Information Flows Associated with the 2021 Inland Flooding in Western Europe: Germany, Belgium, and the Netherlands

Nathan Schunk, Economics, B.S., East Carolina University

Acknowledgements

This work was supported by the National Aeronautics and Space Administration (NASA) [grant number NASA#80NSSC22K0048]

Abstract:

In July 2021, Western Europe experienced significant flooding, resulting in millions of euros worth of damage costs and claiming over 200 lives. The people of Germany, Belgium, and the Netherlands had different levels of preparedness when facing the rising waters of the Rhine and Meuse Rivers. In all three cases, international forecasts and national warnings were issued several days before rains began. This paper compares the different experiences of these three countries. Germany was the first country impacted. Their temporal and geographic proximity to the rivers were only part of their challenge; decentralized communication networks, localized emergency management responsibilities, and outdated warning infrastructure hampered their preparations and responses. The most severe property damage in Germany occurred in the North-Rhine Westphalia and Rhineland Palatinate states along the Rhine River and its tributaries. In Belgium, flooding occurred primarily in the Wallonia Region along the Meuse River. There, regional tensions, language barriers, and undersubscription to the cellular warning system undermined preparedness. There were therefore areas where the messaging was clear and cities were evacuated (Verviers), as well as areas caught off guard (Pepinster). The Netherlands had additional time to prepare, a water

management infrastructure, and a regularly tested communication network, all of which contributed to comparatively low damage reports and no lives lost. By summarizing these different experiences, this information could improve preparedness for future hazard events.

Introduction:

In July 2021, a slow-moving, heavy rainfall associated with a cut-off low-pressure system led to severe flooding in the German states of North Rhine-Westphalia and Rhineland-Palatinate, as well as along the river Meuse and its tributaries in Belgium and the Netherlands. At the time of the event, soils were already saturated from snowmelt and precipitation. Localized factors, such impervious soil due to urban development topography; low-lying valleys near catchment areas for local tributaries; and differing governance of levees, dikes, dams, and catchment areas; also influenced the effects of the heavy rains. For example, in the Netherlands, the rivers were contained by levees. In Germany, however, water coming off the Eiffel Mountains flowed through narrow valleys with steep slopes creating funnel-like rushing waters. Although in the relatively flat areas rivers typically wind through towns with homes built along the banks, the rising waters eliminated the twists and turns, causing the river to widen and flow through the towns.

The Ahr River flooding was described as a 400-year (or rarer) event (Kreienakmp et al, 2021). The flooding resulted in at least 184 fatalities in Germany and 38 in Belgium, and caused considerable damage to infrastructure, including houses, motorways, railway lines, and bridges (Chadwick, 2021). Road closures left some places inaccessible for days, cutting off villages from evacuation routes and emergency

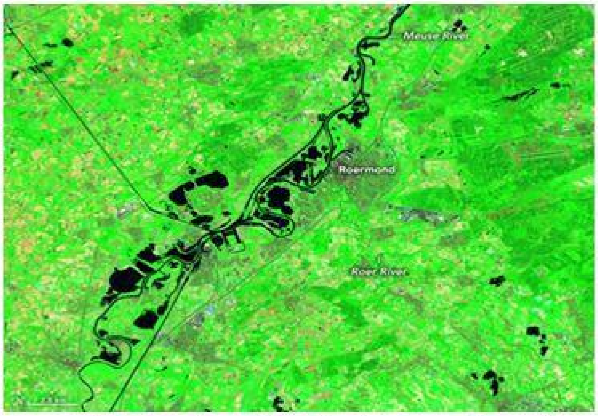

Image 1 "Roermond, NL Before Flooding June 16th, 2021", Lauren Dauphin, [*https://earthobservatory.nasa.gov/images/148598/deadly-floods-surprise-europe*](https://earthobservatory.nasa.gov/images/148598/deadly-floods-surprise-europe)

Image 2 "Roermond, NL After Flooding June 18th, 2021", Lauren Dauphin, [*https://earthobservatory.nasa.gov/images/148598/deadly-floods-surprise-europe*](https://earthobservatory.nasa.gov/images/148598/deadly-floods-surprise-europe)

response. Devastated communities experienced a significant slowing in their economies, losing key sources of income. Table 1 compares losses across the three countries in this study. Germany had the most fatalities and estimates of property loss.

