DETERMINATION OF ROUGHNESS LENGTH AT NY-ALESUND-SVALBARD USING NEAR NEUTRAL CONDITIONS

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1. Introduction

The climatological characterization or numerical modeling of the Arctic region needs, for the accurate simulations, the evaluation of the roughness length z_0. In the parameterizations of the PBL features, mean wind profiles, variances of turbulent variables are dependent on z_0. In case of ideal horizontally homogeneous conditions and of negligible heat flux, the logarithmic wind profile is the best approach to simulate the observed data. In such cases, a strictly neutral conditions are the most appropriate to evaluate the roughness length to each observed wind direction. The knowledge of neutral conditions turn out important for the determination of the parameters necessary to obtain vertical wind profiles in stable and unstable conditions. In next sections will be given an overview on statistical analysis for meteorological data and the main results on calculation of Z_0.

2. Dataset description

The neutral atmosphere is the basic condition for the reconstruction of vertical wind profiles in stable and unstable atmosphere. As known (Garrat JR. (1990), Businger et al. (1971), Hogstrom (1996)), the neutral profiles is characterized by the equation

$$u(z) = \frac{u_*}{k} \ln\left(\frac{z}{z_0}\right)$$

This equation is strictly valid in flat terrain, as at NyAlesund. In our analysis we have used two way for calculation of z_0. First is classical one (named 'clas'), where the roughness z_0 is calculated based on the assumption that the Von Karman constant is always equal to 0.41. Second, assuming a best fitting process where k is considered as a variables in the process itself. In such simulation (named 'fit') both k and z_0 can change. In this work we shows only results on z_0.

The dataset used refers to measurements collected at four levels of the Climate Change Tower (Choi et al. (2014), Mazzola et al. (2016)) at Ny Alesund for the periods 25/5/2012 – 17/08/2012 and 14/6/2013 – 31/10/2013.

For all data set (13891 profiles), 288 neutral profiles have been selected using following criteria:

- $|z/L| < 0.01$ ($1/|L| < 0.0015$ m-1)
- momentum flux constant with height
- direction of the wind almost constant with height

where L is the Obukhov length.

These selected profiles are representative of the main neutral conditions measured at NyAlesund.

For these profile the average values of meteorological parameters are provided in following table:

	Np	WD	WS	T	u*
Winter	26	199.1	7	-0.22	0.48
Spring	34	272.6	8.2	-7.43	0.33
Summer	97	189.2	7.1	5.42	0.34
Autumn	131	208.3	11.4	-0.65	0.43

Table 1: main seasonally average of meteorological variables for neutral condition.

The Figure 1, 2 and 3 shows the distribution for wind speed, friction velocity and temperature respectively along the main direction for selected profiles. For these data the minimum speed is coming from SW (Figure 1), where the wind cross the mountain.

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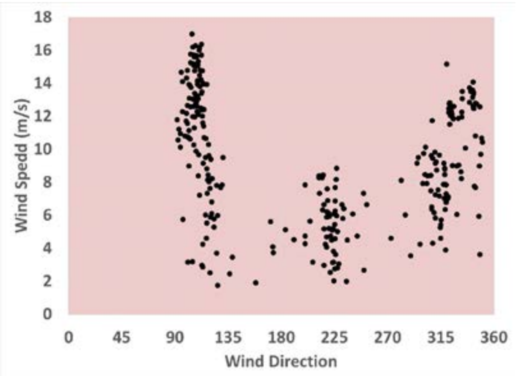

