GLORI
GLObal to Regional | ICON Digital Twin

Deutscher Wetterdienst
Wetter und Klima aus einer Hand
DWD

Diagnostic approaches for the GLObal-to-Regional ICON (GLORI) Digital Twin

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with contributions of Alberto de Lozar, Ina Blumenstein-Weingartz, Vanessa Fundel, Jan-Peter Schulz, Günther Zängl, Tommaso Diomede, Thomas Gastaldo, Virginia Poli

The GLORI Digital Twin

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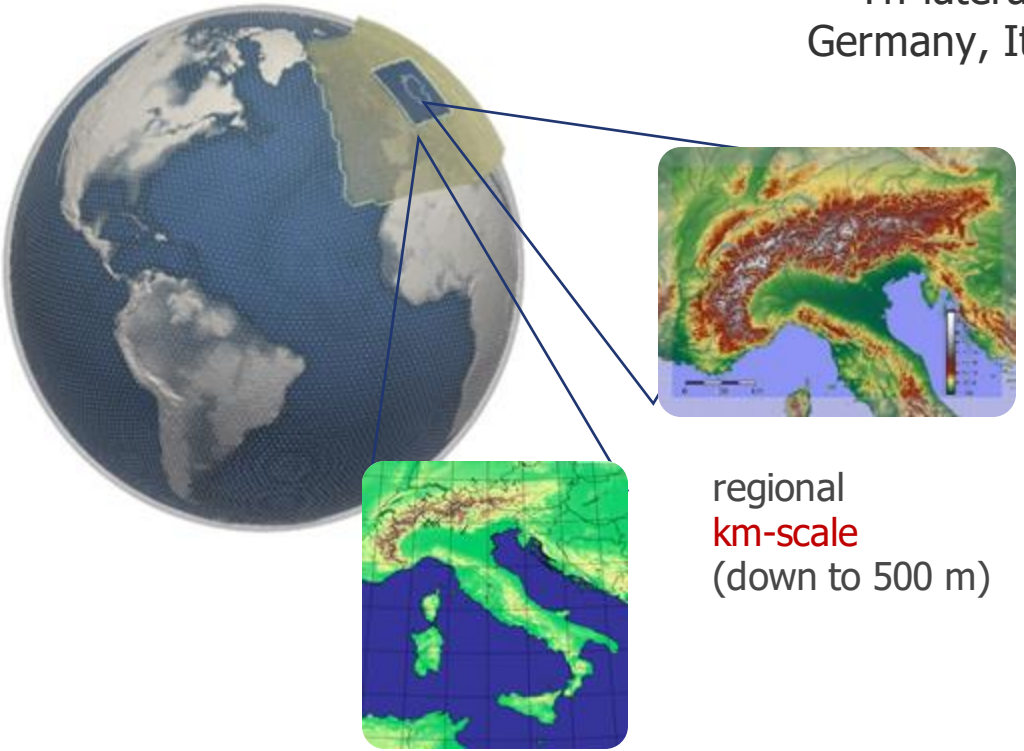
global storm-resolving (~3km)



regional
km-scale
(down to 500 m)

Tri-lateral Cooperation
Germany, Italy, Switzerland

Global-to-Regional short-range high resolution Digital Twin

configurable

on-demand

based on the prediction capability of the

ICON modeling system

and the

Data Assimilation Coding Environment DACE

GLORI Partners

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Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

CSCS

JÜLICH
Forschungszentrum

KIT
Karlsruhe Institute of Technology

ItaliaMeteo

arpae
agenzia prevenzione ambiente energia emilia-romagna

CINECA

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cmcc
Centro Euro-Mediterraneo sui Cambiamenti Climatici

IDEA-S4S

CONSORTIUM FOR SMALL SCALE MODELING
COSMO

GLORI HPC infrastructure

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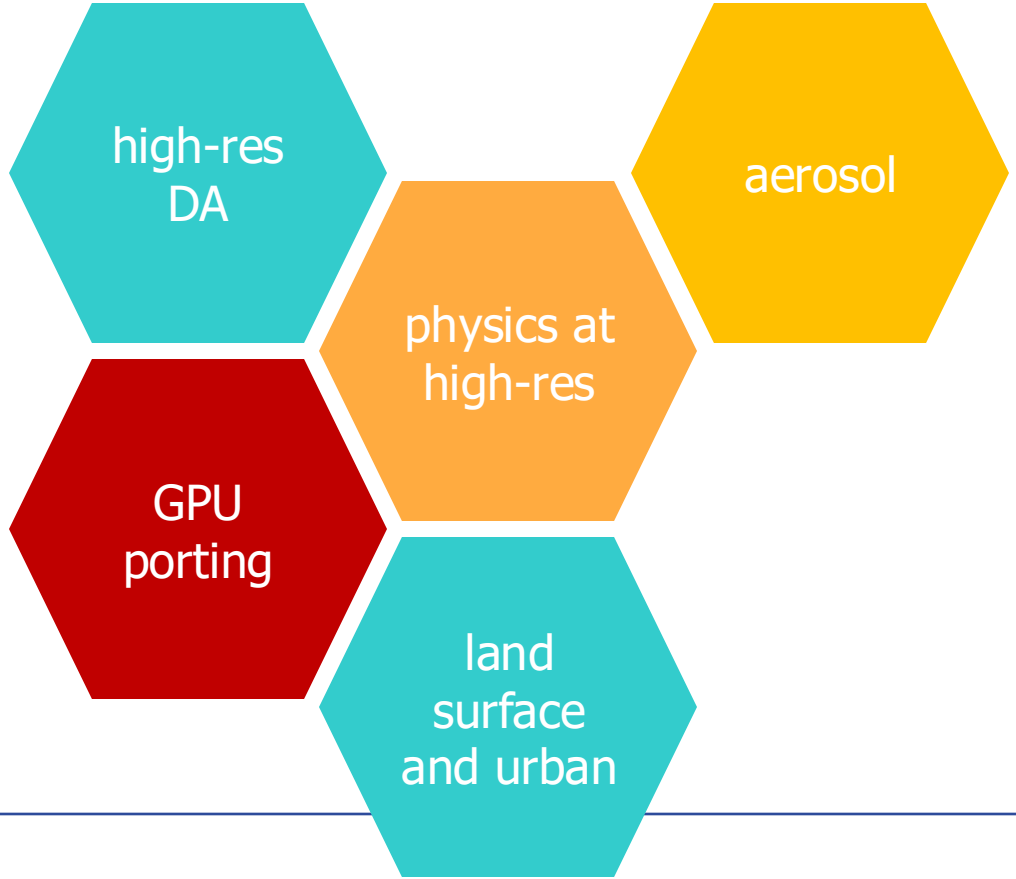
Model development …



… with a focus on impacts

TEAMx

high-res DA

physics at high-res

GPU porting

land surface and urban

aerosol

floods

urban flooding

urban heat island

pollen (health)

mineral dust (energy)

GLORI Digital Twin Configuration

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Global – EU nest

Deterministic Run: 13 km → 6.5km

Ensemble: 26 km

EU (two-way-nested)

Deterministic Run: 6.5 km → 3.25km

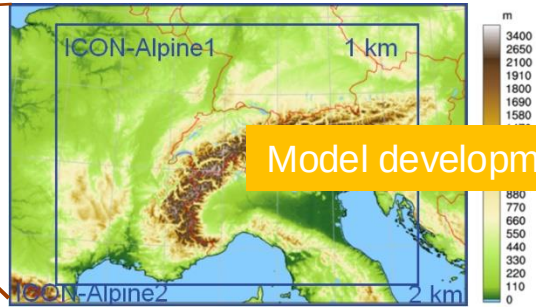
Ensembles: 13 km

Ensemble members: 40

Hybrid data assimilation: 3dvar + LETKF

GLORI (Alpine)

Basic Setup: 2km -> 1km



Deterministic Run: 2 km

Ensemble: 2 km

Nest (two-way-nested)

Deterministic Run: 1 km

Ensemble: 1 km

Ensemble members: 20/10

Model development for the high resolution

High resolution

1km -> 500m

Deterministic Run: 1 km

Ensemble: 1 km

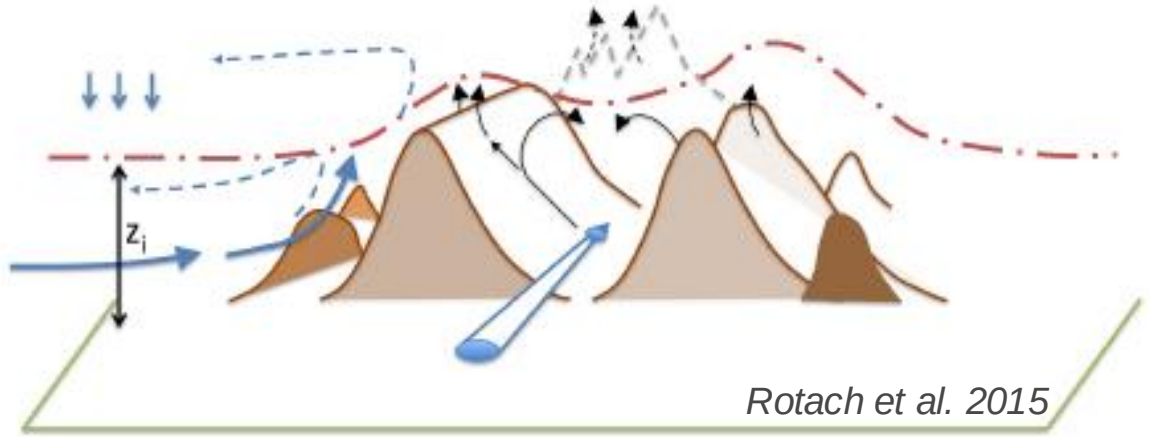
Nest (two-way-nested)

