Navigating Climate Finance: Software Solutions for Climate Risk Management

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Agenda

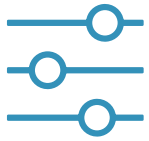
- What makes a “good” climate risk solution?
- Case Studies
  - Flood Risk for Mortgage Portfolio
  - Tropical Cyclone

Key Customer Requirements

For climate risk solutions

- Transparency

- Customizability



- Scalability

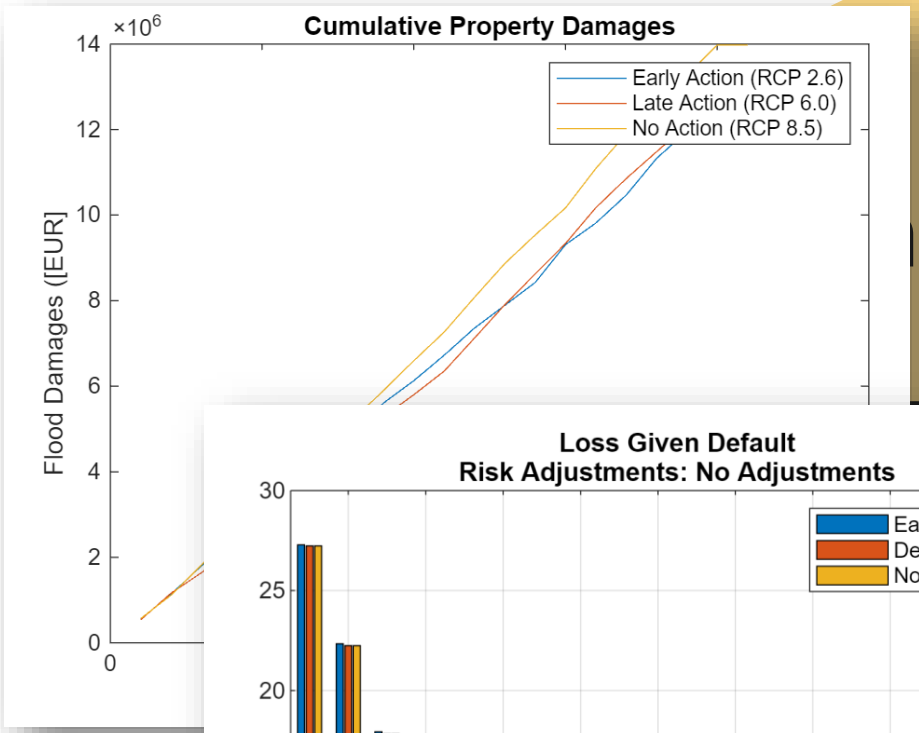
Case Studies

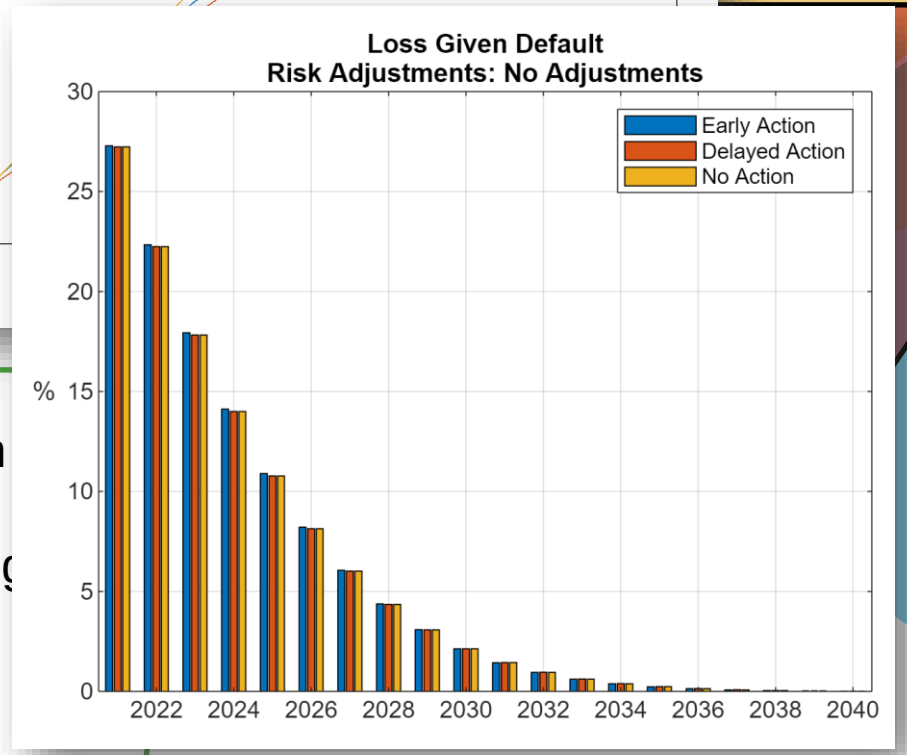
Flooding Risk

Tropical Cyclones

Flood Risk Impact on Mortgage Portfolio

Flood Risk Impact on Mortgage Portfolio





erability

Exposure

Damage function:

(,) → financial impact

Average flood depth

Likelihood of flooding

Sources like JBA, ISIMIP, BRGM, etc

Property address

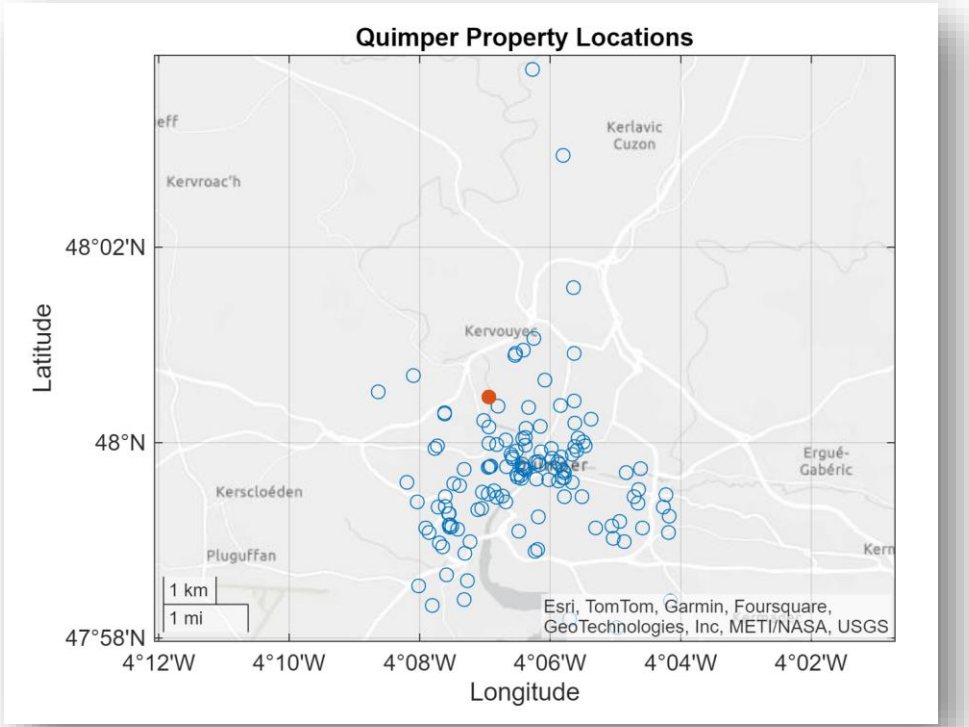
Outstanding loan amount

Property value

Exposure Data - Asset Data and Geocoding

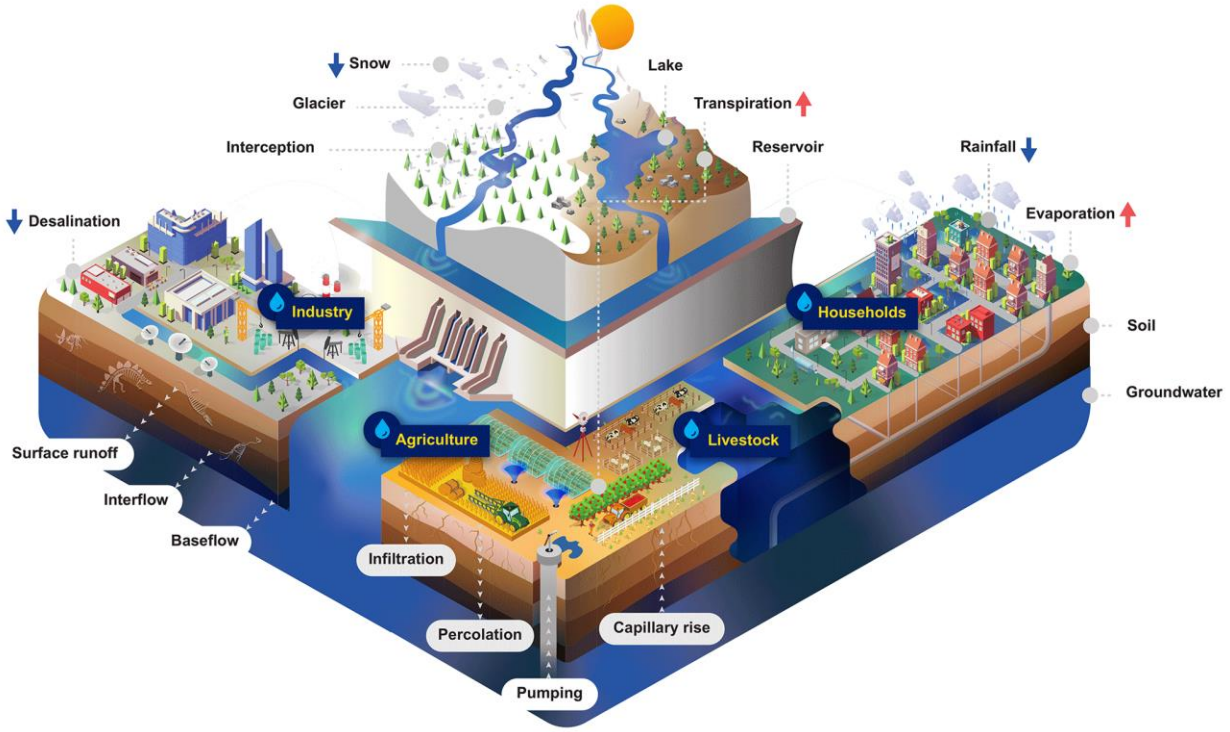
	ID	Address	Town	Postal...	Type
1	'yiX3Y_0VdOPKIZmw_N4Id'	'4, Rue de Ludugris'	'QUIMPER,'	29000	'Domestic'
2	'DVKqjfeWlrGBsIXsxD1TF'	'20 RUE JULES VALLES'	'QUIMPER'	29000	'Domestic'
3	'XVtidLom5B4VX0e-p39fu'	'203 Route de Guengat'	'QUIMPER'	29000	'Domestic'
4	'btEm-W-RwO2u3N-EmE…	'62 Rue Guy Autret'	'QUIMPER'	29000	'Domestic'
5	'pfojwgNCmhaA4Qq1hlGwj'	'46 Rue Emile Souvestre'	'Quimper, F…	29000	'Domestic'
6	'ZPAV_ShTTxvQu3cxVL64C'	'42 AVENUE DE LIMERICK'	'QUIMPER'	29000	'Domestic'
7	'A4MkLIv-NHZoC8V6Y4e…	'11 RUE TEILHARS DE C…	'QUIMPER'	29000	'Domestic'
8	'Eyk51eQcBPlPRfXFIttqs'	'3 ALEZ AN DOUAR DU'	'QUIMPER'	29000	'Domestic'
9	'429ksXAWYBDZX3Jhz 4Pl'	'3 RUE DU ROUSSILLON'	'QUIMPER'	29000	'Domestic'

