

Thai Flood Modelling in Action GC Enhanced Thailand Flood Model

November 5th, 2018

CEO Focus Group Seminar
Thai General Insurance Association

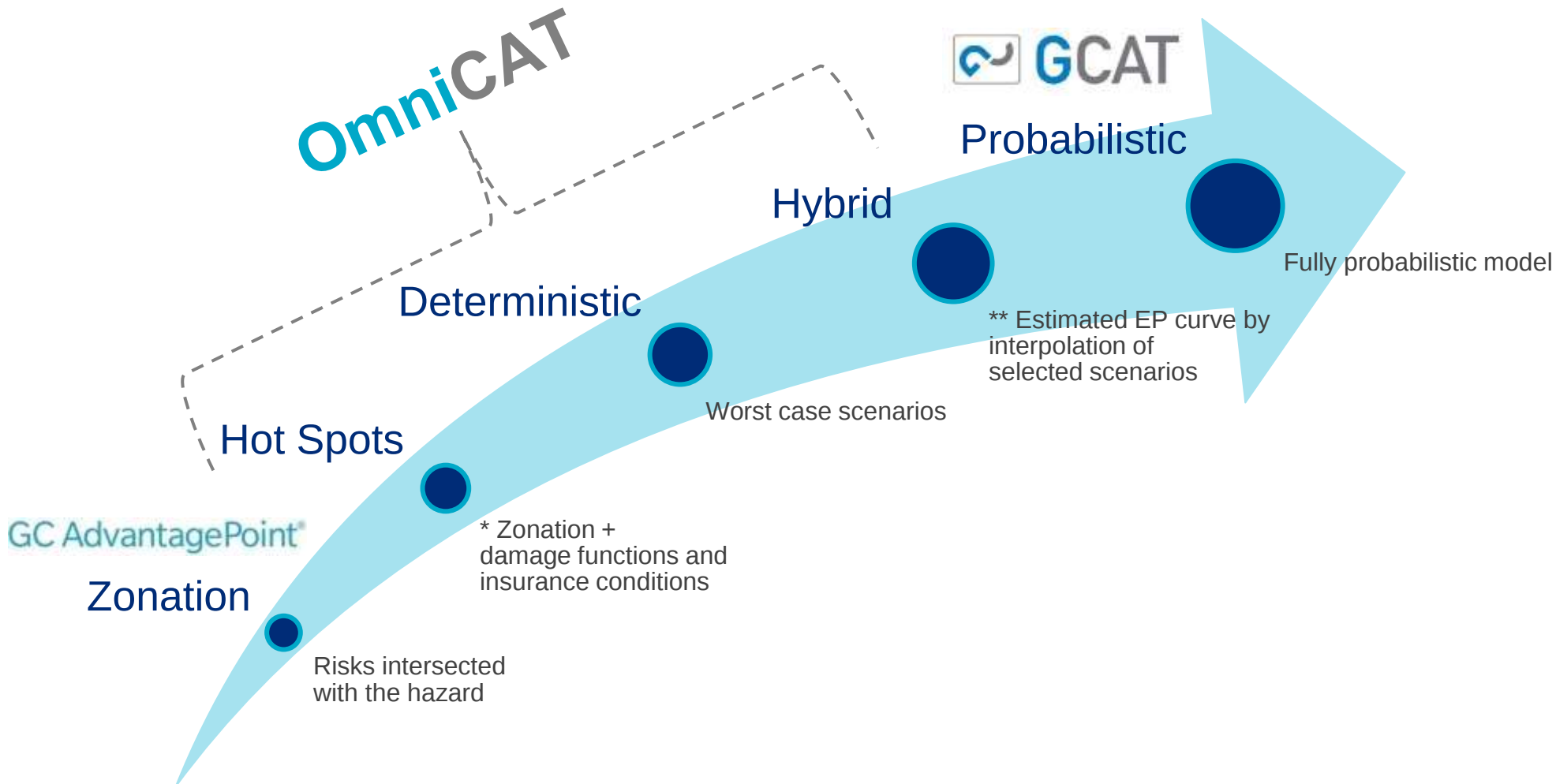
GC Analytics
Singapore

Sections:

- GC flood modelling overview
- Modelling components
 - Hazard module
 - Event set
 - Flood hazard map
 - Defences
 - Built environment module
 - Vulnerability module
- Model validation
- Flood output

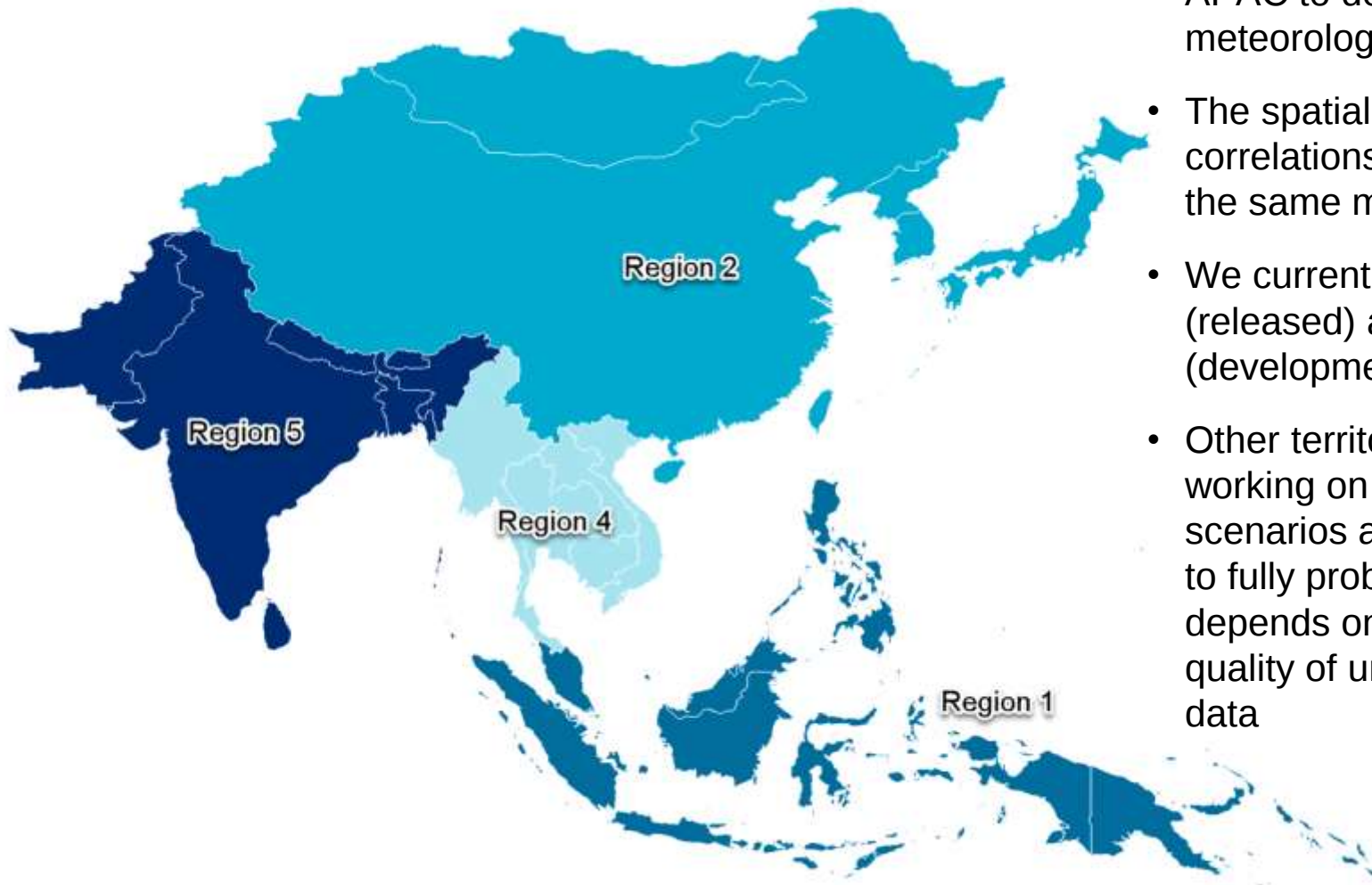
GC Modelling Overview

Modelling Methodology



Flood Coverage – APAC

Modelling Regions



- 4 modelling regions defined for APAC to develop the meteorological events
- The spatial and temporal correlations are defined within the same modelling domain
- We currently have Malaysia (released) and Thailand (development) flood
- Other territories, we have been working on the worst case scenarios approach. Upgrading to fully probabilistic model depends on availability and quality of underlying modelling data

GC Thailand Flood Modelling Overview

2011 Model

Losses at various return periods for key flood prone areas. Covers 2011 Thai flood.

2018 – Countrywide Probabilistic Model

Numerous stochastic scenarios covering the full range of flood possibilities

Hazard

- Flood hazard maps and historical flood events

Vulnerability

- Vulnerability curve
- Damage functions
- Claims data

Built environment

- Building inventory
- Land use land cover
- Urban Planning



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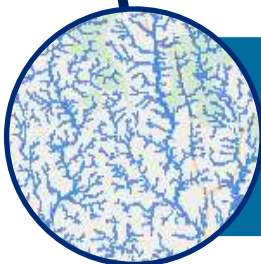
Flood Hazard Module

Main Components



Event Set = catalogue of events defined as:

- River discharges (m^3/s and RP) at river gauge stations
- Pluvial intensities (mm/d and RP) – on a grid



Flood Hazard Maps

- Fluvial: 6 RP flood hazard maps
- Pluvial: we don't use the JBA pluvial hazard maps!



Flood Defences:

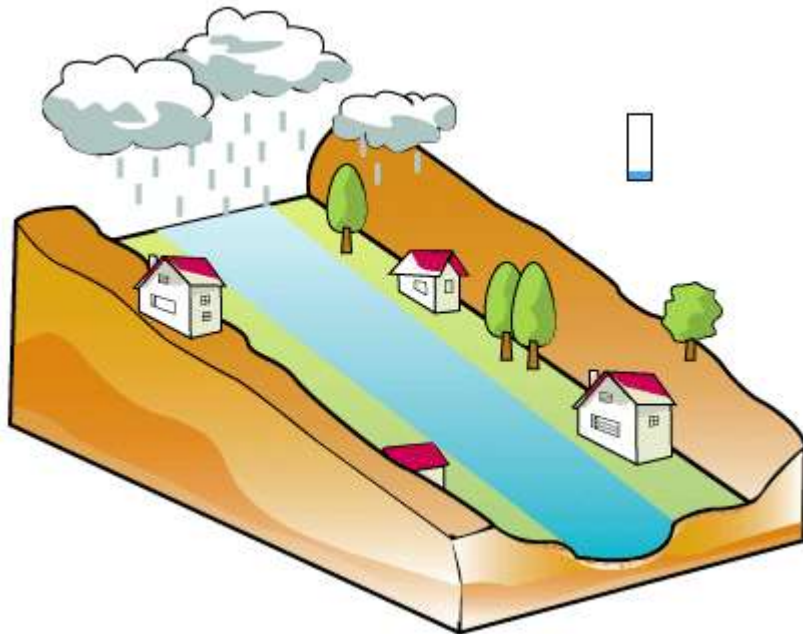
- Fluvial: information on dikes, retention basins/dams, polders...
- Pluvial: information on drainage systems

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Fluvial floods

- Also known as: river flooding, on-plain, riverine...
- Occurs when **water levels rise over the top of river banks** due to excessive rain, snowmelt, combined rainfall and snowmelt, or an ice jam.



Pluvial floods

- Also known as: off-plain, surface-runoff, flash...
- Occurs when precipitation intensities exceed the infiltration rate/capacity of the soil surface or of the urban drainage system due to excessive rainfall. Pluvial floods can happen anywhere.

