

# Searching for added values

- Reflections on verifications
- On configuration of sub-km scale NWP
  - DA & LBC

Xiaohua Yang, DMI

## Finalized analysis and evaluation for capability demonstration

NWP evaluation of the On-Demand prototype for a selection of case studies

DE\_330\_MeteoFrance - Destination Earth  
On-Demand Extremes

(DE330 Report D330532)

### Glossary

#### 1 Executive Summary

#### 2 Introduction

#### 3 Convection with heavy rain, 3 May 2022 in Valencia

#### 4 Finland flooding case; 12 August 2017

#### 5 Flooding caused by an orographic wind storm; Oct 2017

#### 6 AQ - Cold period Central Europe 2017

#### 7 Eunice Case

#### 8 AQ - Benelux heatwave 2018

#### 9 Flooding case in Ireland; December 2021

#### 10 Derecho- and flooding event in Austria (Aug 22)

#### 11 Fluvial flooding case - Slovakia May 2021

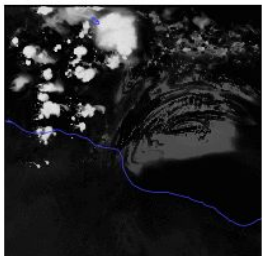
#### 12 Flooding case in Denmark; February 2020

#### 13 Heavy Precipitation on Madeira anchored to orography, Dec 2020

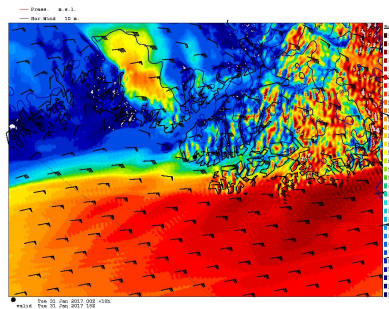
#### 14 Conclusions/Outlook

#### 15 References

2020-09-15

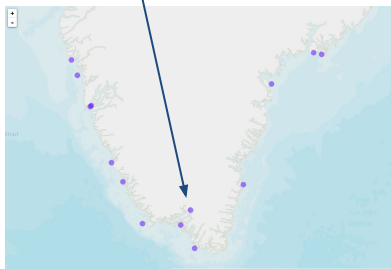


Operational 750 m forecast @DMI

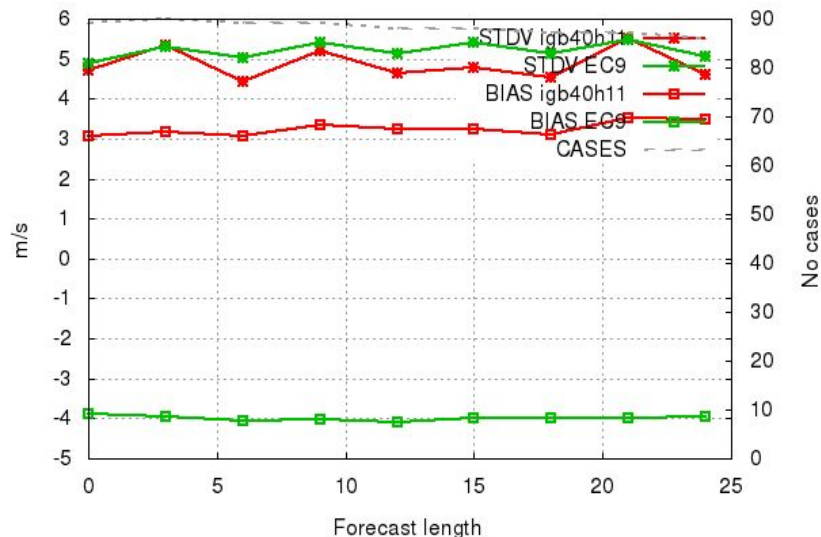


# What hides behind the verification scores?

Narsarsuaq



Selection: NARSARSUAQ using 1 stations  
U10m Period: 20190120-20190211  
Hours: {00,06,12,18}

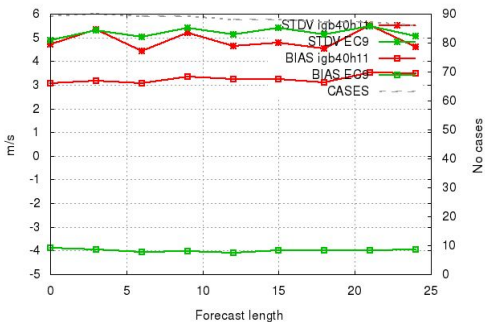


**HRES 9 km**  
**Harmonie 2.5 km**

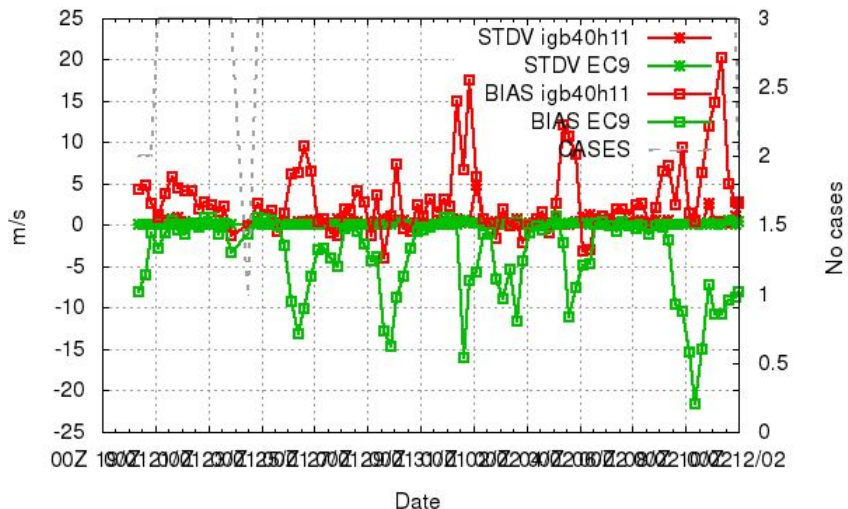
**Harmonie-2.5 km** (red) vs **ECMWF HRES** (green): equally bad wind bias!

# What hides behind the verification scores?

Selection: NARSARSUAQ using 1 stations  
U10m Period: 20190120-20190211  
Hours: {00,06,12,18}



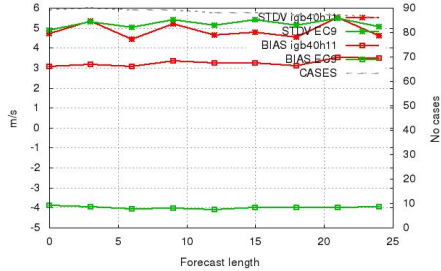
U10m  
Selection: NARSARSUAQ 1 stations  
Used {00,06,12,18} + 03 06 24  
Averaging window: 6h



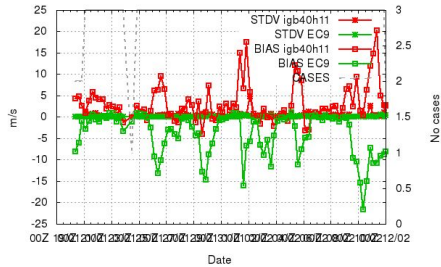
**HRES 9 km**  
**Harmonie 2.5 km**

... daily positive (2.5 km) or negative (9 km) bias errors at similar magnitude

Selection: NARSARSUAQ using 1 stations  
 U10m Period: 20190120-20190211  
 Hours: {00,06,12,18}

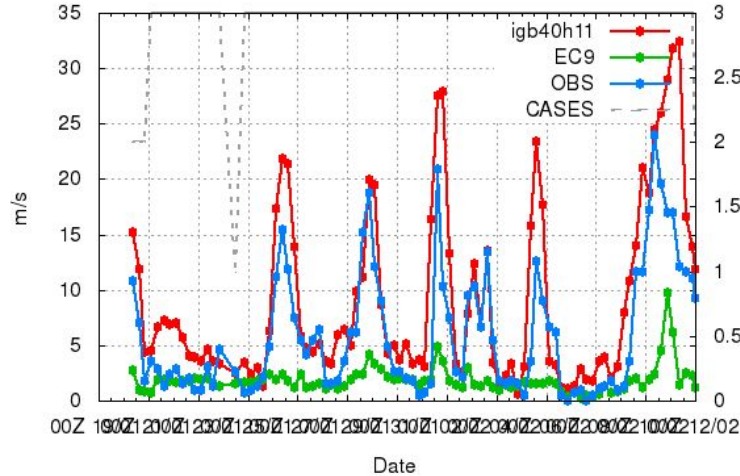


U10m  
 Selection: NARSARSUAQ 1 stations  
 Used {00,06,12,18} + 03 06 24  
 Averaging window: 6h



