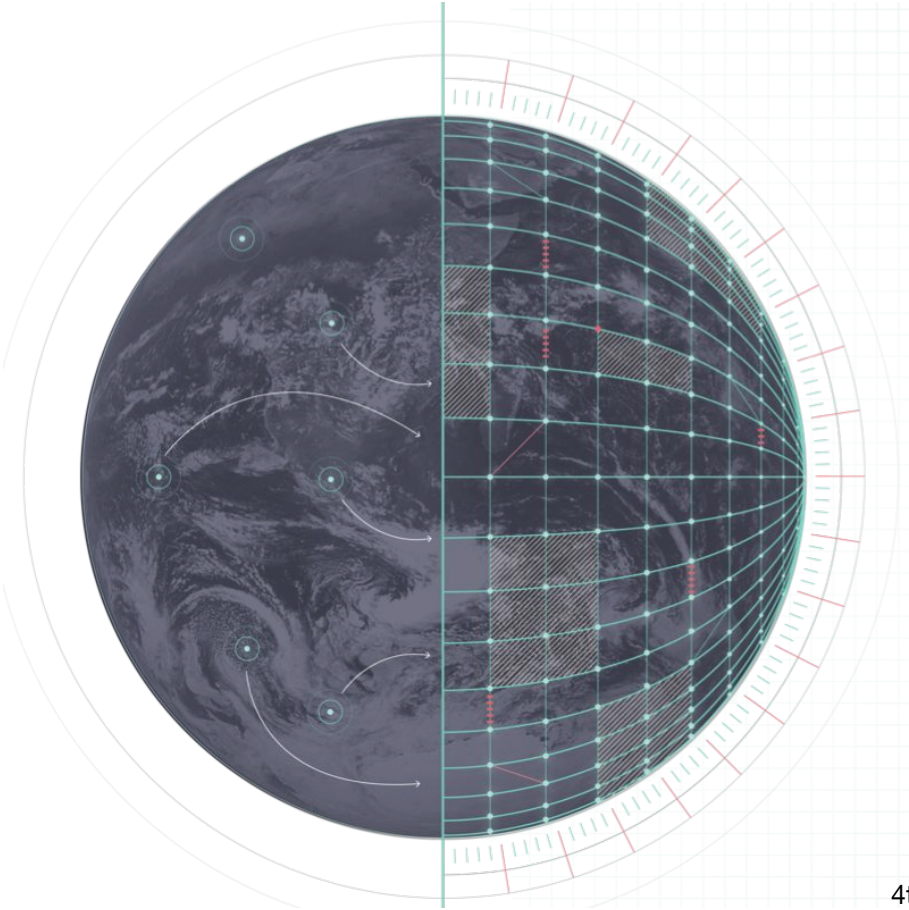


DESTINATION EARTH

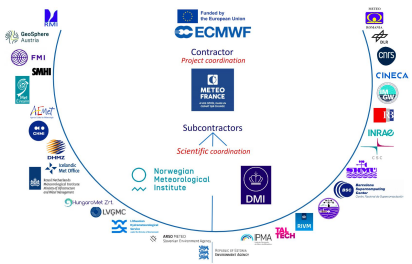
Destination Earth On-Demand Extremes Digital Twin

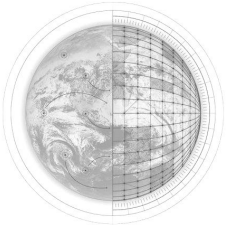
Status and challenges in Phase 2

Roger Randriamampianina
&
The On-Demand Extremes Team

4th ACCORD All Staff Workshop 15-19 April, Norrkoping and hybrid

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



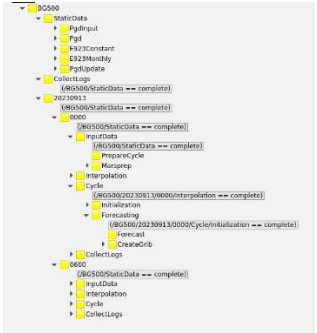


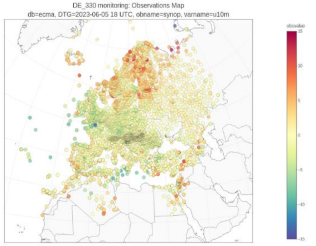
Outline

- Objectives and capability provision
- Some achievements in phase 1
- Phase 2 and challenges
- Concluding remarks

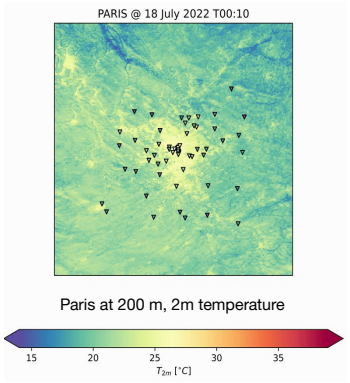
Objectives

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





Benedikt Strajnar (ARSO)



