Introduction to Multi-hazard Risk-based Early Warning System in Japan

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Natural Disasters in Asia

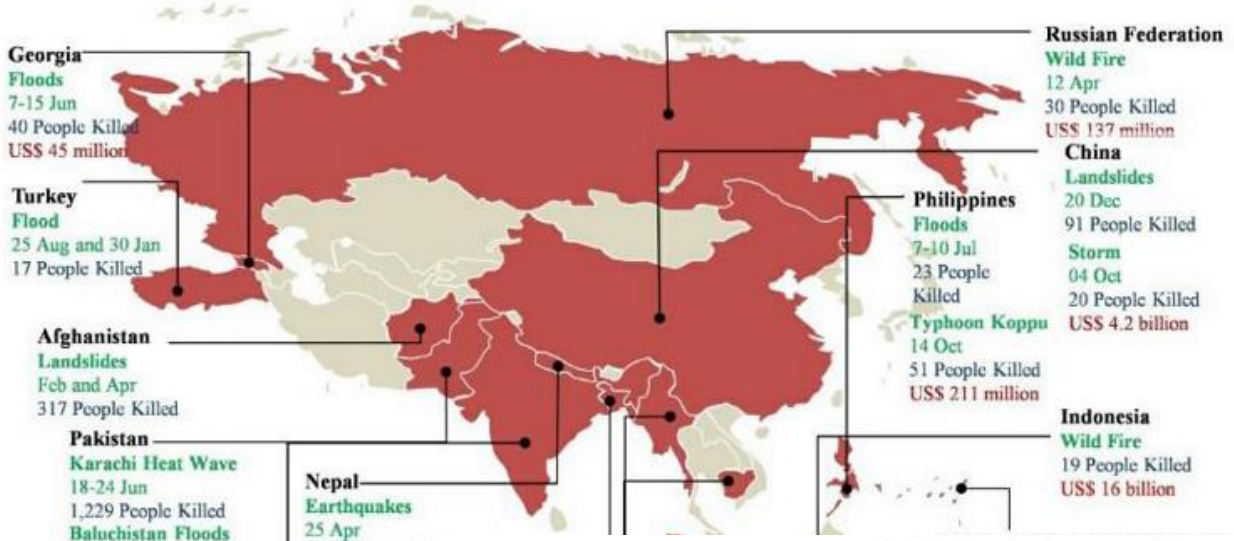


Table 1. 2015 Asia-Pacific losses by disaster type

Disaster Type	Occurrence	Deaths	Affected	Economic Damage (US$)
Flood	63	1,863	21,661,443	11.5 billion
Storm	43	446	9,135,551	11.8 billion
Earthquake	17	9,327	6,484,533	5.2 billion
Landslide	15	626	45,234	-
Extreme temperature	4	3,536	1,045,000	-
Others*	18	248	20,883,788	16.7 billion
Total	160	16,046	59,255,549	45.1 billion

Source: Disasters in Asia and the Pacific: 2015 Year in Review (UN ESCAP)

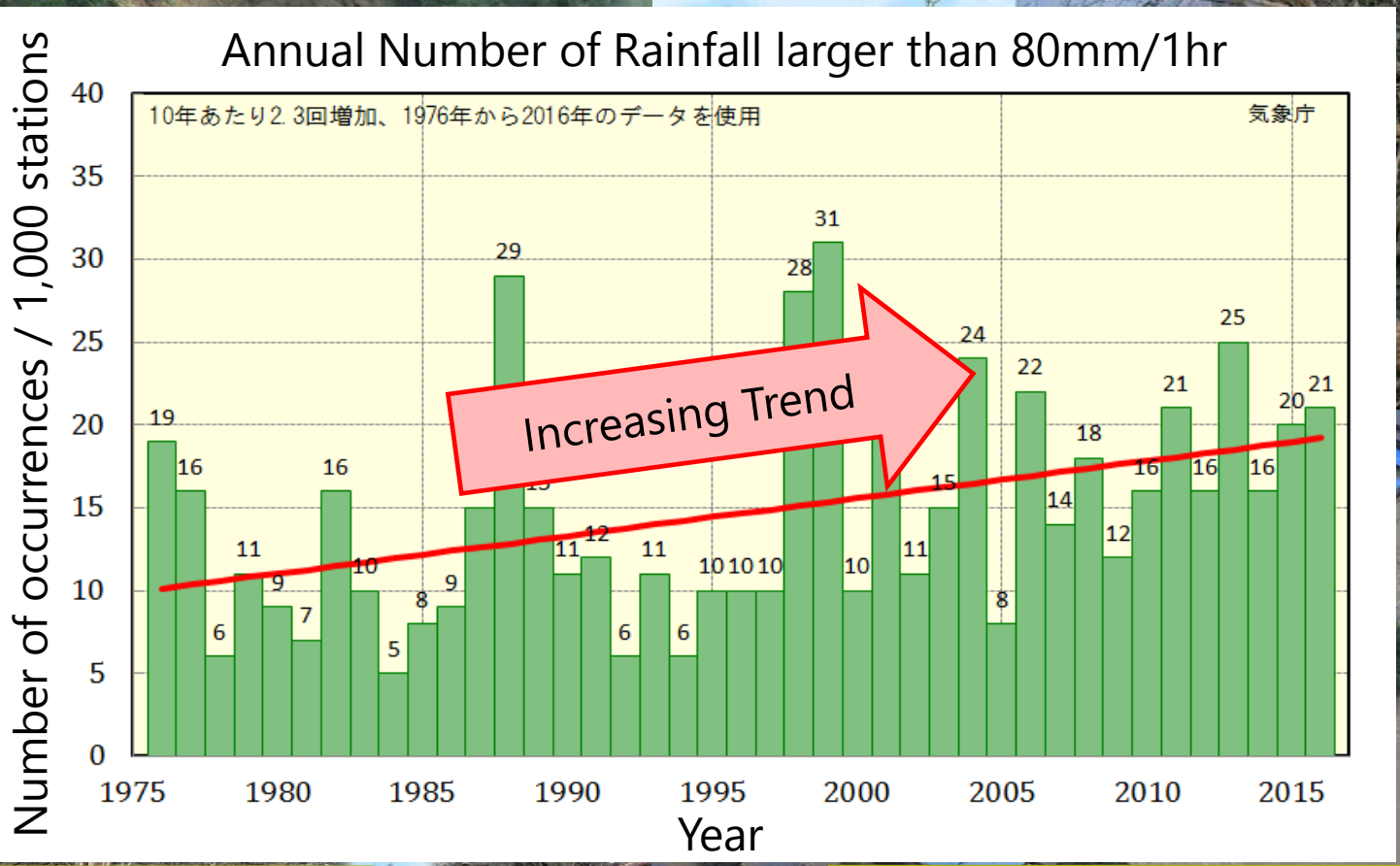
Recent Water-related Disasters in Japan

Landslide Disaster in Hiroshima in 2014

20 Aug. 2014
217.5 mm/3hr in Hiroshima City
74 People Killed

Flood Disaster by Lionrock (T1610)

30 Aug. 2016
231 mm/24hr in Kuji City, Iwate
22 People Killed, 5 People Missing



16 Oct. 2013
122.5mm/1hr, 824.0mm/24hr in Izu-Oshima
35 People Killed, 4 People Missing

Landslide Disaster by Wipha (T1326)

7-10 Sep. 2015
541.0mm/24hr in Imaichi, Tochigi
7,280/12,035 houses flooded above/below floor level

Flood Disaster by Kilo (T1517) & Etau (T1518)

Toward Effective Warning Service

Lessons learned

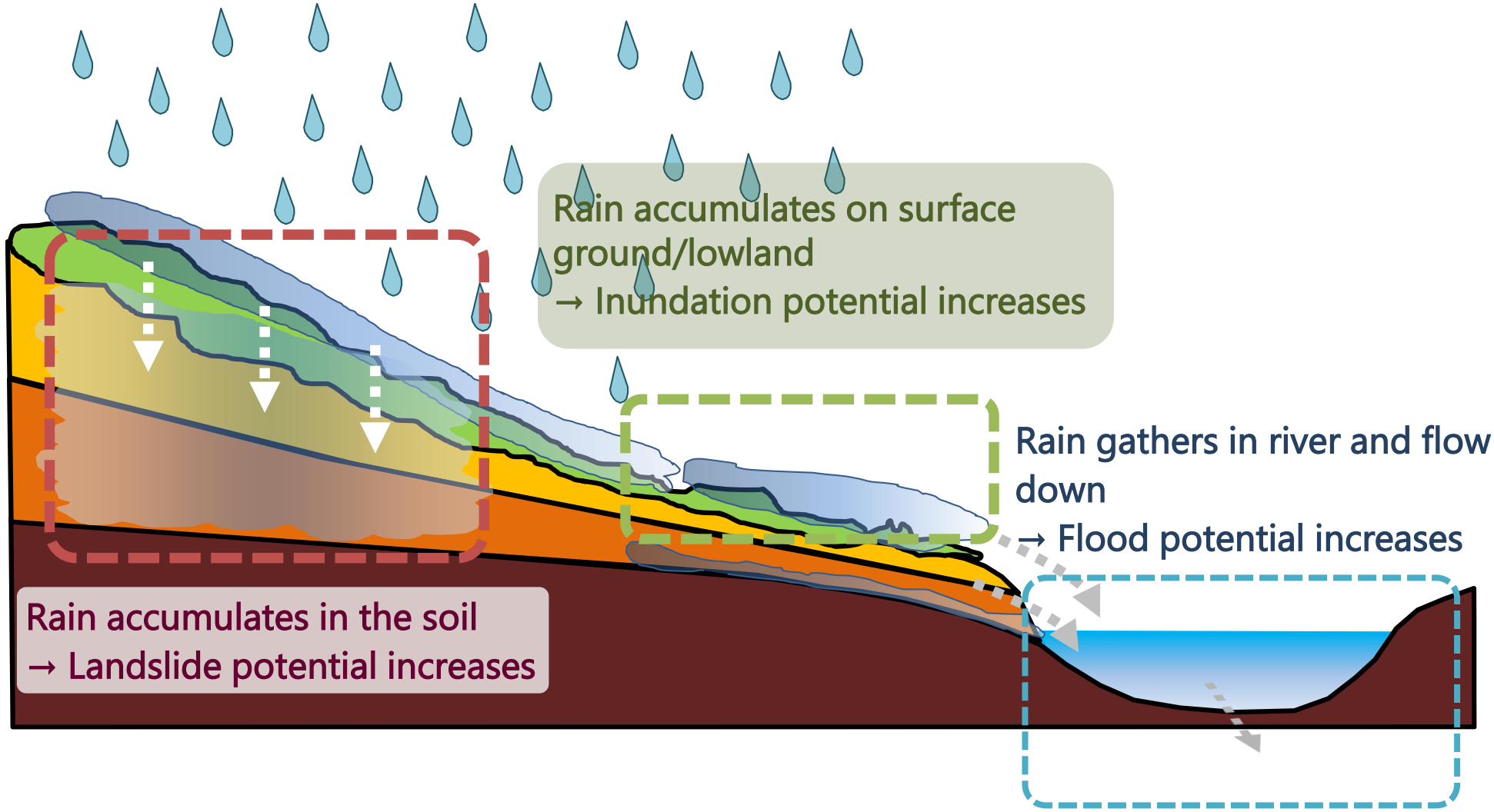
- Effective warning system should provide
  - spatially and temporally specific disaster risk information in an easy-to-understand format
  - Probabilistic information on disaster risks incl. uncertainty with a few days lead time.
- Needs for support for emergency managers

