

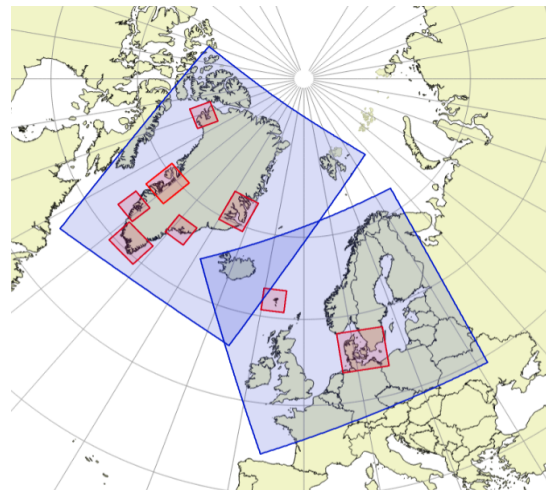


Danmarks
Meteorologiske
Institut

Harmonie-arome at hectometric grid scale

Xiaohua Yang
Danish Meteorological Institute

- **Sub-km configurations for wind forecast in complex terrain**
- **Sub-km nowcasting setup for Denmark**



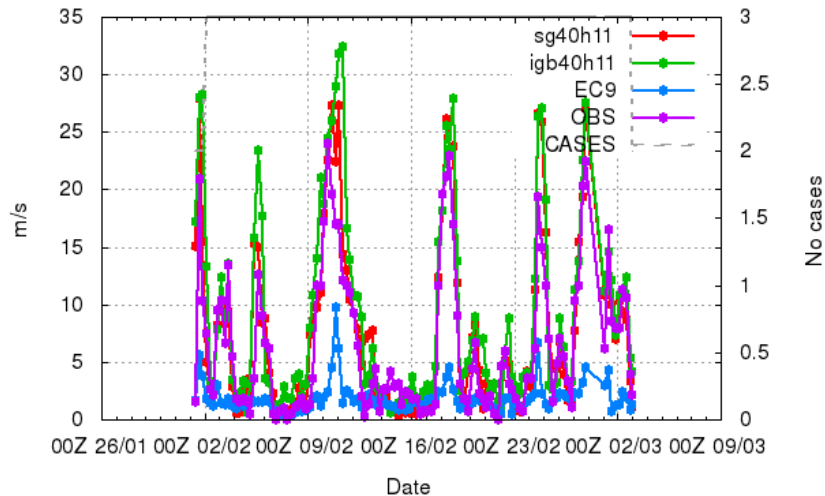


Danmarks
Meteorologiske
Institut

HARMONIE-arome for storm forecast in Greenland/Faroe Islands

Selection: NARSARSUAQ 1 stations
Used {00,06,12,18} + 03 06 24
Averaging window: 6h

2.5 km
9 km
OBS



NARSARSUAQ

Much of the HARMONIE advantages are associated with finer spatial resolution

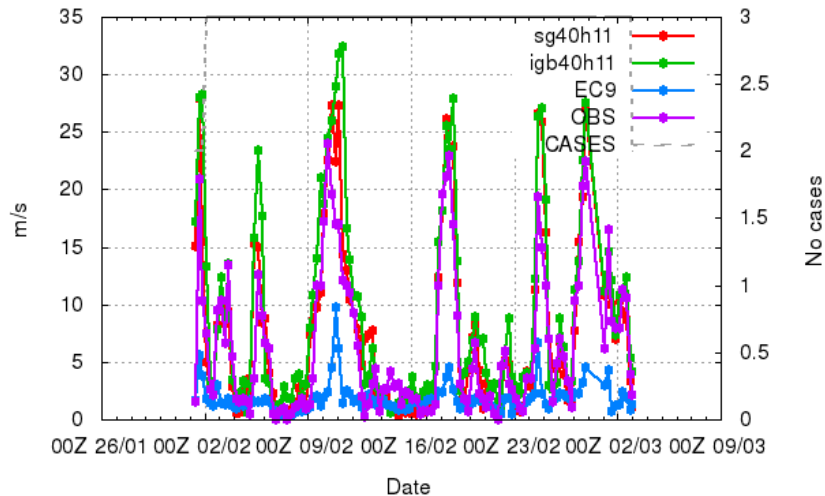


Danmarks
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HARMONIE-arome for storm forecast in Greenland/Faroe Islands

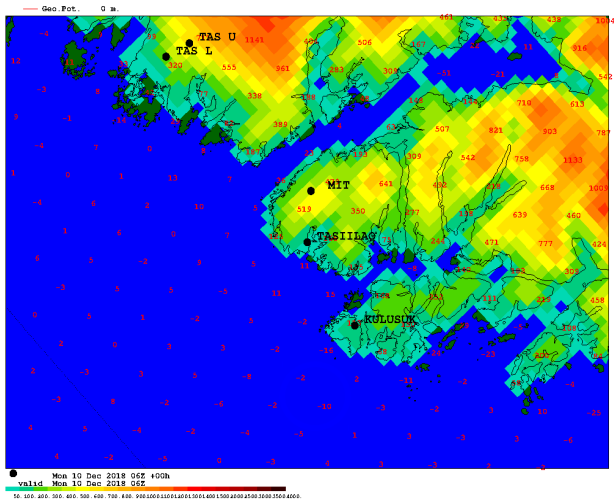
Selection: NARSARSUAQ 1 stations
Used {00,06,12,18} + 03 06 24
Averaging window: 6h

750m
2.5 km
9 km
OBS

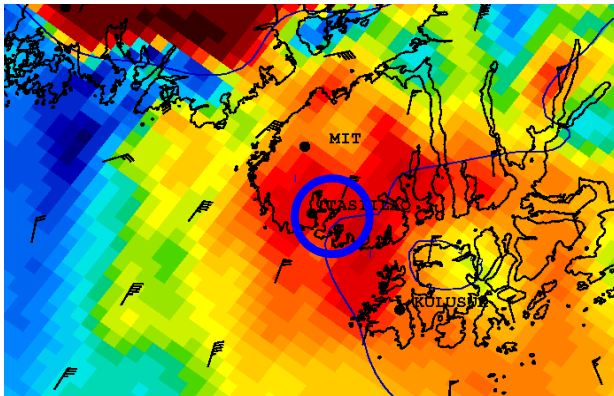
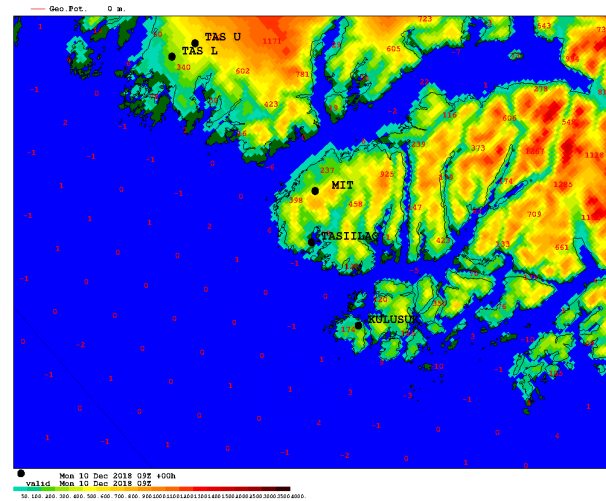


