



ICON-PL vs COSMO-CE-PL

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ICON-PL 2.6.2.2 (includes cp/cv bug fix, the RRTM radiation scheme)

ICON-PL verification using MEC/Rfdbk

Comparison with: the Polish SYNOP (Poland domain),

TEMP stations (Poland stations)

COSMO-CE-PL

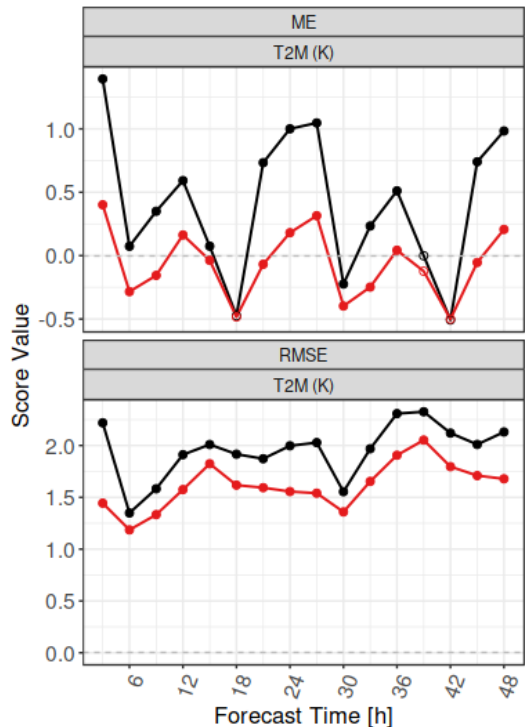
Verification period: Summer 2022-Spring 2023

Temperature 2m, JJA 2022 - MAM 2023



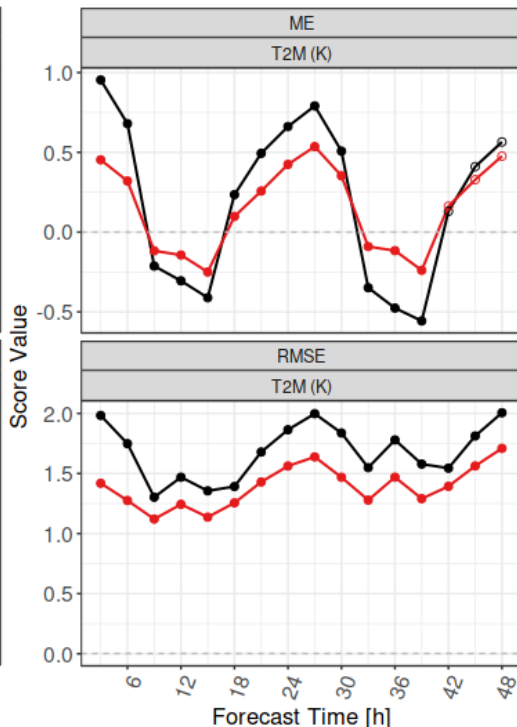
Summer

2022/06/01-03UTC - 2022/08/31-21UTC
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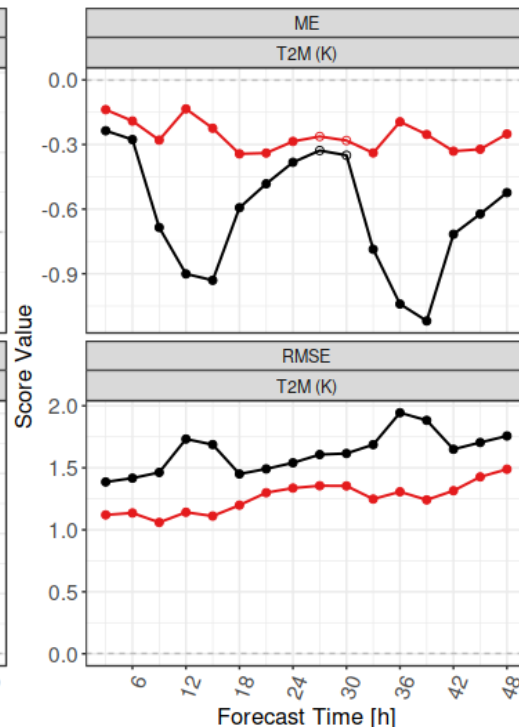
Autumn

2022/09/01-00UTC - 2022/11/30-21UTC
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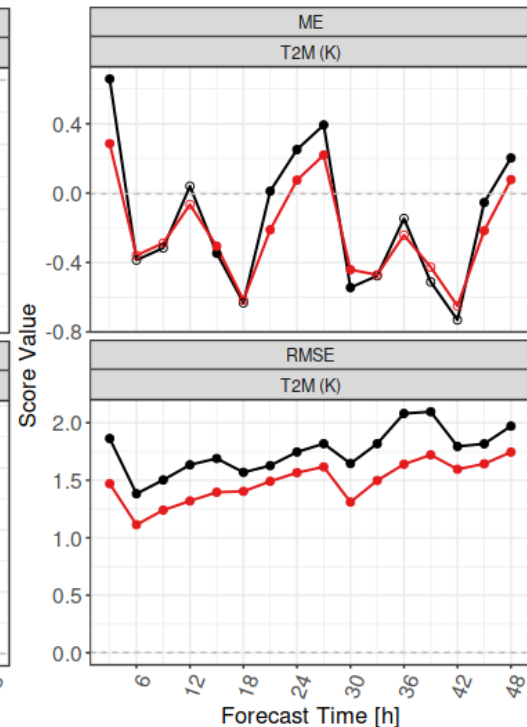
Winter

2022/12/01-00UTC - 2023/02/28-21UTC
INI: 00 UTC, DOM: Poland, STAT: ALL



Spring

2023/03/01-00UTC - 2023/05/31-21UTC
INI: 00 UTC, DOM: Poland, STAT: ALL



ICON-PL has a much reduced RMSE compared to **COSMO-CE-PL** for the all seasons.

ICON-PL is cooler than **COSMO-CE PL** in Summer and reduces the warm bias, particularly at nighttime.

ICON-PL is warmer than **COSMO-CE-PL** in Winter and reduces the cold bias, particularly during daytime.

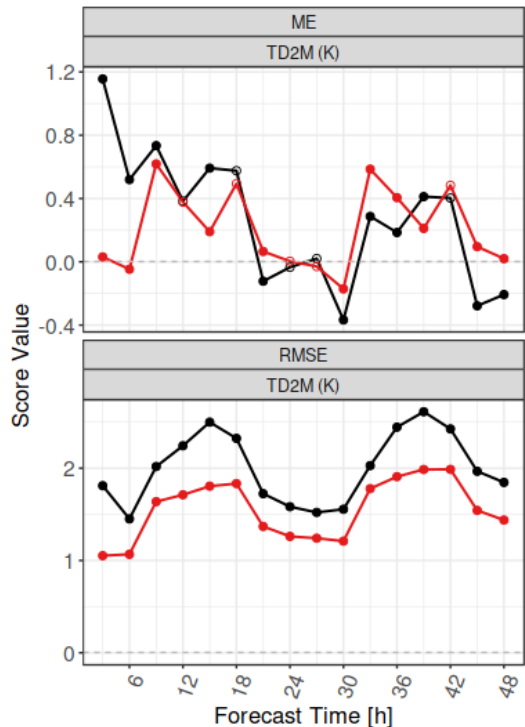
ICON-PL has a reduced bias in the diurnal cycle compared to **COSMO-CE PL** in Autumn with a reduced warm bias at nighttime and a reduced cold bias during daytime.

