# Feedback File Based Verification at DWD
# -recent developments-

# Outline



I. Recap of Rfdbk concept

II. Recent developments within Rfdbk

III. Recap of verification concept

IV. Recent progress in verification based on feedback files

V. Future plans

# I. Recap on Rfdbk Concept



- Feedback files are produced during DA and contain observations, analysis and past forecast and lots of meta information valuable for observation based verification tasks
- Using feedback files for the verification means a huge reduction in workload as much of the tedious data preparation tasks are done within DA
- Rfdbk (source on https://github.com/rfxf/Rfdbk) is a R interface for COSMO feedback files
- Main purpose of Rfdbk is to load feedback file content with R
- Additional functionality useful for verification is implemented as well
- As guideline a set of verification scripts (used at DWD) can be obtained via https://github.com/rfxf/fdbk_verification

# I. Recap on Rfdbk Concept



**The idea behind Rfdbk**

- Feedback file information is transformed into data table (each information related to a observation can be a table column) using R data.table package (https://cran.r-project.org/web/packages/data.table)

- data.table allows to perform operations on huge tables very quickly with elegant syntax

DT[i,j,by]

i : where (address only a set of rows)
j : select (address only a set of columns, column names can be used as input for R functions)
by : group (group results by instances of variables in columns)

# I. Recap on Rfdbk Concept

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Wetter und Klima aus einer Hand

```
> DT
    obs     veri_data     veri_forecast_time
1: 291.65   291.3145                      0
2: 292.15   292.2571                      0
3: 293.65   292.7871                      0
4: 293.25   291.4255                      0
5: 301.45   300.2931                      0
---
172796: 266.45   266.2054                  18000
172797: 269.55   268.9154                  18000
172798: 272.05   271.6369                  18000
172799: 271.65   271.7378                  18000
172800: 273.65   271.7899                  18000
> DT[,list(BIAS=mean(veri_data-obs)),by="veri_forecast_time"]

veri_forecast_time            BIAS
1:                  0    0.20529260
2:                600    0.07754623
3:               1200    0.14901599
---
```

# I. Recap on Rfdbk Concept



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- Based on data.tables not only scores can be calculated but also a data adjustment between experiments or conditions could be implemented

- data.table is used extensively not only in Rfdbk but also in the DWD verification scripts

# II. Recent Developments within Rfdbk

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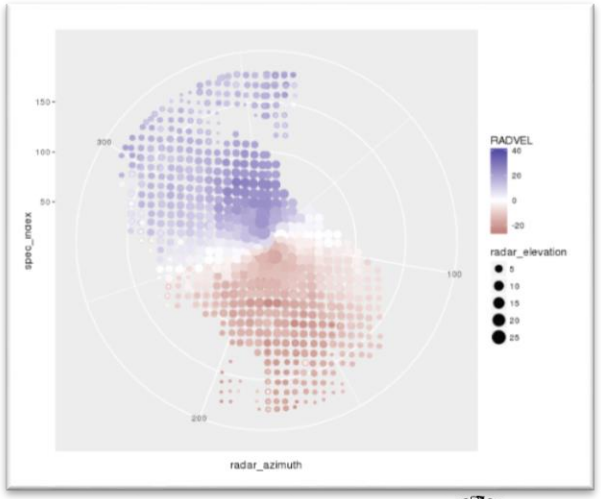
**Since CUS only small changes/bug-fixes have been conducted**

