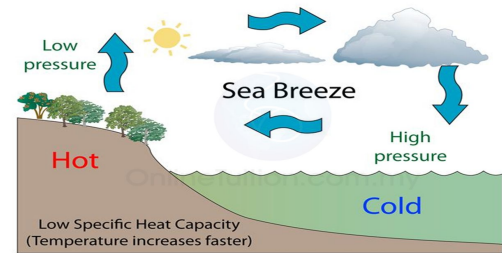
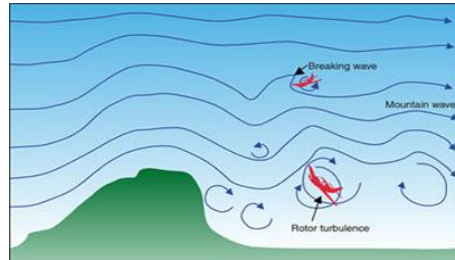
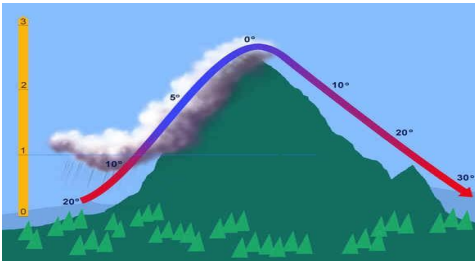


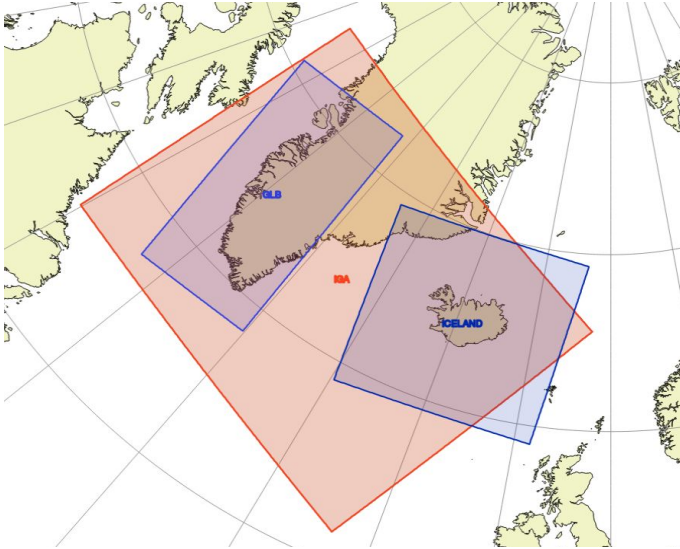
Sub-km grid NWP for regions with complex orography

- Challenges with station forecast
- Experimental 750-metre HARMONIE-AROME @ DMI



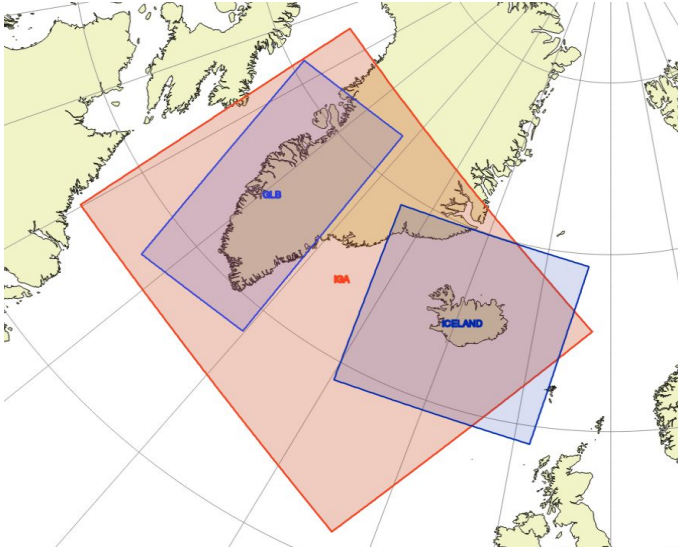
Xiaohua Yang, DMI

Operational experiences



Since late 2016, DMI and IMO operate jointly IGA-2.5 km with HARMONIE-AROME 40h1.1
On a 2500 km x 2000 km domain covering South Greenland and Iceland

Operational experiences



Since late 2016, DMI and IMO operate jointly IGA-2.5 km with HARMONIE-AROME 40h1.1 On a 2500 km x 2000 km domain covering South Greenland and Iceland

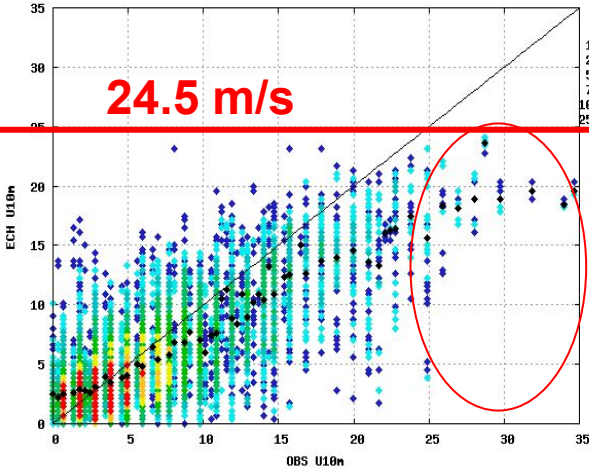
(almost) All measurement stations (residential areas) in Greenland are at the coastal regions with complex orography

Statement of problems: Pros& Cons with HARMONIE-IGA (2.5 km)

Scatterplot for 38 stations Selection: GL
U10m [m/s]
Period: 20161211-20170207
Used {00,06,12,18} + 06 12 18 24

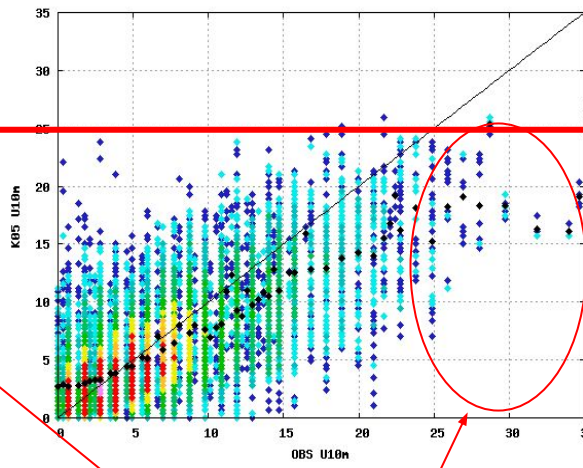
Scatterplot for 45 stations Selection: ALL
U10m [m/s]
Period: 20161211-20170207
Used {00,06,12,18} + 06 12 18 24

Scatterplot for 45 stations Selection: ALL
U10m [m/s]
Period: 20161211-20170207
Used {00,06,12,18} + 06 12 18 24

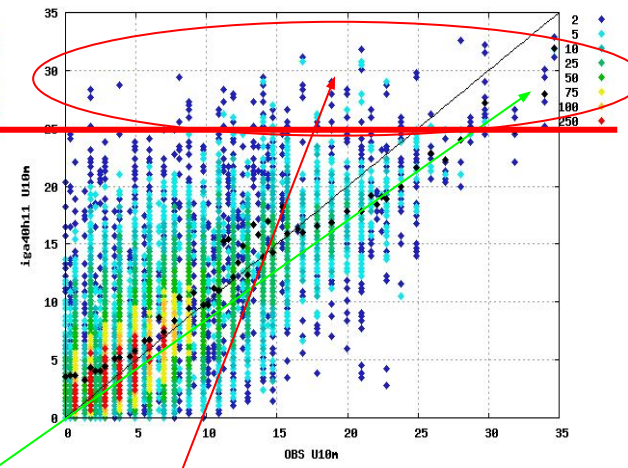


24.5 m/s

ECMWF



DMI-HIRLAM-K05



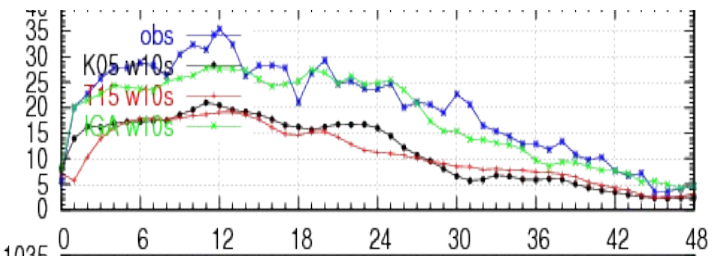
IGA



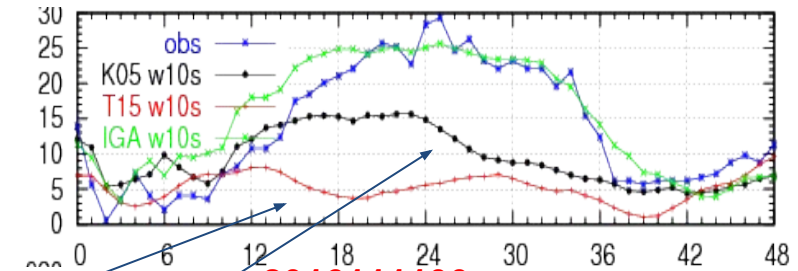
While ECMWF HiRES (9 km) and HIRLAM K05 (5.5 km) fail to predict wind over storm (24.5 m/s) for winter Greenland, HARMONIE-IGA (2.5 km) can.