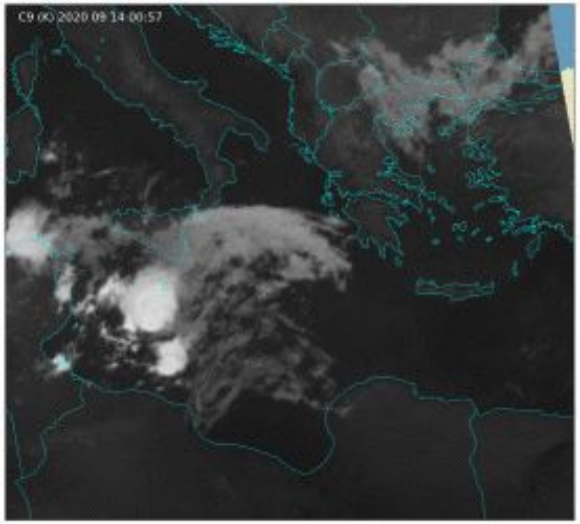
Jean Wurtz (Météo France) and Natalie Theeuwes, (KNMI)

Capability provision:

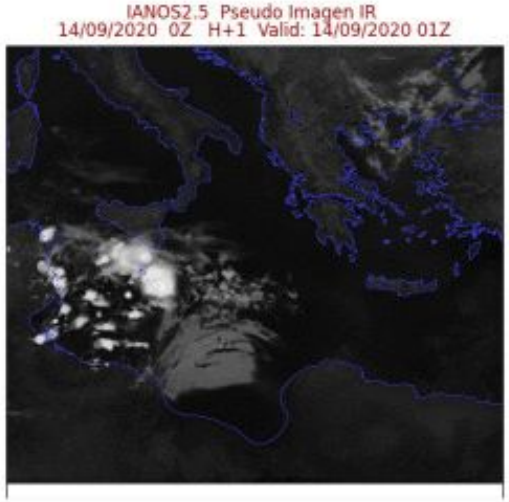
On Demand Extremes Digital Twin
The Ianos Medicane 2020-09 14-20

Envisage an On-Demand high resolution system (at around 500 m) capable for forecasting/monitoring of a fast moving mesoscale event around 1-2 days ahead

MSG SEVIRI CH. 9 (IR)



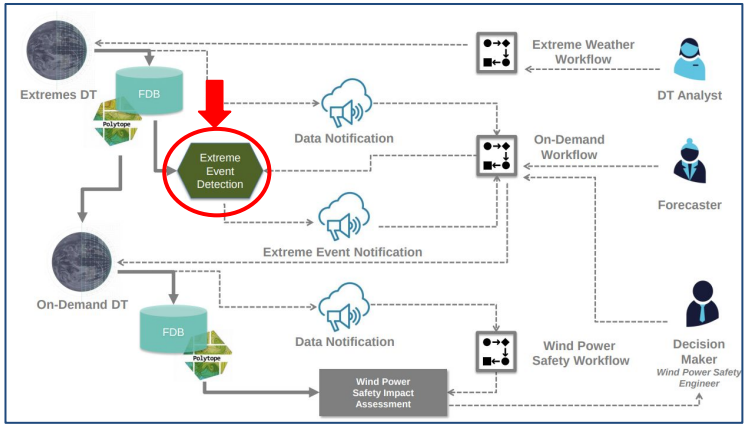
NWP model 2.5 km



NWP model 0.5 km

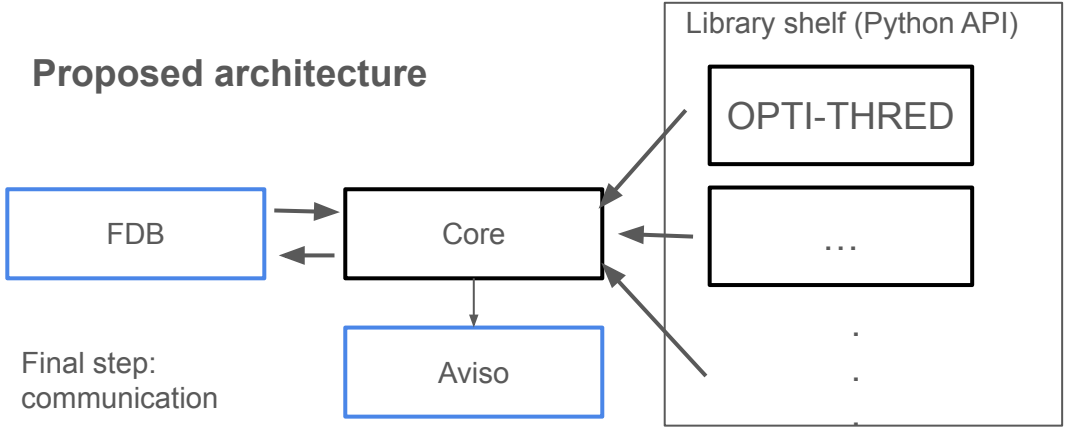
(Javier Calvo, AEMET)

Extreme Detection Framework (EDF)



(T. Quintino, 2nd Destination Earth User eXchange)

Proposed architecture

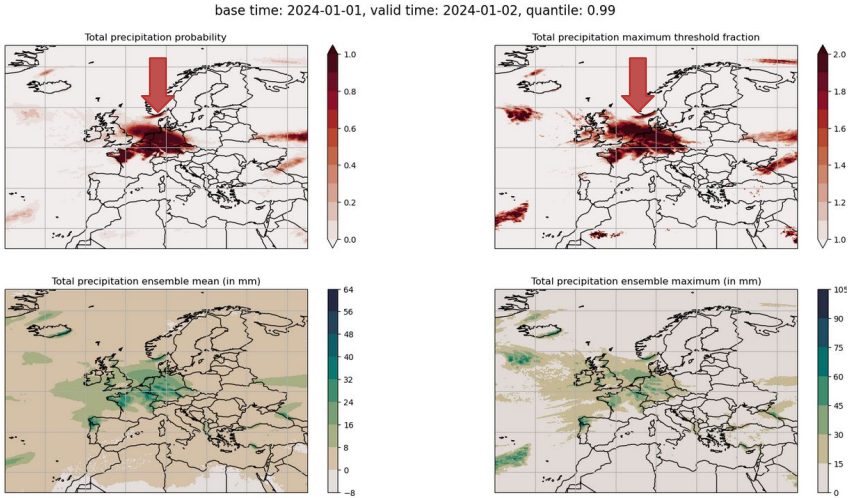


Available on GitHub:
https://github.com/destination-earth-digital-twins/EDF-Prototype

