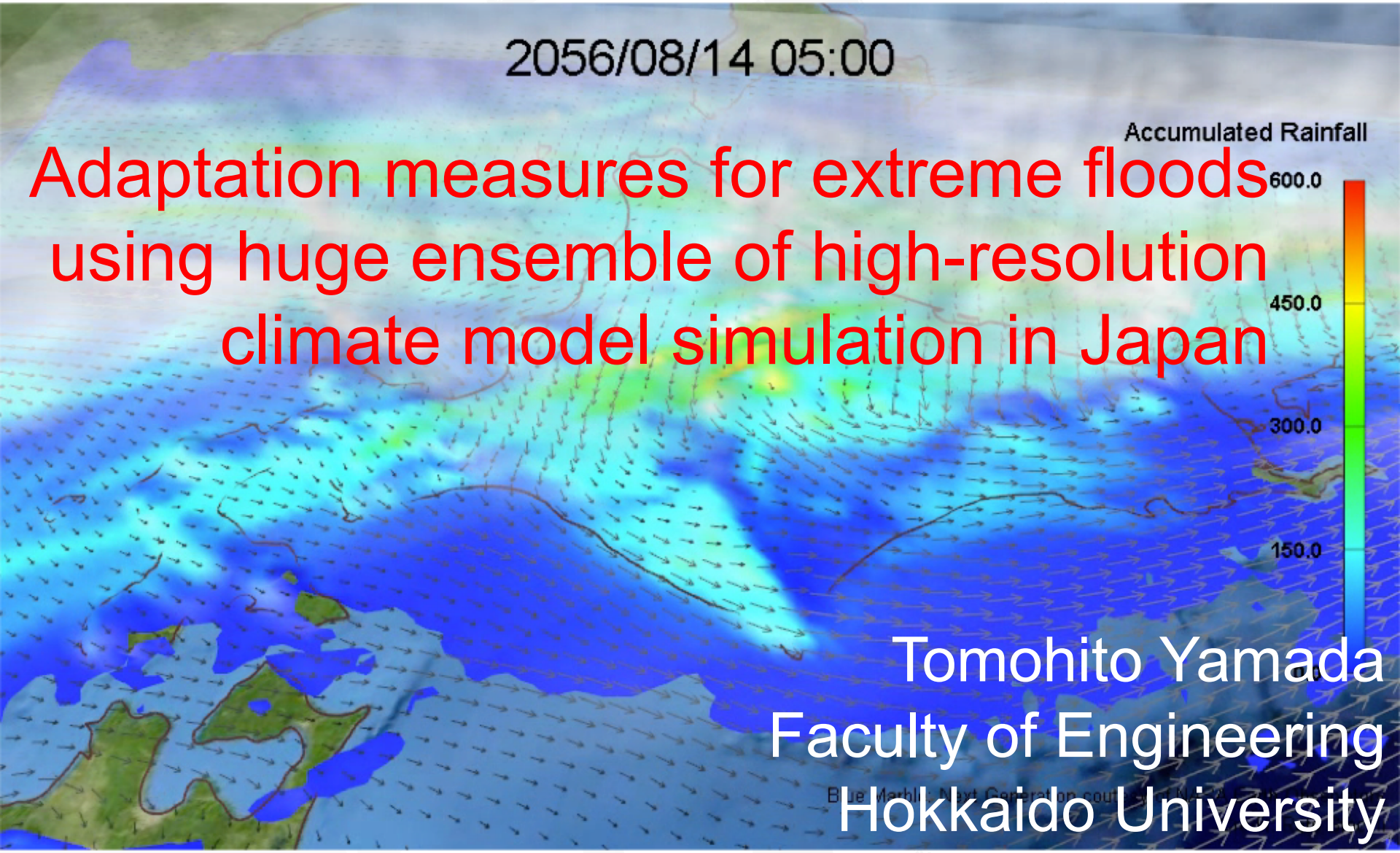


Adaptation measures for extreme floods using huge ensemble of high-resolution climate model simulation in Japan

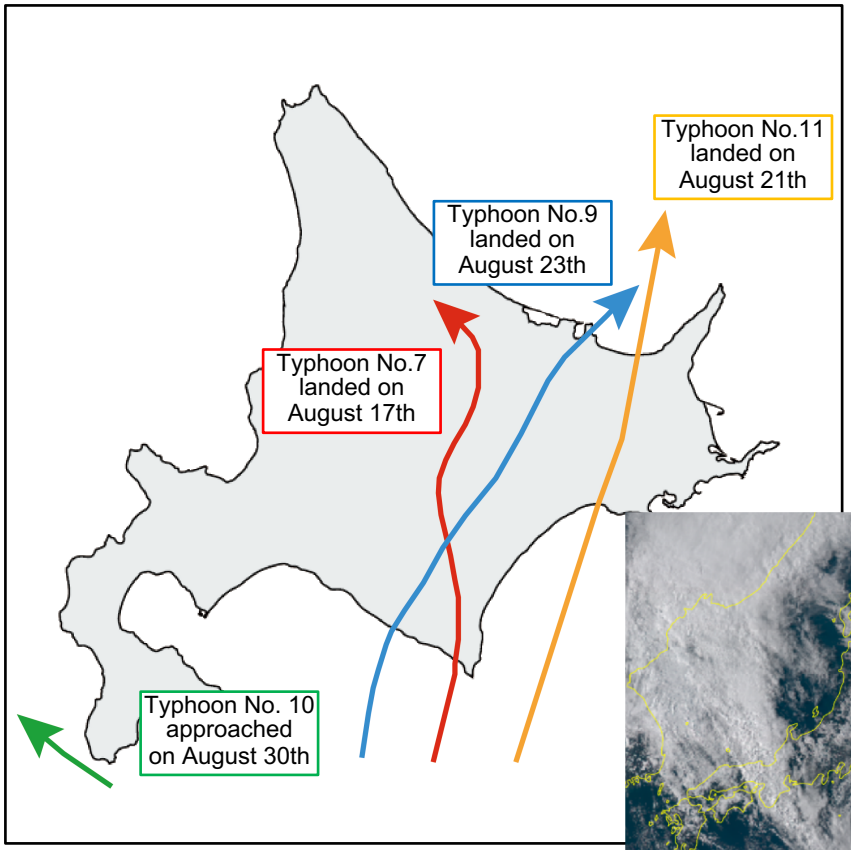
Tomohito Yamada
Faculty of Engineering
Hokkaido University

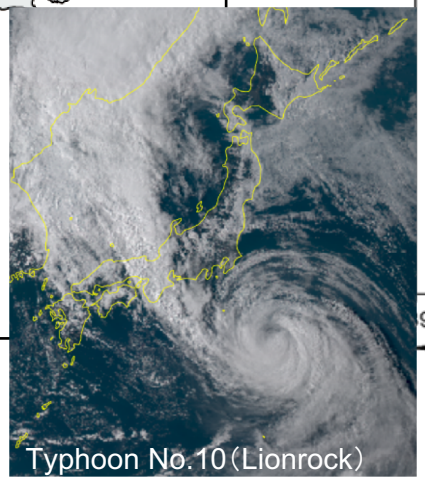
This study (dynamical downscaling) is supported by MEXT/SI-CAT.

Background Of The Study ～Extreme Disasters Caused By Heavy Rain In August, 2016

■ Three typhoons landed in Hokkaido for the first time in recorded history in a week of August 17th to 23th, 2016. After that, typhoon No. 10 approached to Hokkaido, and it brought recordable heavy rain in various places. Floods of rivers and sediment disasters occurred mainly in eastern of Hokkaido.

