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1 Introduction

1.1 Overview

The primary purpose of the High-Frequency (HF) Propagation system is to provide AFWA the capability to monitor high-latitude HF propagation conditions in near-real time. Specifically, the software uses real-time data collected by the SuperDARN network of HF radars to determine ionospheric F-region critical frequencies and MUF as a function of range from the radar.

1.2 Summary of Architecture

Figure 1.1 shows a diagram of the architecture and data flow.

Figure 1.1: Architecture and Data Flow, HF Propagation Software System

The HF propagation software receives real-time SuperDARN data from the server located at JHU/APL. For each radar running in a mode compatible with this product, tasks on the local computer generate maps of MUF as a function of range and F-region critical frequencies. These maps are generated every five minutes, and the most recent set is made available on the web page output display.
1.3 Statement of Purpose

The purpose of this document is to describe the HF Propagation software architecture and to identify the components of the system.
2 Product Structure

2.1 Executive Script Software Calling Hierarchy

1.0 real_time_muf.script
   1.1 real_time.script
      1.1.1 find_times
      1.1.2 generate_real_time_MUF
         1.1.2.1 fit_real_time_gscat
         1.1.2.2 do_linear_fit
         1.1.2.3 compute_muf
         1.1.2.4 compute_fof2
         1.1.2.5 plot_real_time_mufs
            1.1.2.5.1 setup_map
            1.1.2.5.2 map_muf
            1.1.2.5.3 finish_map
      1.1.3 purge_history_files
      1.1.4 plot_history
         1.1.4.1 plot_scatter_history
   1.2 scale_ps
   1.3 critical_freqs
      1.3.1 map_critical_freqs
         1.3.1.1 get_site_info

2.0 purge_old_data.script
3.0 check_real_time_feed
4.0 client2
3 Object Descriptions

3.1 SCRIPT Objects

3.1.1 real_time_muf.script

This executive script will run the software using data from each of the radars listed in the parameters.

CALLING SEQUENCE: real_time_muf.script s1 s2 ... sn

WHERE:

\[ s1, s2, ... sn = \text{SuperDARN radar site ID numbers} \]

3.1.2 real_time.script

This script is called by the executive script and performs station-keeping tasks as well as calling the main HF propagation software for each SuperDARN radar identified by the executive script.

CALLING SEQUENCE: real_time.script s1

WHERE:

\[ s1 = \text{SuperDARN radar site ID number} \]

3.1.3 purge_old_data.script

This script simply calls the executable named “purge_old_data”.

CALLING SEQUENCE: purge_old_data.script

3.2 C Objects

3.2.1 find_times

This routine examines the SuperDARN data collected in real-time to determine the range of times over which the most current sweep was collected. The output from this routine is sent to a file named “time_range” and gives the time range of the current sweep or a message stating, “No Sounder Mode Data Found” if there is no current data from the selected radar.

CALLING SEQUENCE: find_times s1
WHERE:

\[ s1 = \text{SuperDARN radar site ID number} \]

3.2.2 purge_history_files

This routine erases any stored history files that are older than 23.5 hours.

CALLING SEQUENCE: purge_history_files s1

WHERE:

\[ s1 = \text{SuperDARN radar site ID number} \]

3.2.3 scale_ps

This routine reads a postscript file and scales it to a size appropriate for web display.

CALLING SEQUENCE: scale_ps fname.ps

WHERE:

\[ fname.ps = \text{name of the postscript file to scale} \]

3.2.4 purge_old_data

This routine examines all the near-real time SuperDARN data and erases any files that are more than one hour old.

CALLING SEQUENCE: purge_old_data s1 s2....sn

WHERE:

\[ sn = \text{SuperDARN radar site ID number} \]

3.2.5 check_real_time_feed

This routine checks the most recent near-real time SuperDARN data file to determine if the data feed is still active. If the most recent file for any radar is more than one minute old, the data client software for that radar is stopped and restarted.

CALLING SEQUENCE: check_real_time_feed s1 s2...sn
WHERE:

\[ sn = \text{SuperDARN radar site ID number} \]

3.2.6 client2

This routine is the data client which receives the real-time SuperDARN data and stores it on disk.

CALLING SEQUENCE: client2 add port

WHERE:

\[ add = \text{internet address of the data server} \]
\[ port = \text{remote connection port} \]

3.3 IDL Objects

3.3.1 generate_real_time_MUF.pro

This routine calls the various other IDL routines which perform the actual calculations and fitting.

CALLING SEQUENCE: idl generate_real_time_MUF.pro

3.3.2 fit_real_time_gscat.pro

This routine reads the near-real time data from the selected SuperDARN radar and performs a non-linear fitting to the E- and F-region ground scatter returns. In addition to fitting the ground scatter profiles, this routine locates the skip distance for each frequency and beam number and outputs this information to a data file named “min_range.fits”. Plots of the raw data, fitted profiles, and skip distances are generated and stored for later web viewing.

CALLING SEQUENCE: fit_real_time_gscat

3.3.3 do_linear_fit.pro

This procedure reads data from the data file “min_range.fits” and performs a linear fit to those data, iteratively eliminating outlying points. Output is to a data file named “linear_fits.data”. Plots of the linear fits are generated and stored for later web viewing.

