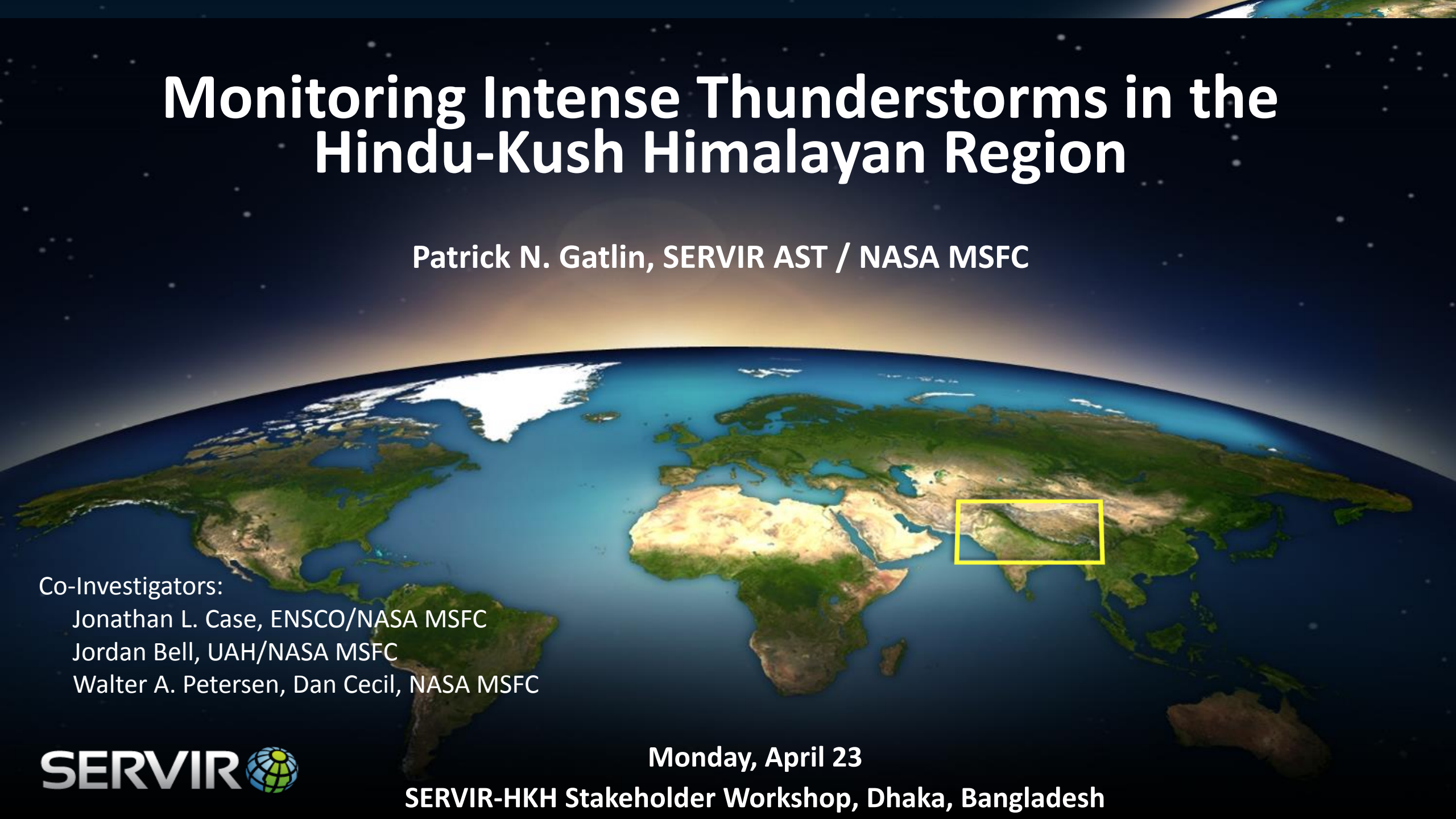
Monitoring Intense Thunderstorms in the Hindu-Kush Himalayan Region

Patrick N. Gatlin, SERVIR AST / NASA MSFC



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SERVIR

Monday, April 23

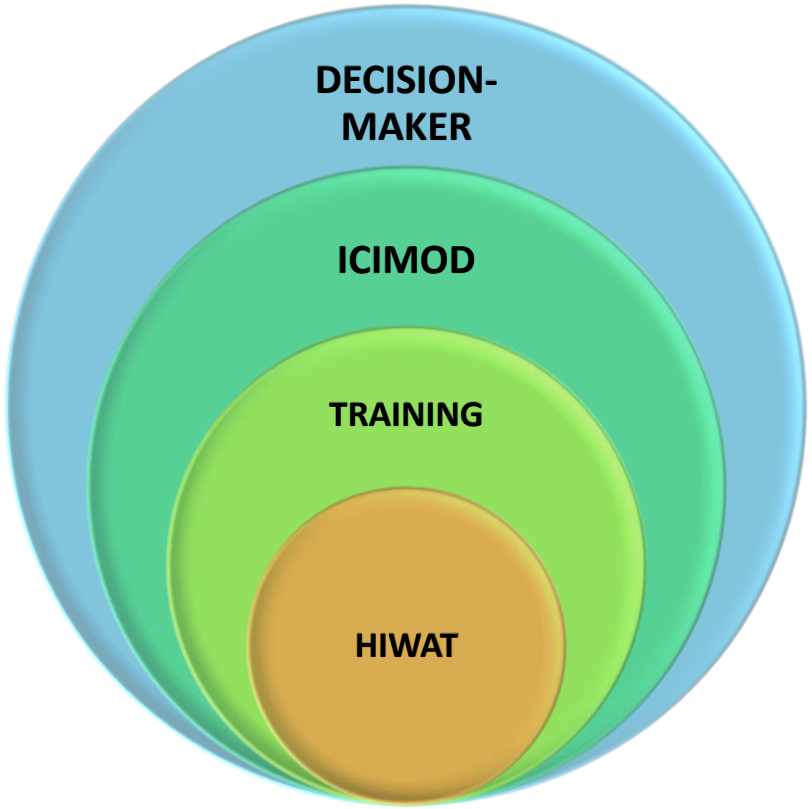
SERVIR-HKH Stakeholder Workshop, Dhaka, Bangladesh

Project Objectives

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

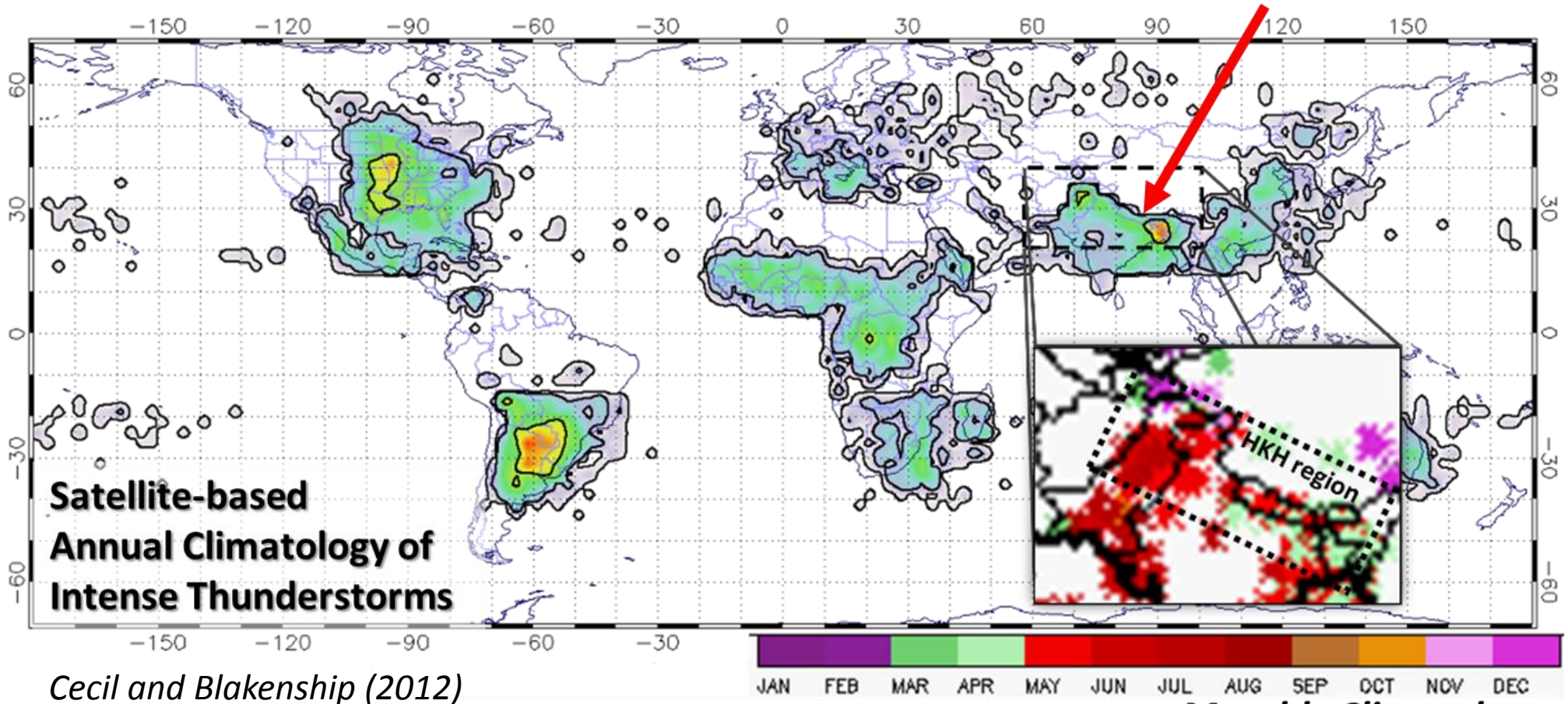
Objectives:

