Global Radar Wind Profiler (GRWP) data README FILE

This README FILE contains information about the GRWP-Planetary Boundary Layer Height (GRWP-PBLH) data set, the GRWP-Signal to Noise Ratio (GRWP-SNR) data set from which the PBLH estimates were obtained, and the GRWP-Software provided to perform desired calculations, analyses and data visualizations. The information presented below will allow a user to quickly begin producing visualizations and to retrieve desired information from the provided GRWP-SNR and GRWP-PBLH NetCDF files. In addition, (1) the steps to download the raw data from UKMO, (2) produce intermediary restructured CSV files from the raw data, (3) produce GRWP-SNR NetCDF files from the restructured CSV files, and (4) produce GRWP-PBLH NetCDF files from GRWP-SNR NetCDF files are also detailed.

Information about the source data, details of data processing and production of PBL height estimates, along with a description of supplementary data and the available software, are discussed in more detail in Salmun, H., H. Josephs, and A. Molod, 2023: GRWP-PBLH: Global Radar Wind Profiler Planetary Boundary Layer Height Data. Bull. Amer. Meteor. Soc., 104, E1044–E1057, https://doi.org/10.1175/BAMS-D-22-0002.1.

The present file is structured as follows: Section 1 provides a table summarizing the inventory of these data and software and an overview of the data's production and use, Section 2, provides a guide to SNR/PBLH visualizations, Section 3 presents a guide to retrieve PBLH from SNR data and produce GRWP-PBLH NetCDF files from GRWP-SNR NetCDF files, and Section 4 is a guide to restructure the raw SNR data from the UKMO data source into the GRWP-SNR file structure that our software requires. An Appendix B is also included to document the scripts that are called by the parent scripts described in Sections 2-4.

For users interested only in obtaining PBLH estimates and producing a variety of visualizations, the GRWP data (NetCDF format) and a subset of options in the GRWP software discussed in Section 2 will be sufficient. Sections 2, 3 and 4 are provided to facilitate users' experimentation with the PBLH retrieval and visualization software. Each script contains an in-depth description of its step-by-step functionality with detailed comments throughout.

IT IS RECOMMENDED THAT USERS COPY THE PROVIDED DIRECTORY STRUCTURE AND NAMES TO BE CONSISTENT WITH THE RELATIVE PATHS USED IN THE SOFTWARE.

Section 1 - Inventory/Directory Structure and Overview of Data Production/Use

Directory Name	Subdirectories	Description
GRWP_PBLH_NetCDFs	none	One file per station (91 stations) Each file contains the station number, latitude, longitude, altitude, UTC times, local times, PBLH estimates, total cloud fractions, PBLH error estimates, and SNR quality control indicators
GRWP_SNR_NetCDFs	none	One file per station per year of data available. Each file contains the station number, latitude, longitude, altitude, UTC times, local times, interpolated heights, total cloud fractions, SNR values as a function of time and height, and a mask to be applied to the SNR values in order to obtain the raw SNR values with dimensions of time and height
GRWP_Software	● Process_raw_data_Python ● Load_visualize_data_Matlab	Software to reproduce our SNR NetCDF files and PBLH NetCDF files and to produce desired visualizations

OVERVIEW OF PROCESS FOR PRODUCTION AND USE OF GRWP DATA

Steps 1-4 are only for users desiring to reproduce the provided GRWP data sets, add the most recent data to the GRWP data sets, and/or change the code to produce modified GRWP data sets. For users interested only in using the provided GRWP data sets to produce visualizations and query the data, Steps 5-6 will be sufficient.

PRODUCE RESTRUCTURED CSV FILES FROM RAW DATA (Section 4, Steps 1-6)

1. Download raw data from UKMO source
2. Restructure data using *readUKMOraw.py, separateNAdata.py* and *addLocalTime.py.*

PRODUCE GRWP-SNR FILES FROM RESTRUCTURED CSV FILES (Section 4, Step 7)

3. Run *createGRWPsnr.m*

PRODUCE GRWP-PBLH FILES FROM GRWP-SNR FILES (Section 3, Step 2b)

4. Run *createGRWPpblh.m*

USE GRWP-SNR AND GRWP-PBLH DATA TO PRODUCE DESIRED VISUALIZATIONS (Section 2)

5. Run *loadSNRdata.m* (Section 2, Step 1)
6. Run any of the scripts described in Section 2b-2e

Section 2 - Visualize SNR and PBLH

The steps to plot SNR profiles/contours, PBLH retrievals, PBLH time series, various means, and comparisons of means are detailed below.

1. Load the SNR data for one year from one station. This is a necessary first step to perform Step 2a. Steps 2b-2e do not require the user to complete Step 1 because they rely only on GRWP-PBLH data and do not utilize SNR data.
   File: *Load_visualize_data_Matlab/loadSNRdata.m*
   Arguments:
   - Station number
   - Year
   - snrSourceOption
     - Enter 'netcdf' (***suggested***) unless user has produced SNR CSV files using the Python code described in Section 4
     - Enter 'csv' to load from the files produced as per Section 4
     - or enter 'both' to load from both, if comparisons are desired **(1)**

   Functionality: Loads the data from the specified station and year into memory
   Example Command: This example will load the data from the GRWP-SNR NetCDF for station 10394 in 2018.

   [dates,levelheights,snr,alldatesmdy,timeDifs,cloud_fracs_csv,avgtime_csv,heightVec_nc,utcTime_nc,localTime_nc,cloud_fracs_nc,snr_grid_nc,mask_for_snr,stationNum,latitude,longitude,altitude] = loadSNRdata(10394, 2018, 'netcdf');

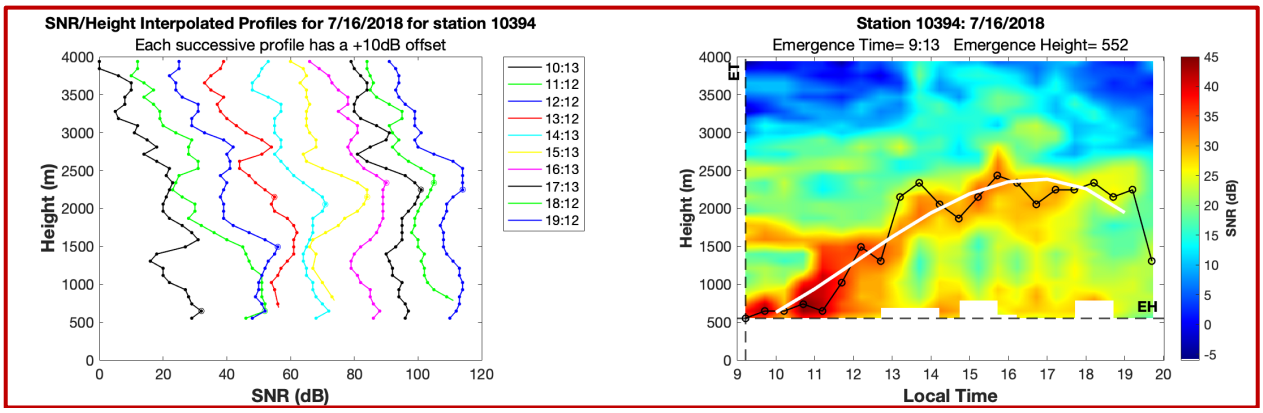
2. Produce desired visualization - The provided software allows for plots of one day of SNR profiles/contours and PBLH, PBLH time series for a station's entire record, and various PBLH means and mean comparisons.

