

On radar data assimilation with the 2-moment microphysics

**23rd COSMO General Meeting
WG1/KENDAScope Session on Radar Data
06 Sep 2021**

**Kobra Khosravian, Alberto De Lozar, Sven Ulbrich, Klaus Stephan,
Ulrich Blahak and Christoph Schraff**

- ◆ **First apply of 2-mom experiments**
- ◆ **The problem of tiny false alarm cells**
 - **Finding the reason of the problem**
 - ✓ The effect of conventional data
 - ✓ The effect of different inflation methods
 - **Trying different solutions**
 - ✓ 2-step assimilation
 - ✓ Updating only hydrometeors and fix the mean mass
- ◆ **Comparison between 2 Long-term experiments with different 2-mom microphysic setting**

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→ The two-moment-scheme of Seifert and Beheng (2006) can provide more realistic reflectivities because:

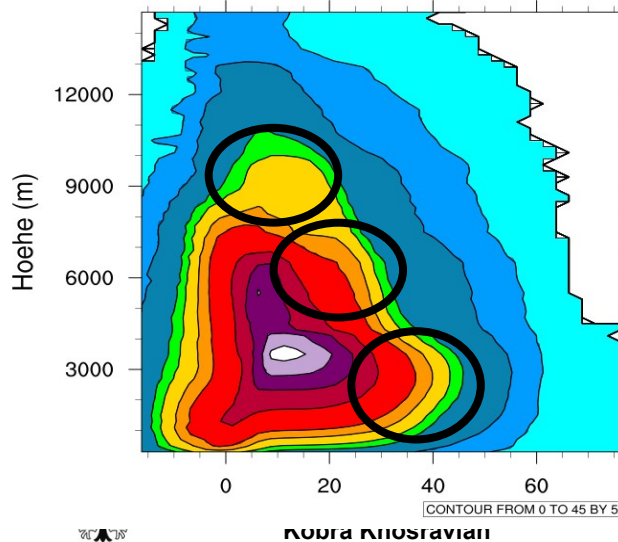
- Additional prognostic equation for number concentrations (N).
- $R \sim r^6 \sim (q/N)^2$
- Additional hail class allowing for large hail particles

→ We also couple the two-moment scheme to the radiation calculations (model and operators) through the calculation on the effective radius, and account for the large hydrometeors in the radiation calculation.

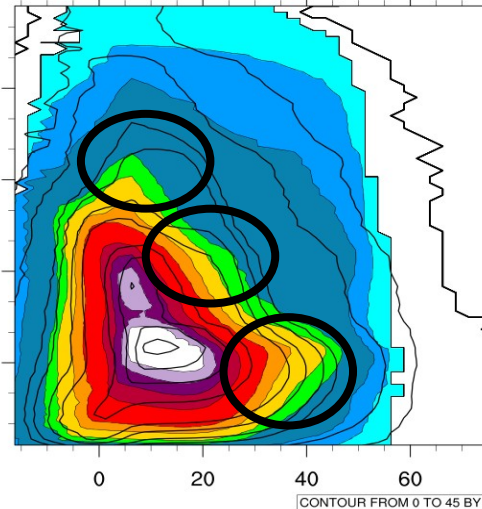


CFADS plots

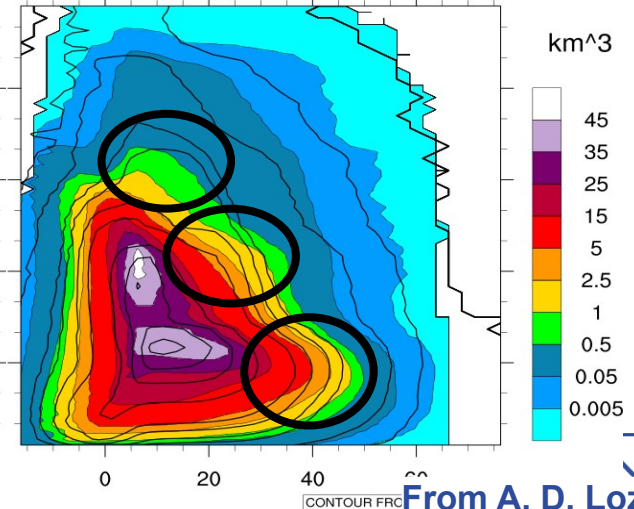
Observation



1 Mom



2 Mom



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Date: from **20 Jun 2019** from **01 UTC** to **05 UTC**

- 1-mom experiment: assimilation using conventional data and radar reflectivity with **qi**, **qr**, **qs** and **qg** update
- 2-mom experiment: assimilation using conventional data and radar reflectivity with **qr**, **qs**, **qg**, **qh** and **qi** as well as **qnr**, **qns**, **qng**, **qnh** and **qni** update

Setting of radar reflectivity assimilation:

- Using **5** radar beams (**1.5**, **3.5**, **5.5**, **8** and **12** degree)
- **h_loc**: **16 km**
- **v_loc**: **0.07 Lnp** (vertically increasing)
- **Obs_error**: **10 dbz**
- From now: **qr**, **qs**, **qg**, **qh** and **qi** shown by **qx** and **qnr**, **qns**, **qng**, **qnh**,

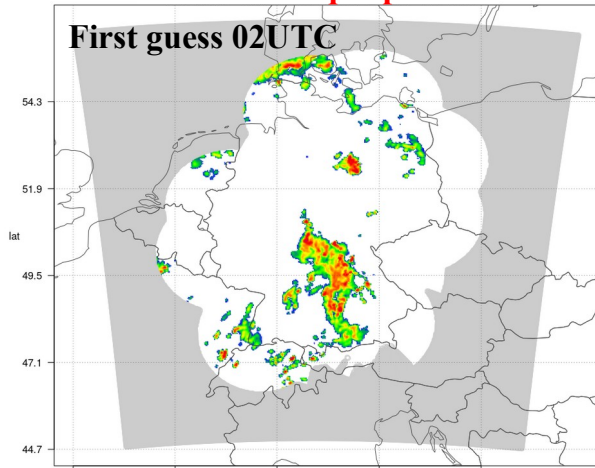
Case study

20 Jun 2019 02 UTC

(1 assimilation step after the same first guess of 1-mom)

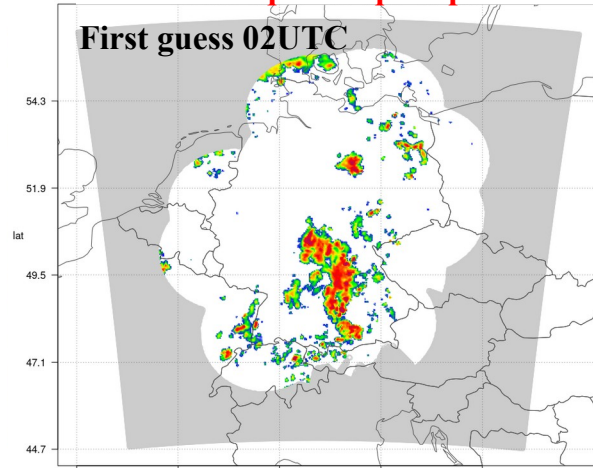
1-mom with qx update

First guess 02UTC

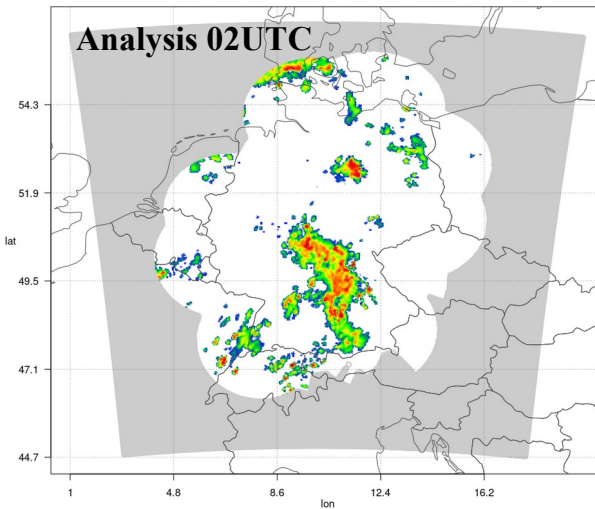


2-mom with qx and qnx update

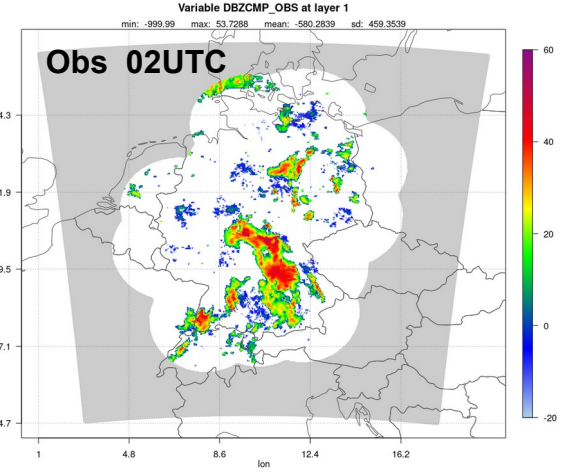
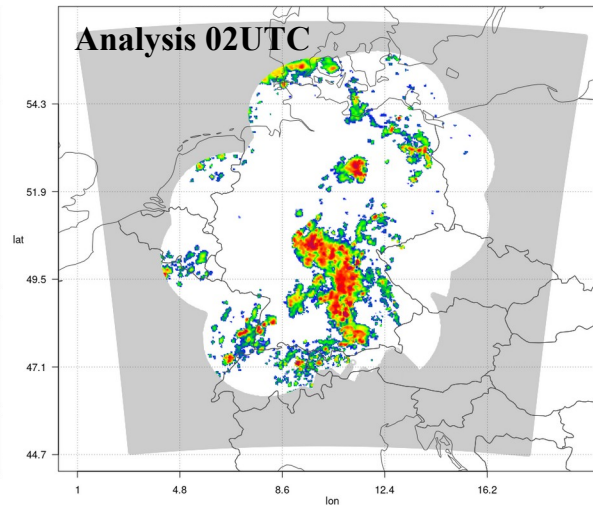
First guess 02UTC



Analysis 02UTC



Analysis 02UTC



Case study

20 Jun 2019 05 UTC

(4 assimilation steps after the same first guess of 1-mom)

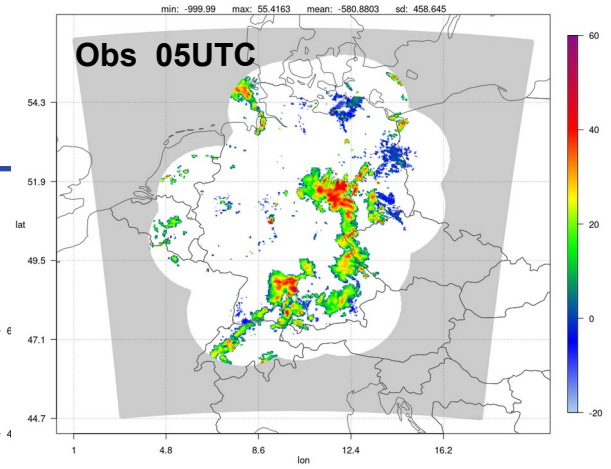
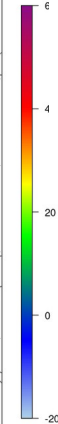
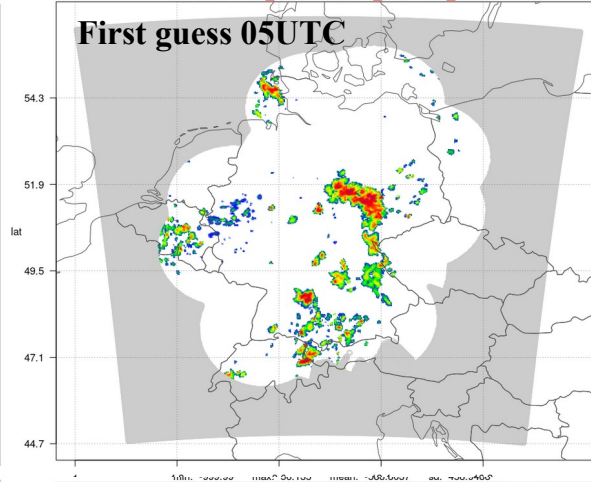
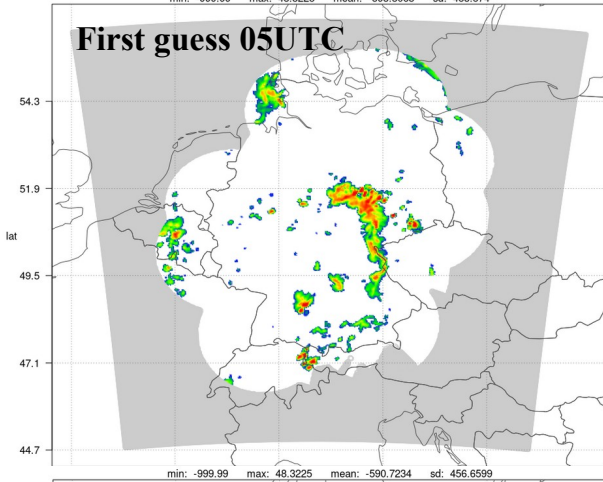
1-mom with qx update

2-mom with qx and qnx update

First guess 05UTC

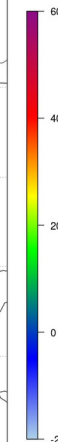
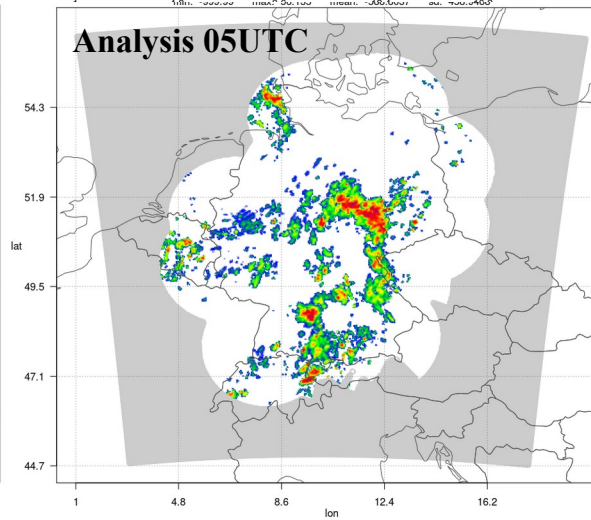
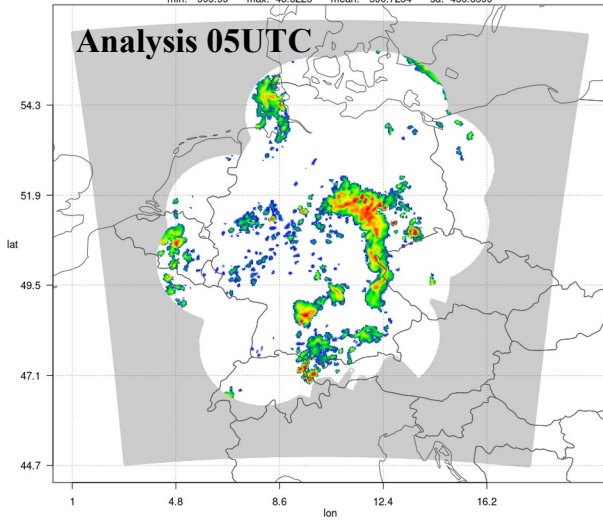
First guess 05UTC

Obs 05UTC



Analysis 05UTC

Analysis 05UTC

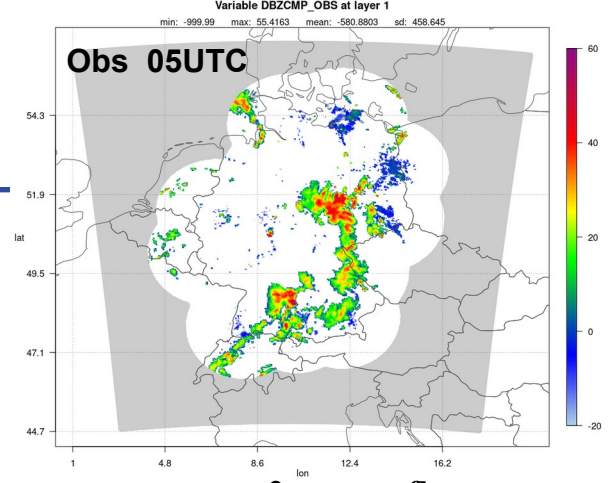


Case study

20 Jun 2019 05 UTC

(4 assimilation steps after the same first guess of 1-mom)

