

# Forecast provider comparison 2021 Worldwide

meteoblue

2022-07-29

[www.meteoblue.com](http://www.meteoblue.com)

# Validation of raw numerical models

## • Raw models:

- ERA5
- NEMSGLOBAL
- ICON
- GFS05
- MFGLOBAL
- UMGLOBAL

## • Measurement data for validation:

- METAR – 475 stations
- Distribution: worldwide
- Special comparisons:  
Meteosuisse (7), Metos (12)

## • Meteorological Variables:

- Air Temperature 2 meters      °C
- Windspeed 10 meters            m/s
- Dewpoint temperature           °C
- Precipitation                        mm/d

## • Evaluation Scores :

➤ **MAE = Mean absolute error**  
(hourly)

$$\text{MAE} = \frac{\sum_{i=1}^n |y_i - x_i|}{n}$$

➤ **MBE = Mean bias error**  
(hourly)

$$\text{ME} = \frac{\sum_{i=1}^n y_i - x_i}{n}$$

➤ **HSS = Heidke Skill Score**  
(daily)

$$\text{HSS} = \frac{\text{PC} - E}{1 - E}$$

a = number of hits  
b = number of false alarms  
c = number of misses  
d = number of rejects

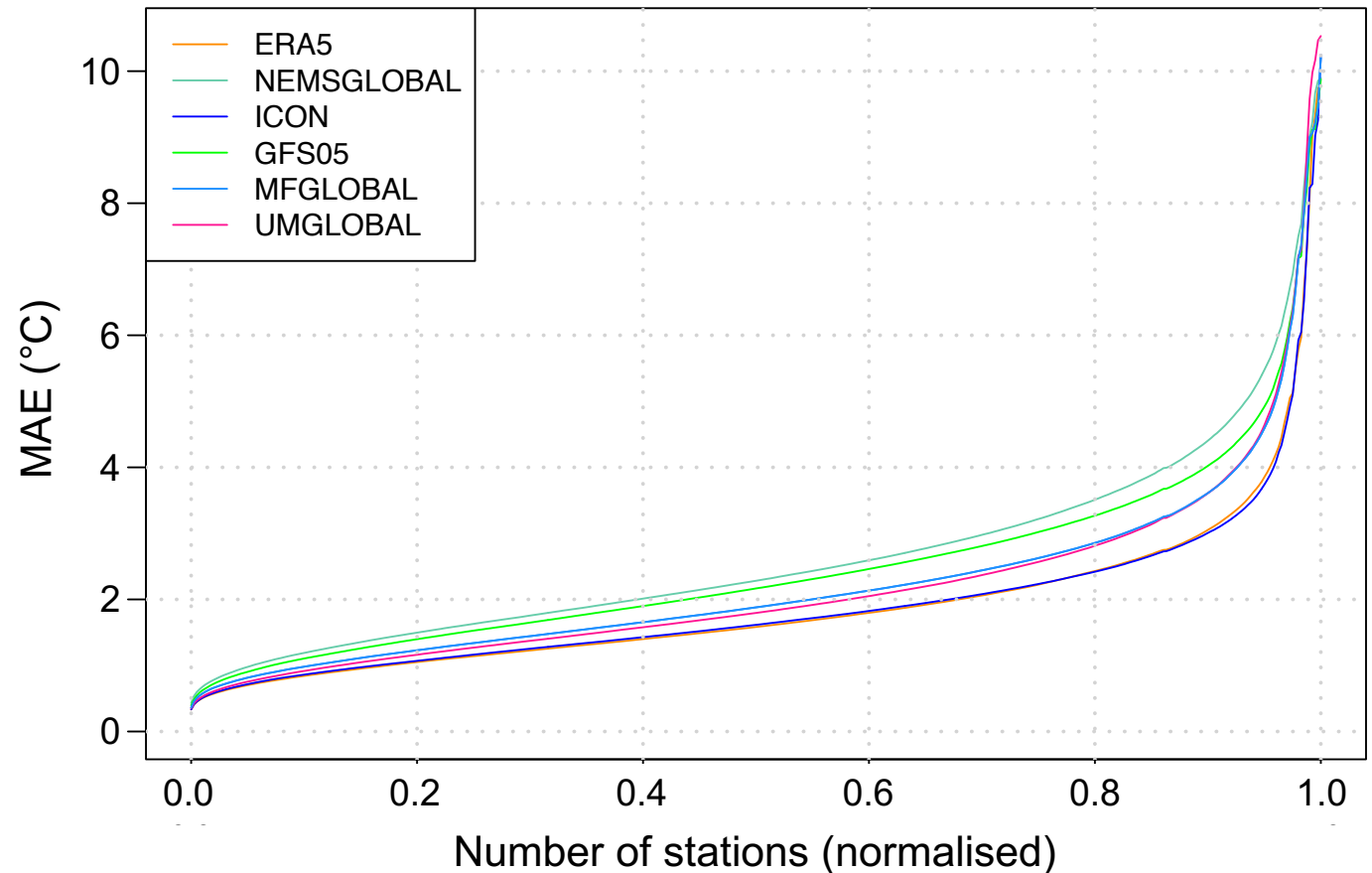
$$\text{PC} = \frac{a + d}{n}$$

$$E = \frac{a + b}{n} * \frac{a + c}{n} + \frac{d + b}{n} * \frac{d + c}{n}$$

# Air temperature (12-35h forecast hourly). MAE

12-35h forecast temp

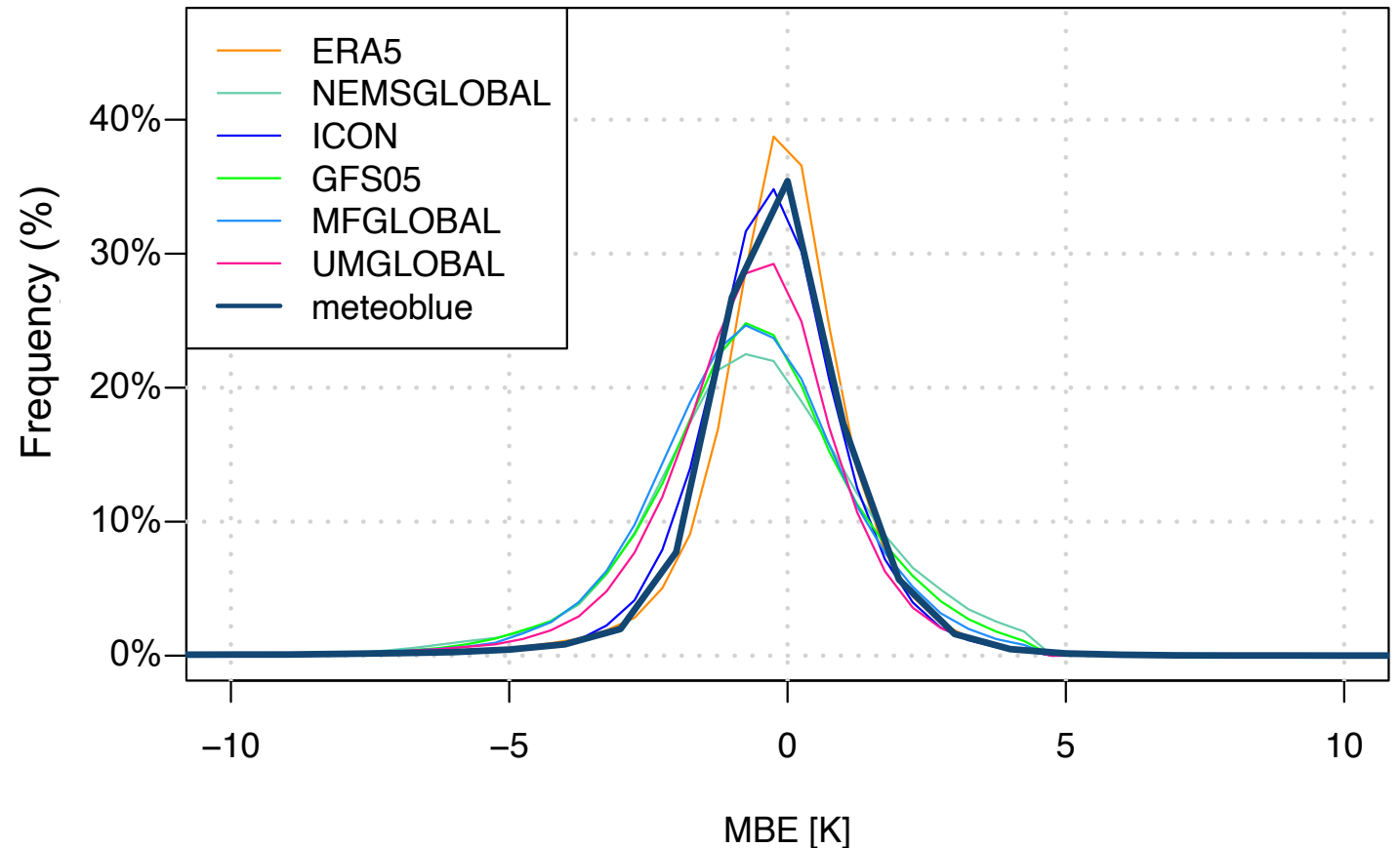
- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (worldwide)
- Station number: 475



# Air temperature (12-35h forecast hourly): MBE

- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (worldwide)
- Station number: 475

MBE [K] 12-35h forecast temp



# Air temperature (12-35h forecast hourly)

- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (worldwide)
- Station number: 475

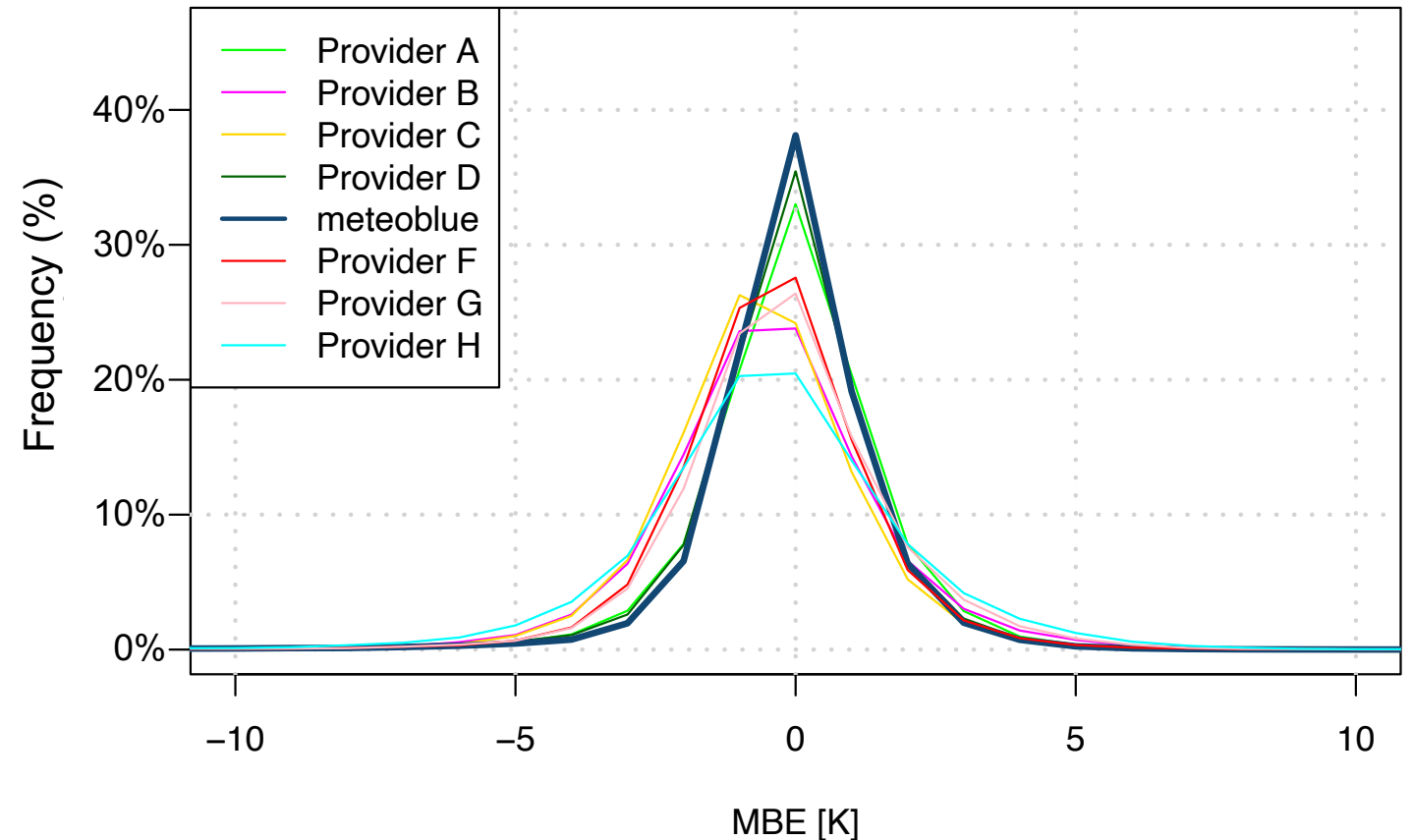
Provider	MAE [°C]	MBE [°C]	Percentage below 1.5°C	Percentage below 1°C
2 meteoblue	1.29	-0.16	65 %	36 %
1 Provider_D	1.26	-0.02	67 %	36 %
3 Provider_F	1.48	-0.21	57 %	25 %
Provider_C	1.61	-0.52	51 %	23 %
Provider_G	1.73	-0.03	48 %	22 %
Provider_B	1.71	-0.38	51 %	29 %
Provider_H	2.03	-0.23	37 %	14 %

Raw model	MAE [°C]	MBE [°C]	Percentage below 1.5°C	Percentage below 1°C
ERA5	1.77	0.03	56 %	27 %
NEMSGLOBAL	2.57	-0.33	26 %	9 %
ICON	1.76	-0.17	50 %	22 %
GFS05	2.43	-0.45	30 %	11 %
MFGLOBAL	2.15	-0.58	35 %	11 %
UMGLOBAL	2.02	-0.60	42 %	18 %

# Air temperature (00-11h forecast hourly): MBE

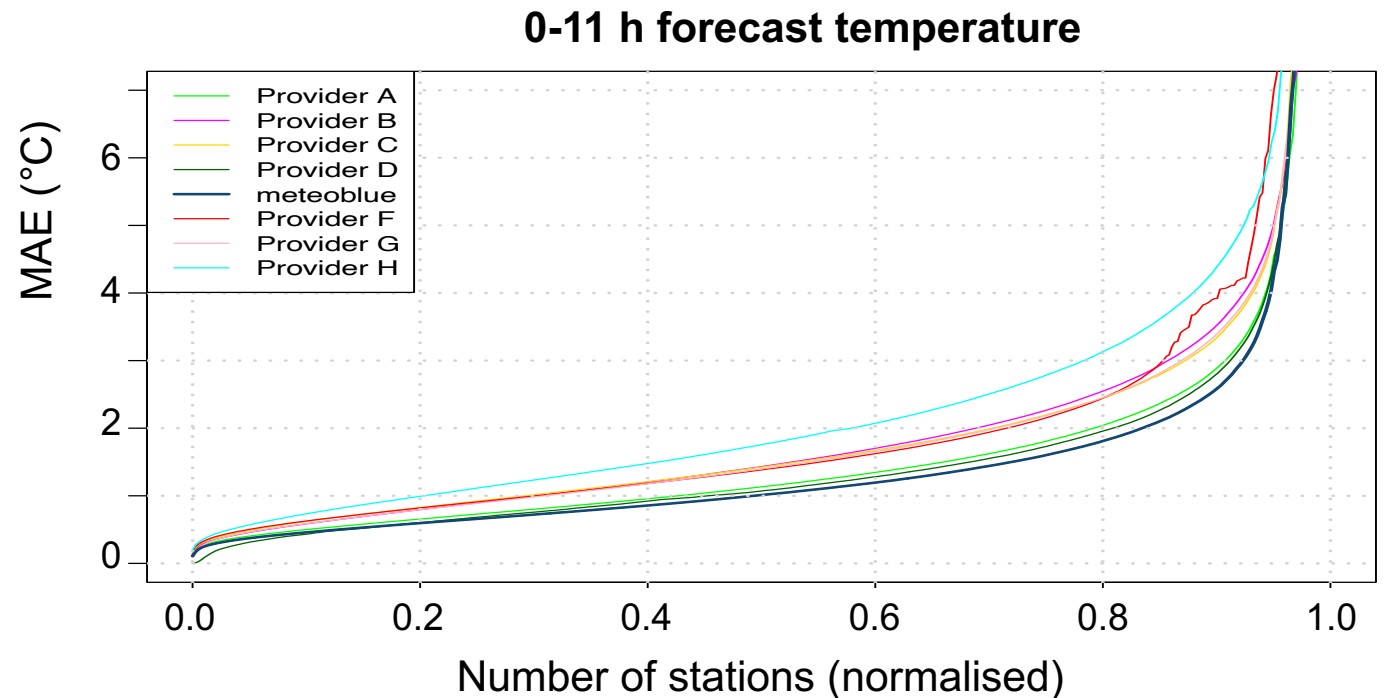
- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (worldwide)
- Station number: 475

MBE [K] 0-11h forecast temp



# Air temperature (01-11h forecast hourly). MAE

- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (worldwide)
- Station number: 475



# Air temperature (00-11h forecast hourly)

- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (worldwide)
- Station number: 475

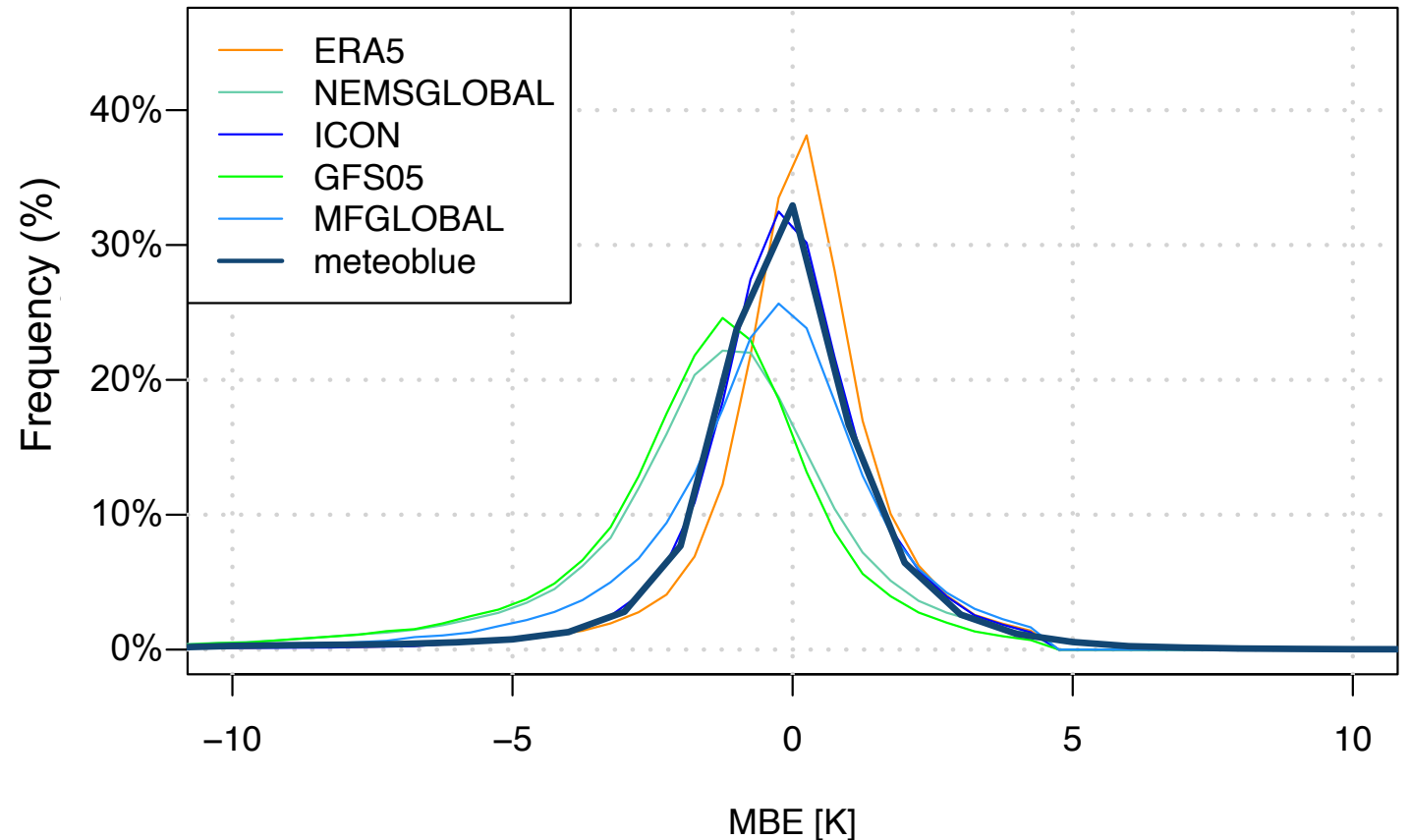
Provider	MAE [°C]	MBE [°C]	Percentage below 1.5°C	Percentage below 1°C
1 meteoblue	0.90	-0.05	88 %	69 %
2 Provider_D	1.16	0.07	75 %	48 %
3 Provider_A	1.28	0.05	72 %	48 %
Provider_F	1.39	-0.20	65 %	35 %
Provider_C	1.54	-0.50	59 %	33 %
Provider_G	1.56	-0.01	59 %	34 %
Provider_B	1.67	-0.40	54 %	31 %
Provider_H	2.00	-0.28	43 %	20 %



# Dewpoint (12-35h forecast hourly): MBE

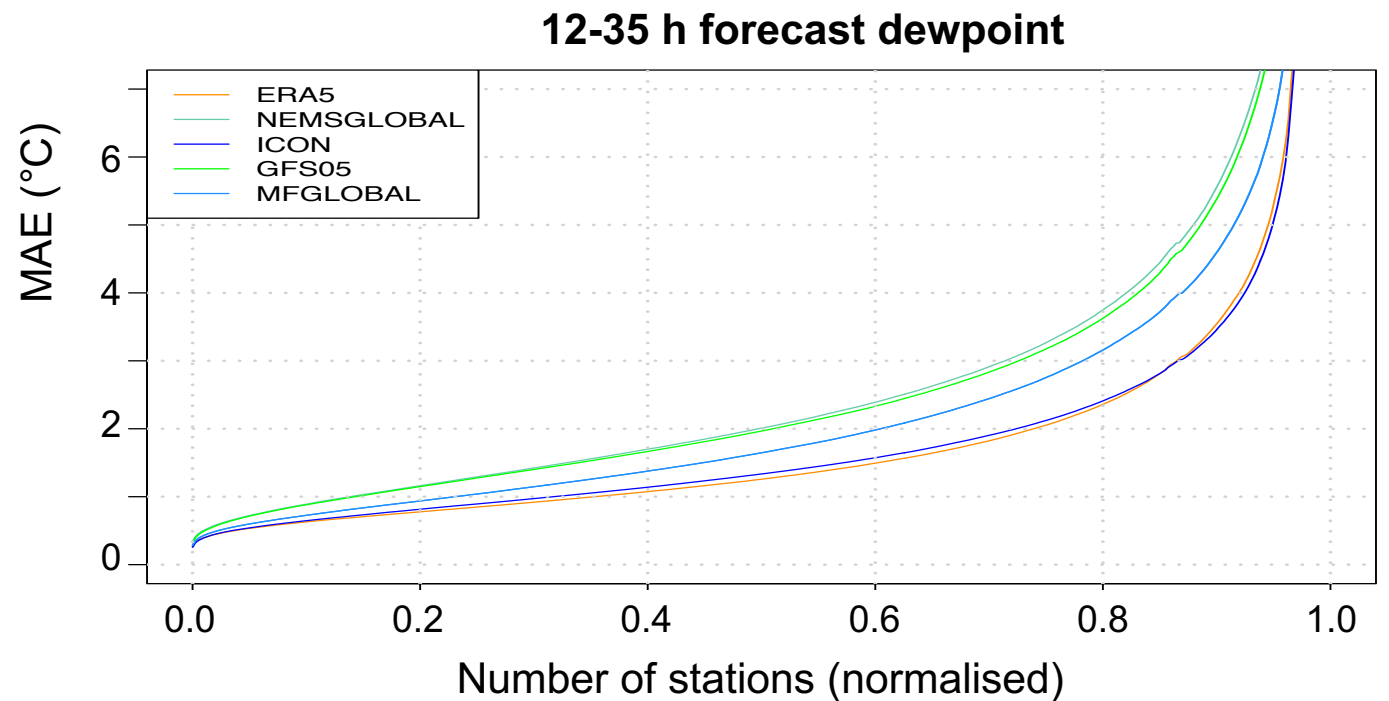
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- Stations : METAR (worldwide)
- Station number: 475

