Latest tools and methodologies for flood modeling

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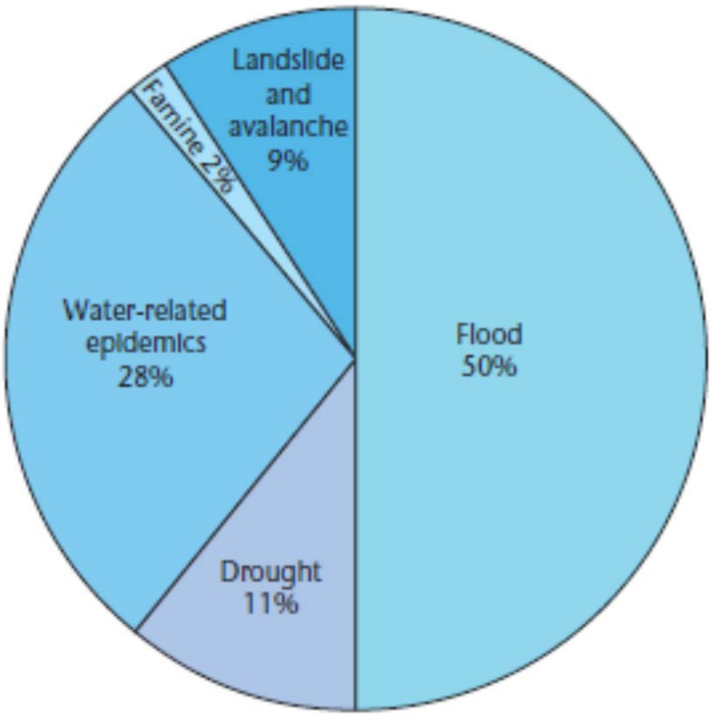
Floods - background



Types of water-related natural Disasters (UNESCO World Water Assessment Program)

Facts:

- Floods threaten human life and property worldwide - floods account for 15% of all deaths related to natural disasters.
- Floods can occur anywhere after heavy rain – all flood plains are vulnerable and heavy storms cause flash flooding in any part of the world.
- Flooding is a chronic natural hazard with potentially devastating consequences, giving rise to a third of all losses due to natural events.
- The risks and cost of floods are likely to increase due to global social and environmental change.

Flood forecasting

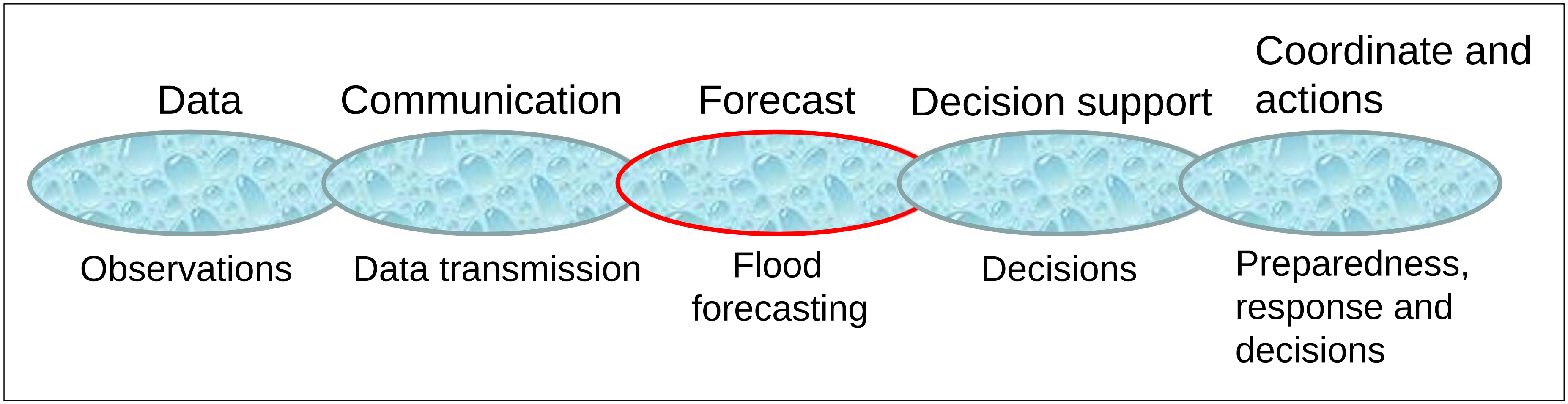
- Exponentially increasing impact of flooding has raised the profile of the practice of flood forecasting and warning.
- Since late 80-s there has been a move away from the primacy of major structural interventions for flood control towards more integrated approach, of which flood forecasting and warning is a component.
- The main components of a national flood forecasting and warning system are the following:
  - provision of specific forecasts relating to rainfall for quantity and timing;
  - establishment of a network of manual or automatic hydrometric stations (linked to a central control);
  - *flood forecasting model* software, linked to the observing network and operating in real time.

