Title

Entwine Point Tiles for 3D Visualization and Querying of ICESat-2

Abstract

Point Cloud data from non-optical sensors present challenges in scientific computing in both volume of data and files, even for cloud services environments. As part of the Multi-Mission Algorithm and Analysis Platform (MAAP), a joint open science platform for global biomass modelling, we've developed a cloud optimized workflow for using ATL08 (ICESat-2) data as a point cloud. For MAAP, the ATL08 data product is published as Entwine Point Tiles (EPT), allowing users to visualize and query the full extent of this collection interactively without pre-downloading, or preprocessing. The EPT format is a cloud-optimized point cloud data format which re-organizes points into a cloud friendly spatially indexed data structure. MAAP uses AWS S3 to store these point clouds and serves them over OGC specified APIs, 3DTiles for visualization, and WFS for querying. This workflow allows for interactive 3D visualizations in a web browser, including notebook environments and facilitates on the fly subsetting for interactive data exploration, all of which can be applied to other similar sensors.

Poster

The below material will end up in the AGU virtual poster system. The graphics and specific layout will be done in the AGU online system that's why it's not formatted as a poster here.

Authors

Alex Mandel, Kaylin Bugbee, Aimee Barciauskas

Background

Advanced Topographic Laser Altimeter System (ATLAS) is a sensor on the ICESat-2 satellite platform. ATLAS is one of a new class of recent space-based LiDAR sensors that produce a large volume of data with sparse geographic density. ATLAS has been estimated to produce at least 1 TB per day (Blumenfeld, 2019), and will collect data for at least 3 years. We consider the ATLAS data to be a sparse point cloud as data collection occurs 6 tracks, 3 pairs of 2, 90 m between pairs, and 3.3 km between tracks. By design, over time the density of points will increase, and after 3 years there will be approximately 1 km between all tracks (Neuenschwander and Magruder, 2016).

The Multi-Mission Algorithm and Analysis Platform (MAAP) is a joint NASA & ESA open science platform for global biomass modelling. The biomass research community is using the ATL08 dataset in developing the global spatial and temporal extent of their models, however, the volume of files for doing this work is prohibitively large for this task. ATL08 is the Land and Vegetation Height product that can be used to measure canopy height relative to ground height.

Challenges

- Selecting a contiguous area of interest requires reading many granules (scenes) from HDF5 files. Each data record has X,Y, Z coordinates and additional dimensions (variables)
- Visualizing the data set requires reading thousands of files. HDF5 is not optimized for use via web requests.

Solution

Convert all of ATL08 granules into a single global Entwine Point Tile (EPT) data store. EPT is a cloud optimized format for point cloud data. Conversion is achieved by using Point Data Abstraction Library, PDAL(“Point Data Abstraction Library,” 2020) to read from source HDF5 into intermediate temporary LAS files and then combined into an EPT with Entwine (“Entwine,” 2020).

Description of Entwine Point Tile (EPT) for ATL08:

- 3D spatial index (Octree), reorganizing data by 3D geography to optimize spatial queries. (Mosa et al., 2012)
- Combines over 100,000 input files into a geospatially optimized and indexed directory structure that can be queried as a single data source, in this case online cloud storage, S3 on Amazon Web Services.
- Normalizes data to common LiDAR dimensions:

- X - Longitude
- Y - Latitude
- Z - DEM height
- ElevationLow - segment terrain height best fit (h_te_best_fit)
- HeightAboveGround - canopy height (h_canopy)
- OriginId - a reference to an origin file for each data point
- GpsTime - standardize timestamps to GpsTime for cross dataset querying.

