

## NG-TEPHRA: Enabling Large-Scale Volcanic Hazard Simulations in the Pragma Grid Environment

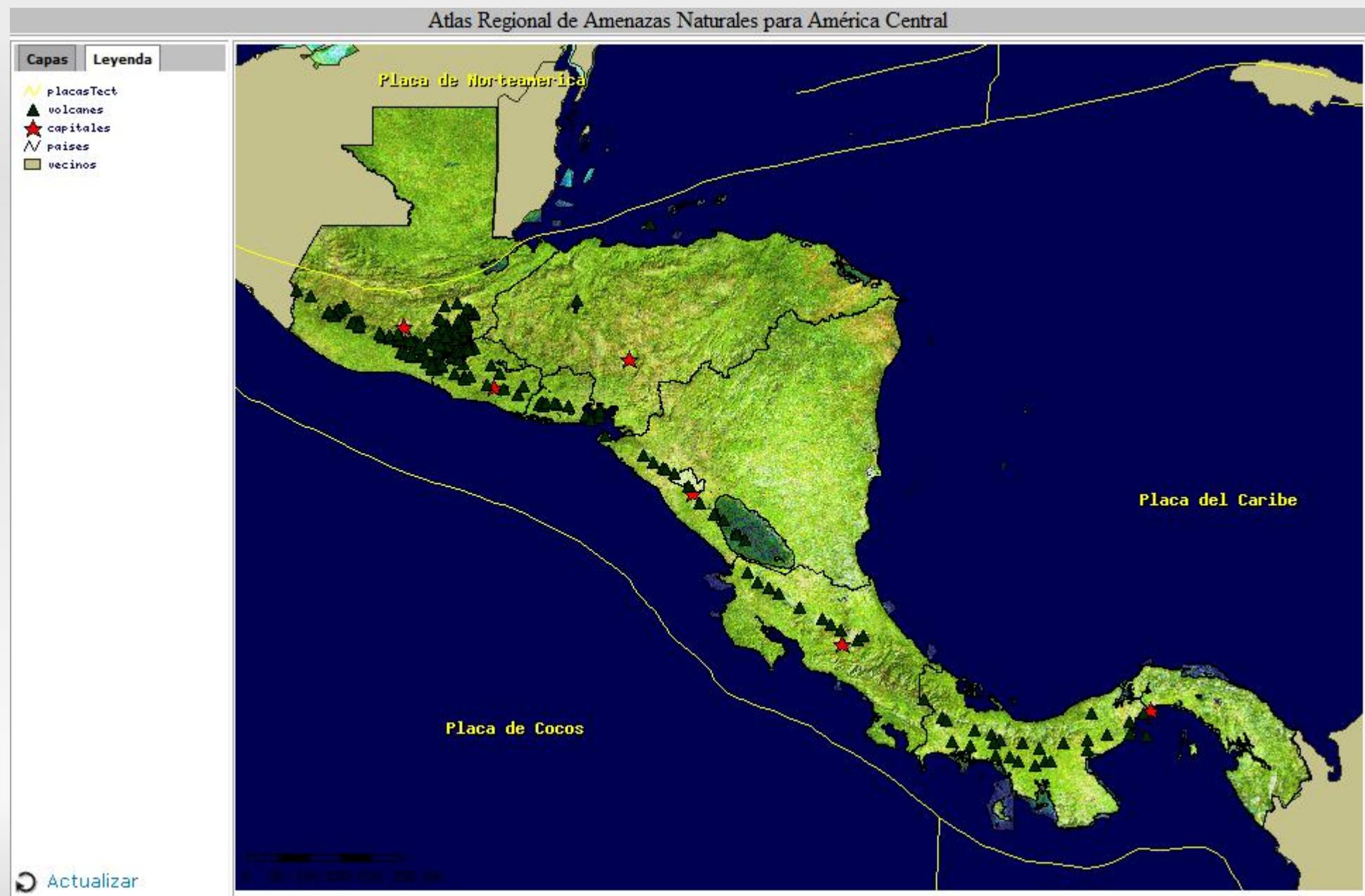
<sup>1</sup>Santiago Nunez, <sup>2</sup>Gustavo Barrantes  
<sup>2</sup>Eduardo Malavassi, <sup>3</sup>Jose Brenes

1 Costa Rica Institute of Technology (ITCR)  
2 National Autonomous University (UNA)  
3 University of Costa Rica (UCR)

# The Context

- Costa Rica is within an active geological region in terms of its seismology and volcanology
- 10 active volcanoes with different eruptive cycles
- Most local disaster management plans are outdated and do not provide precise assessments of potential situations
- It is also essential to have the risk assessment (area) and the hazard assessment (material and human loss)

