# WWRP Warning Value Chain Project

## Warning Chain Database questionnaire

### I. Purpose

Please use this form to record as much information as possible on the end-to-end warning chain for a hazardous weather event. This information will:

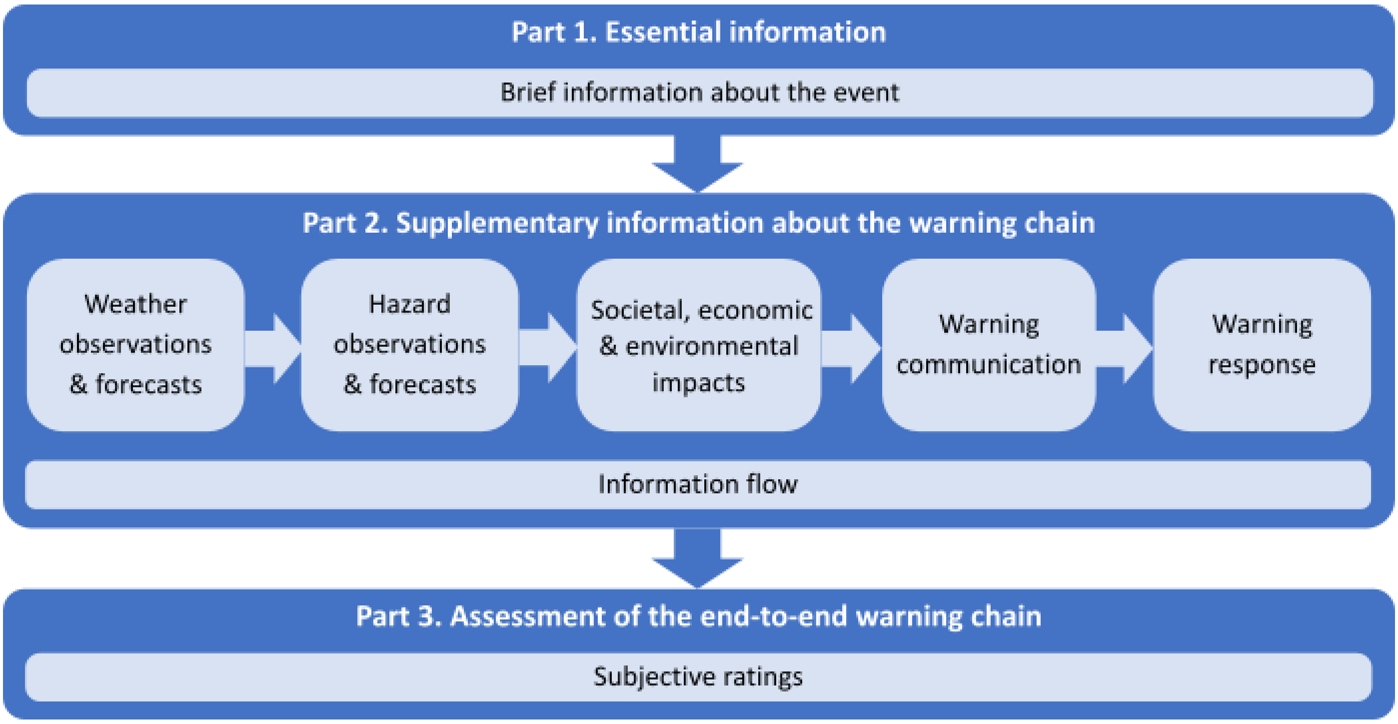
- add to a global database of hazardous weather events with rich information covering the many components of the warning value chain
- enable case studies and cross-cutting analysis of end-to-end warning value chains, from simple to complex, to understand effective practices.

The warning value chain database tries not to duplicate data collected in databases for other purposes. This template provides for a comprehensive picture of the information flow, decision making and response during a high impact weather event.

More information about the WWRP Warning Value Chain Project can be found at http://hiweather.net/Lists/130.html.

### II. Structure and format

The form consists of three main parts.




Part 1. The **essential information table** requests brief facts about a particular event, such as what happened, when, where, impacts and responses. This information will help users to filter events. Please provide numerical and short text entries. Links to other databases and catalogues (e.g., ECMWF Severe Event Catalogue, EM-DAT, DesInventar, etc.) about this event should be provided.

