ECMWF – DESTINATION EARTH

DESTINE AND AI FOR FLOOD FORECASTING AND ADAPTATION

AI FOR PREPAREDNESS

Kun Yan, Senior Researcher Flood Forecasting, Deltares

Funded by the European Union
Destination Earth implemented by ECMWF esa EUMETSAT

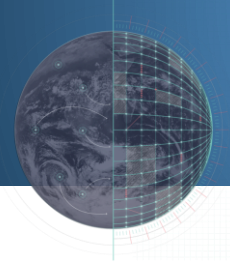
Deltares

Independent Institute for Water and Subsurface Research

- Not-for-profit
- **Applied** research with leading **software** and state-of-the-art experimental facilities
- ~950 staff across diverse disciplines
- **Global** presence with offices in the Netherlands, Singapore, Vietnam, Indonesia, UAE, and the USA

Driving Smart Innovations

- Trusted knowledge partner of the **Dutch** government
- **Dare to Share**
- **Specialized consultancy** and tailored solutions worldwide



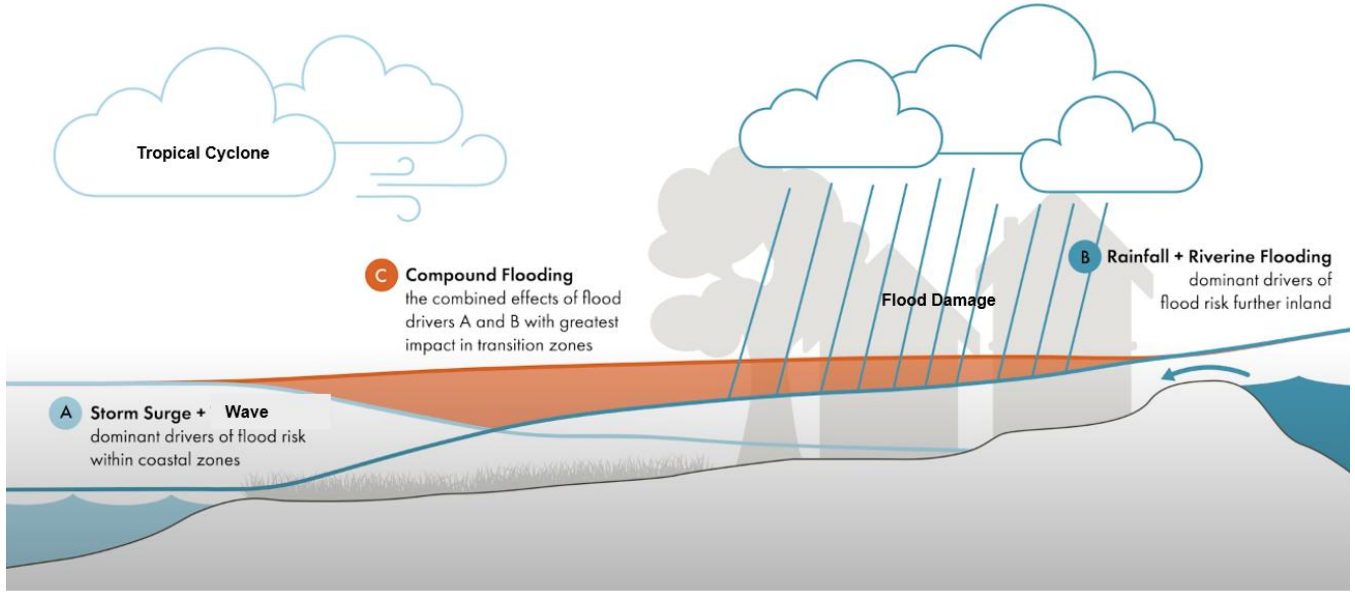
DELTARES` CONTRIBUTION TO DESTINE DRR

- DestinE related work
  - DE_370a – **Compound Flooding** Demonstrator
  - DE_374d – **Global storm surge** and compound flooding **forecasting Pilot Service**
  - DE_372 – Adaptation Modelling Framework

- AI related work
  - AI Research programs at Deltares
  - Showcases

DE_370A - COMPOUND FLOODING DEMONSTATORS

- Focus on impact sector of **Compound flooding**
- DT demonstrators for climate adaptation and disaster mitigation
  - **Five use cases:** Humber estuary (UK), Reunion, Philippines, Basque (Spain), Caribbean Netherlands
  - **User requirements** via co-creation
  - Leverage **Extremes DT** and **Climate DT data**
- Connect to existing platforms/services
  - Yet flexible in models, forecast product, forcing, boundary condition used
  - Global to local approach
  - Connect to DEDL

