

# Earth system forecasts for water resource decision making

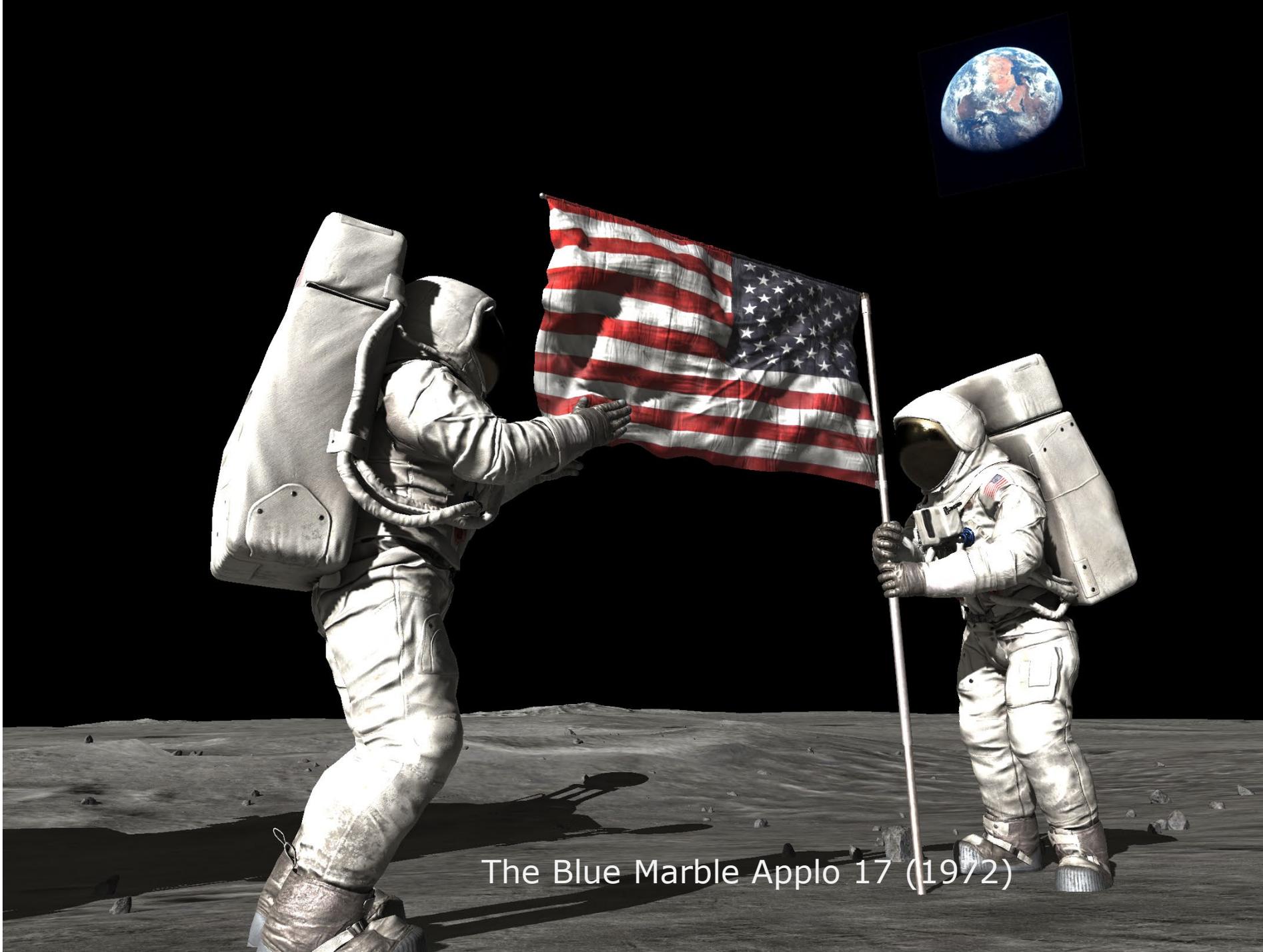
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