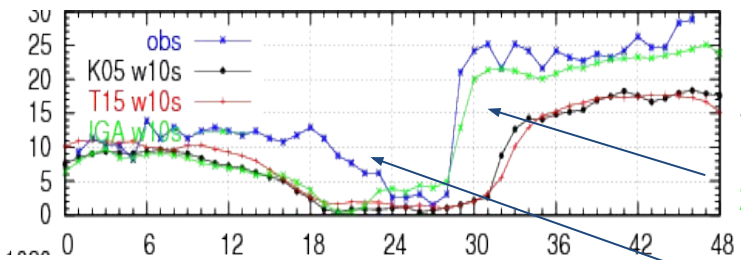
There is many incidence of over-prediction compared to observations.



2016110200



2016111100



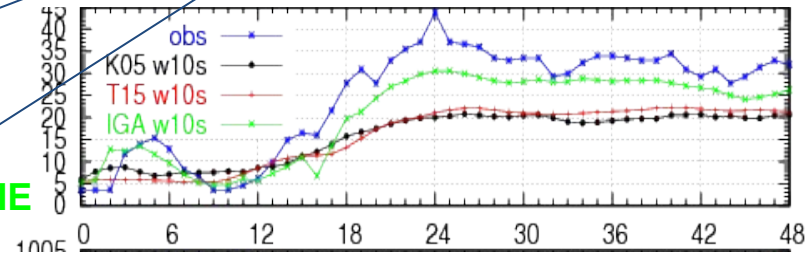
2016110518

15km HIRLAM

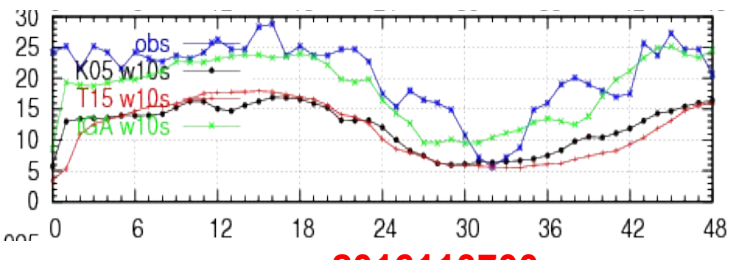
5 km HIRLAM

2.5 km HARMONIE

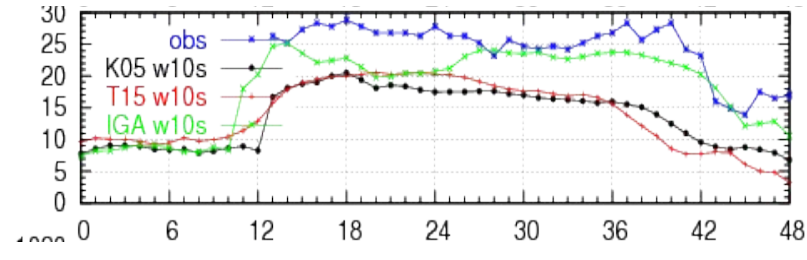
Observation



2016111418



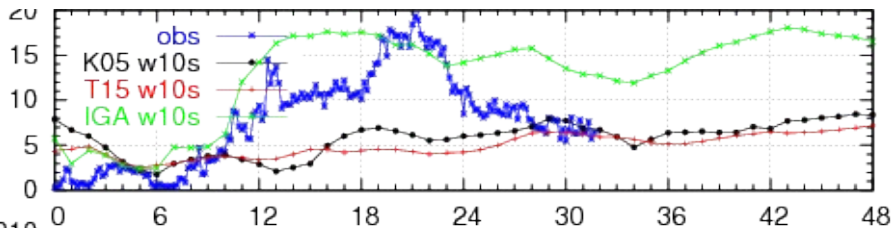
2016110700



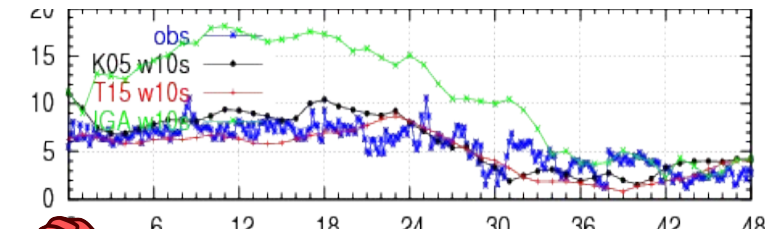
2016112312



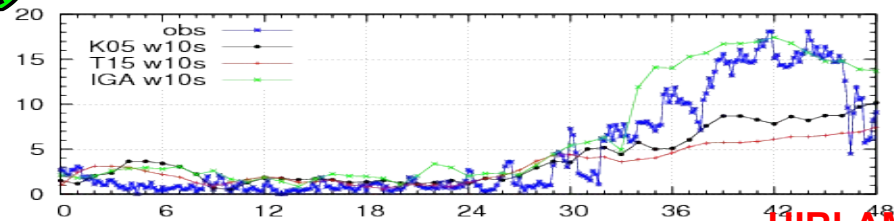
24h wind forecast with IGA for Ikermit: extraordinarily good



