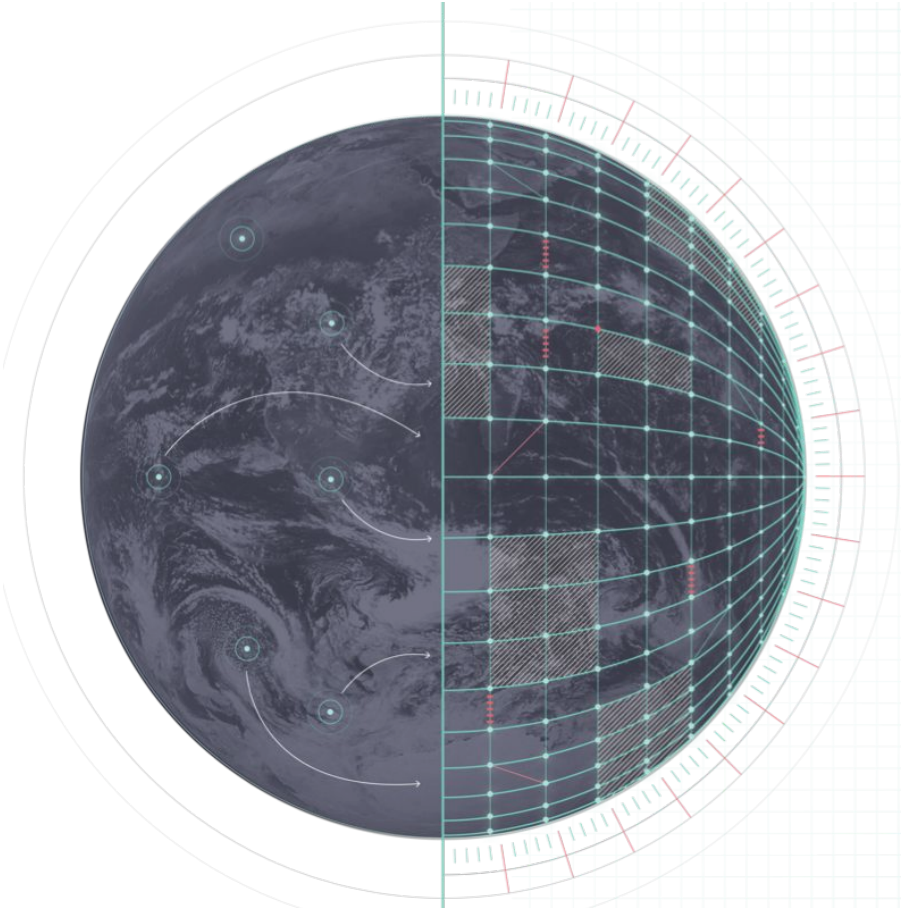


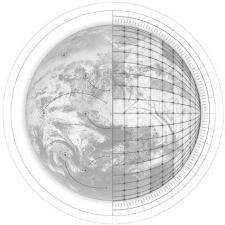
DESTINATION EARTH

Destination Earth On-Demand Extremes Digital Twin

Roger Randriamampianina
&
The On-Demand Extremes Team

3rd ACCORD All Staff Workshop 27-31 March, Tallinn and hybrid

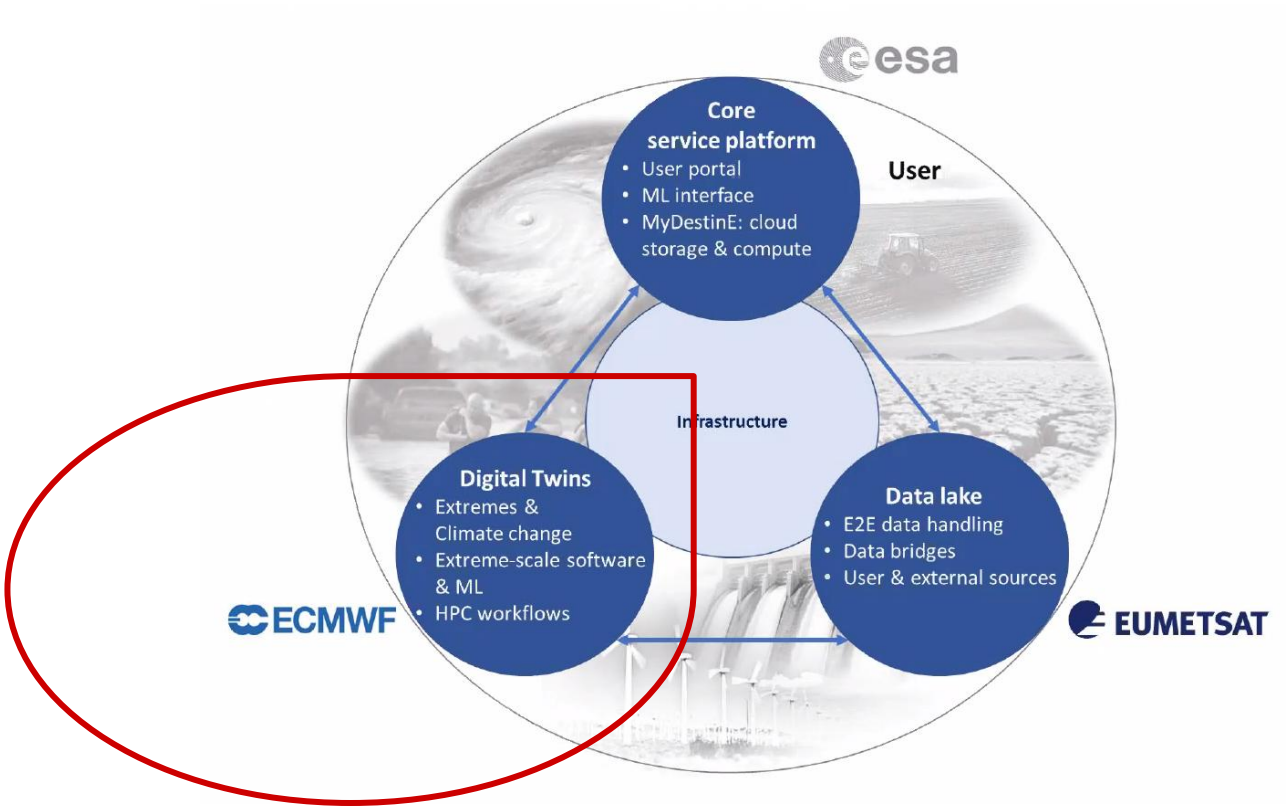
Funded by the European Union
Destination Earth implemented by ECMWF esa EUMETSAT



