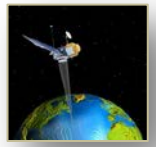






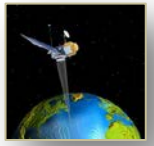


To study Atmospheric Composition and Climate Change Impacts over Pakistan

M. Fahim Khokhar[1], M. Hussain[2], E. Palazzi[3] and SHARE-PAPRIKA-Karakorum project team

1: Institute of Environmental Sciences and Engineering, SCEE-NUST Pakistan
2: College of Civil Engineering Risalpur, NUST Pakistan
3: Institute of Atmospheric Sciences and Climate, National Research Council Torino, Italy

Contact: fahim.khokhar@iese.nust.edu.pk









Outline

- Climate of Pakistan
  - Precipitation
    - Summer – Monsoon
    - Winter – Westerlies
  - Temperature

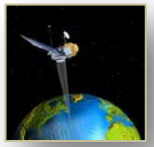
- Climate Change Impacts
  - Floods in 2010
  - Frequent Heat waves

- Ev-K2-CNR
  - SHARED Paprika Project
  - SHARE Box Device (trace gases)

- Climate Change impact and adaptation activities at NUST
  - EPAC- Project
  - ROGPA- Project

- Conclusions

Ev-K2-CNR, Pyramid Laboratory-Observatory - Mount Everest



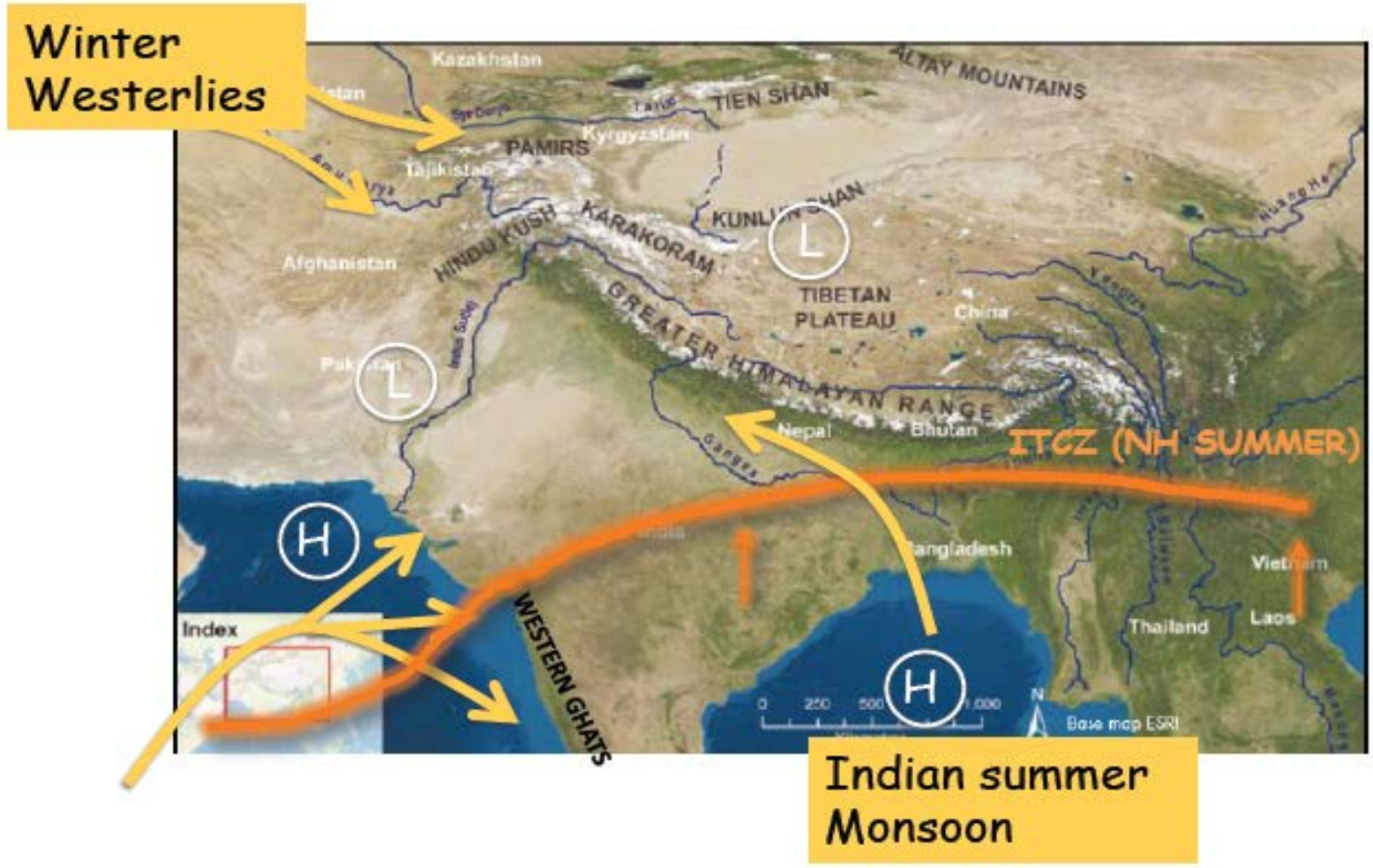






Circulation patterns in the Hindu-Kush Karakoram Himalaya (HKKH) and the Indian subcontinent

- **Himalaya-Karakorum-Hindukush** (HKH) together constitute one of the largest mountain range
- Third largest ice reserves after the Polar Regions (**Third Pole of the Earth**)

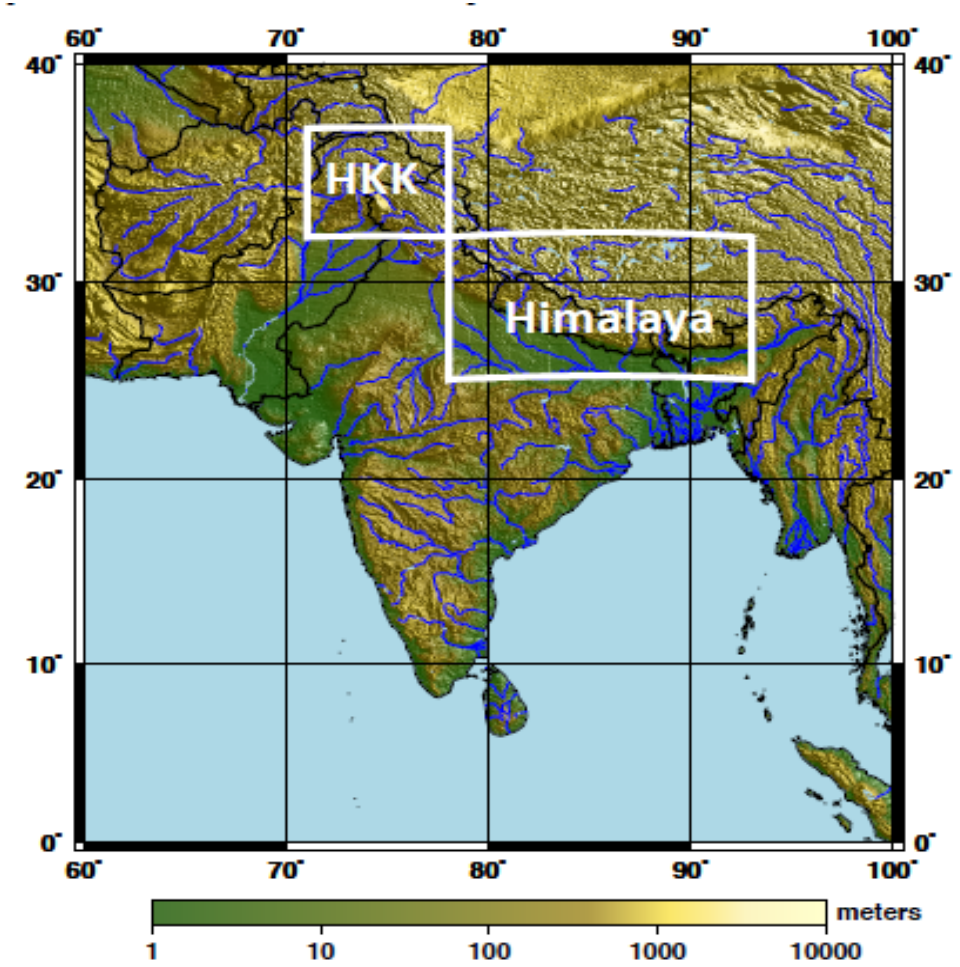


Himalaya-Karakorum-Hindukush Region

- **Himalaya-Karakorum-Hindukush** (HKH) together constitute one of the largest mountain range
- Third largest ice reserves after the Polar Regions (**Third Pole of the Earth**)

