

# COSMO Priority Project C2I

D. Rieger and the PP C2I team



# Verification Report

For SON 2020

C21

# SON Verification Report

## Report was published!

[https://doi.org/10.5676/DWD\\_pub/nwv/icon\\_006](https://doi.org/10.5676/DWD_pub/nwv/icon_006)

→ 55 pages, 7 contributions

- Greece
- Israel
- Italy
- Poland
- Romania
- Russia
- Common Area



## Report was published!

- Verification results mostly positive
  - Especially for surface
- Upper air shows slightly better results for COSMO
  - First results with new ICON versions are promising
- Precipitation
  - Improvements for Poland, Romania and Common Area
  - Neutral for Greece, Italy and Israel

*Thanks for the excellent contributions!*



# Selected Results

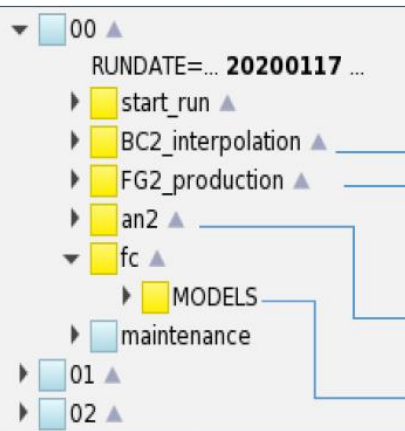
Focussing on results with cp/cv bugfix

C21

# Operational ICON-IT run (R19B7/65v1)

## IFS LBC and ICON-KENDA (1h DA cycle)

- ❖ ICON-IT designed similar to COSMO-IT (same namelist as ICON-D2)  
*increased box\_liq = 0.08 (before 0.04)*  
*decreased box\_liq\_asy = 2 (before 4)*
- ❖ Feb2021-version of ICON code («icon-nwp» branch - *cp/cv bug fixed* )  
Last version of KENDA code (*+ T2M/RH2M from SYNOP* )
- ❖ EcfLOW suite implemented: 1hour KENDA cycle (40 members) with IFS BC operational since **july 2020**  
***(ecmwf time critical user)***



❖ Remap of LBC on the ICON-IT domain (EPS and HRES IFS-ECMWF)

❖ ICON background ens. (fof files production)

OPE: init\_mode=5 (*IAU*)

COLD START: init\_mode=2 (*IFS AN*)

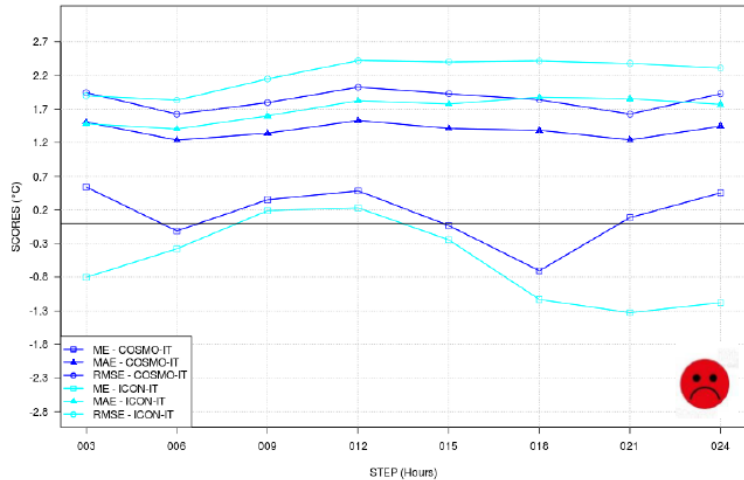
❖ KENDA-ICON analysis (*ingested obs: temp,synop,local,ship,buoy,wprof,ascats,amdar,modes,AMSUA,MHS,ATMS radiances*)

❖ Long model run (up to 48h) at 00/12UTC

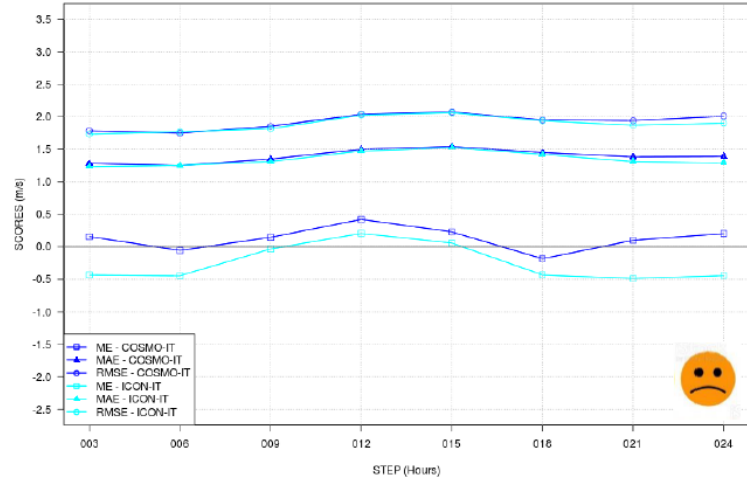


# Surface verifications (SYNOP-All Italian Stations)

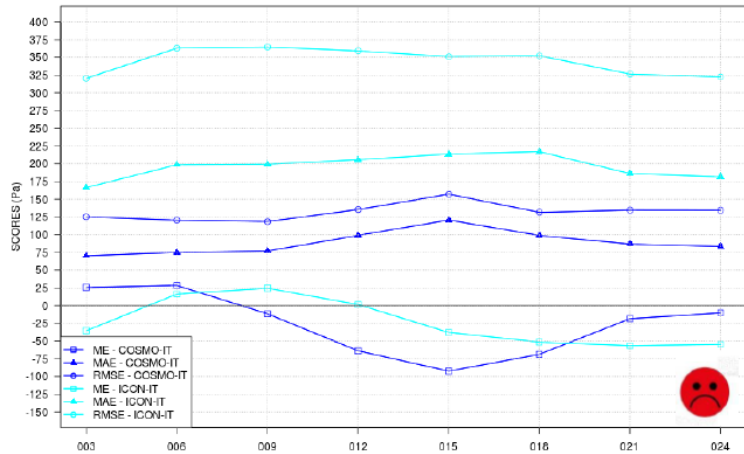
SCORES vs STEP - T2m - MJJ 2021 - ALL ITA stations



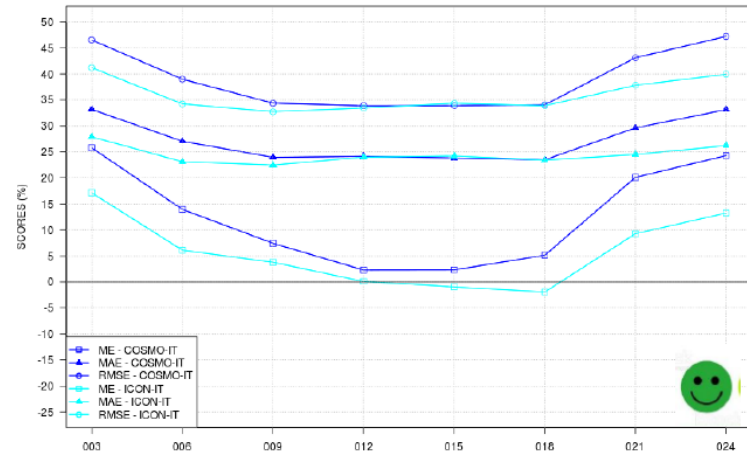
SCORES vs STEP - WSpeed - MJJ 2021 - ALL ITA stations



