SPACE BASED ASSESSMENT OF GLACIER FLUCTUATION IN THE HUNZA BASIN, WESTERN KARAKORAM, PAKISTAN

Presented by:

Dr Muhammad Ateeq Qureshi

Pakistan Space & Upper Atmosphere Research Commission (SUPARCO)

4th United Nations/Pakistan International Conference on the use of Space Technology for Water Management
Islamabad, Pakistan
Presentation Outline

- Background
- Objectives
- Study area
- Methodology
- Results
- Conclusion
Background

- **Glaciers**
  - Sensitive indicator of climate change
  - Contain a considerable part of the world’s fresh water
  - Critical component of the Earth’s system
  - Fluctuation in glacier represents fast and abrupt climate change

- **Glaciers impacts on environment and human**
  - Natural disaster
  - Water supply
  - Economic livelihood
  - Sea level change
Background conti....

- **Problems**
  - Lack of systematic observation of the glaciers extent
  - Complex topography
  - High elevation
  - Remoteness of the terrain
  - High altitude climate records
Currently, limited studies on glaciation in the Karakoram Mountains

- Inform no ice loss and slight mass gain
  (Cogley 2012, Gardelle et al., 2012)

- Retreat and advance of glaciers are reported
  (Hewitt 2005, Rankl, Kienholz and Braun 2014, Bishop et al., 2008)

- The situation is still unclear which factor control glacier behavior
Remote sensing approach promise to offer new insight into the nature of glacier fluctuations

RS and GIS in glacial studies plays an important role to find out the scientific reasons

Systematic approaches may develop spatial database of contemporary glaciers, which would be used significantly for understanding the present situation of glaciers fluctuations and dynamics
Objective

Determine the contemporary glaciers extent, fluctuation and understanding the present situation of glaciers dynamics

- Implementation of remote sensing techniques to extract glacier extent (1973 to 2014)
- Apply GIS methods to calculate glacier parameters (area, length, slope, aspect)
- Analyze the changes in glacier parameters
Study Area
The Hunza Basin is an important sub-basin of the Upper Indus Basin (UIB).

Geographically, it is located in extremely northern part of Pakistan.
- The basin covers 13,718 km² catchment area
- Elevation range from 1391 to 7850 m above sea level
- The basin contains several large glacial systems such as Hispar (349 km²) and Batura (226 km²)
Study area - Climate (CRU)

Average Mean Temperature (°C)

AMP 1901-2014

AMT 1901-2014

Average Mean Precipitation (mm)

Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec
<table>
<thead>
<tr>
<th>Data source</th>
<th>Path/ Row</th>
<th>Acquisition Date</th>
<th>Image resolution (meter)</th>
<th>RMSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CORONA KH-9</td>
<td>DZB/1206, DZB/1207</td>
<td>Aug-1973</td>
<td>8</td>
<td>7.25 (58 m)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Landsat-8 Operational Land Imager (OLI)</td>
<td>149/34, 149/35, 150/34, 150/35</td>
<td>Sep - 2014</td>
<td>30</td>
<td>0.12 (3.6 m)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Landsat-5 Thematic Mapper (TM)</td>
<td>149/34, 149/35, 150/34, 150/35</td>
<td>Oct - 2008, Aug - 1998, Oct - 1992</td>
<td>30, 30, 28.5</td>
<td>0.12 (3.6 m), 0.0, 0.15 (4.27 m)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Landsat-2 Multispectral Scanner (MSS)</td>
<td>160/34, 161/35</td>
<td>Aug - 1977</td>
<td>57</td>
<td>0.5 (28.5 m)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SRTM</td>
<td>-</td>
<td>Feb 2000</td>
<td>30</td>
<td>0.25 (7.5 m)</td>
</tr>
</tbody>
</table>
Methodological framework

- Digital Elevation Model
- Satellite images
- Climate Data

Contemporary glacier Mapping (1973-2014)

- Aspect
- Slope
- Glacier boundaries
- Area / Length / Terminus
- Glacier Fluctuation
- Temperature
- Precipitation
Analysis:
Hassanabad glacier (AQ-84) slightly advancing occurred in length is about 356 meter during the period 1973-1977 and retreating observed from 1977 to 2008 at an average rate of 51 m/y. although, its behave as a stable mode from 2008 to 2014.
Analysis:
Retreating observed in length from 1977 to 2008 at an average rate of 25.8 m/y. from 2008 to 2014 on advancing mode at an average rate of 88 meter per year.
Analysis:
Retreating observed in the length on Pasu glacier (AQ-58) from 1977 to 2014 at an average rate of 11.4 m/y. It is also noted that the Pasu lake may developed during the period of 1973-1992 when glacier average retreat rate of 47 m/y.
Analysis:
No changes in length observed from 1973 to 1977. Advancing observed from 1977 to 2014 at an average rate of 15 m/y. An abrupt advancing found between 1998-2008 at the rate of 122 m/y.
Statistical analysis of glaciers changes between 1973-1977
Statistical analysis of glaciers changes between 1977-1992
Spatial distribution 1977 - 1992
Statistical analysis of glaciers changes between 1992-1998
Spatial distribution 1992-1998

- Advance (m)
  - 64 - 174
  - 174 - 280
  - 280 - 426
  - 426 - 647
  - 647 - 1947
- Retreat (m)
  - -174 - -46
  - -277 - -174
  - -339 - -277
  - -968 - -339
  - -2019 - -968

- Stable

- Glaciers
  - Elevation (m)
  - 7850
  - 1391

Kilometers

74°30'0"E 75°0'0"E 75°30'0"E
Statistical analysis of glaciers changes between 1998-2008
Spatial distribution 1998-2008
Statistical analysis of glaciers changes between 1998-2008

2008-2014

[Graph showing changes in retreat and advance of glaciers]

- Stable
- Retreat
- Advance

Pie chart showing:
- 14 glaciers (3%) stable
- 364 glaciers (92%) retreat
- 19 glaciers (5%) advance

Glacier ID:
- AQ-58
- AQ-126
- AQ-61
- AQ-66
- AQ-75
- AQ-76
- AQ-187
- AQ-324
- AQ-300
- AQ-22
- AQ-285
- AQ-235
- AQ-276
- AQ-371
- AQ-194
- AQ-183
- AQ-204
- AQ-176
- AQ-30
- AQ-33
- AQ-359
- AQ-21
- AQ-121
- AQ-123
- AQ-119
- AQ-104
Statistical analysis of glaciers changes between 1973-2014
Conclusion

- Glaciers of various size and orientation have examined
- Our analysis reveals that the larger glaciers with lower terminus altitude don’t show greater retreat distance
- The number of retreating glaciers during 1992-1998 is account for about 30% suggesting the glacier retreat was extensive
- An increase trend occurred in 1998-2008 (8%) and 2008-2014 (5%)
- The stability of the glacier appears to be associated with increased trend in winter precipitation
- The frequency of retreating glaciers is decreased and glaciers are in stable position
Thanks for your attention!