   a. Plot SNR Profiles/Contours + PBLH Diurnal Cycle for specified date
      File: *Load_visualize_data_Matlab/main_plotProfilesContours.m*
      Arguments:
      - Station number
      - year, month, day
      - snrSourceOption
        - Enter 'netcdf'(***suggested***) unless user produced SNR csv files using the Python code described in Section 4
        - Enter 'csv' to load from the files produced as per Section 4
        - or enter 'both' to load from both, if comparisons are desired. **(1)**
      - pblhSourceOption
        - Enter 'grwp' to load from the GRWP-PBLH data set. Note that this option will only display the smoothed diurnal cycle, not the profile-by-profile retrieval.
        - Enter 'retrieve' to run the algorithm and retrieve from the loaded SNR data. This option will display the smoothed diurnal cycle and the profile-by-profile retrieval.
      - Returns from *loadSNRdata.m*

      Functionality: Produces a figure with two panels. The panel on the left contains SNR profiles throughout the selected day with the PBLH retrievals highlighted on each

profile. The panel on the right contains the corresponding contoured SNR data with an overlay of the retrieved PBLH values for the selected day. Note: *getDiurnal.m* from Section 3 Step 2a can be used to simply return the specified SNR and PBLH without producing a visualization.
Example command: This command will create the figure below.

[diurnalCycle_csv, smoothDiurnalCycle_csv, polyEvalTimes_csv, diurnalCycle_nc, smoothDiurnalCycle_nc, polyEvalTimes_nc, stationNum, latitude, longitude, altitude] = main_plotProfilesContours(10394, 2018, 7, 16, 'netcdf', 'retrieve', dates, levelheights, snr, cloud_fracs_csv, avgtime_csv, heightVec_nc, utcTime_nc, localTime_nc, cloud_fracs_nc, snr_grid_nc, mask_for_snr, latitude, longitude, altitude);

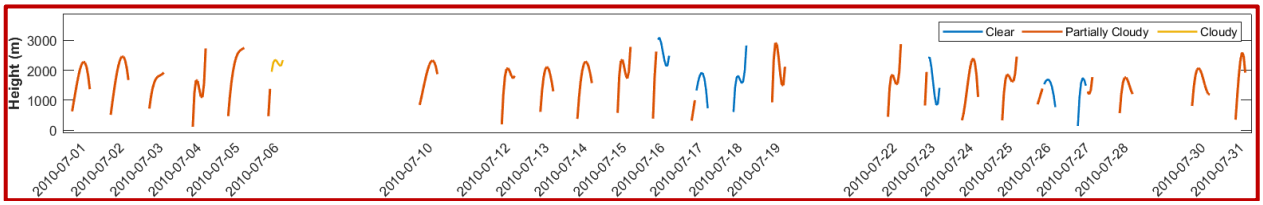


Left panel: Selected RWP SNR profiles (dB) throughout the day at the times indicated in the legend. Open circles on each profile indicate the PBL height estimated by the RWP algorithm. Right panel: Shading indicates SNR strength, the black curve with open circles corresponds to the PBL heights retrieved by the RWP algorithm and the white line to the third-degree polynomial smoothing of that curve. 'ET' denotes emergence time and 'EH' emergence height.

b. Plot PBLH Time Series[2]
File: *Load_visualize_data_Matlab/main_plotPBLHTimeSeries.m*
Arguments:
- Station number
- Year
- Negative SNR indicator option
  - 0: to include only PBLH retrievals from profiles without negative SNR values below the absolute maximum in the SNR signal
  - 1: to include only PBLH retrievals from profiles with negative SNR values below the absolute maximum in the SNR signal
  - 2: to include all PBLH retrievals

Functionality: Produces a figure containing all selected PBLH diurnal cycles from the GRWP-PBLH NetCDF file for the selected station and selected year.
Example command: This command will create the figure below (zoomed in for clarity).

[spacedPBLHcloudy, spacedPBLHclr, spacedPBLHpcloudy, spacedTime, timeLabels] = main_plotPBLHTimeSeries(47674, 2010, 0);



Discontinuous time series of PBL heights (m) for Station 47674 (Japan), zooming in to show the portion of the series from July 1, 2010 - July 31, 2010. Missing times indicate that there were no SNR data for that time or that the GRWP algorithm was unable to retrieve PBL heights from the SNR profiles of that time.

c. Plot Specified Means[2]

File: *Load_visualize_data_Matlab/main_plotMeans.m*

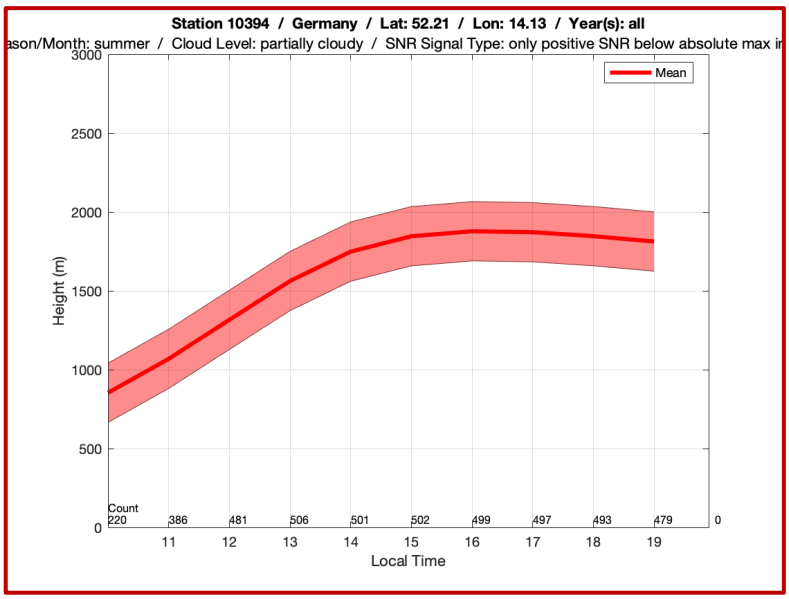
Arguments:

- Station number
- Year[3]: specify a year 2009-2020 or input 'all' to include all data
- Month/season option: specify the month of the year by number 1-12 or season 'winter', 'spring', 'summer', 'fall' or 'all'
- Cloud option: specify 'clear', 'partially cloudy', 'cloudy', 'clr+partial' or 'all' to include only PBLH retrievals that occurred during specified cloud conditions
- Negative SNR indicator option:
  - 0: to include only PBLH retrievals from profiles without negative SNR values below the absolute maximum in the SNR signal
  - 1: to include only PBLH retrievals from profiles with negative SNR values below the absolute maximum in the SNR signal
  - 2: to include all PBLH retrievals

Functionality: Produce a plot of the mean PBLH diurnal cycle including the selected data. The plot will have an error estimate of twice the vertical resolution of the data.

Example command: This command will produce the figure below.