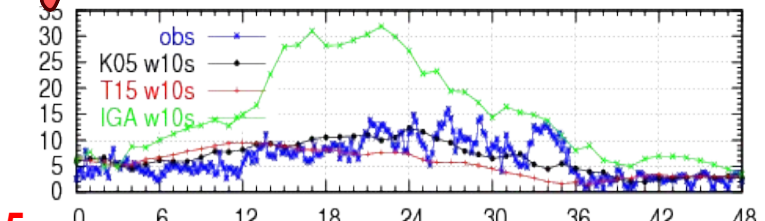
2016111500



2016111612

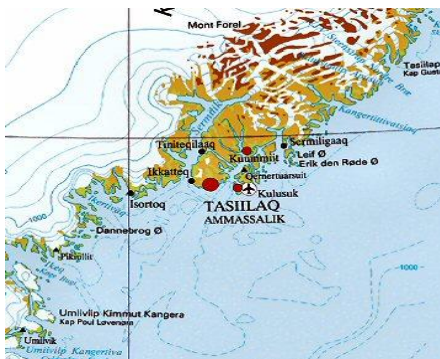


2017010100

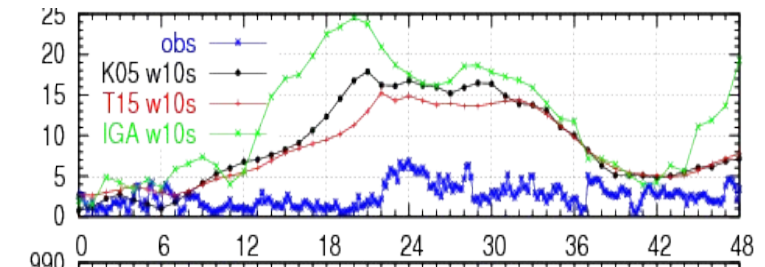


2017011712

HIRLAM T15
HIRLAM K05
HARMONIE IGA

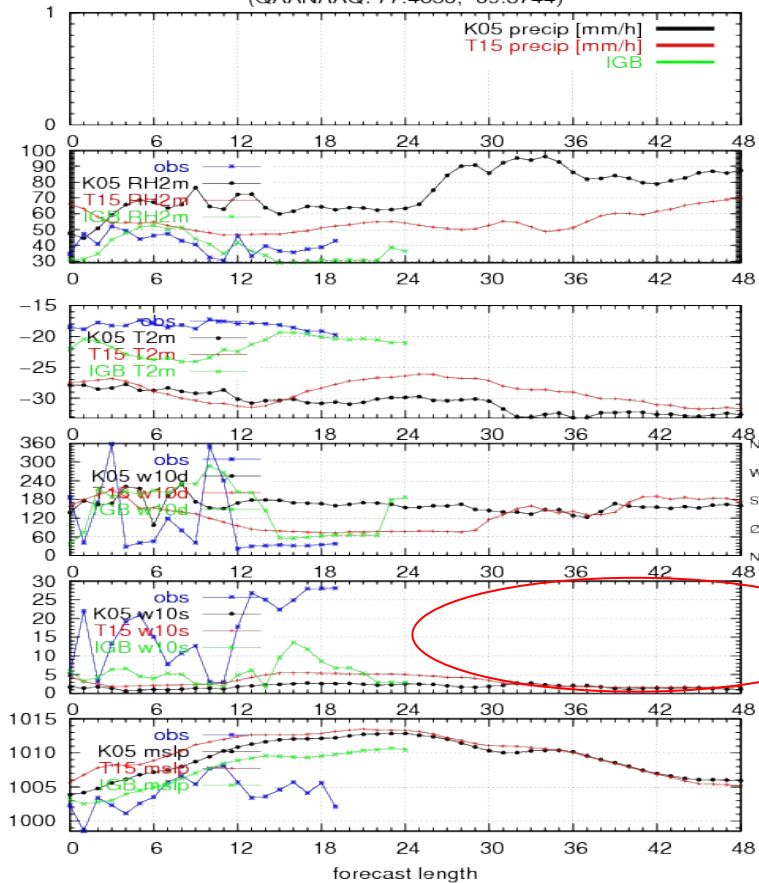


**Tasilaq
Greenland**

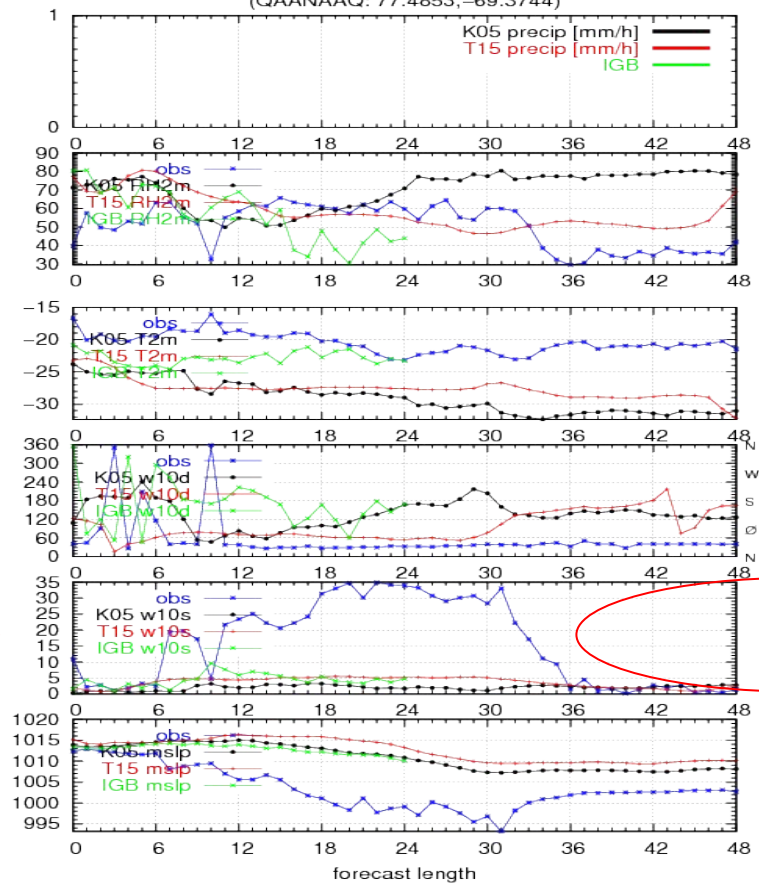


2017020400

initial (UTC) time 17022012 – K05/T15 – at 4205
(QAANAQ: 77.4853, -69.3744)



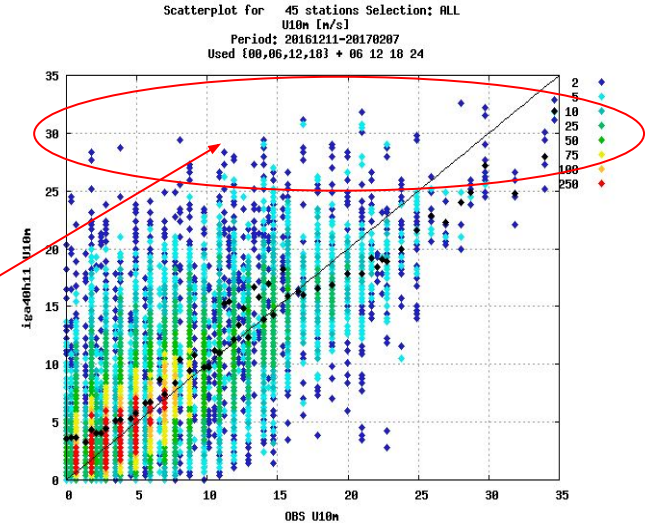
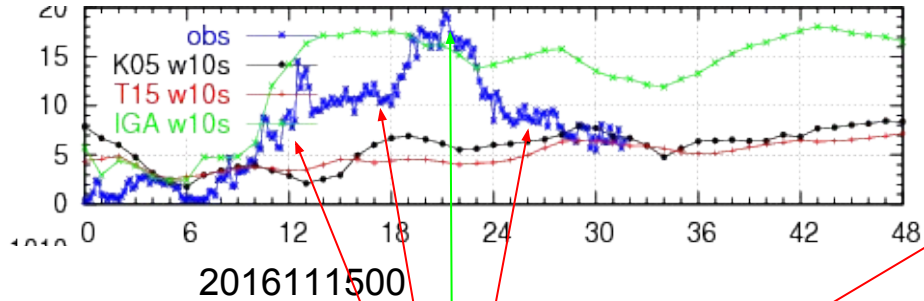
initial (UTC) time 16120700 – K05/T15 – at 4205
(QAANAQ: 77.4853, -69.3744)



For Qaanaq, IGA & other models under-forecast storms.

Operational experiences

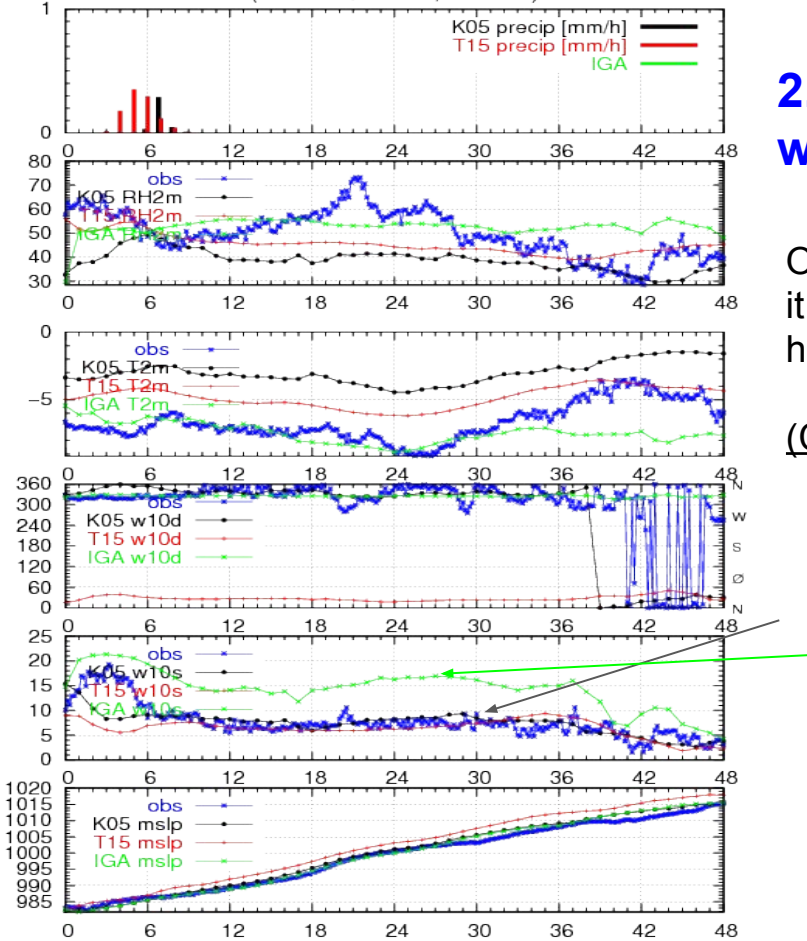
Wind forecast for TASIILAQ



1. Some of the over-prediction are associated with intensity and phase error

Operational experiences

initial (UTC) time 16111600 – K05/T15 – at 4360
(TASIIAQ: 65.611, -37.6367)



2. Some 'over-forecast' cases were associated with strong local variability

On 17/11 2016, while TASIIAQ wind measurement reads 6 m/s, it measured 15-22 m/s from the ship mast offshore the TASIIAQ harbour a few km away.