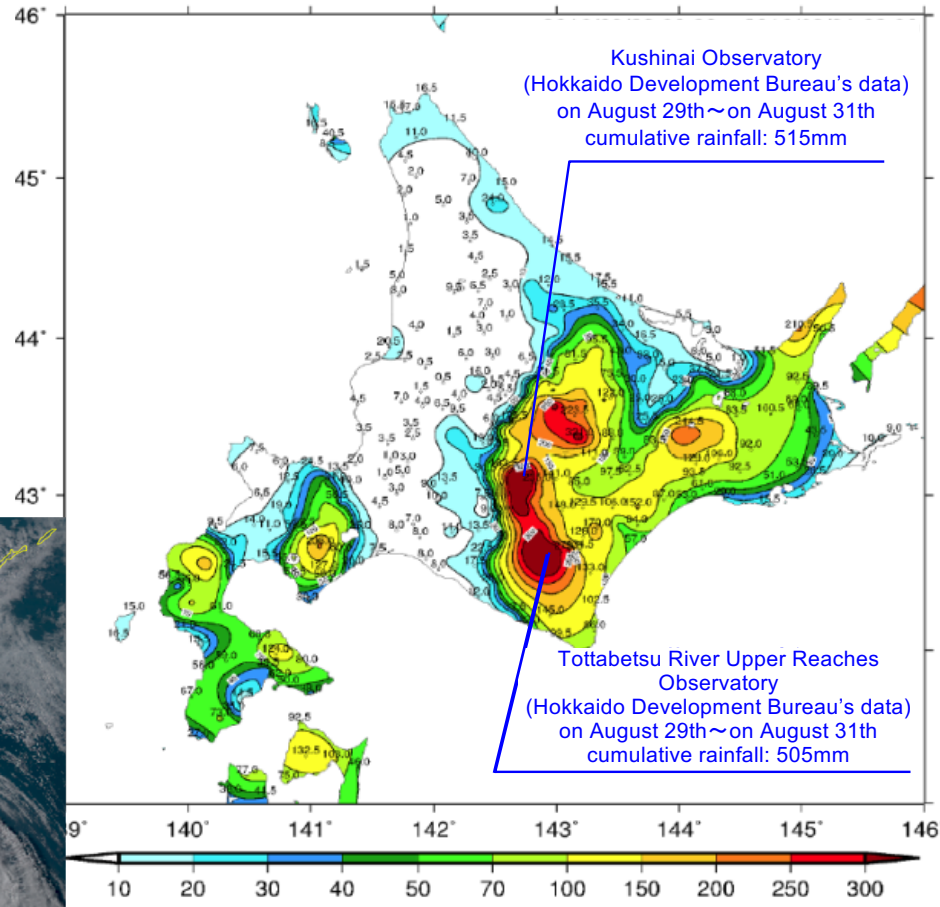
Typhoon routes in August, 2016





Precipitation distribution（AMEDAS）

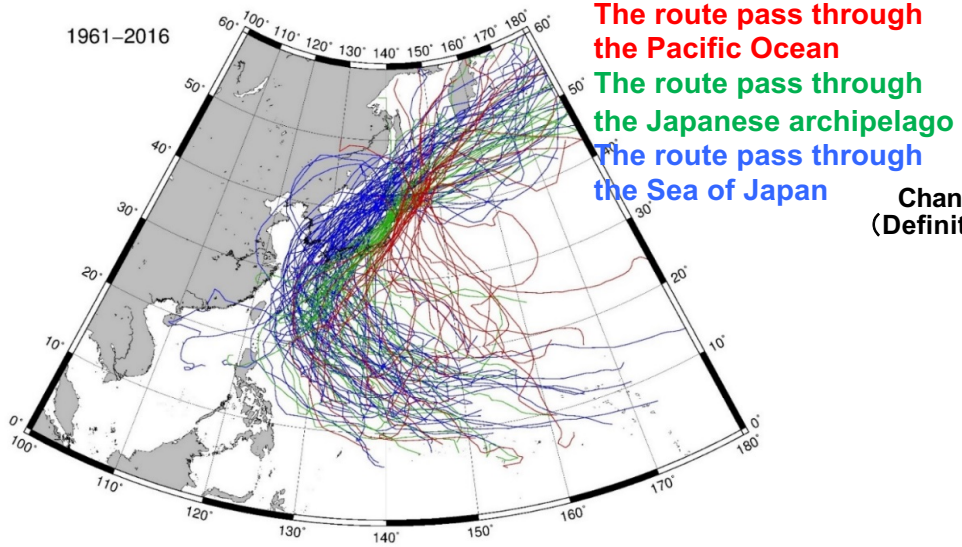
at 1:00 on August 29th, 2016 ～ at 9:00 on August 31th, 2016

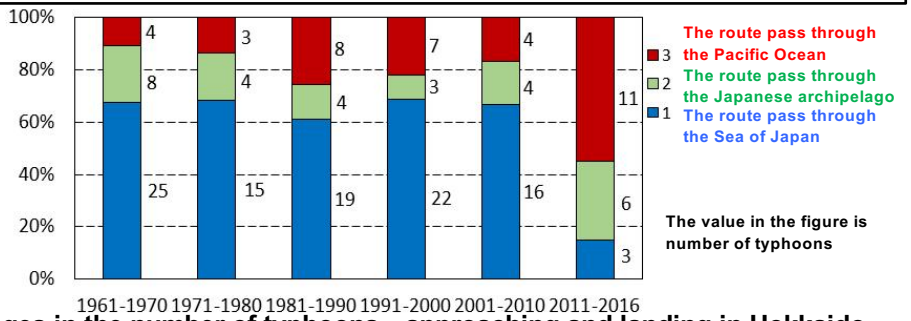


Typhoon Characteristics Approaching Hokkaido

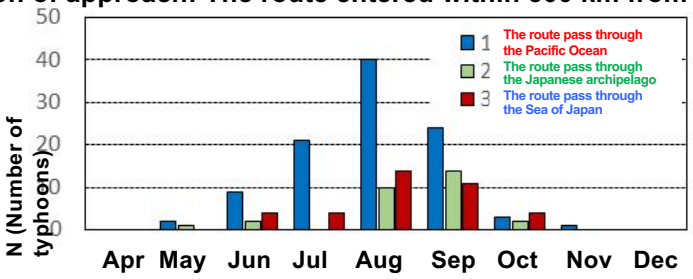
- The typhoon approach route to Hokkaido has changed in recent years, and in the past 60% was the route pass the Sea of Japan before, but the route pass through the Pacific Oceans is increasing more than 50%.
- Typhoons approaching Hokkaido from the Pacific Ocean tend to head northward keeping central atmospheric pressure lower than other routes.

The route of typhoons approaching and landing in Hokkaido over the past 56 years





Changes in the number of typhoons approaching and landing in Hokkaido
(Definition of approach: The route entered within 300 km from Hokkaido)



Traditionally, there were many typhoons of the Sea of Japan in August.

