Did you ever wonder which model to use?

Navigating weather information in a changing climate - from digital twins to users

DEEP DIVE PRESENTATION

Estíbaliz Gascón

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

Climate DT evaluation

Evaluation

Simulations are quality-controlled and contextualized (observations, CMIP6, …)

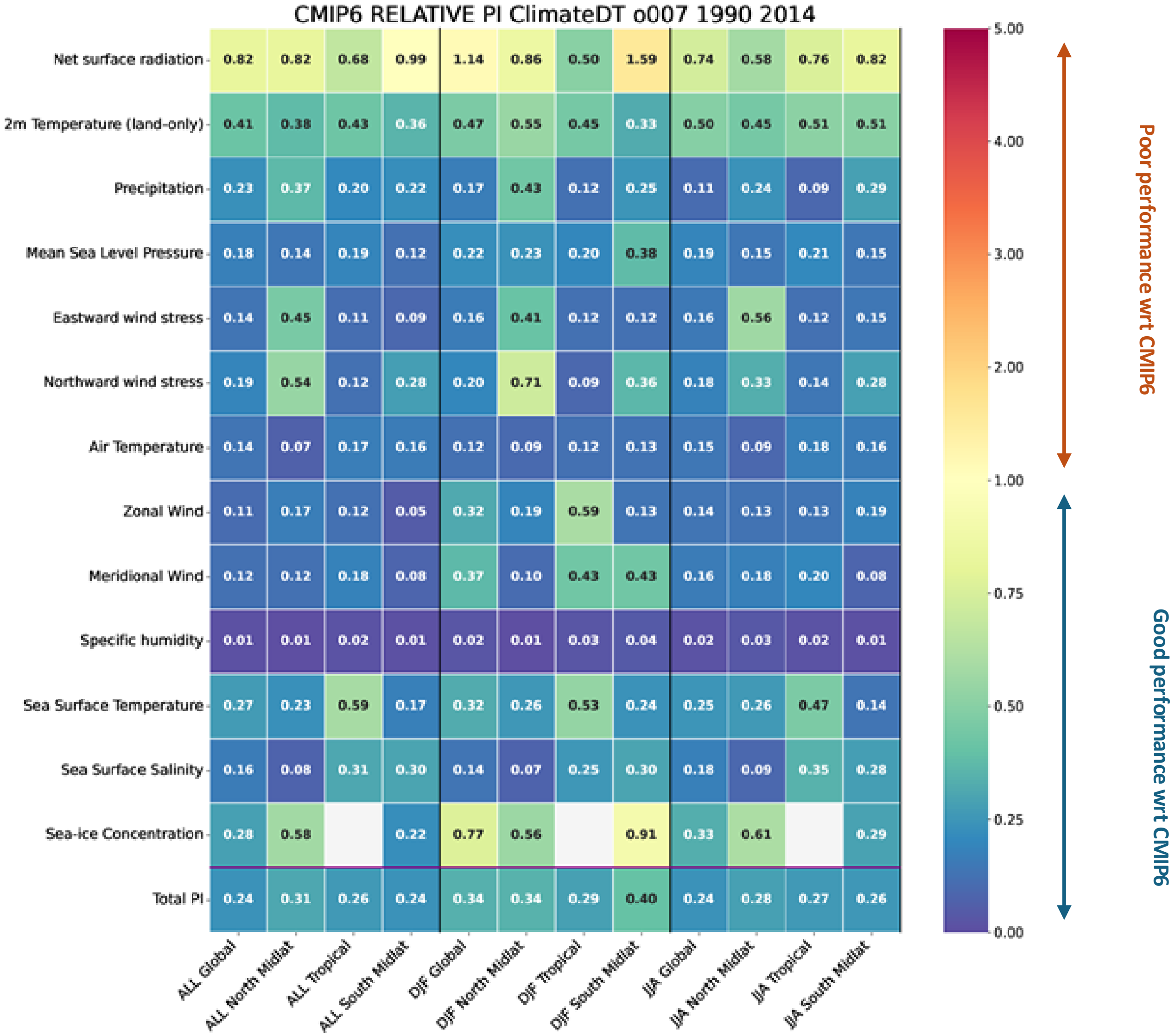
High resolution

➔ represent high-impact events with local granularity

➔ capture earth system dynamics that require high-resolution

Expected to provide added value for climate adaptation

Evaluation vs CMIP6



	ALL Global	ALL North Midlat	ALL Tropical	ALL South Midlat	DJF Global	DJF North Midlat	DJF Tropical	DJF South Midlat	JJA Global	JJA North Midlat	JJA Tropical	JJA South Midlat
Net surface radiation	0.82	0.82	0.68	0.99	1.14	0.86	0.50	1.59	0.74	0.58	0.76	0.82
2m Temperature (land-only)	0.41	0.38	0.43	0.36	0.47	0.55	0.45	0.33	0.50	0.45	0.51	0.51
Precipitation	0.23	0.37	0.20	0.22	0.17	0.43	0.12	0.25	0.11	0.24	0.09	0.29
Mean Sea Level Pressure	0.18	0.14	0.19	0.12	0.22	0.23	0.20	0.38	0.19	0.15	0.21	0.15
Eastward wind stress	0.14	0.45	0.11	0.09	0.16	0.41	0.12	0.12	0.16	0.56	0.12	0.15
Northward wind stress	0.19	0.54	0.12	0.28	0.20	0.71	0.09	0.36	0.18	0.33	0.14	0.28
Air Temperature	0.14	0.07	0.17	0.16	0.12	0.09	0.12	0.13	0.15	0.09	0.18	0.16
Zonal Wind	0.11	0.17	0.12	0.05	0.32	0.19	0.59	0.13	0.14	0.13	0.13	0.19
Meridional Wind	0.12	0.12	0.18	0.08	0.37	0.10	0.43	0.43	0.16	0.18	0.20	0.08
Specific humidity	0.01	0.01	0.02	0.01	0.02	0.01	0.03	0.04	0.02	0.03	0.02	0.01
Sea Surface Temperature	0.27	0.23	0.59	0.17	0.32	0.26	0.53	0.24	0.25	0.26	0.47	0.14
Sea Surface Salinity	0.16	0.08	0.31	0.30	0.14	0.07	0.25	0.30	0.18	0.09	0.35	0.28
Sea-ice Concentration	0.28	0.58		0.22	0.77	0.56		0.91	0.33	0.61		0.29
Total PI	0.24	0.31	0.26	0.24	0.34	0.34	0.29	0.40	0.24	0.28	0.27	0.26