SCORES vs STEP - PS - MJJ 2021 - ALL ITA stations

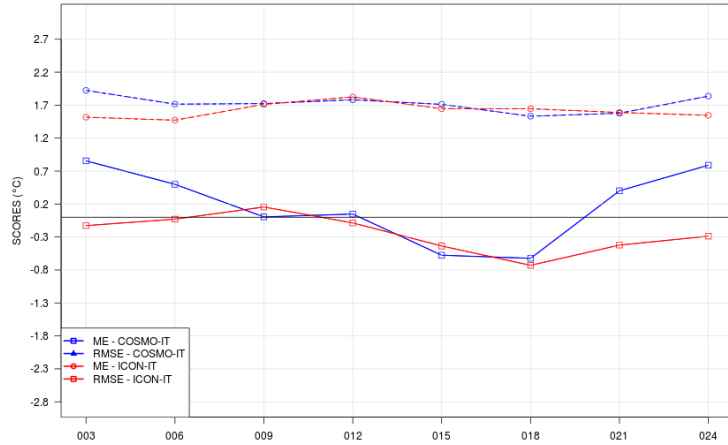


SCORES vs STEP - TCC - MJJ 2021 - ALL ITA stations

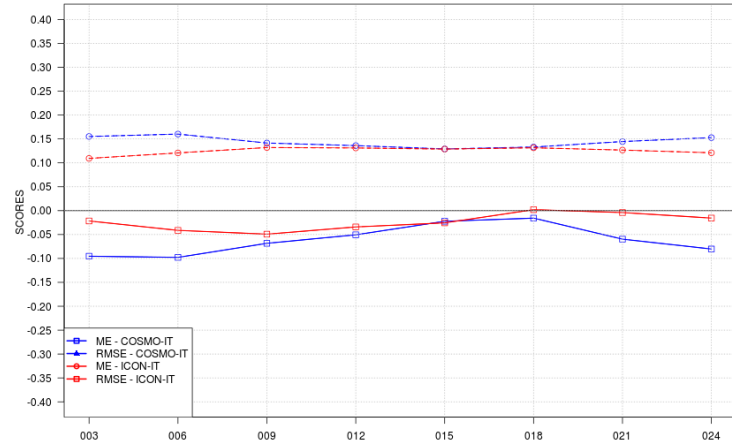


# Updated Orography, Results for 01 - 12 September 2021

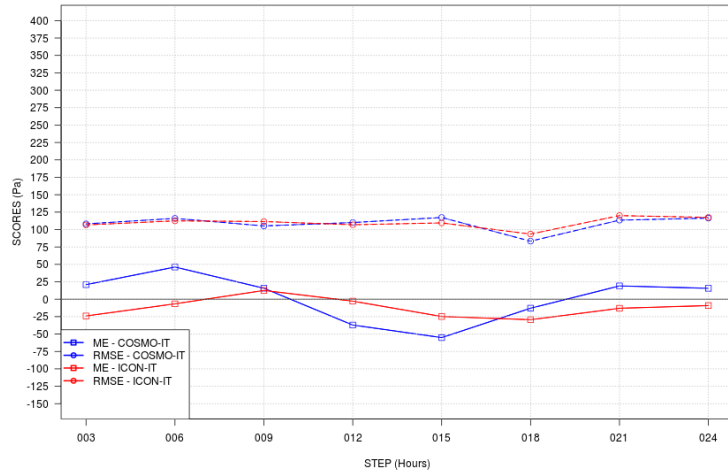
SCORES vs STEP - T2m - 1-12 sept 2021 - ALL ITA stations



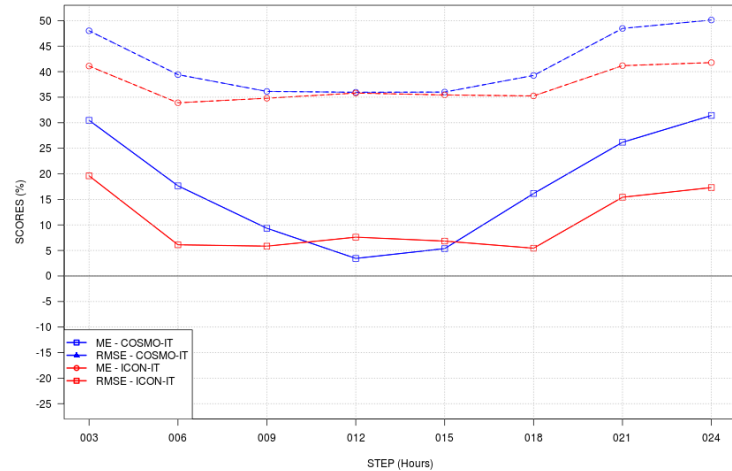
SCORES vs STEP - RH2M - 1-12 sept 2021 - ALL ITA stations



SCORES vs STEP - PS - 1-12sept 2021 - ALL ITA stations ALL



SCORES vs STEP - TCC - 1-12sept 2021 - ALL ITA stations

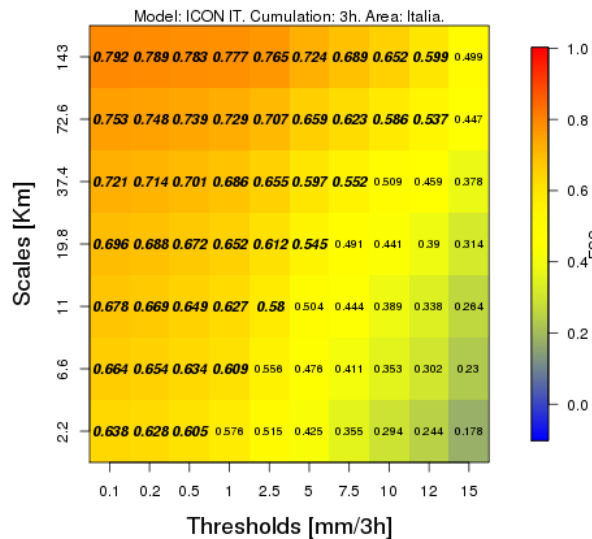




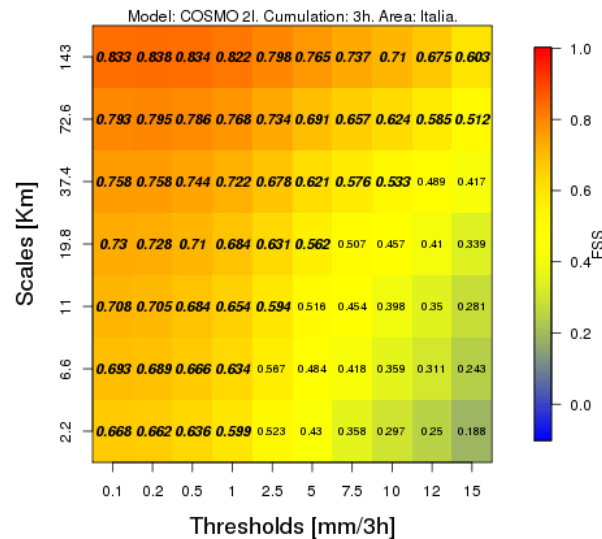
## Phase 3: 3D Fuzzy verification – D0

12 April 2021 – 30 June (bug fixed version, new namelist and grid)

Fractions Skill Score AMJ2021 - d0 - 3 Tsteps



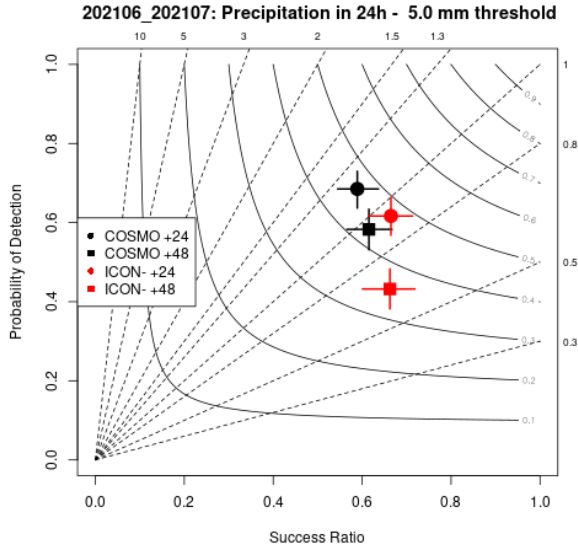
Fractions Skill Score AMJ2021 - d0 - 3 Tsteps



