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Asteroid Impacts and Cascading Hazards

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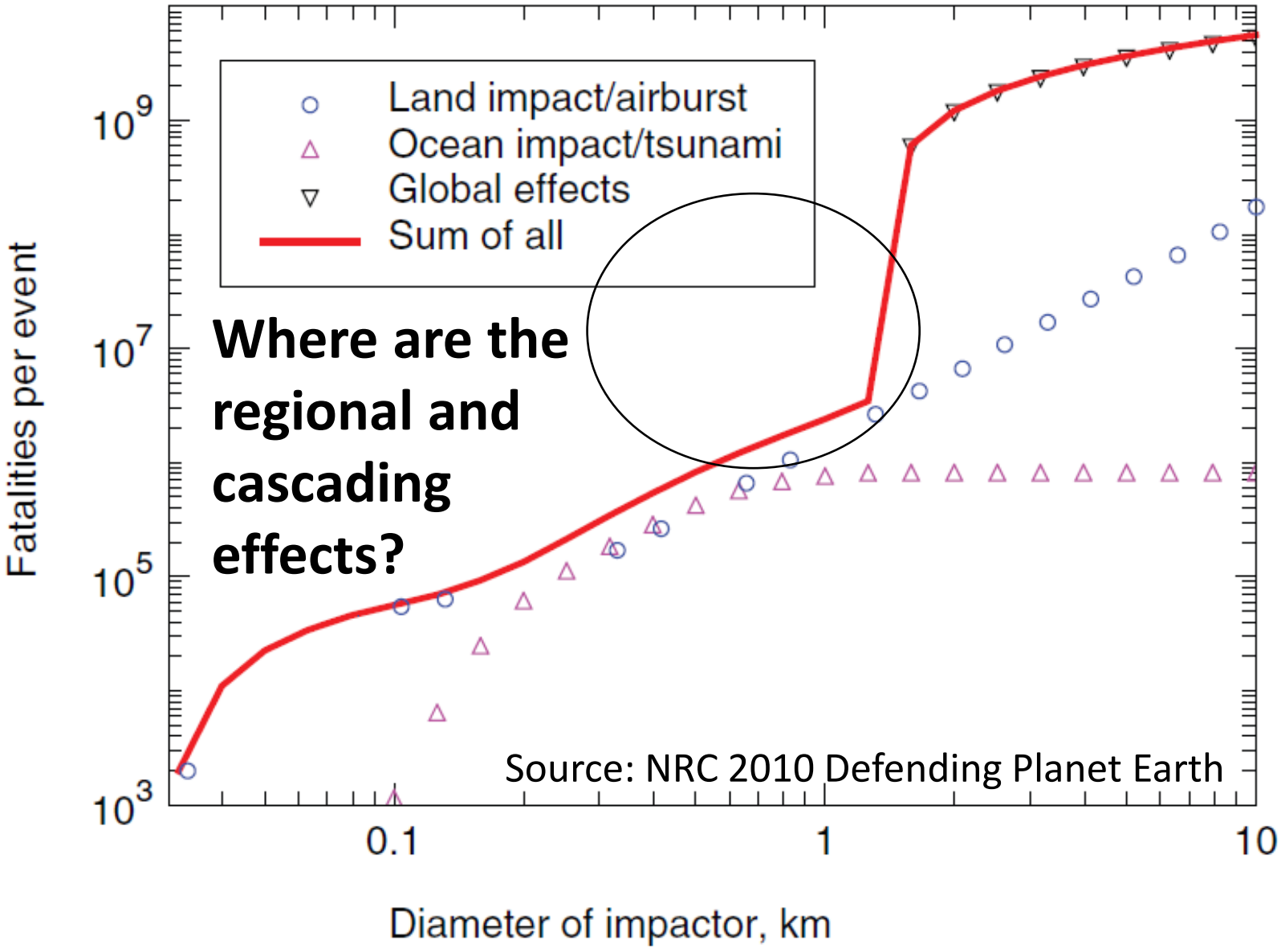
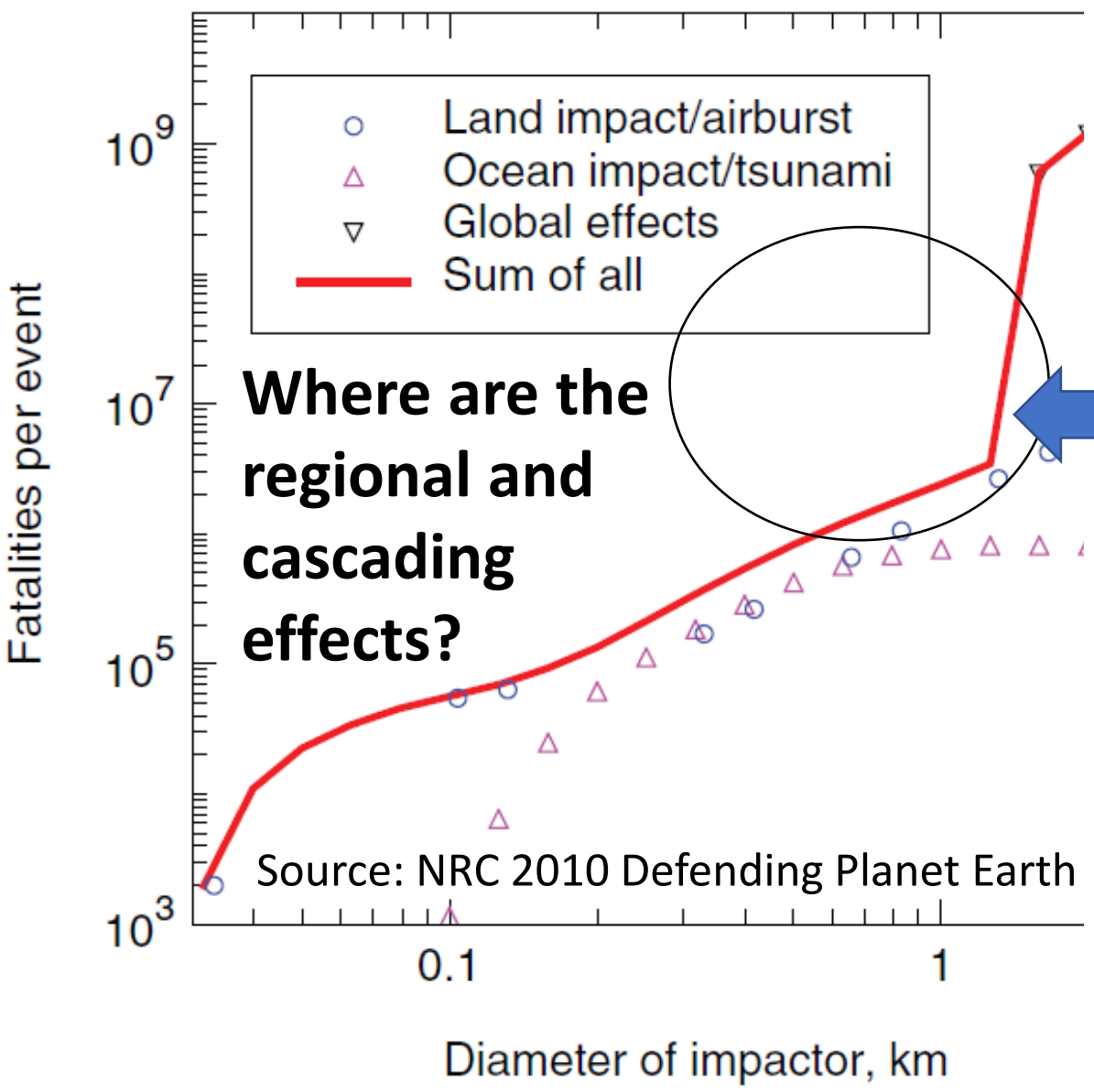
U.S. Department of the Interior
U.S. Geological Survey



