



Will Alpine Snow Depth Updates in ERA5/ERA5T Influence Higher Winds Across Europe and Beyond?

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2024-11-20
Vindkraftnet @ EMD International A/S, Aalborg





Setting the Scene (1/3) – ECMWF Announcement in October 2024

Summary

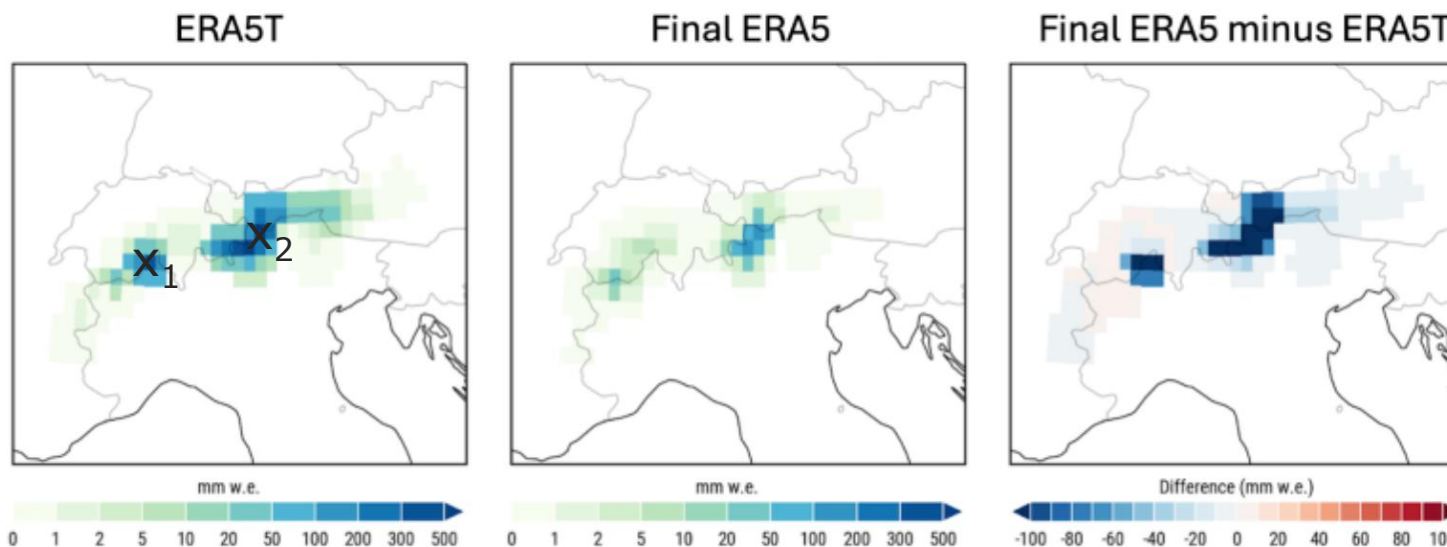
Quality control by the ECMWF Reanalysis team flagged an issue with snow data for an area in the Alps from July 2024 that was not consistent with the weather pattern for the region. Subsequent investigation revealed the cause of the problem, enabling the Reanalysis team to correct the data before the final ERA5 release was made available.

As a result, for the months **July, August, September and October 2024**, the final ERA5 product is (and will be) different from ERA5T (the preliminary version of ERA5 made available about 5 days after real time). The differences are mostly limited to the Alps and mainly to surface parameters (in particular snow depth and 2m temperature and 2m dewpoint temperature). However, all the resulting reanalysis fields do differ slightly over the whole globe but these differences should be within their range of uncertainty (which is estimated by the ensemble spread and which can be large for some parameters). On the Climate Data Store (CDS), the initial (ERA5T) fields have been/will be overwritten, i.e., for these months, access to the original CDS ERA5T product will not be possible after it has been overwritten.



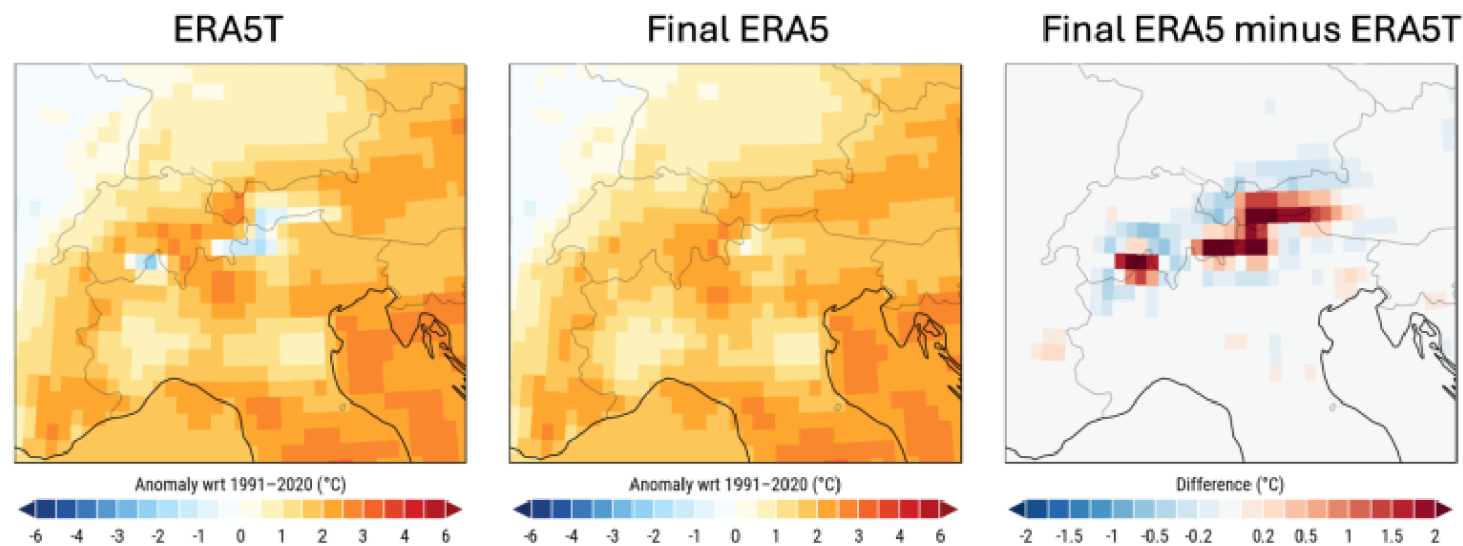
Setting the Scene (2/3) – ECMWF Analysis Plots

July snow depth



x_1 : E8.2 N46.4
 x_2 : E10.5 N46.7

July surface air temperature anomalies





Setting the Scene (3/3) – Our actions on this

- **Inform users and stakeholders**
- **Replace all ERA5T samples within the windPRO datasets (when available)**
 - This issue influences July, August, September & October ERA5T (preliminary) data
 - ERA5 (final) data will be available with a latency of 3 months, i.e. final data is available in 4 batches at months of November 2024 to February 2025
- **Re-do our mesoscale pre-run datasets (when final data is available)**
- **Repeat above x 4**
(November, December, January, February)
- **Quantify the (small) differences seen from the use-case of renewables**
- **(smells like something we have seen before)**



Questionnaire (1/2) – four short questions



<https://forms.office.com/e/43yZSS8FaC>

1. Will Alpine Snow Depth Updates in ERA5/ERA5T Influence Higher Winds Across Europe and Beyond? (Yes/No)
2. My ERA5/ERA5T use-case (or analysis) relies on the accuracy of..... (some options)
3. Will the ERA5/ERA5T Snow Depth Issue impact wind speeds in mesoscale derived datasets? (some options)
4. Any other comments or inputs?



Re-visit previous ERA5/ERA5T Event from December 2021 (1/5)

From: Copernicus Support (Legacy) <copernicus-support@ecmwf.int>
Sent: Wednesday, 1 December 2021 12.07
To: era5-users@lists.ecmwf.int
Subject: IMPORTANT: Final validated ERA5 product to differ from ERA5T for Sep-Dec 2021