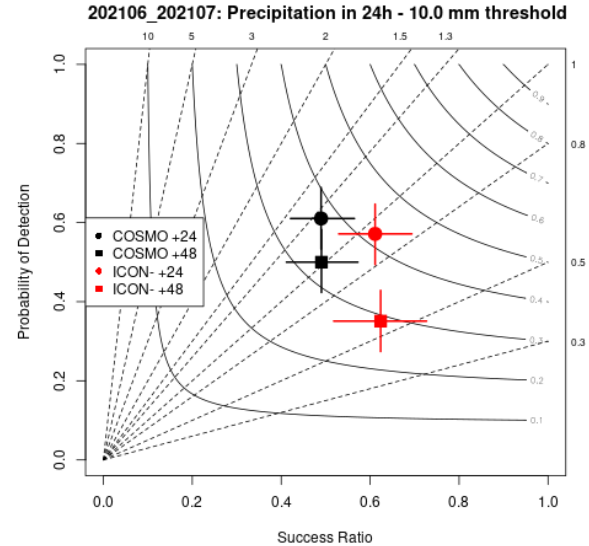
COSMO-2I: better scores for very low and very high thresholds  
Useful scale at 2.2 km for 0.1 mm/3h and at 143 km for 15 mm/3h

# Performance diagram: 24h prec cumulated averaged over alert areas

First 24h ICON is better, not for the second 24h



First 24h ICON is better, not for the second 24h





## Conclusions

No clear added value of ICON-IT with regard to precipitation but these are preliminary results to draft a unique conclusion: longer period should be verified

Different case studies will be considered: test by changing ICON-LAM parametrization schemes and ICBC are planned in order to calibrate the model

Verification on other variables than precipitation (T2m, RH2m, U10m, pressure, etc..) is planned

# The ICON Environment

- *Software configuration:* ICON Version: icon-2.6.2.2, ICONTOOLS Version: 2.4.12
- Compiler used: Intel parallel studio XE v.19.5 and Intel-mpi v.19.5
- *CMCC cluster specifications :*
  - **Operating System:** Linux CentOS 7.6 x86\_64;
  - **Processor:** Intel Xeon Gold 6154 (18 cores);
  - **Processor Speed:** 3.0 GHz;
  - **# of processor cores:** 12528;
  - **# of nodes:** 348 (dual processors nodes);
  - **Memory per node:** 96 GB;
  - **Interconnection:** Infiniband EDR (100Gbps);
- *Grid:* an R2B10 and is made up of 451384 triangular cells, with a spatial resolution of about 2.5 km. The geometrical centre of the grid is positioned in Gaeta (longitude 13.802°E latitude 41.560°N);
- *Forcing data:* ECMWF IFS (resolution of 0.075°);
- *Test cases considered:*
  1. August 16 to August 31, 2020;
  2. January 01 to January 14, 2019.



## ICON tests: physics schemes - CONVECTION

Sim	Convective scheme	Shallow conv	Radiation scheme	Cloud Microphysics	Land Surface	Cloud Cover	Turbulent transfer
	<code>inwp_convection</code>	<code>lshallowconv_only</code>	<code>inwp_radiation</code>	<code>inwp_gscp</code>	<code>inwp_surface</code>	<code>inwp_cldcover</code>	<code>inwp_turb</code>
#1_ref1	Tiedtke/Bechtold convection (1)	<b>TRUE</b>	ecRad (4) *	hydc_i_gr (COSMO-DE microphysics, 3-cat ice: cloud ice, snow, graupel) (2)	TERRA (1)	1: diagnostic cloud cover (by Martin Koehler)	1: COSMO diffusion and transfer
#2	Tiedtke/Bechtold convection (1)	<b>FALSE</b>	ecRad (4) *	hydc_i_gr (COSMO-DE microphysics, 3-cat ice: cloud ice, snow, graupel) (2)	TERRA (1)	1: diagnostic cloud cover (by Martin Koehler)	1: COSMO diffusion and transfer

### Full convection vs shallow convection only:

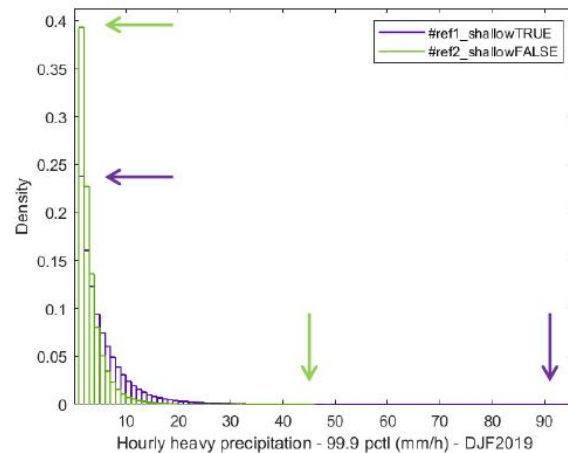
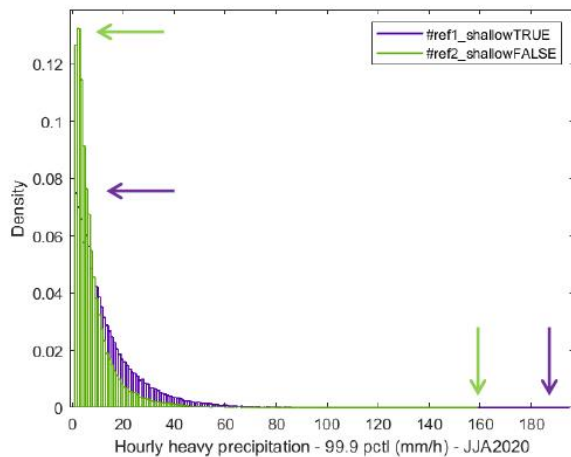
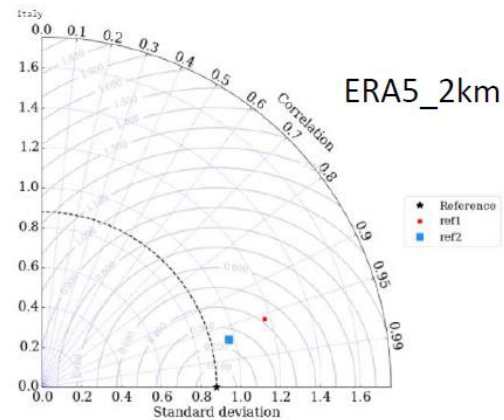
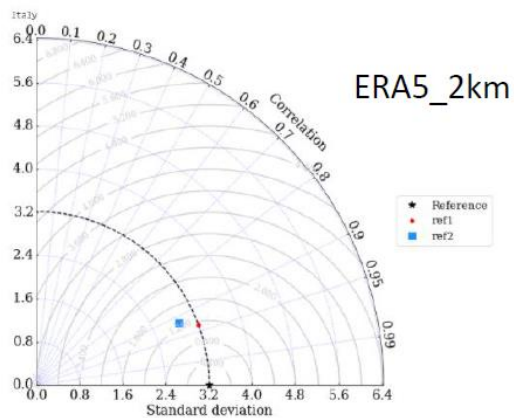
- ref1 and ref2 generally overestimate precipitation over North Italy in winter 2019 and over South Italy in summer 2020
- Simulation ref1 shows better performances in summer 2020 thanks to the explicit treatment of deep convection.
- The differences between the two simulations are generally limited to 1 mm/day.