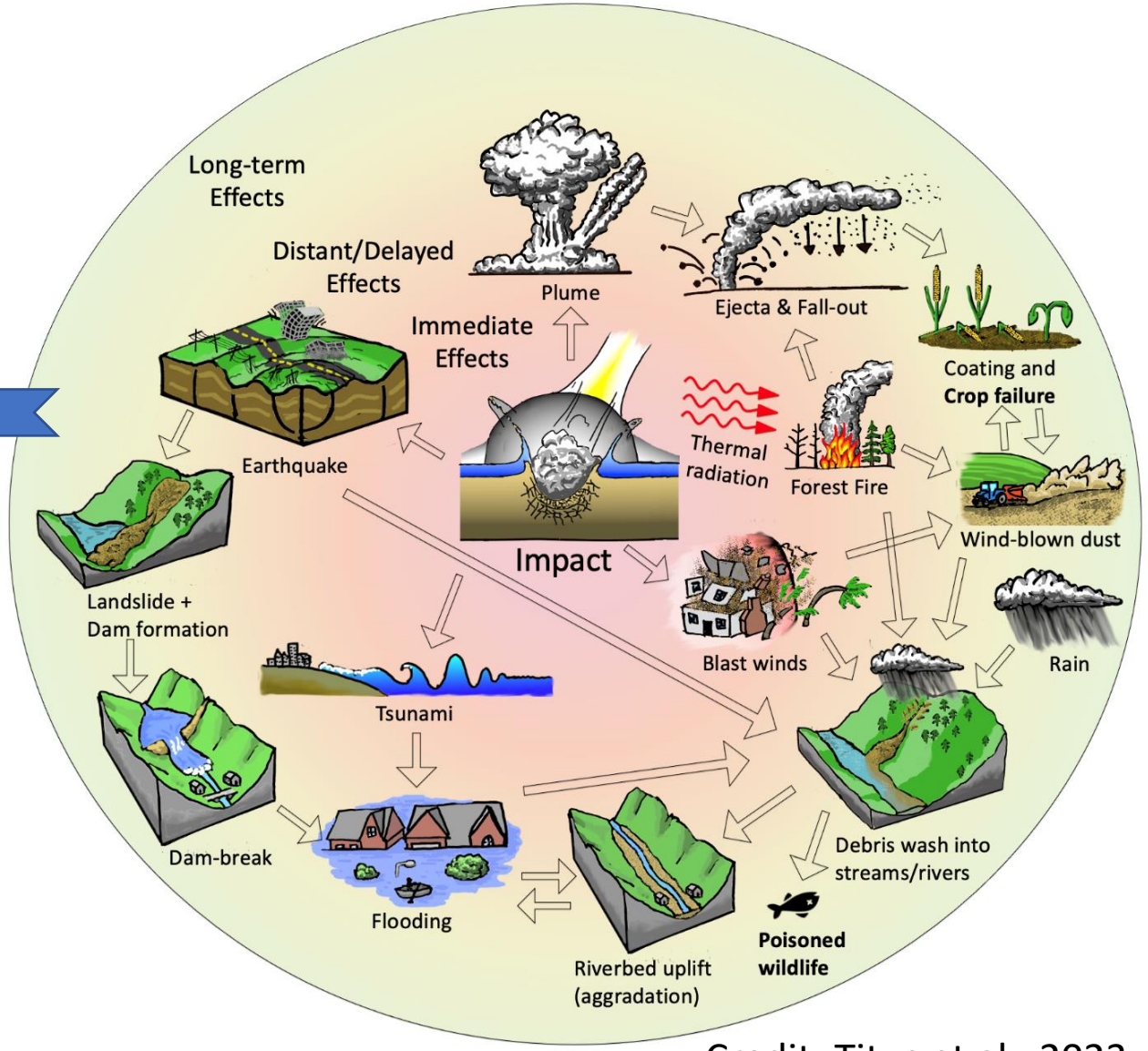
Motivation for analysis of cascading effects:

