First results from comparison ERA5 and Aeolus measurements: Lidar measurements to Identify Streamers and analyze Atmospheric waves (LISA) (Aeolus+Innovation)

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Motivation

- Aeolus measurements provide wind data (meridional or zonal component) for the whole stratosphere
- ERA5 is available for the whole AEOLUS period on hourly basis with grid points 0.25° in lat/lon
- Streamer events occur mainly in the middle latitude over Atlantic
- ERA5 will help us to see dynamics not only in the middle atmosphere but in polar region as well
- Analysis of Doppler sounding or microbarographs can show us condition in lower or higher levels

Infrasound observations at WBCI

Frequency range of interest, f = 0.0033-0.4 Hz

Calm periods

02.03.-08.03.2020
09.03.-14.03.2020
28.03.-10.04.2020
19.04.-27.05.2020
09.11.-15.11.2020
12.12.-22.12.2020
30.12.20-06.01.21
21.01.-20.02.2021
28.02.-07.03.2021
13.03.-24.03.2021
29.03.-07.04.2021

Σ 153 days

Streamer(-like) events

06.02.-10.02.2020
31.08.-03.09.2020
05.09.-11.09.2020
03.11.-07.11.2020
21.11.-25.11.2020
23.02.-27.02.2021
09.03.-12.03.2021

Σ 35 days

Homogeneity testing Streamer 1

- Statistical description ERA5 dataset

- **Homogeneity testing, using AIC** (Akaike's information criterion), Chapter 5.1.1

AIC = - (maximumlog - likelihood) + 2(number of free parameters)
statistics for whole AEOLUS measurements period but the comparison will be applied mainly on the streamer events.

- the AIC of the pooled model is $AIC_A = (T+T_1)\ log(\sigma_A^2) + 2(p_A + intercept + 1)$, where σ_A^2 is the pooled error variance and p_A is the order chosen to fit the pooled data set.
- **Decision**
- If $AIC_J < AIC_A$ switch to the new model, since there is a change in the structure of the time series.
- If $AIC_J \geq AIC_A$ pool the two data sets, since two data sets are considered to be homogeneous

Homogeneity testing Streamer 1

- Fit statistics comparison for streamer event 1.- 9.11. 2020
- data segment 40° N - 60° N latitudes meets the homogeneity criterion slightly worse than whole file (40°N-90°N), larger variance,

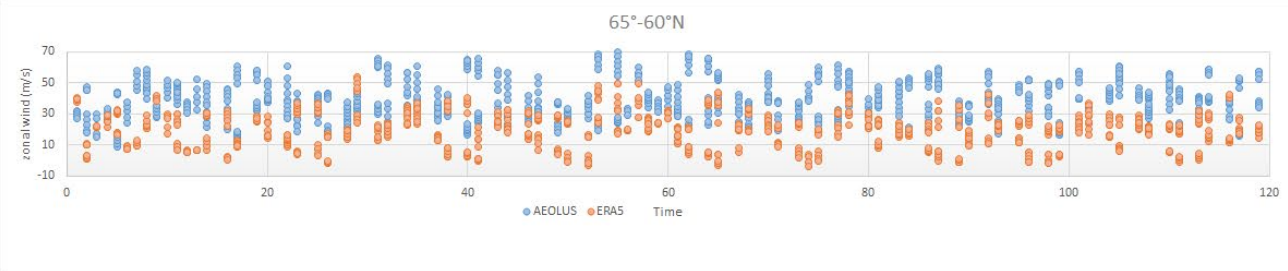
Fit Statistics 40° N - 60° N	
-2 RLL (Res Log Likelihood)	655.62
AIC (Akaike's information criterion)	653.60
AICC (Corrected AIC)	653.74
BIC (Bayesian information criterion)	655.60

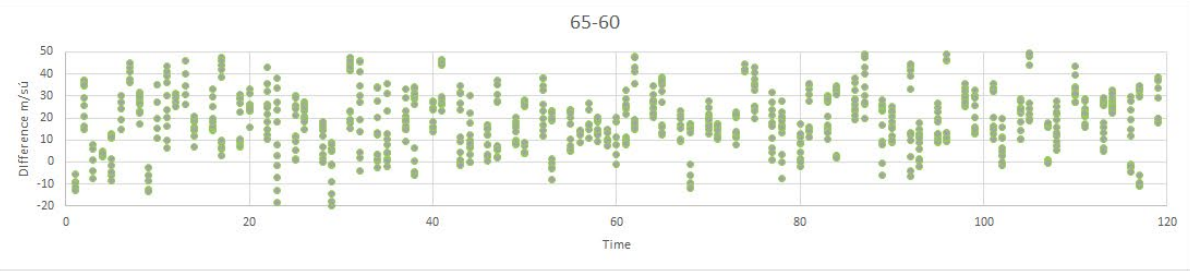
Covariance Parameter Estimates		
Cov Parm	Estimate	Standard Error
Var (RSmooth)	174.19	56.7565
Residual	1.4553	0.5628

