Climate Change in Pakistan

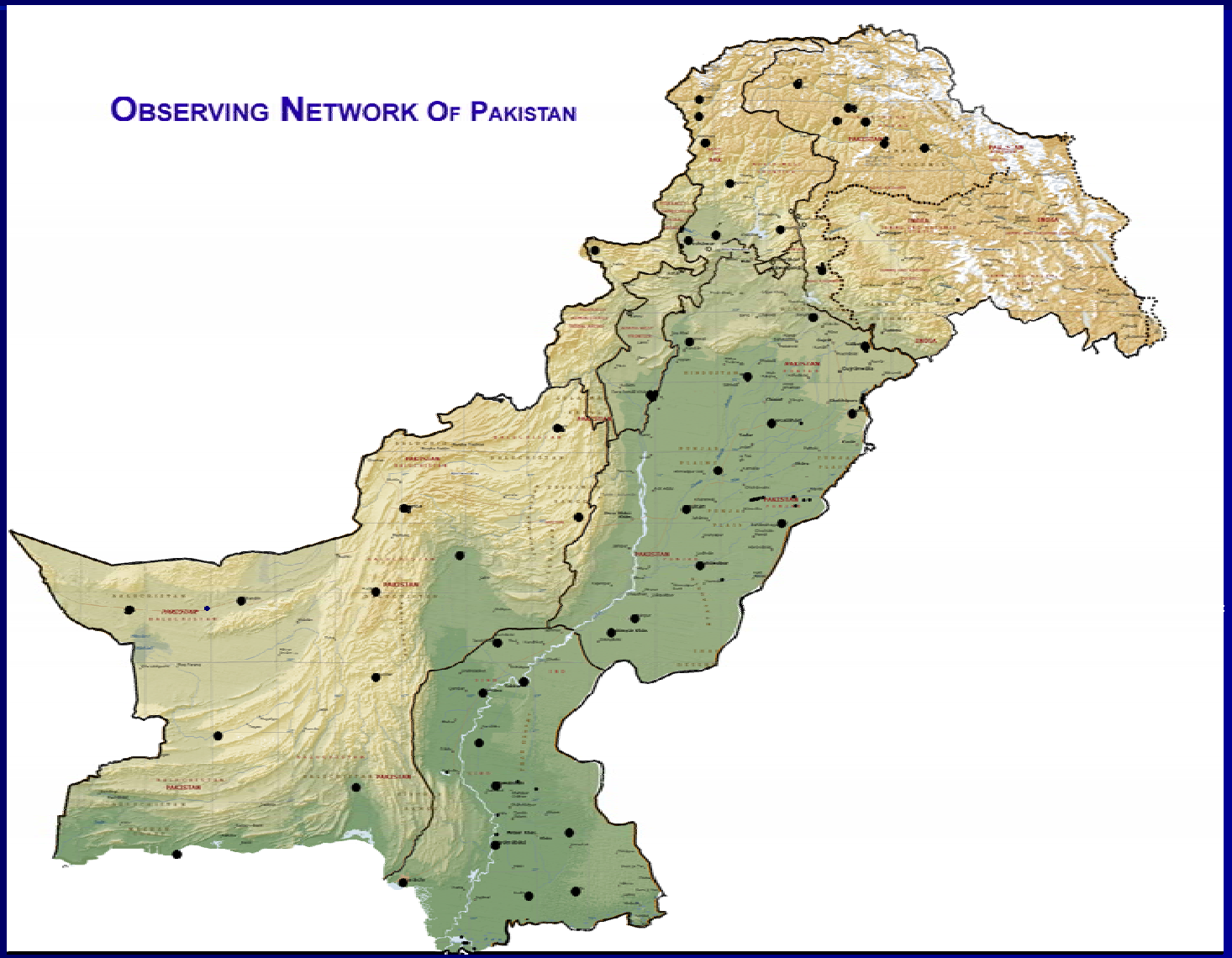
By

Dr. Ghulam Rasul

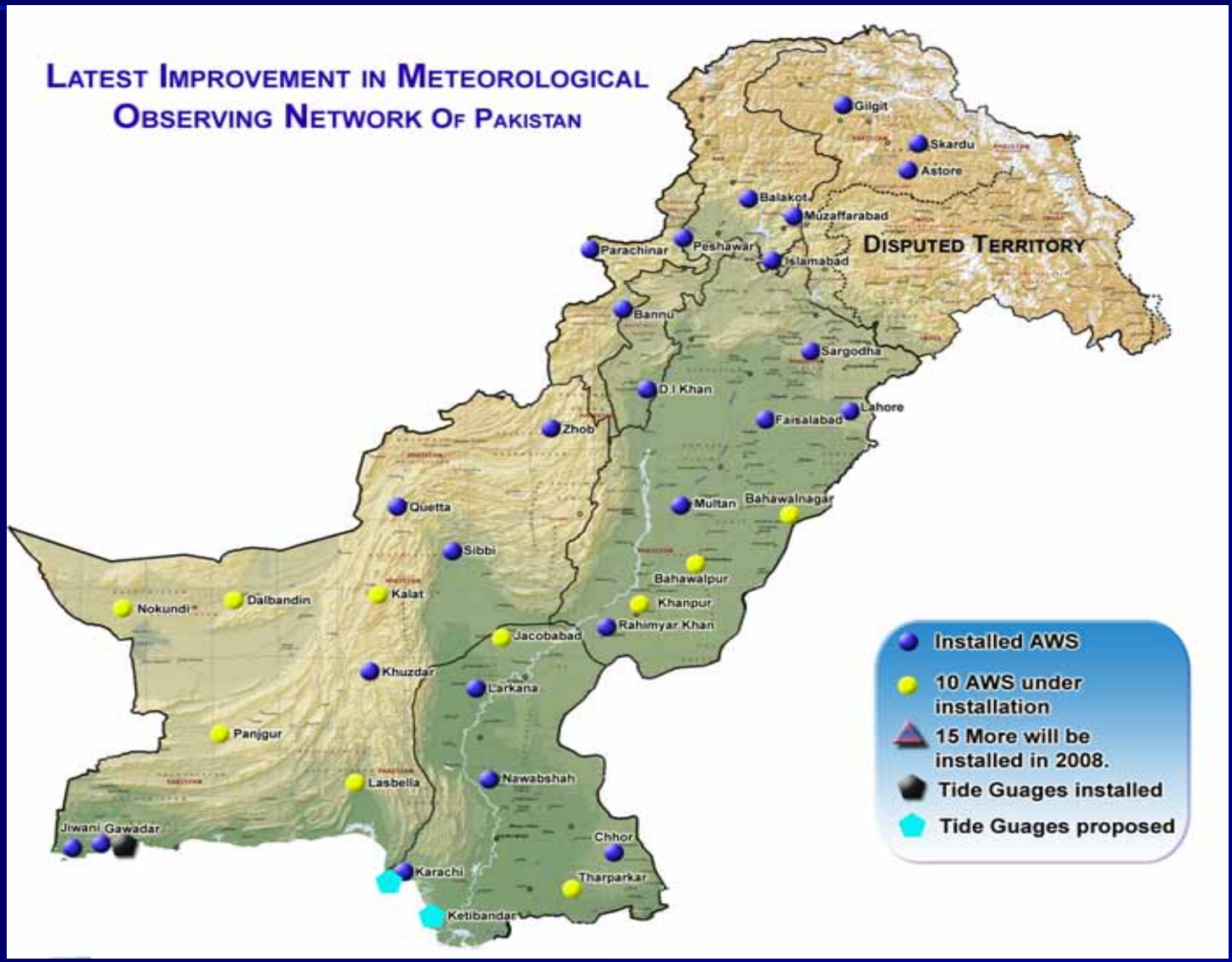
&

Dr. Bashir Ahmad

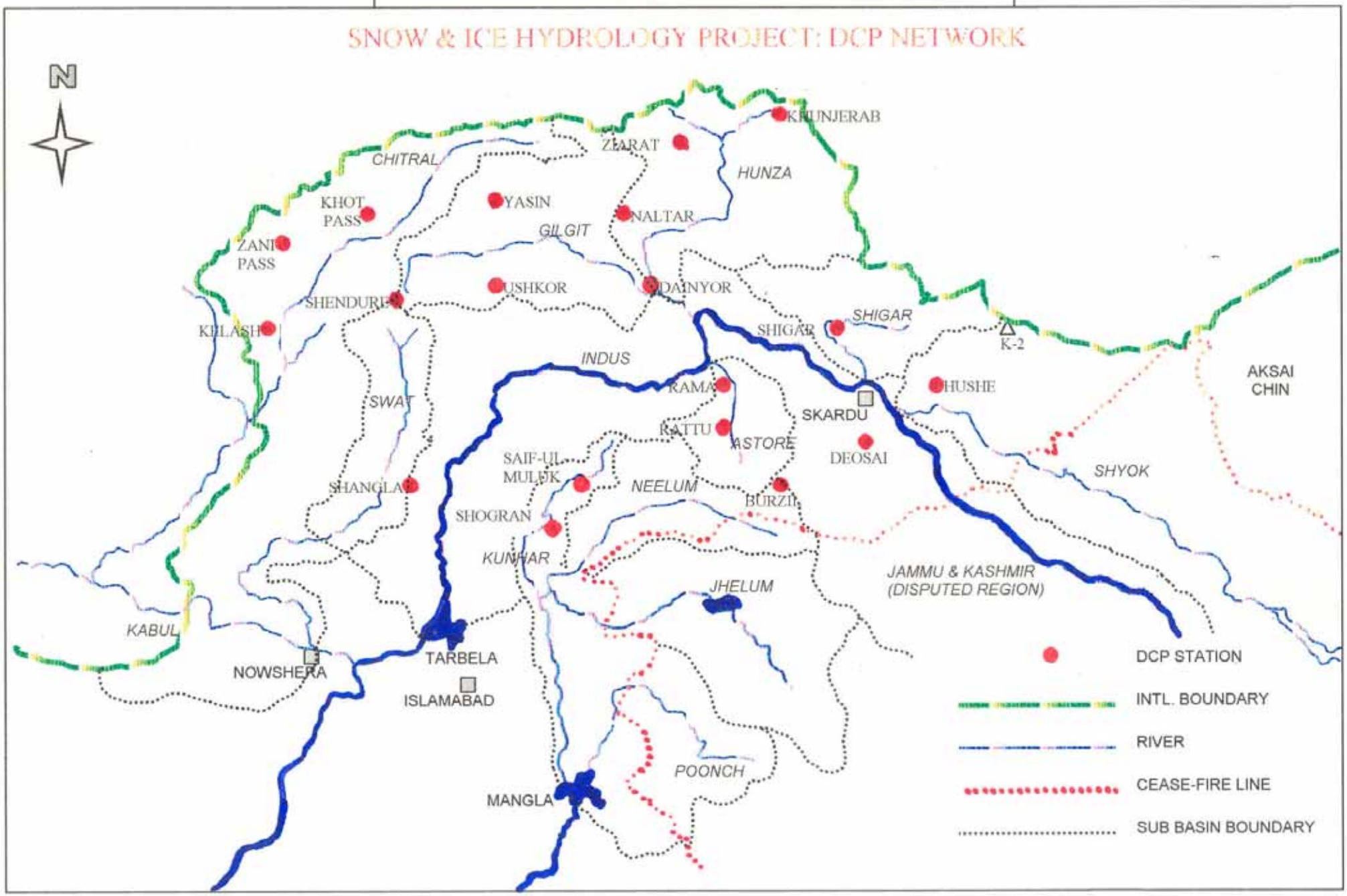
Observation Network



AWS Installations

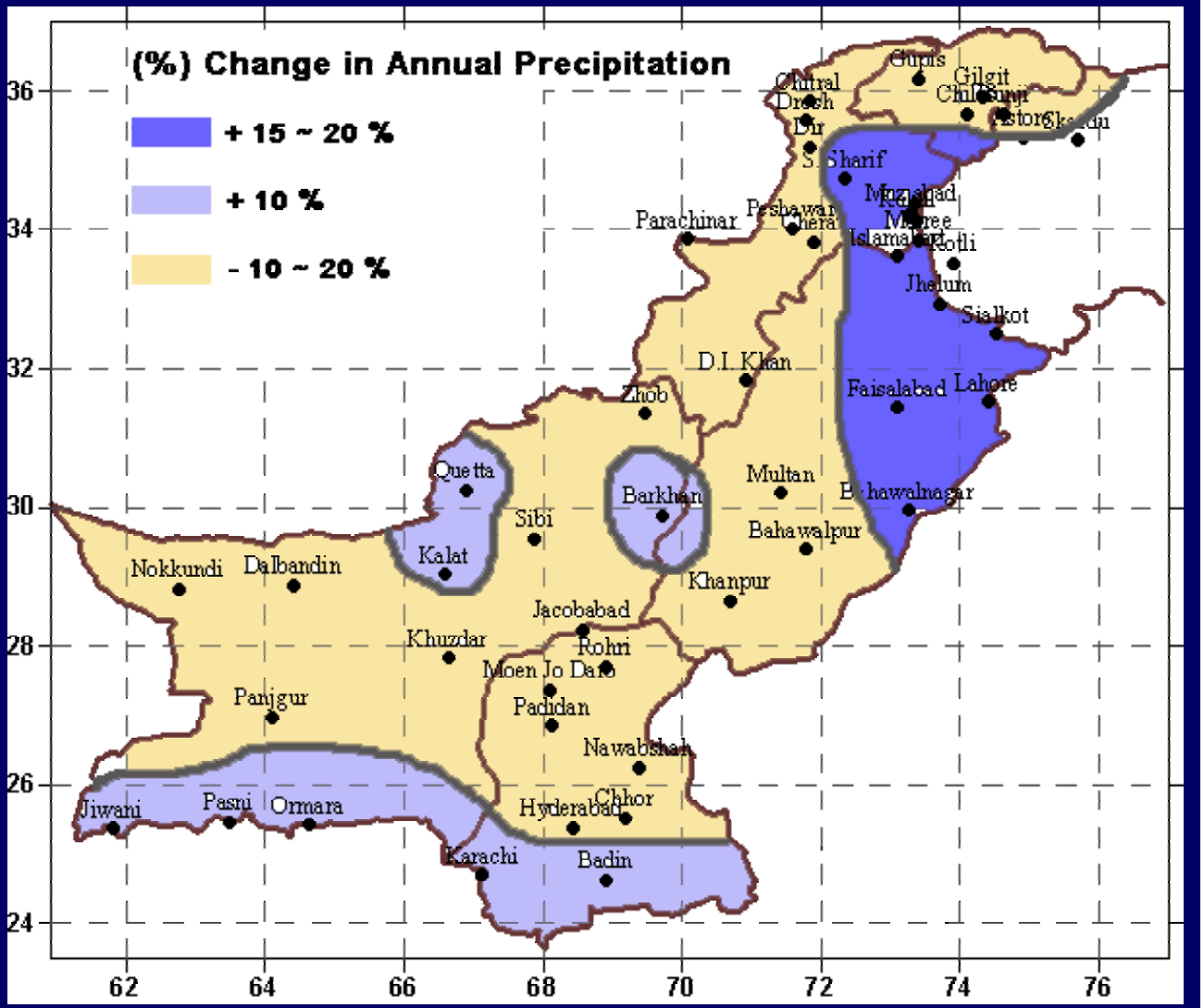


PAKISTAN WATER AND POWER DEVELOPMENT

