Training in the Demonstration Version of the Syr Darya Flood and Drought Monitor (SYR-FDM)

Lecture: Overview of the system and its use

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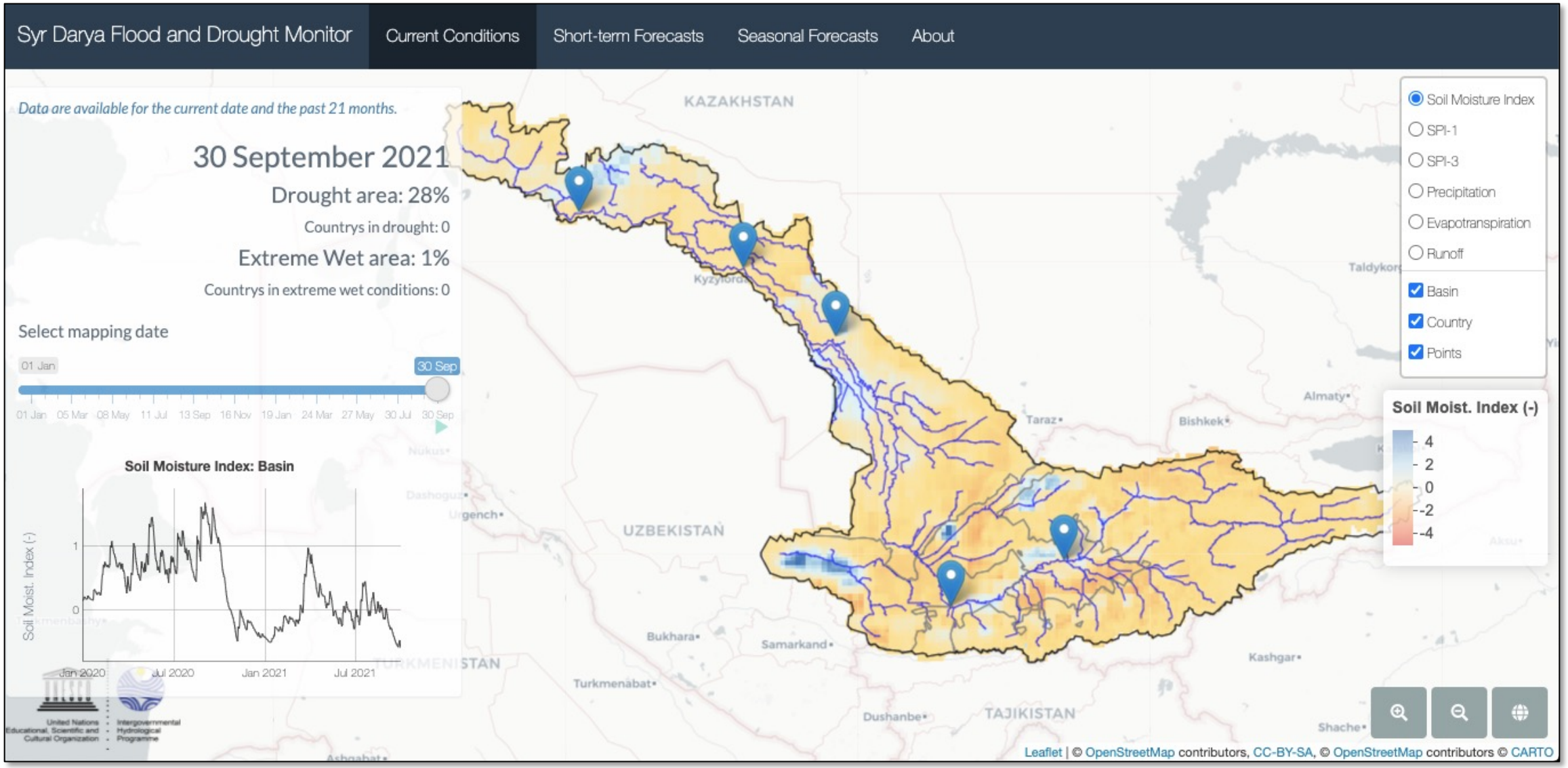
Overview of the Lecture

1. Overview of the web interface
2. How to access
3. Some caveats and potential bugs
4. Contributing data and methods
5. Drought and flood definitions and indices
6. Data Products
7. Example applications
8. Any questions?

A quick tour (15 minutes)

Practical Exercise

Overview of the Web Interface



How to Access the Interface

The interface is hosted at

http://stream.princeton.edu/test/

- There is no registration or login required – the system is open access
- The interface is written in the R language and uses the R-Shiny interface builder.

Some caveats and potential bugs

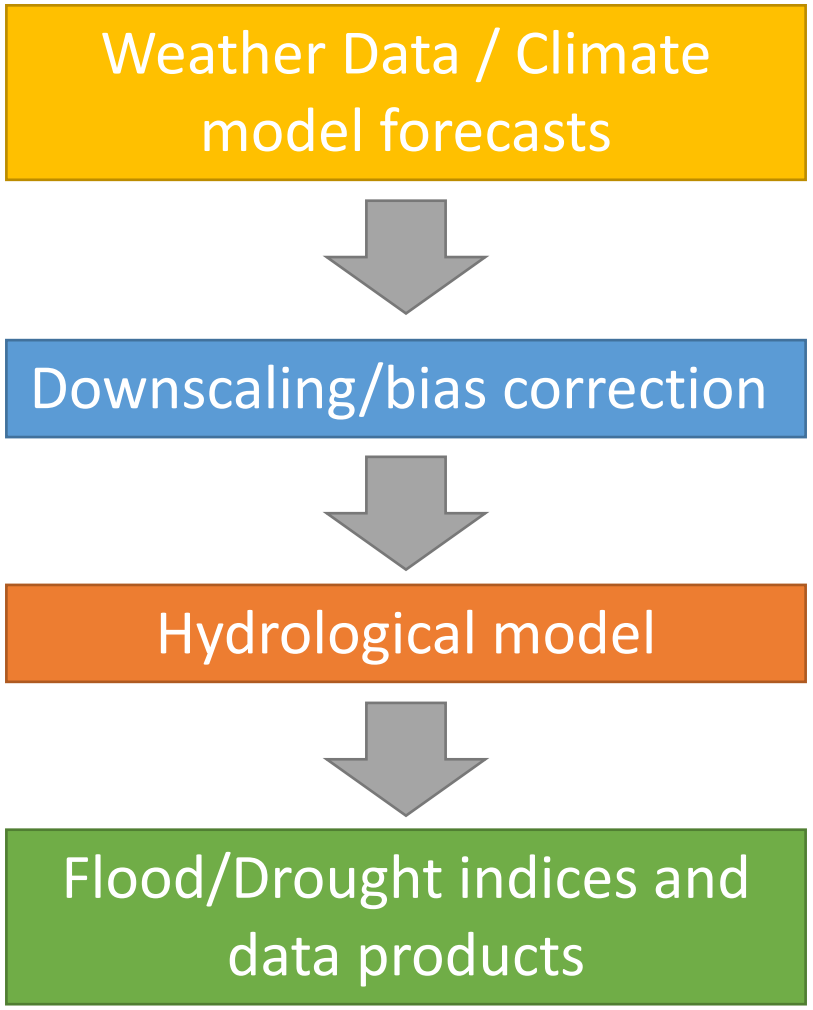
Caveat – this is a demonstration version of a pilot system and web interface.

NOTE

- The system takes a a few seconds to initialize and render the maps and charts, but once loaded will be very responsive
- There may be bugs and some things that don’t work yet.
- We value your feedback!