The number of typhoons every month and its approach route

Degree of atmospheric pressure change of central pressure from the north latitude 30 degrees to the north latitude 40 degrees（hPa/° N）, and number of typhoons (N)

（For typhoons that passed through 30 degrees north latitude at a center pressure 980 hPa or less.）

Average period	Years	All routes		1. The route of the Sea of Japan		2. The route of the Japanese archipelago		3. The route of the Pacific Ocean	
		Degree of atmospheric pressure change	N	Degree of atmospheric pressure change	N	Degree of atmospheric pressure change	N	Degree of atmospheric pressure change	N
1961–2016	56	2.62	116	2.90	67	2.68	24	1.82	25

Typhoons approaching Hokkaido through the Pacific Oceans are harder to weaken than other routes

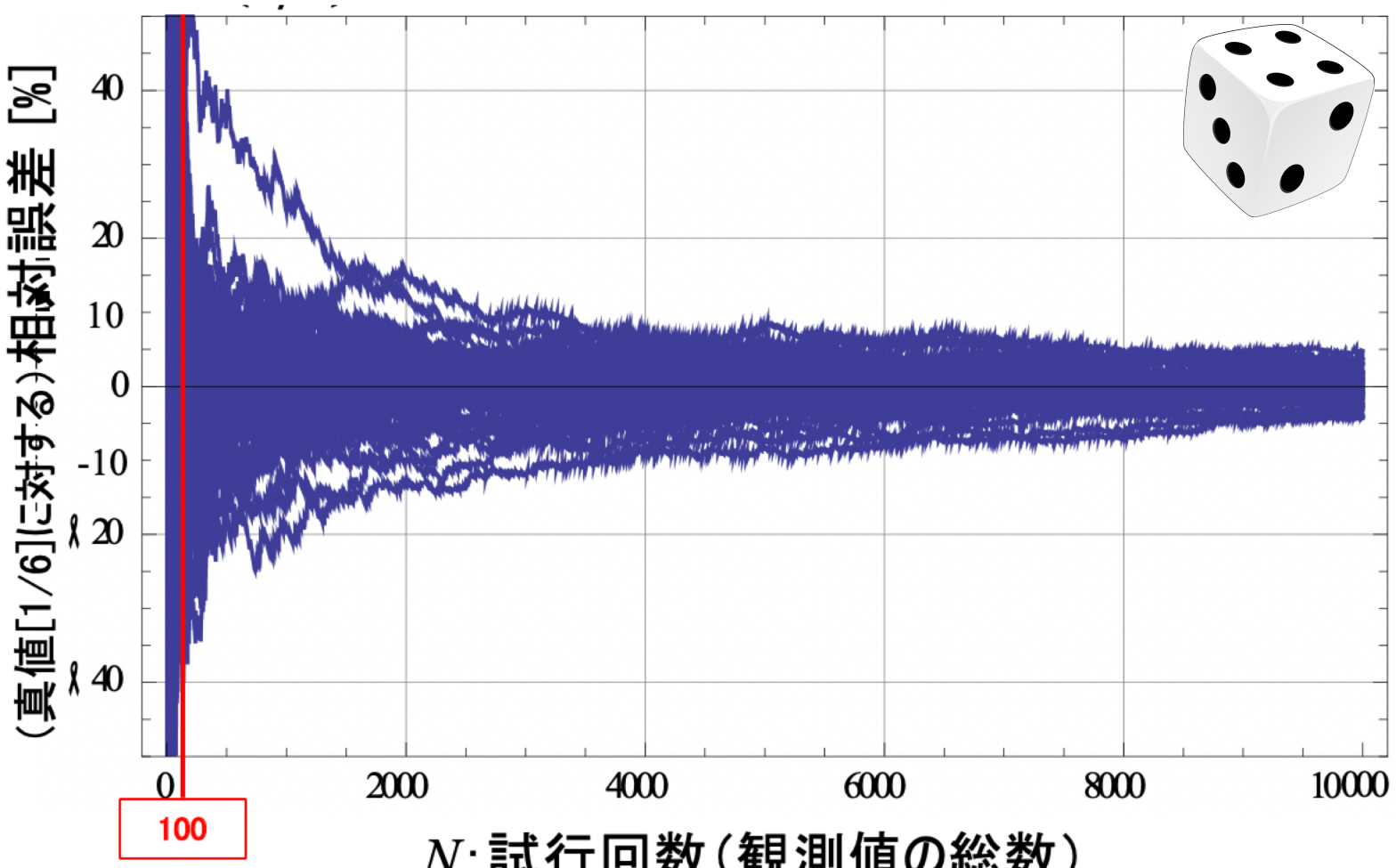
Degree of atmospheric pressure change :
Amount of change in central atmospheric pressure [hPa] / Latitude change [°] , N : Number of target typhoons [hPa]

From document by Associate Professor Tomohito Yamada (Hokkaido University) and Mr. Taro Yamamoto (Hokkaido River Center)

Freedom of Climate System (an example: dice)

$$\text{Relative error}[\%] = \frac{(M/N) - (1/6)}{(1/6)} \times 100\ [\%]$$

M: O(N回サイコロを振り，ある目が出た総数)
N: 試行回数(サイコロを振った総数)



Relative Error against Truth (1/6)

N: Number of cases (total number of observation)

Our Mission

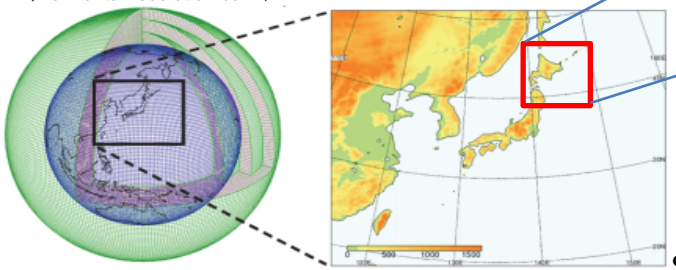
○We scientifically predict the influence of climate change(rainfall and discharge change) in Hokkaido based on the latest knowledge.

○We calculate the change of risks (scale, form and frequency, etc) due to the influence of climate change and share them with society.

Analysis Of Rainfall In The Future Climate

AGCM
(Horizontal resolution 60km)

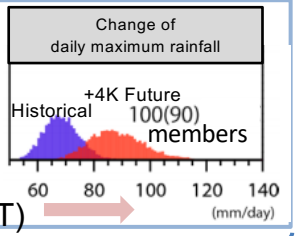
JMA/ NHRCM
(Horizontal resolution 20km)



We calculate dynamical downscaling Hokkaido region to several km by using “database for Policy Decision making for Future climate change(d4PDF)“.(Start from 4 degrees rise model)

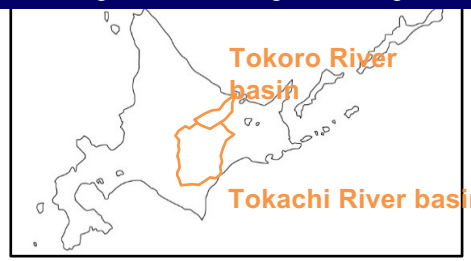
We analyze the occurrence intensity and frequency of heavy rain based on high resolution and large scale ensemble simulation.

・Explanation of Extreme Phenomena
・Statistical Analysis



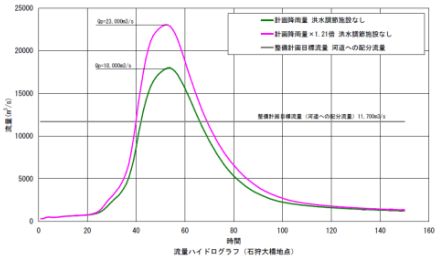
Supported by SOUSEI and SI-CAT (MEXT)

Estimation Of Change Of Discharge On target Basin



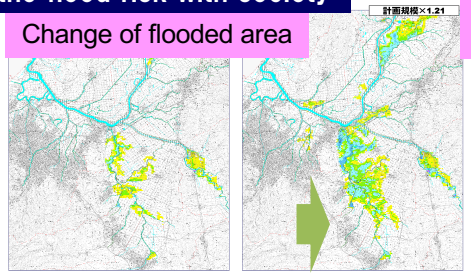
Using Tokachi River and Tokoro River where extensive damage occurred, we predict changes of flood runoff in future climate.