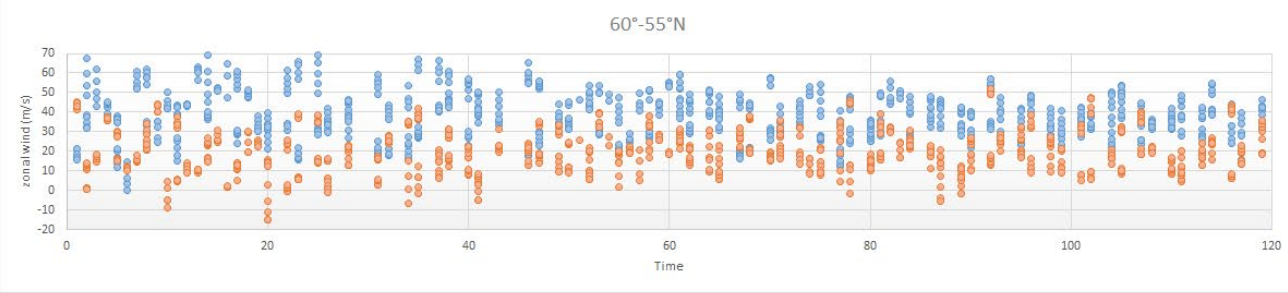
Fit Statistics 40° N - 90° N	
-2 RLL (Res Log Likelihood)	915.5
AIC (Akaike's information criterion)	913.5
AICC (Corrected AIC)	913.48
BIC (Bayesian information criterion)	915.5

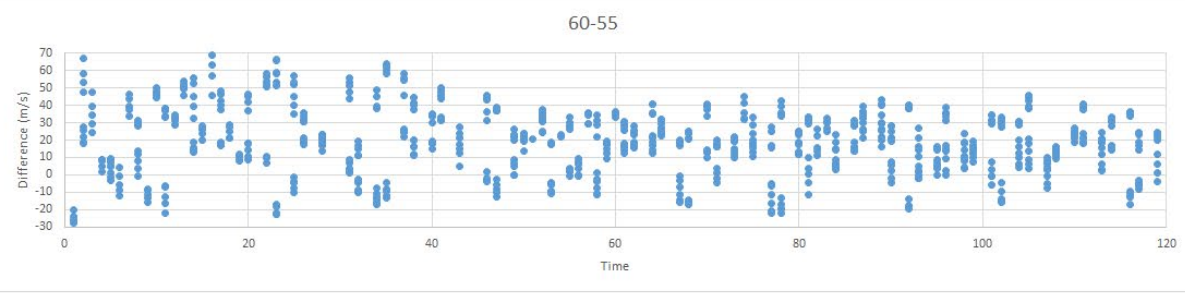
Covariance Parameter Estimates		
Cov Parm	Estimate	Standard Error
Var (RSmooth)	137.23	42.78
Residual	4.453	0.3638