Nature of flood risks

- Flood risks are related to hydrological uncertainties, linked to social, economic and political uncertainties.
- One of the biggest aspect of flood risk is connected to population density and economic activities within a river basin.
- Flood warning activities are largely designed to deal with certain design limits of flooding (100 years, 50 years, 20 years flood).
- Modeling systems are set up in relation to know risks and impact.

Flood forecasting, warning and response systems

A critical chain of events and actions within a flood forecasting and warning system



Center of any flood forecasting system is hydrological flood forecasting model

Flood forecasting models

Hydrological model represents watershed and river channel processes.

Aim - to transform precipitation into channel flow.

Hydrological models:
- wide range of models (have been produced by government agencies, universities, and private companies);
- wide range of process simulation options;
- differing levels of complexity and data requirements;
- various degrees of technical support and training.

Their application depends on the *forecasting objective*, geographical and environmental factors, as well as institutional capabilities.

The selection of a “best choice” flood forecasting model needs to be based on a systematic approach.

Hydrological model types

1. Routing models
- methods, based on description of river channel processes;
- for reach of relatively large rivers;
- equations are based on different simplifications of mass and movement conservation equations;
- hydrometric data;

2. Catchment models
- methods, based on description of watershed processes;
- theoretical basis – equations of thermal and water transfer in soil layer and in atmosphere surface layer;
- hydrometeorological observations;

3. Combined catchment and routing model
- for big river system;
- catchment model is used to simulate the response of the catchment to produce runoff at a point ;
- this runoff is routed appropriately using routing model.

4. Special case models
- Flash floods, urban floods, reservoir flood control.

Hydrological model types

Box 4.1. Data-driven models

Data-driven models are generally simple and easy to calibrate, but many end-users fear that the models could be less reliable beyond the range of the historical data on which they are based. Data-driven models should be preferably used where:

(a) The predictand, namely the quantity of interest to be forecast, is at a gauged river section (extension of their use to ungauged cross sections is practically impossible);
(b) Relatively long data time series are available that encompass most of the range of variability over time of the predictand;
(c) The required forecasting span is relatively short compared to the concentration time (or the travel time) of the catchment to the cross section of interest.

Box 4.2. Conceptual (hydrological) models

Conceptual models are the most widely used for flood forecasting. This is largely because they are more easily understood by flood managers (usually civil engineers) in that they try to describe rationally the different components of the hydrological cycle. This is achieved by using simple analogues of processes, whilst avoiding the "system engineer" jargon typical of data-driven models. Continuous time conceptual models should be used where:

(a) The predictand is at a gauged river section (extension of their use to ungauged sections is often difficult);
(b) Relatively long data time series are available that encompass most of the variability over time of the predictand;
(c) The required forecasting span is of the same order of magnitude as the concentration time (or the travel time) to the cross section of interest.

Event-type models (as distinct from continuous time models) should be restricted to cases where the initial conditions are known and thus do not have a significantly varying impact on response, for example when floods always happen during the same period of the year when the soil moisture content is high.

Box 4.3. Physical-process models

In physical-process models, the different parts of the hydrological cycle are more specifically represented by mathematics of the physical process, for example fluid flow in rivers and through porous media in aquifers. In particular, spatially distributed process models should be used when:

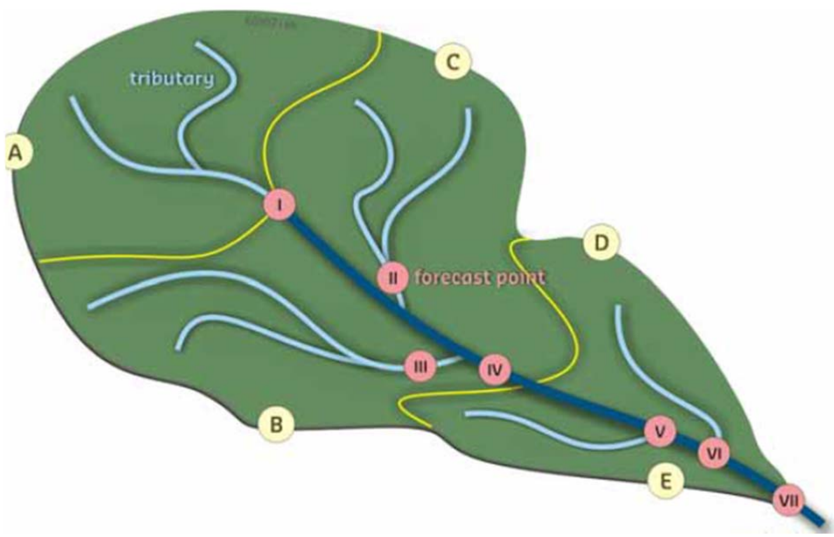
(a) Sufficient geomorphological and hydromorphological data are available;
(b) There is a particular requirement to extrapolate the forecasts to ungauged locations;
(c) The model computational time required is sufficiently small to allow for timely forecasts;
(d) The rainfall input is available in spatially distributed form (for instance as pixels from radar output);
(e) The spatially distributed rainfall input shows marked variability over different parts of the catchment.

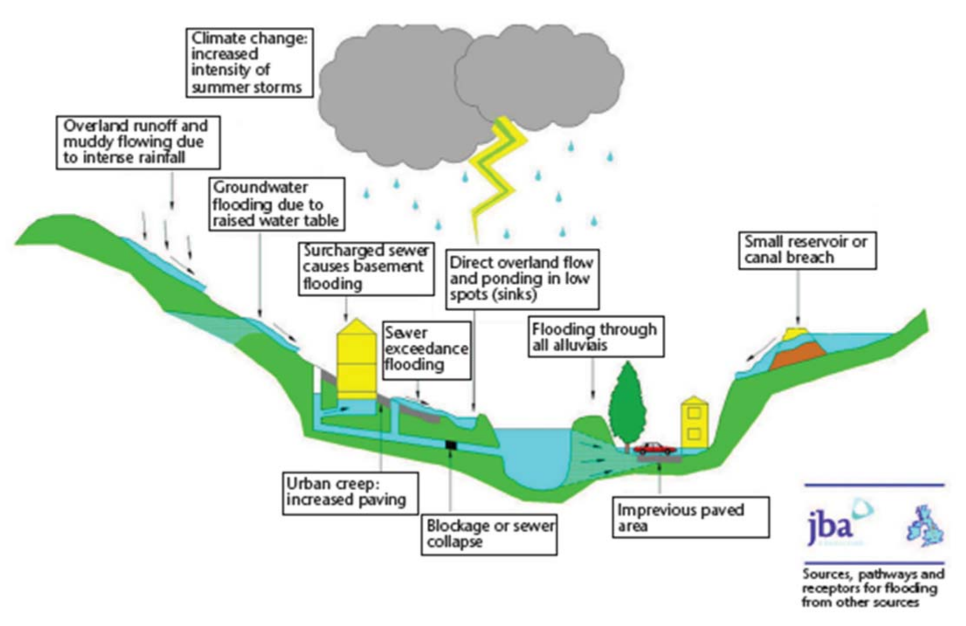
Selecting hydrological model

Main factor – understanding and correct definition of the purposes for which the model will be used.

Data availability conditions the selection of the type of modeling approach.

Model selection factors:
(a)The choice of forecast lead time versus time of concentration
(a)The robustness of the approach
(b)The computational time required





WMO latest actions on flood forecasting

WMO Flood Forecasting Initiative (FFI)

