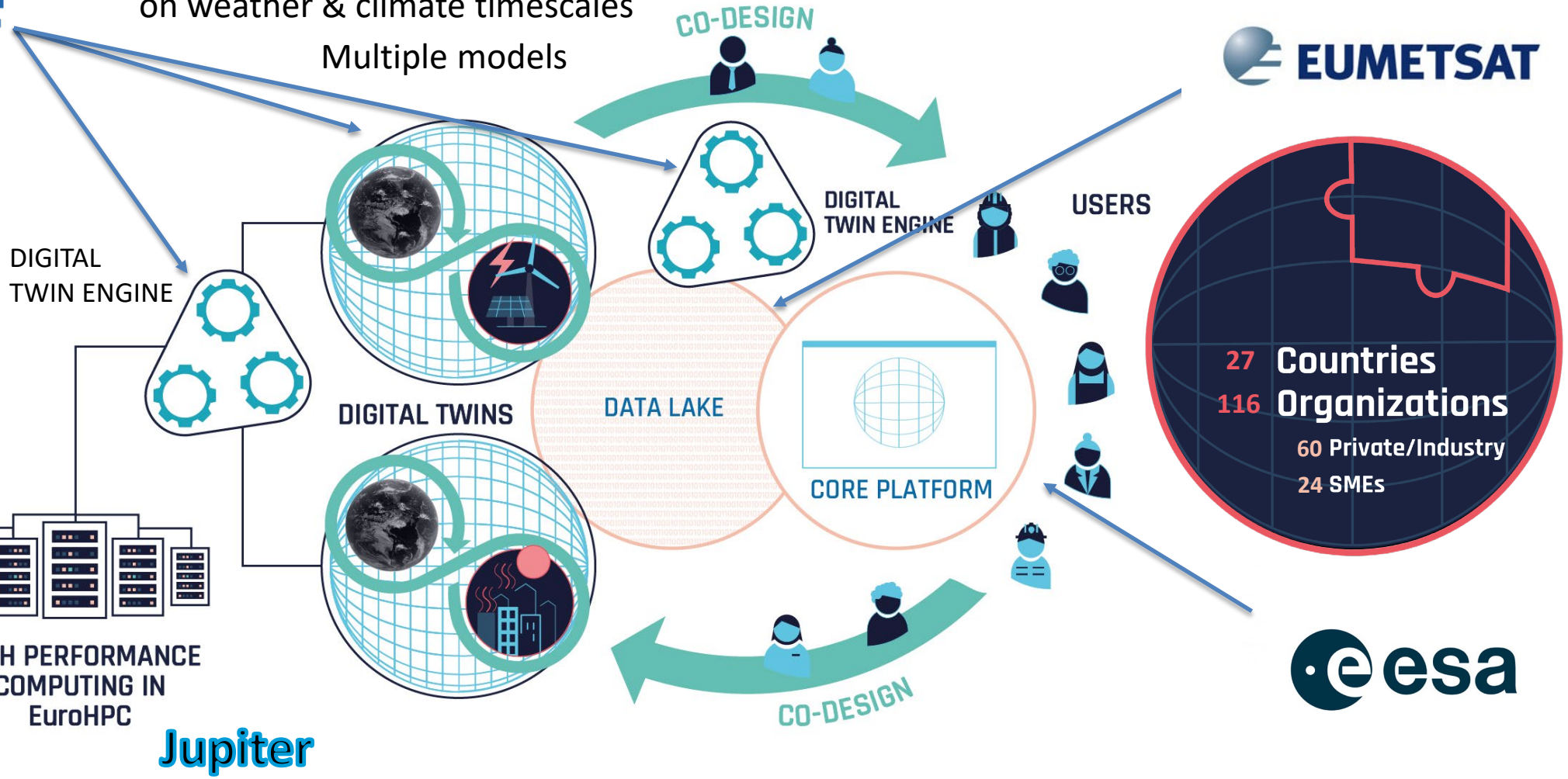
DESTINE: A EUROPEAN ENDEAVOUR

ECMWF

hybrid physical modelling and AI on weather & climate timescales

Multiple models

300+ scientists, analysts and HPC experts enrolled!



