

The new operational model setup COSMO-D2 at DWD

ICCARUS seminar
26-28 Feb. 2018, DWD, Offenbach

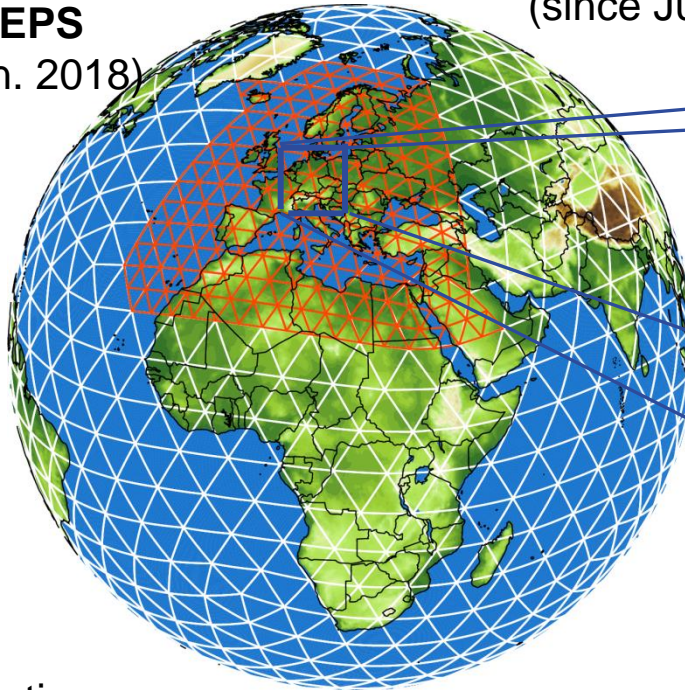
Michael Baldauf, Thomas Hanisch, Helmut Frank, Klaus Stephan,
Barbara Fay, Hendrik Reich, Günther Zängl, Jürgen Helmert (DWD)

further thanks to

Bodo Ritter, Ulrich Schättler, Christoph Gebhardt, Axel Seifert, Felix Fundel,
Christoph Schraff, Michael Buchhold, Jonas von Schumann, Jan-Peter Schulz,
Christian Koziar, Detlev Majewski

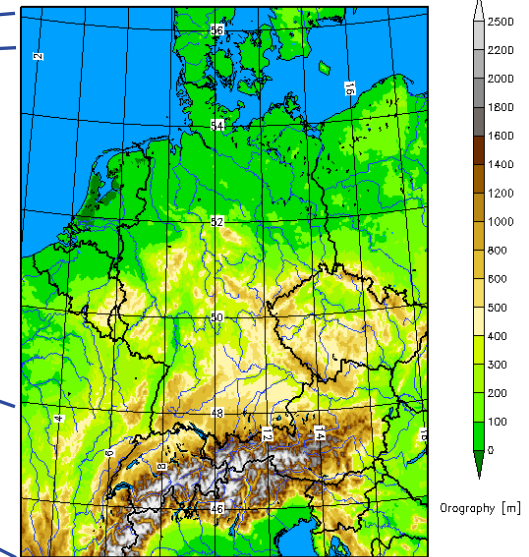
The current operational Model Chain of DWD

ICON
(since Jan. 2015)
ICON-EPS
(since Jan. 2018)



ICON-EU
(since July 2015)

COSMO-DE
and **-EPS** (20 members)
(since April 2007)



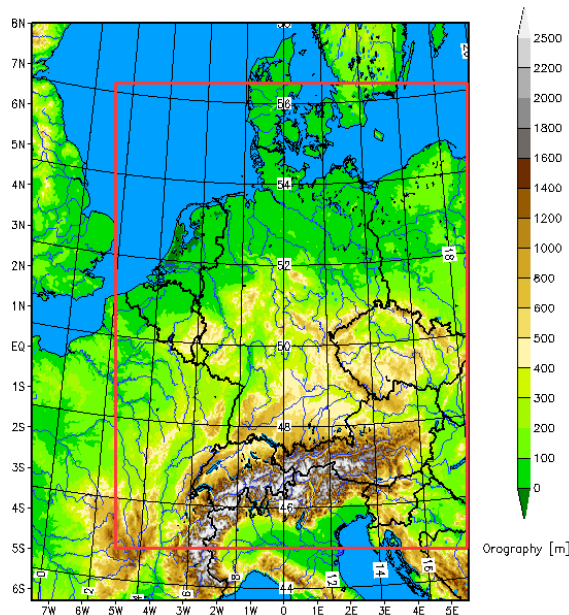
non-hydrostatic
parameterised convection
 $\Delta x \approx 13$ km, $\Delta t = 120$ (24) sec.
2.95 Mio. * 90 GPs
T = 180h (00, 12 UTC runs)
120h (06, 18 UTC runs)

non-hydrostatic
parameterised convection
 $\Delta x \approx 6.5$ km, $\Delta t = 60$ (12) sec.
659156 * 60 GPs
T = 120 h (0, 6, 12, 18 UTC runs)

non-hydrostatic
convection-permitting
 $\Delta x = 2.8$ km, $\Delta t = 25$ sec.
421 * 461 * 50 GPs
T = 27 h (every 3 hrs)

At **DWD**, **COSMO-D2 (-EPS)** will replace the current COSMO-DE (-EPS) by the following changes:

- ➔ increase horizontal grid mesh size from 2.8 km to 2.2 km
- ➔ increase number of vertical levels from 50 to 65
- ➔ increase area from $10.5^\circ * 11.5^\circ$ to $13^\circ * 14.3^\circ$



COSMO-D2: 651 * 716 * 65 GPe
1440 * 1590 * 22 km³

COSMO-DE: 421 * 461 * 50 GPe
1160 * 1280 * 22 km³

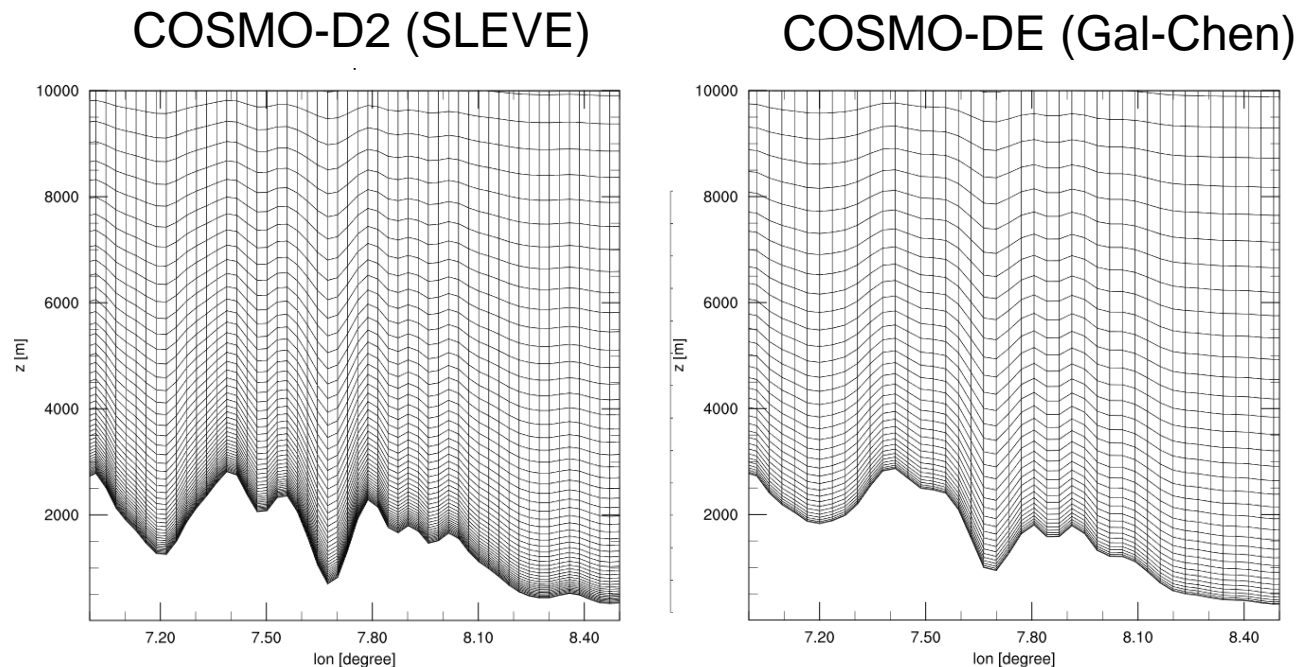
Time schedule:

since 1 June 2017: pre-operational phase

15 May 2018: **operational** introduction

New choice of vertical levels in COSMO-D2:

- increase resolution mainly of the boundary layer
→ motivation: improve initiation of convection
- change from Gal-Chen to SLEVE-coordinate

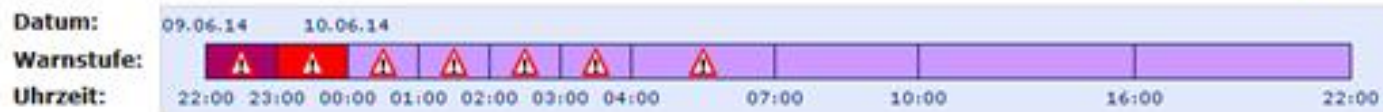


Leuenberger et al. (2010) MWR: SLEVE coord.

Test case: 09.06.2014 ,Düsseldorfer Unwetter‘

From the ,regionaler Sofortbericht‘ of ,Tief Ela‘:

Es sind 5 Warnungen für Soest vorhanden:



Amtliche UNWETTERWARNUNG vor SCHWEREM GEWITTER mit EXTREMEN ORKANBÖEN,
HEFTIGEM STARKREGEN und HAGEL

für Kreis Soest

gültig von: Montag, 09.06.2014 22:01 Uhr

bis: Montag, 09.06.2014 23:00 Uhr

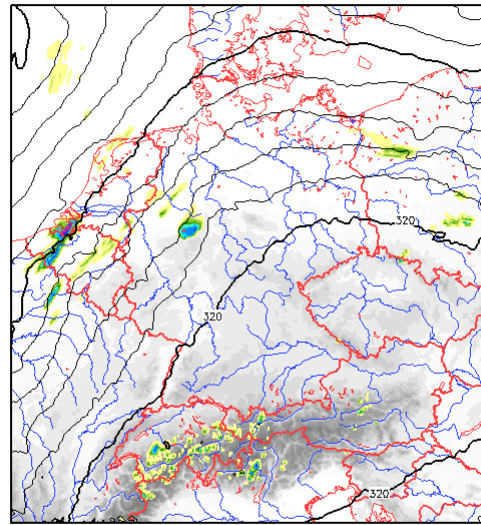
ausgegeben vom Deutschen Wetterdienst

am: Montag, 09.06.2014 22:01 Uhr

Von Westen ziehen Gewitter auf. Dabei gibt es extreme Orkanböen mit Geschwindigkeiten um 140 km/h (39m/s, 76kn, Bft 12+) sowie heftigen Starkregen mit Niederschlagsmengen zwischen 30 l/m² und 40 l/m² pro Stunde und Hagel mit Korngrößen um 3 cm.

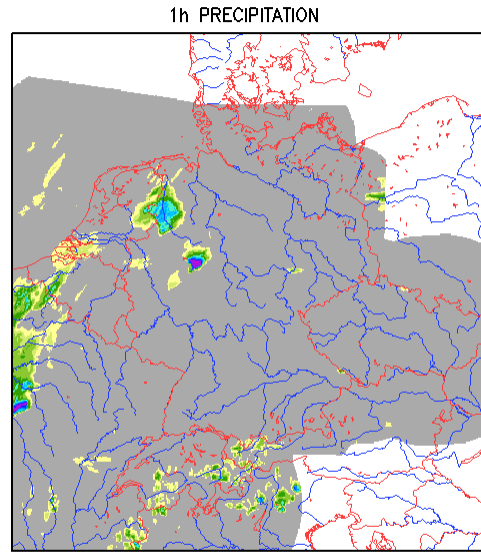
06.09.14, 12 UTC-run, 1h precipitation sum + radar obs. + 2h

Start time: 09.06.2014 12:00 UTC COSMO-DE_Routine
Forecast time: 09.06.2014 14:00 UTC
Total precipitation [mm/1h] (shaded) Geopot. at 700 hPa [gpm] (dist. isol. 1gpm)

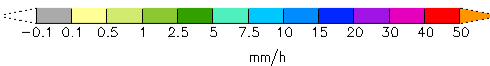


Totprec: Mean: 0.0515743 Min: -0.000244141 Max: 31.1272 Sigma: 0.642235
F1700: Mean: 317.9 Min: 309.836 Max: 321.494 Sigma: 2.83164

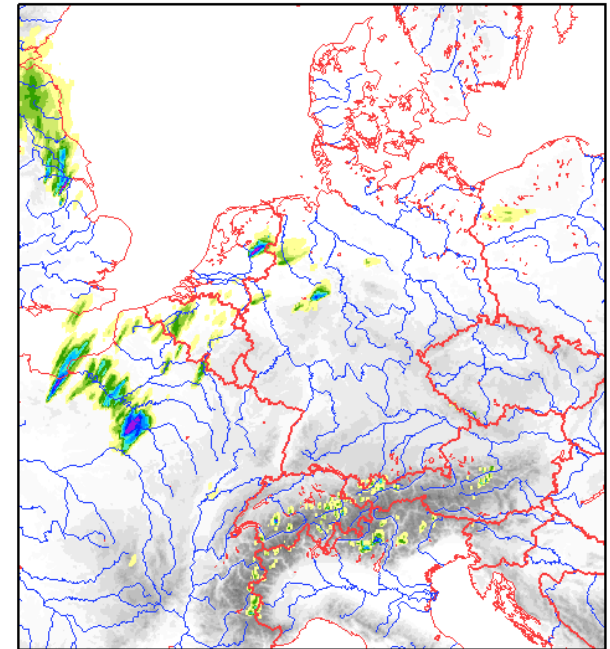
RADAR COMPOSITE
valid: 09 JUN 2014 13 - 14 UTC



Mean: 0.137601 Min: 0 Max: 33.3409



Start time: 09.06.2014 12:00 UTC C-DE 2.2km L65 5.1
Forecast time: 09.06.2014 14:00 UTC
Total precipitation [mm/1h] (shaded)



Totprec: Mean: 0.106616 Min: -0.000488281 Max: 42.3594 Sigma: 0.961952

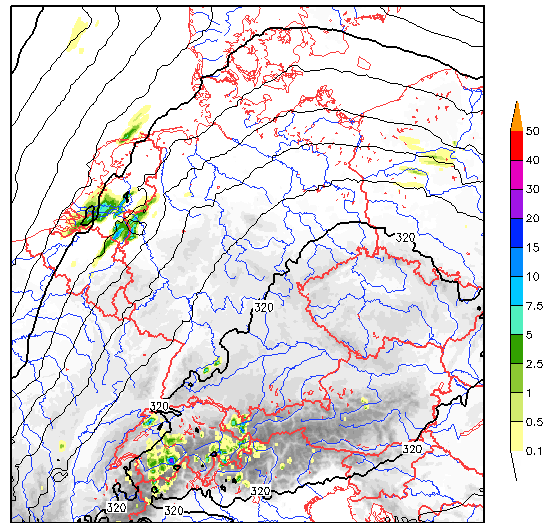
operational
COSMO-DE

Radar

COSMO-D2 setup
(2.2km, L65, ...)

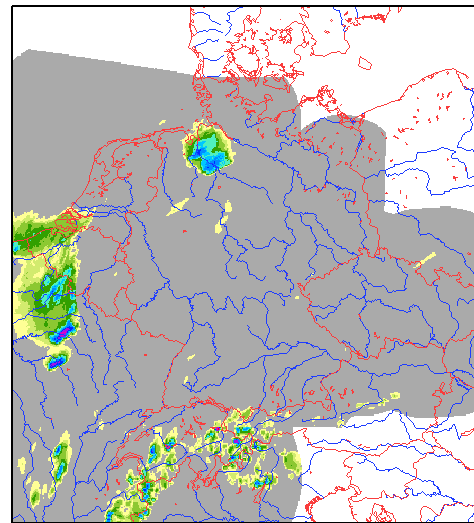
06.09.14, 12 UTC-run, 1h precipitation sum + radar obs. + 4h

Start time: 09.06.2014 12:00 UTC COSMO-DE_Routine
Forecast time: 09.06.2014 16:00 UTC
Total precipitation [mm/1h] (shaded) Geopot. at 700 hPa [gpm] (dist. isol. 1gpm)

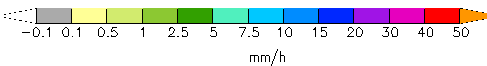


Totprec: Mean: 0.0468751 Min: 0 Max: 31.7891 Sigma: 0.500337
FI700: Mean: 317.595 Min: 309.063 Max: 321.257 Sigma: 2.73649

RADAR COMPOSITE
valid: 09 JUN 2014 15 - 16 UTC
1h PRECIPITATION

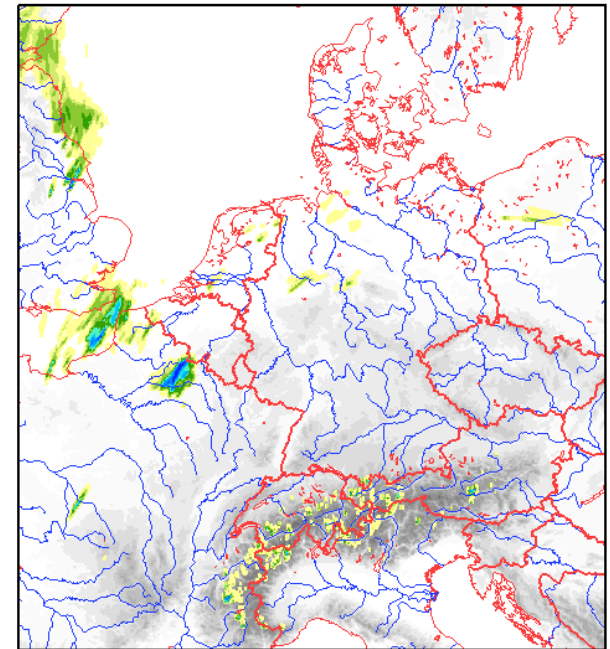


Mean: 0.263899 Min: 0 Max: 41.952



Radar

Start time: 09.06.2014 12:00 UTC C-DE 2.2km L65 5.1
Forecast time: 09.06.2014 16:00 UTC
Total precipitation [mm/1h] (shaded)



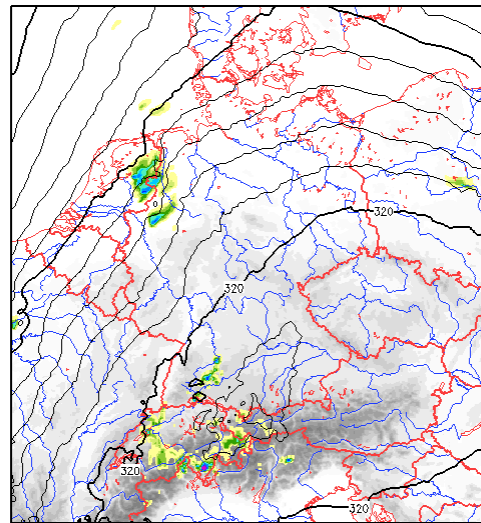
Totprec: Mean: 0.0638758 Min: 0 Max: 25.3975 Sigma: 0.586368

COSMO-D2 setup
(2.2km, L65, ...)

