Active precipitation zone with many showers and thunderstorms in the end of the summer

Case Study

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Summary

1 Abstract

An active precipitation zone associated with frontal activity around a low-pressure system moving north of Belgium is analyzed by using weather radar and H SAF precipitation products. The main characteristic of the precipitation event was a large number of intense showers that affected the country on September 8 and 9, 2022.

2 Summary

Date & Time	*8 September 2022 00:00 UTC – 9 September 2022 23:00 UTC*
Region	Belgium
HSAF Products	*H64 (**Precipitation/Soil Moisture integrated product**, accumulated rainfall), H68 (**Gridded MW instantaneous precipitation rate based on intercalibrated PMW instantaneous precipitation rate estimates on extended H SAF area**)*
Satellites	*SM2RAIN algorithm and constellation of Passive Microwave satellites*
Instruments	*SSMIS, AMSR-2, GMI, ATMS, AMSU/MHS*
Channels/Products	*SSM ASCAT-A/B/C-NRT-O12.5 (H101, H16 and H104) soil moisture products; instantaneous rain rate estimates from P-IN-SSMIS (H01), P-IN-MHS (H02B), P-IN-ATMS (H18), H-AUX-17, H-AUX-20, combined and inter-calibrated.*
Latitude/Longitude	*49.9° ± 1.5° N, 5.5° ± 1.5° E*

A low-pressure system in the British Isles is accompanied by occluded fronts. The system formed in the Atlantic Ocean and started moving towards the North Sea. Its dynamics was affected by the highly unpredictable atmospheric conditions related to hurricane Danielle, which transformed to tropical storm while moving to northern latitudes in the Atlantic Ocean. As a result, there was a strong transfer of warm air masses to Western Europe.

The fronts also were combined with atmospheric instabilities and were at the origin of many intense showers across the country for many hours in September 8 and 9, 2022.

3 Description

In Fig. 1 the synoptic situation in September 8 and 9, 2022, is shown.

