

Using MATLAB to View OPeNDAP Files in the NCAR/EOL Field Data Archive

Updated: 3 March 2022

Authorship: NCAR Earth Observing Laboratory Data Management & Services Group

Contact: eol-archive@ucar.edu

Licensing: The code associated with this document is provided freely and openly. Users are hereby granted a license to access and use this code, *unless otherwise stated, subject to the terms and conditions of the GNU Affero General Public License 3.0 (AGPL-3.0;* <https://www.gnu.org/licenses/agpl-3.0.en.html>). This documentation and associated code are provided “as is” and are not supported. By using or downloading this code, the user agrees to the terms and conditions set forth in this document.

Acknowledgment: This work was sponsored by the National Science Foundation. This material is based upon work supported by the National Center for Atmospheric Research, a major facility sponsored by the National Science Foundation and managed by the University Corporation for Atmospheric Research. Any opinions, findings and conclusions or recommendations expressed in this material do not necessarily reflect the views of the National Science Foundation.

Note: There is an issue with **MATLAB R2021b**. If you are running a matlab program on a linux computer and you receive the following error:

“Error using matlab.internal.imagesci.netcdflib”

try creating a **.dodsrc** file in the directory where the matlab program exists that contains the following line:

HTTP.SSL.CAINFO=/etc/ssl/certs/ca-bundle.crt

Then restart matlab and try running the program again. It appears that something changed in the MATLAB code of MATLAB R2021b that changed the way it uses system certificates.

General Description

This document serves as a guide on how MATLAB can be used with OPeNDAP within the EOL Field Data Archive to plot variables found in files with OPeNDAP access without needing to download the files. Two examples of matlab plotting scripts can be found in the files “**matlab_xy.m**” and “**matlab_xyz.m**”. The scripts were created by NCAR EOL and show how 2D and 3D plots can be created in matlab, respectively. Note that these scripts are provided “as is” and are not supported. For any questions about MATLAB features, functions, etc. refer to the MathWorks help center at:

OPeNDAP within the EOL Field Data Archive

The EOL Field Data Archive (FDA) contains datasets that have OPeNDAP compatibility. An example dataset in the FDA would be [GCIP/ESOP-95 Surface: Hourly Surface Meteorological Composite](#). This dataset was used to generate the plots in the sections below.

For this dataset, 2D plots were created for a site (Ashton) for Temperature and Dew Point using script `matlab_xy.m`. See Figure 22. A 3D plot was also created using `matlab_xyz.m` that shows Temperature specific time over the entire area of interest in the file (See figure 29).

How to use the Matlab Plot tools with the OPeNDAP Capabilities in the EOL Field Data Archive

Choose a dataset in the EOL FDA that has OPeNDAP Capabilities

Figure 1 shows the top portion of the EOL FDA dataset description page for the [GCIP/ESOP-95 Surface: Hourly Surface Meteorological Composite](#) dataset. The OPeNDAP feature is located in the “Data access” section of the dataset page. Clicking on the “OPeNDAP access” link will show the OPeNDAP page for the dataset. This page will show a list of all the files in the dataset and their corresponding OPeNDAP links. If a dataset in the EOL FDA does not have an OPeNDAP link in the “Data access” section, then the dataset does not have OPeNDAP capabilities. The user must then download the data (via the Order link) and apply the provided matlab scripts to plot the data.

GCIP/ESOP-95 Surface: Hourly Surface Meteorological Composite

Summary

The GCIP/ESOP-95 Hourly Surface Composite contains data from several networks (i.e., Artais Automated Weather Observation System, Handar AWOS, and Qualimetrics AWOS, Oklahoma Mesonet, Department Of Energy Atmospheric Radiation Measurement Surface, High Plains Climate Network, Automated Surface Observing System, Wind Profiler Network, national Climatic Data Center Surface Airways Observations, and Colorado Agricultural Meteorological data) for the ESOP 95 domain. Data from these sources were merged and quality controlled to form this Surface Composite.

Data access




-  [ORDER](#) data for delivery by FTP
-  [Preview](#) dataset (plots/images)
-  [OPeNDAP access](#)

Figure 1: Top portion of the dataset description page for the EOL GCIP/ESOP-95 Surface: Hourly Surface Meteorological Composite dataset. The OPeNDAP feature for datasets (if applicable) is located in the “Data access” section of the dataset description page.

Get the Link to the File for Plotting

Figure 2 shows the “OPeNDAP access” page for the EOL GCIP/ESOP-95 Surface: Hourly Surface Meteorological Composite dataset. This page lists all files in the dataset. From here the OPeNDAP link files can be found. Clicking the “scissors” symbol will show the OPeNDAP link for a specific file. This link can then be fed into the MATLAB scripts for plotting. For the plots shown in this document, file “ES95HRLY_950715.qcf” was used and the OPeNDAP link for that file is:

https://data.eol.ucar.edu/opendap/data/esop_95/hrly_sfc/ES95HRLY_950715.qcf

GCIP/ESOP-95 Surface: Hourly Surface Meteorological Composite

Back to [dataset homepage](#)

OPeNDAP access links are available below. The "Webform" links provide an HTML web interface to the OPeNDAP data protocol and is useful for limited textual review of the data file. The "DAP" links provide access for OPeNDAP-enabled software applications. You cannot access the DAP link via a web browser or standard HTTP. Right-click the DAP link or use the scissors icon to copy the link for pasting into your application.