# What hides behind the verification scores?

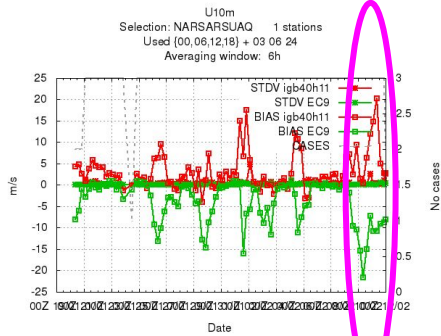
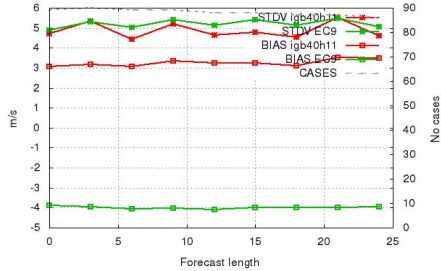
U10m  
 Selection: NARSARSUAQ 1 stations  
 Used {00,06,12,18} + 03 06 24  
 Averaging window: 6h



**HRES 9 km**  
**Harmonie 2.5 km**  
**Observation**

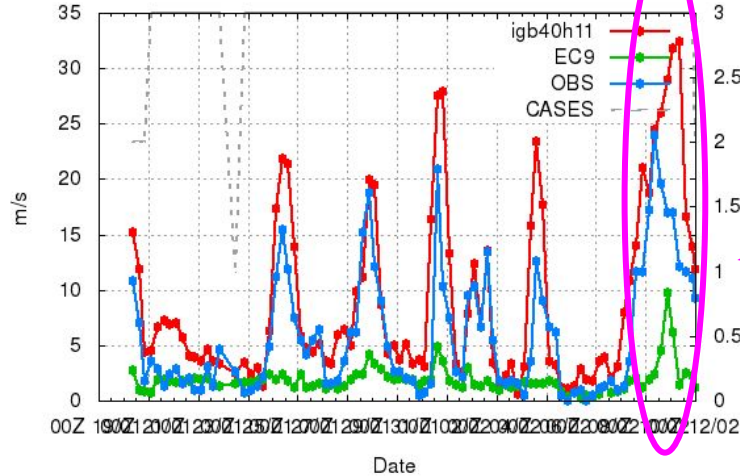
Harmonie-2.5 has a very good skill to forecast strong wind, albeit a bit excessive. HRES-9 on the other hand has too weak wind.

Selection: NARSARSUAQ using 1 stations  
 U10m Period: 20190120-20190211  
 Hours: {00,06,12,18}



# What hides behind the verification scores?

U10m  
 Selection: NARSARSUAQ 1 stations  
 Used {00,06,12,18} + 03 06 24  
 Averaging window: 6h

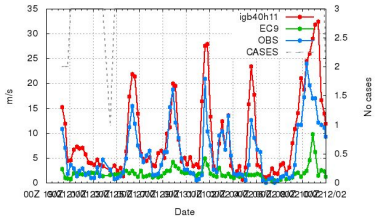
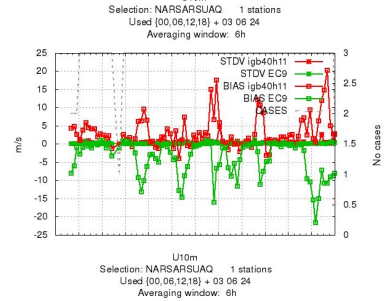
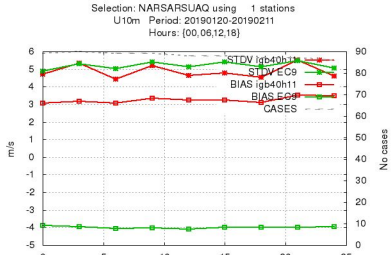


**HRES 9 km**  
**Harmonie 2.5 km**  
**Observation**

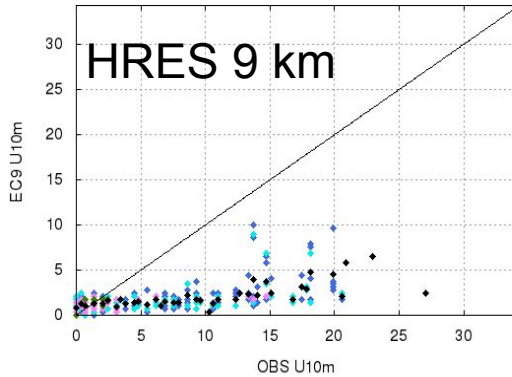
← No cases  
 phase error penalty!

Better skill in detecting import events is not always awarded by verification scores.

# What hides behind the verification scores?

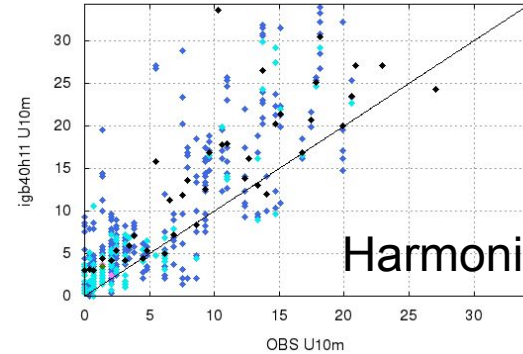


Scatterplot for 1 stations Selection: NARSARSUAQ  
U10m [m/s]  
Period: 20190120-20190211  
Used {00,06,12,18} + 03 06 12 18 24



2  
5  
10  
25

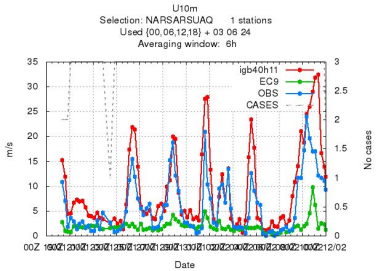
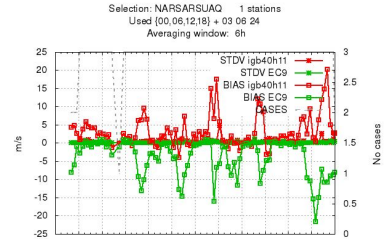
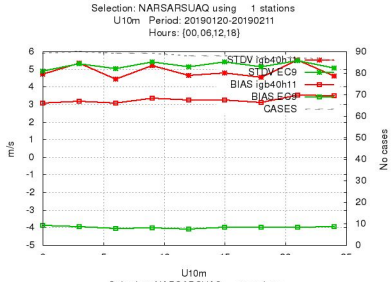
Scatterplot for 1 stations Selection: NARSARSUAQ  
U10m [m/s]  
Period: 20190120-20190211  
Used {00,06,12,18} + 03 06 12 18 24



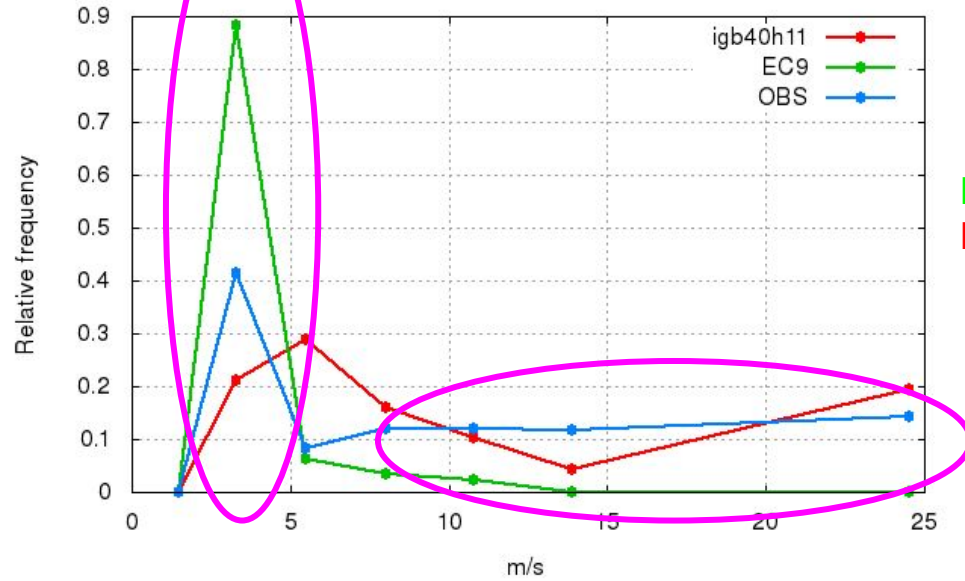
2  
5  
10  
25

HRES fails to predict strong winds. Harmonie-2.5 captures storms albeit with intensity and phase. Part of the trend in overprediction are associated with phase errors.