General Approach to Hydrological Monitoring and Forecasting

Typical modeling chain



The SYR-FDM Monitoring and Forecasting Approach

Real-time monitoring - updated every day

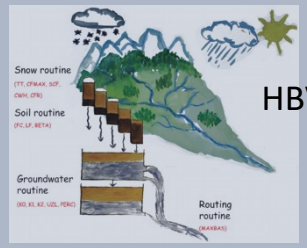
Real-time climate data

MSWEP

MSMet

+

Hydrological model



HBV

Hydrologic (initial) conditions

- Soil moisture
- Groundwater
- Streamflow
- …

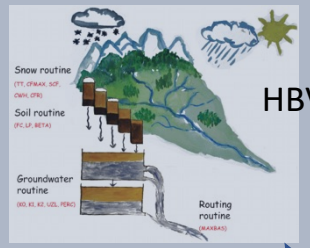
Short-term forecasts - updated every day

Short-term weather forecasts

GFS Global Forecast System

+

Hydrological model



HBV

Forecasts out to 7 days:

- Precip., Evap, Runoff,
- Streamflow + index
- Soil moisture + index
- SPI
- …

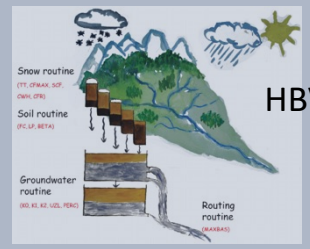
Seasonal forecasts - updated every month

Seasonal climate forecasts

Climate Change Service

+

Hydrological model

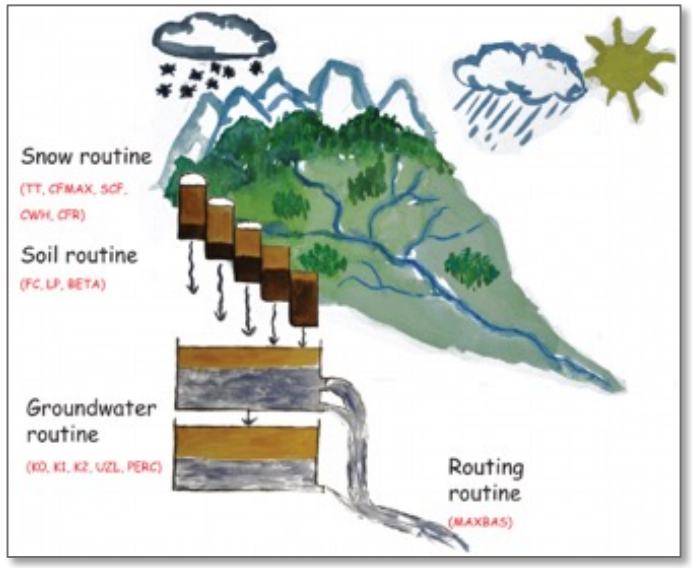


HBV

Forecasts out to 7 days or 6 months:

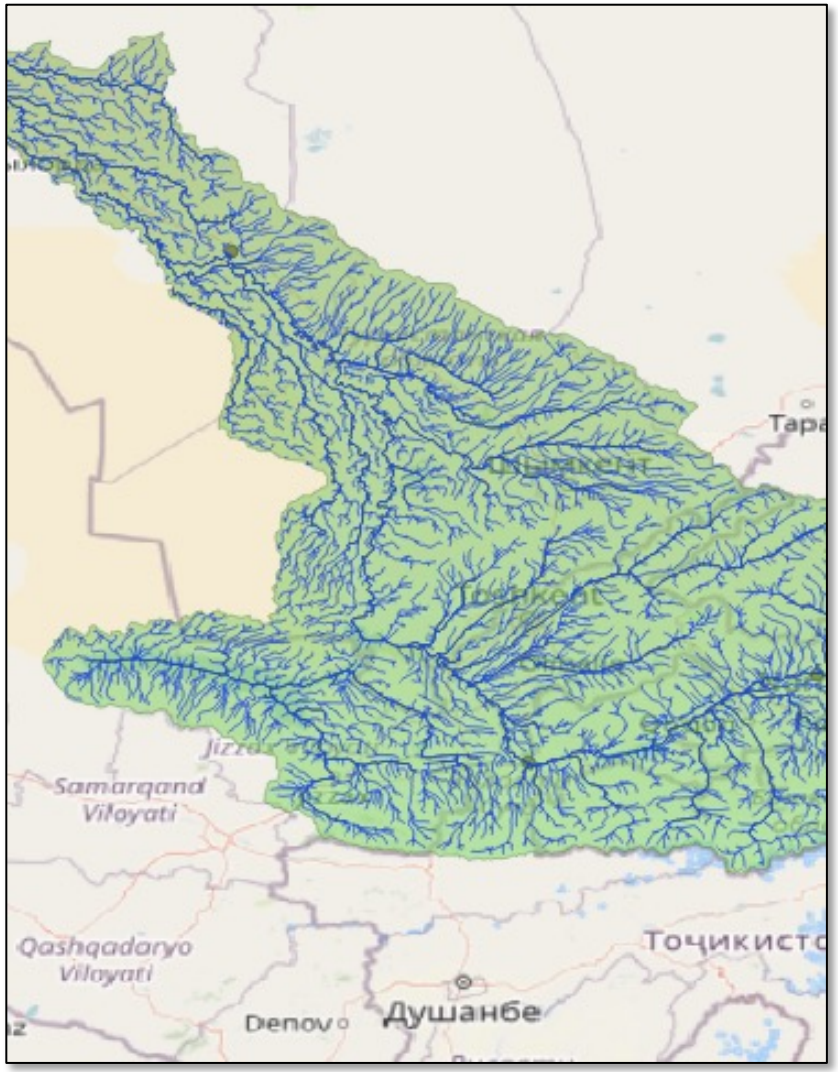
- Precip., Evap, Runoff,
- Streamflow + index
- Soil moisture + index
- SPI
- …

Contributing data and methods: Hydrological Models



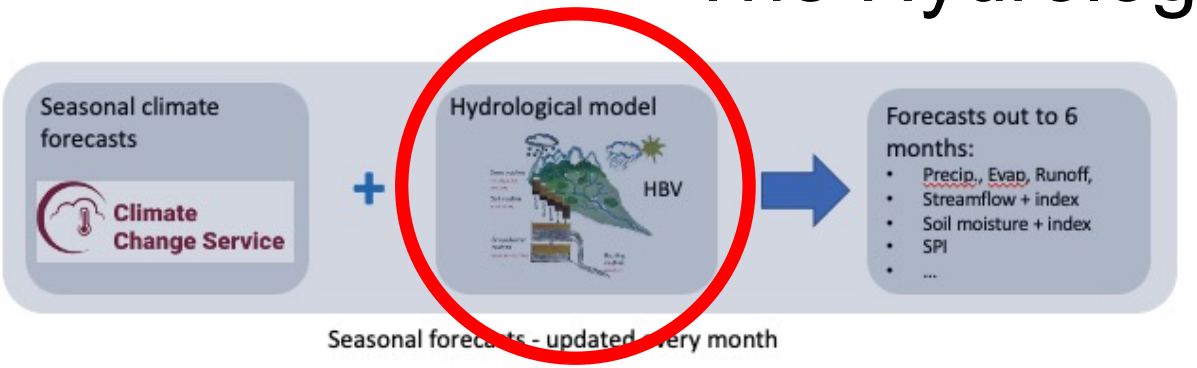
The **HBV** hydrological model – parsimonious hydrological model that can be rapidly calibrated and applied at high resolution for multiple ensemble forecasts

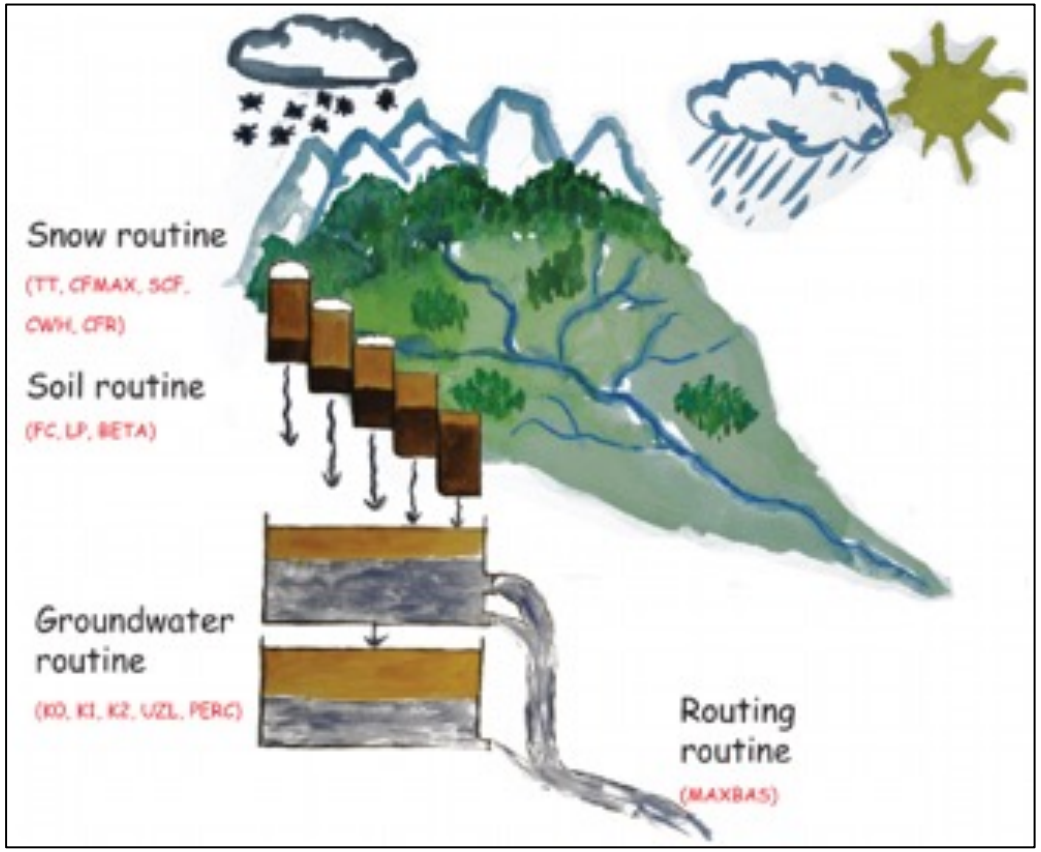
HBV predicts runoff, which is then passed to RAPID to predict streamflow



RAPID streamflow routing model: a flexible framework for simulating on vector-based river networks at large-scale.

