The New Inland Flood Model and Updated Typhoon Model for Japan

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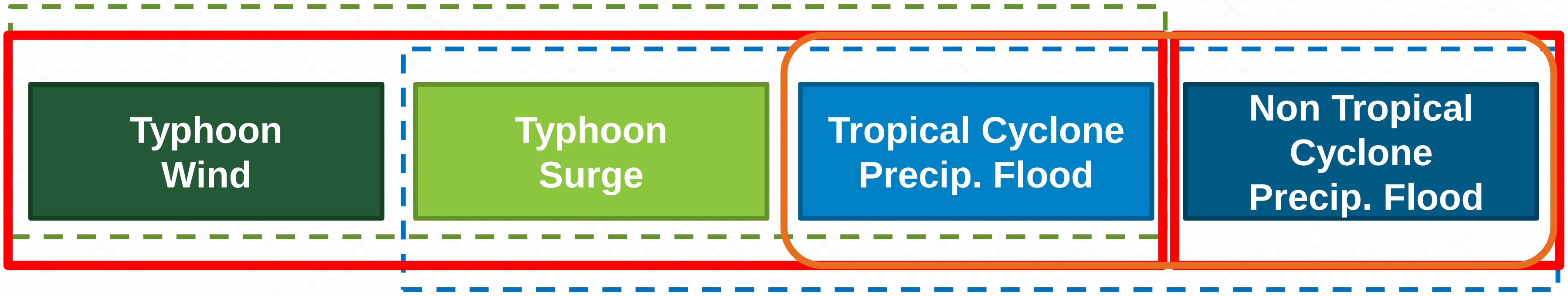
AIR WORLDWIDE®

Agenda

- Modeling Flood Hazard for Japan
- Modeling Flood Vulnerability for Japan
- Updates to the AIR Typhoon Model for Japan

Modeling Precipitation in Touchstone

Japan Typhoon Model

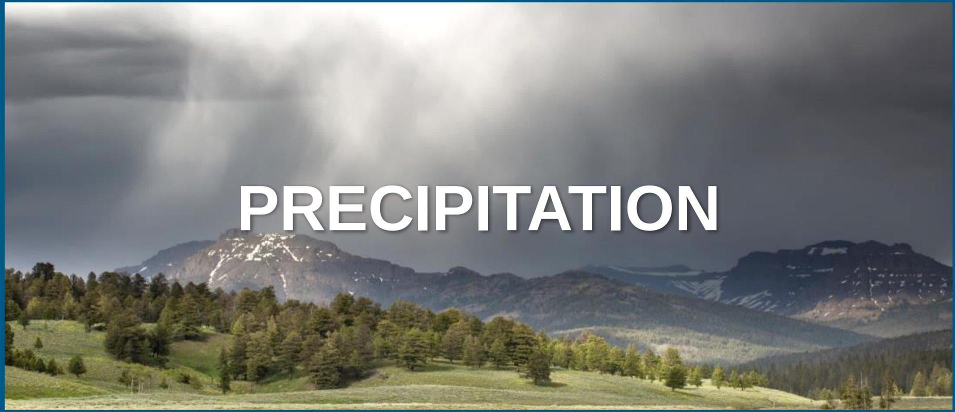


Japan Inland Flood Model

- **SOLUTIONS in Touchstone®:**
  - Two models in Touchstone
    - AIR Typhoon Model for Japan: wind, surge, tropical cyclone precipitation flood
    - AIR Inland Flood Model for Japan: non tropical cyclone precipitation flood

Modeling Flood Hazard for Japan

Flood Model Components



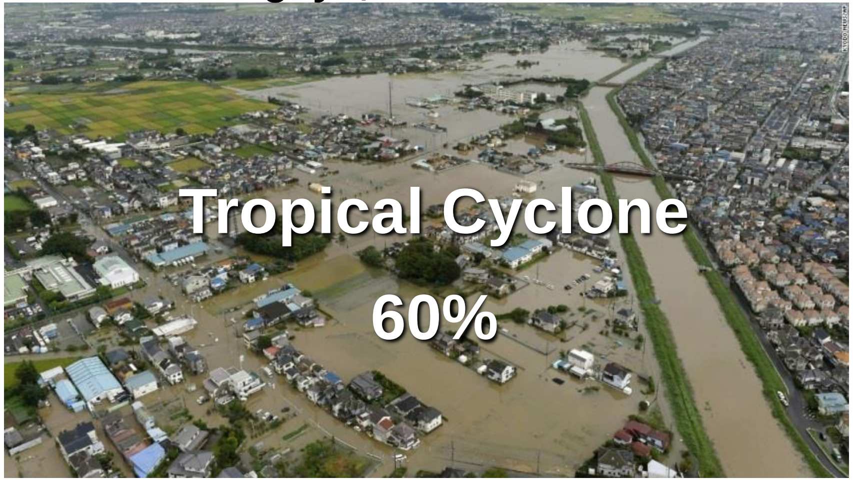
Flooding in Japan

Flood peril is a significant risk for Japan

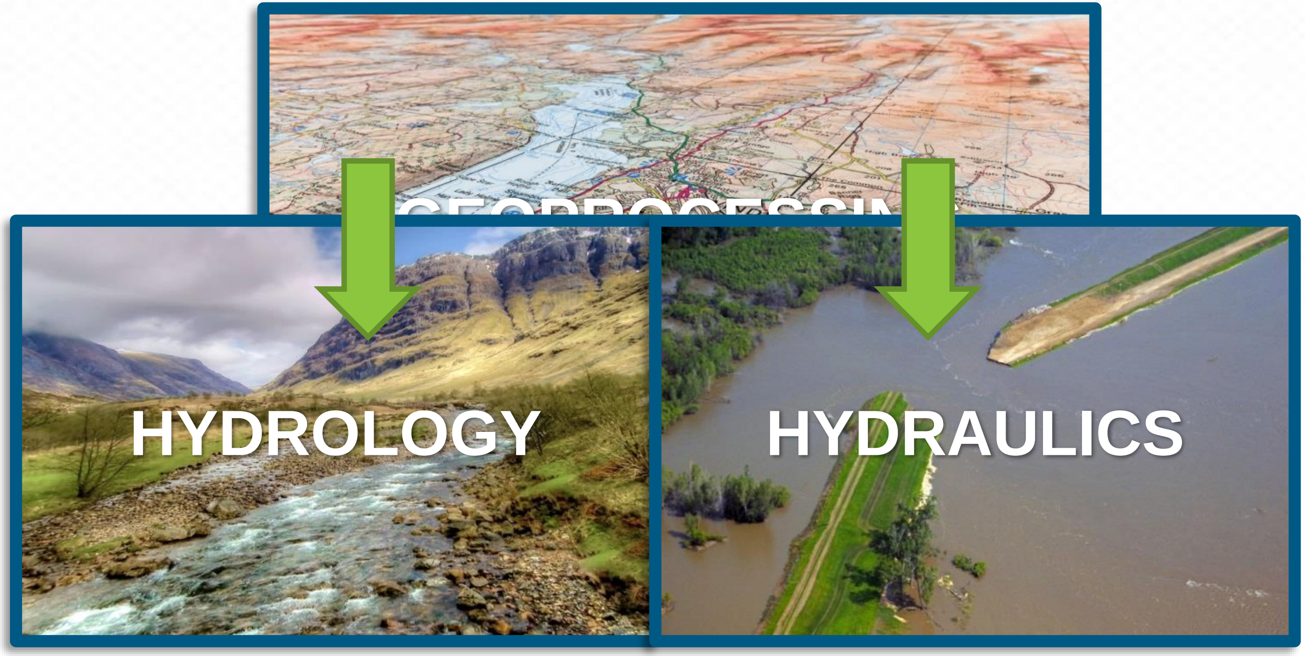
- 50% of population and 75% of assets located in a floodplain
- Major evacuations, loss of life, and billions in damage

Aso, Kyushu - 2012

Koshigaya, Honshu - 2015

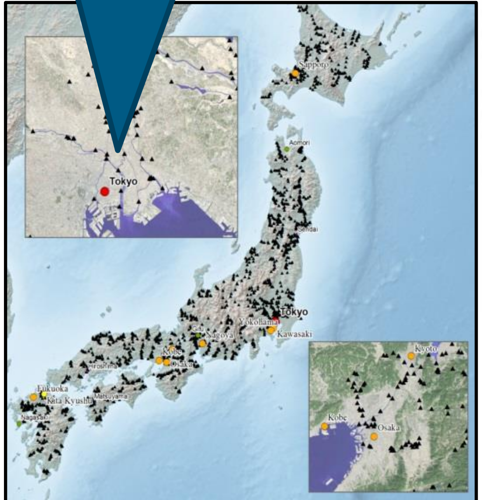


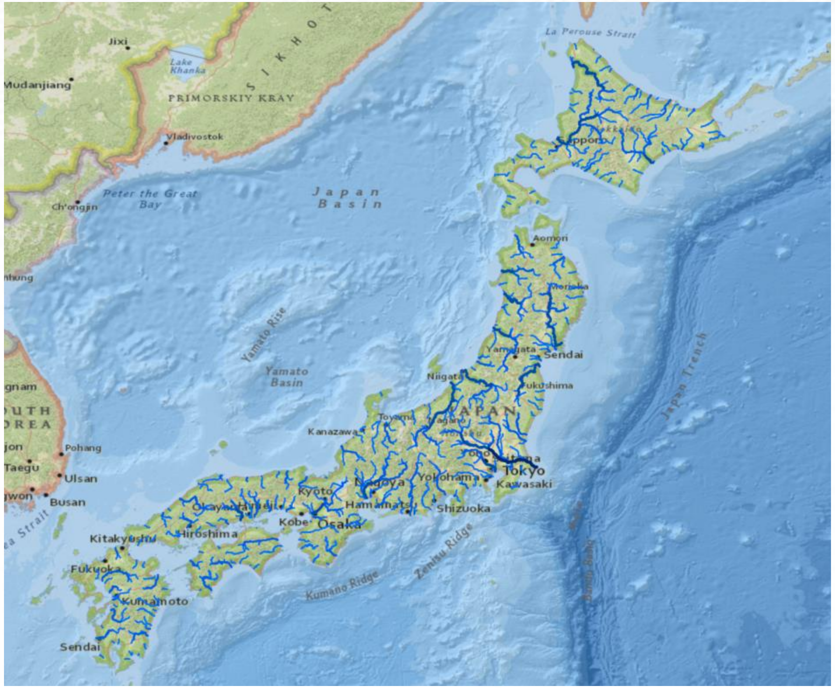
Geoprocessing



17,425
river
segments

~1,000
streamflow
gauge stations





~1,100
dams & Reservoirs

103,000 km
total stream
length

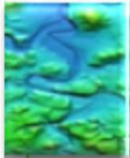
338,000 km²
modeled

20,263
catchments

Geoprocessing Data Layers

Model Boundary:

Country Border



Digital Terrain Model (DTM):

Provided by MLIT

River Network:

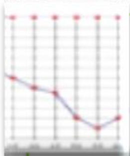
Derived from DTM

Unit Catchments:

From DTM & River Networks

Catchment Properties:

Land Use: JAXA, MODIS, AIR , Impervious Surface: NOAA & Soil: MLIT



Cross Sections:

MLIT & DTM River Network

Flood Defenses:

