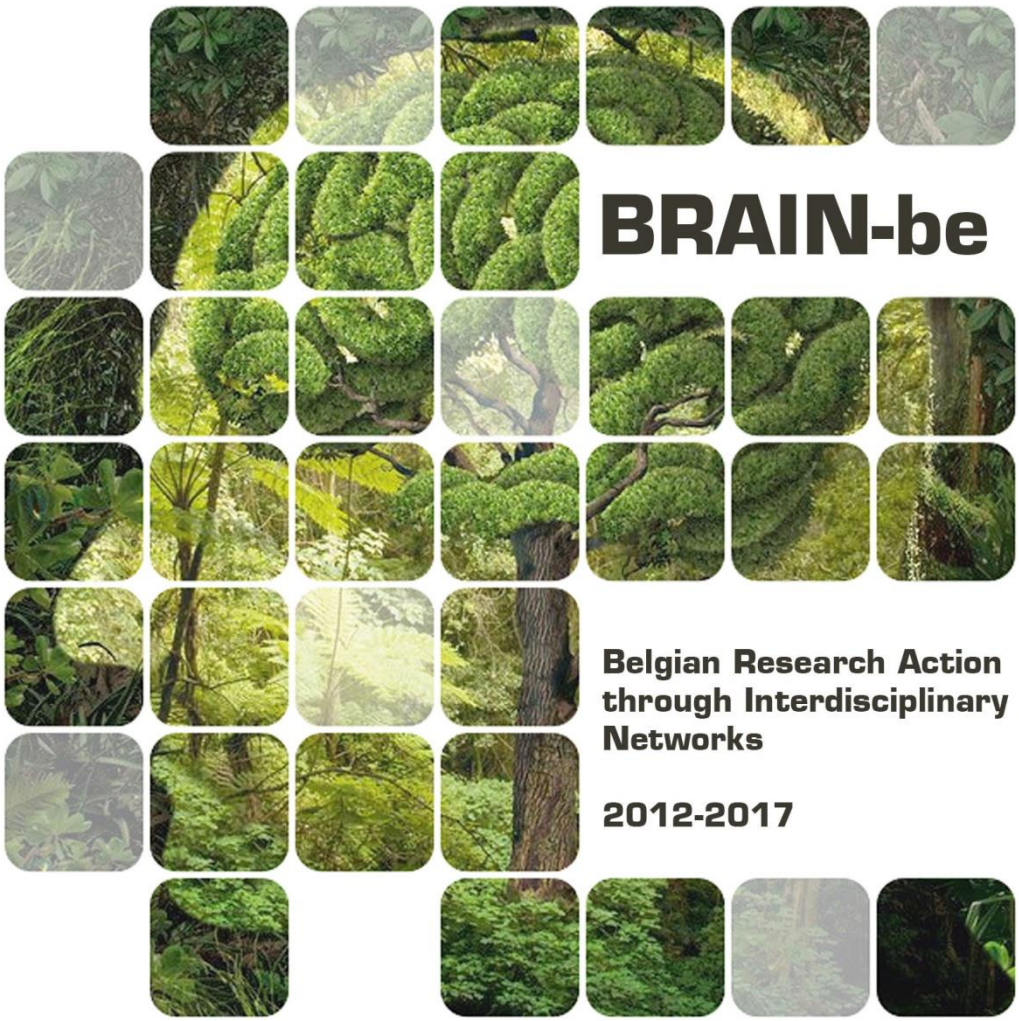

VALORISATION PROJECT

CROW

Communicating RAVen to the Outside World

belspo .be

VALORISATION PROJECT

PROMOTORS: Maarten REYNIERS (Royal Meteorological Institute of Belgium)
Peter DESMET (Research Institute Nature and Forest)
Robin BRABANT (Royal Belgian Institute of Natural Sciences)

RESEARCH INSTITUTE
NATURE AND FOREST

KMI - IRM

museum

belspo

.be

Published in 2021 by the Belgian Science Policy Office
WTCIII
Simon Bolivarlaan 30 Boulevard Simon Bolivar
B-1000 Brussels
Belgium
Tel: +32 (0)2 238 34 11
http://www.belspo.be
http://www.belspo.be/brain-be

Contact persons: Delis Aurore, Van der Werf Aline
Tel: +32 (0)2 238 37 61

Neither the Belgian Science Policy Office nor any person acting on behalf of the Belgian Science Policy Office is responsible for the use which might be made of the following information. The authors are responsible for the content.

