CONSORTIUM FOR SMALL SCALE MODELING

COSMO

# Verification Activities Overview

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**COSMO Working Group on Verification and Case studies**

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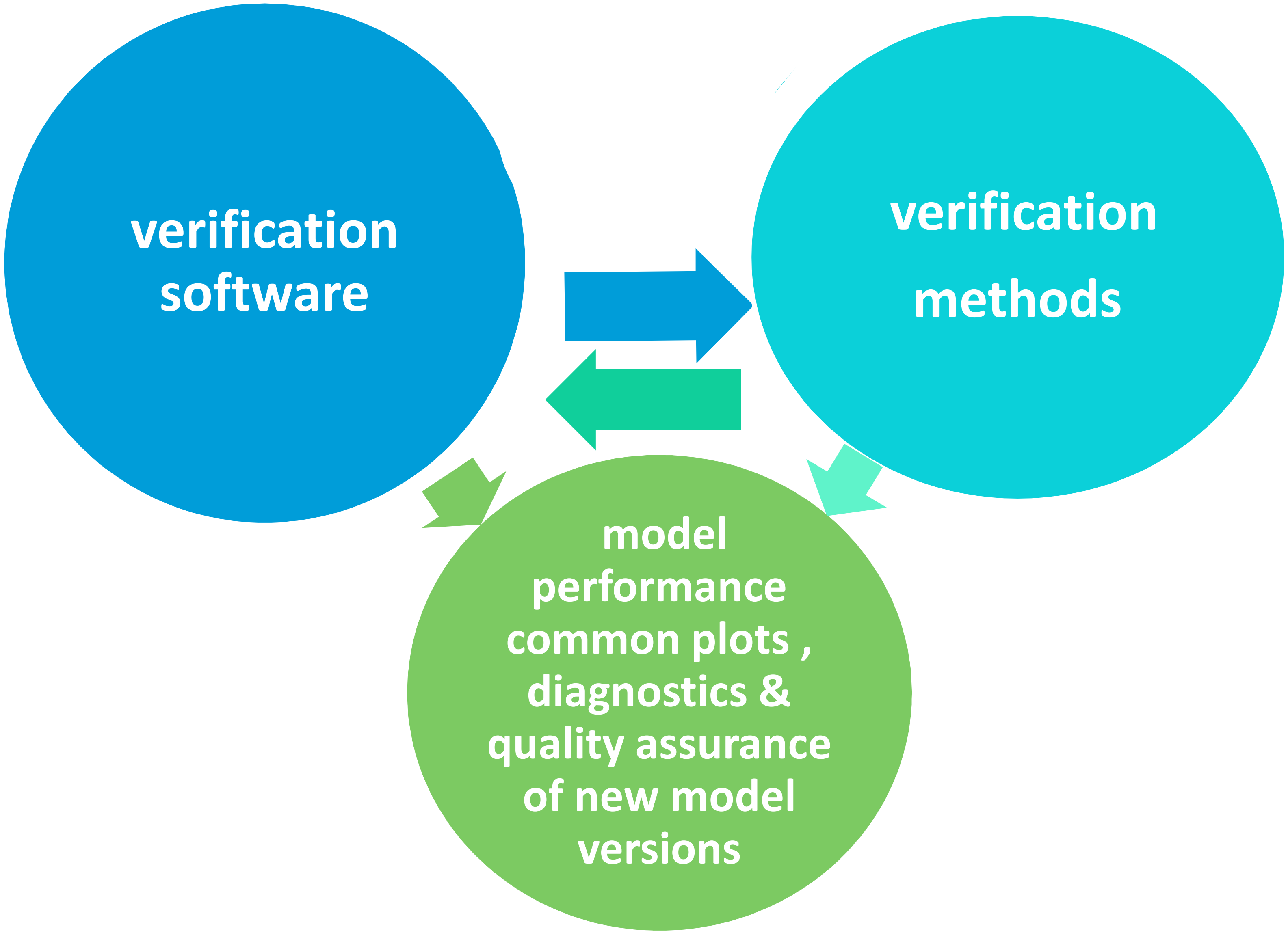
COSMO

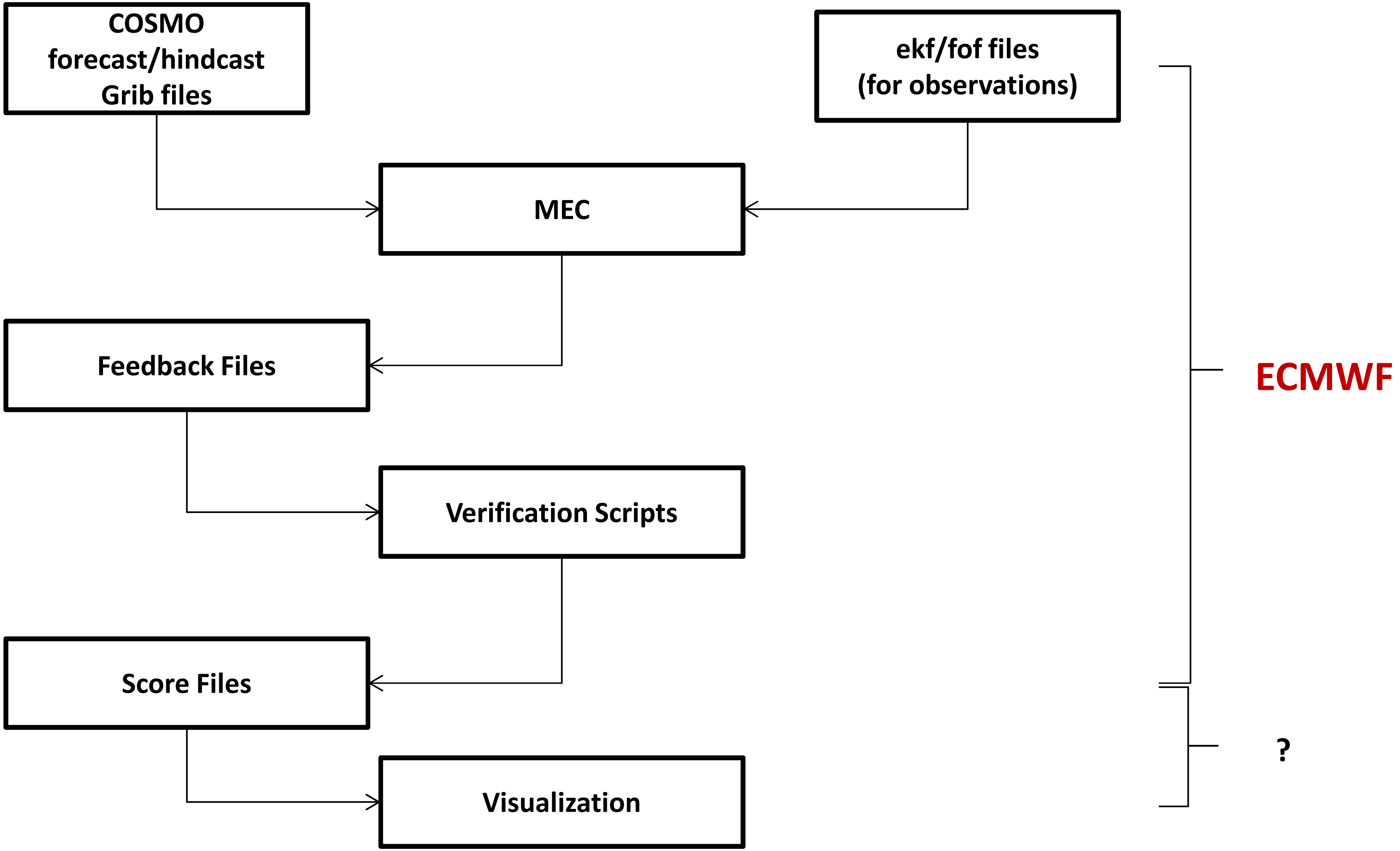
# main activities



# Feedback File Based Verification at DWD - Rfdbk

# Workflow




COSMO
forecast/hindcast
Grib files
ekf/fof files
(for observations)
MEC
Feedback Files
Verification Scripts
Score Files
Visualization
ECMWF
?

# 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

# Recap on Rfdbk Concept



- 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 is a R interface for COSMO feedback files
- Main purpose of Rfdbk is to load feedback file content with R
- Additional functionalities useful for verification is implemented as well

# Status

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

## Models
- 3 ICON global deterministic routines
- 3 ICON EU Nest deterministic routines
- 2 ICON global EPS
- 2 ICON EU Nest EPS
- 3 COSMO-DE deterministic routines
- 3 COSMO-DE-EPS ensemble routines
- IFS deterministic
- IFS EPS

\+ Experiments

## Observation systems
- SYNOP
- TEMP (radiosondes)
- SATOB (AMV)
- GPSRO (radio occultations)
- SCATT (scatterometer)
- AIREP (aircraft)
- PILOT (wind profiler)

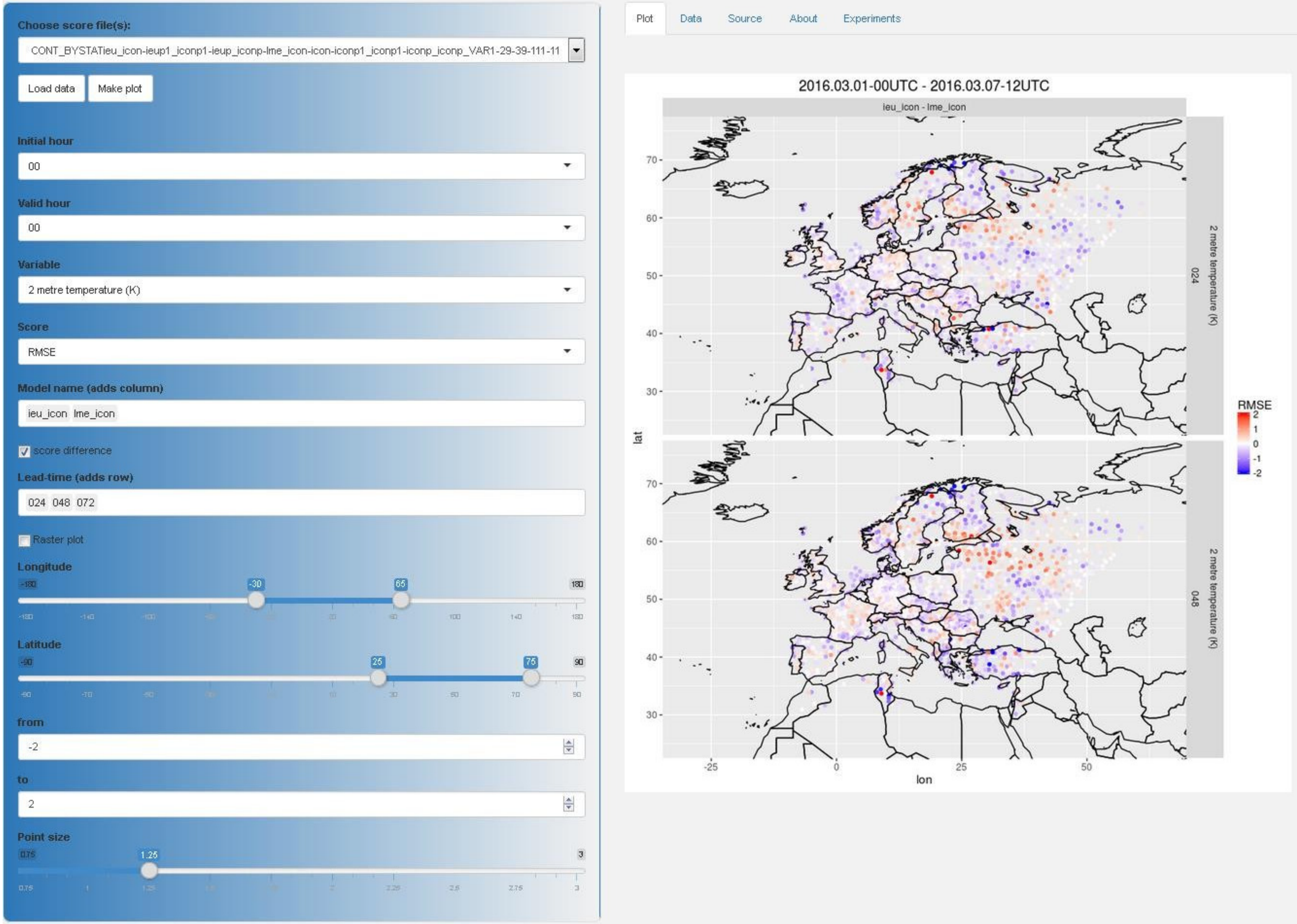
## Methods
- Deterministic: continuous and categorical
- EPS: ensemble and probabilistic

