Inland Coastal Flooding Risk by Tropical Cyclone

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Massachusetts Institute of Technology

HURRICANE FLOOD RISK

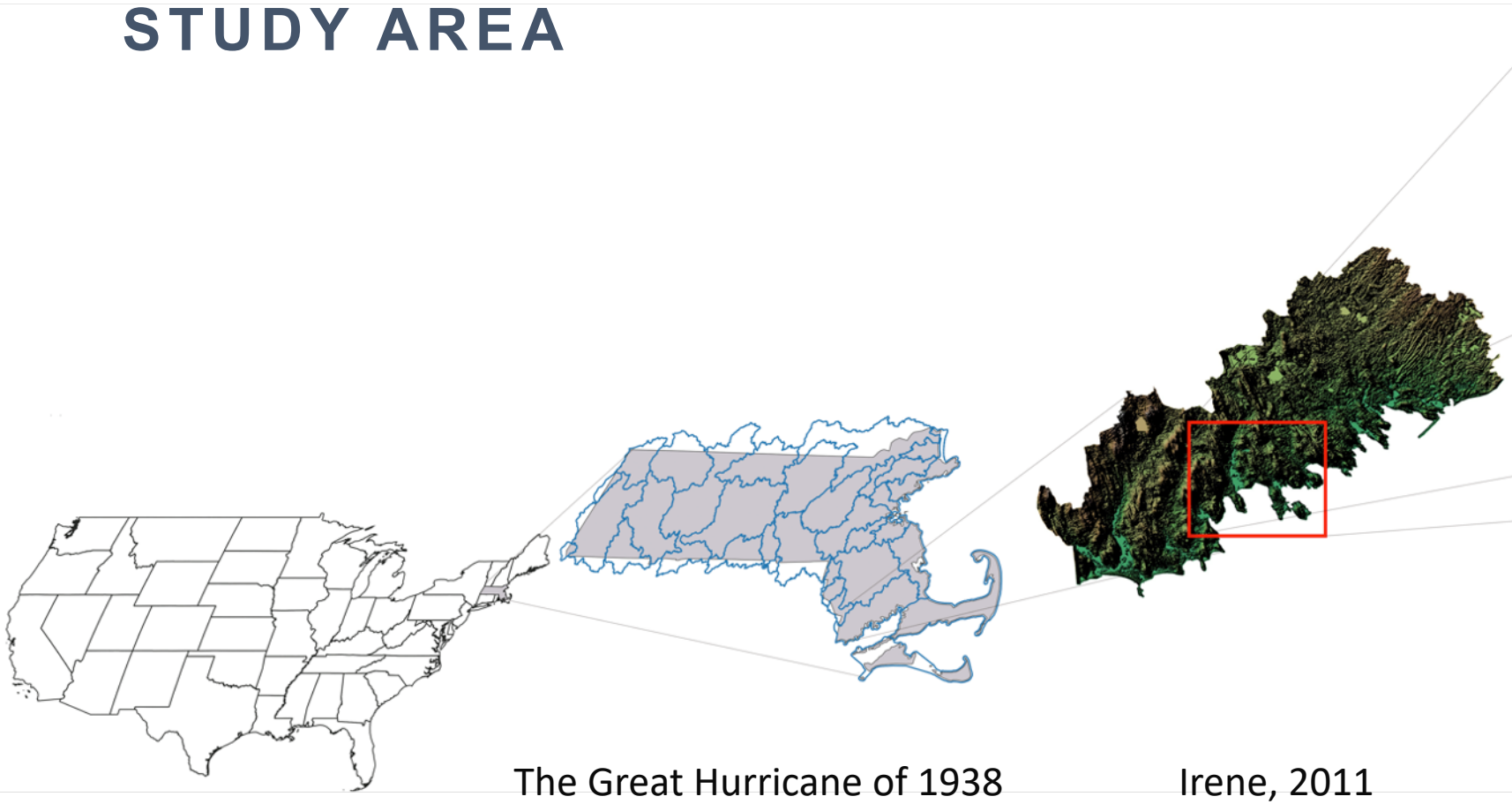
- Risk of extreme rainfall from TCs is increasing under a warming climate (Emanuel 2005, 2017), Examples: Hurricanes *Katrina*, *Harvey*, *Galveston*





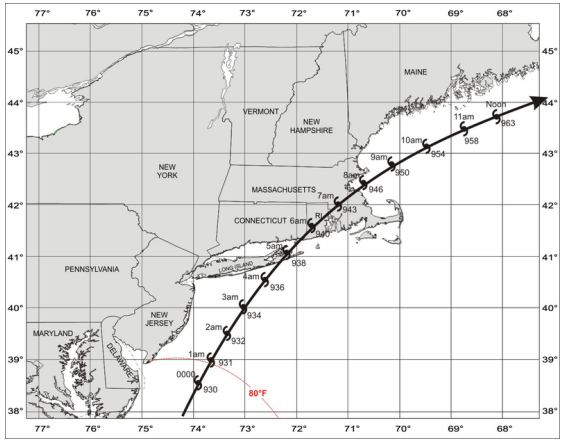
www.nasa.gov/

STUDY AREA





The Great Hurricane of 1938





Irene, 2011



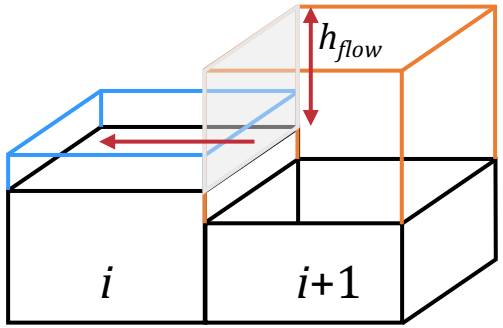


SUB-GRID DYNAMIC HYDRAULIC MODEL

- **Continuity Equation**

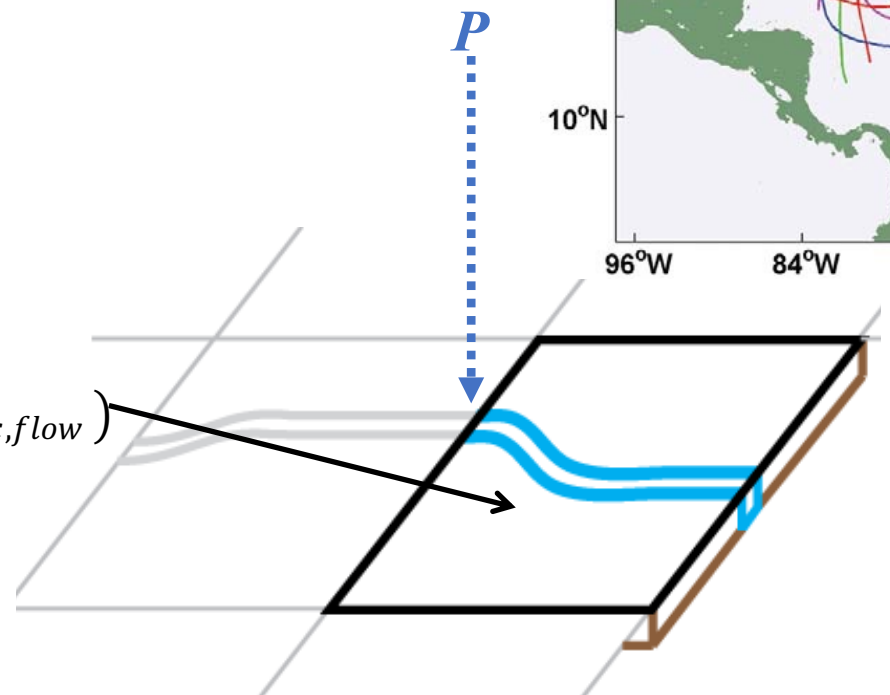
$$V_{i,j}^{t+\Delta t} = V_{i,j}^{t} + \Delta t\left(Q_{i-\frac{1}{2},j}^{t+\Delta t} - Q_{i-\frac{1}{2},j}^{t+\Delta t} + Q_{i-\frac{1}{2},j}^{t+\Delta t} - Q_{i-\frac{1}{2},j}^{t+\Delta t} + dx{\times}dy\,(P_{i,j}^{t+\Delta t} - I_{i,j}^{t+\Delta t})\right)$$

