

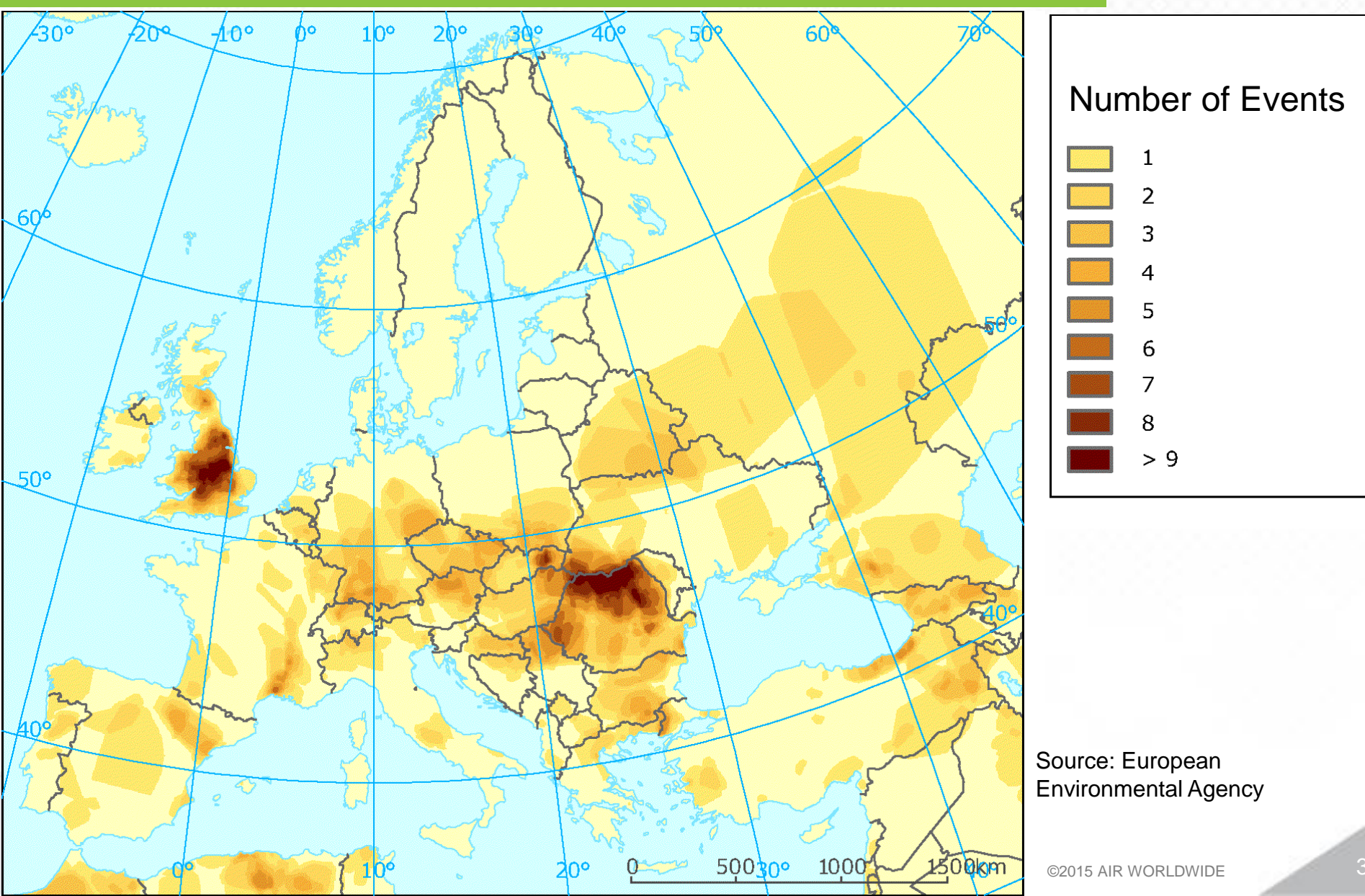
When the Rivers Rise and the Waters Flow: AIR Inland Flood Model for Central Europe

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Bernhard Reinhardt, Ph.D., CCM*

Agenda

- Overview
- Hazard model
 - Methodology
 - Validation
- Vulnerability model
 - Development of vulnerability functions
 - Secondary risk characteristics
 - Loss validation
- Historical Events
- Country Specific Model Statistics

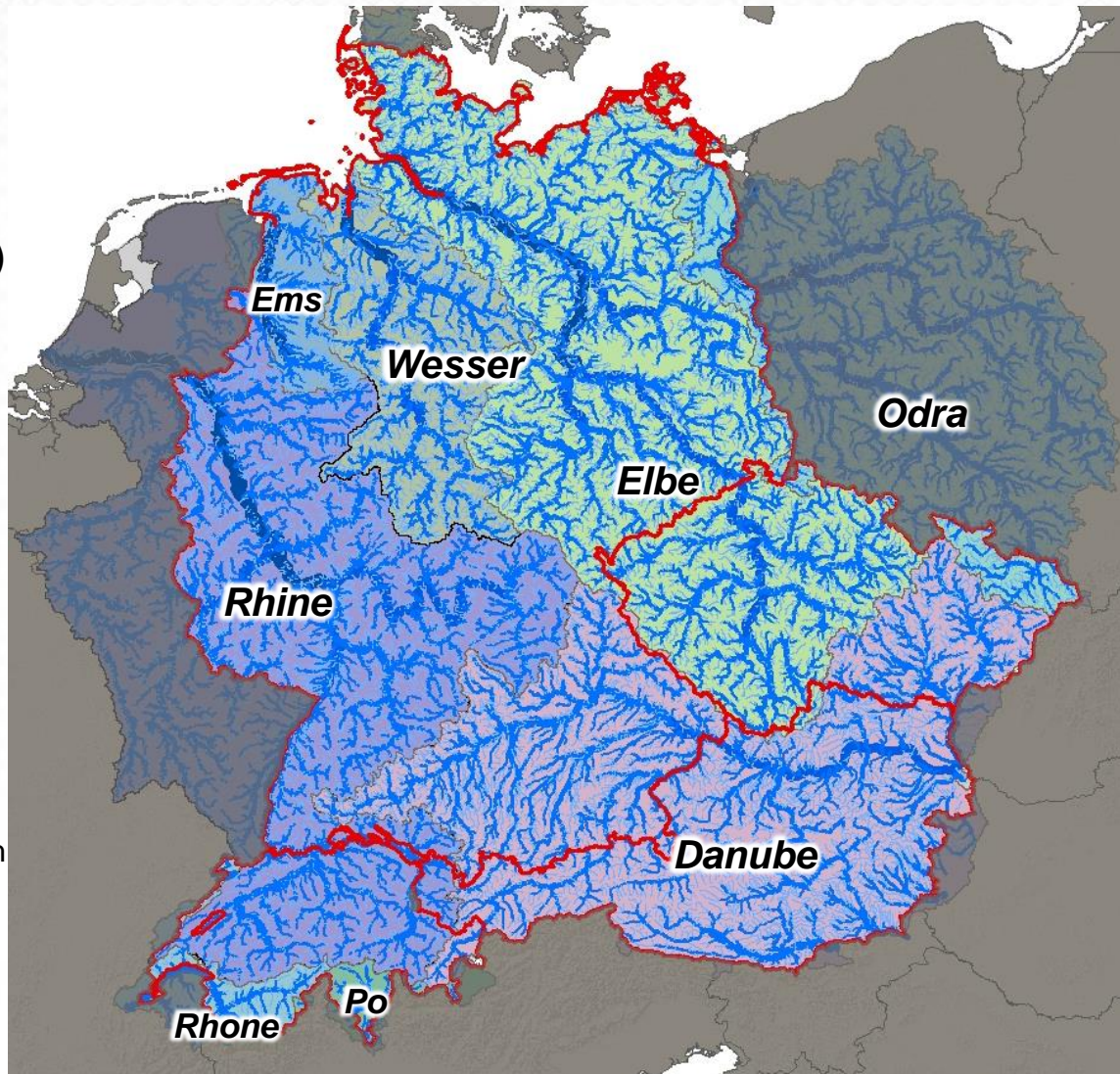
Occurrence of Major Floods in Europe (1998–2009)



Model Facts

- 8 major river basins
- Every river reach with drainage area larger than 10 km²
- Over 37,000 catchments (11,000*)
- Over 185,000 km stream length (70,000 km*)
- ~260,000 (98,000*) river cross sections at intervals of 500 m
- 2700+ (1,200+*) streamflow gauges
- 25 m Digital Terrain Model
 - Federal Agency for Cartography and Geodetics – Germany
 - Intermap – Switzerland, Austria, and Czech Republic
- 504 hours clause

* in CH, AT and CZ

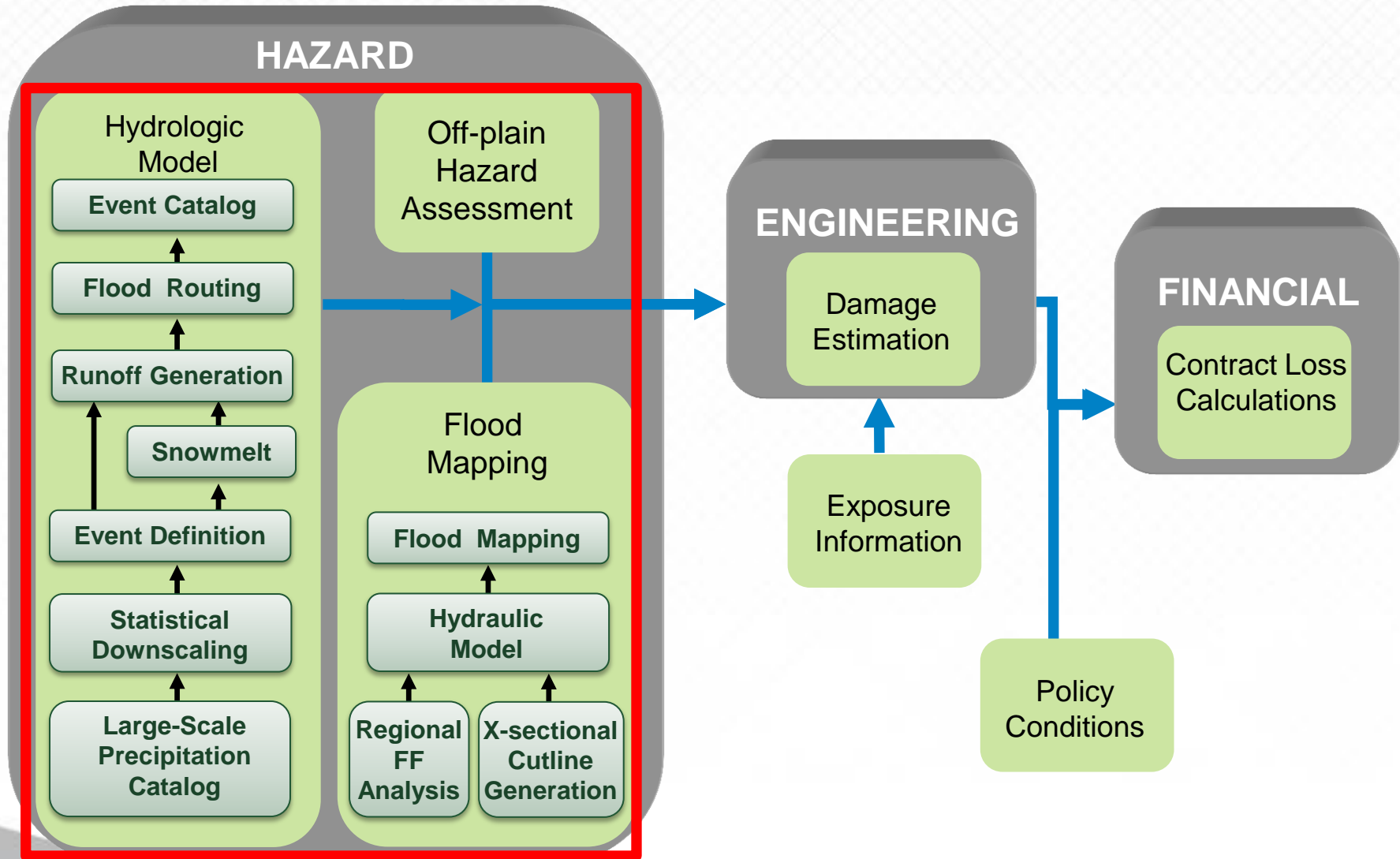


Hazard Model

Physical Modeling—Domain-wide Correlations

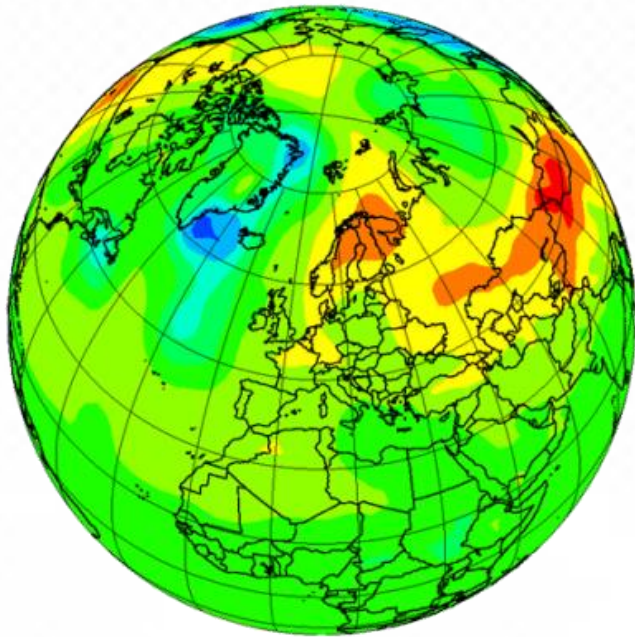


Model Framework Incorporates Hydrologic and Hydraulic Components to Realistically Simulate Floods