# What hides behind the verification scores?

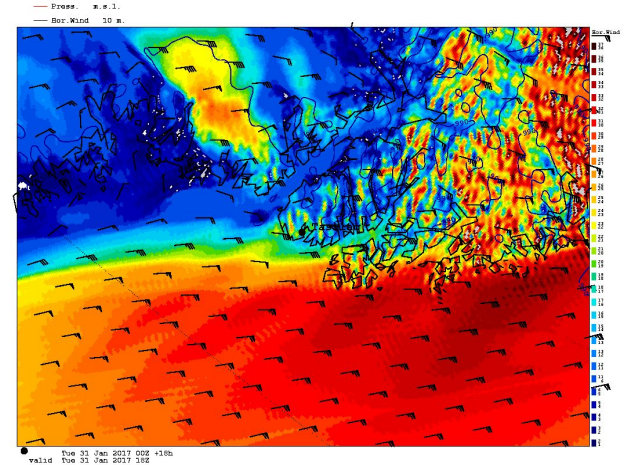
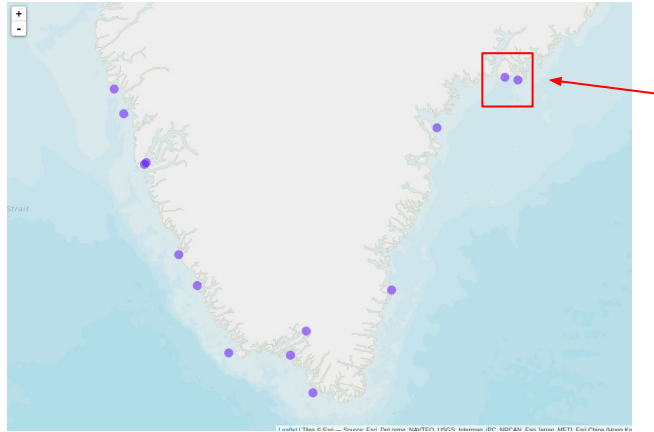
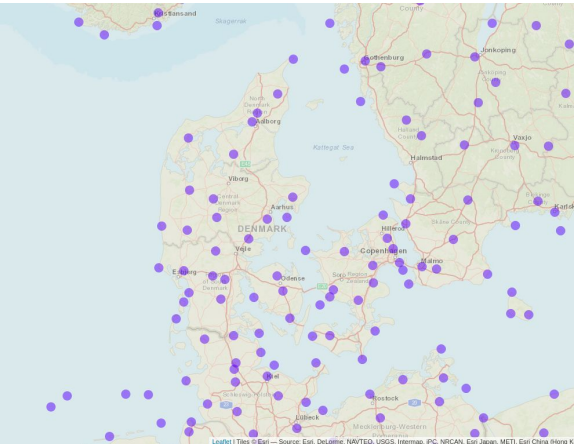


Selection: NARSARSUAQ 1 stations  
U10m Period: 20190120-20190211  
Used {00,06,12,18} + 03 06 12 18 24



**HRES-9km**  
**Harmonie-2.5 km**

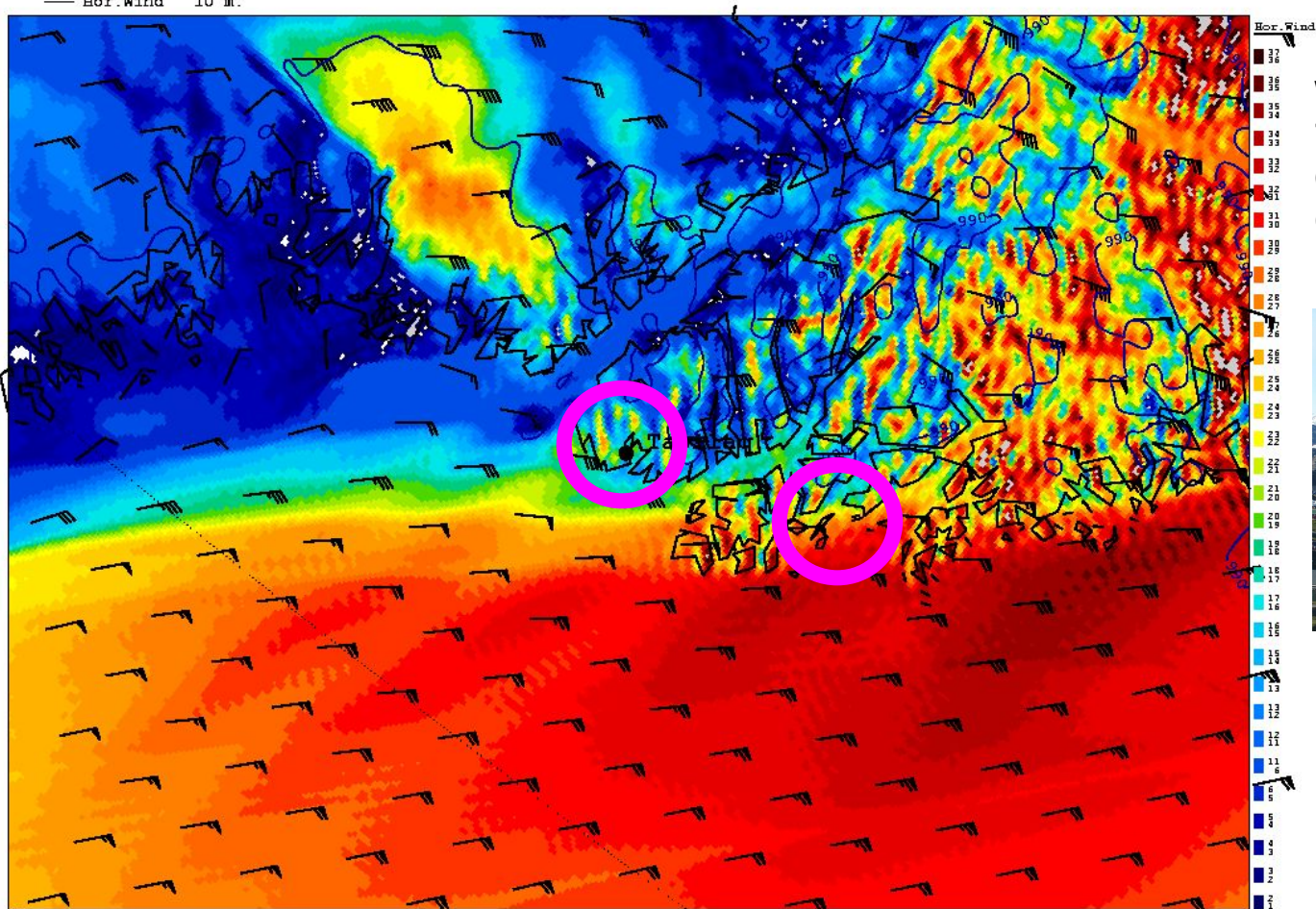
# Challenges with sub-km NWP verification



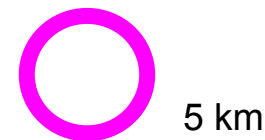
One of the fundamental challenges with hectometric scale verification is the mismatch between resolved scales by observation network (1-1000,  $\sim 10^3$ ) and by models (1000x1000,  $\sim 10^6$ )



— Press. m.s.l.  
— Hor.Wind 10 m.



