Updates on magnetic footprint reader for Juno and Jovian moons at UI

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- Magnetic footprints for Juno and Jovian moons(Amalthea, Io, Europa, Ganymede, and Callisto) and Juno's M-value are computed using JRM09 [Connerney+, 2018] and current sheet models [Connerney+, 1981] when Juno is within 15 R_J from the center of the planet.

- All of the data from Juno's perijove 0 through 34 are computed with IDL programs at University of Iowa (UI), and stored in the hdf5 format; these computations are regularly performed with the recent Juno SPICE kernels (i.e. ~1-2 month after each perijove).

- The original hdf5 files and IDL reader for these files are available at http://space.physics.uiowa.edu/juno/mwg/magfootprint.html (Juno MWG website at UI). If you have questions and requests, please direct to masafumi-imai@uiowa.edu

- In the recent version, I added the following variables for each perijove data.
  - FootB0UV and JunoB0 (Modeled B0 at Juno's footprint and instantaneous position at given time)
  - EqWLon and EqLat (Juno's magnetic field line crossing with the JRM09-dipole magnetic equator)
  - MagEqWLon and MagEqLat (EqWLon and EqLat in Jovimagnetic coordinates)
  - NorthFootWlonUV, NorthFootLatUV, NorthFootB0UV, NorthJunoFieldLineLengthUV (Juno's footprint information on northern hemisphere)
  - SouthFootWlonUV, SouthFootLatUV, SouthFootB0UV, SouthJunoFieldLineLengthUV (Juno's footprint information on southern hemisphere)

Jovian 1-bar level surface

- Latitude-dependent distance from the center of Jupiter at 1-bar level is computed as follows.

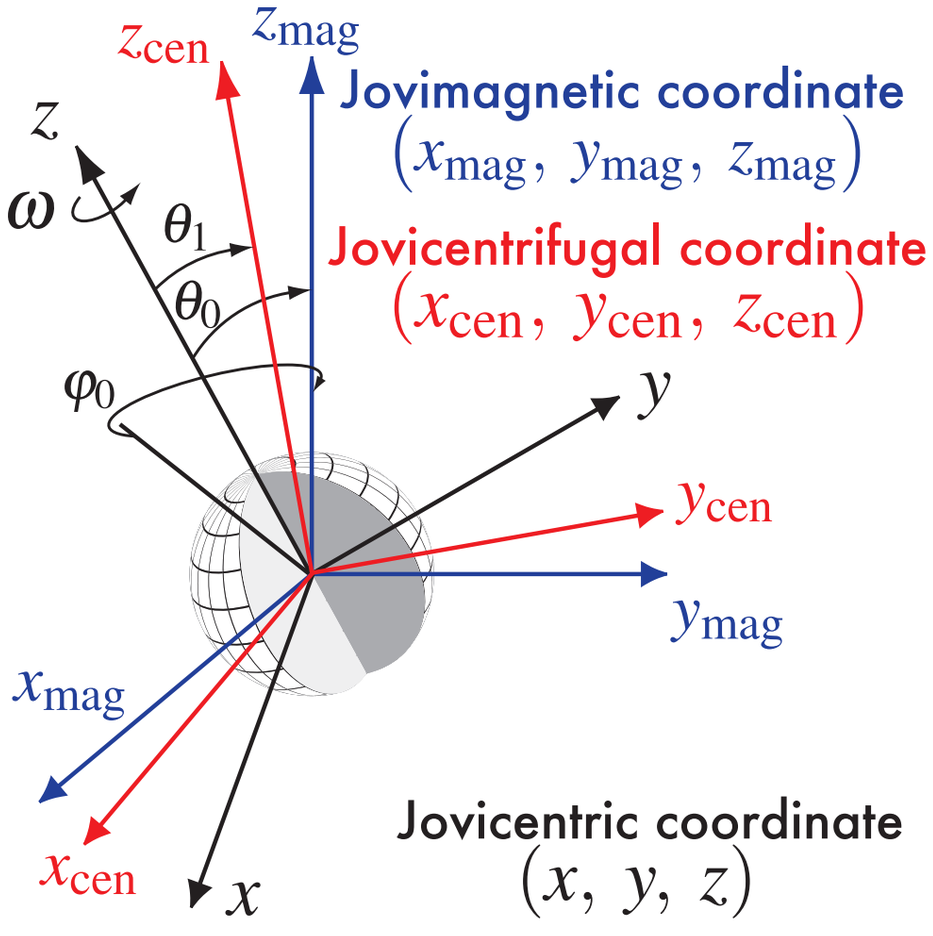
$$\left| \frac{R_J / \cos\lambda}{\sqrt{1 + (\tan\lambda)^2 / (1-f)^2}} \right|$$

where f = (71492-66854)/71492, R_J = 71492 km, and λ is Jovicentric latitude in radian.