Ensemble runs

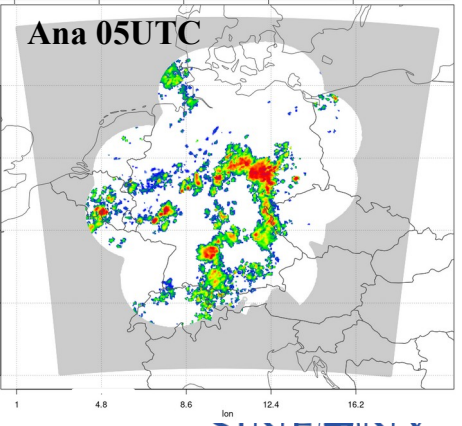
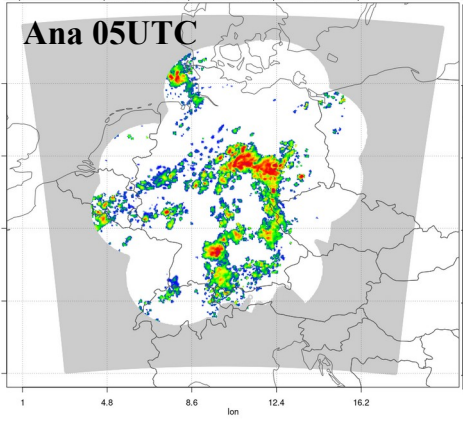
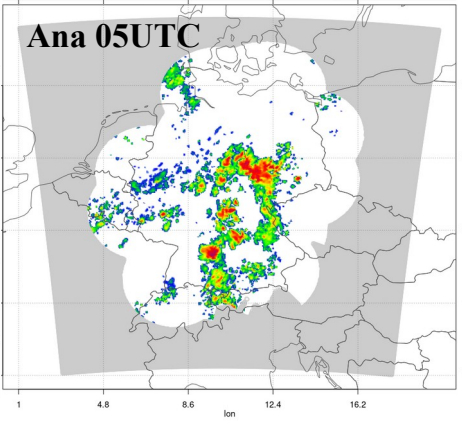
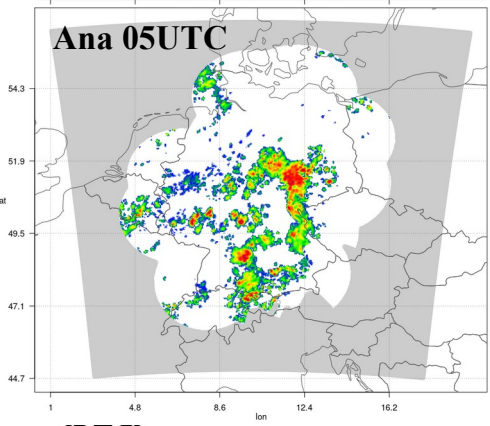
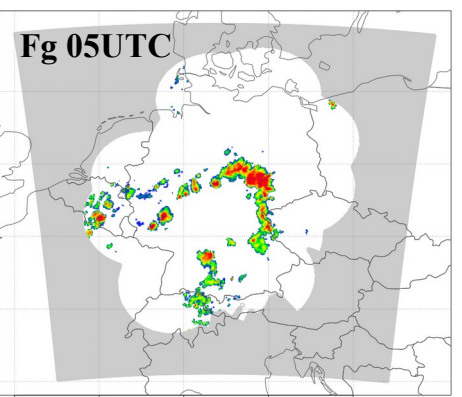
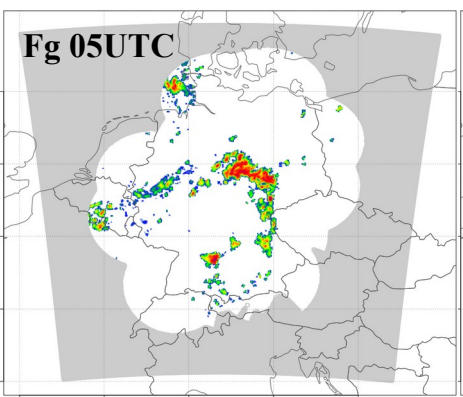
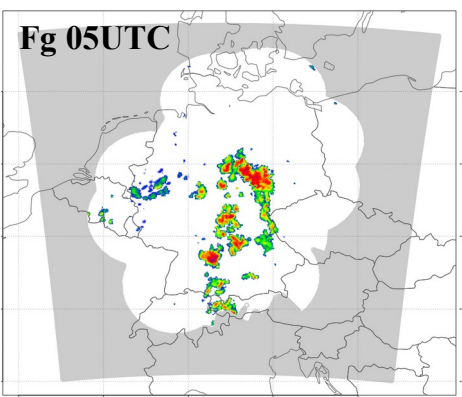
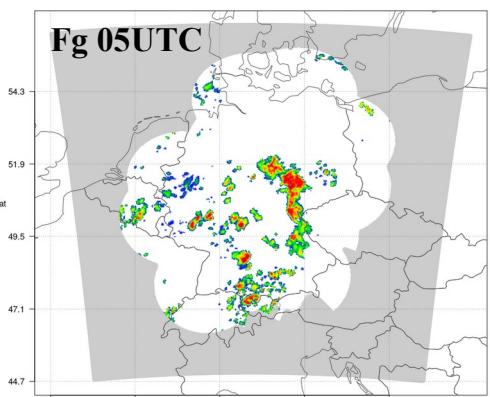


2-mom refl+conv
Ens10

2-mom refl+conv
Ens15

2-mom refl+conv
Ens25

2-mom refl+conv
Ens38



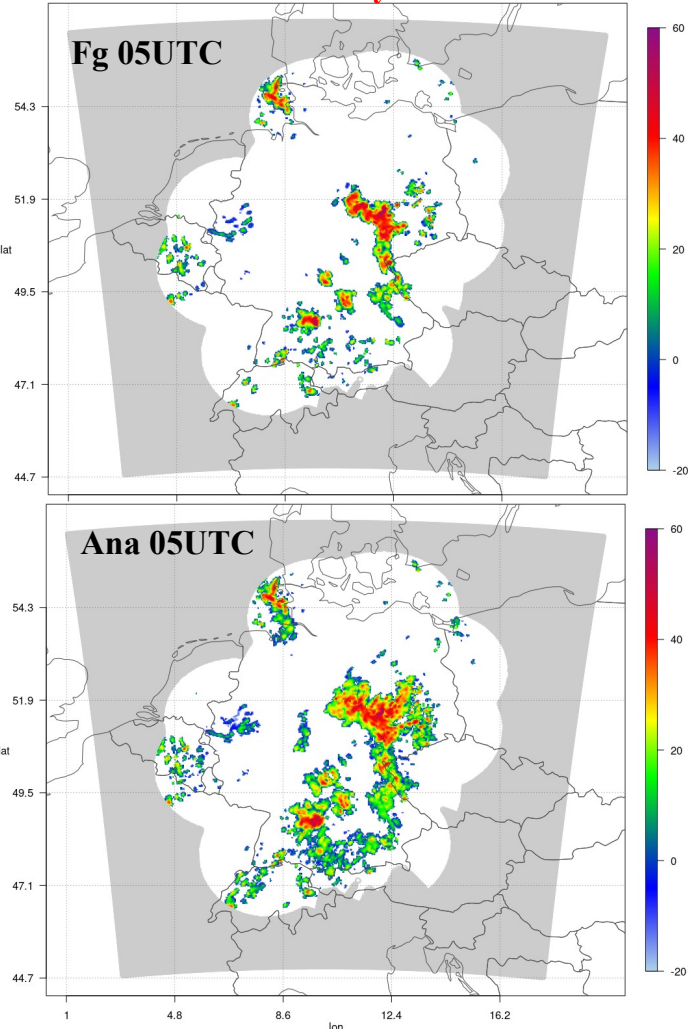
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Case study

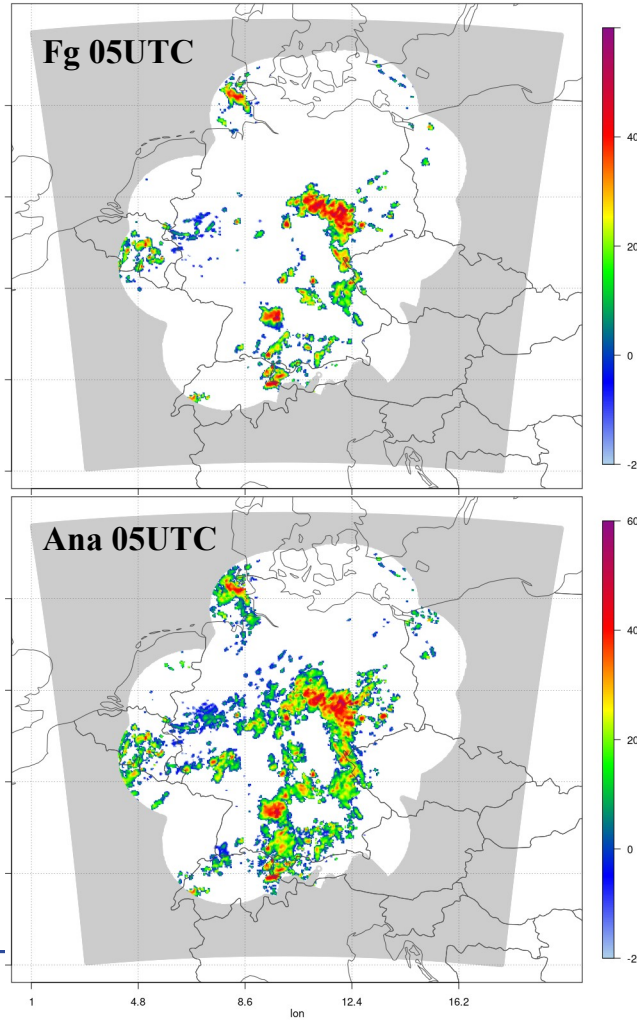
20 Jun 2019 05 UTC

(4 assimilation steps after the same first guess of 1-mom)

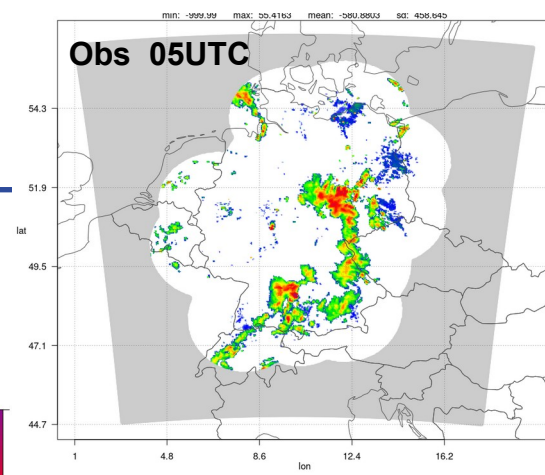
2-mom with only
reflectivity



2-mom with
reflectivity+conventional obs



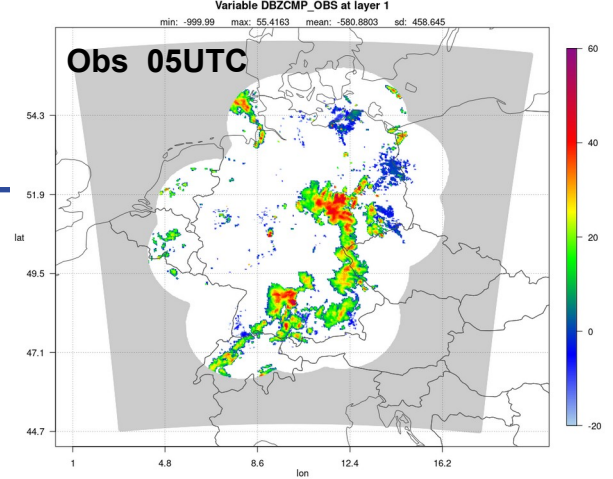
Obs 05UTC



Case study

20 Jun 2019 05 UTC

(4 assimilation steps after the same first guess of 1-mom)



2-mom refl+conv
Without **AIREP**

2-mom refl+conv
Without **PILOT**

2-mom refl+conv
Without **SYNOP**

2-mom refl+conv
Without **TEMP**

Fg 05UTC

Fg 05UTC

Fg 05UTC

Fg 05UTC

Ana 05UTC

Ana 05UTC

Ana 05UTC

Ana 05UTC



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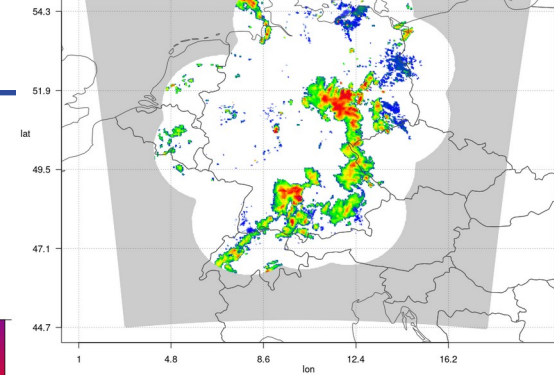
20 Jun 2019 05 UTC

(4 assimilation steps after the same first guess of 1-mom)

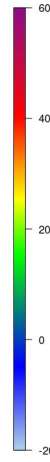
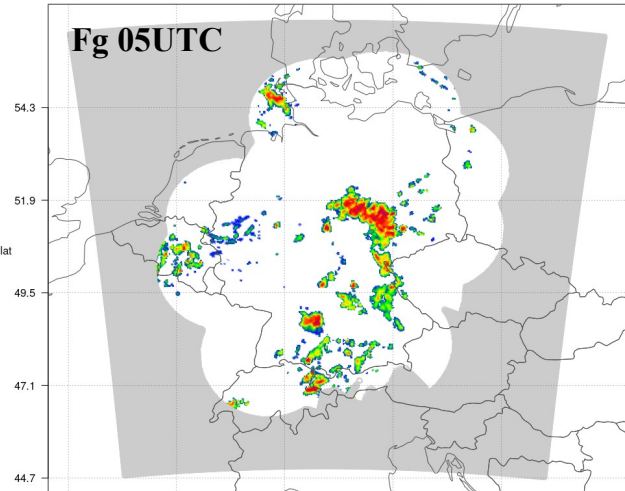
2-mom (refl+conv)
with inflation

2-mom (refl+conv)
without inflation

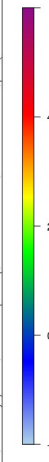
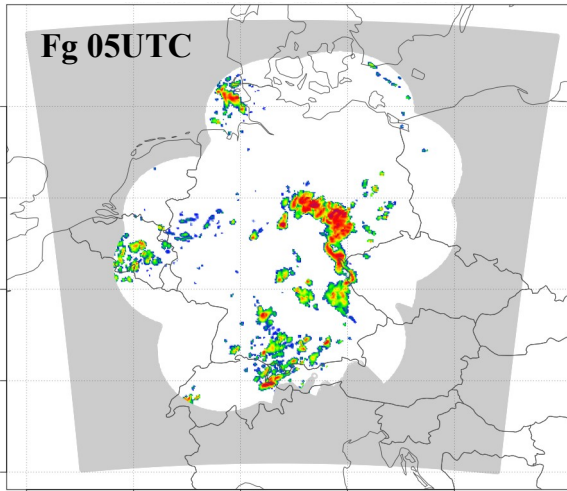
Obs 05UTC



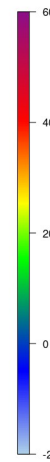
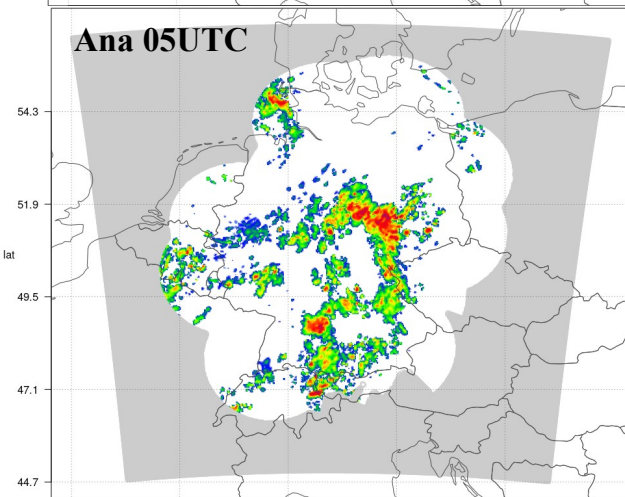
Fg 05UTC



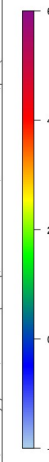
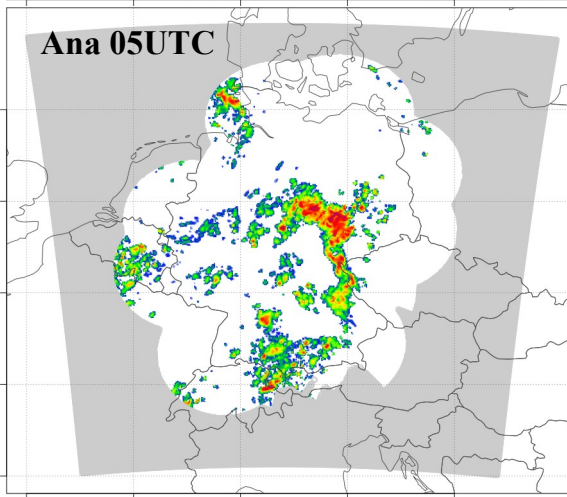
Fg 05UTC



Ana 05UTC



Ana 05UTC



Inflation settings:
with/without

&ENKF

rho=1.1/1.0

m_flag = 1/0

adap_rho = T/F (adapt. rho infl)

apply_rttp = T/F (apply relaxation to prior perturbations)

apply_rtps = F/F (apply relaxation to prior spread)

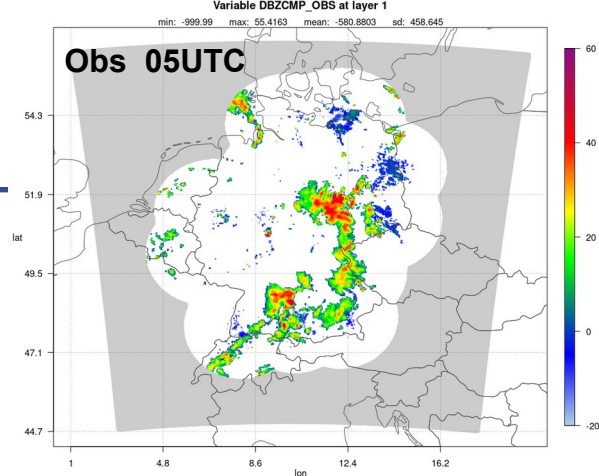
With/without perturbation of soil temperature nad moisture