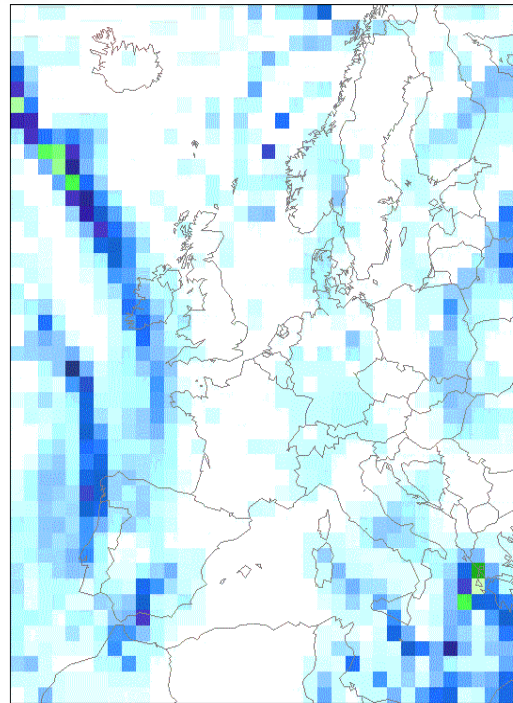


Precipitation is Modeled Continuously for All of Europe

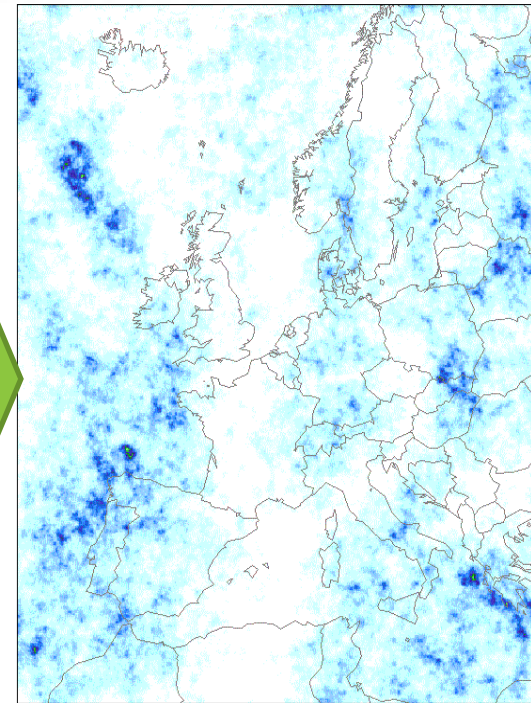
**Global
Circulation
Model**



**Numerical
Weather
Prediction**

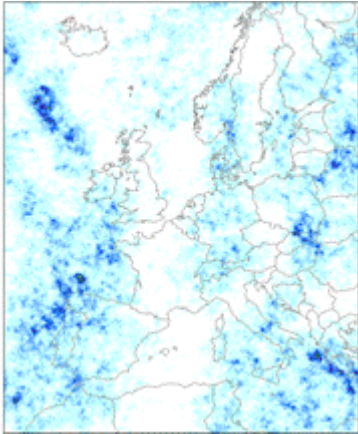


Downscaled

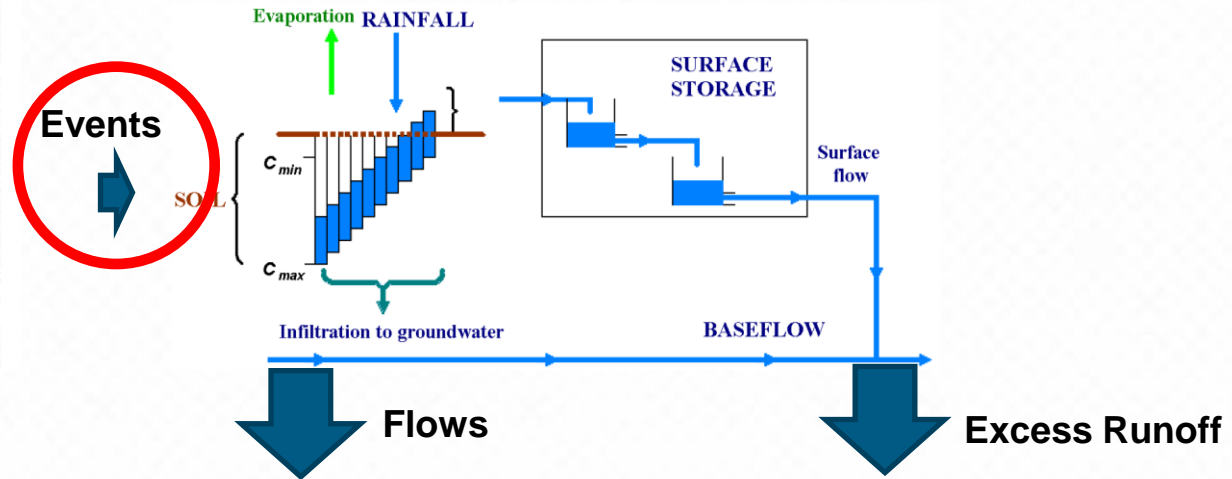


Transforming Precipitation to Runoff and Flows

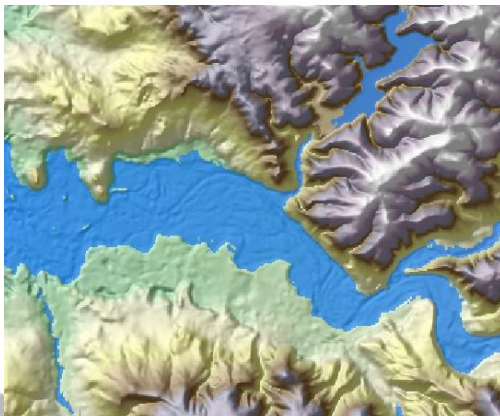
Precipitation



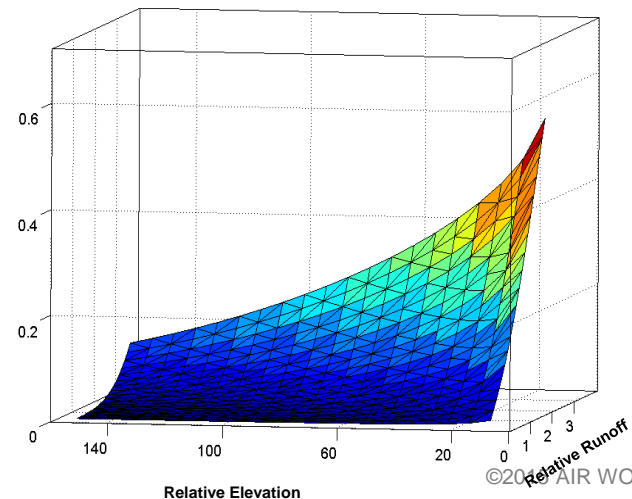
Runoff and Flow Generation



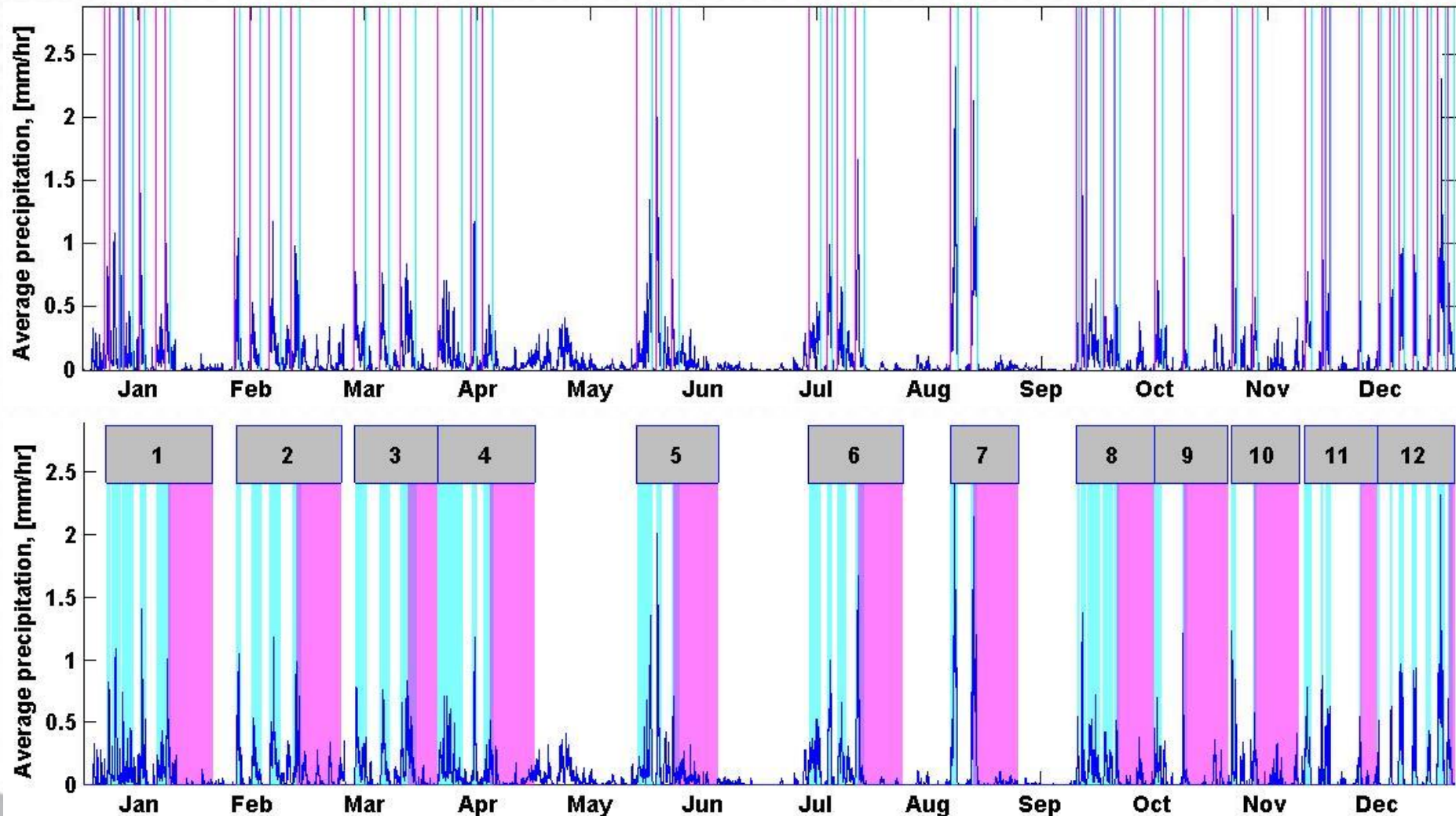
Hydraulics



Off-Plain Hazard

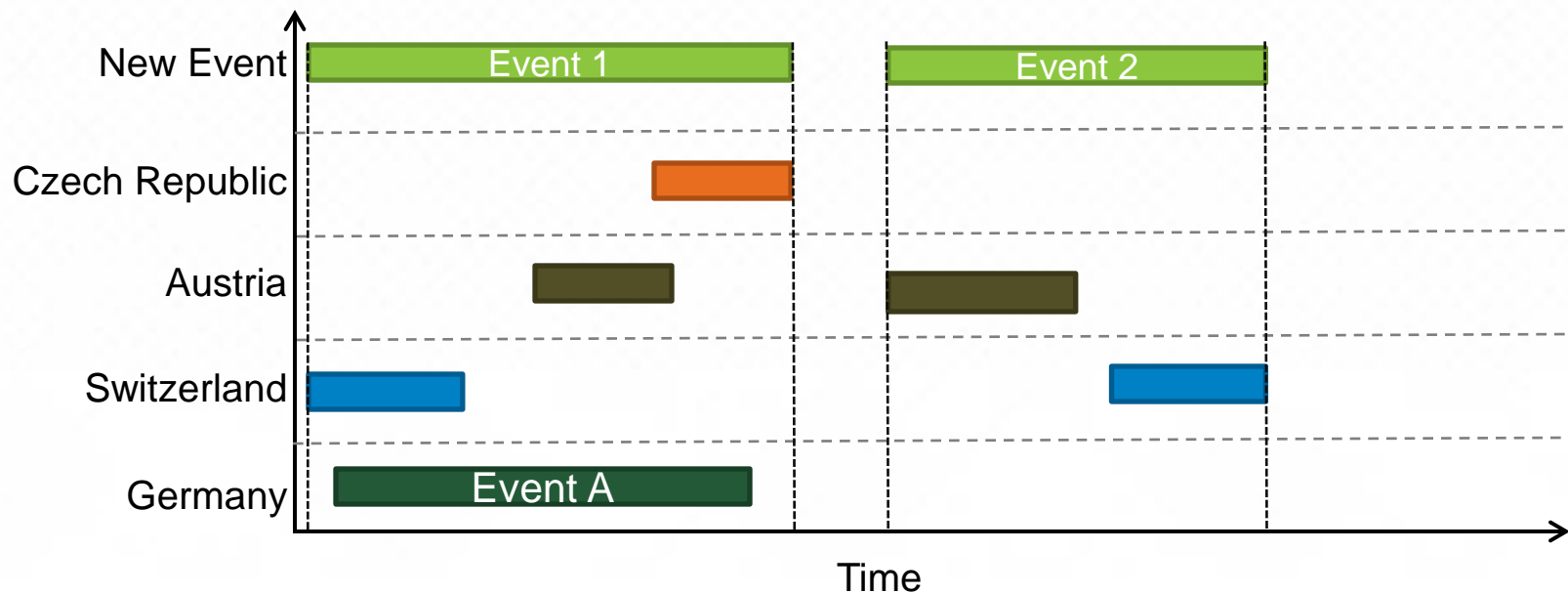


Flood Events were Created by Clustering Individual Storm Events While Conforming to the Hours Clause

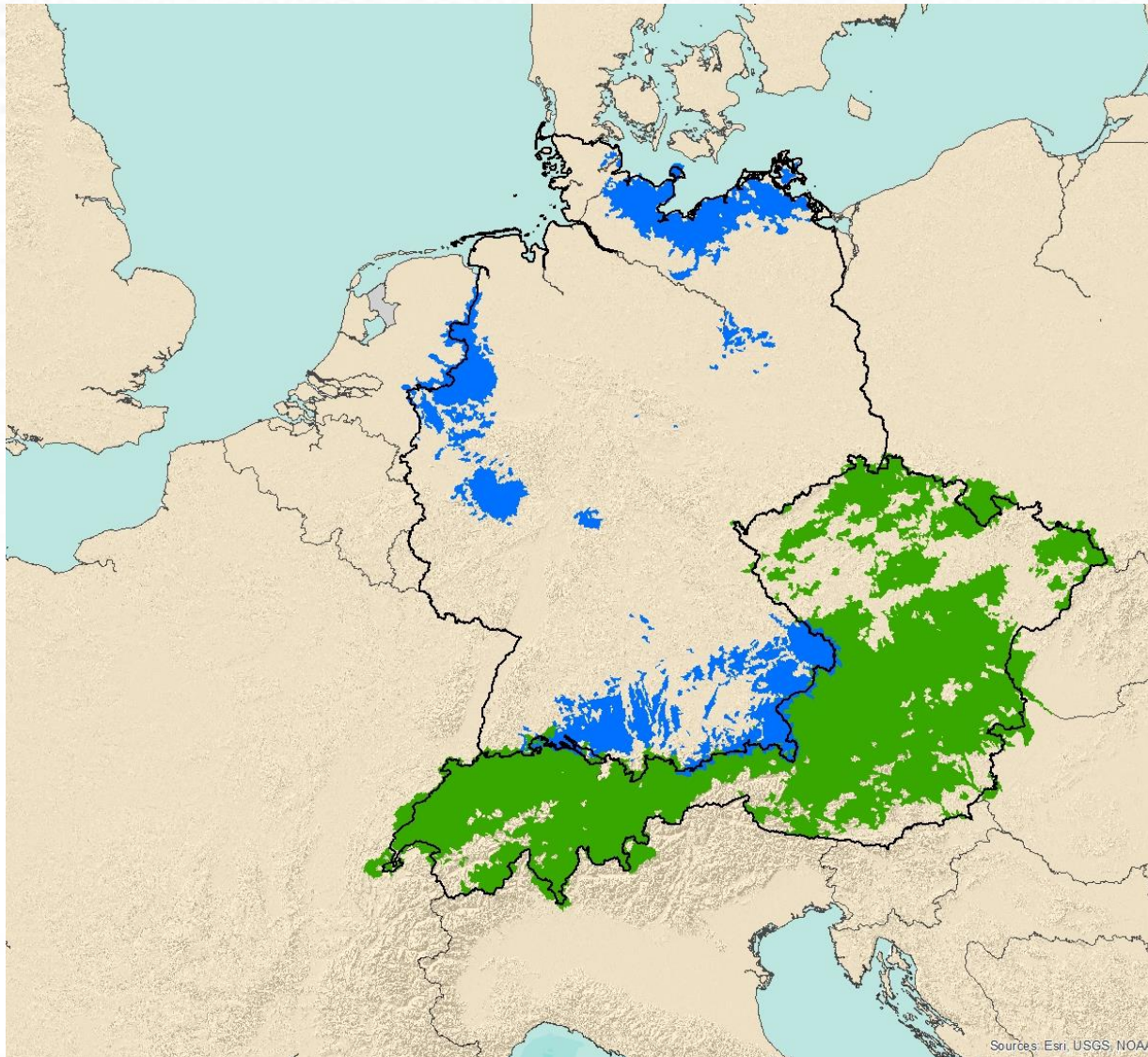


Precipitation Events from the Three Countries Are Mapped to Events in Germany

- Precipitation events in the three countries are first clustered to conform to 168 hours clause events
- Mapping of events between the countries is based on the timing and duration of events