- Please note that this expression is an approximation and valid in the order of tens of km because the shape of Jupiter is like a diamond (Buccino et al., AGU Fall Meeting, 2018). Because of this, there is a slight discrepancy between the above value and the Galileo Probe's measurement at 1-bar level (Seiff et al., JGR, 1998). Nevertheless, I use the above equation to compute Jovian 1-bar level surface.

Coordinate System for VIP4- and JRM09-based dipoles

Offset dipole configuration	VIP4-based dipole	JRM09-based dipole
Magnetic tilt colatitude θ_0	9.52°	10.31°
West longitude ϕ_0	200.77°	196.61°



According to Chapman & Bartels (1940), the transformation forms may be written as:

$$\theta_0 = \arccos\left(\frac{g_1^0}{\sqrt{(g_1^0)^2 + (g_1^1)^2 + (h_1^1)^2}}\right)$$

$$\phi_0 = \arctan\left(\frac{h_1^1}{g_1^1}\right)$$

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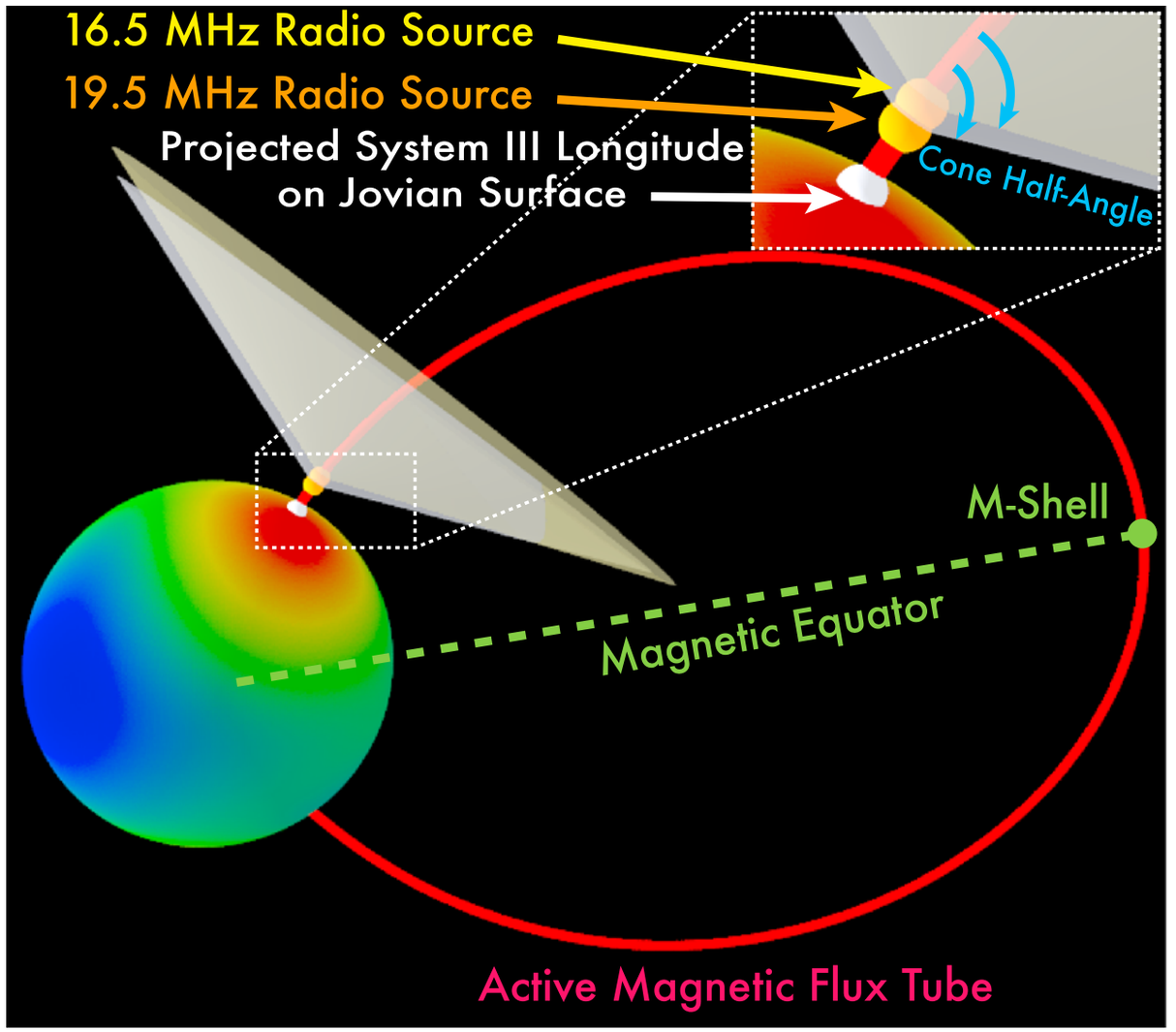
(a) Geometry of Jovian Radio Model



