Use of external weather sites

D.T1.2.3 Public data weather site collection
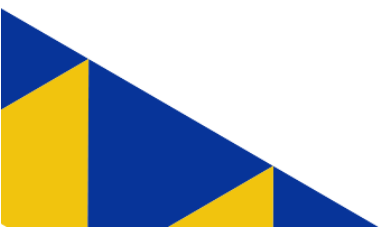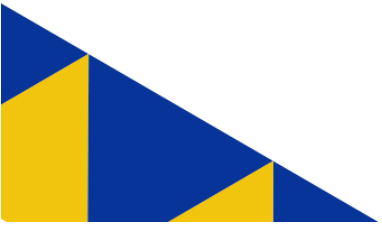
HL-P23039

October 2023

Management summary

In July 2021 extreme precipitation events in Limburg and the surrounding regions led to an exceptionally high discharge in the regional water systems, resulting in flooding. To be able to take suitable actions during these extreme events, it is important to have access to reliable precipitation observations. Currently, water board Limburg has access to a network of weather stations in Limburg and Wallonia. As a part of the EMfloodResilience project from the Interreg program, in this research an inventory was made of the available external weather sites for the Euregion Rijn-Maas providing precipitation observations.

Information was obtained through an internal inventory within HydroLogic, interviews with experts on precipitation information in the region and additional research consisting of an internet search and contacting the owners of different external weather sites for additional information. Water board Limburg guided this research and provided input for the websites included in the overview. This research focusses on external weather sites providing precipitation observations for an operational setting for the Euregion Rijn-Maas. Characteristics of interest are the website owner, region, used measuring systems, data actuality, data validation and correction and the availability in an external system.

23 Websites providing operational precipitation observations for the Euregion Rijn-Maas are available. Most external weather sites use data from the national weather services from Germany, the Netherlands and Belgium. It is often unclear if the validated or unvalidated product is used by the external weather site and whether they use their own correction method as well. Additionally, websites with data from personal weather stations could potentially be an useful additional data source as they have a high density of measurement points. Fifteen external weather sites have the option to use the data in an external system through an API. These include the national weather services (DWD, KMI, KNMI, VMM), three websites with personal weather stations (Netatmo, PWSWeather, WunderMap) and data providers (DTN, HydroNET , Infoplaza).

As most external weather sites use radar and weather station information from the national weather service, it would be logical to use data directly from the data provider. Nevertheless, it should be considered that data providers (DTN, HydroNET, Infoplaza) provide helpdesk and support and provide precipitation information from multiple data sources via one central API connection. Websites using personal weather stations could potentially be utilized as an useful additional data source, but it is important to note that there is not a lot of detailed information available on the data quality and correction. Future research could be focused on investigating the use of this data in operational water management for water board Limburg.

List of abbreviations

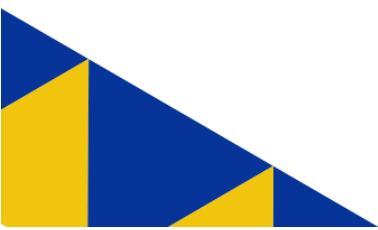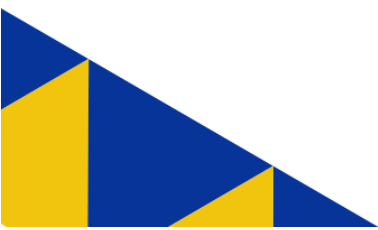|	
API	Application Programming Interface
AWS	Automatic Weather Station
DWD	German Weather Service
IRC	International Radar Composite
KNMI	Royal Dutch Meteorological Institute
KMI	Royal Meteorological Institute
PWS	Personal Weather Station
VMM	Flanders Environment Agency
KNMI IRIS station	Voluntary network of weather observations by the KNMI
WOW	Weather Observation Website

Table of Contents

1. Introduction

1.1 Background

In July 2021 extreme precipitation events in Limburg and the surrounding regions led to an exceptionally high discharge in the regional water systems of the Maas, Geul and Roer. In the south of Limburg up to nearly 160 mm of precipitation was locally measured in 48 hours. Precipitation amounts in the Ardennes and Eiffel were even higher (Ref. 1). This led to flooding and damage to houses and businesses at different locations. While weather forecasts provide insight in the expected amount of precipitation, information about the observed amount of precipitation is important as well. This information helps water managers understand the current state of rivers catchments, for example. Consequently, suitable actions can be taken such as closing flood defenses, blocking roads and informing citizens. Furthermore, precipitation information can be used in operational models for high water and to evaluate the impact of these events afterwards.

