

Emerging Geospatial Innovations Enabling Global Capability for Climate and Crisis Response

Second United Nations World Geospatial
Information Congress

Budhendra Bhaduri (@budhubhaduri)

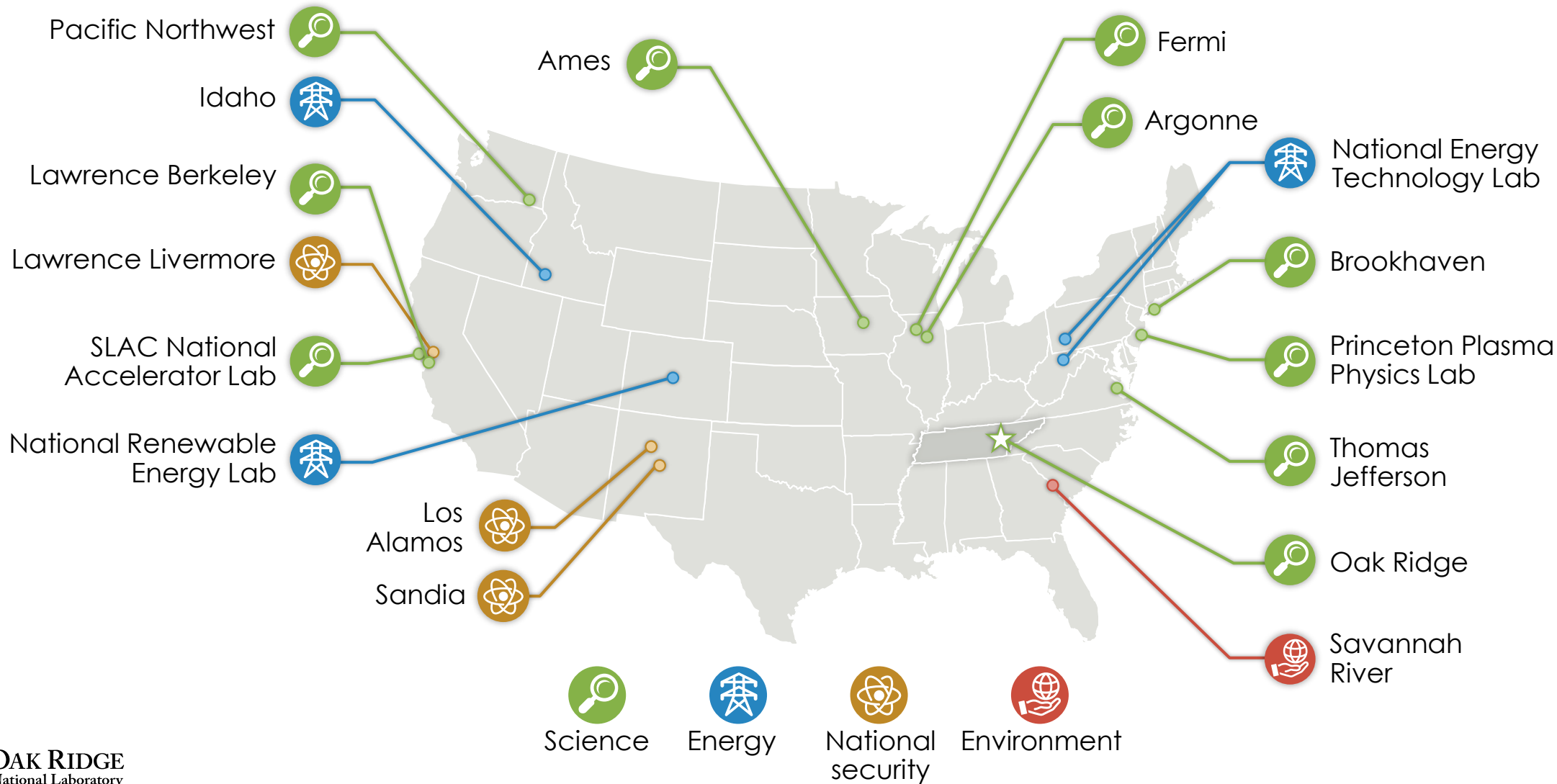
Hyderabad, India. October 12, 2022



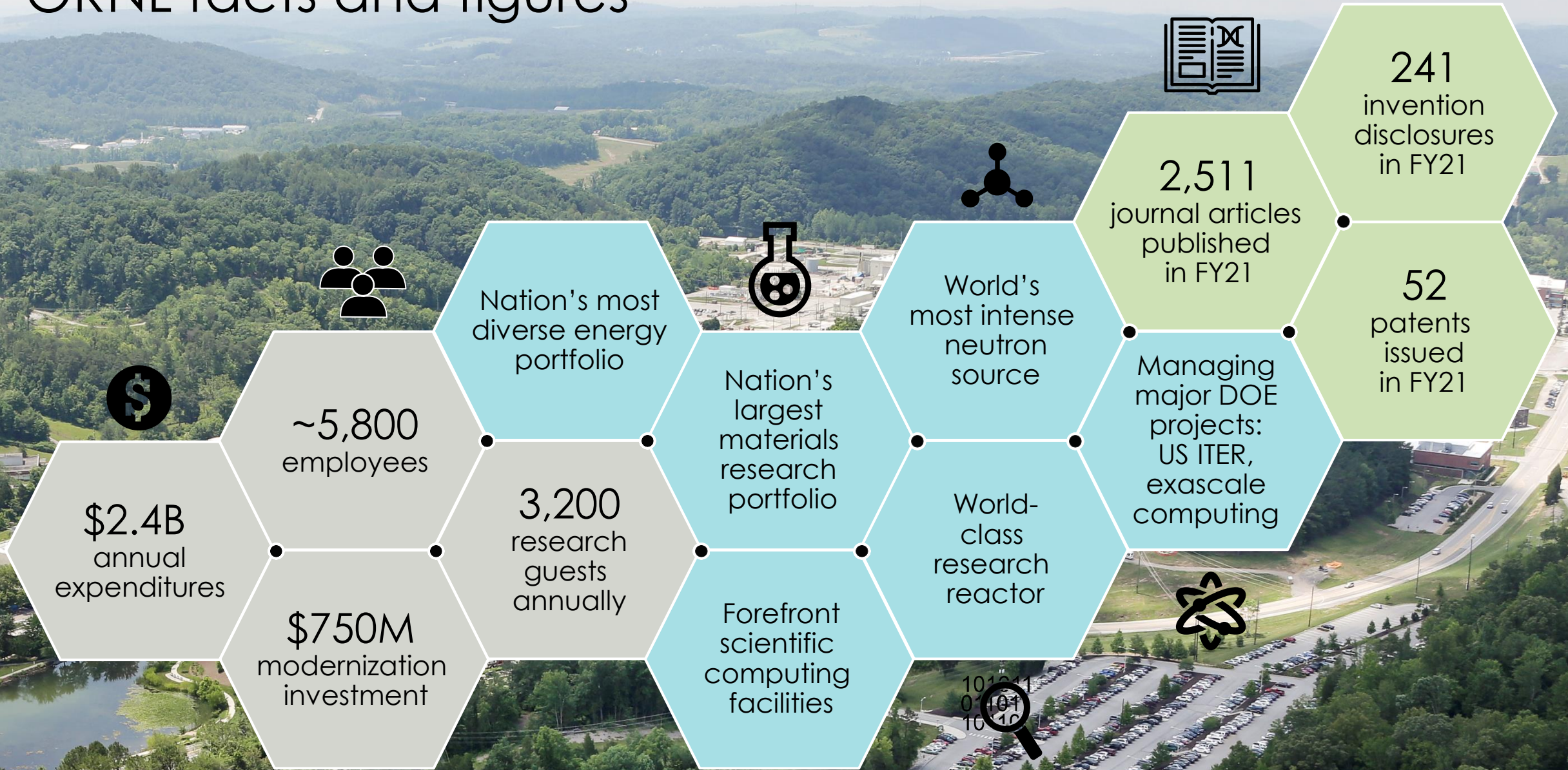
**EXPERIENCE
ORNL**
MEET. EXPLORE. LEARN.

