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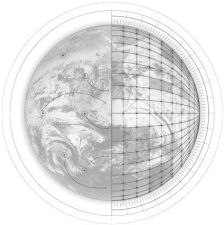
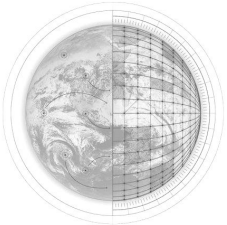


Destination Earth On-Demand Extremes Digital Twin

Roger Randriamampianina, Met Norway
and the
On-Demand Extremes Team

EWGLAM Meeting, 26-29 Sept. 2022, Brussels



Outline:

- Digital Twins
- Team formation and On-Demand Extremes design
- On-Demand Extremes concept
- On-Demand Extremes components
- Capability demonstration

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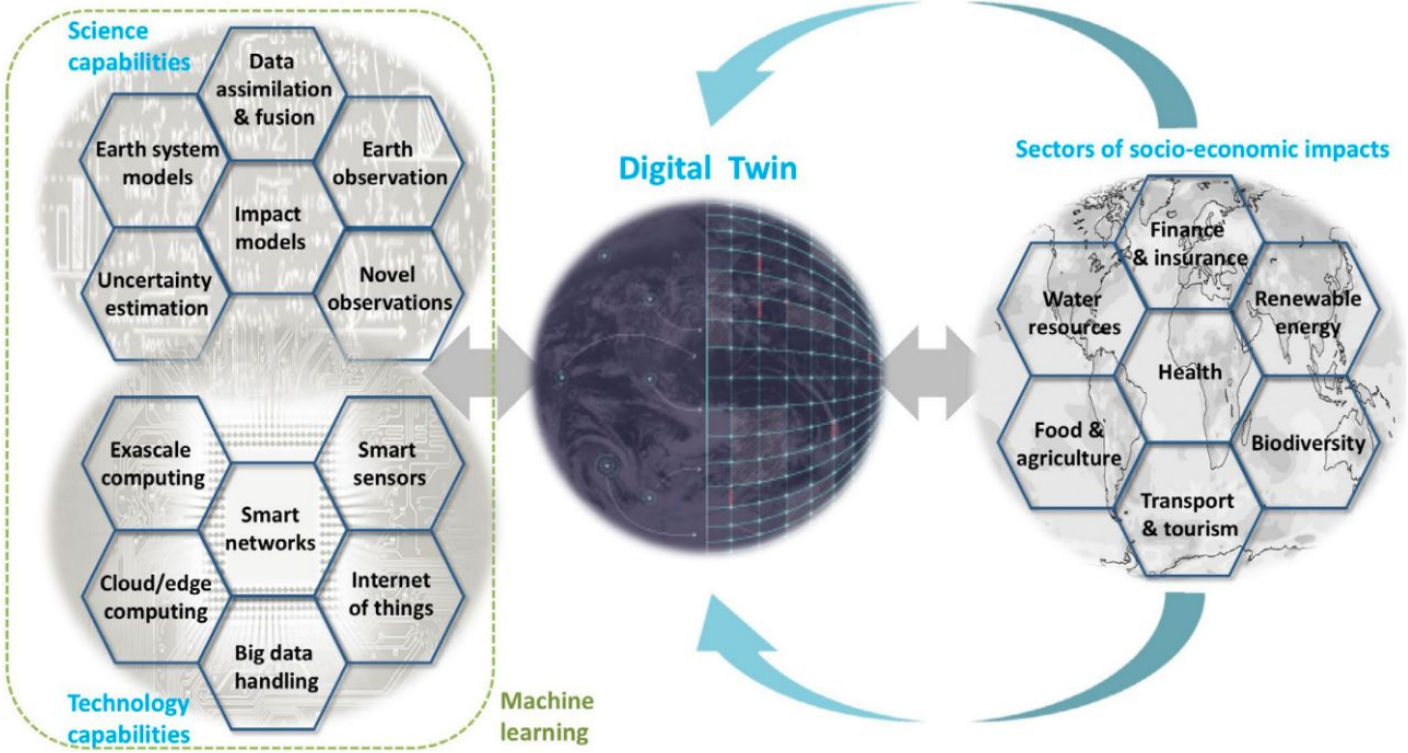