Approach

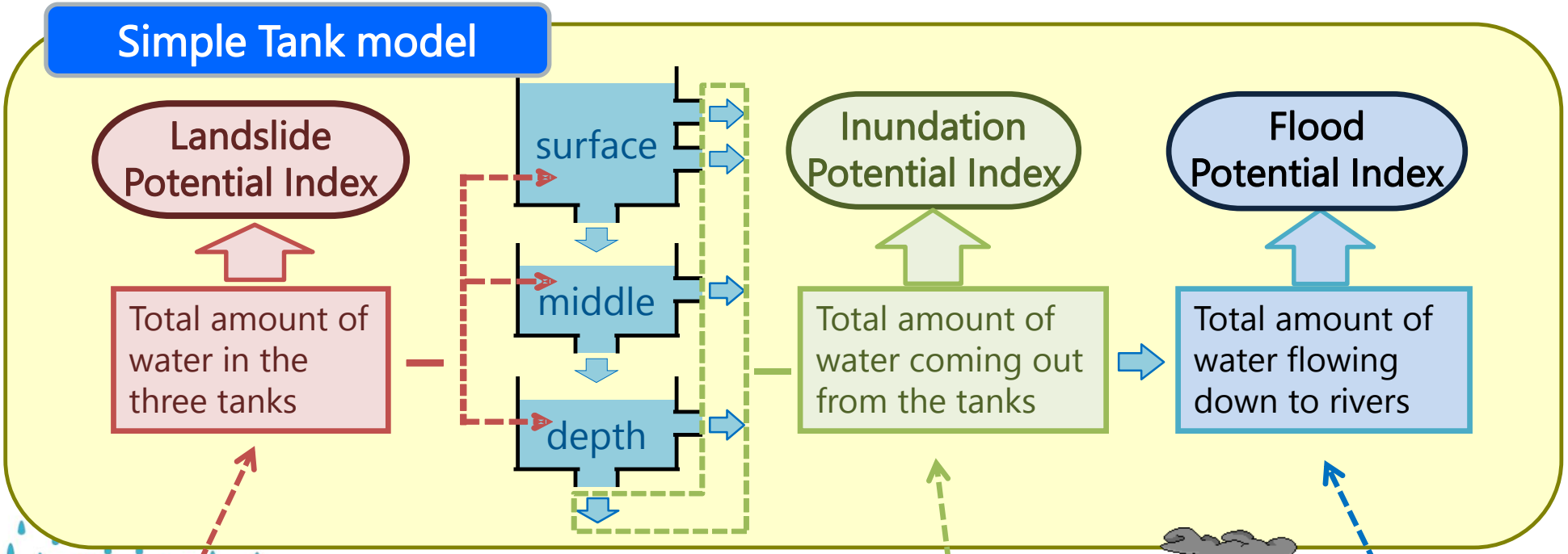
- Effective warning system
  - **Real-time Disaster Risk Map**
  - **Probability of Warning-class Phenomenon**
- Support for emergency managers
  - **Guideline on refuge information**
  - **Dispatch of forecasters** to DRR stakeholders