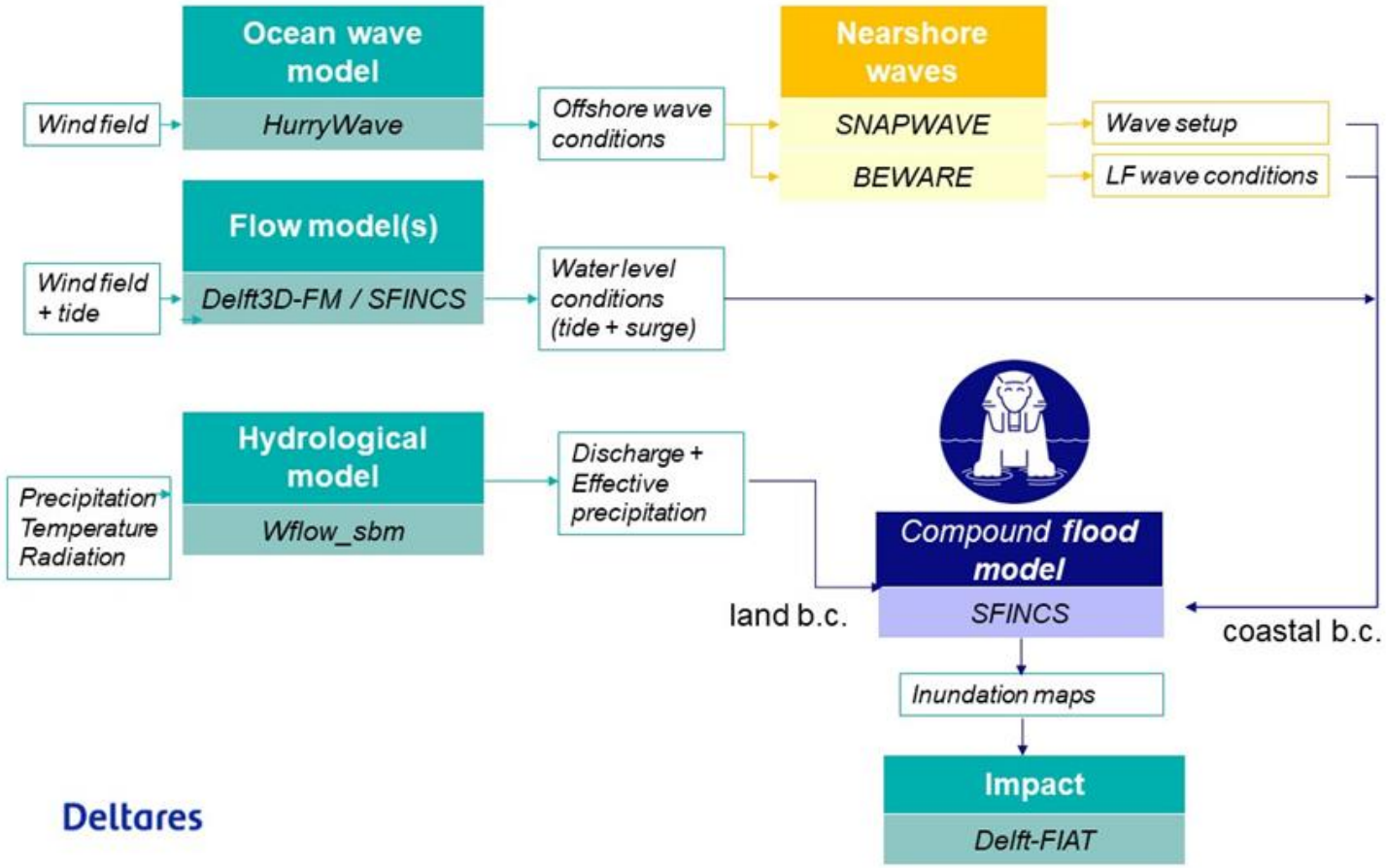


Credit: modified based on compound flooding research of The Water Institute

ECMWF Deltares

MODEL WORKFLOW

- Meteorological input from ECMWF: ERA5, IFS or **Extremes DT**
- Hydrological model WFLOW can be replaced by e.g. local, or **GLOFAS**
- Coastal hydrodynamics downscaled from **GTSM**, simulated by DFLOW-FM
- Offshore waves provided by **Hurrywave** regional and local models
- Flood extent simulated by **SFINCS**
- Impact estimated by **Delft-FIAT**