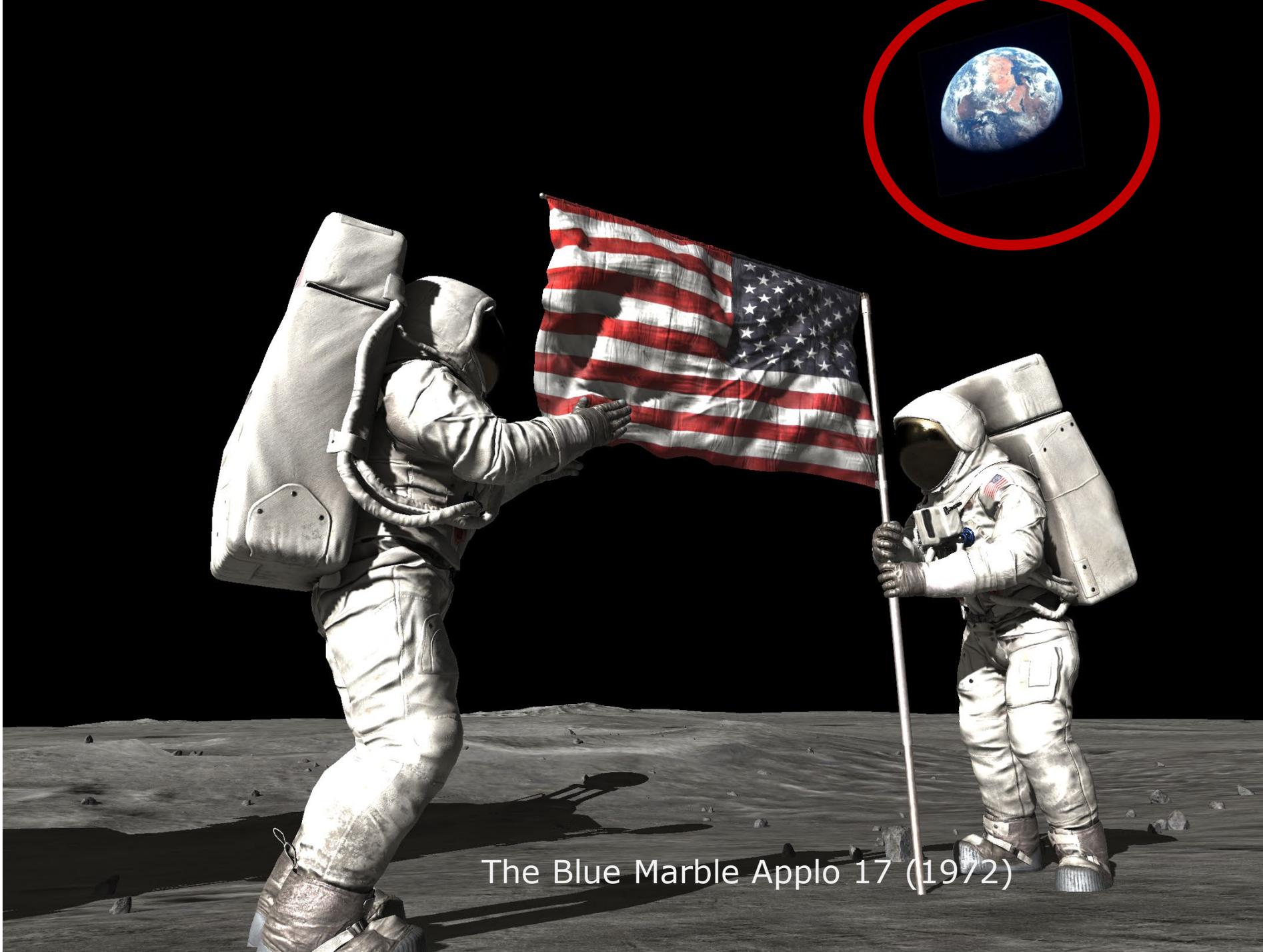
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**We have  
come a long  
way .....**