The Hydrological Model - HBV



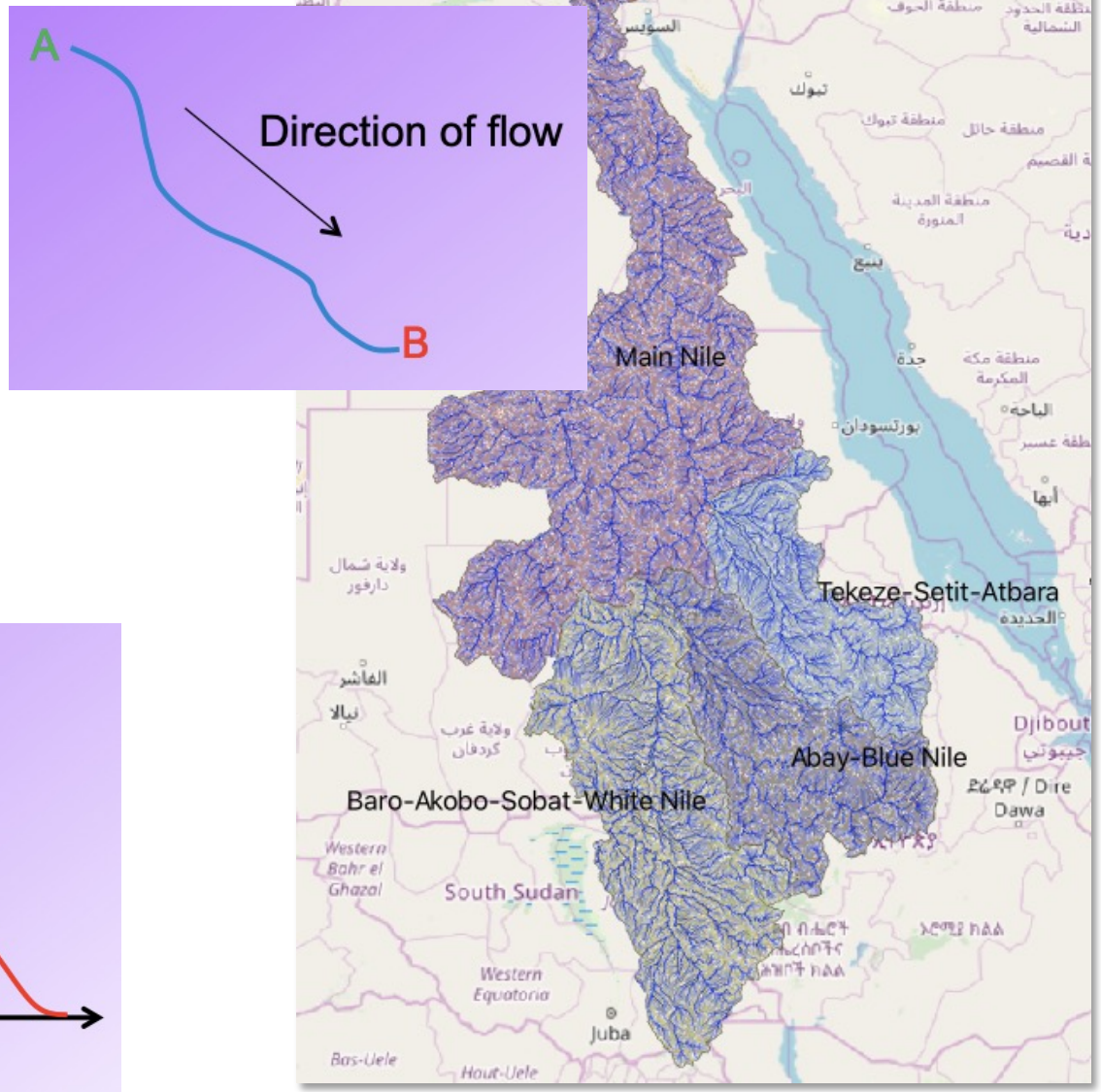


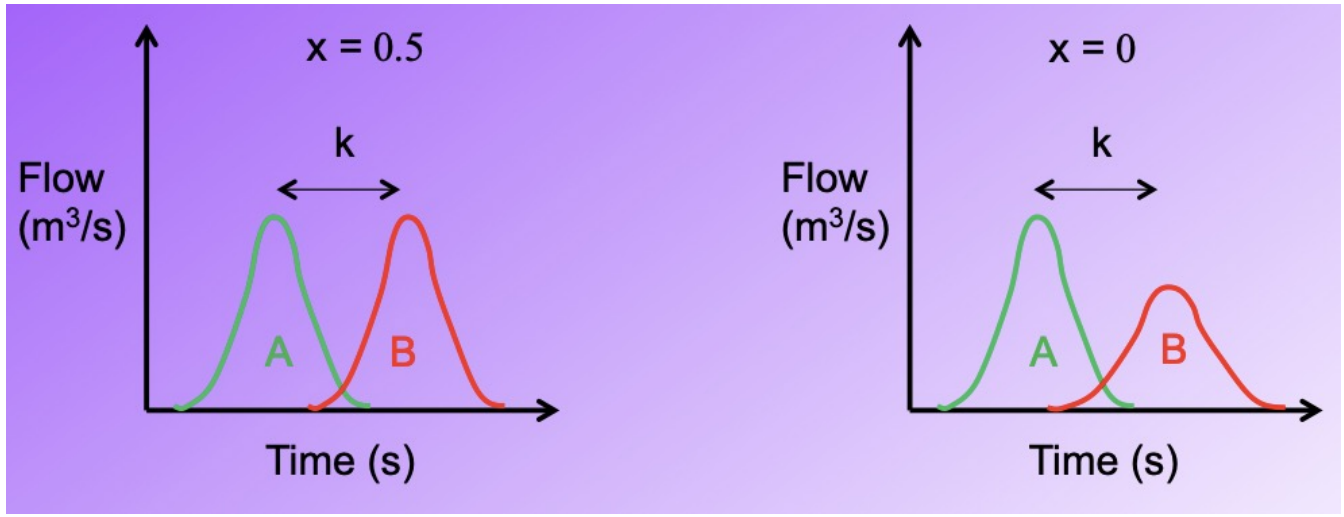
The HBV model …

- is a conceptual model for runoff simulation
- ... has a simple structure
- ... is semi-distributed, i.e., allows to divide the catchment into subbasins, elevation and vegetation zones
- ... is easy to understand, learn and apply
- ... has been applied to many catchments globally
- ... provided good results in most applications
- ... has become a standard tool for runoff studies in the many countries
- ... needs a moderate amount of input data
- ... can be run on a low-end PC
- ... (partly) used in other models

The Streamflow Routing Model - RAPID

- **RAPID** streamflow routing model (Routing Application for Parallel computation of Discharge; David et al., 2011; David, 2019)
- A flexible framework for simulating on vector-based river networks at large-scale.
- Solves a matrix version of the Muskingum method which incorporates the continuity equation with a lumped storage-discharge relationship
- k is a time ($k \geq 0$) related to the celerity of the flow wave
- x is a non-dimensional parameter ($0 \leq x \leq 0.5$) related to diffusion of the flow wave