See the [EOL data archive OPeNDAP help](#) page for more info.

183 files
Max results:

File info	Download	OPeNDAP
ES95HRLY_950401.qcf	1911 KiB	Webform DAP <div> https://data.eol.ucar.edu/opendap/data/esop_95/h </div>
ES95HRLY_950402.qcf	2 MiB	Webform DAP
ES95HRLY_950403.qcf	2 MiB	Webform DAP

Figure 2: The OPeNDAP page for the EOL GCIP/ESOP-95 Surface: Hourly Surface Meteorological Composite dataset. Clicking on the “scissors” symbol for a file will show the OPeNDAP link for that specific file.

Store the Data File Link in the MATLAB script

In the MATLAB script, this link to the data file should be stored in a variable as shown in Figure 3 below. Figure 3 shows how the file link is stored in the provided sample scripts. (Note: All of the MATLAB figures come from the sample script “matlab_xy.m”.) The variable “myFile” stores

the link to the data file. If the file was downloaded locally onto the users system, the full path to the file could be included as well. If the file is located in the same directory as the script, the following line can be used instead:

```
myFile = ES95HRLY_950715.qcf
```

If the file is located in a different directory, this line can be used instead:

```
myFile = /directory1/directory2/ES95HRLY_950715.qcf
```

In the line above, “directory1” and “directory2” are placeholders indicating the full system path to the data file. Replace these directories with the proper path where the file is located on the machine. After the file link is stored, the data in the file can be displayed.

```
35 % Create the variable to store the opendap url or for the local file.
36
37 myFile='https://data.eol.ucar.edu/opendap/data/esop_95/hrly_sfc/ES95HRLY_950715.qcf';
38 %myFile='ES95HRLY_950715.qcf';
39
```

Figure 3: The link for the file should be stored in a variable in the MATLAB script. In this example, the link is stored in a variable named “myFile” as seen in line 37.

MATLAB ncdisp Command

The MATLAB command “ncdisp” is used to view the metadata and the variables in a file. Figures 4-6 show what is displayed in the Command Window when the “ncdisp” command is executed. The metadata and variables in the data file can be determined this way. These variable names are then used in the “ncread” MATLAB commands to retrieve and plot specific variables. See the “ncread” command example in Figure 7.

```
40 % Display the information in the netCDF file with 'ncdisp'.
41
42 ncdisp(myFile)
```

Figure 4: The “ncdisp” command is used to view the file in the Command Window in MATLAB.

```

Command Window
New to MATLAB? See resources for Getting Started.

>> ncdisp(myFile)
Source:
    https://data.eol.ucar.edu/pendap/data/esop_95/hrly_sfc/ES95HRLY_950715.qcf

Format:
    classic

Global Attributes:
    Server      = 'DODS FreeFrom based on FFND release 4.2.3'
    text        = 'Nominal Time Actual Time Network Station Latit
    Title       = 'GCIP/ESOP-95 Surface: Hourly Surface Meteorological Composite'
    Project     = 'GCIP/ESOP-95: GCIP Large Scale Area-South West ESOP-95'
    Description = 'The GCIP/ESOP-95 Hourly Surface Composite contains data from several net
    Start_Date_Time = '1995-07-15 00:00:00'
    End_Date_Time   = '1995-07-15 23:59:59'
    Documentation   = 'https://data.eol.ucar.edu/datafile/nph-get/1.003/es60_sfc.txt'
    Detailed_Description = 'The ESOP 1995 Hourly Surface Composite contains ten metadata parameters
    Processing_Version = '1.0'
    Release_Date     = '2011-08-24'
    Author           = 'EOL Data Support <eol-datahelp at ucar dot edu>'
    References       = 'DOI: https://doi.org/10.5065/D6C827KC'
    Institution      = 'National Center for Atmospheric Research - Earth Observing Laboratory'
    Creator_URL      = 'http://www.eol.ucar.edu'
    Creator_Email    = 'eol-datahelp at ucar dot edu'

Dimensions:

```

Figure 5: After the “ncdisp” command is executed, the contents of the Command Window in MATLAB should look like this. The Command Window will show the metadata of the file under the “Source”, “Format”, “Global Attributes”, and “Dimensions” section.

```

Command Window
New to MATLAB? See resources for Getting Started.

References = 'DOI: https://doi.org/10.5065/D6C827KC'
Institution = 'National Center for Atmospheric Research - Earth Observing Laboratory'
Creator_URL = 'http://www.eol.ucar.edu'
Creator_Email = 'eol-datahelp at ucar dot edu'

Dimensions:
    QCF      = 7953
    maxStrlen64 = 64

Variables:
    QCF.date_nominal
        Size:      64x7953
        Dimensions: maxStrlen64,QCF
        Datatype:  char
        Attributes:
            Description = 'UTC Nominal Date of Observation (YYYY/MM/DD)'

    QCF.time_nominal
        Size:      64x7953
        Dimensions: maxStrlen64,QCF
        Datatype:  char
        Attributes:
            Description = 'UTC Nominal Time of Observation (HH:mm:ss)'

    QCF.date
        Size:      64x7953
        Dimensions: maxStrlen64,QCF
        Datatype:  char

```

Figure 6: After the metadata of the file, the section for “Variables” can be found. This section shows the variables for the file and the metadata for each variable can be found.