## Visualization
- Lead-time
- Time series
- Station based

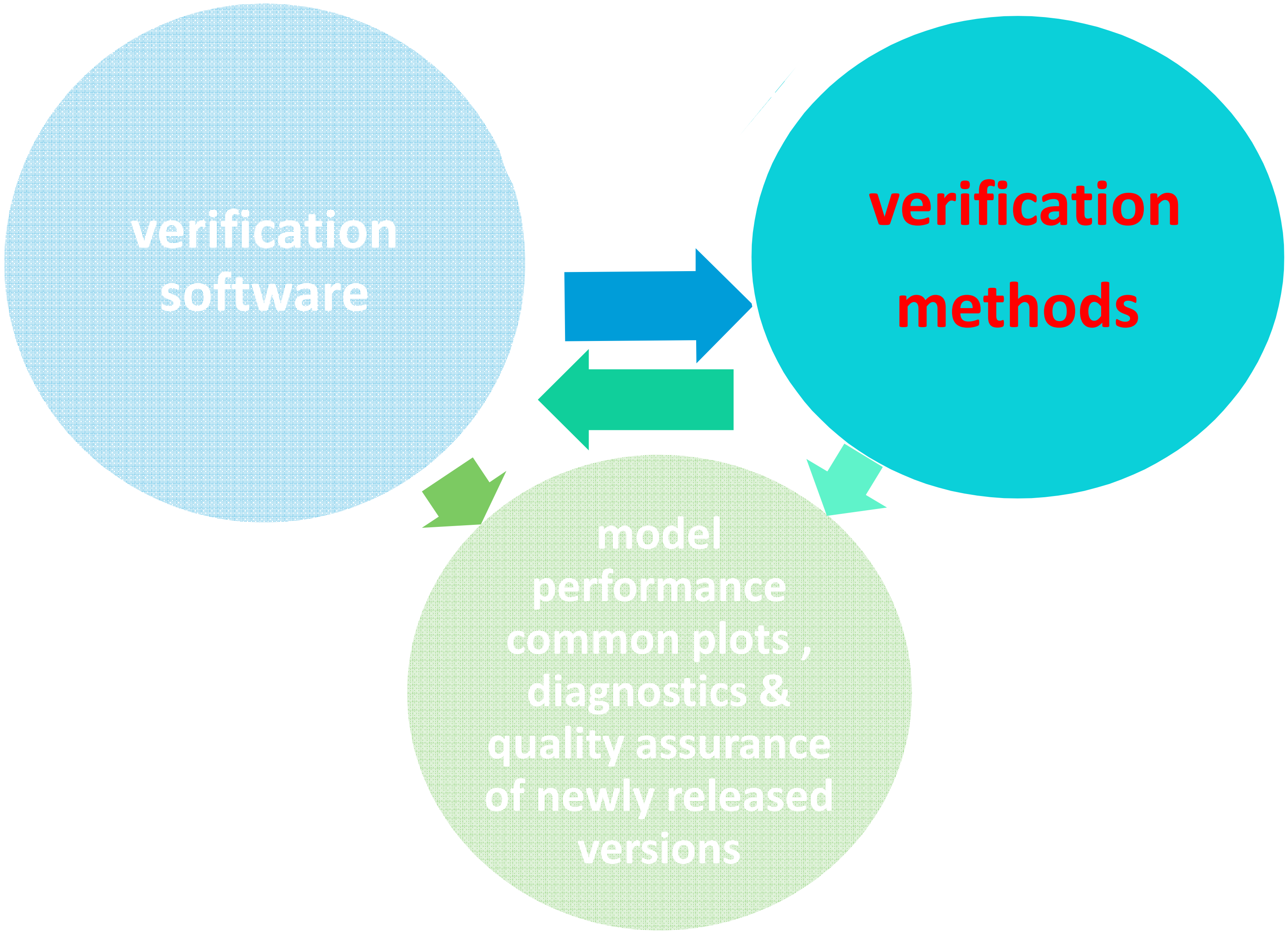
## Aggregation
- Sub-domains
- Height bins or levels
- Lead-time to time of day conversion („hindcast mode“)

# Visualization





# main activities



# Mesoscale Verification Inter-Comparison over Complex Terrain (https://www.ral.ucar.edu/projects/icp/)

Prerequisite for verification method inter-comparison:

-use of same data (Obs and FC) on the same grid and over the same area (Alpine area)

**From MAP D-PHASE COPS archive**

- Deterministic 2 km COSMO-2 Init-time: Initialised 06 UTC FC-range: 24h
- Deterministic 2 km CMC-GEM-H Init-time: Initialised 06 UTC FC-range: 18h
- Ensemble 10 km COSMO-LEPS Init-time: Initialised 12 UTC FC-range:132h

**MCH**

•Reruns COSMO-1 models for 4 cases

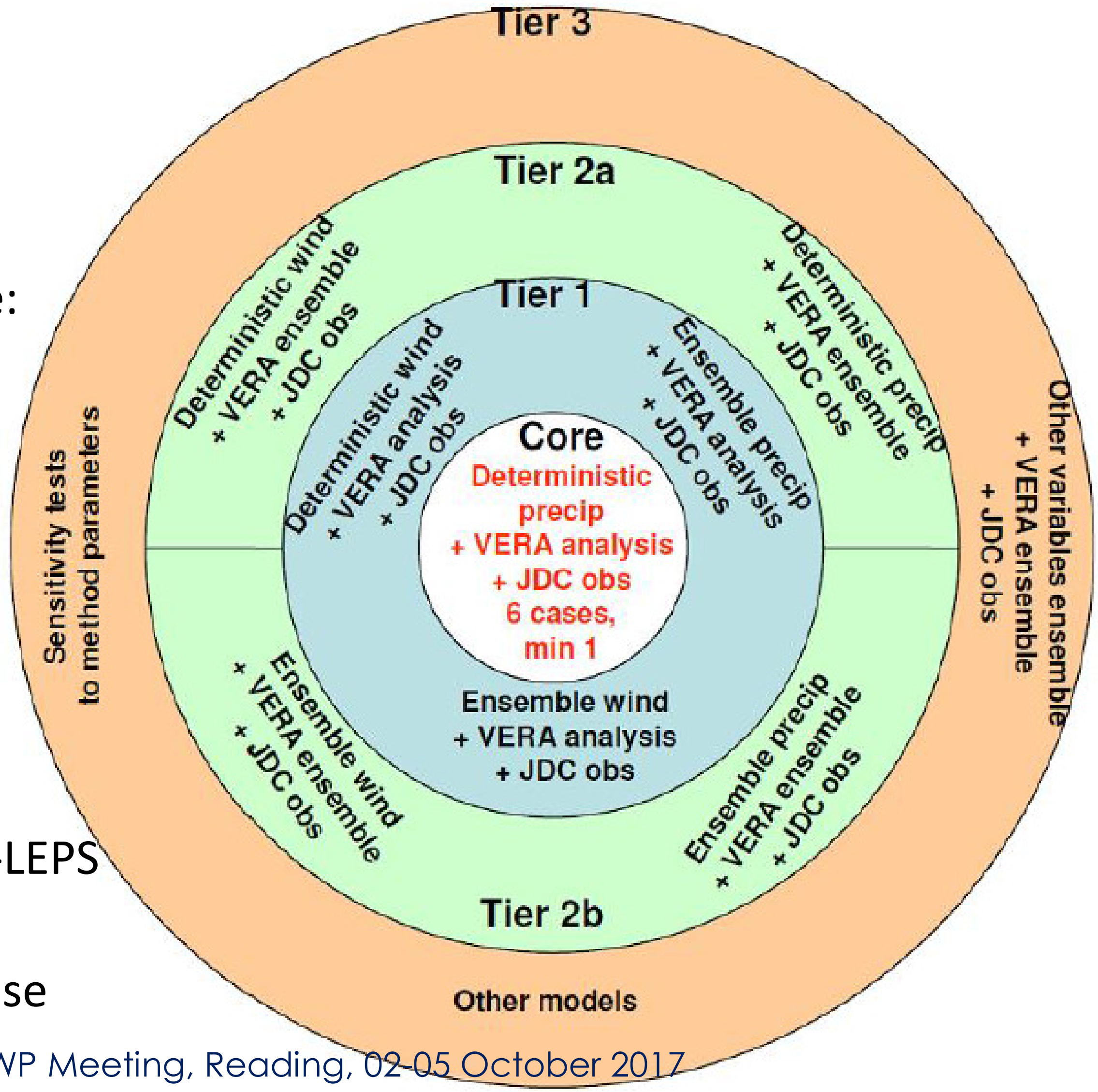
**ARPAE**

•ECMWF-IFS reruns for cases 1,2

•to provide boundary conditions for COSMO-LEPS

•**Roshydromet**

•COSMO-Ru2-EPS: rerun for 1st MesoVICT case



# PP-INSPECT: INtercomparison of Spatial vErification methods for COSMO Terrain

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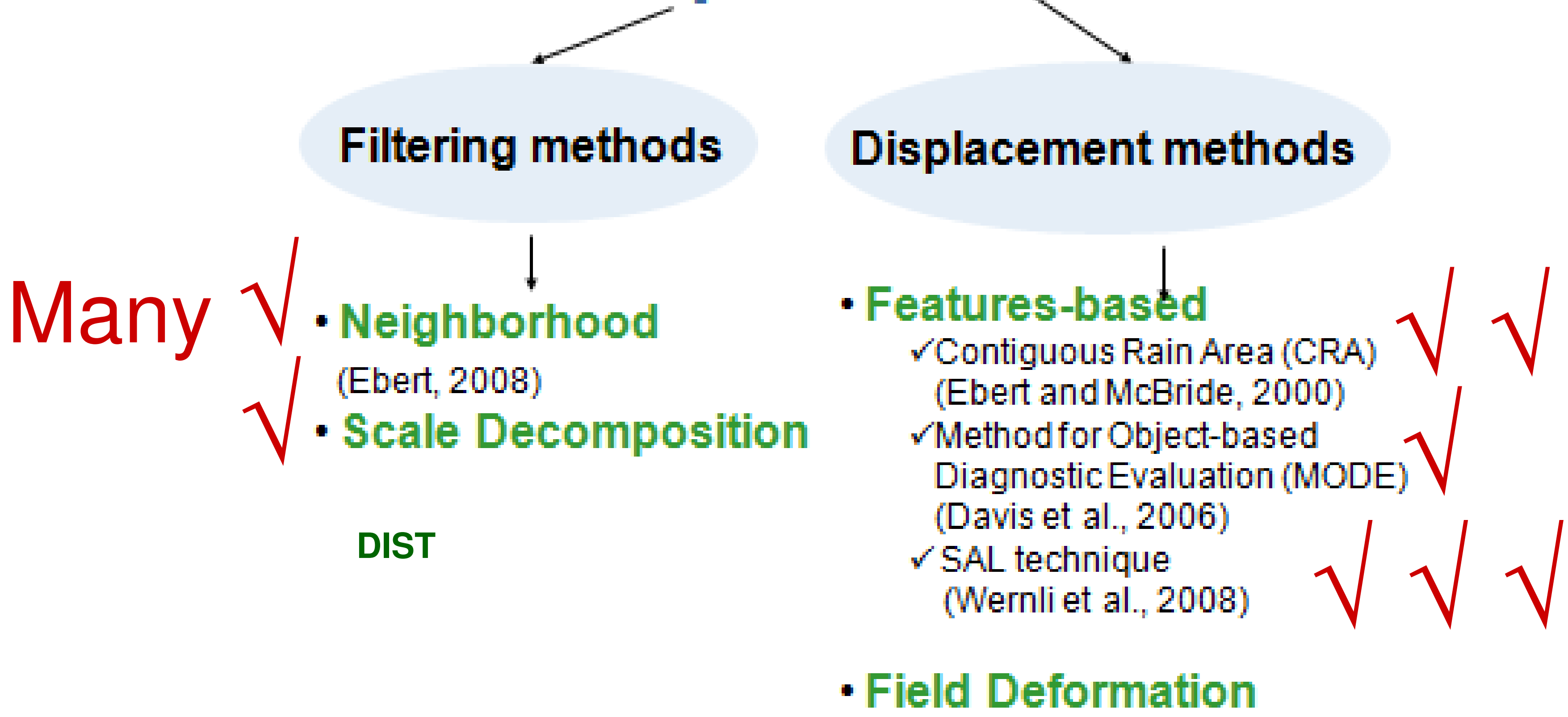
- summarizes COSMO experience of applying spatial verification methods able to capture the relative skill of very high-resolution systems
- INSPECT runs in parallel to MesoVICT (INSPECT tasks involve reruns of COSMO models (determ and EPS) for MesoVICT test cases over **complex terrain** and analysis of them)
- Same as MesoVICT, INSPECT focuses also on the ensembles and variables besides precipitation
- In addition to targeting the goals of MesoVICT, INSPECT is providing COSMO users more choice of verification domains and reference data – more recent and longer periods, two complex terrains (the Alps and the Caucasus)
- Sharing of software/scripts/methods
- **Finally, INSPECT provides criteria for deciding which methods are best suited to particular applications**

# Tasks involving development of routines for neighborhood, CRA, SAL, and MODE applications

- For the most part, the software is based on **free R SpatialVx package** (developed by E. Gilleland). For SAL and Neighborhood  methods comparisons are made with alternative packages -> bug fixing of SpatialVx (scripts available in WG5  code repository)
- VAST software development (for neighborhood methods only):  ***inclusion of time dimension and the possibility to operate with other variables besides precipitation, primarily TCC***

# New spatial methods




Almost all the categories of spatial methods are applied by PPINSPECT participants.

# Compact visualization of total precipitation FSS: to focus on the useful scale for a given lead-time and threshold (MCH)

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$$FSS = 1 - \frac{\frac{1}{N}\sum_{N}(P_f - P_o)^2}{\frac{1}{N}\left[\sum_{N} P_f^2 + \sum_{N} P_o^2\right]}$$

*FSS: Fractions Skill Score*

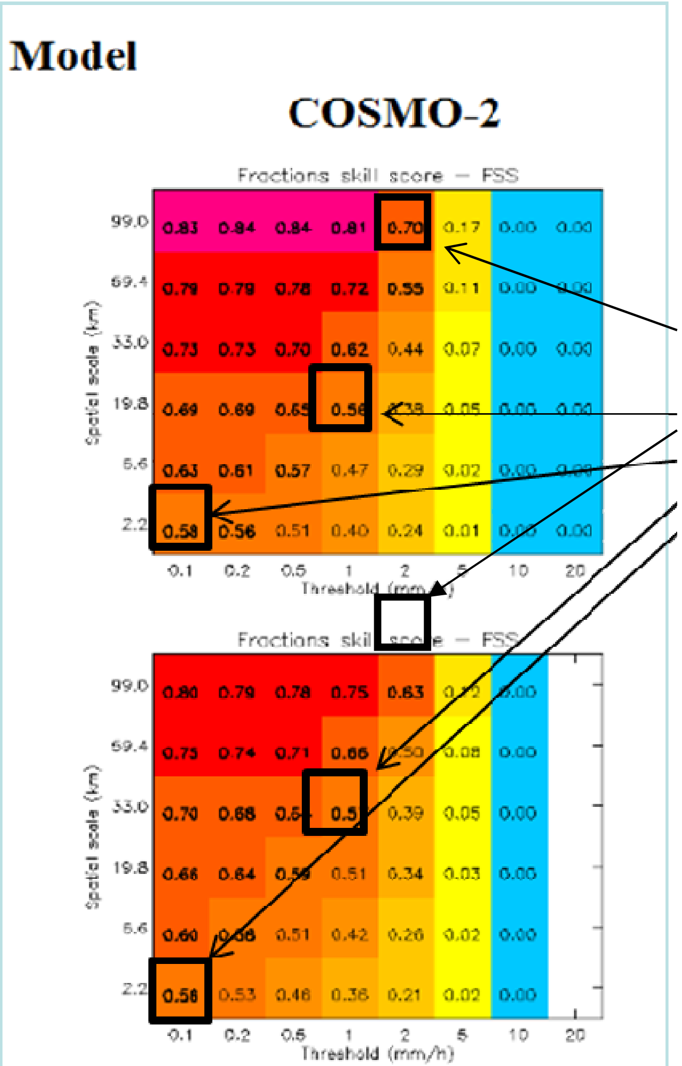
*P* is the event fraction in the neighborhood.

