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CGIAR

SADMS
Drought Prediction

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Innovative water solutions for sustainable development

Food · Climate · Growth

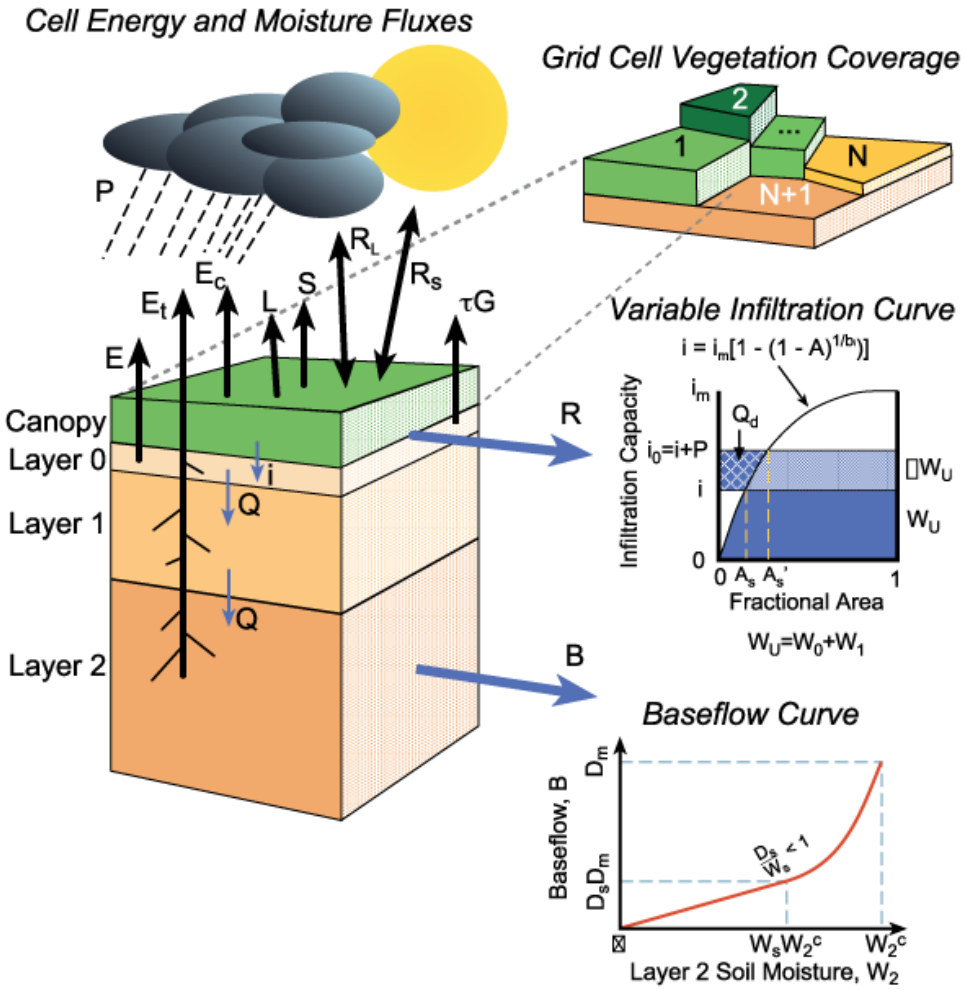
Drought Prediction

- Drought prediction is of critical importance to early warning for drought managements.
- Indices calculated based on long-term hydrometeorological simulations, short-term weather forecast products, and hydrologic modelling for forecast.
- Present capability of drought prediction is for 10 days of forecast based on short-term weather forecast products and hydrologic model simulation.
- Provides drought prediction in terms of meteorological forecast from the forecast product, and hydrological forecast, and top-layer soil moisture forecast simulated by VIC global hydrological model.
- Challenges still exist in drought prediction at long lead time and under a changing environment resulting from natural and anthropogenic factors.
- Future research to improve drought prediction, high-quality data assimilation, improved model development with key processes related to drought occurrence, optimal ensemble forecast to select or weight ensembles, and hybrid drought prediction to merge statistical and dynamical forecasts.

VIC Model

Liang et al. (1994)
https://doi.org/10.1029/94JD00483

- Grid based hydrological model
- Available with two schemes for flux, i.e. (water budgeting) & (water + energy budgeting)
- Fluxes and storages are averaged together (using area fraction) to give grid-cell average.
- Vegetated and non-vegetated area fractions are controlled by vegetated area fraction



VIC model used by other institutions

Bhuvan, ISRO [Near real time hydrological monitoring]:

https://bhuvan-app3.nrsc.gov.in/hydrological_fluxes/

GLDAS & NLDAS, NASA [Terrestrial water flux monitoring]:

https://disc.gsfc.nasa.gov/datasets/GLDAS_VIC10_M_2.1/summary?keywords=GLDAS%20VIC

