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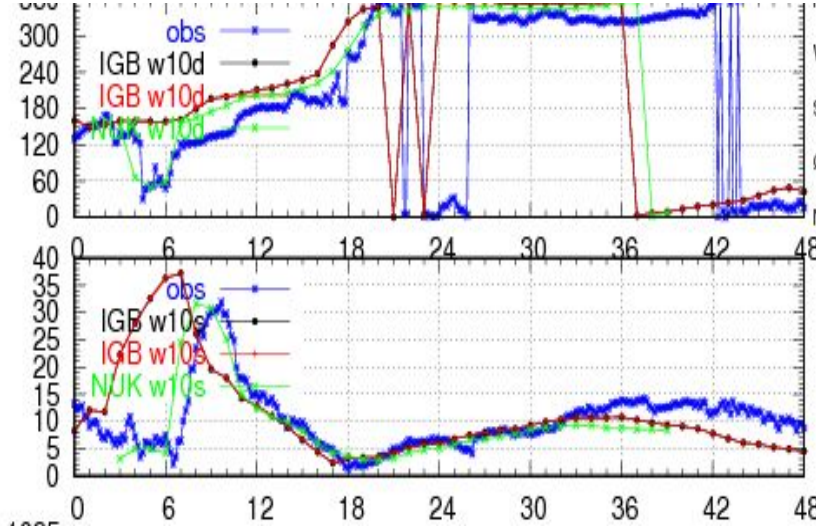
On-demand, Very High Resolution Operational Weather Forecasting

Xiaohua Yang, with contribution from
Emy Alerskans

NUUK, Greenland
2023.02.28



Observation
2.5 km
750 m, ondemand

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Outlines

1. **Higher resolution**
2. On-demand
3. Implementation
   a. Triggering
4. Perspectives
   a. Coupling
   b. PGD
   c. Other on-demand applications

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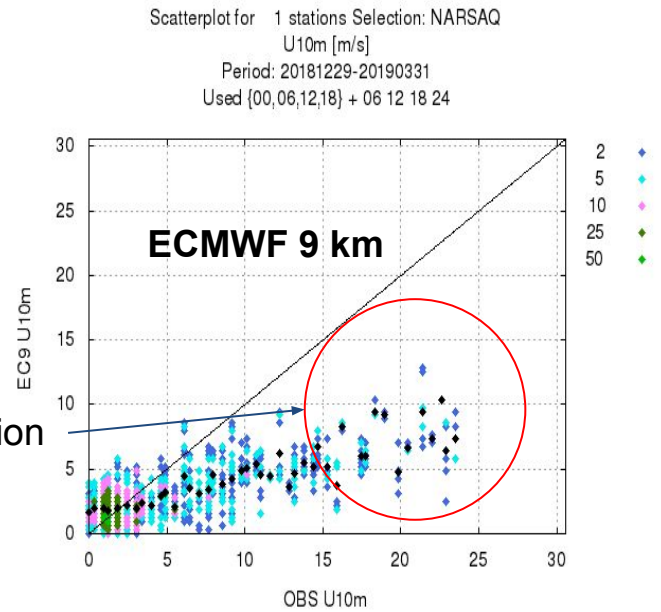
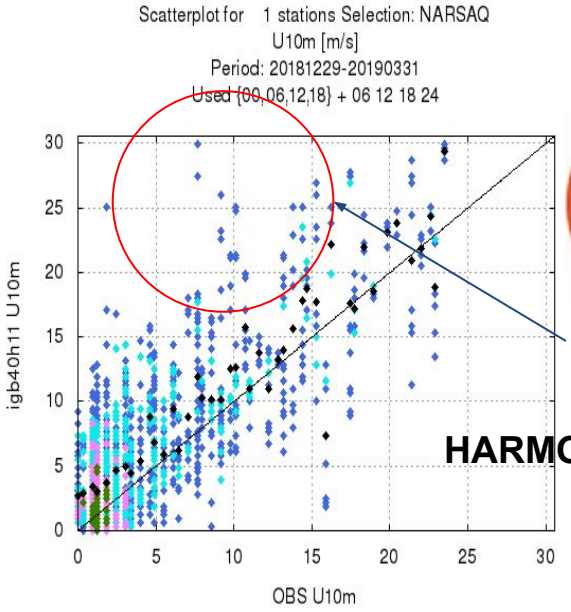
Regular wind forecast lacks skill



Under-prediction



over-forecast

Too weak winds

Too strong winds

"Regular" = insufficient grid resolution

HIgh flow variability in small scales

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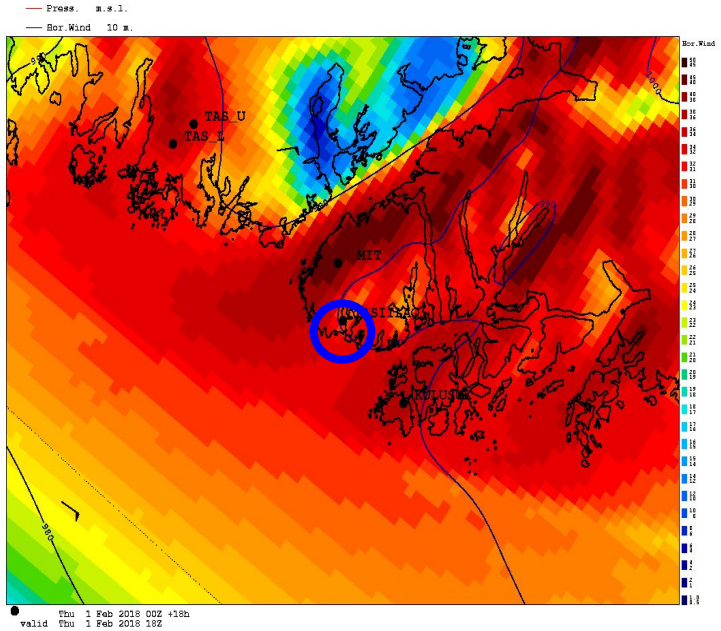
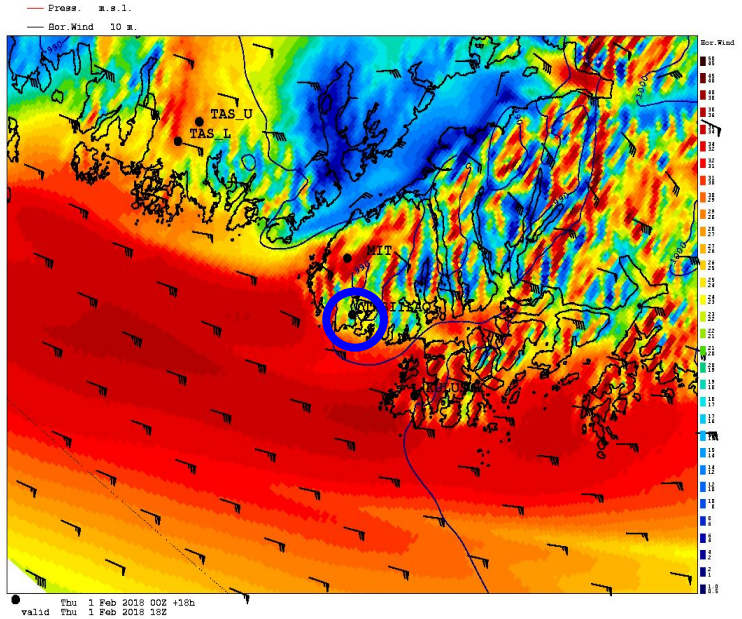
Tasiilaq, 1 Feb 2018

