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4D Laser Performance Visualization for Speed of Light Effects

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Abstract

Mission planning software which assesses performance of next-generation speed of light capabilities will require high capacity computing to respond to current and forecasted weather patterns anywhere on the globe. Using super computing resources, several conceptual frameworks were explored for their utility towards visualizing effects crucial to future fire control and mission planning.

Background

As new hardware and software become more precise, an increasingly large amount of data is generated. To be capable of utilizing this new precision and process the data, a significant amount of computing resources is needed to produce actionable global information using the atmospheric characterization code, LEEDR, and laser propagation code, HELEEOS, an accurate model of the battlespace can be generated to help predict optimal firing geometries using laser weapons. With conventional servers, the rate at which calculations can be crunched for a project of potential world-wide dimension would be too slow during battle, where sub–second responses are needed, and impractical for generating many scenarios during mission planning.

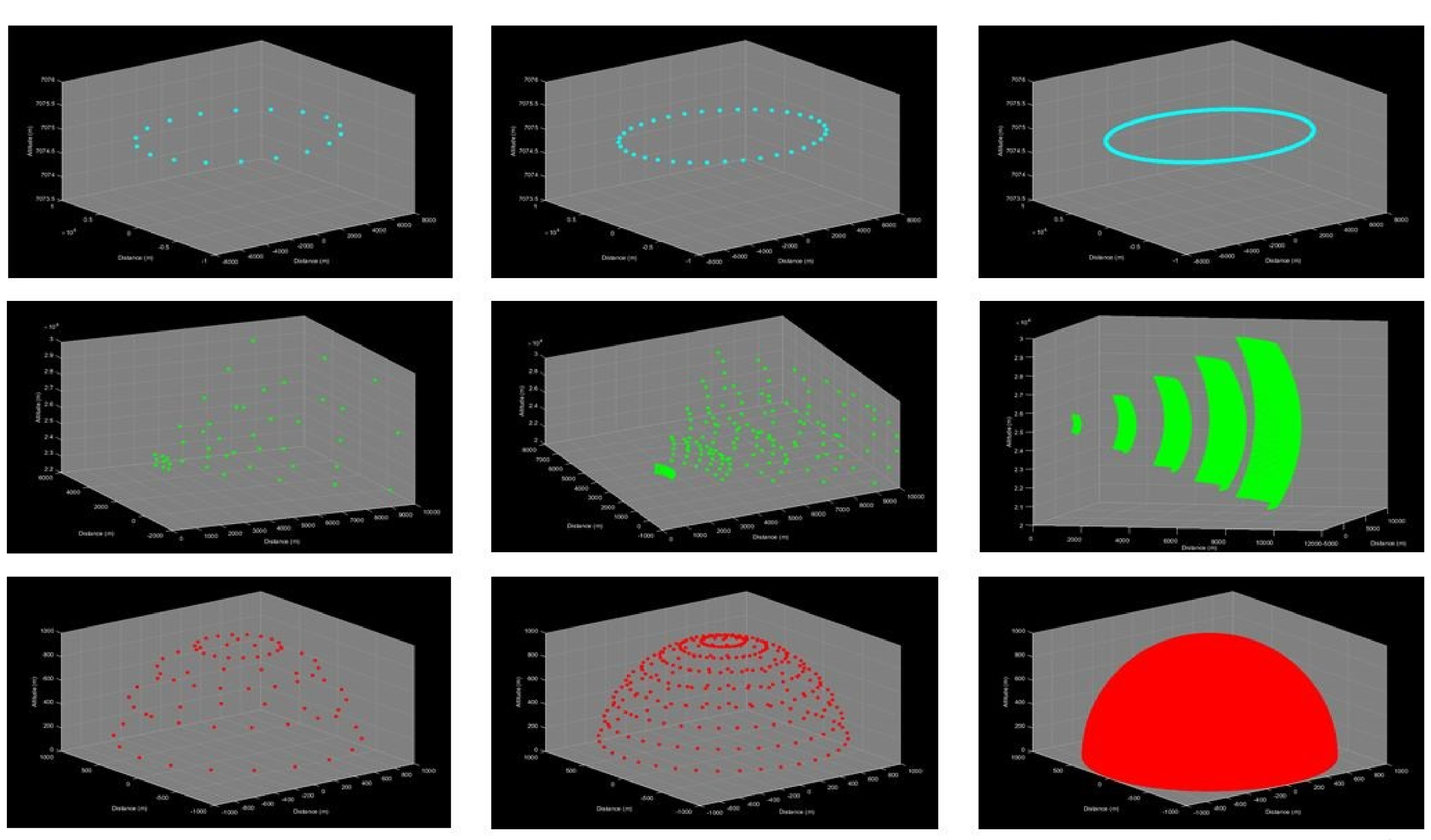

Figure 1: Different geometries indicating all possible target locations depending on input of platform altitude, target distance, azimuth range, and zenith range

Methods

- Visualizing Geometries.
- Using parallelization (parfor loop) and catching special cases to reduce run time.
- Uploaded geometries onto HPC.
- Used LEEDR and HELEEOS to grab real weather data and calculate laser effects.
- Combined geometries with real weather data and calculated laser effects across different locations on the globe.
- Generated multiple domes on a single plot, each with unique weather data.
- Overlaid multiple domes on map to demonstrate what future users will see.