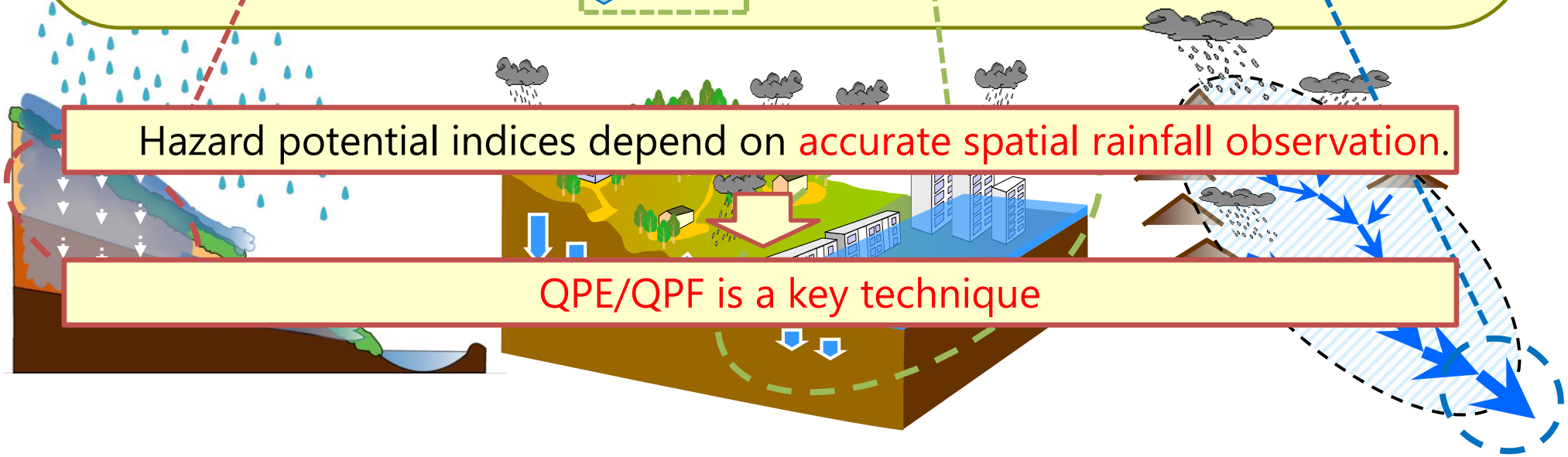
Real-time Disaster Risk Map

Mechanism of Rainfall-induced Hazards



Hazard Potential Indices



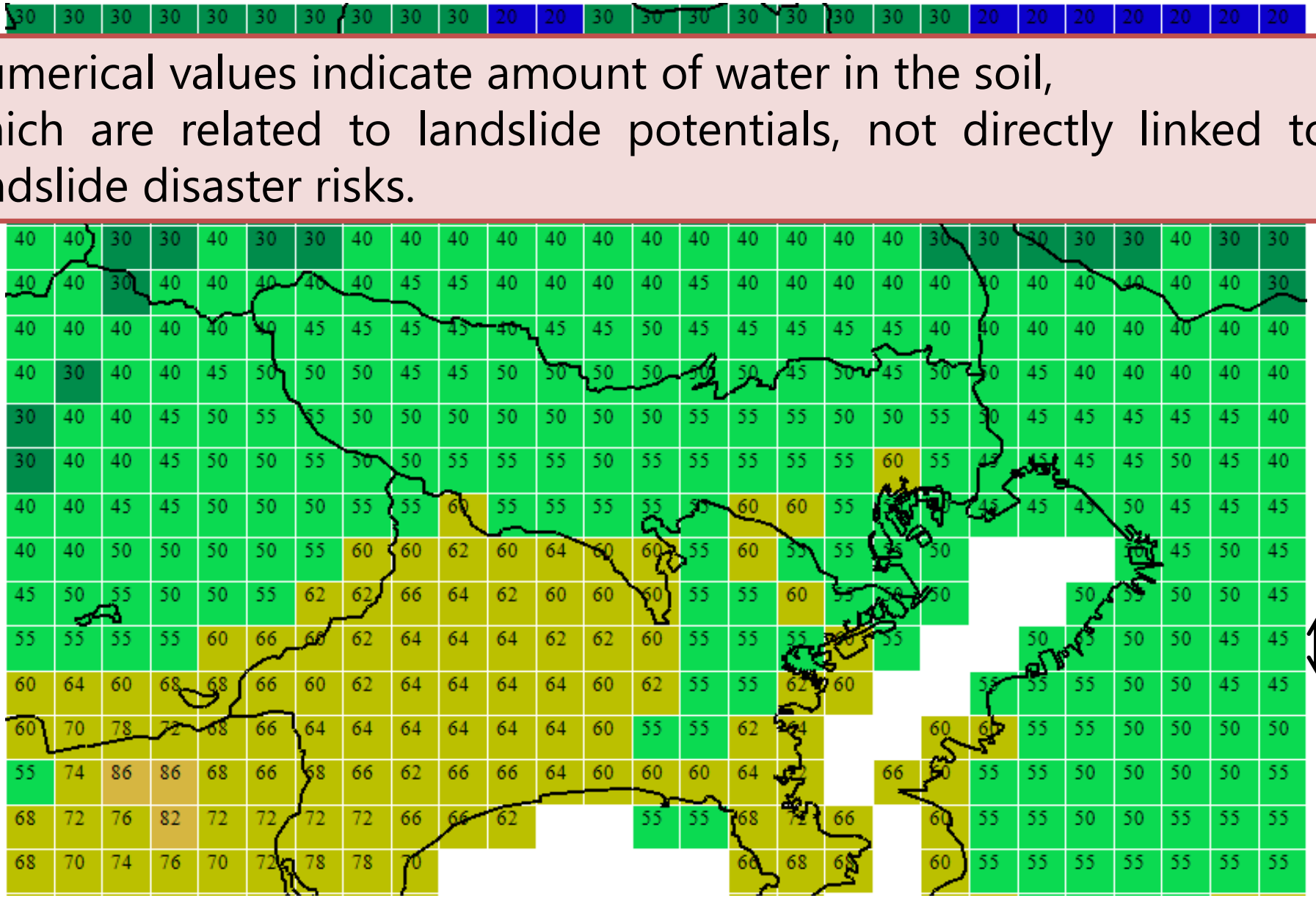


Hazard potential indices depend on accurate spatial rainfall observation.

QPE/QPF is a key technique

Example: Landslide Potential Index

Numerical values indicate amount of water in the soil,
which are related to landslide potentials, not directly linked to landslide disaster risks.



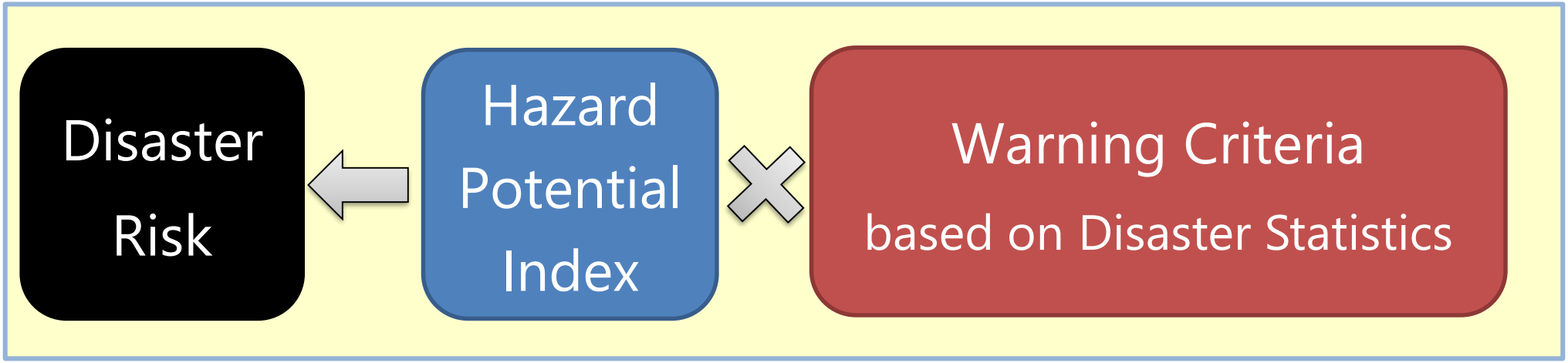
Linkage btw Hazard and Disaster Risk (1)

Risk = **Hazard** × **Exposure** × **Vulnerability**

Hazard: Potentially damaging physical events

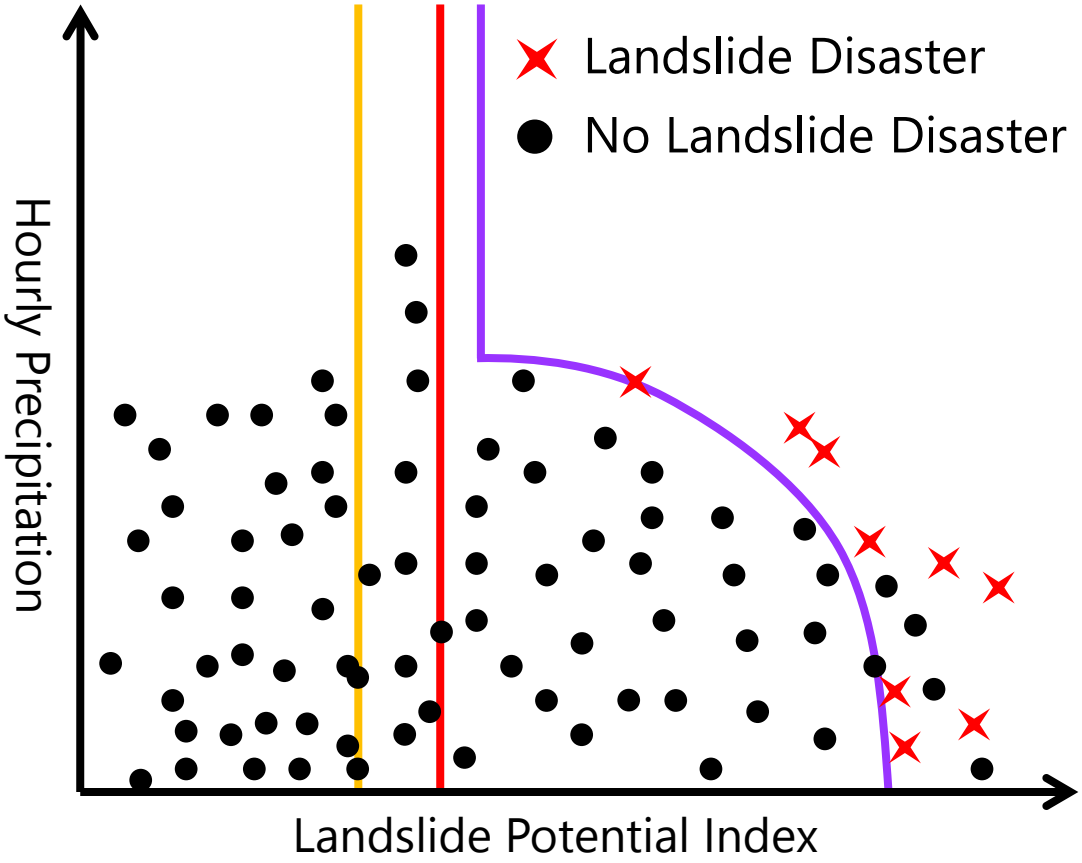
Exposure: total value of elements at-risk (e.g. number of human lives and properties)

Vulnerability: Physical, social, economic, and environmental factors increasing the susceptibility to hazards



Linkage btw Hazard and Disaster Risk (2)

Decision of Warning Criteria based on Disaster Statistics

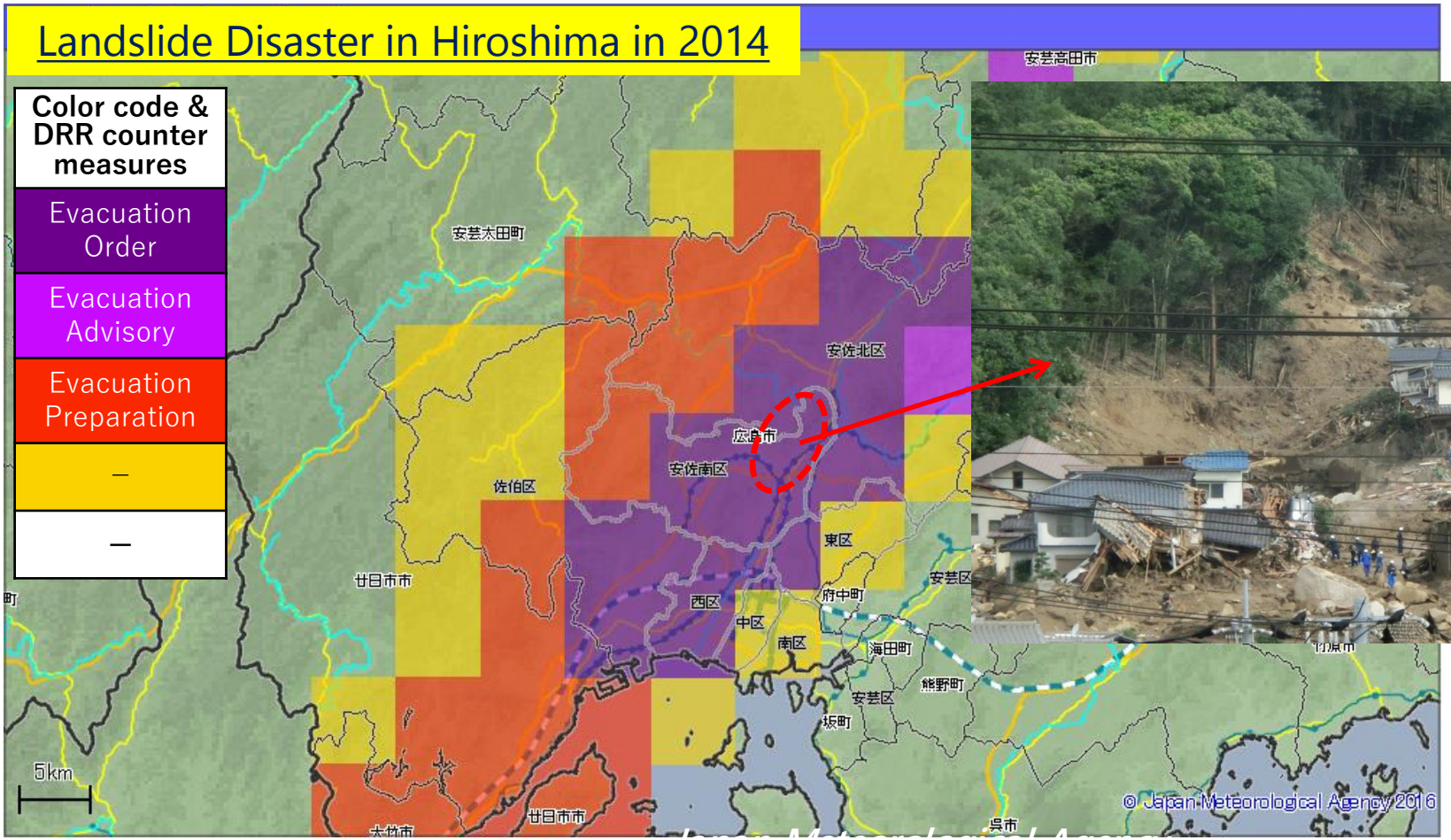


Color code & DRR counter measures
Evacuation Order
Evacuation Advisory
Evacuation Preparation
–
–