Ca 5 km radius



IGB@**2.5** km



TAS@**750** m

High flow variability in small scales

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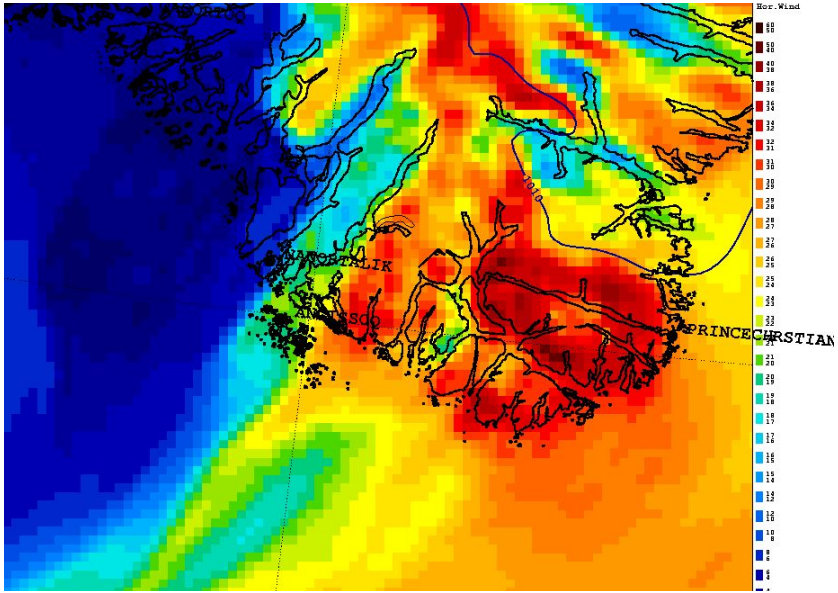
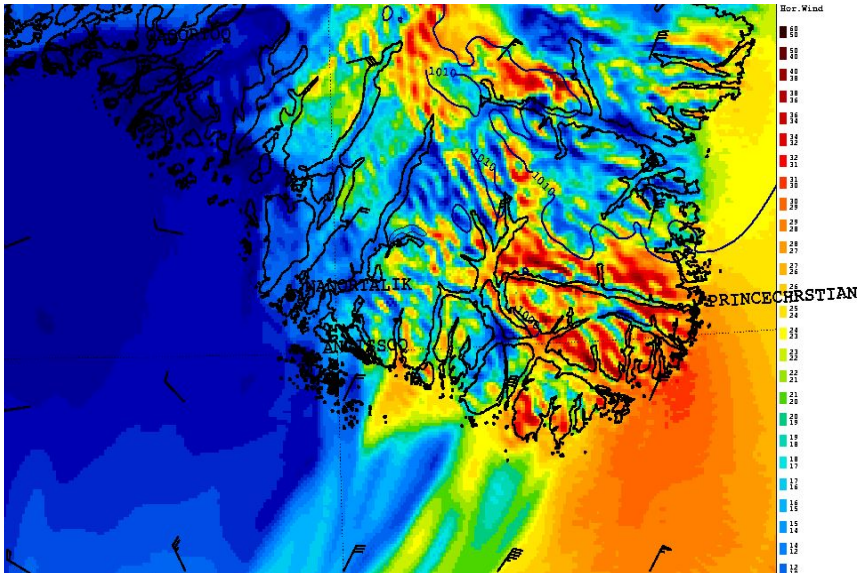
South Greenland Coast, May 12 2019



IGB@**2.5** km



SGL@ **750** m

Point forecasting become meaningless for flow with significant variability within limited time and space.

Operational forecast @ DMI

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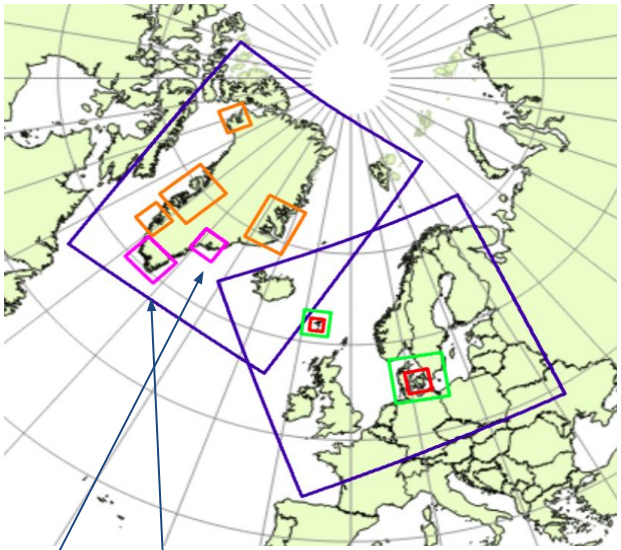
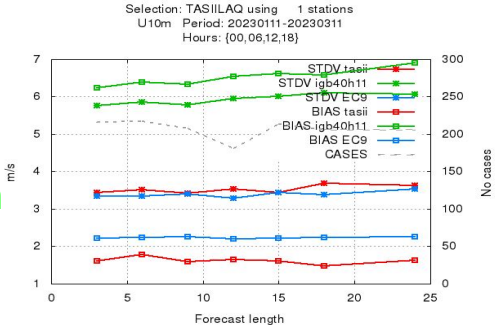
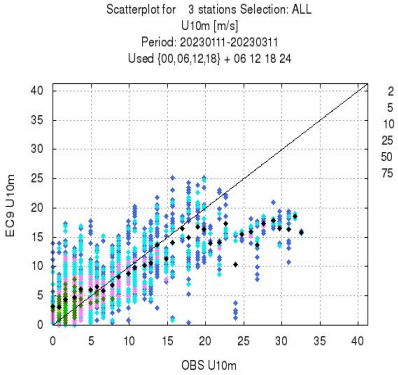