Outline

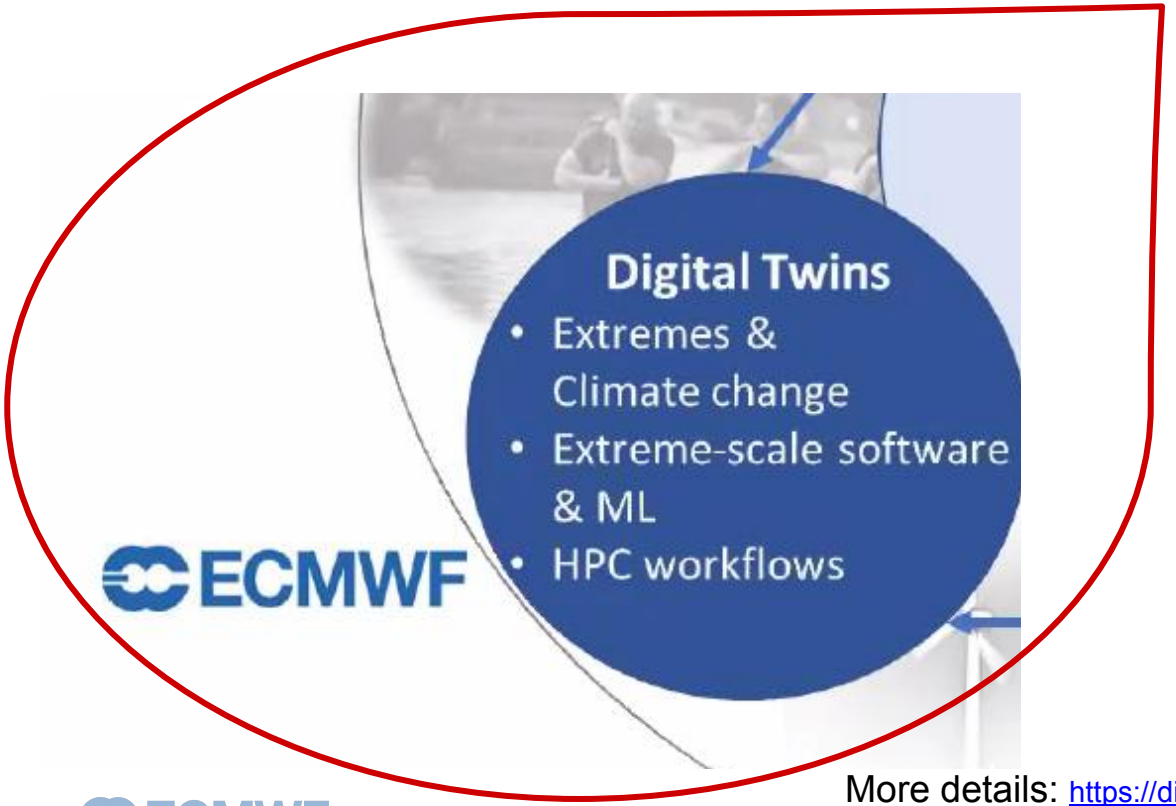
- Destination Earth & Digital Twins
- On-Demand Extremes Digital Twin requirements
- On-Demand Extremes:
  - Formation, design, components
- Value demonstration
- DestinE system functionality and (user) connection options

Destination Earth



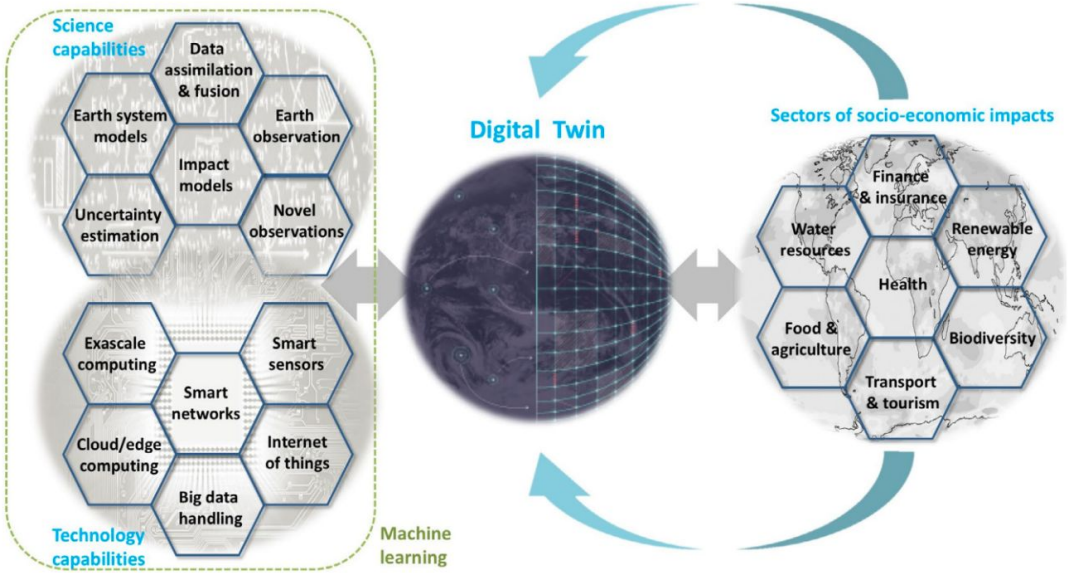
More details: https://digital-strategy.ec.europa.eu/en/policies/destination-earth
https://stories.ecmwf.int/destination-earth/index.html

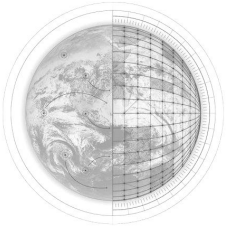
Destination Earth



More details: https://digital-strategy.ec.europa.eu/en/policies/destination-earth
https://stories.ecmwf.int/destination-earth/index.html