Evaluation

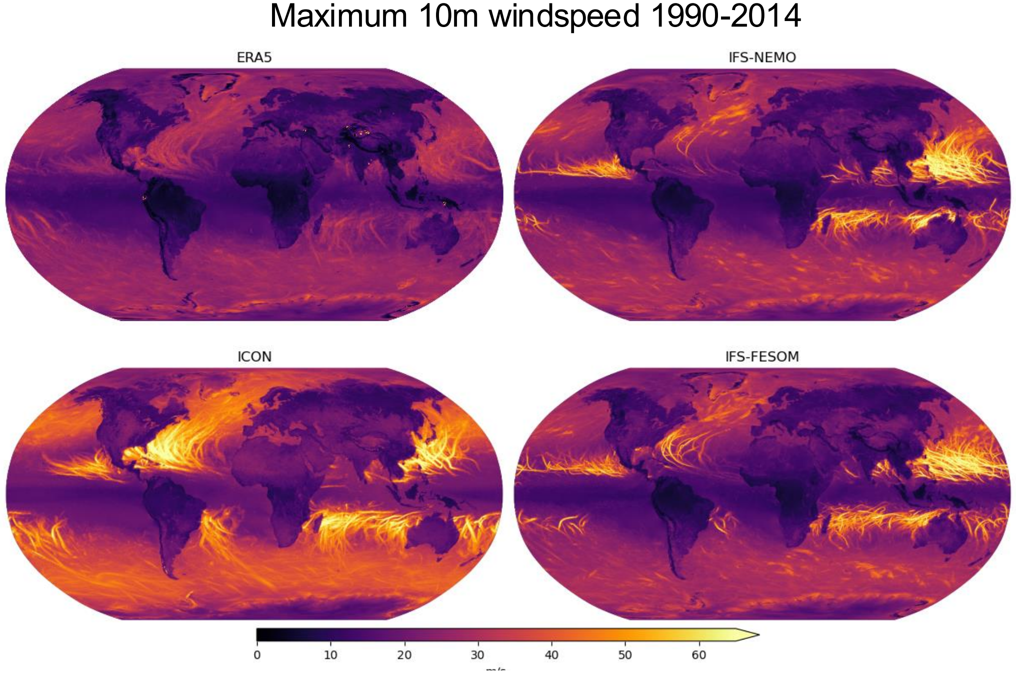
Phase 2 simulations are quality-controlled and contextualized (observations, CMIP6, …)