The Blue Marble Applo 17 (1972)

**We have  
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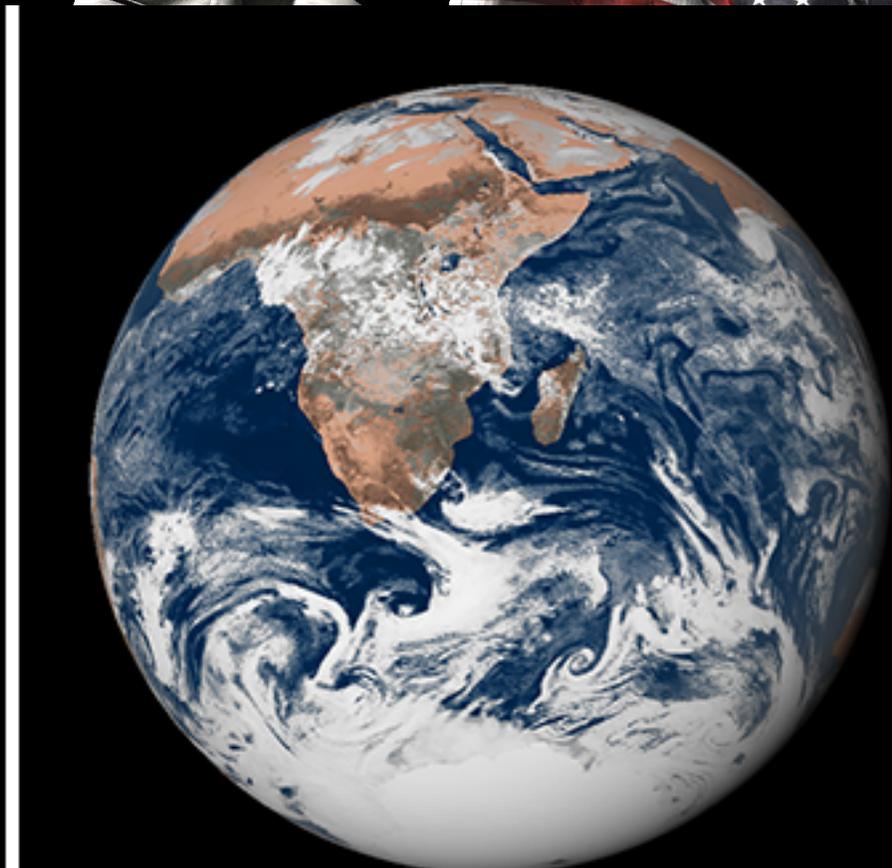


The Blue Marble Applo 17 (1972)

We have  
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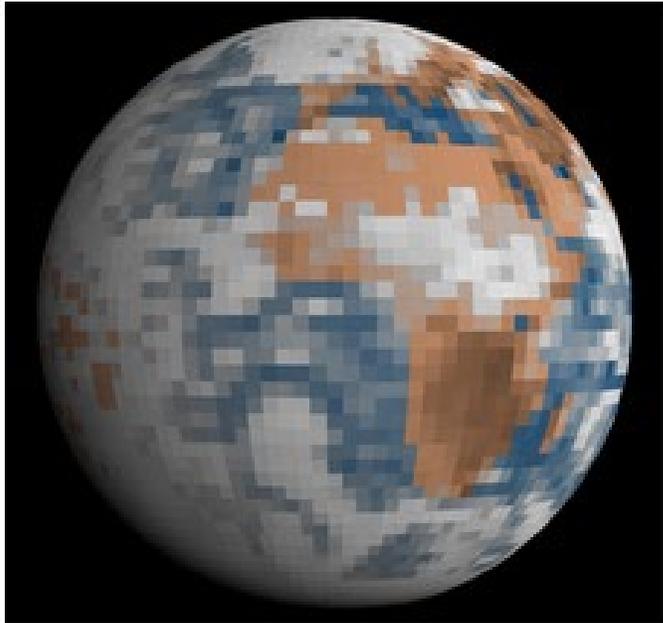
The Blue Marble Apollo 17 (1972)



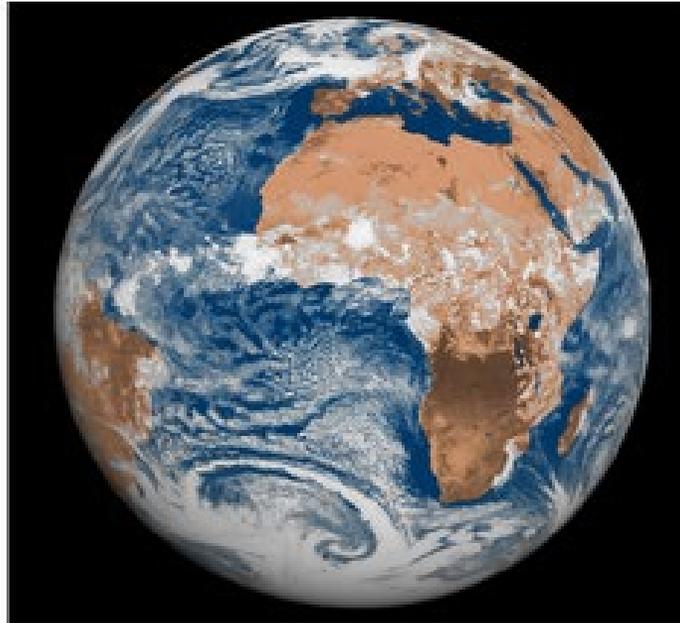
The Blue Marble with ECMWF IFS



# We have come a long way .....



First Forecast (1985, ~200km)



Forecast today (9km)

