Title: Monitoring greenhouse gases of the Continental Collision plates & glacial lakes outburst flood over the Hindu Kush Himalayan range

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（Yes）We apply for Student Prize.
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Need:
The Hindu-Kush Himalayan range runs through eight countries- China, India, Nepal, Bhutan, Pakistan, Myanmar, Afghanistan, Bangladesh. It has a length of 2400 km with average elevation of more than 6100 m and area coverage more than 4,192,000 km^2 [1]. The range, also known as "Water Tower of Asia", is a geographical barrier between the Indo Gangetic Plain and the Tibetan plateau, formed as a result of continental drift. Currently the range is polluted from long range transport of pollutants.

Water resources: The range is source to ten of the largest rivers in Asia - Amu Darya, Indus, Ganges, Brahmaputra, Irrawaddy, Salween, Mekong, Yangtze, Yellow, and Tarim. Collectively, these basins provide water to around 1.3 billion people [2]. These rivers are being affected from the pollutants and the melting glaciers. Over succeeding decades, the pollutants will likely have additional negative impacts across these mountains, including significant cascading effects on river flows, groundwater recharge, natural hazards, and biodiversity; ecosystem composition, structure, and function; and human livelihoods.

Geographical terrain: The formation of The Hindu-Kush Himalayan range is similar to other ranges as the Appalachians, the Scottish and Scandinavian Caledonides, the Alps and the Urals [3]. The study of Himalayas has been used to learn the geological aspects of the other ranges. Likely the effect that is seen on the geography of the range can correspond to these other ranges. Therefore, even remote sensing of Himalayan range alone can help us learn about the effects on the other ranges.

Glacial lakes: A total of 25,614 glacial lakes covering an area of 1,444 km2 were identified within the five major river basins — Amu Darya, Indus, Ganges, Brahmaputra, and Irrawaddy, including Mansarovar Interior Basin — in the Hindu-Kush Himalayan range (*The Status of Glacial Lakes in the Hindu Kush Himalaya*, n.d.). They pose potential threats for Glacial Lake Outburst Floods (GLOFs) for which a warning system is required.

Low earth satellite systems can be an effective tool to understand the Himalayan ranges, enabling us to take stringent action when required.

Mission objective: The mission is to operate a constellation of three 6U CubeSats in the hybrid orbit SSO/LEO with the Hindu-Kush Himalayan range as our area of interest. Using this constellation, the objectives are so divided:

Primary objective: The higher altitude regions have enhanced warming in comparison to the lower regions, primarily during the cold season [4]. So, the primary objective of the mission is to take the measurements of the greenhouse gasses (GHGs) at different terrains and altitudes of the range. Then related analysis can be done on the effect of these greenhouse gasses at higher temperature over the water resources and terrain. The general effects on terrain can be mapped onto the other ranges with the same formation as Hindu-Kush Himalayan range.

Secondary objective: The secondary objective of the mission is to provide a warning system for the GLOFs by satellite imagery of analysis of the size of lakes. The satellites in the LEO will have higher rate of revisits and because of the eccentric orbit the dwelling time over the area of interest (AOI) increases so that the speculation of area covered by the lake will be detailed enough for making a warning system. Using the modified normal difference water index [5], the temporal variation of the glacial lake area is monitored.

Concept of Operations:

Space Segment: The operation will consist of three 6U cube satellites in a hybrid orbit of SSO & LEO. One satellite will be in SSO and two of them will be in LEO. The two satellites in LEO will be exactly opposite to each other in order to get simultaneous data from different locations without creating a gap. One of the satellites will remain in the SSO.

Ground segment: This mission requires communication between satellite and ground station. Constant uplink and downlink of data and images require a proper communication between ground station and satellite. For this, the satellite is equipped with Syrlinks' X-band transmitter and Syrlinks' X/S Transceiver. It operates in the X(downlink)/S(uplink) band. The ground station that will communicate with the satellites for this mission is the National Remote Sensing Centre (NRSC) which receives and sends signals in the S/X band.

Launch Segment: The probable option considered for deployment is via Nanoracks Kaber Microsat dispenser. It provides command and control for satellite deployment into orbit from the Japanese Experimental Module Airlock slide table of the ISS (International Space station). Satellites are launched to the ISS on pressurized launch vehicles, mounted to Kaber deployer and deployed to orbit.

Key Performance Parameters:

The mission objective is to monitor the greenhouse gasses and create a warning system for GLOFs. The mission heavily depends on the payloads of the satellites.