No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without indicating the reference:

Reyniers M., Desmet P., Noé N. and Brabant R.: **Communicating RAVen to the Outside World (CROW)**. Final Report. Brussels: Belgian Science Policy Office 2021 – 19 p. (BRAIN-be - (Belgian Research Action through Interdisciplinary Networks))

TABLE OF CONTENTS

1. SUMMARY

The objective of the valorisation project CROW was to exploit the full potential of the RMIB's bird detection capacity acquired in the BELSPO project RAVen (BR/154/PI/RAVEN), by

1. the transfer of the research to operations;
2. adding a modern, interactive data visualisation appealing to a large community of potential users;
3. offering the data visualisation package as open source and the bird detection data as open data.

All three objectives were achieved in a very convincing way: the bird detection software now runs on the operational IT-infrastructure of the RMIB (first objective) and its output is available on the RMIB's open data portal (third objective). An online tool to interactively explore and visualize these data – developed by project partner INBO – is installed on https://meteo.be/birddetection (second objective) and is available as open source software (third objective).

Furthermore, the realisation of the project objectives intensified the collaboration between the project partners, and also contributed to the internal capacity building of the two main partners, RMIB and INBO. At RMIB, important experience in the relatively new technology of container software as the framework for the transformation of scientific R&D into a production environment was acquired. At INBO, the existing know-how of client-side visualisation frameworks was further expanded, making INBO's Open science lab for biodiversity an important international reference for the visualisation of this type of data, with potential future applications in the BiodivERsA/Belmont Forum funded project GloBAM (BELSPO BR/185/A1/GloBAM-BE).

2. INITIAL OBJECTIVES AND VALORISATION FOCUS

The original project proposal of CROW covered three clearly defined objectives.

OBJ-1. The transfer at RMIB of the bird detection algorithm **from research to operations**, including a flexible upgrading process (OBJ-1.1), training and documentation (OBJ-1.2). The software suite will be installed and maintained in an operational setting at the RMIB (OBJ-1.3), which covers a 24/7 monitoring.

OBJ-2. Develop an **interactive visualisation hosted at RMIB's public website** that allows an exploration of the bird quantity estimations. For this front-end, we envisage a two-level approach: basic and easily accessible information will be shown as the page opens, with the possibility to further explore the bird data in a more detailed way (OBJ-2.1). The platform will be offered in three languages: Dutch, French and English (OBJ-2.2). The data visualisation layers should contain the following elements:

- an *overview component*: visitors of the page should get a quick idea of the bird migration over Belgium (OBJ-2.3);
- a *detail component*: visitors should be able to explore the bird migration for each radar for the last week (OBJ-2.4);
- an *archive component*: visitors should be able to visualise historical data as well (OBJ-2.5).

The visualisation will be offered as an open source software suite (OBJ-2.6), so that it can be easily reused by other meteorological services, research institutes, or wildlife organisations.

OBJ-3. Integrate the (machine-readable) bird detection data into the **open data** portal of the RMIB.

3. OVERVIEW EXTERNAL COLLABORATION(S)

3.1. Between CROW partners

Even though the two main project partners RMIB and INBO had not collaborated before, there was intensive collaboration between them throughout this project. This is mainly reflected in the discussions and decisions regarding the development of the web application, which are publicly available as issues at https://github.com/inbo/crow/issues?q=. In total, 133 different issues (03/2021) were discussed; 36 of these 133 issues involved extended discussion between the project partners. RBINS, the third project partner, was mainly involved in the application launch and joint press release.