Geocoding

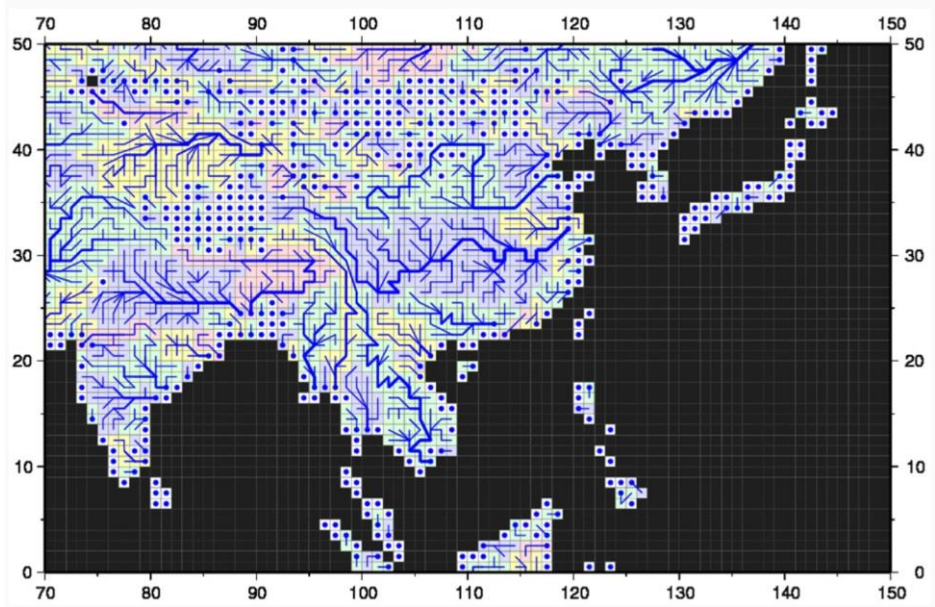


Hazard Data – Flood Depth

ISIMIP: Inter-Sectoral Impact Model Intercomparison Project



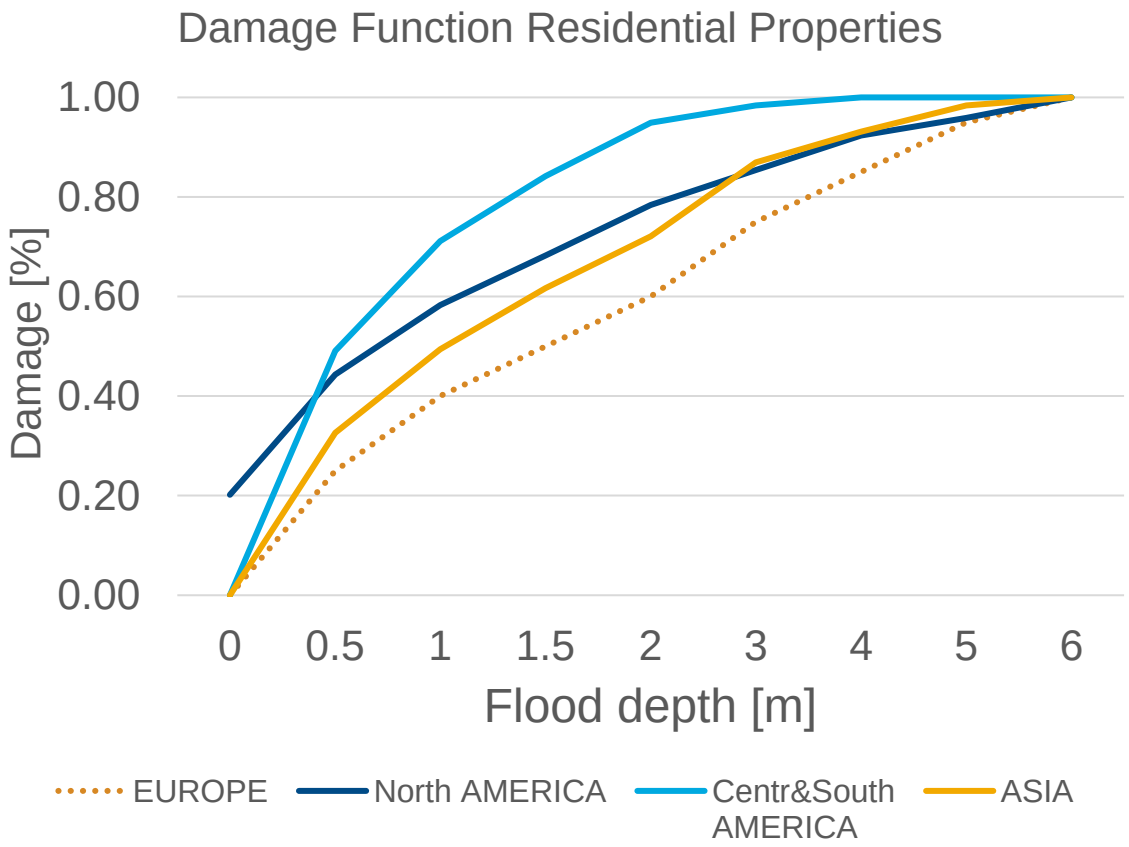
Community water model (CWatM) (Source)



Catchment-based Macro-scale Floodplain (CaMa-Flood) (Source)

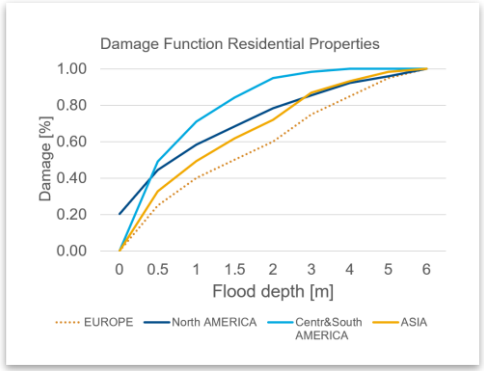
Vulnerability - Damage Function

- **Damage Function** relates water height in case of flooding to property damages expressed in percentage of property value lost



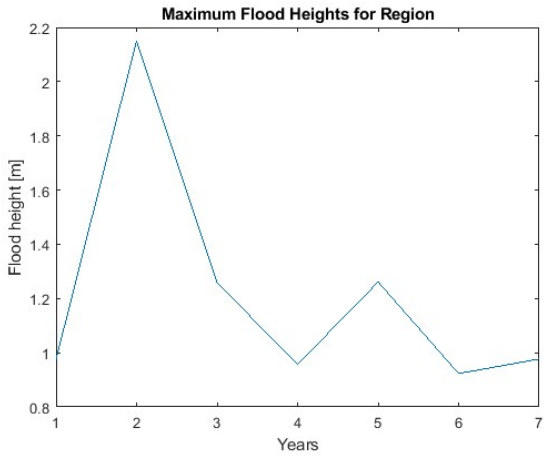
- Based on a technical report by the European Commission's Joint Research Centre, which distinguishes between different countries and property usages