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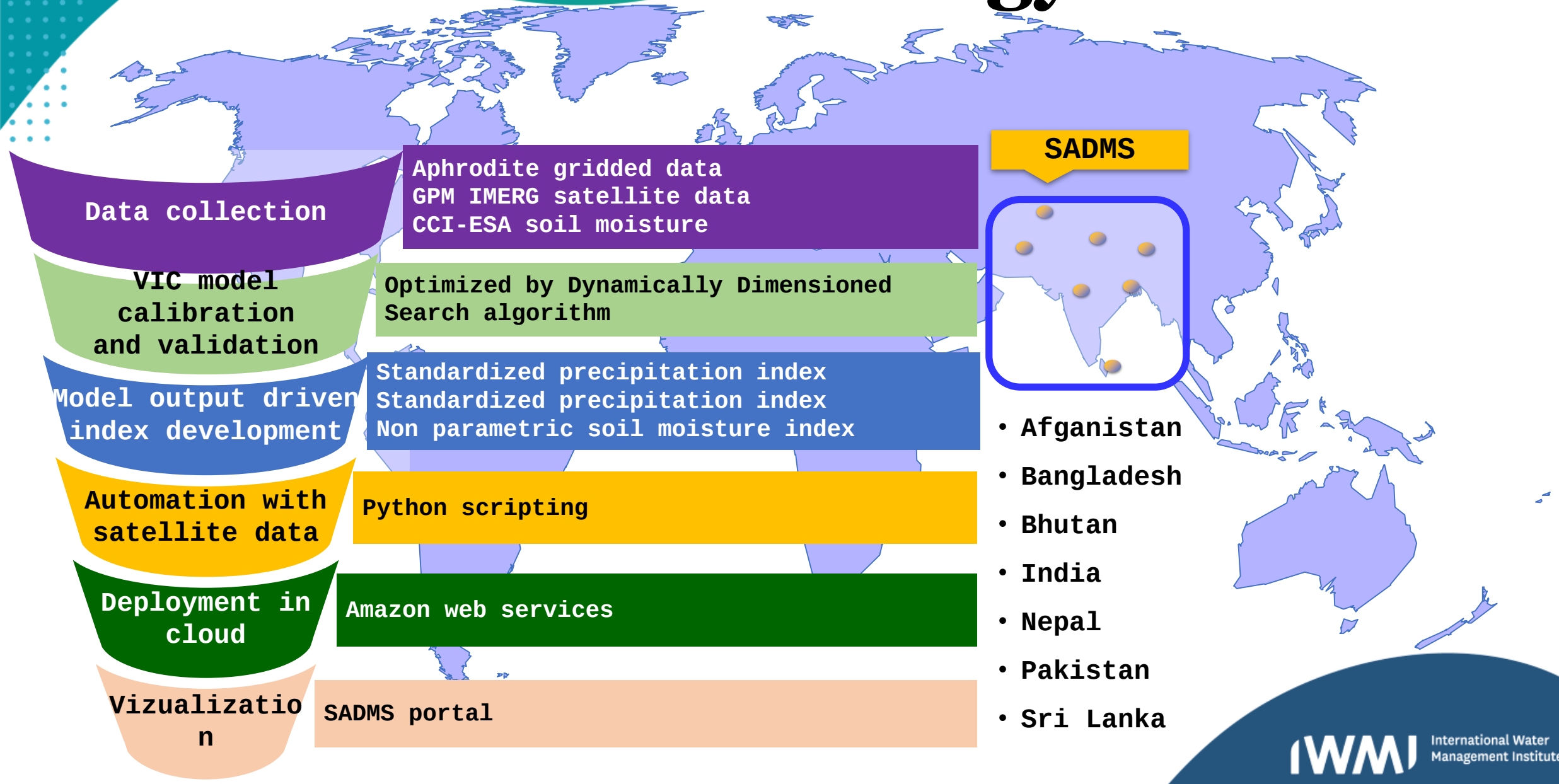
Methodology



Data collection
Aphrodite gridded data
GPM IMERG satellite data
CCI-ESA soil moisture

VIC model calibration and validation
Optimized by Dynamically Dimensioned Search algorithm

Model output driven index development
Standardized precipitation index
Standardized precipitation index
Non parametric soil moisture index

Automation with satellite data
Python scripting

Deployment in cloud
Amazon web services

Vizualization
SADMS portal

SADMS

- Afganistan
- Bangladesh
- Bhutan
- India
- Nepal
- Pakistan
- Sri Lanka

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Calibration and Validation

Calibration (2001 – 2010):