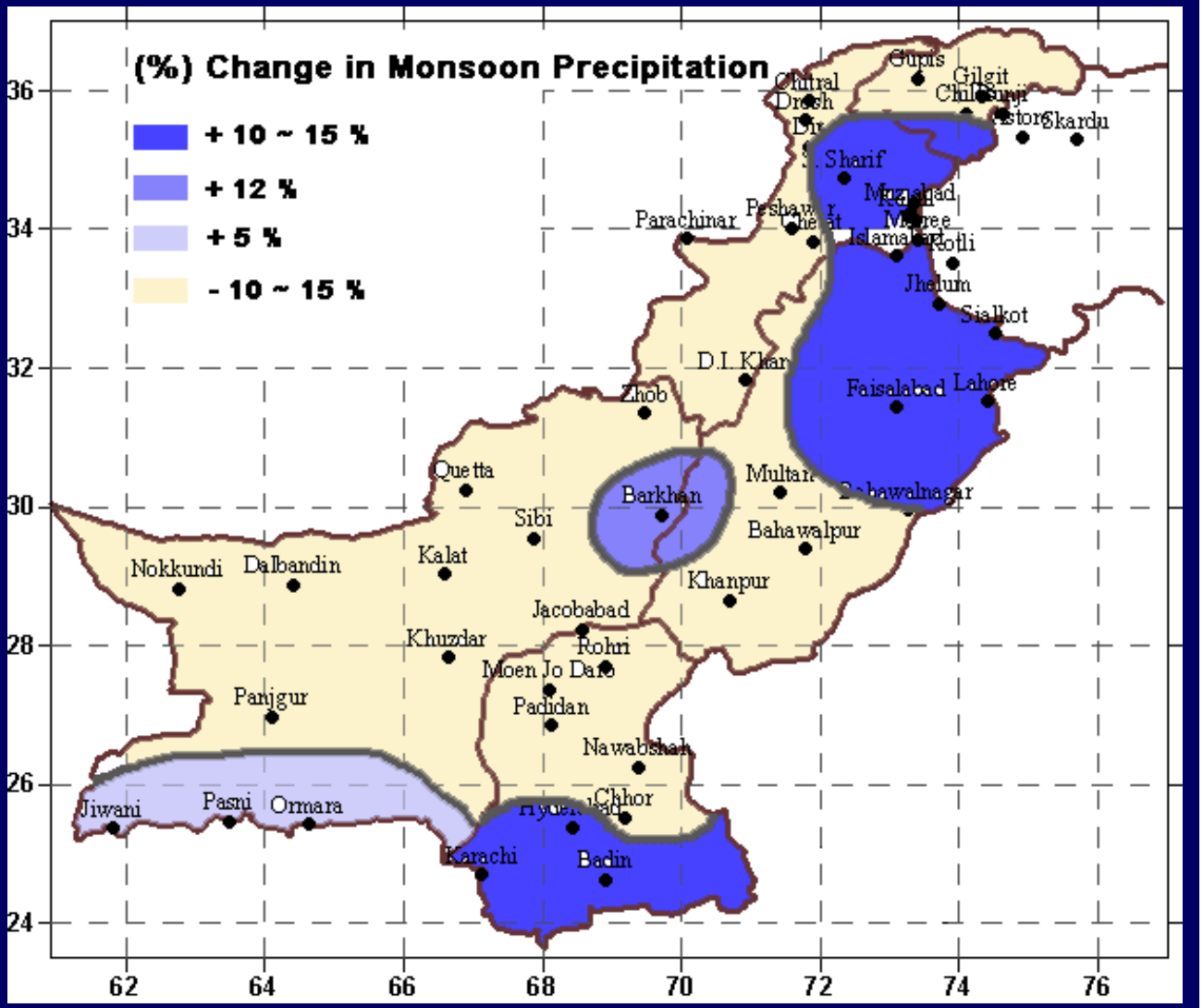


Climate Change

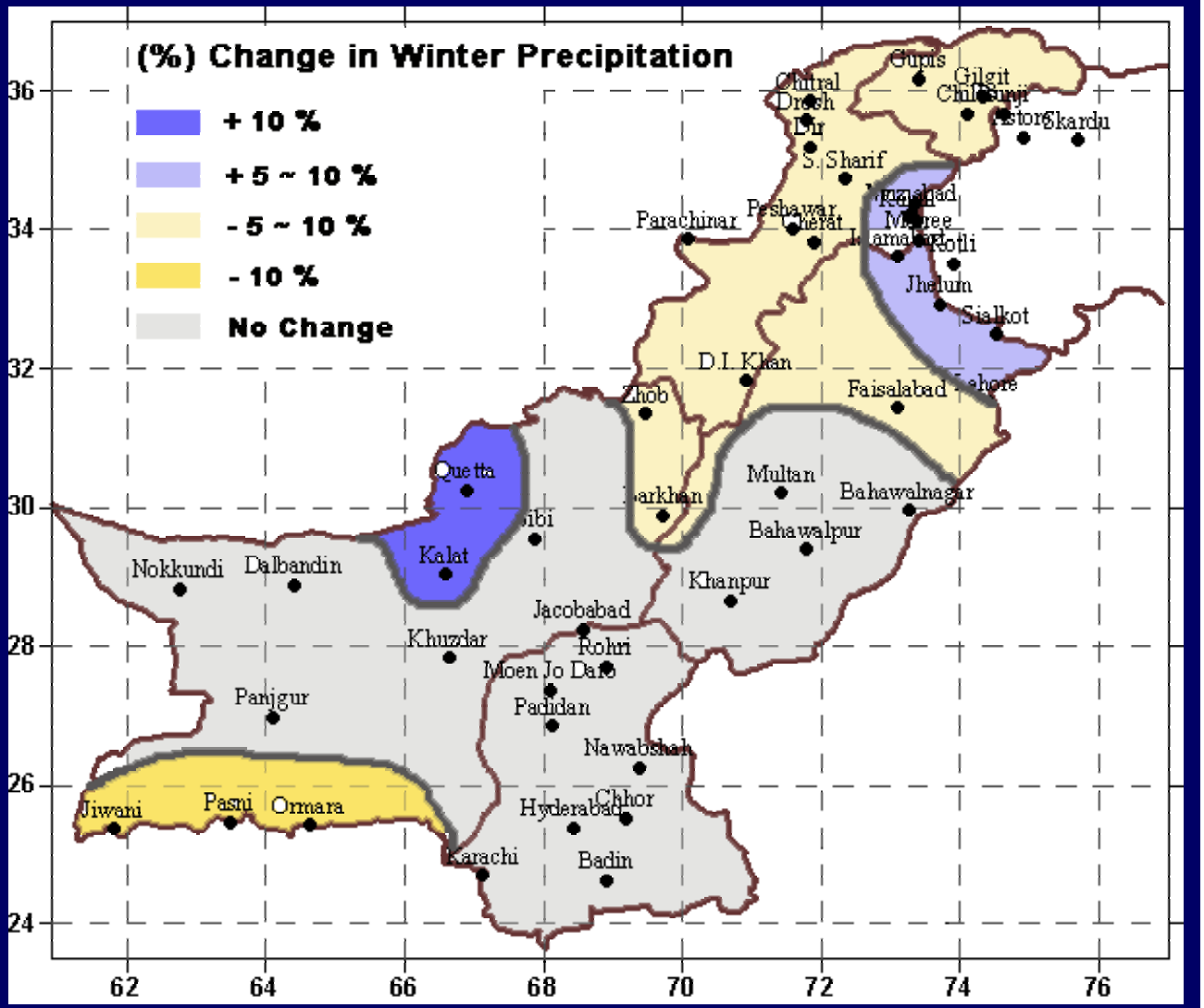
Percentage Change – Annual Precipitation



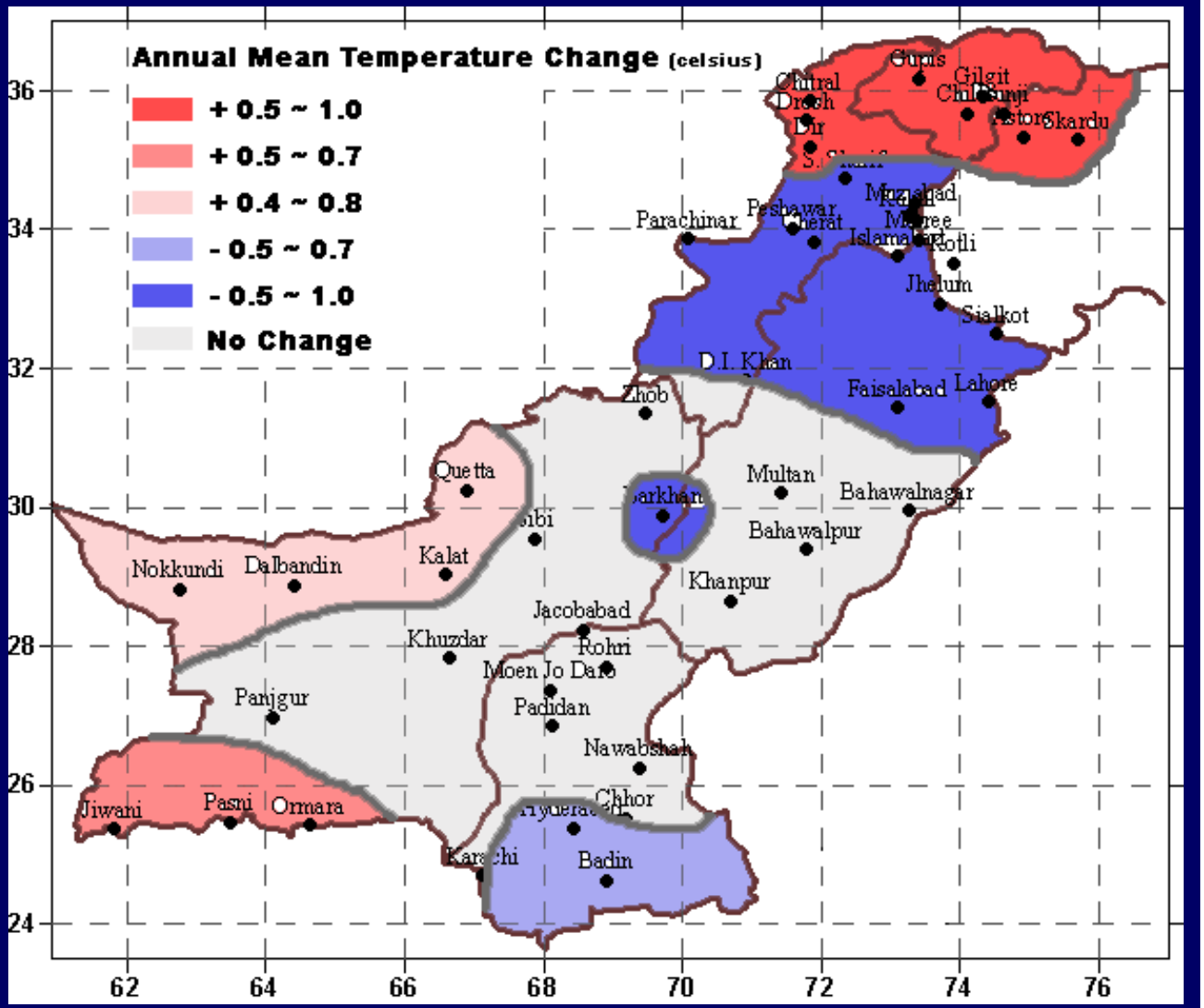
Percentage Change – Monsoon Precipitation



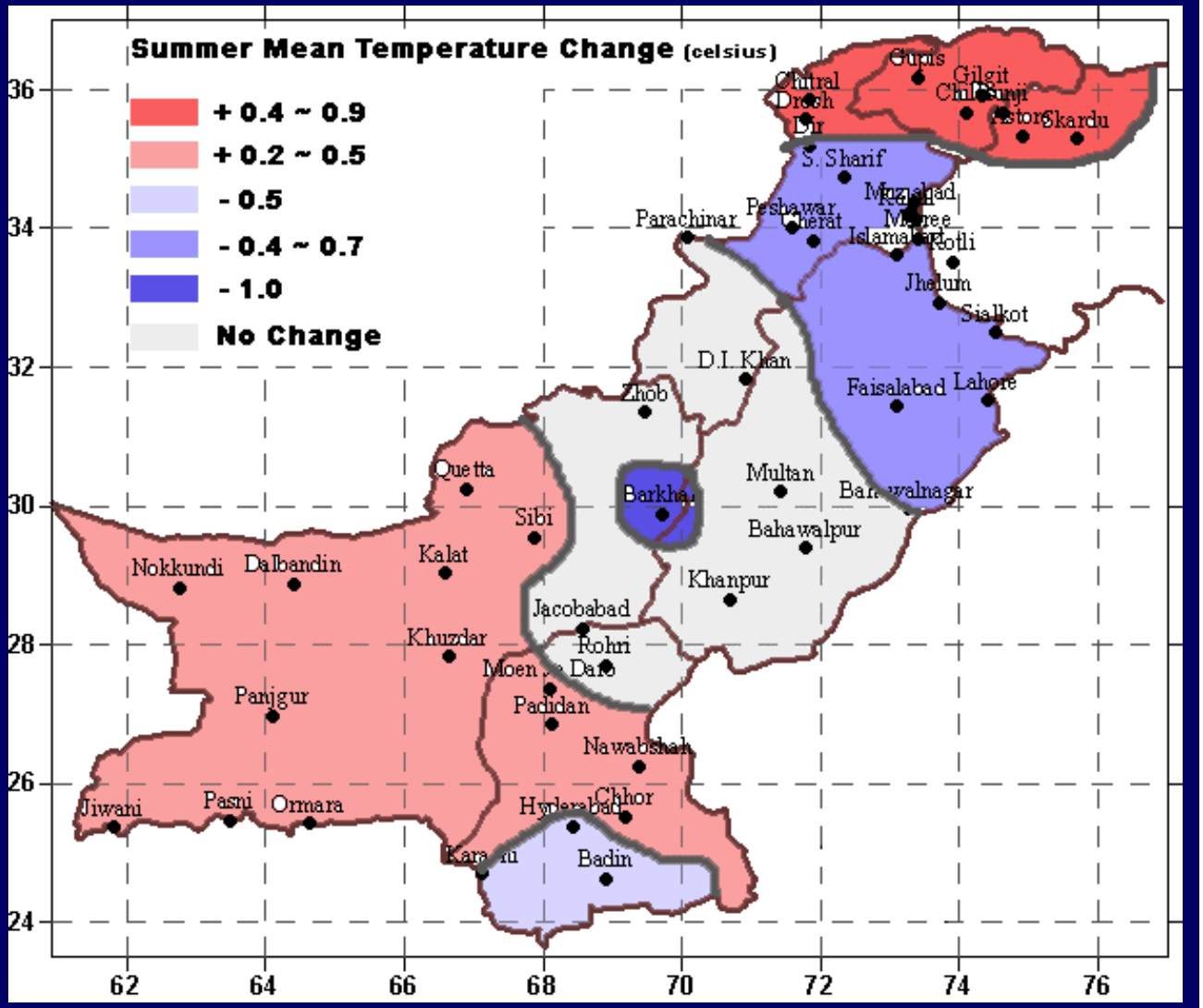
Percentage Change – Winter Precipitation



