

# Using Projection Distortion in Panoramic Maps

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Hello everyone, I thought I might share some experiments I've been trying with how you can take advantage of projection distortion when you're creating a panoramic map.



Broken Top and the Three Sisters

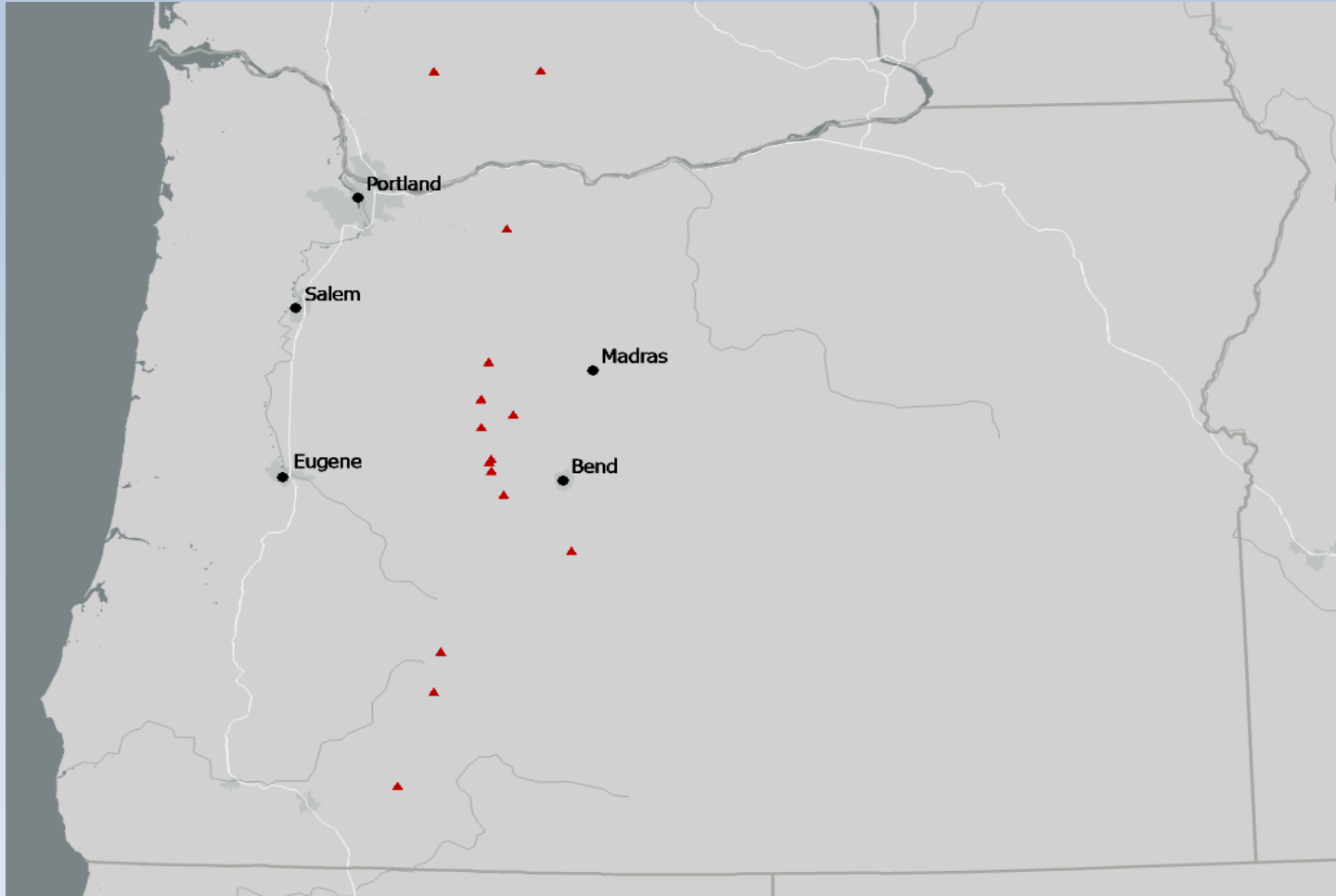


Mount Jefferson

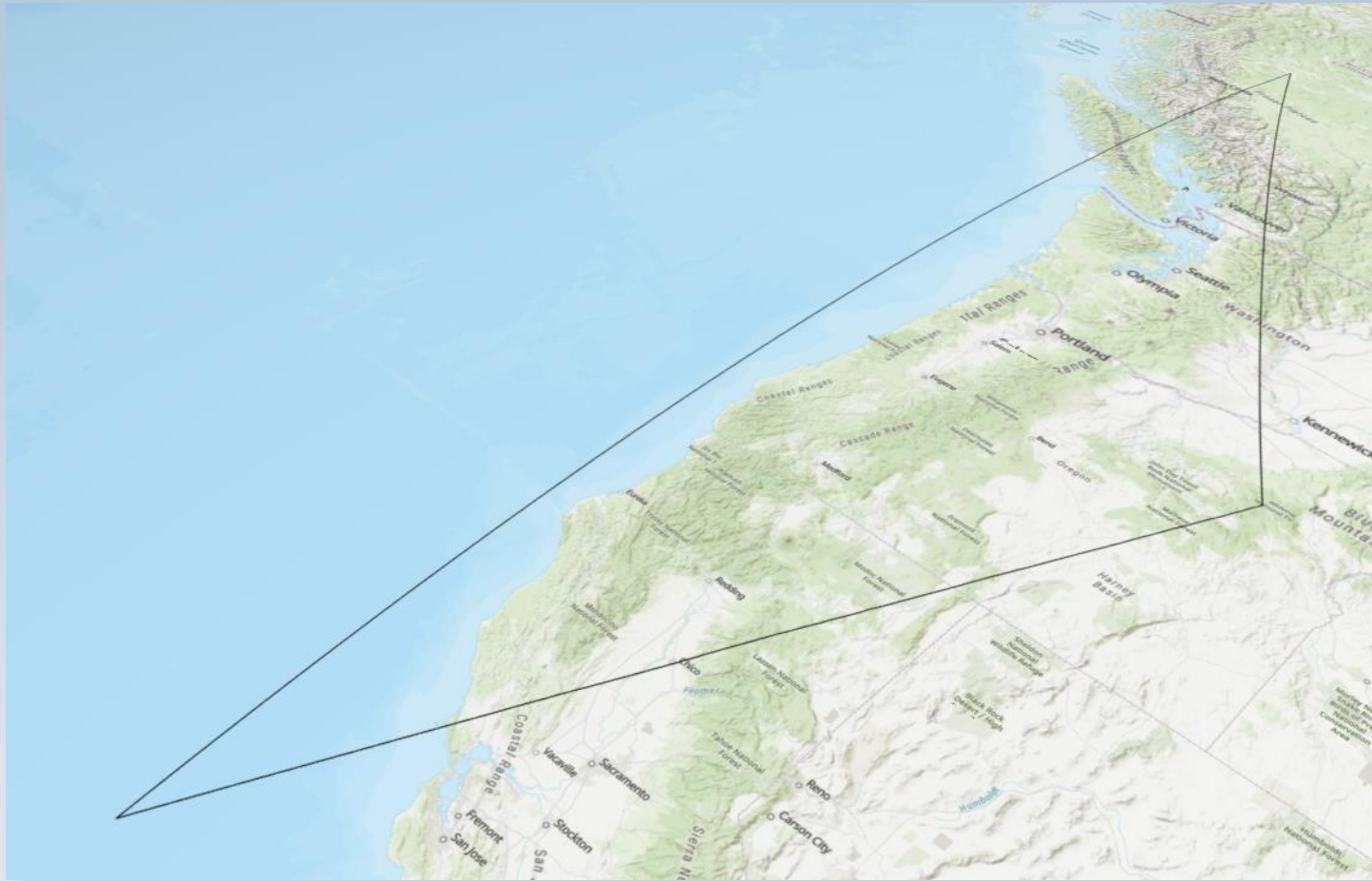


Mount Hood

I recently moved to Madras, Oregon, which is about an hour north of Bend. My house has a view of the Oregon Cascades from