NARSARSUAQ

Much of the HARMONIE advantages are associated with finer spatial resolution



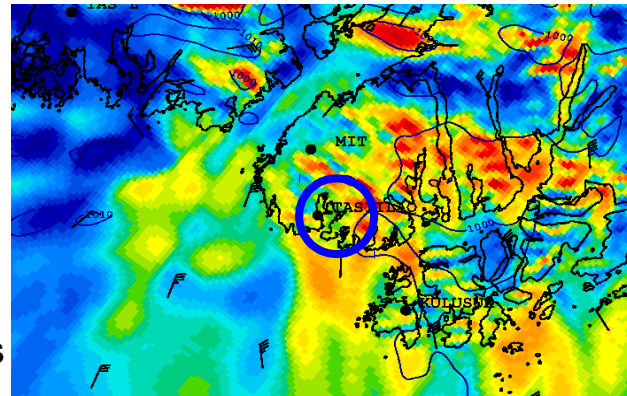
Orographys



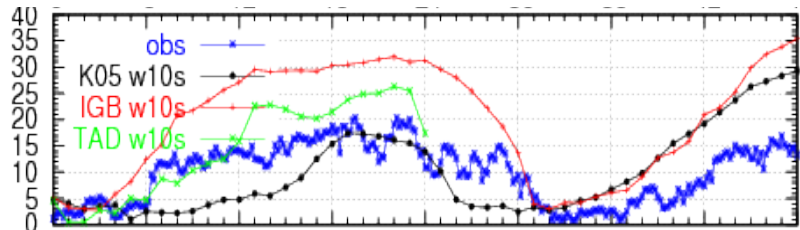
Wind



Ca 5 km in radius

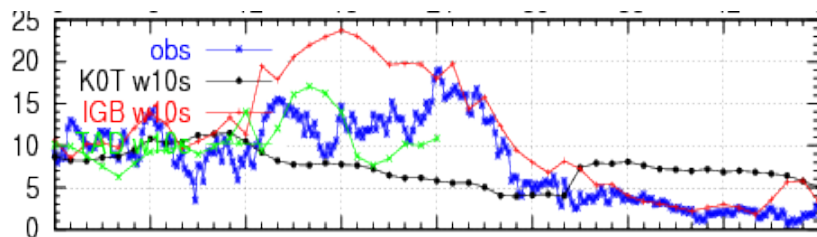


2018020500



2018050600

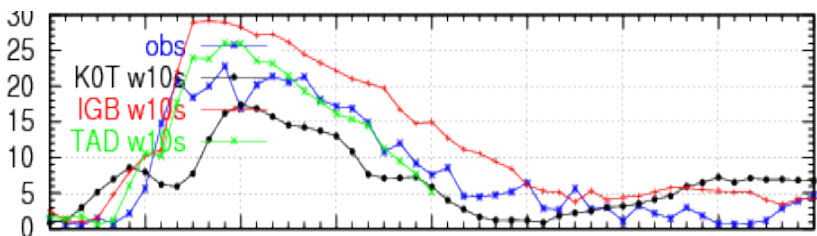
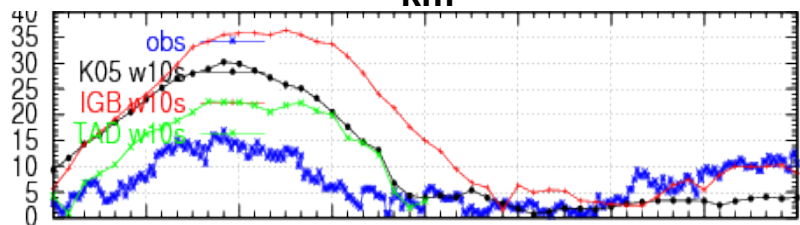
TASIILAQ