Table 1: Damages from July 2021 Floods

	Germany	**Belgium**	**Netherlands**
Damages in Euros	26-30 Billion[1]	~10 Billion[2]	~500 Billion[3]
Fatalities	184	38-41[4]	0

---

1 "German Floods: Up to €30 Billion Needed for Recovery Fund: DW: 09.08.2021." *DW.COM*, 8 Sept. 2021, https://www.dw.com/en/german-floods-up-to-30-billion-needed-for-recovery-fund/a-58807147

2 Newsam. "Flood Damage in Belgium Exceeds € 10 Billion." *RSS*, 22 July 2021, https://news.am/eng/news/654826.html

3 Séveno, Victoria. "Flooding Leads to Half a Billion Euros Worth of Damage in Limburg." *IamExpat*, 22 July 2021, https://www.iamexpat.nl/expat-info/dutch-expat-news/flooding-leads-half-billion-euros-worth-damage-limburg

4 "Inondations En Wallonie: Le Corps D'un Homme Trouvé à Trooz, Il y a à Présent 38 Morts Identifiés, Une Personne Reste Portée Disparue." *RTBF*, RTBF.be, 29 July 2021, https://www.rtbf.be/article/inondations-en-wallonie-le-corps-d-un-homme-trouve-a-trooz-il-y-a-a-present-38-morts-identifies-une-personne-reste-portee-disparue-10813802

Many have pointed to climate change as being responsible for the intense 2-day rainstorm (Gathmann, et al, 2021). Studies predict that climate change will continue to increase the intensity and frequency of this type of precipitation as temperatures continue to rise, causing more frequent and extreme flooding (Cendrowicz, 2021). Meteorologists had predicted the intense rain several days in advance. These forecasts were communicated to local authorities with accompanying warnings to prepare for an extreme event and potential flash flooding. (Copernicus EMS-Mapping*,* 2021; Cuddy, 2021). Unfortunately, these warnings failed to initiate sufficient preparation and evacuations, resulting in loss of life and property.

This paper seeks to describe how the information about the extreme weather and associated dangers were transmitted from satellite imagery to European Union meteorological warning systems, to national agencies, and, finally, to local end-users. Understanding how the information flowed and motivated protective actions, and where it did not, can provide insight for revising responses in the future. Communication plans can be designed to leverage positive system attributes and implement corrective practices to improve outcomes and reduce damages. Specifically, this paper tracks human interaction with the information flows from satellite meteorological flood warnings, through the governance processes and warning systems, down to the local level where preparations and protective actions were initiated in Germany, Belgium, and the Netherlands. The people in these countries had very different experiences due, in part, to differences in history, governance systems, communication networks, and localized responses. Comparisons across the three countries can be used to improve the translation of information into action to reduce future loss of life and property in these areas. The lessons learned can also be applied more broadly to other contexts.

The first section of this paper provides an overview of the flooding timeline, the information flow, and the regional geography. The next three sections describe the experiences in Germany, Belgium, and the Netherlands. The conclusion includes a summary of lessons learned and offers possible next steps in this line of research.

Overview:

Flooding Timeline

On July 9th, the National Aeronautics and Space Administration (NASA), the European Space Agency (ESA), and the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) had issued warnings based on satellite images that indicated a severe storm event (Jeppesen, 2022). These warnings were sent to the European Center for Medium-Range Weather Forecasts for computation, which is a part of the European Flood Awareness System (EFAS). The next day, July 10th, EFAS interpreted the information and issued flood warnings to the national weather services in Germany, Belgium, the Netherlands, and other European Union nations, as well as the Emergency Response Coordination Center (ERCC) for the EU. The EFAS warnings were specific to the Rhine River Basin. On July 12th, EFAS included the Meuse River Basin in its warnings. Additionally, national weather services in affected countries started sending advanced severe weather warnings on July 12th. Precipitation began in most areas on July 13th with the heaviest precipitation and the start of major flooding occurring on July 14th in Germany and Belgium. The Meuse and the Rhine both reached peak flow on July 15th. The damages were extreme, both in terms of loss of life and property, in Germany, the first country to experience the flooding. Belgium and the Netherlands downriver had additional time to prepare and were able to observe the news and social media posts about Germany's experiences.