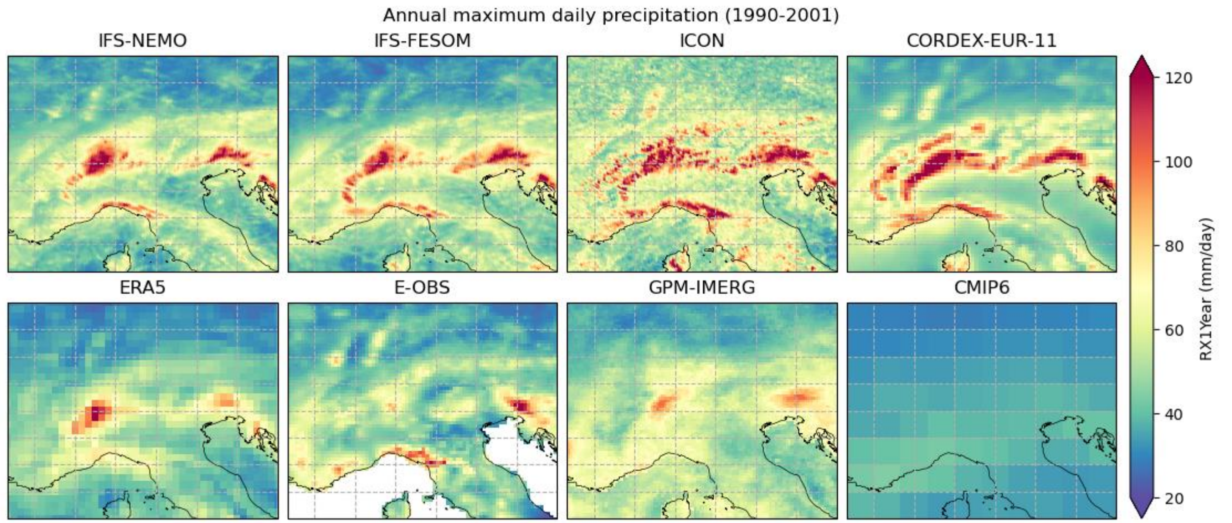
High resolution

➔ represent high-impact events with local granularity

➔ capture earth system dynamics that require high-resolution

Expected to provide added value for climate adaptation

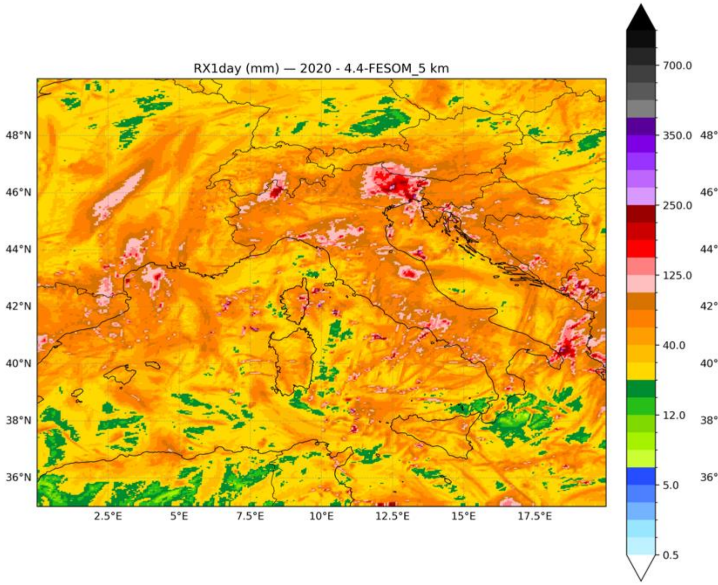


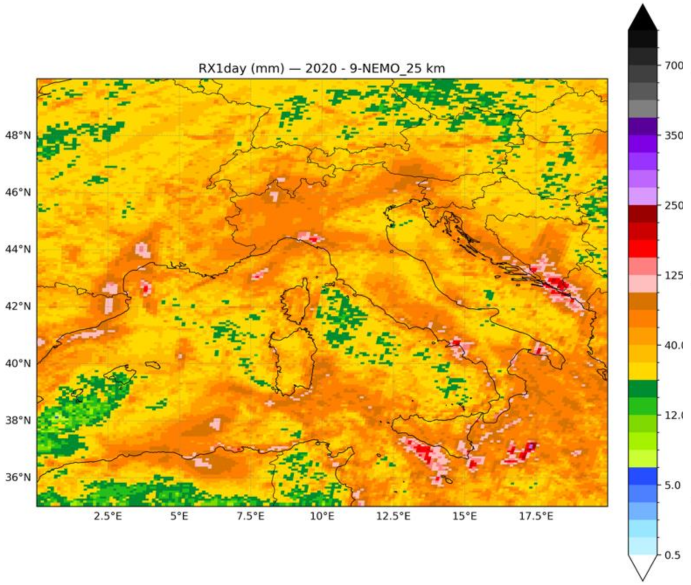


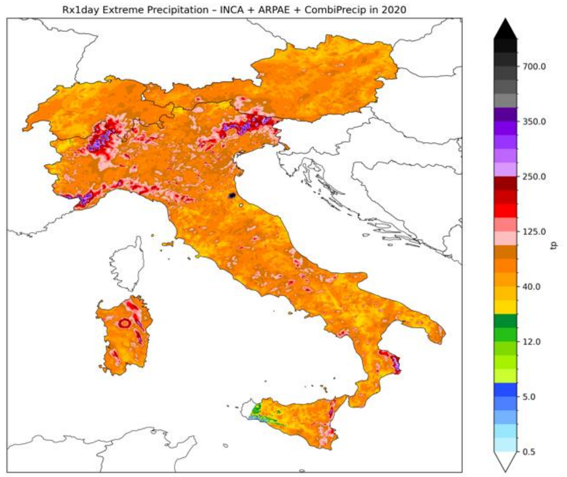
Climate model evaluation for extreme precipitation

4.4 km + FESOM | **9 km + NEMO** | **Observations (RADAR data)**

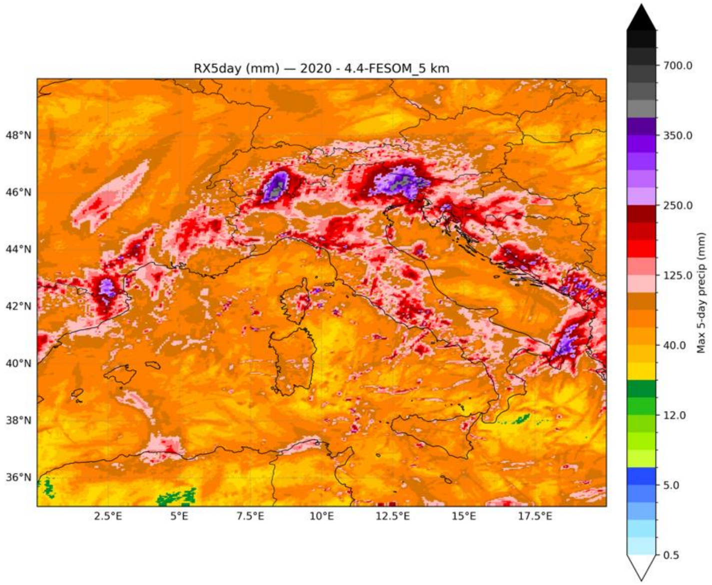
Max. 24h accumulated precipitation in 2020