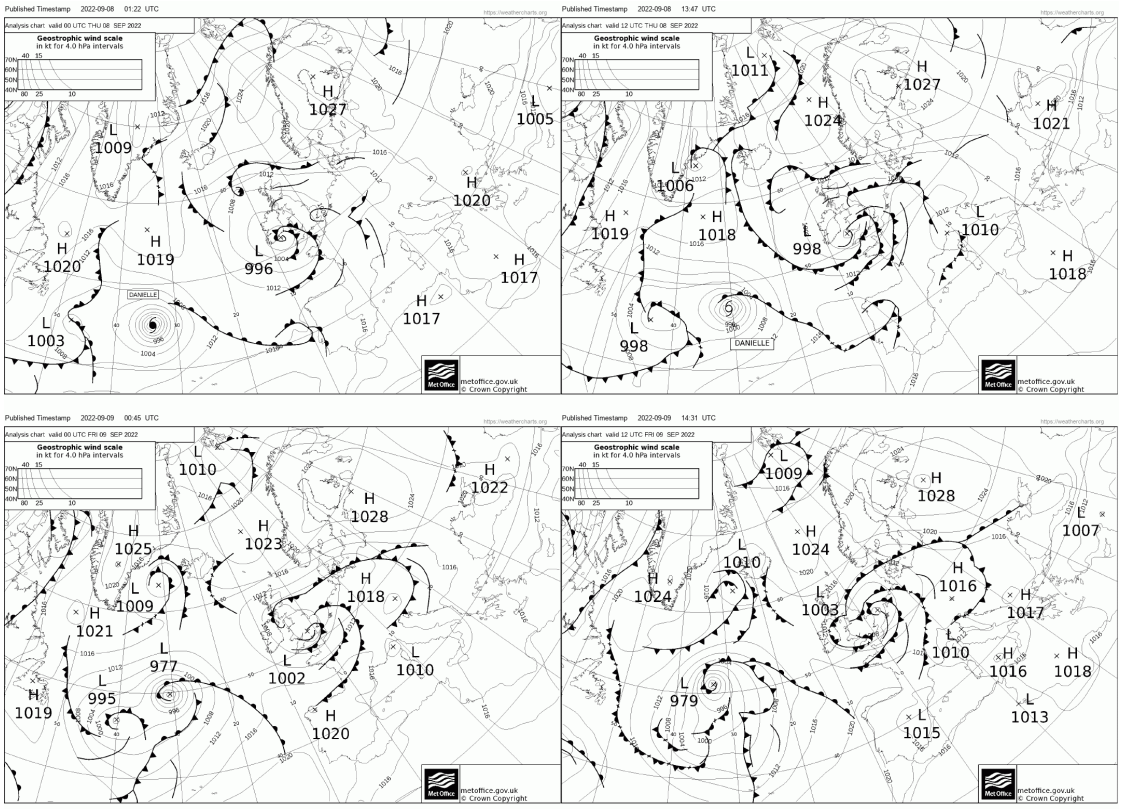

Figure 1. Analysis charts valid for 00:00 and 12:00 UTC. Top: September 8, bottom: September 9, 2022 (Contains public sector information under the Open Government License v3.0).

Several fronts, mainly occluded, are accompanying the low-pressure system over the British Isles and develop over Northwestern Europe. Benelux and France, being in the southern part of the system received convective precipitation in the form of intense showers and thunderstorms.

The approaching hurricane Danielle, which already downgraded to tropical storm, created difficult forecast conditions for numerical weather models due to intense energy exchanges resulting from the transfer of very warm and humid air masses. The result of this atmospheric circulation was the locally intense convective phenomena mentioned previously.

In order to analyze this precipitation event, three sources of data have been used, the H SAF products H64 and H68, and data from the RMI radar located at Wideumont in the Ardennes (Walloon Region).

The Level 3 Product H68 is on a regular grid with spatial resolution of 0.25° x 0.25° and provides an instantaneous precipitation rate based on passive microwave (PMW) intercalibrated estimates, every 30 minutes for available radiometers in a so-called extended H SAF area, including Europe and Africa.

The product H64 provides gridded daily precipitation by merging soil moisture-derived rainfall with Passive Microwave rainfall estimates at spatial resolution of 0.25° x 0.25°. For more information, see Section 4 (Related content).

The Wideumont radar is a C-band radar at 592 m above sea level with Doppler capability used to filter ground echoes. There is one reflectivity scan every 5 min, the radial resolution is 500 m and the azimuthal resolution is 1°.

The radar data are upscaled to the grid of the two products for more direct comparison. The upscaling is carried out using the Unique Common Code (UCC). This is a set of scripts and programs, developed by the H SAF Product Validation Group, used in order to validate a series of precipitation products in a uniform way across all H SAF participating partners (Petracca et al: *Comparison between H18 and 2A-DPR precipitation products over MSG full disk area according to the H-SAF validation methodology.* Poster presentation, EGU General Assembly, 7-12 April 2019, Vienna, Austria). In the following figures, the center of the circular domain is at the location of the radar.