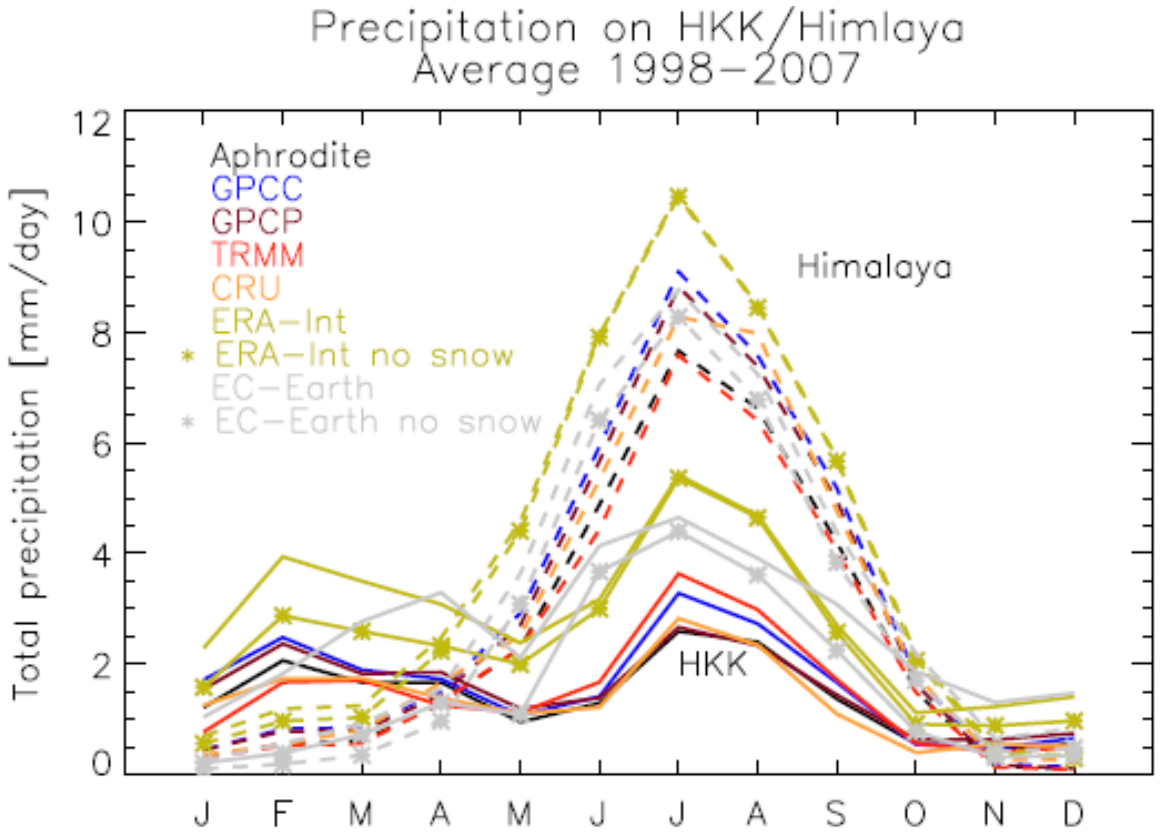
- The **complex meteoclimatic regimes** in the different parts of the HKKH hampers a description of this area in terms of a homogenous region.

- Therefore need to be subdivided in to different regions:
  - **HKK region** (westerly winds system)
  - **Himalaya region** (Monsoon system)



Precipitation seasonality in the HKK and Himalaya

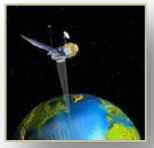
Different colors represents different data sets like in-situ data, satellite observations (TRMM), reanalysis data (green)and model simulations (grey)



- HKK region with winter and summer maxima (bimodal distribution)
- Himalaya region with maximum in summer (one modal).

The mean annual cycle of precipitation is coherently reproduced by the various data sets.

Palazzi E., von Hardenberg and Provenzale, submitted to JGR





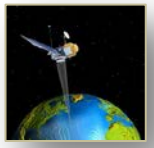




Climate of Hindukush –Karakorum (HKK) Region

- ✓ Climate: Not dominated by the summer monsoon
- ✓ Precipitation: concentrated in winter and spring, carried on broad scale western weather patterns originating from the Mediterranean or from the area of the Caspian Sea
- ✓ The pattern of climatic change in Karakoram is controversial → conflicting signals of climate change. Stable/advancing glaciers (retreating glaciers in the Himalaya). Decreasing summer temperatures. Increasing winter precipitation.

The HKK and the Himalayan regions cannot be considered as a single region: they differ for circulation pattern, precipitation amount and seasonality and glacier behavior and dynamics.

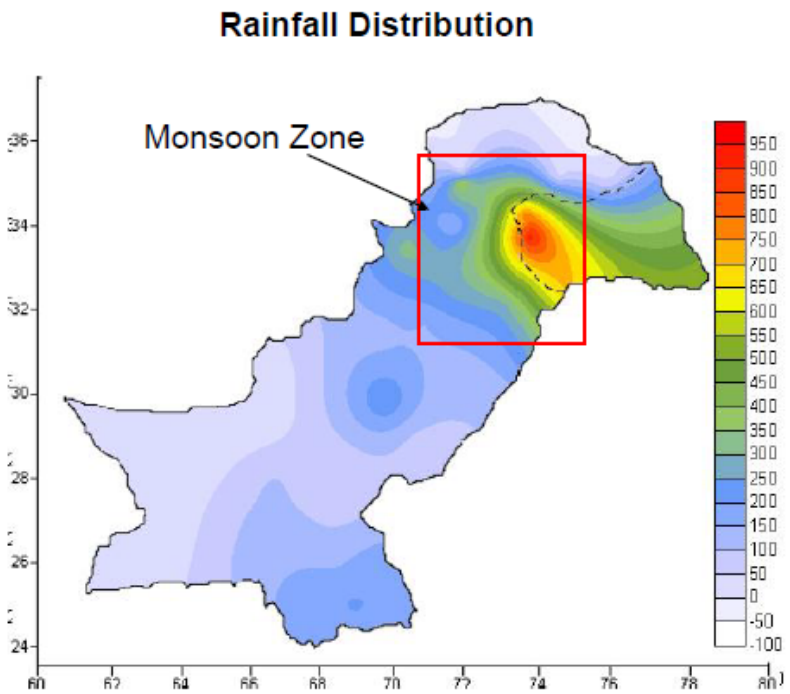






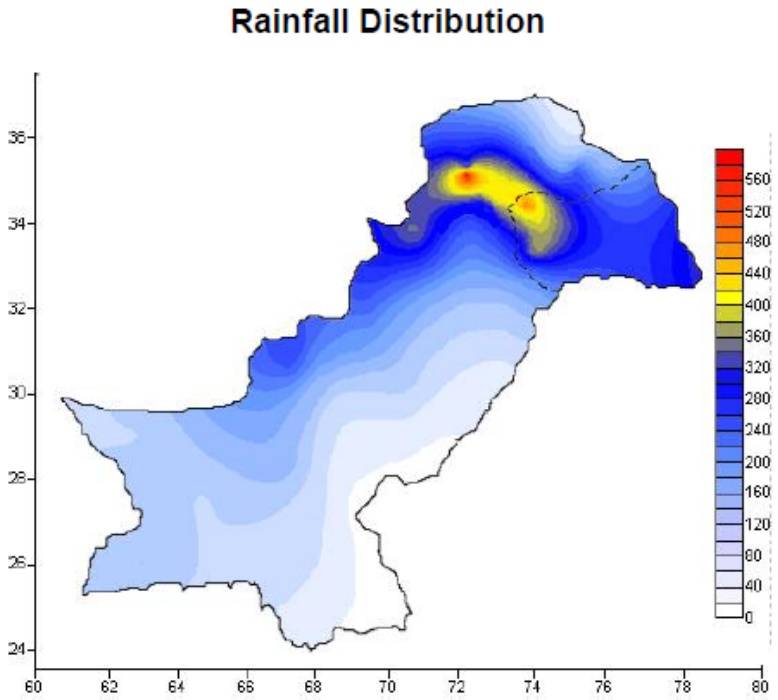


Climate of Pakistan



Monsoon (JJAS)

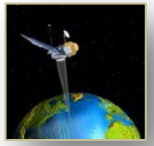
65% of Annual Rainfall



Winter (DJF)

25% of Annual Rainfall

Figure curtsey: PMD Pak.









Pakistan Meteorological Department Network

- PMD-network consists of 43 monitoring stations across the country
- real time data for temperature and precipitation

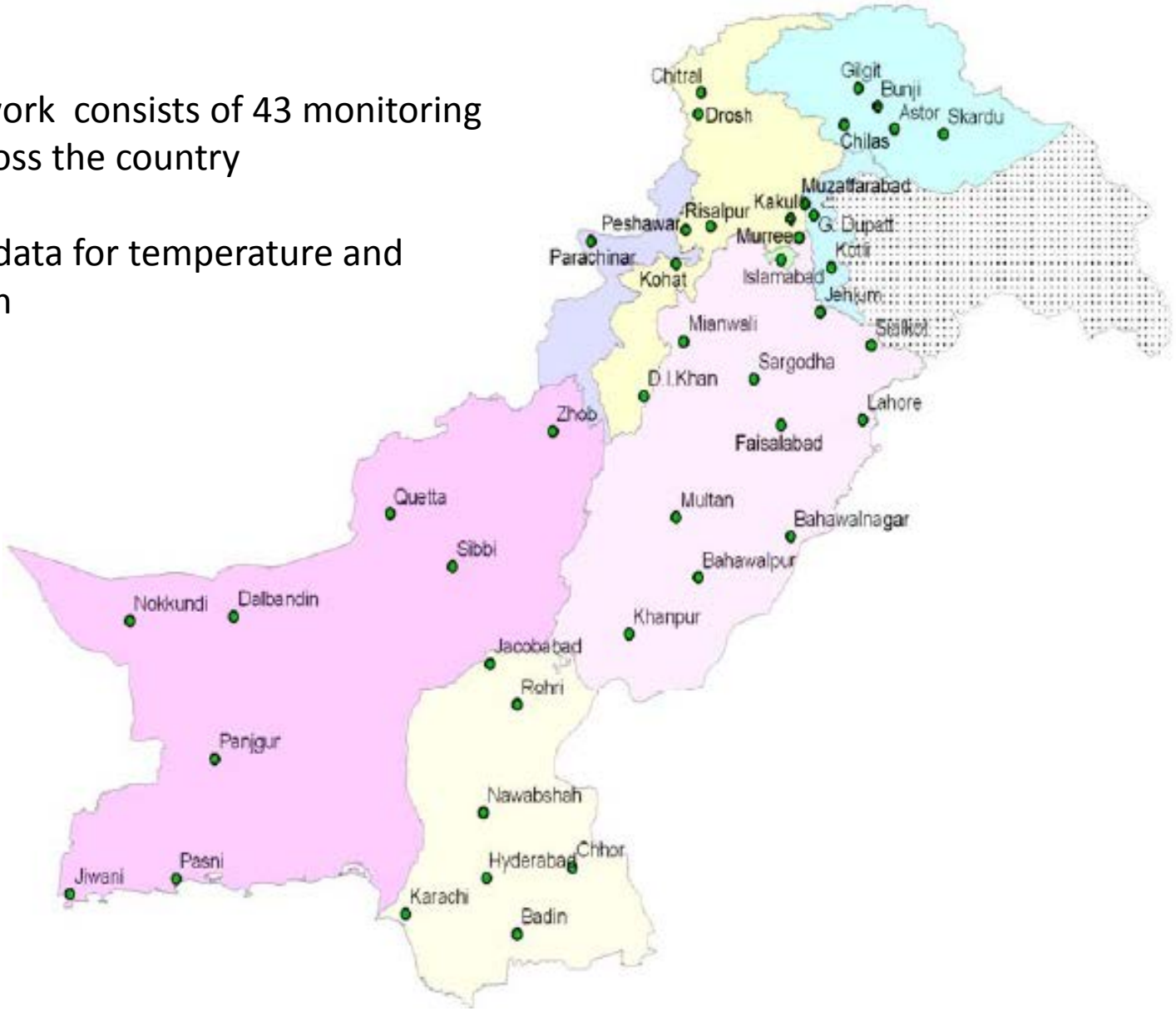


Figure curtsey: PMD Pak.