Camera: Multiscape 100 CIS is the camera for the payload. The camera has a ground sampling distance of 4.75m at an orbit height of 500 km. But the LEO orbits are eccentric so when the satellite is over the Himalaya region, the actual distance will be greater. However, a large image acquisition may be performed to identify the change of area with the increased dwelling time.

Sensor: Argus 2000 Spectrometer is the sensor used as a payload. The sensor is used to monitor the GHGs and when combined with the camera, the monitored GHGs can be mapped over a given area. The data obtained from our SSO can be used to analyse the GHGs at a certain time over a certain place and be compared with the data from the LEO orbit, which is from a different time. Likely we can map these effects onto other ranges formed from collision of continental plates.

Space Segment Description:

The subsystems present in the satellites are described below:

Components	Description	Power	COTS/ Custom	Voltage	Mass	Dimensions
General						
Structure	6U XL CUBESAT		COTS		850gm	100*266.3*366mm
ADCS	IADCS400	2-5W	COTS	4-15V	1300gm	95.4*95.9*67.3mm

Solar Panel	6U Deployable solar array	Provides 19.2 W	COTS	Provides 9-19.2 V	390 gm	
EPS	Starbuck Nano Plus		COTS	8.2V	148gm	95.89*90.18*20.28
Battery	Li -Po Battery	50 Whr	COTS	3.7V	210 gm	95*89*7 mm
OBDH	SIRIUS TCM LEON 3FT	1.3W	COTS	4-16V	130gm	95.89*90.27*17.20mm
Payload						
Sensors	Argus 2000 spectrometer	< 1W	COTS	3.2-4.6V	280gm	80*80*46mm
Camera	Multiscape 100 CIS	2.5W-readout 5.8W - imaging	COTS	5V DC	1600 gm	98*98*176mm

Communication System

Electronics	Data rate	Power	Size	COTS/Custom
Transmitter	2.8-50Mbps	<10W	96*90*24	COTS
Transreceiver	10kbps-3mbps	<5.7W	96*90*20mm	COTS

Payload: The satellites will carry two different payloads. Argus 2000 spectrometer for GHG's detection and Multiscape 100 CIS push broom for optical sensing. The Multiscape 100 CIS push broom multispectral imager will be operating in the green and Short Wave Infrared (SWIR) spectral bands because of the higher reflectance of water in those bands, making it possible to extract water body information. [The camera will be positioned at nadir/glint angles because of better signal to noise ratio over water bodies.]

Mechanical Subsystem: The 3 satellites used are standard 6U CubeSat. The structure will consist of the general 6U structure proposed by enduro sat 6U XL CUBESAT. The structure is made up of either Al 606-T651 or Al 7075. The structure has dimensions of 100mm * 266.3mm * 366 mm.

Command and Data Handling Subsystem: All the subsystems of the satellite are controlled by the SIRIUS TCM LEON3FT. The SIRIUS TCM LEON3FT consists of an on-board computer, the Sirius OBC, and a combined mass memory module with CCSDS stack, the Sirius TCM. The SIRIUS TCM LEON3FT was chosen because it is compatible with most leading ground station networks and includes S and X-band transceiver interfaces.

Electrical Power Subsystem (EPS) and battery: The EPS system for satellites is STARBUCK NANO PLUS. It has met ISS Crewed flight design requirements. With 8.2V max power voltage, 3,3V, 5V and 12V regulated power buses, it is the most robust solution for our satellite. Endurosat 6U deployable solar array will be used as an external power source. A 50Whr High Energy Density Lipo battery will be used as the primary power source. The BIRDS open source bus has been implemented here [6].

Attitude Development and Control Subsystem (ADCS): The ADCS system for the satellites is IADCS400. IADCS400 is a fully autonomous attitude determination and control system which has radiation shielding, built in, plug and play ready design with full three axis control, featuring 3RW 400 series reaction wheel and three MTQ400 series magnetorquers.

Communication Subsystem (COMMS): The satellite requires a high speed transmitter to download the payload data. For this, the satellite is equipped with Syrlinks' X-band transmitter. It has a high telemetry data downlink rate of up to 140 Mbps and functions in the CCSDS encoding standards. The satellite is also equipped with Syrlinks' X/S Transceiver. It operates in the X(downlink)/S(uplink) bands. The ground station that will communicate with the satellites for this mission is the National Remote Sensing Centre (NRSC) which receives and sends signals in the S/X band.