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:



Cecil and Blakenship (2012)

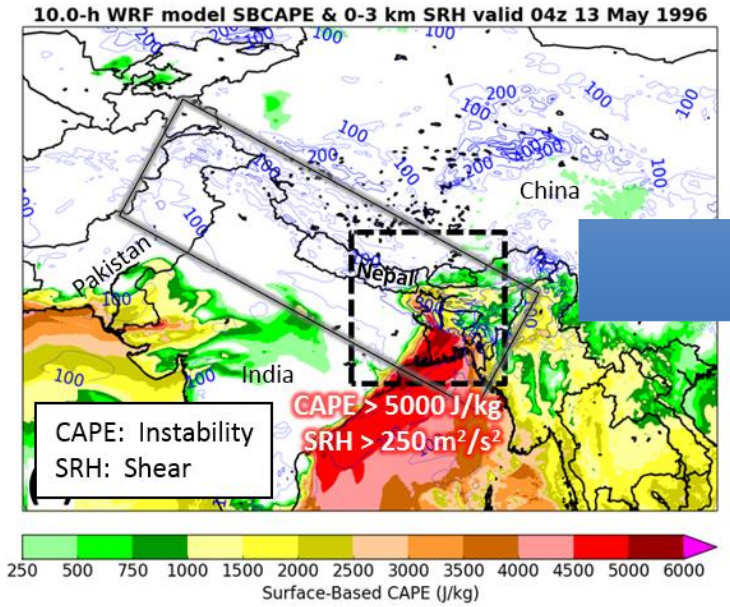
Monthly Climatology

Premonsoon (April-May): Bangladesh to eastern Nepal

Monsoon (June-August): Nepal to northern Pakistan

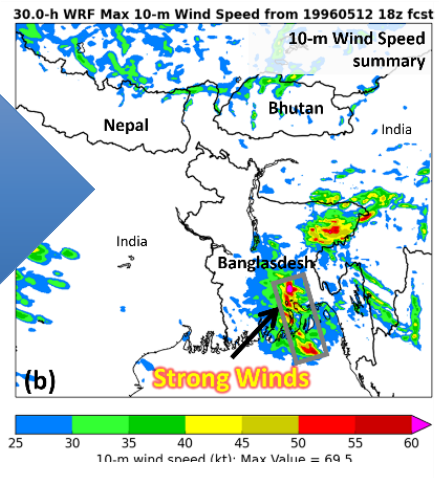
High Impact Weather Assessment Toolkit (HIWAT)