Dew Point Temperature 2m, JJA 2022 - MAM 2023



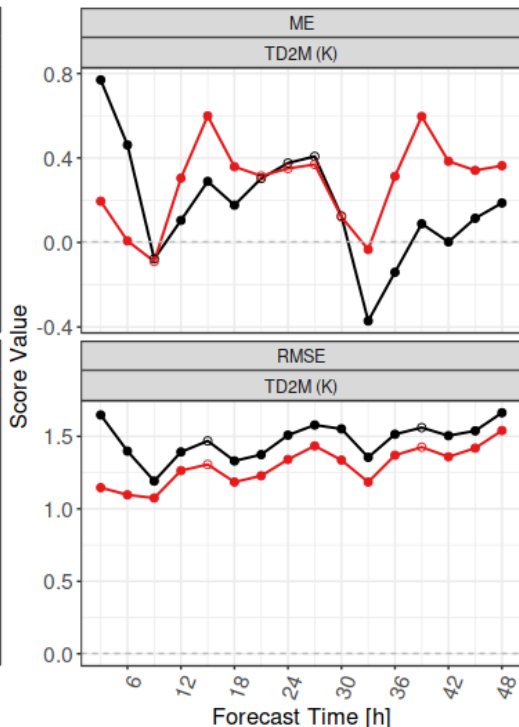
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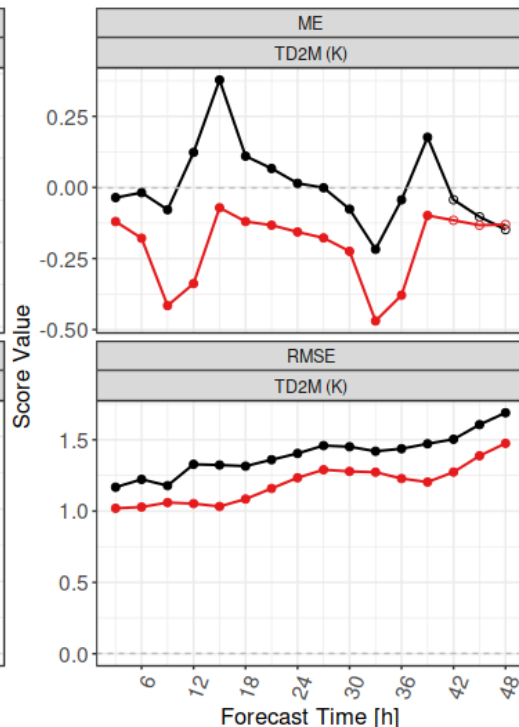
Autumn

2022/09/01-00UTC - 2022/11/30-21UTC
INI: 00 UTC, DOM: Poland, STAT: ALL



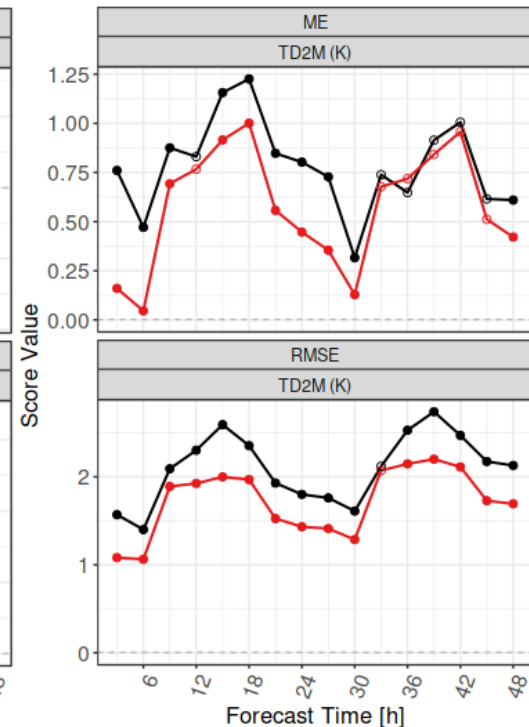
Winter

2022/12/01-00UTC - 2023/02/28-21UTC
INI: 00 UTC, DOM: Poland, STAT: ALL



Spring

2023/03/01-00UTC - 2023/05/31-21UTC
INI: 00 UTC, DOM: Poland, STAT: ALL



ICON-PL has a much reduced RMSE compared to **COSMO-CE-PL** for the all seasons.

ICON-PL is cooler than **COSMO-CE-PL** in Winter for the whole forecast range, up to T+30 in Spring, up to T+12 in Summer and Autumn. **ICON-PL** is warmer than **COSMO-CE-PL** in Autumn after T+12.

RH relative humidity 2m, JJA 2022 - MAM 2023



Summer

2022/06/01-03UTC - 2022/08/31-21UTC
INI: 00 UTC, DOM: Poland, STAT: ALL

Autumn

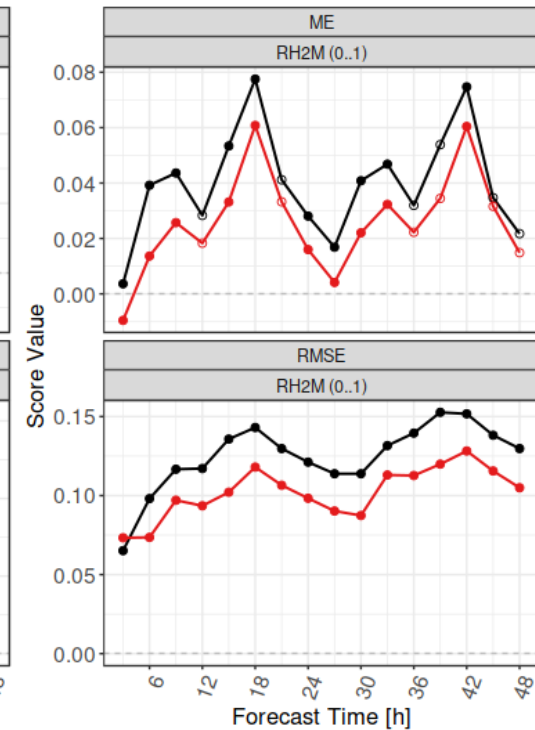
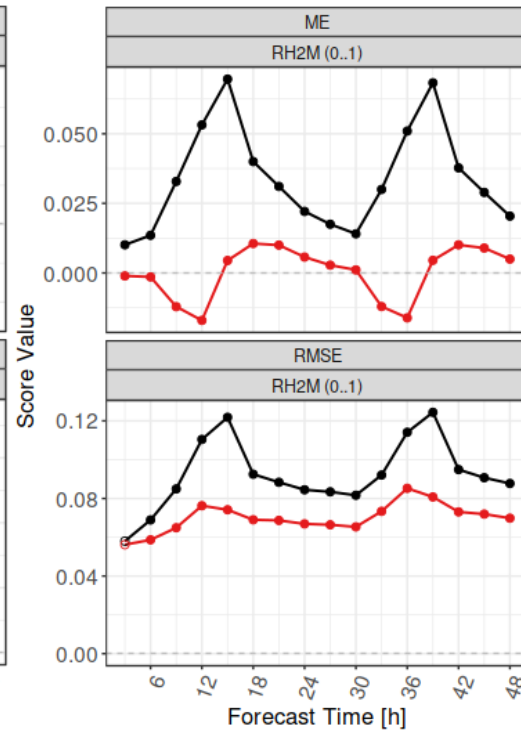
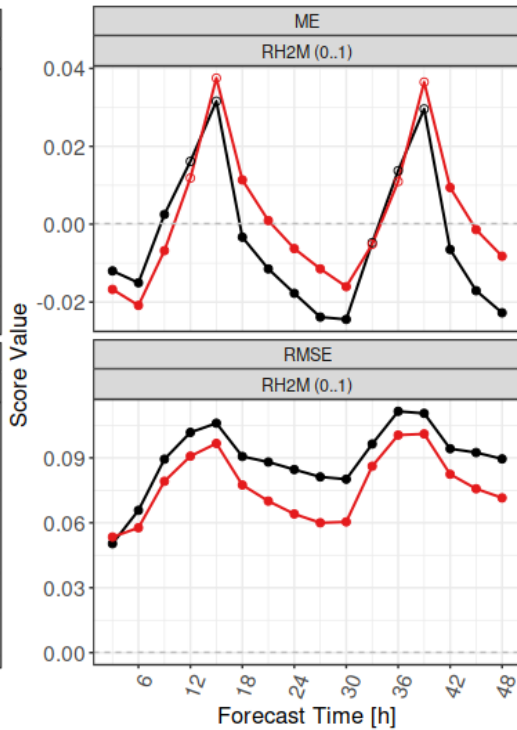
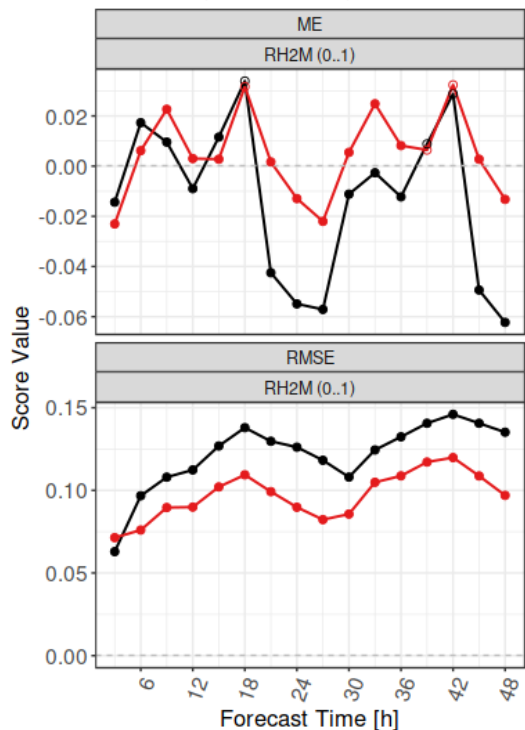
2022/09/01-00UTC - 2022/11/30-21UTC
INI: 00 UTC, DOM: Poland, STAT: ALL

Winter

2022/12/01-00UTC - 2023/02/28-21UTC
INI: 00 UTC, DOM: Poland, STAT: ALL

Spring

2023/03/01-00UTC - 2023/05/31-21UTC
INI: 00 UTC, DOM: Poland, STAT: ALL



ICON-PL has a much reduced RMSE compared to **COSMO-CE-PL** for the all seasons.

