11/2/23 | State Department Pakistan Desk

Global Hydrometeorology Resource Center (GHRC) User Working Group (UWG):

User Presentation: High Impact Weather Analysis Toolkit (HIWAT)
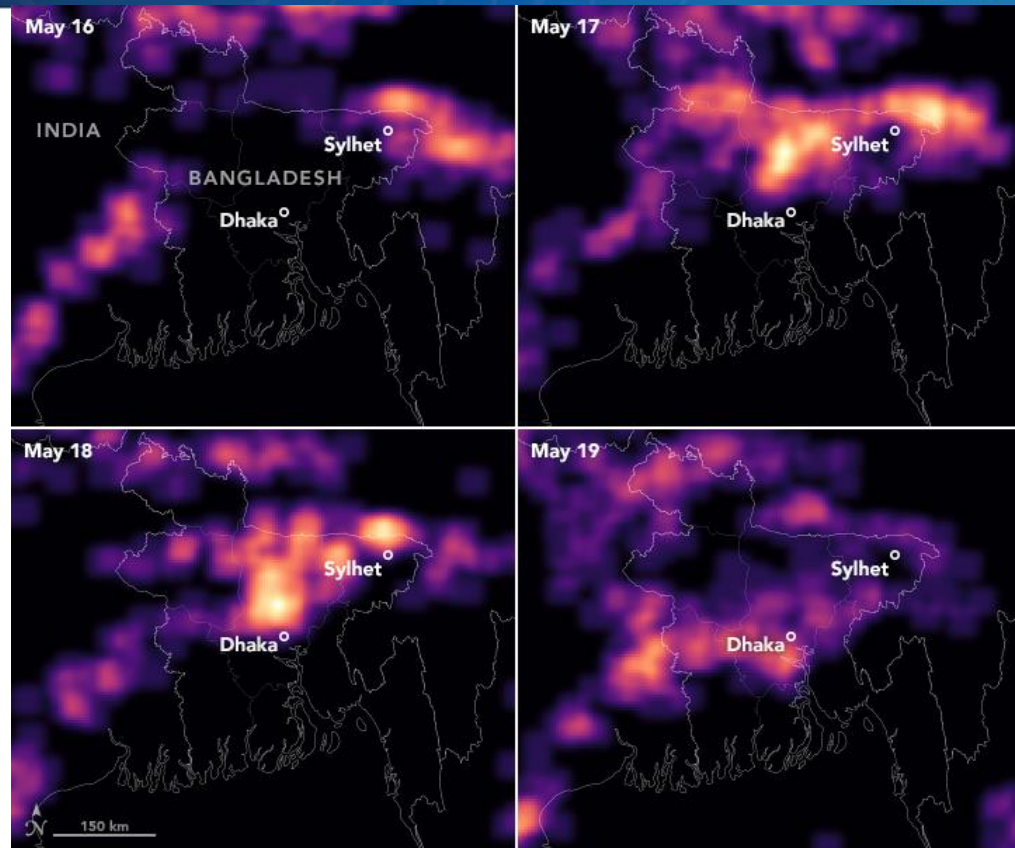
Tim Mayer
NASA – SERVIR, Hindu Kush Himalaya Regional Science Coordination Lead
Earth System Science Center – University of Alabama in Huntsville, Research Scientist

Overview

- What is SERVIR
- SERVIR Services in the HKH region
- HIWAT History
- GHRC HIWAT Archive

May 16 • INDIA • Sylhet • BANGLADESH • Dhaka

May 17 • Sylhet • Dhaka

May 18 • Sylhet • Dhaka • 150 km

May 19 • Sylhet • Dhaka

Lightning Forecast (flashes per km² each 5 min)

0   45   ≥90

CHALLENGE:

- Climate change impacts are accelerating around the world.

- Disadvantaged and marginalized people are most adversely affected.

- The power of satellite data helps partner countries identify and manage climate risks.
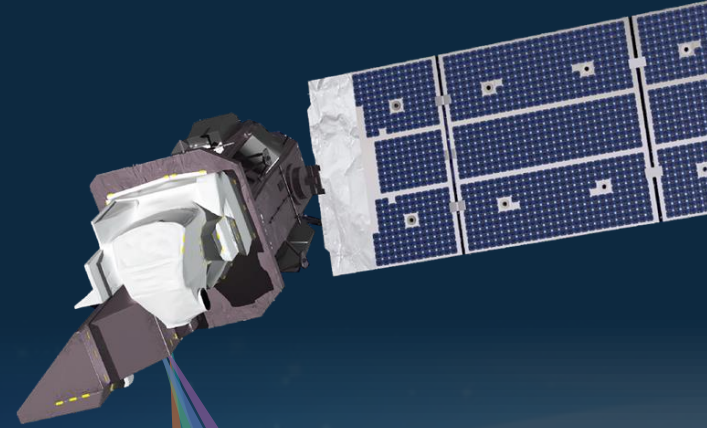
CONNECTING
SPACE TO VILLAGE

SERVIR is a joint initiative of NASA, USAID, and leading geospatial organizations in Asia, Africa, and Latin America that partners with countries and organizations to address challenges in climate change, food security, water and related disasters, land use, and air quality.

Using satellite data and geospatial technology, SERVIR co-develops innovative solutions through a network of regional hubs to improve resilience and sustainable resource management at local, national and regional scales.