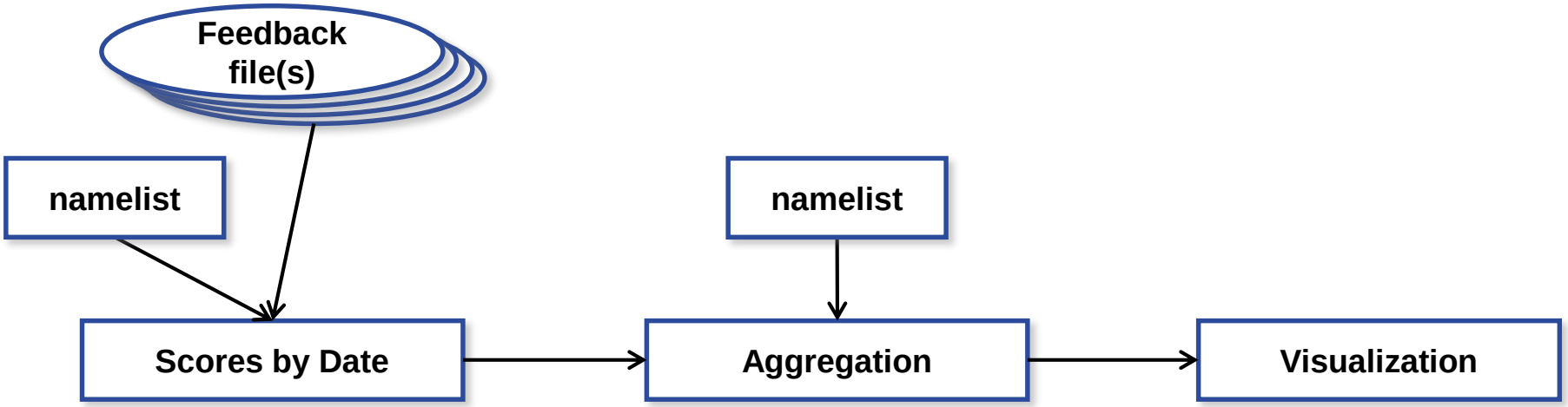
- Rfdbk can now correctly deal with radar information, which are stored differently from other observation types (in order to account for sparse data and the underlying coordinate system)
- Rfdbk now has a function to help with conditional verification
- Function for CRPS calculation has been revised to accept missing values
- Function for adding past observation to forecast (needed to calculate persistence scores) does not cause errors in case of corrupt feedback files

```
  varno obs lat lon
1    DD   1  10   5
2:   DD   2  20   6
3:   DD   3   30   7
4:   FF   0  10   5
5:   FF   1   20   6
6:   RR   4  10   8
> fdbk_dt_conditional(DT,condition="varno=='DD'",on="varno=='FF' & obs>0",by=c("lon","lat"))
  varno obs lat lon
1:   FF   0  10   5
2:   FF   1  20   6
3:   RR   4  10   8
4:   DD   2  20   6
```



# III. Recap of Verification






- 1x per valid date
- SYNOP, TEMP, etc.
- ICON, ICON-EU, COSMO-EU, IFS
- Deterministic or ensemble
- Routines or experiments
- Scores: continuous and categorical, EPS
- Conditional on: model, lead-time, valid-time, level, etc.
- All scores are based on same observation sample
- Uses R Rfdbk functionality

- Pool scores over period, levels, lead-time etc.
- Decide on period by setting valid date range and/or initial date range
- Pooling done correctly, considering number of observations per date, except correlations are simple averages.
- Score files transferred to visualization server
- Uses R

- On demand interactive plot web browser application
- Plot and arrange scores, summaries, browse data
- Separate web based apps for observation and verification types
- Uses the R shiny web server

# IV. Recent verification progress

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## Status

- Observation Types: SYNOP, TEMP, GPSRO, SATOB (AMV), PILOT (wind profiler)
- Models: ICON, ICON_P, ICON_P1, ICON-EU, ICON-EU, ICON-EU_P1, ICON-EPS, ICON-EPS_P1, COSMO-EU, COSMO-DE, COSMO-DE_P, COSMO-DE-KENDA, COSMO-DE-EPS, COSMO-DE-EPS_KENDABCEPS, COSMO-DE-EPS_KENDAICON, IFS + experiments
- Verification types: continuous, categorical, ensemble, probabilistic
- Aggregation: by period, by valid-time, by station, time series of monthly means