- Possibly smooth the transition from local to global effects
- Cascading effects can increase:
  - number of people affected
  - area affected
  - infrastructure affected
  - economic costs
  - food insecurity
- Cascading effects can be reoccurring:
  - triggered by high winds
  - triggered by precipitation or snowmelt
- Underestimating cascading effects could negatively impact mitigation decisions.



Where are the regional and cascading effects?

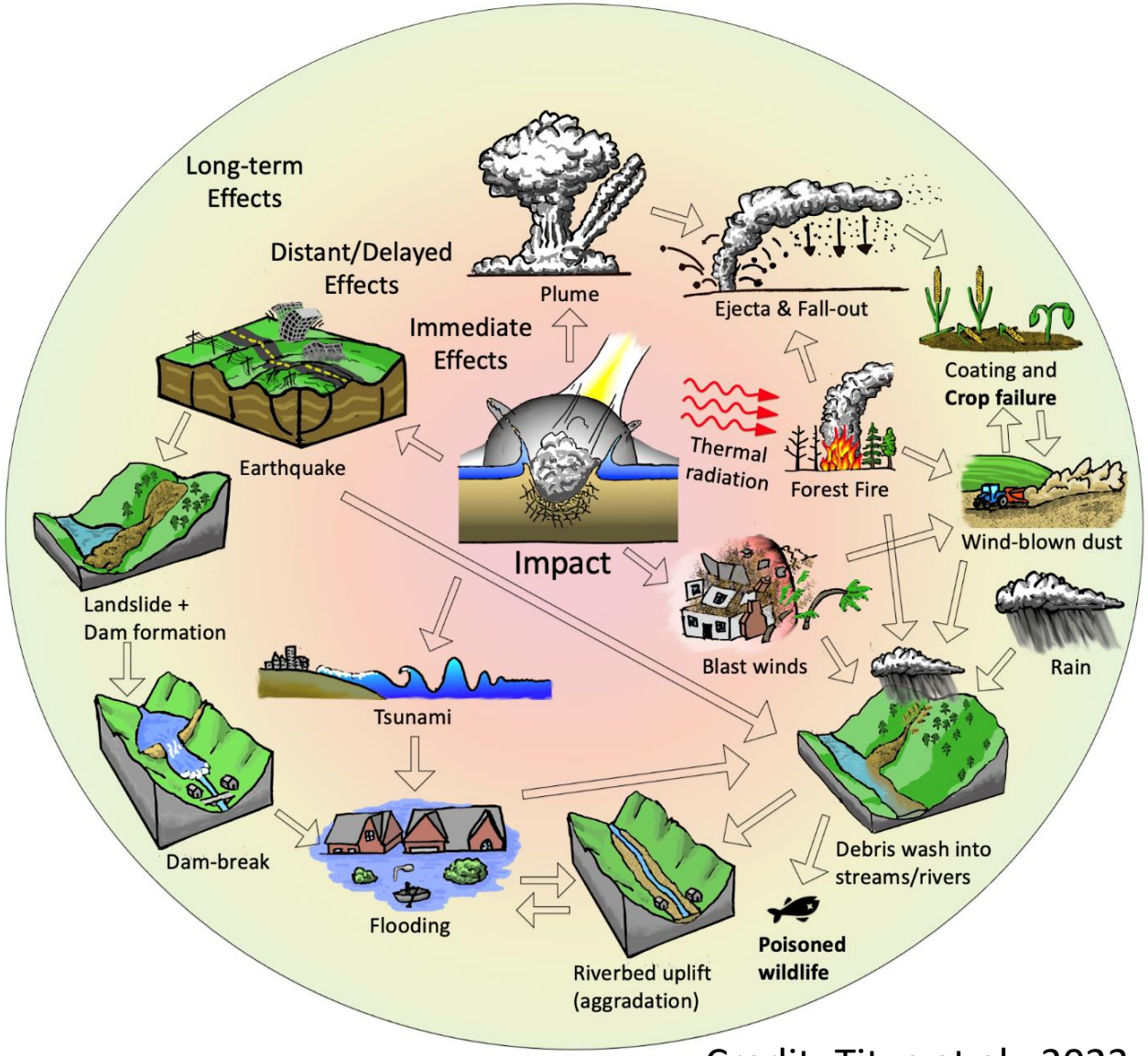
Source: NRC 2010 Defending Planet Earth



Credit: Titus et al., 2023

Regional & cascading hazards

- Downwind (Blow)
  - **Debris plume**
  - Resuspension
  - Possible long-term suspension of particulates in the stratosphere
- Downstream (Flow)
  - **Thermal radiation causes soil to be hydrophobic**
  - Landslides & landslide dams
  - Debris flows
  - **Flooding**



Credit: Titus et al., 2023

Case study in Scenarios:
800-m impact event, 22-Oct-2036, 15:04 UTC

Impact Site:

Dallas-Fort Worth, Texas

- Topography: Rolling hills
- Latitude zone: Subtropics
- Major River Basin(s):
  - Trinity
  - Brazos
  - San Jacinto
  - Colorado

Image courtesy of the Texas Water Development Board.

Impact Site:

Near Jebba, Nigeria

- Topography: Mountainous
- Latitude zone: Tropics
- Major River Basin(s):
  - Niger
  - Ogun-Osun
  - Benin Owena

Regional and cascading effects: Climatic triggers: wind & water

Downwind Model: Ash3D (volcanic plumes)

Where does the "dust" blow?

- 20 Runs: Oct 22, 2000–2019
- 15:04 UTC
- Debris size distribution used is same as for volcanic tephra
- Event duration = 0.2 hours
- Release 0.12 km^3 of dense rock equivalent (DRE) of ash (or dust)

Downstream Model: "Simply downhill"

Where does the water flow?

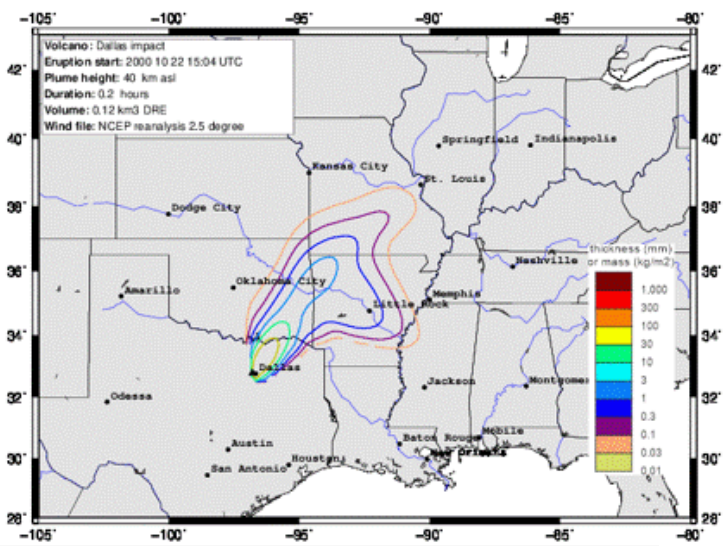
- Based on 30-m topography
- USGS EROS, 2018, Digital Elevation - Shuttle Radar Topography Mission (SRTM) 1 Arc-Second Global, doi: 10.5066/F7PR7TFT.
- Doesn't compute flow velocities, only inundation
- Does not include soil infiltration or evaporation
- Depends on area of initial water source: radius of precipitation (or hydrophobicity)