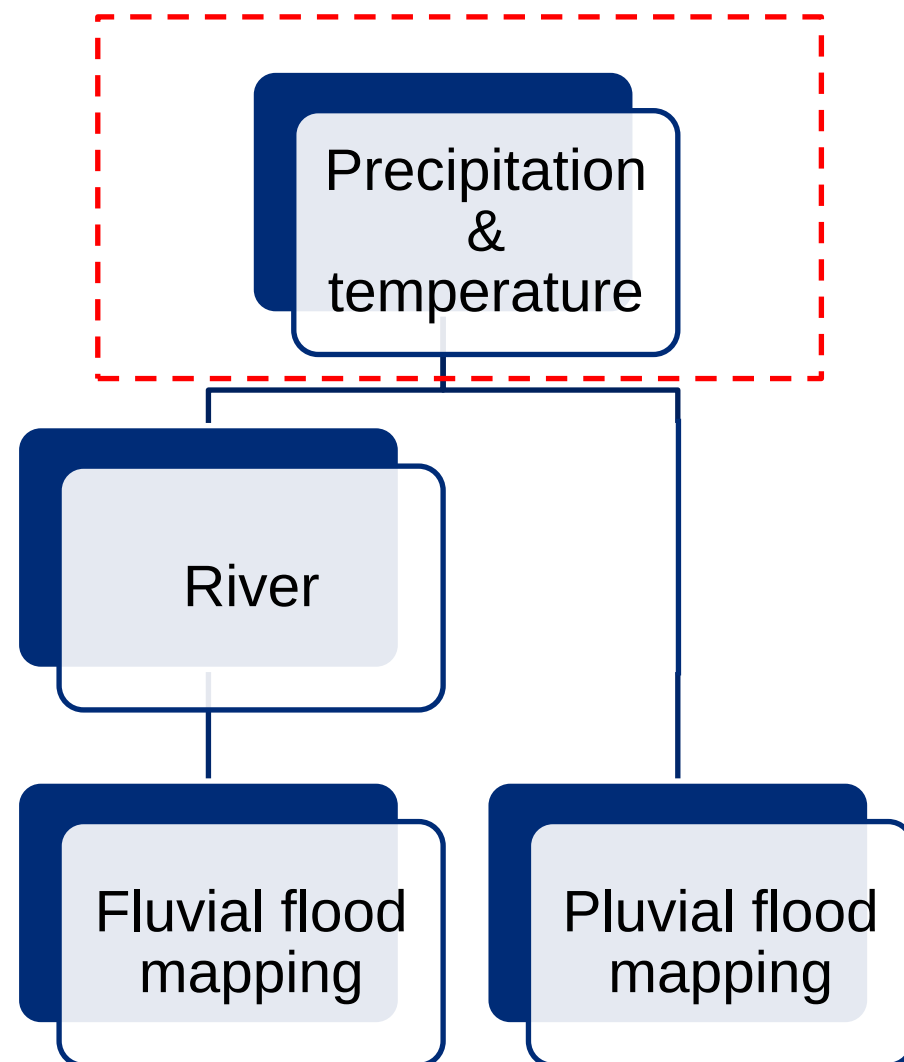


Flash Flood in Bangkok October 2017 (Source: Nation Media)

Event Set (GFES)

Overview

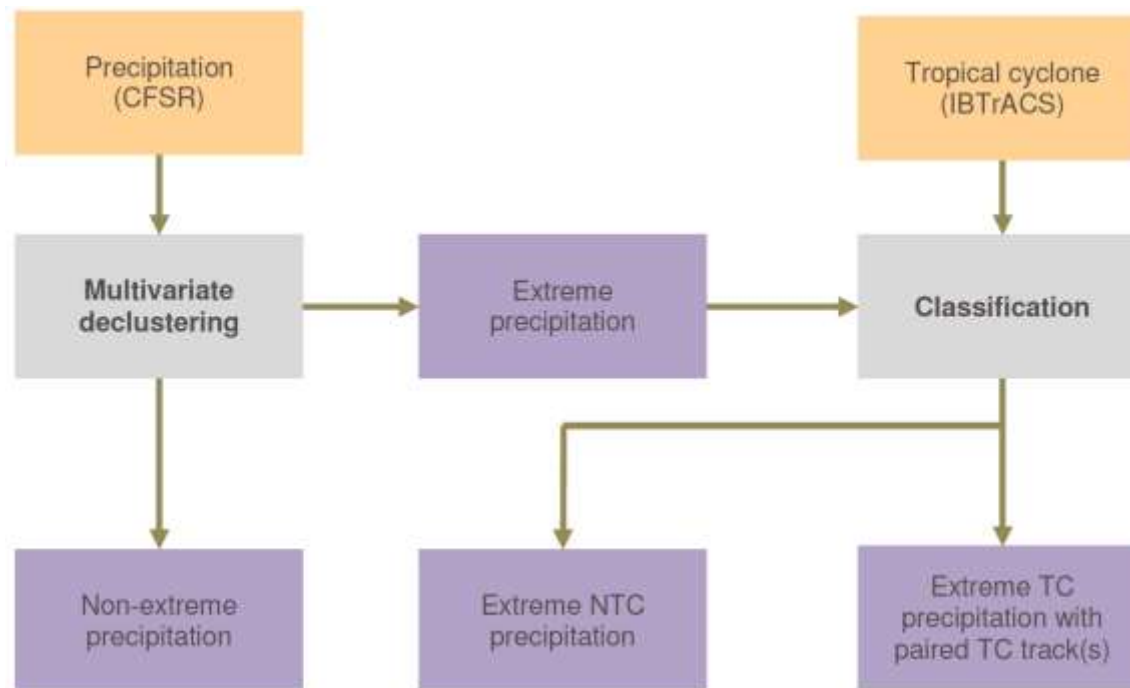
- Partnered with JBA Risk Management for the **Global Flood Event Set (GFES)**
- Overall hazard processing steps:
 - Produce stochastic **precipitation and temperature** data over 10k years
 - Perform **rainfall runoff modeling** to convert precipitation, snow pack and temperature into river flows



Flood Event Set

Hazard Component: Meteorological Modelling

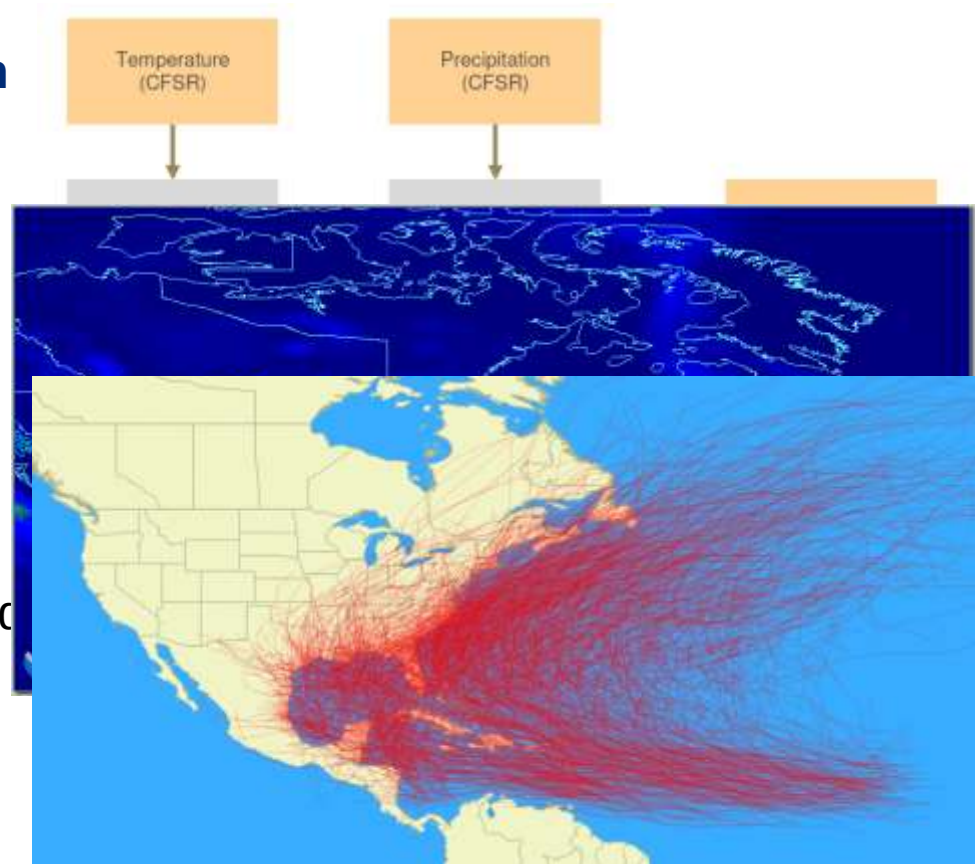
- Climate Forecast System Reanalysis (CFSR) and IBTrACS
- Tropical cyclone and non-tropical cyclone precipitation
- Temperature data to model snowmelt and evapotranspiration



Event Set (GFES)

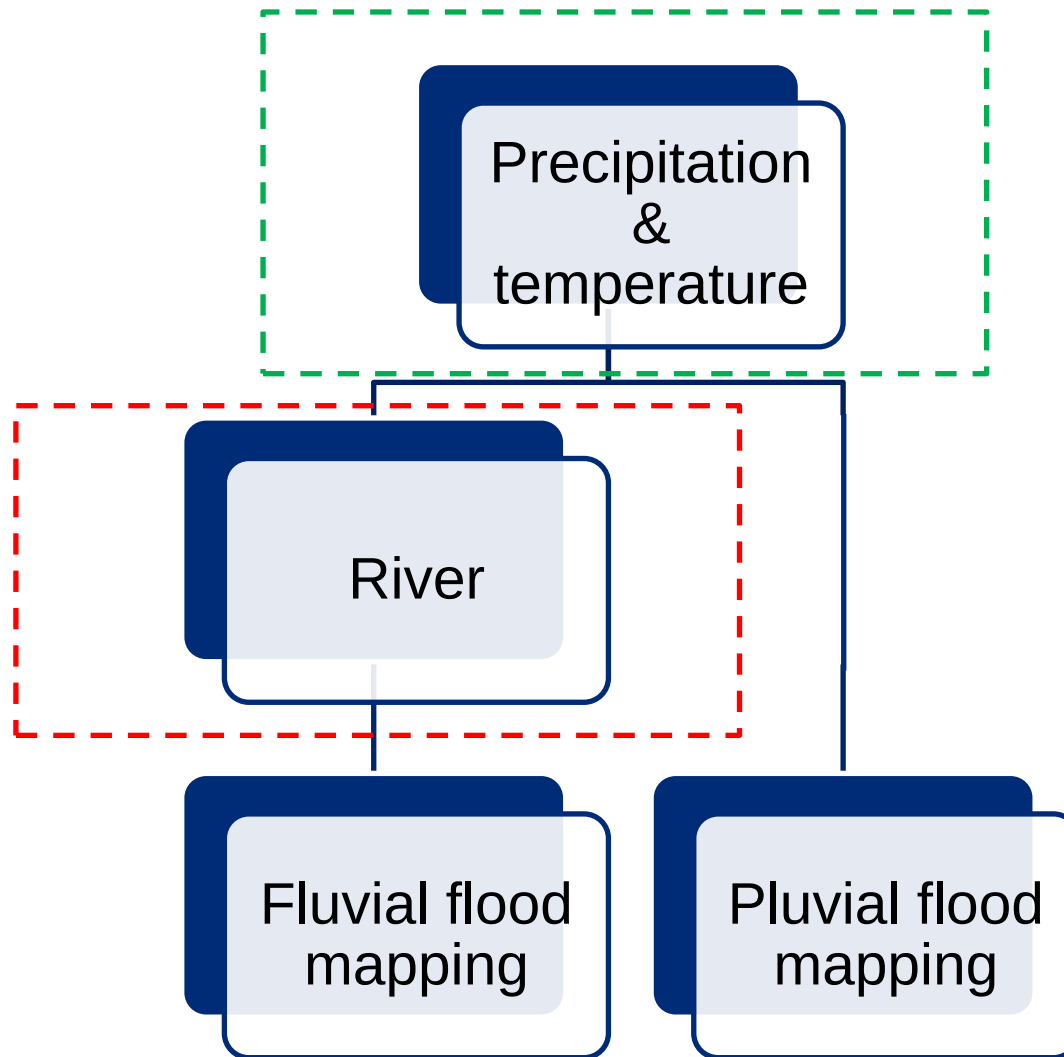
Precipitation and Temperature Generation

