Ada Gjermundsen,
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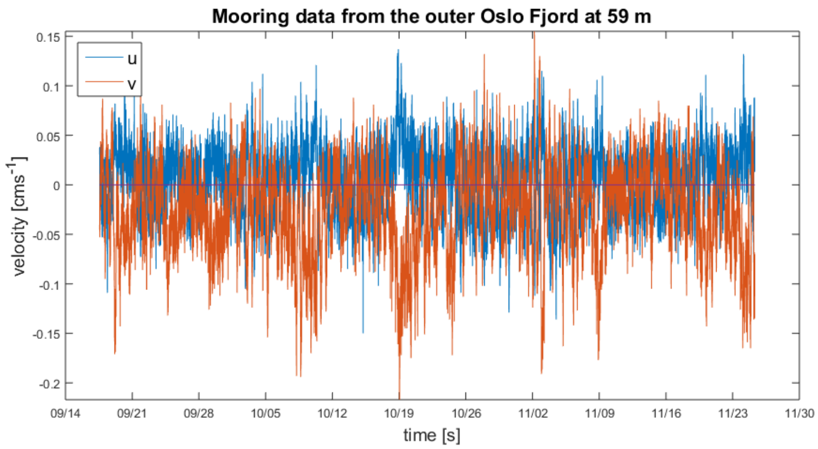
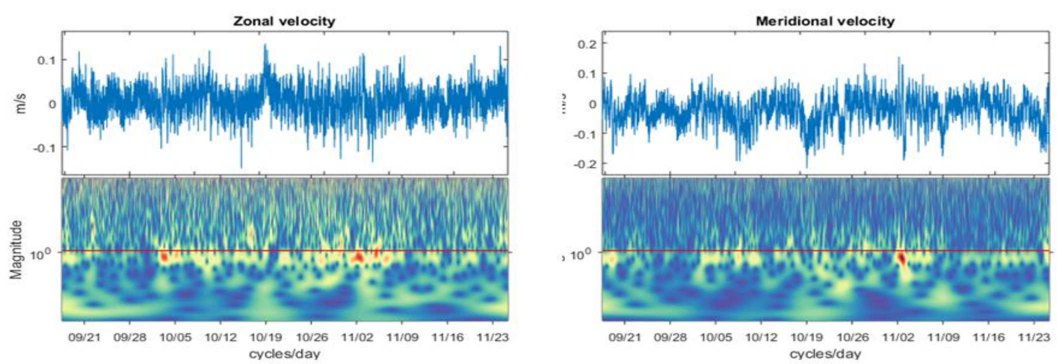
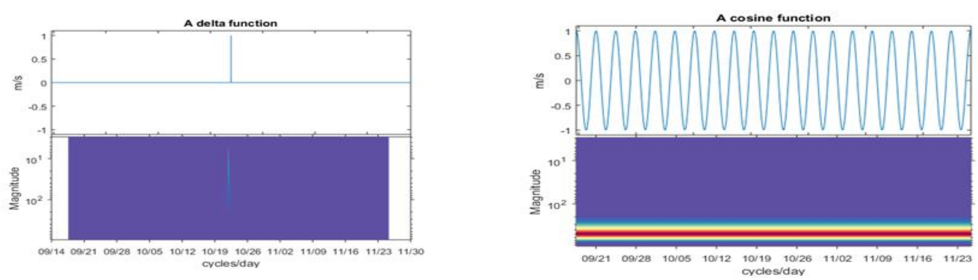


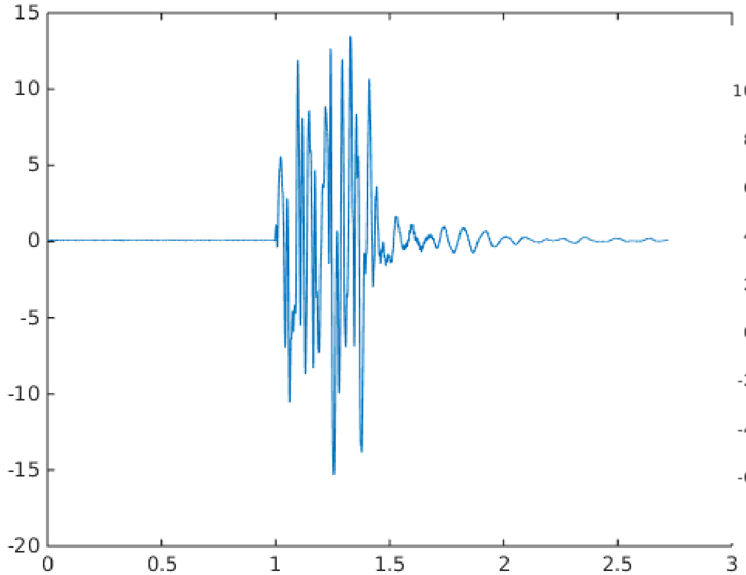
The velocity data have small-scale oscillations which is the noise or the so called "fuzziness" of the data. The velocity components also feature larger scale oscillations with similar amplitude for u and v, but out of face by approximately 180 degrees