MAM2015

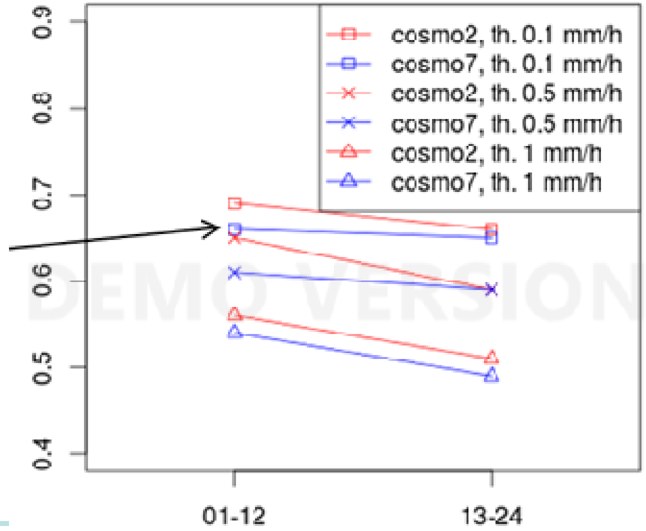
**Lead time**

**01-12**

**13-24**




**Score as a function of leadtime for a single meaningful scale**




Useful scale as a function of lead time

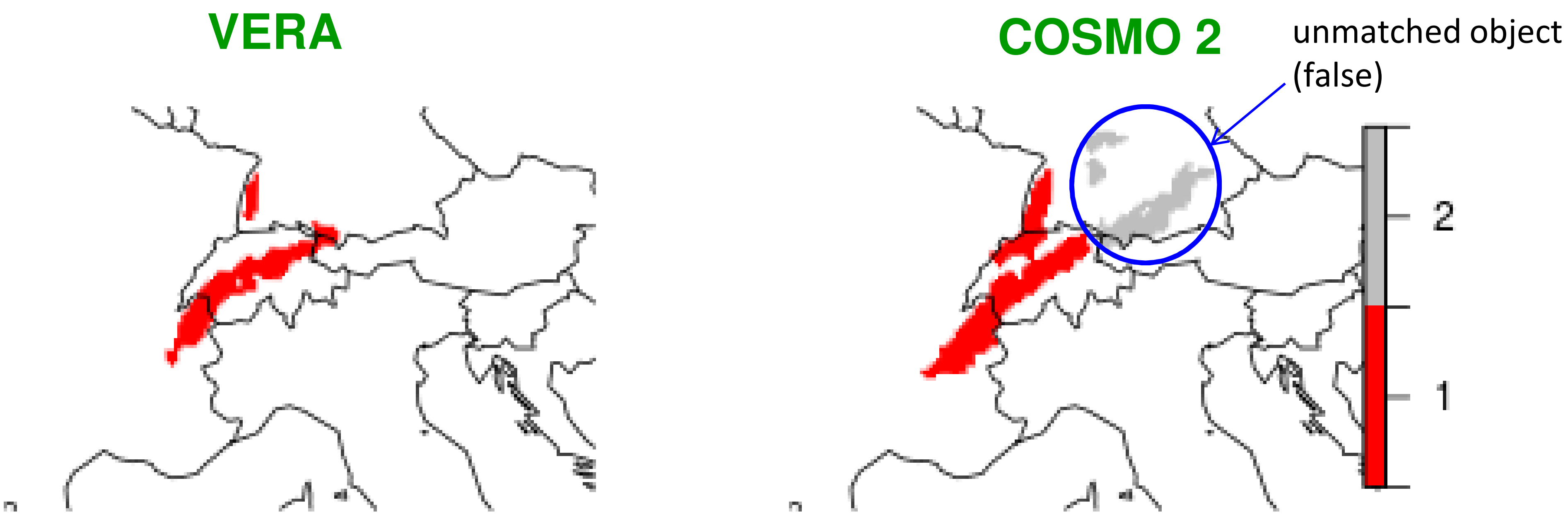
| Threshold<br>Lead time | 0.1 mm/h | 1mm/h | 2 mm/h |
|---|---|---|---|
| 01-12 | 2.2 km | 19.8 km | 59.4 km |
| 13-24 | 2.2 km | 33.0 km | 99.0 km |

# Object-based methods

- MODE, CRA, SAL

**Case study**

**2007.09.25.06, 6h precipitation, threshold>=5mm**




Selected feature pairings based on total interest

| obs feature | mod feature | total interest |
| --- | --- | --- |
| 1 | 1 | 0.898 |

# Methods of calculating SAL for EPS evaluation

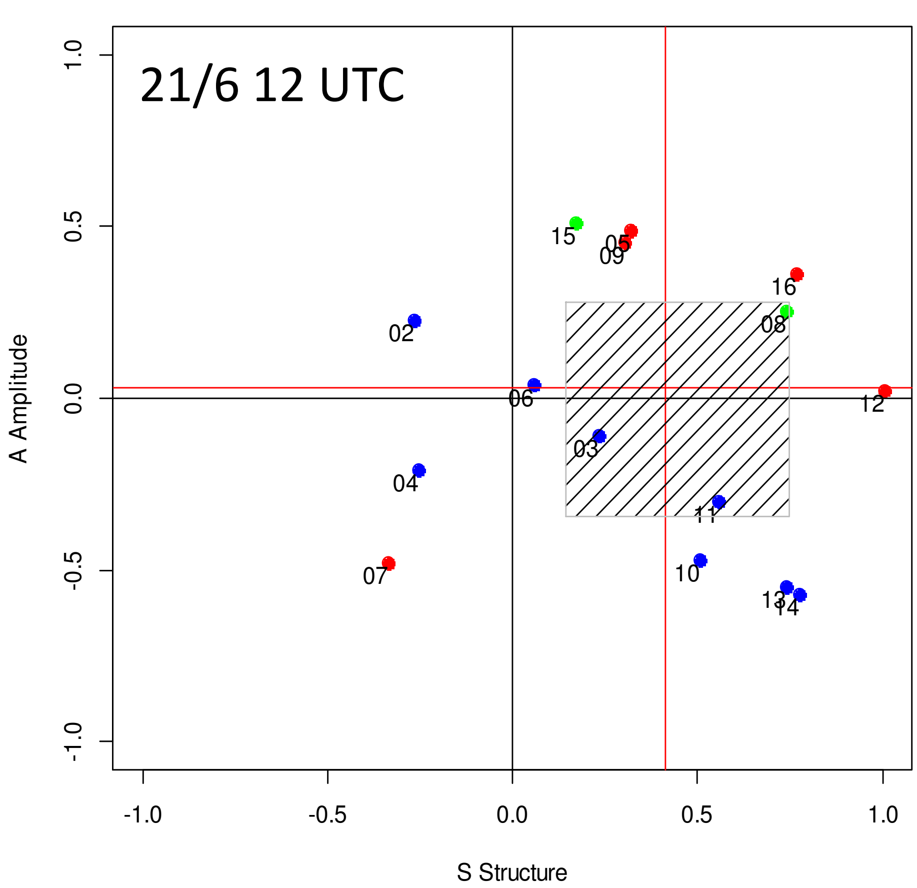
ΕΘΝΙΚΗ ΜΕΤΕΩΡΟΛΟΓΙΚΗ ΥΠΗΡΕΣΙΑ
HELLENIC NATIONAL METEOROLOGICAL SERVICE

## 1) For one specific timestep:

SAL method can be applied in order to estimate the performance of an ensemble forecast ***(Barrett et al. 2015).*** Each point of the SAL plot represents one member, and an ensemble performance can be estimated.

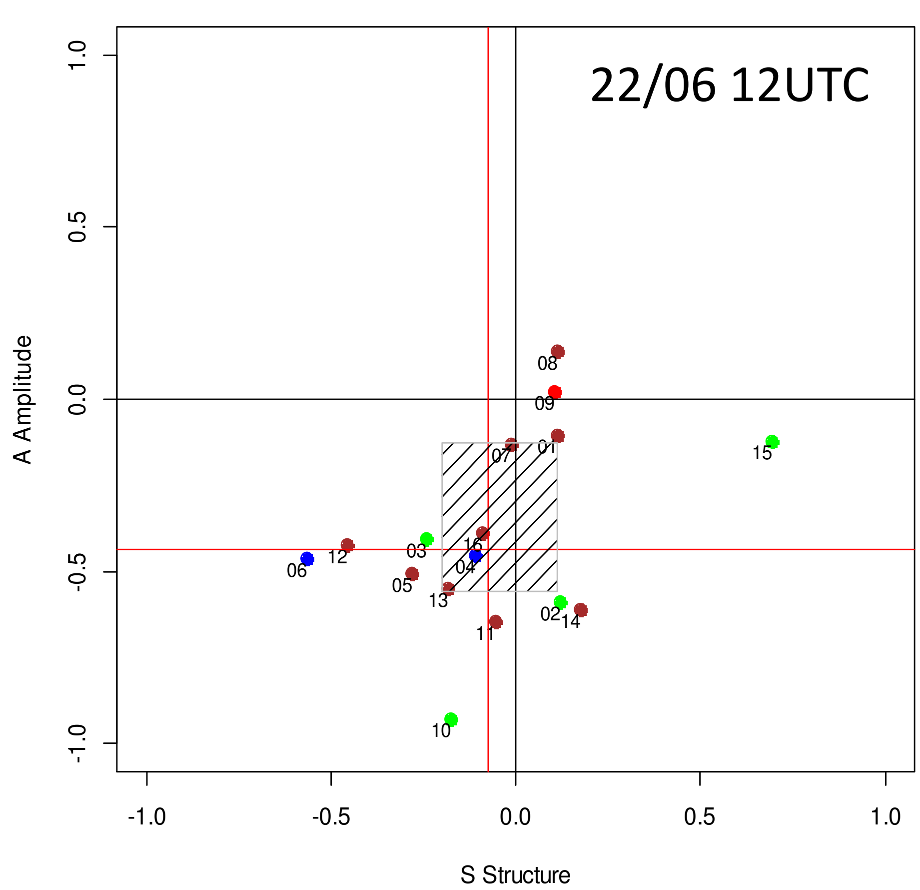
An example case shown here used data for COSMO2 LEPS 16 members MesoVICT case1:

**SAL PLOT EPS**



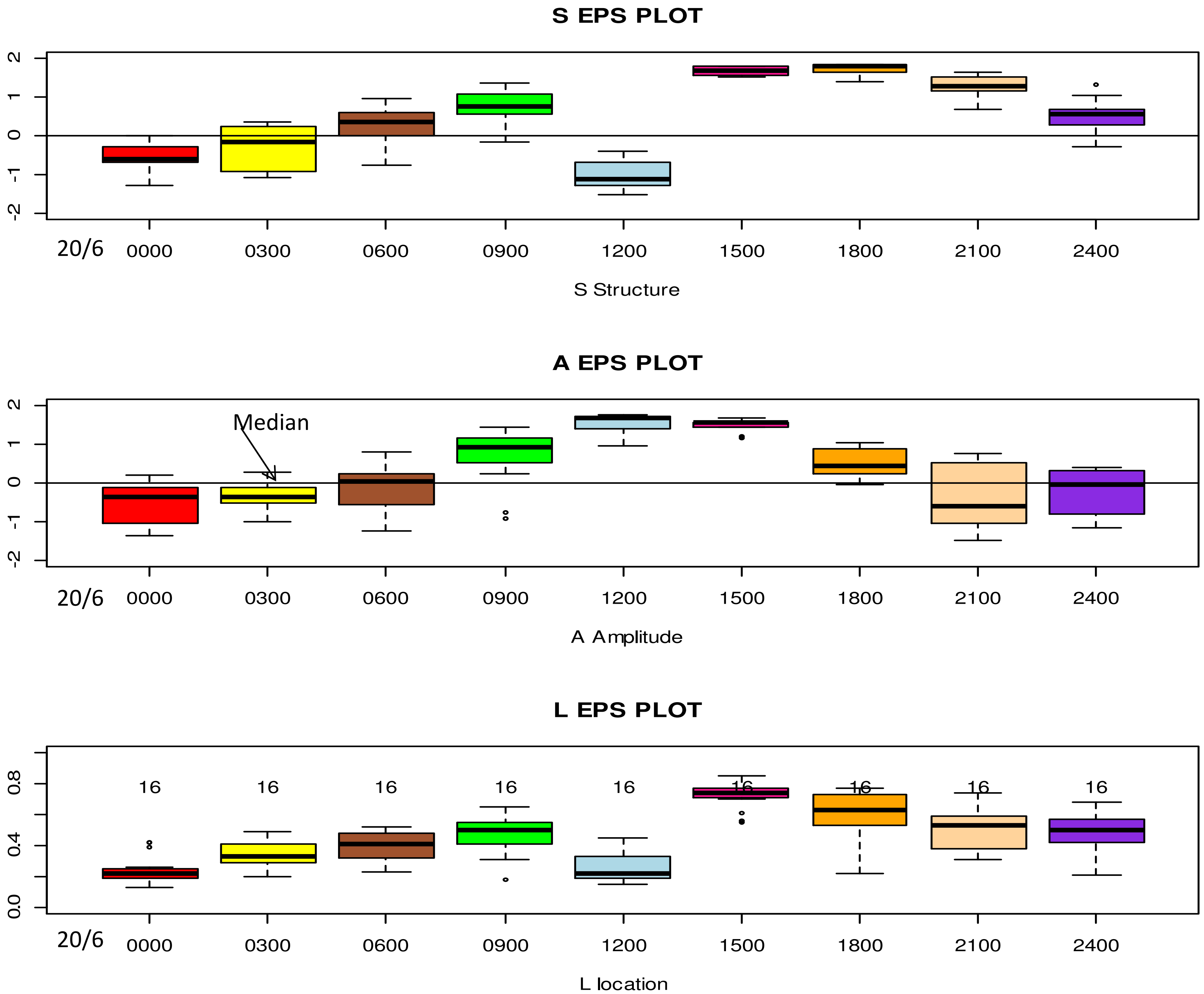

**S >0 larger objects predicted**

**SAL PLOT EPS**




**A < 0 domain values underestimated**

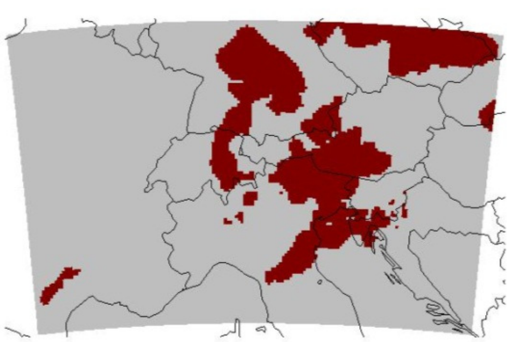
## 2) For a series of time leads in one plot boxplots can be used