Mount Hood in the north to Mount Bachelor in the south. A cartographer can only live in such a place for so long before feeling compelled to make a map of it.



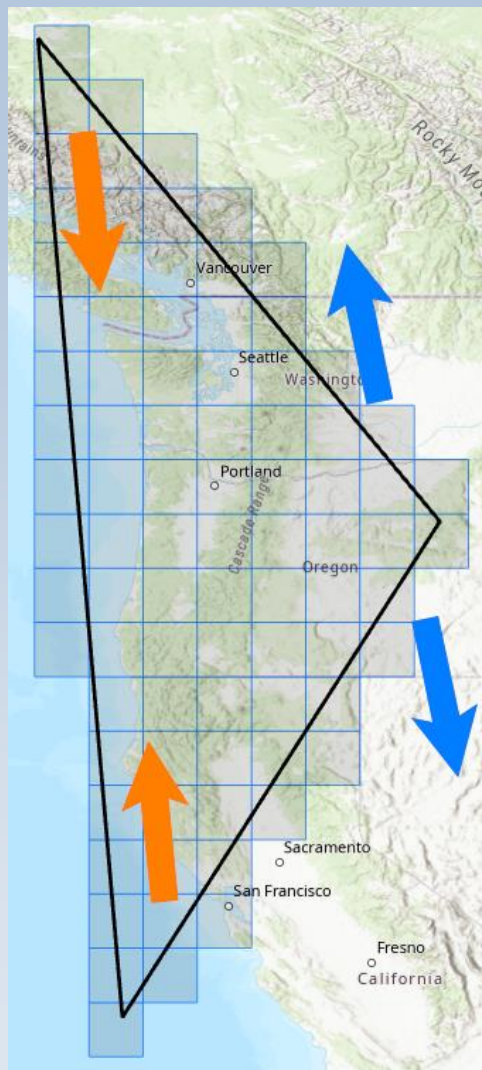
Initially my plan was to make a map with Madras and Bend in the foreground, and the aforementioned peaks in the background.



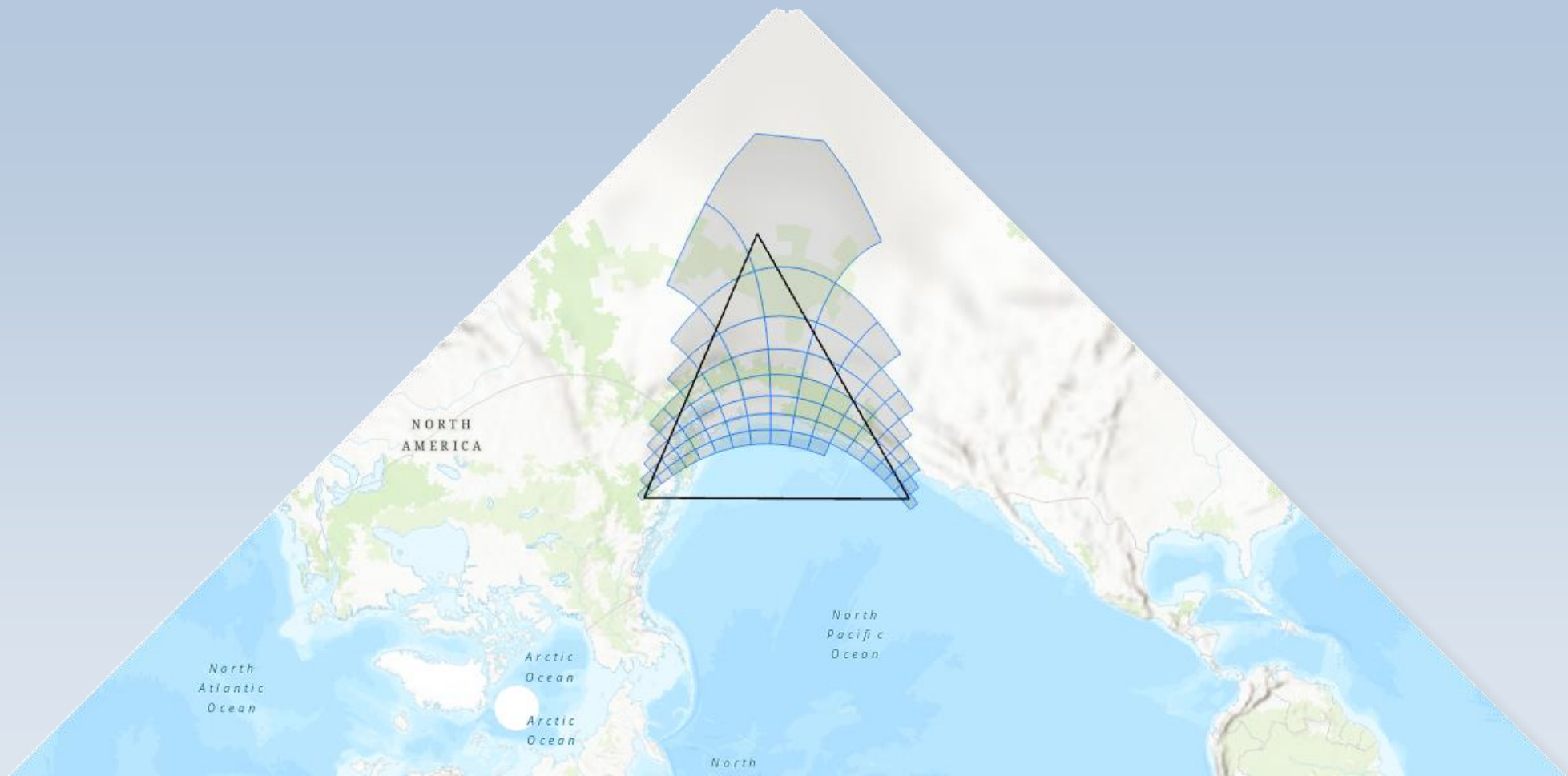
However, during the design I kept wanting to add "just one more mountain" that was outside the view, until finally my desired frustum included nearly the entire US Cascade range.