Precipitation over Pakistan

- Time series of average rain fall over Pakistan during 1901 to 2009
- There is an overall increasing trend of about 50 mm
- Data exhibits random inter annual variation in precipitation amount

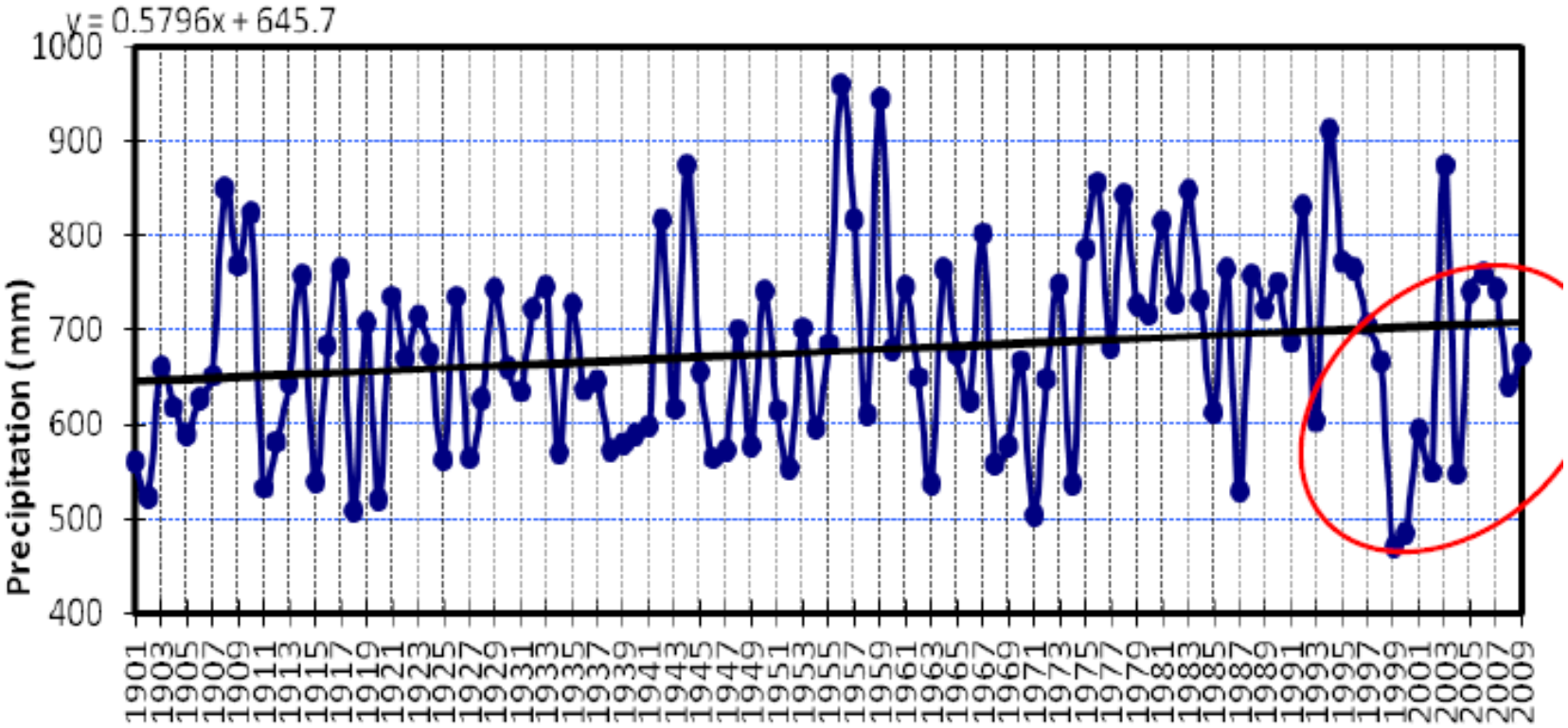


Figure curtsey: PMD Pak.

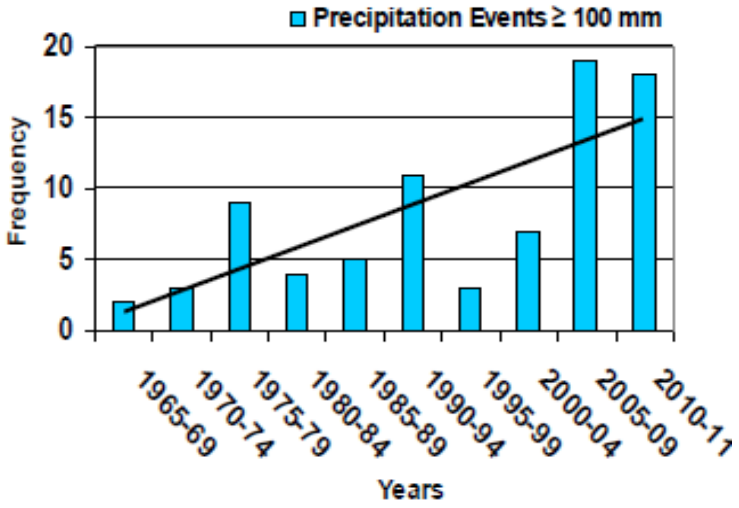
High Impact Climate Event over Pakistan

HIC: an event that lead to significant losses and damages.
>> Heavy/Torrential Rains leading to *Urban Floods, Flash Floods, Riverine Floods & Landslides* **are among the high impact weather/climate events**

The frequency of heavy rain fall during last seventy years:

- With precipitation more than 100 mm per day (top)
- With precipitation more than 150 mm per day (bottom)
- The frequency is increased during last 7 years

The reason of Monsoonal Extreme Rainfall Extreme Events is yet unknown.



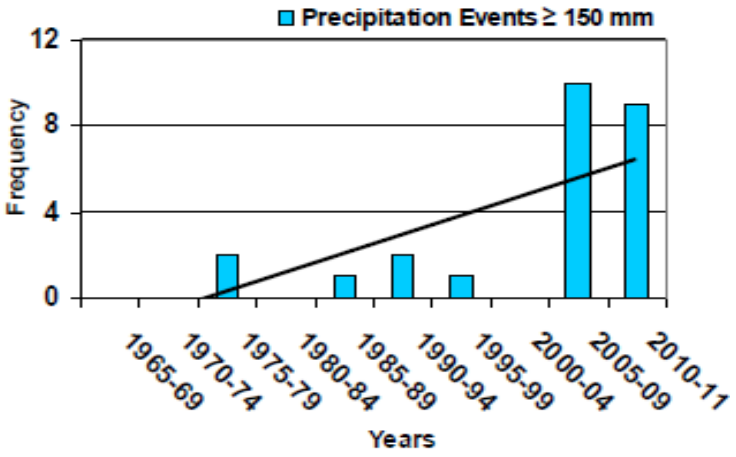
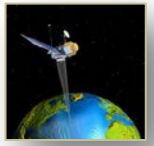


Figure curtsey: PMD Pak.



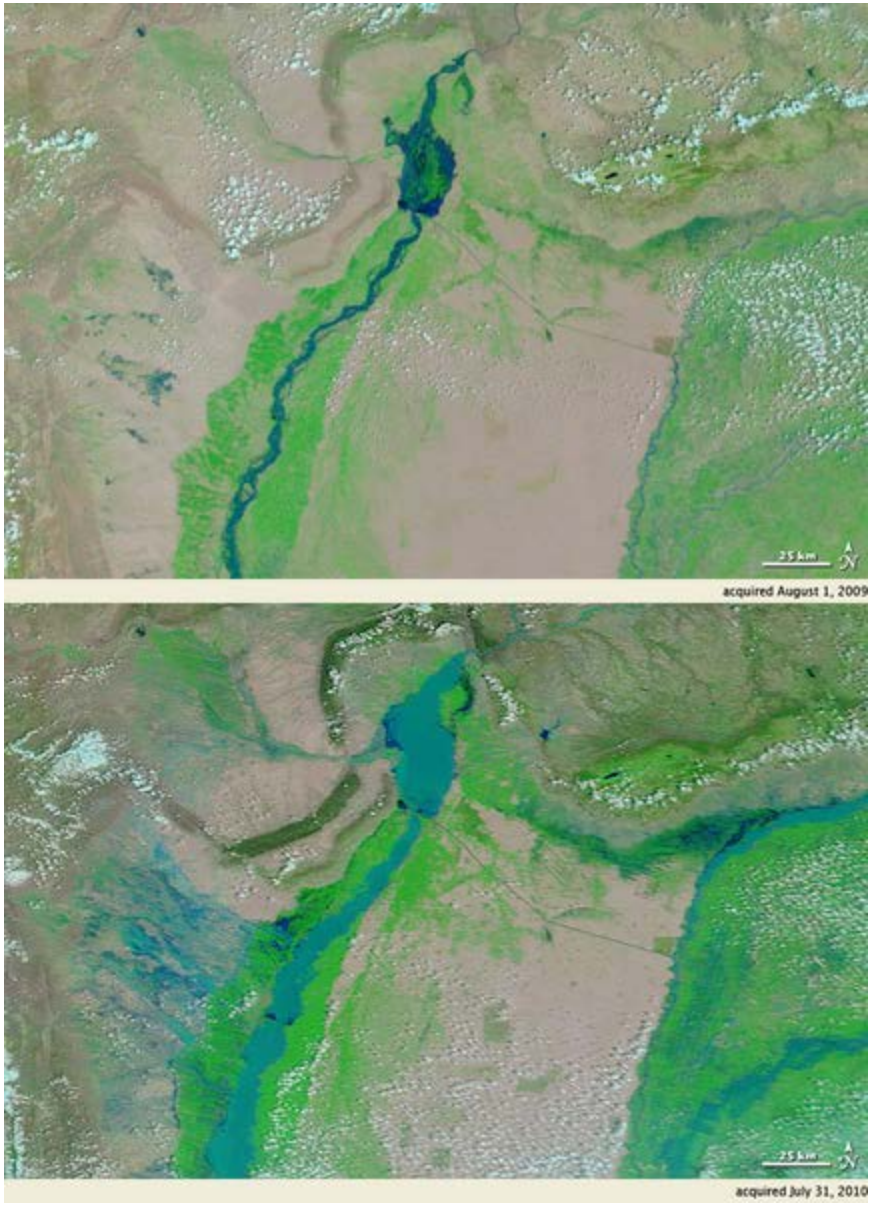






Year 2010 flood in Pakistan

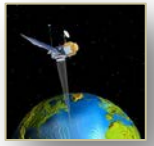
- Satellite images of the upper **Indus River valley**, comparing water-levels on 1 August 2009 (top) and 31 July 2010 (bottom)