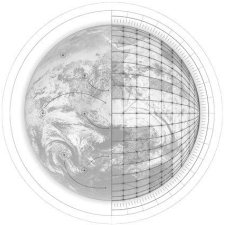

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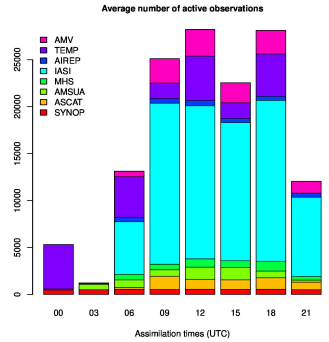
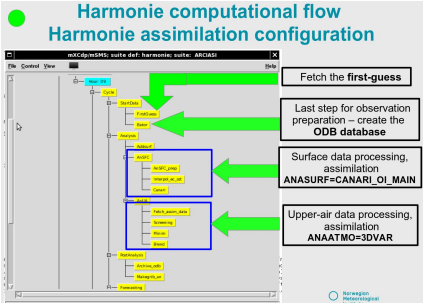
The requirements are, among others:

1) Pan-European observation processing
2) Configurable, flexible and scalable workflows
3) Reliable high-performance computing (EuroHPC)
4) Value demonstration
5) Interfacing with ECMWF DTE, DEDL, DESP as required





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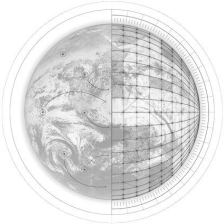

On-Demand Extremes DT design and Team formation

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: Co-design & co-development & co-production