CONNECTING
SPACE TO VILLAGE

Agriculture & Food Security
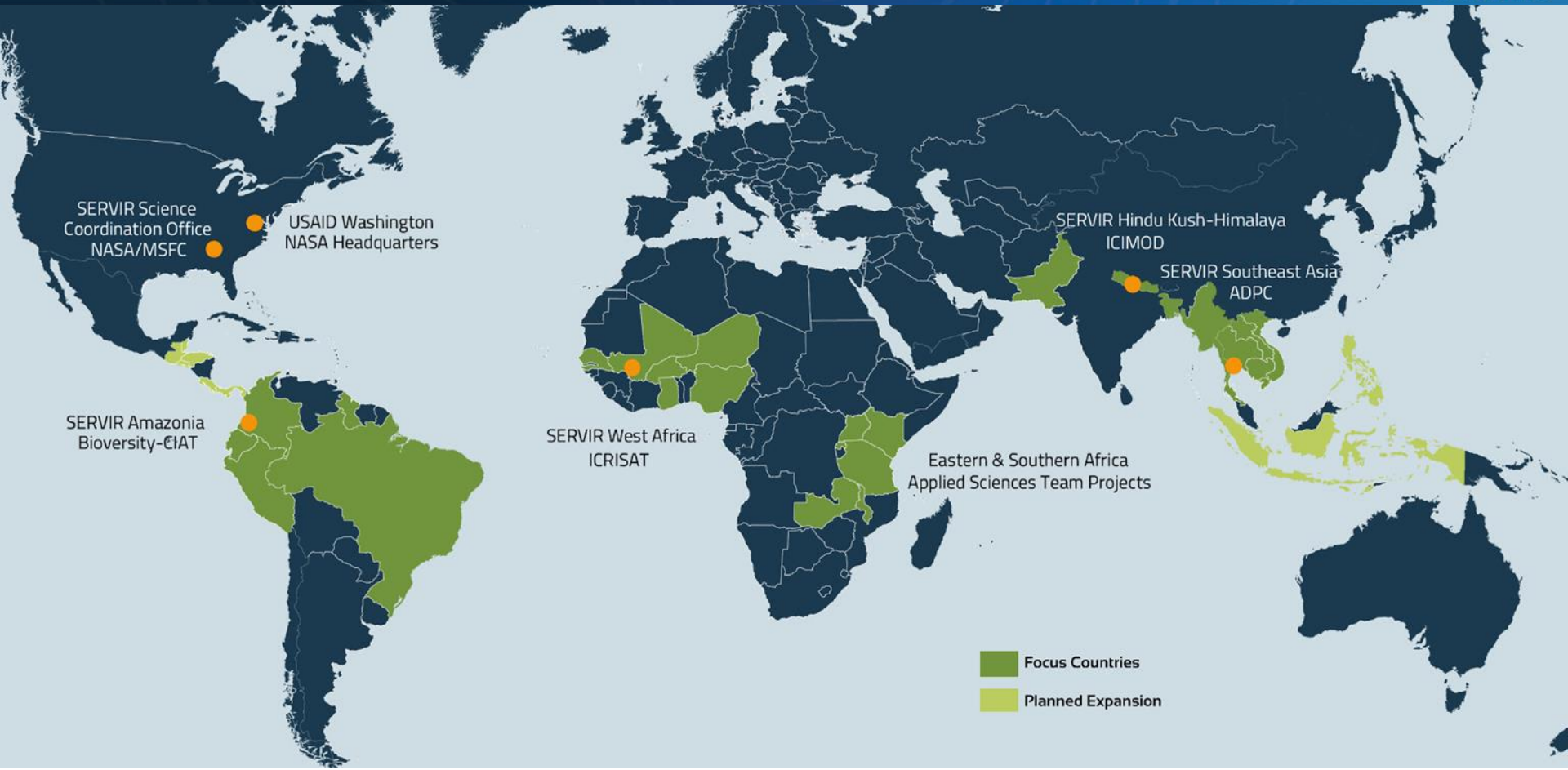
Water Security

Ecosystem & Carbon Management

Weather & Climate Resilience

Air Quality & Health

USAID FROM THE AMERICAN PEOPLE | NASA | SERVIR | ALLIANCE Bioversity International CIAT | ICRISAT INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS | ICIMOD | adpc

SERVIR Focuses on Countries in Asia, Africa, & the Americas

SERVIR Connects US Science to Global Challenges

Brigham Young University
US Forest Service, Rocky Mountain Research Station
US Geological Survey, Salt Lake City

Amazon
University of Washington

Oregon State University
US Forest Service, PNW Research Station

Desert Research Institute

Columbus Technologies
ESRI
Google
Mapbox
NASA Jet Propulsion Laboratory
Spatial Informatics Group, LLC
University Of California, Los Angeles
University Of California, Santa Barbara
University of California, Berkeley
University of California, Irvine
University of San Francisco

Geospatial Collaborative LLC

Alaska Satellite Facility
University of Alaska Fairbanks

Maxar Technologies
Univ. of Colorado, Boulder

University of Wisconsin, Madison

University of Minnesota

Michigan State University

New Mexico
State University

University Of Houston
Texas Agricultural Experiment Station

IFDC
NASA Marshall Space Flight Center
NASA SPoRT Center/ENSCO
Universities Space Research Association
University of Alabama in Huntsville

NOAA/National Severe Storms Laboratory
University of Oklahoma, Norman

International Research Institute for Climate & Society
Lamont Doherty Earth Observatory
Columbia University

Boston University
Clark University
Earth Big Data
Univ. of Massachusetts, Amherst
Woods Hole Research Center

Johns Hopkins University
NASA Goddard Space Flight Center
University of Maryland
Univ. of Maryland, Baltimore County
Univ. of Maryland, College Park
USRA, Columbia

DevSeed
Resources For The Future, Inc.
World Wildlife Fund

George Mason University
US Agency for International Development
USGS, Eastern Geographic Science Center
University of Richmond

University of South Carolina

University of Florida, Gainesville

- Poverty reduction & resilience
- Data-dependent issues in data-scarce places
- International field presence

- 30+ Earth observing satellite missions, free & open data
- Major research portfolio
- Societal benefit from space

Regional Hub Host Institutions:

Private sector collaborators:

Google   mapbox   developmentSEED   planet.   esri   aws   MAXAR TECHNOLOGIES

USG collaborators: NOAA   USGS science for a changing world   US FOREST SERVICE

Intergovernmental, NGO collaborators:

FAO Food and Agriculture Organization of the United Nations   WFP World Food Programme   Red Cross   MERCY CORPS

Research collaborators: 20+ US universities & research centers through the SERVIR Applied Sciences Team; ITC, in-region university networks

ALLIANCE
Bioversity International   CIAT International Center for Tropical Agriculture Since 1967 Science to cultivate change   ICRISAT INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS   ICIMOD   adpc

Hub Consortium Members:

Deltares   SEI Stockholm Environment Institute   Spatial Informatics Group   CONSERVACIÓN AMAZÓNICA ACCA   imaflora   eco ciencia   CILSS   AFRIGIST   CERSGIS   CSE Centre de Suivi Ecologique   AIMS   ISESTEL   COLUMBIA UNIVERSITY   University of Virginia 1853
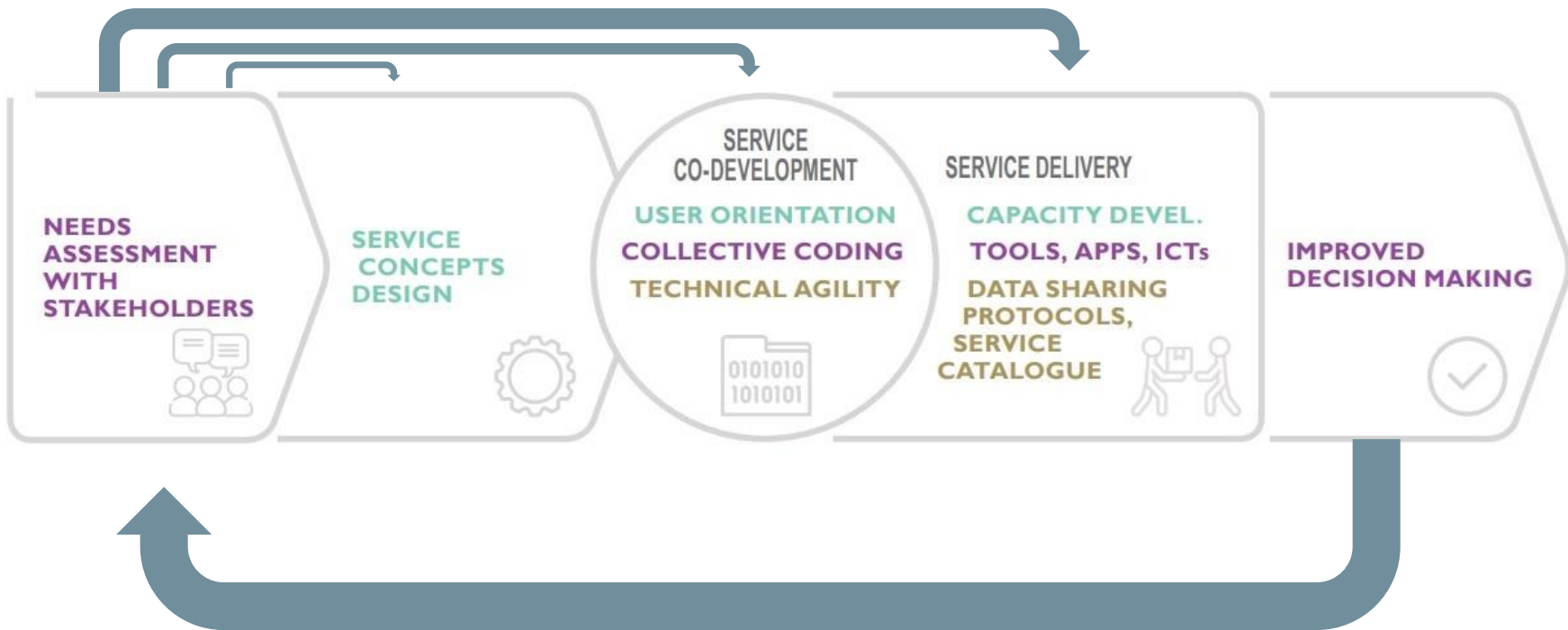
SERVIR-HKH SERVICES

Service Area:	Service:	Service:	Service:	Service:
Agriculture and Food Security	Regional Drought Monitoring and Outlook System (RDMOS) (AST-2)	Crop monitoring and assessment (AST-3 + AST-4)	-	-
Water Security	Enhancing regional flood early warning (AST-2 + AST-4)	Flood inundation mapping and forecasting (AST-3 + AST-4)	Strengthening and localization of multi-hazard early warning systems (AST-4)	-
Ecosystem & Carbon Management	Land cover and forest monitoring (AST-3 + AST-4)	Monitoring land use change in the HKH	Resilient Forest Management	Digital Platform for Ten Billion Tree Plantation Management and Ecosystem Restoration of Pakistan
Weather & Climate Resilience	High Impact Weather Assessment (HIWAT) (AST-2)	-	-	-
Air Quality & Health	Monitoring and prediction of Air Quality (AQ) and visibility reductions in HKH region (AST-3 + AST-4)	-	-	-

High Impact Weather Assessment Toolkit (HIWAT)

HIWAT provides a service to address any hazardous weather that is a result of **Deep Moist Convection.** HIWAT which is an ensemble probabilistic Numerical Weather Prediction (**NWP**) approach which utilizes the Weather Research and Forecasting (**WRF**) system. Data acquisition, initialization, timing, pre- and post-processing, interpolation, and derived fields administered via the Unified Environmental Modeling System (**UEMS**)

Photo by Brad Goddard
Tornado

What type of weather events:

- Straight-line wind damages
- Tornado
- Flash Flooding
- Shelf clouds
- Lightning
- Large Hail

Large Hail

Flash Flooding

Shelf clouds

Lightning

Straight-line wind damage

High Impact Weather Assessment Toolkit (HIWAT)
Version 1 (2017-2022)

Nested mode grid domain over South Asia

- **Unified Environmental Modeling System (UEMS)** version 21.3.1 running the **Weather Research and Forecasting (WRF)** community model version 4.2.2

- 12-km outer grid 4-km nested grid (picture at right)

- **Daily 54-hour forecasts** with 1200 UTC initialization

- System approach: Utilize a diversity of both initial/boundary conditions and physics parameters to capture more variability utilized in the **ensemble** step
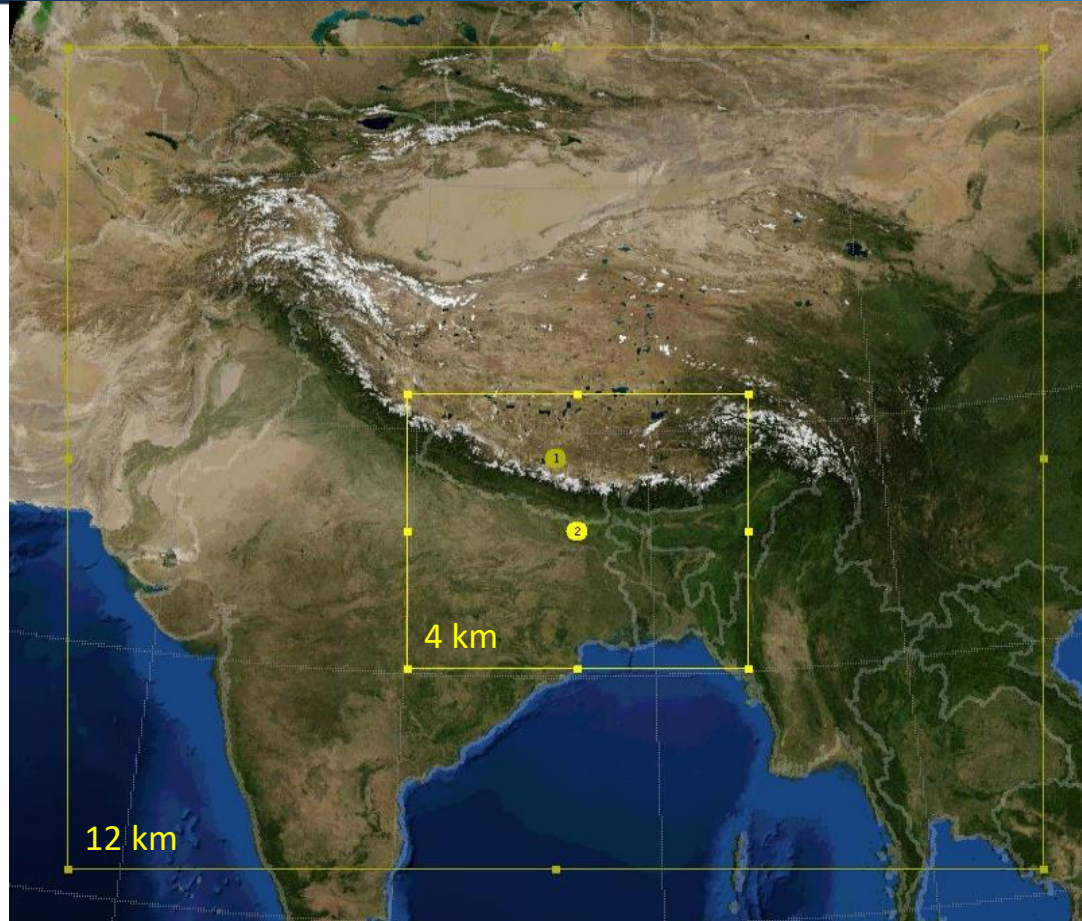
Example 9-member HIWAT Model **ensemble** producing a severe thunderstorm forecast