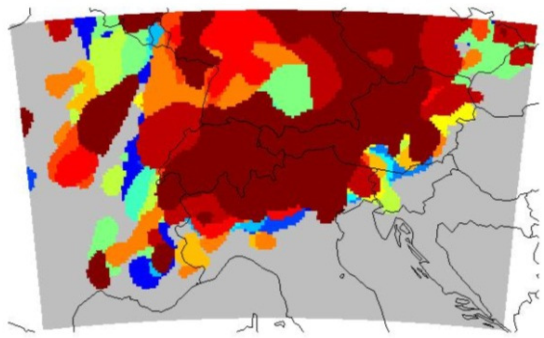

Run of 19/12

## A new approach into investigation : EPS Probability Objects

- Without observation uncertainty



Observations



LEPS


Probability

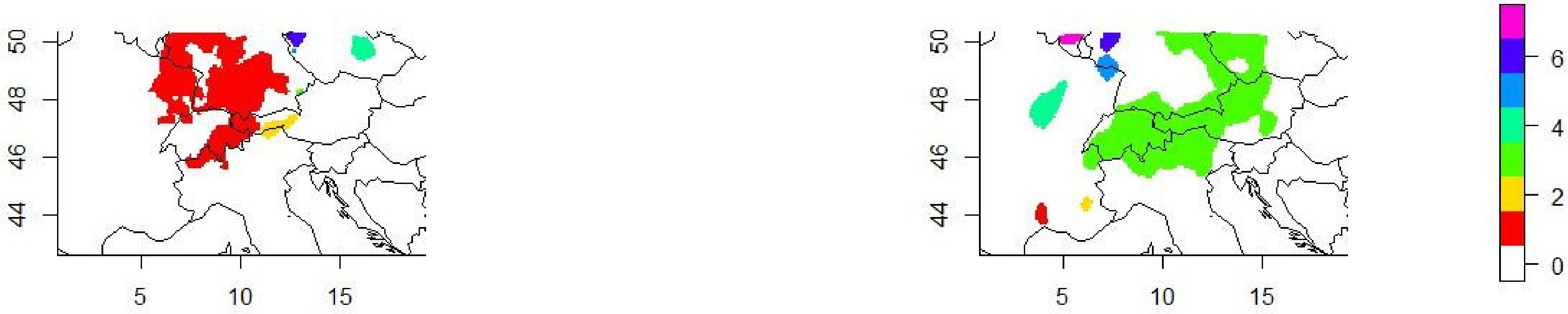

Probability

3 h Prec. 21/6 12 UTC

Constant threshold : Probability that precipitation >= 2mm

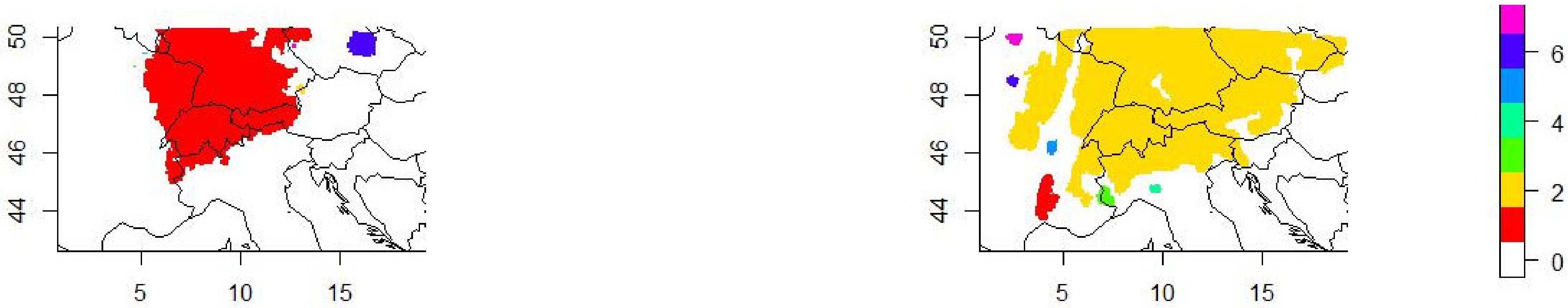
- What is the fraction of model members that predicts precipitation >=2 mm ?
- Observation certainty (P=1) compared with probability objects of 16 members exceeding the threshold (the brown objects)

## Objects comparison for probability of precipitation  >= 2mm




Prob (Preci >=2mm)= 1 (All models and all VERA ens predict >=0.2)

S=0.37, A=0.6, L=0.1

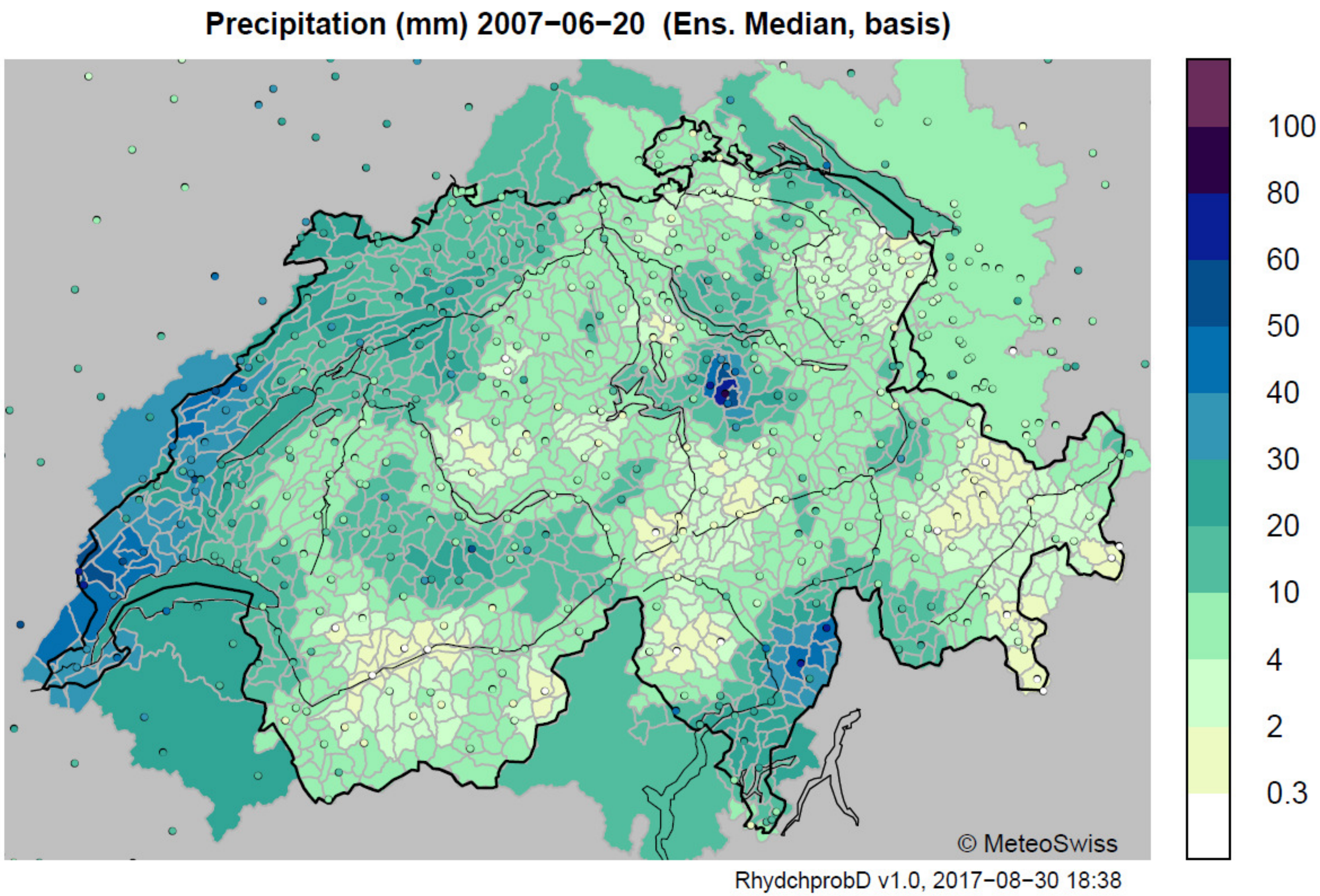



Prob (Preci >=2mm)>=0.5 (At least half of the members )

