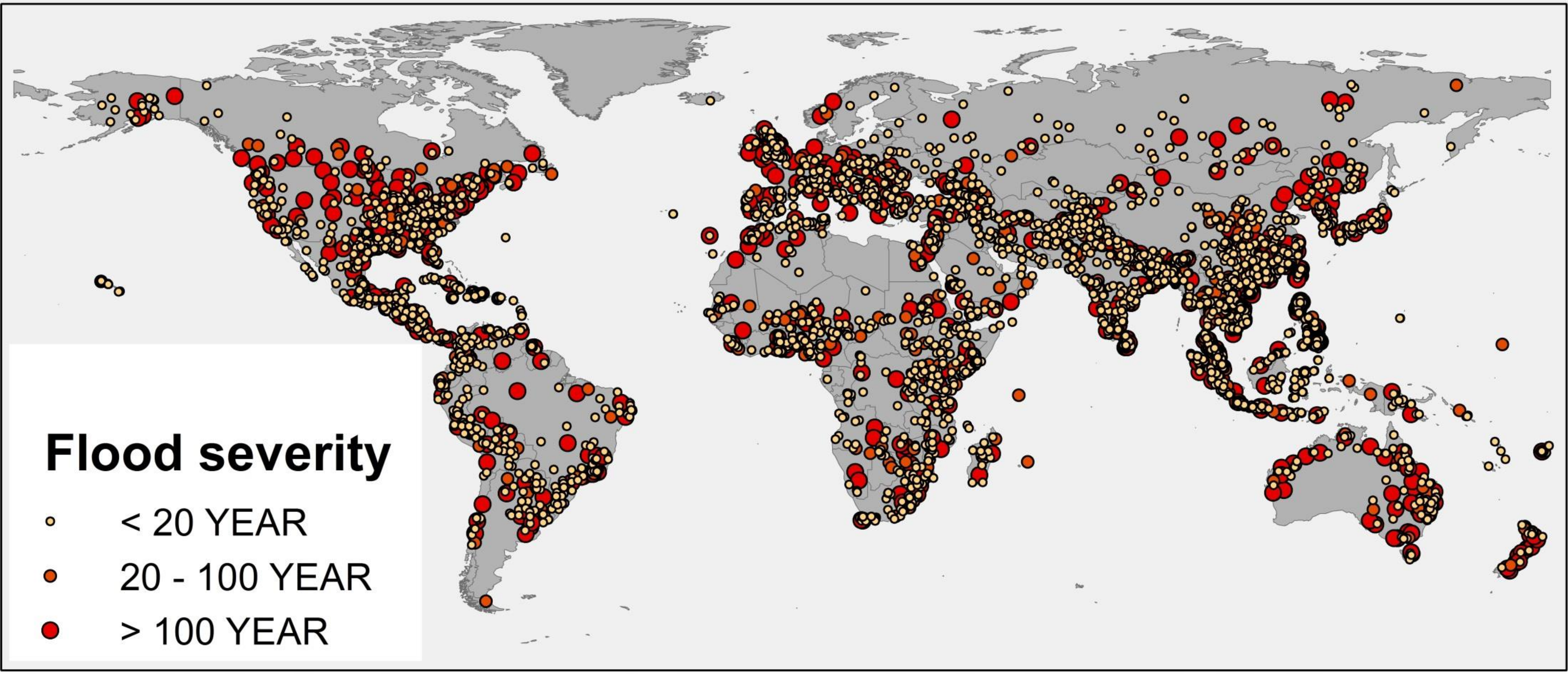
MODELING INLAND FLOOD: DEMANDS, CHALLENGES AND SOLUTIONS

BOYKO DODOV, Ph.D.