Currently, water board Limburg has access to a network of weather stations in the central and southern part of the region of the water board. Two automatic weather stations of the KNMI are located in the area and there is information available from all the operational weather stations of the SPW in Wallonia. As the flooding events in July 2021 were also caused by extreme precipitations in catchments in Germany and Belgium, it is important to have reliable measurements of observed precipitation in both the Netherlands as parts of Germany and Belgium (figure 1).

As a part of the EMfloodResilience project from the Interreg program, the question was raised to provide insight in the precipitation information that is available on external weather sites for the Euregion Rijn-Maas.
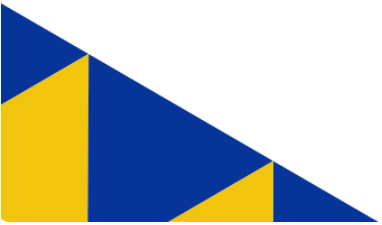

Figure 1 Euregion Rijn-Maas

1.2 Goal of this document

This document aims to provide an overview of the different external weather sites providing precipitation information for the Euregion Rijn-Maas and their characteristics. Amongst others, the following questions will be answered within this document:

- Who is the owner or administrator of the website?
- What measuring system is used for the information presented (radar, satellite, weather station, personal weather station) and from which source?
- Is the data validated or corrected? If so, is there additional information available?
- Is it possible to use the data in an external system with an API for example?

1.3 Reading guide

Chapter 2 provides information on the methods used for this research. An overview of the external weather sites is provided in chapter 3. This chapter provides an explanation on the scope of the research, a summary of the interviews, lists each website and it's characteristics individually and provides an overview table with the most important characteristics for each site. Chapter 4 presents the conclusions of this research, while chapter 5 contains the recommendations.

2. Method

The following paragraphs describe the methods used in this research. Water board Limburg guided this research and provided input for the websites included in the overview.

2.1 Research scope
Firstly, during the first project meeting the scope of this research was determined based on the requirements of the EMfloodResilience project and the requirements of water board Limburg. When required, the scope was further detailed during the follow-up meeting. There is a wide range of different external weather sites available, all providing different types of precipitation information (historical, current, forecasts) and using different formats to present the data. Therefore, determining the scope beforehand helped to focus this research and report. It also helped to avoid overlap with other research objectives of the EMfloodResilience project such as determining the most suitable weather forecast or improving the radar product for the region.

2.2 HydroLogic internal inventory
As a result of our experience with the HydroNET platform and other consultancy projects, a lot of knowledge on external weather sites with precipitation information is available at HydroLogic. The HydroNET platform is connected to different suppliers of weather information. Additionally, different connections have been explored in the past. Consequently, an important step of this research was to combine knowledge available within the organization to create an overview of websites with precipitation information.
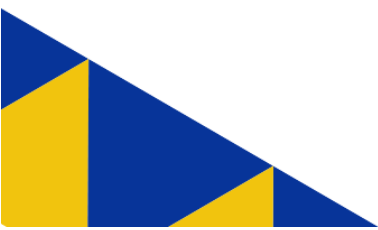
2.3 Interviews
Interviews were conducted with experts on precipitation information in the Euregion Rijn-Maas to complement the internal inventory. Interviews were used to obtain external knowledge on the different types of external weather sites and their characteristics. A list of experts was formed and contacted after the HydroLogic internal inventory. The list was supplemented with experts of missing regions after an online search. Please note that we were dependent on the willingness to participate of the persons contacted for setting up interviews. Four interviews were conducted in August 2023 with the following experts:

- Edouard Goudenhoofdt (KMI) - 23th of August 2023
- Ruben Imhoff (Deltares) - 23th of August 2023
- Aart Overeem (KNMI) - 24th of August 2023
- Bob Ammerlaan (Weather Impact) - 30th of August 2023

2.4 Additional research
A desk study was conducted to supplement the information obtained during the internal inventory and interviews. When required information wasn't available on the website of the external weather site or the internet, the owner of the external weather site was contacted. The information was collected and combined into this document and a detailed Excel matrix .

3. External weather sites

This chapter provides an overview of the external weather sites that are part of this research. Paragraph 3.1 provides the outline of the scope of this research. Paragraph 3.2 provides a review of the In paragraph 3.3 the different external weather sites and their characteristics are presented. interviews. Paragraph 3.4 presents a table with an overview of the external weather sites included in this document.

3.1 Scope

This research focusses on external weather sites providing precipitation observations. External weather sites were included in the research based on the following scope:
- The website contains precipitation observations for an operational setting.
- The website can contain forecast information, but this is of secondary interest to observational information.
- The website can be international, but has to provide precipitation information for the Euregion Rijn-Maas.
- Both websites with publicly available information and data providers are included.

