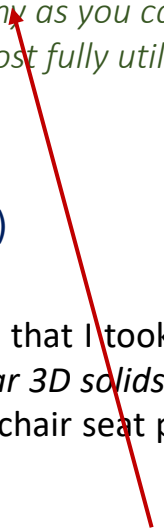
Assessment 7: **Pack random boxes into a large container**

Optimization (fun problem and open-ended solution)

*"You need a fairly optimal way to bunch of **small boxes** into a **big box**. It doesn't need to be perfect, as coming up with a provably optimal solution is likely a really hard problem. The input is a text file with a listing of **integer** volumes(width, length, height). The first line is the container volume, the rest are the volumes of boxes to be placed inside. Place as many as you can. Output the best configuration you find to optimize the number of boxes put into the container, and/or the configuration that most fully utilizes the space within the container.*
If you write in a low-level language, you can use a library for basic data structures"



Oscar's solution: Algorithm and Code Implementation: (it took me three days)

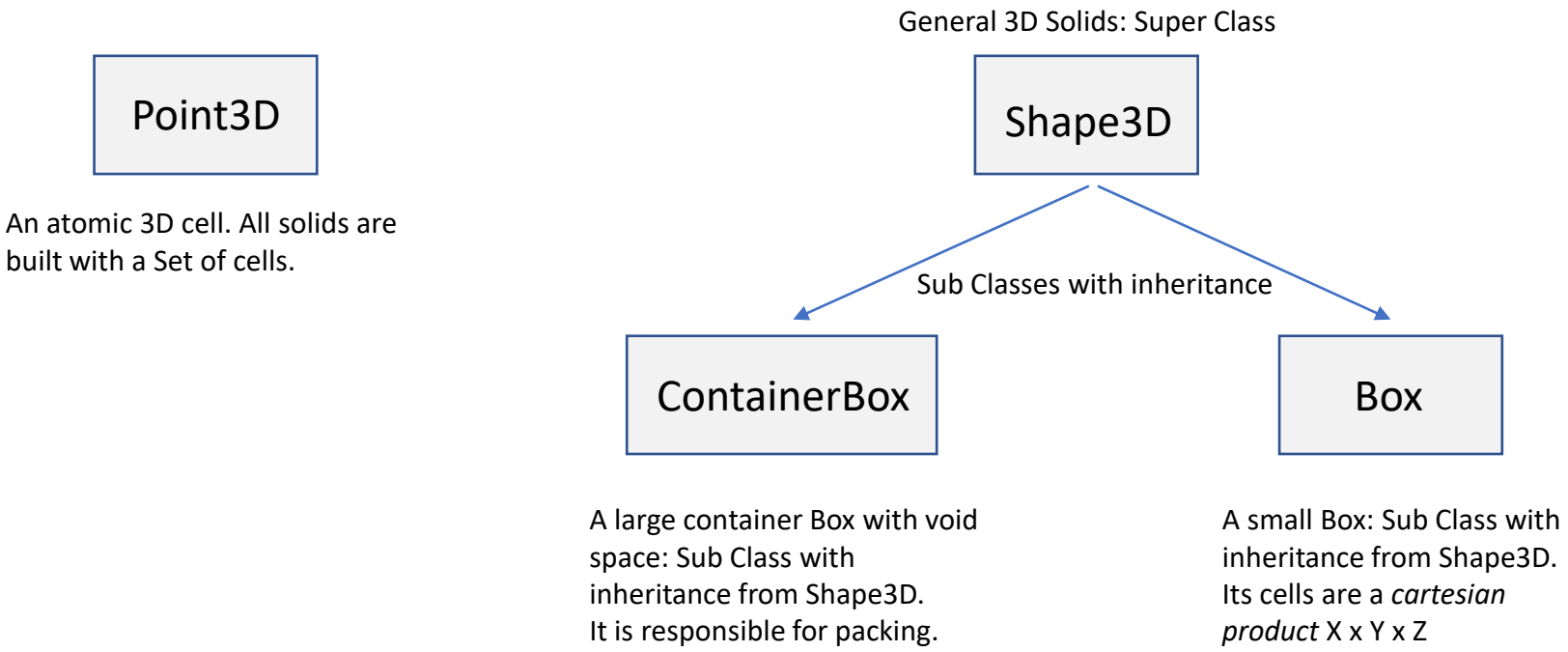
- I have moved so many times towing an U-Haul trailer with my house-holdings that I took the problem almost personal. The problem turns even more interesting if instead of different boxes, you pack ***real** irregular 3D solids*: You may start packing a *table* flipped down with its legs up, then put a *coach*, then the *chairs*, and below and above each chair seat put *boxes* with math books and so forth. And don't forget room for your *bike*.

- The problem statement mentions a word that immediately suggests an approach: "**Integer** *width, length, and heights*". It settles the framework to extend from boxes to full irregular 3D shapes. Dealing with integers (instead of real numbers), immediately allows us to model each irregular 3D body in a *3D grid* of *cells* (or *3D pixels*). So each body is just a **Set** or 3D points (or cells): Body = {(ix,iy,iz)}

- Start randomly, or perhaps choosing a large *Body1* (Count of pixels {(ix,iy,iz)} is a large integer). Perform random body transforms (6 translations East, West, North, South, Up, Down), and 4^3=64 3D rotations along axis x, y, z. Collocate this body on the floor (z layer=0)

- Choose a next *Body2* and place it in the container or trailer. If the Set intersection between *Body1* and *Body2* 3D cells is not empty, it means that there is a collision between the two bodies: Reject and remove *Body2* from the container. If the intersection is empty accept *Body2* placement, and then continue to a next *Body_i*, and so on.