AIR WORLDWIDE®

No Place on Earth Is Safe from the Flood Peril

Worldwide Floods 1978 - 2013



CORTESY: National Flood Observatory, Dartmouth College, University of Colorado

Types and Causes of Floods

- Inland flood

- Storm surge / Tsunami

On-floodplain / fluvial

Off-floodplain / pluvial

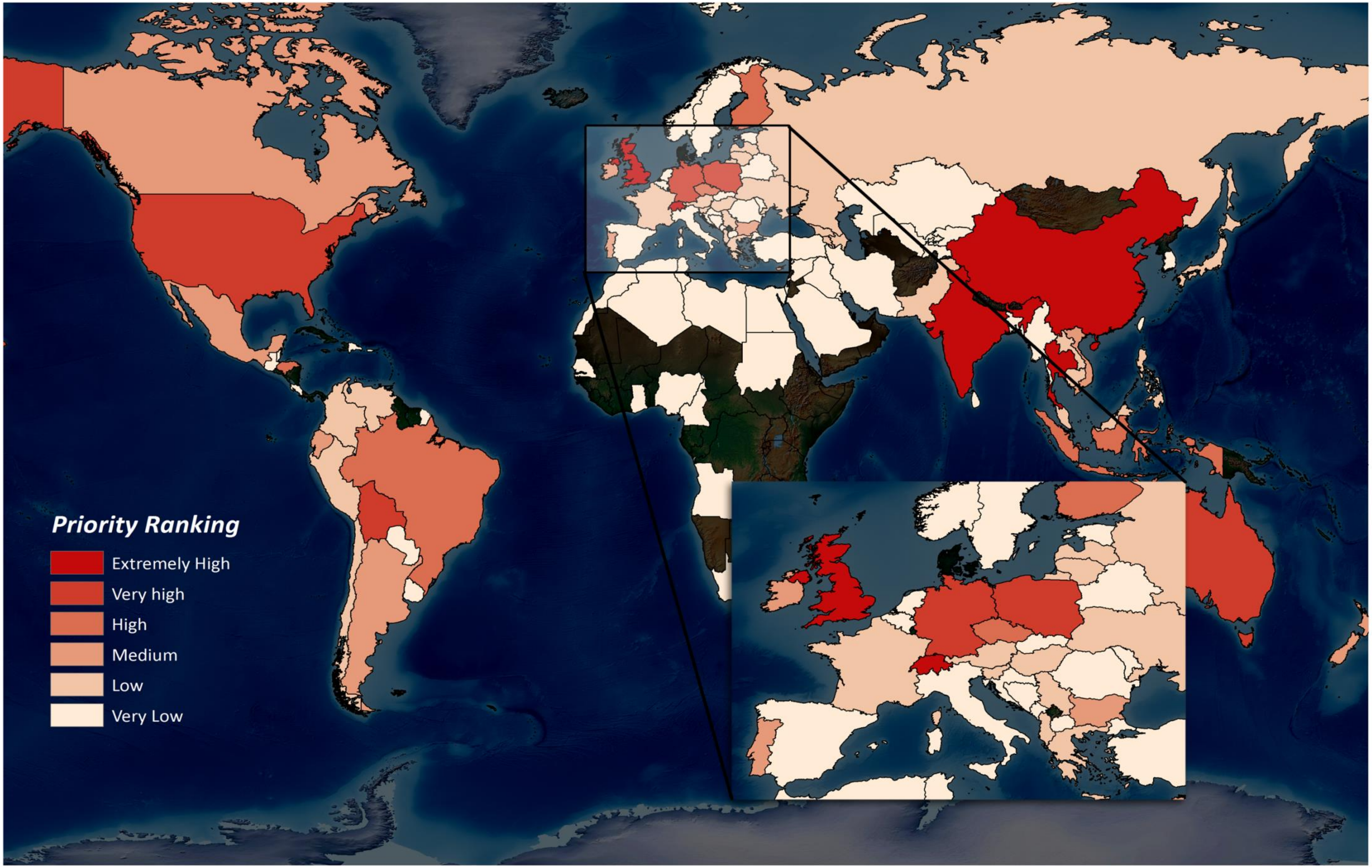
Extreme rainfall

Snowmelt

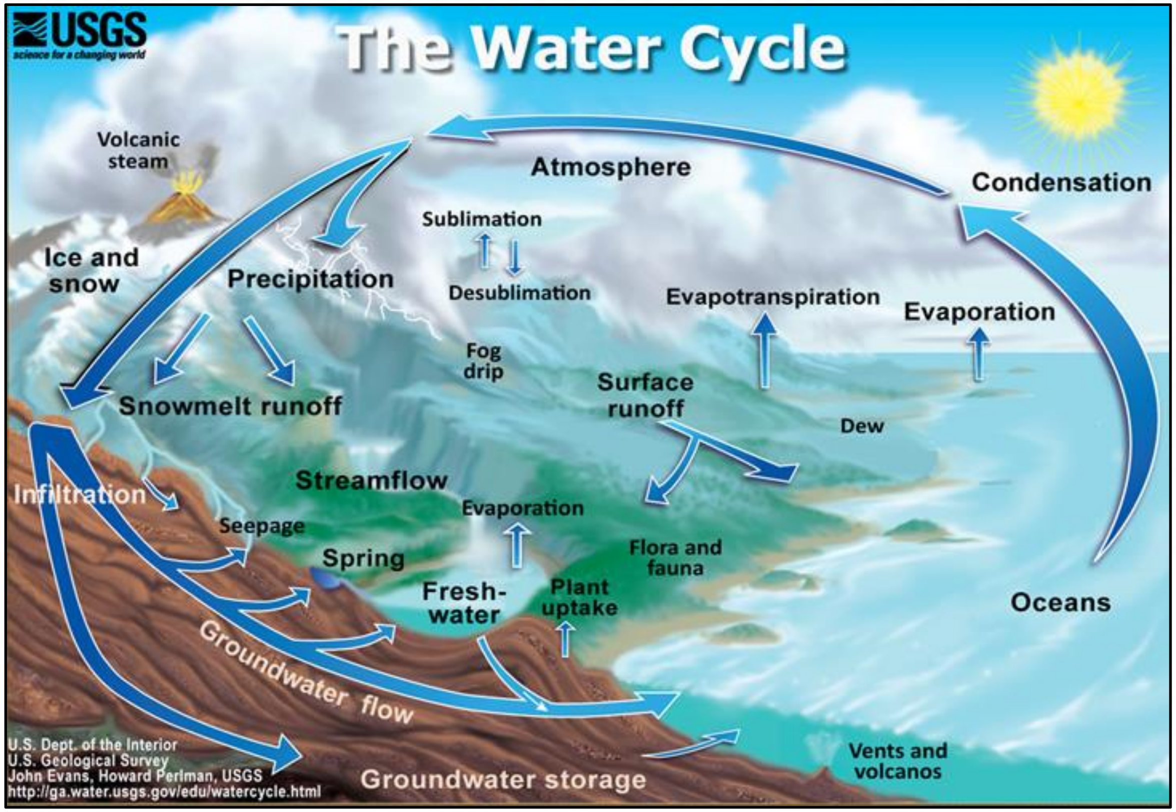
Drainage backup

Ice-jam

Assessing the Demand for Inland Flood Modeling



Inland Flood Is the Most Complex Natural Hazard to Model



The antecedent soil moisture conditions are determined by previous rainfall

A new storm brings additional rainfall

Precipitation is transformed into runoff depending on the antecedent conditions