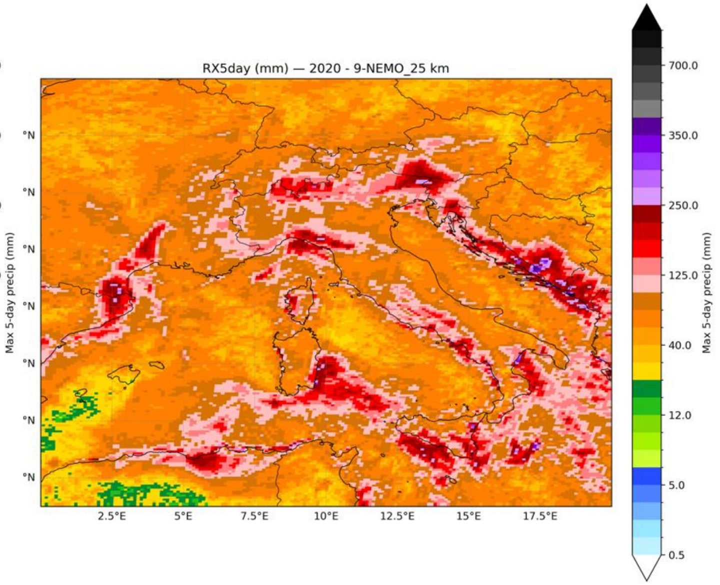


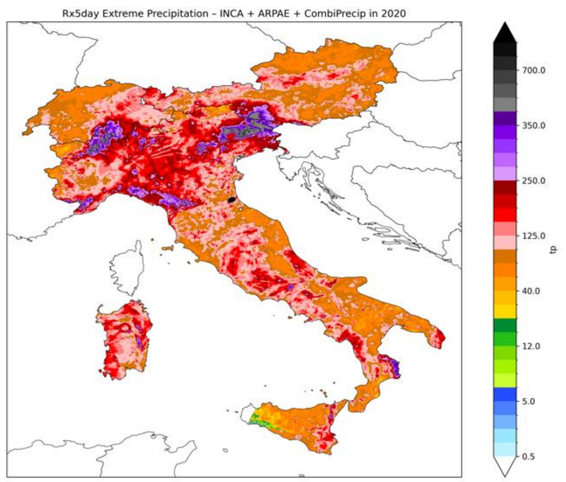




Max. 5-day accumulated precipitation in 2020

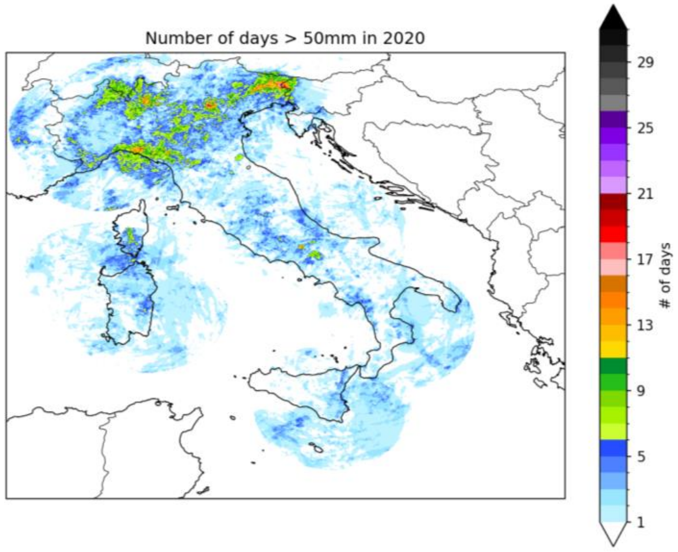




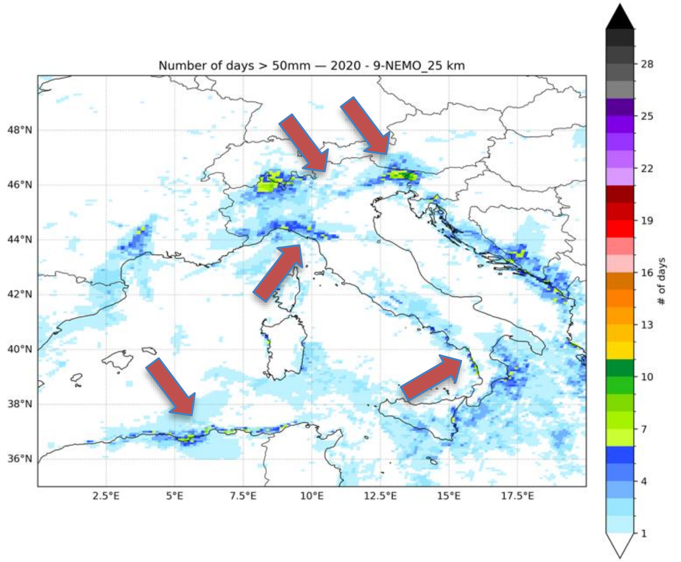


Number of days with 24h precipitation > 50mm in 2020

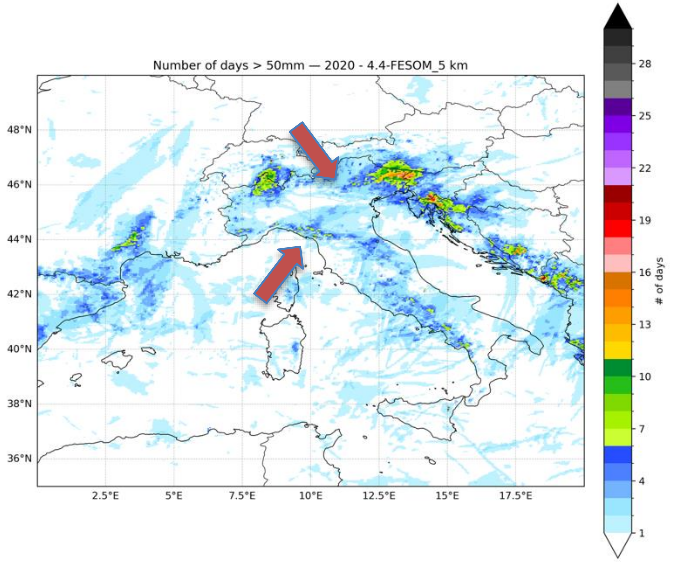
Observations



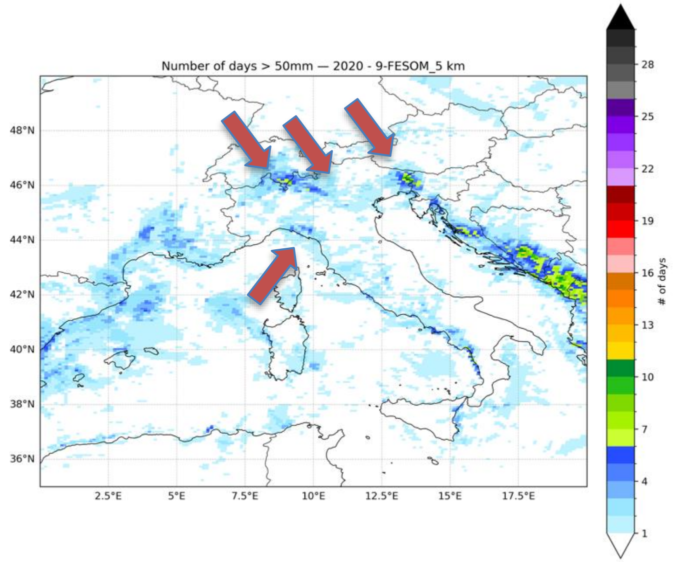
9 km + NEMO



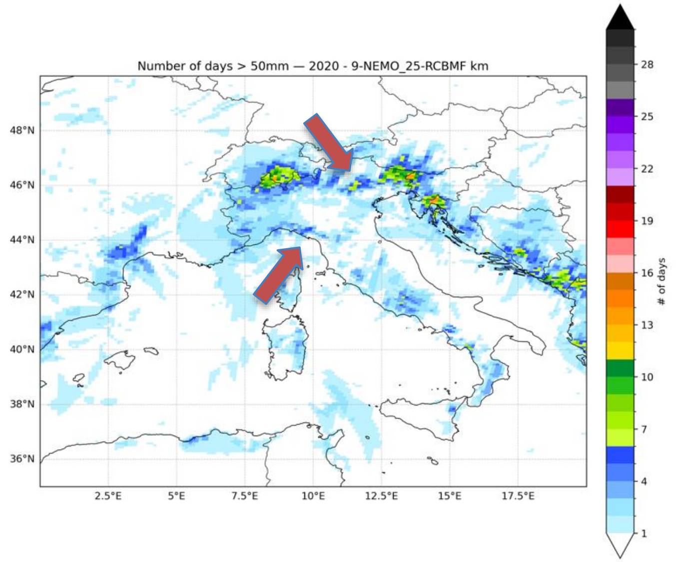
4.4 km + FESOM



9 km + FESOM



9 km + NEMO + red. conv.



→ Coastal issue improves with reduced convection scheme and FESOM

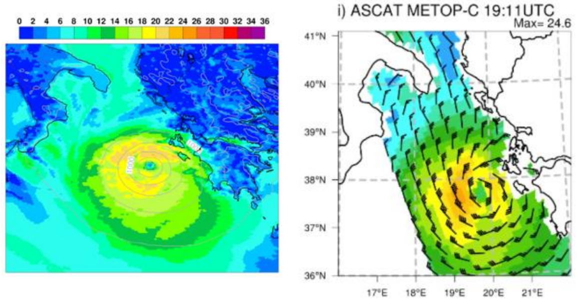
→ Peaks over mountains improve with higher resolution

Extremes DT evaluation

Extremes DT evaluation for extremes: complementary strategies

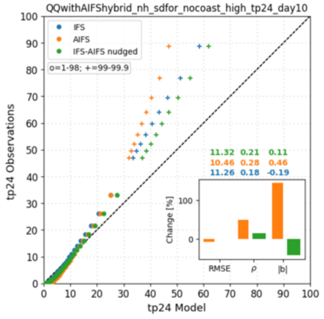
Evaluation of extreme case studies

- Evaluation of past case studies
- Continuous evaluation of emerging events (Daily Report, Severe event catalogue)



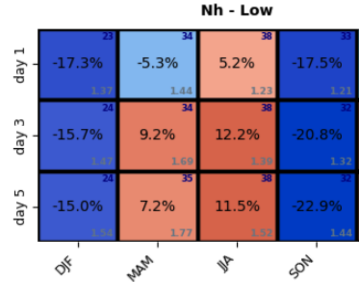
Verification of the climatology of extremes

- To evaluate how much the model climatology fits the observations climatology
- i.e. Quantile-quantile comparison focused on extremes (highlighting >99th percentile)



Verification with specific scores for extremes

- We must choose useful verification scores for extremes
- How to define extremes? Percentiles or fixed thresholds
- Evaluation against point observations (SYNOP/HDOBS)



Why might these models predict extremes better than the current operational IFS?

AIFS

AI MODEL

- **Longer predictability** and less forecast jumpiness: fewer location errors. Higher scores in synoptic variables.

