MET (Model Evaluation Tools) application for gridded COSMO-Ru/ICON forecasts (Task 3.3)

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With contributions from Ju. Khlestova and A. Kirsanov

PP AWARE session at the COSMO General Meeting, 13 September 2021

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Motivation for using MET

- Availability of almost all the necessary methods in one package (PointStat, GridStat, MODE, EPS scores, IS, etc.)
- We had already had some experience in using MET during the Sochi2014 project
- MET as a candidate for a standard verification package in the world
- Good support from MET developers
- **Verification of new RHM hi-res EPS system as a trial for MET at RHM**

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So

At present, three verification packages are used in RHM COSMO group:

- VERSUS (issues with precipitation and cloudiness)
- MEC-Rfdbk for CP
- MET in the test mode
- We also use R SpatialVx for some applications

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CRA or MODE?

- We have been using *R SpatialVx craer* function to run CRA (Contigous Rain Area), but idealized cases showed some bugs in Volume and Fine-pattern error terms (Displacement term is ok)
- Turned out difficult to fix *craer* at present
- We decided to use MODE (Davis et al. 2009), and probably to return to using CRA at later stage.

METplus: MET and companion packages

(https://dtcenter.org/community-code/metplus)

- MET is a set of verification tools developed and supported to community via the Developmental Testbed Center (DTC) for use by the numerical weather prediction community.
- The core components of the framework include MET, the associated database and display systems called METviewer and METexpress, and a suite of Python wrappers to provide low-level automation and examples, also called use-cases.
- METplus will be a component of NOAA's Unified Forecast System cross-cutting infrastructure as well as NCAR's System for Integrated Modeling of the Atmosphere. METplus is being actively developed by NCAR/Research Applications Laboratory (RAL), NOAA/Earth Systems Research Laboratories (ESRL), NOAA/Environmental Modeling Center (EMC), and is open to community contributions.

We are using MET 9.1.3 version, but version 10 is already available

The most important packages for us besides MET:

- METplus wrappers (The primary goal of METplus wrappers development is to provide MET users with a highly configurable and simple means to perform model verification using the MET tools. A wrapper is generally a Python script that encapsulates the behavior of a corresponding MET tool)
- METviewer

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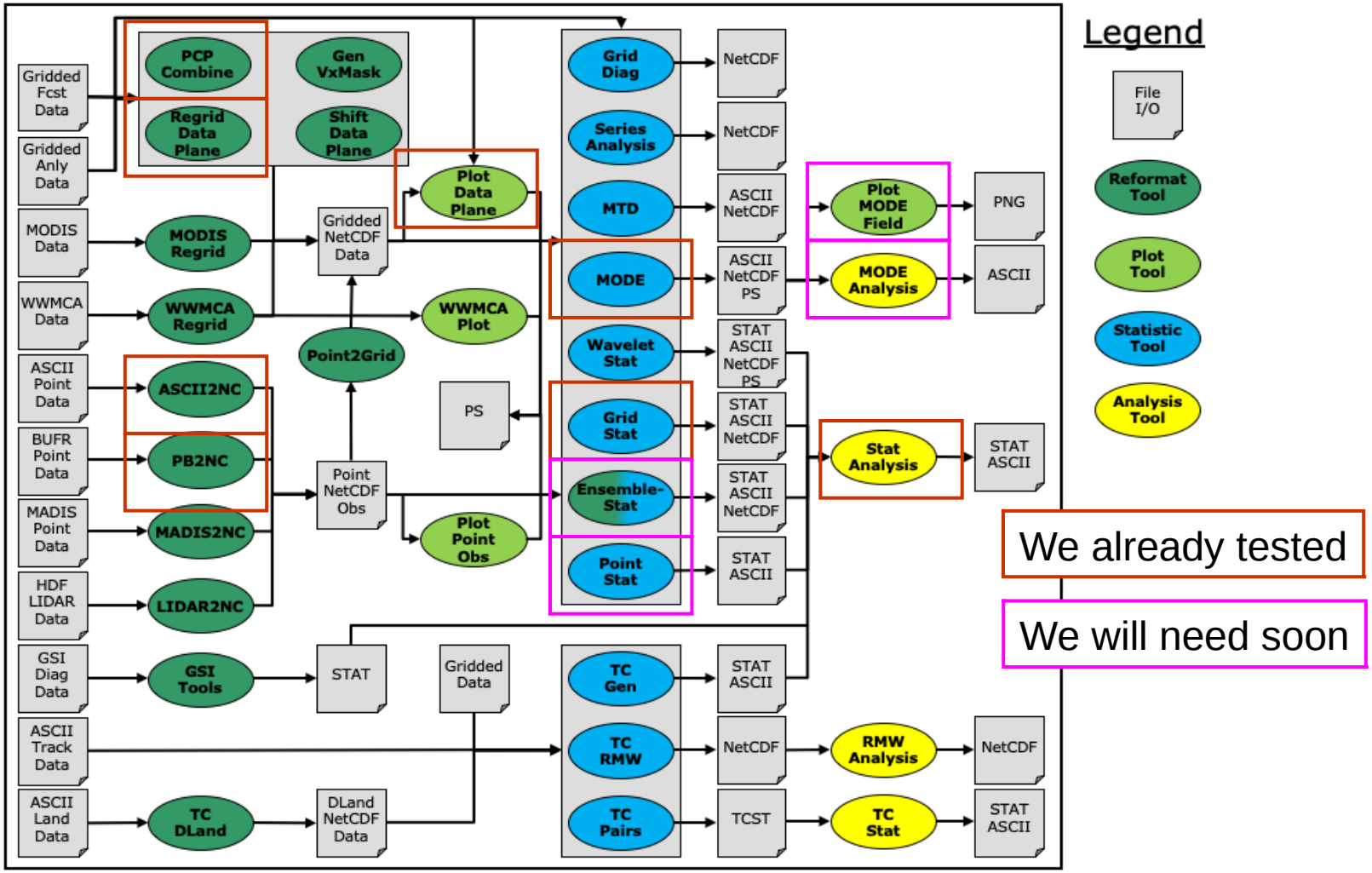
MET Overview v9.0