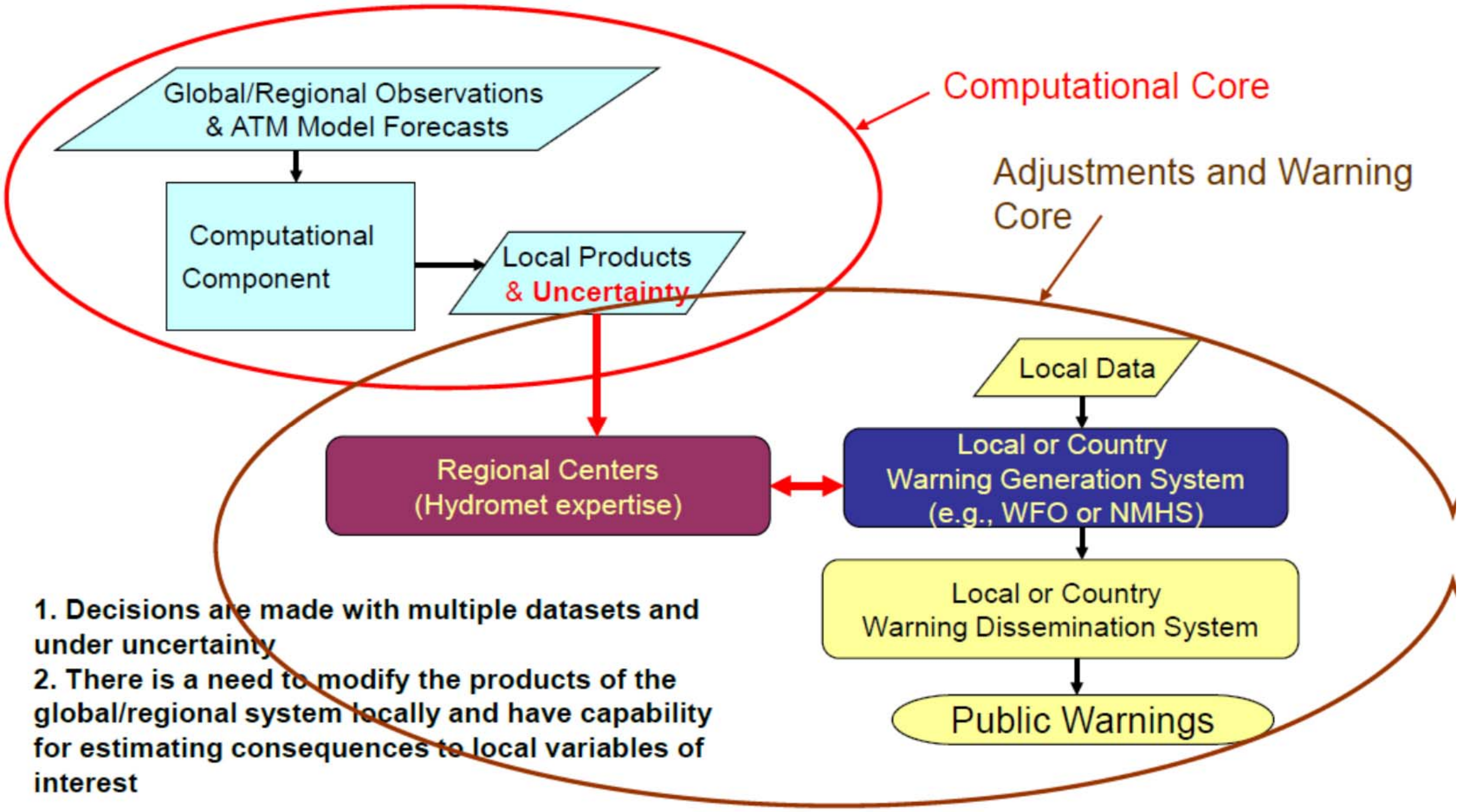
- developed in 2003 (expert meeting);

- objective: improve the capacity of meteorological and hydrological services to jointly deliver timely and more accurate products and services required in flood forecasting and warning and in collaborating with disaster managers, active in flood emergency preparedness and response;

- in 2011, the World Meteorological Congress (Cg) passed Resolution (15) establishing Flood Forecasting Initiative – Advisory Working Group with the objective to provide guidance and advice on the hydrological forecasting elements Of a number of flood related initiatives and programs of WMO.