[Fig. 2 of Imai+, 2017b]

HDF5 original data and IDL reader

- The original hdf5 files and IDL reader for these files are available at http://space.physics.uiowa.edu/juno/mwg/magfootprint.html (Juno MWG website at UI).

- Currently, "Juno_Foot_PJXX_20190408_all.hdf5" (where XX=00 to 34) and "read_Juno_foot.pro" are being shared.

- Example of running "read_Juno_foot" procedure in IDL

```
Masafumi$ idl
IDL Version 8.3, Mac OS X (darwin x86_64 m64). (c) 2013, Exelis Visual Information Solutions, Inc.
Installation number: XXXXXX
Licensed for use by: University of Iowa

IDL> .rnew read_Juno_foot
% Compiled module: READ_JUNO_FOOT.
% Compiled module: TEST.
IDL> test
% Loaded DLM: HDF5.
JunoFoot_PJ18_20190408_all.hdf5       2458526.6       2458526.6       204.86850
      63.577764       37.429677       204.98638       63.622541       346.07294
      61.901187       359.47225       80.955793       253.71806       71.802482
      286.60351       84.370483       249.76165       75.540949       5.7137377
     -48.428061       16.556507      -61.233603       315.51533      -70.685424
      2.5346775      -68.740758       330.31321      -72.626584       1128041.3
      15.796060    0.0015930291       245.07433      -6.8770481       47.999395
 -0.00030712749       204.98638       63.622541       15.796060       1128041.3
      272.07999      -79.709236       13.310347       4508123.1
```

- HDF5 files are supported in Autoplot, IDL, MATLAB, Python, C, Fortran, Java, C++, Mathematica.

Header of “read_Juno_foot.pro”

```
; all of computations were done with JRM09 + CS models
; file       <- File name
; jed        -> Julian ephemeris date (JED)
; jdutc       -> Julian Date UTC (jdutc)
; FootWlon   -> Juno footprint at 1-bar in System III W longitude
; FootLat    -> Juno footprint at 1-bar in Jovicentric latitude
; FootWlonUV -> Juno footprint at 400 km above 1-bar in System III W longitude
; FootLatUV  -> Juno footprint at 400 km above 1-bar in Jovicentric latitude
; {North,South}FootWlon{Am,Io,Eu,Ga,Ca}UV
;            -> Footprints for {Amalthea, Io, Europa, Ganymede, Callisto} on
;               {northern, southern} hemisphere at 400 km above 1-bar in
;               System III W longitude
; {North,South}FootLat{Am,Io,Eu,Ga,Ca}UV
;            -> Footprints for {Amalthea, Io, Europa, Ganymede, Callisto} on
;               {northern, southern} hemisphere at 400 km above 1-bar in
;               Jovicentric latitude
; MShell     -> M-shell
; JunoFieldLineLengthUV -> Integrated length in km along Juno's magnetic field
;               line onto 400 km altitude above 1-bar leve
; FootB0UV   -> Modeled magnetic field magnitude at Juno footprint, 400 km
;               above 1-bar
; JunoB0     -> Modeled magnetic field magnitude at the instantaneous Juno
;               position
; EqWLon    -> System III west longitude at the point crossing with the magnetic equator
; EqLat     -> Latitude at the point crossing with the magnetic equator
; MagEqWLon -> Magnetic longitude (based on JRM09 dipole) at the point crossing with the magnetic equator
; MagEqLat  -> Magnetic latitude (based on JRM09 dipole) at the point crossing with the magnetic equator
; {North,South}FootWlonUV -> Juno footprint on {northern, southern} hemisphere
;                            at 400 km above 1-bar in System III W longitude
; {North,South}FootLatUV  -> Juno footprint on {northern, southern} hemisphere
;                            at 400 km above 1-bar in Jovicentric latitude
; {North,South}FootB0UV   -> Modeled magnetic field magnitude on {northern, southern} hemisphere
;                            at Juno footprint, 400 km above 1-bar
; {North,South}JunoFieldLineLengthUV -> Integrated length in km along Juno's magnetic field
;                                       line toward {northern, southern} hemisphere onto 400 km
;                                       altitude above 1-bar level
;
; N.B. -999.0 means undetermined data due to largest M-shell
; ---
; Author: Masafumi Imai (masafumi-imai@uiowa.edu)
;
```

