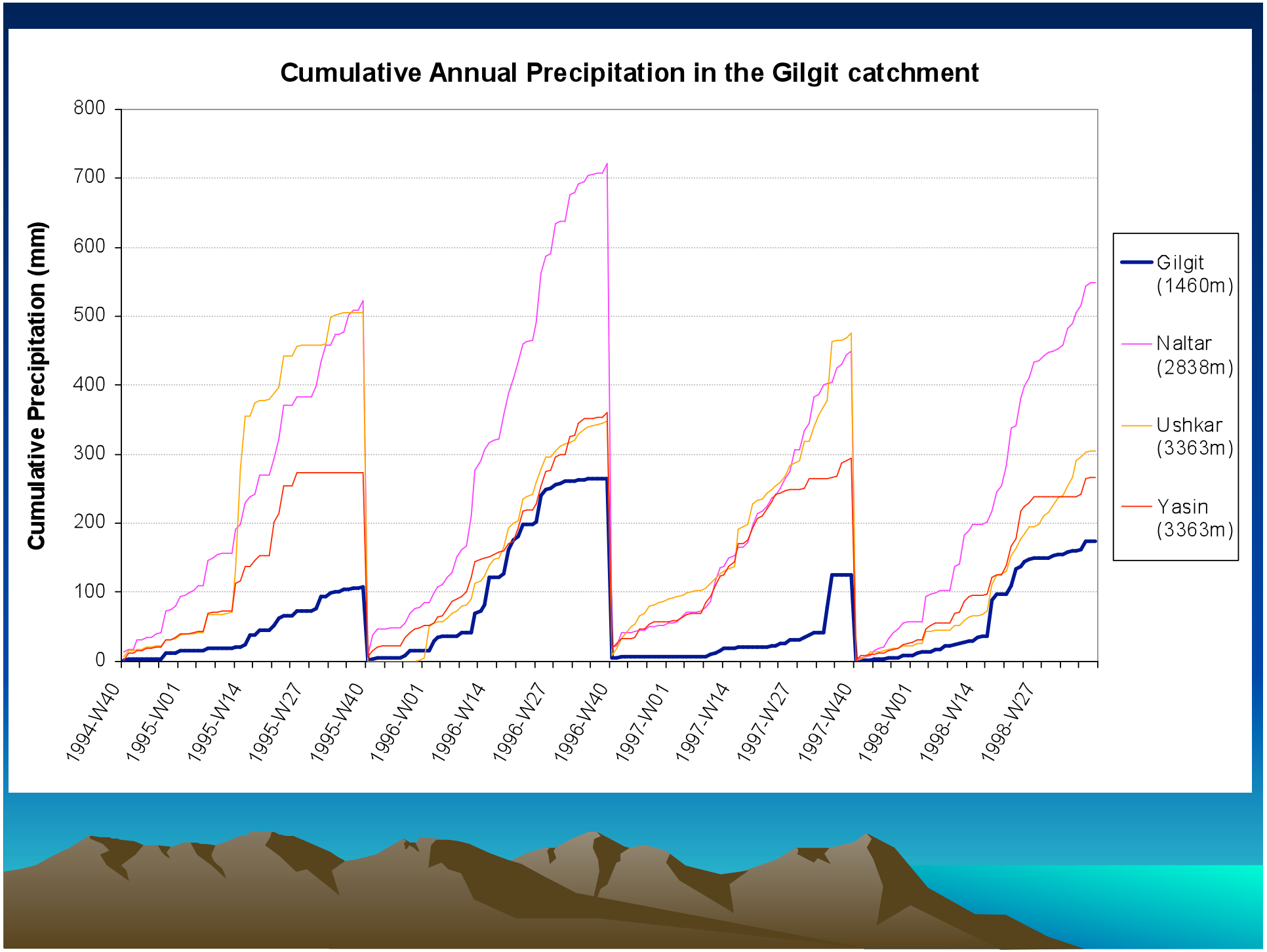

Cumulative Precipitation Estimates for Water-year 1989 :
spatial average for the Upper Indus Basin
(Water Equivalent) Precipitation (mm)
1000
900
800
700
600
500
400
300
200
100
0
Oct-88
Nov-88
Dec-88
Jan-89
Feb-89
Mar-89
Apr-89
May-89
Jun-89
Jul-89
Aug-89
Sep-89
Precip GPCC
Precip ERA40