# The Regional Perspective



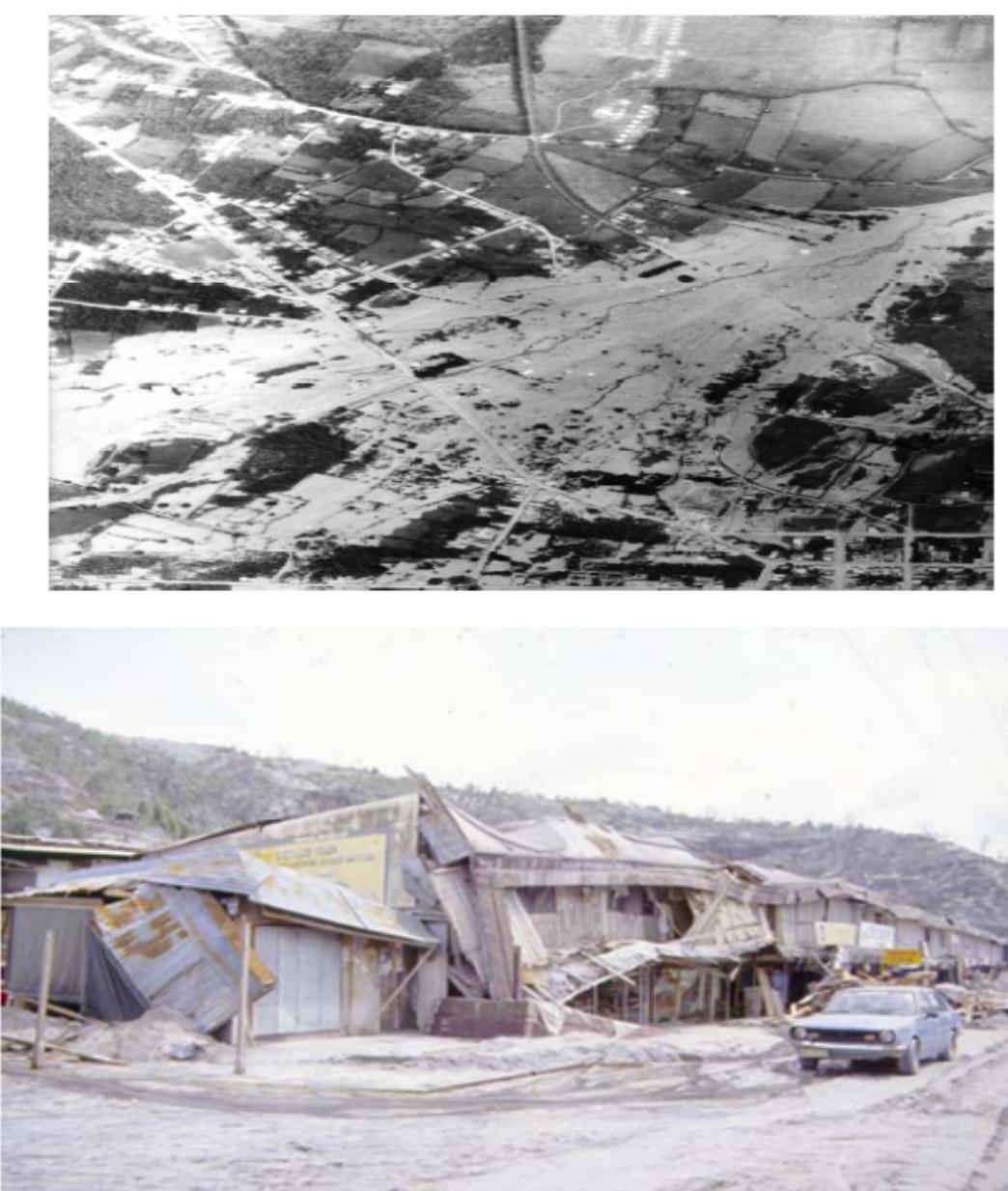
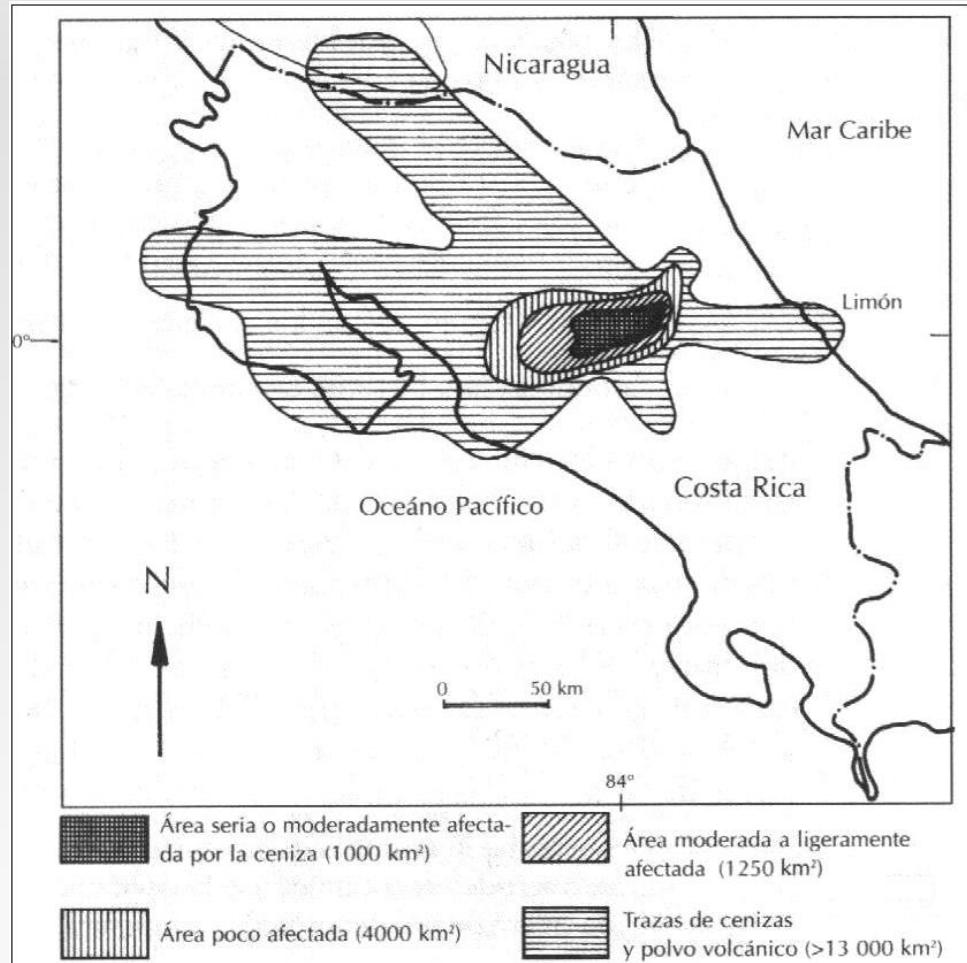
# Irazu 1963-1965