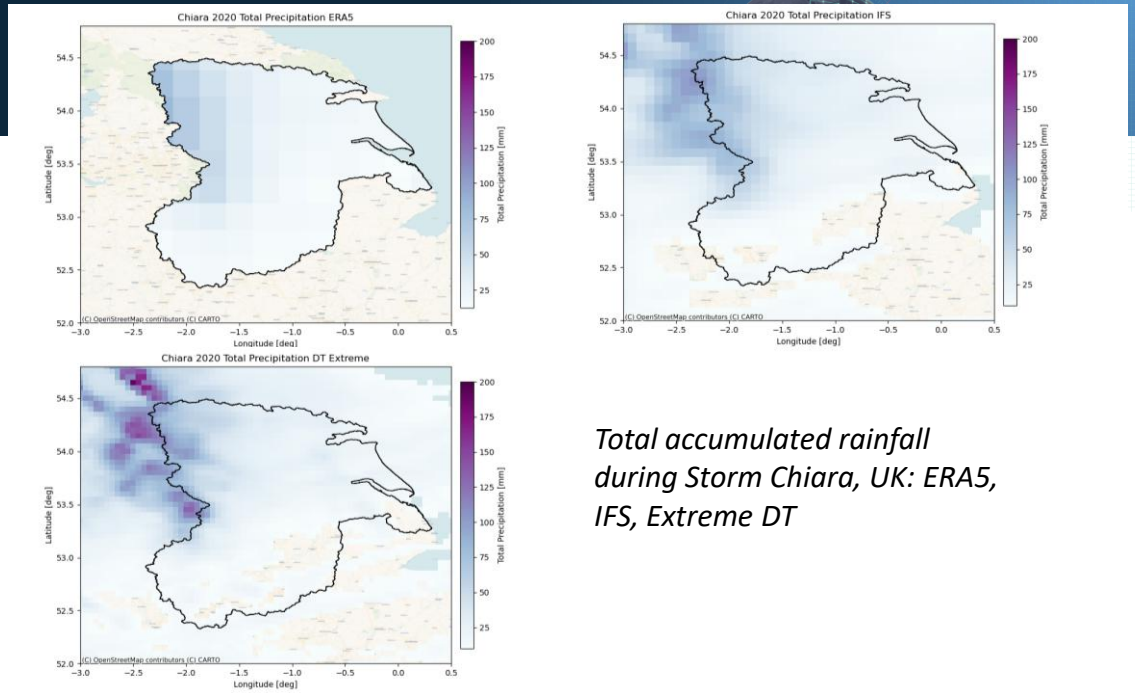
ECMWF Deltares

Story map

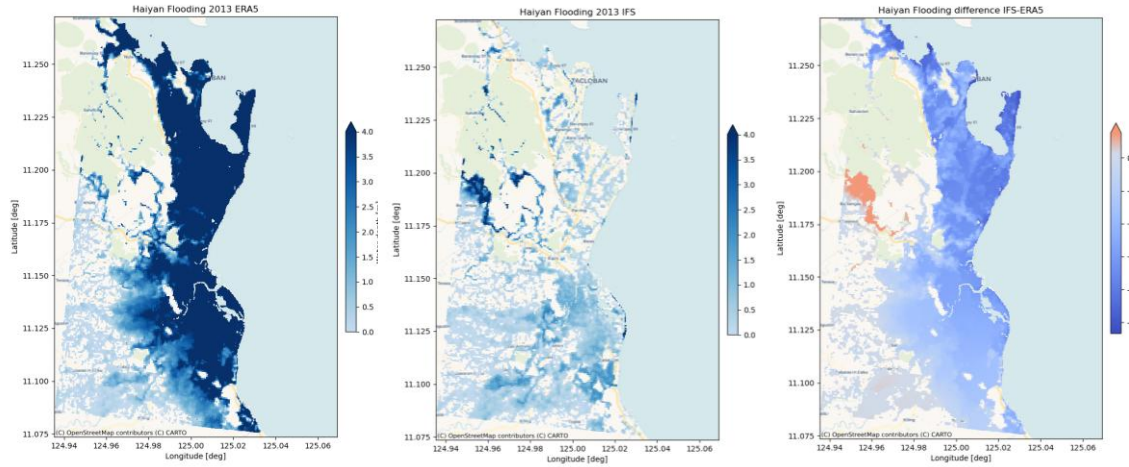
MAIN OUTCOME

- Will high resolution NWP of Extremes DT leads to **improved** flood impact simulation
  - It depends on flood drivers (rainfall, surge, wave, river), events, area of interest

- Recommendations
  - More validation with **recent events**, incl. TC
  - Include **uncertainty**
  - Explore **AI** based applications
  - Provide **global consistent** forecast under DestinE
  - Develop **pilot services**



Total accumulated rainfall during Storm Chiara, UK: ERA5, IFS, Extreme DT

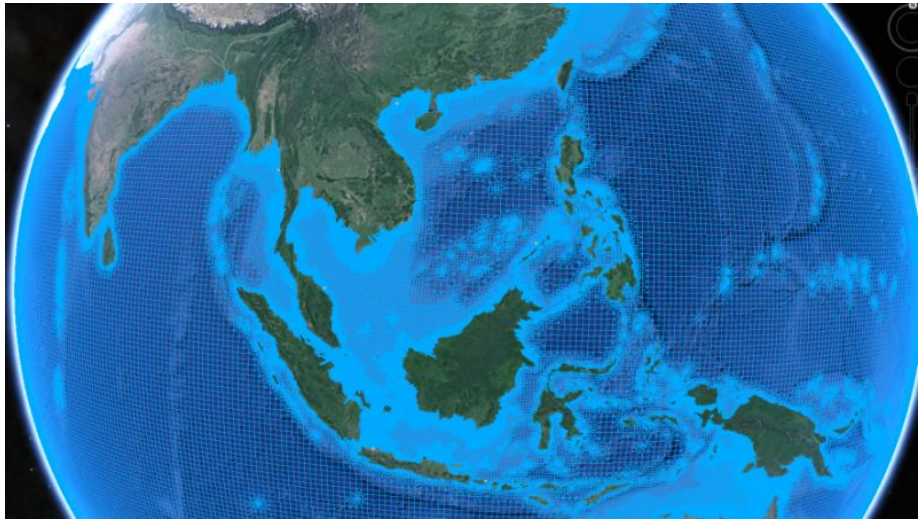


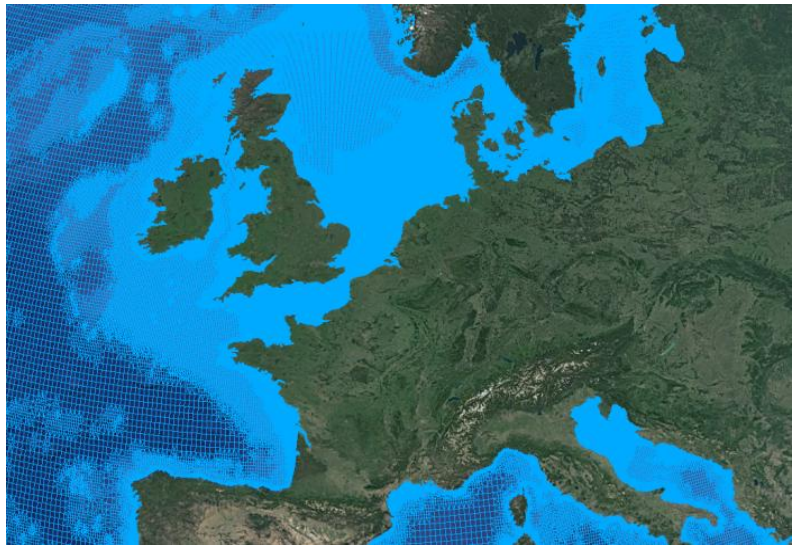
Flood maps for TC Haiyan near Tacloban Philippines: a) ERA5/IBTrACS; b) IFS; c) Difference;

ECMWF Deltares

DE_374D – FROM DEMONSTRATOR TO PILOT SERVICES

- Deploy pilot services to DestinE
  - **Core service**: Global storm surge, tide and currents forecasting
  - Downstream **Service One**: Compound flood forecasting in Philippines
  - Downstream **Service Two**: Global shipping routes optimization





GTSM model grid in Southeast Asia (left) and Europe (right)