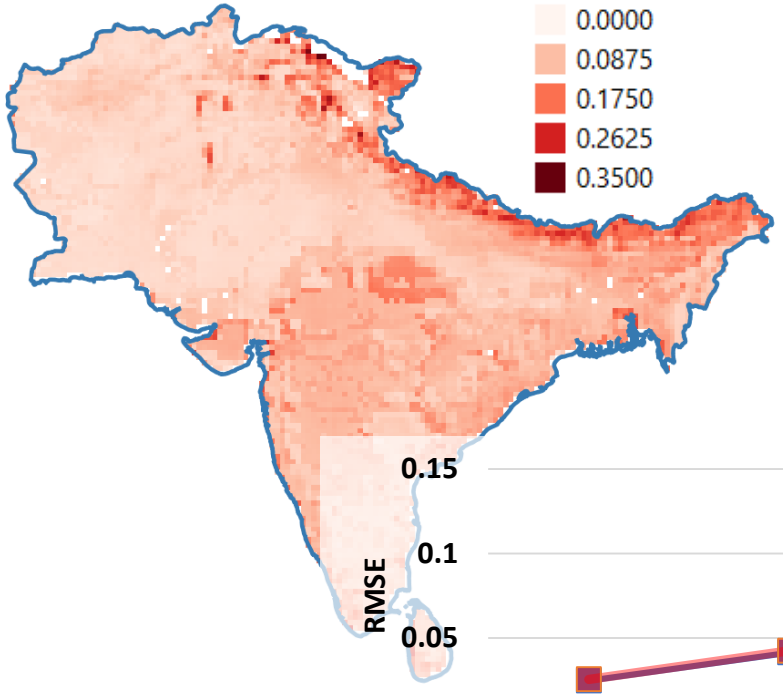
Aphrodite gridded rainfall

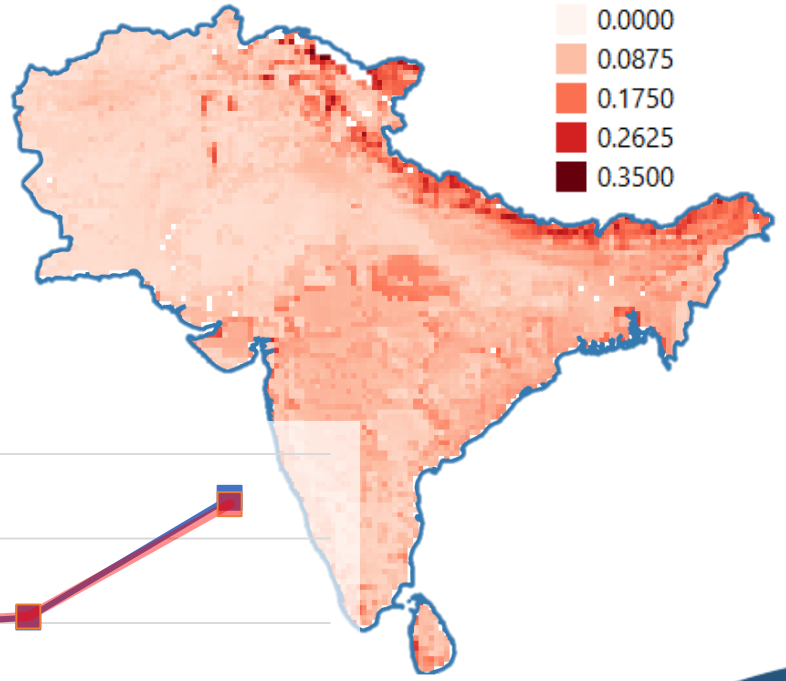
CCI-ESA top layer soil moisture

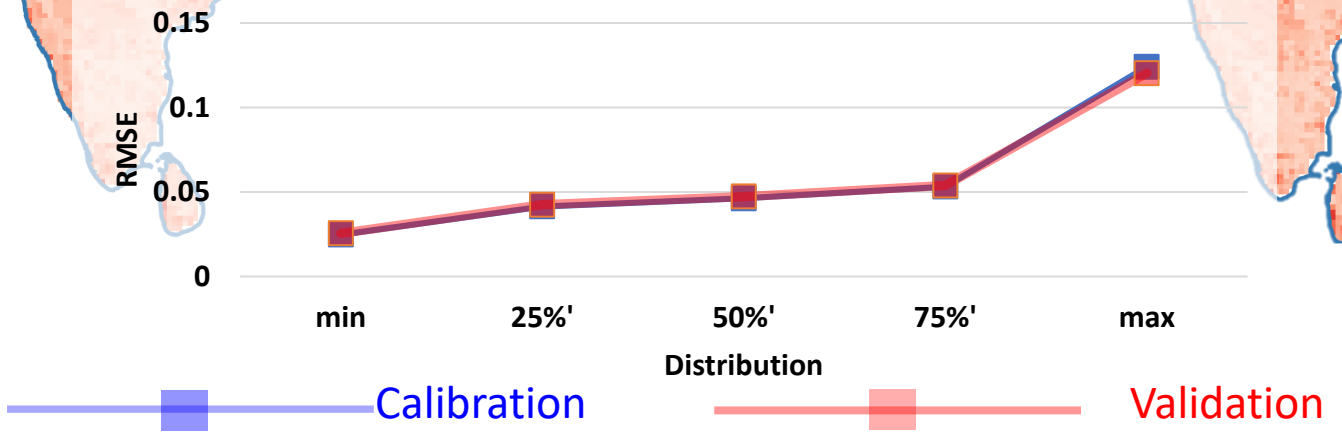
Validation (2011 - 2019):

GPM satellite rainfall

CCI-ESA top layer soil moisture







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VIC model outputs-based index

Standardized Precipitation Index (SPI) McKee et al. (1993)