Part 2. The second part requests **supplementary information** about different stages in the warning value chain. This more detailed information and analysis about the weather, the hazards, the impacts, the

warning communication and warning response will help users understand what was unique about the warning chain for this event. The guidelines are just suggestions, they are not exhaustive.
Information here might include:

- Graphics (for example, forecast charts, reanalysis maps, warning graphics, photos of impacts, etc.)
- Videos (for example, from social media, weather service outlooks, etc.)
- Free-form text (for example, description of meteorology, selected extracts from reports, data analysis, tables, etc.)
- Links (e.g., to other databases/catalogues, external reports, media, etc.)

Note:

⇒ Part 2 is optional, provide what you feel able to.

⇒ Each section has an "additional analysis" where you can add further information not covered by the items in the template.

⇒ Try to keep your entries brief and include references and links (URLs) to where additional information can be found.

⇒ Many people may contribute information on this event. Where you disagree try to provide evidence to support your position.

⇒ You can acknowledge contributors that provided you with information for the template at the end of the template before Annex 1. This is optional.

Part 3. The subjective assessment asks contributors to rate the effectiveness of the individual elements of the end-to-end warning chain, and its overall effectiveness, on a scale of 1 (poor) to 5 (excellent). This may assist users of the database in choosing cases and performing meta-analysis (recognising the large variability in contributor' judgments).

## III. Tips

- Detailed instructions, explanations and examples about the data asked for are provided in the dedicated Guidance document (link to document on VC webpage).
- The Value Chain Glossary provides a common terminology. Use the names of hazard types listed in *Annex 1* of the template or this guide.
- A series of prompts (i) in this template provide some quick information to assist with entering the required data. Simply put your cursor over the information symbol i and text should pop up next to it (ignore the “Ctrl+click to follow link” instruction). *Note, that this feature is only available in the Microsoft Word App, not in the SharePoint or Google Drive browser page.* Consult the Guidance document instead if this feature does not work for you.
- It is not anticipated that a single person can fill in the entire template. Rather, we encourage to share the template with colleagues who can provide information.
- See HERE for a worked example of the template.

# Part 1. Essential information

| | |
|---|---|
| Editors (Name & Institute) | *Brian Golding, Met Office, UK；Qinghong Zhang, Peking University* |

| | |
|---|---|
| **HIGH IMPACT WEATHER EVENT** | |
| Unique identifier i | |
| Name of event | *Henan Flood* |
| When did it happen i? | 16-20 July 2021 |
| Where did it happen i? | Henan province, China, especially Zhengzhou city. |
| **WHAT HAPPENED – WEATHER, HAZARDS, IMPACTS, WARNINGS, RESPONSES** | |
| Weather event type/system that caused hazards i *Refer to Annex 1* | *Heavy rain associated with blocking anticyclone and Typhoon In-fa* |
| If possible, provide more detail about weather observations & forecasts (*link to page*) | |
| Hazards that caused the main impacts i *Refer to Annex* 1 | River Flood |
| Classify hazard in regard to the location's climatology i | *3-day rainfall close to average annual amount. Hourly and daily totals exceeded historical record of 60 years in Zhengzhou.* |
| If possible, provide more detail about hazard observations and forecasts (*link to page*) | |
| What were the main direct impacts i? | *Flooding of Zhengzhou subway; Flooding of Jingguang North Road Tunnel; Vehicles washed away in flooded streets. Hospital evacuated in Weihui. Industrial explosion in Dengfeng; Rural areas cut off; 815,000 evacuated.* |
| Economic damage in USD i | *6.4bn insurance claims in Zhengzhou,* |
| Fatalities | *398 died,* |
| If possible, provide more detail about impact observations and forecast (*link to page)* | |
| Main warnings issued i | Red alarm |
| Who issued the warnings? i | Zhenghou Flood Observatory. |
| If possible, provide more detail about the warnings and communication (*link to page*) | |
| Main responses to warnings i | *Subway was not suspended until after it was flooded.*<br>*Evacuations were ordered for dams at risk of breach.* |
| If possible, provide more detail about responses to warnings (*link to page*) | |
| Links to other databases *(ECMWF catalogue of severe events, WMO CHE, DesInventar, EM-DAT, GLIDE, etc.)* | |