Case study

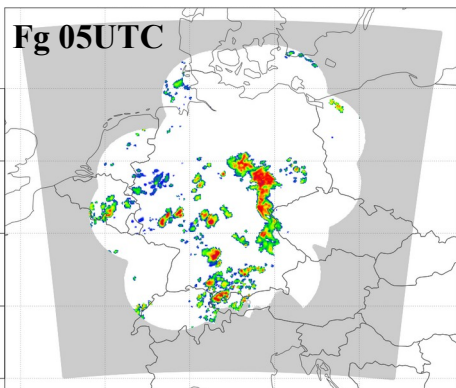
20 Jun 2019 05 UTC

(4 assimilation steps after the same first guess of 1-mom)

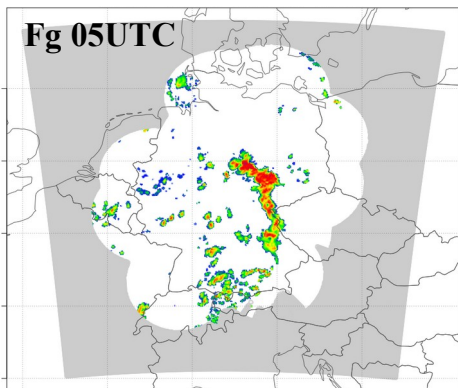
Ensemble runs



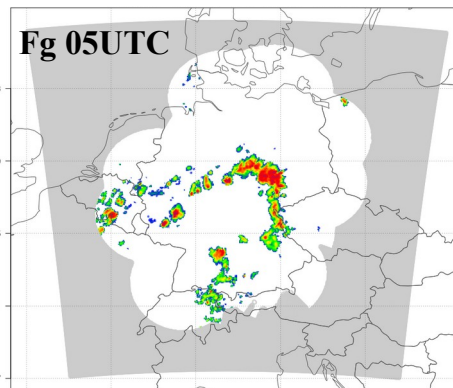
2-mom refl+conv
(with infl) **Ens10**



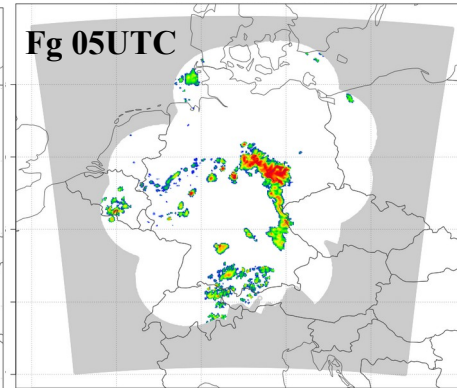
2-mom refl+conv
(without infl) **Ens10**



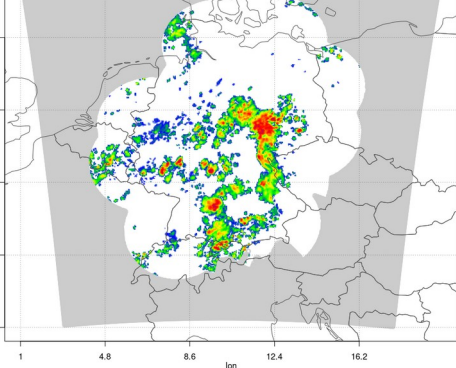
2-mom refl+conv
(with infl) **Ens38**



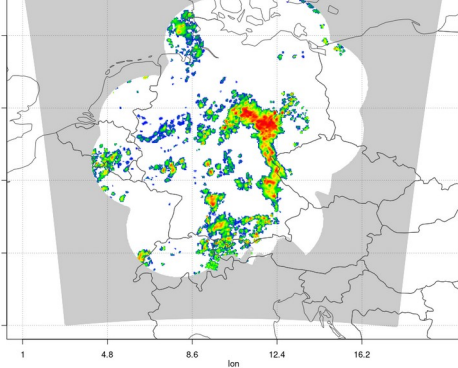
2-mom refl+conv
(without infl) **Ens38**



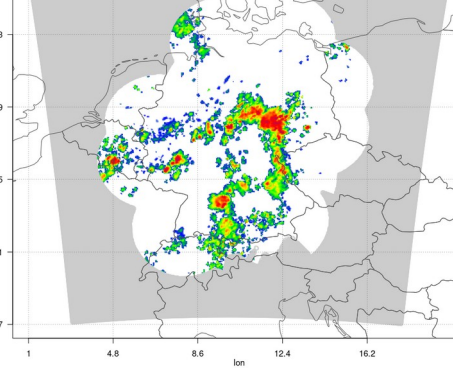
Ana 05UTC



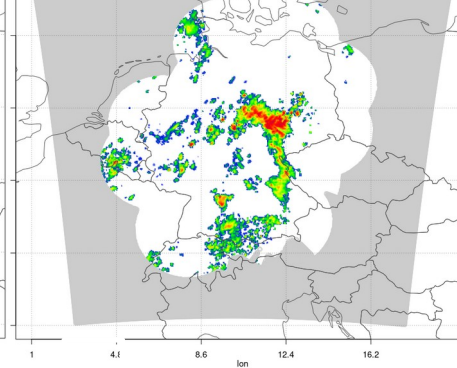
Ana 05UTC



Ana 05UTC



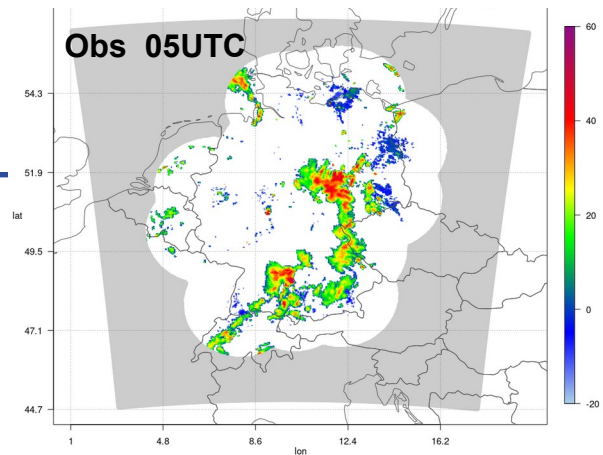
Ana 05UTC



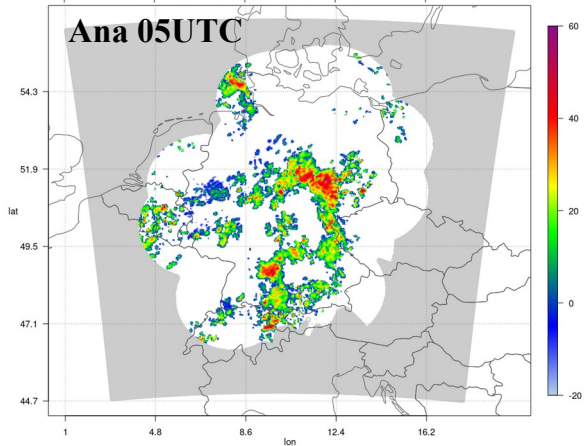
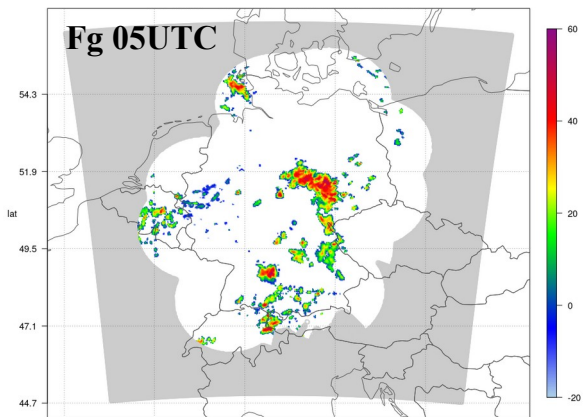
Case study

20 Jun 2019 05 UTC

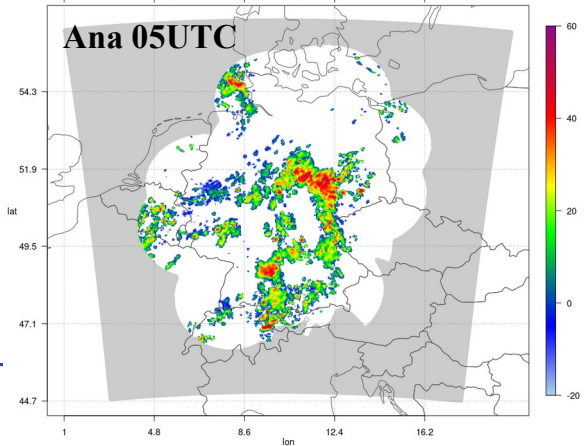
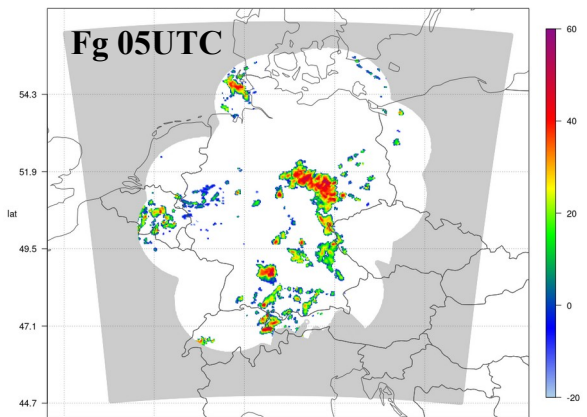
(4 assimilation steps after the same first guess of 1-mom)



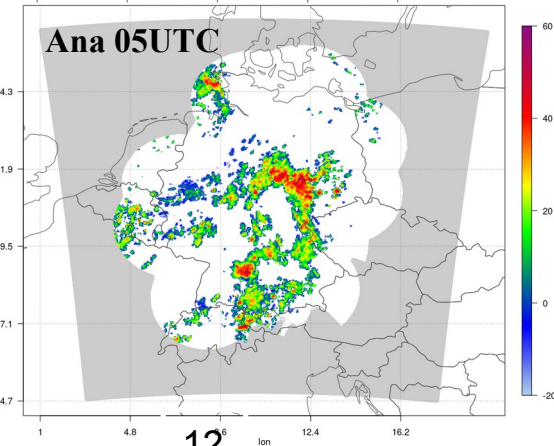
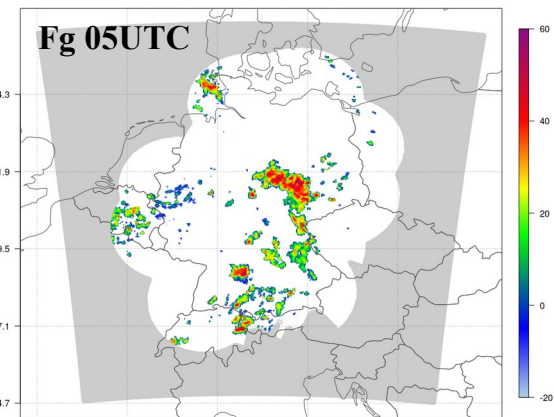
2-mom (refl+conv) with inflation
(excluding Conv data from calculate inflation)



2-mom (refl+conv) with inflation
(excluding AIREP from calculate inflation)



2-mom (refl+conv)
with inflation



Case study

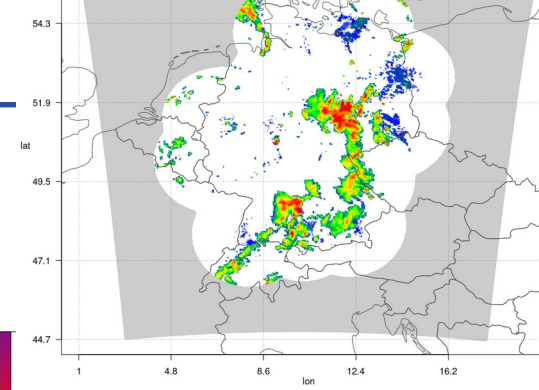
20 Jun 2019 05 UTC

(4 assimilation steps after the same first guess of 1-mom)

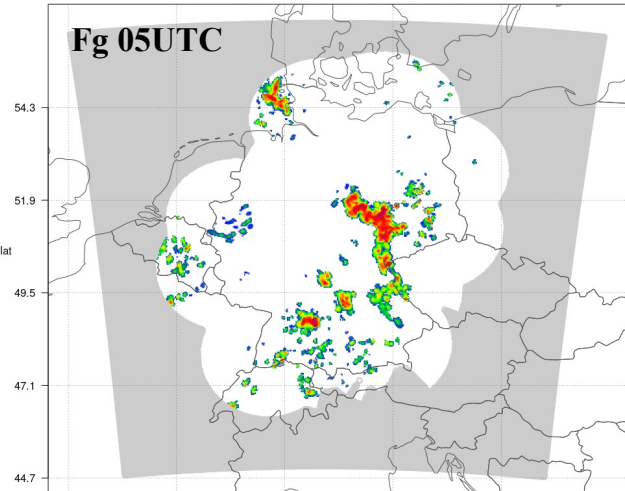
2-mom (only refl)
with inflation

2-mom (only refl)
without inflation

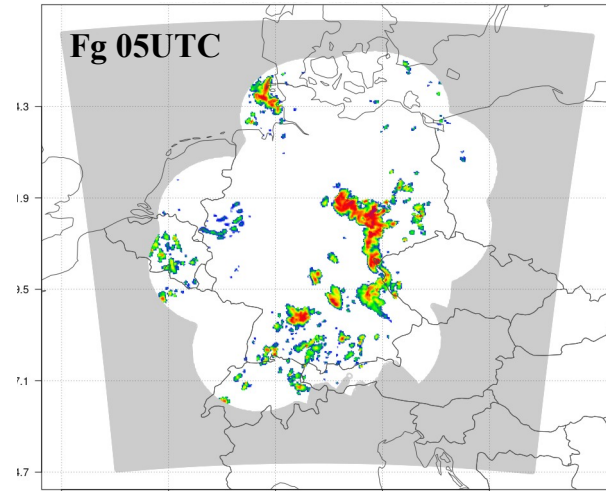
Obs 05UTC



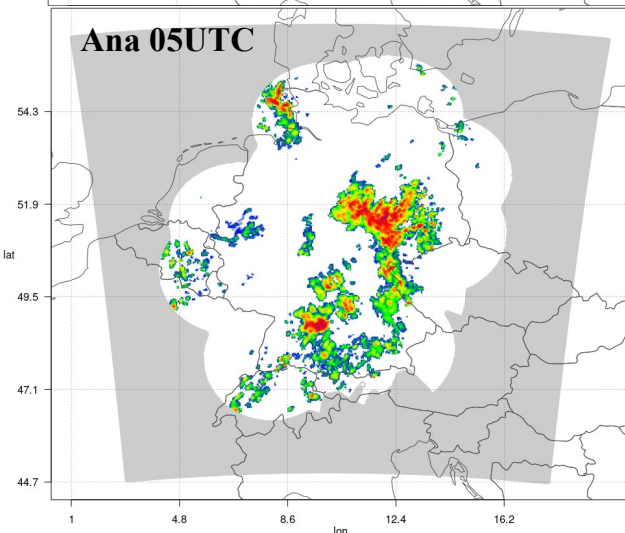
Fg 05UTC



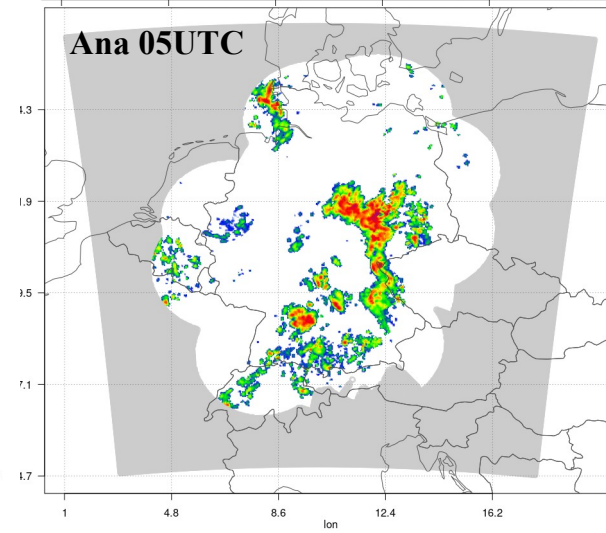
Fg 05UTC



Ana 05UTC



Ana 05UTC



Inflation settings:
with/without

&ENKF

rho=1.1/1.0

m_flag = 1/0

adap_rho = T/F (adapt. rho infl)

apply_rtp = T/F (apply relaxation to prior perturbations)

apply_rtps = F/F (apply relaxation to prior spread)

With/without perturbation of soil temperature nad moisture

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Changed to cp/cv bug fixed ICON binary

Case study

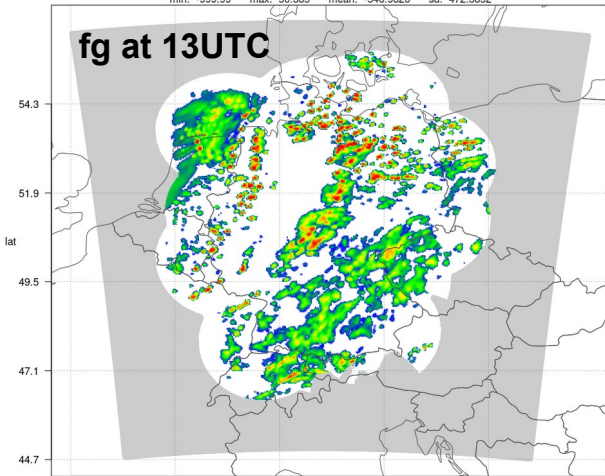
06 Jun 2020 13 UTC

(1 assimilation step after the same first guess of 1-mom)