・Change of the peak discharge
・Reduction of safety level of flood control

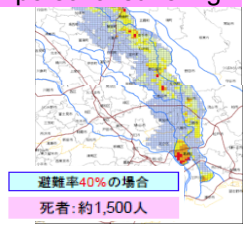


Share the flood risk with society

Change of flooded area



Estimation of personal suffering



Estimation of damaged area of agricultural land

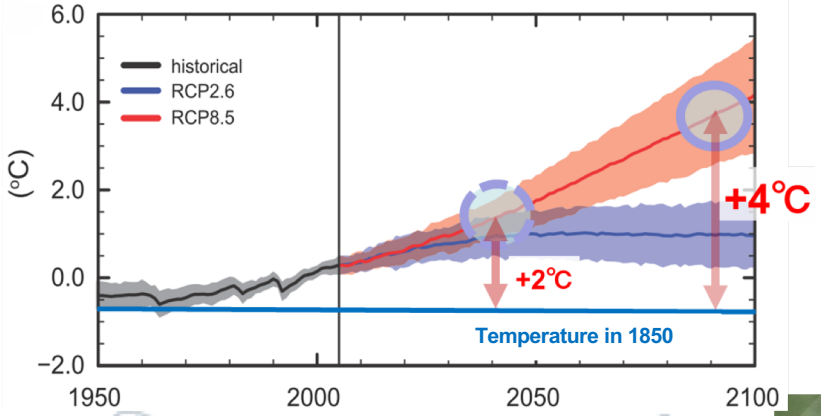
Perform risk assessment due to the influence of climate change, and share with society.

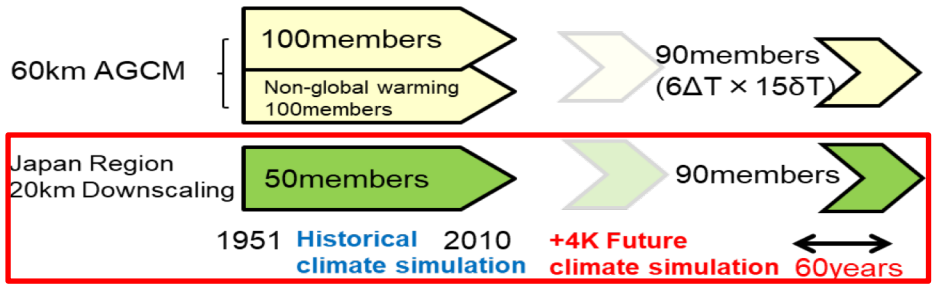
・Increase of flooded area
・Increase of personal suffering
・Increase of social risk
・Comparison with other risks such as traffic accidents

Discuss adaptation policy for future flood control in nationwide committees (MLIT)

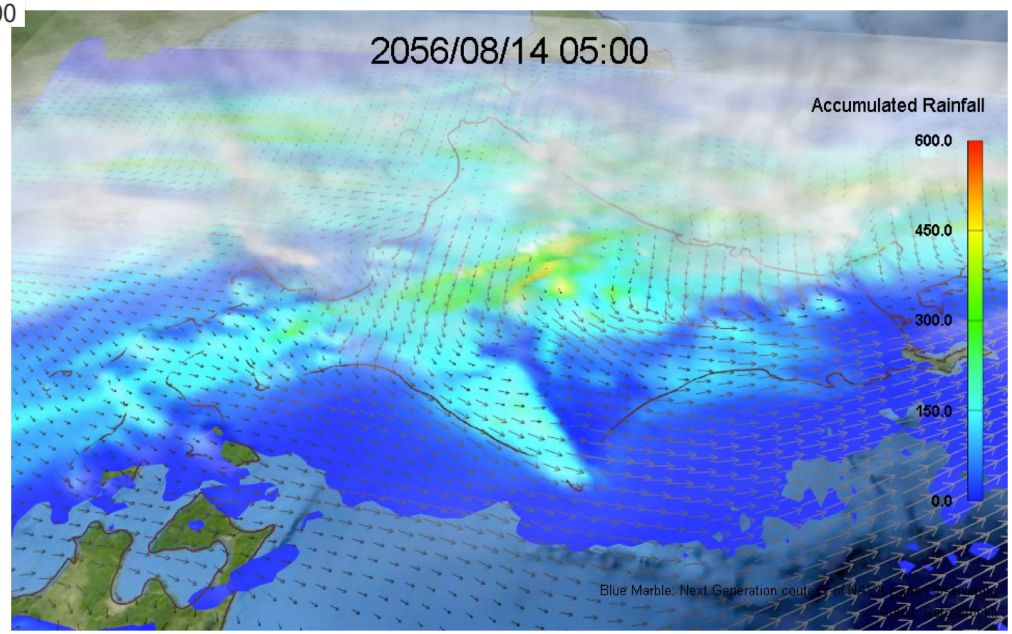
■In this study, we downscaled from results of regional climate model experiments (horizontal resolution 20 × 20km) of d4PDF to 5 × 5km using the regional climate model (NHRCM) of Japan Meteorological Agency.

Average ground temperature of global





Resolution and calculation area of AGCM and NHRCM



Probability Evaluation Of Historical Climate Simulation Rainfall And +4K Future Climate Simulation Rainfall 【Tokachi River Obihiro Reference Point】

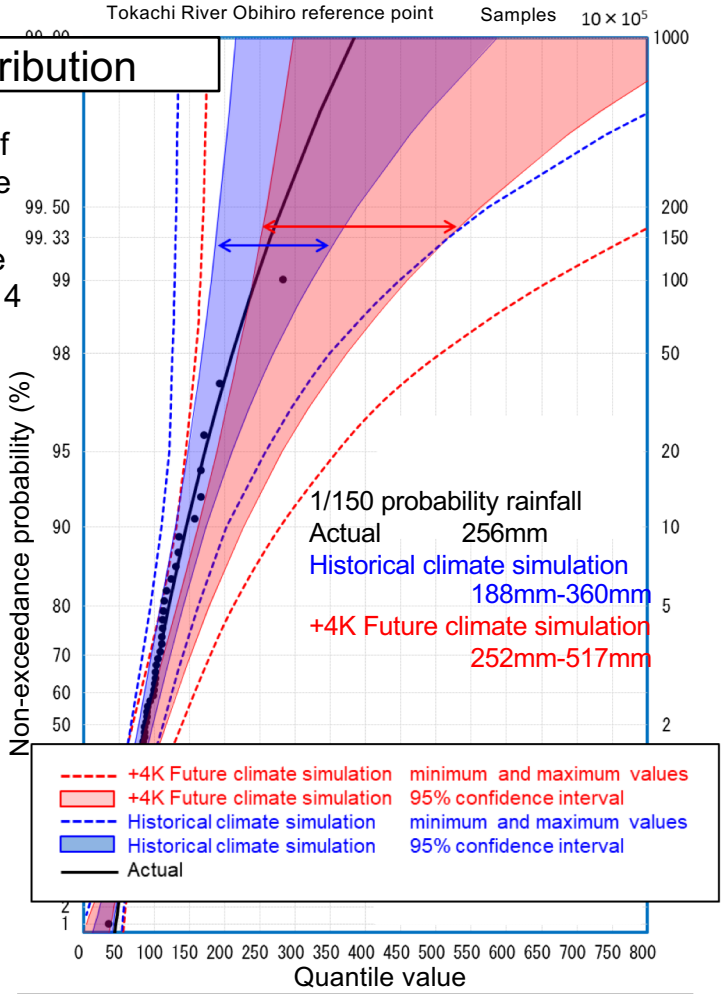
- 95% confidence interval of historical climate simulation based on 1/150 probability rainfall is between 188mm - 360mm in Highly compatible GEV distribution. 95% confidence interval of +4K future climate simulation is between 252mm - 517mm, which shows the trend of increasing rainfall.
- Multiple samples using weather simulation enable us to respond with maximum value of confidence interval by risk management.