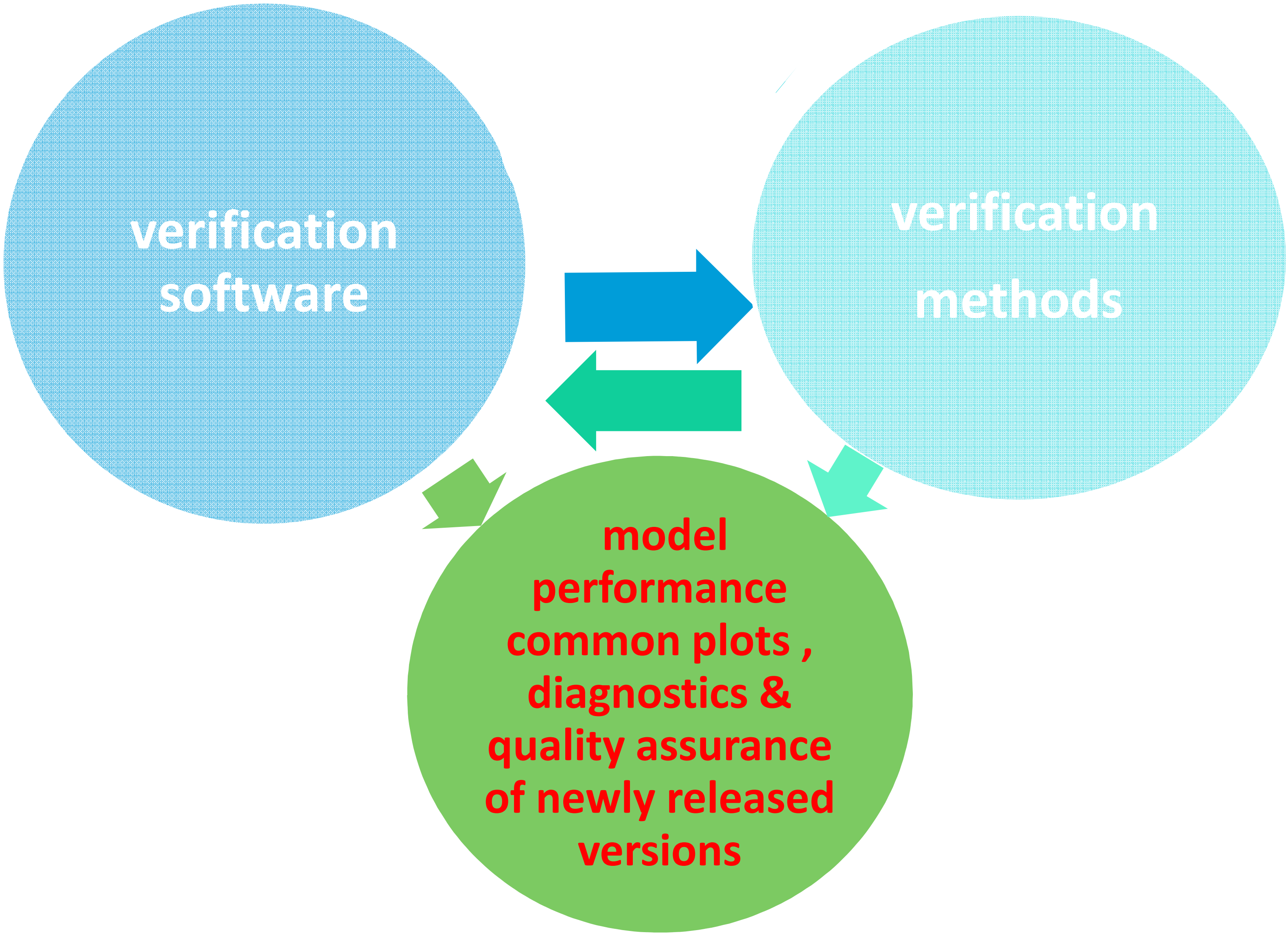
S=0.65, A=0.6, L=0.05

# New ensemble precipitation observation product by MeteoSwiss

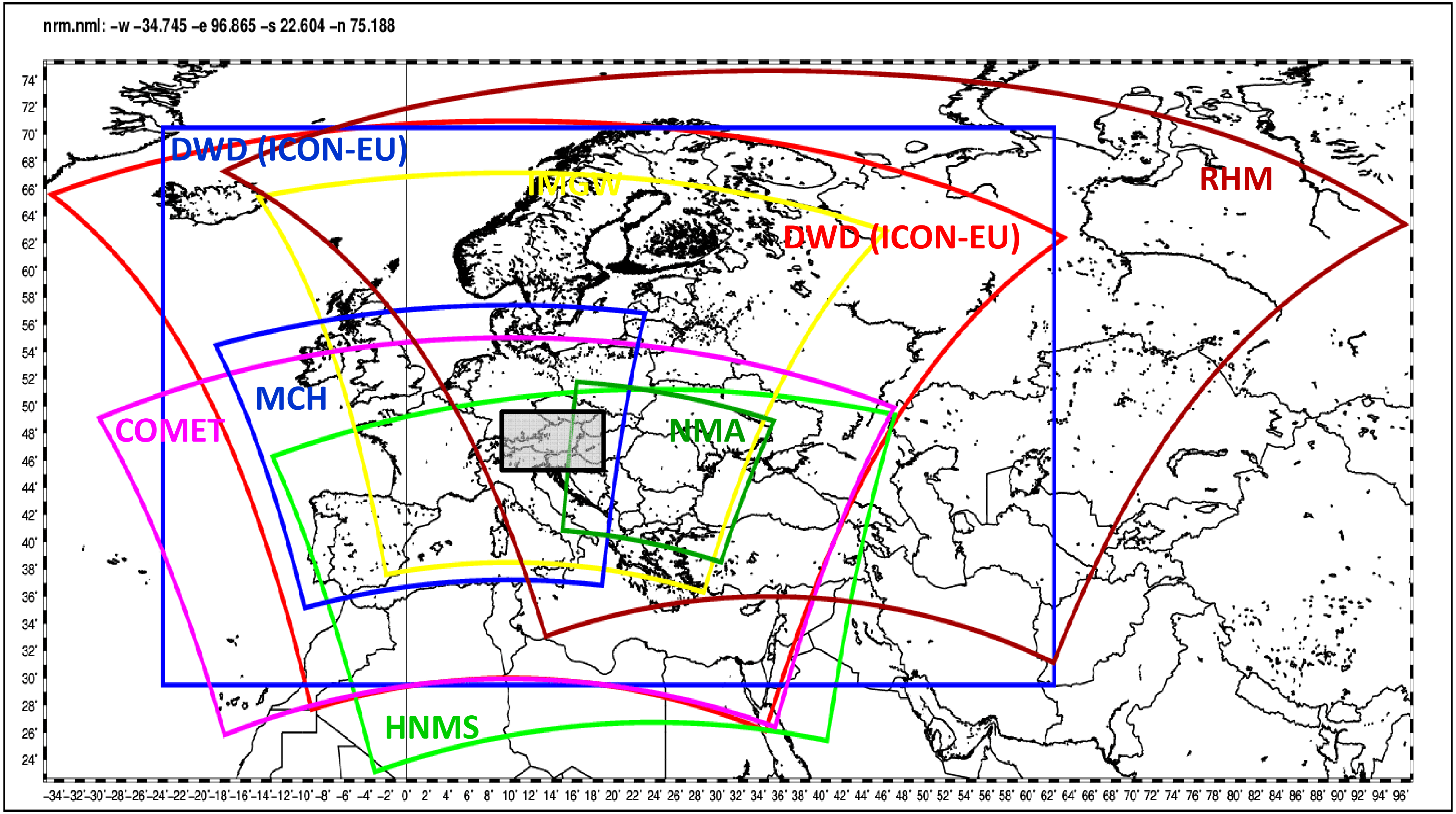
- Available for the past data (e.g. for Mesovict cases)
- Available for Swiss + whole alpine domain for daily accumulation