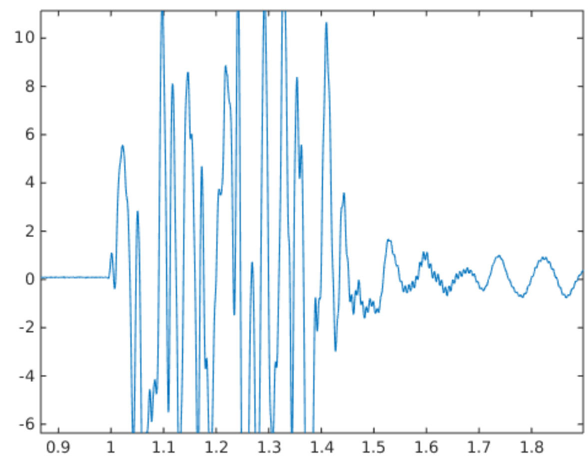




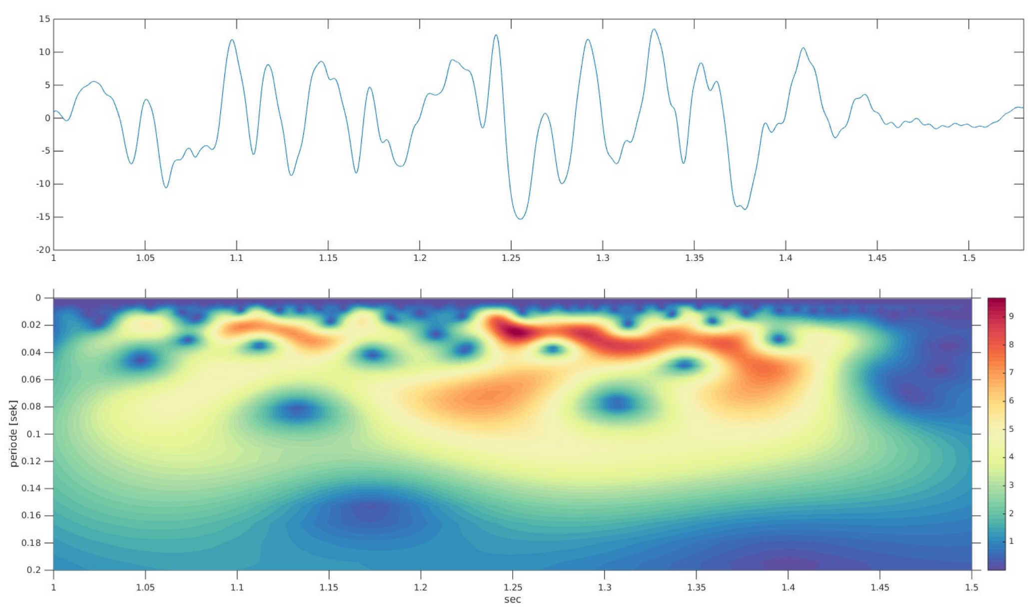
The wavelet transform provides both frequency and time information, but the way you construct the wavelets will impact the results you get. This is why we need to know what features in the resulting figure are due to the wavelets and what is a genuine feature of the data. One method to provide some information about your wavelet structure is to include a figure of a delta function and a cosine function. Then you can tell how fast transitions and oscillations look using the wavelet structure you choose. The dominant oscillation in this data is due to tides with a period of approximately 25 hrs. Higher frequencies are dominated by noise (as expected from looking at the data).

Astrid Fremme
Univeristy of Bergen





Looking at the plot of the data we can see that for the time between 1 and 1.5 seconds the measurements have a high amplitude and short period, with ~13 tops in 0.5 seconds. An average period of 0.04 s?



Looking at the wavelet spectrum we can see that the frequencies (periods) change, but that there is an important range covering the frequencies that appear in the data. These are ~0.01 to ~0.05 for the largest amplitudes and ~0.01 to ~0.16 s for the middle aplitude waves.

Arctic Sea Ice Cover 1850-2013

Carina Bringedal

Geophysical Institute, University of Bergen, Bergen, Norway

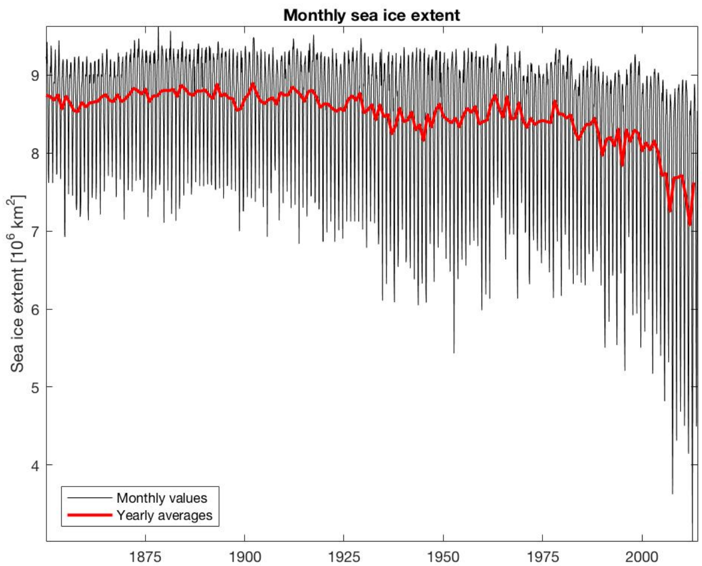


Figure 1: Looking at the data we see a large variability. The frequency of the variability does not seem to change, but follows a yearly cycle. The amplitude of the annual variations seems to be quite stable for the first 50 years, but then gradually increases; mainly as summer sea ice extent is lower. Towards the last decades the winter sea ice extent also decreases a bit. The yearly average shows that the average sea ice extent is fairly stable in the beginning, but has an increasing decline towards the end of the period.

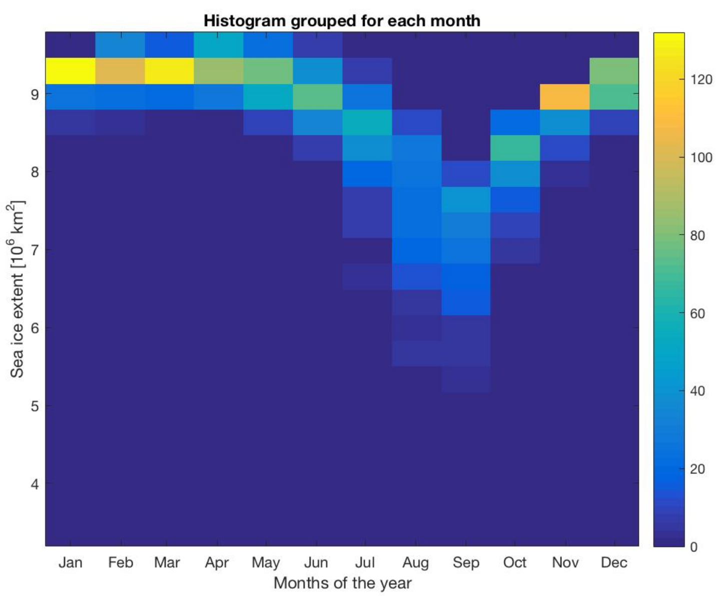


Figure 2: Using a "2D" histogram; grouped for each month, reveals the spread and stability of the yearly cycle. The winter months (Dec-May) has little variability, with most values over 9 million km^2 of sea ice, while the summer months (Jun-Nov) has a larger spread in the sea ice extent, with some medium and some low values. As the Arctic can be completely ice covered in winter, there is a maximum for how large the sea ice extent can be, and the winter months are probably close to this maximum value. The summer months vary more as some ice melts, but a lot remains.