ECMWF

TWO HIGH PRIORITY DIGITAL TWINS

Weather-Induced Extremes Digital Twin

Climate Change Adaptation Digital Twin

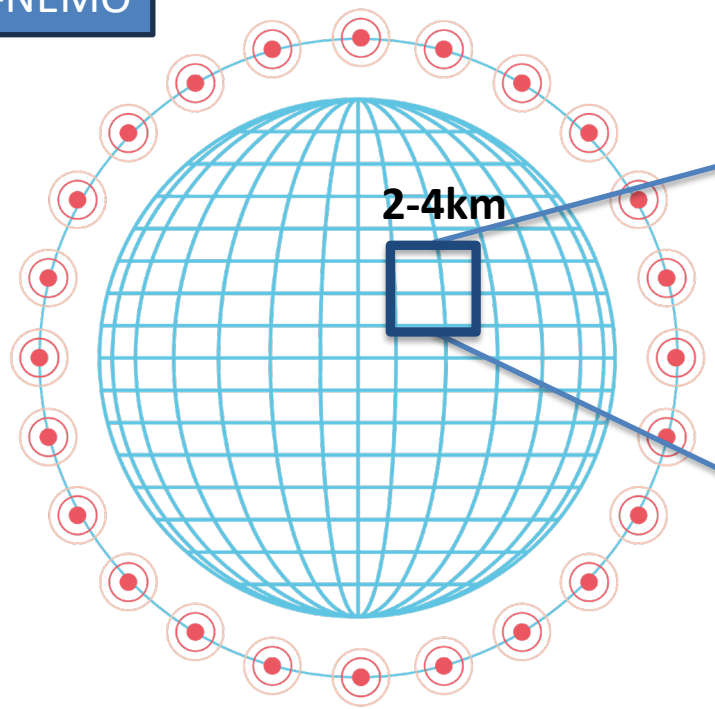
WEATHER-INDUCED EXTREMES DIGITAL TWIN

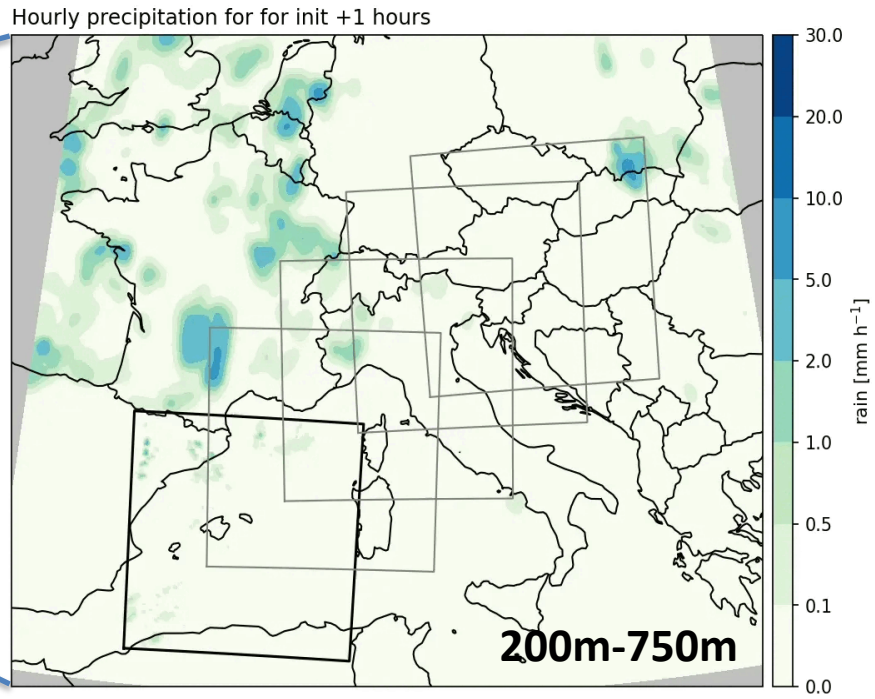
Continuous global component
4-days ahead, 2-4km

On-demand regional component over Europe
2-days ahead, 200m-750m

IFS-NEMO

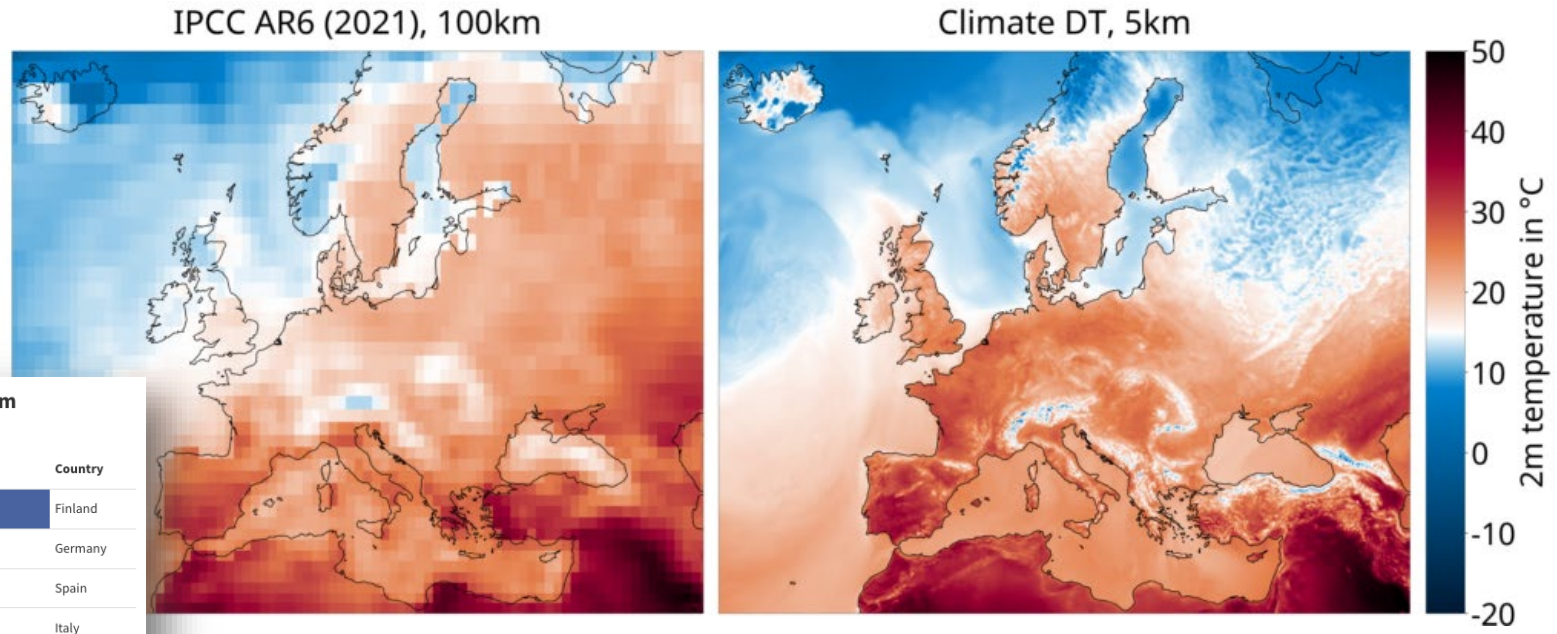
ACCORD configuration





CLIMATE CHANGE ADAPTATION DIGITAL TWIN

3 Models:
- ICON
- IFS-NEMO
- IFS-FESOM



Destination Earth Climate Adaptation Digital Twin Consortium
Procured by ECMWF. List of participant institutions in Phase I

