

A world map showing the outlines of continents and a network of blue lines representing major river systems. The map is centered on the Atlantic Ocean, with North and South America on the left, Europe and Africa in the center, and Asia and Australia on the right. The title text is overlaid on the map.

Earth system forecasts for water resource decision making

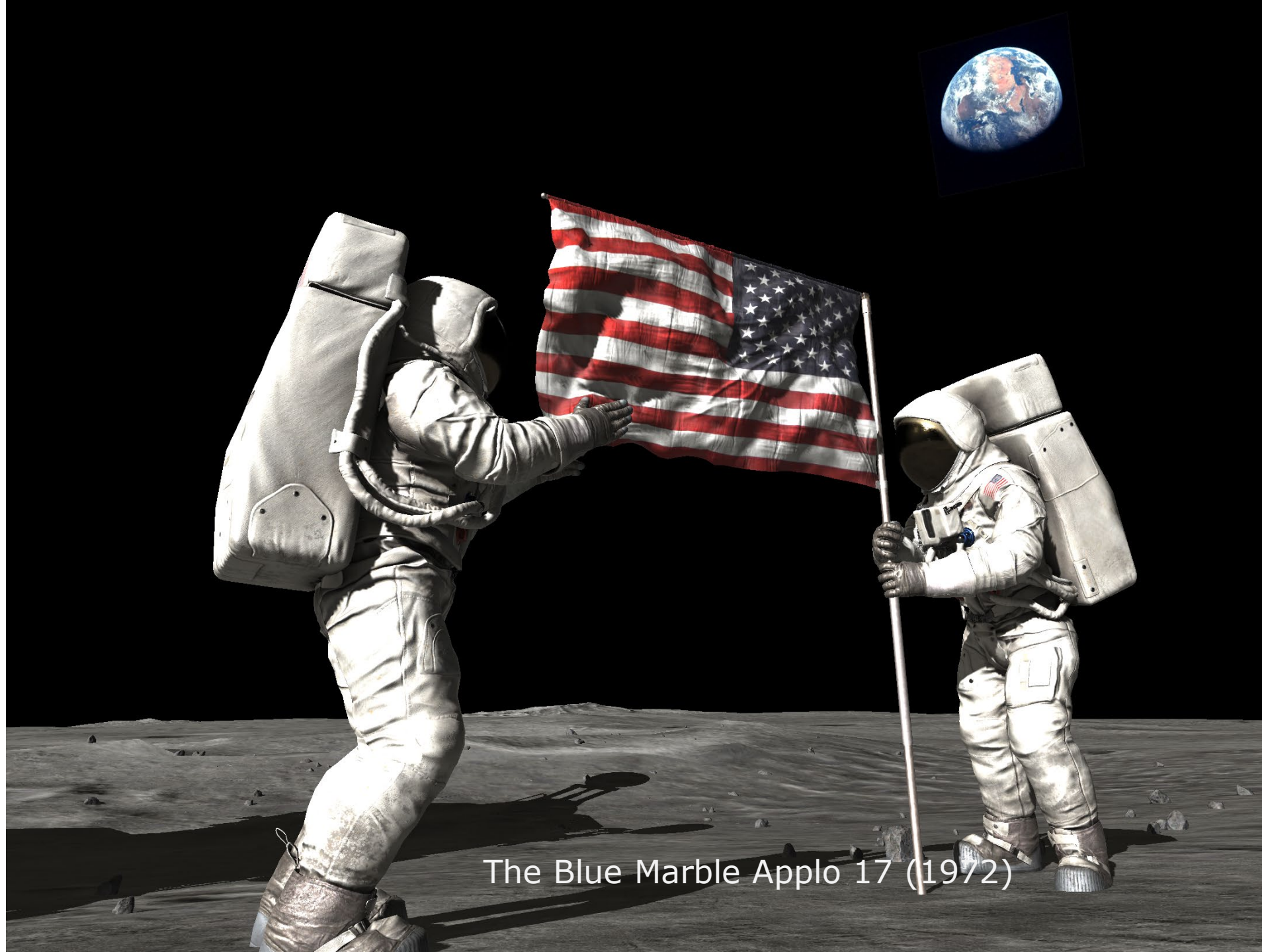
Florian Pappenberger, Rebecca Emerton, Shaun Harrigan, Calum Baugh,
Irina Sandu