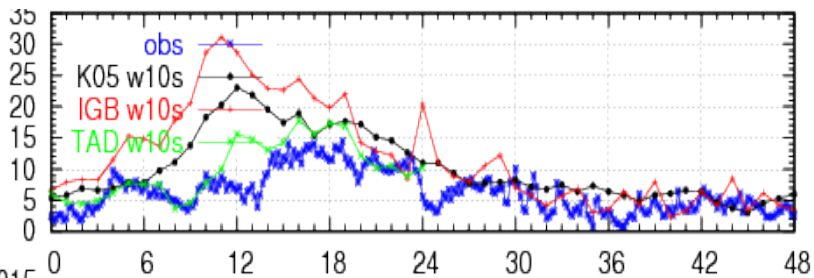
2018020612

Harmonie-750m vs Harmonie-2.5 km HIRLAM-5.5 km

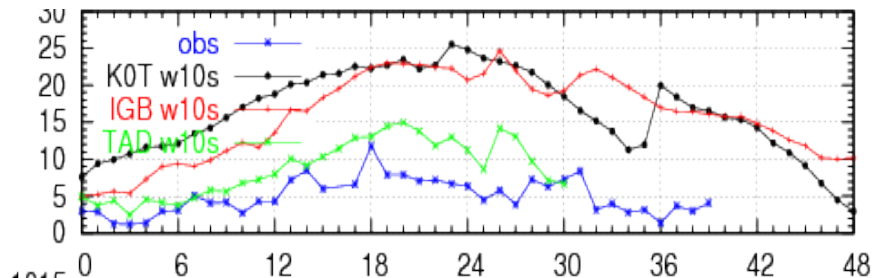
2018092812



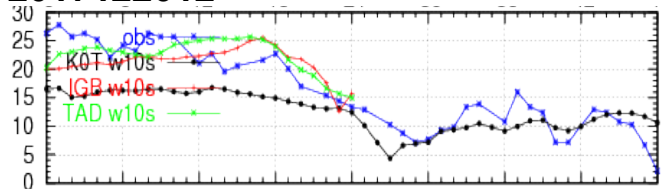
2018022312



2018100518

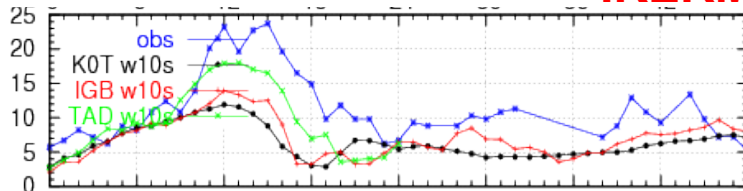


2017122012

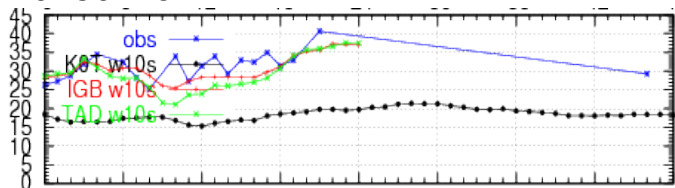


2018041012

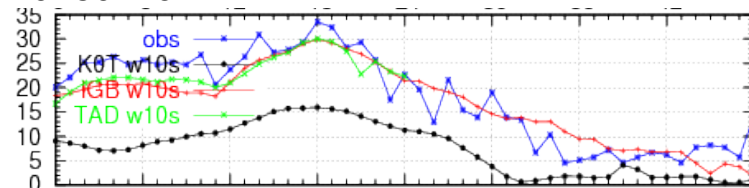
IKERMIIT



2018011312

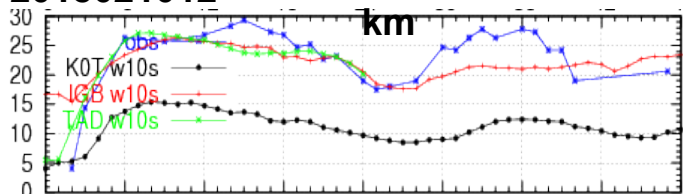


2018042912

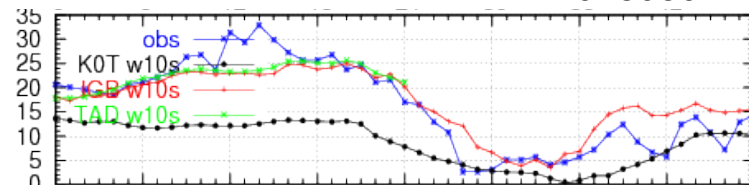


2018021012

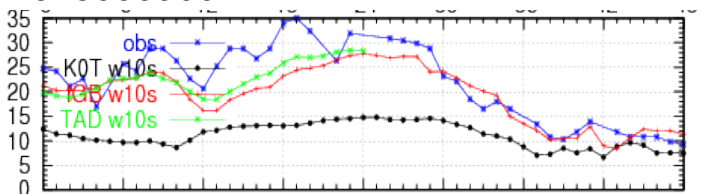
Harmonie-750m vs Harmonie-2.5 km HIRLAM-5.5



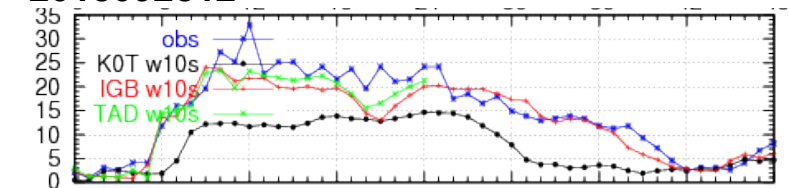
2018050412



2018030900

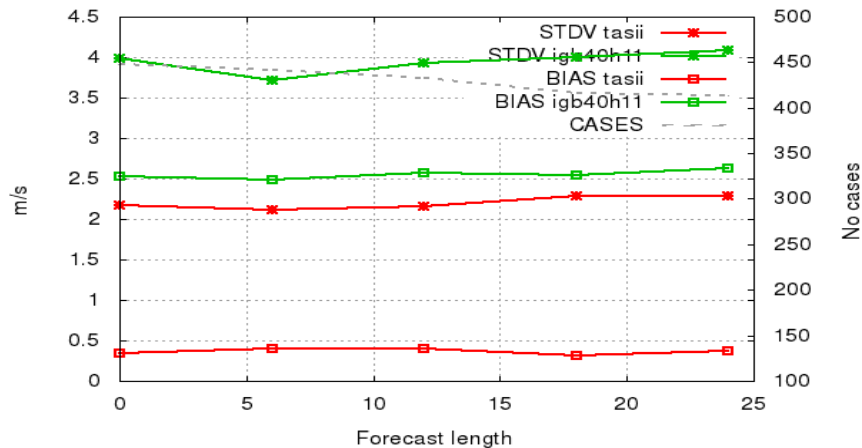


2018092812



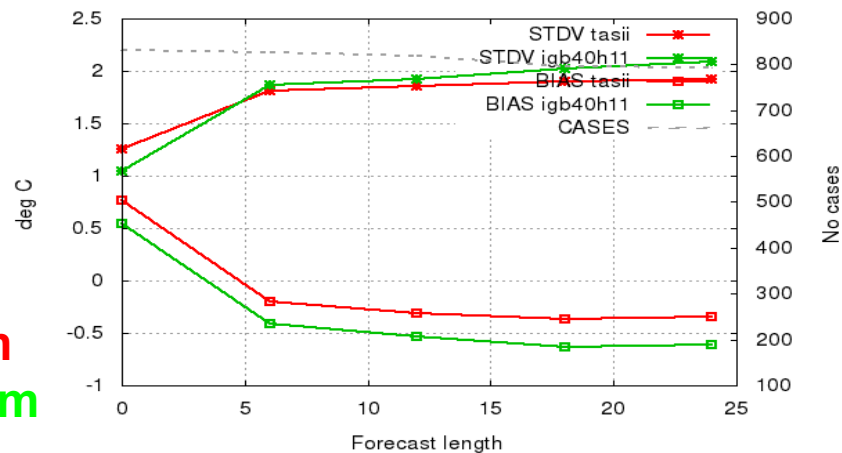
WIND

Selection: TASIILAQ using 1 stations
U10m Period: 20171001-20180930
Hours: {00,06,12,18}



T2M

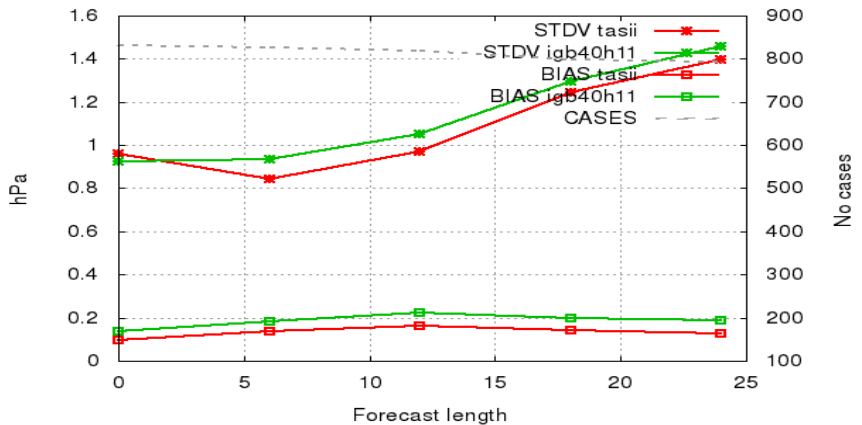
Selection: TASIILAQ using 1 stations
T2m, height adjusted Period: 20171001-20180930
Hours: {00,06,12,18}