2020

## Daily Cumulative Precipitation

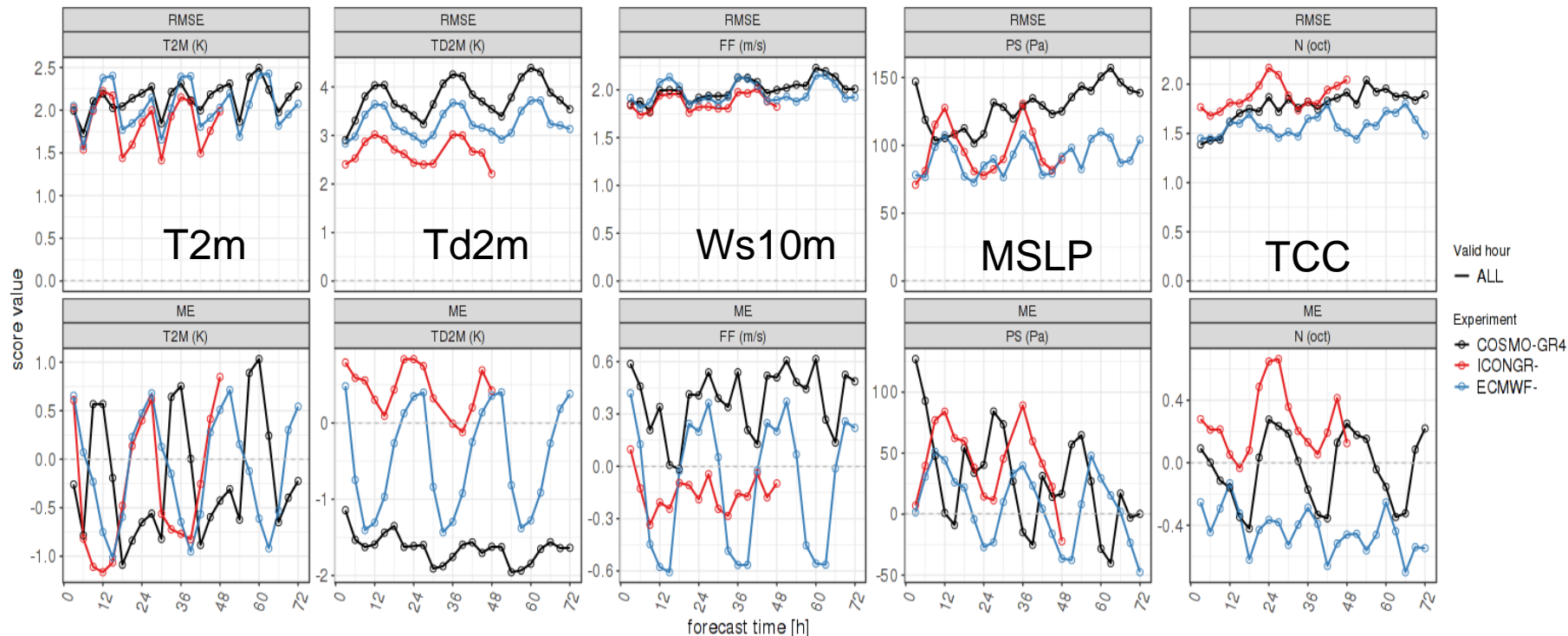
2019



# SUMMER-2021 Greek domain (with VERSION 2.6.2.2)

2021/06/01-00UTC - 2021/08/31-21UTC  
INI: 00 UTC, DOM: ALL, STAT: ALL

## COSMO-GR4, ICON-GR2.5, ECMWF-IFS



- **RMSE** : **ICON-GR** performs better than COSMO-GR4 for T2m, Td2m, Ws10m, MSLP (values close to **ECMWF**) but **ICON-GR** RMSE is slightly higher for TCC.
- **ME** : **ICON-GR** Diurnal cycles for T2m, Td2m, Ws10m differ from COSMO-GR4 (T2m consistent with **ECMWF** with nighttime overestimation). **ICON-GR** overestimation of Td2m, slight underestimation of Ws10m ( abs ME value lower than COSMO). **ICON-GR** TCC nighttime overestimation.

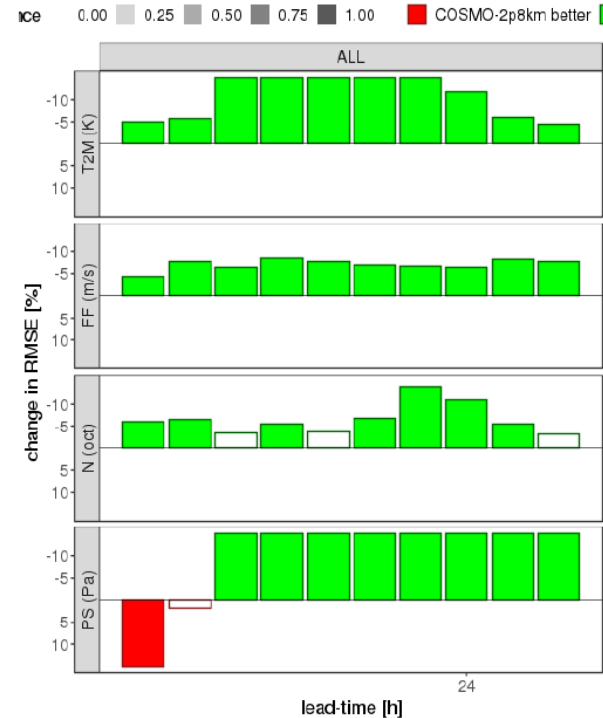
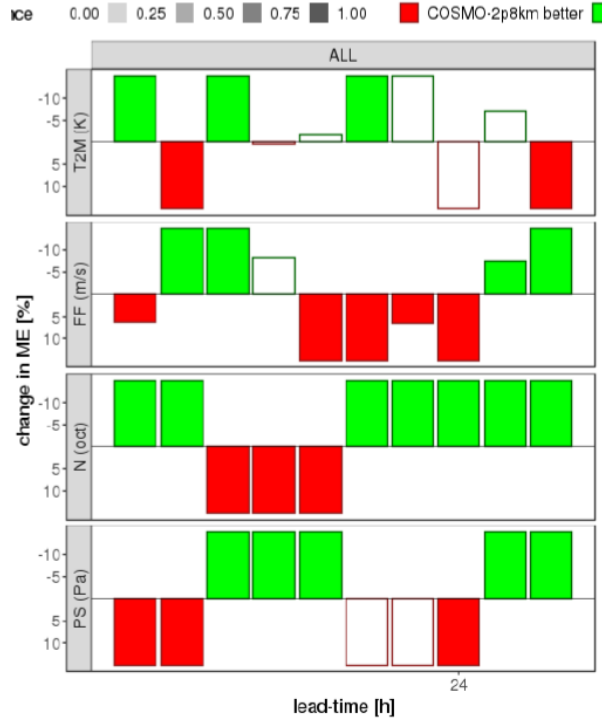
## Conclusions on Verification (HNMS, Greece)

- Results for DJF20-21 with v2.4.0 and JJA21 with v2.6.2.2 were presented
- RMSE scores are better for ICON-GR for both seasons except for TCC.
- There are bias differences between COSMO and ICON-GR mainly for T2m, Td2m and Ws10m.
- ICON-GR 2mT and Td2m is overestimated at night for both seasons.
- ICON-GR Wind speed 10m is overestimated in DJF and underestimated in JJA
- Precipitation scores are better for ICON-GR (but POD is lower in JJA season).