operational
COSMO-DE

06.09.14, 12 UTC-run, 1h precipitation sum + radar obs. + 6h

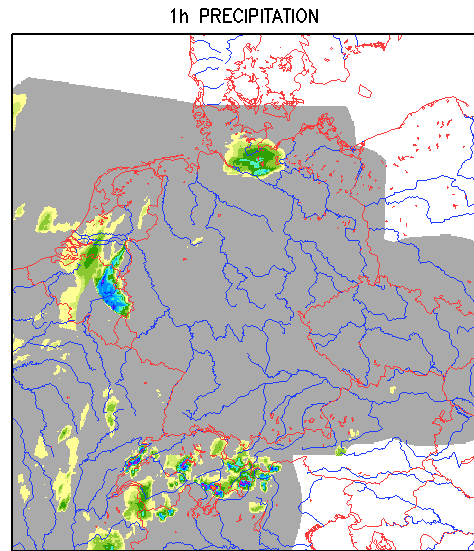
Start time: 09.06.2014 12:00 UTC COSMO-DE_Routine
Forecast time: 09.06.2014 18:00 UTC
Total precipitation [mm/1h] (shaded) Geopot. at 700 hPa [gpm] (dist. isol. 1gpm)



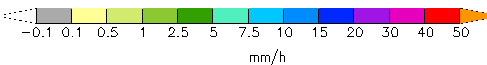
Totprec: Mean: 0.0447192 Min: 0 Max: 38.3994 Sigma: 0.549413
FI700: Mean: 317.984 Min: 309.101 Max: 321.551 Sigma: 2.83498

operational
COSMO-DE

RADAR COMPOSITE
valid: 09 JUN 2014 17 - 18 UTC

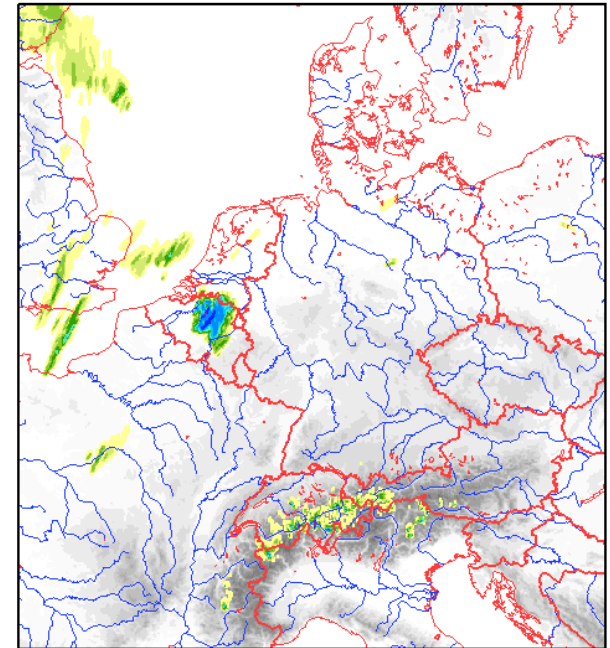


Mean: 0.187798 Min: 0 Max: 75.4816



Radar

Start time: 09.06.2014 12:00 UTC C-DE 2.2km L65 5.1
Forecast time: 09.06.2014 18:00 UTC
Total precipitation [mm/1h] (shaded)

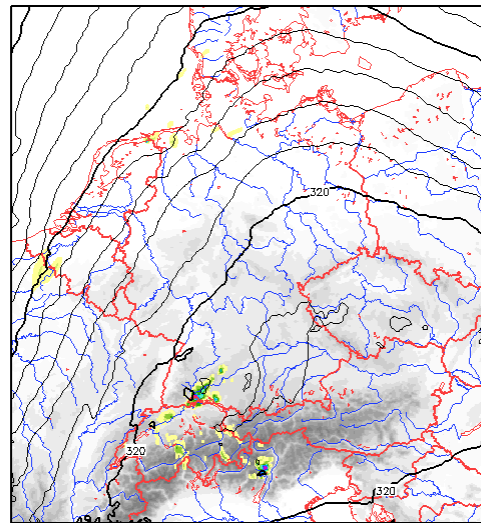


Totprec: Mean: 0.0657431 Min: 0 Max: 44.9941 Sigma: 0.679625

COSMO-D2 setup
(2.2km, L65, ...)

06.09.14, 12 UTC-run, 1h precipitation sum + radar obs. + 8h

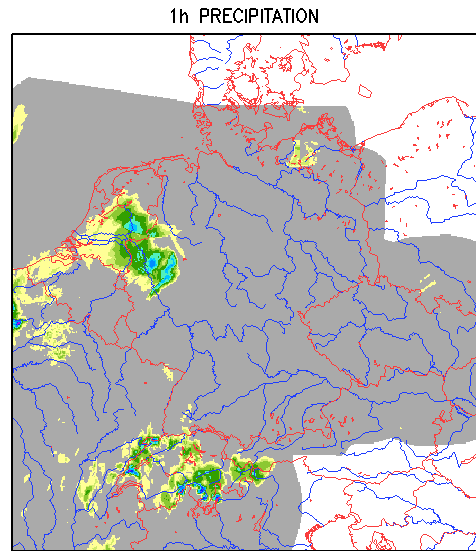
Start time: 09.06.2014 12:00 UTC COSMO-DE_Routine
Forecast time: 09.06.2014 20:00 UTC
Total precipitation [mm/1h] (shaded) Geopot. at 700 hPa [gpm] (dist. isol. 1gpm)



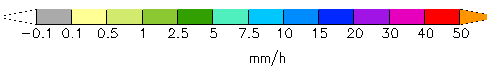
Totprec: Mean: 0.0129784 Min: 0 Max: 33.584 Sigma: 0.330949
FI700: Mean: 318.188 Min: 309.329 Max: 321.454 Sigma: 2.6999

operational
COSMO-DE

RADAR COMPOSITE
valid: 09 JUN 2014 19 - 20 UTC

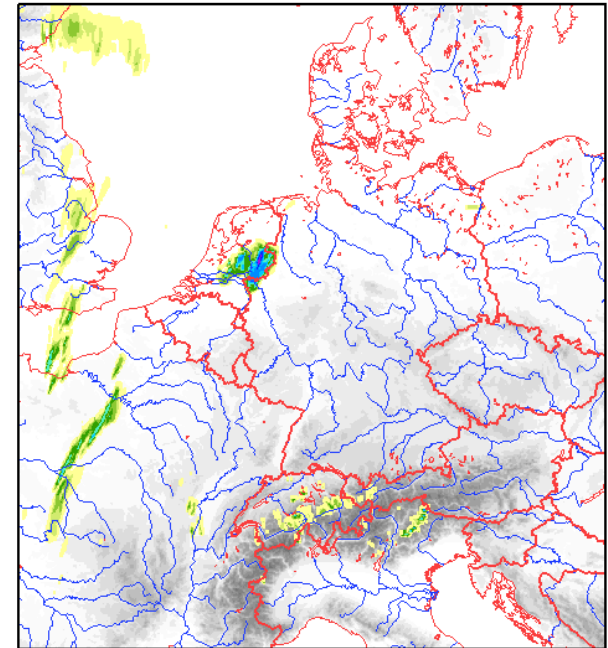


Mean: 0.1536 Min: 0 Max: 27.1446



Radar

Start time: 09.06.2014 12:00 UTC C-DE 2.2km L65 5.1
Forecast time: 09.06.2014 20:00 UTC
Total precipitation [mm/1h] (shaded)

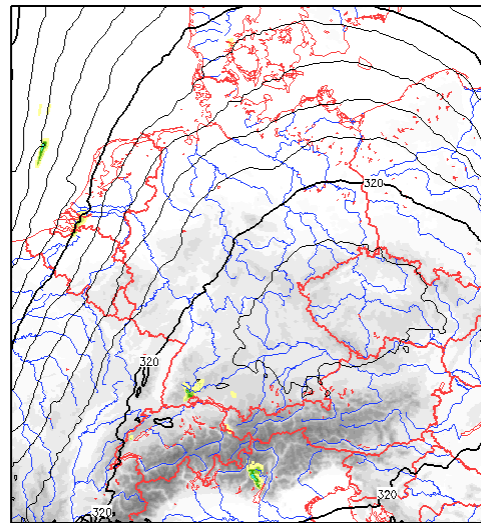


Totprec: Mean: 0.0512751 Min: 0 Max: 23.1084 Sigma: 0.525618

COSMO-D2 setup
(2.2km, L65, ...)

06.09.14, 12 UTC-run, 1h precipitation sum + radar obs. +10h

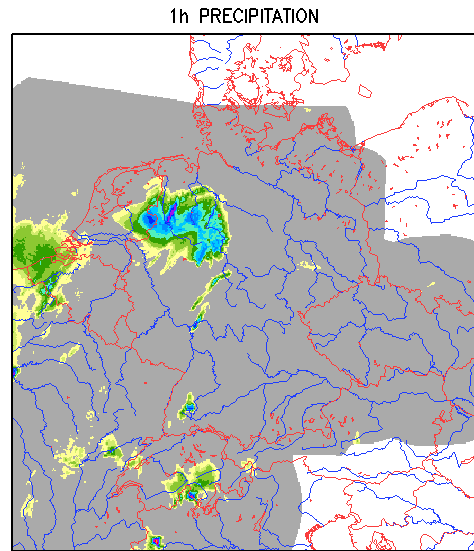
Start time: 09.06.2014 12:00 UTC COSMO-DE_Routine
Forecast time: 09.06.2014 22:00 UTC
Total precipitation [mm/1h] (shaded) Geopot. at 700 hPa [gpm] (dist. isol. 1gpm)



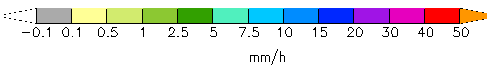
Totprec: Mean: 0.00397445 Min: 0 Max: 6.45898 Sigma: 0.104983
F1700: Mean: 318.332 Min: 309.528 Max: 321.377 Sigma: 2.70015

operational
COSMO-DE

RADAR COMPOSITE
valid: 09 JUN 2014 21 - 22 UTC

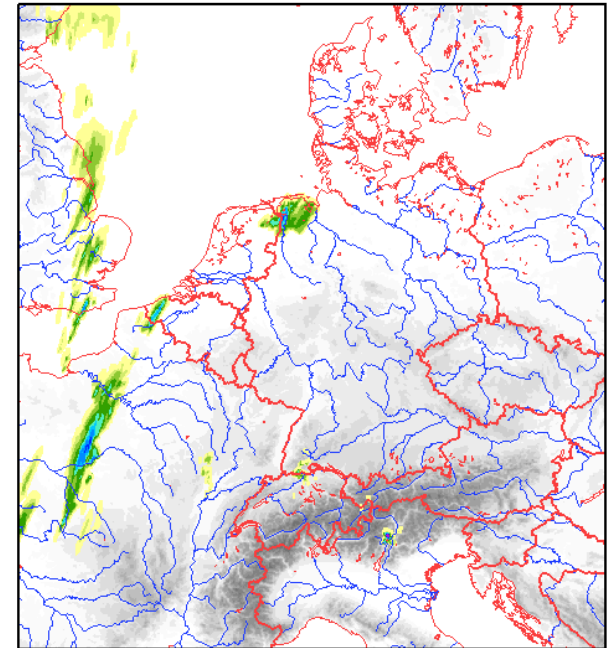


Mean: 0.258078 Min: 0 Max: 56.0343



Radar

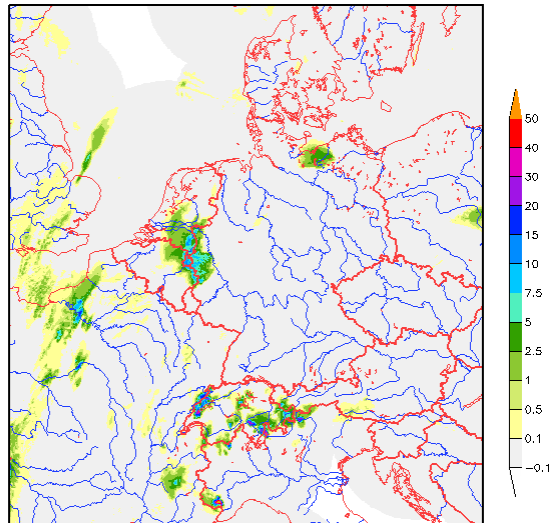
Start time: 09.06.2014 12:00 UTC C-DE 2.2km L65 5.1
Forecast time: 09.06.2014 22:00 UTC
Total precipitation [mm/1h] (shaded)



Totprec: Mean: 0.0659948 Min: 0 Max: 31.4951 Sigma: 0.571627

COSMO-D2 setup
(2.2km, L65, ...)

Radar obs.



Advantage of higher horizontal resolution:

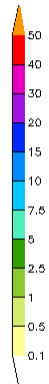
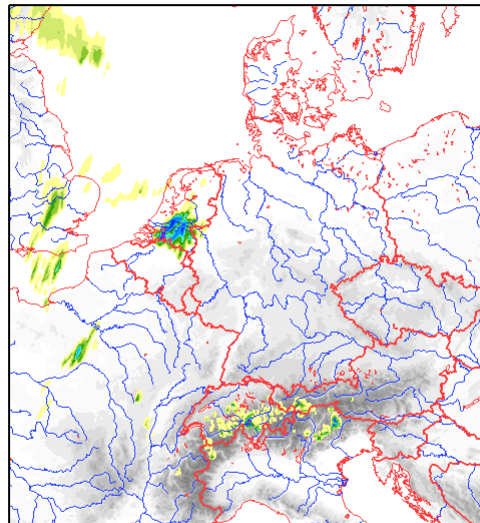
1h precipitation sum

12 UTC + 7h

Start time: 09.06.2014 12:00 UTC
Forecast time: 09.06.2014 19:00 UTC
Total precipitation [mm/1h] (shaded)

C-DE 2.8km L65 5.1

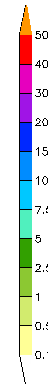
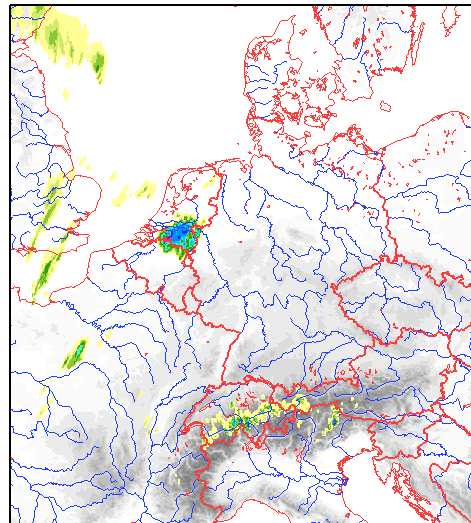
dx=2.8 km



Start time: 09.06.2014 12:00 UTC
Forecast time: 09.06.2014 19:00 UTC
Total precipitation [mm/1h] (shaded)

C-DE 2.2km L65 5.1

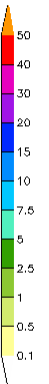
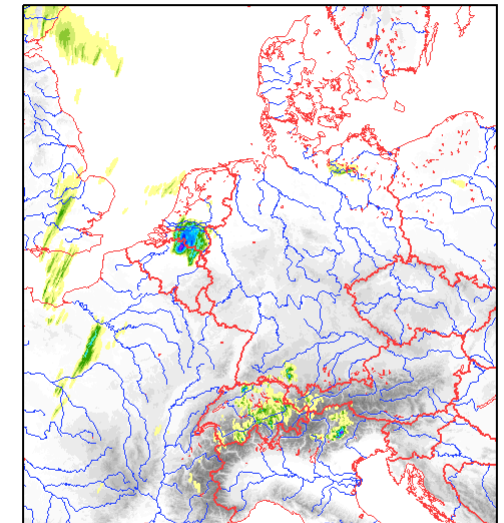
dx=2.2 km



Start time: 09.06.2014 12:00 UTC
Forecast time: 09.06.2014 19:00 UTC
Total precipitation [mm/1h] (shaded)

C-DE 1.1km L65 5.1_Rodnew

dx=1.1 km



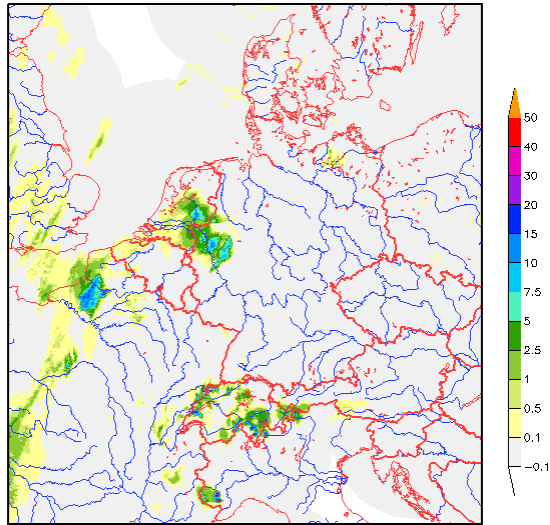
Totprec: Mean: 0.0533321 Min: 0 Max: 34.8086 Sigma: 0.598397

Totprec: Mean: 0.0546045 Min: 0 Max: 32.826 Sigma: 0.605009

Totprec: Mean: 0.0574578 Min: 0 Max: 39.4053 Sigma: 0.614342



Radar obs.