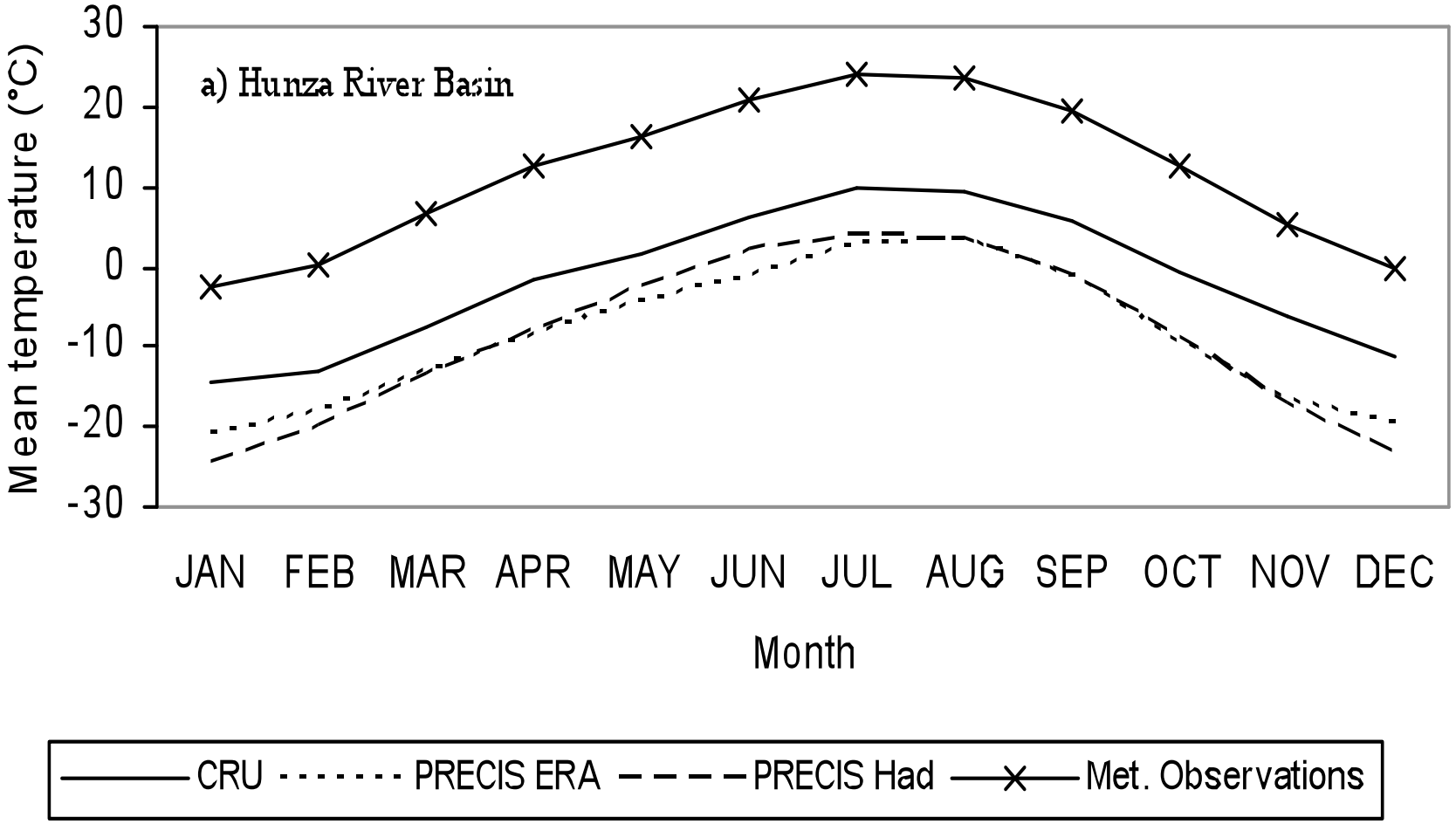

Mean Temperature Estimates for 1989 :
spatial average for the Upper Indus Basin
(Water Equivalent) Precipitation (mm)
15.0
10.0
5.0
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Temp CRU
Temp ERA40

Insights from local observations



-from Akhtar et al, HESS 2009


Cumulative Annual Precipitation in the Gilgit catchment
Cumulative Precipitation (mm)
800
700
600
500
400
300
200
100
0
1994-W40
1995-W01
1995-W14
1995-W27
1995-W40
1996-W01
1996-W14
1996-W27
1996-W40
1997-W01
1997-W14
1997-W27
1997-W40
1998-W01
1998-W14
1998-W27
Gilgit (1460m)
Naltar (2838m)
Ushkar (3363m)
Yasin (3363m)