(Courtesy Ship Captain Eyðun Simonsen, M/V Arina Arctica)



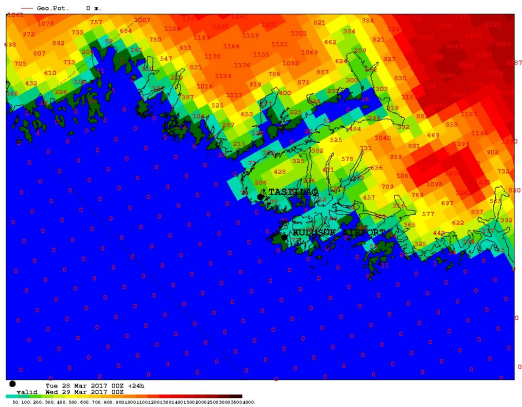
“Strong local variability”



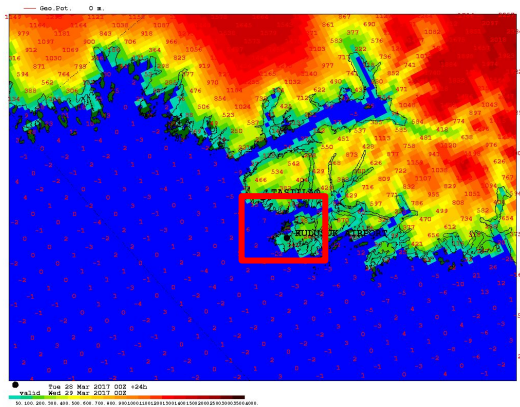
Complex orography



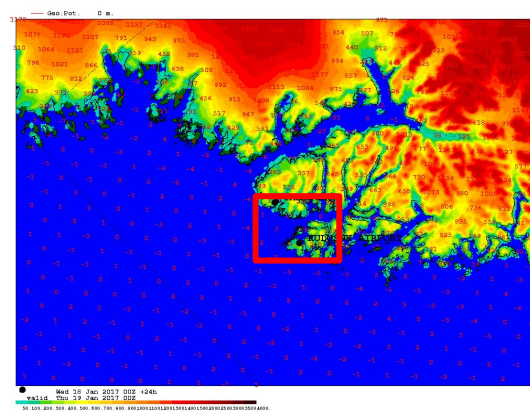
Needs very high resolution to resolve!!



5 km

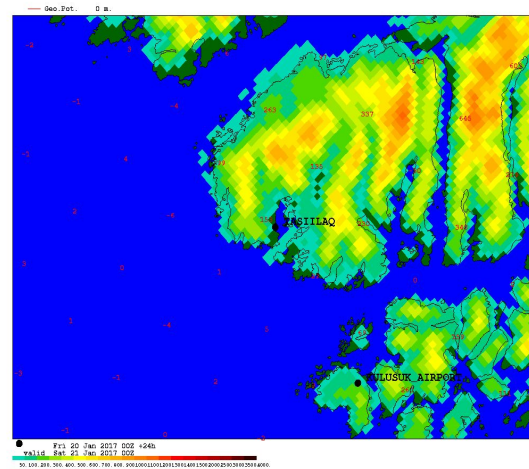
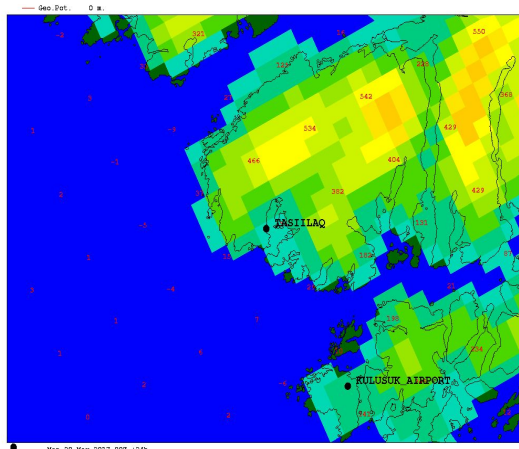


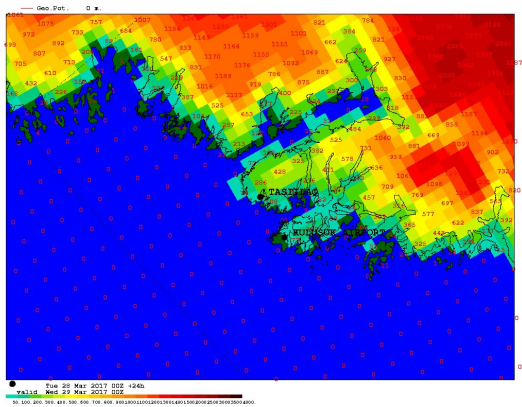
2.5 km



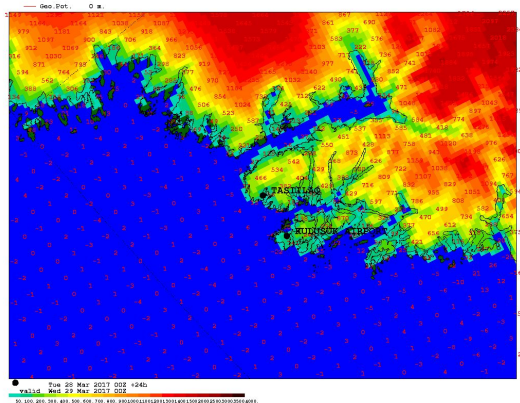
750 m

Aspect ratio ~1

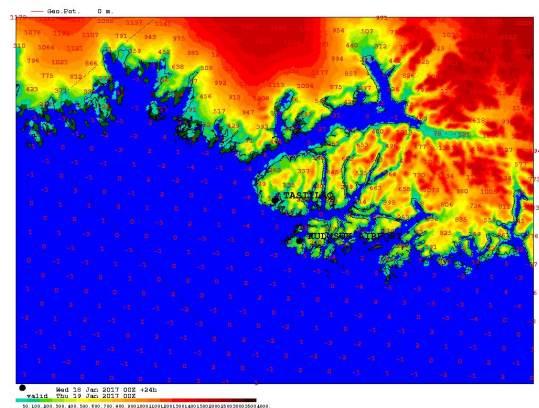




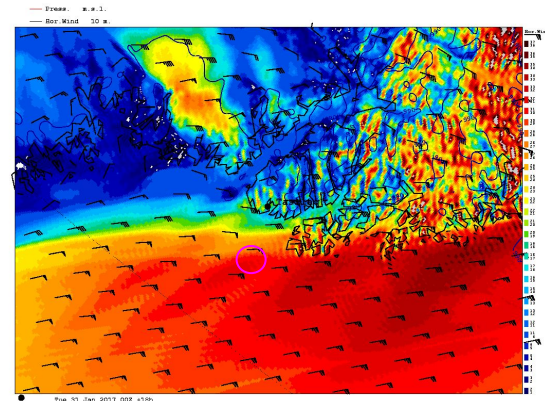
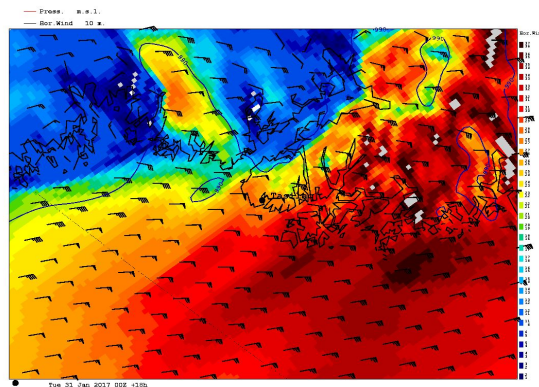
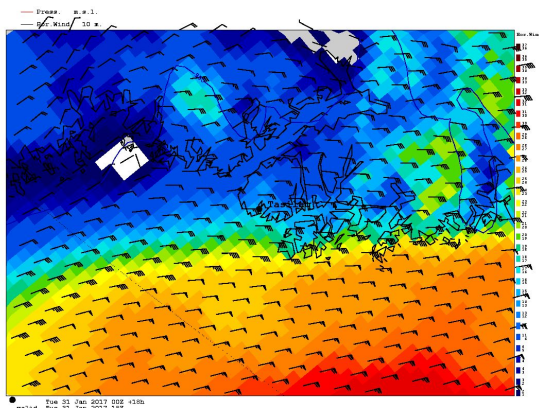
HIRLAM-K05 5 km



