The first months of EMADDC during COVID-19

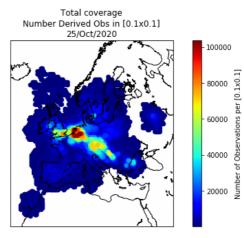*Siebren de Haan , Paul de Jong, Michal Koutek and Jan Sondij*

Early March 2020 KNMI started to distribute Mode-S EHS observations produced within the EMADDC framework. The first version, called 'COVID-19 TEST' was not fully developed, but it showed it's potential.
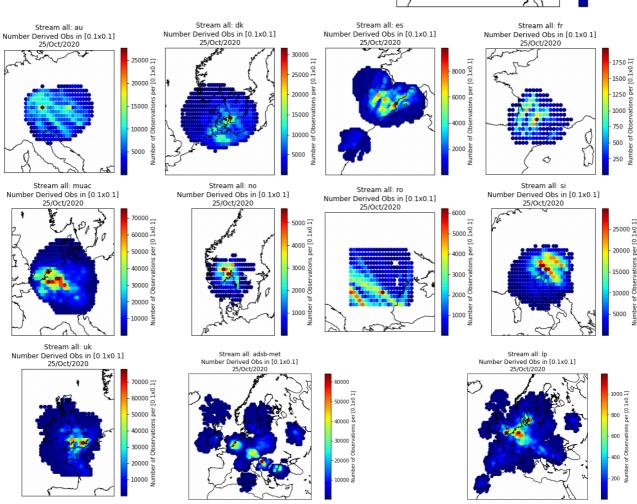
During the summer of 2020 a more enhanced and improved processing chain came available, called 'COVID-19 VER2'. Here we discuss the quality of the observations by comparison with NWP (HIRLAM).
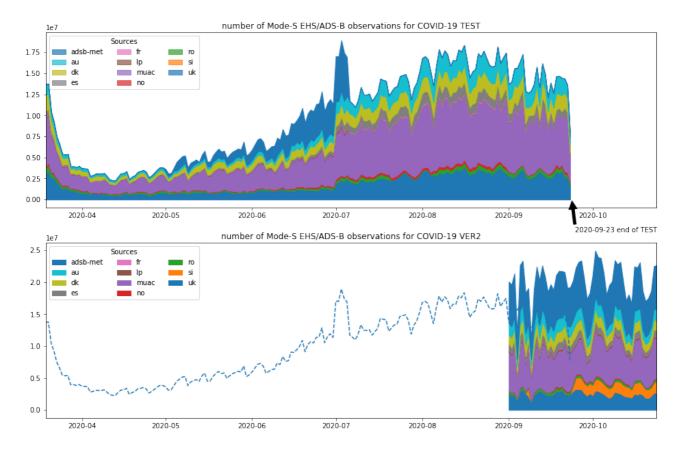
Mode-S EHS /ADS-B input

Data coverage

The graphs below show observation coverages (total and for each stream separately), of the different Input streams. Note that streams gradually became available.

Total coverage
Number Derived Obs in [0.1x0.1]
25/Oct/2020

Stream all: au
Number Derived Obs in [0.1x0.1]
25/Oct/2020

Stream all: dk
Number Derived Obs in [0.1x0.1]
25/Oct/2020

Stream all: es
Number Derived Obs in [0.1x0.1]
25/Oct/2020

Stream all: fr
Number Derived Obs in [0.1x0.1]
25/Oct/2020

Stream all: muac
Number Derived Obs in [0.1x0.1]
25/Oct/2020

Stream all: no
Number Derived Obs in [0.1x0.1]
25/Oct/2020

Stream all: ro
Number Derived Obs in [0.1x0.1]
25/Oct/2020

Stream all: si
Number Derived Obs in [0.1x0.1]
25/Oct/2020

Stream all: uk
Number Derived Obs in [0.1x0.1]
25/Oct/2020

Stream all: adsb-met
Number Derived Obs in [0.1x0.1]
25/Oct/2020

Stream all: lp
Number Derived Obs in [0.1x0.1]
25/Oct/2020

Data over time

The top panel shows the number of observations received by COVID-19 TEST for the different streams. The bottom panel shows the number of observations received by COVID-19 VER2.