Advantage of higher horizontal resolution:

1h precipitation sum

12 UTC + 8h

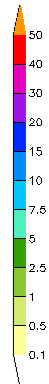
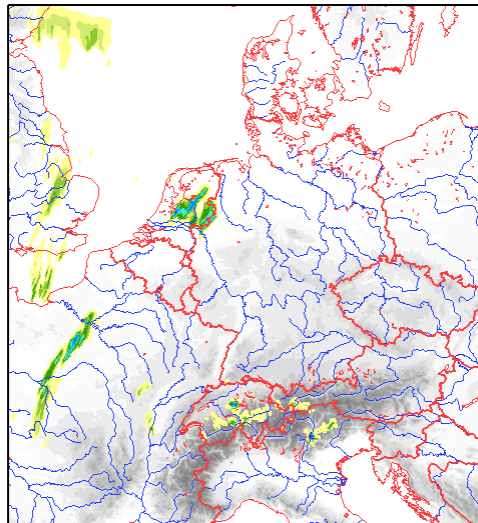
Start time: 09.06.2014 12:00 UTC

C-DE 2.8km L65 5.1

Forecast time: 09.06.2014 20:00 UTC

dx=2.8 km

Total precipitation [mm/1h] (shaded)



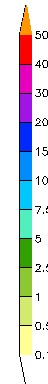
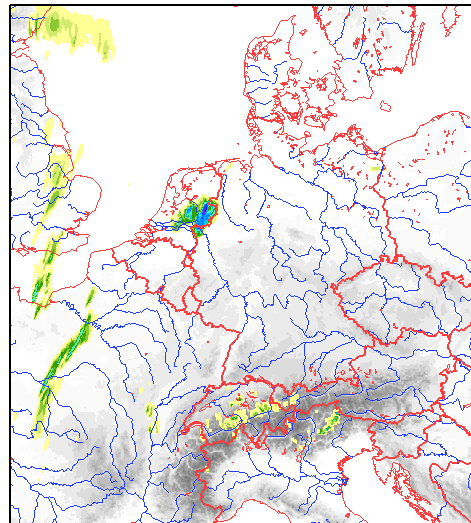
Start time: 09.06.2014 12:00 UTC

C-DE 2.2km L65 5.1

Forecast time: 09.06.2014 20:00 UTC

dx=2.2 km

Total precipitation [mm/1h] (shaded)



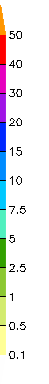
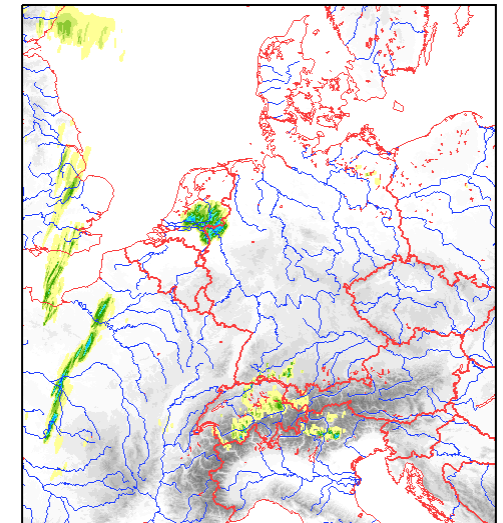
Start time: 09.06.2014 12:00 UTC

C-DE 1.1km L65 5.1_Rodnew

Forecast time: 09.06.2014 20:00 UTC

dx=1.1 km

Total precipitation [mm/1h] (shaded)

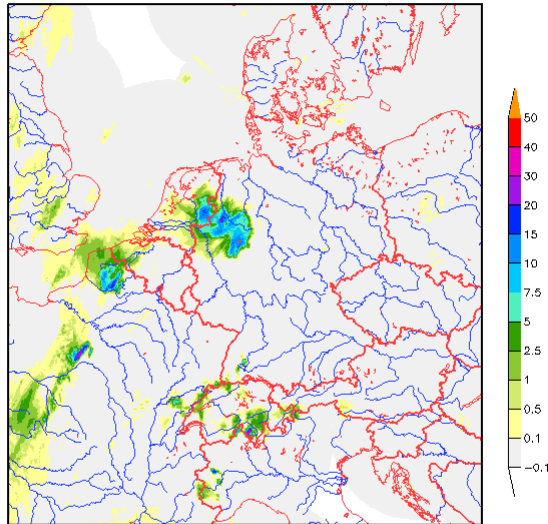


Totprec: Mean: 0.0512751 Min: 0 Max: 23.1084 Sigma: 0.525618

Totprec: Mean: 0.047712 Min: 0 Max: 27.0449 Sigma: 0.472518

Totprec: Mean: 0.053798 Min: 0 Max: 32.0527 Sigma: 0.490882





Advantage of horizontal resolution:

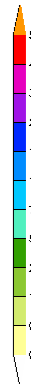
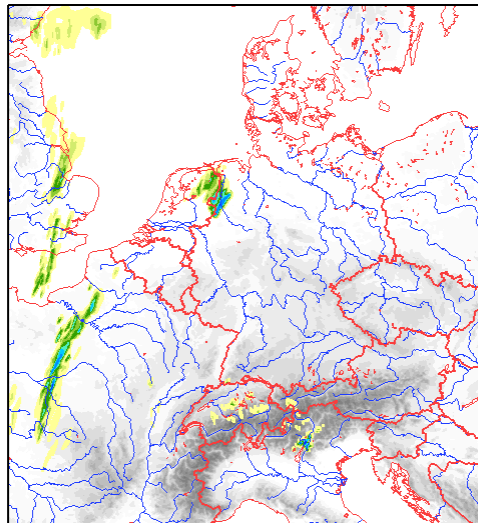
1h precipitation sum

12 UTC + 9h

Start time: 09.06.2014 12:00 UTC
 Forecast time: 09.06.2014 21:00 UTC
 Total precipitation [mm/1h] (shaded)

C-DE 2.8km L65 5.1

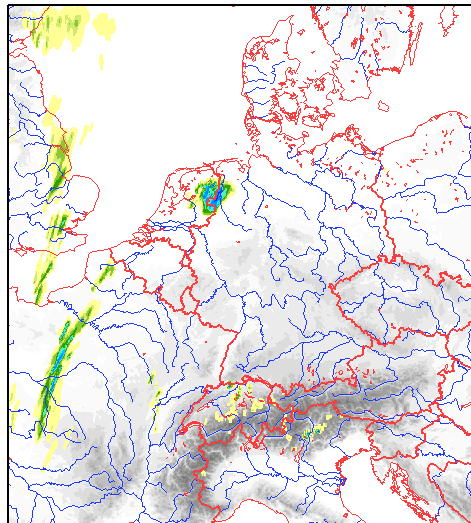
dx=2.8 km



Start time: 09.06.2014 12:00 UTC
 Forecast time: 09.06.2014 21:00 UTC
 Total precipitation [mm/1h] (shaded)

C-DE 2.2km L65 5.1_Rodnew

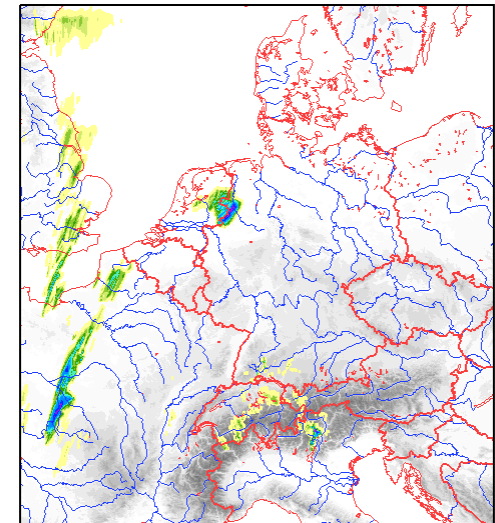
dx=2.2 km



Start time: 09.06.2014 12:00 UTC
 Forecast time: 09.06.2014 21:00 UTC
 Total precipitation [mm/1h] (shaded)

C-DE 1.1km L65 5.1_Rodnew

dx=1.1 km



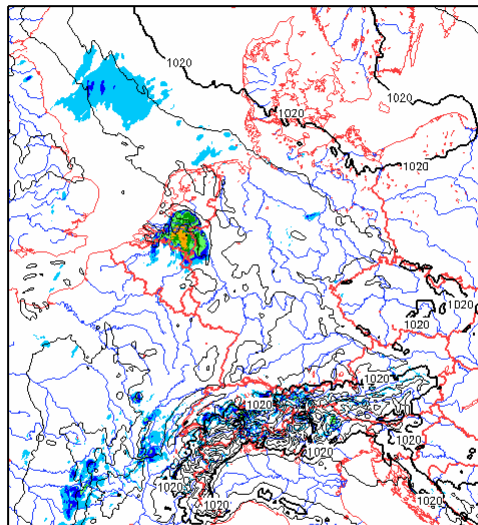
Advantage of horizontal resolution:

Gusts

12 UTC + 7h

dx=2.8 km

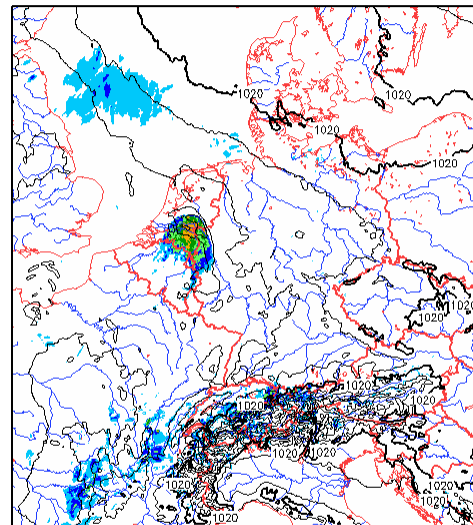
Start time: 09.06.2014 12:00 UTC C-DE 2.8km L65 5.1
Forecast time: 09.06.2014 19:00 UTC
max |v| in 10 m [m/s] (shaded) MSL Pressure [hPa] (dist. isol.2.0hPa)



vmax_10m:	Mean: 5.97632	Min: 0.149542	Max: 30.3829	Sigma: 2.86182
PMSL:	Mean: 1017.75	Min: 1012.24	Max: 1030.91	Sigma: 2.64373

dx=2.2 km

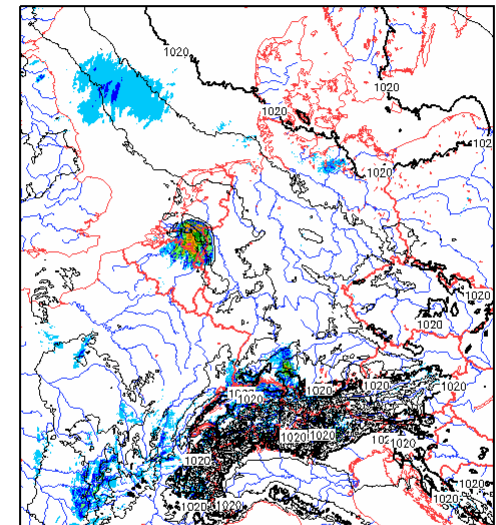
Start time: 09.06.2014 12:00 UTC C-DE 2.2km L65 5.1
Forecast time: 09.06.2014 19:00 UTC
max |v| in 10 m [m/s] (shaded) MSL Pressure [hPa] (dist. isol. 2.0 hPa)



vmax_10m:	Mean: 5.99232	Min: 0.21632	Max: 30.2339	Sigma: 2.90324
PMSL:	Mean: 1017.78	Min: 1012.17	Max: 1031.47	Sigma: 2.86087

dx=1.1 km

Start time: 09.06.2014 12:00 UTC C-DE 1.1km L65 5.1_Radnew
Forecast time: 09.06.2014 19:00 UTC
max |v| in 10 m [m/s] (shaded) MSL Pressure [hPa] (dist. isol.2.0hPa)



vmax_10m:	Mean: 6.04681	Min: 0.142141	Max: 34.8267	Sigma: 3.00713
PMSL:	Mean: 1017.82	Min: 1012.27	Max: 1031.29	Sigma: 2.62455

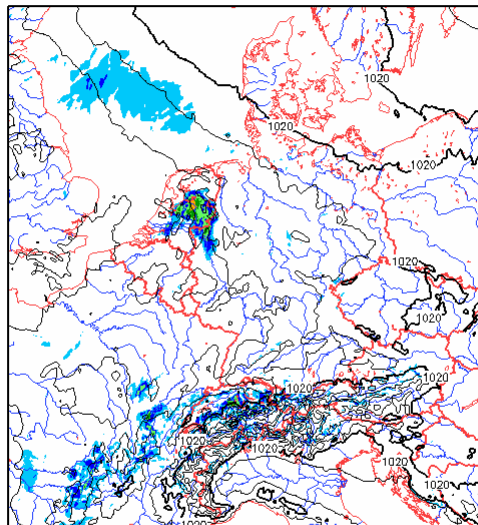
Advantage of horizontal resolution:

Gusts

12 UTC + 8h

dx=2.8 km

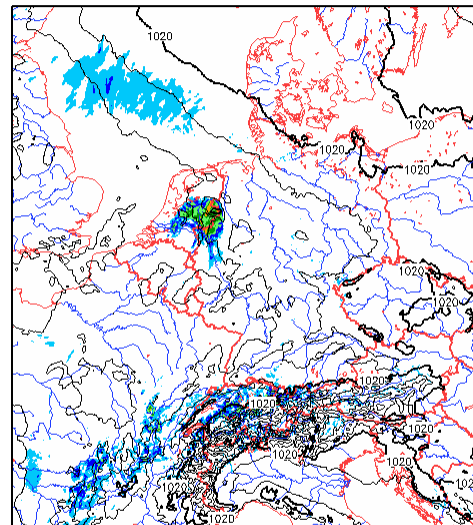
Start time: 09.06.2014 12:00 UTC C-DE 2.8km L65 5.1
Forecast time: 09.06.2014 20:00 UTC
max |v| in 10 m [m/s] (shaded) MSL Pressure [hPa] (dist. isol.2.0hPa)



vmax_10m:	Mean: 5.94722	Min: 0.202422	Max: 29.0867	Sigma: 2.84161
PMSL:	Mean: 1017.96	Min: 1012.54	Max: 1030.98	Sigma: 2.50859

dx=2.2 km

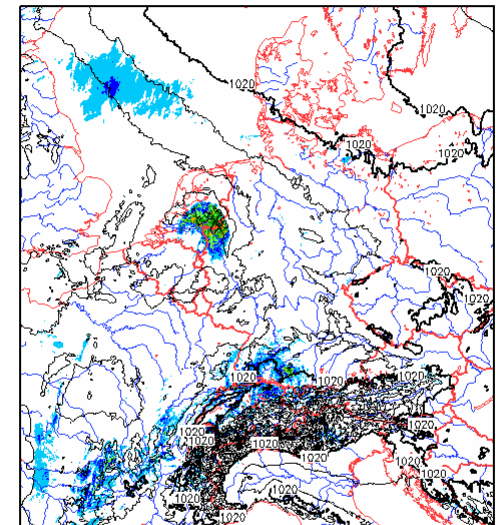
Start time: 09.06.2014 12:00 UTC C-DE 2.2km L65 5.1
Forecast time: 09.06.2014 20:00 UTC
max |v| in 10 m [m/s] (shaded) MSL Pressure [hPa] (dist. isol. 2.0 hPa)



vmax_10m:	Mean: 5.92489	Min: 0.206287	Max: 29.5232	Sigma: 2.87594
PMSL:	Mean: 1017.98	Min: 1012.52	Max: 1031.04	Sigma: 2.53299

dx=1.1 km

Start time: 09.06.2014 12:00 UTC C-DE 1.1km L65 5.1_Radnex
Forecast time: 09.06.2014 20:00 UTC
max |v| in 10 m [m/s] (shaded) MSL Pressure [hPa] (dist. isol.2.0hPa)



vmax_10m:	Mean: 5.90282	Min: 0.147533	Max: 33.6358	Sigma: 2.98159
PMSL:	Mean: 1018.02	Min: 1012.15	Max: 1031.4	Sigma: 2.52503

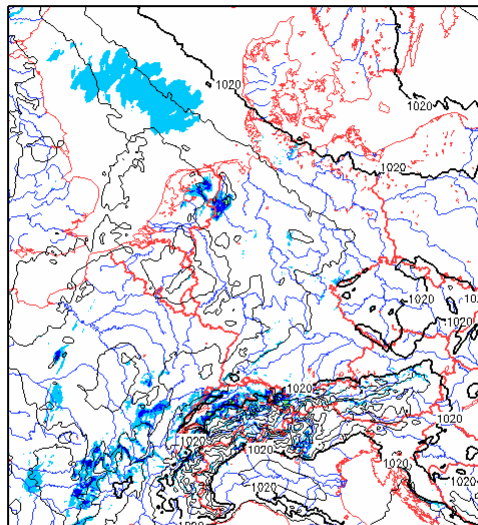
Advantage of horizontal resolution:

12 UTC + 9h

Gusts

dx=2.8 km

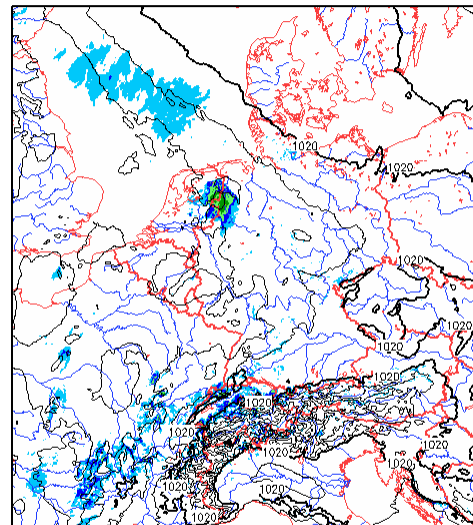
Start time: 09.06.2014 12:00 UTC C-DE 2.8km L65 5.1
Forecast time: 09.06.2014 21:00 UTC
max |v| in 10 m [m/s] (shaded) MSL Pressure [hPa] (dist. isol.2.0hPa)



vmax_10m: Mean: 5.64814 Min: 0.234328 Max: 23.1435 Sigma: 2.78202
PMSL: Mean: 1018.24 Min: 1012.86 Max: 1030.01 Sigma: 2.5385

dx=2.2 km

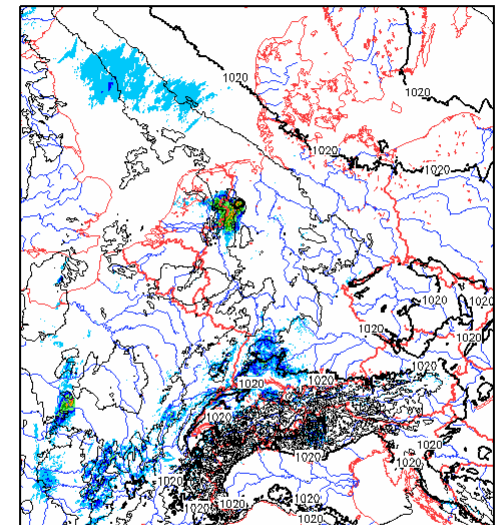
Start time: 09.06.2014 12:00 UTC C-DE 2.2km L65 5.1
Forecast time: 09.06.2014 21:00 UTC
max |v| in 10 m [m/s] (shaded) MSL Pressure [hPa] (dist. isol. 2.0 hPa)



vmax_10m: Mean: 5.85177 Min: 0.153197 Max: 26.4135 Sigma: 2.86391
PMSL: Mean: 1018.26 Min: 1012.9 Max: 1030.46 Sigma: 2.57371

dx=1.1 km

Start time: 09.06.2014 12:00 UTC C-DE 1.1km L65 5.1_Radnew
Forecast time: 09.06.2014 21:00 UTC
max |v| in 10 m [m/s] (shaded) MSL Pressure [hPa] (dist. isol.2.0hPa)



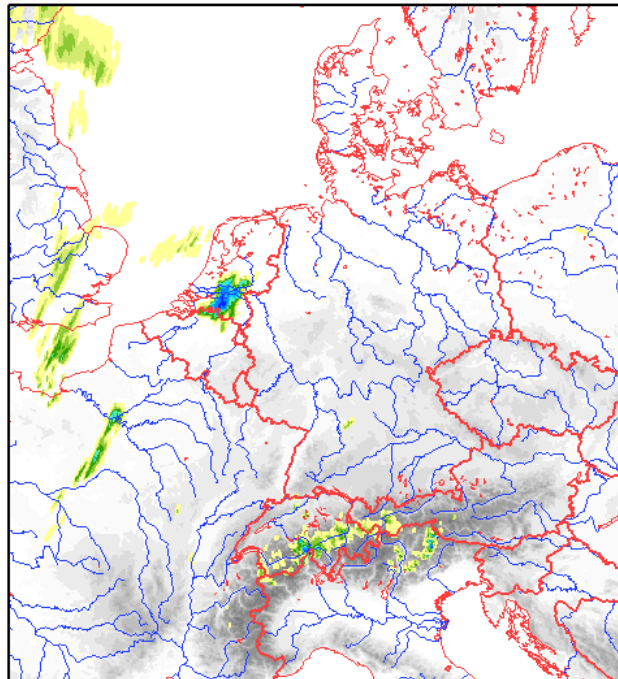
vmax_10m: Mean: 5.80167 Min: 0.117333 Max: 37.2062 Sigma: 2.99677
PMSL: Mean: 1018.27 Min: 1012.79 Max: 1031.81 Sigma: 2.60408

Advantage of increase of # Levels

12 UTC + 7h

Start time: 09.06.2014 12:00 UTC C-DE 2.2km L50 5.1
Forecast time: 09.06.2014 19:00 UTC
Total precipitation [mm/1h] (shaded)