- Goal:
 - Produce **stochastic continuous daily precipitation and temperature at high resolution** grid across Canada
- Methods for the precipitation model:
 1. Block bootstrapping for non-intense precipitation
 2. “Event trigger” to a) identify intense events, b) relocate to new position and c) statistically propagate precipitation
 3. a) develop storm track and intensity and b) R-Cliper model to estimate induced precipitation
- Primary Input Data:
 - **Climate Forecast System Reanalysis (CFSR):** 6 hourly; 0.5 x 0.5 degree



Event Set (GFES)

Hazard Modeling – Overview



Event Set (GFES)

Hazard Modeling – River Flow Modeling

- Goal:
 - **Convert continuous precipitation and snow pack conditions into river discharges**
- Methods:
 - Calibrate **daily IHACRES** conceptual rainfall runoff model using historical precipitation and simulate using stochastic precipitation and temperature data



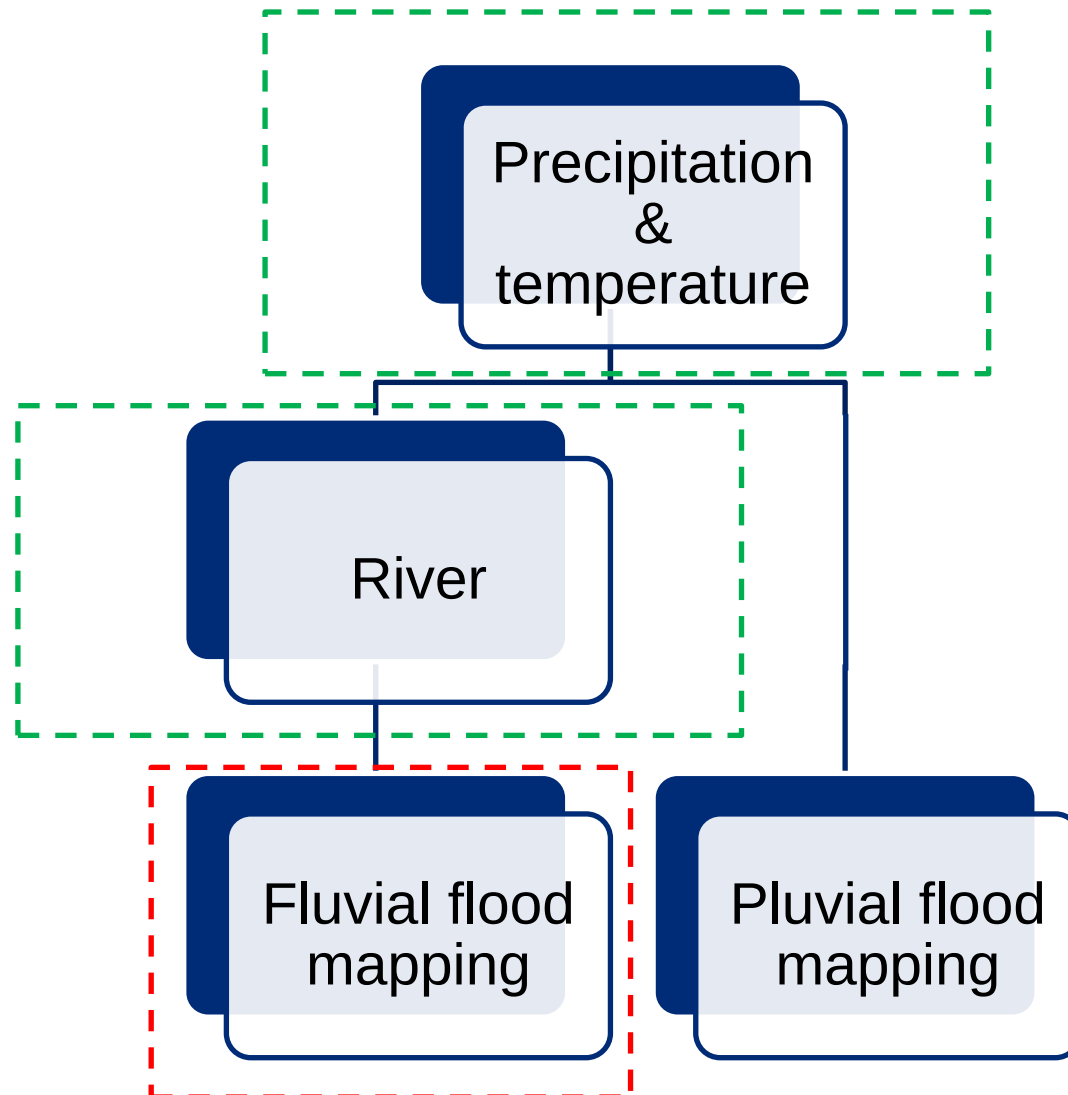
- **Catchment Moisture Deficit model** with **snow accounting**
 - 2 stage flow routing to convert effective rainfall into river discharge (fast and slow)
 - Convert river flows into return periods using extreme value theory
- Primary Input Data:
 - **Discharges at river gauge stations**

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Event Set (GFES)

Hazard Modeling – Overview



Flood Mapping

Fluvial

- **Hydraulic model** = mathematical model reproducing free surface flow dynamics
- Use simplifications of the full Navier-Stokes equations:
 - **1D: one dimensional:**
 - Velocity is calculated in 1 direction only (same velocity at all points of a cross section)
 - Best for in-bank flow
 - Out-of-bank acceptable if direction of flow readily estimated (narrow cross sections)
 - **2D: two dimensional:**
 - Flow velocity is calculated in 2 directions (vertical direction not considered)
 - Best for out-of-bank flows

Flood Mapping

Fluvial

- **Input**

- Large scale modelling:
 - Digital Terrain Model (DTM) / Digital Surface Model (DSM)
 - Hydrology: discharges at the modelled return periods
- Detailed modelling:
 - Past flood extents and water stages -> calibration of the friction coefficients
 - Hydraulic structures / flood defences
 - Operation details of controlled structures

