eoldist web application

User Guide

Research programme
« Reduction of bird mortality in windfarms »

User guide of the web application EolDist

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Introduction

The web application "*eoldist*" was developed by Julie Fluhr in the framework of the Workpackage WP3 R3 of the MAPE research program. Intended for various users (DREALs, study offices, wind farm operators, etc.), this tool allows to determine the minimum detection distances of 163 bird species according to different parameters such as the flight context and the characteristics of the turbines, in order to reduce the risks of collision in wind farms.

This document details guidance on how to use the application.

Launching the calculations

When opening the application, the tab "Calculation of detection distances" allows access to the tool "eoldist" dedicated to the calculation of:

- the flight speed of the referenced species (upper block of the interface), and
- detection distances of species according to different parameters (lower block)

These two blocks are built in such a way that the sub-blocks (left part of the interface) allow the user to choose the parameters from which will be calculated and represented graphically the flight speeds of the species and their detection distances (right part of the interface).

1. Calculation of flight speed of bird species

1.1. Choice of parameters : Enter bird data

The first sub-block entitled "Enter Bird Data" allows the user to select the bird species and flight context from which the mean (± standard deviation) flight speed of the species will be calculated (if data are available).

Target species

L'utilisateur choisit une espèce à partir du menu déroulant précédé de la mention « Sélectionner une espèce ». L'utilisateur peut rechercher une espèce en faisant défiler la liste manuellement ou en saisissant son nom vernaculaire (en français) ou son nom scientifique (en latin).

The user chooses a species from the drop-down menu preceded by the words "Select a species". The user can search for a species by scrolling manually or by entering its vernacular name (in English) or its scientific name (in Latin)

Flight context

The user can choose the flight context / movement scale of the species:

- "Migration": this category includes medium to long distance movements including migratory flights and dispersal in juvenile individuals. During these migratory or dispersal movements, birds generally choose to fly at high speeds.

- "Local": This category includes short-distance movements such as foraging flights, transits between a feeding area and the colony, and courtship or hunting flights. During local flight movements, birds generally choose slower travel speeds. There are notable exceptions, however, such as raptor chase or dive hunting flights, which involve much higher flight speeds.

1.2. Display of results : distribution of flight speeds of the species

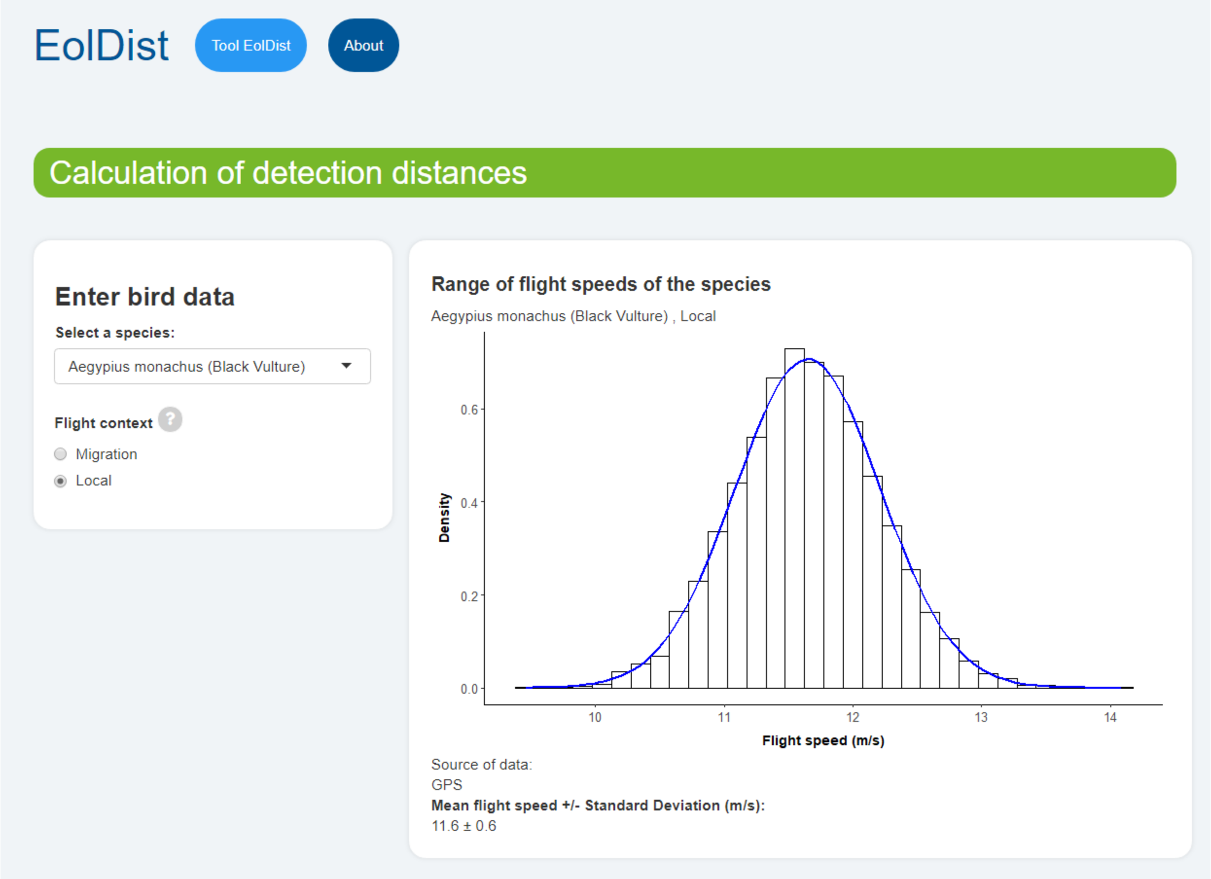
The top right sub-block displays the probability distribution of flight speeds, i.e. the range of possible flight speeds of the species in the flight context chosen by the user. This distribution is built from the observed or theoretical average flight speed values of the species in the chosen flight context, and their standard deviation.