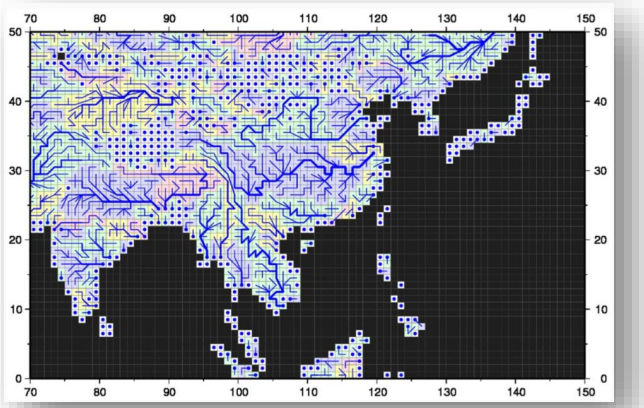
Financial Impact



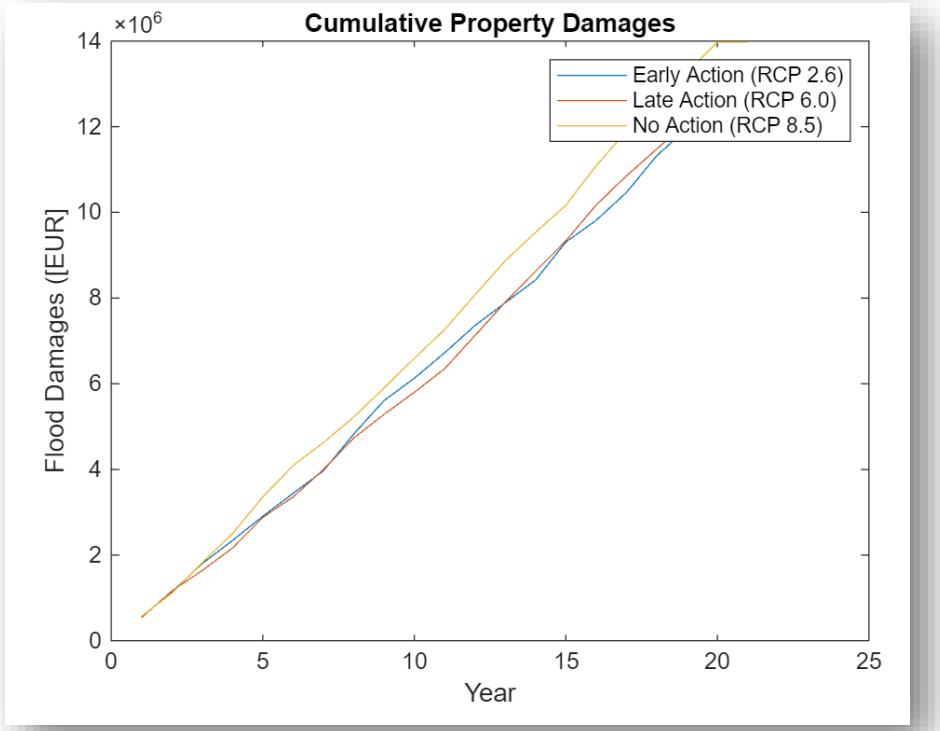
$$D = d(h_{max}) \cdot f \cdot v$$

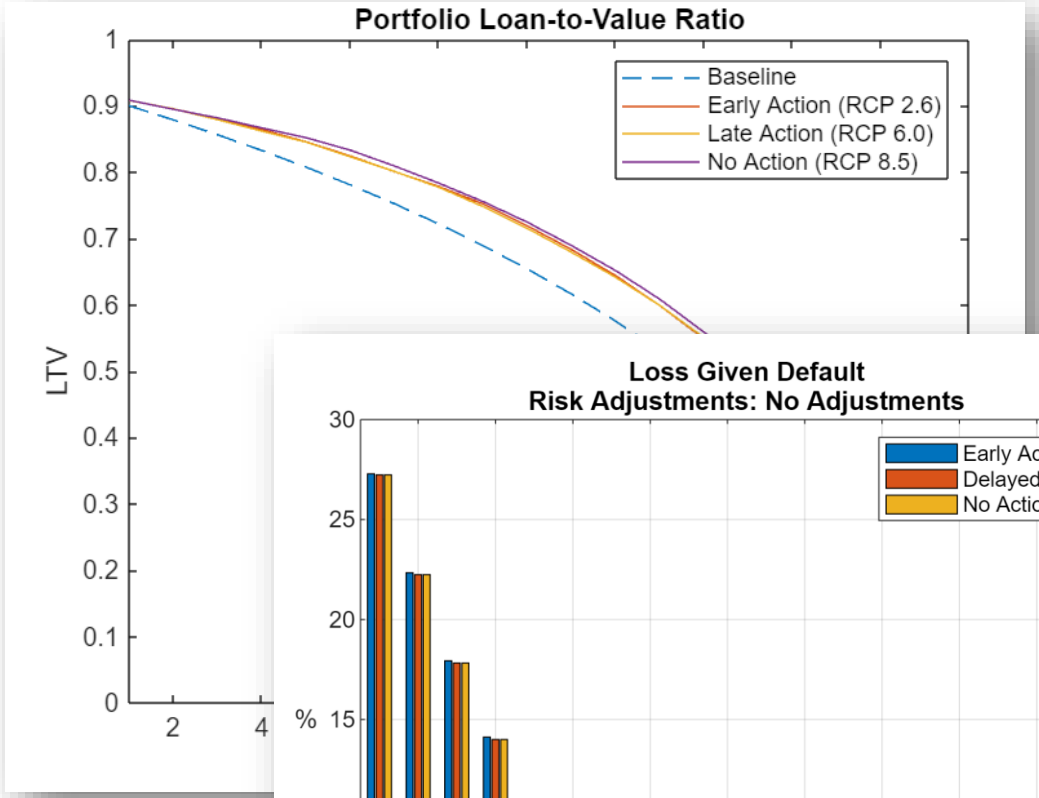
d – damage function
h_{max} – max flood height
f – flooded fraction for region
v – property value





Financial Impact



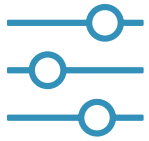


Key Customer Requirements

For climate risk solutions

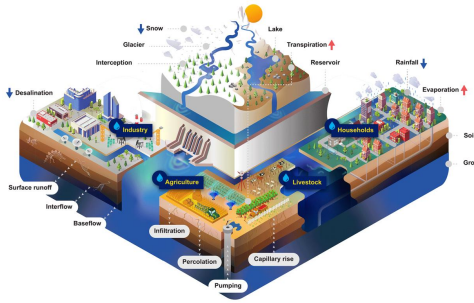
- Transparency

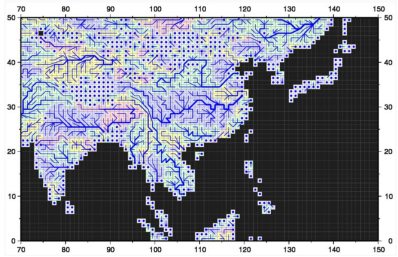
- Customizability



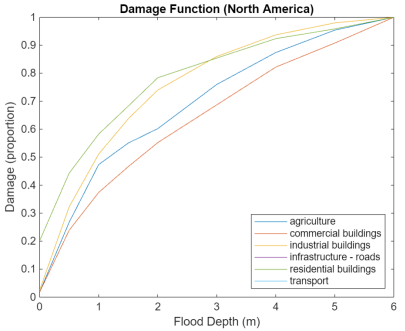
- Scalability

Transparency





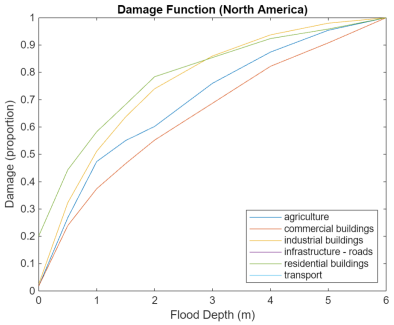
- Publicly available, peer-reviewed climate models
- Clear modelling assumptions of damages
- Understanding of every component in damages equation



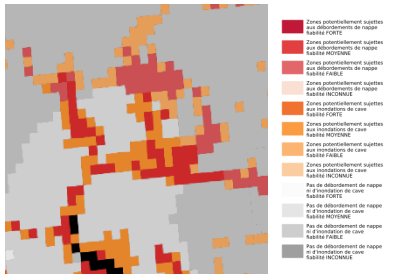
$$D = d(h_{max}) \cdot f \cdot v$$

Customizability

Solutions are not one-size-fits-all



- Desire for different modelling assumptions
- Incorporation of additional, informative data when available



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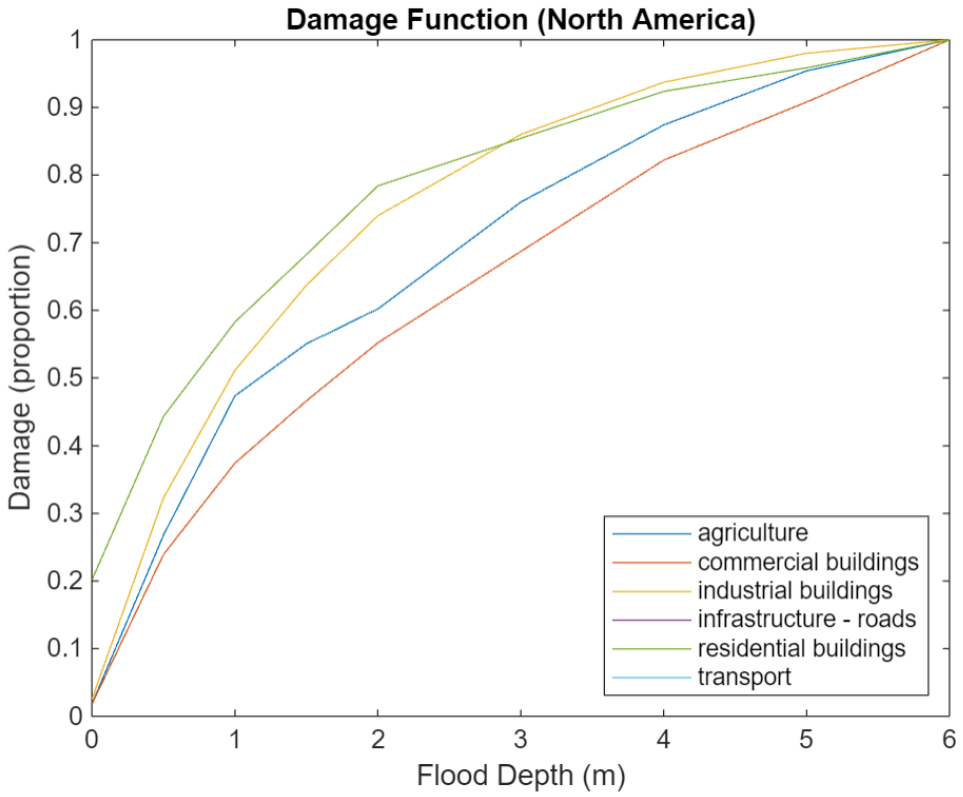
Damage Function

Alternative modelling assumptions

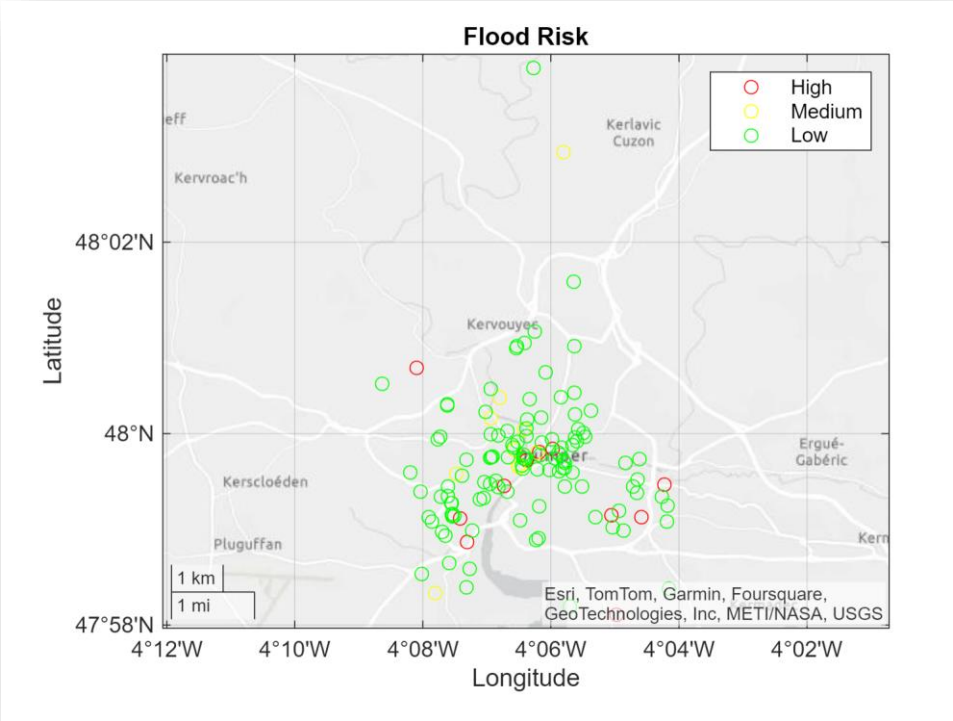


- Denormalize to obtain maximum damage per m^2 of building
  - If m^2 is available, or could be estimated from building type (e.g. single family home)
- Account for undamageable part of building
  - Example: 0.4 for concrete or masonry, 0.2 for corrugated iron, 0.0 for wood
- Different assumptions of building content value

