Astronomical Observatory Sites

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Overview

Half of current astronomy is in theoretical chalkboard-math that takes place in offices and labs; but the more tangible, equally important half remains in the sky. Scattered across the world are astronomical observatories to allow scientists to both discover and confirm new questions and theories about our universe. This case study analyzes the types of considerations that go into choosing these observatory sites (we will not be considering satellite telescopes in this case study, only terrestrial observatory locations).

What is being organized?

While it may be seemingly-obvious to focus on the observatories themselves and claim that these are the resources being organized, it will be more telling to instead organize the possible observatory *sites* (i.e., locations) into relevant categories. This approach will allow us to better understand the organizing system by revealing information about not only the selected sites, but also those that were deselected. Focusing on the existing observatories would not provide as thorough of an analysis for this organizing system. It is a minute detail, but vital to this analysis all the same.

Why is it being organized?

The average quality of observations certainly corresponds to the inherent, static properties of a telescope — something that is *not* directly affected by observatory site. However, the average quality of observations is also closely related to the environmental conditions of the site (for instance, thickness of atmosphere, typical weather patterns, average humidity, light pollution, etc.)[4]. Because these conditions can change drastically depending on geographic location, categorization and subsequent classification of locations is required when planning construction of an observatory.

However, while the environmental conditions are often the most obvious[4], they are not the only categories to consider. For instance, physical accessibility to a location is a consideration (for both construction materials and teams, as well as astronomy research teams that will be performing the observing for centuries to come). A related facet here is one of centrality to the funding groups: if one or more universities are funding an observatory, it is likely that they will prefer the observatory is not on the other side of the world, if that can be avoided.

Another facet that often goes unnoticed is that of local responsiveness. Often, the response of natives is never an issue[1], but in a few cases it has been a fatal error to leave out in the planning. For instance, the planning team of the Thirty Meter Telescope (TMT) never considered this to be a concern when plotting out the land on Mauna Kea; however, protests by local citizens refusing to let scientists take over a sacred mountain are now becoming so out of hand that the TMT will likely be relocated to another location[2,3]. If this had been a consideration in the initial planning stages, there would not be quite so much chaos, but instead, large amounts of time, money, and emotions have been wasted.

How much is it being organized?

The classification of an observing site is a hierarchical categorization system made up of spectrum facets. For instance, each of the considerations of where to put a telescope — environmental, political, financial, social — are facets. Within each of these facets is some ranking or value that can be assigned to represent how proficient that location is in that category. However, different facets will have different weights — for instance, a site that has great financial and social responses is not necessarily as good as a site that has a great environmental and political implications. The specific hierarchy will likely vary from team to team, depending on their biggest priorities and goals for the project. The structure of this classification system makes it possible for the scouting teams to choose the *best* location by assigning a score to each considered site, and classifying the best as the chosen site.

When is it being organized?

The process of choosing a site location is one of the first considerations of the entire process. Often, the location will dictate certain parts of the telescope design — e.g., if the location is notoriously cold, the dome insulation will be a priority to keep the telescope at a reasonable working temperature, whereas if a location is in a more temperate area, this may not be as large of a concern. Certainly, before any building takes place, a site must be chosen and confirmed, which requires site-scouting to be an essential first step in observatory planning.

How or by whom is it being organized?

It may initially appear as if the scouting teams — those communities of expert astronomers employed by the funding universities that are assigned to the task of finding a location —

are the only ones performing the organizing of sites. They are, indeed, the ones to construct the classification system and determine the hierarchy of relevant facets, as well as to observe the sites and assign values to each of the corresponding spectrum facets. Often times, there are multiple universities and/or research institutions that go into funding an observatory together; depending on how wide the financial contributions vary, each institution typically holds a corresponding fraction of the decision.

However, there are other more indirect players that take part in this process; for instance, everyone that takes part in the economic nature of a region, as well as more vocal local communities (as it has been shown in the case of the TMT, native activist groups can play a large role in inhibiting an observatory from being built[2,3]).

Other considerations

As technology and science continuously progress, it is likely that the current astronomical observing methods will morph to match advances. Many universities now have remote observing stations within the buildings on campus for resident astronomers to use without leaving their offices. Due to the large amount of resources required to send a single astronomer to an observatory for local viewing (transportation fare, hotel fees, time lost), it is likely that the number of remote observing locations will only continue to increase with time.

If this is the way of the future, it is likely that the site-scouting categorization scheme will begin to put a lot less emphasis on physical accessibility, as long as it is still accessible enough of a region to both easily complete construction and implement reliable technological systems that will support this new type of user interaction.

References

[1] Buckley, Chris, and Adam Wu. "China Hunts for Scientific Glory, and Aliens, With New Telescope." The New York Times. The New York Times, 26 Sept. 2016.

[2] Overbye, Dennis. "Under Hawaiis Starriest Skies, a Fight Over Sacred Ground." The New York Times. The New York Times, 04 Oct. 2016.