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As a U.S. Department of Energy (DOE) national lab, ORNL is part of a network for discovery and innovation



ORNL facts and figures



\$2.4B
annual
expenditures



~5,800
employees

\$750M
modernization
investment

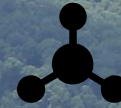
Nation's most
diverse energy
portfolio



Nation's
largest
materials
research
portfolio

3,200
research
guests
annually

Forefront
scientific
computing
facilities



World's
most intense
neutron
source

World-
class
research
reactor



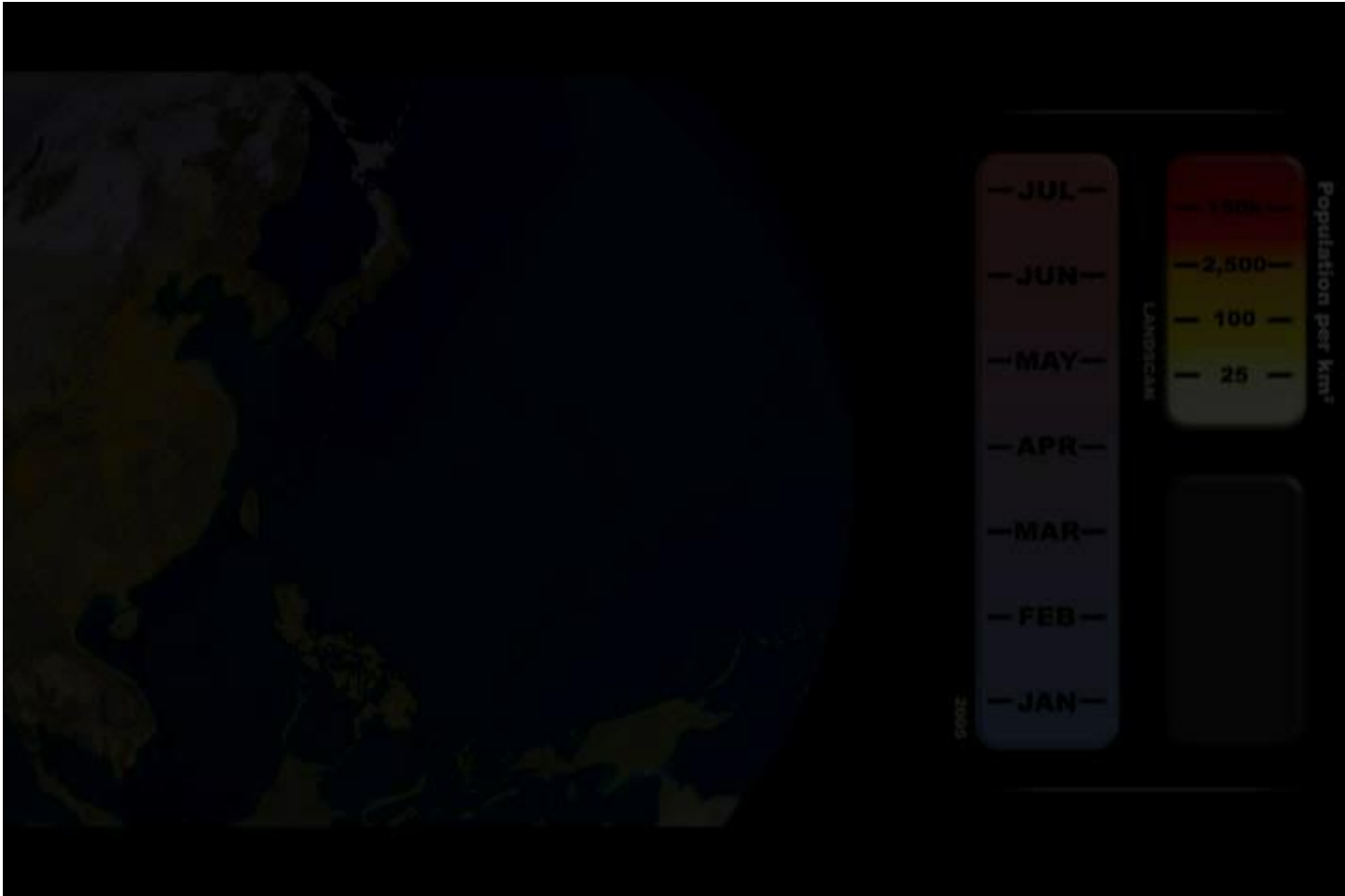
2,511
journal articles
published
in FY21