Information Flow:

Updated warning information from EFAS was distributed through three organizations: (1) Rijkswaterstaat, which is responsible for France, Luxembourg, the United Kingdom, Ireland, the Netherlands, Belgium, Spain, Portugal, and western Germany; (2) the Swedish Meteorological and Hydrological Institute, which is responsible for Poland, Denmark, Latvia, Lithuania, Estonia, Norway, Sweden, Finland, and the northwest region of the Czech Republic; and (3) the Slovak Hydro-Meteorological Institute, which is responsible for Italy, Austria, Ukraine, Romania, Hungary, Bulgaria, Moldova, Macedonia, Greece, Slovakia, Slovenia, Croatia, Kosovo, and the southeast region of the Czech Republic ("Data Access", 2022). In the Rijkswaterstaat district, which includes Germany, Belgium, and the Netherlands, information was disseminated to hydrological and meteorological organizations in affected countries. This paper focuses on the different paths of this information through Germany, Belgium, and the Netherlands.

Table 2: Information and Warnings through Germany, Belgium, and Netherlands

Information Flow	Germany	Belgium	Netherlands
Satellite Imaging	Imaging and atmospheric data collected	Imaging and atmospheric data collected	Imaging and atmospheric data collected
EFAS	Data received from satellites. Warnings issued for Germany.	Data received from satellites. Warnings issued for Belgium	Data received from satellites. Warnings issued to the Netherlands
National	The National Weather Service issues warnings. BBK also issues limited warnings with NINA and KATWARN.	The National Weather Service issues warnings. Crisis Center of Belgium issues warnings to each of the three regions	The National Weather Service issues warnings. Rijkswaterstaat sends warnings and manages emergency response
State/Regional	Each of the states receives warnings which are passed to communities who are responsible for local preparations.	Crisis Center of Wallonia passes information to the responsible officials in the regional provinces	N/A
Provincial	N/A	Provincial Governor's offices coordinate emergency response organizations	N/A
Municipality	Local mayors and EMS coordinate emergency response	Towns and municipalities coordinate preparations for possible evacuations	Rijkswaterstaat manages local emergency response. NL-Alert sends warnings

Regional Geography:

Image 3 "Map of flooded areas", The Visual and Data Journalism Team, BBC, https://www.bbc.com/news/world-europe-57862894

The Meuse and Rhine rivers flow north through Belgium and Germany respectively, meeting in the Netherlands and emptying into the North Sea. This study focuses on compound flooding including the pluvial flooding from the soil saturation and the weather system and fluvial flooding from Eiffel Mountains snowmelt and rain. The rains pushed the water levels of these two rivers and tributaries over their banks and onto surrounding saturated lands. The resulting flooding caused significant damage.

The following sections compare the three countries' responses to the impending floodwaters in terms of communication infrastructure including governance (who was responsible) and warning infrastructure (sirens, news outlets, and cellular applications).

Germany:

The EFAS flood warnings were issued four days before precipitation began to several German partner organizations ("Partners List", 2022), including the Federal Office of Civil Protection and Disaster Assistance (BBK), the State Office for the Environment of Rhineland Palatinate (LFURLP), and the North Rhine-Westphalian State Agency for Nature, Environment, and Consumer

Protection (LANUV-NRW). The German National Weather Service (DWD) sent advanced storm information and warnings which forecasted severe weather and heavy precipitation for the Rhineland Palatinate and North Rhine-Westphalia areas. The initial warnings sent by the DWD on July 12th described the impending storm as a level-three dangerous weather event, which is defined as a very dangerous weather development with possible widespread damage. This event would be upgraded to level-four on the morning of July 13th, meaning
it was considered an extremely dangerous weather development with life threatening situations and major damage possible (Davis et al., 2021; “Warnstufen Und Farbskala”, 2022). The state agencies transmitted the forecasts and warnings to the municipalities. The state authorities then coordinated emergency measures with local emergency services on a case-by-case basis.

One challenge to preparedness in Germany is that governing authority is not centrally held; each of the 16 federal states has different internal organizational and communication systems. The warnings were therefore inconsistently distributed, and logistical challenges undermined coordinated mobilization efforts. According to the LFURLP, “a decentralized organization of the flood reporting centers is required so that regional characteristics can be considered when creating flood forecasts so the interested local authorities and the public can be informed quickly and comprehensively” (“Hochwassermeldedienst”, 2022). During an interview with the German weekly news magazine, *Spiegel*, Albrecht Broemme, former president of the Federal Agency for Technical Relief in Germany, said, “the scattering of responsibility is a problem in disaster management” (Gathmann et al., 2021).