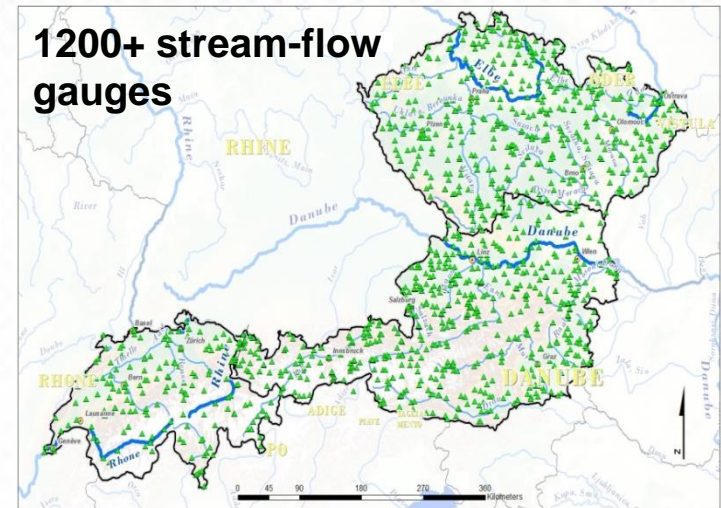
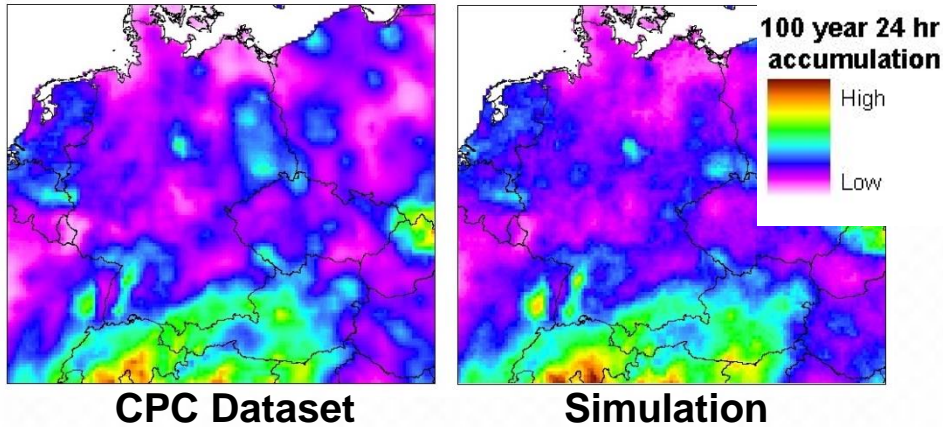


Precipitation Events from the Three Countries Are Mapped to Events in Germany

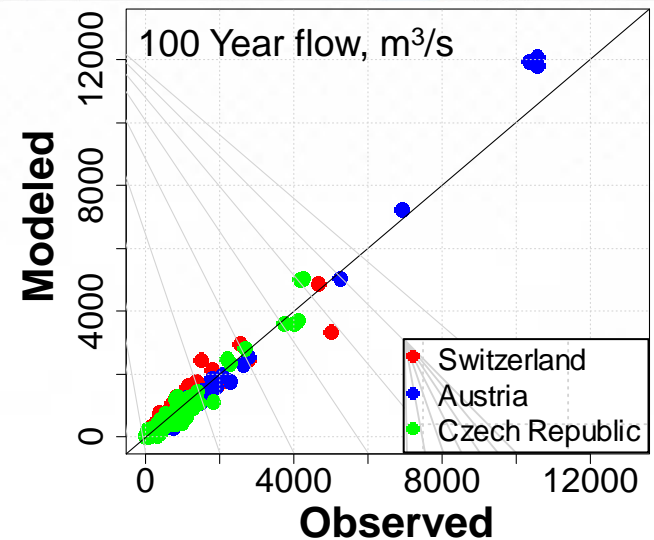
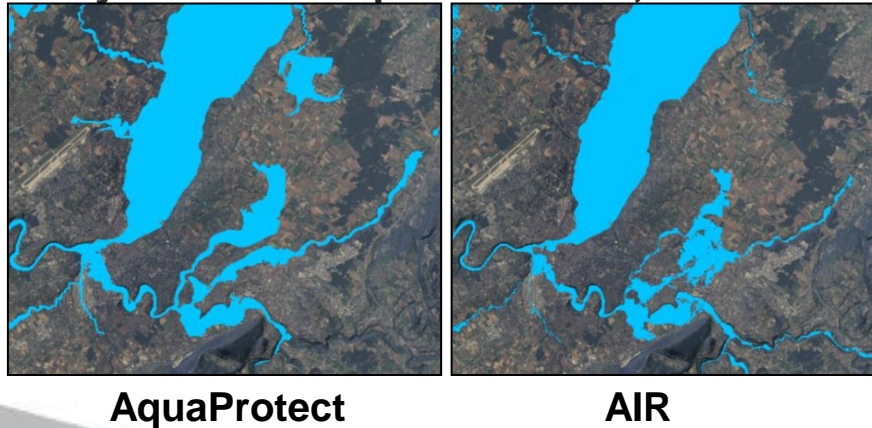


Each Model Component Validated Independently

Precipitation Validated with CPC Data

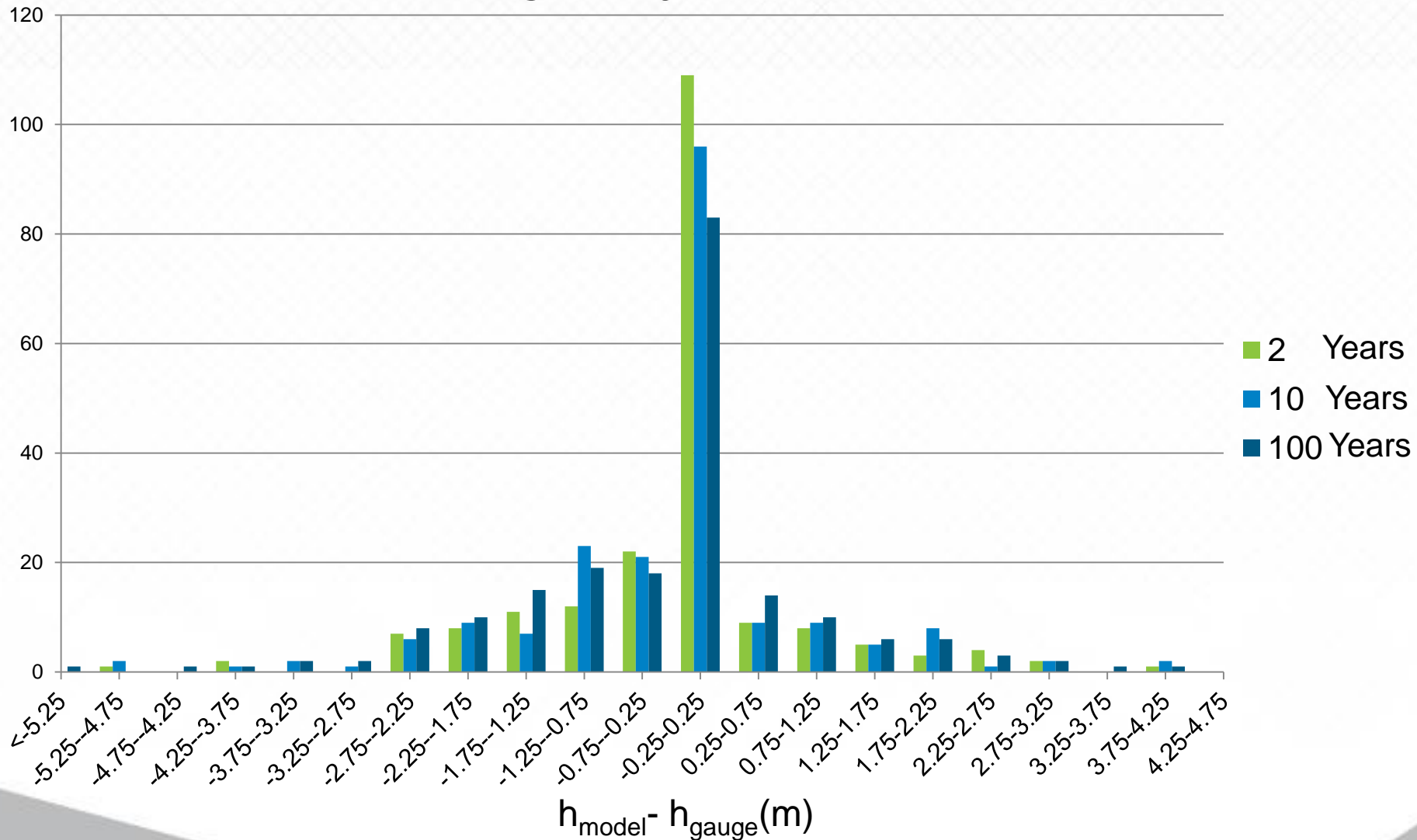


100-year flood map for Geneva, Switzerland



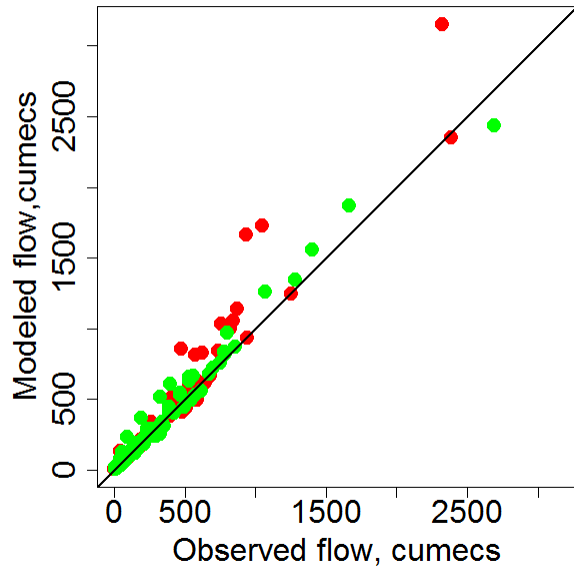
Overall Water Elevation Error at Gauge Stations (201) Falls Within the DTM Accuracy