MBE [K] 12–35h forecast dewpoint



# Dewpoint (12-35h forecast hourly): MAE

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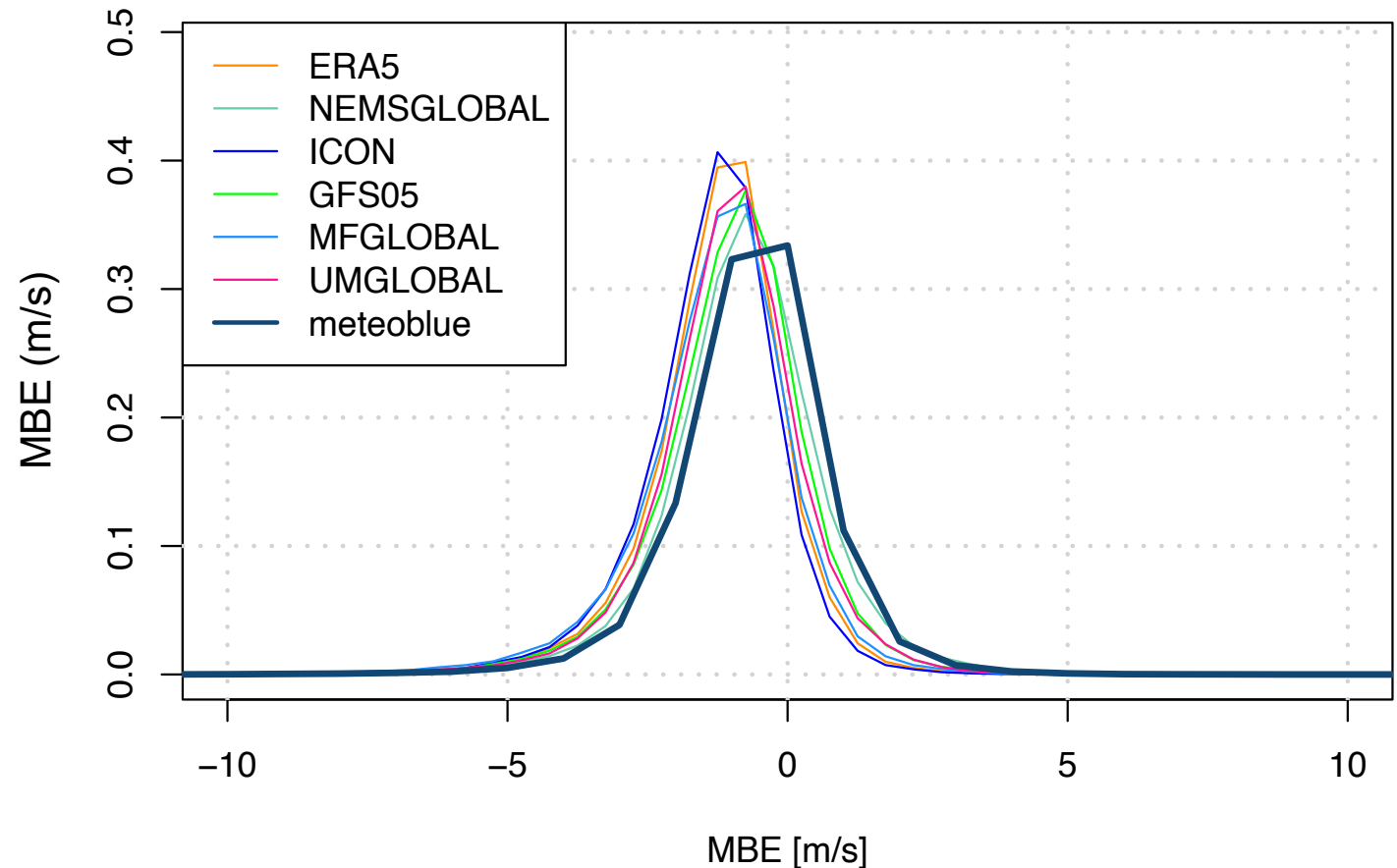
Provider	MAE [°C]	MBE [°C]	Percentage below 1.5°C	Percentage below 1°C
1 meteoblue	1.43	-0.21	62 %	37 %
3 Provider_D	1.88	0.20	49 %	23 %
2 Provider_C	1.78	-0.32	53 %	31 %
Provider_G	2.19	-1.29	45 %	24 %
Provider_B	2.10	-1.15	49 %	28 %
Provider_H	2.09	-0.90	44 %	23 %

Raw model	MAE [°C]	MBE [°C]	Percentage below 1.5°C	Percentage below 1°C
ERA5	1.64	0.38	57 %	34 %
NEMSGLOBAL	2.63	-1.41	35 %	17 %
ICON	1.69	0.04	56 %	33 %
GFS05	2.53	-1.64	39 %	20 %
MFGLOBAL	2.20	-0.41	44 %	24 %

# Wind speed (12-35h forecast hourly): MBE

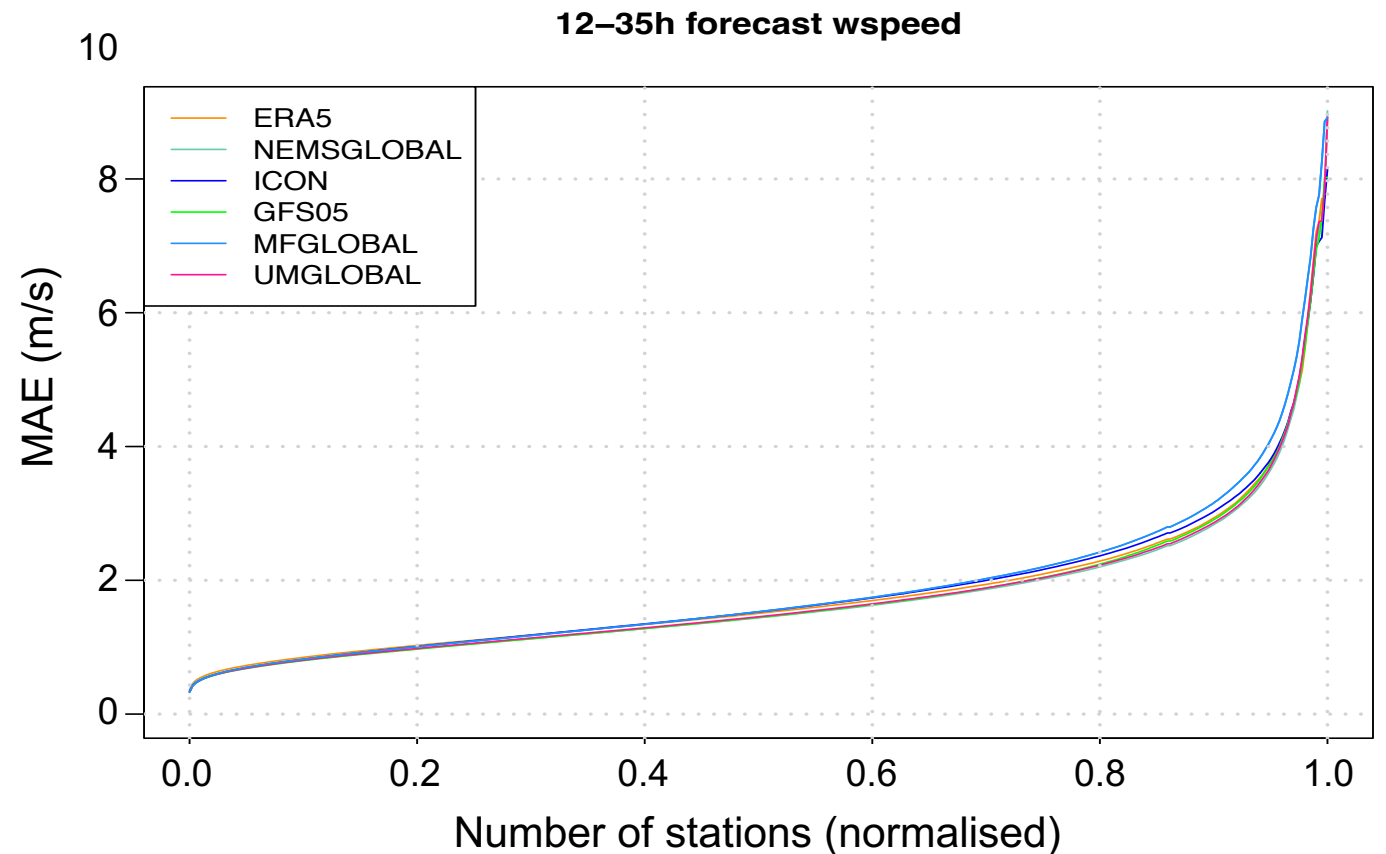
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- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (worldwide)
- Station number: 475

MBE [m/s] 12-35h forecast wspeed



# Wind speed (12-35h forecast hourly). MAE

- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
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- Stations : METAR (worldwide)
- Station number: 475



# Wind speed (12-35h forecast hourly)

- Forecast created at 12:00 UTC
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- Stations : METAR (worldwide)
- Station number: 475

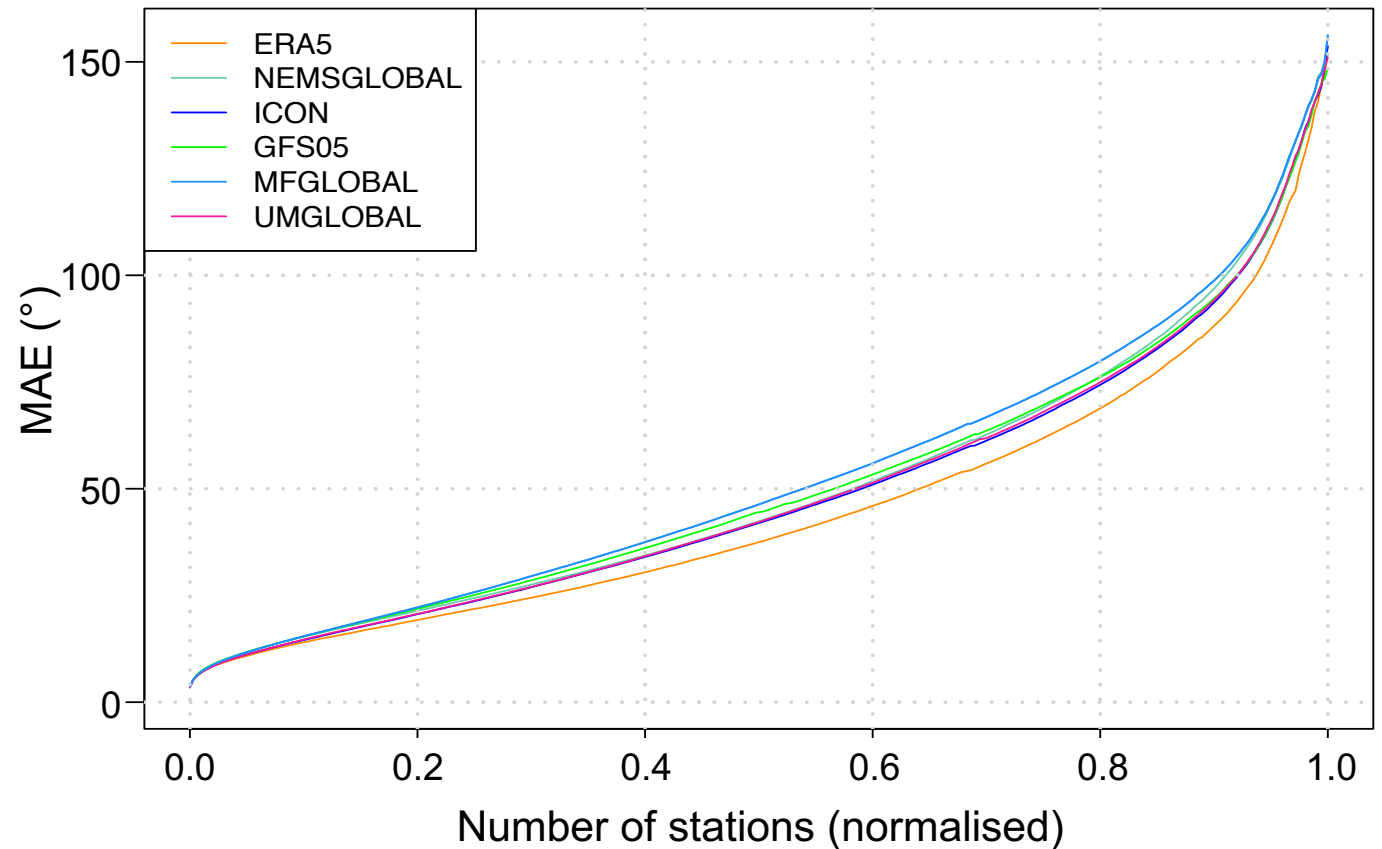
Provider	MAE [m/s]	MBE [m/s]	Percentage below 1.5 m/s	Percentage below 1 m/s
<b>1</b> meteoblue	1.36	-0.53	67	34
Provider_D	1.41	-0.42	67	29
<b>2</b> Provider_F	1.38	-0.29	69	32
Provider_C	1.41	-0.36	67	29
Provider_G	1.48	-0.09	63	28
<b>3</b> Provider_B	1.40	-0.14	68	37
Provider_H	1.51	-0.11	60	27

Raw model	MAE [m/s]	MBE [m/s]	Percentage below 1.5 m/s	Percentage below 1 m/s
ERA5	1.70	-1.22	53	24
NEMSGLOBAL	1.69	-0.88	55	24
ICON	1.70	-1.33	52	23
GFS05	1.67	-1.04	53	23
MFGLOBAL	1.80	-1.31	50	24
UMGLOBAL	1.68	-1.13	54	23

# Wind direction (12-35h forecast hourly)

- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (worldwide)
- Station number: 475

12-35 h forecast wind direction



# Wind direction (12-35h forecast hourly)

- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (worldwide)
- Station number: 475

Provider	MAE [°]	MBE [°]	Percentage below 90°	Percentage below 45°
meteoblue	44.81	0.60	94	68
<b>1</b> Provider_D	43.13	1.71	95	71
<b>2</b> Provider_F	43.20	1.56	95	71
<b>3</b> Provider_C	43.61	0.53	95	70
Provider_G	44.90	2.10	94	67
Provider_B	46.76	0.72	90	63
Provider_H	46.14	2.86	92	62

Raw model	MAE [°]	MBE [°]	Percentage below 90°	Percentage below 45°
ERA5	42.66	1.63	95	68
NEMSGLOBAL	48.28	1.51	91	60
ICON	45.16	0.74	95	65
GFS05	48.00	1.30	93	58
MFGLOBAL	49.54	-1.17	92	57
UMGLOBAL	46.66	1.04	94	62



# Precipitation (12-35h forecast hourly)

- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly (by day)
- Time period: 20210101-20211231
- Stations : GSOD (worldwide)
- Station number: 319

Provider	Sums [mm]	MBE [mm]	MPE [%]
GSOD (measurement)	712.04		
ERA5	674.23	-37.81	-5.31
NEMSGLOBAL	461.20	-250.84	-35.23
ICON	584.51	-127.53	-17.91
GFS05	738.97	26.93	3.78
MFGLOBAL	801.52	89.48	12.57
UMGLOBAL	728.78	16.74	2.35
1 meteoblue	720.46	8.42	1.18
Provider_C	666.05	-45.99	-6.46
3 Provider_D	752.99	40.95	5.75
2 Provider_F	689.14	-22.90	-3.22
Provider_H	2'681.36	1'969.32	276.57

# Precipitation (12-35h forecast hourly)

- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly (by day)
- Time period: 20210101-20211231
- Stations : GSOD (worldwide)
- Station number: 319

Provider	HSS >0.1mm	POD > 0.1mm	FAR > 0.1mm
ERA5	0.42	0.83	0.49
NEMSGLOBAL	0.42	0.72	0.46
ICON	0.44	0.80	0.47
GFS05	0.42	0.84	0.49
MFGLOBAL	0.37	0.87	0.53
UMGLOBAL	0.37	0.87	0.53
1 meteoblue	0.51	0.78	0.40
Provider_C	0.40	0.77	0.48
3 Provider_D	0.42	0.89	0.50
2 Provider_F	0.44	0.83	0.47
Provider_H	0.36	0.81	0.52

# Precipitation (12-35h forecast hourly)

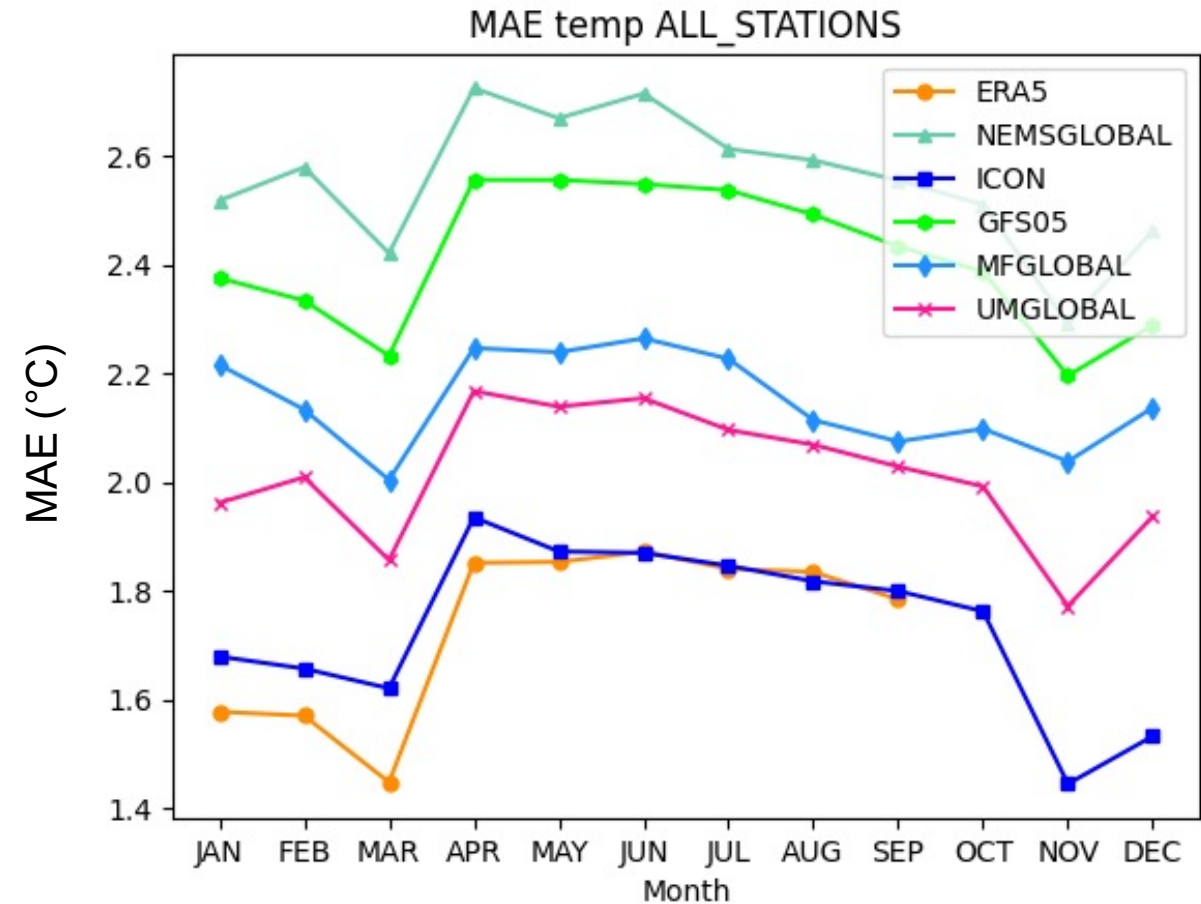
- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly (by day)
- Time period: 20210101-20211231
- Stations : GSOD (worldwide)
- Station number: 319

Raw Model	Events > 0.1 mm			Events > 1 mm			Events > 10 mm		
	HSS	POD	FAR	HSS	POD	FAR	HSS	POD	FAR
ERA5	0.42	0.83	0.49	0.44	0.70	0.50	0.30	0.38	0.67
NEMSGLOBAL	0.42	0.72	0.46	0.38	0.57	0.50	0.20	0.21	0.69
ICON	0.44	0.80	0.47	0.43	0.66	0.49	0.27	0.31	0.67
GFS05	0.42	0.84	0.49	0.41	0.75	0.53	0.27	0.38	0.70
MFGLOBAL	0.37	0.87	0.53	0.37	0.78	0.57	0.24	0.34	0.73
UMGLOBAL	0.37	0.87	0.53	0.40	0.75	0.54	0.28	0.36	0.69

Raw Model	Events > 0.1 mm			Events > 1 mm			Events > 10 mm		
	HSS	POD	FAR	HSS	POD	FAR	HSS	POD	FAR
1 meteoblue	0.51	0.78	0.40	0.49	0.79	0.47	0.37	0.47	0.62
3 Provider_C	0.40	0.77	0.48	0.44	0.69	0.48	0.33	0.40	0.63
2 Provider_D	0.42	0.89	0.50	0.47	0.80	0.49	0.36	0.46	0.62
Provider_F	0.44	0.83	0.47	0.47	0.76	0.48	0.35	0.42	0.62
Provider_H	0.36	0.81	0.52	0.37	0.78	0.57	0.23	0.62	0.79