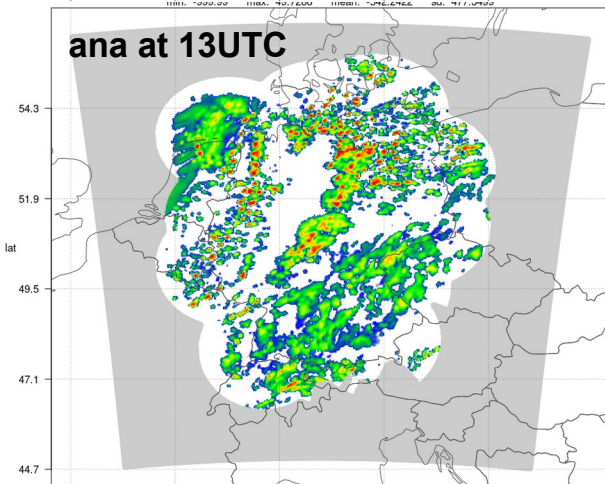
1-mom scheme

qx update

fg at 13UTC



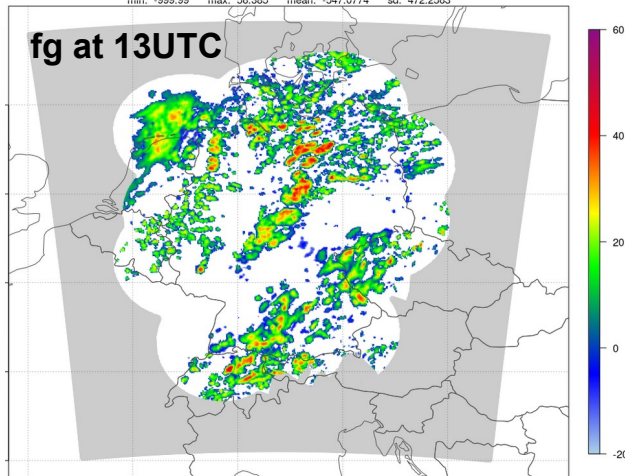
ana at 13UTC



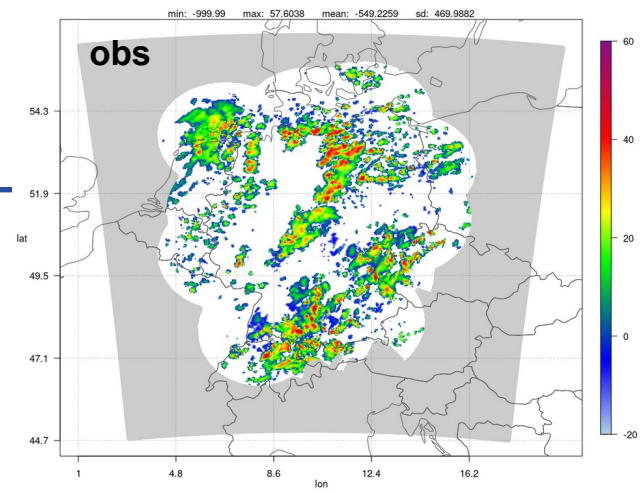
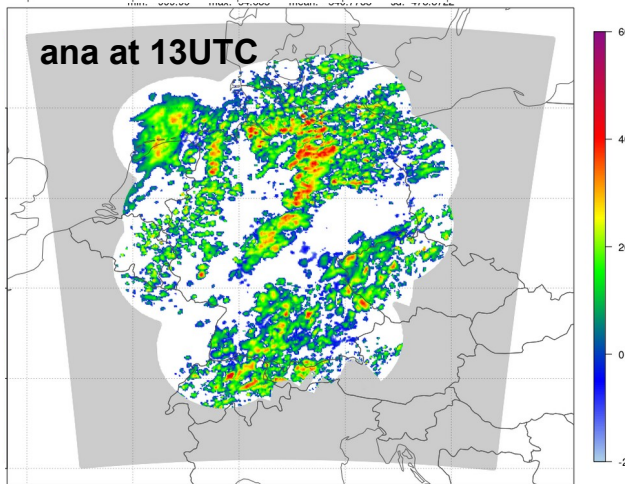
2-mom scheme

qx and qnx update

fg at 13UTC



ana at 13UTC



Case study

06 Jun 2020 15 UTC

(3 assimilation steps after the same first guess of 1-mom)

1-mom scheme

qx update

2-mom scheme

qx and qnx update

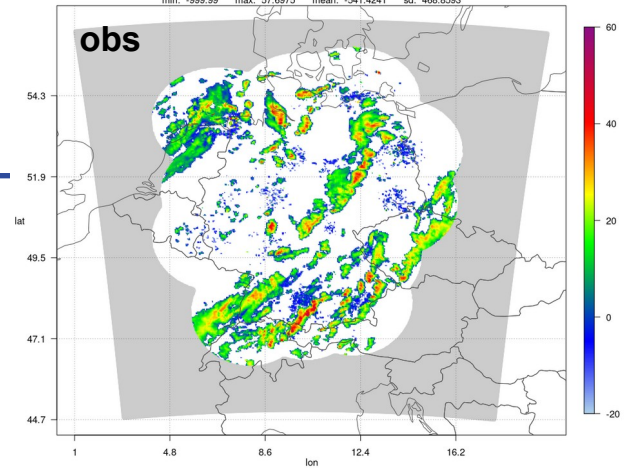
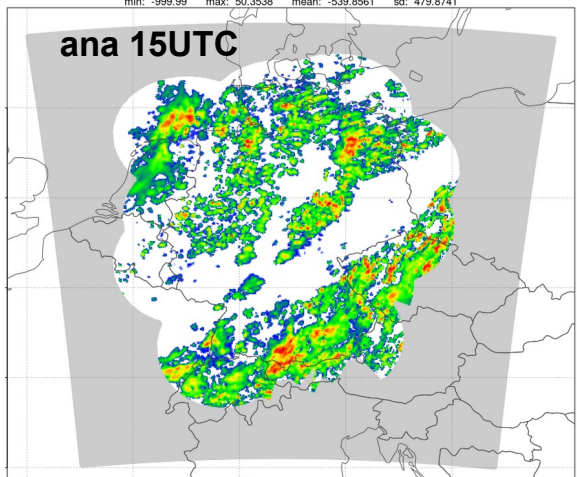
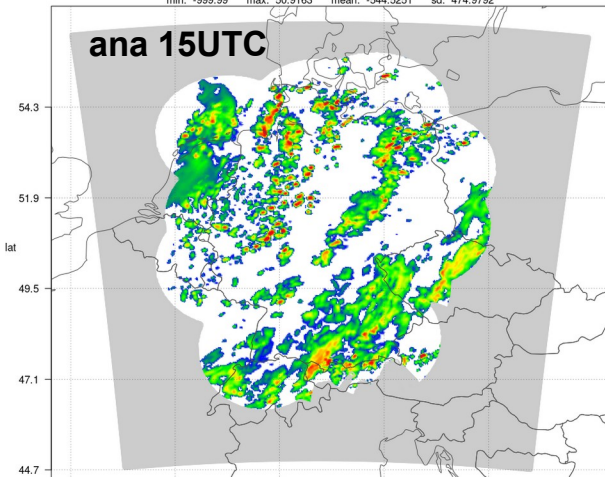
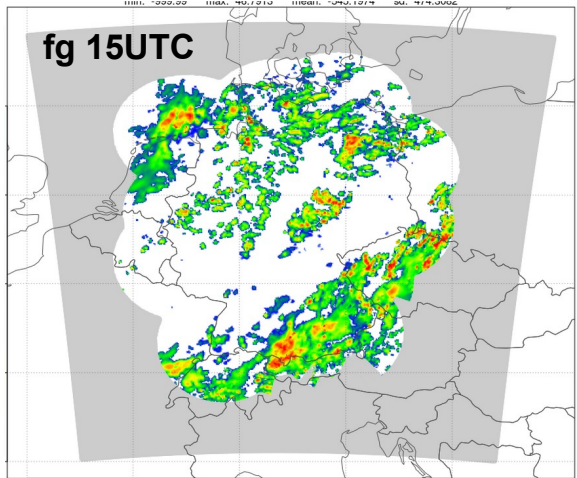
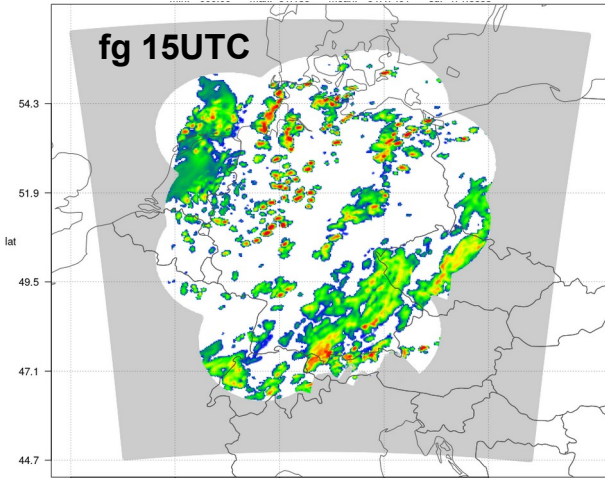
fg 15UTC

fg 15UTC

ana 15UTC

ana 15UTC

obs



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- ◆ **The problem of tiny false alarm cells**
 - **Finding the reason of the problem**
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2-step assimilation

- **1st LETKF step:** using conventional observation and radar reflectivity to update **t**, **qv**, **qc**, **u**, **v** and **p**
- **2nd LETKF step:** using radar reflectivity to update **qx** and **qnx**
- **Merge** 2 analysis increment files for det and all ensemble runs
- **ICON step:** using conventional obs and radar reflectivity and merged analysis increment files

Case study

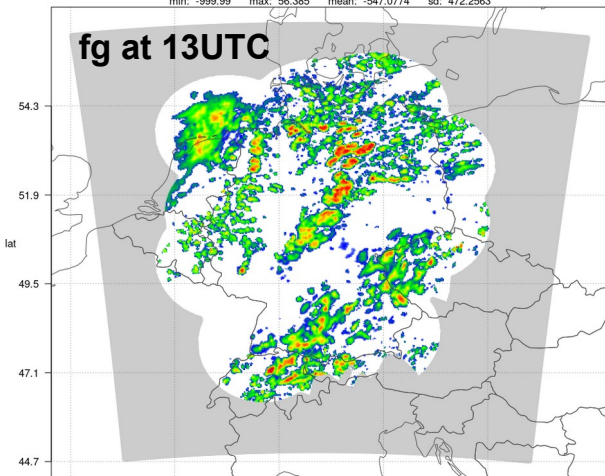
06 Jun 2020 13 UTC

(1 assimilation step after the same first guess of 1-mom)

2-step assimilation
with qx and qnx update

min: -999.99 max: 56.385 mean: -547.0774 sd: 472.2563

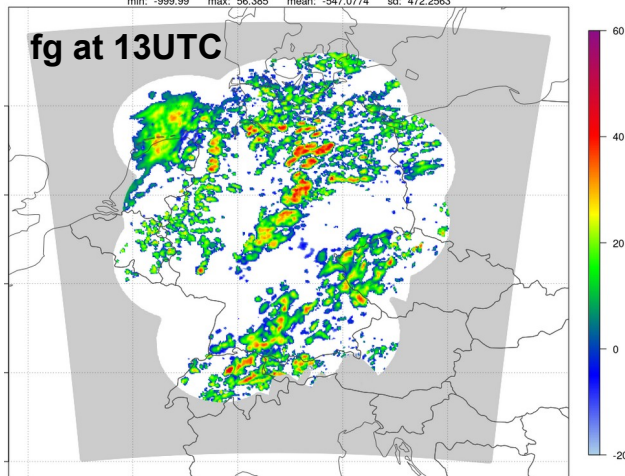
fg at 13UTC



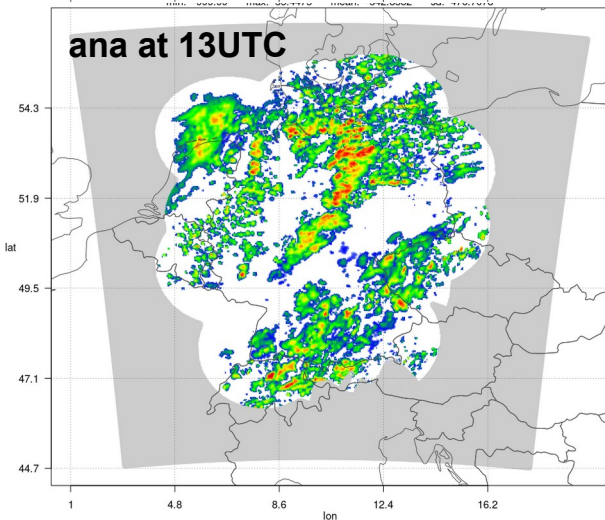
default 2-mom assimilation
with qx and qnx update

min: -999.99 max: 56.385 mean: -547.0774 sd: 472.2563

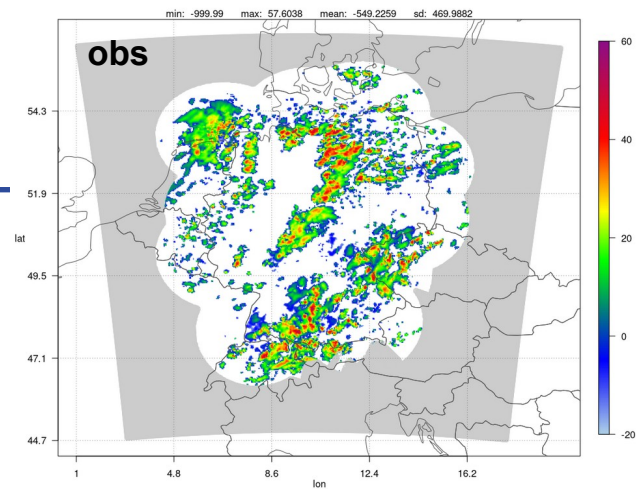
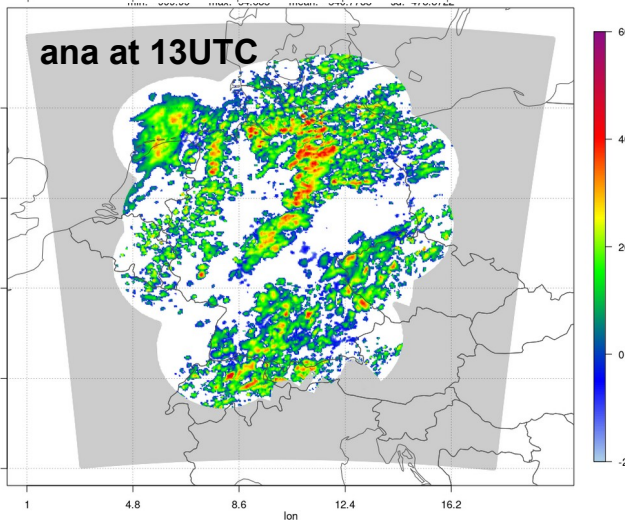
fg at 13UTC



ana at 13UTC



ana at 13UTC



Case study

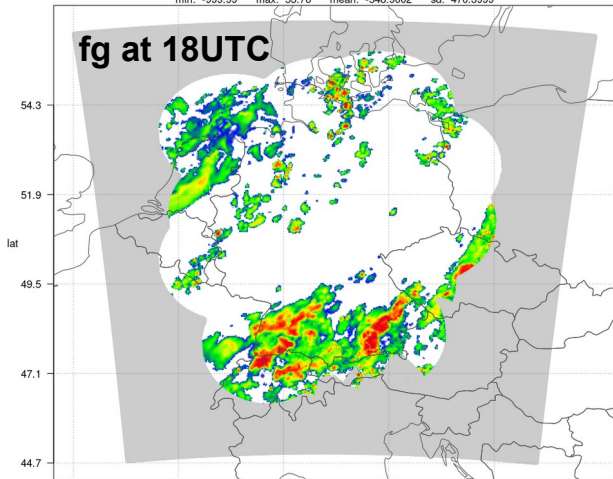
06 Jun 2020 18 UTC

(6 assimilation step after the same first guess of 1-mom)