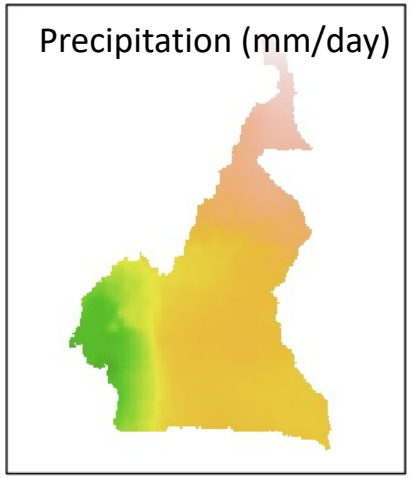


Contributing data and methods: Meteorological Data

Historically and near real-time: MSWEP, MSMet

MSWEP

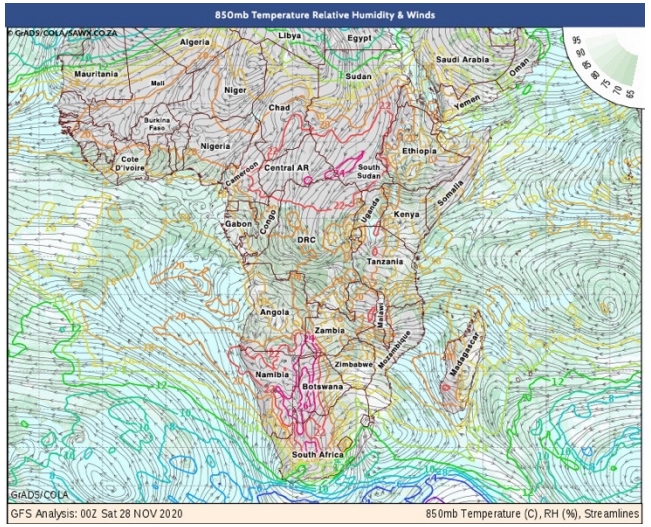
MSMet



Short-term forecasts: NOAA Global Forecast System (GFS) weather forecast model

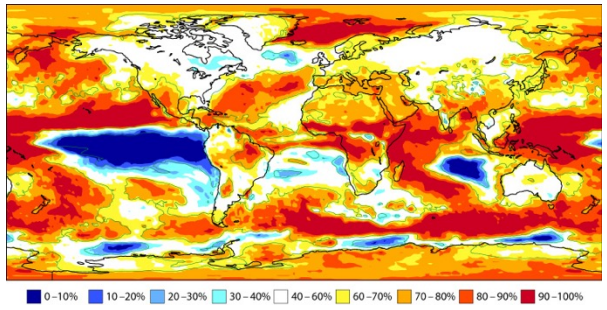
NOAA

GFS Global Forecast System



Seasonal forecasts: ECMWF V4 seasonal forecast model

Climate Change Service



Flood Types

River floods

Flash floods

Dam and dyke breaks

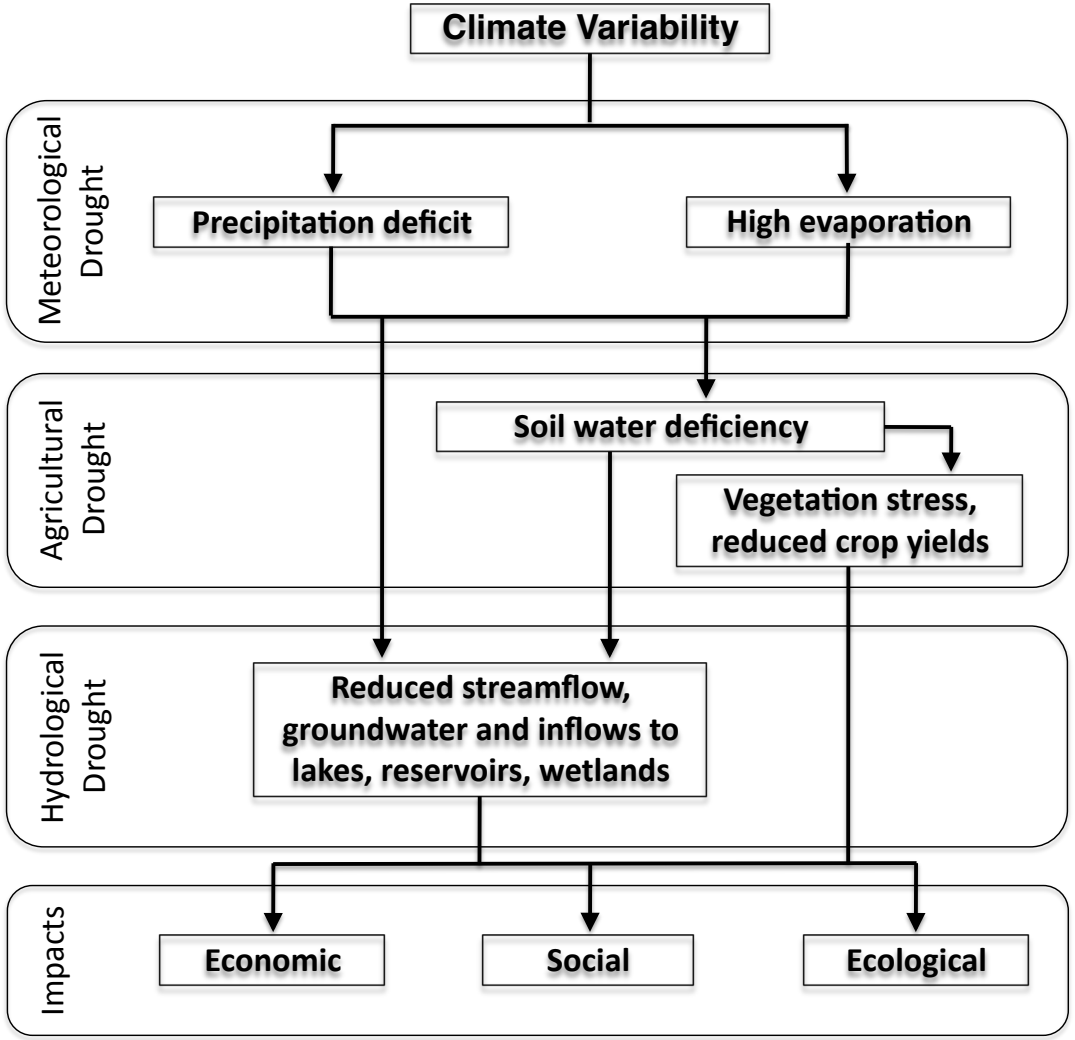
Coastal flooding and storm surges

Drought Types

In the scientific literature, droughts are typically classified into four major types:

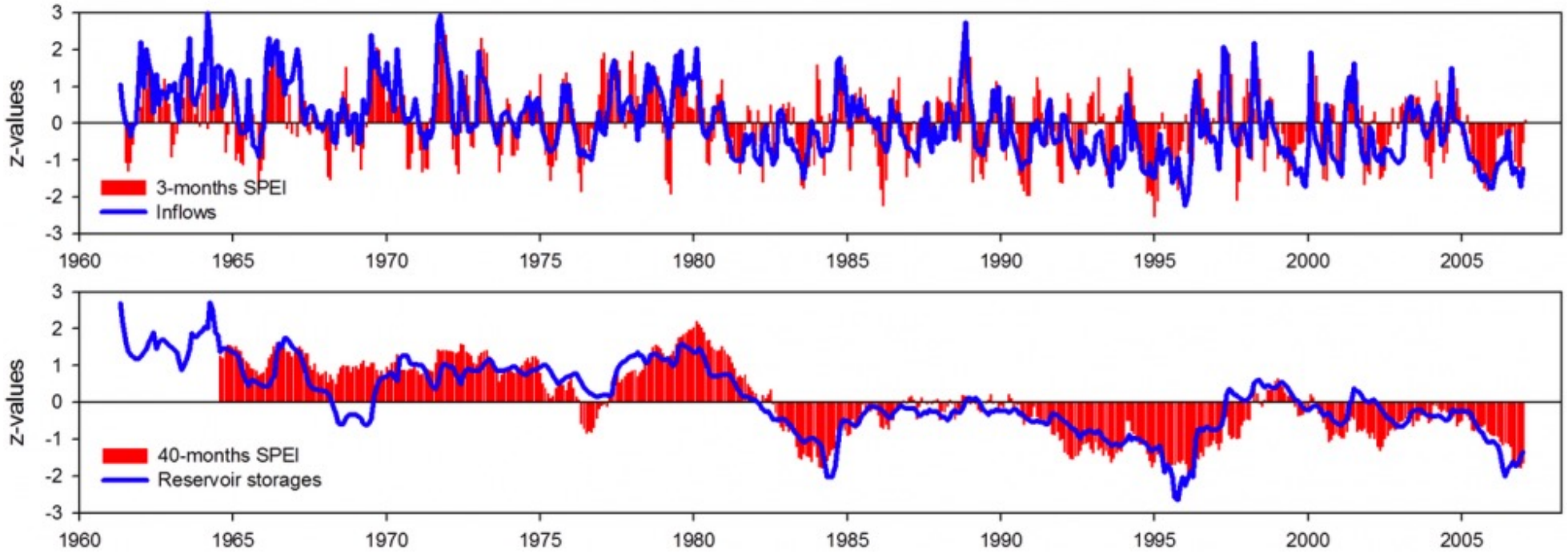
1. *meteorological drought*, a significant negative deviation from mean precipitation;
2. *hydrological drought*, a deficit in the supply of surface and subsurface water;
3. *soil moisture* or *agricultural drought*, a deficit in soil moisture, driven by meteorological and hydrological drought, reducing the supply of moisture for vegetation;
4. *socio-economic drought*, a combination of the above three types leading to undesirable social and economic impacts.