CALLING SEQUENCE: do_linear_fit
3.3.4 compute_muf.pro

This procedure reads data from the data file “linear_fits.data” and inverts these data to obtain MUF as a function of range from the selected radar. Several output files are written: “MUF_3000km.data” contains the MUF at 3000 km for each radar beam, “MUF_0km.data” contains the MUF at 0 km for each radar beam and “latest_muf_data” contains information specifying the linear variation of MUF with range.

CALLING SEQUENCE: compute_muf

3.3.5 compute_fof2.pro

This procedure reads data from the data file “min_range.fits” and uses these data to estimate F-region critical frequencies at half the skip distance (i.e. at the reflection point of the skip ray). The computed values are written to a data file name “critical_freqs.out”.

CALLING SEQUENCE: compute_fof2

3.3.6 plot_real_time_mufs.pro

This procedure reads data from the file “latest_muf_data” and uses these data to generate plots of MUF versus beam number and range from the selected radar. Plots are output to a postscript file named “muf_map.ps”.

CALLING SEQUENCE: plot_real_time_mufs

3.3.7 setup_map.pro

This procedure initializes variables and sets parameters used in making the MUF plots.

CALLING SEQUENCE: setup_map, title, radar_id

WHERE:

\[ title = \text{Desired MUF plot title} \]
\[ radar\_id = \text{SuperDARN radar site ID number} \]

3.3.8 map_muf.pro

This procedure does the actual plotting of MUF values to the “muf_map.ps” plot.

CALLING SEQUENCE: map_muf, radar_id, beam, range, muf,
max_muf, min_muf

WHERE:

\(\text{radar\_id}\) = SuperDARN radar site ID number
\(\text{beam}\) = array of beam numbers for which MUF will be plotted
\(\text{range}\) = array of ranges at which MUF is determined

3.3.9 \textit{finish\_map.pro}

This procedure reads data from several data files and uses this information to annotate the MUF plots.

CALLING SEQUENCE: \textit{finish\_map}, max\_muf, min\_muf, colorbar\_pos, radar\_id

WHERE:

max\_muf = maximum plotting limit used on the colorbar
min\_muf = minimum plotting limit used on the colorbar
colorbar\_pos = where to locate the colorbar
radar\_id = SuperDARN radar site ID number

3.3.10 \textit{plot\_history.pro}

This routine calls an IDL procedure which plots the ionospheric scatter history.

CALLING SEQUENCE: \textit{plot\_history}

3.3.11 \textit{plot\_scatter\_history.pro}

This routine reads the ionospheric scatter history and generates a plot named “optimal\_freq\_history.gif”.

CALLING SEQUENCE: \textit{plot\_scatter\_history}

3.3.12 \textit{critical\_freqs.pro}

This routine simply calls the \textit{map\_critical\_freqs} procedure.

CALLING SEQUENCE: \textit{critical\_freqs}
3.3.13 map_critical_freqs.pro

This routine reads the data file “critical_freqs.all_sites” and uses the data to generate a map of SuperDARN-estimated F-region critical frequencies. The data are plotted to a file named “critical_freq_map.ps”.

CALLING SEQUENCE: map_critical_freqs

3.3.14 get_site_info.pro

This routine reads various information related to each SuperDARN radar.

CALLING SEQUENCE: get_site_info, site_name, site_lat, site_lon, site_angle, site_beam_width

WHERE:

site_name = array of radar names with one entry for each radar ID
site_lat = array containing the latitudes of each radar
site_lon = array containing the longitudes of each radar
site_angle = array containing the mean look-direction for each radar
site_beam_width = array containing the beam width for each radar
4 External Interface

4.1 Input Data

The HF propagation software shall ingest near-real time SuperDARN data recorded in a specific mode designed for this project named the “sounding mode”. The data are received by client software supplied by JHU/APL and modified at UAF/GI.

4.2 Operating System Services

The shell scripts and C routines of the HF propagation application will execute under the Linux operating system.

4.3 Output

For each radar running in a mode compatible with this product, the HF propagation software generates maps of MUF as a function of range and F-region critical frequencies. These maps are generated every five minutes, and the most recent set is made available on the web page output display.

4.4 Other Software Programs or Libraries

The data client software supplied by JHU/APL and modified at UAF/GI depends upon several libraries which are part of the SuperDARN library suite. All required libraries are provided with the HF propagation software package.
Related Documentation

### Appendix A  Acronyms and Abbreviations

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<th>Definition</th>
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<tbody>
<tr>
<td>AFWA</td>
<td>Air Force Weather Agency</td>
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<tr>
<td>APL</td>
<td>Applied Physics Laboratory of Johns Hopkins University</td>
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<tr>
<td>foF2</td>
<td>F2-region critical frequency</td>
</tr>
<tr>
<td>JHU</td>
<td>Johns Hopkins University</td>
</tr>
<tr>
<td>MUF</td>
<td>Maximum Usable Frequency</td>
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<tr>
<td>SuperDARN</td>
<td>Super Dual Auroral Radar Network</td>
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