Day-2 Max Lightning Forecast Algorithm (fl km^{-2} (5min)$^{-1}$): Forecast hours 31-54
Init: 20210429 1200 UTC / Valid: 20210501 1800 UTC
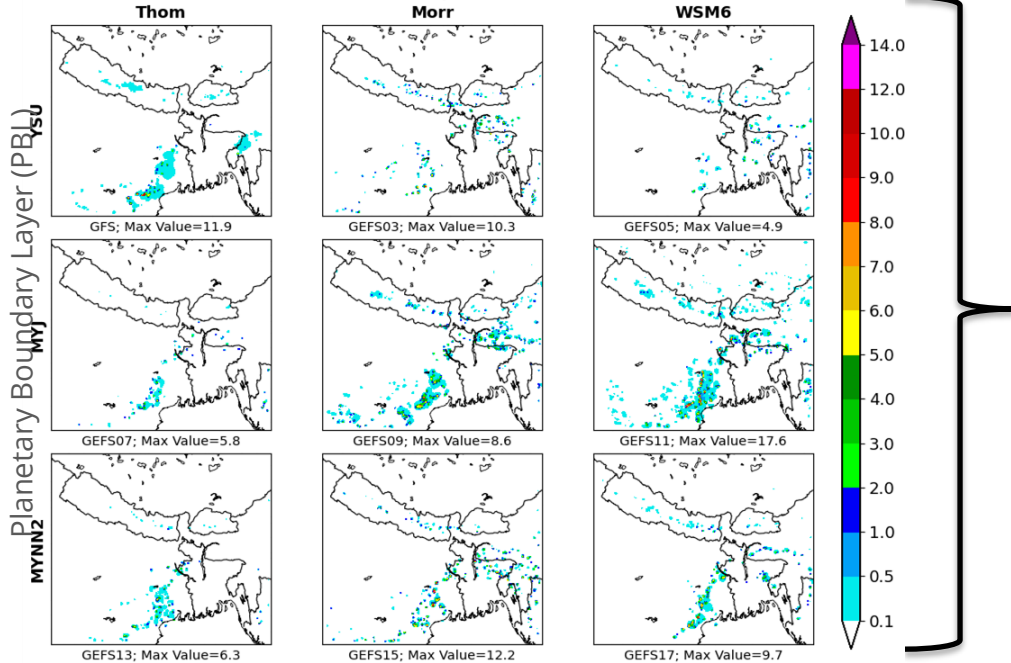
01-h forecast Ensemble Max
Interval Max 10m Wnd Spd (kt)
Init: 20190502 1800 UTC
Valid: 20190502 1900 UTC
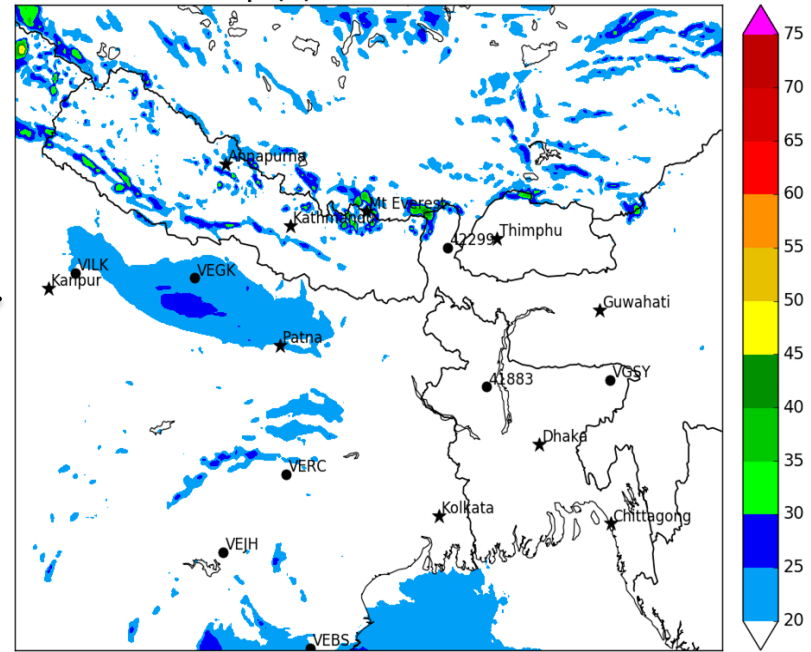
HIWAT SERVIR-HKH Application(s)

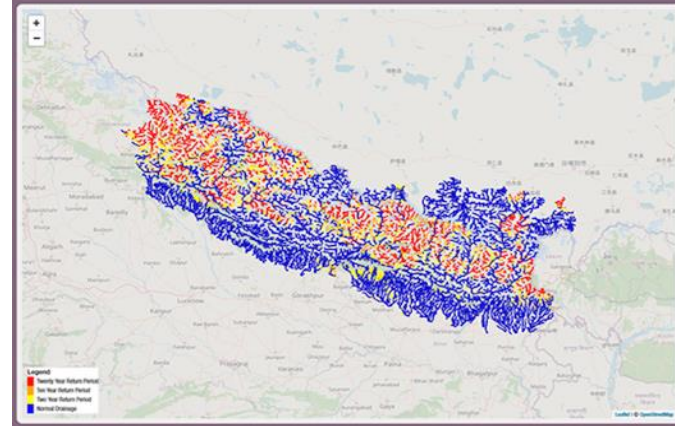SERVIR-HKH Has developed an array of end-user oriented **applications** leveraging HIWAT data products to address thematic areas including **Weather** and **Climate**, **Flooding** and **Disaster**.