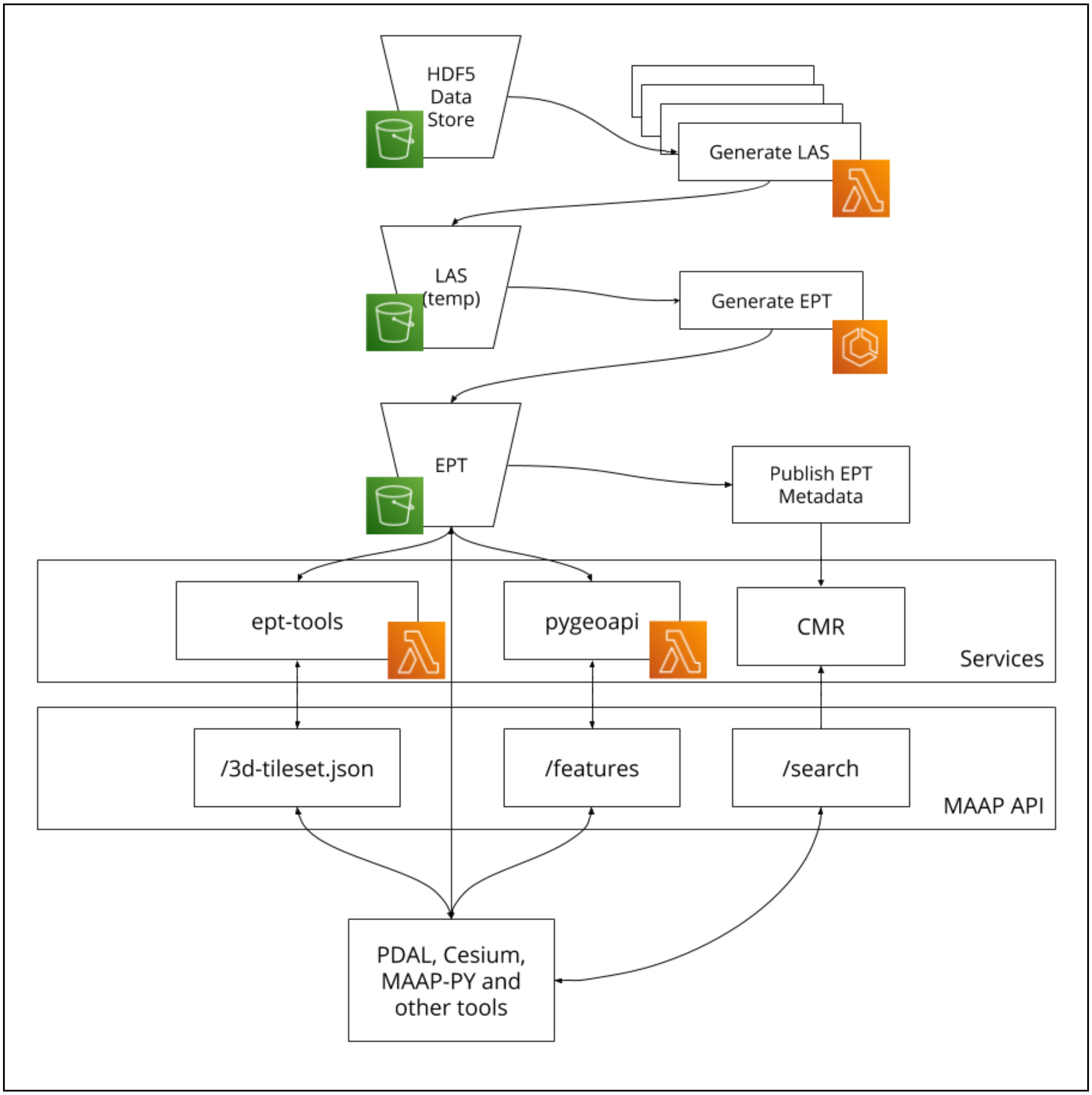

Fig. # EPT generation and service api workflow.

Results

- Allows on the fly generation of 3D Tiles (OGC cite) for use in clients like Cesium, Potree, or Deck.gl
- 3D Tiles automatically resample and reduce density based on zoom level requested

Fig. # Sample visualization of ATL08 3D tiles.

Bonus

New EPT store is now queryable with PDAL:

- PDAL pipelines allow 3D bounding box queries, dimension filtering, data conversions, and custom data workflows.
- Can be used from Jupyter notebooks with Python.

```
{
 "pipeline": [
   {
     "type": "readers.ept",
     "filename": "https://mybucket.s3.amazonaws.com/ept/atl08/ept.json"
   },
   {
```

```
      "type":"filters.crop",
      "bounds": "([64.7,64.8], [81.0,81.1])"
    },
    {
      "type" : "writers.text",
      "format": "geojson",
      "write_header": True
    }
  ]
}
```

Fig. # Example PDAL pipeline query filtering with a geographic bounding box, writing results to a geojson file.

Wrap EPT with a web service for quick access:

- Using pygeoapi ("pygeoapi documentation," 2020) and PDAL to create a OGC API - Feature service that allows for subsampling data and returning a GeoJson

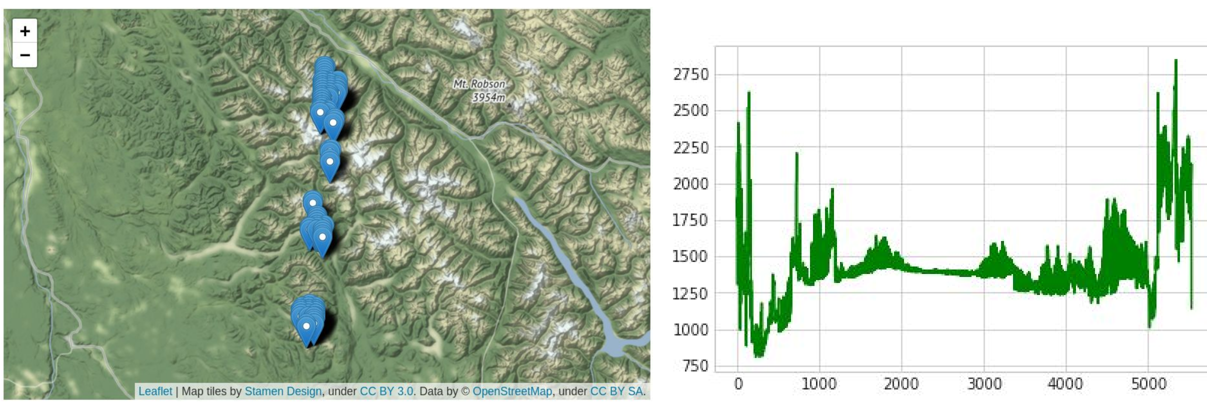

Fig. # Sample GeoJson selection of ATL08 data, and Z values in the selection.

Future

- Technique can be used on other sparse point cloud satellite data.
- 3D Tiles and OGC API - Feature services are still relatively new and end user client support can be improved.

Acknowledgements

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References

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