The program is experimental and will be improved if found useful. In case of any issues, please contact jackurbanski@gmail.com.

!!! The program creates temporary files (of SHP type) in the directory where it saves output files, with the main names tempfeatch00, tempfeatch11, tempfeatch22. After completion, they are automatically deleted. If the program stops working correctly during operation, these files need to be deleted manually for the program to function again.!!!

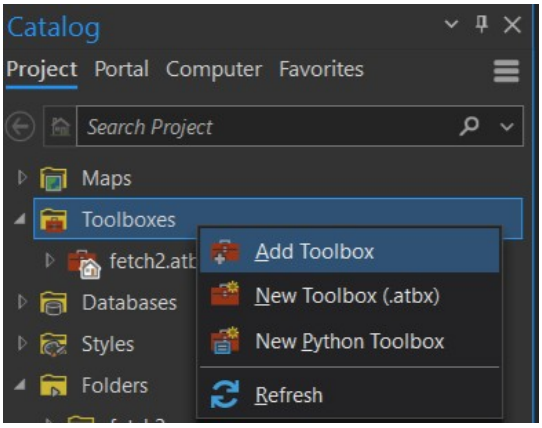
Using wind fetch tools in ArcGIS Pro

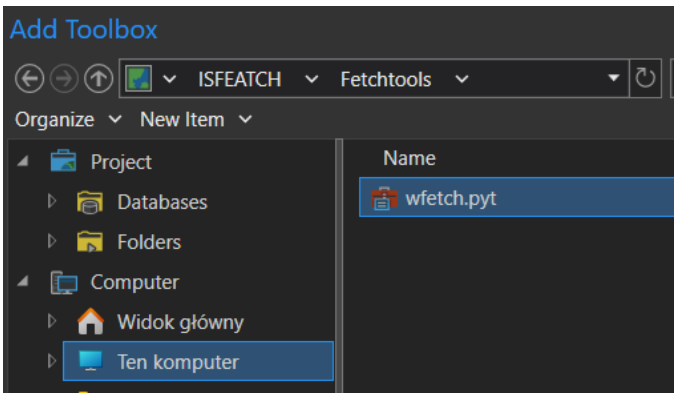
(works with basic licence - no esri extensions are needed)

The Wind Fetch toolkit is used for calculating and analyzing a reservoir's exposure to wind-induced waves. The fetch line is the distance in meters between any point in the reservoir and the shoreline, measured in the direction from which the wind blows. This is illustrated in the diagram on page 3 (fetch type 4). In practice, the so-called effective fetch (fetch types 1, 2, and 3) is used, as it better approximates how the wind generates wave action. The tools utilize a layer of points and the reservoir's outline as a polygon.

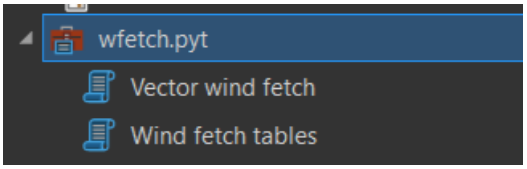
In the first step, fetch lines required by the fetch definition are created for each point (from the point to the shore). In the second step, based on these lines, points are assigned values for effective fetch, the average fetch calculated using wind frequency from different directions, the maximum fetch, the most frequent fetch, and the REI (Relative Exposure Index). Assigning these values to points enables the creation of continuous maps for the reservoir and shoreline

Start with adding toolbox **wfetch.pyt** to the project:



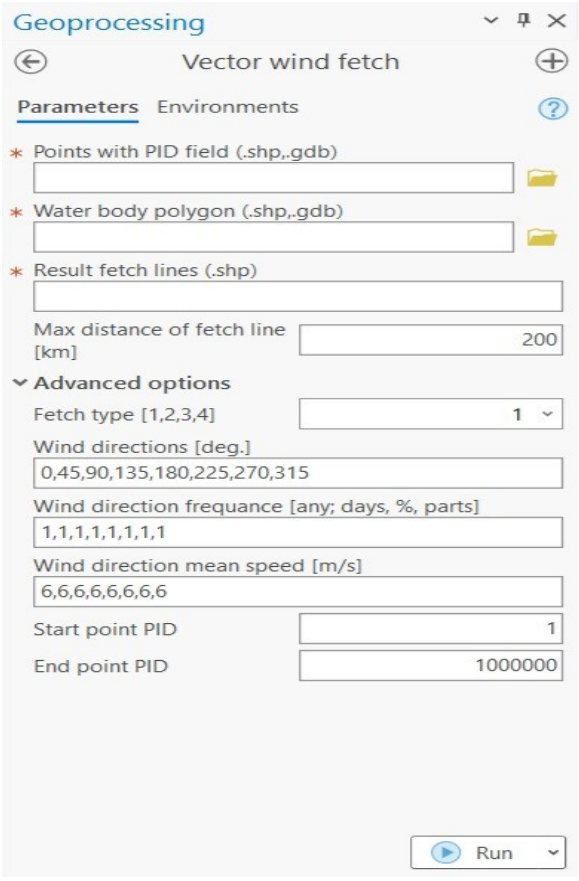


The **wfetch** toolbox contains two tools. : **Vector wind fetch** i **Wind fetch tables**



Vector Wind Fetch is the primary tool that performs the complete cycle of determining wind fetch. The tool utilizes two layers that must be in a projected coordinate system. The vertical map frame should indicate the northern direction. The first layer is a point layer (SHP or feature class in a file geodatabase) that must contain a PID field (integer type) with point numbers (identifiers). The second layer is a polygon layer that defines the water body. Points must be located within the polygon layer. When determining wind fetch for the shoreline, the points should be near the shore but not directly on it (e.g., within 20 meters). The tool first creates a layer of wind fetch lines for each point, and then generates two text files. The first file contains the effective fetch length for each wind direction, and the second provides a statistical analysis of fetch for each point. Since creating fetch lines can be a time-consuming process, an additional tool, **Wind Fetch Tables**, allows for the creation of the aforementioned text files directly from a previously generated fetch lines file for any wind frequency and speed.

The Vector Wind Fetch tool operates as follows:



PARAMETERS:

Points with PID field (.shp, .gdb)

Layer of points with a PID field (Short or Long type) containing unique point identifiers as natural numbers (1, 2, 3, ...). The point layer should be in a projected coordinate system. Points should be inside the polygon, not on its boundary. The point layer should be in SHP format or as a feature class in a file geodatabase.

Water body polygon (.shp, .gdb)

Layer of the polygon representing the water body in which the fetch is analyzed. It should be in the same coordinate system as the points. The polygon layer should be in SHP format or as a feature class in a file geodatabase.

Result fetch line (.shp)

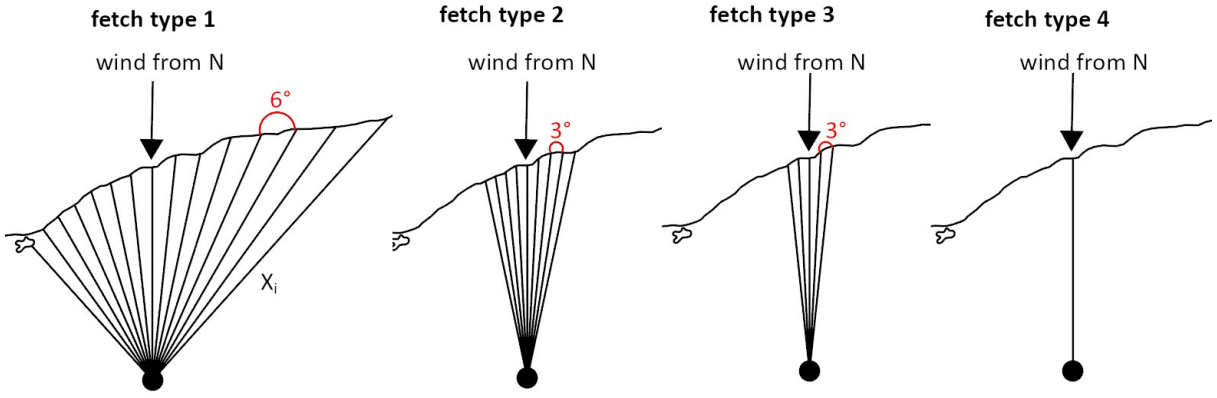
Full name with path (SHP format only), e.g., C:\project\result.shp. A line layer of individual fetch lines is created. The attribute table description of the created layer is shown in the example below.