Forecasts initialized from 2021/03/01 to 2021/05/31  
 Reduction of ME [%], INI; OOUTC, SIGTEST: TRUE

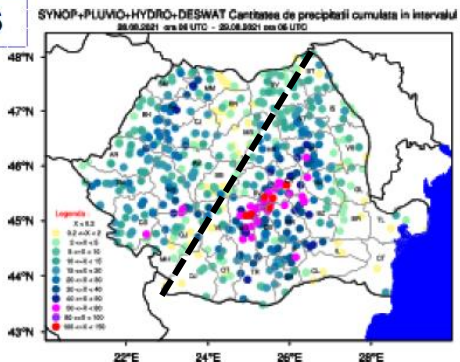
Forecasts initialized from 2021/03/01 to 2021/05/31  
 Reduction of RMSE [%], INI; OOUTC, SIGTEST: TF



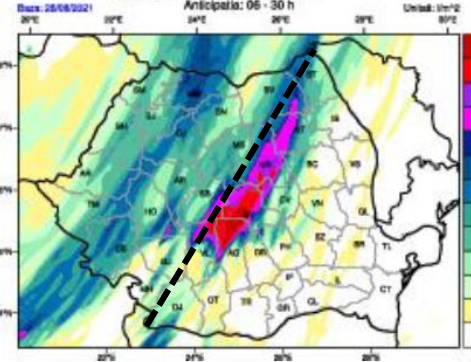
**ICON-2.8 (green) vs. COSMO-2.8 (red)**

## Problem with Forecast for Precipitation

**OBS**

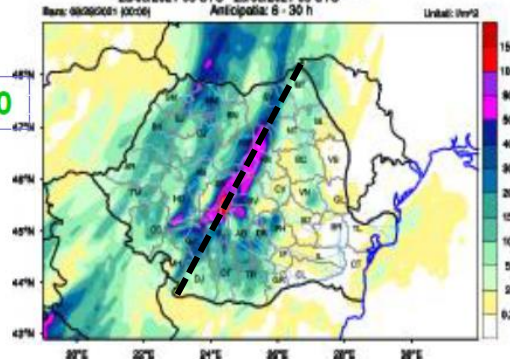


Model: ICON-2.8km Cantitatea de precipitatii prognozata in intervalul  
 28/08/2021-06 UTC - 29/08/2021-06 UTC  
 Data: 28/08/2021 Anticipatia: 06 - 30 h Unitati: (mm/h)<sup>2</sup>



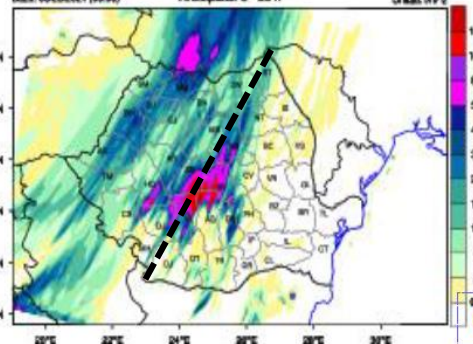
**ICON-2.8**

Model: COSMO Cantitatea de precipitatii prognozata in intervalul  
 28/08/2021-06 UTC - 29/08/2021-06 UTC  
 Data: 08/08/2021 (0000h) Anticipatia: 6 - 30 h Unitati: (mm/h)<sup>2</sup>



**COSMO-7.0**

COSMO2.8 Cantitatea de precipitatii prognozata in intervalul  
 28.08.2021 ora 06 UTC - 29.08.2021 ora 06 UTC  
 Data: 08/08/2021 (0000) Anticipatia: 6 - 30 h Unitati: (mm/h)<sup>2</sup>



**COSMO-2.8**

28-29.08.2021

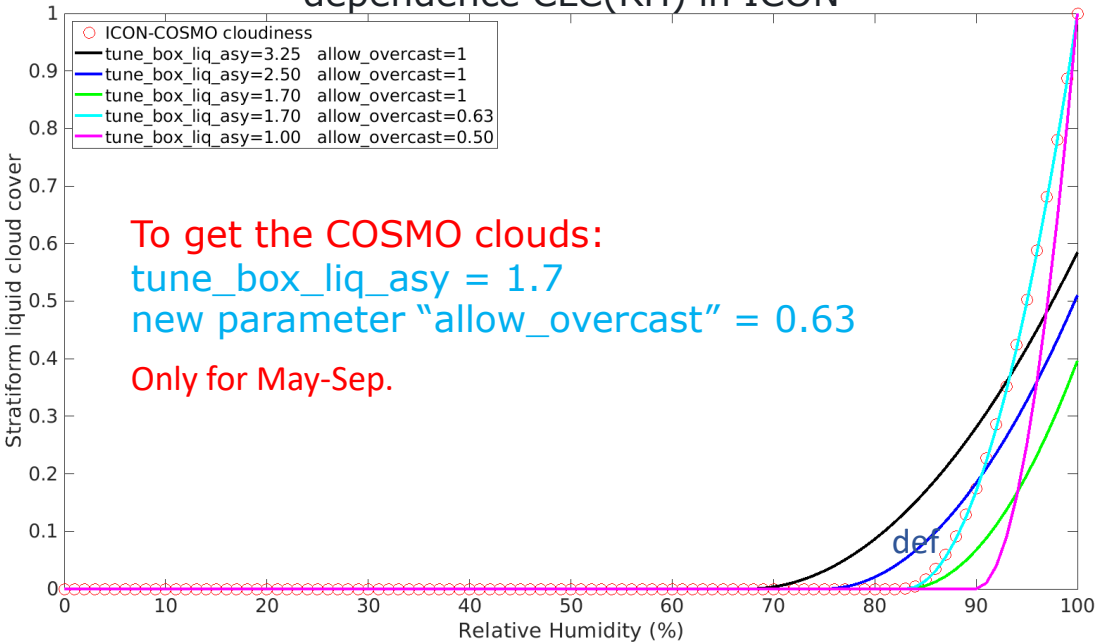
# Cloud Cover verification versus



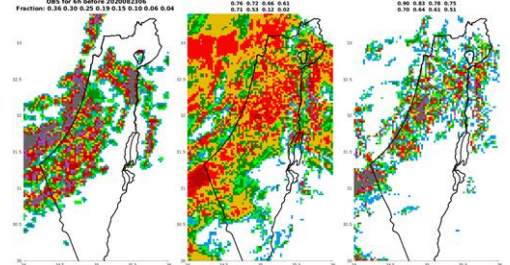
Example: 20200821 + 2d



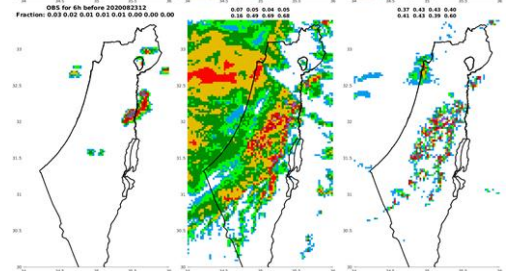
dependence CLC(RH) in ICON



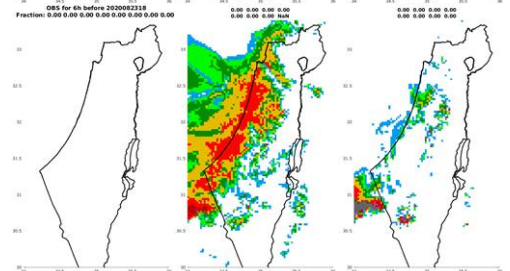
06 UTC



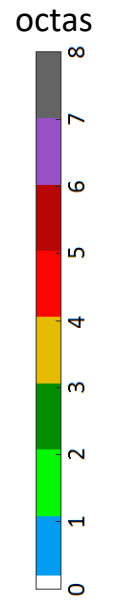
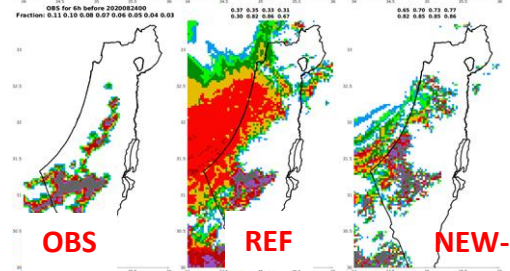
12 UTC