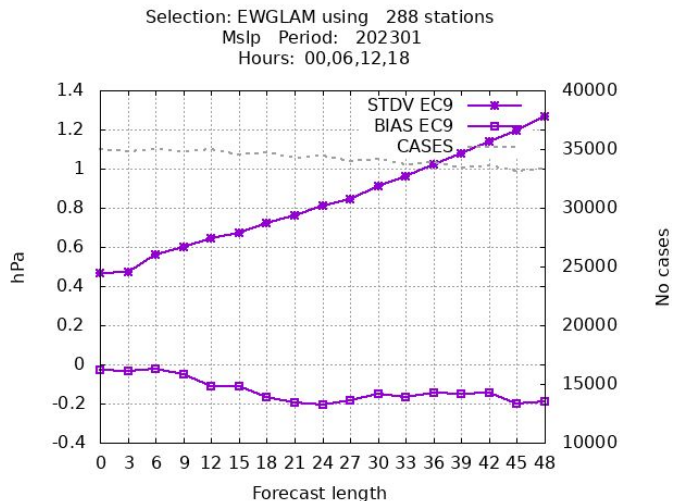
Wind forecast from a  
750 m HARMONIE-AROME  
Centered around Tasiilaq,  
Greenland, Jan 31 2017



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

# Importance with delivery time

Background: NWP forecast quality deteriorates along lead-time



MSLP errors of ECMWF HRES forecast along lead-time, Jan 2023

# Forecast data availability at DMI (NWS)



Danmarks  
Meteorologiske  
Institut

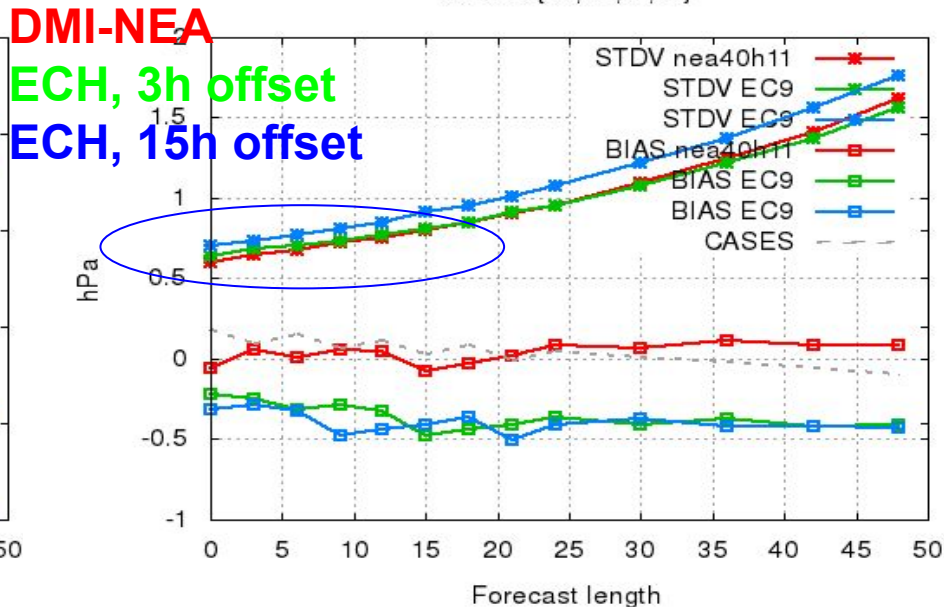
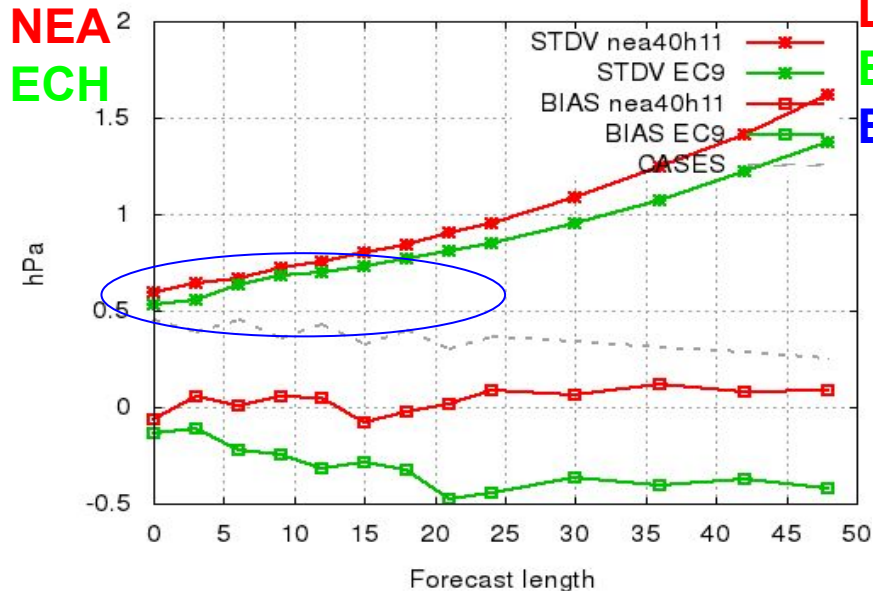
	Update frequency	Data Age + Lead-time	Quickest delivery scenario			Slowest delivery scenario		
			Time point	Base time	Data age	Time point	Basetime	Data age
DK750, nowcasting	24+/day	1h +	13	12	1h	13	12	1h
DMI-COMEPS	24/day	3h +	15	12	3h	15	12	3h
UWCW-DINI	8/day	3h +	15	12	3h	15	12	3h
ECMWF BC	4/day	7 - 12h +	19	12	7h	18	06	12h
EC HRes	2/day	7 - 18h +	19	12	7h	18	00	18h

- LAM forecasts (DK750, COMECS, DINI) are typically delivered within 1 to 3 h with 1-3 h updates
- ECMWF HRES typically delivers within 6h
- NWS users access LAM forecasts with 3h delay, and ECMWF forecasts with 7 to 18h delay

# Verification taking into account delivery time

Selection: ALL using 1168 stations  
Mslp Period: 20190128-20190226  
Hours: {00,06,12,18}

Selection: ALL using 1168 stations  
Mslp Period: 20190128-20190227  
Hours: {00,06,12,18}



**Comparison with same base-time**

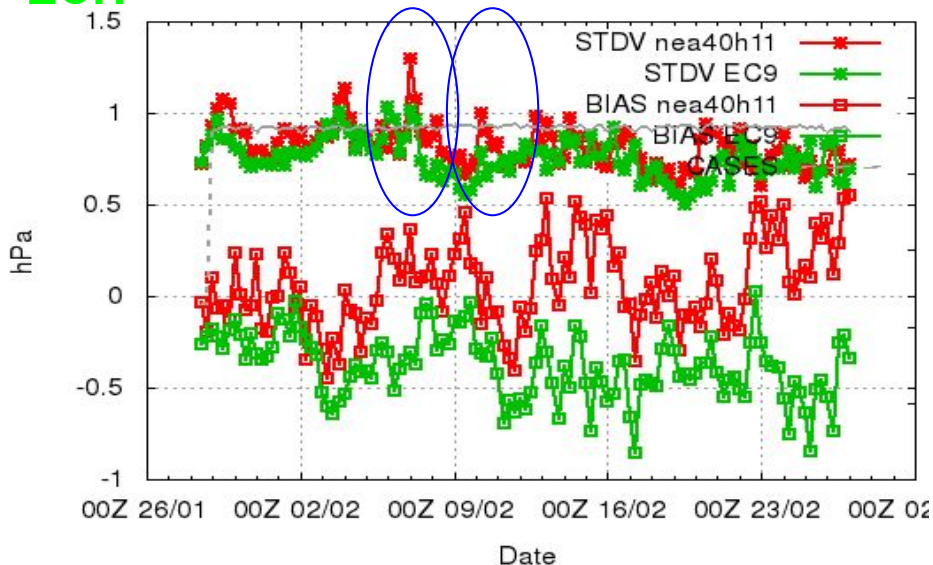
**Comparison between available forecasts**

# Verification taking into account delivery time

DMI-NEA

ECH

Mslp  
 Selection: ALL 1168 stations  
 Used {00,06,12,18} + 12 24  
 Averaging window: 6h

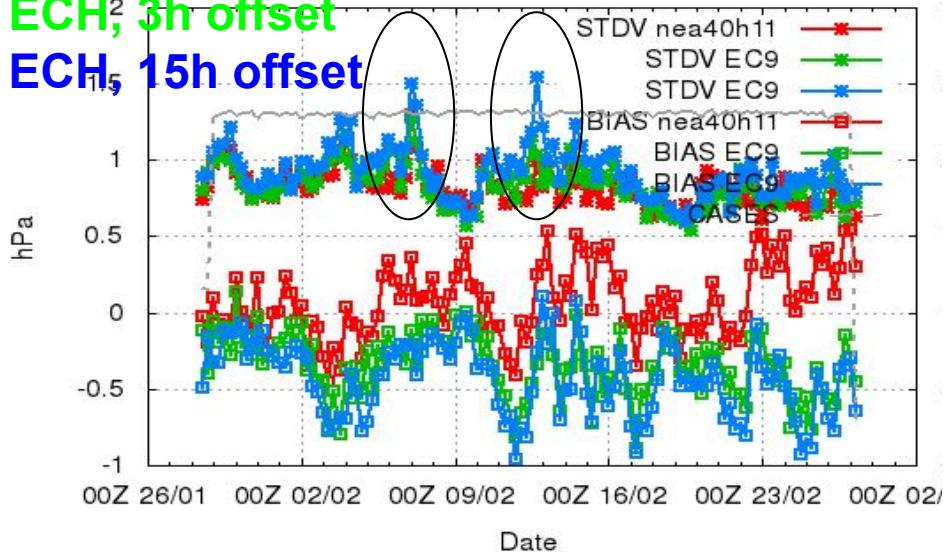


Comparison with same base-time

DMI-NEA

ECH<sup>2</sup>, 3h offset  
 ECH<sup>15</sup>, 15h offset

Mslp  
 Selection: ALL 1168 stations  
 Used {00,06,12,18} + 12 24  
 Averaging window: 6h