Deterministic Run: 500m

Ensemble: 500m

Ensemble members: 10

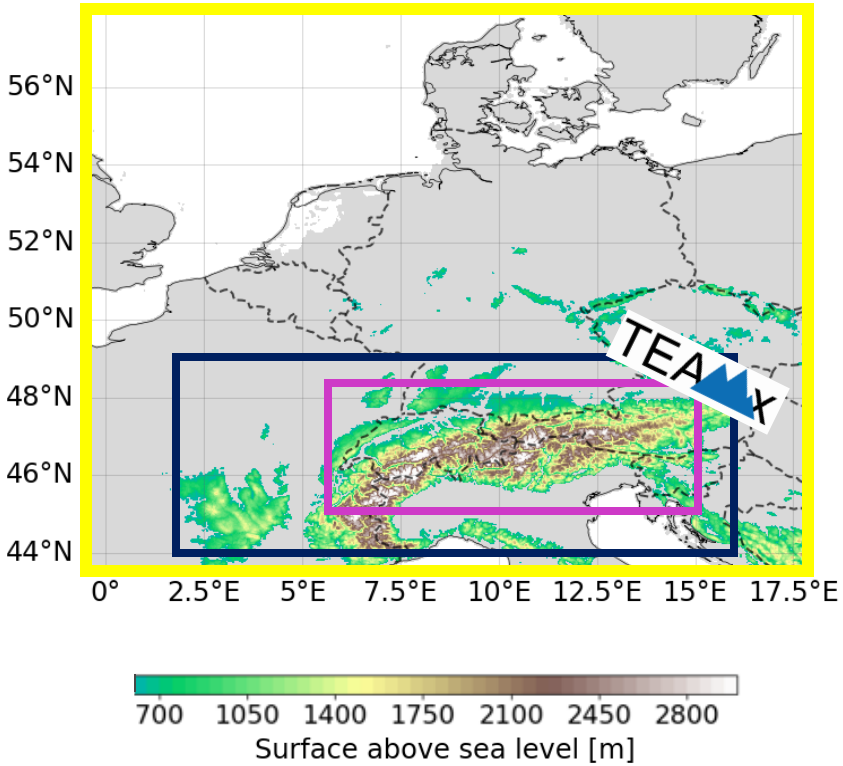
Flow over complex terrain



- The flow and boundary layer over complex terrain are probably under resolved for current NWP resolutions (2km). This improves for higher resolutions.
- Resolved thermal circulations can produce quite different surface fluxes.

Daniela Littmann

Experimental Model Domain



TEAMx

Multi-scale Transport and Exchange Processes in the Atmosphere over Mountains – Programme and experiment

Δx

2 km

1 km

500 m

Daniela Littmann

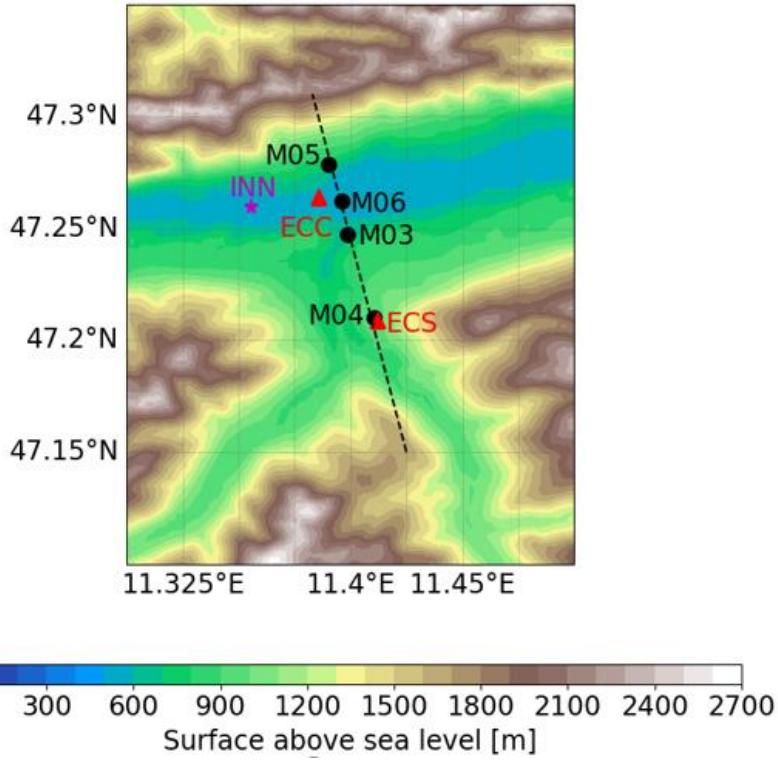
PIANO Observation

Penetration and **I**nterruption of **A**lpi**N**e F**O**ehn (2017)

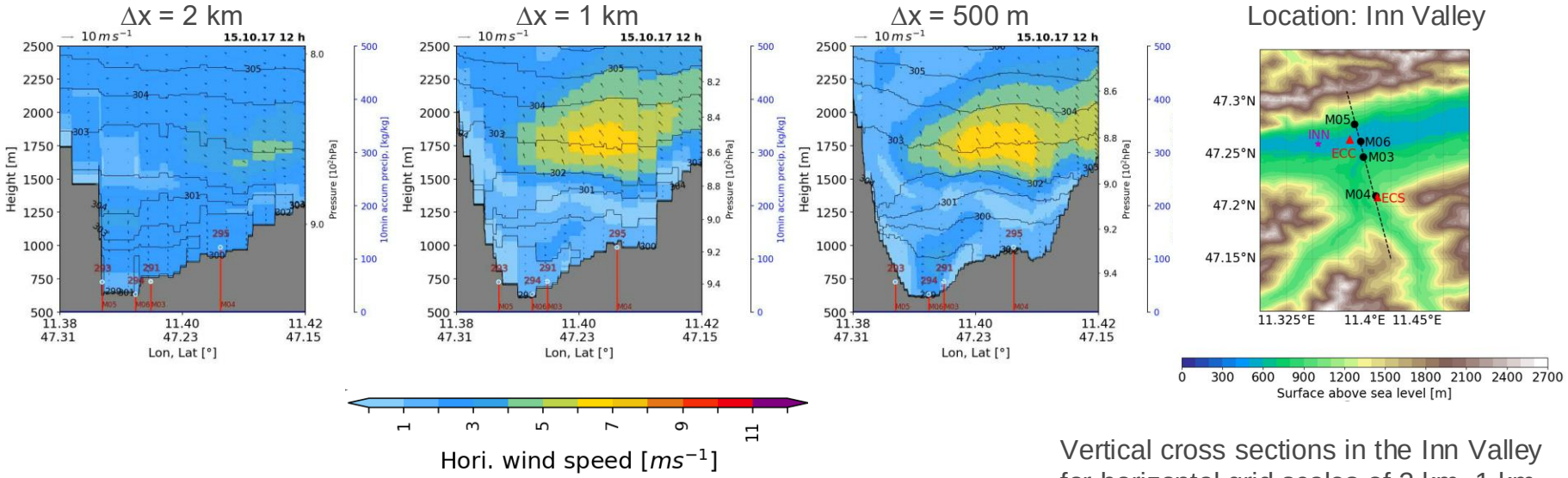
- Inn Valley and Wipp Valley
- Fall & early winter
- Study erosion and cold air pools

MOMAA weather station data M0*
Radiosonde data INN
Flux station data EC*

Gohm et al. 2021



Case study: The Cold Air Pool 2017



Vertical cross sections in the Inn Valley for horizontal grid scales of 2 km, 1 km, and 500 m for a cold air pool case during the night of 15-16 October 2017

Coloured contours: averaged horizontal wind speed
Arrows: wind direction
Contour lines: potential temperature
Measurements from *Gohm et al. 2017* marked as dots (in the map) and as lines (in the cross sections)

A strong jet (observed) is resolved by higher resolutions

Hypotheses

1. The wind over complex terrain is better resolved at higher resolutions.
2. 1-km simulations are in the gray zone; improvements can be expected for higher resolutions (here 500m)

Experiments:

- Compare forecasts over the Alps at 2 km and 1 km resolution
- Compare 1km and 500m domain

High-resolution experiments

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Model top	22 km
Vertical level	65 full (66 half)
Hor. grid scale	2 km, 1 km, 500 m
LATBC (at start)	Forecast (ICON-EU)
Forecast restart	12 h
Duration	36 h
1-way-Nesting	
Model version icon-2024.07	

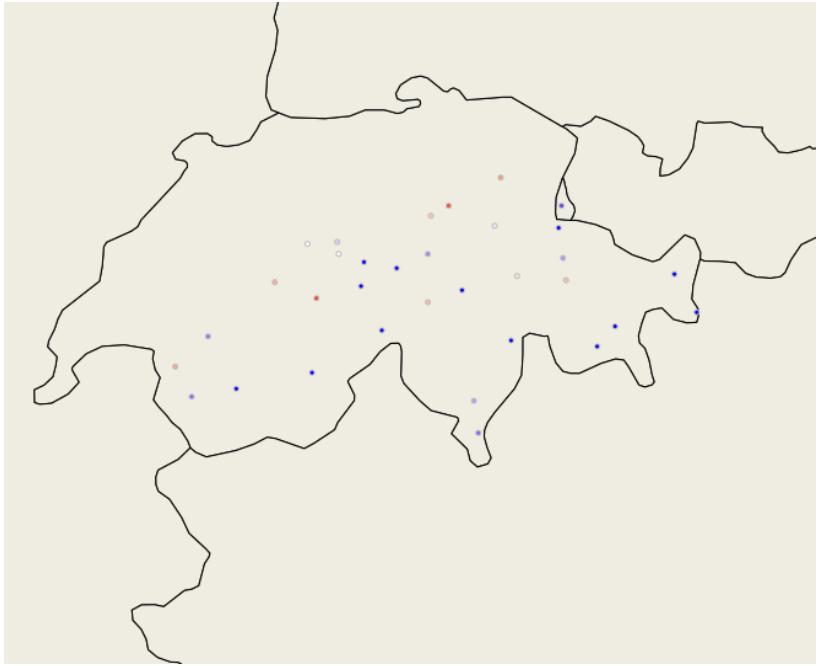
Experiments:

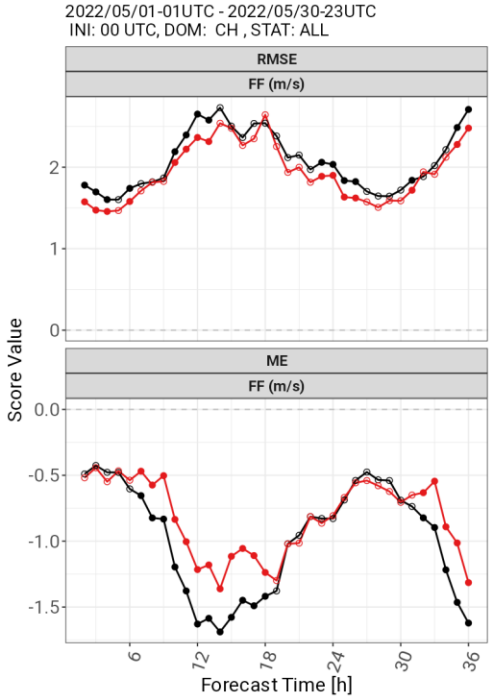
Experiment	Resolution	Model
ICON-D2	2 km	Reference
ICON-A1	1 km	Reference
ICON-A05	500 m	Reference
ICON-mix	500 m	No convection, turlen (t_0=80 m)