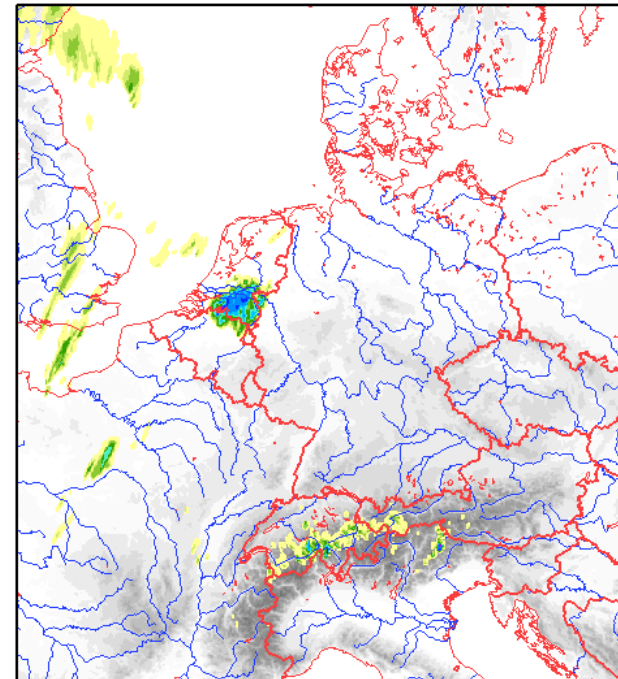
L50



Totprec: Mean: 0.0484582 Min: 0 Max: 28.3379 Sigma: 0.50431

Start time: 09.06.2014 12:00 UTC C-DE 2.2km L65 5.1
Forecast time: 09.06.2014 19:00 UTC
Total precipitation [mm/1h] (shaded)

L65



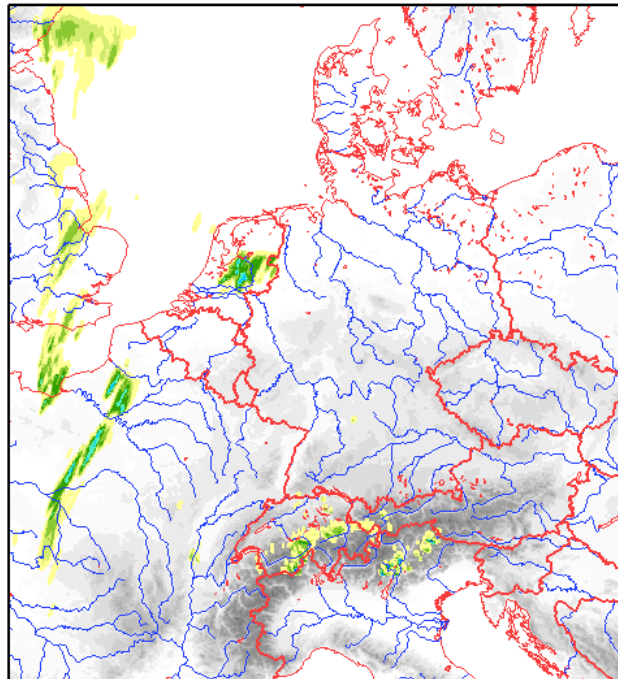
Totprec: Mean: 0.0533321 Min: 0 Max: 34.8086 Sigma: 0.598397

Advantage of increase of # Levels

12 UTC + 8h

Start time: 09.06.2014 12:00 UTC C-DE 2.2km L50 5.1
Forecast time: 09.06.2014 20:00 UTC
Total precipitation [mm/1h] (shaded)

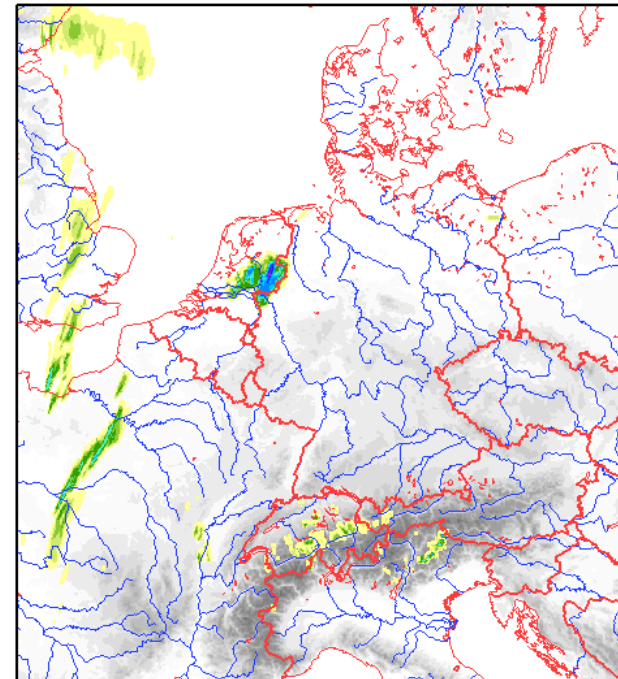
L50



Totprec: Mean: 0.0466139 Min: 0 Max: 35.1055 Sigma: 0.39507

Start time: 09.06.2014 12:00 UTC C-DE 2.2km L65 5.1
Forecast time: 09.06.2014 20:00 UTC
Total precipitation [mm/1h] (shaded)

L65



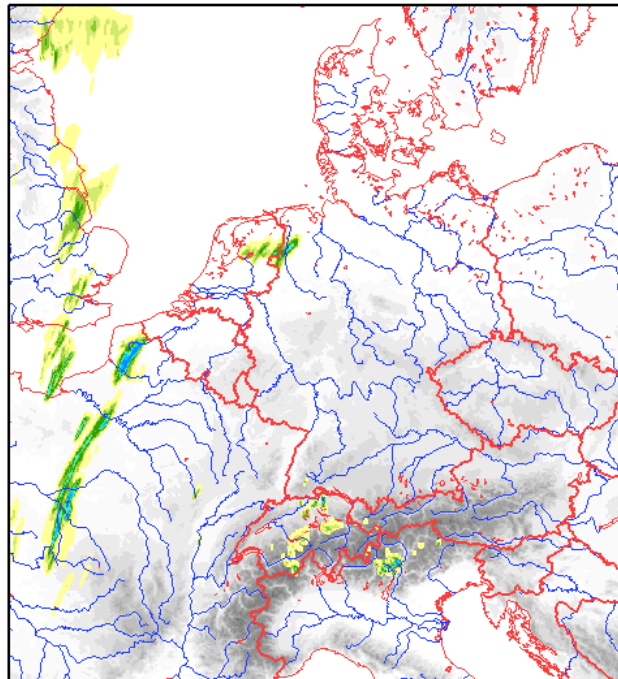
Totprec: Mean: 0.0512751 Min: 0 Max: 23.1084 Sigma: 0.525618

Advantage of increase of # Levels

12 UTC + 9h

Start time: 09.06.2014 12:00 UTC C-DE 2.2km L50 5.1
Forecast time: 09.06.2014 21:00 UTC
Total precipitation [mm/1h] (shaded)

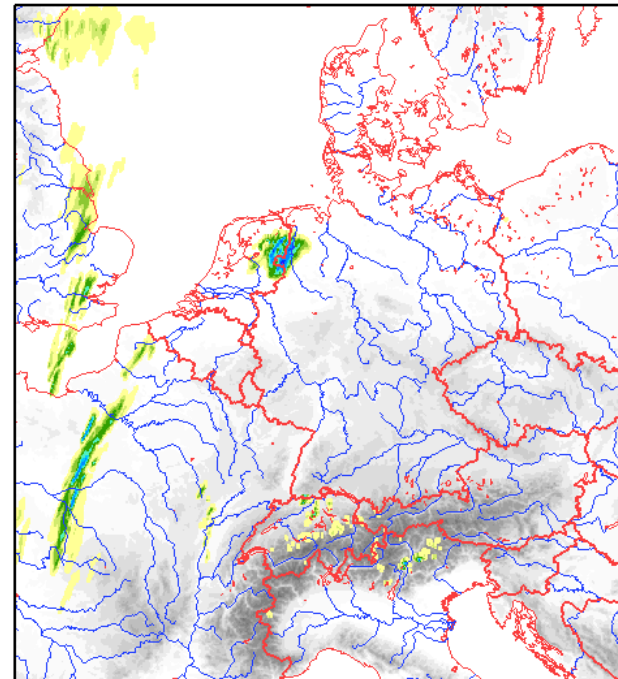
L50



Totprec: Mean: 0.0521431 Min: 0 Max: 22.5879 Sigma: 0.46961

Start time: 09.06.2014 12:00 UTC C-DE 2.2km L65 5.1
Forecast time: 09.06.2014 21:00 UTC
Total precipitation [mm/1h] (shaded)

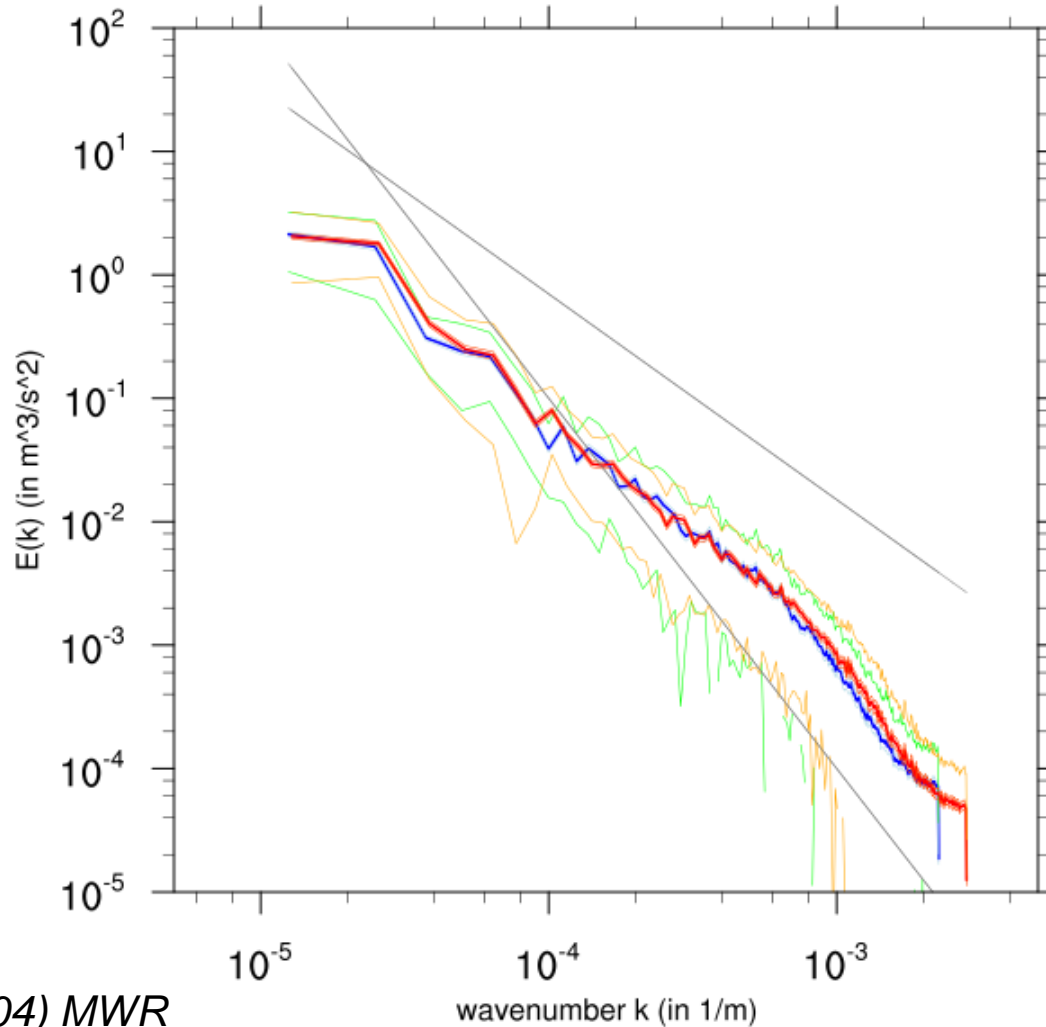
L65



Totprec: Mean: 0.0561208 Min: 0 Max: 20.2354 Sigma: 0.536436

Power spectra of kinetic energy

2017081500 +0h in z=5000m



KE spectra

COSMO-D2

COSMO-DE

SW-inflow,
some heavy showers

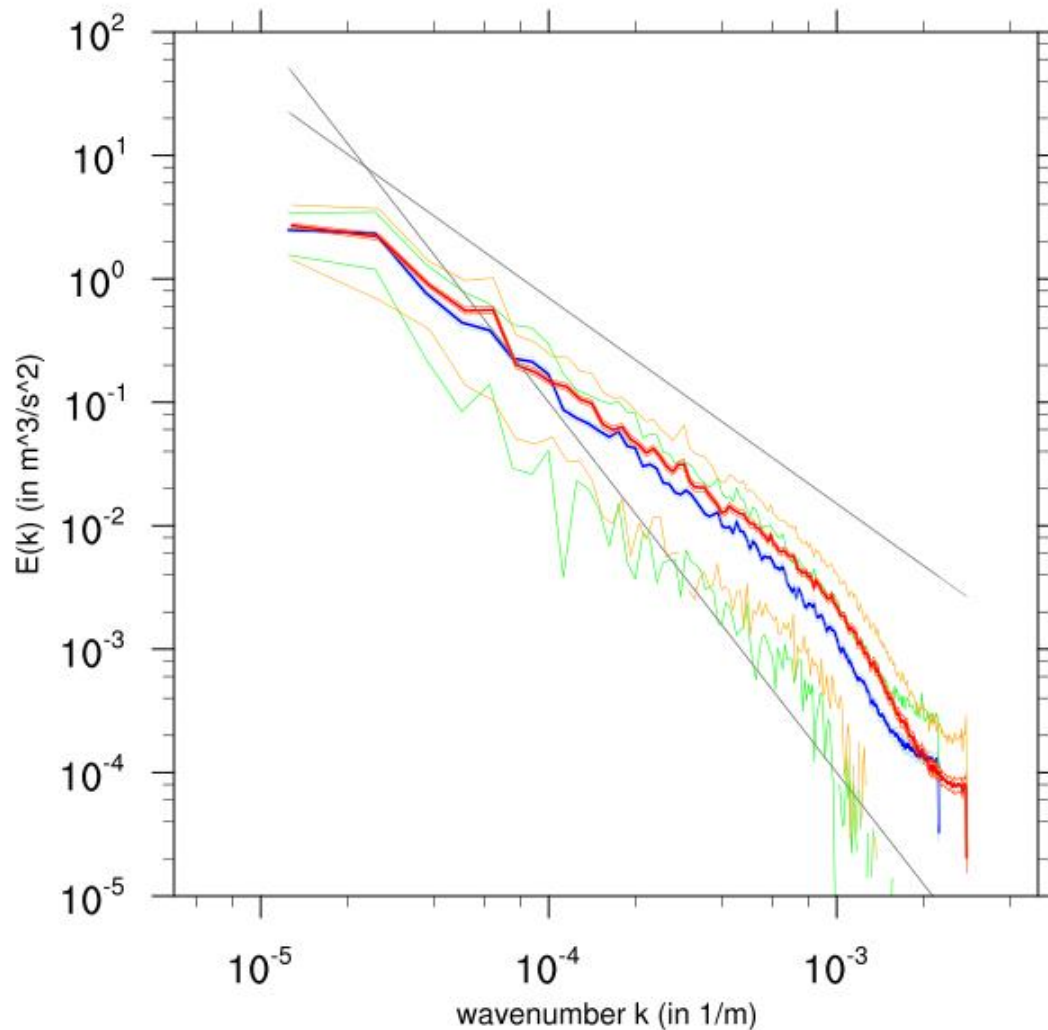
Skamarock (2004) MWR

FFT over 439 gridpoints, averaged over 504 lines; area (4.257938E,45.665855N)...(18.408329E,55.632652N)
FFT over 361 gridpoints, averaged over 401 lines; area (3.939074E,45.578014N)...(18.409288E,55.506725N)

/lustre2/gtmp/mbaldauf/2017081500/COSMO-D2_P1/lfff00000000_uv.grb
/lustre2/gtmp/mbaldauf/2017081500/COSMO-DE_Routine/lfff00000000_uv.grb



2017081500 +12h in z=5000m



KE spectra

COSMO-D2

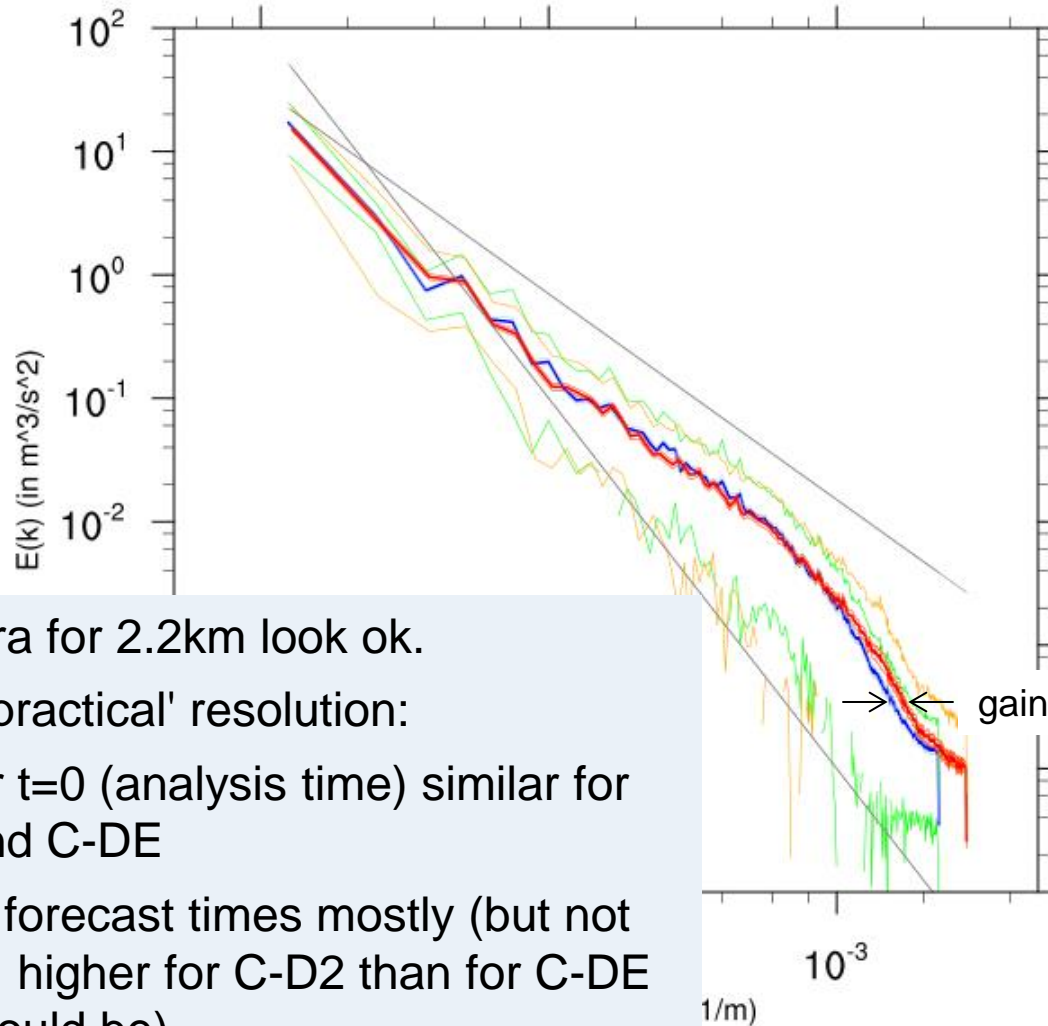
COSMO-DE

FFT over 439 gridpoints, averaged over 504 lines; area (4.257938E,45.665855N)...(18.408329E,55.632652N)
 FFT over 361 gridpoints, averaged over 401 lines; area (3.939074E,45.578014N)...(18.409288E,55.506725N)

/lustre2/gtmp/mbaldauf/2017081500/COSMO-D2_P1/lfff00120000_uv.grb
 /lustre2/gtmp/mbaldauf/2017081500/COSMO-DE_Routine/lfff00120000_uv.grb



2017081500 +24h in z=5000m



KE spectra

COSMO-D2

COSMO-DE

→ ← gain in effective resolution

- power spectra for 2.2km look ok.
- effective or 'practical' resolution:
 - often for t=0 (analysis time) similar for C-D2 and C-DE
 - for later forecast times mostly (but not always!) higher for C-D2 than for C-DE (as it should be)

FFT over 361 gridpoints, averaged over 401 lines; area (3.939074E,45.578014N)...(18.408329E,55.632652N)

/lustre2/gtmp/mbaldauf/2017081500/COSMO-D2_P1/lfff01000000_uv.grb

/lustre2/gtmp/mbaldauf/2017081500/COSMO-DE_Routine/lfff01000000_uv.grb

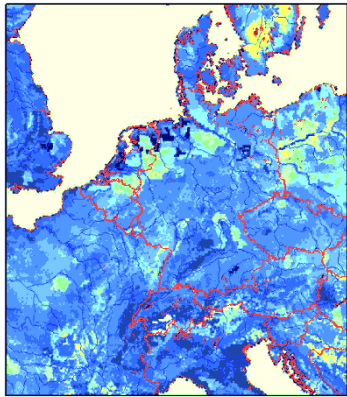


Since the start of the pre-operational phase (at 1. June 2017) several problems had to be solved ...