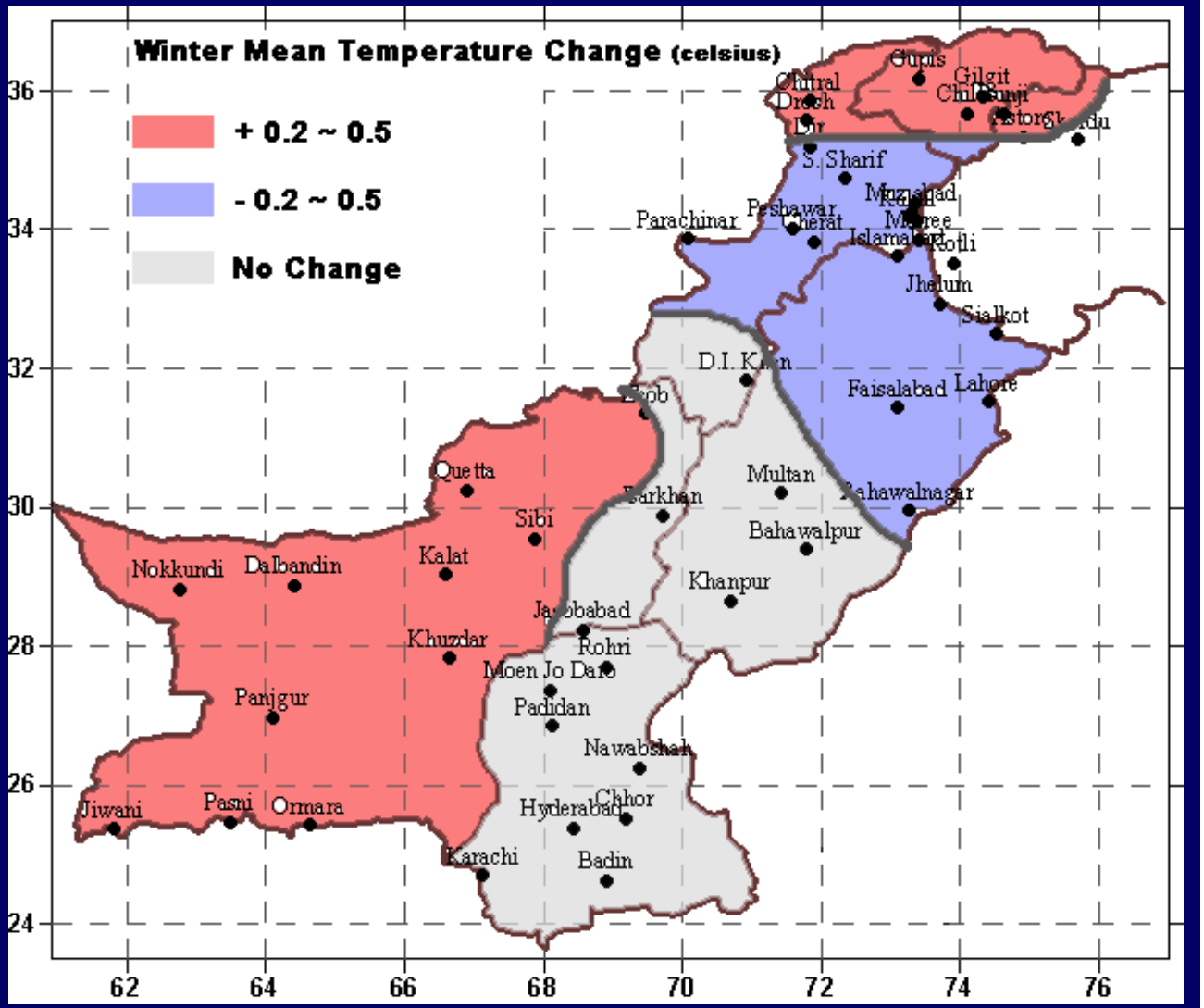
Annual Change – Mean Temperature

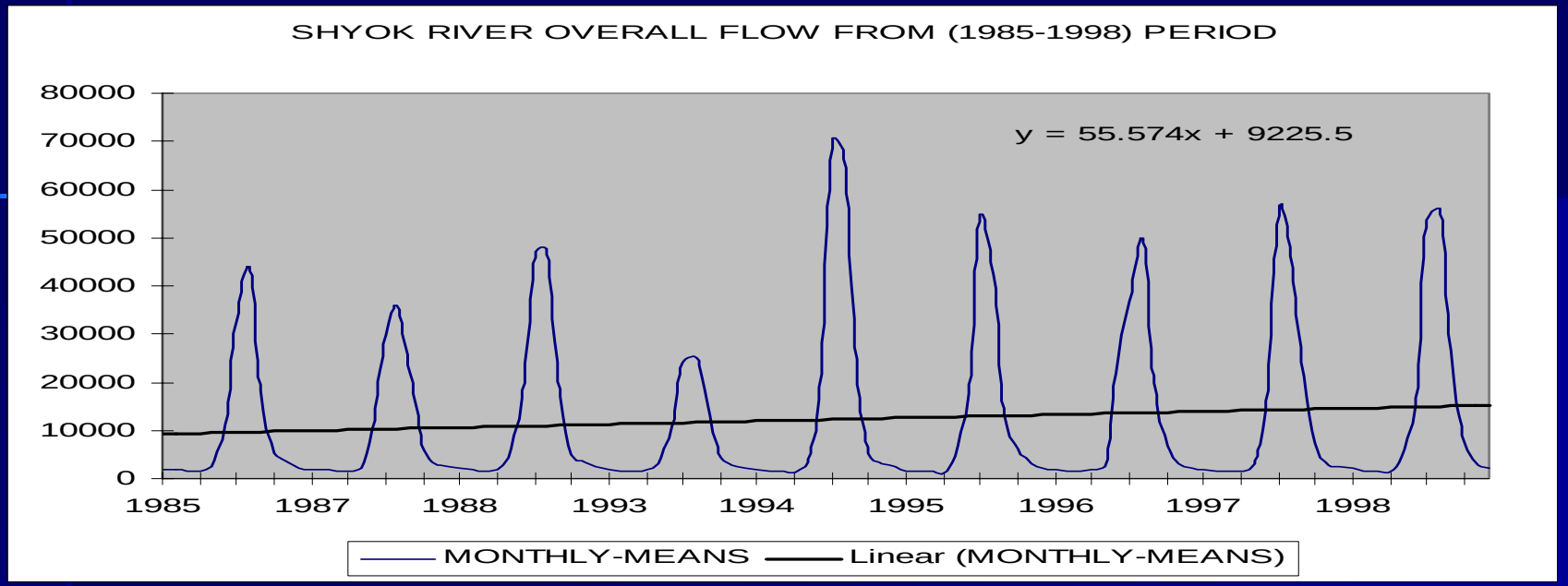


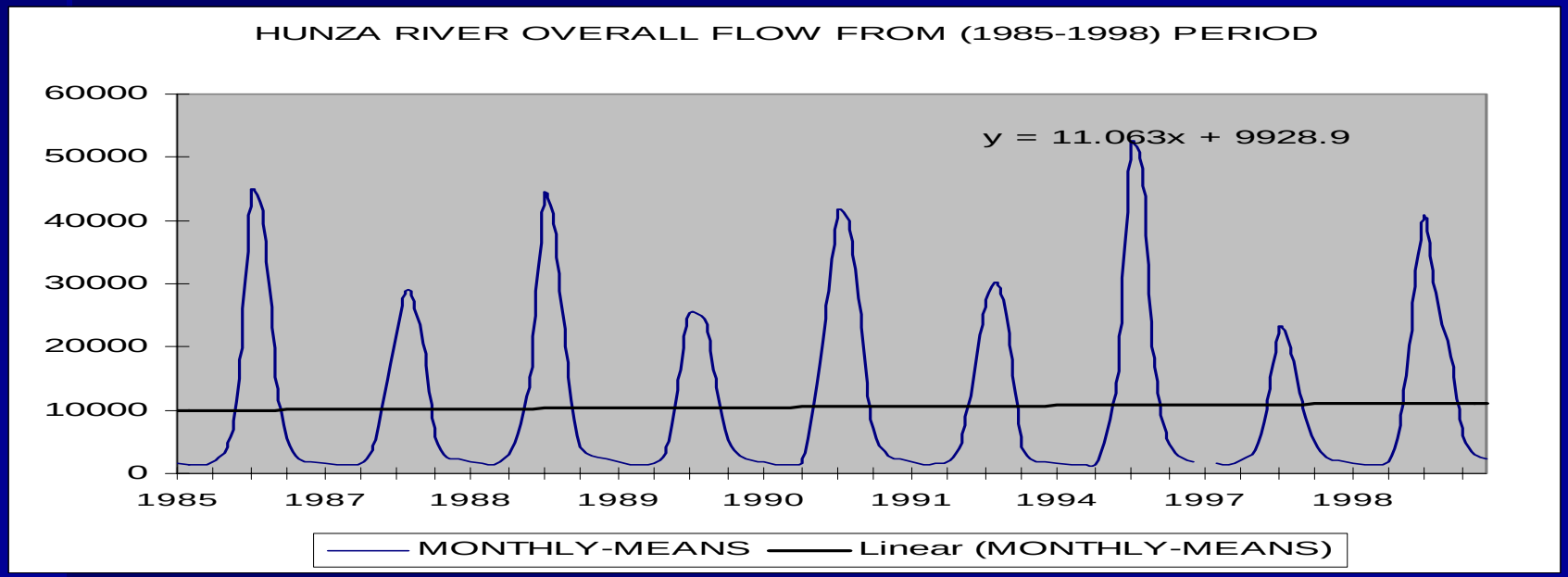
Summer – Change in Mean Temperature

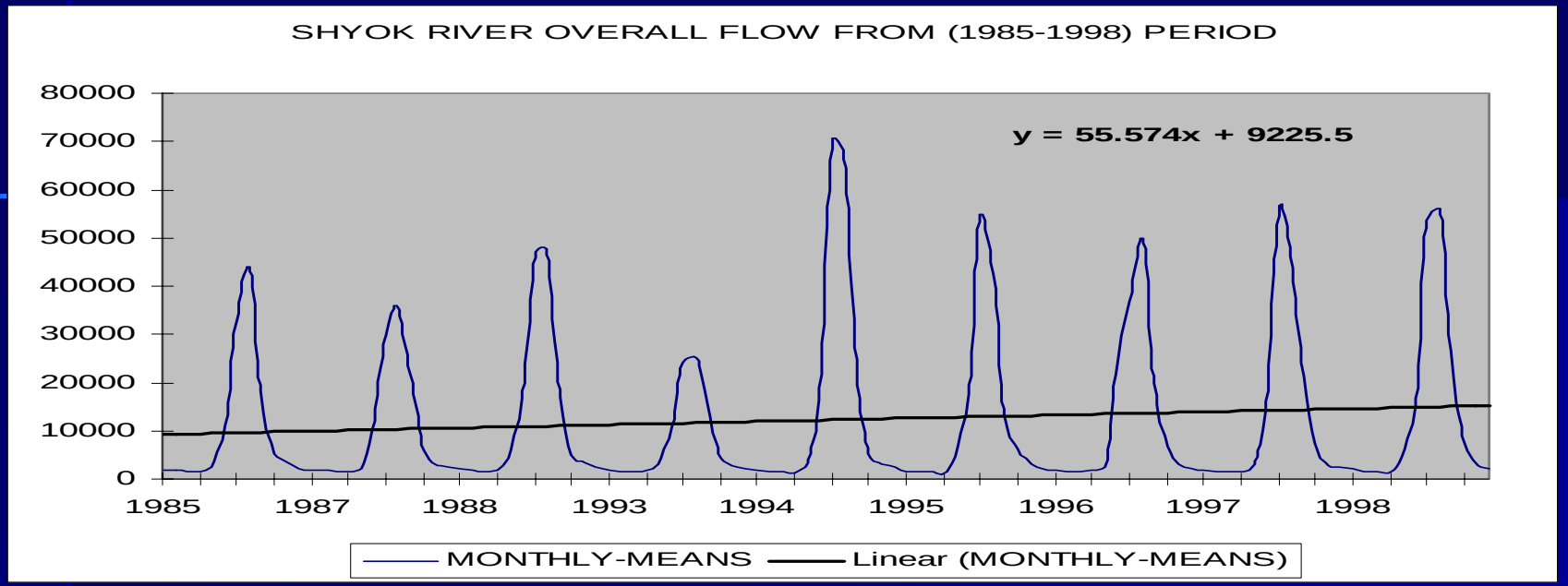


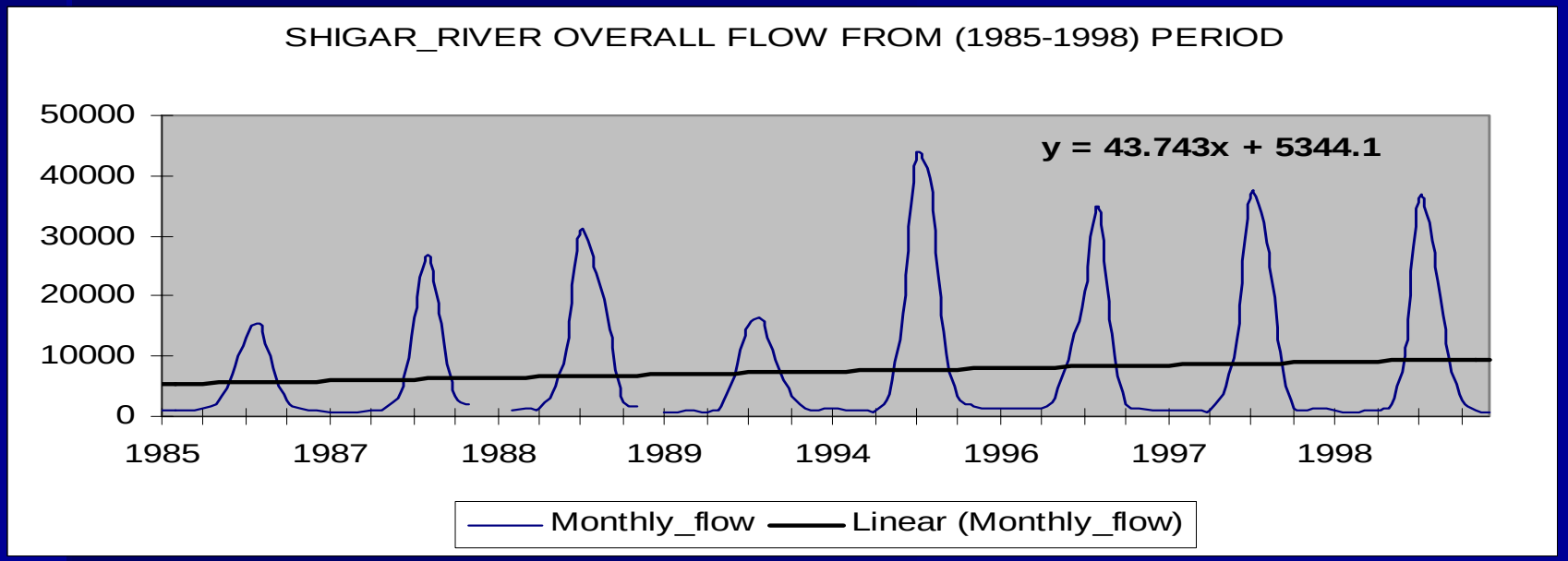
Winter – Change in Mean Temperature




SHYOK RIVER OVERALL FLOW FROM (1985-1998) PERIOD
y = 55.574x + 9225.5
80000
70000
60000
50000
40000
30000
20000
10000
0
1985
1987
1988
1993
1994
1995
1996
1997
1998
MONTHLY-MEANS
Linear (MONTHLY-MEANS)


HUNZA RIVER OVERALL FLOW FROM (1985-1998) PERIOD
y = 11.063x + 9928.9
60000
50000
40000
30000
20000
10000
0
1985
1987
1988
1989
1990
1991
1994
1997
1998
MONTHLY-MEANS
Linear (MONTHLY-MEANS)


SHYOK RIVER OVERALL FLOW FROM (1985-1998) PERIOD
y = 55.574x + 9225.5
80000
70000
60000
50000
40000
30000
20000
10000
0
1985
1987
1988
1993
1994
1995
1996
1997
1998
MONTHLY-MEANS
Linear (MONTHLY-MEANS)


SHIGAR_RIVER OVERALL FLOW FROM (1985-1998) PERIOD
y = 43.743x + 5344.1
50000
40000
30000
20000
10000
0
1985
1987
1988
1989
1994
1996
1997
1998
Monthly_flow
Linear (Monthly_flow)