ICON-PL is moister than **COSMO-CE PL** in Summer and reduces the dry bias, particularly at T+24.

ICON-PL is drier than **COSMO-CE-PL** in Winter and reduces the moist bias, particularly during daytime.

ICON-PL is drier than **COSMO-CE PL** in Spring and moister in Autumn at longer forecast ranges (from T+12).

Surface Pressure, JJA 2022 - MAM 2023



Summer

2022/06/01-03UTC - 2022/08/31-21UTC
INI: 00 UTC, DOM: Poland, STAT: ALL

Autumn

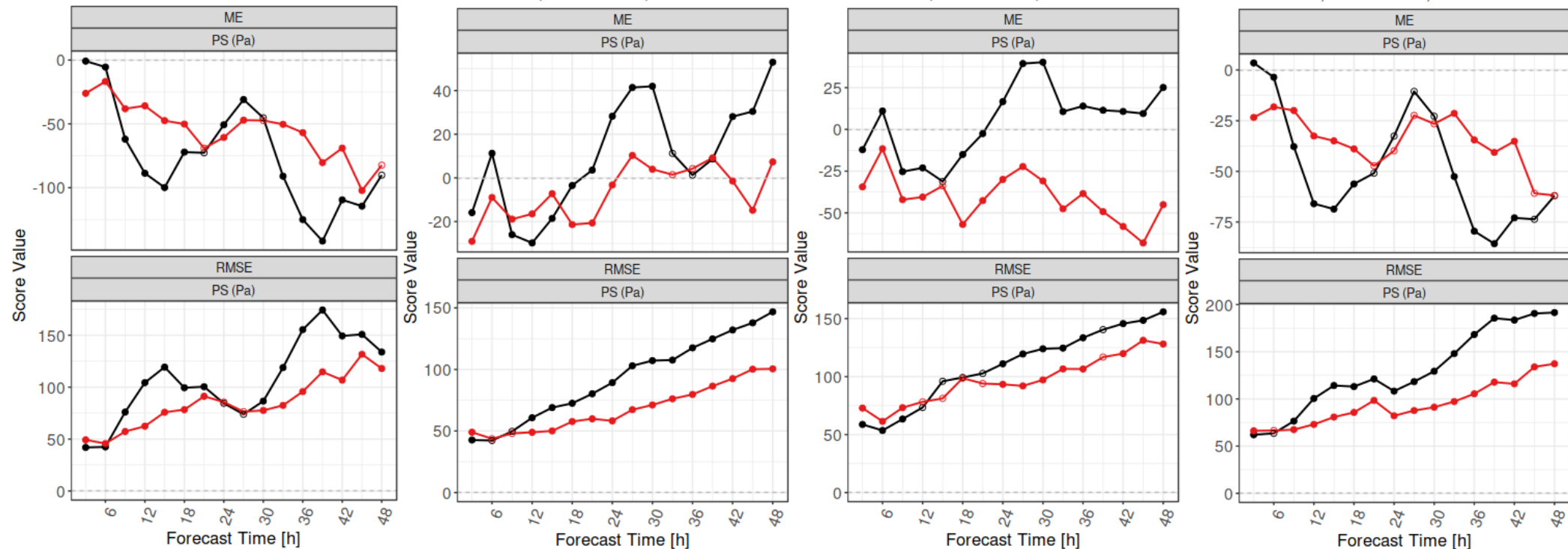
2022/09/01-00UTC - 2022/11/30-21UTC
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Winter

2022/12/01-00UTC - 2023/02/28-21UTC
INI: 00 UTC, DOM: Poland, STAT: ALL

Spring

2023/03/01-00UTC - 2023/05/31-21UTC
INI: 00 UTC, DOM: Poland, STAT: ALL



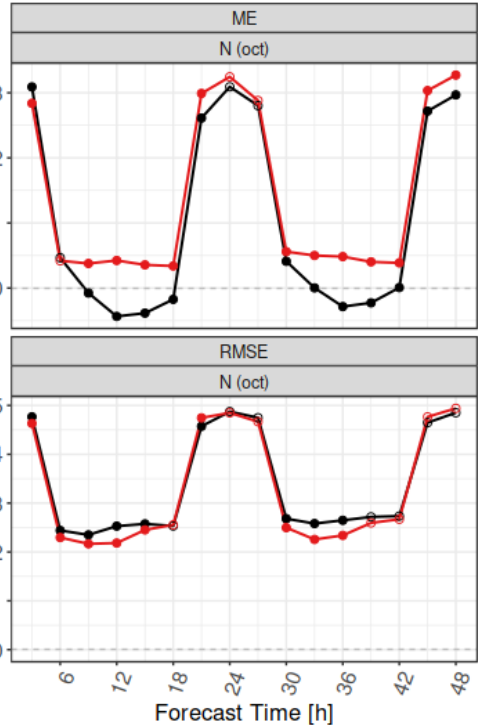
ICON-PL has a reduced overall RMSE and slower error growth compared to **COSMO-CE-PL** for all seasons. Both models have a negative bias in Spring and Summer with the bias being generally more pronounced (larger) in **COSMO-CE-PL**. **ICON-PL** has lower pressure than **COSMO-CE-PL** in Winter.

Total Cloud, JJA 2022 - MAM 2023



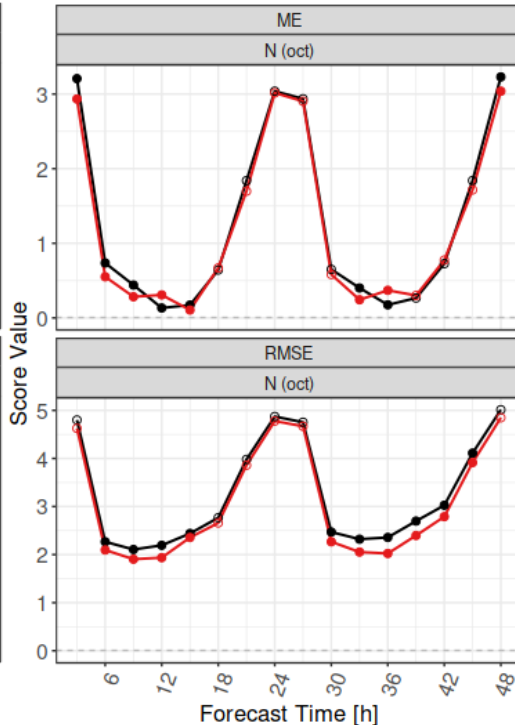
Summer

2022/06/01-03UTC - 2022/08/31-21UTC
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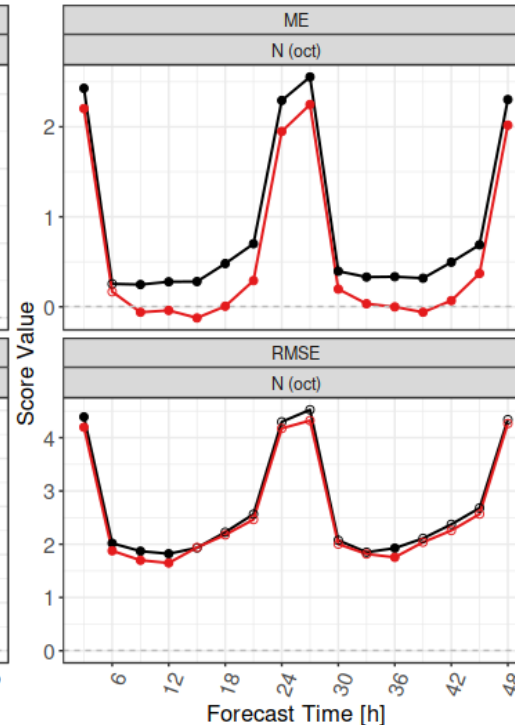
Autumn