@FPappenberger
@irinasandu_ec
@BeccaLizE
@shaunharrigan



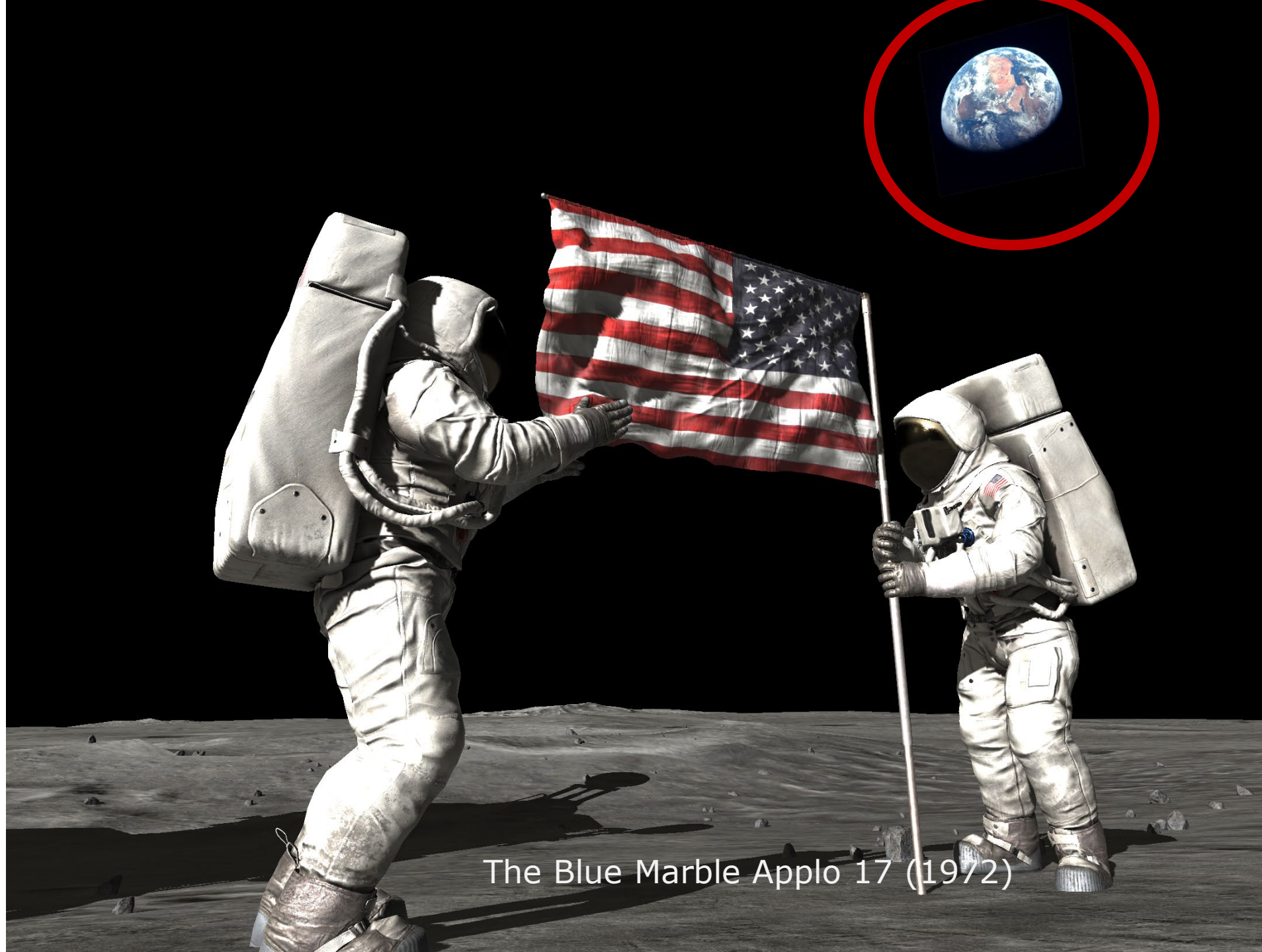
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**We have
come a long
way**



The Blue Marble Apollo 17 (1972)

**We have
come a long
way**

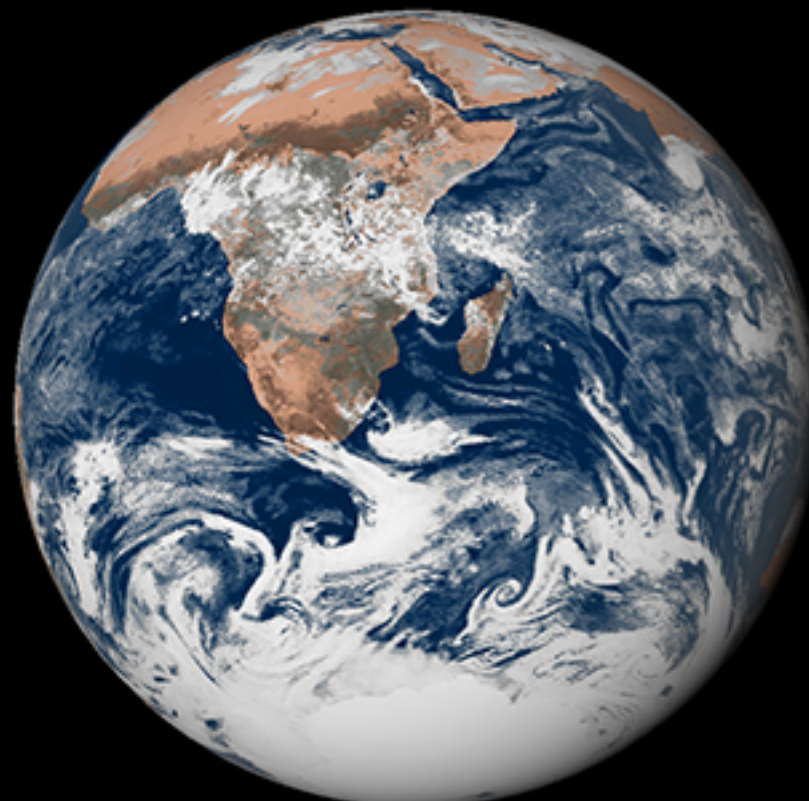


The Blue Marble Apollo 17 (1972)

We have
come a long
way



The Blue Marble Apollo 17 (1972)