Institution	Country
CSC - IT Center for Science (Contract lead)	Finland
Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (AWI)	Germany
Barcelona Supercomputing Center (BSC)	Spain
Institute of Atmospheric Sciences and Climate (CNR-ISAC)	Italy
German Climate Computing Centre (DKRZ)	Germany
National Meteorological Service of Germany (DWD)	Germany
Finnish Meteorological Institute (FMI)	Finland
Max Planck Institute for Meteorology (MPI-M)	Germany
Catholic University of Louvain (UCL)	Belgium
Helmholtz Centre for Environmental Research (UFZ)	Germany
University of Helsinki (UH)	Finland
Polytechnic University of Turin (POLITO)	Italy
Hewlett Packard Enterprise (HPE)	France

Future projection

Historical simulation

Control simulation

Storyline simulation

CLIMATE DT SIMULATIONS

IFS-NEMO 4.4km/8km 20-year projection: 2020-2039

- 215 LUMI-C nodes
- 823TB fields output, 2.5PB model restart files
- 230 forecast days per day throughput (on a good day)
- Feb 15 2024 – April 15 2024
- 488 two-week chunks
- 2 hours per two week chunk
- 175.000 CSC LUMI-C node hours

https://destine.ecmwf.int/climate-change-adaptation-digital-twin-climate-dt/#simulations

Type of simulation	Model	Resolution	Period
Future projection	ICON	5km across Earth system components	2020-2039
Future projection	IFS-NEMO	4.4 km atmosphere, 1/12 ocean/sea-ice	2020-2039
Future projection	IFS-FESOM	4.4 km atmosphere, 5km ocean/sea-ice	2020-2039
Future projection (nextGEMS)	IFS-FESOM	9 km atmosphere, 5km ocean/sea-ice	2020-2049
Historical simulation	ICON	10km atmosphere, 5km ocean/sea-ice	1993-2019
Historical simulation	IFS-NEMO	9 km atmosphere, 1/12 ocean/sea-ice	1990-2001
Historical simulation (nextGEMS)	IFS-FESOM	9 km atmosphere, 5km ocean/sea-ice	1990-2019
Control simulation	IFS-NEMO	9 km atmosphere, 1/12 ocean/sea-ice	1990-2004
Control simulation	IFS-FESOM	9 km atmosphere, 1/12 ocean/sea-ice	1990-2006
Storyline simulation past climate	IFS-FESOM	9 km atmosphere, 5km ocean/sea-ice	2017-2024
Storyline simulation present climate	IFS-FESOM	9 km atmosphere, 5km ocean/sea-ice	2017-2024
Storyline simulation future climate	IFS-FESOM	9 km atmosphere, 5km ocean/sea-ice	2017-2024

EUROHPC SUPERCOMPUTERS

LEONARDO CINECA

JÜLICH Forschungszentrum JUPITER

BSC Barcelona Supercomputing Center Centro Nacional de Supercomputación

CSC LUMI

EuroHPC Joint Undertaking

DIVERSE HARDWARE PLATFORMS

DCGP: 1536 nodes, 2x56c Intel Sapphire Rapids
Booster: 3456 nodes, 1x32c Icelake, 4xA100-64G

LEONARDO CINECA

Booster: ~6000 nodes, 4x72c Grace, 4xH100

JÜLICH Forschungszentrum JUPITER

CSC LUMI

LUMI-C: 2048 nodes, 2x64c AMD EPYC (Milan)
LUMI-G: 2978 nodes, 1x64c Trento, 4xMI250X

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

GPP: 6408 nodes, 2x56c Intel Sapphire Rapids
ACC: 1120 nodes, 2x40c Intel SPR, 4xH100

EuroHPC Joint Undertaking

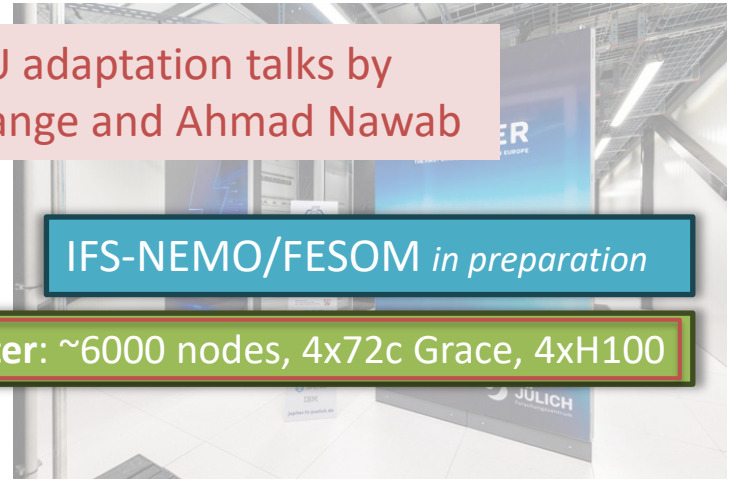
WHAT RUNS WHERE

IFS-NEMO (Extremes DT)
in preparation

DCGP: 1536 nodes, 2x56c Intel Sapphire Rapids
Booster: 3456 nodes, 1x32c Icelake, 4xA100-64G