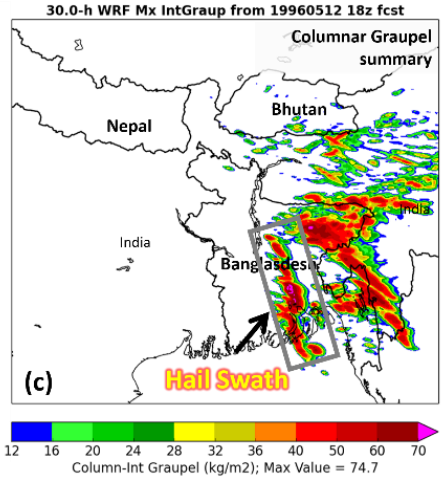
REGIONAL WRF MODEL

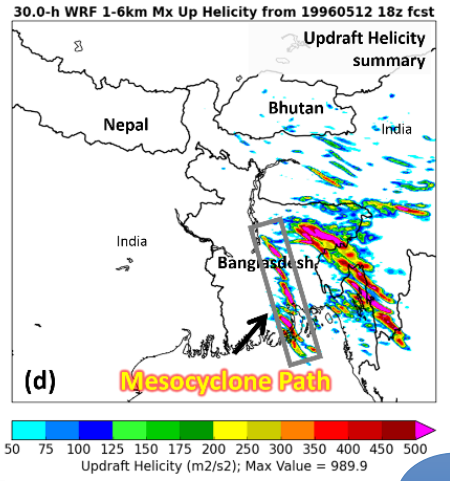


HIGH IMPACT WEATHER ENSEMBLE DIAGNOSTICS

Situational Awareness

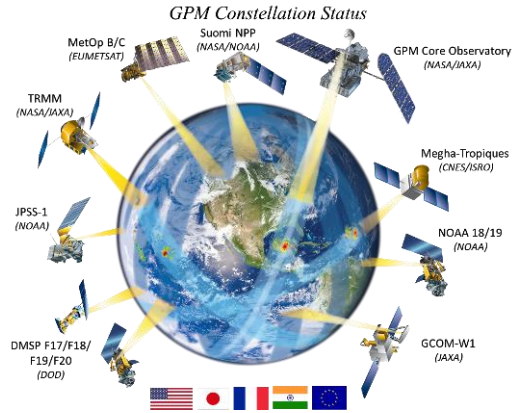


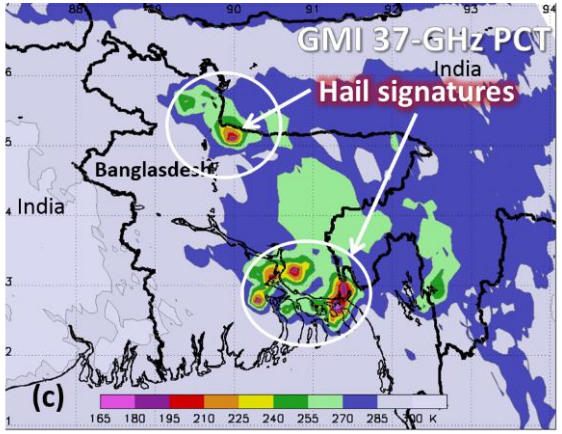




GPM SATELLITE OBSERVATIONS

Threat Assessment



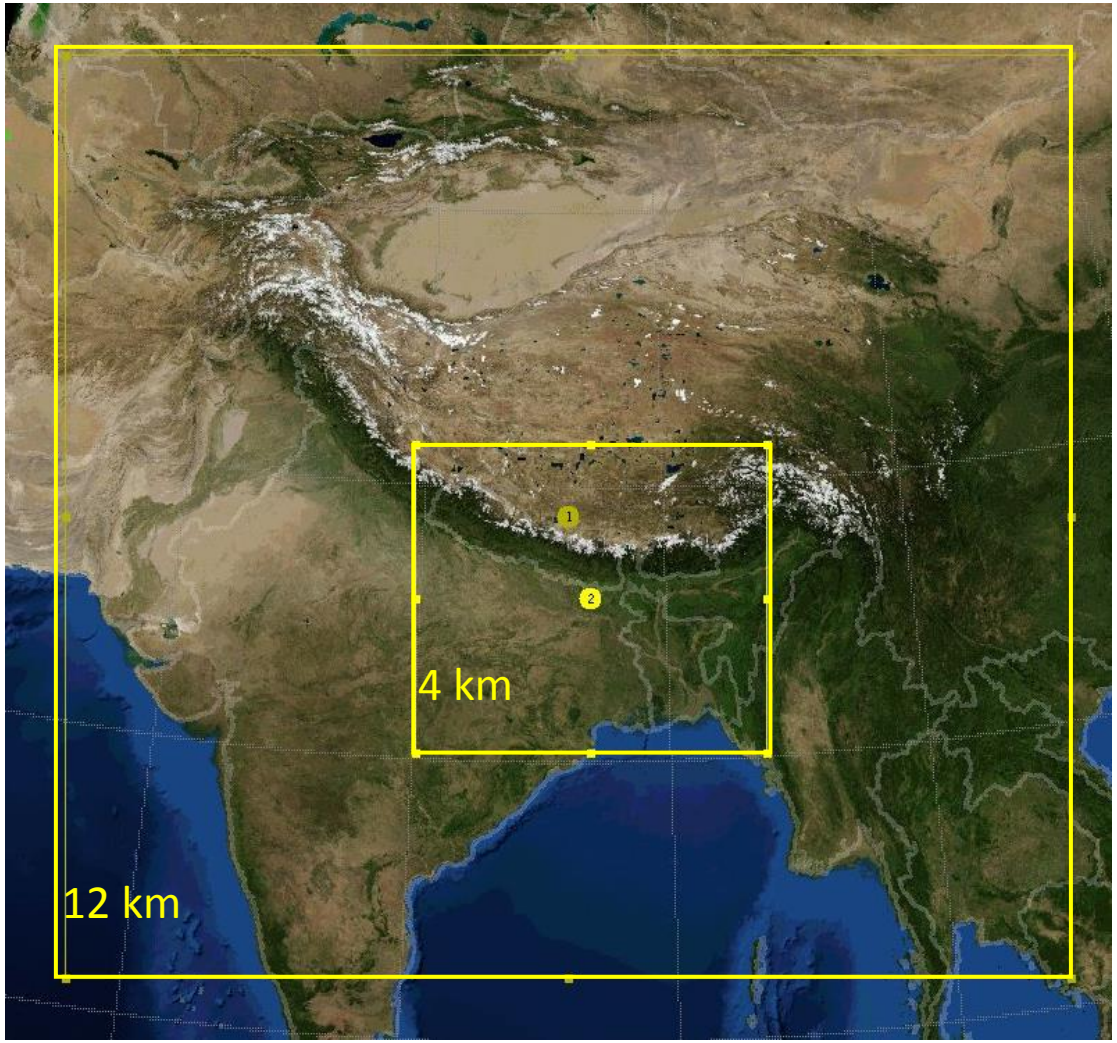


SATELLITE LAND IMAGERY

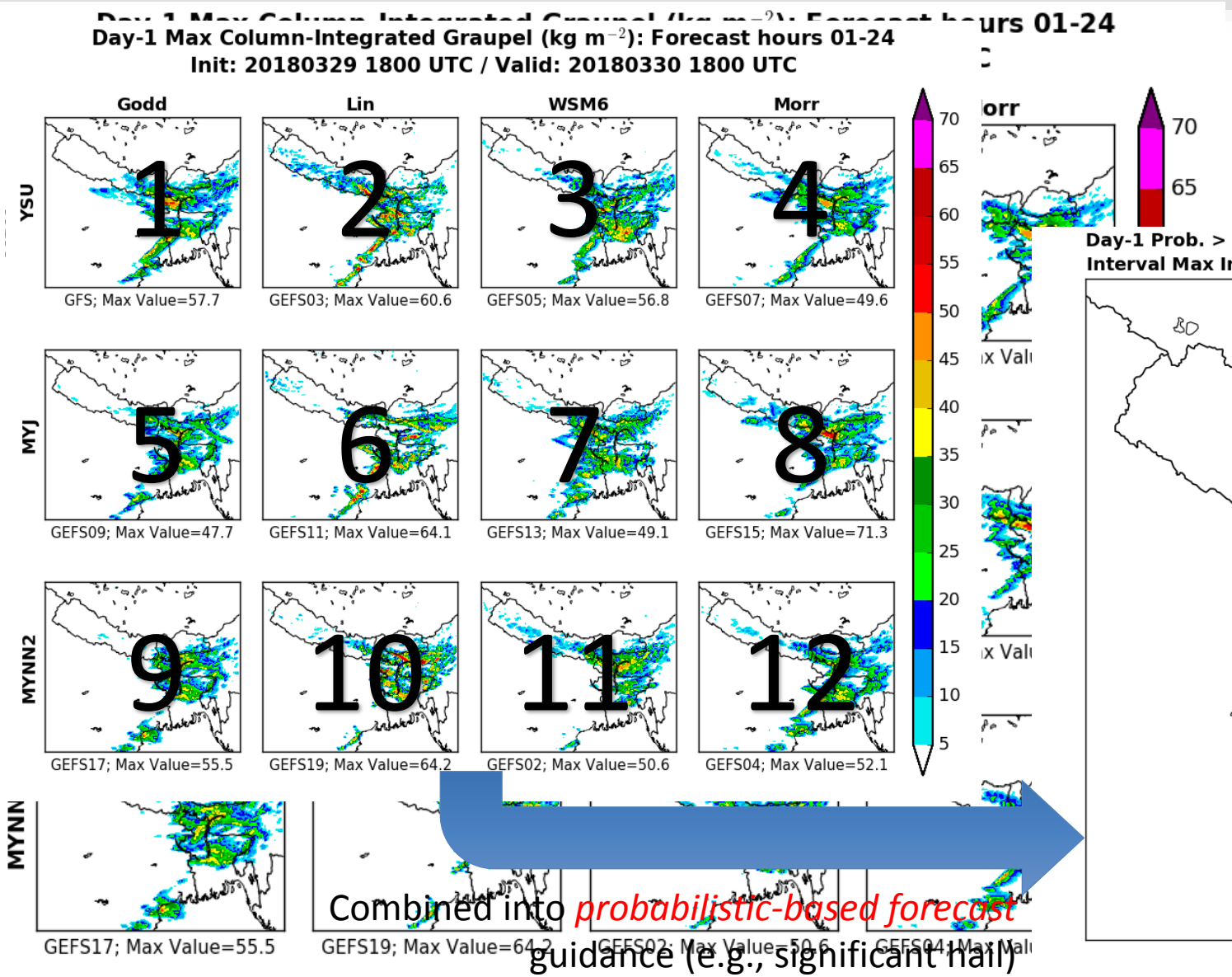
Impact Assessment

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

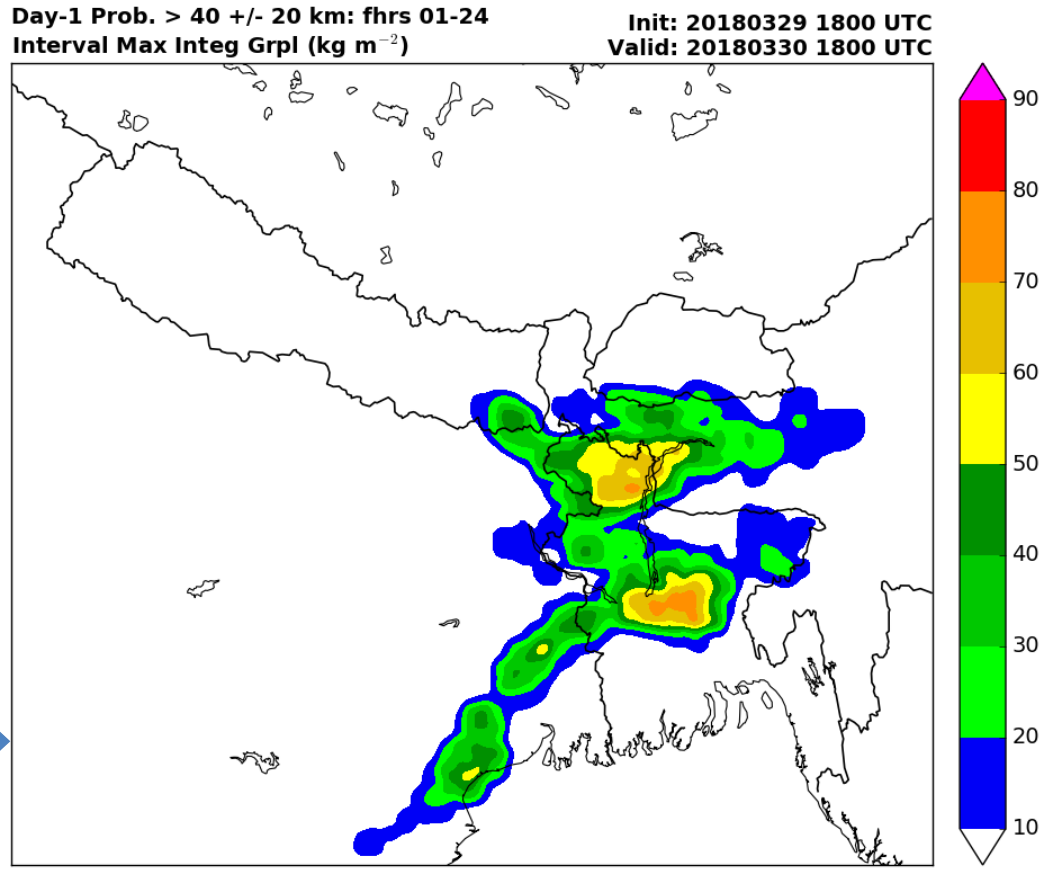


Ensemble forecasting of thunderstorm hazards



Ensemble-based Forecast

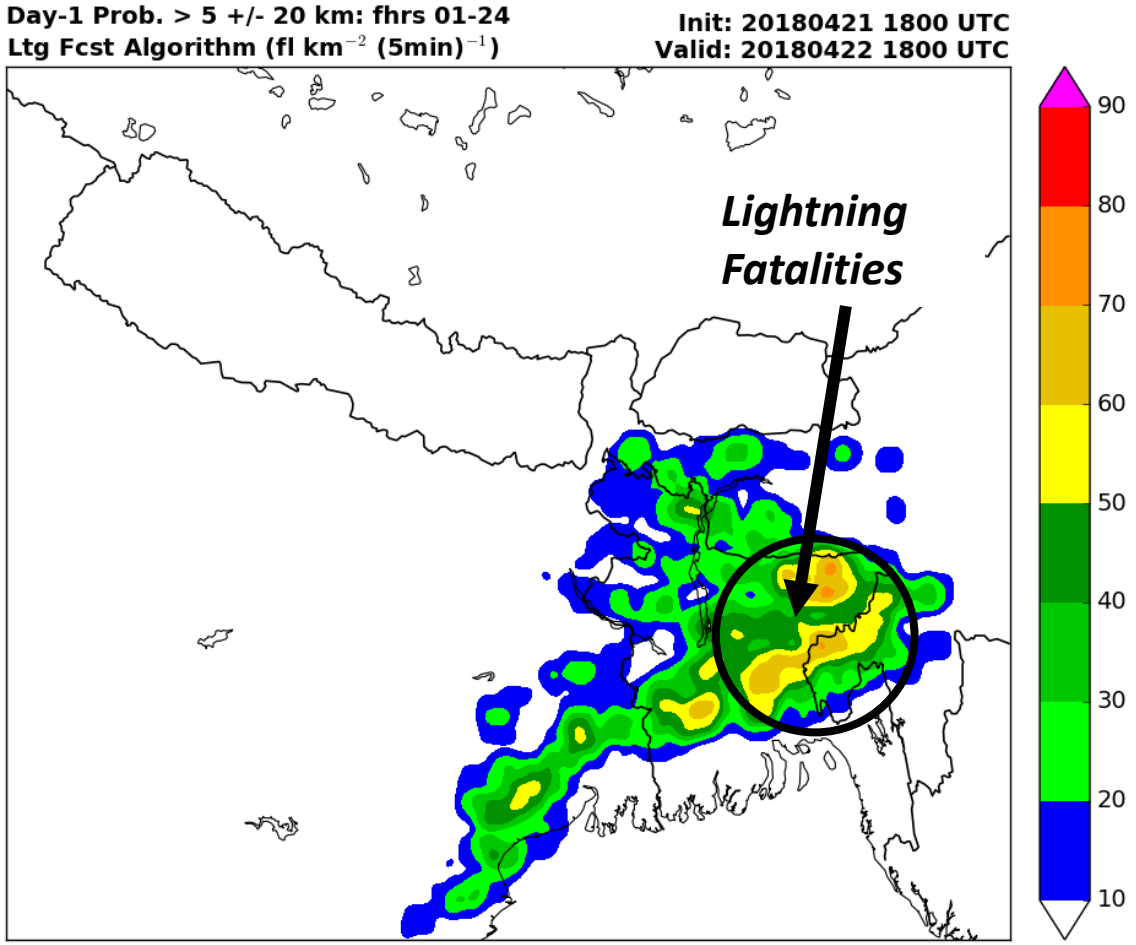
12 model forecasts produced over focus region using different initial conditions and physics options