2022/09/01-00UTC - 2022/11/30-21UTC
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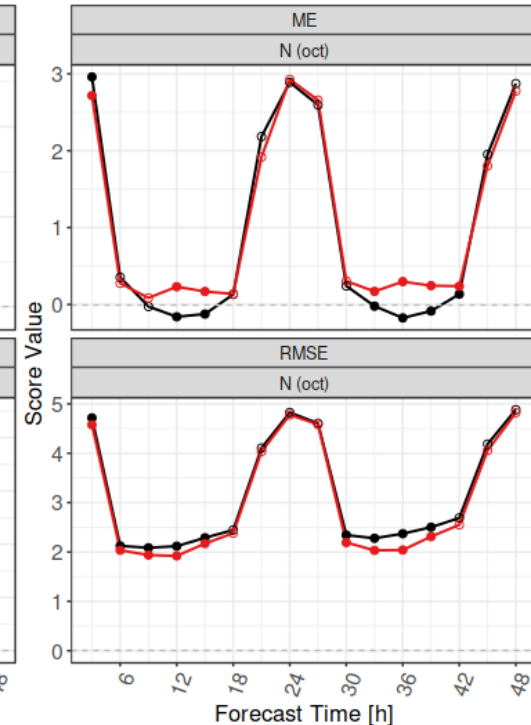
Winter

2022/12/01-00UTC - 2023/02/28-21UTC
INI: 00 UTC, DOM: Poland, STAT: ALL



Spring

2023/03/01-00UTC - 2023/05/31-21UTC
INI: 00 UTC, DOM: Poland, STAT: ALL



Both **ICON-PL** and **COSMO-CE-PL** models have a diurnal cycle to their bias for all seasons. This bias is largest at nighttime when there is a large positive bias. The bias is smallest during the daytime. **ICON-PL** has more cloud than **COSMO-CE-PL** in Spring and Summer and less cloud in Winter.

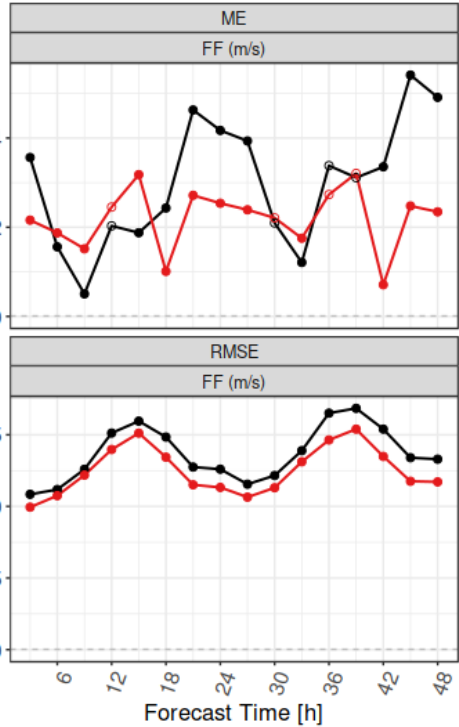
ICON-PL has a positive bias for all seasons for the whole forecast range. **COSMO-CE-PL** has also a positive bias for all seasons except for a small negative bias during daytime in Summer and Spring.

Wind speed, JJA 2022 - MAM 2023



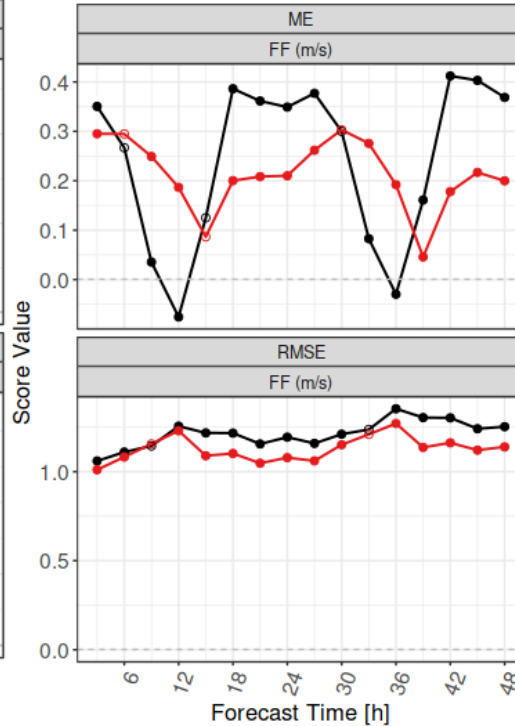
Summer

2022/06/01-03UTC - 2022/08/31-21UTC
INI: 00 UTC, DOM: Poland, STAT: ALL



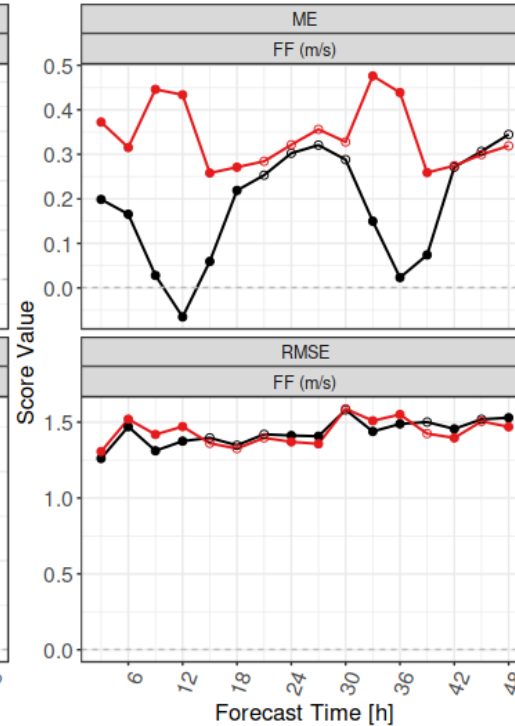
Autumn

2022/09/01-00UTC - 2022/11/30-21UTC
INI: 00 UTC, DOM: Poland, STAT: ALL



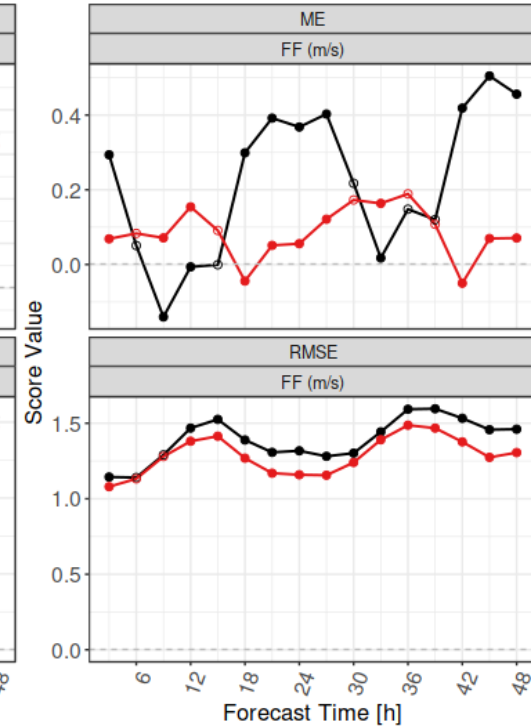
Winter

2022/12/01-00UTC - 2023/02/28-21UTC
INI: 00 UTC, DOM: Poland, STAT: ALL



Spring

2023/03/01-00UTC - 2023/05/31-21UTC
INI: 00 UTC, DOM: Poland, STAT: ALL



ICON-PL has a reduced RMSE compared to **COSMO-CE-PL** for Spring, Summer and Autumn seasons.