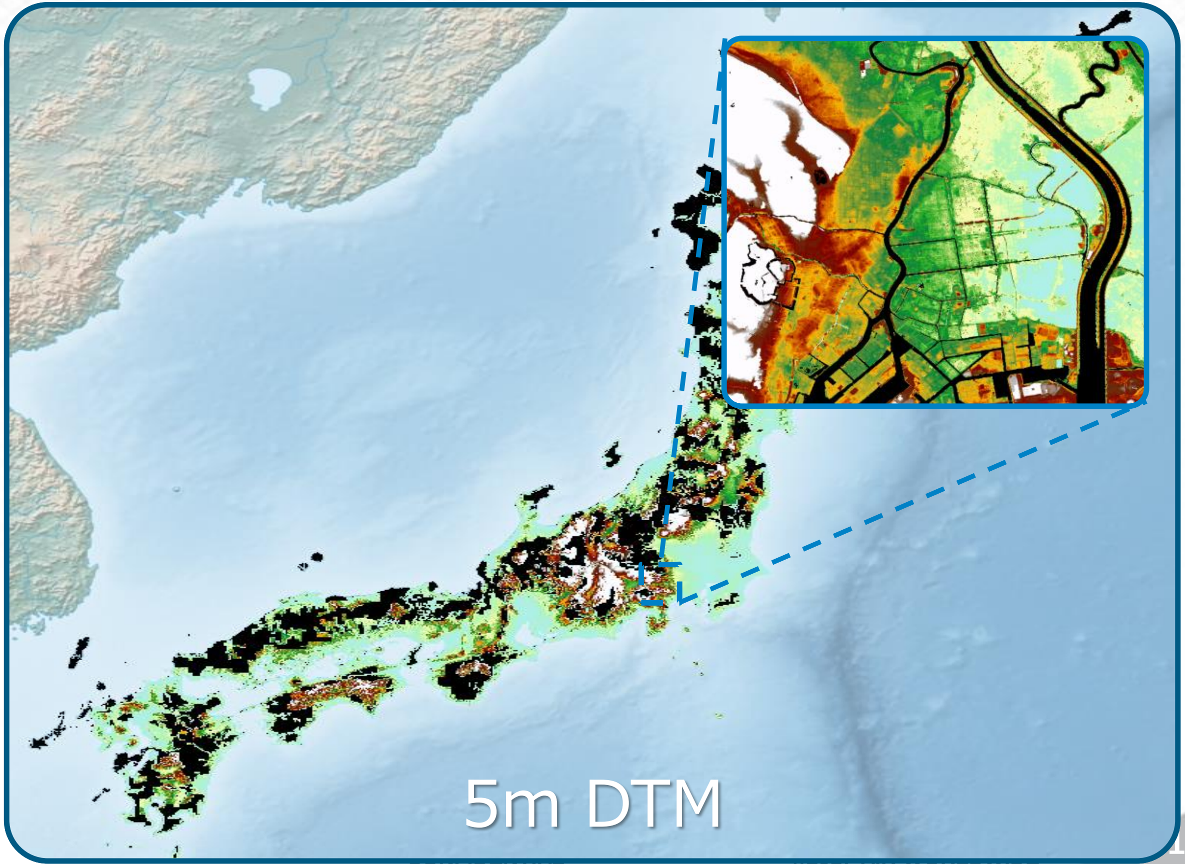
DTM & River Network

Dams & Reservoirs:

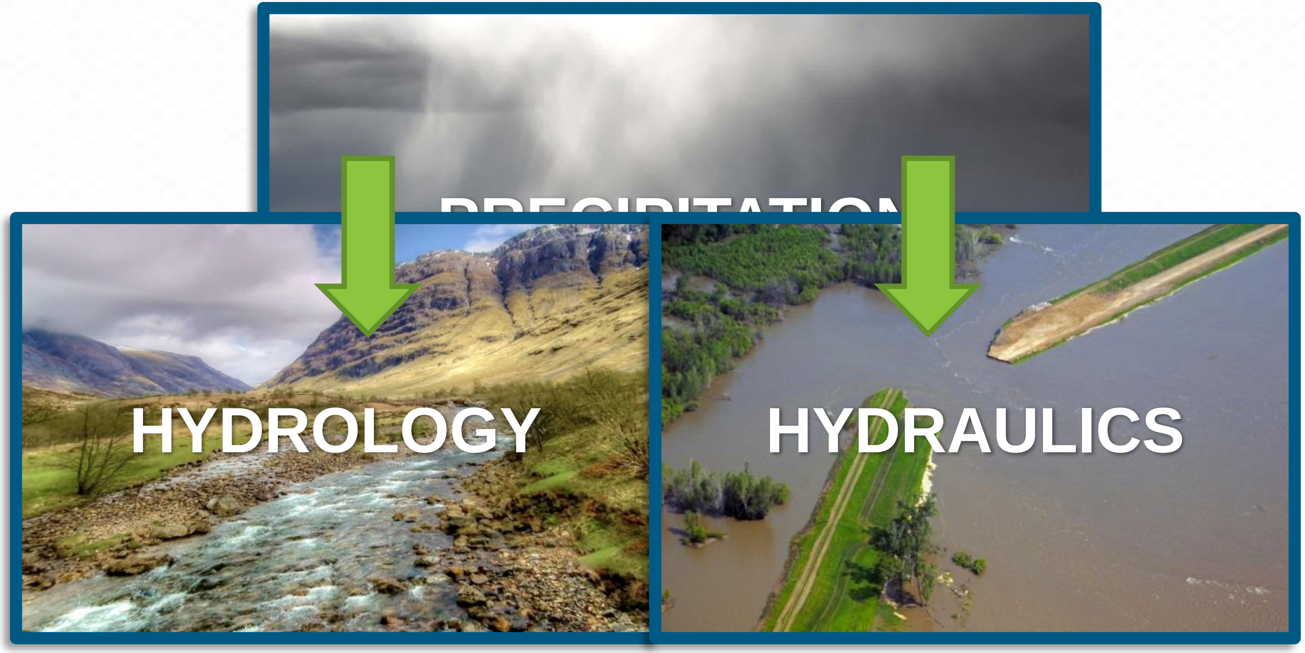
MLIT, iCold, GRAND & SRTM

Japan Digital Terrain Model Availability

- 5m DTM covers 60% of Japan
- Most major cities and rivers included
- 10m DTM used to supplement remaining area

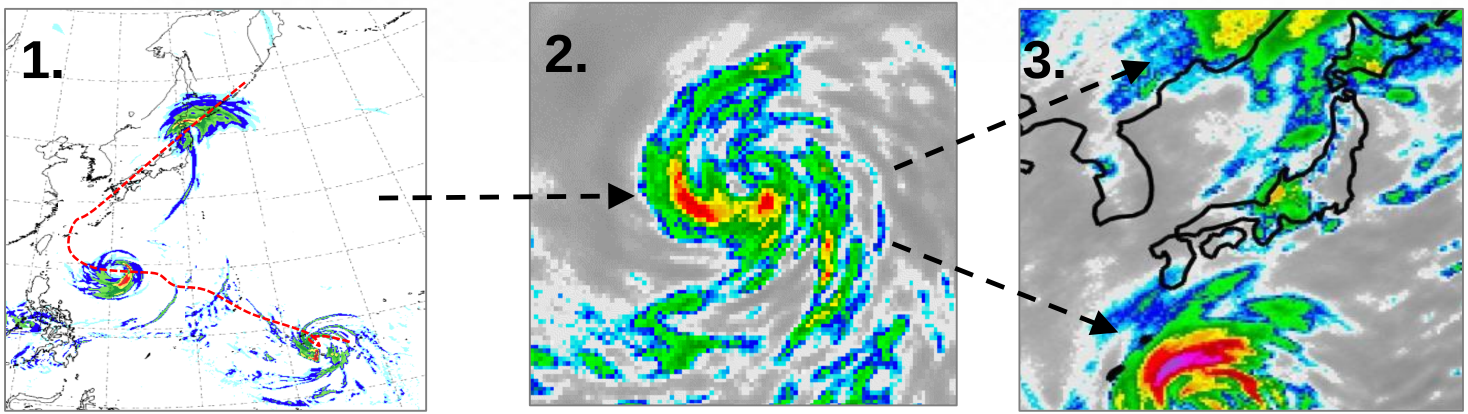


Precipitation Generation



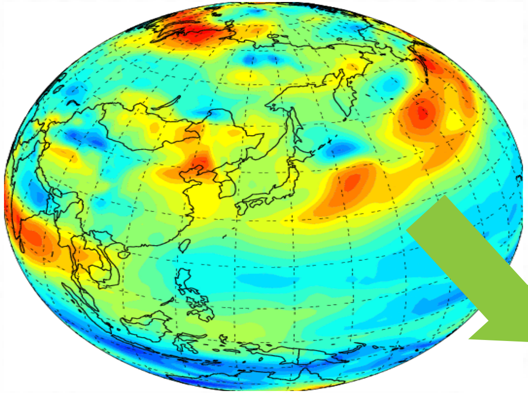
Overview of Steps for Simulating Precipitation

1. Numerical modeling of historical TC events and non TC rainfall
2. Stochastic simulations of precipitation learning from numerically modeled precipitation
3. Blending of non TC and TC precipitation.



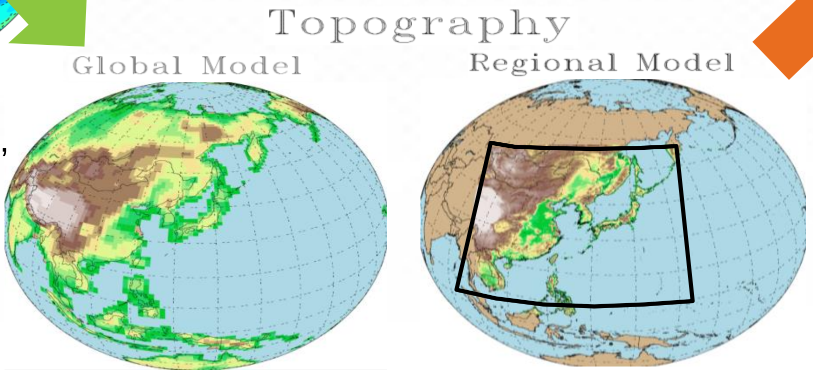
Step 1: Numerical Modeling

Coarse-Resolution Global Model



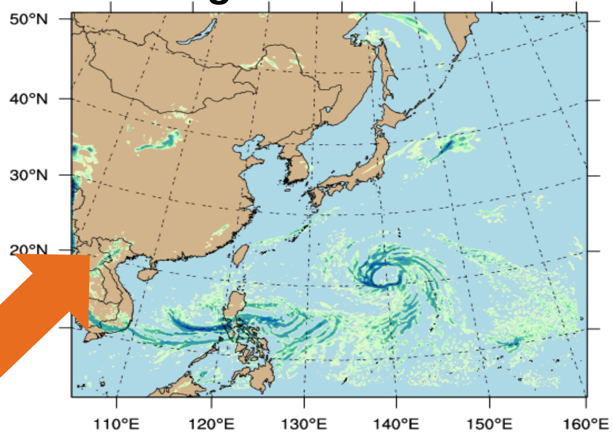
General Circulation Model, Reanalysis Data

downscaling



Regional Domain Selection for Numerical Weather Prediction (fine resolution)