Max distance of fetch line [km]

Maximum length of the fetch line in kilometers. The default is 200 km. It should be set such that further extending it does not change the wind wave parameters or reaches the shore for each point and direction.

Fetch type [1, 2, 3, 4]

Specifies one of the four methods to determine the effective fetch F. The default type is 1.



$$F = \frac{\sum_{i=1}^{15} x_i * (\cos \alpha)}{\sum_{i=1}^{15} (\cos \alpha)} \qquad F = \frac{\sum_{i=1}^{9} x_i}{9} \qquad F = \frac{\sum_{i=1}^{5} x_i}{5} \qquad F = x$$

Wind directions [deg.]

Specifies a series of wind directions for which fetch will be determined as text. Wind direction values should be separated by commas. Default wind directions are 0, 45, 90, 135, 180, 225, 270, 315. If incorrect values are entered or the field is left blank, default values will be used.

Wind direction frequency [any; days, %, parts]

Specifies a series of wind frequencies from each direction. Values should be separated by commas and correspond to the number of wind directions. By default, all directions have equal frequency. Wind frequency can be entered in any format (days, percentages, or parts). The algorithm calculates values relative to the sum of the provided frequencies. Default values are applied in case of input errors.

Wind direction mean speed [m/s]

Specifies a series of average wind speeds from each direction. Values should be separated by commas and correspond to the number of wind directions. By default, all directions have a speed of 6 m/s. Default values are applied in case of input errors. These values are used solely for REI calculations.

Start point PID

With a large number of points, work can be divided into stages and performed for a subset of points defined by PID. This parameter defines the first point for which calculations will be performed. The default value is 1.

End point PID

With a large number of points, work can be divided into stages and performed for a subset of points defined by PID. This parameter defines the last point for which calculations will be performed. The default value is 1,000,000.

The **Wind Fetch Tables** tool is structured as follows:

Due to the potentially lengthy process of creating fetch lines, the additional **Wind Fetch Tables** tool allows for the creation of the aforementioned text files directly from previously obtained fetch line files for any wind frequency and speed.

PARAMETERS:

Fetch lines created be Vector wind fetch tool (.shp)

Pełna nazwa wraz ze ścieżką fetch lines created by Vector wind fetch tool.

Tables suffix (1,2,3...)

Narzędzie te tworzy tabele obliczonych wartości fetchu i ich statystyczną analizę analogicznie do poprzedniego narzędzia. Nazwy budowane są na podstawie nazwy linii fechu plus liczba naturalna.

Wind direction frequance [any; days, %,parts]