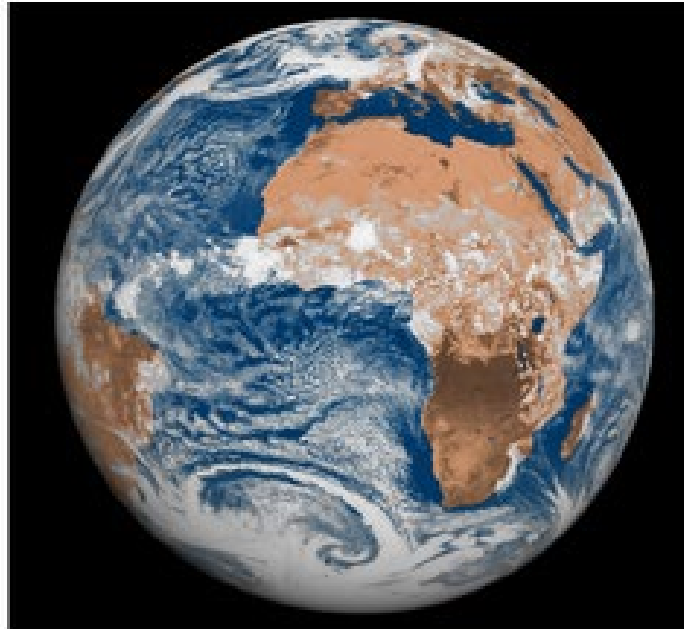
The Blue Marble with ECMWF IFS



We have come a long way



First Forecast (1985, ~200km)



Forecast today (9km)

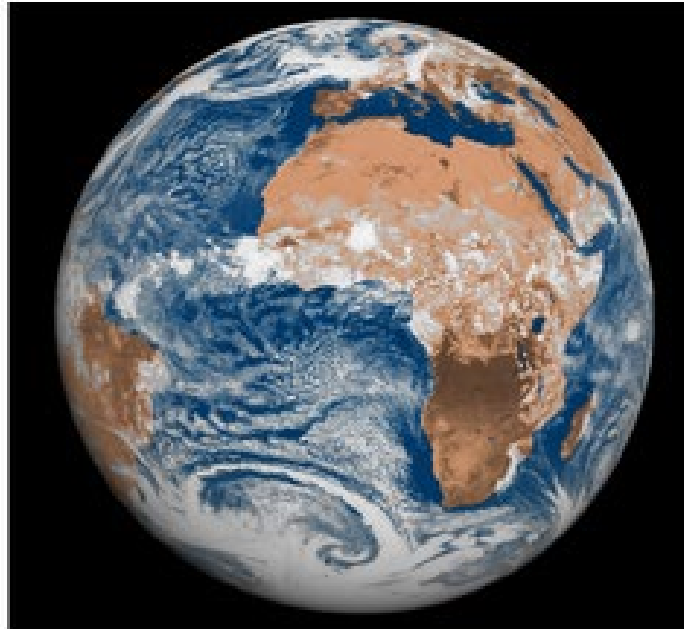


Meteosat-2

We have come a long way



First Forecast (1985, ~200km)



Forecast today (9km)



Meteosat-2

*Just announced: **ENS horizontal resolution increase: 9 km***

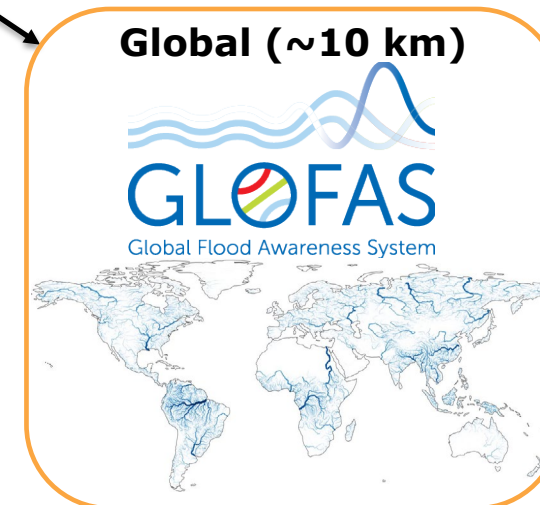
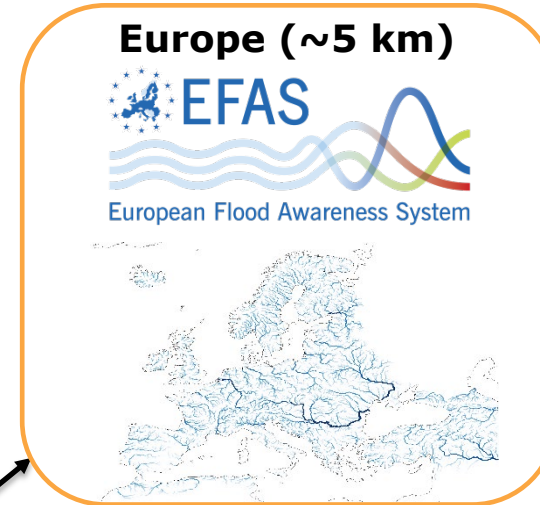
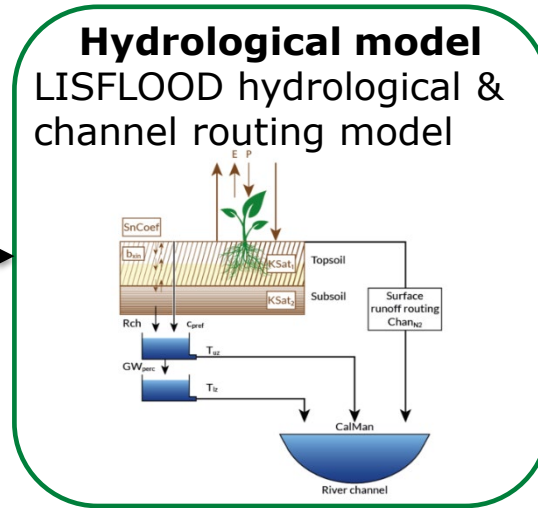
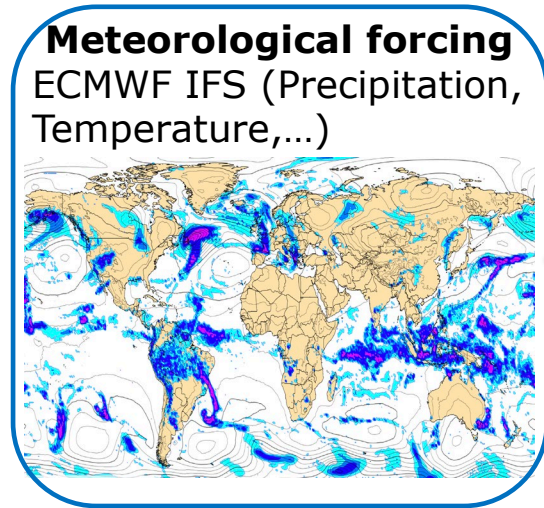
Daily extended-range ensembles
(100 members)