ICON-mix:

- reduced asymptotic length scale l = 80m instead of =300m
- no shallow convection

Wind verification over valley stations



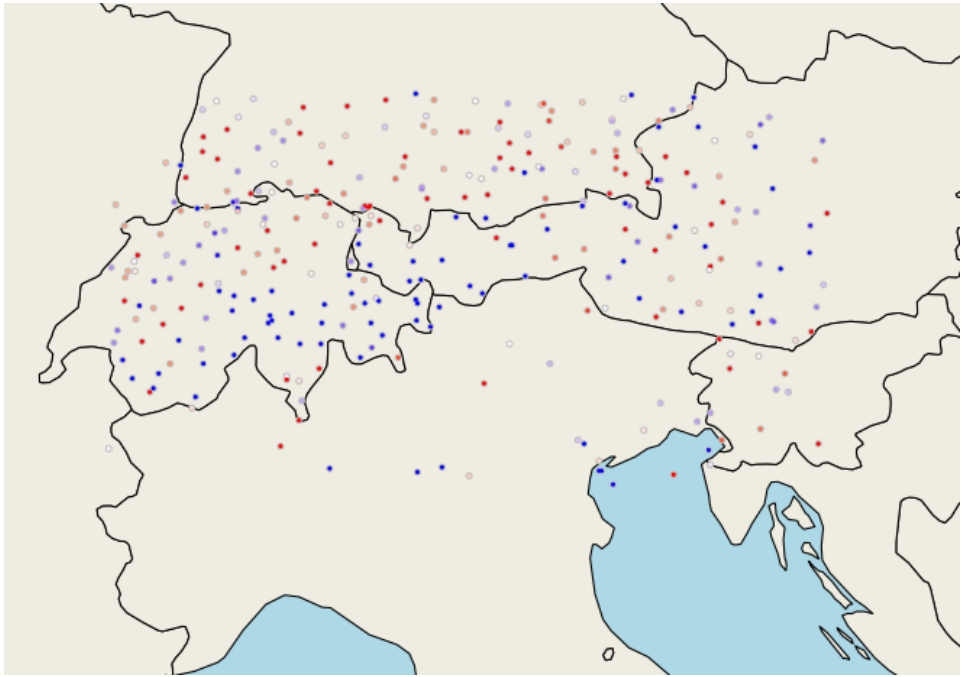


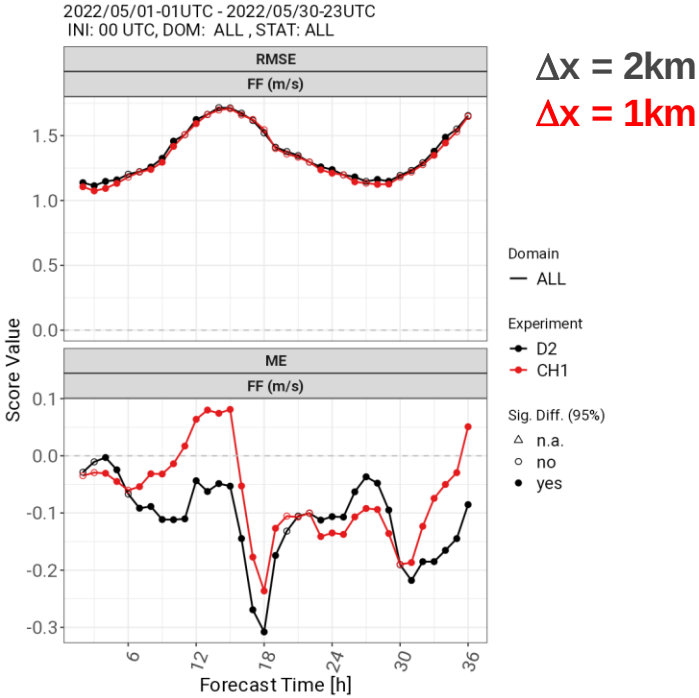
Δx = 2km

Δx = 1km

Clear improvement for wind speed, but not much differences for other parameters (not shown)

Wind verification over all stations





Δx = 2km

Δx = 1km

When looking at all stations the improvement for wind almost disappears

Mean Error for wind speed

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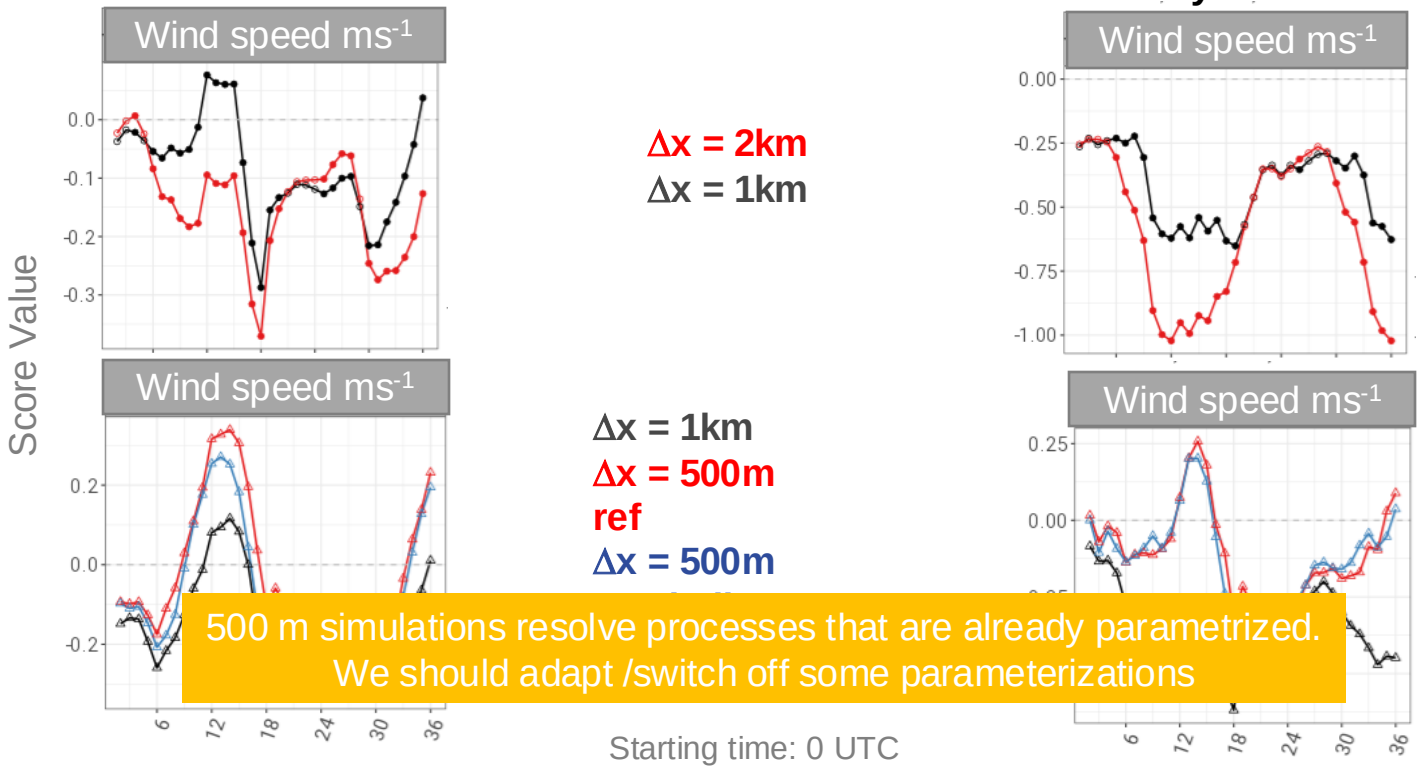
May 2022

All stations



Valley stations

Δx = 2km
Δx = 1km

Δx = 1km
Δx = 500m
ref
Δx = 500m

500 m simulations resolve processes that are already parametrized.
We should adapt /switch off some parameterizations

Starting time: 0 UTC

June 2024

Daniela Littmann

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Verification for all (standard) variables