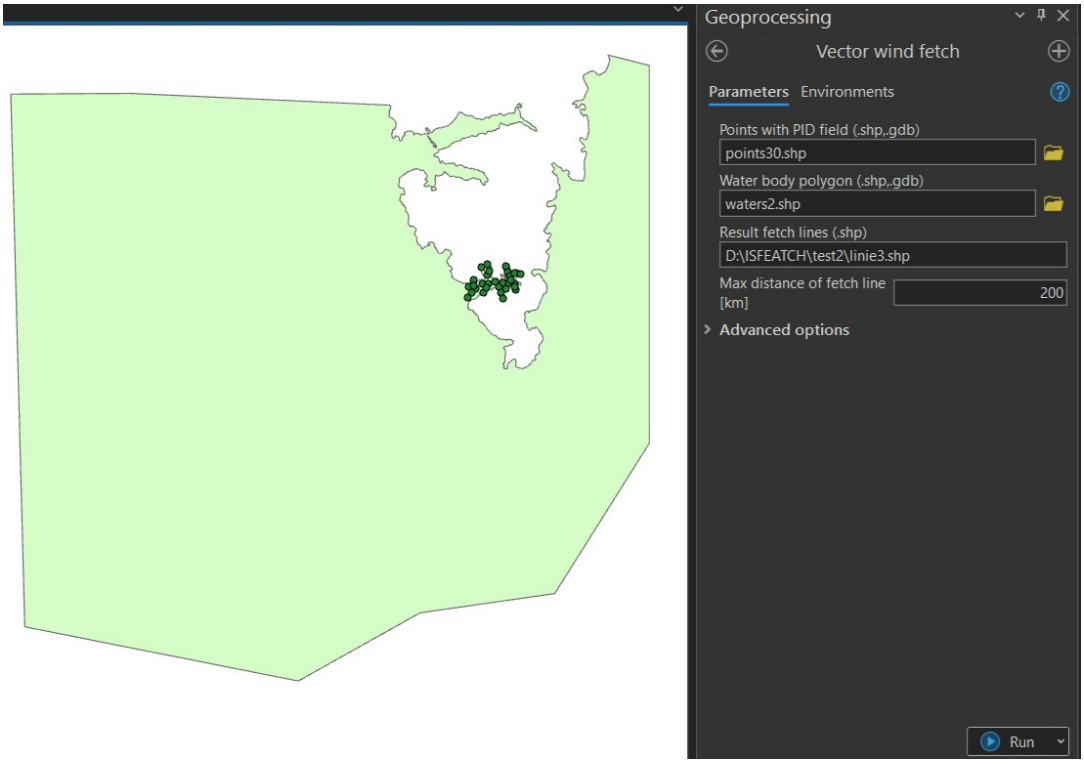
Określa je szereg częstości wiatru z danego kierunku. Powinny być rozdzielone przecinkiem i odpowiadać liczbie kierunków wiatru. Domyślnie wszystkie kierunki mają jednakowy udział. Częstość wiatru może być wpisana w dowolny sposób (w dniach, procentach lub częściach). Algorytm wyznacza wartości względem sumy podanych wartości. W przypadku błędnego wprowadzenia stosowane są wartości domyślne.

Wind direction mean speed[m/s]

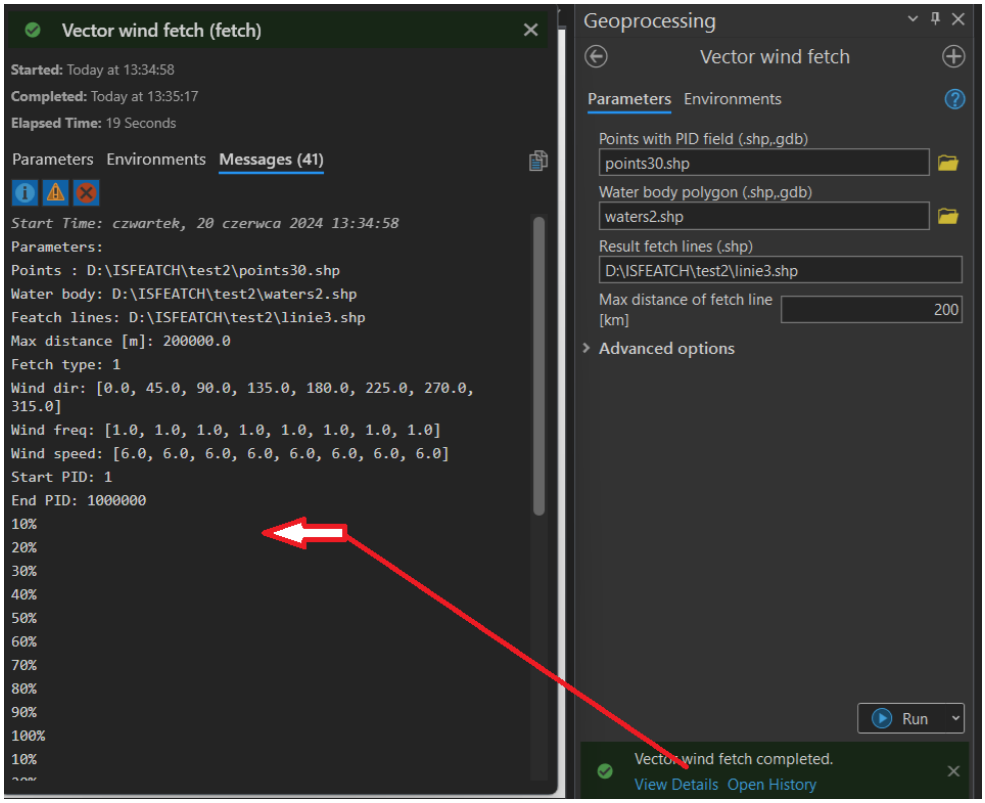
Określa je szereg średnich prędkości wiatru z danego kierunku. Powinny być rozdzielone przecinkiem i odpowiadać liczbie kierunków wiatru. Domyślnie wszystkie kierunki mają wartość 6 m/s.W przypadku błędnego wprowadzenia stosowane są wartości domyślne. Te wartości są wykorzystywane do obliczeń indeksu REI (page 8).