Multi-layer snow scheme

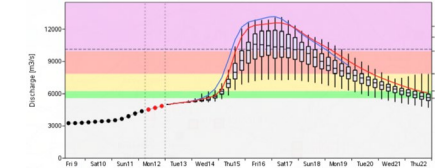
OOPS (multi-executable) operational implementation

Current capabilities for water resource decision making: EFAS & GloFAS

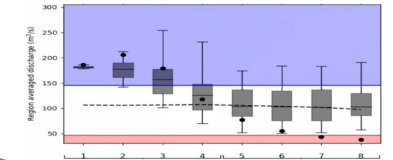
ECMWF is the computational centre for the Copernicus Emergency Management Service (CEMS) European & Global Flood Awareness Systems (**EFAS** & **GloFAS**)



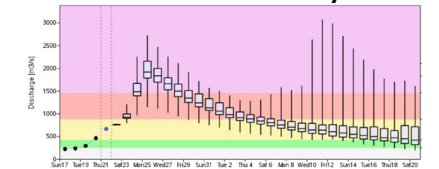
Flood forecasting
6hr; issued 2 per day out to 10-days



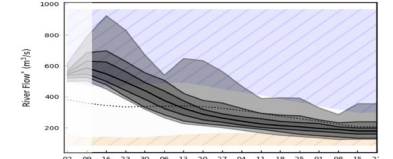
Seasonal forecasting
Weekly; issued 1 per month out to 8 wks



Flood forecasting
24hr; issued 1 per day out to 30-days

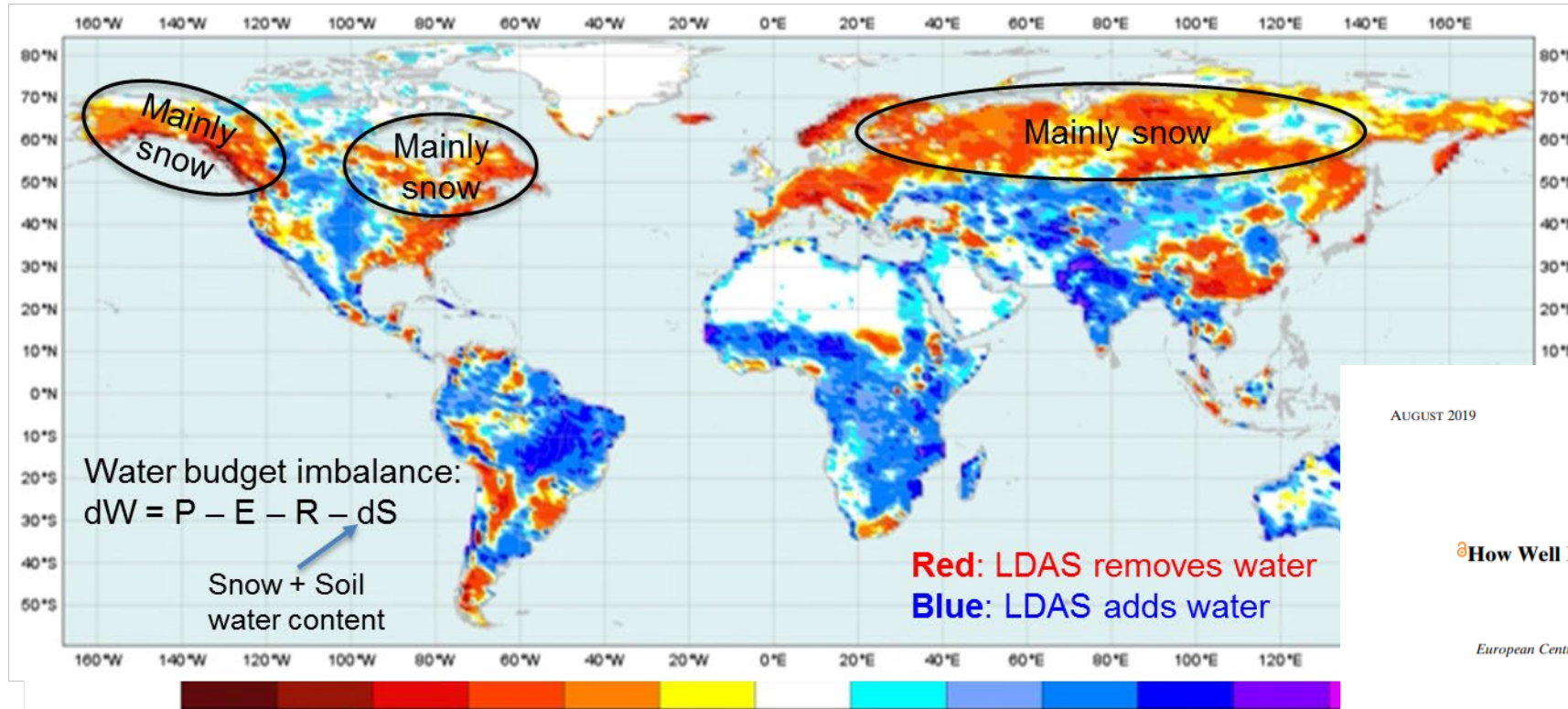


Seasonal forecasting
Weekly; issued 1 per month out to 16 wks



We have come a long way ...and yet...