https://tethys.servirglobal.net/apps/hiwat/
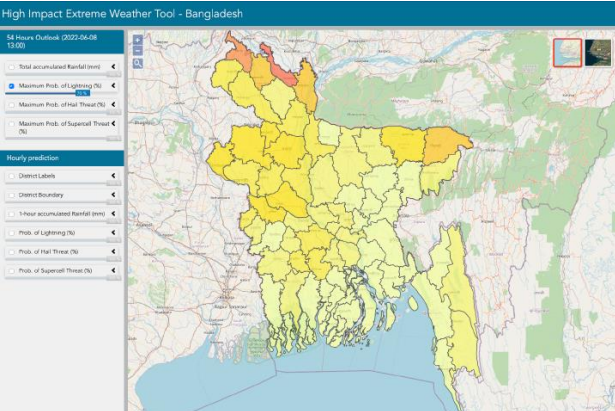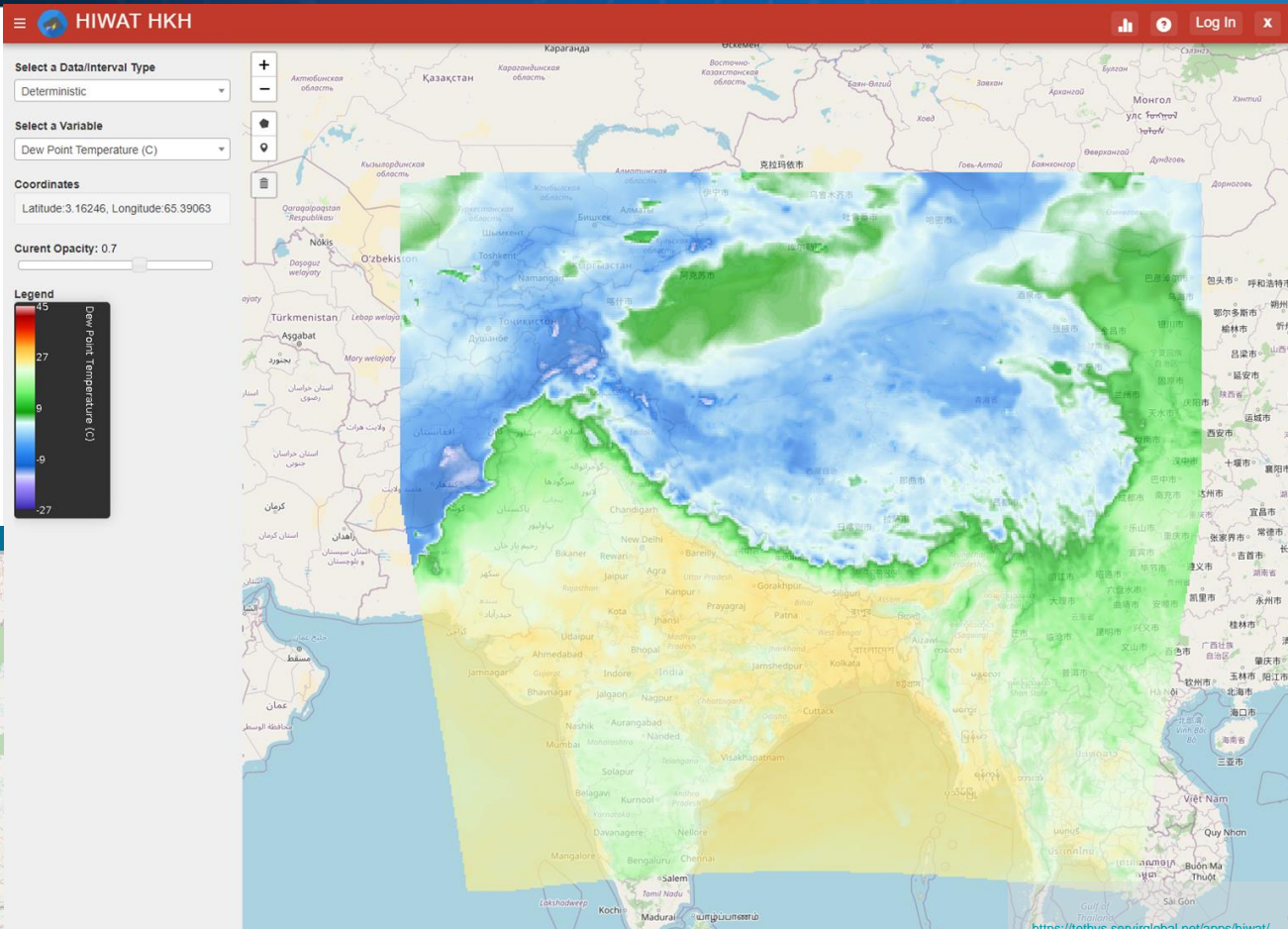
HIWAT In Action

Through Capacity Building efforts **HIWAT** Streamflow Prediction Tool is used avert damage and in Nepal

HIWAT Streamflow Prediction Tool - Nepal

Legend
Twenty Year Return Period
Ten Year Return Period
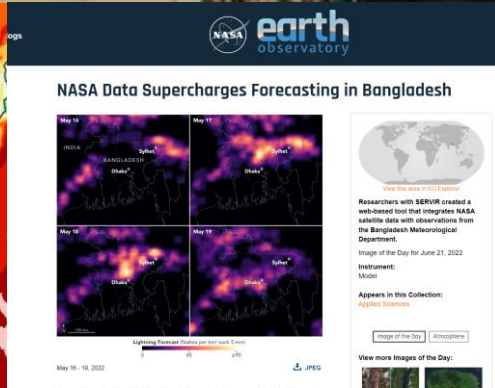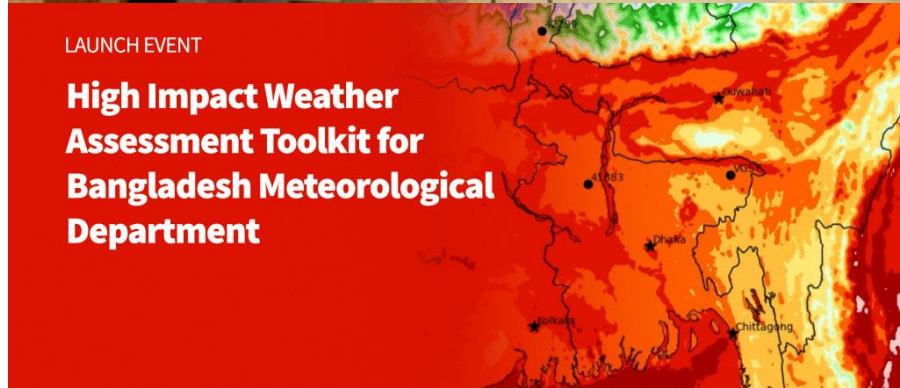Two Year Return Period
Normal Drainage

Build on Version 1

HIWAT has been established at the Bangladesh Meteorological Department (**BMD**). Providing a Bangladesh focused weather forecast

Bangladesh-Extreme-Weather-Alert (BEWA)

SERVIR

Bangladesh-Extreme-Weather-Alert

Automated email generation for alerts in key POCs, and/or extension officers to issue warnings