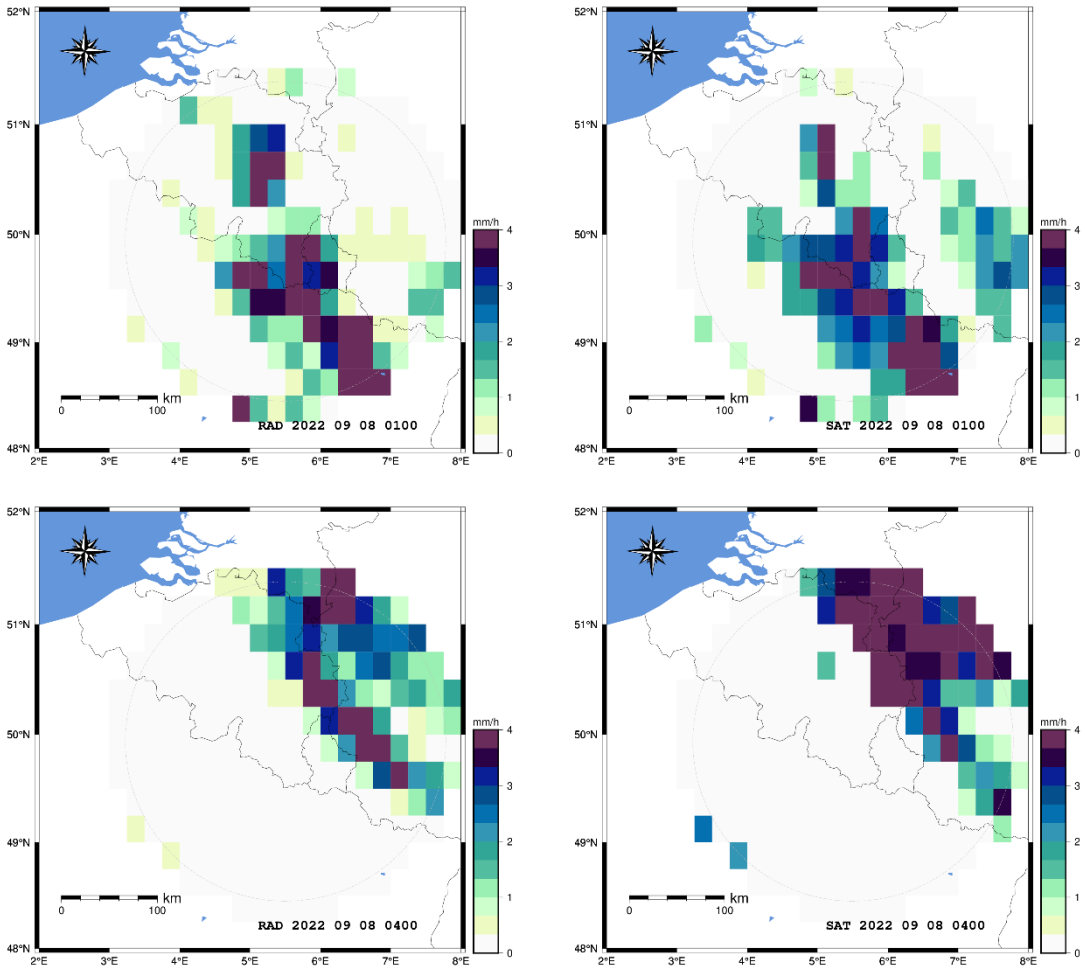

Figure 2. Rain rate from upscaled radar (left) and H SAF product H68 (right), during the night (top: 01:00 UTC, bottom: 04:00 UTC), September 8, 2022.