Real-time Landslide Risk Map (2013 -)

Resolution	Update Interval	Lead-time
5 km	10 min	2 hours

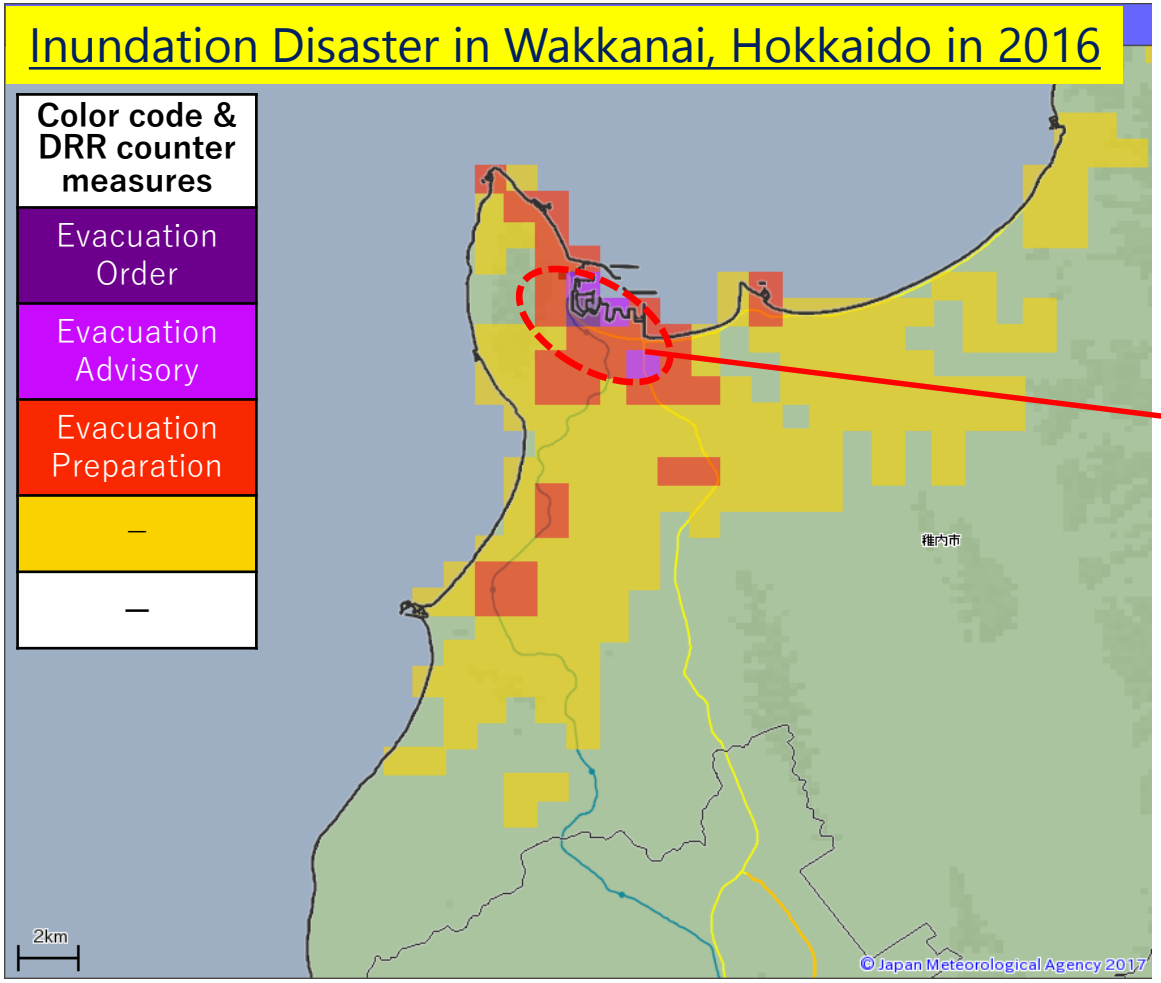
Landslide Disaster in Hiroshima in 2014

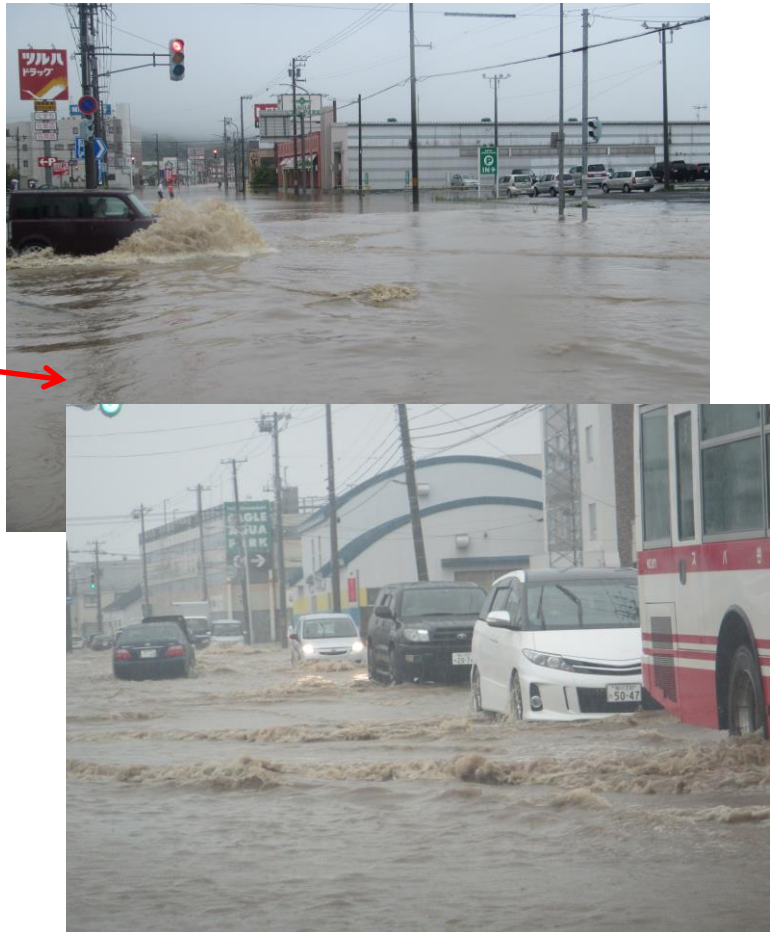


Real-time Inundation Risk Map (2017 -)