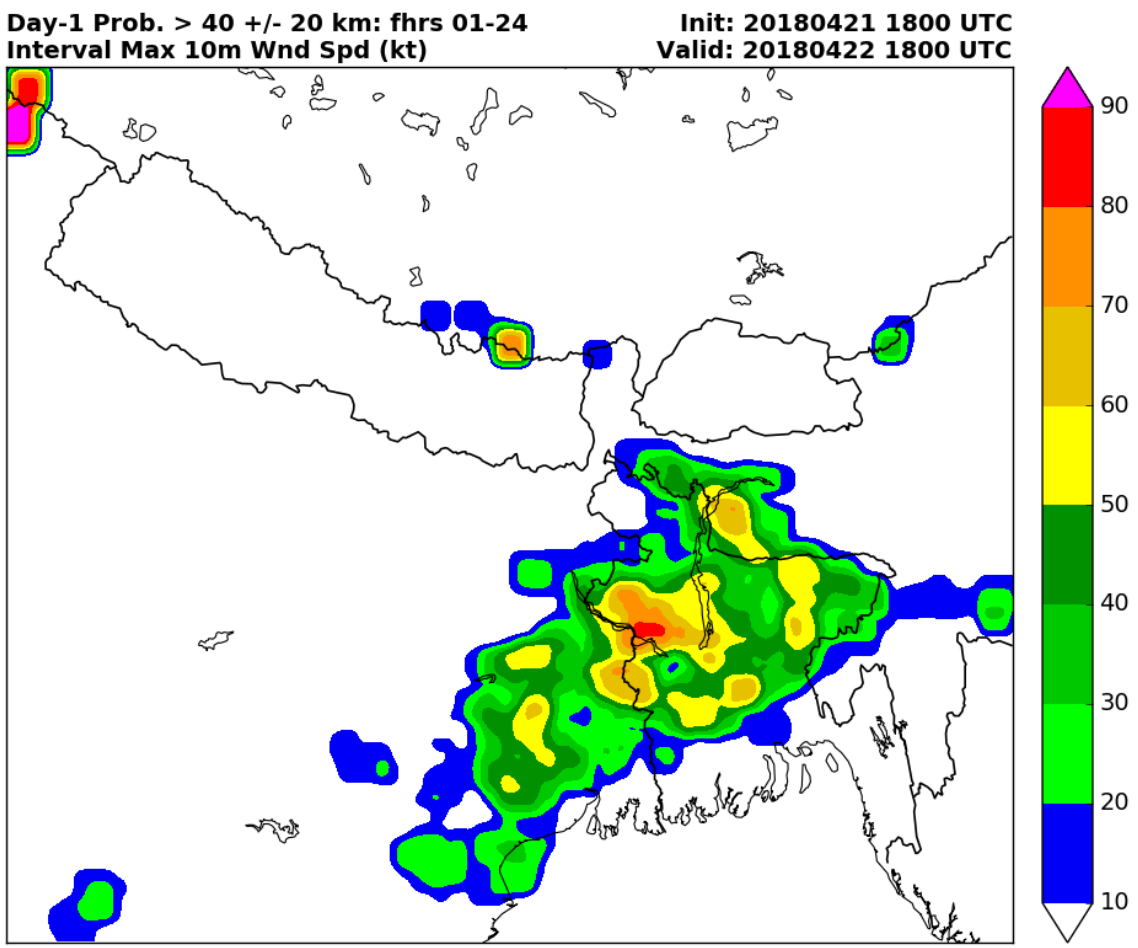
Combined into *probabilistic-based forecast* guidance (e.g., significant hail)