GitHub

forecast CSV

	A	B	C	D	E	F	G	H	I	J	K	L	
1	id	min	max	mean	median	sd	sum	count					
2	BD4001	0	9.04	0.29	0	1.15	73.93	252					
3	BD2003	0	0	0	0	0	0	308					
4	BD1004	0	0	0	0	0	0	95					
5	BD1006	0	6.71	0.63	0.01	1.35	93.32	148					
6	BD1009	0	0	0	0	0	0	134					
7	BD5010	0	21.69	9.53	9.8	7.53	1895.73	199					
8	BD2012	39.09	73.99	48.92	45.81	6.84	6457.71	132					
9	BD2013	0.98	65.76	30.56	27.64	19.32	3117.04	102					
10	BD2015	0	0	0	0	0	0	302					
11	BD4018	8.9	15.38	11.41	11.14	1.11	855.68	75					
12	BD2019	0	74.57	32.88	35.21	23.04	7002.49	213					
13	BD2022	0	0	0	0	0	0	144					
14	BD3026	31.88	81.59	57.91	58.34	16.16	5849.15	101					
15	BD5527	0.01	11.11	7.26	9.22	4.11	1763.57	243					

User defined thresholds and data products
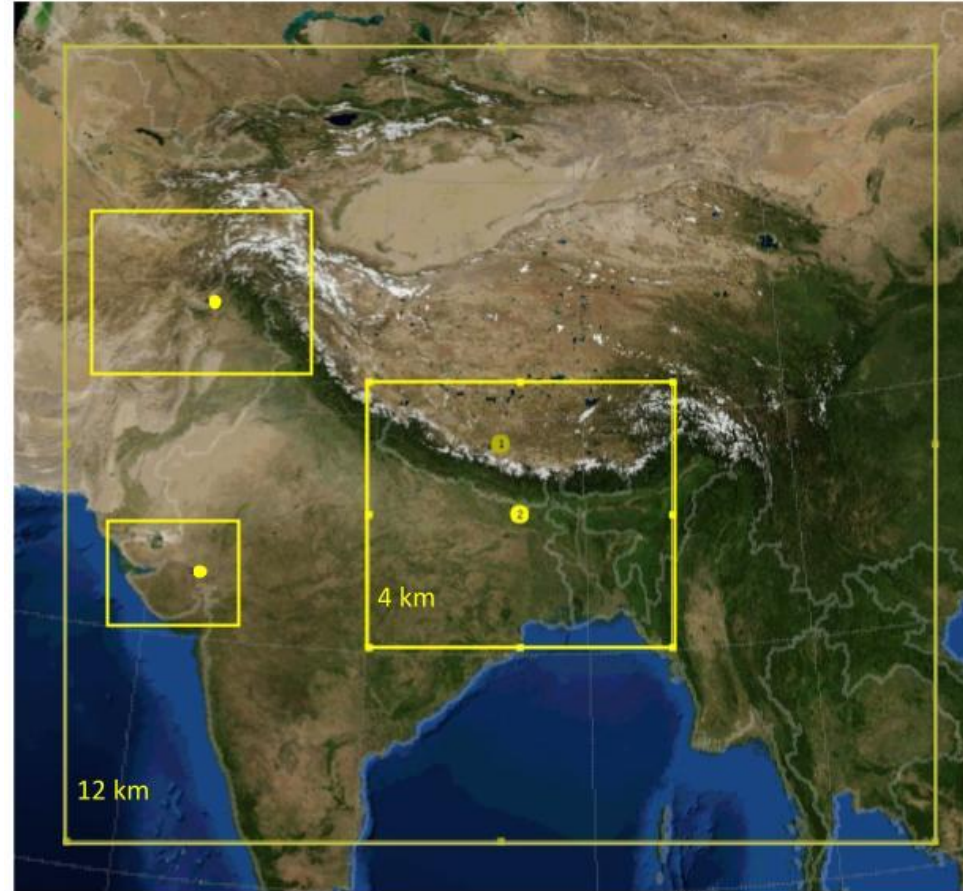
Sample forecast outputs

forecast map

DAY-1 PROB. > 0.07 +/- 20 KM: FHRS 07-30
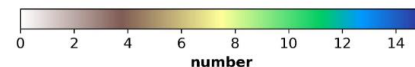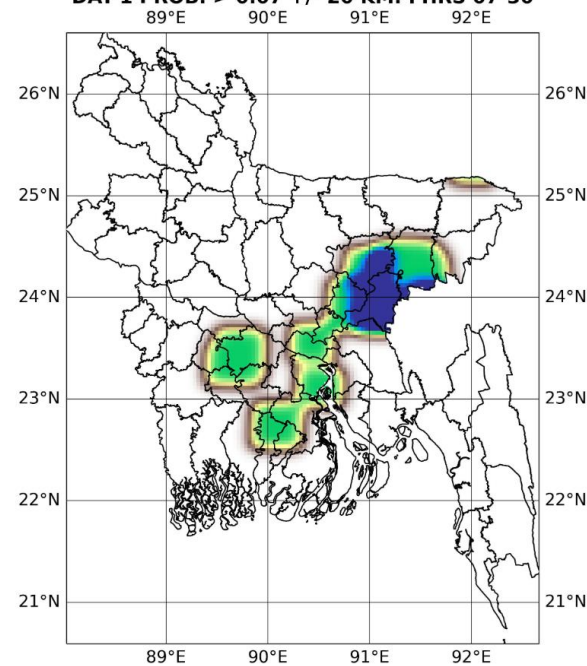
Same model scheme but now with:

- ICIMOD has a dedicated HPC
- Runs Faster
- More ROIs
- And a full year round run time
- [New Web Application](#)

Aligning with SERVIR's guiding strategic goals we aim to work with partner and end-users around the world to enable EO based services for **decision-makers**, build capacity, as well as coordination and collaboration on how to best integrate this EO technology.