Managing
major DOE
projects:
US ITER,
exascale
computing

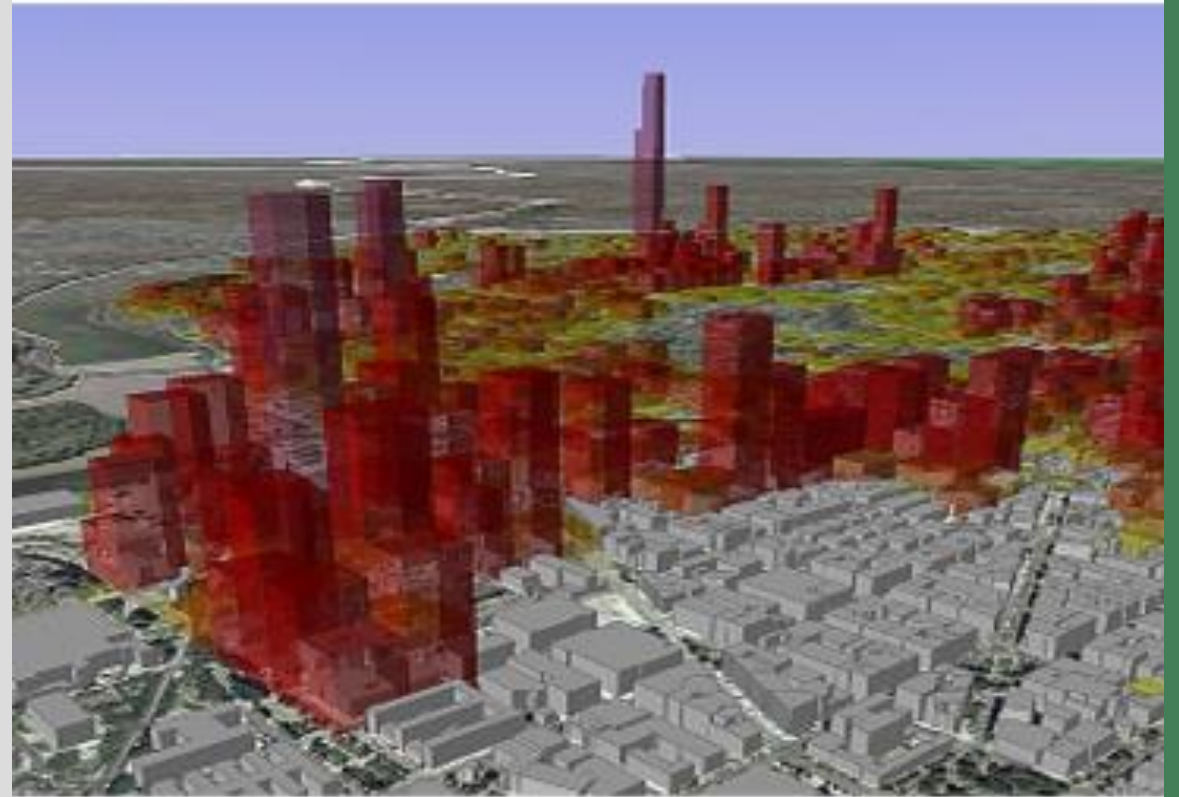
241
invention
disclosures
in FY21

52
patents
issued
in FY21

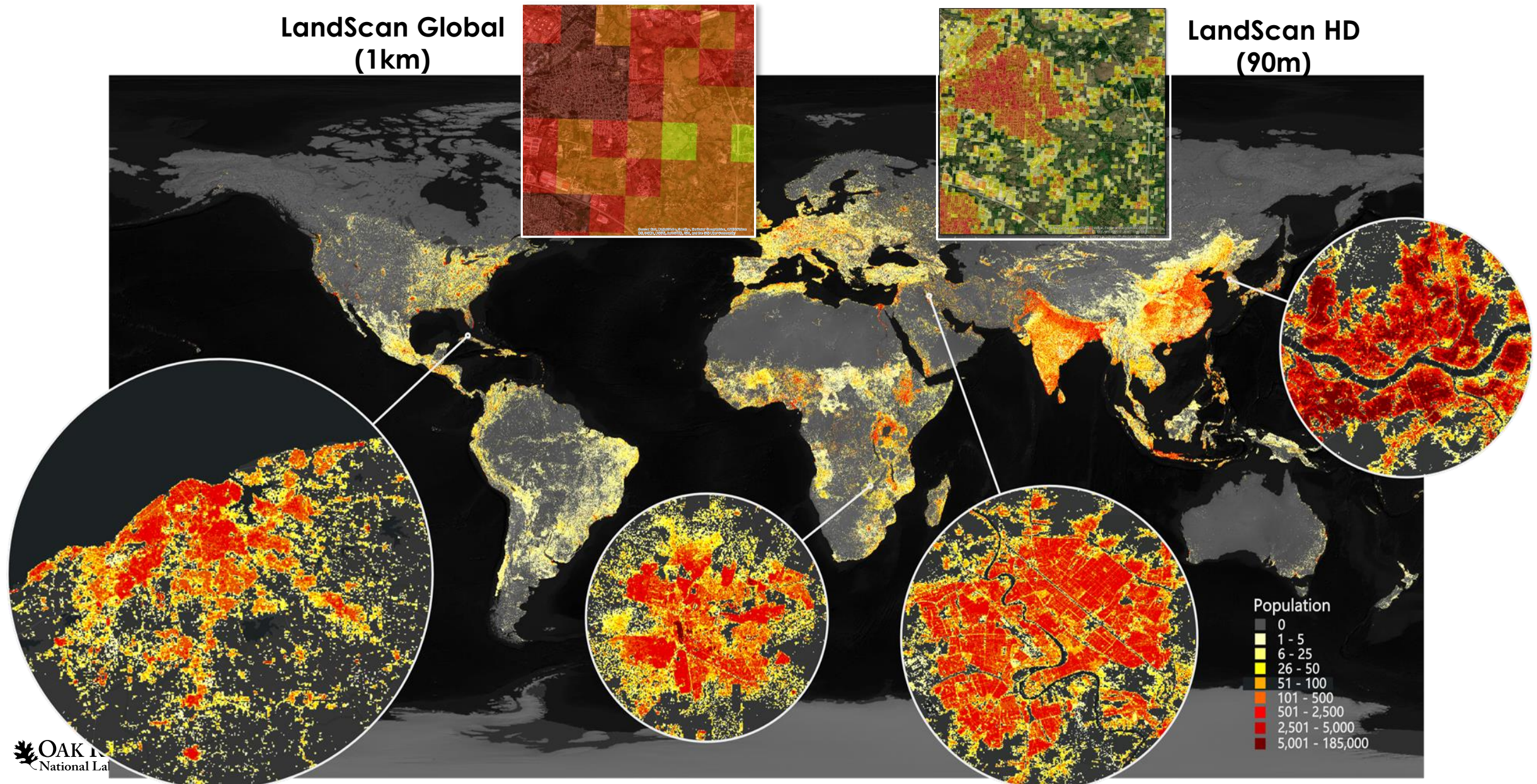




High resolution settlement and population data with GeoAI and HPC

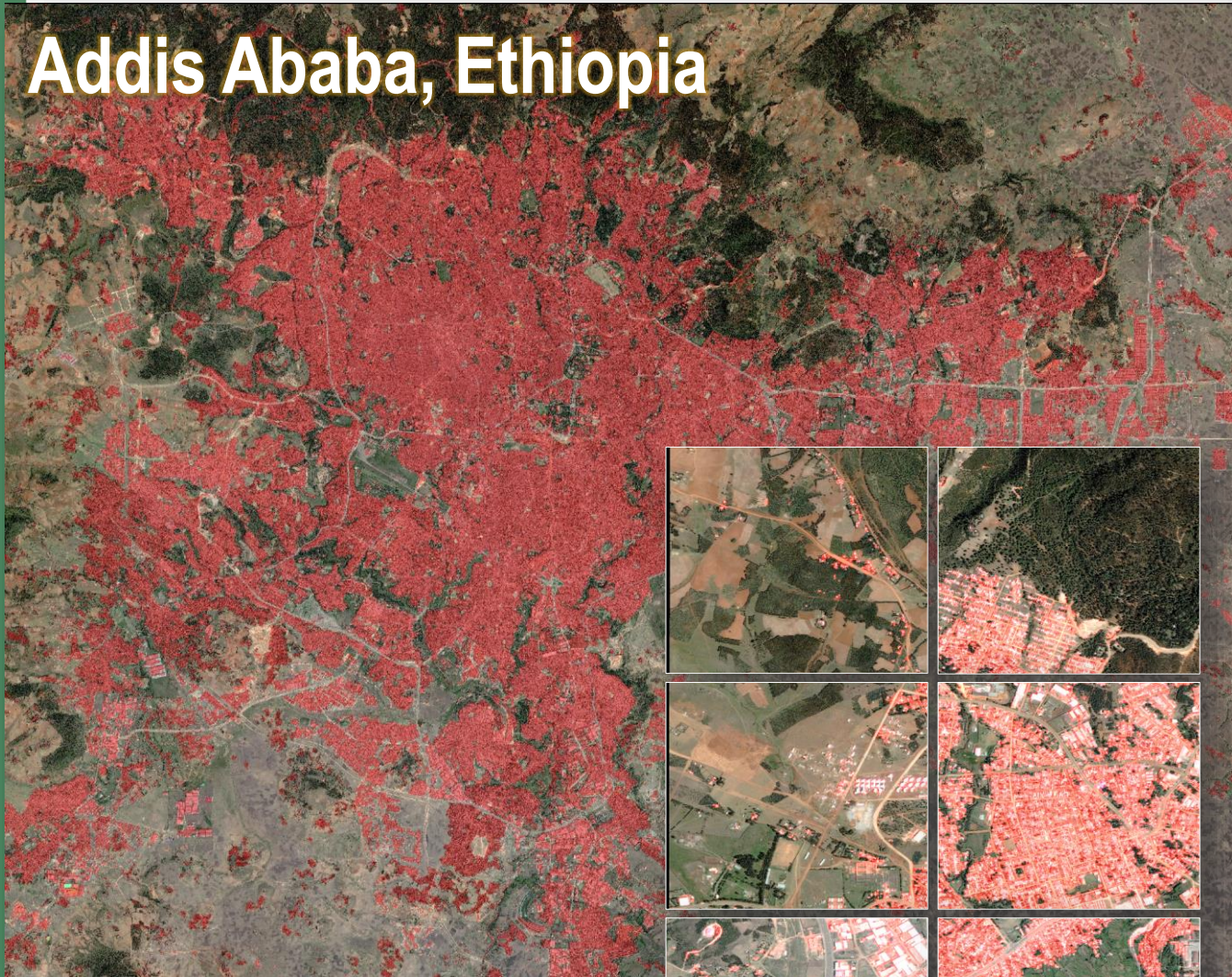


LandScan Global Population Distribution Data Sets

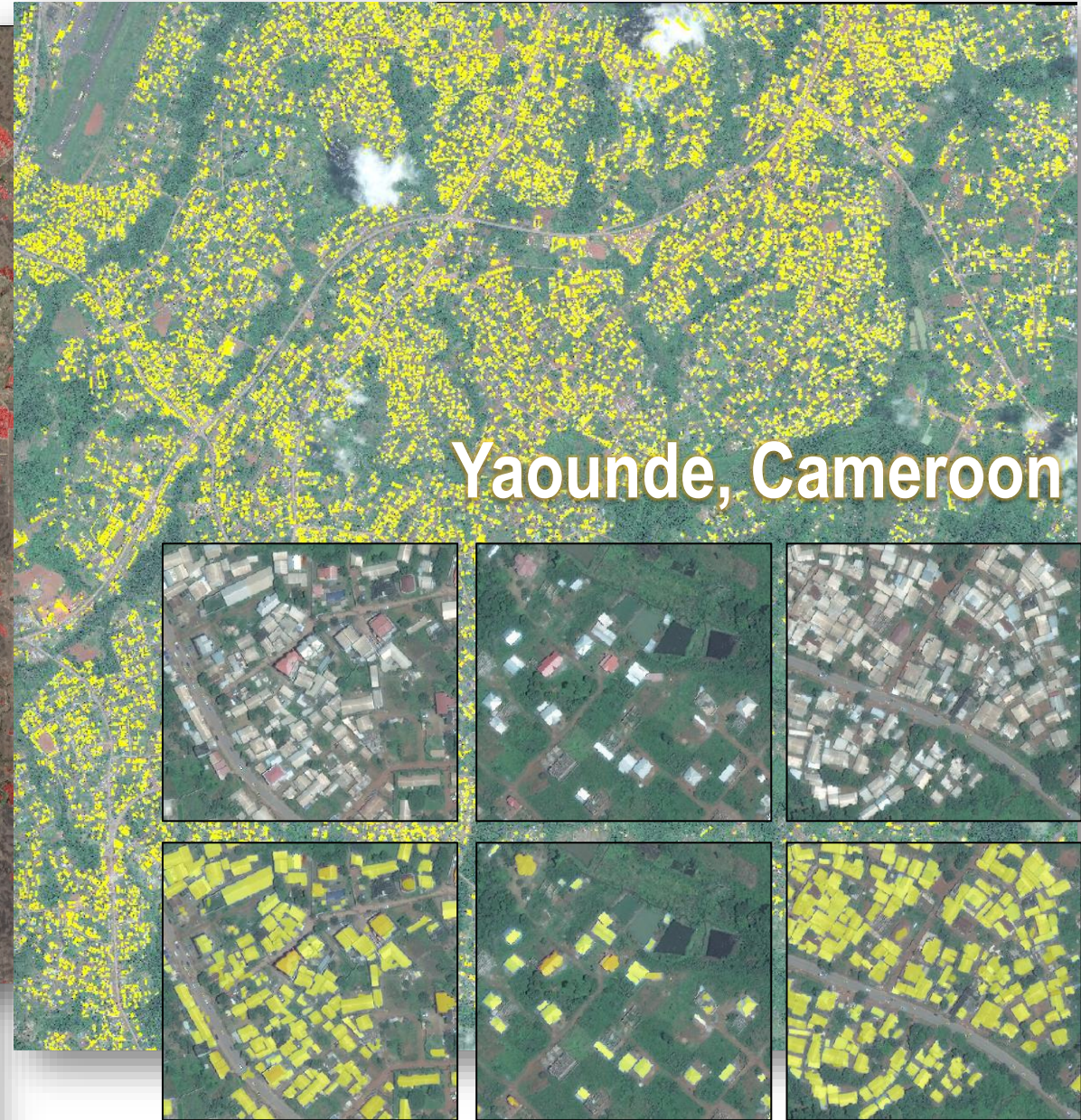


Mapping human settlements from high resolution images

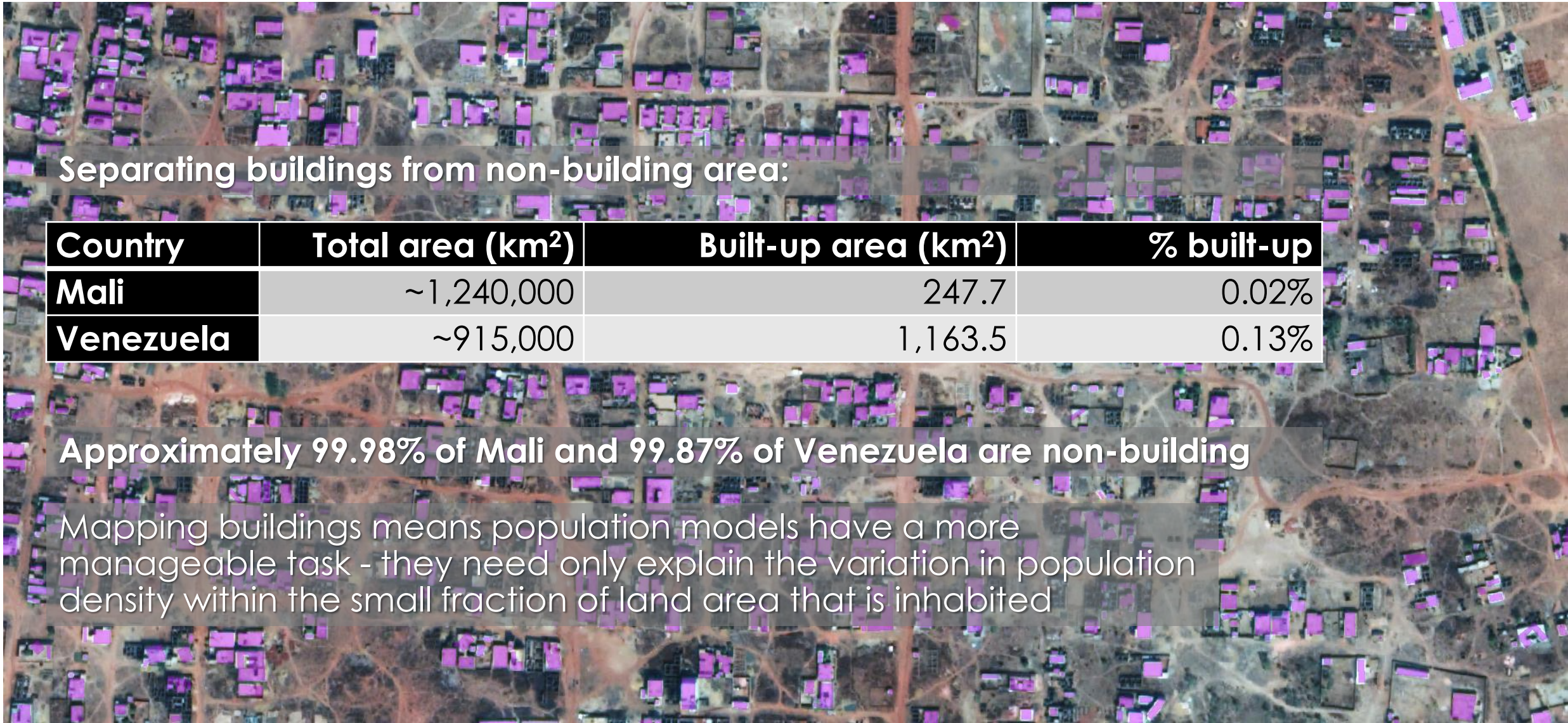
Addis Ababa, Ethiopia



Yaounde, Cameroon



Reducing the scope of the population mapping problem



Separating buildings from non-building area:

| Country | Total area (km ²) | Built-up area (km ²) | % built-up |
|-----------|-------------------------------|----------------------------------|------------|
| Mali | ~1,240,000 | 247.7 | 0.02% |
| Venezuela | ~915,000 | 1,163.5 | 0.13% |

Approximately 99.98% of Mali and 99.87% of Venezuela are non-building

Mapping buildings means population models have a more manageable task - they need only explain the variation in population density within the small fraction of land area that is inhabited

United States: high resolution buildings map



- 60,000 images (~1.2 PB)
- 0.3-1 m multispectral 2011-2021
- 74 trillion pixels

Technology Description

- Automated high-resolution building extraction based on advanced deep learning applications