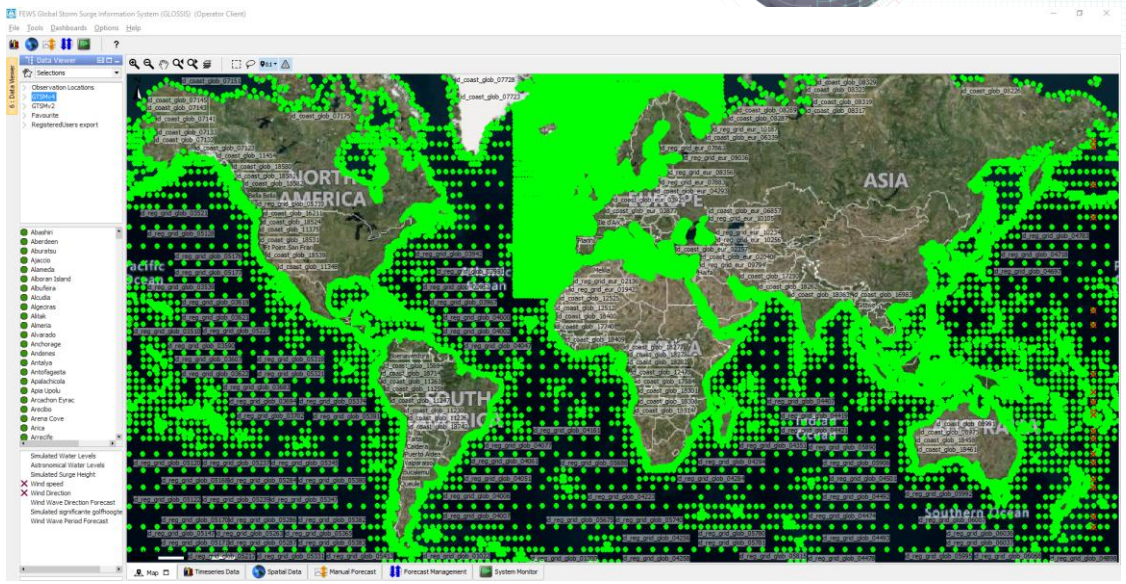
CORE PILOT SERVICE

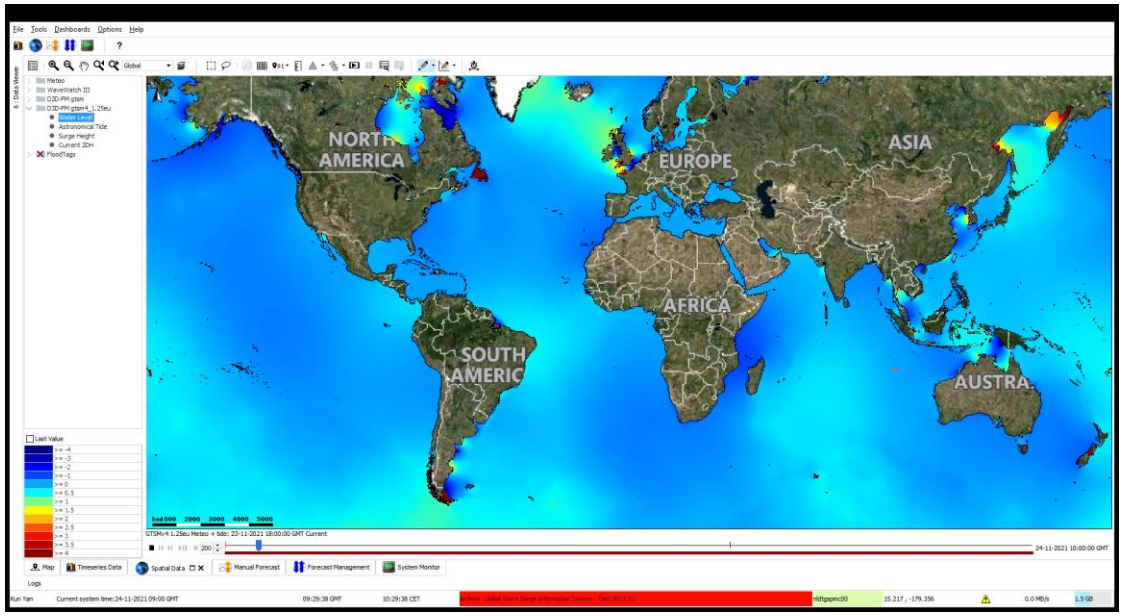
- Global Storm Surge Information System - GLOSSIS
  - Forecast **global** storm surge, tide and currents
  - Provides inputs to downstream services
  - Connect to **Extremes DT** global high-res NWP
  - Deploy in DestinE Data Lake (**DEDL**)
  - Dissemination on DestinE Service Platform (**DESP**)
  - Forecast validation/verification
  - Support & maintenance