3.2. Collaborations and contacts at RMIB side

At the international level, the existing contacts with the radar operators of the neighbouring countries were tightened and intensified. Indeed, for the bird detection software to be executed for a certain weather radar, one needs the "raw" radar files (more precise: "uncorrected" reflectivity and radial velocity files) from the radar operator.

- **KNMI** (Koninklijk Nederlands Meteorologisch Instituut, The Netherlands): the dataflow before CROW covered the radar files of only one radar (Herwijnen). In the context of CROW, the data flow of the radar of Den Helder was established between KNMI and RMIB.
- **DWD** (Deutscher Wetterdienst, Germany): prior to CROW only corrected reflectivity of one radar (Neuheilenbach) was received from DWD. In the context of CROW, the data flow of the "raw" (uncorrected) data from two radars was established: Neuheilenbach and Essen.
- **Météo-France** (France): the data flow was already established for the two French radars (Avesnois and Abbeville), but the permission was received to use these data for bird detection purposes, including the publication of the results as open data.

3.3. Collaborations and contacts at INBO side

INBO collaborated with international partners of the concurrent project GloBAM (BELSPO BR/185/A1/GloBAM-BE) as well as Hans van Gasteren (Nature Bureau Royal Netherlands Air Force) to validate the accuracy of the visualisations and request feedback regarding the intuitiveness of the user interface, colour schemes, and terminology. This not only improved the web application, but also made sure it has the potential to be (re)used by a larger research community.

4. GENERATED PRODUCTS AND IMPLEMENTED APPROACHES

We will pointwise discuss the successful realisation of the three objectives presented in Section 1.

4.1. Transfer the bird detection algorithm from research to operations [OBJ-1]

Before the CROW project, the bird detection software (the so-called "vol2bird" algorithm) was already available at RMIB, but it was embedded in the software of the radar manufacturer (Selex-Leonardo) that is installed at RMIB. This proprietary software suite offers only limited possibilities to finetune the bird detection settings. Moreover, there is no access to the source code ("black box") and there is no possibility to upgrade the detection software to the latest version. Note that the "vol2bird" algorithm is continuously updated and maintained by Adriaan Dokter (Cornell Lab of Ornithology) and co-workers, and is available under a MIT license on https://github.com/adokter/vol2bird/

The first objective of CROW was to replace the proprietary software of the radar manufacturer by our own instance of the "vol2bird" software at RMIB, and transfer this software suite to the operational environment of the RMIB. This objective was realised by the development of a dedicated piece of software ("container") in which the bird detection software resides. Such a container has the strong advantage of being reproducible (and hence very portable) and easily upgradable. The container was shaped to the template imposed by the operational product generation team at RMIB.

OBJ-1.1: Flexible upgrading process ✓

> The upgrading process to the latest version of the bird detection software and other dependent libraries is naturally handled in the construction of the container. The construction of the container is managed by one single instruction file (called the "Dockerfile"), and dependencies or upgrade actions can easily be handled by modifying this Dockerfile. The upgrading process is done in a staged approach, making use of a "development container" for testing purposes, and a "production container" for generating the operational output files.

OBJ-1.2: Training and documentation ✓

> The container software developed in CROW is stored on the internal git framework of the RMIB (GitLab), on which it is also heavily documented. GitLab is a framework for hosting projects that use "git", which is a type of version control system that makes it easier to track changes to files, and to collaborate on a common software project. An extra layer of documentation is found in the source code itself (by means of comment lines inside the code). A screenshot of the GitLab repository for CROW is given in Fig. 1. There is an extensive README and a maintenance guide provided.

OBJ-1.3: Operational implementation at the RMIB ✓

> There is a version of the container (the "production container") running in the operational software environment of the RMIB. This environment is monitored 24/7 by the RMIB operator team. In case of malfunctioning, the product generation team at RMIB is warned and will do actions to fix the issue.