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDROLOGY AND RESEARCH DIRECTORATE
Pakistan Snow and Ice Hydrology Project

Forecast Bulletin For River Kabul @ Nowshera

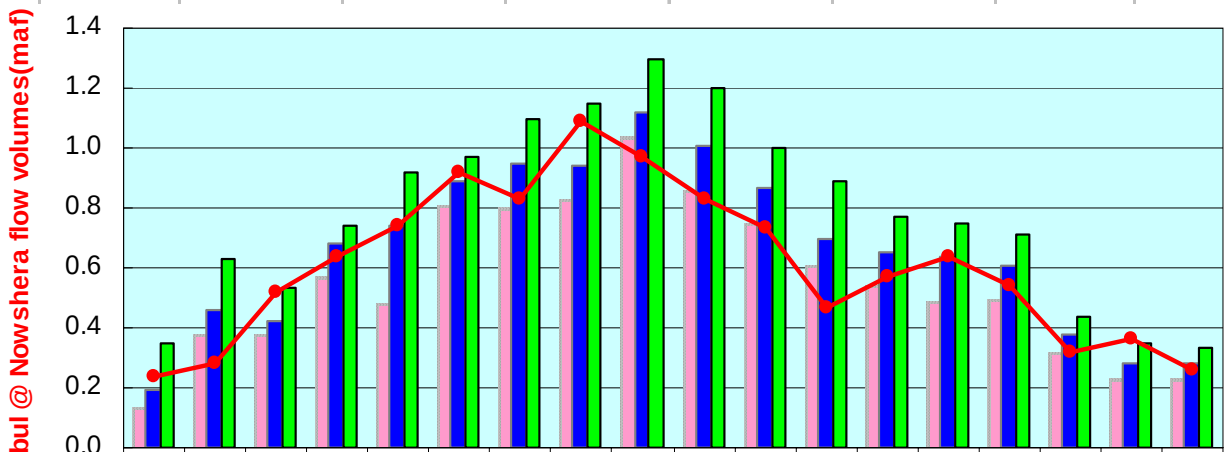
(Kharif Season 2004)

Ten-Daily Forecast

Season Summary

	Forecasted			Actual
	LOW [maf]	AVG [maf]	HIGH [maf]	[maf]
April 1 to Sep. 30	9.95	**11.81**	14.13	10.95

Comparison of 10 - Daily Forecast With Observed Flows
(Khraif Season 2004)



	Apr-I	Apr-II	Apr-III	May-I	May-II	May-III	Jun-I	Jun-II	Jun-III	Jul-I	Jul-II	Jul-III	Aug-I	Aug-II	Aug-III	Sep-I	Sep-II	Sep-III
LOW	0.13	0.38	0.38	0.57	0.48	0.81	0.80	0.83	1.04	0.86	0.75	0.61	0.54	0.49	0.50	0.32	0.23	0.23
AVG	0.19	0.46	0.42	0.68	0.74	0.89	0.95	0.94	1.12	1.01	0.87	0.70	0.65	0.64	0.61	0.38	0.28	0.28
HIGH	0.35	0.63	0.53	0.74	0.92	0.97	1.10	1.15	1.30	1.20	1.00	0.89	0.77	0.75	0.71	0.44	0.35	0.33
OBS	0.24	0.28	0.52	0.64	0.74	0.92	0.83	1.09	0.97	0.83	0.73	0.47	0.57	0.64	0.54	0.32	0.36	0.26

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
HYDROLOGY AND RESEARCH DIRECTORATE
Pakistan Snow and Ice Hydrology Project

Forecast Bulletin For River Kabul @ Nowshera

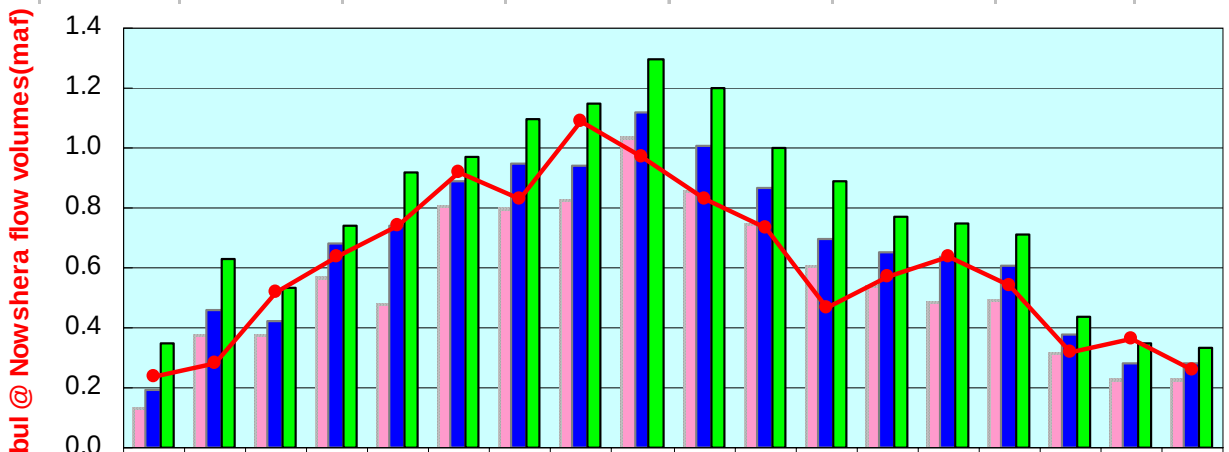
(Kharif Season 2004)

Ten-Daily Forecast

Season Summary

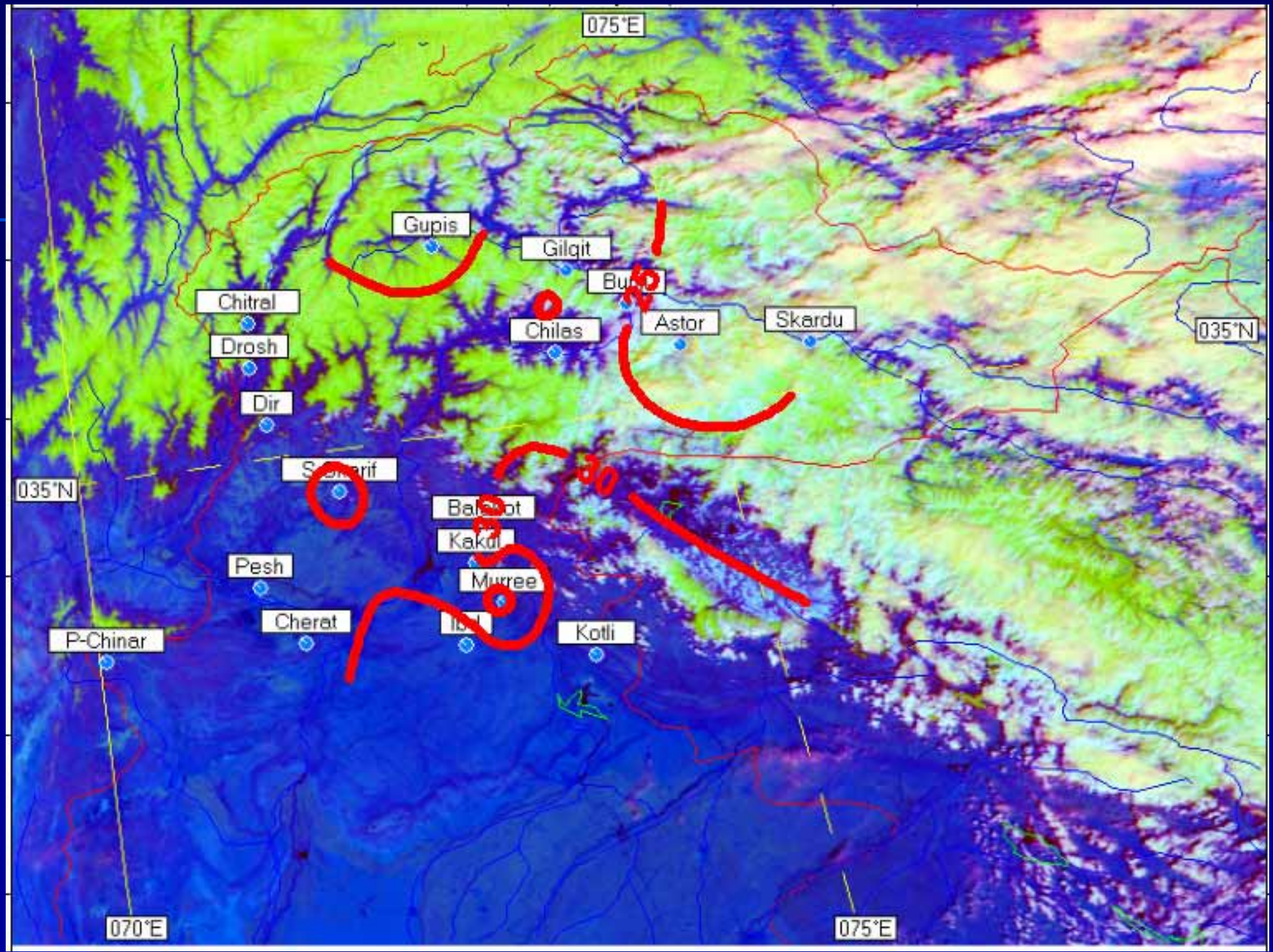
	Forecasted			Actual
	LOW [maf]	AVG [maf]	HIGH [maf]	[maf]
April 1 to Sep. 30	9.95	**11.81**	14.13	10.95

Comparison of 10 - Daily Forecast With Observed Flows
(Khraif Season 2004)

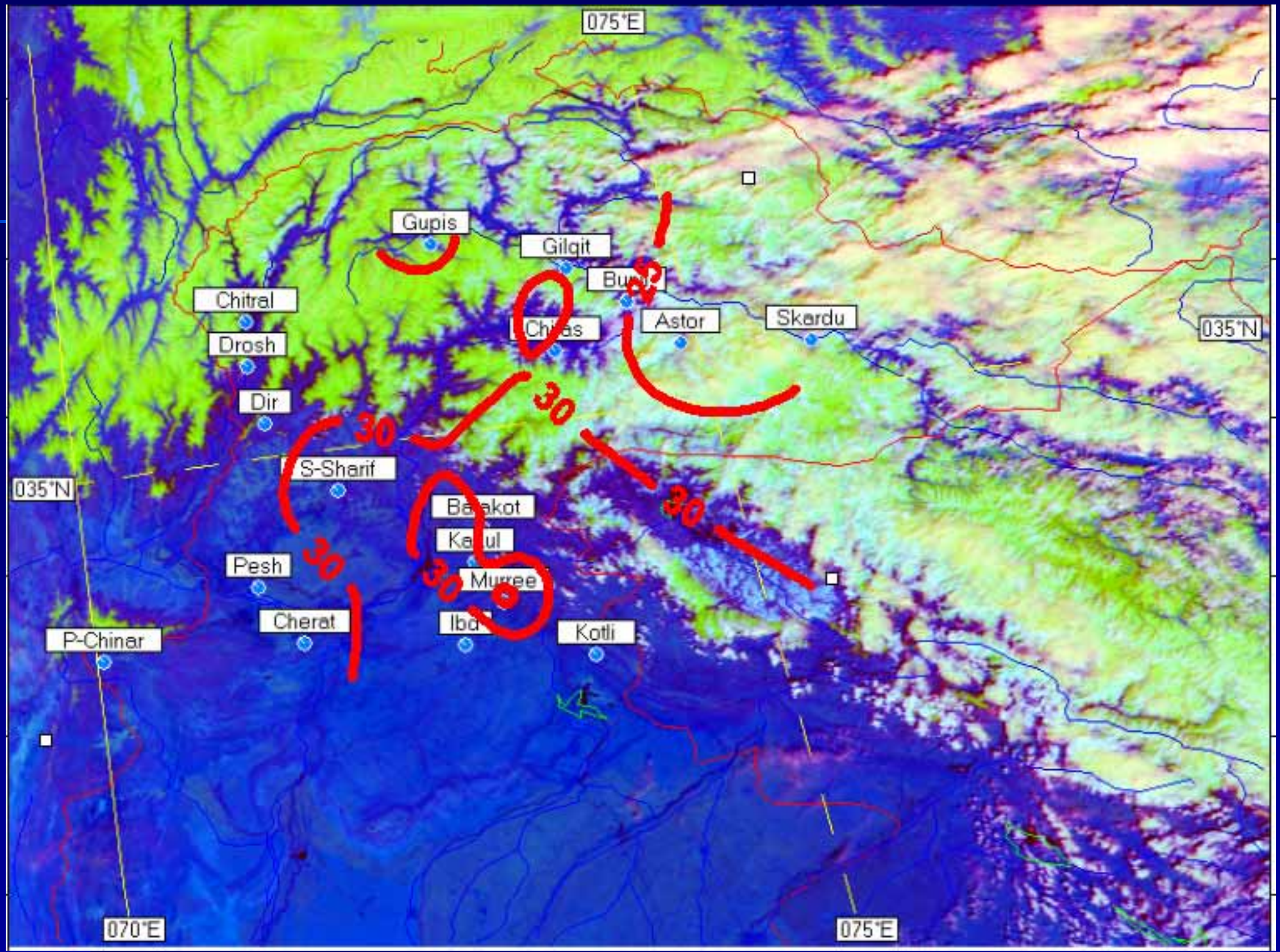


	Apr-I	Apr-II	Apr-III	May-I	May-II	May-III	Jun-I	Jun-II	Jun-III	Jul-I	Jul-II	Jul-III	Aug-I	Aug-II	Aug-III	Sep-I	Sep-II	Sep-III
LOW	0.13	0.38	0.38	0.57	0.48	0.81	0.80	0.83	1.04	0.86	0.75	0.61	0.54	0.49	0.50	0.32	0.23	0.23
AVG	0.19	0.46	0.42	0.68	0.74	0.89	0.95	0.94	1.12	1.01	0.87	0.70	0.65	0.64	0.61	0.38	0.28	0.28
HIGH	0.35	0.63	0.53	0.74	0.92	0.97	1.10	1.15	1.30	1.20	1.00	0.89	0.77	0.75	0.71	0.44	0.35	0.33
OBS	0.24	0.28	0.52	0.64	0.74	0.92	0.83	1.09	0.97	0.83	0.73	0.47	0.57	0.64	0.54	0.32	0.36	0.26