A widely used index to characterize meteorological drought on a range of timescales.
https://www.droughtmanagement.info/literature/AMS_Relationship_Drought_Frequency_Duration_Time_Scales_1993.pdf

Standardized Runoff Index (SRI) Shukla and Wood (2008)

A commonly used hydrological drought monitoring index.
https://doi.org/10.1029/2007GL032487

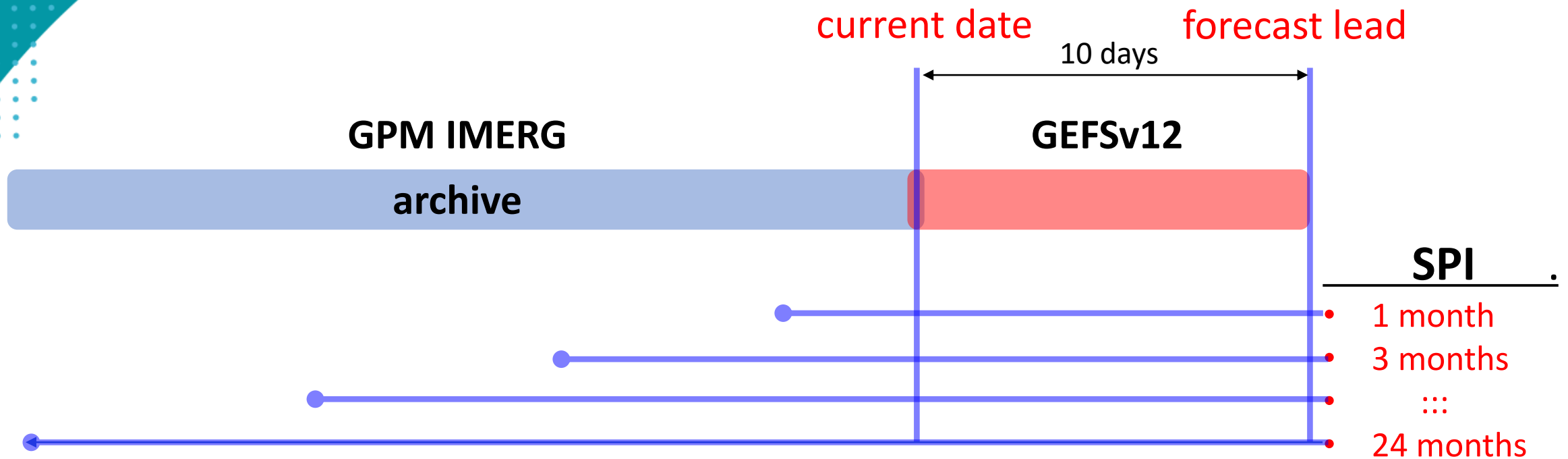
Non-parametric Soil Moisture Index (NPSMI) Shiau (2006)

Indicates joint return period by fitting drought duration and severity with Two-

SPI/SRI	Condition
2.00 and above	Extremely wet
1.50 to 1.99	Very wet
1.00 to 1.49	Moderately wet
-0.99 to 0.99	Near normal
-1.00 to -1.49	Moderately dry
-1.50 to -1.99	Severely dry
-2.00 and less	Extremely dry

NPSMI	Condition
0.5 and below	No drought
0.5 to 0.6	Mild drought
0.6 to 0.7	Moderate drought
0.7 to 0.8	Severe drought
0.8 to 0.9	Extreme drought
0.9 to 1.0	Exceptional drought

SPI and SRI



SPI

- 1 month
- 3 months
- :::
- 24 months

VIC model

SRI

- 1 month
- 3 months
- :::
- 24 months

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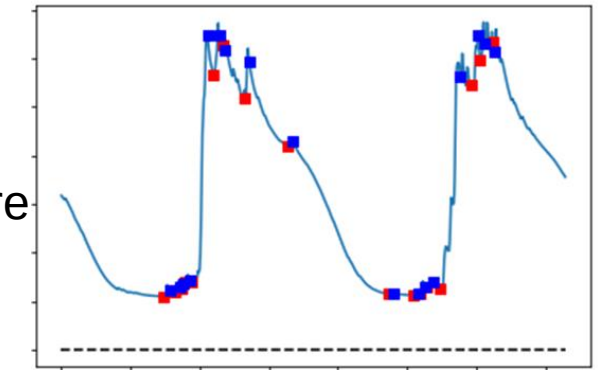
NPSMI

1

Soil moisture Time-series



2

Depreciation days time-series = *F*(soil moisture time-series)