- In early August, the heaviest flooding moved southward along the Indus River from severely affected northern regions toward western Punjab

- at least 1,400,000 acres (570,000 ha) of cropland were destroyed

- almost $ 43 billion of damage to the Pakistan's economy.





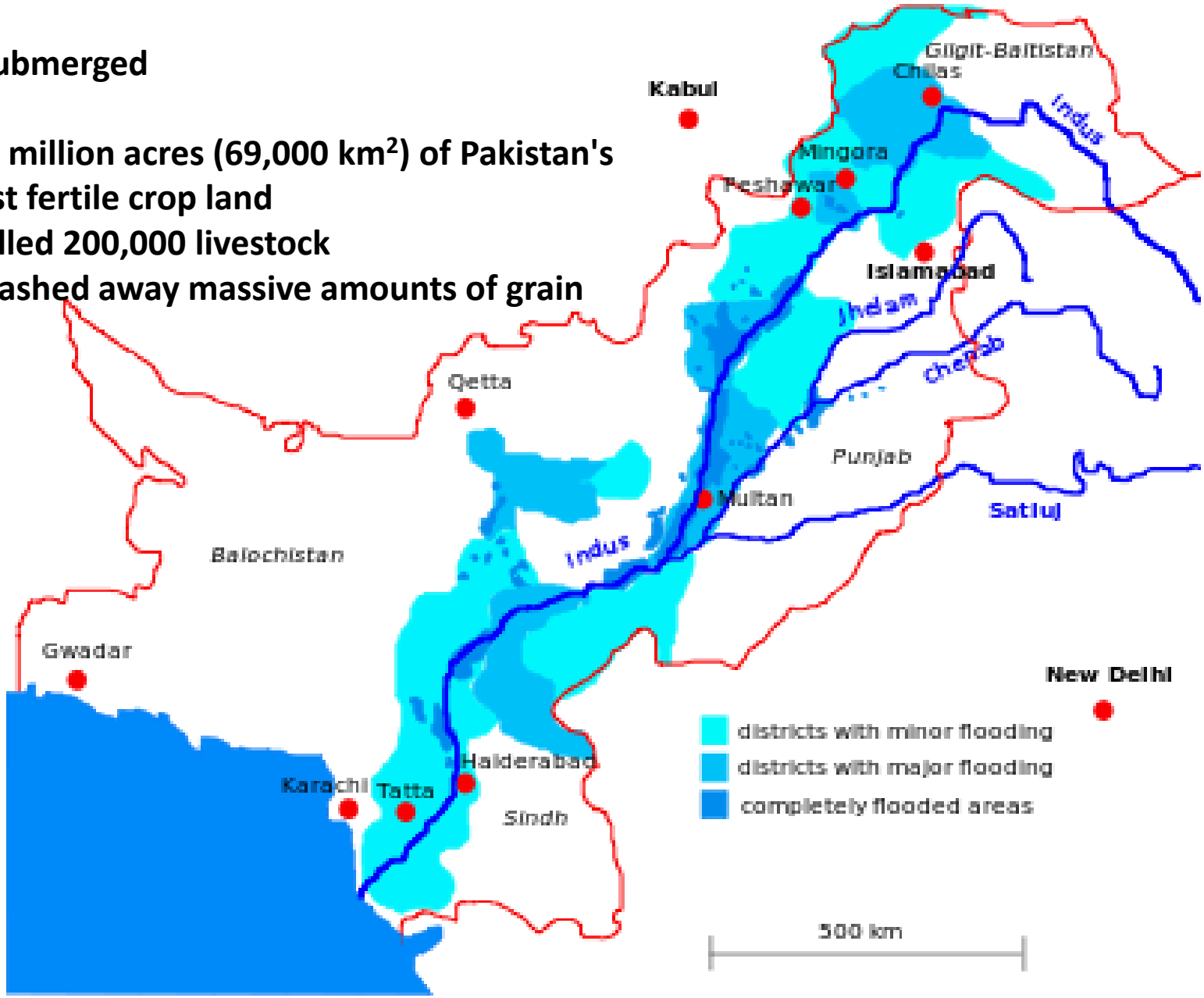


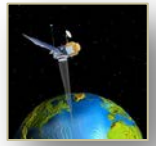


Year 2010 Flood affected Area

Floods submerged

- **17 million acres (69,000 km^2) of Pakistan's most fertile crop land**
- **killed 200,000 livestock**
- **washed away massive amounts of grain**







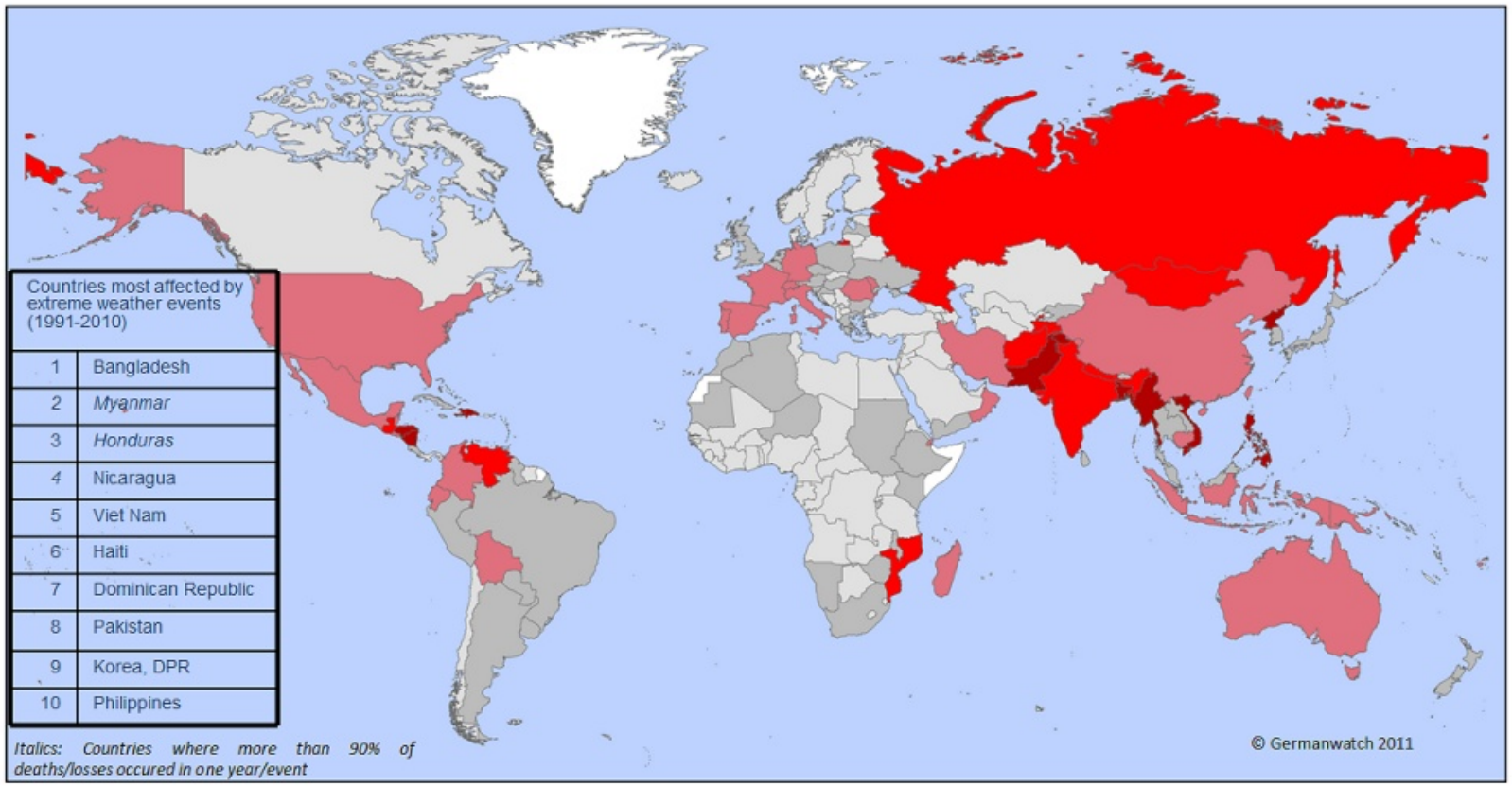




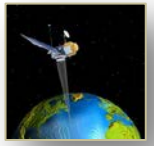
Global Climate Risk Index 2012 (covering 1991–2010)

Source: Germanwatch and Munich Re NatCatSERVICE

GERMANWATCH



Pakistan is among the top 10 nations that are most vulnerable to the global warming [Pachauri, 2009].