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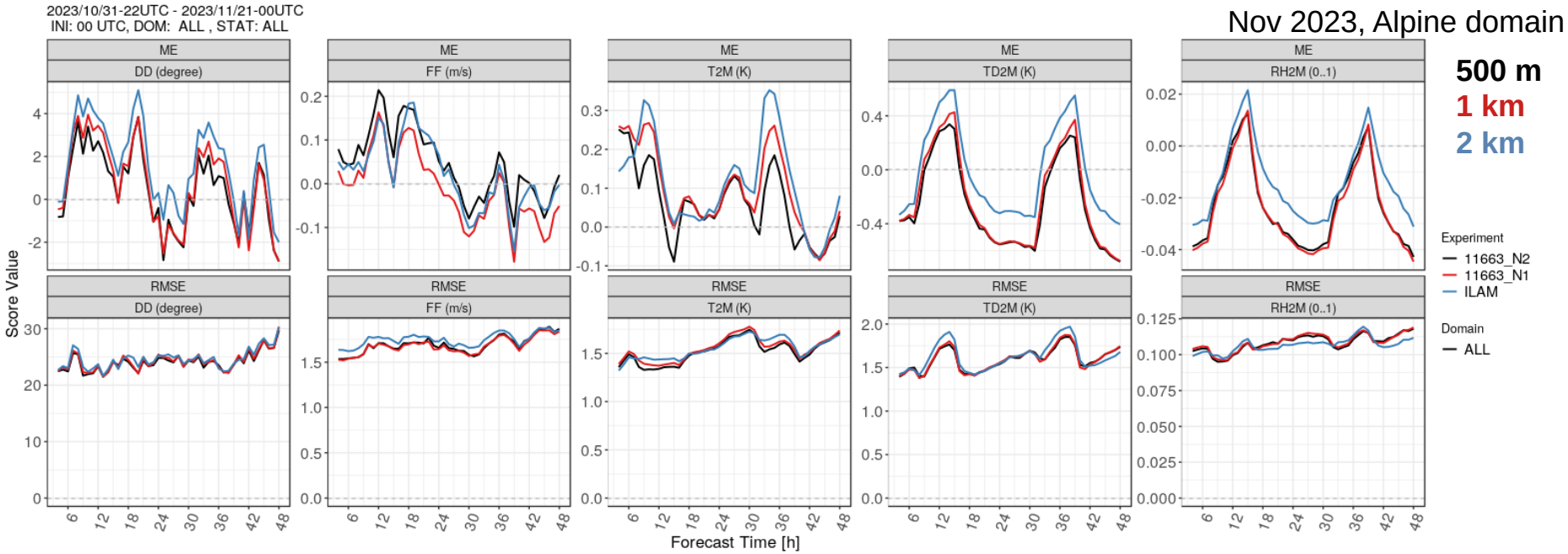
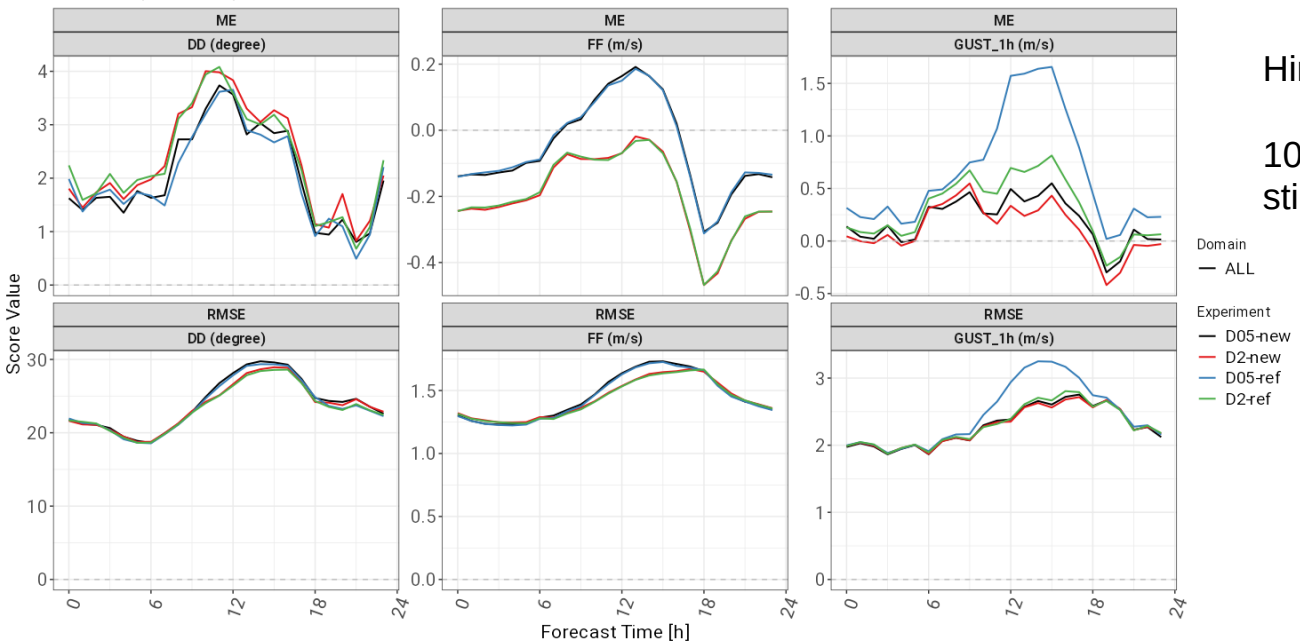


- Refining the mesh size from 2 km to 500 m tends to improve the model skill in various aspects
- But there are issues that require further model development

Gust parametrisation



Hindcast for June 2020

10-m winds used for verification are still instantaneous values

2 km REF
500 m REF

2 km NEW
500 m NEW

Adapted gust parameterization

- ➔ Based upon 10-min averaged 10-m winds rather than instantaneous values
- ➔ Limitation of gust excess speed to resolved PBL wind maximum (times tuning factor)

WMO WWRP Research Demonstration Project Paris 2024 Olympics

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Research Demonstration Project Paris 2024 Olympics

Logged as Jan-Peter Schulz

Logout

Home | About RDP | Science questions | Observation strategy | Meetings | Data | Intercomparison

METEO FRANCE | CNRM | cnrs | WMO | WWRP WORLD WEATHER RESEARCH PROGRAMME | GURME

COSMO CONSORTIUM FOR SMALL SCALE MODELING

Priority Project CITTA´: urban module in ICON

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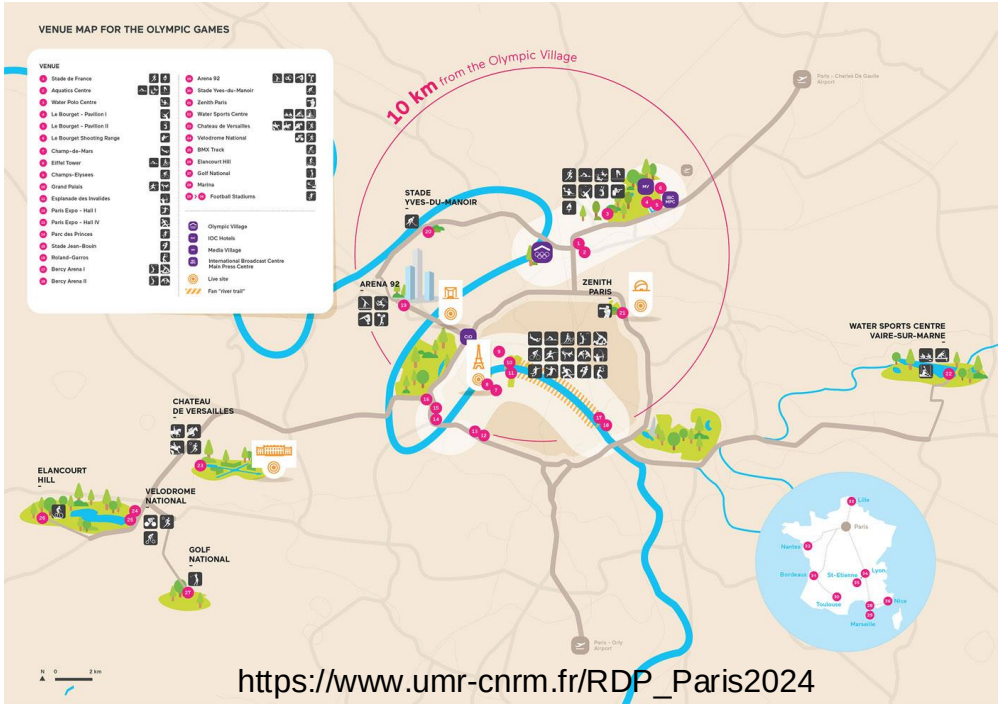
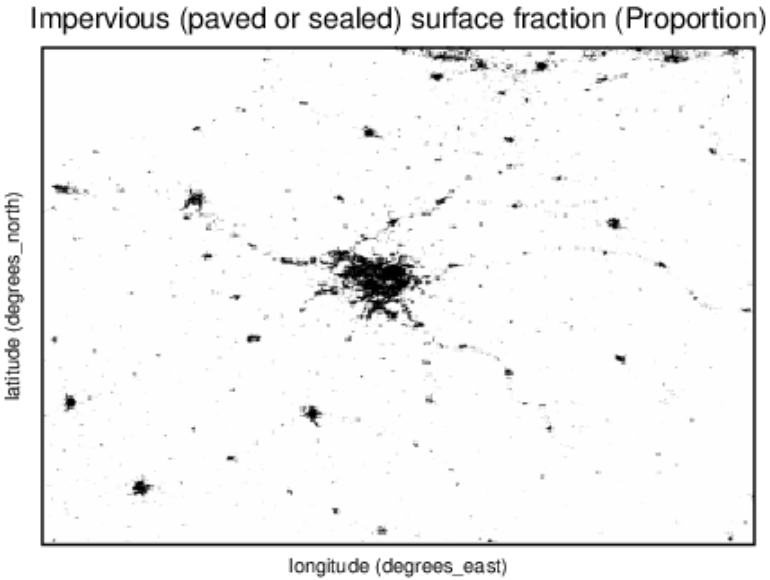
WMO WWRP Research Demonstration Project Paris 2024 Olympics