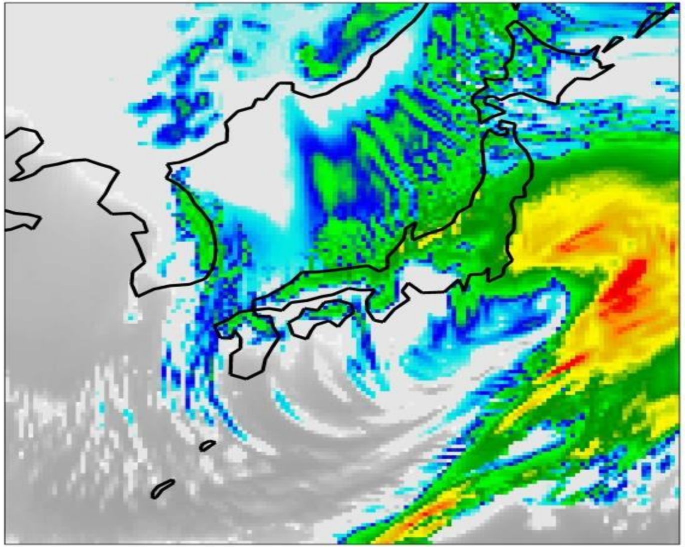
Fine-Resolution Regional Model



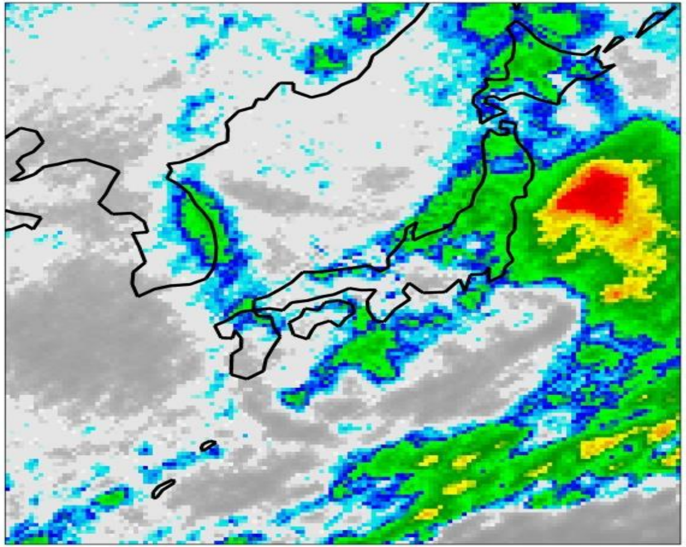
Numerical Weather Prediction Model

Step 2: Stochastic Simulation of Non TC Precipitation

Numerical Weather Prediction Model



Stochastic Simulation Output



Statistically robust perturbation of precipitation patterns

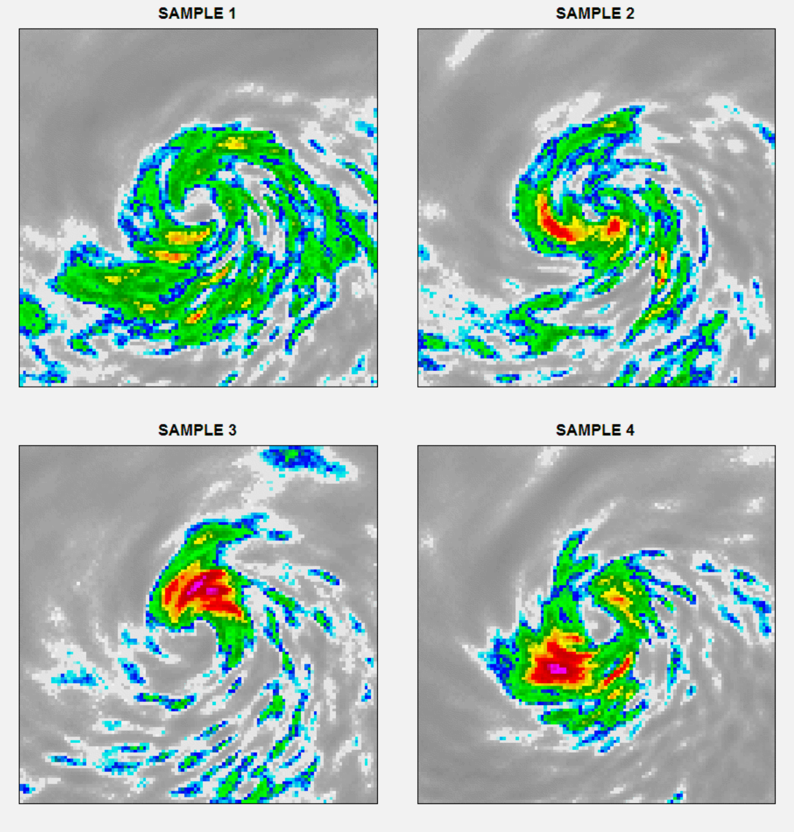
Step 2: Stochastic Simulation of TC Precipitation

Group models in bundles representing different stages during a typical TC life cycle:

1. Central pressure
2. Storm evolution time (genesis, dissipation, etc.)

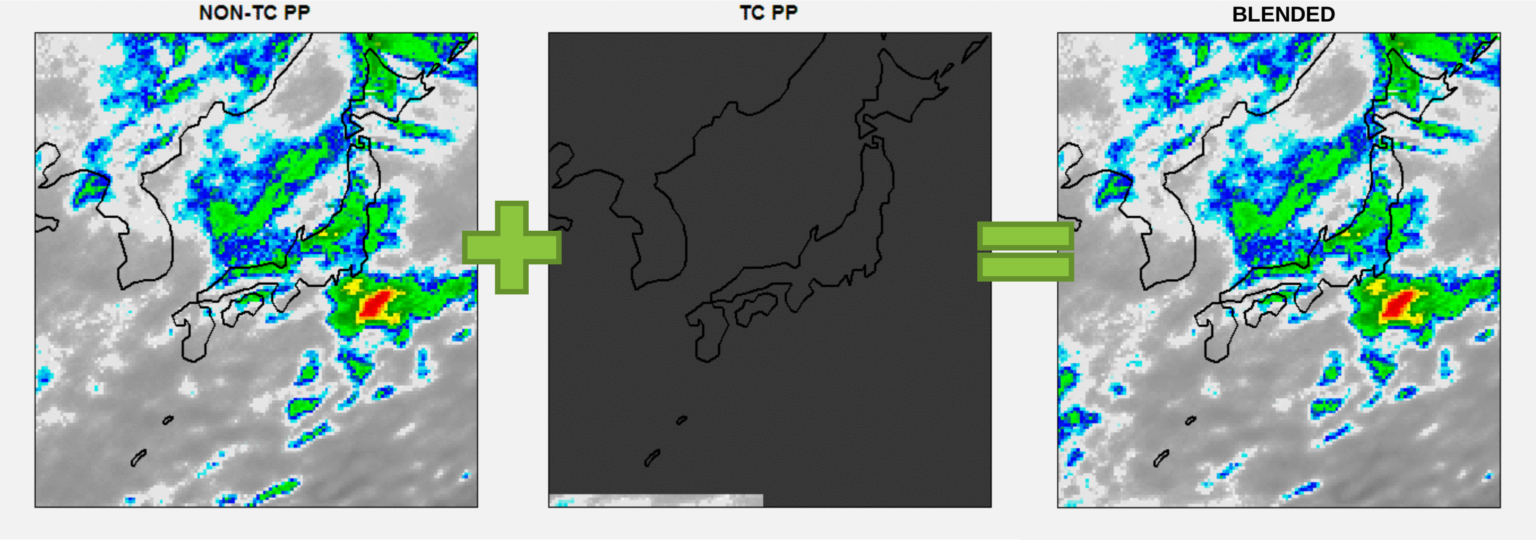
At simulation stage, draw samples from distinct models according to stochastic tracks:

1. Central pressure value
2. Time within storm cycle of stochastically simulated Japan catalog track



Step 3: Blending Non TC and TC Precipitation

Tropical cyclone simulations are blended into the non tropical cyclone rainfall simulation



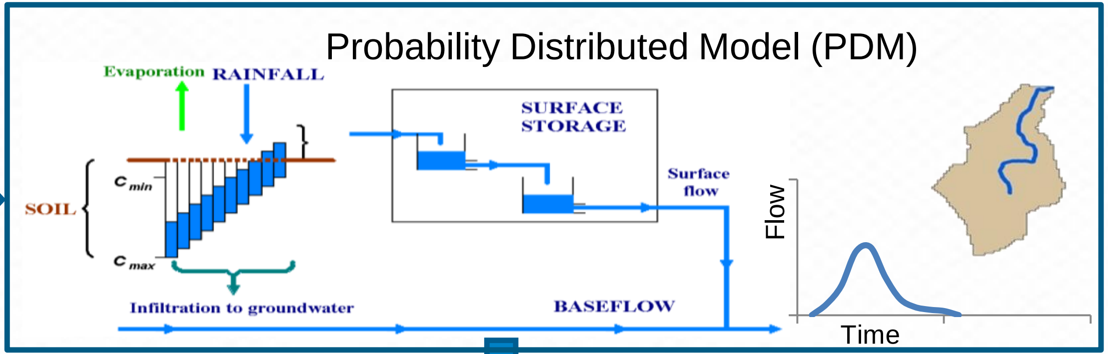
Hydrology Model

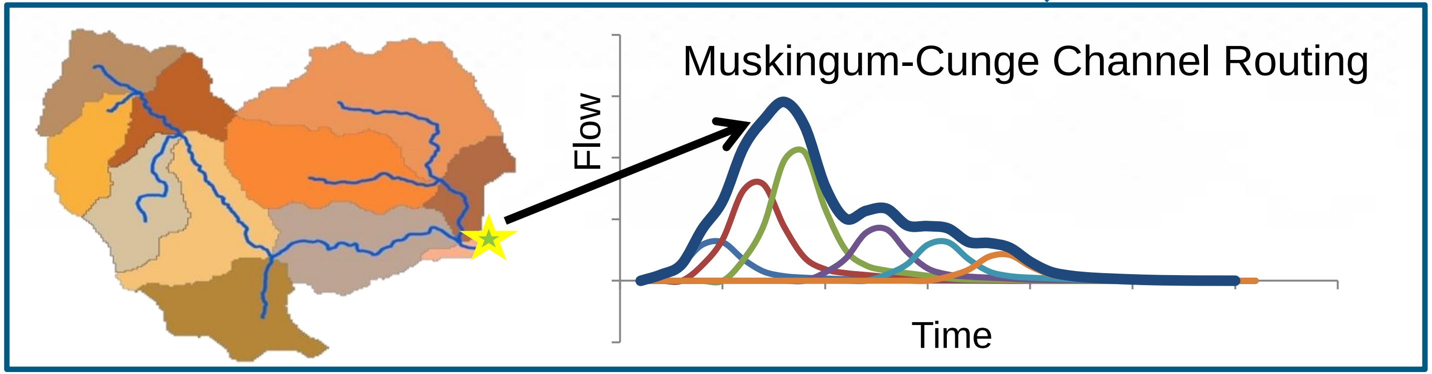
Hydrologic Model: Transforming Precipitation to Flow