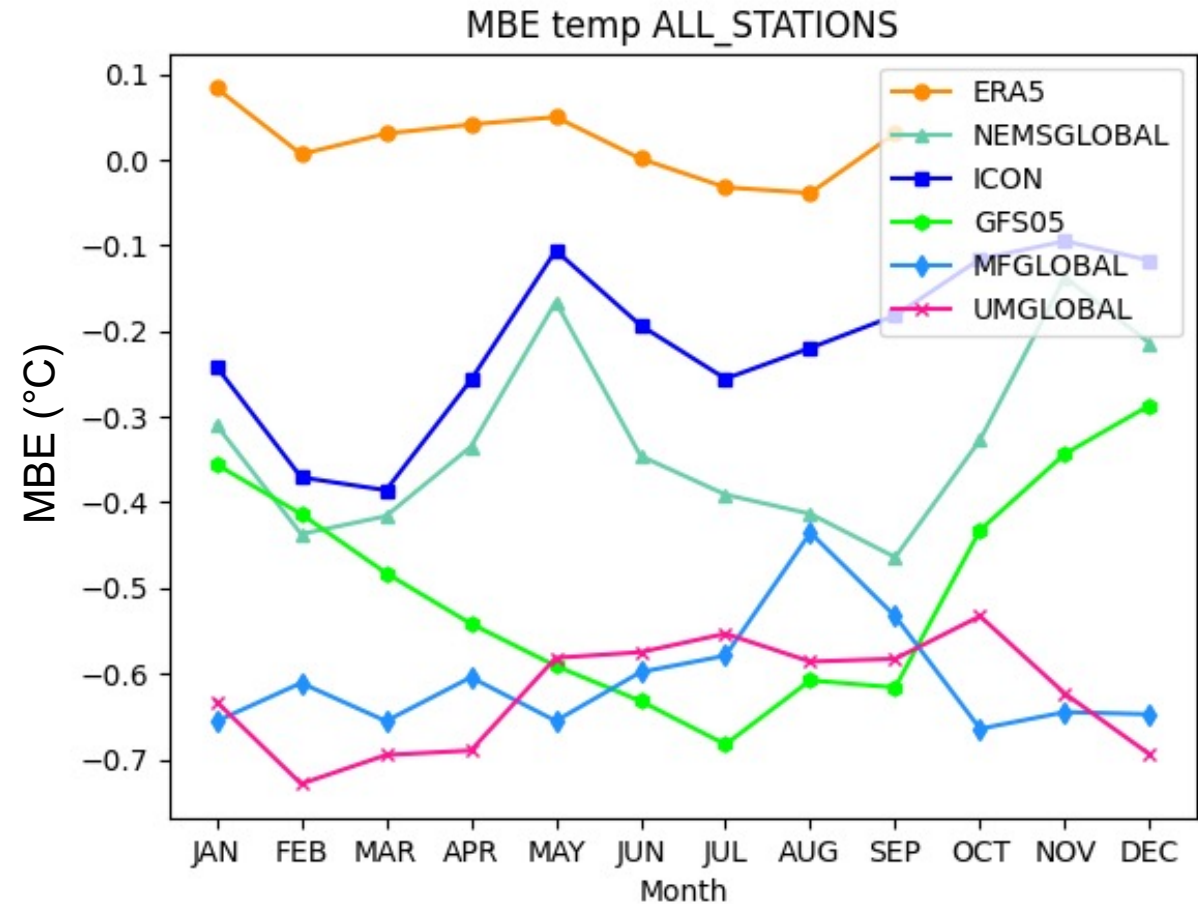
# Monthly MAE of raw models | Temperature

- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (worldwide)
- Station number: 475



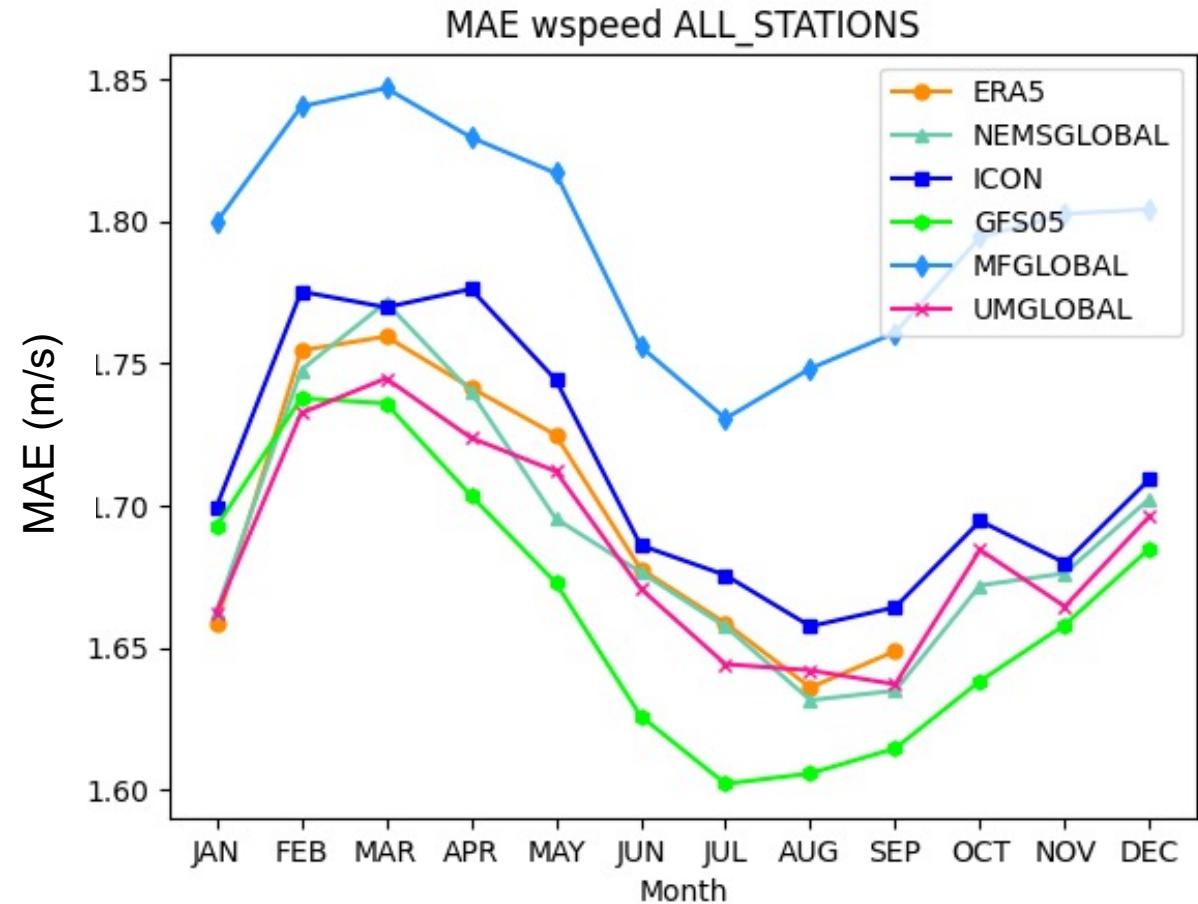
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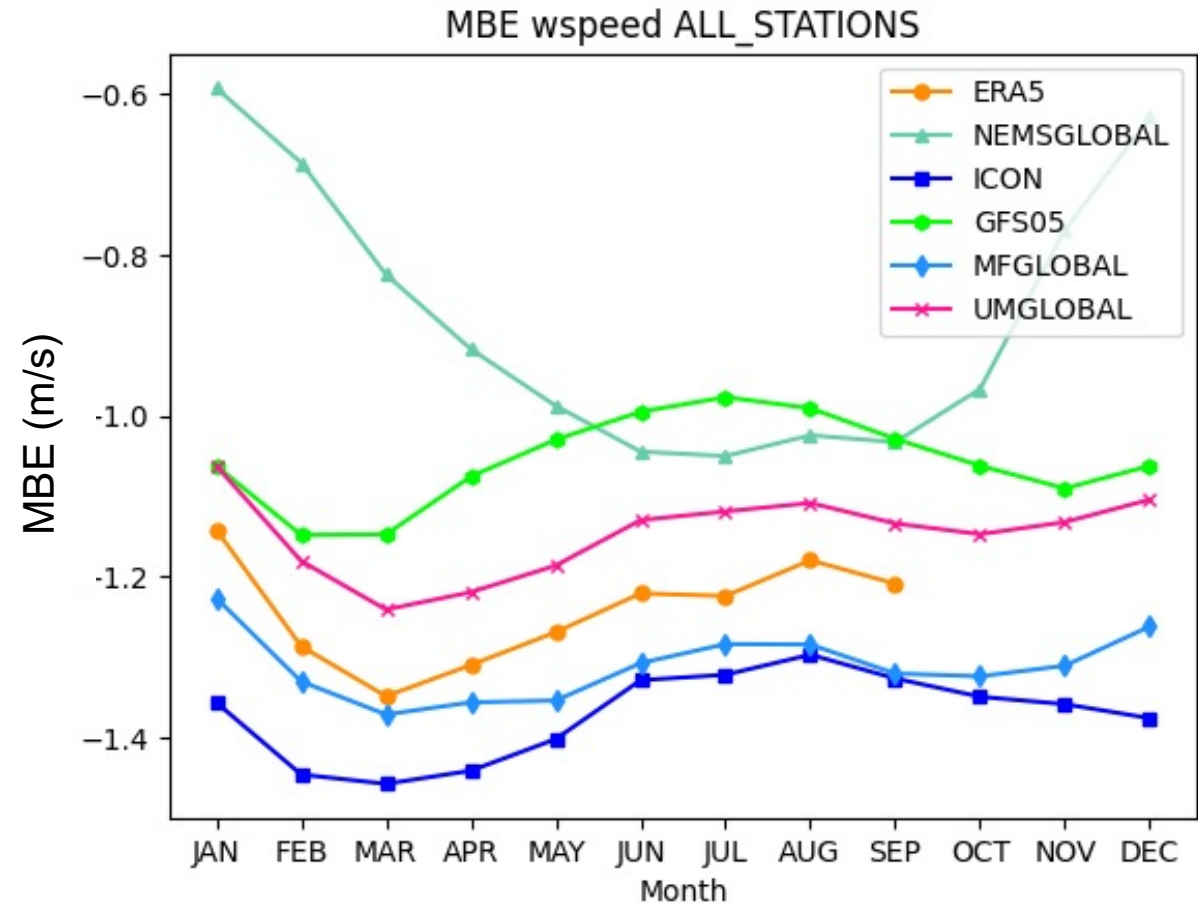
# Monthly MAE of raw models | Wind speed

- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (worldwide)
- Station number: 475



# Monthly MBE of raw models | Wind speed

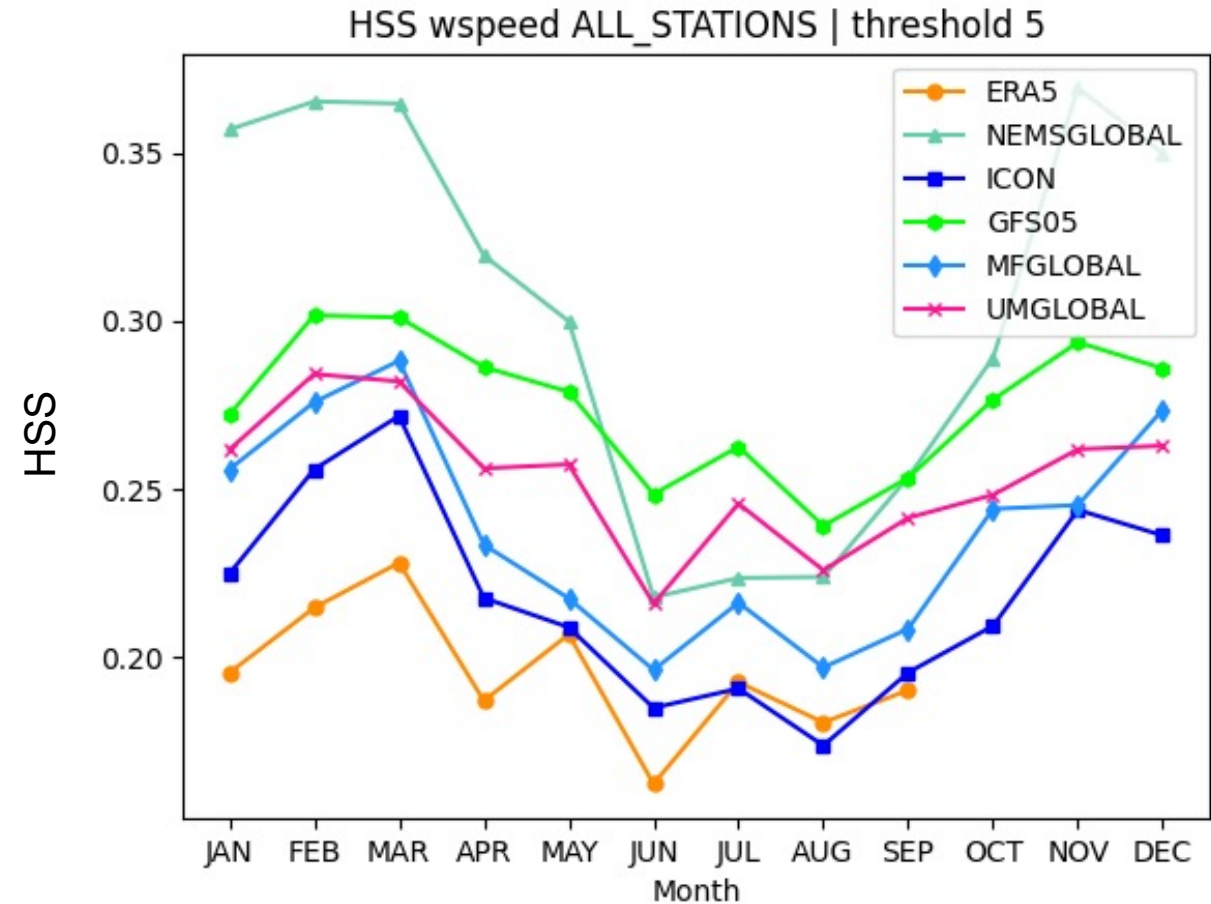
- Forecast created at 12:00 UTC
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- Stations : METAR (worldwide)
- Station number: 475





# Monthly HSS (>5 m/s) of raw models | Wind speed

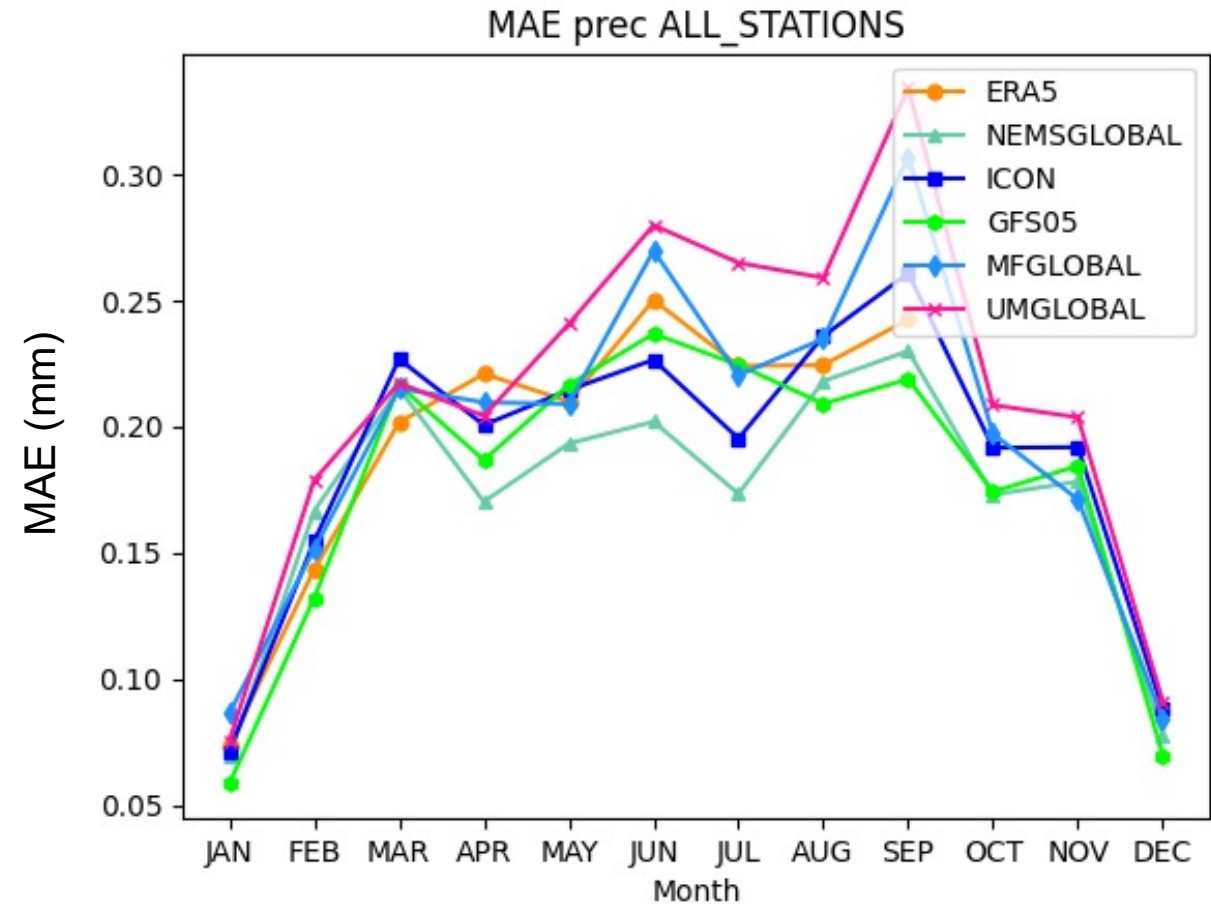
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- Stations : METAR (worldwide)
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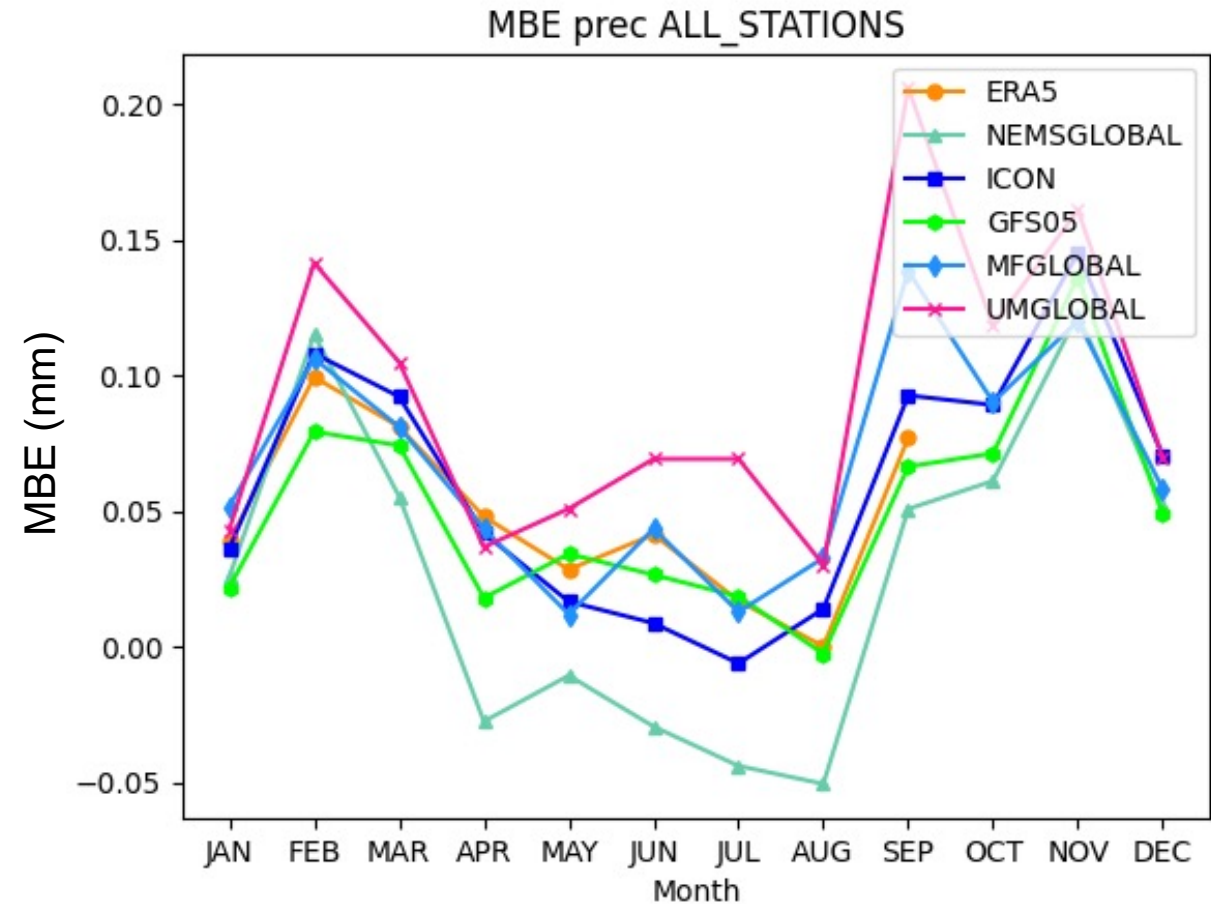
# Monthly MAE of raw models | Precipitation (N-Am.)

- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (N.-America)
- Station number: 36



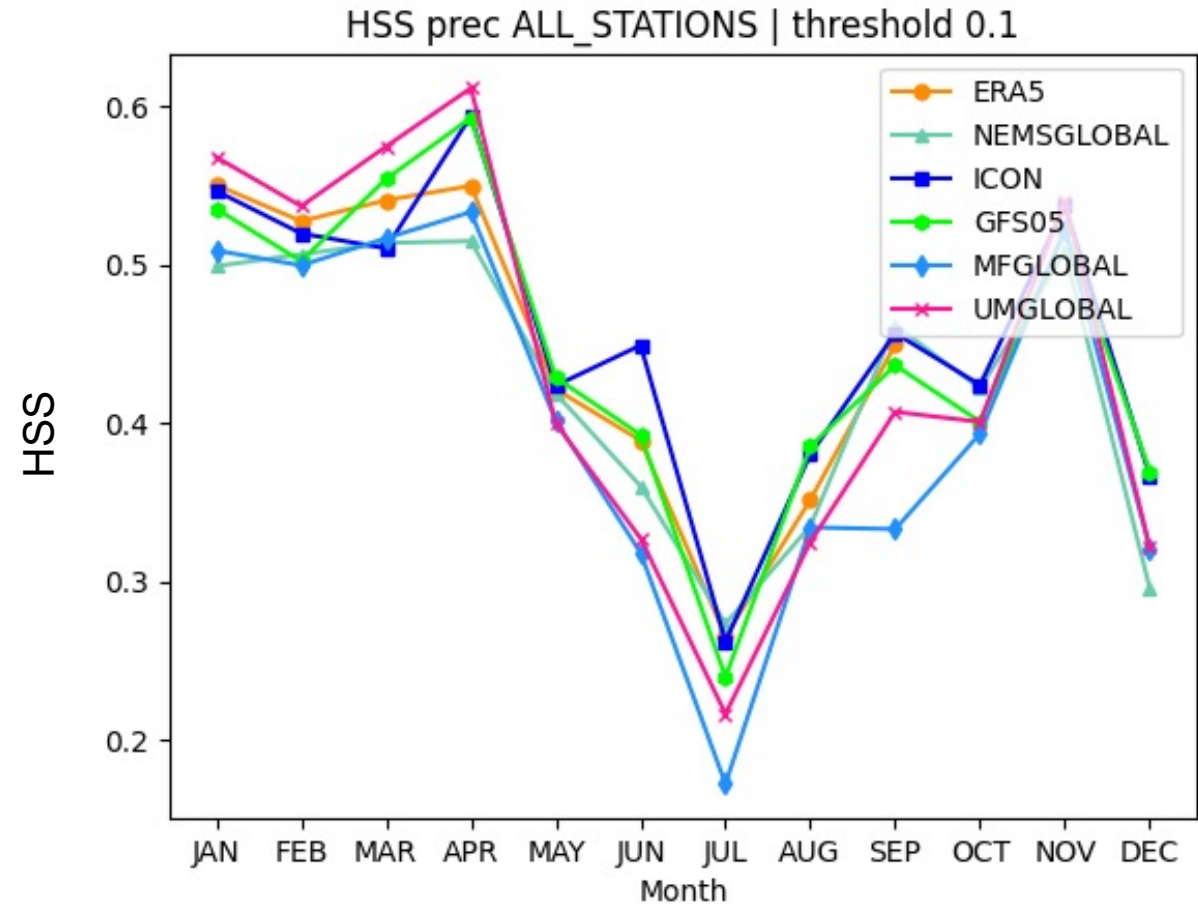
# Monthly MBE of raw models | Precipitation (N-Am.)

- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (N.-America)
- Station number: 36



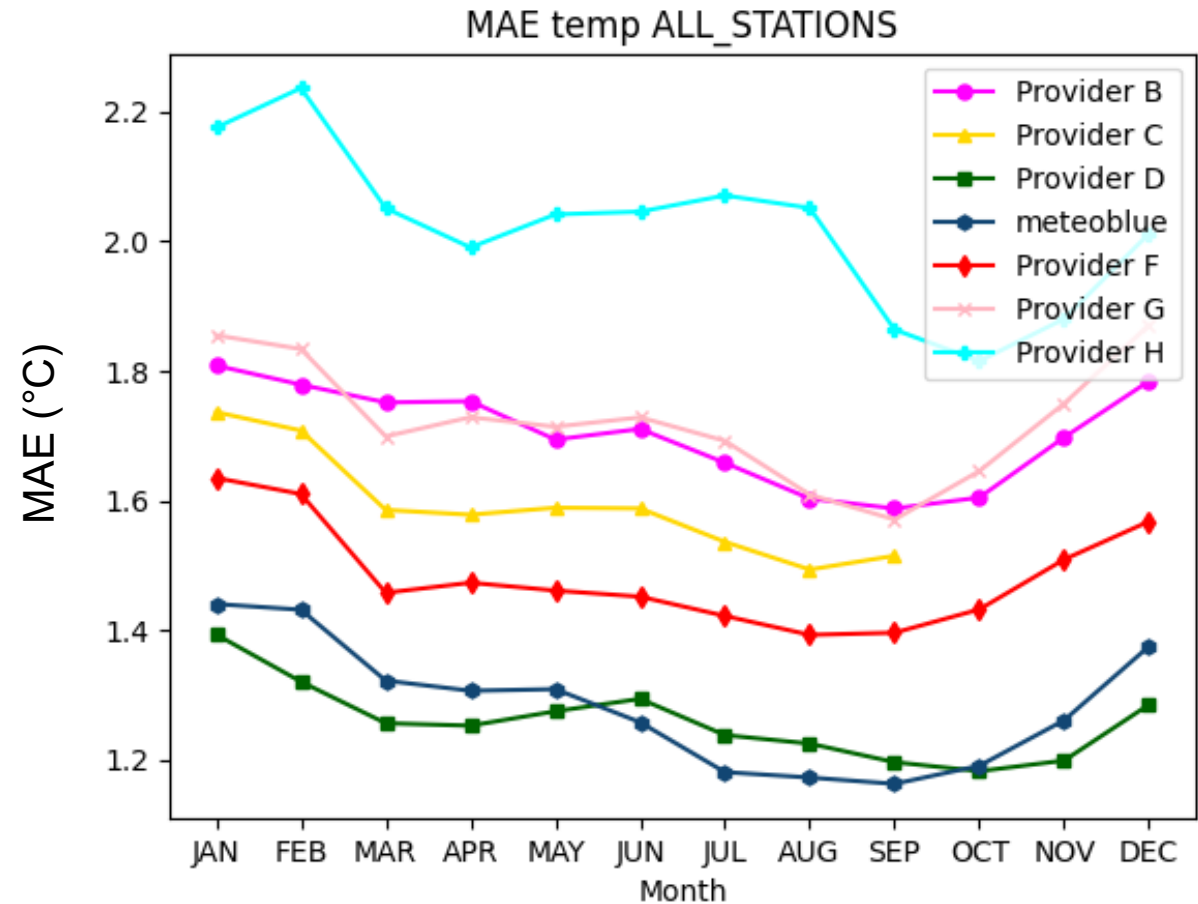
# Monthly HSS (>0.1 mm/h) models | Precipitation (N.A.)

- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (N.-America)
- Station number: 36



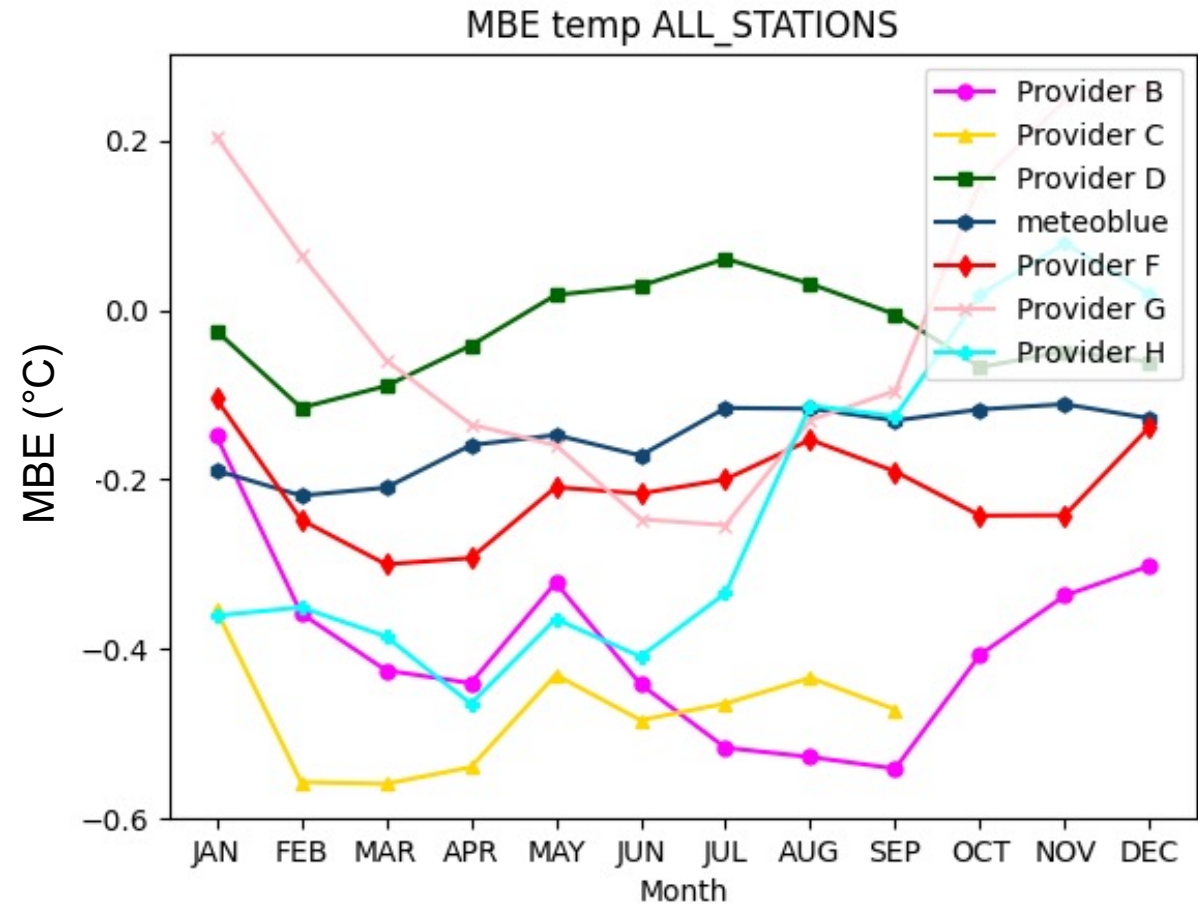
# Monthly MAE of providers | Temperature

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- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (worldwide)
- Station number: 475



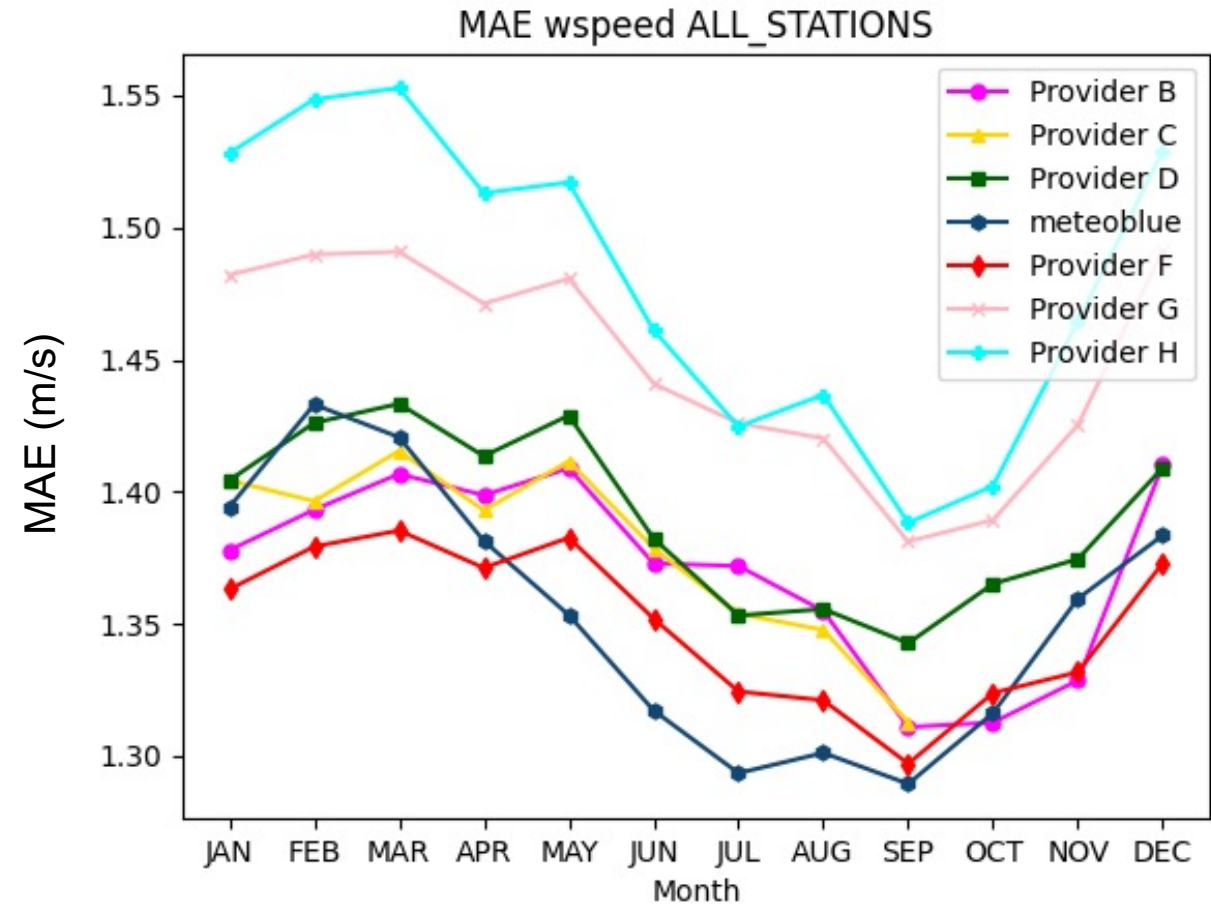
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# Monthly MAE of providers | Wind speed

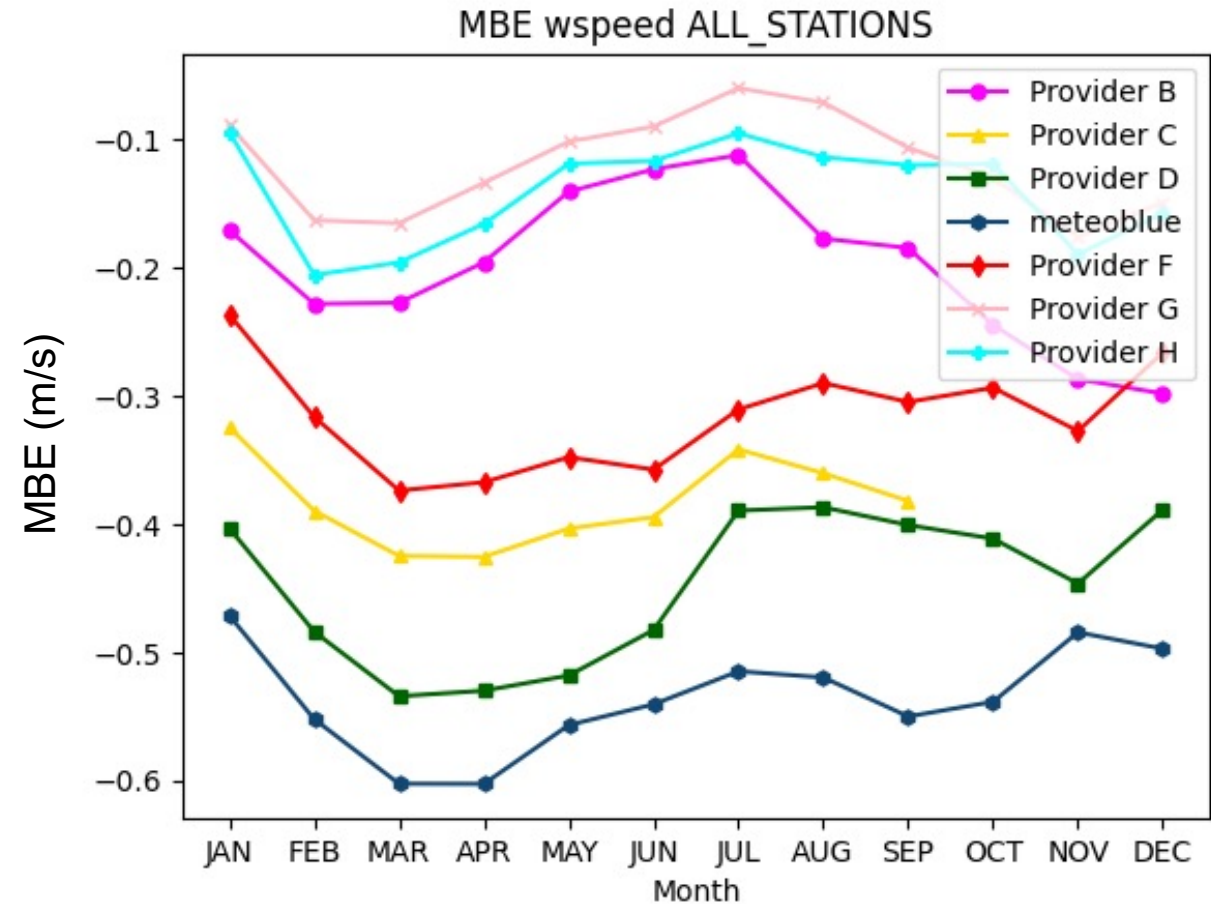
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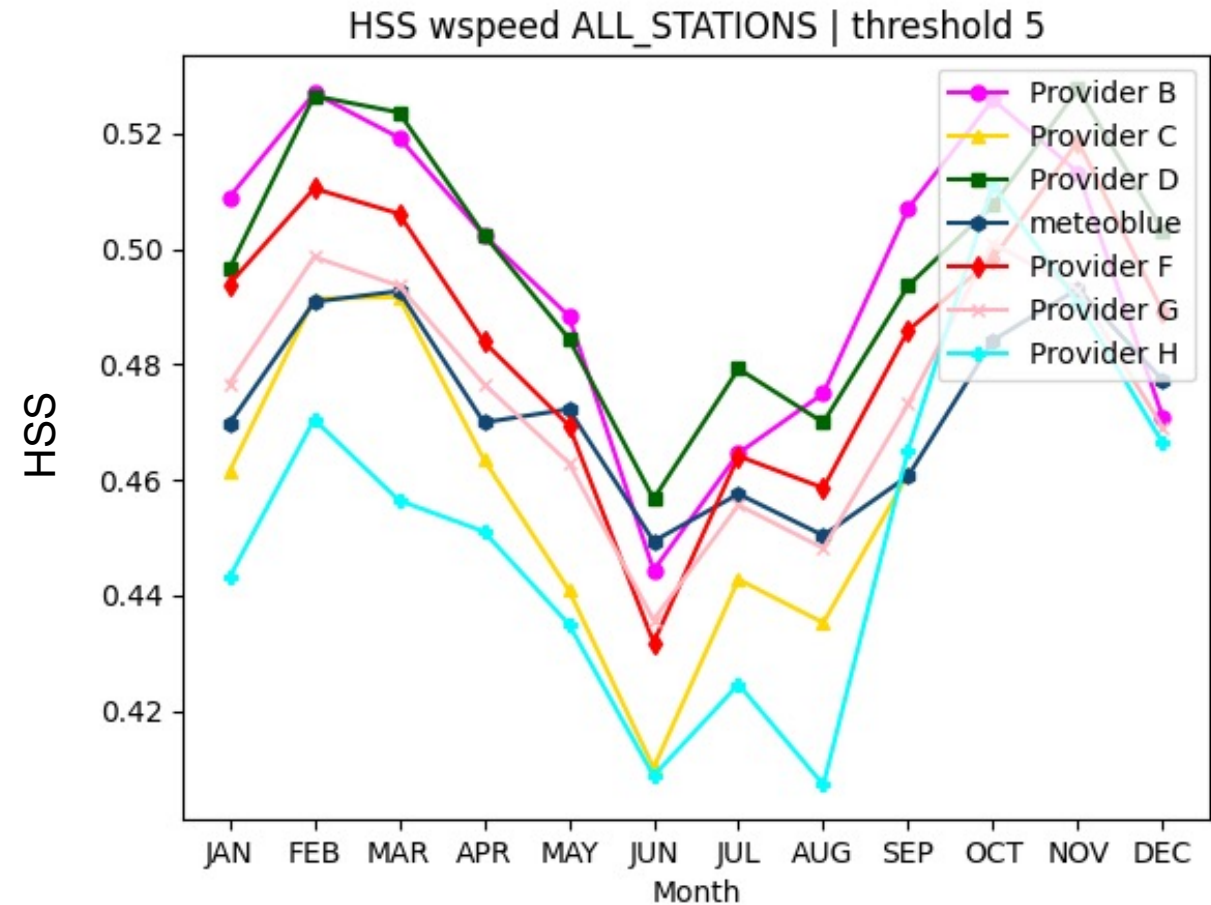
# Monthly MBE of providers | Wind speed

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- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (worldwide)
- Station number: 475



# Monthly HSS (>5 m/s) of raw models | Wind speed

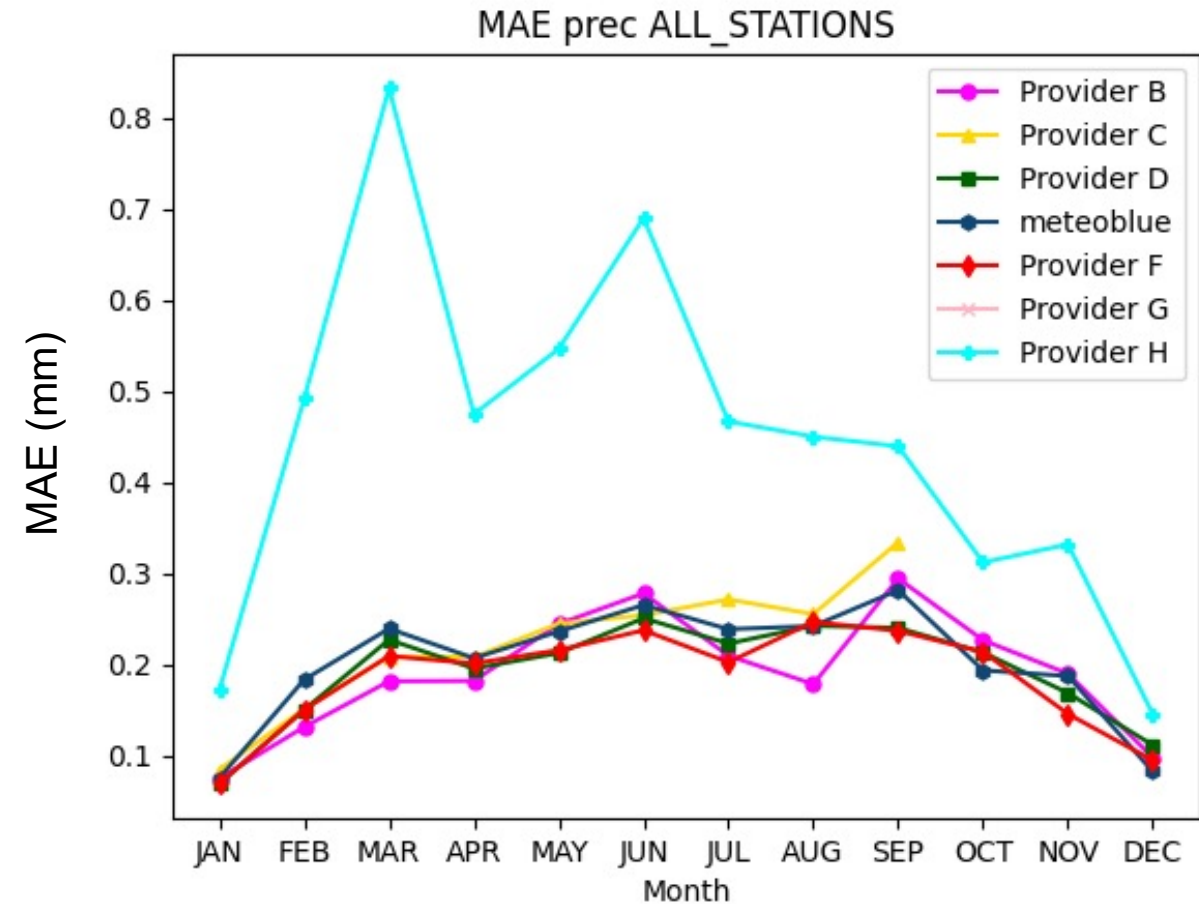
- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (worldwide)
- Station number: 475





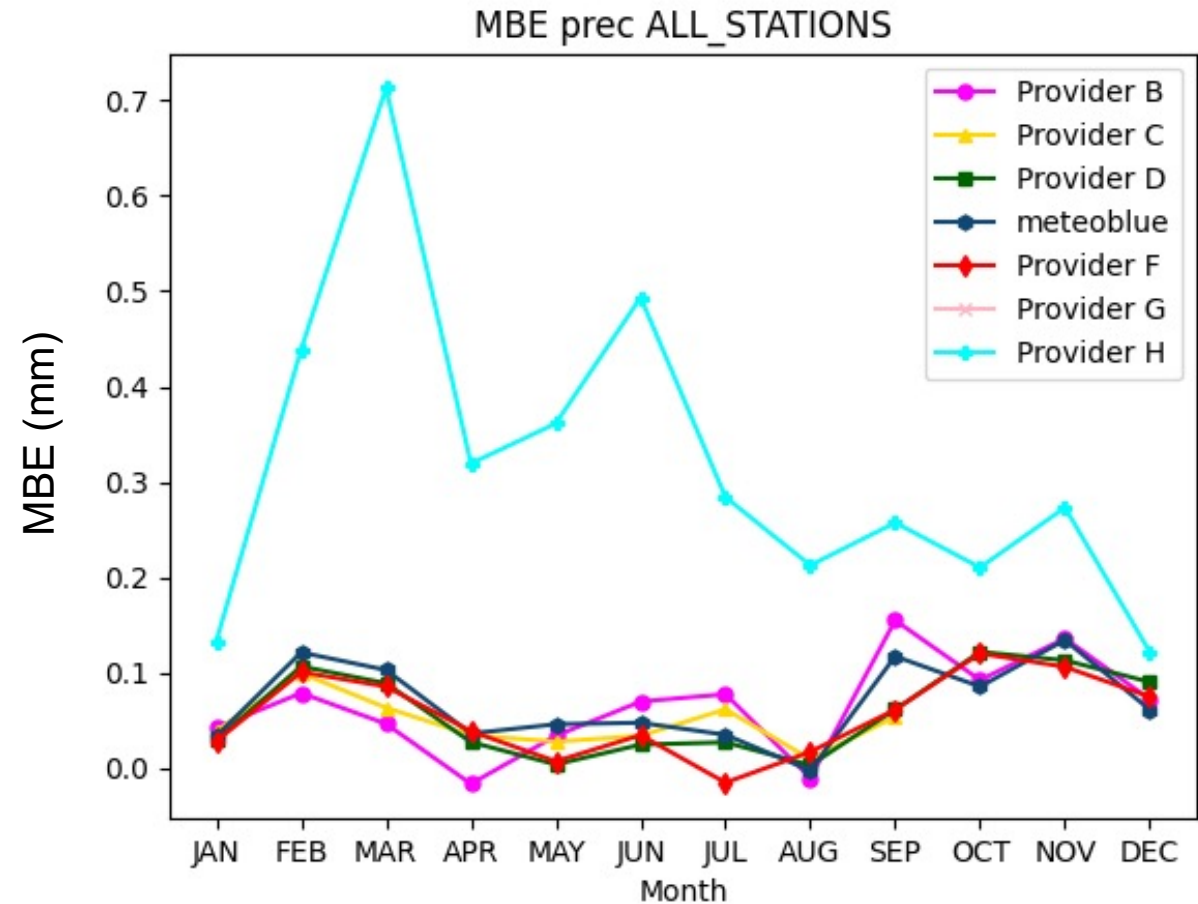
# Monthly MAE of providers | Precipitation (N-Am.)