Example: Yesterday's nor'wester

Probability of Frequent Lightning

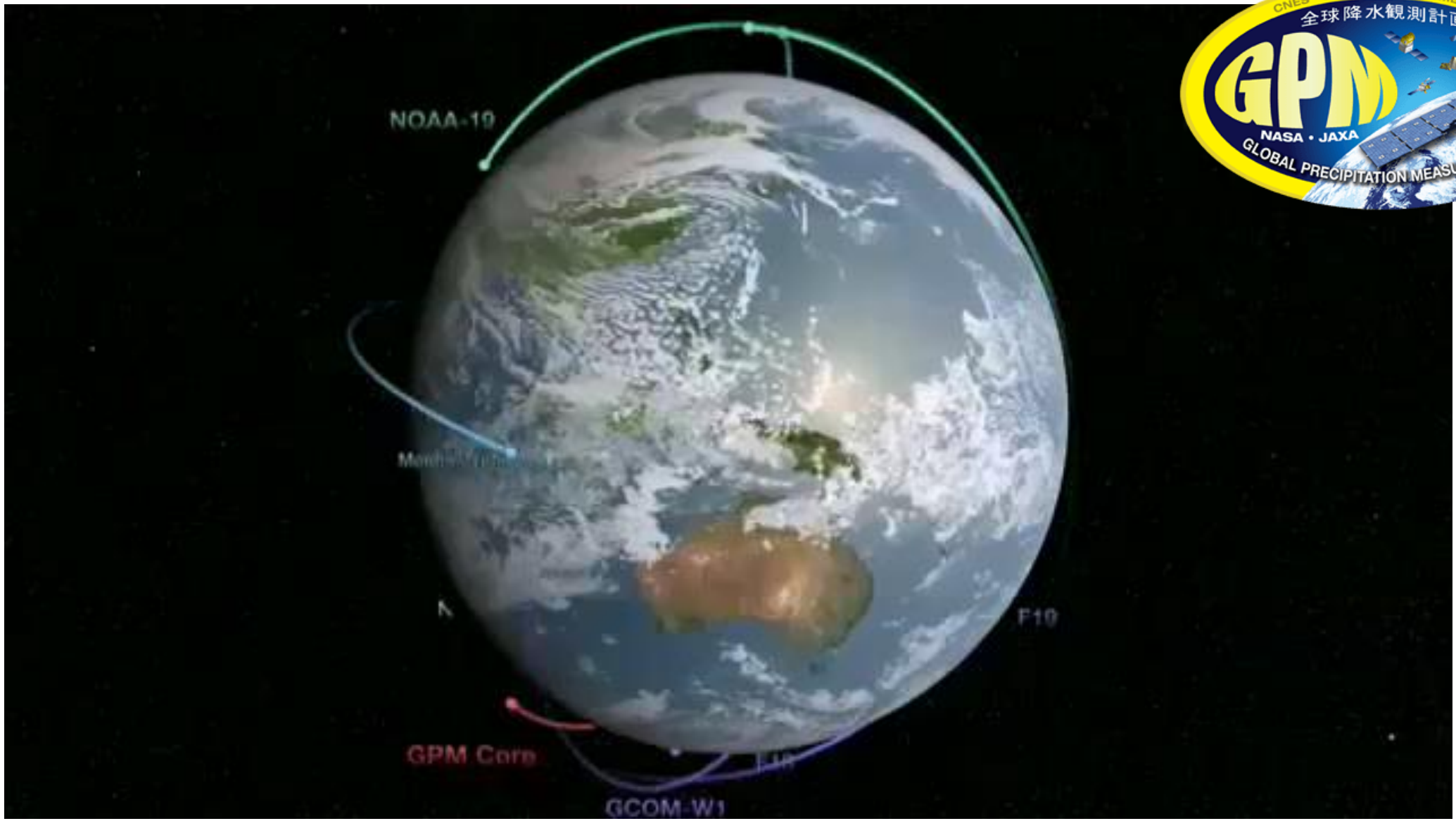


Probability of Frequent Winds > 40kts



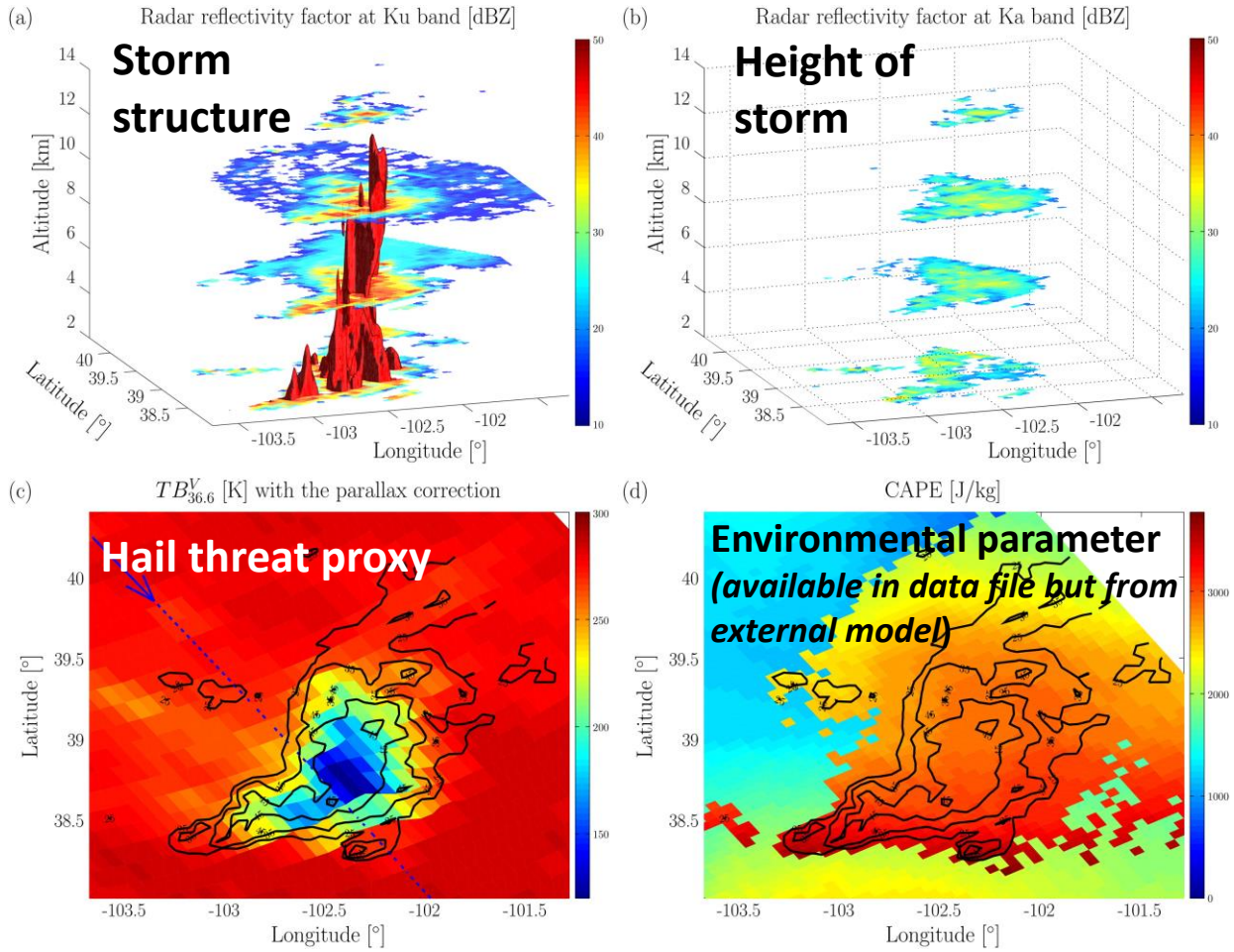
Satellite-based thunderstorm intensity tool

GPM Constellation of passive microwave sensors

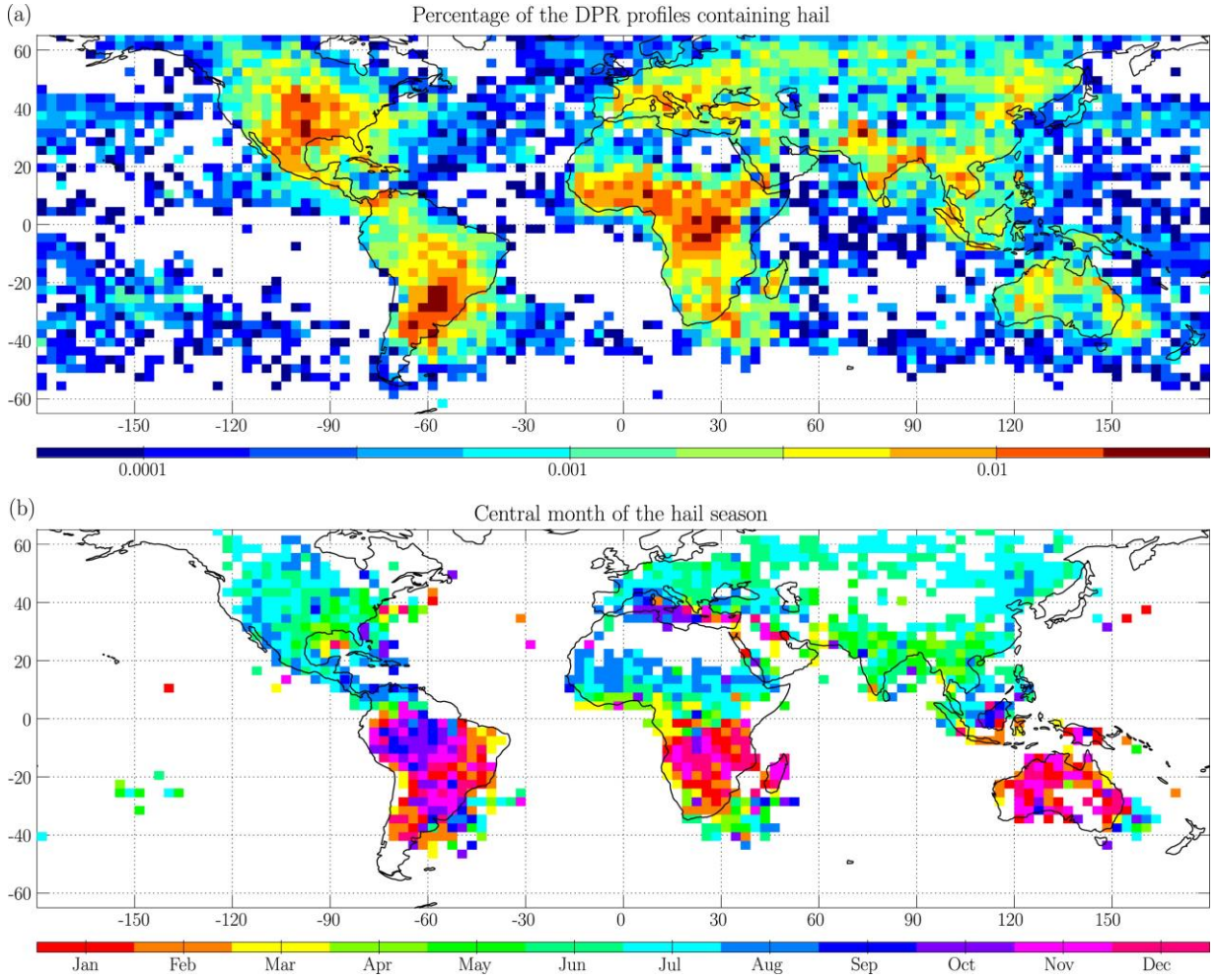


GPM Enables Detection of Severe Storms on a Global Scale

GPM core satellite radar and radiometer measurements of an intense storm



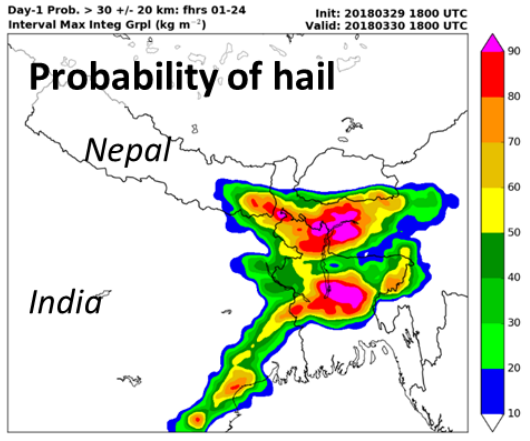
Global climatology of GPM radar inferred precipitation features that contain hail

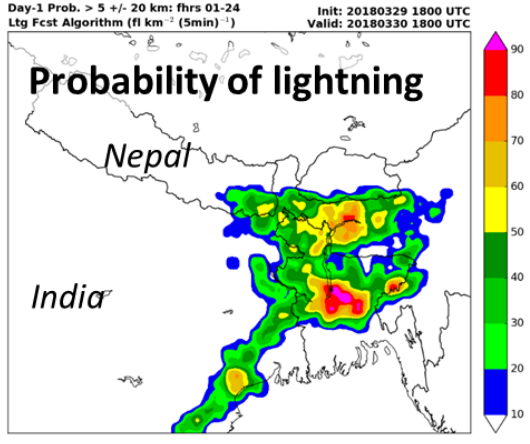


Ni et al. (2017)