We already tested

We will need soon

From *Model Evaluation Tools Version 9.0.2 User's Guide*

Each tool is set up by a configuration file and run by sh script

```
#!/bin/sh

export TEST_OUT_DIR=/RHM-Lustre3.2/users/cosmo/abundel/MET/EPS
echo
echo "*** Running Grid-Stat on precip using GRIB2 forecast observation ***"
grid_stat \
  ~/MET/EPS/model/2021070100.CFO2/01/ilfr_00010000s.cfoeps.grb \
  ~/MET/EPS/RADARS/20210701/PRCP-ETR_20210701_0100.grib\
  ~/MET/EPS/GridStatConfig_radar \
  -outdir ${TEST_OUT_DIR}/grid_stat -v 2
```

Extract from GridStat config file

```
////////////////////////////////////////////////////////////////////////////////
//
// Grid-Stat configuration file.
//
// For additional information, see the MET_BASE/config/README file.
//
////////////////////////////////////////////////////////////////////////////////

//
// Output model name to be written
//
model = "ICON";

//
// Output description to be written
// May be set separately in each "obs.field" entry
//
desc = "NA";

//
// Output observation type to be written
//
obtype = "ANALYS";

////////////////////////////////////////////////////////////////////////////////

//
// Verification grid
//
regrid = {
   to_grid    = FCST;
   method     = NEAREST;
   width      = 1;
   vld_thresh = 0.5;
   shape      = SQUARE;
}

////////////////////////////////////////////////////////////////////////////////

//
// May be set separately in each "field" entry
//
censor_thresh        = [];
censor_val           = [];
cat_thresh           = [];
cnt_thresh           = [ NA ];
cnt_logic            = UNION;
wind_thresh          = [ NA ];
wind_logic           = UNION;
eclv_points          = 0.05;
nc_pairs_var_name    = "";
nc_pairs_var_suffix  = "";
rank_corr_flag       = FALSE;

//
// Forecast and observation fields to be verified
//
fcst = {

   file_type = GRIB2;

   field = [
      {
        name       = "TPRATE";
        level      = [ "A01" ];
        cat_thresh = [  >=0.1 ];
      }

   ];

}

//obs = fcst;
obs =  {

   file_type = GRIB2;

   field = [
      {
        name       = "TPRATE";
        level      = [ "A01" ];
        cat_thresh = [ >=0.1 ];
      }
```