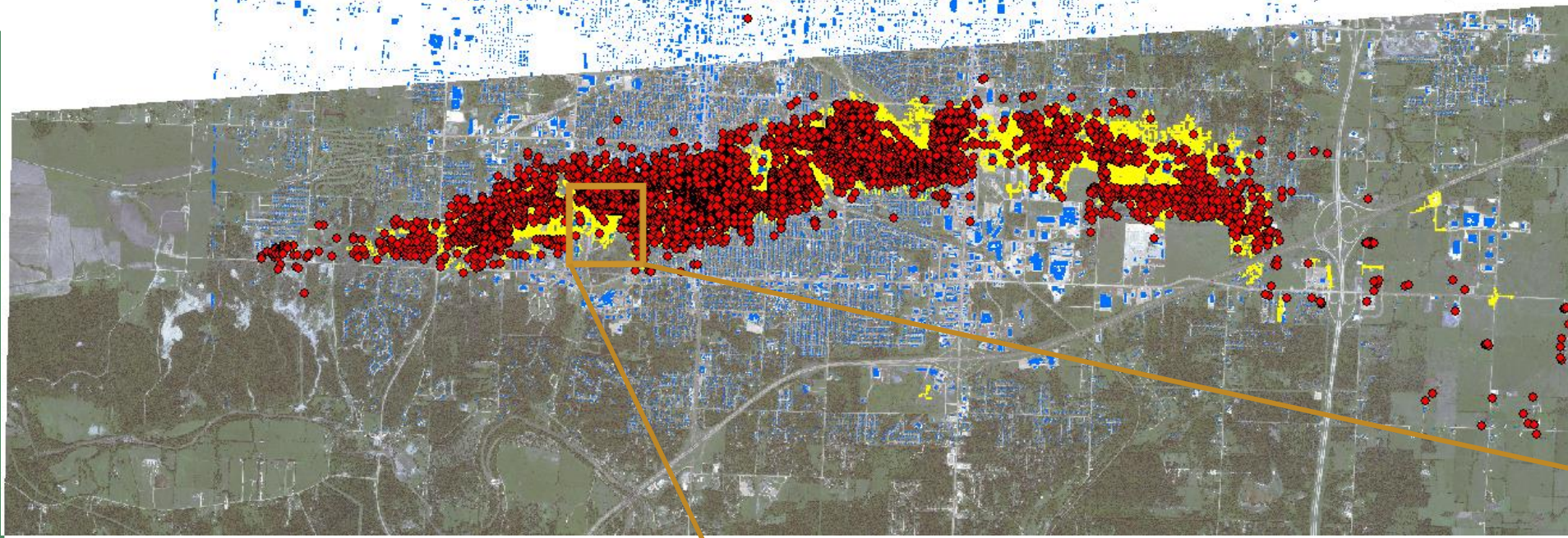
HPC Utilization

- Scaled to 12 Summit nodes (96 total GPUs)
- Model training with 110,000 World View labelled images (covering 9,314 km² globally) in less than 45 minutes

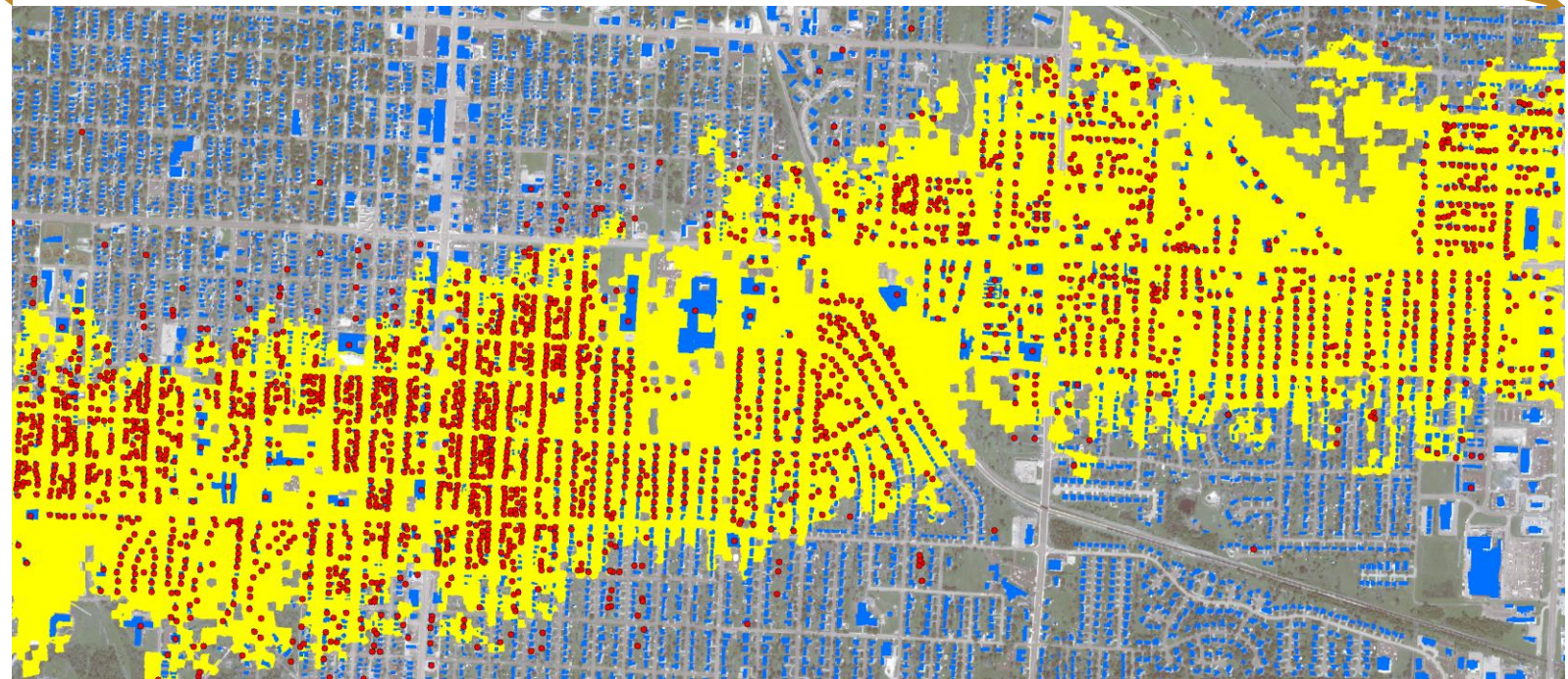


Impact

- Average processing time for a half-meter 4-band image averaging 35,000 x 35,000 pixels is 3 minutes using a single V100 GPU.
- For the country of Iraq:
 - 4 minutes to extract all buildings using 3,206 GPUs on Summit
 - 8 hours to extract all buildings using 24 DGX1 GPUs plus 16 DGX2 GPUs



