Ionospheric Nowcast

Report in support of BAA16-086

Altamira Corporation Inc.

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Contents

1 Introduction

Now-casting is a relatively new form of forecasting that focuses on time frames as close to "now" as possible. While the beginnings appear to be in the meteorological area, now-casting has found uses in economics and has been used to help shape governmental policies [2].

In the meteorological world, now-casting is taken as to be anywhere from 0-6 hours looking forward in time. Very Short-Range Forecasts (VSRF) takes the time fame of 0-12 hours [4]. Instacast is starting to take hold as a term used for events that need immediate actions, such as severe thunderstorms and tornadoes.

For the sake of this report, Ionospheric Now-casting will be defined by the 0-6 hour time frame.

2 Ionospheric Now-casting Considerations

Ionospheric Forecasting and Ionospheric Now-casting will rely on numerous types of sensors spanning across multiple areas of meteorology and communications. The quality of these sensors will range in quality from poor to good to excellent[4].

The anticipated amount of data the sort through and process will be high. This will be made more challenging do to the variety of sensors to be used. In the case of Ionospheric Now-casting the use of Artificial Intelligence and Machine Learning techniques will be crucial to aid analysts in making quick and accruated predictions.

3 Vertical Soundings

Vertical Soundings are the traditional means to measure the conditions in the Ionosphere. They operate by performing a High Frequency (HF) sweep and recording which frequencies reflect back to the transmitter/receiver. As the name implies, these signals are directed vertically. Figure 1 shows a typical Vertical Sounding.

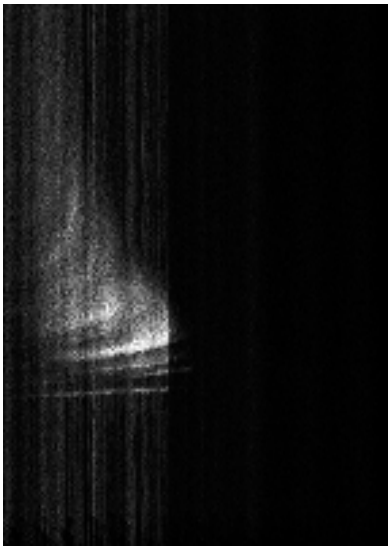

Figure 1: Typical Vertical Sounding

4 Modeling

Ionospheric Modeling is another traditional forcast mechanism for the ionosphere. Typical models rely on ray tracing and refractions based on electron densities in the ionophere. Ray tracing modeles can render acurate signal paths. Figure 2 show output from one such model.

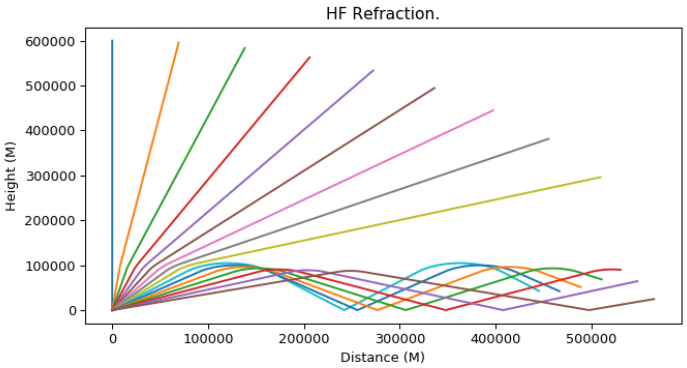

Figure 2: Altamira Ionosphere Modeling

5 Meteor Reflections

Meteor Reflections, also known as meteor scatter, is the bouncing of radio signals off the ionized trails of meteors entering the earths upper atmosphere (ionosphere.) Along with the FM radio band, frequencies that reflect the best are around 30MHz, 50MHz, and 150MHz [3]. An example of meteor scatter is shown in figure 3.

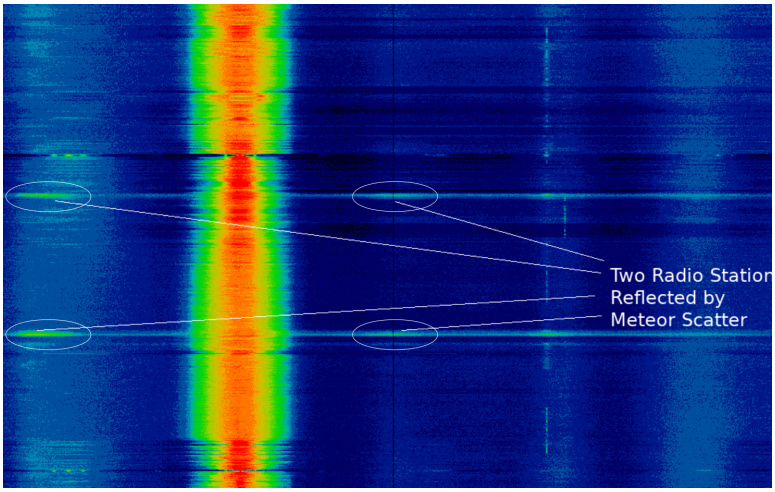

Figure 3: Altamira 2019 Zeta Aquariids Collect

6 Meteor Reflections with SBIR

Meteor Reflections between two radio transmit/receive stations will take the form of familiar bisatatic ellipse containment. The meteor trail needs to be tangential at some point to an ellipse with the two stations at the foci[3]. In addition, the duration that the ionized trails are "active" is usually measured in seconds. The ambiguity generated by these constraints can be significant. With the addition of SBIR data being able precisely locate positions of a meteor's heat signature, corresponding meteor scatter data collections can be made vastly more informative.

7 ADS-B

Automatic Dependent Surveillance/Broadcast (ADS-B) is scheduled to be a requirement by January 1, 2020[1]. As such, the required position broadcasts will make excellent Known Reference Points (KRP) for RADAR calibration, since position, velocity, and airplane type will be contained in the ADS-B message.

Below is an example of an ADS-B hex code and some of the decoded information.

```
8DAD84DE202CC371C32CE0576098

The structure of the message is as follows:

     DF--- CA-  ICAO--  DATA------------------  PI----
HEX: 8   D      AD84DE  2   0     2CC371C32CE0  576098
BIN: 10001|101  ******  00100|000 ************  ******
DEC: 17   |4            4     0
                         TC    *
```

The International Civil Aviation Organization (ICAO) code is an unique identifier for a particular air-frame. The ICAO code "4840D6" is is a Boeing 737-823 run by American Airlines, according to "https://junzisun.com/adb/", see figure 4.

Figure 4: Not an American Airlines 737-823

References

[1] *Automatic Dependent SurveillanceBroadcast (ADSB) Out Performance Requirements To Support Air Traffic Control (ATC) Service; Final Rule.* United States Department of Transportation, Federal Aviation Administration, May 2010.

[2] Chris Fleisher. There goes the neighborhood, June 2018.

[3] NT0Z Kirk Kleinschmidt. Catch a falling star. *QST*, 4:62–67, October 1997. American Radio Relay League (ARRL).

[4] World Meteorological Organization (WMO). *Guidelines for Nowcastng Techniques, WMO-No. 1198.* Chairperson, Publications Board, World Meteorological Organization (WMO), 2017.