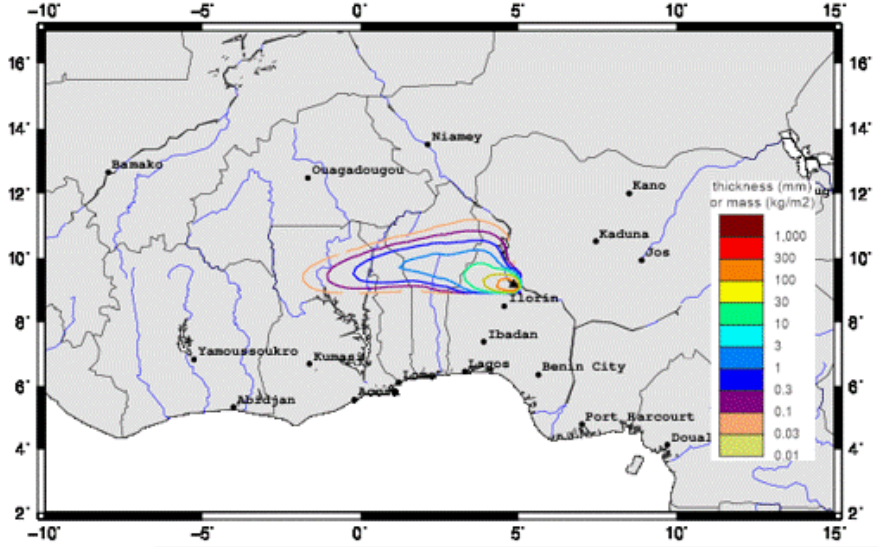
Case study model results:

← Texas

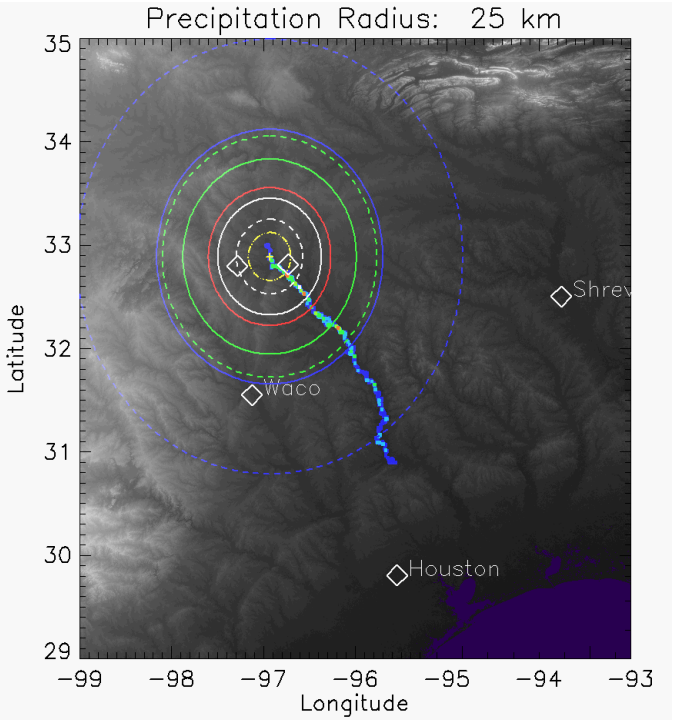
Nigeria →

Downwind





Downwind



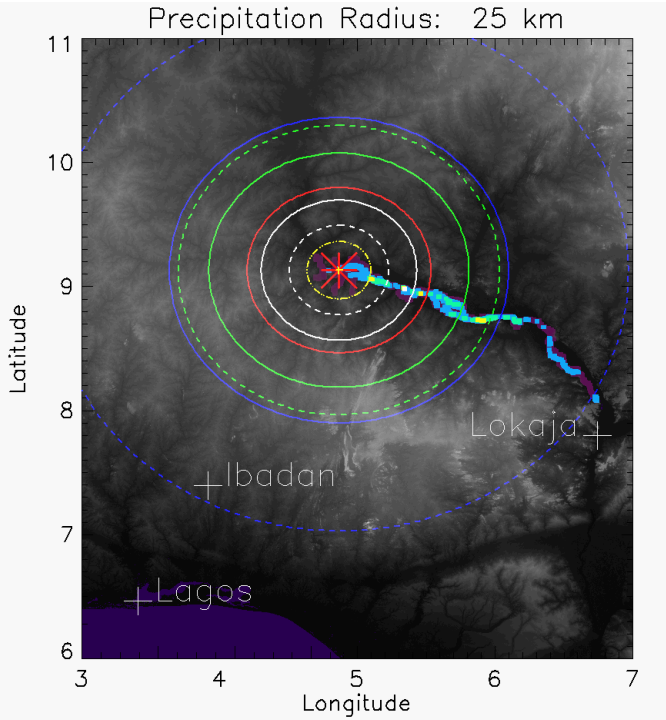
Legend:

Yellow – assumed radius of precipitation (radius of hydrophobicity)