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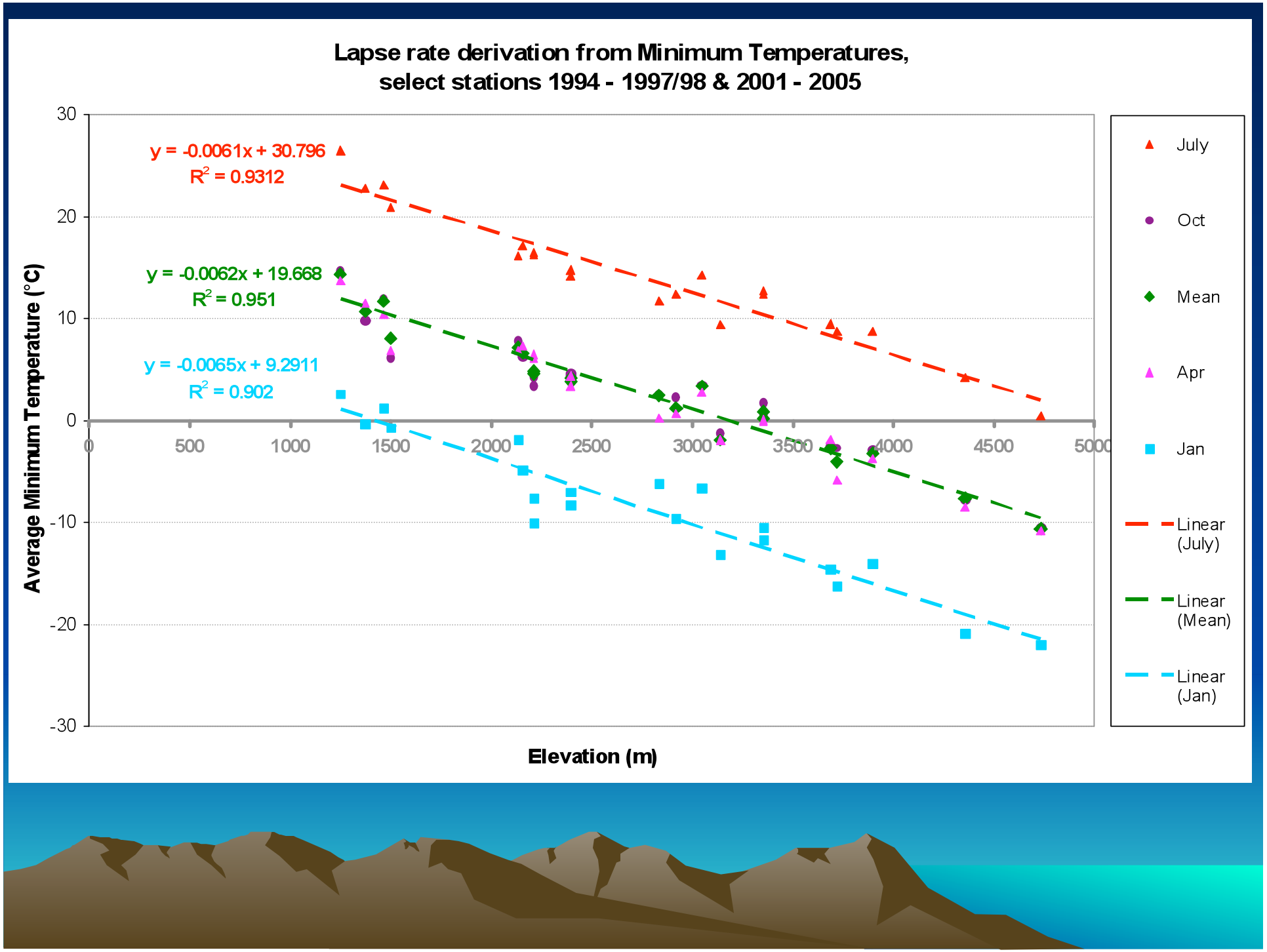