[mean] = main_plotMeans(10394,'all','summer','partially cloudy',1);



d. Plot Seasonal/Months Means Comparison [2]

File: *Load_visualize_data_Matlab/main_plotSeasonalMeansComparison.m*

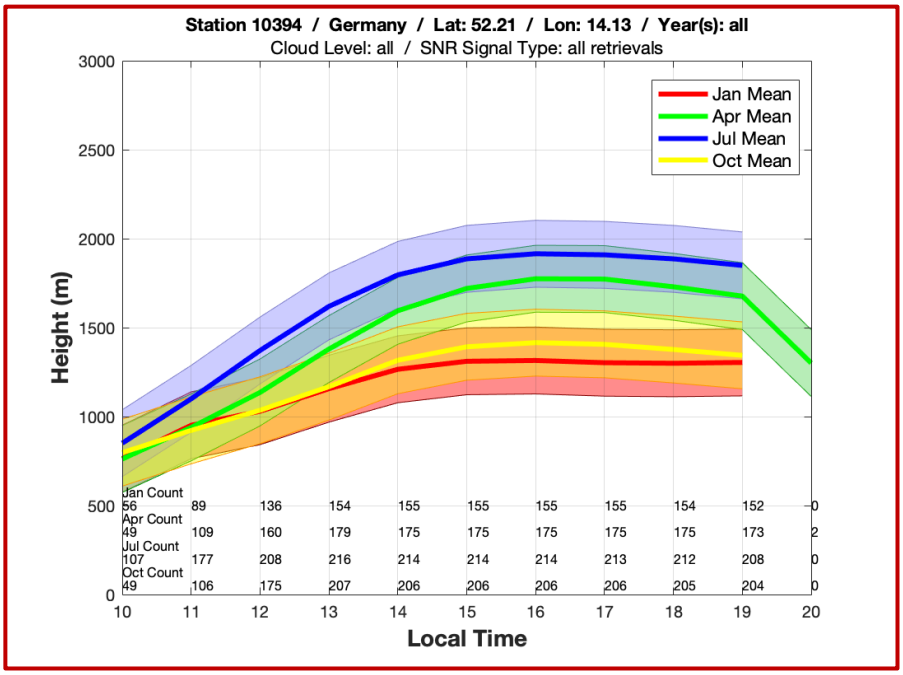
Arguments:

- Station number
- Seasonal or characteristic month option: Input 'seasonal' to compare seasonal means or 'months' to compare characteristic months of January, April, July, and October
- Year[3]: specify a year 2009-2020 or input 'all' to include all data
- Cloud option: specify 'clear', 'partially cloudy', 'cloudy', 'clr+partial' or 'all' to include only PBLH retrievals that occurred during specified cloud conditions
- Negative SNR indicator option:
  - 0: to include only PBLH retrievals from profiles without negative SNR values below the absolute maximum in the SNR signal
  - 1: to include only PBLH retrievals from profiles with negative SNR values below the absolute maximum in the SNR signal
  - 2: to include all PBLH retrievals

Functionality: Produce a plot of the mean PBLH diurnal cycles for winter/spring/summer/fall or January/April/July/October including the selected data. Each mean diurnal cycle will have an error estimate of twice the vertical resolution of the data.

Example command: This command will produce the figure below.

[seasonalmean_1,seasonalmean_4,seasonalmean_7,seasonalmean_10] = main_plotSeasonalMeansComparison(10394,'months','all','all',2);



e. Plot Clear/Cloudy Comparison [2]

File: *Load_visualize_data_Matlab/main_plotCloudMeansComparison.m*

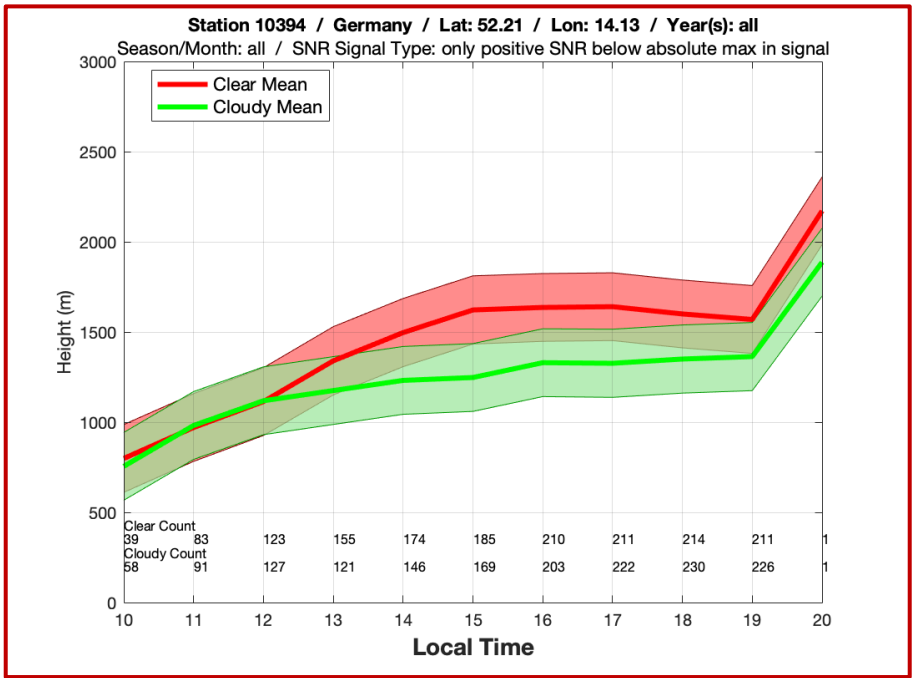
Arguments:

- Station number
- Year[3]: specify a year 2009-2020 or input 'all' to include all data
- Month/season option: specify the month of the year by number 1-12 or season 'winter', 'spring', 'summer', 'fall' or 'all'
- Negative SNR indicator option:
  - 0: to include only PBLH retrievals from profiles without negative SNR values below the absolute maximum in the SNR signal
  - 1: to include all PBLH retrievals

Functionality: Produce a plot of the mean PBLH diurnal cycles for clear and cloudy days including the selected data. Clear: total cloud fraction <0.15. Cloudy: total cloud fraction >0.85. Each mean diurnal cycle will have an error estimate of 2x the vertical resolution of the data.

Example command: This command will produce the figure below.

[mean_clear,mean_cloudy] = main_plotCloudMeansComparison(10394,'all','all',0);



[1] *The results from using the argument 'both' are identical when using the provided version of the code.*

[2] *Automatically use the GRWP-PBLH NetCDF files provided. Produce your own by following the steps in Section 4 and placing them in the correct directory for use in these Matlab scripts.*

[3] *When calculating climatological means from selected data, only data that is in the GRWP-PBLH data set will be included in the mean. For example, if a user selects to calculate a climatological mean for a station from 2009-2020, but that station only has data available for 2010-2011, the mean will only be for 2010-2011. Information about the time period available for each station in the data set is given in Appendix A.*

Section 3 - Obtain PBLH Estimates

This section describes how to obtain PBLH estimates for a single day from a station (Steps 1 and 2a) and how to generate PBLH estimates for a station's entire data record to produce a NetCDF file in the format of the GRWP-PBLH data set (Step 2b). The user can regenerate the PBLH that has been provided in the GRWP-PBLH data or generate new retrievals of PBLH as new data may become available.