Daily average water budget imbalance (mm), coming from snow and soil moisture increments



AUGUST 2019

ZSOTER ET AL.

1533

How Well Do Operational Numerical Weather Prediction Configurations Represent Hydrology?

ERVIN ZSOTER

European Centre for Medium-Range Weather Forecasts, and Department of Geography and Environmental Science, University of Reading, Reading, United Kingdom

HANNAH CLOKE

Department of Geography and Environmental Science, and Department of Meteorology, University of Reading, Reading, United Kingdom, and Department of Earth Sciences, Uppsala University, and Centre of Natural Hazards and Disaster Science, Uppsala, Sweden

ELISABETH STEPHENS

Department of Geography and Environmental Science, University of Reading, Reading, United Kingdom

PATRICIA DE ROSNAY, JOAQUIN MUÑOZ-SABATER, CHRISTEL PRUDHOMME, AND FLORIAN PAPPENBERGER

European Centre for Medium-Range Weather Forecasts, Reading, United Kingdom

(Manuscript received 27 April 2018, in final form 16 April 2019)

ABSTRACT

Land surface models (LSMs) have traditionally been designed to focus on providing lower-boundary conditions to the atmosphere with less focus on hydrological processes. State-of-the-art application of LSMs includes a land data assimilation system (LDAS), which incorporates available land surface observations to

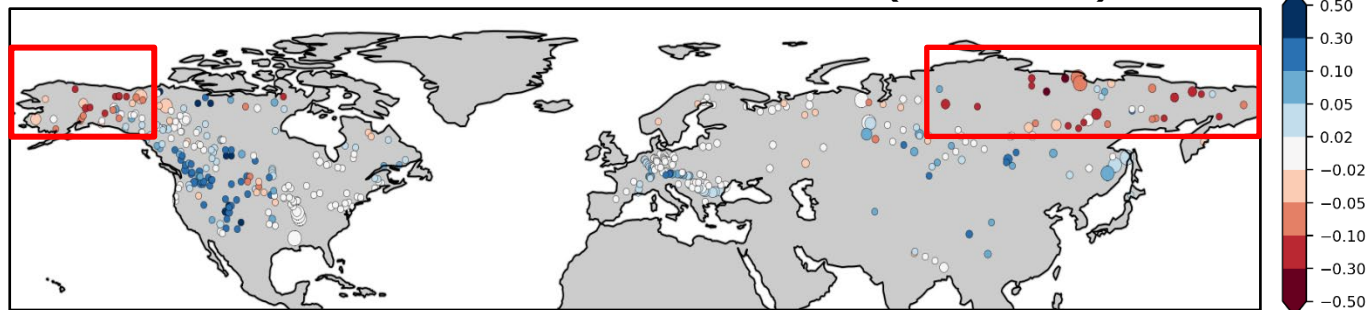
Diagnoses problems for peak river flow, particularly in snowmelt-dominated areas, caused by land-atmosphere coupling & data assimilation

Hydrological diagnostic of multi-layer snow scheme

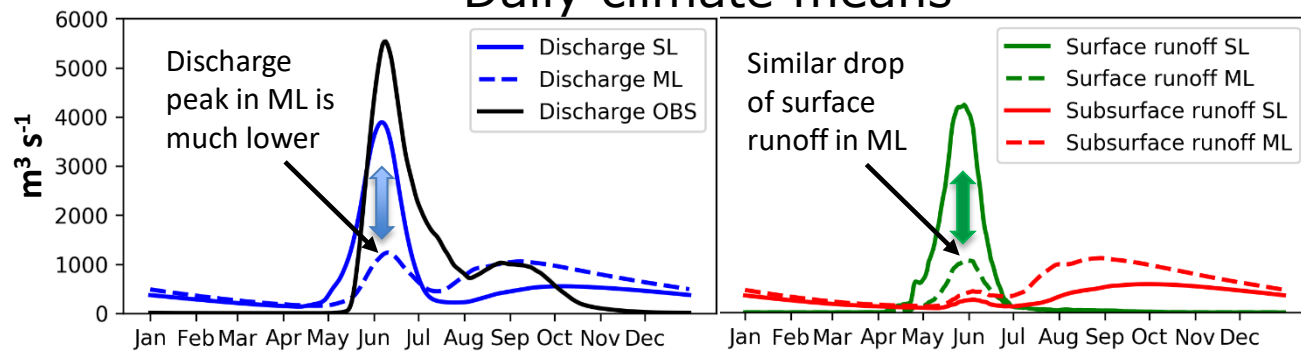
River discharge simulation compared for two snow schemes: single- (SL) vs Multi-layer scheme (ML)

General improvement in mid-latitudes except **in cold climates where skill greatly reduced**

Difference in the KGE score (ML – SL)