Resolution	Update Interval	Lead-time
1 km	10 min	1 hour

Inundation Disaster in Wakkanai, Hokkaido in 2016

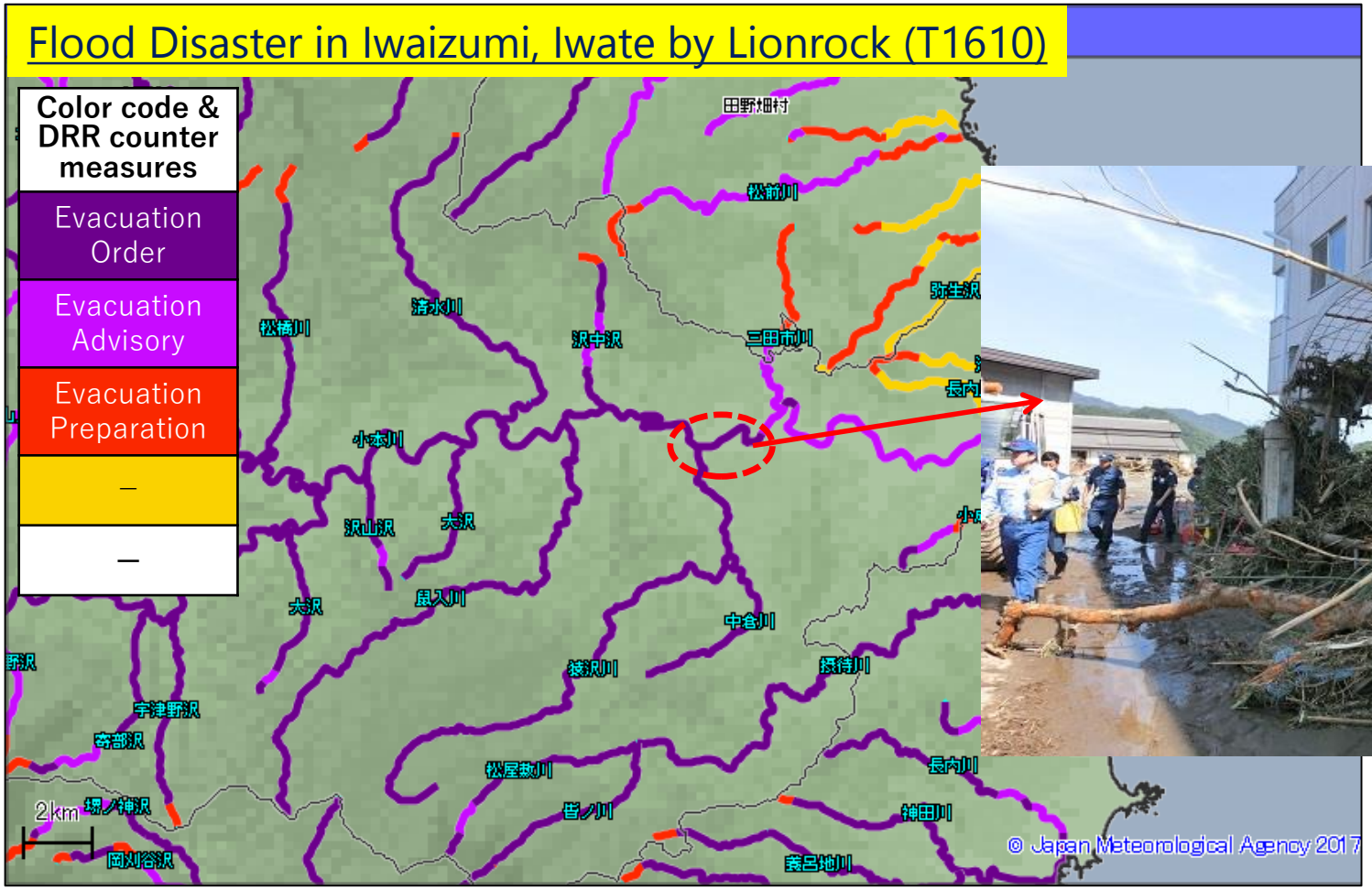




Real-time Flood Risk Map (2017-)

Target river	Resolution	Update Interval	Lead-time
Small to medium sized river (shorter than 15 km)	1 km	10 min	3 hours

Flood Disaster in Iwaizumi, Iwate by Lionrock (T1610)



Utilization of Real-time Risk Map

Warning Message

- Heavy rain Advisory
- Heavy rain Warning
- Landslide Disaster Alert Information

etc.

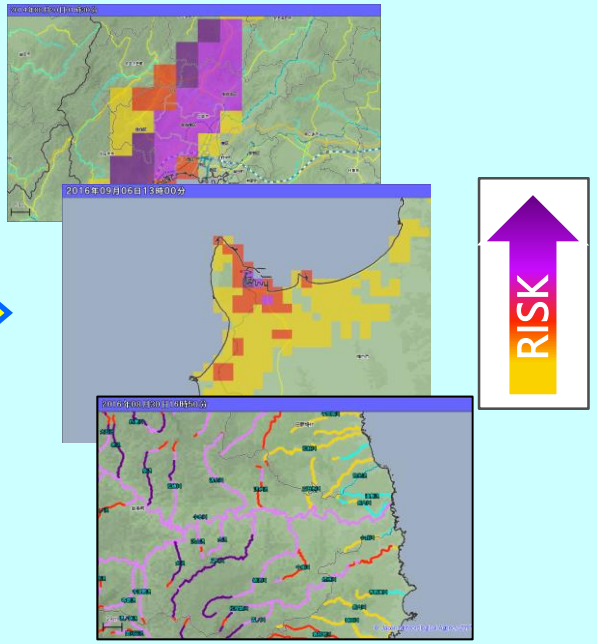
Inform Increase of Risk

DRR stakeholders

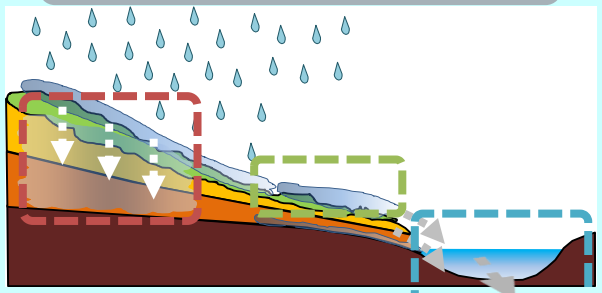
Residents

Check the risk area in detail

Real-time Risk Map



Hazard Potential Index



Probability of Warning-class Phenomenon

Probability of Warning-class Phenomenon

- Provides **probability information** on the risk of severe weather phenomena that may have significant impacts **with a lead time of up to 5 days**.

Image

From today to tomorrow

From day after tomorrow to five days ahead

Southern ○○ Prefecture		Issued at 17:00 JST, 3 August					Issued at 17:00 JST, 3 August			
Phenomenon		3 Aug.		4 Aug.			5 Aug.	6 Aug.	7 Aug.	8 Aug.
		To early morning		From morning to midnight						
		18-24	0-6	6-12	12-18	18-24				
Heavy rain	Probability of	Middle		–			–	–	Middle	–
Storm(Gale)	Warning-class	–		High			–	Middle	High	–
High waves	Phenomenon	–		High			–	Middle	High	–

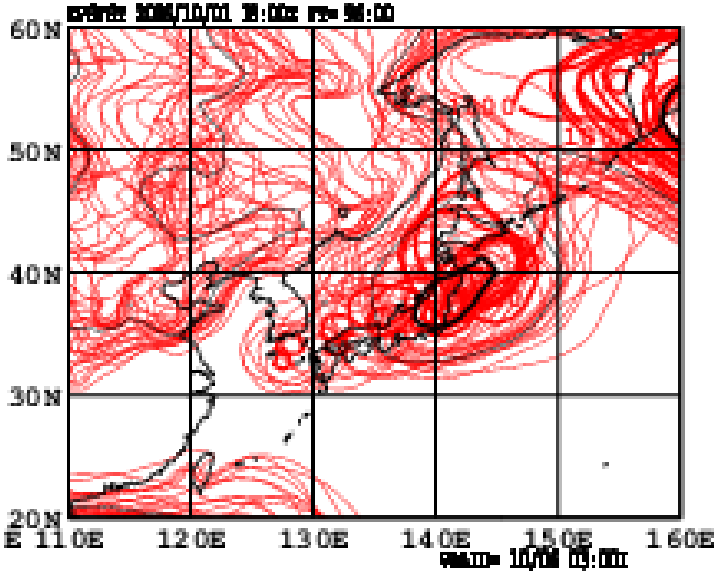
Middle probability of warning issuance from tonight to early tomorrow morning.

Middle to high probability of warning issuance from 2 to 3 days ahead.

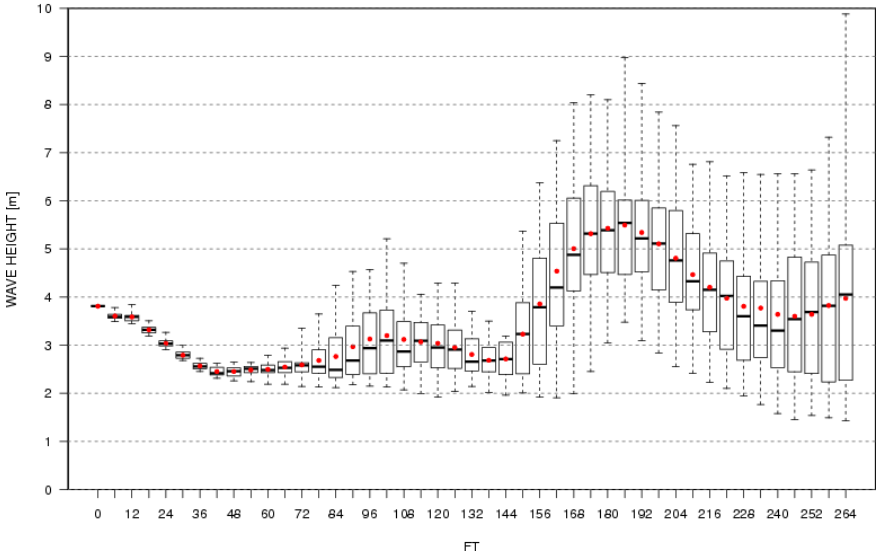
Employment of Ensemble Prediction Techniques

- **Ensemble prediction techniques** are employed as the main basis of the probability information.
  - Global Ensemble Prediction System (Atmosphere)
    - Integrated from previous Typhoon EPS, Weekly EPS, One month EPS in Feb. 2017
  - Wave Ensemble Prediction System (Ocean wave)
    - Put into operation in Dec. 2016

Global EPS Spaghetti Diagram for Sea Surface Pressure (FT120)



Wave height prediction for a point by Wave EPS

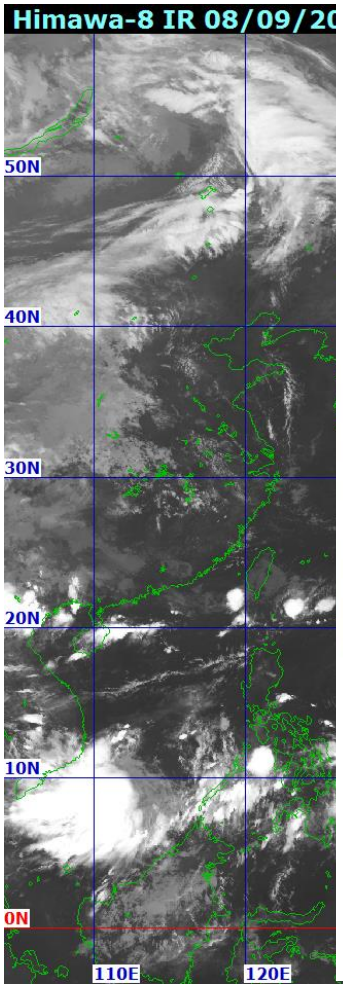


Landslide disaster (Kilo(T1517)&Etau(T1518))