RMSE=1.25 m

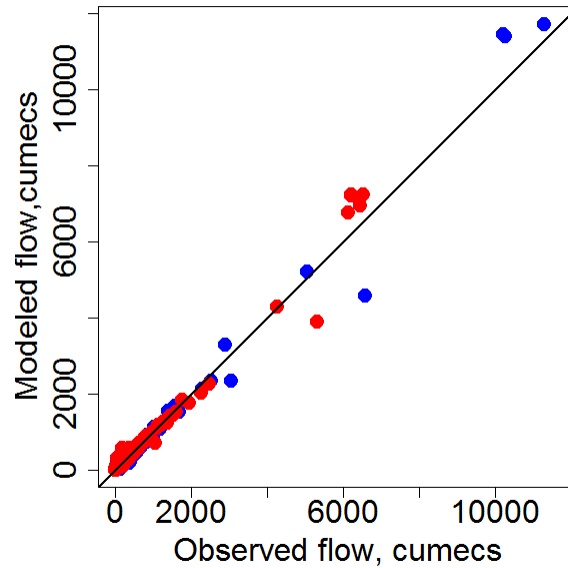


Historical Events from 2002, 2005, and 2007 Are Included in the Model

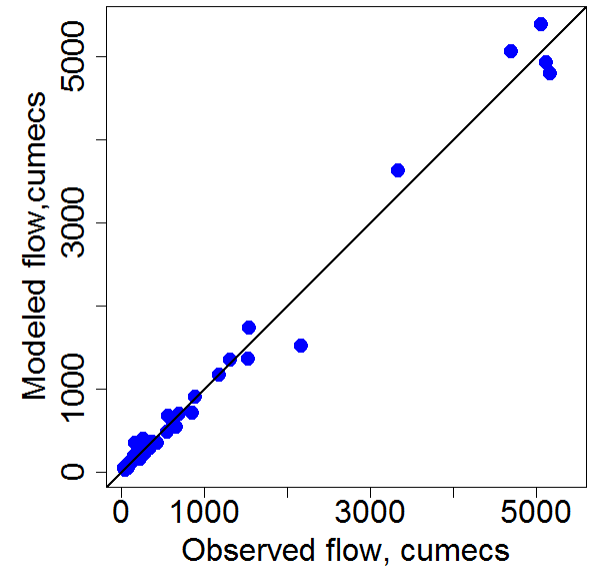
Switzerland



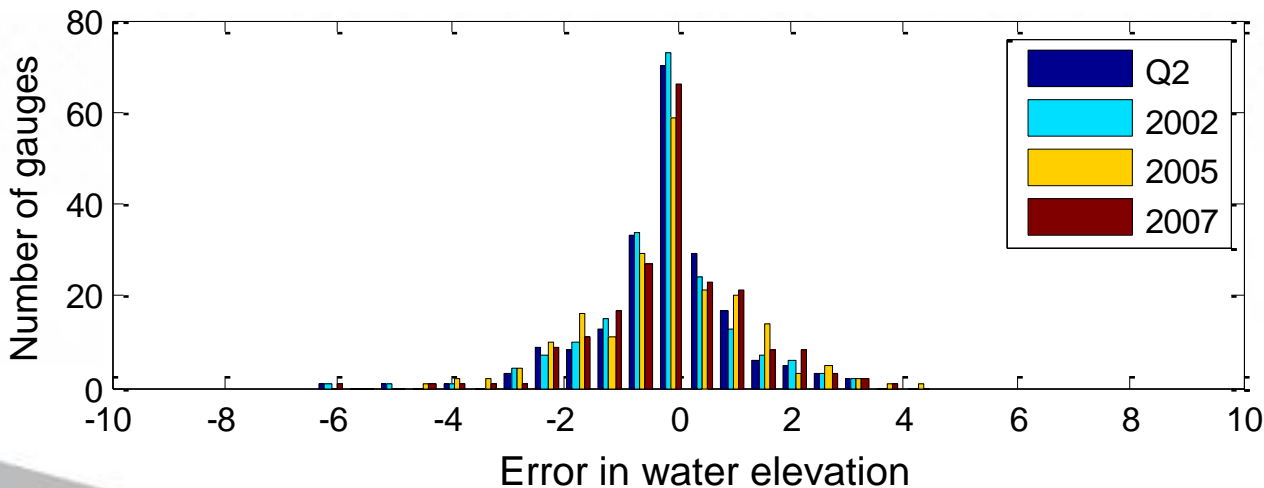
Austria



Czech Republic



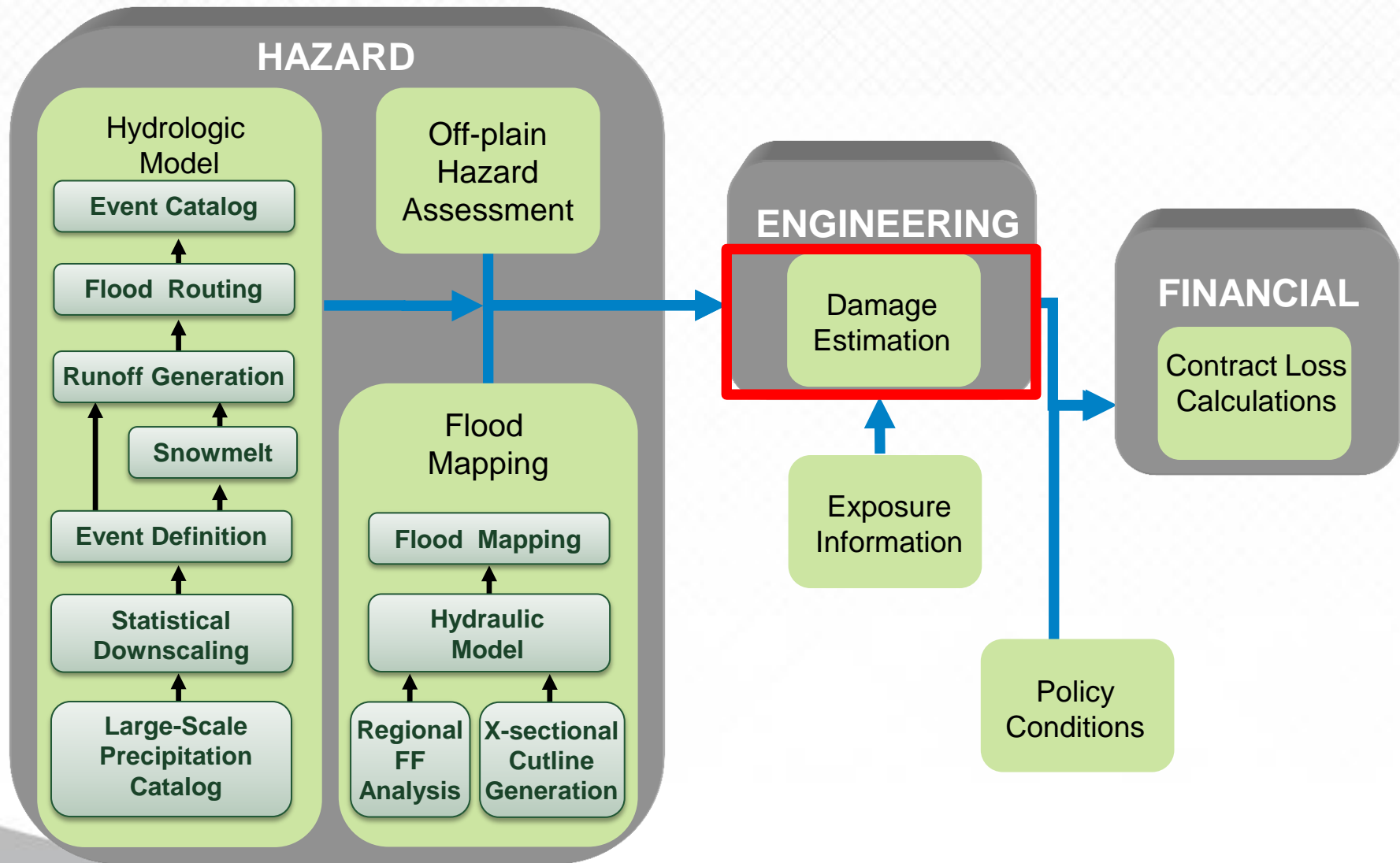
● 2002
● 2005
● 2007



Water elevation
RMSE (in m):
AT Q2 = 1.21
2002 = 1.23
2005 = 1.40
2007 = 1.30

Vulnerability Model

Model Framework Incorporates Hydrologic and Hydraulic Components to Realistically Simulate Floods



Losses to Commercial Buildings Are Dominated by Non-Structural Components

Services



Fixtures



AIR Damage Survey 2013

AIR Uses a Component-Based Approach to Develop Vulnerability Functions

Structure



Building

Fixtures

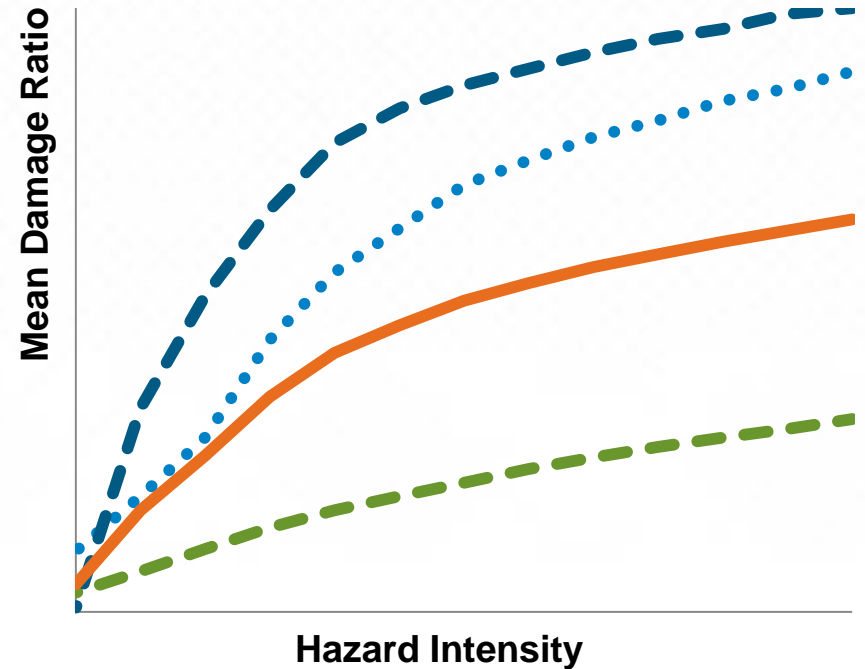


Services



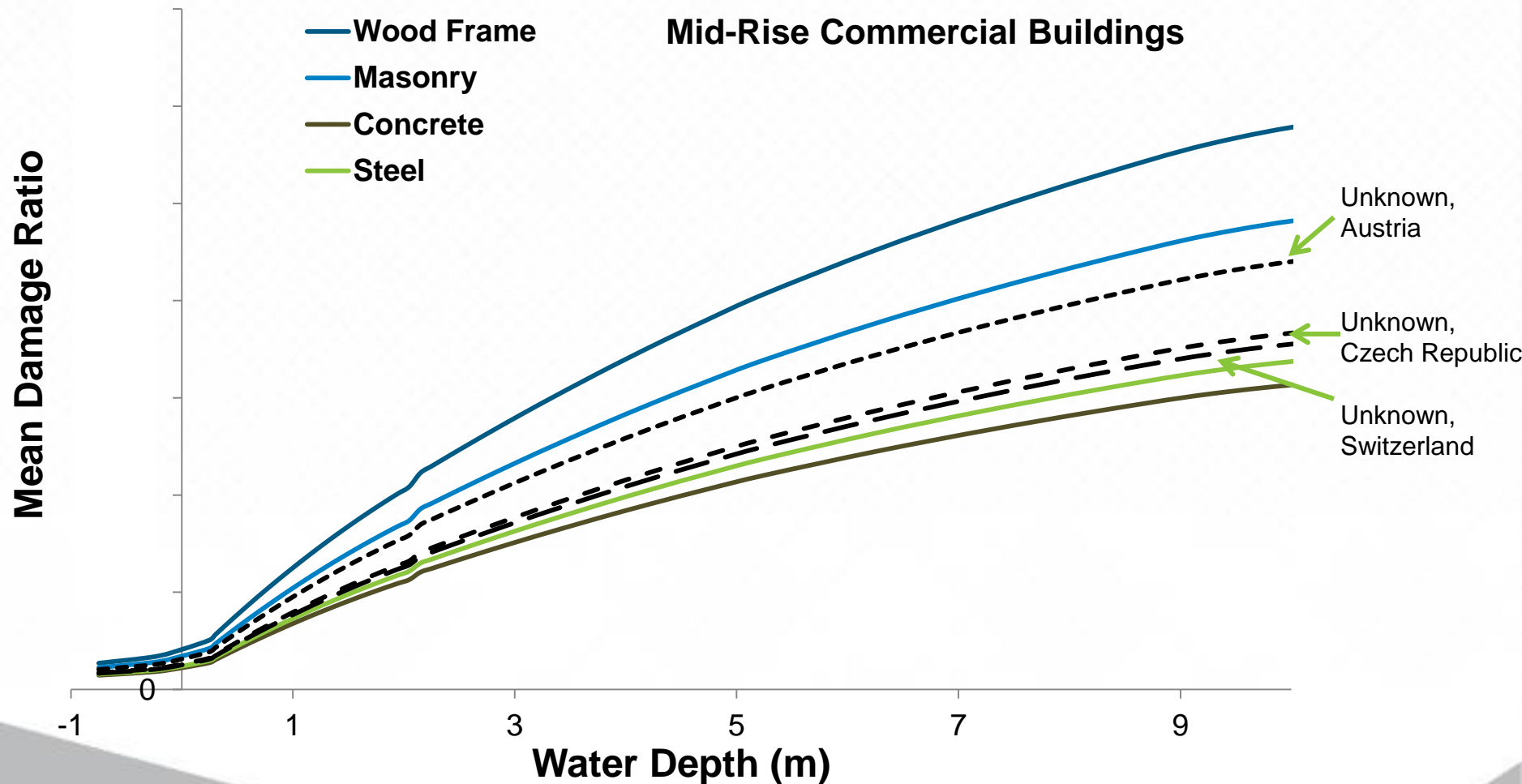
Building and Component Damage Functions for a Retail Shop

- Building Structure
- Services
- Fixtures and Fittings
- Overall Building Coverage