Processing chains

	muac OPER	covid-19 TEST	covid-19 VER2	covid-19 VER2b
operational period	since 2018	April - 23 Sept. 2020	June 2020 - now	-
storage	files	database	database	database
heading correction	1 declination per aircraft determined over muac area	1 datum coefficient per aircraft determined and valid over whole area	1 datum coefficient per aircraft determined and valid over whole area	1 datum coefficient per aircraft determined and valid over whole area
airspeed correction	lookup-table based on long term differences from NWP	-	-	1 correction coefficient per aircraft determined and valid over whole area
temperature correction	bias correction using flight phase (asc/desc/level) per aircraft	pressure defect correction using flight phase based on barometric altitude rate (asc/desc/level) per aircraft	pressure defect correction using flight phase based on barometric altitude rate (asc/desc/level) per aircraft	pressure defect correction using flight phase based on change in FL over time (asc/desc/level) per aircraft
updates of corrections	daily	no	daily	daily
quality of corrections	based one long term data; quality is good	based on data from Jan 2019 to March 2020; quality is good but will become poorer over time	based on data started March 2020; quality is moderate but will improve over time	based on data started March 2020; quality is moderate but will improve over time
averaging	linear fit of Mach and True Airspeed of close observations (within 30s for level flight, 7s for asc/desc) : both wind and temperature	averaging of 5 closest raw temperature observation within 25s, before correction. No averaging for wind	averaging of 5 closest raw temperature observation within 25s, before correction. No averaging for wind	averaging of 5 closest raw temperature observation within 25s, before correction. No averaging for wind
output	separate file for each stream	one combined file	one combined file	one combined file
output frequency	depending on input	15'	15'	15'
output number in muac-area (reference is muac-OPER)	wind: 1 temperature: 1	wind: 5-6 x temperature: 2-3 x	wind: 4-5x temperature: 2-3x	wind: 3-4x temperature: 0.5 ->1x

Notes:
- The validity of the correction method is assumed to be independent of position. This needs to be confirmed by checking the corrections in other regions (e.g. Asia)
- The pressure correction method is explained in De Haan, et al (2021)
- Documentation of the algorithms is in progress

Data quality control

All processing methods have quality control. This Quality Control depends on input parameters like ground speed and differ between processing message. Additionally, white listing is applied for all covid-19 processing method. Gross error check was applied to the operational version because there were some extreme wind and temperature observations recorded.

Reprocessing results

The tables below present the statistics of observation minus model in the MUAC area for the given period. Note that the test version ended on 23 September.

"obs in" denotes the number of observations passing the quality control and "obs out" is the number of observations after white listing and cross error check.
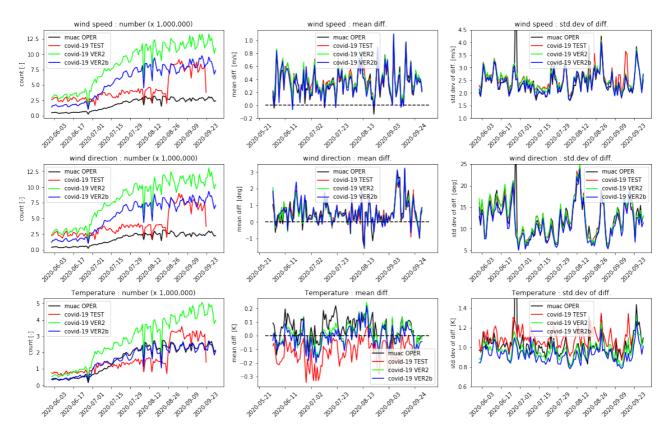
		wind speed				wind direction		
source	period	obs in	obs out	bias	s.d	obs out	bias	s.d
muac-OPER	2020-06-01 2020-09-30	113,552,729	113,488,116	0.33	2.36	105,420,272	0.58	12.54
TEST	2020-06-01 2020-09-23	407,438,533	223,788,000	0.39	2.49	207,763,483	0.63	13.56
VER2	2020-06-01 2020-09-30	636,229,713	485,298,800	0.41	2.51	453,386,648	0.50	13.45
VER2b	2020-06-01 2020-09-30	427,005,238	326,691,584	0.36	2.39	306,976,063	0.56	12.19

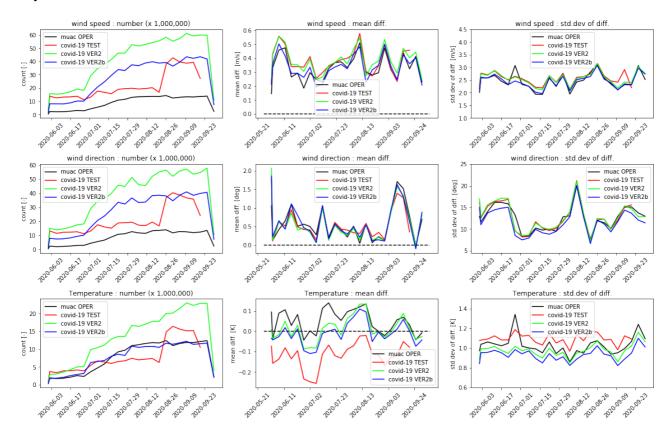|		temperature			
source	period	obs in	obs out	bias	s.d
muac-OPER	2020-06-01 2020-09-30	99,186,523	99,041,032	0.02	0.99
TEST	2020-06-01 2020-09-23	193,264,928	79,688,693	-0.09	1.04
VER2	2020-06-01 2020-09-30	171,643,410	164,454,593	0.03	0.95
VER2b	2020-06-01 2020-09-30	105,677,469	101,691,514	0.01	0.91

Statistics over time

The figures below show the statistics of wind and temperature of the re-processing over the period from June 2020 till end of September 2020. Operational version is denoted by the black line, the TEST version is denoted by the red line, VER2 by the green line and the proposed new processing method VER2b by the blue lines.

The first figure displays the statistics on a daily basis. The left panel shows the number of observations the middle panel the mean difference and the right panel shows the standard deviation.