Please note that there is a large variety of websites providing visualization of precipitation information from the national weather services (DWD, KMI, KNMI, VMM) without the possibility to use the underlying data in an external system. This document doesn't aim to include all these comparable websites, but rather highlights a few as an example.
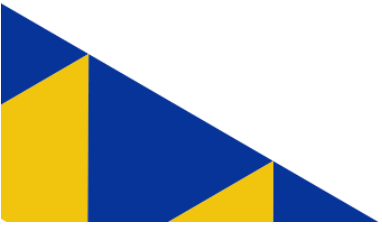
For each external weather site, the following characteristics of interest have been determined and will be included in the rest of the document (if available or applicable):

- **Website owner:** who is the owner or administrator of the website (if there is a difference)?
- **Region:** for which region is the information available?
- **Measuring system**: what measuring system is used for the information presented (radar, satellite, weather station, personal weather station) and from which source.
- **Data actuality**: after which period of time are the measurements available?
- **Data correction**: is the data corrected? If available, how is the data corrected?
- **Data validation**: is there information available on the quality of the data and the data validation by the website?
- **Use in external systems**: is it possible to use the data in an external system with an API for example?

Please note that the information in this document depends on the availability of information online and the transparency of websites to obtain the information.

3.2 Interviews

Four experts were interviewed to gain more insight in the use of external weather sites for the Euregion Rijn-Maas. Most interviewees indicated that they use information from the national

weather services such as the German Weather Service (DWD), Royal Meteorological Institute (KMI), Royal Dutch Meteorological Institute (KNMI) or the Flanders Environment Agency (VMM). Other external weather sites often use the same source data as the national weather services. However, there's less information available on the correction methods used or if they receive uncorrected or corrected data from the national weather services. An exception that was often mentioned was the use of personal weather stations such as the WOW-network or Netatmo. Personal weather stations provide a high density of measurements that are easily available and can provide insight in local precipitation events that can be missed by the sparser network of official weather stations. Consequently, they were mentioned as a potentially valuable addition to other precipitation information sources such as radar and official weather stations from national weather services. An important consideration with the use of information of personal weather stations is the continuity of the use of the weather stations and the lack of information on the quality of the measurements. A brief summary of the interviews can be found in annex A.

3.3 Inventory external weather sites

3.3.1 Overview external weather sites

The different external weather sites and their characteristics are presented below. Each table has the following lay-out:

Website name			
👥 Website owner		🌍 Region	
🗄 Measuring system (Radar, PWS, Weather stations, Satellite)		🕐 Data actuality, at what interval will new data be uploaded	
▽ Information available on data correction and validation?		⚡ Is it possible to use the data in an external system with an API for example?	
💻 Link to website			

Please note the following:
- When the data actuality is mentioned as 'near real time', it means that measurements generally become available within 10 minutes (for example: measurements from 12:00 are generally available at 12:10 at the latest).
- When a website has multiple data sources with precipitation information available, it is possible that the time mentioned for 'data actuality' is not applicable for all data sources. Details can be found in the Excel matrix.

Buienradar

👥 RTL Nederland		🌍 NL, BE, DU, EU	
🗄 Radar		🕐 Unknown	
▽ Unknown		🔌 No	
💻 https://www.buienradar.nl/ https://www.buienradar.be/			

Deutscher Wetterdienst (Climate Data Centre)

👥 Deutscher Wetterdienst		🌍 DU	
🗄 Radar, Weather stations		🕐 Near real-time	
▽ Yes		🔌 Yes, free use	
💻 https://www.dwd.de/DE/Home/ https://cdc.dwd.de/portal/			

DTN

👥 DTN		🌍 NL, BE, DU, World	
🗄 Radar, Weather station (KNMI, DWD, possibly KMI), Personal Weather Stations (Netatmo)		🕐 Near real-time	
▽ Yes, by DTN		🔌 Yes, API subscription available	
💻 https://www.dtn.com/weather/			

Het Weer Actueel

👥 Weerstation Kessel		🌍 NL, BE	
🗄 Personal Weather Stations		🕐 Approximately 30 minutes	
▽ Yes, by website moderators		🔌 No	
💻 https://www.hetweeractueel.nl/			

HydroNET

👥	HydroLogic	🌍	NL, BE, DU
🗄️	Radar, Weather stations (KNMI, KMI, DWD)	🕐	Near real-time
🔻	Yes, by HydroLogic	🔗	Yes, API subscription available
💻	https://www.hydronet.com/		