Eli Anne Ersdal, University Centre in Svalbard

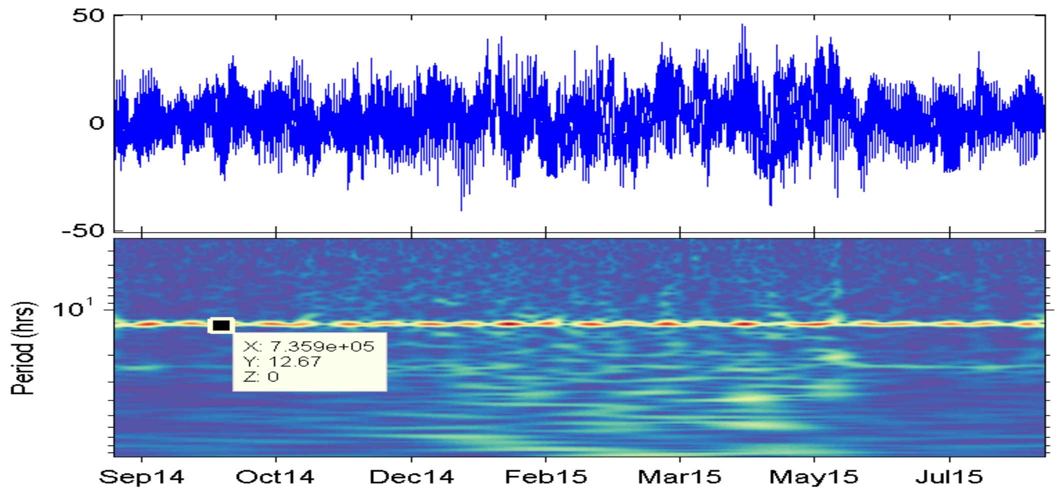


Figure 1: The upper panel is the uvplot of the current meter data from 200 m depth located in The Fram Strait above the Yermak Plateau northwest of Svalbard. The strength of the current varies between -35 cm/s and up to 50 cm/s. The spring neap cycle due to the tides is the most dominant feature. In addition one can see that the current is stronger during the winter months (JFMAM). The wavelet analysis in lower panel shows that most of the energy in the time series has a period of around 12 hrs which coincides with the semidiurnal tide.

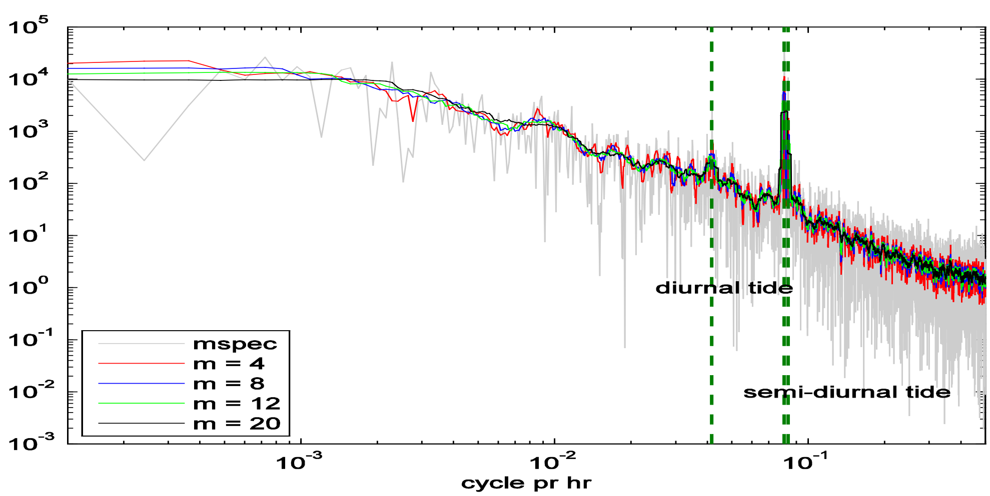


Figure2: Power spectrum with different tapers. The plot shows that both the diurnal and semidiurnal tides are dominant in this region.

Timeseries analasys with MatLab jlilly workpackage

Henrik Grythe

June 3, 2016

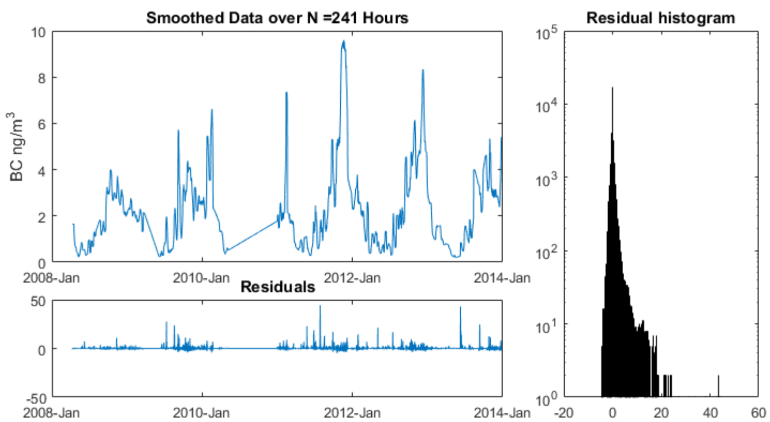


Figure 1: Black Carbon (BC) measured at Dome C, Antarctica. The data has been smoothed with vfilt, over a 10 day period, taking a median value over that time-period. This filter clearly brings forward the seasonal cycle and it also highlight some shorter events. Below is the residuals and on the right, the histogram of the residuals, showing a very skewed distribution.