4.2. Develop an interactive visualisation hosted at RMIB's public website [OBJ-2]

The interactive visualisation proposed in this objective is realised, and is available on https://meteo.be/birddetection. A screenshot of the developed web application with some explanatory tags is given in Fig. 2. Below we highlight the main characteristics of the web app.

OBJ-2.1: Basic + detailed representation ✓

The whole concept of the web app is built around this concept. At initial load of the web app, the bird detection data of the previous day are shown in the charts. The graph on top and the density chart below give an immediate qualitative impression of the current bird migration intensity. The detailed representation is further discussed in OBJ-2.4.

OBJ-2.2: Dutch, French and English ✓

The web application is offered in the three proposed languages. The language can be selected by the dropdown button in the top right corner (Fig. 2), or one can make use of the following URLs, which directly load the app in the preferred language:
- (Dutch) https://www.meteo.be/vogeldetectie
- (French) https://www.meteo.be/detectiondoiseaux
- (English) https://www.meteo.be/birddetection

OBJ-2.3: Overview component ✓

The overview component consists of a map of all radars for which data can be viewed, allowing users to quickly navigate between radars. For each radar, a summarized estimate of the numbers of birds that flew across a 1 km line during the time interval is shown. The user can also increase the viewed time interval to three days to obtain a more general overview of the bird intensities over a longer period. To improve performance and scalability, it was decided not to show bird migration "over Belgium" and "the last week" as originally proposed.

OBJ-2.4: Detailed component ✓

The user can "hover" over the charts to display the exact bird intensities.

OBJ-2.5: Archive component ✓

By means of a date selector (included in the navigation bar on the left hand side of the web application, Fig. 2), the user can choose a day in the past. For most radars, archived data are available from October 2019 onwards, hence covering several bird migration seasons.

OBJ-2.6: Open source and portable ✓

The source code of the web app is publicly available at https://github.com/inbo/crow, under the permissive "MIT" license (https://github.com/inbo/crow/blob/main/LICENSE). It is also deposited as open source software in Zenodo, where it is assigned a DOI (https://doi.org/10.5281/zenodo.4629448) and can be downloaded and cited. The application is entirely developed in the Vue framework (https://vuejs.org/) which ensures a complete client-side deployment of the web app, and hence the complete portability of the software suite. Instructions for the deployment are given in the README of the project.

4.3. Integration the bird detection data into the open data portal of the RMIB [OBJ-3]

The bird detection data are fully integrated in the open data portal of the RMIB:

https://opendata.meteo.be/

There is a dedicated page to describe all relevant **metadata**:

https://opendata.meteo.be/geonetwork/srv/eng/catalog.search#/metadata/RMI_DATASET_CROW

which is also propagated to the catalogue of the open data at federal level:

https://data.gov.be/en/dataset/rmidatasetcrow

A direct access to the **machine-readable output data** is provided both by the https and ftp protocols:
- Text files HTTP repository https://opendata.meteo.be/ftp/observations/radar/vbird/
- Text files FTP repository ftp://opendata-me.oma.be/observations/radar/vbird

The **licence** attached to the data is the permissive "CC-BY" licence (https://creativecommons.org/licenses/by/4.0/). This licence ensures (1) sharing, copying and redistributing the data in any medium or format, and (2) adapting the data (remix, transform, and build upon) for any purpose, even commercially. The only restriction is to give appropriate credit to the data provider by linking to the metadata page given above.

5. IMPACT AND ADDED VALUE OF THE VALORISATION ACTION

The valorisation action resulted in clear, tangible results, both at the level of the capacity of the institutions themselves, as at the level of the impact of the developed tools.

5.1. Capacity building at RMIB

At RMIB, the realisation of the valorisation project was the perfect occasion of gaining experience in the relatively new technology of container software, as a framework for a standardised transition from scientific R&D into a production environment.