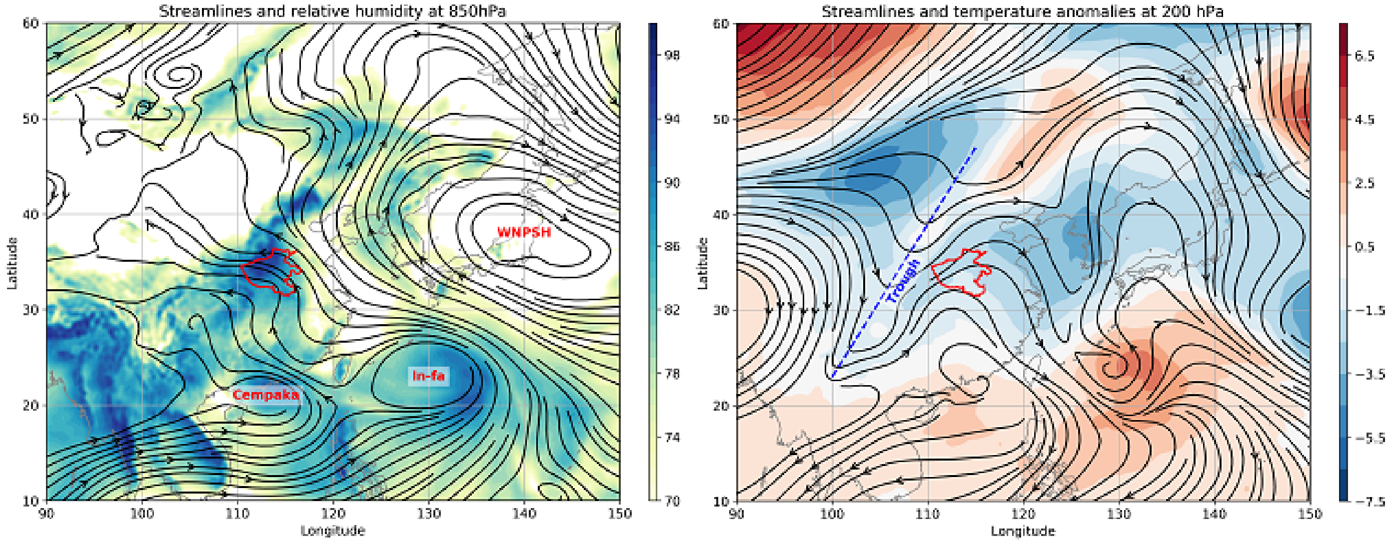
# Part 2a. Supplementary information about weather

Wherever possible, please include references to information you provide!

Editors (Name & Institute):