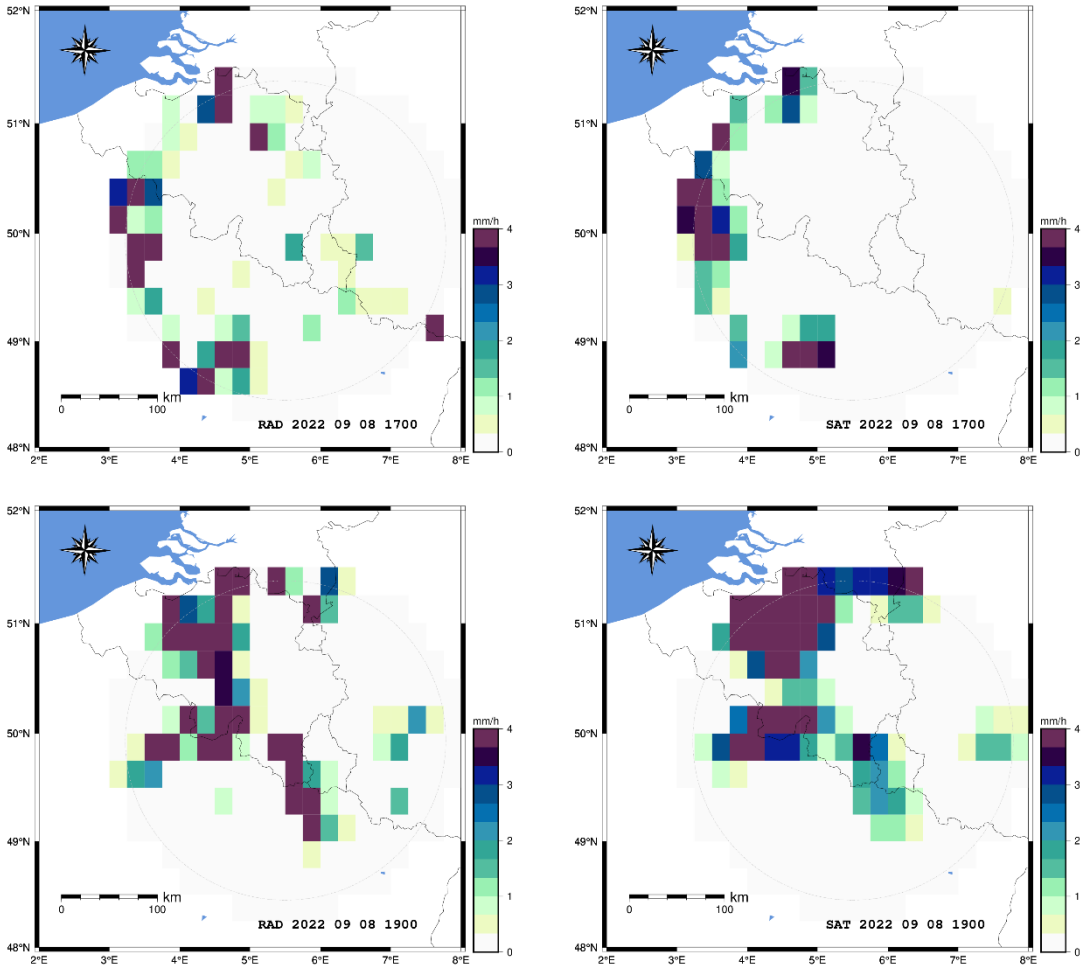

Figure 3. Rain rate from upscaled radar (left) and H SAF product H68 (right), during the day (top: 17:00 UTC, bottom: 19:00 UTC), September 8, 2022.

In both cases (groups of night and day images), visual inspection reveals a fairly good agreement between the radar observations and the H68. The picture is completed with the H64 product, which provides the accumulated precipitation over 24 hours.

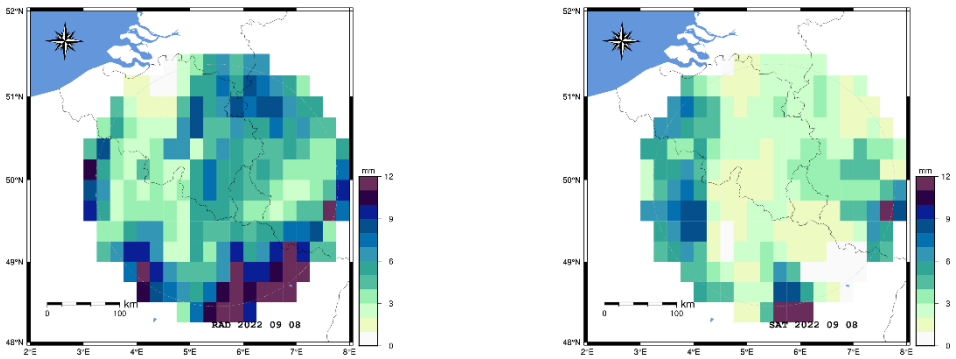

Figure 4. 24-hour accumulated precipitation from upscaled radar (left) and H SAF product H64 (right), September 8, 2022.

The product H64 represents fairly well the event with some exceptions. For example, on September 8 and in the southeastern part of the domain, it shows low precipitation totals in contrast with the radar image, although some grid cells are in accordance.

The situation on September 9 is depicted in the following figures.