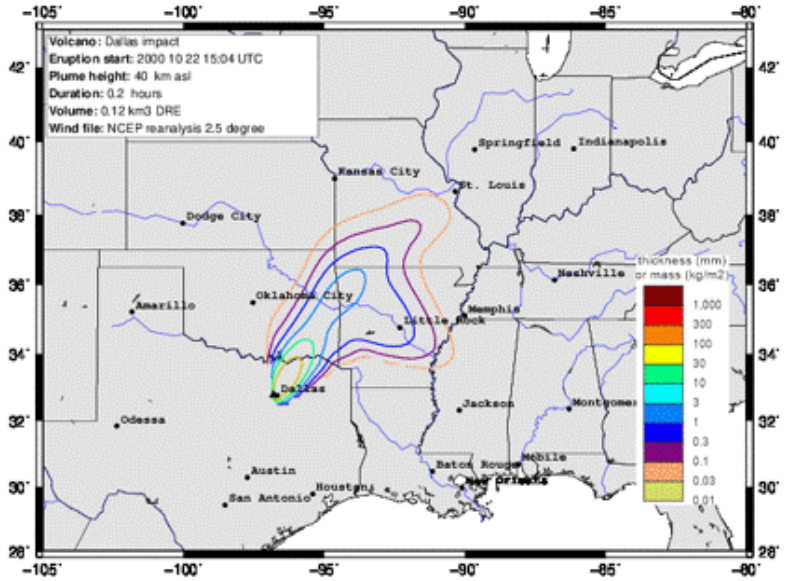
Solid Circles: Thermal Severity

Dashed Circles: Blast Severity

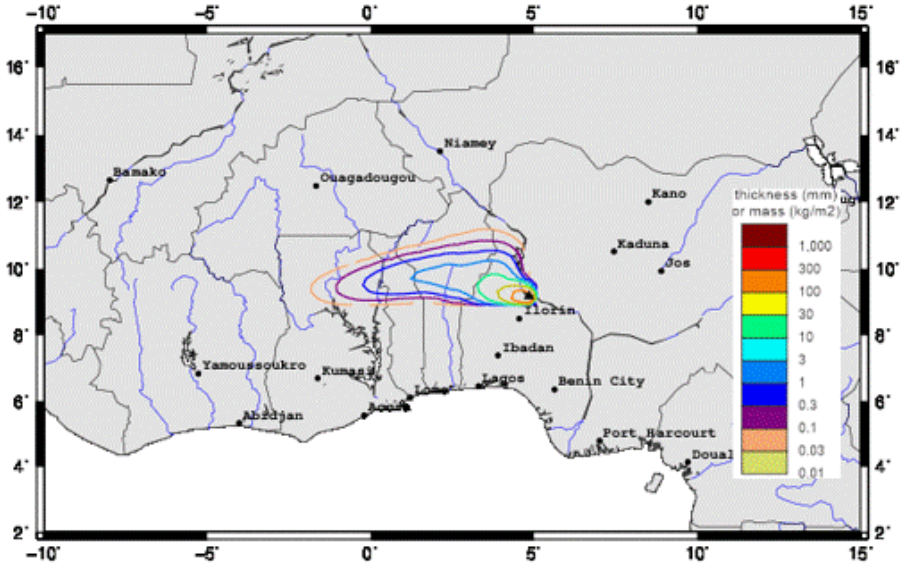
Damage Level	Blast (psi)	Radius (km)	Thermal Severity	Radius (km)
Serious	1	227	2nd degree burns	133
Severe	2	126	3rd degree burns	102
Critical	4	72	Clothing ignites	72
Nonsurvivable	10	39	Structures ignite	61



Downstream



Downwind Results:



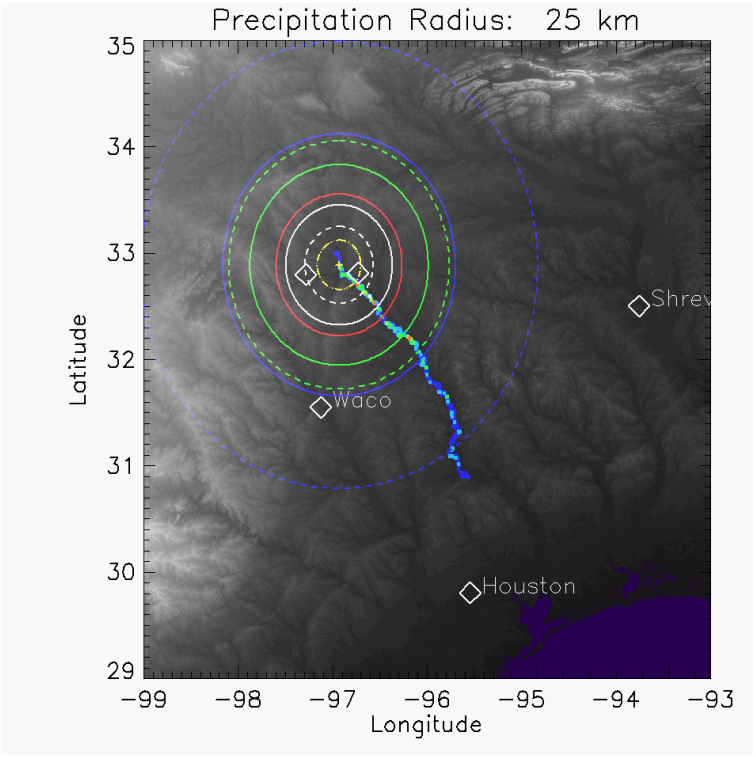
Texas Results:

- Dust is generally blown to the east or northeast.
- Dust is generally blown across multiple states.
- Occasional dust remains centered on east Texas.
- Probability distributions could be derived from these output.