- **Initialization of soil moisture** at 1. June 2017 from ICON-EU soil
→ much too dry soil for the COSMO physical parameterizations!
experience: it takes at least **several months** to reduce this problem
remedy: init. by mixed COSMO-DE/ICON-EU-soil
remark: COSMO-DE/-D2 don't use a soil moisture analysis, instead use
,realistic' precipitation by latent heat nudging (*Stephan et al. (2008) QJRMS*)
- but still drying of soil: could be solved by **several bug fixes/improvements in TERRA** by *Günther Zängl (DWD)* and *Linda Schlemmer (ETH)*
- it turned out that the **OPERA-product** just westwards of the COSMO-DE area delivers too less precipitation → additional drying of soil over France.
Replacement by the **,EUCOM-product'**

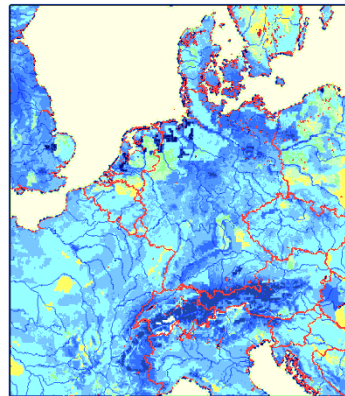
Soil moisture in COSMO-D2_P1 (level 27-81cm)

Start time: 02.06.2017 00:00 UTC COSMO-D2_P1
Forecast time: 02.06.2017 00:00 UTC
soil moisture in lev=4 (27.0-81.0cm) [kg/m³]



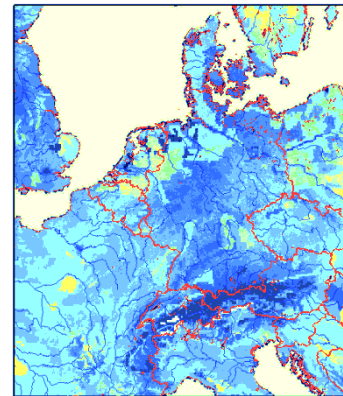
W_SO(L4)(C-D) Mean: 188.148 Min: 0 Max: 731.12 Sigma: 120.842
W_SO(L4): Mean: 188.148 Min: 0 Max: 731.12 Sigma: 120.842

Start time: 27.07.2017 00:00 UTC COSMO-D2_P1
Forecast time: 27.07.2017 00:00 UTC
soil moisture in lev=4 (27.0-81.0cm) [kg/m³]



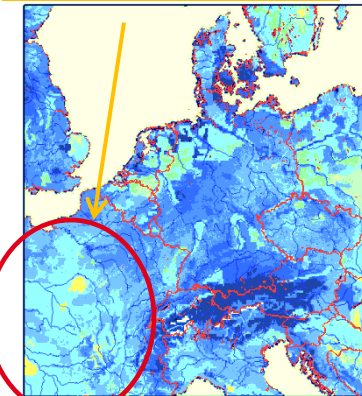
W_SO(L4)(C-D) Mean: 142.997 Min: 0 Max: 722.049 Sigma: 104.532
W_SO(L4): Mean: 132.6 Min: 0 Max: 731.12 Sigma: 106.692

Start time: 23.08.2017 00:00 UTC COSMO-D2_P1
Forecast time: 23.08.2017 00:00 UTC
soil moisture in lev=4 (27.0-81.0cm) [kg/m³]



W_SO(L4)(C-D) Mean: 148.787 Min: 0 Max: 722.049 Sigma: 105.455
W_SO(L4): Mean: 135.965 Min: 0 Max: 731.12 Sigma: 107.513

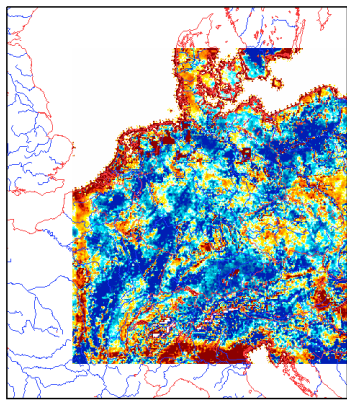
unrealistic dry



W_SO(L4)(C-D) Mean: 164.156 Min: 0 Max: 722.049 Sigma: 108.735
W_SO(L4): Mean: 147.774 Min: 0 Max: 731.12 Sigma: 111.859

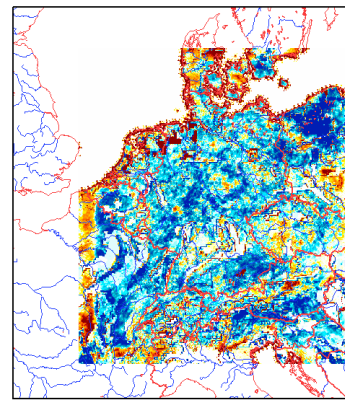
Difference: 'COSMO-D2' - 'COSMO-DE':

Start time: 02.06.2017 00:00 UTC COSMO-D2_P1
Forecast time: 02.06.2017 00:00 UTC
soil moisture diff. in lev=4 (27.0-81.0cm) [kg/m³]



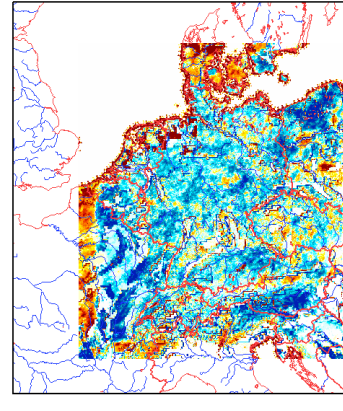
W_SO_diff(L4): Mean: 2.08492 Min: -376.558 Max: 721.759 RMSE: 63.678

Start time: 27.07.2017 00:00 UTC COSMO-D2_P1
Forecast time: 27.07.2017 00:00 UTC
soil moisture diff. in lev=4 (27.0-81.0cm) [kg/m³]



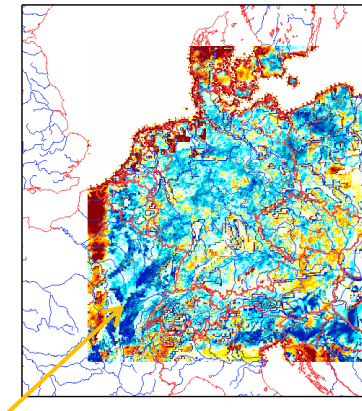
W_SO_diff(L4): Mean: 3.65679 Min: -381.093 Max: 721.759 RMSE: 76.3533

Start time: 23.08.2017 00:00 UTC COSMO-D2_P1
Forecast time: 23.08.2017 00:00 UTC
soil moisture diff. in lev=4 (27.0-81.0cm) [kg/m³]



W_SO_diff(L4): Mean: 6.1684 Min: -379.791 Max: 721.759 RMSE: 77.3979

Start time: 19.09.2017 00:00 UTC COSMO-D2_P1
Forecast time: 19.09.2017 00:00 UTC
soil moisture diff. in lev=4 (27.0-81.0cm) [kg/m³]



W_SO_diff(L4): Mean: 7.86094 Min: -369.856 Max: 721.759 RMSE: 77.4397

02.06.2017

27.07.2017

23.08.2017

19.09.2017

soil remains too dry

M. Baldauf (DWD)



Since the start of the pre-operational phase (at 1. June 2017) several problems had to be solved ...

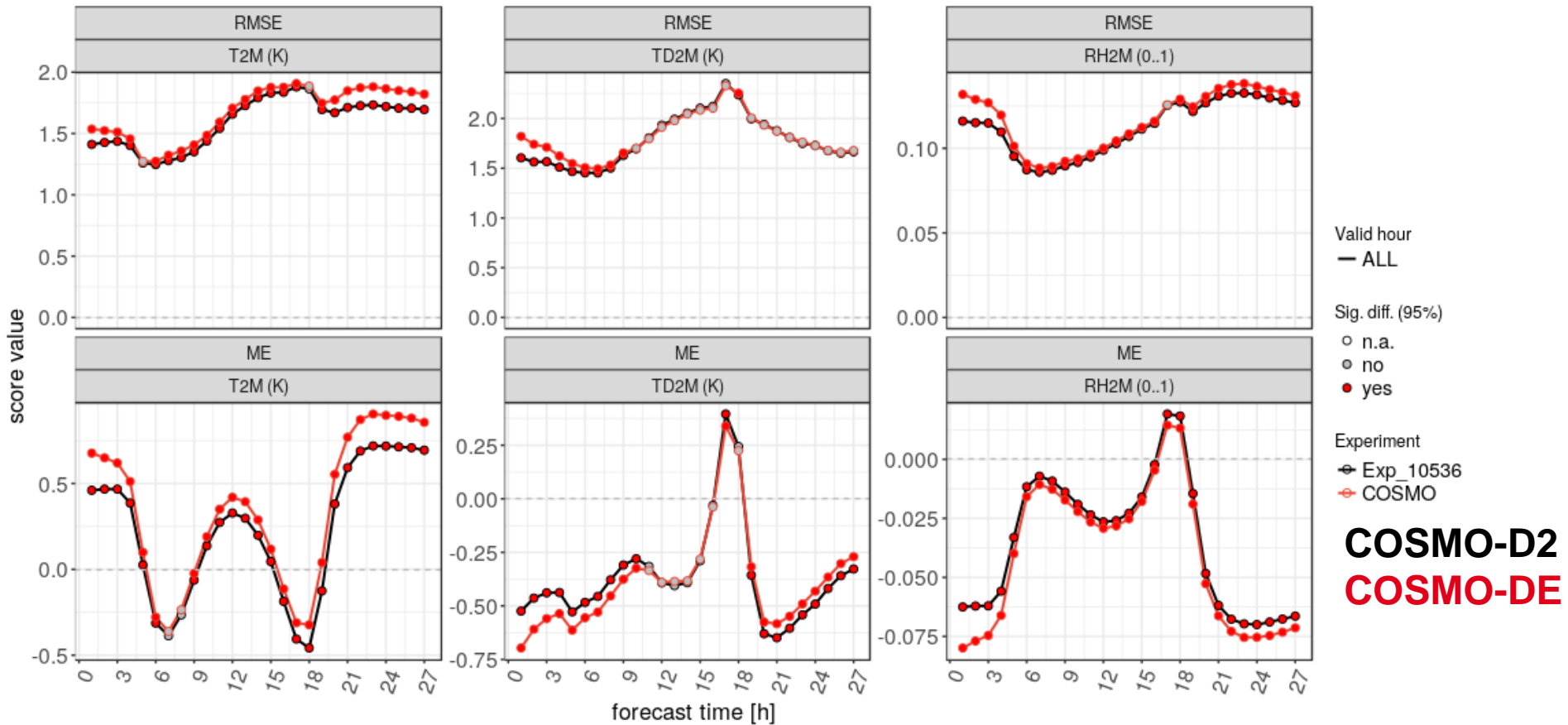
- **Initialization of soil moisture** at 1. June 2017 from ICON-EU soil
→ much too dry soil for the COSMO physical parameterizations!
experience: it takes at least **several months** to reduce this problem
remedy: init. by mixed COSMO-DE/ICON-EU-soil
remark: COSMO-DE/-D2 don't use a soil moisture analysis, instead use
,realistic' precipitation by latent heat nudging (*Stephan et al. (2008) QJRMS*)
- it turned out that the **OPERA-radar-product** westwards of the COSMO-DE area delivers too less precipitation → additional drying of soil over France.
Replacement by the **EUCOM-product** (at least until Oct. 2017)
- but still drying of soil: could be solved by **several bug fixes/improvements in TERRA** by *Günther Zängl (DWD)* and *Linda Schlemmer (ETH)*

After fixing these problems, restart of COSMO-D2 (Exp. 10536) ...

Synop-Verification (contin. scores), 0 UTC runs



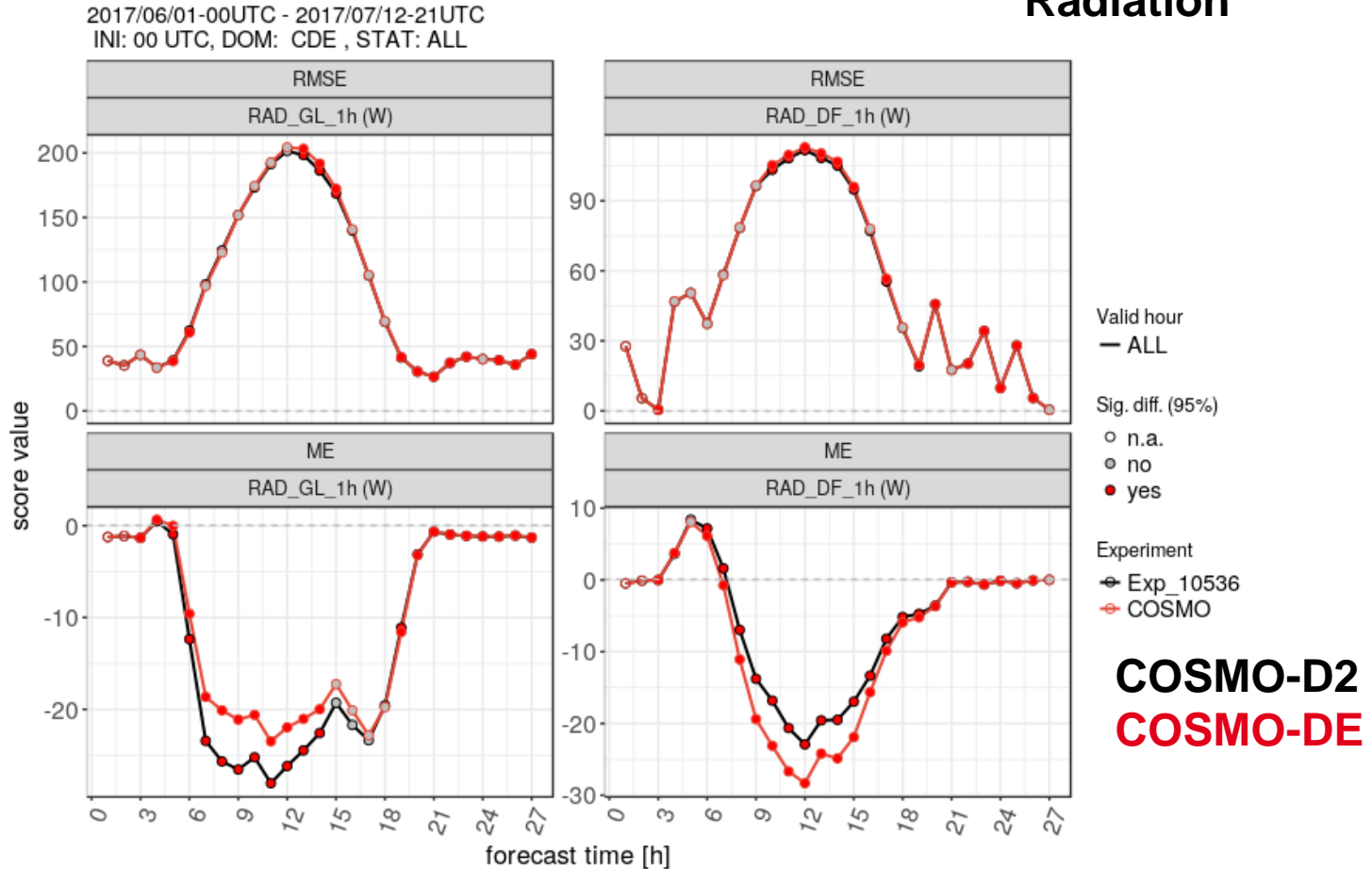
2017/06/01-00UTC - 2017/07/12-21UTC
INI: 00 UTC, DOM: CDE, STAT: ALL



Verification tool by Felix Fundel



Radiation

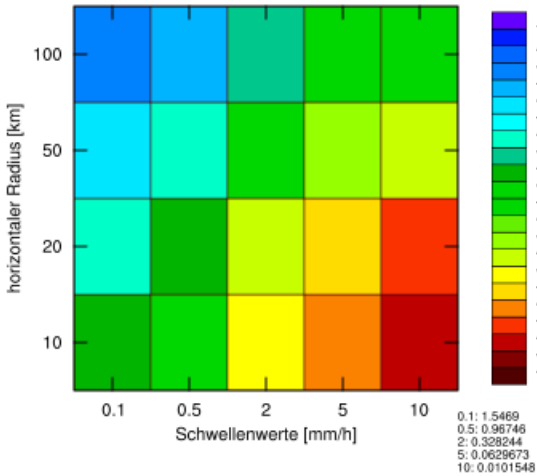


cloudiness in COSMO-D2 slightly higher → rad_gl reduced, rad_dif increased

Fraction Skill Score of precipitation against RW (=adjusted radar obs.)