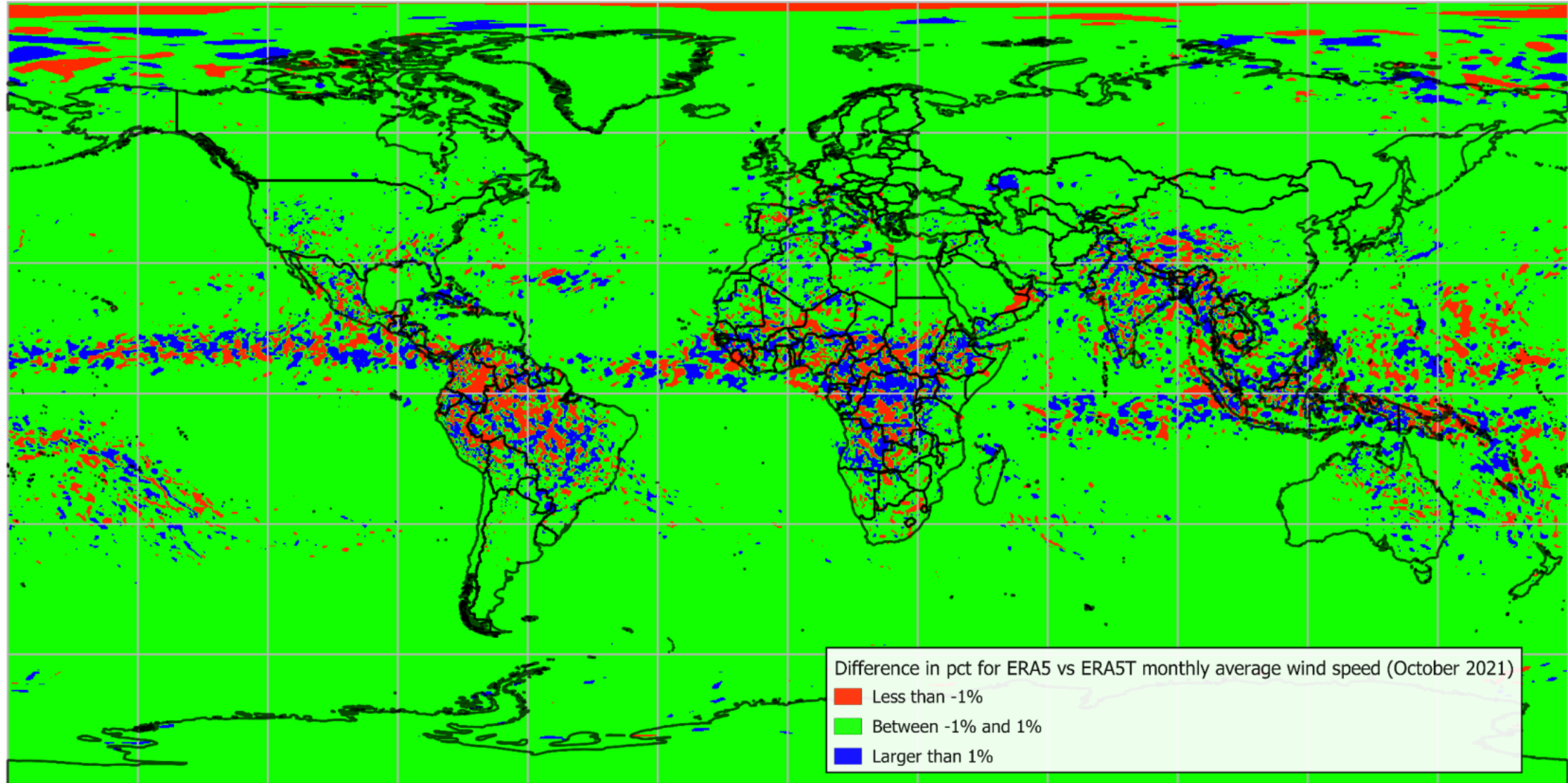
Dear ERA5 user,

We are writing to you because you may have downloaded preliminary data (ERA5T) from September 2021 onwards which, following continuous monitoring by the ECMWF Reanalysis team was identified as needing correction due to the assimilation of **anomalous snow depth observations over Central Asia**.

As a result of this, for September, October, November and at least part of December 2021, the final ERA5 product will differ from ERA5T. Although the affected area of ERA5T is limited to a few relatively small areas and affects mainly surface parameters such as snow depth, soil moisture and to a lesser extent 2-metre temperature and humidity, the results of the final, corrected, release (where the anomalous station observations were now withdrawn) will vary slightly everywhere around the globe for most parameters.

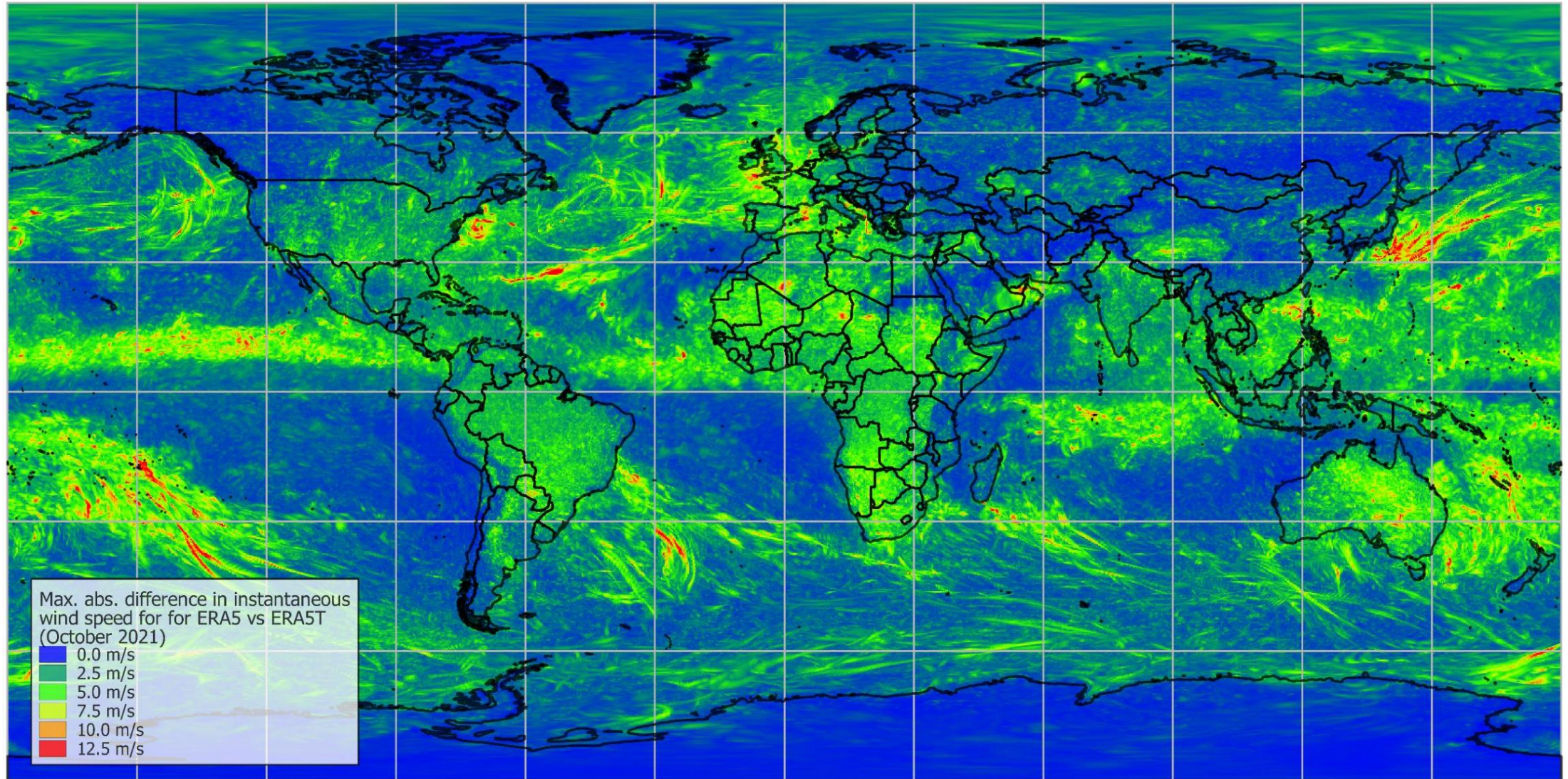


Re-visit previous ERA5/ERA5T Event from December 2021 (2/5)