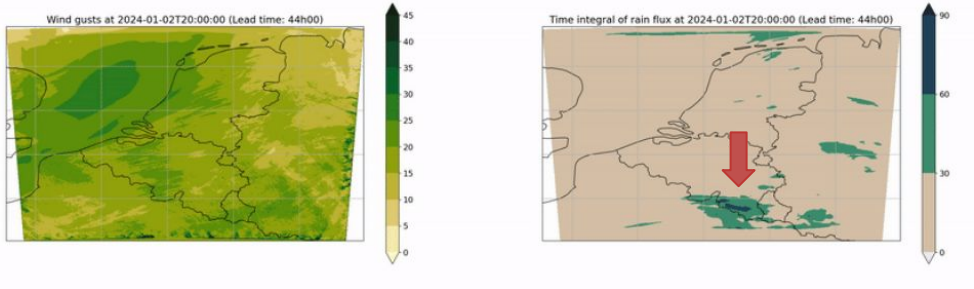
(Jonathan Demaeyer, RMI & Petter Lind, SMHI)

Extreme Detection Framework (EDF)

- Tested for a precipitation case in Belgium: 01-01-2024



On-Demand DT (HARMONIE-AROME) prototype at 500 m

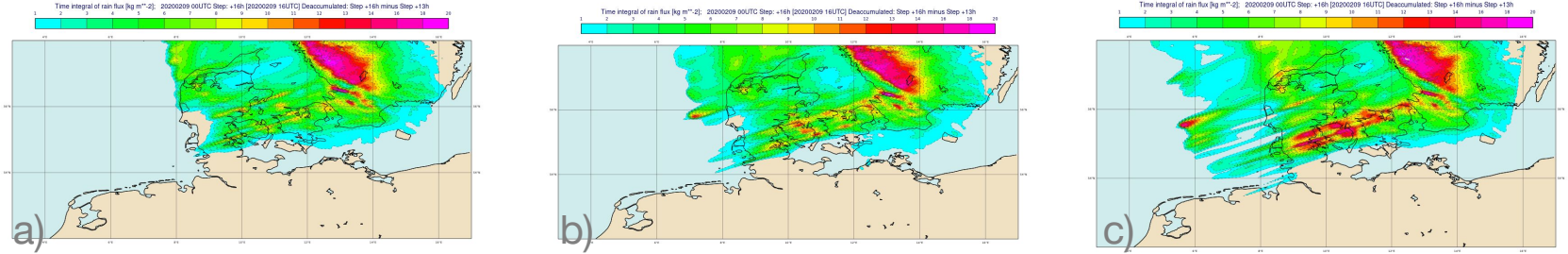


(Jonathan Demaeyer, RMI)

On-Demand Extremes DT (deode) prototype

- Take shape and currently under test
- Started to be used on LUMI
- Tested across different regions in Europe

Which domain size
and
where would be appropriate?

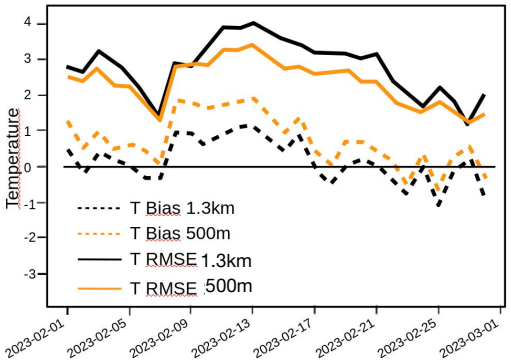


Simulation of **the flooding cases** over Denmark on Feb 9 2021 by the On-demand DT prototype at 750m using Harmonie-arome. The illustrated 3 simulations are equivalent except that the domain coverage have been shifted horizontally toward west in b) by 150 km and c) by 250 km. The simulation c) is closer to observations. The extent of the domain coverage is showns to be essential to capture the system developed from west side. (Fabrizio Baordo, DMI)