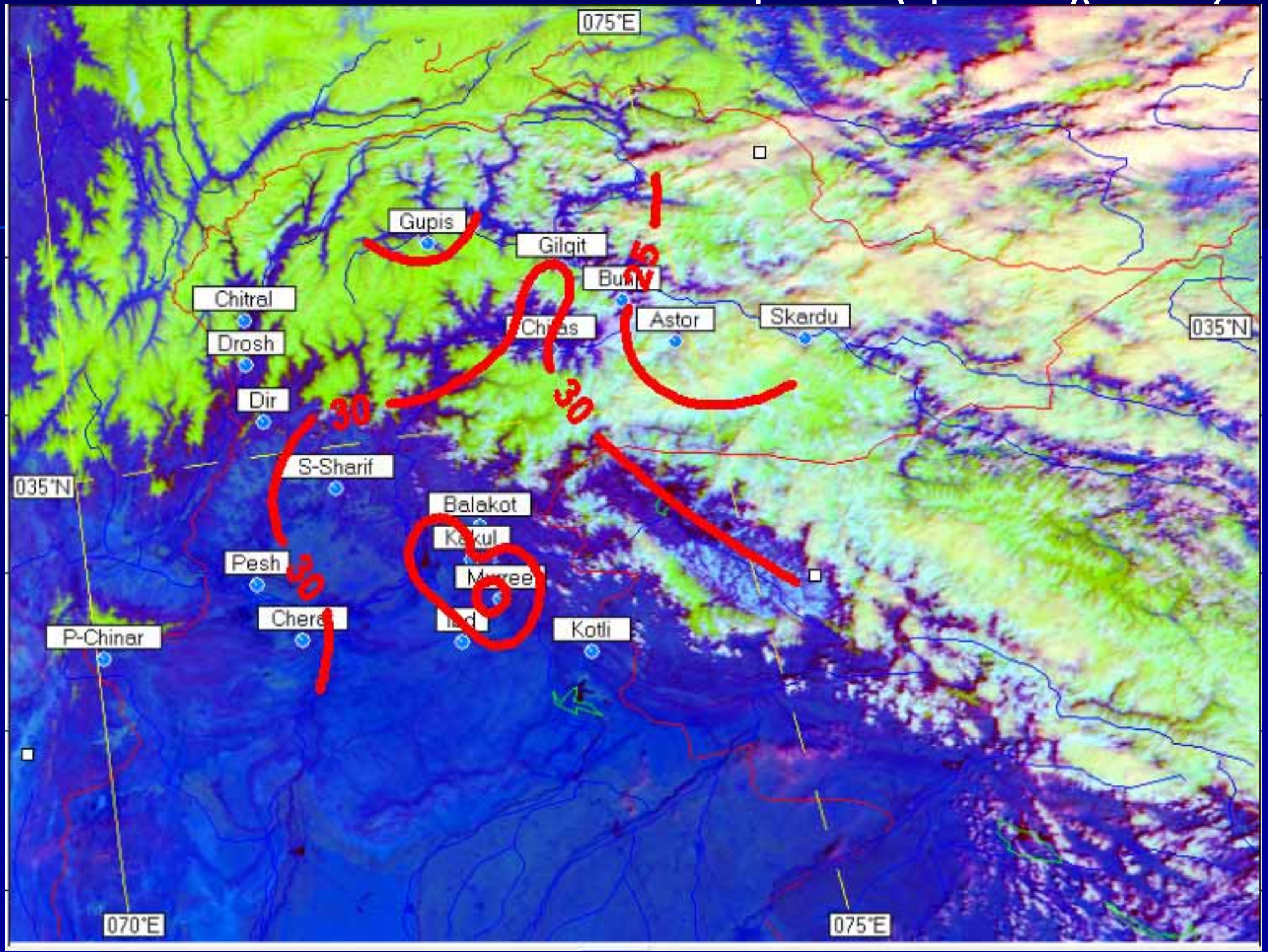
Isotherms Based on Mean Summer Max Temperature (April-June) (1981-85)



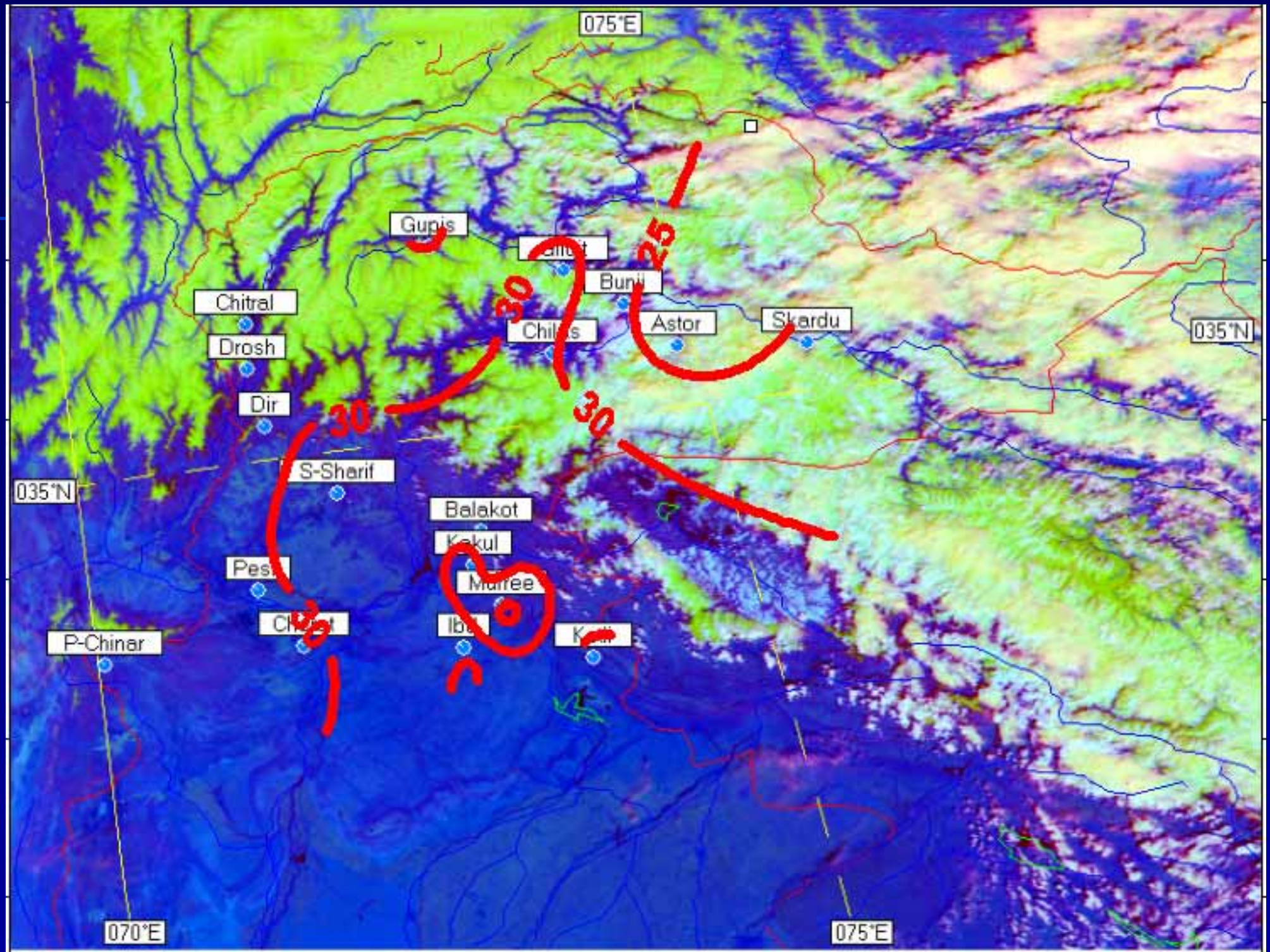
Isotherms Based on Mean Summer Max Temperature (April-June)(1986-1990)



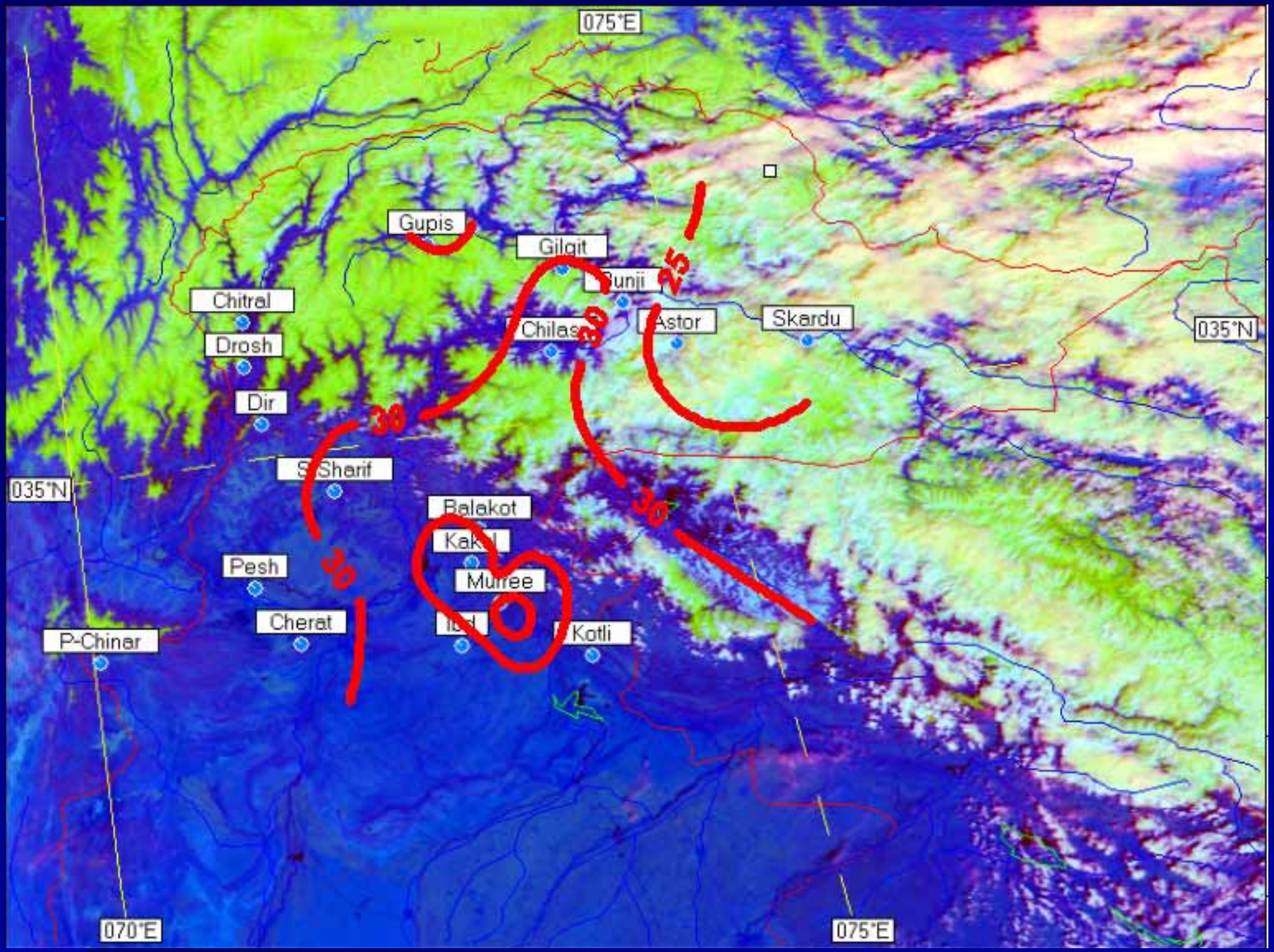
Isotherms Based on Mean Summer Max Temperature (April-June)(1991-95)

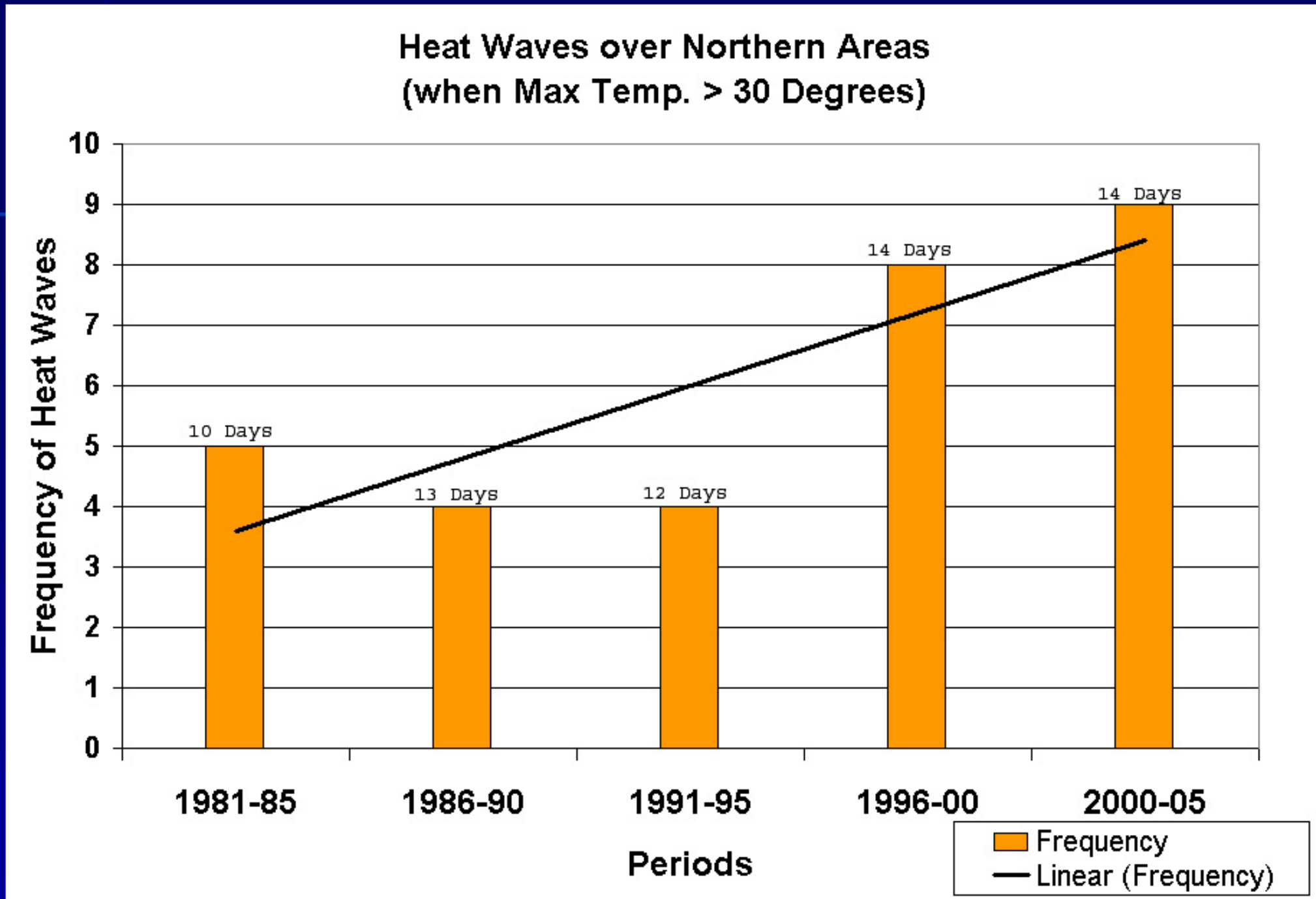


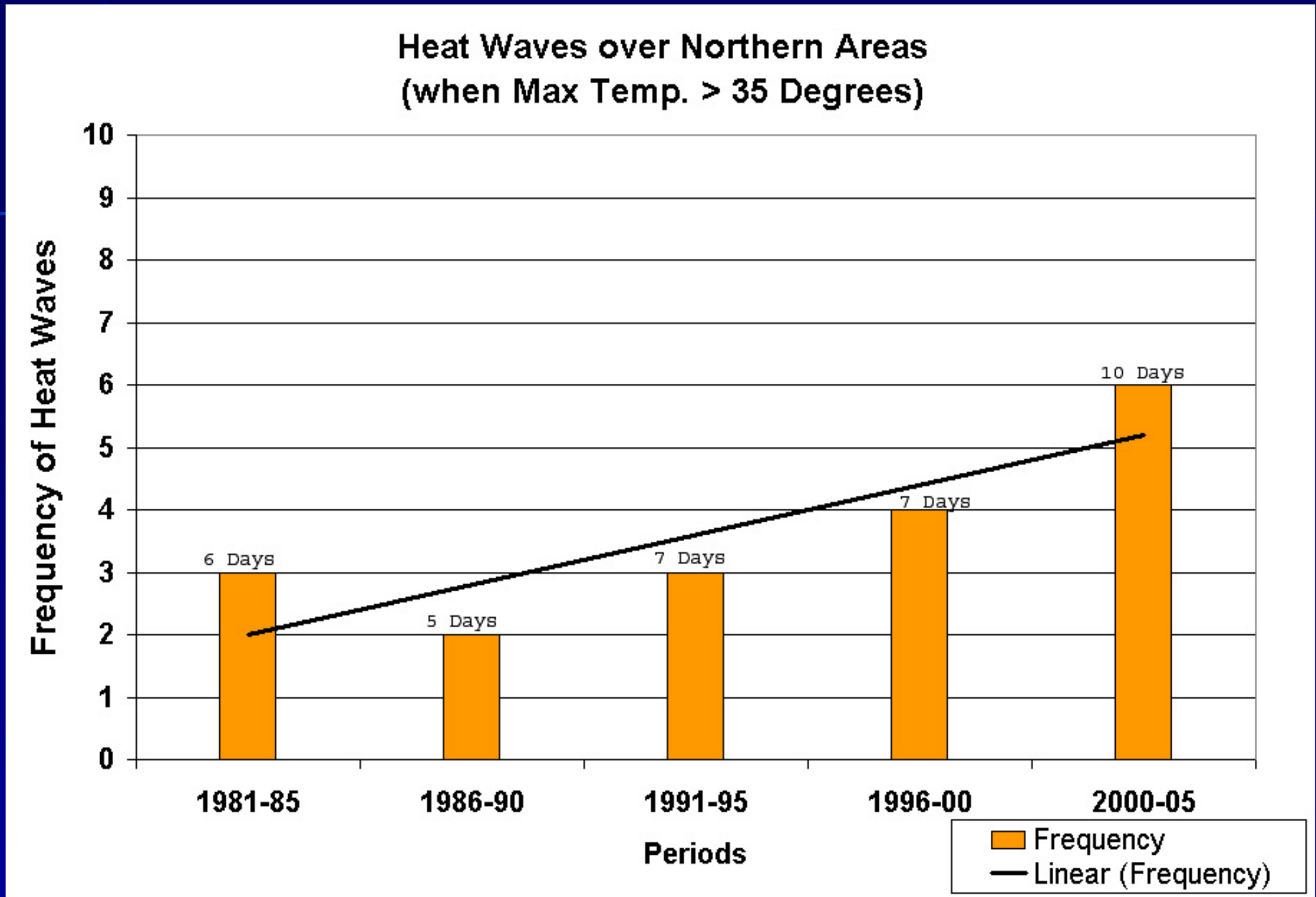
Isotherms Based on Mean Summer Max Temperature (April-June)(1995-2000)