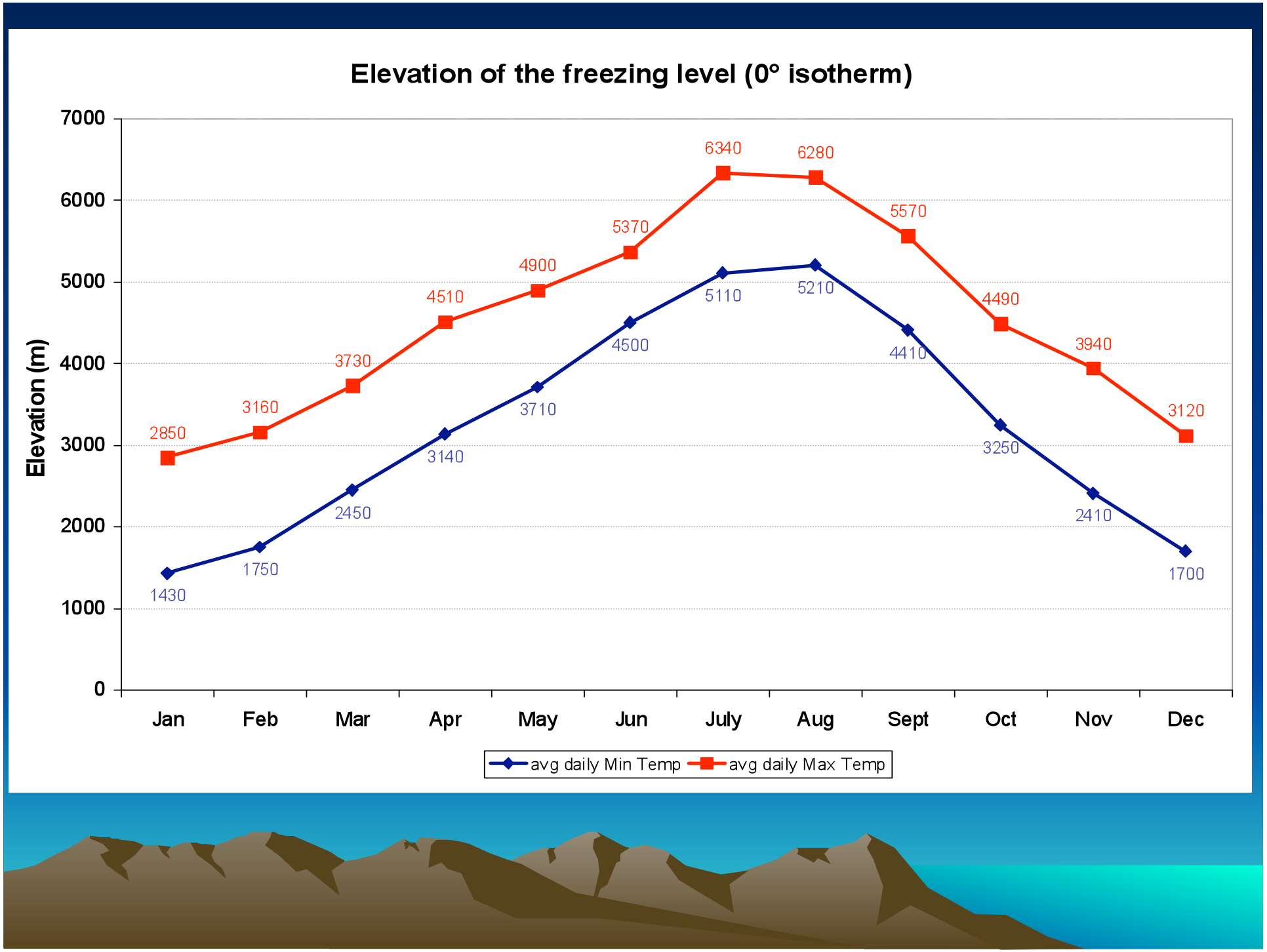