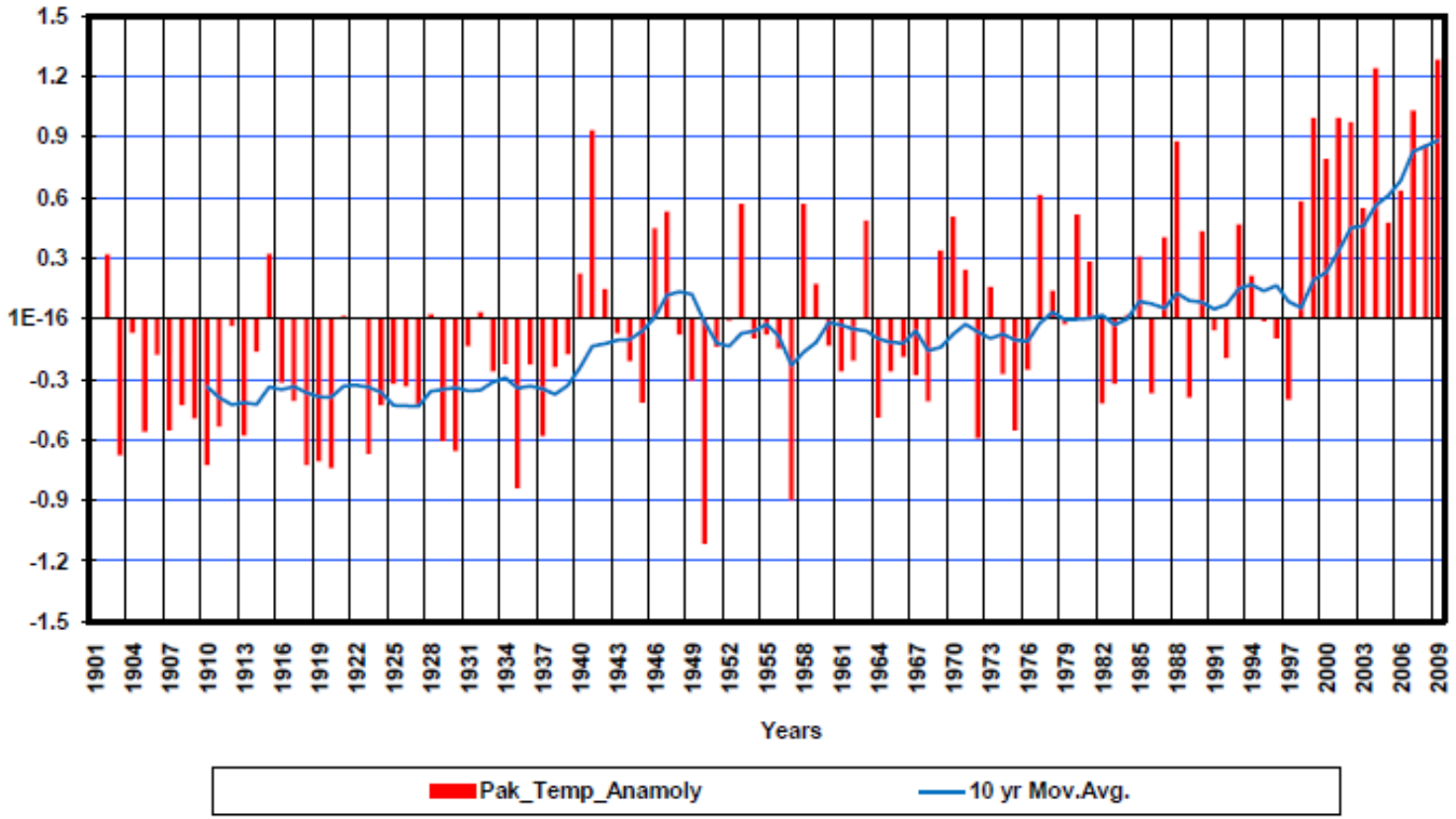


Pakistan Temperature Anomaly

Time series (1901-2009) of air temperature anomaly over Pakistan with 10years moving average

Data shows a greater inter-annual variability

A significant increasing trend is observed after 1998



Frequency of heat waves in Pakistan

- Heat waves are a continuous stretch of persisting maximum temperatures above certain threshold for a specified time period.

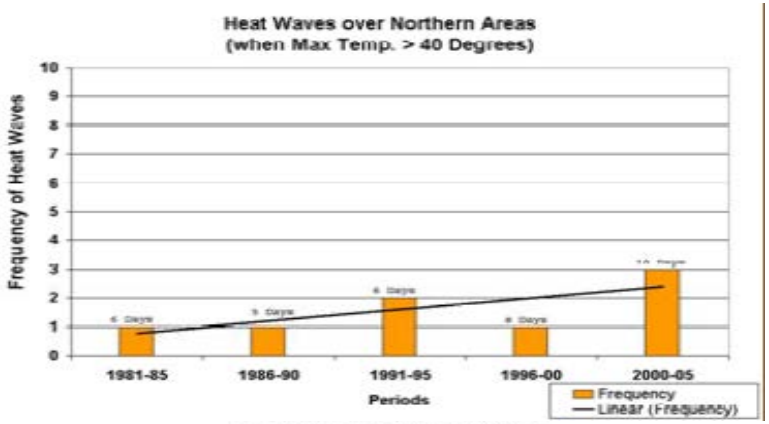
- Rising number heat waves in the north high latitudes of Pakistan

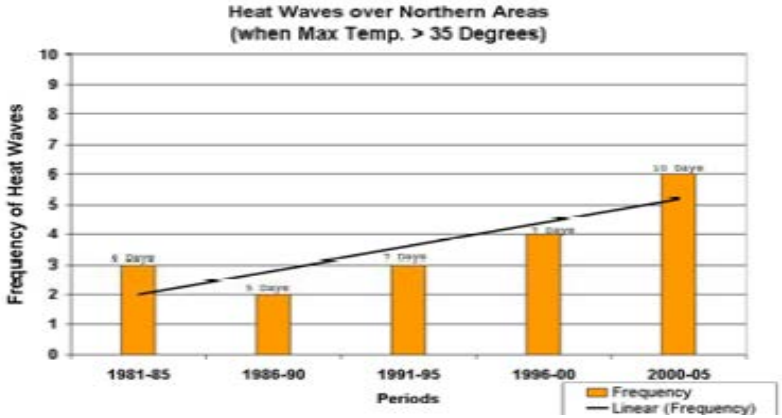
- They are grouped into three categories as defined below:

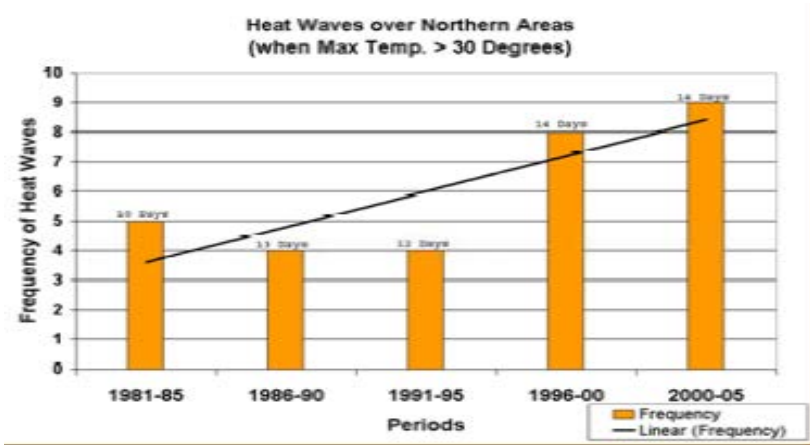
- *Severe Heat Wave=Five consecutive Days with Daily Max. Tem ≥ 40°C*

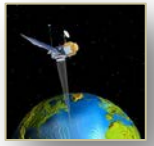
- *Moderate Heat Wave= Five consecutive Days with Daily Max.Tem ≥ 35°C and <40°C*

- *Mild Heat Wave= Five consecutive Days with Daily Max Tem ≥ 30°C and <35°C*











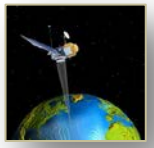




Extreme Weather Events in Pakistan

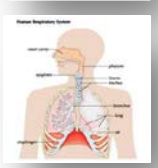
Pakistan meteorological department following extreme weather events took place during the last decade

- **Cloudburst Events**
  - **2001, 2003, 2007, 2008,2009, 2010, 2011**
- **Prolonged Drought**
  - **1999-2002**
- **Historic River Flooding**
- **Tropical Cyclones**
  - **1999,2007,2009**
- **Severe Urban Flooding**
  - **2001, 2003, 2007, 2008, 2009, 2010, 2011,2012**
- **Heat Waves in Spring**
  - **2006, 2007, 2010, 2011 (Reduced wheat yield)**
- **Snowmelt flooding**
  - **2005, 2007 and 2010**
- **Drought at sowing stage**







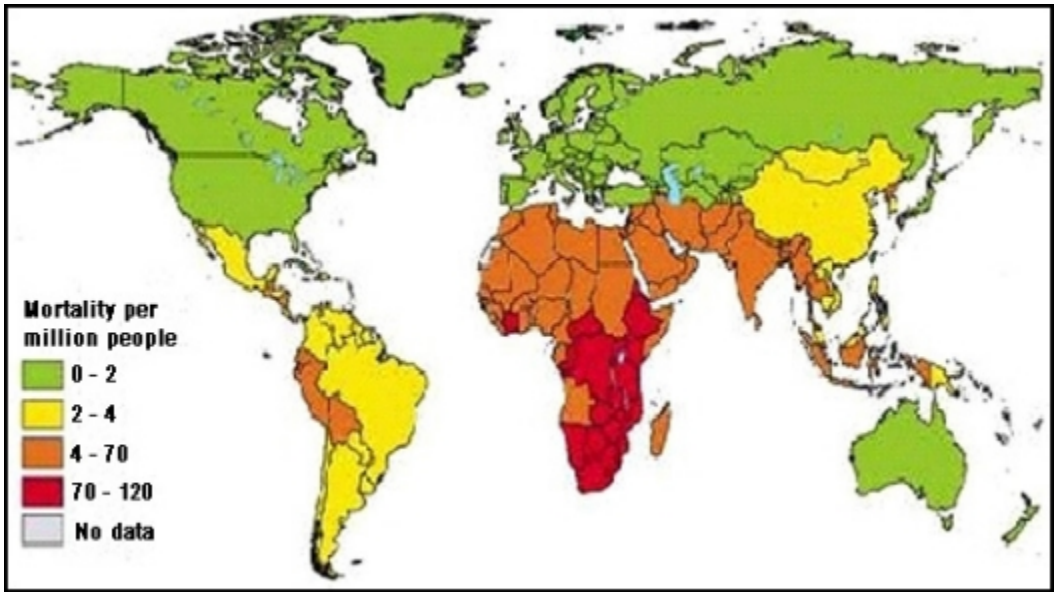




Effects on Human Health

An increase in average global temperature is likely to increase the incidence of infectious diseases, such as :

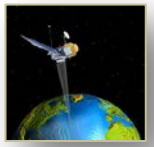
- Malaria
- Sleeping sickness,
- Dengue and Yellow fever

- The developing countries, where these diseases are already prevalent would receive the most deadly punch from the climate change impacts.