Particularly for an institute like RMIB, with very important operational duties for the Belgian society, it is of utmost importance that there is a clear workflow of converting research into operations. In the past, this process was often hampered by the fact that the institute's scientists (responsible for the research and innovation in meteorology and meteorological tools) and the IT specialists (responsible for the operational implementation and monitoring) did not share common ground for this conversion. With the virtualisation realised in container software following a template imposed by the IT team, the scientists now have tools at hand to allow a smooth transition of scientific developments to an operational setting.

5.2. Capacity building at INBO

At INBO, the project strengthened the Open science lab for biodiversity's experience in developing single page applications. Vue.js and BootstrapVue were used before, but never in combination with the visualisation library D3. It also introduced the use of TypeScript, which allowed for more rigorous documentation and easier maintenance. It also deepened knowledge of radar data and related algorithms and exchange formats, which will be beneficial for the GloBAM project.

5.3. Impact of the developed web app

A coordinated press release was organised between the project partners, to announce the official launch of the web app on March 09, 2021. The text for this press release was jointly prepared in three languages by the project partners, and simultaneously published on the news sections of the organisational websites. It was also sent (beforehand) to the two organisations that provided an expression of interest along with the original project submission in 2018 (the nature conservation NGOs Natuurpunt Studie vzw and Natagora asbl).

In order to maximise the impact of the press attention, the choice was made to join forces for one coordinated, elaborated press release during an intense bird migration period (instead of two separate press releases as suggested in the original CROW proposal). This choice was clearly justified by the successful coverage of the launch in the media. In the **Appendix**, we give an overview of the articles that appeared in the media, both in the printed press as on radio/TV.

In the development of the web app, the choice was made not to use visitor profiling technology, since these generally diminish the user experience (i.e. because of "cookie consent popups"). As a consequence, we have only some overall statistics for the first days after launch. These statistics are inferred from the complete "access logs" from the meteo.be webserver, but filtered on the URL of the web app. In the first three days, 23 716 visitors were counted, but this is likely an underestimation since visitors behind a common IP-address are counted as 1 visitor. An overview of the statistics for the first three days after launch is given in Table 1.

Some more general, qualitative conclusions from these analytics are given in the points below.

– 45% of the visitors use a mobile device (Android or iOS, see *Table 2*) to visit the web app, and thus these mobile operating systems (OSes) are equally important as desktop OSes. The choice to develop a fully responsive web app was hence justified.
– There is a clear peak in the number of visitors around 20h at the day of launch, highly probably caused by the announcement of the app in the weather forecast on VRT.
– The articles in the press (De Standaard, HLN, Knack) generated extra traffic to the web app, as can be deduced from the "referrer" statistics (which gives information through which source the visitor reached the web app).
– Some attention from abroad was recorded (e.g. 1 187 visitors from The Netherlands, 357 from the U.S.).

Date	Unique visitors*	Hits
09 March 2021 (day of launch)	9 741	107 281
10 March 2021	11 132	123 886
11 March 2021	2 843	29 922
***based on unique IP-addresses; actual number of visitors may be higher as different visitors can share the same IP-address, e.g. if they are behind a corporate IP-address.**		

Table 1: Some basic visitor statistics for the first three days after the official launch of the CROW web app.

	OS	Visitors	Hits
1	Windows	8 657 (37%)	96 421
2	Android	6 392 (27%)	74 857
3	iOS	4 260 (18%)	47 248
4	macOS	3 522 (15%)	38 100
5	Linux	283 (1%)	3 056

Table 2: Top 5 of the most used operating systems to visit the CROW web app for the same period as Table 1 (09-11 March 2021).

6. MEASURES TO MAINTAIN THE COLLABORATION(S)

In the original project proposal of CROW, there is an engagement of maintaining the current infrastructure operational for **three years** from launch, i.e. until **March 09, 2024**. Due to the robust and portable architecture of the developed tools (both the Docker container in the back-end and the webapp as the front-end), this engagement will easily be realised, and very likely to be maintained thereafter.