Observed" speeds were calculated from telemetric data (GPS or VHF) or from data collected by radar or ornithodolite (laser rangefinder). On the other hand, "observed" flight speeds can be derived from two sources: either collected in scientific publications, or calculated from GPS data collected from French and international researchers and managers (see "About" tab) and analyzed in the framework of the MAPE program. The "observed" speeds are relative to the ground, which are the most relevant in the wind-energy context where the detection systems are fixed with respect to the ground. These relative speeds on the ground (“groundspeed”) thus take into account the naturally observed variability of the speeds of flight which can be accelerated by tailwind and slowed down by headwind.

If for a given species, no flight speed measurements were found in the literature or calculated by telemetry, then a theoretical flight speed was calculated from the aerodynamic models of Pennycuick (2008 Program Flight) based on biometric data (body mass, wingspan and surface area of both wings). Unlike "observed" flight speeds where the reference frame is the ground, these theoretical models allow for the calculation of flight speed relative to the air mass. In the context of local flight, birds generally fly slower than in migration. In this context, it was chosen to use the speed Vmp (minimum power). In a migratory context, the higher Vmr (maximum range) speed was used. It should be noted that the theoretical calculations do not return a standard error on the flight speeds. However, flight speeds are of course variable in reality. Moreover, the *eoldist* application needs this variability to calculate the distribution of minimum detection distances. For these species, we have therefore fixed a standard error based on that of the species for which we had the information. To obtain this standard error, we calculated for all species studied by GPS or radar, the coefficient of variation of flight speeds and applied the average coefficient of variation of these species.

When more than one type of data was available for a species, we used the "observed" speeds first, not the "theoretical" speeds.

The type(s) of data used and the average speed (± standard deviation) of the species are displayed on the right side of the graph.



Calculation of detection distances

Enter bird data

Select a species: Aegypius monachus (Black Vulture)

Flight context

○ Migration

● Local

Range of flight speeds of the species

Aegypius monachus (Black Vulture) , Local

Source of data:
GPS

Mean flight speed +/- Standard Deviation (m/s):
11.6 ± 0.6

2. Calculation of minimum detection distances for species

According to the equation proposed in a report by KNE (competence center for nature conservation and energy transition, Germany) published in 2019:

Detection distance = $[(T_{decision} + T_{signal} + T_{rotor}) * V_{target}] + L_{rotor}$ with

- $T_{decision}$: the decision-making time inherent to the system. This is the time needed to detect, classify and identify the target, and to estimate the risk of collision according to different parameters such as the trajectory and the speed of the target. In the "*EolDist*" tool, this time is arbitrarily set to 1 second.