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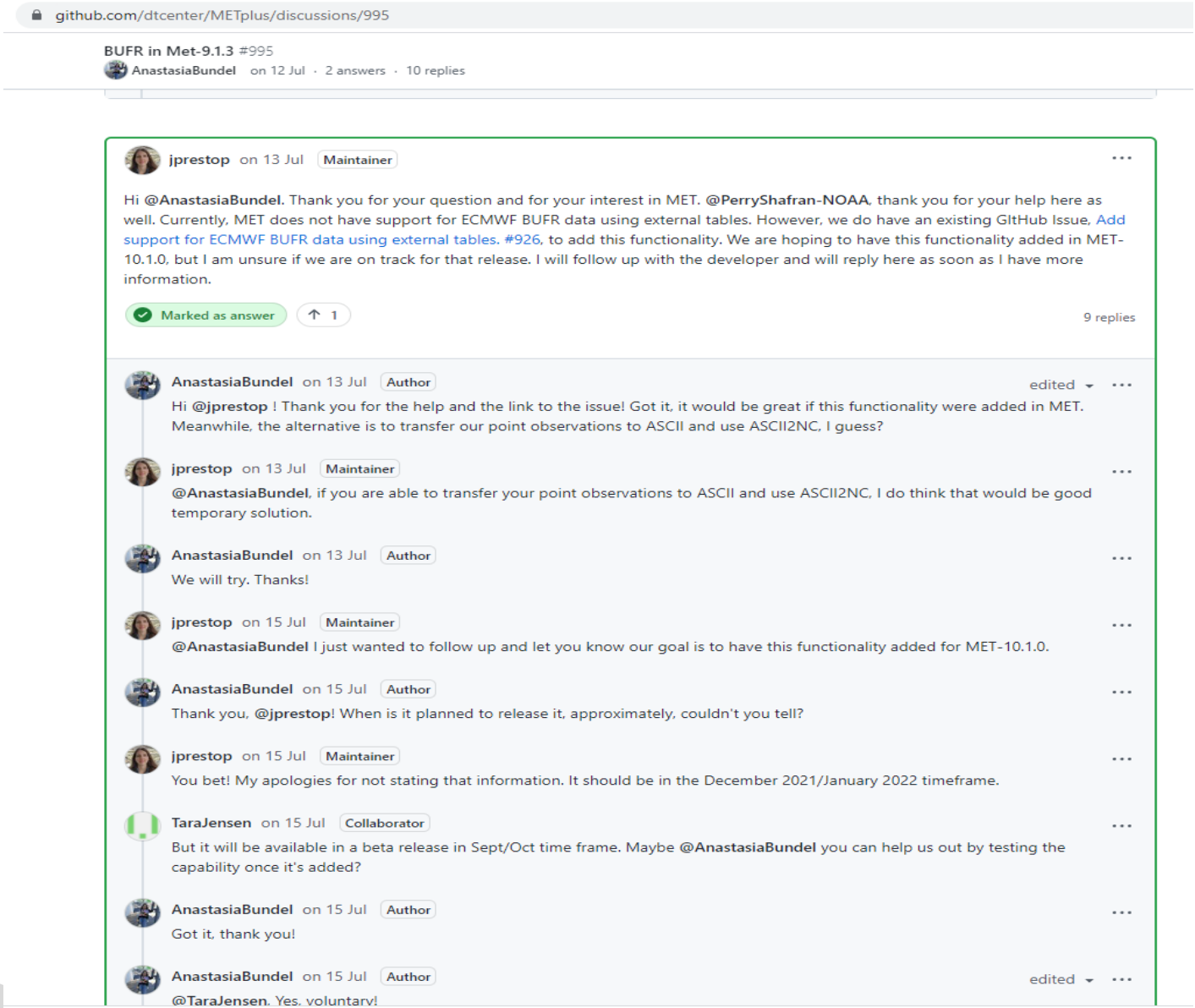
PB2NC to transfer PrepBUFR to NetCDF

- To use PointStat we need station data in NetCDF format. They can be prepared using PB2NC tool
- A problem: MET uses BUFR files with embedded tables at present (PrepBUFR). At RHM, ECMWF-type BUFRs are produced using external tables
- Alternative: To use ASCII point observations or try our own NetCDF observations
- But! Support for external BUFR tables is planned by developers very soon (next slide)

https://github.com/dtcenter/METplus/discussions
METplus help forum



github.com/dtcenter/METplus/discussions/995

BUFR in Met-9.1.3 #995

AnastasiaBundel on 12 Jul · 2 answers · 10 replies

jprestop on 13 Jul Maintainer

Hi **@AnastasiaBundel**. Thank you for your question and for your interest in MET. **@PerryShafran-NOAA**, thank you for your help here as well. Currently, MET does not have support for ECMWF BUFR data using external tables. However, we do have an existing GItHub Issue, Add support for ECMWF BUFR data using external tables. #926, to add this functionality. We are hoping to have this functionality added in MET-10.1.0, but I am unsure if we are on track for that release. I will follow up with the developer and will reply here as soon as I have more information.

Marked as answer · 1 · 9 replies

AnastasiaBundel on 13 Jul Author — edited

Hi **@jprestop** ! Thank you for the help and the link to the issue! Got it, it would be great if this functionality were added in MET. Meanwhile, the alternative is to transfer our point observations to ASCII and use ASCII2NC, I guess?

jprestop on 13 Jul Maintainer

@AnastasiaBundel, if you are able to transfer your point observations to ASCII and use ASCII2NC, I do think that would be good temporary solution.

AnastasiaBundel on 13 Jul Author

We will try. Thanks!

jprestop on 15 Jul Maintainer

@AnastasiaBundel I just wanted to follow up and let you know our goal is to have this functionality added for MET-10.1.0.

AnastasiaBundel on 15 Jul Author

Thank you, **@jprestop**! When is it planned to release it, approximately, couldn't you tell?

jprestop on 15 Jul Maintainer

You bet! My apologies for not stating that information. It should be in the December 2021/January 2022 timeframe.

TaraJensen on 15 Jul Collaborator

But it will be available in a beta release in Sept/Oct time frame. Maybe **@AnastasiaBundel** you can help us out by testing the capability once it's added?

AnastasiaBundel on 15 Jul Author

Got it, thank you!