MATLAB ncread Command

The data for a variable can be saved in the MATLAB script by using the “ncread” command. Figure 7 shows how the “ncread” command is used. The data file and variable name are both needed. In this example, the nominal date is read from “myfile” into the “date” parameter. The exact variable name from the data file (i.e., “QCF.date_nominal”) must be used in the ncread command. Use the ncdisp command to determine the exact variable names. This process can then be repeated for all variables to be plotted.

```
49  
50     date = ncread(myFile, 'QCF.date_nominal');  
51
```

Figure 7: The “ncread” command is used to read and store the data from the input file for a given variable. In this case, the nominal date is read. Notice in Figure 6 that the variable name for the nominal date is “QCF.date_nominal”. This variable name is used in the “ncread” command.

Preprocessing of Input Data

Depending on the input file and data used from OPeNDAP, some preprocessing may be necessary before plotting the data. The following information explains the processing used in the sample input file mentioned in this document. Processing may vary depending on the file used.

Figures 8 and 9 show what the input data looks like before and after preprocessing. In Figure 8, the nominal date is stored with each character in its own cell with trailing whitespace. The whitespace needs to be removed and the nominal date should be one string as shown in Figure 9.


```

61 % Find the dimensions of the 'date' matrix.
62
63 [rows,cols] = size(date);
64
65 % Create an array of the type 'string'.
66
67 final_date = strings(cols,1);

```

Figure 10: The matrix for the nominal date needs to be rearranged into an array for the plots. The dimensions for the matrix are needed.

```

74 % This loop takes every 'char' column from the matrix and stores it as a
75 % 'string' into the array.
76
77 c = 1;
78 while c <= cols
79     final_date(c,1) = string([date(:,c)].');
80     final_time(c,1) = string([Time(:,c)].');
81     c = c + 1;
82 end
83
84 % The empty elements of the array are removed.
85
86 final_date(:,1) = deblank(final_date(:,1));
87 final_time(:,1) = deblank(final_time(:,1));
88

```

Figure 11: A loop is created to take each column of characters shown in Figure 8 and arrange them into one string shown in Figure 9 and place them into an array. The nominal time also needs to be processed like this. Lines 77-82 of the sample code show this process. After the array is filled, the whitespaces need to be removed. Lines 86-87 remove the whitespaces from the date and time.

```

89 % The date and time are then used to create the datetime.
90
91 date_time_arr = final_date + ' ' + final_time;
92 date_time = datetime(date_time_arr,'InputFormat','yyyy/MM/dd HH:mm:ss');
93 u_datetime = unique(date_time);
94 u_date = unique(final_date);
95 u_time = unique(final_time);

```

Figure 12: The nominal date and time are combined into a single datetime. All repeating datetimes are also removed.

Up to this point in the code, the process for “matlab_xy.m” and “matlab_xyz.m” scripts have been the same, but the code for the 2D plot and 3D plot scripts diverge after this. The following section describes the procedure specifically for the 2D “matlab_xy.m” script. Both the temperature and dew point variables are plotted on the sample 2D plot.

For the “matlab_xy.m” script, the variables for the dew point temperature, air temperature, network, and station/platform are used. Variables like the temperature did not need preprocessing as they are already stored as arrays. The network and station/platform need the preprocessing as done for the nominal date data. See Figures 13-16.

```
97      % Read the dew point and air temp.
98
99      dew_point = ncread(myFile, 'QCF.dew_point_temperature');
100     air_temp = ncread(myFile, 'QCF.air_temperature');
```

Figure 13: Some variables like the dew point temperature and air temperature in the example do not need processing. The temperatures are already in arrays.

```
102     % Read in the network and repeat the process above.
103
104     Network = ncread(myFile, 'QCF.network_name');
105
106     [netrows,netcols] = size(Network);
107
108     final_net = strings(netcols,1);
109
110     c = 1;
111     while c <= cols
112         final_net(c,1) = string([Network(:,c)].');
113         c = c + 1;
114     end
115
116     final_net(:,1) = deblank(final_net(:,1));
```

Figure 14: The process of putting the metadata into an array is repeated for the “network” variable.

```

118 % Read in the platform and repeat the process.
119
120 Station = ncread(myFile, 'QCF.platform_name');
121
122 [starows, stacols] = size(Station);
123
124 final_sta = strings(stacols,1);
125
126 c = 1;
127 while c <= cols
128     final_sta(c,1) = string([Station(:,c)].');
129     c = c + 1;
130 end
131
132 final_sta(:,1) = deblank(final_sta(:,1));

```

Figure 15: The process of putting the metadata in an array is repeated for the “platform/station” variable.

```

134 % Combine the network and platform to make the location.
135
136 location = final_net + final_sta;
137
138 % Remove the duplicate locations.
139
140 unique_location = unique(location);

```

Figure 16: The network and station/platform are combined to create the location. Duplicate locations are then removed.