TAS 750m, since 2018
SGL 750 m, since 2019

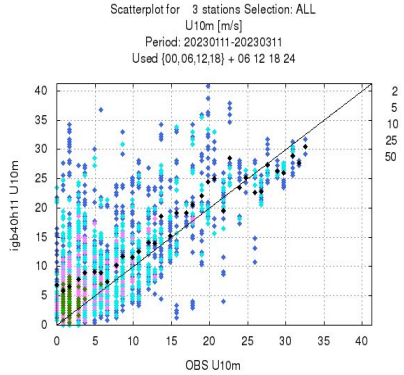
750 m
2.5 km
EC 9



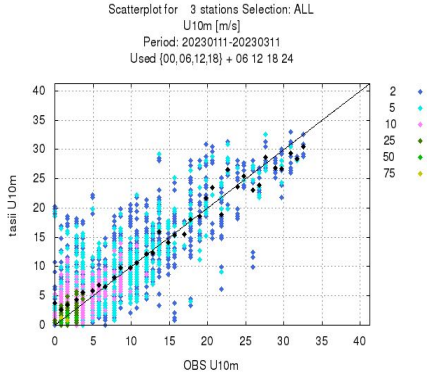
Wind forecast errors for
Tasiilaq, Greenland



EC 9 km



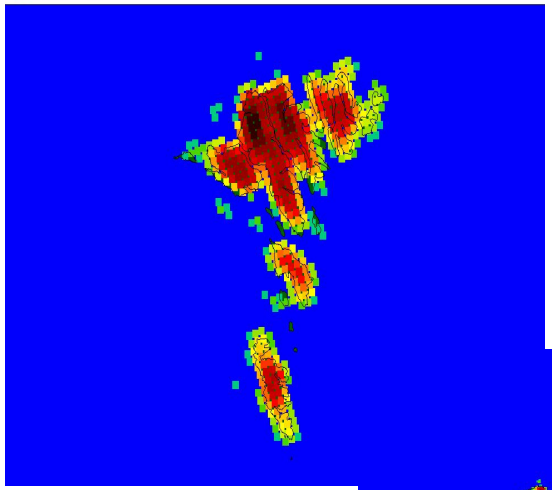
2.5 km



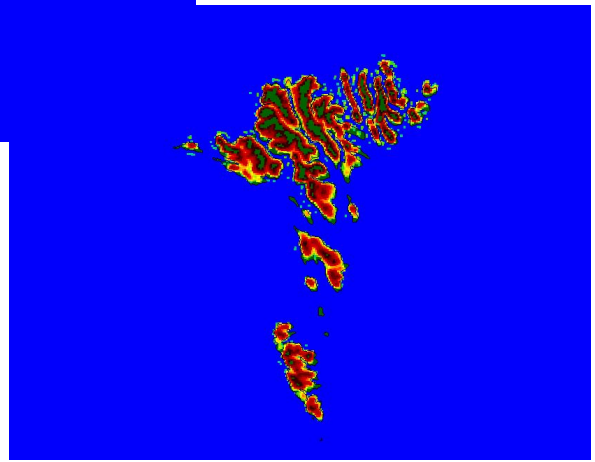
750 m

Sub-km forecasts become successful for wind warning at Greenland. But the needs are extensive