Orbit/Constellation Description:

The orbit for this constellation will be a hybrid orbit of SSO/LEO. The *SSO (Sun Synchronous Orbit 600-800 km)* will consist of a single satellite and the *LEO (Low Earth Orbit 600-800 km)* will consist of two satellites with true anomaly of 0^0 and 180^0. The time period of the satellite will be around 90 minutes. The SSO orbit is chosen so that the GHGs data measurement can be done at the same time everyday under the same conditions. In this way we can have an idea of how the values are being affected in a certain place at a certain time. The LEO orbit is chosen because the floods could occur at any time of the data and we need real time analysis. The orbit is made eccentric so the dwelling time over the AOI is longer. The two satellites opposite to each other assure the real time analysis with the increased rate of revisits.

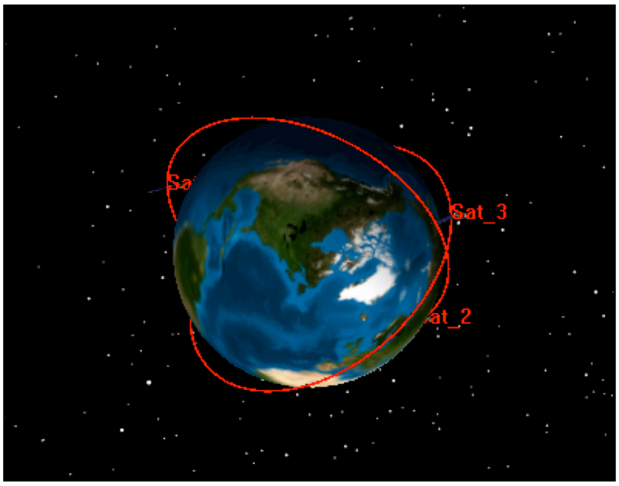

Figure 1 Illustration of orbit in GMAT

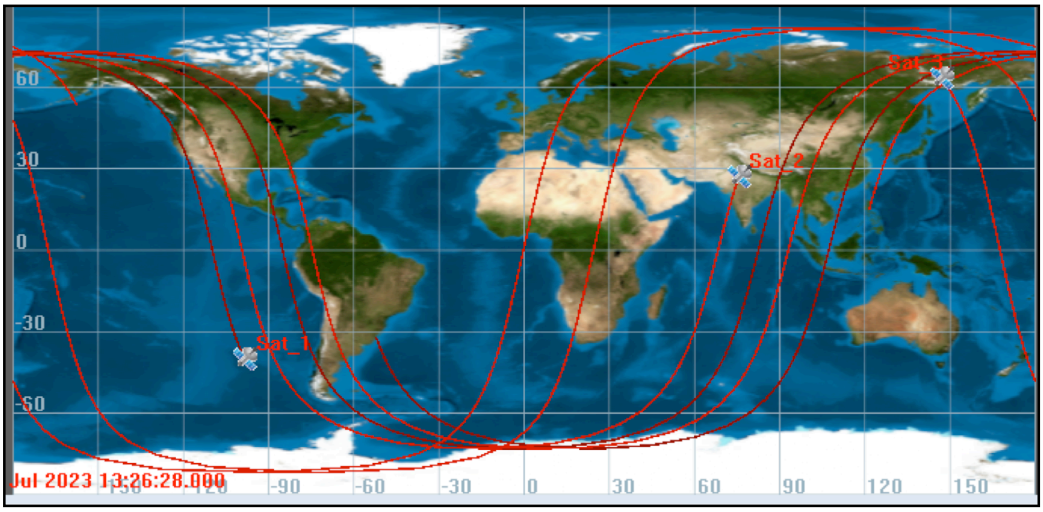

Figure 2 Mapping of orbit onto map

Implementation plan:

The process from generalizing ideas to actual implementation and deployment may take the time up to 4 years. After publishing a paper, there are five stages before we obtain data from our satellite including the design (conceptual and preliminary) and simulation phase, development phase, assembly phase, testing and launching, and receiving data from satellites. The CubeSat is mostly made of commercial systems so assembly of the materials could be done anywhere once every component is acquired.

Major Project Risks:

- Ground Segment and space segments communication failures.

- Electronics and Launch system failures.
- Imaging and lens problems.
- Improper power accumulation.
- Collision with other satellites in low earth orbit.

References

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