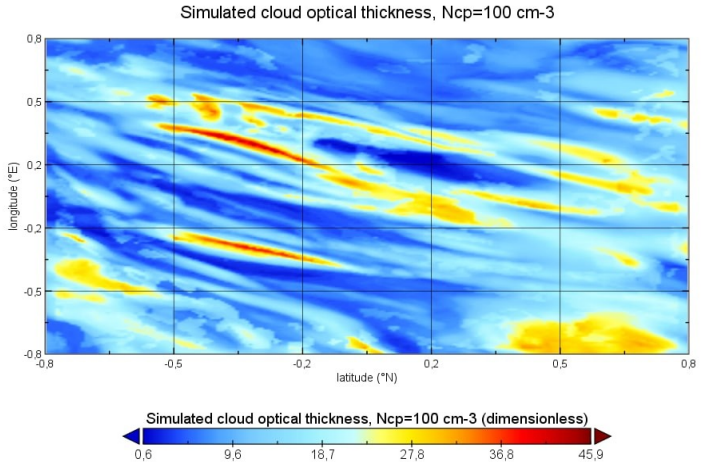
AnastasiaBundel on 15 Jul Author — edited

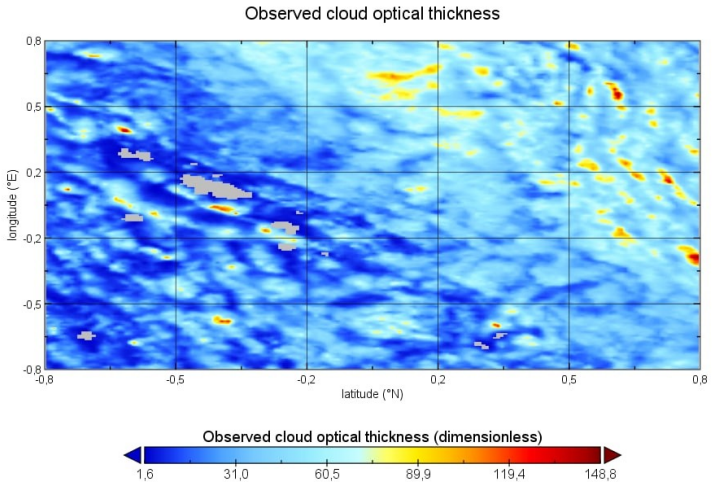
@TaraJensen, Yes, voluntary!

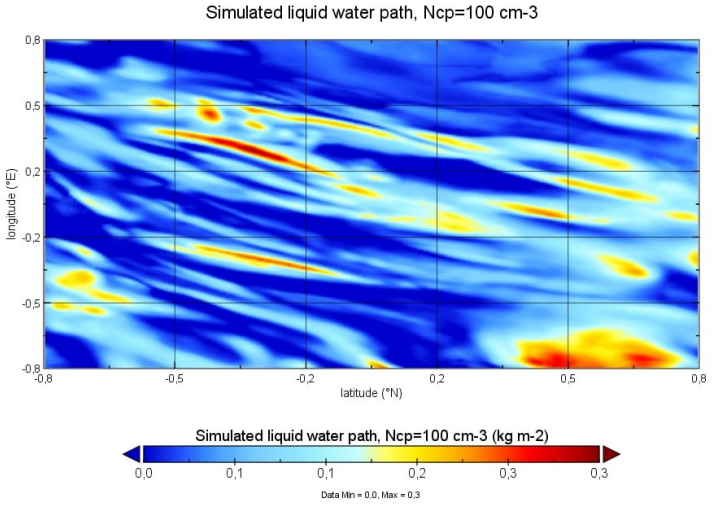
Minor issues encountered up to now

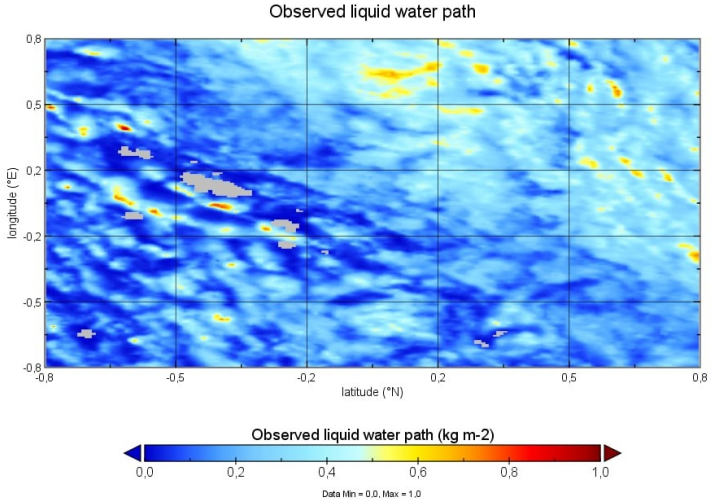
- MET didn’t want to ingest data on **COSMO rotated lat-lon grid** in grib1, **only in grib2**
- **StatAnalysis tool** (used to aggregate the scores from Grid_Stat over time periods) cannot compute bootstrap confidence intervals during the aggregate_stat job type, while it does compute parametric CI's from GridStat and both CI types from PointStat tool
- Solution: **The METviewer database and display system DOES have the ability to bootstrap this type of aggregation and compute CI's**. The DTCenter relies heavily on METviewer for this type of analysis, and that feature request has never risen high enough in priority. (https://github.com/dtcenter/METplus/discussions/1017)

GridStat and StatAnal tools for COT (cloud optical thickness) and LWP (liquid water path)