Flood Risk Scores

Incorporating additional data

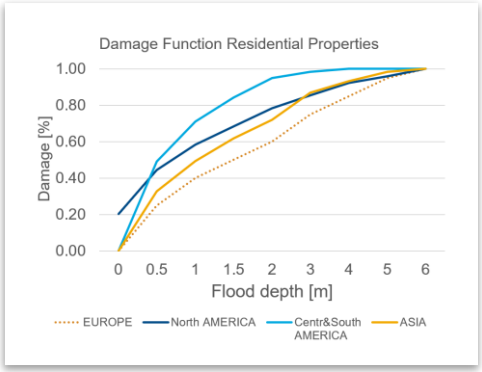
GASPAR Flood Risk



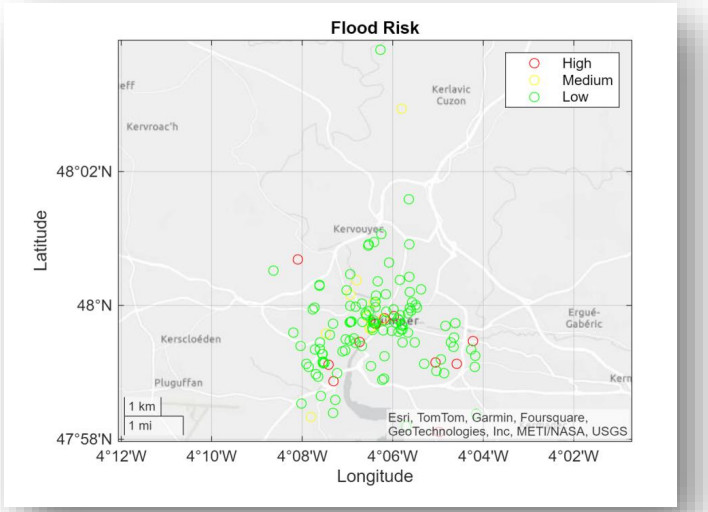
BRGM Flooding Risk

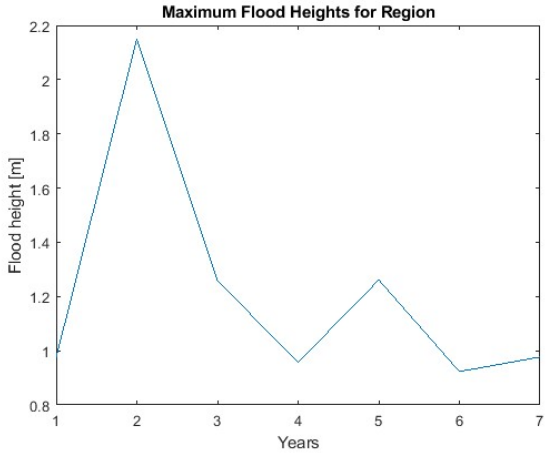
Flood Risk Scores

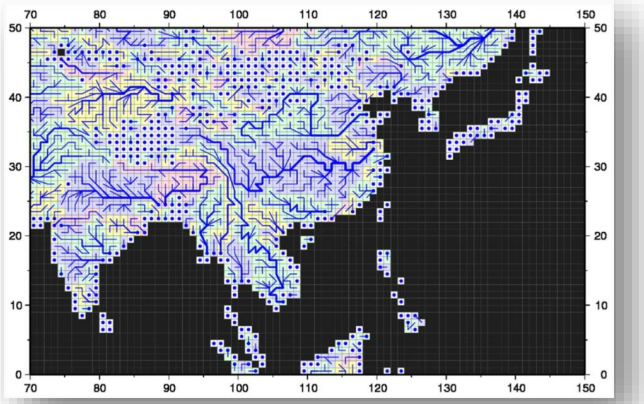
Incorporating additional data



$$D = d(h_{max}) \cdot f \cdot r \cdot v$$







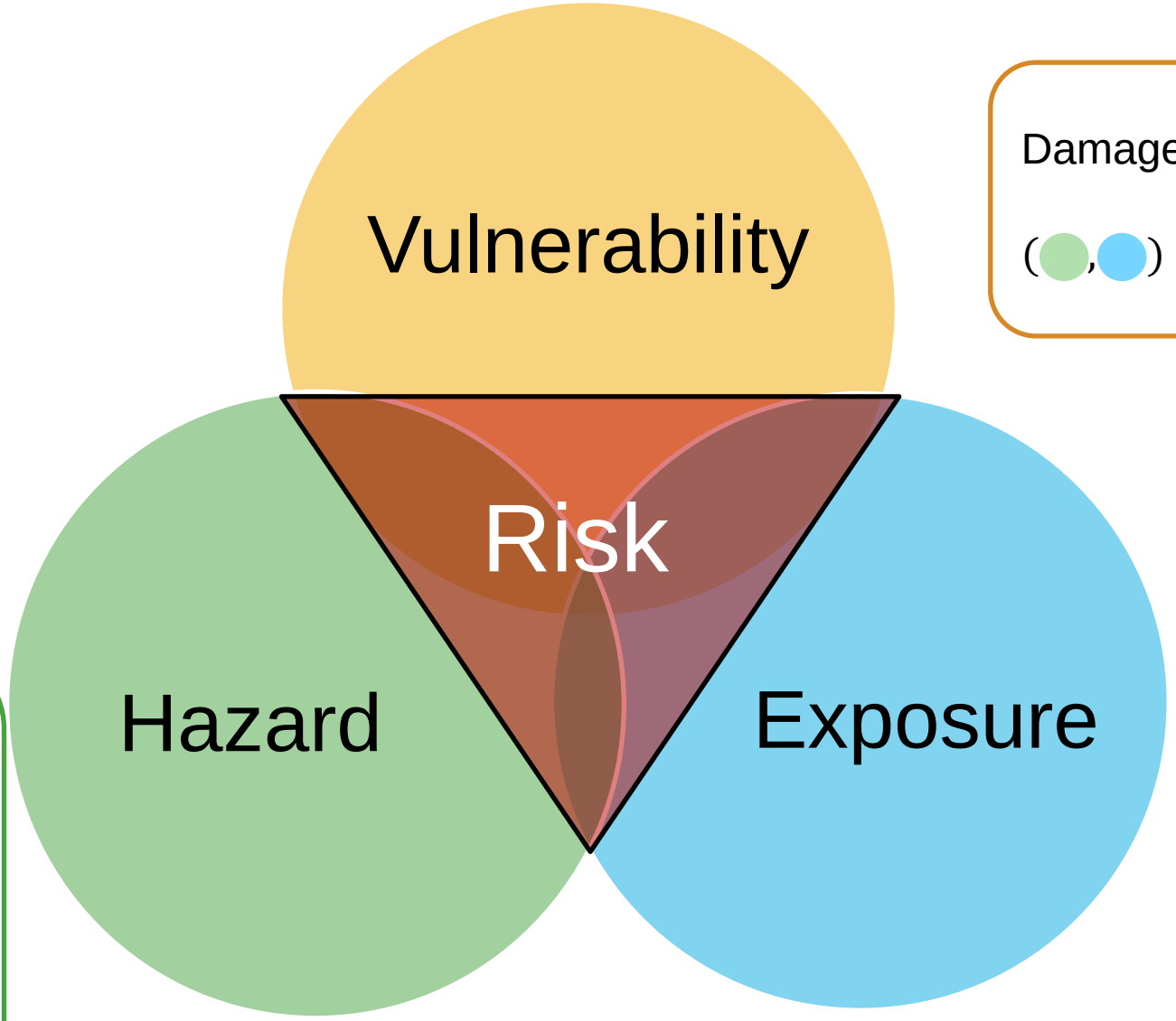
d – damage function
h_{max} – max flood height
f – flooded fraction for region
v – property value
r – flood risk weight

Case Studies

Flooding Risk

Tropical Cyclones

Tropical Cyclones



Damage function:

(●,●) → financial impact

Average wind speed

Cyclone paths

Time and pressure

Source is Bloemendaal et. al (2020)