This is easily the largest area I've ever tried to make a panorama of, and it presented some problems. These blue squares here are the 10m elevation tiles I had to download. But even if I mosaicked all these DEM tiles together and made a raster out of the rectangular extent you see here, nearly half the pixels in that raster wouldn't even be within the view frustum. Not only is this inefficient, but it would also probably exhaust my machine's RAM at render time. There's also the problem that I don't actually need the background to be as detailed as the foreground.



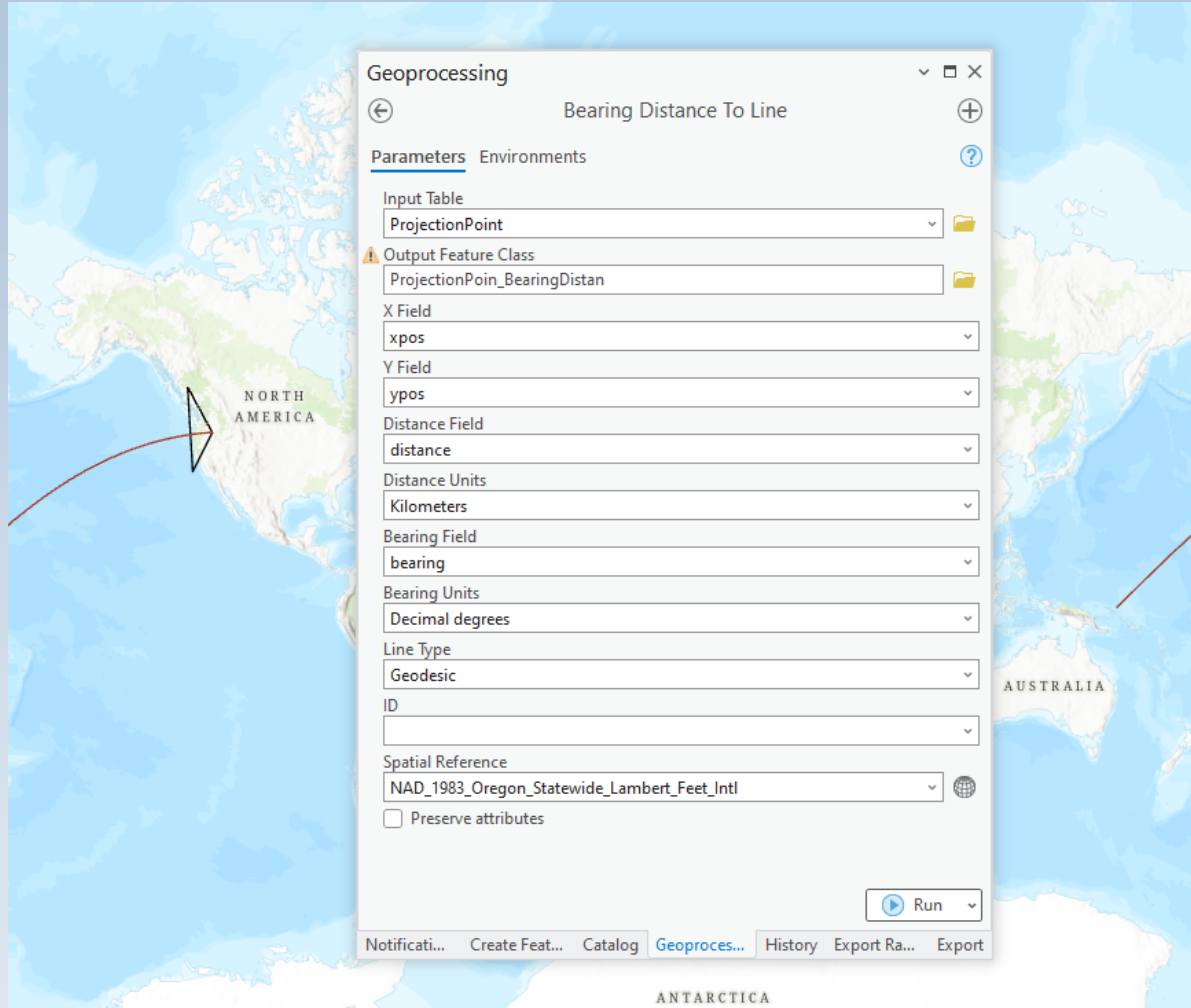
Now others at this conference have talked about this same problem but I wondered if there was a different way to address it. If I could compress the background and expand the foreground, I could make a rectangular raster that would use the downloaded tiles without including any unseen areas. It would also have a smoothly increasing cell size from east to west, which would be a more memory-efficient way to capture that extremely wide background.



The solution I came up with was to abuse the distortion caused by certain map projections. I got a decent proof of concept by trying to position the frustum in one of the corners of an Adams Square II projection, but I found it difficult to fine-tune the parameters in a way that gave me exactly what I wanted. So I did what I always do when I have a problem involving projections; I went to talk to Bojan Šavrič.



