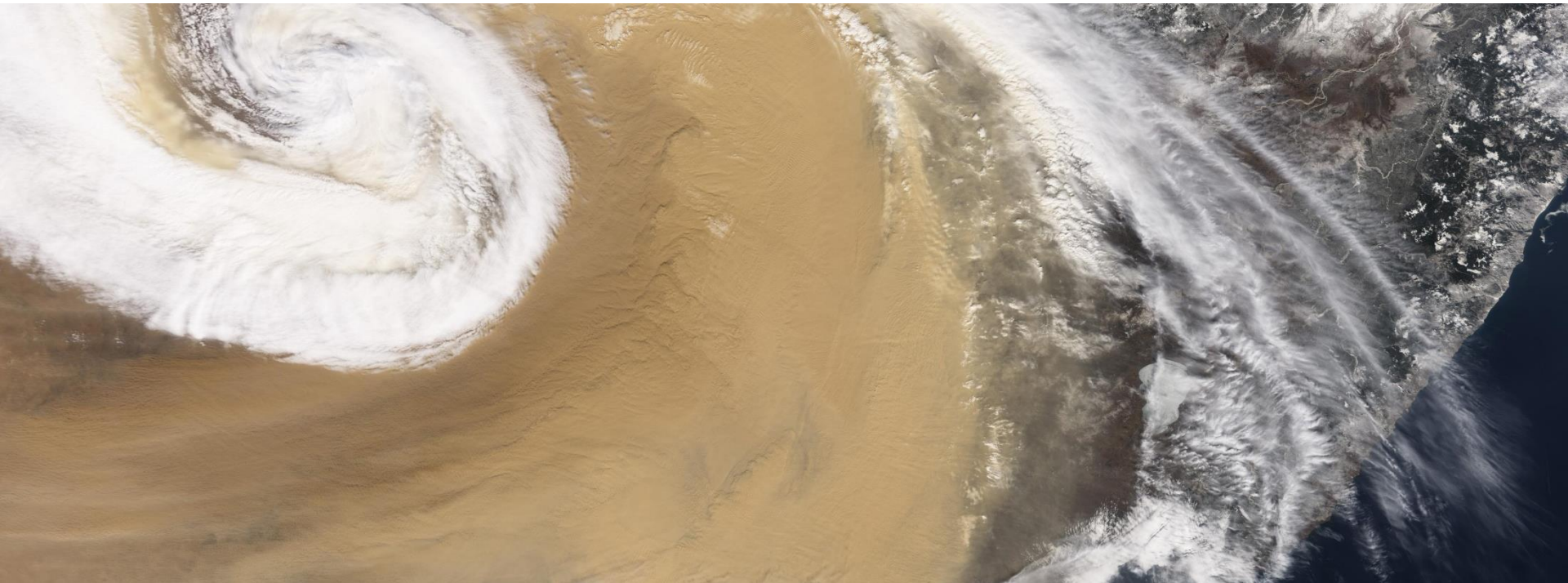# ICON Radiation Scheme using CAMS Forecasted Aerosols

Harel Muskatel (IMS), Daniel Rieger (DWD), Pavel Khain (IMS)

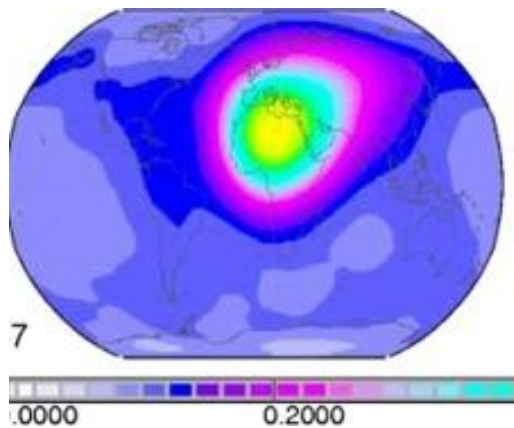**CAIIR Priority Project, COSMO General Meeting, September 9, 2021**

בס"ד

Outline

- Aerosols models in ICON radiation

- Interpolation methods used for CAMS forecasted aerosols

- Aerosols optical properties

- Verifications in Israel for year 2020

- Outlook

Aerosols Inputs for ICON Radiation
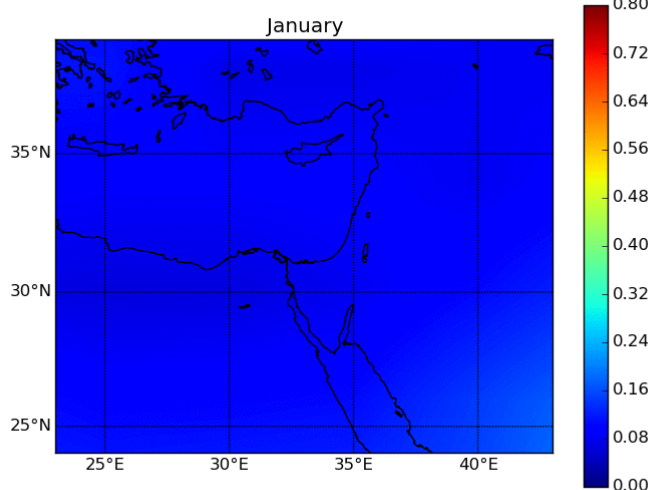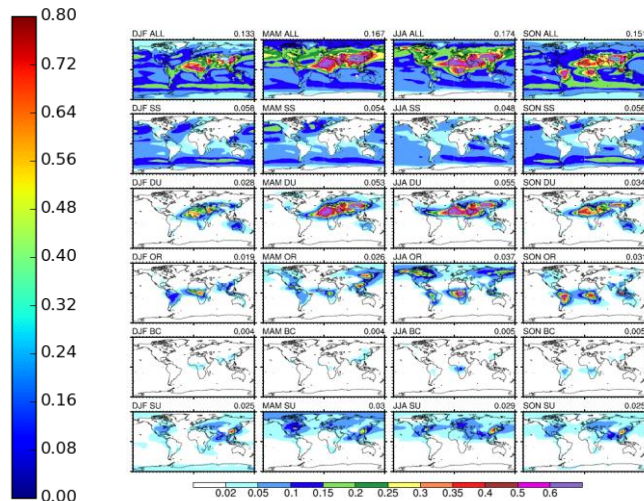
Tanre (1983)
irad_aero = 5