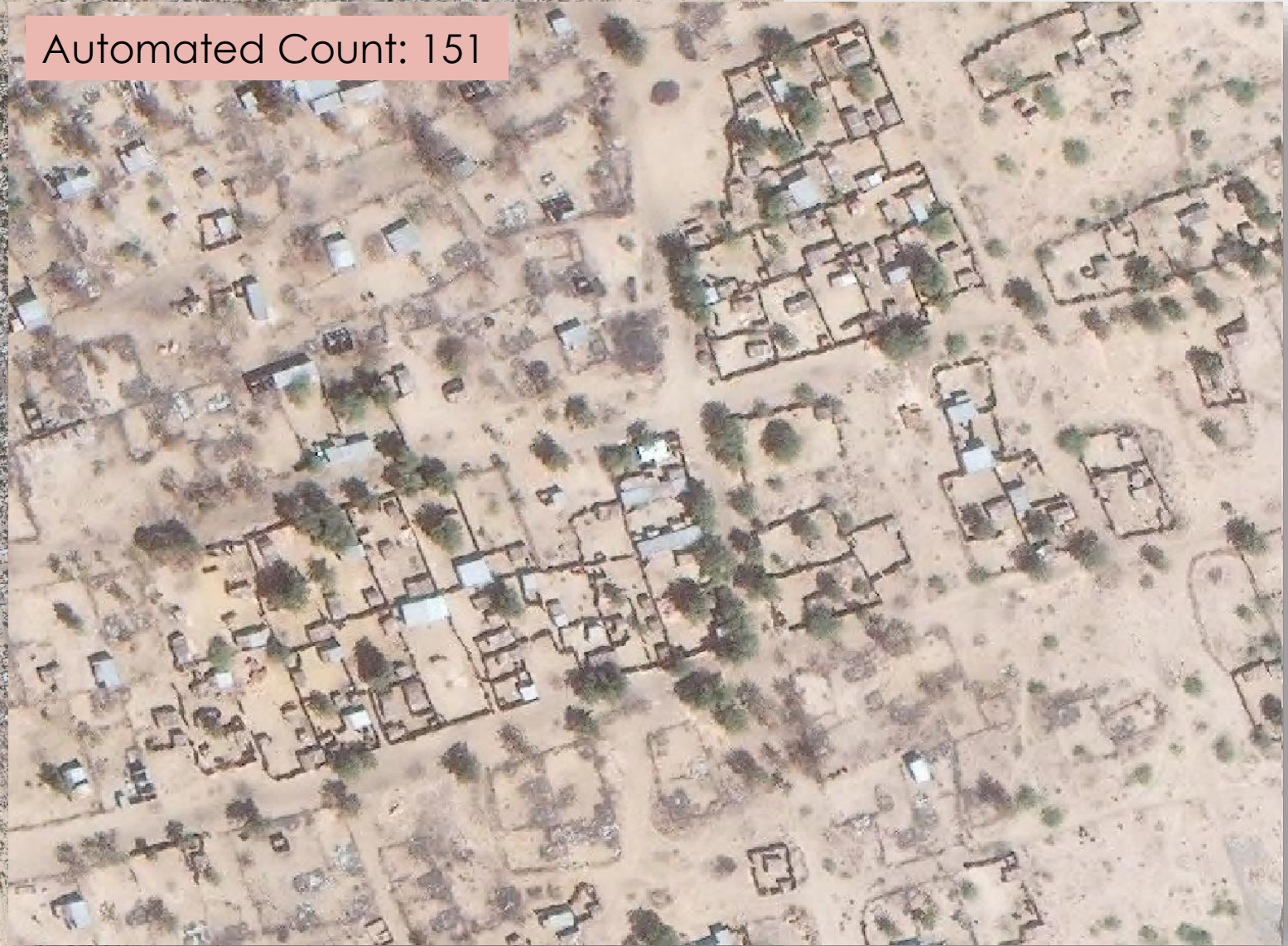
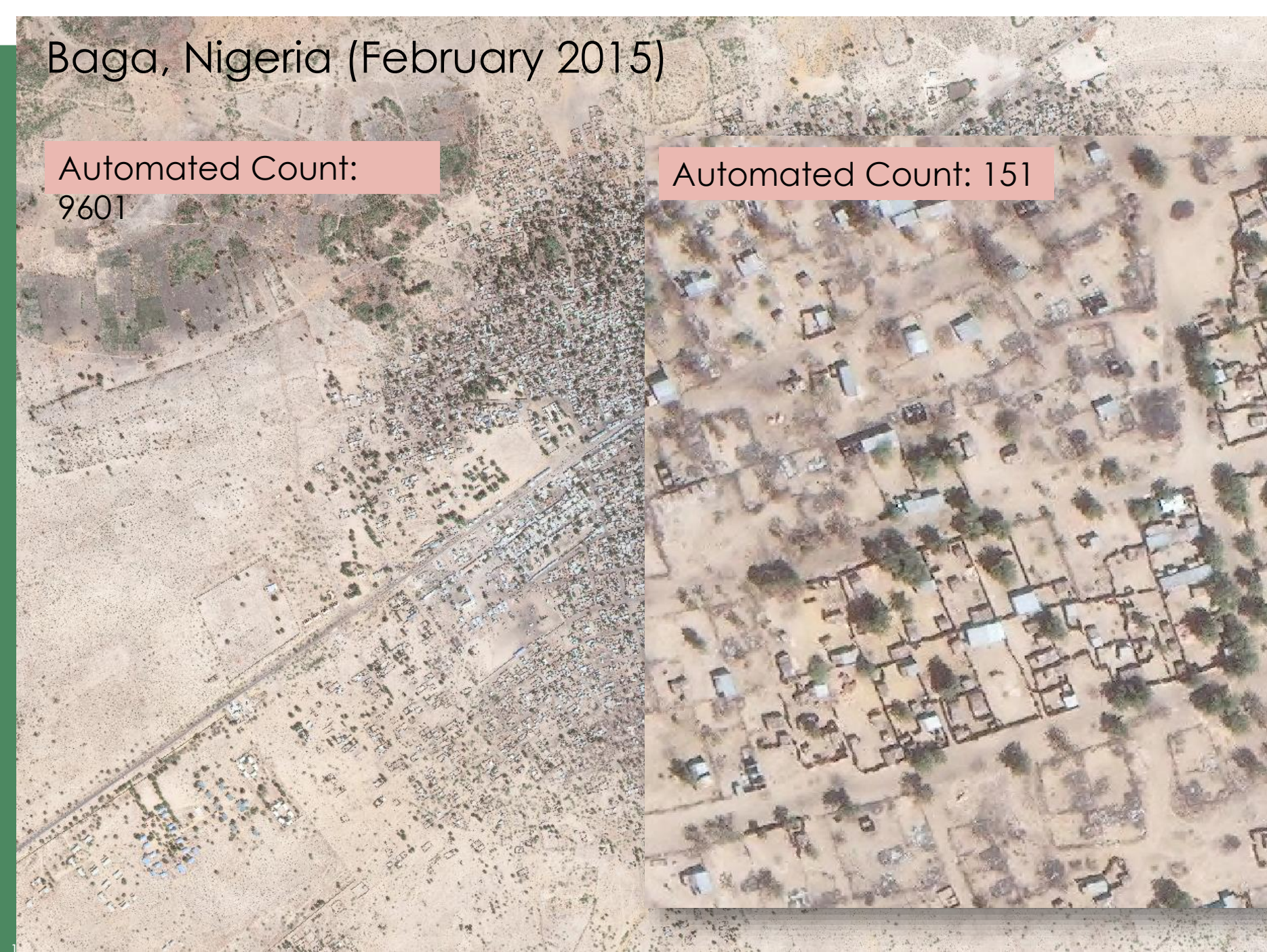
- Overlay pre-event building footprints (in blue), we compare our results to the FEMA damage assessment database
- 88% of destroyed/major damaged building (3722 out of 4225) are identified through this rapid assessment



Baga, Nigeria (February 2015)

