Data

1 Introduction

For this project we need needed various layers of GIS Data that would form important features necessary for identification of suitable locations for solar farms. Terrain information is a really important feature for this study because for setting up a solar farm we require large tracts of land with little changes in elevation. Solar irradiance is another important feature to be considered, Solar irradiance is defined as the amount of energy that could be generated from solar radiation incident on that certain place it is measured in watts per meter square W/m^2. Other important factors to consider are land cost, population density, land use, protected wildlife sanctuaries, etc.

2 Terrain Data

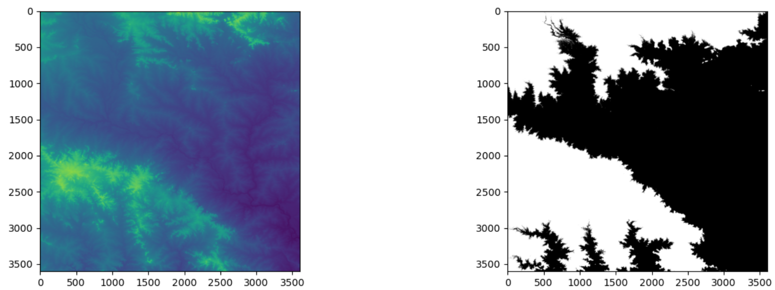
United States Geological Survey (USGS) is an agency of United States government that works across disciplines like geology, geography and hydrology. SRTM (Shuttle Radar Topography Mission) was undertaken to created digital elevation models (DEM) of earth surface in collaboration with NASA (National Aeronautics and Space Agency). This resulted in two Digital Elevation Models available for research with spatial resolutions of 1 arc-second (30 meters) and 3 arc-second (90 meters). For this study we will be using the DEM model with 1 arc second of spatial resolution[1].

2.1 How to Access Data

The Data is hosted on OpenTopography as a data collection[2]. It can be accessed via OpenTopography API after setting up an account. The data is hosted on a AWS S3 bucket in a linear file structure with many data files of '.tif' format. These are raster files that contain a raster band for elevation data with data value in meters. The files are named with corresponding latitude and longitude that helps in indentification of corresponding land area.

2.2 Data preparation and visualisation

We can use GDAL library[3] from Open Source GeoSpatial Foundation for reading the raster layers from '.tif' files and extracting the terrain data and visualising it.



(a) Elevation map for coordinates N 20' E 78'

(b) Elevation values with a mask on average

Figure 1: Comparison of Elevation and Elevation Data

```
In [19]: arr

Out[19]: array([[274.34293, 275.34253, 275.34213, ..., 215.55145, 213.55148,
                 212.55153],
                [277.34164, 277.34125, 276.34082, ..., 215.55042, 214.55045,
                 212.55049],
                [279.34033, 278.33994, 277.33954, ..., 215.54938, 214.54941,
                 212.54945],
                ...,
                [255.06439, 254.06436, 253.0643 , ..., 132.61017, 132.61002,
                 132.60985],
                [256.06323, 255.0632 , 254.06314, ..., 131.60904, 131.60889,
                 131.60873],
                [257.06207, 255.06204, 255.06198, ..., 131.60793, 131.60777,
                 131.60762]], dtype=float32)
```

Figure 2: Elevation values for coordinates N 20' E 78' in meters

3 Solar Irradiance Data

National Solar Irradiance Database (NSRDB)[4] is a database of solar irradiance calculated on hourly and half hourly bases. It is created and maintained by National Renewable Energy Laborartory (NREL), U.S. Department of Energy and many other contributors. Solar irradiance is measured in three types of measurement- Global horizontal, direct normal and diffuse horizontal irradiance.

DNI (Direct Normal Irradiance) refers to the amount of solar radiation recevied per unit area on the surface that is perpendicular to the sun rays incident on the surface, whereas GHI (Global Horizontal Irradiance) refers to the total amount of solar radiation received per unit area on earth's surface. It represents cumilation of diffused horizontal irradiance, ground-reflected radiation and diffused sky radiation.

3.1 How to access the data

The data is maintained by NREL in HDF5 (Hierarchical Data Format) format. In python h5pyd[5] package is used for accessing the database as per the NREL documentation. As the data is access through API, a token is needed that can be access on NREL's website. Files accessed are numbered by year. Hierarchical data contains various attributes like air temperature, DNI, GHI and relative humidity.

3.2 Data Preparation and Data Visualisation

There are two methods to prepare the data

3.2.1 By Accessing the HDF5 file system

The HDF5 file system can be accessed configuring the API on local system. Files are read as a python object and attributes can be subsetted and access based on the hierarchical structure of the file.

```
Out[6]: ['air_temperature',
         'clearsky_dhi',
         'clearsky_dni',
         'clearsky_ghi',
         'cloud_type',
         'coordinates',
         'dew_point',
         'dhi',
         'dni',
         'fill_flag',
         'ghi',
         'meta',
         'relative_humidity',
         'solar_zenith_angle',
         'surface_albedo',
         'surface_pressure',
         'time_index',
         'total_precipitable_water',
         'wind_direction',
         'wind_speed']
```

Figure 3: Attributes of a NSRDB dataset

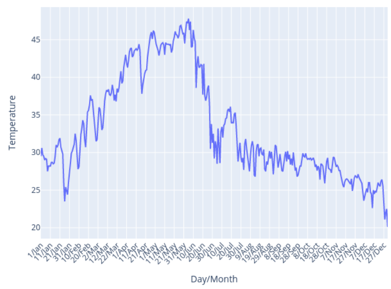
3.2.2 By using NSRDB web application

NSRDB viewer on the NREL website can be used to get afore mentioned attribute values for a specific location based on its latitude and longitude as we have DEM (digital elevation model) based on latitude and longitude this method would be preferred in this study.

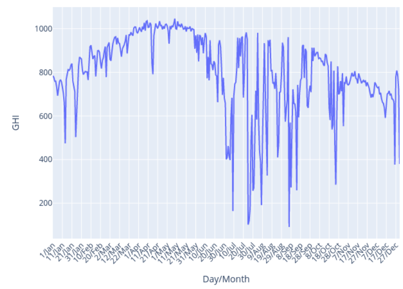
References

[1] USGS, "Usgs eros archive - landsat archives - landsat 8 oli (operational land imager) and tirs (thermal infrared sensor) level-1 data products active," 2023.

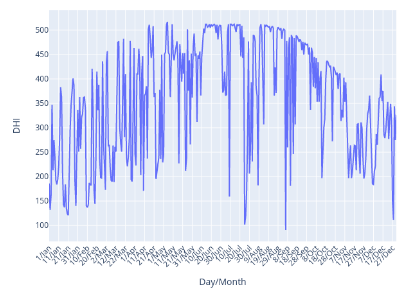
[2] T. G. Farr and M. Kobrick, "Shuttle radar topography mission produces a wealth of data," *Eos Trans. AGU*, vol. 81, pp. 583–583, 2000.



(a) Temperature for coordinates N 20’ E 78’



(b) GHI value by time



(c) DNI values by time

Figure 4: Comparison of Elevation and Elevation Data

[3] G. contributors, “GDAL/OGR geospatial data abstraction software library,” Open Source Geospatial Foundation, 2020. [Online]. Available: https://gdal.org

[4] M. Sengupta, Y. Xie, A. Lopez, A. Habte, G. Maclaurin, and J. Shelby, “The national solar radiation data base (nsrdb),” *Renewable and Sustainable Energy Reviews*, vol. 89, p. 51–60, 2018.

[5] A. Collette, *Python and HDF5*. O’Reilly, 2013.