Nigeria Results:

- Dust is generally blown to the west.
- Dust is generally blown across west African nations.
- Occasional dust remains centered on western Nigeria.
- Probability distributions could be derived from these output.

Downstream Results



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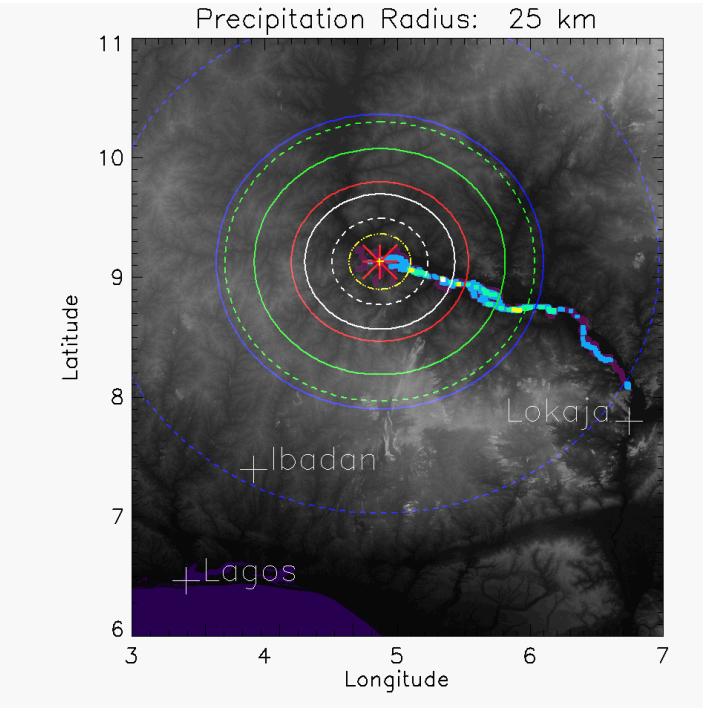


Texas Results
- R=25 km: Trinity River
  - Houston?
- R=100 km: Brazos River
  - Waco, Houston.
- R=225 km: Red River
  - Shreveport, LA.
- Most likely – Waco, Houston flooded.

Nigeria Results:
- R=25 km: Niger River
  - Lokoja, Nigeria.
- R=125 km: Ogun & Osun Rivers
  - Lagos, Nigeria (1st Pop)
  - Ibadan, Nigeria (3rd pop)
- R=225 km: Multiple rivers.
- Most likely – Water flows restricted to the Niger River basin.

Next Steps:

Downwind

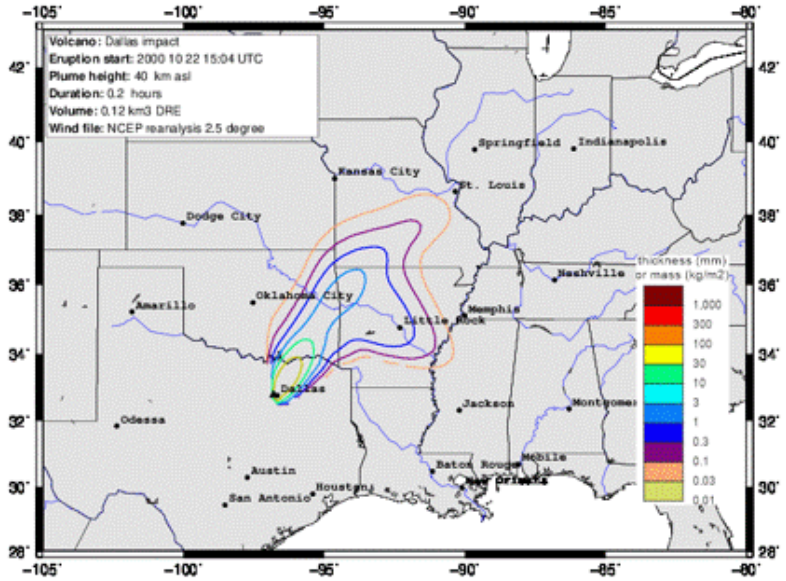
- Overlay dust distributions over:
  - Agriculture
    - Crops
    - Livestock
  - Transportation
    - Corridors
    - Hubs
  - Industry
  - Population – Human Health
- Convert to probability distributions
  - People affected
  - Economic losses

Downstream

- Determine the relationship to thermal severity and soil hydrophobicity
- Implement code (e.g., GeoCLAW) to estimate flood levels
- Overlay flooding on:
  - Population
  - Infrastructure
  - Agriculture
- Add in effects of sediment flux from erosion