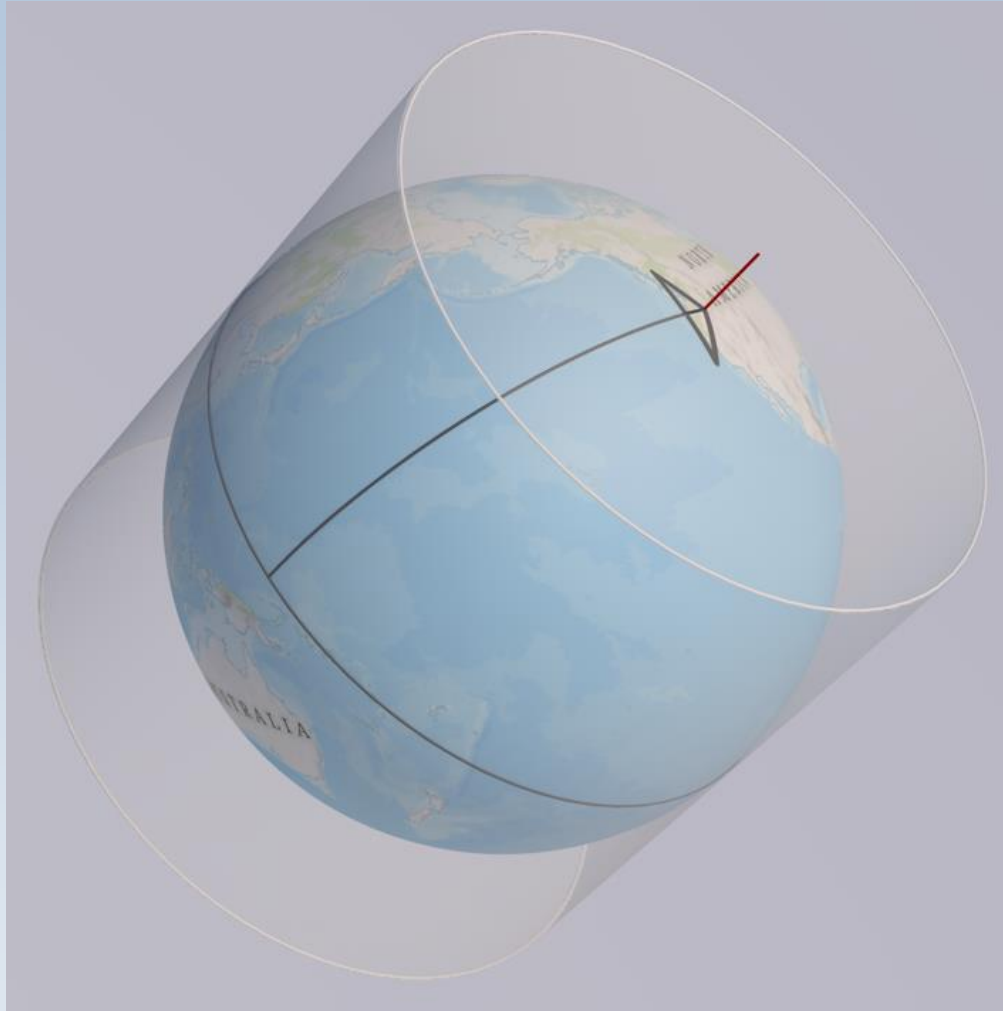
Bojan suggested I try the Rectified Skew Orthomorphic, or RSO, projection. This is a variant of Oblique Mercator most often used for Malaysia. This particular implementation offered a set of adjustable parameters that fit my use case very well. And, since Mercator projections increase scale near the poles, I could take advantage of this to achieve the result that I wanted.



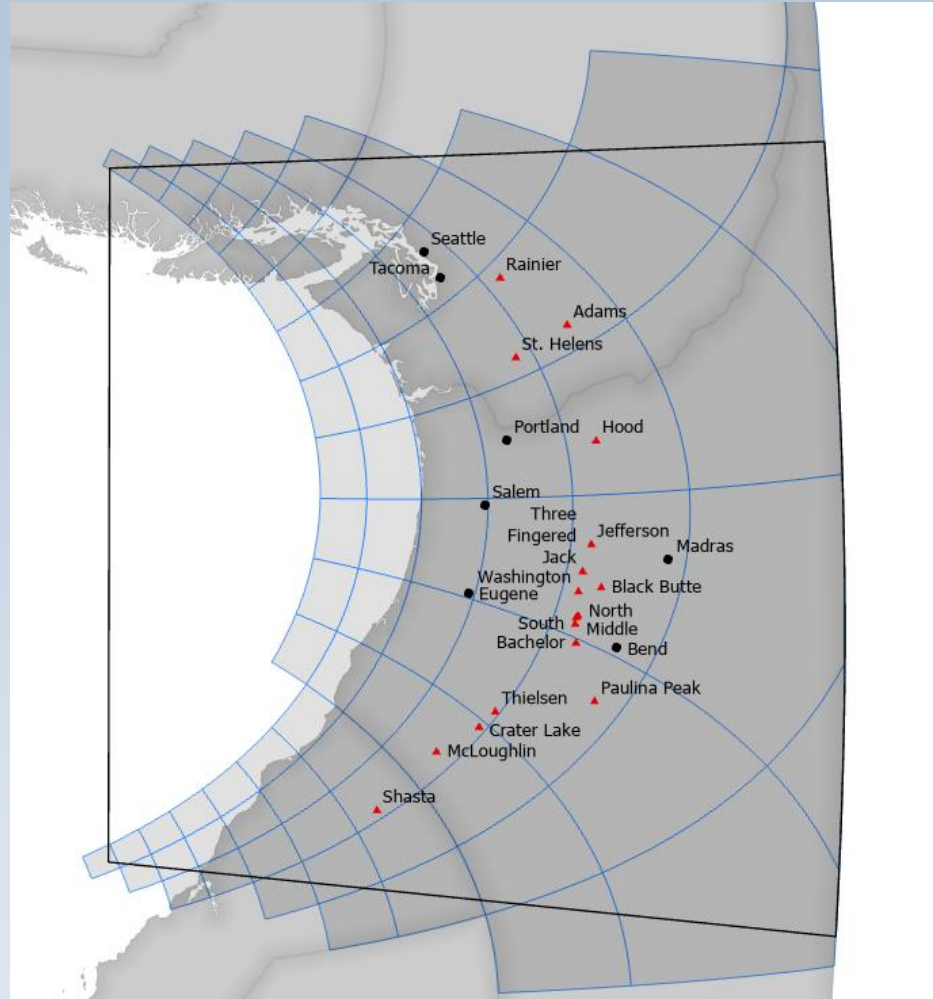
First, in a standard Mercator projection I used the Bearing Distance to Line tool to project a line along the camera's line of sight, which would travel  $90^\circ$  around the earth. This line would be part of the "Central Meridian" in my custom Mercator projection.