Faroe Islands



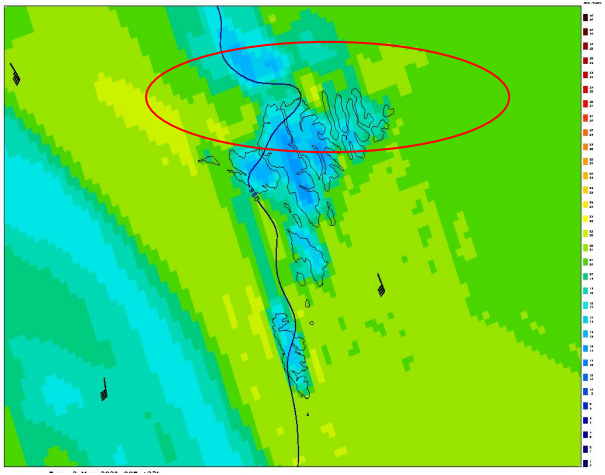
500m grid



150 m grid

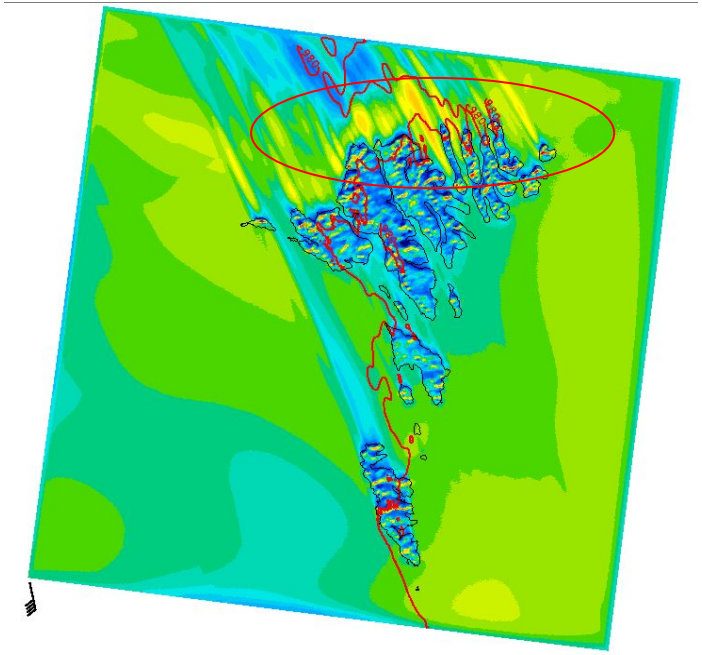
Harmonie-arome for Faroe Islands

Hurrican case March 9-10 2021

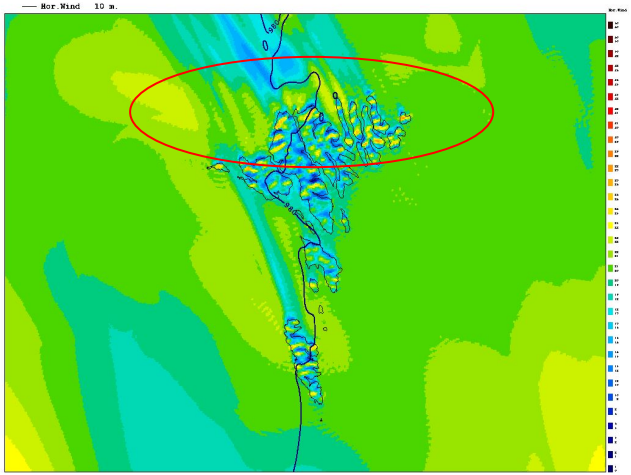


2.5 km

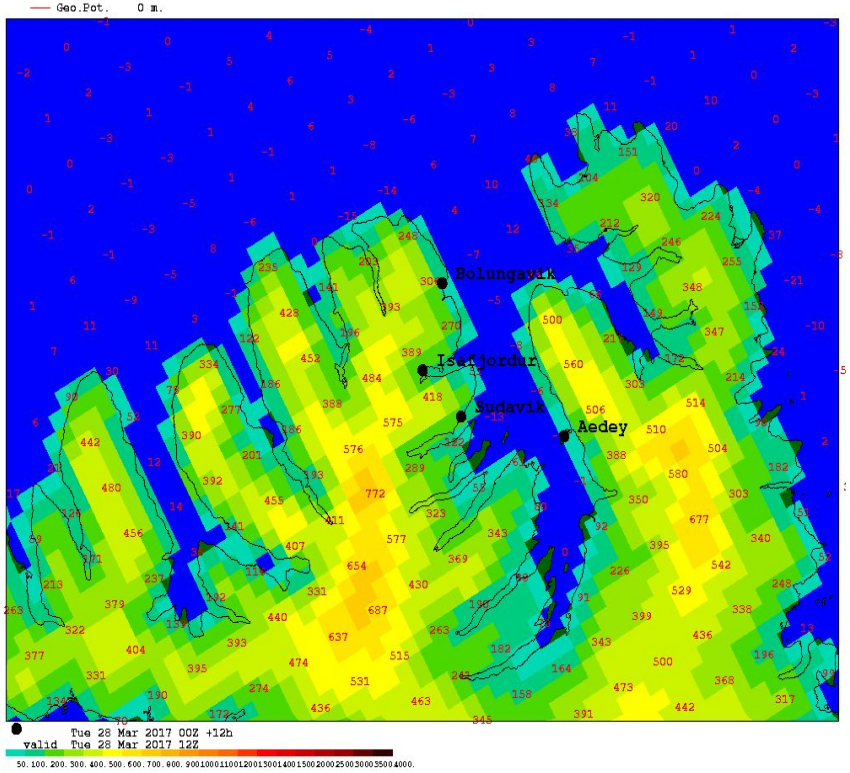
150 m



500 m

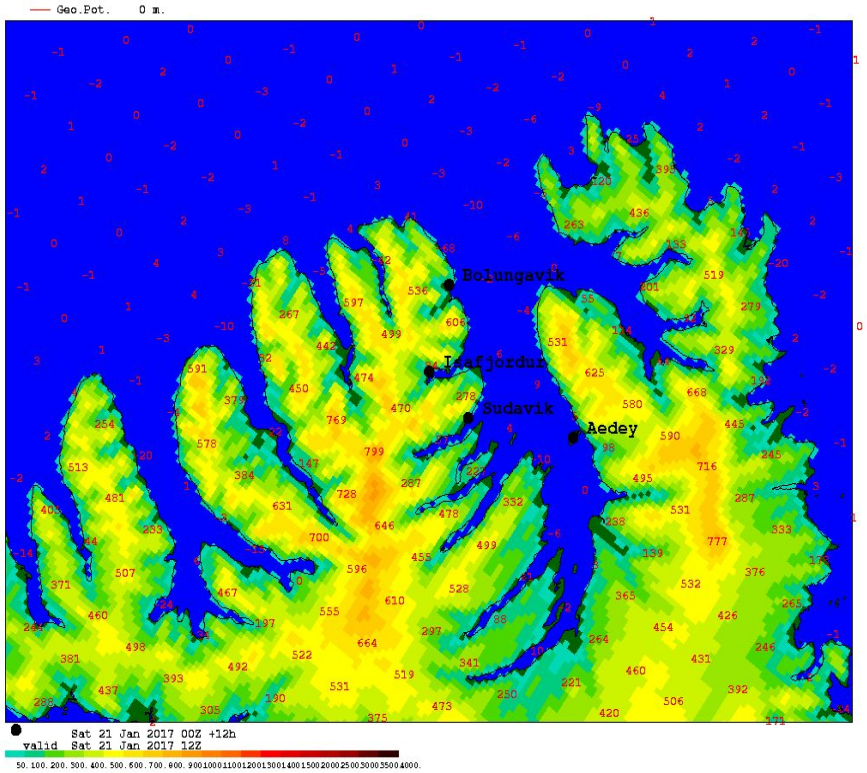


Westfjords, Iceland



DX= 2.5 km

Insufficient to "see" coastal stations



DX= 750 m

Sub-km also relevant for flat area/weak flow

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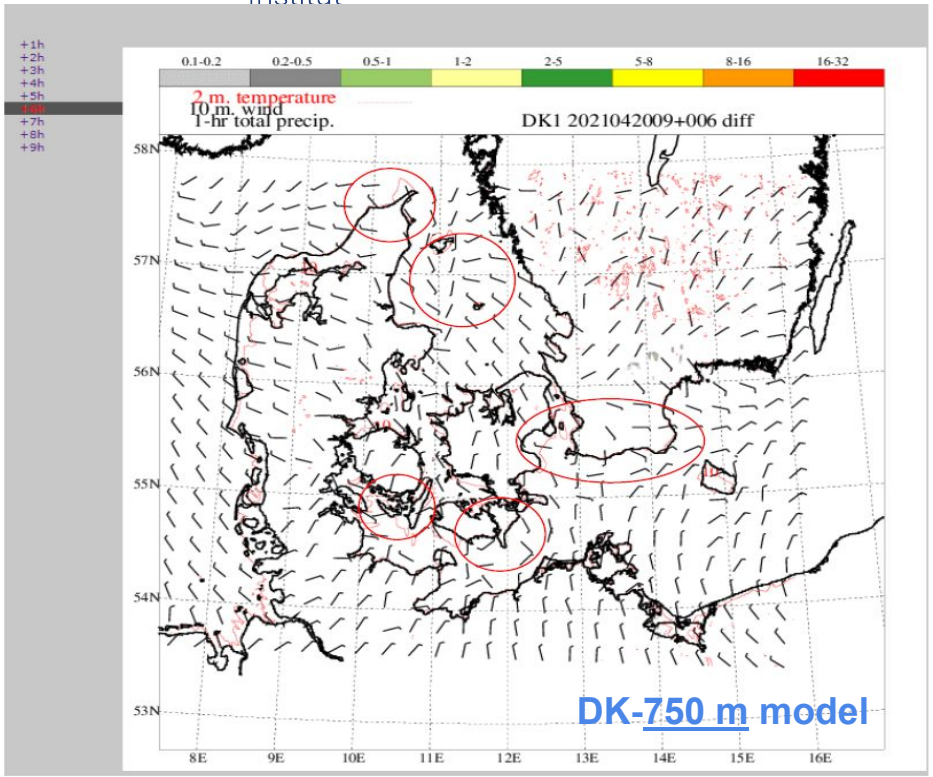

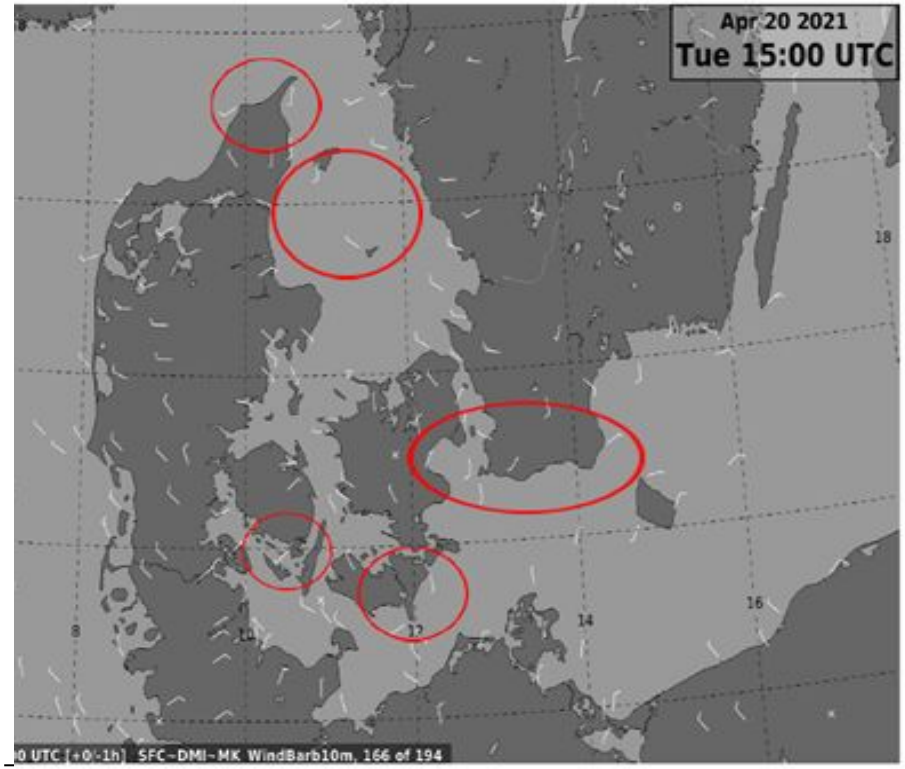

(Courtesy of Lars Henriksen, DMI)

Observation

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Outlines

1. Higher resolution
2. **On-demand**
3. Implementation
   a. Triggering
4. Perspectives
   a. Other on-demand applications
   b. Coupling