Texas

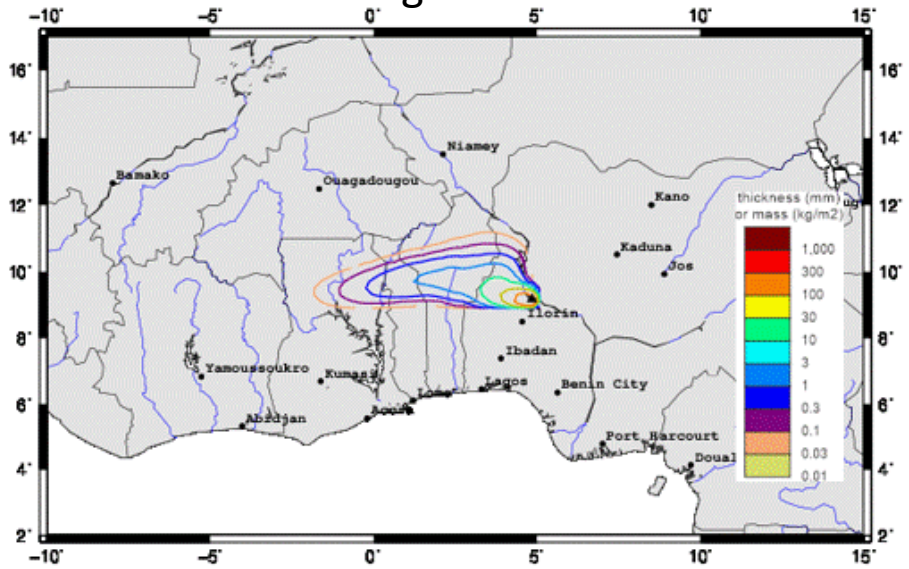
Downwind



Conclusions:

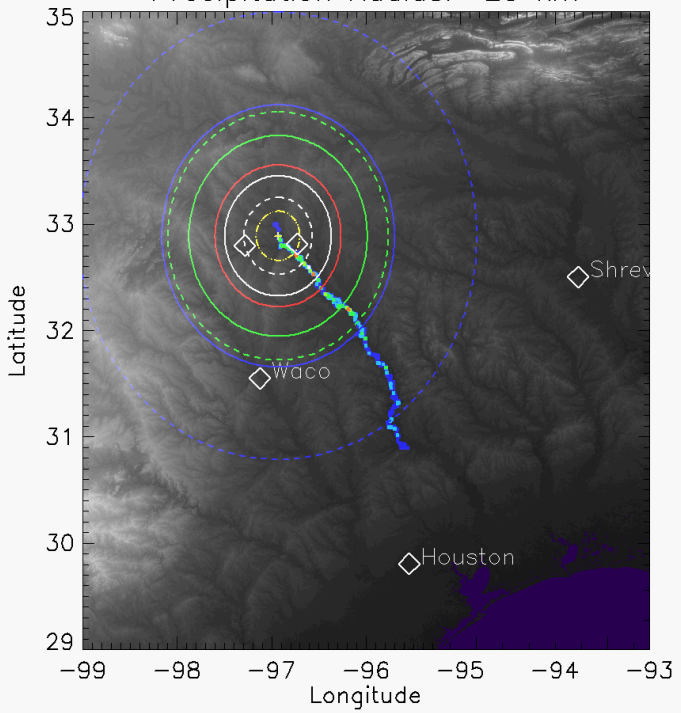
- Location
- Topography
- Climate

Nigeria



Downwind

Downstream



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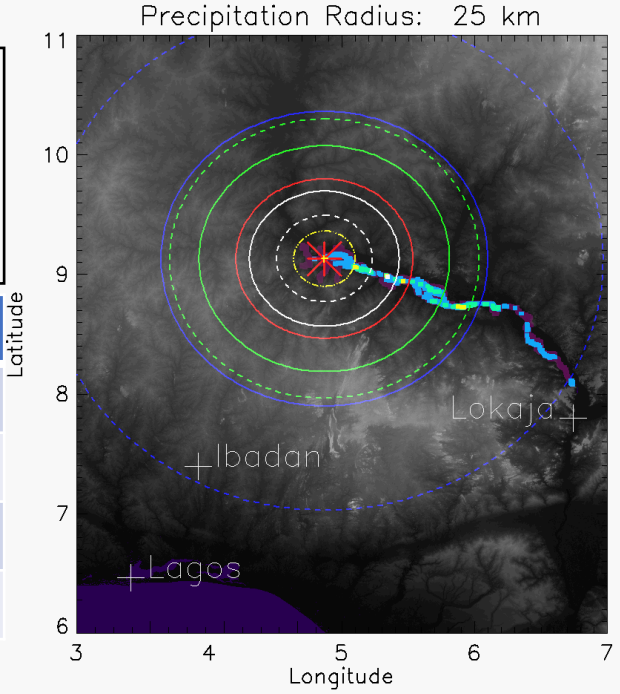

Downstream