The next figure is similar to the previous one, except that now the statistics are based on bins of 5 days.
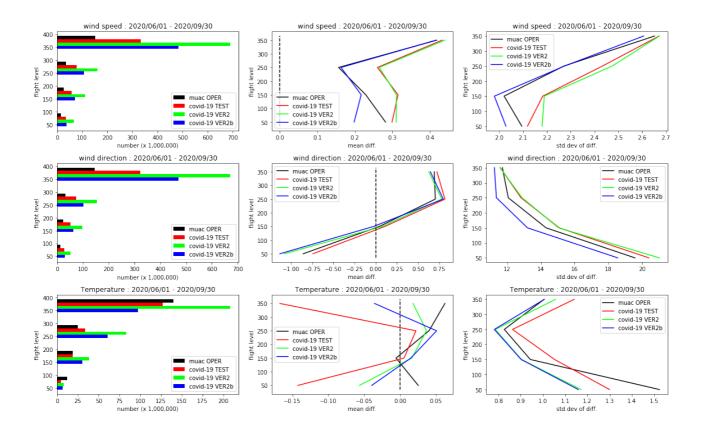

For wind speed and direction we observe that the TEST is worse than the Oper and VER2, both in mean difference as well as standard deviation. The VER2 processing has clearly the lowest temperature standard deviation over the whole period. The temperature bias for the processing chain VER2 is closest to zero.

Statistics with respect to height

All observations

In this section we present the statistics of the 4 different processing methods based on all available observations. This implies that the observation datasets are not equal; in the section hereafter we present the statistics on the intersection of the used datasets.

The graph below shows the statistics accumulated over time with respect to height.
The left panel shows the number of observations the middle panel the mean difference and the right panel shows the standard deviation.
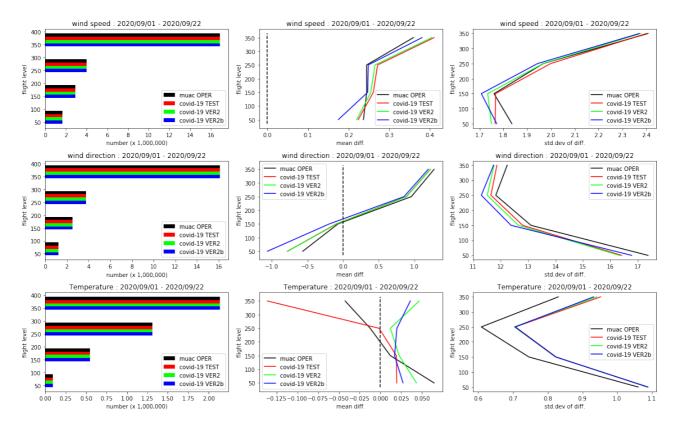

Again, we see that for TEST processing the wind statistics are worse both in mean difference as well as standard deviation. For temperature, VER2/VER2b is the best.

Overlapping observations

In this section we present the statistics of the 4 different processing methods based on the inter-section of the used datasets. Note that the overlapping data in the data set passed quality control of all processing methods,

The graph below shows the statistics accumulated over time with respect to height.
The left panel shows the number of observations the middle panel the mean difference and the right panel shows the standard deviation.

For wind statistics the new version is clearly the best.
For temperature statistics operational version is the best one, with respect to standard deviation; the bias, however, exhibits a height dependence. Recall that this version has a bias correction which forces observation to the main average of the model.

Summary and Conclusion

Table below summaries the observed number of observations.

reference to muac-OPER	covid-19 TEST	covid-19 VER2	covid-19 VER2b
output number in muac-area	wind: 5-6 x temperature: 2-3 x	wind: 4-5x temperature: 2-3x	wind: 3-4x temperature: 0.5 ->1x

Summary of statistics of the 4 different processing methods based on all available observations.

reference to muac-OPER	covid-19 TEST	covid-19 VER2	covid-19 VER2b
wind speed bias	worse	worse	similar
wind speed standard deviation	worse	worse	similar
wind direction bias	better, apart from bottom	better, apart from bottom	better, apart from bottom
wind direction standard deviation	worse	worse	better
temperature bias	negative	around zero	around zero
temperature standard deviation	larger	equal or better	equal or better

Summary of the statistics based on the intersection of the used datasets.

reference to muac-OPER	covid-19 TEST	covid-19 VER2	covid-19 VER2b
wind speed bias	worse	similar	similar
wind speed standard deviation	similar	similar	similar
wind direction bias	similar	slightly better	slightly better
wind direction standard deviation	similar	slightly better	better
temperature bias	closer to zero	closer to zero	better
temperature standard deviation	slightly worse	slightly worse	slightly worse

Conclusions:
- The new version (VER2b) has better quality winds than VER2 and TEST, similar to OPER.
- The temperature, over the intersection data set, is slightly worse than OPER but over the complete data sets the new version (VER2b) has better standard deviation.

Reference:
Characterizing and correcting the warm bias observed in AMDAR temperature observations
Siebren de Haan, Paul M. A. de Jong, and Jitze van der Meulen
Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2020-519, 2021