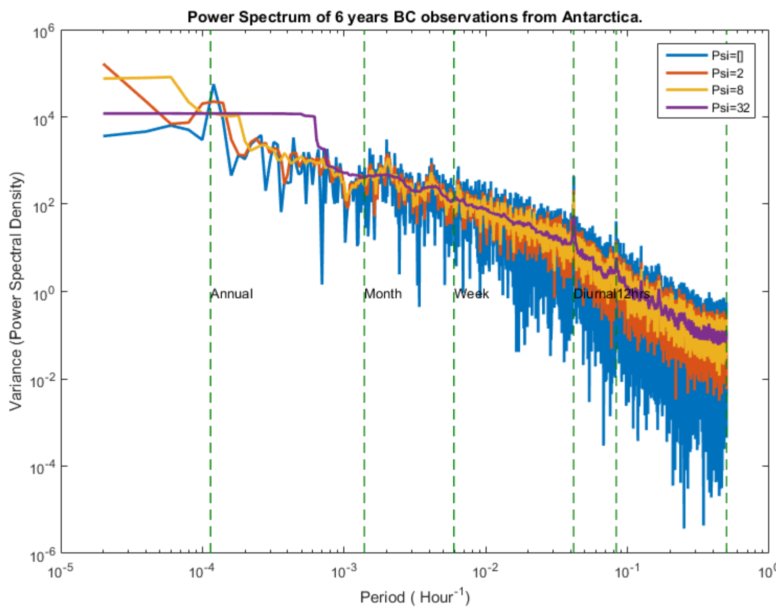


Figure 2: Power spectrum of the whole timeseries using various degrees of smoothing. The most recognizable feaurure is the diurnal cycle and annual cycle. It is not obvious that a place in Antarctica (1100km from the nearest coast) should have a diurnal cycle as it is far from sources, and have long dark / ligh periods, but this feauture of the data is quite prominent when viewed in the power spectrum.

Kjersti Opstad Strand
Institute of Marine Research
PhD student at the Geophysical Institute, University of Bergen

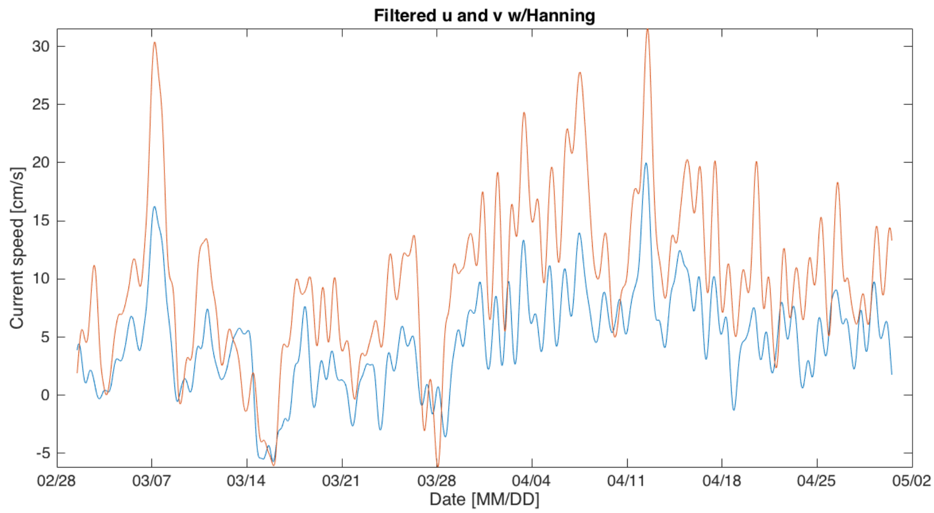


Figure 1: Time Series of current speeds, both u- and v-component, plotted using "uvplot" from the Matlab JLAB-package. The data is filtered using the "vfilt" with Hanning window of one day.

Looking at the data

The data is not symmetric around zero. The v-component (orange line) has the highest amplitude and mostly northward direction (positive). The u-component is slightly weaker, and mostly going eastward (positive values). There seems to be some temporal variability, both high and low frequency. There exist two periods where the current shifts direction, going southwestward.

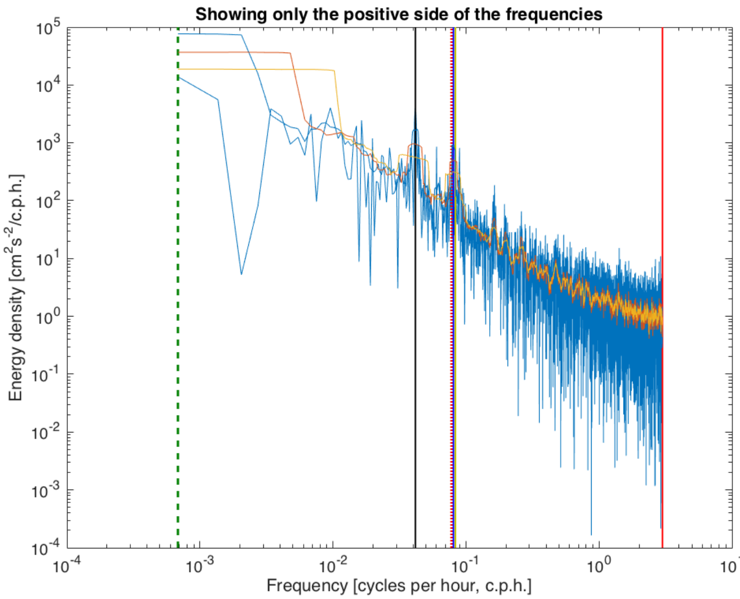


Figure 2: A one-sided periodogram (calculated with "mspec" in JLAB) of the total current speed with several versions of the multitaper spectrum setting time-bandwidth product of 4,8 and 16 in "sleptap". The Nyquist-frequency, the highest resolvable frequency, is marked with a red vertical line (using "vlines"in JLAB). The Rayleigh-frequency, the lowest resolvable frequency, is marked with a green dashed line. The daily cycle is marked with a black vertical line. The solar tide cycle (yellow), the lunar tide (blue) and the Coriolis frequency (dashed red calculated using "corfreq") for this area are almost at the same location in this periodogram.

Looking at the analysis plot

Higher value of the time-bandwidth is equivalent to higher smoothing in the frequency-domain reducing the variability, but also spreading out features like strong peaks. This is called the bias/variance trade-off. The daily cycle is marked with a black vertical line, and we clearly see a peak here. I also see a peak around 12 hours, but this is where both the different tidal cycles and the Coriolis frequency for this area is located, so it is hard to distinguish between these frequencies.