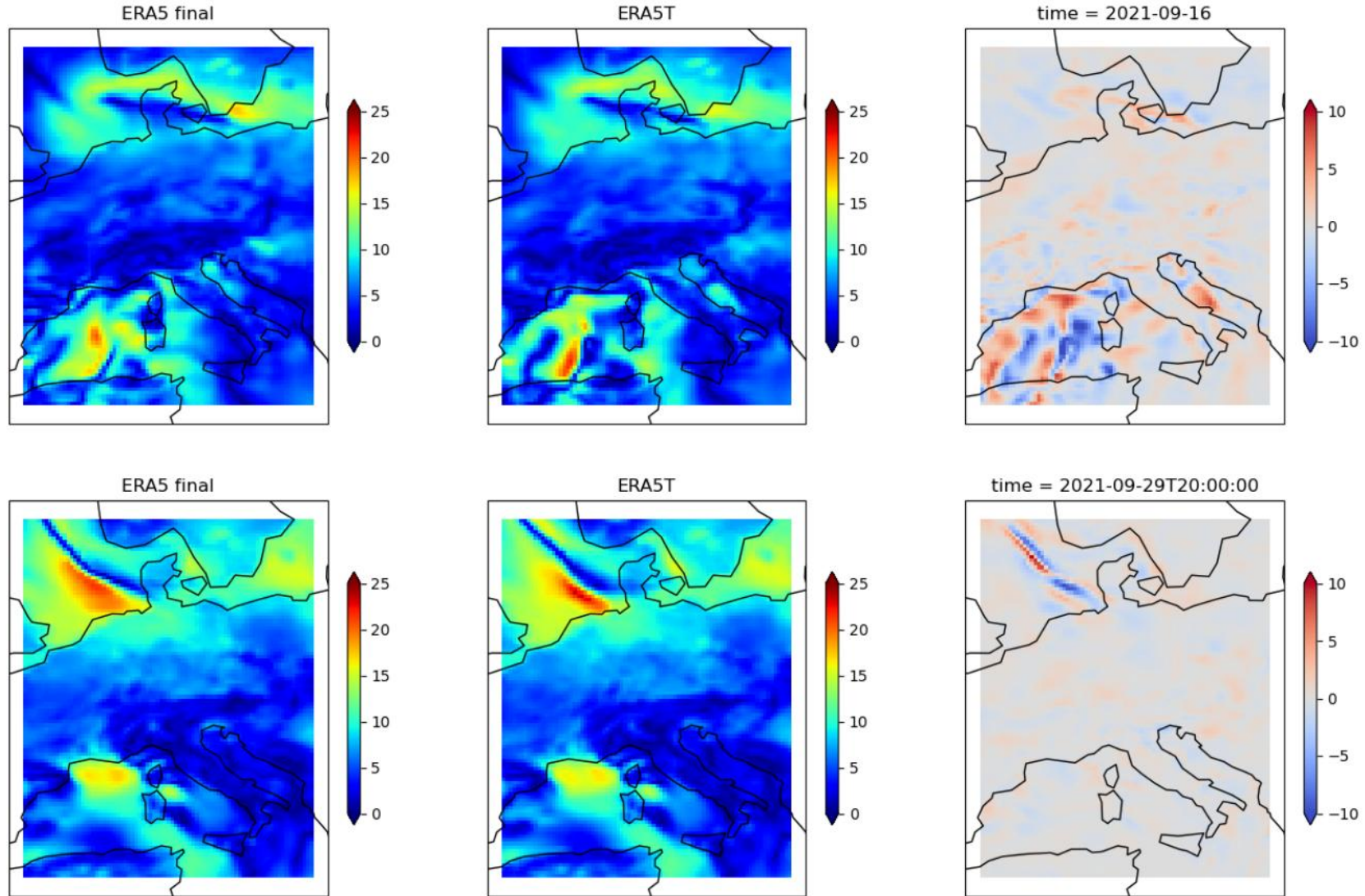
Re-visit previous ERA5/ERA5T Event from December 2021 (3/5)





Re-visit previous ERA5/ERA5T Event from December 2021 (4/5)

Parameter:
100m wind speed fields
at different time-stamps





Learnings from December 2021 on raw ERA5/ERA5T data (5/5)

• **Situation:**

Assimilation of anomalous snow depths over Asia did trigger a re-run of the ERA5/ERA5T models by ECMWF. The two datasets differed for months of Sep-Dec 2021.

• **Monthly Averaged Wind Speeds**

These differences are below 0.1 m/s for most of the world. The largest relative deviations are in the tropics where wind speeds are small.

• **Individual Time Step Wind Speeds**

Differences between the model runs exceed 10-15 m/s.

These differences are caused by a slight shift in the position of the fronts together with small differences in magnitude (North Sea study).

• **Overall:**

Wind speed differences between the ERA5T and ERA5 datasets can be very large when looking at individual time series samples ($>10\text{m/s}$), but mostly average out to acceptable levels on a monthly basis ($\sim 0.1\text{m/s}$).

Important: ERA5 data from Sep-Nov 2021 will differ from ERA5T - with Sep 2021 updated now!

Dear windPRO online-data user

EMCWF support has notified us about an issue with the preliminary ERA5T data from a 3-month period ranging from Sep-Nov 2021. This means that - for the first time since the introduction of ERA5 and ERA5T in late 2019 - that the final, validated ERA5 data will differ from the preliminary ERA5T data.

The issue is caused by the assimilation of anomalous snow depths over Central Asia - and this assimilation is thought mainly to affect surface parameters - read more in the notification from ECMWF, [here](#). As final ERA5 data from Sep 2021 has now become available, EMD has made an analysis to determine if the Sep 2021 wind speeds also differ, and if so, how much and at which geographical locations? A memo with this analysis is available [here](#) and it clearly shows, that wind speeds from ERA5T and ERA5 also do differ with a magnitude that is quite different from region to region. As a monthly average, the difference is quite small (typically below 0.1 m/s), but for individual timestamps (hourly values) the difference can be as large as 10-15 m/s.

EMD will handle this issue by replacing ERA5T data with ERA5 data when it becomes available. For windPRO users, ERA5T data for Sep 2021 has been updated with ERA5 data on 2021-12-07. For users who have already downloaded and used ERA5T data from Sep-Nov 2021 - or intend to use ERA5T data for Oct-Nov 2021, we recommend the following actions:

- Use proper caution when using the preliminary ERA5T data from Sep-Nov 2021, especially if your analysis relies on individual sample values (hourly values)
- Update the preliminary ERA5T data with the final, validated ERA5 data when it becomes available (2-3 months after current date)
- Given updated ERA5 data: Redo any calculations for your project, site or application and analyse any differences
- Take action in the event that results for your project/site/application is affected

Maximum absolute difference in instantaneous wind speed for ERA5 vs ERA5T (September 2021)

Read more:

- EMD memo on "2021 September Wind Speed Differences from the ERA5T-ERA5 Anomalous Snow Depth Assimilation Issue" - [here](#)
- See an image of the differences in the 100m winds over central Europe [here](#).
- Follow the status at the ECMWF homepage - [here](#)
- windPRO wiki on ERA5T - [here](#).

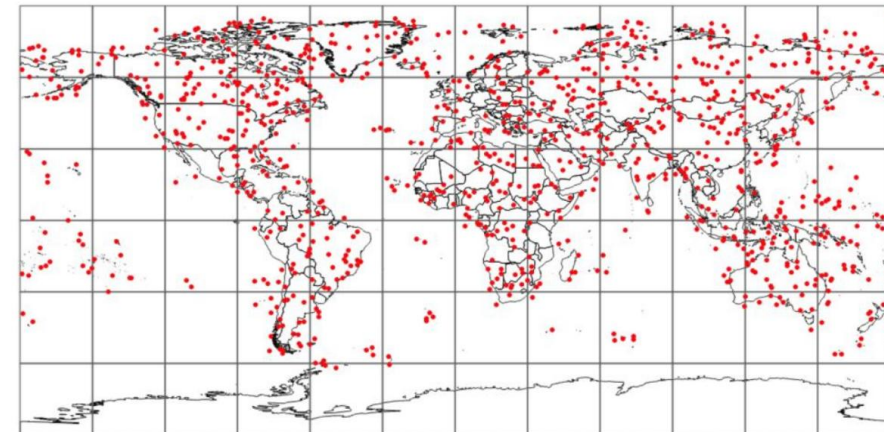
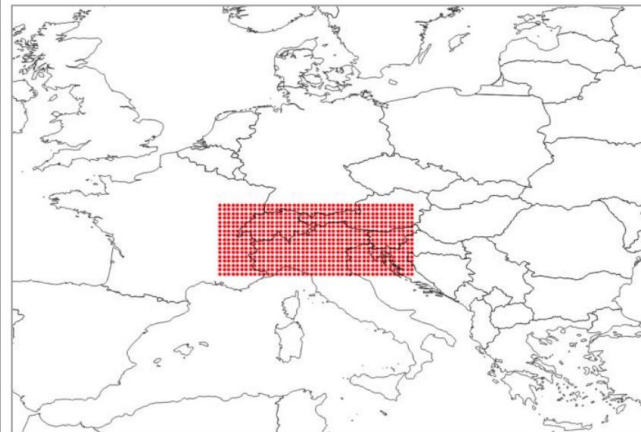
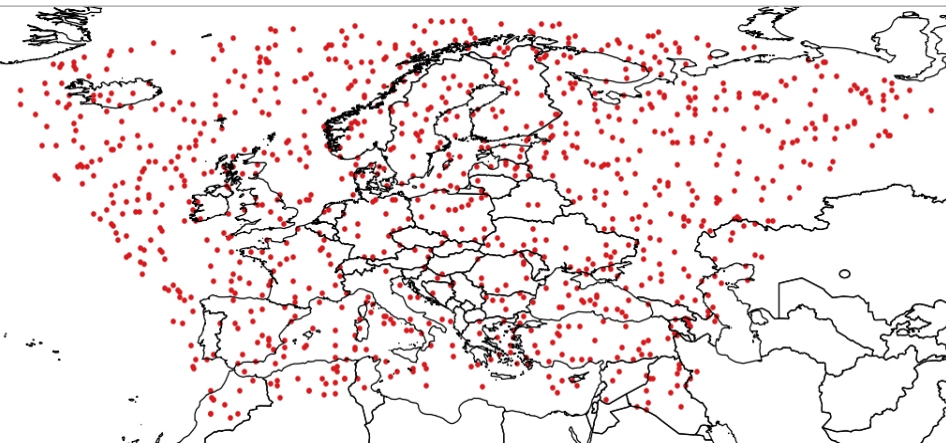
Best regards,
The windPRO online data team



Analysis: 2024 Jul-Oct Wind Speed and Solar Radiation Differences from the ERA5T-ERA5 Alps-Region Snow Depth Issue (1/9)