1. Load the data for one station and one year into memory. This is a necessary first step to perform Step 2a but is not required for Step 2b.

   File: *Load_visualize_data_Matlab/loadSNRdata.m*
   Arguments:
   - Station number
   - Year
   - snrSourceOption
     - Enter 'netcdf' unless user has produced SNR csv files using the Python code described in Section 4
     - Enter 'csv' to load from the files produced as per Section 4
     - or, enter 'both' to load from both, if comparisons are desired [(1)]

   Functionality: Loads the data from the specified station and year into Matlab
   Example Command: This example will load the data from the GRWP-SNR NetCDF for station 2043 in 2018.

   ```
   [dates,levelheights,snr,alldatesmdy,timeDifs,cloud_fracs_csv,avgtime_csv,heightVec_nc,utcTime_nc,localTime_nc,cloud_fracs_nc,snr_grid_nc,mask_for_snr,stationNum,latitude,longitude,altitude] = loadSNRdata(2043, 2018, 'netcdf');
   ```

2. Obtain PBLH estimates
   a. For one day at one station. Note that *main_plotProfilesContours.m* from Section 2 Step 2a above produces a visualization of these data.
      File: *Load_visualize_data_Matlab/getDiurnal.m*
      Arguments:
      - Station number
      - Month, day, year
      - snrSourceOption
      - Enter 'netcdf' unless user produced SNR CSV files using the Python code described in Section 4
      - Enter 'csv' to load from the files produced as per Section 4
      - or, enter 'both' to load from both, if comparisons are desired. [(1)]
      - Outputs from *loadSNRdata.m*
        Functionality: Returns the smoothed and unsmoothed (profile-by-profile) PBLH diurnal cycle, the associated times, matrices of the SNR profiles and heights, the emergence time and height, and the latitude/longitude/altitude for the specified date/location.
        Example command: The following command produces the returns below.

        ```
        [diurnalCycle_csv,smoothDiurnalCycle_csv,time_vector_unsmooth_csv,time_vector_smooth_csv,actualLevels_csv,actualProfiles_csv,emergeTime_csv,emergeHeight_csv,diurnalCycle_nc,smoothDiurnalCycle_nc,time_vector_unsmooth_nc,time_vector_smooth_nc,actualLevels_nc,actualProfiles_nc,emergeTime_nc,emergeHeight_nc,stationNum,latitude,longitude,altitude] =
        ```

getDiurnal(2043,7,11,2018,'netcdf',dates,levelheights,snr,avgtime_csv,heightVec_nc,utcTime_nc,localTime_nc,cloud_fracs_nc,snr_grid_nc,mask_for_snr,latitude,longitude,altitude)

Profile-by-profile PBLH diurnal cycle: [NaN 495 2045 995 945 1145
1195 1195 1195 2395 1395 1595 695 2845 1445 1745
1045 1045 695 995 995 945 1045]

Times of PBLH estimates (in minutes since midnight): [540 570 600 630
660 690 720 750 780 810 840 870 900 930
960 990 1020 1050 1080 1110 1140 1170 1200]

Smooth PBLH diurnal cycle: [1023.6420 1254.3760 1413.4230 1506.5660
1539.5885 1518.2737 1448.4047 1335.7646 1186.1370
1005.3049 799.05145]

Times of smoothed PBLH estimates (in minutes since midnight): [600 660 720
780 840 900 960 1020 1080 1140 1200]

Emergence time (time at which signal comes into instrument range): 570 minutes since midnight

Emergence height (lowest height of signal at emergence time): 495 meters

SNR profiles (rows associated with 'Time of PBLH Estimates', heights associated with 'Height Profiles' below):

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV
1	11	15	16	14	15	17	15	15	13	13	17	15	13	11	8	8	11	14	16	14	17	17	19	18	18	15	16	17	15	14	13	15	15	13	11	6	4	13	13	16	9	17	20	20	16	21	17	15
2	18	17	14	19	18	18	17	15	14	15	18	20	14	9	10	11	12	14	16	16	17	16	17	15	14	15	18	15	15	16	17	17	16	12	11	9	5	15	16	16	9	21	17	15	14	18	21	12
3	16	22	21	18	18	20	20	18	16	18	18	16	13	14	15	13	13	15	15	14	13	13	16	18	20	19	18	16	15	15	18	20	19	15	12	10	7	16	17	17	9	18	23	18	14	16	16	16
4	12	15	16	18	17	17	20	18	19	18	19	18	14	13	12	17	20	18	14	11	10	13	14	15	13	15	17	16	16	15	17	19	16	14	15	13	10	19	12	15	10	20	20	16	15	11	15	19
5	14	15	18	18	19	18	17	16	19	22	21	19	15	15	13	13	15	14	14	13	14	14	15	14	13	12	15	17	17	17	17	19	18	16	13	11	8	17	16	14	11	19	21	14	20	18	16	19
6	15	18	16	17	18	18	15	13	15	18	20	20	19	20	19	18	16	14	13	16	16	17	17	18	18	17	15	11	11	12	16	20	20	19	15	13	11	19	14	11	12	17	18	18	13	16	21	18
7	16	17	18	18	20	16	15	15	16	19	20	21	21	19	22	20	17	13	11	12	11	13	14	15	14	12	7	9	14	17	18	21	19	19	17	14	11	10	10	9	9	19	17	19	11	15	20	15
8	12	13	14	15	16	15	17	20	17	16	16	19	20	21	22	22	21	19	18	15	15	13	13	14	12	11	11	13	12	13	17	20	18	19	20	18	16	15	11	12	11	17	18	15	16	17	22	17
9	11	11	13	17	17	18	16	15	16	16	15	15	17	16	18	17	16	15	14	13	12	11	11	11	9	9	8	8	8	7	10	14	16	16	18	19	18	16	16	11	9	11	18	19	19	21	11	15
10	14	16	17	17	16	17	15	14	14	13	14	15	12	12	11	12	13	15	16	15	14	16	14	12	10	11	9	8	8	13	16	16	14	13	15	15	16	18	15	13	10	14	17	19	18	24	18	15
11	15	18	20	20	20	20	15	15	17	18	19	18	20	20	21	20	19	19	20	19	18	17	15	13	11	11	8	8	8	8	5	6	7	9	14	15	14	20	19	15	11	10	14	18	18	17	16	16
12	16	17	17	16	16	14	13	17	13	14	17	17	17	16	16	18	17	18	19	20	22	19	20	19	18	17	16	15	14	14	14	12	11	10	10	11	13	13	16	20	8	2	7	14	17	18	21	13
13	13	16	17	15	19	11	21	20	18	20	22	21	19	20	19	16	16	16	15	13	13	13	13	13	13	14	15	15	15	15	15	14	14	11	11	8	8	15	16	18	16	7	12	16	15	15	17	13
14	13	14	15	15	14	13	12	14	13	14	13	15	12	13	13	11	13	13	14	15	15	15	14	14	16	15	16	15	15	14	14	15	15	15	16	13	11	14	10	13	21	12	14	15	18	20	20	12
15	14	15	18	17	17	17	16	15	15	18	18	17	17	16	15	15	14	14	15	14	14	14	14	12	10	9	11	9	8	8	5	8	10	11	15	16	16	13	11	16	14	12	16	9	17	18	13
16	14	16	17	18	17	16	15	13	17	16	15	16	14	11	13	13	13	12	11	11	11	12	12	11	11	12	11	9	6	3	1	0	1	3	3	9	13	14	16	12	16	13	13	15	23	16	16	12
17	16	14	16	18	19	18	18	17	14	17	16	20	16	12	9	9	6	6	4	4	3	3	2	3	2	-1	-1	-1	0	0	-1	-3	-3	-2	2	3	2	10	17	19	13	14	10	11	21	17	14	12
18	19	11	16	20	18	17	17	15	13	14	16	17	15	11	6	5	4	3	2	1	-1	-1	-1	-2	-2	-2	-4	-2	0	-2	-1	2	1	1	0	-1	-1	13	16	22	15	15	10	12	18	17	18	19
19	14	14	16	19	20	16	13	13	14	15	21	19	14	7	5	4	4	2	1	-1	-3	-4	-4	-5	-5	-5	-5	-4	-5	-6	-4	-2	-1	4	7	10	10	17	17	18	17	15	9	14	14	18	18	20
20	16	16	17	20	18	14	15	16	16	17	18	16	10	11	8	6	5	3	2	1	1	0	1	0	0	1	1	1	3	3	3	5	4	4	5	7	5	11	12	16	15	14	13	12	16	17	19	17
21	13	15	16	12	10	12	13	12	12	16	21	15	6	5	5	4	3	3	2	1	2	1	-1	-1	-2	-4	-4	-4	-2	-1	-1	-2	-2	-3	-3	-1	3	12	16	13	14	17	13	13	19	19	19	16
22	16	16	17	17	14	13	13	11	15	16	15	13	10	3	3	3	2	2	1	0	1	2	3	3	3	3	3	3	2	0	0	-2	-2	0	2	4	6	13	17	19	14	15	12	16	16	19	18	15
23	15	16	14	15	17	18	15	14	12	13	14	20	13	10	7	6	6	5	2	1	0	0	0	0	-1	-1	0	1	2	0	-1	1	1	3	5	7	9	15	16	15	15	16	17	18	20	23	21	15