IPCC climate models>> projects the mortality from "cardiovascular diseases, diarrhoea, malaria, inland and coastal flooding, and malnutrition, for the years 2000 to 2030"

- An increase in the global temperature is suspected to extend the range of vectors, the mosquitoes, flies and snails-that transmit infectious diseases.









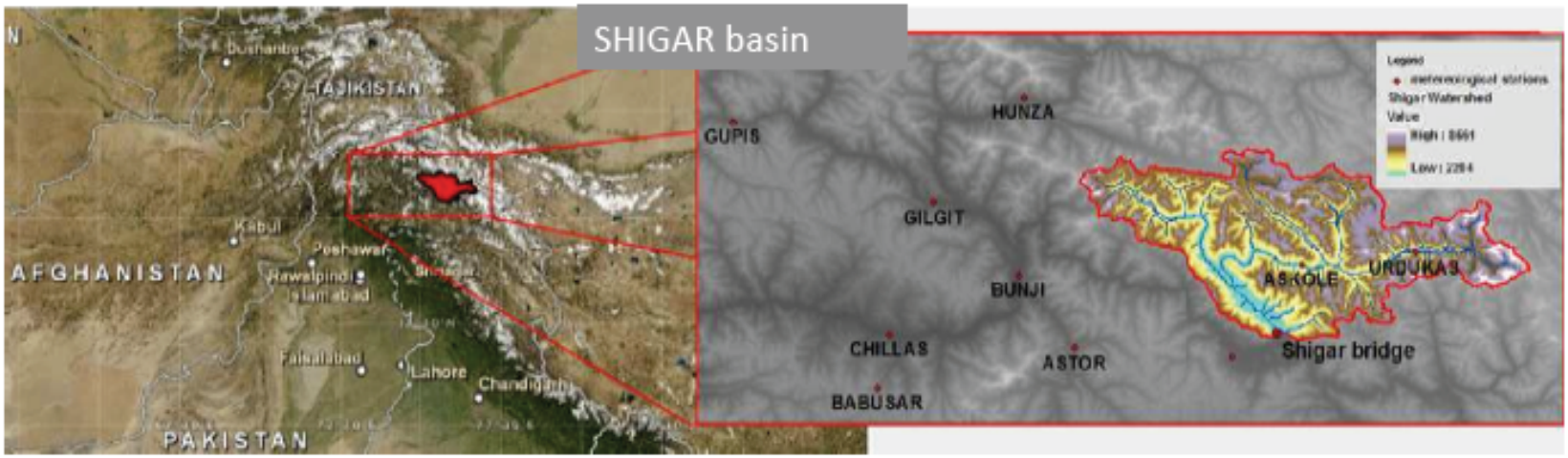
SHARE paprika
Stations at High Altitude for Research on the Environment

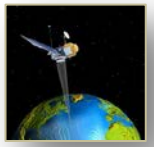
PAPRIKA Karakorum:

Period of activity: June 2010 – June 2013

Goal: Determine the effects of atmospheric aerosols, particularly BC and mineral dust, on glacier dynamics, on the hydrologic cycle and on water availability in the Karakorum area (Baltoro glacier) and the upper Indus basin in Pakistan

Means: in-situ, remotely-sensed data and an integrated modelling approach











ISAC

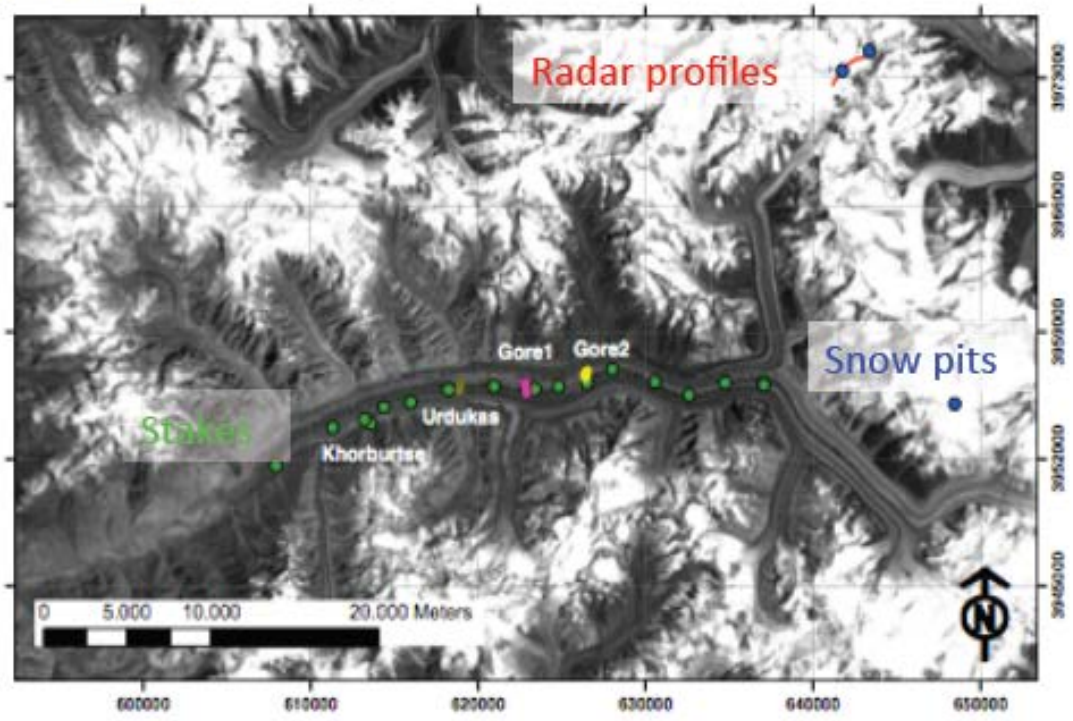
SHARE paprika

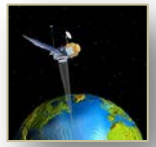
Stations at High Altitude for Research on the Environment

EvK2CNR

Ablation and accumulation conditions on Baltoro Glacier

July-August 2011 expedition: investigation of processes of the lower glacier and accumulation conditions in the high basins.











ISAC

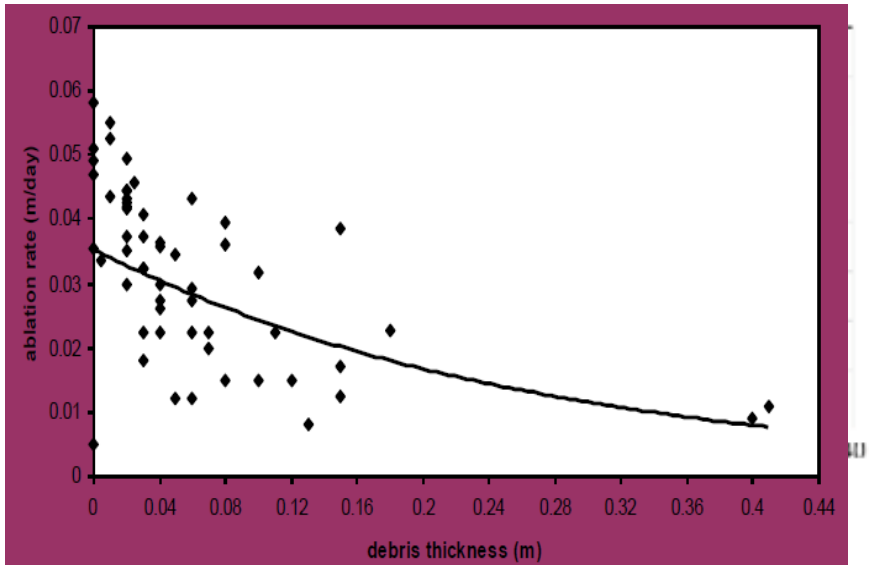
SHARE paprika

Stations at High Altitude for Research on the Environment

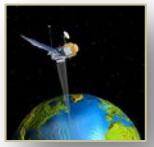
EvK2CNR

Ablation and accumulation conditions on Baltoro Glacier

Ablation stake network installed between the snout of Baltoro Glacier and Concordia, consisting of 17 stakes. They cover a range of debris thickness from zero (clean ice) up to 37 cm. To investigate the relationship betweeen ablation rate and debris thickness



Glacier depth and debris cover by mean of ground penetrating radar (GPR)









ISAC

SHARE paprika

Stations at High Altitude for Research on the Environment

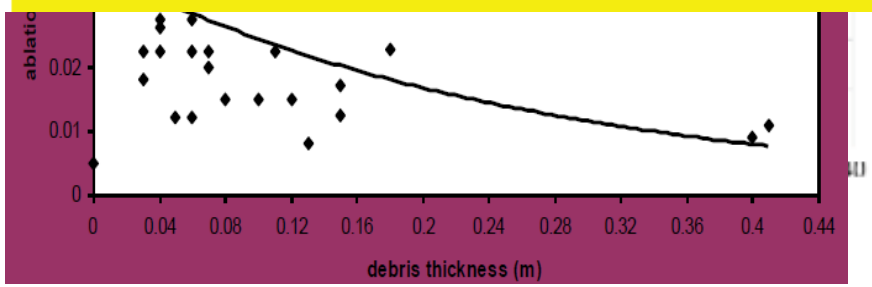
EvK2CNR

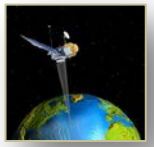
Ablation and accumulation conditions on Baltoro Glacier

Ablation stake network installed between the snout of Baltoro Glacier and Concordia, consisting of 17 stakes. They cover a range of debris thickness from zero (clean ice) up to 37 cm. To investigate the relationship betweeen ablation rate and debris thickness

The Baltoro and other glaciers in the Karakoram are covered mostly with debris which helps insulating the ice from the warmth.