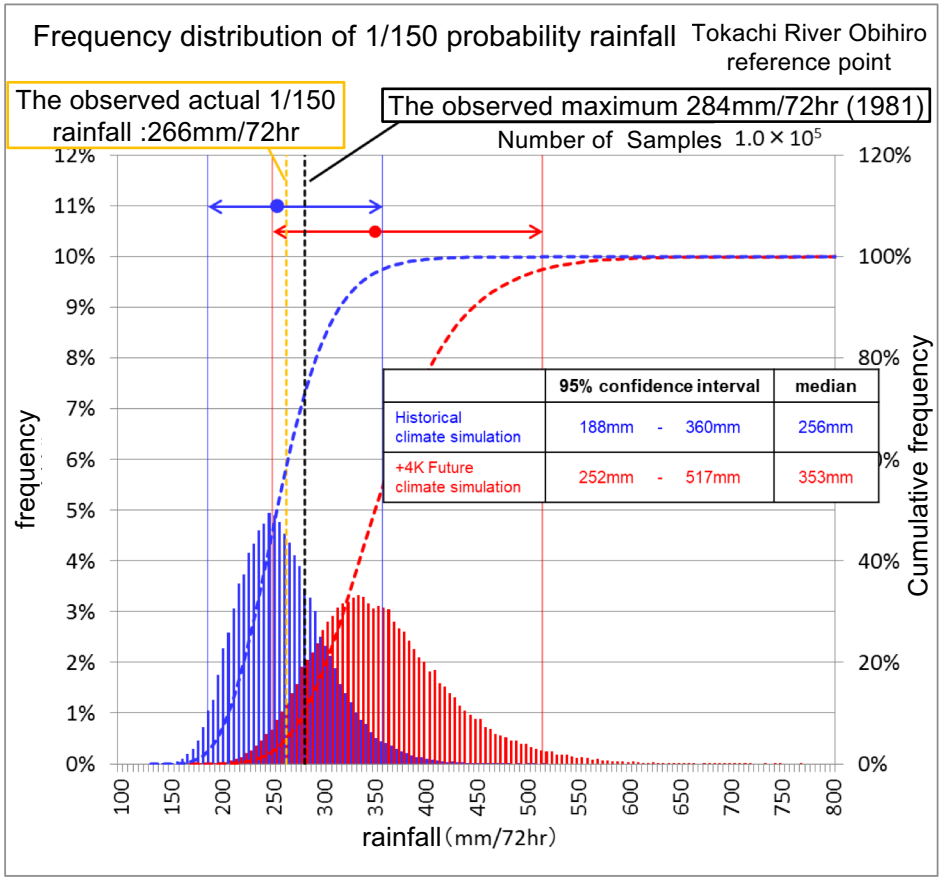
GEV distribution

SLSC Average of 1.0 × 105 Sample

Historical climate simulation : 0.014

+4K Future clim simulation : 0.0



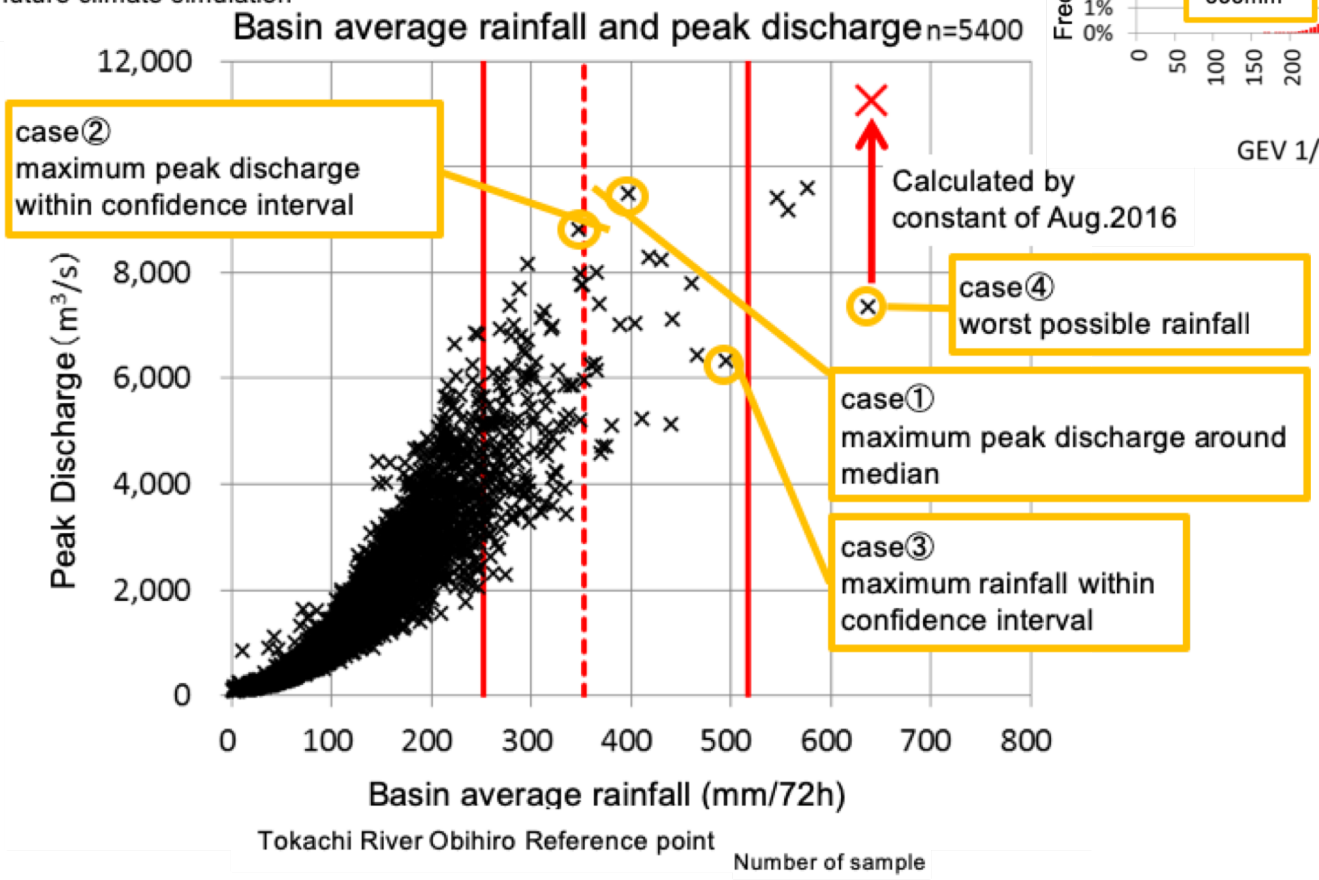


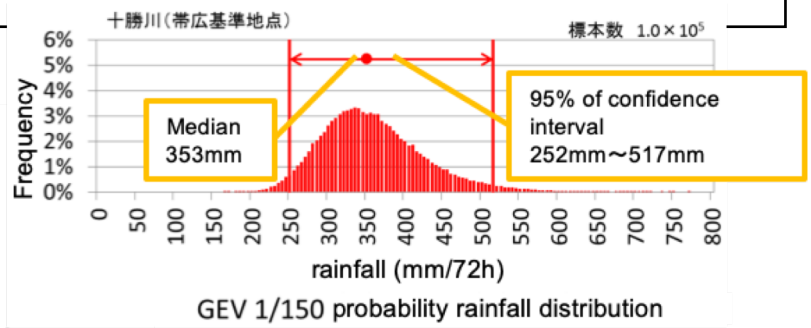
External Force Utilized For Risk Assessment【 Future Experimant Of Tokachi River 】

- **Selected 3 external forces for the risk assessment, within the range of 1/150 probability rainfall of +4K future climate simulation GEV distribution at Tokachi river Obihiro reference point: ①maximum peak discharge around median ②maximum peak discharge within 95% of confidence interval ③ maximum basin average 72-hour-rainfall within 95% of confidence interval.**
- **Sampled maximum basin average 72-hour-rainfall out of 5400 cases of +4K future climate simulations to assume the worst possible scenario in the future Tokachi River basin.**