Tegen (1997)
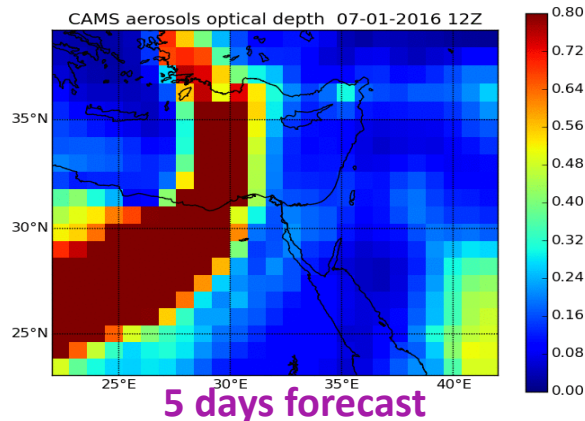**irad_aero = 6**

CAMS (2017)
irad_aero = 7

CAMS
irad_aero = 8

Prognostic 2D AOD
irad_aero=6 & iprog_aero=1
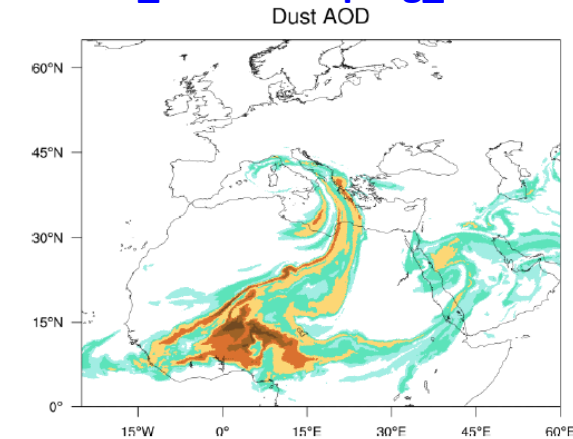
ICON-ART
irad_aero = 9

5 days forecast
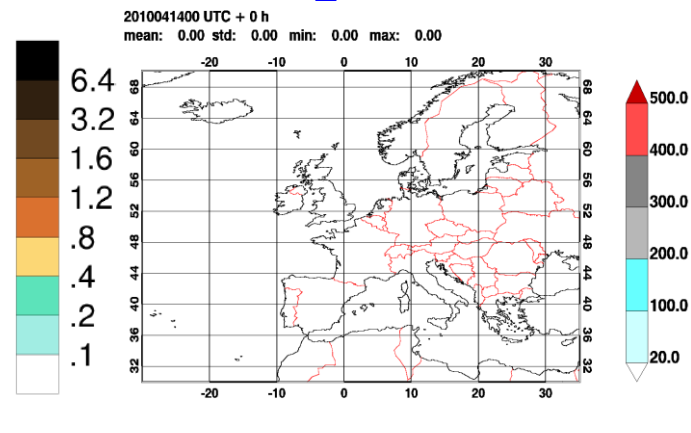
Horizontal Interpolation

- CAMS 3D mixing ratios – 5 days ahead, 3hr resolution are interpolated in space and time into 1 hr resolution latbc fields using iconremap. The fields fill the whole domain.