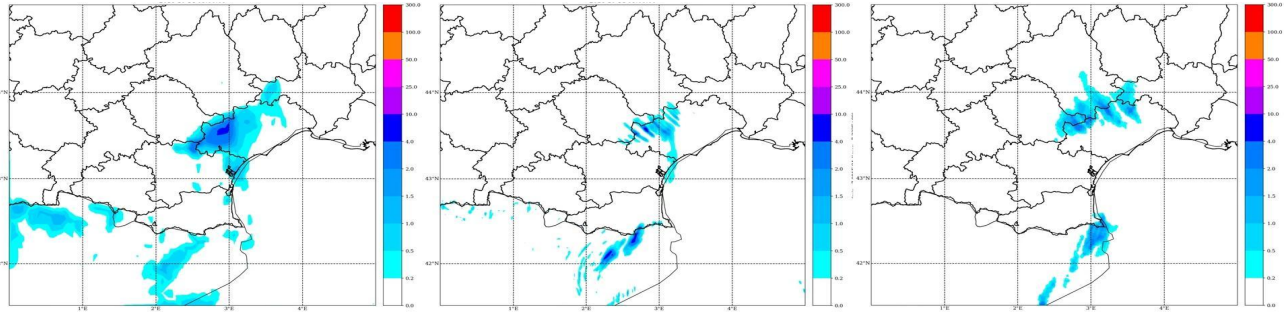
(see also pres. by Ulf Andrae, Xiaohua Yang,Phillip scheffknecht, & Juan Jesus G Aleman & more …)

On-Demand Extremes DT (deode) prototype

Added value of the sub-km scale in the On-Demand DT



Temperature scores are improved over alpine domain compared to lower resolution 1.3km model



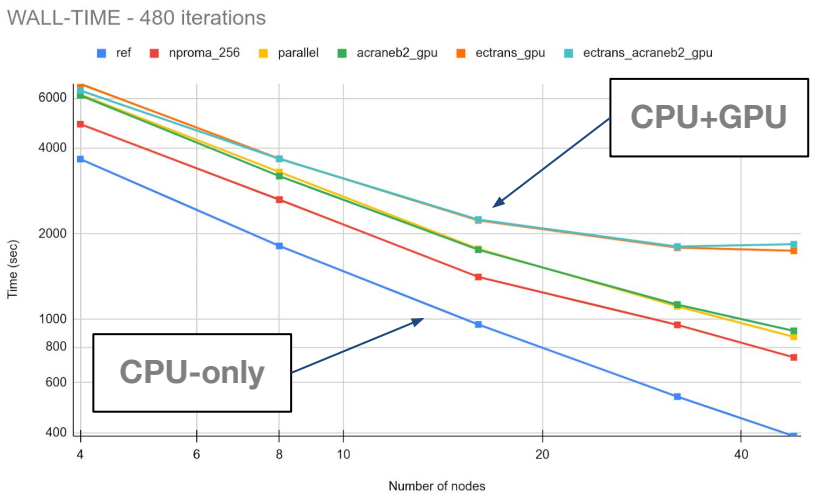
global DT | LAM DT@500m | observations

2018 Aude case: Precipitation patterns and maxima are much better represented with the LAM DT at 500m resolution thanks to higher resolution and more realistic microphysical scheme

(Ludovic Auger, Meteo France)

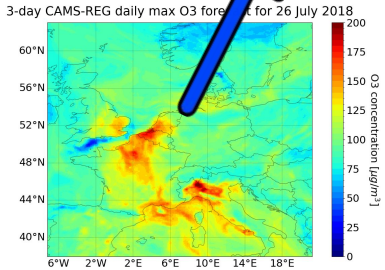
Code adaptation

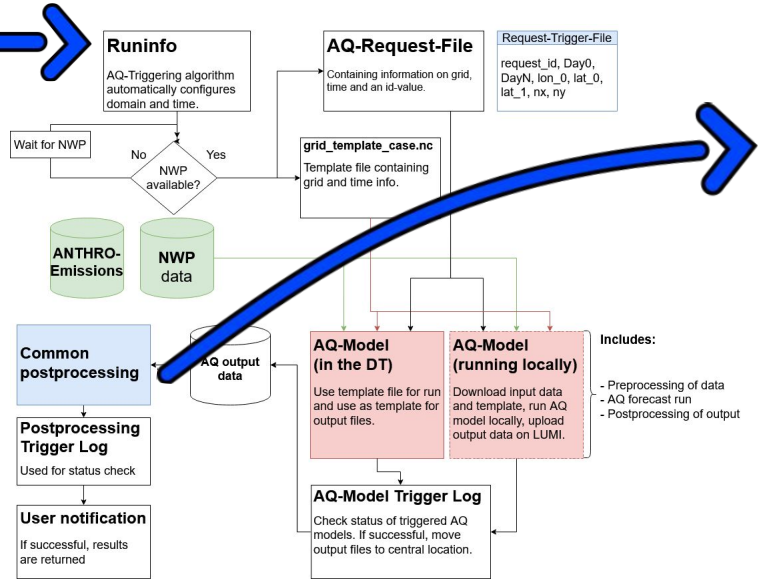
- Porting of limited-area spectral transforms to GPU:
  - Using combination of HIP and OpenACC
  - Working on LUMI AMD GPUs (in principle also on NVIDIA GPUs)
- Porting of ACRANEB2 radiation scheme to GPU using loki source-to-source translator
- Integration of GPU-ported parts in 3D model:
  ALARO forecast with spectral transforms
  and radiation scheme on GPU.
- Performance not impressive (yet)
  due to high cost of CPU-GPU transfers
- Should improve as more parts are ported to GPU