Flood Mapping

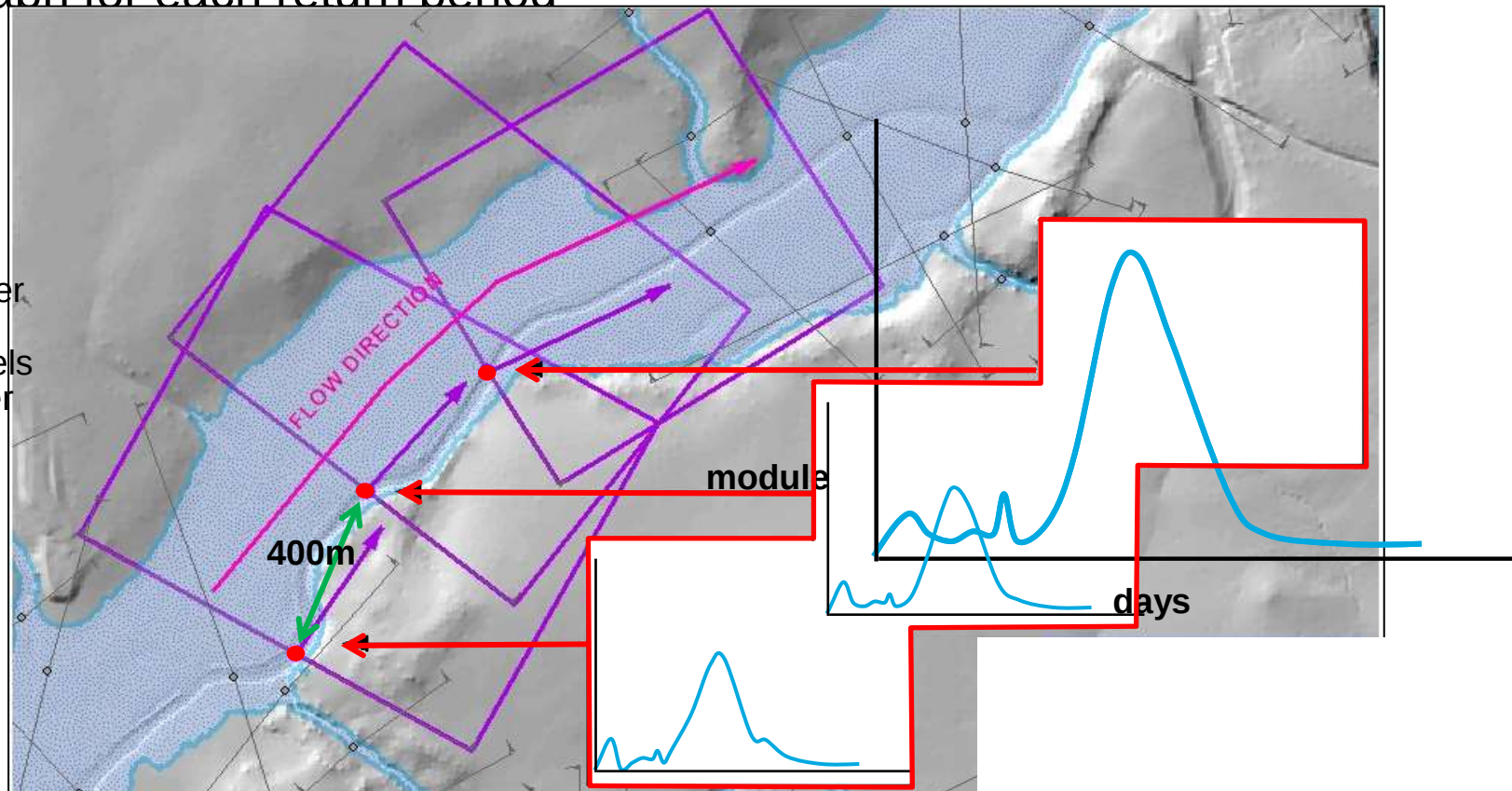
Fluvial

2. « Inflow points »
Located every 400m along
the river network

3. Digital Terrain Model (DTM)

Input hydrograph for each return period

4. Hydraulic model
Simulates water
flow over the
DTM and models
resulting water
depths

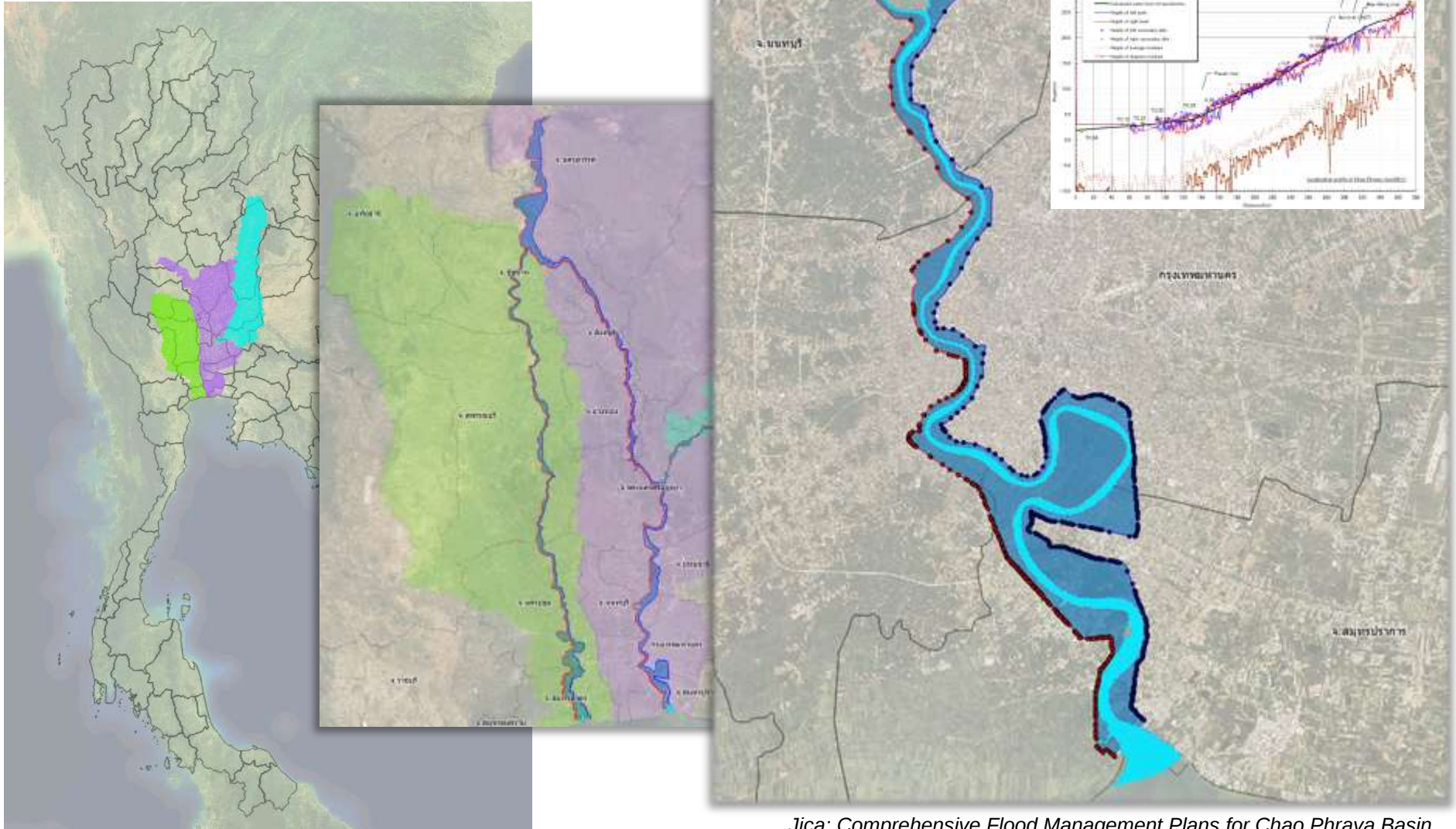


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Defences: Secondary Dikes

Chao Phraya Basin

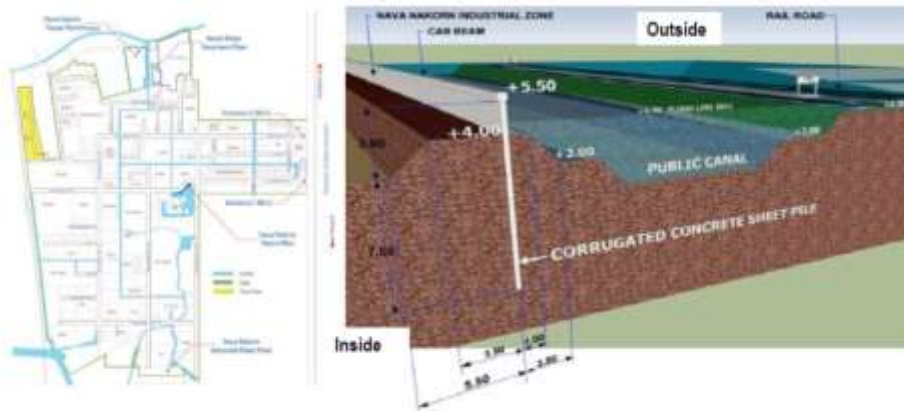


Jica: Comprehensive Flood Management Plans for Chao Phraya Basin

Defences

Industrial Parks Flood Mitigation

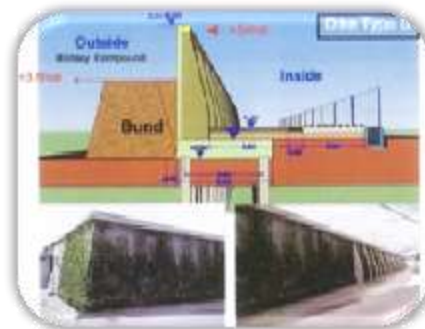
- Enhanced flood mitigations for major industrial parks implemented after 2011 event were considered in GC Thailand Flood model



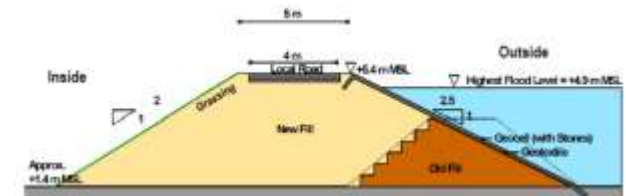
Nava Nakorn Industrial Park, Mitigation Projects



Rojana Industrial Park, Mitigation Projects



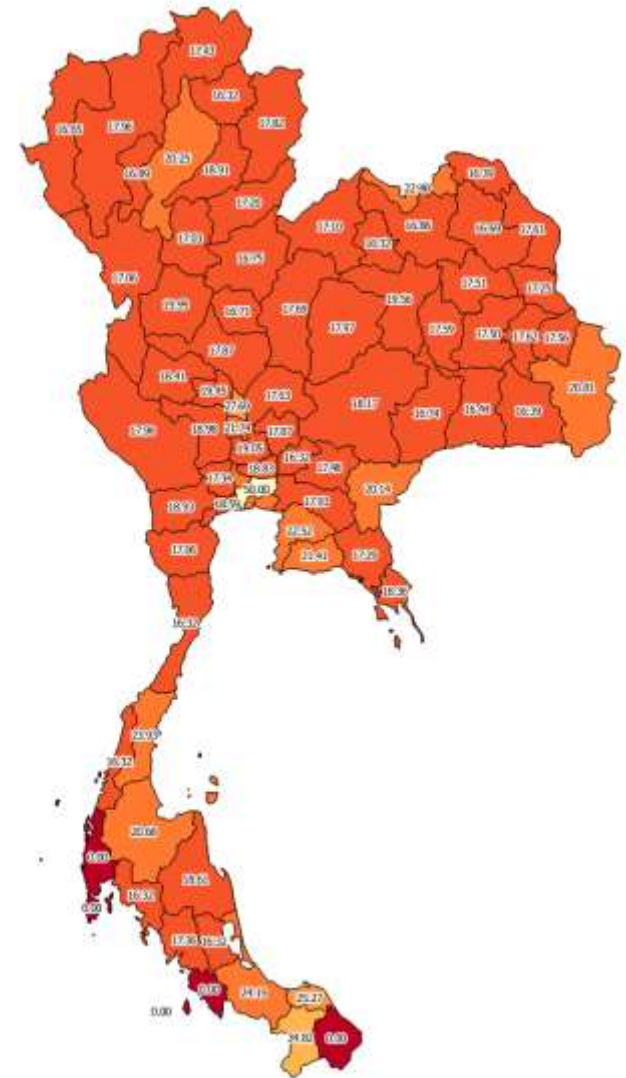
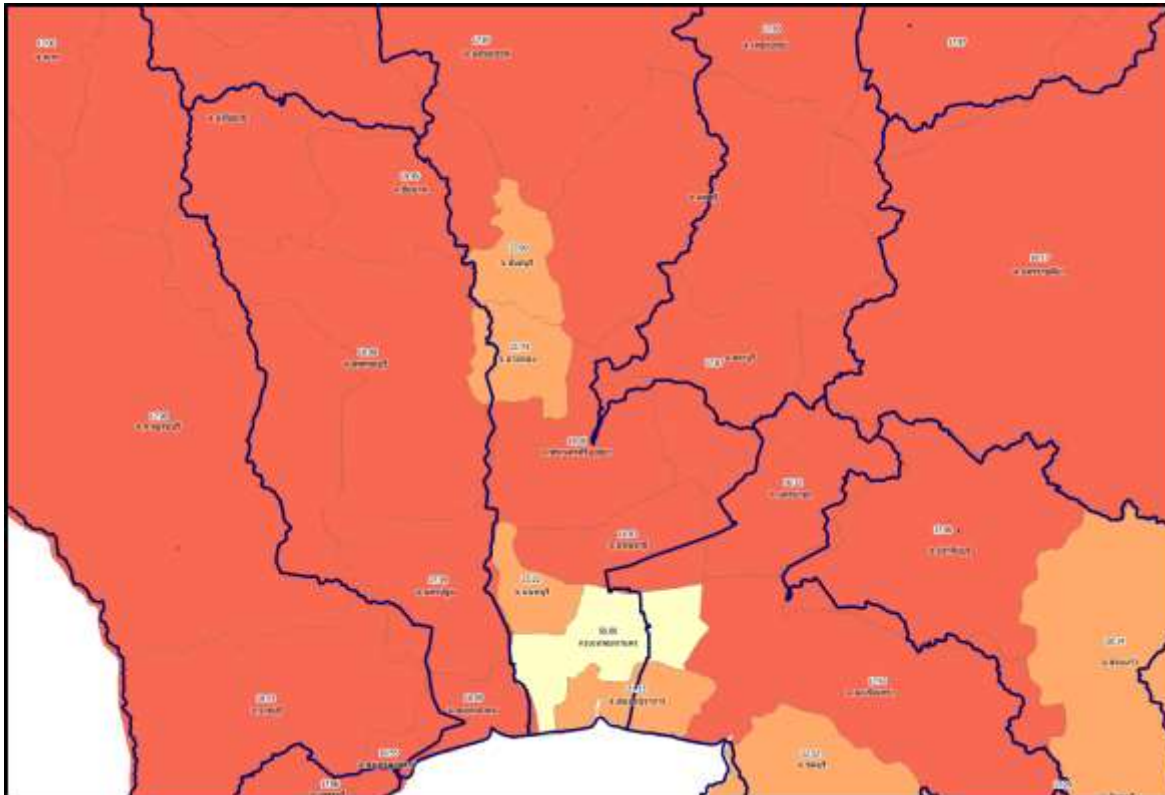
Bang Kadi Industrial Park, Mitigation Projects



Hi-Tech Industrial Estate, Mitigation Projects

Defences: Global Database of Flood Protection Standards

- Standard protection at administrative levels based off scientific studies applied where no levee/dikes available