HARMONIE IGA 2.5 km

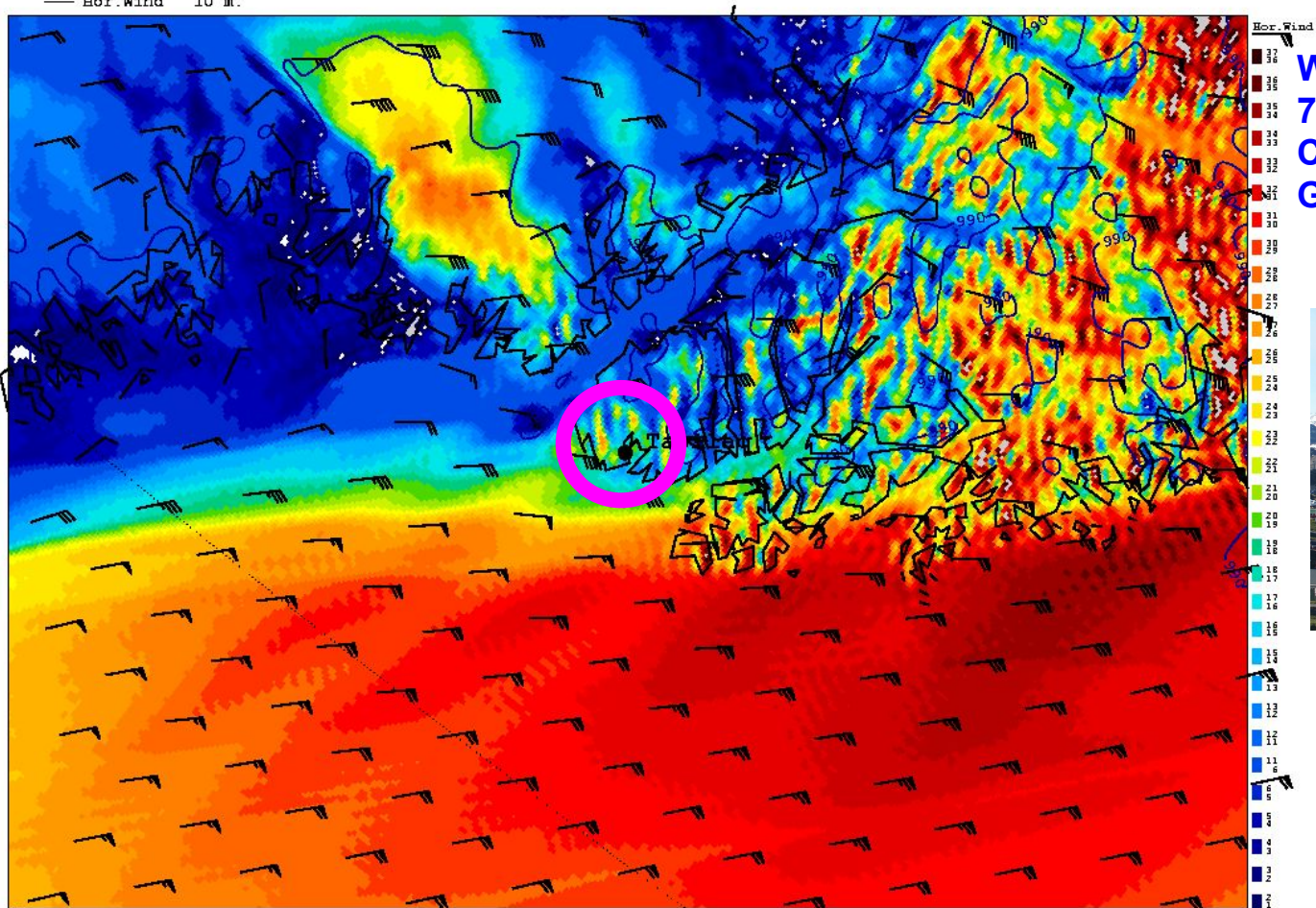


HARMONIE TAS 750 m

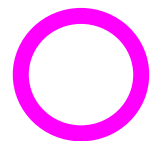


Jan 31 2017, 18 UTC

— Press. m.s.l.
— Hor.Wind 10 m.



Wind forecast from a 750 m HARMONIE-AROME Centered in Tasiilaq, East Greenland, Jan 31 2017

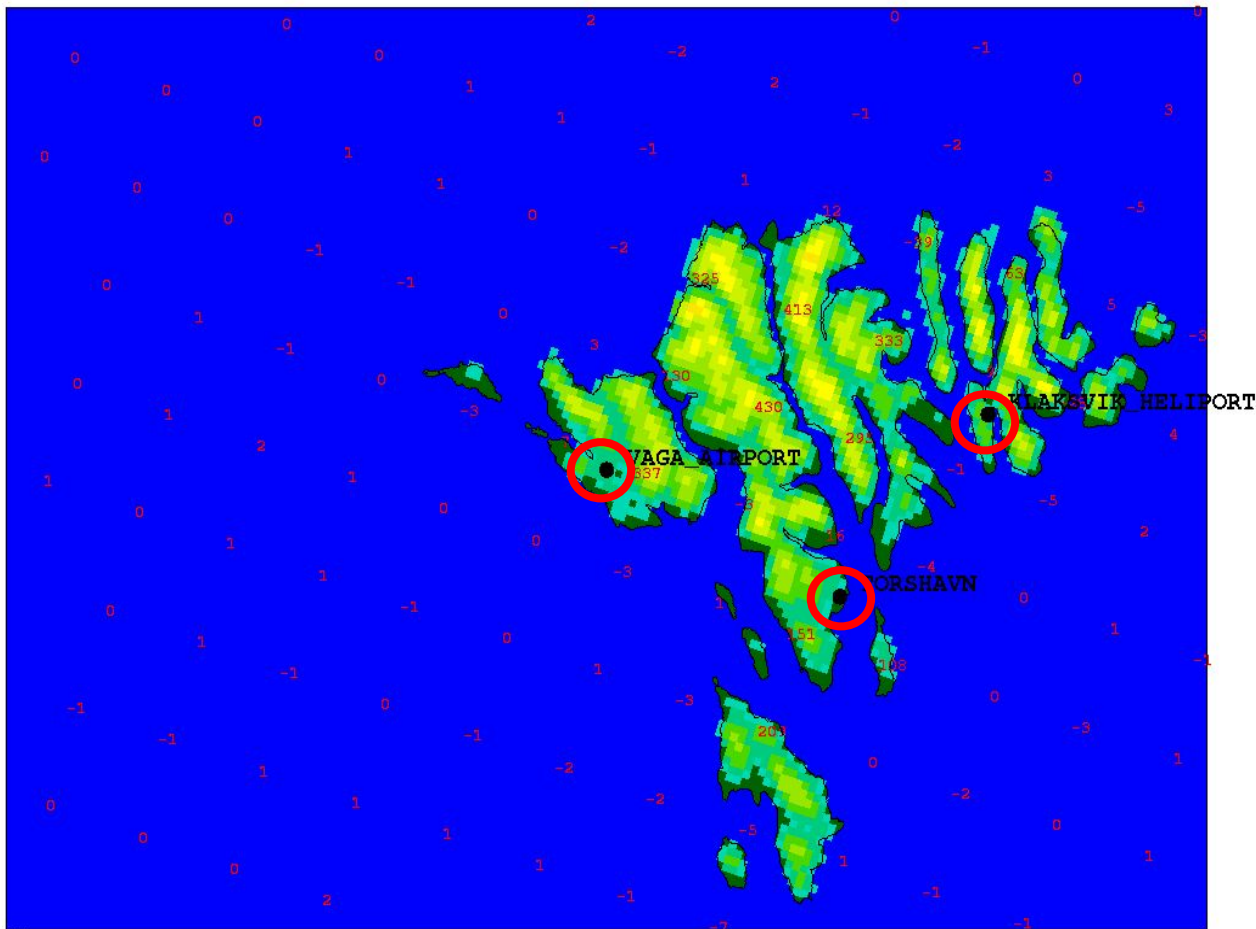


5 km

“Seeing a storm”

● Tue 31 Jan 2017 00Z +18h
valid Tue 31 Jan 2017 18Z

Geo.Pot. 0 m.