Plotting the Data with the 2D Matlab Plot Script

In the input data file used for this example, the data for multiple stations/sites is sorted by date and time and then by station, so all data collected for all stations at a specific time are listed together for each date/time. Here is a sample from the input data file:

Nominal	Time	Actual	Time	Network	Station	Latitude	Longitude	Occ Elev	STN	Q Sea Lvl	Q Cmpdt	Q Drybulb	Q Dewpnt	Q Wind	Q Wind	Q Total
g CF Q CA Q	Date	Date	Date	ID	ID	ur	Press	F Press	F Sea Lvl	F Temp	F Temp	F Speed	F Dir	F Prcp		
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
9 15 N 15 N	1995/07/15 00:00:00	1995/07/15 00:00:00	1995/07/15 00:00:00	AWOSQ20	ILE	31.08000	-97.69000	0	256.00	983.80 G	-999.99 N	1012.20 G	32.75 G	18.85 G	3.60 G	120.00 G
9 15 N 15 N	1995/07/15 00:00:00	1995/07/14 23:55:00	1995/07/14 23:55:00	NCDC	ILE	31.08333	-97.68333	0	257.00	983.70 G	-999.99 M	1012.10 G	33.35 G	18.95 G	4.10 G	100.00 G
9 15 N 15 N	1995/07/15 00:00:00	1995/07/15 00:00:00	1995/07/15 00:00:00	AWOSQ20	TPL	31.15000	-97.41000	0	208.00	-999.99 M	-999.99 N	-999.99 M	-999.99 M	-999.99 M	-999.99 M	0.00
9 15 N 15 N	1995/07/15 00:00:00	1995/07/14 23:56:00	1995/07/14 23:56:00	ASOSH	LFK	31.23000	-94.75000	0	88.00	1004.70 U	-999.99 N	-999.99 M	-999.99 M	-999.99 M	-999.99 M	0.00
9 15 N 15 N	1995/07/15 00:00:00	1995/07/14 23:51:00	1995/07/14 23:51:00	NCDC	LFK	31.23333	-94.75000	1	86.00	1005.00 G	1014.50 G	1014.60 G	29.45 G	22.85 D	3.60 G	130.00 G
9 15 N 15 N	1995/07/15 00:00:00	1995/07/14 23:51:00	1995/07/14 23:51:00	NCDC	AEX	31.33333	-92.55000	0	27.00	1013.00 G	-999.99 M	1016.10 G	23.35 D	22.25 G	1.00 G	360.00 G
9 15 N 15 N	1995/07/15 00:00:00	1995/07/14 23:50:00	1995/07/14 23:50:00	NCDC	SJT	31.36667	-100.50000	1	580.00	946.70 G	1011.10 G	1009.70 G	34.45 G	14.45 G	5.70 G	140.00 G
9 15 N 15 N	1995/07/15 00:00:00	1995/07/14 23:56:00	1995/07/14 23:56:00	ASOSH	SJT	31.37000	-100.50000	0	584.00	945.60 U	-999.99 N	-999.99 M	-999.99 M	-999.99 M	-999.99 M	0.00
9 15 N 15 N	1995/07/15 00:00:00	1995/07/14 23:56:00	1995/07/14 23:56:00	ASOSH	ESF	31.40000	-92.30000	0	34.00	1013.20 G	1016.70 G	1017.10 G	22.25 B	21.65 G	1.50 G	60.00 D
9 15 N 15 N	1995/07/15 00:00:00	1995/07/14 23:50:00	1995/07/14 23:50:00	NCDC	ESF	31.40000	-92.30000	1	33.00	1013.30 G	1016.80 G	1017.10 G	22.85 B	21.75 G	2.60 G	10.00 D
9 15 N 15 N	1995/07/15 00:00:00	1995/07/15 00:00:00	1995/07/15 00:00:00	AWOSQ20	OCH	31.57000	-94.71000	0	108.00	1001.60 G	-999.99 N	1013.80 G	30.05 G	20.55 D	3.10 G	140.00 G
9 15 N 15 N	1995/07/15 00:00:00	1995/07/15 00:00:00	1995/07/15 00:00:00	AWOSQ20	HEZ	31.61000	-91.30000	0	83.00	1007.30 G	-999.99 N	1016.90 G	22.75 G	21.15 G	1.50 G	210.00 G
9 15 N 15 N	1995/07/15 00:00:00	1995/07/14 23:56:00	1995/07/14 23:56:00	NCDC	ACT	31.61667	-97.21667	0	152.00	995.40 G	1012.40 G	1012.40 G	31.75 G	20.65 G	5.10 G	100.00 G
9 15 N 15 N	1995/07/15 00:00:00	1995/07/14 23:56:00	1995/07/14 23:56:00	NCDC	HEZ	31.61667	-91.28333	0	83.00	1007.30 G	-999.99 M	1016.90 G	22.85 G	21.75 G	1.50 G	230.00 G
9 15 N 15 N	1995/07/15 00:00:00	1995/07/14 23:56:00	1995/07/14 23:56:00	ASOSH	ACT	31.62000	-97.22000	0	157.00	994.80 G	1012.40 G	1012.40 G	31.65 G	20.55 G	5.10 G	100.00 G
9 15 N 15 N	1995/07/15 00:00:00	1995/07/15 00:00:00	1995/07/15 00:00:00	WPDN	Palestine	31.77917	-95.71333	0	119.00	-999.99 N	1013.70 U	-999.99 N	28.05 U	22.95 U	-999.99 M	0.00
9 15 N 15 N	1995/07/15 00:00:00	1995/07/14 23:50:00	1995/07/14 23:50:00	NCDC	INK	31.78333	-103.20000	0	857.00	915.10 G	1008.90 G	1006.80 G	34.45 G	11.15 G	6.20 G	110.00 G
9 15 N 15 N	1995/07/15 00:00:00	1995/07/14 23:56:00	1995/07/14 23:56:00	NCDC	ELP	31.80000	-106.40000	1	1199.00	878.80 D	1006.40 D	1006.10 D	31.75 D	10.65 G	0.00 D	0.00 D
9 15 N 15 N	1995/07/15 00:00:00	1995/07/14 23:56:00	1995/07/14 23:56:00	ASOSH	ELP	31.80000	-106.40000	0	1198.00	878.80 D	1006.40 D	1006.10 D	31.65 D	10.55 G	0.00 D	0.00 D
9 15 N 15 N	1995/07/15 00:00:00	1995/07/14 23:56:00	1995/07/14 23:56:00	ASOSH	E02	31.92000	-102.38000	0	915.00	909.60 G	1010.70 G	1007.60 G	33.35 G	13.35 G	6.70 G	110.00 G