Precipitation

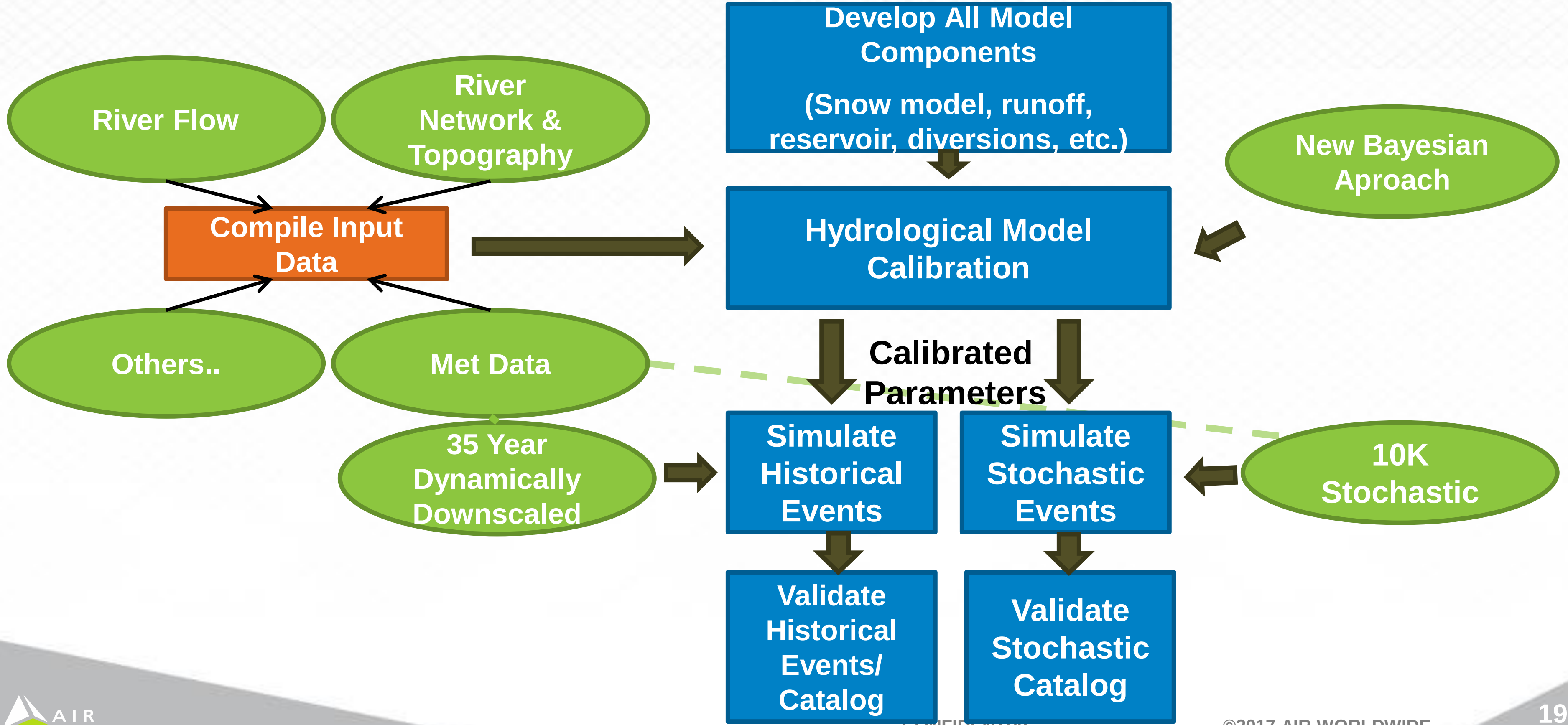
Runoff and Flow Generation

Snow Model

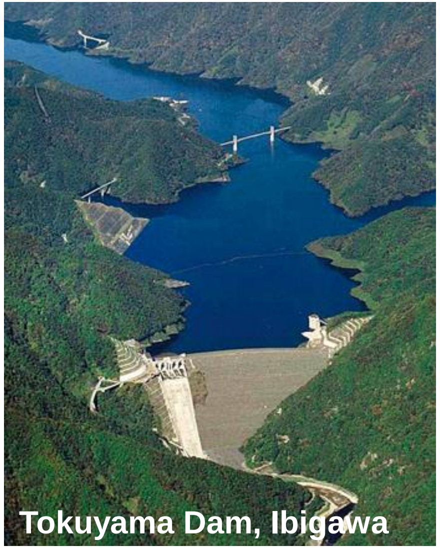




Hydrologic Modeling Stages



Reservoirs, Dams, and Diversions



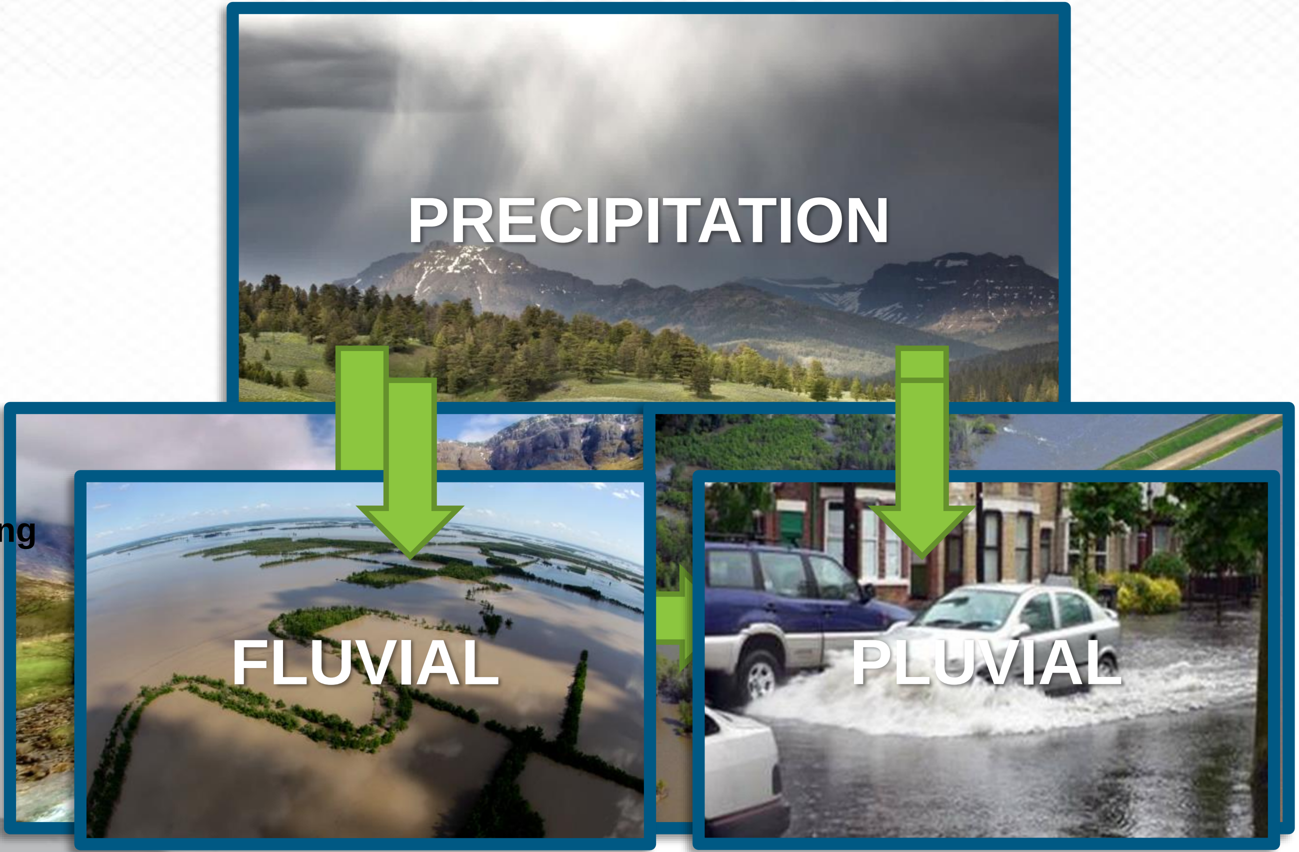
- Reservoirs/dams significantly attenuate the flows downstream
- The operation rules (reservoir rule curves) determine the desired reservoir stage at any given time

Hydraulics Model

Riverine flooding

On-floodplain

Widespread

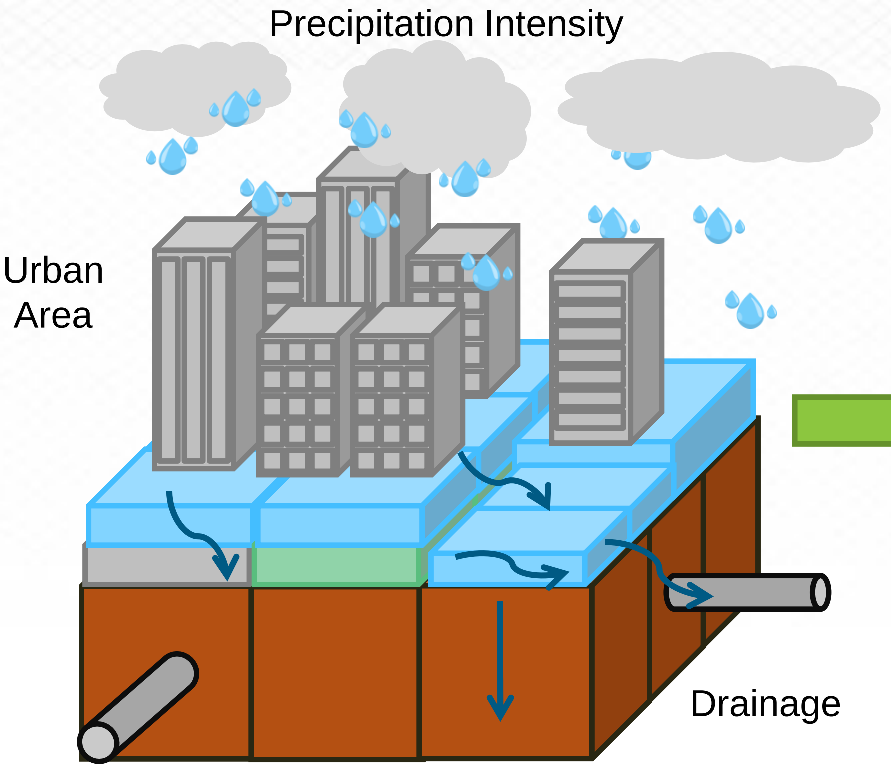


Flash flooding

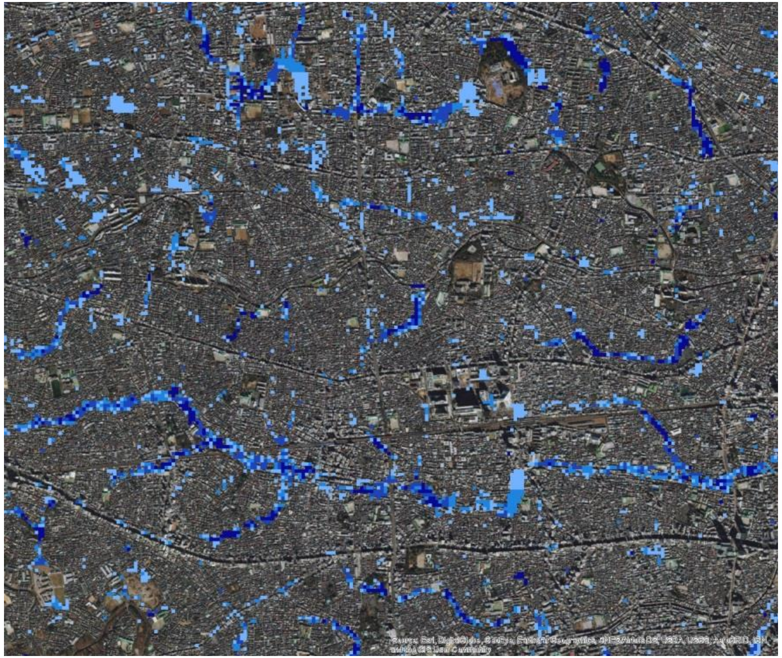
Off-floodplain

Localized

Pluvial: New Off-Plain Flood Model

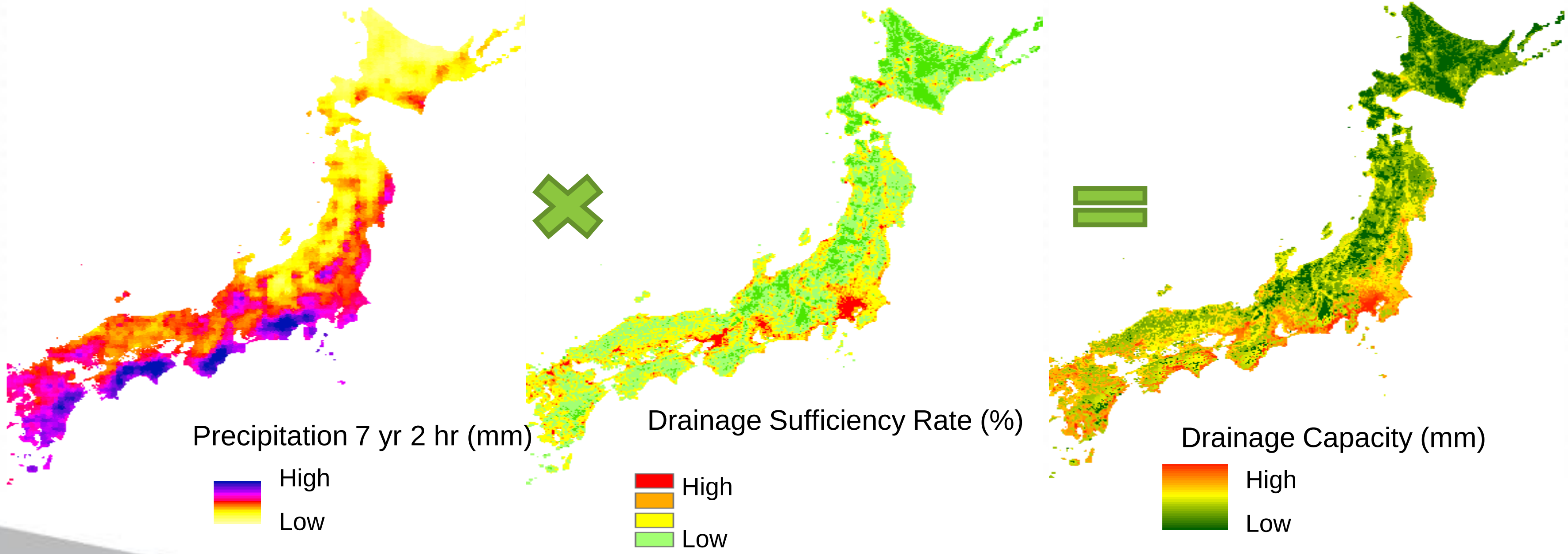


2D Pluvial Model Schematic

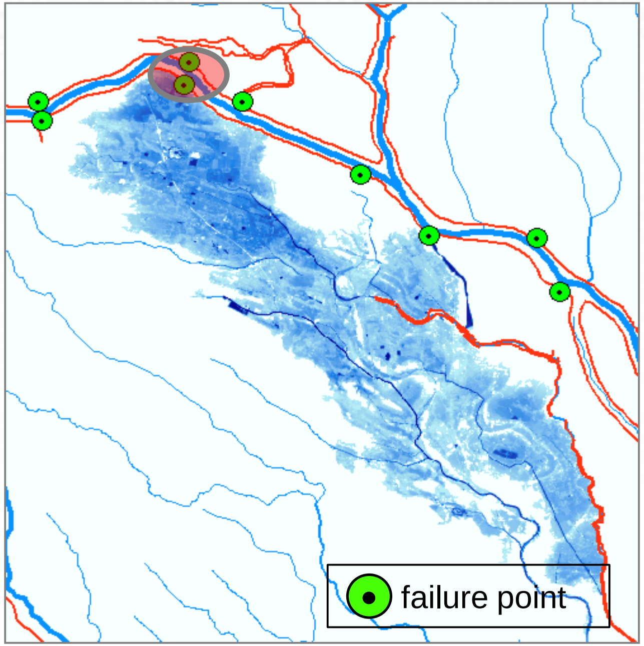


Pluvial Flood Model: Storm Drainage Capacity in Urbanized Areas

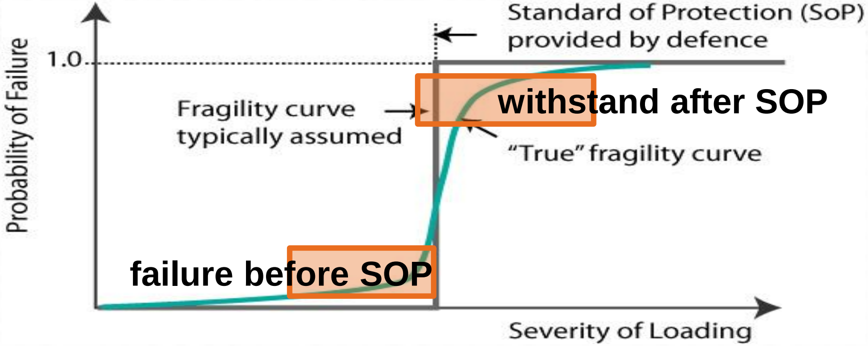
Drainage sufficiency rate and design precipitation are used to estimate storm drainage capacity