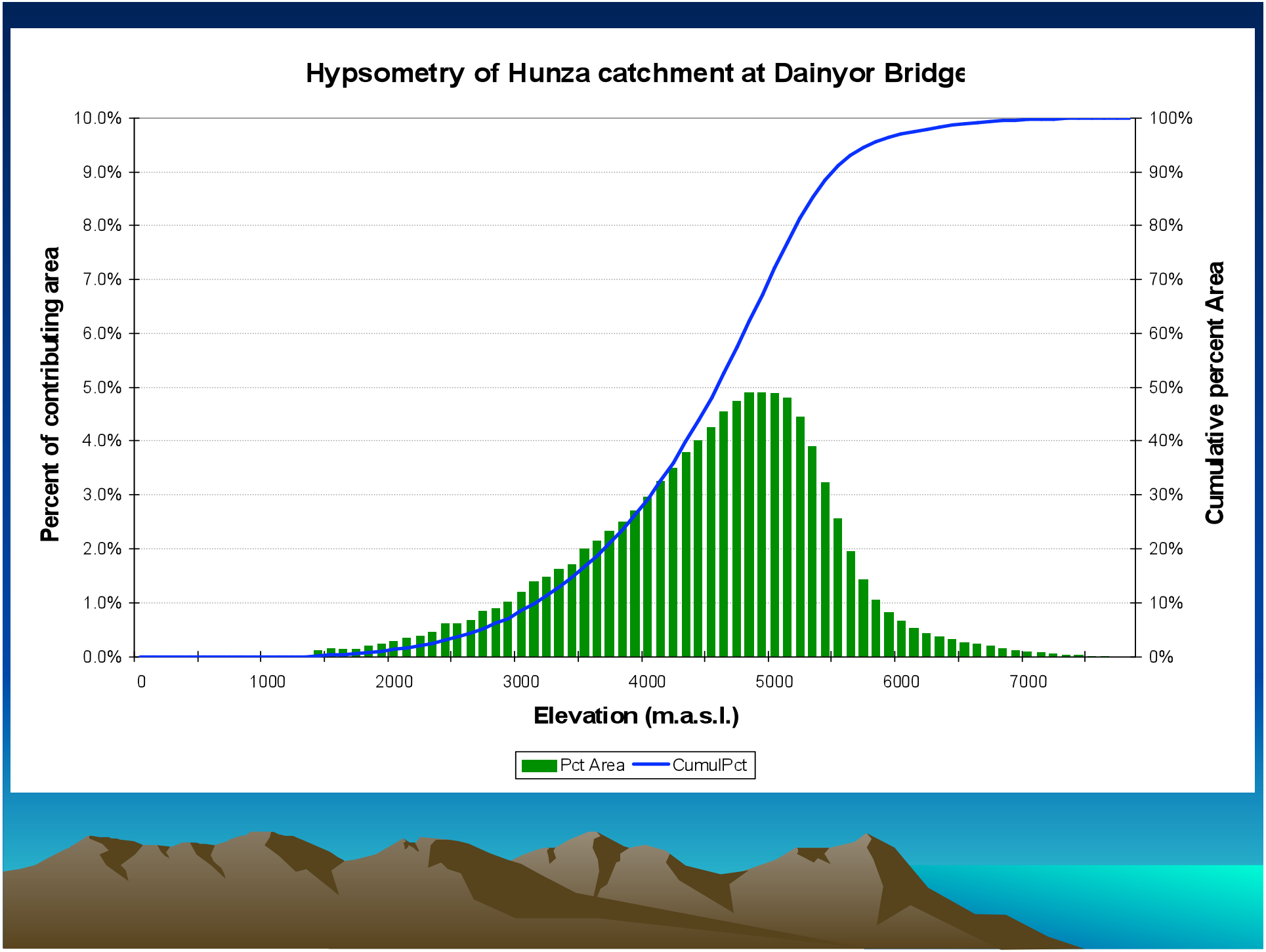
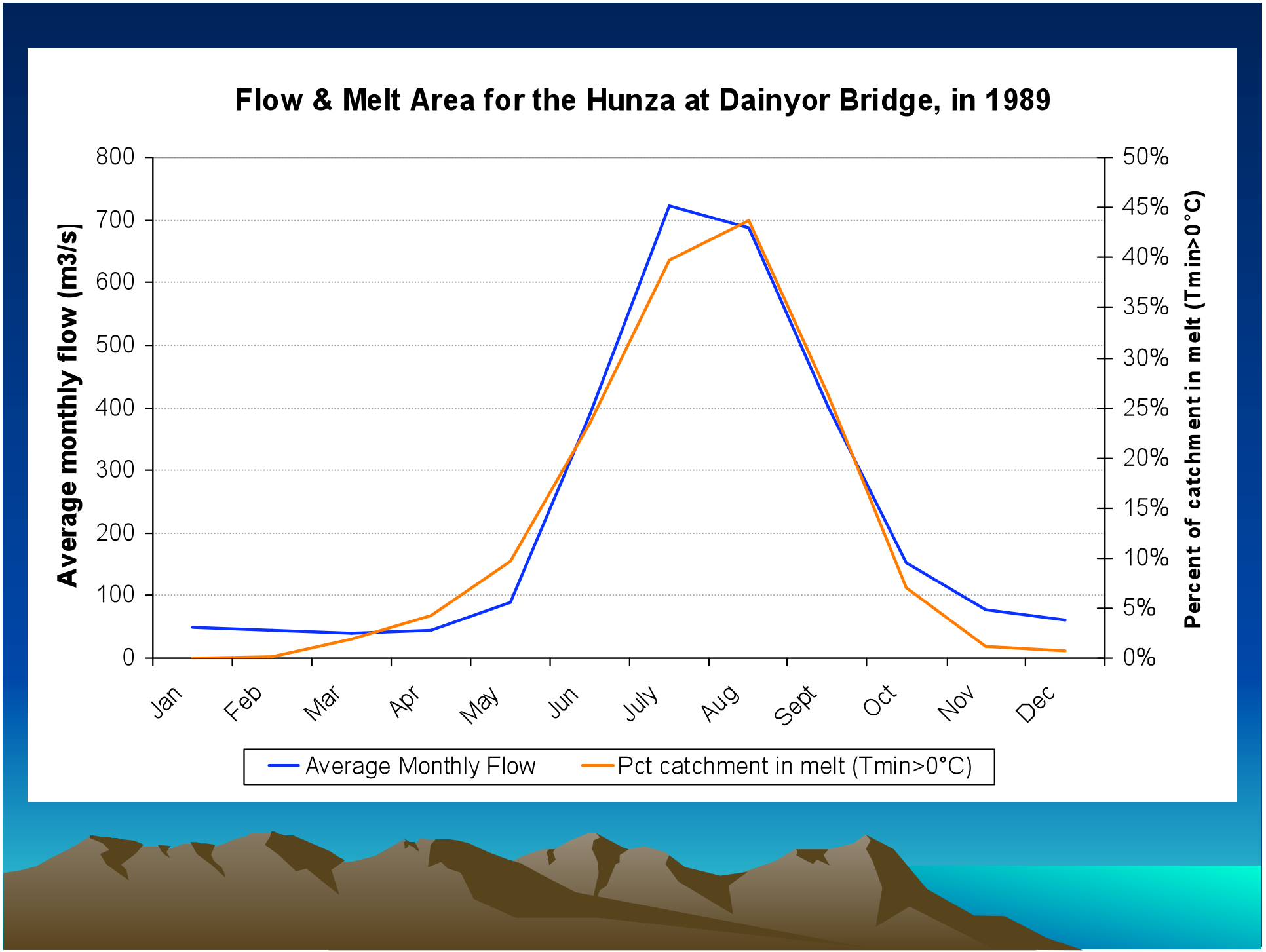