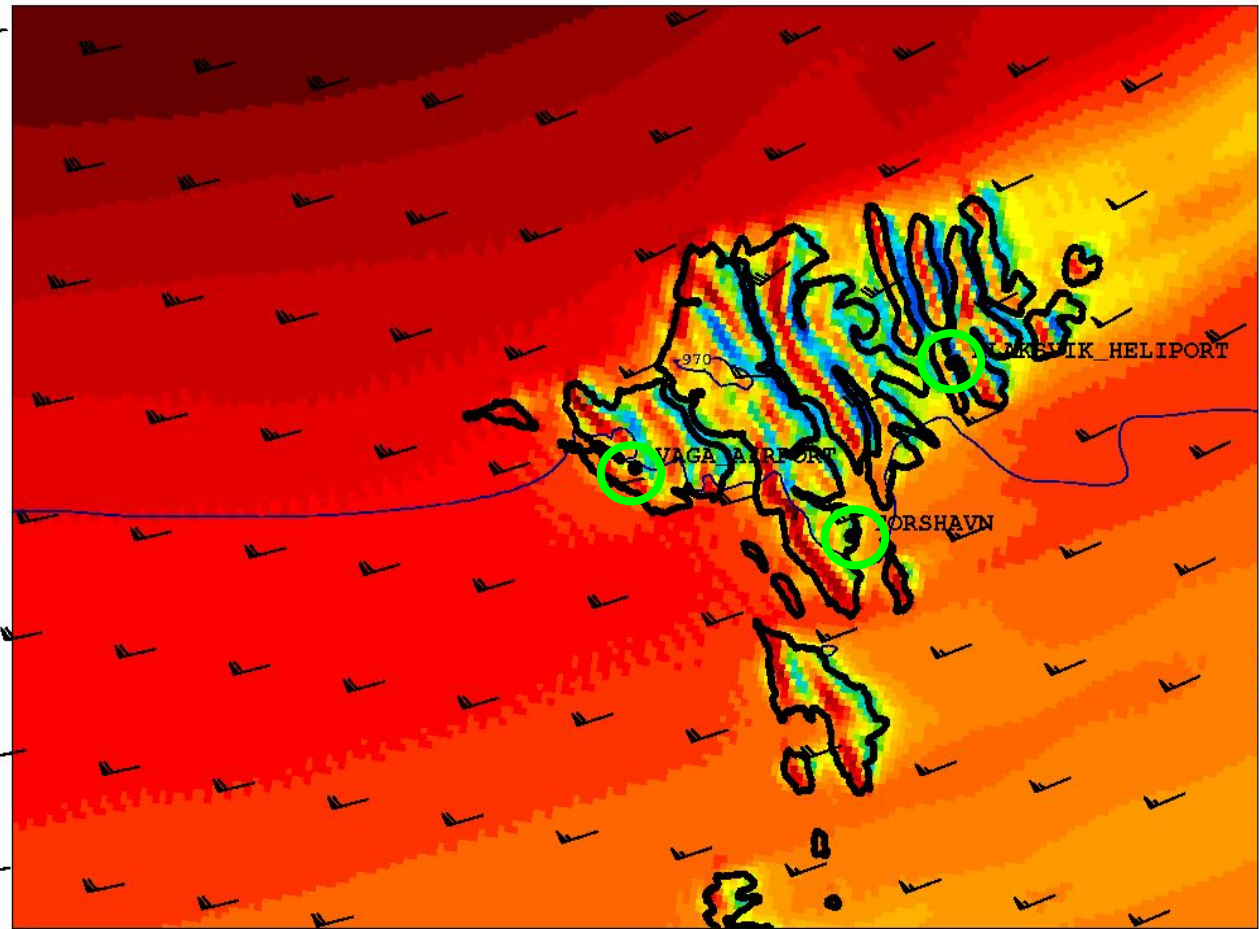


Faroe Islands
Orography as seen with
750 m HARMONIE

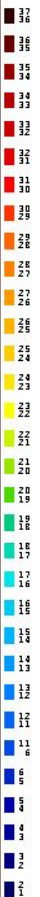


● Sat 25 Mar 2017 00Z +18h
valid Sat 25 Mar 2017 18Z
50. 100. 200. 300. 400. 500. 600. 700. 800. 900.1000.1100.1200.1300.1400.1500.2000.2500.3000.3500.4000.

— Press. m.s.l.
— Hor.Wind 10 m.

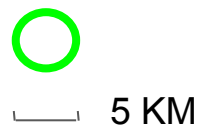


Hor.Wind



Christmas hurrican/ storm in Faroe Islands as simulated by 0.75 km-grid HARMONIE-arome

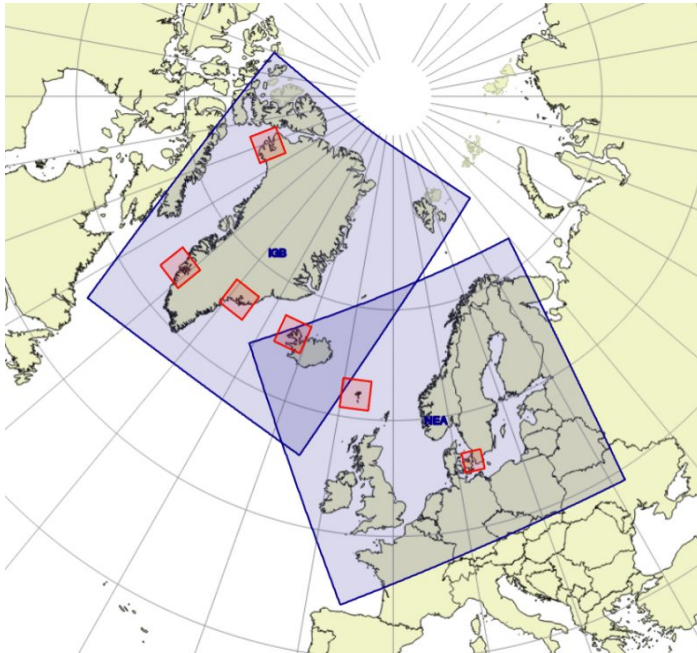
Dec 25 2016



● Sun 25 Dec 2016 00Z +15h
valid Sun 25 Dec 2016 15Z

“HARMONIE-lite”

--- Possible supplementary NWP setup focusing on local storms @DMI@2018



Domains: 400x400x65, 0.75 km
Cubic grid, LUNBC=T, VESL=0.1
DT=30s

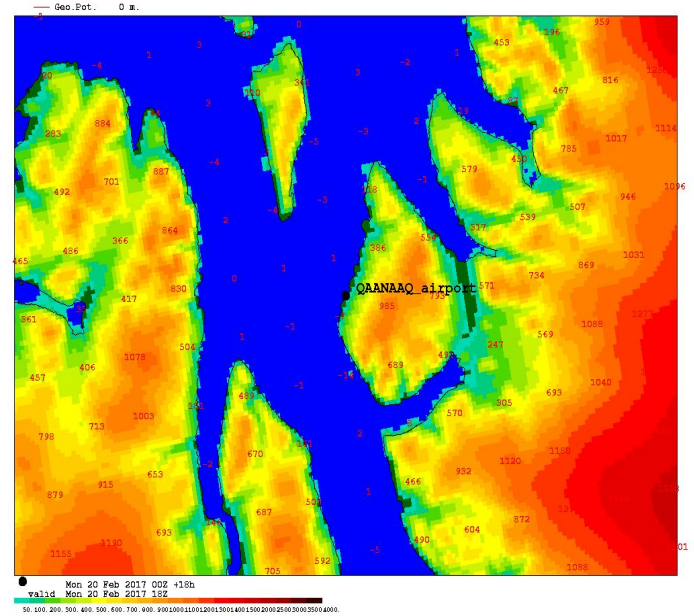
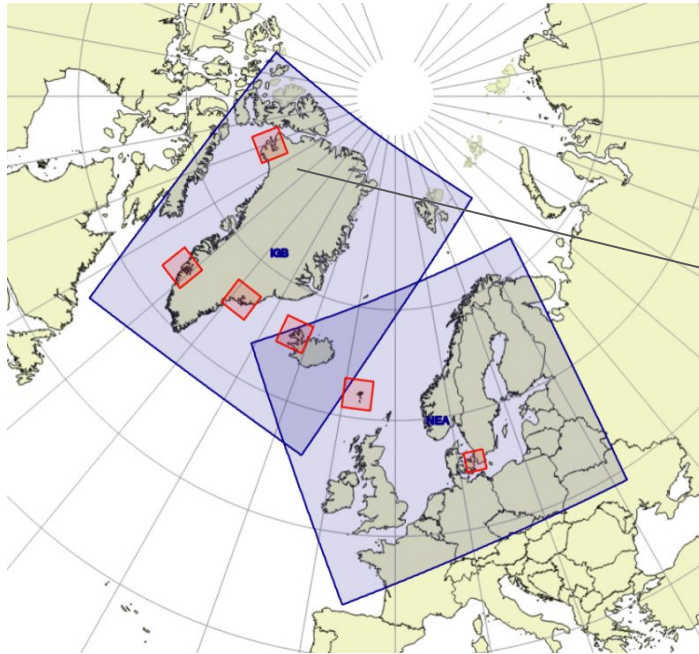
Blending, 24 fcst/6 h

Peak use of CPU capacity on DMI's current
operational Cray clustre: 3%

Additional domains “on-demand”

“HARMONIE-lite”