Infoplaza

👥	Infoplaza	🌍	NL, DU, World
🗄️	Radar, Weather stations (KNMI, DWD)	🕐	Near real-time
🔻	Yes, by Infoplaza	🔗	Yes, API subscription available
💻	https://www.infoplaza.com/nl/		

KMI

👥	KMI	🌍	BE
🗄️	Radar, Weather stations	🕐	Near real-time
🔻	Yes	🔗	Partly
💻	https://www.meteo.be/nl/belgie https://opendata.meteo.be/		

KNMI

👥	KNMI	🌍	NL
🗄️	Radar, Weather stations	🕐	Near real-time
🔻	Yes	🔗	Yes, API freely available
💻	https://www.knmi.nl/home https://dataplatform.knmi.nl/		

MeteoBelgie

👥 MeteoBelgie		🌍 BE	
🗄 Radar (VMM, Meteociel), Weather Stations (Metar stations, MeteoBelgie), PWS (BMCM)		🕐 15 - 20 min	
🔽 No, but can be corrected after multiple days		🔌 Yes, private API can be compiled depending on user needs	
💻 https://www.meteobelgie.be/			

Netatmo

👥 Netatmo		🌍 World	
🗄 Personal Weather Stations		🕐 Near real-time	
🔽 Possibility to filter measurements for quality control		🔌 Yes, API available depending on use	
💻 https://www.netatmo.com/en-eu https://weathermap.netatmo.com/			

PWSweather

👥 AerisWeather		🌍 World	
🗄 Radar		🕐 Near real-time	
🔽 Yes, validated by AerisWeather before publication		🔌 Yes, but details are unknown	
💻 https://www.pwsweather.com/ https://www.pwsweather.com/map			

RainGuru

👥 HKV, TU Delft		🌍 NL	
🗄 Radar		🕐 Unknown	
🔽 Unknown		🔌 Yes, API available on request	
💻 https://www.hkv.nl/projecten/rainguru/ https://rainguru.nl/			

RainViewer

👥 MeteoLab Inc.		🌍 World	
🗄 Radar (KNMI, DWD)		🕐 Unknown	
▽ Unknown		🔌 Yes, API freely available	
💻 https://www.rainviewer.com/			

VMM (Waterinfo)

👥 Vlaamse Milieu Maatschappij (VMM)		🌍 BE	
🗄 Radar, Weather stations		🕐 Near real-time	
▽ Yes		🔌 Yes, free use of data portal	
💻 https://www.vmm.be/ https://www.waterinfo.be/			

WeatherCloud

👥 WeatherCloud		🌍 World	
🗄 Personal Weather Stations		🕐 Near real-time	
▽ No, but measurements outside of the threshold range are rejected by the API		🔌 CSV export, possibly API in the future	
💻 https://weathercloud.net/en https://app.weathercloud.net/map			

Weerdata

👥 Neerslagkaart.nl		🌍 NL	
🗄 Weather station (KNMI)		🕐 Daily	
▽ No		🔌 No	
💻 https://weerdata.nl/ https://neerslagkaart.nl/			

Wetterzentrale

👥 Wetterzentrale		🌍 NL, DU	
🛢 Radar, Weather stations (KNMI, DWD)		🕐 Unknown	
🔽 Unknown		🔌 No	
💻 https://www.wetterzentrale.de/en/default.php			

WetterOnline

👥 WetterOnline		🌍 DU, Europe	
🛢 Radar, Weather stations (DWD)		🕐 Near real-time	
🔽 No		🔌 No	
💻 https://www.wetteronline.de/			

Windy

👥 Windy		🌍 World	
🛢 Radar, Satellite		🕐 Unknown	
🔽 Unknown		🔌 Yes, API subscription available	
💻 https://www.windy.com/			

Weer Informatie Waterbeheer (WIWB)

👥 Het Waterschapshuis		🌍 NL	
🛢 Radar, Weather stations (KNMI)		🕐 Near real-time	
🔽 Data directly available from KNMI		🔌 Yes, API for Dutch waterboards	
💻 https://www.hetwaterschapshuis.nl/neerslag-weer-informatie-waterbeheer https://www.meteobase.nl/			

Weather Observation Website (WOW)			
👥 MET Office, KMI, KNMI		🌍 Europe	
🗄 Personal Weather Stations		🕐 Near real-time	
▽ No		🔌 No, but export to Excel is available for some stations	
💻 https://wow.metoffice.gov.uk/ https://wow.meteo.be/nl/ https://wow.knmi.nl/			

Wundermap			
👥 Wunderground		🌍 Europe	
🗄 Personal Weather Stations		🕐 Every 5 - 15 minutes	
▽ Yes, but process is proprietary		🔌 Yes, API subscription available	
💻 https://www.wunderground.com/ https://www.wunderground.com/wundermap			