Software Design Diagram: Use class objects



Language implementation (fully coded, up and running):

- A detailed API was written in **Java** for the core four classes
- A builder was written in Bash shell under Linux. (Far more detailed and general than a Makefile)
- The access to the API is done though several *JVM* interpreted script languages:
  - **Groovy** (The one I choose)
  - Python (Jython)
  - Ruby (JRuby)
  - Lisp (Clojure)
  - Scala
  - Kotlin

Next Step: Let’s check the implementation code and **run alive!**

Optimization Algorithm

The assessment statement asks to **maximize the amount of boxes**. That is an over-simplification. You may fit in your trailer perhaps only two mattresses and one coach, but would you prefer to fit one thousand of cheap pencils or colored crayons instead? We may want to define many objective functions to **minimize**, like:

- O1: The amount of 3D shapes. To minimize, just use instead -1.0 * O1
- O2: The void space volume of the container after packaging should be a minimum
- O3: Safety first!, compute the center of gravity of the filled container, you want its Z coordinate as close as possible to the floor layer Z=0

Combine all desired optimizations in a single global Optimization, for instance:

- Oglobal = w1 * O1 + w2 * O3 + . . . + wn * On

Optimization Strategy: Slow thermal cooling of “temperature”: Oglobal (called *Annealing*)

It usually works nicely and emulates the real physical world: Perform small random arrangements of the objects, including translations and rotations, entering and removing of objects. For each scenario realization compute Oglobal. Iterate for a maximum allowance of CPU time, then just simply choose, the arrangement 3D solids realization that yields the minimum value for Oglobal, that is, let it cool down the “temperature”.

I have worked on Annealing when studying GeoStatistics at Stanford. I could fully implement the code, that honestly would take weeks or even a couple of months, so it is beyond of the scope of the assessment.

Assessment 1: **IRI Electron Density Profile**

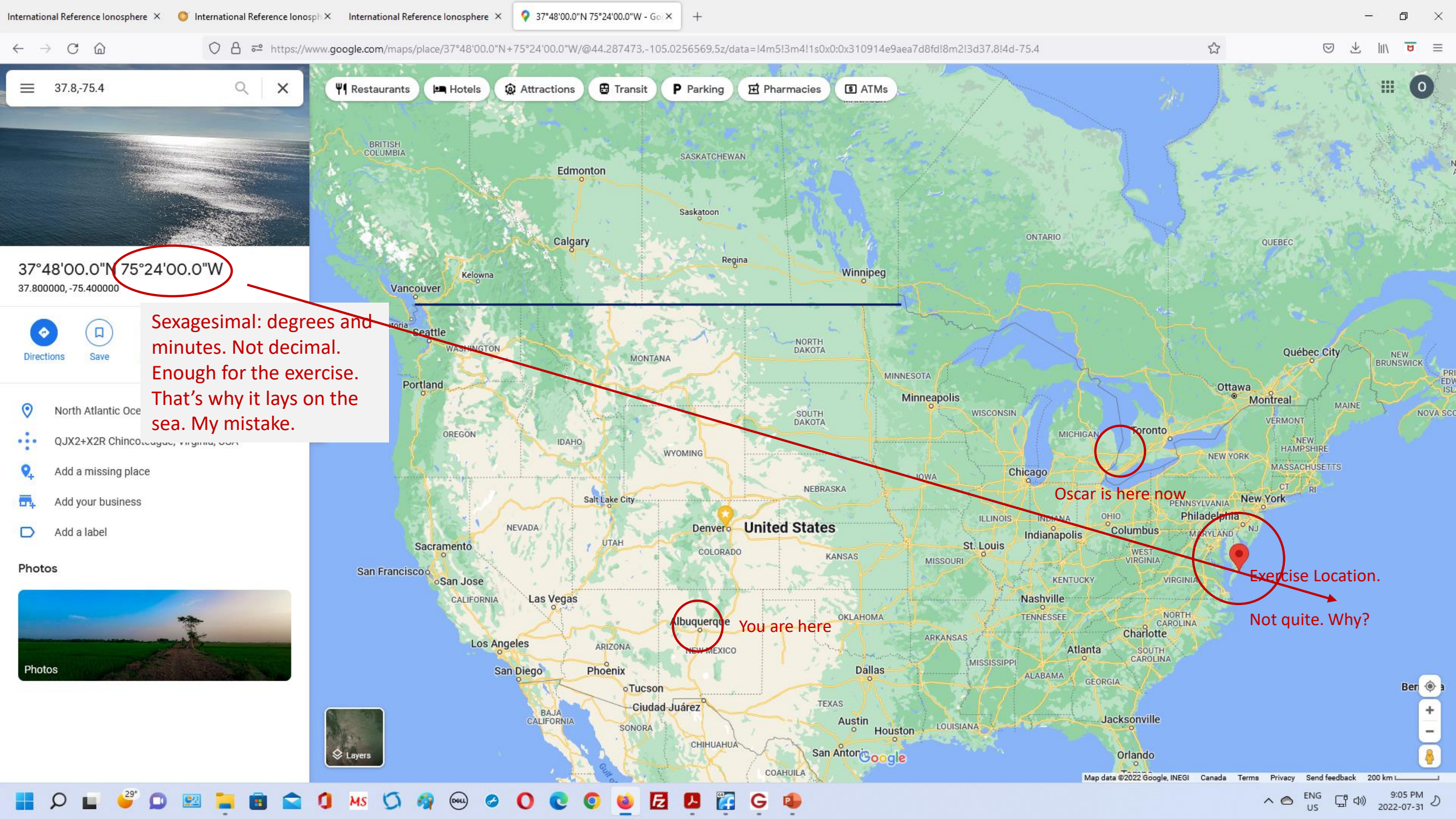
Assessment IRI EDP: Create a C-based modeling and simulation program that drive IRI model Fortran code. The code should capture and generate vertical EDP (Electron Density Profile) for a given time and location of interest.

time of interest: Mar 3 2021 UT 11:00:00 and Mar 4, 2021 UT 23:00:00

location o interest: Lat 37.8N and Lon 75.4W

Assessment Criteria:

1) Create a simple Makefile that can compile iri2016 (http://irimodel.org) and generate a shared object/library
2) Write a C-program that links with the shared object created and create all data needed for step 3)
3) Use gnuplot (www.gnuplot.info) or other similar C-based plotting tools to generate plots of EDP parameters using the shared objective created in step 1.
4) alternatively, use F2PY (https://www.numfys.net/howto/F2PY/) and Python to create EDP plots using the shared object created in step 1. (Although C-based plotting is the preferred solution)
5) Furnish instructions/documentation, etc. on how to run the code and lesson/insights learned by doing this exercise.