Height profiles:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV
1	495	545	595	645	695	745	795	845	895	945	995	1045	1095	1145	1195	1245	1295	1345	1395	1445	1495	1545	1595	1645	1695	1745	1795	1845	1895	1945	1995	2045	2095	2145	2195	2245	2295	2395	2545	2695	2845	2995	3145	3295	3445	3595	3745	3895
2	495	545	595	645	695	745	795	845	895	945	995	1045	1095	1145	1195	1245	1295	1345	1395	1445	1495	1545	1595	1645	1695	1745	1795	1845	1895	1945	1995	2045	2095	2145	2195	2245	2295	2395	2545	2695	2845	2995	3145	3295	3445	3595	3745	3895
3	495	545	595	645	695	745	795	845	895	945	995	1045	1095	1145	1195	1245	1295	1345	1395	1445	1495	1545	1595	1645	1695	1745	1795	1845	1895	1945	1995	2045	2095	2145	2195	2245	2295	2395	2545	2695	2845	2995	3145	3295	3445	3595	3745	3895
4	495	545	595	645	695	745	795	845	895	945	995	1045	1095	1145	1195	1245	1295	1345	1395	1445	1495	1545	1595	1645	1695	1745	1795	1845	1895	1945	1995	2045	2095	2145	2195	2245	2295	2395	2545	2695	2845	2995	3145	3295	3445	3595	3745	3895
5	495	545	595	645	695	745	795	845	895	945	995	1045	1095	1145	1195	1245	1295	1345	1395	1445	1495	1545	1595	1645	1695	1745	1795	1845	1895	1945	1995	2045	2095	2145	2195	2245	2295	2395	2545	2695	2845	2995	3145	3295	3445	3595	3745	3895
6	495	545	595	645	695	745	795	845	895	945	995	1045	1095	1145	1195	1245	1295	1345	1395	1445	1495	1545	1595	1645	1695	1745	1795	1845	1895	1945	1995	2045	2095	2145	2195	2245	2295	2395	2545	2695	2845	2995	3145	3295	3445	3595	3745	3895
7	495	545	595	645	695	745	795	845	895	945	995	1045	1095	1145	1195	1245	1295	1345	1395	1445	1495	1545	1595	1645	1695	1745	1795	1845	1895	1945	1995	2045	2095	2145	2195	2245	2295	2395	2545	2695	2845	2995	3145	3295	3445	3595	3745	3895
8	495	545	595	645	695	745	795	845	895	945	995	1045	1095	1145	1195	1245	1295	1345	1395	1445	1495	1545	1595	1645	1695	1745	1795	1845	1895	1945	1995	2045	2095	2145	2195	2245	2295	2395	2545	2695	2845	2995	3145	3295	3445	3595	3745	3895
9	495	545	595	645	695	745	795	845	895	945	995	1045	1095	1145	1195	1245	1295	1345	1395	1445	1495	1545	1595	1645	1695	1745	1795	1845	1895	1945	1995	2045	2095	2145	2195	2245	2295	2395	2545	2695	2845	2995	3145	3295	3445	3595	3745	3895
10	495	545	595	645	695	745	795	845	895	945	995	1045	1095	1145	1195	1245	1295	1345	1395	1445	1495	1545	1595	1645	1695	1745	1795	1845	1895	1945	1995	2045	2095	2145	2195	2245	2295	2395	2545	2695	2845	2995	3145	3295	3445	3595	3745	3895
11	495	545	595	645	695	745	795	845	895	945	995	1045	1095	1145	1195	1245	1295	1345	1395	1445	1495	1545	1595	1645	1695	1745	1795	1845	1895	1945	1995	2045	2095	2145	2195	2245	2295	2395	2545	2695	2845	2995	3145	3295	3445	3595	3745	3895
12	495	545	595	645	695	745	795	845	895	945	995	1045	1095	1145	1195	1245	1295	1345	1395	1445	1495	1545	1595	1645	1695	1745	1795	1845	1895	1945	1995	2045	2095	2145	2195	2245	2295	2395	2545	2695	2845	2995	3145	3295	3445	3595	3745	3895
13	495	545	595	645	695	745	795	845	895	945	995	1045	1095	1145	1195	1245	1295	1345	1395	1445	1495	1545	1595	1645	1695	1745	1795	1845	1895	1945	1995	2045	2095	2145	2195	2245	2295	2395	2545	2695	2845	2995	3145	3295	3445	3595	3745	3895
14	495	545	595	645	695	745	795	845	895	945	995	1045	1095	1145	1195	1245	1295	1345	1395	1445	1495	1545	1595	1645	1695	1745	1795	1845	1895	1945	1995	2045	2095	2145	2195	2245	2295	2395	2545	2695	2845	2995	3145	3295	3445	3595	3745	3895
15	495	545	595	645	695	745	795	845	895	945	995	1045	1095	1145	1195	1245	1295	1345	1395	1445	1495	1545	1595	1645	1695	1745	1795	1845	1895	1945	1995	2045	2095	2145	2195	2245	2295	2395	2545	2695	2845	2995	3145	3295	3445	3595	3745	3895
16	495	545	595	645	695	745	795	845	895	945	995	1045	1095	1145	1195	1245	1295	1345	1395	1445	1495	1545	1595	1645	1695	1745	1795	1845	1895	1945	1995	2045	2095	2145	2195	2245	2295	2395	2545	2695	2845	2995	3145	3295	3445	3595	3745	3895
17	495	545	595	645	695	745	795	845	895	945	995	1045	1095	1145	1195	1245	1295	1345	1395	1445	1495	1545	1595	1645	1695	1745	1795	1845	1895	1945	1995	2045	2095	2145	2195	2245	2295	2395	2545	2695	2845	2995	3145	3295	3445	3595	3745	3895
18	495	545	595	645	695	745	795	845	895	945	995	1045	1095	1145	1195	1245	1295	1345	1395	1445	1495	1545	1595	1645	1695	1745	1795	1845	1895	1945	1995	2045	2095	2145	2195	2245	2295	2395	2545	2695	2845	2995	3145	3295	3445	3595	3745	3895
19	495	545	595	645	695	745	795	845	895	945	995	1045	1095	1145	1195	1245	1295	1345	1395	1445	1495	1545	1595	1645	1695	1745	1795	1845	1895	1945	1995	2045	2095	2145	2195	2245	2295	2395	2545	2695	2845	2995	3145	3295	3445	3595	3745	3895
20	495	545	595	645	695	745	795	845	895	945	995	1045	1095	1145	1195	1245	1295	1345	1395	1445	1495	1545	1595	1645	1695	1745	1795	1845	1895	1945	1995	2045	2095	2145	2195	2245	2295	2395	2545	2695	2845	2995	3145	3295	3445	3595	3745	3895
21	495	545	595	645	695	745	795	845	895	945	995	1045	1095	1145	1195	1245	1295	1345	1395	1445	1495	1545	1595	1645	1695	1745	1795	1845	1895	1945	1995	2045	2095	2145	2195	2245	2295	2395	2545	2695	2845	2995	3145	3295	3445	3595	3745	3895
22	495	545	595	645	695	745	795	845	895	945	995	1045	1095	1145	1195	1245	1295	1345	1395	1445	1495	1545	1595	1645	1695	1745	1795	1845	1895	1945	1995	2045	2095	2145	2195	2245	2295	2395	2545	2695	2845	2995	3145	3295	3445	3595	3745	3895
23	495	545	595	645	695	745	795	845	895	945	995	1045	1095	1145	1195	1245	1295	1345	1395	1445	1495	1545	1595	1645	1695	1745	1795	1845	1895	1945	1995	2045	2095	2145	2195	2245	2295	2395	2545	2695	2845	2995	3145	3295	3445	3595	3745	3895