A more fundamental aspect in this context is the publication of the machine-readable output on the open data portal of the RMIB, with a permissive licence. This facilitates the reuse of this particular dataset by any interested citizen, institution, research facility, NGO or private company. Hence these data can serve as a building block for future research projects or flourish new collaborations. For example, bird migration research with dedicated bird radars, like the one RBINS is using to study bird migration at sea, will benefit from this easy access tool to cross-validate findings and to frame local observations in a spatially wider ecological context.

The launch of the CROW web application also caught the attention of (aeroecology) researchers and triggered ideas for new collaborations. Especially in the GloBAM project (BELSPO BR/185/A1/GloBAM-BE) there is an interest to adapt the application to visualize the same type of data, but at a European scale and United States scale. Indeed, currently more than 100 radars all across Europe are already sending their data to the ENRAM data repository for bird detection purposes, but more work is needed to make this data high-quality and standardized. The RMIB is an active member of OPERA, which is EUMETNET's initiative to collaborate on European level for all weather radar related aspects. OPERA is managing the raw radar data delivery from the side of the European NMHSes (National Meteorological and Hydrological Services), and the RMIB will strongly promote the engagement of the different radar operators to continue the current activities and support new initiatives in this context. In the U.S., where a continental-scale open data archive of bird migration data already exists, CROW might be more readily adapted to visualize this wealth of information.

APPENDIX: OVERVIEW OF THE PRESS COVERAGE

Note: the validity of the links below was checked just before submission of this report. Obviously, the authors cannot guarantee the functionality of these links in the future. A pdf of the different articles can be received upon request.

A.1. Original press release by project partners

RMIB

- https://www.meteo.be/nl/info/nieuwsoverzicht/tien-weerradars-detecteren-vogeltrek-over-de-benelux-en-jij-kan-meekijken (Dutch)
- https://www.meteo.be/fr/infos/actualite/dix-radars-meteorologiques-detectent-la-migration-des-oiseaux-dans-tout-le-benelux-et-vous-pouvez-regarder-en-temps-reel (French)

INBO

- At the level of the organisation: https://www.vlaanderen.be/inbo/persberichten/tien-weerradars-detecteren-vogeltrek-over-de-benelux-en-jij-kan-meekijken/
- At the level of the Open science lab for biodiversity: https://oscibio.inbo.be/blog/crow/

RBINS

- https://www.naturalsciences.be/en/news/item/20722/

Natuurpunt (as involved stakeholder, having provided an EoI at submission)

- https://www.natuurpunt.be/nieuws/tien-weerradars-detecteren-vogeltrek-over-de-benelux-en-jij-kan-meekijken-20210309

A.2. Coverage in the printed/online press

- News article on vrtnws.be: https://vrtnws.be/p.bDeyXxQ8m
- News article on HLN.be: https://www.hln.be/wetenschap-en-planeet/volg-nu-zelf-de-vogeltrek-over-de-benelux~ac214ea7/
- News article on Knack.be: https://www.knack.be/s/r/c/1709523
- News article in De Standaard: https://www.standaard.be/cnt/dmf20210309_98162354
- News article in Het Nieuwsblad: https://www.nieuwsblad.be/cnt/dmf20210309_97064923
- News article in DH: https://www.dhnet.be/actu/societe/les-radars-de-l-irm-vont-surveiller-la-migration-des-oiseaux-6047a82e7b50a605177d4942
- Article on DailyScience: https://dailyscience.be/15/03/2021/la-migration-des-oiseaux-en-mode-2-0
- News article in monthly magazine “Chasse et Nature” by the Royal Saint-Hubert Club de Belgique (in preparation for the May 2021 issue)

A.3. Coverage on radio/TV

- Project mentioned in the VRT weather forecast on 09.03.2021 (Fig. 3): https://vrtnu.page.link/KfHoWBBLCgfjE2Y86
- Mentioned in the news bulletins of VRT radio on 09.03.2021 (16h, 17h, 18h)

- Interview with Nicolas Noé (INBO) on RTL Info (radio) on 09.03.2021 (18h50-19h00)
- News item on RTL Info (TV) including an interview with Kelle Moreau (RBINS) on 17.03.2021 https://www.rtl.be/info/video/775413.aspx

A.4. Other

CROW as inspiration of the daily cartoon in newspaper De Standaard on 10.03.2021. The reproduction rights were acquired by INBO afterwards to use this cartoon on social media and in presentations (Fig. 4).