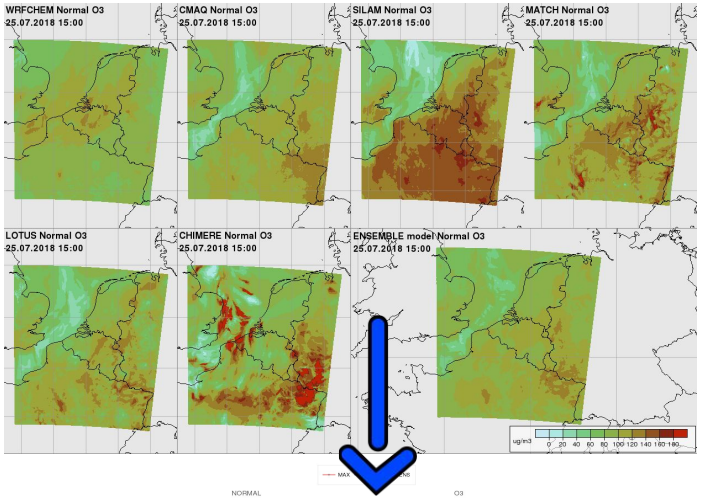


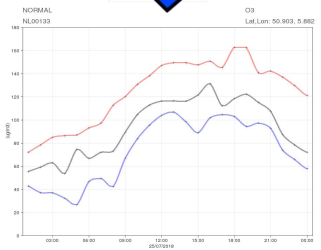
(see also Daan Degrauwe's presentation)

Air quality - workflow

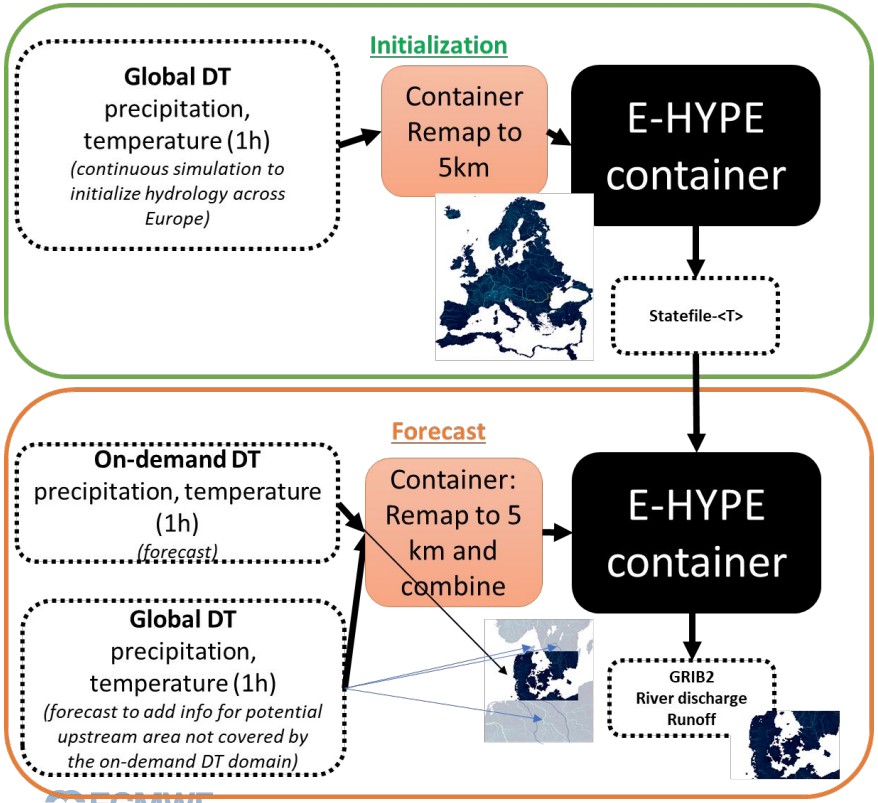








Hydrology



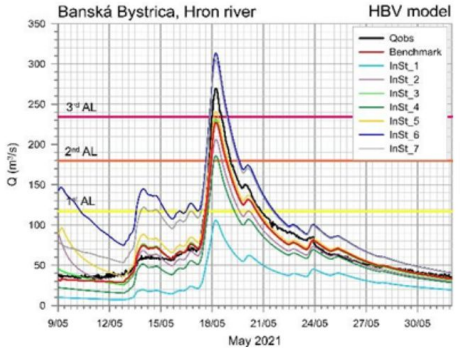
Hydro workflow

ecFlow – daily init suite
TRIGGER: date
- Download global DT analysis
- Remap
- Initialization run

=> Hydrological statefile

ecFlow – on-demand forecast suite
TRIGGER: 'on-demand produced'
- Download global DT forecast
- Download on-demand DT forecast
- Remap & combine
- Run forecast starting from statefile
- Produce and deliver GRIB2 data

All contributing models passed sensitivity study through selected cases



Sensitivity study at SHMU

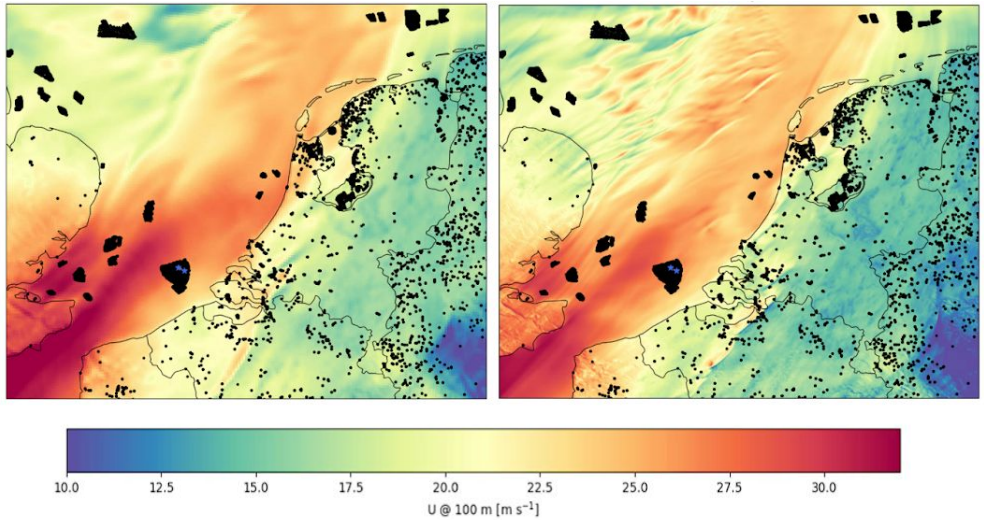
SMHI INRAE DMI FMI Met Éireann SHMU Icelandic Met Office 1890 CHMI