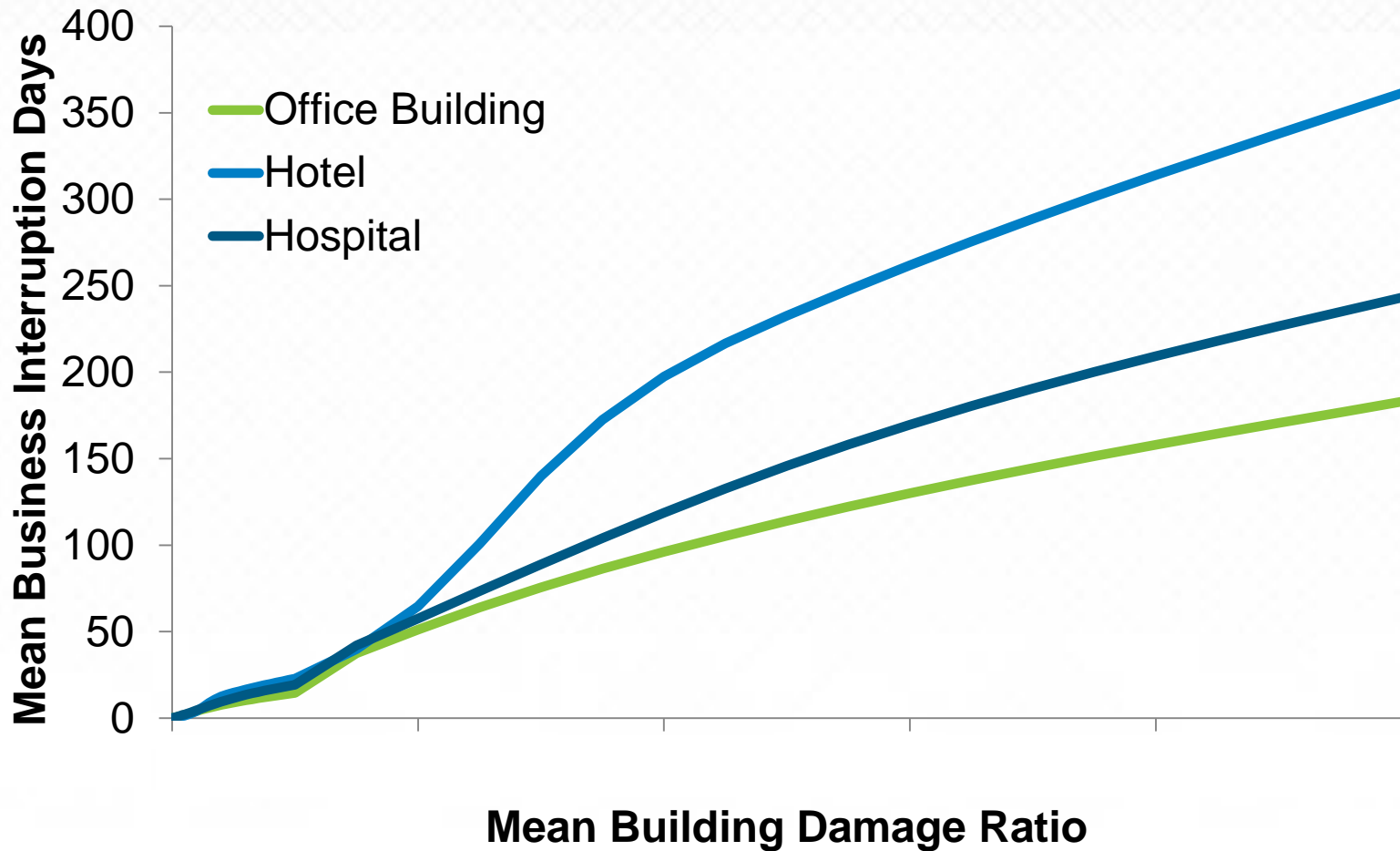


Damage Functions for Unknown Construction

Consider Local Building Stock

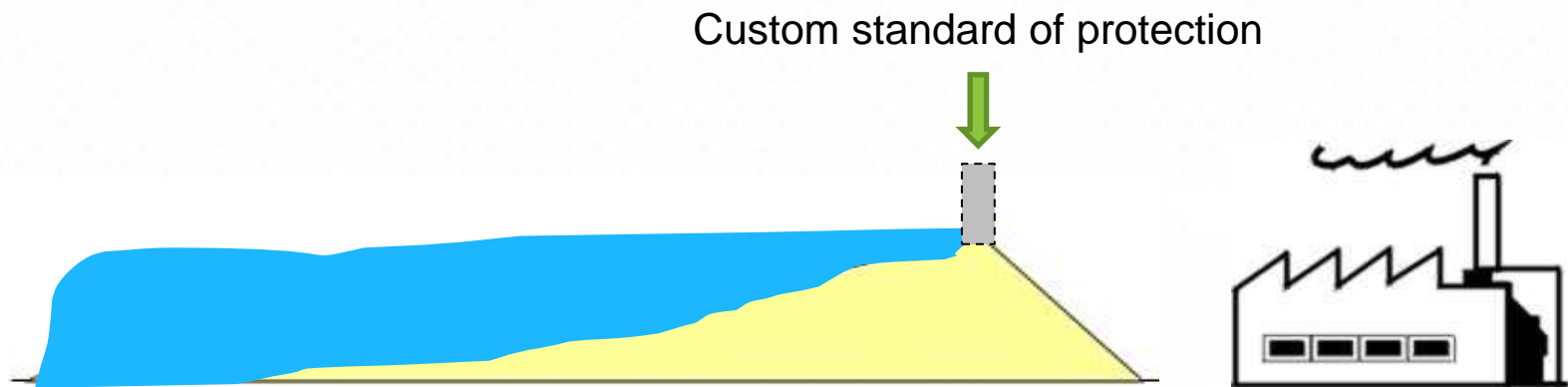


Business Interruption Accounts for Variations Across Occupancies

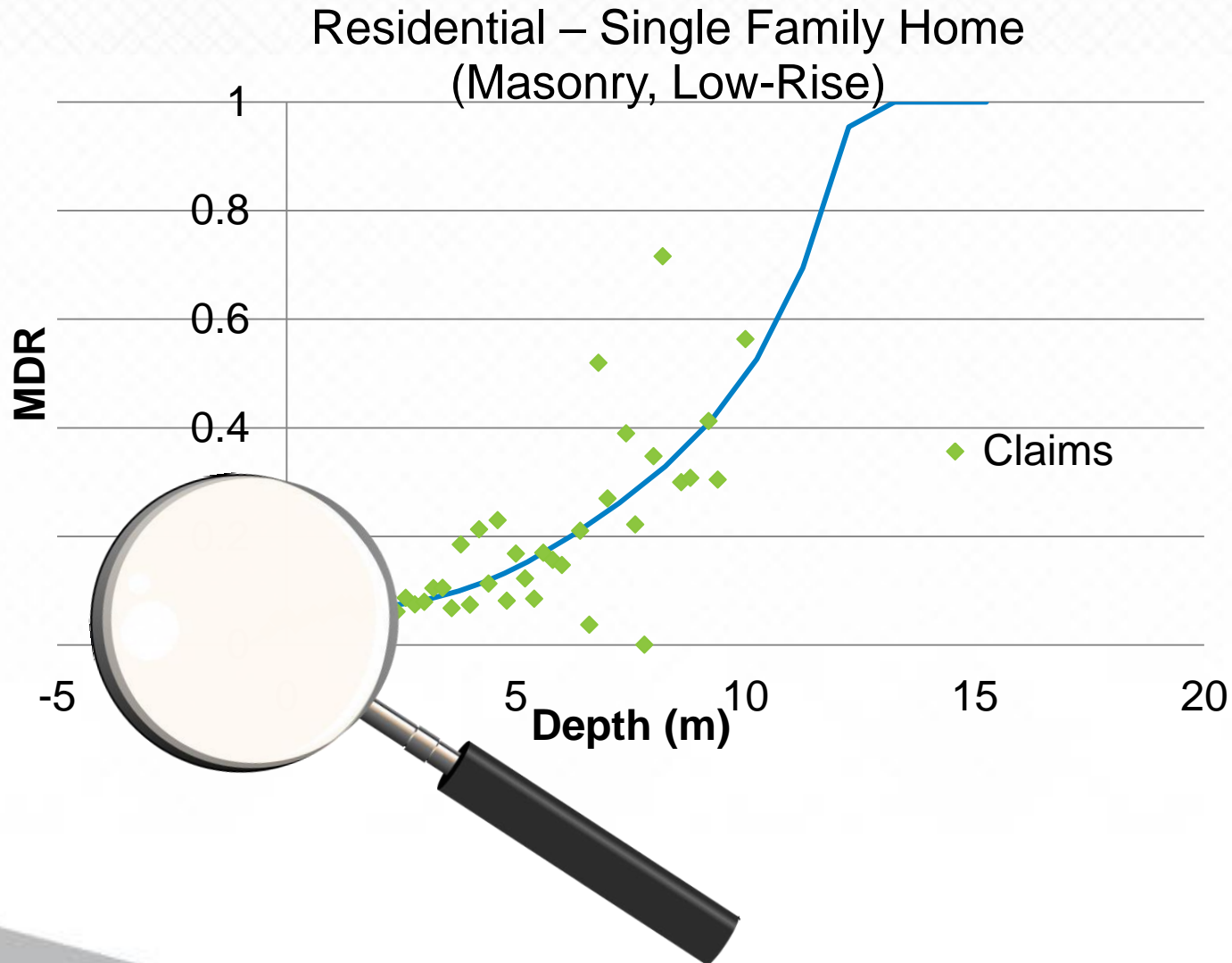


Primary and Secondary Risk Features Allow for Improved Loss Estimates

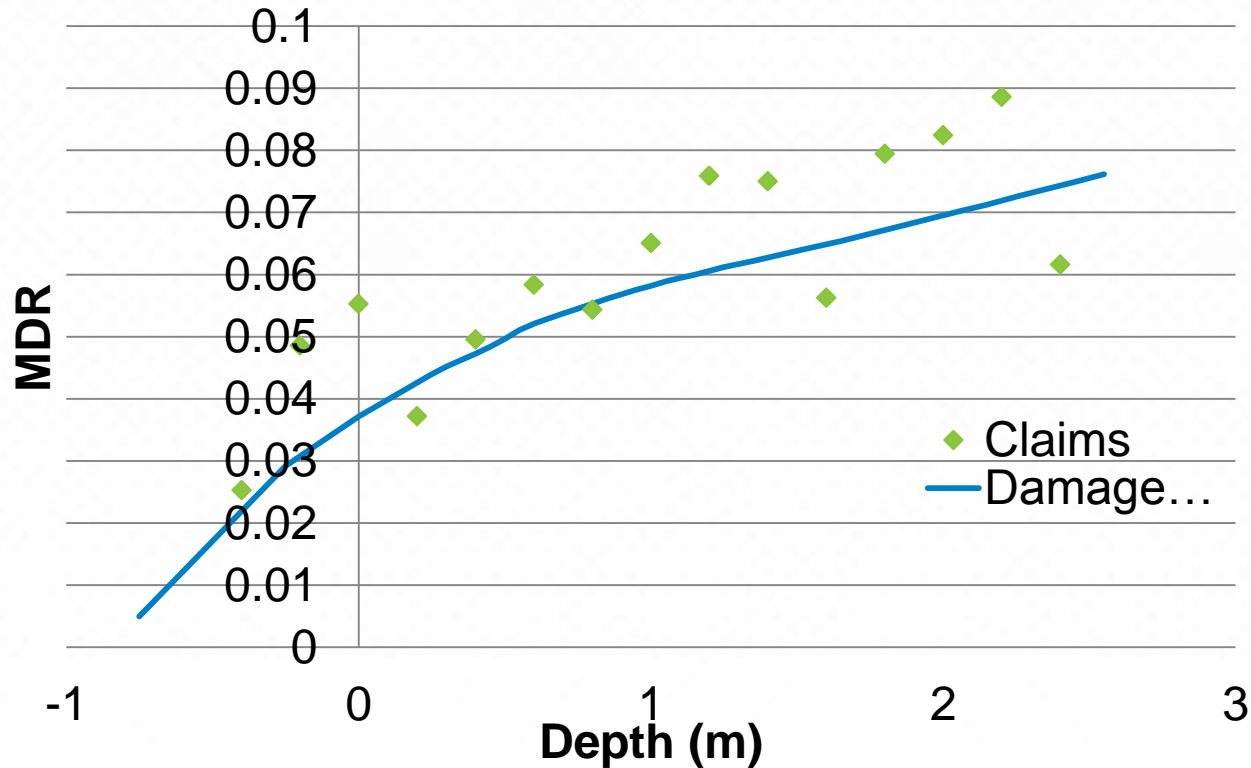
- Primary
 - Occupancy, construction, height
- Secondary
 - Foundation type, including basement
 - Floor of interest
 - Custom standards of protection



AIR Uses Claims Data to Validate Vulnerability Functions for Residential Properties

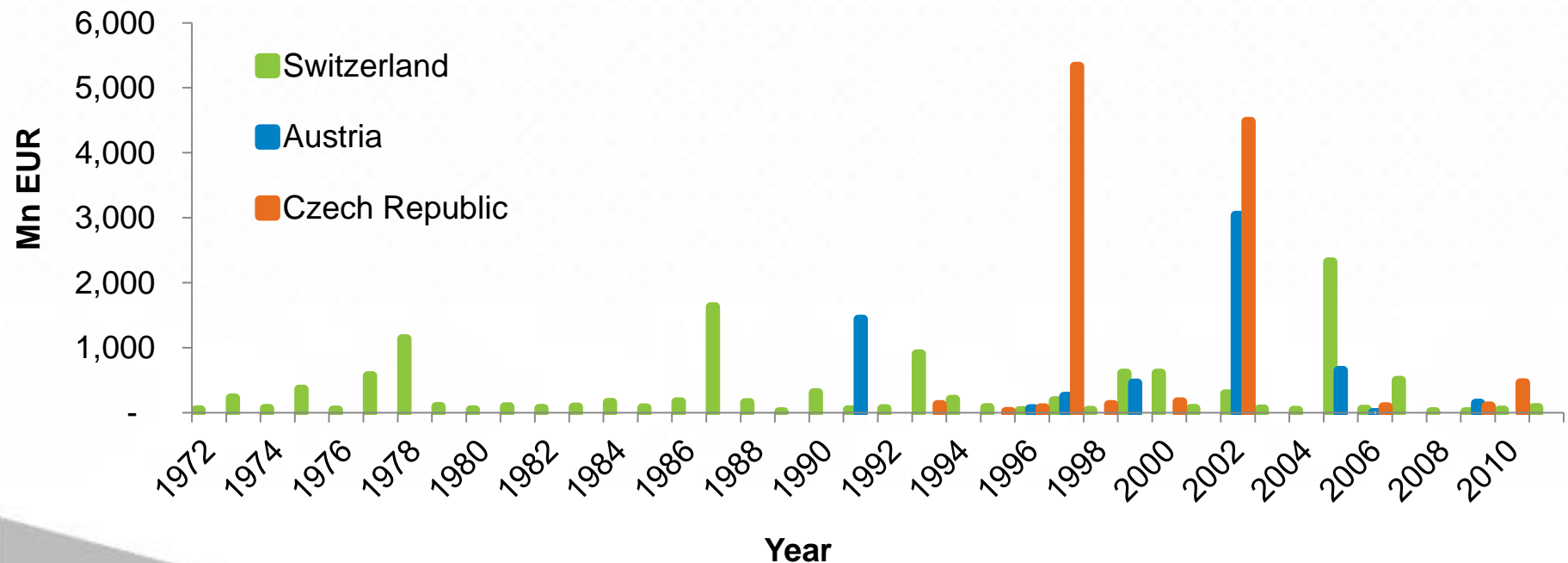


AIR Uses Claims Data to Validate Vulnerability Functions for Residential Properties—a Closer Look

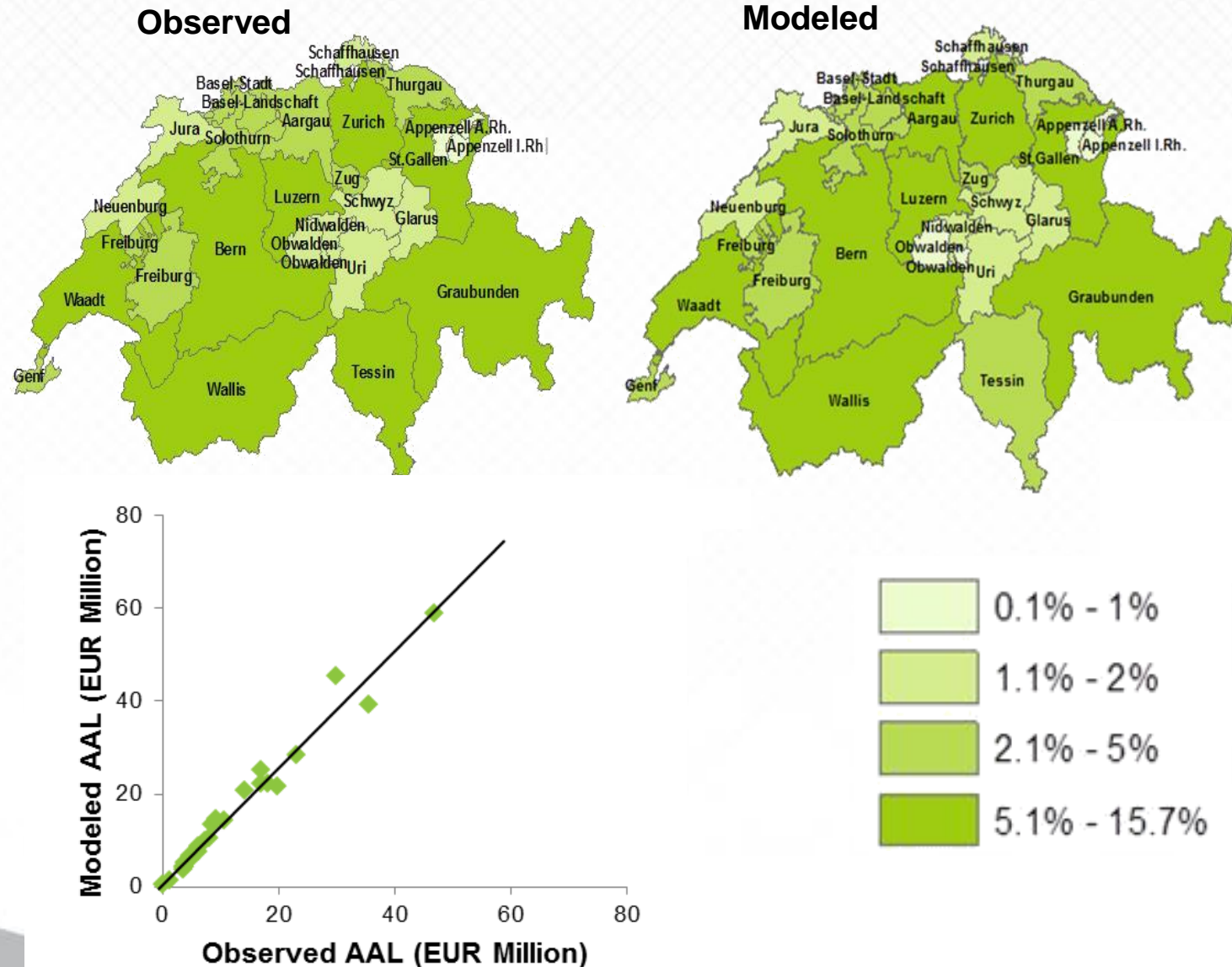


European Inland Flood Model Has Been Validated Using Loss Data from Historical Events

- Historical data sources for validation
 - Swiss Federal Research Institute flood database
 - Czech Ministry of Environment
 - Austrian Federal Ministry of Agriculture, Forestry, Environment, and Water Management
 - 100 years of frequency of catastrophic flood events



European Inland Flood Model Has Been Validated Using Loss Data from Historical Events