LIST OF ACRONYMS

CC-BY Creative Common Attribution 4.0 International licence

CROW Communicating RAVen to the Outside World

DWD Deutscher Wetterdienst

ENRAM European Network for the Radar surveillance of Animal Movement

EUMETNET network of 31 European National Meteorological services (https://www.eumetnet.eu/)

GloBAM Towards monitoring, understanding and forecasting Global Biomass flows of Aerial Migrants (https://globam.science/)

INBO Instituut Natuur- en Bosonderzoek

KNMI Koninklijk Nederlands Meteorologisch Instituut

MIT Massachusetts Institute of Technology

NMHS National Meteorological and Hydrological Service

OPERA Operational Programme for the Exchange of Weather Radar Information

OS Operating System

RAVen RAdar registrations of bird migration Validation through an interdisciplinary approach

RBINS Royal Belgian Institute of Natural Sciences

RMIB Royal Meteorological Institute of Belgium

FIGURES

Figure 1. Screenshot of the repository for the "vol2bird" container on the internal GitLab of the RMIB. The README file gives the essential instructions to deploy the container, while the maintenance guide (file `maintenanceGuide.txt` in the `/doc` directory) gives detailed information about the structure of the software, the data flow and some troubleshooting information.

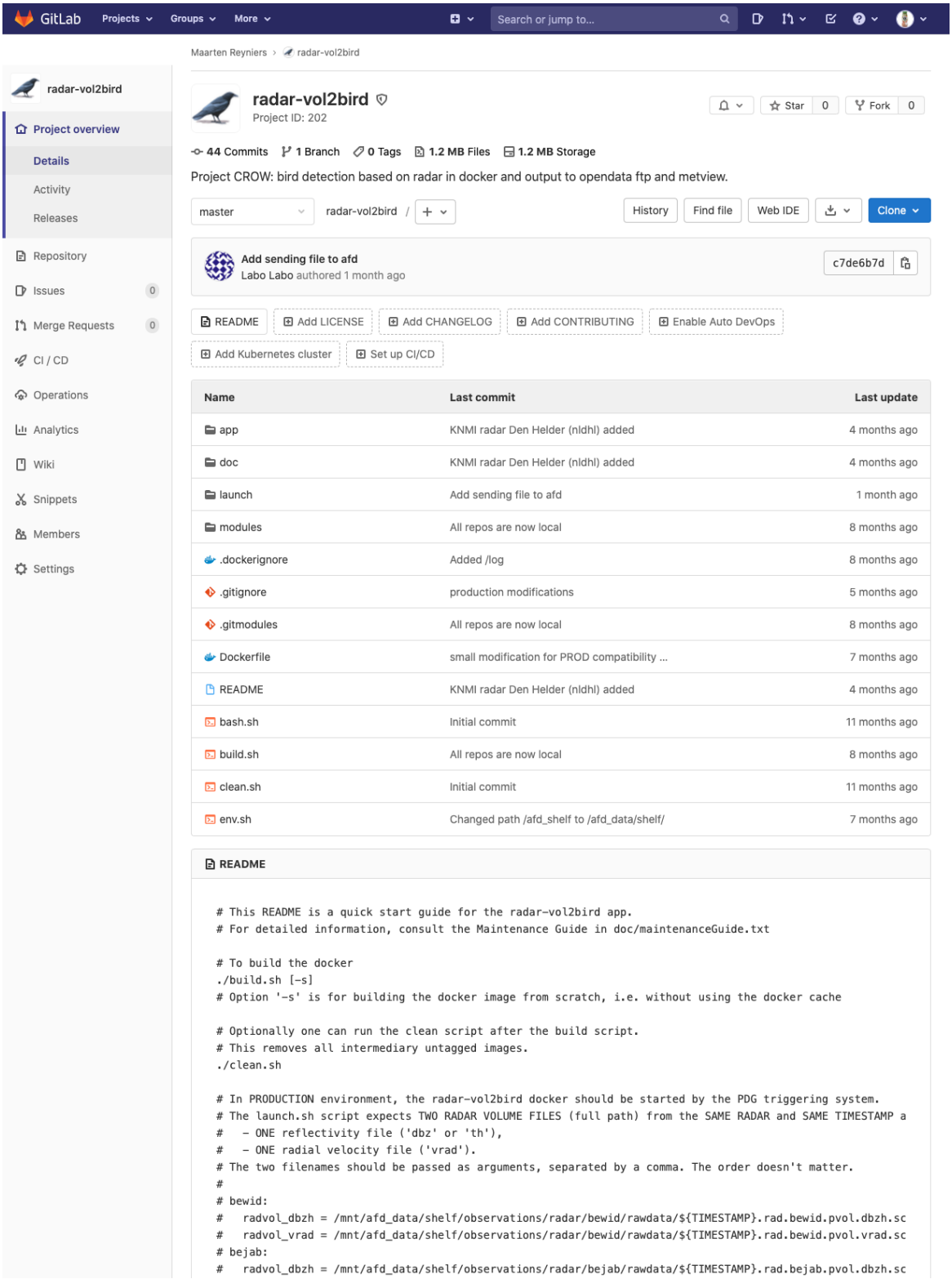

Figure 2. Screenshot of the developed web app. The following elements are highlighted: 1 language selector (OBJ-2.2), 2 short and accessible introductory text, 3 indicative number for the total bird mass shown on the chart (OBJ-2.3), 4 detailed data exploration via tooltip (OBJ-2.4), 5 several bird quantities are available, default "MTR", 6 density chart showing the vertical distribution of the birds (OBJ-2.4), 7 date selector (OBJ-2.5), 8 choice between chart generation for 1 or 3 days (OBJ-2.3), 9 radar selector via drop-down or via map (OBJ-2.3), 10 link to the source code on GitHub (OBJ-2.6).

Figure 3. Screenshot of the VRT weather forecast on 09.03.2021 in which CROW was briefly discussed, while showing a (customized) MTR-graph and the URL of the web app.

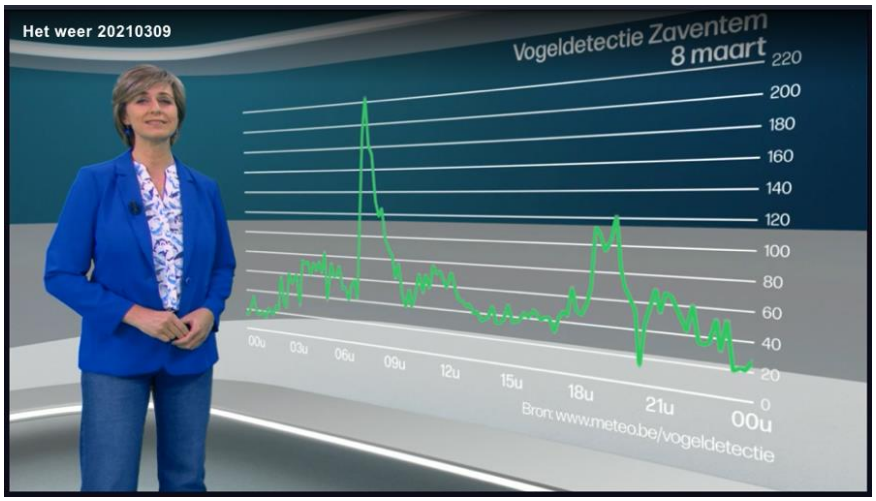

Figure 4. Cartoon in newspaper De Standaard of 10.03.2021. Note that INBO ordered the translation of the cartoon to English and acquired the reproduction rights (for social media and presentations).