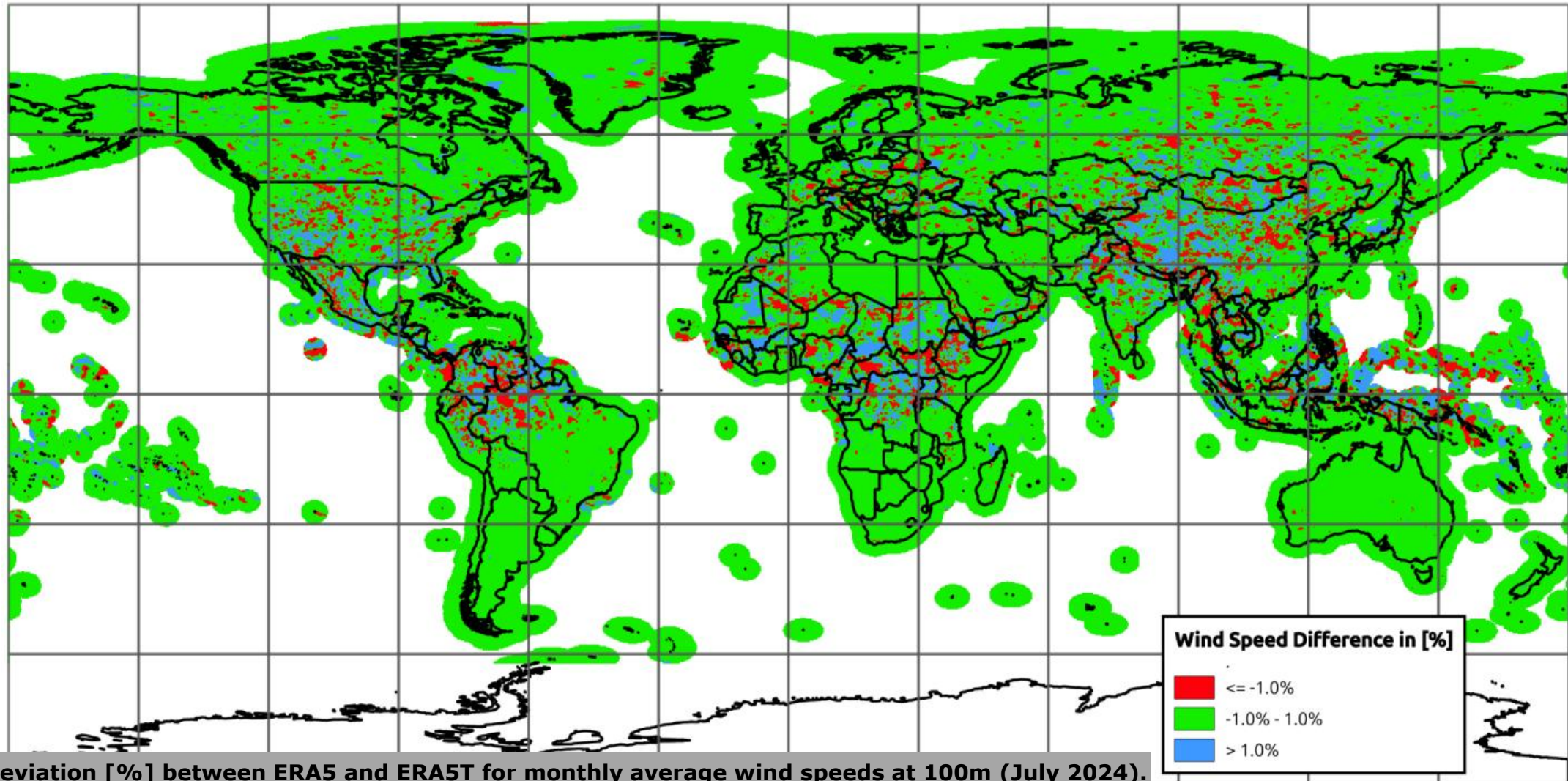
Analysis overview

- **3 domains with structured or random time-series samples**
 - Global (1000 node locations, up to 300km from land)
 - Alps (765 node locations)
 - Europe (1000 node locations)
- **2 (3) datasets**
 - EMD-WRF Europe+ mesoscale data
 - ERA5 on native (gaussian) grid
 - ERA5/ERA5T on interpolated (rectangular grid)





Analysis: 2024 Jul-Oct Wind Speed and Solar Radiation Differences from the ERA5T-ERA5 Alps-Region Snow Depth Issue (2/9)





Analysis: 2024 Jul-Oct Wind Speed and Solar Radiation Differences from the ERA5T-ERA5 Alps-Region Snow Depth Issue (3/9)

Climate Parameter	Metric	Unit	Alps Region 765 samples				Globe 1000 random samples			
			Mean	StDev	Min	Max	Mean	StDev	Min	Max
Wind Speed @ 100m	Average Bias - Monthly	m/s	0.00	0.03	-0.11	0.14	0.00	0.04	-0.28	0.28
	Absolute Maximal Difference	m/s	2.70	1.07	0.93	7.62	2.69	0.05	0.50	13.3
	Correlation Instantaneous Winds	-	0.93	0.04	0.77	0.99	0.97	0.05	0.50	0.99
Wind Speed @ 10m	Average Bias - Monthly	m/s	0.00	0.03	-0.15	0.17	0.00	0.03	-0.23	0.18
	Absolute Maximal Difference	m/s	1.78	0.86	0.68	7.17	1.96	1.27	0.24	11.1
	Correlation Instantaneous Winds	-	0.92	0.05	0.64	0.99	0.96	0.05	0.52	0.99
Temperature @ 2m	Average Bias - Monthly	°C	-0.1	0.4	-4.0	0.6	0.0	0.05	-0.4	0.43
	Absolute Maximal Difference	°C	2.5	1.5	0.5	12.1	1.9	1.1	0.2	6.5
	Correlation Instantaneous Samples	-	0.99	0.02	0.81	1.00	0.97	0.05	0.63	0.99
Solar Radiation	Average Bias - Monthly	W/m ²	0.5	3.0	-6.8	18.1	0.0	2.1	-10.0	9.9
	Absolute Maximal Difference	W/m ²	264	75	104	524	221	121	1	633
	Correlation Instantaneous Samples	-	0.99	0.00	0.97	1.00	0.99	0.01	0.91	1.00

Sample statistics for 4 different climate variables for ERA5/ERA5T- Alps Region and the Globe (July 2024)



Analysis: 2024 Jul-Oct Wind Speed and Solar Radiation Differences from the ERA5T-ERA5 Alps-Region Snow Depth Issue (4/9)

Climate Parameter	Metric	Unit	Alps Region 765 samples				European Domain 1000 random samples			
			Mean	StDev	Min	Max	Mean	StDev	Min	Max
Wind Speed @ 100m	Average Bias - Monthly	m/s	0.00	0.08	-0.62	0.40	0.00	0.06	-0.26	0.26
	Absolute Maximal Difference	m/s	8.45	2.17	4.11	22.1	6.93	2.74	0.81	17.8
	Correlation Instantaneous Winds	-	0.82	0.08	0.44	0.98	0.91	0.07	0.53	1.00
Wind Speed @ 10m	Average Bias - Monthly	m/s	0.01	0.10	-0.38	1.49	0.00	0.05	-0.19	0.27
	Absolute Maximal Difference	m/s	6.31	1.77	3.17	17.51	5.63	1.99	0.52	16.1
	Correlation Instantaneous Winds	-	0.77	0.10	0.32	0.96	0.89	0.07	0.58	1.00
Temperature @ 2m	Average Bias - Monthly	°C	-0.1	0.3	-3.1	0.2	0.0	0.05	-0.3	0.2
	Absolute Maximal Difference	°C	5.3	1.8	1.0	12.3	3.9	2.6	0.2	14.7
	Correlation Instantaneous Samples	-	0.98	0.04	0.36	1.00	0.98	0.01	0.91	1.00
Solar Radiation	Average Bias - Monthly	W/m ²	0.5	6.1	-17.2	48.2	0.0	4.2	-22.9	13.6
	Absolute Maximal Difference	W/m ²	820	81	476	995	650	167	2	981
	Correlation Instantaneous Samples	-	0.94	0.03	0.81	0.99	0.95	0.03	0.84	1.00

Sample statistics for 4 different climate variables for EMD-WRF Europe+ Alps Region and the EUR+ Domain (July 2024).