750m
2.5 km

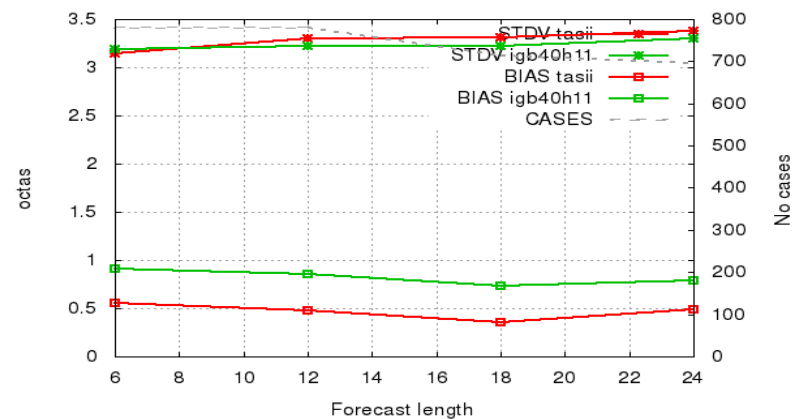
MSLP

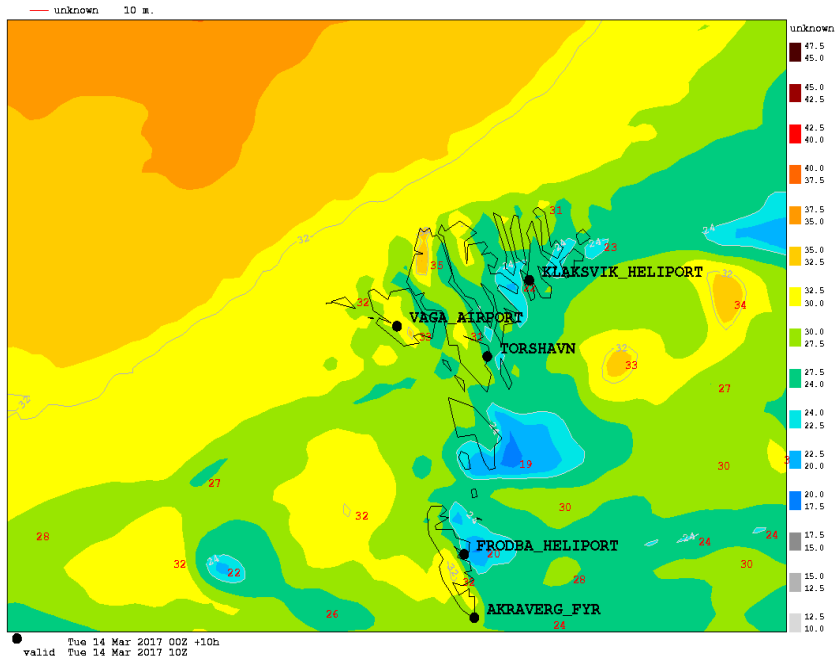
Selection: TASIILAQ using 1 stations
Mslp Period: 20171001-20180930
Hours: {00,06,12,18}



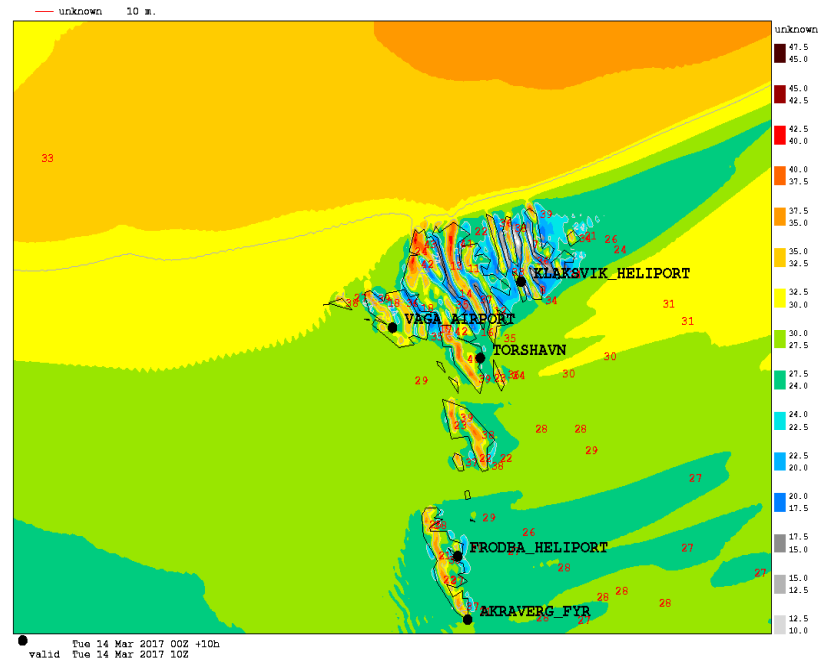
Cloud

Selection: TASIILAQ using 1 stations
Cloud cover Period: 20171001-20180930
Hours: {00,06,12,18}





DX=2.5 km



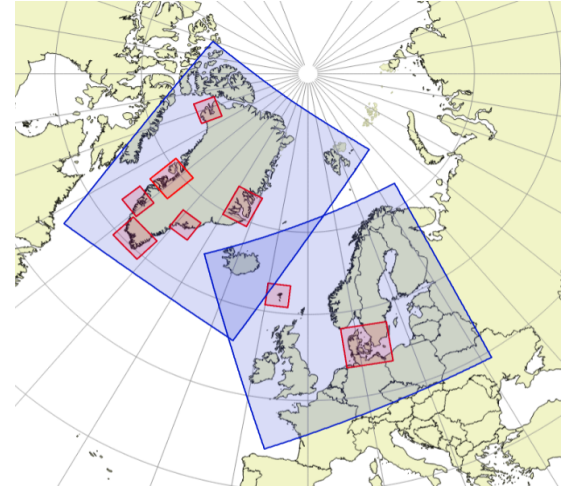
DX=750 m

Wind gust forecast for Faroe Islands, 20170314. Maximum observed gust > 52 m/s



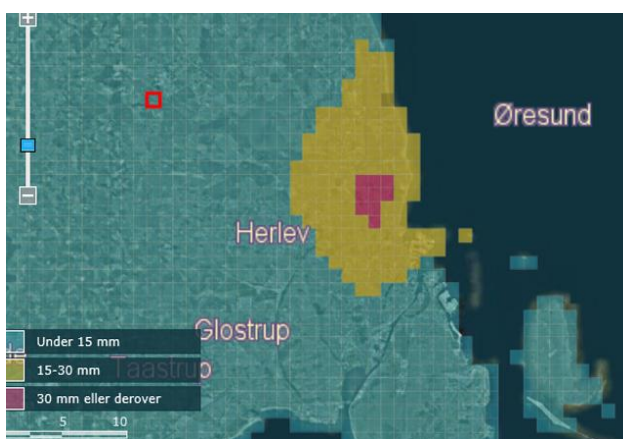
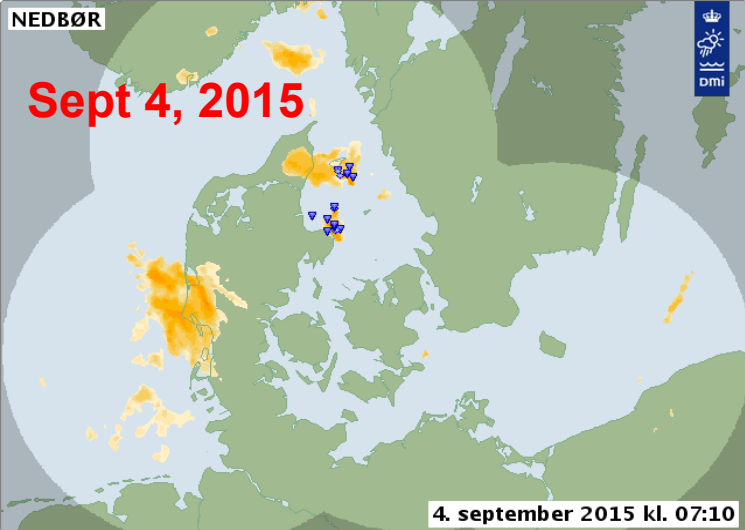
“Harmonie-lite”: basic configuration