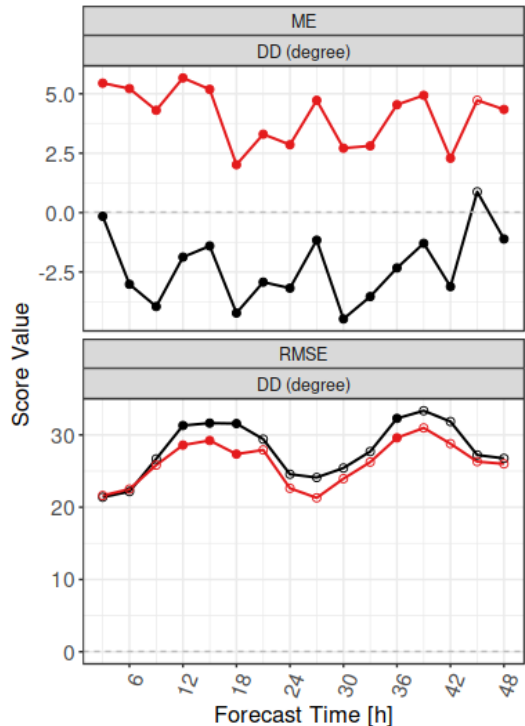
This is often associated with a reduced nighttime positive (strong) bias. In contrast the winds during the morning and early afternoon are stronger in **ICON-PL** compared to **COSMO-CE-PL**.

ICON-PL has stronger winds than **COSMO-CE-PL** throughout the day in Winter and has a greater positive bias.

Wind direction, JJA 2022 - MAM 2023

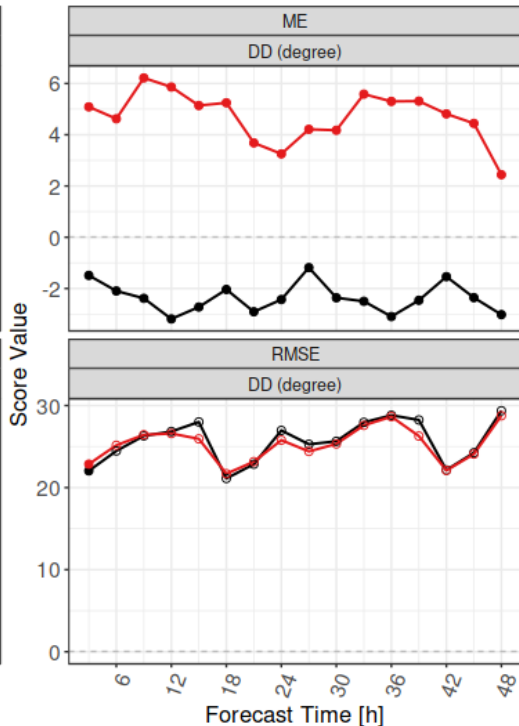
Summer

2022/06/01-03UTC - 2022/08/31-21UTC
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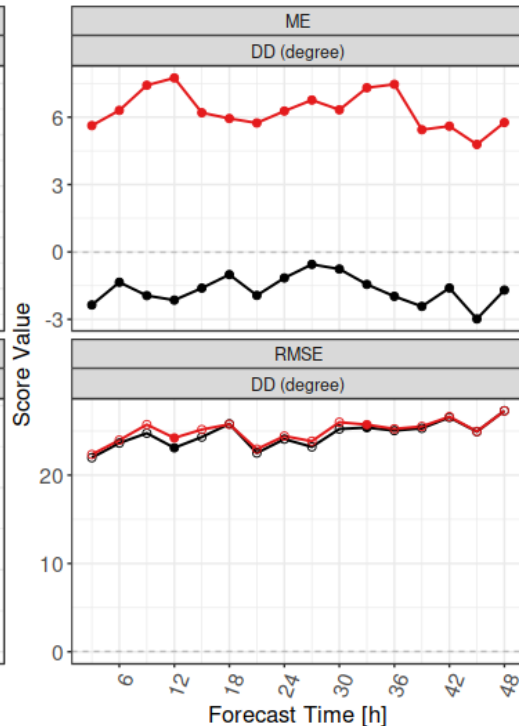
Autumn

2022/09/01-00UTC - 2022/11/30-21UTC
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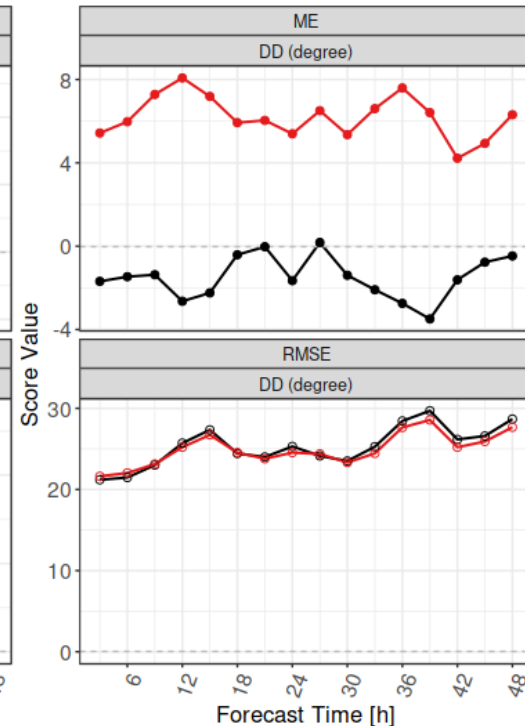
Winter

2022/12/01-00UTC - 2023/02/28-21UTC
INI: 00 UTC, DOM: Poland, STAT: ALL



Spring

2023/03/01-00UTC - 2023/05/31-21UTC
INI: 00 UTC, DOM: Poland, STAT: ALL



ICON-PL veers the wind direction (positive bias) by about 2-8 degrees compared to observations.

COSMO-CE-PL backs the wind direction (negative bias) by about 0-4 degrees compared to observations.

Despite the slightly larger bias, **ICON-PL** has RMSE values which are the same or lower than **COSMO-CE-PL**.

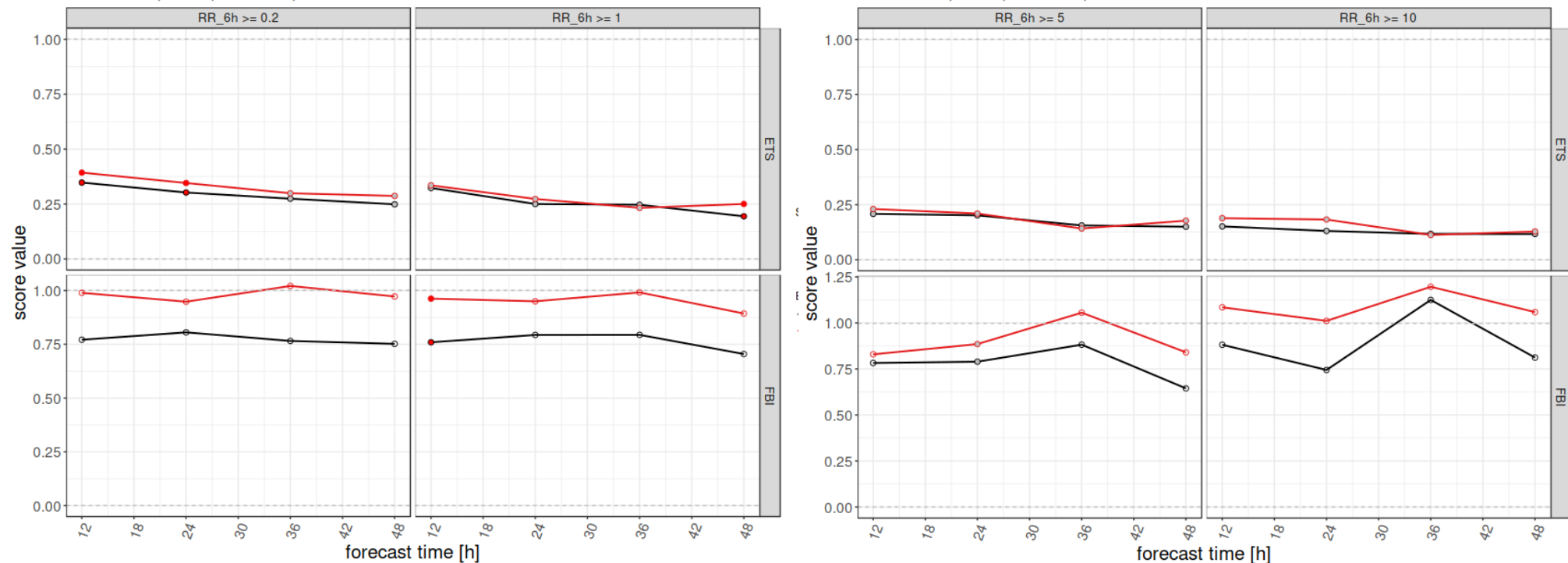
6-hourly precipitation accumulation, ETS, FBI, Summer 2022

COSMO-CE-PL vs **ICON PL**



2022.06.01-03UTC - 2022.08.31-21UTC
VAL: ALL UTC, INI: 00, STAT: ALL, DOM: Poland

2022.06.01-03UTC - 2022.08.31-21UTC
VAL: ALL UTC, INI: 00, STAT: ALL, DOM: Poland



ICON-PL has better ETS scores overall than **COSMO-CE-PL**. This is seen most clearly at the 0.2mm threshold, but also at certain forecast ranges at higher thresholds.