Example using test data (Minimal tool execution configuration):

Test layers (test_fetch.zip) - points30 (SHP) and waters2 (SHP)



Executing the tool displays a report that provides all parameters and shows the progress of the task. The tool operates in three stages, with progress shown as a percentage completed (from 10% to 100%) for each stage.

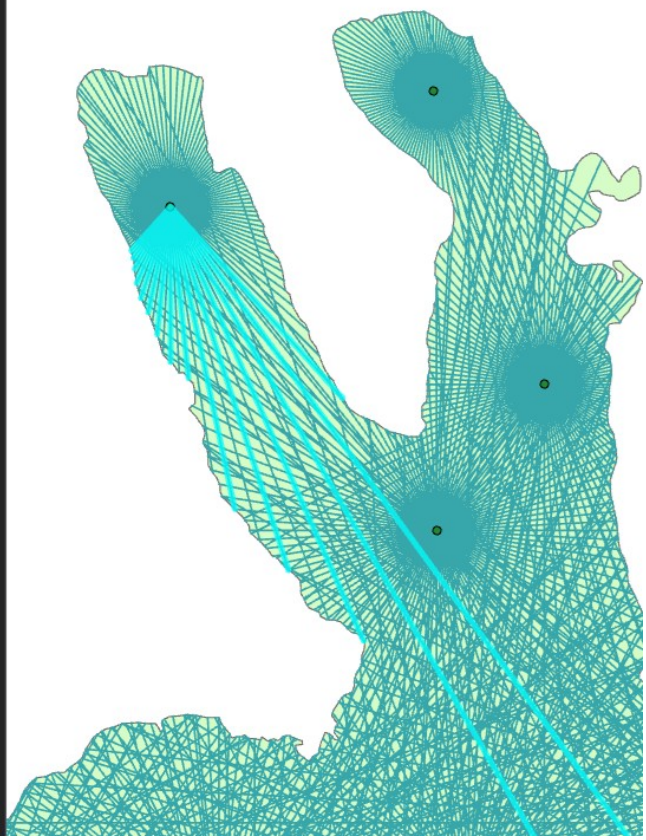


The program creates a new line layer and two text files:

- qline2.shp - fetch layer for each point and each wind direction

Field: Selection:

	FID	Shape	PID	Iff	nrfl	SHPL
2699	2698	Polyline	23	135	14	3543.036042
2700	2699	Polyline	23	135	15	2186.738182
2701	2700	Polyline	23	180	1	3393.582223
2702	2701	Polyline	23	180	2	15132.166176
2703	2702	Polyline	23	180	3	13440.343752
2704	2703	Polyline	23	180	4	6263.028094
2705	2704	Polyline	23	180	5	5036.26225
2706	2705	Polyline	23	180	6	4074.306435
2707	2706	Polyline	23	180	7	2272.308594
2708	2707	Polyline	23	180	8	2047.679435
2709	2708	Polyline	23	180	9	1694.26517
2710	2709	Polyline	23	180	10	1422.500588
2711	2710	Polyline	23	180	11	1267.306145
2712	2711	Polyline	23	180	12	1102.80961
2713	2712	Polyline	23	180	13	947.628501
2714	2713	Polyline	23	180	14	838.692767
2715	2714	Polyline	23	180	15	776.074828
2716	2715	Polyline	23	225	1	1930.152536
2717	2716	Polyline	23	225	2	1539.011103
2718	2717	Polyline	23	225	3	1340.381336
2719	2718	Polyline	23	225	4	1178.147026



The attribute table contains the point number (PID), wind direction (180), line number (their count depends on the selected fetch type), and line length in meters.