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Reasoning for On-demand setup

We need finer resolution than km-scale!

Problematic to rely completely on ECMWF nor Harmonie-x km,

- Either too much failure of detection, or too many false alarms

Cost efficiency is a major concern

- too expensive to run more than 6 sub-km setup for Greenland@DMI
- Too expensive to run regularly at hectometric scale for DK area too.

On-demand may be a sustainable approach

Focus on critical situations and critical regions where it is beneficial

Affordable!

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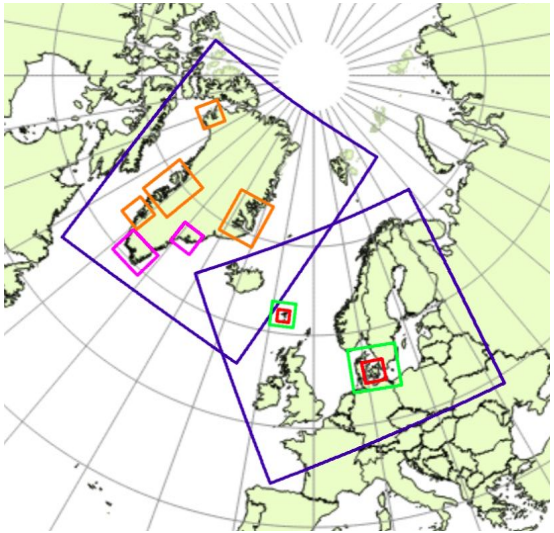
Sub-km models at DMI (2018-)



Number of days with high resolution model launch

	Thresh-hold (Wmax)	January 2023	Feb 2023	Mar 2023
TASiilaq	0	124	112	124
South GreenLand	0	124	112	124
Nuuk	20 m/s	10	18	4
Diskobugt	20 m/s	18	15	6
Scoresbysund	20 m/s	18	24	9
Qanaaq	18 m/s	13	17	6