Comparison between available forecasts

## Sub-km NWP in DEODE

- grid in 500 m- 750 m, also 200m
- run on EuroHPC on hybrid CPU-GPU
- on-demand configurable with downscaling
- end-user tailored output portfolio
- unified DEODE prototype system with CICD pipeline
- **coupling to global DT at 4.5-2.8 km once per day**
- Cold start. Offline surfex in development but with no upper air DA

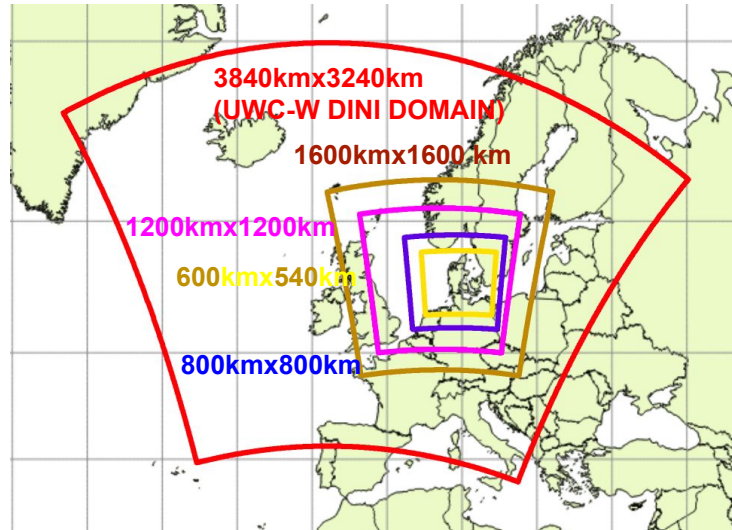
## operational NWP in ACCORD

- grid in 1 to 2.5 km
- run on CPU at home HPCF
- fix model configuration with continuous cycling end-user tailored output portfolio
- ACCORD releases with operational adaptation and diverse scripting system
- **coupling to HRES or Arpege with 6h update, or double nesting**
- continuous data assimilation cycling

# LBC update and DA cycling

Numerical experiments are set up to examine

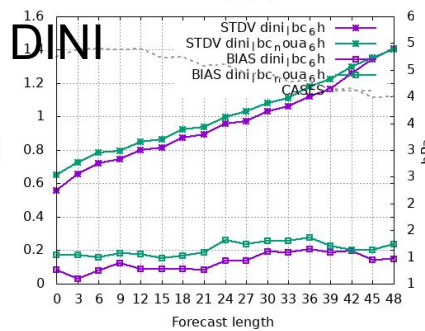
- Implication of infrequent LBC update with use of global DT
- Role of upper air 3DVAR in light of the infrequent LBC update



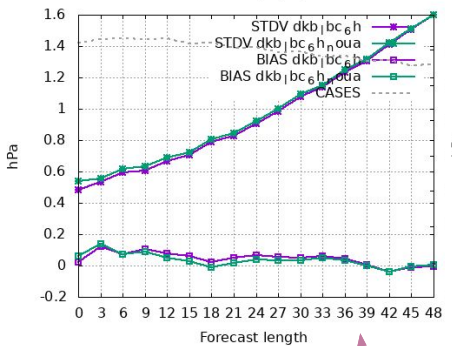
(DE330 D330372 report)

# MSLP error along leadtime, Jan 2023

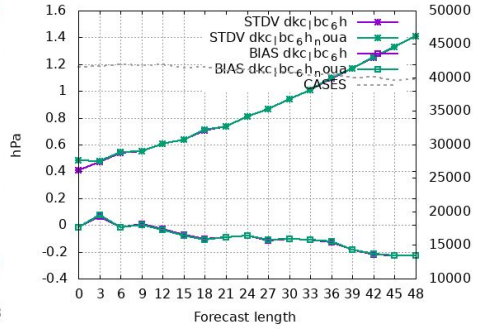
Selection: ALL using 1527 stations  
Mslp Period: 202301  
Hours: 00,06,12,18



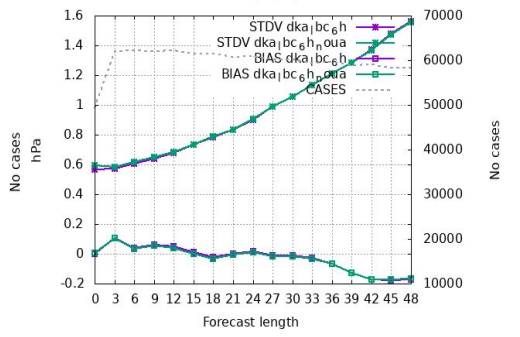
Selection: ALL using 632 stations  
Mslp Period: 202301  
Hours: 00,06,12,18



Selection: ALL using 363 stations  
Mslp Period: 202301  
Hours: 00,06,12,18



Selection: ALL using 646 stations  
Mslp Period: 202301  
Hours: 00,06,12,18



3840 km wide, 2 km grid

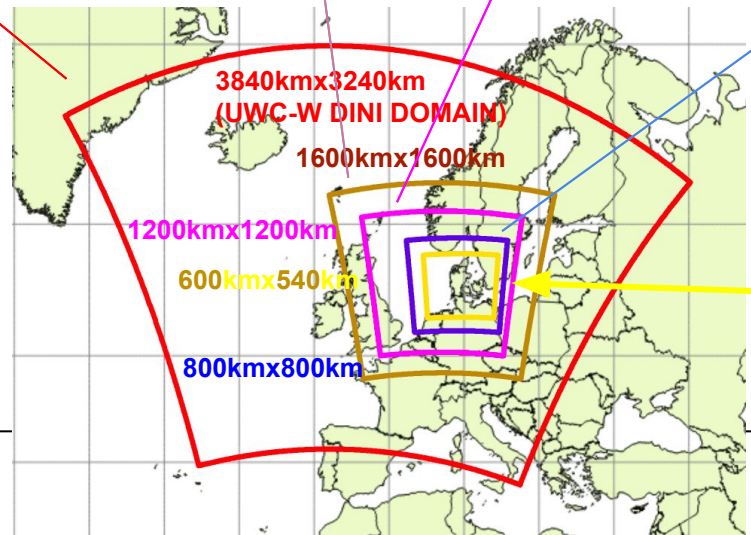
1600 km wide

1200 km wide

800 km wide

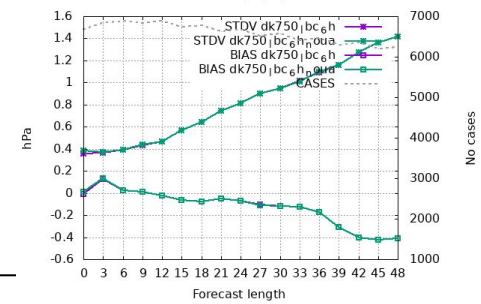
no 3DVAR

3DVAR



# DK750

Selection: ALL using 108 stations  
Mslp Period: 202301  
Hours: 00,06,12,18





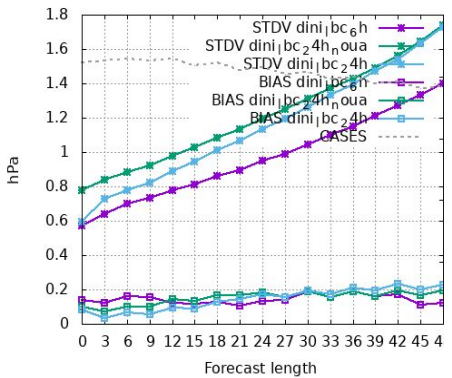
# DINI

Selection: ALL using 1535 stations  
 Mslp Period: 202301  
 Hours: 00,06,12,18

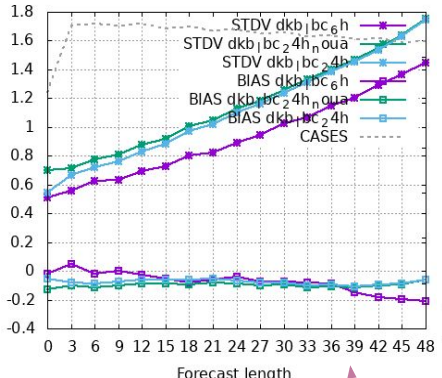
Selection: ALL using 633 stations  
 Mslp Period: 202301  
 Hours: 00,06,12,18