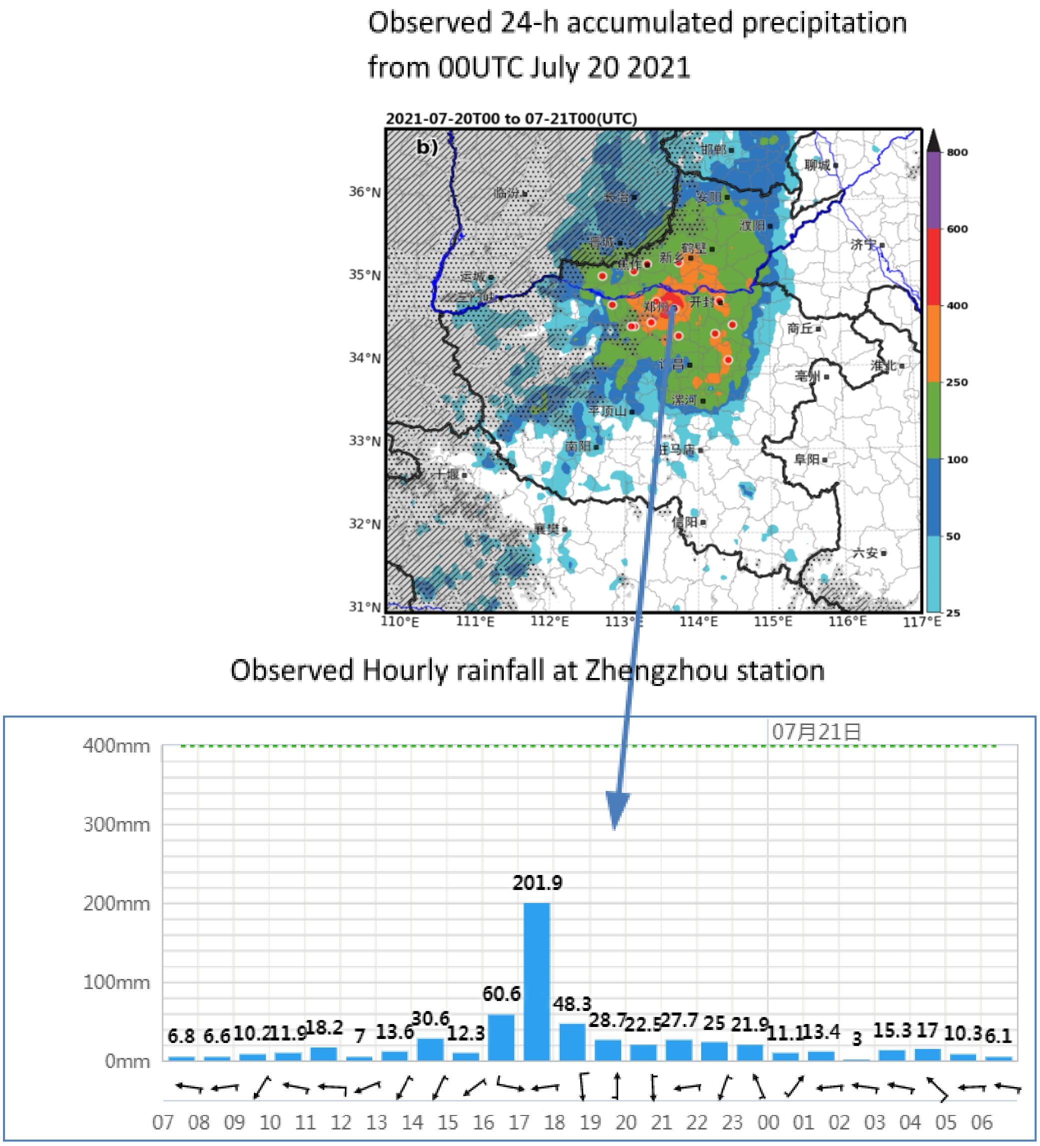
**Meteorological overview** i

The WNPSH was situated unusually far north in mid-July 2021. It was centered in Japan with its western edge over the East China Sea, leading to a southeasterly flow over northern China. A large amount of moisture was supplied inland with enhancement from Tropical Cyclone Cempaka in the South China Sea and In-fa from the southeast of Okinawa. When this moist air stream entered Henan, it was forced to rise due to the Taihang Mountains to the northwest of the province, generating orographic precipitation around Zhengzhou. These weather systems moved slowly, resulting in rainy weather which lasted for 6 days. At the same time, an upper-level disturbance to the west of Henan developed on July 19, further enhancing convective activity in Henan. The combined effect of the WNPSH and the upper-level trough triggered heavy precipitation on July 20.




a)Mean near-surface (850 hPa) air flow and relative humidity between July 17 and July 20 (left)
b)Mean upper-level (200 hPa) air flow and temperature anomalies between July 19 and July 20 (right)
*Source: ERA5/Guy Carpenter.*

**Weather observations and analyses** ℹ




Figures from Zudong Liang, CMA

**How did the observed weather relate to climatology and/or previous extreme events?** ℹ 3-day rainfall close to average annual amount. Hourly and daily totals exceeded historical record of 60 years in Zhengzhou. Hourly total is comparable to world extrema observed in tropical cyclones, e.g. in Japan (Takara, 2004).