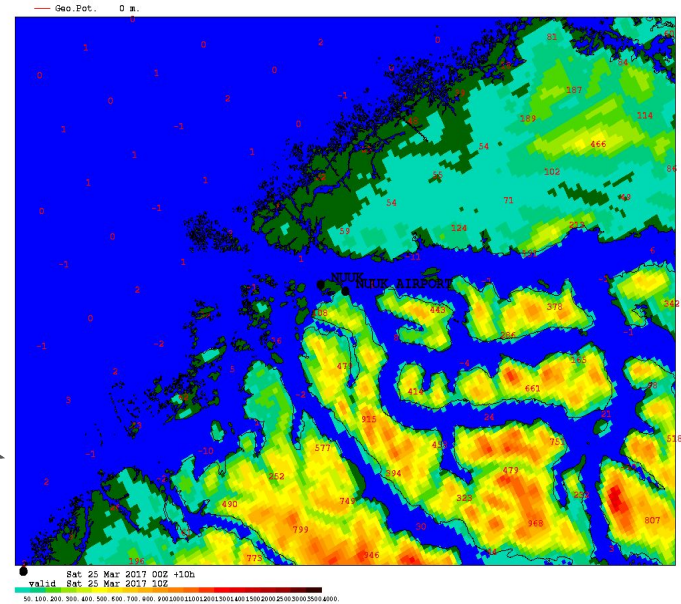
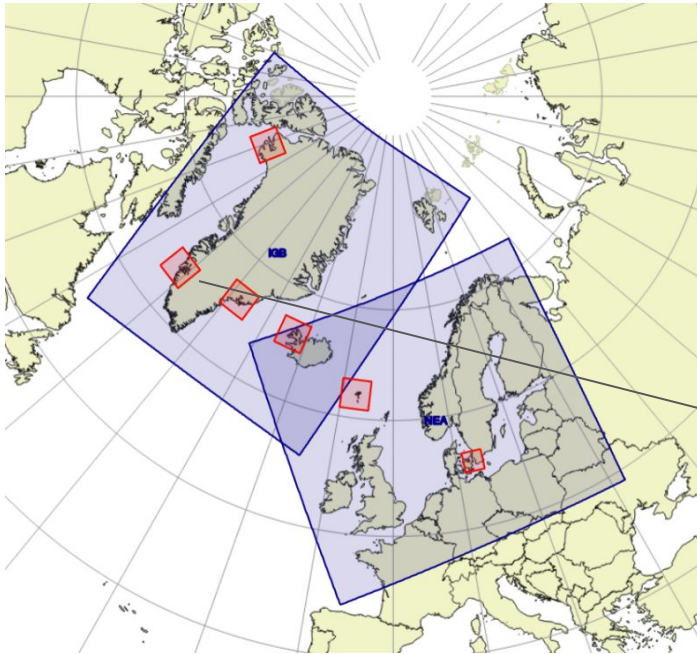
--- Possible supplementary NWP setup focusing on local storms @DMI@2018



Qaanaaq, Greenland

“HARMONIE-lite”

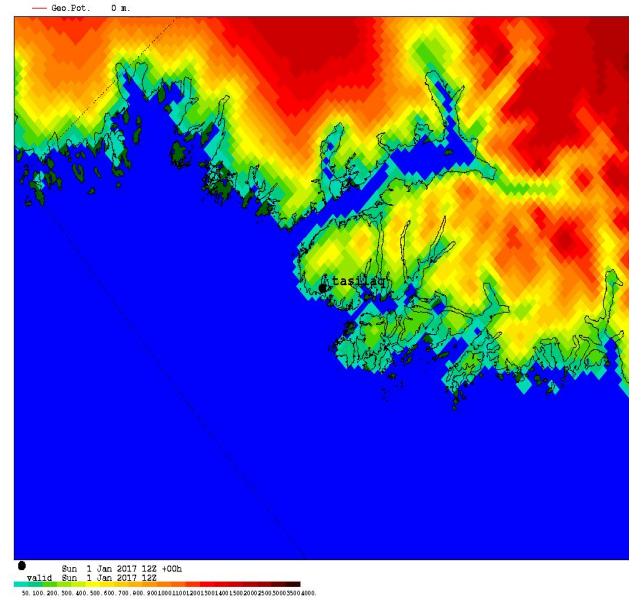
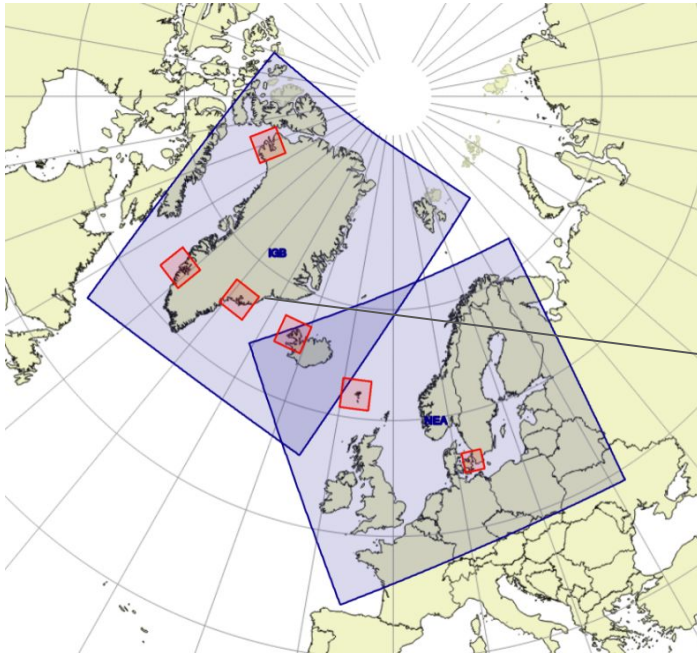
--- Possible supplementary NWP setup focusing on local storms @DMI@2018



Nuuk, Greenland

“HARMONIE-lite”

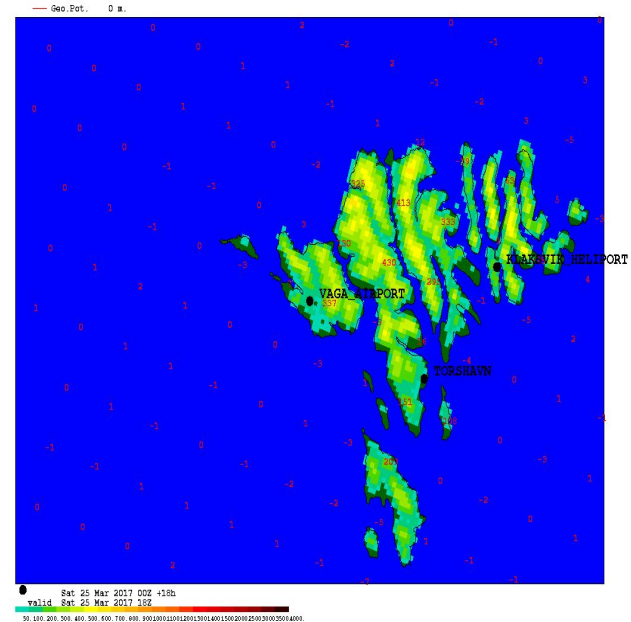
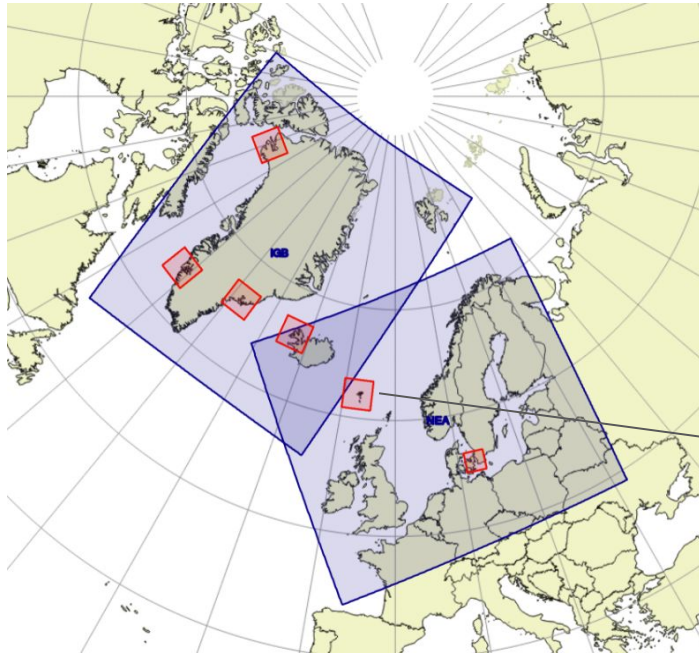
--- Possible supplementary NWP setup focusing on local storms @DMI@2018