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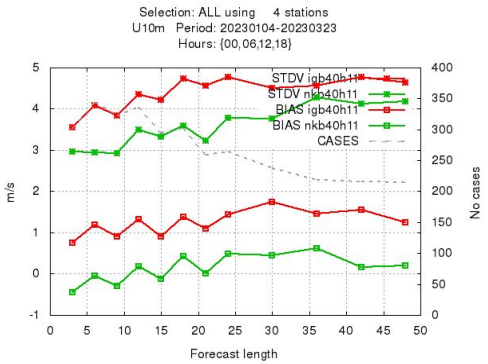
On-demand models reduce wind bias

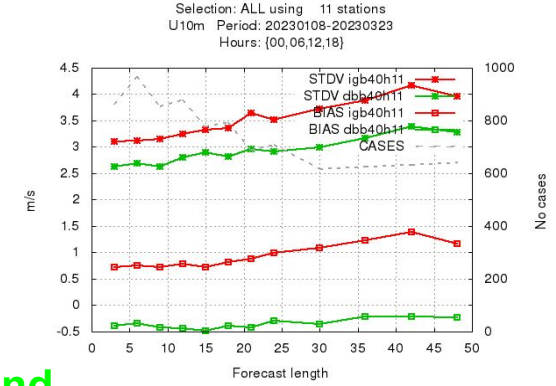
Nuuk



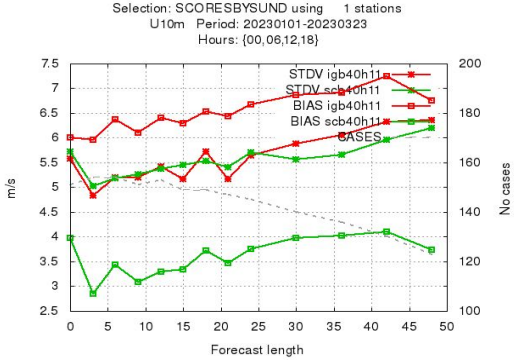
IGB-2.5

On-demand

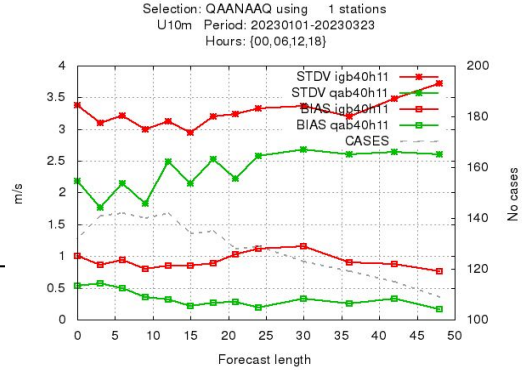
Diskobugt



Scoresbysund



Qanaaq



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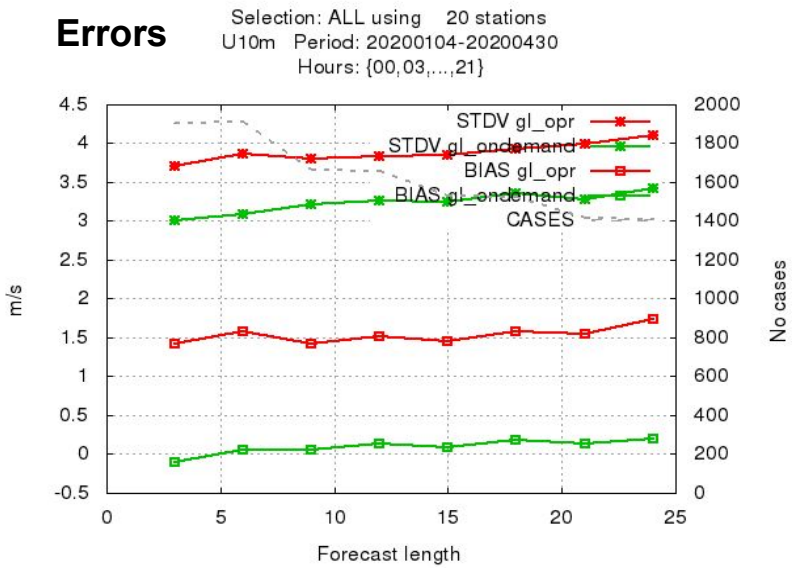
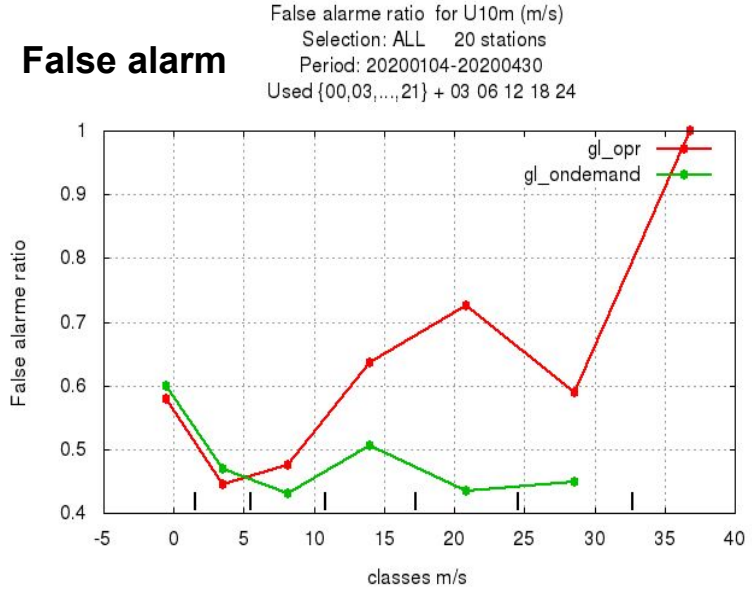
On-demand models reduce wind bias

Errors



False alarm



Verification of wind speed forecast during pre-operational phase (Jan-Apr 2020) for 4 sub-km on-demand suits in comparison to the operational 2.5 km model

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Outlines

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3. **Operational implementation**
   a. Triggering
4. Perspectives
   a. Coupling
   b. Other on-demand applications

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Triggering

On-demand suites are activated by a triggering module daily

- By model. A thresh-hold (~20 m/s) based on wind forecasts by coarser resolution operational model Harmonie-IGB 2.5 km, 66h fcst
- By observation
  - Observed maximum wind > threshold (~ 18-20 m/s)
- By duty forecasters

When triggered, it runs every 6h with forecast up to 54 h. The suites will terminate by day 2 unless triggering module activates it again.