- Quadratic or cubic grids, 750 m, $DT=25s$
- $VESL=0.1$, $LUNBC=T$
- Internal AROME nesting with $NFPBOYD=1$ and full coupling including hydrometeors
- SST and ice from ECMWF
- Surface assimilation, 1 to 2 day forecast/6h
- ~ca 1/5 cost compared to NEA/IGB
- Plan for operationalisation with south Greenland and Faroe Island domains

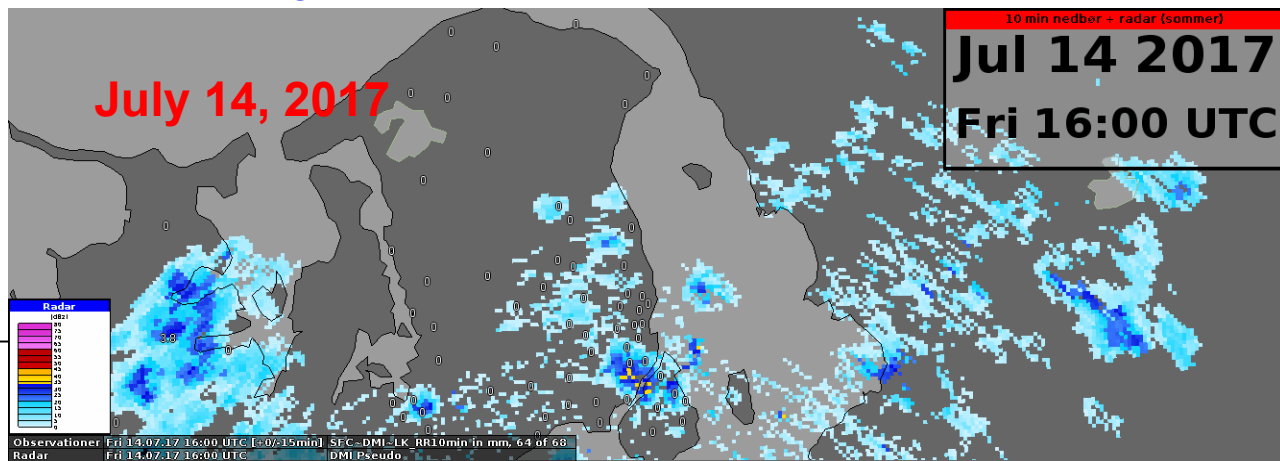
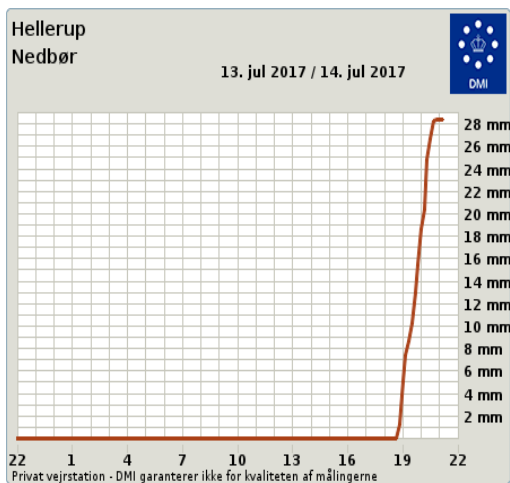


(Yang 2019, ALADIN-HIRLAM newsletter 11)

2. Sub-km ensemble nowcasting



Denmark experiences increasingly more often extreme precipitation in summer (strong intensity, short duration, small horizontal scale)

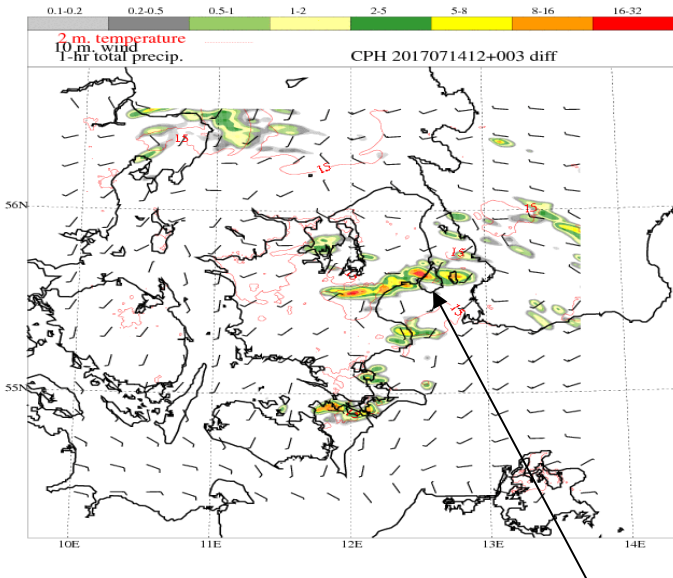


Sub-km ensemble nowcasting

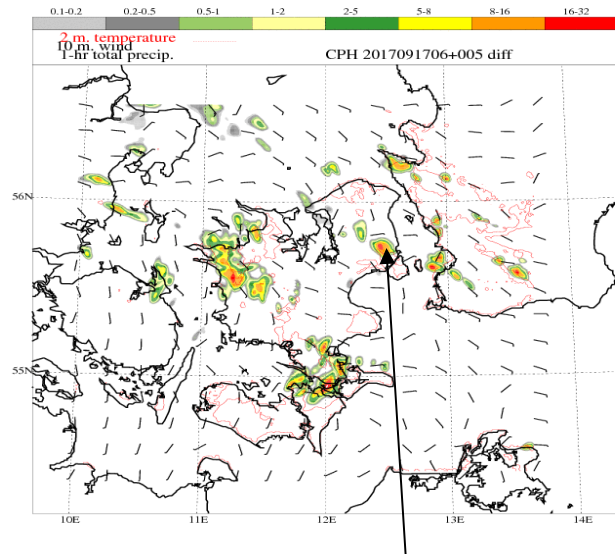
1. Describe the phenomena itself
2. Capability in warning: nowcasting through RUC
Make use of high resolution and high frequency obs
(radar data and crowd source)
3. Uncertainty information
4. Efficient, robust