Standard of Protection Level by Province

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Built Environment Overview

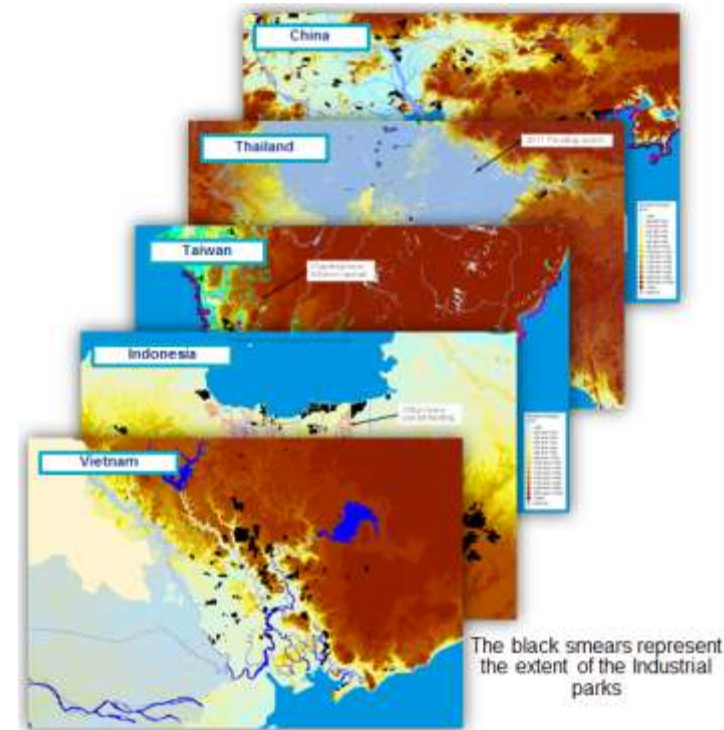
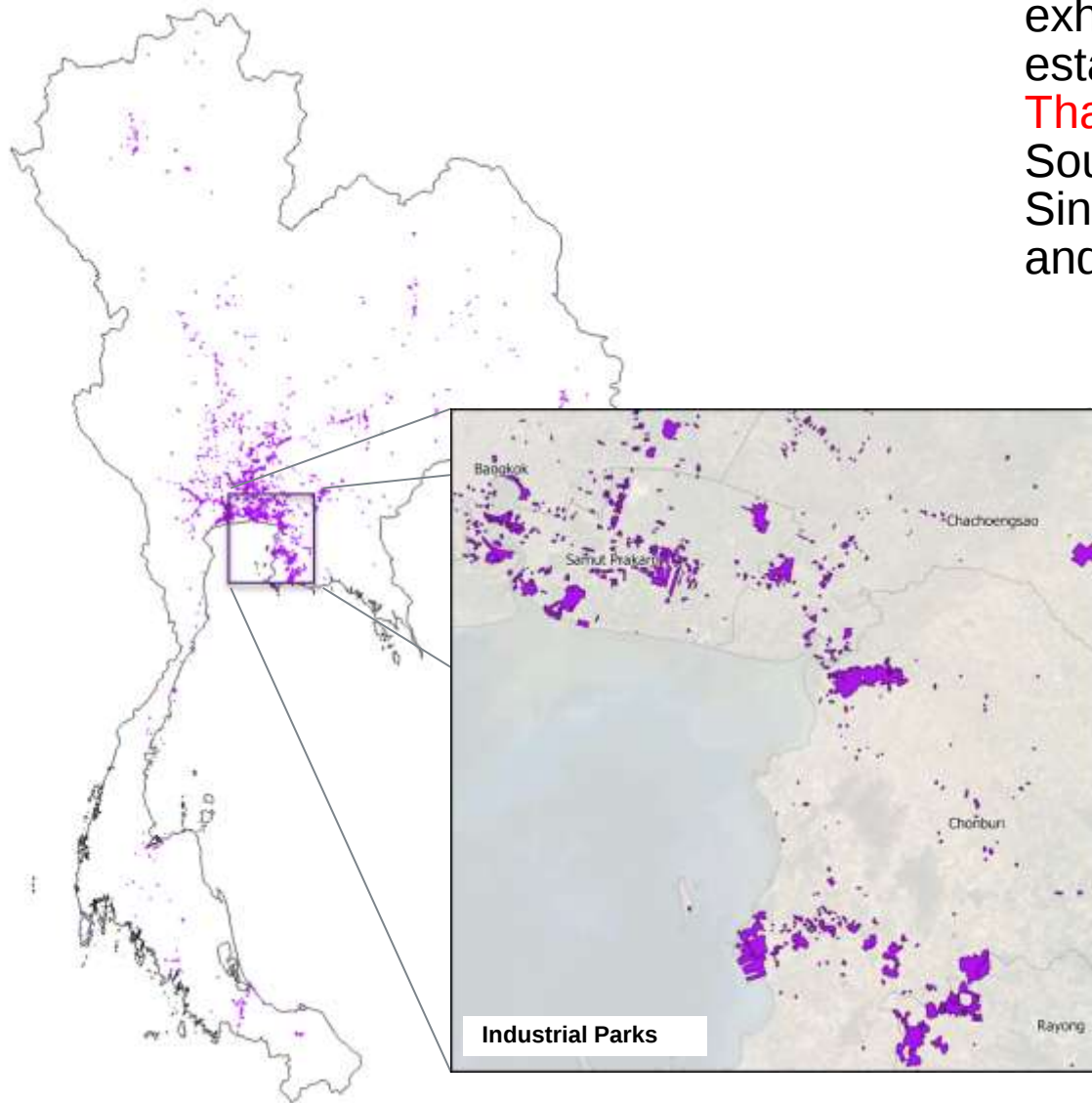
- Aim – distribution of risks into a “modelling grid”, which is the highest resolution of modelling
- Contains information of all risks (buildings, contents) to be modelled
 - Location
 - Risk type
 - Value
 - Secondary characteristics (height, age)



Industrial Park

GC Proprietary Data

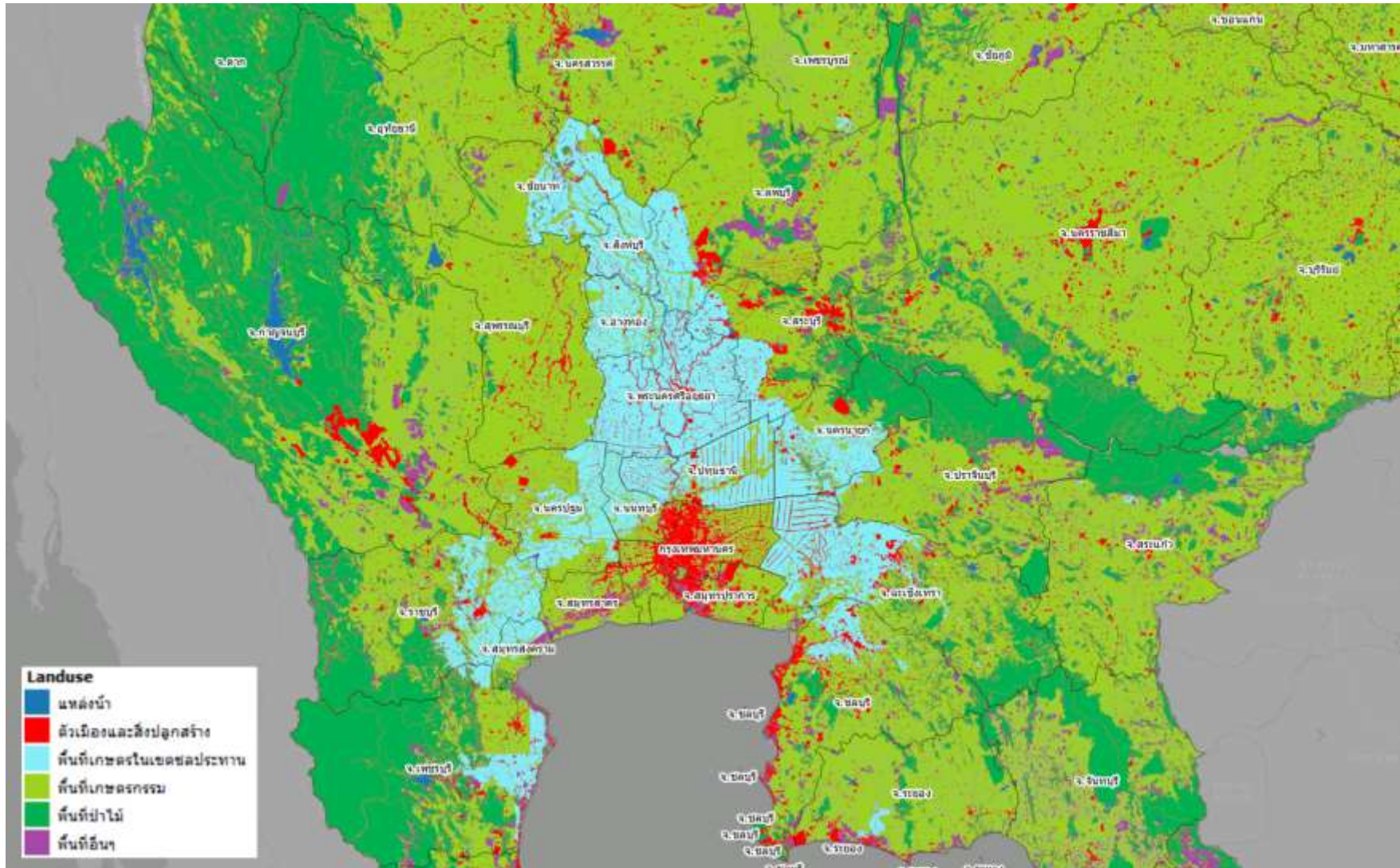
- Guy Carpenter has developed an exhaustive database of Industrial estates in China, Taiwan, **Thailand**, Indonesia, Vietnam, South Korea, Malaysia, Singapore, Hong Kong, Japan and India



Land Use Land Cover Map

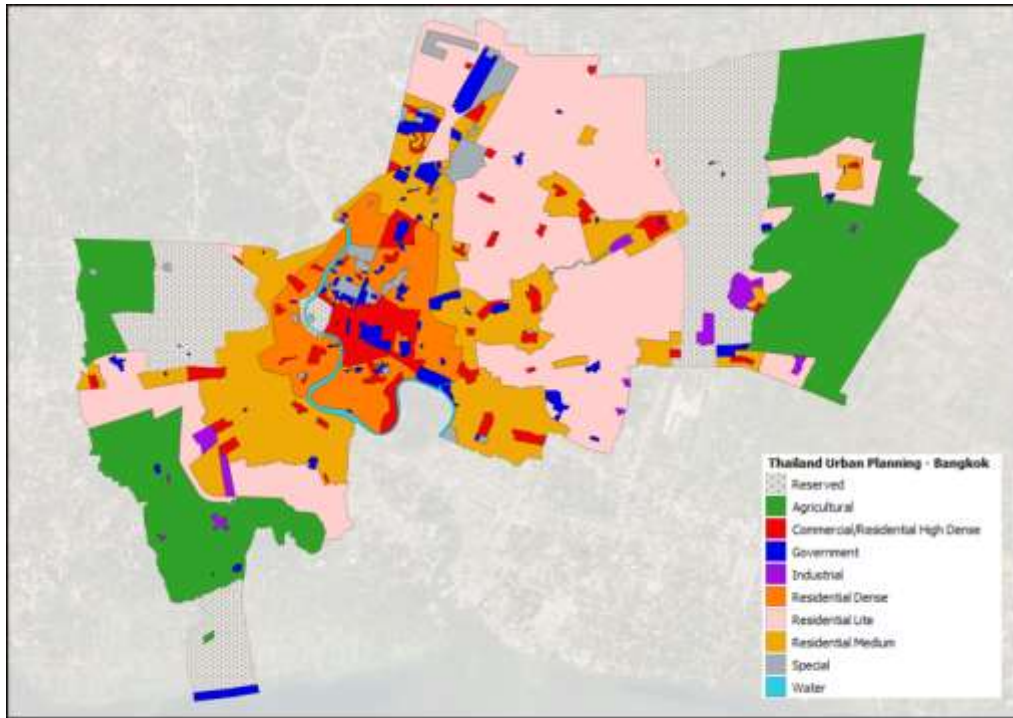
Department of Water Resources

Land Use Map for Central Thailand
(Chao Phraya Basin)

