STEPS TO FOLLOW:

1) Download all folders: *code*, *idl_routines* and *tests*

2) Go to *code* folder and edit the *Makefile* file changing the path where you have installed the lapack library

3) Run *make vfisv*

4) If there are an error and you do not know how to solve it, please contact me sending an email to abgm@sun.stanford.edu
   If there are no errors, go to folder *tests* where you have different folders:
   i. *jsoc_database*: run these tests just if you have access to the JSOC database
   ii. *local_data*
   iii. *synthesis*

5) To run the tests, just open an IDL session and type *program*

* Remember to add the *idl_routines* to your IDL path or copy the *idl_routines* folder to your IDL folder

* You should have installed the lapack library in your computer

MAIN FUNCTIONS:
join_inverted_data.pro
prepare_data_to_invert_in_parallel.pro
vfisv_invert.pro

SECONDARY FUNCTIONS:
calculate_phase_parameters.pro
get_date_hmi_vfisv.pro
get_scat_profile.pro
initialize_vfisv_filters.pro
prepare_data.pro
read_stokes_hmi.pro
run_vfisv.pro
save_filters_hmi.pro
show_infered_hmi_products.pro
take_values.pro
take_values_wd_fd.pro
vfisv_filter.pro

REQUIRED FUNCTIONS/FILES:
abgm_tvframe.pro
filePhaseMaps.txt
non_tunable_contrasts_710660_June09_cal_128_2.bin
non_tunable_phases_710660_June09_cal_128_2.bin
phaseMaps folder
tunable_contrasts_710660_June09_cal_128.bin

You can synthesize an atmosphere or invert a single pixel or a field of view with X*Y pixels using one or several IDL sessions (like "parallelize" the code):

1) Inversion in one IDL session. You will use the vfisv_invert.pro program. There are different keywords:
    a. **vfisv_path (Mandatory):** path where the VFISV was compiled.
    b. **in_path (Optional, in_data by default):** folder where to save the required files to do the inversions.
    c. **out_path (Optional, out_data by default):** folder where to save the inversion products.
    d. **data_folder / date_it (Mandatory, you should introduce one):** you can invert data saved in your computer or data from the JSOC database.
        - From your computer, just say *data_folder = 'path_of_the_data'*.
        - Looking for in the database, write *date = ['2010','07','02','12','00']*, where the format is [year, month, day, hour, minute].
    e. **info_date (Mandatory if you use the keyword *data_folder*):** you should introduce the information about the day and time of the observations. The format is 'YYYY.MM.DD_hh:mm:ss_TAI'.

    f. **cut / points / pixel_single (Optional):**

- If you do not know the spatial coordinates you can select *cut = 1* and then you will be able to select the field of view in a map.
- If you know them, just write *points = [x0, y0, x1, y1]*.
- In case you want to invert a single pixel, you have 2 options:
  1. Knowing the coordinates, just write *points = [x0, y0, x0, y0]*.
  2. If you do not know the coordinates, just write *single_pixel = 1*.

g. **ff_value (Optional, 1 by default):** this keyword allows you to fix the value of the filling factor.

h. **invert_ff (Optional, 0 by default):** it allows to invert the Stokes parameters leaving the filling factor as free parameter.

i. **list_free_params (Optional, [1,1,1,0,1,1,1,1,1,0] by default):** list of 0's and 1's to say which parameter you want to leave as free parameter. The order of parameters is: eta0, inclination, azimuth, damping, Doppler width, magnetic field strength, los velocity, s0, s1 and filling factor.

j. **guess (Optional, [15.0, 90.0, 45.0, 0.50, 50.0, 150.0, 0.0, 2400.0, 3600.0, 1.0] by default):** list of initial guesses for the atmospheric parameters.

k. **num_lambdas (Optional, 6 by default):** number of filters/wavelengths of the profiles to invert.

l. **synthesis (Optional, 0 by default):** this keyword controls if you want to invert the Stokes profiles or synthesize an atmosphere. This option is only available to use in one IDL session.

m. **deconv (Optional, 0 by default):** you can activate this keyword in case you want to invert the deconvolved data. This keyword is only available if you invert the data looking for in the JSOC Database.

n. **see (Optional, 0 by default):** activate this keyword in case you want to see the fits of the 4 Stokes parameters. This option is only available to use in one IDL session. It is recommended to use when you invert few pixels.

o. **print_parameters (Optional, 0 by default):** if you activate this keyword, the program will show you the value of the atmospheric parameters obtained after the inversion. This option is only available to use in one IDL session. It is recommended to use when you invert few pixels.

EXAMPLE:

```
PRO program
     points = [2000,2760,2000,2760]
     vfisv_path = "/homed/abgm/libraries/src/standalone_vfisv_code/"
     date_it = ['2010','07','02','12','00']
     numw = 6
     vfisv_invert,vfisv_path,date_it=date_it,points=points, $
                  num_lambdas=numw,/see,/print
END
```

2) Inversion in several IDL sessions. You will use the prepare_data_to_invert_in_parallel.pro program and the join_inverted_data.pro.

prepare_data_to_invert_in_parallel.pro: this program creates several folders (depending on the number of processors you want to use) to invert the field of view you want. There are different keywords:

a. **num_proc (Mandatory, 1 by default):** number of processors you want to use and the pieces you want to split the field of view to invert
b. **vfisv_path, data_folder, date_it, cut, points, in_path, out_path, ff_value, invert_ff, list_free_params, guess, num_lambdas and deconv:** are the same than for the inversion in one IDL session.
c. **suffix (Optional):** by default, the name of the folders created for each piece of the field of view is part? (? means a number). If you want to add a suffix at the end of these names, you can use this keyword.

join_inverted_data.pro: this program joins the results obtained in the different folders. There is one keyword:

a. **show_products:** to show the joined maps of the inversion products

EXAMPLE:

```
PRO program
    vfisv_path = '/homed/abgm/libraries/src/standalone_vfisv_code/'
    year = '2012'
    month = '09'
    day = '24'
    hour = '19'
    minute = '00'
    second = '00'

    data_folder = 'data/'
    info_date = year + '.' + month + '.' + day + '_' + $
                hour + ':' + minute + ':' + second + '_TAI'

    ;;;date_it = [year,month,day,hour,minute]

    points = ['1925','1980','1975','2030']
    invert_ff = 1

    num_proc = 4

    prepare_data_to_invert_in_parallel,num_proc=num_proc, $
            vfisv_path=vfisv_path, $
            data_folder=data_folder,info_date=info_date, $
            ;;;date_it=date_it, $
            points=points,invert_ff=1
END
```

For both cases, the results will be saved in the folder out_data with the name hmidata_ready4vfisv_yearmonthday_hourminutesecond_TAI_ points[0]_points[2]_points[1]_points[3]_products.sav

3) Synthesize an atmosphere: to synthesize an atmosphere, you can use the vfisv_intert.pro program, but in this case you have to use the next keywords:
   a. **vfisv_path (Mandatory):** path where the VFISV was compiled.
   b. **synthesis (Mandatory):** this keyword has to be = 1

c. **date_it and points (Mandatory):** the filters used to synthesize an atmosphere depend on the observation day and on the location of the pixel in the disk, so the keywords "date" and "points" are mandatory to synthesize.
d. **guess (Mandatory):** list of atmospheric parameters to synthesize.
e. **num_lambdas (Optional, 6 by default):** number of filters/wavelengths of the profiles to synthesize.

The result of the synthesis will be saved in the folder out_data with the name synthesis_numLambdas_filters.sav