Automated Count:
9601

Automated Count: 151

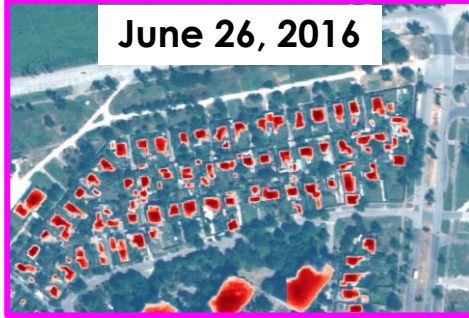


Mariupol damage assessment

Pre-event



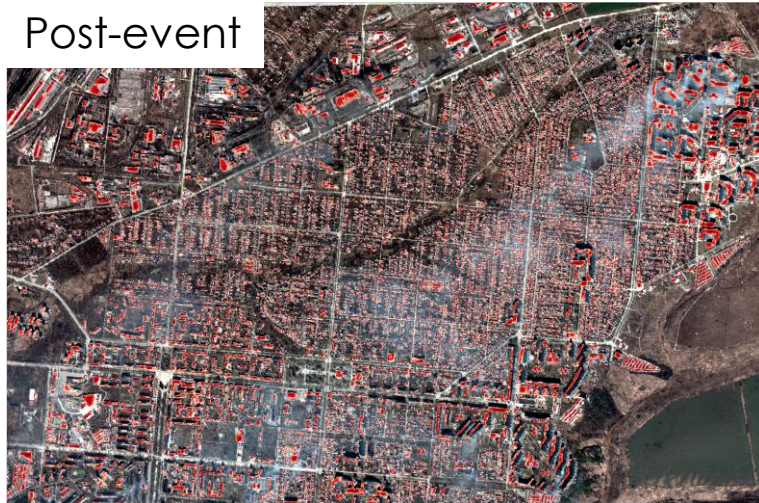
June 26, 2016



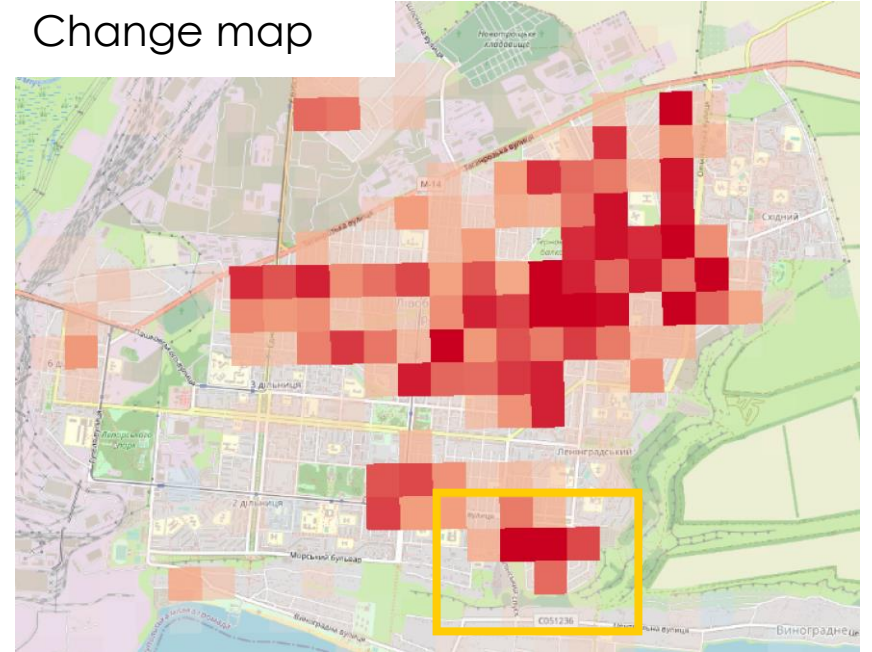
March 22, 2022



Post-event



Change map



Mariupol Derived Products:

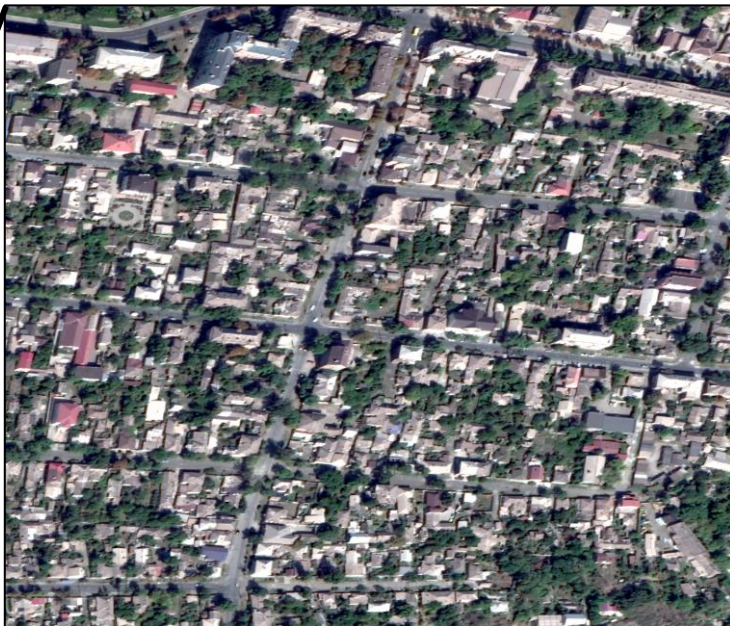
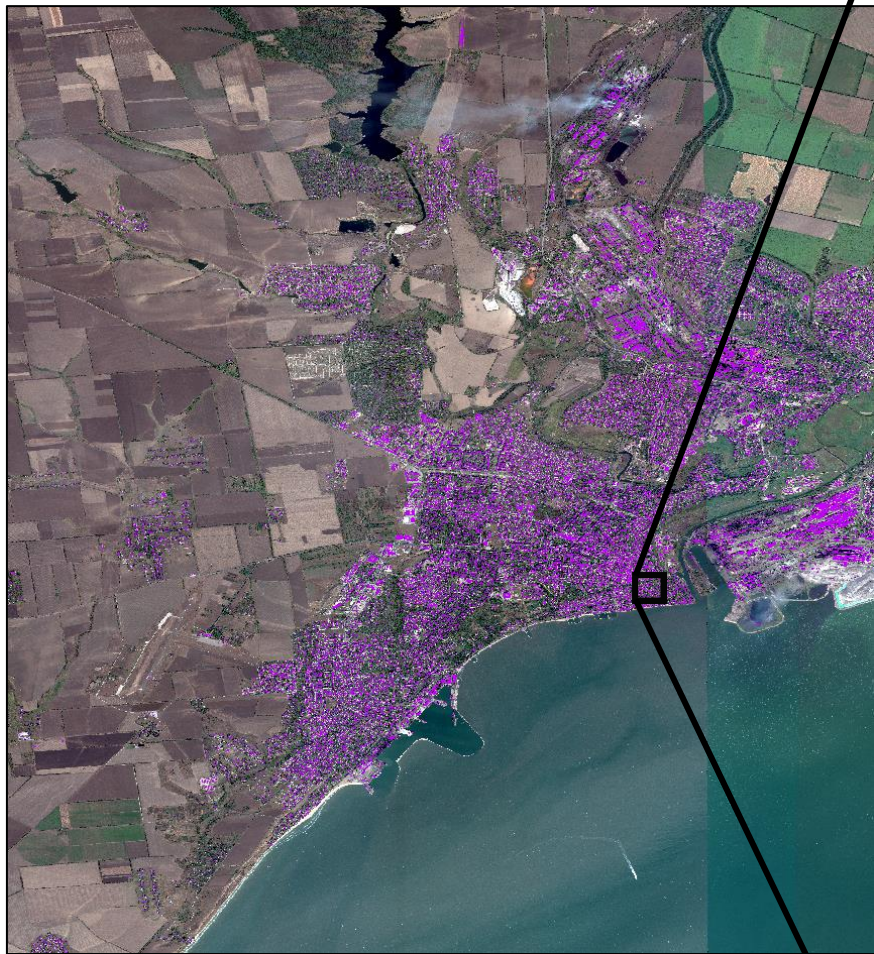
- Building structure footprints
- Change map and analysis
- Land use/Land cover map
- Building structure use map
- Change driven damage map



September 2019

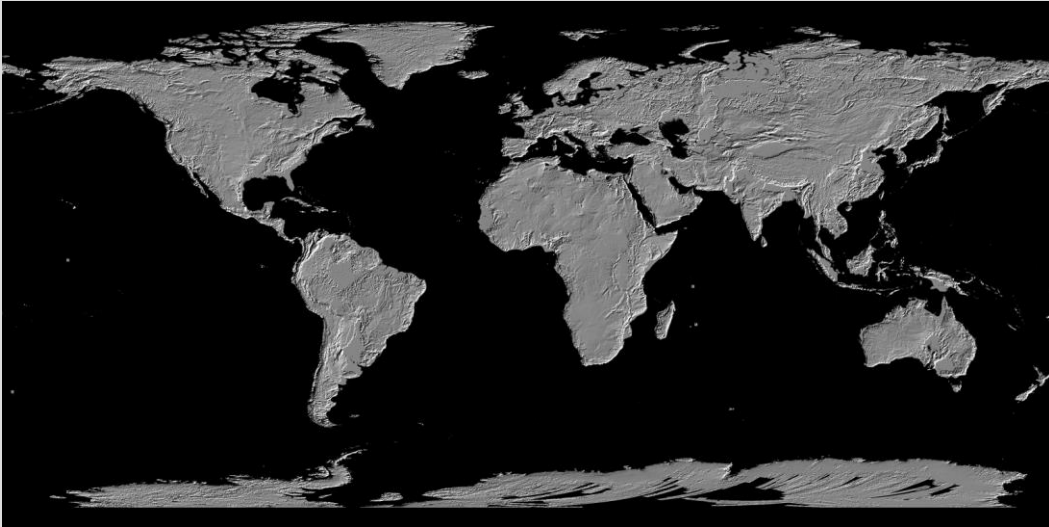
March 2022

Mosaic of
July 2015 and September 2019



Damages: Significant apartments and residential structures show damages in March 2022 imagery