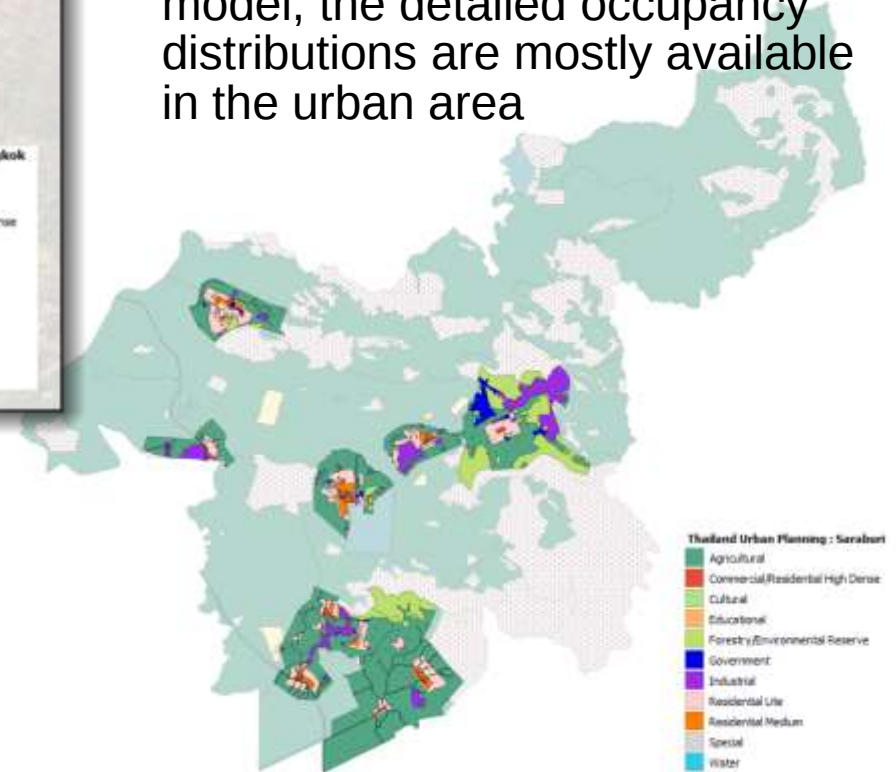


Urban Planning Map

Department of Public Work and Town & Country Planning



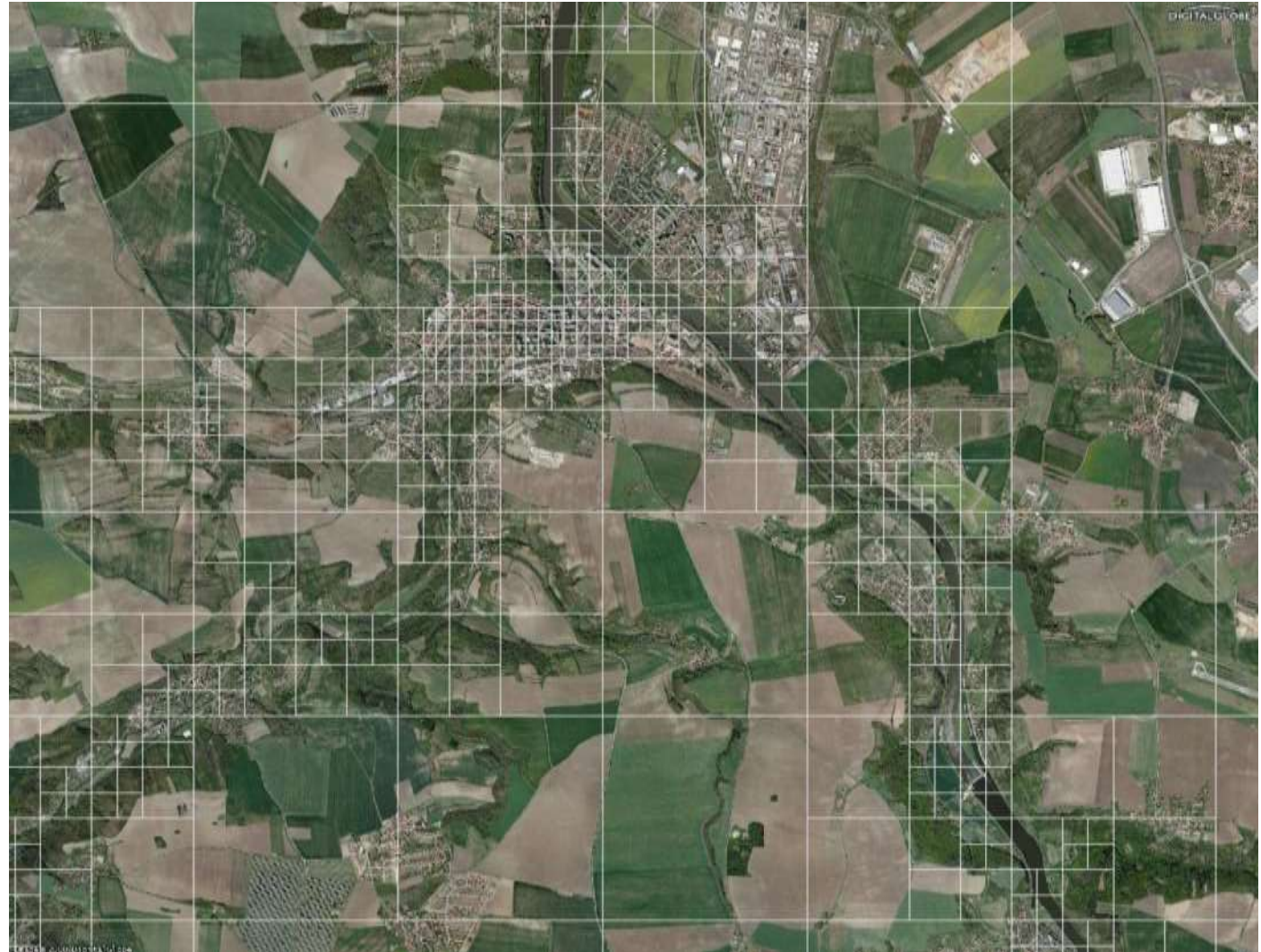
- Urban Planning Shapefile was integrated into Built Environment module for occupancy disaggregation
- As example shows for Thailand model, the detailed occupancy distributions are mostly available in the urban area



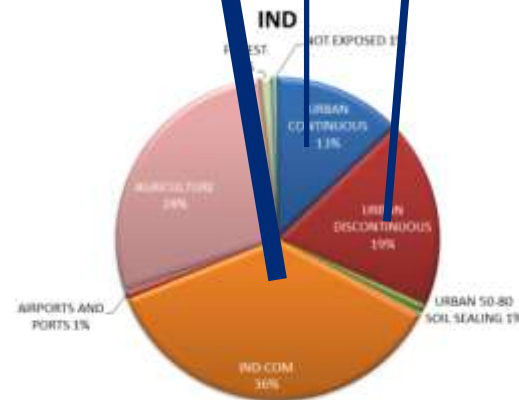
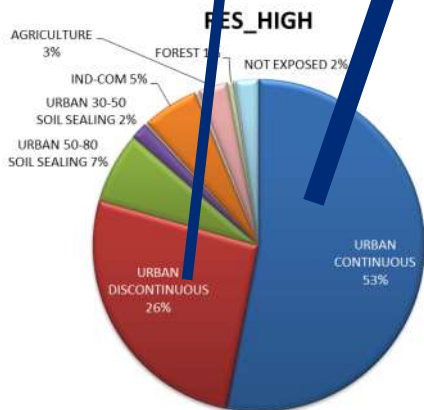
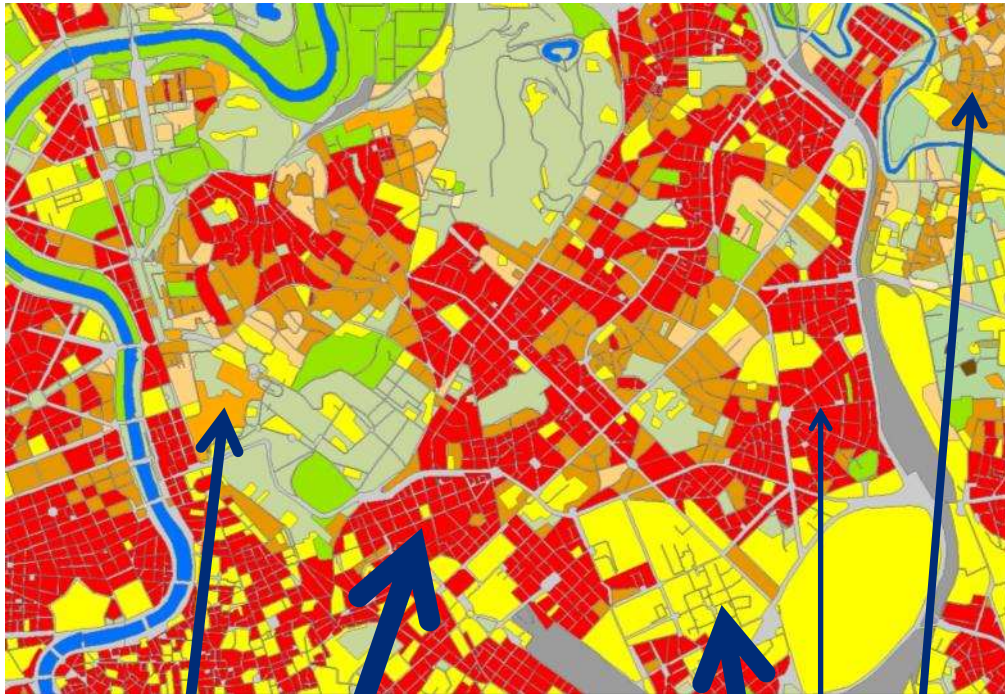
Exposure Module

Development of the Variable Resolution Grid (VRG)

- The resolution of the grid is increased in areas of interest.
- Increases model efficiency; focuses on land use types found inside the flood plain.
- X/Y data import directly into grid cells.



Disaggregation Approach



- Allows for spatial disaggregation and estimation of secondary characteristics
- Based on range of data sources as available including:
 - Detailed land cover data
 - Census information
 - Commercial data sources
- Calibrated against detailed exposure data

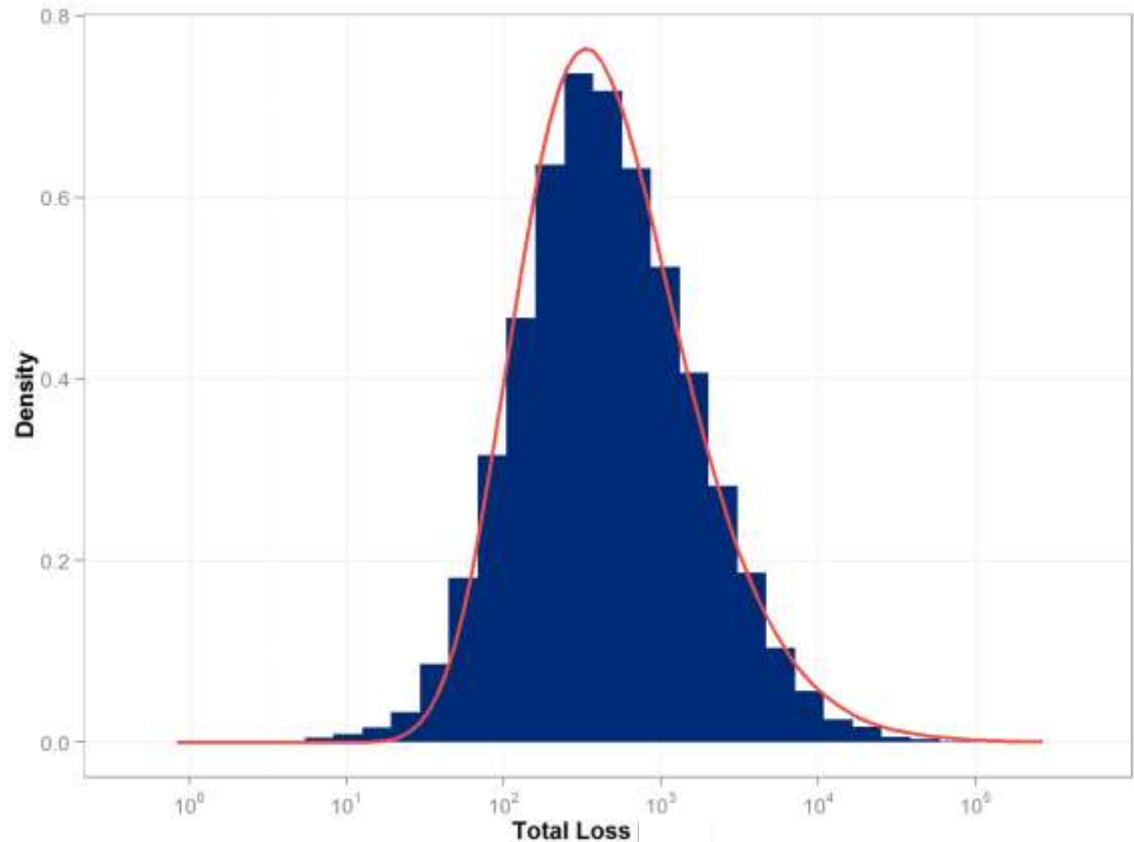
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Vulnerability Functions