ICON-PL produces more rain (higher FBI) than **COSMO-CE-PL**. The FBI is closer to unity in **ICON-PL** than **COSMO-CE-PL** for 0.2mm, 1.0mm and 5.0mm thresholds whilst at the 10.0mm threshold, the FBI is above unity in **ICON-PL** and below unity in **COSMO-CE-PL**.

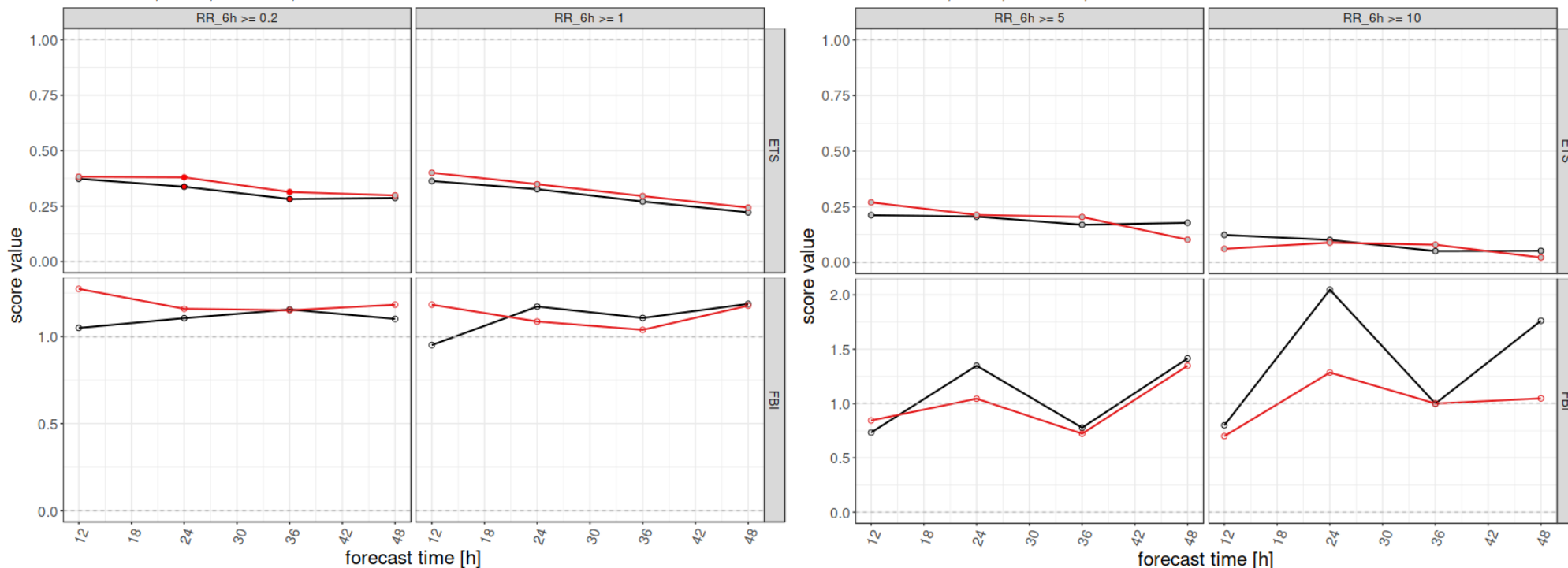
6-hourly precipitation accumulation, ETS, FBI, Autumn 2022



COSMO-CE-PL vs **ICON PL**

2022.09.01-00UTC - 2022.11.30-21UTC
VAL: ALL UTC, INI: 00, STAT: ALL, DOM: Poland

2022.09.01-00UTC - 2022.11.30-21UTC
VAL: ALL UTC, INI: 00, STAT: ALL, DOM: Poland



ICON-PL has better ETS scores than **COSMO-CE-PL** at the 0.2mm and 1.0mm thresholds for the whole forecast range and 5.0mm threshold up to T+39. At the 10.0mm threshold, both models have similar scores.

ICON-PL and **COSMO-CE-PL** overestimate precipitation at the 0.2mm and 1.0mm thresholds.

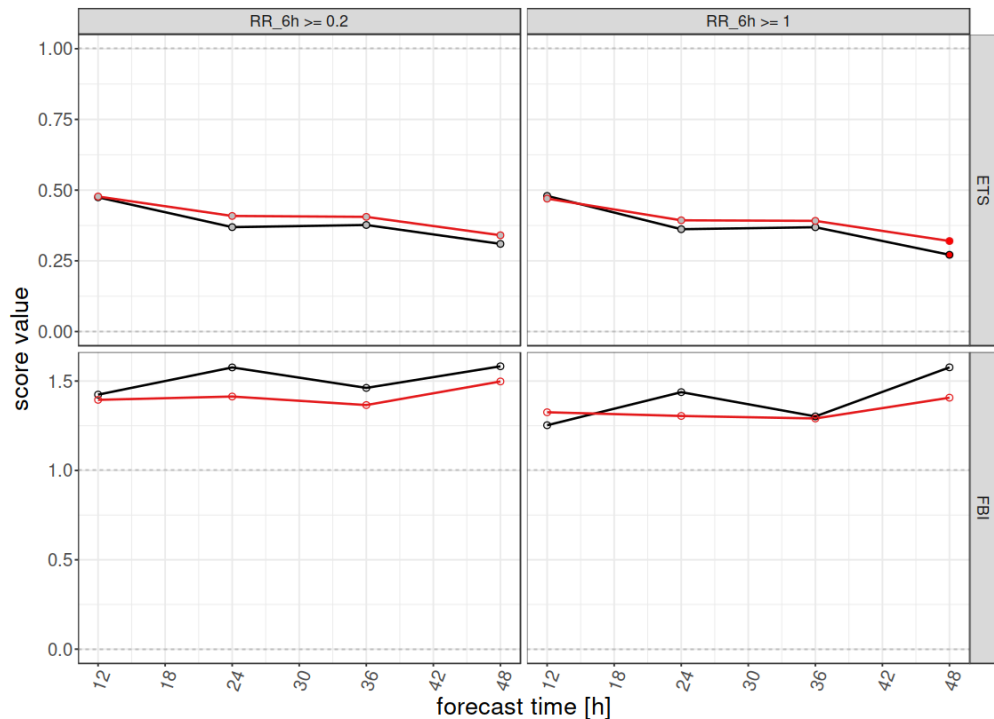
ICON-PL produces more rain (higher FBI) than **COSMO-CE-PL** at all forecast ranges at the 0.2mm threshold and up to T+21 at 1.0mm threshold. However, the FBI is closer to unity in **ICON-PL** than **COSMO-CE-PL** at the 10.0 mm threshold for forecast ranges from T+18