Delft-FEWS

Delft3D-FM

GLOSSIS



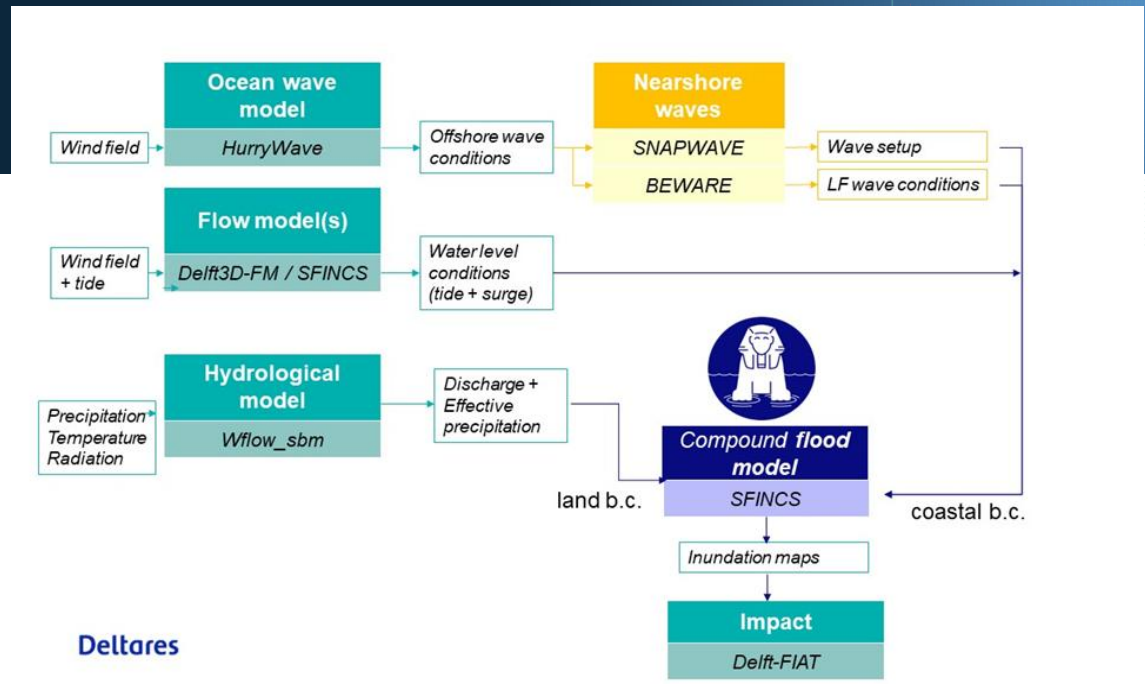


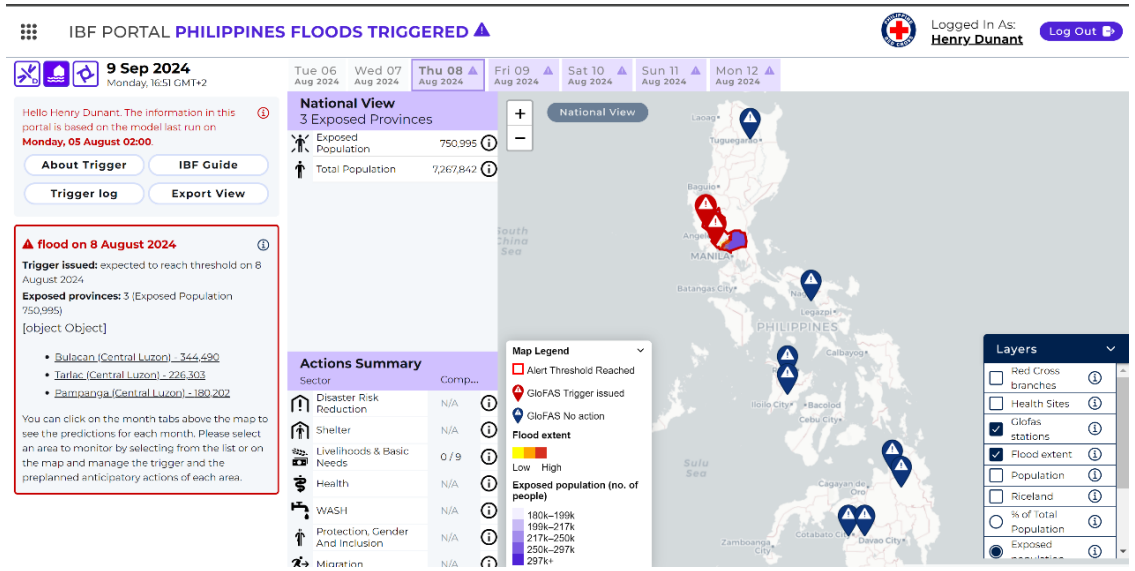
ECMWF Deltares

GLOSSIS output locations (up) and total water level forecast (low)

DOWNSTREAM SERVICE - COMPOUND FLOOD PHILIPPINES

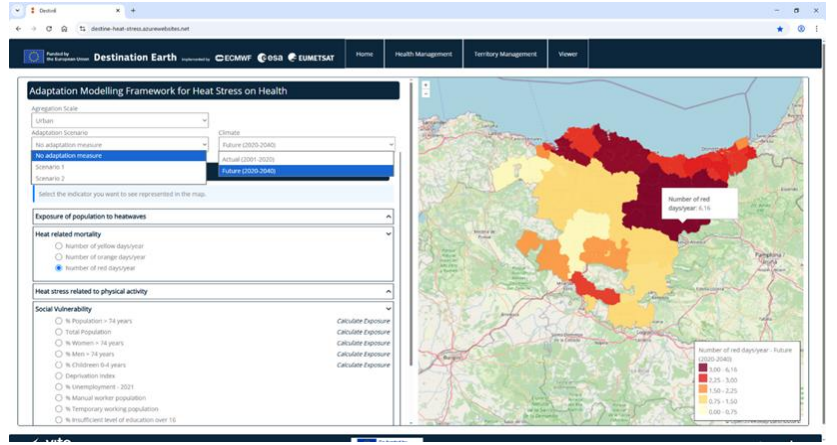
- Compound flood forecasting pilot service
  - **Global2local**: connect to GLOSSIS & GLOFAS
  - Support **humanitarian & anticipatory actions**
  - Expand to **three flood prone** regions in Philippines
  - Based on compound flood framework
  - Service co-design via user engagement
  - Visualization & dissemination via Impact-based forecasting platform of Red Cross





Red Cross`s impact-based forecasting portal

DE372 - OBJECTIVE



Develop a **Generic Adaptation Modelling Framework** for Destination Earth that supports community resilience globally

Motivation

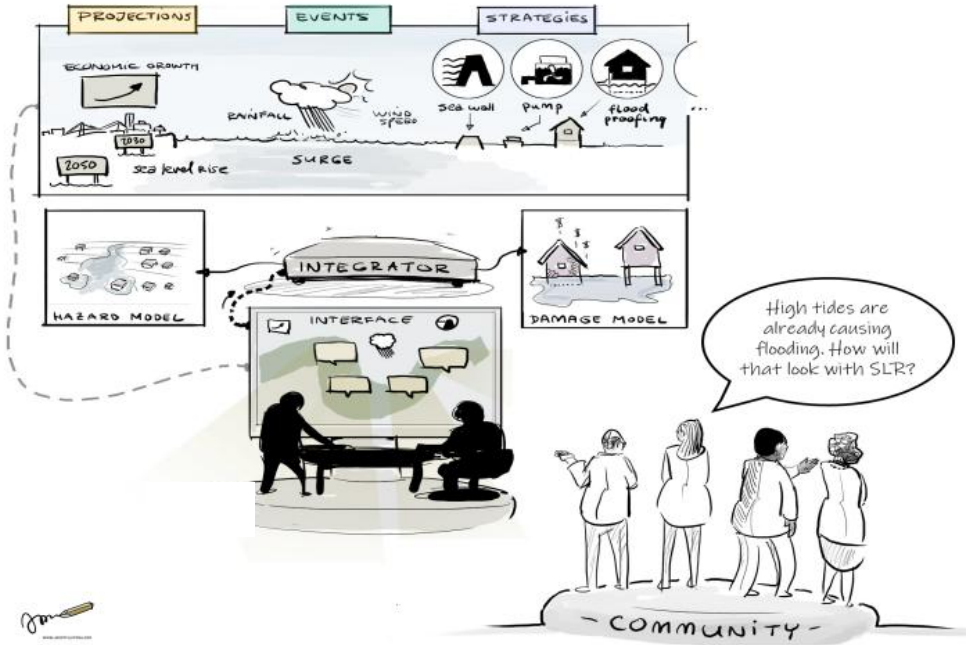
– *Adaptation modelling* is often a bottleneck for adaptation planning