Experiments comparing COT and LWP from one- (on the plots) and two-moment COSMO microphysics with the satellite product (MODIS spectroradiometer data of Terra and Aqua satellites (a paper by N. Chubarova, Yu. Khlestova, et. al. under preparation)

Example of the scores

Файл Правка Поиск Кодировки Настройки Справка

exp=	100	200	400	800
TOTAL number of pairs:	216962	216962	216962	216962
Base rate:	0.676700	0.676700	0.676700	0.676700
Mean frc event frequency:	0.197500	0.269190	0.333610	0.368790
FBI:	0.291860	0.397800	0.492990	0.544980
PODY (hit rate):	0.243360	0.323610	0.389850	0.426520
PODY NCL:	0.241560	0.321640	0.387800	0.424440
PODY NCU:	0.245170	0.325580	0.391900	0.428600
POFD (false alarm rate):	0.101510	0.155300	0.215890	0.247960
POFD NCL:	0.100240	0.153780	0.214160	0.246150
POFD NCU:	0.102780	0.156830	0.217620	0.249790
GSS (ETS)	0.053891	0.067596	0.073084	0.077001
HK (Pierce Skill Score):	0.141850	0.168310	0.173960	0.178550
HK NCL:	0.137990	0.164100	0.169570	0.174100
HK NCU:	0.145710	0.172520	0.178350	0.183000
EDI:	0.236280	0.245500	0.238790	0.241420
EDI NCL:	0.232660	0.241530	0.234330	0.236650
EDI NCU:	0.239890	0.249470	0.243250	0.246190
Continuous scores				
TOTAL number of pairs:	216962	216962	216962	216962
FBAR (mean forecast):	13.202480	15.018470	16.861190	18.294180
FBAR NCL:	13.167230	14.976280	16.810880	18.236630
FBAR NCU:	13.237720	15.060670	16.911510	18.351720
FSTDEV (frc stand.dev.):	8.376520	10.027700	11.957650	13.675690
FSTDEV NCL:	8.351670	9.997950	11.922180	13.635120
FSTDEV NCU:	8.401520	10.057630	11.993340	13.716500
OBAR (mean obs):	34.058250	34.058250	34.058250	34.058250
OBAR NCL:	33.964570	33.964570	33.964570	33.964570
OBAR NCU:	34.151940	34.151940	34.151940	34.151940
OSTDEV (obs stand.dev):	22.264190	22.264190	22.264190	22.264190
OSTDEV NCL:	22.198150	22.198150	22.198150	22.198150
OSTDEV NCU:	22.330640	22.330640	22.330640	22.330640
PR_CORR (Pearson corr.coef):	0.273200	0.278810	0.273190	0.269740
PR_CORR NCL:	0.269300	0.274920	0.269290	0.265840
PR_CORR NCU:	0.277090	0.282680	0.277080	0.273640
ME :	-20.855780	-19.039780	-17.197060	-15.764070
ME NCL:	-20.946410	-19.131180	-17.290510	-15.859880
ME NCU:	-20.765140	-18.948390	-17.103610	-15.668260
RMSE:	29.982010	28.883690	28.088310	27.694060
MSE:	898.921010	834.267830	788.953340	766.960710
BCMSE (Bias corrected MSE) :	463.957620	471.754530	493.214420	518.454680