6-hourly precipitation accumulation, ETS, FBI, Winter 2023

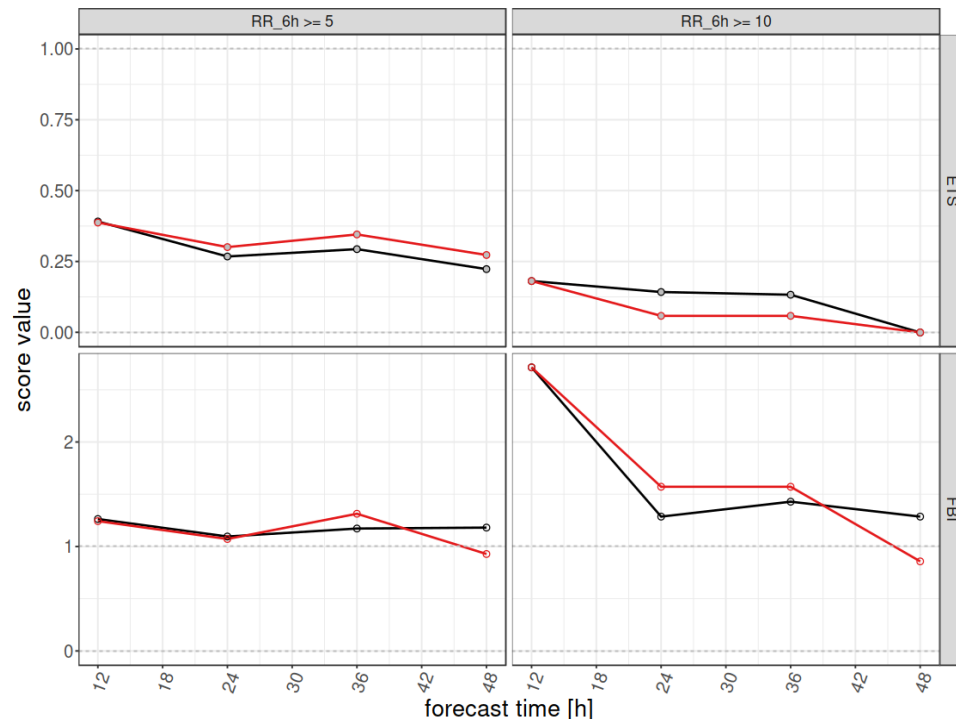


COSMO-CE-PL vs ICON PL

2022.12.01-00UTC - 2023.02.28-21UTC
VAL: ALL UTC, INI: 00, STAT: ALL, DOM: Poland



2022.12.01-00UTC - 2023.02.28-21UTC
VAL: ALL UTC, INI: 00, STAT: ALL, DOM: Poland



ICON-PL has better ETS scores than **COSMO-CE-PL** at the 0.2mm, 1.0mm and 5.0mm thresholds. However it has worse scores at the 10.0mm threshold.

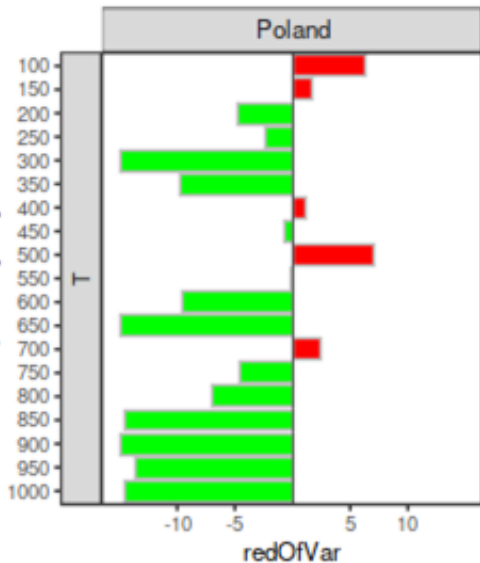
ICON-PL produces less rain (lower FBI) than **COSMO-CE-PL** at the 0.2mm and 1.0mm thresholds. The FBI is closer to unity in **ICON-PL** than **COSMO-CE-PL** at these thresholds. For the 5.0mm and 10.0mm thresholds, the FBI is quite noisy.

Upper air temperature (K), JJA 2022 - MAM 2023



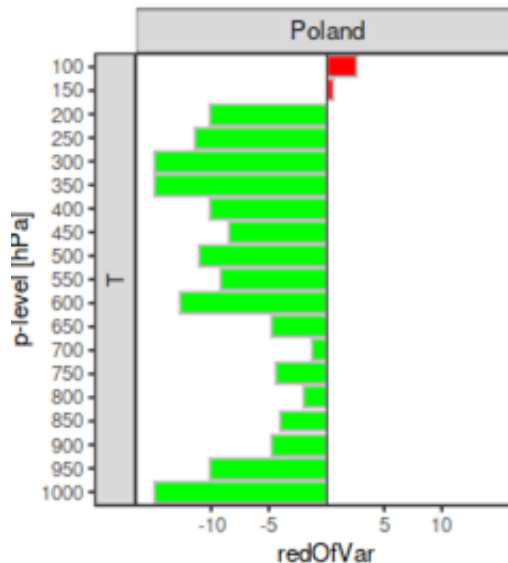
Summer 2022

Reduction of RMSE [%]



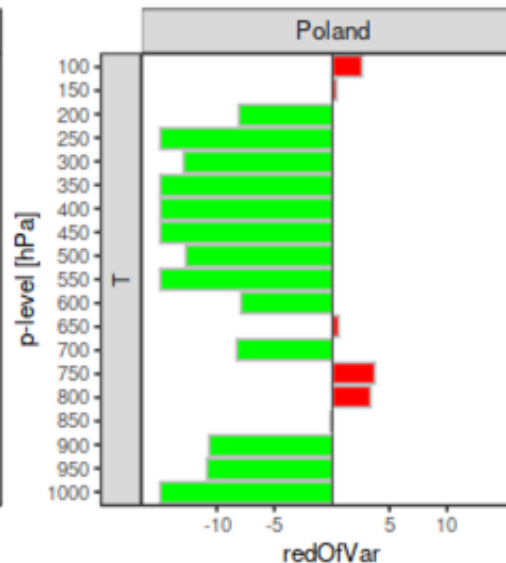
Autumn 2022

Reduction of RMSE [%]



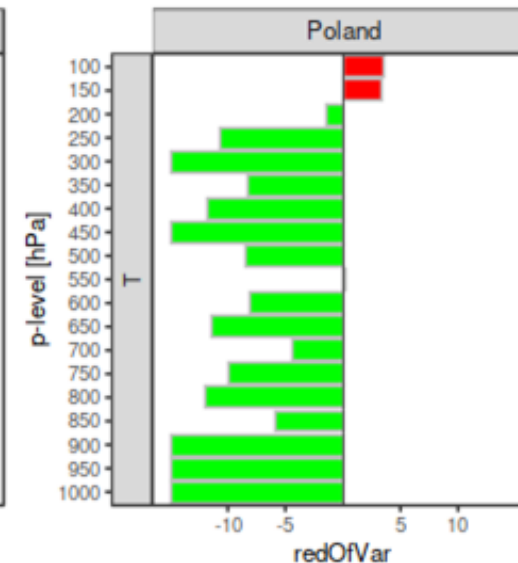
Winter 2023

Reduction of RMSE [%]



Spring 2022

Reduction of RMSE [%]



ICON-PL vs
COSMOCE



ICON-PL has a reduced RMSE compared to COSMO-CE-PL for temperature throughout the depth of the atmosphere and for all seasons. The reduction is greatest between 200-600hPa and 900-1000hPa for all seasons.

There is a small increase in RMSE at the very top of the atmosphere (100-150hPa), 750hPa in Winter and around 500hPa in Summer.

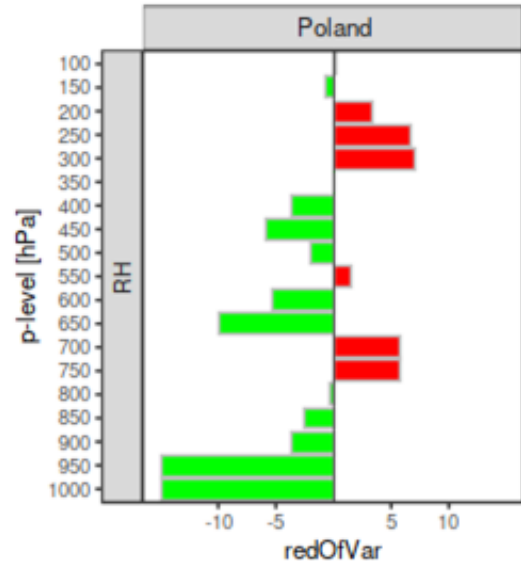
RH relative humidity, JJA 2022 - MAM 2023



Summer 2022

Reduction of RMSE [%]

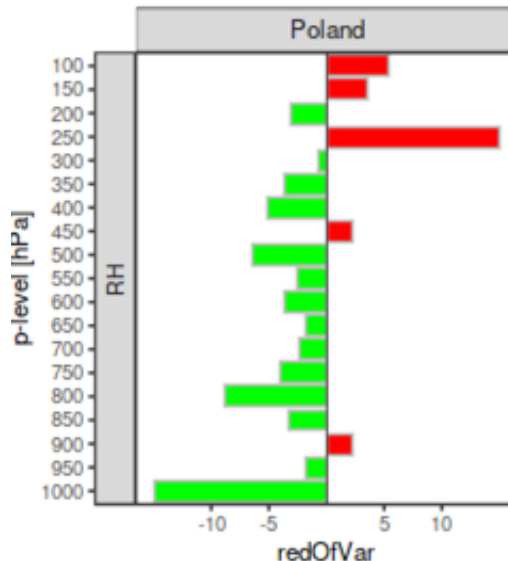
Poland



Autumn 2022

Reduction of RMSE [%]