LEONARDO CINECA

→ GPU adaptation talks by Michael Lange and Ahmad Nawab

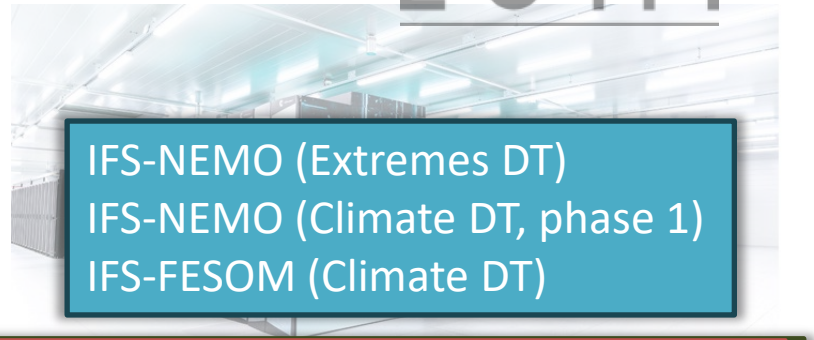


IFS-NEMO/FESOM *in preparation*

Booster: ~6000 nodes, 4x72c Grace, 4xH100

JÜLICH Forschungszentrum JUPITER

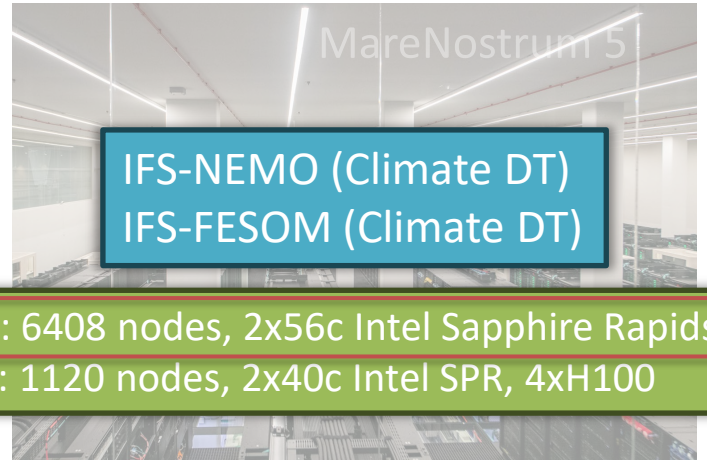
CSC LUMI



IFS-NEMO (Extremes DT)
IFS-NEMO (Climate DT, phase 1)
IFS-FESOM (Climate DT)

LUMI-C: 2048 nodes, 2x64c AMD EPYC (Milan)
LUMI-G: 2978 nodes, 1x64c Trento, 4xMI250X

BSC Barcelona Supercomputing Center Centro Nacional de Supercomputación

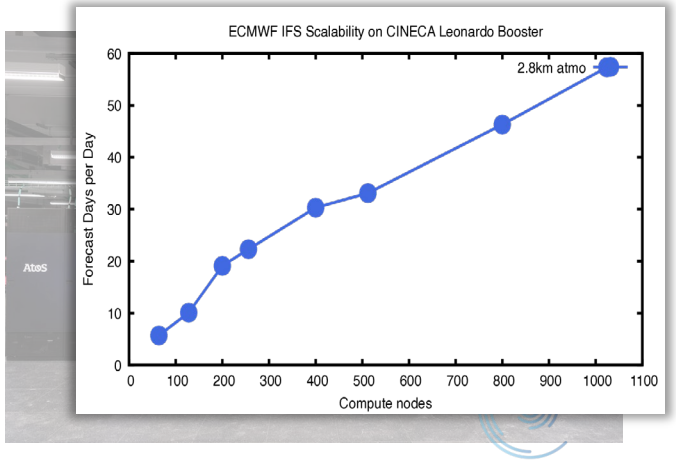


IFS-NEMO (Climate DT)
IFS-FESOM (Climate DT)

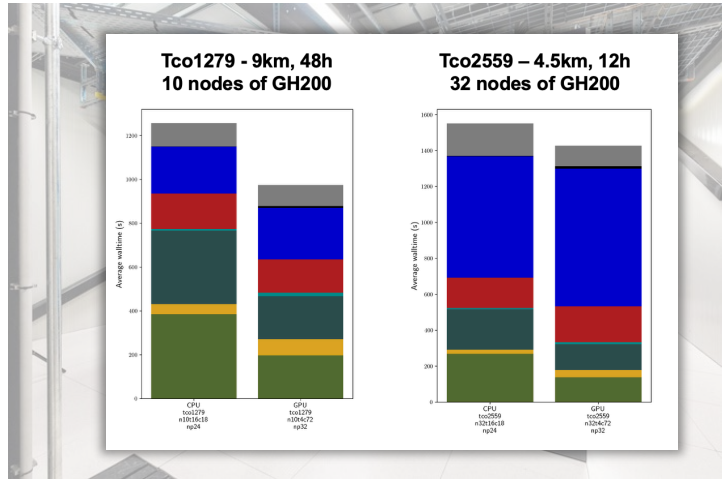
GPP: 6408 nodes, 2x56c Intel Sapphire Rapids
ACC: 1120 nodes, 2x40c Intel SPR, 4xH100