37.8,-75.4
37°48'00.0"N 75°24'00.0"W
37.800000, -75.400000
Directions
Save
North Atlantic Oce
QJX2+X2R Chinco
Add a missing place
Add your business
Add a label
Photos
Photos
Restaurants
Hotels
Attractions
Transit
Parking
Pharmacies
ATMs
Sexagesimal: degrees and minutes. Not decimal. Enough for the exercise. That's why it lays on the sea. My mistake.
Oscar is here now
Exercise Location.
Not quite. Why?
You are here
United States
Edmonton
Saskatoon
Calgary
Regina
Winnipeg
Vancouver
Kelowna
Seattle
Portland
Minneapolis
Toronto
Ottawa
Montreal
Québec City
Chicago
New York
Philadelphia
Columbus
Indianapolis
St. Louis
Nashville
Charlotte
Atlanta
Jacksonville
Orlando
Miami
Houston
Austin
San Antonio
Dallas
Denver
Salt Lake City
Sacramento
San Francisco
San Jose
Las Vegas
Albuquerque
Los Angeles
San Diego
Phoenix
Tucson
Ciudad Juárez
Layers
Map data ©2022 Google, INEGI
Canada
Terms
Privacy
Send feedback
200 km

International Reference Ionosphere

BRIEF DESCRIPTION:
The International Reference Ionosphere (IRI) is an international project sponsored by the Committee on Space Research (COSPAR) and the International Union of Radio Science (URSI). These organizations formed a Working Group (**members list**) in the late sixties to produce an empirical standard model of the ionosphere, based on all available data sources (**Charter**). Several steadily improved editions of the model have been released. For given location, time and date, IRI provides monthly averages of the electron density, electron temperature, ion temperature, and ion composition in the ionospheric altitude range (see details below).

The major data sources are the worldwide network of ionosondes, the powerful incoherent scatter radars (Jicamarca, Arecibo, Millstone Hill, Malvern, St. Santin), the ISIS and Alouette topside sounders, and in situ instruments flown on many satellites and rockets. IRI is updated yearly during special **IRI Workshops** (e.g., during COSPAR general assembly). More information can be found in the workshop reports.

The IRI model and software is updated according to the decisions of the IRI Working Group. The software package includes the FORTRAN subroutines, model coefficients (CCIR, URSI, IGRF), indices files (IG_RZ.DAT, APF107.DAT) and README and LICENSE files. The IRI build-up and formulas are described in detail in a 158-page NSSDC report by Bilitza (1990) (PDF accessible in REFERENCES).

An IRI listserver keeps the community informed about model updates, workshops, publication, and other IRI-related matters. To subscribe send a message to **info@irimodel.org** with 'subscribe IRI your_email_address' in the SUBJECT line and your name, affiliation and mailing address in the body of the message.

PARAMETERS:
Electron density, electron temperature, ion temperature, ion composition (O^+, H^+, He^+, N^+, NO^+, O^+_2, Cluster ions), equatorial vertical ion drift, vertical ionospheric electron content (vTEC; a user can select the ending height for the integration along the electron density profile), F1 probability, spread-F probability, auroral boundaries, effects of ionospheric storms on F and E peak densities

INPUTS:
Required: solar indices (F10.7 daily, 81-day, and 12-month running mean; sunspot number 12-month running mean), ionospheric index (ionosonde-based IG index 12-month running mean), magnetic index (3-h ap, daily ap). The indices are found internally by IRI for the user-specified date and time. In the case of F10.7D, F10.7_81, F10.7_12, R_12, and IG_12 a user can input his/her own values.
Optional: The user can provide a number of input parameters and the IRI profiles will than be adjusted to these input parameters:
F2-peak height (hmF2) or propagation factor M3000F2, F2-peak plasmafrequency (foF2) or electron density (NmF2)
F1-ledge height (hmF1), plasmafrequency (foF1) or electron density (NmF1)
E-peak height (hmE), plasmafrequency (foE) or electron density (NmE)
D-ledge height (hmD), plasmafrequency (foD) or electron density (NmD)

HEIGHT RANGE:
Electron density: daytime: 65-2000km, nighttime: 80-2000km
Electron and ion temperature: 60-2500km (IRI-95 option: 60-3000km)
Ion composition: 75-2000km (DS95/DY85 option: 80-2000km)

AVAILABILITY:
* Fortran source code: IRI-2016 (10/13/2021), IRI-2012, IRI-2007, IRI-2001, COMMON FILES for all versions
NOTE: Besides the files that come with each version you also need to download the COMMON FILES and INDICES FILES.

International Reference Ionosphere - IRI (2016) with IGRF-13 coefficients

This page enables the computation and plotting of IRI parameters: electron and ion (O+, H+, He+, O2+, NO+) densities, total electron content, electron, ion and neutral (CIRA-86) temperatures, equatorial vertical ion drift and others.

Go to the IRI description

Help

Select Date and Time

Year(1958-2020): 2000

Month: January **Day(1-31):** 01

Note: If date is outside the Ap index range (1958/02/14-2022/6/6),then STORM model will be turned off.

Time Universal **Time** (0. - 24.0 in decimal hours): 1.5

Select Coordinates

Coord. Type Geographic **Latitude**(-90. - 90. deg.): 50. **Longitude**(0. - 360. deg.) 40.

Height (km, from 60. to 2000.): 100.

Select profile type and range:

Height [60. - 2000. km] Start 100. Stop 2000. Stepsize 50.