- T_{signal} : the processing and sending time of the rotor slowdown/stop command between the detection-reaction system and the SCADA, then between the SCADA and the turbine. In the "*EolDist*" tool, this time is arbitrarily set to 1 second.

- T_{rotor} = the slowing down/stopping time of the rotor. This is the time required for the rotor to reach a residual rotation threshold speed once the stop command is sent to the SCADA. In the "*EolDist*" tool, this time is modeled according to four parameters: turbine type, blade length, initial wind speed, rotor residual speed threshold. The data used to model the rotor deceleration times were collected within the framework of a protocol developed by us and proposed to the wind operators involved in the MAPE project. Also the results relative to this part of the application are brought to evolve if new tests are carried out in the field.

- V_{target} = the speed of movement of the target (calculated in part 1 of the "*EolDist*" tool).
- L_{rotor} = the length of the blade.

2.1. Parameter selection : Enter wind turbine data

The second sub-block entitled "Enter wind turbine data" allows the user to choose the values of the parameters used to compute, on the one hand, the average duration (± standard deviation) of rotor slowing down to reach a residual rotation threshold speed, and on the other hand, the minimum detection distance of the species (from the KNE formula presented previously).

In a first step, the user chooses the values of the four parameters from which the rotor slowdown time is modeled.

Type of machine

The user chooses the type of turbine: synchronous or asynchronous. The turbines currently on the market are divided into two main families according to the architecture of their electrical generator: those equipped with a synchronous generator (about 25% of the market), and those equipped with an asynchronous generator (about 75% of the market). The synchronous turbine involves a direct mechanical drive between the hub of the turbine and the generator. The asynchronous turbine requires operation at a rated speed of several hundred revolutions per minute, which implies the use of a gearbox between the rotor and the generator. This kinetic chain implies frictional forces that prevent the rotation of the rotor in light wind. The asynchronous turbine can withstand slight variations in wind speed, especially during gusts.

Blade length (m)

The blade length is both a parameter used to model the rotor deceleration time, and a parameter included in the KNE formula for calculating the detection distance of a target on approach to a wind turbine.

Based on the data collected to date (November 2021) in the proposed protocol for wind operators, the range of possible values for blade lengths is between 35 m and 56 m for synchronous machines and between 40 m and 63 m for asynchronous machines.

Mean wind speed (m/s)

The user selects the average wind speed (5, 10 or 15 m/s) from which the rotor deceleration time is modeled. The results of our statistical analysis show that the interaction between wind speed and blade length significantly influences the rotor deceleration time, which implies that for a given wind speed, the rotor speed slows down differently depending on the turbine blade length.

To date (January 2022), very few tests have been performed in wind conditions > 10 m/s, and these few tests concern mostly synchronous machines. Therefore, the associated results should be considered with caution because of these imbalances.

Residual rotation speed threshold (rpm)