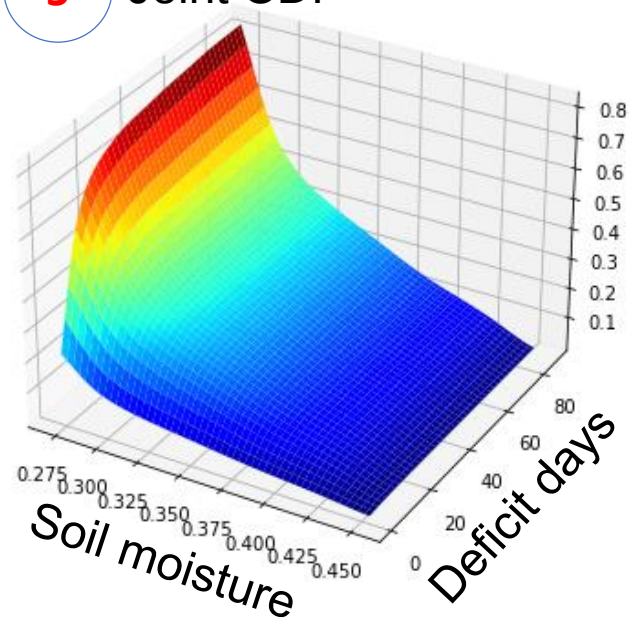
3

non-parametric PDF, CDF of soil moisture to scale severity

4

non-parametric PDF, CDF of deficit days to scale duration

5 Joint CDF



NPSMI

0.0 0.5 1.0

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Past drought events in Sri Lanka

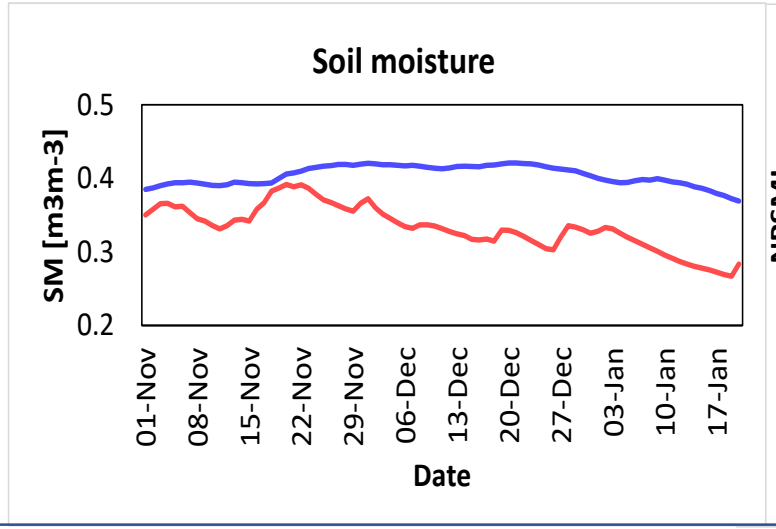
Global Drought Observatory (Reports from 2000 - 2018)

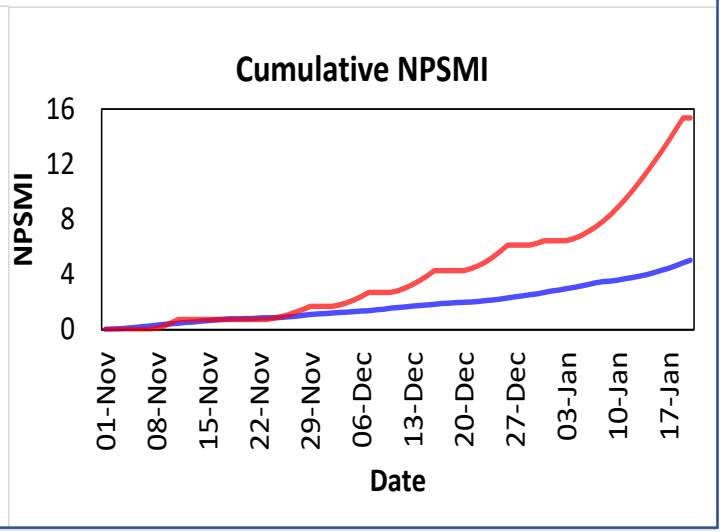
From	To	Country	State	Reason
01.Nov.16	20.Jan.17	Sri Lanka	NA	Rainfall deficit

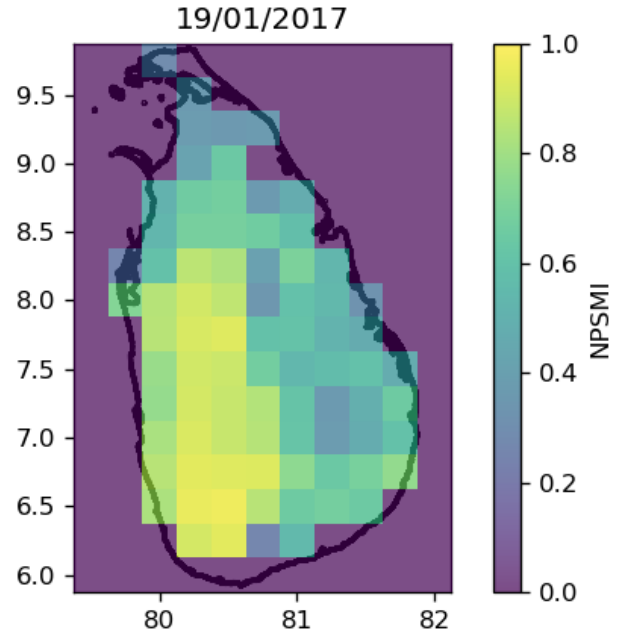
Sri Lanka [01.Nov.16 to 20.Jan.17]