- **Trained with ERA5**: detection of observed extremes that are not easy to capture with the current IFS configuration

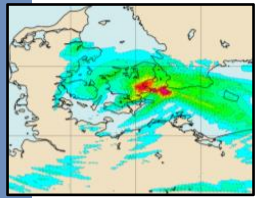
DestinE

HIGH-RESOLUTION PHYSICAL MODEL

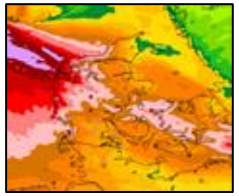
- **Higher horizontal resolution** helps to improve the prediction of extremes which depend on small-scale processes and orography

- **Physical processes** are generally **better resolved** with higher horizontal resolution forecasts: better prediction of extremes

Extreme events evaluated in the Global and Regional extremes DT

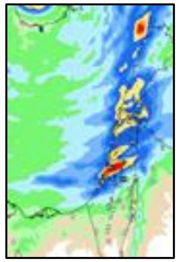


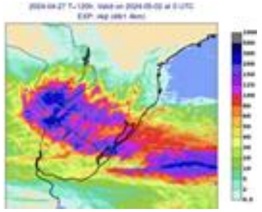
Extreme precipitation
(16/11)



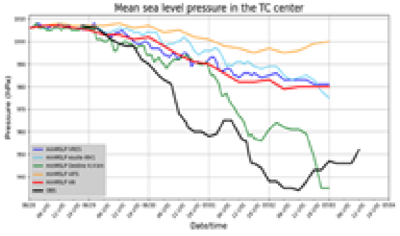
Storm Pia
(20/12)
Wind gust in Denmark

Heavy rain
(27/01) Israel

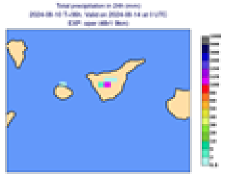




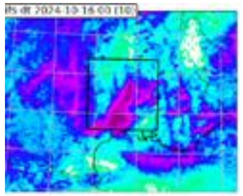
Floods
(28/04-02/05)
Brazil



TC Beryl
(26/06-06/07)
Caribbean



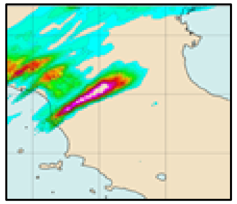
Extreme precipitation
False alarms
(10-08) Canary Islands



Mediterranean event
(17/10) France

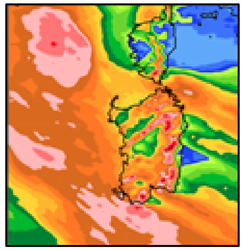
Nov | Dec | Jan | Feb | Mar | Apr | May | June | July | Aug | Sep | Oct | Nov | Dec

2023 2024

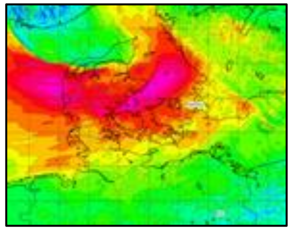


Storm Ciaran
Wind gust in Brittany
(01/11)
Floods in Tuscany
(02/11)

Wind gust
(23/12)
Corsica



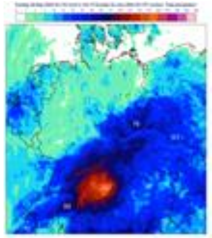
TC Belal
(14/01)
La Réunion



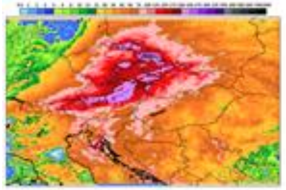
Storm Rolf
(23/02)
Denmark

Floods
(10/03)
South of France

Extreme precipitation
(01/06)
South Germany

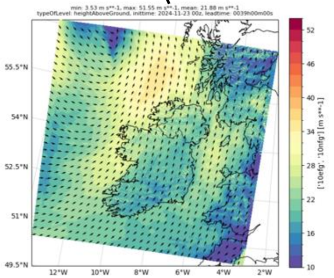


Strong wind gusts and floods
(24/06)
Italy and Croatia



Storm Boris
(26/06-06/07)

Austria, Czech Republic



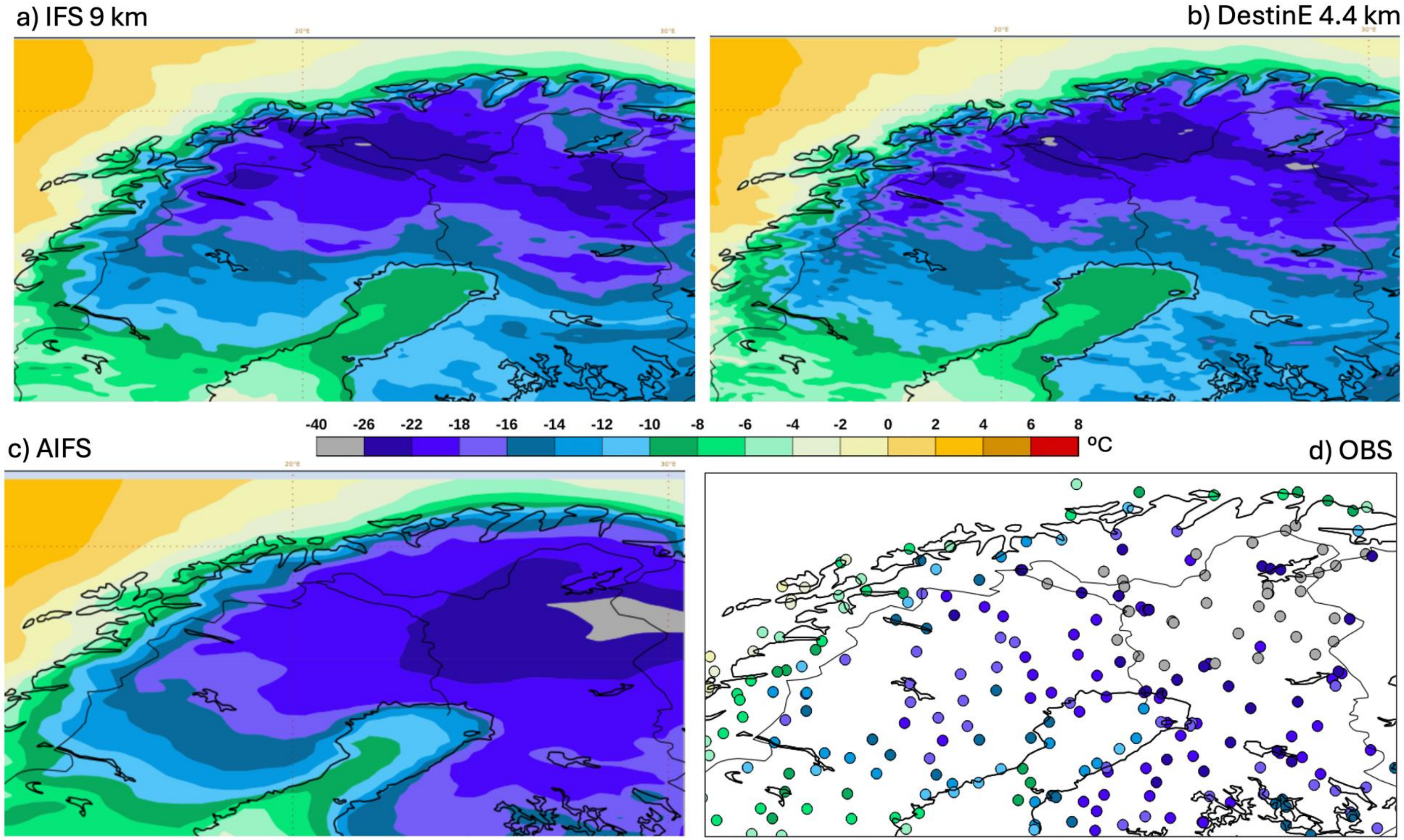
Storm Bert
(22-23/11)