Runoff is propagated downstream along the river network as a flood wave

Flood waters burst river banks if the peak flows exceeds the bankfull discharge

Major Challenges with Inland Flood Modeling

Rainfall-Runoff Modeling

- Preserve the coherence of precipitation/snowmelt footprints in space and time
- Preserve the statistical properties of rainfall at each location
- Account for antecedent moisture conditions and preserve the long-term memory of the hydrologic system
- Account for the local physiography

River Hydraulics

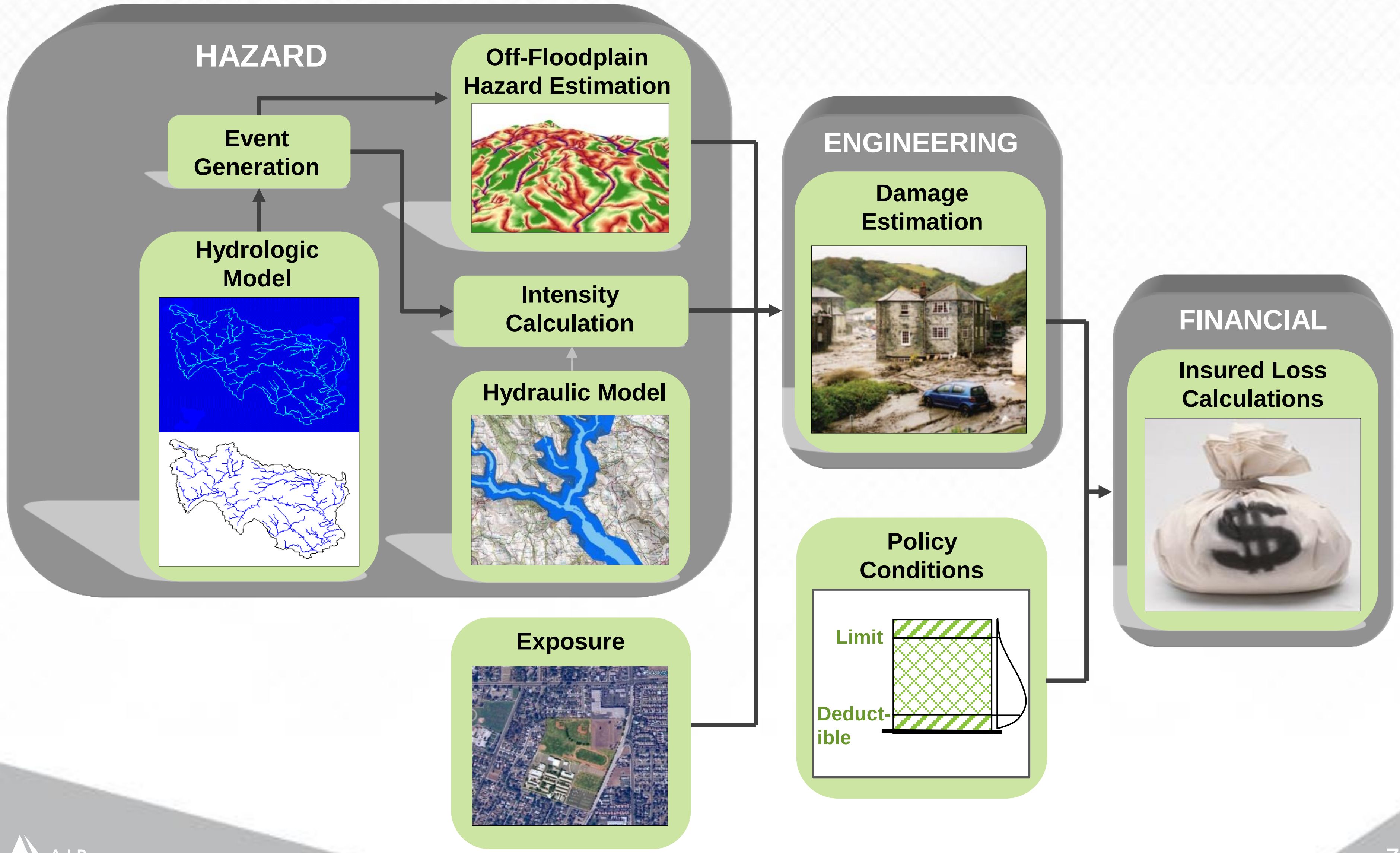
- Account for the hydraulic details at each location along the river network
- Precisely estimate inundation depths at each location of interest
- Account for various defense structures