Daily climate means



Hydrological performance able to diagnose issues in permafrost parameters

Identification of **soil temperature issues** and resulting water infiltration

Sensitivity analysis enabled to identify **optimal parameterization consistent with hydrological processes**

Towards a full integration of Earth-system & impact-sector modelling

Earth-system &
impact-sector modelling

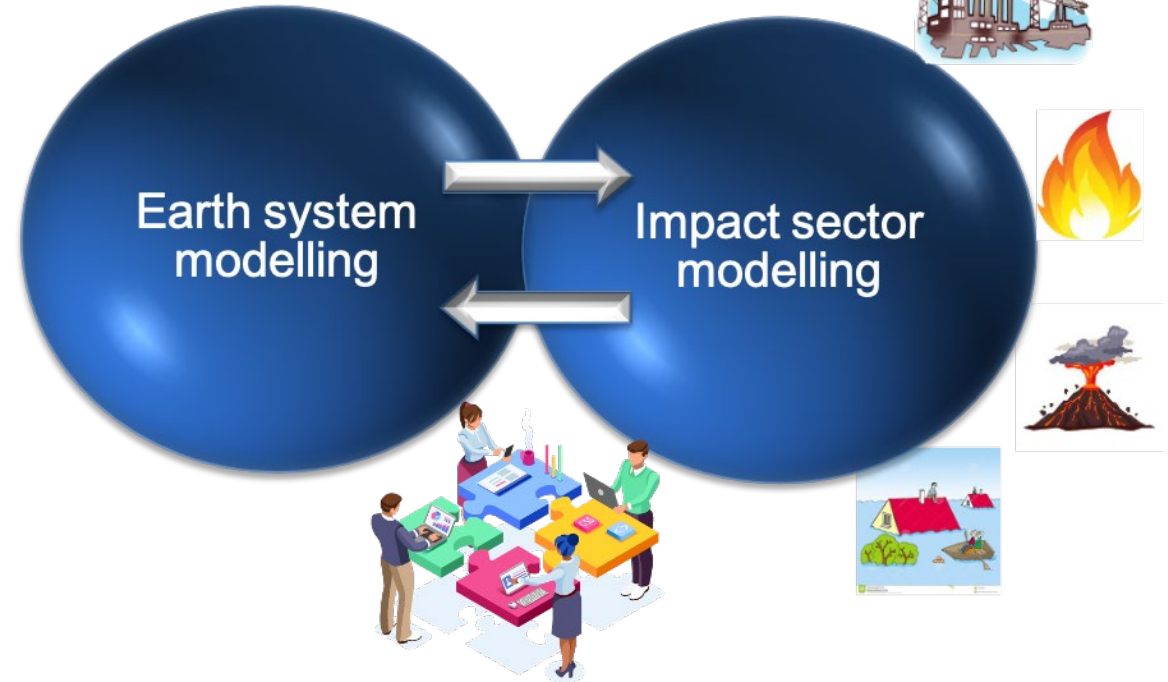
Earth system
modelling



Impact sector
modelling



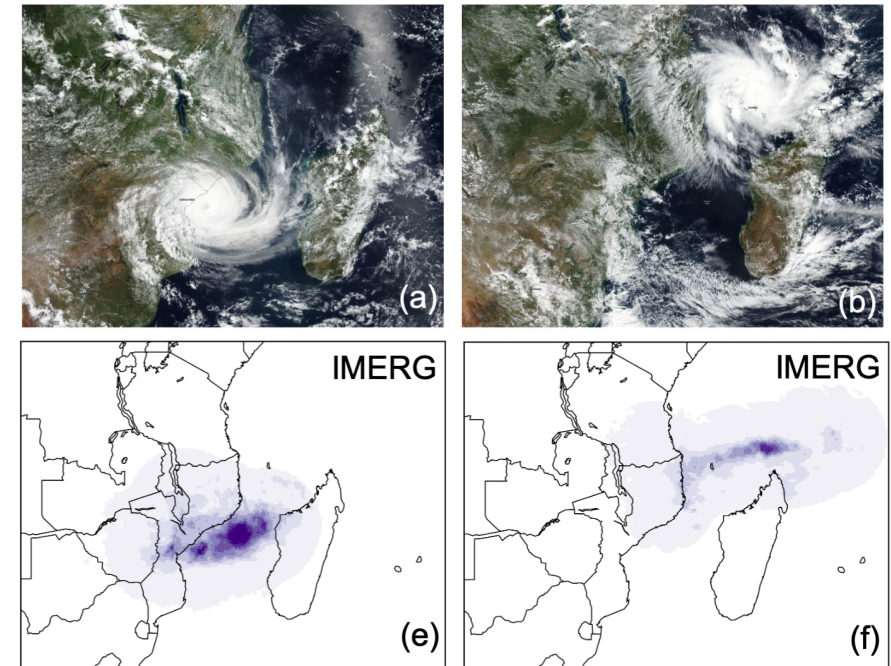
Integrated Earth-system &
impact-sector modelling



Codesign with users

Connecting global forecasts to local decision-making

- Co-production / co-design of forecasting systems with the applications sector is key
- GloFAS development is often informed by feedback from users and decision-makers
- Examples of collaborations towards use of global forecasts for local action:
 - GloFAS collaboration with Bangladesh FFWC; GloFAS used to extend lead time for pre-activation up to 15 days ahead; local forecasts used for detail & decision-making up to 3 days ahead
 - GloFAS collaboration with UoR and Red Cross to develop and improve forecasts for humanitarian action
 - DFID/FCDO flood bulletins for tropical cyclones, using ECMWF meteorological & GloFAS forecasts to provide information on local flood hazard and risk
 - GEOGloWS ECMWF streamflow service for local applications e.g. urban flooding in Tel Aviv
 - GloFAS new Global Flood Monitoring service
- Collaborative research projects, e.g. TAMIR and I-CISK