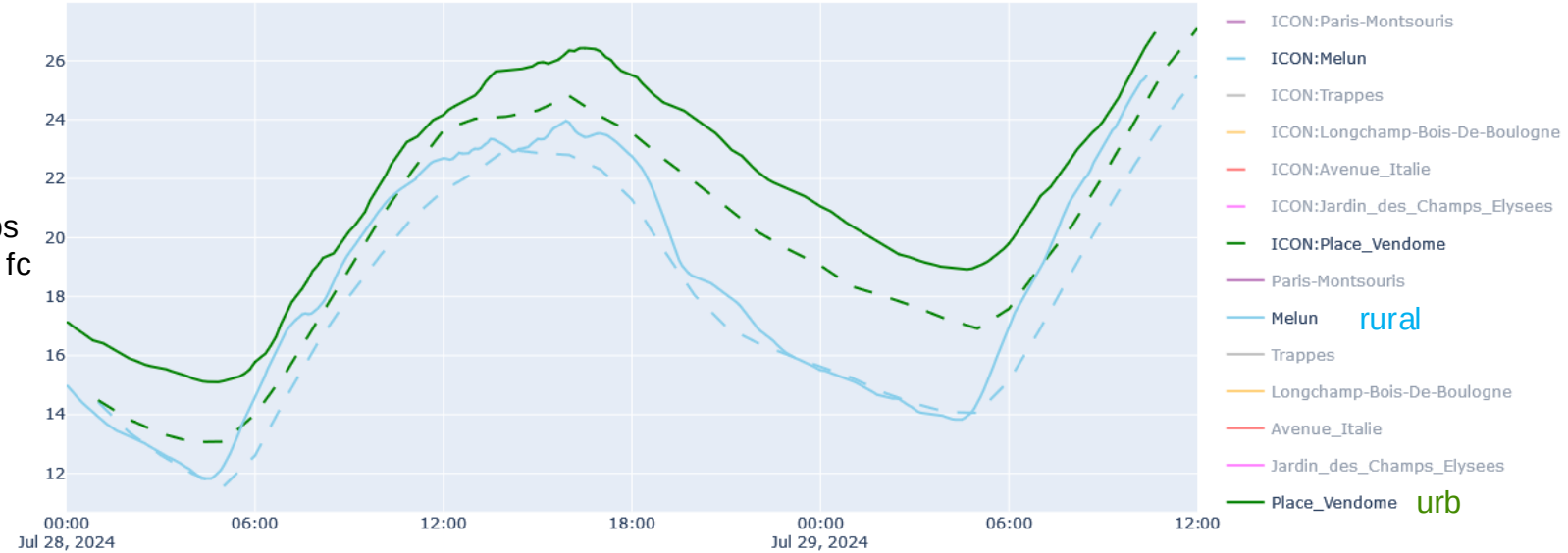
https://www.umr-cnrm.fr/RDP_Paris2024



Jan-Peter Schulz

2m temperature

Solid: obs
Dashed: fc

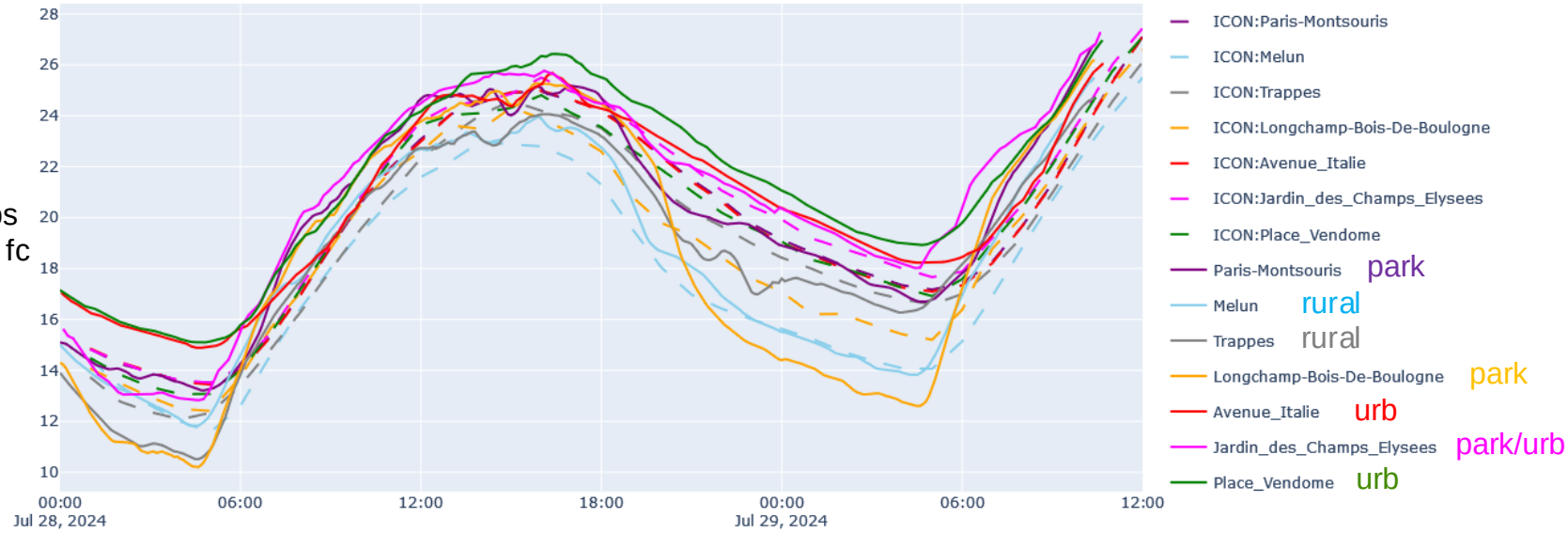


J. Wurtz (Meteo France), S. Ulbrich and Jan-Peter Schulz (DWD)

WMO WWRP Research Demonstration Project Paris 2024 Olympics

2m temperature

Solid: obs
Dashed: fc



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2m temperature

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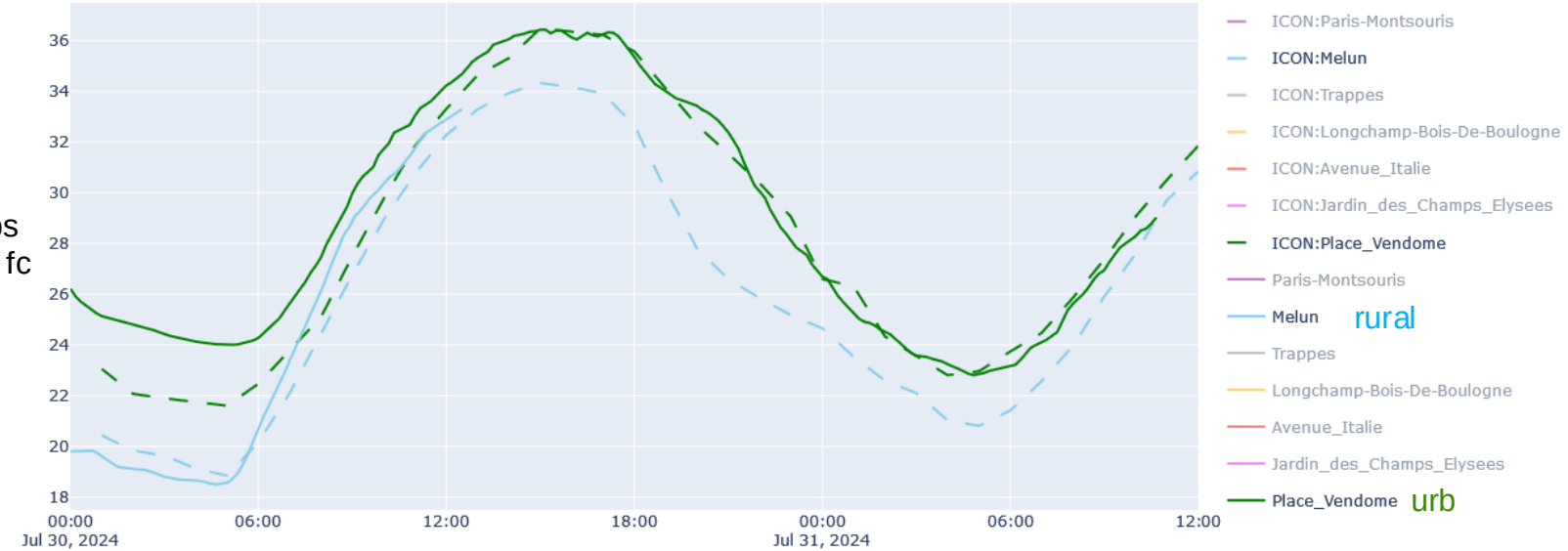

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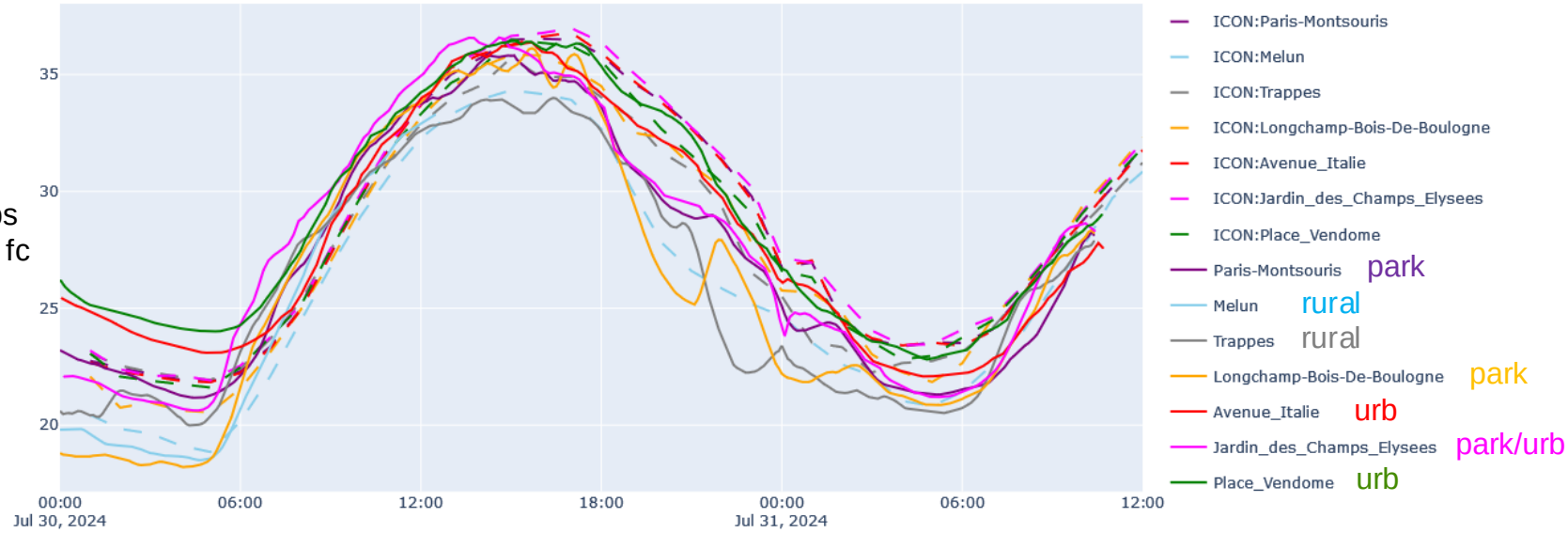

J. Wurtz (Meteo France), S. Ulbrich and Jan-Peter Schulz (DWD)

Co-Design in hydro-meteorological partnership

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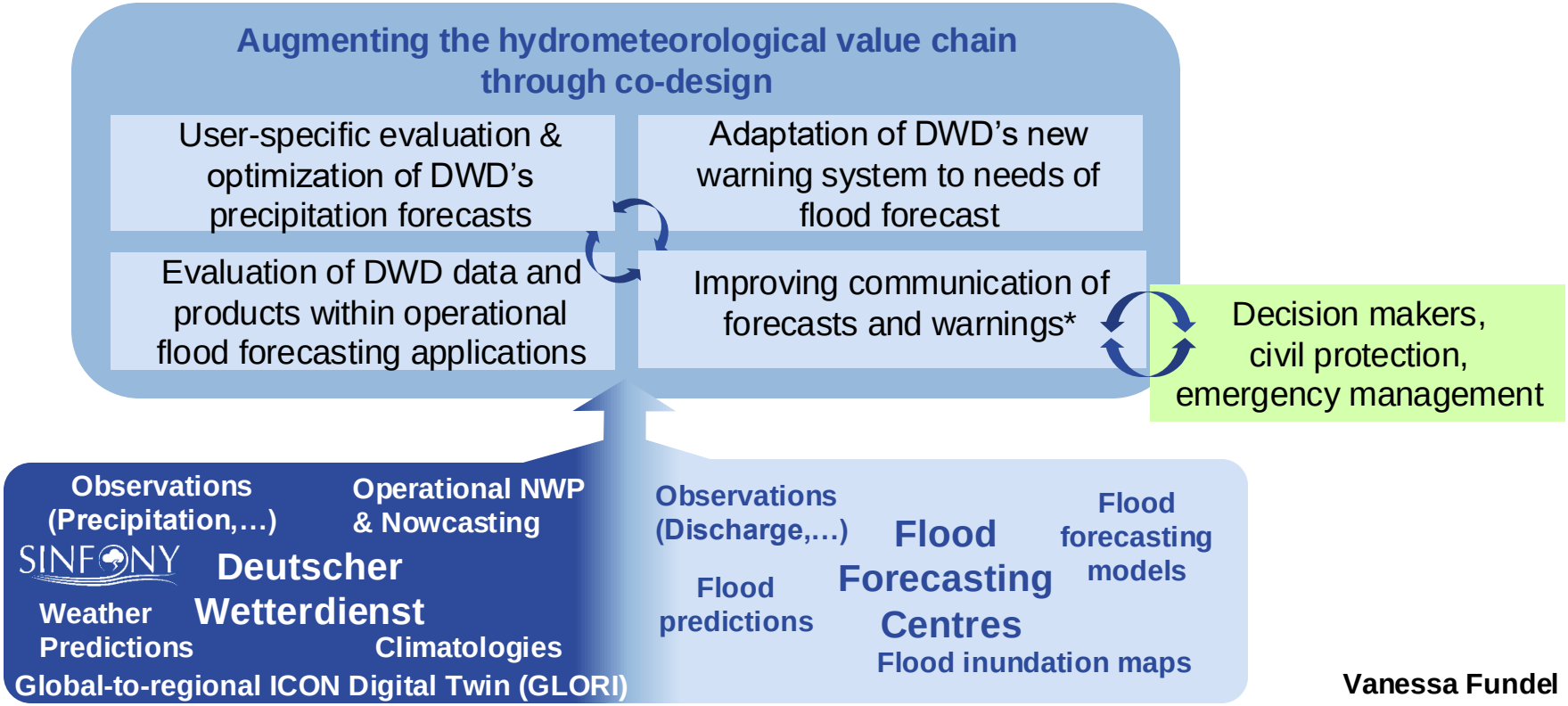