Fluvial: Explicit Two-Dimensional Modeling



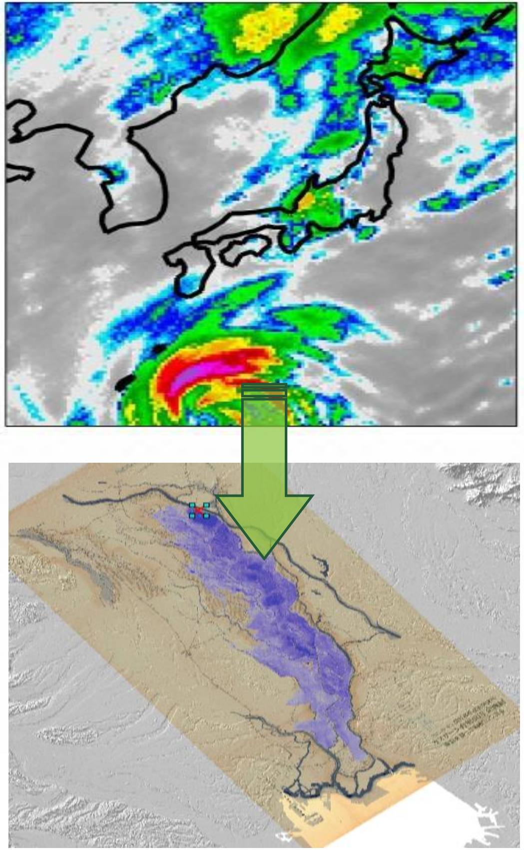
Wide floodplains modeled more effectively, with a more-robust approach and more-complex conditions



Flood defense failures are dynamically simulated with one-sided failure possible

Summary of Advancements

- Unified view of hazard, including tropical cyclone and non tropical cyclone rainfall
- New, improved approach to hydrologic model calibration, as well as detailed reservoir representation
- New physically based off-plain flood model explicitly simulates pluvial flooding
- Explicit modeling of certain failure points, including one-sided flood defense failure

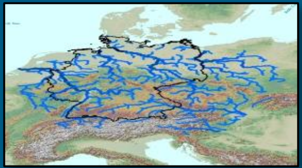


Modeling Flood Vulnerability for Japan

AIR

AIR's Inland Flood Modeling Experience

Inland Flood Model for Germany



Inland Flood Model for Central Europe

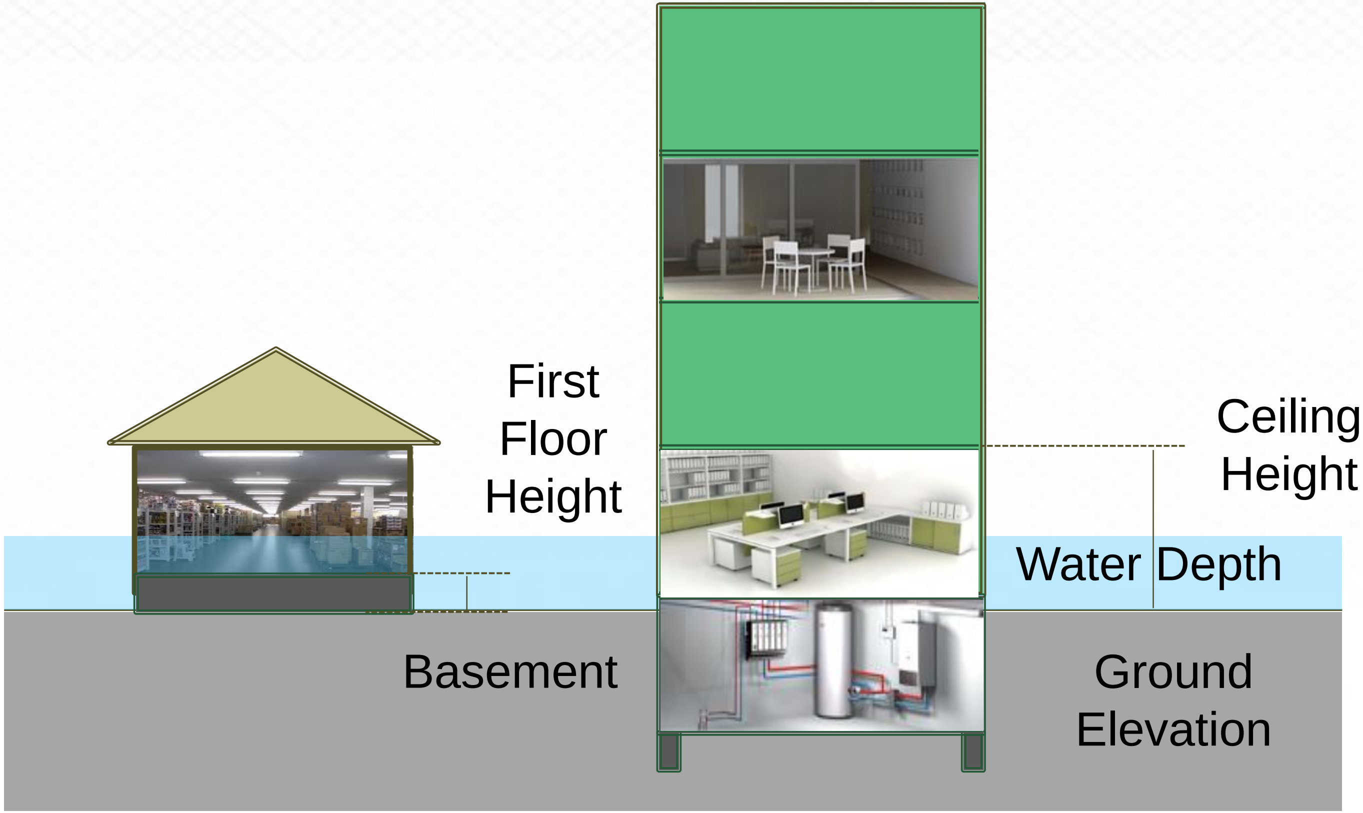
2008 2011 2014 2015 2017

Inland Flood Model for Great Britain

Inland Flood Model for the United States

Inland Flood & Typhoon Models for Japan

Vulnerability Modeling Framework: Overview of Risk Features and Modeling Approach

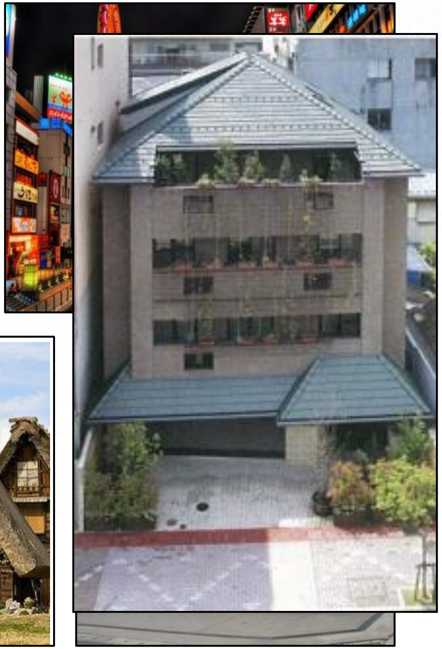


Vulnerability Modeling Framework: Overview of Risk Features and Modeling Approach

Primary Risk Features Supported in Japan

Conventional Occupancy, Construction, Height, and Coverage




- Composite Construction Class (Fire Codes)
- Low Rise: 1-, 2-, and 3-Story
- Unknown at Prefecture level

Special Properties Supported in Japan Inland Flood Modeling

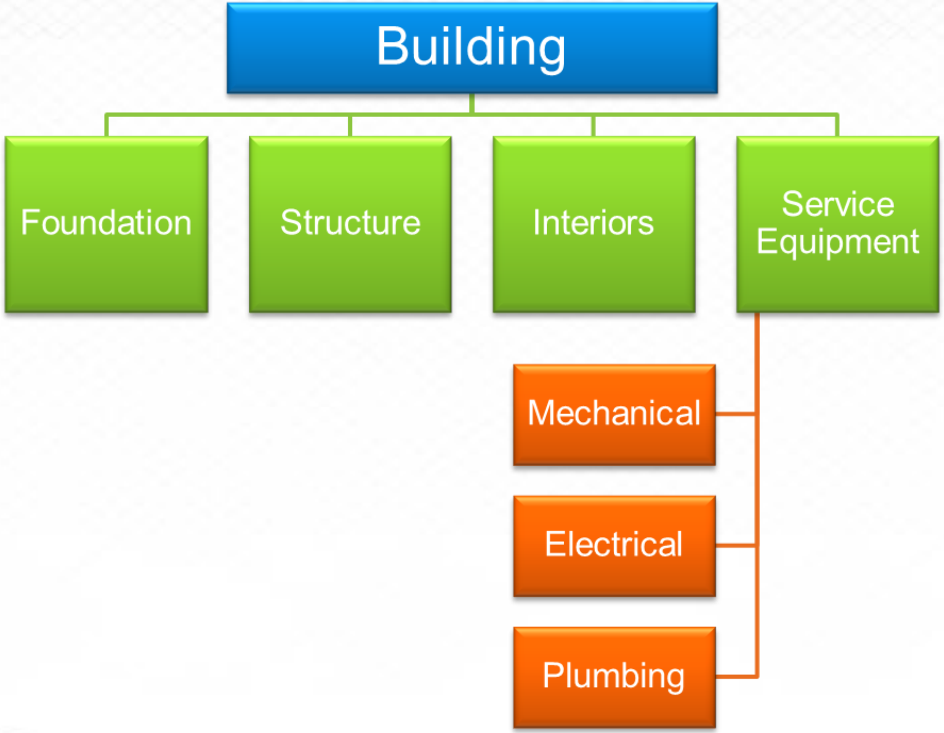
Marine, Inland Transit, Builder's Risk, and Railway





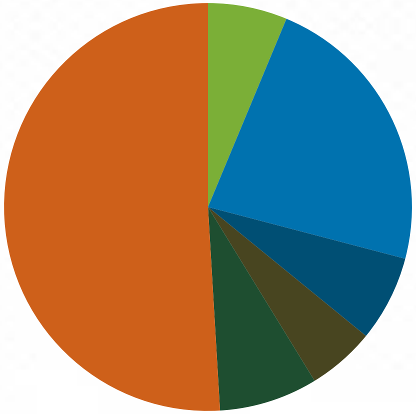

~147,000 unique damage functions

Vulnerability: Component-Level Approach to Developing Damage Functions

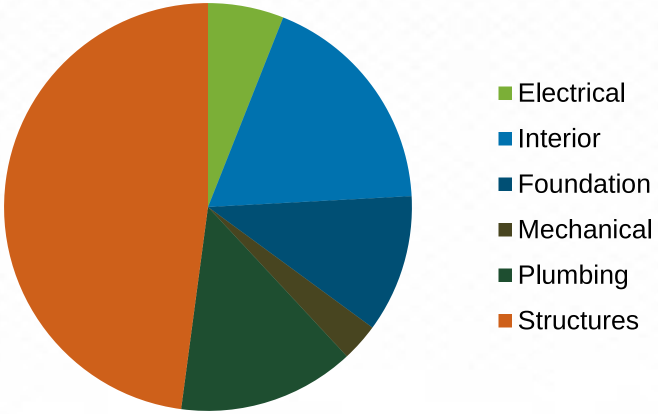


- Buildings are divided into 6 components, which total 100% of replacement value
- Component-level damage functions (DFs) are then combined in proportion to their contribution to the overall replacement value