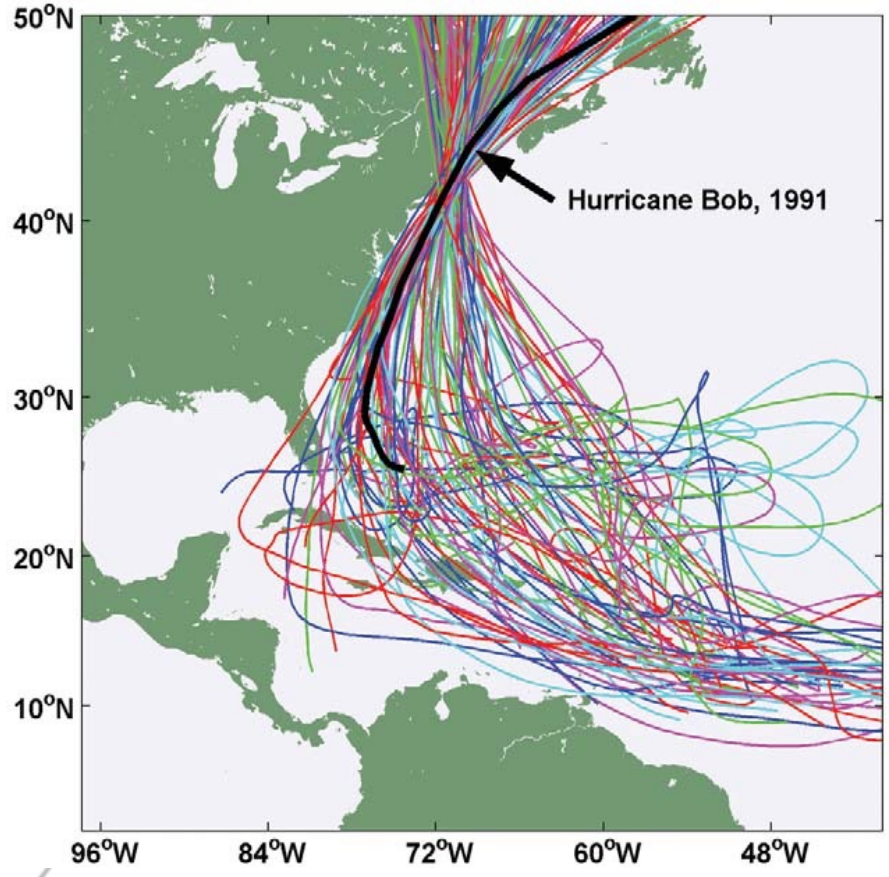
$dx{\times}dy = Cell\ surface\ area$



- **Momentum equation**

$$Q_{f,i+1/2}^{t+\Delta t} = \frac{q_{f,i+1/2}^{t} - g h_{f,flow}^{t}\,\Delta t S_{i+1/2}^{t}}{1 + g\Delta t n^2 \left|q_{f,flow}^{t}\right| \left[\left(h_{f,flow}^{t}\right)^{7/3}\right]} \left(\Delta x - w_{c,flow}\right)$$





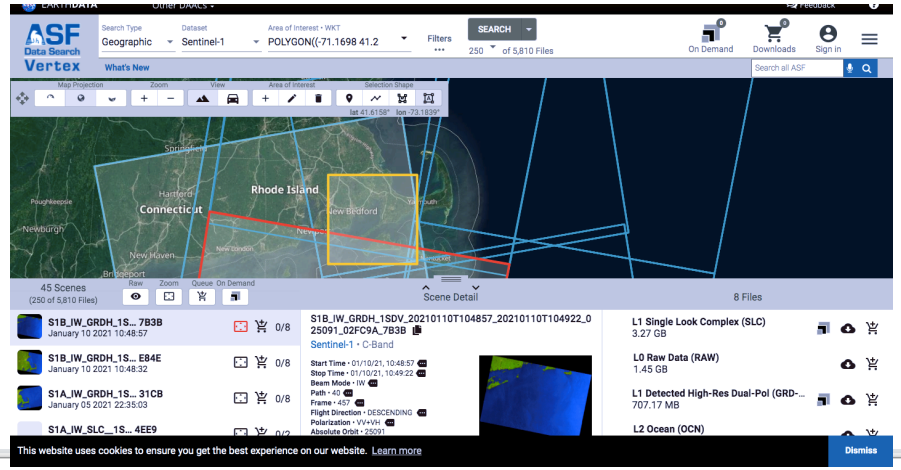
(1979-2019)

SENTINEL-1 SAR (SYNTHETIC APERTURE RADAR)