Engineering/Finance

- Account for a number of uncertainties and non-linearity due to human interference
- Account for the vulnerability specifics of each region/country of interest
- Account for damage off the river floodplain

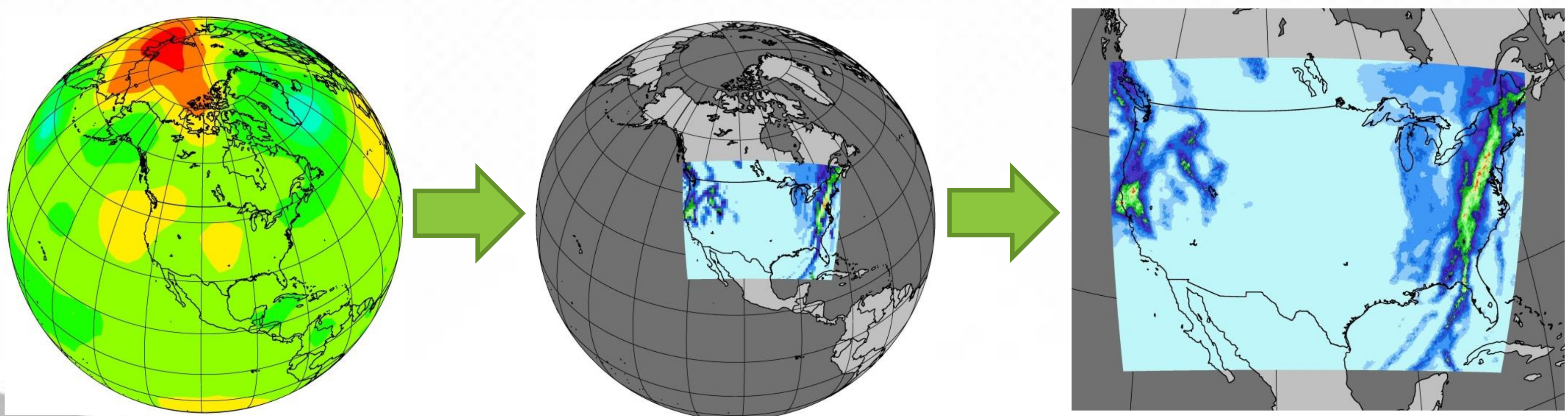
The quality of data is critical—more so than for other natural perils

AIR Modeling Framework Uses Physically-based Components to Realistically Simulate Floods