Digital Twin

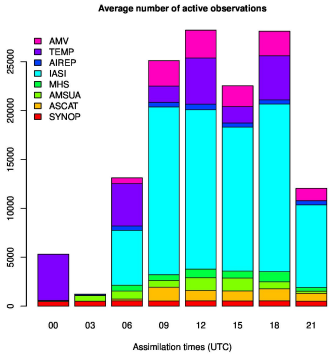


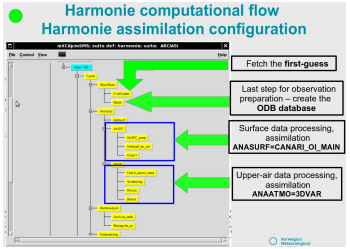


- Digital Twin for Weather induced and geophysical extremes consists of two main components:
  - Global continuous digital twin component (ECMWF)
  - On-demand extremes digital twin (DE_330_MF project consortium led by Météo-France)

The requirements are, among others:

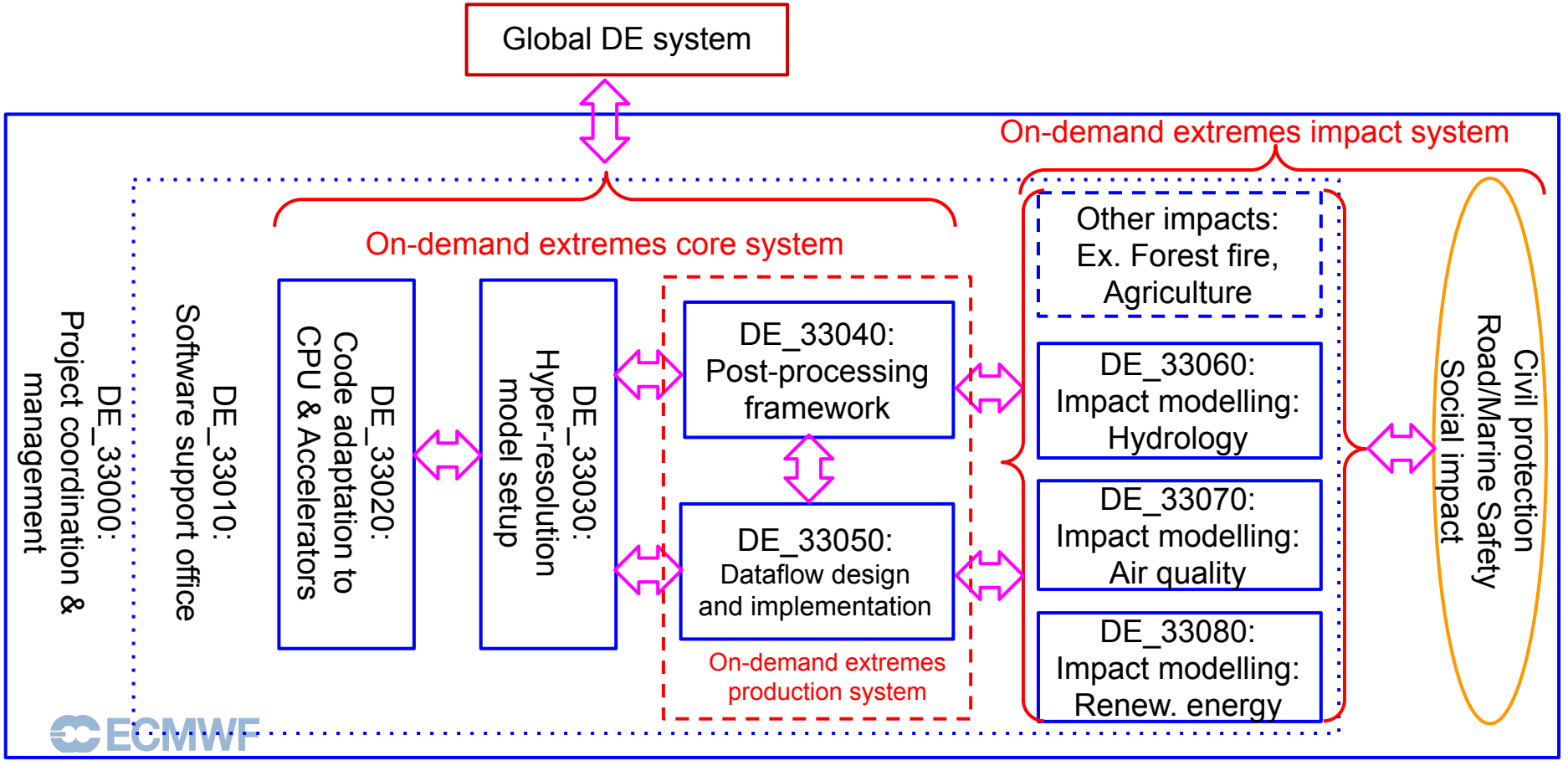
1) Pan-European observation processing for verification, post-processing and data assimilation
2) Configurable, flexible and scalable workflows with hyper-resolution NWP and impact models
3) Reliable load on high-performance computing (EuroHPC)
4) Value demonstration
5) Interfacing with ECMWF DTE, DEDL, DESP as required