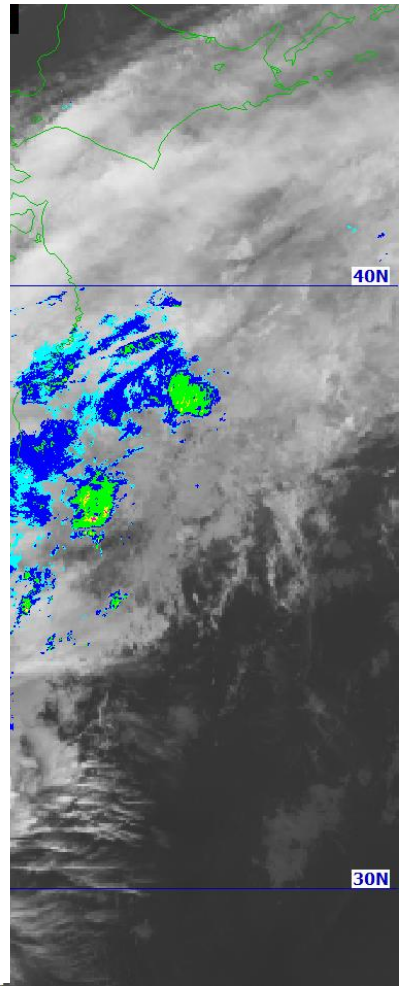
Landslide disaster (Kilo(T1517)&Etau(T1518))

Occurrence time: 2015.09.10 04JST

Himawari-8 IR Image



Himawari-8 IR Image + Radar echo



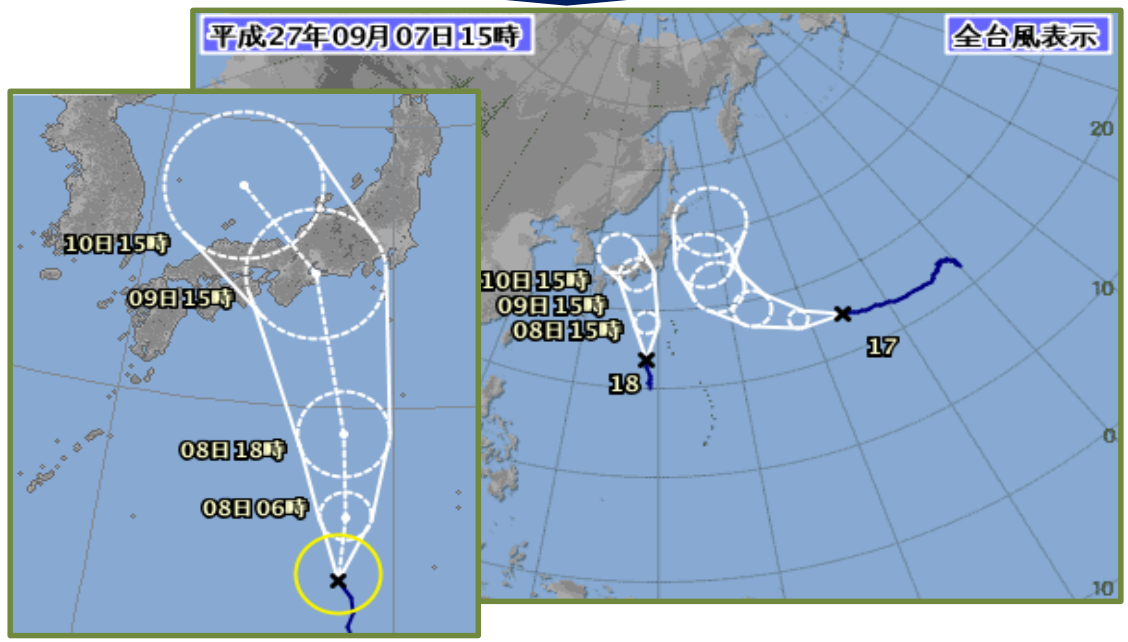
Three days before landslide disaster

Weather condition	Information issued by JMA	
A few days to 1 day before heavy rain Probability of heavy rain increases	Probability of Warning-class Phenomenon	Bulletin for Heavy rain
Half a day to a several hours before heavy rain It starts raining	Heavy rain Advisory	
Rain strength increases		
A several hours to 2 hours before heavy rain	Heavy rain Warning	
Rain becomes heavy		
Rain becomes very heavy		Landslide Alert Information
Heavy rain only once every 50 years in wide area	Heavy rain Emergency Warning	

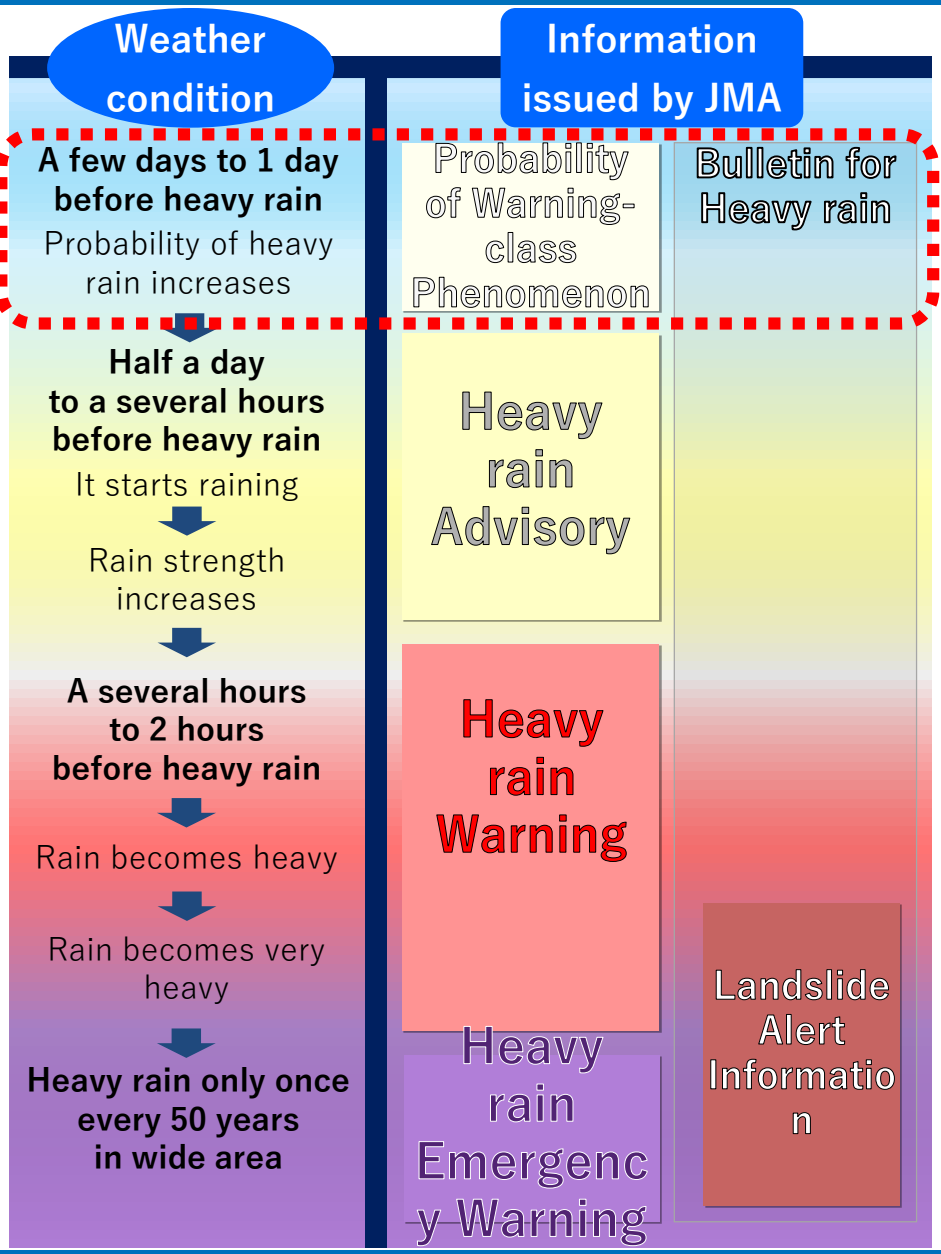
Probability of Warning-class Phenomenon

Southern Tochigi Prefecture		Issued at 17:00 JST, 7 Sep.					Issued at 17:00 JST, 7 Sep.			
Phenomenon		7 Sep.	8 Sep.				9 Sep.	10 Sep.	11 Sep.	12 Sep.
		18-24	0-6	6-12	12-18	18-24				
Heavy rain	Probability of Warning-class Phenomenon	–		–			Middle	–	–	–

Check Typhoon Information



Two days before landslide disaster



Probability of Warning-class Phenomenon

Southern Tochigi Prefecture		Issued at 17:00 JST, 8 Sep.					Issued at 17:00 JST, 8 Sep.			
Phenomenon		8 Sep.	9 Sep.				10 Sep.	11 Sep.	12 Sep.	13 Sep.
		18-24	0-6	6-12	12-18	18-24				
Heavy rain	Probability of Warning-class Phenomenon	Middle	High				High	–	–	–

Check Bulletin

平成２７年台風第１８号に関する栃木県気象情報　第２号

平成２７年９月８日１６時５６分　宇都宮地方気象台発表

（見出し）

台風第１８号と前線の影響で、栃木県では９日朝から１０日にかけて大雨となるでしょう。土砂災害、河川の増水、はん濫に警戒し、低い土地の浸水、落雷や竜巻などの激しい突風に注意してください。