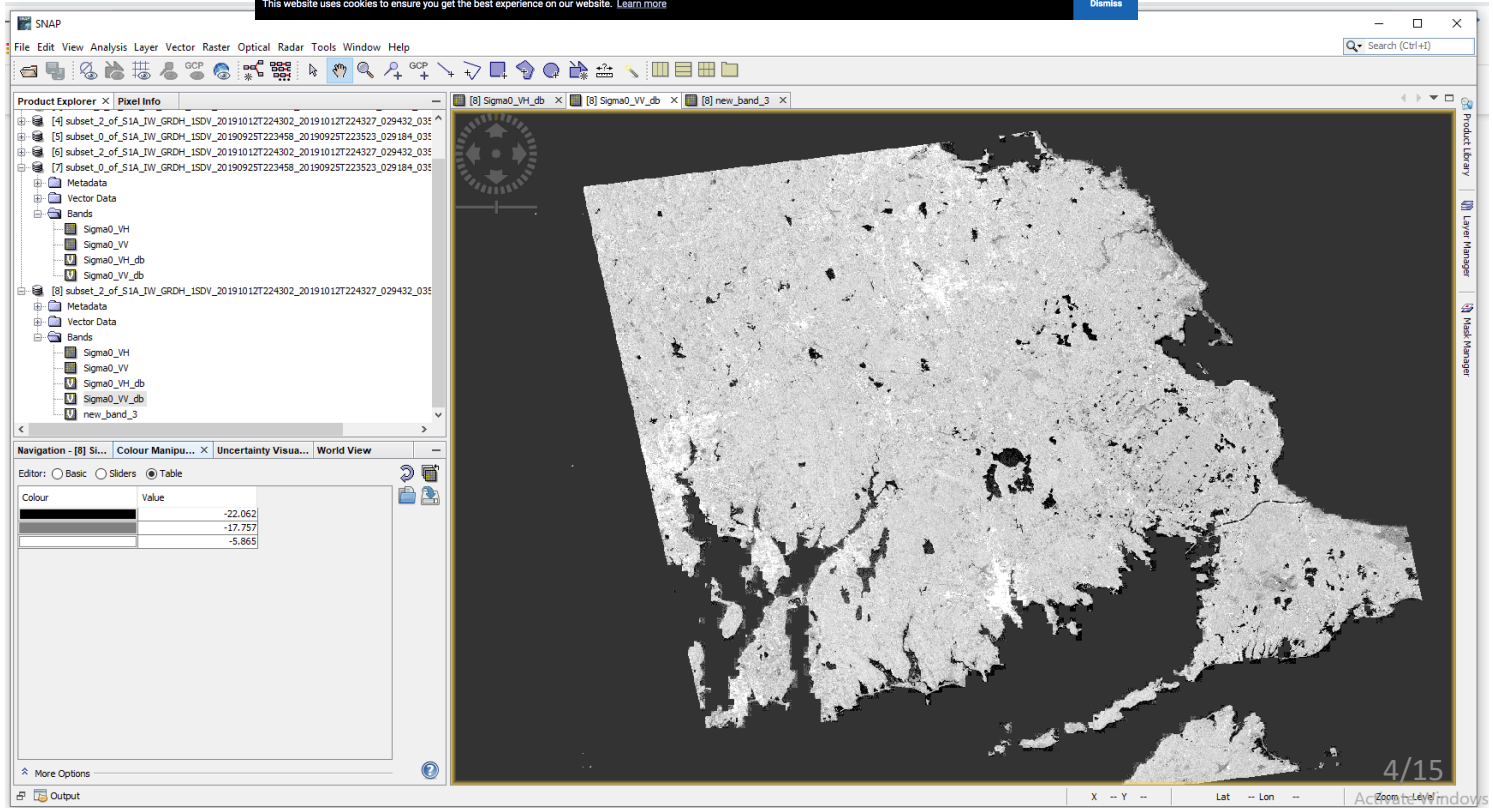
Hurricane Michael

2018–10–12

https://search.asf.alaska.edu/

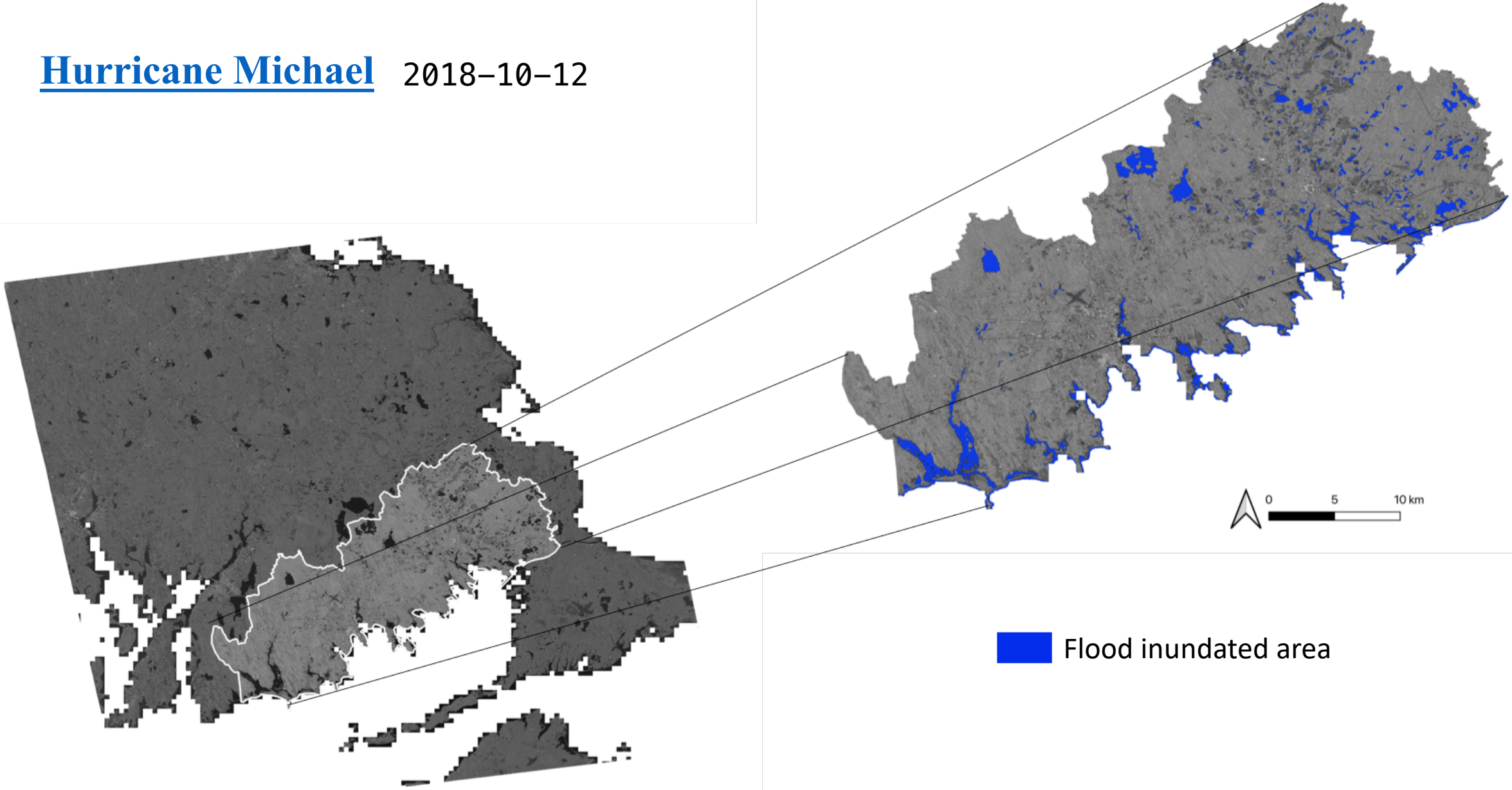


- SAR image – Sentinel-1
- Orbital file correction
- Radiometric Calibration
- Geometric Calibration
- Back Scatter image generation
- Threshold detection
- Flood inundation Map