EuroHPC Joint Undertaking

DEMONSTRATING SCALABILITY ACROSS PLATFORMS



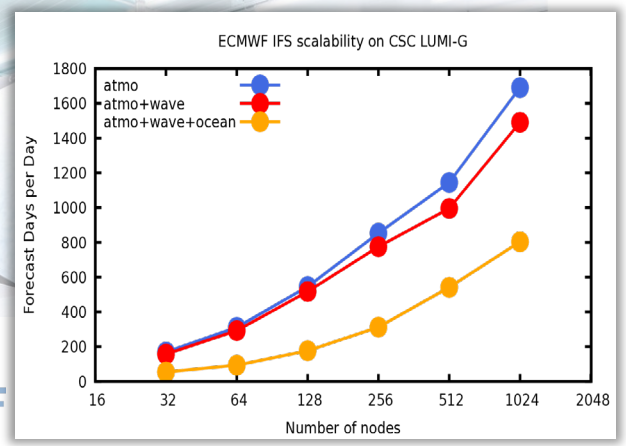
LEONARDO CINECA

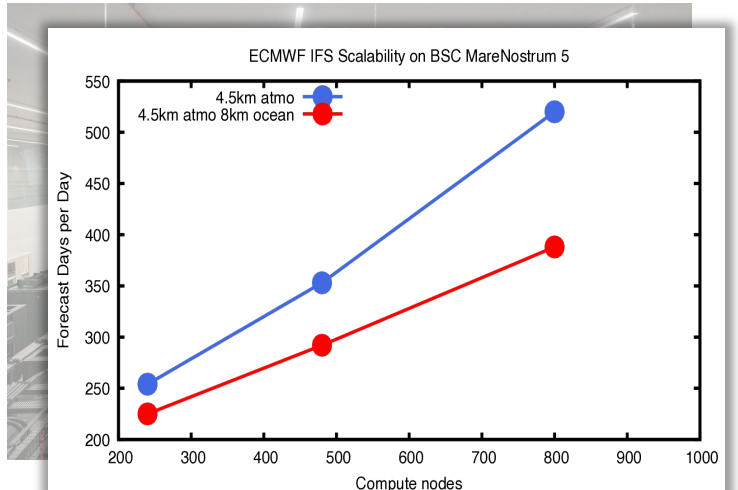


Barcelona Supercomputing Center
Centro Nacional de Supercomputación

JÜLICH Forschungszentrum JUPITER

CSC LUMI





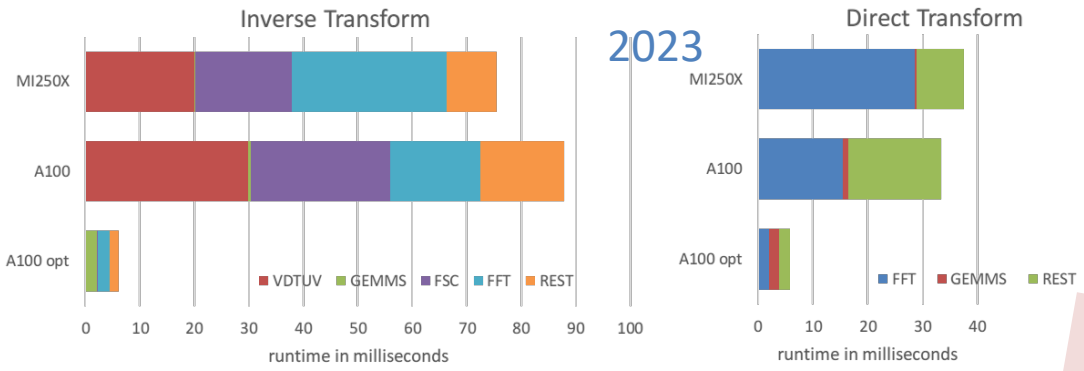
→ Talk by Ioan Hadade

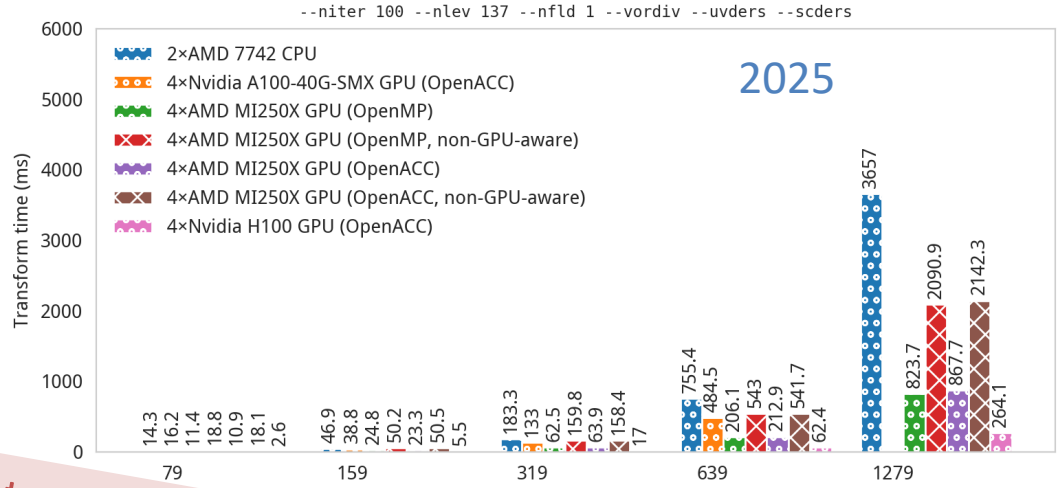
ECMWF

EuroHPC Joint Undertaking

...BUT NOT WITHOUT PERFORMANCE CHALLENGES

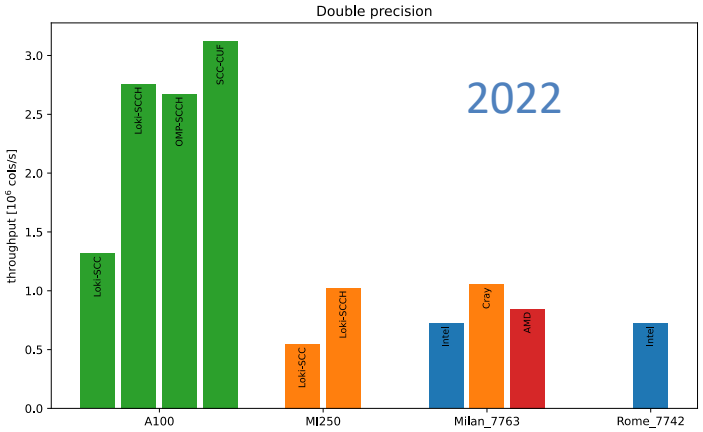
Evolution of spectral transforms library ecTrans