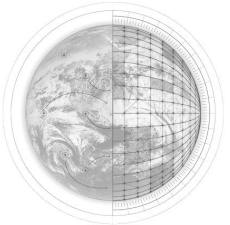


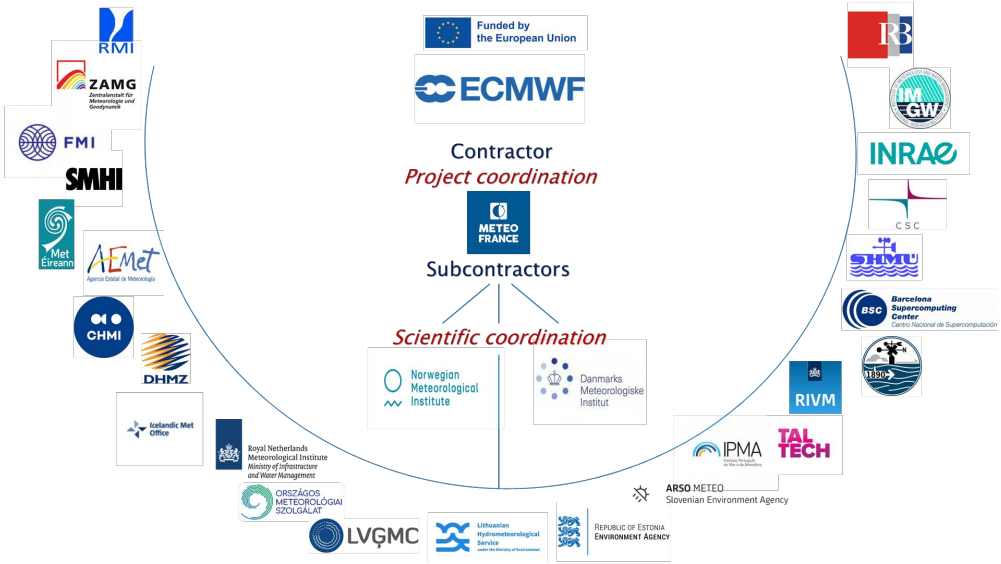
ECMWF
Funded by the European Union

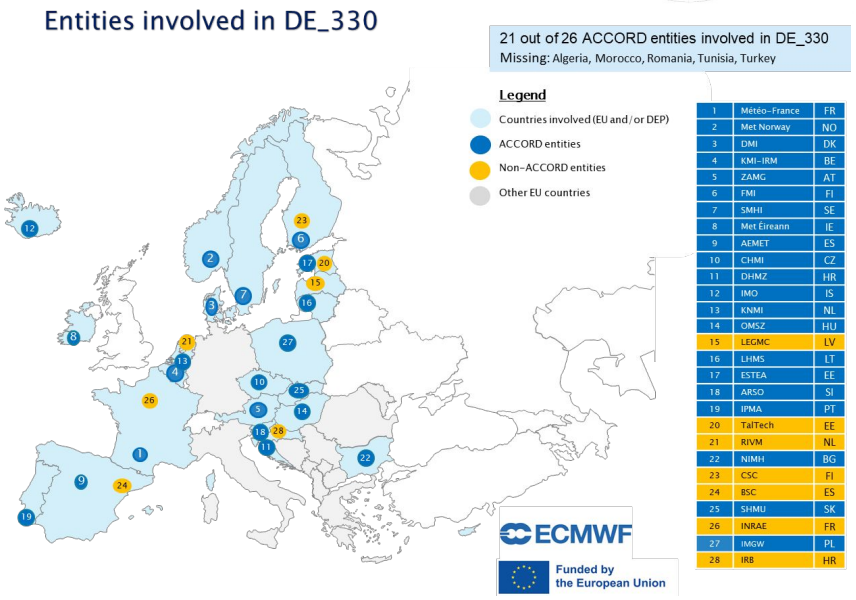
: Co-design & co-development & co-production



DE_330 Team




Funded by the European Union
ECMWF
Contractor
Project coordination
METEO FRANCE
Subcontractors
Scientific coordination
RMI
ZAMG
FMI
SMHI
Met Eireann
AEMet
CHMI
DHMZ
Icelandic Met Office
Norwegian Meteorological Institute
Danmarks Meteorologiske Institut
Royal Netherlands Meteorological Institute
ORSZÁGOS METEOROLÓGIAI SZOLGÁLAT
LVĢMC
Lithuanian Hydrometeorological Service
Republic of Estonia Environment Agency
ARSO METEO
Slovenian Environment Agency
IPMA
TALTECH
RIVM
IMGW
INRAE
CSC
SHMU
BSC Barcelona Supercomputing Center
IRB


Entities involved in DE_330
21 out of 26 ACCORD entities involved in DE_330
Missing: Algeria, Morocco, Romania, Tunisia, Turkey
Legend
Countries involved (EU and/or DEP)
ACCORD entities
Non-ACCORD entities
Other EU countries
1 Météo-France FR
2 Met Norway NO
3 DMI DK
4 KMI-IRM BE
5 ZAMG AT
6 FMI FI
7 SMHI SE
8 Met Eireann IE
9 AEMET ES
10 CHMI CZ
11 DHMZ HR
12 IMO IS
13 KNMI NL
14 OMSZ HU
15 LEGMC LV
16 LHMS LT
17 ESTEA EE
18 ARSO SI
19 IPMA PT
20 TalTech EE
21 RIVM NL
22 NIMH BG
23 CSC FI
24 BSC ES
25 SHMU SK
26 INRAE FR
27 IMGW PL
28 IRB HR
ECMWF
Funded by the European Union

DESTINATION EARTH

Management Team

E. Gérard; R. Randriamampianina; K. P. Nielsen;
N. Rubio; M. Canzek; C. Fischer;
C. Wittmann; P. Termonia; L. Auger

DT environment

Software support service office (DE_33010)
H. Nortamo; R. Randriamampianina

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; R. Capell

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

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

ECMWF

ECMWF

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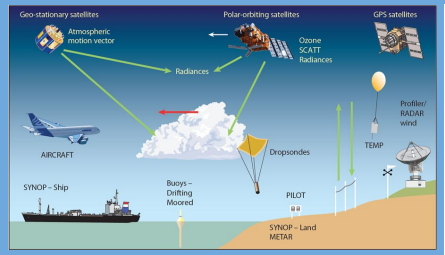
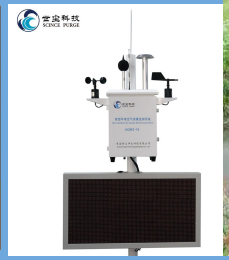
On-Demand Extremes workflow