- 1963-1965 is a singular period of study for the current case
- Irazu volcano: NE, in the wind path of the Great Metropolitan Area (GAM) for most of the year
- The eruption wiped out two of the most important agriculture/livestock production sites
- Health issues, buildings succumbed to heavy weight of ashes
- What would happen today? (~3M people in the GAM)





# Irazú 1963-1965



# TEPHRA 2005-2007

- TEPHRA started as a project at ITCR and continued at other sites (UNA, UCR, CeNAT)
- Jose Castro @ ITCR: use TEPHRA as an application to start a national supercomputing program
- Main problem for modeling: lack of good data!
- Existing data was lost 20 years after the main event
- Any hazard assessment had to be based on remaining observations and simulation

# TEPHRA

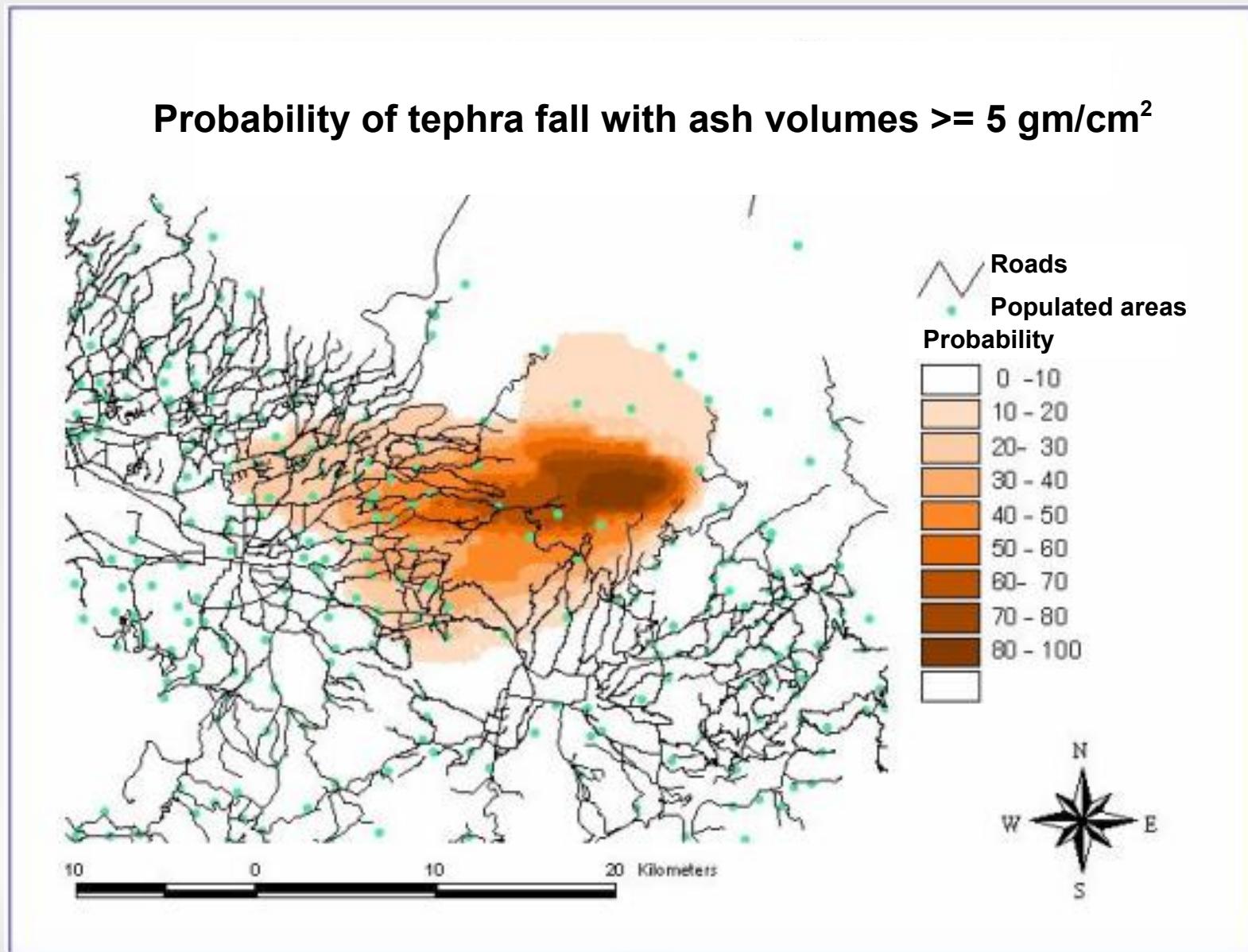
- TEPHRA is an application written by Charles Connor, USF in 2001 for simulating ash fall and deposition
- Based on the Suzuki ash dispersion model
- Modifications to the code have been made to improve precision and include probability per each possible simulation scenario

$$X(x, y) = \int_{\phi_{min}}^{\phi_{max}} \int_0^H \frac{5f_z(z)f_\phi(\phi)Q}{8\pi C(t + t_s)^{\frac{5}{2}}} e^{\frac{[(x - ut)^2 + y^2]}{8C(t + t_s)^{\frac{5}{2}}}}$$

# The Parameter Space

- The model requires the following input parameters:
  - Volcano spatial coordinates (CRTM05 → UTM)
  - Particle size descriptors
  - Column height and eruption total mass
  - Geomorphology of the volcano and its DEM
  - Climate and thermodynamics
- Runs on MPI clusters
- 16-nodes → approx 15 mins

# The Hazard Map



# (Very) Early 3D Visualization



# NG-TEPHRA

- Two years of intense research yielded a set of physically-meaningful limits for the simulation process (2008-2010)
- Workflow implemented on local test clusters