- Step by step interpolation is done by ICON

- 11 species aermrXX fields are combined with the usual IFS latbc fields

- Recommendation: intp_method = 3 INTP_RBF_SCALAR (Radial Basis Function) instead of = 4 INTP_NNB_SCALAR (nearest-neighbor interpolation)
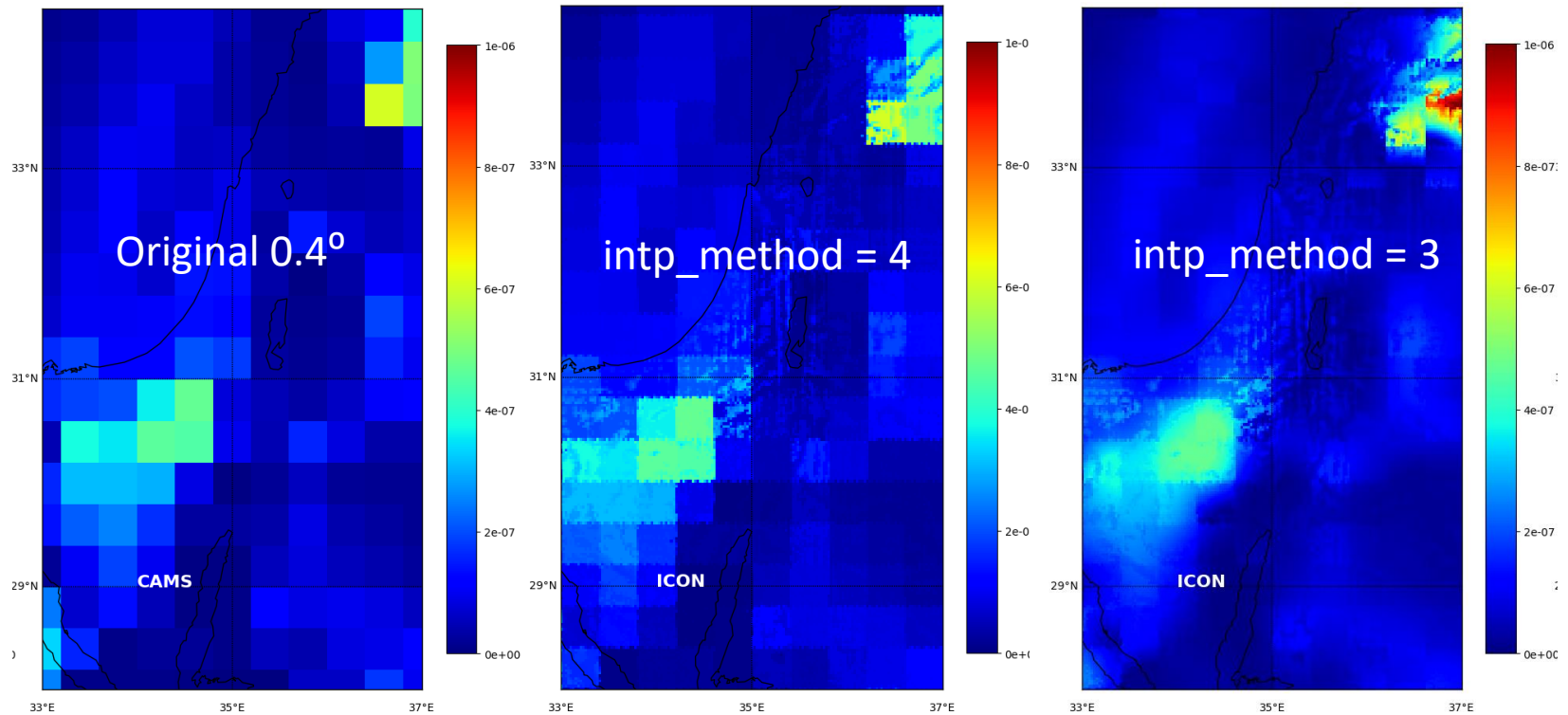
Vertical interpolation
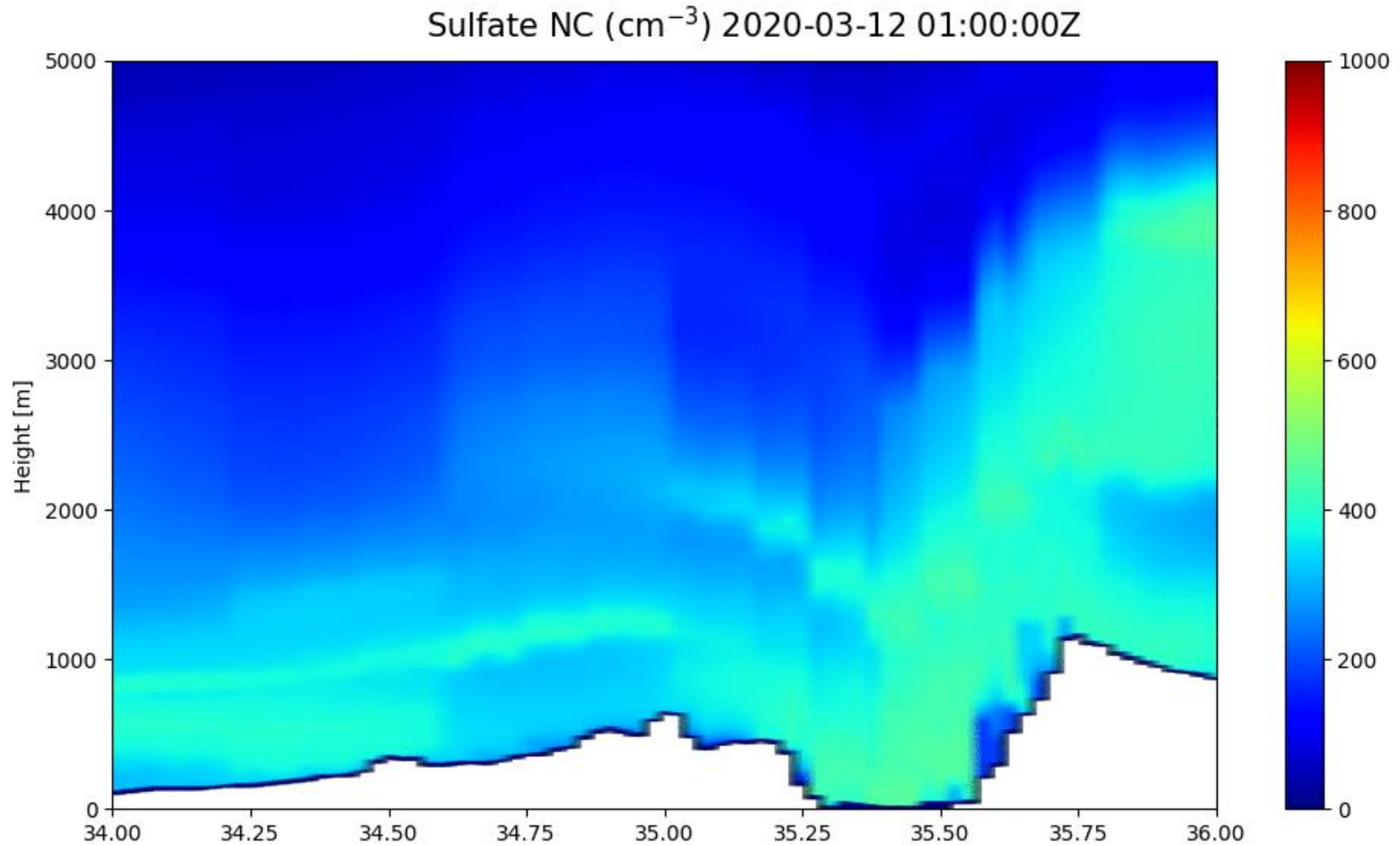
Sulfate NC (cm^{-3}) 2020-03-12 01:00:00Z

- Hydrophilic aerosols (Sea-salt, sulfate, black carbon) optical properties are RH dependent. Therefore, RH at each grid point is diagnosed.
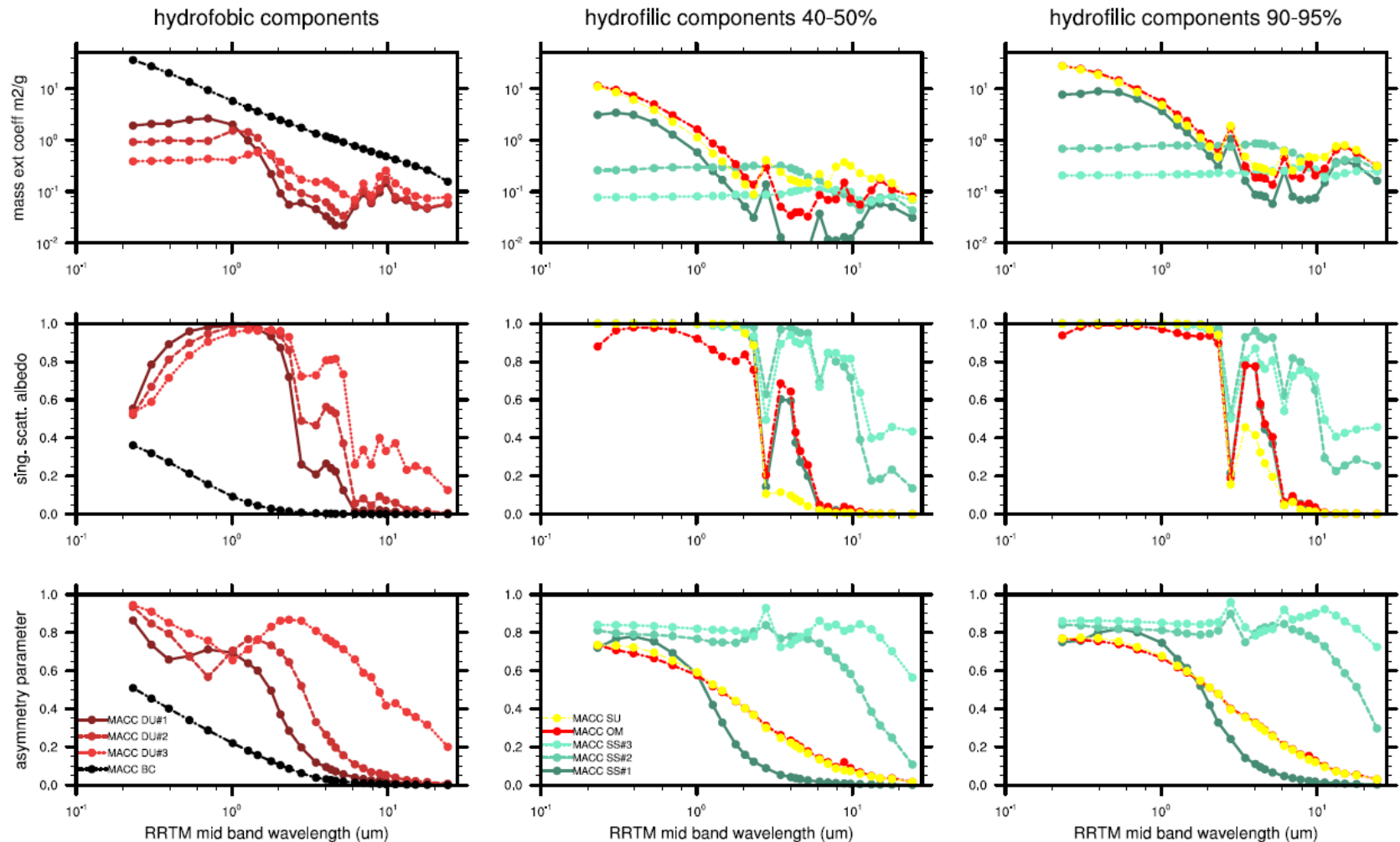
2D integrated AOD