Description

– Design a flexible, modular, expandable and transferable framework that can be used across sectors and disciplines
– Demonstrate applicability via flood risk & heat stress cases

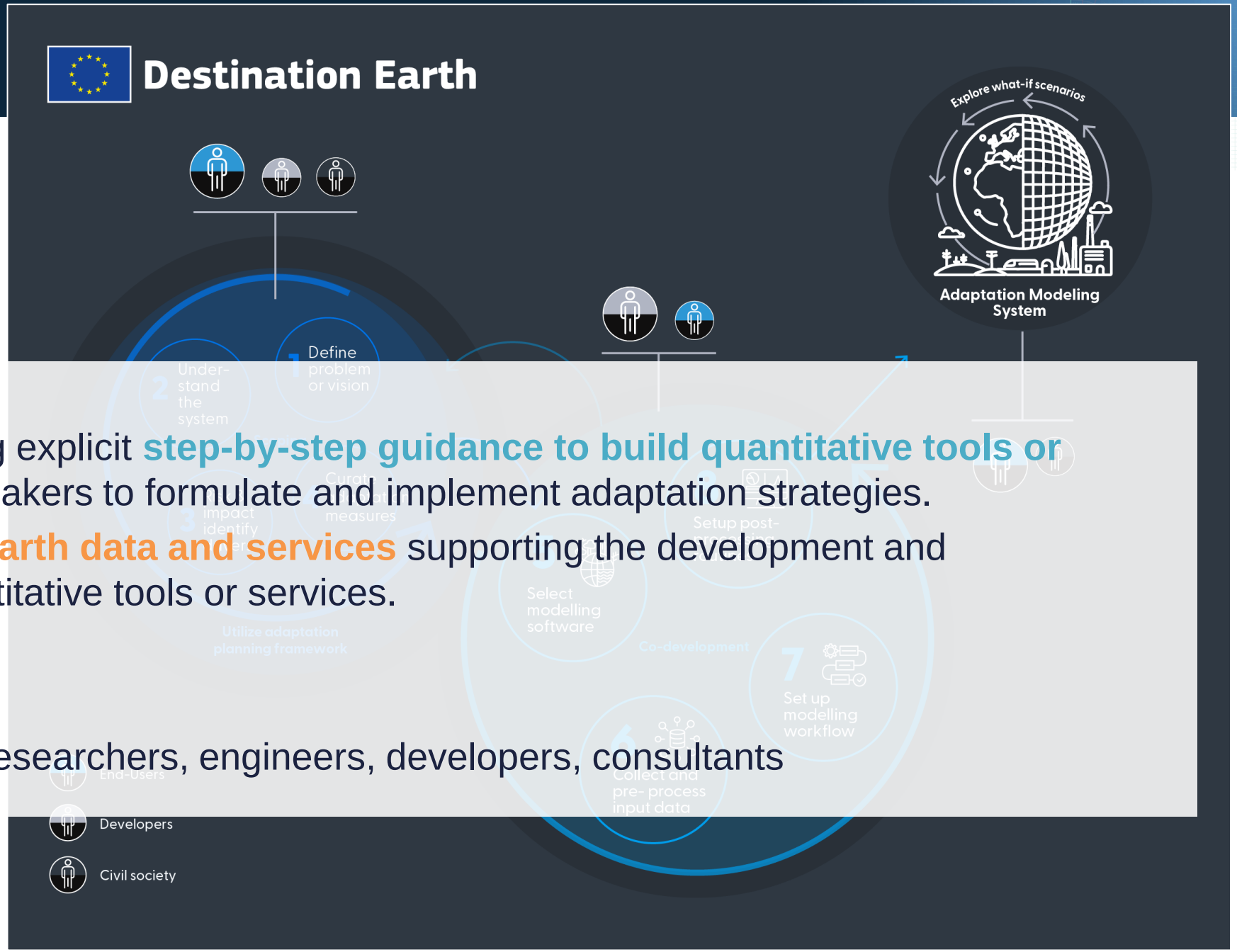
Users involved

– Project collaboration and stakeholder engagement for co-creation.



ECMWF Deltares

FINAL VERSION



What is it?

- A process guide offering explicit **step-by-step guidance to build quantitative tools or services** for decision-makers to formulate and implement adaptation strategies.
- A **link to Destination Earth data and services** supporting the development and implementation of quantitative tools or services.

Who is it for?