Presently, on-demand suites are coupled directly to IFS LBC

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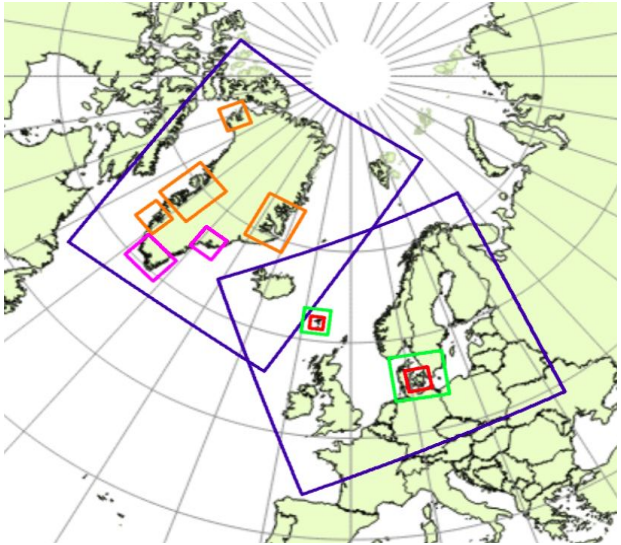
Regular vs On-demand

On-demand suites provides improved wind forecasts, hence useful for storm warning.
Other less extreme situations may also benefit from on-demand system



Regular vs On-demand Cycling

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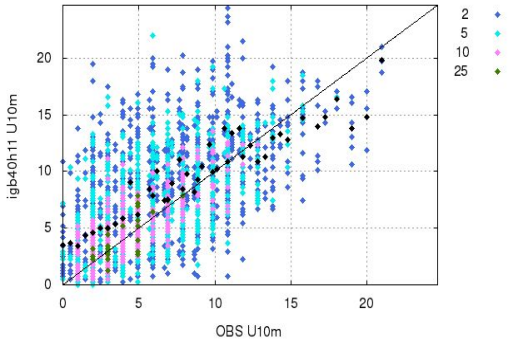
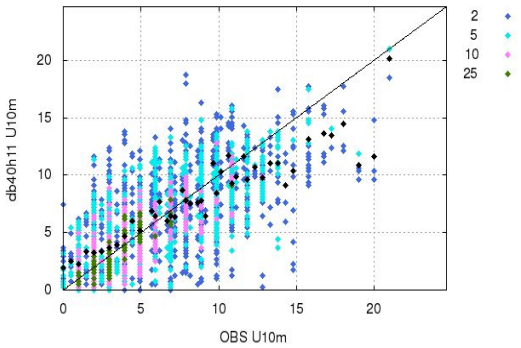
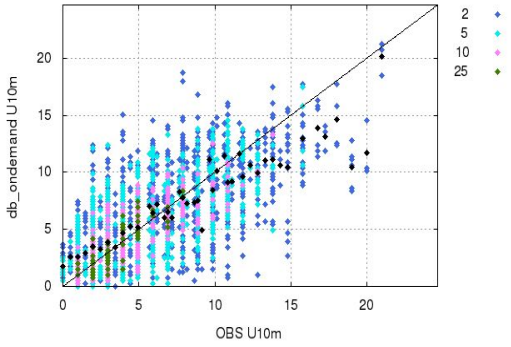


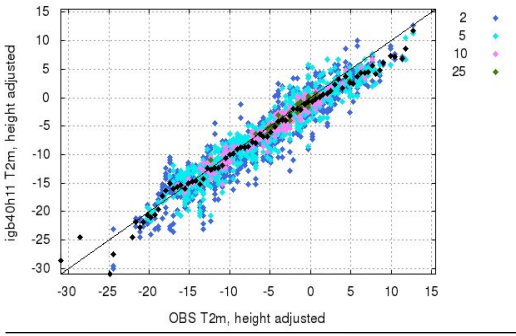
IGB, 2.5 km

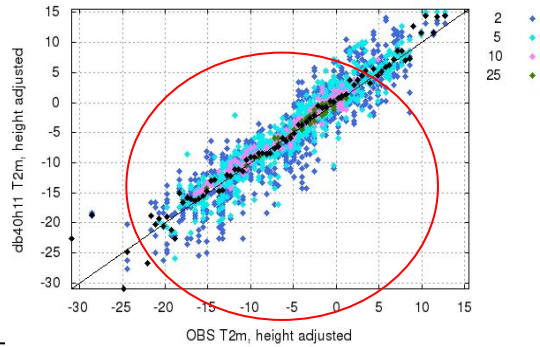


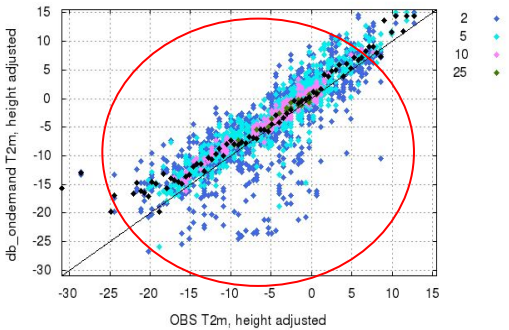
1km, regular



1km, on-demand







DiskoBugt, Greenland

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Regular vs On-demand

On-demand suites provides improved wind forecasts, hence useful for storm warning.
- Other less extreme situations may also benefit from on-demand system

The quality of on-demand suites is not fully compatible to regular (continuous cycling) ones
- A nested setup may help
- High resolution PGD database may be crucial
- Application situation needs to be carefully chosen
  - Maybe in general, beneficial to phenomena with heavy dominance of local feature, or weak-flow situation?
  - Destination Earth On-Demand Extreme (aka XXXXX) event- or user- driven DT

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Summary and Conclusions

1. **Higher resolution** beneficial in predicting orographically induced wind
2. **On-demand** configuration to makes value added setup affordable
3. Simple **triggering** based on experiences from operational monitoring
4. Operational **implementation** successful for wind forecasts
5. **Coupling** to host model crucial for general usefulness
6. Challenges and opportunities if applied to other on-demand setup
    a. Main challenge in cold-start/initialisation/**coupling**: more research!
    b. Hectometric model configuration may not yet be generally mature
    c. Surface database a major issue
    d. Identification of relevant and value-added application necessary