Environmental observation and monitoring

Trigger: Statist. or AI-based extreme

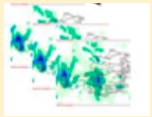
event detection

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

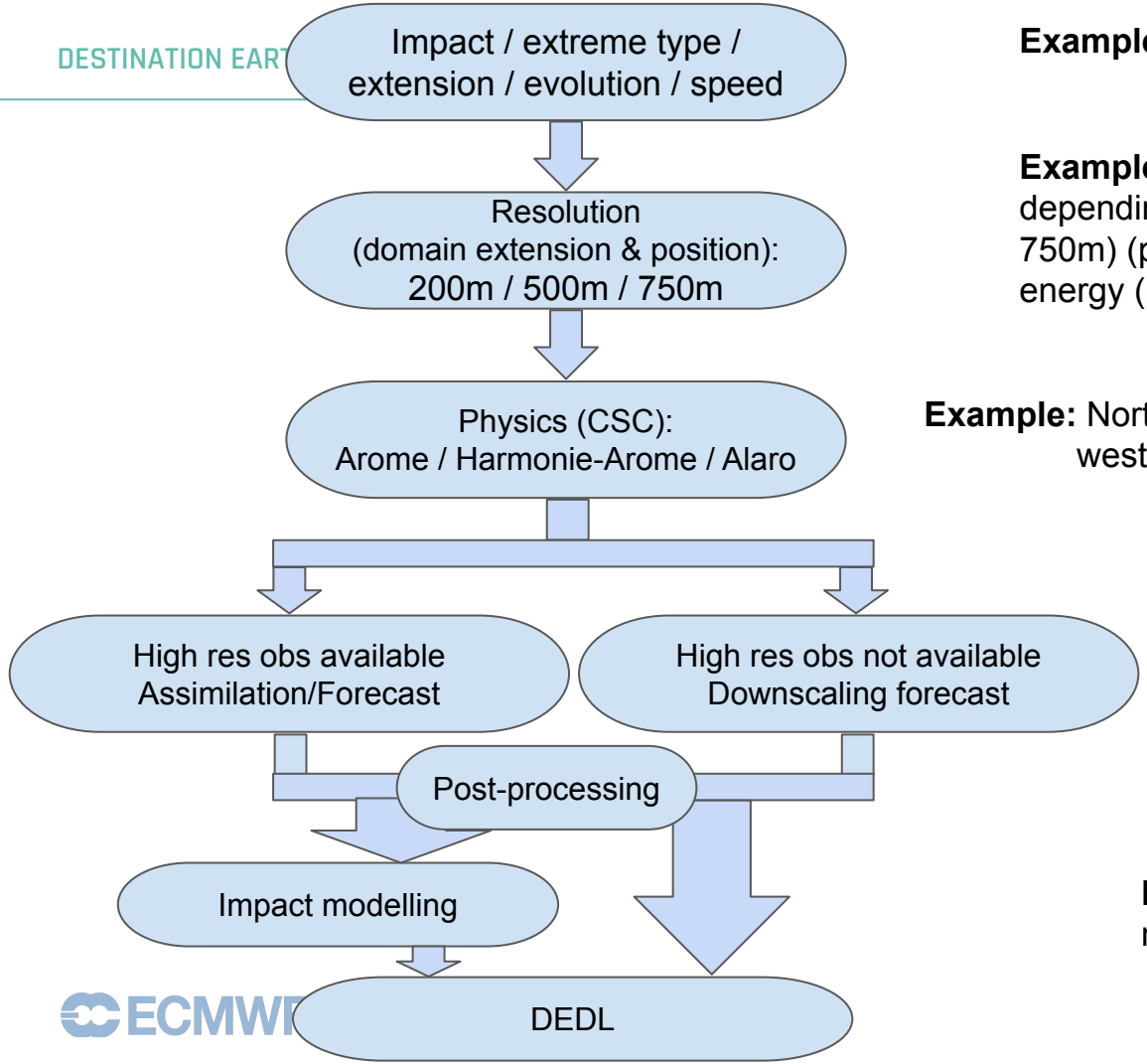
EuroHPC

Key users

Hydrology
Air quality
Renewable energy

Civil protection
Marine/Road safety
Social impact

Other impacts:
Forest fire
Agriculture



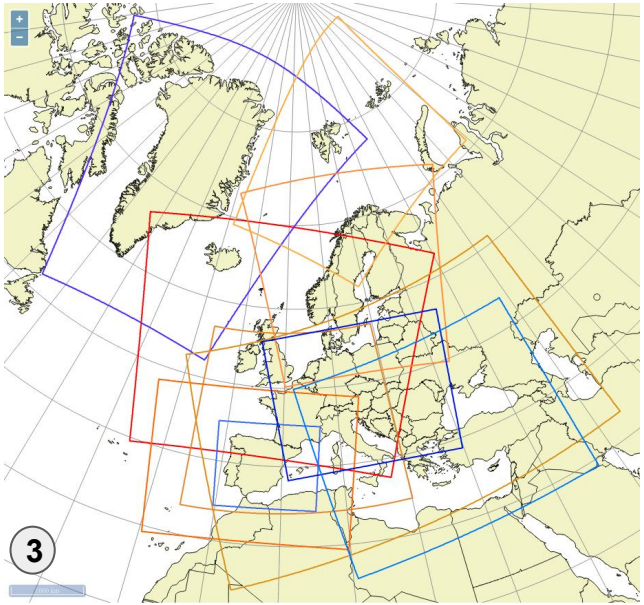
Example: Pollution - stationary large; flooding - varying extension, different speed;

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

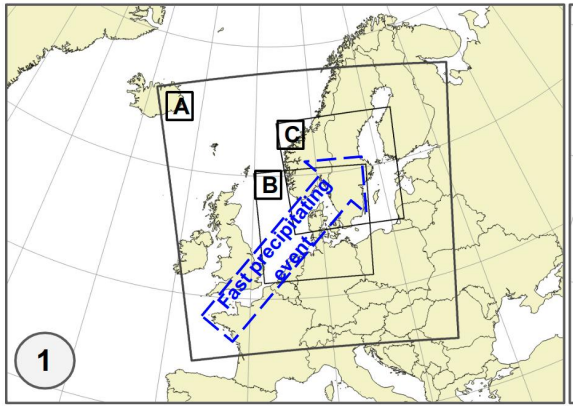
Initialisation: using operational global IFS / ARPEGE / LAM

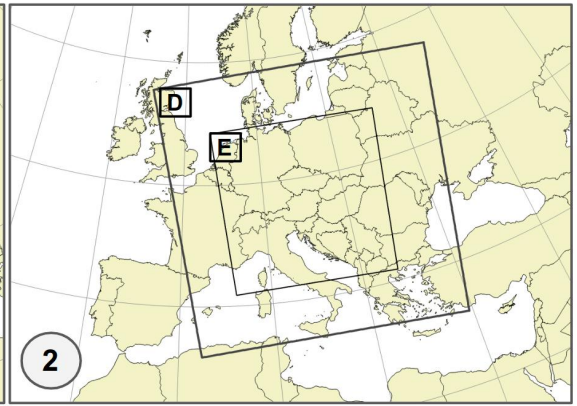
Example: hydrology; air quality; energy meteorology; agriculture; road safety