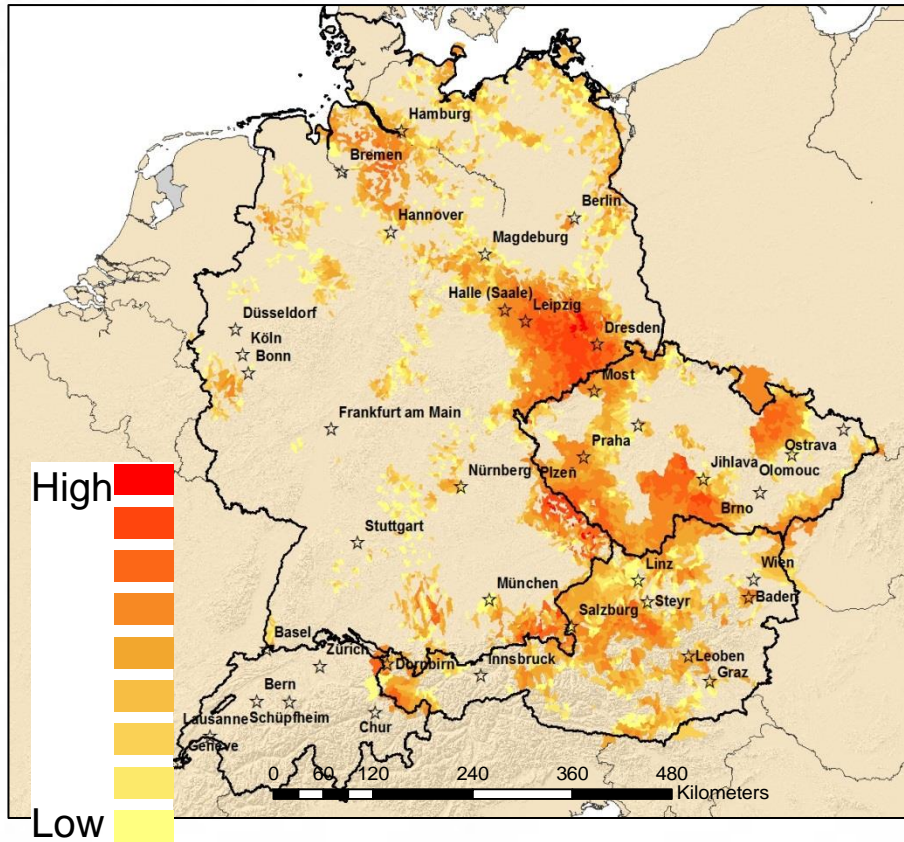


Historical Events

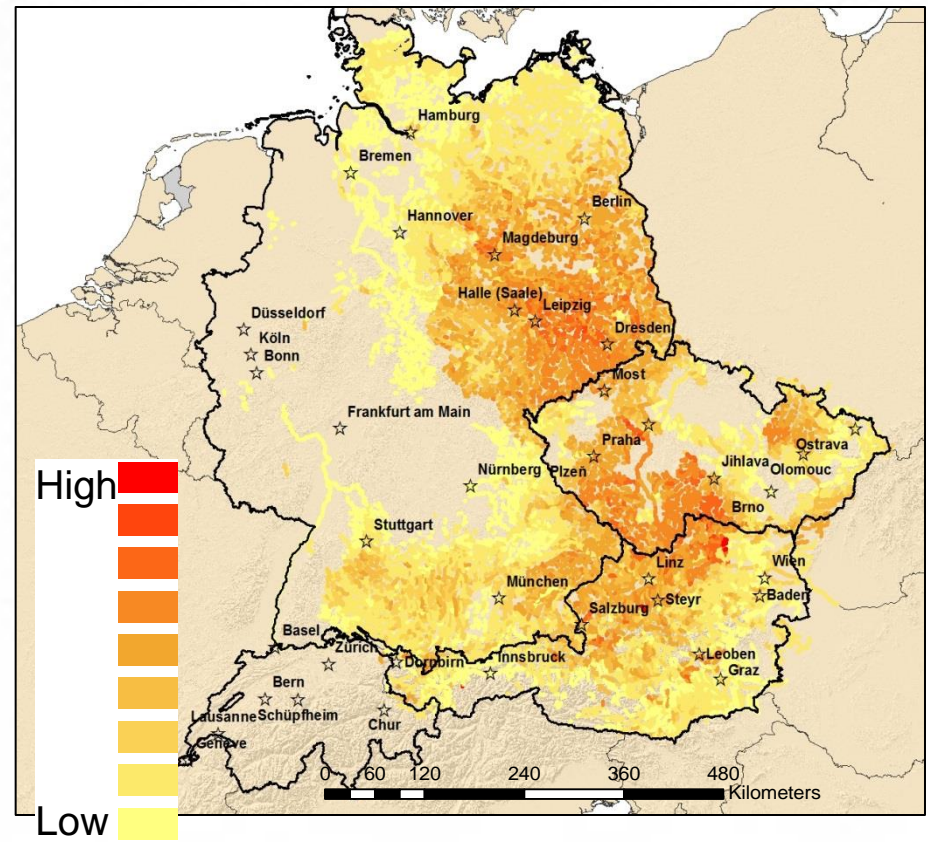


2002 Event Impacted Germany, Austria, and Czech Republic

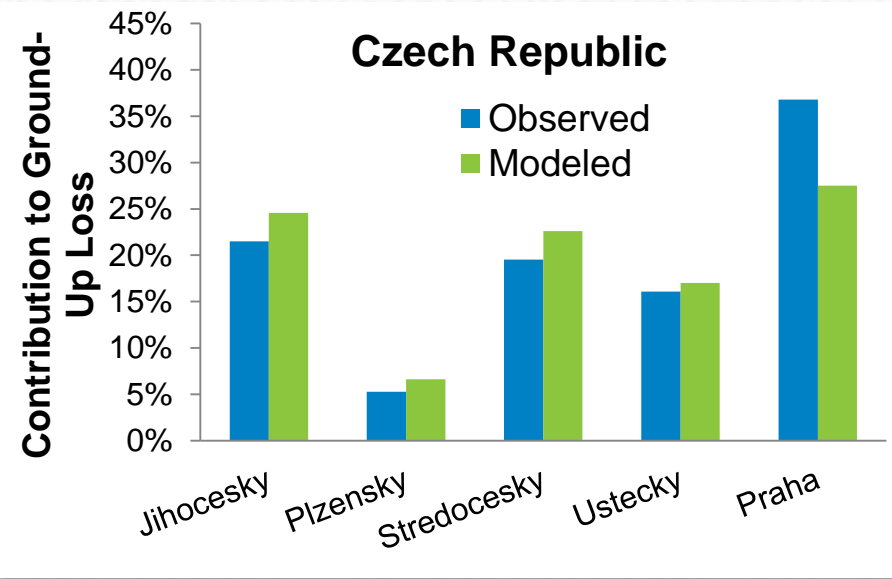
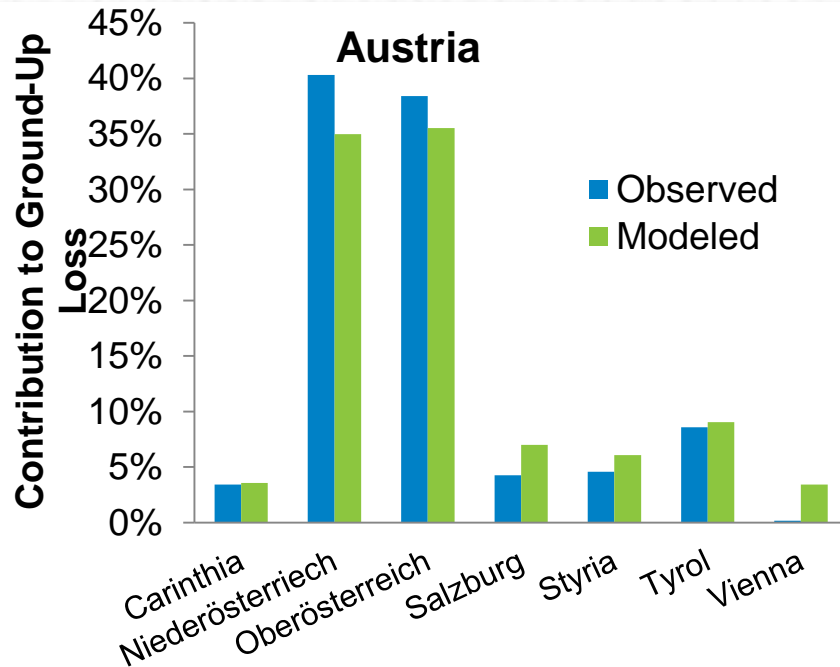
Relative Runoff



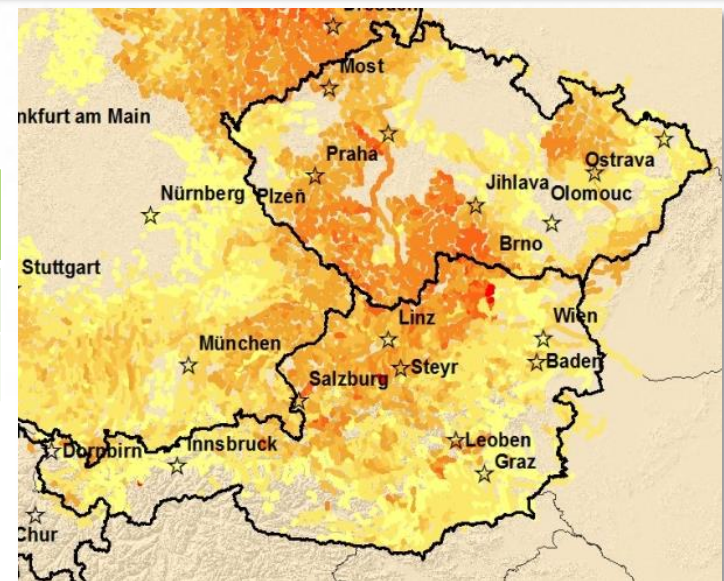
Relative Flow



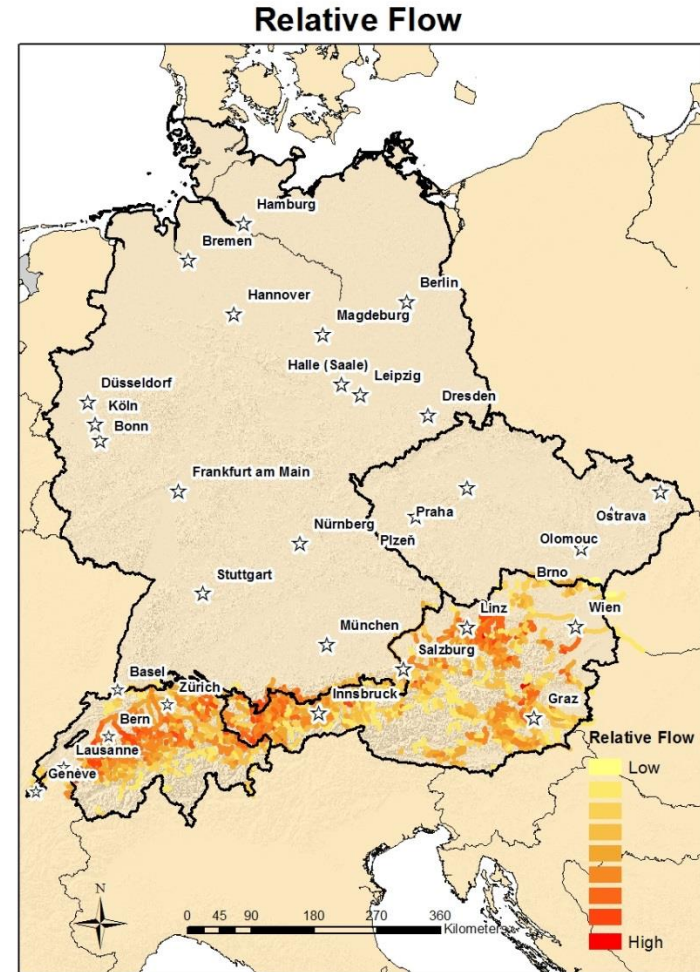
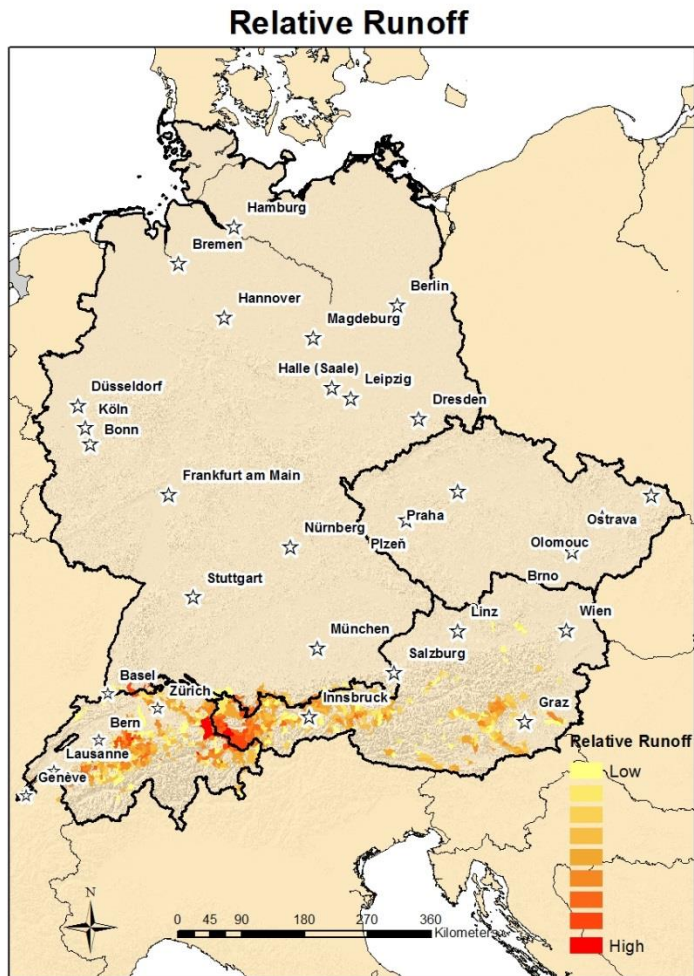
2002 Event—Impact on Austria and the Czech Republic



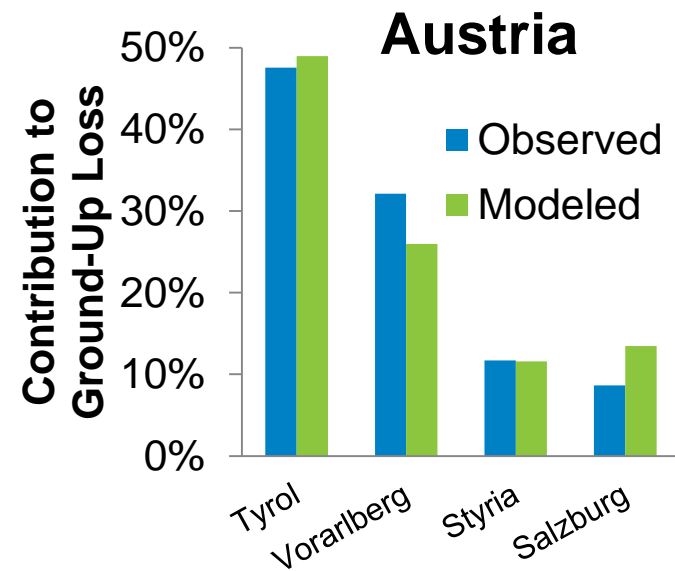
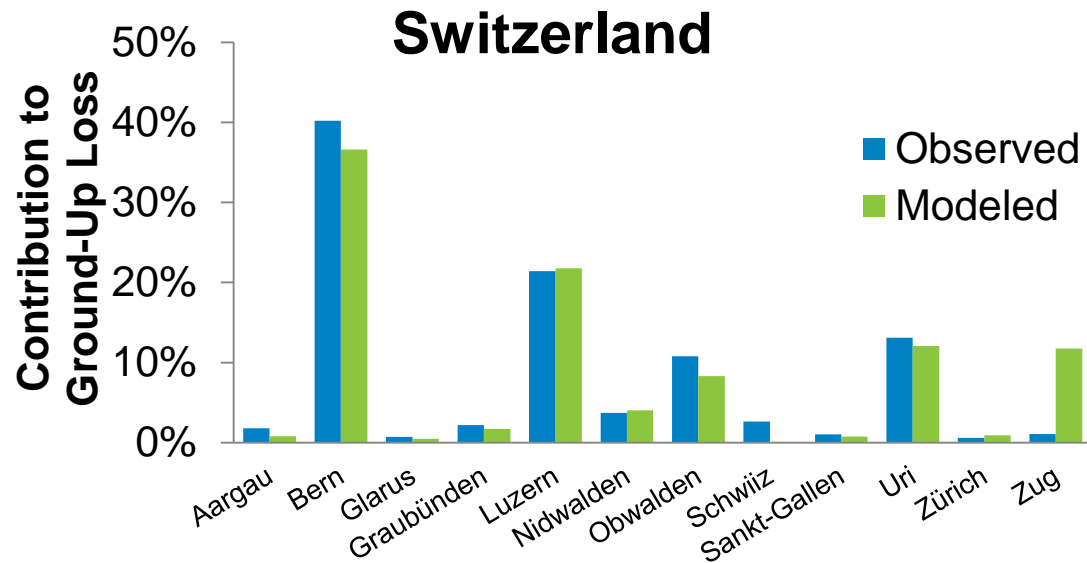
Country	Modeled Ground-Up Loss (Billion €)	Observed Ground-Up Loss (Billion €)
Austria	4.0	2.7 - 3.9
Czech Republic	3.5	3.1 - 4.5