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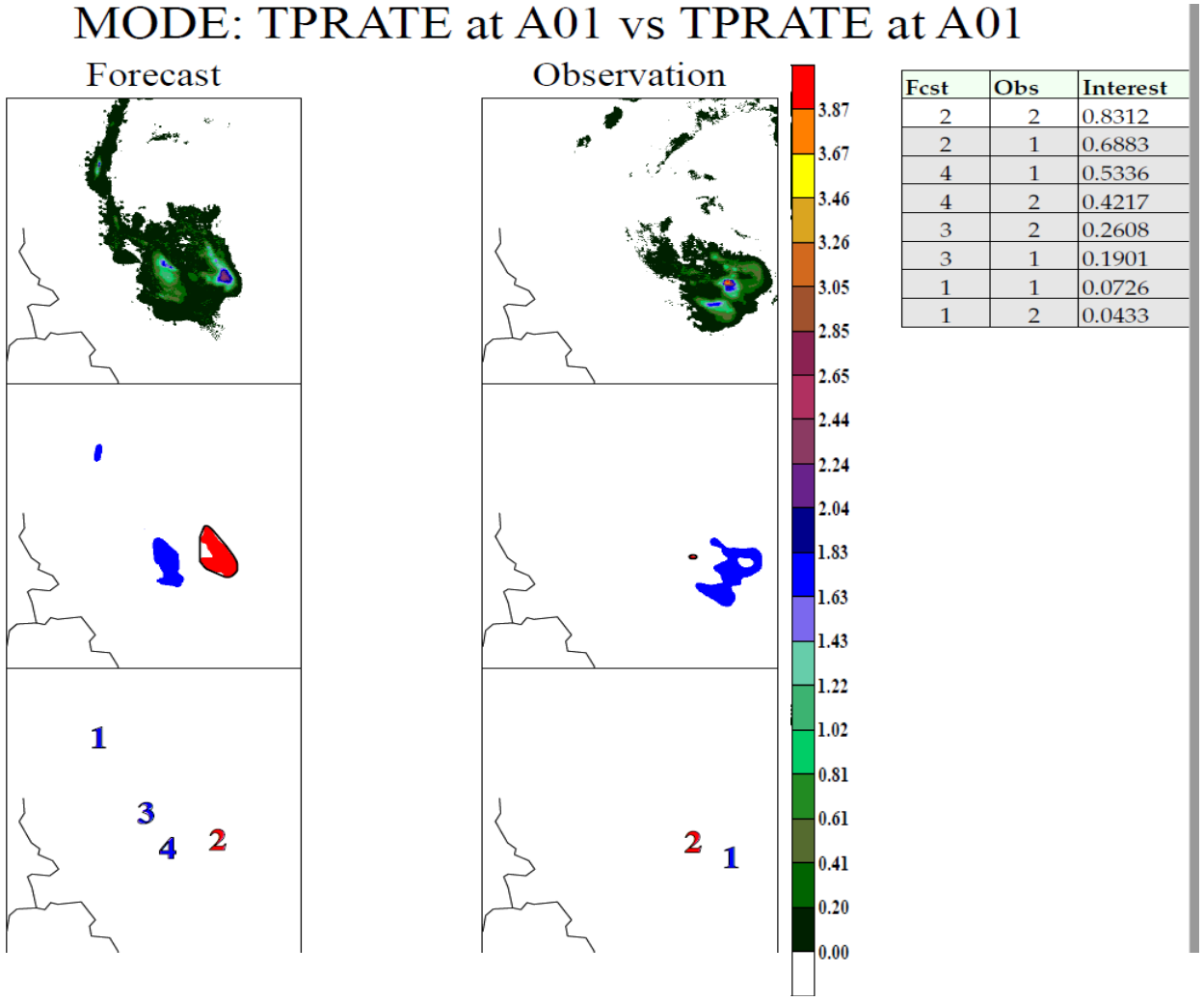
First experiments with MODE and GridStat for EPS precipitation

- EPS for Central Russian region, 2.2 km
- Radar composite as observed data, pcp_combine MET tool is used to prepare 1 hour accumulations from 10 minutes radar fields
  - Problems to produce grib2 radar data from grib1 at present, hopefully will be fixed soon
  - In the plots in next slides, another ensemble member is used temporarily as observation field to demonstrate the MODE output

MET MODE output graphics, precip threshold >=0.3 mm/h



Fcst	Obs	Interest
2	2	0.8312
2	1	0.6883
4	1	0.5336
4	2	0.4217
3	2	0.2608
3	1	0.1901
1	1	0.0726
1	2	0.0433

MET MODE output graphics, precip threshold >=0.3 mm/h

	Forecast	Observation
Model	ICON	
Field	TPRATE	TPRATE
Level	A01	A01
Units	kg/m^2/s	kg/m^2/s
Initial	2021 07 01 00:00:00	2021 07 01 06:00:00
Valid	2021 07 01 01:00:00	2021 07 01 07:00:00
Accum	01:00:00	01:00:00

Centroid/Boundary	2.00	4.00
Convex Hull/Angle	0.00	1.00
Aspect/Area	0.00	1.00
Int Area/Curvature	2.00	0.00
Complexity/Intensity	0.00	0.00
Total Interest Thresh	0.70	

	Forecast	Observation
Mask M/G/P	on/off/off	on/off/off
Conv Radius	5	5
Conv Thresh	>=0.3	>=0.3
Obj Filters	0	0
Inten Perc	p50	
Merge Thresh	>=0.15	>=0.15
Merging	none	none
Matching	match/merge	
Simple/M/U	4/1/3	2/1/1
Area	4432	4118
Area M/U	2172/2260	42/4076
Cluster	1	1
MMI	0.3972	0.7597
MMI (F+O)	0.6109	

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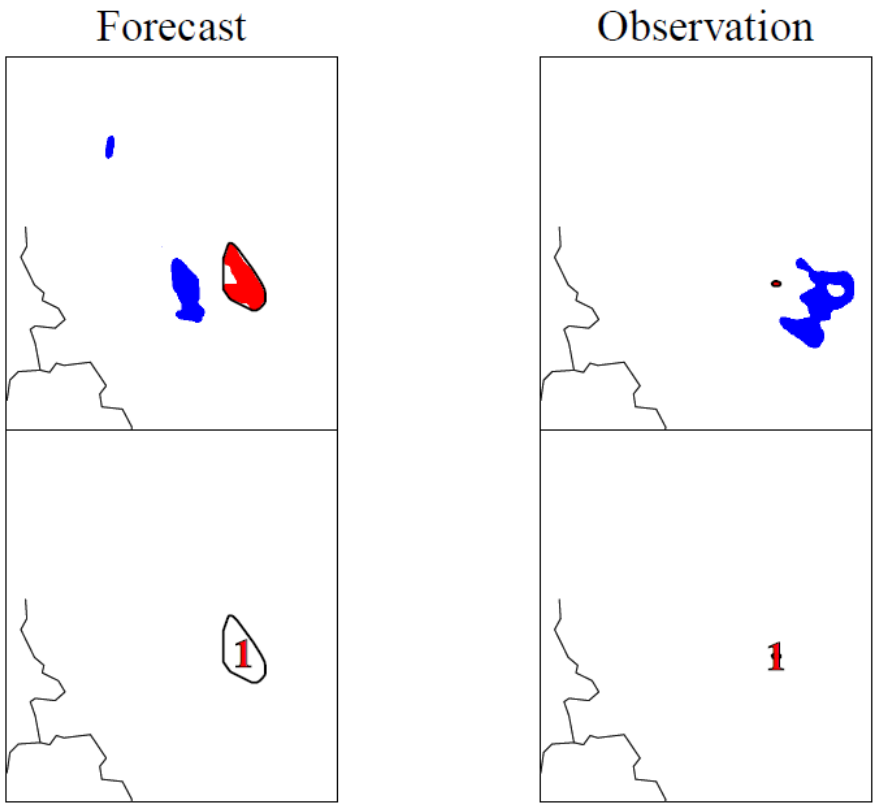
MET MODE output graphics, precip threshold >=0.3 mm/h