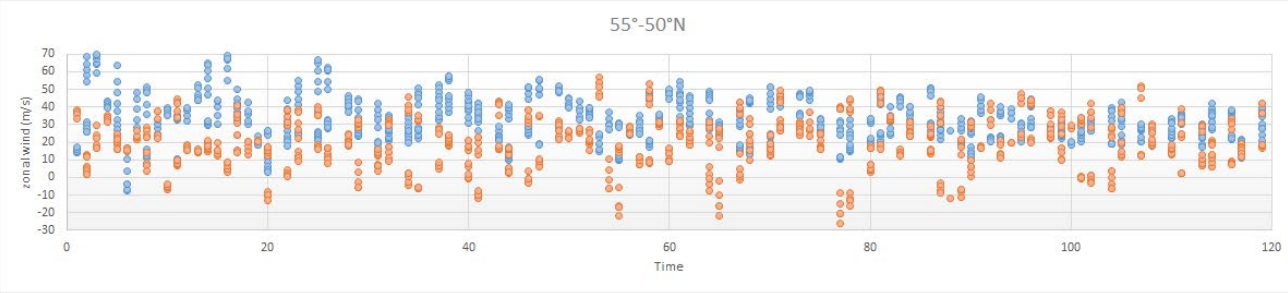
Comparison of ERA5 and AEOLUS

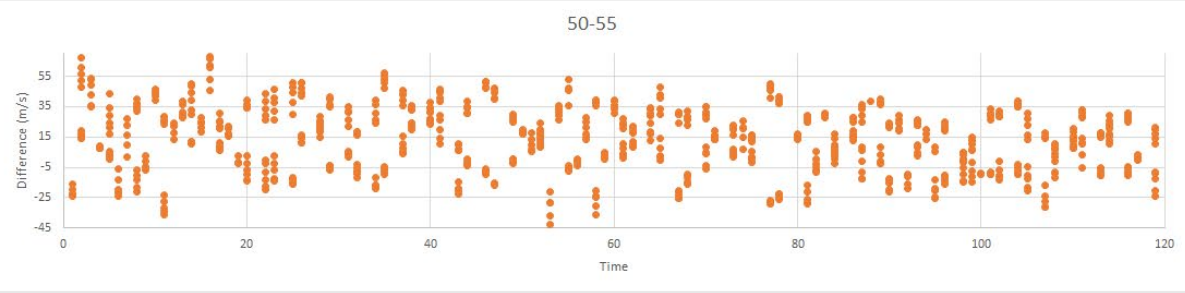


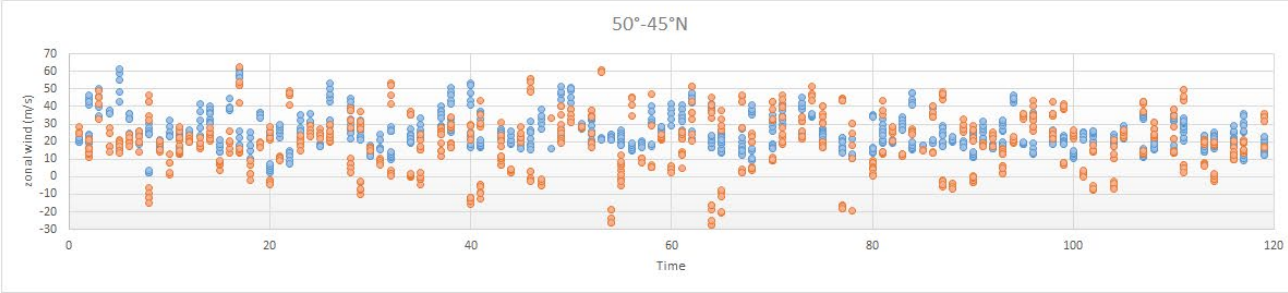


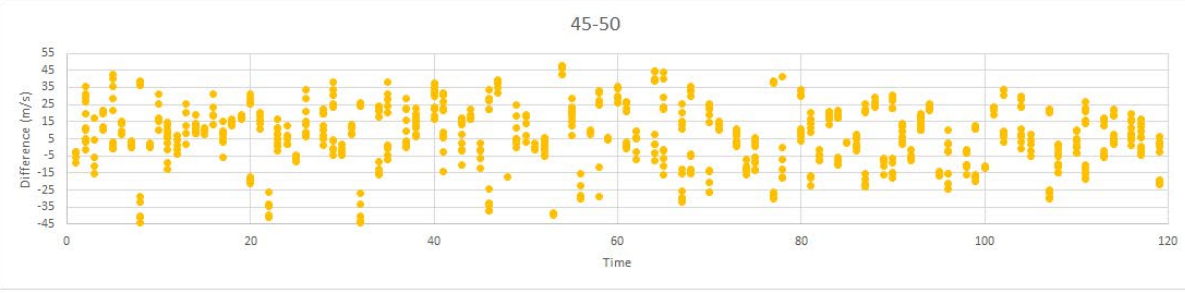




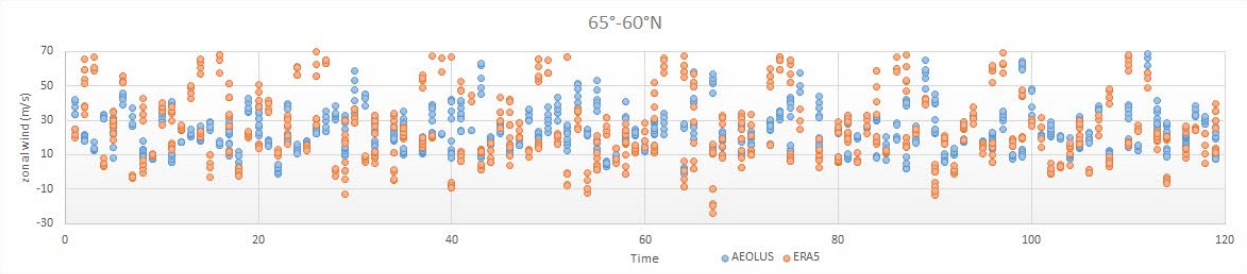


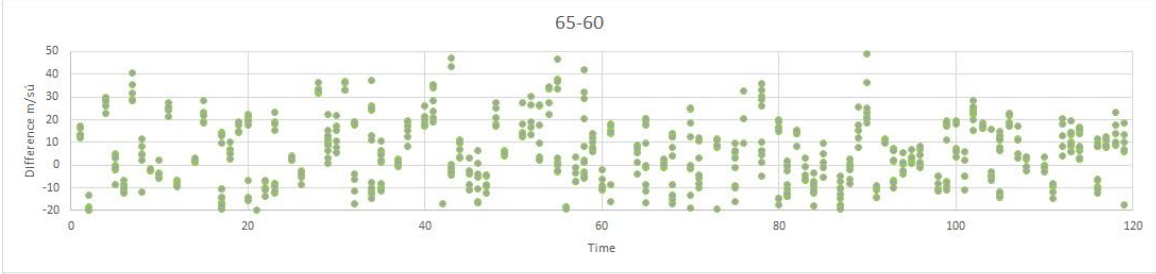


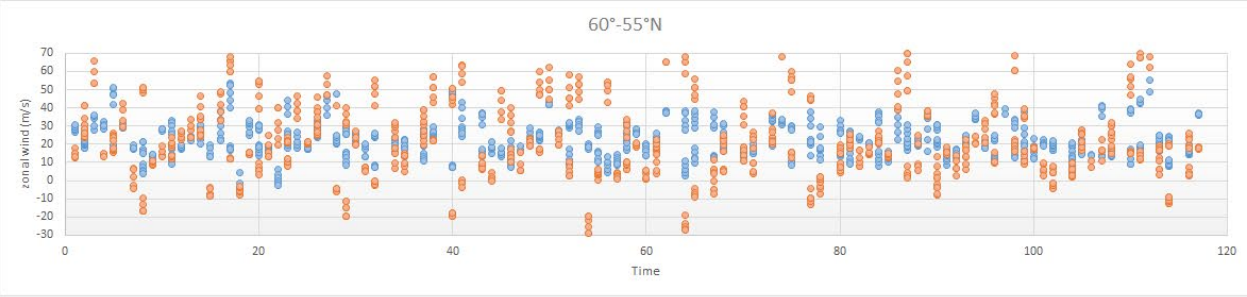


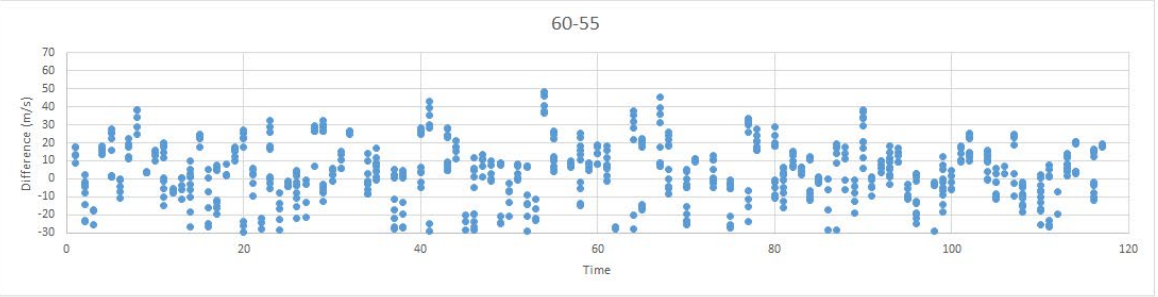


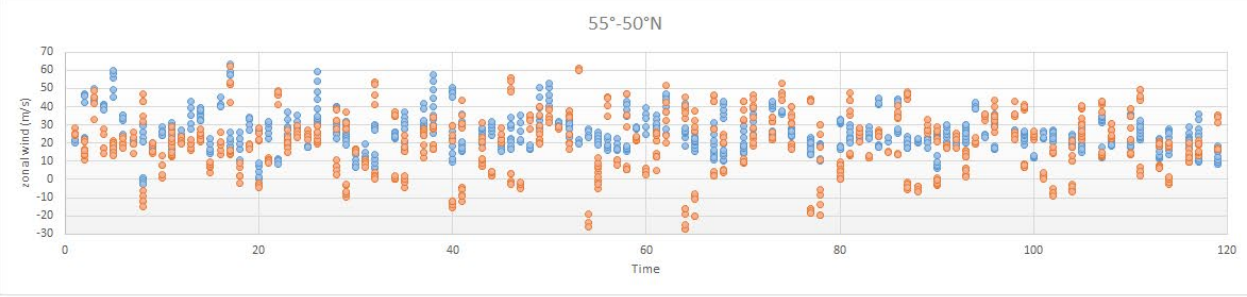
Comparison of ERA5 and AEOLUS