Historical mean by VIC

Simulated by VIC







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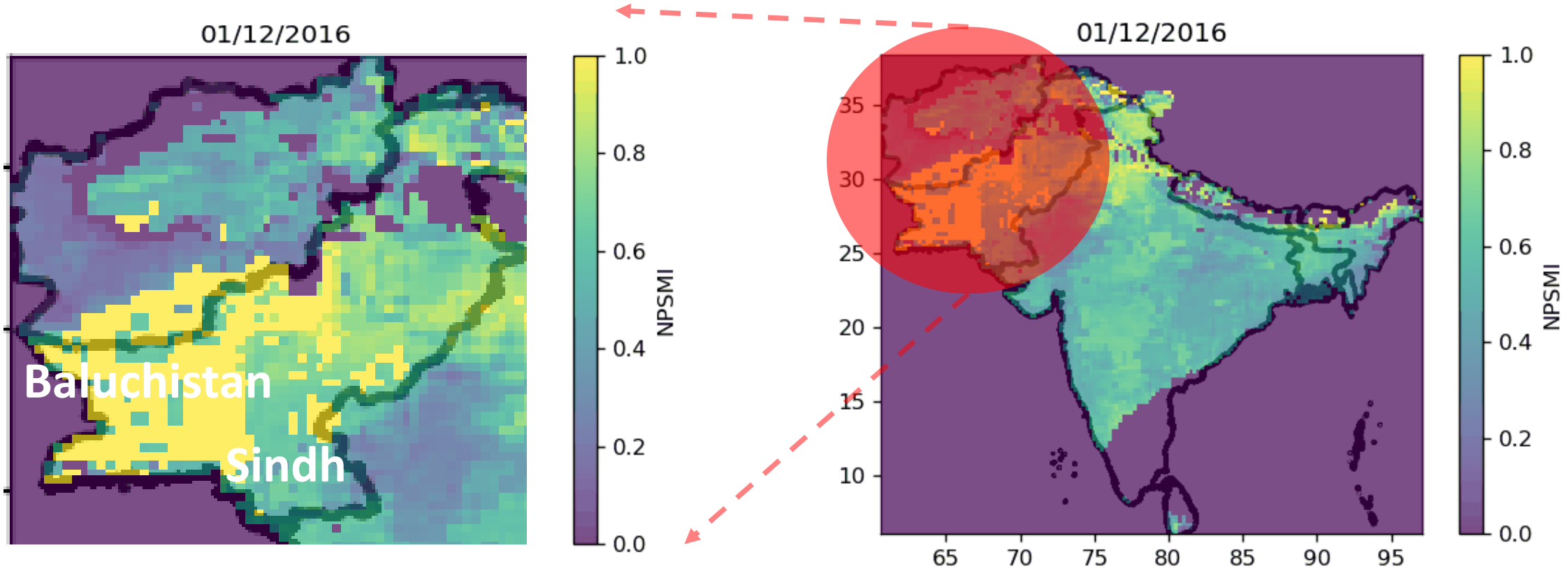
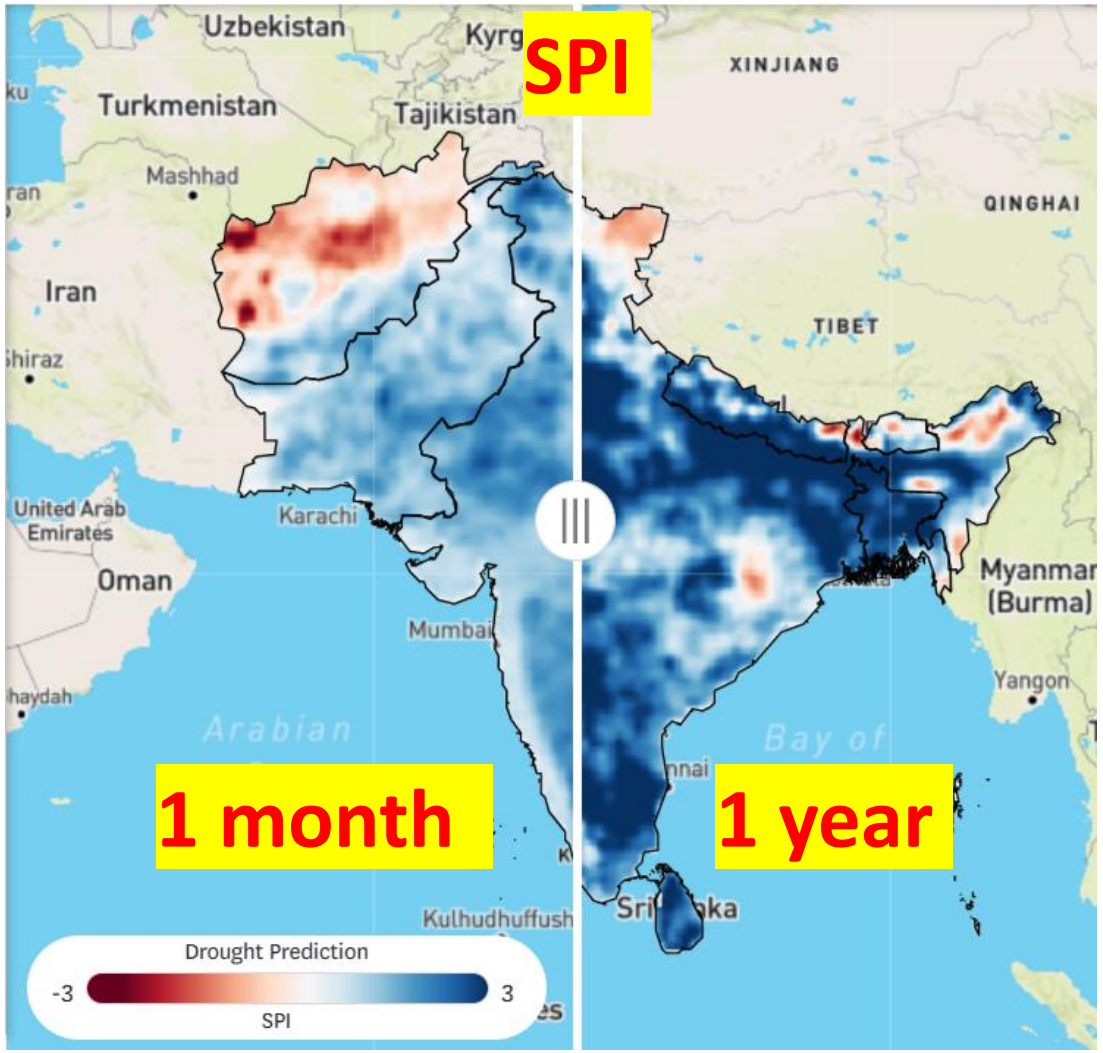
Past drought events in Pakistan