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- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (N.-America)
- Station number: 36



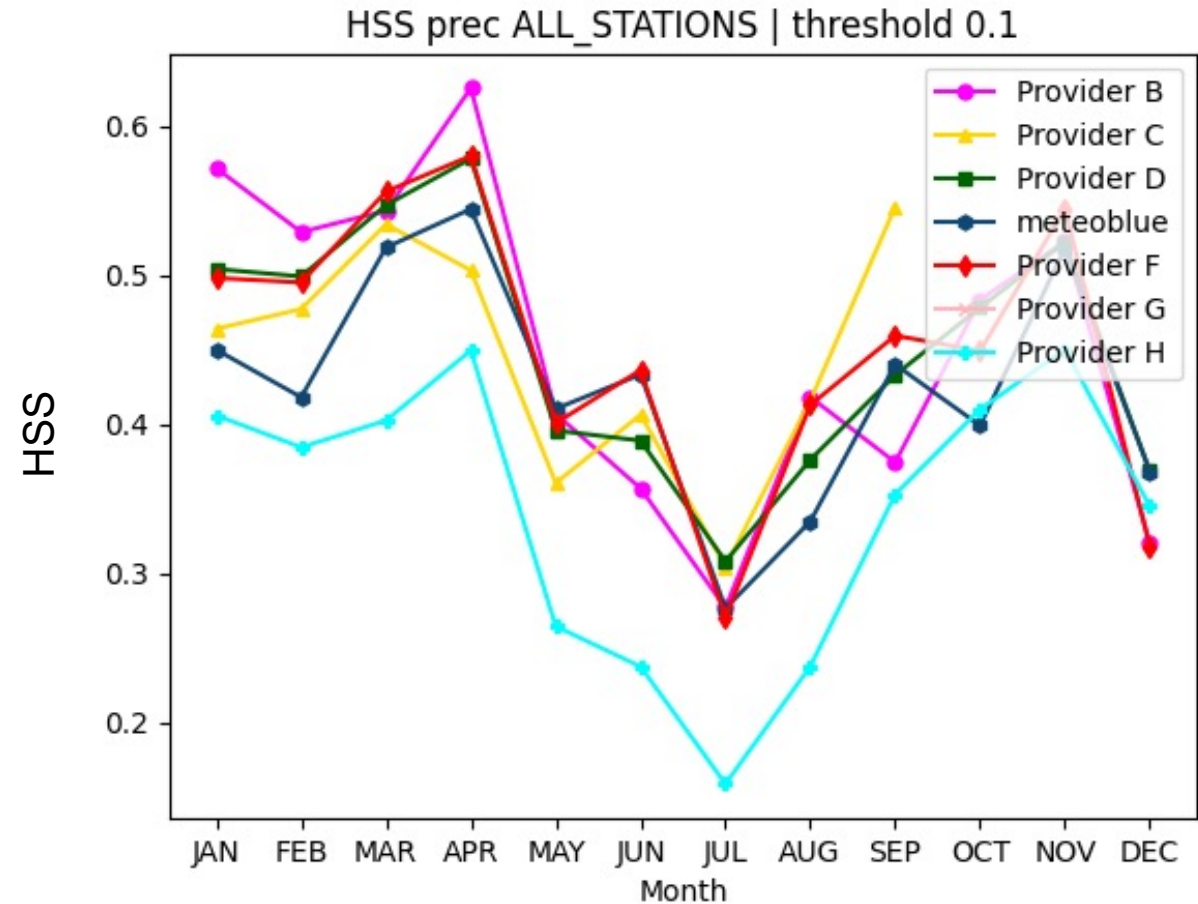
# Monthly MBE of providers | Precipitation (N-Am.)

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# Meteorological providers: forecast range

## Available forecast days

Provider	1 days	2 days	3 days	4 days	5 days	6 days
meteoblue	Green	Green	Green	Green	Green	Green
Provider_A*	Green	Orange	Orange	Orange	Orange	Orange
Provider_B	Green	Orange	Orange	Orange	Orange	Orange
Provider_F	Green	Green	Green	Green	Green	Green
Provider_G	Green	Green	Orange	Orange	Orange	Orange
Provider_H	Green	Green	Green	Green	Green	Green
Provider_D	Green	Green	Green	Green	Green	Green
Provider_C	Green	Green	Green	Green	Green	Green

\* Provider\_A provides forecast data only for forecast hours 0-11

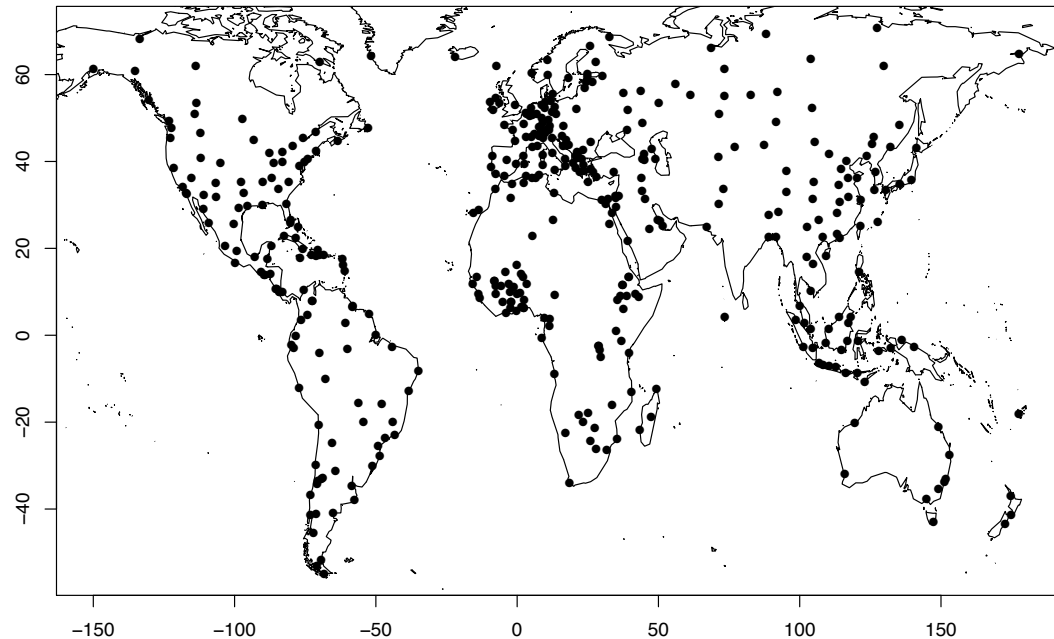
# Meteorological provider

## Available variables per provider

Provider	Air temperature	Apparant temperature	Dewpoint temperature	Precipitation amount	Precipitation Probability	Relative humidity	Cloud cover	Horizontal visibility	Wind speed	Wind direction	Wind gust	Air pressure	Weather
<b>Measurements</b>													
meteoblue													
Provider_A													
Provider_B													
Provider_F													
Provider_G													
Provider_H													
Provider_D													
Provider_C													

## Location selection

- **500 measurements total**
- METAR measurements (475 stations)
- MeteoSwiss measurements (7 stations)
- Metos measurements (12 stations)
- No measurement in surrounding (6 locations: Mount Everest, Russia, Canada, Sahara)



# Air temperature (12-35h forecast hourly)

Provider	at 12:00 UTC	Provider	MAE [°C]	MBE [°C]	Percentage below 1.5°C	Percentage below 1.0°C
Provider_A	-35h		1.29	-0.16	65	36
Provider_B	hourly		1.26	-0.02	67	36
Provider_F	0101-20211231		1.24	0.08	66	49
Provider_G	(worldwide)		1.48	-0.21	57	25
Provider_H	75		1.61	-0.52	51	23
Provider_D			1.73	-0.03	48	22
Provider_C			1.71	-0.38	51	29
meteoblue			2.03	-0.23	37	14

# Air temperature (12-35h forecast hourly)

- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (worldwide)
- Station number: 475

Provider	MAE [°C]	MBE [°C]	Percentage below 1.5°C	Percentage below 1°C
3 meteoblue	1.29	-0.16	65	36
2 Provider_D	1.26	-0.02	67	36
1 Provider_A	1.24	0.08	66	49
Provider_F	1.48	-0.21	57	25
Provider_C	1.61	-0.52	51	23
Provider_G	1.73	-0.03	48	22
Provider_B	1.71	-0.38	51	29
Provider_H	2.03	-0.23	37	14



## Air temperature (hourly) MAE [°C]: forecast days 0-3

- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (worldwide)
- Station number: 475

Provider	Day 0 (0 – 11 h)	Day 1 (12 – 35 h)	Day 2 (36 – 47 h)	Day 3 (48 – 71 h)
meteoblue	0.71 <b>1</b>	1.29 <b>2</b>	1.37 <b>2</b>	1.44 <b>2</b>
Provider_D	1.16 <b>3</b>	1.26 <b>1</b>	1.34 <b>1</b>	1.43 <b>1</b>
Provider_A	1.28 <b>3</b>	1.24	-	-
Provider_F	1.36	1.48	1.56	1.65
Provider_C	1.54	1.61	1.68	1.92
Provider_G	1.56	1.73	1.77	-
Provider_B	1.68	1.71	-	-
Provider_H	1.95	2.03	2.11	2.29

# Air temperature (hourly): Percentage below 1°C [%]

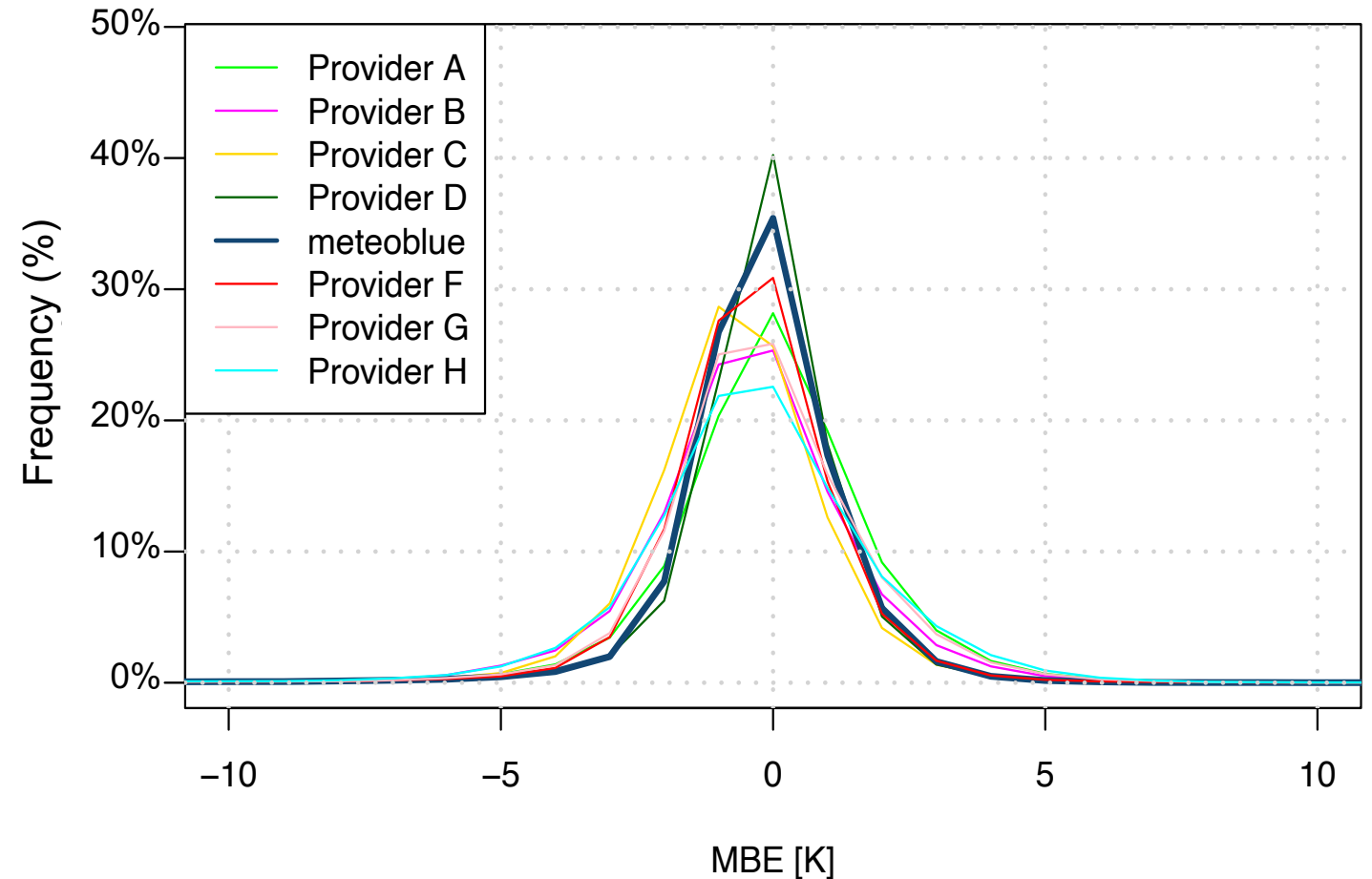
- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (worldwide)
- Station number: 475

Provider	Day 0 (0 – 11 h)	Day 1 (12 – 35 h)	Day 2 (36 – 47 h)	Day 3 (48 – 71 h)
meteoblue	73.45 <span style="color: green;">1</span>	35.89 <span style="color: green;">2</span>	31.36 <span style="color: green;">1</span>	29.13 <span style="color: green;">1</span>
Provider_D	44.95 <span style="color: green;">2</span>	36.1 <span style="color: green;">1</span>	31.64 <span style="color: green;">2</span>	27.93 <span style="color: green;">2</span>
Provider_A	46.33 <span style="color: green;">3</span>	48.81 <span style="color: green;">3</span>	-	-
Provider_F	32.36	25.25	22.32	19.67
Provider_C	30.05	23.36	20.54	13.51
Provider_G	33.41	21.76	28.74	-
Provider_B	28.95	28.71	-	-
Provider_H	16.43	14.42	13.92	28.67

# Air temperature (12-35h forecast hourly): provider MBE

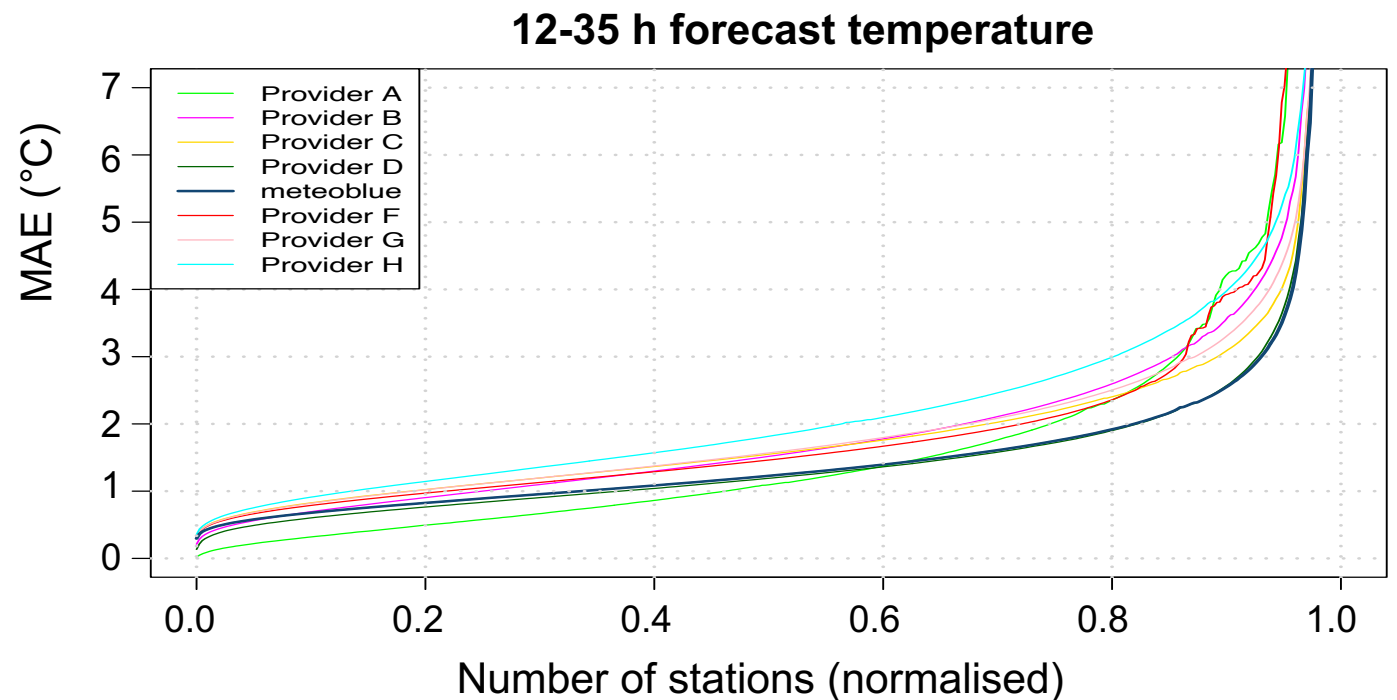
MBE [K] 12-35h forecast temp

- Forecast created 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (worldwide)
- Station number: 475

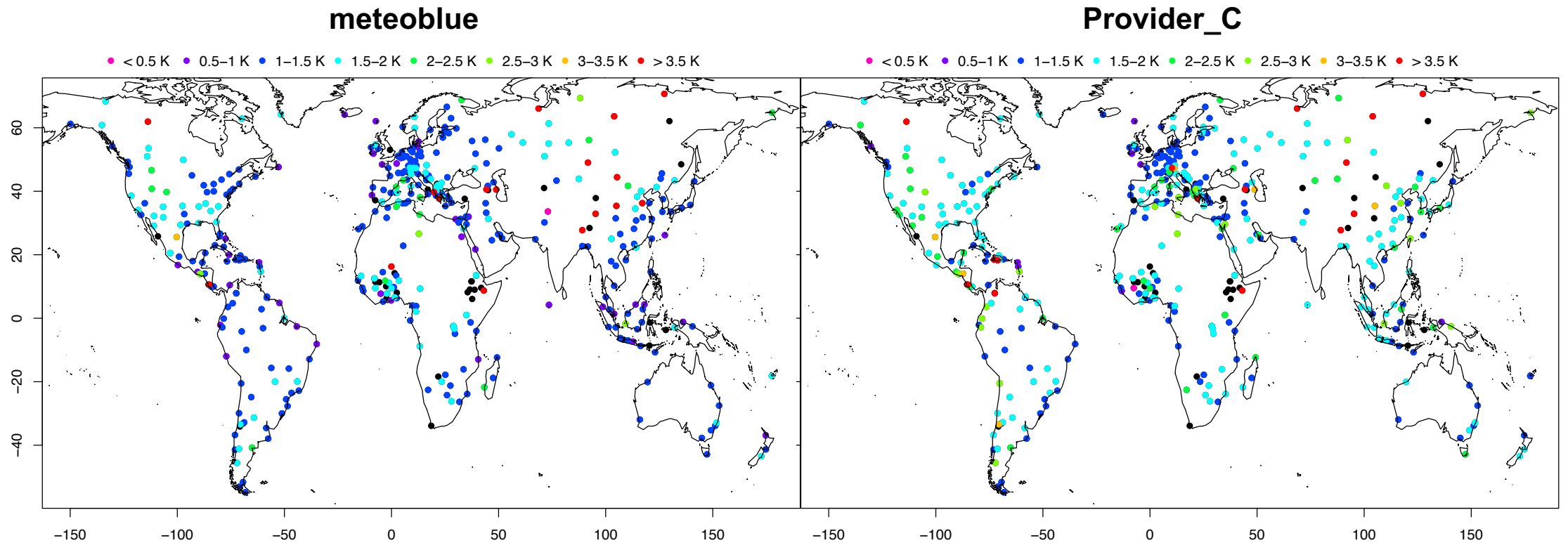


# Air temperature (12-35h forecast hourly): provider MAE

- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (worldwide)
- Station number: 475