Risk Assessment based on probability rainfall scale

Tokachi River Obihiro Reference point
+4K future climate simulation



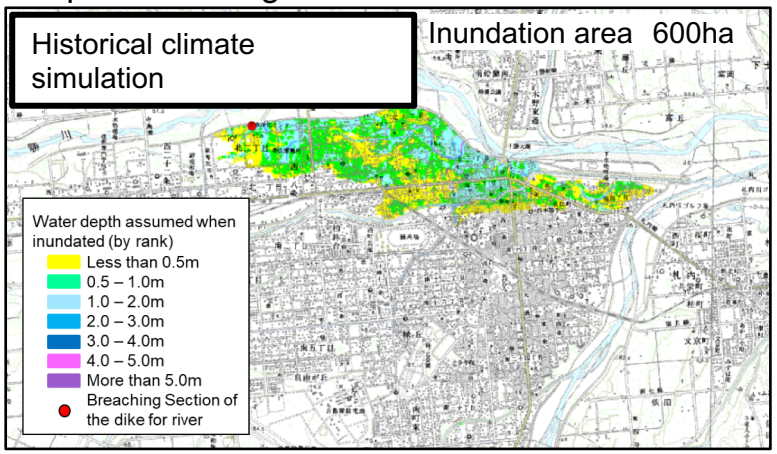


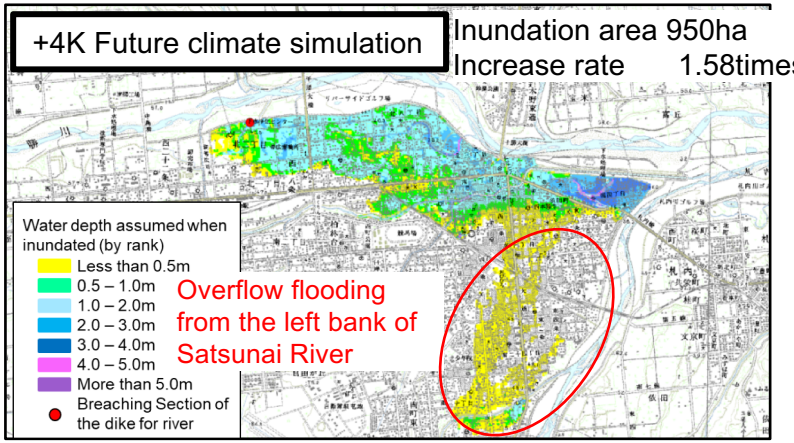
GEV 1/150 probability rainfall distribution

Maximum Inundation Area【Obihiro Urban Area】

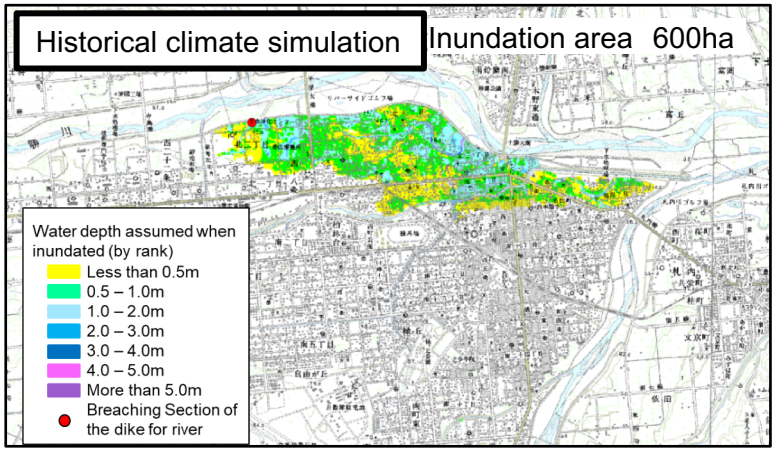
- ①Inundation area increases by 1.58 times in +4K future climate simulation at Obihiro, where the peak discharge increases 2,300m^3/s.
- ②Inundation area increases by 1.32 times in +4K future climate simulation at Obihiro, where the peak discharge increases 2,900m^3/s.

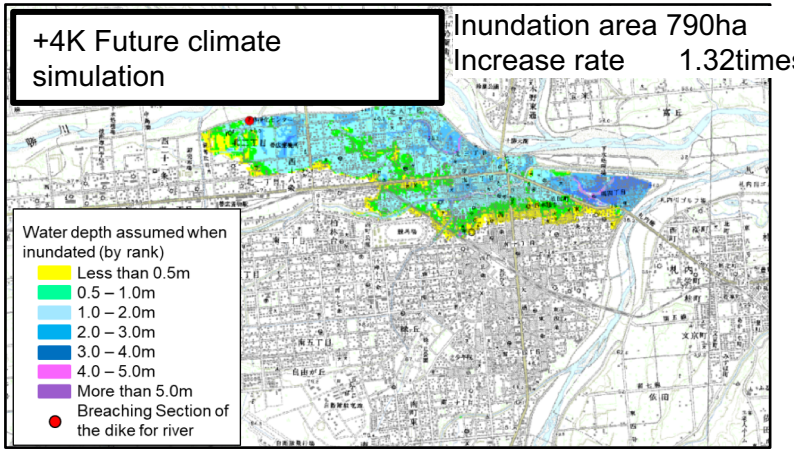
①Maximum peak discharge around median





②Maximum peak discharge within confidence interval





2018.1 Climate Change Adaptation Delegation to the Netherlands

- **There are leading examples of climate change examination in the field of water management in other countries, while there is little example in Japan. Our attention was drawn to the Netherlands where systematic approach was done from future rainfall/run-of projection to risk assessment and detailed adaptation measures.**
- **January 2018, Hokkaido Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism sent a delegation led by Professor Nakatsugawa from Muroran Institute of Technology, to the Netherlands to exchange with Dutch experts on water management.**

Exchanged Organizations and Contents

Organization	Main Contents of Exchange
The executive body "Rijkswaterstaat" of the Ministry of Infrastructure and Water Management (Administrative Agency for Water Management)	Dutch Climate Change Adaptation Measures ・History of Dutch Water Management ・Overview of Relevant Organizations and Tasks ・Concept of Safety Standard ・Flood Projection Scheme and Cooperation with Neighbor Countries ・Climate Change Adaptation Measures in Delta Program Climate Change Approach in Hokkaido
TU Delft, HKV consultant (Reserchers and Expers on Risk Assessment)	Details of Dutch Risk Assessment ・Calculation Method of Estimated Loss of Life ・Flood Simulation Method Climate Change Approach in Hokkaido
Delta Commission (Independent Organization for Delta Program)	Background of Delta Program Development ・Task and Authority of Delta Commission ・How to deal with Climate Change Scenario ・Determination of Tolerable Risk Climate Change Approach in Hokkaido
Royal Netherlands Meteorological Institute "KNMI" (Institute for Weather Forecast)	Details of Climate Change Projection in the Netherlands ・Rainfall Projection Method (Bias Correction and Resampling) ・Run-off Calculation Method Climate Change Approach in Hokkaido

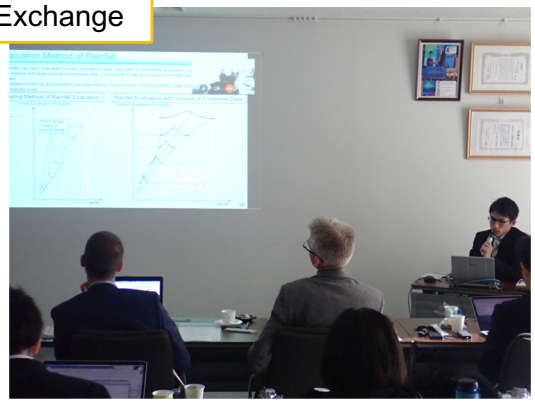
Discussion(Delta Commission)

Discussion(KNMI)

2018.11 Dutch Water Management Experts' Visit to Japan

- **November 2018, Dutch Water Management Experts (Rijkswaterstaat, Deltares, HKV consultant) visited Japan for another exchange. Discussions were focused on themes such as "How to switch water management planning in accordance with climate change" and "How to explain risk to society."**
- **During the visit by Dutch water management experts to Japan, River Center of Hokkaido organized "Seminar for Water Management in Japan and the Netherlands: How to respond to increasing flood risk by climate change," where more details were discussed on response to future climate change.**

Exchange



Presentation on Climate Change Projection in Hokkaido (Japanese side)

Questions to Climate Change Projection in Hokkaido (Dutch side)

Discussion on Water Management in Both Countries (Dutch Side)

Seminar for Water management in Japan and the Netherlands

Lecture (Dutch side)

Lecture (Japanese side)

Discussion on Risk Assessment in Both Countries

2019.6 Climate Change Adaptation Delegation to the Netherlands

■ June 2019, Hokkaido Regional Development Bureau sent another delegation led by Prof. Nakatsugawa to the Netherlands to exchange with Dutch water management experts.