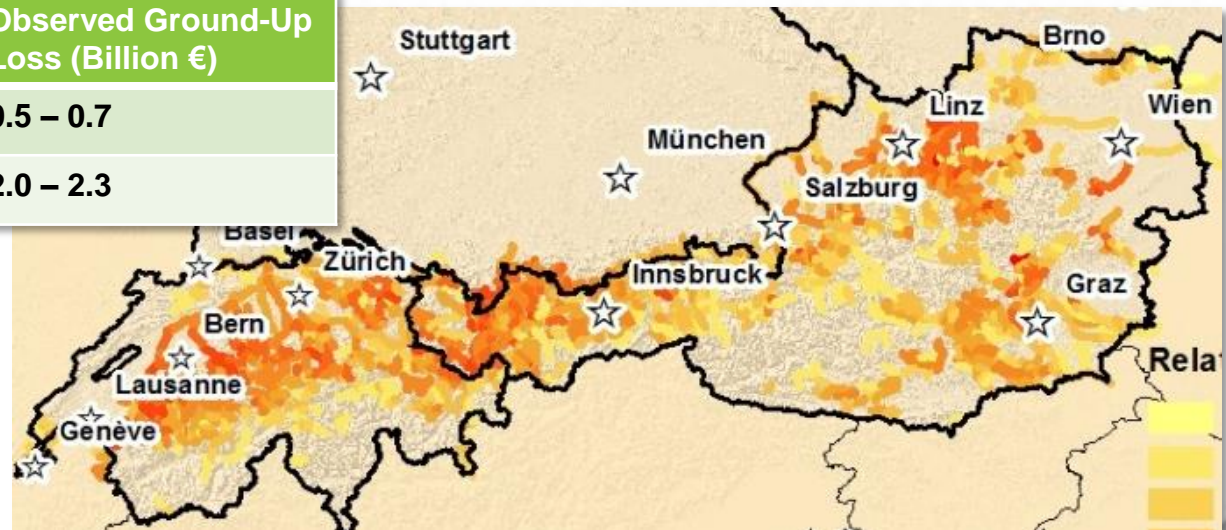
2005 Alpine Event Impacted Austria and Switzerland



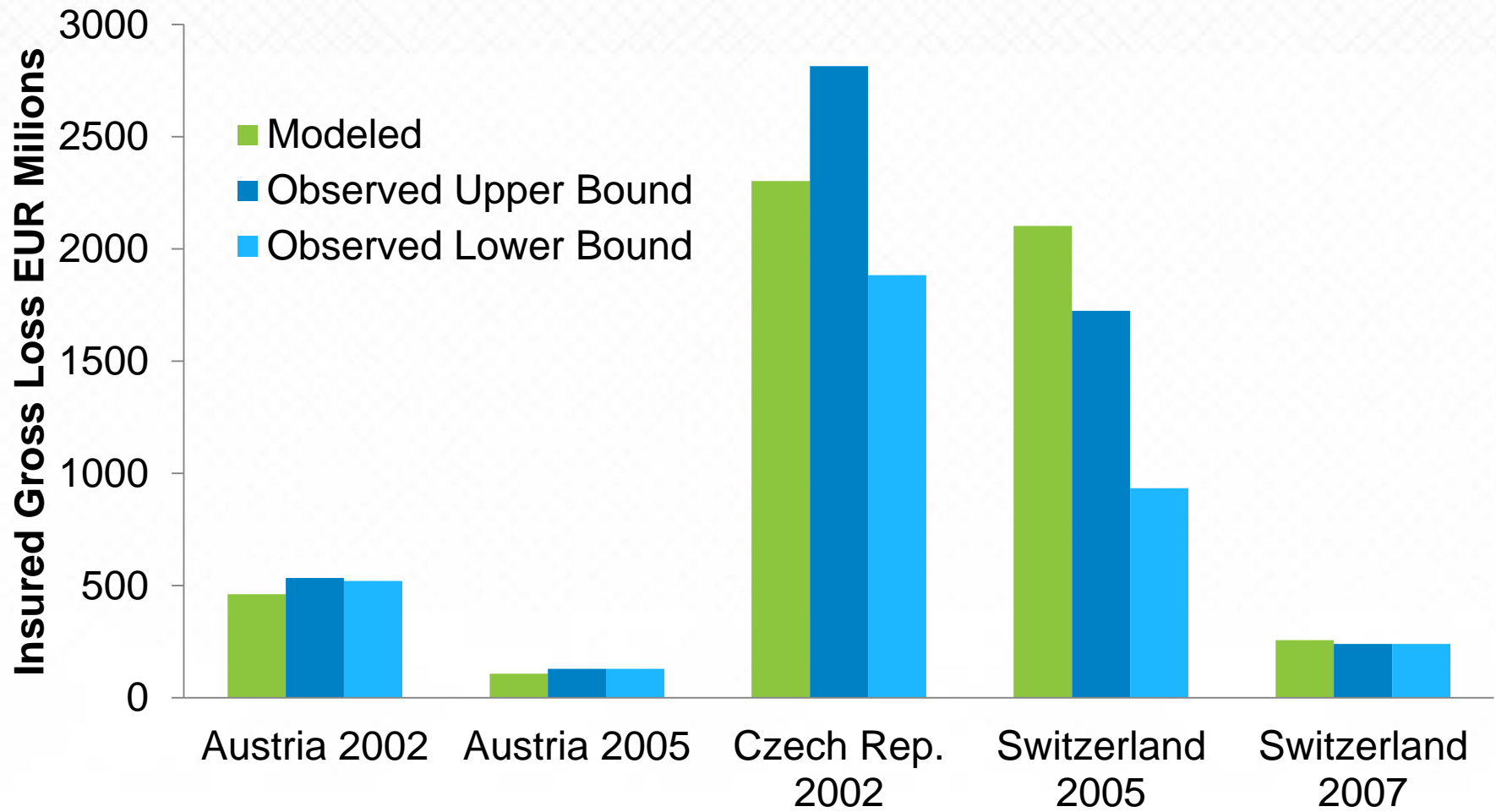
2005 Event—Impact on Austria and Switzerland



Country	Modeled Ground-Up Loss (Billion €)	Observed Ground-Up Loss (Billion €)
Austria	0.8	0.5 – 0.7
Switzerland	2.2	2.0 – 2.3



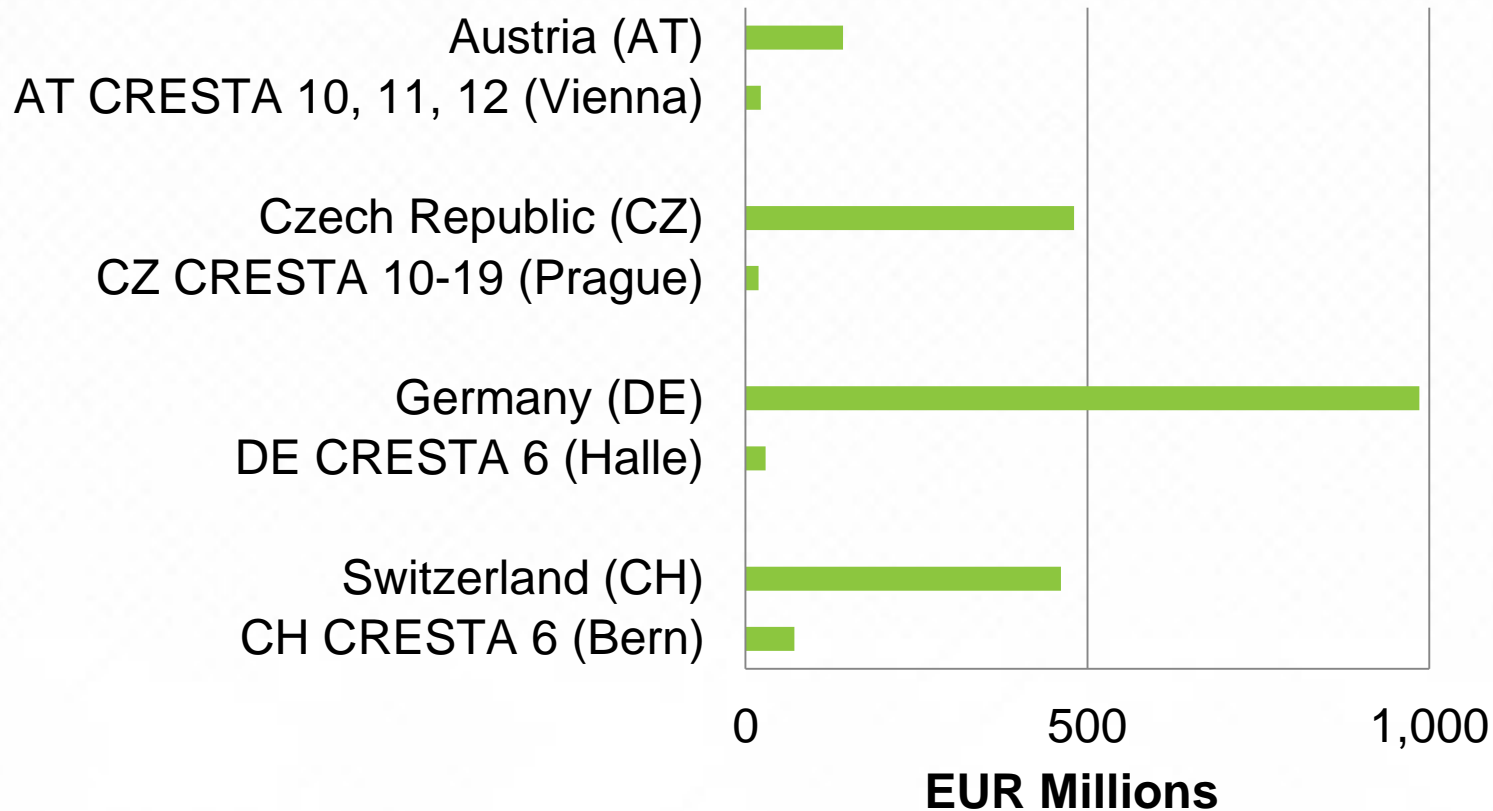
Modeled and Observed Insured Gross Losses



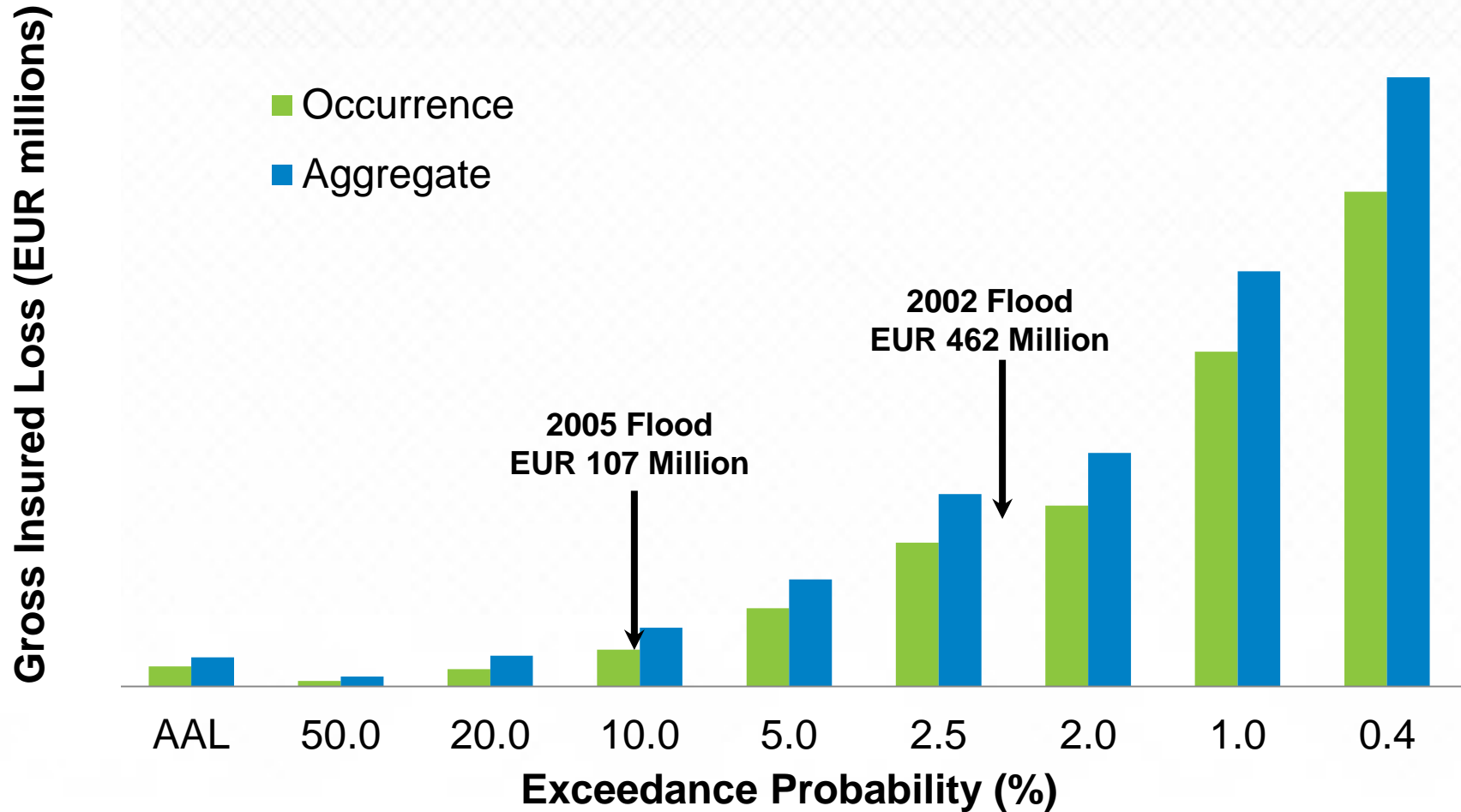
Model Statistics

Average Annual Aggregate Insurable Losses Are Driven by Combination of Hazard and Exposure