Property address

Property value

Distance to the sea

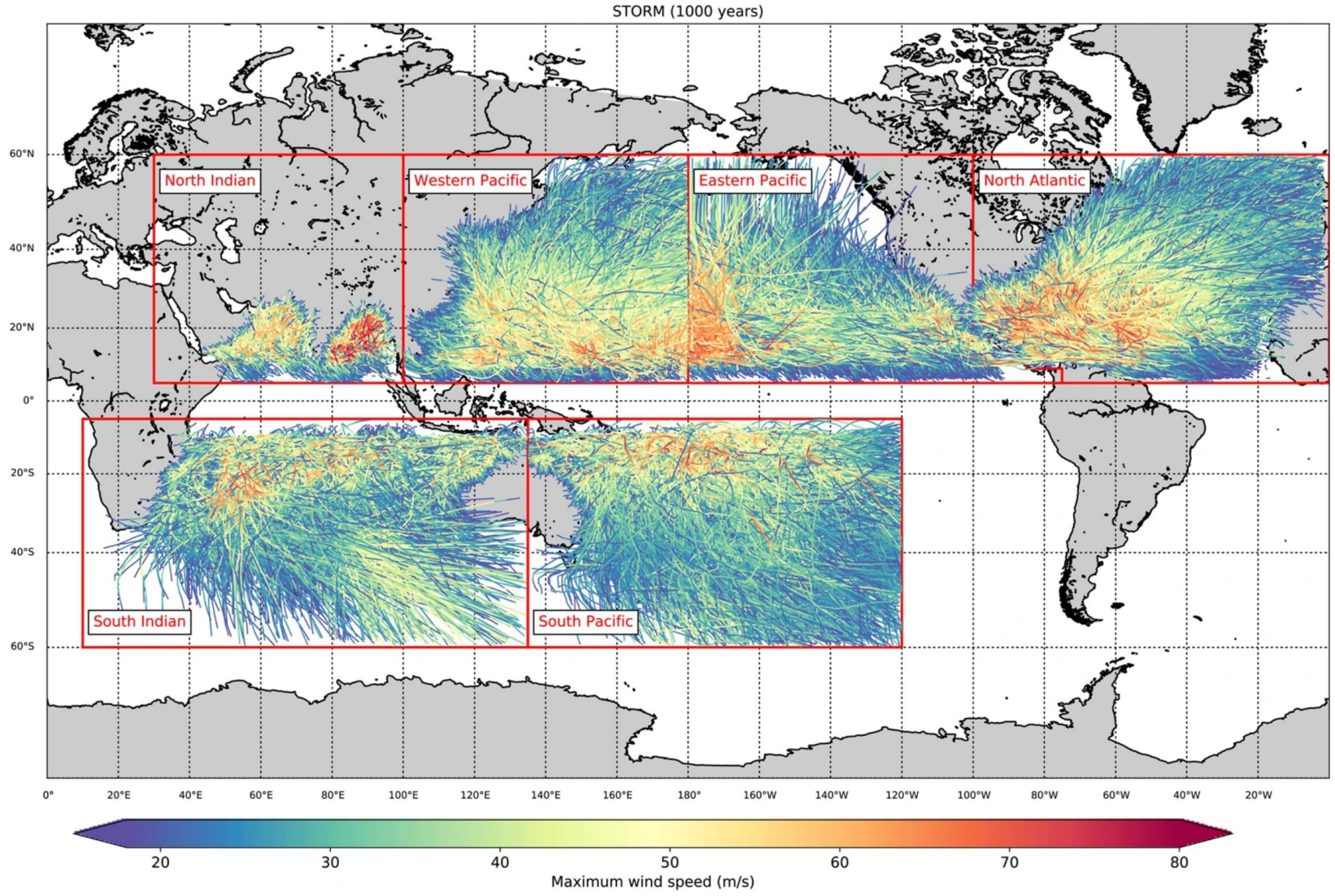
Asset Data

Asset localization

PropertyTable = *18×5 table*

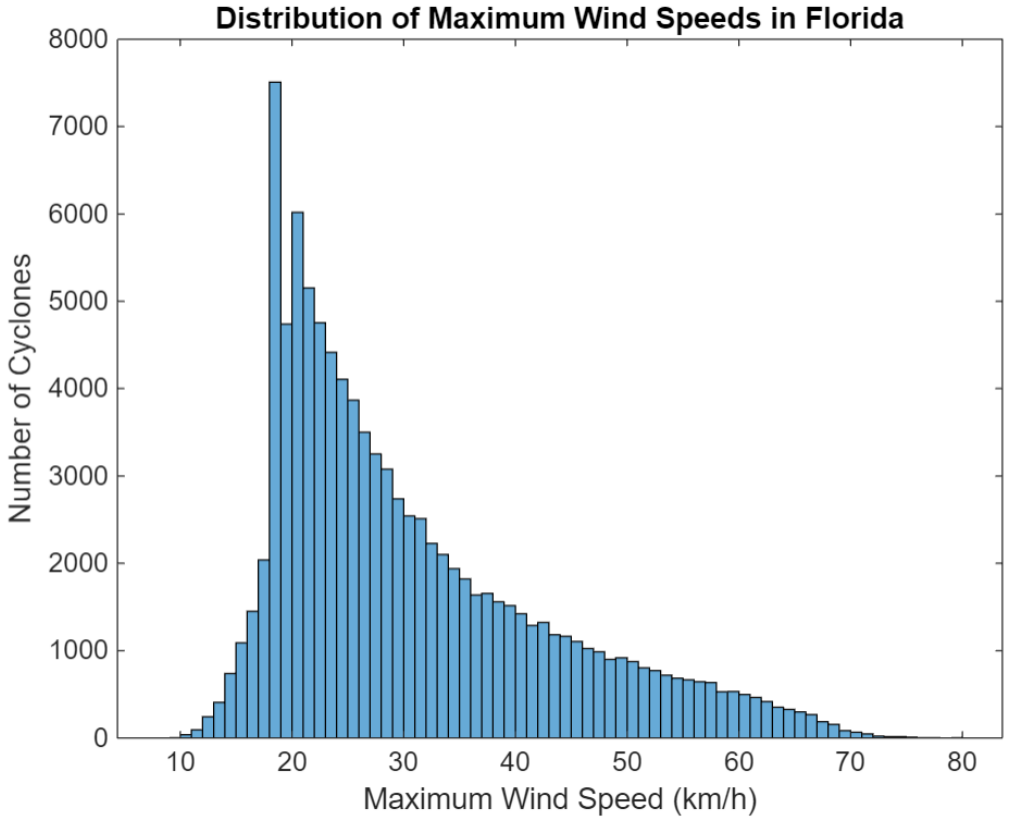
	Latitude	Longitude	Property_Location	Property_Values	DistanceToSea
1	30.4116	-84.3065	'Tallahassee'	554500	35
2	30.4423	-84.2158	'Tallahassee'	554500	35
3	30.4150	-84.3302	'Tallahassee'	554500	35
4	27.9132	-82.3700	'Tampa'	460000	5
5	28.0195	-82.5225	'Tampa'	460000	5
6	27.8777	-82.5011	'Tampa'	460000	5
7	30.2755	-81.6088	'Jacksonville'	301000	20
8	30.4423	-81.7429	'Jacksonville'	301000	20

STORM IBTrACS Dataset

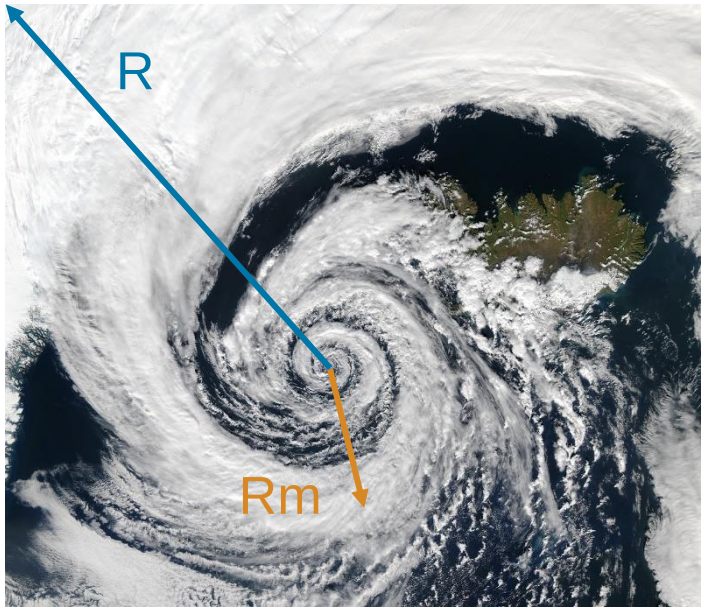


Source: Bloemendaal et. al (2020)

Hazard Data – Simulated Tropical Cyclones

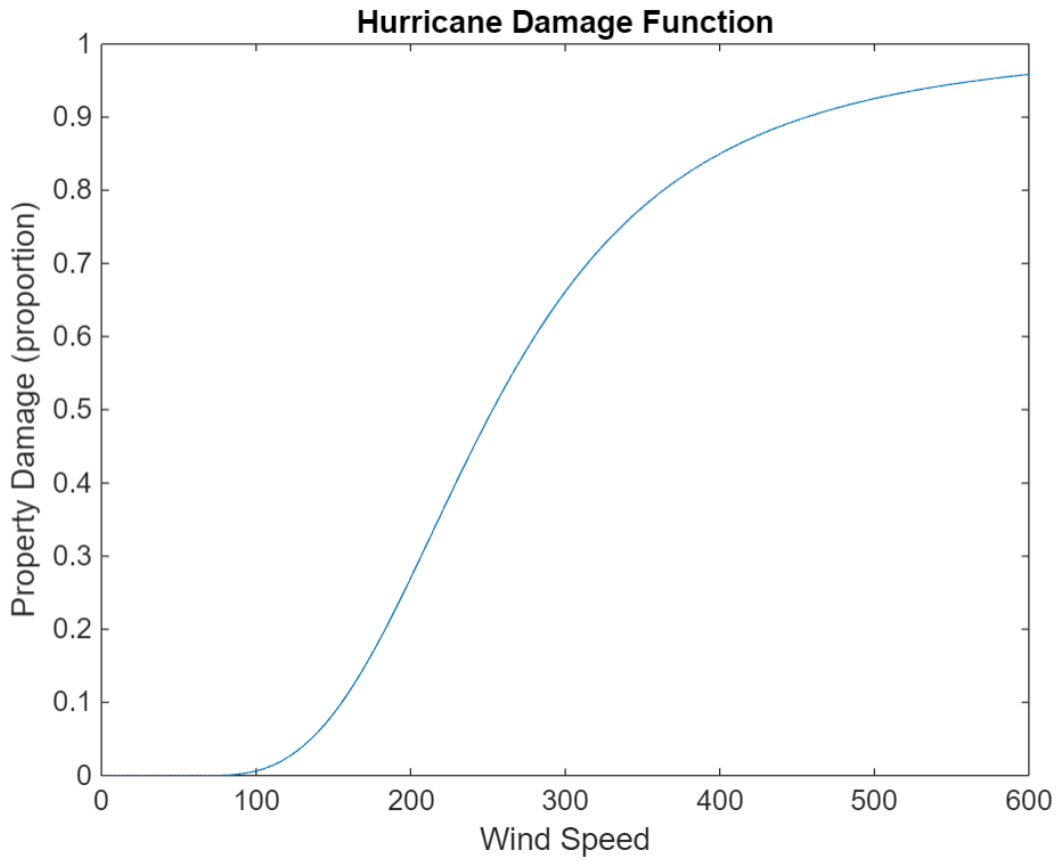


Radius and Radius of Maximum Velocity



Wind Damage Function

$$D = \frac{W^3}{1 + W^3}, \text{ where } W = \frac{\max([V - V_{\text{thresh}}], 0)}{V_{\text{half}} - V_{\text{thresh}}}$$



Source: Emanuel (2011)

Calculating Wind Speed

$$V_i = \mathrm{GF}\left[V_m - S(1-\sin(T_i))\frac{V_h}{2}\right] * \left[\left(\frac{R_m}{R_i}\right)^B \exp\left(1-\left[\frac{R_m}{R_i}\right]^B\right)\right]^{\frac{1}{2}}$$

Source: Ishizawa et al (2019)

Where

$G = 1.5$ (Gust Factor)

$F = .7(1-R)$ (Friction Parameter)

Here R is a reduction factor that scales linearly as a function of distance inland. It starts at .14 and scales to .28 50km from the coast.