Results

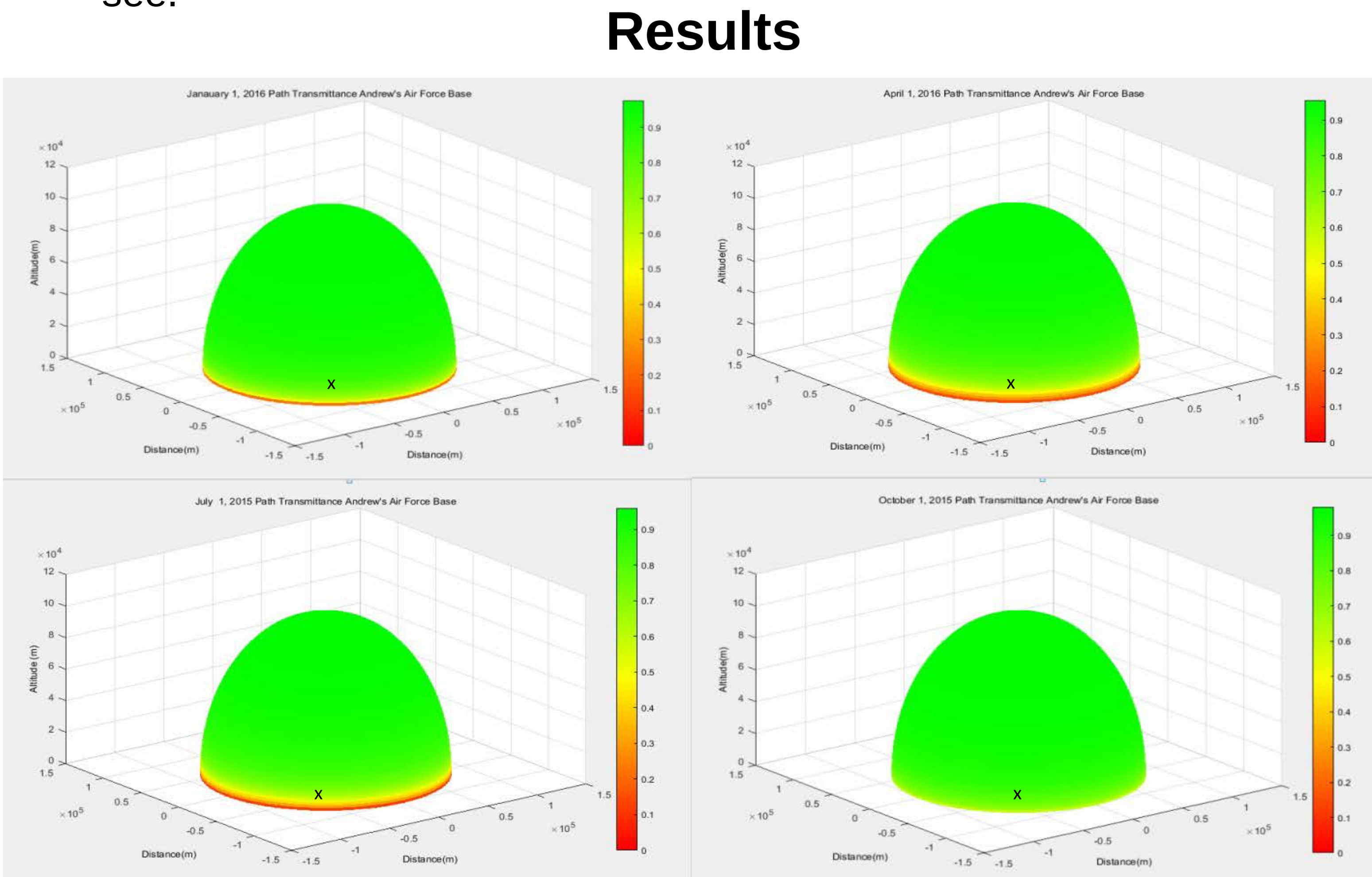

Figure 2 represents four domes generated at the same location on 4 different dates. Green represents a higher transmission and is prevalent on higher elevation angles.