Projected Coordinate System	RSO1_2
Projection	Rectified Skew Orthomorphic Center
Authority	Custom
Linear Unit	Meters (1.0)
False Easting	0.0
False Northing	0.0
Scale Factor	1.0
Azimuth	135.1480556
Longitude Of Center	154.0263943
Latitude Of Center	-2.58409081
XY Plane Rotation	0.0
Geographic Coordinate System	WGS 1984
WKID	4326
Authority	EPSG
Angular Unit	Degree (0.0174532925199433)
Prime Meridian	Greenwich (0.0)
Datum	D WGS 1984
Spheroid	WGS 1984
Semimajor Axis	6378137.0
Semiminor Axis	6356752.314245179
Inverse Flattening	298.257223563

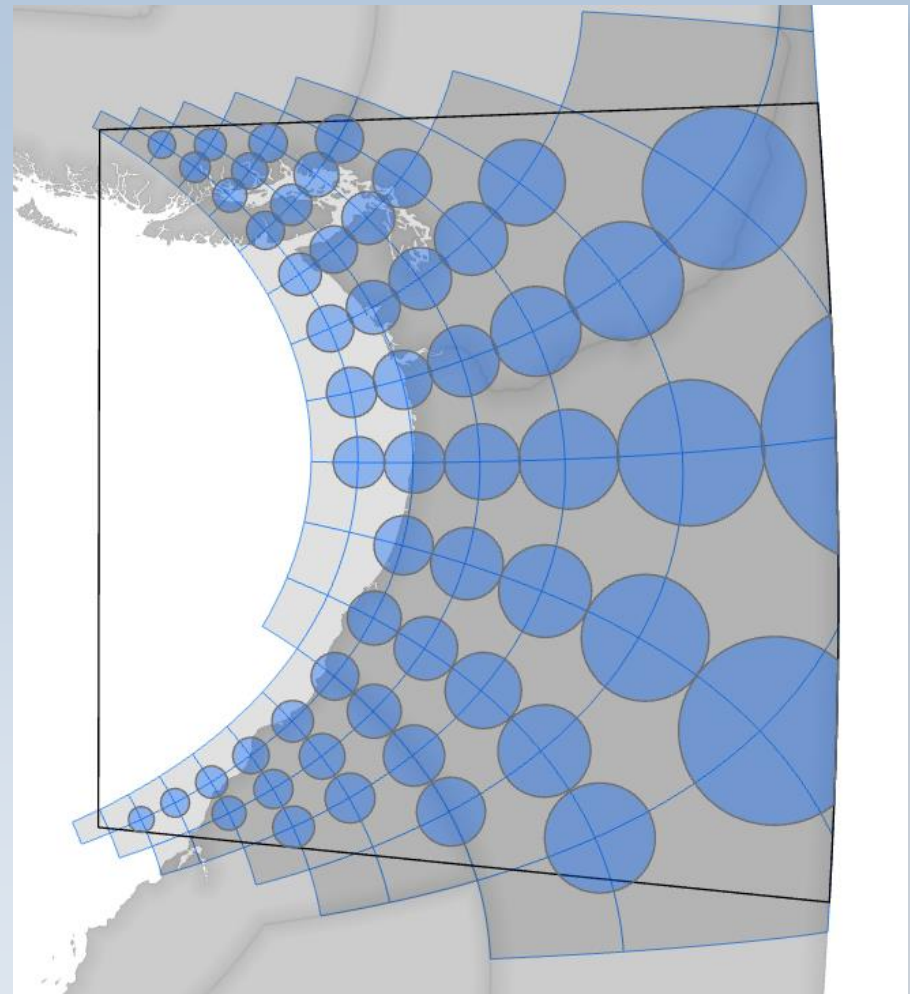
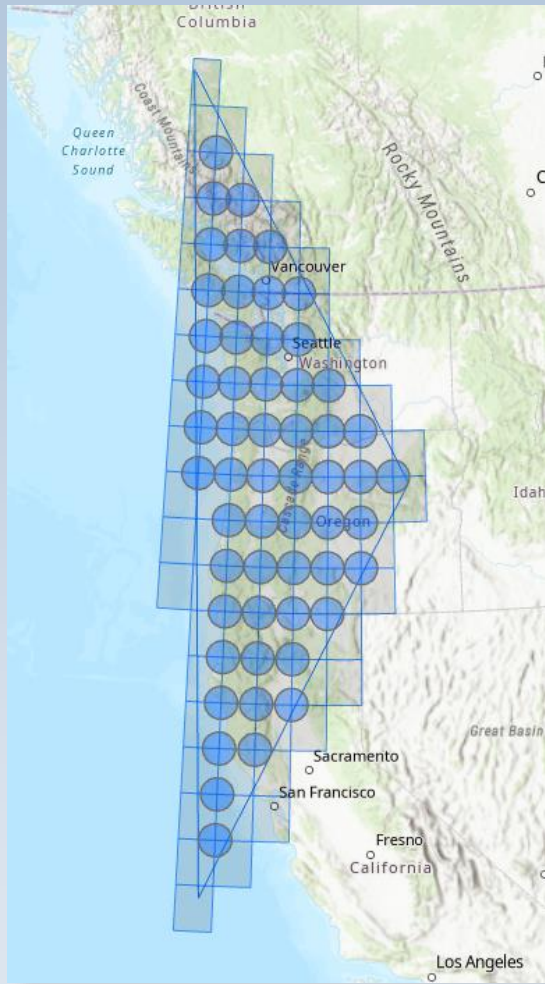
Then, I obtained the final bearing of the line and the location of its endpoint. I used these to determine the center and azimuth of a custom RSO coordinate system. I had to subtract  $90^\circ$  from the bearing in order to get the desired azimuth. Measuring this bearing is also the reason why I did this part in a standard Mercator projection.