## Missing

- Complete set of SYNOP observations in ICON feedback files
- Observations contained in national bufr file (RR and GUST over Germany)

## Visualization examples (COSMO (DE-EPS) routine vs. KENDA)

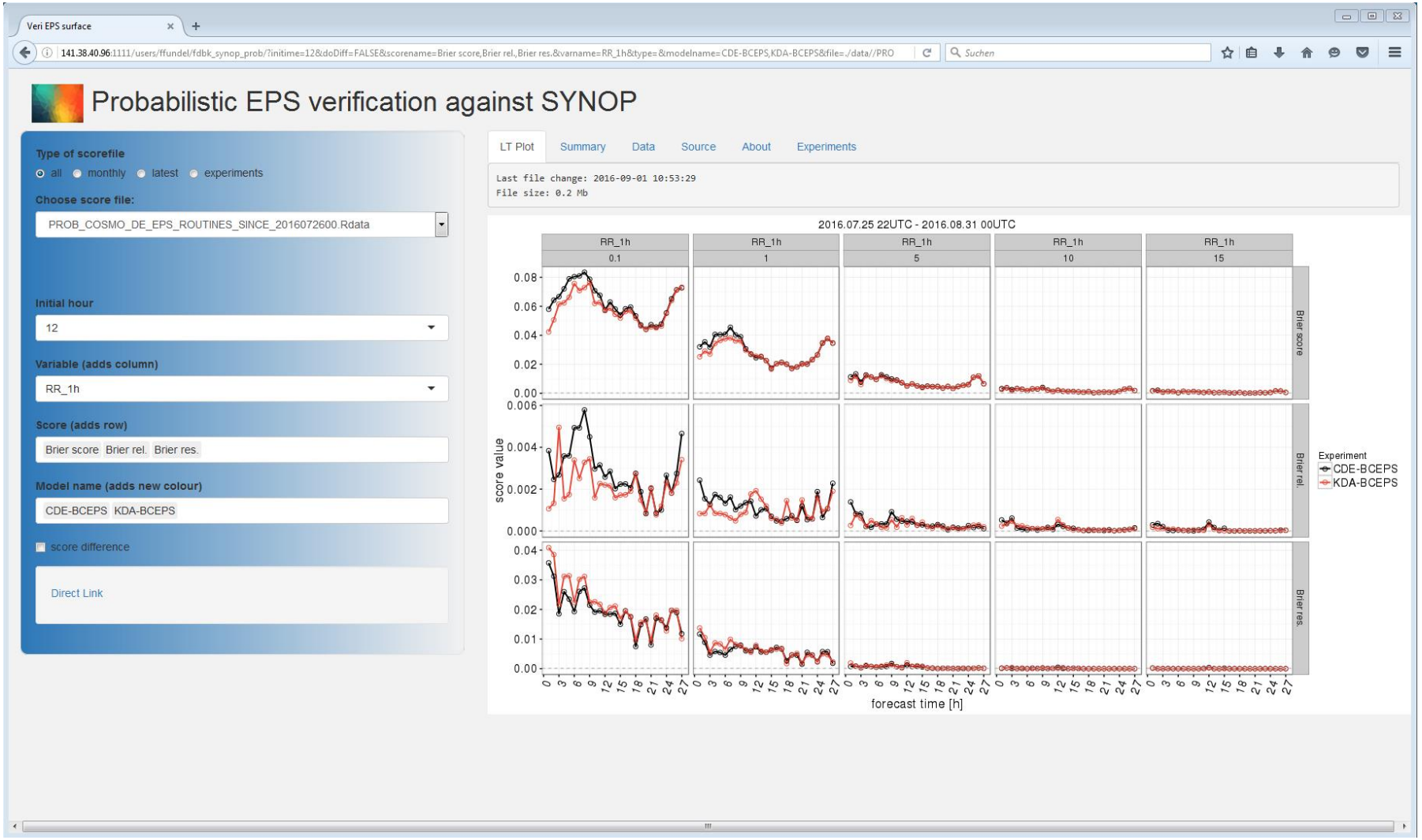
- Ensemble / Probabilistic
- Continuous / Categorical / Hit rates
- Continuous by Station
- Continuous time series
- DIY/WMO