$S = 1$ (Storm asymmetry factor)

$V_m =$ Maximum wind velocity (km/h)

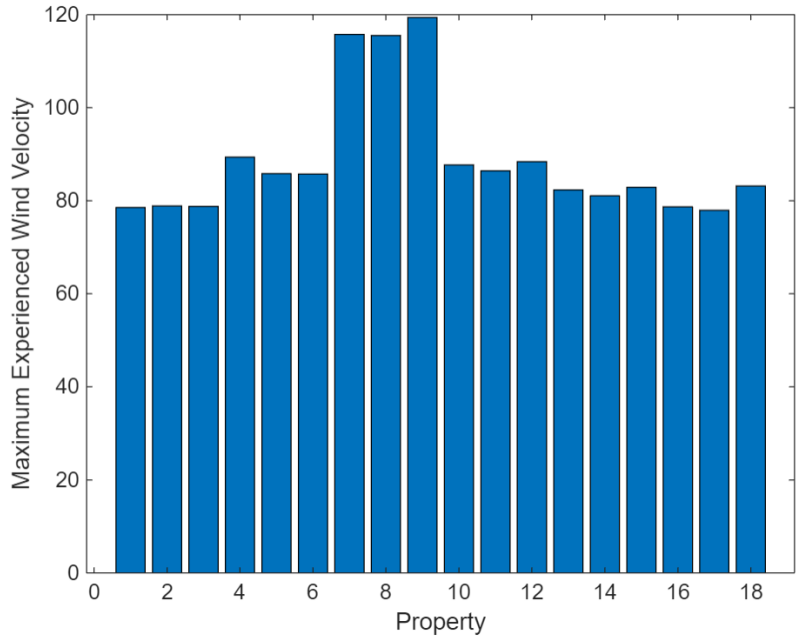
T_i = clockwise angle made by the forward direction of the hurricane and the line made by the center of the hurricane with property i.

$V_h =$ Forward velocity of the hurricane (km/h)

$R_m =$ Radius to winds of maximum velocity (km)

$R_i =$ Radius to property i (km)

$B =$ Wind profile parameter described in Holland (2008).

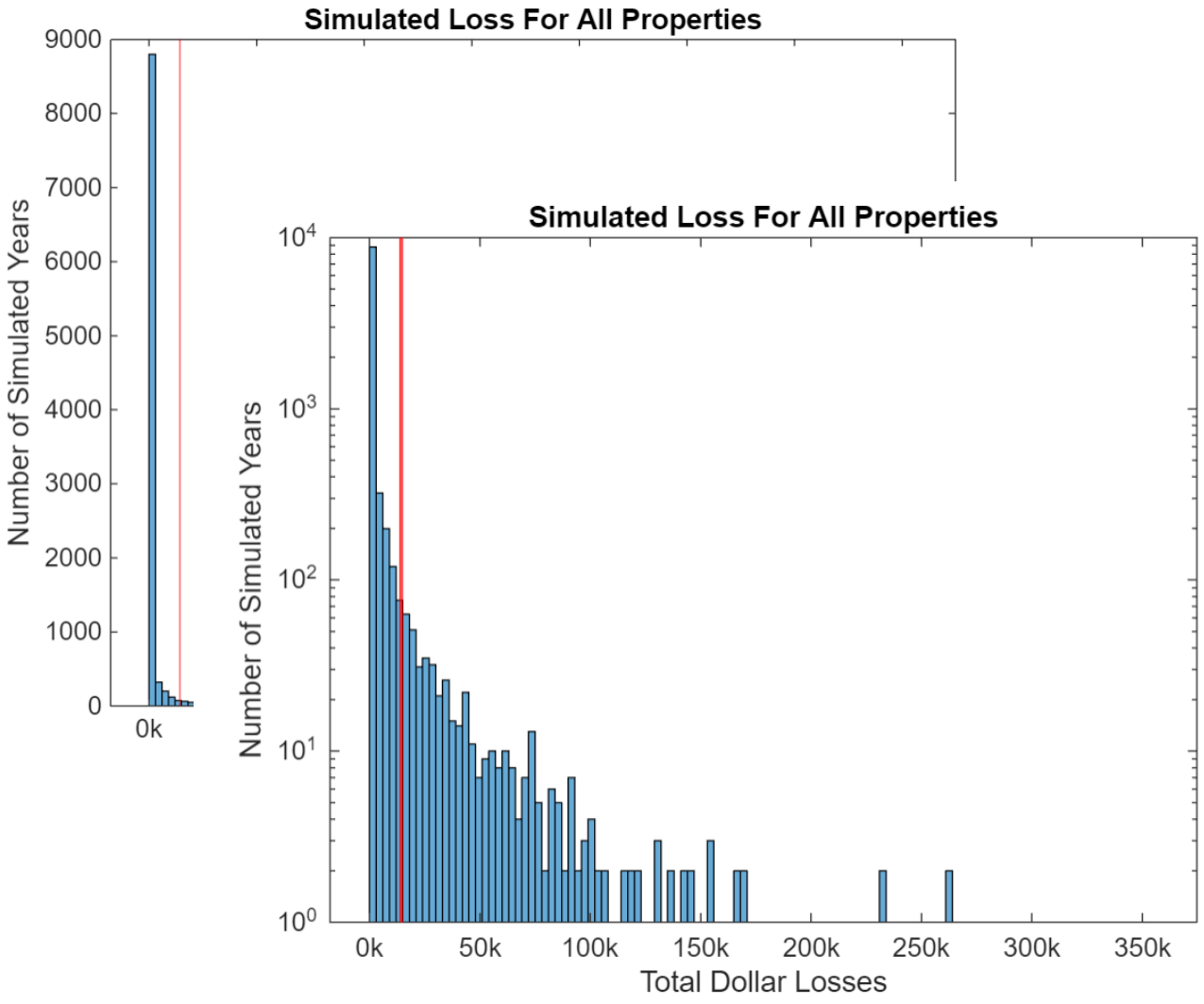


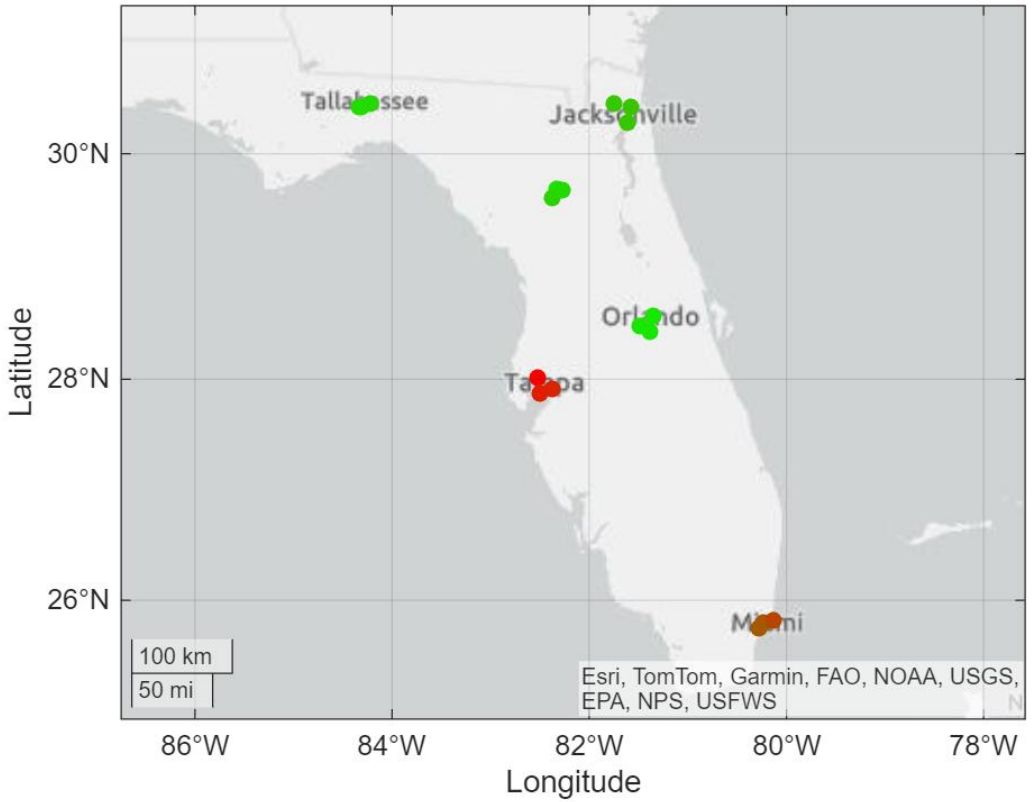
$$B = 1.6 * B_s$$

$$B_s = -4.4 * 10^{-5}\Delta p^2 + 0.01\Delta p + 0.03\frac{\partial p_c}{\partial t} - 0.014\phi + 0.15V_t^x + 1$$

Source: Holland (2008)

Hurricane Impact



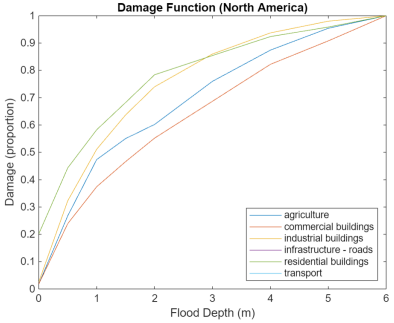


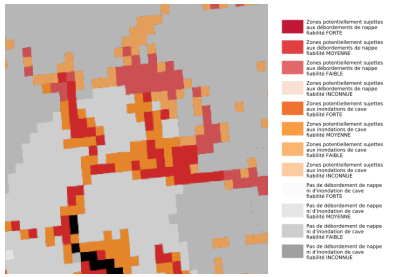
- None of the properties take damage in 72% of simulations
- Worst 5%, combined yearly losses exceed $14,327 and get substantial in the tails