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Global DE system

On-demand extremes impact system

On-demand extremes core system

DE_33000: Project coordination & management

DE_33010: Software support office

DE_33020: Code adaptation to GPU & Accelerators

DE_33030: Hyper-resolution model setup

DE_33040: Post-processing framework

DE_33050: Dataflow design and implementation

On-demand extremes production system

Other impacts: Ex. Forest fire, Agriculture

DE_33060: Impact modelling: Hydrology

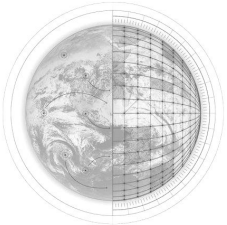
DE_33070: Impact modelling: Air quality

DE_33080: Impact modelling: Renew. energy

Civil protection
Road/Marine Safety
Social impact

Management Team

E. Gérard; R. Randriamampianina; K. P. Nielsen
C. Fischer; C. Wittmann; P. Termonia; L. Auger



DT environment

Software support service office (DE_33010)
J. Kristiansen; P. Manninen

DT development & tuning

Code adaptation (DE_33020)
P. Termonia; N. Sokka

Hyper-High resolution model setup (DE_33030)
L. Auger; C. Clancy

DT production

Post-processing (DE_33040)
A. Kann; S. Vannitsem

Dataflow design & implementation (DE_33050)
X. Yang; U. Andrae

Impact modelling

Hydrology (DE_33060)
U. McKnight; B. Arheimer

Air quality (DE_33070)
M. Hirtl; M. Sofiev; G. Velders

Renew. Energy (DE_3308)
N. Theeuwes; K. P. Nielsen

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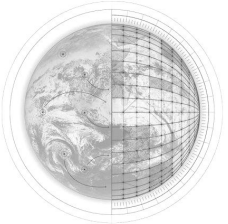
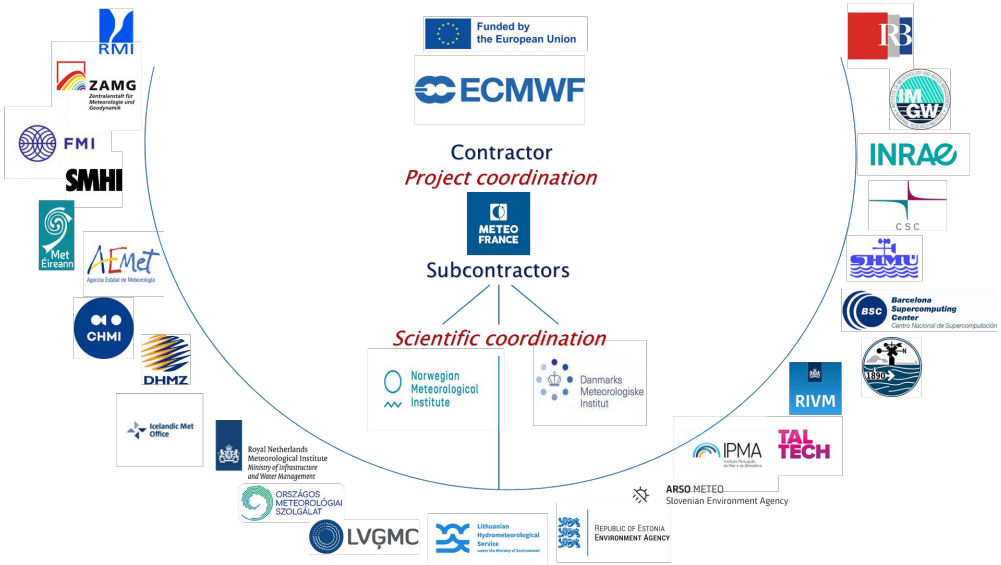
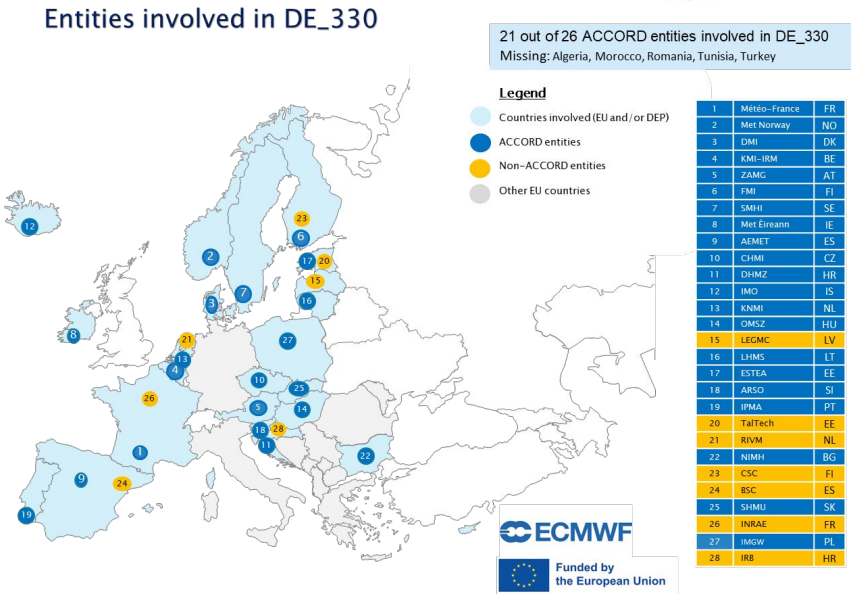
Entities involved in DE_330







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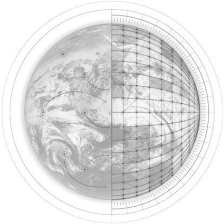

On-Demand Extremes DT concept

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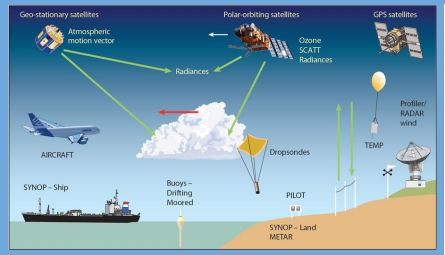
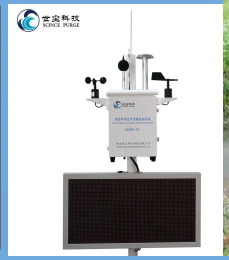
On-Demand Extremes workflow