18 UTC



24 UTC



# Precipitation

# FSS Winter rain November - April



Average

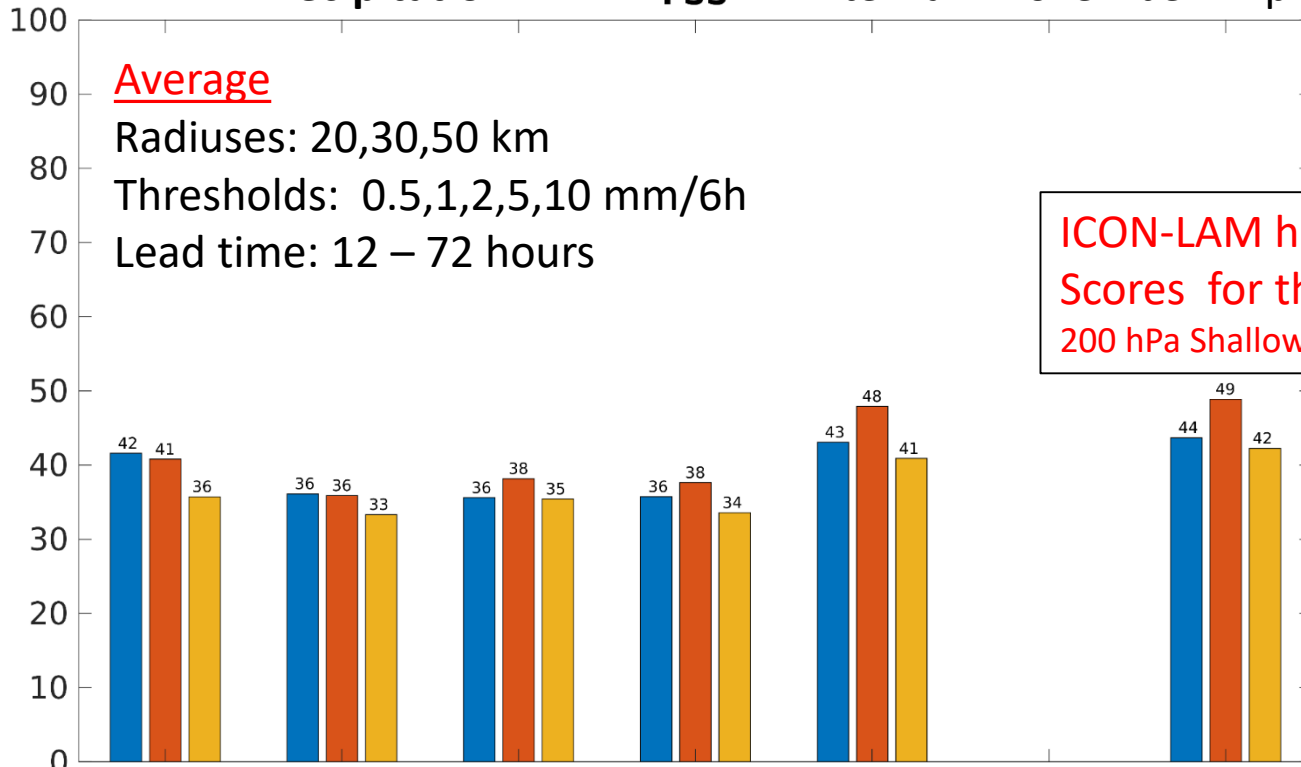
Radiuses: 20,30,50 km

Thresholds: 0.5,1,2,5,10 mm/6h

Lead time: 12 – 72 hours

ICON-LAM has the best Scores for the 3 years  
200 hPa Shallow convection max. depth

FSS\*100



IFS

GFS

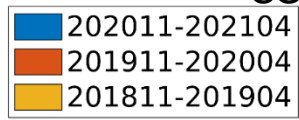
UKMO

ICON-GL

COSMO-IL

IC-IL

ICON-IL

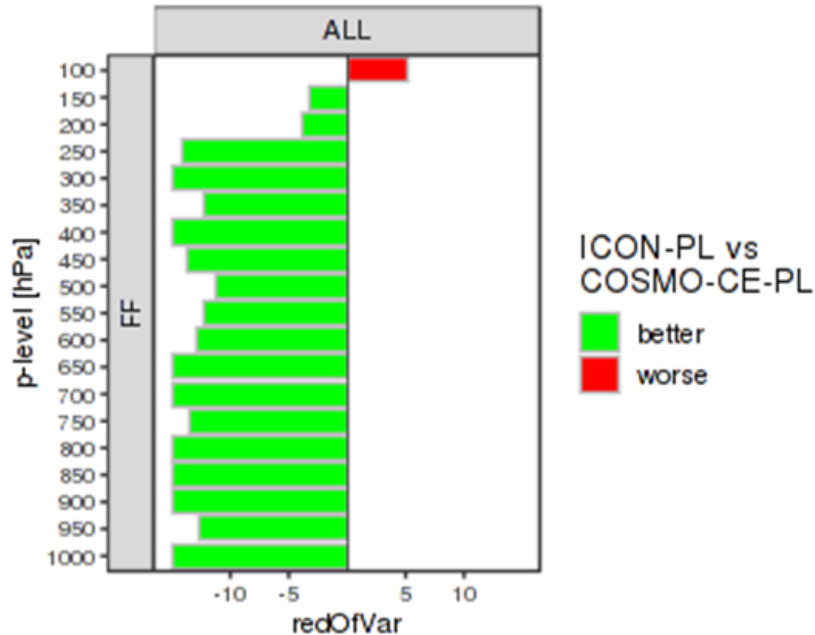


Reforecast  
ICON-LAM  
IL domain



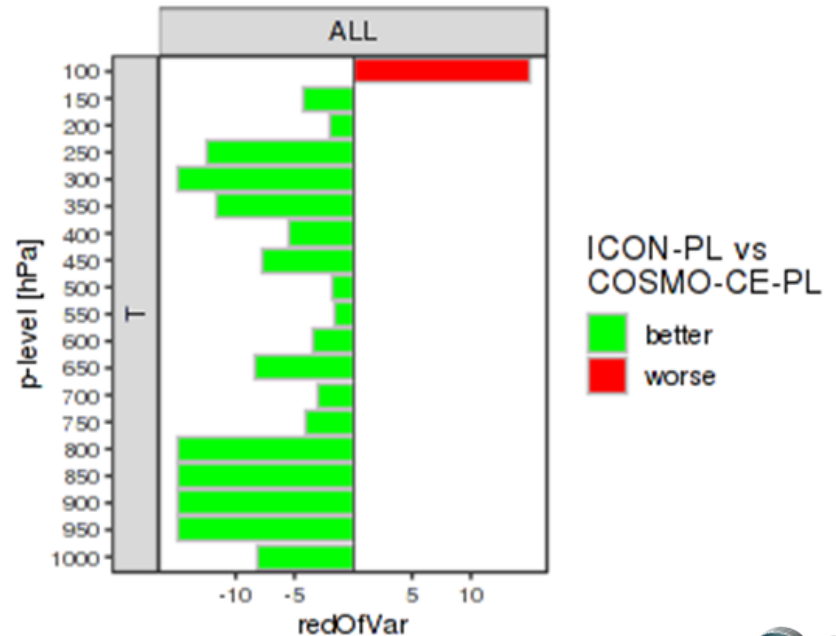
## Wind speed

Verification period: 2020/12/01 - 2021/02/28  
Data selection by initial-date  
Reduction of RMSE [%]



## Temperature

Verification period: 2020/12/01 - 2021/02/28  
Data selection by initial-date  
Reduction of RMSE [%]



(The scores are aggregated over all initial times and all forecast ranges > 0h.)