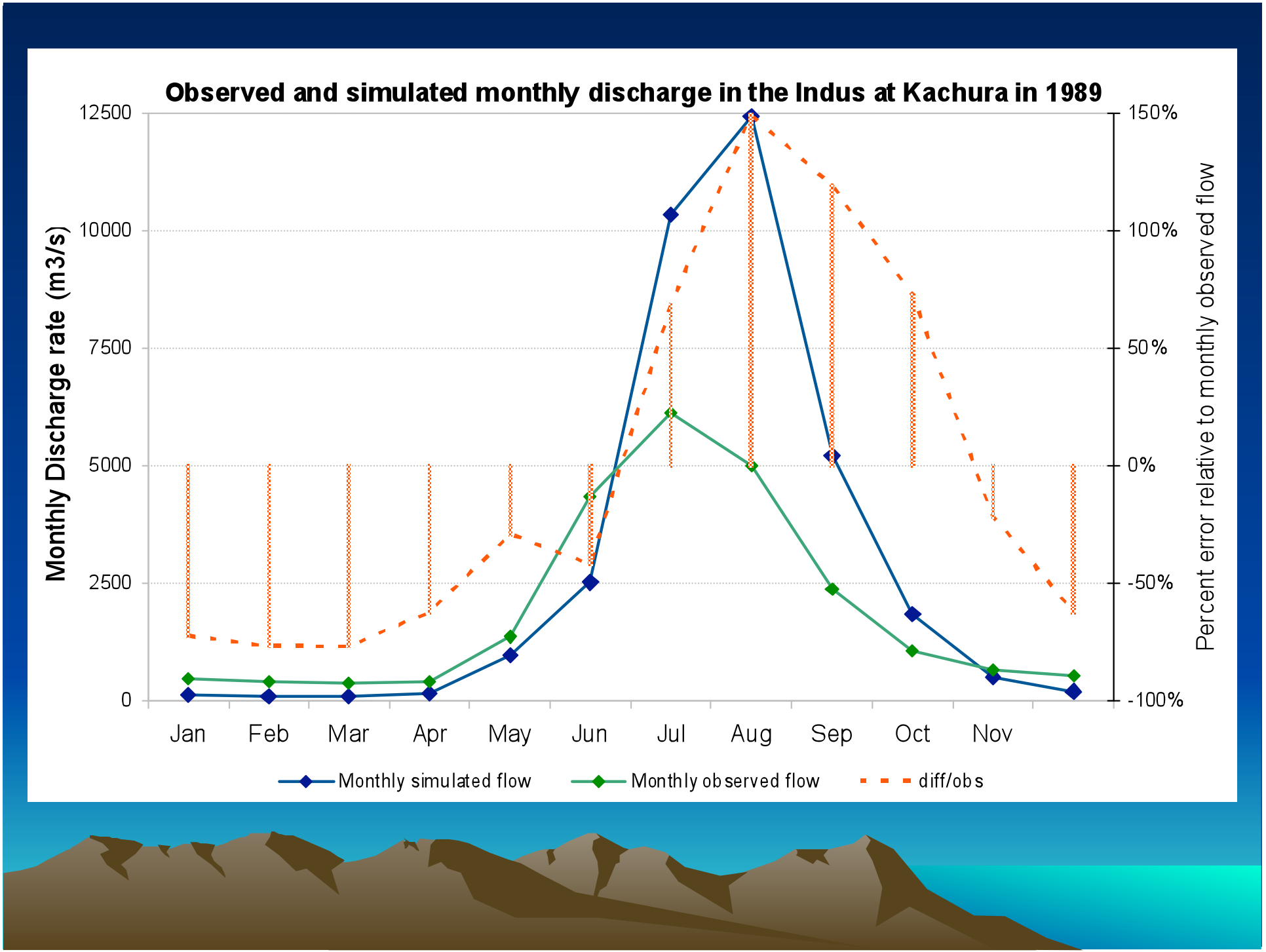