Vanessa Fundel

* Sub-project, co-financed by the Landesamt für Umwelt Rheinland-Pfalz

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Co-Design in hydro-meteorological partnership

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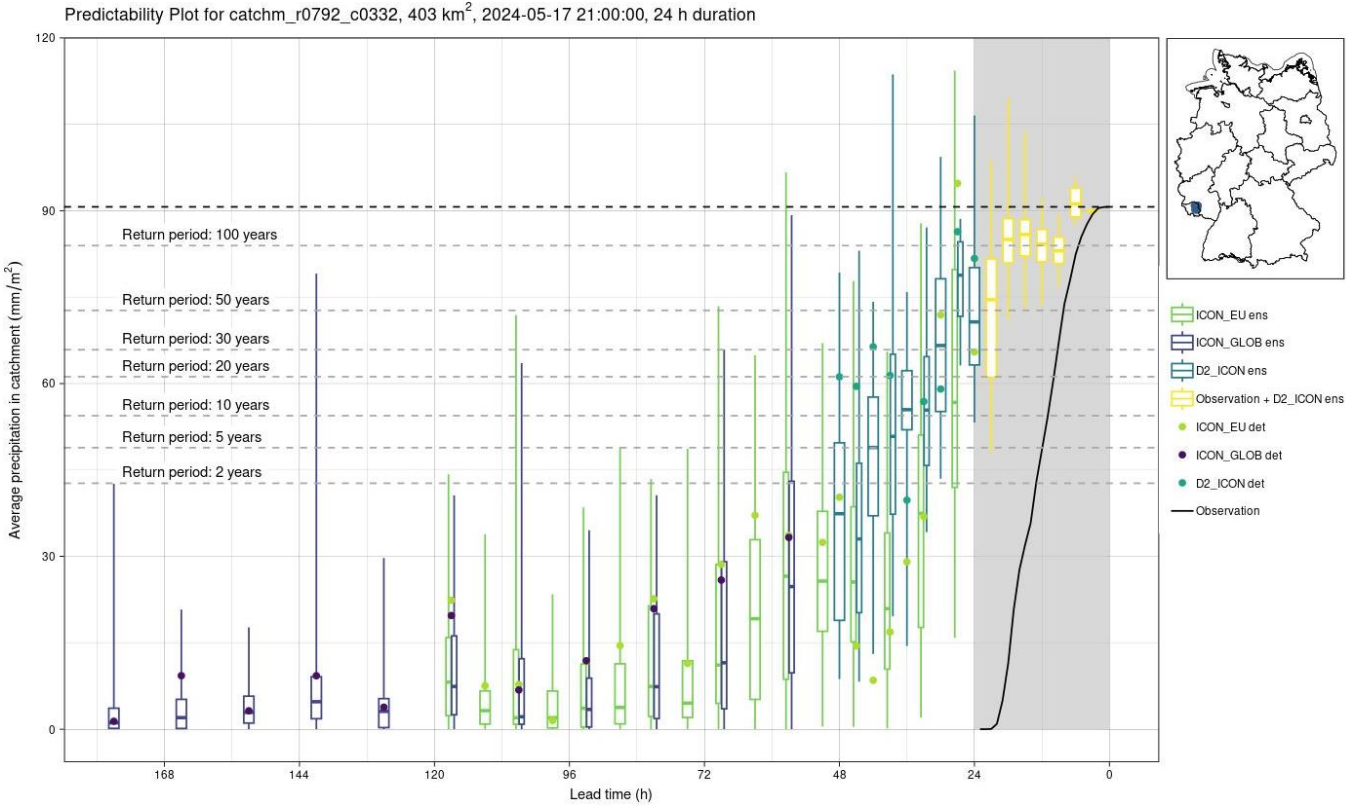
- extreme events in observations and forecasts from different models and ensemble members (also for GLORI) will be verified based on the catchment areas

- catchment predictability plot



Ina Blumenstein-Weingartz

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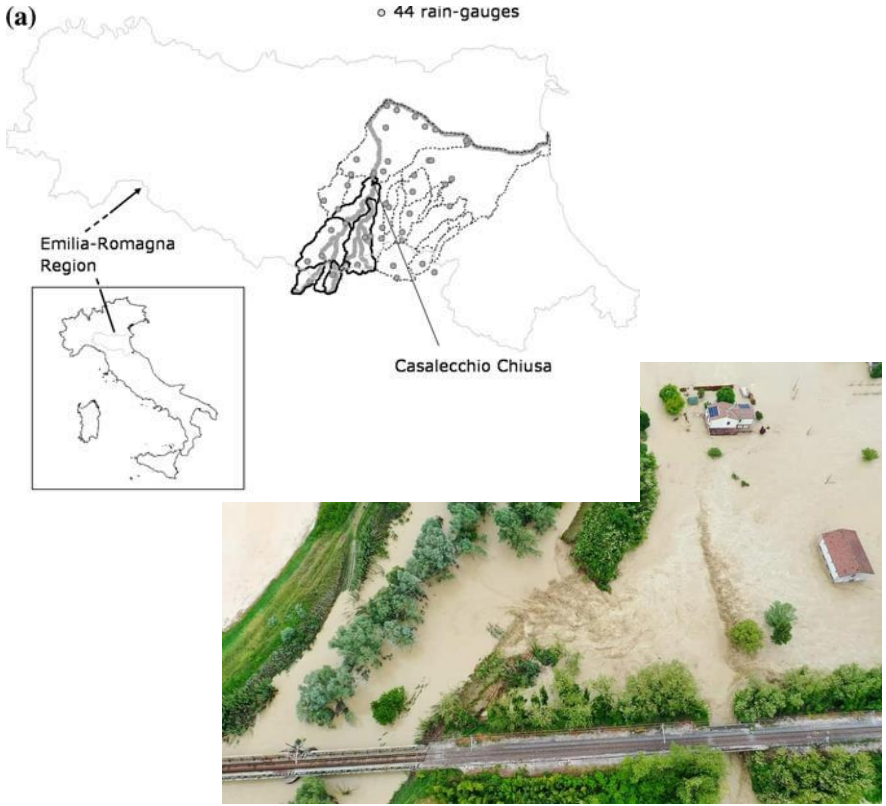
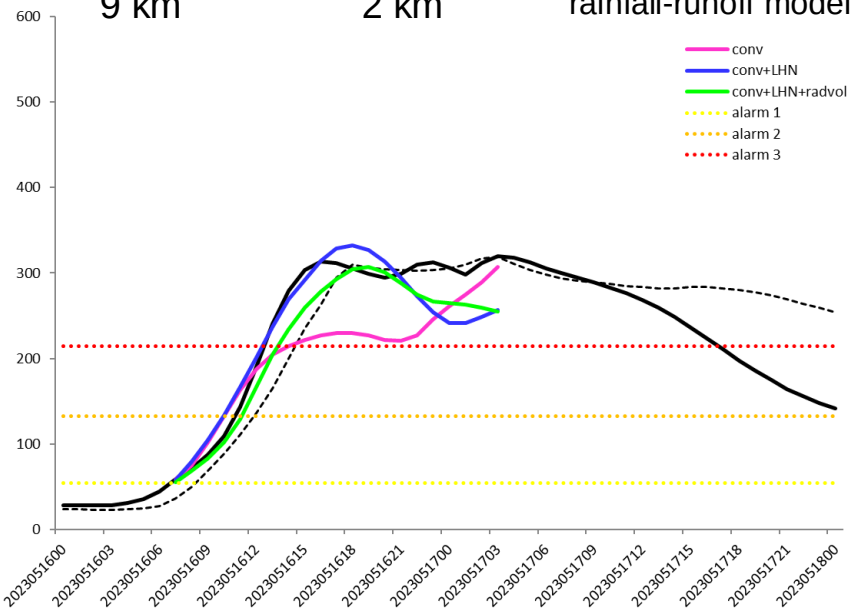
Use case flood: May 2023 events in Italy