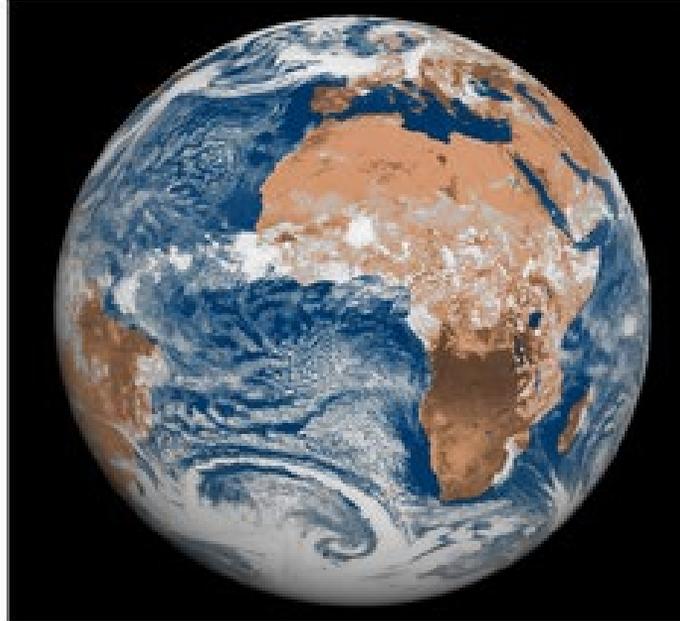


Meteosat-2

# 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**)

**Meteorological forcing**  
ECMWF IFS (Precipitation, Temperature,...)

**Hydrological model**  
LISFLOOD hydrological & channel routing model

**Europe (~5 km)**

**EFAS**  
European Flood Awareness System

**Global (~10 km)**

**GLOFAS**  
Global Flood Awareness System

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

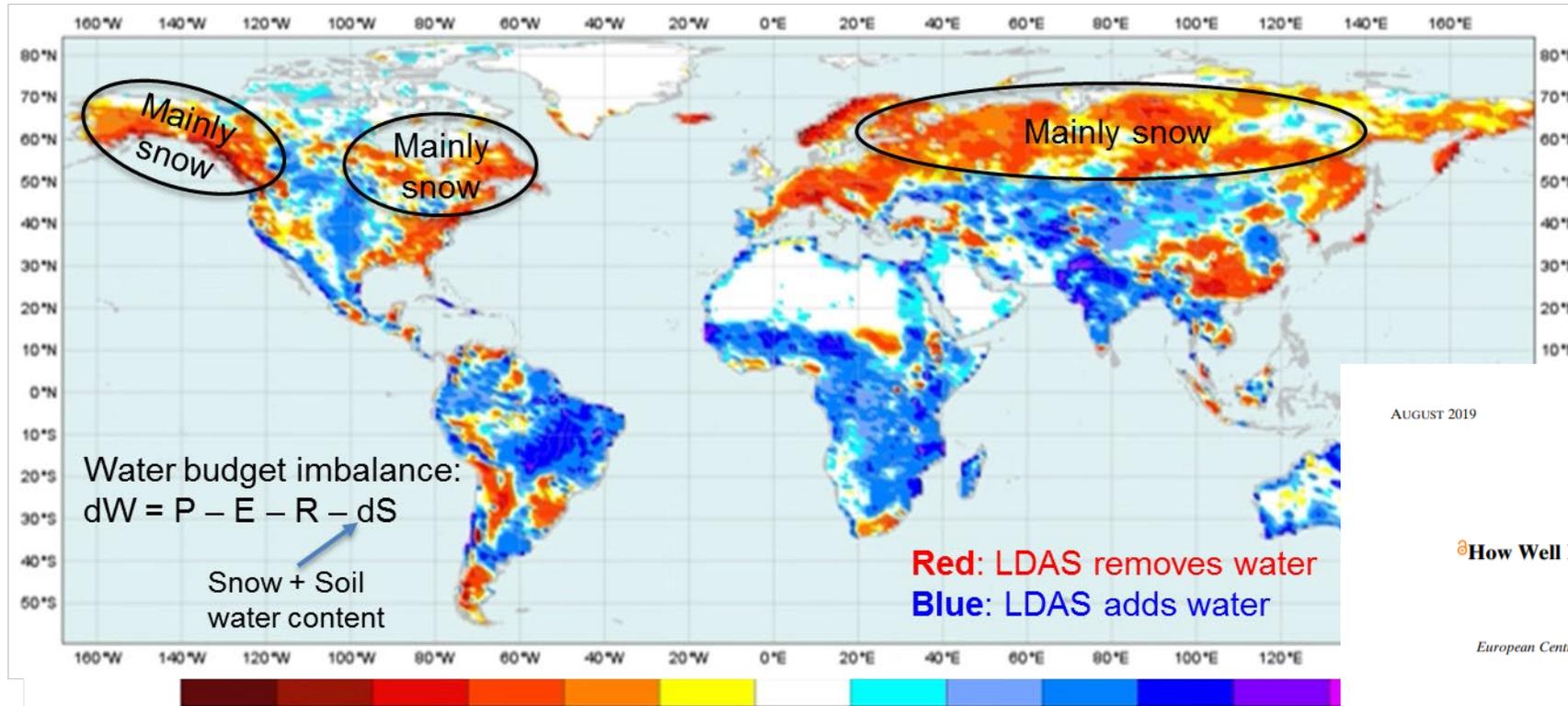
**Seasonal forecasting**  
Weekly; issued 1 per month out to 8 wks

**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



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

AUGUST 2019

ZSOTER ET AL.