These classifications of drought are not rigid, since the definitions incorporate many different physical, biological and socio-economic variables. Further definitions may apply, based on environmental impacts.

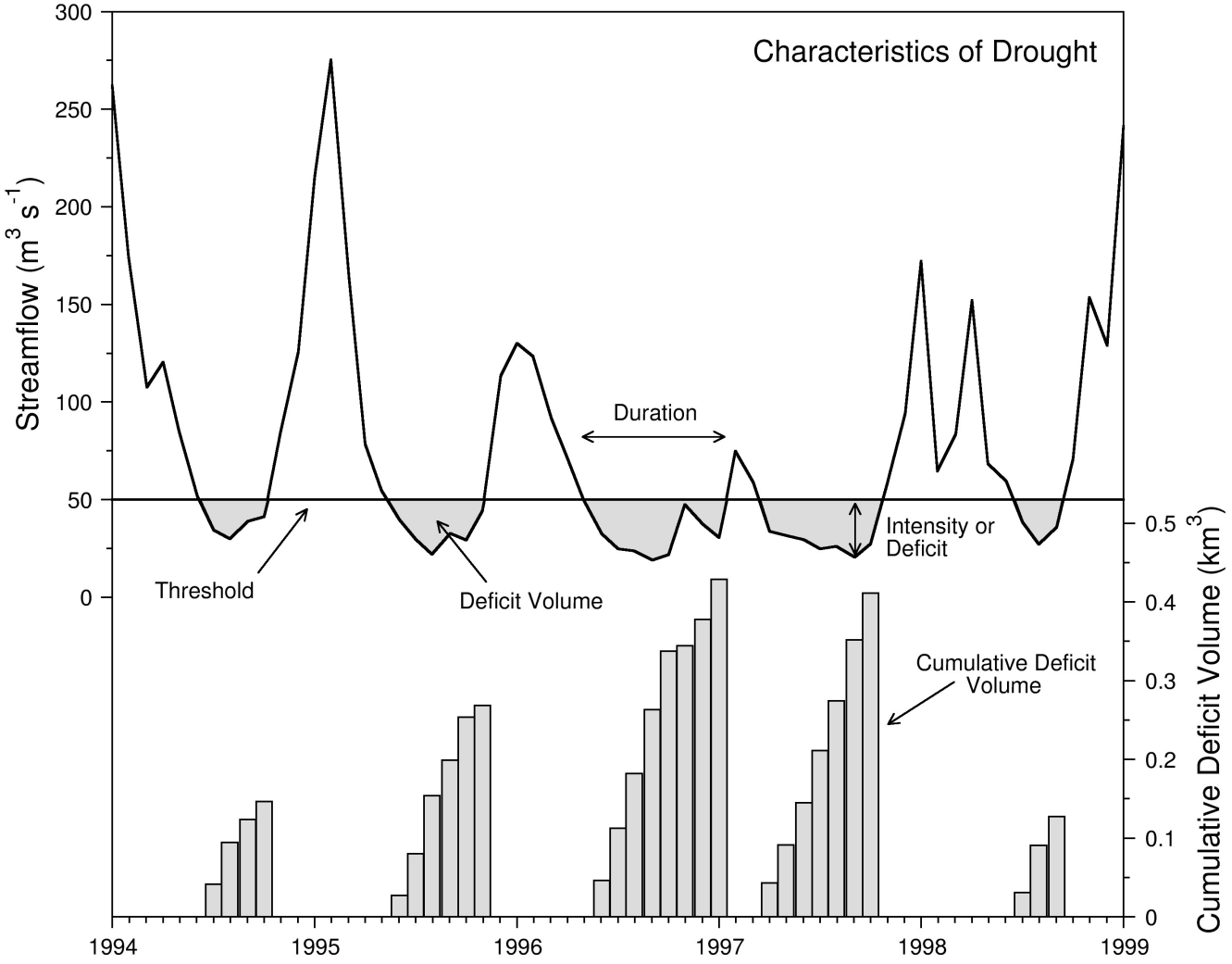


Drought (and Flood) Indices

- A quantitative expression for the state of drought – to understand current conditions, relative to past droughts and for other regions
- This is usually called a drought index and allows a scientist, farmer, manager or policy-maker to objectively analyse a system and make quantitative management and policy decisions.
- There are many different types of index, but they are generally a rescaled version of a meteorological or hydrological variable at a time step of weekly/monthly or longer (e.g. percentile, Z-score, …).



Drought (and Flood) Characteristics



- A drought is defined when the quantity drops below a threshold level.
- The time that the index is below the threshold is the duration of the drought.
- The level below the threshold at any particular time is the deficit, magnitude or intensity of the drought.
- The severity describes the combined duration and intensity/magnitude of the drought.
- Also often referred to as the deficit volume for hydrological drought.