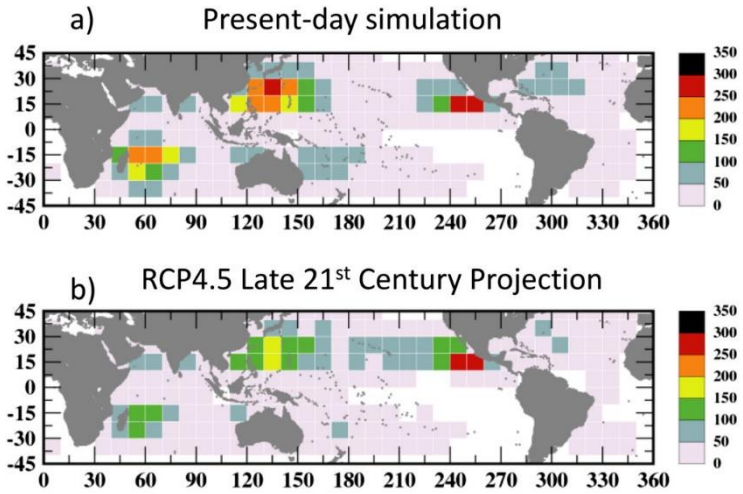
Customizability

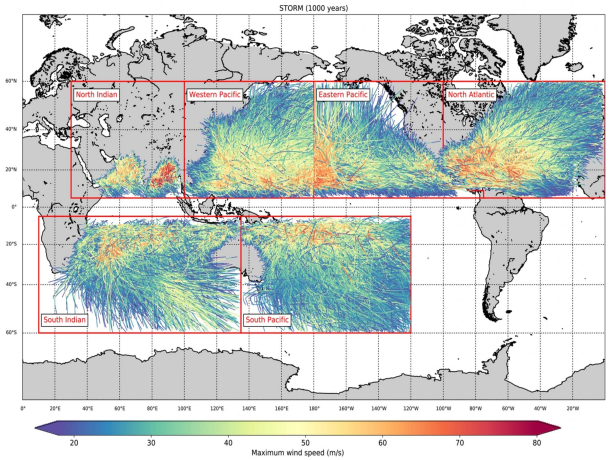
Solutions are not one-size-fits-all

- Desire for different modelling assumptions
- Incorporation of additional, informative data when available
- Relevance of perils and transition risks differ
- Varying appetite for uncertainty



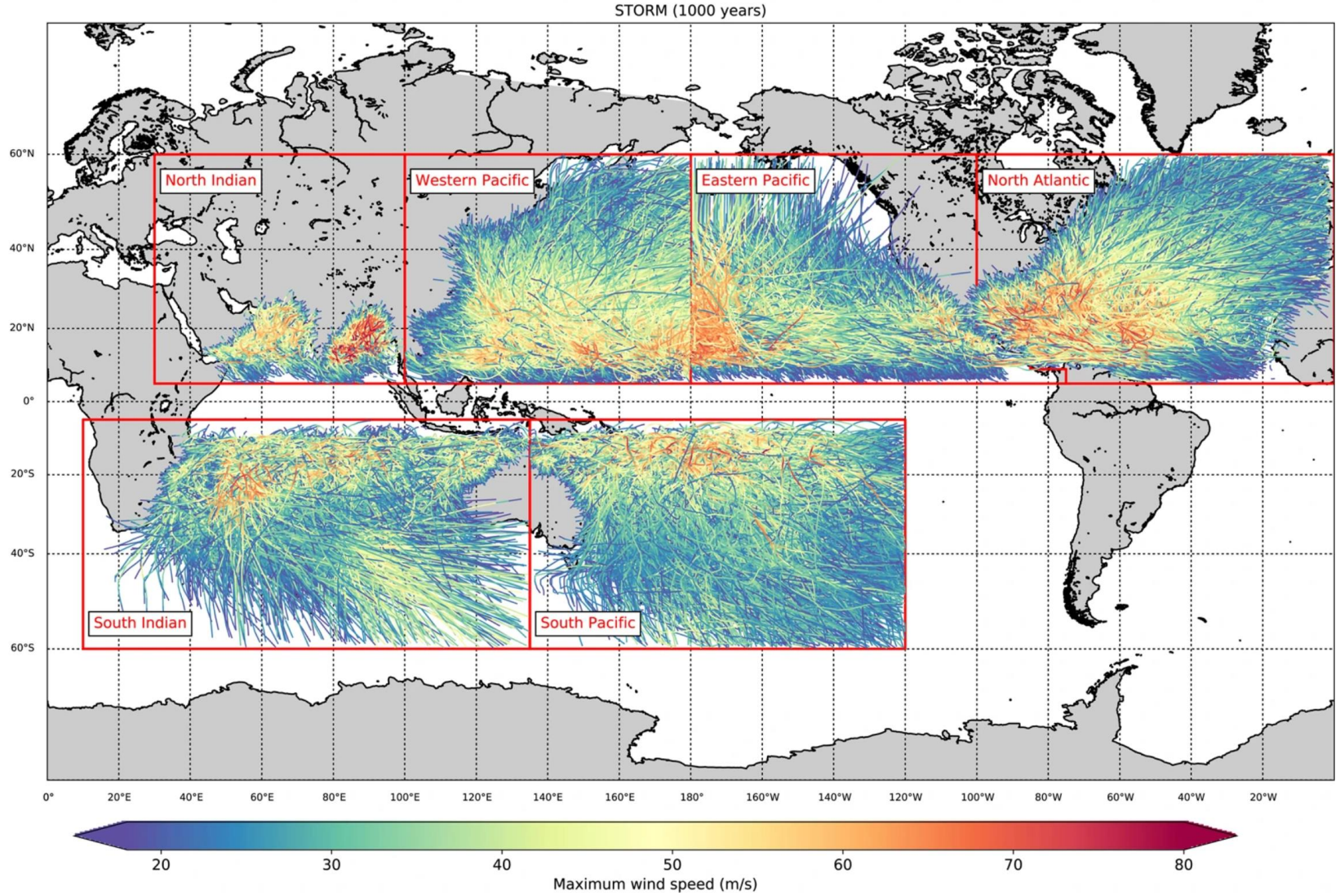






Tropical Cyclones

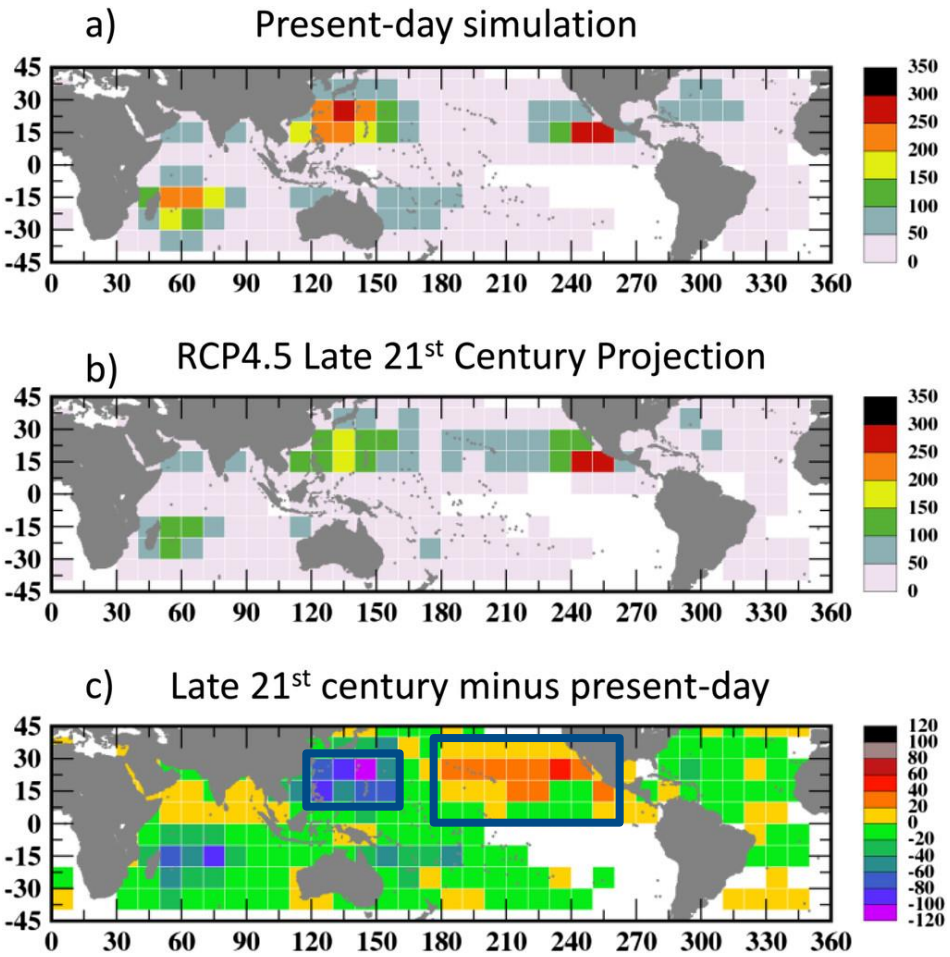
Relevance of Perils Differ



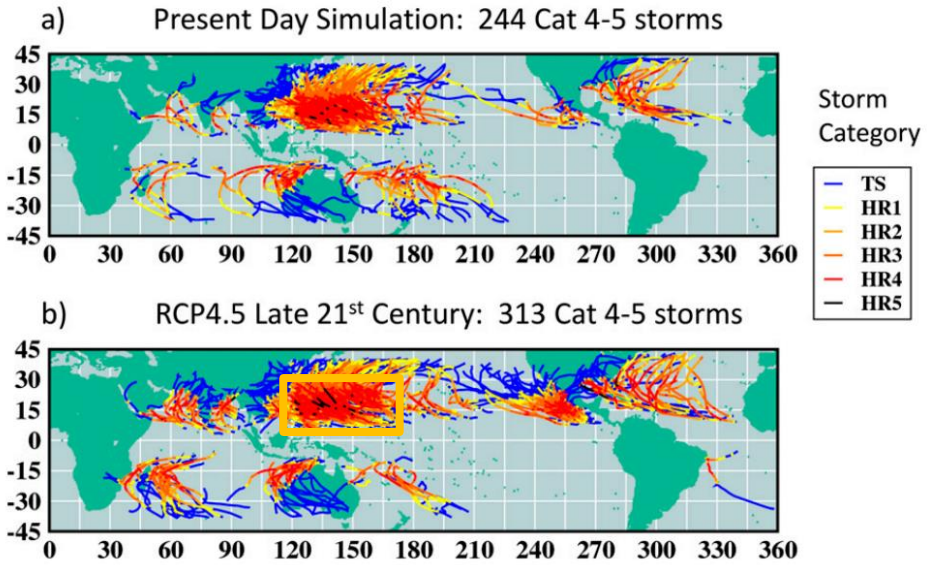
Source: [Bloemendaal et. al (2020)]