2-step assimilation
with qx and qnx update

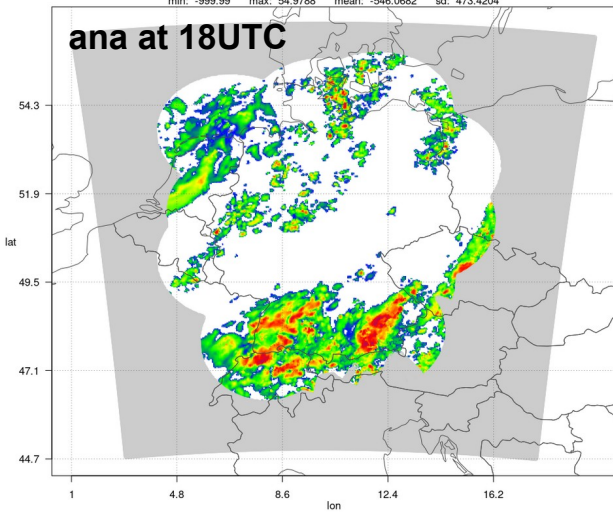
min: -999.99 max: 53.76 mean: -548.9002 sd: 470.3999

fg at 18UTC



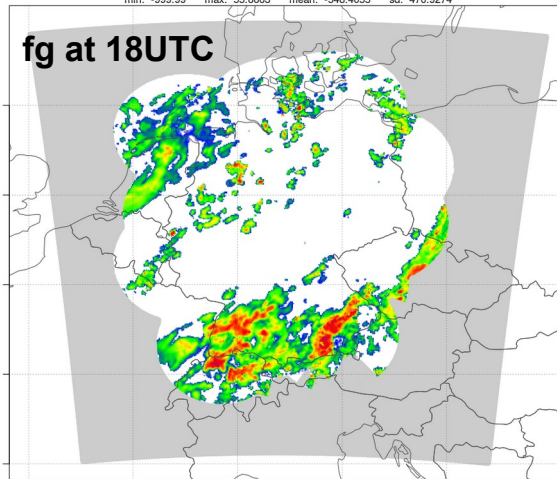
min: -999.99 max: 54.9788 mean: -546.0682 sd: 473.4204

ana at 18UTC



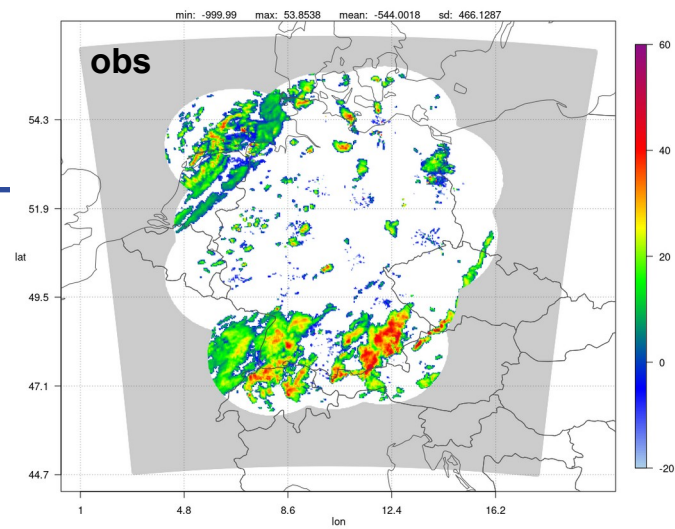
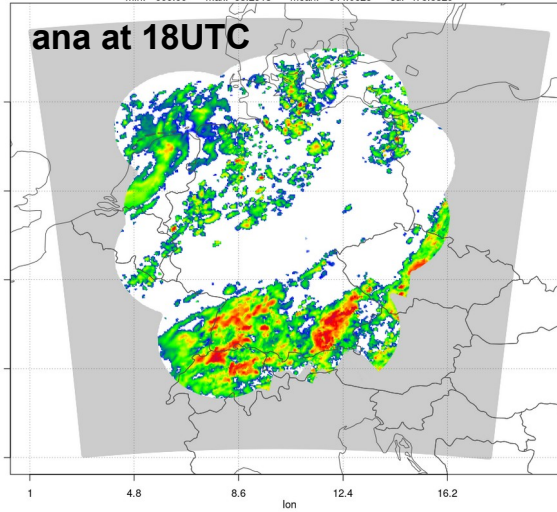
default 2-mom assimilation
with qx and qnx update

fg at 18UTC



min: -999.99 max: 53.2913 mean: -544.0628 sd: 475.5329

ana at 18UTC

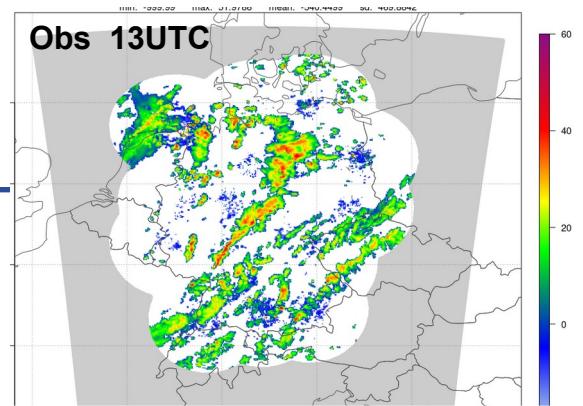


- ◆ First apply of 2-mom experiments
- ◆ The problem of tiny false alarm cells
 - Finding the reason of the problem
 - ✓ The effect of conventional data
 - ✓ The effect of different inflation methods
 - Trying different solutions
 - ✓ 2-step assimilation
 - ✓ Updating only hydrometeors and indirect update of qnx
- ◆ Comparison between 2 Long-term experiments with different 2-mom microphysic setting

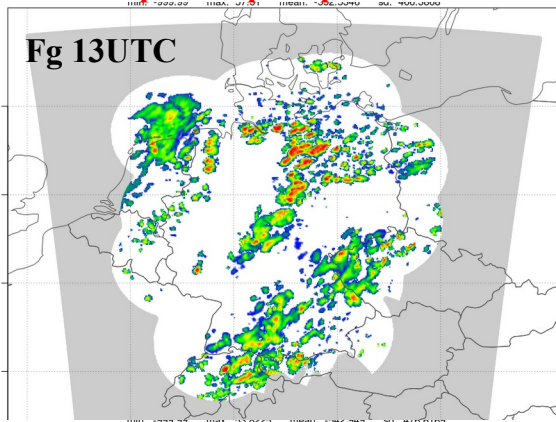
Case study

06 Jun 2020 13 UTC

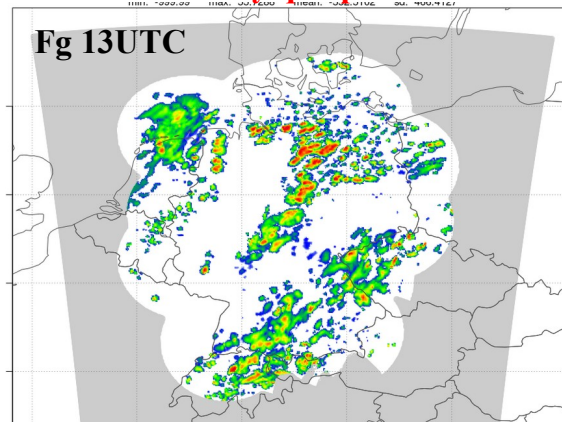
(1 assimilation steps after the same first guess of 1-mom)



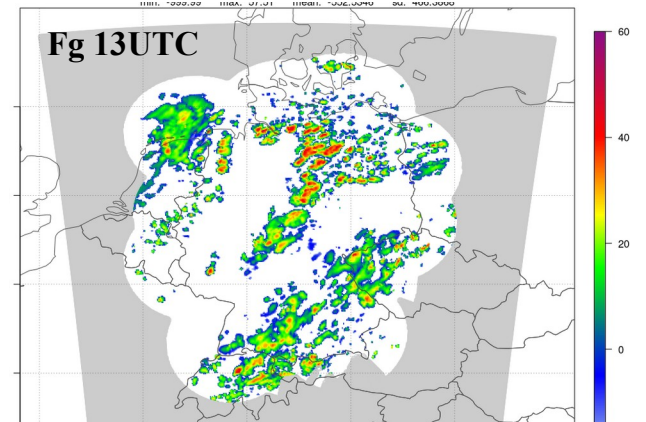
**2-mom (refl+conv)
qx and qnx update**



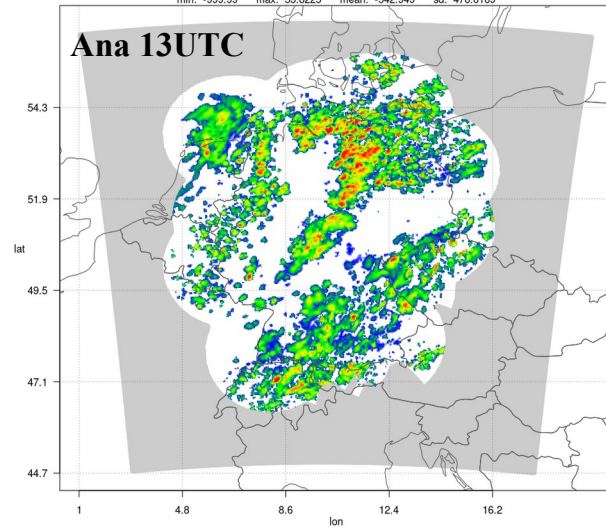
**2-mom (refl+conv)
Only qx update**



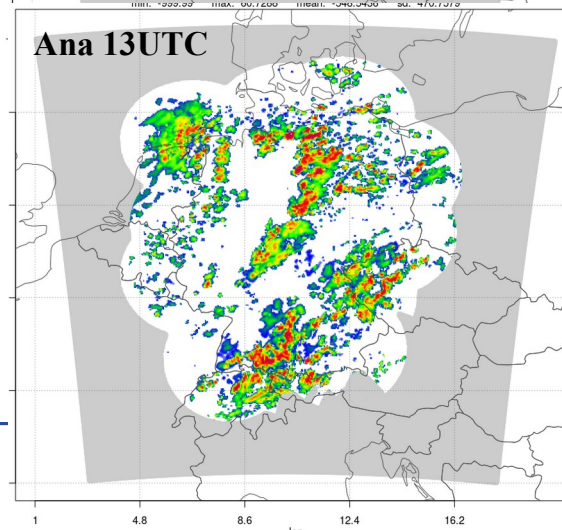
**2-mom (refl+conv)
Only qnx update with indirect qnx update**



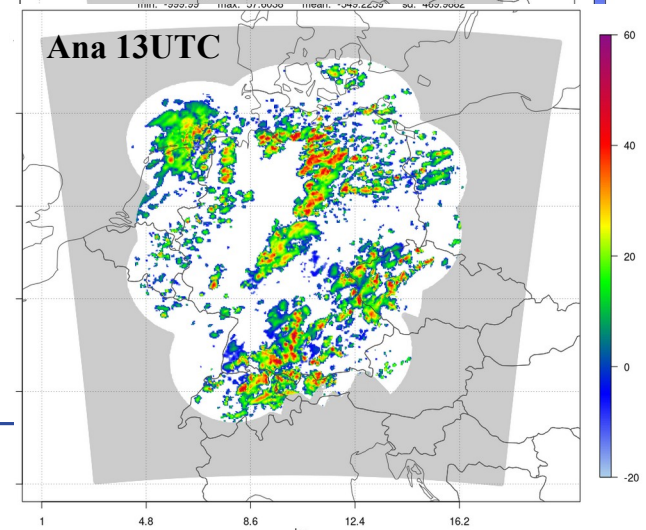
Ana 13UTC



Ana 13UTC



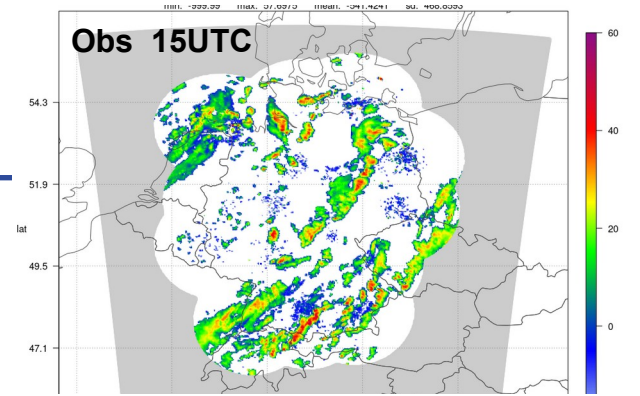
Ana 13UTC



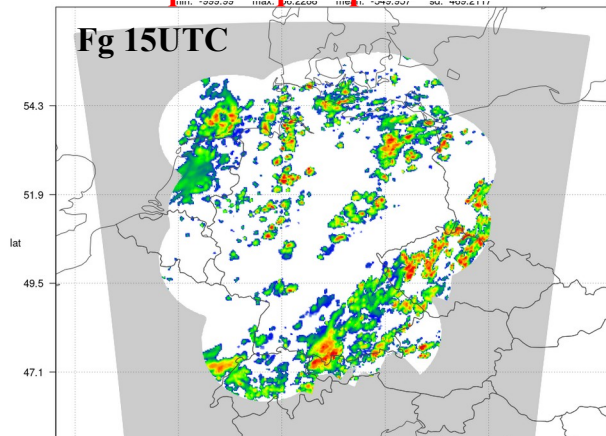
Case study

06 Jun 2020 15 UTC

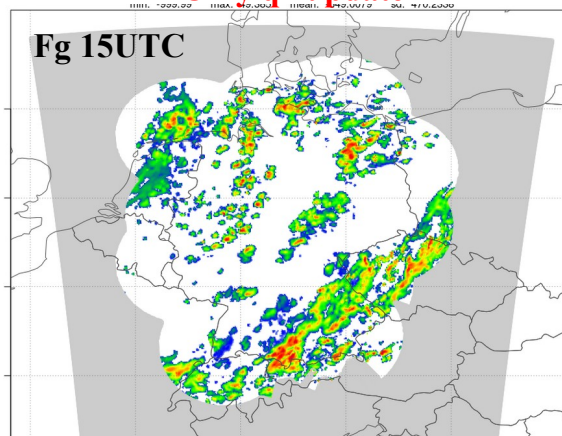
(3 assimilation steps after the same first guess of 1-mom)



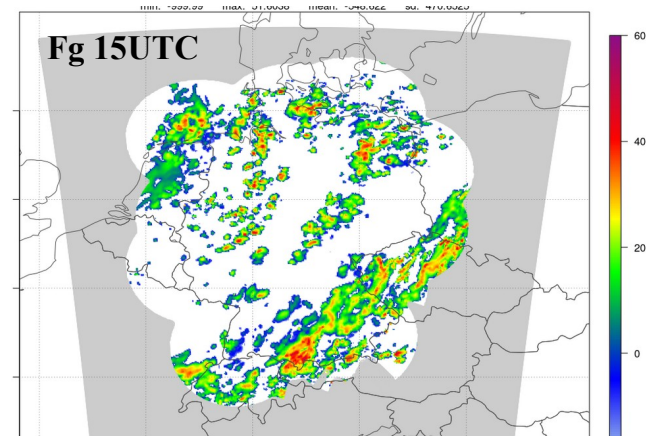
2-mom (refl+conv)
qx and qnx update



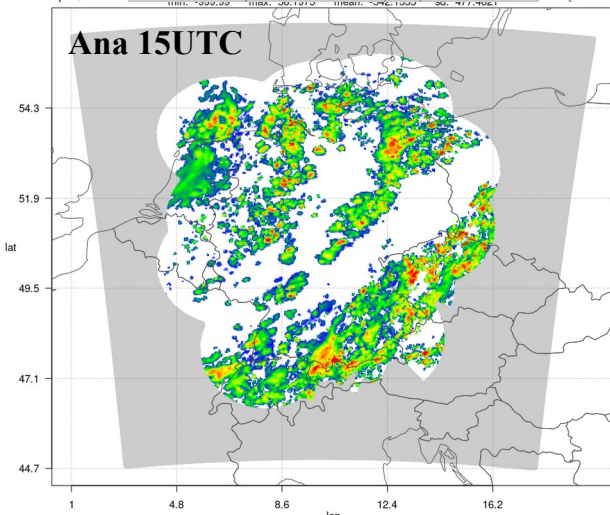
2-mom (refl+conv)
Only qx update



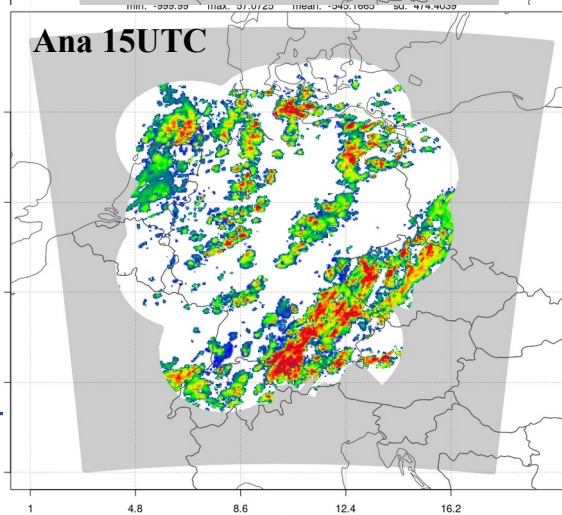
2-mom (refl+conv)
Only qnx update with indirect qnx update



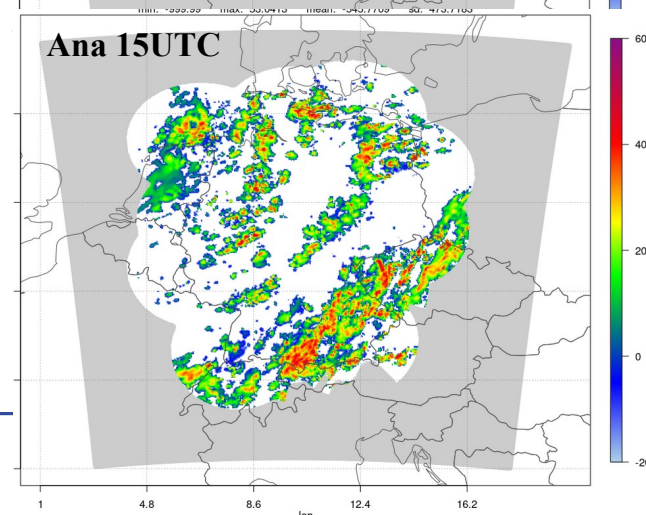
Ana 15UTC



Ana 15UTC



Ana 15UTC



- ◆ **First apply of 2-mom experiments**
- ◆ **The problem of tiny false alarm cells**
 - **Finding the reason of the problem**
 - ✓ The effect of conventional data
 - ✓ The effect of different inflation methods
 - **Trying different solutions**
 - ✓ 2-step assimilation
 - ✓ Updating only hydrometeors and indirect update of qnx
- ◆ **Comparison between 2 Long-term experiments with different 2-mom microphysic setting**