Physical realism with sub-km Harmonie-arome

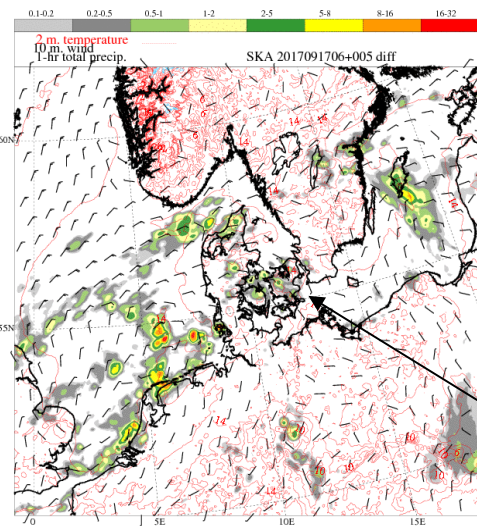


July 14, 2017, Copenhagen flashflood

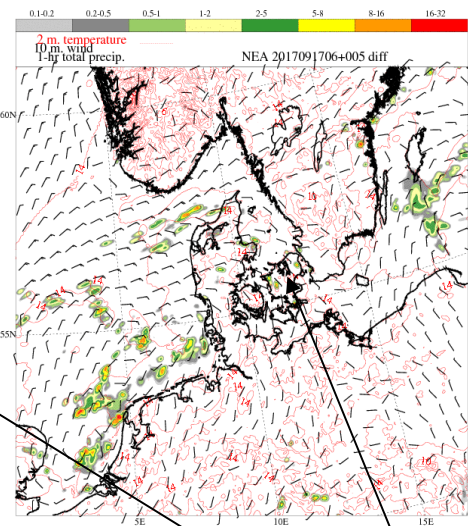


Sept 17, 2017, Copenhagen flashflood

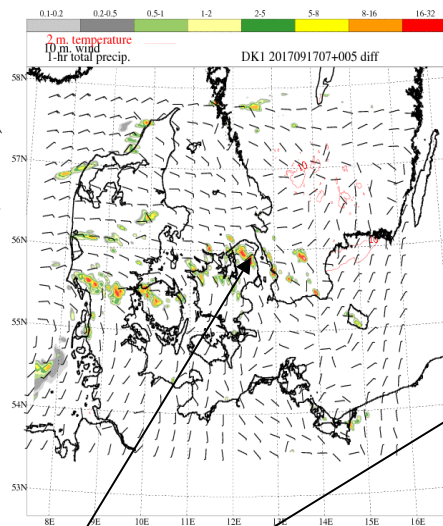
17 Sept 2017, 11 UTC, 1h accumulated



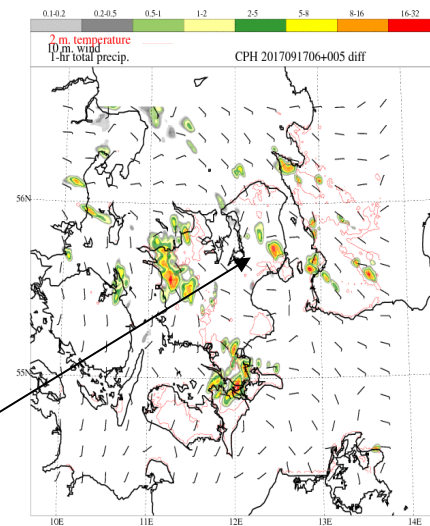
SKA-3 km



NEA-2.5 km
(Operational)



DK- 0.75 km



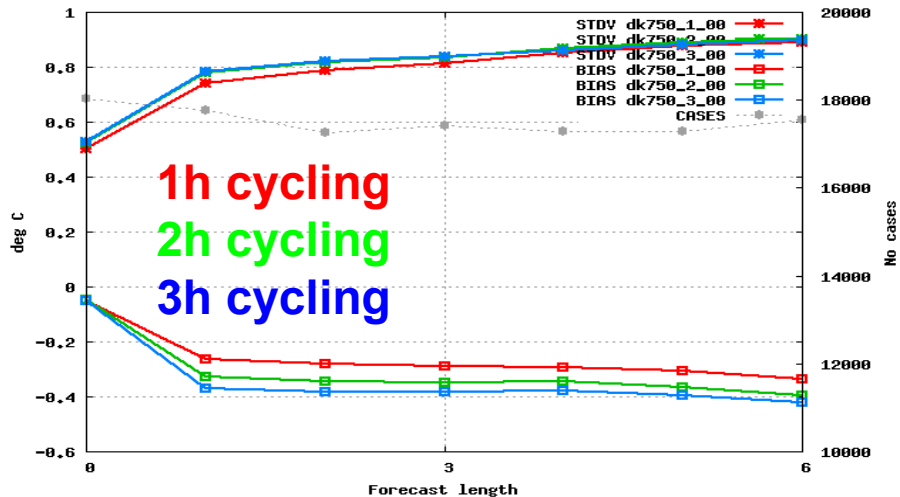
CPH- 0.5 km

Short range forecasts has progressively increased skills in prediction of strong convection... ..

Std & bias

Selection: ALL using 126 stations
T2m, height adjusted Period: 20170922-20171028
Hours: {00,06,12,18}

T2



Kuiper skill score for 1h Precipitation (mm/1h)