Submit Reset

Compile the IRI 2016 Program

- Download all the *Fortran* source code files. Download also all the necessary non-embedded data files.
- Install a Linux Fortran compiler. GNU *gcc* and *gfortran* makes the work, the create a file soft link "*f77*" to *gfortran* in root */bin/*
- How to compile the code?
  1. Write a *.sh Linux Bash script* with full control on dates, folders, and more (**My recommendation**)

```
# Normally prefer a full fresh compile:

rm *.o
rm iri

# Compile to .o object files using -c

f77 -c iriflip.for
f77 -c cira.for
f77 -c igrf.for
f77 -c iridreg.for
f77 -c iritec.for
f77 -c irifun.for
f77 -c irisub.for
f77 -c iritest.for

# The final Fortran iri executable:

f77 *.o -o iri
```

  2. Straightforward command line: `gfortran -o iri iritest.for irisub.for irifun.for iritec.for iridreg.for igrf.for cira.for iriflip.for`

  3. Write a *Makefile* to be run through Linux *make:*

     ***My opinion**: make is a legacy, very old program with primitive syntaxis, like using "TAB" character at start of rules.*

```
allObjectFiles: iriflip.o cira.o igrf.o iridreg.o iritec.o irifun.o irisub.o iritest.o iri

iriflip.o: iriflip.for
	f77 -c iriflip.for

cira.o: cira.for
	f77 -c cira.for

igrf.o: igrf.for
	f77 -c igrf.for

iridreg.o: iridreg.for
	f77 -c iridreg.for

iritec.o: iritec.for
	f77 -c iritec.for

irifun.o: irifun.for
	f77 -c irifun.for

irisub.o: irisub.for
	f77 -c irisub.for

iritest.o: iritest.for
	f77 -c iritest.for

iri:
	f77 iriflip.o cira.o igrf.o iridreg.o iritec.o irifun.o irisub.o iritest.o -o iri
```

  4. Check alive the builder-compiler

5. Check alive the ASCII compiled executable

```
662 $ cat iri_keyboardInput.txt
0,37.8,-75.4
2021,0303,1,11
100
1
100,2000,50
0
0
0
0
```

Create a keyboard input text-file, instead of typing any time you need to run.

6. Run it. The source code has unstable numerical underflow IEE floating point number exceptions!, but managed to produce results. Poor math coding?

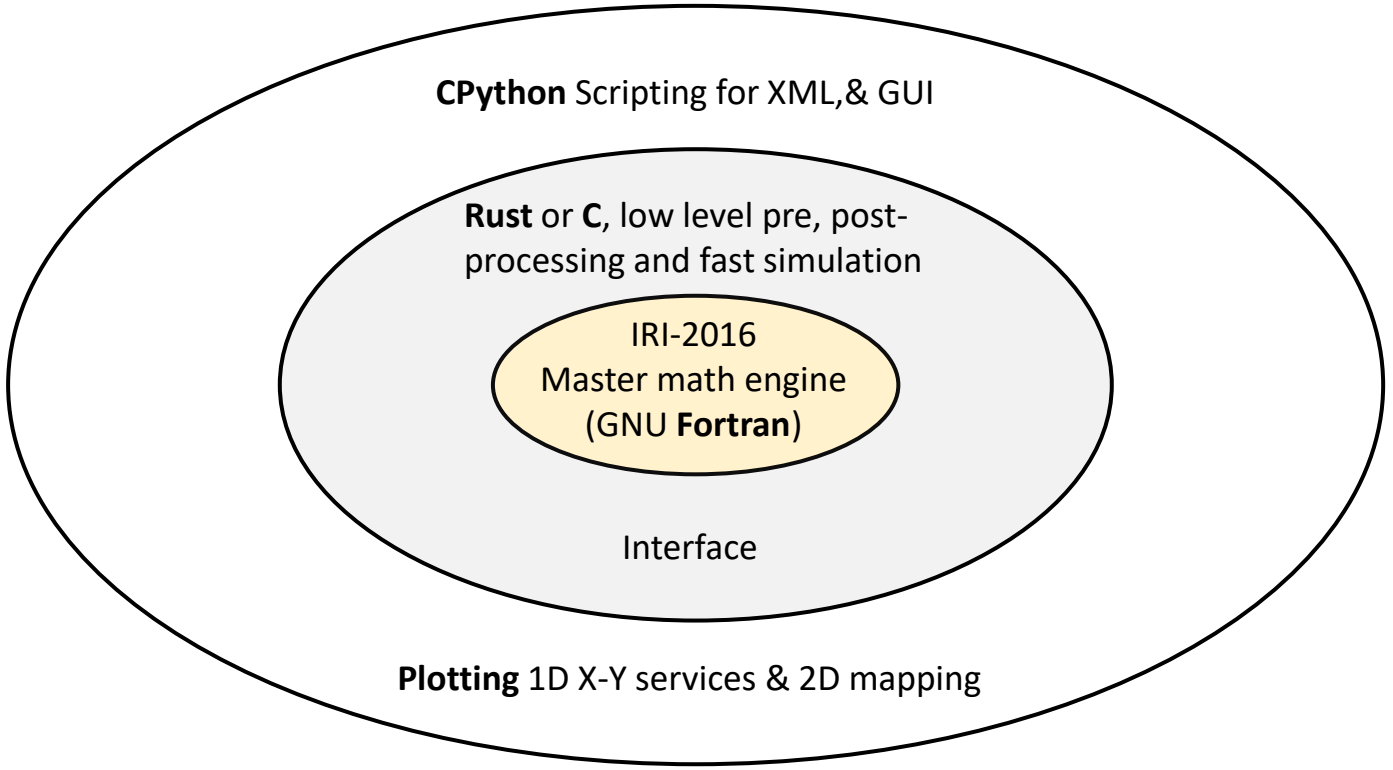
```
650 $ iri < iri_keyboardInput.txt
 jmag(=0/1,geog/geom),lati/deg,long/deg
 year(yyyy),mmdd(or -ddd),iut(=0/1,LT/UT),hour
 height/km
 variable? (1/2/../8 for height/lat/long/year/month/day/day of year/hour)
 begin, end, and stepsize for the selected variable
 output-option (if variable=height then choose 0, 3,4, or 5)
 (enter 0 for standard table of IRI parameters)
 (enter 1 for list of peak heights and densities)
 (enter 2 for plasma frequencies, B0, M3000, valley, width and depth,)
 (enter 3 for 6 parameters of your choice)
 (enter 4 for D-region models at 60,65,..,110 km)
 (enter 5 special test output)
 upper height [km] for TEC integration (0 for no TEC)
 Options: t(rue) or f(alse)
 Enter 0 to use standard or 1 to enter your own


*** IRI parameters are being calculated ***
Ne: NeQuick for Topside
Ne, foF2: URSI model is used.
Ne: B0,B1-ABT-2009
Ne, foF1: probability function used.
Ne, D: IRI1990
Ne, foF2: storm model included
Ion Com.: RBV-10 & TBT-15
Te: TBT-2012 model
Auroral boundary model off
Ne, foE: storm model off
 Enter 0 to exit or 1 to generate another profile?
Note: The following floating-point exceptions are signalling: IEEE_UNDERFLOW_FLAG IEEE_DENORMAL
```