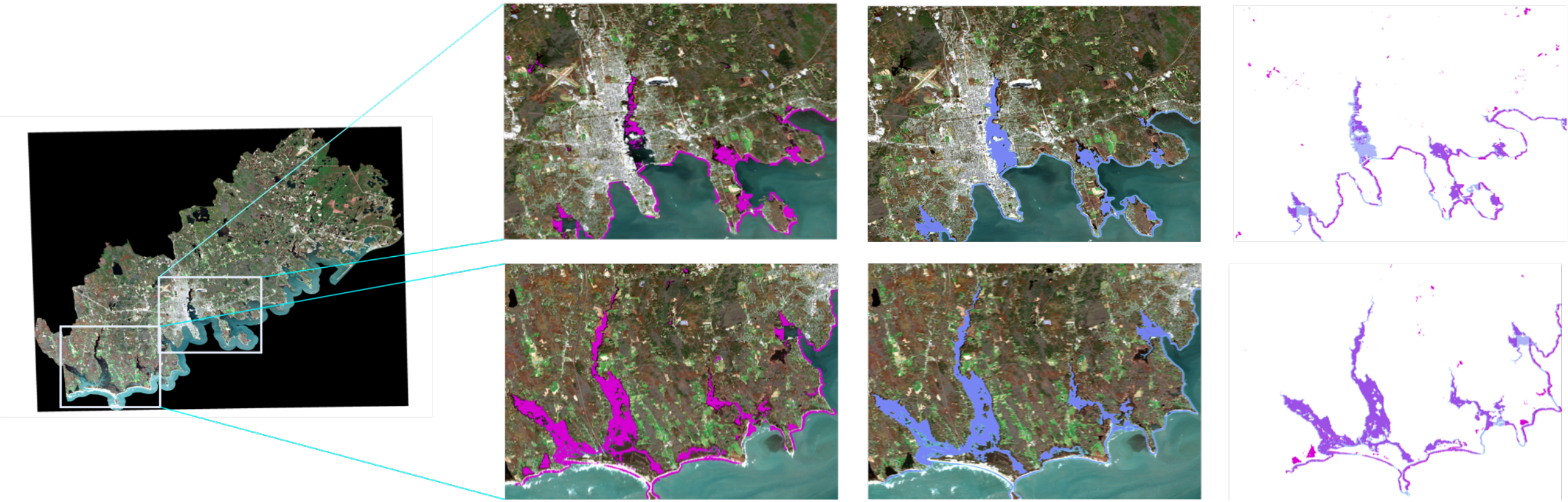
MODEL VALIDATION: S.A.R. RADAR IMAGE PROCESSING

Hurricane Michael 2018-10-12

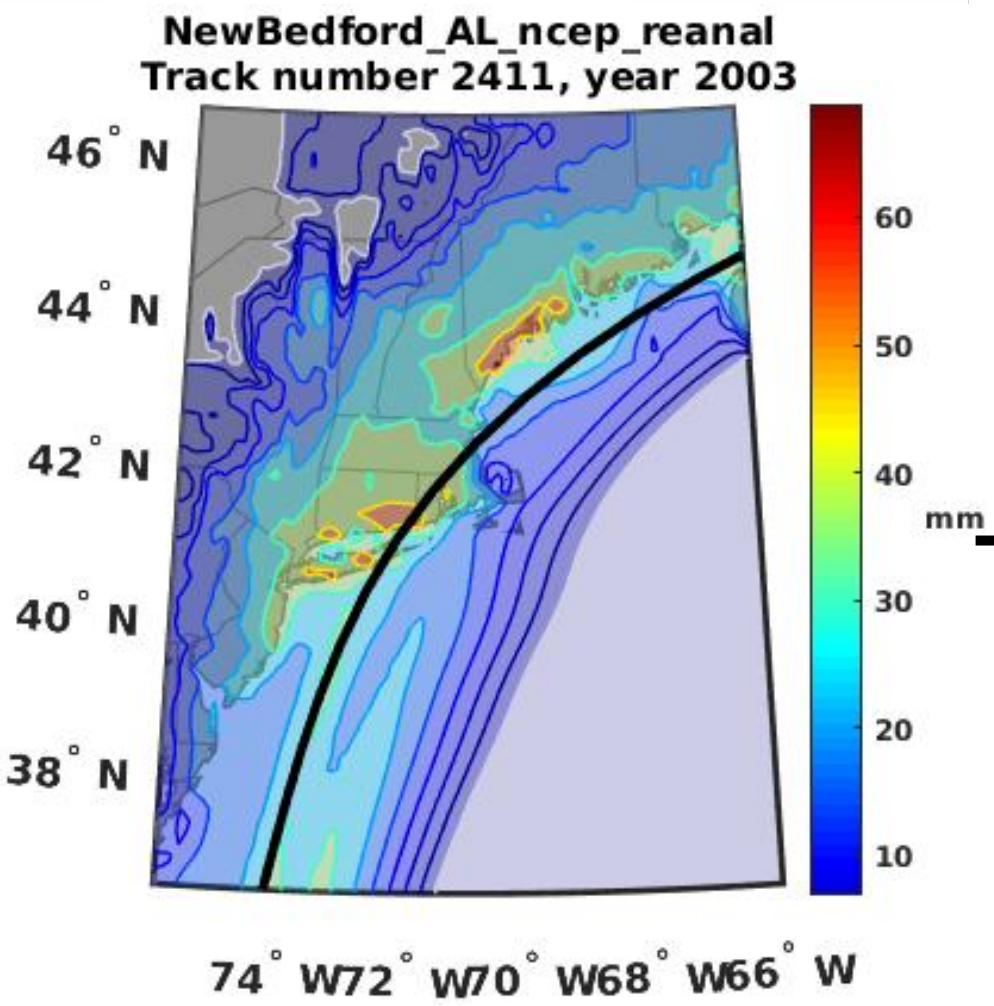


MODEL VALIDATION

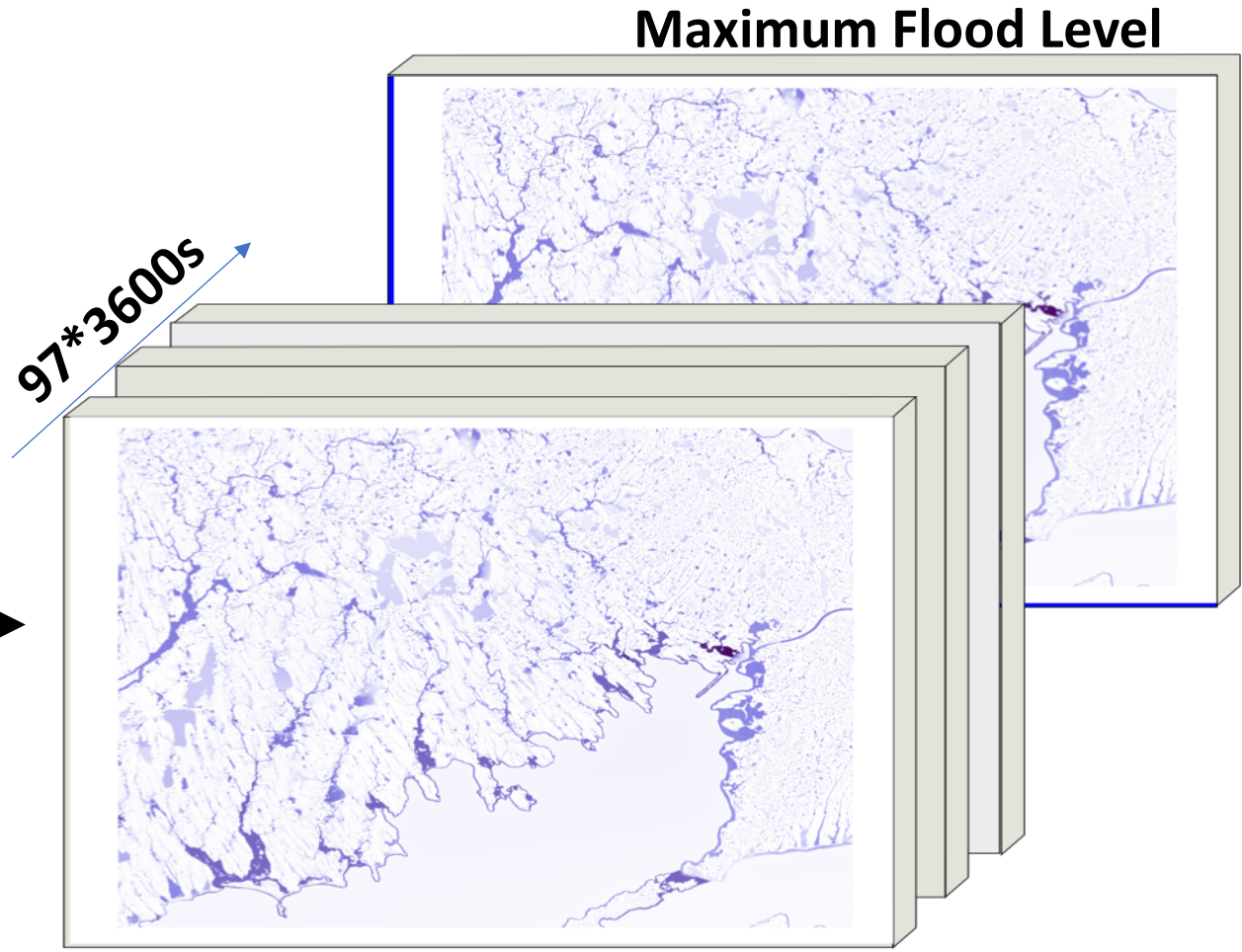
Hurricane Michael 2018-10-12