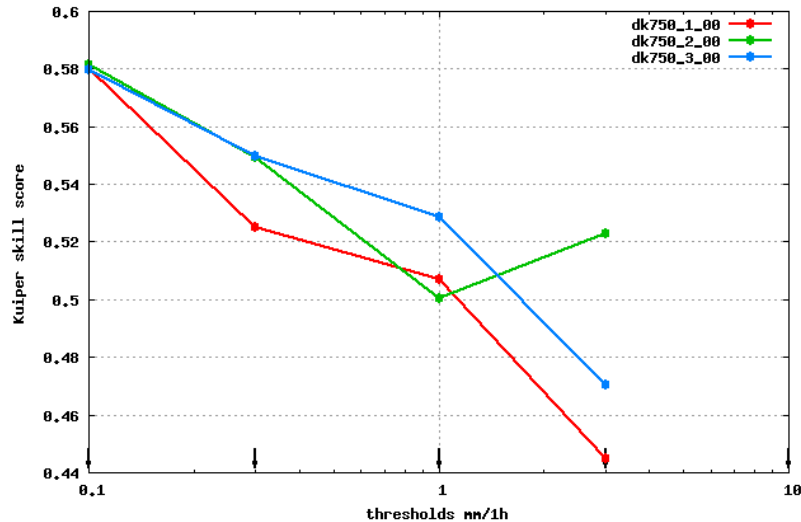
Selection: ALL 24 stations

Period: 20170922-20171028

Used {00,06,12,18} + 01-00 02-01 03-02

Rain

KSS



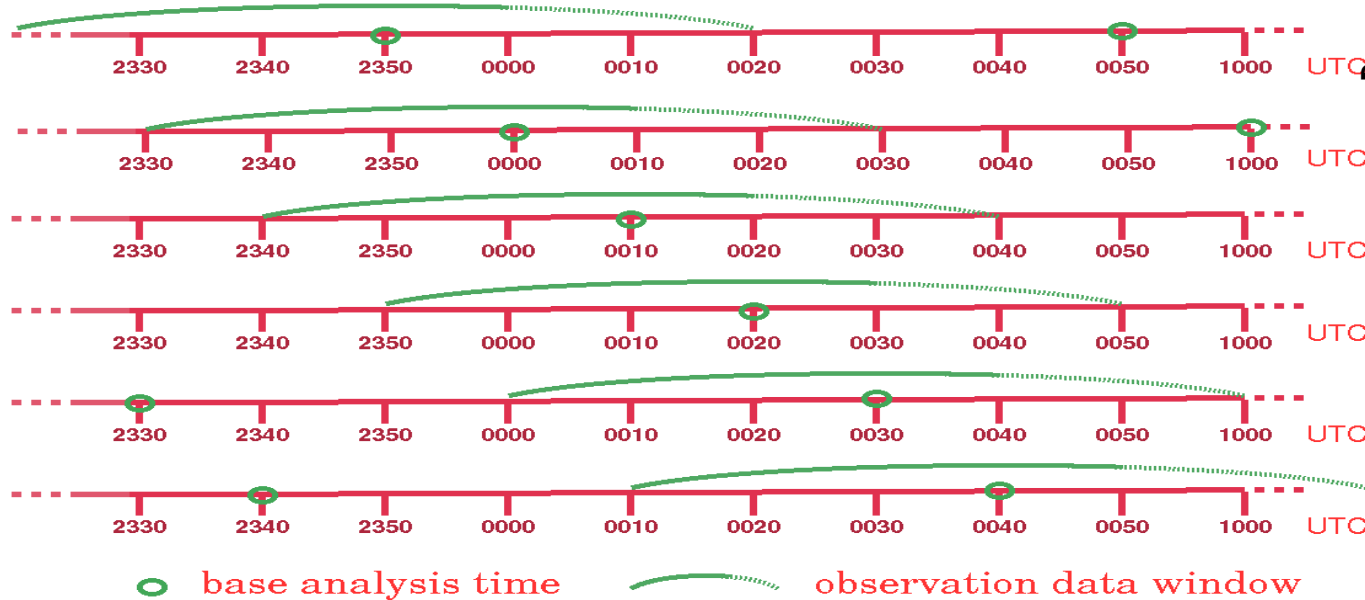
Dilemma about assimilation window length & cycling frequency

1h cycling clearly advantageous for dry surface parameters like MSLP/T2m
But for cloud and precipitation, 1h cycling is less optimal compared to 2h/3h

Similar finding from test with 2.5 km Harmonie-arome (Yang and Randriamampianina, 2017)



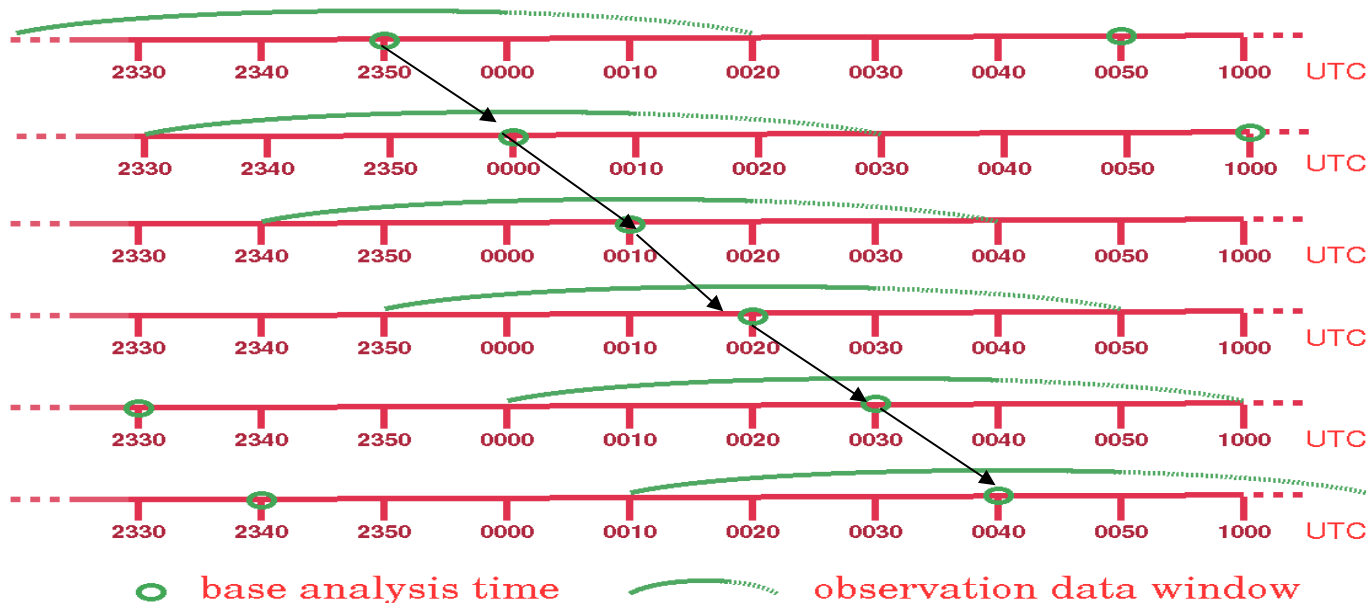
Cycling strategy with 3DVAR-RUC & EPS



“COMEPS”-style

*Sub-hourly launch
1h to 2h window
Update each 10 m
Elapse time 15 m
< 30 m after obs*

