Google Earth Visualization of Magnetometer Data

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Abstract

The PENGUIn Automatic Geophysical Observatories in the Antarctic contain a wide array of scientific instruments including several magnetometers. This data are made available in a variety of forms to researchers around the world including binary data, ASCII data, graphs, and spectrograms. As part of this project, Keyhole Markup Language (KML) files were created to allow the user to visualize the time lapse of magnetic field vectors at our stations. This allows us to observe the activity and motion of the field during magnetic storms. We are trying to better understand the effects of the changing magnetic fields on surface conditions such as communication and power distribution systems.

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1 Introduction

As part of the study of Earth's magnetic field, a series of unmanned stations in the Antarctic collect and record data using magnetometers. This data is currently analyzed using graphs and spectrograms. To provide a different way of looking at the data, an application was developed using Keyhole Markup Language (KML).

2 Background

The Augsburg College Physics Department, along with a number of other colleges and universities, has been involved in space physics research since the 1980s. In the early 1990s a series of unmanned stations were deployed to collect more data than can be collected from just the manned Antarctic stations. The Augsburg College Computer Science Department is involved in the collecting and processing of this data. [2]

2.1 PENGUIn AGO stations

The Polar Experiment Network for Geophysical Uppper atmosphere Investigations (PENGUIn) Automatic Geophysical Observatories (AGO) are unmanned stations that contain a wide range of scientific instruments, including several magnetometers. The first of the six AGOs were installed during the 1993-94 Antarctic summer, with all six having been installed by the 1997-1998 summer. AGO station P1 is shown in Figure 1. As of 2011, five stations are active. [3] [5]

Figure 1: AGO P1 in 2003. [1]

Each station contains a variety of instruments, including wind sensors, thermometers, riometers, and magnetometers, and cameras to take pictures of auroras. The AGOs use two different types of magnetometers, fluxgate and searchcoil magnetometers. Fluxgate magnetometers measure the absolute value of the magnetic field with high accuracy, while searchcoil magnetometers measure the change in the field at higher sampling rates.