To plot a particular station's data, code must be included to pull only that station's data into a plottable array. **Figures 13-21** show the procedure for preparing the input data from the specific sample file for the 2D "matlab_xy.m" script. Figure 22 shows the final result of the script.

```

142 % Use a for loop to repeat the process for any number of locations.
143
144 for a = 1:2
145
146 % Take the 'a' location and use it later in the loop.
147
148 example_location = unique_location(a);
149
150 % The information in this file is organized by time. The following lines
151 % here gathers the information for the given location. The array "array"
152 % stores the indices where the chosen station information is located.
153
154 time_size = length(final_time);
155 array = zeros(time_size,1);
156 array(1) = 1;

```

Figure 17: The "for" loop shown above is used for plotting the data for a unique station location. In this example, the first 2 locations are plotted. Originally, all of the data in the file is organized by time. Because of this, the values for one station are scattered throughout the file. The loop takes the site location wanted for plotting and then compares the station to every other site location in the file. The index for every instance of the site location matching in the file as this would show where all the temperature, dew point temperature, etc. are located in the file.

```

177     inc = 1;
178
179     for i = 1:time_size
180
181         % The script saves the current network, station, and occurrence for the
182         % current iteration of the loop.
183
184         current_station = location(i);
185
186         % If the location information is the same as the current station, save
187         % the index into the array. Note that "..." means continue the code on
188         % a different line.
189
190         if isequal(current_station, example_location)
191
192             array(inc) = i;
193             inc = inc + 1;
194         end
195     end

```

Figure 18: The loop shown above shows how all the indices for one location are found. The unique site location saved in Figure 17 is then compared to all of the other station locations in the location array.

```

182     % The "array" variable contains the indices but also contains unnecessary
183     % zeros at the end. The following loop removes the ending zeros
184     % Because the previous for loop incremented the "inc" one
185     % more than needed, this loop subtracts the "inc" by 1.
186
187     final_arr = zeros(inc-1,1);
188     for j = 1:(inc-1)
189         final_arr(j) = array(j);
190     end
191
192     % With the given indices, gather the time, temperature, and dew point
193     % temperature that correspond to the given location.
194
195     final_temp = zeros(length(final_arr),1);
196     final_dew_temp = zeros(length(final_arr),1);

```

Figure 19: The loop in Figure 18 only stores the indices where there are matches with the unique site location being plotted. The array that stores these indices was initialized as an array full of 0s. Because there are many site locations in the array, many did not match with the unique site being plotted leaving 0s in the index array. A final array is created to remove these 0s. The dimensions of this array are then used to create the arrays for the temperature and dew point temperature.

```

198 % The file contains values of -999 temp. Change these values to 'NaN' so it
199 % does not plot these values.
200
201 for k = 1:(length(final_arr))
202     if air_temp(final_arr(k)) < -100
203         final_temp(k) = NaN;
204     end
205     if air_temp(final_arr(k)) > -100
206         final_temp(k) = air_temp(final_arr(k));
207     end
208     if dew_point(final_arr(k)) < -100
209         final_dew_temp(k) = NaN;
210     end
211     if dew_point(final_arr(k)) > -100
212         final_dew_temp(k) = dew_point(final_arr(k));
213     end
214
215 end