Exchanged Organizations and Contents

Organization	Main Contents
Rijkswaterstaat Rivierenland Water Board	Future River Management ・Background and Overview of Project, Room for the River ・New program for river management Organization relevant to Water Management in the Netherlands ・Tasks and responsibilities
City of Dordrecht	Risk management in Dordrecht ・Impact analysis method and analysis results ・Overview of Flexible evacuation strategy ・ How to apply Multi-layer safety
Rijkswaterstaat	Depoldering of the Noordwaard ・Development of Evacuation route ・Efforts for Ecological Reservation
Rijkswaterstaat/Deltares /TU Delft/HKV consultant	KICK OFF meeting for Joint Research between Japan and the Netherlands
Deltares	Details of Climate Change Projection in the Netherlands ・How to determine Delta scenarios ・How to use RCP Scenarios Cost Benefit Analysis in the Netherlands ・Overview of dynamic/static cost benefit analysis ・Monetizing human life
Rijkswaterstaat	Flood Protection Standard in the Netherlands ・How to determine flood protection standard ・Concept of evacuation rate Flood Control Scheme in Japan

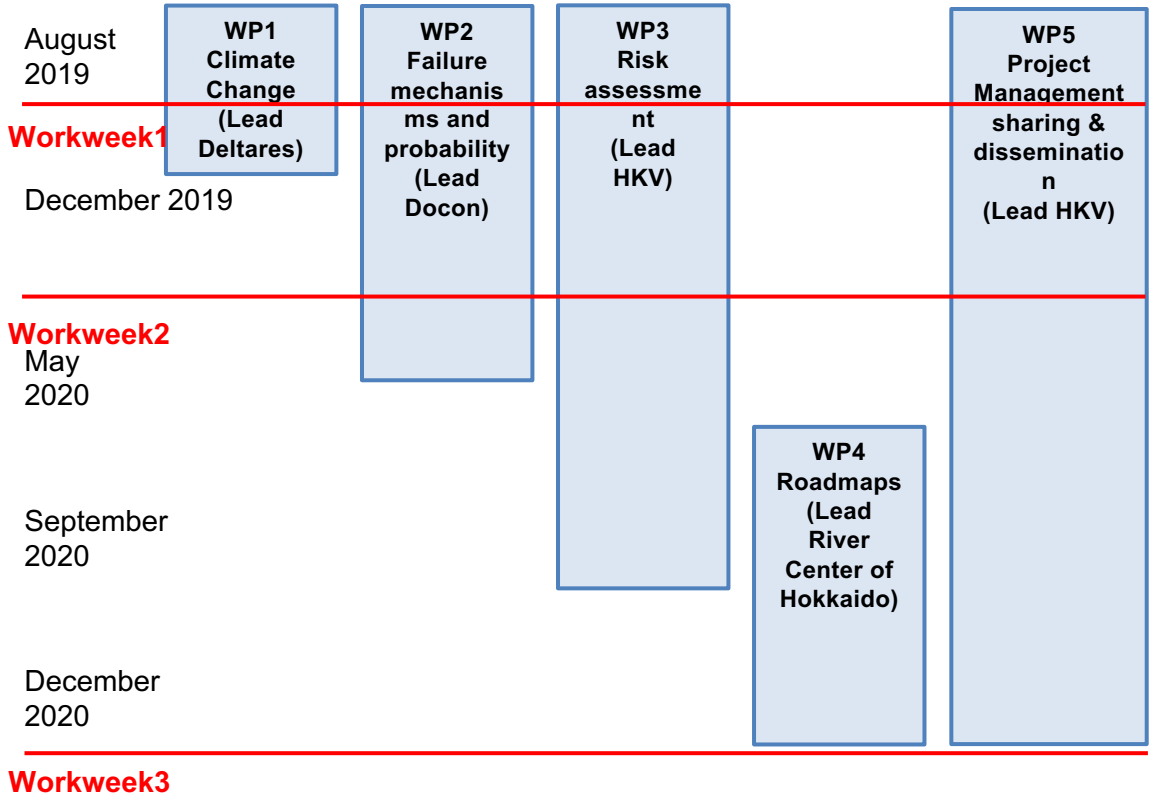
Discussion(HKV)

Discussion(Rijkswaterstaat)

Joint Research between the Japan and the Netherlands

- Dutch Enterprise Agency(Rijksdienst voor Ondernemend Nederland) has supported innovative projects by subsidizing scheme “Partners for Water” for internationally oriented Dutch business.
- By subsidy system of Partners for Water, HKV consultant , Deltares, TU Delft, River Center of Hokkaido, Docon, and Hokkaido University decided to start a joint research between Japan and the Netherlands on “Flood Risk and Climate Change Hokkaido” (Selected in May 2019 and started in August 2019.)

Five work packages in the project



Work Packages	Contents of 5 work packages
WP1	Determine the effect of climate change on the frequency and scale of flood risk hazards.
WP2	Determine relations between climate change and meandering rivers related to dike failure.
WP3	Combining the results from the first two work packages, a flood risk assessment is carried out for Hokkaido taking typhoons, rainfall (and high river discharge) and storm surges into account.
WP4	Determine research roadmaps and business roadmaps.
WP5	Knowledge sharing & dissemination & project management.

出典：※ Rijksdienst voor Ondernemend Nederland, PARTNERS VOOR WATER, https://www.partnersvoorwater.nl/

“Flood Risk and Climate Change Hokkaido” Work week1

- October 2019, Dutch team (HKV and Deltares) visited Japan, where Work Week 1 was organized.
- Target area of flood risk assessment in this joint research, Obihiro city, Hokkaido, in the midstream of Tokachi river was mainly visited for field survey, as well as Satsunaigawa Dam, Satsunai River, Tokachi River main stream and Pekerebetsu River.

Explanation of Dutch Expertise (Dutch side)

Explanation of Tokachi River basin (Japanese side)

Explanation of Satsunaigawa Dam in the management office

Explanation at Satsunai River

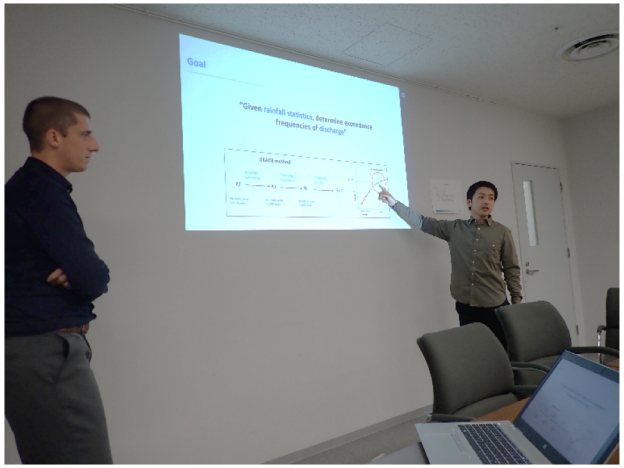
Explanation on bank of Tokachi River

Explanation at Pekerebetsu River

“Flood Risk and Climate Change Hokkaido” Work week1

- Work week was concluded by presentations on achievements and future efforts per WP and Q&A on the last day.
- Future approach: Each WP will construct a model and improve accuracy, which will be integrated into risk assessment in accordance with climate change.