Damage functions development

- Implementation of Damage Functions
[Importance of Claims Data Analysis](#)
- The development of vulnerabilities for the G-CAT flood model is based on the analysis of empirical flood damage data from several relevant sources, including a comprehensive database of flood claims, and vulnerability functions from the scientific literature.
- GC and GeoForschungsZentrum Potsdam (GFZ) built a comprehensive compendium of references for flood vulnerability functions, and published a scientific paper on the state of the art of flood vulnerability modelling:
- Gerl T, Kreibich H, Franco G, Marechal D, Schröter K (2016) A Review of Flood Loss Models as Basis for Harmonization and Benchmarking. PLoS ONE 11(7): e0159791.

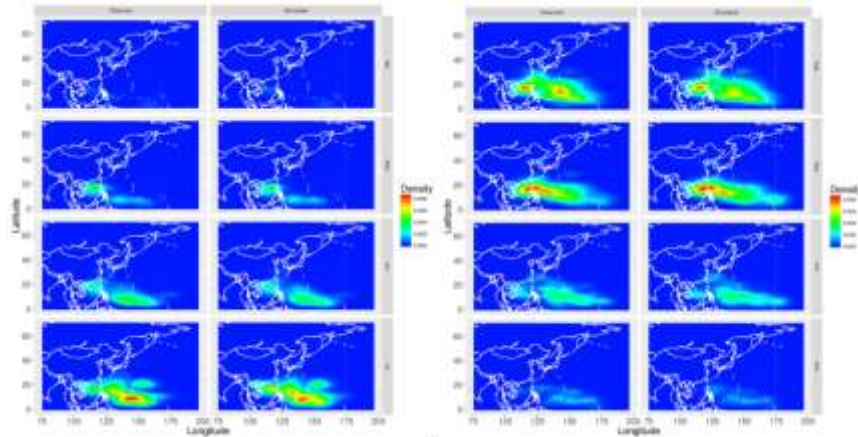


Sections:

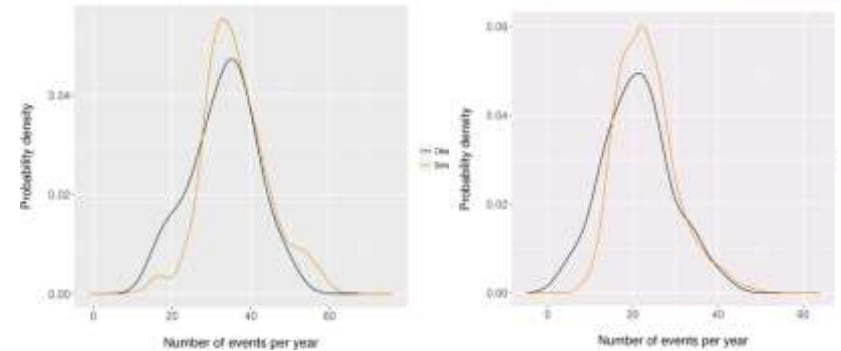
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Hazard Module Validations

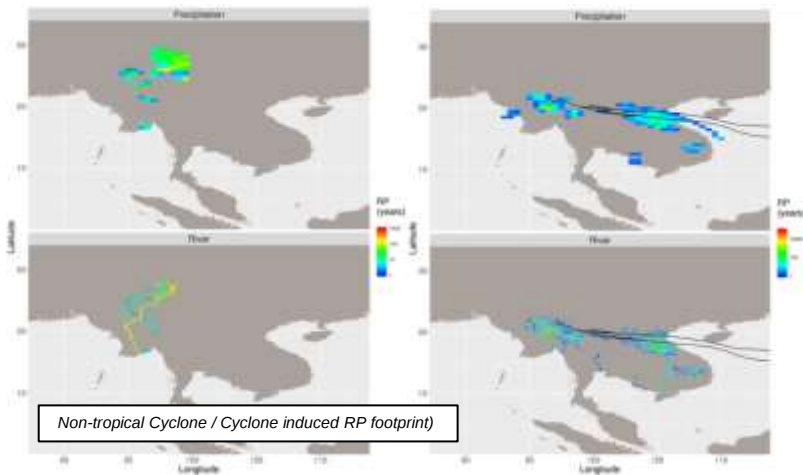
GFES (selected tests)



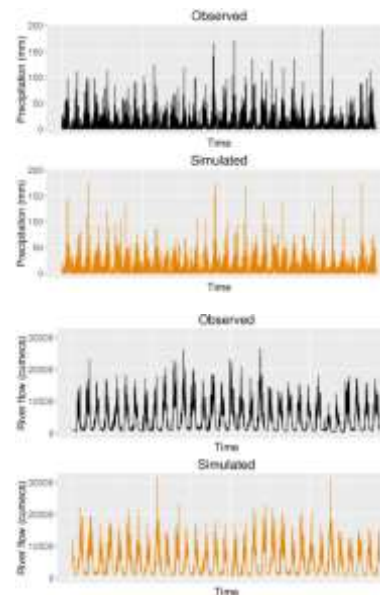
Cyclone Geneses (monthly)



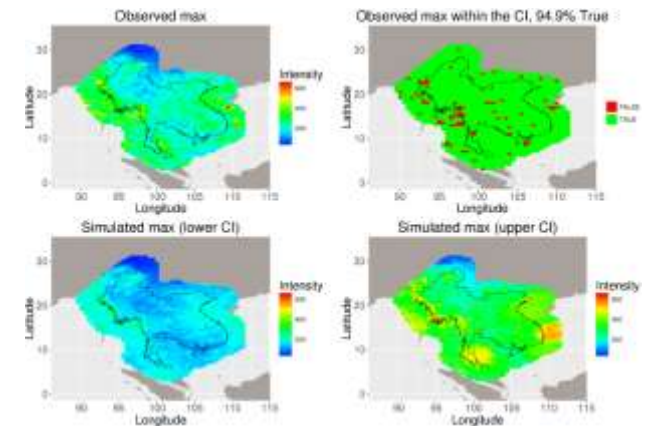
Overall event frequency for precipitation events and river events



Non-tropical Cyclone / Cyclone induced RP footprint



Time series comparison for precipitation and river flow at selected observation points