CLUS PAIR	CEN DIST	ANG DIFF	FCST AREA	OBS AREA	INTER AREA	UNION AREA	SYMM DIFF	FCST INT 50	OBS INT 50	FCST INT 90	OBS INT 90	TOT INTR
1	3.60	62.96	2172	42	42	2172	2130	0.80	0.41	1.85	0.49	0.8312

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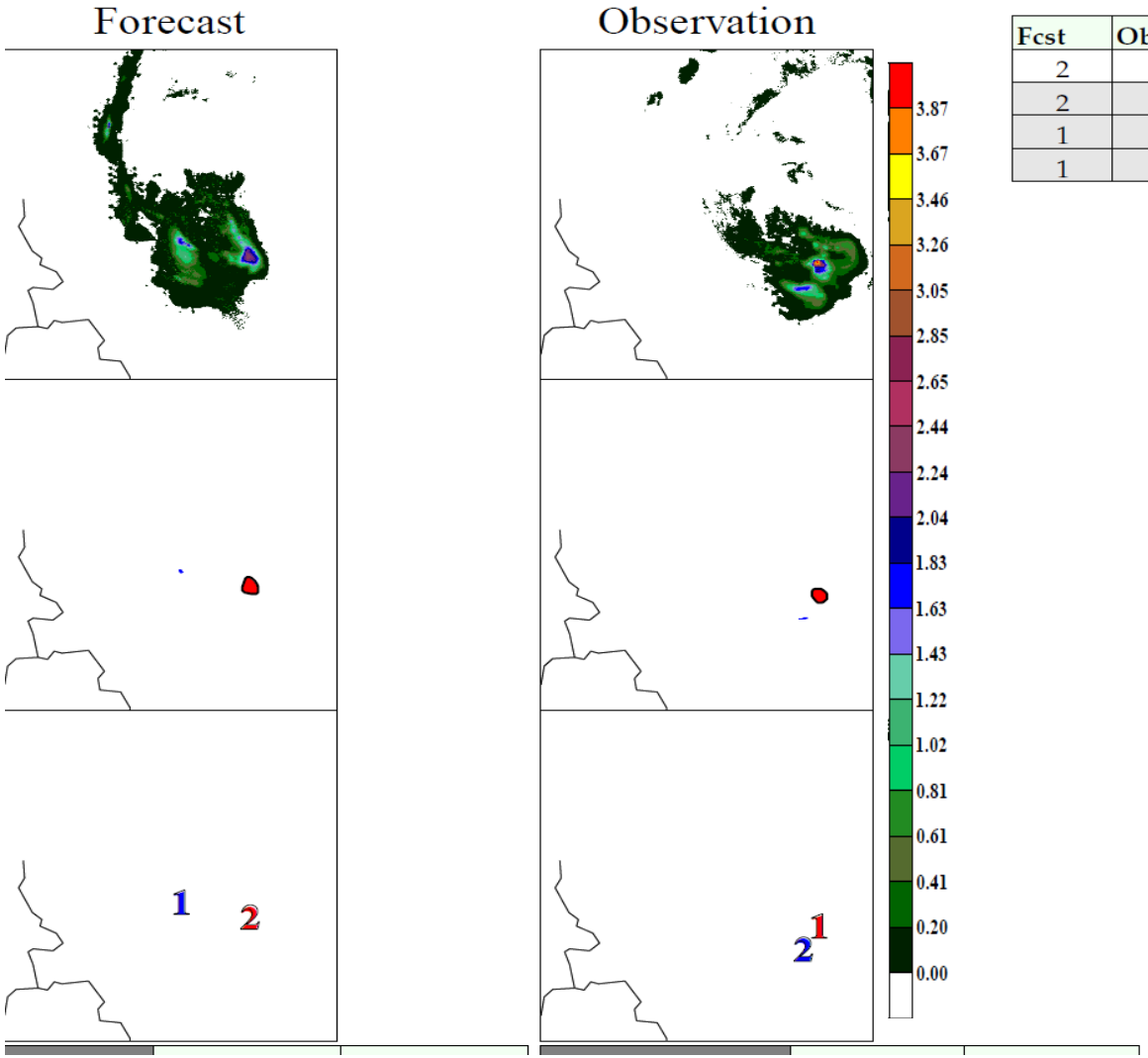
MET MODE output graphics, precip threshold >=1.5 mm/h