The text file with effective fetch has a name format of line + _effe.csv

	PID	f0	f45	f90	f135	f180	f225	f270	f315
1	1	2554.8	7689.9	10759.6	8536.2	95325.3	188816.2	164822.9	51283.1
2	2	11430	11890.4	7814.1	2761.8	91674.5	188043.2	197916.6	109250
3	3	4741.4	9378.8	10368.6	5242	40058	152202.2	152118.7	53036
4	4	3469.6	6526.4	8271.4	6740.7	17019.1	125029.6	109191.7	3354.6
5	5	9468.3	8121.7	2798.9	1401.6	1283.9	1349.5	59355.9	55657.9
6	6	3801.1	3573	3165.8	7378	8437.8	4210.7	2776.5	3271.8
7	7	6129.8	5852.3	7101.4	5186.8	4836.6	96456.9	95714.8	5370.6

0 of 30 selected

It contains the calculated effective fetch in meters (according to the selected type) for each wind direction.

The second file (named line + _stat.csv) contains statistics of the effective fetch for each point (PID) and the REI (Relative Exposure Index).

	PID	WAFETCH	MXFETCH	MFFETCH	REI
1	1	66224	188816	188816	397341
2	2	77598	197917	197917	465585
3	3	53393	152202	152202	320359
4	4	34950	125030	125030	209702
5	5	17430	59356	59356	104578
6	6	4577	8438	8438	27461
7	7	28331	96457	96457	169987

WAFETCH - weighted average of effective wind fetch (using wind frequancy)

$$WAFETCH = \sum_{i=1}^{n(wind\,direction)} effective\,fetch\,for\,i\,direction * frequance\,of\,wind\,for\,i\,direction$$

MXFETCH - maximum efective fetch

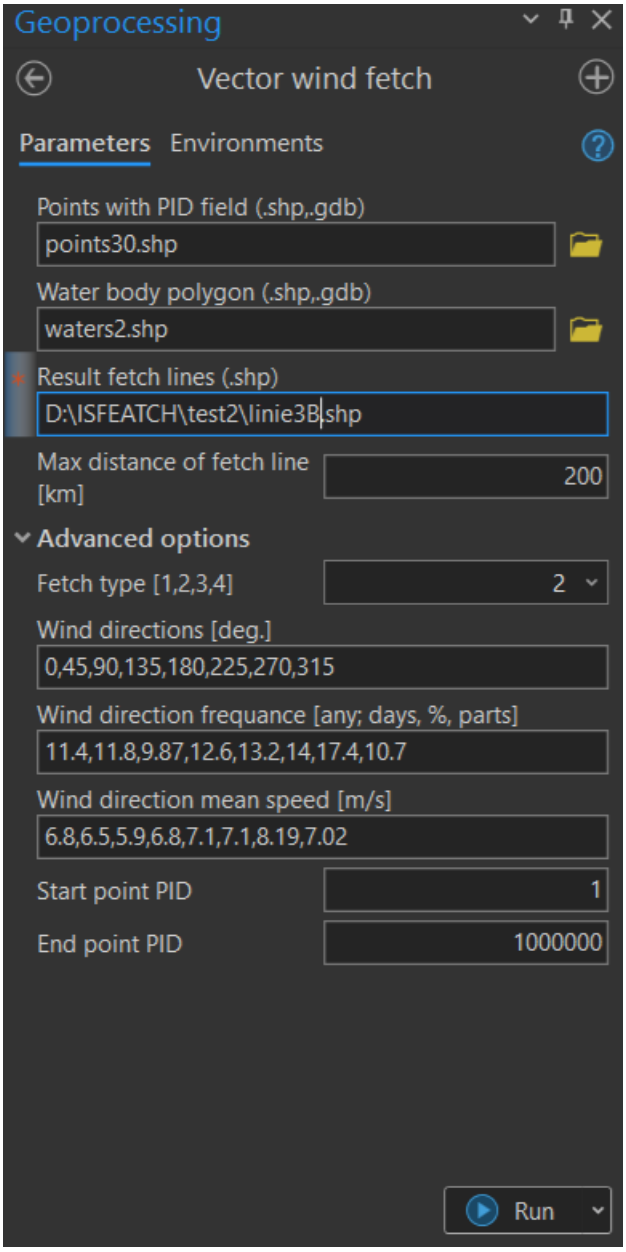
MFFETCH - most frequant effective fetch (define by wind frequance)