When debris is thicker than 2 cm it acts as a thermal insulator; melt rates are lower below that debris cover than where the ice is directly exposed.











ISAC

SHADE paprika
Stations at High Altitude for Research on the Environment

EvK2CNR

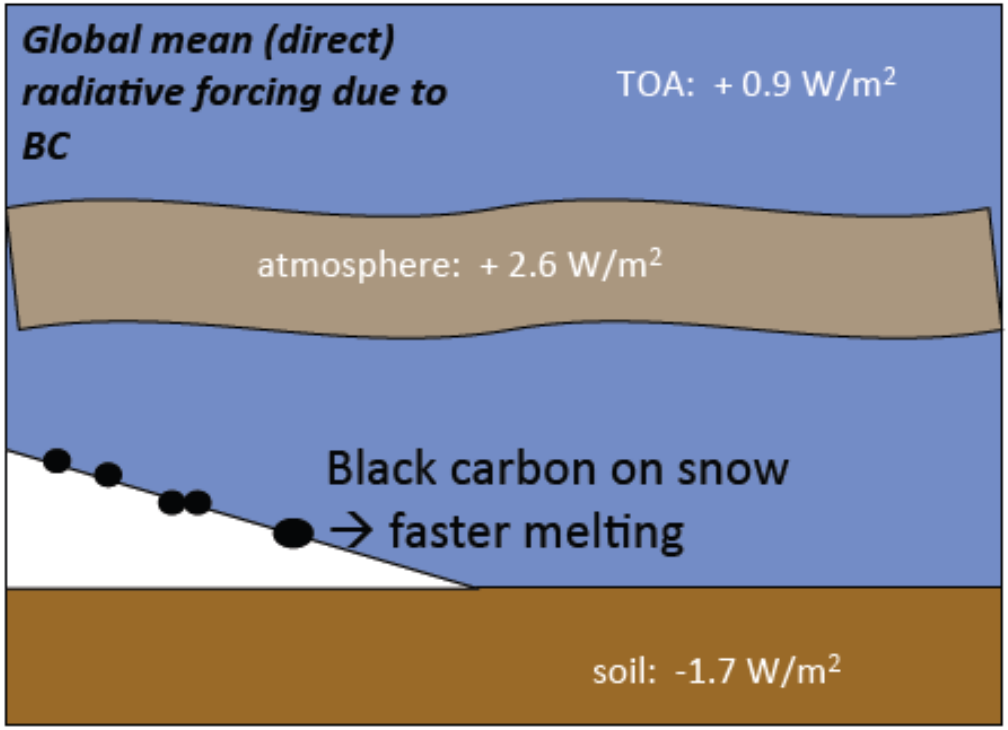
SCIENTIFIC ISSUE

Importance of aerosols: the Atmospheric Brown Cloud

Aerosols in the ABCs cause **cooling of the surface** (dimming effect) and **heating of the atmosphere**

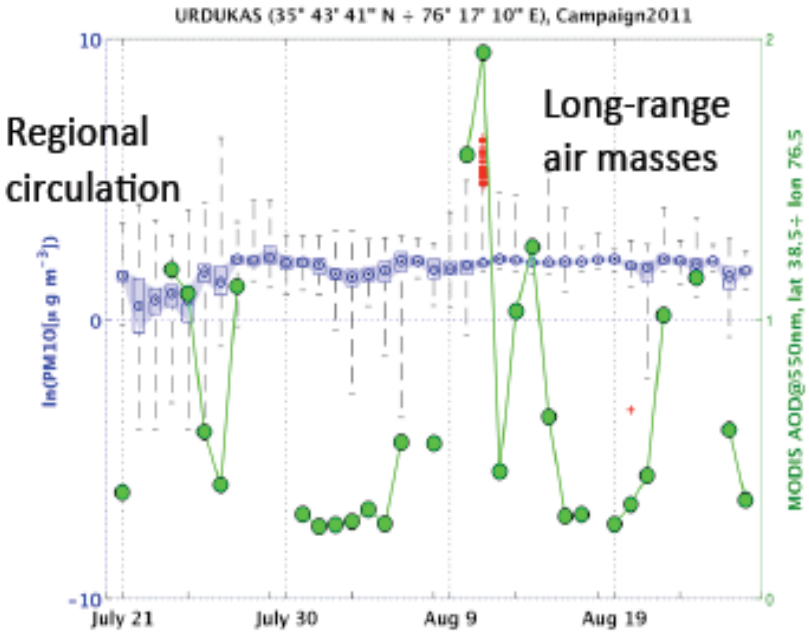
Effects on:
-Atmospheric stability
-Monsoon circulation
- precipitation

Also: indirect and semi-direct effects and deposition of BC on snow



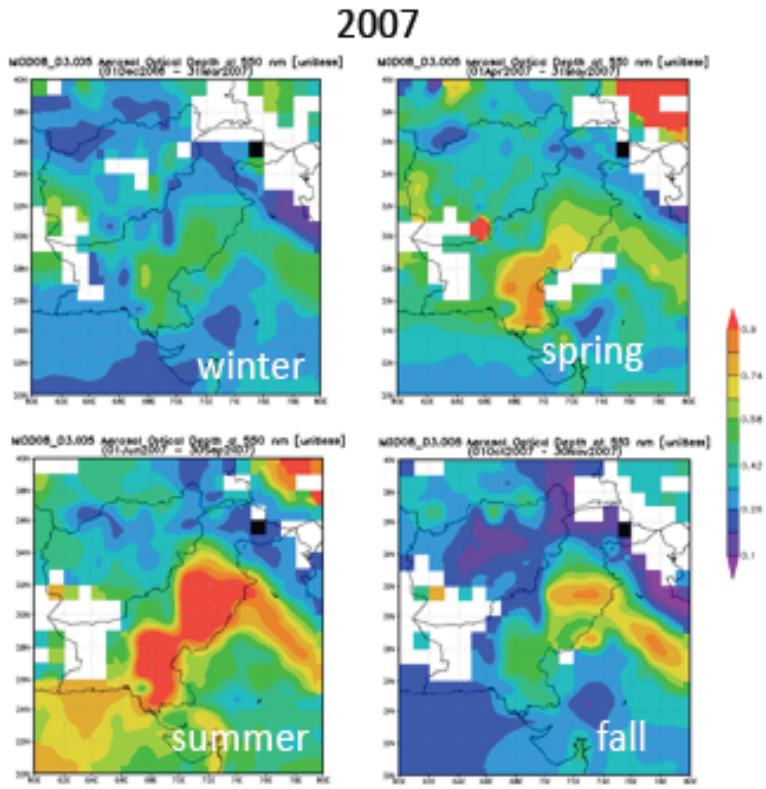
Aerosols observations in the Karakoram

A summer field campaign (August 2011) was performed at Urdukas for investigating the **aerosol variability** by using an Optical Particles Counter - Aeroqual AQM60 system



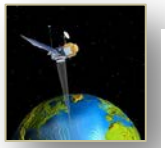
- 2 different regimes of aerosol variability
- anomalous high values (direct input of mineral dust)

In-situ, satellite data (MODIS + Calipso) data



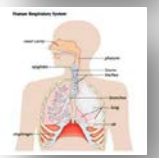
Seasonal AOD variability

T. C. Landi, P. Cristofanelli (ISAC-CNR)








Atmospheric observatory in the Karakoram

SHARE-Box device

Summer 2012: intensive field campaign in the Pakistani northern areas (Deosai) by using the portable SHARE-box system

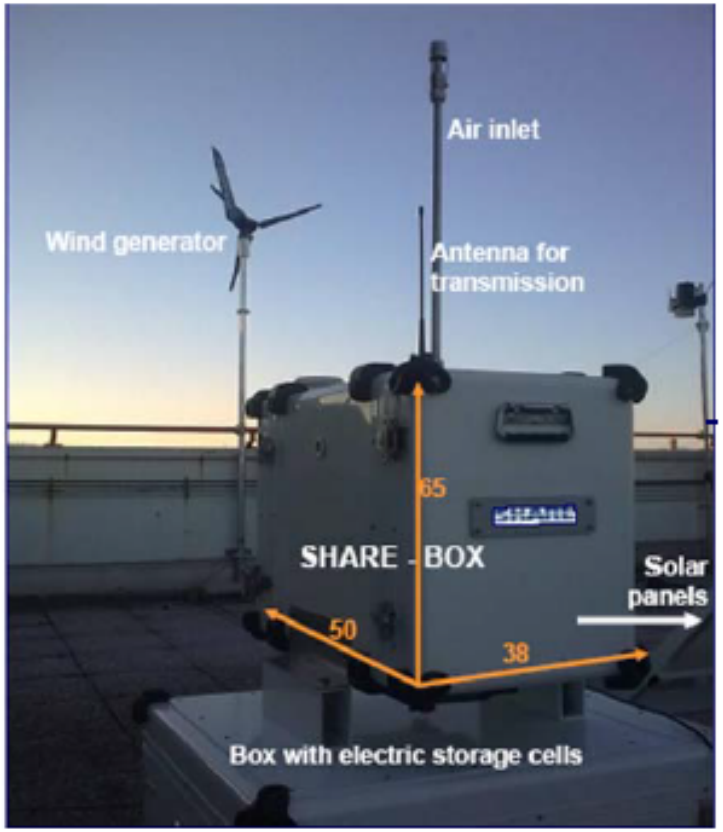
1. UV-absorption ozone analyser
2. Optical Particle Counter
3. Condensation particle counter
4. Black carbon analyser
5. NDIR CO2 probe
6. Integrated weather station