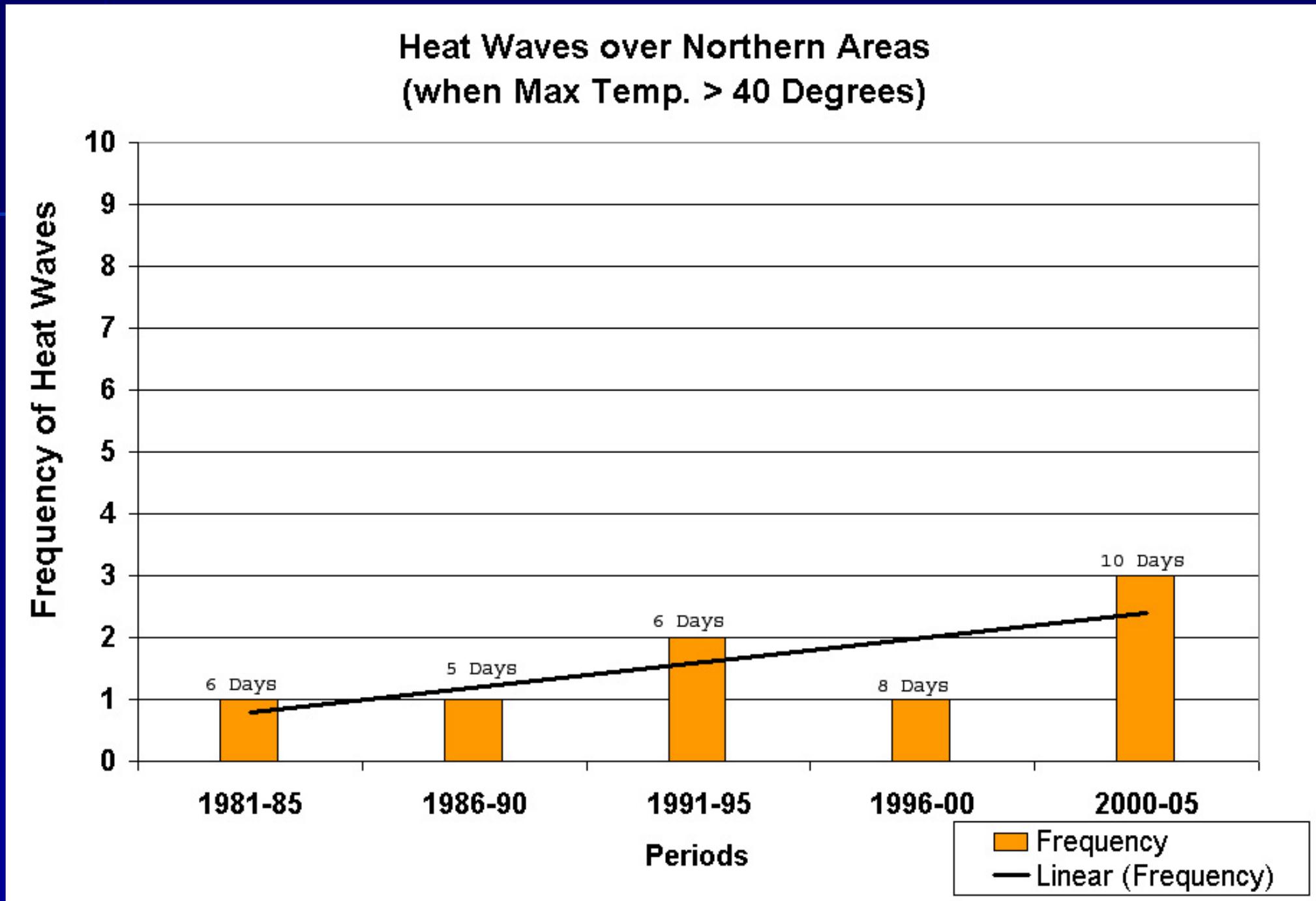


Isotherms Based on Mean Summer Max Temperature (April-June)(2001-05)



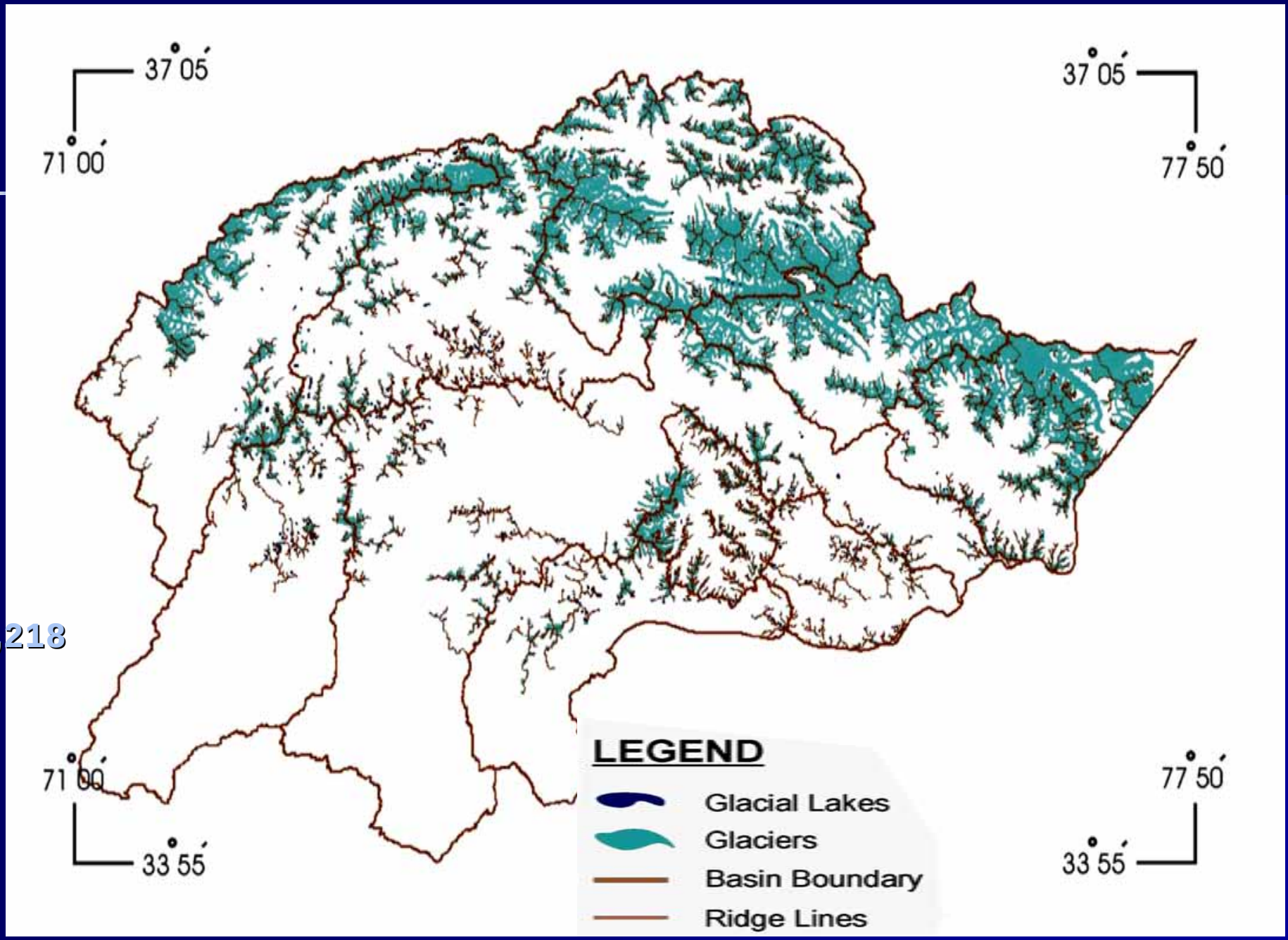

Heat Waves over Northern Areas
(when Max Temp. > 30 Degrees)
Frequency of Heat Waves
10
9
8
7
6
5
4
3
2
1
0
10 Days
13 Days
12 Days
14 Days
14 Days
1981-85
1986-90
1991-95
1996-00
2000-05
Periods
Frequency
Linear (Frequency)


Heat Waves over Northern Areas
(when Max Temp. > 35 Degrees)
Frequency of Heat Waves
10
9
8
7
6
5
4
3
2
1
0
6 Days
5 Days
7 Days
7 Days
10 Days
1981-85
1986-90
1991-95
1996-00
2000-05
Periods
Frequency
Linear (Frequency)


Heat Waves over Northern Areas
(when Max Temp. > 40 Degrees)
Frequency of Heat Waves
10
9
8
7
6
5
4
3
2
1
0
6 Days
5 Days
6 Days
8 Days
10 Days
1981-85
1986-90
1991-95
1996-00
2000-05
Periods
Frequency
Linear (Frequency)

Glaciers / Ice Cover Monitoring

Glaciers of Upper Indus Basins



Total Area **5,218**

Source: WRRI, NARC (2005) " Inventory of glaciers"