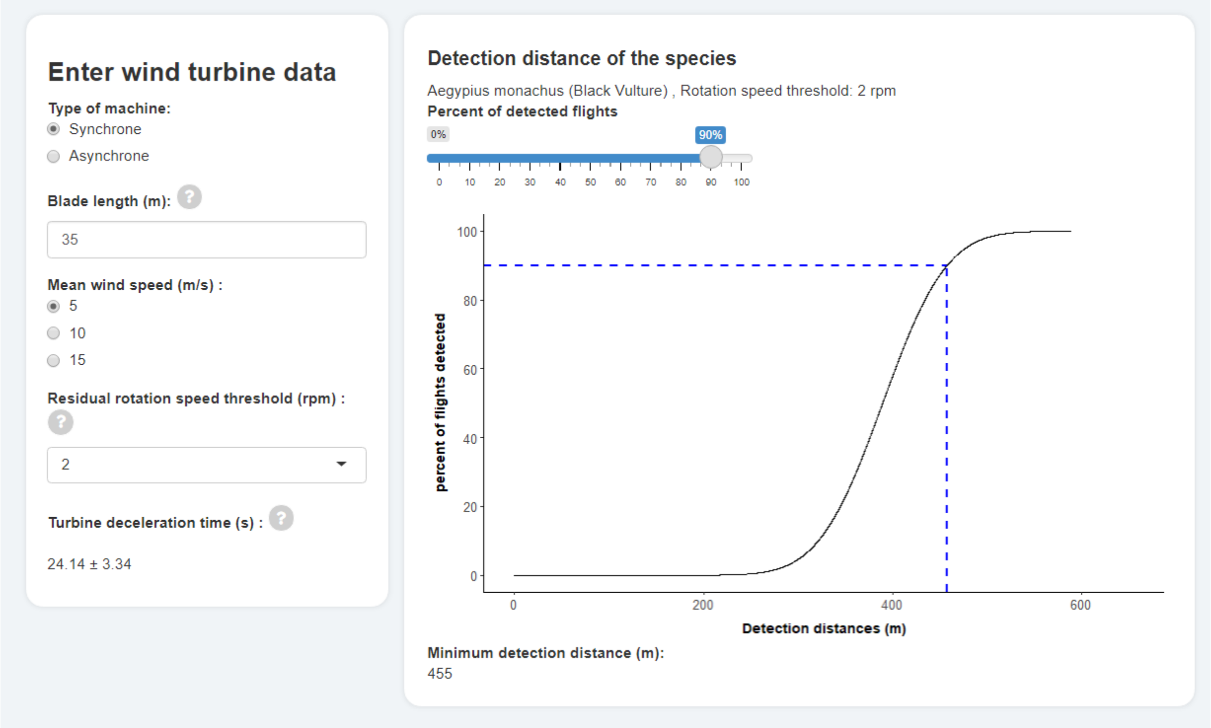
The user chooses the residual rotor speed threshold (1, 2 or 3 rpm) to calculate the time required to reach this threshold (i.e. rotor speed equal to or lower than this threshold speed), once the stop command is issued. Note that the formula for converting an angular velocity (N) expressed in revolutions per minute (rpm) into a linear velocity (V) expressed in meters per second (m/s) is the following: $V = \frac{2\pi * r}{60} * N$ with r, the blade length of the turbine.

Turbine deceleration time (s)

Depending on the values of the first three parameters (type of machine, blade length, wind speed), the application estimates and displays the time needed for the residual rotor speed to be less than or equal to the threshold set by the user (1, 2 or 3 rpm). Note that the residual rotor speed of synchronous machines with short blades does not go below 2 or 3 rpm for winds higher than 10 m/s in the tests that have been performed in the MAPE program. Therefore, when these characteristics are selected by the user, this information is displayed and no distance calculation is possible.

2.2. Display of results : detection distance of the species

The graph displayed in the right sub-block represents the minimum detection distance of the species in the chosen flight context (local or migration) according to the percentage of detected flights of the species. This percentage of detected flights is defined by the user with the slider above the graph. The higher the percentage of detected flights, the better the range of possible flight speeds of the species will be taken into account, and therefore the more cautious the recommended detection distance will be. The user can vary this percentage of detected flights in 5% steps.



Enter wind turbine data

Type of machine:

● Synchrone

○ Asynchrone

Blade length (m): ?

35

Mean wind speed (m/s) :

● 5

○ 10

○ 15

Residual rotation speed threshold (rpm) : ?

2

Turbine deceleration time (s) : ?

24.14 ± 3.34

Detection distance of the species

Aegypius monachus (Black Vulture) , Rotation speed threshold: 2 rpm

Percent of detected flights

90%

Minimum detection distance (m):

455

Recommendations

Limitations of the application

The application does not take into account the size of the targeted bird. Indeed, as we have no information on the capabilities of the optical or radar systems used to detect the bird, and assuming that the performances of these detection-reaction systems are likely to evolve with technological advances, we assumed that all species could be detected in the same way at each distance. Consequently, the application assumes that a passerine like a lark will be detected with the same probability for a given distance as a large raptor like a vulture. The user must therefore keep in mind that the distance values displayed are theoretical and sometimes unrealistic with current technologies (e.g. minimum detection distance of a sparrow at more than one kilometer). The application therefore informs the user about the minimum detection distance that should be obtained to achieve an effective clamping of the machine to avoid any risk of collision.

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