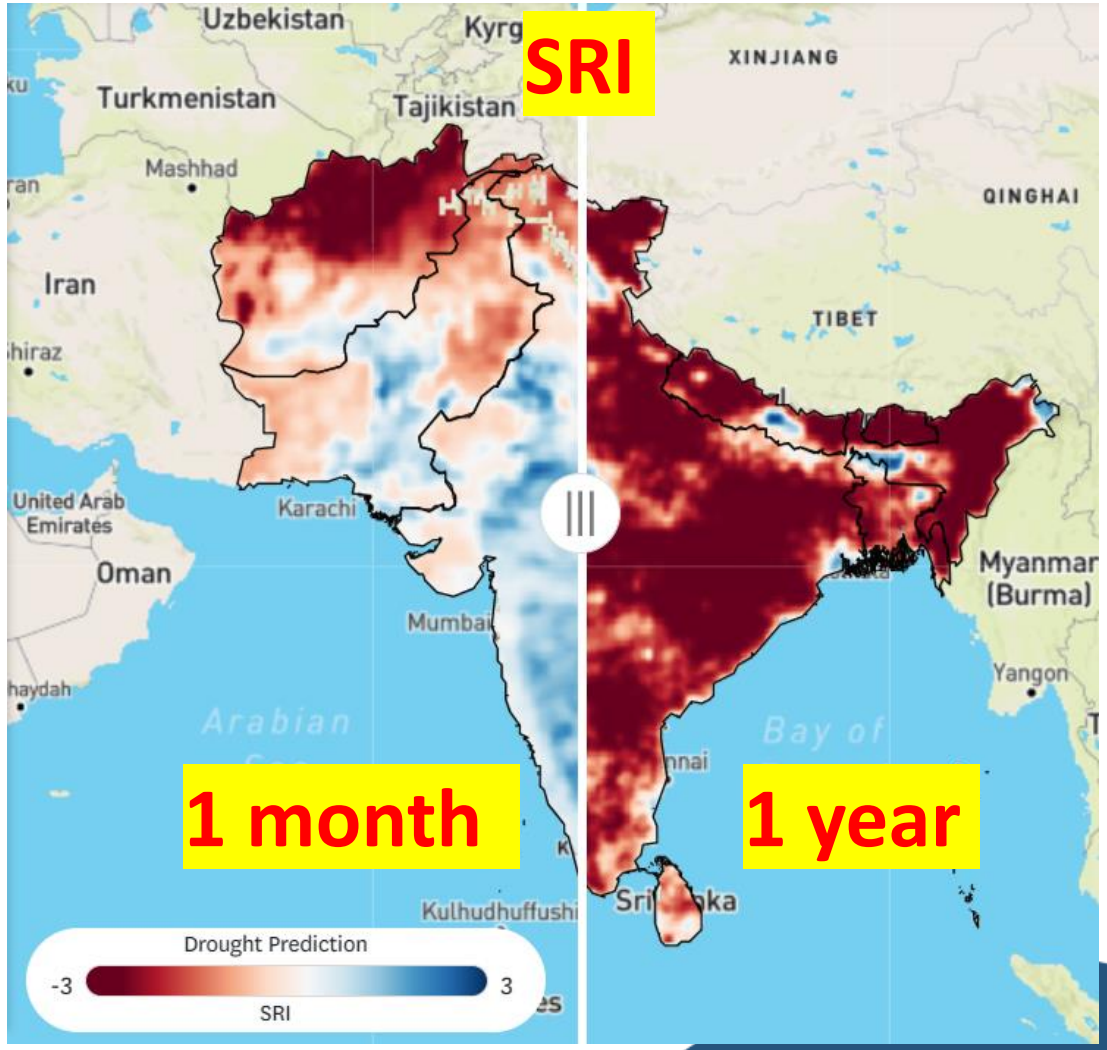
- **Global Drought Observatory (Reports from 2000 - 2018)**