1533

## How Well Do Operational Numerical Weather Prediction Configurations Represent Hydrology?

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

### ABSTRACT

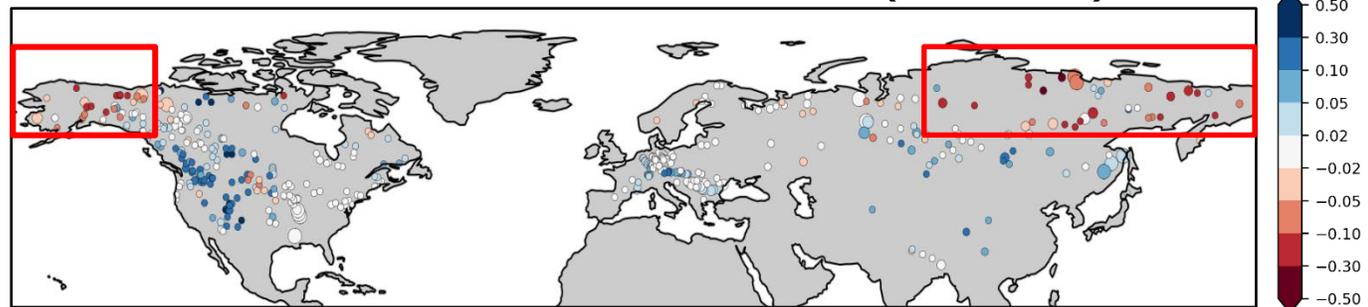
Land surface models (LSMs) have traditionally been designed to focus on providing lower-boundary conditions to the atmosphere with less focus on hydrological processes. State-of-the-art application of LSMs includes a land data assimilation system (LDAS), which incorporates available land surface observations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

# Hydrological diagnostic of multi-layer snow scheme

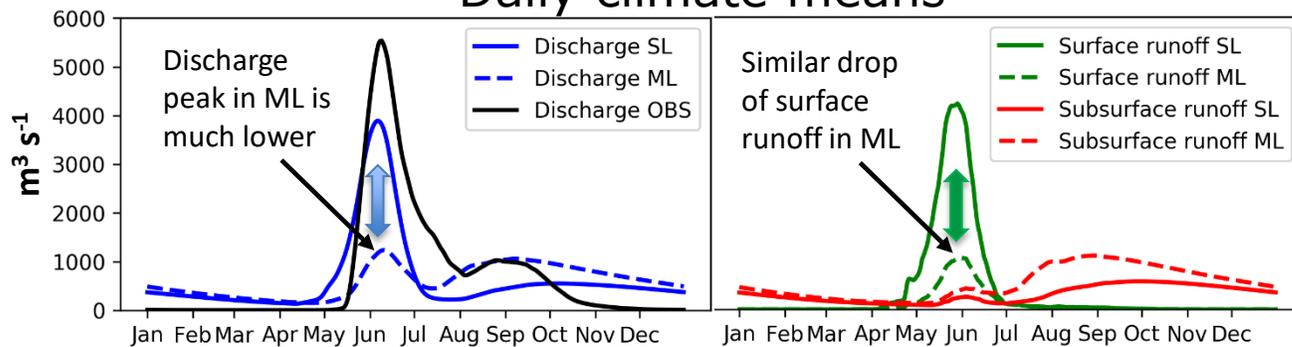
River discharge simulation compared for two snow schemes: single- (SL) vs Multi-layer scheme (ML)