（本文）

＜＜中略＞＞

［防災事項］

＜大雨・雷・突風＞

栃木県では、９日朝から１０日にかけて１時間に４０ミリの激しい雨が降る見込みです。山地を中心に総雨量が多くなり、大雨となるおそれがあります

９日１８時までの２４時間に予想される雨量は、多い

北部、南部ともに　２００ミリ

の見込みです。

その後、９日１８時から１０日１８時までの２４時間に予想される雨量は、多い所で

北部、南部ともに　１００ミリから２００ミリ

の見込みです。

土砂災害、河川の増水、はん濫に警戒してください。

＜＜後略＞＞

Period of severe weather phenomena

Expected hourly rainfall amount

Expected 24-hour rainfall amount

Morning on the previous day of landslide disaster

Weather condition	Information issued by JMA	
	Probability of Warning-class Phenomenon	Bulletin for Heavy rain
A few days to 1 day before heavy rain Probability of heavy rain increases		
Half a day to a several hours before heavy rain It starts raining Rain strength increases	Heavy rain Advisory	
A several hours to 2 hours before heavy rain Rain becomes heavy Rain becomes very heavy	Heavy rain Warning	
Heavy rain only once every 50 years in wide area	Heavy rain Emergency Warning	Landslide Alert Information

Probability of Warning-class Phenomenon

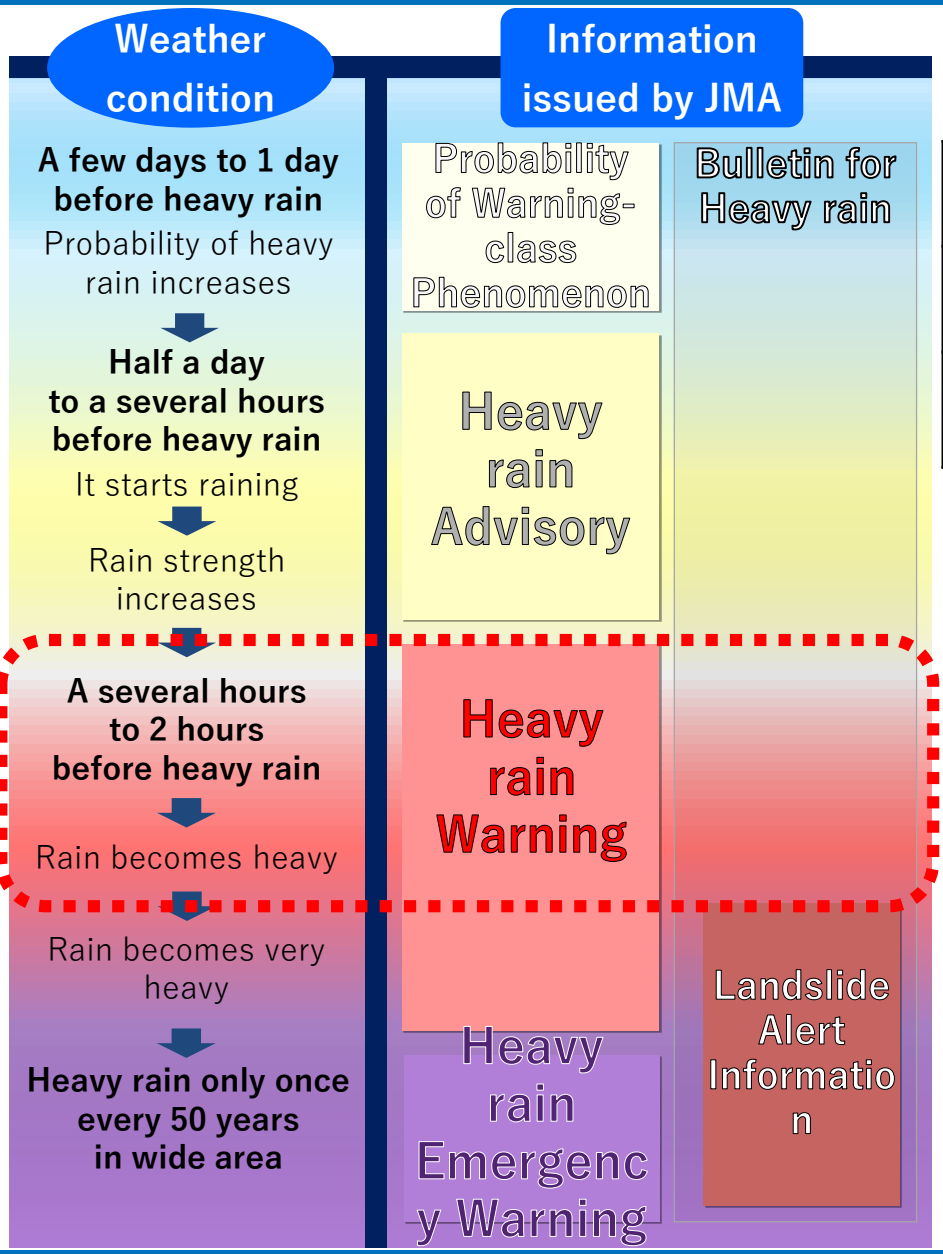
Southern Tochigi Prefecture		Issued at 05:00 JST, 9 Sep.					Issued at 05:00 JST, 9 Sep.		
Phenomenon		9 Sep.			10 Sep.		11 Sep.	12 Sep.	13 Sep.
		6-12	12-18	18-24	0-6	6-24			
Heavy rain	Probability of Warning-class Phenomenon	Middle	High				–	–	–

Check Advisory

Kanuma-shi	Future condition (Warning-class Advisory-class)									Remarks
Warning/ Advisory	9 Sep.						10 Sep.			
	6-9	9-12	12-15	15-18	18-21	21-24	0-3	3-6	6-9	
Heavy rain	Maximum 1-hr rainfall (mm)	40	40	50	50	50	40				
	Inundation									
	Landslide									Warning-class further ahead

Warning-class From Early night

At noon on the previous day of landslide disaster



Probability of Warning-class Phenomenon

Southern Tochigi Prefecture		Issued at 11:00 JST, 9 Sep.					Issued at 11:00 JST, 9 Sep.		
Phenomenon		9 Sep.		10 Sep.			11 Sep.	12 Sep.	13 Sep.
		12-18	18-24	0-6	6-18	6-24			
Heavy rain	Probability of Warning-class Phenomenon	Middle	High		High		–	–	–

Check Warning

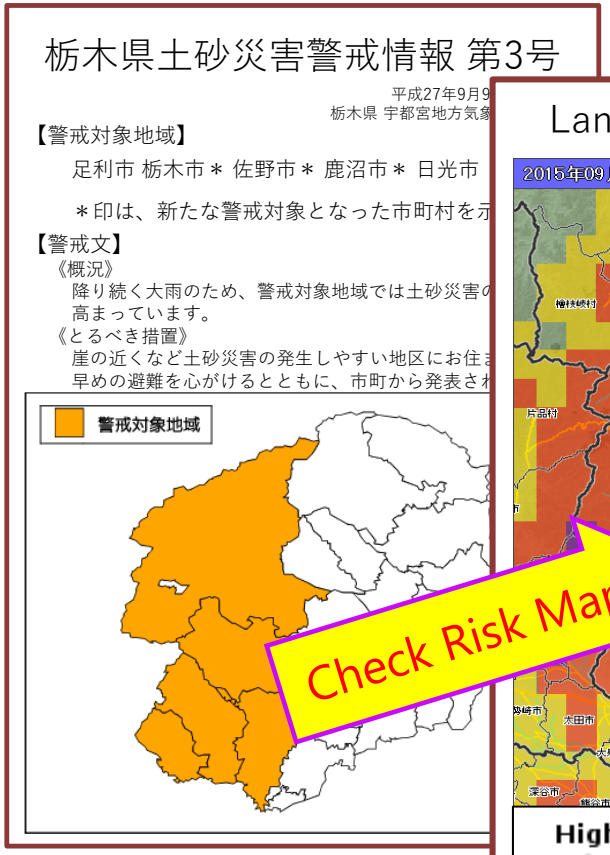
Kanuma-shi		Future condition (Warning-class Advisory-class)									Remarks
Warning/ Advisory		9 Sep.				10 Sep.					
		12-15	15-18	18-21	21-24	0-3	3-6	6-9	9-12	12-15	
Heavy rain	Maximum 1-hr rainfall (mm)	50	50	50	50						
	Inundation										
	Landslide										Warning-class further ahead

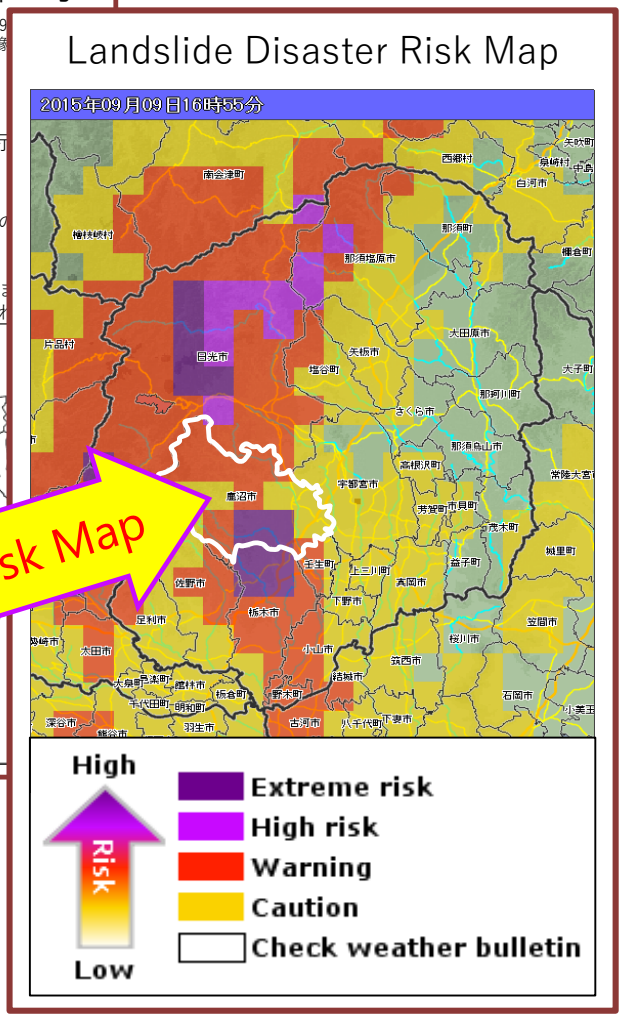
Warning-class From evening

Several hours before landslide disaster

Weather condition	Information issued by JMA	
	Probability of Warning-class Phenomenon	Bulletin for Heavy rain
A few days to 1 day before heavy rain Probability of heavy rain increases		
Half a day to a several hours before heavy rain It starts raining	Heavy rain Advisory	
Rain strength increases		
A several hours to 2 hours before heavy rain	Heavy rain Warning	
Rain becomes heavy		
Rain becomes very heavy		Landslide Alert Information
Heavy rain only once every 50 years in wide area	Heavy rain Emergency Warning	