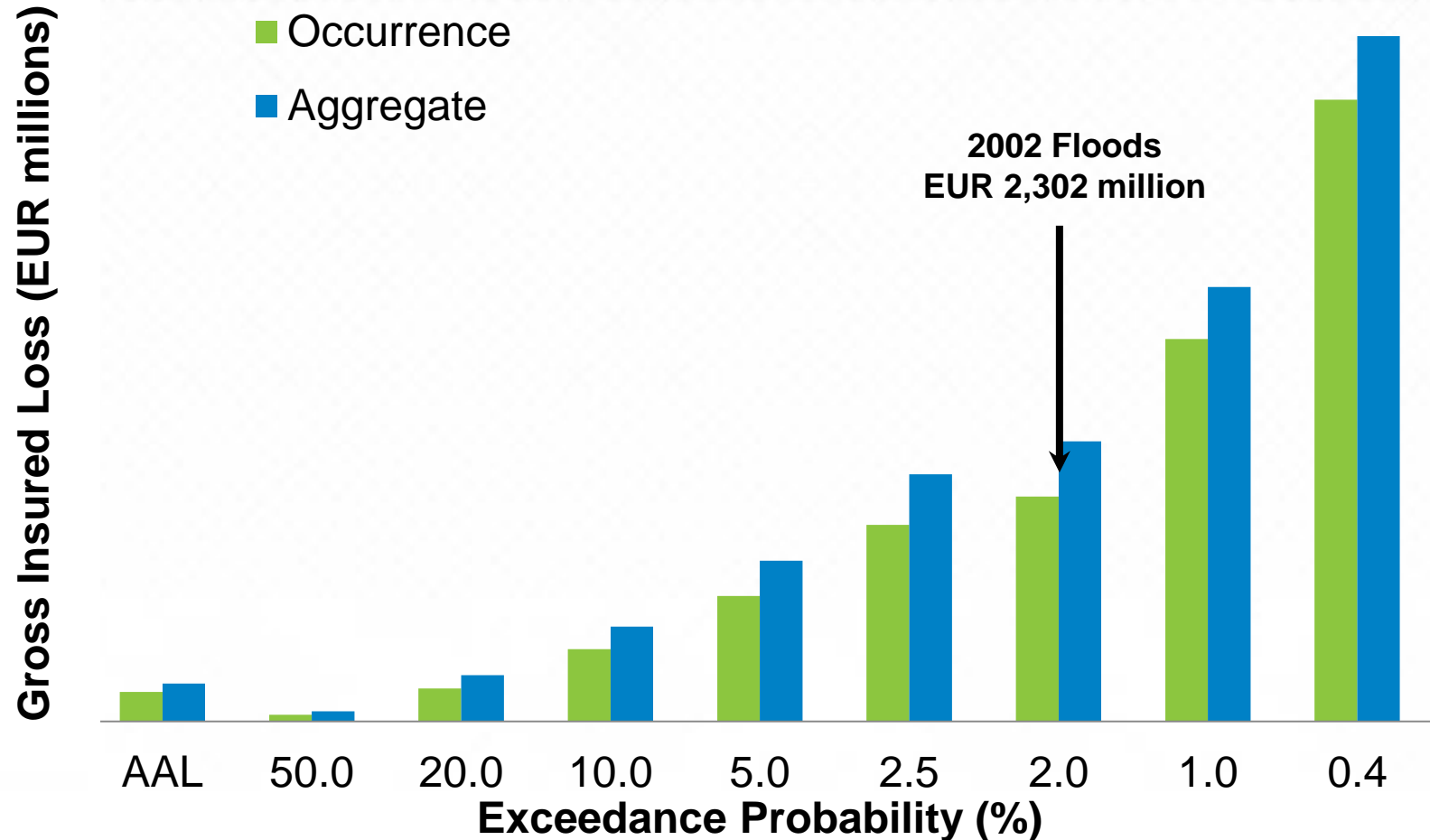
Insurable



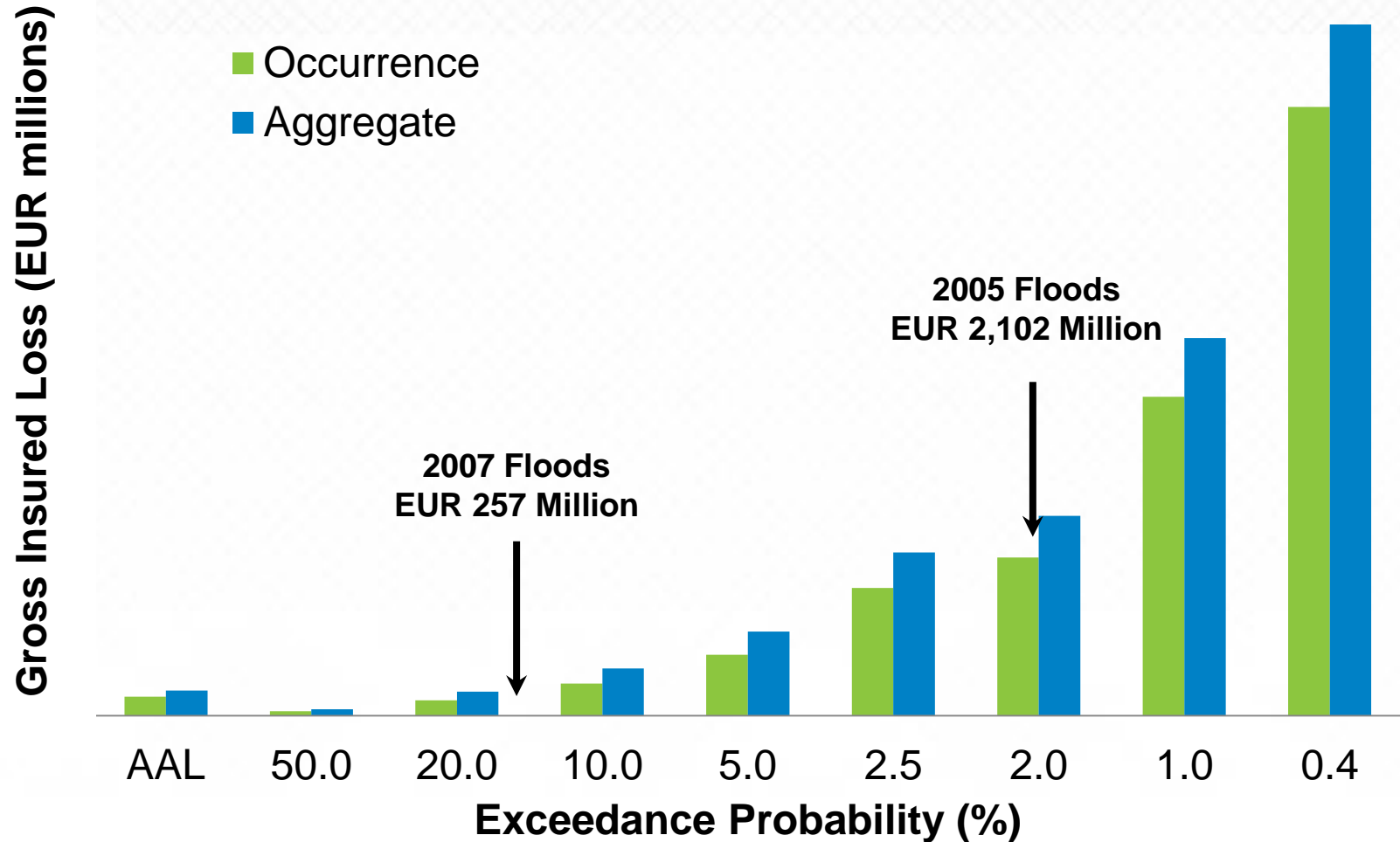
Modeled Occurrence and Aggregate Exceedance Probabilities for Gross Insured Losses for Austria



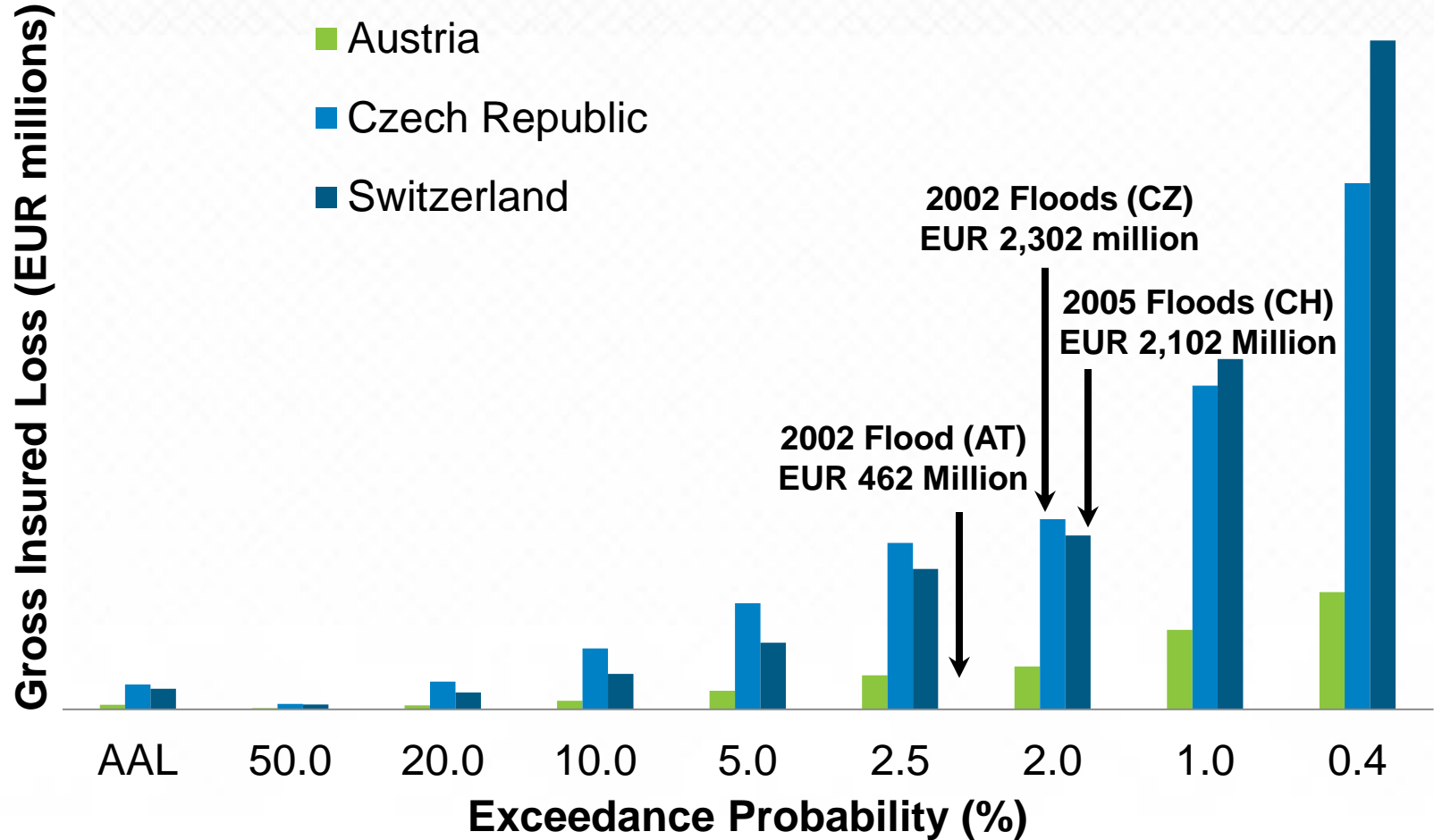
Modeled Occurrence and Aggregate Exceedance Probabilities for Gross Insured Losses for Czech Republic



Modeled Occurrence and Aggregate Exceedance Probabilities for Gross Insured Losses for Switzerland



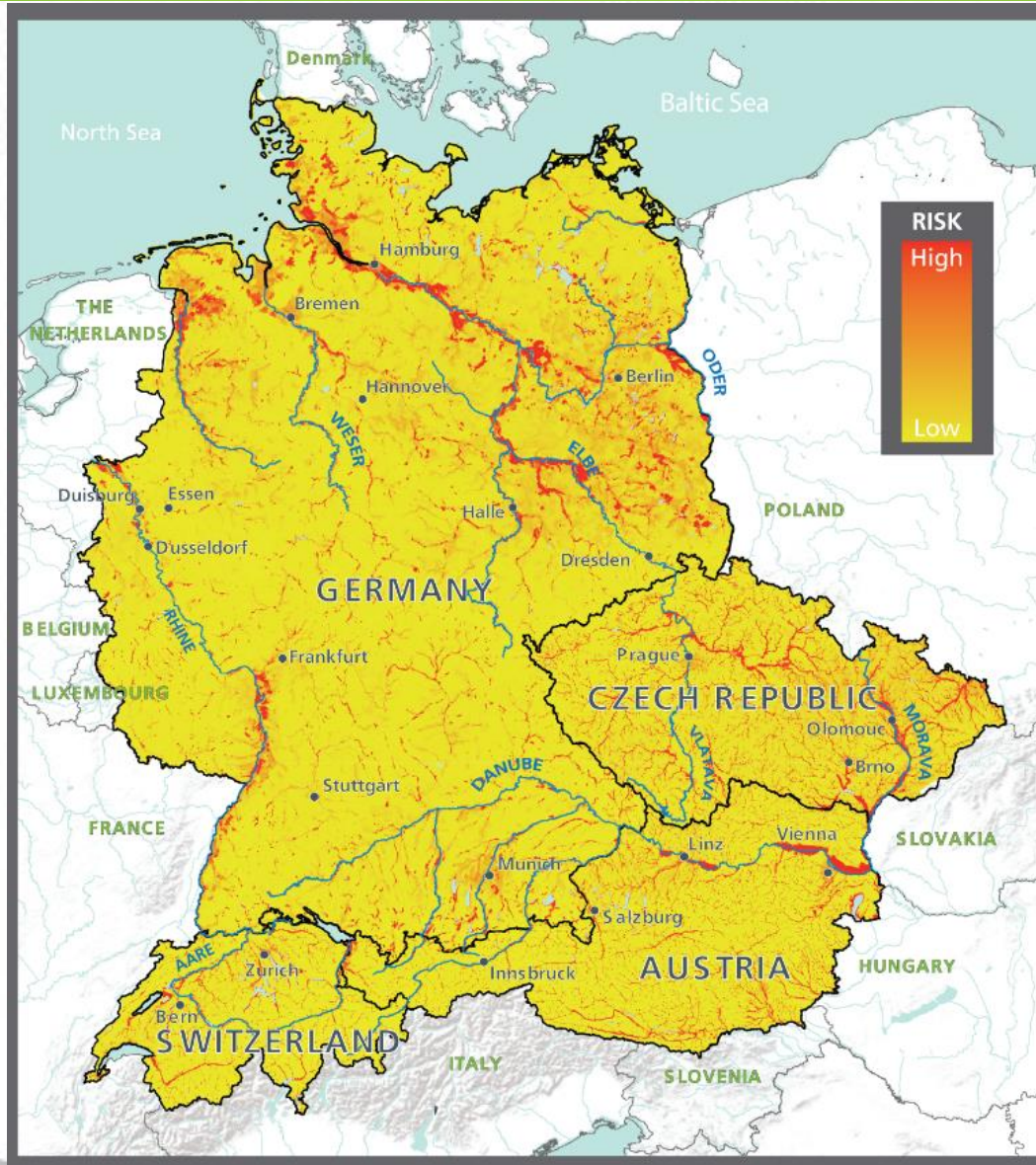
Modeled Occurance Exceedance Probabilities



Highlights



Central Europe Inland Flood Model Highlights



Model Highlights

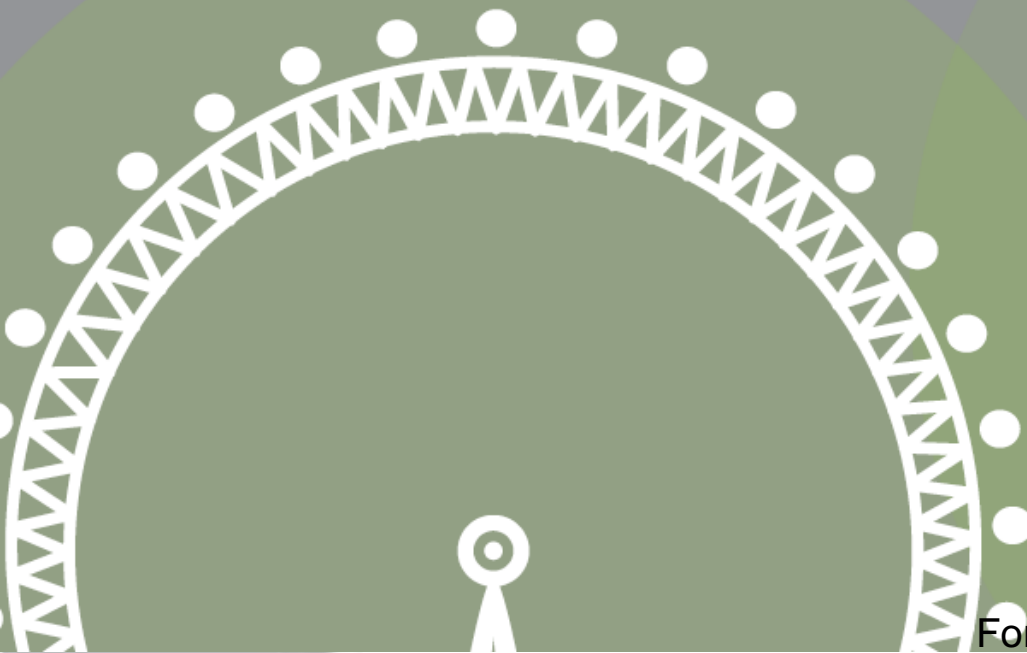
- **Physically** based, fully **probabilistic** methodology
- Events are **congruent** across all **four countries** (Germany, Austria, Czech Republic, and Switzerland). Event set covers all four countries
- Defined events conform consistently to **504 hours clause**
- Accounts for all key components of the **water cycle** such as **snow retention** in a state-of-the-art hydrological model
- Accounts for **flood defenses** and supports user-defined **custom flood defenses** as secondary modifier
- Explicitly models **off-floodplain losses** to capture a major source of insured losses
- Features a **component-based** approach to damage estimation for commercial buildings
- **Validated** against both aggregate and detailed historical loss and claims data, including **2002, 2005, and 2007 flood events**

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