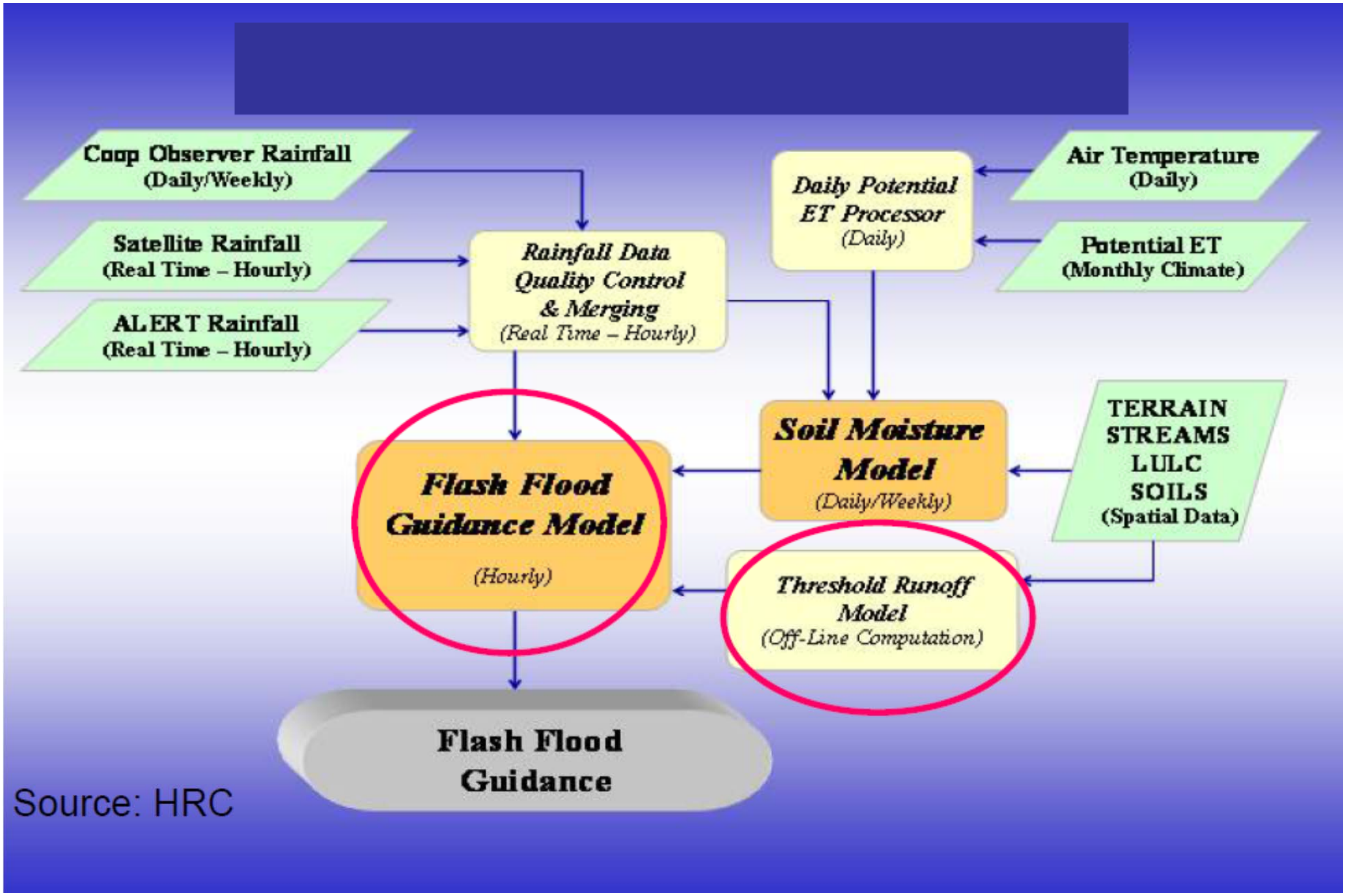
Regional Flash Flood Guidance and Early Warning Systems

Main objective – to contribute towards reducing the vulnerability of regions around the world to hydrometeorological disasters, specifically ***flash floods***