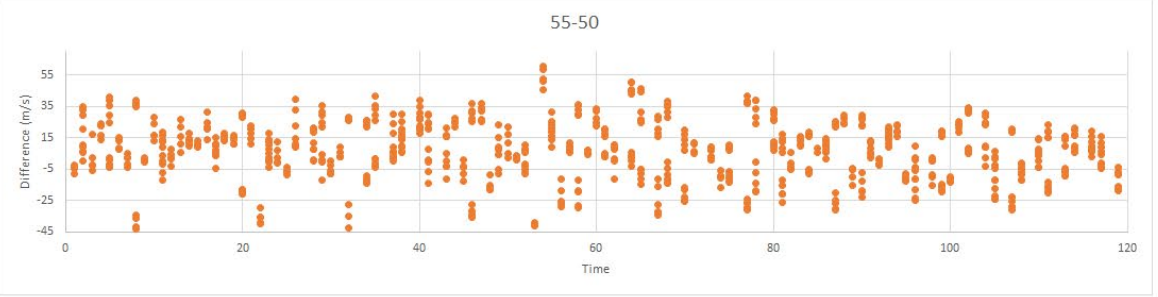


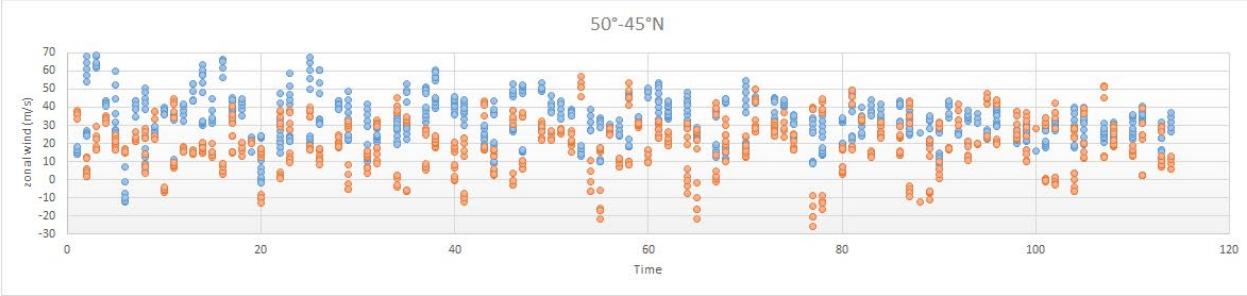


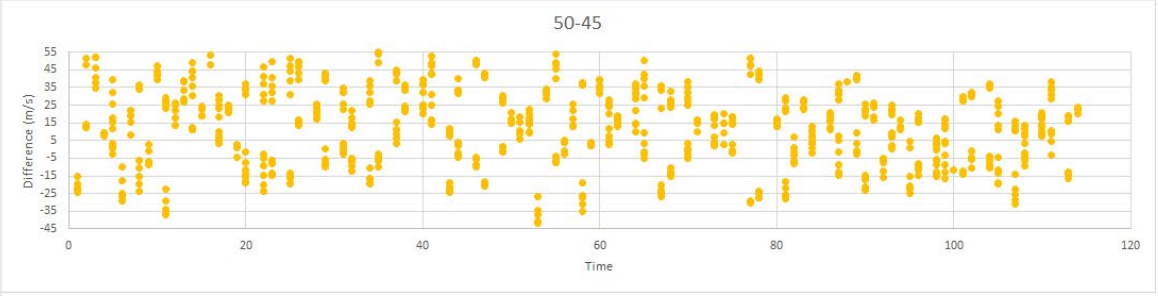












Comparison of ERA5 and AEOLUS

- Comparison of zonal wind at 150 and 175 hPa from AEOLUS and ERA5 show that Aeolus measurements are biased
- The difference between ERA5 and Aeolus are different for each zonal bends (table bellow)
- The biggest one is for higher latitudes
- The main features are very similar