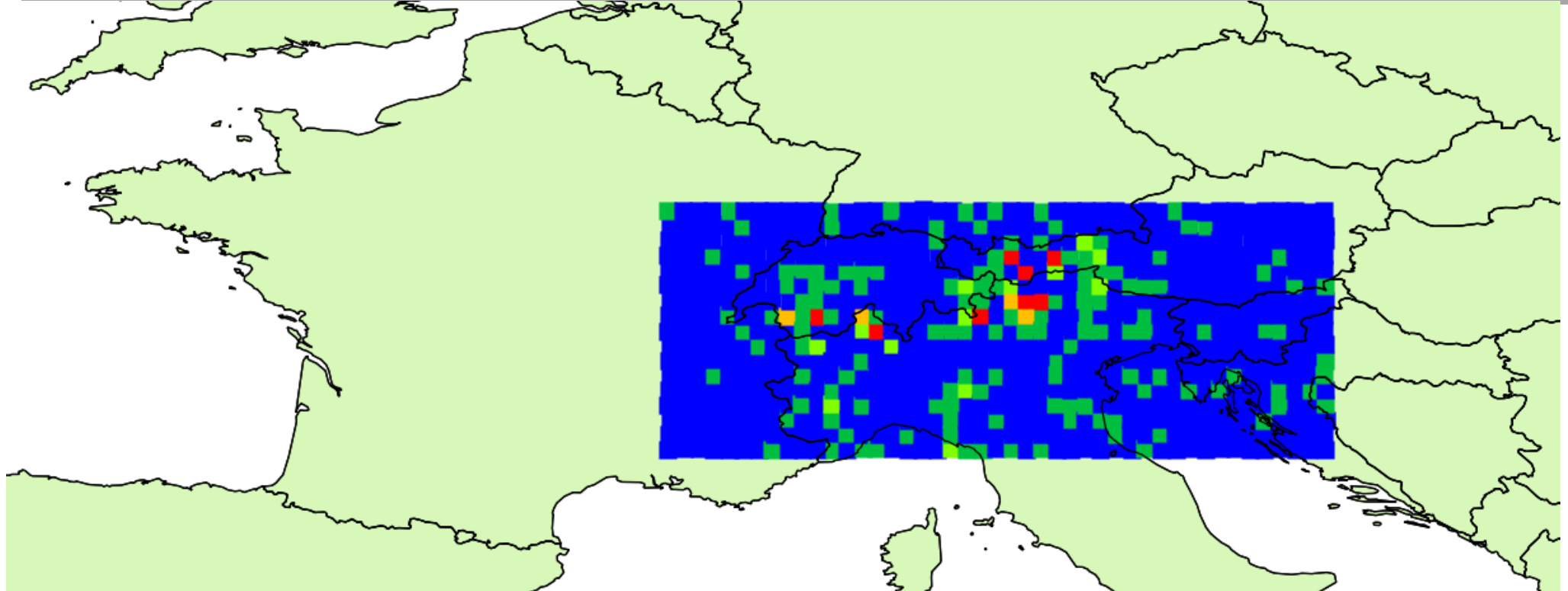
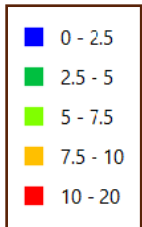




Analysis: 2024 Jul-Oct Wind Speed and Solar Radiation Differences from the ERA5T-ERA5 Alps-Region Snow Depth Issue (7/9)

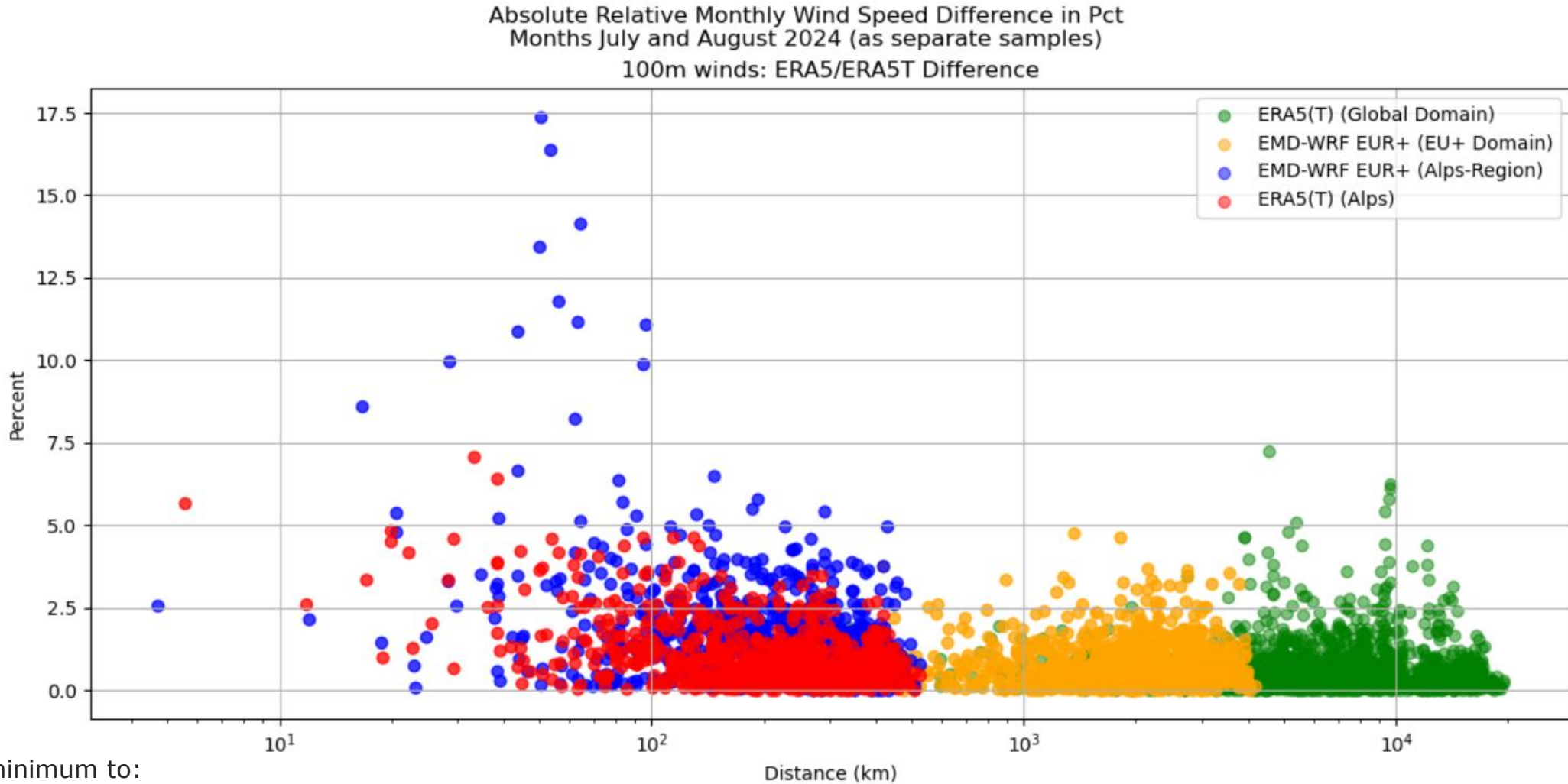
EMD-WRF Europe+: Map shows absolute difference in percent (%) on monthly average wind speed (July 2024)

Legend(%)





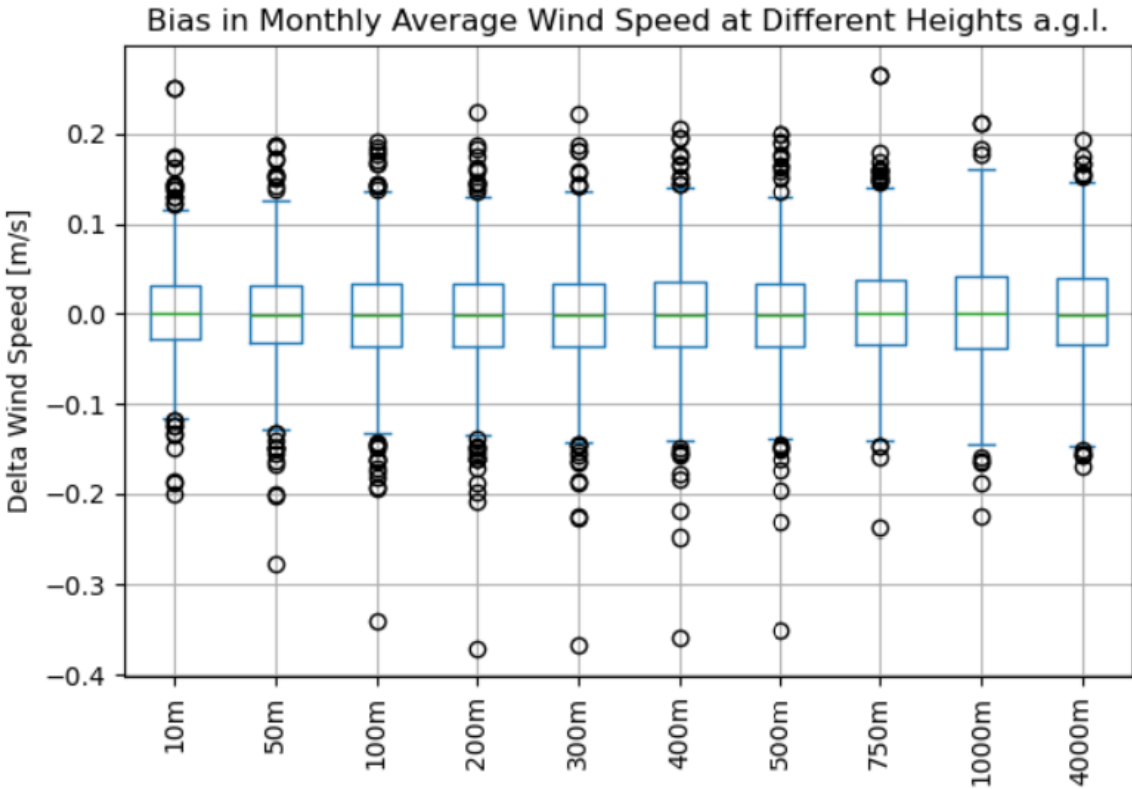
Analysis: 2024 Jul-Oct Wind Speed and Solar Radiation Differences from the ERA5T-ERA5 Alps-Region Snow Depth Issue (8/9)