A glimpse into the atmospheric surface layer

Showcasing skills learned in the ResClim course *Ocean/Atmosphere Time Series Analysis: Theory and Practice* held in Oslo, May 2016

Kristoffer Aalstad (kristaal@geo.uio.no), Department of Geosciences, University of Oslo

June 3, 2016

Herein we briefly analyze a time series of temperature in a statically unstable atmospheric surface layer as measured by a sonic anemometer. This instrument and the associated eddy covariance system, extensively discussed in Westermann et al. (2009) and Aalstad (2015), is located in the Bayelva catchment near Ny Ålesund (Svalbard, Norway). In light of limited space we refer readers unfamiliar with boundary layer meteorology to Kaimal and Finnigan (1994) for an overview of the notation and concepts that we make use of.

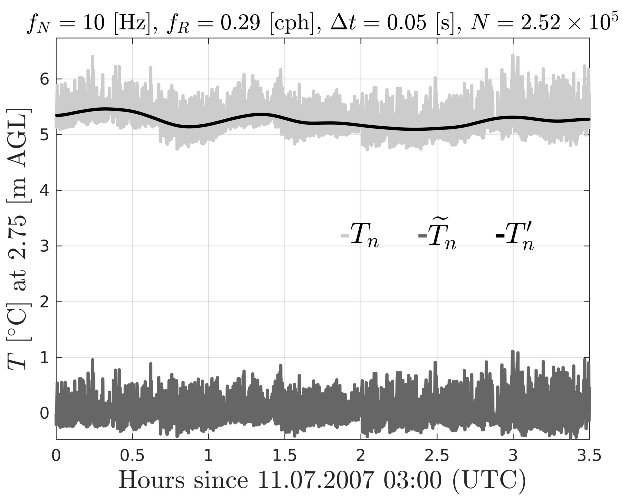


Figure 1: *The discrete time series of temperature (T_n; light gray) along with its low pass filtered version ($\widetilde{T}_n$; black) and a high pass filtered residual ($T'_n = T_n - \widetilde{T}_n$; dark gray). The low pass filter is a running weighted mean that uses a $0,5$ hour Hanning window with mirroring at the endpoints. Key parameters, i.e. the Nyquist (f_N) and Rayleigh (f_R) frequencies along with the sampling interval (Δt) and the number of samples (N), are specified in the Figure title.*

We begin with a visual inspection of the time series as shown in Figure 1. Just by a rough eyeball of the time series we can immediately identify two distinct timescales of variability. The first, easily seen in the low pass filtered signal, is a lower frequency oscillation with weak amplitude and a period of about one hour associated with mesoscale phenomena. The second, visible in the high pass filtered signal, is a high frequency oscillation with higher but varying amplitude with a period on the order of a minute or less associated with microscale turbulence or maybe just noise. Other than that there is no visible trend in the time series and the first and second moments appear to be quasi stationary at timescales at and above an hour or so. Nonetheless, there is some heteroscedasticity in the time series as the variance is at a noticeable minimum about half way through the time interval and a distinct maximum in the last half hour. Still, in the time domain this data appears a bit bland. After all much of the high frequency variability could just be noise.

Viewed in the frequency domain shown in Figure 2, however, the data becomes a lot more vibrant. In fact both spectral estimates (henceforth spectra), calculated using different methods, not only agree reasonably well but show the same four distinct features. Firstly, the spectra exhibit a clear peak in the mid frequency range corresponding to a period of about one minute as we suspected after the inspection of the time domain. Secondly, around a decade below the peak a narrow low frequency spectral gap is visible at a period corresponding to around 15 minutes. Thirdly, as also identified in the time domain, at frequencies just below this narrow gap we see a new local maximum in the spectrum quite close to the value of the peak itself. This is in the mesoscale domain, i.e. periods above 30 minutes, where classical theory (and scale separation in many models) assumes that there should be no such peak. Finally we come to the question of whether or not the high frequency oscillations are noise. Not only do both spectra roll into the expected $f^{-2/3}$ slope about a decade after they peak, but their *magnitude* also matches that of the inertial subrange independently determined by spectral similarity theory (see Kaimal and Finnigan 1994) at this particular stability. Thus, given that this prediction holds strictly for stationary, isotropic and homogeneous turbulence, it is clear that we are in fact dealing with a microscale turbulent cascade and not some form of noise. The only exception to this is at the very highest frequencies where we see that the multitaper estimate rises up again. This is a known issue associated with aliasing of the unresolved high frequency instrument noise in sonic anemometers. The independent estimate has been corrected externally using a standard dealiasing filter (the red curve shows the corresponding aliased estimate).

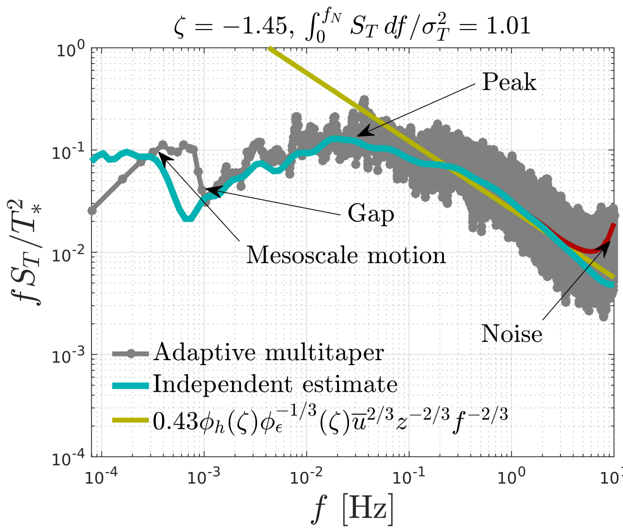


Figure 2: *Estimates of an unstably stratified ($\zeta < 0$) nondimensional temperature spectrum as a function of frequency using an adaptive Slepian multitaper (gray) in* `JLAB` *and a simpler more approximate approach (turquoise) detailed in Aalstad (2015). For both estimates the variance is recovered upon integration (as shown in the title). The corresponding intertial subrange predicted by spectral similarity theory and confirmed empirically (Kaimal and Finnigan, 1994) is shown in yellow.*

References

Aalstad, K. (2015). Applying the Eddy Covariance Method Under Difficult Conditions. MSc Thesis, University of Oslo, doi: 10.13140/RG.2.1.3083.7844.

Kaimal, J. C. and Finnigan, J. J. (1994). *Atmospheric Boundary Layer Flows–Their Structure and Measurement*. Oxford University Press. doi: 10.1002/qj.49712152512.