Start time: 2017060100
Forecast time: 12
FSS of totprec for the last 1 h

C-D2_Exp_10536 <-> Radar RW

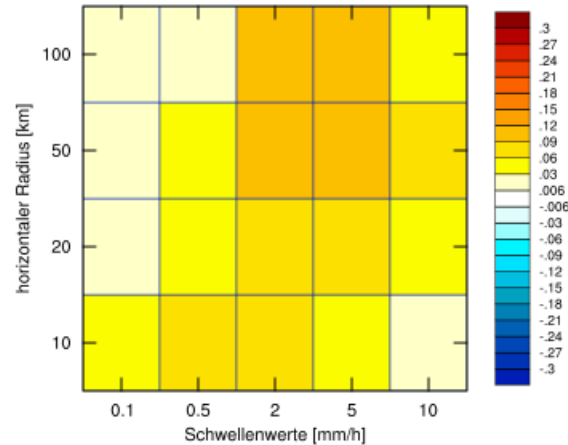


COSMO-D2
Exp. 10536
and 10526

Start time: 2017060100
Forecast time: 12
Diff. FSS of totprec for the last 1 h

(C-D2_Exp_10536 <-> RW)

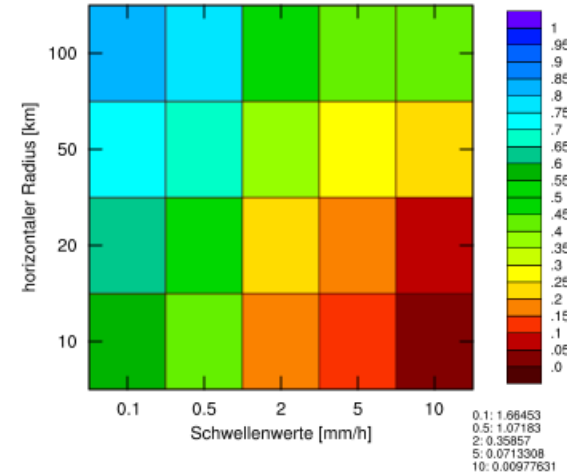
-(COSMO-DE_Routine <-> RW)



Difference

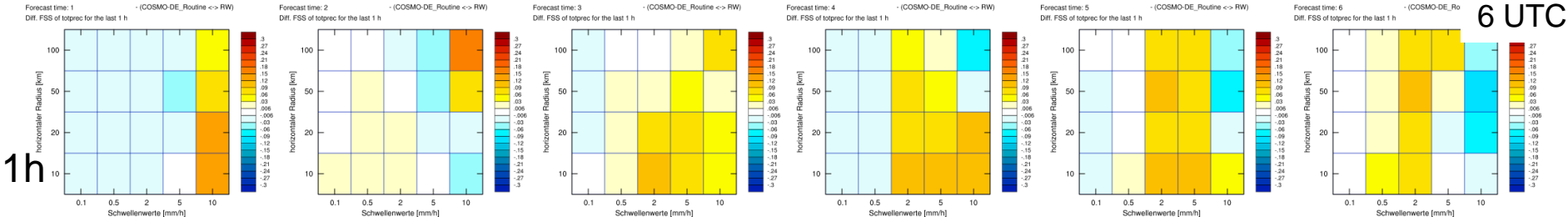
Start time: 2017060100
Forecast time: 12
FSS of totprec for the last 1 h

COSMO-DE_Routine <-> Radar RW

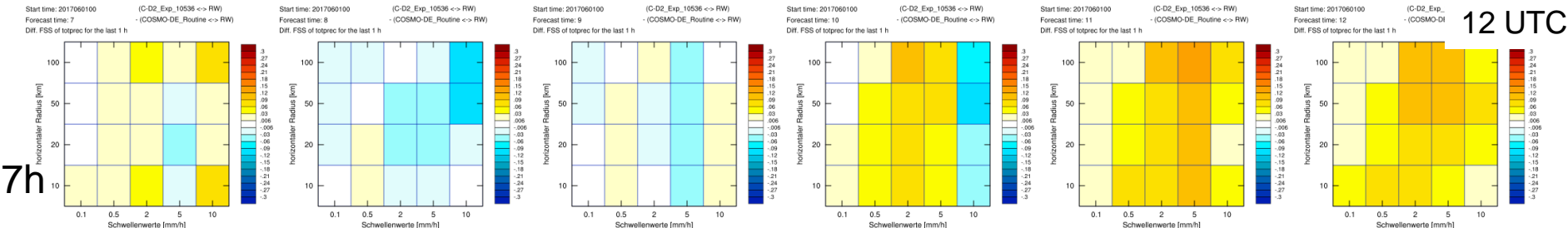


COSMO-DE (Rout.)

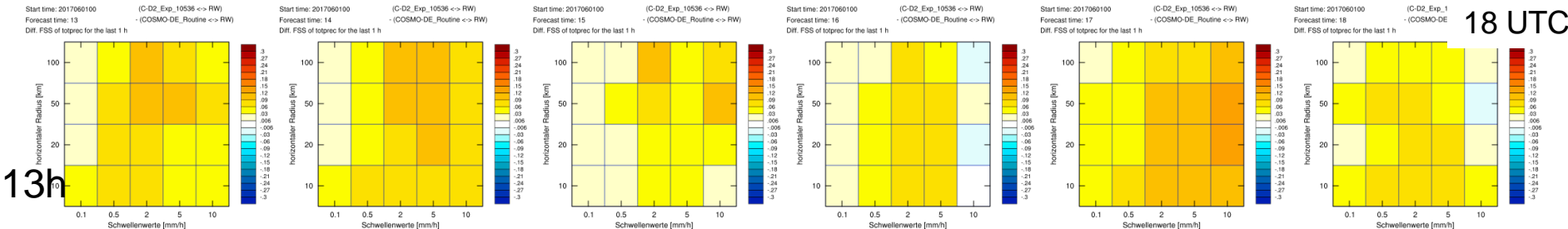
6 UTC



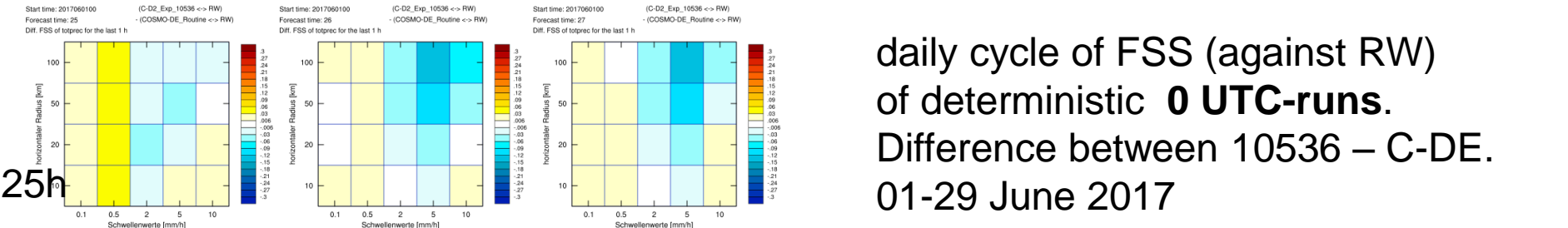
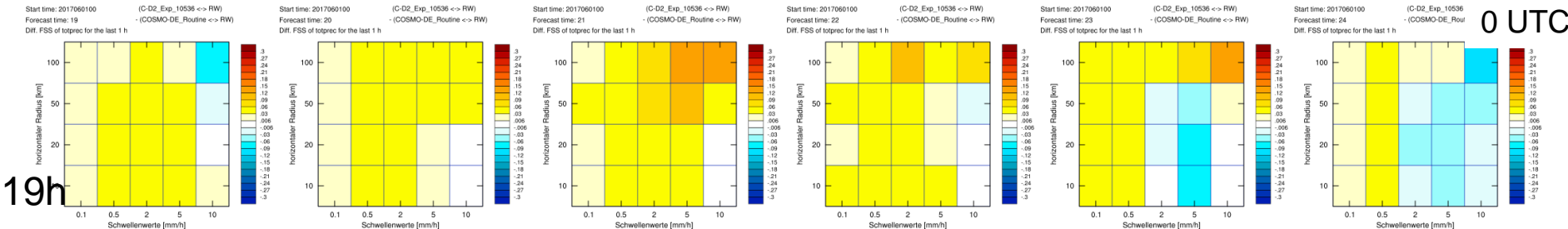
12 UTC



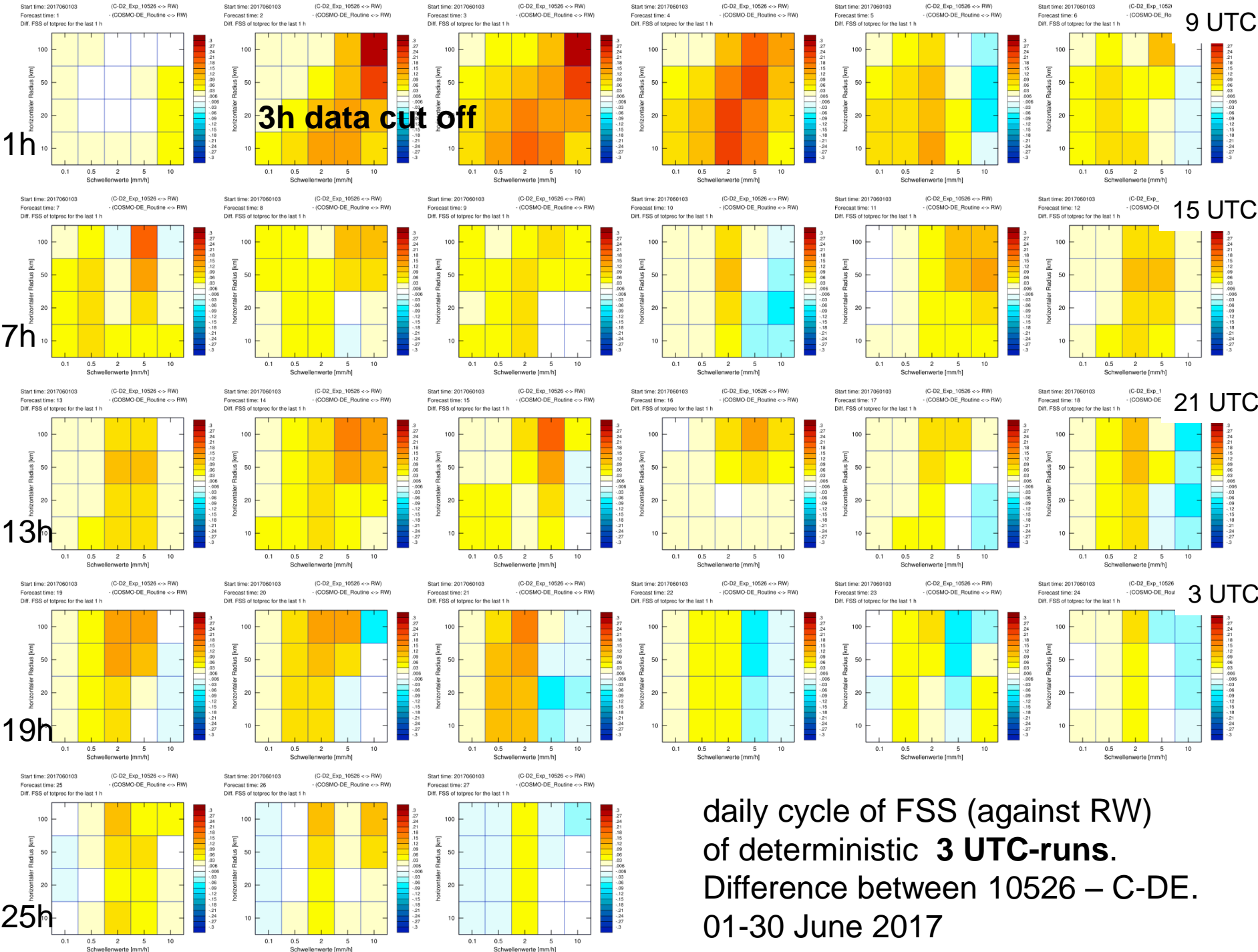
18 UTC



0 UTC

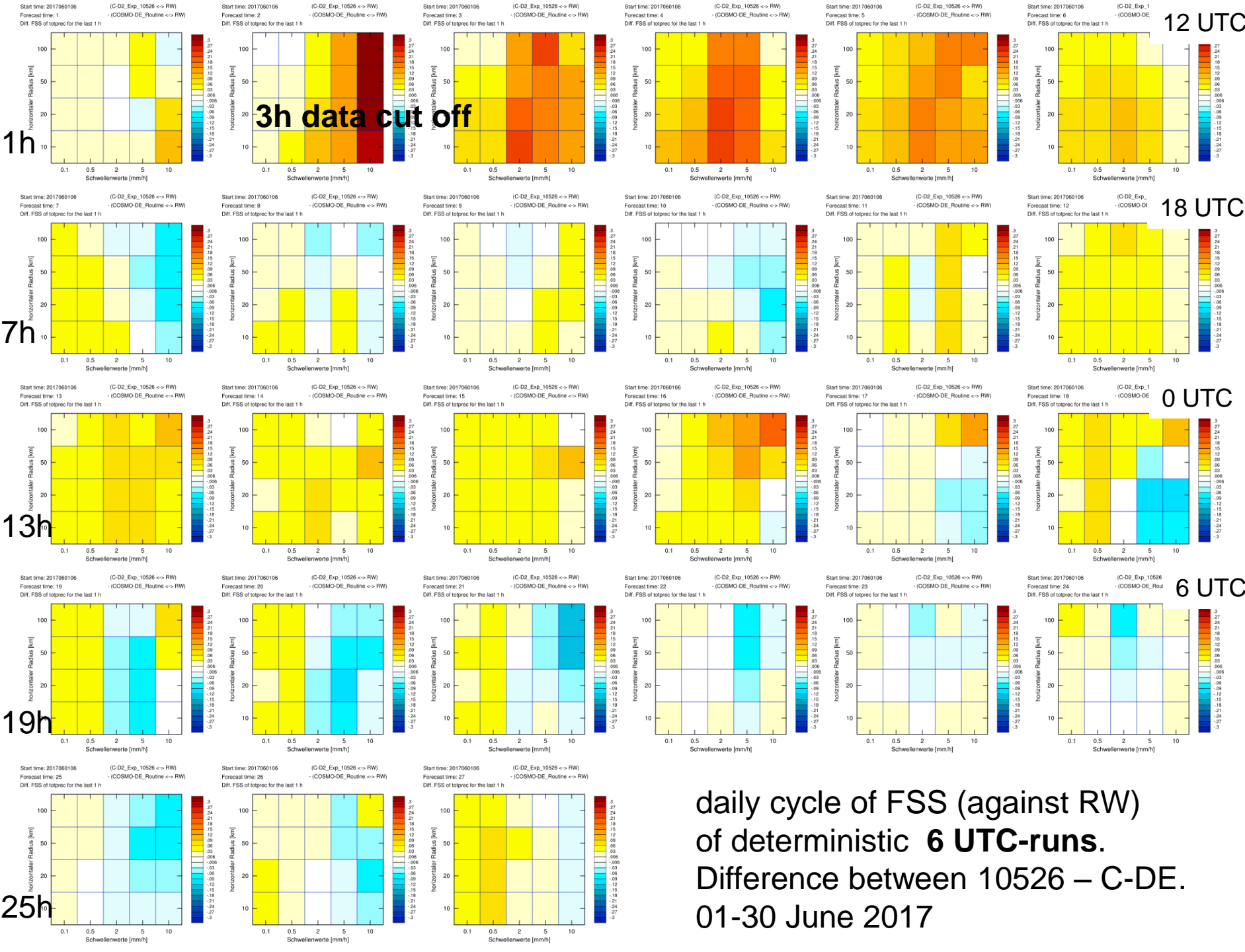


daily cycle of FSS (against RW)
 of deterministic 0 UTC-runs.
 Difference between 10536 – C-DE.
 01-29 June 2017

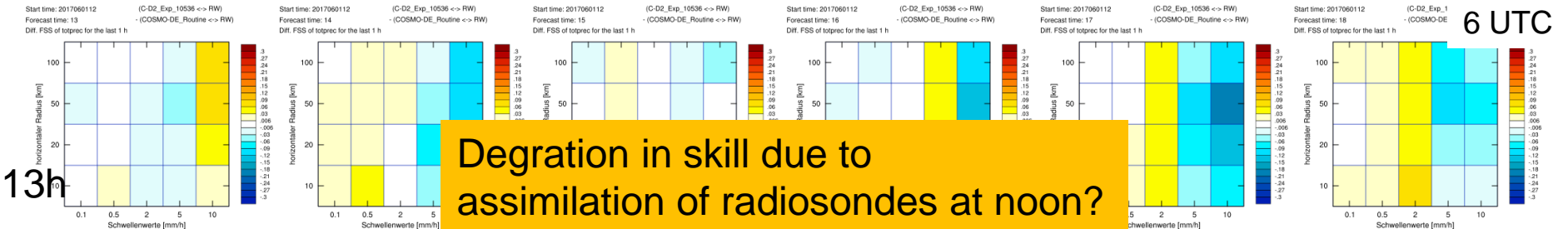
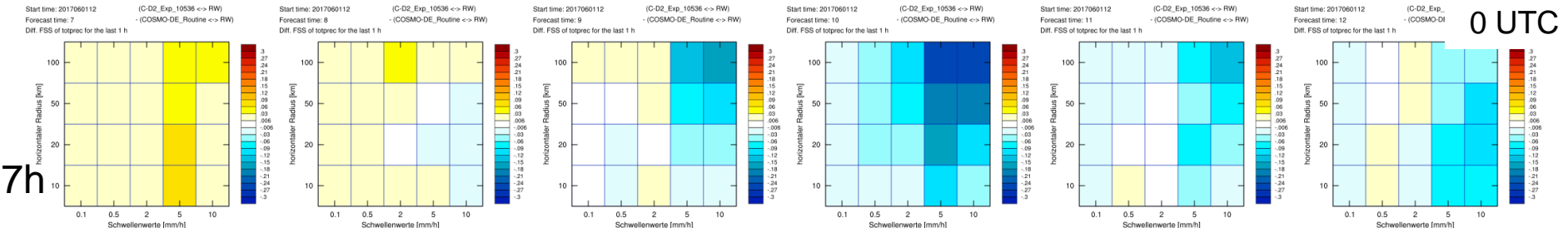
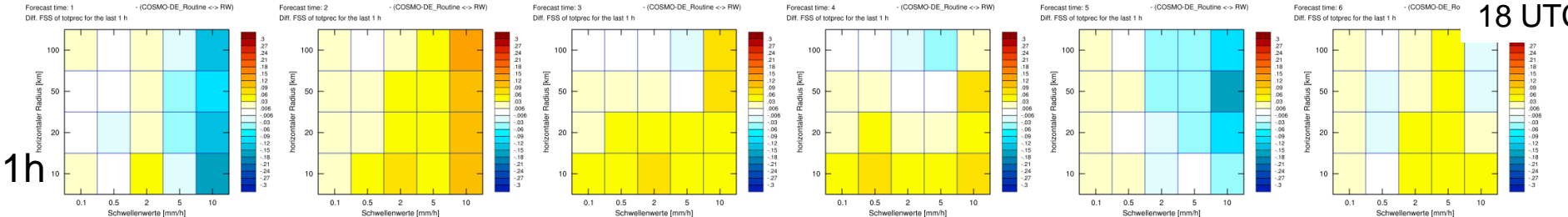


3h data cut off

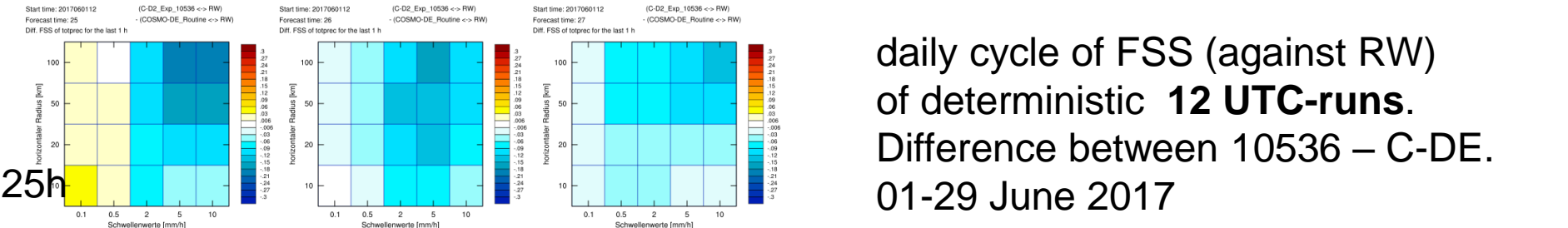
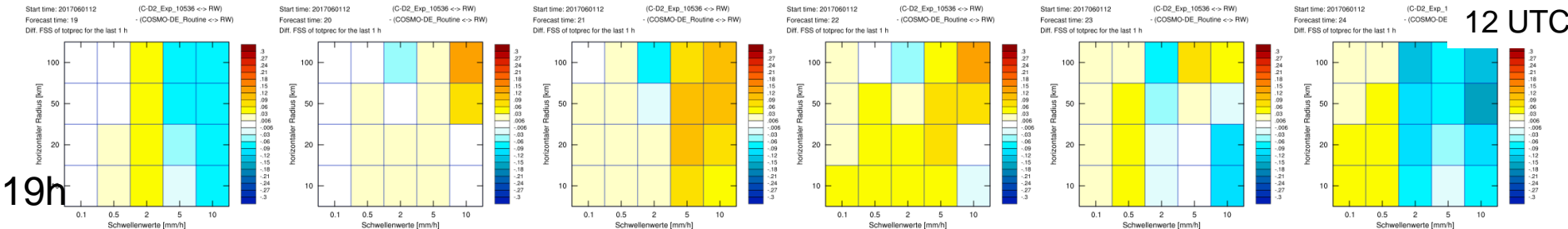
daily cycle of FSS (against RW)
of deterministic 3 UTC-runs.
Difference between 10526 – C-DE.
01-30 June 2017



daily cycle of FSS (against RW)
of deterministic 6 UTC-runs.
Difference between 10526 – C-DE.
01-30 June 2017