Landslide Alert Information





A few hours before the landslide disaster

Weather condition	Information issued by JMA	
	Probability of Warning-class Phenomenon	Bulletin for Heavy rain
A few days to 1 day before heavy rain Probability of heavy rain increases		
Half a day to a several hours before heavy rain It starts raining	Heavy rain Advisory	
Rain strength increases		
A several hours to 2 hours before heavy rain	Heavy rain Warning	
Rain becomes heavy		
Rain becomes very heavy		Landslide Alert Information
Heavy rain only once every 50 years in wide area	Heavy rain Emergency Warning	

Emergency Warning

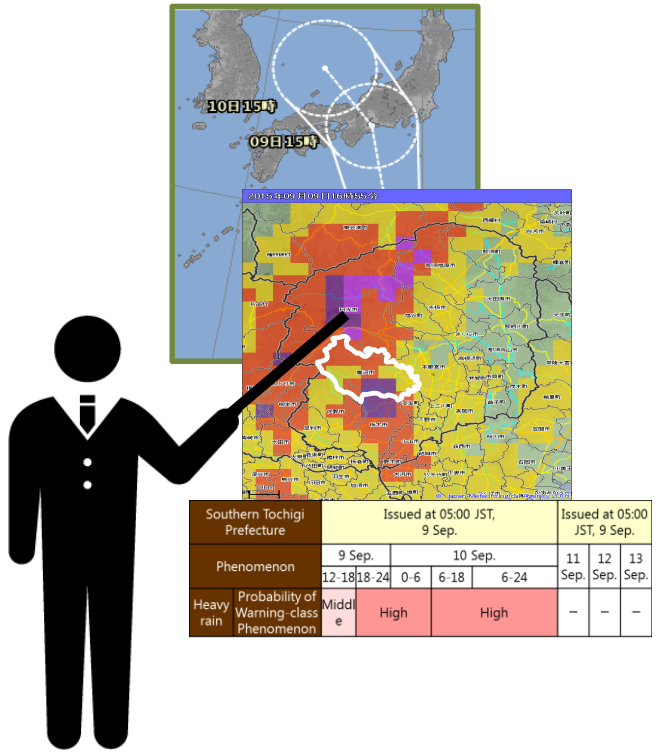
Kanuma-shi		Future condition (■Emergency Warning-class ■Warning-class □Advisory-class)									Remarks
Warning/ Advisory		10 Sep.								11 Sep.	
		0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24	0-3	
Heavy rain	Maximum 1-hr rainfall (mm)	80	80	40	40						
	Inundation	■	■	□	□						
	Landslide	■	■	■	■	■	□	□			

Press conference

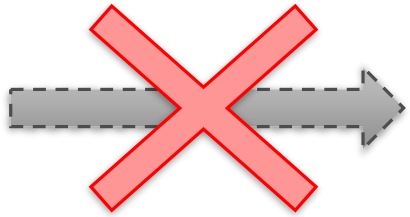
Supports for Emergency Managers

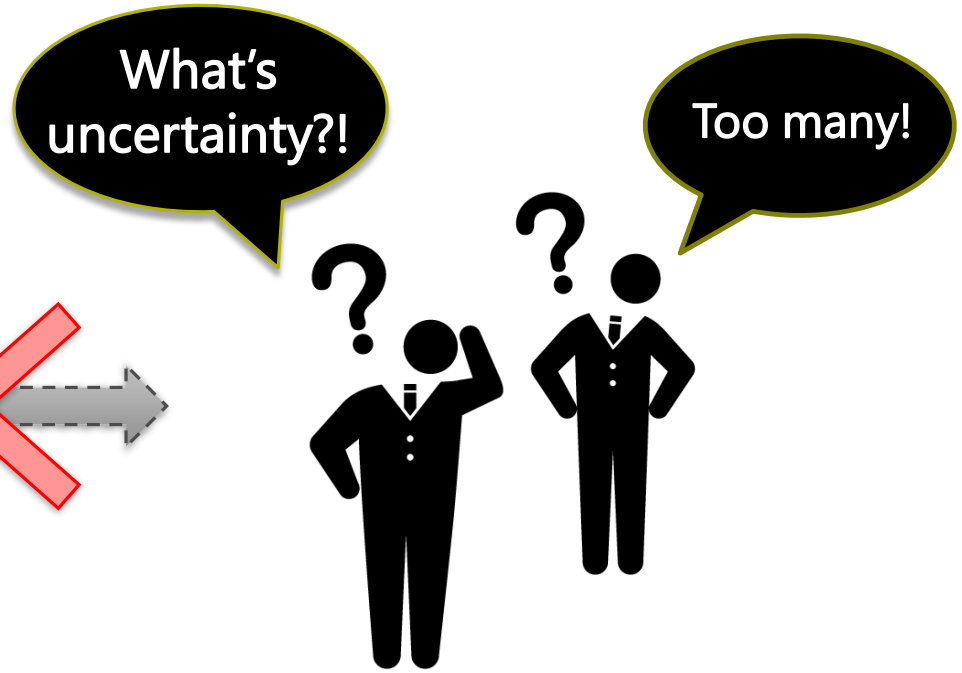
To fill the last mile gap (1)

- Any sophisticated disaster risk information will not be effective unless users can understand and use it appropriately.



Southern Tochigi Prefecture		Issued at 05:00 JST, 9 Sep.				Issued at 05:00 JST, 9 Sep.		
Phenomenon		9 Sep.		10 Sep.		11 Sep.	12 Sep.	13 Sep.
		12-18	18-24	0-6	6-18	6-24			
Heavy rain	Probability of Warning-class Phenomenon	Middle	High	High			–	–	–

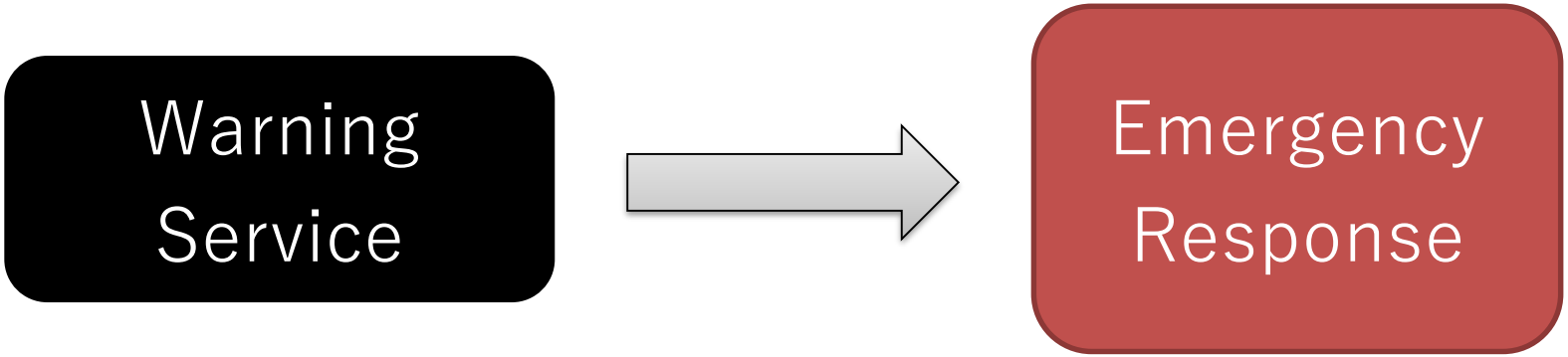




Information

DRR stakeholders

To fill the last mile gap (2)



- In order to **fill the last mile gap …**
  - The Japanese Cabinet Office developed the **Guideline on evacuation order**, to help decision making on evacuation orders by DRR emergency managers. It describes how information including JMA's warning messages is to be used for **appropriate emergency response.**
  - JMA **started dispatching forecasters with JMA's certificates to local governments** for supporting their use of meteorological information more effectively.

Summary

- **Real-time Disaster Risk Map**
  - **Hazard potential indices** depend on accurate spatial rainfall observation
  - Linkage btw Hazard and Disaster Risk based on **Disaster Statistics**
- **Probability of Warning-class Phenomena**
  - Probabilistic risk information based on **Ensemble prediction techniques**, including uncertainty, with longer lead time.
- **A series of information Issuance**
  - JMA supports emergency responses by providing **a series of information** which help decision makings in various stages up to 5 days prior to disaster occurrence.
- **Supports for DRR stakeholders**
  - As meteorological information is sophisticated, **more technical supports for DRR stakeholders** are needed.

Thank you