Detecting change in Landsat time series with BFAST in the eastern Hindu Kush region

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1. Introduction

- Environmental change is a trigger of land cover and land use change in the eastern Hindu Kush mountains. Vegetation along the river valleys has undergone alterations by the impact of geomorphological processes and flood dynamics, but little research has been carried out to detect and map these changes.
- Breaks For Additive Seasonal and Trend (BFAST) method was developed in 2010 to detect changes in both trend and seasonal components of the time series. It has been used for change detection in various climates and regions[1].
- We applied BFAST method to Landsat time series analysis in a semi-arid and high mountain environment of Chitral district, northern Pakistan.
- On pilot basis, two sites (Sanoghar and Reshun) with known history of flood events were selected (Fig.1). Both sites have irrigated agriculture and low vegetation cover with exposed soil surface.
- We aimed to map out changes detected by BFAST for both locations and compare results for both vegetation indices.

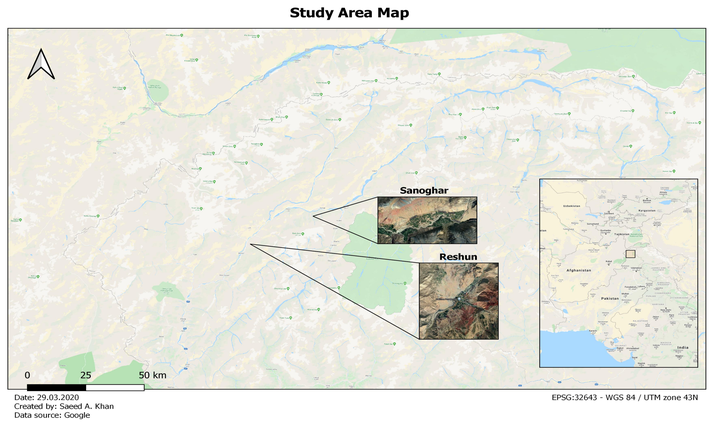

***Fig.1**: Study area map*

2. Methods

- Landsat Level-2 Surface Reflectance – derived Normalised Difference Vegetation Index[2] (NDVI) and Modified Soil Adjust Vegetation Index[3] (MSAVI) products were accessed from United States Geological Survey (World Reference System-2, Path 151 and Row 35) for the years 1988 to 2019. Data was acquired from corresponding scenes of Landsat 4-5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+) and Landsat 8 Operational Land Imager (OLI). Data is processed for geo-referencing and atmospheric correction by USGS. Clouds and cloud shadows were masked using pixel quality assurance band provided by USGS[4].
- Data have spatial and temporal resolutions of 30 m and 16 days, respectively.
- BFAST iteratively decomposes the time series into trend, seasonal and remainder components. The changes in the trend component denote abrupt and gradual changes while changes in seasonal component represent phenological changes[1].
- 'Dummy' seasonal model was chosen[1]. 'h' is an important parameter which determines the minimal segment size, trend segments and potential breaks[1]. Several h values were tested and h = 0.13 was chosen.

3. Results

- BFAST results (number of breakpoints in trend and seasonal components, magnitude and timing of largest breakpoint in trend components) of NDVI and MSAVI time series for both sites are produced. Changes detected in trend component of time series for both sites are shown in Fig. 2.