Data Products in the SYR-FDM

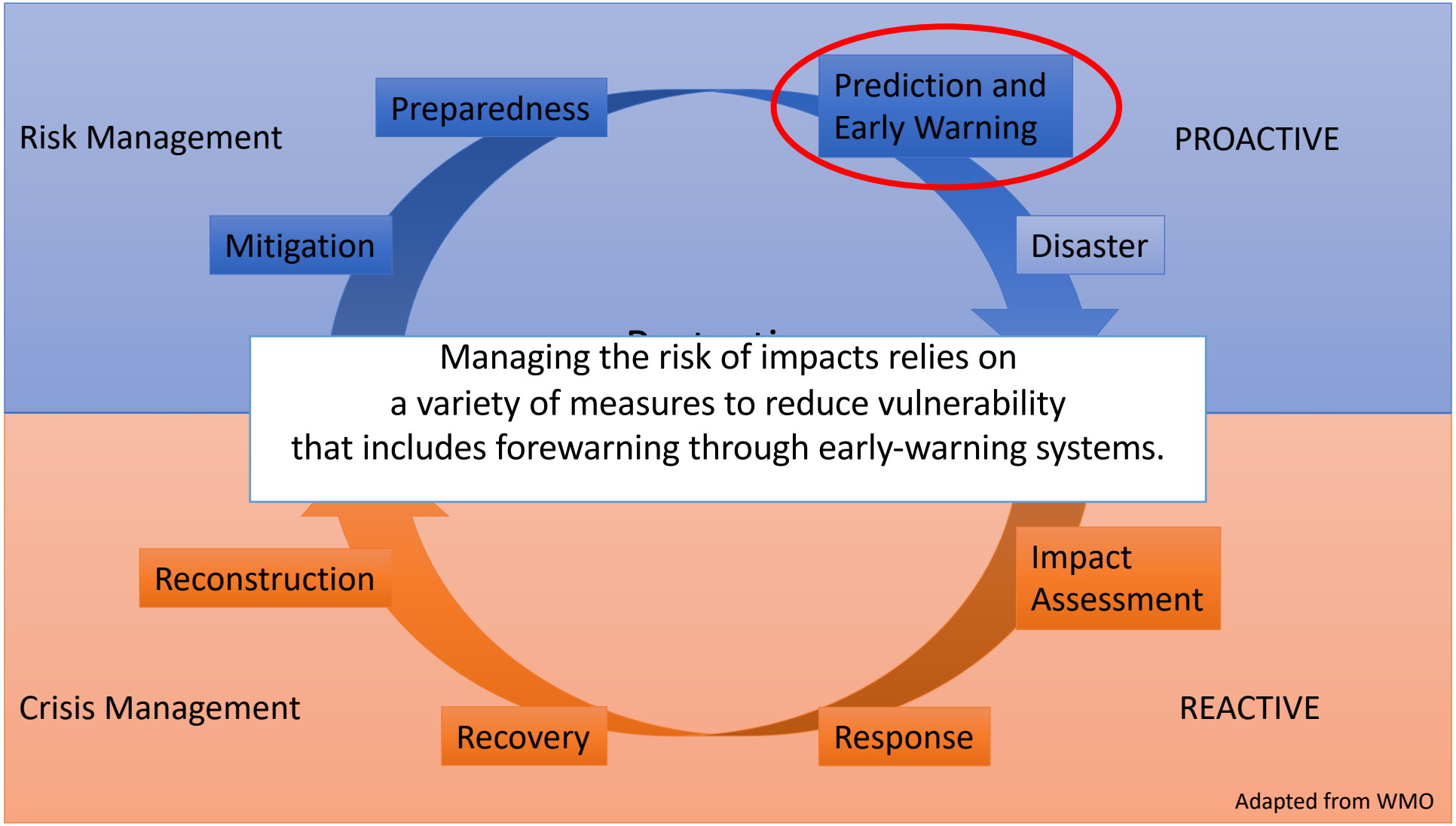
Variable	Data source	Type	Attributes
Precipitation (P)	MSWEP	Meteorological	5km, daily
Runoff (R)	HBV	Hydrological	5km, daily
Evaporation (ET)	HBV	Hydrological	5km, daily
Soil moisture (SM)	HBV	Hydrological	5km, daily
Q	HBV+RAPID	Hydrological	Reach, daily
Index	Data source	Drought Type	Attributes
SPI	MSWEP	Meteorological	5km, daily, SPI-1, -3
SM stand. anomaly	HBV	Agricultural	5km, daily
Q percentile	HBV+RAPID	Hydrological	Reach, daily
Index	Data source	Flood Type	Attributes
P percentile	MSWEP	Potential flooding from rainfall - heavy (R95) or extreme (R99)	5km, daily
SPI	MSWEP	Meteorological – indicates longer-term wet conditions	5km, daily, SPI-1, -3
SM stand. anomaly	HBV	Agricultural – indicates wet soils and potential water logging	5km, daily
Q percentile	HBV+RAPID	Hydrological – indicates flood flows above Q95 or Q99	Reach, daily

Relationship between Indices

Index	Type	Timescale	Physical time scale	Drought (flood) threshold	Drought (flood) probability
SPI-1, SPI-3	Standardized normal	1 month	1-3 months	-1 (3)	~15% (5%)
SMindex	Standardized anomaly	1 day	Several days to weeks	-1 (3)	~15% (5%)
Qpctl	Percentile	1 day	Several days to weeks	15^{th} (5^{th}) percentile	15% (5%)

- Note: each index is calculated differently as appropriate for the variable.
- They are not the same types of indices but can be approximately compared based on their individual thresholds and return periods.
- For example, an *SPI-1* value below -1 is approximately the same risk as a *SMindex* value below -1 or a *Qpctl* value below 15^{th} percentile (15%).

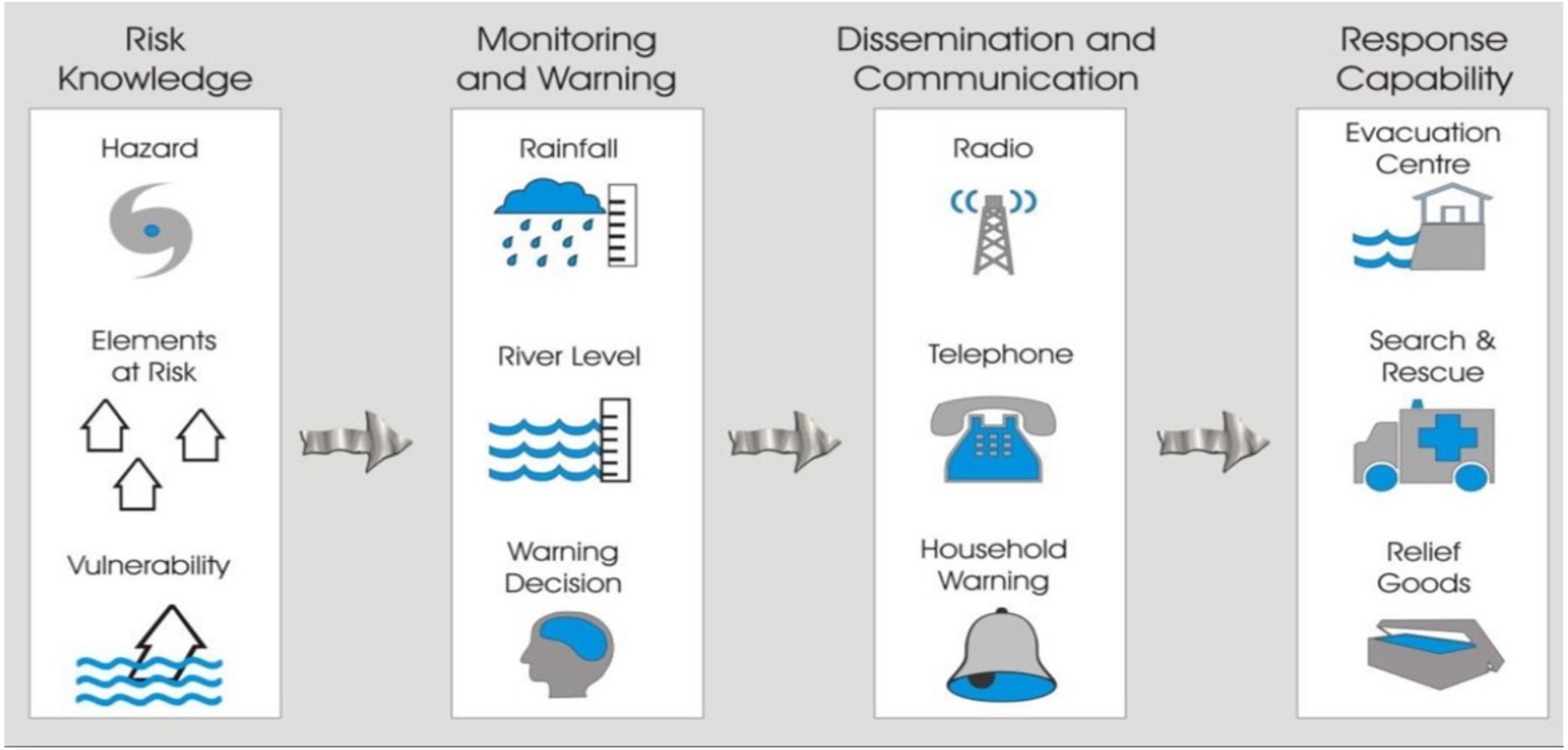
Flood and Drought Prediction and Early Warning Systems



US Federal Emergency Management Agency (FEMA) and other disaster management organizations estimate that for every $1 spent on reducing vulnerability to disaster $4 is saved.

Flood and Drought Prediction and Early Warning Systems

Example for floods

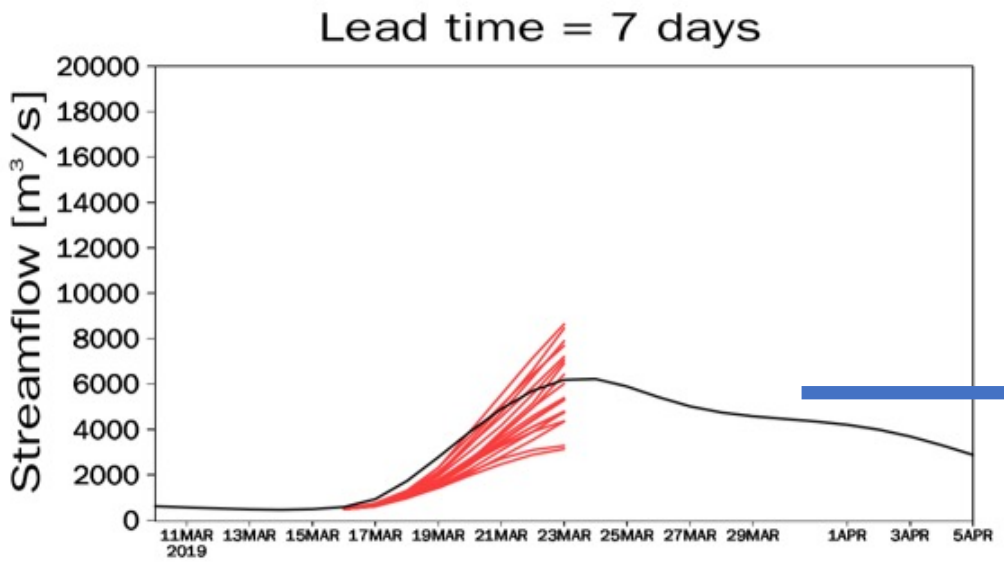


Drought early warning systems operate in a similar way but the time-scales are much longer