CAMS vs Tegen AOD 2020-03-12 01:00:00Z
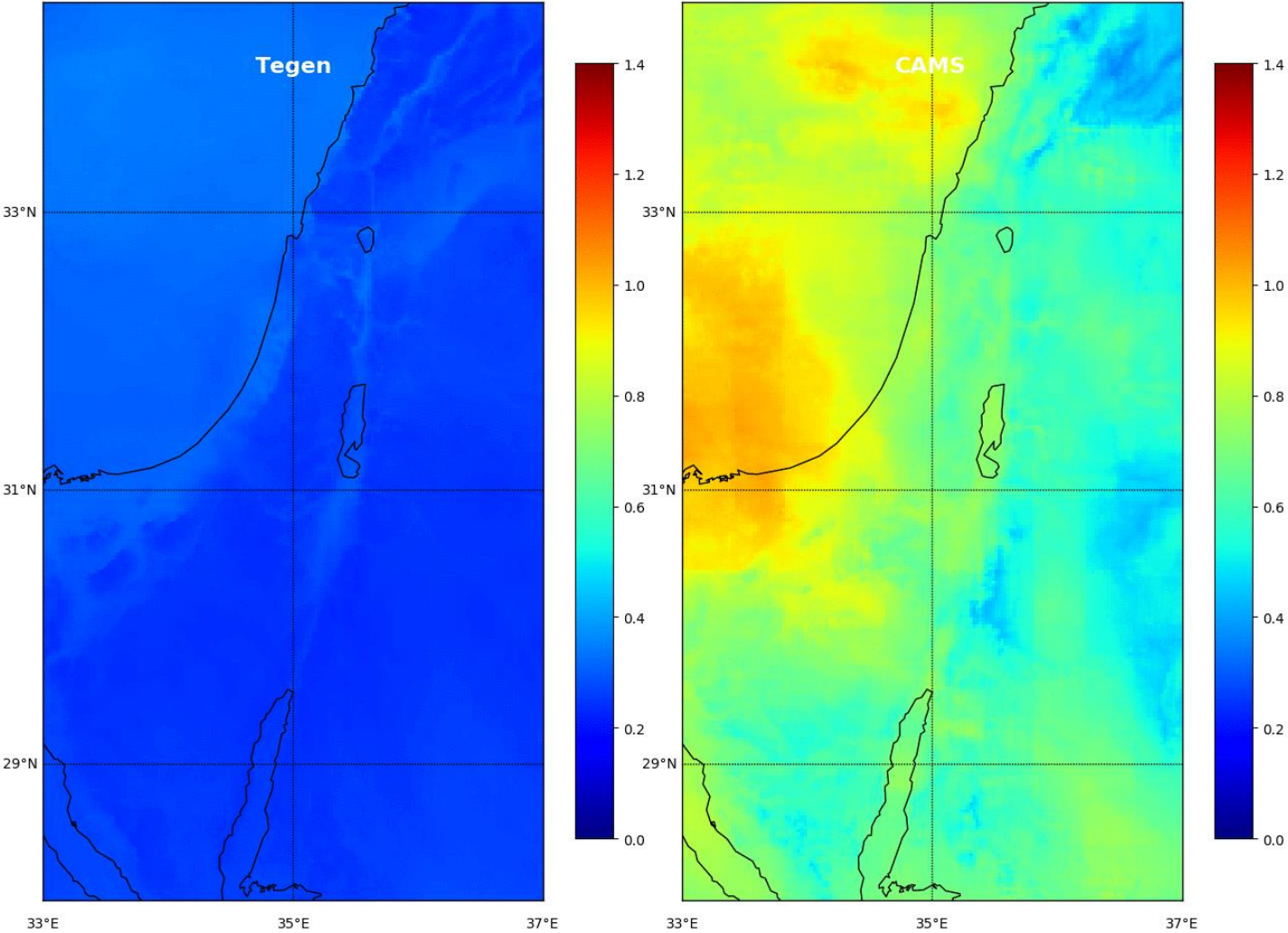
Tegen   CAMS

Verifications – very polluted days

- 9 test cases in 2020, 24 hours lead time, against ground based stations in Israel

- When average measurements of PM2.5 all over Israel is more than x3 greater than annual average

ICON_CAMS RMSE wins all models!