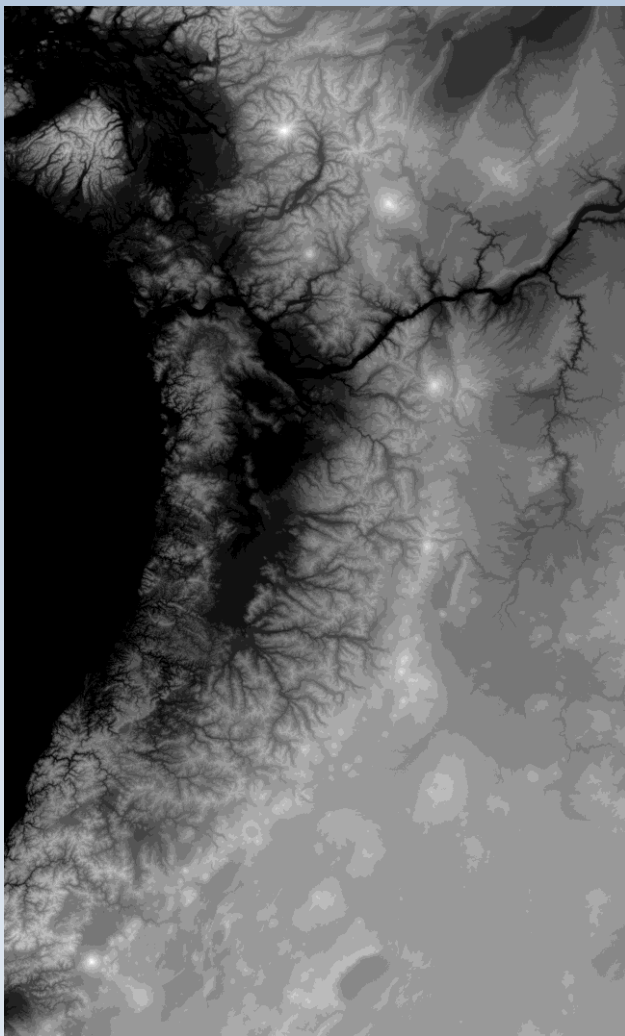
This creates a Mercator projection where the camera is near the "pole" and looking directly away from it, so scale distortion is highest in the foreground and decreases with distance from the camera. Some trial and error was needed to define the center just right...



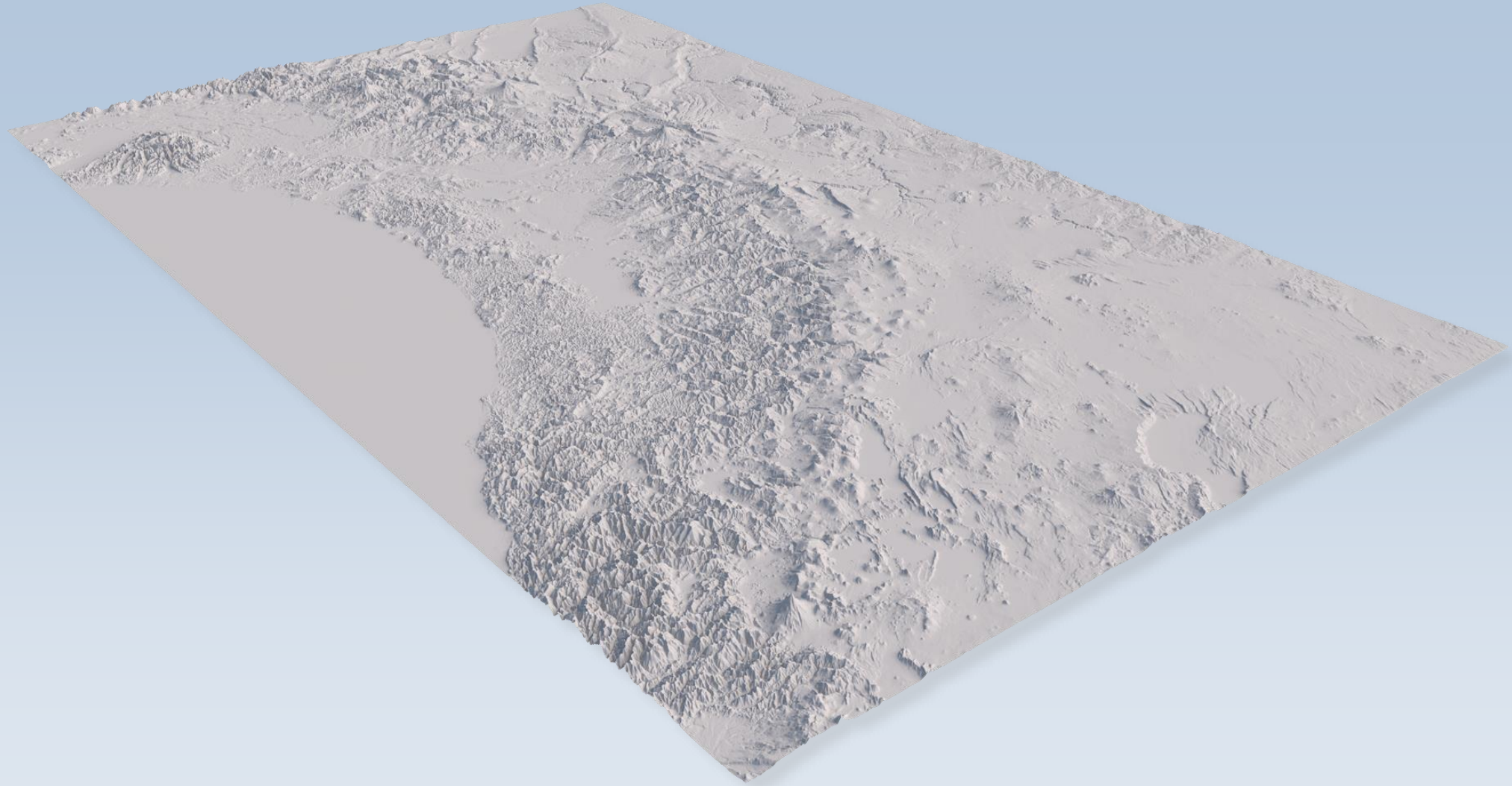
But in the end it gave me exactly what I was looking for. My frustum was now essentially a rectangle so there's no need to include unseen areas in the extracted raster. Effective cell size smoothly increases from east to west, so the extracted raster will make a more efficient use of data during the render.