Using weather data collected from the National Oceanic and Atmospheric Administration (NOAA), an atmospheric profile is generated. The points on the dome's surface shown in Figure 2 represent all possible target locations, while the platform is at the "**x**". The color variations across the four plots indicate the different atmospheric effects associated with the NOAA numerical weather data for each of 4 different days. Domes with a greater coverage of green indicate better laser transmission. The upper portion of the domes are always green since the laser need travel through smaller concentration of highly scattering aerosol layers known to reside in the boundary layer close to the surface. On the other hand, lasers fired at low elevation near the surface are accordingly more heavily scattered.

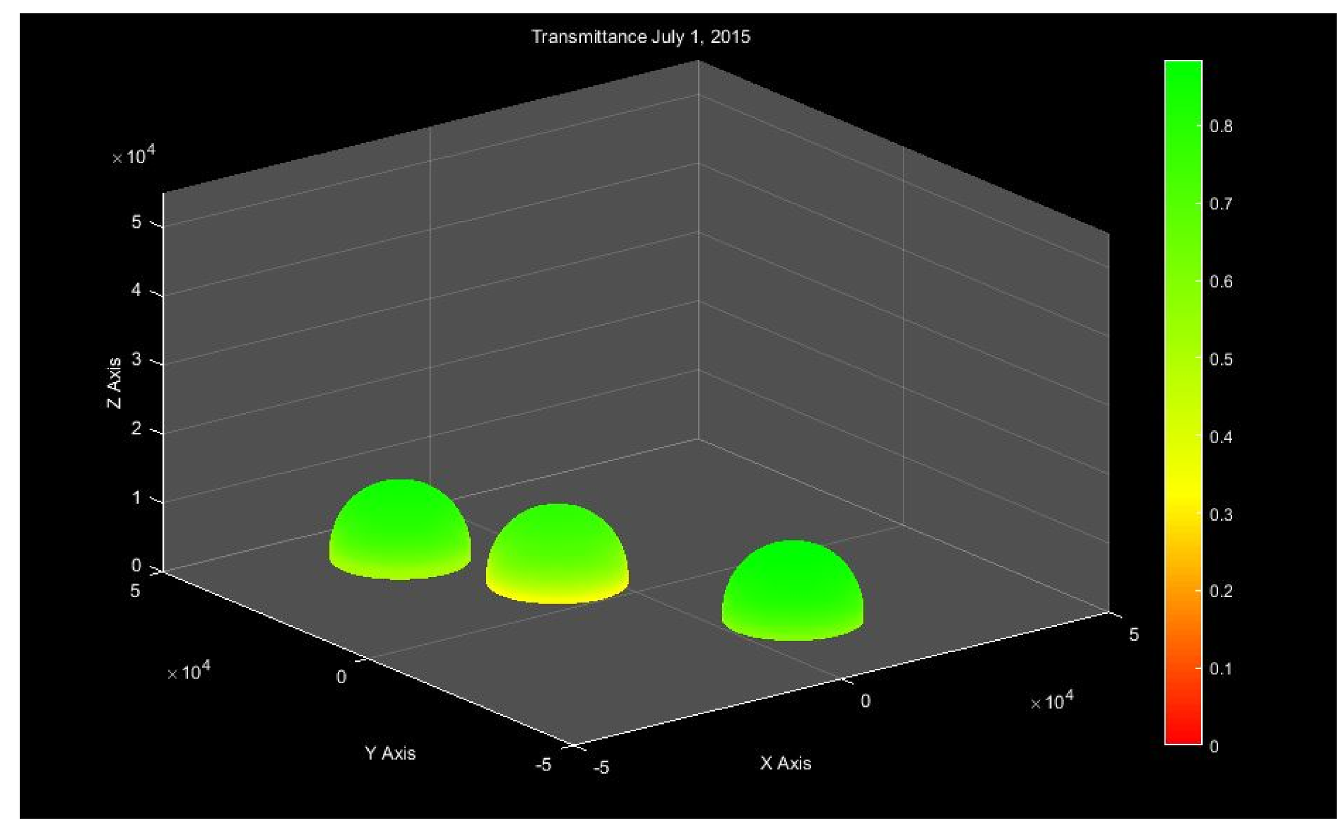

Figure 3 – The generated domes represent 3 different locations on the globe, each with different weather data

Once single domes were generated for each of several locations, multiple domes were subsequently calculated in one batch run and represented simultaneously. This way multiple sectors could be covered and maintained to increase an area's defense. Using three different latitude and longitude points, Figure 3 was generated. The slight variation in color among the three domes indicates that the program is capable of taking in various locations' weather data and resolving the distinctive atmospheric effects tied to three distinct atmospheres for the three locations. While this figure shows only three domes, the program is capable of generating and computing *n* amount of domes.