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

Fast moving precipitating mesoscale event (500 m resolution)



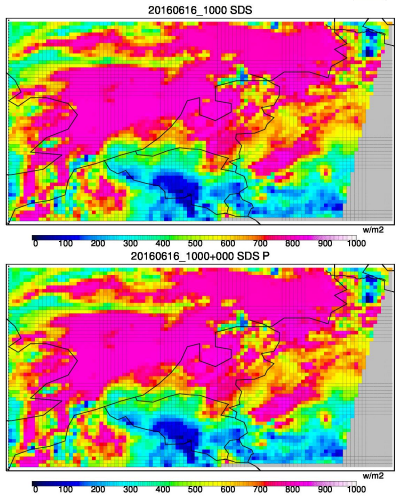


Stationary synoptic scale (air quality) event (750 m resolution)

On-Demand extremes DT components

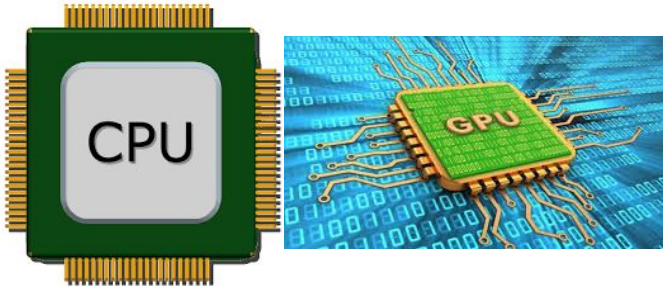
To be containerised and loaded on Euro-HPC:

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



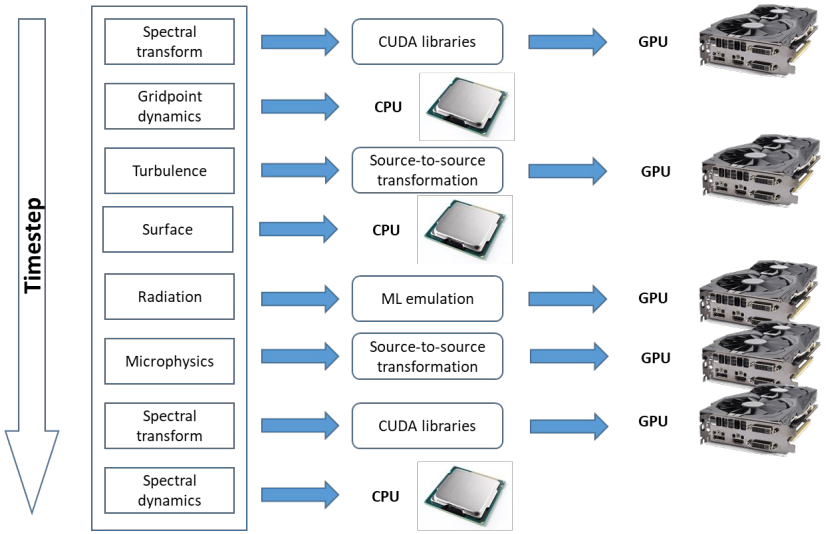
Code adaptation to CPUs and GPU

Code adaptation to CPUs and accelerators:



- Make the codes of the three ACCORD CSCs parser-ready for the source-to-source tools (LOKI and others).
- Apply the source-to-source tools to parts of the codes.
- Develop a ML version of the ecRad radiation scheme.
- Carry out profiling on various platforms.
- Implement a configuration within the DT Engine.

(*see also Daan DEGRAUWE's presentation*)



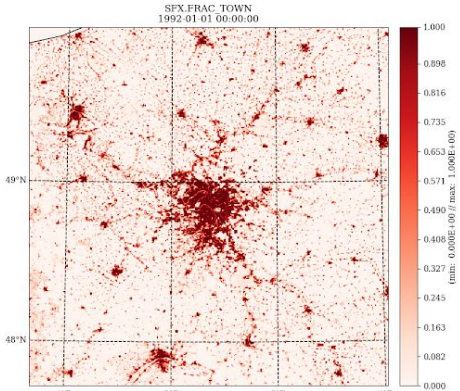
Workflow management and hyper resolution NWP model

- **Workflow management and scripting system:**
  - Develop a common script system to run all NWP components of the On-Demand DTE
  - The script system will facilitate organisation NWP data flow with three ACCORD Canonical System Configurations (CSCs)
  - ecFlow will be the primary tool for the On-Demand Extremes DT workflow management
  - The target system version (CY48t3) agreed and baseline repository released (*see also Ulf Andrae's presentation*)

(from *Trygve Aspelien*)