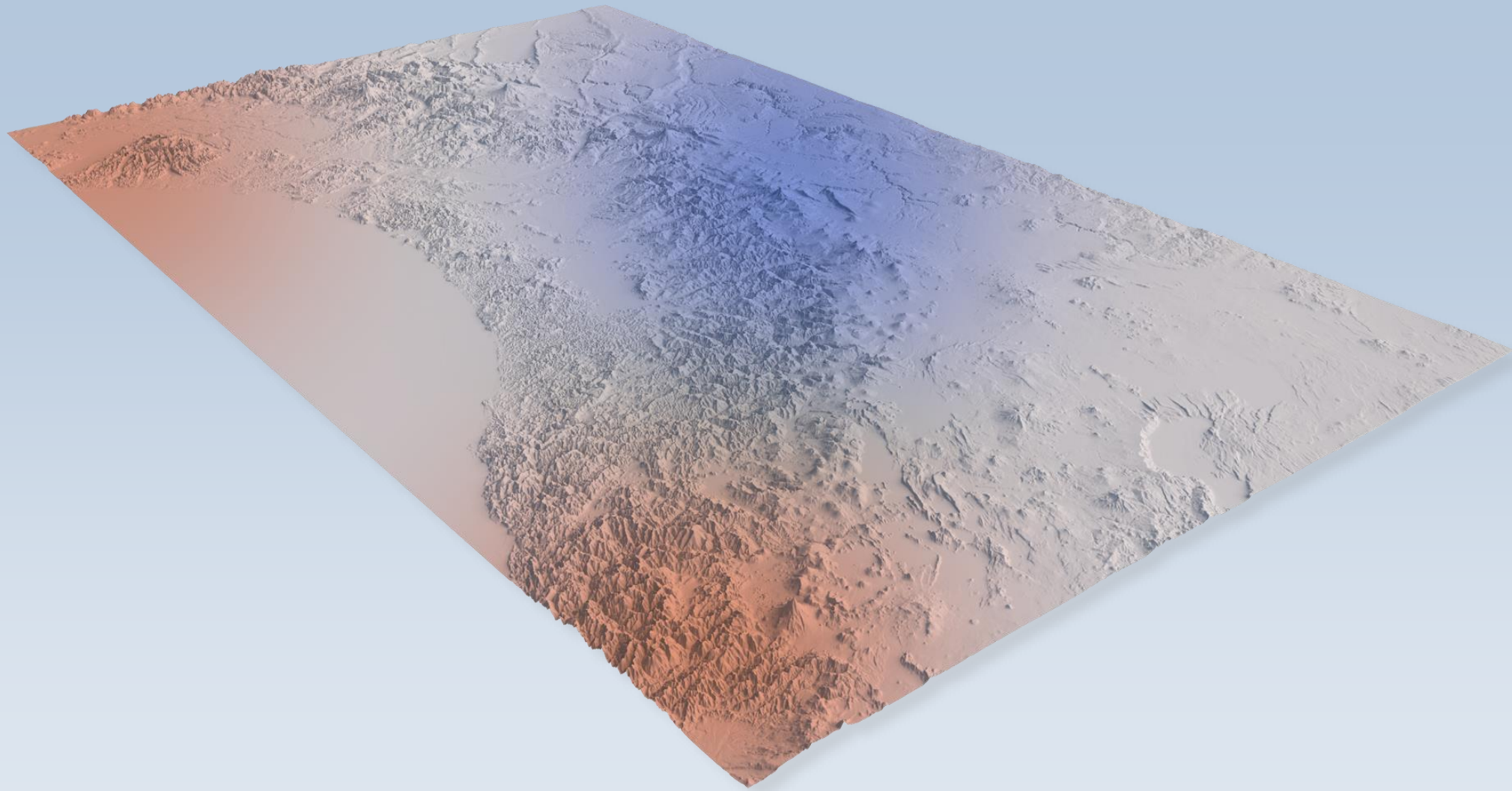
Also, since this is a variant of the Mercator projection, the map is conformal, and so the local shape of terrain features remains relatively recognizable.



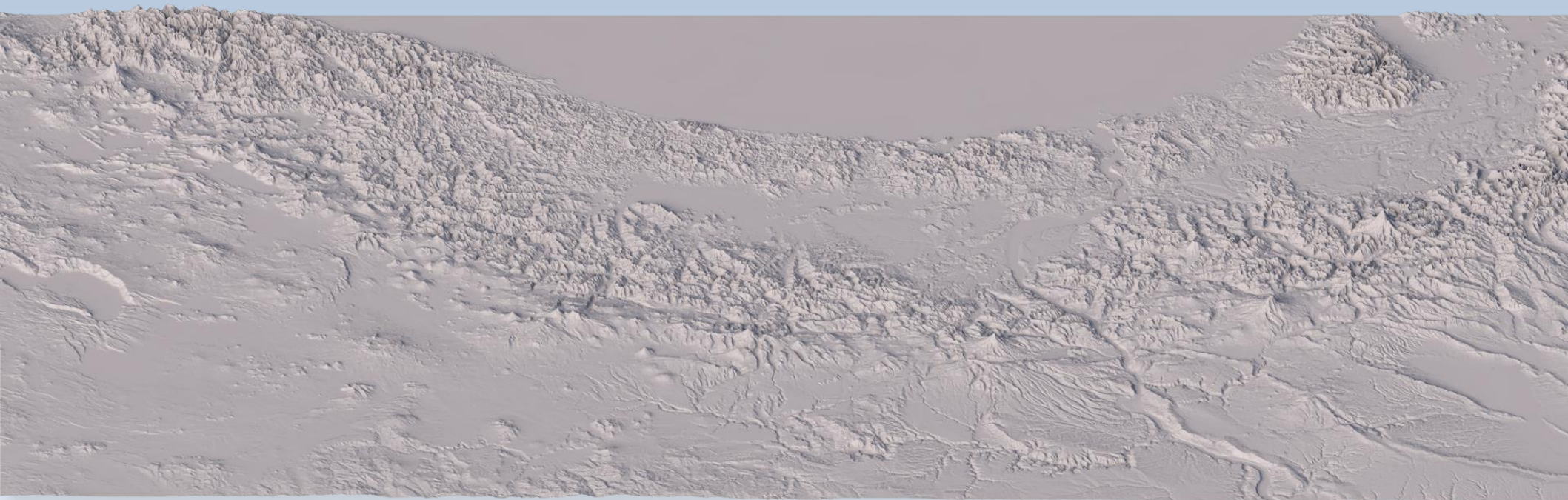
So, all of that was to get this terrain tile.