REI - Relative Expousure Index

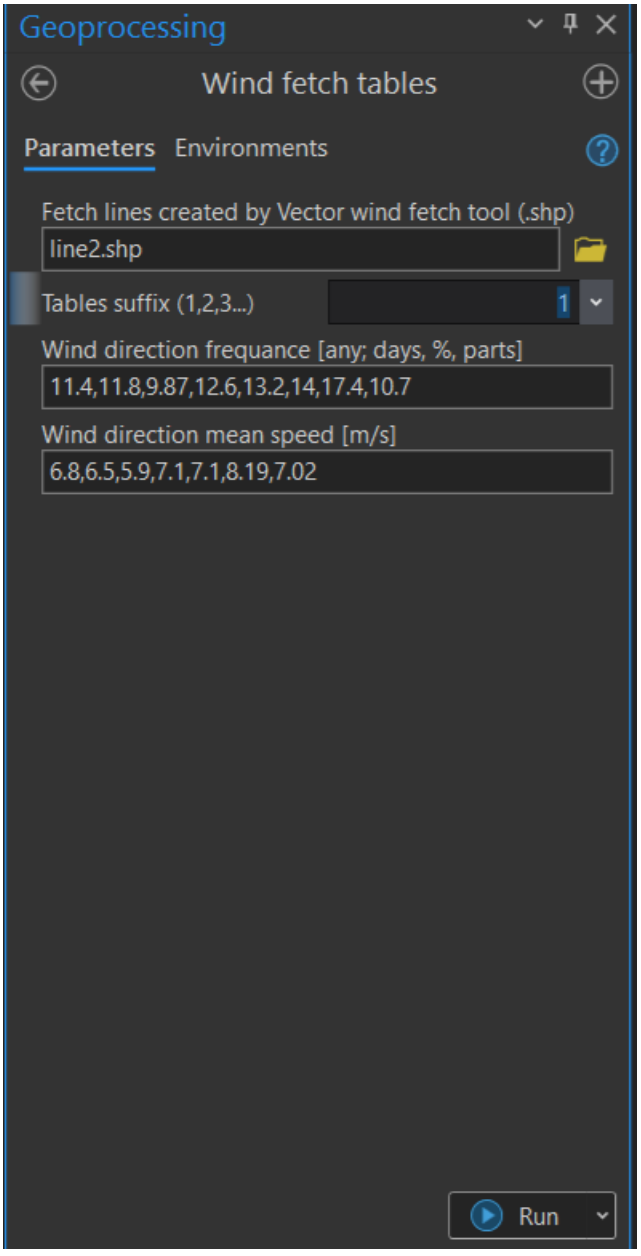
$$REI = \sum_{i=1}^{n(wind\,direction)} effective\,fetch\,for\,i\,direction * frequance\,of\ wind\,for\,i\,direction * wind\,speed\,for\,i\,direction$$

Using advanced options allows inputting different wind directions, wind frequency, and average speed values (for calculating RMI). Different types of effective fetch can also be specified using numbers (1, 2, 3, 4 as shown in the diagram above).

If advanced values are not entered, the tool will apply default parameters. The applied parameters can be viewed in View Details after executing the tool.



The Wind Fetch Tables tool is used to create text files with computed values, similar to the previous tool, but based on existing fetch lines. This allows inputting different wind frequency and speed values without the need to recreate lines, which can be time-consuming. The table suffix allows creating subsequent versions of files with appended numbers.



Example carried out in ArcGIS Pro (continuous map creation):

On the analyzed area, the average effective fetch (type=1) was calculated taking into account the wind frequency for Hornsund in Svalbard. The calculated values were joined to point data (500 points), and then a spatial distribution map was generated using the IDW method. The computation time was 24 minutes.