meteo-hydrorological forecast

IFS → ICON → TOPKAPI

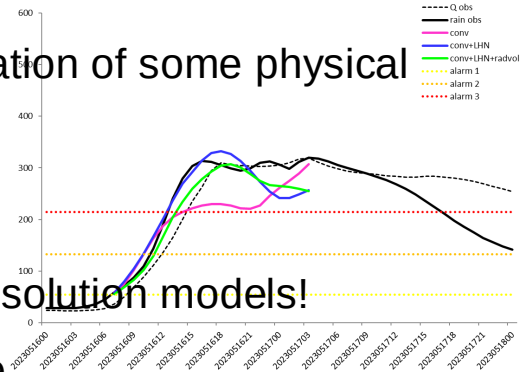
9 km | 2 km | rainfall-runoff model

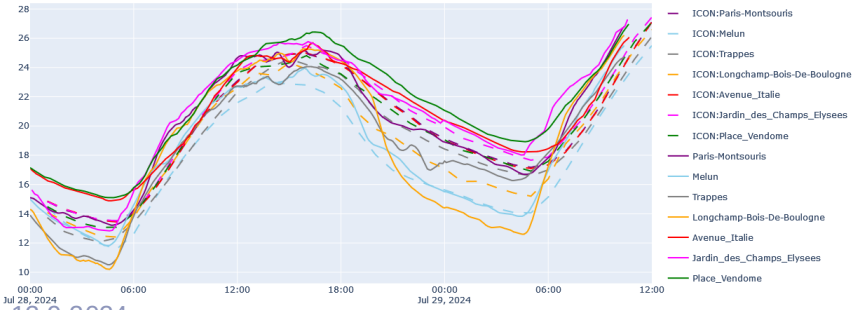


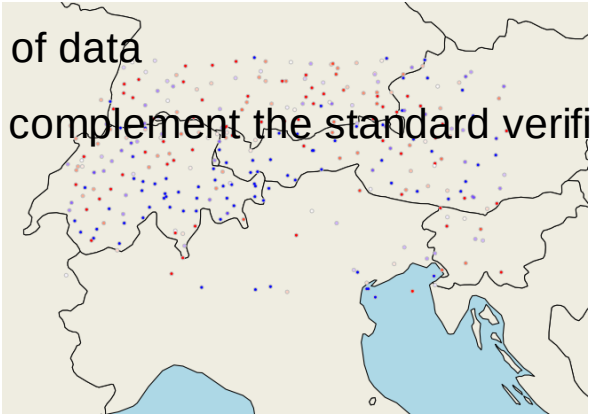
T. Diomede (Arpae), T. Gastaldo, C. Marsigli, V. Poli (Agenzia ItaliaMeteo)

Concluding remarks

- High-resolution modeling allows a more sophisticated representation of some physical processes
- Process-based verification is often needed
- High-resolution observations are needed to diagnose the high resolution models!
- Data for verifying precipitation at high resolution are still an issue
- Campaign and experiments are a precious source of data
- Diagnostics based on the usage of impact models complement the standard verification

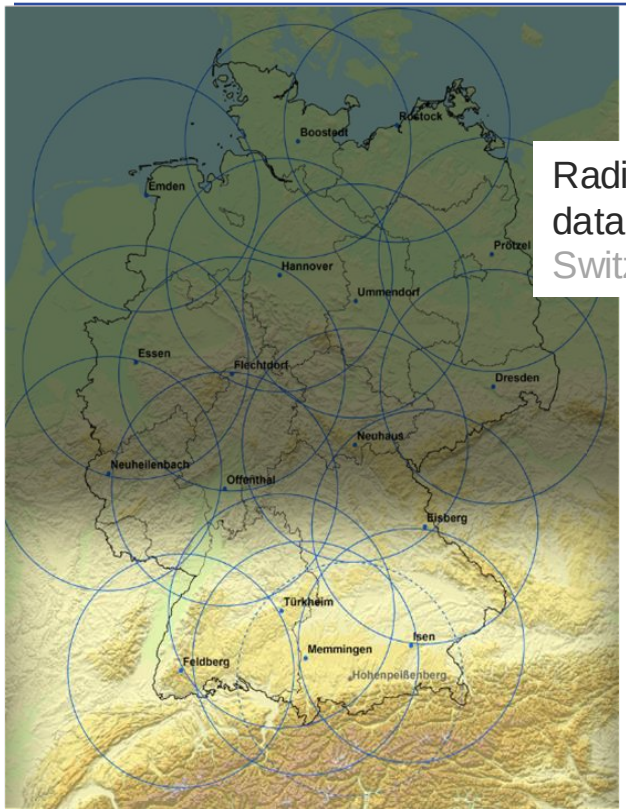




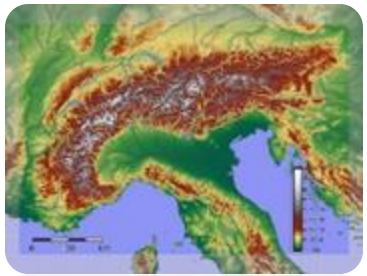


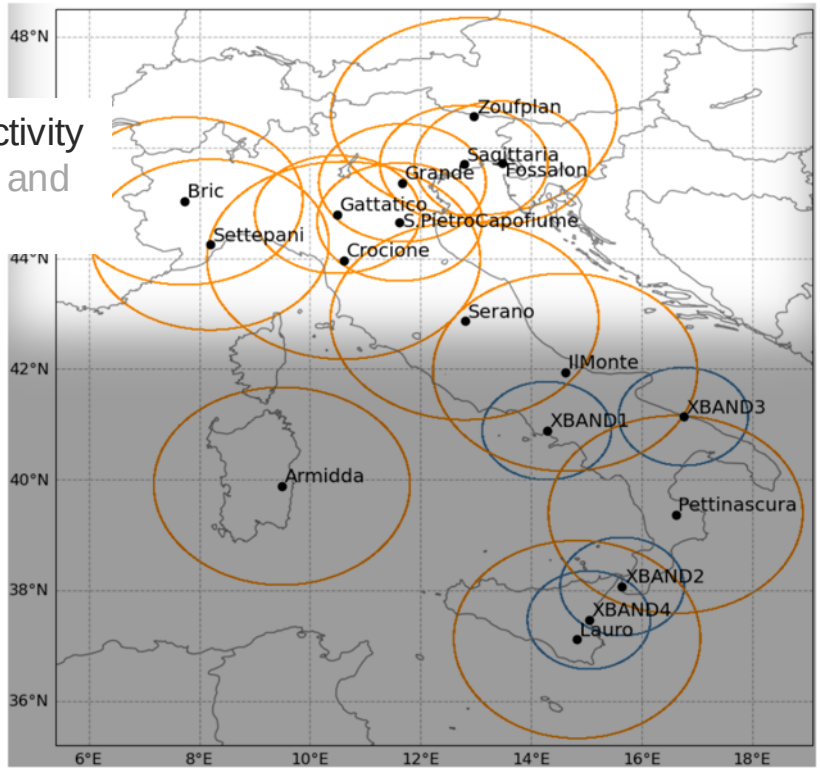
Thank you for your attention!

Assimilation of 3D radar data



Radial winds and 3D radar reflectivity data from Germany (D), Italy (I), and Switzerland (CH).





Xu Xu

Radar Reflectivity Composites Obs

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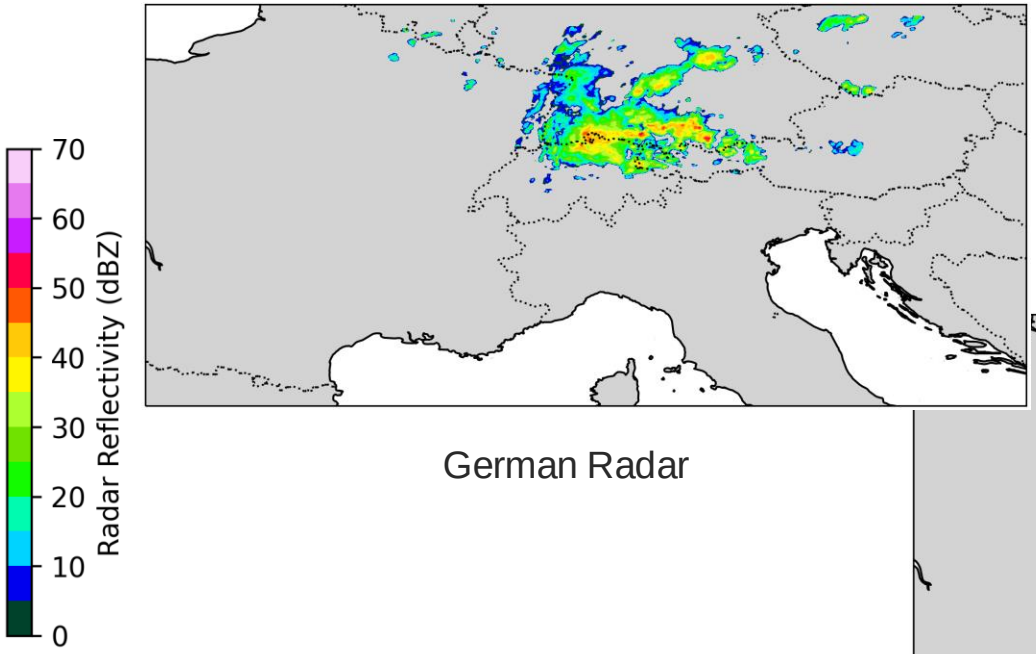
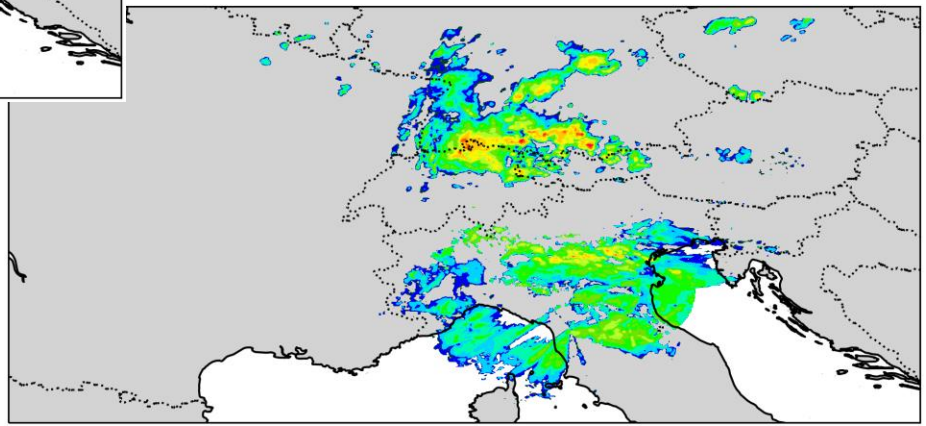
202205051900