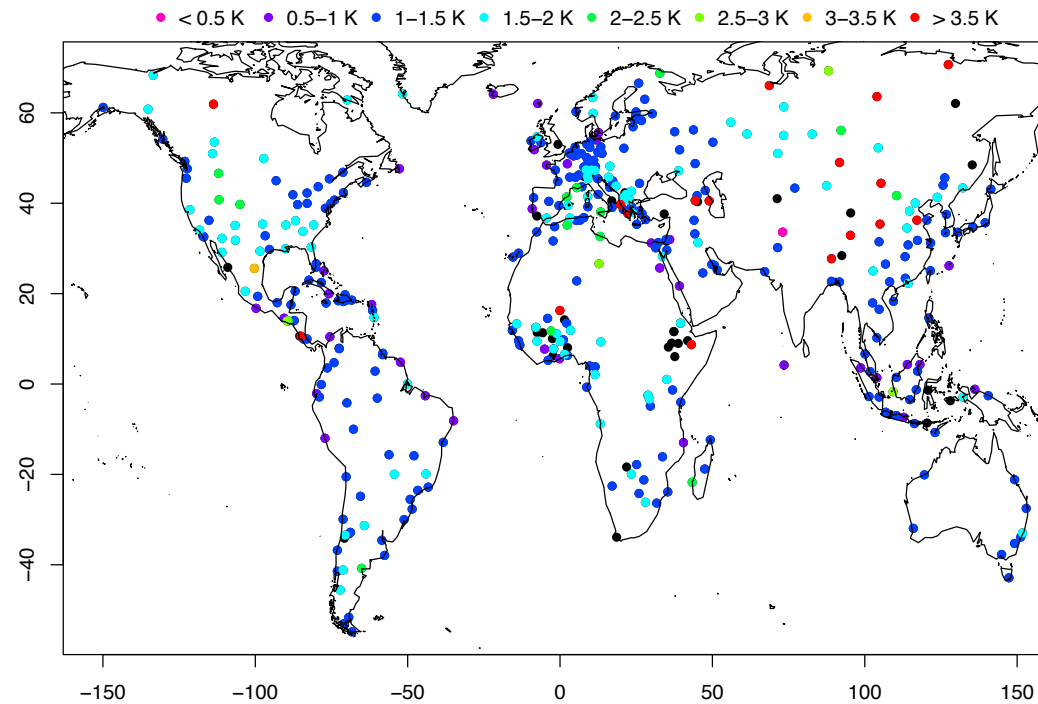


# Air temperature (12 -35h forecast hourly)

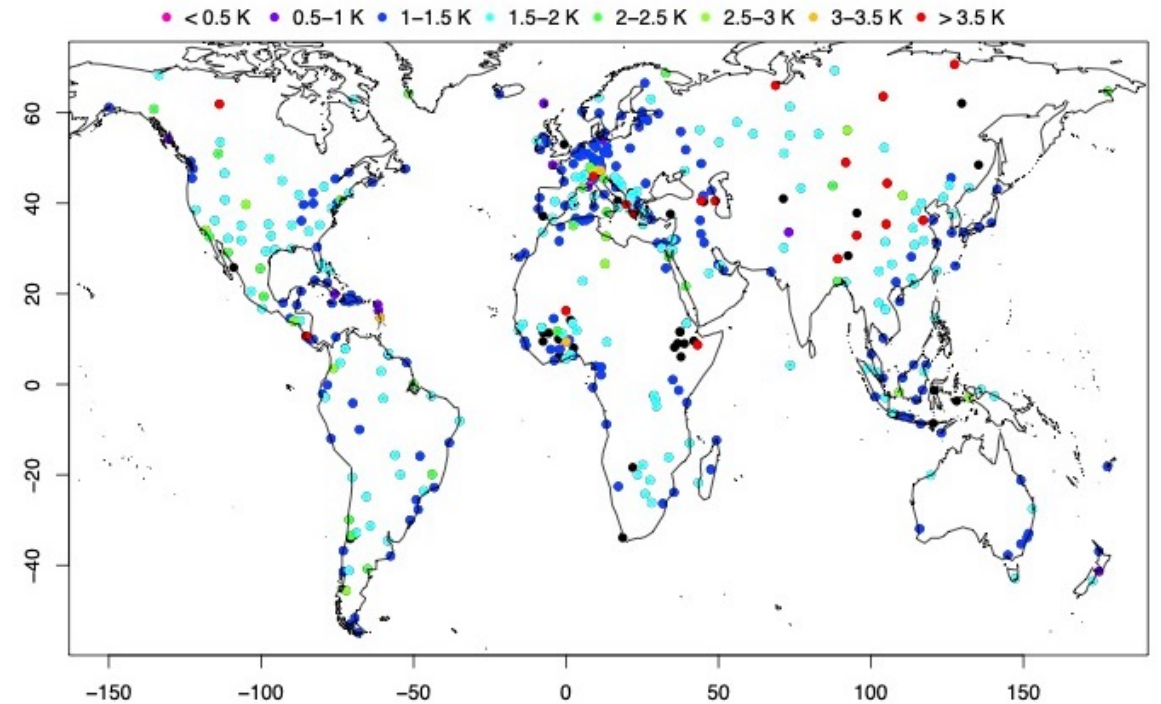


# Air temperature (12 -35h forecast hourly)

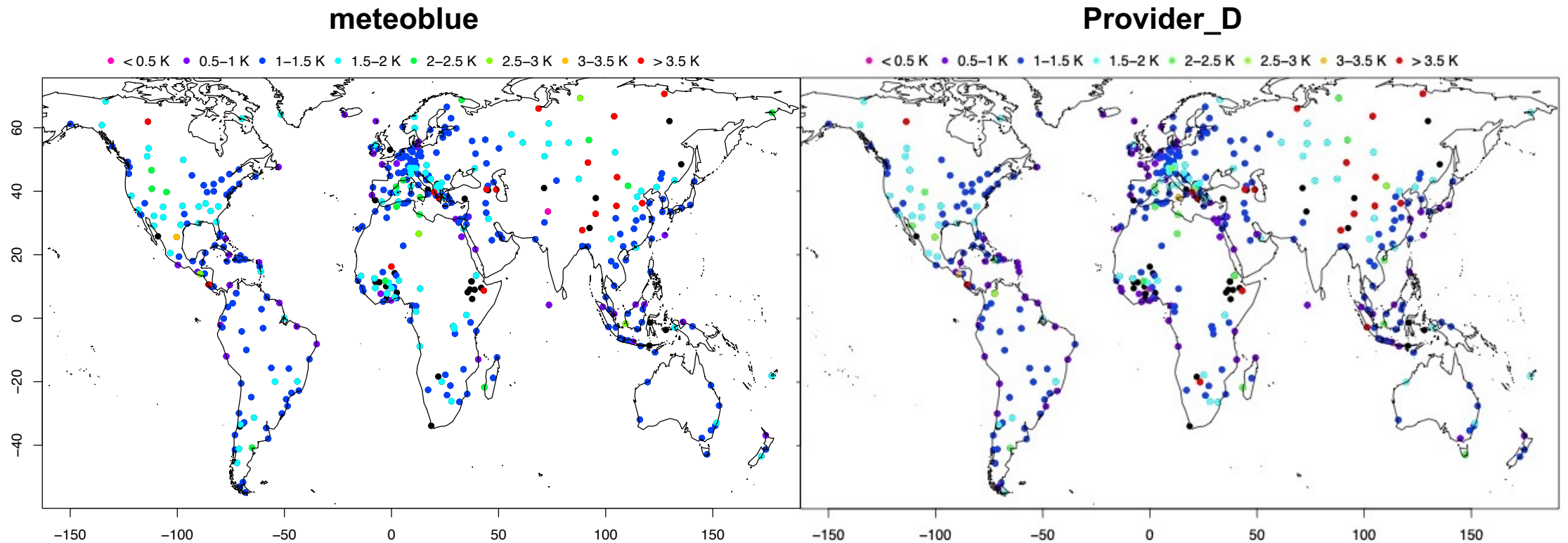
meteoblue



Provider\_F



# Air temperature (12 -35h forecast hourly)



# Daily Tmax, Tmean, Tmin

Provider	Hourly values		Daily mean values		Daily max values		Daily min values		
	[°C]	MAE	MBE	MAE	MBE	MAE	MBE	MAE	MBE
meteoblue		1.29	-0.16	0.85	-0.12	1.21	-0.43	1.30	0.22
Provider_D		1.26	-0.02	0.78	-0.06	1.14	-0.31	1.24	0.34
Provider_F		1.48	-0.21	1.08	-0.38	1.61	-0.89	1.53	0.25
Provider_C		1.61	-0.52	1.23	0.03	1.62	-0.55	1.99	0.94
Provider_G		1.73	-0.03	1.43	-0.20	1.92	-0.48	2.19	0.14
Provider_H				➤ Data missing Provider_H (add later)					

- Other providers optimise their forecast to daily min/max values, too.
- All providers predict daily maxima as too low and daily minimum temperatures as too high.



# Air temperature (hourly) MAE [°C]: forecast days 0-3

- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (worldwide)
- Station number: 475

Provider	Daily range	
	MAE [°C]	MBE [°C]
meteoblue	1.70 <span style="color: green;">2</span>	-0.65 <span style="color: green;">3</span>
Provider_D	1.69 <span style="color: green;">1</span>	-0.65 <span style="color: green;">3</span>
Provider_F	1.99 <span style="color: green;">3</span>	-0.53 <span style="color: green;">1</span>
Provider_C	2.12	-1.14
Provider_G	2.55	-1.49
Provider_H	2.58	-0.62 <span style="color: green;">2</span>

# Daily Tmax, Tmean, Tmin

**Provider analysis from 2019, different stations, different approach**

Daily minimum	Provider A	meteoblue	Wetter.com
MAE [°C]	2.78	2.40	2.97
MBE [°C]	0.31	0.99	1.89

Daily minimum	Provider A	meteoblue	Wetter.com
MAE [°C]	1.79	1.84	2.10
MBE [°C]	-0.02	-0.31	-0.26

➤ Improvement of daily minimum temperature

## Air temperature (12-35h forecast hourly) MAE [°C]

Provider	METAR	Metos	MeteoSwiss
meteoblue	1.32	1.59	1.55
Provider_D	1.26	2.00	3.23
Provider_F	1.48	1.98	2.09
Provider_C	1.59	1.91	4.30
Provider_G	1.75	2.44	2.44
Provider_B	1.77	1.94	4.07
Provider_H	2.03	3.01	4.64

- meteoblue and Provider\_F use MeteoSwiss stations: other competitors have much larger errors.
- meteoblue uses Metos stations. Decrease in model accuracy for other competitors

## Air temperature means [°C] Switzerland (January 2021)

Provider	Davos	Weissfluhjoch	Andermatt	Guetsch	Samedan	Zermatt
Measurement	-6.58	-10.56	-6.04	-7.88	-10.02	-5.27
meteoblue	-6.56	-10.18	-6.11	-8.02	-10.20	-5.81
Provider_D	-6.58	-7.01	-5.19	-5.31	-8.63	-10.97
Provider_F	-4.80	-11.34	-3.58	-7.96	-5.42	-3.73
Provider_C	-8.44	-8.44	-8.54	-8.56	-11.33	-11.82
Provider_G	-6.46	-12.76	-4.73	-9.18	-7.41	-5.69
Provider_H	-9.69	-9.69	-9.33	-9.52	-15.35	-13.05

➤ Forecast temperature lapse is not working well for most providers.

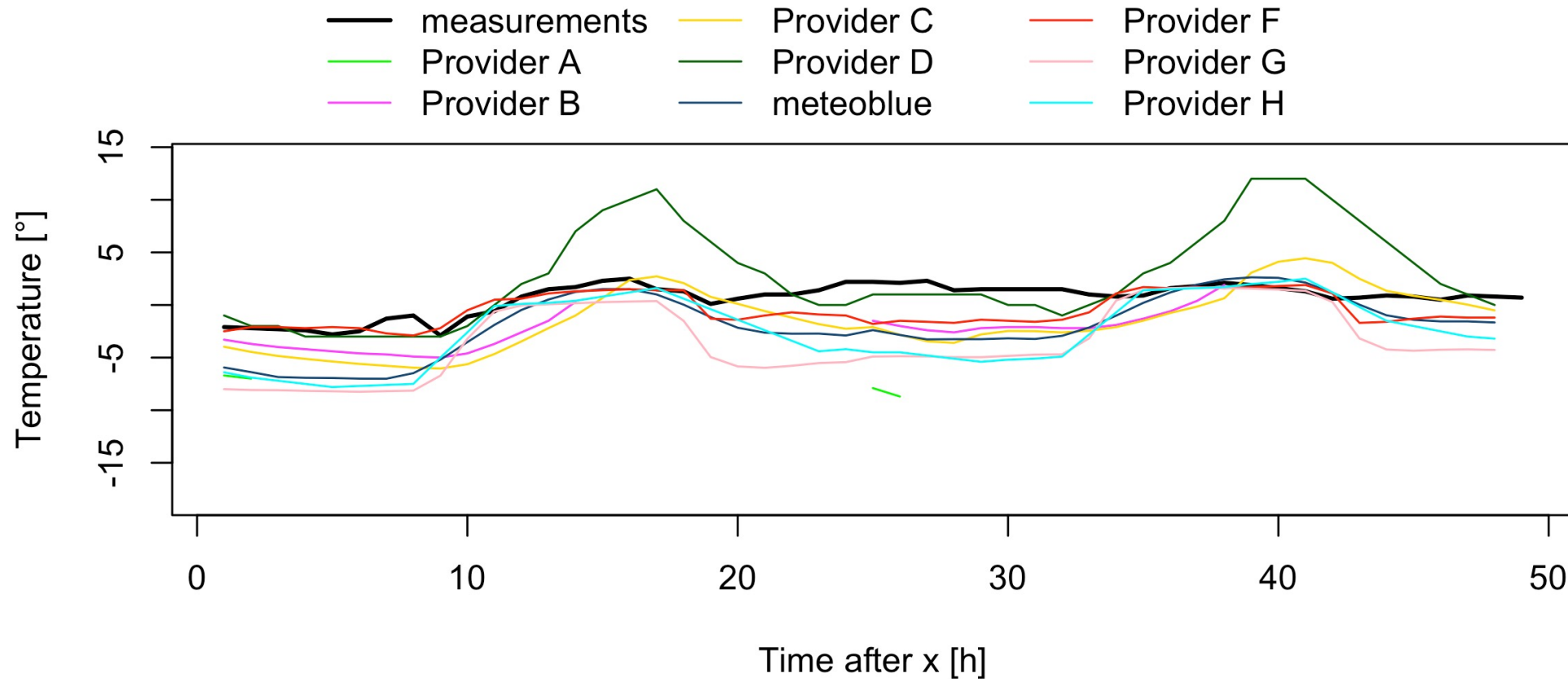
## Air temperature means [°C] Switzerland (April 2021)

Provider	Davos	Weissfluhjoch	Andermatt	Guetsch	Samedan	Zermatt
Measurement	0.91	-6.57	0.82	-3.79	-0.53	2.82
meteoblue	0.58	-5.88	-0.19	-3.91	-1.24	1.28
Provider_D	0.40	-0.61	0.36	0.11	-0.49	-1.60
Provider_F	-1.10	-7.60	-0.15	-4.81	-0.65	-0.12
Provider_C	-1.58	-1.58	-1.99	-2.57	-3.48	-6.95
Provider_G	-1.08	-7.30	-0.65	-5.06	-1.91	-0.57
Provider_H	-3.08	-3.08	-3.26	-3.84	-5.98	-7.13

➤ Forecast temperature lapse is not working well for most providers.

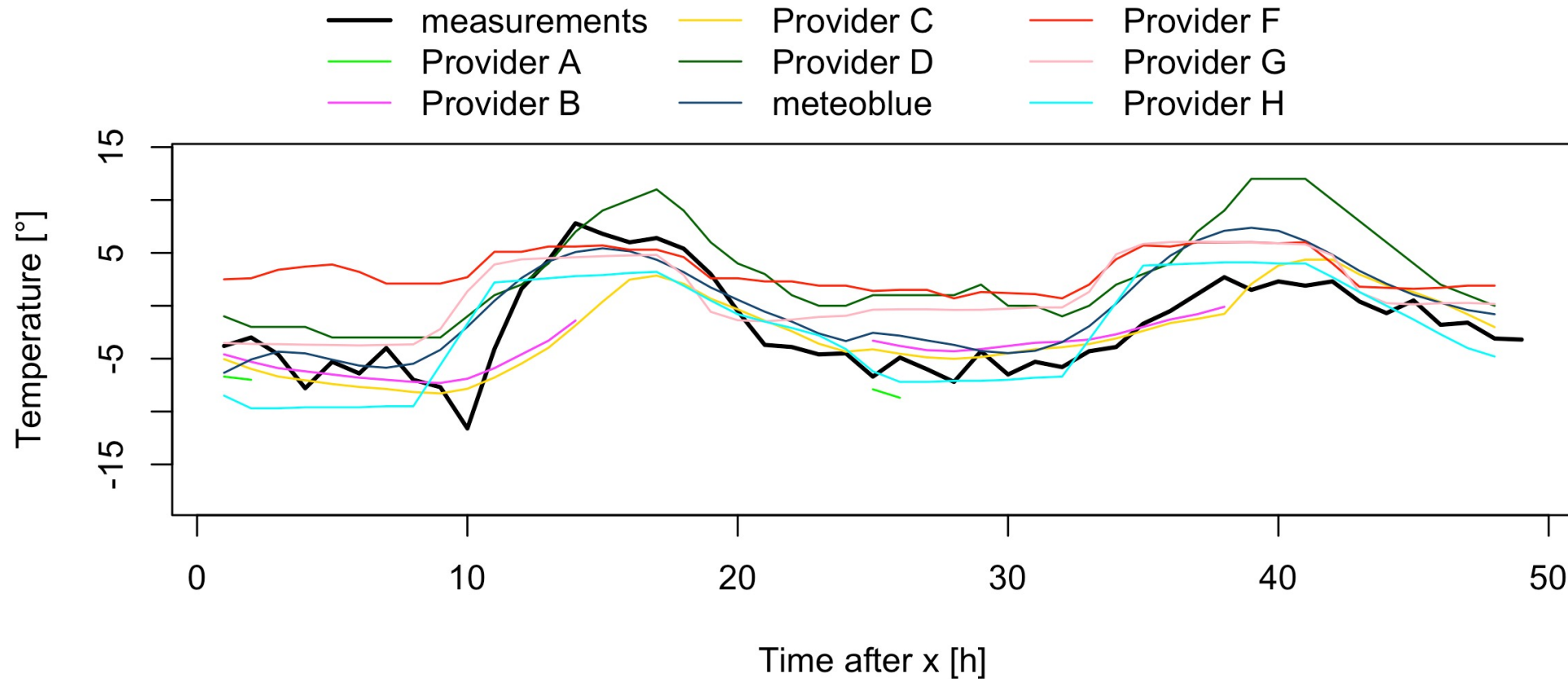
# Air temperature time series (forecast & MeteoSwiss): March