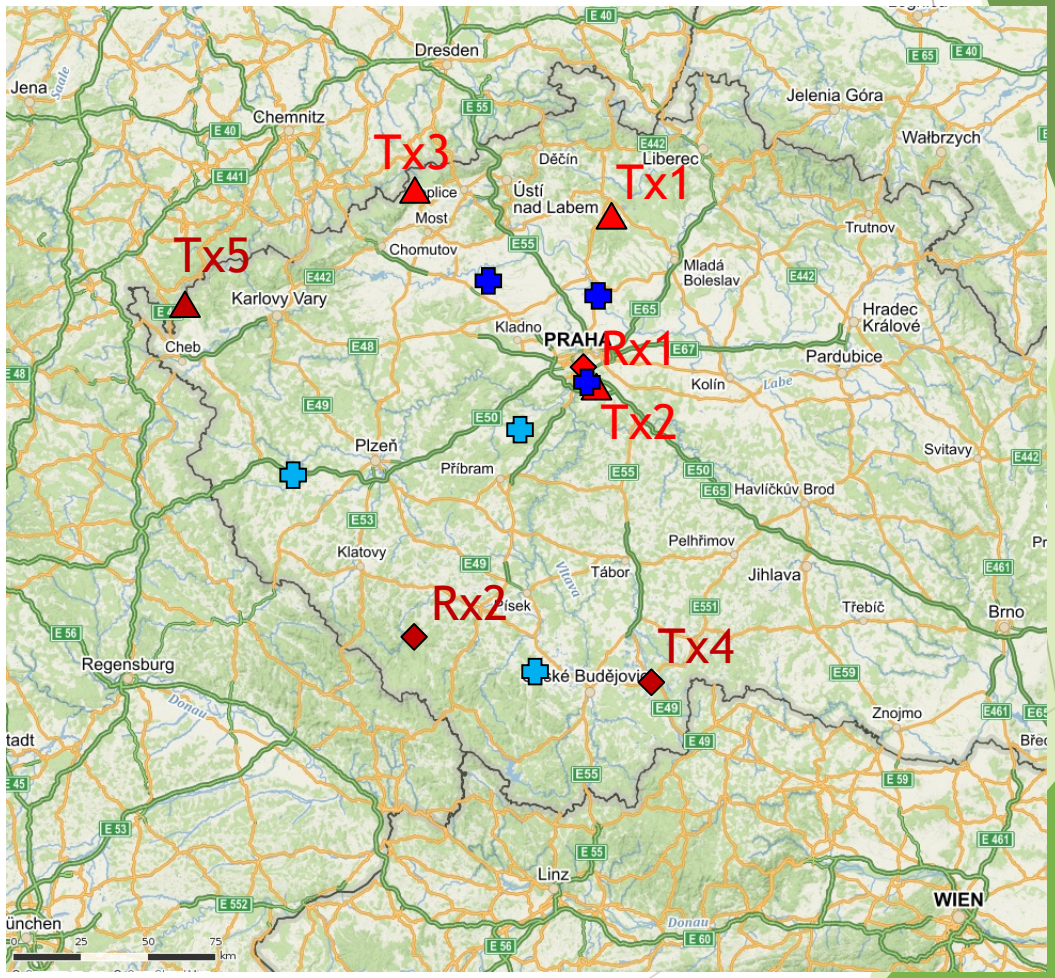
	65°-60°N	60°-55°N	55°-50°N	50°-45°N
150 hPa	20	20	15	9
175 hPa	16	20	15	8

Measurement setup for GWs,
Absolute microbarometers and Continuous Doppler sounding

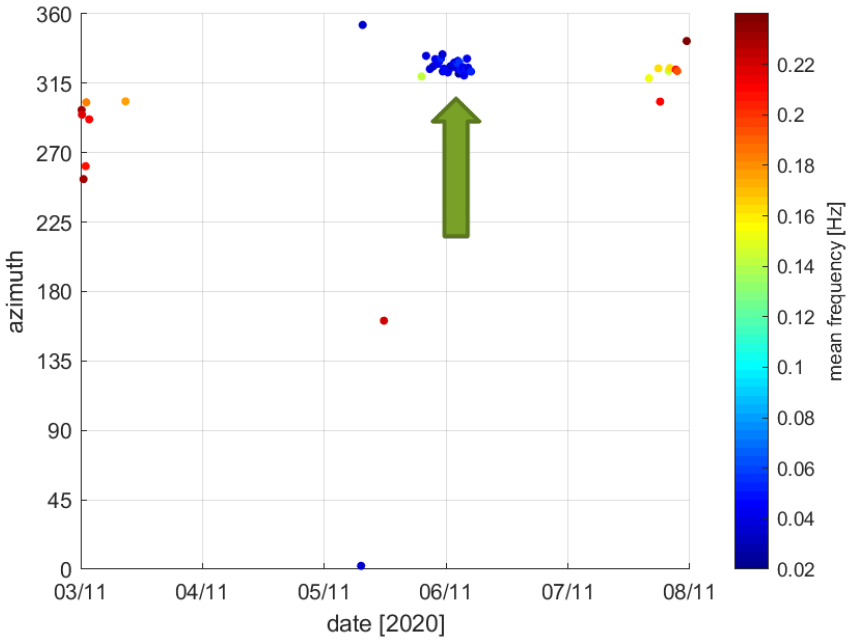
Small triangle, 3 freq. since 2014
Tx1, Tx2, Tx3
at each location, frequency of
3.59, 4.65 and 7.04 MHz transmitted
Digital ionosonde is close to Tx2.
Rx1 is at the Institute in Prague