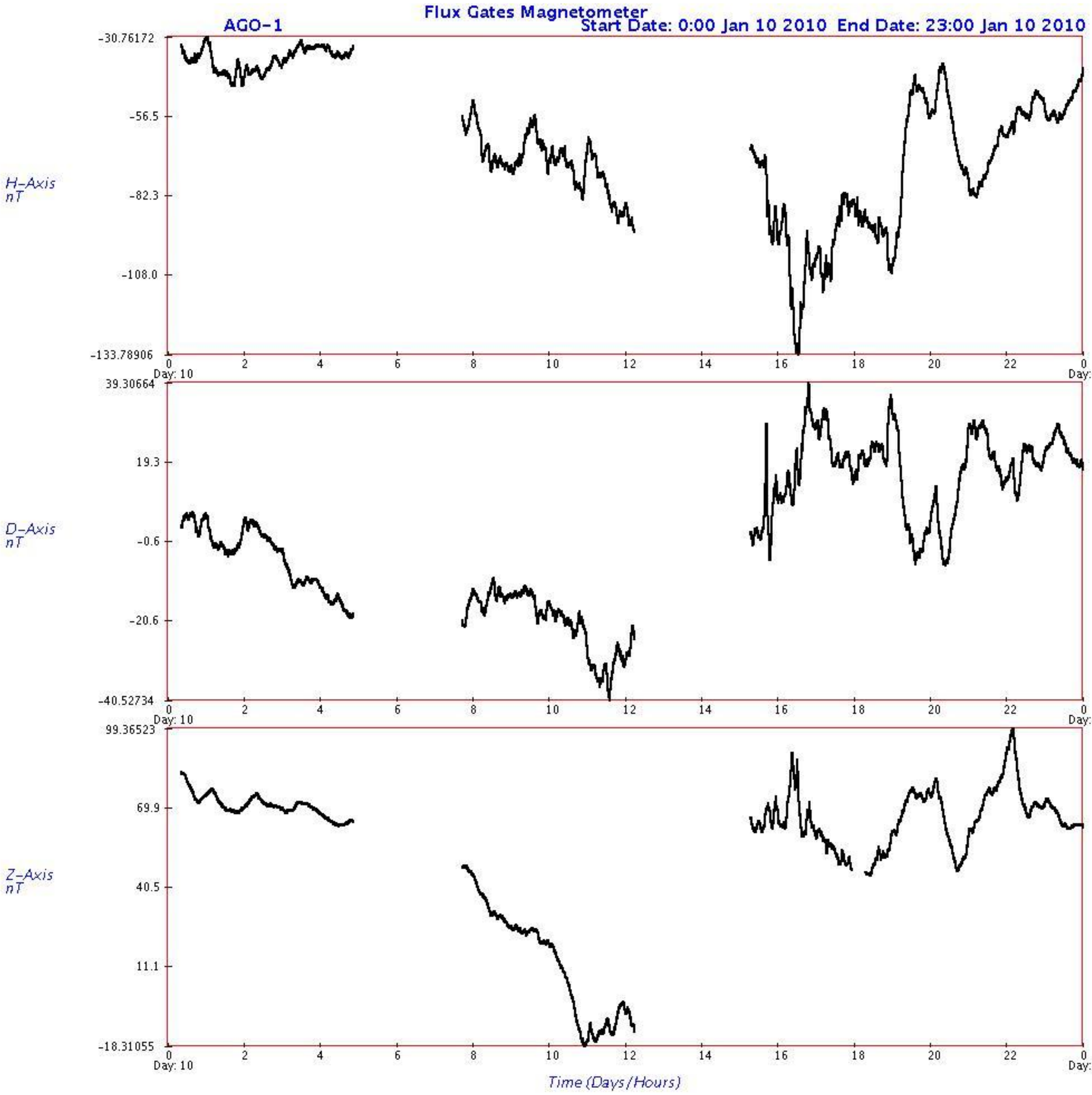

Figure 2: Fluxgate magnetometer data for AGO P1, 10 January 2010. [6]