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

HKH Model Prob.-Forecasts



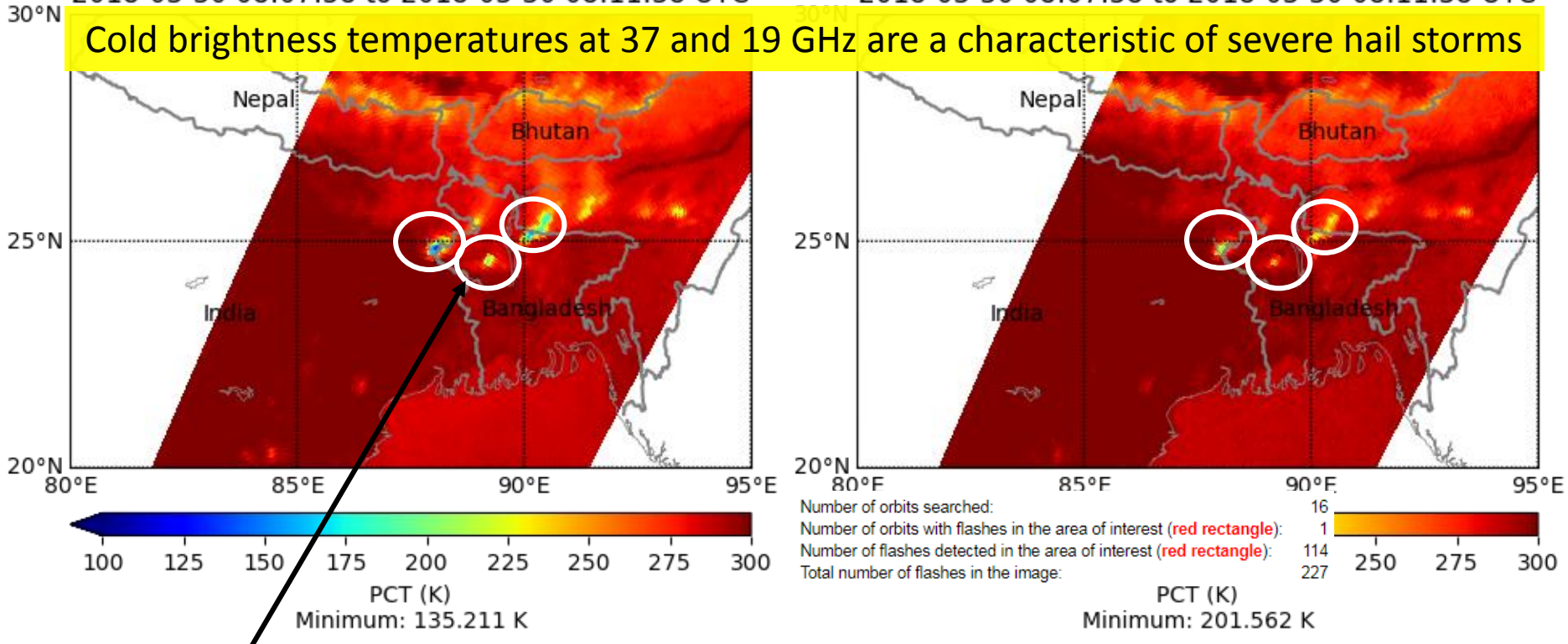


- Several fatalities due to hail and lightning
- Numerous houses and vast areas of cropland damaged by hail

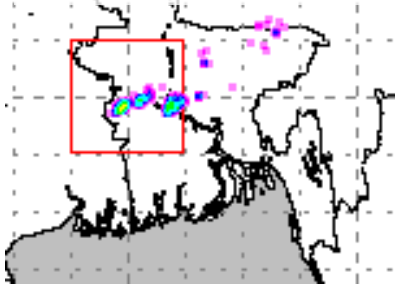
GPM satellite Frequency 37 GHz
2018-03-30 08:07:58 to 2018-03-30 08:11:38 UTC

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

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

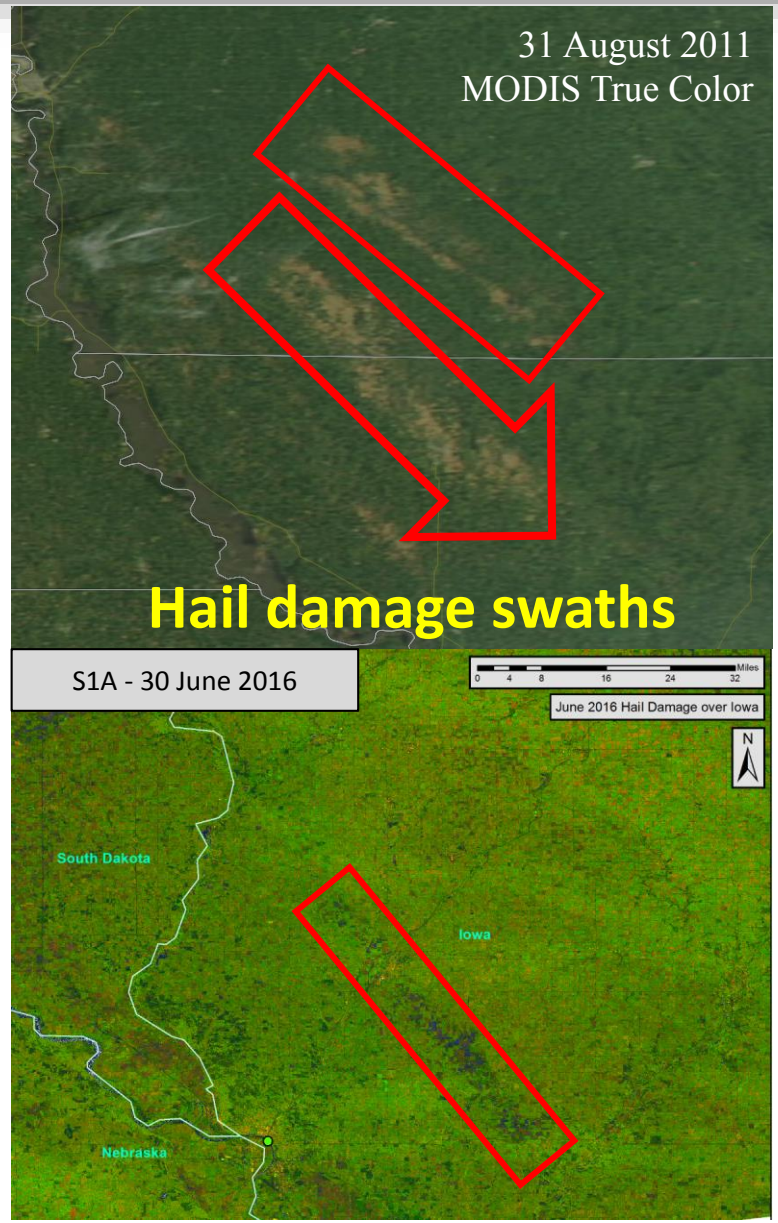


Satellite-based lightning activity



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



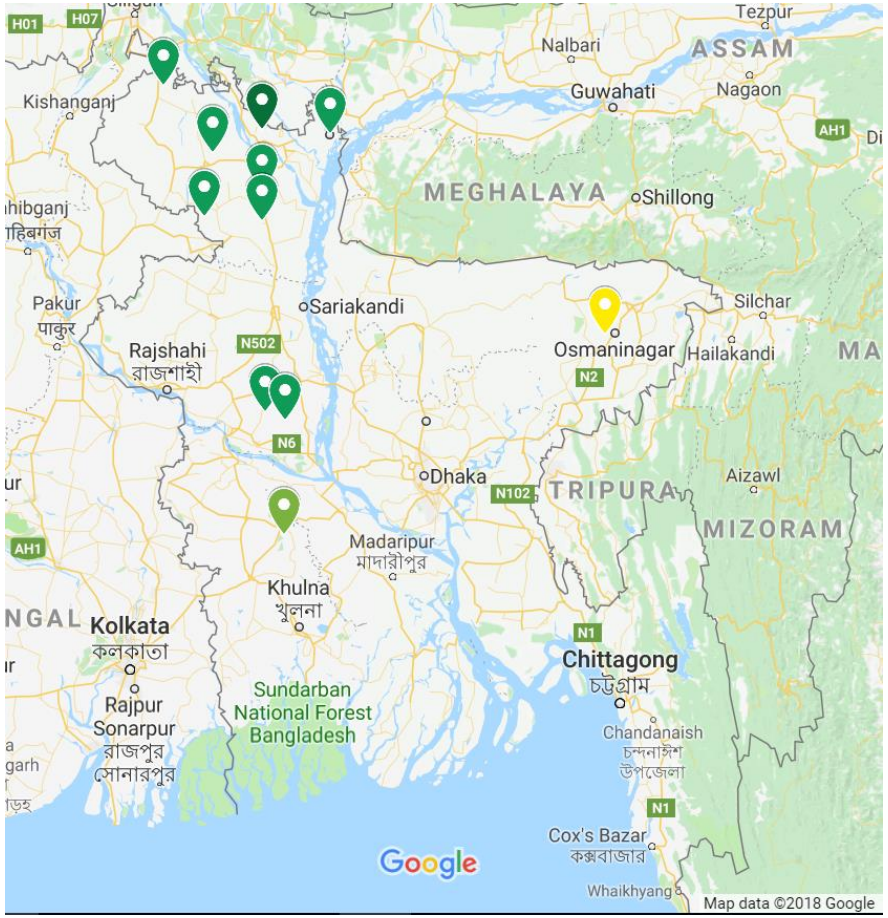
250-meter resolution

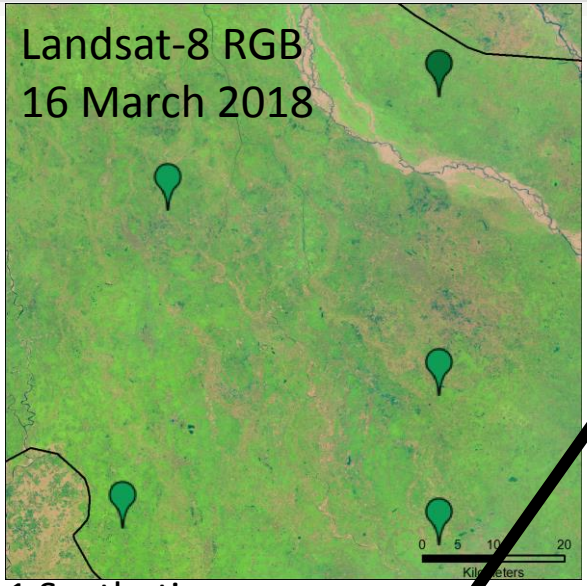
Damage produced by hailstorms in the Central United States