The Middle Rhine and its tributaries flow through the western states of Rhineland Palatinate and North Rhine-Westphalia which are home to 22 million people. The warnings covered most areas directly along the Rhine; however, the warning messaging did not fully cover the impacted area. Specifically, much of the Ahr Valley was not included in the forecasts or warnings. The Ahr Valley is in the Rhineland Palatinate, which is where most deaths occurred during the flooding. According to the interactive map provided by EFAS, areas in the Ahr Valley, such as Ahrweiler, were not included in the projected flood area until July 12th and only indicated a one to ten percent chance of flooding over the next 48 hours (*Copernicus EMS - European Flood Awareness System*, 2021).

In North Rhine-Westphalia along the Erft river, the fire department in the town of Erftstadt received the national weather service warnings on July 12th but did not activate the warning sirens until the threat was imminent on July 14th. The residents therefore did not have sufficient time to react. To further complicate the situation, warning sirens were from the Cold-War era, and many did not work. The infrastructure for communicating danger had failed, so firefighters went door-to-door to wake up residents, instructing them to move to higher ground as the floodwaters rose.

In addition to the siren system, the federal BBK developed apps, NINA and KATWARN, to distribute messaging through cellular networks. The NINA app sent out emergency response instructions and the KATWARN app included location-specific warnings linked to the phones' GPS (Dani, 2021). While the apps were designed to complement each other, the coverage, messaging, and user adoption rates of the apps were lacking and did not provide sufficient warnings.

The rains began in Germany on July 13th. Images of devastated communities, homes, railways, bridges, and roads were posted on social media and shown on the news around the world by July 16th, with real-time updates coming out each day. These images served as evidence of impending danger for the people who lived in Belgium and the Netherlands.

Image 5 "Car swept into tree during flooding in Ahrweiler", BBC, https://www.bbc.com/news/world-europe-57858826

Image 6 "Aftermath in the town of Erfstadt", BBC, https://www.bbc.com/news/world-europe-58992093

Belgium:

Image 7 "Map of Belgium with regions and rivers identified", Wiki-Travel, https://wikitravel.org/en/Belgium

Belgium is a densely populated country of 11.6 million people. Regional differences in the country date back decades and are reflected in language, governance, and cultural differences across the three regions of Flanders, Wallonia, and Brussels. (Gupta, 2021). There are three national languages: French (which is most common in both Brussels and Wallonia), Dutch (which is most common in Flanders), and German (which is common in western Wallonia). Internal tensions created impediments to national mitigation infrastructure and in the flow of information during the 2021 flooding.

Much of the damage from flooding in Belgium occurred along the Meuse River, which flows north through Wallonia into the Netherlands and converges with the Rhine River. On July 14th, the Vesdre Dam on Lake Espen and the Vesdre River were discharged at a rate of 150 cubic meters per second to relieve some of the pressure from rising waters on the lake. This contributed to rising water levels rising in the Vesdre River, potentially intensifying flooding in areas of Liege.

Much like Germany, the warning system of Belgium is decentralized. The advantages of localized warnings are that the forecasts, messaging, and instructions can be tailored to the specific areas. However, in Belgium, information flows from (1) the national weather service (IRM) to (2) the National Crisis Center to (3) the Wallonian Crisis Center to (4) the Provincial Crisis Centers (such as Liege), and finally to (5) the specific municipalities to coordinate local emergency responses. In the event of an emergency, the provincial Governor handles the organization and dissemination of information to their municipalities. They are also charged with triggering a "provincial phase" which gives them the authority to coordinate many different organizations to manage the emergency effectively. Thus, responsibilities for emergency response lie primarily at the local level.

In addition, there is a direct messaging system called "Be-Alert" which is a national public safety cellular messaging system administered by the Belgian National Crisis Center. Through this app, warnings are sent via texts, emails, and voice, leaving messages of impending crises to subscribers. One potential problem with the Be-Alert system is that it requires the end-user to opt-in to receiving the warnings. Relying on end-users to activate their Be-Alert messaging could therefore have contributed to under-subscription to the service, leaving many people ill-informed and under-prepared.