RMSE reduction = 27 W/m^2

bias reduction = 46 W/m^2

Legend:
- IFS bias:41.9117 rmse:122.3486
- COSMO 65.219 rmse:137.3027
- COSMO_CAMS:-6.1661 rmse:118.0762
- ICON_Tegen bias:67.4037 rmse:128.7169
- ICON_CAMS bias:22.846 rmse:102.0646
- OBS

Surface radiation (W/m^2) vs Hour (UTC)
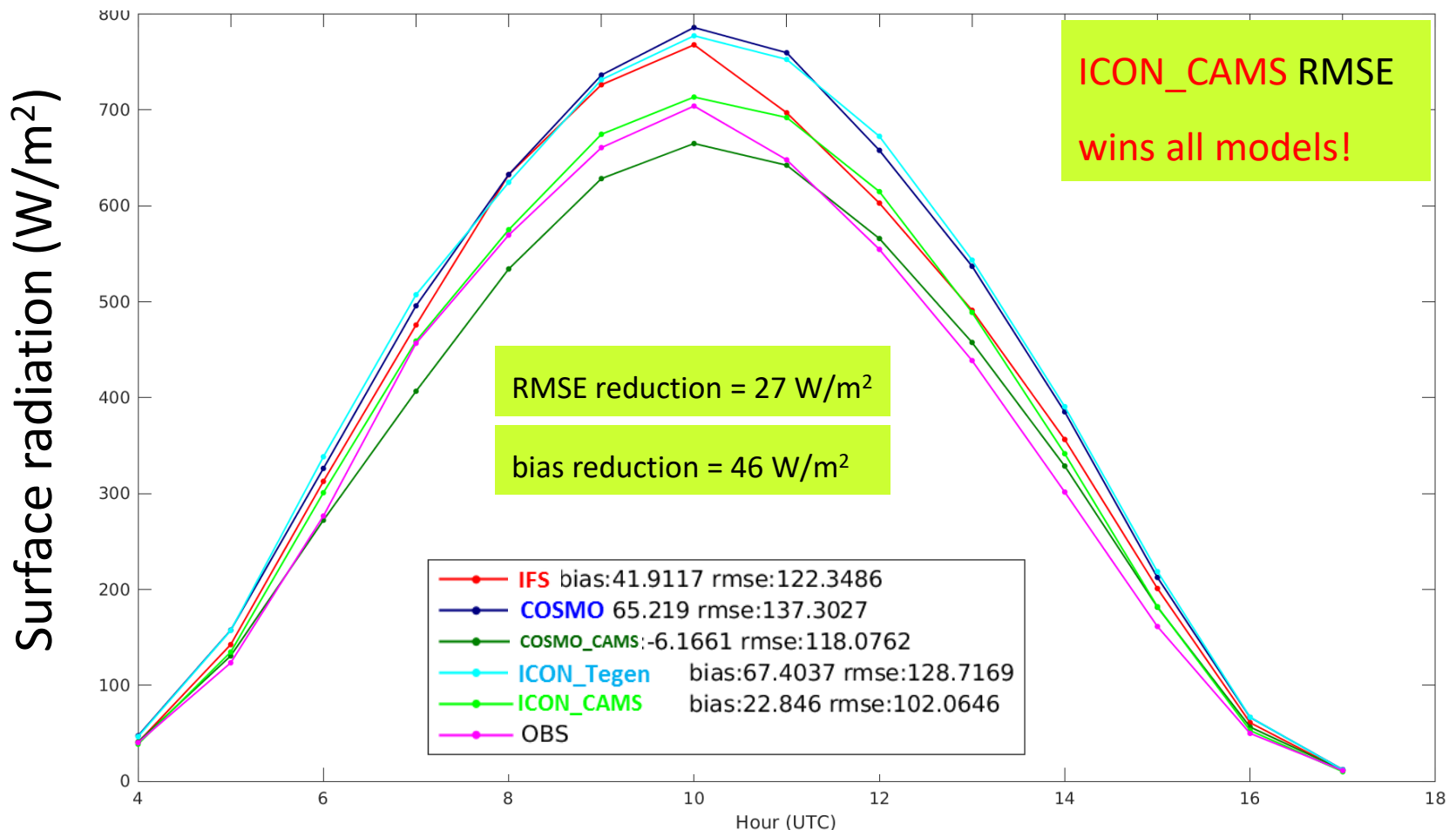
Verifications – polluted days

- 28 test cases in 2020, 24 hours lead time

- When average measurements of PM2.5 all over Israel is more than x2 greater than annual average

ICON_CAMS RMSE
+bias wins all models!

RMSE reduction = 15 W/m^2

bias reduction = 28 W/m^2

IFS bias:17.2871 rmse:79.5731
COSMO 37.5484 rmse:93.1297
COSMO_CAMS :8.6622 rmse:83.4587
ICON_Tegen bias:34.3964 rmse:84.1446
ICON_CAMS bias:6.5419 rmse:69.4579
OBS

Surface radiation (W/m^2)