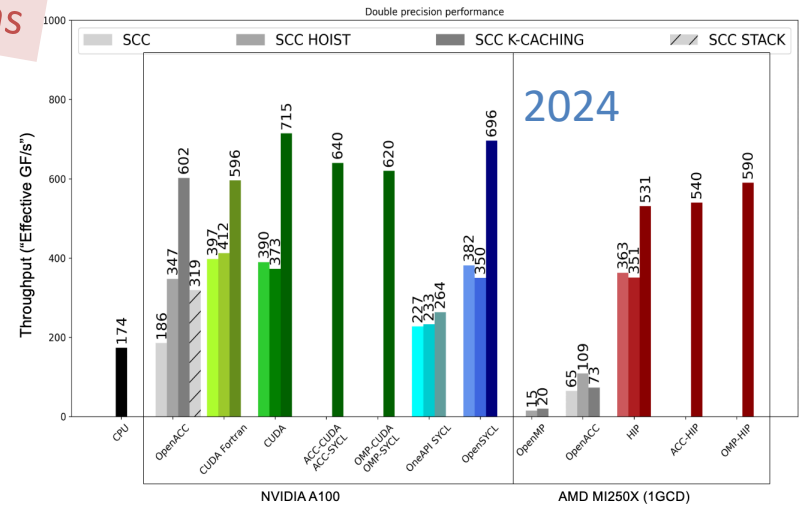




Many thanks to vendor support and contributions

Evolution of cloud microphysics scheme CLOUDSC

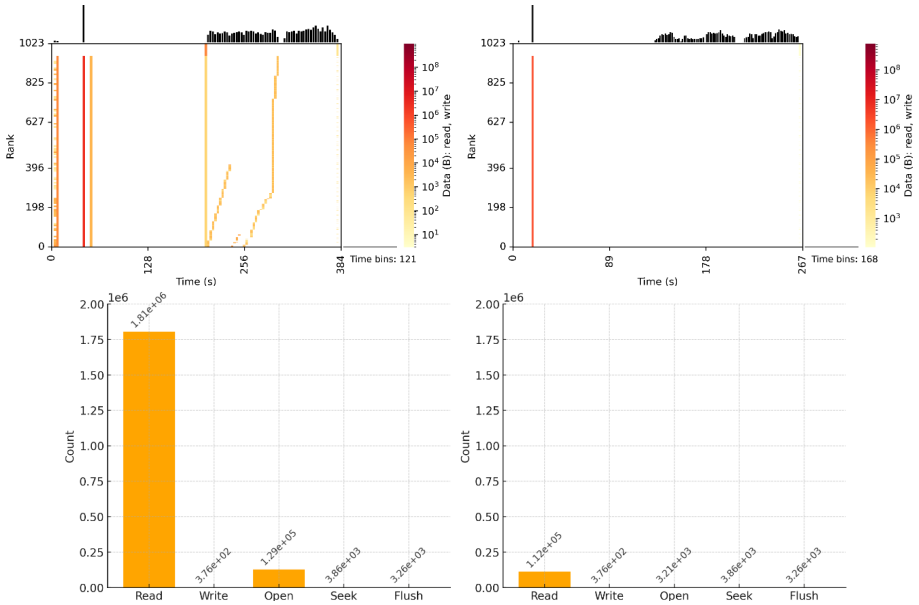




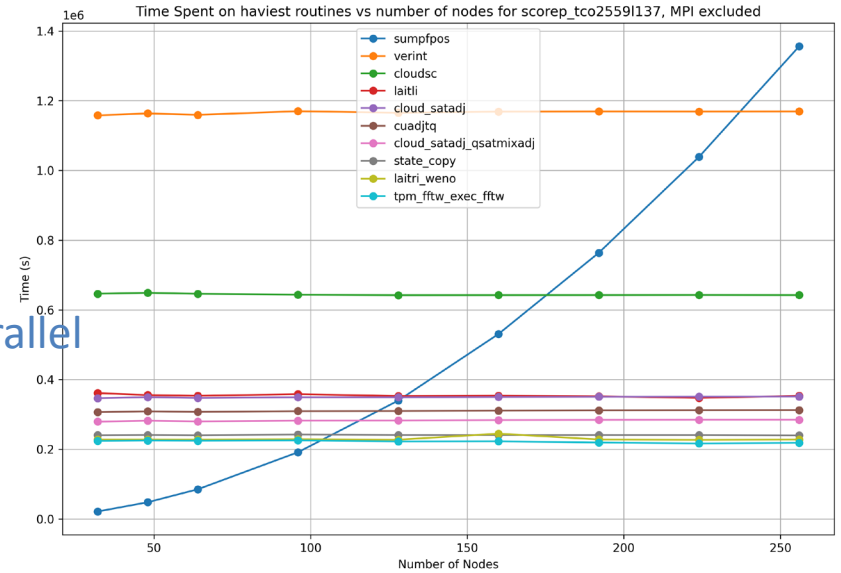
...BUT NOT WITHOUT INITIALISATION CHALLENGES

Repeated and regular performance profiling and assessment is essential

→ Talk by Fabio Di Sante (CINECA)