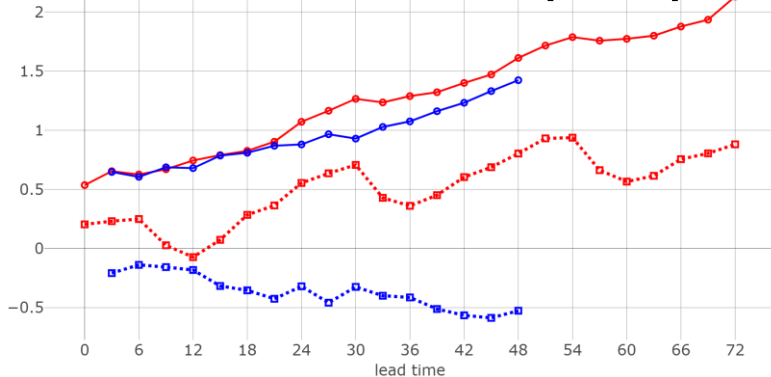
- Required version of ICON  $\geq$  2.5.0 (2.6.2.2, planned 2.6.3) is finally installed and regularly running in preoperational mode
- MEC and Rfdbk based verification is done regularly
- Verification results generally show better performance of ICON-PL than COSMO-CE-PL for analyzed parameters, period and model version



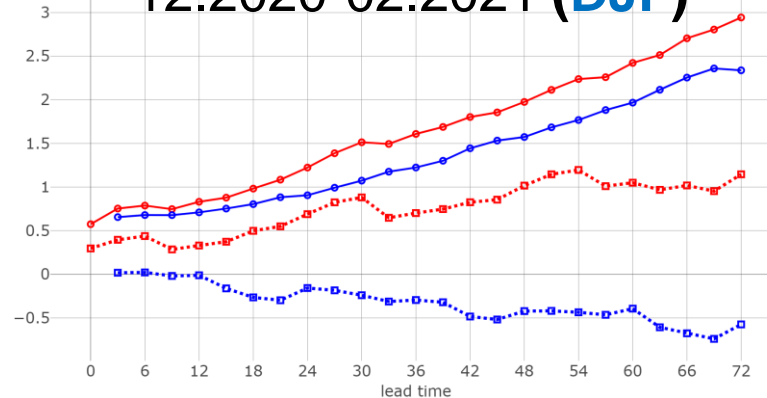
# Pressure reduced to Mean Sea Level scores over Central Russia



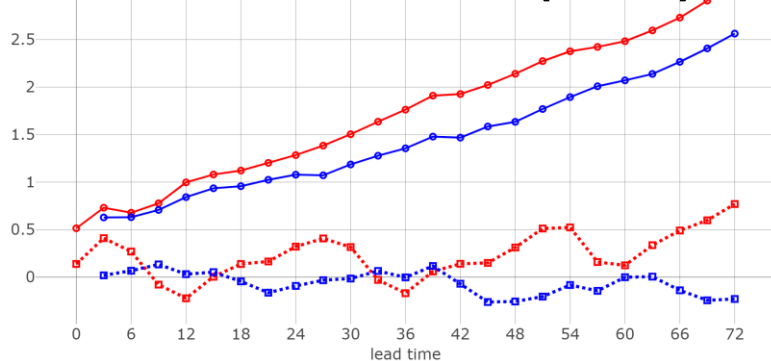
09.2020-11.2020 (SON)



12.2020-02.2021 (DJF)



03.2021-05.2021 (MAM)



● COSMO-RU7 ● ICON-RU7 ⊖ RMSE □ ME

- Generally better **ICON-RU7** scores, especially on the second forecast day
- **ICON-RU7** tends to underestimate MSLP over Central Russia, **COSMO-RU7** tends to overestimate

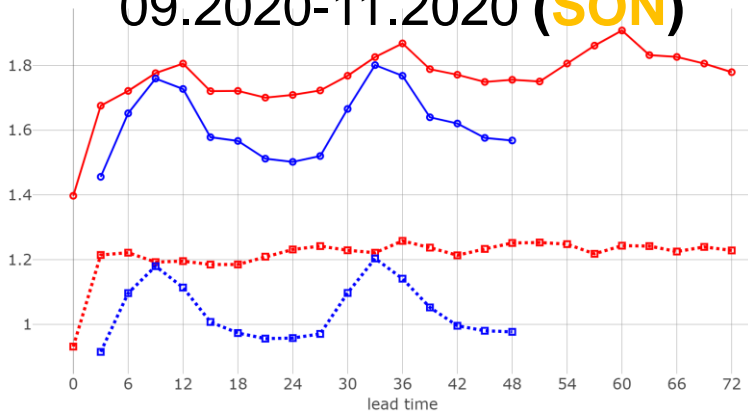




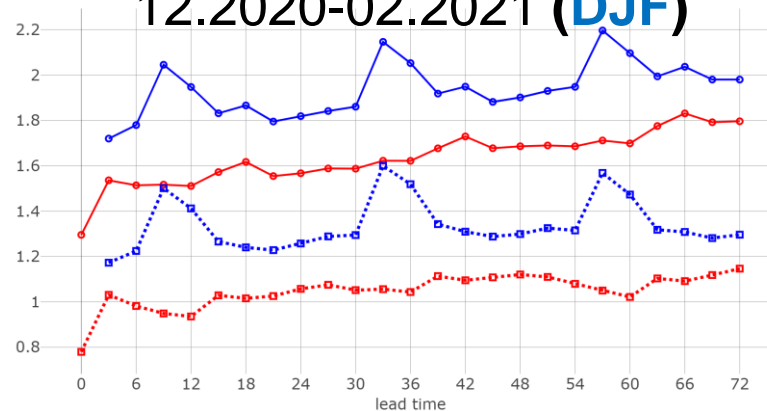
# Wind speed at 10 m height scores over Central Russia



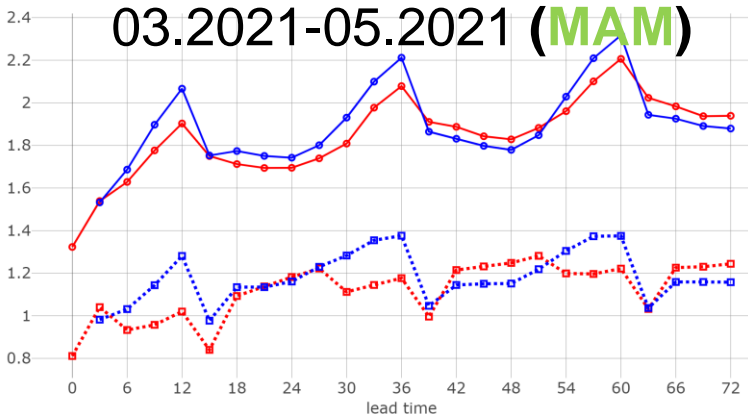
## 09.2020-11.2020 (SON)