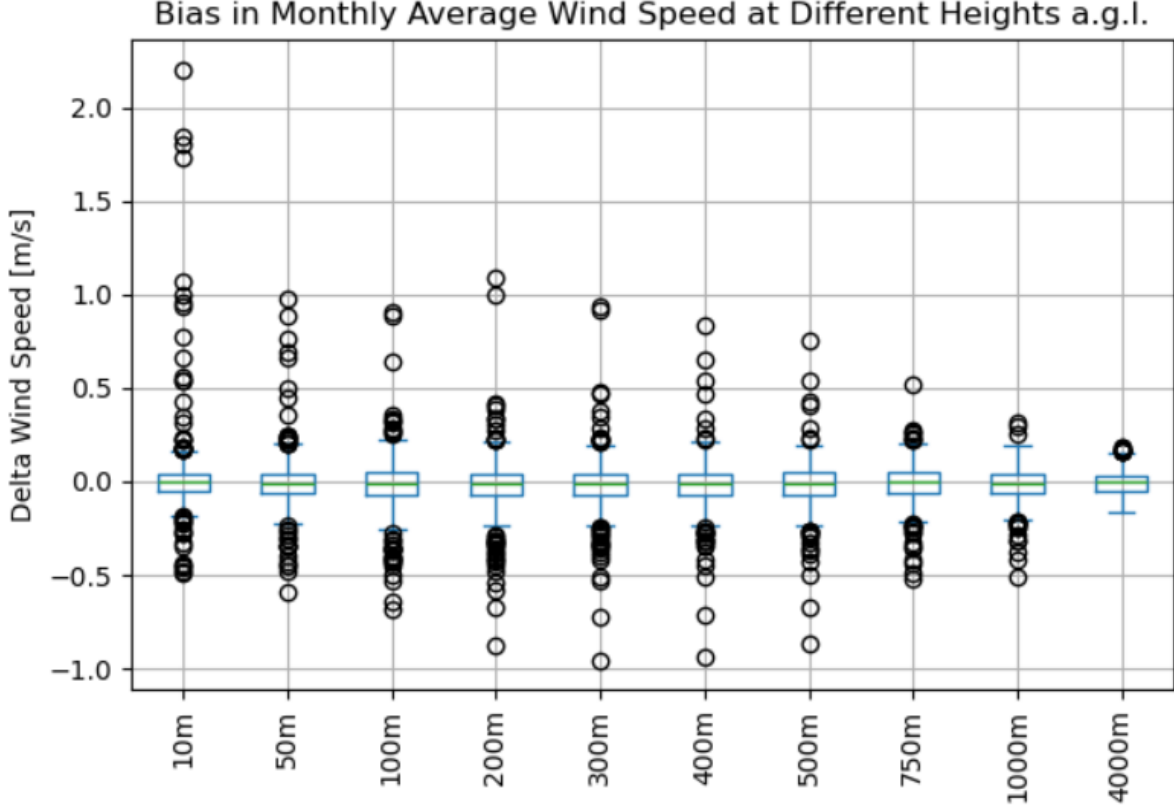


Analysis: 2024 Jul-Oct Wind Speed and Solar Radiation Differences from the ERA5T-ERA5 Alps-Region Snow Depth Issue (9/9)

ERA5T vs. ERA5 for August 2024 (EMD-WRF Europe+ Mesoscale Data)



Left: EMD-WRF Europe+ Full Domain



Right: EMD-WRF Europe+ Alps Domain

Plot: Standard Matplotlib Box-and-Whiskers, with Quantiles and 1.5xIQR + outliers beyond.

Will Alpine Snow Depth Updates in ERA5/ERA5T Influence Higher Winds Across Europe and Beyond?





Summary of findings

Monthly Averaged Wind Speeds

- These differences are below 0.10m/s–0.15m/s for most of the domain, except for the Alps region in a range of 100km-200km from the area with the erroneous snow depths .
- The difference is slightly less for raw ERA5/ERA5T and slightly more for EMD-WRF EUR+ mesoscale data
- The largest relative deviations are in the tropics where wind speeds are small.
- Individual locations may exhibit 'outlier' behaviour – especially in the affected Alps region where individual locations may have 0.5m/s to 2.0m/s difference in monthly average wind speed

Individual Time Step Wind Speeds

- ERA5/ERA5T: Differences between the model runs exceed 10 m/s.
- EMD-WRF Europe+: The difference is about double of that from the raw data, with largest differences in the alps region.
- These differences are caused by a slight shift in the position of the fronts together with small differences in magnitude (from the inner-workings of the reanalysis model).





Conclusions

**Consider your use-case and site-location.
(Take action – if required)**

**ECMWF note is correct, mainly surface parameters are affected.
Differences get bigger the closer you are to the erroneous data area.**

**Keep data consistency – update your data when ERA5 final data becomes available.
(help your future you)**





Questionnaire (2/2) – Results A – 22 responses

Questionnaire - Vindkraftnet 2024-11-20

Questions related to presentation "Will Alpine Snow Depth Updates in ERA5/ERA5T Influence Higher Winds Across Europe and Beyond?". This survey is anonymous.

1. Will Alpine Snow Depth Updates in ERA5/ERA5T Influence Higher Winds Across Europe and Beyond?

Yes
 No
 Maybe

2. My ERA5/ERA5T use-case (or analysis) relies on the accuracy of:

Individual nodes and individual data-samples time-stamps (e.g. extremes at a specific location)
 Individual nodes and temporally averaged data (e.g. monthly averaged wind-speeds at a specific location)
 Data fields over larger areas at a specific time-stamp (e.g. gradients in winds, front passages)
 Data fields over larger areas at as averaged data (e.g. statistical wind atlas' data)
 Other

3. Will the ERA5/ERA5T Snow Depth Issue impact wind speeds in mesoscale derived datasets?

Yes - but the errors become larger when comparing to raw ERA5/ERA5T data
 Yes - the errors become smaller when comparing to raw ERA5/ERA5T data
 Yes - but it does not matter, as data-users are very well aware of the uncertainties related to both reanalysis and mesoscale modelling
 No - this is such a small effect, that it just disappears
 Other

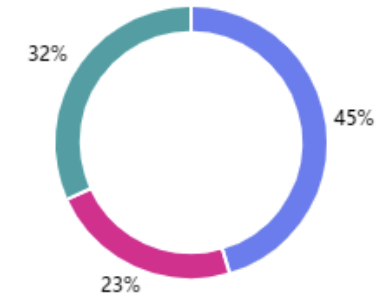
4. Any other comments or inputs?

Enter your answer

1. Will Alpine Snow Depth Updates in ERA5/ERA5T Influence Higher Winds Across Europe and Beyond?

[More details](#)

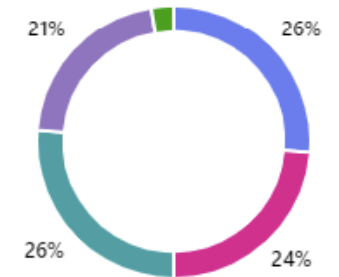
● Yes	10
● No	5
● Maybe	7



2. My ERA5/ERA5T use-case (or analysis) relies on the accuracy of:

[More details](#)

● Individual nodes and individual data-samples time-stamps (e.g. extremes at a specific location)	10
● Individual nodes and temporally averaged data (e.g. monthly averaged wind-speeds at a specific...)	9
● Data fields over larger areas at a specific time-stamp (e.g. gradients in winds, front passages)	10
● Data fields over larger areas at as averaged data (e.g. statistical wind atlas' data)	8
● Other	1





Questionnaire (2/2) – Results B – 22 responses

Questionnaire - Vindkraftnet 2024-11-20

Questions related to presentation "Will Alpine Snow Depth Updates in ERA5/ERA5T Influence Higher Winds Across Europe and Beyond?"; This survey is anonymous.