(P Berg, SMHI)

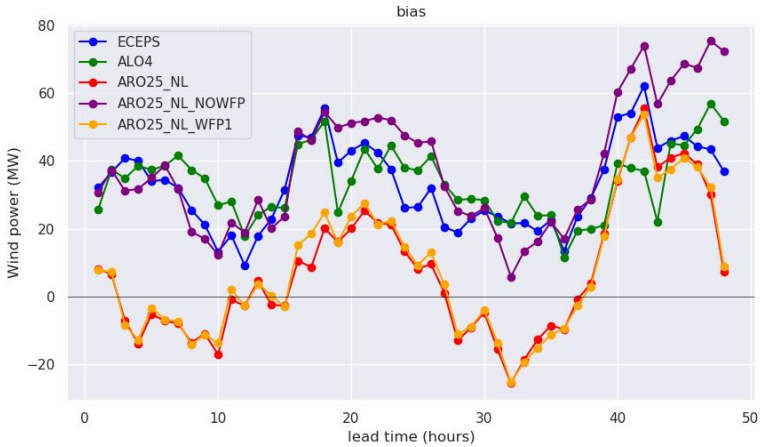
Wind power modelling

2.5 km grid spacing

750 m grid spacing



Resolving more details in the wind field



Bias in wind power production

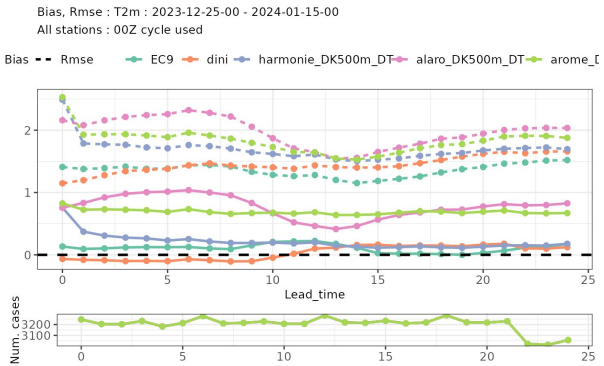
Blue, green, purple - current operational models
Red and yellow – DE330 models with wind farms in atmospheric model

Verification

- Point verification-based **HARP package** is currently a collection of DE On-Demand verifications for selected extreme weather case studies and longer test periods.

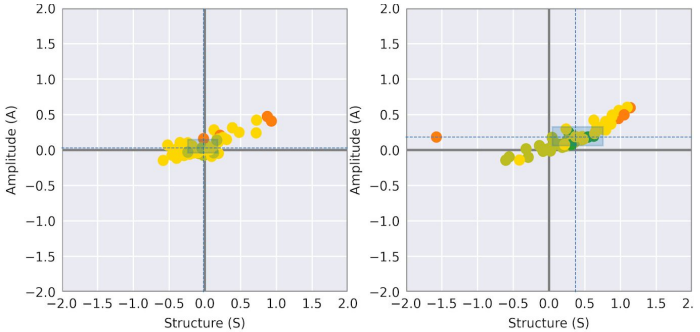
- Spatial verification using traditional scores **FSS** (Fractional Skill Score *(Robert and Lean, 2008)*) and **SAL** (structure (S), amplitude (A), and location (L)) *(Wernli et al., 2008)* are also under exploration.

Example of HARP results



Scripts updated for Harp 0.2.2, instructions in the WP3.5 wiki
GitHub:
https://github.com/DEODE-NWP/DE_330-verif-scripts

Example of SAL results



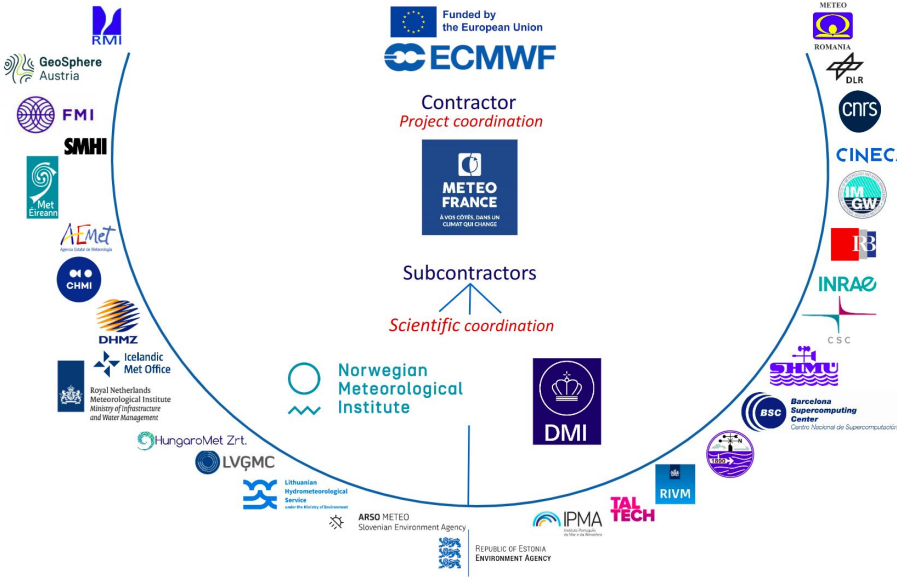
Code & instructions: GitHub:
https://github.com/DEODE-NWP/deode_spatial_verif