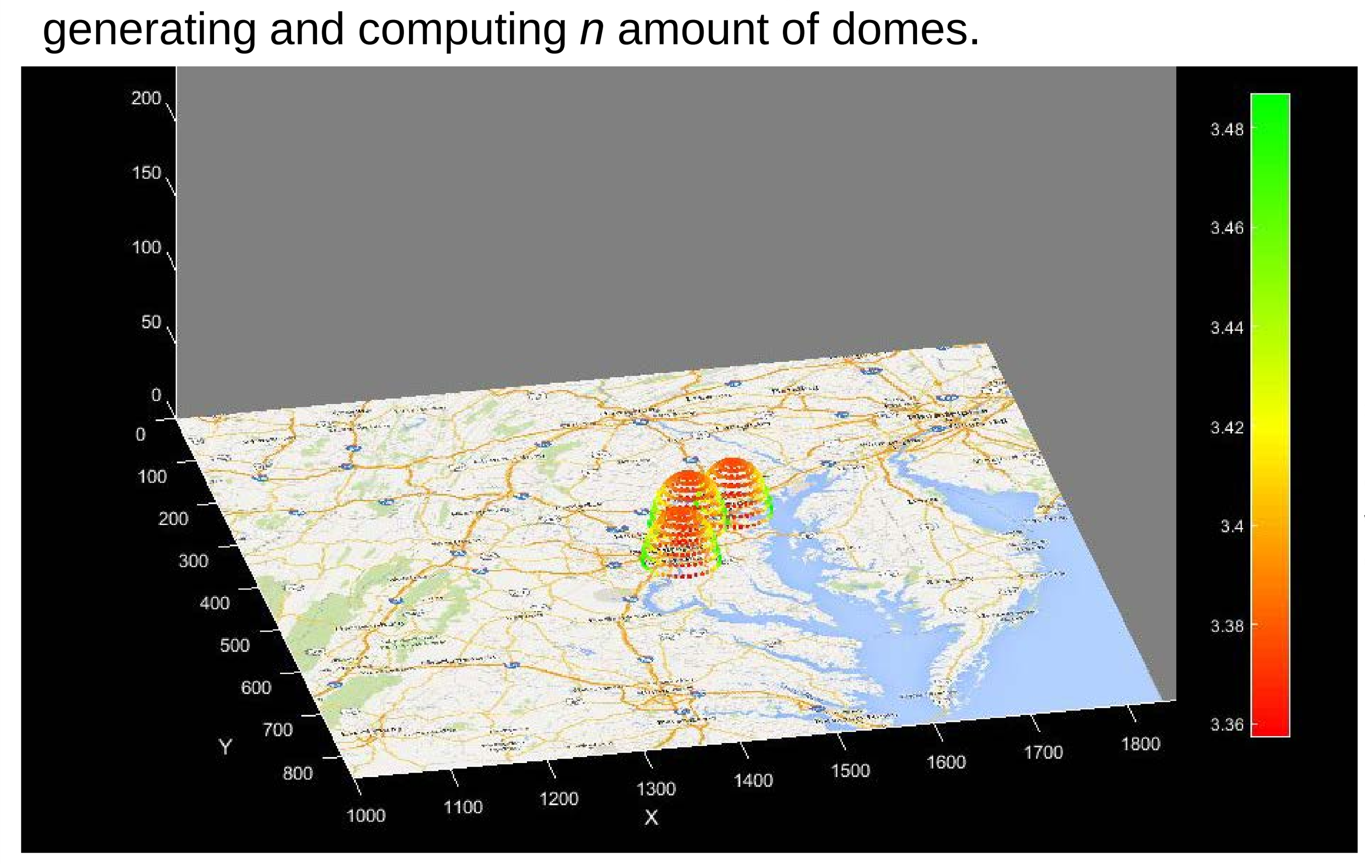

Figure 4 – Three domes stretching from Washington DC to Baltimore. Overlapping indicates areas where more than one dome can engage.

To better visualize how the simulations would be used as both fire control and mission planning, the domes were overlaid on a map. In Figure 4, three domes stretch from Washington DC to Baltimore. Having several domes in an area means both greater spatial coverage as well as redundancy. If, for example, a target was flying from northeast to southwest on Figure 4, it would have to go through all three domes. Having several of these geometries arrayed as a network allows for a higher probability of taking out a target. The domes (each representing a single laser platform) are also overlapping. This means if any dome should fail to engage the target, the HPC might be configured to assist with battle management and switch fire control to another dome to pick up the task of the previous dome's defense responsibilities.

Future Work

- Optimizing software
- Increase model precision
- Expanding software to other HPC operating systems and making it compatible
- Create backups in case of node or system failure on the HPC
- Prototype / "Field" Testing

References

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2. S. Fiorino, R. Bartell, M. Krizo, G.Caylor, K. Moore, T. Harris, and S. Cusumano, "A first principles atmospheric propagation & characterization tool: the laser environmental effects definition and reference(LEEDR)."Proc. SPIE 6878.68780B(2008)

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