```

Figure 20: The temperatures in the file may have a missing value of -999. These values are changed to “Not a Number” values or NaN so they will not be plotted. Matlab ignores NaN values for plotting.

```

217 % Plot the data. x axis is date time and y axis is temperature in Celsius.
218
219 figure(a)
220 plot(u_datetime,final_dew_temp,'b','DisplayName','dew point temperature')
221 hold on;
222 scatter(u_datetime,final_dew_temp,'b','DisplayName','dew point temperature')
223 hold on;
224 plot(u_datetime,final_temp,'r','DisplayName','air temperature')
225 hold on;
226 scatter(u_datetime,final_temp,'r','DisplayName','air temperature' )
227
228 % xlabel('date time ')
229 ylabel('°C')
230 %legend({'dew point temp', 'air temp'}, 'Location', 'northwest')
231 legend('Location', 'northwest')
232 title("GCIP/ESOP-95 Surface Temp UTC" + strjoin(split(example_location)))

```

Figure 21: The data is then plotted and the resulting 2D plot is shown in Figure 22.

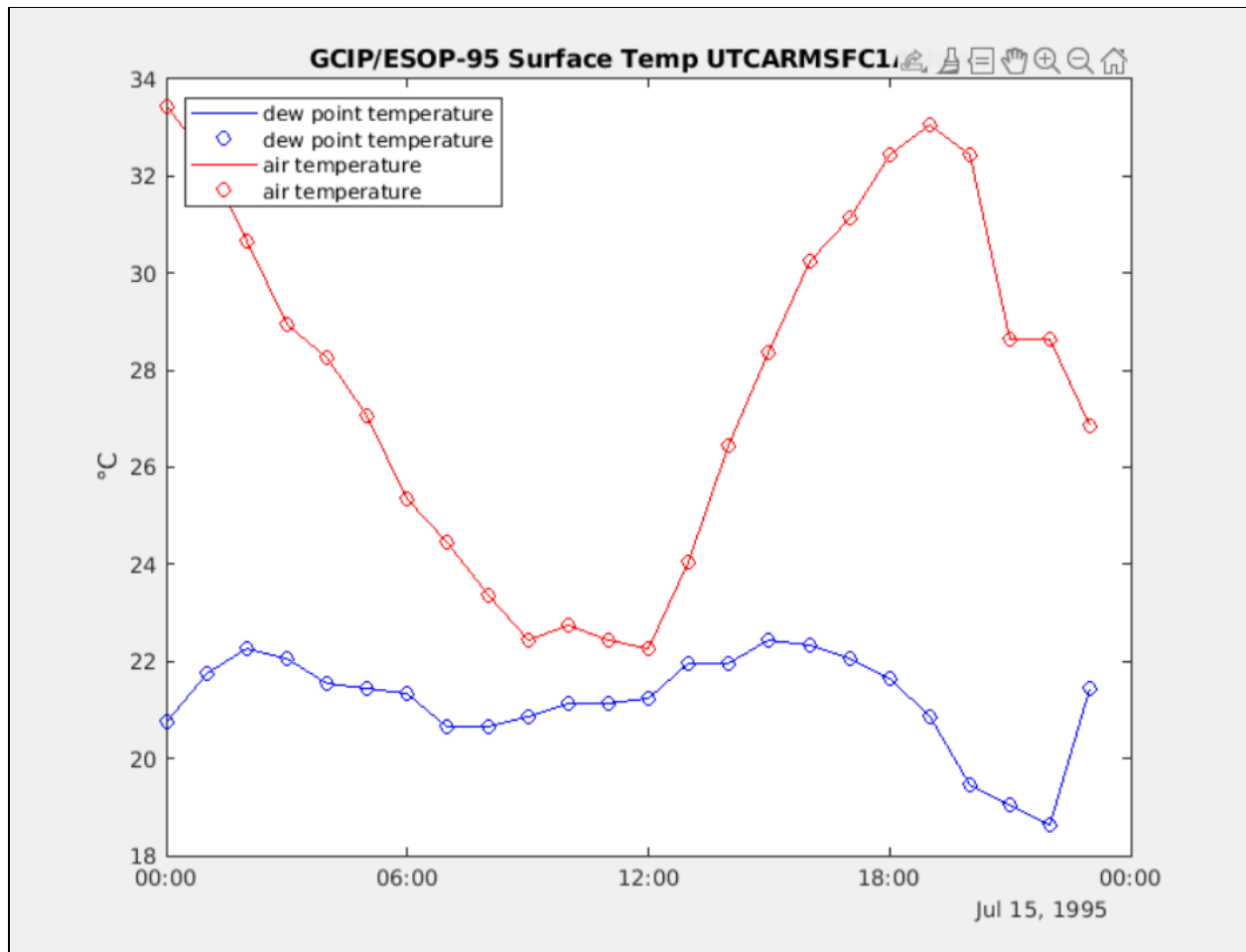


Figure 22: The final result of the 2D “matlab_xy.m” script for Temperature and Dew Point for the Ashton site.