http://floodproofing-vietnam.org.vn/en/activities/early-warning-system

Example application – flood early warning

Shot-term streamflow forecast



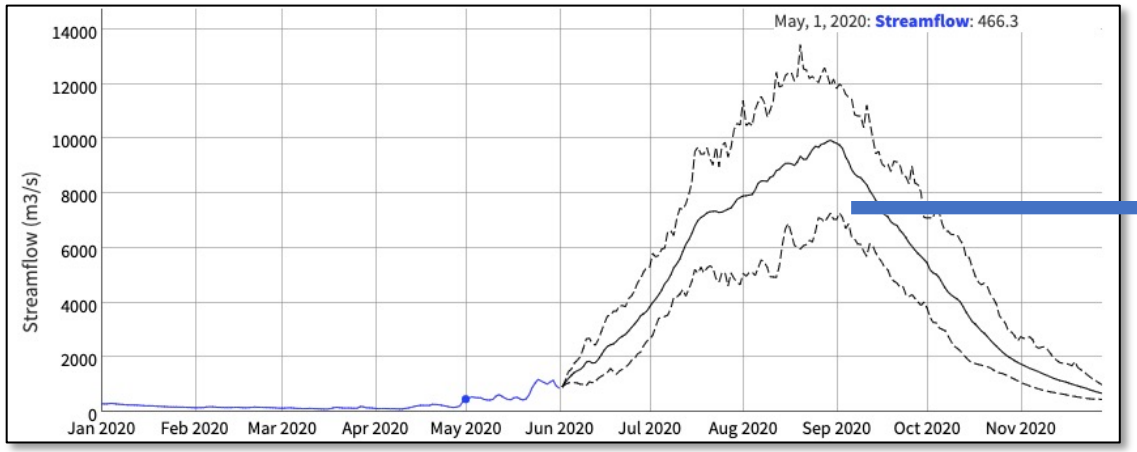
Flood Mitigation Options

FLOOD WARNING

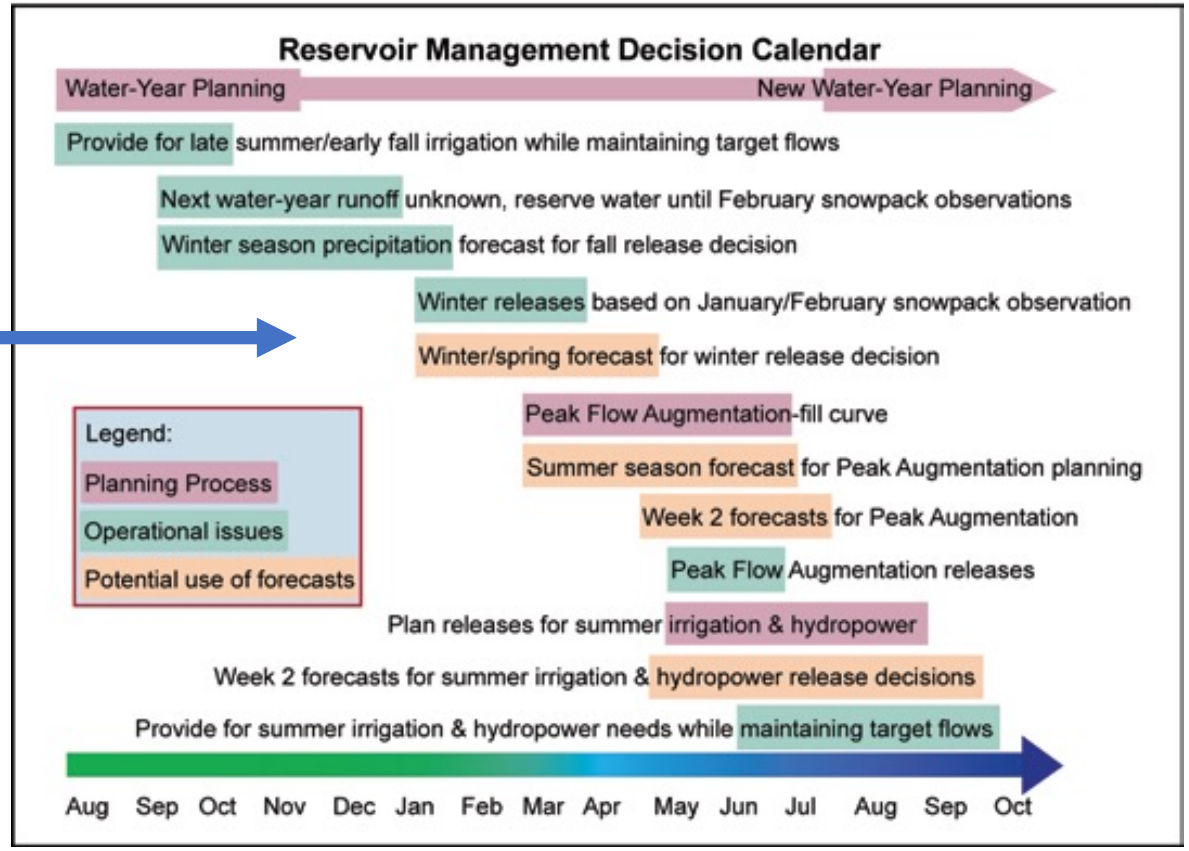
FLOODING IS EXPECTED. IMMEDIATE ACTION REQUIRED.