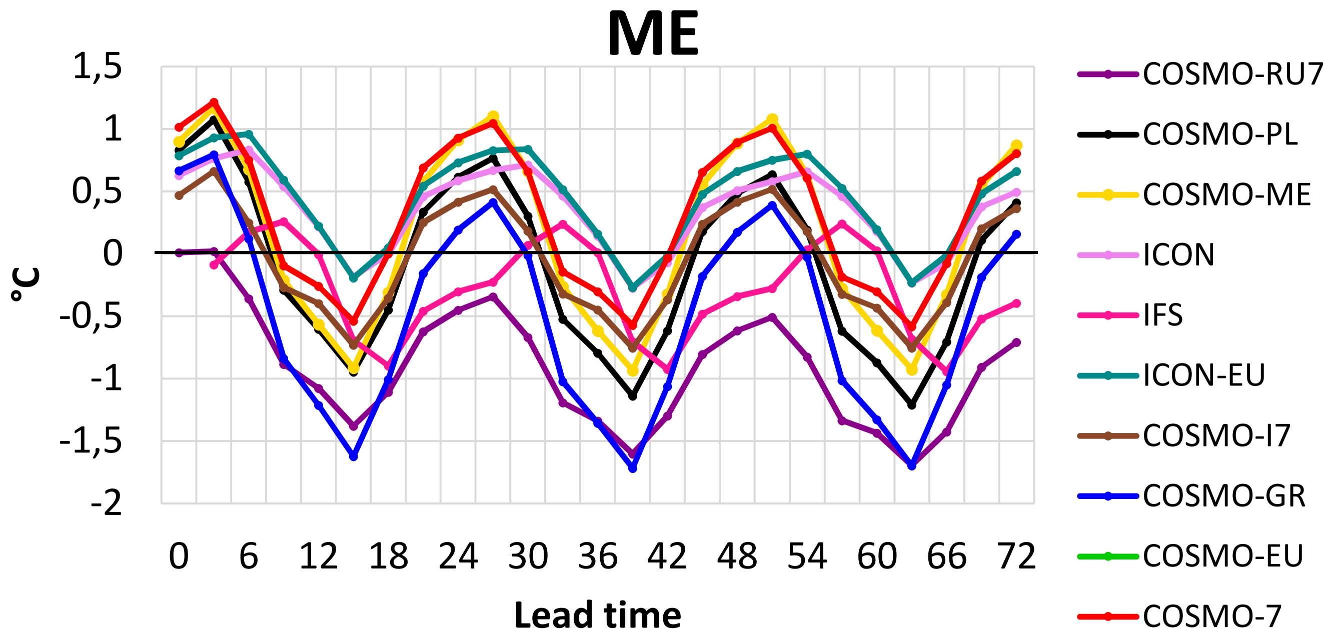
# main activities



# operational coarse res models

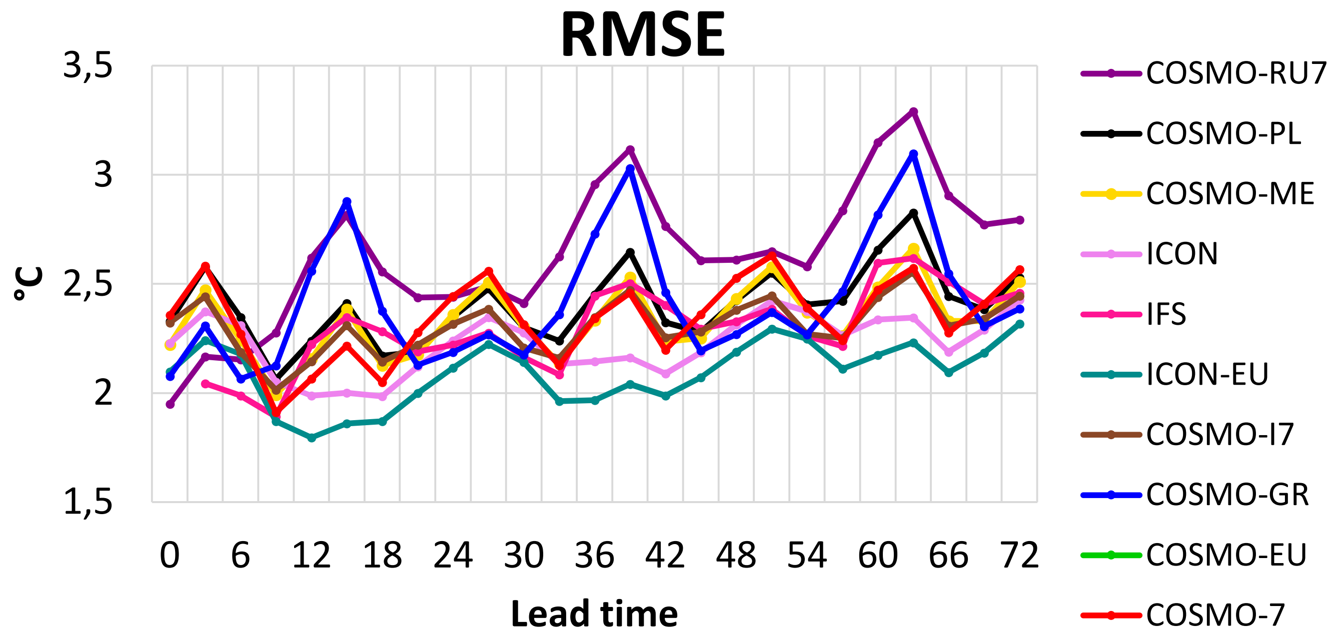


# TEMPERATURE AT 2M From: 2016-06-01 To: 2017-05-31



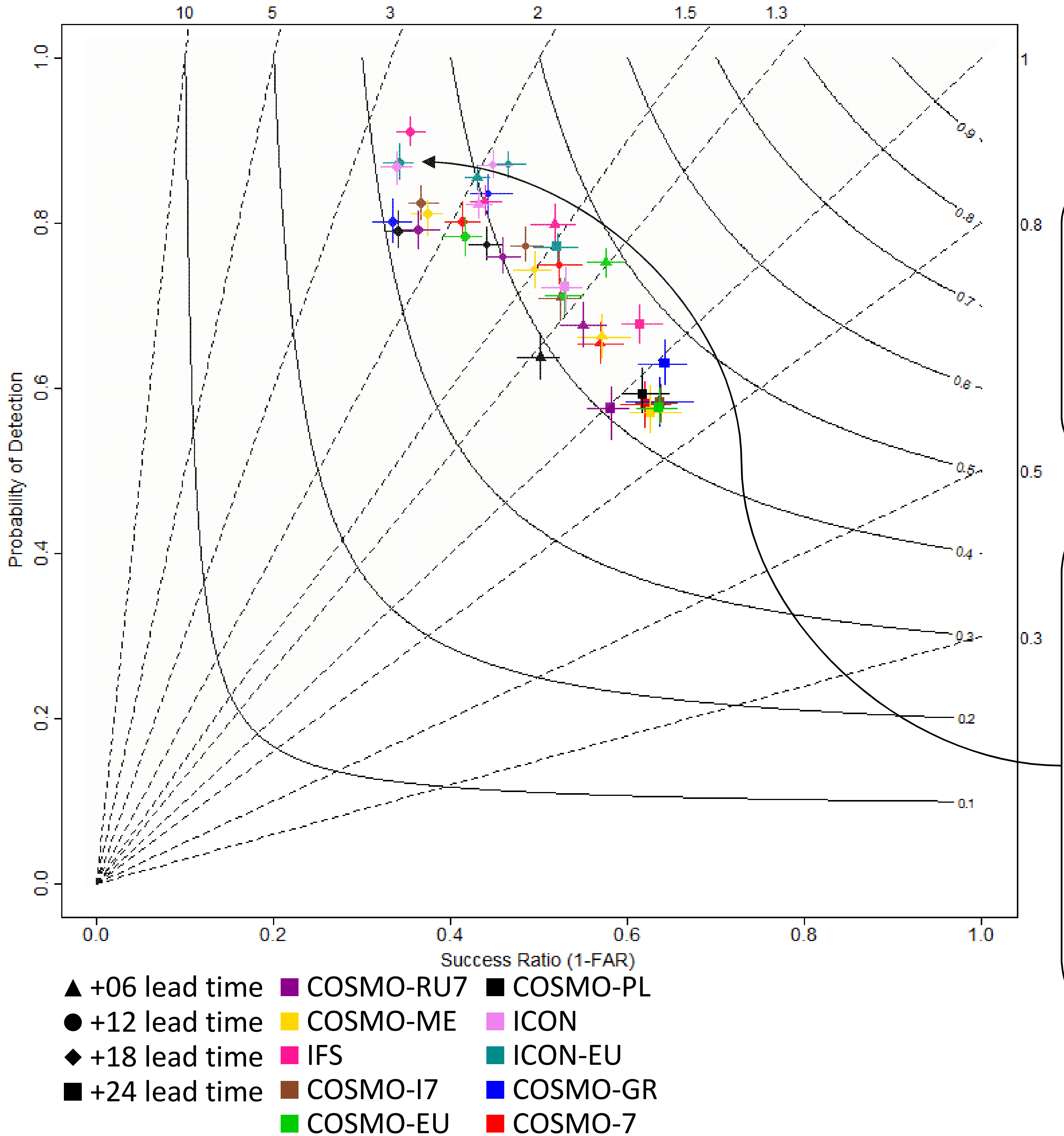

**Diurnal variability underestimation**: negative ME during day, positive ME during night

**ICON-EU/ICON**: the **lowest RMSE** and diurnal score variations




Last year tendency: JJA RMSE ↓ SON RMSE ↓ DJF RMSE ↑ MAM RMSE ↑

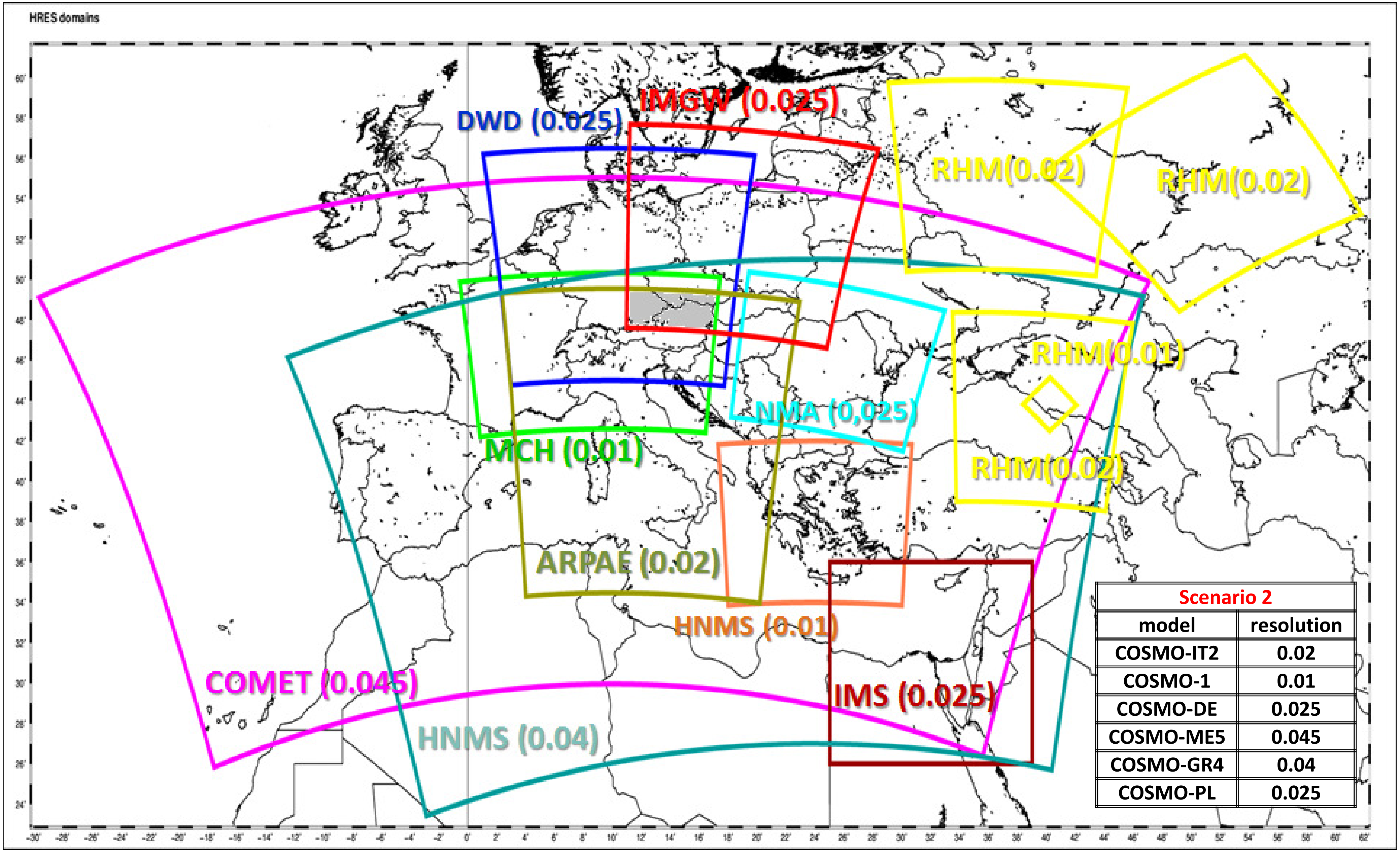
# Precipitation in 6h 0.2 mm threshold From: 2016-06-01 To: 2016-08-31




The most significant diurnal variation and the lowest Threat Score compared to other seasons

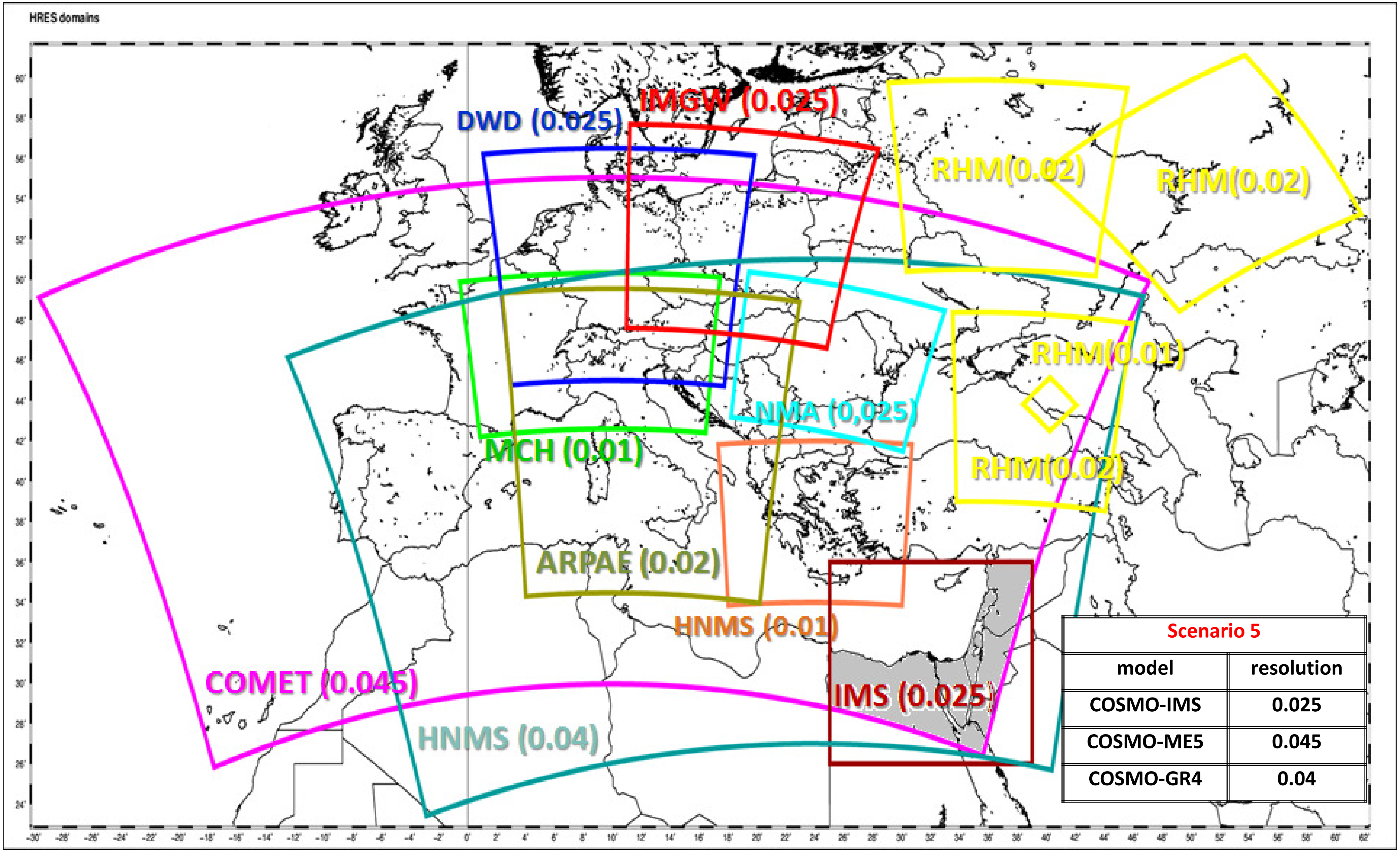
**ICON**, **ICON-EU**, and **IFS** overestimate low precipitation more than **COSMO** models: Presumably, IFS/ICON convection scheme impact?

# CP HRES scenario 2



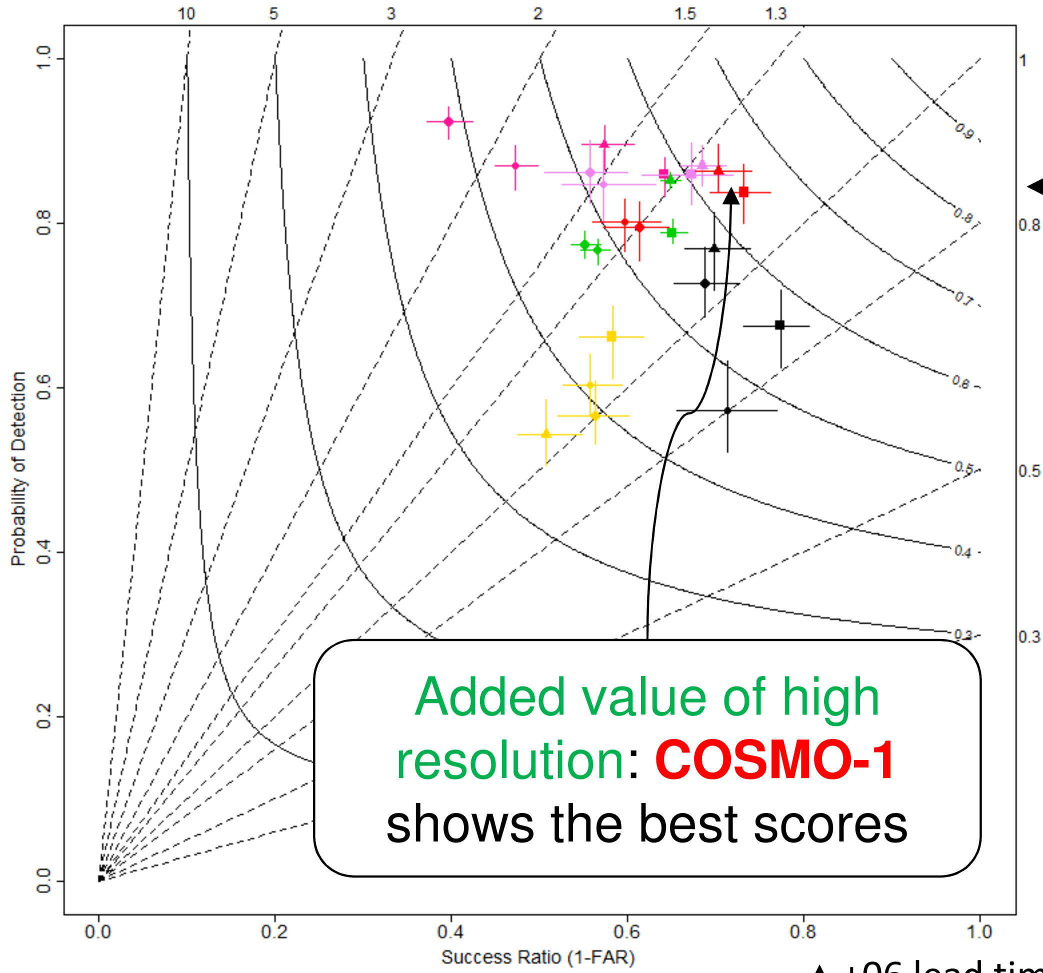

| Scenario 2 | |
|---|---|
| model | resolution |
| COSMO-IT2 | 0.02 |
| COSMO-1 | 0.01 |
| COSMO-DE | 0.025 |
| COSMO-ME5 | 0.045 |
| COSMO-GR4 | 0.04 |
| COSMO-PL | 0.025 |

# CP HRES scenario 5




| Scenario 5 | |
|---|---|
| model | resolution |
| COSMO-IMS | 0.025 |
| COSMO-ME5 | 0.045 |
| COSMO-GR4 | 0.04 |

# Precipitation in 6h 0.2 mm threshold From: 2017-03-01 To: 2017-05-31




Common Area 2: Fine Resolution

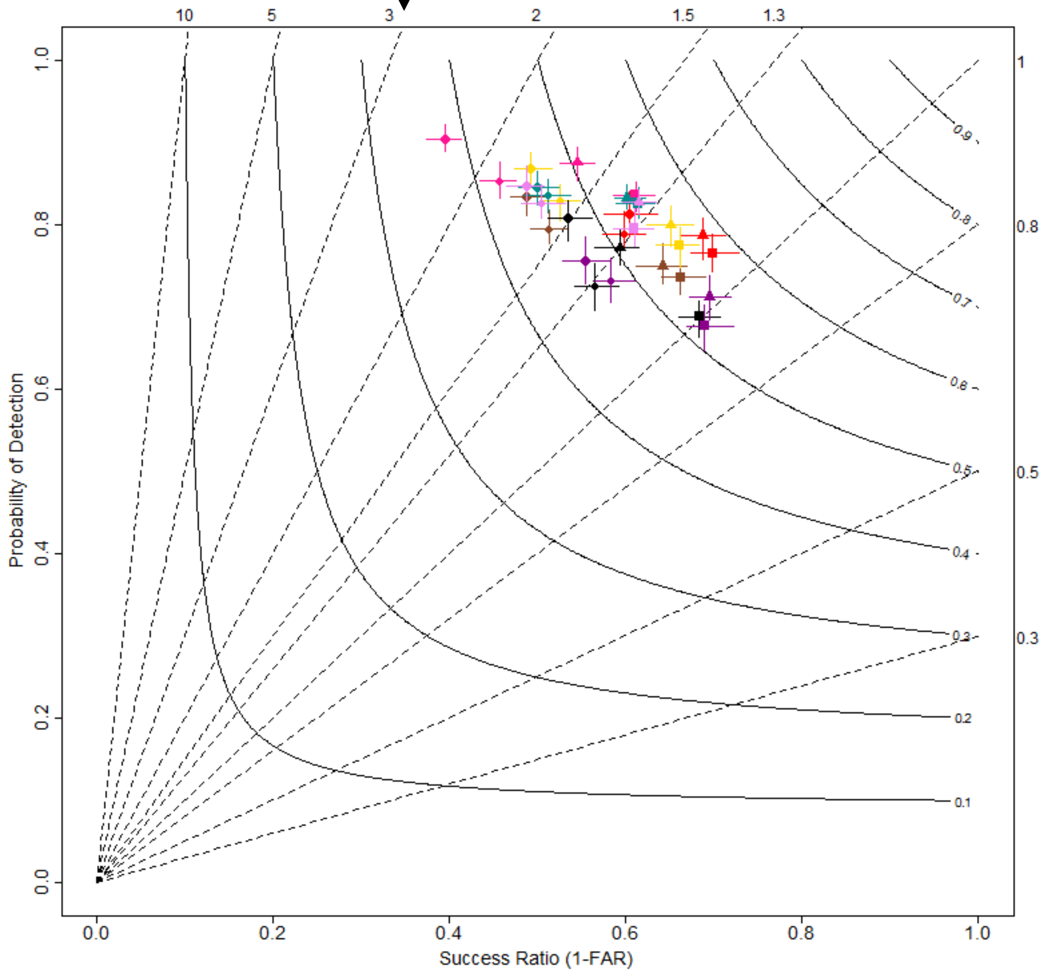
Added value of high resolution: **COSMO-1** shows the best scores