Vulnerability: Component-Level Approach to Developing Damage Functions

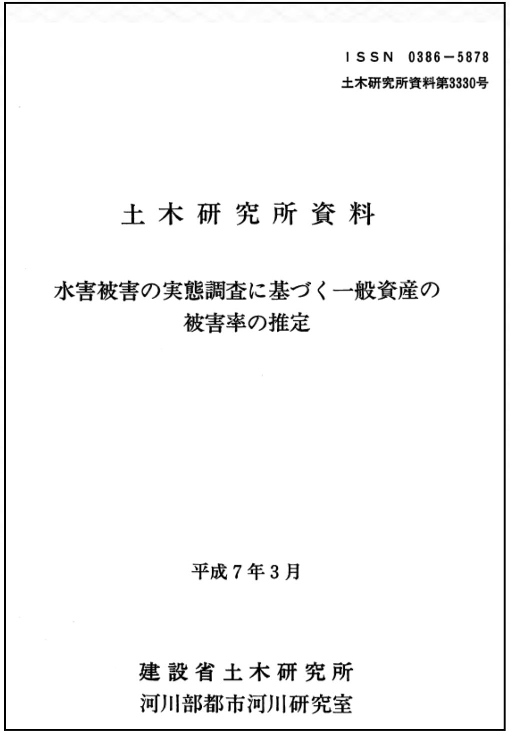


U.S. Single-Family Home: Wood Building



Japan Single-Family Home: Wood Building

Data Sources for Vulnerability Model Development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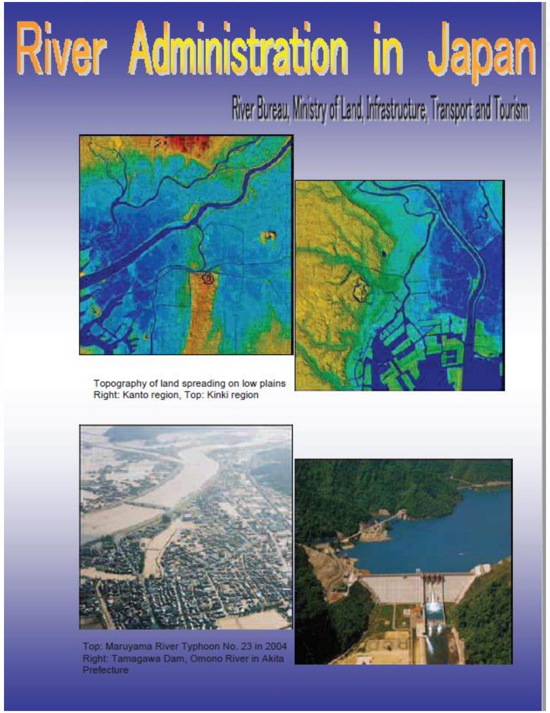
水害被害の実態調査に基づく一般資産の
被害率の推定

平成７年３月

建設省土木研究所
河川部都市河川研究室

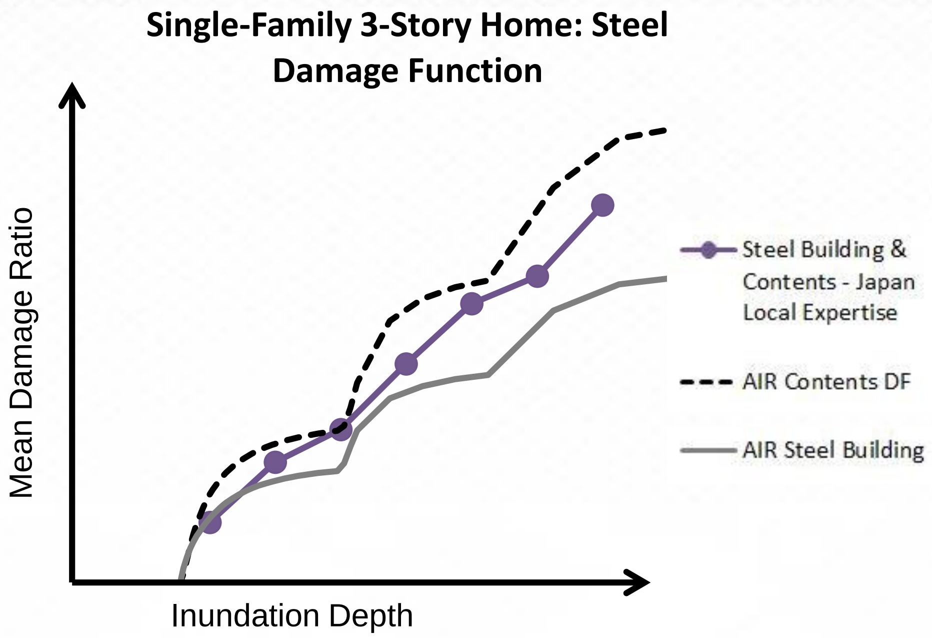
Japanese & Global Publications

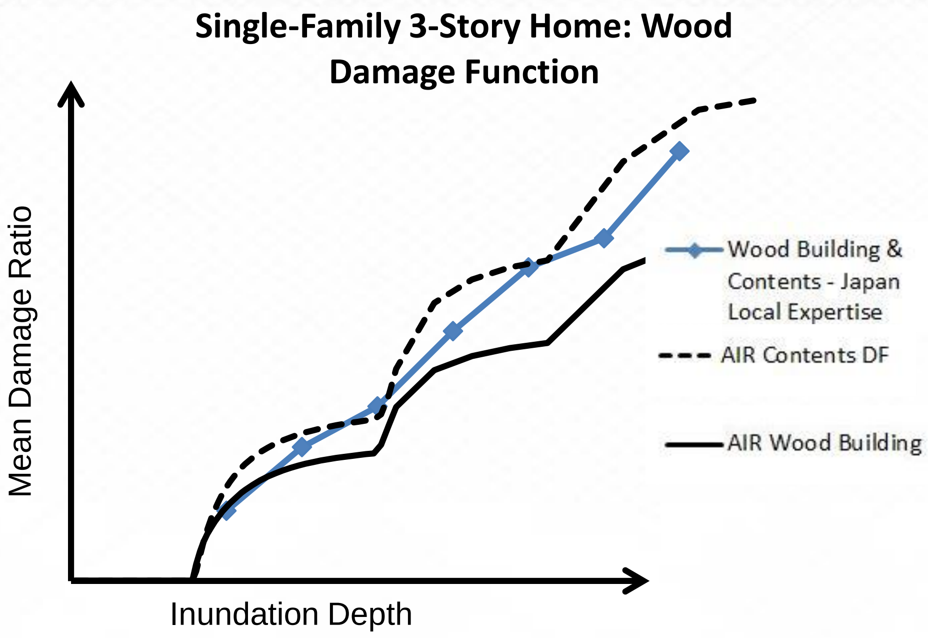
- Construction Research Institute Monthly Price Index
- Japan Survey and Inter-Risk Research Institute
- Japanese Architecture Disaster Prevention Association



Ministry of Land, Infrastructure and Transport Water Management (MLIT)

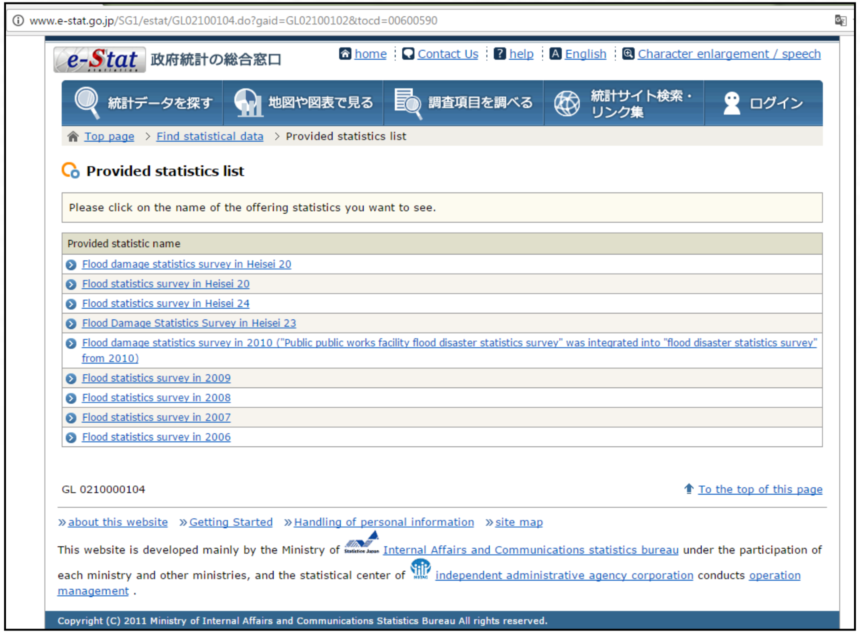
Component-Based Damage Functions Evaluation

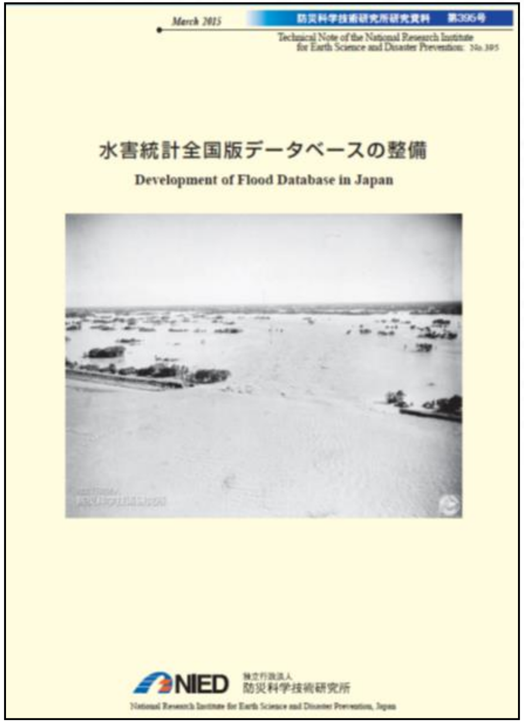




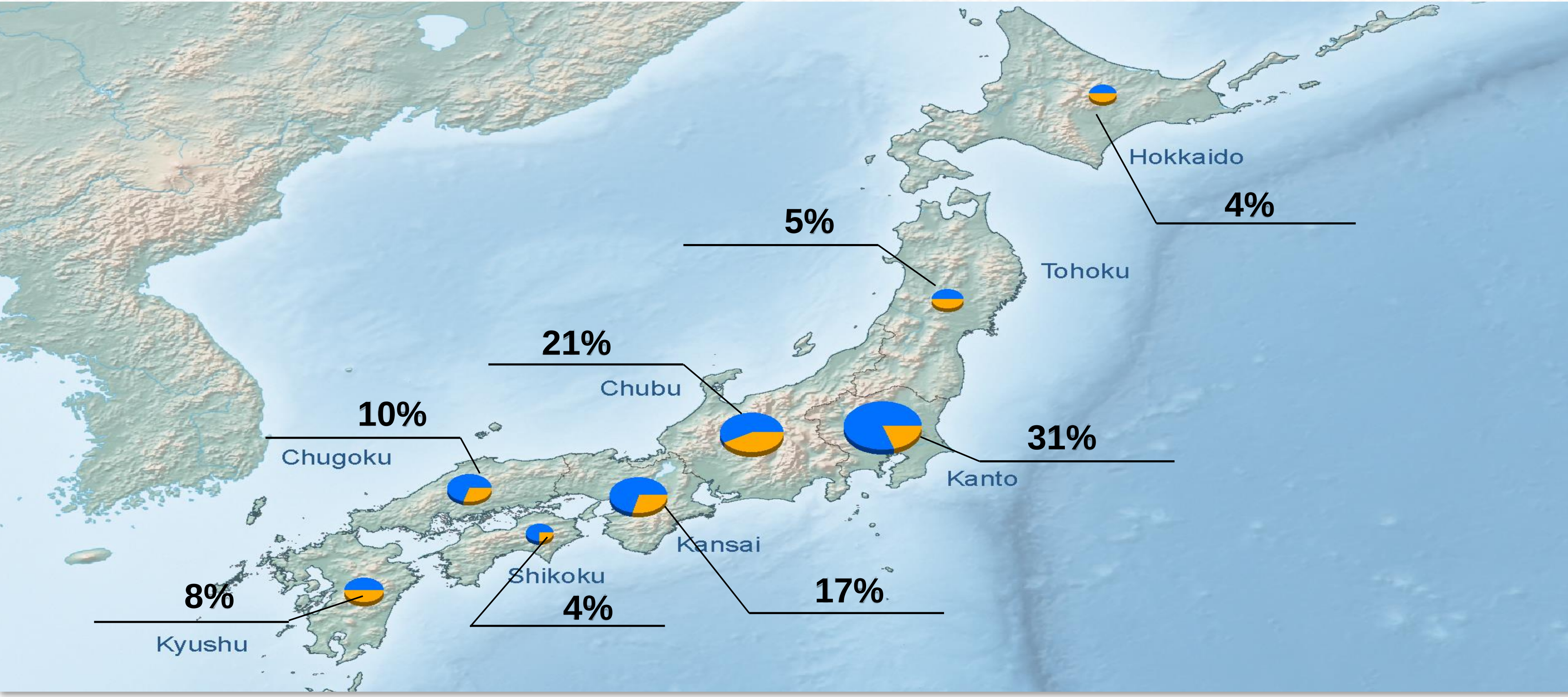
Benchmarking Loss Sources for Loss Validation