Date: from **3 Jun** until **17 Jun 2020**

- 2-mom experiment: assimilation using conventional observation and radar reflectivity with **qx** and **qnx** update
- 2-mom experiment: assimilation using conventional observation and radar reflectivity with **only qx** update (**fixed mean mass**)

Setting of radar reflectivity assimilation:

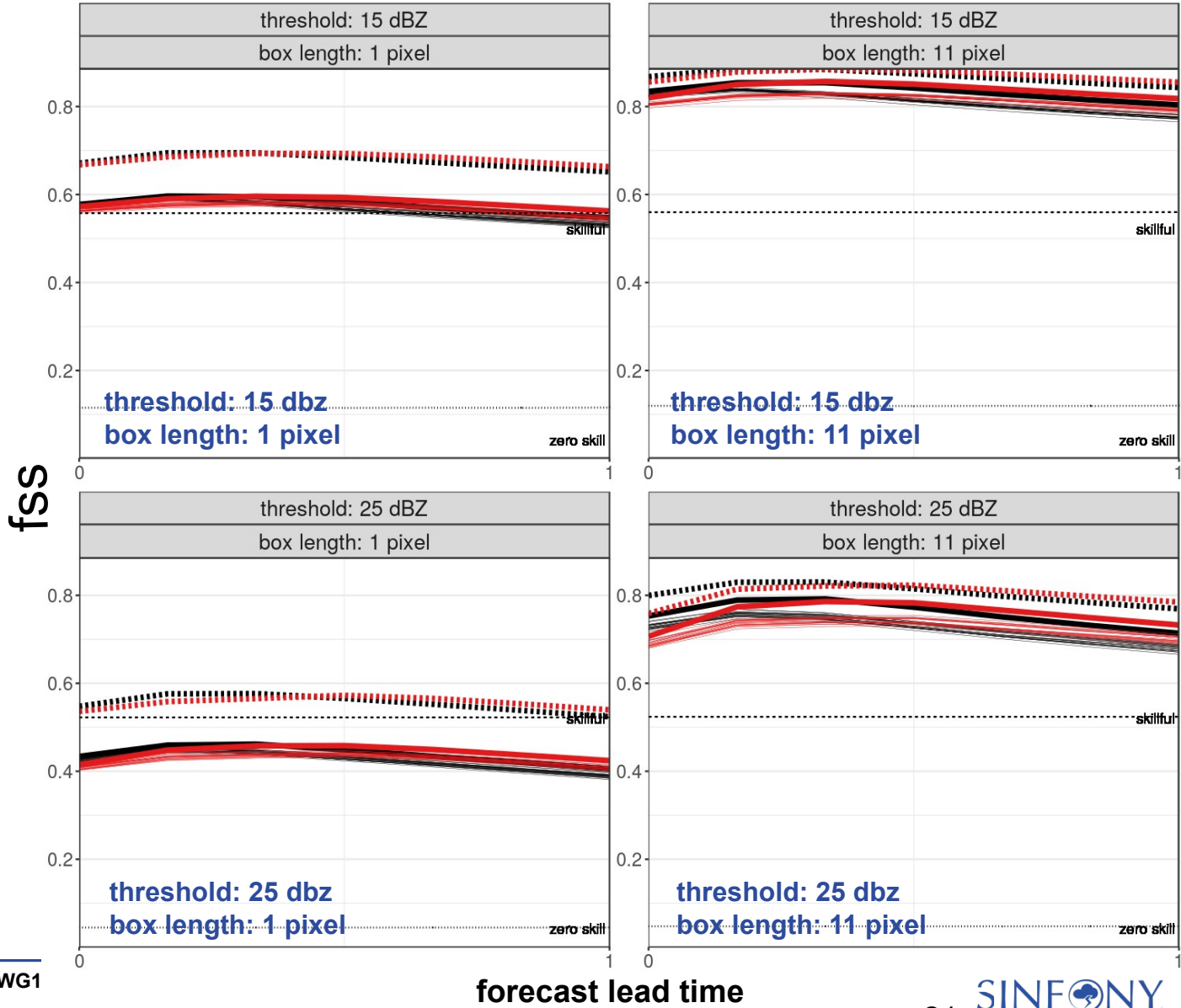
- Using **5** radar beams (**1.5, 3.5, 5.5, 8 and 12** degree)
- **h_loc: 16 km**
- **v_loc: 0.07 Lnp (vertically increasing)**
- **Obs_error: 10 dbz**

dbz verification of 1st hour after assimilation

member type

- det
- fc_members
- ... nep

2mom with only qx update
2mom with qx & qnx update

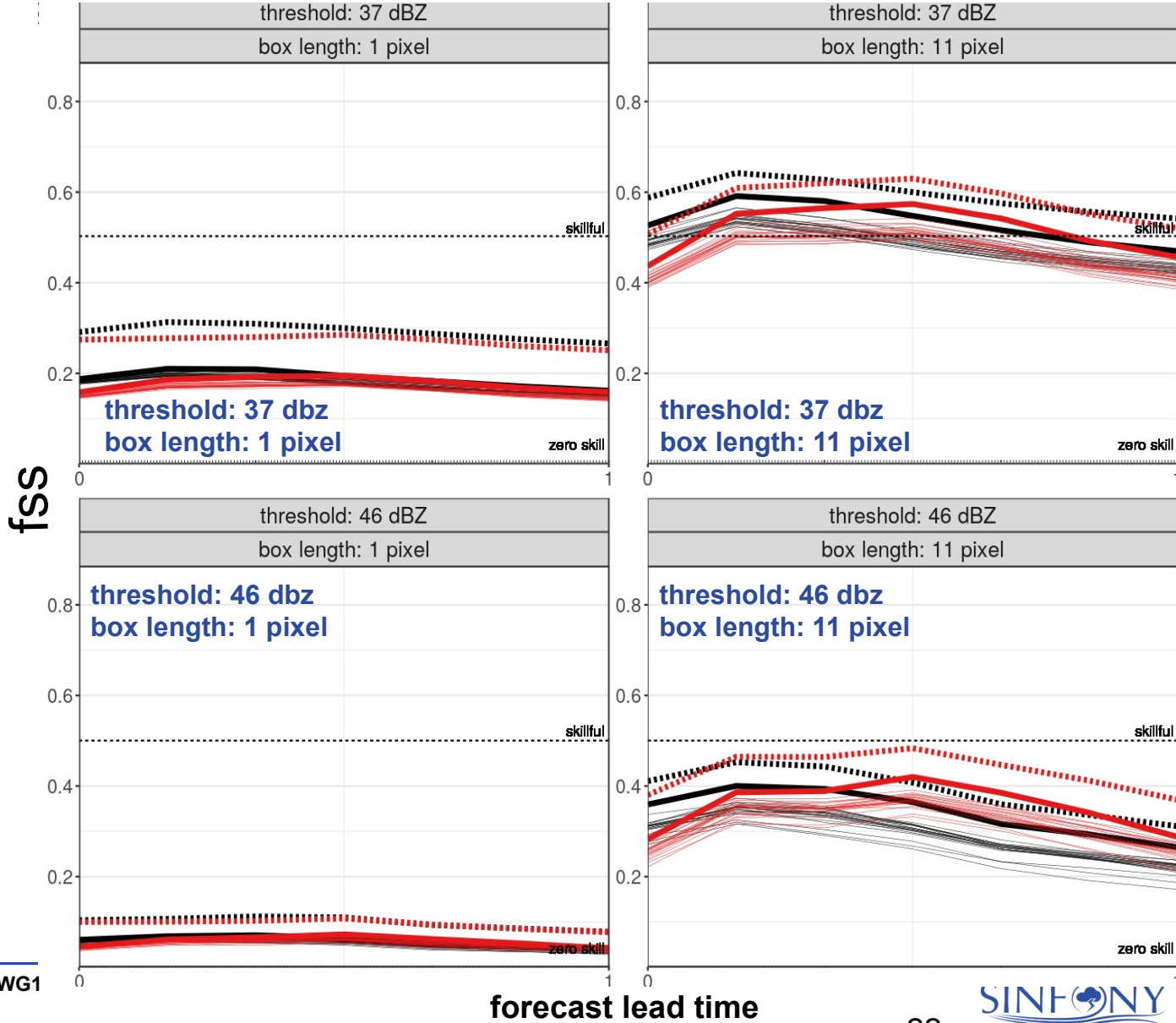


dbz verification of 1st hour after assimilation

member type

- det
- fc_members
- ... nep

2mom with only qx update
2mom with qx & qnx update



dbz verification of 24 hours forecast run

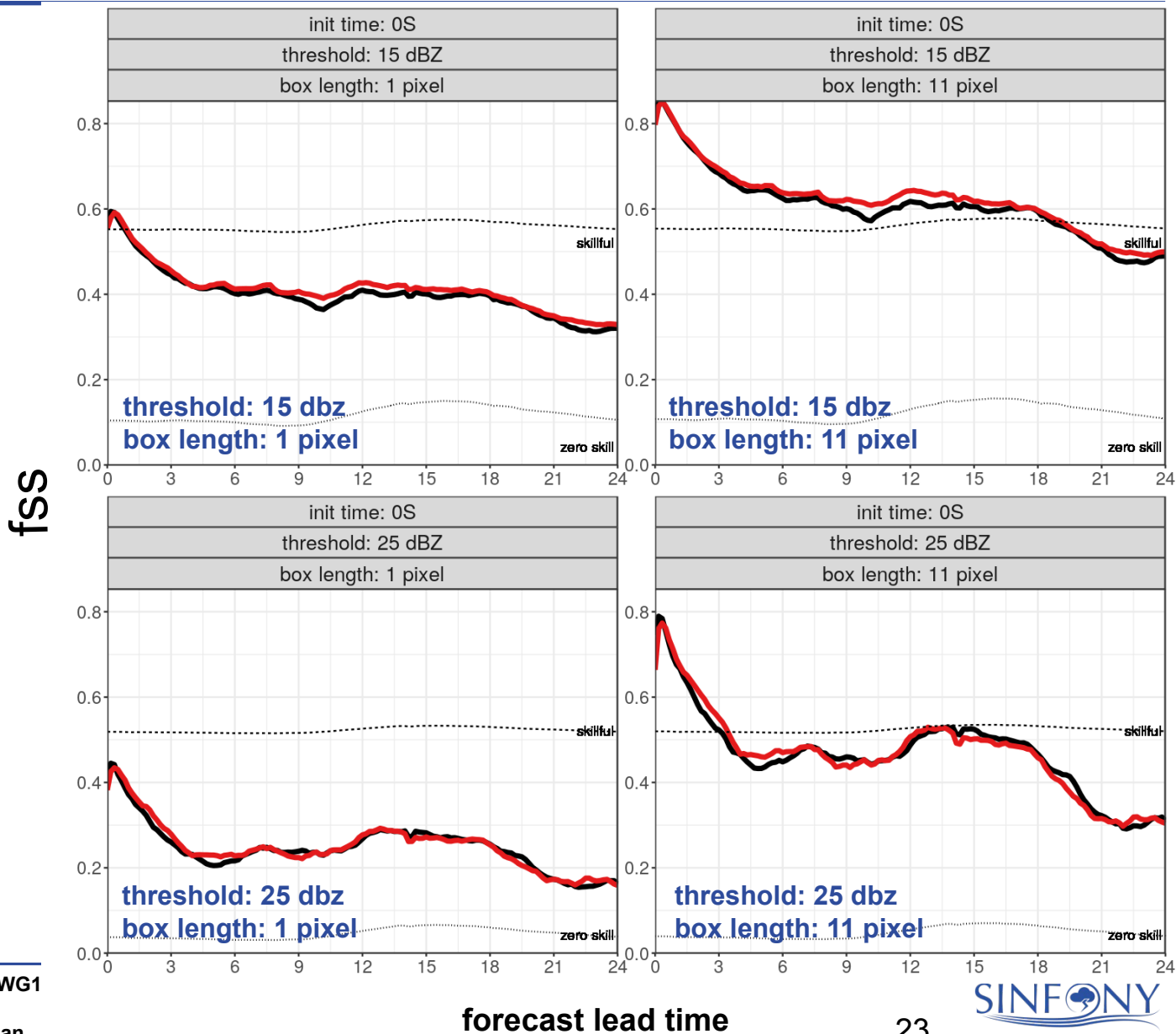
Initial time: 00 UTC

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



— det

2mom with only qx update
2mom with qx & qnx update



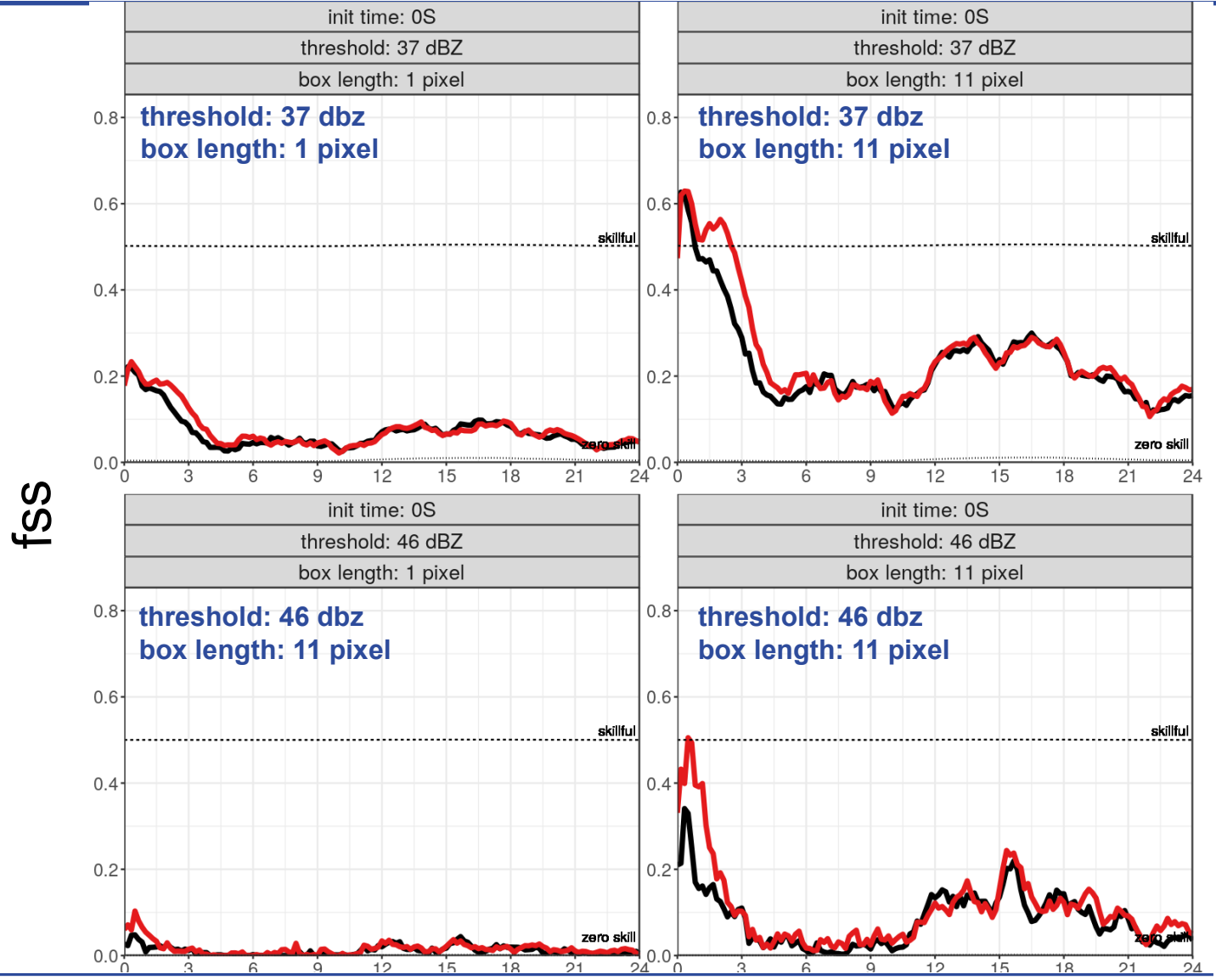
dbz verification of 24 hours forecast run