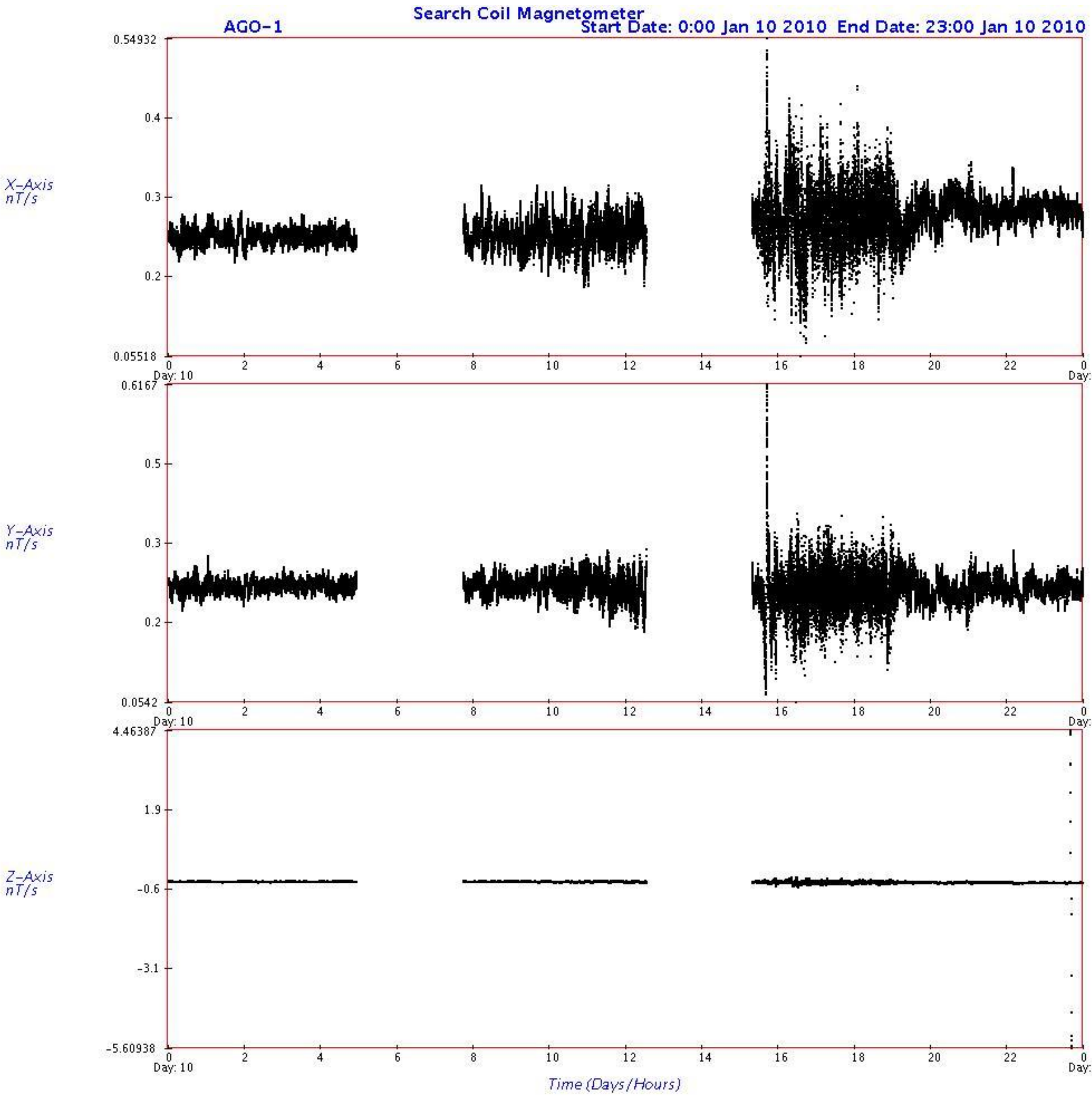

Figure 3: Searchcoil magnetometer data for AGO P1, 10 January 2010. [6]

After data are collected by the instruments, they are recorded to a flash memory card on site and are then transmitted via Iridium satellite link to Augsburg College. At Augsburg, the raw data are processed and made publicly available on the space physics website (space.augsburg.edu). Currently the magnetometer data are available in the original binary form, as ASCII text files, as graphs, and as spectrograms. As part of this project, software was developed that creates Keyhole Markup Language (KML) files to allow the user to visualize the time lapse of magnetic fields at the stations.

3 Google Earth Magnetometer Visualizer

3.1 Keyhole Markup Language

Keyhole Markup Language (KML) is an XML schema developed for Google Earth to allow for the display of geographic data. KML files can define lines, polygons, placemarks, and photo overlays. These shapes can also optionally have a time span specified, which can consist of a begin and end time, or, alternatively, only a begin time or end time. When time spans are included, the Google Earth user can either choose to view the shapes at a specific time, or play back all the shapes. This allows for animations of data to be created.

3.2 Development

Before development of the program could begin, it was necessary to understand the format of KML files and any limitations of KML. One limitation noticed very quickly is that there is no way to quickly create a circle. After a bit of research a PHP script created by ink_polaroid [4] was found that takes either a center and a radius or a center and another point and outputs a block of KML code to form a circle.

For the visualization of the magnetic fields, a vector starting at the position of the station showing the X (north-south) and Y (east-west) components of the magnetic field at a station was needed. Although Z axis (vertical) data are available for the stations, KML does not easily allow for the start and end points to have different elevations. As a result, visualization of the Z component of the magnetic field was omitted.

The program starts by reading in a parameter file, which would be created by a request form on the Augsburg space physics website. This file specifies the station(s) to include in the visualization, the start and end times, and the amount of time between each sample. For each individual data sample that is being included in the output, a KML `Placemark` block (sample shown in Figure 4) is created, consisting of a dot showing the location of the station, and a `LineString`. The points for the `LineString` are calculated using a formula derived from ink_polaroid’s KML circle generator. The individual `Placemark`s are then assembled into the final KML file, which is then placed on an FTP server to be downloaded by the user. Each request is named with the current date and a random five digit number, and consists of the parameter file and the KML file.

```xml
<Placemark>
    <name>PENGUIn AGO P1</name>
    <TimeSpan>
        <begin>2010-02-09T00:01:00Z</begin>
        <end>2010-02-09T00:02:00Z</end>
    </TimeSpan>
    <Style>
        <IconStyle>
            <scale>0.4</scale>
            <Icon>
                <href>images/dot.png</href>
            </Icon>
            <hotSpot x="0.5" y="0.5" xunits="fraction" yunits="fraction" />
        </IconStyle>
        <LineStyle>
            <color>ff0000ff</color>
            <width>6</width>
        </LineStyle>
    </Style>
    <MultiGeometry>
        <Point>
            <coordinates>129.61,-83.86,0</coordinates>
        </Point>
        <LineString>
            <coordinates>129.61,-83.86,0 134.362198587,-83.3405278321,0</coordinates>
        </LineString>
    </MultiGeometry>
</Placemark>
```

Figure 4: KML code sample.

Figure 5: Sample KML as viewed in Google Earth.

4 Future work

The current version is extremely slow, taking a minute or more per request. This is most likely due to the large numbers of I/O operations done while reading the ASCII files. The ASCII files currently contain data samples for each second. Since it seems unlikely that data at this resolution would need to be visualized in Google Earth, one solution would be to create copies of the data files that only have data every minute. This would reduce the number of file read operations by a factor of sixty, greatly increasing the speed of the software. In addition, there are other opportunities for the code to be optimized, since this is only an early version of the final program.

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