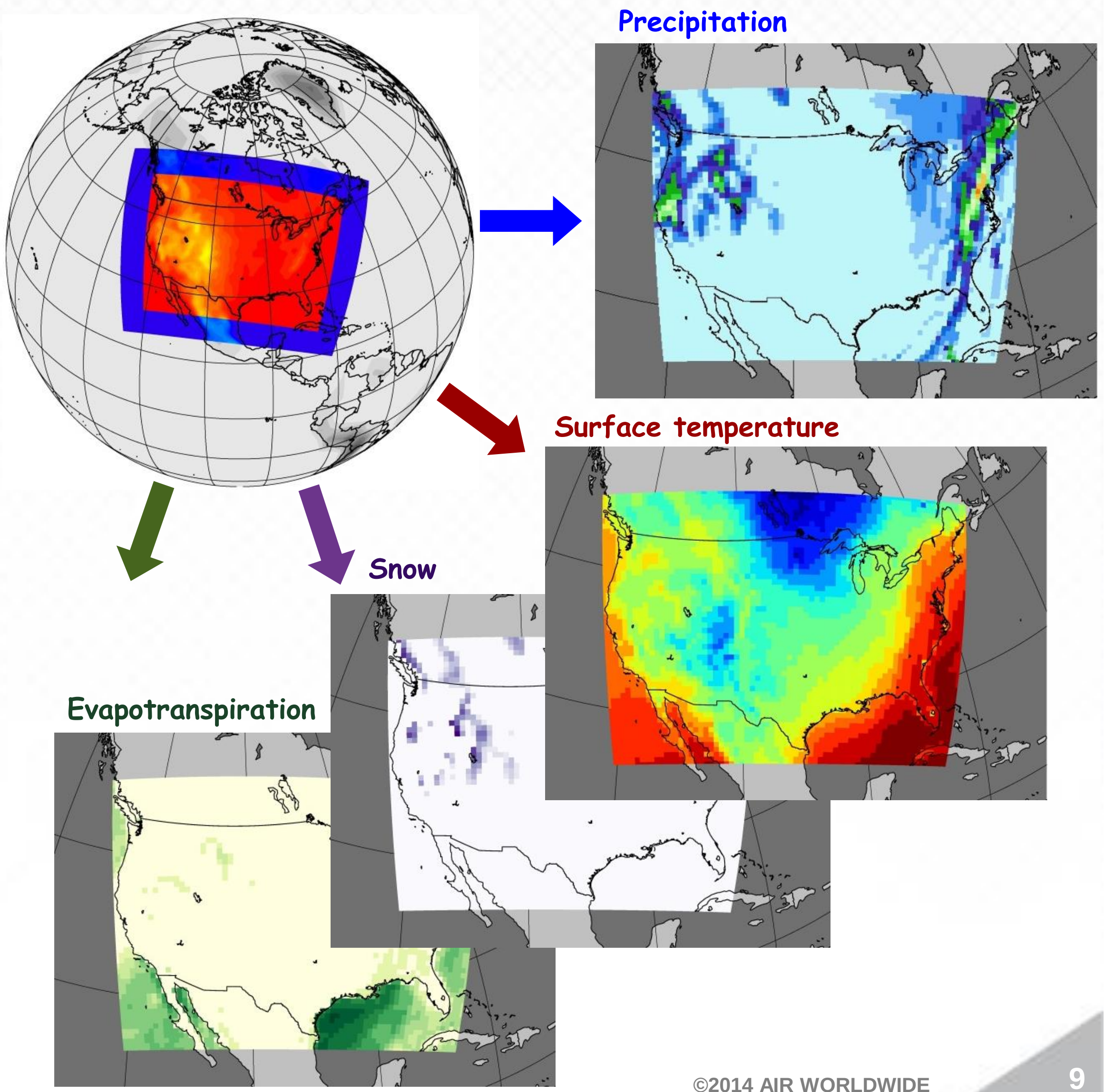
AIR's Innovative Solution to Large Scale Precipitation Simulation

- Couples a Global Circulation Model (GCM) at the global scale with a mesoscale Numerical Weather Prediction (NWP) model at the regional scale to provide coherent large scale patterns
- Employs a sophisticated downscaling technique to realistically simulate small scale features