3.3.2 Weather sites providing visualization

Several external weather sites only provide a visualization of precipitation data and don't provide insight in the amount of precipitation that was measured for a location. While these weather sites are easily accessible for citizens, they are less suited for operational use in a professional setting. Therefore, only a short description is included in the following overview:

- **Hessenschau**. A websites owned by Hessenschau providing an animation of the precipitation data for Germany based on radar data from the German Weather service (DWD).
- **MeteoBlue.** A website owned by MeteoBlue providing animations of the precipitation data for the world based on radar and satellite images.
- **Meteox.** A website owned by the Meteo Company providing animations of the precipitation data for Europe based on radar.
- **Noodweer Benelux.** A website owned by Noodweer Benelux providing animations of the precipitation data for the Benelux for the previous 2 - 2.5 hours based on radar.
- **Sat24.** A website owned by the Meteo Company providing animations of precipitation data for the Benelux and Europe for the previous 2 hours based on satellite images (EUMETSAT).
- **SkyWarn Deutschland eV.** A website owned by SkyWarn providing an animation of precipitation data for Germany for the previous 24 hours based on radar data from the German Weather service (DWD).
- **Ventusky**. A website owned by InMeteo providing animations and mostly forecast data of the precipitation data for the world based on radar and satellite images.

- **Weather Online.** A website owned by WeatherOnline providing animations of the precipitation data for Europe for the previous 3 hours based on radar data.
- **Weerplaza.** A website owned by Infoplaza providing animations of the precipitation data for Europe for the previous the last hour, today and yesterday based on radar information and weather station measurements.
- **Weerslag.** A website owned by the Meteo Company providing animations of the precipitation data for Belgium, The Netherlands and Europe for the previous hour, 3 hours and 24 hours based on radar and satellite images. The Meteo Company has an API, more information can be acquired by contacting them.
- **Wetterdienst.** A website owned by the Wettendienst providing images of het precipitation data for Germany based on radar data from the German Weather service (DWD).

3.3.3 Other external weather sites

The websites Meteobase and RIONED are not described in the overview in par. 3.3 as they are not operational at this moment. The Nationale Neerslagradar is not included in this overview as this product is no longer in use.

3.4 Overview external weather sites

Table 1 provides an overview on the external weather sites and their most important characteristics. Par. 3.3 provides more details on each individual website. External weather sites that only provide visualization of precipitation data have not been included in this table, but can be found in par. 3.3.2.

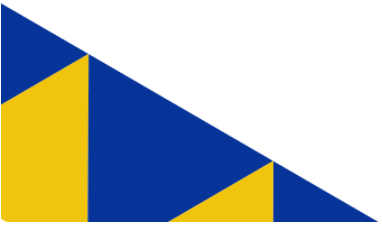*Table 1 Overview external weather sites Euregion Rijn-Maas*

Weather site	Region	Measuring system	Data correction?	Available in external system?
Buienradar	NL, BE, DE, EU	Radar	Unknown	No
Deutscher Wetterdienst (DWD)	DE	Radar, Weather stations	Yes	Yes
DTN	NL, BE, DE, World	Radar, Weather stations, PWS	Yes	Yes
Het Weer Actueel	NL, BE	PWS	Yes	No
HydroNET	NL, BE, DE	Radar, Weather stations	Yes	Yes
Infoplaza	NL, DE, World	Radar, Weather stations	Yes	Yes
KMI	BE	Radar, Weather stations	Yes	Yes
KNMI	NL,	Radar, Weather stations	Yes	Yes
MeteoBelgie	BE	Radar, Weather stations, PWS	No	Yes
Netatmo	World	PWS	No	Yes
PWSweather	World	PWS	Yes	Yes
Rainguru	NL	Radar	Unknown	Yes
RainViewer	World	Radar	Unknown	Yes
VMM (Waterinfo)	BE	Radar, Weather stations	Yes	Yes
WeatherCloud	World	PWS	No	No
Weerdata	NL	Weather stations	Yes	No
Wettenzentrale	NL, DE	Radar, Weather stations	Unknown	No
Wetteronline	DE, EU	Radar, Weather stations	No	No
Windy	World	Radar, Satellite	Unknown	Yes
WIWB	NL	Radar, Weather stations	Yes	Yes[1]
WOW	EU	PWS	No	No
WOW-BE	EU	PWS	No	No
WOW-NL	EU	PWS	No	No
Wundermap	World	PWS	Yes	Yes