Large array, since autumn 2019
(Tx4, Tx5; Rx2 added)
3.59 and 4.65 MHz

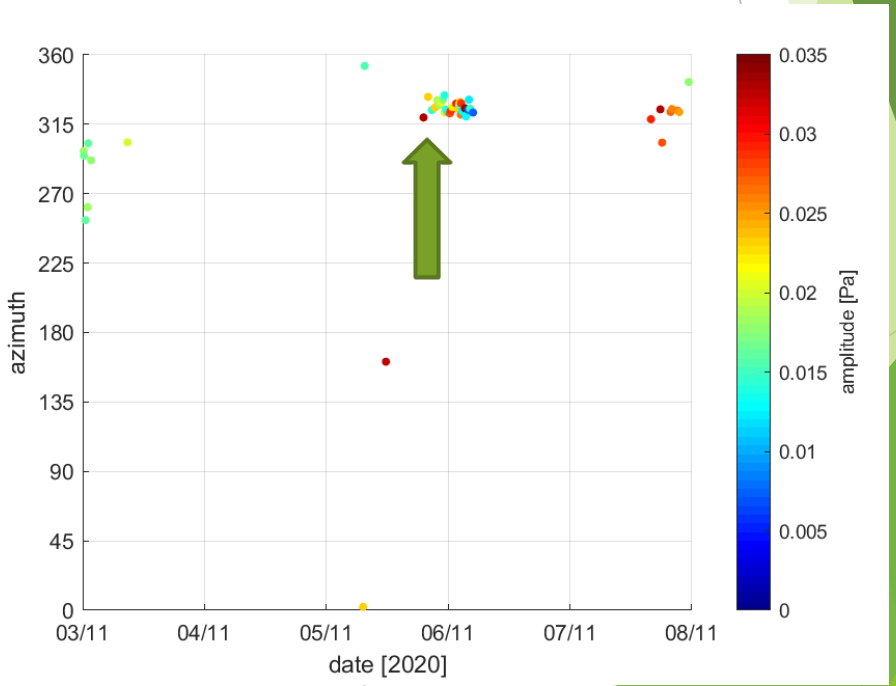
Large scale array of microbarometers around Tx5,



Infrasound arrivals at WBCI from NW



- decrease of signal frequencies on 5-6 November from ~0.2 Hz to 0.04 Hz
- signatures of an amplitude decrease at the same time, but not conclusive