## 12.2020-02.2021 (DJF)



## 03.2021-05.2021 (MAM)



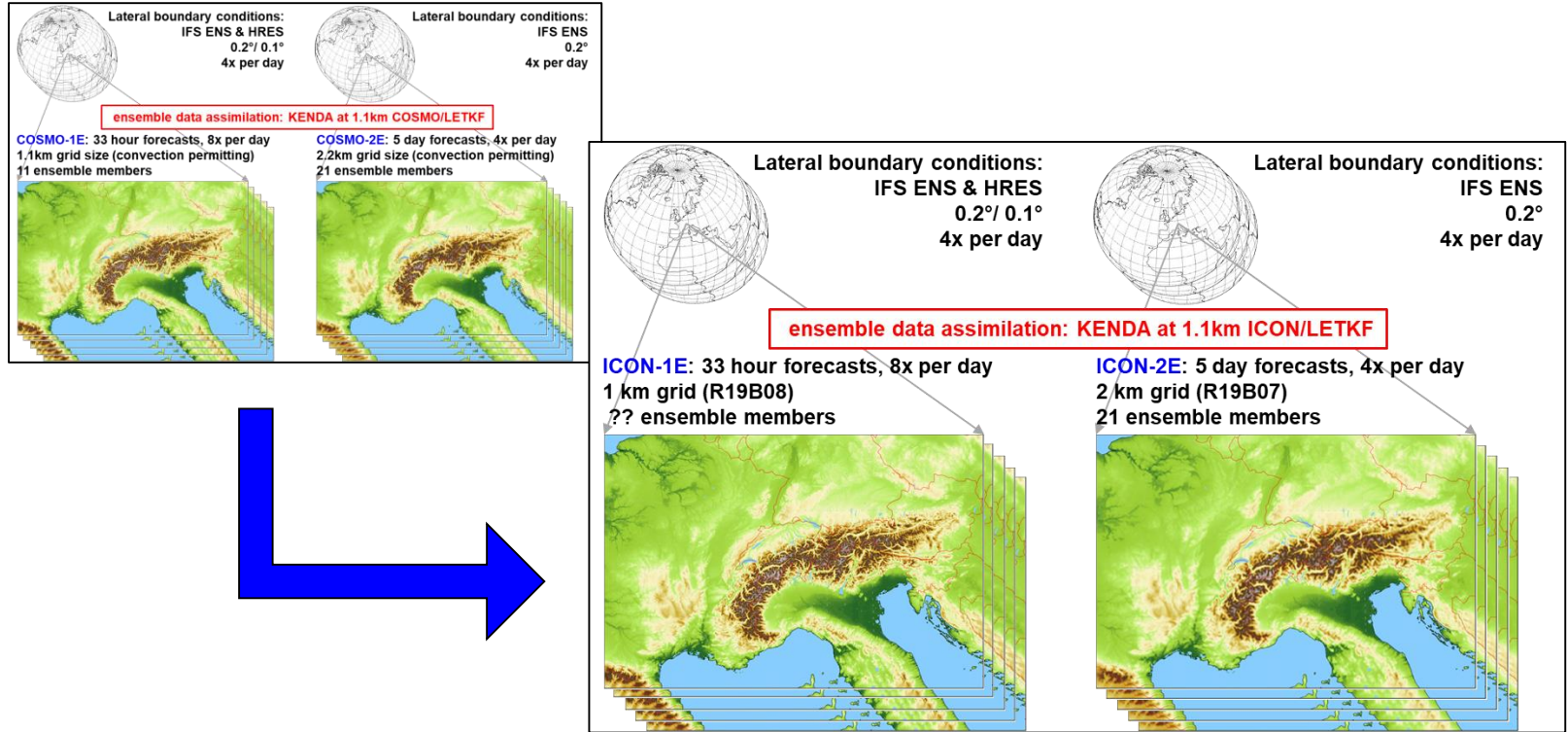
● COSMO-RU7 ● ICON-RU7 ⊖ RMSE ◻ ME

- Better **ICON-RU7** scores during autumn, better **COSMO-RU7** scores during winter
- Both models generally overestimate wind speed at 10 m height





# Project ICON-22: ICON-1E & ICON-2E





# ICON-1 vs. C-1E Ctrl: summer 2021 (+13 to +24h)

Parameter	ME	STDE
PMSL	Red	Red
PS	Light Blue	Light Green
T_2M	Light Blue	Green
TD_2M	Green	Green
RELHUM_2M	Green	Green
GLOB	Light Blue	Light Blue
CLCT	Light Blue	Light Blue
FF_10M	Red	Light Green
DD_10M	Red	Light Green
VMAX_10M1h	Light Blue	Green
TOT_PREC1h	Light Blue	Red

ICON clearly better  
ICON slightly better  
ICON neutral  
ICON slightly worse  
ICON clearly worse

# PP C2I Task 5.6: Survey of Forecasters' Feedback about ICON-LAM NWP

- Feedback received from IMS, HNMS (Theodore's and Forecasters' answers), ARPAP
- MCH, RHM, ARPAE-SIMC:  
ICON-LAM is not yet provided operationally to forecasters
- IMGW, MeteoRomania, COMET or CNMCA – feedbacks expected

# Added value for particular meteorological variable/variables, HIW

- **Fogs, max wind gusts**, however ICON-LAM also gave false alarms for fog that did not occur (IMS)
- **Total precipitation** in some (but not all) **extreme precipitation** events, ICON was a lot closer to the actual values than any other numerical model (HNMS, Theodore),
- The **precipitation, especially convective** (the precipitation objects for ICON are better located at specific areas and not so extended as COSMO forecasts); The **winds** for COSMO forecasts, especially in the summer, are often overestimated, especially for specific ship sea routes. ICON wind forecasts are closer to ECMWF (HNMS forecasters)
- **Thunderstorms, precipitation**, even if sometimes values are extremely overestimated, and **cloudiness** (which is often over-estimated by COSMO) (ARPAP)

**Interesting that verification results (Reports on ICON, June 2021) are not so obvious for intense precipitation (but they are for SON period, before the convective season!). Also, ICON precipitation verification results are not always better than COSMO in Francesca's, Valeria's and Amalia's talks today for summer months. Perhaps, more spatial verification is needed to demonstrate precipitation added value in ICON, as spatial verification tries to mimic human judgment. Positive ICON compared to COSMO precip results in Dimitra's verification report (coincides with forecasters opinions).**

- Ready to run at ECMWF
- ICON version 2.6.1 has been fully tested (Ines) at the beginning of 2021
- We are awaiting requests for new tests
- Cost of a full test  $\approx 1.2 \cdot 10^6$  billing units.

- If we need the test of a “last” Cosmo version it has to be done **very** soon (autumn 2021!), before migration of ECMWF datacenter to Bologna, otherwise a big restructuring of the suite will be required, probably not worth now.
- For 2021 the remaining billing units are  $\approx 1 \cdot 10^6$ , so if we need to do an ICON test instead, we will have to ask for a small extension.
- The raw ICON test suite output largely exceeds the archiving storage requested for the project at ECMWF, it was proposed to permanently archive only a choice of fields roughly equivalent to the Cosmo test suite output, but no reaction followed. Can we consider this proposal accepted?

- There is no need to test the Cosmo version 6.0 since the difference in the results should be limited to sea-ice parameterization which has no impact on the test suite.
- The issue concerning ICON output archiving was actually discussed and there is an overall agreement on archiving only a subset of output data, equivalent to Cosmo test suite output.

# Summary & Outlook

C2I

What are the next steps for PP C2I?



- Verification results look better, or at least neutral, as compared to COSMO results; runtime is mostly better
- With cp/cv bugfix and the ecRad radiation scheme results will likely improve even more (as compared to what is was presented in the SON verification report)
- COSMO partners should now be able to switch their deterministic forecasting system to ICON (this was the major goal of PP C2I!)
- Further issues are addressed in separate, dedicated PPs/PTs.
  - GPU version of ICON (PP IMPACT), ensemble forecasting systems with ICON (PP Prophecy), transition to MEC/Rfdbk based verification (PP CARMA), and further development of data assimilation for ICON (WG1/KENDA)
  - Other projects aimed at further developing ICON are initiated (e.g. CAIIR, CITTA)

**In summary:**                    **The focus of the COSMO partners has shifted to ICON;**  
   **The aims of PP C2I have been fulfilled**

- Further steps should be made through dedicated PTs and PPs, where problems are solved in more target-oriented manner; the scope of C2I (and similar PPs) is too broad, and the management overhead is large

## The cp/cv bugfix

- As reported at the last COSMO GM, a major bug was fixed
- Transition to the new (bugfixed) version has been successful

## Further investigation necessary for...

- Ambiguous surface pressure results. Promising results for Italy with updated orography file
- Mixed results for
  - Precipitation
  - Cloud cover (promising results from IMS!)

## Task 6: Forecasters' feedback

- WG4 has prepared a survey
- PT to monitor the performance of ICON for another year, possibly resulting in a long-term activity

## Final Report

- Preparations starting: Usage of common verification software MEC/Rfdbk should be possible