Degradation in skill due to assimilation of radiosondes at noon?



daily cycle of FSS (against RW) of deterministic 12 UTC-runs. Difference between 10536 – C-DE. 01-29 June 2017



Forecast Centre (Country)	2017 High resolution det.	2017 High res. EPS
Met Office (UK)	950x1015; 1.5km vrb L70	2.2km vrb L70; M12; 2.5 days
Météo France (France)	1536x1440; 1.3 km; L90	2.5kmL90; M12; 2 days twice a day
DWD (Germany)	zooming 6.5 km; L60 651x716; 2.2 km; L65	2.2 km, L65; M40; 1.125
HMC (Russia)	2000x1000, 6.6km, L90 2 dom. 2000x1000, 2.2km, L80 2 dom.: 800x400, 2.2km, L80 2 dom.: 1000x500, 1.1km, L80	2.2 km;M12;2
NCEP (USA)	935x835; 12 km; L60 1827x1467; 3 km; L60 1189x1249; 3 km; L60 373x561; 3 km; L60 401x325; 3 km; L60 501x501; 1 km; L60 935x835; 12 km; L60 1827x1467; 3 km; L60	12km M26 3.5day 4cyc 3km M6 2.5day 4cyc 3km M6 1day 24cyc 12km M6 1day 24cyc
Navy/FNMOC/NRL (USA)	100 relocatable areas. Nested, Variable size, inner nests: 15, 5,1.67, or 0.55 km L60	fixed: 15km, 3 day moving Tc: 5km 5 day
CMC (Canada)	- 3750x3000; 2.5 km; L120	10 km; M21; 5 L80
CPTEC/INPE (Brazil)	500x600, 15 km, L60 2700x2900, 2km, L75	40 km, M7, 5 5 km, L60, M9, 5
JMA (Japan)	817x661; 5 km; L76 1581x1301, 2km, L58	5 km; L48 M11 1 time/day; 39hr
CMA (China)	751x501, 10km, L50	10km, M30, 72h
KMA (Korea)	540x432, 12km, L70 1188x1148, 1.5km~4km, L70	3kmL70;M12
NCMRWF (India)	1.5kmL70	
BoM (Australia)	1650x1120; 8km L70 816x668; 1.5km, L70 300*300; 12km, L70	Nil

What others are
doing ...

High-resolution NWP systems, planings for 2017

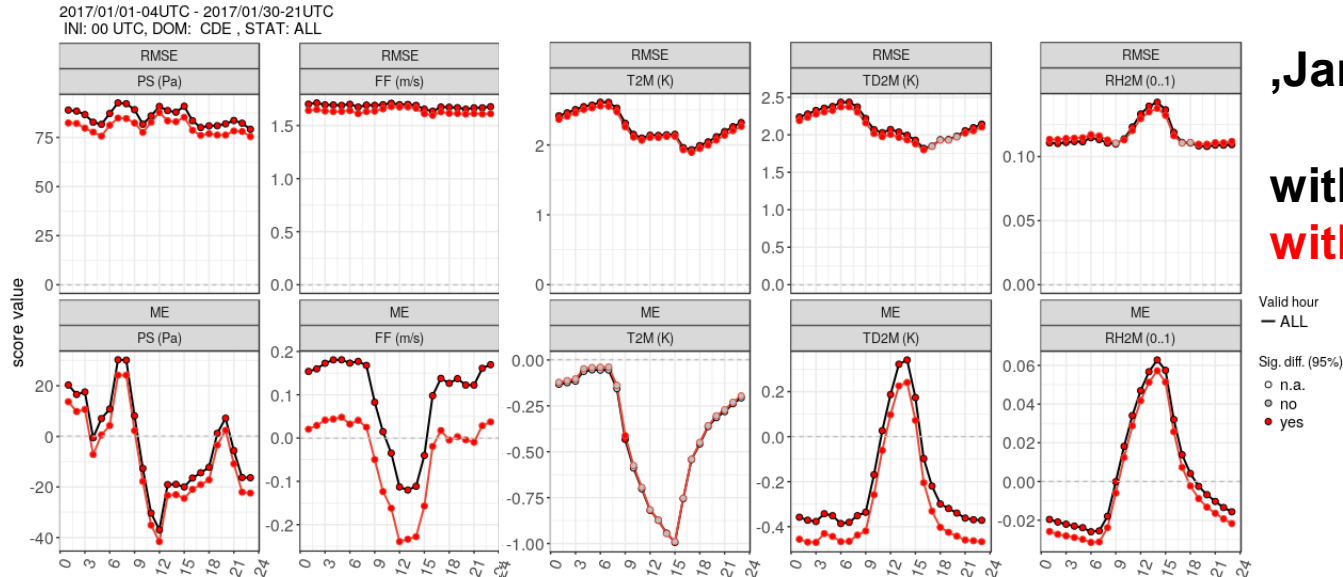
from the
,WGNE-table about the
centre computing
resources and model
configurations 2016'

Outlook: use of an SSO scheme in a convection-permitting model?

SYNOP-Verif. shows that COSMO-D2 is **~0.1 m/s too fast**.

G. Zängl has already demonstrated the positive effect of an SSO scheme for ICON-LAM.

Hindcast runs for **COSMO-D2 with SSO-scheme** (Lott, Miller (1997) QJRMS) show indeed a reduction in wind speed with only little effect to other verification scores:



,Jan. 2017‘

without SSO
with SSO

Summary

- COSMO-D2 has a **significantly positive impact to summerly precipitation**. Especially afternoon convection is much better represented. This is visible in particular in the morning runs, less pronounced in 12-UTC-runs.
- The **improvements in TERRA** (by G. Zängl, L. Schlemmer) with a reduction of drying of the soil have a large positive impact on synoptic scores: T2m, RH2m, Td2m are better than in COSMO-DE routine. This is also an argument to use the new COSMO v5.4h(1) (=v5.5)
- During winter no clear advantage of COSMO-D2 over COSMO-DE visible
- Needs **~3.2x more storage** and **~4x more computer power** compared to COSMO-DE
- *„Kurze Beschreibung des präoperationellen Kurzzeitvorhersagemodells COSMO-D2 und seiner Datenbanken auf dem Datenserver des DWD“* (M. Baldauf, B. Ritter, C. Schraff) v0.9 accessible by www.dwd.de → Fachnutzer → Forschung und Lehre → Numerische Wettervorhersage
- **operational** use of COSMO-D2 is planned for **15 May 2018**

A short history of COSMO-D2

- April 2007 operational start of COSMO-DE (LMK)
- 2010 first tests with COSMO-DE L80 (K. Wapler) → ‚L65-project‘
- Jan. 2013 new fast waves-solver operational (*Baldauf (2013) COSMO Tech. R.*)
→ solution of stability problems
- 2014 → possibility to add higher resolution (2.2km) to L65 and larger domain
- Jan. 2015 New global model ICON
- Jan. 2016 Ensemble DA in ICON
- March 2017 KENDA assimilation in COSMO-DE
- 1. June 2017 pre-operational start of COSMO-D2
- 15. Mai 2018 **goal: operational start COSMO-D2**

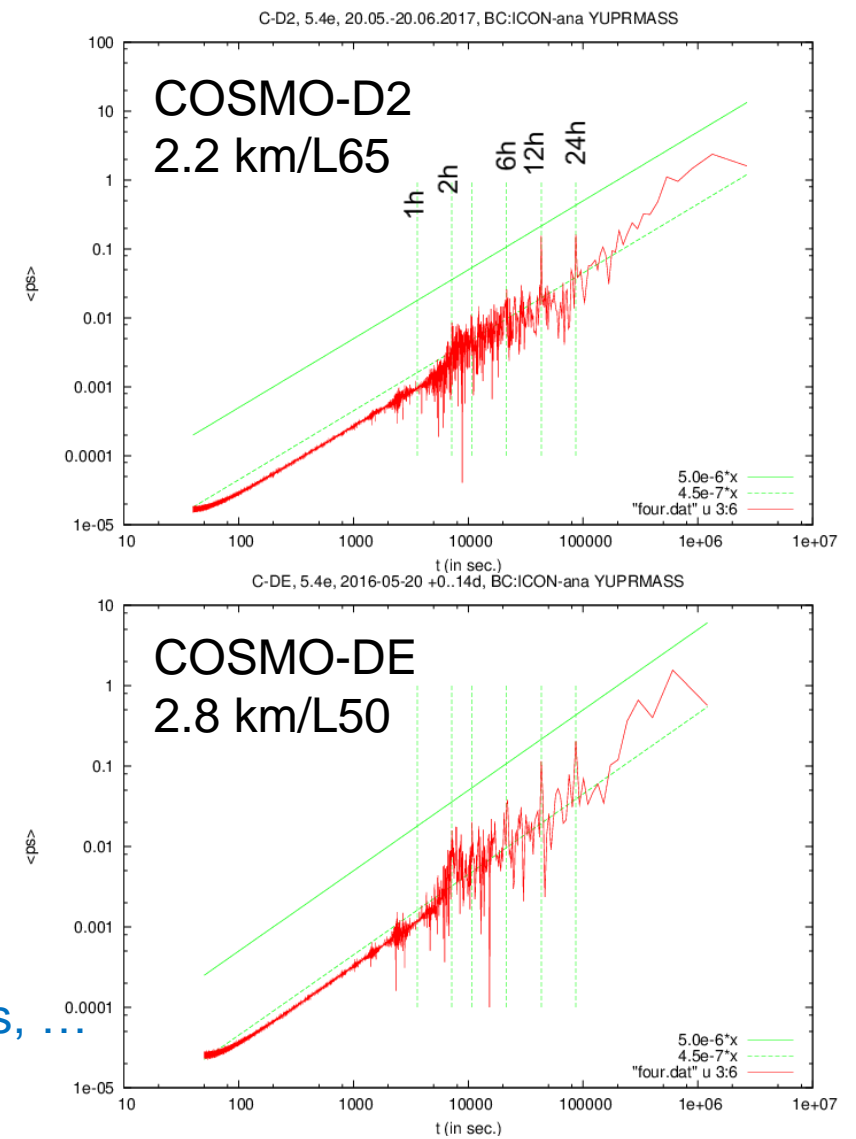
**Frequency spectra for
<PS> (horizontal average)**

Hindcast-runs

i.e. BCs by ICON-EU (6.5km) analysis
from the ENS-VAR-DA

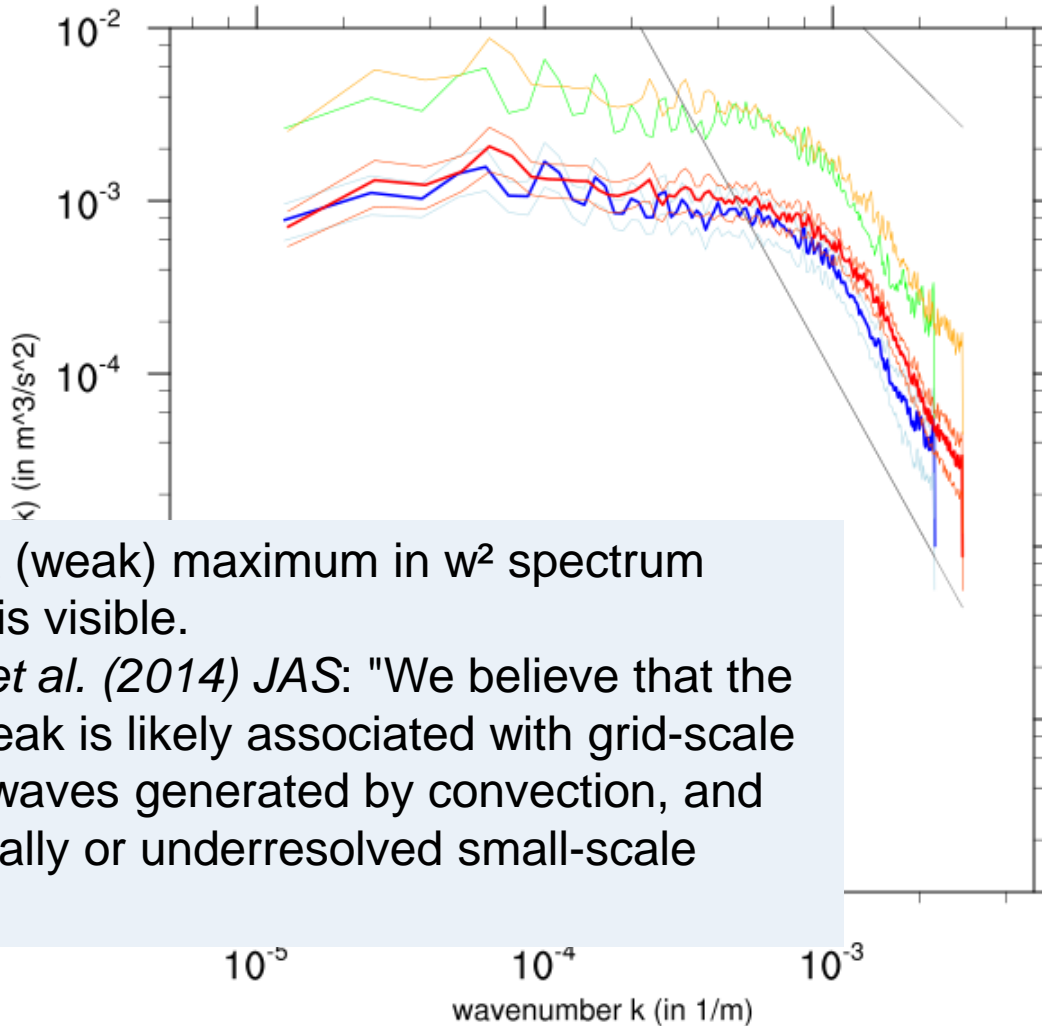
Observations:

- daily cycle: **24h**
- solar tides at period **12h**
(induced from global ICON)
- BC update: Nyquist-fr. = **1/2h!**
- ICON-analysis every 3h → N.-fr.=**1/6h**
- **obviously no further artifacts, instabilities, ...**



Power spectra of vertical velocity

2017081500 +15h in z=5000m



w² spectra

COSMO-D2
COSMO-DE

sometimes a (weak) maximum in w² spectrum around 4 dx is visible.

Skamarock et al. (2014) JAS: "We believe that the filter-scale peak is likely associated with grid-scale convection, waves generated by convection, and other marginally or underresolved small-scale processes."

SW-inflow,
some heavy showers

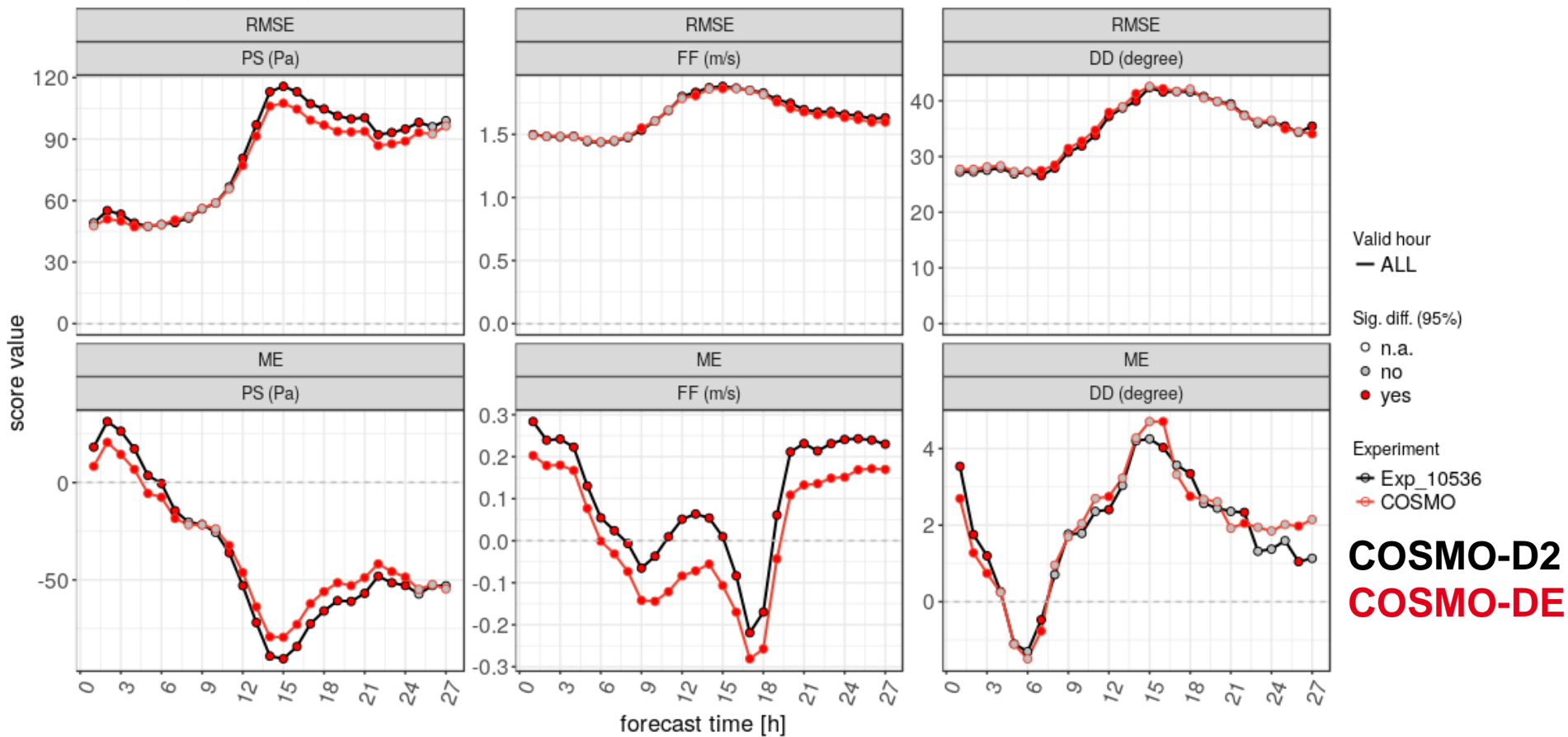
FFT over 439 gridpoints, averaged over 504 lines; area (4.257938E,45.665855N)...(18.408329E,55.632652N)
FFT over 361 gridpoints, averaged over 401 lines; area (3.939074E,45.578014N)...(18.409288E,55.506725N)