Image 8 "Aftermath in Pepinster", Cendrowicz 2021, https://inews.co.uk/news/world/belgium-floods-meet-the-residents-trying-to-rebuild-their-lives-in-the-rain-battered-town-of-pepinster-1191241

The province of Liege in Wallonia provides stark examples of how various communities along the Meuse had different experiences both in terms of messaging, such as the issuances and receipts of warnings, and response, such as evacuation. Based on warnings issued by local authorities and messages sent through the Be-Alert system, the City of Verviers evacuated. Less than 6 km away, in the town of Pepinster, which is also located on the Meuse, the residents did not receive Be-Alert messaging and the local emergency responders did not react until the floodwaters were already rising in their streets and homes. In Verviers, which has a population of 55,000, there were six fatalities. In Pepinster, which has a population of only 9,700, over 12 people died (RTBF, 2021).

Image 9 "Cars swept away be flooding in Verviers", BBC, https://www.bbc.com/news/world-europe-57858826

Netherlands:

The Meuse and Rhine rivers systems meet in the Netherlands. This country of 17.6 million people has a history of flooding and proactive water management.

Historically, their primary perceived risks have been coastal flooding from the North Sea and inland flash flooding in low-lying areas. In 1993 and 1996, they experienced extensive flooding from the Meuse River in the southern part of the country. The Dutch government commissioned the “Meuse Flooding Committee” (Commissie Water-snood Mass) to develop strategies to reduce future flood damage, including higher levees and a coordinated national warning system that evolved into NL-Alert (Wind, 1999). Currently, the Delta program coordinates with the Rijkswaterstaat to maintain the dikes and levees, conduct flood risk analysis, and manage mitigation strategies (Delta Programme, 2021).

Their proactive water management infrastructure of levees and dependable nationalized messaging systems were strategic advantages compared to Belgium and Germany. Information about the rising waters and evacuation planning was communicated via television on the Dutch Broadcasting Foundation (Nederlandse Omroep Stichting – NOS) and the cellular network app NL-Alert, which is tested biannually. The NL-Alert warnings were automatically sent through the cellular networks to all devices. The national television news, Channel 1, was dedicated to warnings and information about the pending floodwaters. The warning sirens, which are tested monthly, were also sounded.

The Netherlands also had the advantage of advanced notice: they had an extra day to prepare as news of Germany’s flooding was shown on the news and shared through social media. The biggest complication for the Netherlands was threats from both the Rhine and Meuse Rivers. Fortunately, their levees were not breached, and the warning systems kept the people who were at risk informed in case of emergency.

While there was €500 billion in estimated property loss (Séveno, 2021), there were no casualties.

Conclusions: Lessons Learned and Next Steps

The July 2021 flooding in Western Europe impacted regions that had warnings and advance notice, yet it caused devastating damage and significant loss of life. The Netherlands had considerable property damage, but no fatalities. Many factors helped them be prepared, including a well-developed water management infrastructure; a centrally coordinated and reliable communication plan; and population sensitized by prior experiences with flooding. By contrast, in Belgium, the flooding was concentrated in a single region, the Wallonian region, which had the lowest per-capita income and the highest flood risk. Its multiple languages and *opt-in* rather than *opt-out* communication networks were barriers to broadcasting warnings and instructions for public safety. Lastly, in Germany, the responsibility for preparedness was decentralized and pushed down to the local levels. As a result, some areas responded effectively while others were caught off guard.

There are a number of important lessons that can be learned from this comparison. For instance, given the Netherlands experience, nationally funded infrastructure projects, like levees, could help reduce future flood risk, as well as the use of a reliable communication infrastructure that can deliver location-specific warnings . Although the Netherlands' water-management infrastructure and communication systems could be replicated in other countries, there may be cultural and logistical challenges to doing so in countries like Belgium and Germany. Indeed, both countries have regional and jurisdictional barriers that could inhibit the development of large-scale preparedness projects. However, there are actions already being taken in these countries in response to the summer 2021 flooding. Wallonia, Belgium, for instance, is developing a warning app that is similar to the one that was utilized in the Netherlands. Moreover, in Germany, the national government is negotiating with the states to resolve privacy concerns around a national cellular alert system.