Fcst	Obs	Interest
2	1	0.7154
2	2	0.4723
1	2	0.4346
1	1	0.2764

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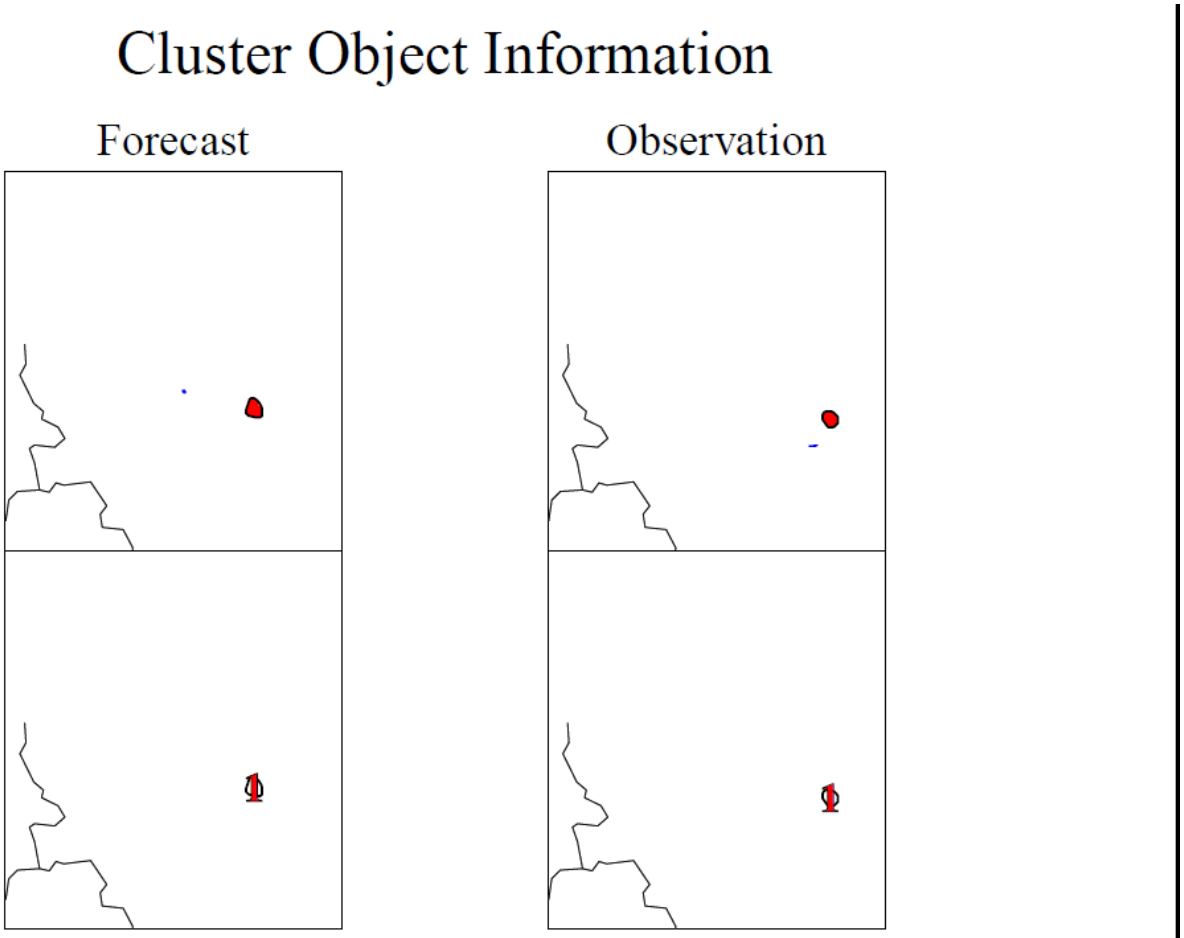
MET MODE output graphics, precip threshold >=1.5 mm/h



CLUS PAIR	CEN DIST	ANG DIFF	FCST AREA	OBS AREA	INTER AREA	UNION AREA	SYMM DIFF	FCST INT 50	OBS INT 50	FCST INT 90	OBS INT 90	TOT INTR
1	41.31	17.25	314	258	0	572	572	1.99	1.93	2.27	3.25	0.7154

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Conclusions and Plans

- The Model Evaluation Tools (MET) developed and supported to community via the Developmental Testbed Center (DTC) installed, first results obtained
- MET is a flexible tool with good support
- PointStat, GridStat, and MODE MET tools will be used to verify the new RHM EPS
- **At the end of AWARE task 3.3, object-based MODE and neighborhood scores for the ensemble mean and single members will be obtained and compared**
- **Further plan: A python-based system to adjust deterministic MODE output for EPS based on the approach of [Johnson et al.2020] and using the experience of DWD colleagues will be developed**