**Special/non-traditional observational data used in the weather forecast or assimilated into NWP** ℹ

**Weather models**

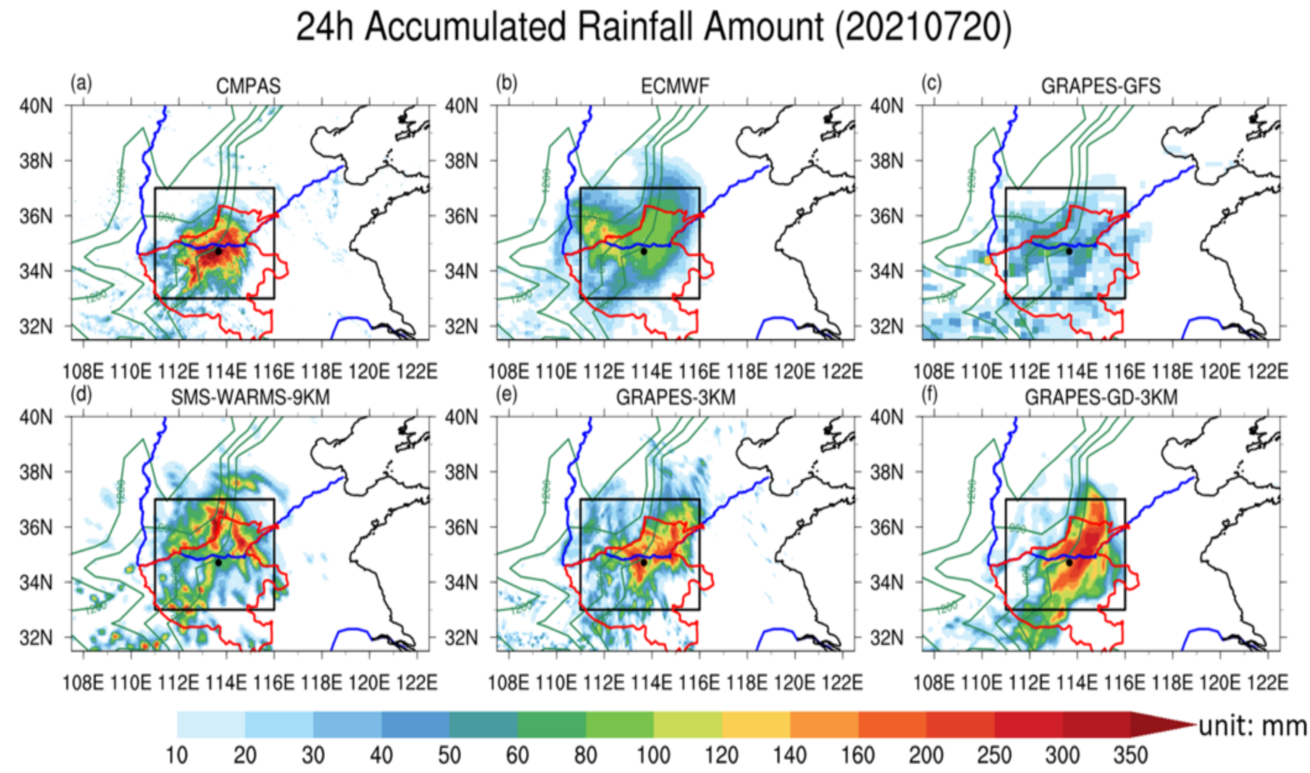
(Info on operational NWP systems: http://wgne.meteoinfo.ru/nwp-systems-wgne-table/wgne-table/)

| **Name** | **Horizontal resolution** | **Ensemble size** | **Forecast length** |
|---|---|---|---|
| EC deterministic | | | |
| GRAPES-3km | | | |
| | | | |

| | | | |
|---|---|---|---|

**Post-processing/calibration applied to weather model output** i

**Deterministic weather forecast outputs and examples** i




Observation (CMPAS) and mode forecasts of 24 h accumulated precipitation in 20 July. Model initial time is 12UTC 19 July, valid time 12 – 35 h. GRAPES is the CMA model. SMS-WARMS is the Shanghai Met Centre model. (Source Zudong Liang, CMA)

**Ensemble/probabilistic weather forecast outputs and examples** i

**Interpretation/guidance for forecast users** i

**What was the level of agreement between the different forecasts?** i

**How reliable and accurate were weather forecasts?** i

**When was the potential event first detected in the models?** i

**Additional analysis** i

**Successes/issues/challenges experienced?** i

## Part 2b. Supplementary information about hazards

Wherever possible, please include references to information you provide!

Editors (Name & Institute):