Figure 1: Wind speed against wind direction for the selected neutral profiles

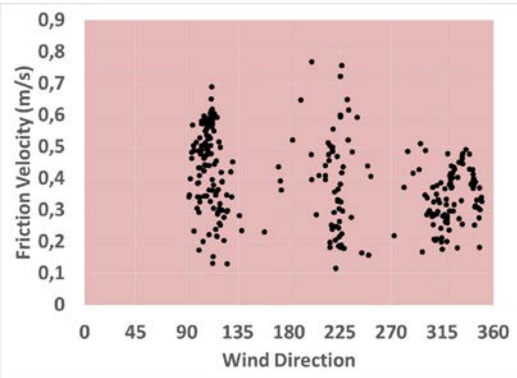

Figure 2: As Figure 1 for friction velocity

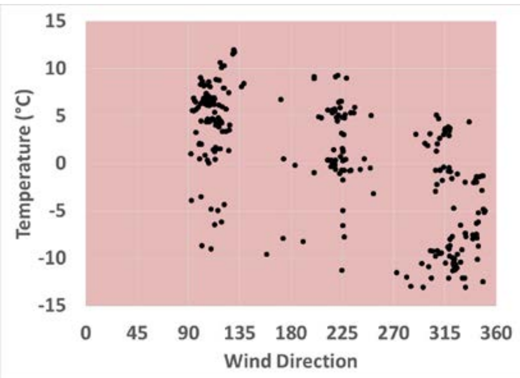

Figure 3: As Figure 1 for Temperature

3. Results

The presented results derives by a profile selection based from the 288 wind profiles, all of them corresponding to vertical almost constant direction and friction velocity u*. These profiles are observed in three main wind direction: East-Southeast (WD=(90°-135°), South-West (WD=180°-270°) and North-West (WD= 270-360°). The total number of neutral profiles for each sector are 120 from the (SSE), 62 from SW and 100 from NW (Table 2).

The best speed profiles are reproduced using the fitting process (fit) for all profiles and calculating both z_0 and k.

- The better results are obtained for wind from ESE (the mean reproducibility is Rp = 0.73%).

- The best wind reproducibility is obtained using all profiles and leaving system free to calculate k and z_0.

- The worst reproducibility is obtained in the classical case, when the constant k = 0.41 is assumed.

The values of z_0 calculated with different formulations are consistent with the characteristics of the site, but they are very different and are depending on the used method. For the two methods it can be noted how the value from SW is smaller than the other two directions.
Using the classic formulation z_0(clas), the roughness increases for SW direction, with an average value z_0 = 70.5mm (Table 3).
The number of selected neutral profiles and of average values of meteorological parameters are provided in Table 2.

	Np	WS (m/s)	T (°)
ESE	120	11.24	4.83
SW	62	5.41	2.10
NW	100	9.44	-5.33

Table 2: main average values of meteorological parameters for three wind direction.

The two different procedures that have been used to determine the roughness length are shown n Table 3. The table shows the average values of z_0 in mm for the three directions.

	z_0 (mm)(Tfit)	z_0 (mm)(Tclas)
ESE	1.27	3.02
SW	0.67	70.45
NW	1.04	3.02

Table 3: Z_0 from derived by two different methods (Fit and Classic)

The values of z_0 calculated with different formulations are consistent with the characteristics of the site, but they can be very different depending on methods used in the analysis. While the expected values for NE and NW direction are quite in according with the characteristic of terrain for both methods, the value of roughness length for SW direction is much great when the Von Karman constant is considered as a constant equal to 0.41 (with classical method). In fact the high value of the roughness, z_0 = 70.5mm for SW direction is totally in disagreement with other directions.

At the contrary, when the roughness coming from the 'fit' method, where k is considered as a variable, the roughness length become coherent for all wind directions.

4. Conclusions

The neutral conditions has been used for an evaluation of the roughness length at site of at the Climate Change Tower installed in Ny Alesund , Svalbard. The resulting value of z_0 provide a clear indication on some fundamental aspects :

- The values of z_0 are dependent by the formulation chosen in the calculation
- The estimation of z_0 depends from the value of k that can be different from 0.41

This work suggest that the role of Von Karman k is crucial to determine the right values of the roughness length starting from the experimental wind profiles. In particular, the distribution for z_0. and k must be deeply investigated to assign a reliable values of roughness length to the Ny.

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