- Parametric sweep, ideal for NIMROD, since it is an embarrassingly parallel problem
- The parameter space accounts for 220000 scenarios for a full probability map
- Reviewed with Monash problem structure and updating code to be a Grid-friendly application

# Next Steps

- Setup the NIMROD resources and scripts
- Run the complete set of experiments and obtain a complete hazard map for Irazu
- Develop a multi-level reduction strategy that allows navigation between the map and individual cases (identification of the interesting amongst the crowd)
- Implement a visualization that is easy to interpret by policy makers and experts
- Create a web service for running individual simulations

# The Larger Practical Perspective

- NG-TEPHRA will be the first PRAGMA-hosted application for Costa Rica
- This project can be replicated in a direct way for any other location as long as data are available
- Inclusive for the whole Central America region, bringing more participants into PRAGMA
- Could be complemented with a sensor network approach for obtaining real time data indicating a high probability of a volcanic eruption and triggering simulations on real-time

# The Costa Rica Roadmap to PRAGMA, the Grid and Beyond

- Our current experience
  - More internal resources are needed
  - Grid computing and supercomputing now understood as fundamental for research
  - Data is not always available in a natural form
- Challenges (a.k.a. advice welcome!)
  - Highly visible applications (visualization array in progress, hardware in place)
  - Development of a strong supercomputing center
  - High speed networks (GLIF for CR)

# The Costa Rica Roadmap to PRAGMA, the Grid and Beyond



# Thanks

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- Contact information
  - [snunezcr@acm.org](mailto:snunezcr@acm.org)