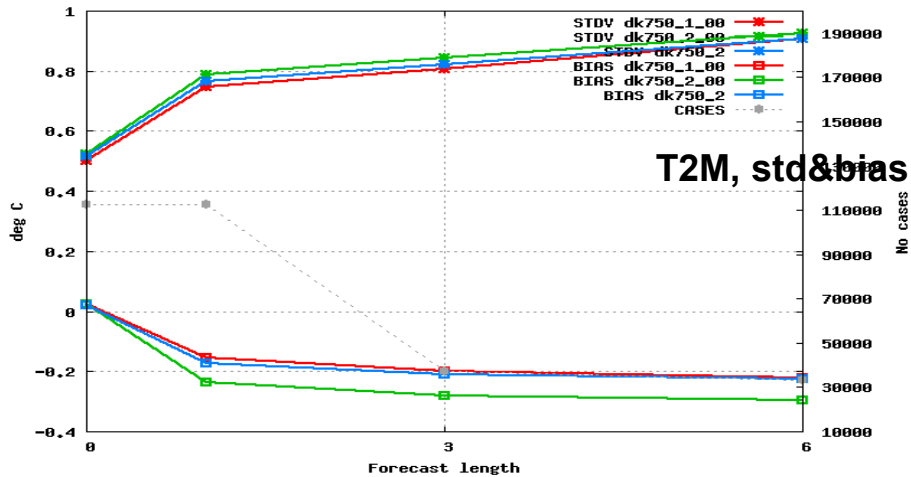
Partially connected adjacent suites



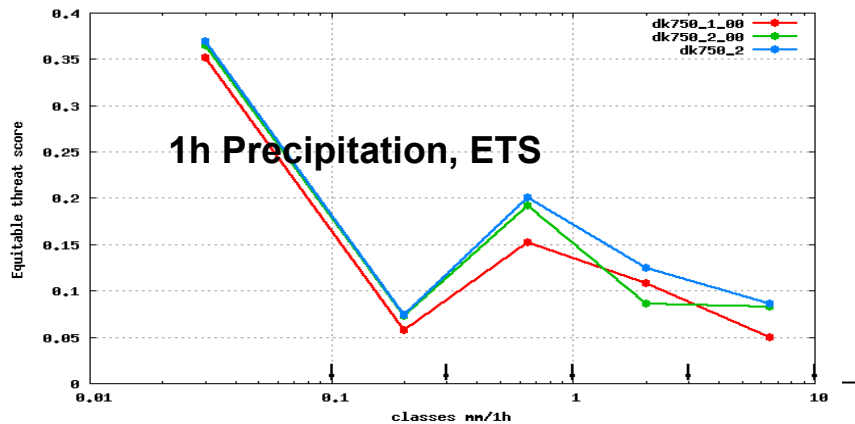
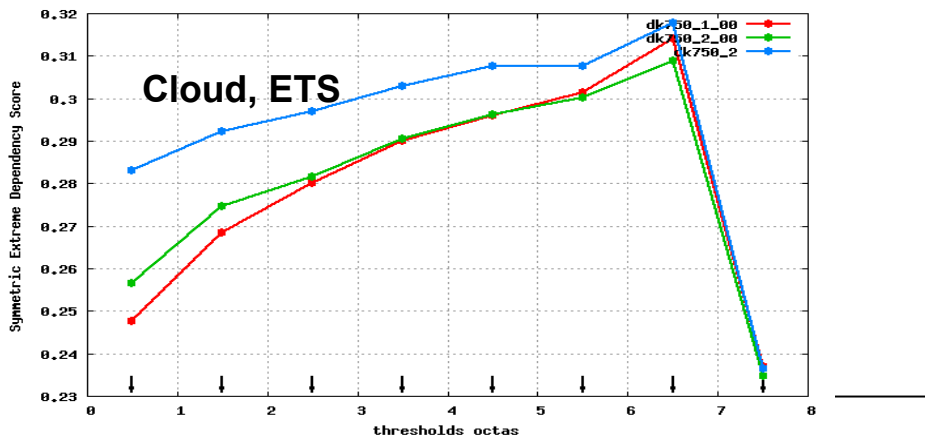
*Sub-hourly suite
1h to 2h window
Partial connection
via surface DA*

*Separation of
BG/FG in VAR?*

Partial coupling
between adjacent suites

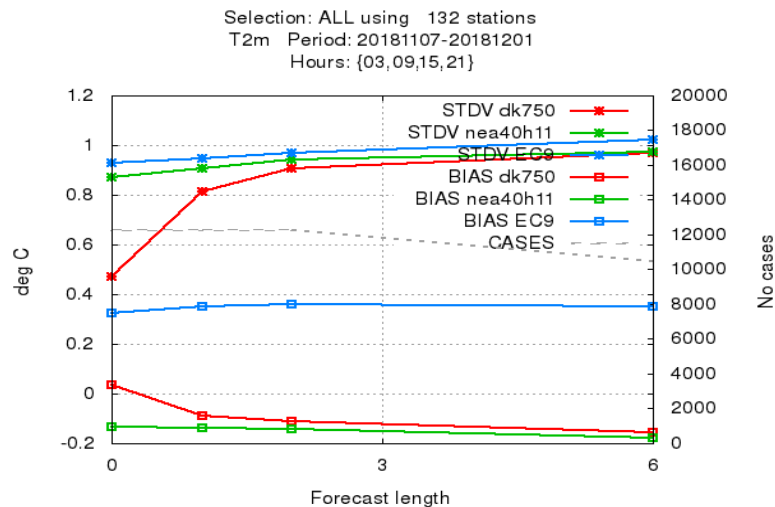
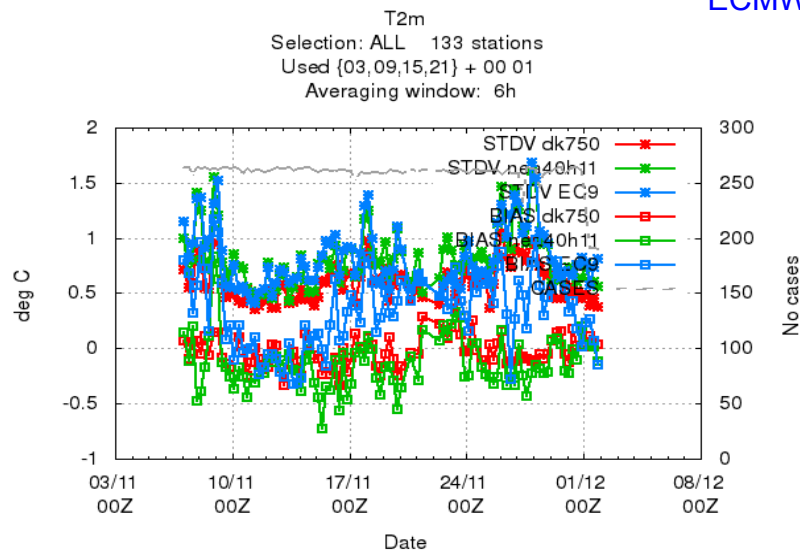


1 hour cycling
2 hour cycling, parallel
2 hour cycling,
partially connected



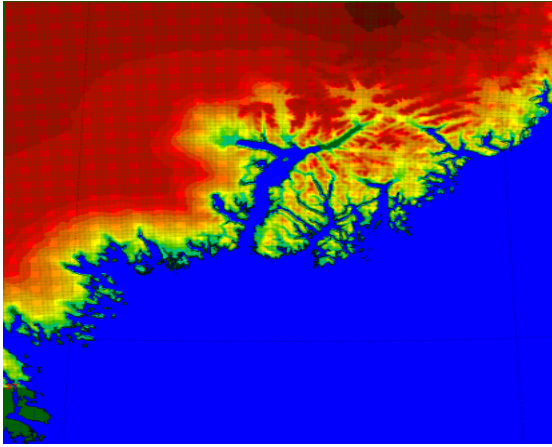
Verification on T2m

nowcasting 750m
Operational 2.6 km
ECMWF 9 km

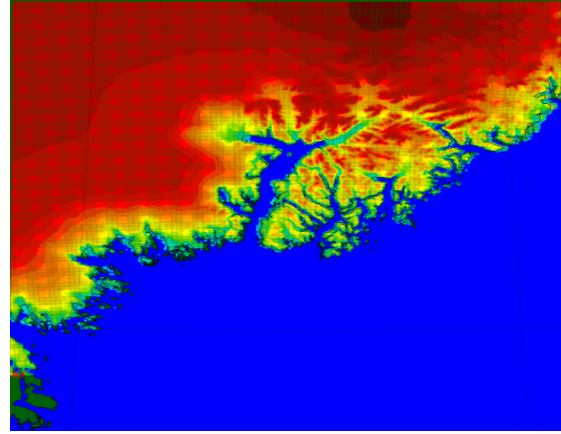


Sub-km ensemble nowcasting

- Pre-operational setup since Nov 2017
- Two hourly lagged and partially coupled suites, each with 2 h cycling
- Internal nesting to the hourly COMEPS-2.5 km control
- Assimilation with available observation with 15 min cutoff
- Plan for sub-hourly output and sub-hourly launch
- We hope for operationalisation 2019-2020!



CARRA-arcDEM TAS



Operational TAS at DMI