- **Technical users**, e.g. researchers, engineers, developers, consultants

ECMWF Deltares

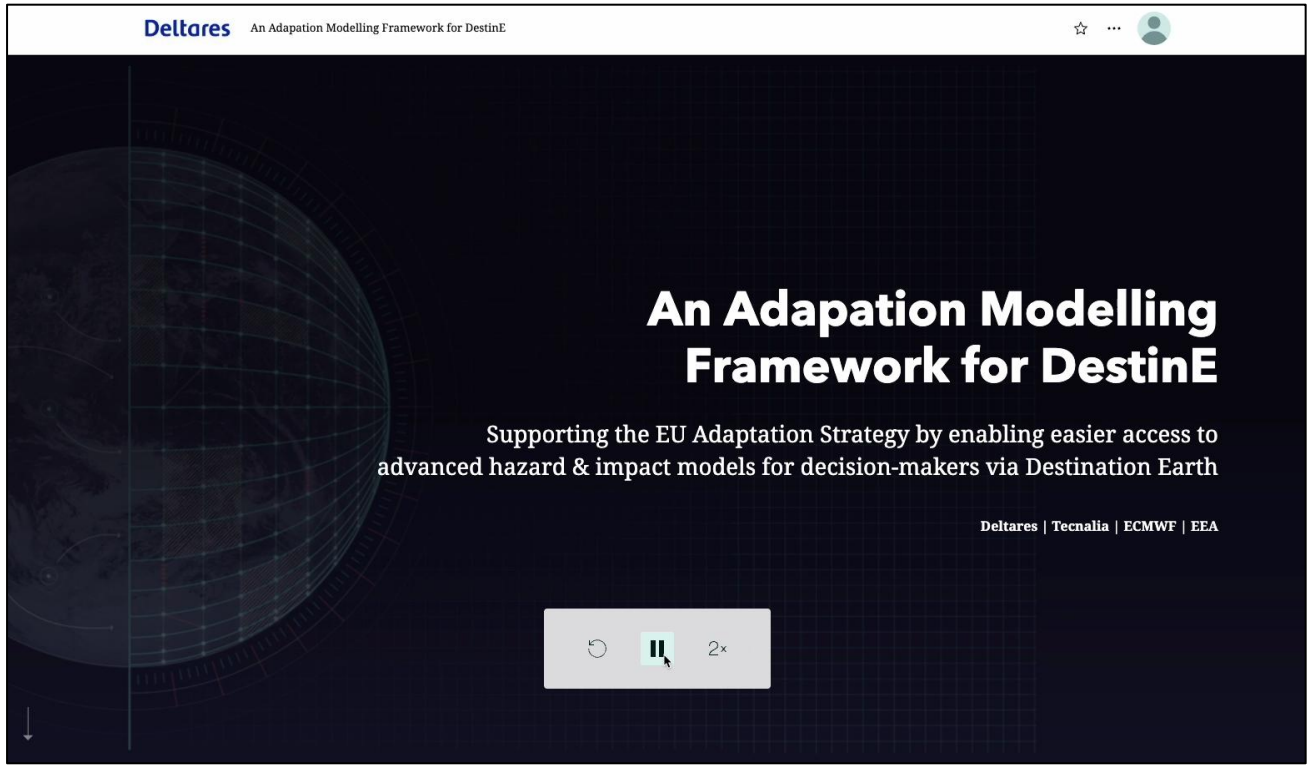
Destination Earth supports Phase 1 by **providing data & visualisation tools** for end-users and developers to **collaboratively scope** their adaptation modelling system

Destination Earth supports Phase 2 by providing the **data**, **tools**, and **computing infrastructure** needed to co-develop, integrate, and validate flexible climate adaptation models tailored to user needs.

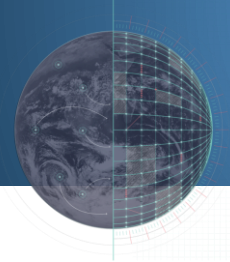
STORYMAP

A guide to building climate adaptation modelling systems with DestinE

- Provides an overview of the Generic Adaptation Modelling Framework
  - Describes its **purpose**, **target audience** and the adaptation modelling system **development process**
  - **Links** to relevant **Destination Earth** services and data supporting the development and implementation
  - **Demonstration** use cases for Flood Risk Management and Heat Stress and Health



← Check out the storymap here!



AI/ML AT DELTARES

- AI/ML is a powerful enabler to increase our impact - if used **responsibly**
- We recognize the **transformative potential** of AI/ML for modelling, forecasting, and decision support.
- **Trust and transparency** are essential — we advocate for **Trustworthy and Explainable AI**, and account for legal and ethical aspects (e.g., auditing, traceability, registration).
- Current **standards** and **best practices** for AI use in applied water/climate projects are still **emerging**.
- Key technical development include:
  - **Emulator** and hybrid modelling
  - **Reanalysis** datasets
  - AI-ready data **pipelines** and **workflow automation** (model training, operational forecasting)
  - Expert Knowledge Integration & **LLM** Upscaling (DeltaChat, FEWS Chat, Inventory of flood measures)
  - EO data extraction

AI FOR IMPROVING FLOOD FORECASTING

- Goal 2025:
  - **End-to-End AI-based Flood Forecast Demonstrators**
  - Aim at TRL 7 (pilot, demonstration)
  - From research to operational pilots
- From **Weather** to hazard
  - Integrate **ECMWF AIFS**
  - AI-downscaled NWP
- From **EO** to flood forecasting
  - Fuse SAR & optical EO and SFINCS flood maps
- From **Rivers** to **Coasts**
  - Hydrological, coastal hydrodynamics and flood inundation
- From process-based model to **Emulators**
  - Develop WFLOW, DFLOW, SFINCS fast AI emulators
- From post-processing to **uncertainty estimation**