SERVIR-HKH is collaborating with partners and end-users about ways to eventually leverage the **public HIWAT archive.**

SERVIR STRATEGIC PLAN 2020-2025

4 km

12 km

- Historical archive is crucial for establishing baseline and active research with Universities in the region
- Efforts such as capacity building trainings for extreme weather with Nepal Department Hydrology and Meteorology (DHM) and University using the data as part of course work and internships
- Integration of HIWAT Prescription to other NASA projects
  - 2022-2023 Collaboration with High Mountain Asia Team (HiMAT) on using HIWAT precip. For landslide modeling

Research

Capacity Building

Implementation

- Rainfall
- Frequent Lightning
- Relative Humidity
- Composite Radar Reflectivity
- Straight-line damaging winds
- Hail
- Max Updraft Helicity
- Relative Humidity
- Temperature
- WRF outfiles
- Native WRF Model
- Post-processed and derived Fields

Data sets	Output Products	Units	Threshold	Fill Value
Day 1 & Day 2	sumprob-precip3h	3 hour accumulated precipitation (mm)	25	9.9990003e+20
		3 hour accumulated precipitation (mm)	50	9.9990003e+20
		3 hour accumulated precipitation (mm)	75	9.9990003e+20
		3 hour accumulated precipitation (mm)	100	9.9990003e+20
	sumprob-lfa	$(Flash/km^2/5min)$	.07	9.9990003e+20
		$(Flash/km^2/5min)$	5	9.9990003e+20
	sumprob-refc	Composite Radar Reflectivity (dBZ)	40	9.9990003e+20
		Composite Radar Reflectivity (dBZ)	50	9.9990003e+20
	sumprob-spd10m	Interval Max 10m Wind Speed (kt)	30	9.9990003e+20
		Interval Max 10m Wind Speed (kt)	40	9.9990003e+20
		Interval Max 10m Wind Speed (kt)	50	9.9990003e+20
	sumprob-tcolg	Max Integ. Graupel (kg/m^2)	30	9.9990003e+20
		Max Integ. Graupel (kg/m^2)	40	9.9990003e+20
	sumprob-uphlcy25	Interval Max 2-5km Updraft Helicity (m^2/s)	50	9.9990003e+20
		Interval Max 2-5km Updraft Helicity (m^2/s)	100	9.9990003e+20
		Interval Max 2-5km Updraft Helicity (m^2/s)	200	9.9990003e+20
Hourly Ensemble	enspmm-prec1h	1-hour Accumulated Precipitation (PMM)	-	9.9990003e+20
	enspmm-prectot	Total Precipitation (PMM)	-	9.9990003e+20
	enspmm-refc	Composite Reflectivity (PMM)	-	9.9990003e+20
	ensprob-lfa	Hourly Probability Total Lightning (Flash/km^2/$5min$)	.07	9.9990003e+20
		Hourly Probability Total Lightning (Flash/km^2/$5min$)	5	9.9990003e+20
	ensprob-refc	Hourly Probability Composite Radar Reflectivity (dBZ)	40	9.9990003e+20
		Hourly Probability Composite Radar Reflectivity (dBZ)	50	9.9990003e+20
	ensprob-spd10m	Hourly Probability Max 10m Wind Speed (kt)	30	9.9990003e+20
		Hourly Probability Max 10m Wind Speed (kt)	40	9.9990003e+20
		Hourly Probability Max 10m Wind Speed (kt)	50	9.9990003e+20
	ensprob-tcolg	Hourly Probability Max Column Graupel (kg/m^2)	30	9.9990003e+20
		Hourly Probability Max Column Graupel (kg/m^2)	40	9.9990003e+20
	ensprob-uphlcy25	Hourly Probability Max Updraft Helicity (m^2/s)	50	9.9990003e+20
		Hourly Probability Max Updraft Helicity (m^2/s)	100	9.9990003e+20
		Hourly Probability Max Updraft Helicity (m^2/s)	200	9.9990003e+20
Fire Ensemble	enspmm-prec24h	24-hour Accumulated Precipitation (PPM)	-	9.9990003e+20
	ensmean-spd10m	Ensemble Mean 10m Wind Speed (kt)	-	9.9990003e+20
	ensmean-rh2m	Ensemble Mean Relative Humidity (%)	-	9.9990003e+20
	ensmean-tmp2m	Ensemble Mean Temperature (deg C)	-	9.9990003e+20
-	Longitude	-135.33123 to -31.543510000000012 degrees East	-	-
	Latitude	26.92475 to 42.90255 degrees North	-	-
	Time	seconds since 1970-1-1 00:00:00	-	-

Archive

Name	Last modified	Size
Parent Directory		-
ghrc_hiwat_2018.txt	2023-03-08 13:41	23M
ghrc_hiwat_2019.txt	2023-03-08 13:41	21M
ghrc_hiwat_current_2020.txt	2023-03-14 10:56	22M
ghrc_hiwat_current_2021.txt	2023-03-08 13:44	11M
ghrc_hiwat_current_2022.txt	2023-03-14 11:00	11M
ghrc_hiwat_snowball_2020.txt	2023-04-13 12:27	343K
ghrc_hiwat_snowball_2021.txt	2023-04-13 12:27	246K
ghrc_hiwat_snowball_2022.txt	2023-04-13 12:27	260K
ghrc_hiwat_snowball_verif_apcp+lfa_2018-19.txt	2023-04-13 12:27	1.9K

AWS Snowballs
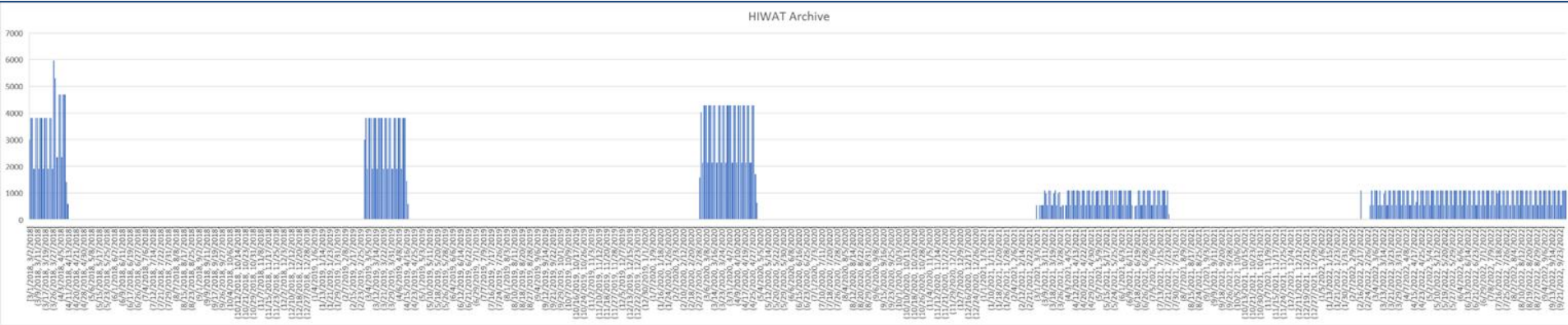
HIWAT Archive

Power & Depth of the SERVIR Network

2020 SERVIR ANNUAL GLOBAL EXCHANGE
Siem Reap, Cambodia

Rainfall

The HIWAT archive provides a variety of rainfall products, including Day 1 and Day 2 forecasts as well as Hourly and Gird ensemble products. The Day 1 and Day 2 forecasts provide the 3-hour accumulated precipitation (mm) at four distinct greater than thresholds at 25, 50, 75,and 100. The Hourly ensemble products provide a 1-hour accumulated precipitation and total precipitation as a PMM from the available model schemes. Lastly the Fire ensemble product is provided as full day (24 hour) accumulated precipitation using the same PMM approach for the available model schemes.