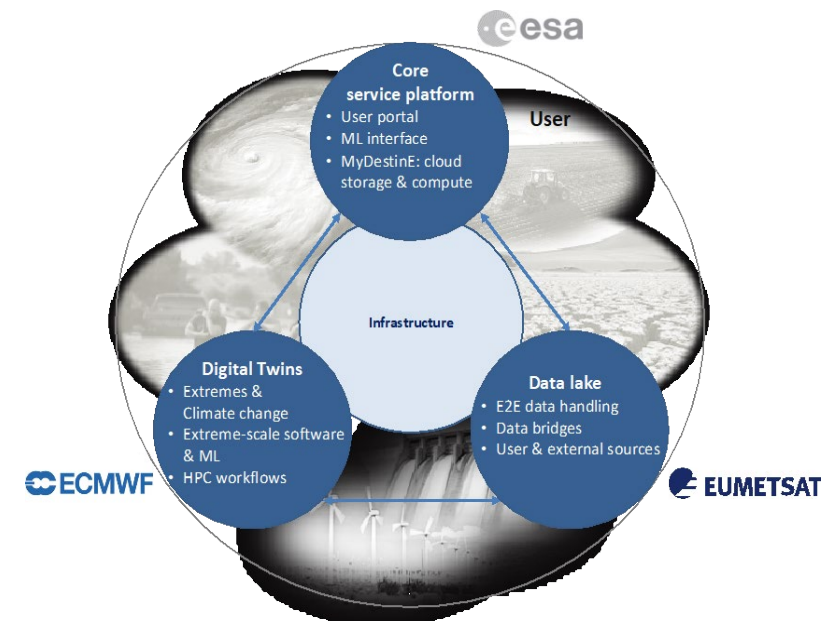


European's Commission Destination Earth (DestinE) programme

Aim and goals

Develop a **very high precision digital model of the Earth (Digital Twin)** of the Earth to monitor and simulate natural and human activity and to develop and test scenarios for

- more sustainable development and achievement of the EU green deal objectives
- saving lives
- avoiding large economic downturns
- **support EU policy-making and implementation**
- reinforce Europe's industrial and technological capabilities in advanced computing, simulation, modelling, predictive data analytics and Artificial intelligence (AI)



2021-2023

- Operational cloud-based platform
- First two digital twins

2023-2025

Platform integrates the next operational digital twins and offers services to public sector users

2025-2027+

Towards a full “digital twin of the Earth” through a convergence of multiple digital twins on the platform

DestinE partnership

DestinE will engage in continuous partnerships to co-evolve its components and deliverables → complementarity!