- MLIT National Flood Database
- Industry reports and research publications about major historical events losses

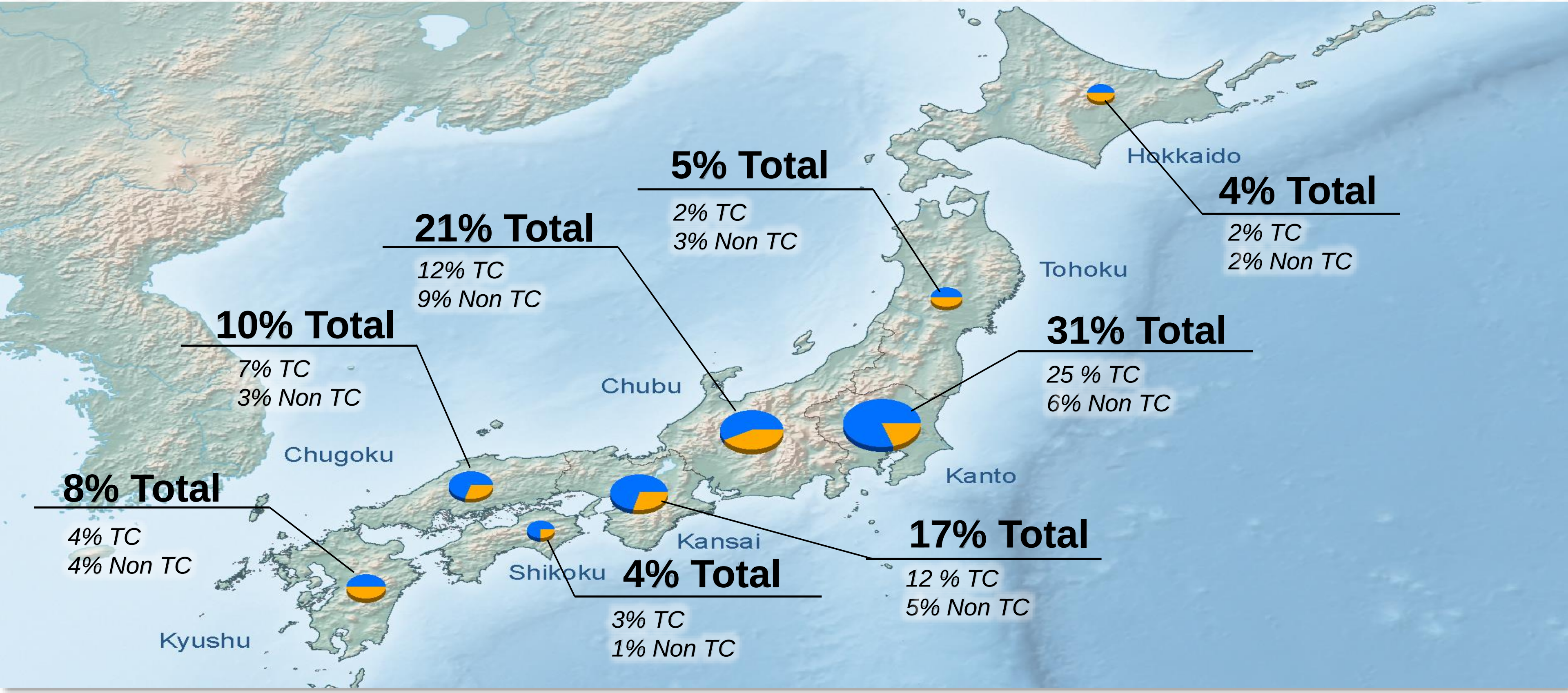




Regional Distribution of Total Flood Risk



Regional Distribution of Flood Risk for TC and Non TC Flood



Updates to the AIR Typhoon Model for Japan

Updates to the Typhoon Model for Japan

2002 — Released the first AIR Typhoon Model for Japan

2007 — Updated the IED and enhanced building and time element damage function (supported old fire codes)

2010 — Became part of the Northwest Pacific Basinwide Typhoon Model, introduced flood module, and supported more LOBs (marine, inland transit, railway, etc.)

2012 — Introduced new IED and enhanced building damage function (supports new fire codes)

2015 — Introduced physically based storm surge module and minor wind vulnerability update

2017 — Introduce new IED, new flood module, and updated wind and surge modules

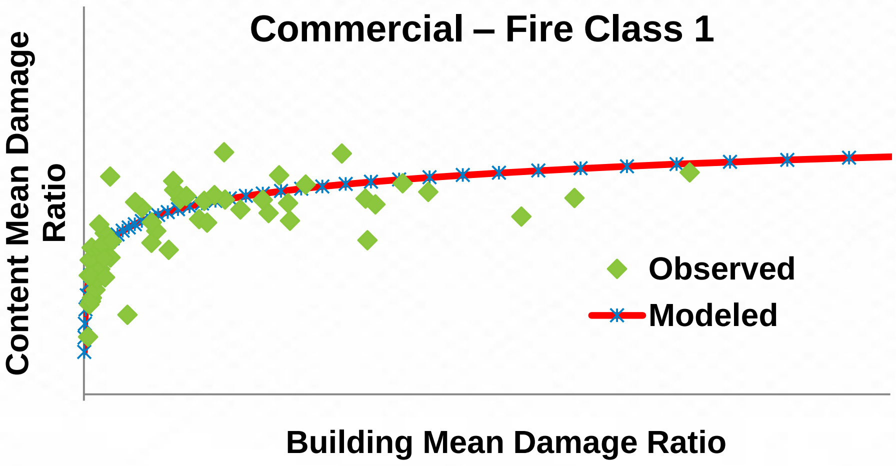
New Data Used to Evaluate the Model

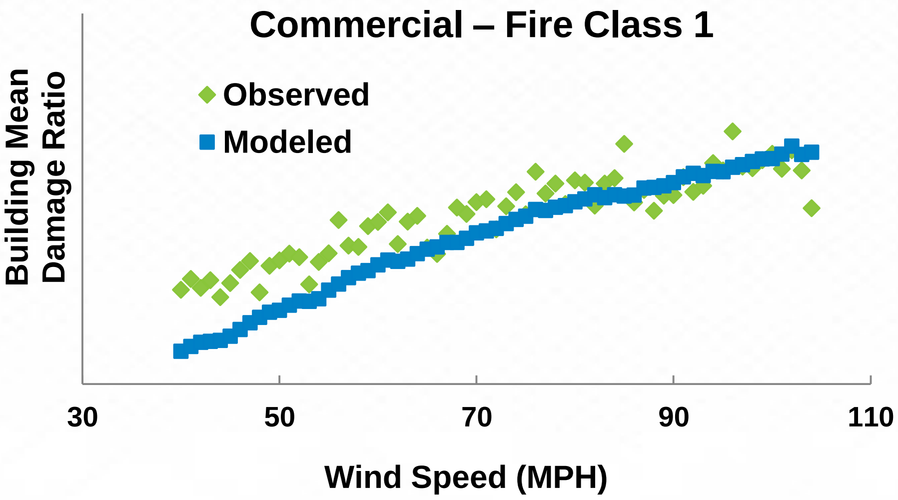
AIR has collected detailed claims and loss information from 2001 to 2015

Typhoon Etau

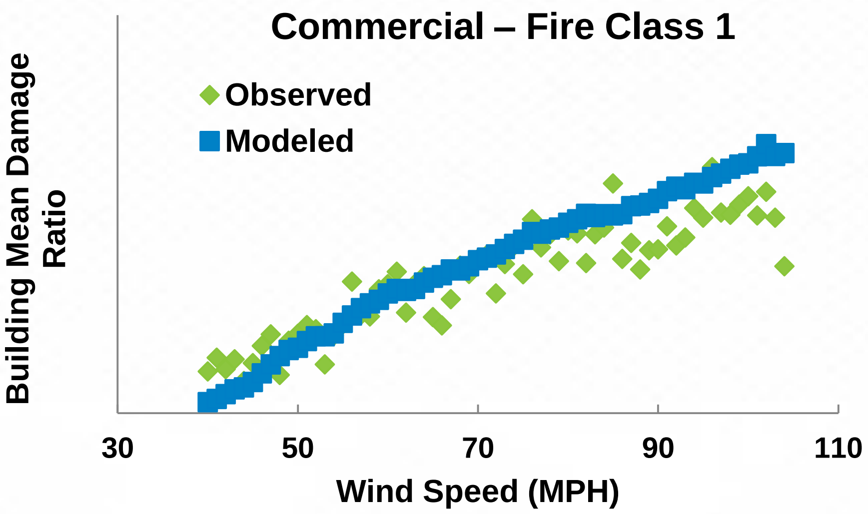
Typhoon Tokage

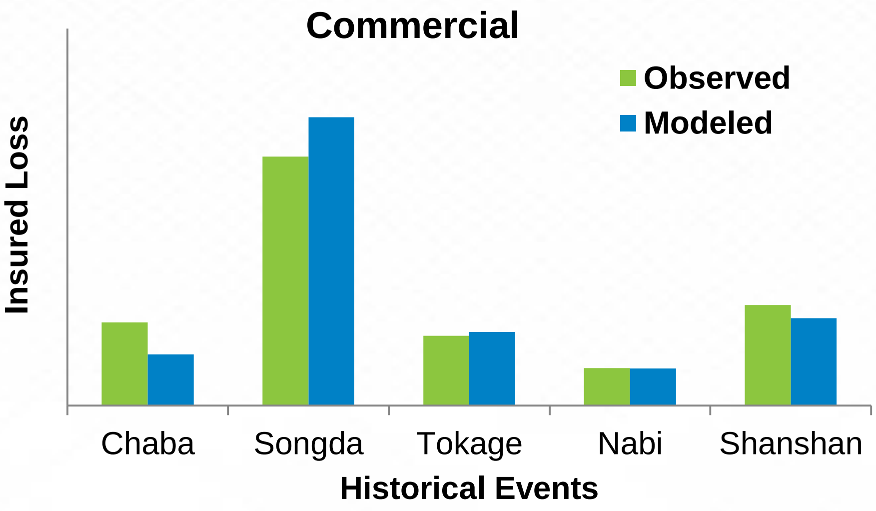
Typhoon Wind: Re-Evaluating the Damage Function





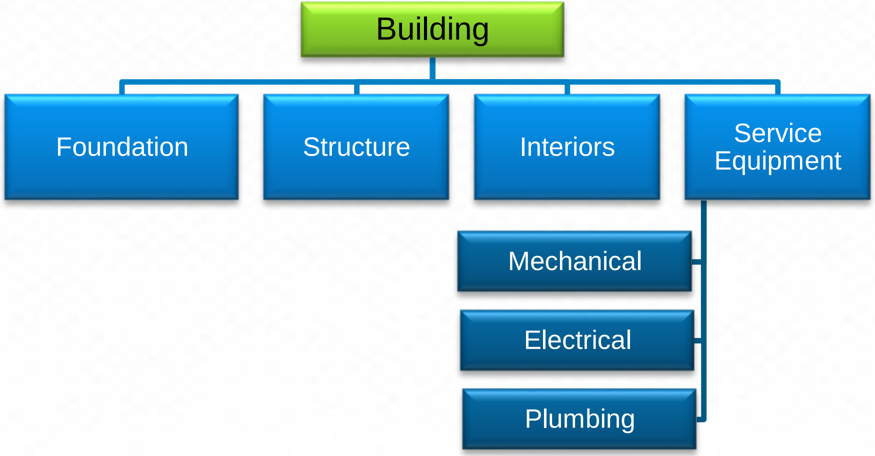
Typhoon Wind: Positive Validation of the Updated Wind Component