Plotting the Data with the 3D Matlab Plot Script

This section shows how the 3D “matlab_xyz.m” script differs from the 2D plot script. The 2D and 3D matlab scripts are basically the same through the datetime step described above. **Figures 23-28** show the process for preparing the input data for the 3D plot using the “matlab_xyz.m” script. Figures 29 and 30 show the final resulting 3D plot.

```

101 % Take one time and find all of the indices where the time shows in the
102 % file. This is used to find all of the information for the given time.
103
104 test_time = 1;
105
106 t = u_time(test_time);
107 array_time = strings(cols,1);
108
109 for p = 1:cols
110     if t == final_time(p)
111         array_time(p) = t;
112     end
113 end

```

Figure 23: The indices for one given time are found. The 3D script generates a plot of the temperature field for the entire surface area at a given time.

```

115 % This statement removes all empty values in the array.
116
117 array_time = array_time(~cellfun('isempty',array_time));
118 % % Create arrays to store lat, long, and dew temp and air temp.
119
120 latitude = zeros(length(array_time),1);
121 longitude = zeros(length(array_time),1);
122 dew_point_temp = zeros(length(array_time),1);
123 air_temp_arr = zeros(length(array_time),1);

```

Figure 24: The empty values are removed from the time array. Arrays are created for various variables for later use/plotting. Unlike the 2D script, this script uses latitude and longitude.

```

125 % % This for loop finds the location info and the dew temp and air temp
126 % % for the given time.
127 %
128 ind = 1;
129 for p = 1:cols
130     if t == final_time(p)
131         latitude(ind,1) = lat(p);
132         longitude(ind,1) = long(p);
133         dew_point_temp(ind,1) = dew_point(p);
134         air_temp_arr(ind,1) = air_temp(p);
135         ind = ind + 1;
136     end
137 end

```

Figure 25: A loop is used to find all of the location and temperature values for the test time at t=00:00:00 using the index values found above.

```

142     for p = 1:length(dew_point_temp)
143         if dew_point_temp(p) < -100
144             dew_point_temp(p) = NaN;
145         end
146     end
147
148     for p = 1:length(air_temp_arr)
149         if air_temp_arr(p) < -100
150             air_temp_arr(p) = NaN;
151         end
152     end

```

Figure 26: The values of temperature may be missing or -999. These missing values are changed to NaN to prevent these values from being plotted.

```

155     %% Create the 3D grid for the plot.
156     %
157     xv = linspace(min(latitude), max(latitude), 100);
158     yv = linspace(min(longitude), max(longitude), 100);
159     [X,Y] = meshgrid(xv, yv);
160     %
161     %% Create a variable to store the 3D plot.
162     %
163     Z = griddata(latitude,longitude,air_temp_arr,X,Y);

```

Figure 27: The grid is created for the 3D plot.

```

165     %% Plot the data.
166     %
167     figure(1)
168     %
169     %% The surf command creates the surface plot.
170     %
171     surf(X, Y, Z);
172     hold on
173     %
174     %% The stem3 command creates the vertical lines in the plots.
175     %
176     stem3(latitude, longitude, air_temp_arr, 'k');
177     grid on
178     xlabel('latitude')
179     ylabel('longitude')
180     zlabel('°C')
181     title("GCIP/ESOP-95 Surface Air Temp" + " " + datestr(u_datetime(test_time,1)))
182     c = colorbar;
183     c.Label.String = '°C';

```

Figure 28: The 3D plot is created.