Altitude of ionosphere electron density is the classic plot

H km	ELECTRON DENSITY Ne/cm-3	Ne/NmF2	TEMPERATURES Tn/K	Ti/K	Te/K	ION PERCENTAGES[%]*10 O+	N+	H+	He+	O2+	NO+	1E16m-2 Clust	TEC	t/%
100.0	6360	0.052	181	181	181	0	0	0	0	80	920	-1	-1.0	-1
150.0	10331	0.085	600	600	775	8	0	0	0	228	763	-1	-1.0	-1
200.0	83393	0.685	722	722	1354	286	2	0	0	291	410	-1	-1.0	-1
250.0	121756	0.999	752	821	1573	905	4	0	0	39	48	-1	-1.0	-1
300.0	102526	0.842	760	920	1784	970	23	3	4	0	0	-1	-1.0	-1
350.0	73028	0.599	763	1019	1991	963	24	7	6	0	0	-1	-1.0	-1
400.0	49816	0.409	763	1119	2146	946	24	19	11	0	0	-1	-1.0	-1
450.0	34312	0.282	763	1223	2297	911	24	46	19	0	0	-1	-1.0	-1
500.0	24306	0.200	763	1336	2447	838	23	109	30	0	0	-1	-1.0	-1
550.0	17781	0.146	763	1448	2595	716	22	218	45	0	0	-1	-1.0	-1
600.0	13417	0.110	763	1561	2728	581	23	337	59	0	0	-1	-1.0	-1
650.0	10412	0.085	763	1674	2858	449	25	454	72	0	0	-1	-1.0	-1
700.0	8283	0.068	763	1786	2988	327	26	565	82	0	0	-1	-1.0	-1
750.0	6733	0.055	763	1899	3117	240	25	646	89	0	0	-1	-1.0	-1
800.0	5577	0.046	763	2011	3243	190	24	691	95	0	0	-1	-1.0	-1
850.0	4696	0.039	763	2124	3340	154	23	723	101	0	0	-1	-1.0	-1
900.0	4011	0.033	763	2237	3369	124	21	750	105	0	0	-1	-1.0	-1
950.0	3470	0.028	763	2349	3368	98	20	772	110	0	0	-1	-1.0	-1
1000.0	3035	0.025	763	2462	3364	77	18	792	113	0	0	-1	-1.0	-1
1050.0	2681	0.022	763	2575	3359	60	17	809	115	0	0	-1	-1.0	-1
1100.0	2389	0.020	763	2687	3355	46	15	822	117	0	0	-1	-1.0	-1
1150.0	2146	0.018	763	2800	3350	35	14	833	118	0	0	-1	-1.0	-1
1200.0	1940	0.016	763	2913	3346	27	12	841	120	0	0	-1	-1.0	-1
1250.0	1766	0.014	763	3025	3341	21	11	848	121	0	0	-1	-1.0	-1
1300.0	1616	0.013	763	3138	3337	16	10	853	121	0	0	-1	-1.0	-1
1350.0	1487	0.012	763	3251	3333	12	9	857	122	0	0	-1	-1.0	-1
1400.0	1374	0.011	763	3335	3336	9	8	860	123	0	0	-1	-1.0	-1
1450.0	1275	0.010	763	3357	3357	7	7	863	123	0	0	-1	-1.0	-1
1500.0	1188	0.010	763	3380	3380	5	7	865	123	0	0	-1	-1.0	-1
1550.0	1111	0.009	763	3403	3403	4	6	867	124	0	0	-1	-1.0	-1
1600.0	1042	0.009	763	3426	3426	3	5	868	124	0	0	-1	-1.0	-1
1650.0	980	0.008	763	3449	3449	2	5	869	124	0	0	-1	-1.0	-1
1700.0	925	0.008	763	3472	3472	2	4	870	124	0	0	-1	-1.0	-1
1750.0	874	0.007	763	3495	3495	1	4	871	124	0	0	-1	-1.0	-1
1800.0	829	0.007	763	3519	3519	1	3	871	124	0	0	-1	-1.0	-1
1850.0	788	0.006	763	3542	3542	1	3	872	124	0	0	-1	-1.0	-1
1900.0	750	0.006	763	3565	3565	1	3	872	124	0	0	-1	-1.0	-1
1950.0	715	0.006	763	3588	3588	0	2	873	124	0	0	-1	-1.0	-1
2000.0	683	0.006	763	3611	3611	0	2	873	124	0	0	-1	-1.0	-1

Write a *C* program that links for *Fortran* *.o libraries and drive pre and post processing