b. Generate PBLH estimates for 12 consecutive years of the data record of one station. This will generate a NetCDF file in the format of the GRWP-PBLH data set.

File: *Load_visualize_data_Matlab/createGRWPpblh.m*

Arguments:

- Station number
- Start year

Functionality: Retrieves PBLH estimates from GRWP-SNR NetCDF files for a station's entire data record. Also returns the PBLHs' associated times in local time and UTC time (returned in hours since May 17, 2009 00:00:00), cloud fractions, and vertical resolution and negative SNR indicators of the associated profiles. This function writes these retrievals to a new NetCDF file. This function also returns the PBLH diurnal cycles in a more easy-to-read format along with their associated dates, times and cloud fractions. These easy-to-read data are not written to the NetCDF files.

Example command:

```
[pblHeightVector,timeVector,utcTimeVector,vertResolutionVector,NegSnrIndicatorVector,cldIndicatorVector,diurnalCyclesAll2,datesAll2,cldIndicators2,cycHours,stationNum,lat,lon,alt]=createGRWPpblh(2043, 2009);
```

The resulting GRWP-PBLH files can be used to produce the visualizations discussed in Section 2.

(1) *The results from using the argument 'both' are identical when using the provided version of the code.*

Section 4 - Prepare SNR Data from Raw UKMO CSV Files

This section is provided for users who wish to go through the entire process of restructuring and reformatting the raw data formatted files to produce GRWP-SNR and GRWP-PBLH data sets. To accomplish this, the user must follow the steps below.

1. Download desired files from UKMO BADC. An account must be made to download the data at the following link: https://catalogue.ceda.ac.uk/uuid/9e22544a66ba7aa902ae431b1ed609d6
2. For each year represented in the downloaded data, create one directory. Move the downloaded files into their appropriate directories to separate the downloaded files by year. Create an empty directory for each represented year for the restructured files that you will create in Step 3. For example, *UKMO_Raw_2009, UKMO_Raw_2010,* etc. and *UKMO_Restructured_2009, UKMO_Restructured_2010,* etc.
3. Restructure the raw CSV files. Run *Process_raw_data_Python/readUKMOraw.py* one time for each year represented in the data. This script will prompt the user for the input and output directory names from Step 2.
4. Remove restructured CSV files that do not have usable data (namely, that have only NaN SNR values) by creating an empty directory corresponding to each year represented in the downloaded data and then running the Python script *Process_raw_data_Python/separateNAdata.py* one time for each year represented in the data. The new directories can be named *UKMO_Restructured_2009_hasdata, UKMO_Restructured_2010_hasdata,* etc. This script will prompt the user for the input and output directory names. This script creates a copy of the files that have SNR data, so the user may delete the source folders after running this script if preferred.
5. Add a column of the local time to the restructured CSV files by first creating an empty directory corresponding to each year represented in the downloaded data and then running the Python script *Process_raw_data_Python/addLocalTime.py* one time for each year represented in the data. The new directories can be named *UKMO_Restructured_2009_hasdata_local, UKMO_Restructured_2010_hasdata_local,* etc. This script will prompt the user for the input and output directory names. Only the output files are necessary for the remaining steps, so the user may delete the input directories if desired.
   (Empty folders for these final restructured csv files are provided in the directory structure as an example.)
6. Download CERES_SYN1deg_Ed4.1 Cloud Area Fraction data for all dates represented in the restructured csv files, available through the link:

   https://ceres-tool.larc.nasa.gov/ord-tool/jsp/SYN1degEd41Selection.jsp

   Choose 'Observed Cloud Parameters' -> 'Cloud Area Fraction' as the parameter. Choose '3-hourly' as the Temporal Resolution. Leave the Spatial Resolution as the default global coverage. Choose Terra+Aqua Edition 4.1 as the Satellite. Specify the dates and order the data. Once the data are downloaded and unzipped, place them in your directory structure to match the location of the empty 'PutYourCERESdataHere' folder as shown in the provided directory structure. If CERES data is unavailable (as it currently only covers up to July 2020), the software will place ‘NaN’ as the cloud area fraction.

   Once Steps 1-6 have been completed, the 'csv' and 'both' options in the scripts detailed in Section 2 Step 1, Section 2 Step 2a, Section 3 Step 1, and Section 3 Step 2a can be used.