Tasiilaq, Greenland

“HARMONIE-lite”

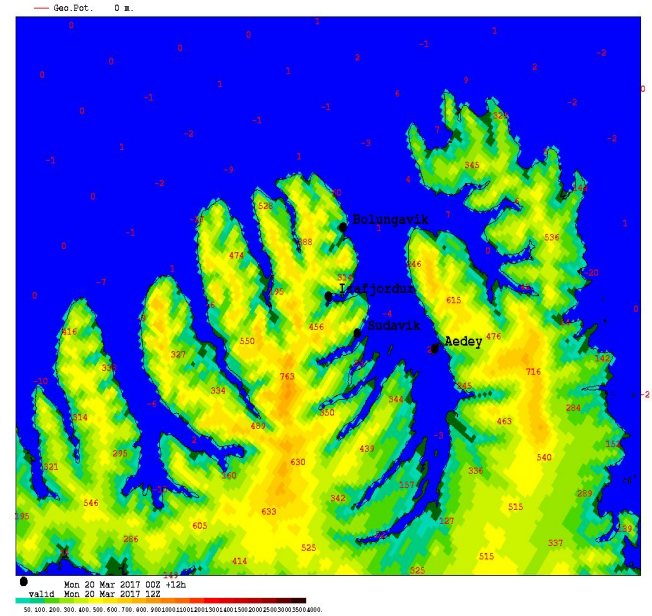
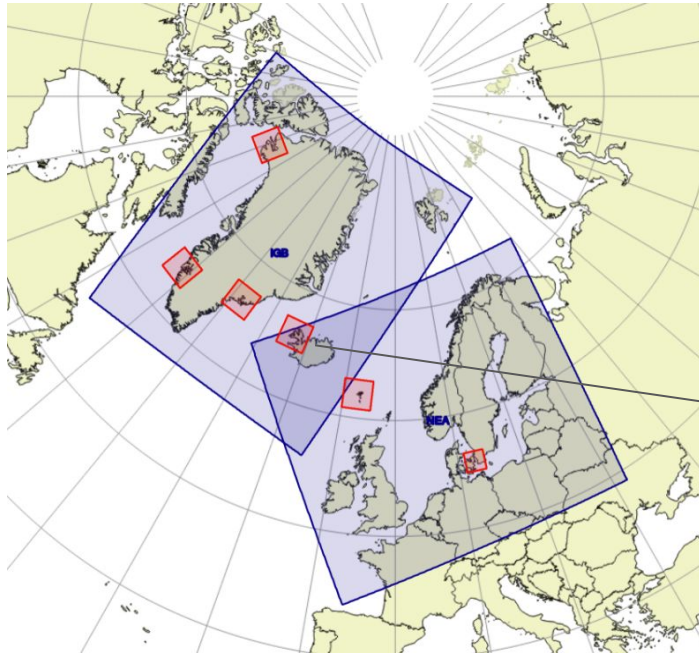
--- Possible supplementary NWP setup focusing on local storms @DMI@2018



Vaga, Faroe Islands

“HARMONIE-lite”

--- Possible supplementary NWP setup focusing on local storms @DMI@2018

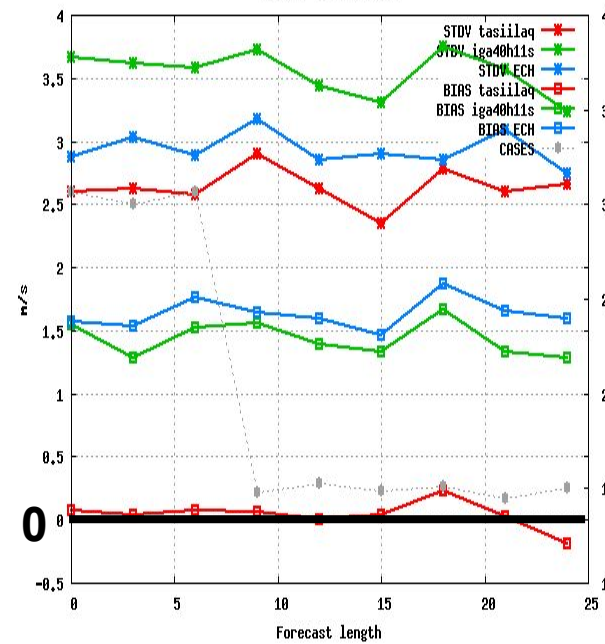


Westfjords, Iceland

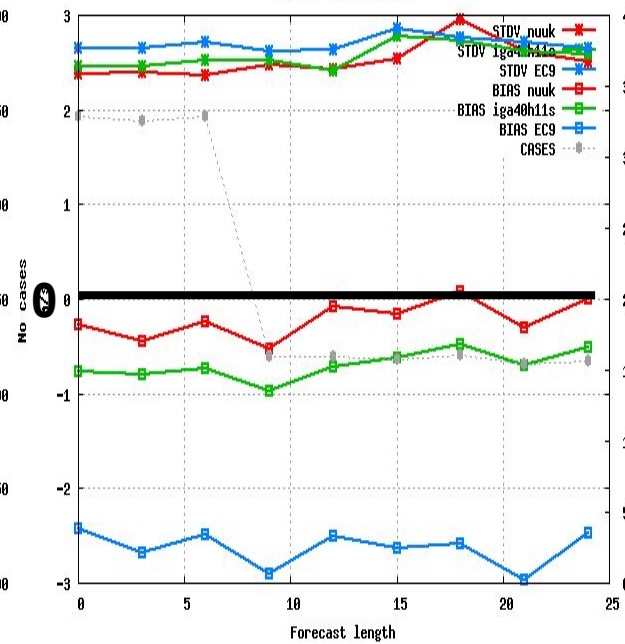
Selection: TASIILAQ using 1 stations
 U10m Period: 20161220-20170328
 Hours: {00,06,12,18}

Selection: NUUK using 1 stations
 U10m Period: 20161221-20170328
 Hours: {00,06,12,18}

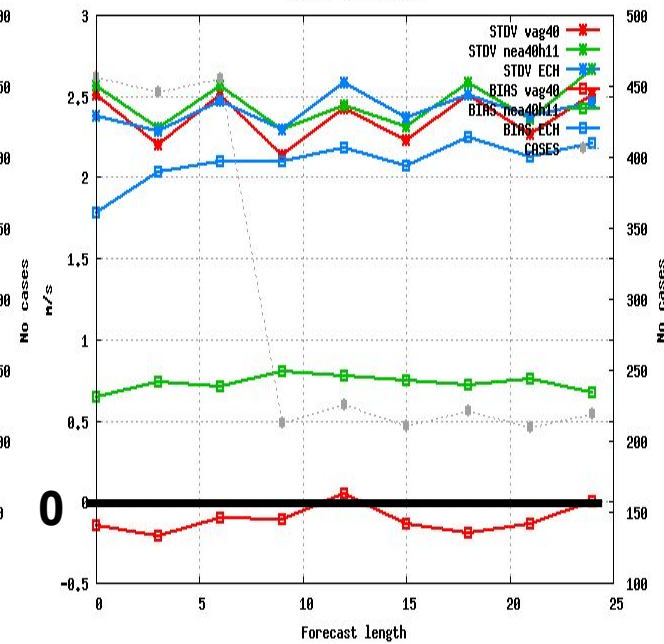
Selection: VAGA using 1 stations
 U10m Period: 20161124-20170328
 Hours: {00,06,12,18}



Tasiilaq



Nuuk



Vaga

Harmonie-arome 0.75 km
 Harmomie-arome 2.5 km
 ECMWF Hires 9 km

Summary

- Coastal Greenland/Iceland/Faroe Islands feature extreme weather situations associated with complex orography of very small scales.
 - Aspect ratio (DX/DZ) approaches 1 ==> nonhydrostatic
 - Weather extremes at km scales => 2.5 km grid resolution not sufficient
- While IGA in general is superior to coarser resolution models for wind forecast in Greenland, it deviates significantly from validating observations for some stations
- Single point deterministic forecast (“station forecast”) needs to consider spatial variability (upscaling; probabilistic information)
- **Preliminary results** with HARMONIE-AROME on sub-km grid-scale NWP appear promising
 - Simulated flow appear realistic
 - Satisfactory stability and affordability (DT=30s for cubic grid, VESL=0.1, LUNBC)
 - Verification statistics on wind parameters look superior to coarser resolution
- Near future outlook: “**HARMONIE-lite**” at DMI: reliable and affordable
 - Several configuration options to be checked further
 - Optimal horizontal resolution (1 km? 750 m? 500m?)
 - domain size (720x720, 400x400)
 - Vertical resolution (L90?)
 - Nesting and data assimilation
 - Physical parameterisation and diagnosis