Westermann, S. et al. (2009). The annual surface energy budget of a high-arctic permafrost site on Svalbard, Norway. *The Cryosphere*, 3:245–263. doi: 10.5194/tc-3-245-2009.

Lukas W.M. Becker – University of Bergen

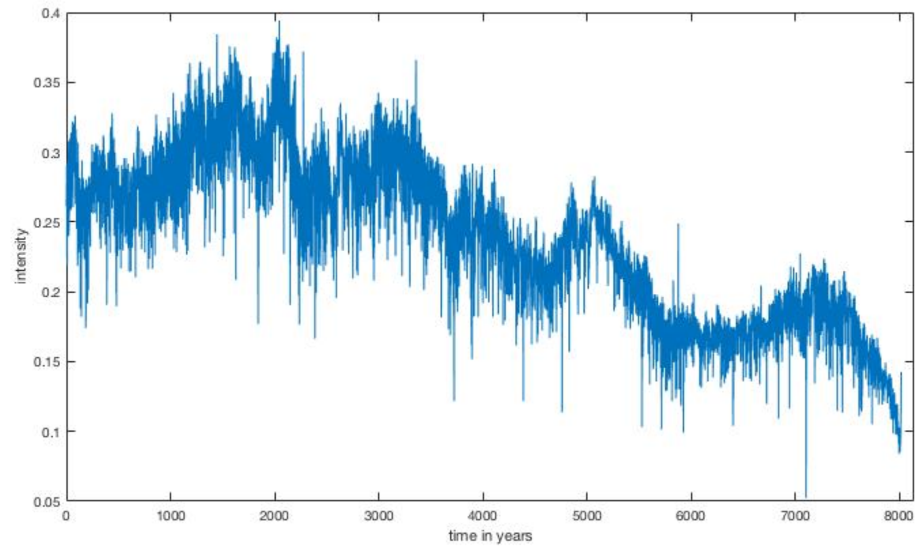


Figure 1 : A time series measured on a sediment core in the North Atlantic. High frequency variability superimposed on frequencies with very long periods, these long periods however appear to change throughout the time series. A trend to larger values is underlying the whole dataset. The data appears rough; the amplitude seems to increase towards younger values. The data is non stationary.

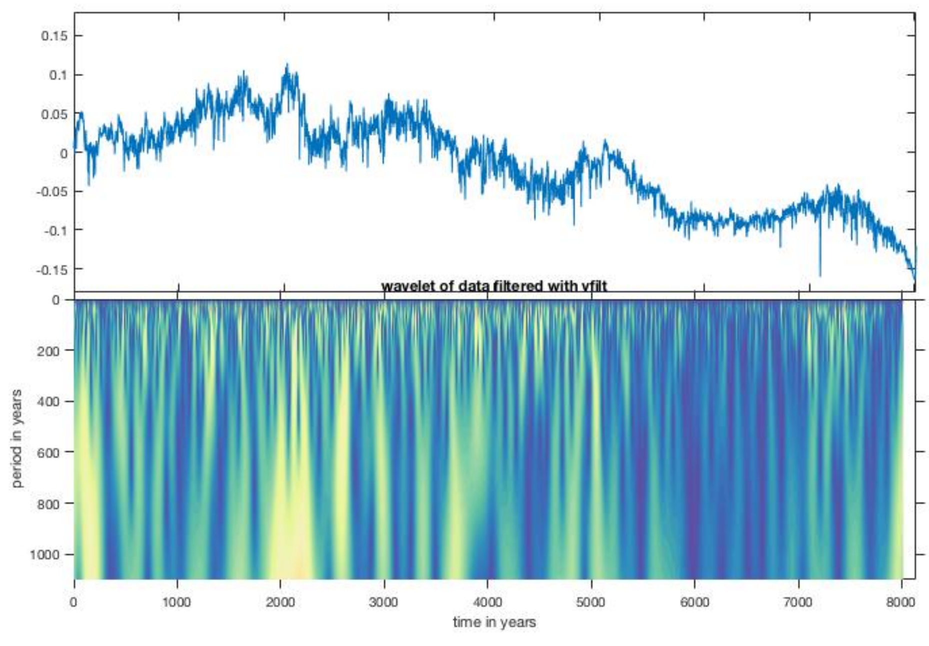


Figure 2: The wavelet of the filtered time series shown in figure 1. The data was filtered with a 5 year Hanning window, to smooth shortest periods. The high variability in the record becomes very visible. Periods >4000 years appear very common throughout the record, but are not displayed. A very regular change between strong and weak periods appears to be between 200 and 1000 year periods. Strong periods are as well visible below ~150 year periods.

Course Work for the ResClim course 'Timeseries analysis' by J.Lilly

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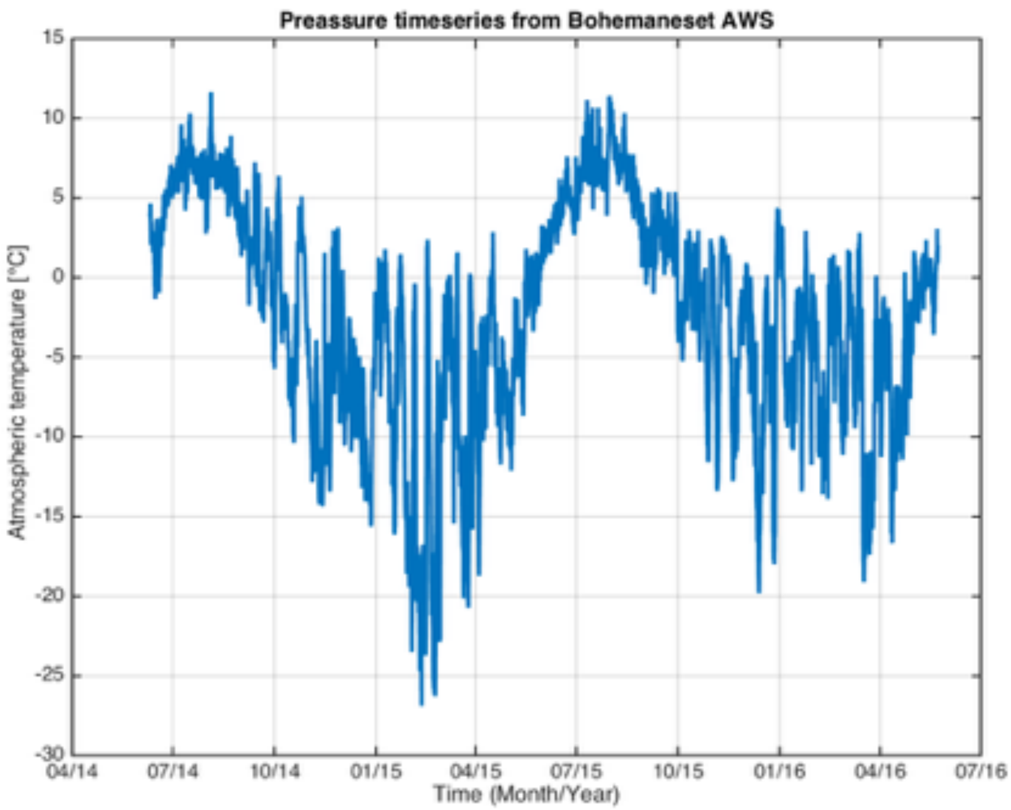
University Centre in Svalbard