**Brief overview of the hazard event(s)** i A severe rainstorm hit Henan, China between July 17 and July 22. During the period, the central and northern parts of the province had more than 400 mm of rainfall, exceeding 1000 mm in some areas. 32 national weather stations in the province had their highest daily rainfall exceeding 500 mm, and 20 of them (a sixth of Henan stations) broke the stations' records. Ten stations had recorded more than a year's precipitation in just 6 days. The heaviest rainfall occurred near Zhengzhou between July 19 and July 20. At 5pm local time July 20, the hourly rainfall record of China was broken as Zhengzhou observed 201.9 mm rainfall in an hour. The station received a total of 624.1 mm of rainfall on July 20, three times higher than the previous station record. The city received 127 percent of annual mean rainfall during the entire event. Zhengzhou is on the banks of the Yellow River, and its urban area belongs to the Huai River Basin; its buildup area has grown materially over recent years and altered the hydrological process. Further, the city is surrounded by the Taihang and Funiu Mountains which cause moist air to rise and intensify rainfall. The extreme rainfall during July 19 -20 resulted in severe floods in Zhengzhou. During the period, 6,331 villages were threatened for flash floods, in which 263 villages experienced greater than 1-in-20 year rainfall, and 255 villages experienced greater than 1-in-50 year rainfall. The inundated area is estimated as 4,010 square kilometers as of July 20 by the China Institute of Water Resources and Hydropower Research (IWHR). The heavy rainfall caused several reservoirs to be in danger of breaching (Figure 4), and people in the surrounding areas had to be evacuated. The severity of this event exceeded the flood control and storm-water drainage facilities in the city including the development via 'sponge city'. (Guy Carpenter)

**Hazard observations and analyses** i From 8:00 on 19 July to 8:00 on 20 July, rainfall monitoring stations in Henan Province, including five Chinese national monitoring stations, measured Songshan (364.6 mm), Xinmi (254.9 mm),Xinzheng (196 mm), Dengfeng (192.8 mm), Yanshi (183.3 mm). Zhengzhou encountered extreme heavy rainfall from 16:00 to 17:00 on the 20th. The rainfall in one hour was as high as 201.9 mm causing serious waterlogging. 13 reservoirs in Henan Province reached the flood control limit. (Wikipedia/China Times 20-7-21)

**How did the hazard(s) relate to climatology?** i Floods are a regular occurrence in Henan, but the rainfall amount was extreme.

**How was the hazard(s) made worse by pre-existing conditions?** i The most severe day of rainfall, July 20$^{th}$ was the fourth day of heavy rainfall, so the ability to absorb water, even given the "sponge city" design, had all been taken up.

**Observational data used in the hazard forecast or assimilated into the hazard model** i

**Hazard prediction models/tools** i

| Name | Resolution | Ensemble size | Forecast length |
|---|---|---|---|
| No evidence of flood models being used in warning preparation. | | | |
| Warnings of dam failures probably based on threshold levels. | | | |

| | | | |
|---|---|---|---|
| | | | |

**Deterministic hazard forecast outputs and examples** i

**Ensemble/probabilistic hazard forecast outputs and examples** i

**How reliable and accurate were the hazard forecasts?** i

**What was the trigger used to classify the event as hazardous and start the warning process?** i Reports suggest trigger was forecast rainfall amount.

**Additional analysis** i

**Successes/issues/challenges experienced?** i

## Part 2c. Supplementary information about impacts

Wherever possible, please include references to information you provide!

Editors (Name & Institute):

**Brief overview of the impact(s)** i Major flooding in Zhengzhou, XinXiang and surrounding areas. Estimated direct economic loss was ~ RMB 88.5 billion ($14bn, £10bn)

**Observed health impacts** i
Wikipedia/China Times reported 302 deaths, 50 missing. Guy Carpenter reported the event affected over 13 million people in the Henan province. Emergency evacuation included 841,400 people, with more than one million people transferred to safety. There were 73 reported fatalities.

**Observed property and business impacts** i
Property: There were 15,500 reported collapsed structures, with 48,500 household units affected. There were also 36,500 seriously damaged structures affecting 132,100 household units, and an additional 111,600 structures moderately damaged with 314,200 household units impacted. The overflow of the East Wind Canal caused heavy damage at the Zhengdong Flower Market near the East Fourth Ring Road. Eight hundred wholesalers were impacted at the site, damaging expensive tea, paintings, flowers, plants and children's play areas. Across the canal, the Muzhuang wet market was inundated and 100 people were trapped on the second floor for two nights and the site lost RMB 30,000,000 worth of goods.
Industrial: Flood water got into contact with calcium carbide and caused a large explosion in Wugangshi on July 21, with three burn victims. Eight people were sent to hospitals for observation. A factory wall collapsed in Zhenquhecun, and water reacted with high temperature metals resulting in explosions in an aluminum factory. No injury was reported, as people were evacuated earlier due to the wall collapse.
According to insurance reports, over 400,000 cars in Zhengzhou were damaged by the floods, resulting in over RMB 6.4 billion in insurance claims.