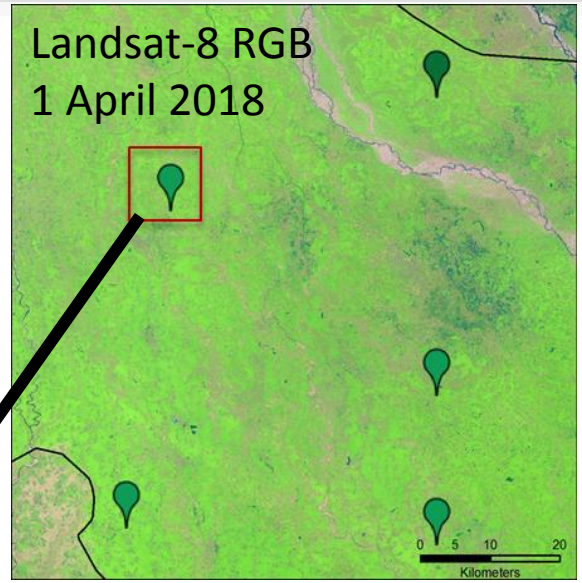
20-meter resolution

Example: 30 March hail damage in Bangladesh

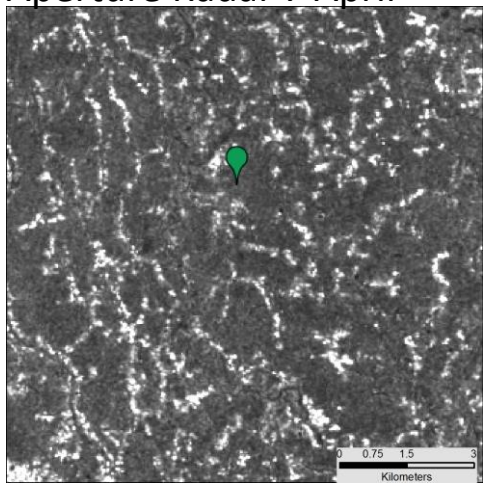
Hail damage reports 30 March 2018



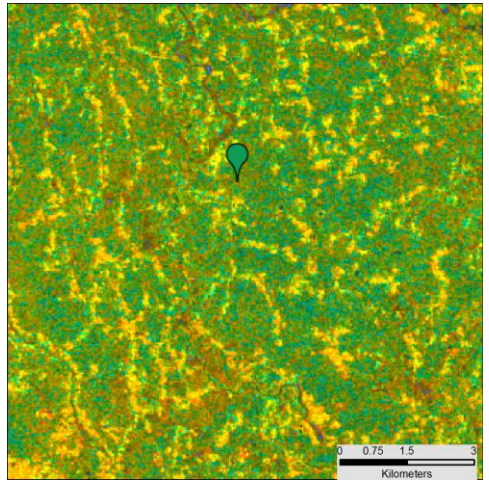




Sentinel-1 Synthetic Aperture Radar 7 April



SAR Vertical channel



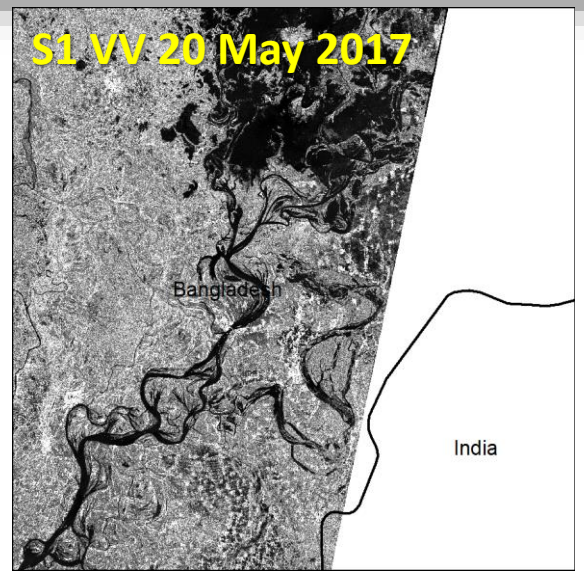
SAR RGB

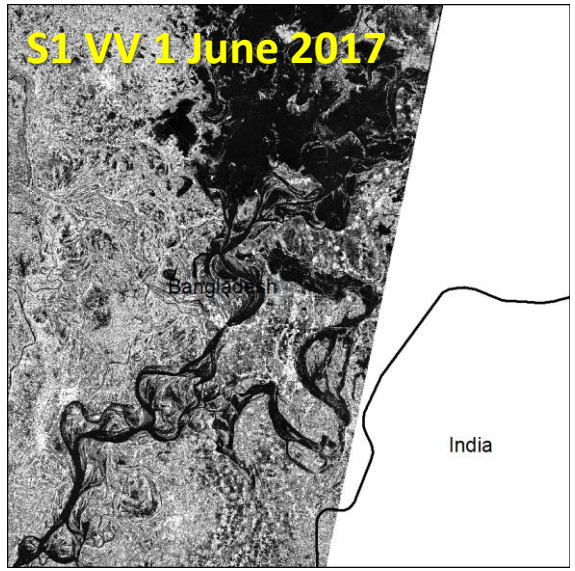
- No apparent large areas of damage or hail swaths are visible in Landsat-8 Natural Color RGB
- SAR data also does not indicate hail swaths like those observed in the U.S.

Better suited in HKH for flood mapping

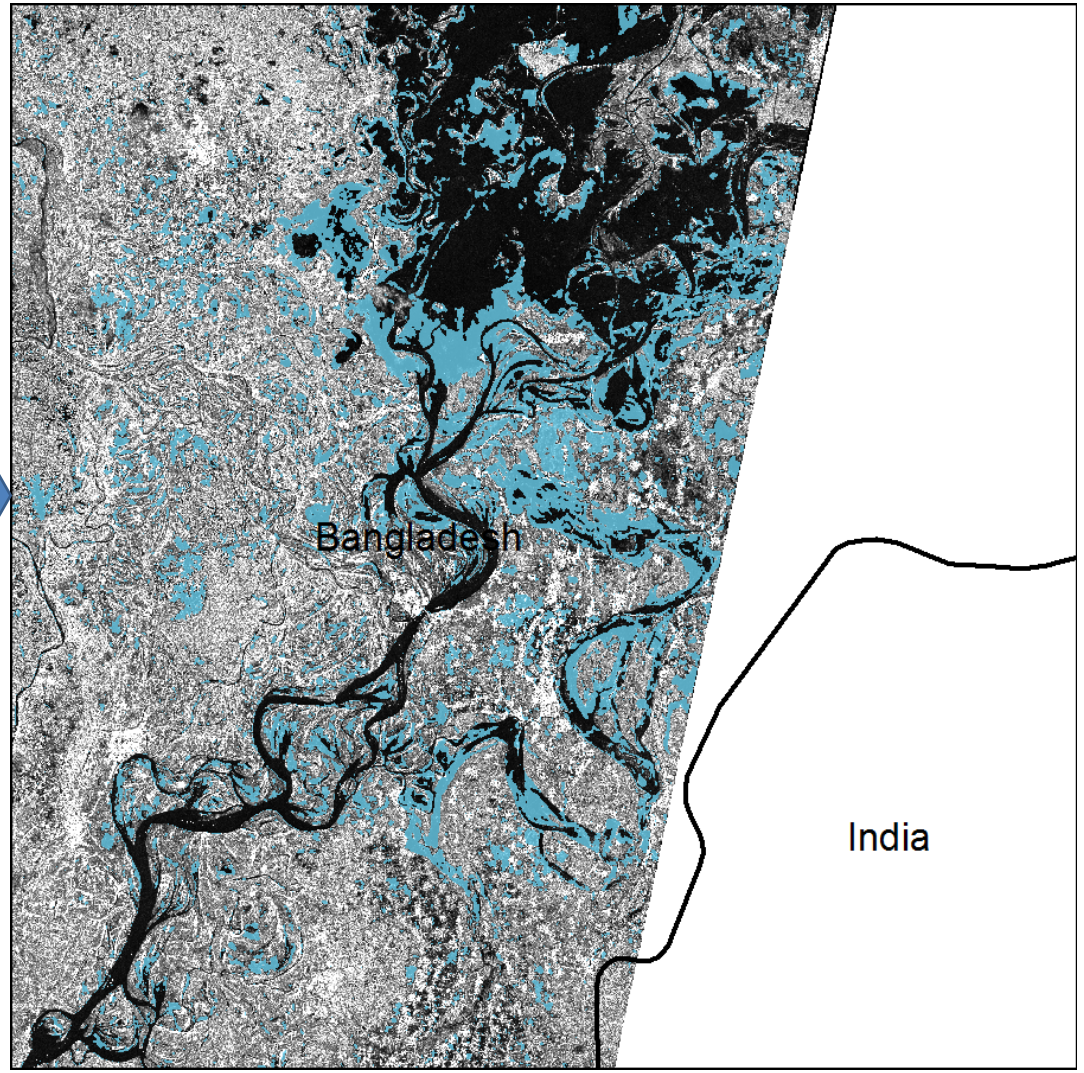
- Hail damage signals are not readily apparent in HKH region…Why?
  → Land use is more diverse in HKH region (smaller plots of land with same crops)