Motivation: Certainly we don't plan to reinvent the wheel. If there is a reliable, reputable, top quality, and fast program already available, don't touch it unless really necessary. Just write or adapt interfaces in other languages. For a Linux GNU Fortran environment, the natural *glue language* choices are ***C*** and ***Rust***. For quick prototyping then interface the C layer with another layer high level Scripting language, like ***CPython*** that may use GNU Fortran and C libraries:



- **Step 1:** Explore the eight Fortran source code files and understand the architecture. Start by searching with *Linux* ***egrep*** the collection of all subroutines and functions:

```
File 1: ./irisub.for
     Line 224: SUBROUTINE IRI_SUB(JF,JMAG,ALATI,ALONG,IYYYY,MMDD,DHOUR,
     Line 2343: subroutine iri_web(jmag,jf,alati,along,iyyyy,mmdd,iut,dhour,

File 3: ./iritec.for
     Line 36: subroutine IRIT13(ALATI,ALONG,jmag,jf,iy,md,hour,hbeg,hend,
     Line 95: subroutine iri_tec (hstart,hend,istep,tectot,tectop,tecbot)

File 4: ./iridreg.for
     Line 28: SUBROUTINE FOO(HGT,GLAT1,IDAY,ZANG,F107T,EDENS,IERROR)

File 5: ./cira.for
     Line 24: SUBROUTINE GTD7(IYD,SEC,ALT,GLAT,GLONG,STL,F107A,F107,AP,MASS,D,T)
     Line 323: SUBROUTINE GTD7D(IYD,SEC,ALT,GLAT,GLONG,STL,F107A,F107,AP,MASS,
     Line 401: SUBROUTINE GHP7(IYD,SEC,ALT,GLAT,GLONG,STL,F107A,F107,AP,
     Line 497: SUBROUTINE GLATF(LAT,GV,REFF)
     Line 561: SUBROUTINE GTS7(IYD,SEC,ALT,GLAT,GLONG,STL,F107A,F107,AP,MASS,D,T)
     Line 1016: SUBROUTINE METERS(METER)
     Line 1266: SUBROUTINE TSELEC(SV)
     Line 1575: SUBROUTINE SPLINEM(X,Y,N,YP1,YPN,Y2)
     Line 1617: SUBROUTINE SPLINTM(XA,YA,Y2A,N,X,Y)
     Line 1653: SUBROUTINE SPLINI(XA,YA,Y2A,N,X,YI)

File 6: ./irirtam.for
     Line 16: SUBROUTINE READIRTAMCOF(ISEL,IDATE,IHHMM,MEF,FF)

File 7: ./irifun.for
     Line 259: subroutine tops_cor2(xh,vmod,a01)
     Line 525: SUBROUTINE ELTEIK(PF107Y,INVDIP,MLT,ALT,DDD,PF107,TE,SIGTE)
     Line 905: SUBROUTINE KODERR(MIRREQ,DOUT)
     Line 1210: SUBROUTINE KOEFD(MIRREQ,DOUT)
     Line 1515: SUBROUTINE KOF107(MIRREQ,DOUT)
```