/lustre2/gtmp/mbaldauf/2017081500/COSMO-D2_P1/lfff00150000_uv.grb
/lustre2/gtmp/mbaldauf/2017081500/COSMO-DE_Routine/lfff00150000_uv.grb



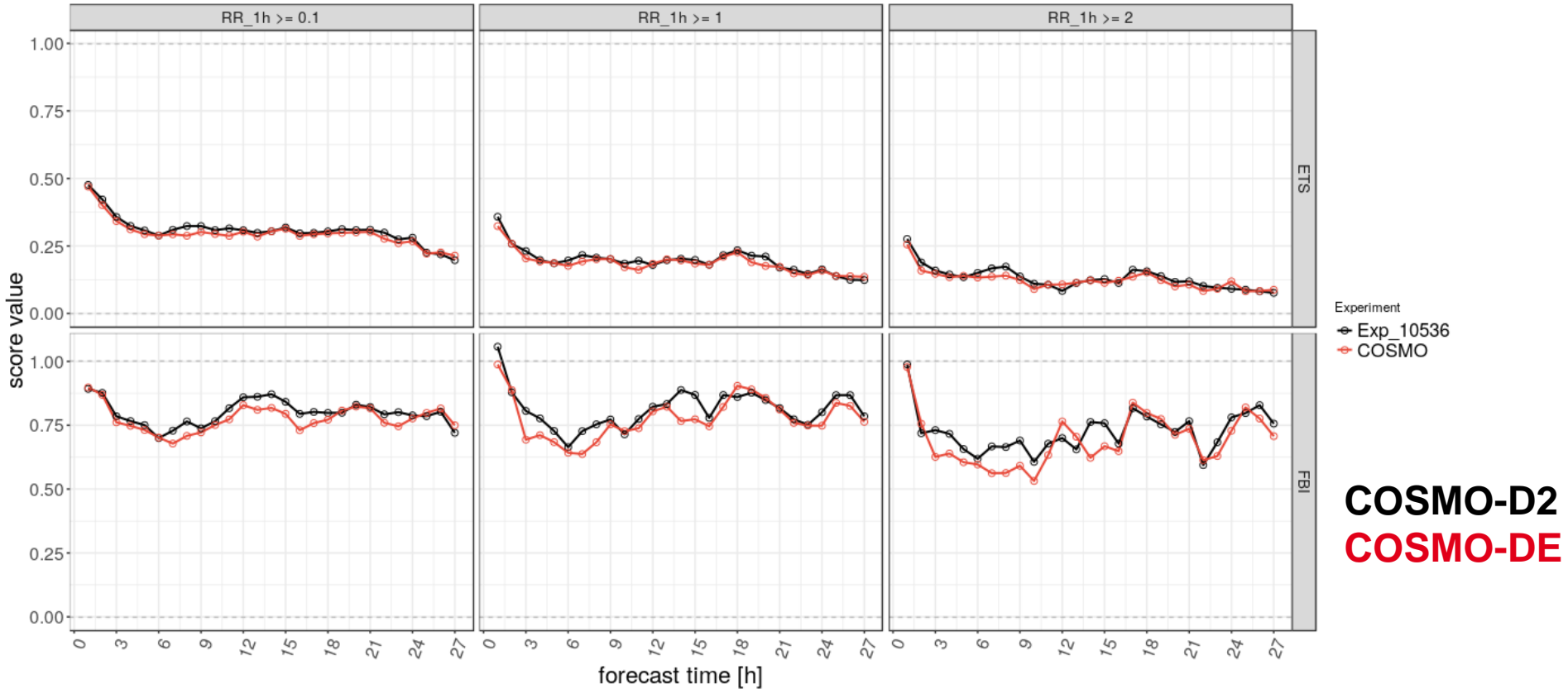
Synop-Verification (contin. scores), 0 UTC runs

2017/06/01-00UTC - 2017/07/12-21UTC
INI: 00 UTC, DOM: CDE, STAT: ALL



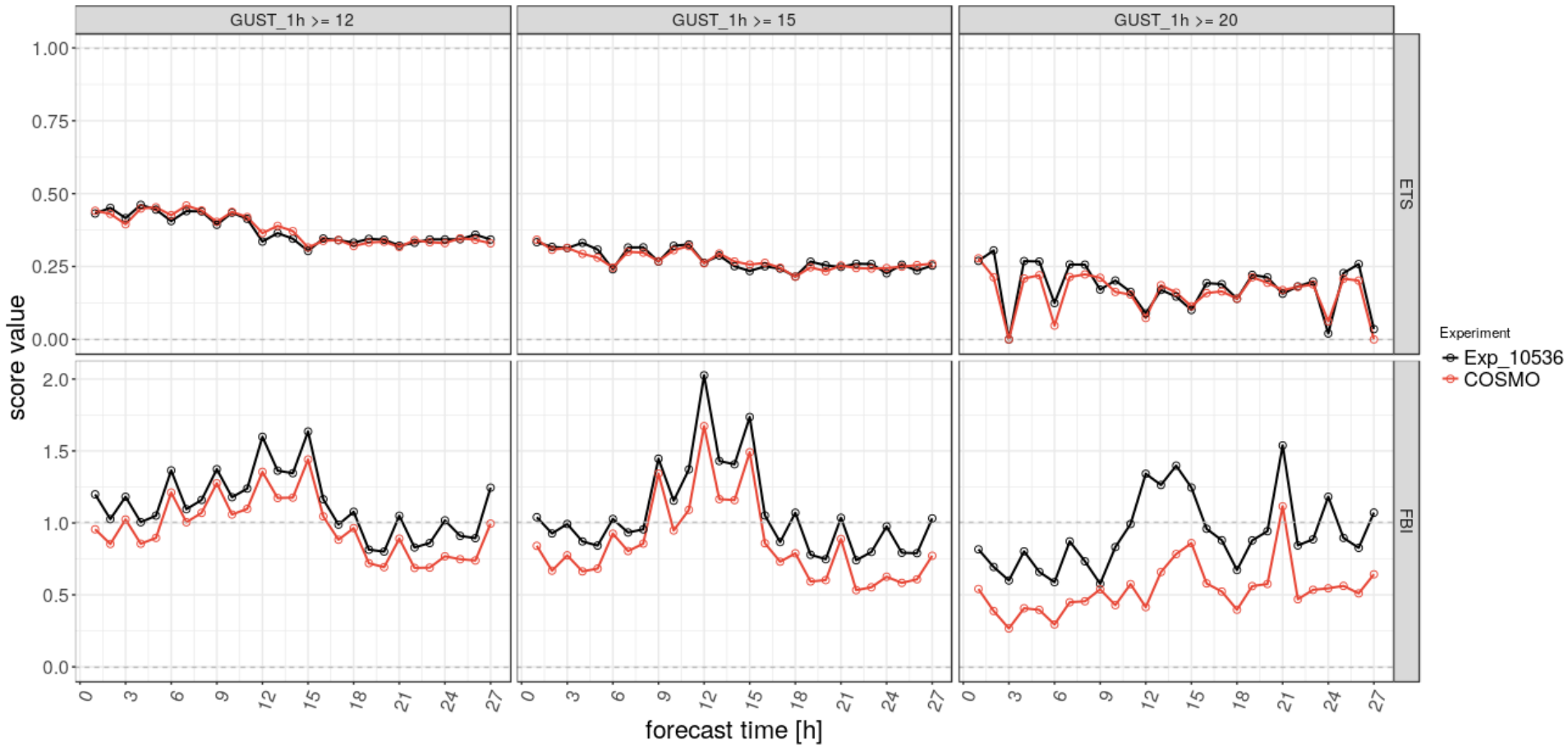
Synop-Verification (categ. scores), 12 UTC runs

2017.06.01-00UTC - 2017.07.12-21UTC
VAL: ALL UTC, INI: 12, STAT: ALL, DOM: CDE



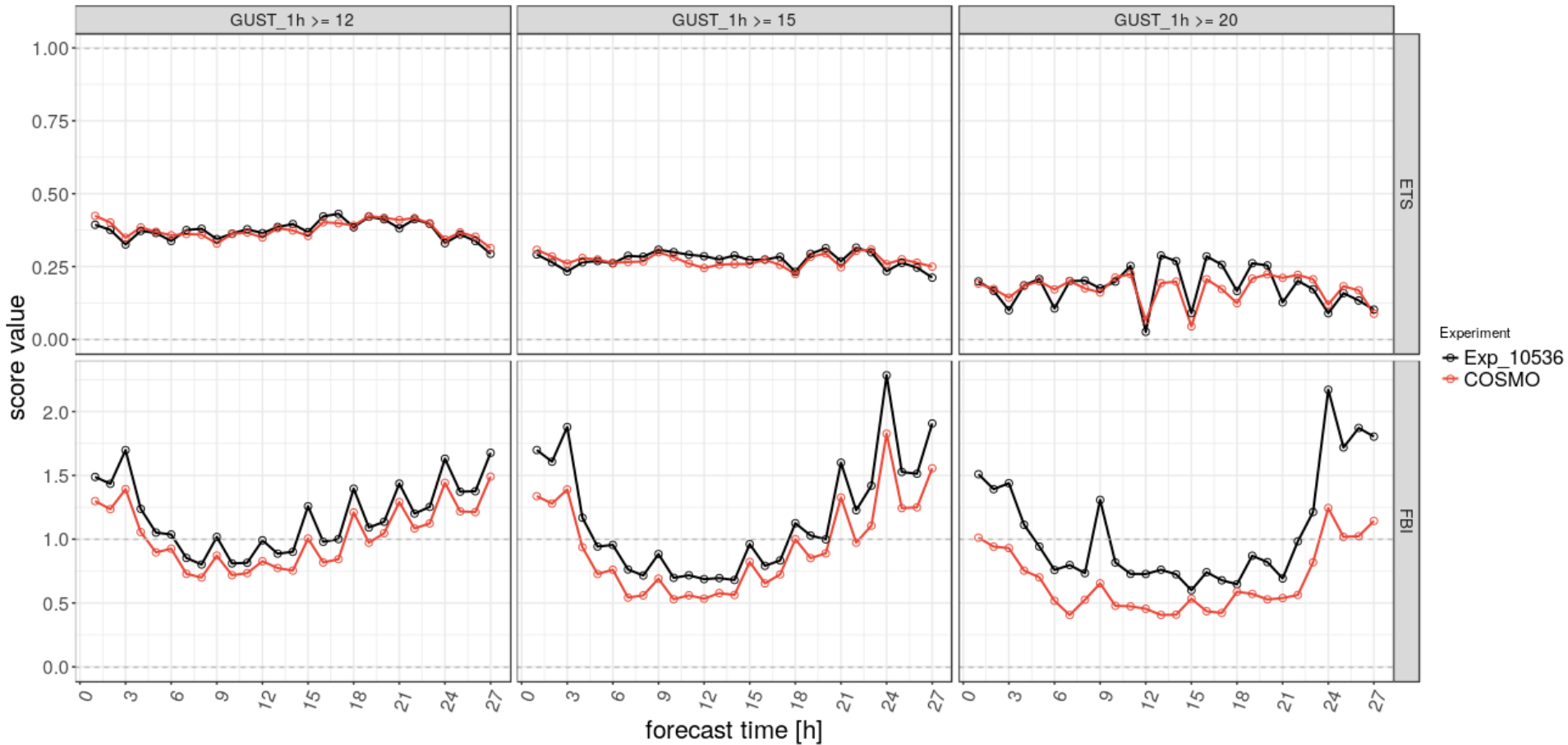
Synop-Verification (categ. scores), 0 UTC runs

2017.06.01-00UTC - 2017.07.12-21UTC
VAL: ALL UTC, INI: 00, STAT: ALL, DOM: CDE

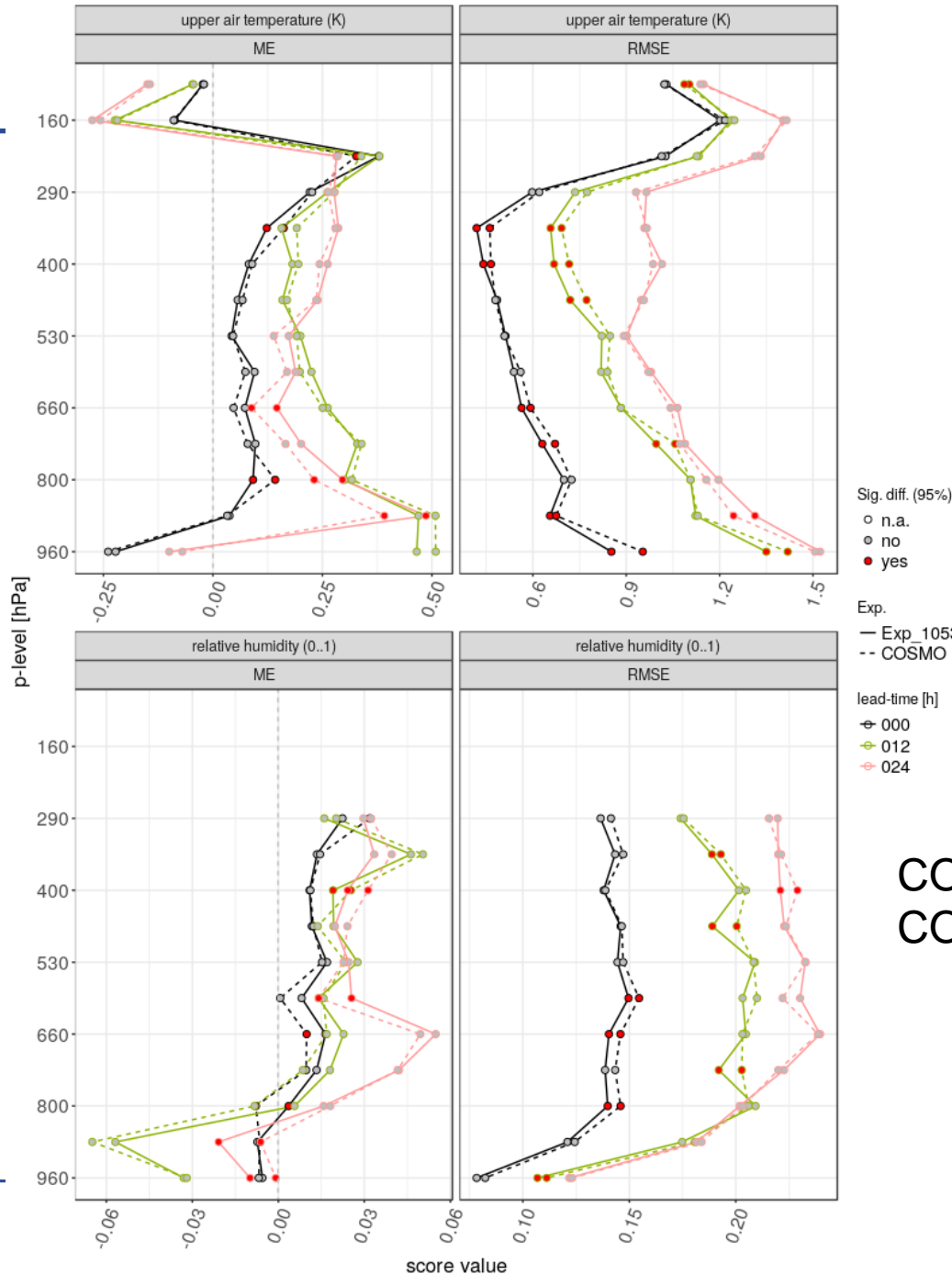


Synop-Verification (categ. scores), 12 UTC runs

2017.06.01-00UTC - 2017.07.12-21UTC
VAL: ALL UTC, INI: 12, STAT: ALL, DOM: CDE



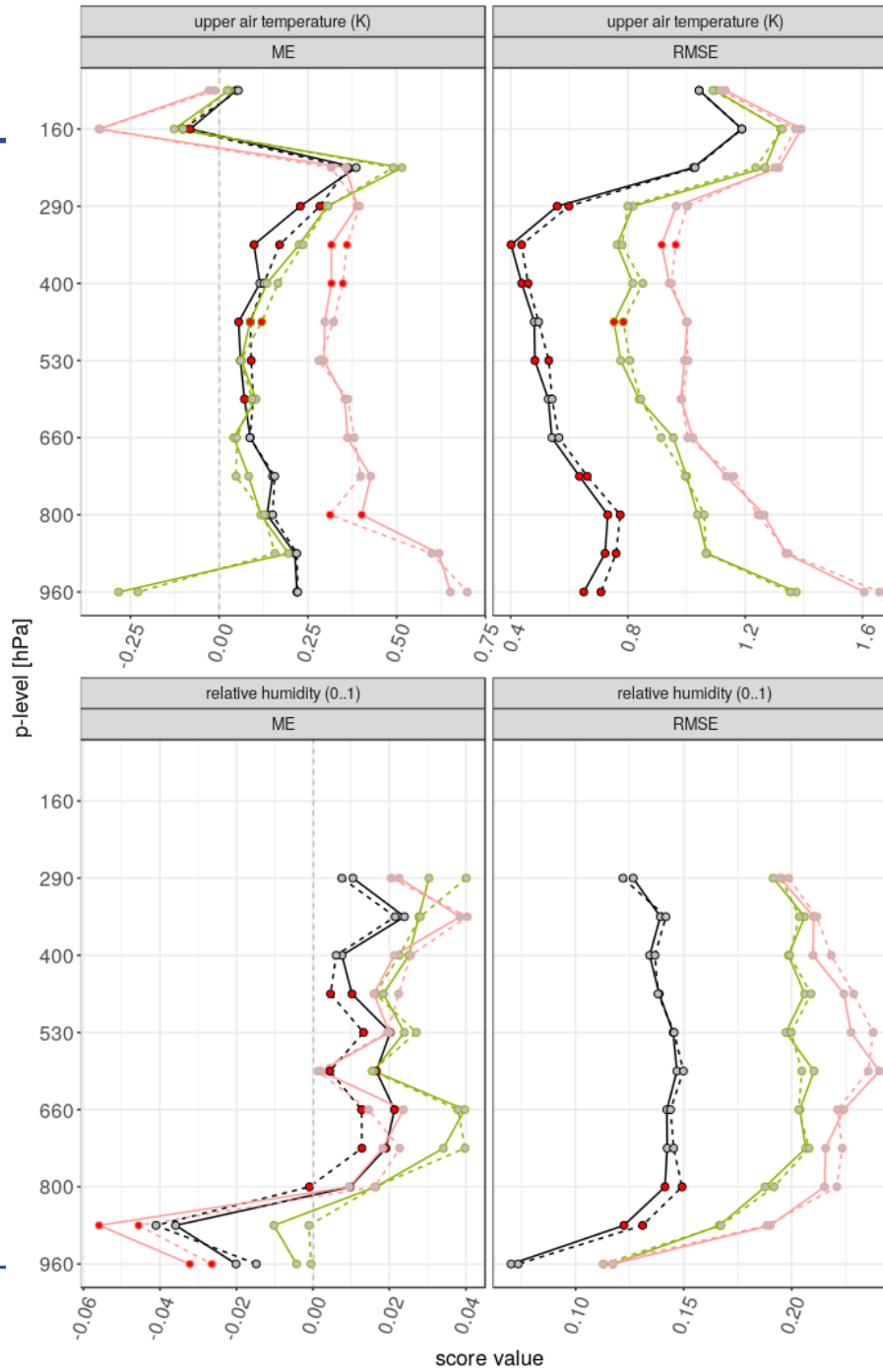
upper air
 verif.
 0 UTC runs



COSMO-D2 —
 COSMO-DE - - -



upper air verif. 12 UTC runs



COSMO-D2 _____
COSMO-DE - - - - -