[3] Rincon, Paul. "Biggest Telescope May Switch Location." BBC News. 01 Nov. 2016.

[4] Stock, J. "Procedures for Location of Astronomical Observatory Sites." Symposium - International Astronomical Union 19 (1963): 35-72.

Astronomical Observatory Sites: *Case Study Artifact*

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Map

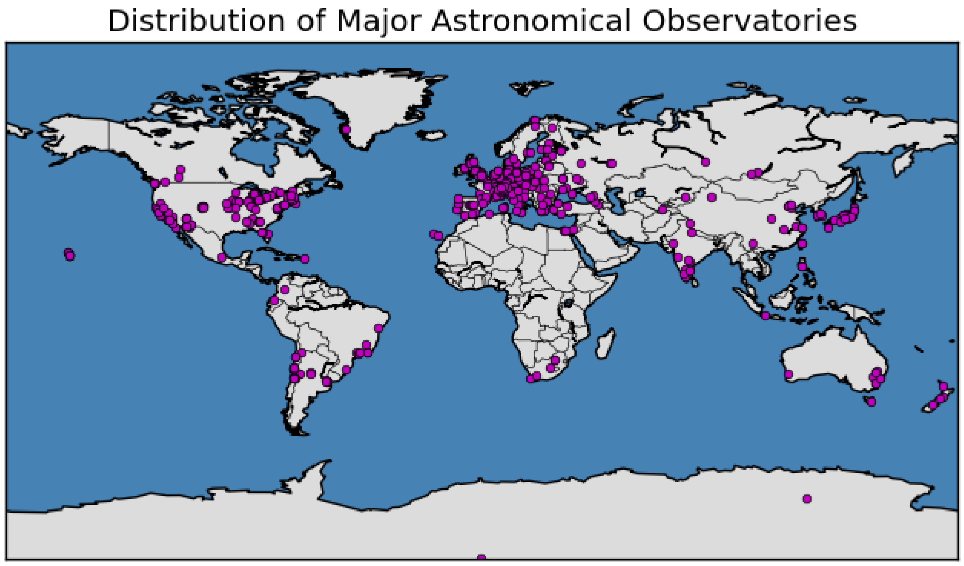

Figure 1: World map with major observatory sites marked in pink.

Description

This artifact is a visualization of the major astronomical observatories around the world, using a data set of 448 terrestrial observatories (see References). It becomes apparent from this map that scientific quality is certainly not the only set of facets applied in categorizing locations as promising (or not) sites for observatories; for instance, locations along the same latitudinal lines should have similar atmospheric conditions, excepting those along a coastline, and it is not necessarily true that the selected locations have much higher altitudes than any of those deselected locations (e.g, any of those countries or general regions without an existing observatory).

This implies that there are other determining facets in the location classifications that correspond to the selected sites. One may be financial stability of a country — indeed, it appears that the areas with the highest density of observatories are relatively stable regions; another related factor may be the number of research or scientific institutions in the region; yet another may be the accessibility of the region for relevant construction materials and/or visiting astronomy teams. However, one facet questioned in the case study is not apparent here: the responses of the local communities — this would require more in-depth social data, and likely a different type of visualization, to observe such responses; from the difficulty in analyzing this facet, it is easy to see why it is often left unconsidered by the groups of astronomers classifying possible telescope sites.

Code

What follows is the code written to generate this artifact using the provided dataset of observatory locations (see References):

```
# Info 202 case study artifact:
# [plotting main observatories around the world]
# Rachel Thorp
# Fall 2016

from bs4 import BeautifulSoup
import numpy as np
import matplotlib.pyplot as plt
from mpl_toolkits.basemap import Basemap

# -----------------------------------------------------------------
# extracting data
# -----------------------------------------------------------------
f = open("obs_sites.kml", "r")
info = BeautifulSoup(f, "lxml")
f.close()

lon_lst = []
lat_lst = []
num = 0
for i in info.findAll("placemark"):
    num += 1
    try:
        coords = i.coordinates.string.split(',')
```

```python
        lon_lst.append(float(coords[0]))
        lat_lst.append(float(coords[1]))

    except AttributeError:
        continue

# check how many observatories are shown:
print(len(lon_lst))

# ------------------------------------------------------------
# plotting on map
# ------------------------------------------------------------
fig = plt.figure()

themap = Basemap(projection='gall',
              llcrnrlon = -180,
              llcrnrlat = -90,
              urcrnrlon = 180,
              urcrnrlat = 90,
              resolution = 'c')

themap.drawcoastlines()
themap.drawcountries()
themap.fillcontinents(color = 'gainsboro', lake_color = "steelblue")
themap.drawmapboundary(fill_color='steelblue')

x, y = themap(lon_lst, lat_lst)
themap.plot(x, y, 'o', color='m', markersize=4)
plt.title("Distribution of Major Astronomical Observatories")
plt.savefig("artifact.png")
plt.show()
```

References

Delmotte, Nausicaa. *Major Astronomical Observatories on Earth.* European Southern Observatory, 11 Oct. 2007. KML.