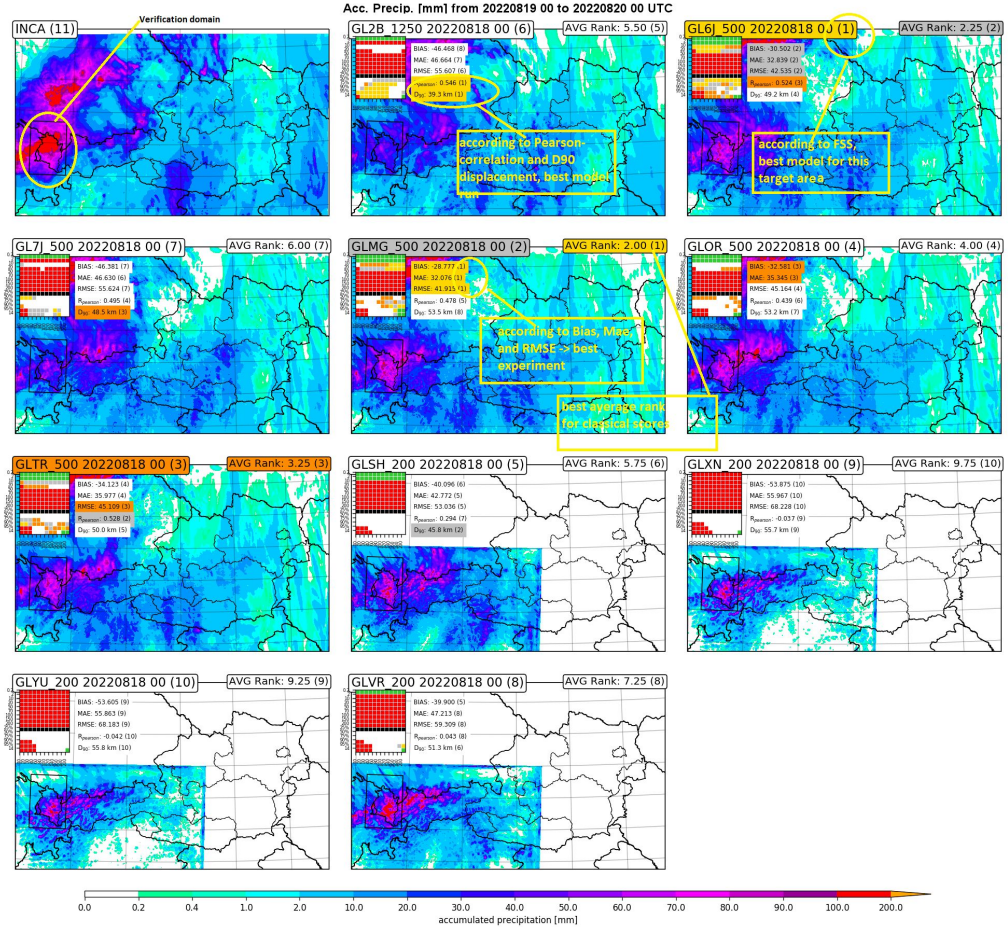
- **Exploring potential optimal forecast configuration parameters for On-Demand Extremes DT (upper-air and surface)**
  - Several tests at very high resolution (750 m, 500 m and 200 m) ongoing
  - Decision to work on a common study domain, the TeamX alpine domain
  - Strategic decisions for the common target SURFEX configuration (for example the use of a diffusive scheme for layers below the surface)

(*see also Colm Clancy's presentation*)



Paris town at 500 m resolution
(*Natalie Theeuwes, KNMI*)

Hyper resolution NWP model testing



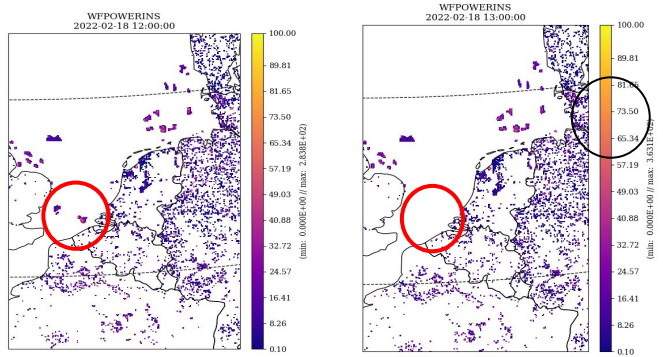
Case study testing different model configurations and the results are very preliminary.

(Courtesy of
Christoph Wittmann
and
Eric Bazile)

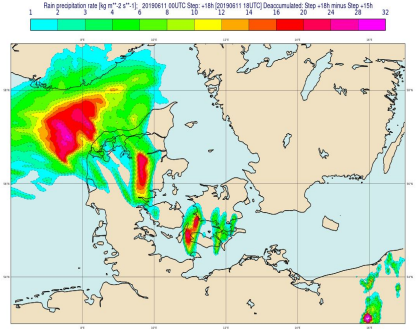
Value demonstration

Capability demonstration:

- An extensive list of test cases have been defined.
- **Strategy:** reference dataset using state-of-art NWP model, followed by a rerun with advanced model version and/or very fine resolution.
- Use cases were selected and their simulation has started. First results are now to be delivered.
- As much as possible contribute to development of a triggering module.
- Wiki page explaining how to get the created data was created.

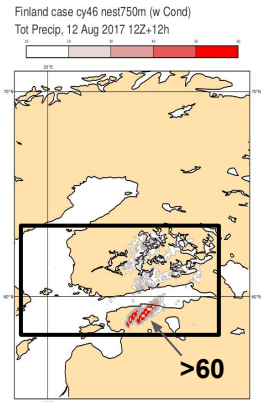


Storm Eunice (strong wind > 25 m/s) (Natalie Theeuwes, KNMI)



Fabrizio Baordo (DMI)

Nested domain



Erik Gregow (FMI)