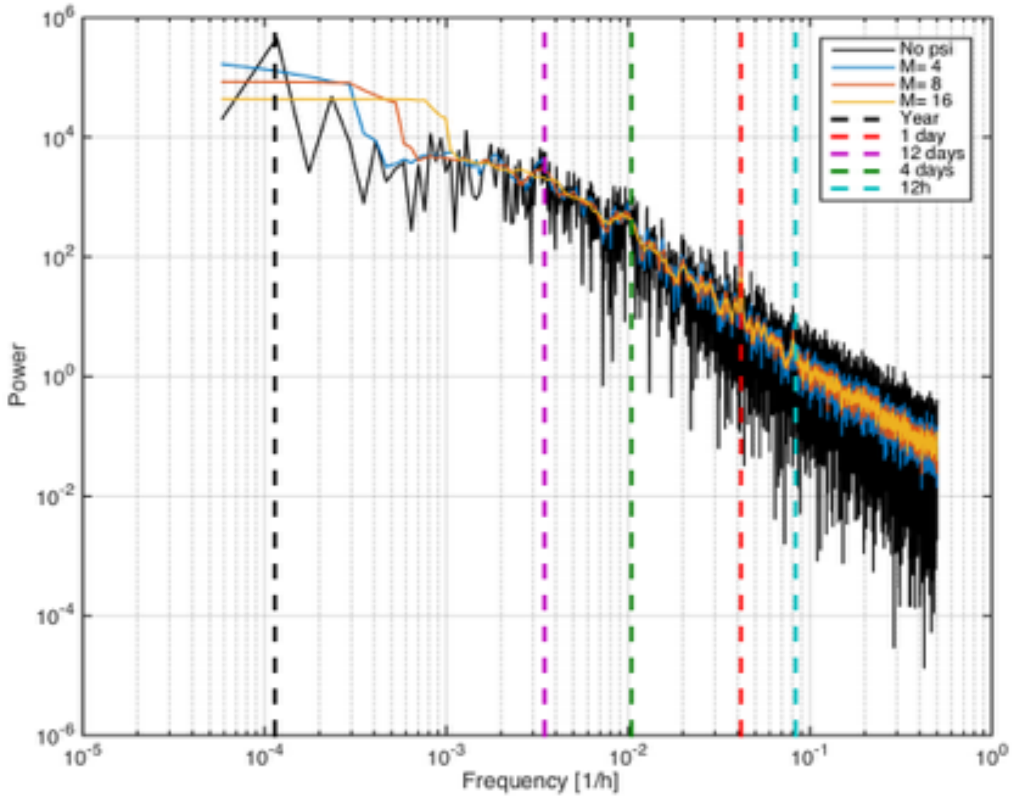
My data:
I'm working with a 2 year long time series of atmospheric 2m temperature from Bohemaneset automatic weather station from Svalbard (79°N). The data is hourly averages from 1 minute data.



Looking at the time series:
The data is quite rough, with a lot of spikiness. The time series has variability of different scales, but it seems irregular and somewhat non-periodic. However, a yearly cycle of warm temperatures in the summer and colder temperatures in the winter is clearly visible. The winter temperatures seem to vary more than summer temperatures and the temperature increase in the spring shows less variability compared to the temperature decrease in the fall. Based on just looking at the time series the data seems to be negatively skewed, with negative peaks being larger compared to the positive ones.

Course Work for the ResClim course ‘Timeseries analysis’ by J.Lilly

My favourite analysis plot:



In my favourite analysis plot you can see the power spectra and the frequencies on a loglog scale. This plots demonstrates how smoothing by the usage of multi tapering affects your data. The black spectra is the non-tapered, raw, temperature time series. When smoothing the data with 4 tapers the data smoothens to the blue spectra and when more tapers, 8 and 16, are added the data ‘smoothens’ to the red and the yellow spectral respectively.

The tapering captures still most of the physically relevant frequencies (dashed lines), even though the amplitude of the peaks is reduced. However, the yearly variation (clearly visible in the original time series) is of too low frequency and all the tampered spectra can not resolve it.

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Geophysical Institute
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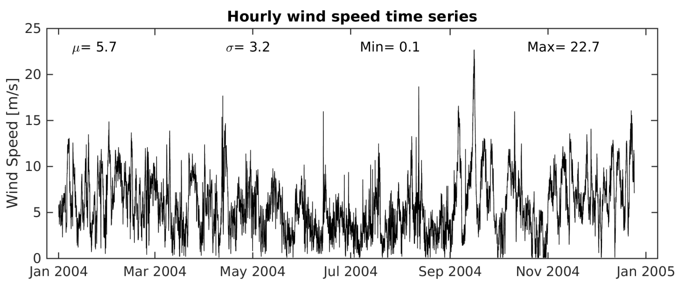
The time series analysis presented here is based on the hourly time series of wind speed data from a buoy located at 28.739N 86.006W. In the first figure the hourly time series from January to December 2004 is presented. The second figure illustrates the power spectrum with three different tapering function.