- COSMO-PL
- ICON
- COSMO-DE
- COSMO-IT
- IFS
- COSMO-1

- ▲ +06 lead time
- ● +12 lead time
- ◆ +18 lead time
- ■ +24 lead time

Common Area: Coarse Resolution

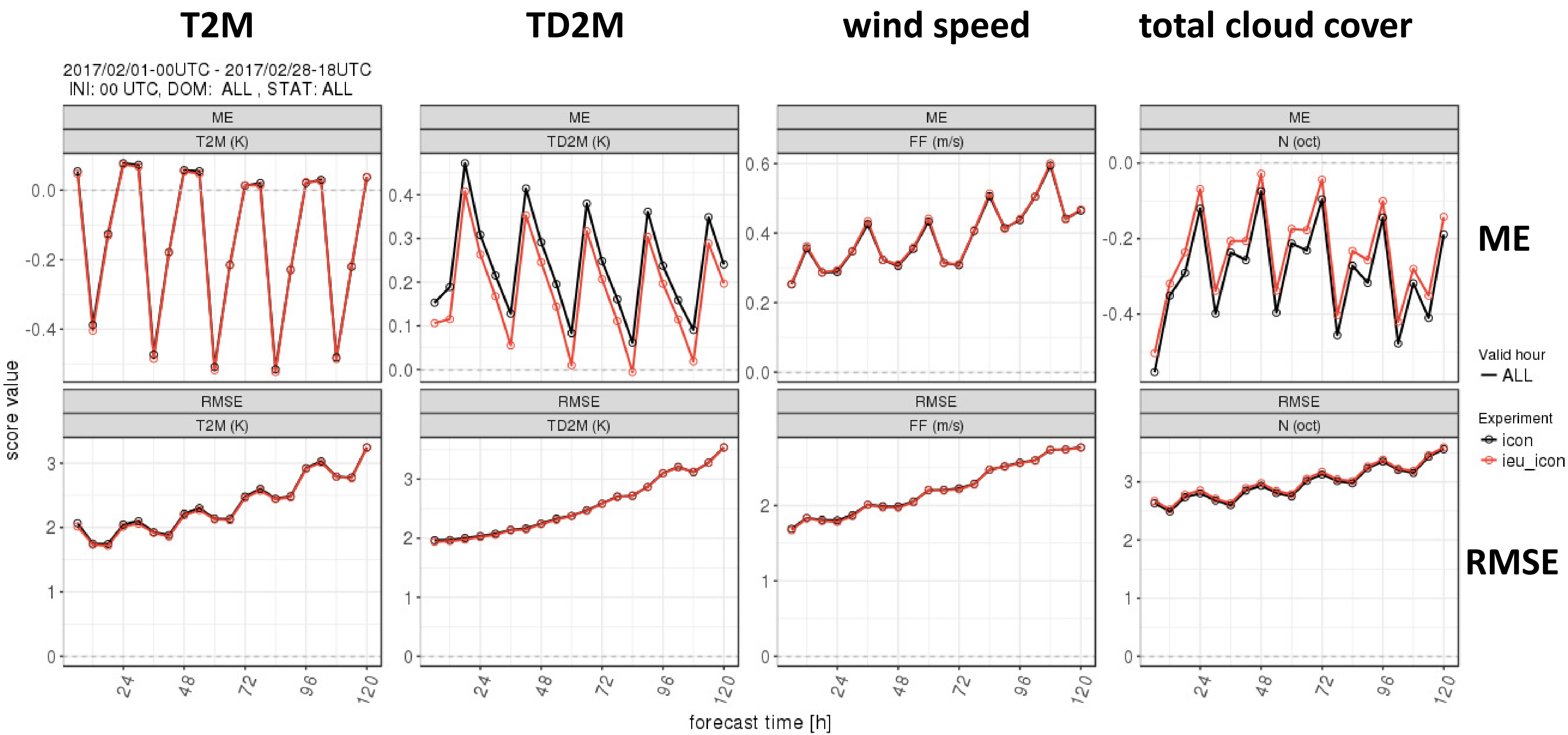
- COSMO-RU7
- COSMO-PL
- COSMO-ME
- ICON
- IFS
- ICON-EU
- COSMO-I7
- COSMO-GR
- COSMO-EU
- COSMO-7




Generally, there are better scores for High Resolution models (than for Coarse Resolution models) for low precipitation events…