Hour (UTC)
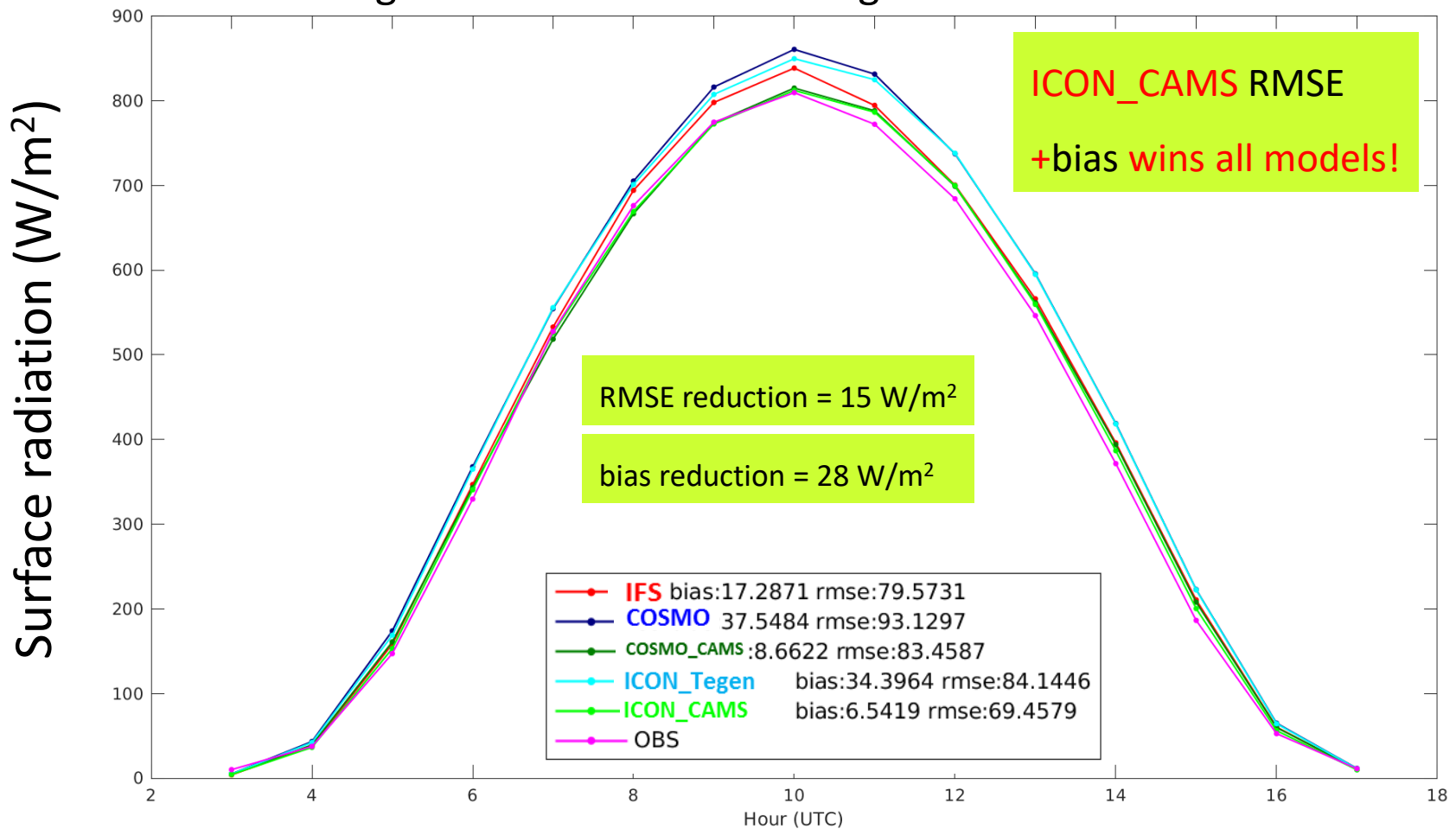
2020 Radiation verifications

78 hours lead time, against ground based stations in Israel

Rad RMSE	EC	COSMO	COSMO_CAMS	ICON_Tegen	ICON_CAMS	CAMS-Tegen
Jan	103.211	113.297	116.952	111.713	**107.491**	-4.222
Feb	114.121	137.431	143.702	120.268	**119.864**	-0.404
Mar	114.249	124.251	127.251	112.696	**106.019**	-6.678
Apr	118.708	128.836	130.143	120.934	**118.331**	-2.603
May	99.345	97.122	95.272	101.434	**98.475**	-2.959
Jun	60.758	63.111	66.759	62.451	**62.059**	-0.392
Jul	58.163	64.489	62.949	57.087	**57.306**	0.219
Aug	59.098	75.366	72.376	57.528	**56.743**	-0.785
Sep	42.811	51.937	47.390	45.984	**41.256**	-4.729
Oct	51.990	61.884	67.901	54.685	**52.836**	-1.849
Nov	82.106	99.831	101.267	89.744	**90.390**	0.646
Dec	71.392	81.337	82.003	77.653	**74.527**	-3.125

ICON_CAMS better than all

ICON_CAMS better than ICON_Tegen

ICON_CAMS worse than ICON_Tegen

Rad bias	EC	COSMO	COSMO_CAMS	ICON_Tegen	ICON_CAMS	ABS(CAMS)-ABS(Tegen)
Jan	5.389	21.412	0.534	17.830	**13.103**	-4.7263
Feb	6.050	23.885	9.135	24.170	**15.491**	-8.679
Mar	5.938	25.847	-11.931	23.323	**3.663**	-19.660
Apr	-1.144	32.363	11.027	21.890	**4.663**	-17.228
May	-7.978	20.431	7.992	16.406	**2.508**	-13.898
Jun	-10.713	-0.443	21.061	-6.560	**3.456**	-3.104
Jul	-1.472	0.254	14.047	0.332	**-3.847**	3.515
Aug	-14.470	-6.660	7.656	-1.626	**-1.806**	0.180
Sep	9.218	18.402	19.840	14.992	**-1.696**	-13.296
Oct	4.422	16.884	9.201	11.109	**3.452**	-7.658
Nov	4.092	8.953	-4.398	16.419	**7.496**	-8.923
Dec	10.027	22.517	5.353	21.358	**12.529**	-8.829