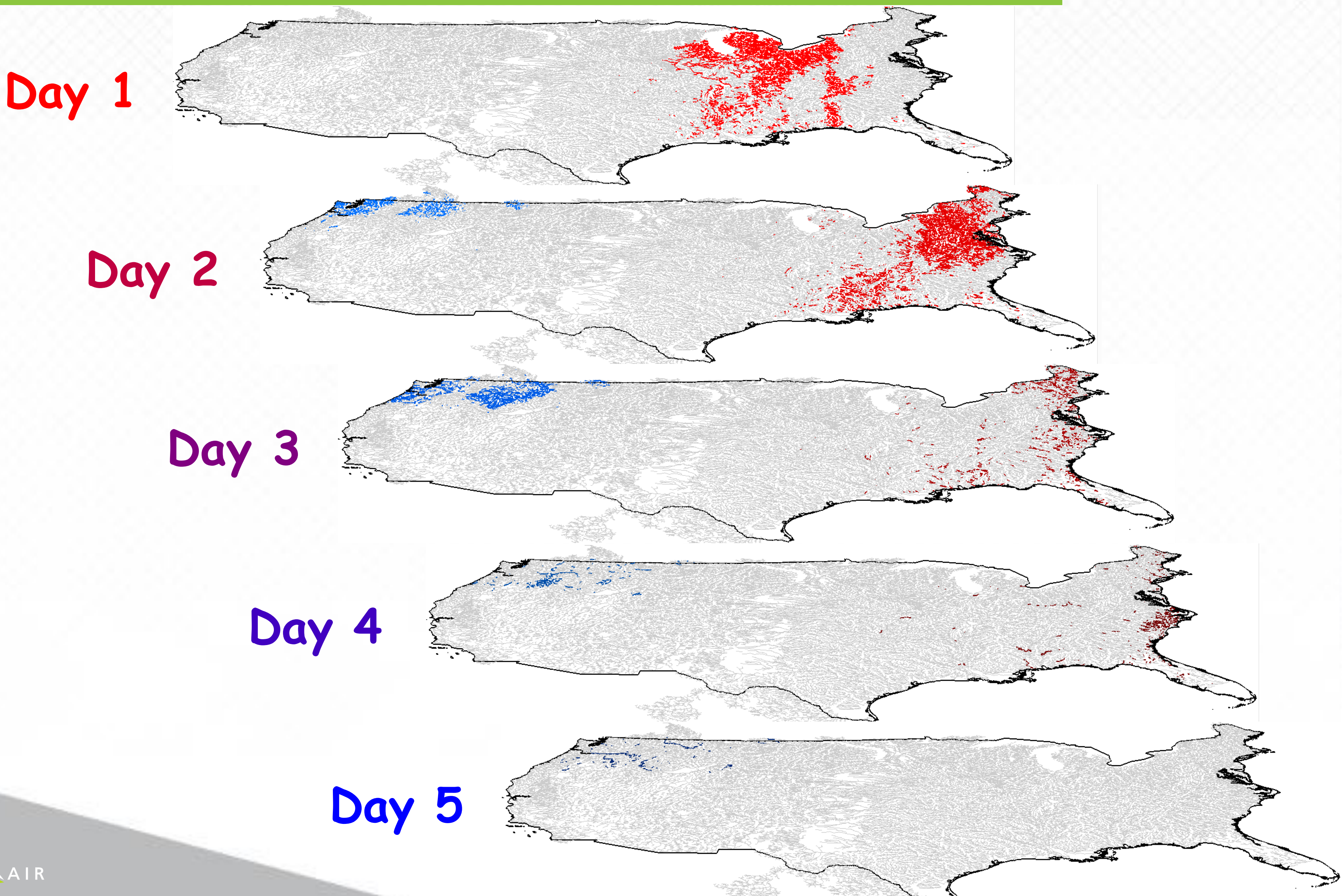


Advantages to Using Coupled GCM and NWP Models

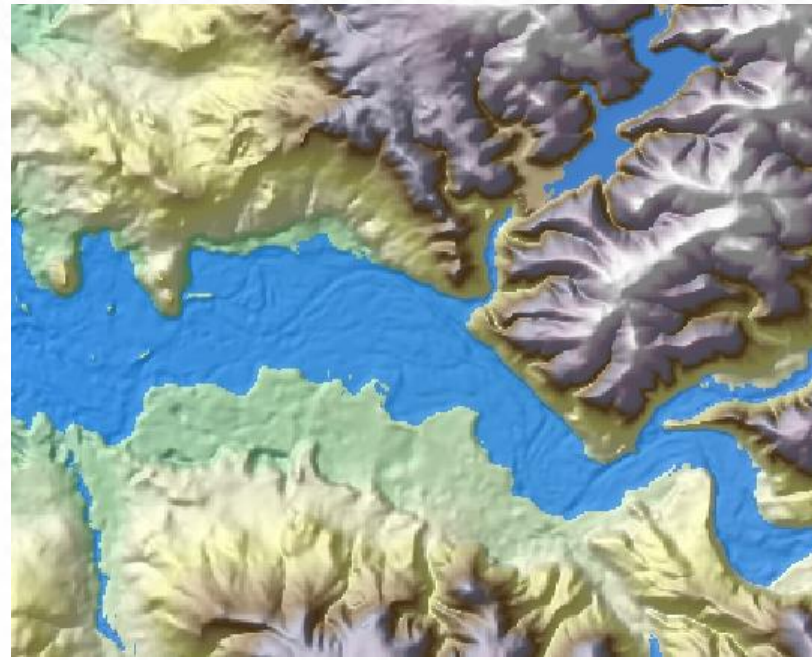
- Provides a continuous, physically-based simulation of all necessary input to the flood model
- Realistically represents precipitation patterns at a continental scale
- Accounts for the effects of local terrain and land cover on the precipitation
- Provides a multi-component output to support a reliable simulation of snowmelt and water balance