1. Will Alpine Snow Depth Updates in ERA5/ERA5T Influence Higher Winds Across Europe and Beyond?

Yes

No

Maybe

2. My ERA5/ERA5T use-case (or analysis) relies on the accuracy of:

Individual nodes and individual data-samples time-stamps (e.g. extremes at a specific location)

Individual nodes and temporally averaged data (e.g. monthly averaged wind-speeds at a specific location)

Data fields over larger areas at a specific time-stamp (e.g. gradients in winds, front passages)

Data fields over larger areas at as averaged data (e.g. statistical wind atlas' data)

Other

3. Will the ERA5/ERA5T Snow Depth Issue impact wind speeds in mesoscale derived datasets?

Yes - but the errors become larger when comparing to raw ERA5/ERA5T data

Yes - the errors become smaller when comparing to raw ERA5/ERA5T data

Yes - but it does not matter, as data-users are very well aware of the uncertainties related to both reanalysis and mesoscale modelling

No - this is such a small effect, that it just disappears

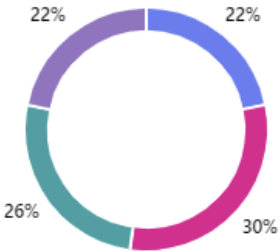
Other

4. Any other comments or inputs?

3. Will the ERA5/ERA5T Snow Depth Issue impact wind speeds in mesoscale derived datasets?

[More details](#)

- Yes - but the errors become larger when comparing to raw ERA5/ERA5T data 5
- Yes - the errors become smaller when comparing to raw ERA5/ERA5T data 7
- Yes - but it does not matter, as data-users are very well aware of the uncertainties related to both... 6
- No - this is such a small effect, that it just disappears 5
- Other 0



4. Any other comments or inputs?

[More details](#)

1 Responses

Latest Responses
"Chaos"

1 respondents (100%) answered Chaos for this question.

Chaos





EMD
International



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References

- [1] EMD (Morten Lybech Thøgersen):
Knowledgebase on windPRO - ERA5(T) Rectangular grid (Known Issues and Usage Notes)
Available from the windPRO knowledgebase- [here](#)
- [2] T. Ahsbahs (ta@emd.dk), M.L. Thøgersen (mlt@emd.dk) & T. G. Sørensen (tgs@emd.dk):
Memo: 2021 Sep-Nov Wind Speed Differences from the ERA5T-ERA5 Anomalous Snow Depth Assimilation Issue
Available from the windPRO knowledgebase - [here](#)
- [3] Morten Lybech Thøgersen, Lasse Svenningsen, Thorkild Guldager Sørensen & Sérgio Augusto Costa:
IS MERRA2 ABLE TO REPLACE MERRA AS A TRUSTED REFERENCE WIND DATASET?
Available from the windPRO knowledgebase - [here](#)
- [4] **Bosilovich et al (2015):**
MERRA-2: Initial Evaluation of the Climate, Technical Report Series on Global Modeling and Data Assimilation – Volume 43, NASA/TM–2015-104606/Vol. 43.
- [5] M.L. Thøgersen (mlt@emd.dk), T.G. Sørensen (tgs@emd.dk) & T. Ahsbahs (ta@emd.dk).
2024 Jul-Oct Wind Speed and Solar Radiation Differences from the ERA5T-ERA5 Alps-Region Snow Depth Issue
Available from the windPRO knowledgebase - [here](#)
- [6] ECMWF - ***Fact sheet: Reanalysis*** - available [here](#)

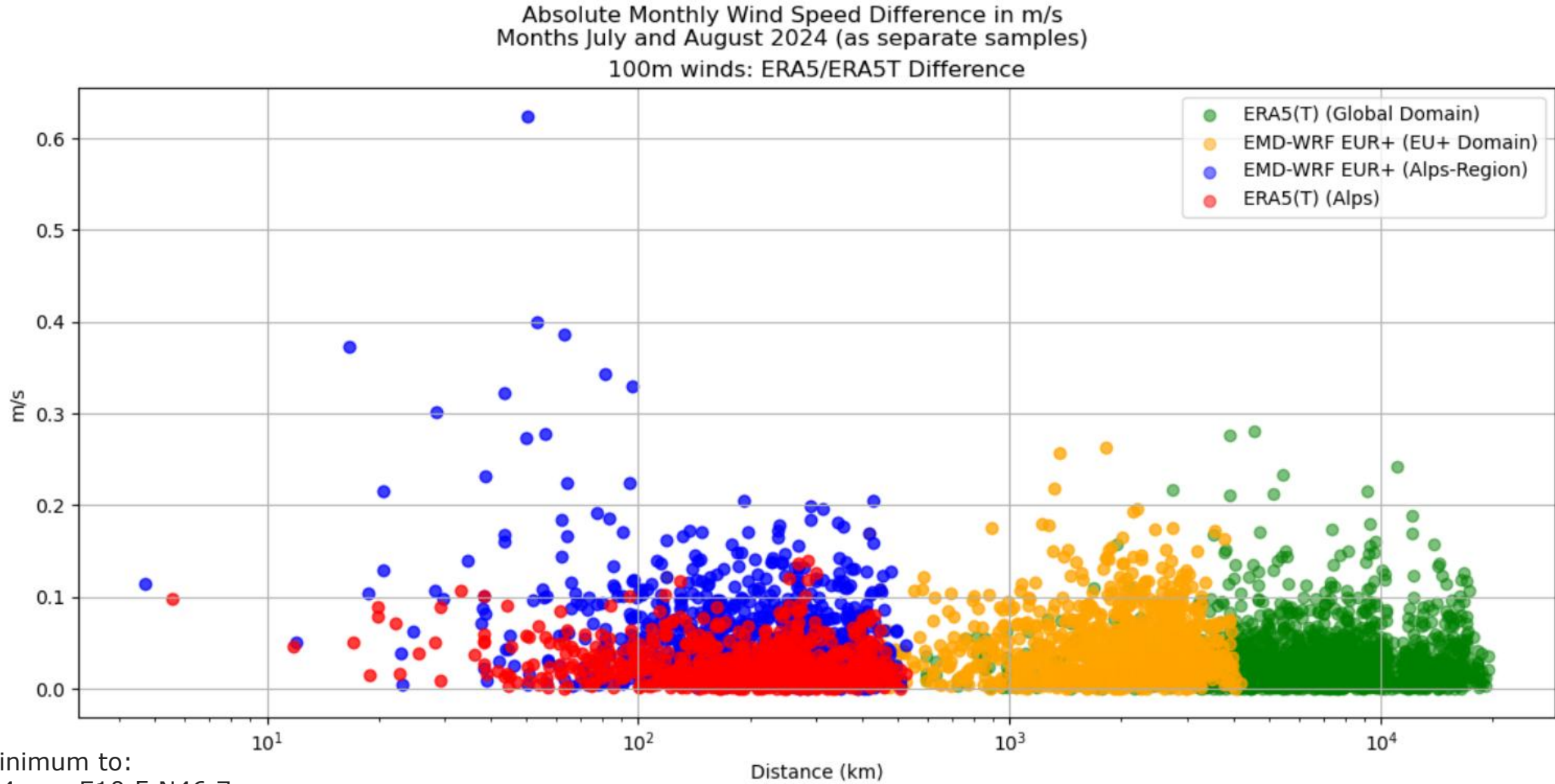


Extra Slides

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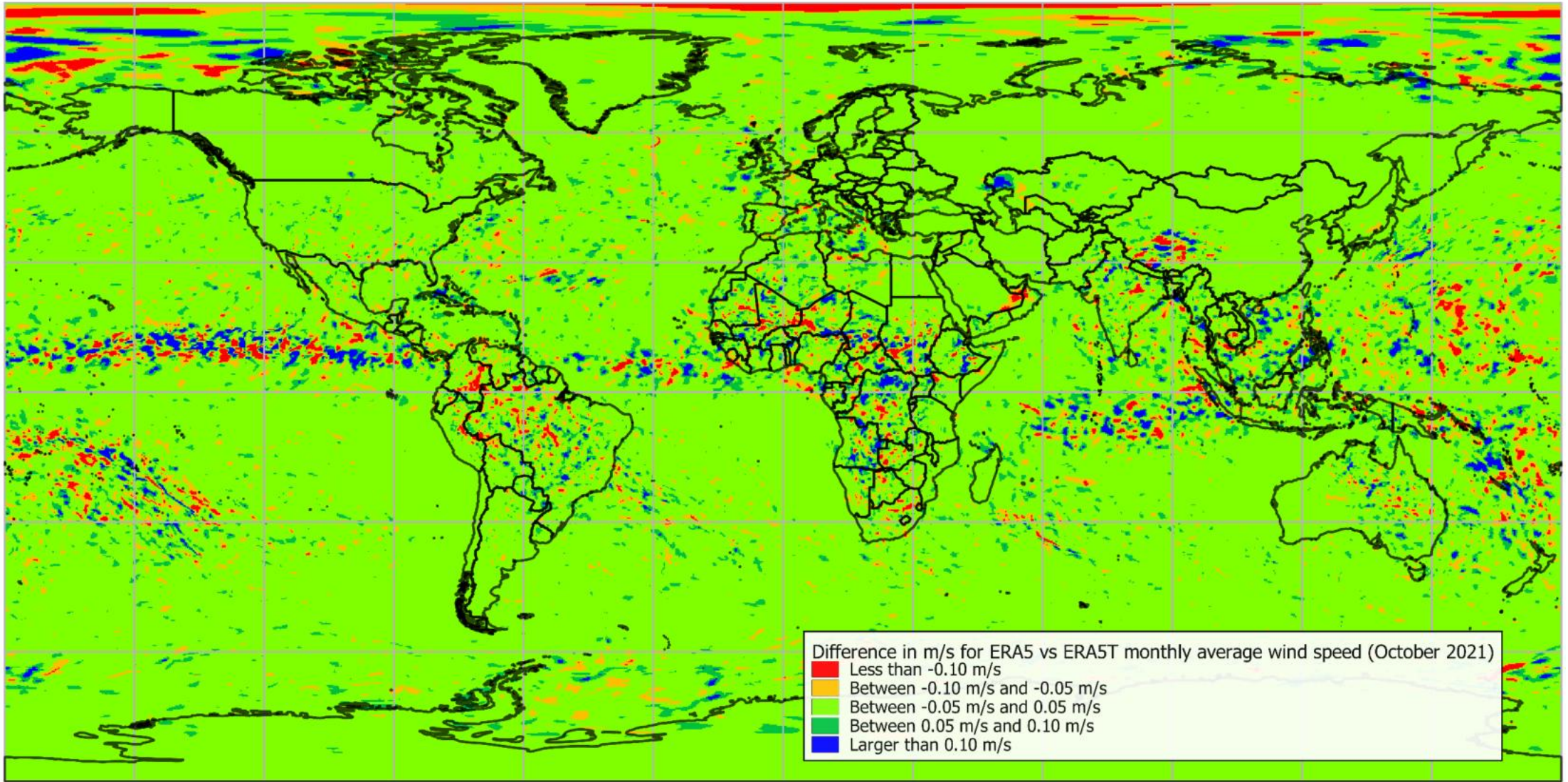