Siachen Glacier

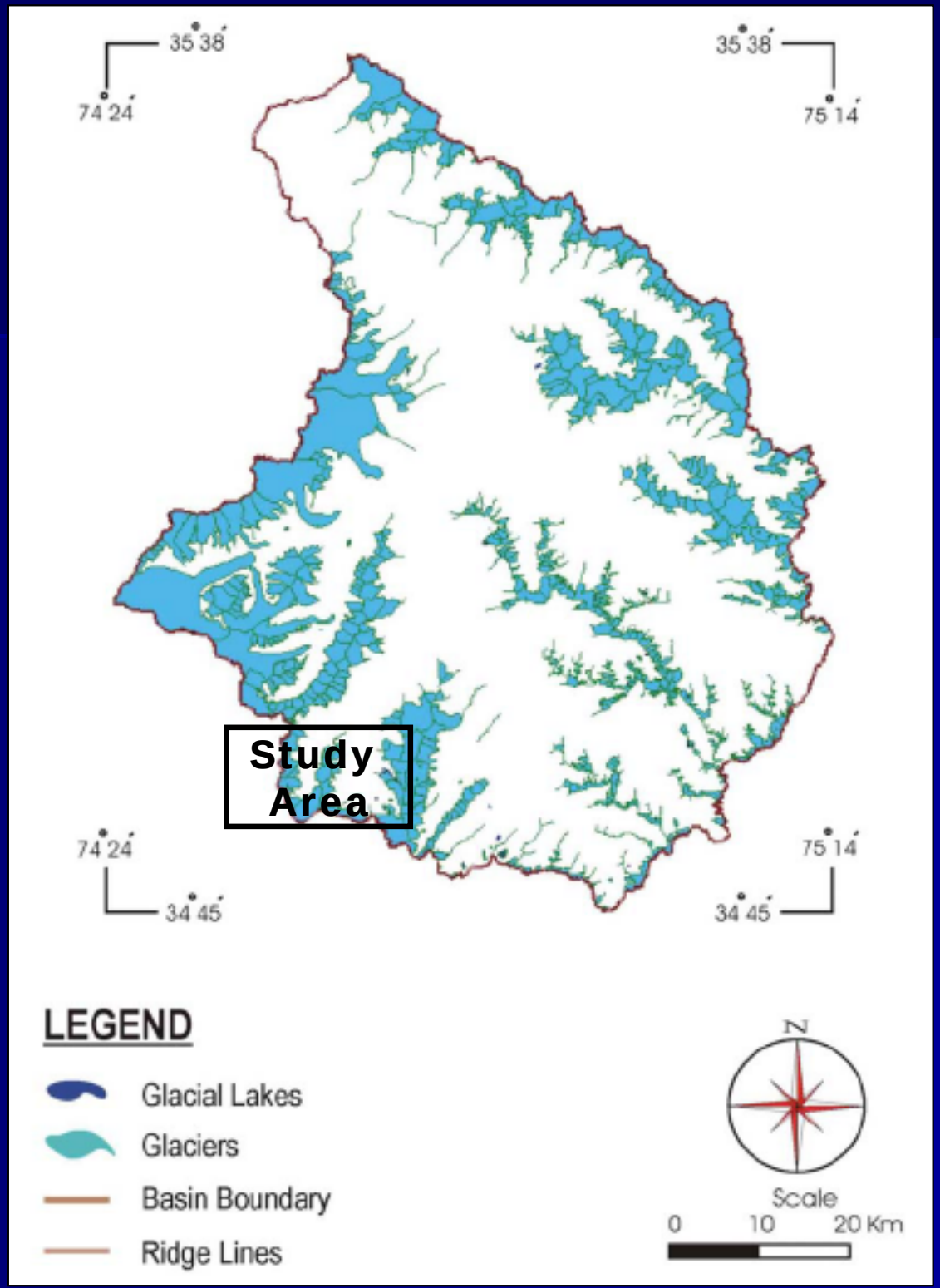
1989

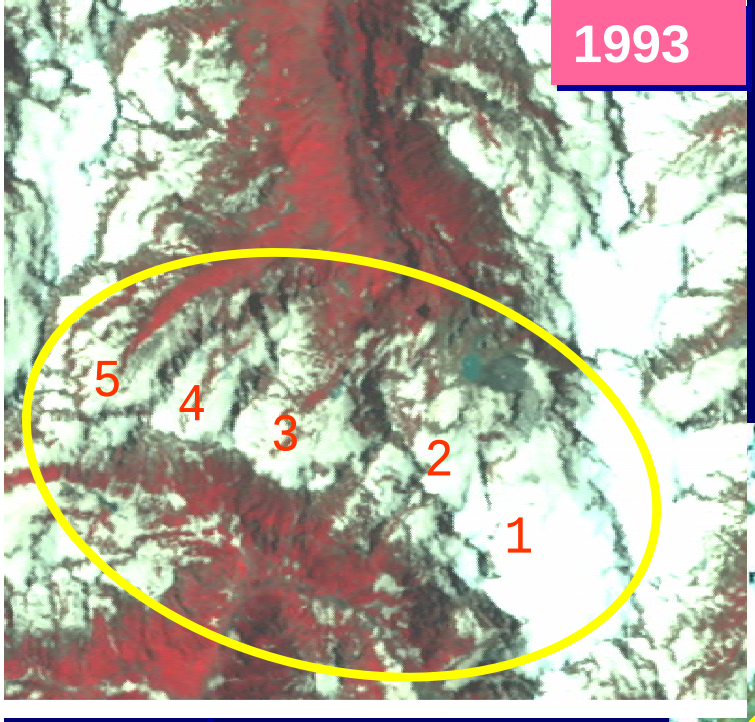
2006

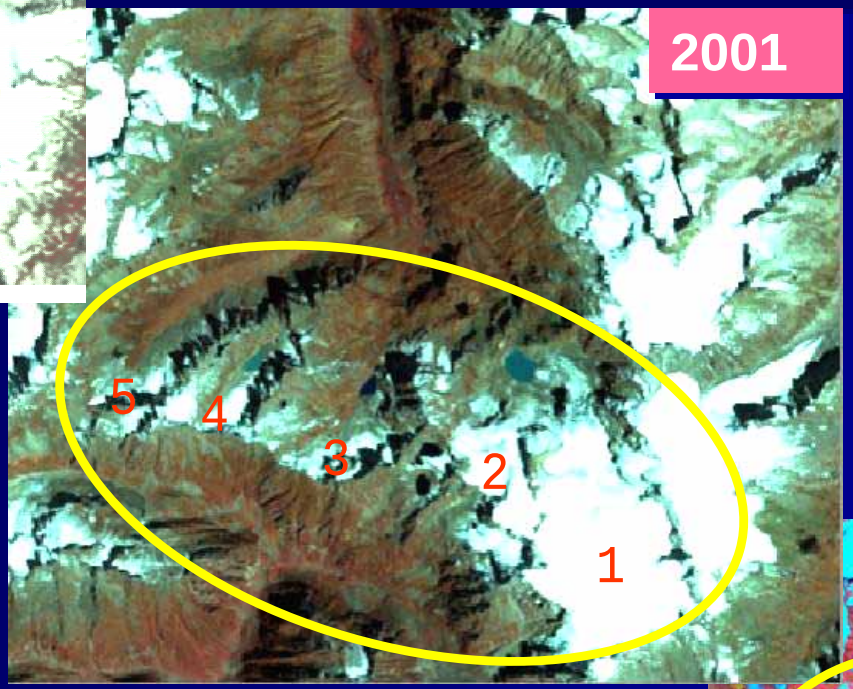
- Siachen Glacier has retreated about 1.7 Km in last 17 years

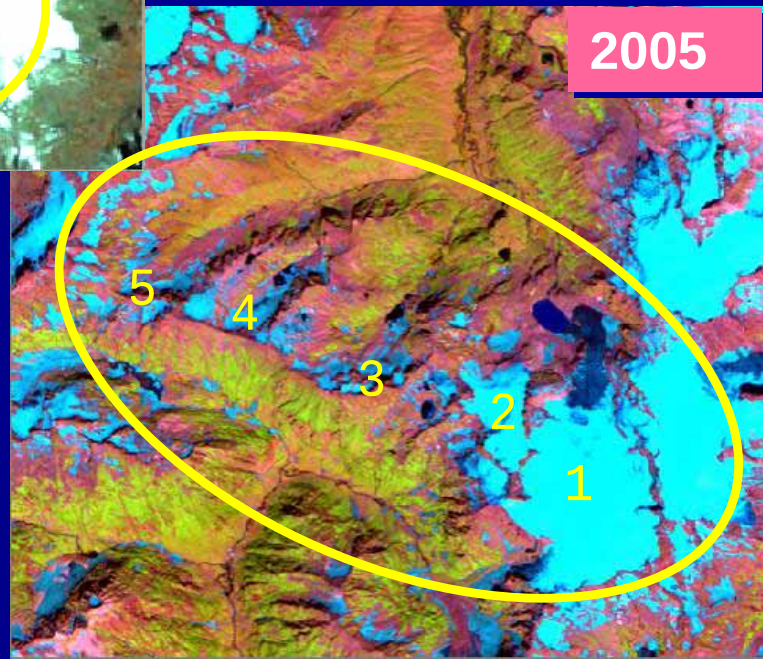
(Landsat 30 km resolution)

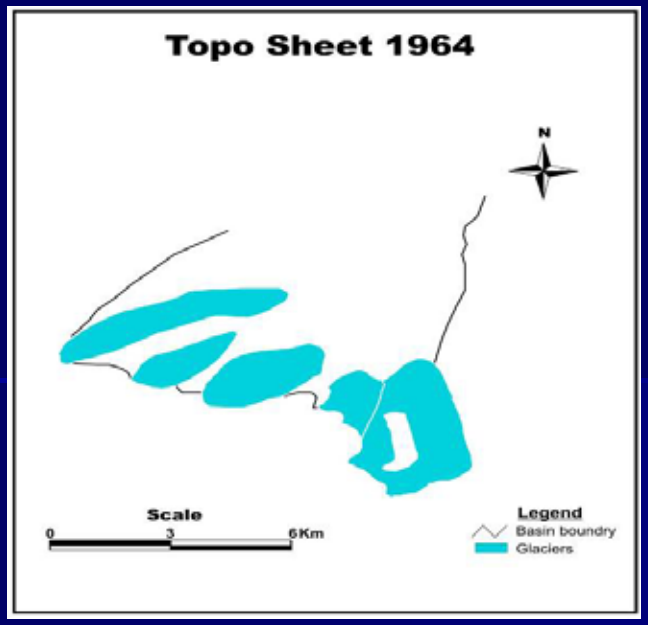
The Glaciers Distribution in Astor River Basin