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

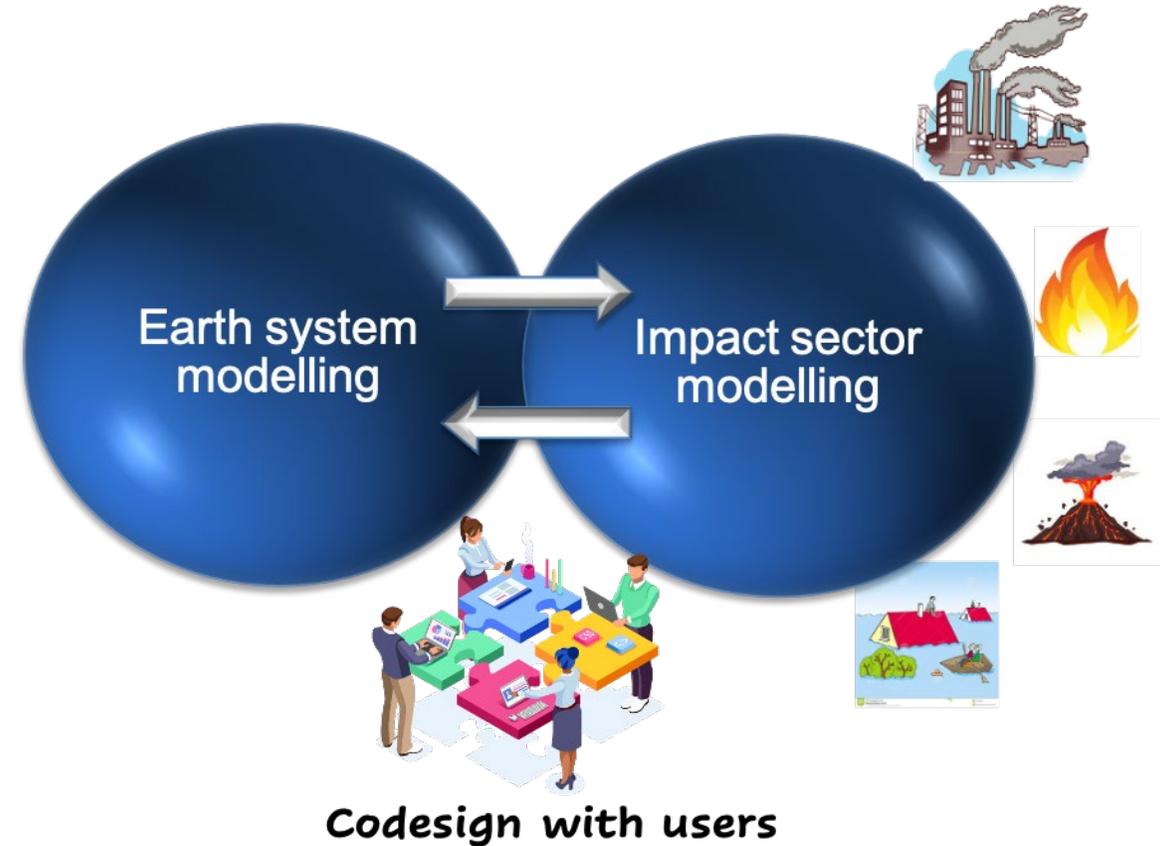
Earth system modelling



Impact sector modelling

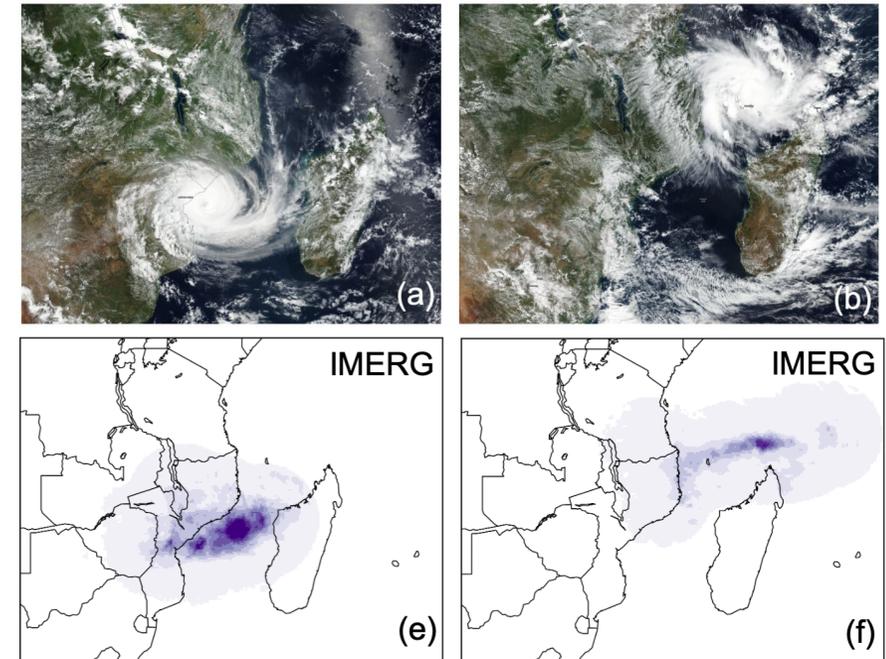


Integrated Earth-system & impact-sector modelling



# 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

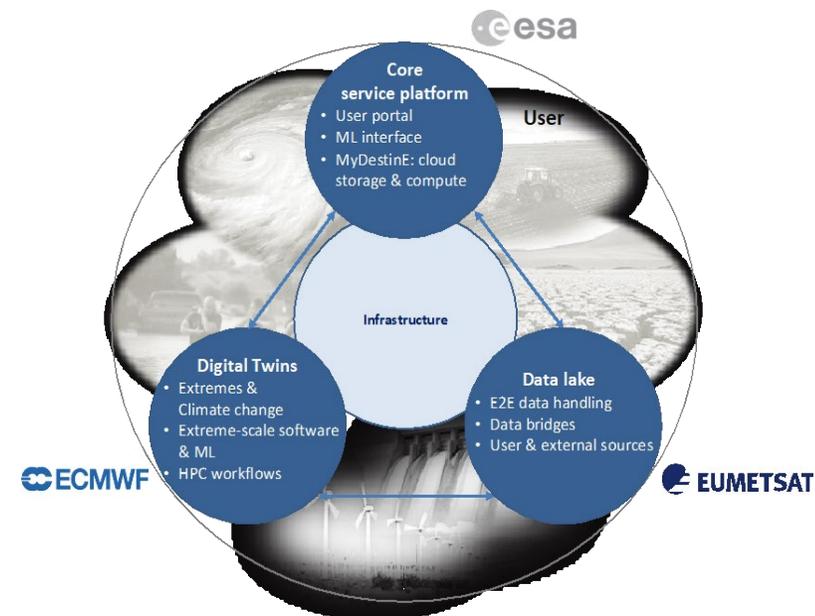