RAINFALL-DRIVEN FLOODING FROM SYNTHETIC TRACKS

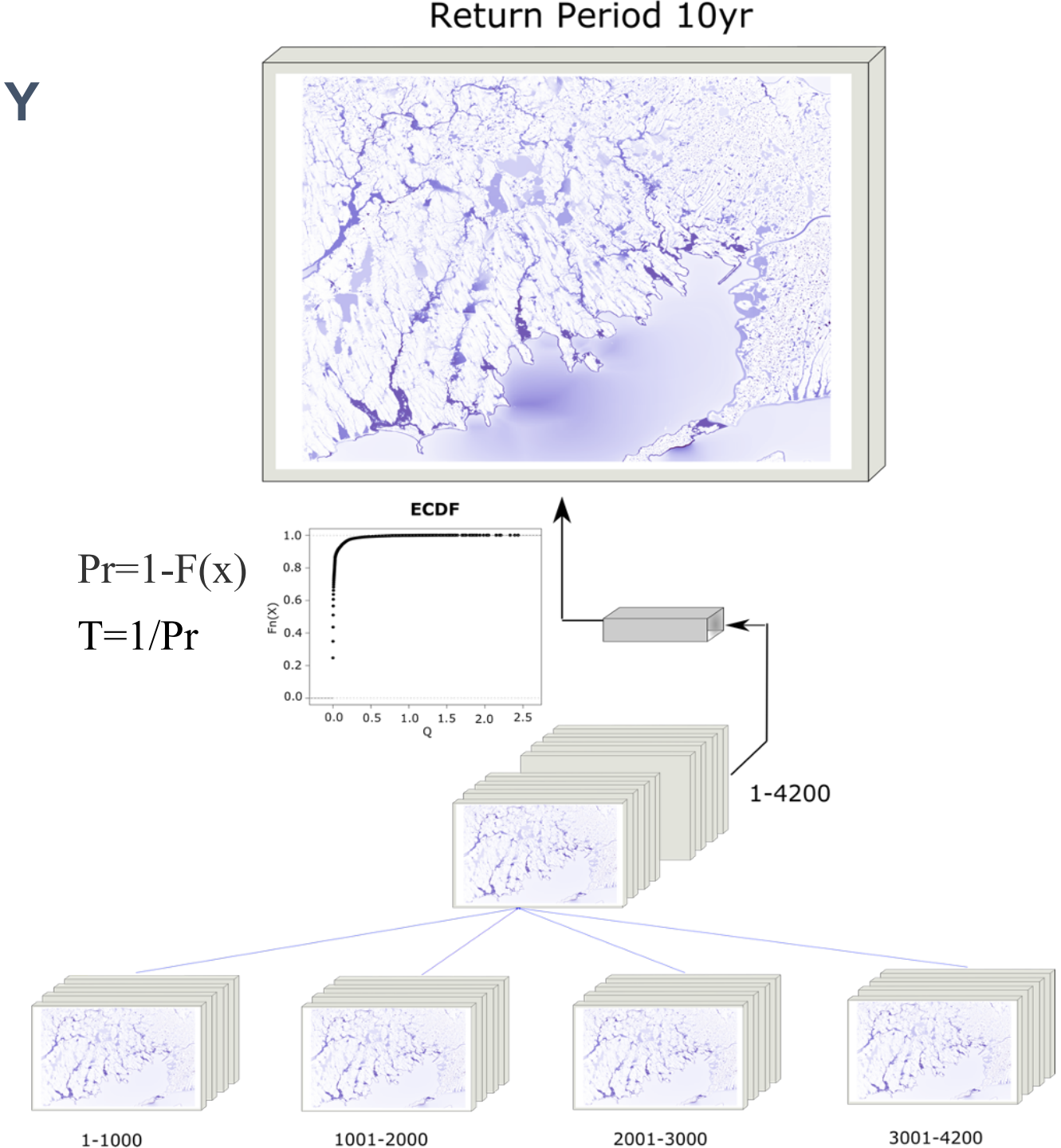


Resolution: 0.03 degree



Flood maps for every second

FLOOD FREQUENCY ANALYSIS

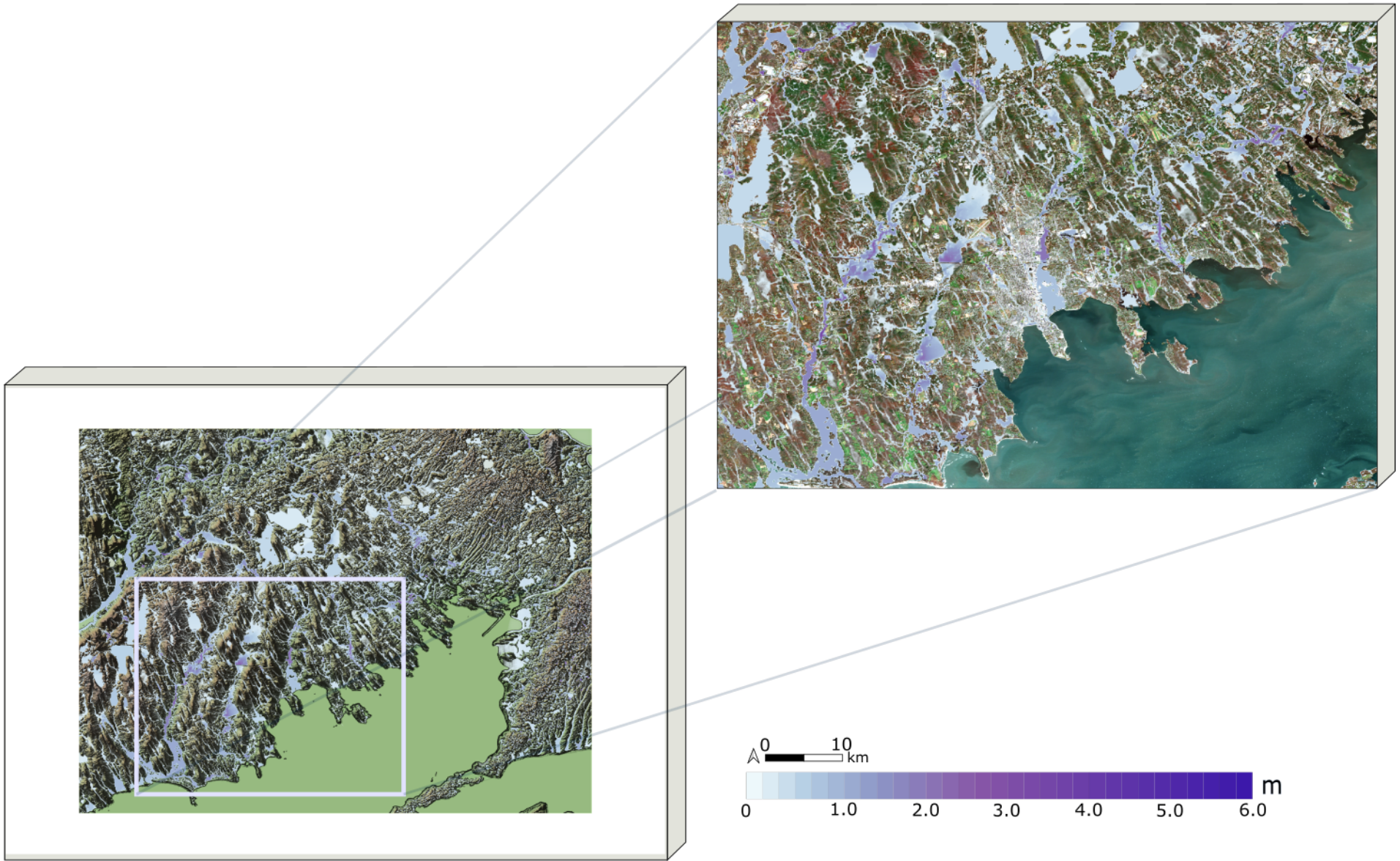


$Pr=1-F(x)$

$T=1/Pr$

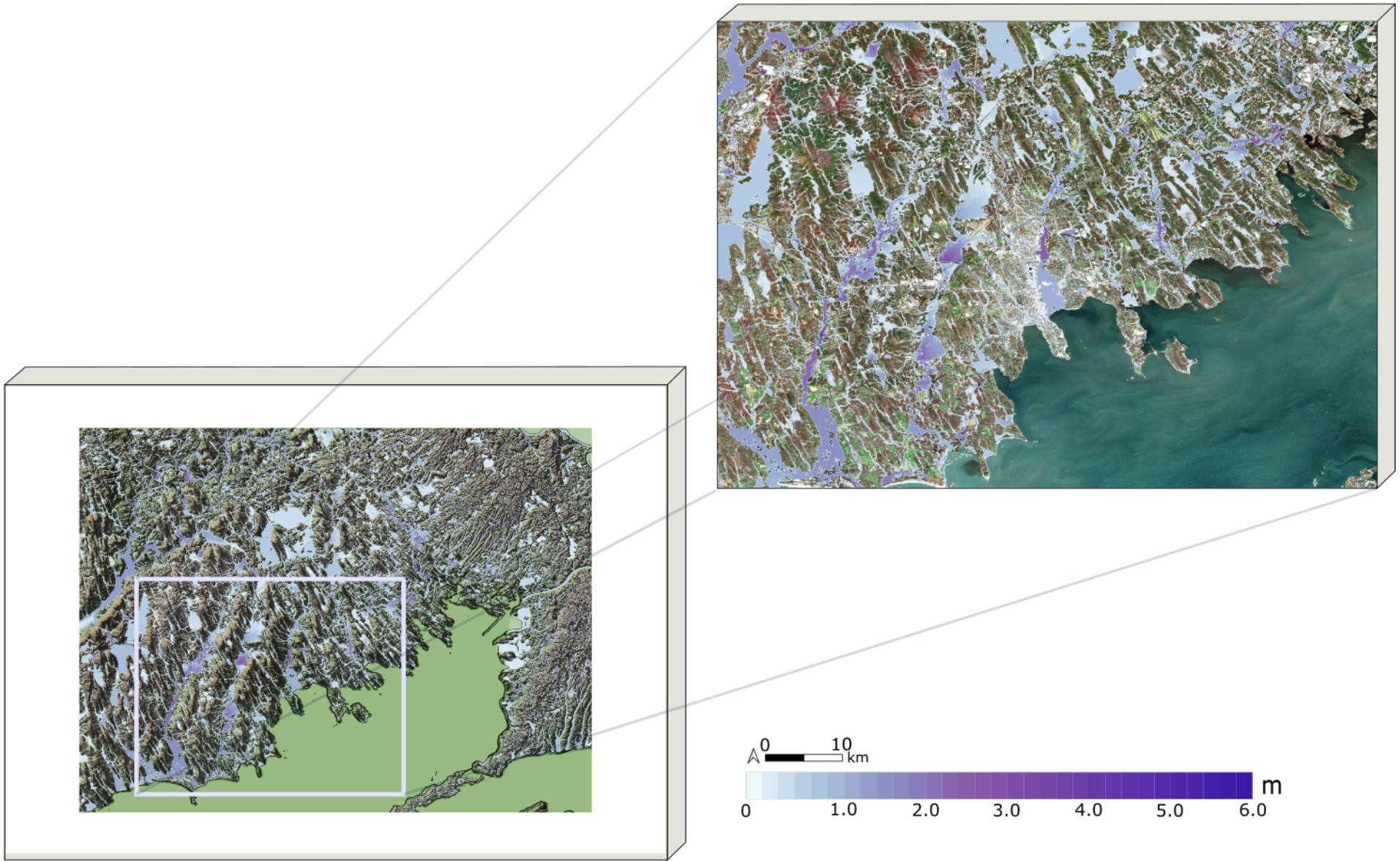