Impact of reading eccodes definitions from file or memfs

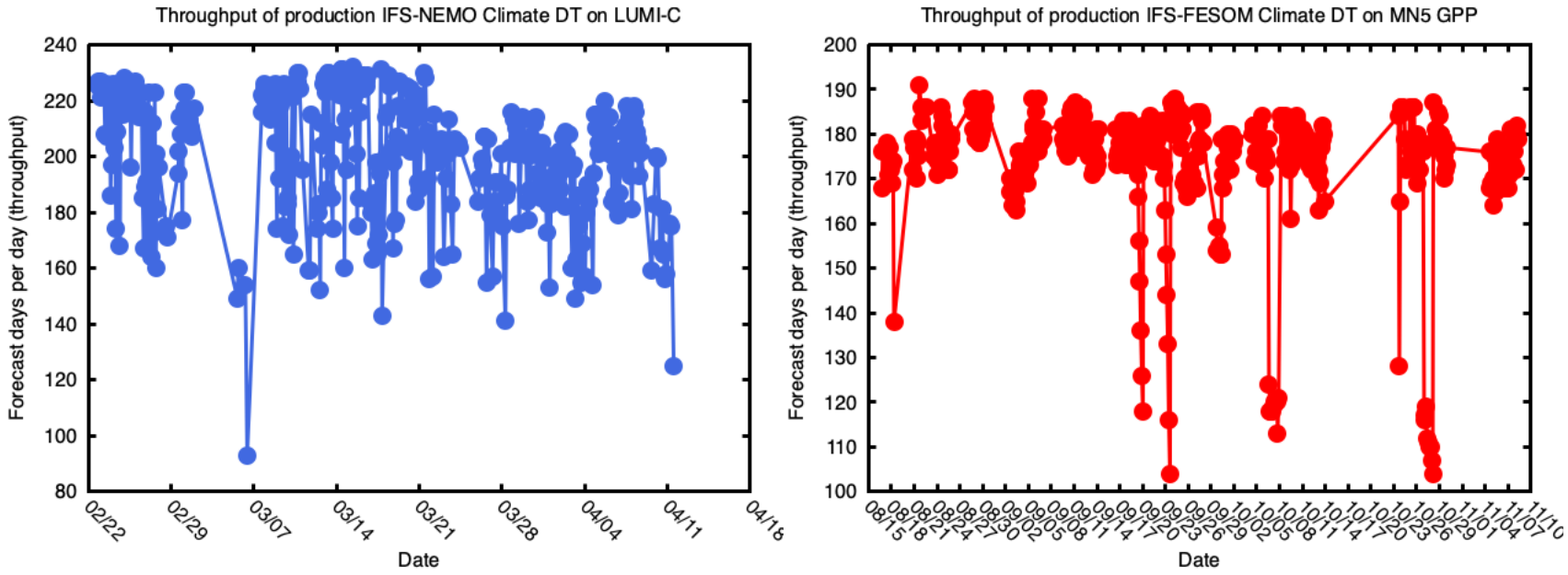


Anti-scaling behaviour of parallel communication set-up

List of most expensive STDIO read operations		
Time value (s)	Bytes read	File name
22.228870	1.52e+10	ICMCLi9tkINIT
10.22	8.24e+09	ICMGGi9tkINIUA
9.49	1.52e+10	specwavein
5.08	4.52e+05	localDefinitionNumber.98.table
3.79	2.88e+06	2.98.128.table
2.95	3.77e+06	4.0.table
2.43	5.48e+05	3.1.table