Environmental observation and monitoring

Trigger: Statist. or AI-based extreme

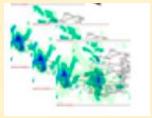
event detection

Quality control; machine learning; data assimilation

Global DT
Regional NWP

Triggered on-demand Hyper-resolution digital twin

Analyses
Nowcasts
Forecasts



Post-processing:
Global DT
Regional NWP

Linear statistics
AI methods
Uncertainty estimation

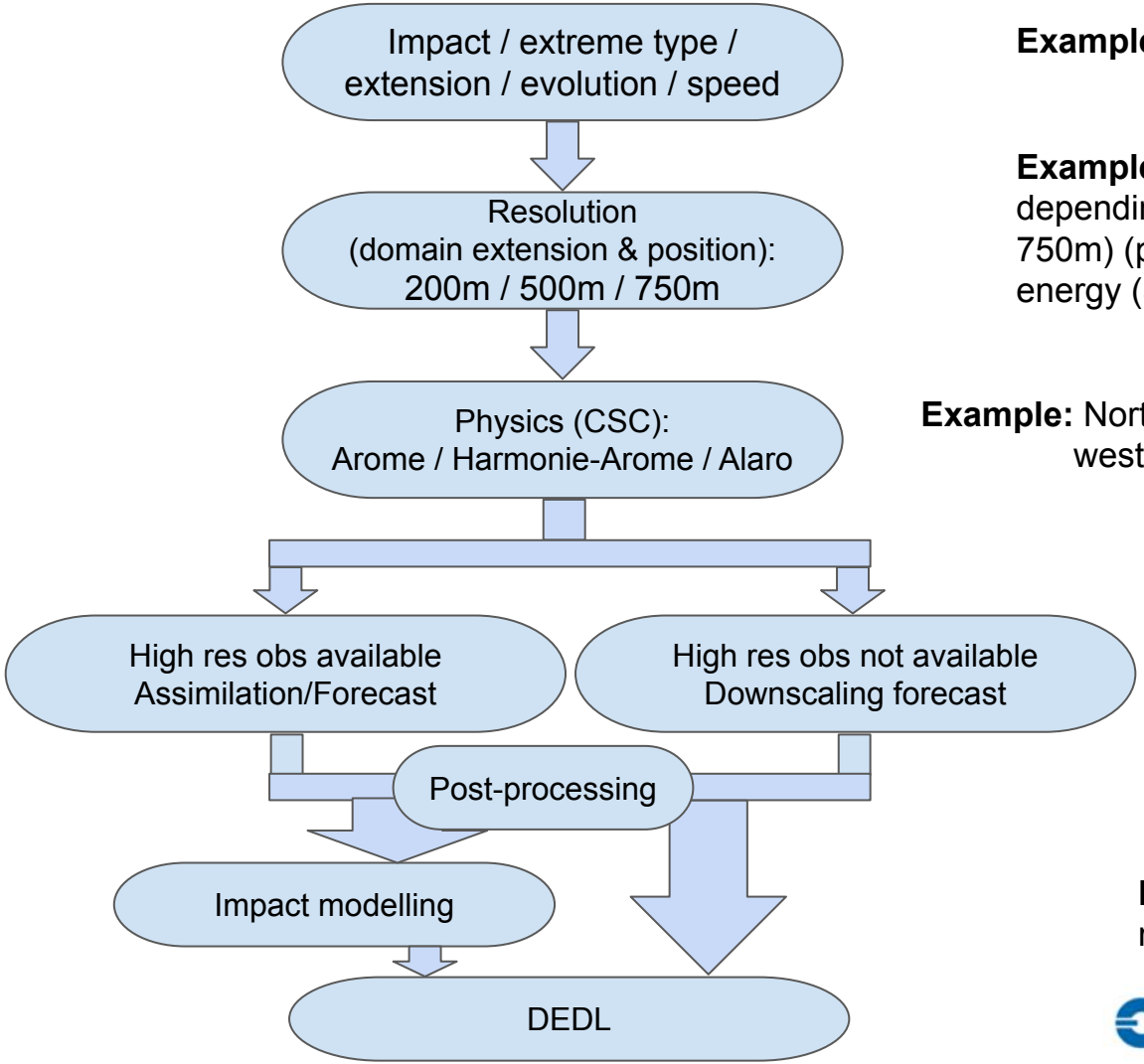
EuroHPC

Key users

Hydrology
Air quality
Renewable energy

Civil protection
Marine/Road safety
Social impact

Other impacts:
Forest fire
Agriculture



Example: Pollution - stationary large; flooding - varying extension, different speed;

Example: Pollution, air quality - 750m; flooding depending on the extension (200m / 500m / 750m) (possible few connected domains), wind energy (500m); urban meteorology (200m)

Example: North or south Europe- Harmonie-Arome western, central, eastern Europe - Arome / Alaro