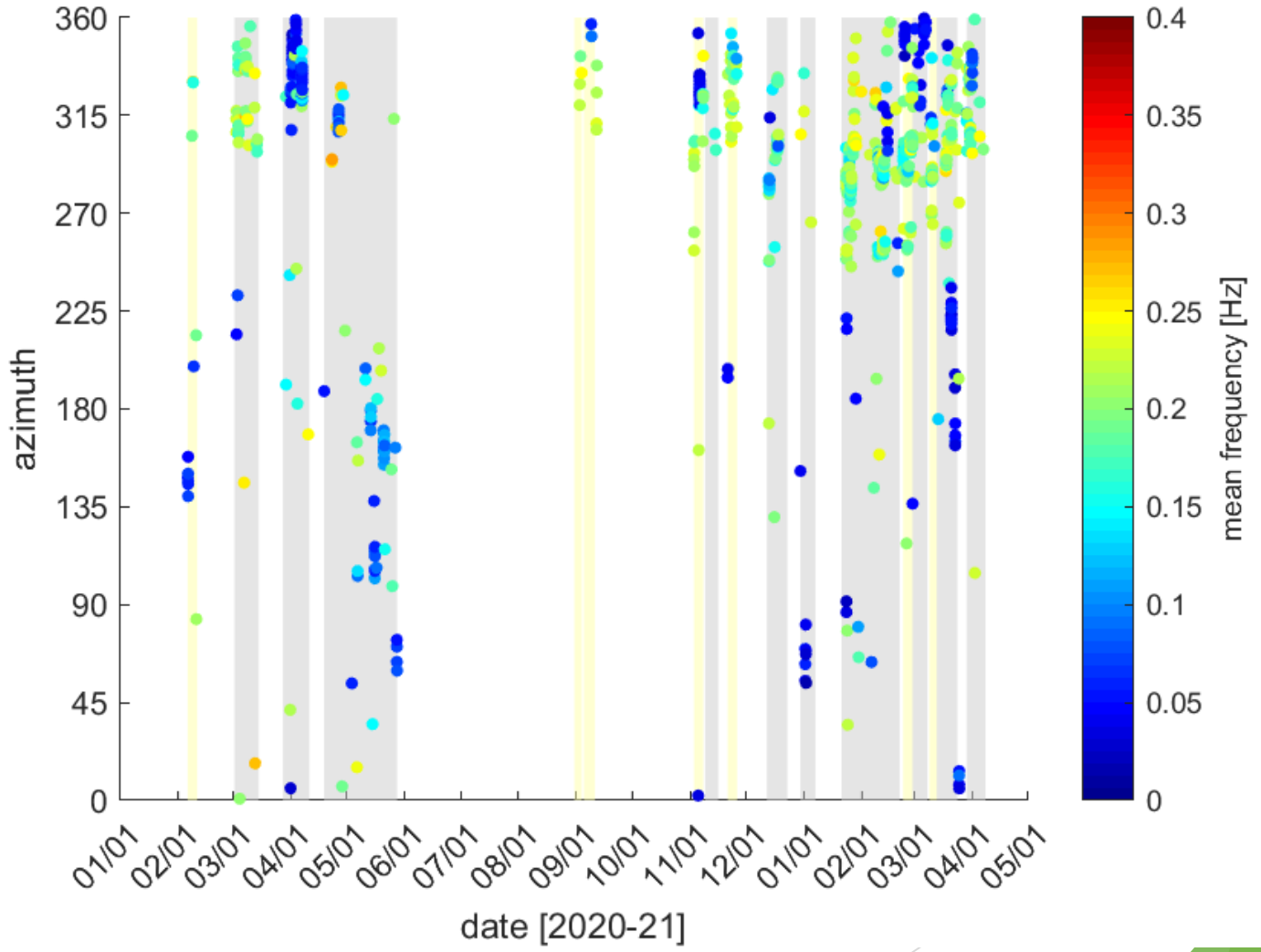


Some considerations

- signals possibly propagated through the streamer event region
- propagation of infrasound against stratospheric winds
  - ➢ signal refraction at higher altitudes (thermospheric wave guide?)
    - ➢ increased signal absorption, at higher frequencies stronger

Azimuth of infrasound arrival, from January 2020 to April 2021

yellow fields = streamer events
grey fields = calm periods



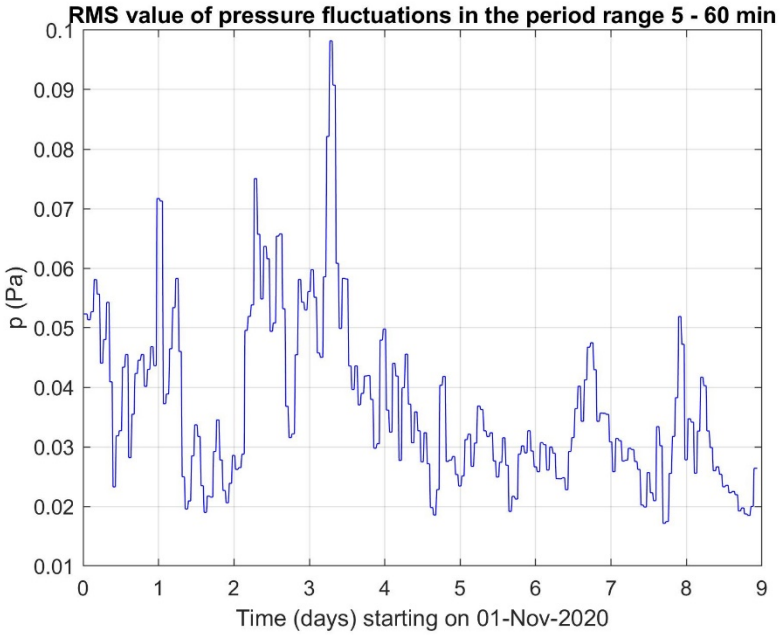
2-D GW analysis from microbarometer network

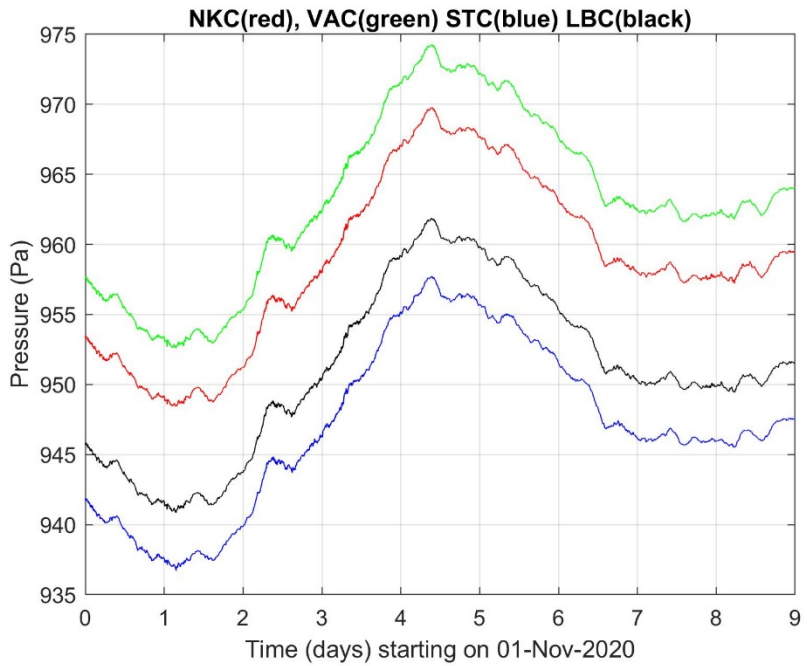
Interval: 1 - 9 November 2020

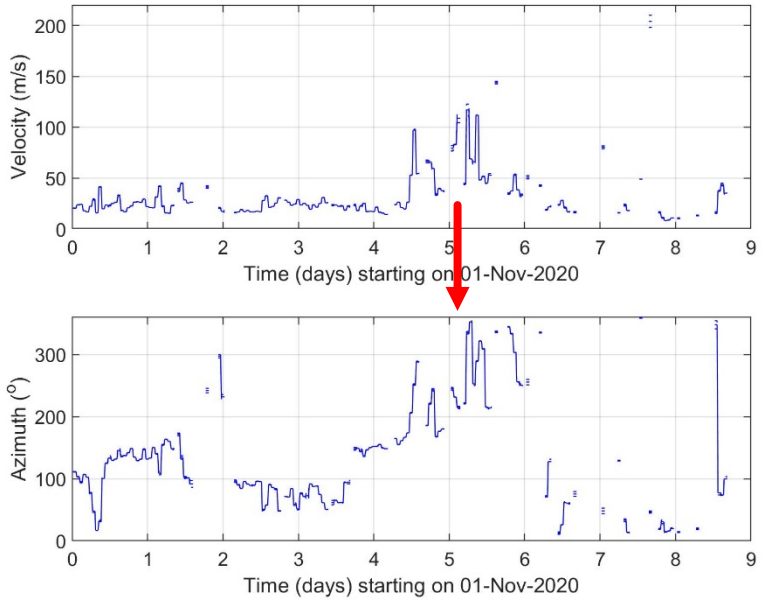
Amplitude (RMS pressure) in the range 5-60 min
Velocity (apparent horizontal velocity) and azimuths.
(120 min intervals, 1-hour step)