Frequent Lightning

The HIWAT archive produces the lightning products utilizing the Lightning Forecast Algorithm (LFA) which represents both in-cloud and cloud-to-ground lightning activity. The algorithm produces a measure of total flashes per square kilometer per 5 minutes (flashes/km2/5 min) [20, 19]. The lightning products is also available as a Day 1 and Day 2 forecast as well as and hourly ensemble. The following thresholds are applied at 0.07 and 5.0. Where the 0.07 threshold corresponds to the occurrence of any lightning activity (approximately a flash per hour) and the 5.0 threshold corresponds to more frequent lightning flash rates (approximately one or more flashes per minute).

Relative Humidity

Available through the Fire Ensemble product the HIWAT archive also provides an ensemble mean of percent relative humidity for the available model schemes.

Temperature

Lastly as also available through the Fire ensemble data set the HIWAT archive provides an ensemble mean temperature in Celsius. See table 3.1.8 for greater detail on all data sets and products.

Composite Radar Reflectivity

Similar to Lightning and Rainfall the Composite Radar Reflectivity product is available as a Day 1 and Day 2 forecasts as well as Hourly ensemble with the latter providing an hourly probability. Each of these data sets use are thresholded at greater than 40 and 50.

SERVIR

Straight-line damaging winds

Straight-line winds are available as part of the Day 1, Day 2 forecasts as well as the Hourly ensemble and finally the Hire ensemble products. The Day 1 and Day 2 forecasts offer a measure of max knots (kt) wind speed at three greater than thresholds 30, 40, and 50. While the Hourly ensemble provides hourly probability at those same thresholds for 140 available model schemes. Finally Straight-line winds is also available as a Fire ensemble product which is offered as an ensemble mean.

Max Updraft Helicity

The HIWAT archive also provided max updraft helicity, which measures the amount of rotation in a storm cell and the unit is (m2/s). The product is available as both a Day 1 and Day 2 forecast and as an hourly ensemble. The forecast provided the max updraft helicity within a 2-5 km range, and the Hourly ensemble provides that same measure but as an hour probability for the available model schemes. This product utilizes three greater than thresholds at 50, 100, and 200.

WRF outfiles

### Post-processed and derived Fields in GRIB2

Native WRF Model

Hail

The hail forecast products is produced by calculating the total column vertically integrated graupel, an indicator for severe hail threat as shown in published literature [17]. The hail unit are in (kg/m2) or mass of hail per area. These hail products are available as both Day 1 and Day 2 forecasts as well as Hourly ensemble products with the hourly probability provided. Again two greater than thresholds at 30 and 40 are used.

HIWAT In Action

Rainfall Forecast from HIWAT on 25 July, 2018
24-hour Rainfall Accumulation ending 26 July, 2018 1800 UTC

>250-300 mm
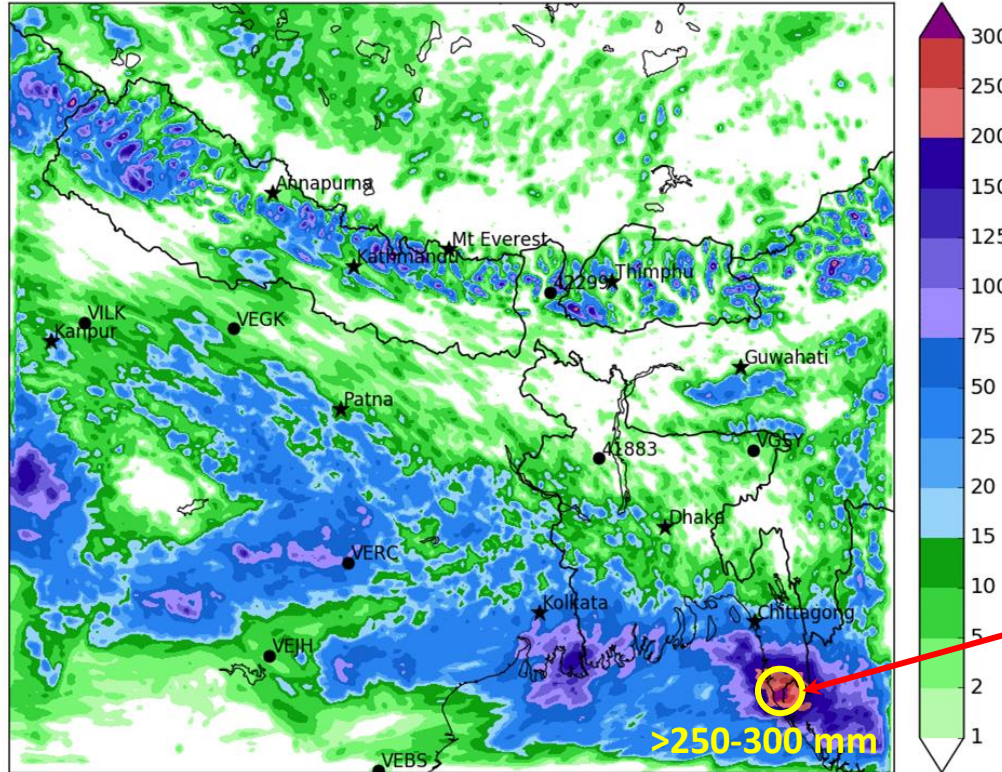
Within a 24-hr period a reported rainfall of 463 mm. This was captured by the

HIWAT system

Capacity & Services: Gender Integration and Action

SERVIR

41% of people trained in 2019 identify as female

SERVIR-Mekong Vietnam Gender Inequality Index (GEII) **serves gender differentiated data**, giving insight into service design and delivery.

SERVIR-HKH has an ongoing country level training series

Empowering women in geospatial information technology – Pakistan

servir.icimod.org

USAID NASA ICIMOD SERVIR@HKH

- Building women leaders and gender champions in SERVIR

- Empowering women and girls to explore STEM fields

- Integrating gender considerations in service planning

- Using remote sensing and GIS to address development issues that are inclusive of underrepresented groups

Services: SERVIR services meet needs in Asia

SERVIR

Hindu-Kush Himalaya

- Crop area estimation
- Regional drought monitoring and outlook system
- Regional land cover monitoring system
- Forest monitoring, and biomass estimation
- Early warning information on floods and other high-impact weather events

South East Asia

- Enhancing drought resilience and crop yield security
- Supporting improved riparian and flash flood forecasting
- Improving regional land cover monitoring
- Supporting transboundary water resource planning and management
- Supporting management of the agriculture, forestry, and other land use through air quality monitoring
- Developing a protected area alerts system for Cambodia
- Data monitoring and evaluation dashboard for landscape improvement in Cambodia

Kathmandu, Nepal
ICIMOD HQ

Bangkok, Thailand
ADPC HQ