Initial time: 00 UTC

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



— det
 2mom with only qx update
 2mom with qx & qnx update



dbz verification of 24 hours forecast run

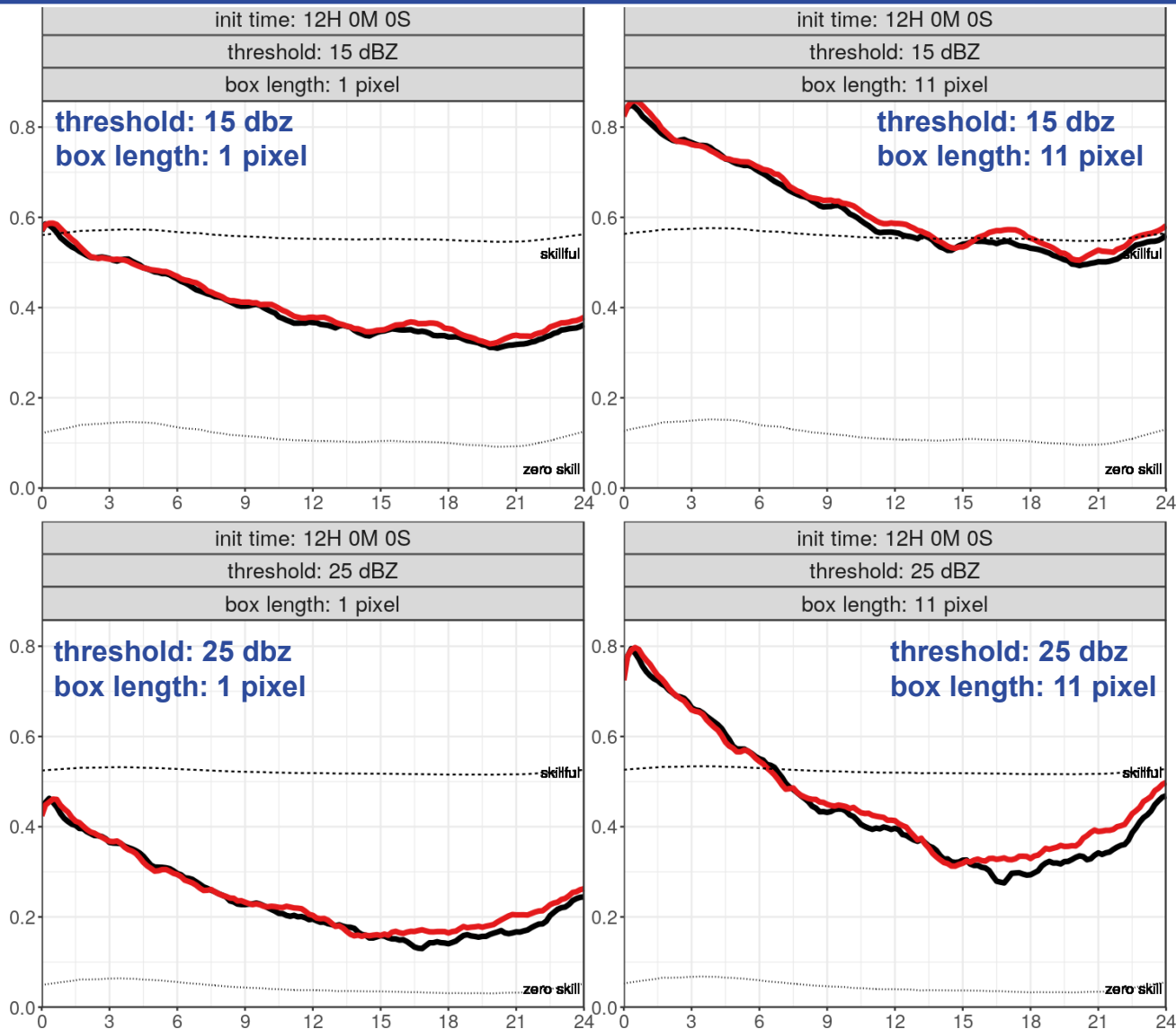
Initial time: 12 UTC

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



— det
 2mom with only qx update
 2mom with qx & qnx update

fss



dbz verification of 24 hours forecast run

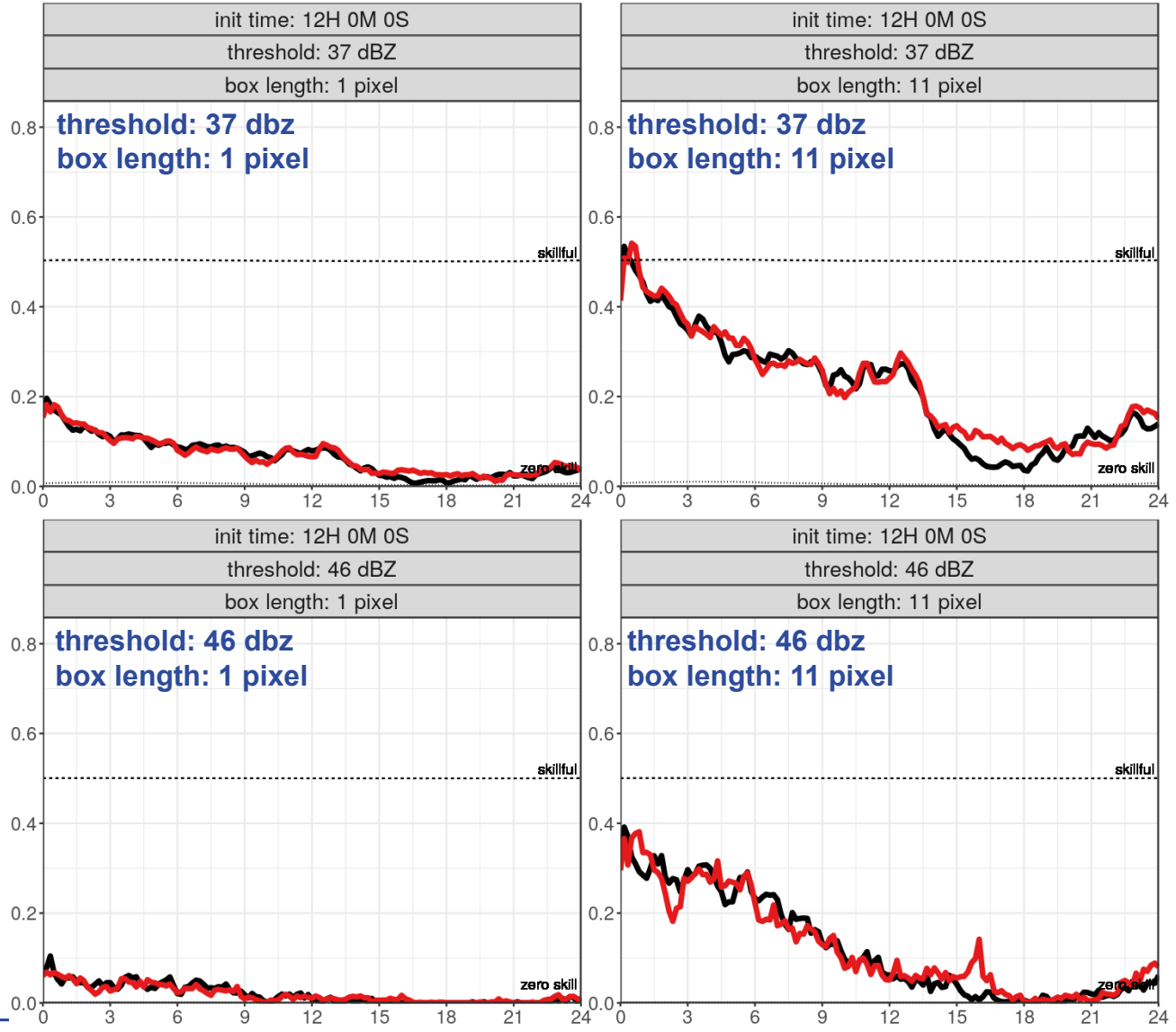
Initial time: 12 UTC

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



— det
 2mom with only qx update
 2mom with qx & qnx update

fss

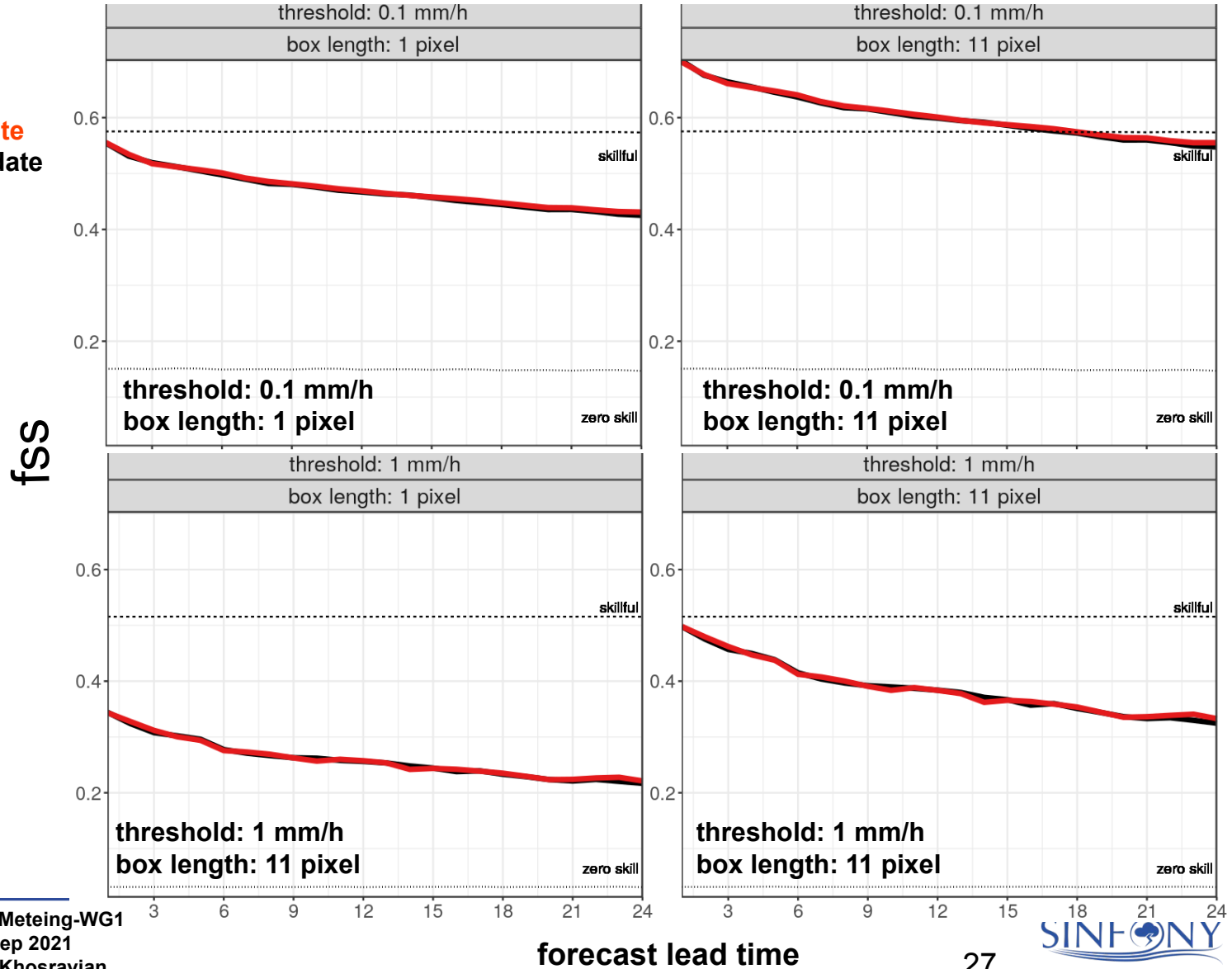


Precipitation verification of 24 hours of forecast runs



— det

2mom with only qx update
2mom with qx & qnx update

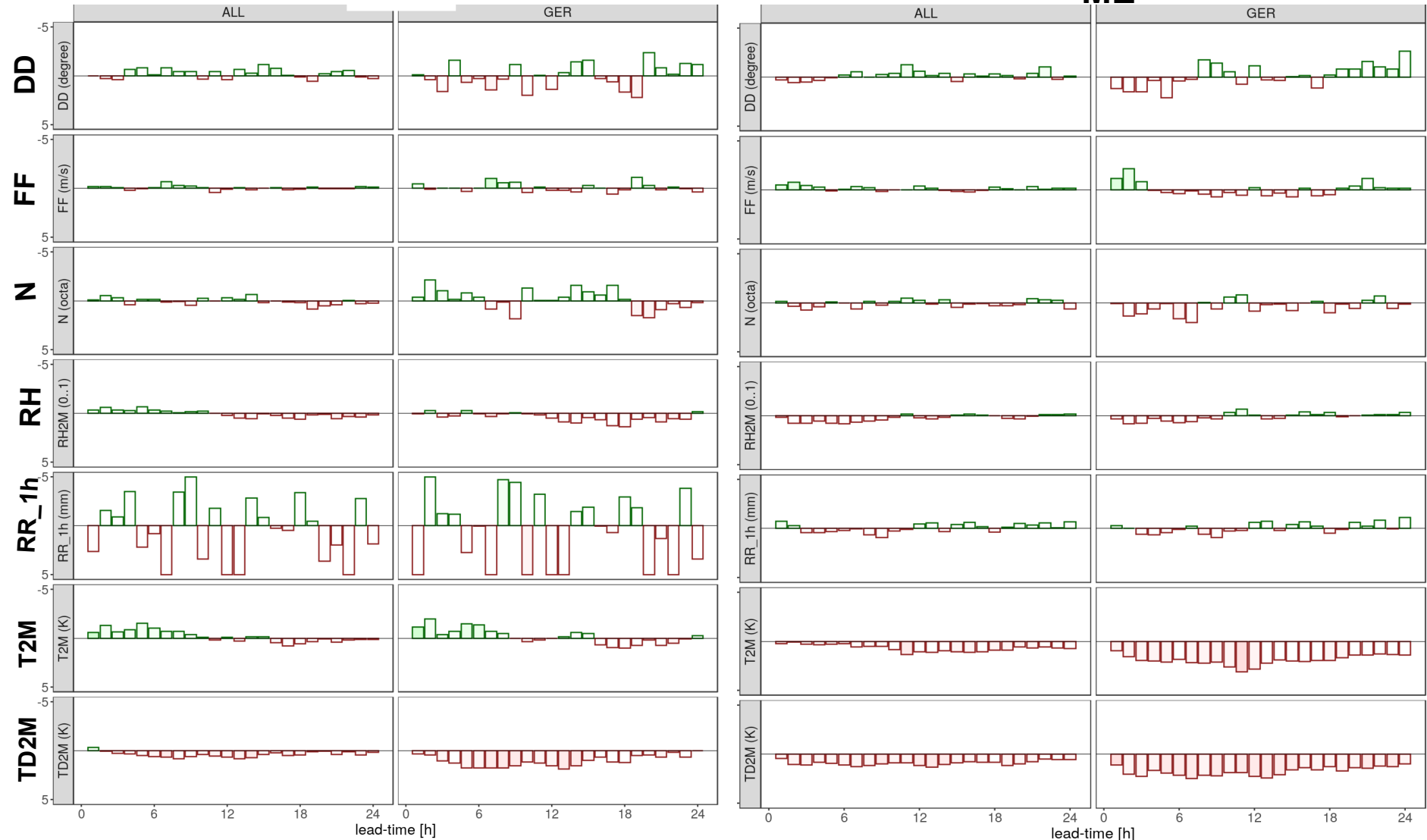


Verification against **SYNOP** observation



RMS

ME



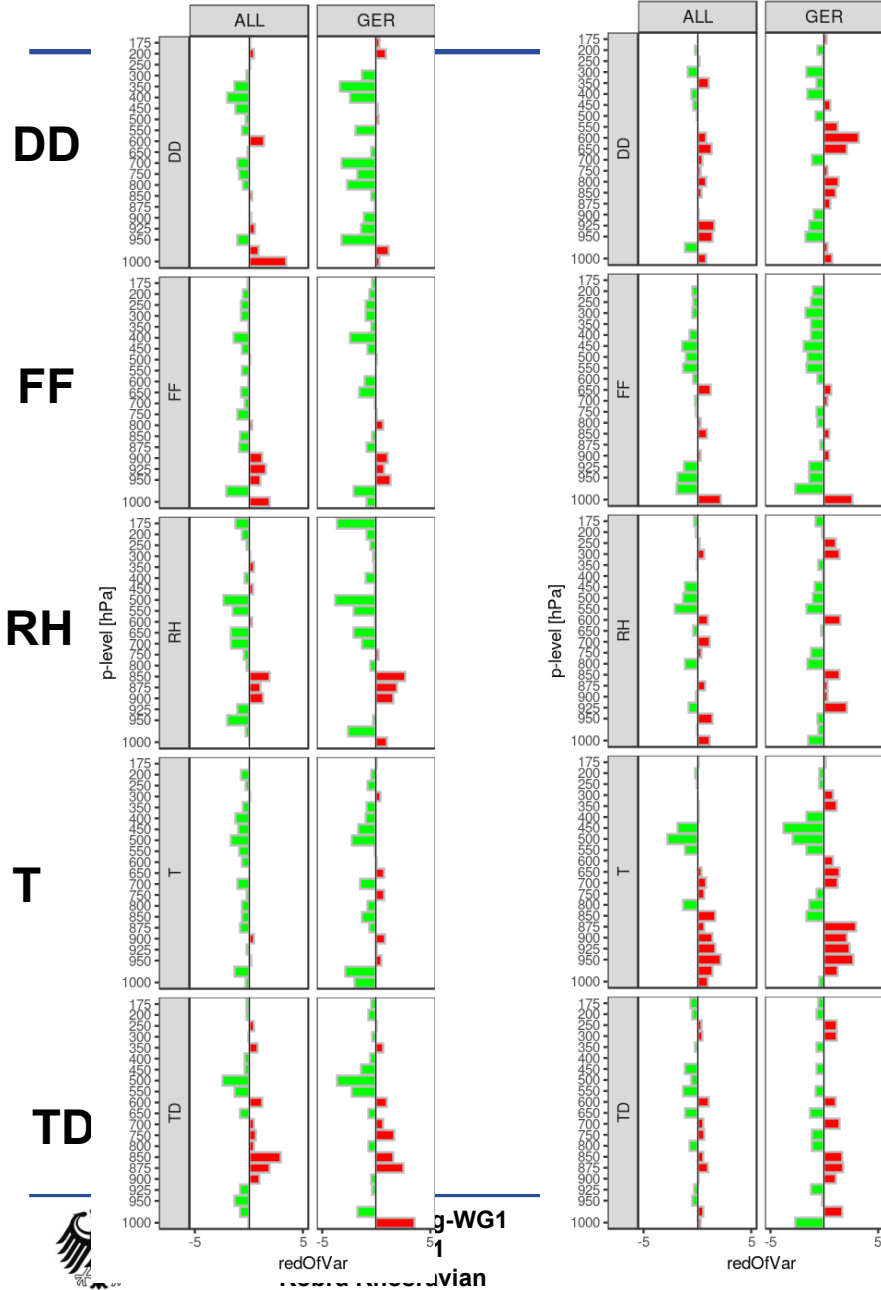
2-mom with only qx update
2-mom with qx & qnx update