Selection: ALL using 363 stations  
 Mslp Period: 202301  
 Hours: 00,06,12,18

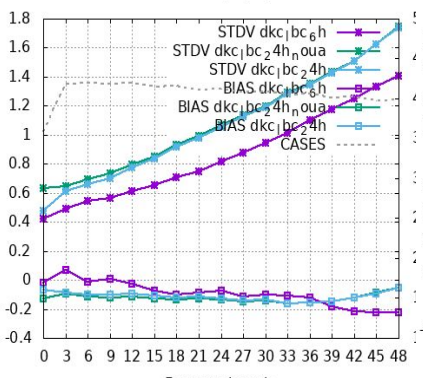
Selection: ALL using 647 stations  
 Mslp Period: 202301  
 Hours: 00,06,12,18



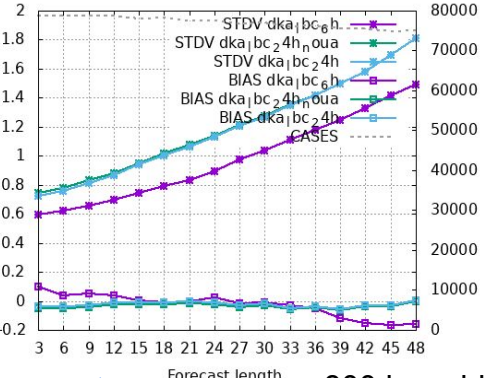
3840 km wide, 2 km grid



1600 km wide



1200 km wide

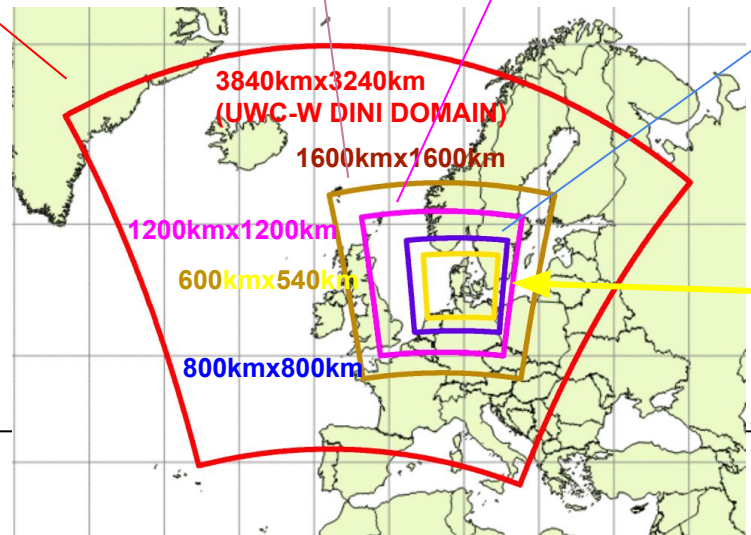


800 km wide

24h LBC update + no 3DVAR

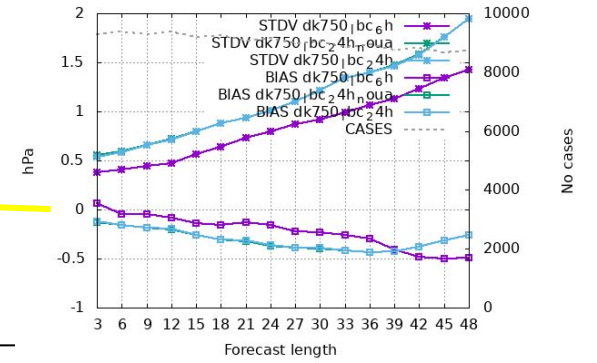
24h LBC update + 3DVAR

6h LBC update + 3DVAR



Selection: ALL using 108 stations  
 Mslp Period: 202301  
 Hours: 00,06,12,18

# DK750

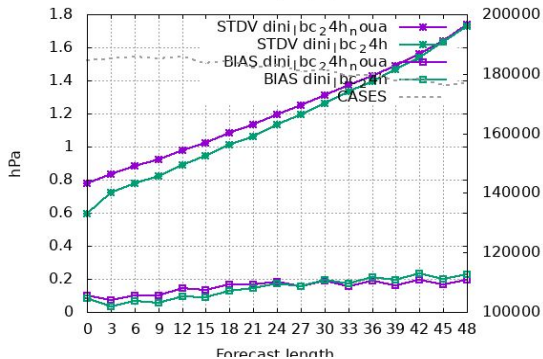


sub-km grid,

600 km wide

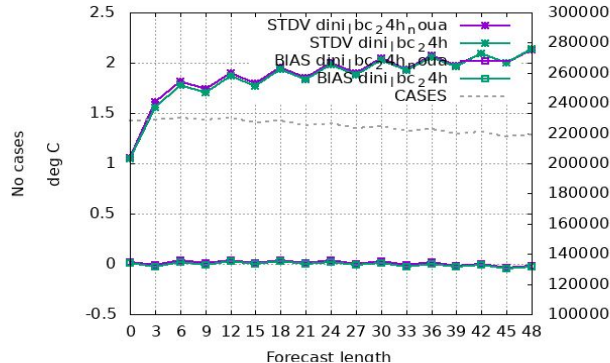
# MSLP

Selection: ALL using 1535 stations  
Mslp Period: 202301  
Hours: 00,06,12,18



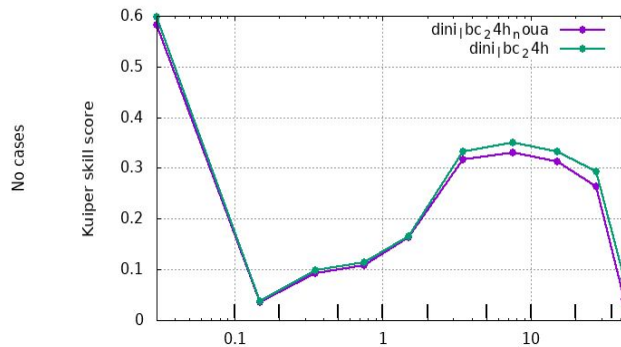
# T2m

Selection: ALL using 1906 stations  
T2m, height corr. Period: 202301  
Hours: 00,06,12,18



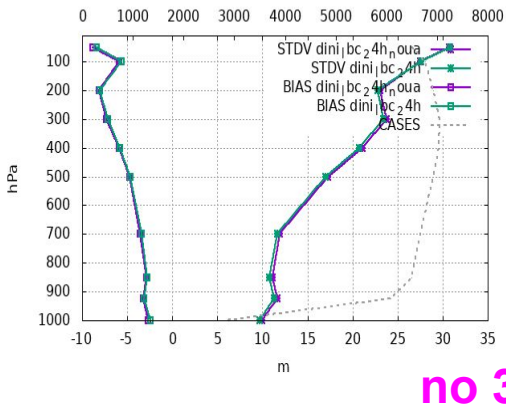
# Precip

Kuiper skill score for 6h Precipitation (mm/6h)  
Selection: ALL 885 stations  
Period: 202301  
Used 00,06,12,18 + 06 09 ... 48



# Height

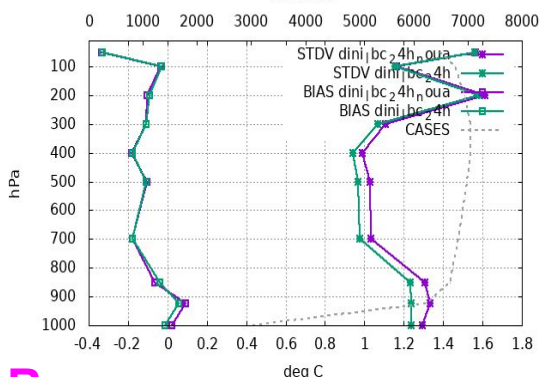
52 stations Selection: ALL  
Geopotential Period: 202301  
Used 00,12 + 00 12 24 36 48  
No cases



no 3DVAR

# Temp

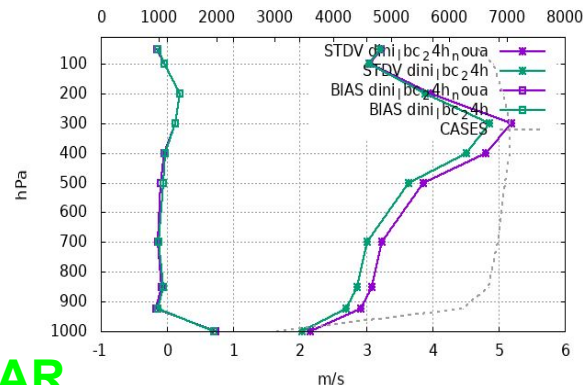
53 stations Selection: ALL  
Temperature Period: 202301  
Used 00,12 + 00 12 24 36 48  
No cases