**Observed critical infrastructure damage and service disruption** i
Transportation: Line 5 of the subway train with about 500 passengers was submerged between Shakoulu and Haitanshi station, resulting in 14 deaths. The Jingguang Tunnel was completely flooded with many cars trapped inside.
Utilities: Many submerged areas lost utilities, including access to electricity, water, gas, and internet.
Health Services: One of the country's largest hospitals, Zhengzhou University No.1 Affiliated Hospital, was heavily flooded and lost electricity, necessitating transfer of patients to upper floors and other hospitals. The hospital suffered significant loss of medical equipment in the basement and ground floor.

**Environmental damage observed** i
Agricultural losses:
Loss of yield >70%: 148,100 hectares
Loss of yield >30%: 457,400 hectares
Loss of yield >10%: 1,017,100 hectares

**Impact prediction models/tools** i

| Name | Method |
|---|---|
| No evidence of impact models used except for dam overflows. | |

**Impact forecast outputs and examples** i

**Comparison of predicted and actual impacts** i

**Informal rules/tools used to identify impacts** i

**Who and what were exposed to the hazards, when, for how long and why?** i

**Out of those exposed, who and what were vulnerable to the hazards and why?** i
Travellers on roads and subway.

**Additional analysis** i

**Successes/issues/challenges experienced?** i

## Part 2d. Supplementary information about warning communication

Wherever possible, please include references to information you provide!

Editors (Name & Institute):

**Brief overview of the communication “story”** i

The Zhengzhou Meteorological Observatory issued a red warning signal for rainstorms, and the Zhengzhou Flood Control and Drought Relief Headquarters upgraded the emergency response of flood control level II to level I.

On the morning of the 20 July, Kaifeng issued a red rainstorm warning, which was changed to an orange rainstorm warning on the afternoon of 20 July

**What information was provided to emergency responders, government and other stakeholders about the hazard and its possible impact, and by whom?** i

**Public warnings in detail** i

| Warning name | Warning lead time | Issued by | Warning area i | Type of warning i | Did it include safety advice? | Scaled i | Channel i | Warning frequency |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

**Warning outputs and examples**

**Was uncertainty included in the warning? If so, how?** i

**Were communication systems in place and operating effectively?**

**Were warning messages received and understood by the public? How did you know?**

“I later learned that the Henan Meteorological Department had issued the red alarm prior to the disaster, but no one can access it from the internet, or they didn’t pay attention, because there are a lot of alarms classified as spams,” a Zhengzhou resident told the Guardian.

**Were the needs of specific communities and populations addressed? If so, how?**

**Additional analysis** i

**Communication success/issues/challenges experienced** i

## Part 2e. Supplementary information about responses to warnings

Wherever possible, please include references to information you provide!

Editors (Name & Institute):

**Brief overview of the response to the hazard by emergency services and other partners** i

Zheng, a safety worker at Zhengzhou metro said they tried to keep the trains running so people could get home but were overwhelmed by the Tuesday afternoon downpour. “This is the first time in my life I have witnessed water flooding into the metro station” he said. (Southern Weekly)

From July 17 -22, many tributaries in the Hai River system exceeded their warning thresholds. In order to manage the heavy rainfall, people in seven detention basins in Henan and three in Hebei were evacuated in anticipation of excess water flow from upstream. The total number of people evacuated exceeds 230,000, and one billion cubic meters of water flowed to these basins, to lower the stress upstream in the southwest and downstream to the northeast. The detention basins are part of the national flood defence network and they mitigate flood damages from extreme events. (Guy Carpenter)

**What were the main response actions by the public to the warnings?** i

“I later learned that the Henan Meteorological Department had issued the red alarm prior to the disaster, but no one can access it from the internet, or they didn’t pay attention, because there are a lot of alarms classified as spams,” a Zhengzhou resident told the Guardian. “The alarms should be sent to the government at all levels and then to individuals. If individuals received alarms from authorities they would have paid serious attention. But I think many authorities didn’t see the alarm,” she said. (Guardian)

**Institutional responses** i

| Response actions | Taken by whom | When taken | On the basis of what information? | Benefit (if any) | Cost |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |

**How did the overall response to this event compare to similar previous events?** i

**How knowledgeable was the community about the hazard?**

**Were disaster preparedness and response plans in place and used?**

**What capacity did the community have to respond to warnings?**

**Additional analysis** i

Zengzhou has made a big thing of Sponge City, which has successfully reduced the incidence of “normal” flooding. However, has it also made officials and public think that the risk from flooding has gone?