Ireland

Evaluated in both in Global DT and On-Demand DT

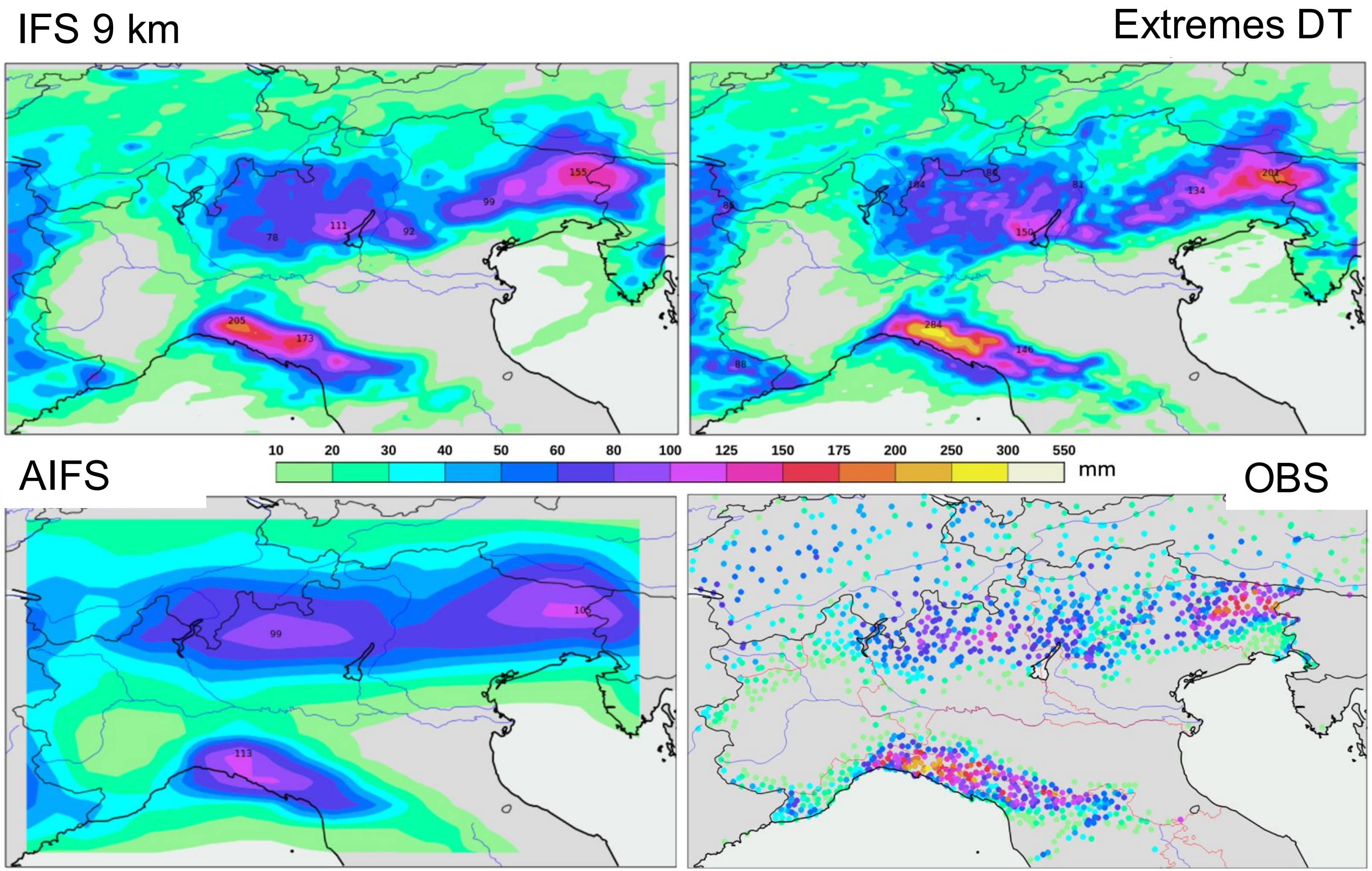
2m temperature extreme case study

Cold spell
4 February 2025
00 UTC (T+72h)



Comparing with current operational models (physics and AIF)

Extreme precipitation
27 January 2025
00 UTC (T+48h)