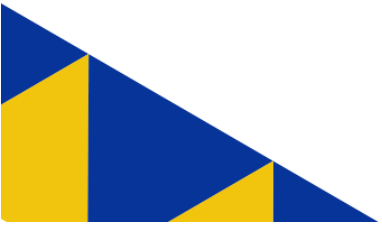[1] API available for Dutch water boards

4. Conclusions

In this research an inventory was made of the available external weather sites for the Euregion Rijn-Maas providing precipitation observations. The most important conclusions following this research include:

- Most external weather sites use data from the national weather services of the Netherlands, Belgium and Germany (DWD, KMI, KNMI and VMM). In some cases the data is used directly as provided by the national weather services, but some websites have their own correction methods for radar observations. As a result, it is often unclear which product (corrected or uncorrected) is used on the external weather site. Websites using their own validation methods include DTN, HydroNET and Infoplaza and they claim to have high quality data.
- Websites with data from personal weather stations could potentially be an useful additional data source for precipitation observations. These websites have a high density of measurement points and contain measurements that are not available on other websites. Although seven websites were found, only Netatmo, PWSweather and WunderMap allow users to use the data in an external system through an API. PWSweather and WunderMap both have basic quality control for the data, but the details of the quality control for WunderMap are proprietary. Netatmo allows for the use of an quality control algorithm (TITAN) developed by the Norwegian Meteorological Institute (Ref. 42.)
- Fifteen websites have the option to use the data in an external system through an API. These include the websites of the national weather services (DWD, KMI, KNMI, VMM), data providers (DTN, HydroNET, Infoplaza) and websites with personal weather stations (Netatmo, PWSweather, WunderMap). The website 'Weer Informatie Waterbeheer' provides an API for Dutch water boards. The website 'RainViewer' provides an API for the open-source data used on the website (such as KNMI and DWD).

5. Recommendations

This report provides an overview of the available external weather sites that can be used for precipitation information in the Euregion Rijn-Maas. Based on this report the following recommendations are formulated:

- As most external weather sites use radar and weather station information from the national weather services (DWD, KNMI, KMI and VMM) it would be logical to use data directly from the data source. DWD, KNMI and VMM have an open data portal with real-time data available. Additionally, the KNMI data can also be obtained through the WIWB API.
- Nevertheless, the added value of data providers such as DTN, HydroNET and Infoplaza that provide helpdesk and support for paying customers should be considered. As DTN, HydroNET and Infoplaza provide precipitation information from different sources, only one API connector has to be set up and maintained.
- Websites with personal weather stations could potentially be utilized as an useful additional data source. Three websites with personal weather stations also have an API available; Netatmo, PWSweather and WunderMap. It is important to note that there is not a lot of detailed information available on the data correction and validation of personal weather stations. Public Python packages such as TITAN could be used to filter the data. Future research could be focused on investigating the use of this data in operational water management, looking at both the quality of the data as well as which website is most suitable to use for water board Limburg.
- Multiple websites allow to combine radar observations from national weather services with measurements from weather stations (such as HydroNET and Infoplaza) or with personal weather stations (DTN). Additionally, HydroNET allows to set up connections with other data sources, such as personal weather stations and water quantity measurements from water board Limburg. Depending on the preferences and intended use of the data by water board Limburg, these options could be further explored.
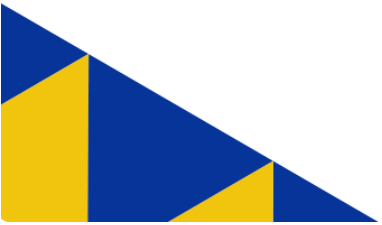
6. References

Ref 1. STOWA (2021). Hoe extreem was de neerslag in Limburg. Retrieved from STOWA: https://www.stowa.nl/nieuws/hoe-extreem-was-neerslag-limburg.

Ref 2. Buienradar (2023). Retrieved August 2023, from Buienradar: https://www.buienradar.nl/.

Ref 3. Deutscher Wetterdienst (2023). Retrieved August 2023, from https://www.dwd.de/.

Ref 4. DTN (2023). Retrieved August 2023, from https://www.dtn.com/.

Ref 5. HetWeerActueel (2023). Retrieved August 2023, from https://www.hetweeractueel.nl/.

Ref 6. HydroNET (2023). Retrieved September 2023, from https://www.hydronet.com/.

Ref 7. Infoplaza (n.d.). Retrieved August 2023, from https://www.infoplaza.com/nl/.

Ref 8. KMI (2023). Retrieved September 2023, from https://www.meteo.be/nl/belgie.

Ref 9. KNMI (n.d.). Retrieved August 2023, from https://www.knmi.nl/home.