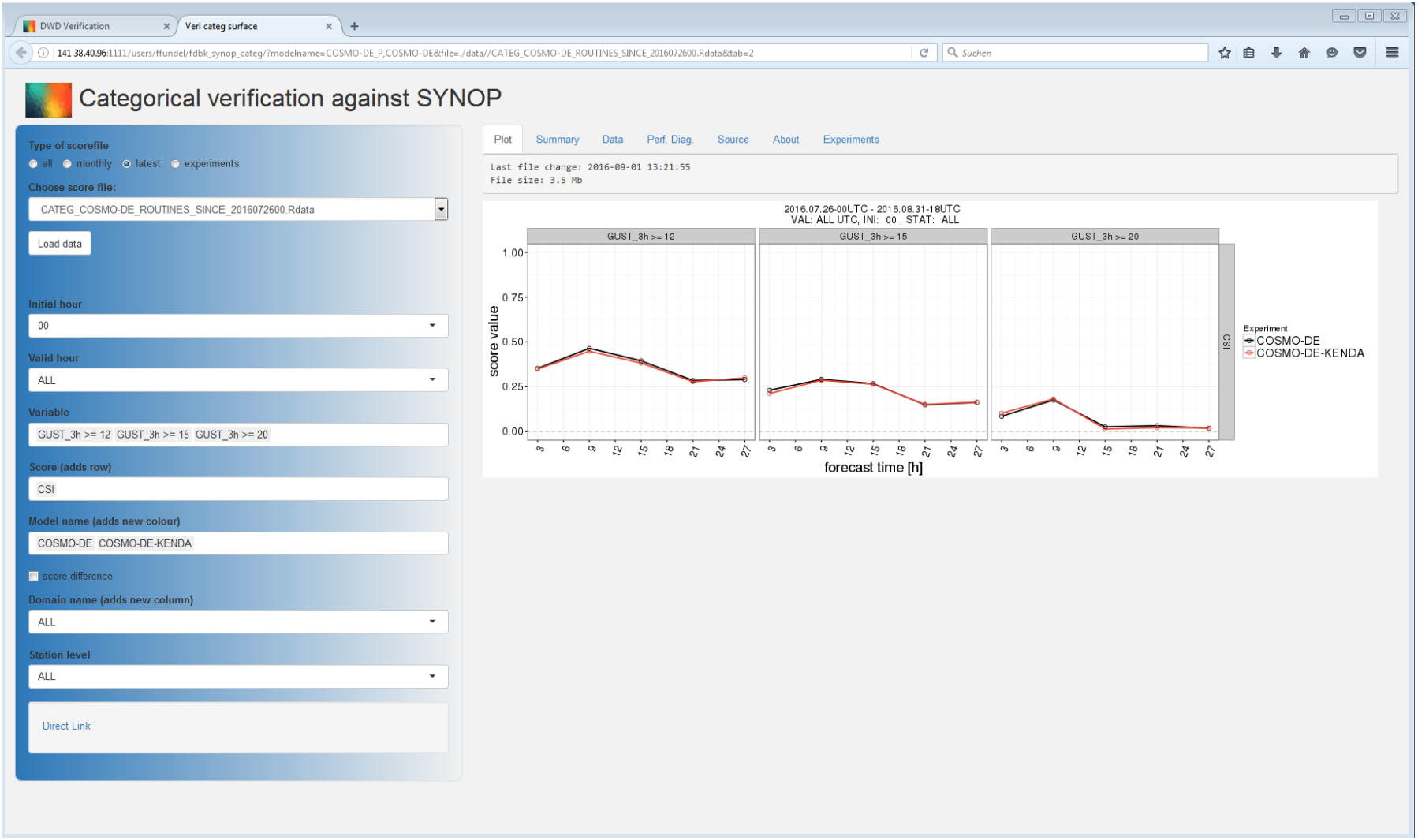
# V. Future Plans

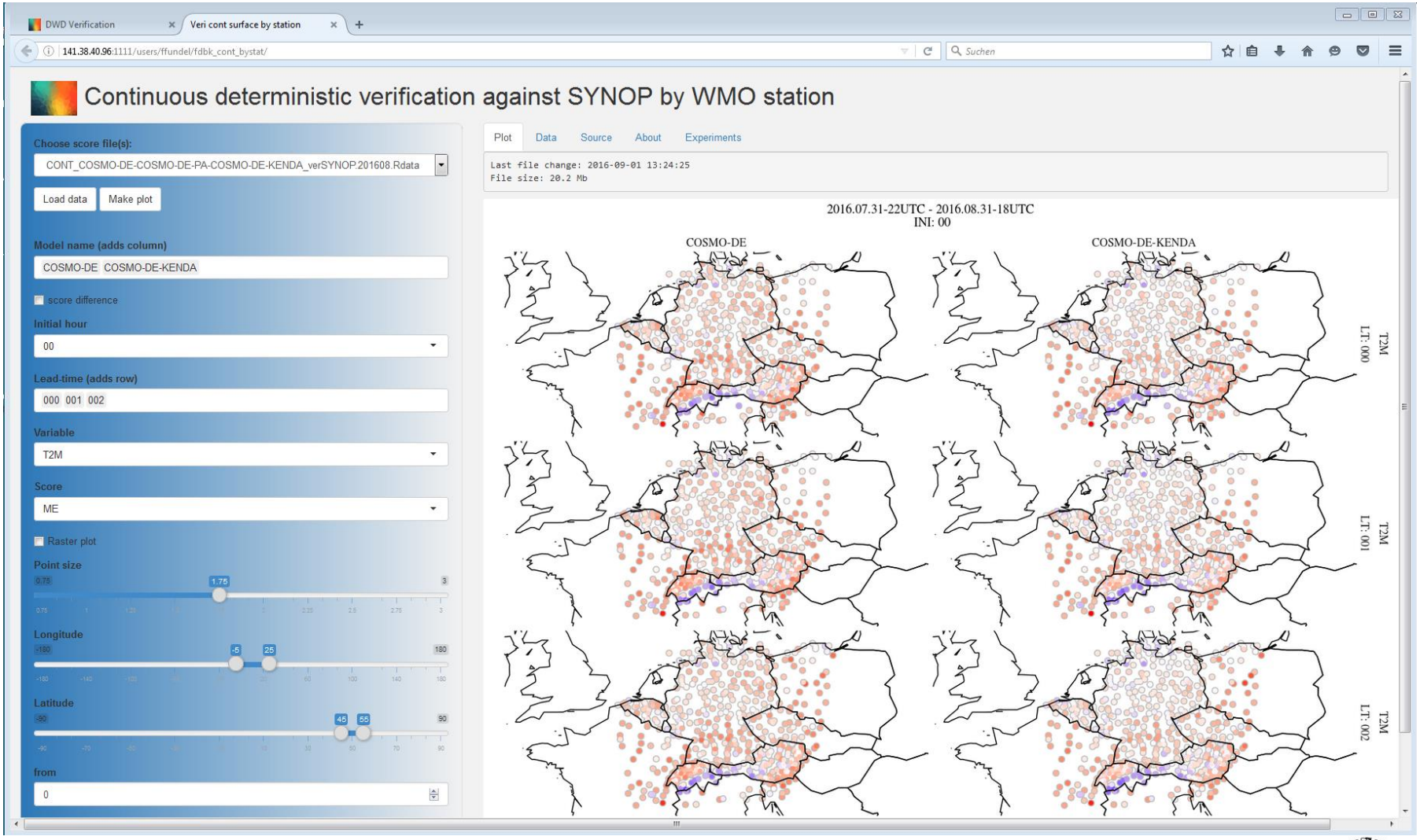


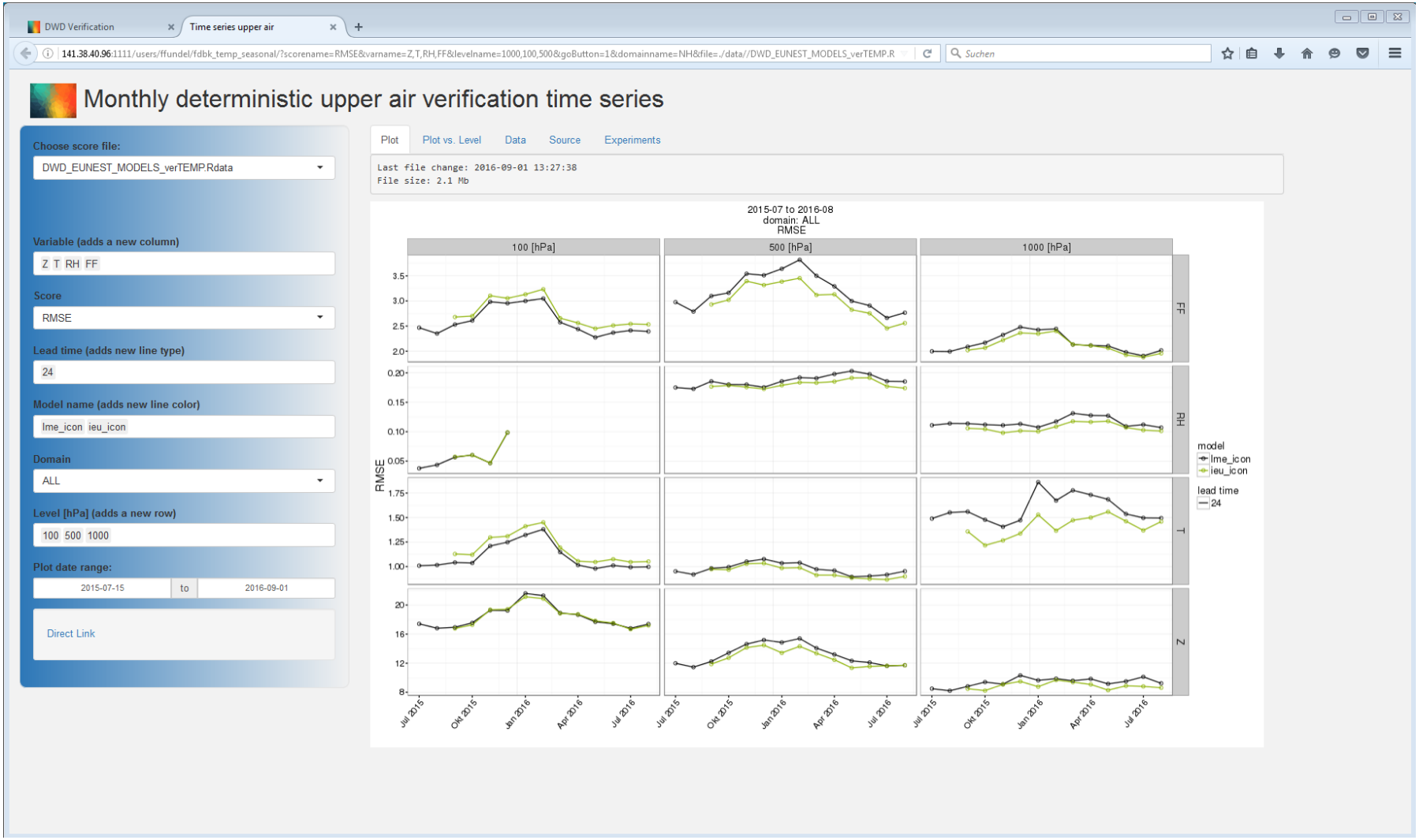
- Address issues with SYNOP verification of precipitation and gusts
- Work on confidence intervals for (some) scores (analytically or bootstrap)
- Move the verification scripts into routine/experiment environment to allow for an online verification
- Use aircraft measurements in verification/monitoring