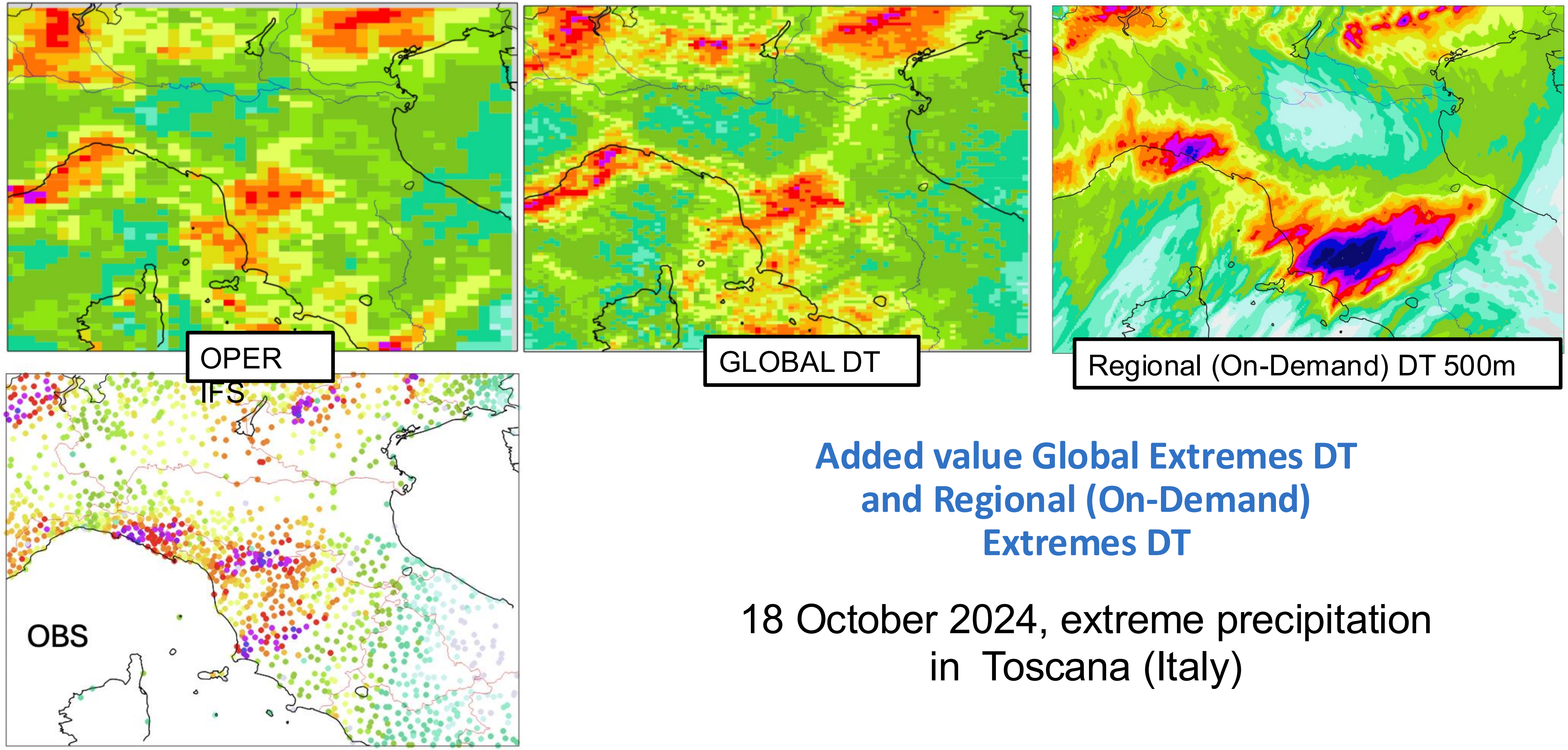


DESTINATION EARTH

Funded by the European Union

implemented by ECMWF esa EUMETSAT

Forecast 17/10/2024 00 UTC **T+34h**

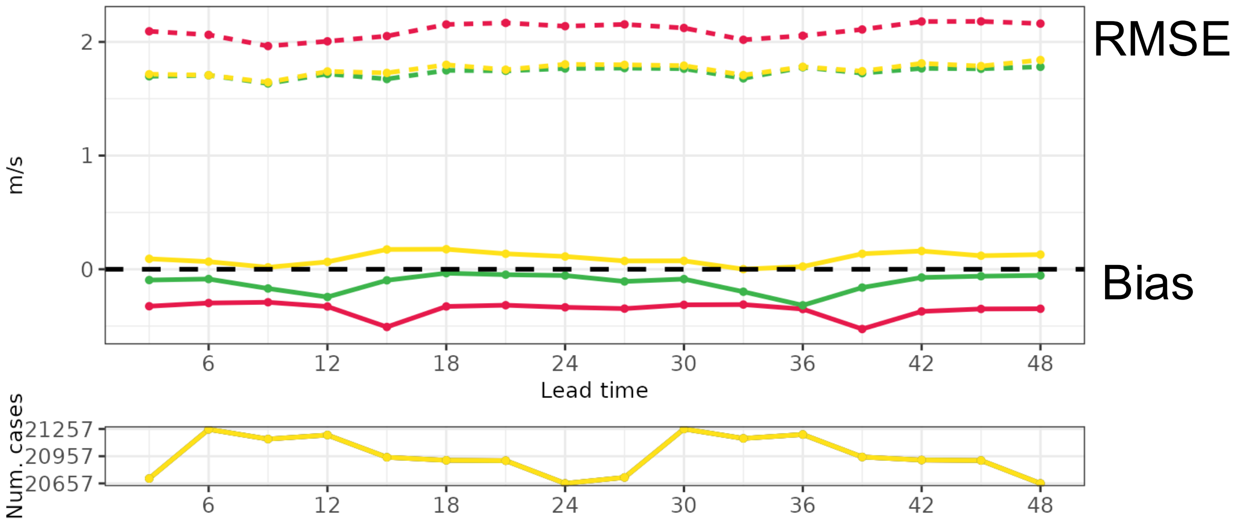


Added value Global Extremes DT and Regional (On-Demand) Extremes DT

18 October 2024, extreme precipitation in Toscana (Italy)

Regional (On-demand) near-surface wind speed

One month of on-demand simulations performed at 500m gridspacing (November 2024)