This assessment of the experiences of Germany, Belgium, and the Netherlands draws on secondary data sources. In the future, research that includes interviews with local decision makers and stakeholders would help to develop a better understanding of people's experiences in the affected areas. In doing so, this future research could contribute to the development of a conceptual system dynamics model, which would not only provide key insights into impacted communities' experiences, but also inform future preparedness planning and responses to protect lives and property from floodwaters.

References

"Alert Municipalities." *BE-ALERT*, https://www.be-alert.be/en/be-alert-municipalities

Belgium - Wikitravel. https://wikitravel.org/en/Belgium

"Belgium Opens Manslaughter Investigation over Flood Deaths." *The Guardian*, Guardian News and Media, 28 July 2021, https://www.theguardian.com/world/2021/jul/29/belgium-opens-manslaughter-investigation-over-flood-deaths#:~:text=The%20latest%20provisional%20death%20toll,more%20than%20180%20people%20there

Bissoli et al. *Hydro-Klimatologische Einordnung Der Stark- Und ... - Dwd.de*. 19 July 2021, https://www.dwd.de/DE/leistungen/besondereereignisse/niederschlag/20210721_bericht_starkniederschlaege_tief_bernd.pdf?__blob=publicationFile&v=6

Cendrowicz, Leo. "Meet the Residents Trying to Rebuild Their Lives in a Flood-Drenched Town in Belgium." *Inews.co.uk*, 10 Sept. 2021, https://inews.co.uk/news/world/belgium-floods-meet-the-residents-trying-to-rebuild-their-lives-in-the-rain-battered-town-of-pepinster-1191241

Chadwick, Jonathan. "Record-Breaking Rainfall That Caused Deadly Flooding across Germany and Belgium in July Was Made up to NINE TIMES More Likely by Climate Change, Study Warns." Daily Mail Online, Associated Newspapers, 30 Sept. 2021, https://www.dailymail.co.uk/sciencetech/article-9921613/Climate-change-Europes-fatal-floods-likely-study-says.html

"The Copernicus Emergency Management Service Forecasts, Notifies, and Monitors Devastating Floods in Germany, Netherlands, Belgium and Switzerland." *Copernicus EMS - Mapping*, 16 July 2021, https://emergency.copernicus.eu/mapping/ems/copernicus-emergency-management-service-forecasts-notifies-and-monitors-devastating-floods

Cuddy, Alice. "Germany Floods: How a Country Was Taken by Surprise." *BBC News*, BBC, 16 July 2021, https://www.bbc.com/news/world-europe-57867773

Dani. "Katwarn or Nina: Which Warning App Is Better?" Practical Tips, 23 July 2021, https://www.practical-tips.com/android/katwarn-or-nina-which-warning-app-is-better-2/

Davis, Austin, and Morris, Loveday. "In Aftermath of Devastating Floods, Germans Wonder What More Could Have Been Done." *The Washington Post*, WP Company, 20 July 2021, https://www.washingtonpost.com/world/europe/germany-flood-warnings-aftermath/2021/07/20/076ee7a2-e8b6-11eb-a2ba-3be31d349258_story.html

"Data Access." *Copernicus EMS - European Flood Awareness System*, https://www.efas.eu/en/data-access

"Delta Programme." Government.nl, Ministerie Van Algemene Zaken, 10 June 2021, https://www.government.nl/topics/delta-programme

"Europe Floods: Victims Face Massive Clean-up as Waters Recede." *BBC News*, BBC, 18 July 2021, https://www.bbc.com/news/world-europe-57876982

"European Flood Awareness System – EFAS." *Copernicus EMS - European Flood Awareness System*, https://www.efas.eu/en/european-flood-awareness-system-efas#:~:text=EFAS%20is%20the%20first%20operational,relevant%20national%20and%20regional%20authorities

"Europe's Floods: Lessons from German Tragedy." *BBC News*, BBC, 29 Oct. 2021, https://www.bbc.com/news/world-europe-58992093

Gathmann, Florian, et al. "Catastrophic Flooding Spotlights Germany's Poor Disaster Preparedness." *DER SPIEGEL*, DER SPIEGEL, 23 July 2021, https://www.spiegel.de/international/germany/left-to-their-own-defenses-catastrophic-flooding-spotlights-germany-s-poor-disaster-preparedness-a-b3821147-97d2-4f23-951c-0206bd9ff9b2