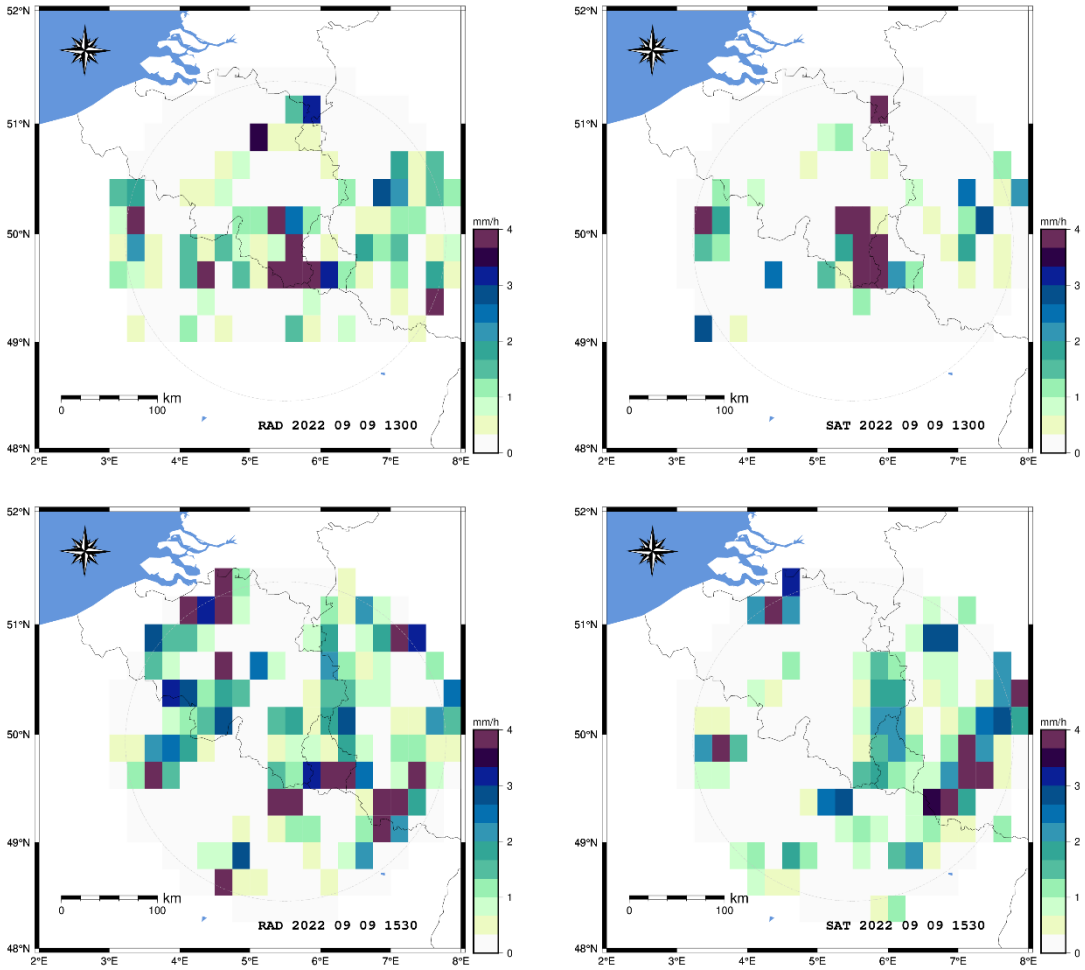

Figure 5. Rain rate from upscaled radar (left) and H SAF product H68 (right); top: 13:00 UTC, bottom: 15:30 UTC, September 9, 2022.