2020 T2m verifications

78 hours lead time, against ground based stations in Israel

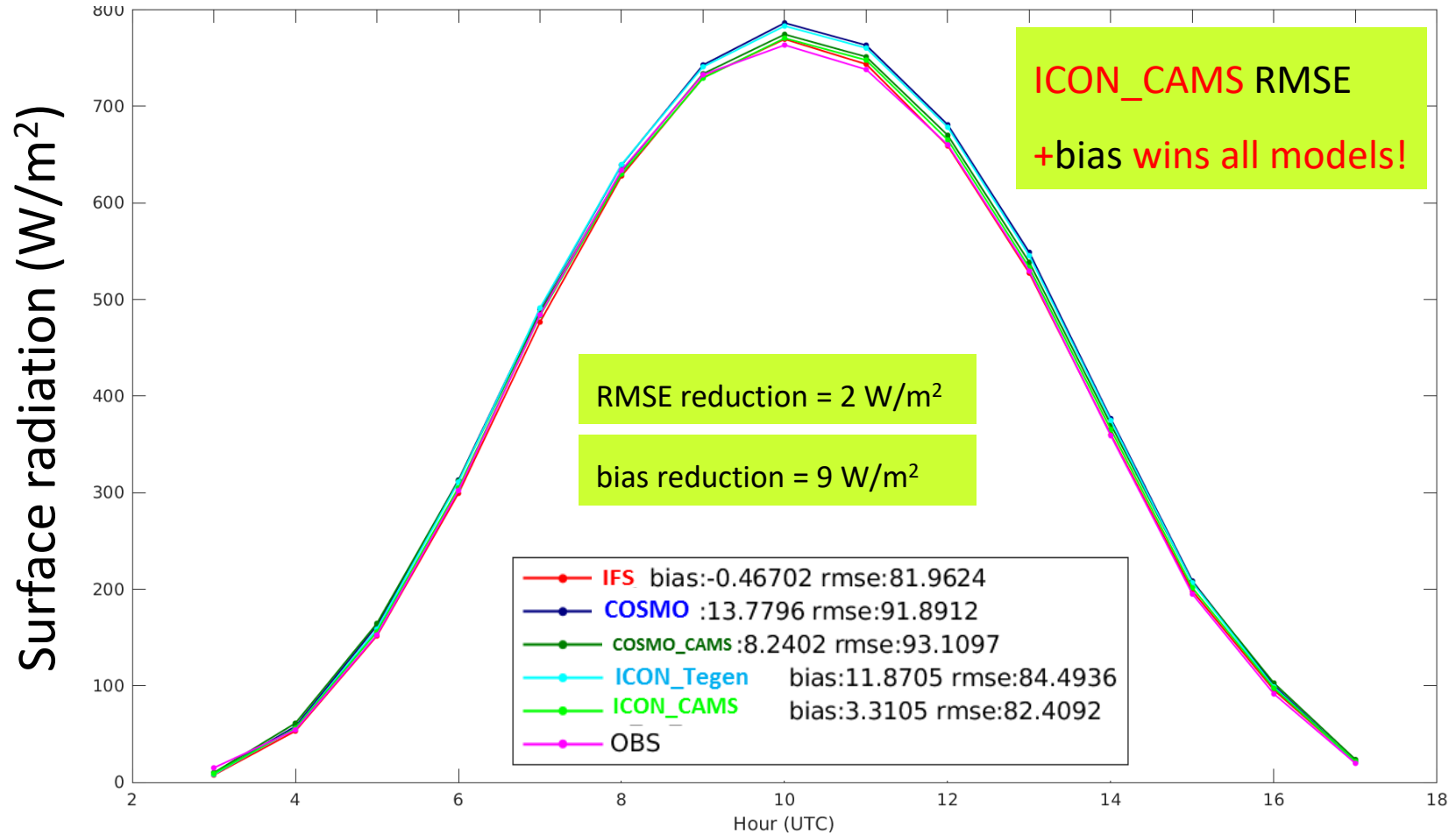| T2m RMSE	COSMO	COSMO_CAMS	ICON_Tegen	ICON_CAMS	CAMS-Tegen
Jan	1.571	1.598	1.423	**1.415**	**-0.008**
Feb	1.608	1.656	1.451	**1.462**	**0.010**
Mar	1.793	1.783	1.735	**1.731**	**-0.005**
Apr	1.704	1.683	1.663	**1.653**	**-0.009**
May	2.275	2.310	2.063	**2.093**	**0.030**
Jun	1.554	1.612	1.395	**1.395**	**0.001**
Jul	1.473	1.492	1.361	**1.367**	**0.006**
Aug	1.453	1.474	1.371	**1.361**	**-0.011**
Sep	1.630	1.643	1.498	**1.503**	**0.005**
Oct	1.861	1.907	1.679	**1.681**	**0.002**
Nov	1.740	1.780	1.539	**1.563**	**0.024**
Dec	1.866	1.861	1.650	**1.652**	**0.002**

ICON_CAMS better than all

ICON_CAMS better than ICON_Tegen

ICON_CAMS worse than ICON_Tegen

T2m bias	COSMO	COSMO_CAMS	ICON_Tegen	ICON_CAMS	ABS(CAMS)-ABS(Tegen)
Jan	-0.136	-0.186	-0.040	**-0.024**	**-0.015**
Feb	-0.047	-0.084	-0.048	**-0.034**	**-0.014**
Mar	-0.264	-0.344	-0.352	**-0.319**	**-0.033**
Apr	-0.035	-0.132	-0.344	**-0.372**	**0.028**
May	0.566	0.390	-0.126	**-0.128**	**0.001**
Jun	0.035	-0.024	-0.169	**-0.167**	**-0.002**
Jul	0.105	0.027	-0.155	**-0.193**	**0.038**
Aug	-0.025	-0.156	-0.096	**-0.069**	**-0.027**
Sep	0.001	-0.033	-0.118	**-0.150**	**0.032**
Oct	-0.432	-0.540	-0.217	**-0.256**	**0.039**
Nov	-0.109	-0.196	-0.205	**-0.235**	**0.029**
Dec	-0.106	-0.161	-0.249	**-0.263**	**0.013**

1 Year Verifications – 2020

- 2020, 78 hours lead time, 00UTC RUNS

ICON_CAMS RMSE

+bias wins all models!

RMSE reduction = 2 W/m²

bias reduction = 9 W/m²

Legend:
- **IFS** bias:-0.46702 rmse:81.9624
- **COSMO** :13.7796 rmse:91.8912
- COSMO_CAMS :8.2402 rmse:93.1097
- ICON_Tegen bias:11.8705 rmse:84.4936
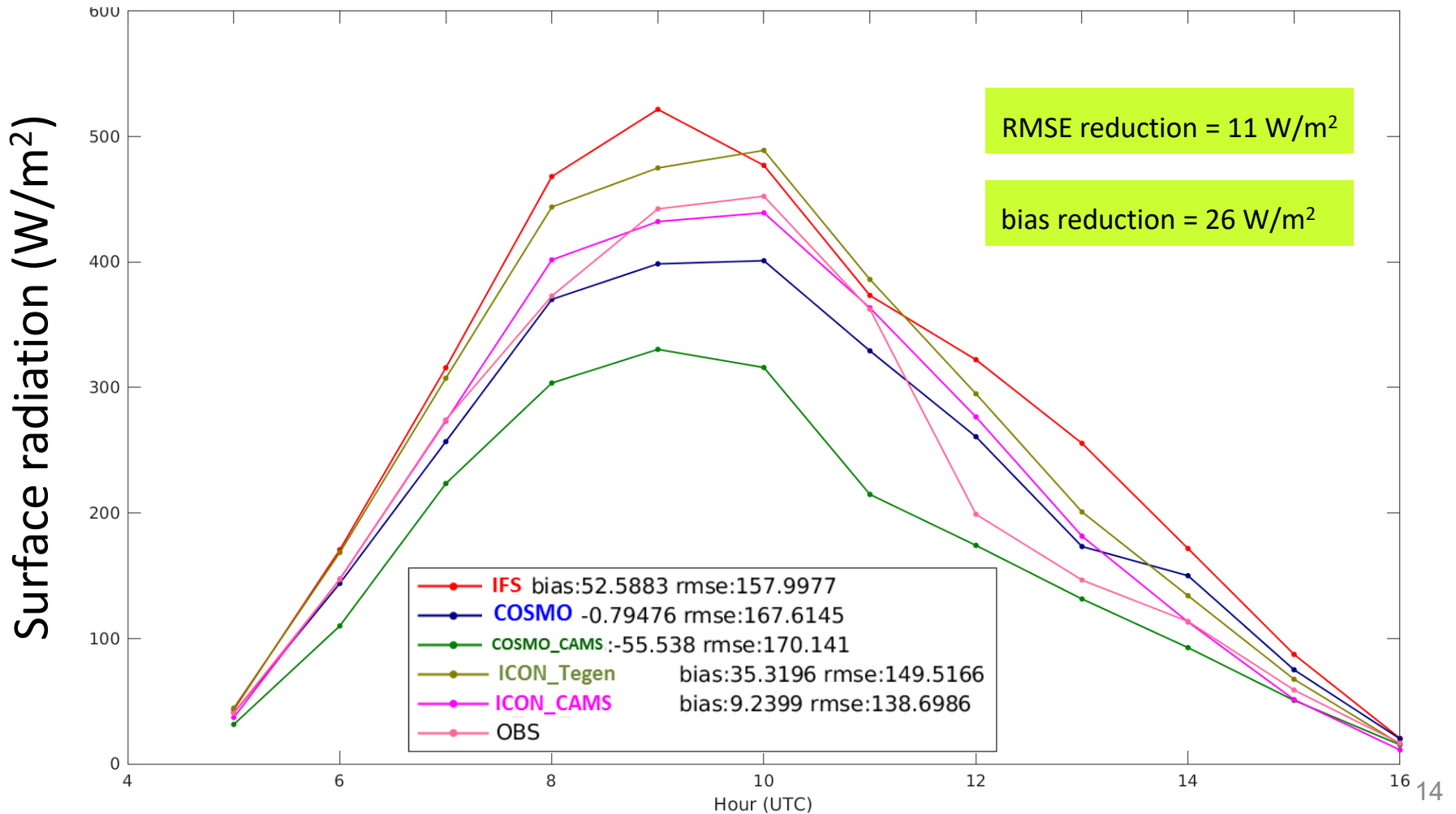- ICON_CAMS bias:3.3105 rmse:82.4092
- OBS