AIR's Event Definition
Is Based on Clustering Extreme Flood Instances



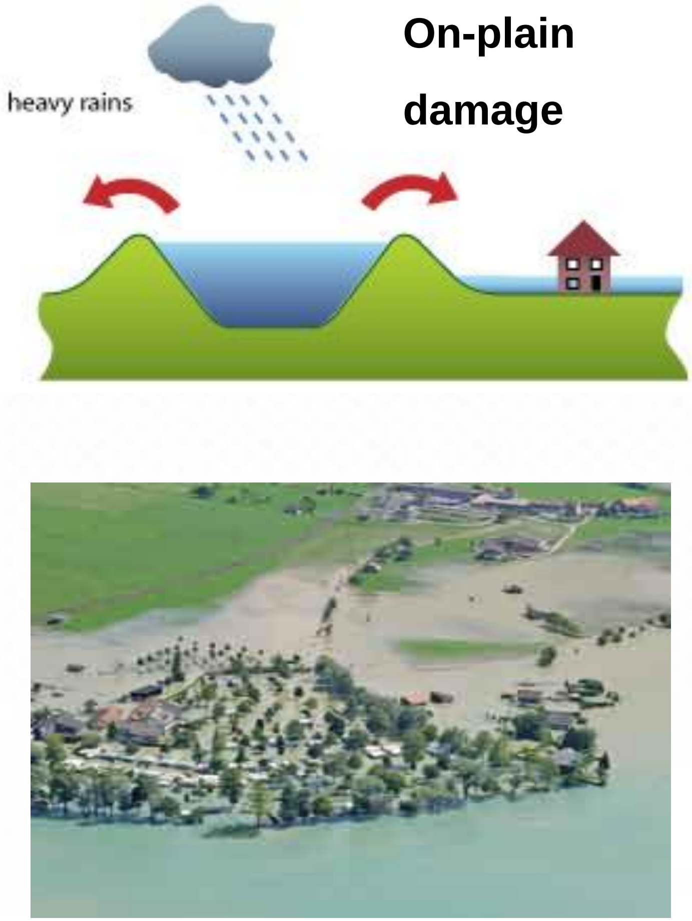
Physically-based Hydraulic Model Determines the Extent of Each Flood Return Period



- Flows at each link are converted to depth at every cross section along the river
- A physically-based mapping methodology converts the depths into flood extents

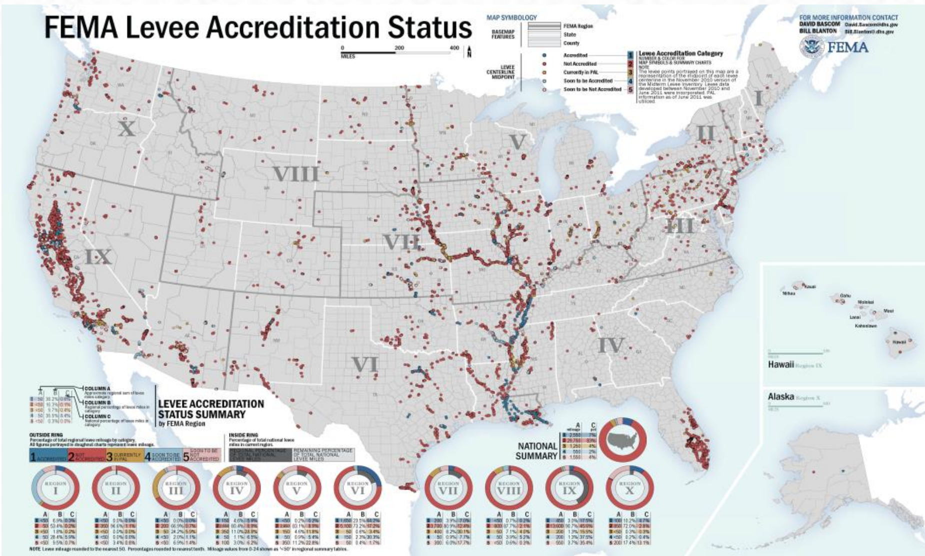
AIR Uses Separate Damage Modules for Modeling On- and Off-floodplain Losses