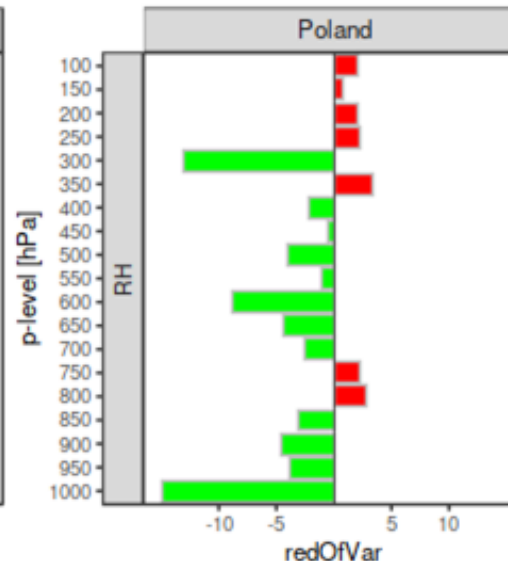
Poland



Winter 2023

Reduction of RMSE [%]

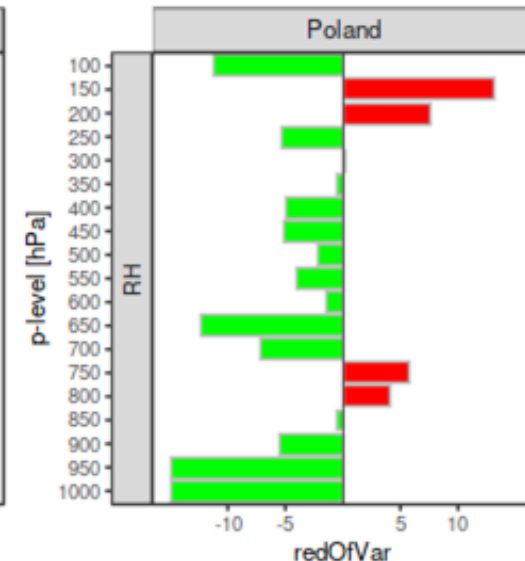
Poland



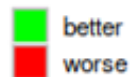
Spring 2022

Reduction of RMSE [%]

Poland



ICON-PL vs
COSMOCE



ICON-PL generally has a reduced RMSE compared to COSMO-CE-PL for relative humidity throughout the depth of the atmosphere and for all seasons. The reduction is greatest at 950-1000hPa for all seasons. There is a small increase in RMSE at the top of the atmosphere (100-300hPa) and 750hPa in Winter, Spring and Summer.

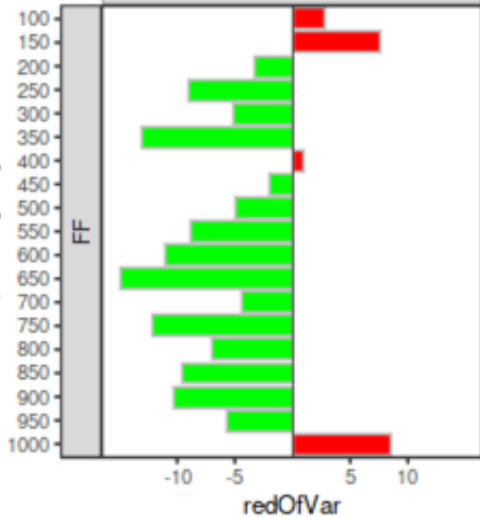
Wind speed (m/s), JJA 2022 - MAM 2023



Summer 2022

Reduction of RMSE [%]

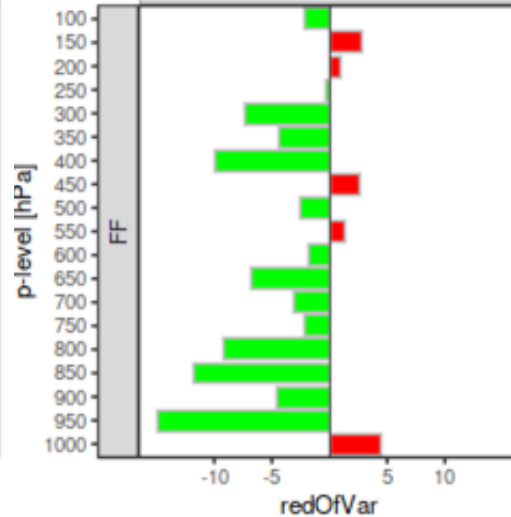
Poland



Autumn 2022

Reduction of RMSE [%]

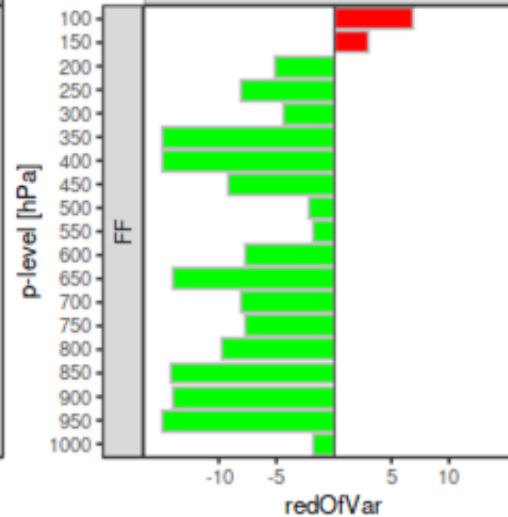
Poland



Winter 2023

Reduction of RMSE [%]

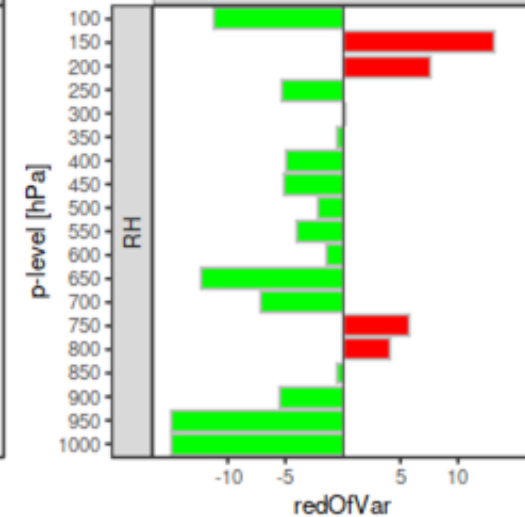
Poland



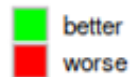
Spring 2022

Reduction of RMSE [%]

Poland



ICON-PL vs
COSMOCE



ICON-PL generally has a reduced RMSE compared to COSMO-CE-PL for wind speed throughout the depth of the atmosphere and for all seasons. The reduction is greatest between 200-950hPa in Summer and Winter.

There is an increase in RMSE at the top of the atmosphere (100-200hPa), around 750hPa in Spring and 1000hPa in Summer and Autumn.

Conclusions

In terms of surface parameters, **ICON-PL** overall performs better than **COSMO-CE-PL**. In all seasons and for all parameters and lead times (except for surface pressure in the first few hours of the forecast) **ICON-PL** has a reduced or similar RMSE compared to **COSMO-CE-PL**.

6-hourly precipitation is more skillful in **ICON-PL** at drizzle and light rain thresholds than **COSMO-CE-PL**. For the 10mm threshold the results are quite noisy.

In terms of upper air verification, **ICON-PL** overall performs better than **COSMO-CE-PL**. **ICON-PL** generally has a reduced or similar RMSE compared to **COSMO-CE-PL** for temperature and wind speed and relative humidity in all seasons. **ICON-PL** is generally worst than **COSMO-CE-PL** at the top of the atmosphere for all analysed parameters and for wind speed at 1000hPa in Summer and Autumn.

Discussion

- There is a systematic difference in wind direction between **ICON-PL** and **COSMO-CE-PL**. **ICON-PL** veers the wind compared to **COSMO-CE-PL** and observations. Could this be due to a difference in BL drag between the two models?
- **ICON-PL** is warmer and drier at 2m and has less cloud than **COSMO-CE-PL** in Winter. It also has less precipitation (0.2mm and 1.0mm thresholds), a lower surface pressure and stronger wind speeds. Less cloud (at night) might be expected to lead to a cooling, not a warming. This could be due to changes in cloud optical depth/thickness or compensating effects from errors in other parts of the model.
- **ICON-PL** is colder and moister at 2m and has more cloud than **COSMO-CE-PL** in Summer.
- The upper-air verification shows a detriment to temperature, relative humidity and wind at 100hPa in **ICON-PL** compared to **COSMO-CE-PL**. Do we have an explanation for this?