Surface radiation (W/m²) — Hour (UTC)

Southeast Europe Domain
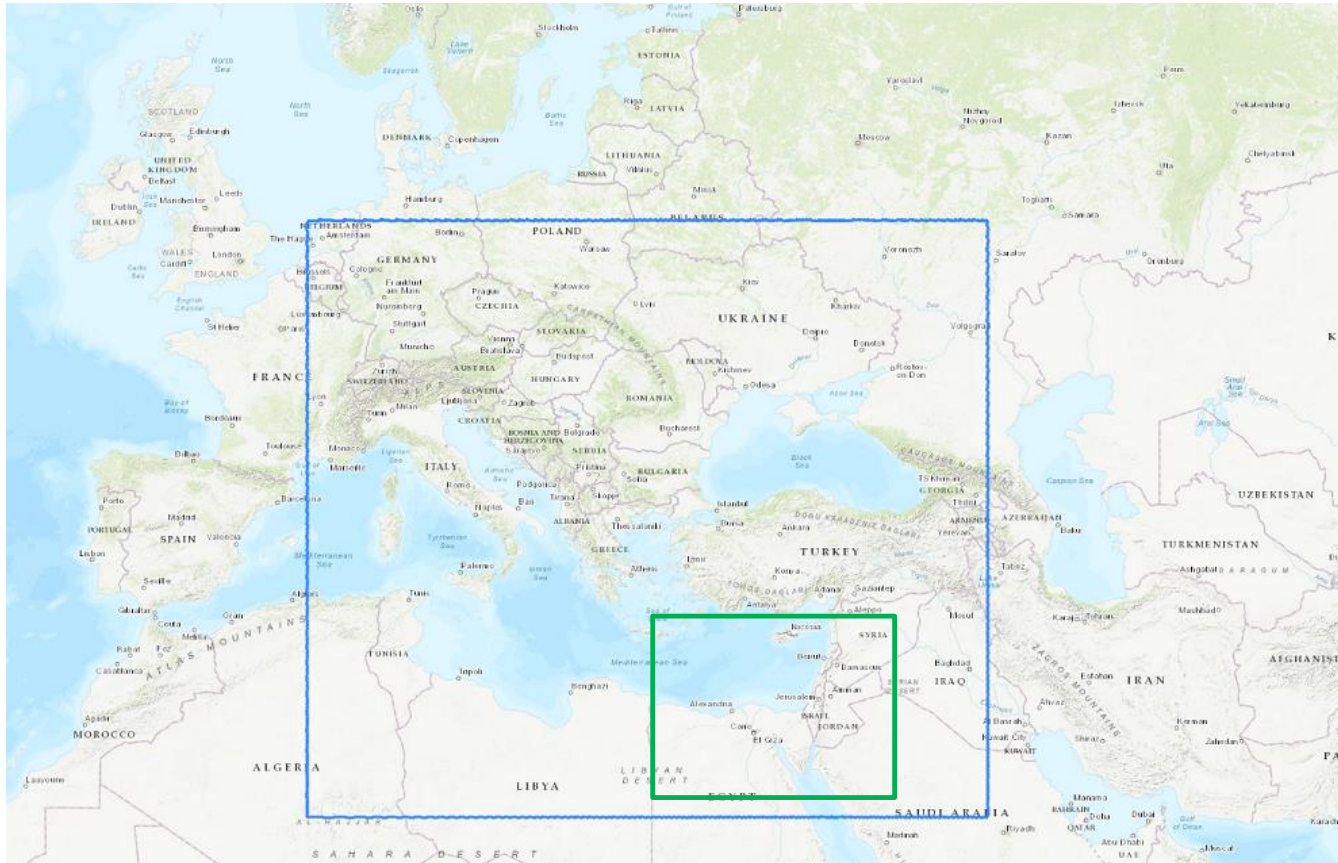
12 March 2020 test case

- 78 hours lead time, 00UTC RUN

- Verifications in Israel only

RMSE reduction = 11 W/m^2

bias reduction = 26 W/m^2

Concluding Remarks

- The interpolation of CAMS forecasted aerosols using iconremap and ICON models is gives reasonable results

- The optical properties of CAMS aerosols are naturally integrated into the models spectral intervals and are defined using prognosed RH

- ICON-ecRad model with CAMS forecasted aerosols performs better compared to the default Tegen climatology throughout the year

- Almost zero impact on T2m (average RMSE increase of 0.004 K)

- The new model performs significantly better in dust outbrakes and polluted days

Next steps:

➢ Running on larger domain – SEE. More test cases (operational?)

➢ Coupling with microphysics: droplets and ice particle nucleation