High resolution elevation models at global scale



High resolution digital surface model



Active sensing

- Radar (e.g., Shuttle Radar Topography Mission)
- Lidar (light detection and ranging)

Stereo imagery

- Higher resolution (900x vs. state-of-practice)
- No additional hardware needed
- Fortuitous – no tasking needed
- Passive – not detectable
- Low SWAP – large standoff distance
- Scalable to the world

3D Digital Surface Model Generation

Technology Description

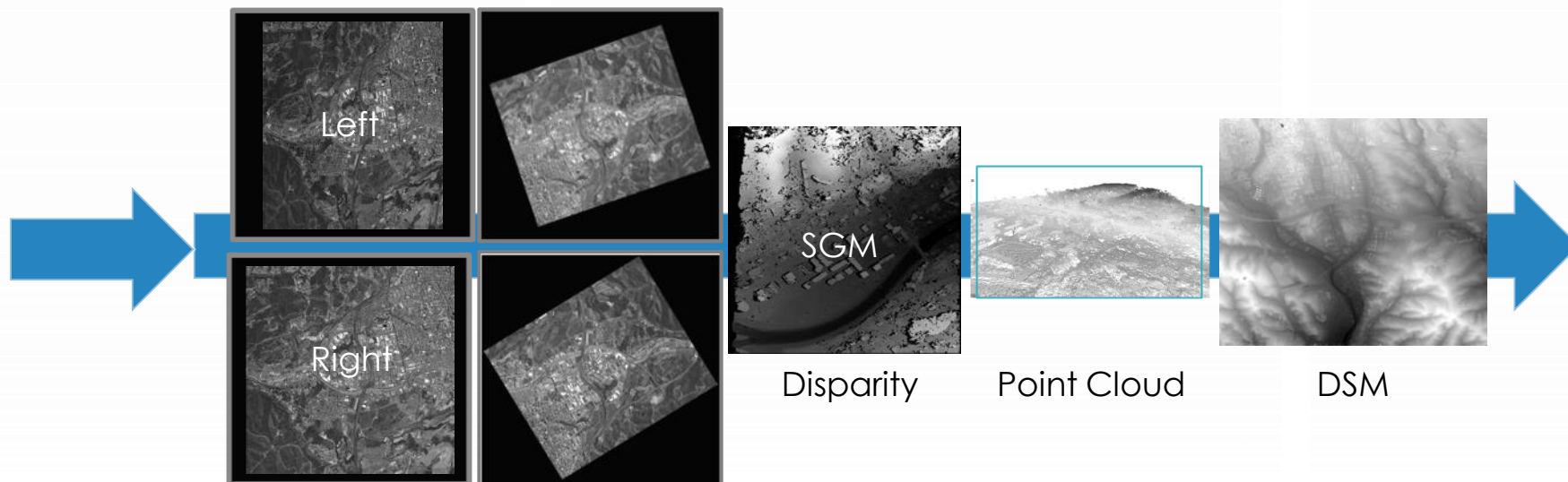
- Automated generation of high-resolution digital surface models (DSM) from optical stereo imagery
- Operational GOTS (govt off the shelf) capability

HPC Utilization

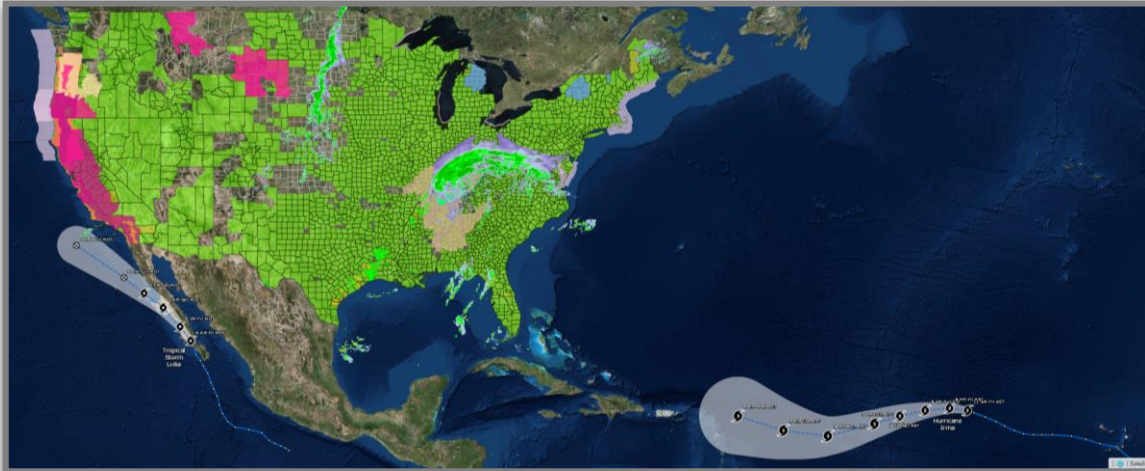
- Implemented best-in-class algorithm in stereo known as semi-global matching (SGM)
- Accelerated SGM for GPU HPC platforms

Impact

- Ability to process roughly 200,000 km² of WorldView-3-quality per week
- High resolution DSMs serve as foundational elements for many humanitarian and disaster response applications

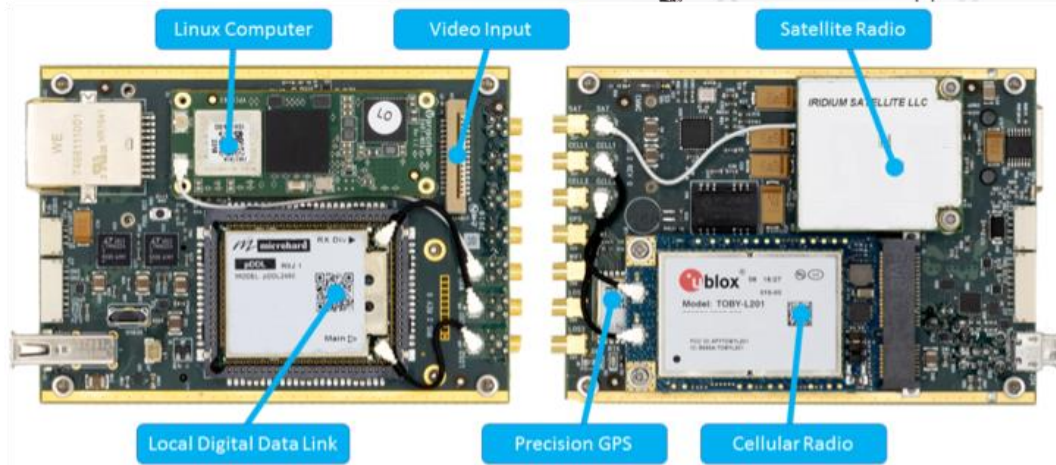


GeoAI/ML Deployment at the Edge



GeoAI at the Edge: Hurricane Damage Assessment

- Utilizing UAS to process imagery onboard, find utility poles and assess their condition (up or down), and reports back over constrained communications environments



Hurricane Ida: machine learning detection/classification on the edge

Small Satellite Ground Station (GS) Infrastructure for Climate and Crisis Response

- Create an interconnected, robust platform for data collection, transmission, analysis, and edge processing for a wide range of science applications
- Develop a high-performance computing and AI/ML test bed for use on/with space-based platforms
- Lower the bar to advance technology for industry, academia, and government
- Phase I partnerships with
 - SAR
 - Hyperspectral



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Federated Cyberinfrastructure: HPC to Edge Computing

- Create access to best in class, geographically distributed resources
 - Data
 - Scalable computation
 - Analysis and visualization
- Platform for data integration and knowledge dissemination
- Enables on time and on demand information and knowledge delivery, particularly for time critical mission support

Interactive and Interoperable Visualization

Development of High Performance, Scalable Simulations

Analysis Models and Tools Development

Knowledgebase Creation

Dynamic Collection, Integration, Management and Dissemination of Disparate Data Resources

Discussion