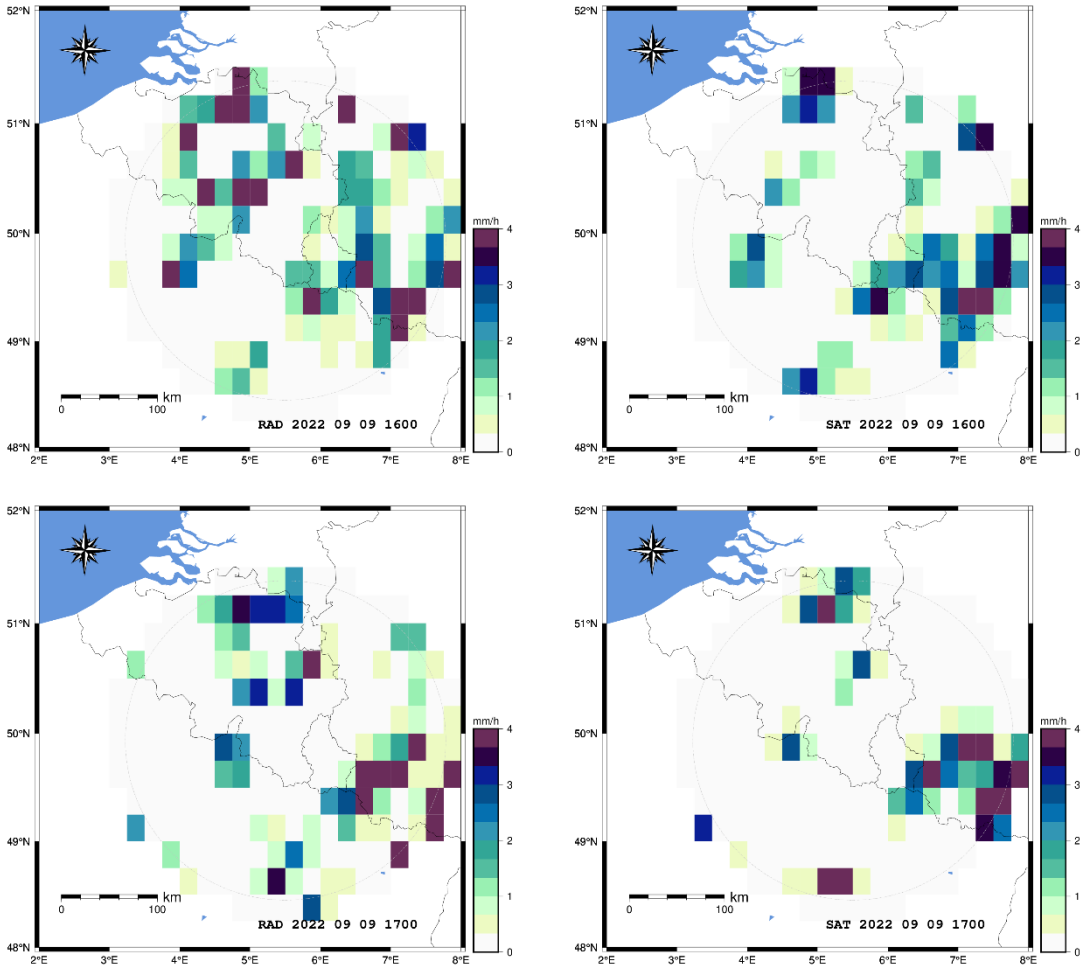

Figure 6. Rain rate from upscaled radar (left) and H SAF product H68 (right); top: 16:00 UTC, bottom: 17:00 UTC, September 9, 2022.

In the examples shown in Figs. 5 and 6 there is a good agreement between radar and H68 images, underlying the potential of this product. For the same day, the comparison between H64 and radar is depicted in Fig. 7.

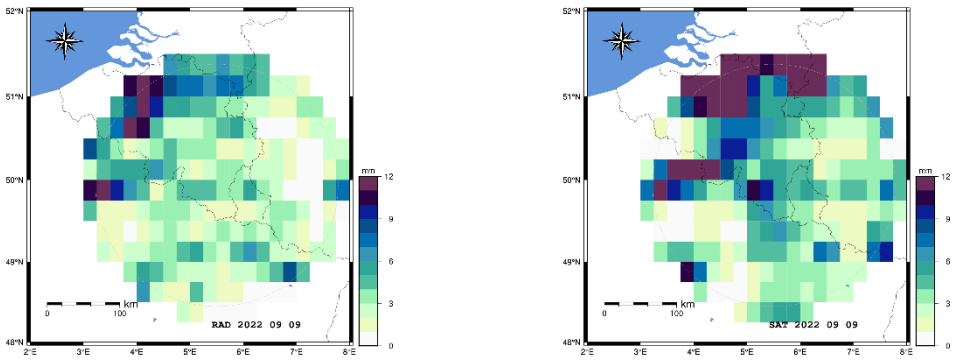

Figure 7. 24-hour accumulated precipitation from upscaled radar (left) and H SAF product H64 (right), September 9, 2022.

The product H64 is visually more coherent with the radar image on September 9 than on September 8, although it shows a larger area with higher accumulation values.