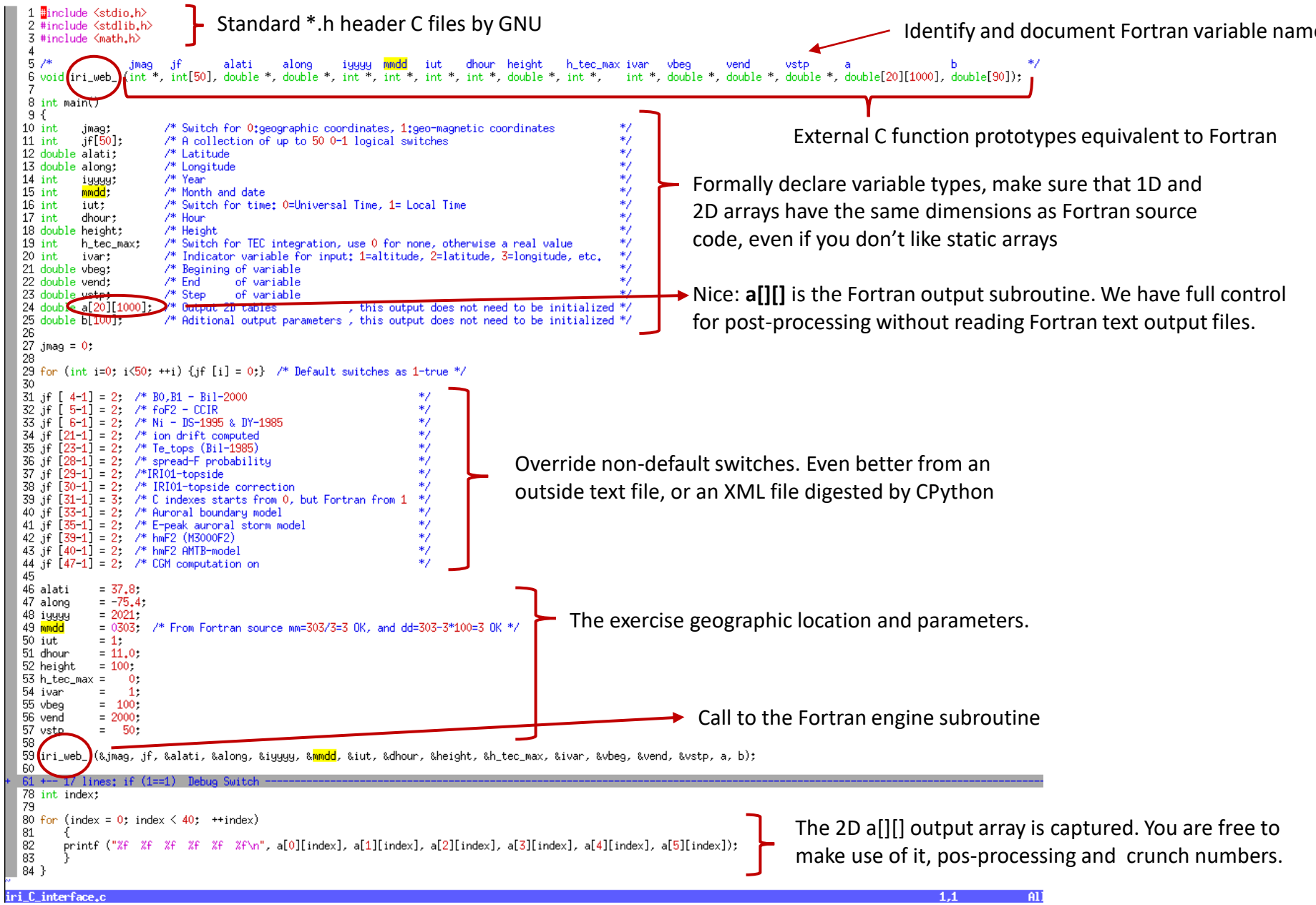
… and much more …

A *Linux Bash Shell* script that uses egrep

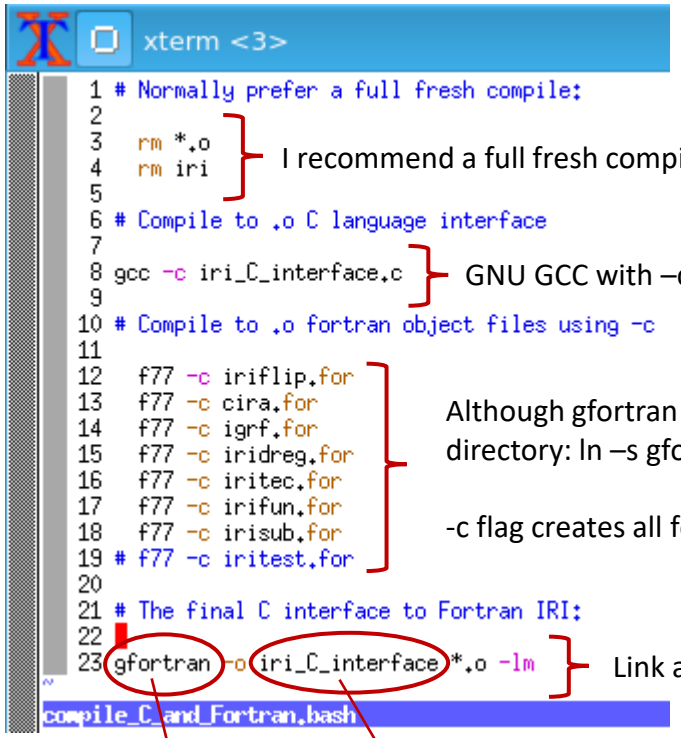
Both subroutines **IRI_SUB** and **iri_web** have suitable entry points to interface with C code driver. Notice how different typing and case styles might reflect the hands of different programmers perhaps along years.

```
2342 c
2343       subroutine iri_web(jmag,jf,alati,along,iyyyy,mmdd,iut,dhour,
2344      &          height,h_tec_max,ivar,vbeg,vend,vstp,a,b)
2345 c-----------------------------------------------------------------------
2346 c changes:
2347 c       11/16/99 jf(30) instead of jf(17)
2348 c       10/31/08 outf, a, b (100 -> 500)
2349 c
2350 c-----------------------------------------------------------------------
2351 c input:   jmag,alati,along,iyyyy,mmdd,dhour  see IRI_SUB
2352 c          height  height in km
2353 c          h_tec_max  =0 no TEC otherwise upper boundary for integral
2354 c          iut     =1 for UT       =0 for LT
2355 c          ivar    =1      altitude
2356 c                  =2,3    latitude,longitude
2357 c                  =4,5,6  year,month,day
2358 c                  =7      day of year
2359 c                  =8      hour (UT or LT)
2360 c          vbeg,vend,vstp  variable range (begin,end,step)
2361 c output:  a       similar to outf in IRI_SUB
2362 c          b       similar to oarr in IRI_SUB
2363 c
2364 c          numstp  number of steps; maximal 1000
2365 c-----------------------------------------------------------------------
2366       dimension   outf(20,1000),oar(100),oarr(100),a(20,1000)
2367       dimension   xvar(8),b(100,1000)
2368       logical     jf(50)
2369
2370                   nummax=1000
2371       numstp=int((vend-vbeg)/vstp)+1
2372       if(numstp.gt.nummax) numstp=nummax
2373
2374       do 6249 i=1,100
2375 6249        oar(i)=b(i,1)
2376
irisub.for
```

- **Step 2:** Write C interface program. Make sure the Fortran subroutines has an appended underscore **“_”**. Carefully declare equivalent variable types, and document the source code.



- **Step 4:** Joint Fortran-C compilation. Write a *Linux Bash* script instead of a *MakeFile* for full control



I recommend a full fresh compilation

GNU GCC with –c flag creates .o object file

Although gfortran is the GCC Fortran compiler, I wrote a symbolic link for readability in /bin/ directory: ln –s gfortran f77, the check if .bashrc path is OK.