## Guetsch

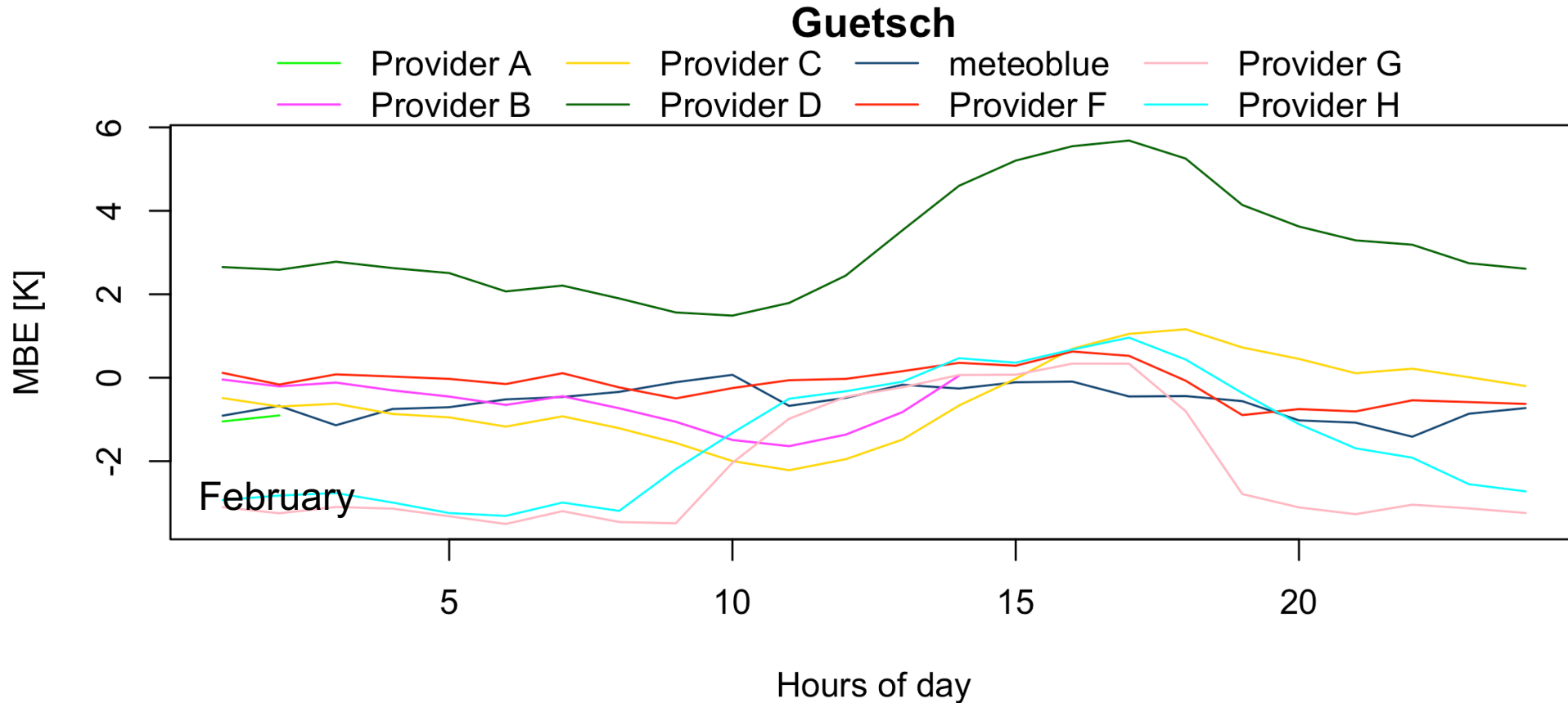


# Air temperature time series (forecast & MeteoSwiss): March

## Andermatt

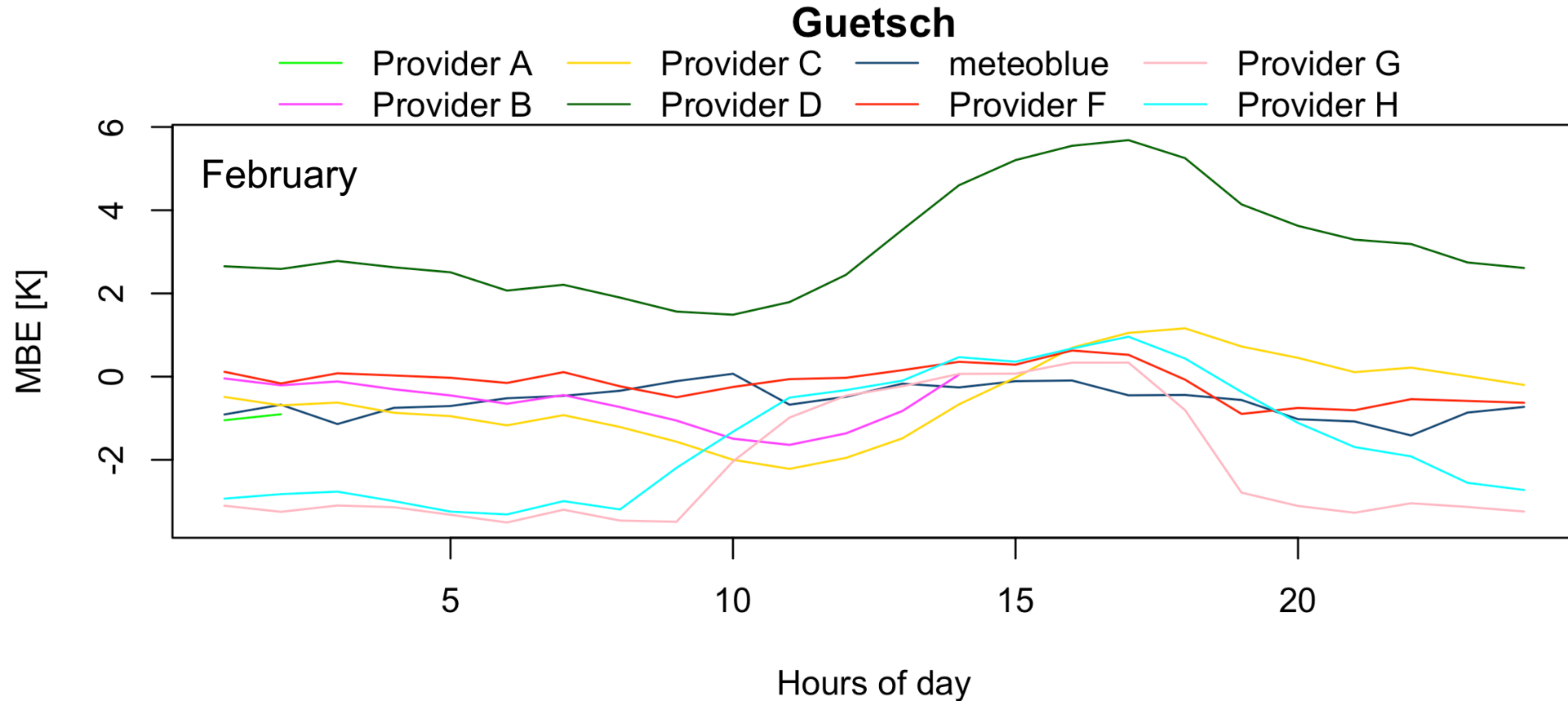


# Air temperature (12 -35h forecast hourly): Diurnal cycle of MBE

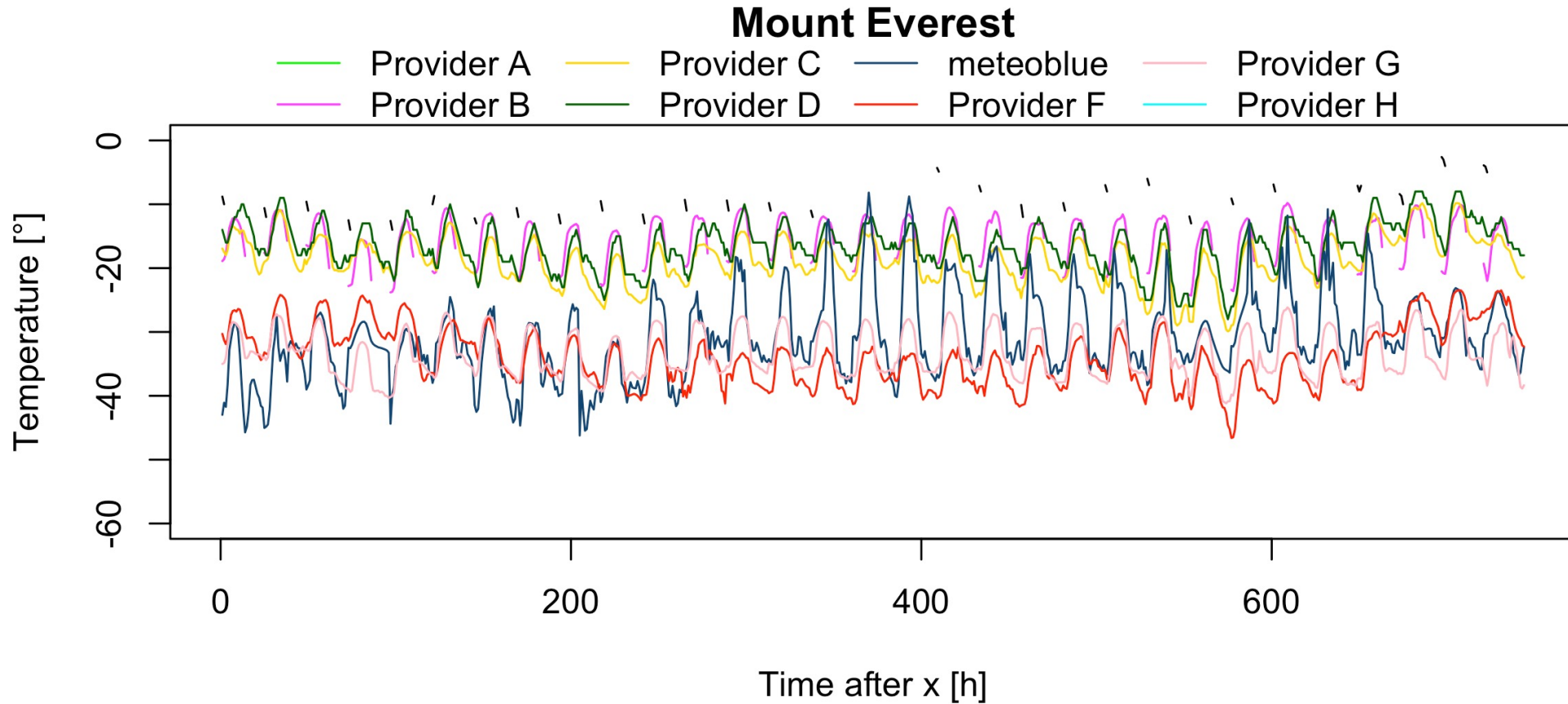




# Air temperature (12 -35h forecast hourly): Diurnal cycle of MBE



# Air temperature (12 -35h forecast hourly): January



# Dewpoint temperature (12-35h forecast hourly): providers

- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (worldwide)
- Station number: 475

Provider	MAE [°C]	MBE [°C]	Percentage below 1.5°C	Percentage below 1°C
1 meteoblue	1.43	-0.21	62	37
Provider_D	1.88	0.20	49	23
2 Provider_A	1.52	-0.35	60	45
3 Provider_C	1.78	-0.32	53	31
Provider_G	2.19	-1.29	45	24
Provider_B	2.10	-1.15	49	28
Provider_H	2.09	-0.90	44	23

- Best model performance for dewpoint temperature for meteoblue

# Dewpoint temperature (12-35h forecast hourly): Sources

- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR , MeteoSwiss
- Station number: 475 (WW) / 8 (CH)

...

Provider	METAR	MeteoSwiss
meteoblue	1.55 <span style="color: green;">1</span>	2.37 <span style="color: green;">1</span>
Provider_D	1.93 <span style="color: green;">3</span>	3.32 <span style="color: green;">2</span>
Provider_A	2.08	4.47
Provider_C	1.88 <span style="color: green;">2</span>	3.76 <span style="color: green;">3</span>
Provider_G	2.20	3.61
Provider_B	2.08	3.73
Provider_H	2.16	4.31

## Dewpoint (12-35h forecast hourly): forecast days 0-3

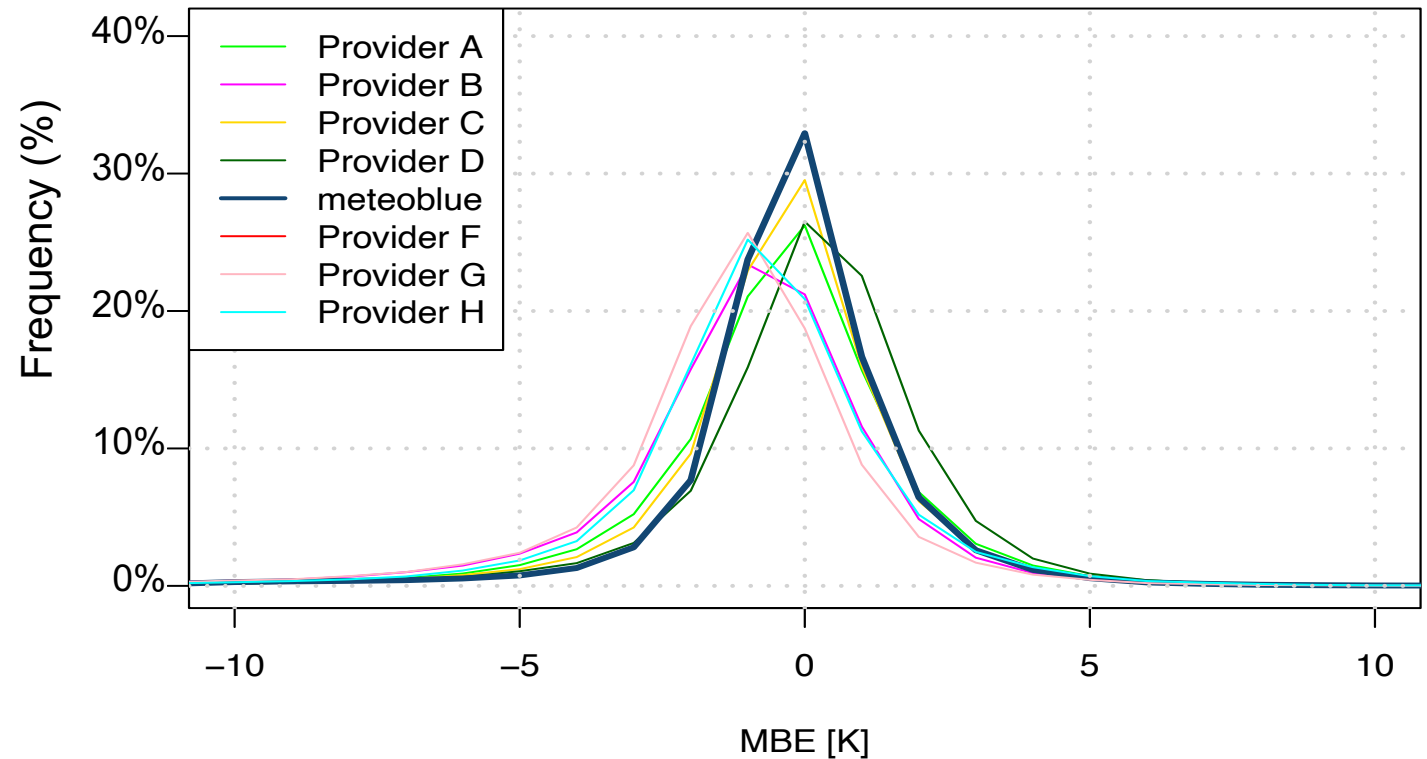
- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (worldwide)
- Station number: 475

Provider	Day 0 (0 – 11 h)	Day 1 (12 – 35 h)	Day 2 (36 – 47 h)	Day 3 (48 – 71 h)
meteoblue	1.44 <span style="color: green;">1</span>	1.43 <span style="color: green;">1</span>	1.55 <span style="color: green;">1</span>	1.67 <span style="color: green;">1</span>
Provider_D	1.89	1.88	1.97 <span style="color: green;">2</span>	2.07 <span style="color: green;">2</span>
Provider_A	1.60 <span style="color: green;">2</span>	1.52 <span style="color: green;">2</span>	-	-
Provider_F				
Provider_C	1.73 <span style="color: green;">3</span>	1.78 <span style="color: green;">3</span>	1.87 <span style="color: green;">3</span>	2.11 <span style="color: green;">3</span>
Provider_G	1.91	2.19	2.20	-
Provider_B	2.13	2.10	-	-
Provider_H	2.02	2.09	2.18	2.08

# Dewpoint temperature: provider MBE

- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (worldwide)
- Station number: 475

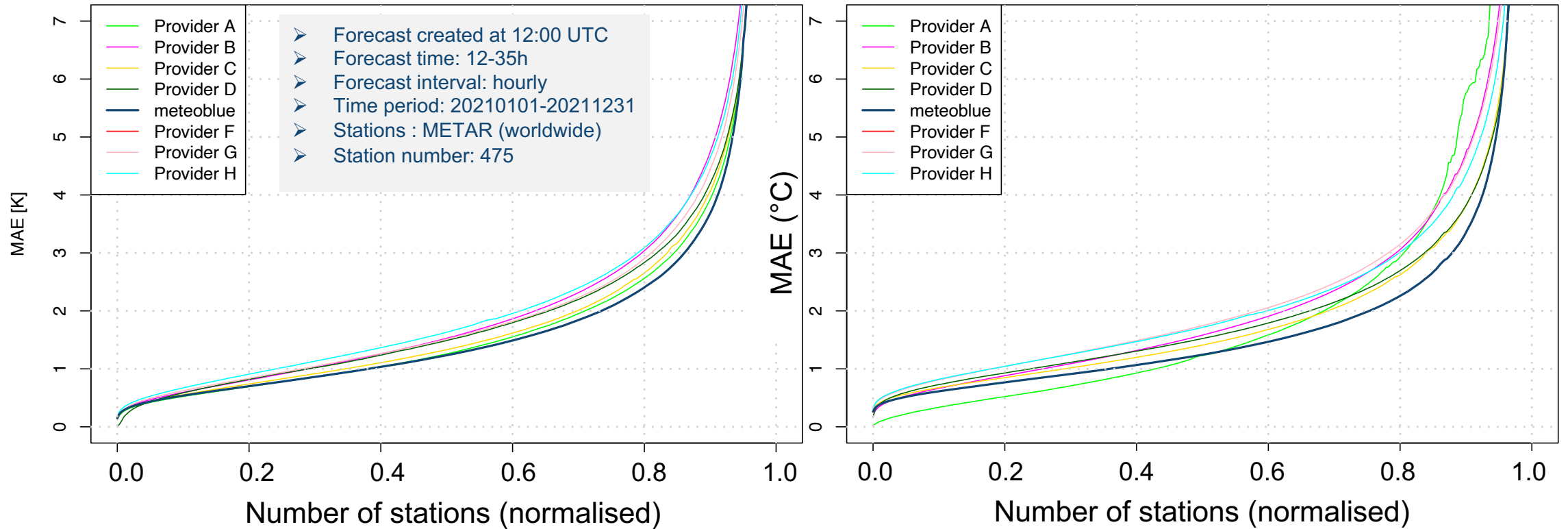
MBE (K) 12-35 h forecast dewpoint



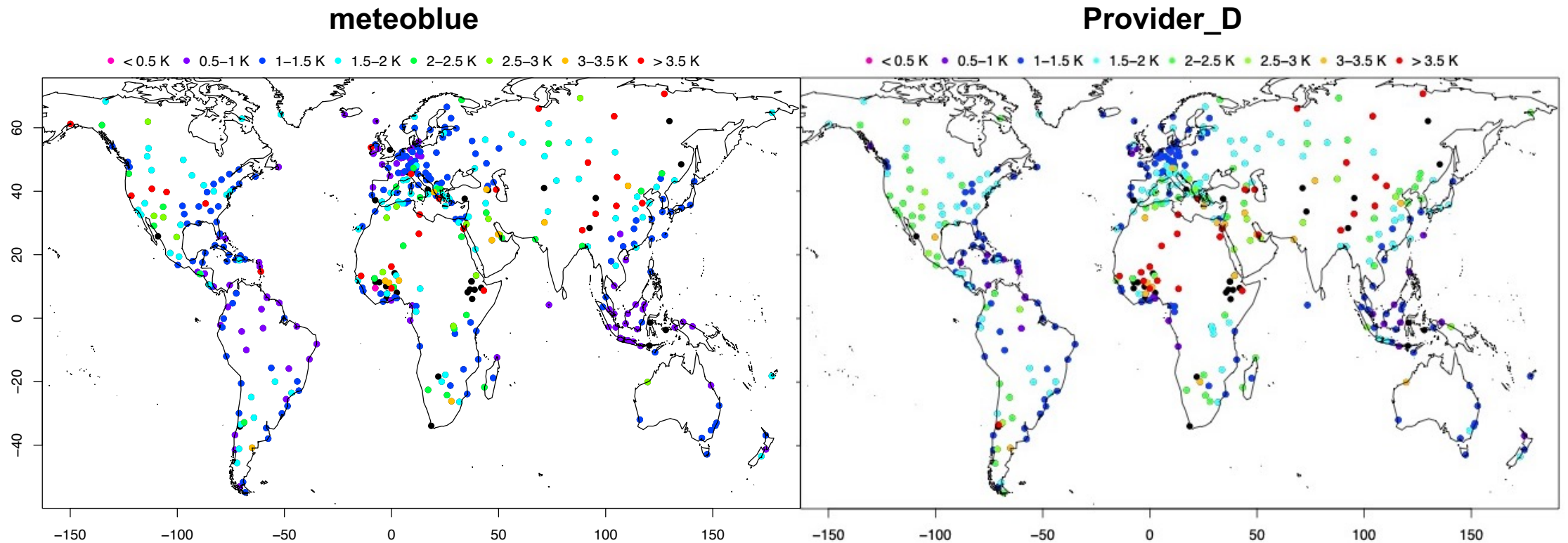
# Dewpoint temperature (0-11, 12-35h forecast hourly): MAE

01-11 h forecast dewpoint

12-35 h forecast dewpoint



# Air temperature (12 -35h forecast hourly)





# Precipitation (12-35h forecast): monthly sums (Jan-Apr)

- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20210430
- Stations : METAR (North America)
- Station number: 36

...

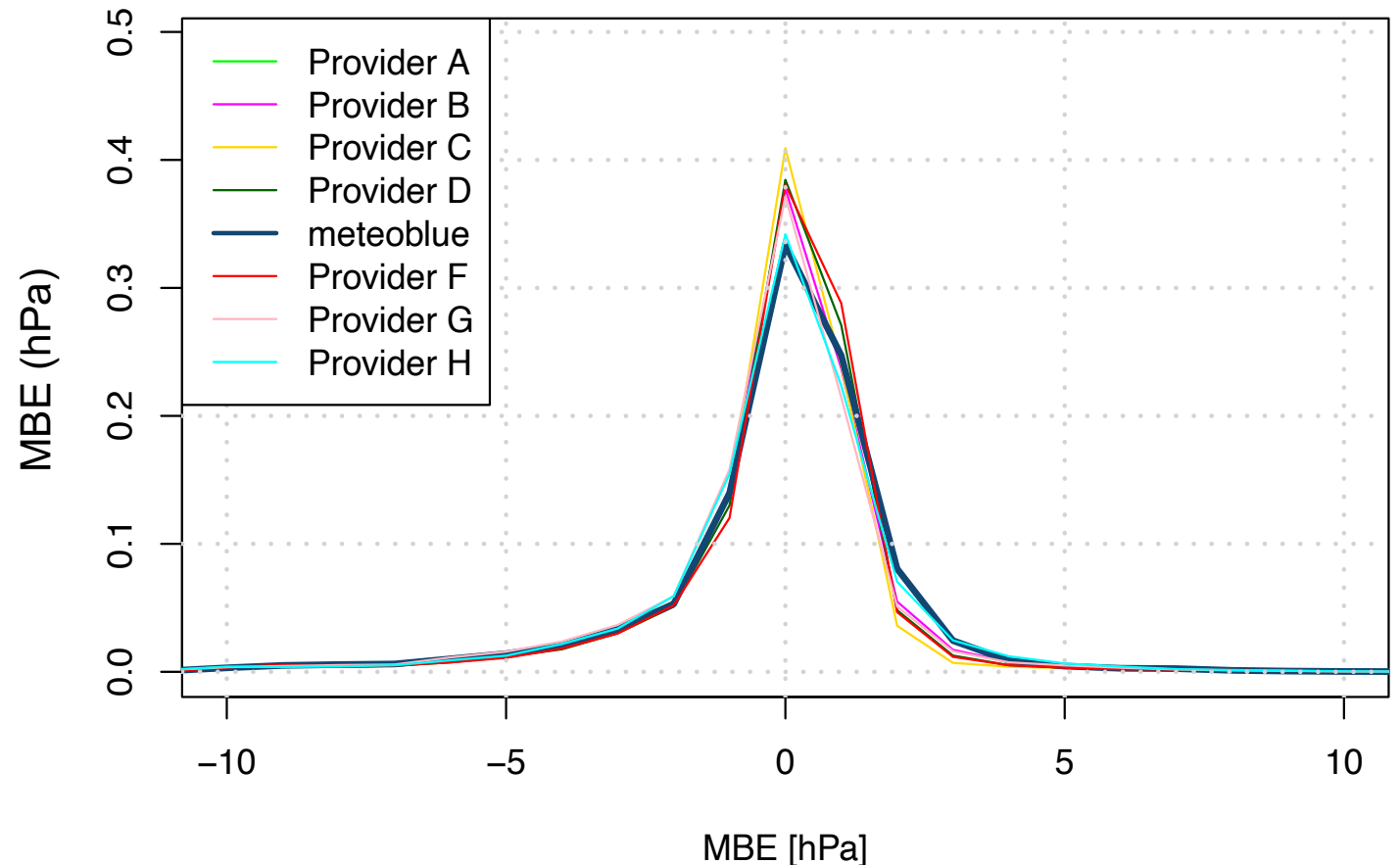
- Interim results

Provider	MAE [mm]	MBE [mm]
meteoblue	42.01	33.47
Provider_D	2 38.67	2 29.42
Provider_F	1 36.00	1 25.95
Provider_C	3 39.33	3 28.66
Provider_G	45.99	-45.99
Provider_B	23.02	-7.24
Provider_H	201.08	200.91

# Air pressure (12-35h forecast hourly):

- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20210430
- Stations : METAR (N-America)
- Station number: 36

MBE [hPa] 12-35h forecast press



## Precipitation (12-35h forecast): N-America (36 stations)

Provider	Events > 0.1 mm			Events > 1 mm			Events > 10 mm		
	HSS	POD	FAR	HSS	POD	FAR	HSS	POD	FAR
meteoblue	<b>0.4088</b>	0.5526	0.5867	<b>0.2452</b>	0.4134	0.8027	<b>0.0060</b>	0.0031	0.9091
Provider_D	<b>0.4389</b>	0.6077	0.5733	<b>0.2903</b>	0.3929	0.7458	<b>0.0187</b>	0.0125	0.9583
Provider_A	<b>0.3090</b>	0.3416	0.5932	<b>0.1748</b>	0.3142	0.8513	<b>-0.0011</b>	0.0000	1.0000
Provider_F	<b>0.4427</b>	0.6047	0.5676	<b>0.2964</b>	0.3944	0.7386	<b>0.0414</b>	0.0261	0.8961
Provider_C	<b>0.3991</b>	0.4803	0.5625	<b>0.2622</b>	0.3298	0.7579	<b>0.0378</b>	0.0363	0.9581
Provider_G	<b>0.4331</b>	0.6586	0.5986	<b>0.2987</b>	0.4039	0.7387	<b>0.0292</b>	0.0165	0.8636
Provider_B	<b>0.2972</b>	0.6737	0.7241	<b>0.1741</b>	0.4528	0.8706	<b>0.0114</b>	0.0303	0.9917

Forecast created at 12:00 UTC, 12-35h, hourly; Time period: 20210101-20211231,  
36 Stations : METAR (North America)

## Precipitation sums [mm] Switzerland (March 2021)

Provider	Davos 1590 m	Weissfluhjoch 2691 m	Andermatt 1400 m	Guetsch 2691 m	Samedan 1750 m	Zermatt 1800 m
Measurement	159.60	250.80	187.30	254.00	38.80	140.60
meteoblue	<b>243.65</b>	<b>218.07</b>	<b>242.04</b>	<b>202.72</b>	<b>144.53</b>	<b>176.29</b>
Provider_D	275.89	306.95	274.07	254.46	192.68	285.46
Provider_F	142.67	247.51	118.97	165.34	68.40	148.63
Provider_C	273.00	273.04	337.57	358.74	133.43	215.31
Provider_H	396.00	396.00	1051.80	1202.00	460.50	314.70

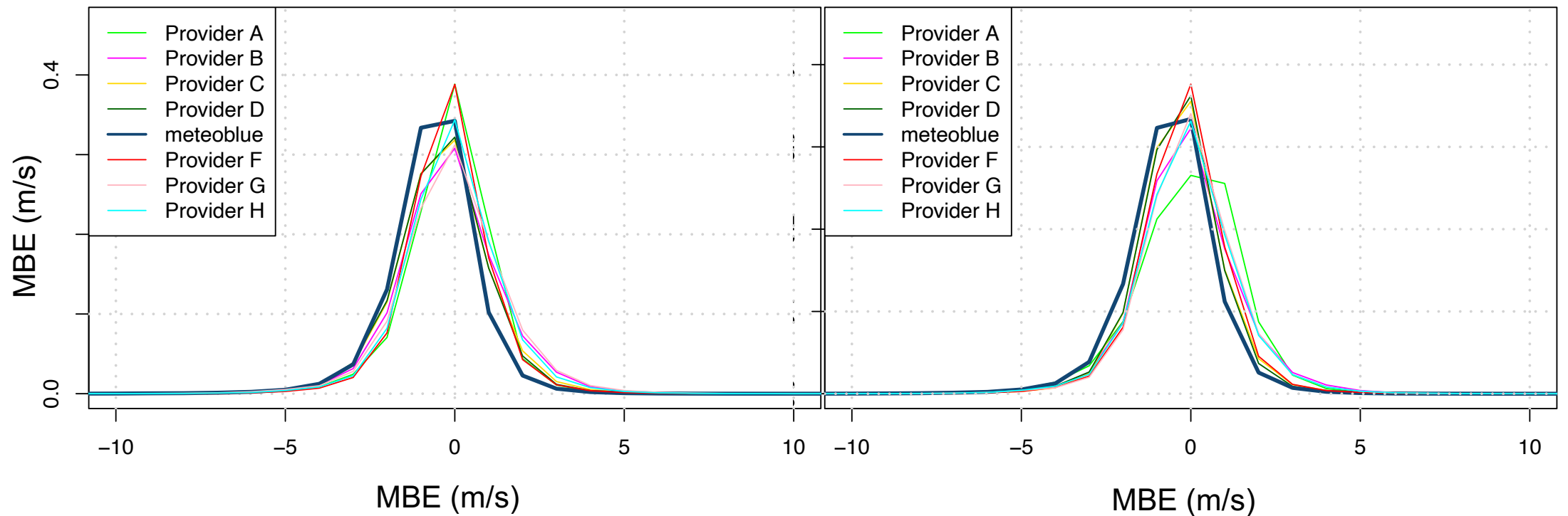
➤ Decreasing relative precipitation amount with elevation in meteoblue forecast.