**Success/issues/challenges experienced** i

# Part 2f. Analysis of the warning chain

### Information flow through the warning chain

| **Warning chain** | **Was all necessary input information available? (yes/no)** | **If no, what input information was missing?** | **Who should have provided the missing information?** |
|---|---|---|---|
| Weather forecast | | | |
| Hazard forecast | | | |
| Impacts forecast | | | |
| Warning communication | | | |
| Warning response | | | |

**Tools and operational workflows for sharing information between partners**

**How were social media data used in the warning chain?** i

**Evidence that warning chain was effective in reducing fatalities, injuries, damage, and/or disruption?**

**What were the strongest links in the warning chain?** i

**What were the weakest links in the warning chain?** i

**What procedures were used to identify lessons learned from the event?** i

**If known, how did lessons learnt from previous events contribute to greater warning success for this event?**

**Additional analysis**

## Part 3. Assessment of the end-to-end warning chain

Assessor (Name & Institute) (optional):
Profession:
Please rate your level of expertise on a scale of 1 (no expertise) to 5 (established expert) for:

Weather:

Hazard:

Impact:

Warning/communication:

Response:

High-impact weather event evaluation:

**HOW SUCCESSFUL WERE THE FORECASTS, WARNINGS AND RESPONSES?**

**How well was the event observed?** *Scale of 1 (poor) to 5 (excellent)*
**Reason for this rating** i

**How well was the weather forecast?** *Scale of 1 (poor) to 5 (excellent)*
**Reason for this rating** i

**How well were the hazards forecast?** *Scale of 1 (poor) to 5 (excellent)*
**Reason for this rating** i

**How well were the impacts predicted?** *Scale of 1 (poor) to 5 (excellent)*
**Reason for this rating** i

**How well were warnings communicated?** *Scale of 1 (poor) to 5 (excellent)*
**Reason for this rating** i

**How well were the warnings used?** *Scale of 1 (poor) to 5 (excellent)*
**Reason for this rating** i

**How well did the entire warning chain perform overall?** *Scale of 1 (poor) to 5 (excellent)*

**Thank you very much for contributing to the WWRP Warning Value Chain Project database!**

## Acknowledgements (e.g., information providers) i

## Annex 1: *Weather system and hazard types based on pre-defined hazards in the Sendai Framework Monitor*

### a) Weather system types

- Blizzard
- High pressure system
- Convective storm
- Cyclone surge
- Cyclonic rain
- Cyclonic wind
- Derecho
- Extra-tropical storm
- Extreme temperature
- Fog
- Rain
- Snow
- Tornado
- Tropical cyclone

### b) Hazard types

- Coastal erosion
- Coastal flood
- Cold wave
- Dust
- Fire
- Flash flood
- Flood
- Fog
- Freak waves
- Freeze
- Frost
- Hail
- Heat wave
- Ice
- Lightning
- Riverine flood
- Snow
- wind
- Wave action
- Wildfire

<table>
<tr><th colspan="2">Weather (system) types</th><th colspan="4">Hazard types</th></tr>
<tr><td>Type</td><td>Sub-type</td><td>Type</td><td>Sub-type I</td><td colspan="2">Sub-type II</td></tr>
<tr><td colspan="2" rowspan="3">Tropical storm/cyclone</td><td>Rain</td><td>Flood</td><td colspan="2">Riverine flood, coastal flood, flash flood</td></tr>
<tr><td rowspan="2">Wind</td><td>Wave action/ storm surge/ freak waves</td><td colspan="2">Coastal erosion</td></tr>
<tr><td colspan="2">Dust</td><td rowspan="2">Dust</td></tr>
<tr><td rowspan="2">Convective storm</td><td>Tornado</td><td>Lightning</td><td>Fire</td><td>Urban fire, wildfire</td></tr>
<tr><td>Derecho</td><td colspan="4" rowspan="2">Hail</td></tr>
<tr><td rowspan="3">Extratropical storm</td><td>Cyclonic storm</td></tr>
<tr><td rowspan="2">Blizzard</td><td rowspan="2">Snow</td><td colspan="3">Avalanche</td></tr>
<tr><td colspan="3">Snow drift</td></tr>
</table>

| | | | |
|---|---|---|---|
| High pressure system | Extreme temperatures | Cold wave | Freeze, frost, ice |
| | | Heat wave | |
| Fog | Fog | | |