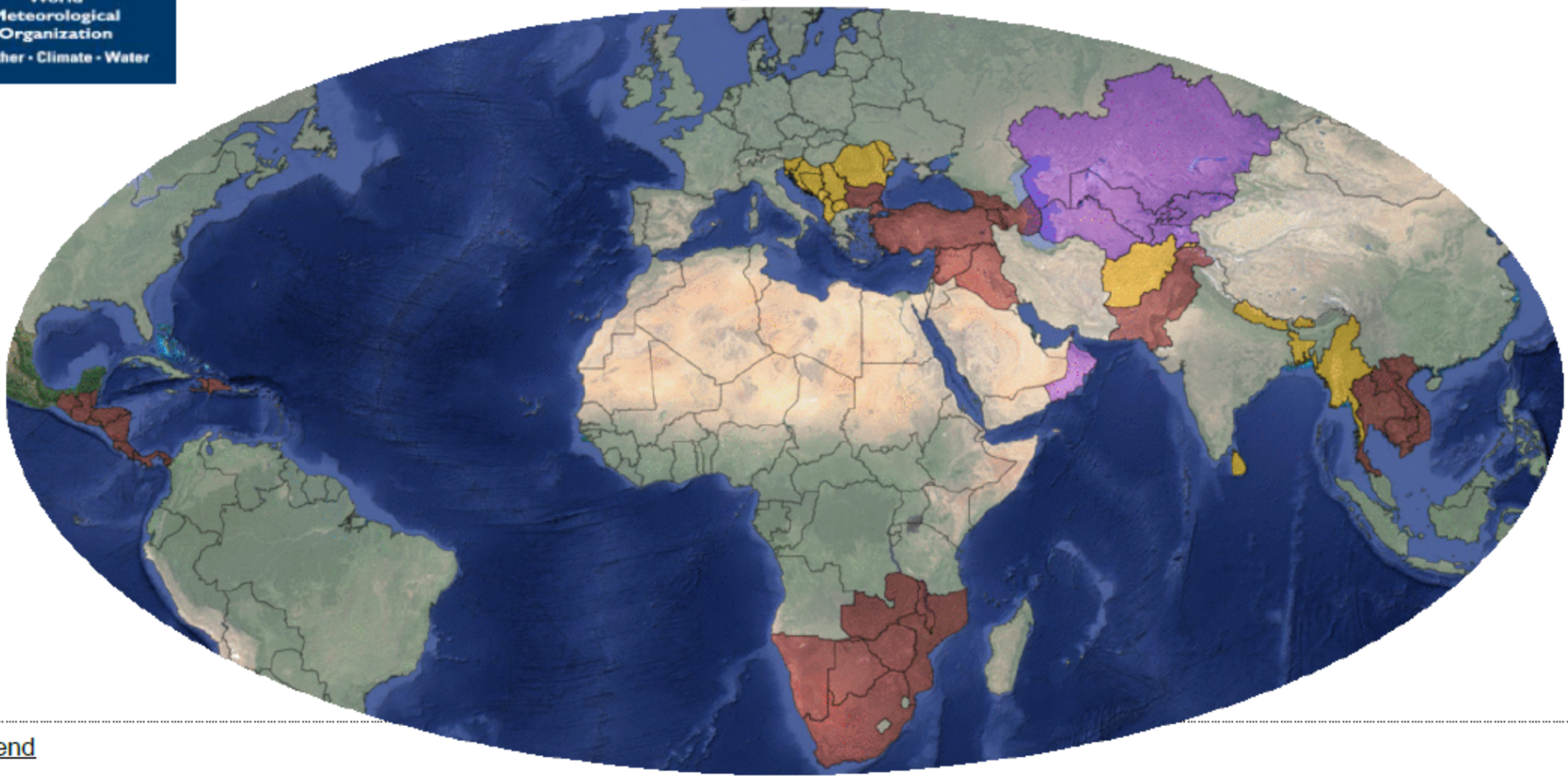


1. Decisions are made with multiple datasets and under uncertainty
2. There is a need to modify the products of the global/regional system locally and have capability for estimating consequences to local variables of interest

FFGS Flow Chart



The Global Distribution of Flash Flood Guidance Systems



Legend

FFG Implementation Status

	Completed	In Progress	Under Planning	Total
Total # Countries	30	15	6	**51**
Total Population Reached	645,698,967	184,846,165	65,542,913	**896,088,045**

WMO - Flood Forecasting and Warning Manual

- **Provides basic knowledge and guidance to develop flood forecasting and warning systems**
- **Addressed to National Meteorological Services**
- **Not a step-by-step guide, rather examples of different practices and technologies for the components of a flood warning system:**
  - **Design of flood forecasting system**
  - **Implementation and operation of the system**
  - **Flood warnings**
  - **Training**