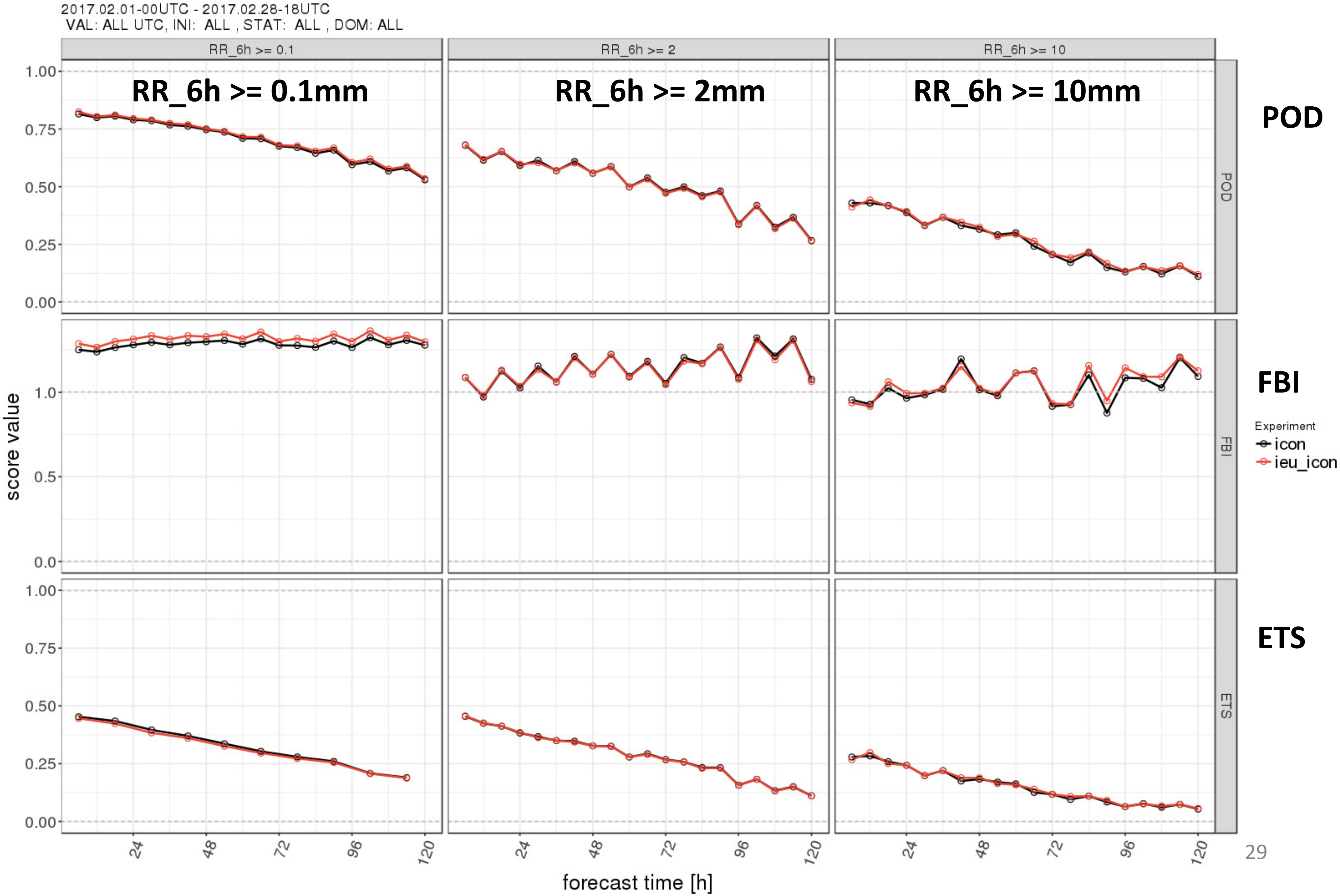
# ICON-EU vs ICON

## 00 UTC runs, continuous verification, SYNOP, Feb 2017



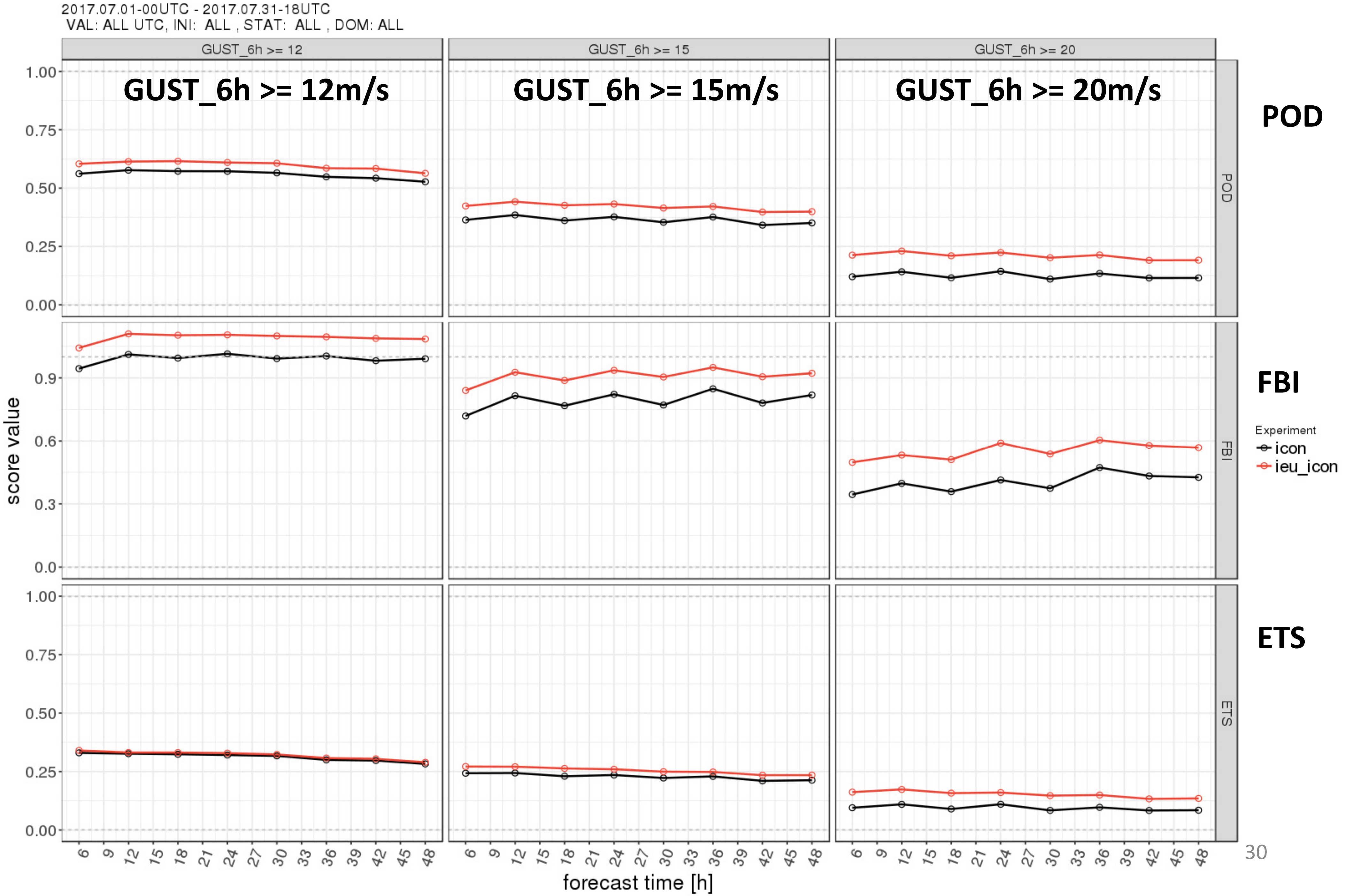
# ICON-EU vs ICON

## All runs, categorical verification, SYNOP, Feb 2017



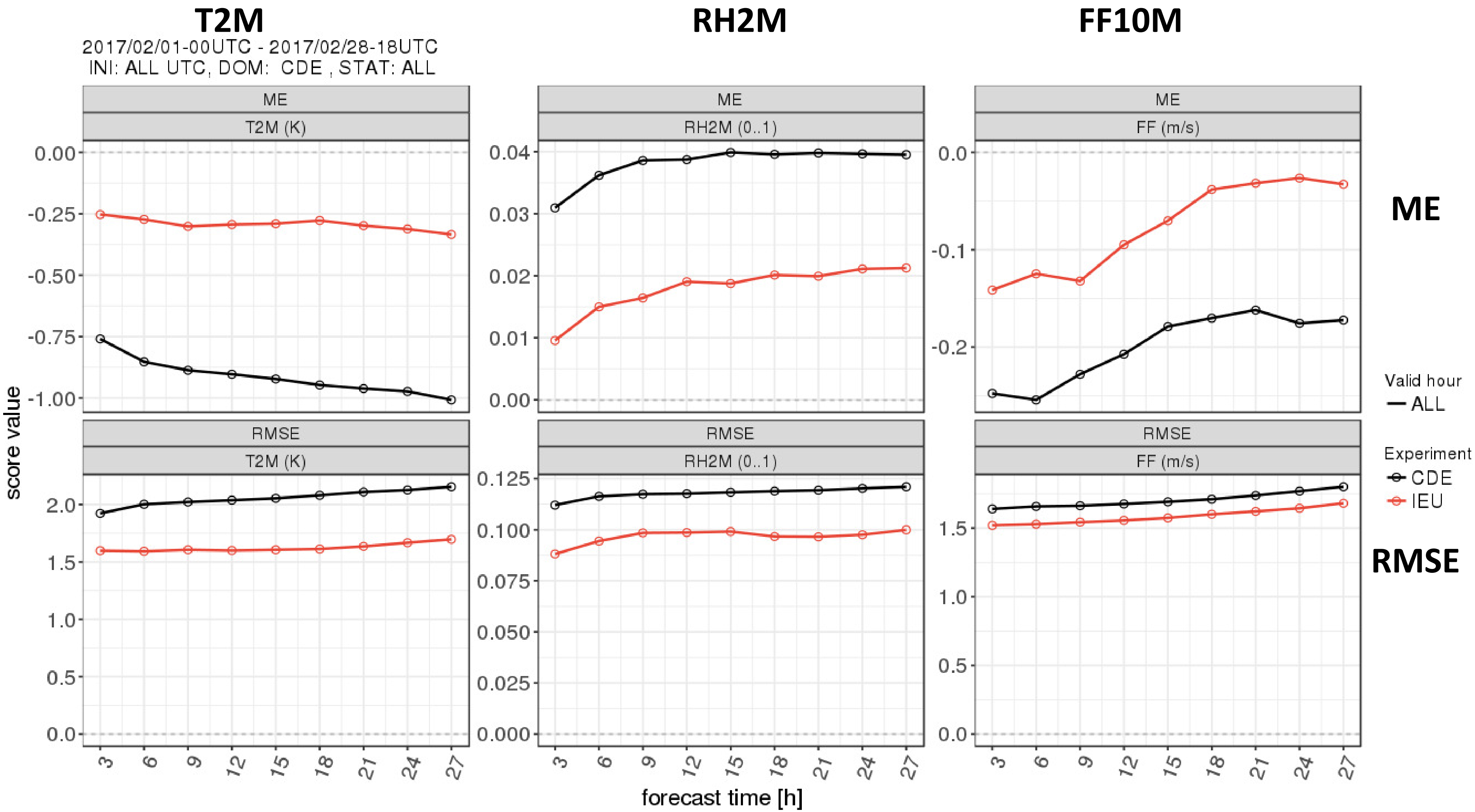
# ICON-EU vs ICON

## All runs, categorical verification, SYNOP, July 2017



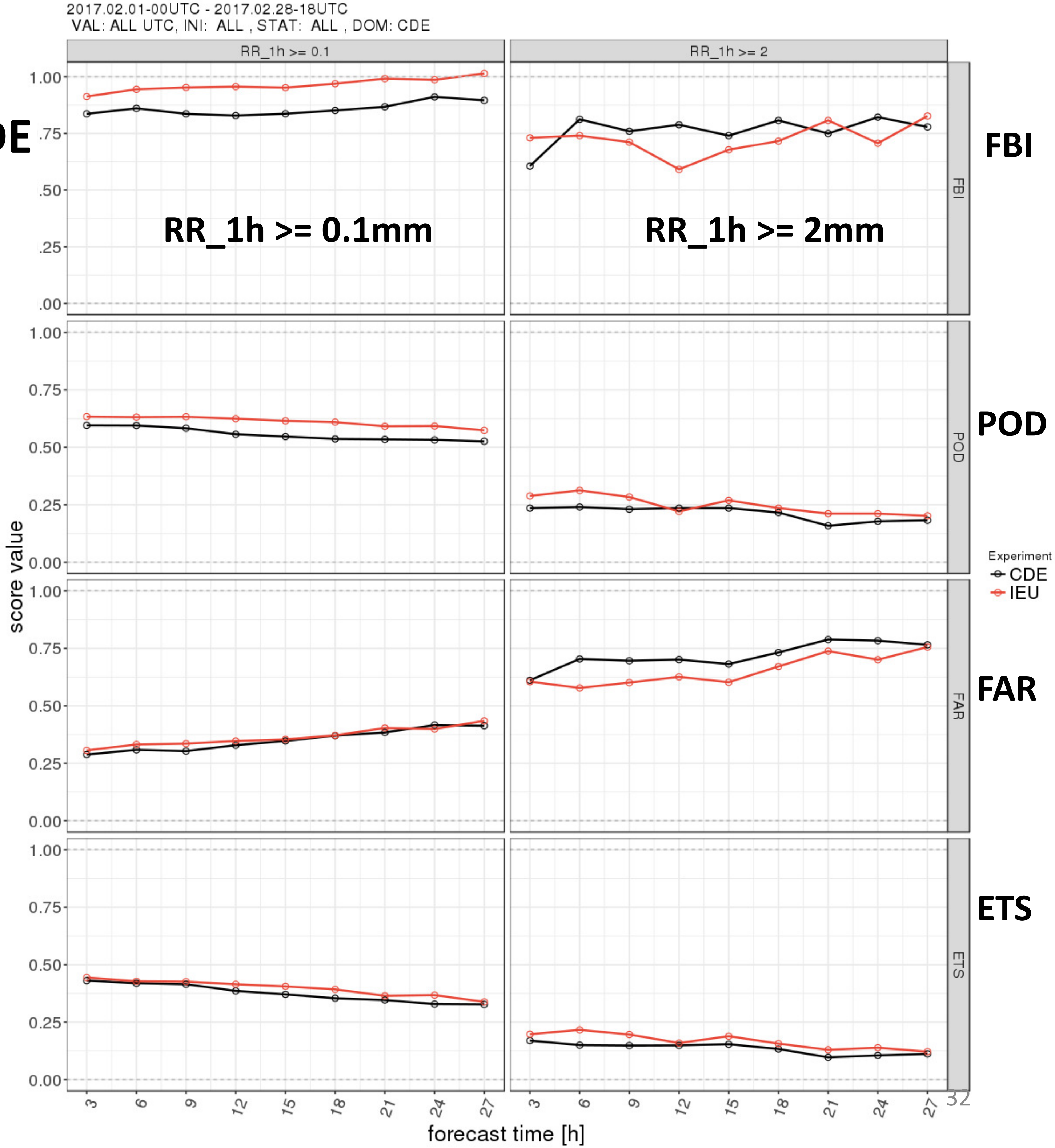
# ICON-EU vs COSMO-DE

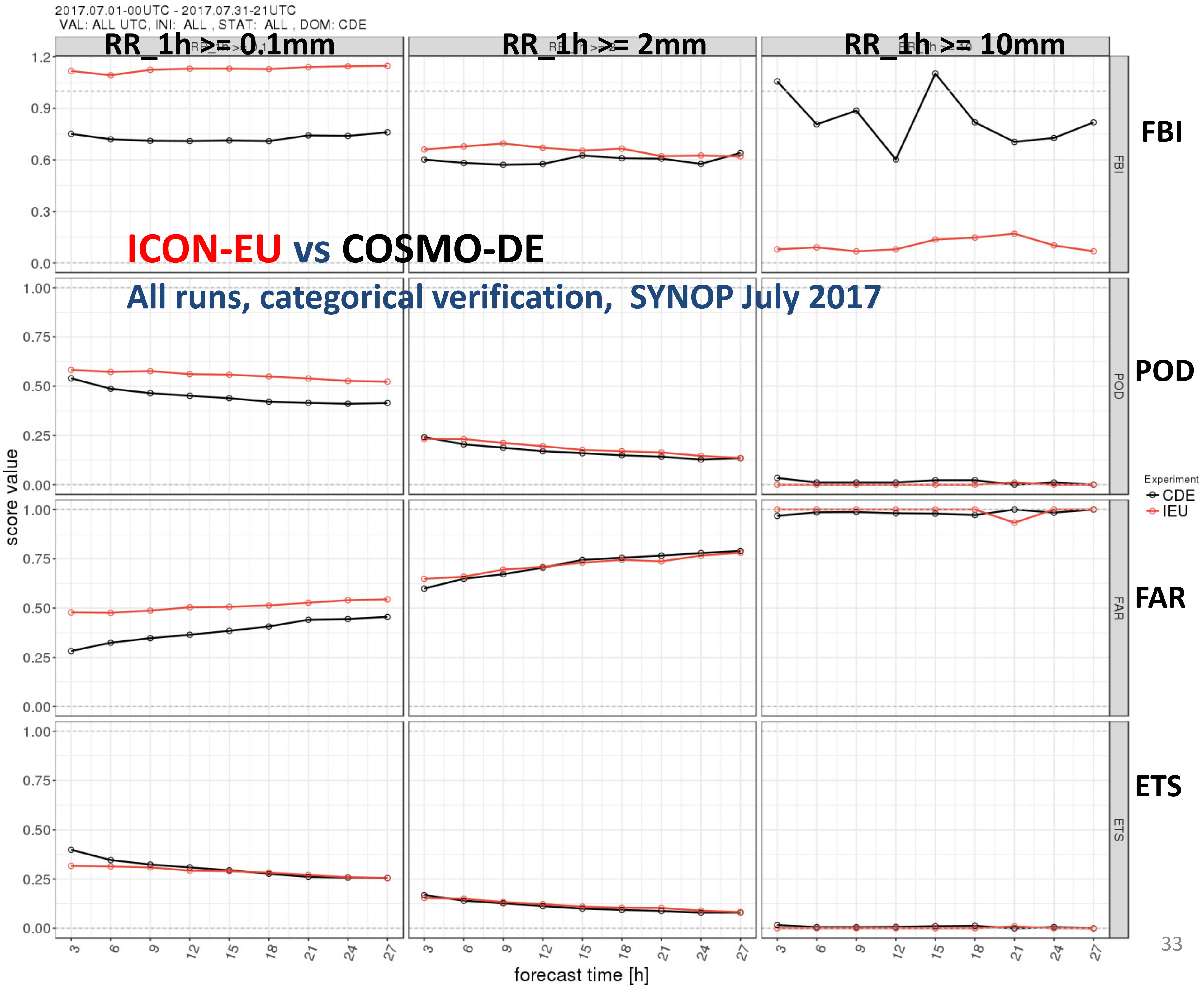
## All runs, continues verification, SYNOP Feb 2017



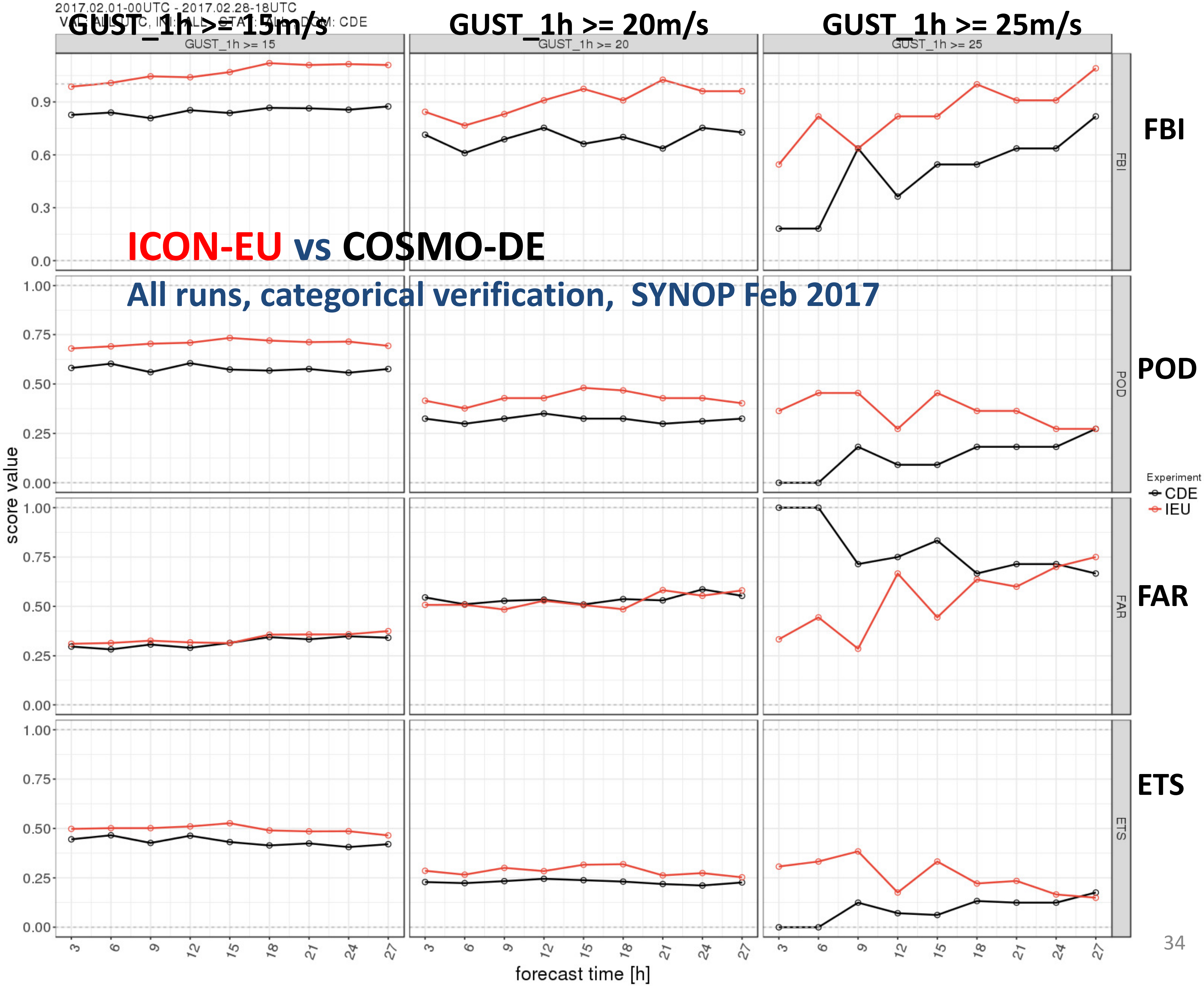
# ICON-EU vs COSMO-DE

## all runs
## categorical verification
## SYNOP Feb 2017





2017.07.01-00UTC - 2017.07.31-21UTC
VAL: ALL UTC, INI: ALL , STAT: ALL , DOM: CDE
RR_1h >= 0.1mm
RR_1h >= 2mm
RR_1h >= 10mm
ICON-EU vs COSMO-DE
All runs, categorical verification, SYNOP July 2017
FBI
POD
FAR
ETS
score value
forecast time [h]
Experiment
CDE
IEU


GUST_1h >= 15m/s
GUST_1h >= 20m/s
GUST_1h >= 25m/s
2017.02.01-00UTC - 2017.02.28-18UTC
ICON-EU vs COSMO-DE
All runs, categorical verification, SYNOP Feb 2017
FBI
POD
FAR
ETS
Experiment
CDE
IEU
score value
forecast time [h]

# contributing team

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Ευχαριστώ

Thank you