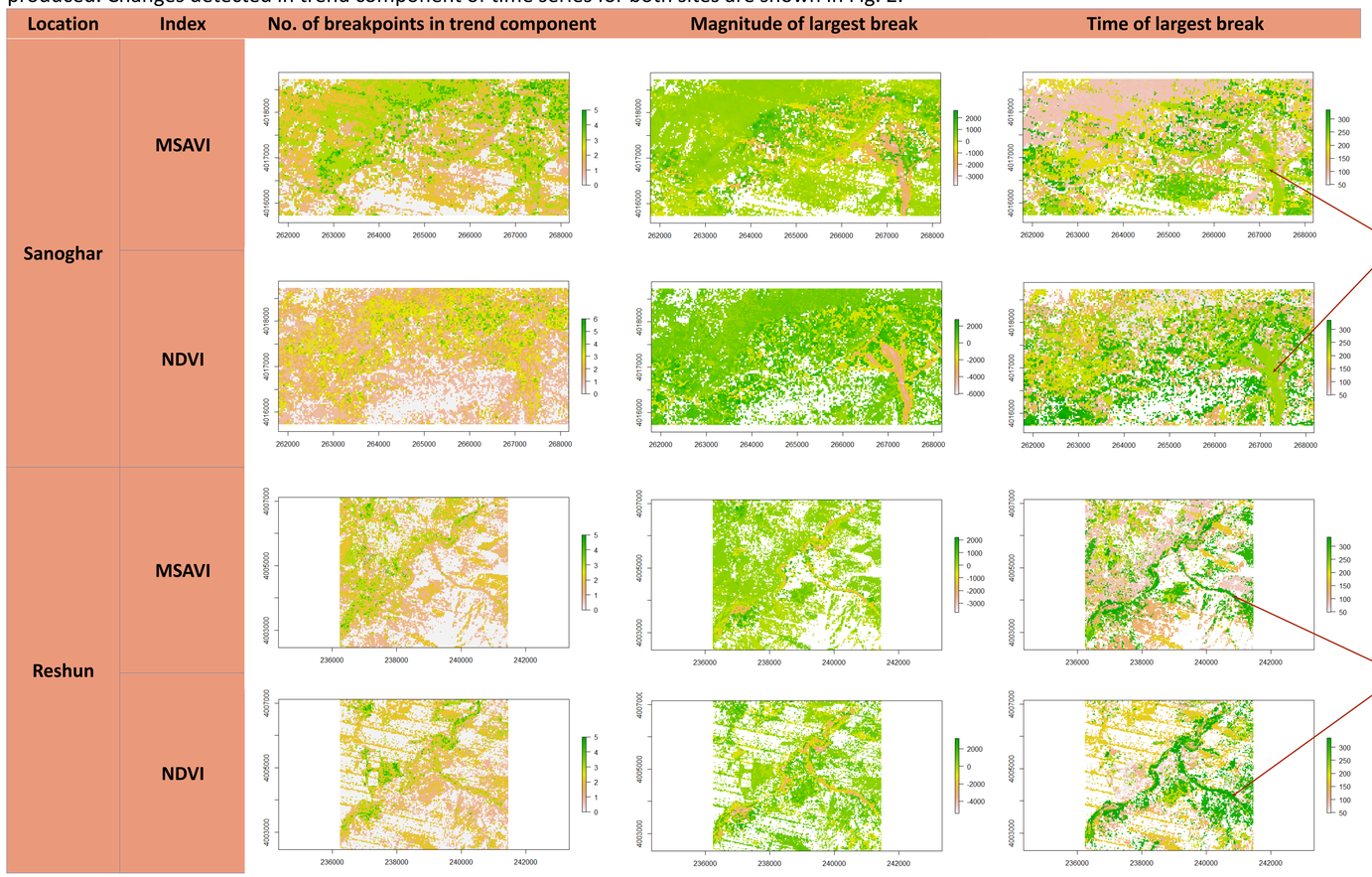

***Fig. 2**: BFAST results for study locations*

BFAST detected flood events of 2013 and 2015 in Sanoghar. Both floods were caused by glacial lake outbursts in Sanoghar Gol.

Flood events of 2007 and 2010 in Reshun were detected by BFAST. 2007 floods were mainly caused by glacial lake outburst in Reshun Gol while 2010 floods were caused by unprecedented monsoon.

- In addition, BFAST was applied to 10 sample pixels belonging to irrigated and low vegetation areas. MSAVI gave better results than NDVI for areas with low vegetation. Results for a sample pixel representing exposed soil surface are shown in Fig. 3. BFAST was able to detect 2 breakpoints in trend component of MSAVI for pixel 8772 at Reshun while it detected none for NDVI. Time and magnitude of breakpoints and magnitude of most significant change in trend component for the sample pixel is shown in Fig. 4.

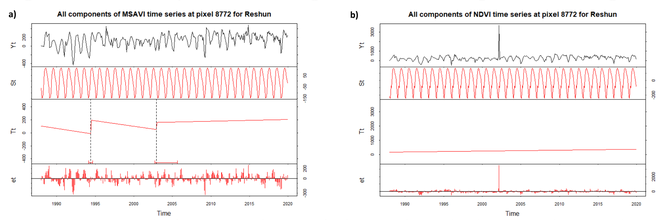

***Fig. 3**: BFAST results (a – MSAVI, b – NDVI) of a sample pixel, where Yt is the input data, St – seasonal component, Tt – trend component and et is remainder of the time series.*

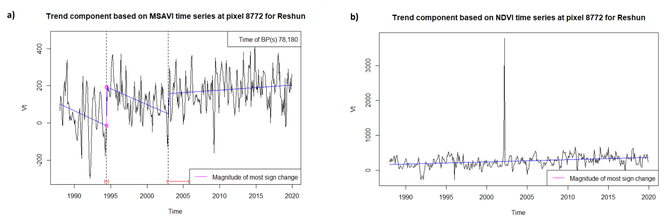

***Fig. 4**: Trend component (a – MSAVI, b – NDVI) of a sample pixel*

4. Conclusion

- BFAST method was successfully applied to detect changes in Landsat time series for two locations of northern Pakistan.
- MSAVI, which is adjusted to account for bare soil, was effective in change detection in a semi-arid environment.
- These initial results show that BFAST method can be applied to larger area such as the eastern Hindu Kush to detect changes in land cover.

5. References

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Photography encouraged