-c flag creates all fortran *.o object files

Link all *.o object files and –lm default libraries

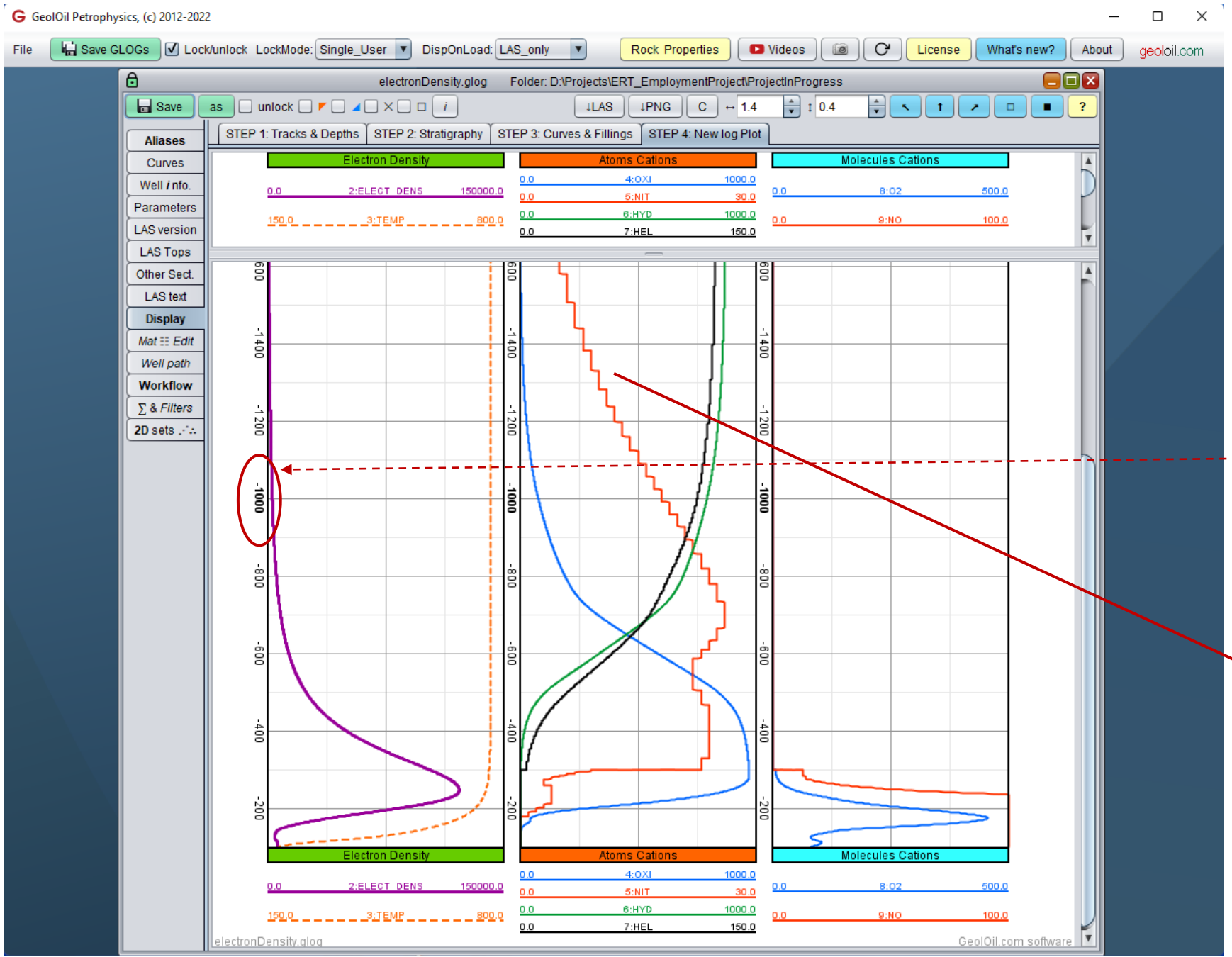
Final “-o” output is the executable file in Linux

Make sure to use gfortran, not gcc here. The reason is that gfortran brings specific fortran defaults and libraries that GCC does not have in C neither C++

```
717 $ ls *.bash
cleanCompiled.bash  compile_C_and_Fortran.bash  compile_IRI.bash  manual_compile_IRI.bash

geoloil@localhost ~/Projects/ERT_Employment/SandBox_IRI_2016_Program
718 $ bash compile_C_and_Fortran.bash
rm: cannot remove 'iri': No such file or directory
iriflip.for:769:72:

  769 |  898  RTS(ITJS)=0.0
      |                                                                        1
Warning: Fortran 2018 deleted feature: DO termination statement which is not END DO or CONTINUE with label 898 at (1)
iriflip.for:1546:72:

 1546 |  9    SIGEX(I)=0.0
      |                                                                        1
Warning: Fortran 2018 deleted feature: DO termination statement which is not END DO or CONTINUE with label 9 at (1)
iriflip.for:1636:72:

 1636 |       DO 10 IK=1,12
      |                                                                        1
Warning: Fortran 2018 deleted feature: Shared DO termination label 10 at (1)
iriflip.for:1643:72:

 1643 |  687  OTHPR1(I)=1.0E-15
      |                                                                        1
Warning: Fortran 2018 deleted feature: DO termination statement which is not END DO or CONTINUE with label 687 at (1)
iriflip.for:1649:72:

 1649 |  786  COLUM(I)=1.0E+25
      |                                                                        1
Warning: Fortran 2018 deleted feature: DO termination statement which is not END DO or CONTINUE with label 786 at (1)
iriflip.for:1987:72:

 1987 |  20   IF(SUM.NE.0.0) PROB(1,I,L)=YO(LL,I)/SUM
      |                                                                        1
Warning: Fortran 2018 deleted feature: DO termination statement which is not END DO or CONTINUE with label 20 at (1)
iriflip.for:2002:72:

 2002 |  50   WRITE(17,90) ZLAM(L),((PROB(IS,J,L),J=1,6),IS=1,3)
      |                                                                        1
Warning: Fortran 2018 deleted feature: DO termination statement which is not END DO or CONTINUE with label 50 at (1)
iriflip.for:2059:72:
```

Many **Warning** compilation messages for the **Fortran** source codes. The C program interface had no warnings at all. Ignore most warnings for legacy old Fortran sources, but make sure that your C code is seamless.

Height Plots of Properties



I used my commercial *petrophysics* software for the exercise. It is a huge Java package of 150,000+ lines of source code and 200+ classes.

It is used in the Oil & Gas industry for depths, not heights or elevations. That's why I had to enforce a **negative sign** on the Z vertical axis.

Staircase type numerical artifacts present in the Fortran library. The C interface post-processing program could easily smooth this behaviour using *Kernel* functions.