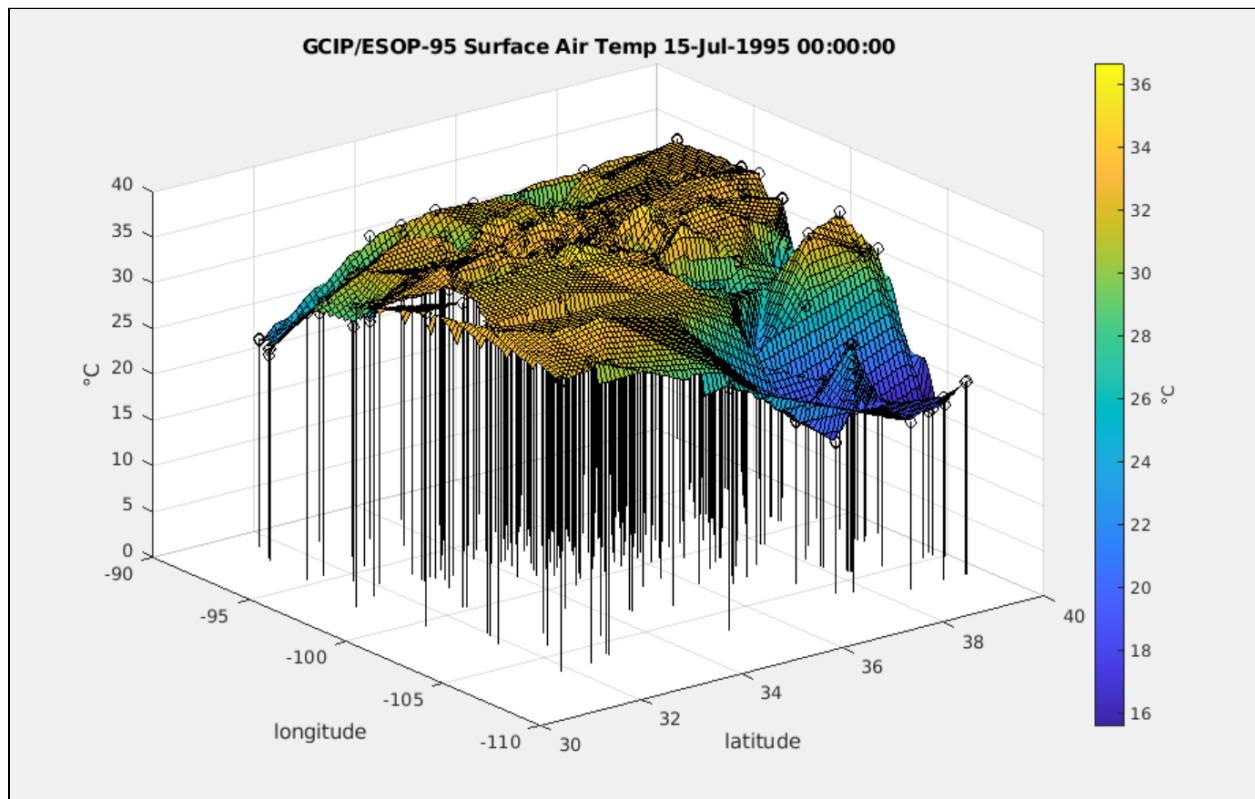


Figure 29: The finished 3D plot for the surface air temperatures for all sites on 15 July 1995 at 00:00:00.

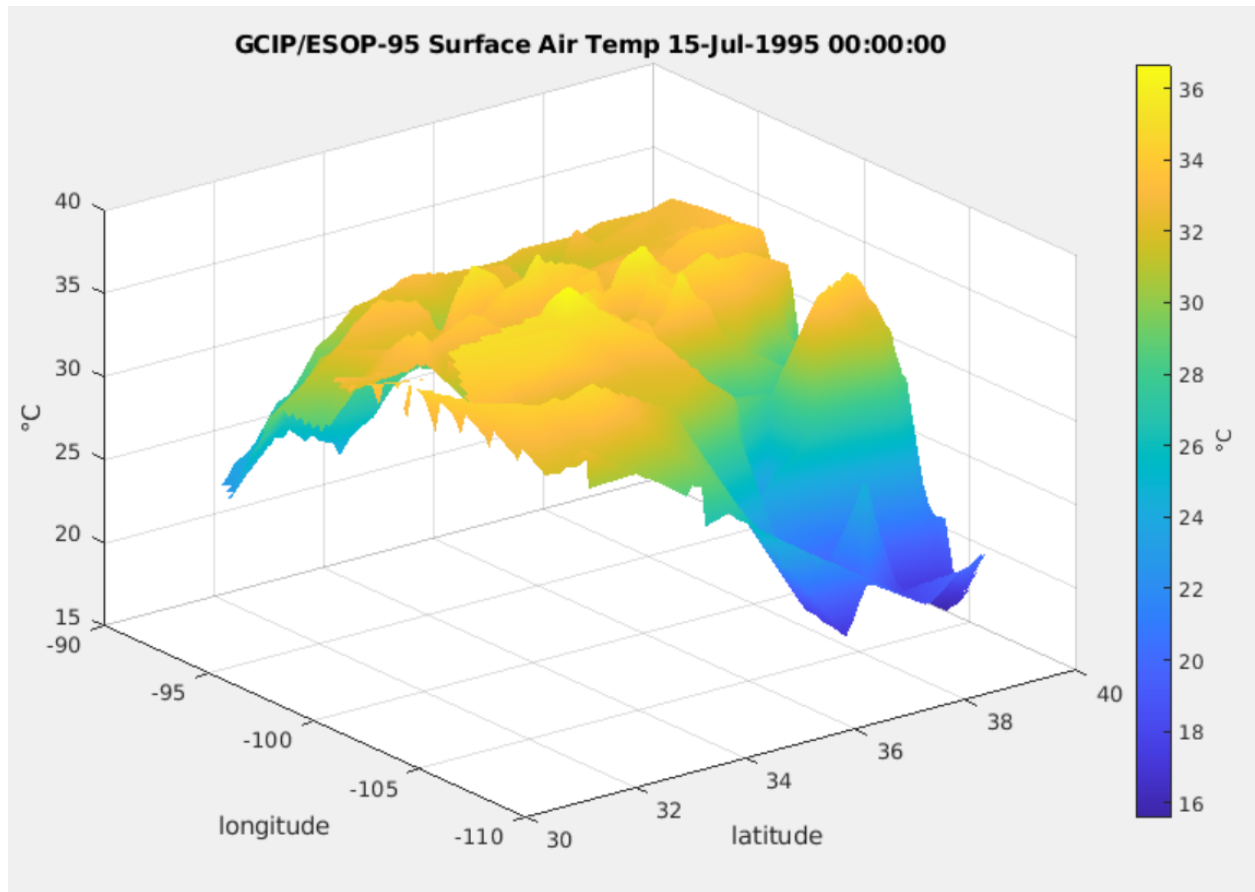


Figure 30: The 3D plot without the grid and site lines.