Lapse rate derivation from Minimum Temperatures,
select stations 1994 - 1997/98 & 2001 - 2005
y = -0.0061x + 30.796
R2 = 0.9312
y = -0.0062x + 19.668
R2 = 0.951
y = -0.0065x + 9.2911
R2 = 0.902
Average Minimum Temperature (°C)
Elevation (m)
30
20
10
0
-10
-20
-30
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
July
Oct
Mean
Apr
Jan
Linear (July)
Linear (Mean)
Linear (Jan)


Elevation of the freezing level (0° isotherm)
Elevation (m)
7000
6000
5000
4000
3000
2000
1000
0
Jan
Feb
Mar
Apr
May
Jun
July
Aug
Sept
Oct
Nov
Dec
2850
3160
3730
4510
4900
5370
6340
6280
5570
4490
3940
3120
1430
1750
2450
3140
3710
4500
5110
5210
4410
3250
2410
1700
avg daily Min Temp
avg daily Max Temp


Hypsometry of Hunza catchment at Dainyor Bridge
Percent of contributing area
Cumulative percent Area
10.0%
9.0%
8.0%
7.0%
6.0%
5.0%
4.0%
3.0%
2.0%
1.0%
0.0%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
1000
2000
3000
4000
5000
6000
7000
Elevation (m.a.s.l.)
Pct Area
CumulPct


Flow & Melt Area for the Hunza at Dainyor Bridge, in 1989
Average monthly flow (m3/s)
800
700
600
500
400
300
200
100
0
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
Percent of catchment in melt (Tmin>0°C)
Jan
Feb
Mar
Apr
May
Jun
July
Aug
Sept
Oct
Nov
Dec
Average Monthly Flow
Pct catchment in melt (Tmin>0°C)


Observed and simulated monthly discharge in the Indus at Kachura in 1989
Monthly Discharge rate (m3/s)
Percent error relative to monthly observed flow
12500
10000
7500
5000
2500
0
150%
100%
50%
0%
-50%
-100%
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Monthly simulated flow
Monthly observed flow
diff/obs

Summary & Conclusions

- HD model provides interesting approach to hydrological simulations
- Required model resolution is dependent on scale to be studied
- Model input (runoff & drainage) need to be bias corrected
- Development of spatial (gridded) estimations for climatological variables from local meteorological observations may provide a pathway to bias correction

Thank you for your time.

Your questions and comments are most welcome !