# Thank you for your attention


Veri EPS surface
141.38.40.96:1111/users/ffundel/fdbk_synop_prob/?initime=12&doDiff=FALSE&scorename=Brier score,Brier rel.,Brier res.&varname=RR_1h&type=&modelname=CDE-BCEPS,KDA-BCEPS&file=./data//PRO
Probabilistic EPS verification against SYNOP
Type of scorefile
all monthly latest experiments
Choose score file:
PROB_COSMO_DE_EPS_ROUTINES_SINCE_2016072600.Rdata
Initial hour
12
Variable (adds column)
RR_1h
Score (adds row)
Brier score Brier rel. Brier res.
Model name (adds new colour)
CDE-BCEPS KDA-BCEPS
score difference
Direct Link
LT Plot
Summary
Data
Source
About
Experiments
Last file change: 2016-09-01 10:53:29
File size: 0.2 Mb
2016.07.25 22UTC - 2016.08.31 00UTC
RR_1h
0.1
1
5
10
15
Brier score
Brier rel.
Brier res.
score value
forecast time [h]
Experiment
CDE-BCEPS
KDA-BCEPS


DWD Verification
Veri categ surface
141.38.40.96:1111/users/ffundel/fdbk_synop_categ/?modelname=COSMO-DE_P,COSMO-DE&file=./data//CATEG_COSMO-DE_ROUTINES_SINCE_2016072600.Rdata&tab=2
Categorical verification against SYNOP
Type of scorefile
all monthly latest experiments
Choose score file:
CATEG_COSMO-DE_ROUTINES_SINCE_2016072600.Rdata
Load data
Initial hour
00
Valid hour
ALL
Variable
GUST_3h >= 12 GUST_3h >= 15 GUST_3h >= 20
Score (adds row)
CSI
Model name (adds new colour)
COSMO-DE COSMO-DE-KENDA
score difference
Domain name (adds new column)
ALL
Station level
ALL
Direct Link
Plot Summary Data Perf. Diag. Source About Experiments
Last file change: 2016-09-01 13:21:55
File size: 3.5 Mb
2016.07.26-00UTC - 2016.08.31-18UTC
VAL: ALL UTC, INI: 00 , STAT: ALL
GUST_3h >= 12
GUST_3h >= 15
GUST_3h >= 20
score value
forecast time [h]
CSI
Experiment
COSMO-DE
COSMO-DE-KENDA


DWD Verification
Veri cont surface by station
141.38.40.96:1111/users/ffundel/fdbk_cont_bystat/
Continuous deterministic verification against SYNOP by WMO station
Choose score file(s):
CONT_COSMO-DE-COSMO-DE-PA-COSMO-DE-KENDA_verSYNOP.201608.Rdata
Load data
Make plot
Model name (adds column)
COSMO-DE COSMO-DE-KENDA
score difference
Initial hour
00
Lead-time (adds row)
000 001 002
Variable
T2M
Score
ME
Raster plot
Point size
Longitude
Latitude
from
0
Plot
Data
Source
About
Experiments
Last file change: 2016-09-01 13:24:25
File size: 20.2 Mb
2016.07.31-22UTC - 2016.08.31-18UTC
INI: 00
COSMO-DE
COSMO-DE-KENDA
T2M
LT: 000
T2M
LT: 001
T2M
LT: 002