ECMWF

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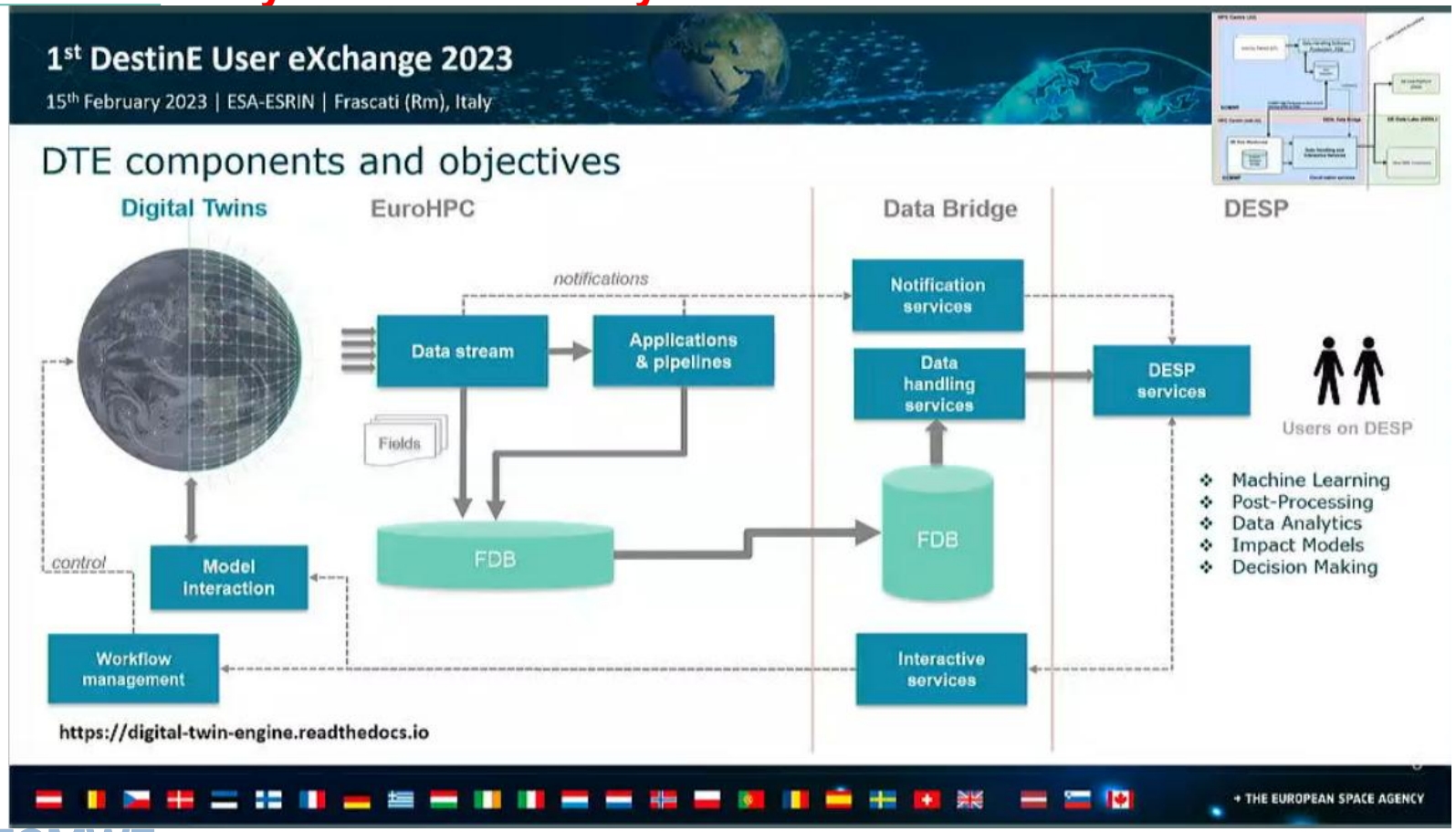
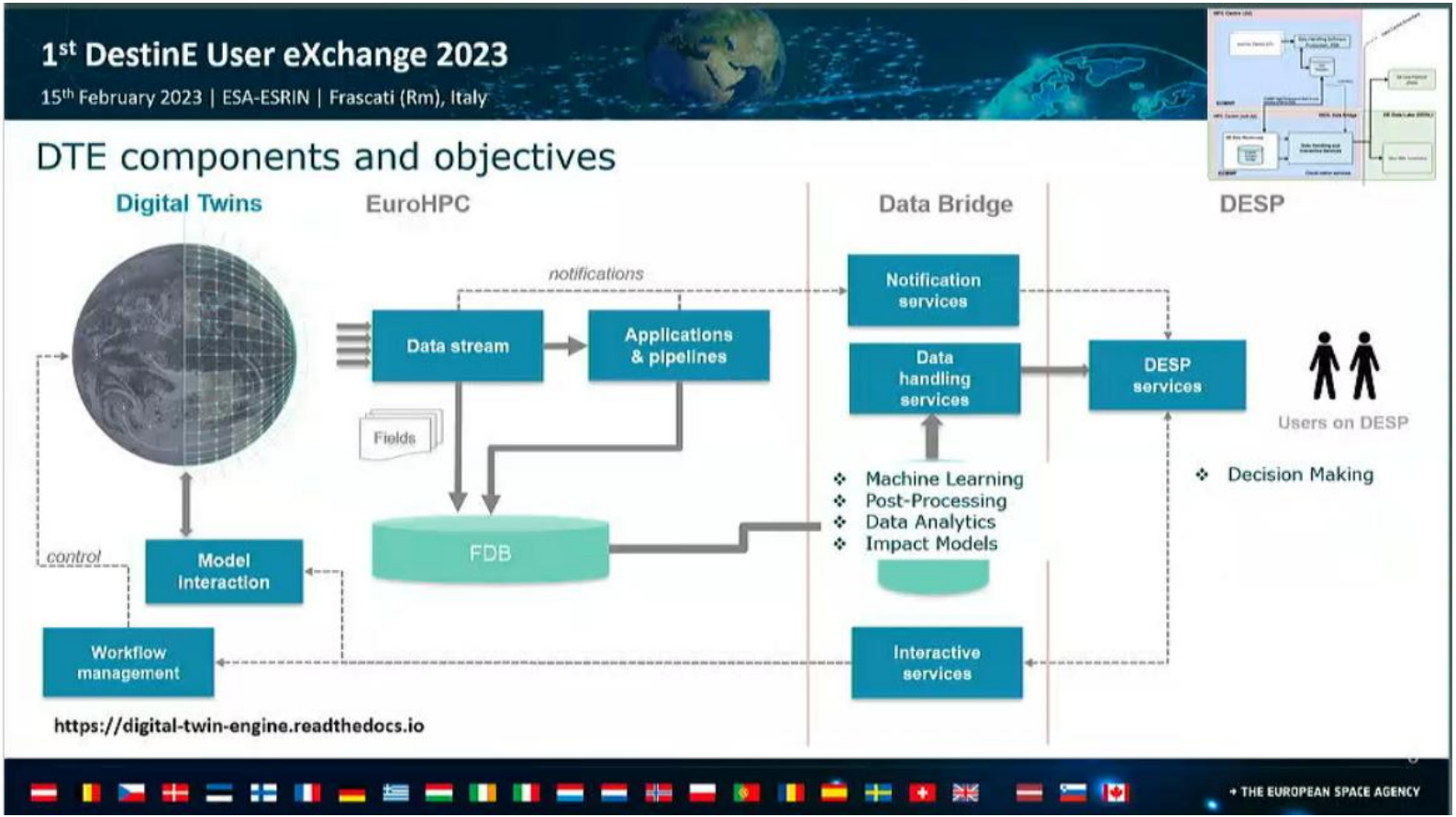
Thank you for you attention

System functionality



System functionality - option for user connection



System functionality - option for user connection