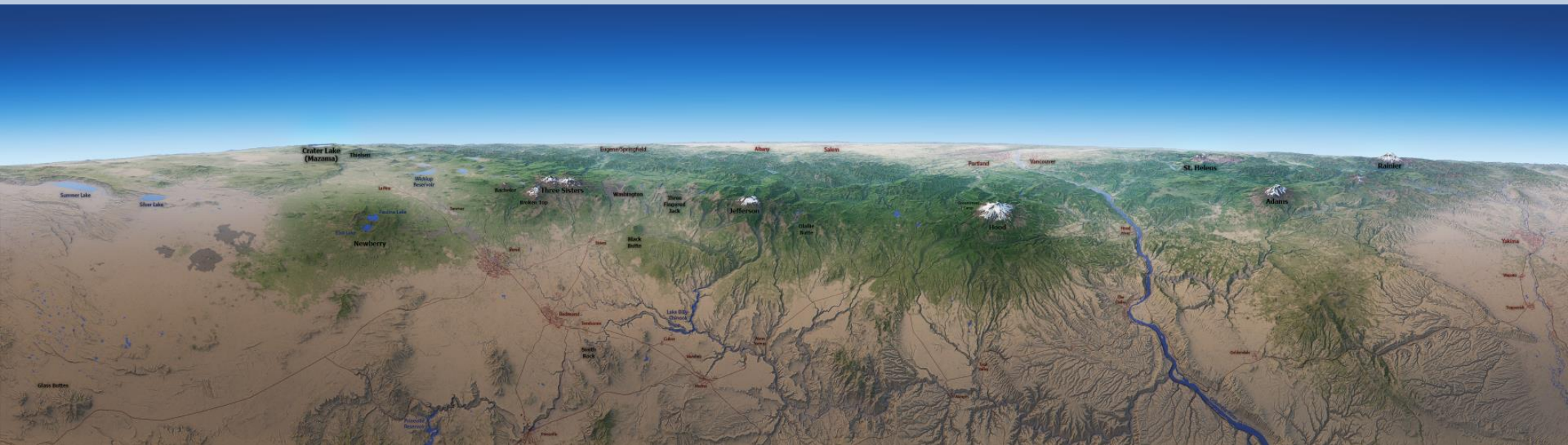
At this point, I noticed some things that I had not anticipated. Because the cell size smoothly increases from foreground to background, but the raster values remain the same, the vertical exaggeration also increases from foreground to background.



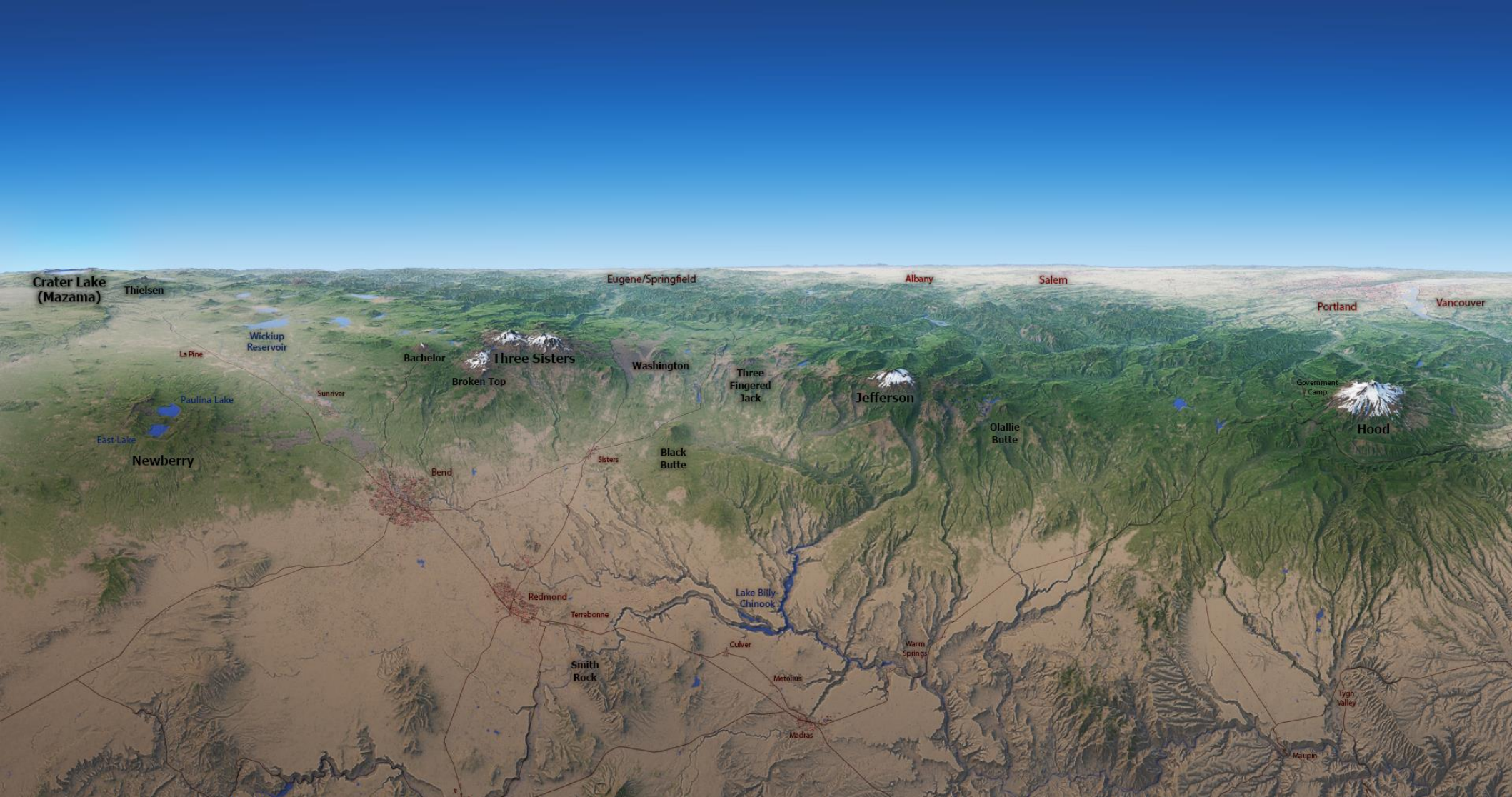
The areas highlighted in orange have a much higher exaggeration than the areas highlighted in blue. Thankfully, this can be corrected for by dampening the elevation values with a foreground to background gradient.



The other thing I realized is that even if you render this with an orthographic or parallel camera as I've done here, it will still look like a wide-angle shot owing to the nature of the distortion I used. I decided I was ok with this for this project but it may not be suitable for all cases. Even then, it can be counteracted during terrain bending by pulling the margins toward the camera.



After some terrain bending, local exaggeration, and several render passes, I put together this view of the Cascades. While I like that this wide view includes a lot of my favorite areas in both Washington and Oregon, in hindsight I feel that the volcanoes just don't have the prominence that I'd like them to have, even when they've been inflated to 300% of their true size. What I will probably do is finish this map and then reuse the terrain tile to make another map focused on the area from Hood to Bachelor, so that those peaks can really be the focus.



In the meantime, here's a closer view of the central portion of the current map, with labels. This is still a work in progress, but I hope to finish it and possibly some additional views in the near future.