Forecast created at 12:00 UTC, 12-35h, hourly; Time period: 20210301-20210331,  
6 Stations : Meteosuisse (Switzerland)

# Wind speed (0-11h, 12-35h forecast hourly): MBE

MBE [m/s] 0-11h forecast wspeed

MBE [m/s] 12-35h forecast wspeed



Forecast created at 12:00 UTC, 12-35h, hourly; Time period: 20210101-20211231, 475 Stations : METAR (world).

## Wind speed (12-35h forecast hourly)

provider	MAE [m/s]	MBE [m/s]	Percentage <1.5 m/s	Percentage < 1.0 m/s	Pearson corr. (all events)	Pearson corr. (> 3 m/s)
meteoblue	1.36	-0.53	67	34	0.65	0.59
Provider_D	1.41	-0.42	67	29	0.64	0.60
Provider_A	1.16	0.04	70	48	0.70	0.63
Provider_F	1.38	-0.29	69	32	0.65	0.60
Provider_C	1.41	-0.36	67	29	0.64	0.59
Provider_G	1.48	-0.09	63	28	0.63	0.56
Provider_B	1.40	-0.14	68	37	0.63	0.56
Provider_H	1.51	-0.11	60	27	0.61	0.51

Forecast created at 12:00 UTC, 12-35h, hourly; Time period: 20210101-20211231, 475 Stations : METAR (world).  
Pearson Correlation

➤ meteoblue underestimates wind speed

## Wind speed (12-35h forecast hourly): HSS, POD, FAR

Provider	Events > 3 m/s			Events > 6 m/s			Events > 10 m/s		
	HSS	POD	FAR	HSS	POD	FAR	HSS	POD	FAR
meteoblue	0.4418	0.5843	0.1620	0.3894	0.3276	0.2955	0.2366	0.1521	0.4098
Provider_D	0.4640	0.7498	0.2466	0.4592	0.4558	0.3748	0.2993	0.2124	0.4534
Provider_A	0.5268	0.7364	0.2316	0.4521	0.3930	0.3143	0.3045	0.2171	0.4565
Provider_F	0.4719	0.6917	0.2103	0.4471	0.4230	0.3505	0.2937	0.2087	0.4645
Provider_C	0.4457	0.6507	0.1989	0.4157	0.3832	0.3517	0.2751	0.1890	0.4497
Provider_G	0.4469	0.6909	0.2298	0.4386	0.4690	0.4307	0.3337	0.3053	0.6072
Provider_B	0.4521	0.6812	0.2359	0.4403	0.4518	0.4177	0.3223	0.2853	0.6055
Provider_H	0.4326	0.6913	0.2331	0.4241	0.4552	0.4367	0.3191	0.2896	0.6176

Forecast created at 12:00 UTC, 12-35h, hourly; Time period: 20210101-20211231, 475 Stations : METAR (world).  
HSS = Heidke Skill Score; POD= Probability of Detection; FAR = False Alarm Rate.

# Wind gusts (12-35h forecast hourly)

- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (worldwide)
- Station number: 475

Provider	MAE [m/s]	MBE [m/s]	Percentage <4 m/s	Percentage <2 m/s
2 meteoblue	3.32	-2.33	69	35
1 Provider_D	2.90	-0.57	77	45
Provider_A	5.02	-4.34	45	18
3 Provider_C	3.35	-1.56	69	40
Provider_B	4.18	-3.15	23	7
Provider_H	4.97	-4.42	47	17

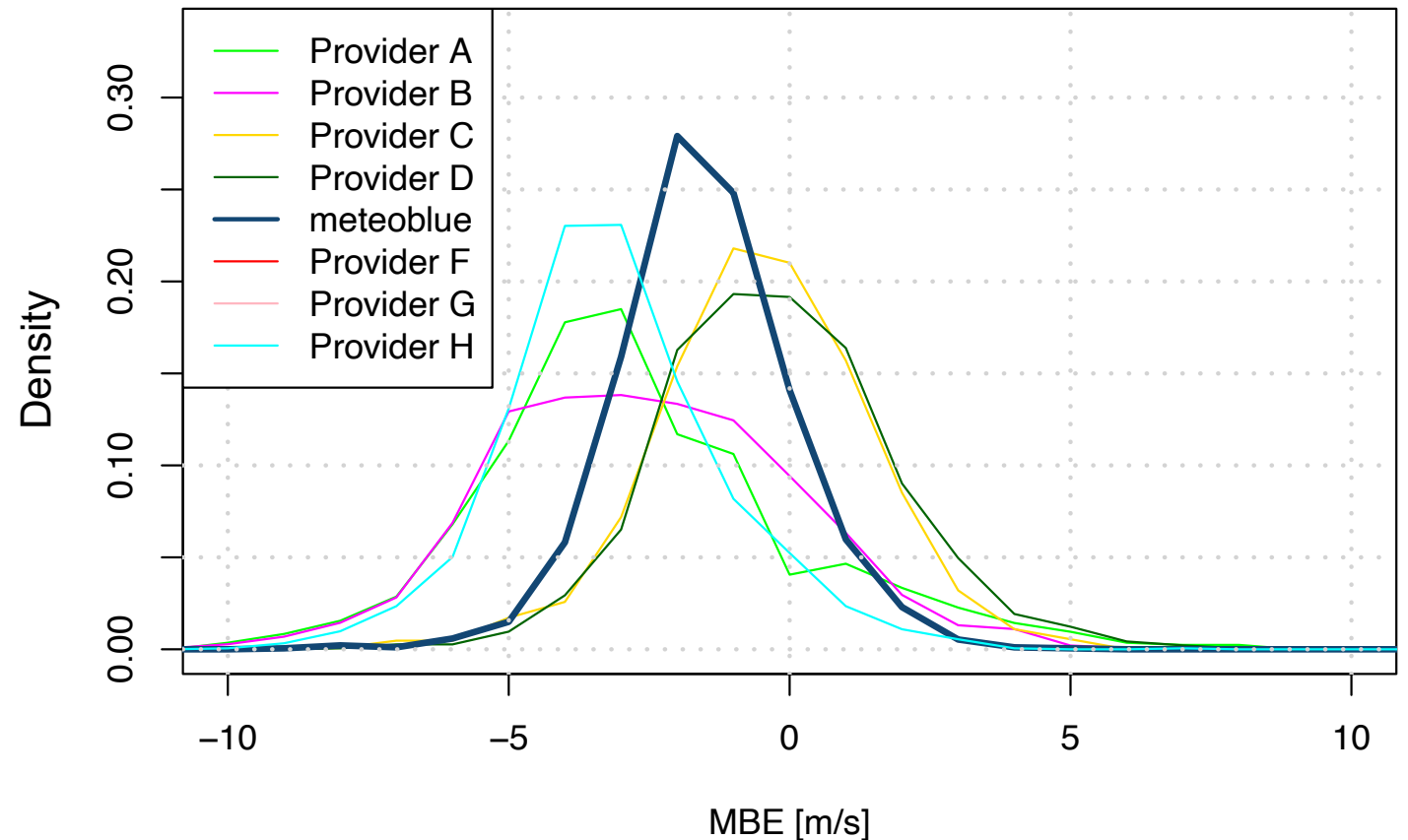
➤ All providers underestimate wind gusts



# Wind gusts (12-35h forecast hourly): MBE

MBE [m/s] 12-35h forecast wgust

- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (worldwide)
- Station number: 475



# Wind gusts (12-35h forecast hourly)

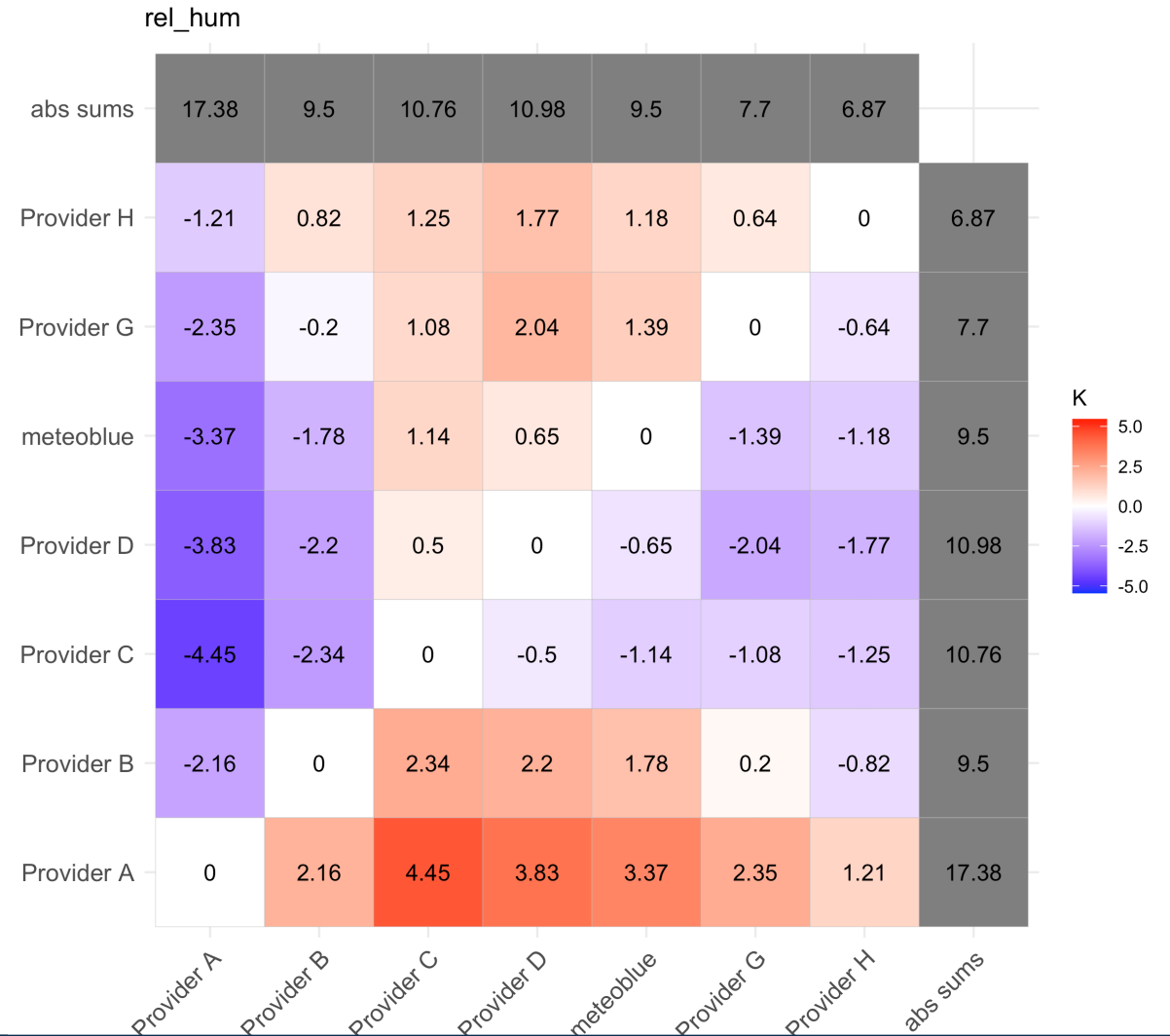
- Forecast created at 12:00 UTC
- Forecast time: 12-35h
- Forecast interval: hourly
- Time period: 20210101-20211231
- Stations : METAR (worldwide)
- Station number: 475

Provider	MAE [°]	MBE [°]	Percentage below 90°	Percentage below 45°
meteoblue	44.81	0.60	94	68
Provider_D	43.13	1.71	95	71
Provider_A	35.25	3.12	92	78
Provider_F	43.20	1.56	95	71
Provider_C	43.61	0.53	95	70
Provider_G	44.90	2.10	94	67
Provider_B	46.76	0.72	90	63
Provider_H	46.14	2.86	92	62

# Relative humidity

## Provider comparison without measurements

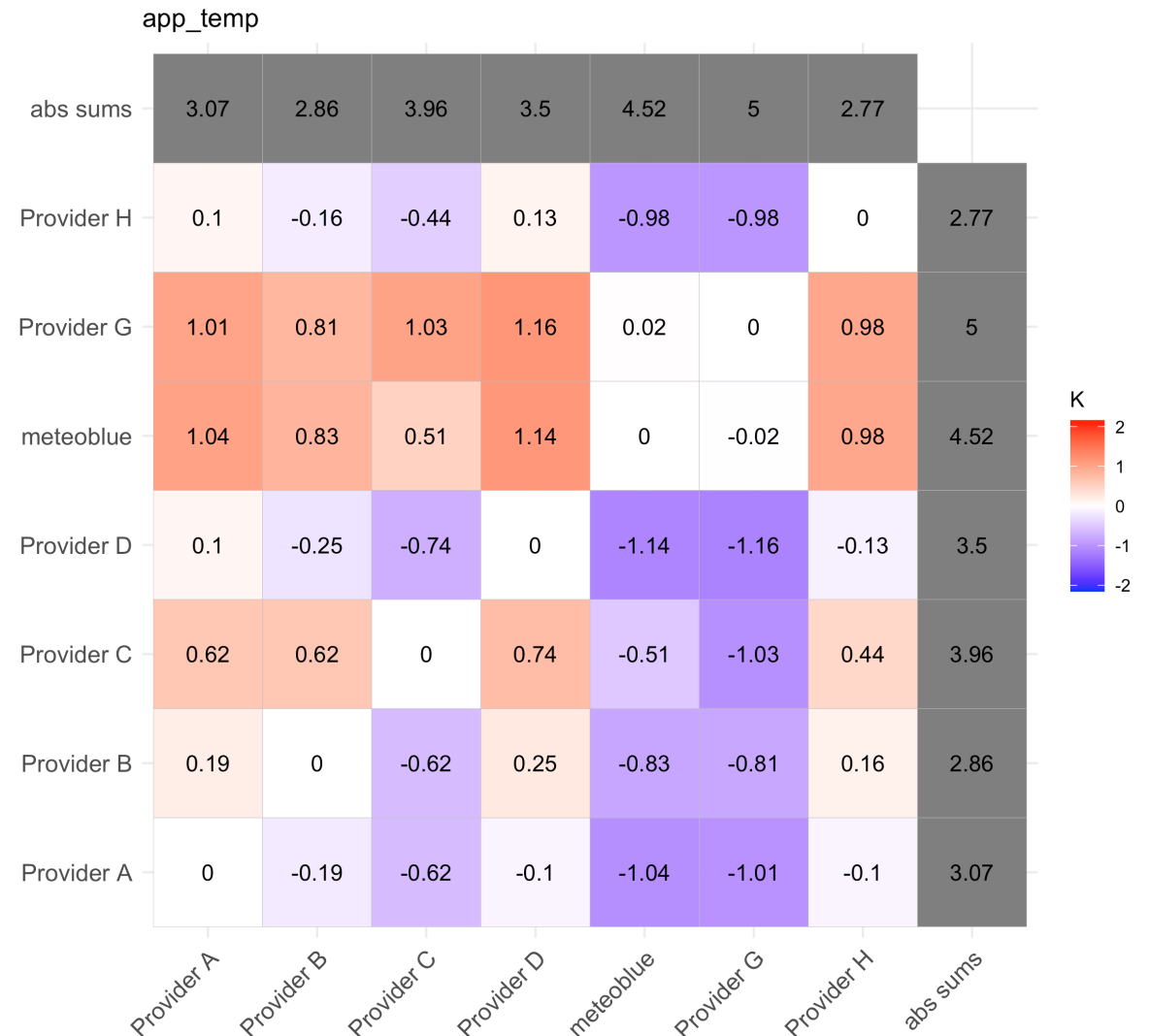
- Provider\_A shows highest relative humidities
- Provider\_G is most similar to the other competitors on average



# Apparent temperature

## Provider comparison without measurements

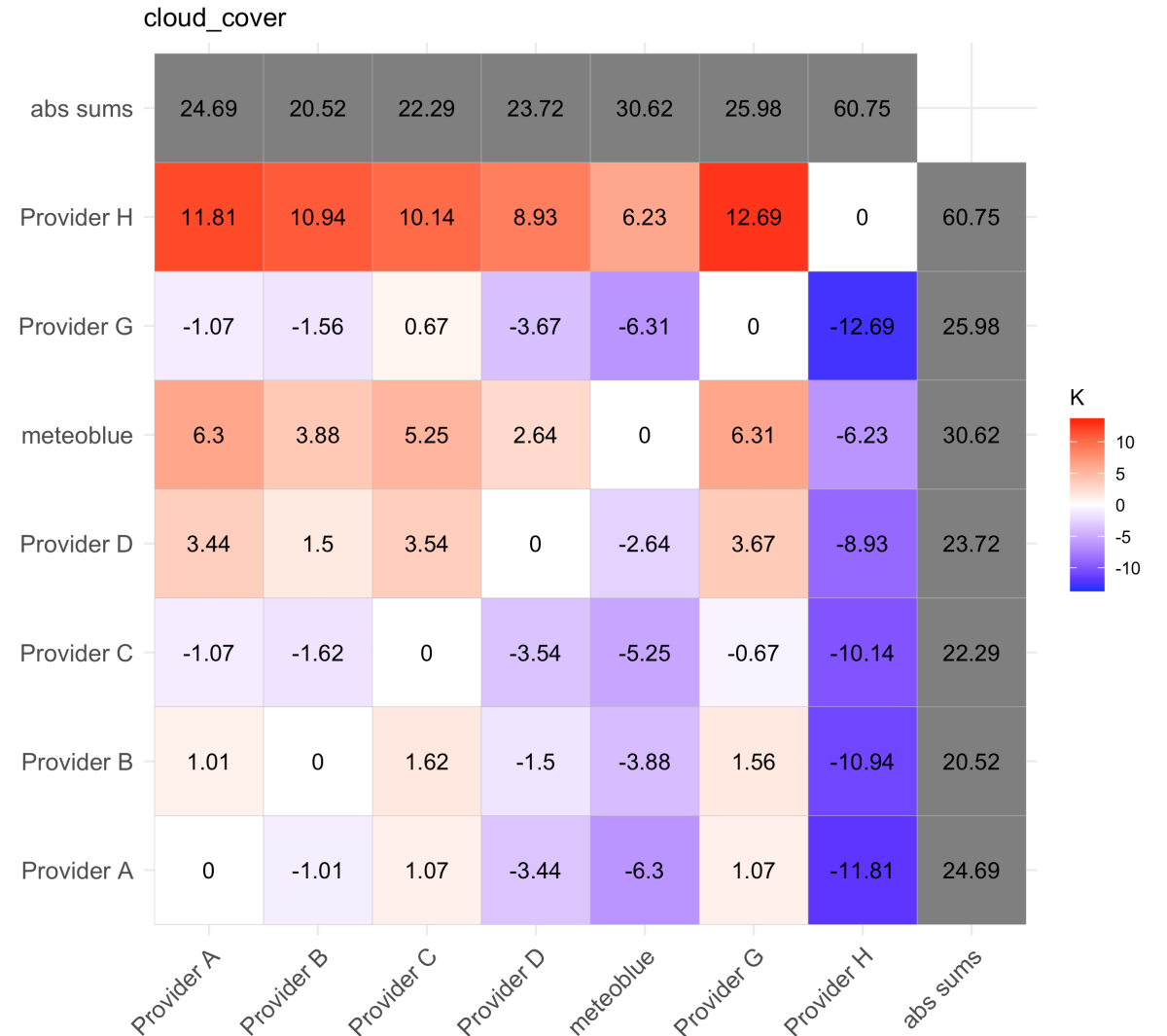
- meteoblue predicts on average 1°C warmer apparent temperatures than Provider\_D



# Cloud cover

## Provider comparison without measurements

- meteoblue predicts on average 6% more cloud cover than Provider\_D



# Key Conclusions

1. meteoblue amongst top 2 for temperature 24 h forecast accuracy
2. meteoblue best for temperature 12 h forecast accuracy
3. meteoblue best for precipitation 24 h forecast accuracy
4. meteoblue best for wind speed 24 h forecast accuracy
5. meteoblue has best temperature downscaling in the mountains
6. meteoblue precipitation 24 h forecast accuracy better than ERA5
7. Global models = ICON almost as good as ERA5, better than GFS and NEMS.
8. Substantial differences between regions.