Monitoring Intense Thunderstorms in the Hindu-Kush Himalayan Region

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**Goal**: Use NASA EOS assets to build early warning capabilities and facilitate timely disaster response for high impact weather events in the HKH region

**Objectives**:
1. High Impact Weather Assessment Toolkit (HIWAT) for the HKH region
2. Jointly develop HIWAT capabilities/training with ICIMOD
3. Demonstrate capability in end-user environment
4. Transition HIWAT to ICIMOD
Why thunderstorms?

Some of the most intense thunderstorms on Earth plague the HKH region:

Satellite-based Annual Climatology of Intense Thunderstorms

Cecil and Blakenship (2012)

Monthly Climatology

Premonsoon (April-May): Bangladesh to eastern Nepal
Monsoon (June-August): Nepal to northern Pakistan
High Impact Weather Assessment Toolkit (HIWAT)

REGIONAL WRF MODEL

HIGH IMPACT WEATHER ENSEMBLE DIAGNOSTICS

Situational Awareness

GPM SATELLITE OBSERVATIONS

Threat Assessment

SATELLITE LAND IMAGERY

Impact Assessment

Hailstorm badly damaged hybrid bitter gourd seedbeds in Bangladesh

Source: thedailystar.net
Forecasting system to predict thunderstorms hazards

- Advanced Weather Research and Forecasting (WRF) model
- 2-domains: South Asia (12-km), eastern HKH (4-km)
- Convection allowing model configured for thunderstorms
- 4-km domain ensemble: 12 variations of the model to obtain probabilistic-based forecast guidance
- Run once per day around 1800 UTC on SERVIR’s SOCRATES computing system
- 0-48 hour forecasts of weather conditions, thunderstorm hazards, including precipitation and lightning
Ensemble forecasting of thunderstorm hazards

Ensemble-based Forecast

12 model forecasts produced over focus region using different initial conditions and physics options

Combined into probabilistic-based forecast guidance (e.g., significant hail)
Example: Yesterday’s nor’wester
Satellite-based thunderstorm intensity tool
GPM Constellation of passive microwave sensors
GPM Enables Detection of Severe Storms on a Global Scale

GPM core satellite radar and radiometer measurements of an intense storm

- Storm structure
- Height of storm
- Environmental parameter (available in data file but from external model)

Global climatology of GPM radar inferred precipitation features that contain hail

Ni et al. (2017)
Several fatalities due to hail and lightning

Numerous houses and vast areas of cropland damaged by hail

Example HIWAT Case Study: Fatal and Damaging hail event in Bangladesh on 30 March, 2018 during Spring Severe Weather Forecast Demostration

Cold brightness temperatures at 37 and 19 GHz are a characteristic of severe hail storms

3-4 inch hailstones produced by this storm

Source: Twitter
Satellite-based weather damage assessment tool

- Intense thunderstorms can cause widespread damage to agricultural areas.
- Remote sensing can be used to help identify with assessing potential damage.
- This damage assessment tool utilizes remote sensing data to assess potential damage areas:
  - MODIS, Landsat ETM, Sentinel-1 SAR
  - Python-based tool suite that can help with creating products from NRT products.

Damage produced by hailstorms in the Central United States:
- 250-meter resolution
- 20-meter resolution
Hail damage reports 30 March 2018

- No apparent large areas of damage or hail swaths are visible in Landsat-8 Natural Color RGB
- SAR data also does not indicate hail swaths like those observed in the U.S.
Better suited in HKH for flood mapping

• Hail damage signals are not readily apparent in HKH region...Why?
  → Land use is more diverse in HKH region (smaller plots of land with same crops)

• Flood waters exhibit a homogeneous signal in land imagery
Looking Forward

PY2
- High Impact Weather Assessment Toolkit (HIWAT) facilitates service to monitor extreme weather in the HKH region
- Spring Severe Weather Forecast Demo during 2018 pre-monsoon
- HIWAT app in Tethys
- Provide 0-48-hr WRF-based precipitation forecast to Flood Early Warning services (e.g., FEWS pilot project with ICIMOD/DHM-Nepal/MercyCorps)
- Collaboration with BMD, NESAC, DHM
- Train the hub advocate

PY3
- Transition HIWAT to ICIMOD
- Training and outreach
- Trial period at DHM-Nepal (or other end-user)
Using Tethys to create a HIWAT App

Point-based forecast

1-hour accumulated Precipitation (mm) values at 23.89, 90.48
1. ICIMOD has capacity to address high impact weather needs of its stakeholders (e.g., early warning service, disaster response)

2. HIWAT capabilities to enrich decision-making have been confirmed by end-user (e.g., BMD, DHM or similar end-user)

3. SERVIR portfolio contains high impact weather modeling and related satellite-based assessment capabilities
From the International Space Station as it crossed a thunderstorm over Nepal on April 13, 2016
(taken by Astronaut Tim Peake, courtesy NASA)
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