Ref 10. MeteoBelgie (2023). Retrieved August 2023, from https://www.meteobelgie.be/.

Ref 11. Netatmo (n.d.). Retrieved August 2023, from https://www.netatmo.com/en-eu.

Ref 12. PWSWeather (2023). Retrieved August 2023, from https://www.pwsweather.com/.

Ref 13. RainGuru (2021). Retrieved September 2023, from https://rainguru.nl/.

Ref 14. RainViewer (2023). Retrieved RainViewer 2023, from https://www.rainviewer.com/.

Ref 15. VMM (n.d.). Retrieved August 2023, from https://www.vmm.be/.

Ref 16. Waterinfo (n.d.). Retrieved September 2023, from https://www.waterinfo.be/.

Ref 17. WeatherCloud (2023). Retrieved August 2023, from https://weathercloud.net/en.

Ref 18. Weerdata (2023). Retrieved August 2023, from https://weerdata.nl/.

Ref 19. Wetterzentrale (n.d.). Retrieved August 2023, from https://www.wetterzentrale.de/en/default.php.

Ref 20. Wetteronline (2023). Retrieved August 2023, from https://www.wetteronline.de/.

Ref 21. Windy (2023). Retrieved August 2023, from https://www.windy.com.

Ref 22. Neerslag - Weer Informatie Waterbeheer (2023). Retrieved July 2023, from https://www.hetwaterschapshuis.nl/neerslag-weer-informatie-waterbeheer.

Ref 23. Meteobase (2016). Retrieved July 2023, from https://www.meteobase.nl/.

Ref 24. WOW Met Office (2023). Retrieved August 2023, from https://wow.metoffice.gov.uk/.

Ref 25. WOW-BE (n.d.). Retrieved August 2023, from https://wow.meteo.be/nl/.

Ref 26. WOW-NL (n.d.). Retrieved August 2023, from https://wow.knmi.nl/.

Ref 27. Weather Underground (2023). Retrieved August 2023, from https://www.wunderground.com/.

Ref 28. WunderMap. (2023). Retrieved August 2023, from https://www.wunderground.com/wundermap

Ref 29. Hessenschau (n.d.). Retrieved September 2023, from https://www.hessenschau.de/.

Ref 30. Meteoblue (2023). Retrieved August 2023, from https://www.meteoblue.com/.

Ref 31. Meteox (2023). Retrieved September 2023, from https://meteox.com/.

Ref 32. NoodweerBenelux (2023). Retrieved August 2023, from https://www.noodweer.be/.

Ref 33. Sat24 (2023). Retrieved August 2023, from https://nl.sat24.com/nl.

Ref 34. SkyWarn Deutschland (2021). Retrieved September 2023, from https://www.skywarn.de/.

Ref 35. Ventusky (n.d.). Retrieved August 2023, from https://www.ventusky.com/.

Ref 36. WeatherOnline (2023). Retrieved August 2023, from https://www.woeurope.eu/.

Ref 37. Weerplaza (2023). Retrieved August 2023, from https://www.weerplaza.nl/.

Ref 38. Weerslag (2023). Retrieved August 2023, from https://weerslag.nl/.

Ref 39. Wetterdienst (2023). Retrieved August 2023, from https://www.wetterdienst.de/.

Ref 40. RIONED RainTools (2021). Retrieved July 2023, from
https://www.riool.net/applicaties/raintools.

Ref 41. Nationale Neerslagradar (n.d.). Retrieved August 2023, from https://nationaleregenradar.nl/.

Ref 42. Båserud, L. L. (2020). TITAN automatic spatial quality control of meteorological in-situ
observations. Advances in Science and Research, 153-163.

Annex A. Interview summaries

This document contains the summary of the interviews carried out in August 2023 as part of the project 'INTERREG: use of external weather sites' by HydroLogic on behalf of Waterschap Limburg. The summaries have been presented to the interviewees for verification. The following interviews were conducted:

- Edouard Goudenhoofdt (RMI) - 23 August 2023.
- Ruben Imhoff (Deltares) - 23 August 2023.
- Aart Overeem (KNMI) - 24 August 2023.
- Bob Ammerlaan (Weather Impact) - 30 augustus 2023.

A.1 Edouard Goudenhoofdt (RMI) - 23th of August 2023

Edouard has a background in civil engineering and applied mathematics has been working at the RMI for 15 years. He is involved in every part of the processing of precipitation information and responsible for the operational radar product. Belgium contains 4 radars (2 from the RMI, 1 from the VMM and 1 from Zaventem airport), which are used by both the RMI and the VMM. The RMI currently uses 3 Belgian radars and 1 French radar, for quality reasons the radar at Zaventem airport is not included.