From	To	Country	State	Reason
01.Nov.17	31.Oct.18	Pakistan	Sindh, Baluchistan	Severe Rainfall deficit



SPI and SRI (1 month – 2 years)





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Automation and deployment to cloud

Automation

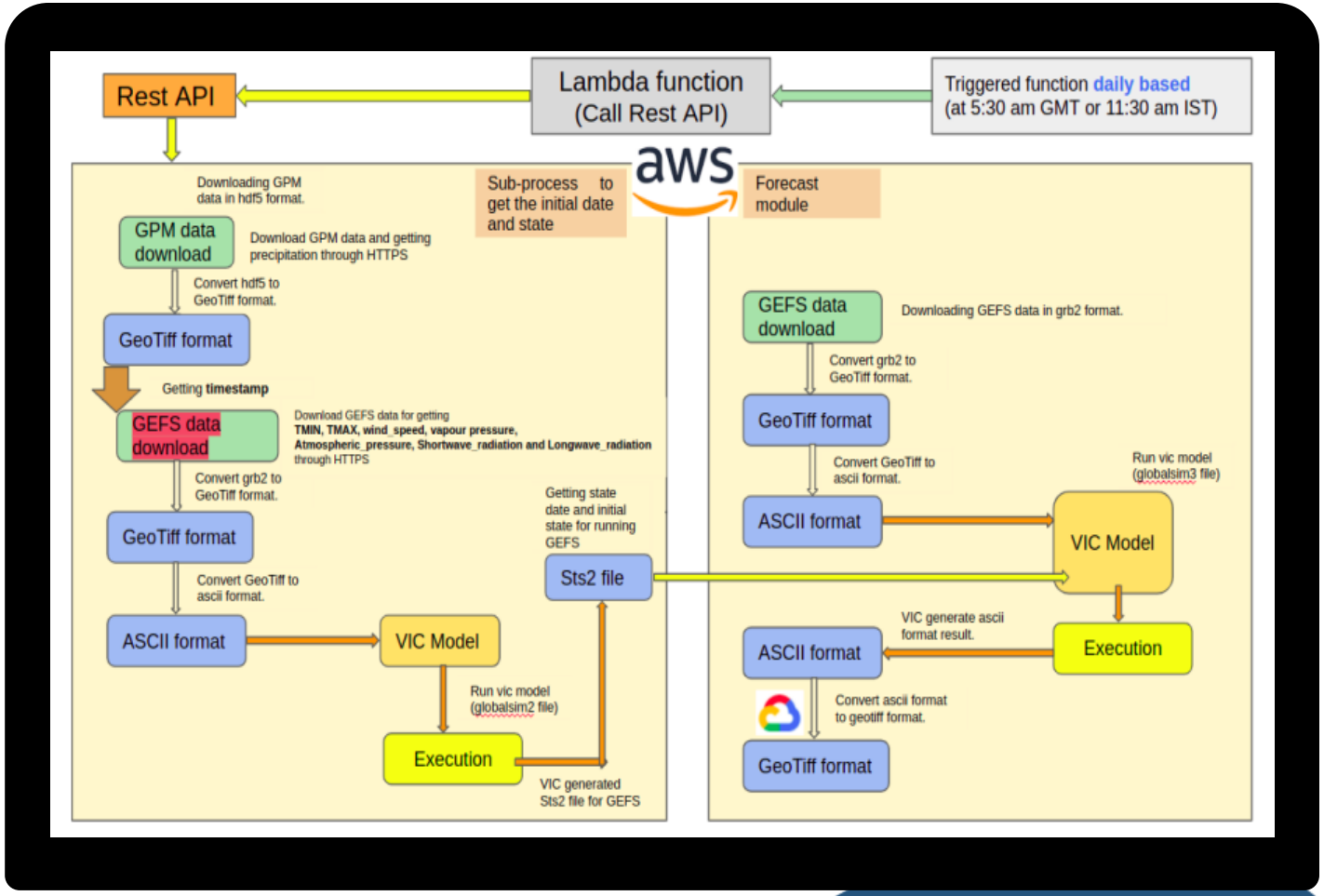
NASA GPM IMERG v6 early run rainfall

[1 day latency]

+

NOAA GEFSv12 sub-daily forecast

[10 days lead]



Cloud deployment

- Downloads GPM
- Runs VIC to update real-time conditions
- Downloads GEFS
- Runs VIC with forecast data
- Generates forecasted drought index

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THANK YOU

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