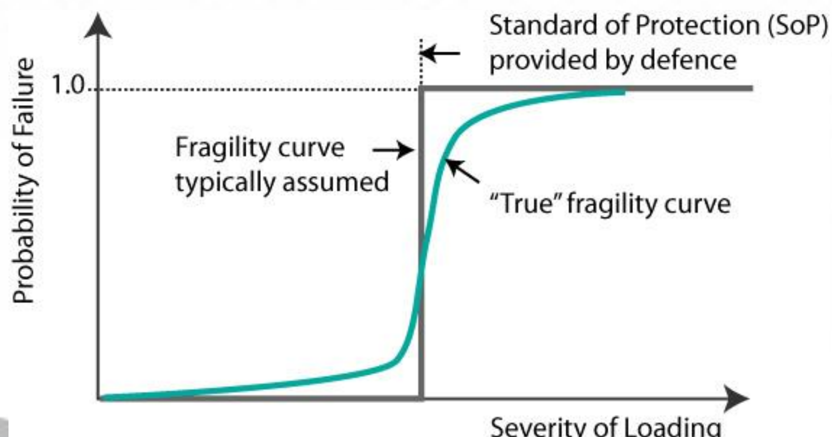
On-plain damage



Off-plain damage

AIR Takes a Probabilistic Approach to Modeling Flood Defenses





Data sources:

FEMA Levee Accreditation Map

USACE National Levee Database

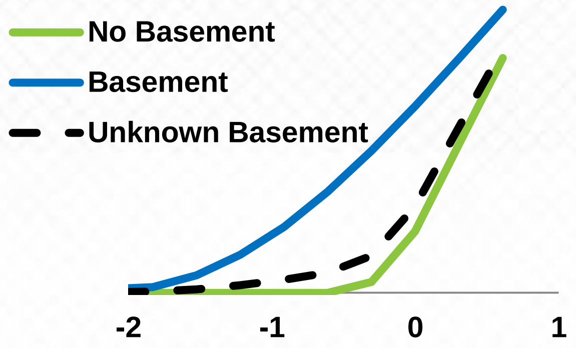
USGS National Hydrologic Dataset

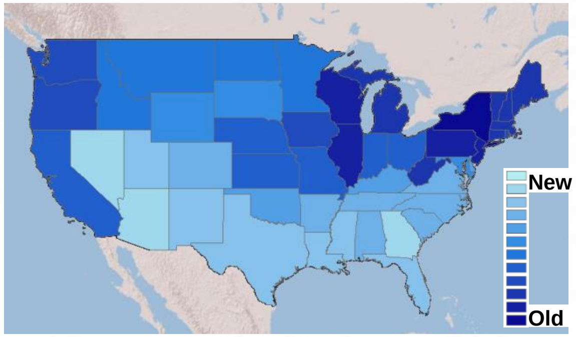
Available levee data ≈ 14,000 miles

Total National estimate by USACE > 100,000 miles

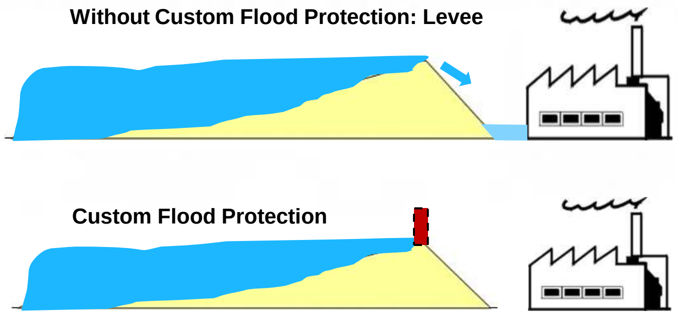
AIR's Comprehensive Damage Module Allows Client Portfolios to be Accurately Modelled

- Damage functions account for occupancy, construction type, presence of basement, height, etc.
- Damage functions reflect year build and state construction code specifics
- A large set of secondary modifiers allows customized loss analysis
- Separate damage module is used for auto portfolio analysis





Commercial Pre-FIRM year built at state level.



Highlights of AIR's Approach to Flood Modeling

- A coupled GCM-NWP model output provides a realistic precipitation/snowmelt input to the flood model
- Physically-based model chain results in a robust flood hazard catalog
- Event definition is based on the clustering of loss occurrences
- Separate damage modules provide explicit modeling of both on- and off-floodplain losses
- A probabilistic approach to modeling flood defenses provides comprehensive risk assessment that includes protected properties (behind flood defenses)
- A comprehensive damage module allows accurate modeling of client portfolios