ISAC-CNR
CNRS-LGGE
Ev-K2-CNR

Collaboration with PMD

- **Low power consumption**
- **Integrated power production unit**
- **Data transmission and remote control**

2011 tests: *Bologna (Italy); Grenoble (France) Mt. Cimone (Italian Apennines); Stelvio Glacier (Italian Alps)*

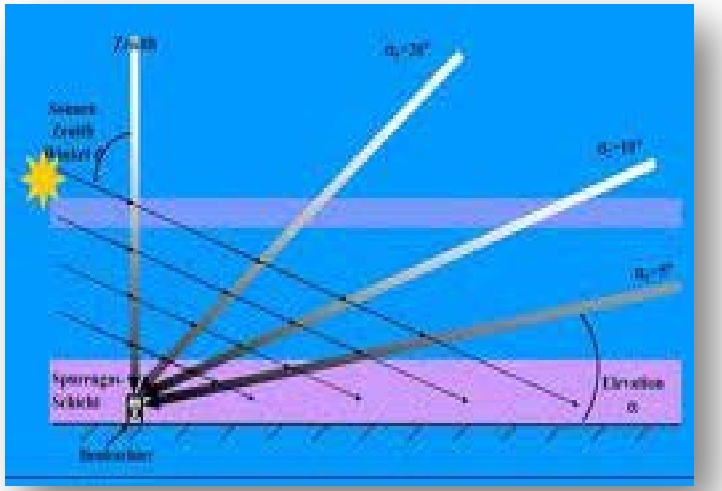


P. Laj (CNRS-LGGE, Grenoble, France)

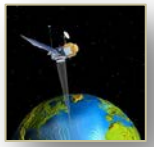
NUST Activities

- NUST activities related
  - To study Climate change impacts over Pakistan
  - To design strategies to adapt climate change impacts in a cost effective manner
  - To provide base line scientific information to policymakers and other stake holders
  - To generate awareness among the general public, government agencies and NGOs

- Collaboration with SHARE-Paprika Karakorum
  - in near future we will collaborate with SHARE-Paprika Karakorum project (in process)
  - We are intended to install a Max-DOAS (Multi Axis – Differential Optical Absorption Spectroscopy) instrument at Baltoro Glacier
    - To study atmospheric composition at high latitudes of Pakistan
    - To observe concentrations of different trace gases (NO_2, SO_2, HCHO, O_3)



Max-DOAS Viewing Technique









Scientific Project at IESE-NUST

1: ROGPA (Record Of Greenhouse gases over PAkistan during last decade (ROGPA)

2: e-PAC (Evolution of Pakistan's Atmospheric Composition during last decade)

Objectives:

- To study the evolution of different GHG and trace gases over Pakistan during the last decade.

Outcome:

- It will provide with a temporal record of green house gases over the Pakistan during the last decade (2002-2011).

- It will facilitate with a scientific database of atmospheric composition and primary information to the policy makers in designing and implementation of strategies to cope with impacts of climate change.

Major stakeholders include industry, tourism, scientists, researchers, academia, and students in the field of atmospheric sciences

Cost: Pk. Rs. 6 million

Time duration: 2years

Investigators:

1: Institute of environmental sciences and engineering, NUST Pakistan

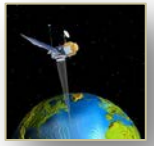
2: Max-Planck Institute for Chemistry Mainz, Germany

3: Institute of Environmental Physics Bremen Germany

Funding Agency:

Higher Education Commission of Pakistan (HEC)

Pakistan Science Foundation (PSF)









Conclusions

• Inappropriate to treat the HKK and Himalaya as a single region. They differ in climate, especially in sources and types of precipitation and in glacier behavior and dynamics

- •Dynamics of western weather patterns:
- • Impact on winter precipitation in the HKK
- • Relationship with monsoon rainfall

• Synergy of surface-satellite observations/estimates and model simulations

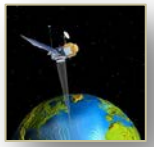
- • Role of aerosol in shaping regional climate change over South Asia
- • concomitant role of GHGs warming and other constituents

• Teleconnections of regional climate with large-scale circulation patterns and their impacts on precipitation extremes and water availability.

• Pakistan is among the most vulnerable nations to the climate change impacts.

•Pakistan is a resource constrain country with extra stress on its economy due to geopolitical activities in the region (e.g. war against terror, local extremism and Afghan refugee etc.) in addition to climate change effects.

•Need to design cost effective solutions to cop climate change impacts and its adaption

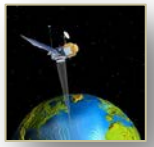








Thanks for your attention









Precipitation data sets

o **TRMM (Tropical Rainfall Measuring Mission)**

Product: 3B42: 3-Hour 0.25 x 0.25 °(30x30 km) from 50°S-50°N. Low spatial, high temporal resolution. 1998-2008

o **APHRODITE (Asian Precipitation - Highly-Resolved Observational Data Integration Towards Evaluation of Water Resources)**

Product: APHRO_MA (Monsoon Asia) _V1003R1. Daily precipitation datasets derived from rain gauge observations with high-resolution grids (Hour 0.25 x 0.25 °) for Asia (domain: 60°E-150°E, 15°S-55°N). 1951-2007

o **Global Precipitation Climatology Centre (GPCC)**

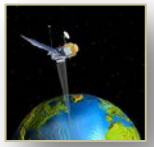
Gauge-based gridded monthly precipitation data sets for the global land surface, spatial resolutions 0.5°x 0.5°. 1901-2009

o **Climate Research Unit (CRU): TS 3.10 precipitation monthly data available from** 1901 to 2009

o **Global Precipitation Climatology Project (GPCP) NOAA**

Version V2.2 of monthly means of precipitation derived from satellite and gauge measurements. Data are supplied into 2.5°x2.5°globa l grids from 88.75°S - 88.75°N and 1.25°E - 358.75°E. From 1979 to present.

o **ERA-40, ERA-Interim**








Cost of Extreme Weather Events

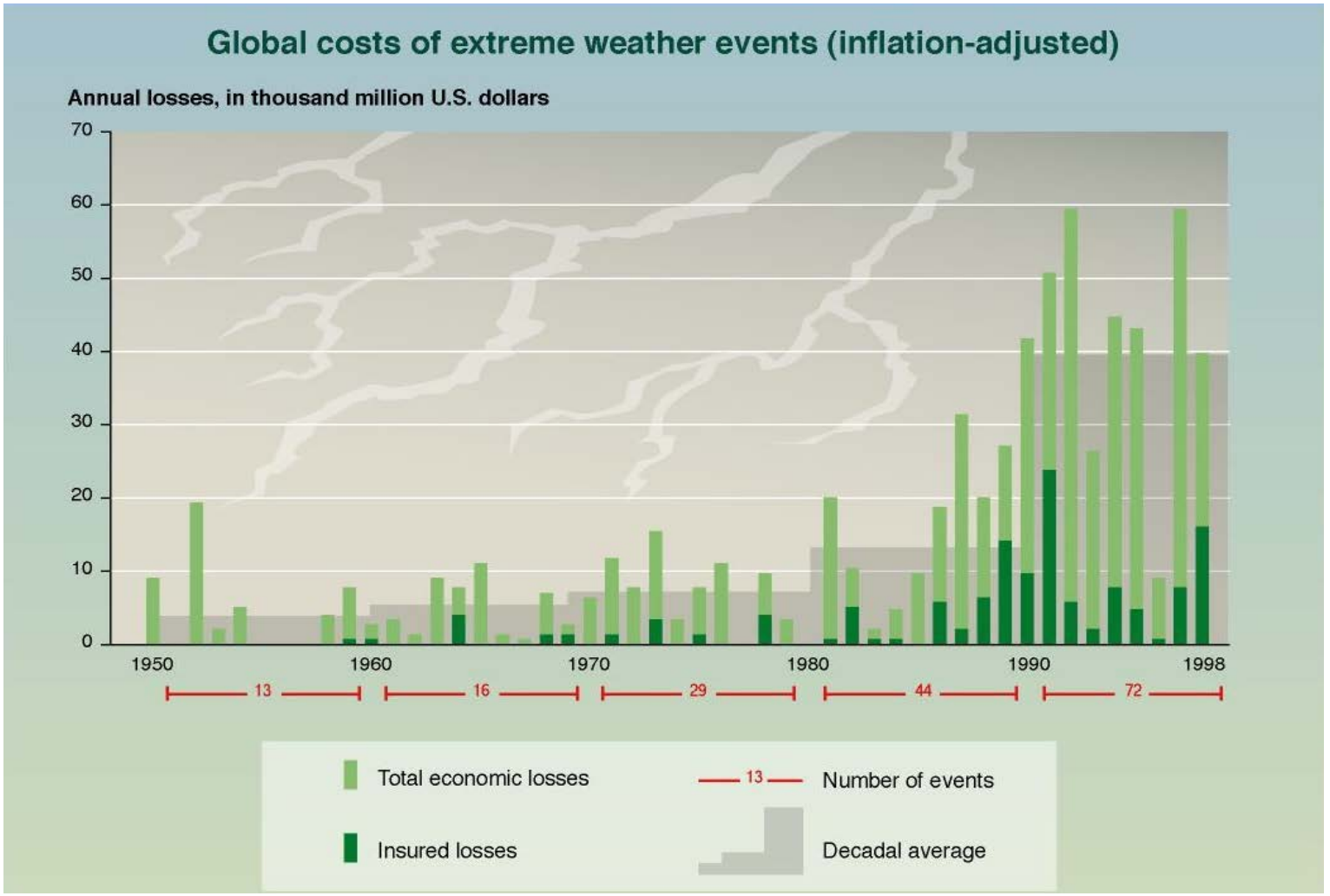


Figure curtsey: IPCC, 2007.