Monitoring Intense Thunderstorms in the Hindu-Kush Himalayan Region

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Monday, April 23
SERVIR-HKH Stakeholder Workshop, Dhaka, Bangladesh
**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

**Probability of Frequent Lightning**

Day-1 Prob. > 5 +/- 20 km: hrs 01-24
Ltg Fcst Algorithm (fl km^-2 (5min)^-1)
Init: 20180421 1800 UTC
Valid: 20180422 1800 UTC

**Probability of Frequent Winds > 40kts**

Day-1 Prob. > 40 +/- 20 km: hrs 01-24
Interval Max 10m Wnd Spd (kt)
Init: 20180421 1800 UTC
Valid: 20180422 1800 UTC
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**
- **Hail threat proxy**

Global climatology of GPM radar inferred precipitation features that contain hail

- **Environmental parameter (available in data file but from external model)**

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

GPM satellite Frequency 37 GHz
2018-03-30 08:07:58 to 2018-03-30 08:11:38 UTC

GPM satellite Frequency 19 GHz
2018-03-30 08:07:58 to 2018-03-30 08:11:38 UTC

3-4 inch hailstones produced by this storm
Source: Twitter
• 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.
Hail damage reports 30 March 2018

Example: 30 March hail damage in Bangladesh

Landsat-8 RGB 16 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
A view from above

From the International Space Station as it crossed a thunderstorm over Nepal on April 13, 2016 (taken by Astronaut Tim Peake, courtesy NASA)
We would like to thank Dr. Bhupesh Adhikary and the other SERVIR-HKH staff members at ICIMOD. We would also like to thank Mr. Sarva Pulla of the SERVIR SCO for facilitating the HIWAT Tethys App. We also thank Mr. Jeff Knickerbocker of SIG and Mrs. Jayanthi Srikishen at NASA MSFC as well as the GIT team at the SERVIR SCO for assisting with the SOCRATES configuration.