Climate Projections for Tropical Cyclones

Varying risk appetite



Change in Frequency



Change in Intensity

Source: [Knutson et. al (2015)]

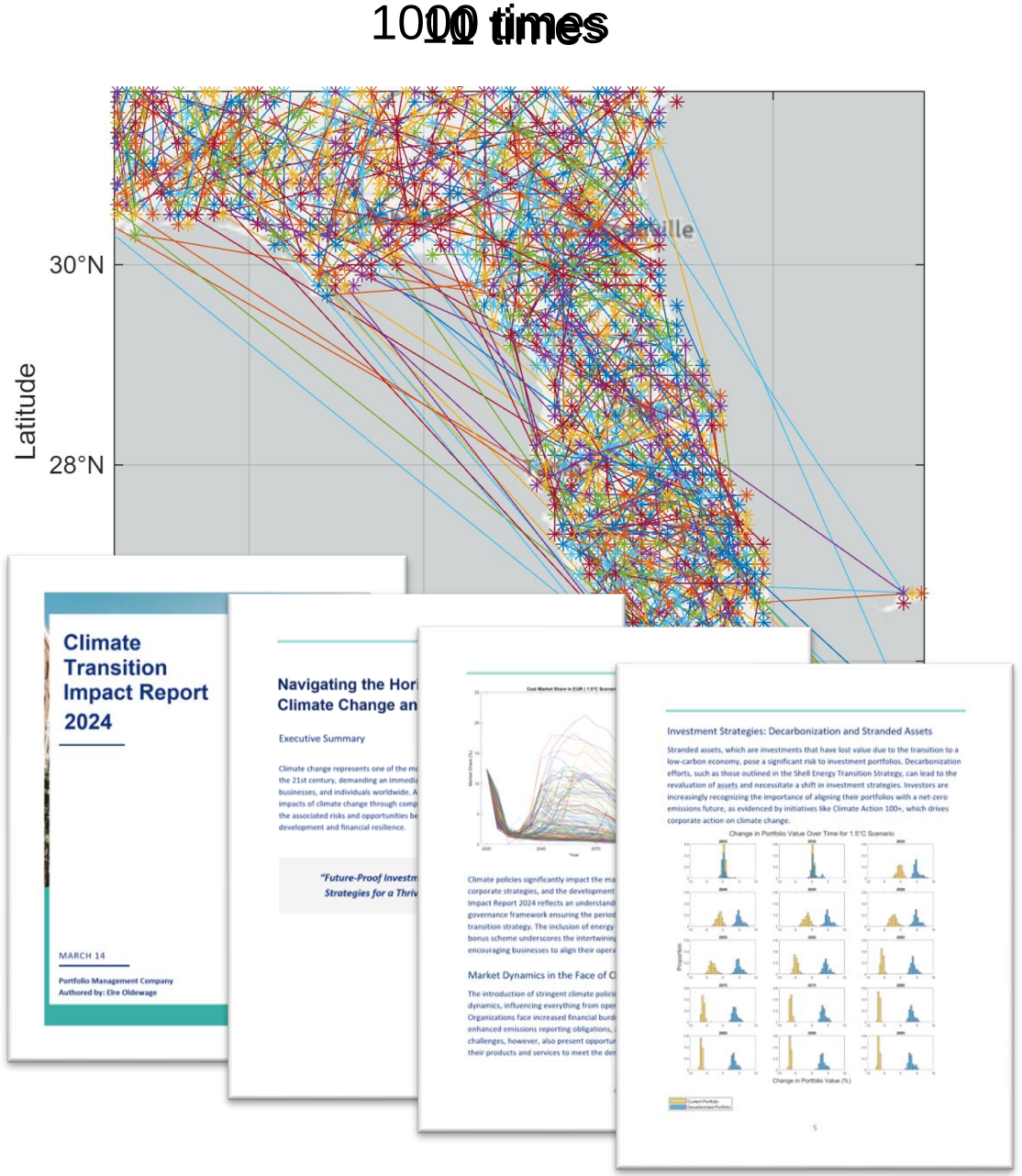
Scalability

Analysis scaling - Parallelization

- Number of simulations
- With portfolio size
- Forward in time
- Number of scenarios

Business-side scaling - Automation

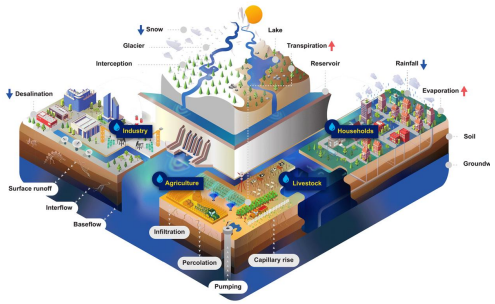
- Understanding analysis outcomes
- Different stakeholders
- Outputs for downstream processes

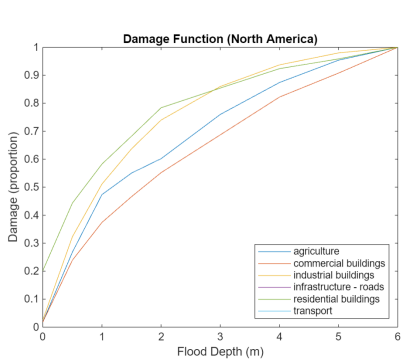


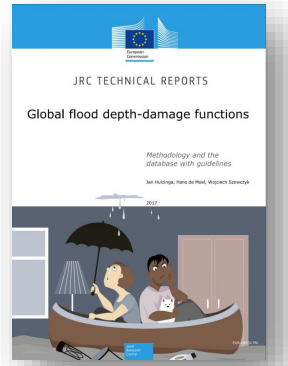
Key Customer Requirements

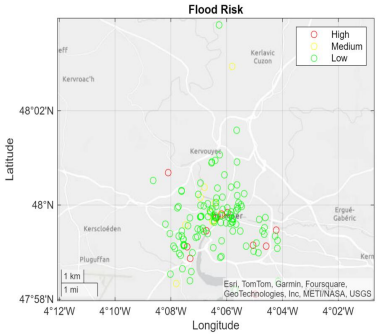
For climate risk solutions

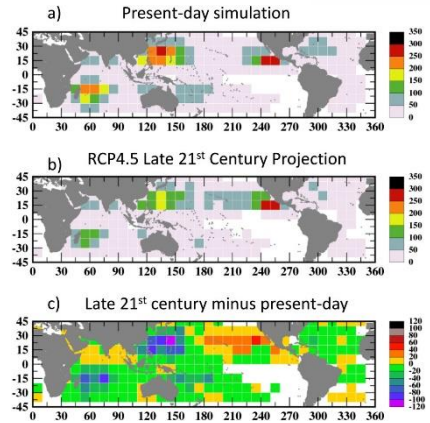
- Transparency
- Customizability
- Scalability

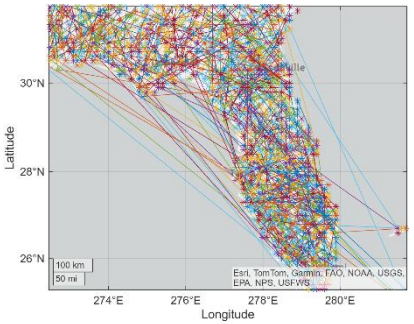












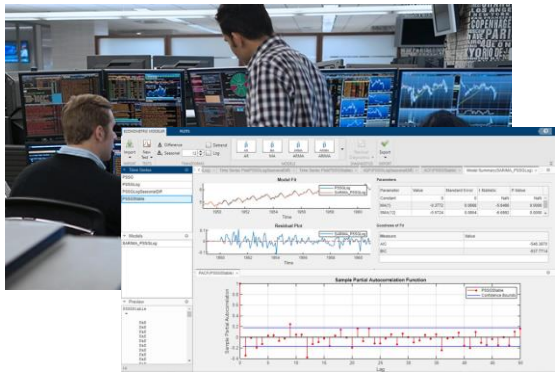
Key Customer Requirements

For climate risk solutions

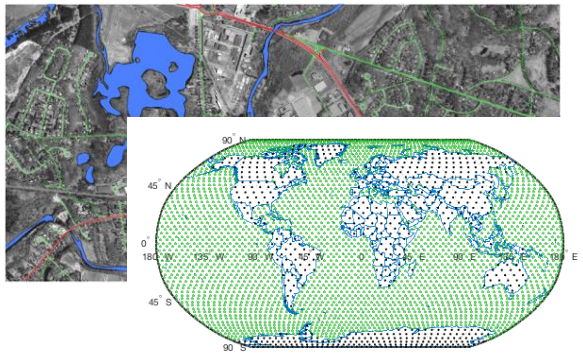
Elre Oldewage

Email: climatefinance@mathworks.com
Search: “MathWorks Climate Risk”

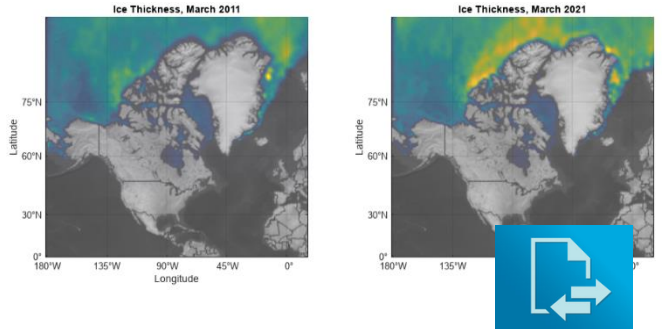
- Transparency
- Customizability
- Scalability



Computational Finance



Mapping and Geo Capabilities



Pre-built APIs

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