Initialisation: using operational global IFS / ARPEGE / LAM

Example: hydrology; air quality; energy meteorology; agriculture; road safety

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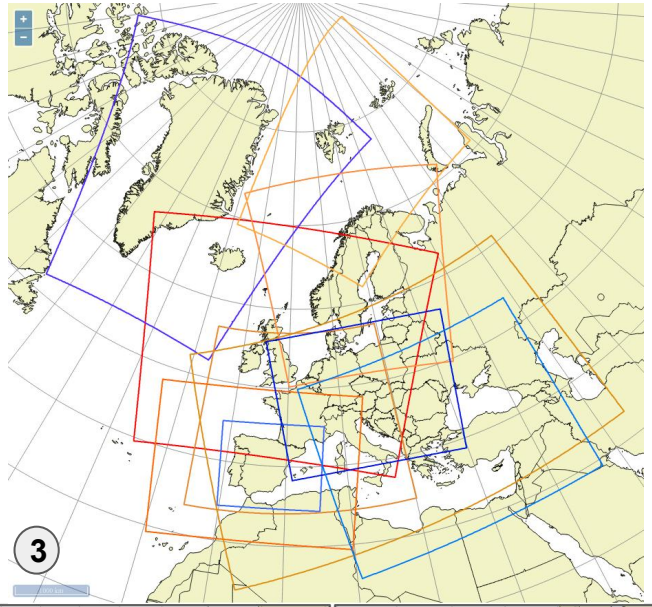
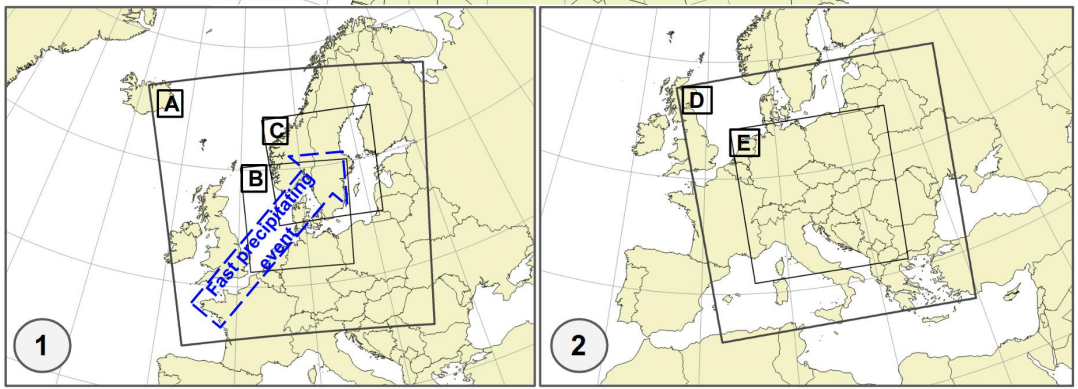


Operational LAM ensemble (yellow) and deterministic (blue) systems

Fast moving precipitating mesoscale event (500 m resolution)



Stationary synoptic scale (air quality) event (750 m resolution)

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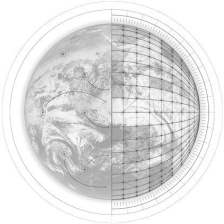

On-Demand Extremes DT component

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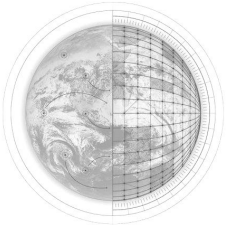
On-Demand extremes DT components



To be containerised and loaded on Euro-HPC:

- Hyper resolution limited area NWP model
  - Renewable energy
- Post-processing module
  - Triggering mechanism, uncertainty estimation, tailored products for users
- Hydrology model (prediction of flooding events)
- Air quality model

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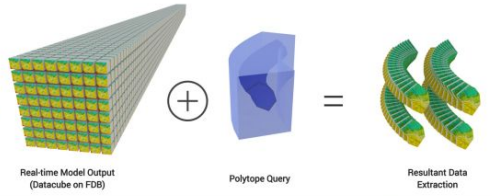
Functionalities



data is streamed at full 4D-resolution and coupled with applications (water, food, energy) on the fly

simulation-observation production can be run in continuous or on-demand modes
(and deployed across distributed HPC)

applications can operate in fully immersive data spaces

machine learning models are trained and applied on the fly

Workflows incl. models and observations can be configured

HPC (EuroHPC)

DIGITAL TWINS (DT)

MultIO Server

Product Generation

FDB

= Digital Twin Engine Component

= Data Flow

= Control Flow

Notifications

High Performance Data Access Interface (FDB-to-FDB)

Interface
• C/C++
• Fortran
• Python

Infero

Input Tensor

Output Tensor

Trained model

DE Service Platform (Data)

DEDL Data Bridge (DEDB)

DE Data Lake (DEDL)

DE Data Warehouse

FDB

Polytope Feature Extraction

Aviso (Notification Service)

Polytope Service (HTTPS Data API)