Criteria for displaying results:

>0.02 Pa , v> 7 m/s
std of AZ<10º,
relative std of |v| <5%





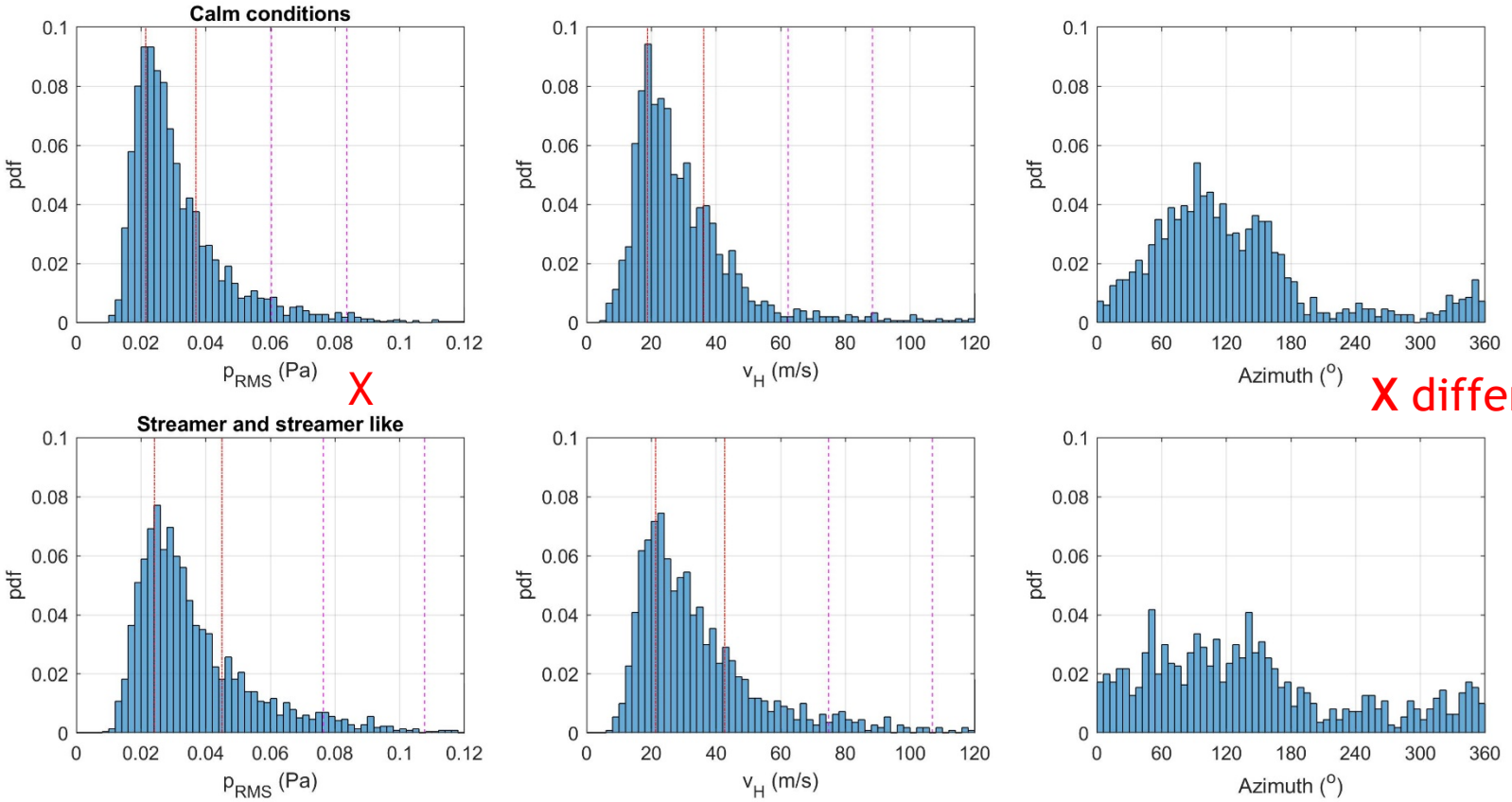


Comparison of GW characteristics in the troposphere, from microbarographs for calm and streamer&streamer-like periods

RMS pressure fluctuations in 5-60 min band (3248/2140 intervals)

Observed horizontal velocity (1517/1102 intervals)

Observed azimuth of propagation (1517/1102 intervals)



Vertical lines mark Q1, Q3, Q3+1.5(Q3-Q1), Q3+3(Q3-Q1); where Q1(Q3) is lower (upper) quartile

Conclusions

- ERA5 dataset streamer event 1 meets the conditions of global homogeneity using AIC.
- BIC does not give much better results and is computationally more demanding

- Streamer events are rather small-scale phenomena (cf. SSW). Variations of stratospheric winds related to streamer events influence signals propagating through the region of the streamer event
- The observations can strongly depend on the mutual location of the infrasound source, the region influenced by the streamer event, and the infrasound array

- Insufficient statistics for pure streamer event
- Some detection for 2-D GW analysis from microbarometer network

Thank you for attention

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