Some quantitative aspects of this comparison are presented in the following tables. In particular, it was computed for the radar and the product H68: (1) the percentages of grid cells inside the radar range with precipitation rate equal to or greater than 1.0 mm/h (P1Rad, P1Sat), 2.0 mm/h (P2Rad, P2Sat) and 5.0 mm/h (P5Rad, P5Sat); and (2) the maximum precipitation rate (mm/h) inside the radar range provided by the radar and satellite product data (MaxRad, MaxSat). Also, the Mean Error (ME) and Root Mean Square Error (RMSE) in the same rain rate units are calculated. Similar calculations are performed for the accumulated precipitation as well (in daily mm [mm/d]).

Product	Time	P1Rad	P2Rad	P5Rad	P1Sat	P2Sat	P5Sat
H68	01:00	27.4	15.2	5.9	38.2	23.1	3.9
H68	04:00	27.0	16.2	2.4	27.4	22.5	2.9
H68	17:00	14.2	8.3	4.4	13.7	7.3	2.9
H68	19:00	22.0	15.2	7.3	27.0	19.1	6.8

Product	Time	MaxRad [mm/h]	MaxSat [mm/h]	ME [mm/h]	RMSE [mm/h]
H68	01:00	12.4	8.3	0.04	1.10
H68	04:00	7.8	7.5	0.25	1.29
H68	17:00	24.7	12.7	-0.32	2.59
H68	19:00	21.1	9.3	-0.04	2.25

Table 1. Precipitation distribution and statistical scores for H SAF product H68, September 8, 2022.

Product	Time	P1Rad	P2Rad	P5Rad	P1Sat	P2Sat	P5Sat
H68	13:00	24.0	8.8	1.7	15.2	8.2	2.3
H68	15:30	32.3	16.7	2.9	24.5	12.7	1.0
H68	16:00	28.4	15.2	4.4	24.5	14.7	0.5
H68	17:00	20.6	12.7	1.9	14.7	10.3	1.0

Product	Time	MaxRad [mm/h]	MaxSat [mm/h]	ME [mm/h]	RMSE [mm/h]
H68	13:00	6.8	8.2	-0.21	1.11
H68	15:30	10.5	5.3	-0.41	1.74
H68	16:00	11.8	5.0	-0.39	1.51
H68	17:00	9.0	8.4	-0.25	1.19

Table 2. Precipitation distribution and statistical scores for H SAF product H68, September 9, 2022.

Product	Day	P1Rad	P2Rad	P5Rad	P1Sat	P2Sat	P5Sat
H64	September 8, 2022	98.5	96.1	53.9	94.1	70.6	20.1
H64	September 9, 2022	89.2	72.5	20.6	91.7	78.4	37.7

Product	Day	MaxRad [mm/d]	MaxSat [mm/d]	ME [mm/d]	RMSE [mm/d]
H64	September 8, 2022	13.9	16.3	-2.23	4.07
H64	September 9, 2022	12.6	29.3	1.82	4.46

Table 3. Precipitation distribution and statistical scores for H SAF product H64, September 8 and 9, 2022.

4 Related content

Title	URL	Source
H SAF product H64	https://hsaf.meteoam.it/Products/Detail?prod=H64	H SAF
H SAF product H68	https://hsaf.meteoam.it/Products/Detail?prod=H68	H SAF
Mesoscale Convective System over central Italy	https://www.eumetsat.int/mesoscale-convective-system-msc-over-central-italy	EUMETSAT, H SAF

5 Conclusions

The zone of intense precipitation that affected Belgium in the beginning of September 2022 was the object of the present study. This zone stands out for the occluded fronts around a low-pressure system, combined with strong transfer of warm and humid air from the Atlantic Ocean to Western Europe as the tropical storm resulting from the downgrade of hurricane Danielle moved to northern latitudes.

This analysis was focused on September 8 and 9 and was carried out using data from the RMI radar in Wideumont (in the Ardennes range) and two H SAF precipitation products, H64 (accumulated precipitation over 24 hours) and H68 (instantaneous rain rate). It turned out that the two products provide a fairly good representation of the precipitation event with small errors. The actual precipitation distribution is also well captured by the products.

6 Related tools

Type	URL	Source
Software (UCC_2.0)		H SAF Precipitation Product Validation Group (PPVG)
Software (GMT)	https://www.generic-mapping-tools.org/	Open source, with support from the School of Ocean and Earth Science and Technology of the University of Hawai'i at Mānoa