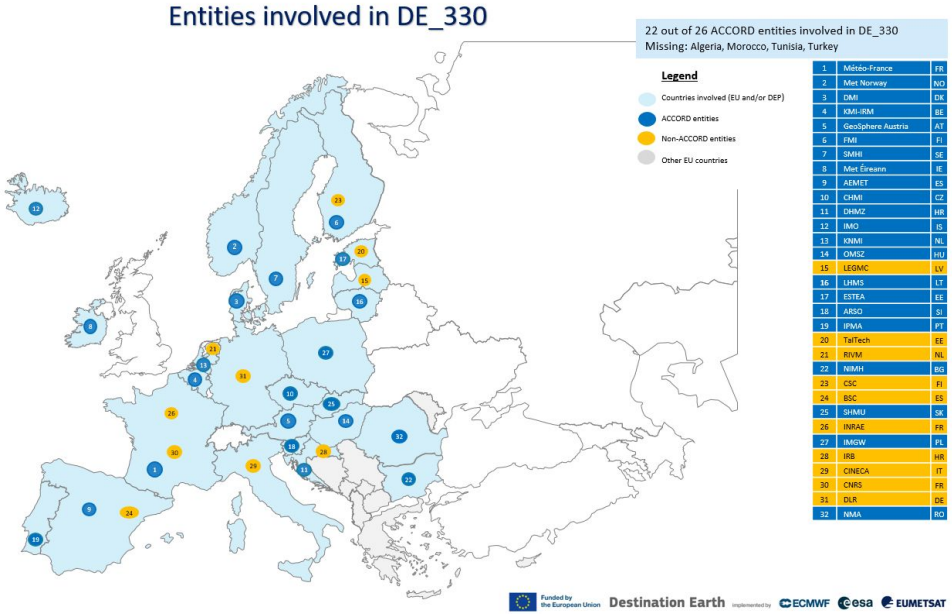
(P Scheffknecht, Geosphere Aus; S Viana & J J G Aleman, AEMET)
(See also Scheffknecht and Aleman's presentations)