Scale: -5 to 5%

Verification against TEMP observation

RMS

ME



2-mom with only qx update
2-mom with qx & qnx update

Scale: -5 to 5%

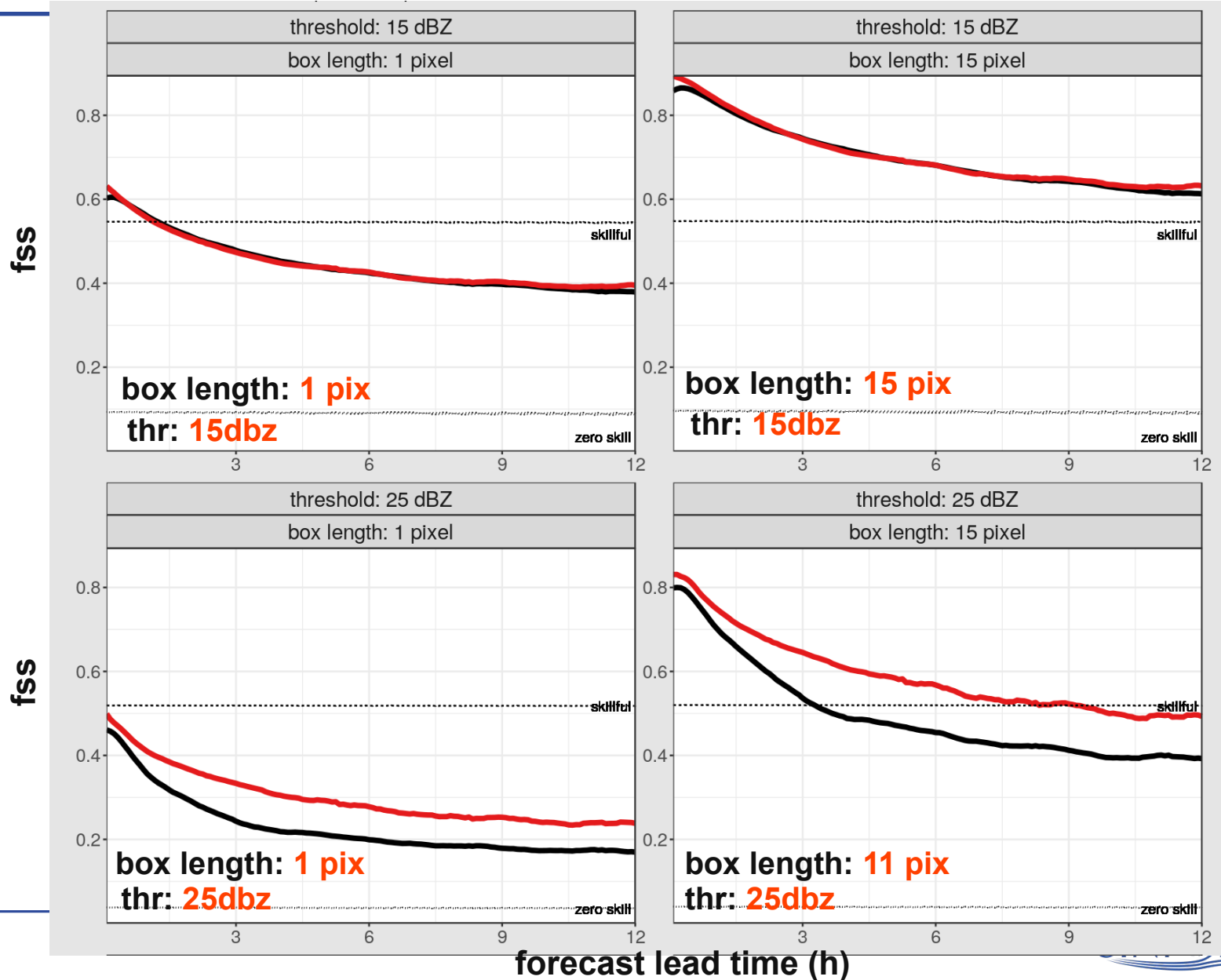
- ◆ **First apply of 2-mom experiments**
- ◆ **The problem of tiny false alarm cells**
 - **Finding the reason of the problem**
 - ✓ The effect of conventional data
 - ✓ The effect of different inflation methods
 - **Trying different solutions**
 - ✓ 2-step assimilation
 - ✓ Updating only hydrometeors and indirect update of qnx
- ◆ **Comparison between 2 Long-term experiments with different 2-mom microphysic setting**

- ◆ 2mom experiment show benefit in capturing higher dbz
- ◆ The long-term results show the benefit of 2mom in dbz verification particularly for the higher dbz. The precipitation verification does not show any improvment after using 2mom particularly for lower precipitation threshold. However, for higher threshold it shows a slight improvement.
- ◆ Indirect update of qnx show a good impact in reducing the tiny false alarm cells; however, it is not a perfect solution
- ◆ Outlook
- ◆ More tuning of 2mom microphysics

Extra slides about the result of Long-term experiments of 1-mom and 2-mom microphysics comparison

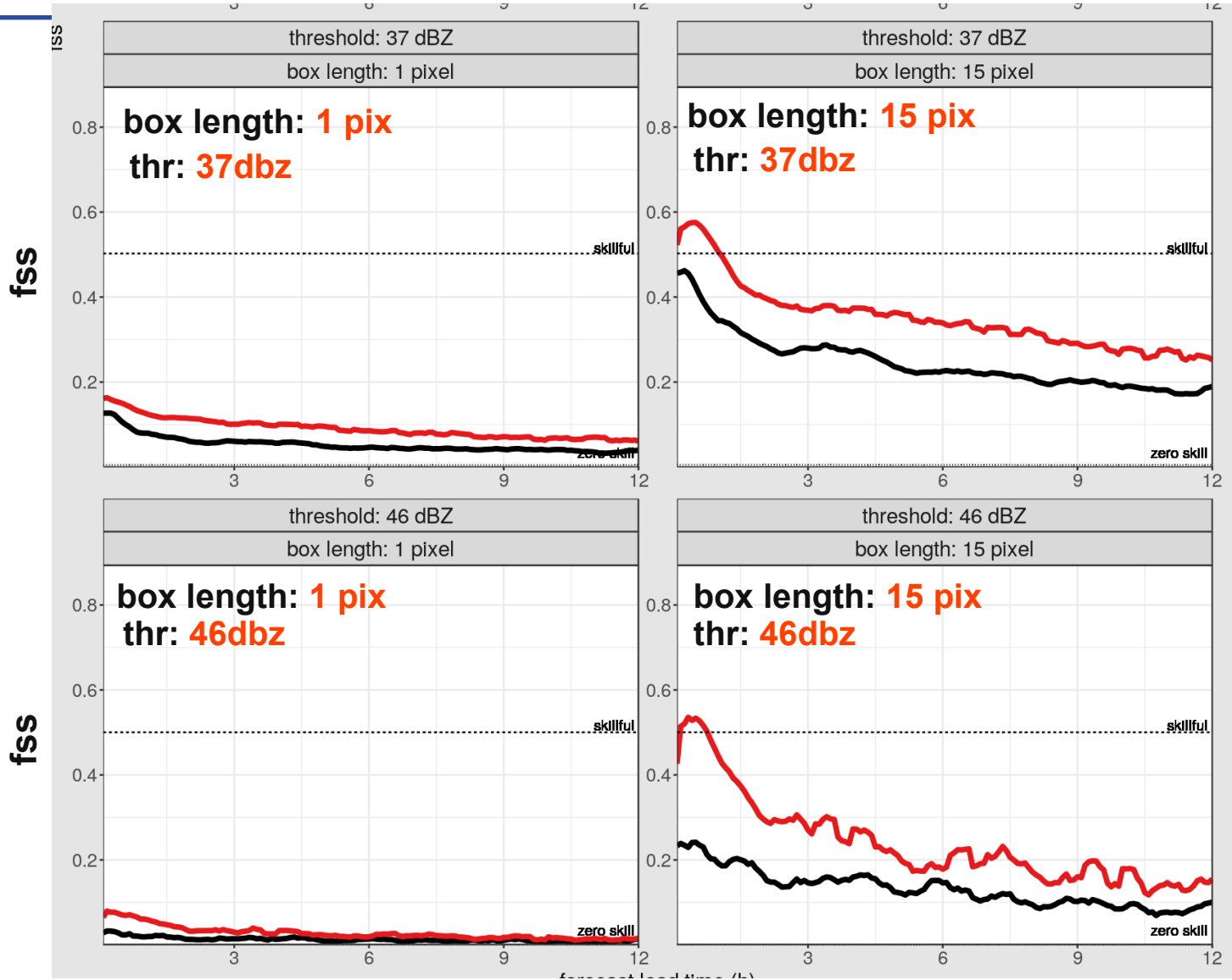
dbz verification (main cycle)

1mom
2mom



dbz verification (main cycle)

1mom
2mom



forecast lead time (h)



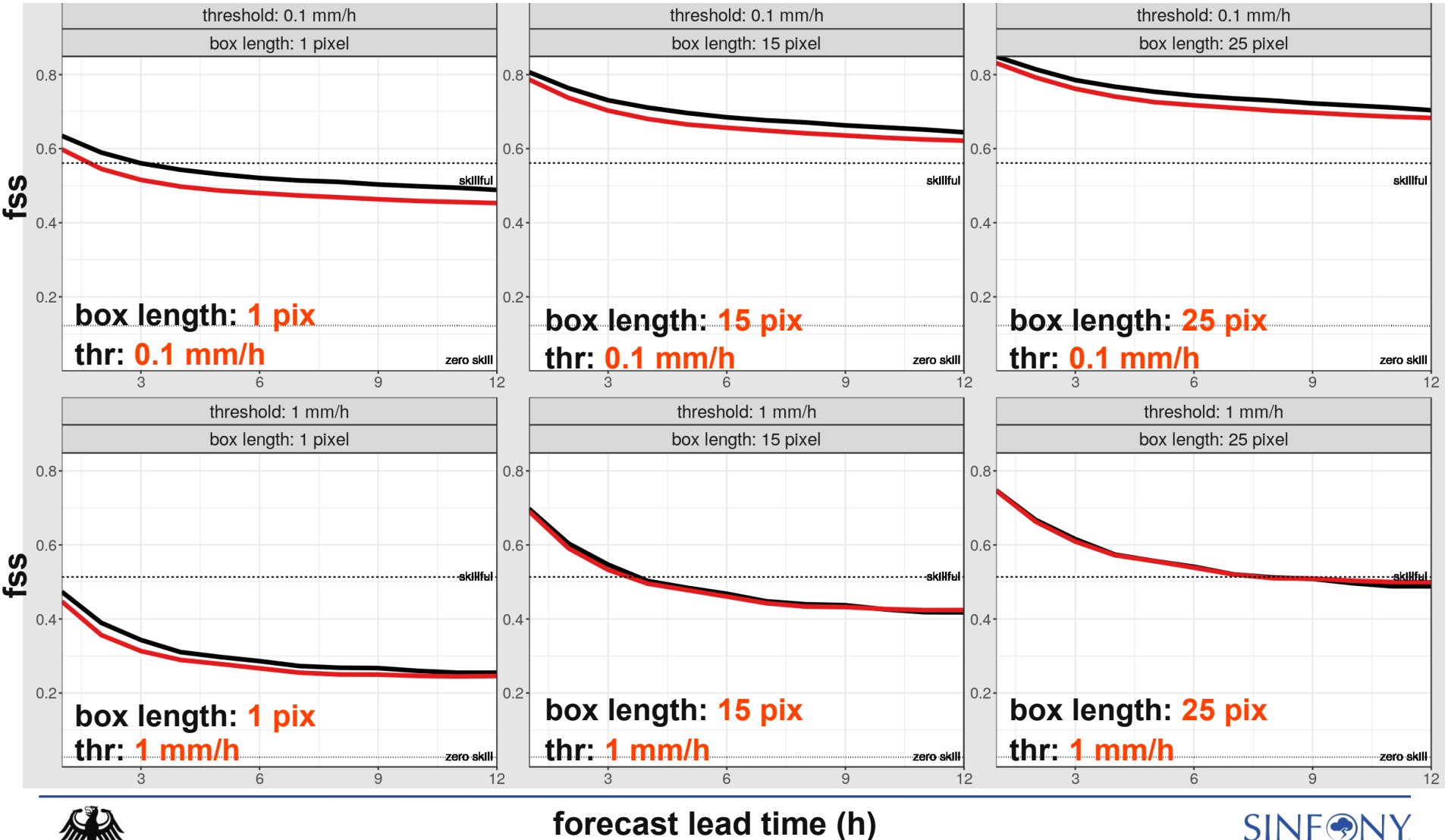
precipitation verification (main cycle)

fss



1mom

2mom



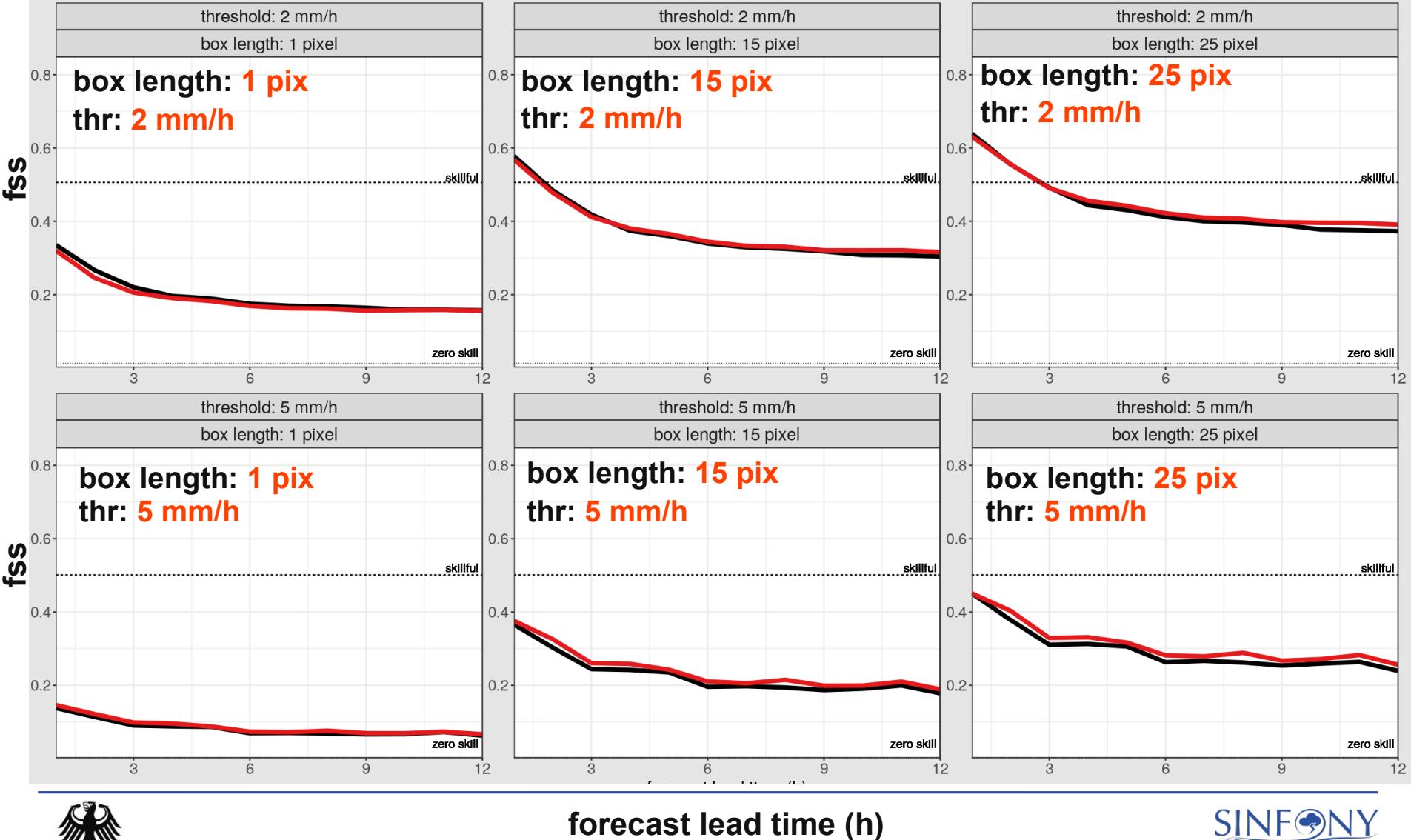
precipitation verification (main cycle)

fss



1mom

2mom



forecast lead time (h)