"German Floods: Up to €30 Billion Needed for Recovery Fund: DW: 09.08.2021." *DW.COM*, 8 Sept. 2021, https://www.dw.com/en/german-floods-up-to-30-billion-needed-for-recovery-fund/a-58807147

“Germany Floods: Dozens Killed after Record Rain in Germany and Belgium.” BBC News, BBC, 15 July 2021, https://www.bbc.com/news/world-europe-57846200

Gupta, Gunjan. “How Can Belgium Overcome Its Regional Linguistic Conflicts?” *Social Policy*, 18 Mar. 2021, https://blogs.lse.ac.uk/socialpolicy/2021/03/18/how-can-belgium-overcome-its-regional-linguistic-conflicts/#:~:text=Despite%20its%20small%20size%2C%20Belgium,the%20Walloon%20region%2C%20and%20Brussels

Hochwassermeldedienst, https://www.bezreg-koeln.nrw.de/brk_internet/leistungen/abteilung05/54/hochwasserschutz/warndienst/index.html

“Hochwassermeldedienst.” *Lfu.rlp.de*, https://lfu.rlp.de/de/wasserwirtschaft/hydrologie/hydrologie/hochwassermeldedienst/

“In Pictures: Floods Kill Dozens in Germany and Belgium.” BBC News, BBC, 16 July 2021, https://www.bbc.com/news/world-europe-57858826

“Inondations En Wallonie: Le Corps D'un Homme Trouvé à Trooz, Il y a à Présent 38 Morts Identifiés, Une Personne Reste Portée Disparue.” *RTBF*, RTBF.be, 29 July 2021, https://www.rtbf.be/article/inondations-en-wallonie-le-corps-d-un-homme-trouve-a-trooz-il-y-a-a-present-38-morts-identifies-une-personne-reste-portee-disparue-10813802

Jeppesen, Joanne. “Partnerships with Space Agencies.” *ECMWF*, 6 Jan. 2022, https://www.ecmwf.int/en/about/what-we-do/serving-meteorology/partnerships-space-agencies

Kreienkamp, Frank, et al. *Rapid Attribution of Heavy Rainfall Events Leading to the Severe …* 2021 https://www.worldweatherattribution.org/wp-content/uploads/Scientific-report-Western-Europe-floods-2021-attribution.pdf

Newsam. “Flood Damage in Belgium Exceeds € 10 Billion.” *RSS*, 22 July 2021, https://news.am/eng/news/654826.html

“Partners List.” *Copernicus EMS - European Flood Awareness System*, https://www.efas.eu/en/partners-list-0

Rtbf. “Inondations En Belgique : 12 Personnes Sont Décédées à Pepinster, IL Reste 20 Personnes Portées Disparues.” *RTBF*, RTBF.be, 18 July 2021, https://www.rtbf.be/article/inondations-en-belgique-12-personnes-sont-decedees-a-pepinster-il-reste-20-personnes-portees-disparues-10806547

Spw. “Systèmes D'alertes.” *Inondations En Wallonie*, 16 Apr. 2021, https://inondations.wallonie.be/home/gestion-de-crise/systemes-dalertes.html

The Visual and Data Journalism Team. “Germany Floods: Where Are the Worst-Hit Areas?” *BBC News*, BBC, 16 July 2021, https://www.bbc.com/news/world-europe-57862894

Voiland, Adam. “Deadly Floods Surprise Europe.” *NASA*, NASA, 20 July 2021, https://earthobservatory.nasa.gov/images/148598/deadly-floods-surprise-europe

“Warn-App Nina.” *BBK*, https://www.bbk.bund.de/DE/Warnung-Vorsorge/Warn-App-NINA/warn-app-nina_node.html

“Warnstufen Und Farbskala.” *Wetter Und Klima - Deutscher Wetterdienst - Warnungen Aktuell - Warnstufen Und Farbskala*, https://www.dwd.de/DE/wetter/warnungen_aktuell/kriterien/warnstufen.html

Wind, H. G., et al. “Analysis of Flood Damages from the 1993 and 1995 Meuse Floods.” *Water Resources Research*, vol. 35, no. 11, 1999, pp. 3459–3465., https://doi.org/10.1029/1999wr900192