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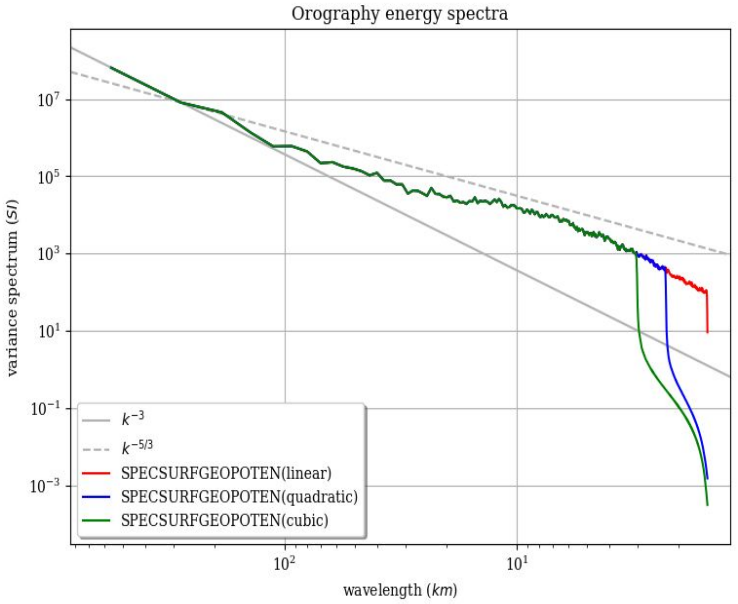
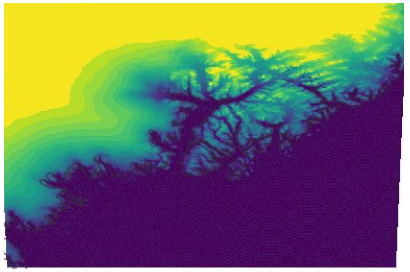
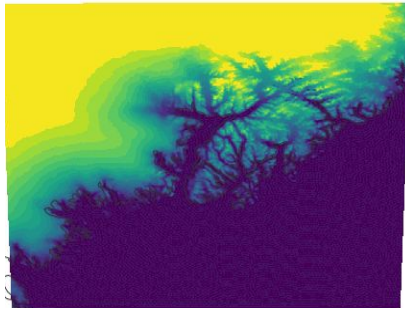
Orography

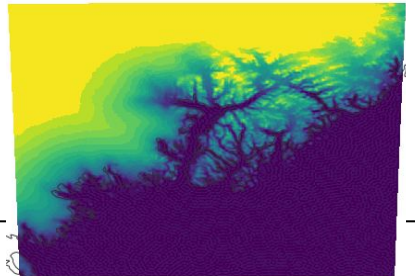




Linear

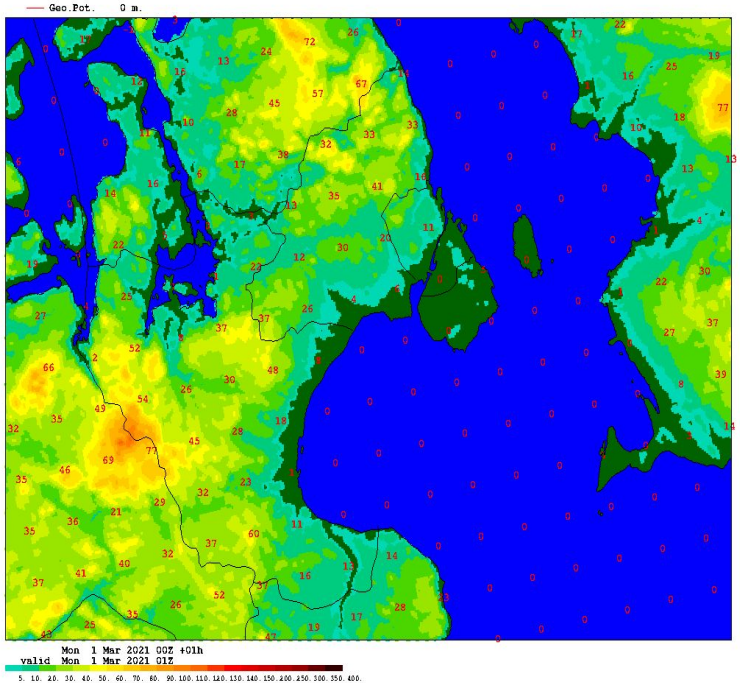


Quadratic

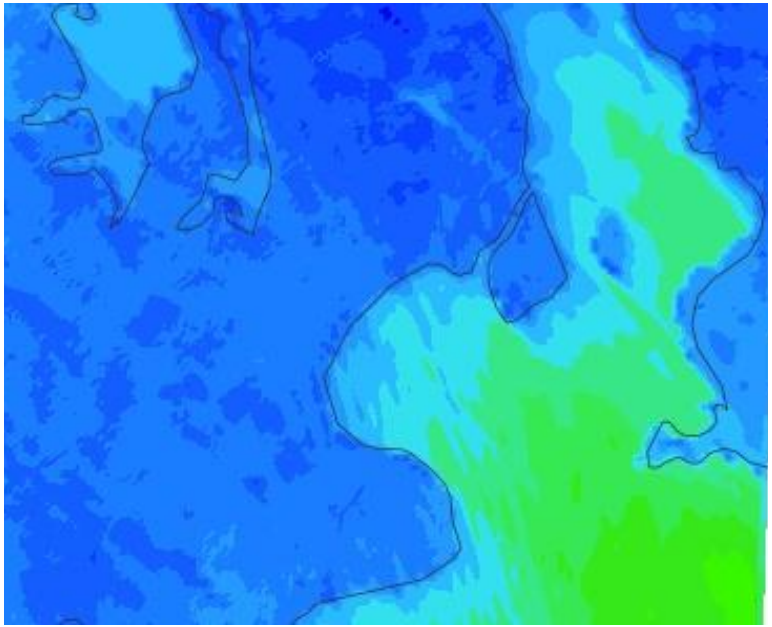


Cubic

Metropolitan Copenhagen@100 m



Orographic height (a “hilly Copenhagen”)



Wind speed 20210314 04