Example application – reservoir management

Seasonal streamflow forecast

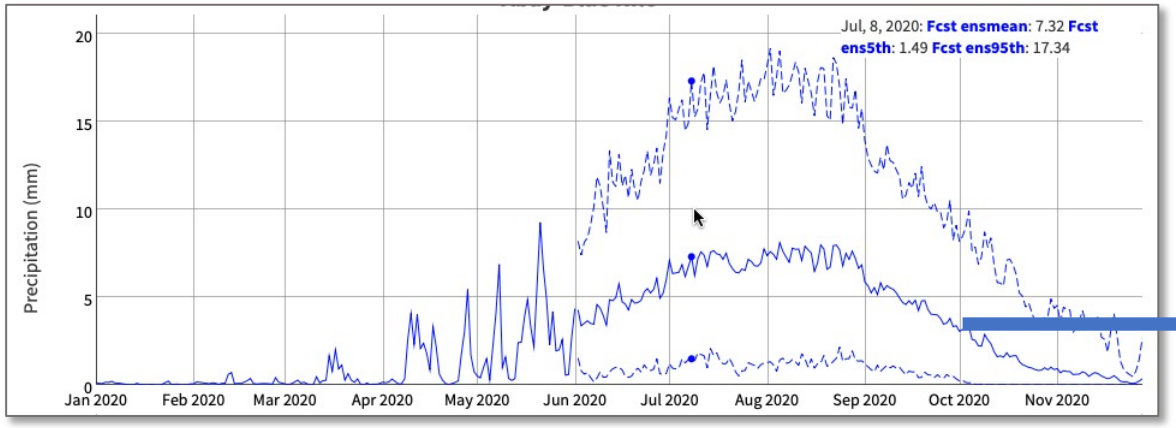


Reservoir Management Options

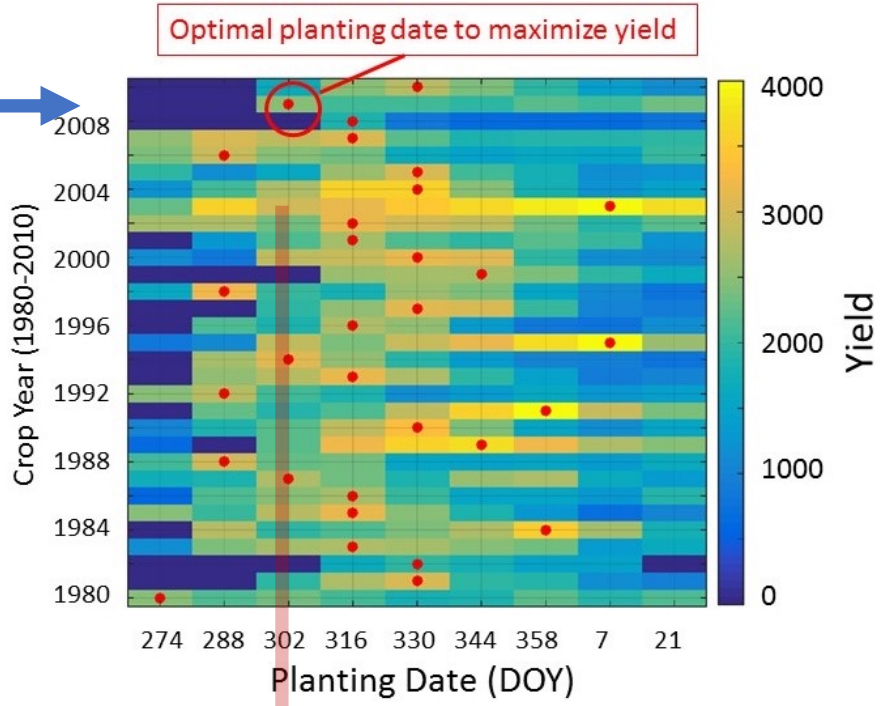


Example application – agricultural decision making

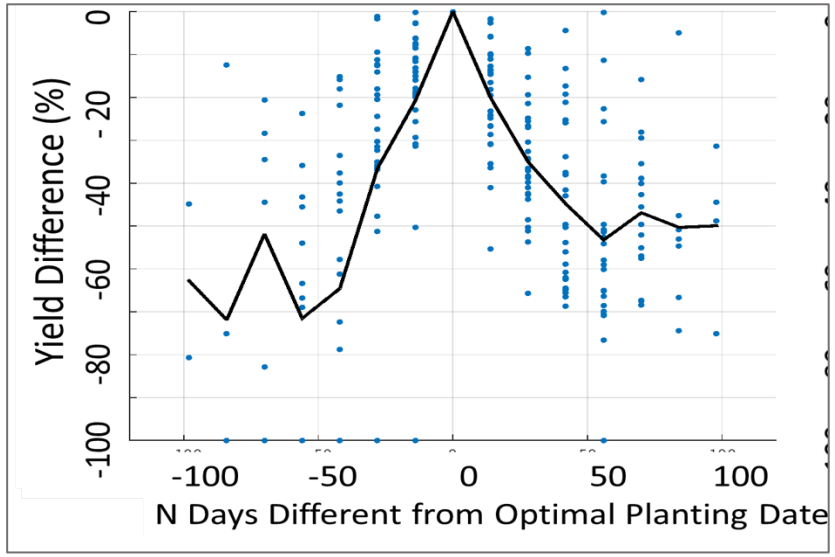
Seasonal precipitation forecast



Optimal planting date



Yield sensitivity to planting date

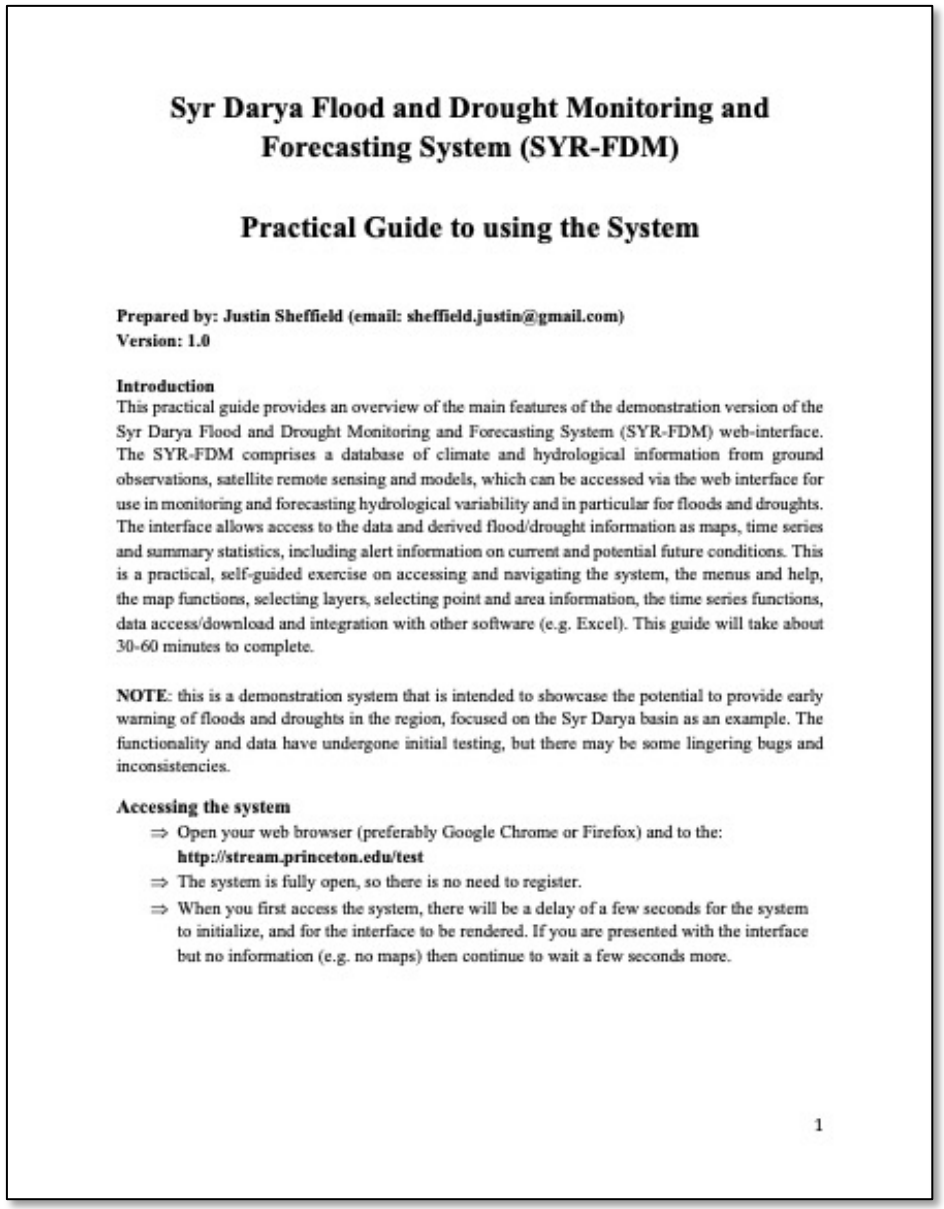


Potential decision on when to plant and what to plant

Any questions?

…. A quick tour of the system

Practical Exercise on using the System



Syr Darya Flood and Drought Monitoring and Forecasting System (SYR-FDM)

Practical Guide to using the System

Prepared by: Justin Sheffield (email: sheffield.justin@gmail.com)
Version: 1.0

Introduction

This practical guide provides an overview of the main features of the demonstration version of the Syr Darya Flood and Drought Monitoring and Forecasting System (SYR-FDM) web-interface. The SYR-FDM comprises a database of climate and hydrological information from ground observations, satellite remote sensing and models, which can be accessed via the web interface for use in monitoring and forecasting hydrological variability and in particular for floods and droughts. The interface allows access to the data and derived flood/drought information as maps, time series and summary statistics, including alert information on current and potential future conditions. This is a practical, self-guided exercise on accessing and navigating the system, the menus and help, the map functions, selecting layers, selecting point and area information, the time series functions, data access/download and integration with other software (e.g. Excel). This guide will take about 30-60 minutes to complete.

NOTE: this is a demonstration system that is intended to showcase the potential to provide early warning of floods and droughts in the region, focused on the Syr Darya basin as an example. The functionality and data have undergone initial testing, but there may be some lingering bugs and inconsistencies.

Accessing the system

⇒ Open your web browser (preferably Google Chrome or Firefox) and to the: **http://stream.princeton.edu/test**

⇒ The system is fully open, so there is no need to register.

⇒ When you first access the system, there will be a delay of a few seconds for the system to initialize, and for the interface to be rendered. If you are presented with the interface but no information (e.g. no maps) then continue to wait a few seconds more.

1

- See: exercise_syr_fdm.pdf
- The exercise should take about 30-60 mins
- Please put your hand up or use the chat if you have a question