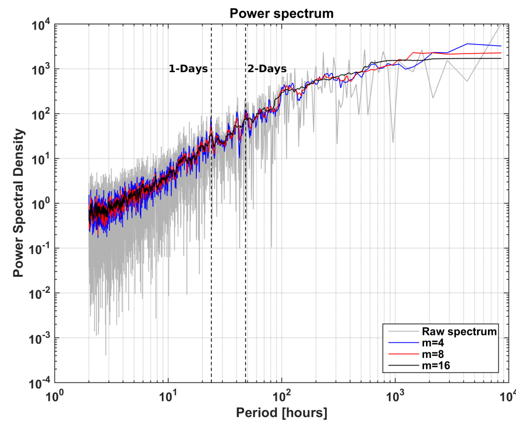


Figure 1. Hourly time series of wind speed in m/s from January to December 2004 (*left*) and the power spectrum (*right*). The vertical lines in the power spectrum indicate the periods in days and m refers to the number of tapers used for smoothing the spectrum.

The hourly time series shows low wind speed during the summer season and high during the winter season (left figure). This low frequency component is simply the seasonal cycle of the wind speed. However, within the seasonal cycle significant low and high frequency variability with varying frequency and magnitude is observed. There are several spikes with different magnitudes indicating high wind episodes. Further, the wind speed shows a periodic pattern with changing periods. For example, during the winter season there are oscillations with shorter periods, while during early winter the periods are relatively long. Such periodicity can be further investigated by the power spectrum (right figure). The gray spectrum is for raw data without any tapering applied, whereas the spectrum with blue, red and black are the ones with increasing number of tapering. The spectrum with tapering applied are smoother than the raw spectrum and thus are expected to better estimate the SPD. In general, the power increases with increasing periods, i.e., the low frequency components have a larger amplitude than the high frequency components. There exists various peaks with period ranging from 1 to 2 days as denoted by vertical lines. The spectral peak with periods of one day is simply the diurnal cycle of wind speed.It is interesting to note that the low frequency components have broad band spectrum. In contrast, the high frequency components show narrow band spectrum. This suggests that the high frequency variability has more consistent periods than the low frequency components. This confirms that the time series of wind speed varies both with respect to frequency (period) and amplitude and hence the time series is non stationary.

Ocean/Atmosphere Time Series Analysis: Theory and Practice

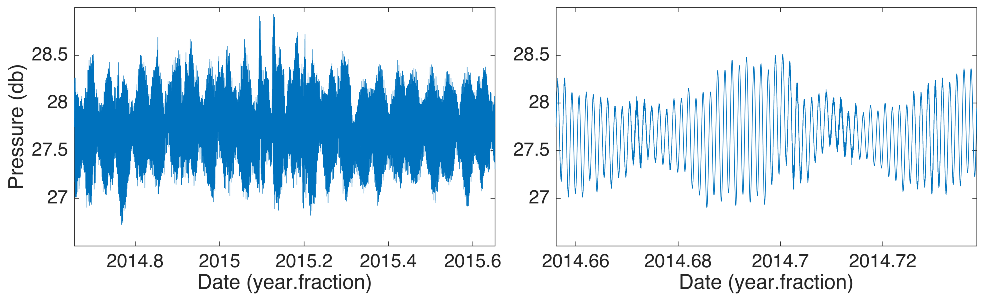


Figure 1. Time series at the Yermak Plateau from a mooring instrumented with a Seagauge Wave and Tide Recorder, SBE26. The instrument was deployed in August 2014 at a depth of 27 m and the pressure data was collected in August 2015. The sample interval was 1 minute. The data belongs to the REOCIRC project and was lent out by Eli Anne Ersdal, UNIS. a) Entire sampling period: Very rough appearance. The amplitude of the roughness changes over time in an almost regular fashion. b) Zooming in on 30 days: The observed roughness is actually an oscillatory pattern not entirely symmetric in any direction but regular in time. This is the semidiurnal tide and we can see that the amplitude of the oscillations varies over a period of nearly two weeks, at least in August 2014.

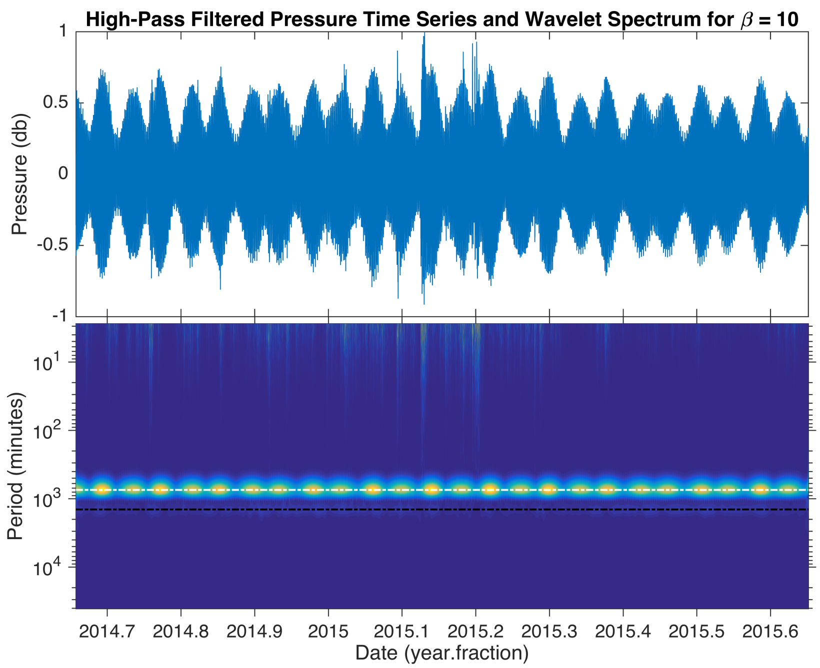


Figure 2. a) The time series was filtered with a Hanning window (length = 1440 minutes) to separate the tidal/inertial and other small-scale variability from variability acting on larger time scales. Data near the end-points were replaced with NaNs. Here we see the residual with a similar roughness as seen in the original data. Most variability in pressure seems to be determined by small-scale features e.g. the tide. b) Wavelet spectrum of the residual using a generalized Morse wavelet. The signal of the semidiurnal tide (dashed and dotted white line, period = 720 minutes) is quite apparent throughout the sampling period. The energy of the spectrum looks like a band of pearls, reflecting the oscillations in the tidal amplitude over a period of two weeks (the fortnightly tide). Hard to see and nearly masked by the dashed and dotted black line is a signal at the diurnal period.