RISK OF RAINFALL-DRIVEN FLOODING

Return Period 10yr



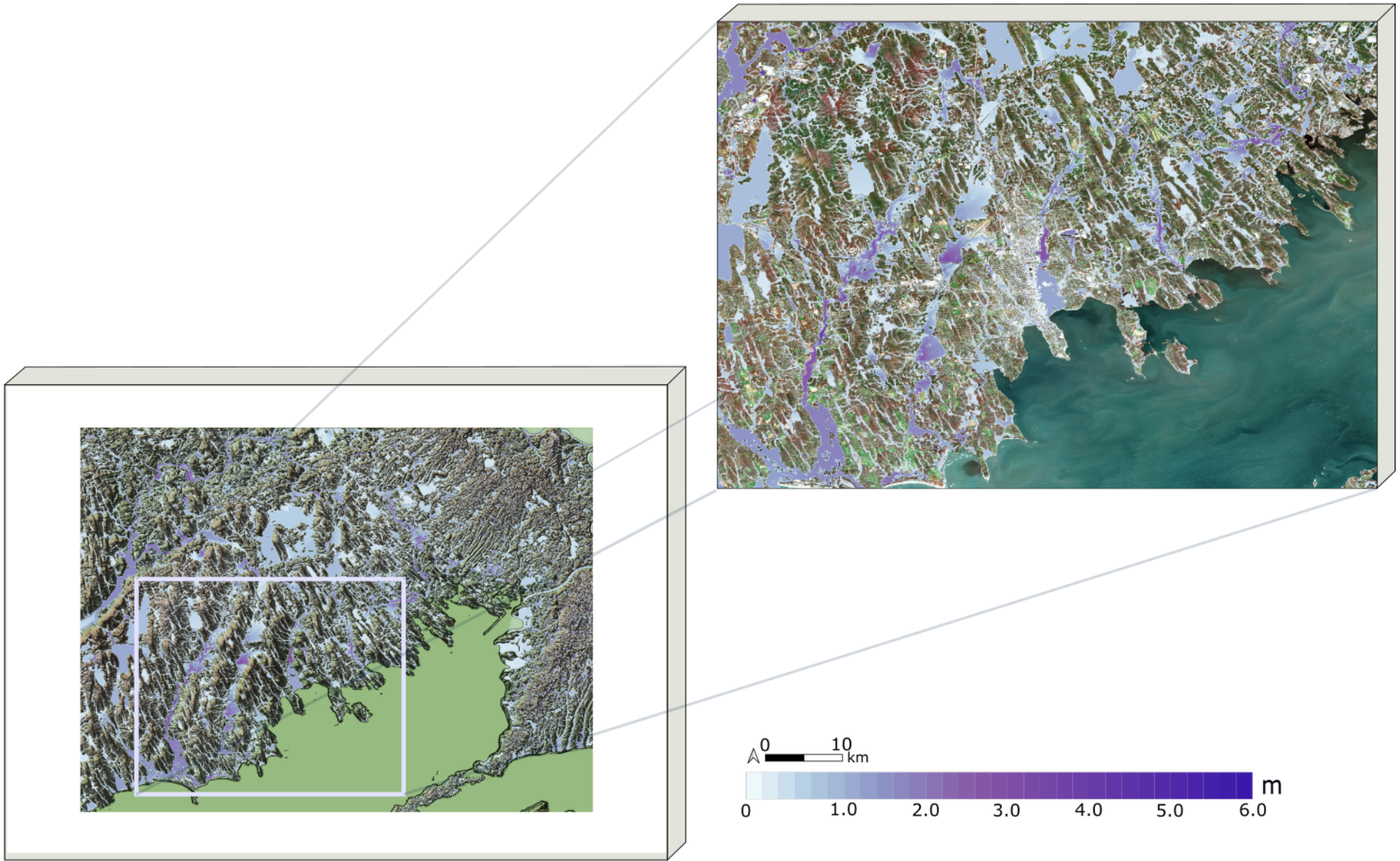
RISK OF RAINFALL-DRIVEN FLOODING

Return Period 25yr



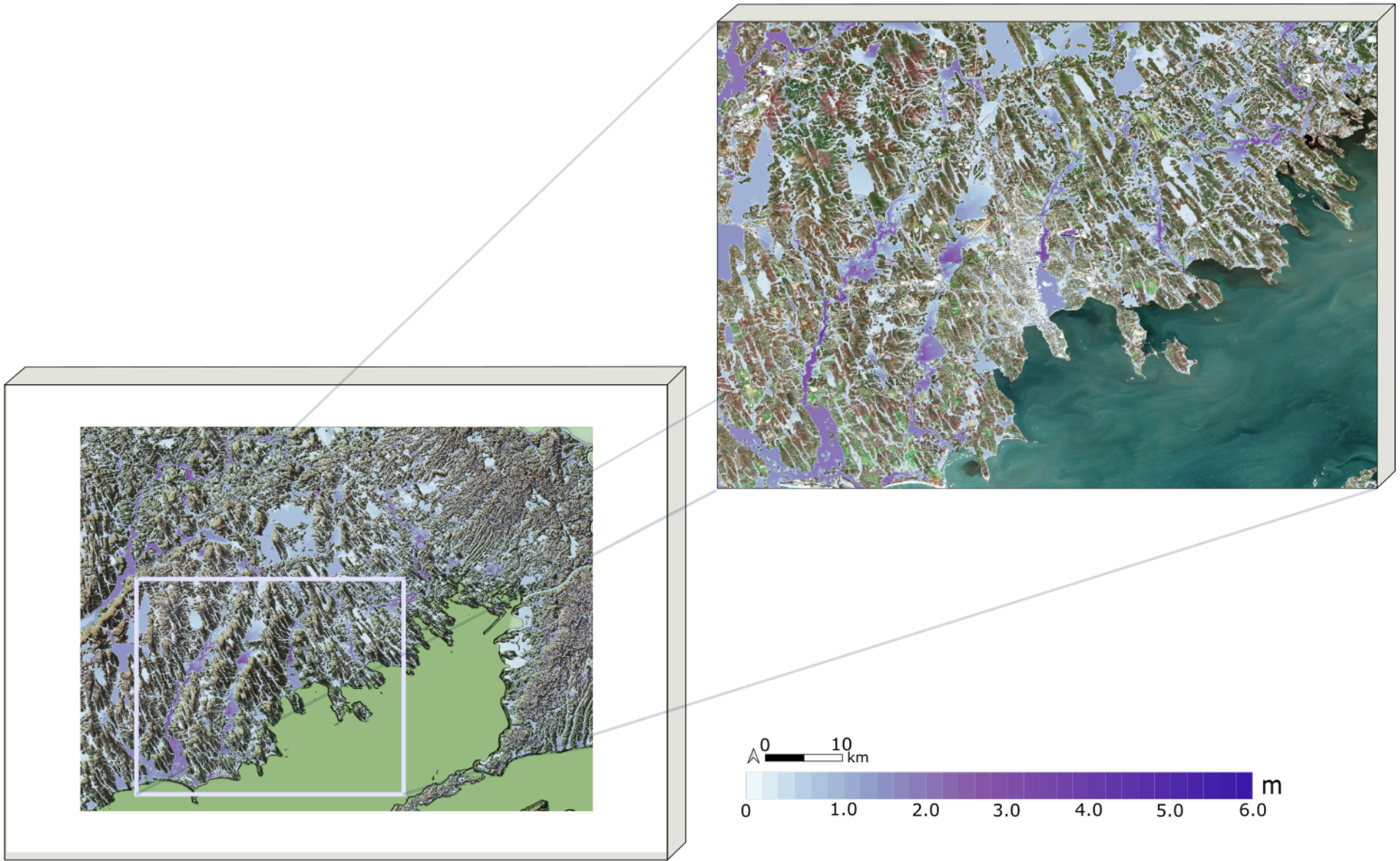
RISK OF RAINFALL-DRIVEN FLOODING