Enhanced Flood Hazard and Vulnerability Module

Flood Hazard

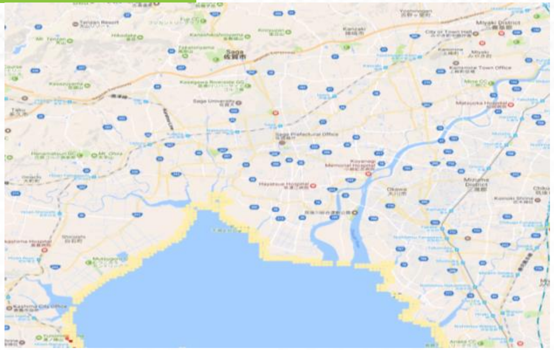


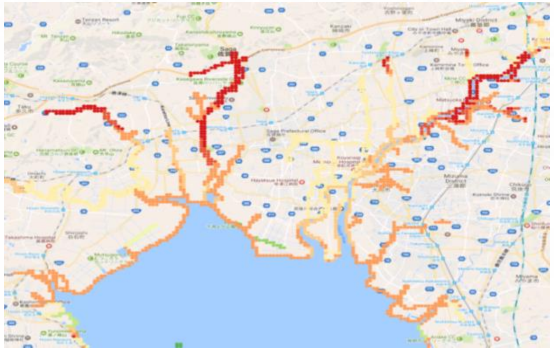
Flood Vulnerability

Enhanced Storm Surge Hazard and Vulnerability Module

Storm Surge Hazard

- Updated the coastal levee system in Hiroshima and Saga
- Increased the storm surge resolution from 250 meters to 25 meters

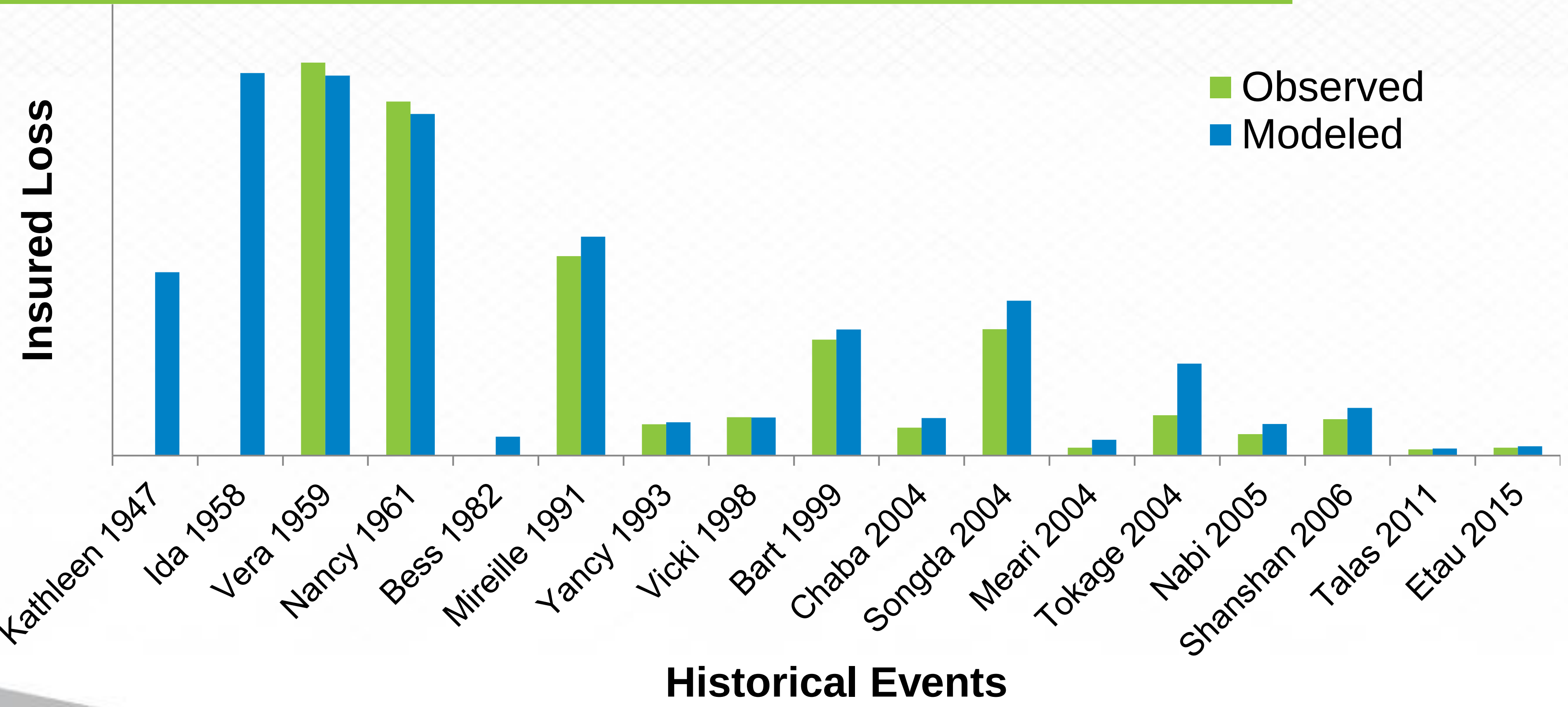




Storm Surge Vulnerability

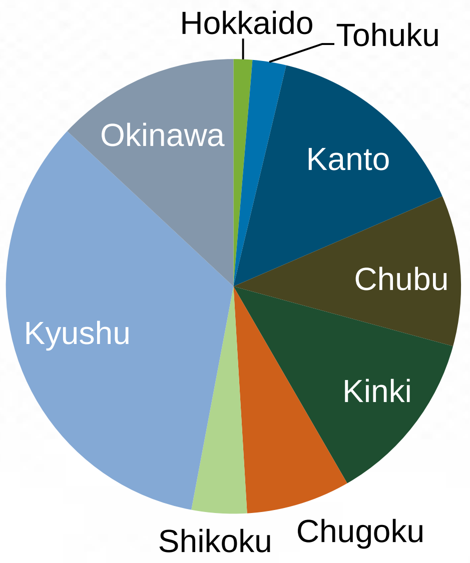
- Used the component level methodology
- Supported the same secondary features as flood

Updated Validation for Historical Events

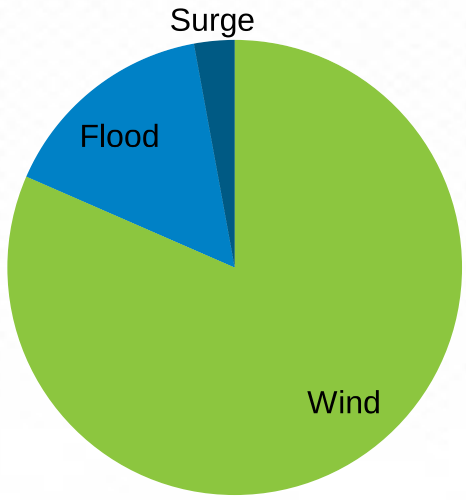


AAL Contribution by Region and Sub-Perils

AAL Distribution by Region



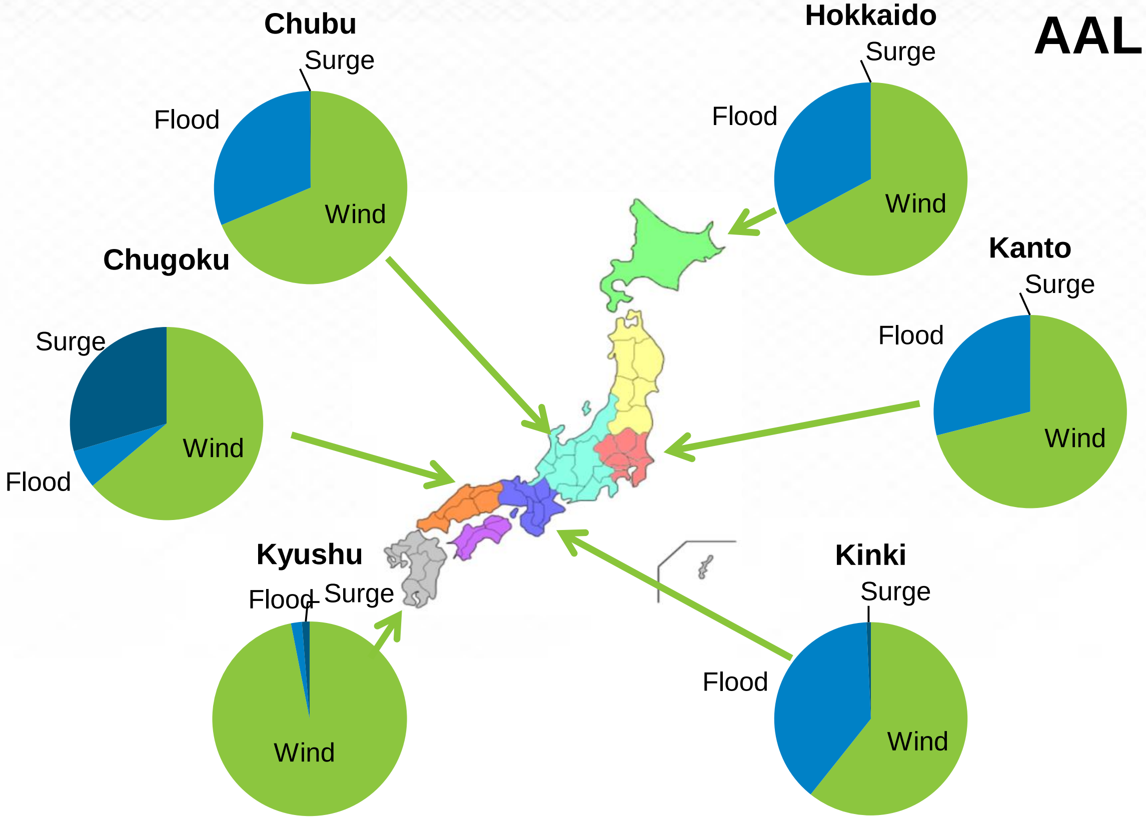
AAL Distribution by Sub-Perils



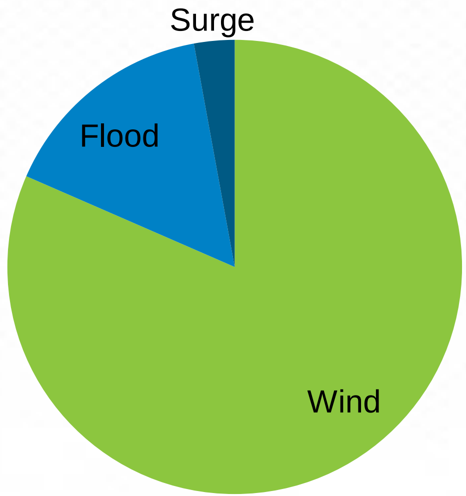
Typhoon risk in Japan is mainly in the southern region, including Kyushu, Okinawa, Chugoku, Kanto, etc.

AAL Contribution by Region and Sub-Perils

AAL Contribution by Sub-Peril for Key Regions



AAL Distribution by Sub-Perils



In the New AIR Model, Typhoon Risk Varies by Region and Sub-Perils in Japan

Region	Total	Wind	Flood	Surge
Japan	Small	Small	Large	Medium
Hokkaido	Small	Small	Medium	Small
Tohoku	Medium	Small	Large	Large
Kanto	Medium	Small	Large	Medium
Chubu	Small	Medium	Medium	Large
Kansai	Small	Medium	Small	Large
Chugoku	Small	Small	Large	Medium
Shikoku	Medium	Small	Medium	Large
Kyushu	Small	Small	Large	Medium
Okinawa	Medium	Medium	Large	Small

Category	Absolute Change %
Small	<10%
Medium	10%-50%
Large	>50%

Closing Remarks

- Introducing a new model for floods from non tropical cyclones and enhancing flood module in typhoon model
- Flood model validates well against observed data from MLIT and other sources
- Updated typhoon model
- AIR provides a comprehensive view of risk in Japan

Thank you!

AIR