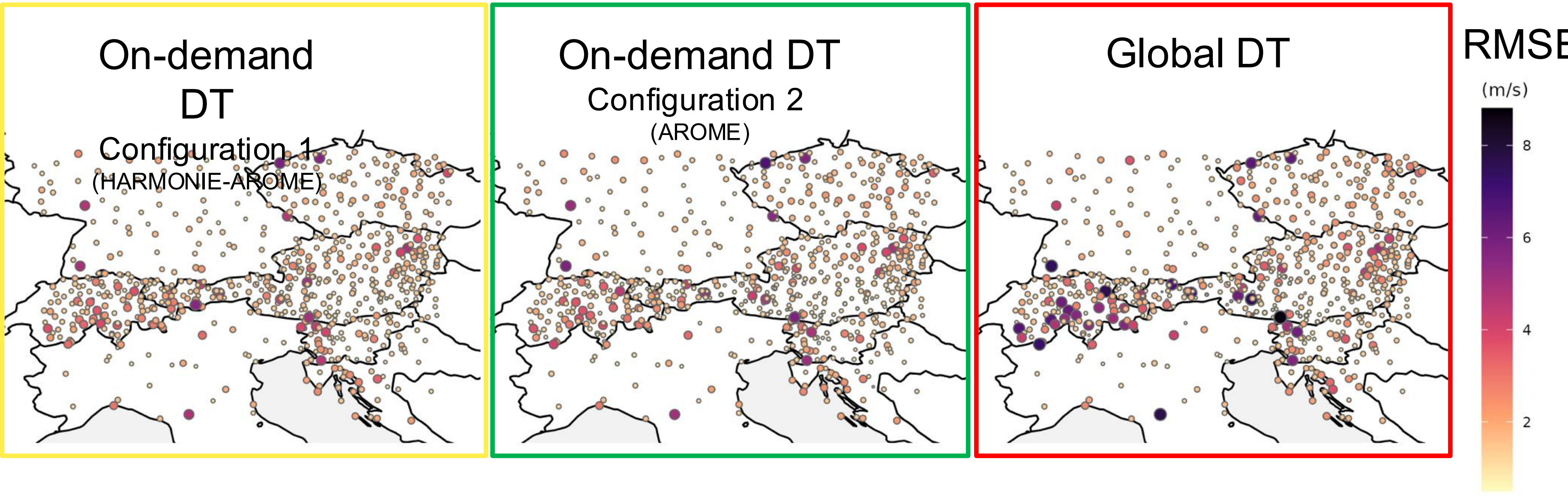


Added improved performance for **wind speed** on top of the Global DT

Especially in **complex orography**

Better representationdue to higher resolution

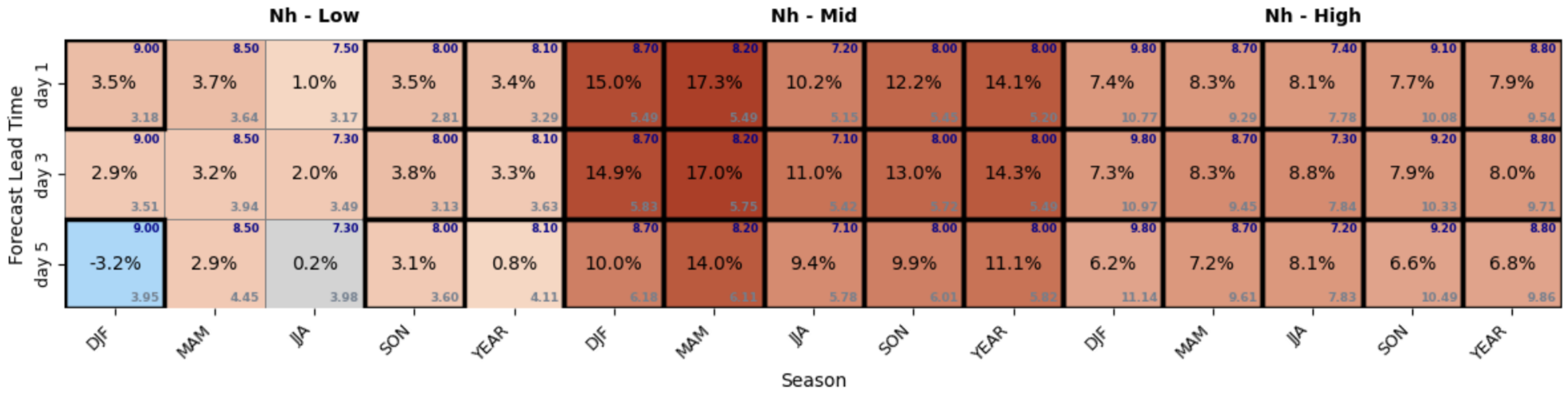
Almost always has **added value** for wind



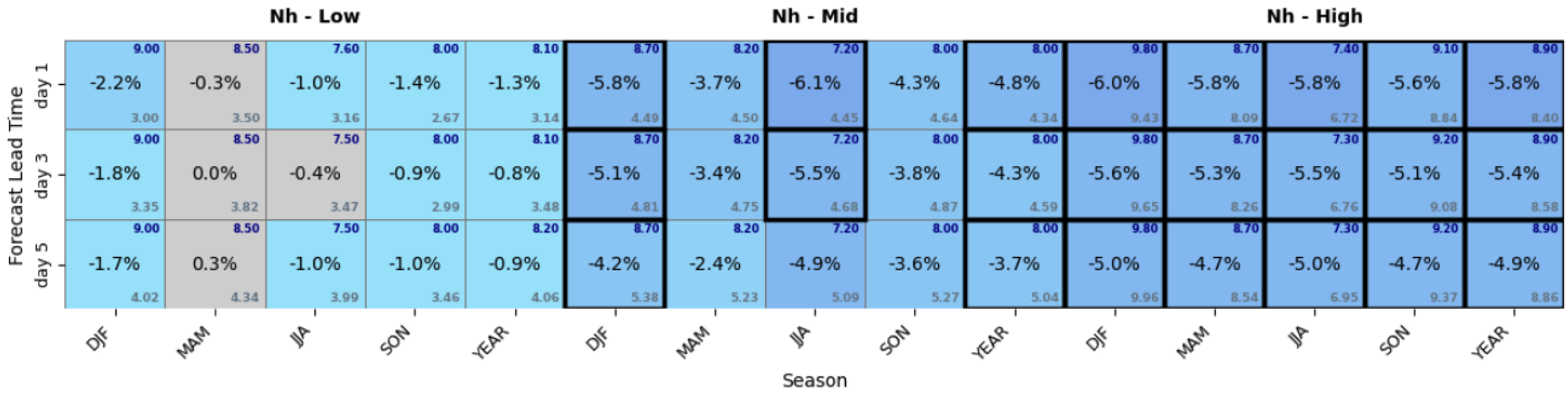
Comparing performance AI models versus Extreme DT
Example scorecards for decision making: wind extremes

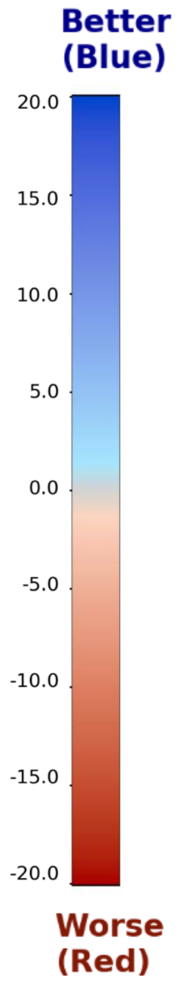
NH extratropics

AIFS versus **IFS**



Destine extremes DT versus **IFS**





SUMMARY: Added value of Extremes DT components

Extreme event		DT Global (4.4 km) added value vs OPER (9 km)		Regional (On-Demand) added value vs DT Global	
Flat areas	Mountains	Flat areas	Mountains	Flat areas	Mountains
Extreme precipitation (convective and large-scale)		↓→	↑	↑	↑
Extreme wind/wind gusts		↑	↑	↑	↑
Extreme low temperatures		→	↑	→↑	→↑
Extreme warm temperatures		→	↑	→↑	→↑
Medicanes/rapid development cyclones		↑	↑	?/↑	?/↑
Squall lines		↑	↑	?	?

Qualitative verification based on case studies

↑ IMPROVEMENT

→ SIMILAR PERFORMANCE

↓ DEGRADATION

SUMMARY: Added value of Extremes DT compared to AI models

Qualitative verification based on case studies

	OROGRAPHY	winter	spring	summer	autumn	YEAR
tp24	flat	DE	AIFS	AIFS	AIFS	AIFS
	complex	DE	DE	AIFS	DE	DE
10ff	flat	DE			DE	DE
	complex	DE	DE	DE	DE	DE
2t cold	flat	AIFS	AIFS	AIFS	AIFS	AIFS
	complex	AIFS	AIFS	AIFS	AIFS	AIFS
2t warm	flat	AIFS			AIFS	
	complex	AIFS	AIFS	DE	DE	DE

Thank you!

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