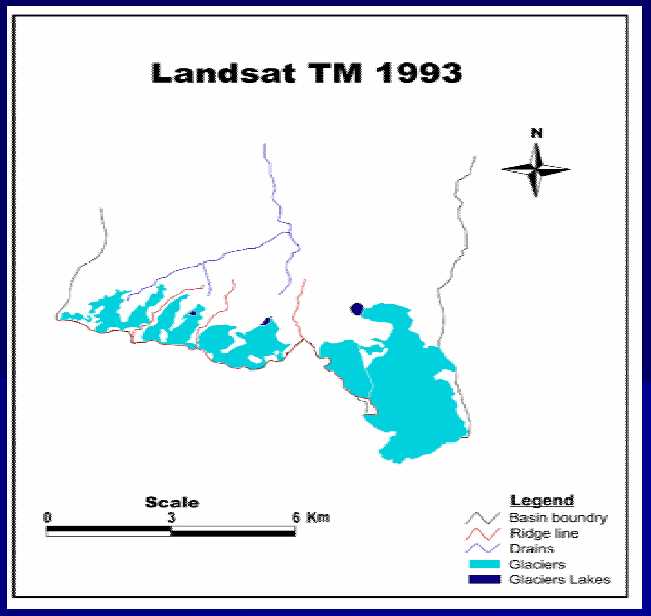


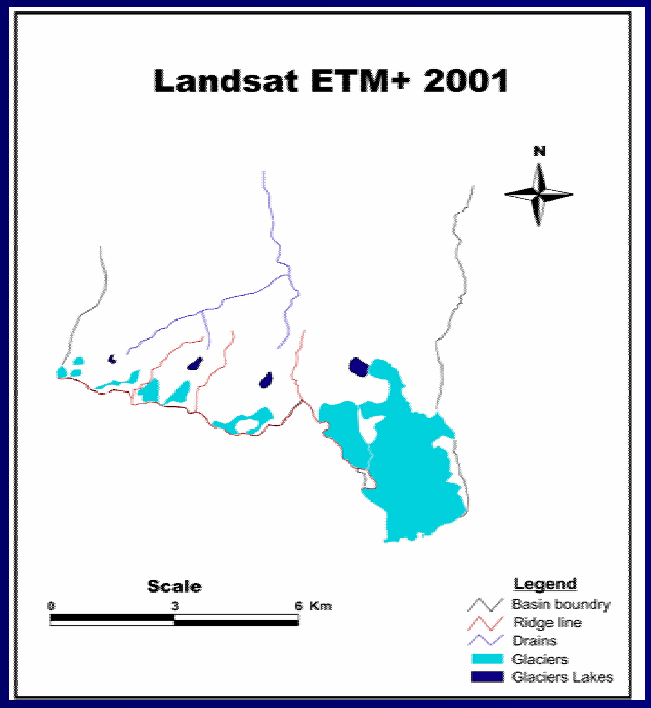

1993
5
4
3
2
1

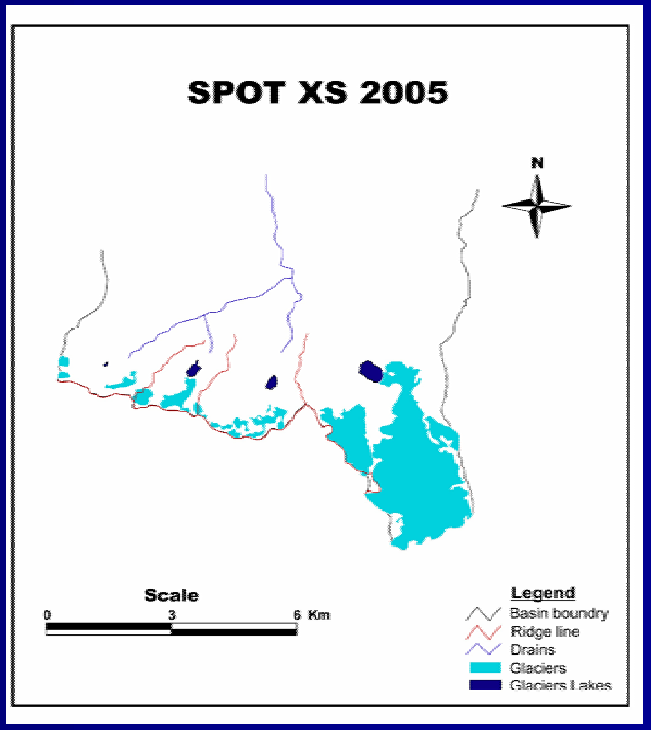

2001
5
4
3
2
1


2005
5
4
3
2
1



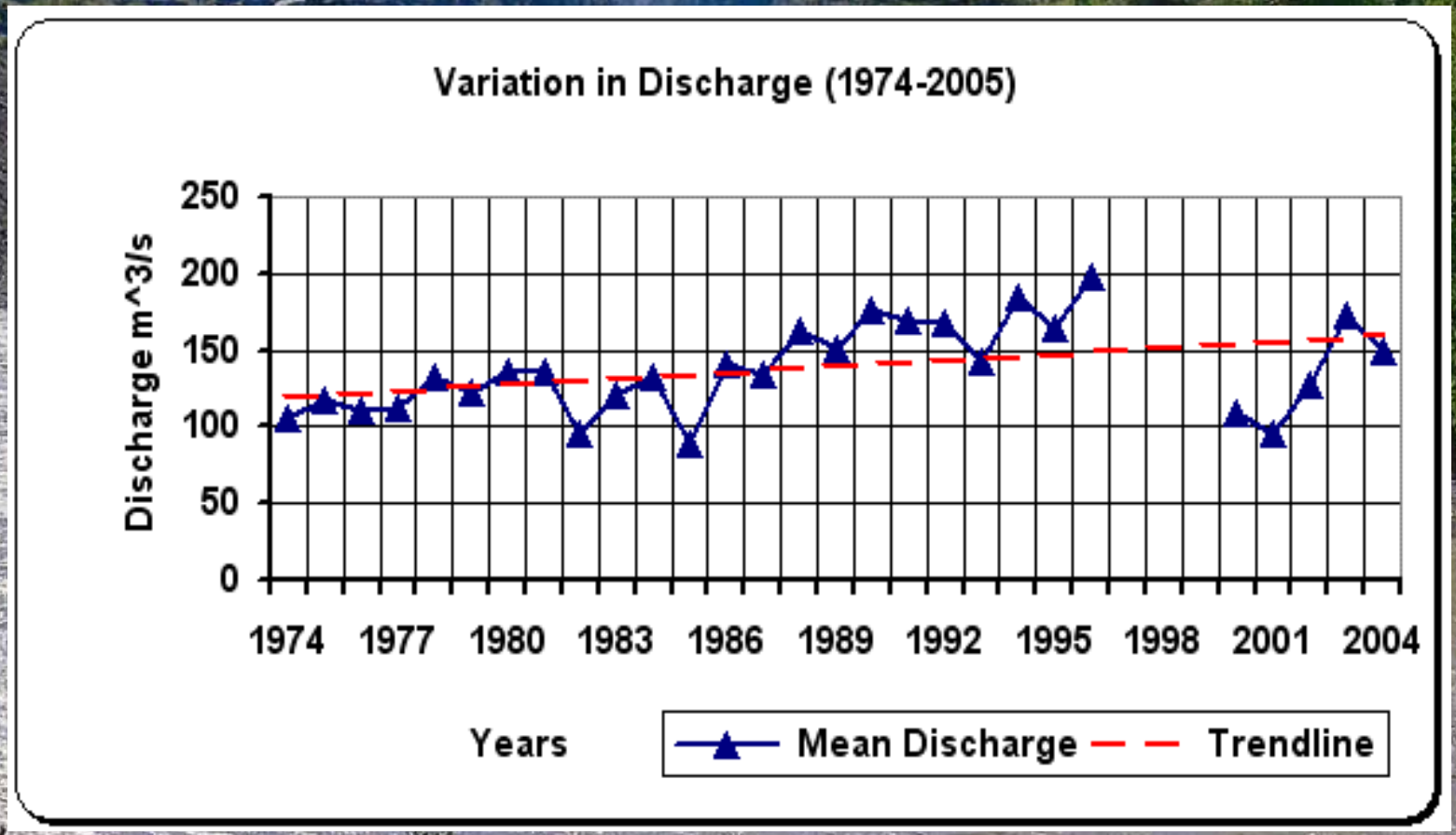






Temporal behavior of Glaciers and Glacial lakes during 1964-2005

Trend of Annual Discharge of Astor River



PART-II

MANAGEMENT OF WATER RESOURCES

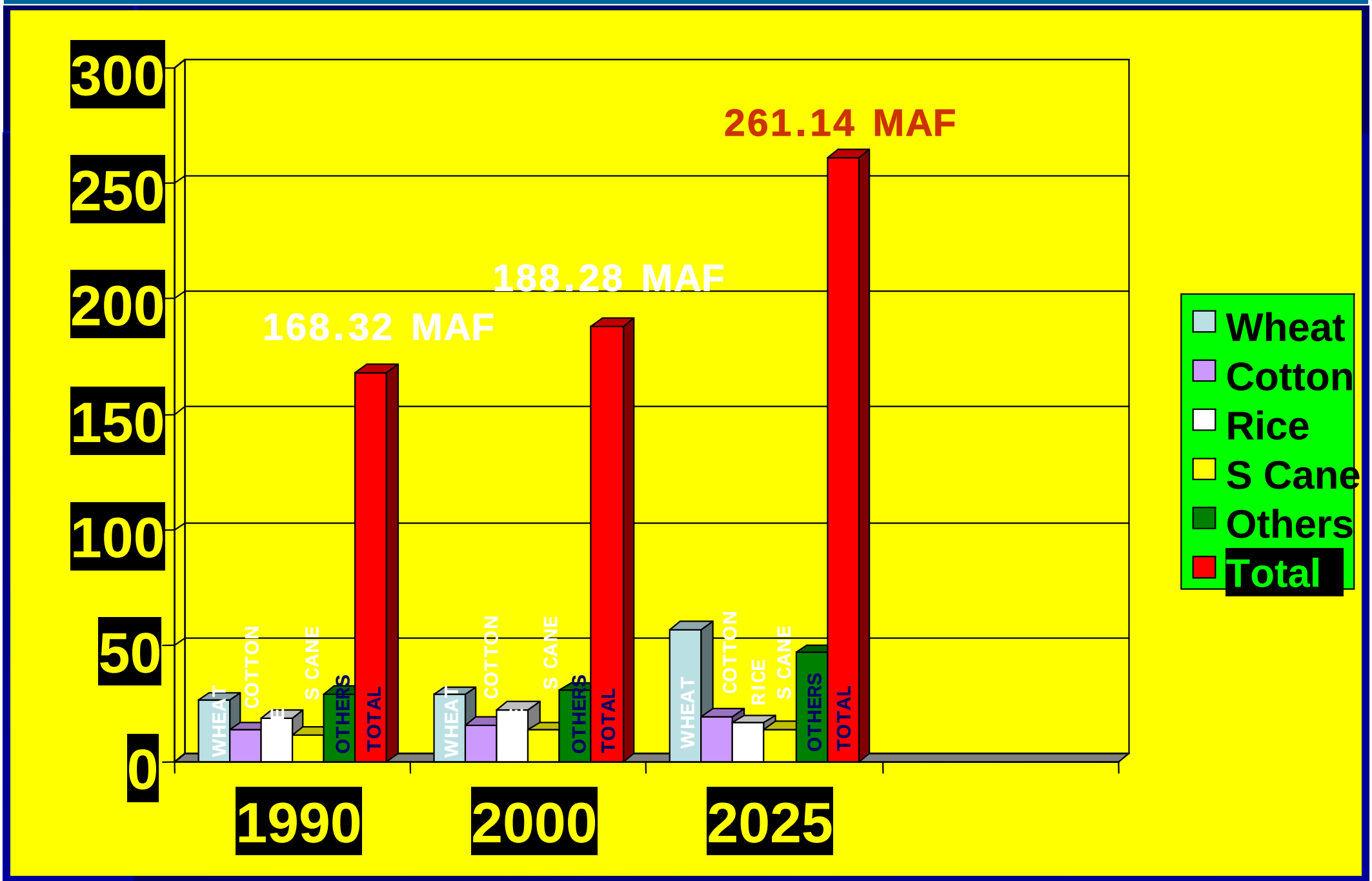
&

WATER REQUIREMENT OF PAKISTAN

TOTAL WATER RESOURCES AVAILABLE

Surface Water availability	Water (MAF)
Mean river inflows	144
Rainfall	26
Hill torrents	17
Total	187
Groundwater availability	50
Total availability	237

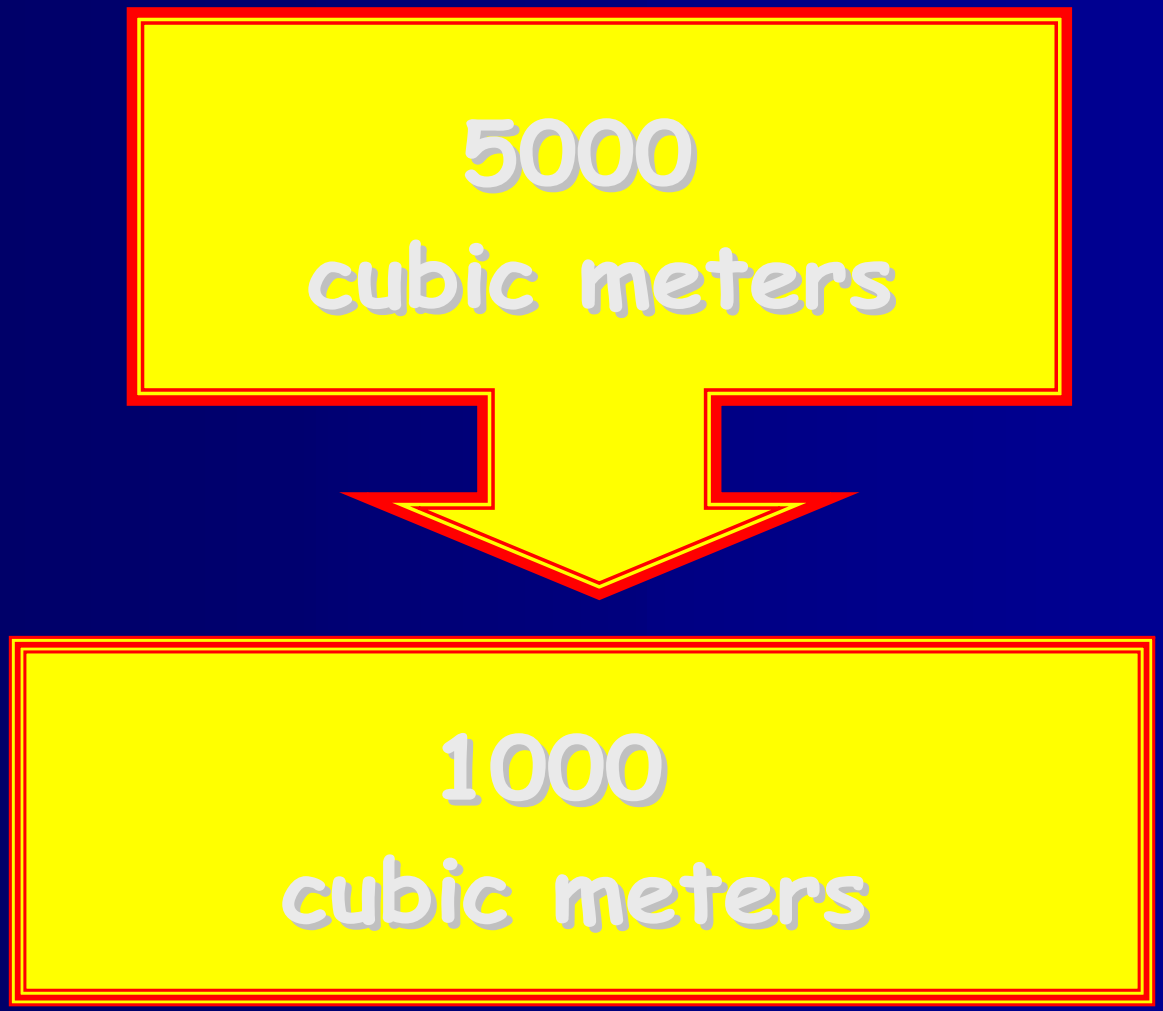
Agricultural Water Demands (MAF)



SYSTEM LOSSES

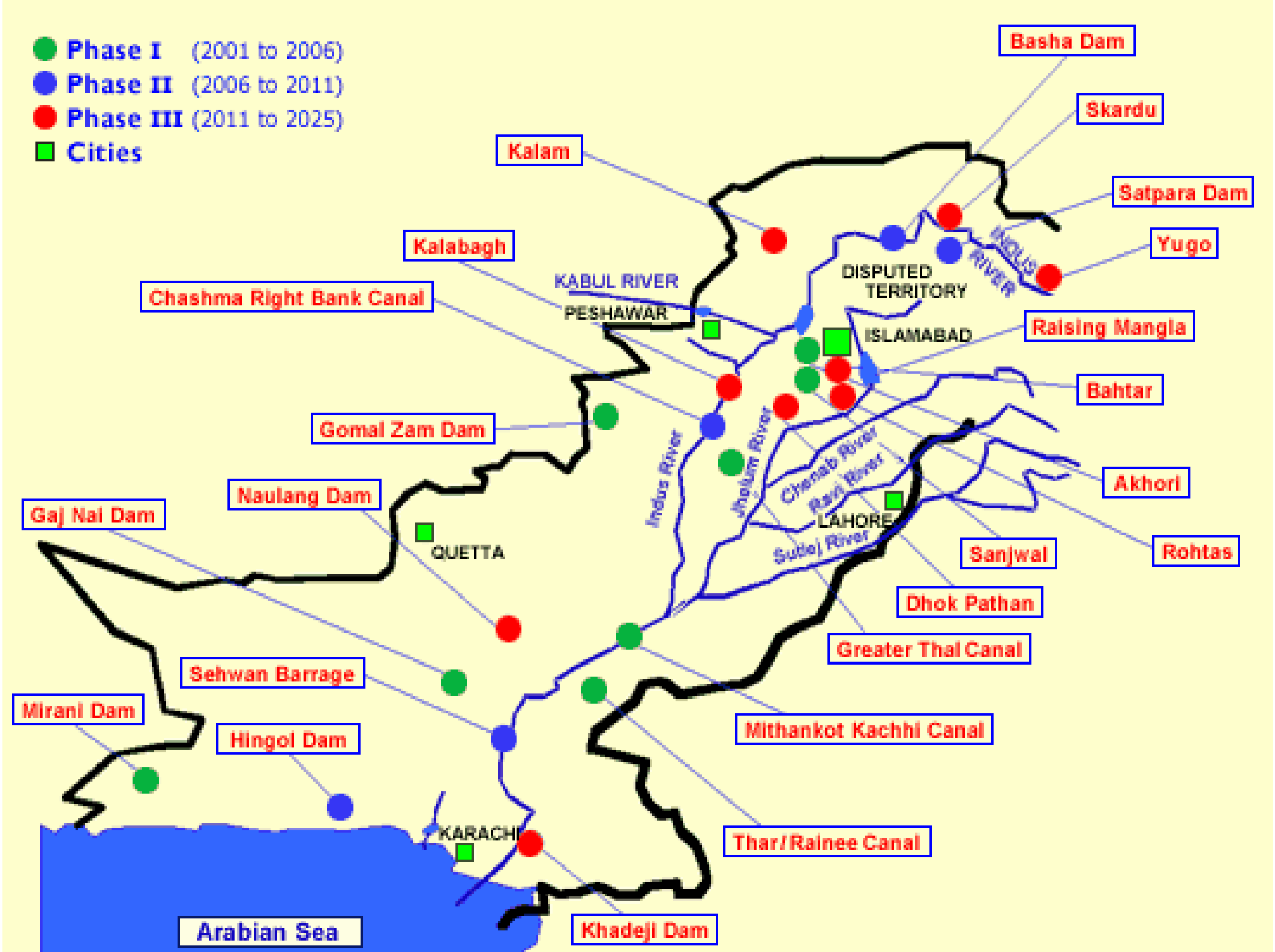
- 39 MAF flows into sea
- 105 MAF for irrigation
- 21 MAF Evaporation/Seepage
- 84 MAF reaches the head of water course
- 46 MAF reaches fields
- 34 MAF available to plants

INCREASE IN POPULATION

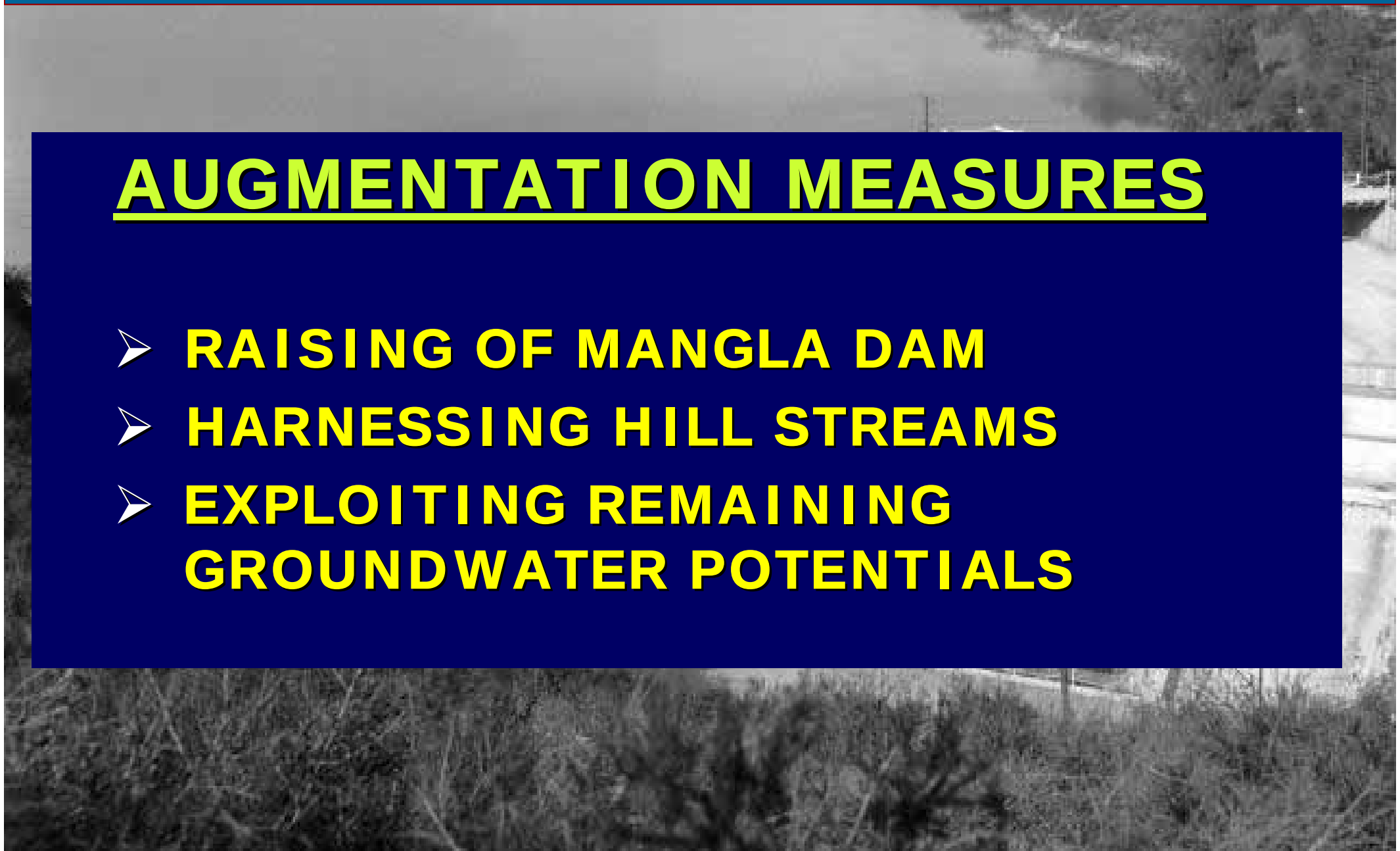


POORLY MANAGED IRRIGATION SYSTEM

DEPLETING GROUND WATER RESOURCES


Phase I (2001 to 2006)
Phase II (2006 to 2011)
Phase III (2011 to 2025)
Cities
Basha Dam
Skardu
Kalam
Satpara Dam
Yugo
Kalabagh
Chashma Right Bank Canal
KABUL RIVER
PESHAWAR
DISPUTED TERRITORY
INDUS RIVER
ISLAMABAD
Raising Mangla
Bahtar
Gomal Zam Dam
Indus River
Jhelum River
Chenab River
Ravi River
Sutlej River
Akhori
Naulang Dam
Gaj Nai Dam
QUETTA
LAHORE
Sanjwal
Rohtas
Dhok Pathan
Greater Thal Canal
Sehwan Barrage
Mithankot Kachhi Canal
Mirani Dam
Hingol Dam
KARACHI
Thar/Rainee Canal
Arabian Sea
Khadeji Dam

PLANNING COMMISSION VISION 2010



AUGMENTATION MEASURES

- RAISING OF MANGLA DAM
- HARNESSING HILL STREAMS
- EXPLOITING REMAINING GROUNDWATER POTENTIALS

PLANNING COMMISSION
VISION 2010

Management Measures

- Lining canals / watercourses
- Changes in cropping pattern
- Using high efficiency irrigation techniques


Thank You