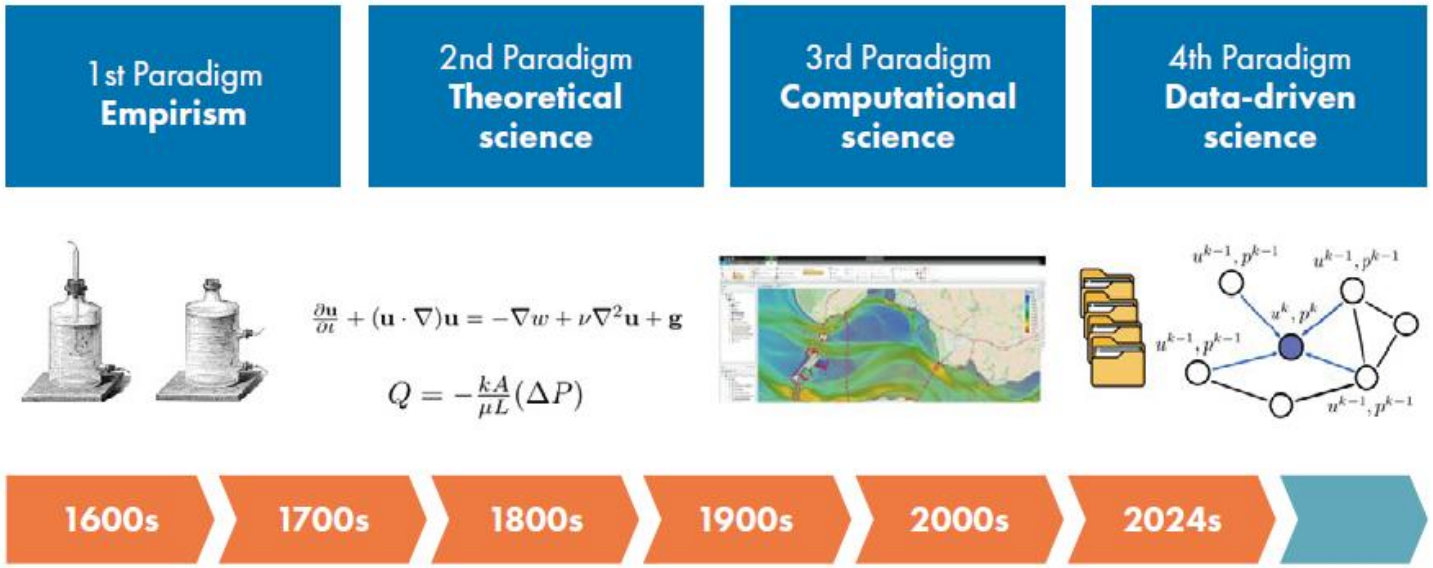
Image created with Microsoft Copilot using input terms: "artificial intelligence", "flooding" and "forecasting"

APPLICATION OF AI FOR WATER MANAGEMENT - BOOK

10.54677/VGVL7976

ECMWF Deltares

Introduction - History of Artificial Intelligence



Part 2 - Overview of relevant AI concepts and techniques

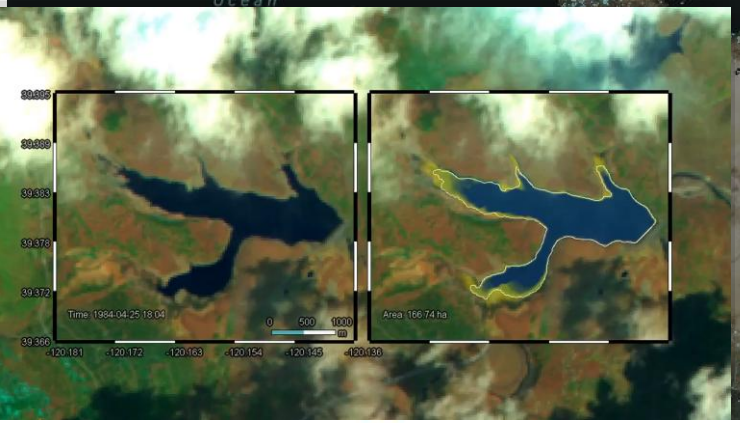
Part 3 - The application of AI in water management

- 3.1. Water Resources Management
- 3.2. Water Risk Management
- 3.3. Climate Change, Adaptation and Resilience Building
- 3.4. Water Quality Management

Part 4 - Ethics and responsible AI for Water Management

GLOBAL WATER WATCH

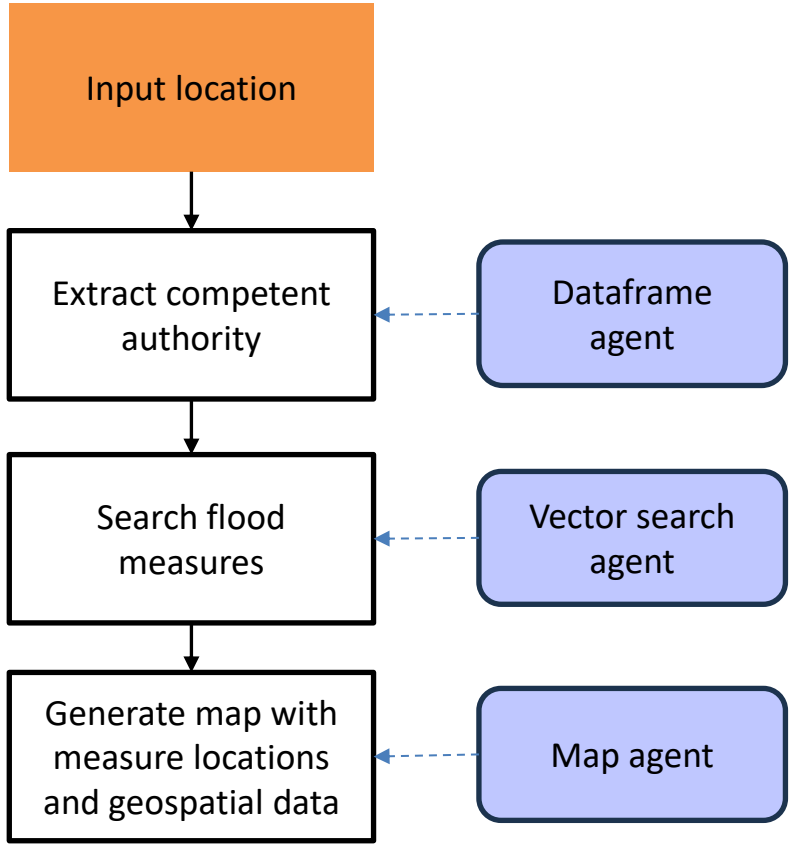
- Monitoring of surface water dynamics at planetary scale
- ~70k reservoirs in near real time
- Satellite image and AI



Deltares WORLD RESOURCES INSTITUTE WWF Google.org wps esa

AGENTIC WORKFLOW – INVENTORY OF FLOOD MEASURES

Develop an inventory of flood measures conducted by authorities at various levels in large catchment



ECMWF Deltares

THANK YOU!

CONTACT: KUN.YAN@DELTARES.NL

www.deltares.nl

info@deltares.nl

linkedin.com/
company/deltares

@deltares

facebook.com
/deltaresNL