3DVAR

# Wind

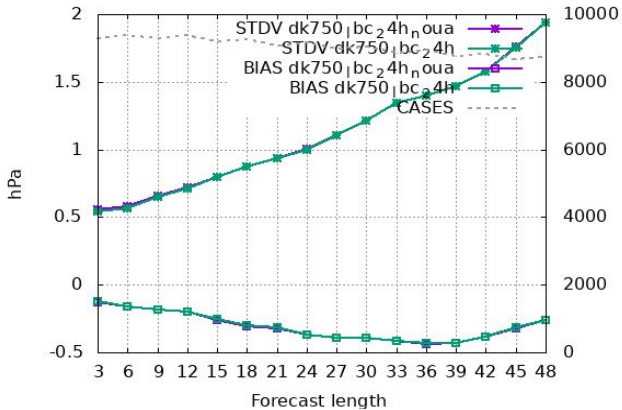
53 stations Selection: ALL  
Wind speed Period: 202301  
Used 00,12 + 00 12 24 36 48  
No cases



DINI, Jan 2023

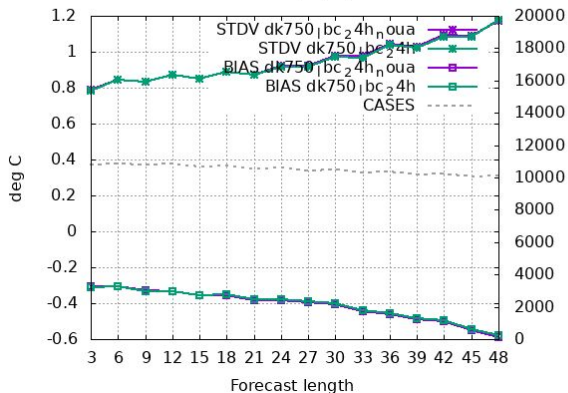
# MSLP

Selection: ALL using 108 stations  
 Mslp Period: 202301  
 Hours: 00,06,12,18



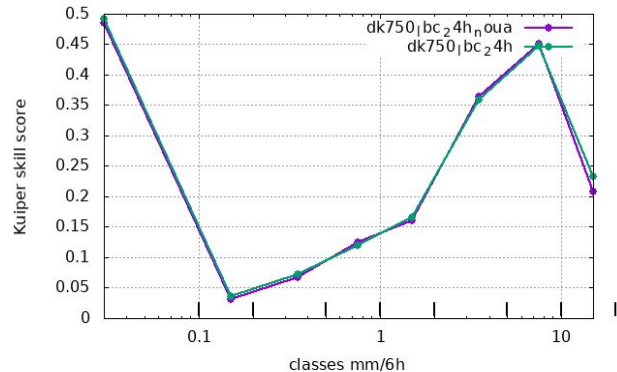
# T2m

Selection: ALL using 126 stations  
 T2m, height corr. Period: 202301  
 Hours: 00,06,12,18



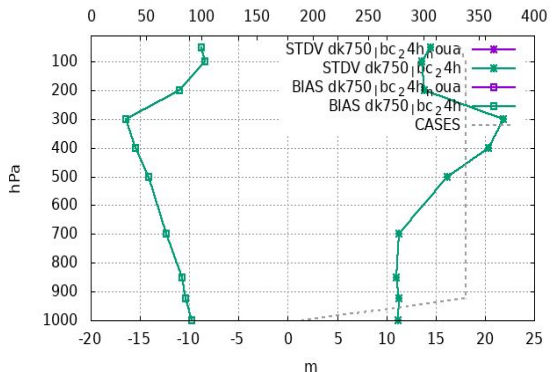
# Precip

Kuiper skill score for 6h Precipitation (mm/6h)  
 Selection: ALL 33 stations  
 Period: 202301  
 Used 00,06,12,18 + 06 09 ... 48



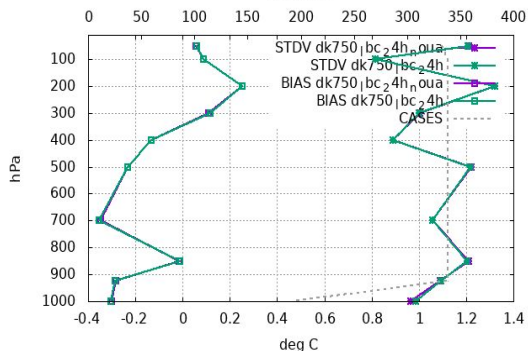
# Height

2 stations Selection: ALL  
 Geopotential Period: 202301  
 Used 00,12 + 12 24 36 48  
 No cases



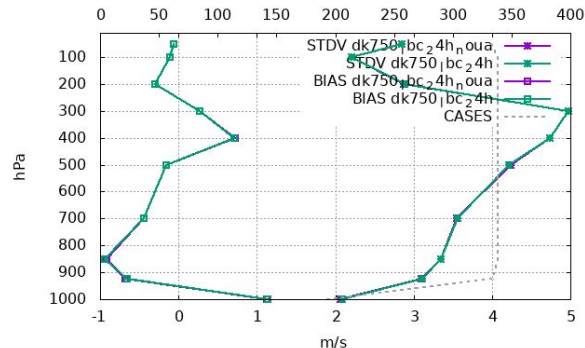
# Temp

2 stations Selection: ALL  
 Temperature Period: 202301  
 Used 00,12 + 12 24 36 48  
 No cases



# Wind

2 stations Selection: ALL  
 Wind speed Period: 202301  
 Used 00,12 + 12 24 36 48  
 No cases



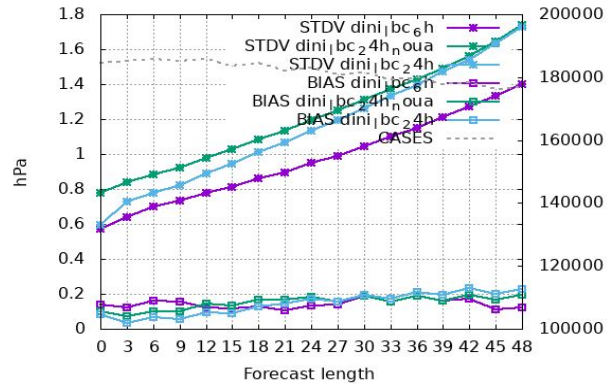
# DK750 domain

no 3DVAR

3DVAR

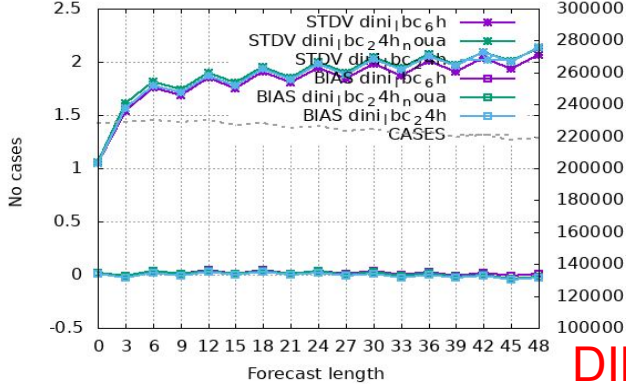
# MSLP

Selection: ALL using 1535 stations  
Mslp Period: 202301  
Hours: 00,06,12,18



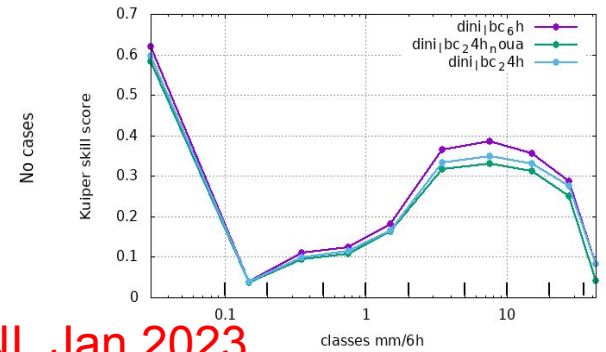
# T2m

Selection: ALL using 1906 stations  
T2m, height corr. Period: 202301  
Hours: 00,06,12,18