Presentation on Achievement WP1
（Deltares and Hokkaido University）



Presentation on Achievement WP2
（Docon and HKV）

Presentation on Achievement WP3
（HKV and Docon）

UNFCCC SB50 (Climate Change Conference, Bonn, Germany)

Transformative adaptation and climate resilient development


Mr. Abdalah Mokssit (Secretary of IPCC)

Nation Level Committees for Future Flood Policy

2016: MLIT/Hokkaido Prefecture
- Agriculture
- Climate Change
- Risk Based Approach

2017: MLIT/Hokkaido Prefecture
- Applied thousands of Simulation for past and future
- Risk Assessment

2018: MLIT (headquarter)
- Nation wide discussion
- Temporal and spatial characteristics of rainfall

2019: MLIT/Hokkaido Prefecture
- Adaptation strategies for future flood control policy
- etc

2019/6/13 Japan to review flood plans as panel warns of more torrential rain from global

The Mainichi
Japan's National Daily Since 1922

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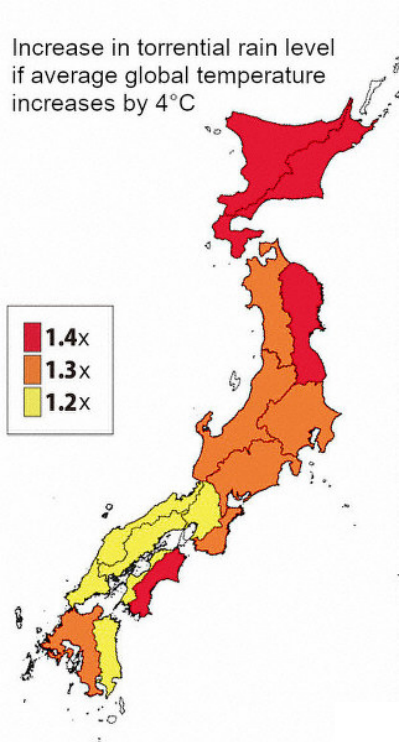
Japan to review flood plans as panel warns o… more torrential rain from global warming

Timeline

June 1, 2019 (Mainichi Japan)

0
Japanese version



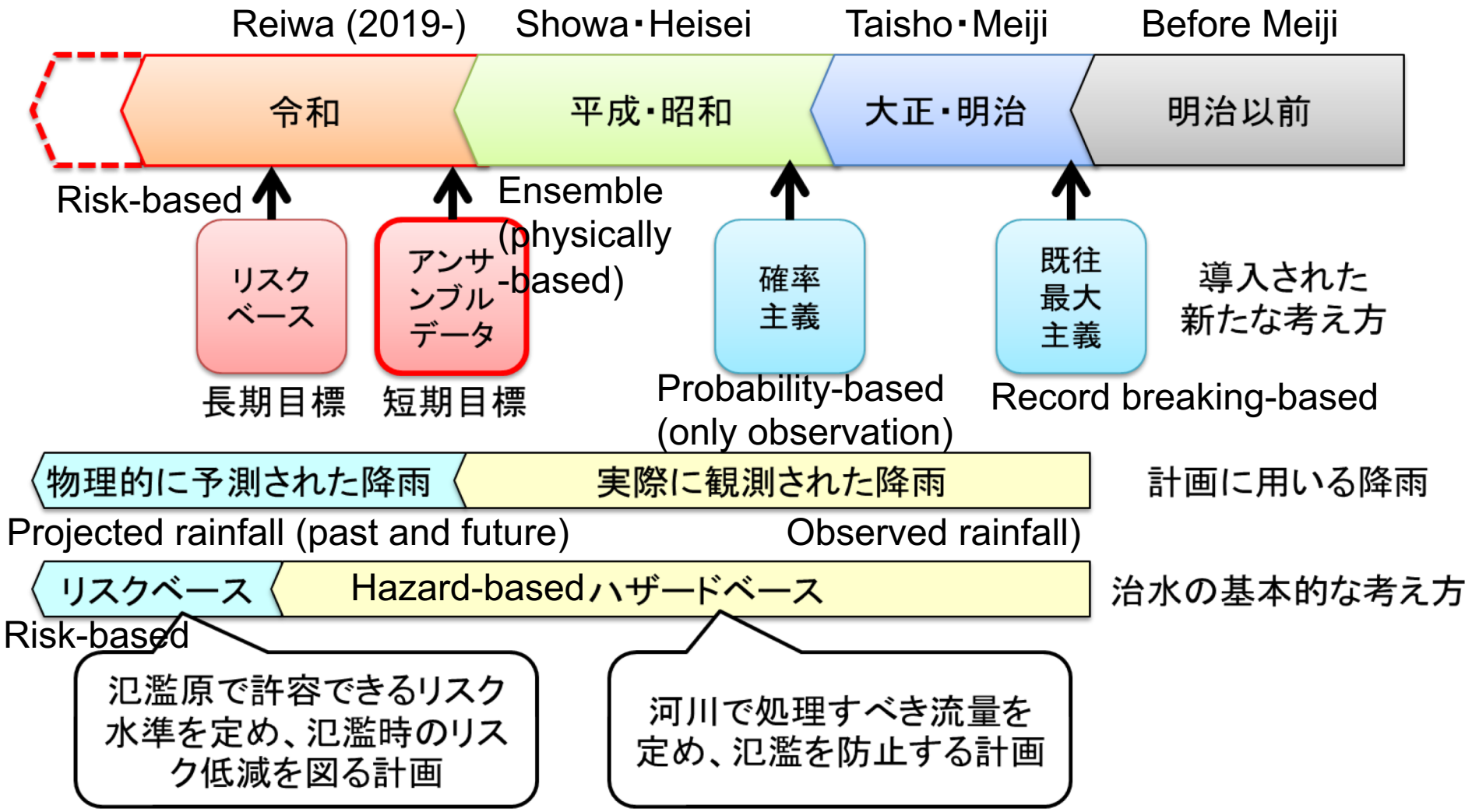
(Mainichi)

TOKYO -- The amount of torrential rain is likely to increase 1.1 times on average across Japan in the future due to global warming, and the rise should be factored into flood-control plans for state-managed rivers, a land ministry panel recommended on May 31.

【Related】Japan research group's free flood water website predicts Tokyo's wettest spots

【Related】Torrential rains in Kyushu could become more common, experts warn

Up until now, river management plans had been created for individual river systems based on the maximum rainfall each region had received during past downpours. But following the recommendation in a proposal drafted by a panel of experts at the Ministry of Land, Infrastructure, Transport and Tourism, the ministry is poised to switch to a method that incorporates future predictions for climate change.


Reiwa (2019-)
Showa・Heisei
Taisho・Meiji
Before Meiji
令和
平成・昭和
大正・明治
明治以前
Risk-based
Ensemble (physically-based)
リスクベース
アンサンブルデータ
確率主義
既往最大主義
導入された新たな考え方
長期目標
短期目標
Probability-based (only observation)
Record breaking-based
物理的に予測された降雨
実際に観測された降雨
計画に用いる降雨
Projected rainfall (past and future)
Observed rainfall)
リスクベース
Hazard-basedハザードベース
治水の基本的な考え方
Risk-based
氾濫原で許容できるリスク水準を定め、氾濫時のリスク低減を図る計画
河川で処理すべき流量を定め、氾濫を防止する計画