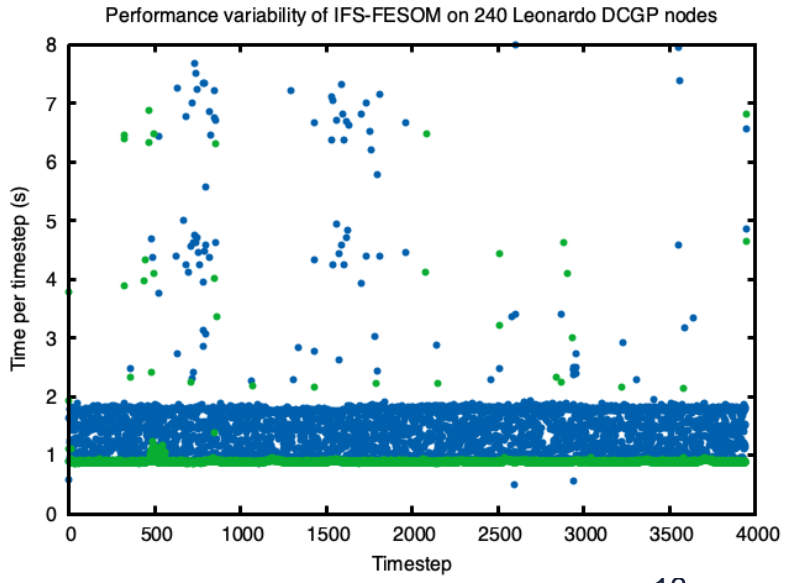
Assessment of SSD-backed file system

…BUT NOT WITHOUT OPERATIONAL CHALLENGES



Throughput of Climate DT integrations on LUMI and MN5

Performance variability on LEONARDO



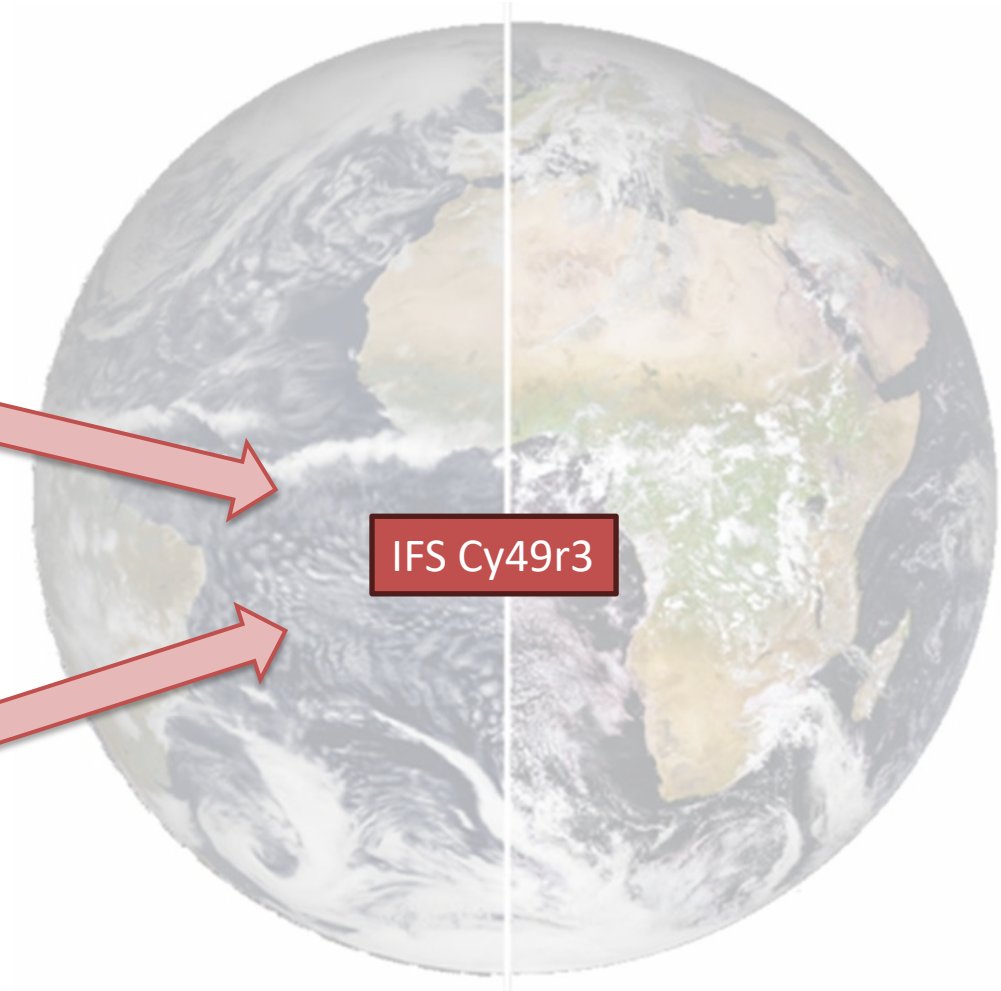
CONVERGENCE OF CODE VERSIONS

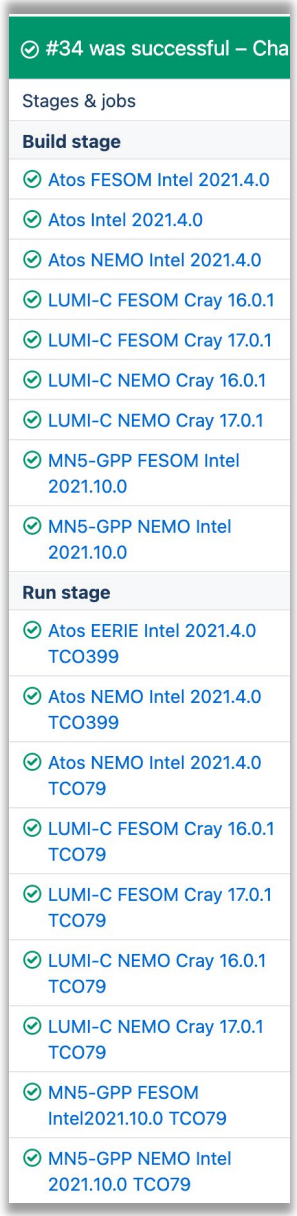
Weather-Induced Extremes Digital Twin

IFS Cy48r3

Climate Change Adaptation Digital Twin

IFS Cy48r1+Climate





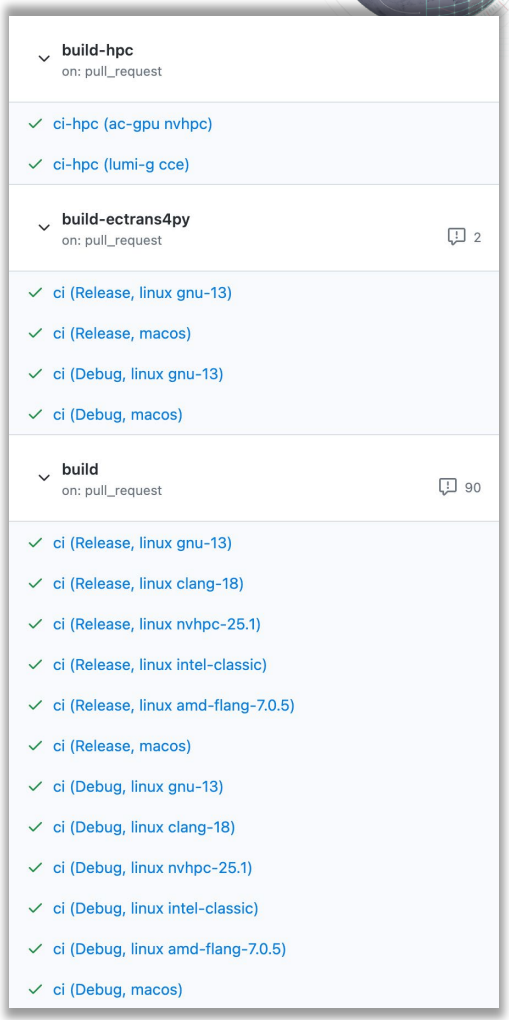
TO KEEP IT ALL RUNNING…

Ongoing evolution of per-component testing and code coverage

→ FORGE talk by Michael Lange

Ongoing evolution of cross-platform testing, improving compiler and hardware coverage

Access policies, identity management and authentication methods need to allow for CI pipelines!



…AUTOMATED TESTING IS ESSENTIAL

TO KEEP IT ALL RUNNING…

Lucian Anton

Ioan Hadade

Ahmad Nawab

Fatemeh Pouyan

Johannes Bulin

Marieke Plesske

Johan Ericsson

Michael Lange

Michael Staneker

Slavko Brdar

Olivier Marsden

Sam Hatfield

Willem Deconinck

Patrick Gillies

Zbigniew Piotrowski

…A SKILLFUL TEAM IS KEY!