# European's Commission Destination Earth (DestinE) programme

## 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

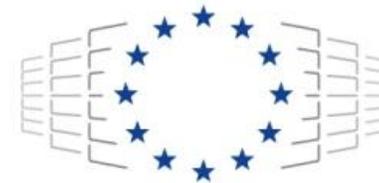
# DestinE partnership

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

- Science
- Technology
- Services
- Infrastructures



**EUMETSAT**



**EuroHPC**  
Joint Undertaking



WORLD  
METEOROLOGICAL  
ORGANIZATION



**TCI**  
TransContinuum Initiative



European  
Commission

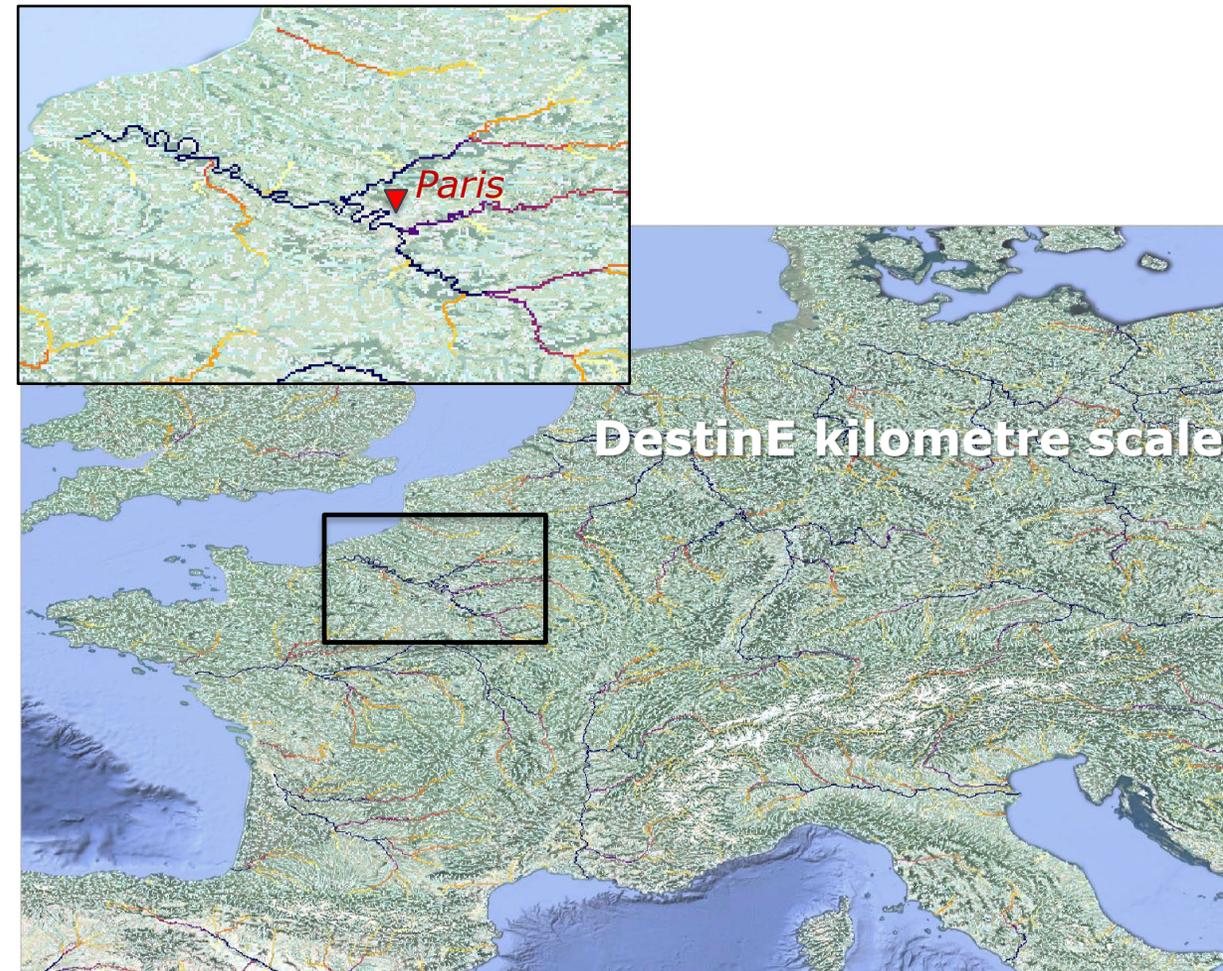
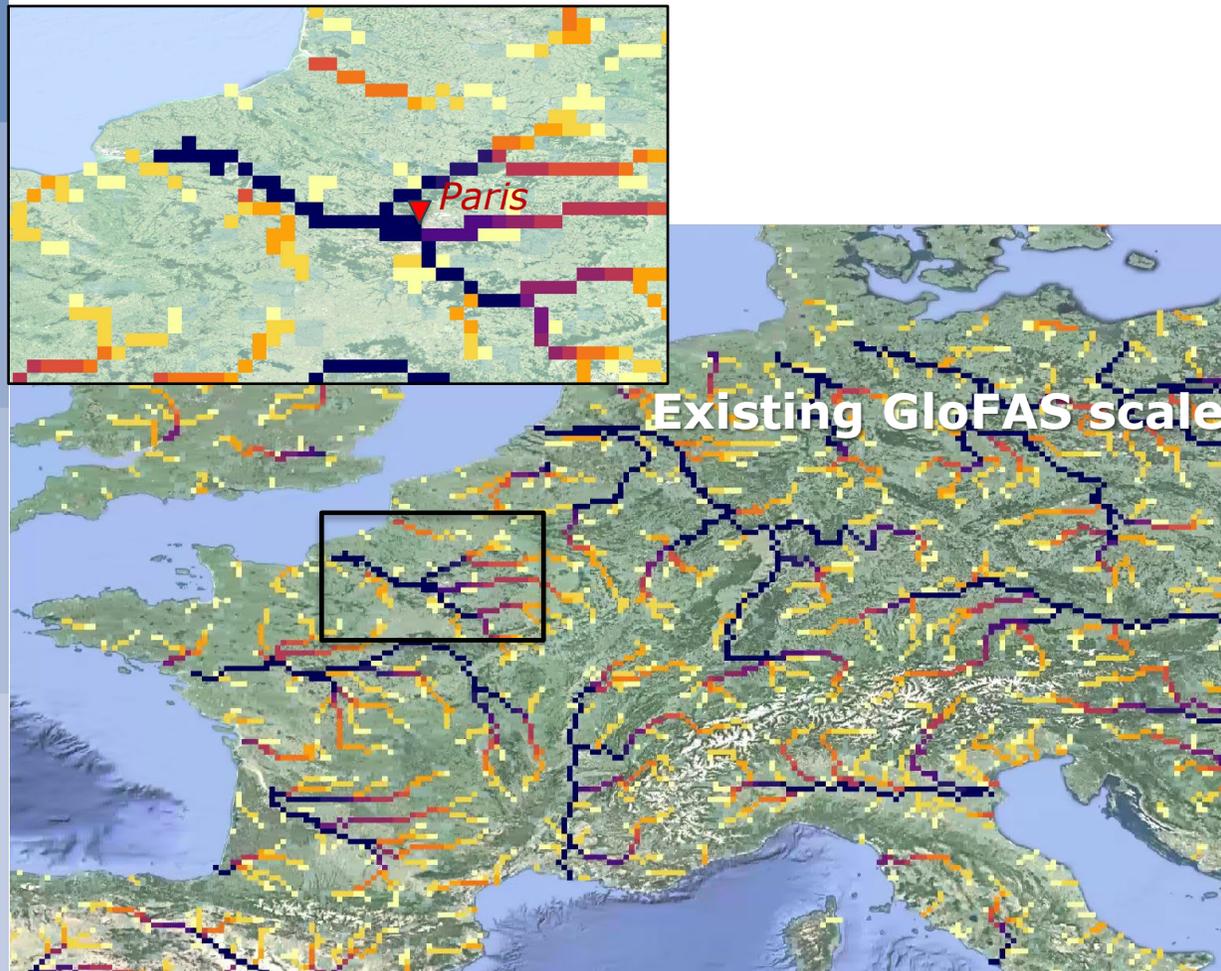
*ECMWF Member States*

# Increasing the spatial resolution: from 0.1 degree to 1 arcmin ( $\sim 1.6$ 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

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