German Radar

German + Italian Radar



Xu Xu

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Precipitation Forecast

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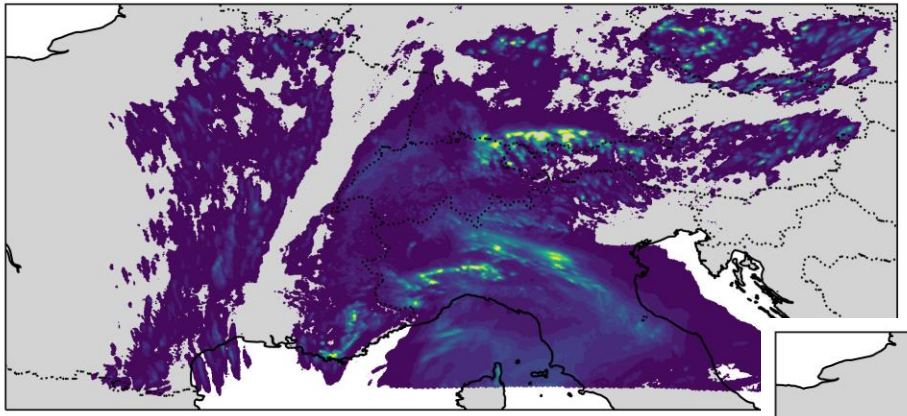
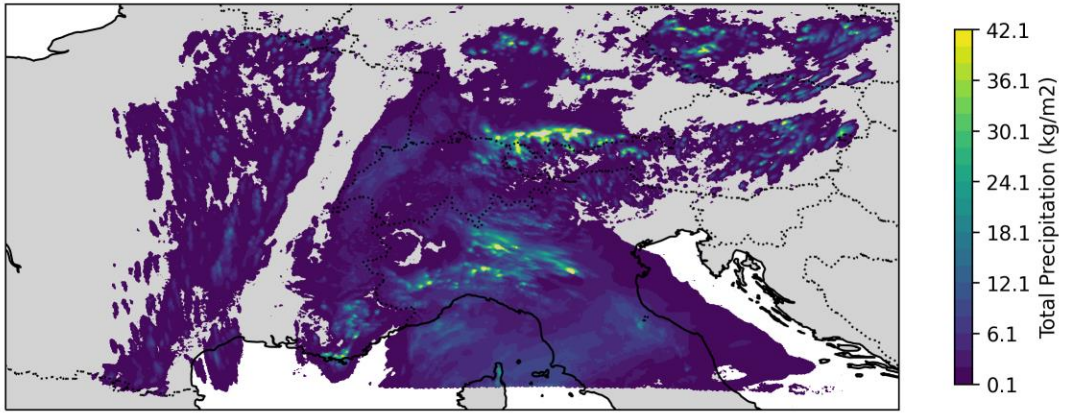
202205051900



German Radar

German + Italian Radar



Xu Xu

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Model perturbation for the high-resolution ensemble

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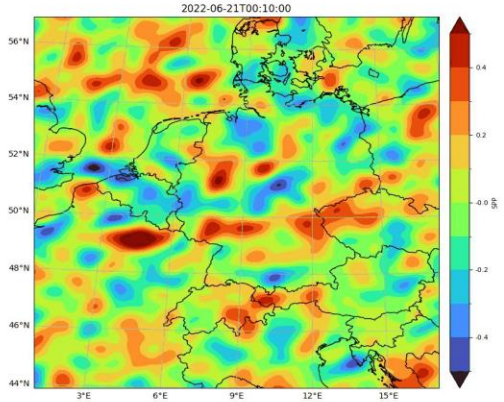
Stochastically perturbed parameterization (SPP) in ICON

- An uncertain parameter is perturbed with a specific temporally evolving stochastic pattern for each member
- Perturbation fields should have both spatial and temporal correlations

SPP properties:

- Fourier Series vs. Legendre Polynomial
- Pattern length scale = 50km
- Pattern time scale = 1 hour
- Pattern modes = 50
- Pattern variance = 0.1



Test on a real case

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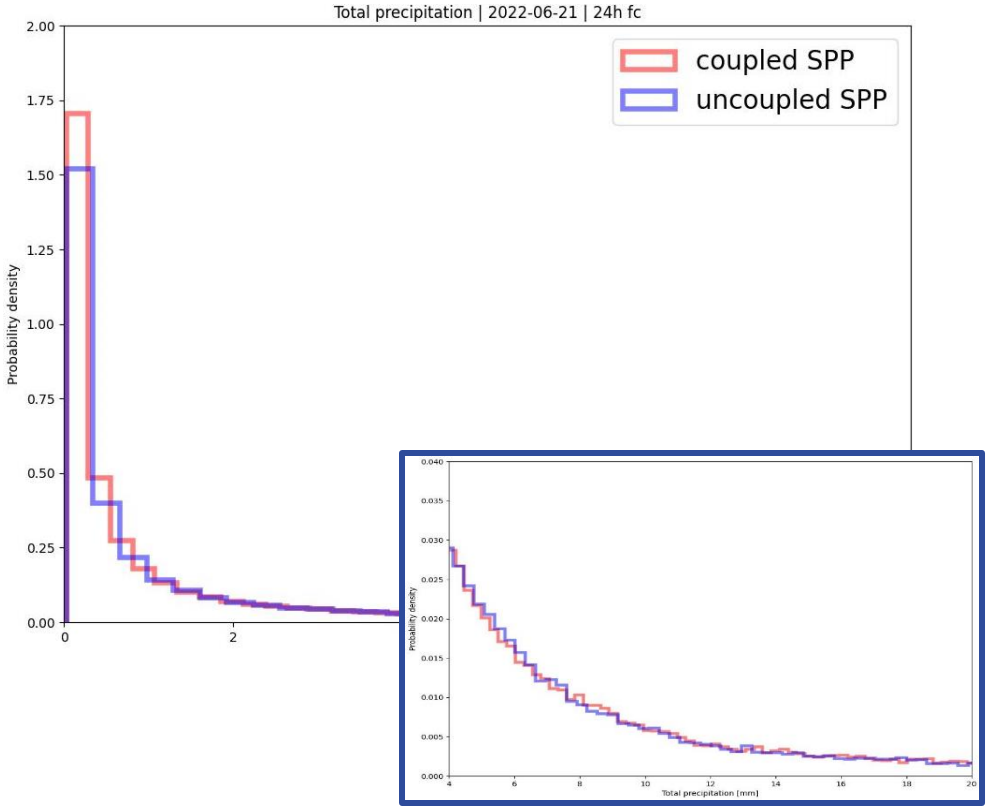
Wetter und Klima aus einer Hand

Test: Coupled SPP with 2mom microphysics scheme

For perturbing the sedimentation velocity of graupel

24h run
ICON-LAM: D2 domain
21st of June 2022



Zahra Parsakhoo

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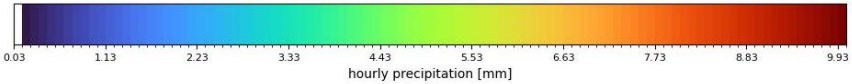
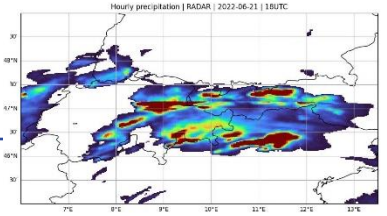
Hourly precipitation



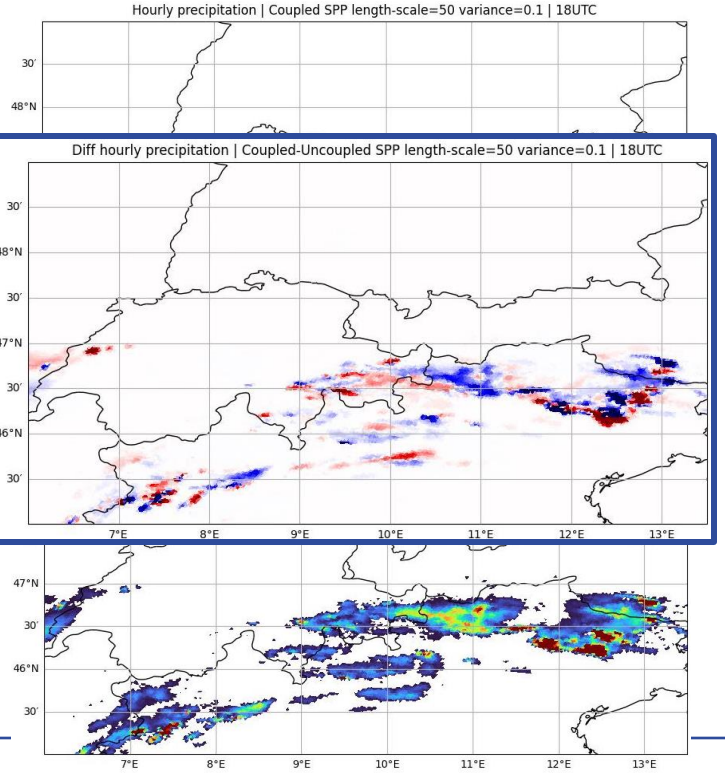


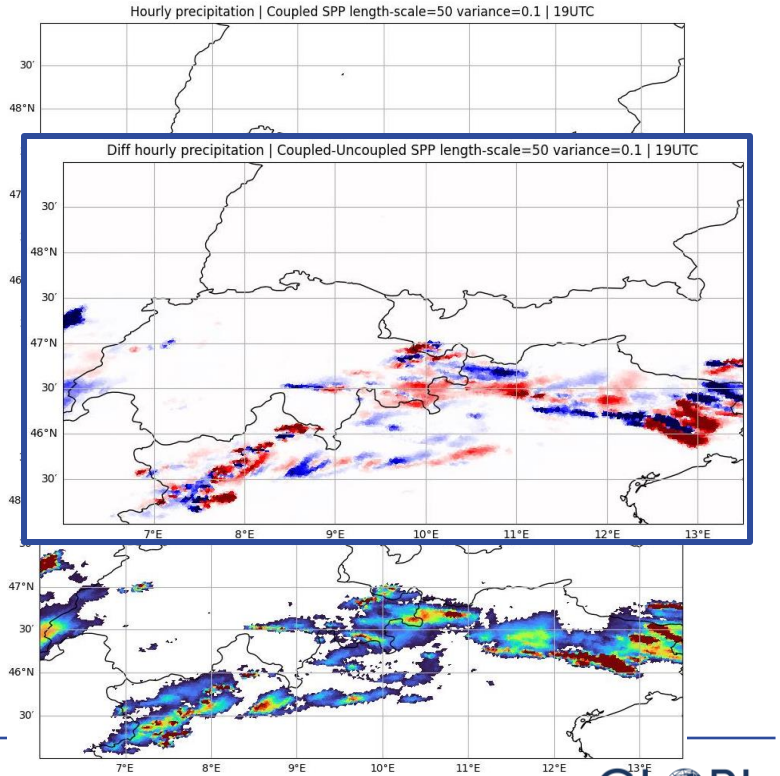
18UTC

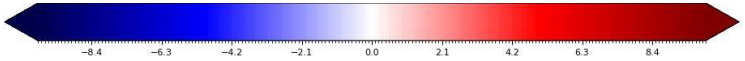
19UTC

coupled SPP

uncoupled SPP







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