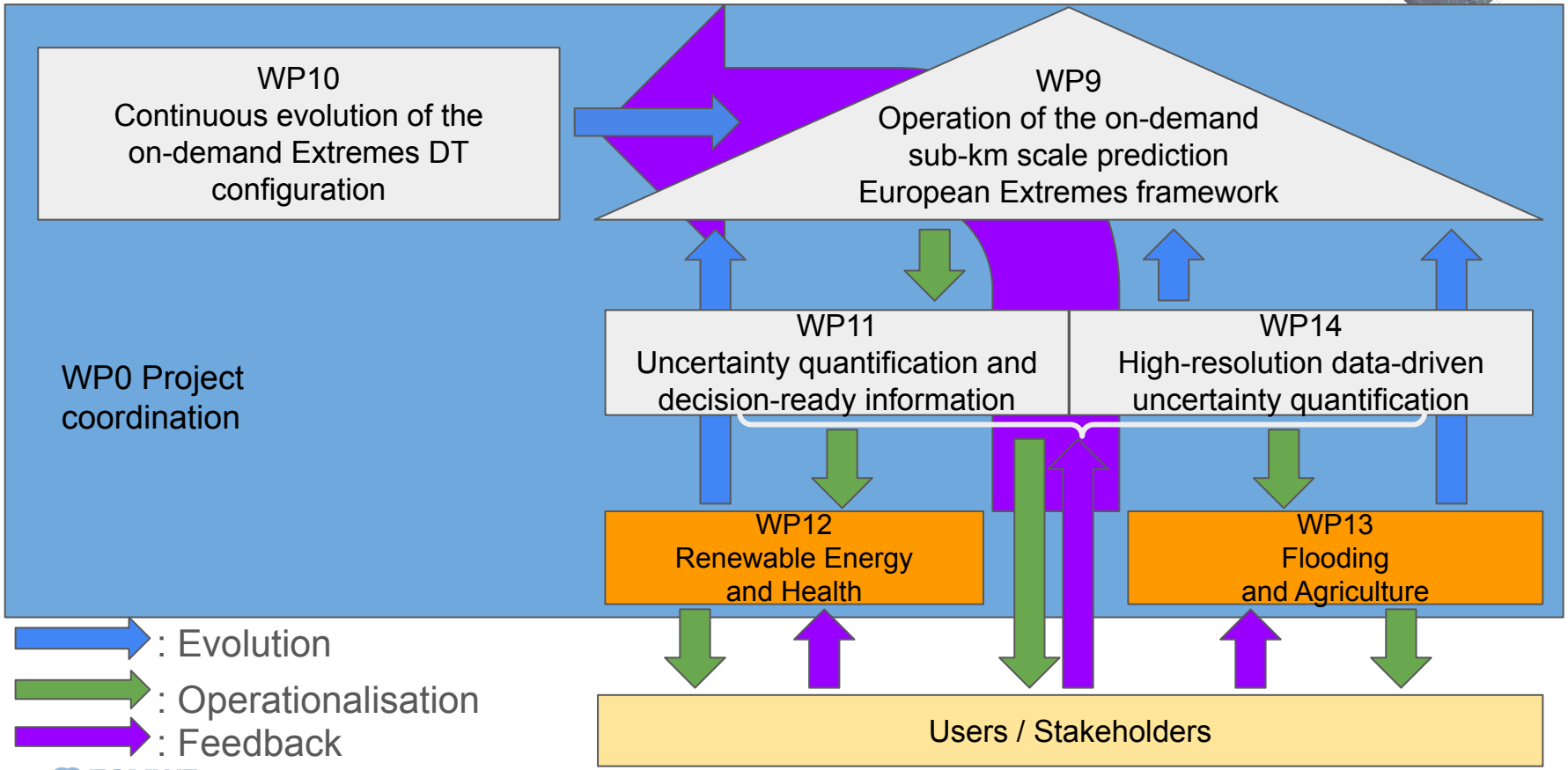

ECMWF
Contractor
Subcontractors
Norwegian Meteorological Institute
DMI

Phase 2

DE_330 Team for Phase 2 (2024-2026)

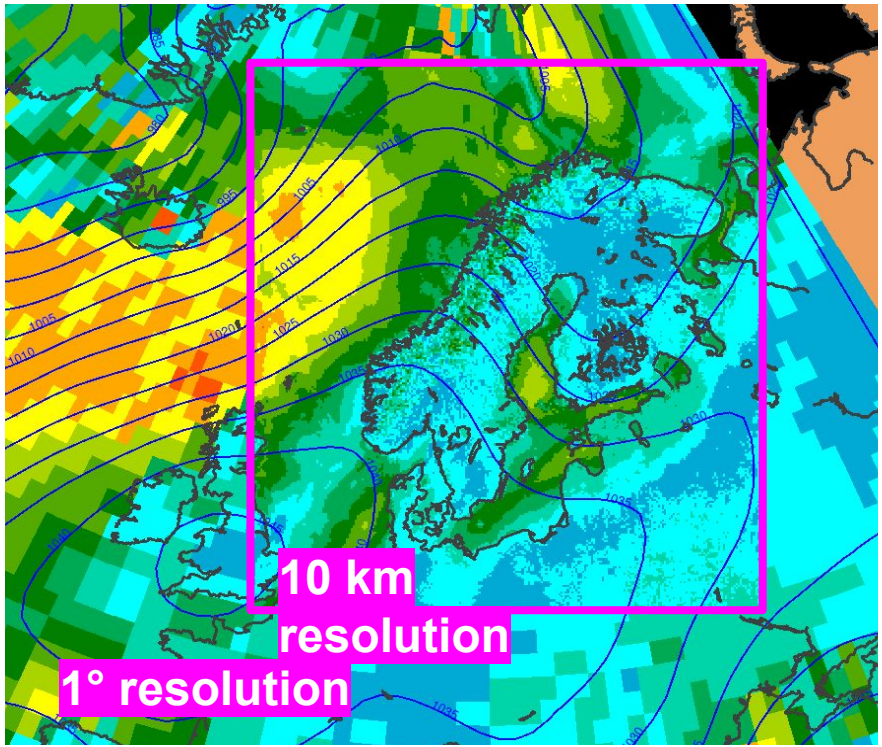





WP10
Continuous evolution of the on-demand Extremes DT configuration
WP9
Operation of the on-demand sub-km scale prediction European Extremes framework
WP0 Project coordination
WP11
Uncertainty quantification and decision-ready information
WP14
High-resolution data-driven uncertainty quantification
WP12
Renewable Energy and Health
WP13
Flooding and Agriculture
: Evolution
: Operationalisation
: Feedback
Users / Stakeholders

Data-driven modelling with AIFS

- Collaboration with ECMWF
- Global stretched-grid ML model with high resolution over Nordics/Arctic
- Promising results with 2 years of MEPS training data
- Will use CARRA and CARRA2 to get more high res training data



(Thomas Nipen & Co, Met Norway)

Concluding remarks

Phase 1:

- The first detection algorithm is ready to be activated in the DE Extremes workflow.
- The DEODE prototype, including the renewable energy production and verification solutions, has been massively tested and is being ported to LUMI.
- Workable workflows for air quality and flood (hydrology) prediction were worked out and are ready to be plugged into the DE Extremes workflow.
- More impact modelling, such as storm surge, frost, wildfire, and thermal comfort still need an integration strategy for the DE Extremes workflow.

Phase 2 challenges:

- Better workflow adaptation to LUMI and other EuroHPCs
- Continuous evolution of the On-Demand sub-km DT.
  - Physics and machine learning based post-processing and uncertainty quantification.
- Build and refine the end-to-end integrated workflow interfacing all parts (NWP and impact modelling) of the DTs
  - Technical and scientific challenges and accounting users needs.

ECMWF

Funded by the European Union

Thank you for you attention