7. Reformat the restructured CSV files into GRWP-SNR NetCDF files (already provided to users through the year 2020).

   File: *Load_visualize_data_Matlab/createGRWPsnr.m*

   Arguments:

   - Station number
   - Year

   Functionality: Produces a grid of SNR values linearly interpolated in height to a resolution of 1-meter. The dimensions of this grid are height by time. It also produces a grid of equal dimensions populated with 0s and 1s for which 1 indicates a raw (from the original data, non-interpolated) SNR value. This script returns the heights of measurements in meters and the local and UTC times of the SNR profiles in minutes since May 17, 2009 00:00:00 (the beginning of the raw UKMO BADC data set). It also returns the cloud fraction associated with each time. Finally, this script returns a list of the dates in MDY format for which SNR data was recorded.

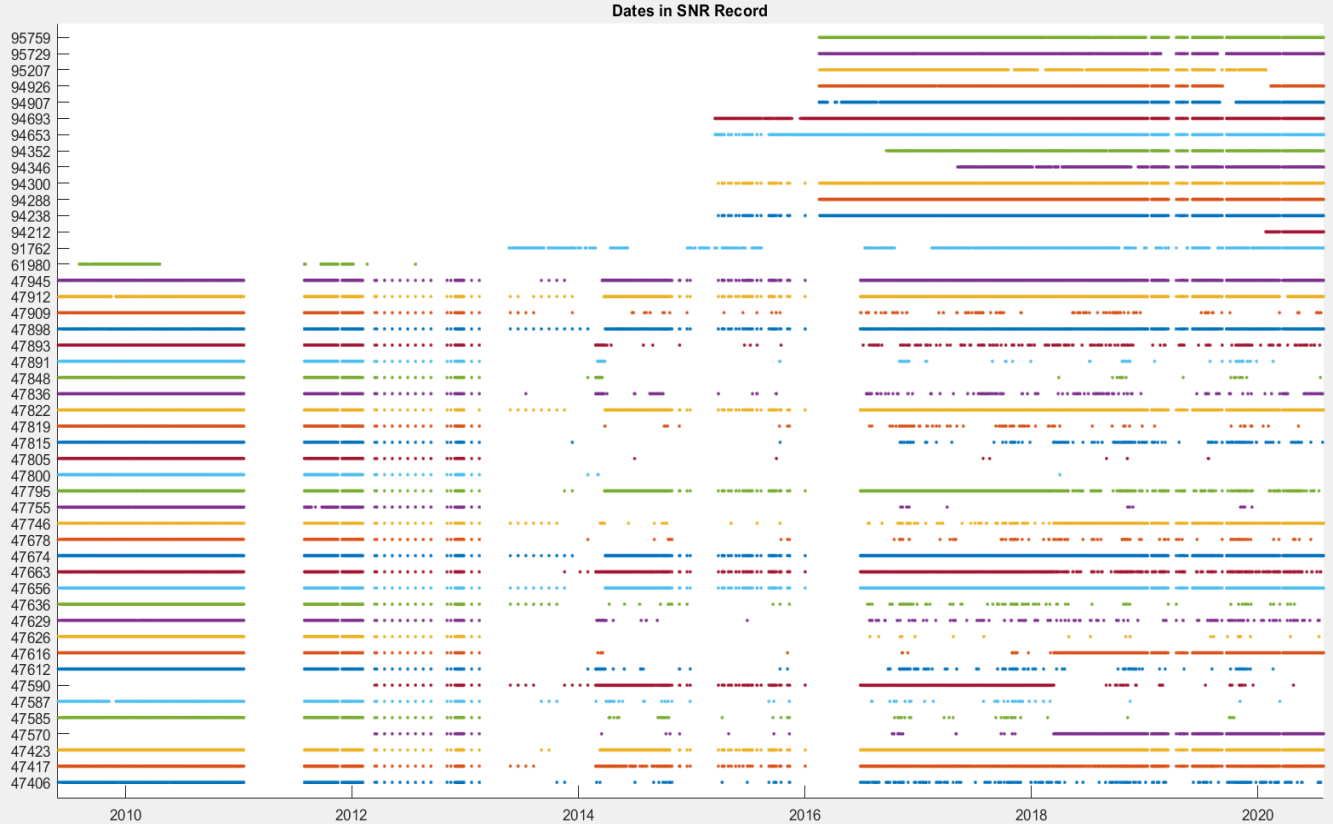
   Example command:

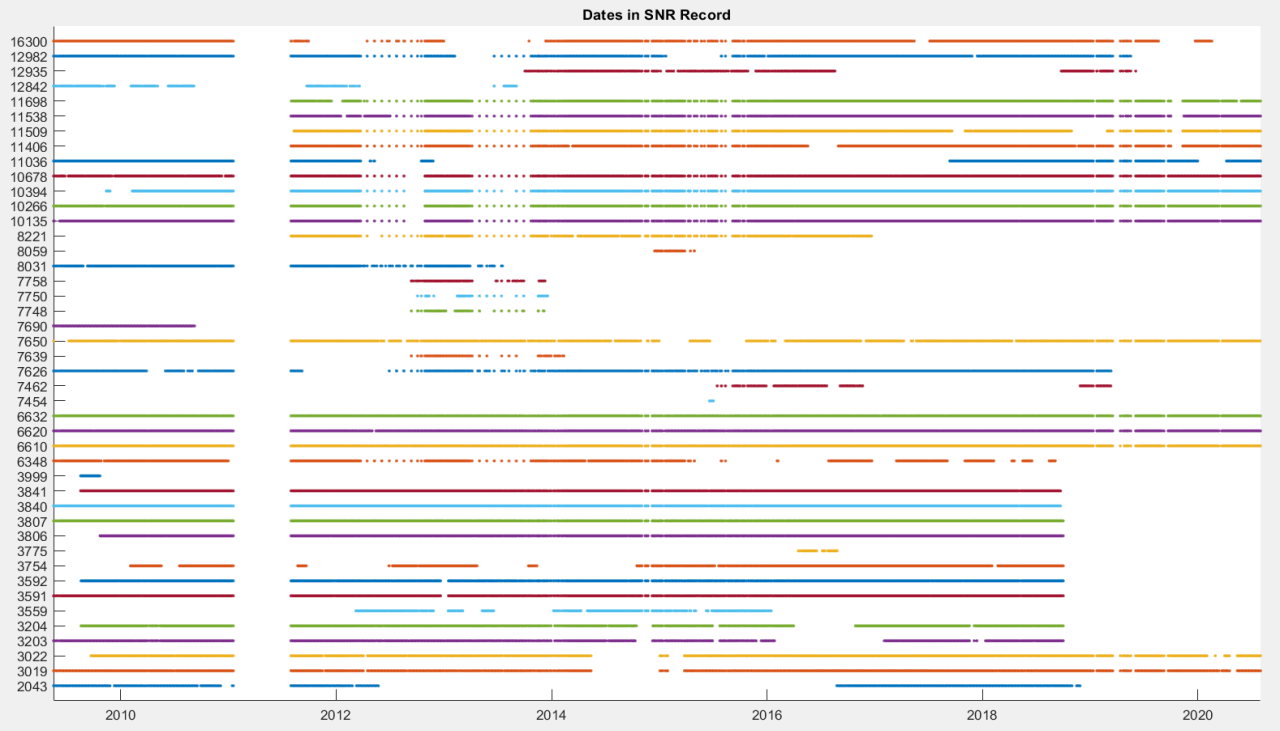
   [timesAll,timesAllUTC,fullGrid,fullGridRaw,datesAll,cloud_fracs_all,heightvectorTot,stationNum,lat,lon,alt,filename]=createGRWPsnr(2043,2018);

The resulting GRWP-SNR NetCDF files can be used to produce the visualizations discussed in Section 2, Step 2a, retrieve PBLH and SNR information discussed in Section 3, Step 2a, and/or generate GRWP-PBLH NetCDF files discussed in Section 3, Step 2b.