Return Period 50yr



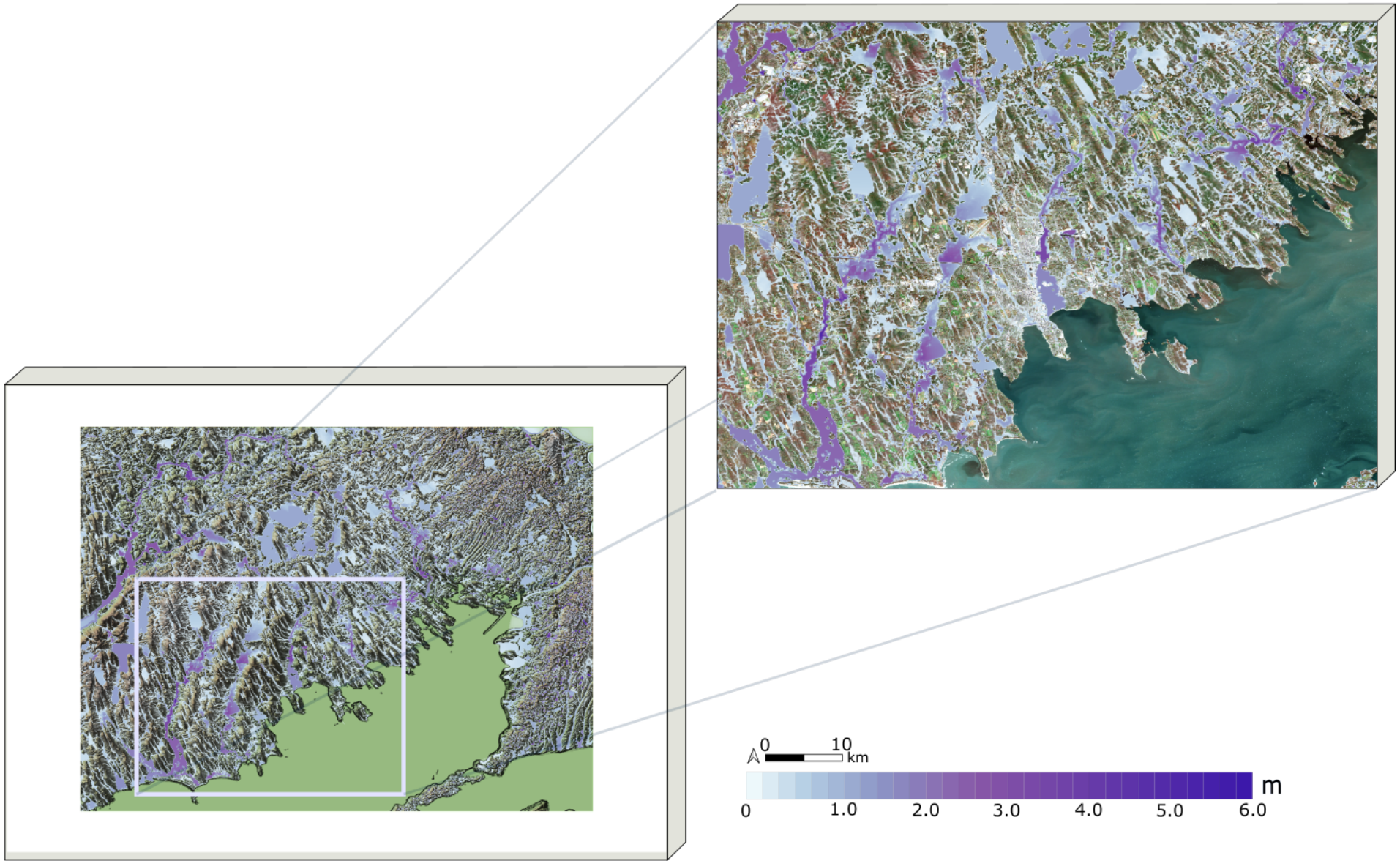
RISK OF RAINFALL-DRIVEN FLOODING

Return Period 100yr



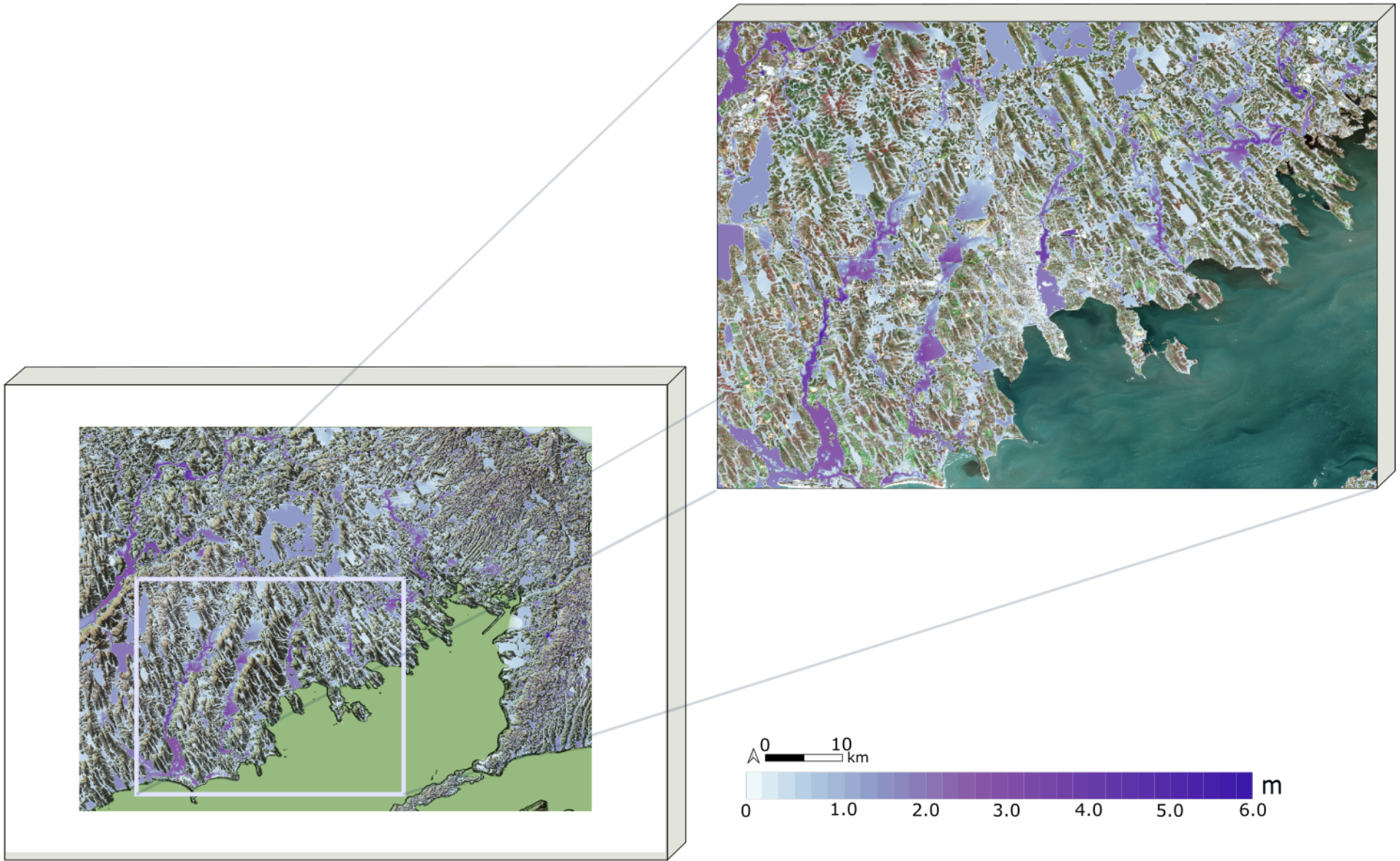
RISK OF RAINFALL-DRIVEN FLOODING

Return Period 200yr



RISK OF RAINFALL-DRIVEN FLOODING