# Precip

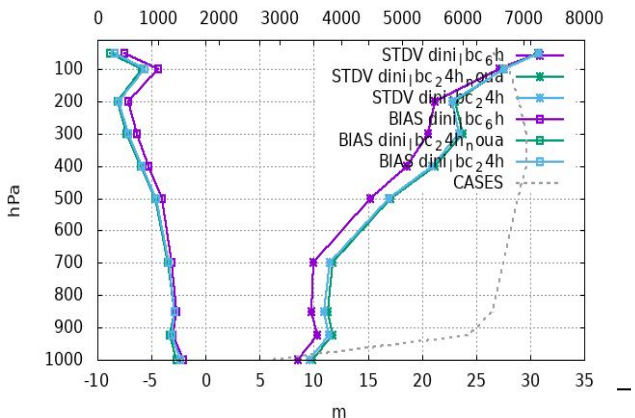
Kuiper skill score for 6h Precipitation (mm/6h)  
Selection: ALL 885 stations  
Period: 202301  
Used 00,06,12,18 + 06 09 ... 48



DINI, Jan 2023

# Height

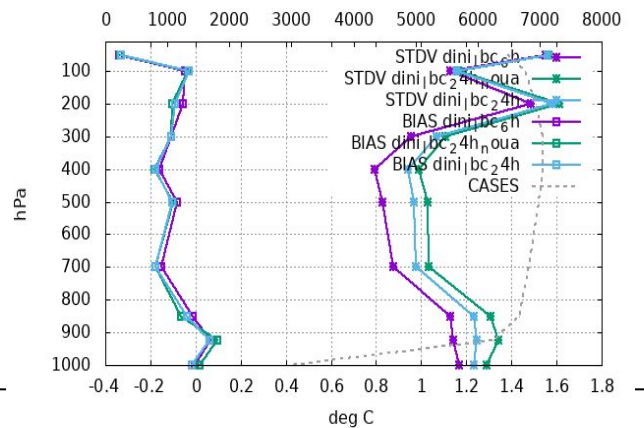
52 stations Selection: ALL  
Geopotential Period: 202301  
Used 00,12 + 00 12 24 36 48  
No cases



3DVAR, 6h LBC update

# Temp

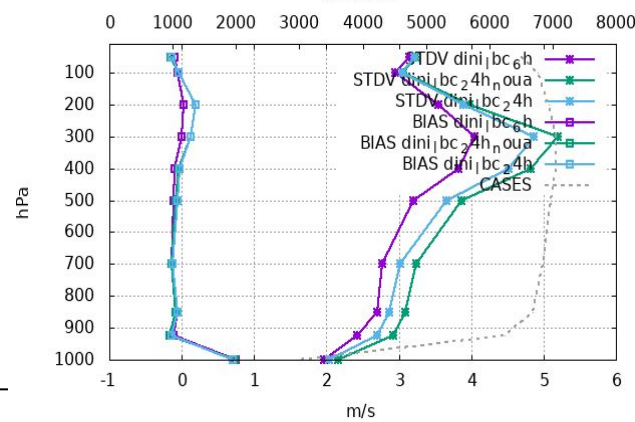
53 stations Selection: ALL  
Temperature Period: 202301  
Used 00,12 + 00 12 24 36 48  
No cases



3DVAR, 24h LBC update

# Wind

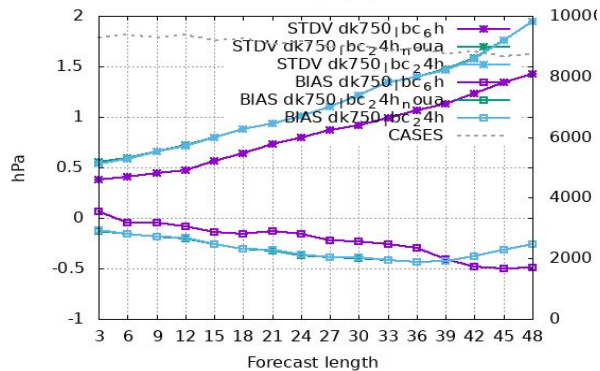
53 stations Selection: ALL  
Wind speed Period: 202301  
Used 00,12 + 00 12 24 36 48  
No cases



no 3DVAR, 24h LBC update

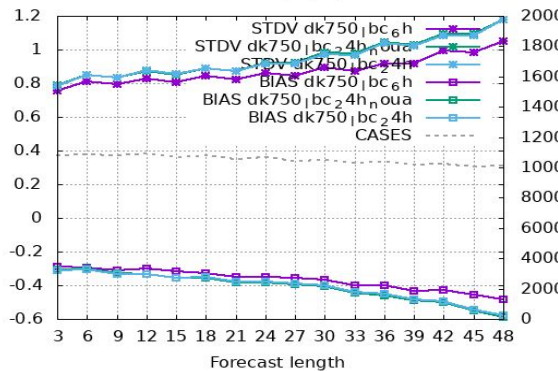
# MSLP

Selection: ALL using 108 stations  
Mslp Period: 202301  
Hours: 00,06,12,18



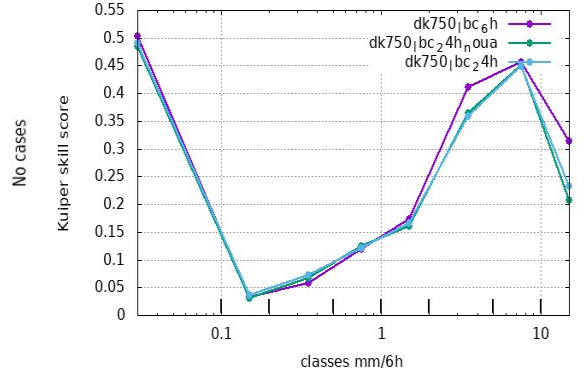
# T2m

Selection: ALL using 126 stations  
T2m, height corr. Period: 202301  
Hours: 00,06,12,18



# Precip

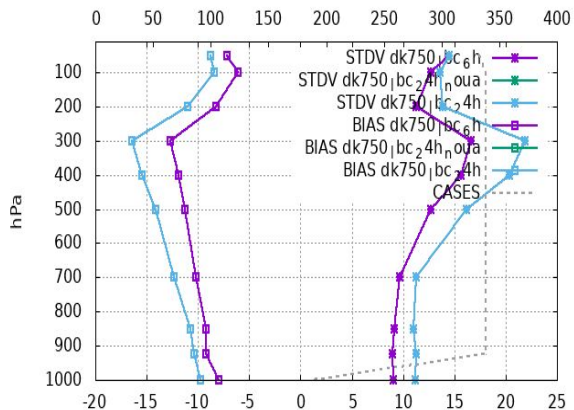
Kuiper skill score for 6h Precipitation (mm/6h)  
Selection: ALL 33 stations  
Period: 202301  
Used 00,06,12,18 + 06 09 ... 48



## DK750 domain

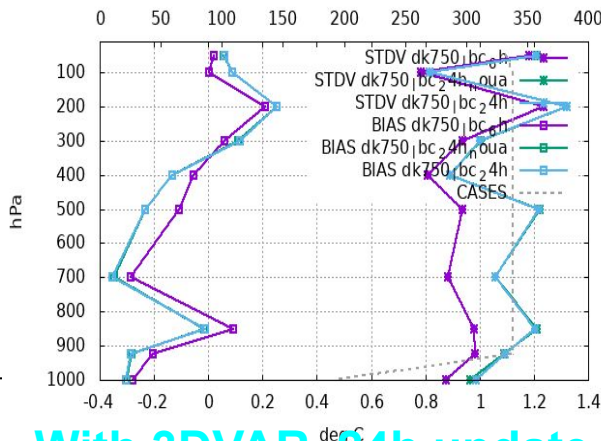
# Height

2 stations Selection: ALL  
Geopotential Period: 202301  
Used 00,12 + 12 24 36 48  
No cases



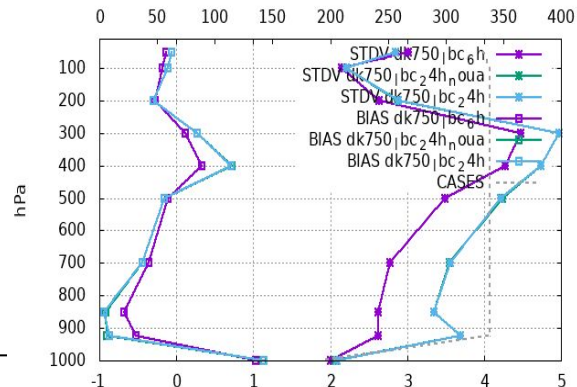
# Temp

2 stations Selection: ALL  
Temperature Period: 202301  
Used 00,12 + 12 24 36 48  
No cases



# Wind

2 stations Selection: ALL  
Wind speed Period: 202301  
Used 00,12 + 12 24 36 48  
No cases



With 3DVAR, 6h update

With 3DVAR, 24h update

no 3DVAR, 24h update

## Summary and conclusions

- Need for stratified verification
- LAM added values may not be fully reflected by skill scores: additional features, timeliness, update frequency... ..
- It is LBC, stupid!