DWD Verification
Time series upper air
141.38.40.96:1111/users/ffundel/fdbk_temp_seasonal/?scorename=RMSE&varname=Z,T,RH,FF&levelname=1000,100,500&goButton=1&domainname=NH&file=./data//DWD_EUNEST_MODELS_verTEMP.R
Monthly deterministic upper air verification time series
Choose score file:
DWD_EUNEST_MODELS_verTEMP.Rdata
Variable (adds a new column)
Z T RH FF
Score
RMSE
Lead time (adds new line type)
24
Model name (adds new line color)
lme_icon ieu_icon
Domain
ALL
Level [hPa] (adds a new row)
100 500 1000
Plot date range:
2015-07-15
to
2016-09-01
Direct Link
Plot
Plot vs. Level
Data
Source
Experiments
Last file change: 2016-09-01 13:27:38
File size: 2.1 Mb
2015-07 to 2016-08
domain: ALL
RMSE
100 [hPa]
500 [hPa]
1000 [hPa]
FF
RH
T
Z
RMSE
model
lme_icon
ieu_icon
lead time
24
Jul 2015
Okt 2015
Jan 2016
Apr 2016
Jul 2016

DWD Verification | WMO-CBS MONTHLY

141.38.40.96:1111/users/ffundel/wmo_cbs/?scorename=rmse&deseas=TRUE&varname=Temperature&validtimename=12&leadtimename=24&centre=GERMANY,ECMWF,AUSTRALIA,FRANCE,JAPAN,U-KI

# WMO LC-DNV Global Model Verification Comparison (observations & analysis)

**Truth**
./data/observations.csv

**Centre**
GERMANY ECMWF AUSTRALIA FRANCE JAPAN U-KINGDOM

**Variable (adds a new row)**
Temperature

**Score**
rmse

☑ deseasonalize
☐ deseasonalized only

**Lead time**
24

**Valid time**
12

**Domain (adds a new column)**
nhem

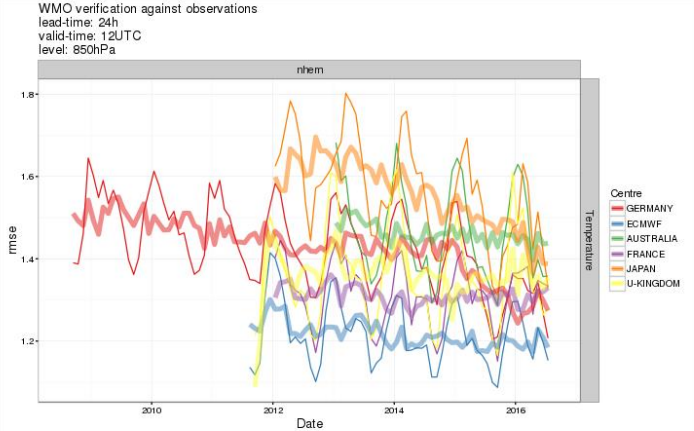
**Level [hPa]**
850

**Date range:**
2008-07-15 to 2016-09-01

Direct Link

Plot_TS | Plot_LT | Data | Info | Source

```
Last file change: 2016-08-31 22:06:52
File size: 285.8 Mb
```



# I. Feedback Files

## Model equivalent Calculator MEC

### Installation

- Sources: Fortran 2003/2008 and some C sources from DWD
- Makefile for gfortran is provided
- NetCDF, CGRIBEX (MPI Hamburg), GRIP-API (ECMWF), (MPI recommended)
- Fortran compiler, C compiler
- Sufficient memory to hold one model state (1 ensemble state)

### Required model input

- Grib or Grib2 files
- COSMO, ICON (EU Nest), IFS, HRM, ECHAM (not fully tested)
- PS, T, U, V, P, Q (mandatory, all model levels)
- T2M, TD2M, CLC, CLCT, CLCL, CLCM, CLCH, CLC, H_SNOW (optional)
- TOT_PREC, VMAX_10, TMIN_2M, TMAX_2M (optional, next release)

### Required observation input

- fof/mon/cof/ekf/ver –files (existing fdbk files from nudging, LETKF or MEC)
- CDFIN (BUFR converted by bufrx2netcdf to NetCDF, BUFR in WMP-templates as used by DWD)

### Output

- ver-files, NetCDF feedback files including past forecasts