The operational radar product is displayed on the RMIB website and smartphone application. It is not publicly available through an API, but sent to different public services for their internal use. According to European law, this product should be available for public use before January 2025. An older and basic product is sold to companies and might appear on some external weather sites.
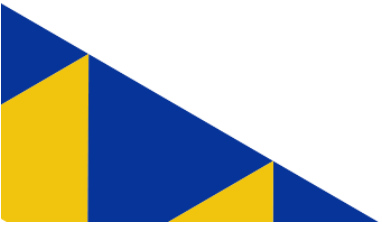
Additional precipitation information from personal weather stations is interesting, also for the correction of the radar. It is difficult to guarantee the quality of the data from personal weather stations. At the moment, he uses it as a backup for verification of the observations with the radar.

A.2 Ruben Imhoff (Deltares) - 23th of August 2023

Ruben is a researcher at Deltares in the field of nowcasting. In the Netherlands, he always uses the available KNMI data for precipitation observations. Since this year, the available radar images have been improved by the KNMI. The KNMI products are of a high quality, commercial parties and other external weather sites use them as well. When looking at forecasts, it is interesting to compare different forecasts and uncertainties.

When looking at precipitation observations it can be interesting to bring in more rain gauges from, for example, water boards as the KNMI only has 32 automatic weather stations at this moment. Additionally, networks of personal weather stations are also interesting, both for correcting radar observations and as a separate information source. For operational use of personal weather stations, it is important to filter for incorrect measurements, public Python packages are available for this.

For water board Limburg data from Germany and Belgium is also of interest. The RMI does not have an open data policy, data is available for paying users. The German Weather Service (DWD) offers a lot of public weather data. The European project OPERA is working on bringing together weather radars, but with a larger time step (15 min instead of 5 min), a lower spatial resolution and more assumptions in the correction method.

A.3 Aart Overeem (KNMI) - 24th of August 2023

Aart is a researcher at the KNMI involved in improving radar precipitation products and involved in opportunistic sensing of rainfall employing commercial microwave links in cellular telecommunication networks (focused on the Global South) and employing crowdsourced rain gauge data from personal weather stations. The KNMI offers real-time data via the KNMI Data Platform and the KNMI website. In the course of 2023 the International Radar Composite (IRC) products have been supplemented with new, improved algorithms and the number of con-tributing foreign radars has been increased from 3 to 5, shortening the distance to the radar for Limburg. Within the framework of this Interreg project, The KNMI investigates the availability and characteristics of Belgian and German rain gauge data from institutes. For instance, the Deutscher Wetterdienst (DWD) has a lot of public data available and many (automatic) weather stations.

The KNMI conducts research into the use of personal weather stations for the Netherlands and Europe. Combining sources (such as radar and Netatmo) would potentially give a better product, but more research is needed to assess the added value for KNMI's current IRC products. Quality control of these types of measurements is important. This and applying an appropriate merging algorithm can be a challenge. Often the personal weather stations can be used because there are many stations available, examples are WOW-NL and Netatmo. Netatmo has been used in several studies because Netatmo has the densest network of rain gauges, information is available on 1 platform and they are willing to cooperate in studies.

The KNMI provides precipitation information (as raw data, corrected data etc.) to external weather sites. When comparing these weather sites, you can sometimes see a difference in the observations, probably because these parties make their own corrections or because they use different KNMI radar products

A.4 Bob Ammerlaan (Weather Impact) - 30th of Augustus 2023

Bob is consultant in meteorology and climate change at Weather Impact and is responsible for the operational services. For a quick check of the short-term forecasts, he uses Weerplaza, mainly because of convenience. If Bob wants to know a point measurement of precipitation, he uses a measurement from a KNMI station if available or the HydroNET radar via the HydroNET Portal. As there are two radars in the Netherlands, all the weather sites use them. It is often not clear whether an external weather sites uses corrected data from the KNMI or if they correct the raw data themselves. When using radar products it is important to take into account the quality of the radar near the edge of the range of the radar. With the expansion of the KNMI radar product with foreign radars, Limburg is no longer at the edge of the radar composite range.

Additionally, there are weather sites that use satellite data, which is less accurate than using radar. Satellites are an useful resource for areas where radars are not available (some areas in Africa for example) or for insights on a global level. Satellites are less suited for regional use.

The use of personal weather stations allows for greater spatial coverage of precipitation in-formation. The continuity of the use of the weather stations and quality of the measurements are a point of interest. As there are many measurements available, it is easier to identify outliers and measurement errors by comparing measurements to other stations in the area. Examples of websites with personal weather stations are Netatmo, WOW and Weather Underground.