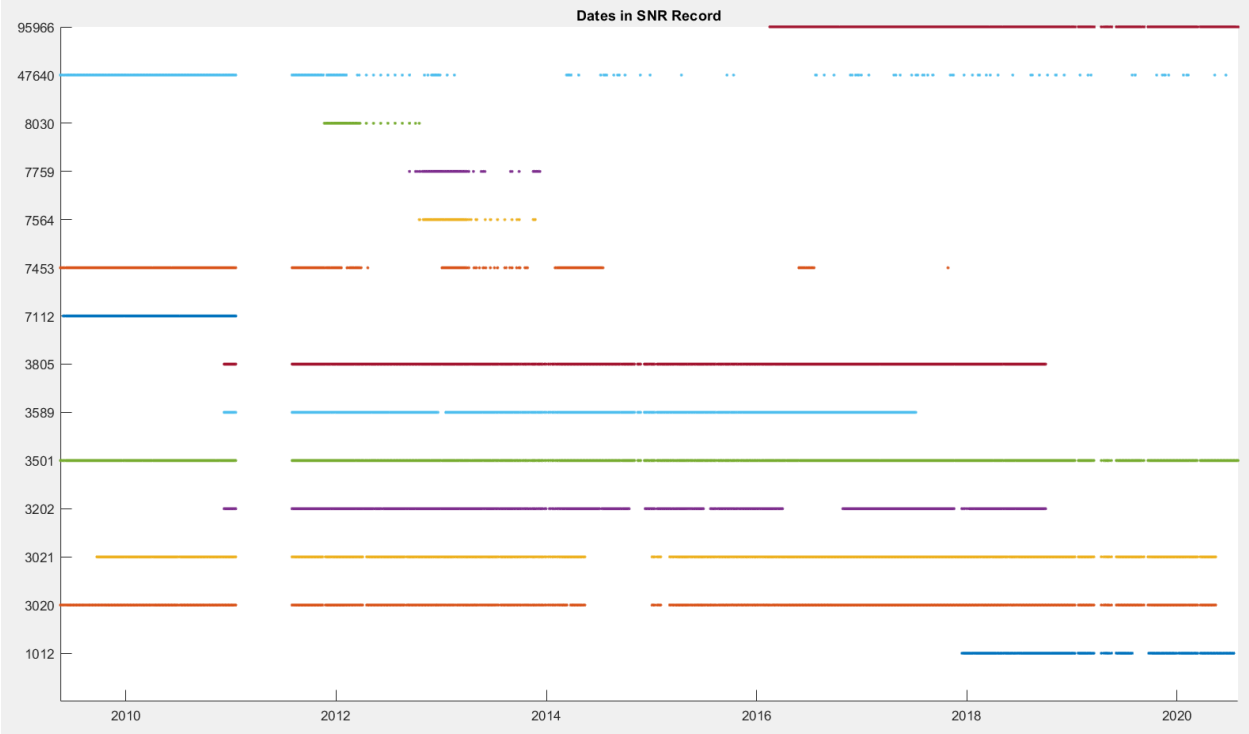
APPENDIX A - Temporal scope of the SNR data available for each station.

Note that some stations that have GRWP-SNR data do not have corresponding GRWP-PBLH data due to the algorithm's determination that PBLH retrievals were not possible for those data.





GRWP-SNR Stations without GRWP-PBLH Data



APPENDIX B - Scripts called by the parent scripts that were described in Sections 2-4

This appendix lists the 'child' scripts called by each parent script described in Sections 2-4. These 'child' scripts are then listed in alphabetical order. See the scripts themselves for comments and further documentation.

From Section 2 Step 1: *loadSNRdata*
Calls: *readerloader* (only when the 'csv' or 'both' option is chosen)

- *readerloader* calls *filefinder* and *getcleardates*
    - *getClearDates* calls *m_srbParseNC*

From Section 2 Step 2a: *main_plotProfilesContours*
Calls: *plotProfilesContours_nc* and/or *plotProfilesContours_csv* (depending on if 'netcdf', 'csv' or 'both' is chosen).

- *plotProfilesContours_nc* calls *getDiurnal_nc*
    - *getDiurnal_nc* calls *runAlgorithm*
- *plotProfilesContours_csv* calls *getDiurnal_csv*
    - *getDiurnal_csv* calls *makeProfiles* and *runAlgorithm*

Section 2 Step 2b does not call any 'child' script.

From Section 2 Step 2c: *main_plotMeans*
Calls: *seasonalMeanFigureSubroutine* and *shadedPlot*[(1)]

From Section 2 Step 2d: *main_plotSeasonalMeansComparison*
Calls: *seasonalMeanFigureSubroutine* and *shadedPlot*[(1)]

From Section 2 Step 2e: *main_plotCloudMeansComparison*
Calls: *seasonalMeanFigureSubroutine* and *shadedPlot*[(1)]

From Section 3 Step 1: *loadSNRdata*
(same as Section 2 Step 1 - see above)

From Section 3 Step 2a: *getDiurnal*
Calls: *getDiurnal_nc* and/or *getDiurnal_csv* (described above from Section 2 Step 2a)

From Section 3 Step 2b: *createGRWPpblh*
Calls: *loadStationRecordNC* and *buildDiurnalCyclesDatabaseNC*

- *loadStationRecordNC* calls *loadSNRdata* described in Section 2 Step 1.
- *buildDiurnalCyclesDatabaseNC* calls *getDiurnal_nc* described above from Section 2 Step 2a.

Section 4 Steps 1-6 do not call any 'child' scripts.

From Section 4 Step 7: *createGRWPsnr*
Calls: *buildInterpolatedSNRdata*

- *buildInterpolatedSNRdata* calls *readerloader* described above from Section 2 Step 1 and *getSNRgrid*
    - *getSNRgrid* calls *makeProfiles*

Alphabetized List of 'Child' Scripts Listed Above

- buildDiurnalCyclesDatabaseNC
- buildInterpolatedSNRdata
- filefinder
- getcleardates

- getDiurnal_csv
- getDiurnal_nc
- getSNRgrid
- loadStationRecordNC
- makeProfiles
- m_srbParseNC
- plotProfilesContours_csv
- plotProfilesContours_nc
- readerloader
- runAlgorithm
- seasonalMeanFigureSubroutine
- shadedPlot[(1)]

[(1)] *Load_visualize_data_Matlab/shadedPlot.m* is not original code. It has been modified from Dave Van Tol (2022). Shaded area plot (https://www.mathworks.com/matlabcentral/fileexchange/18738-shaded-area-plot), MATLAB Central File Exchange. Retrieved July 6, 2022.