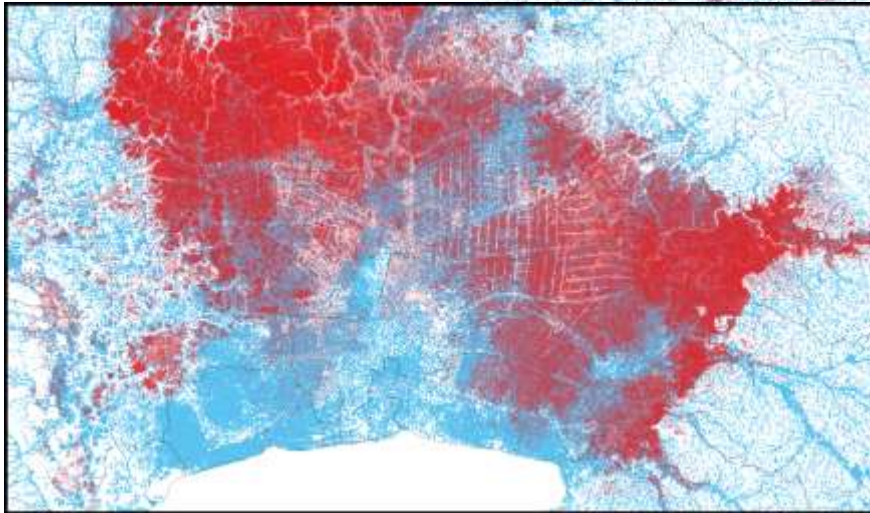


Observed and simulated locations of the trigger over the modelled region

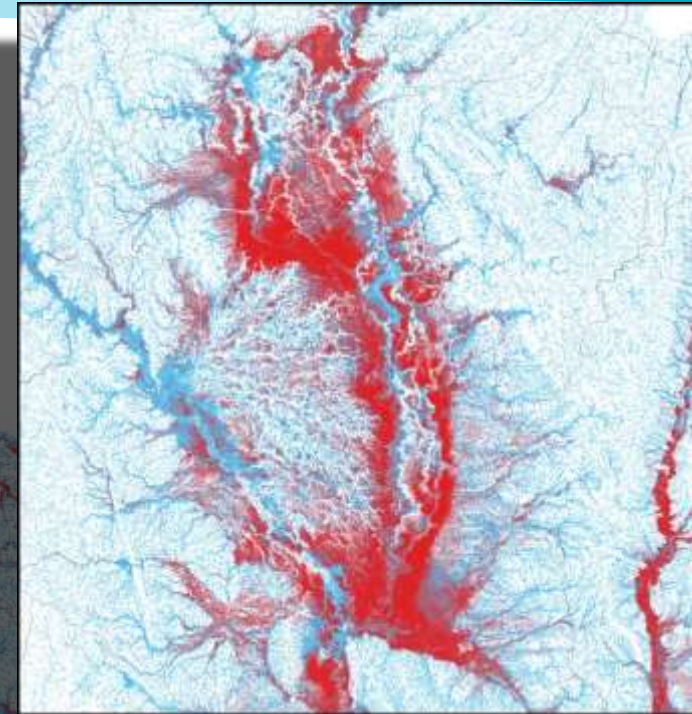
Hazard Module Validations

GFM vs GISTDA

Lower Chao Phraya Basin



Upper Chao Phraya Basin

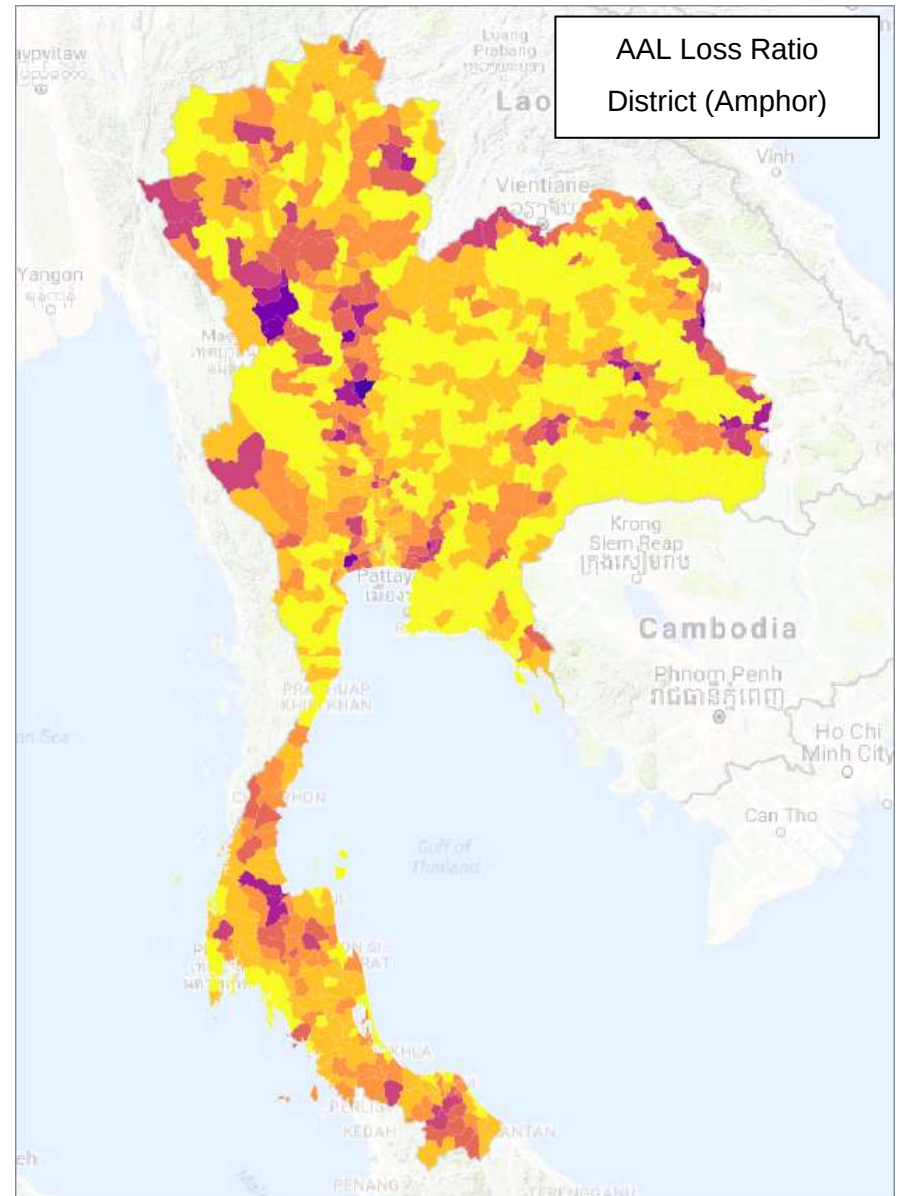
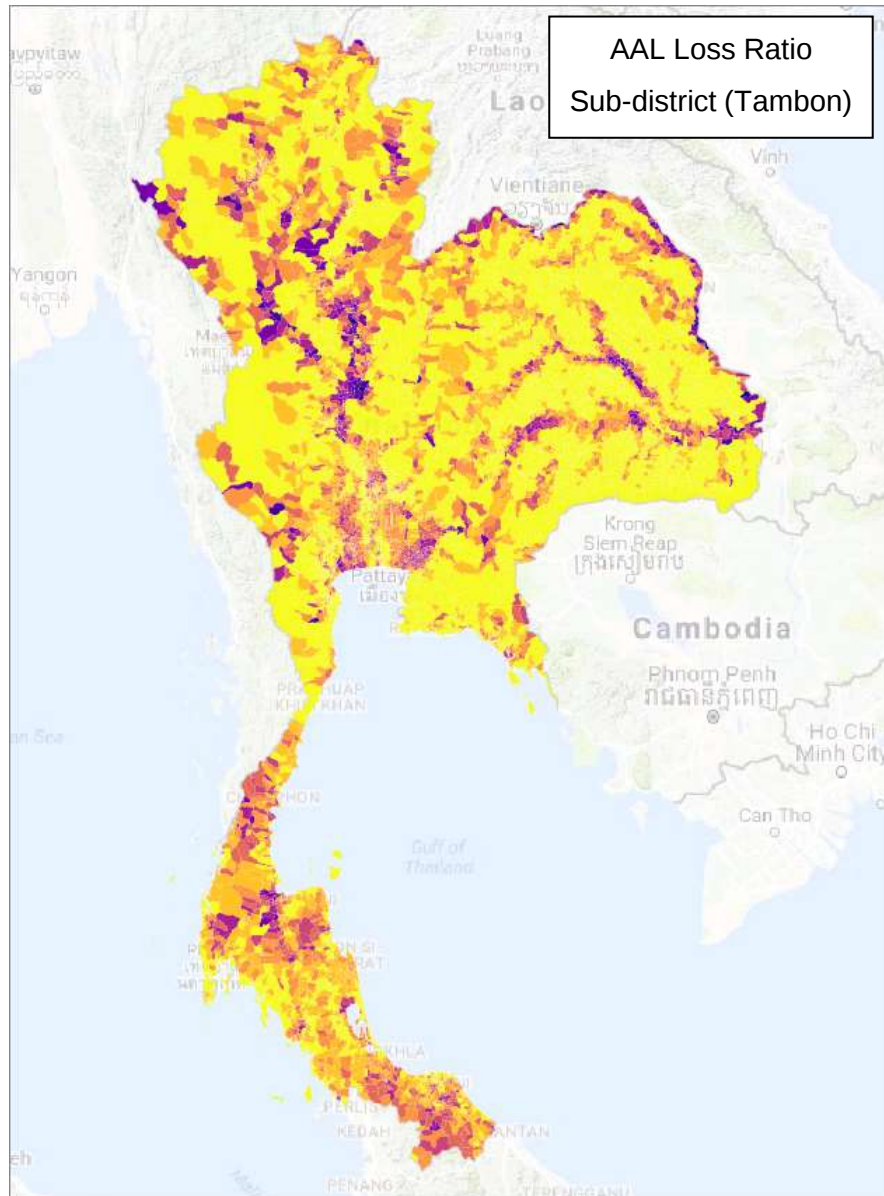


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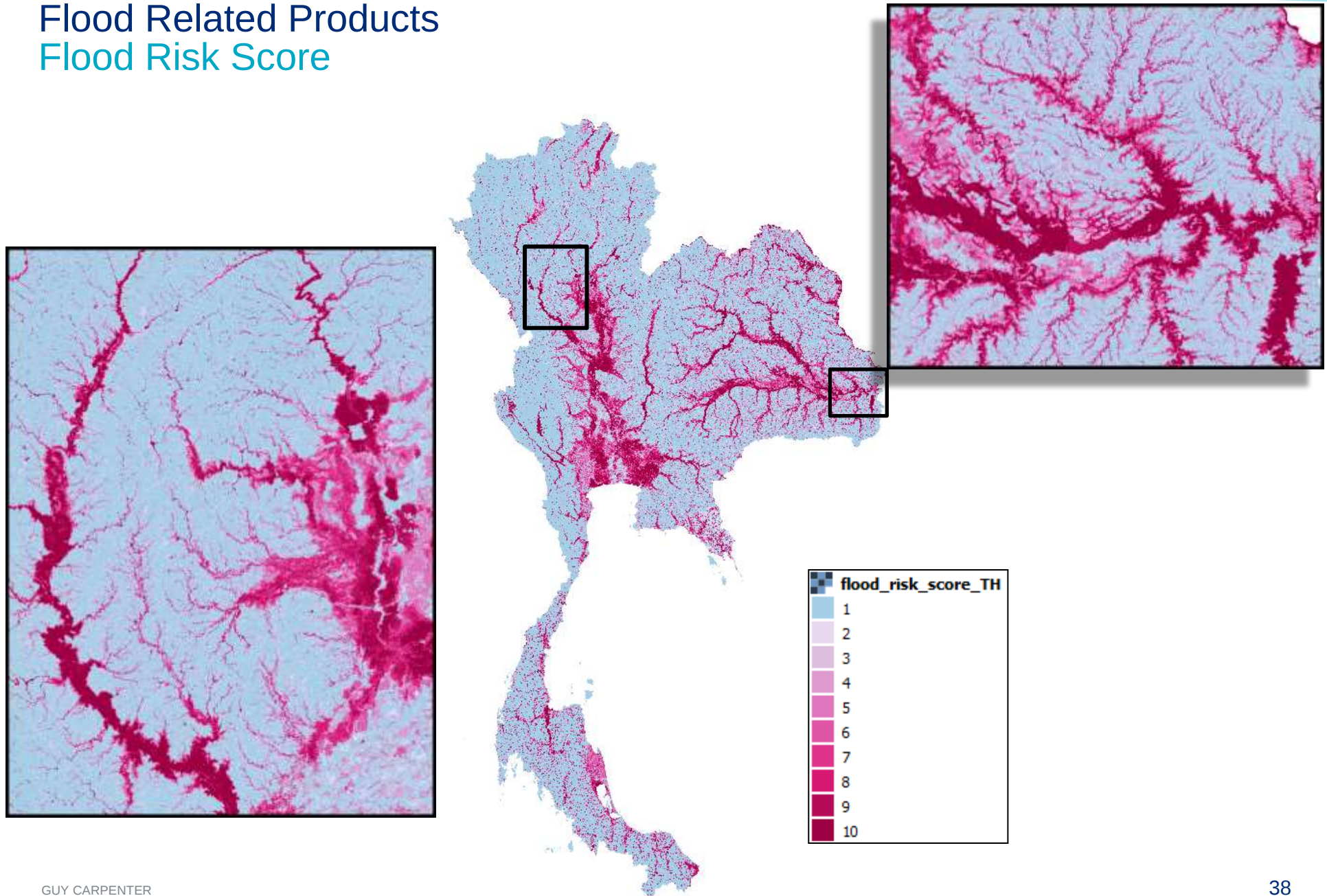
Flood Related Products

AAL / Loss Ratio



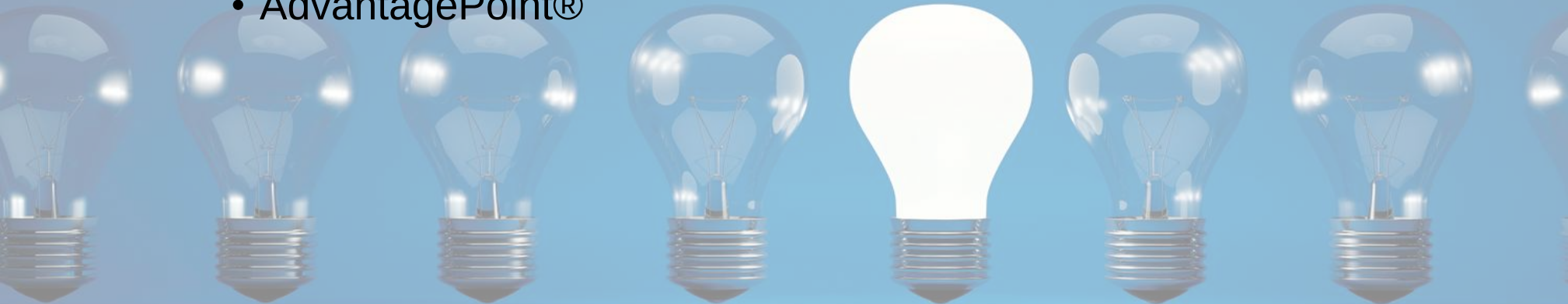
Flood Related Products

Flood Risk Score



Afternoon Sessions:

- ModEx®
- AdvantagePoint®



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There are many limitations on actuarial analyses, including uncertainty in the estimates and reliance on data. We will provide additional information regarding these limitations upon request.

As with any actuarial analysis, the results presented herein are subject to significant variability. While these estimates represent our best professional judgment, it is probable that the actual results will differ from those projected. The degree of such variability could be substantial and could be in either direction from our estimates.

In performing this analysis, we relied on the company for estimates regarding [Enter Relied on Items]. We did not perform an independent review of these estimates.