Analysis: 2024 Jul-Oct Wind Speed and Solar Radiation Differences from the ERA5T-ERA5 Alps-Region Snow Depth Issue





Re-visit previous ERA5/ERA5T Event from December 2021





How are data included in reanalysis?

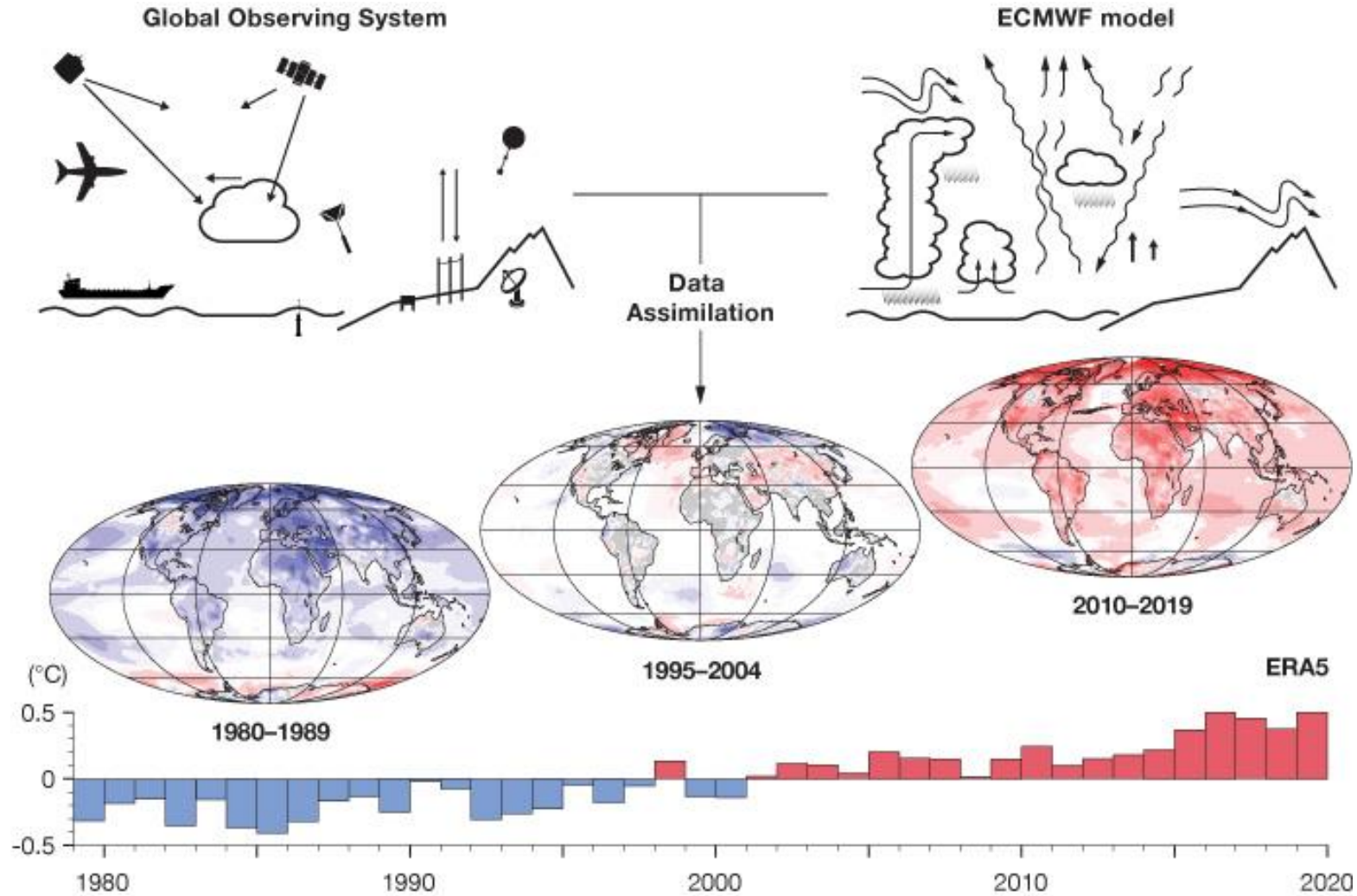
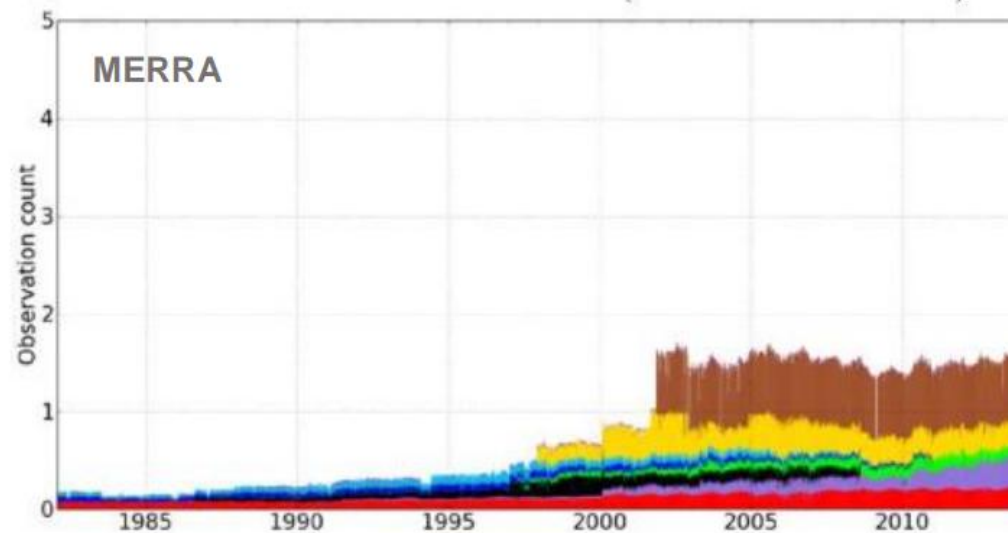
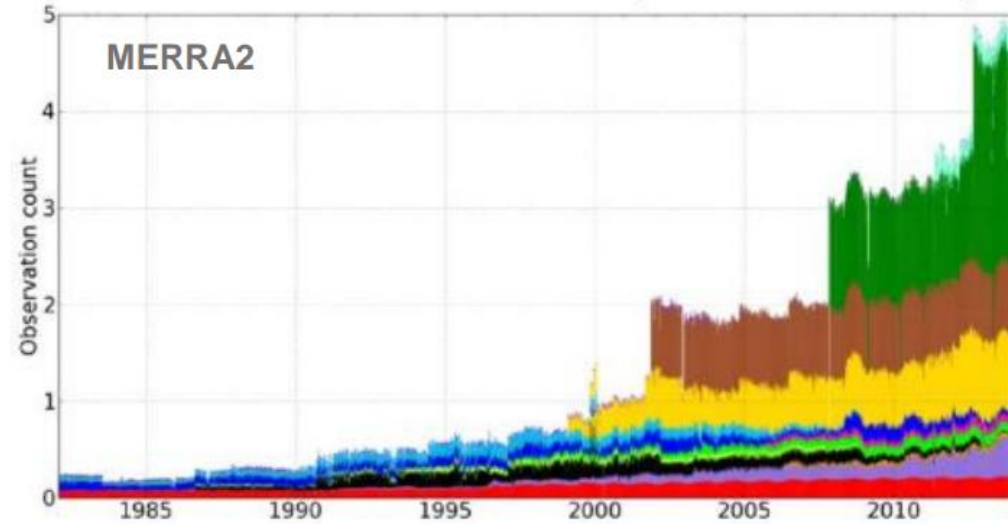


Image credit:
ECMWF Fact sheet – Reanalysis [6]



What source data are available for reanalysis?



Legend - Observations



Observations assimilated in MERRA2 (top) and MERRA (bottom) datasets for the period 01.1980 until 12.2014. Units are millions per 6 hours. From Bosilovich et al. [4].