HTTPS APIs

Other DEDL Components

Data handling architecture becomes scalable

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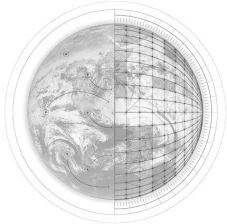
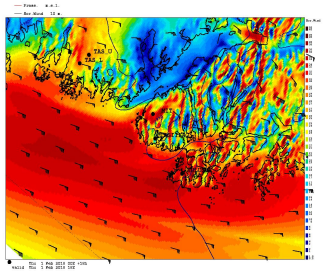
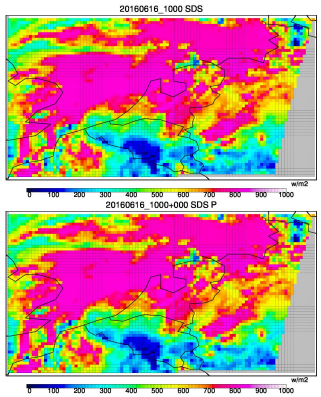
Capability demonstration



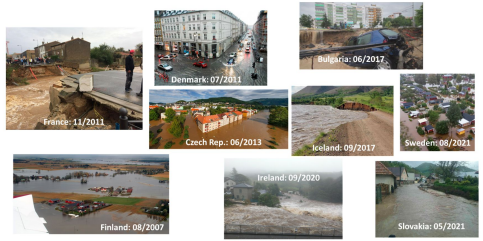
Using past cases:

- All components will be evaluated using proper simulation of known and well chosen past cases
  - NWP components improvements
  - Hydrology model
  - Air quality model
  - Renewable energy modules (Solar & Wind energy; Risk to infrastructure)





Context: extreme flood events in Europe



Consequences of a 20 month project period

: Co-design & co-development & co-production

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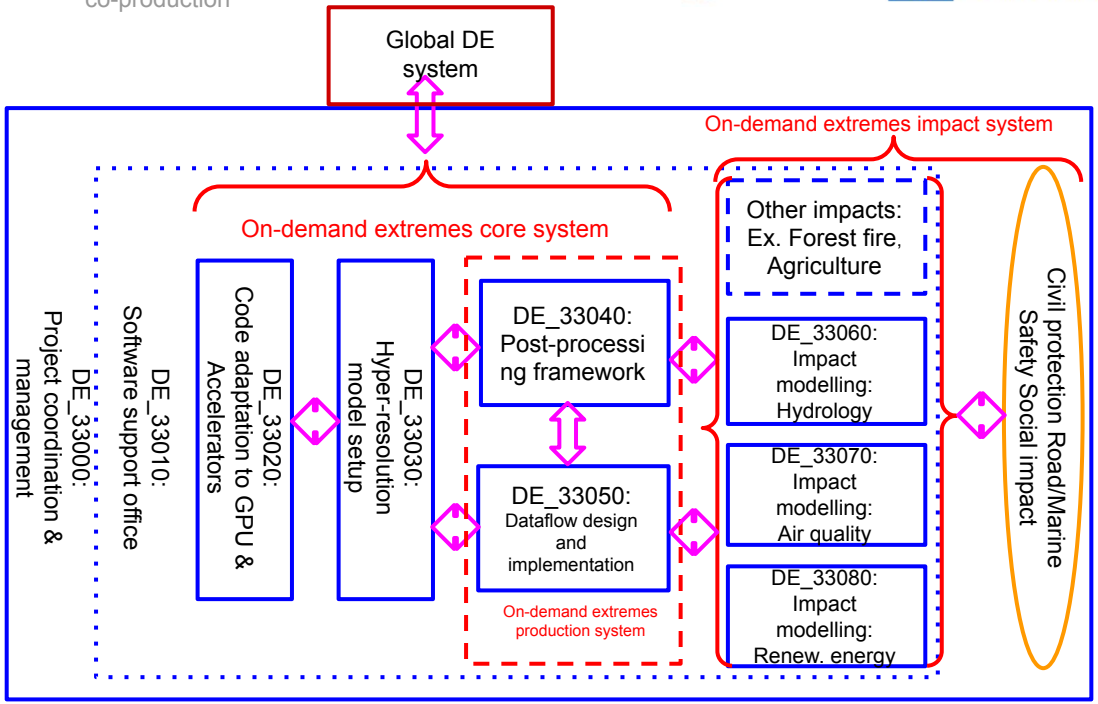

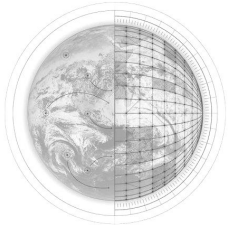

Thank you for your attention

On-Demand Extremes press release:
https://stories.ecmwf.int/m-t-o-france-wins-bid-to-develop-destination-earth-s-on-demand-extremes-digital-twin/index.html
See also https://twitter.com/ecmwf/status/1574385421135380480?s=46&t=UJZ6BRPgT2zLkcA4l8W6Bg

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