- Flood waters exhibit a homogeneous signal in land imagery





Change Detection related to water



Blue is flood

Looking Forward

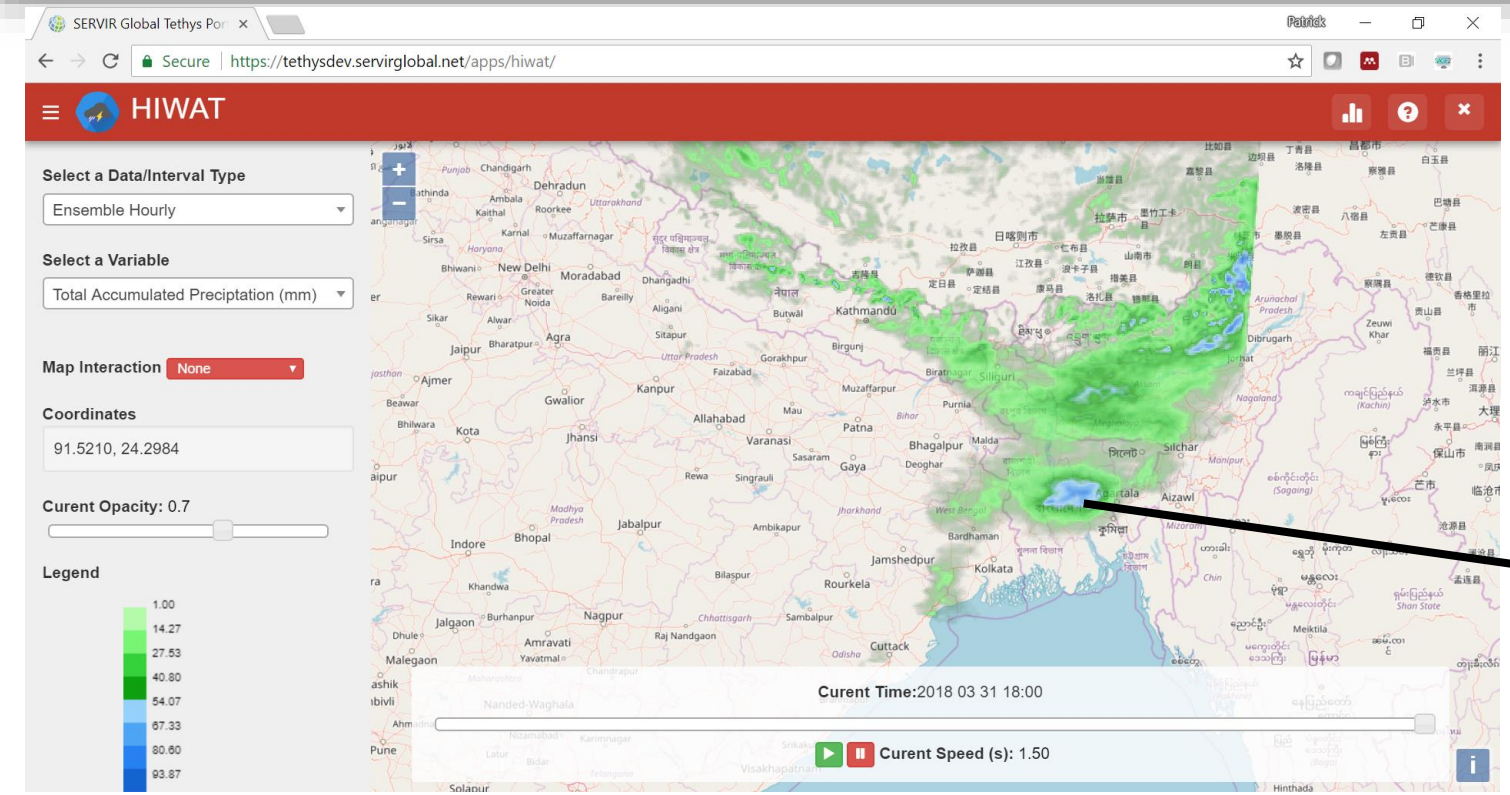
PY2

- 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

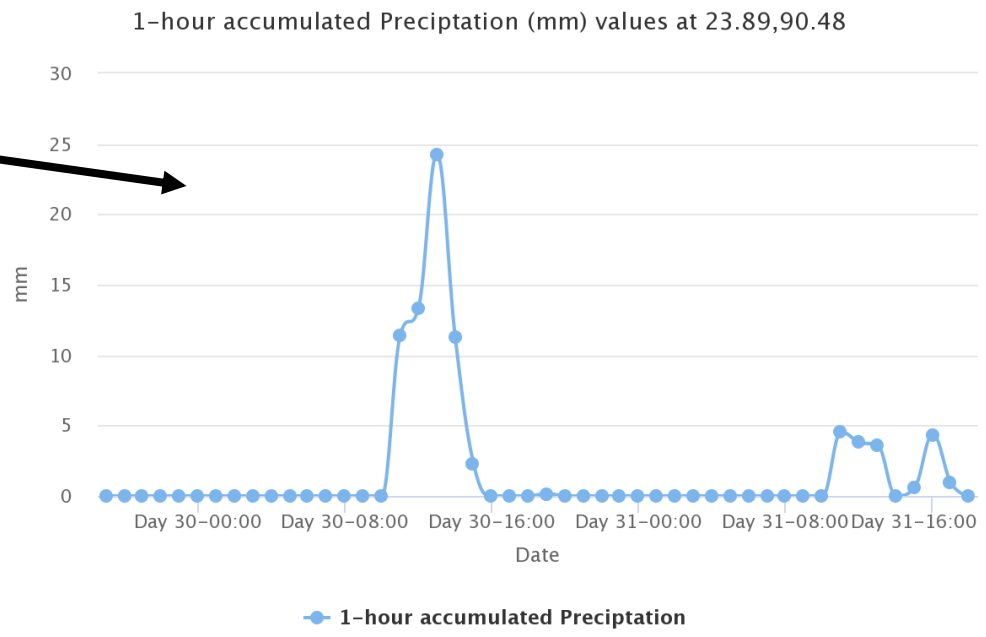
PY3

- Transition HIWAT to ICIMOD
- Training and outreach
- Trial period at DHM-Nepal (or other end-user)

Using Tethys to create a HIWAT App

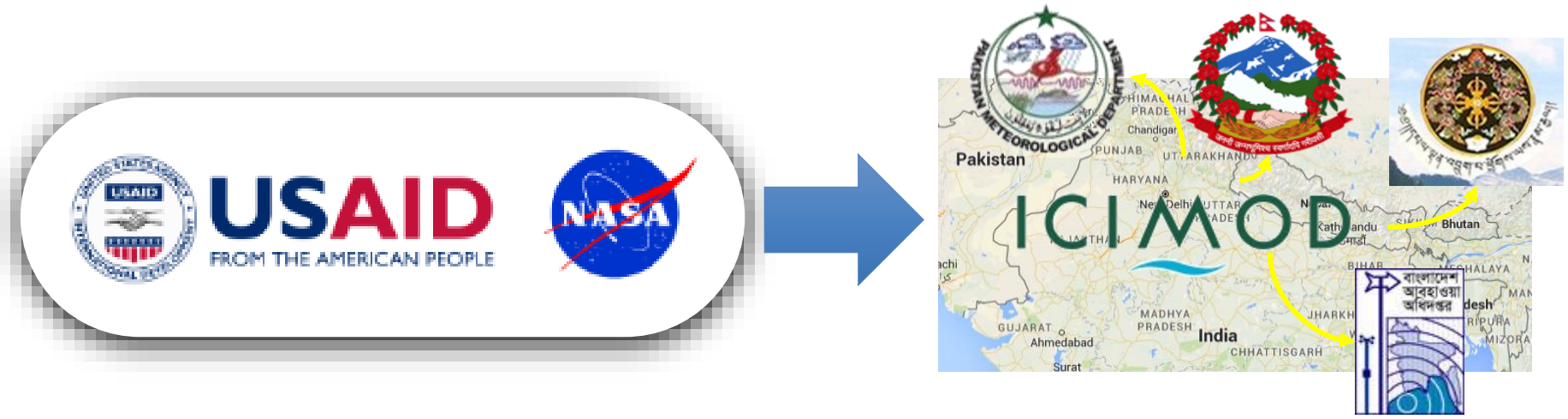


Point-based forecast



Expectations

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)

Acknowledgements

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.