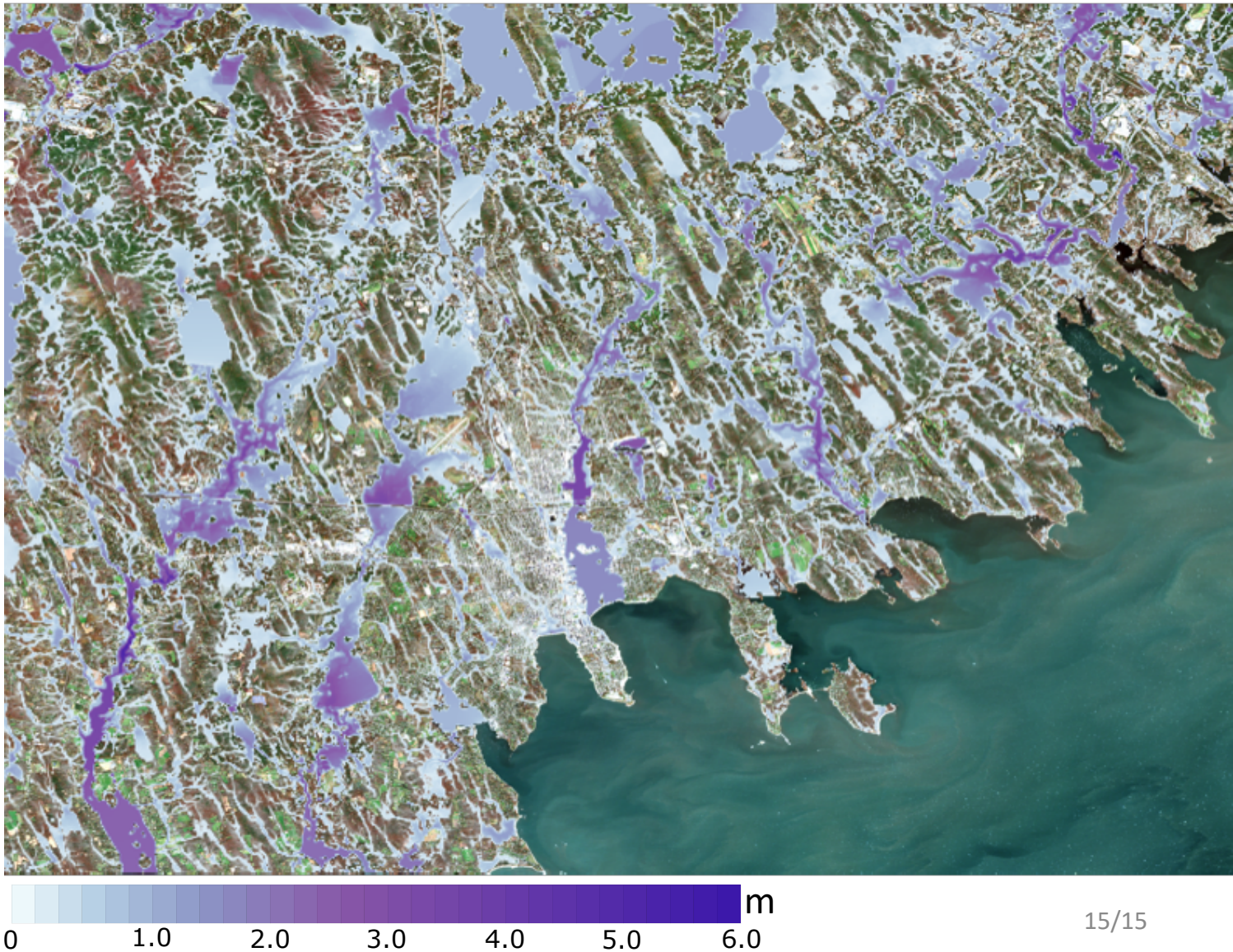
Return Period 500yr



RISK OF RAINFALL-DRIVEN FLOODING

- Resilient infrastructure designs
- Update building codes
- Reform zoning codes
- Fortify critical infrastructure and hazardous facilities

Return Period 200 yr



Thank you!