- Science
- Technology
- Services
- Infrastructures



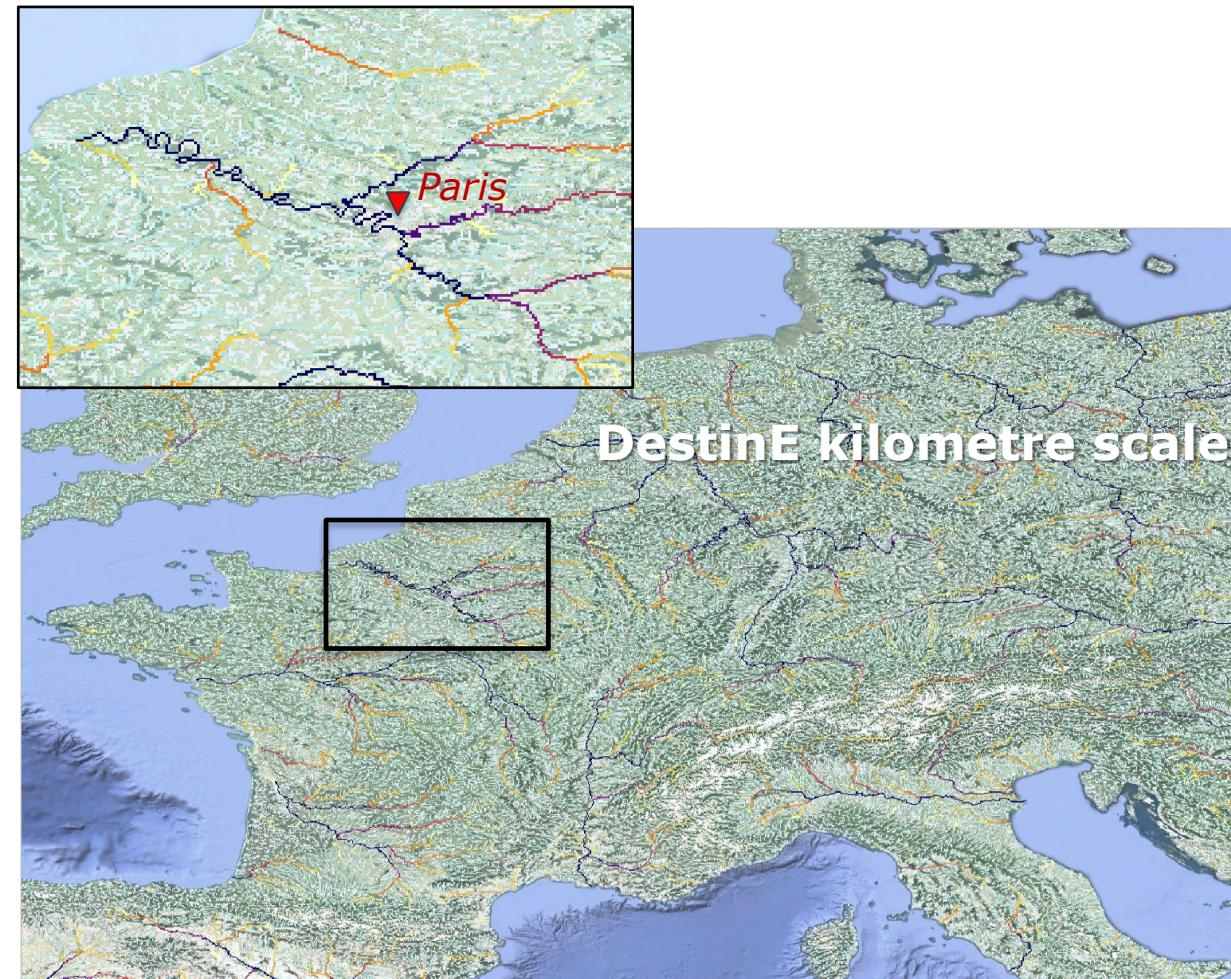
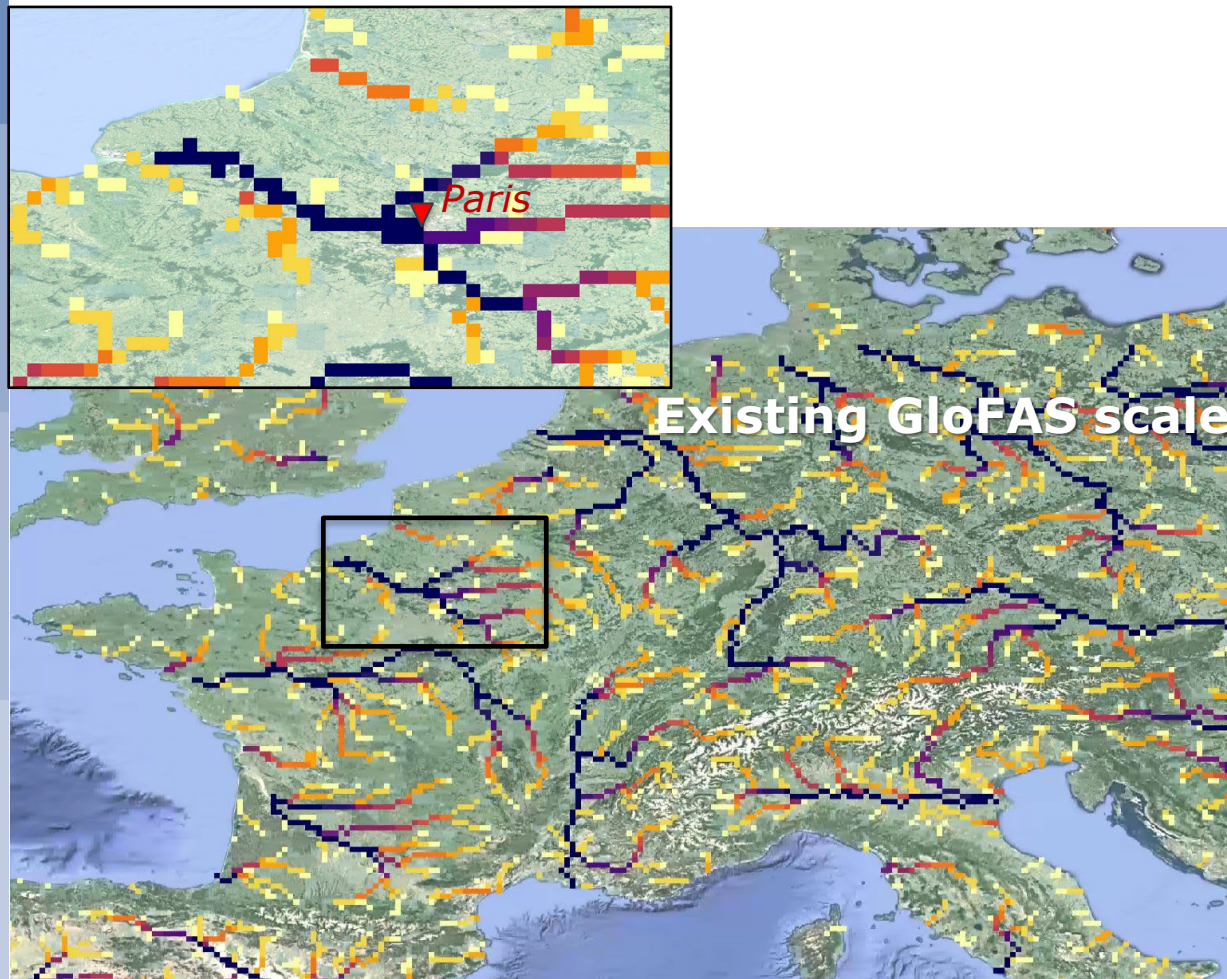
ECMWF Member States

Increasing the spatial resolution: from 0.1 degree to 1 arcmin (~ 1.6 km)

Improve modelling of the drainage network

Improve **representation of smaller catchments** and in flood peak timing

Based on MERIT Hydro (Yamazaki et al. 2019)



Towards Digital Twins of the Earth-system

- Florian Pappenberger, Rebecca Emerton, Shaun Harrigan, Calum Baugh, Irina Sandu

@FPappenberger

@irinasandu_ec

@BeccaLizE

@shaunharrigan