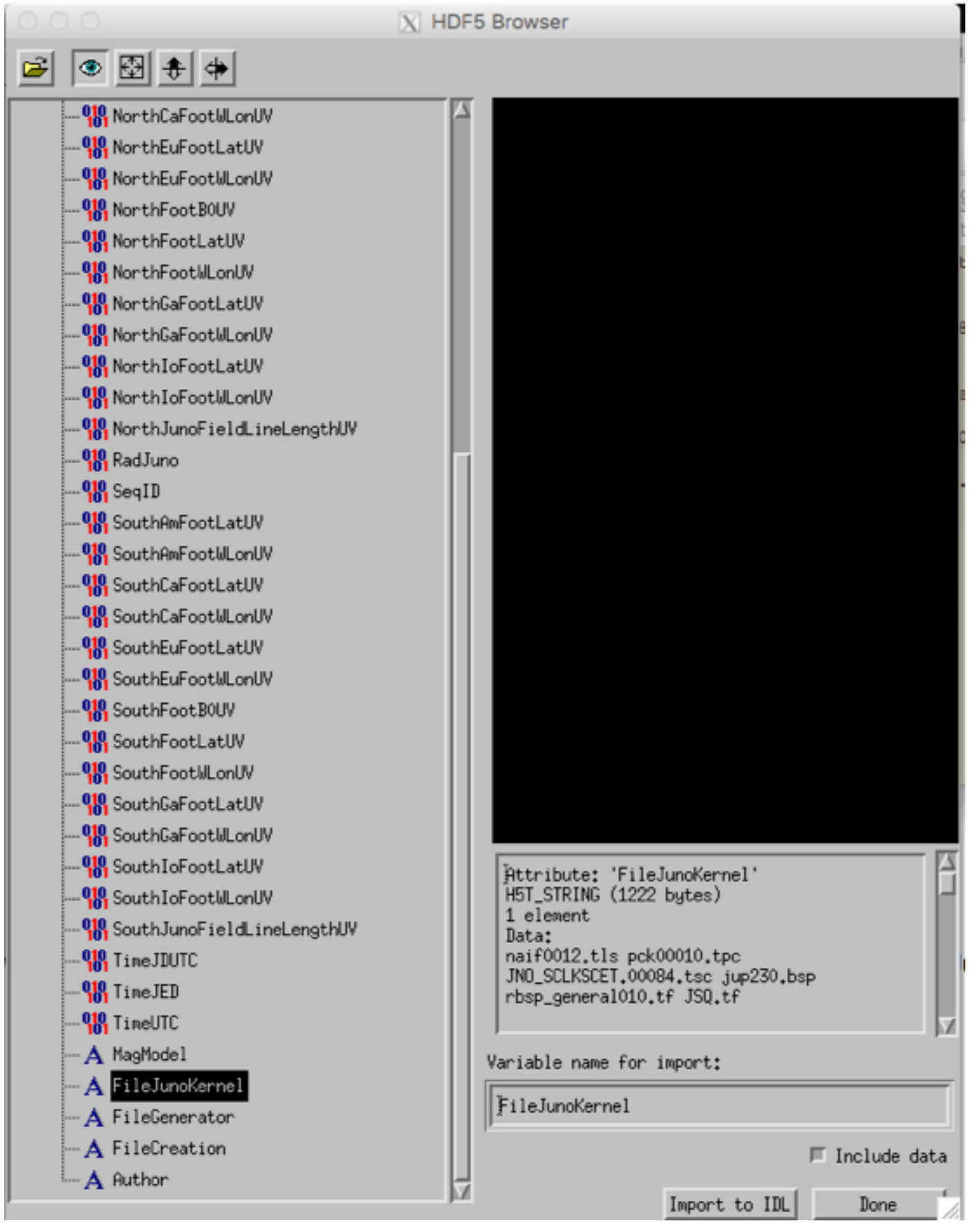
Contents of HDF5 data (e.g. JunoFoot_PJ18_20190408_all.hdf5)

- Please note that the hdf5 files have more variables (including Juno kernel information) than those imported from my IDL reader.

- In accessing all variables, please type the following command in IDL.

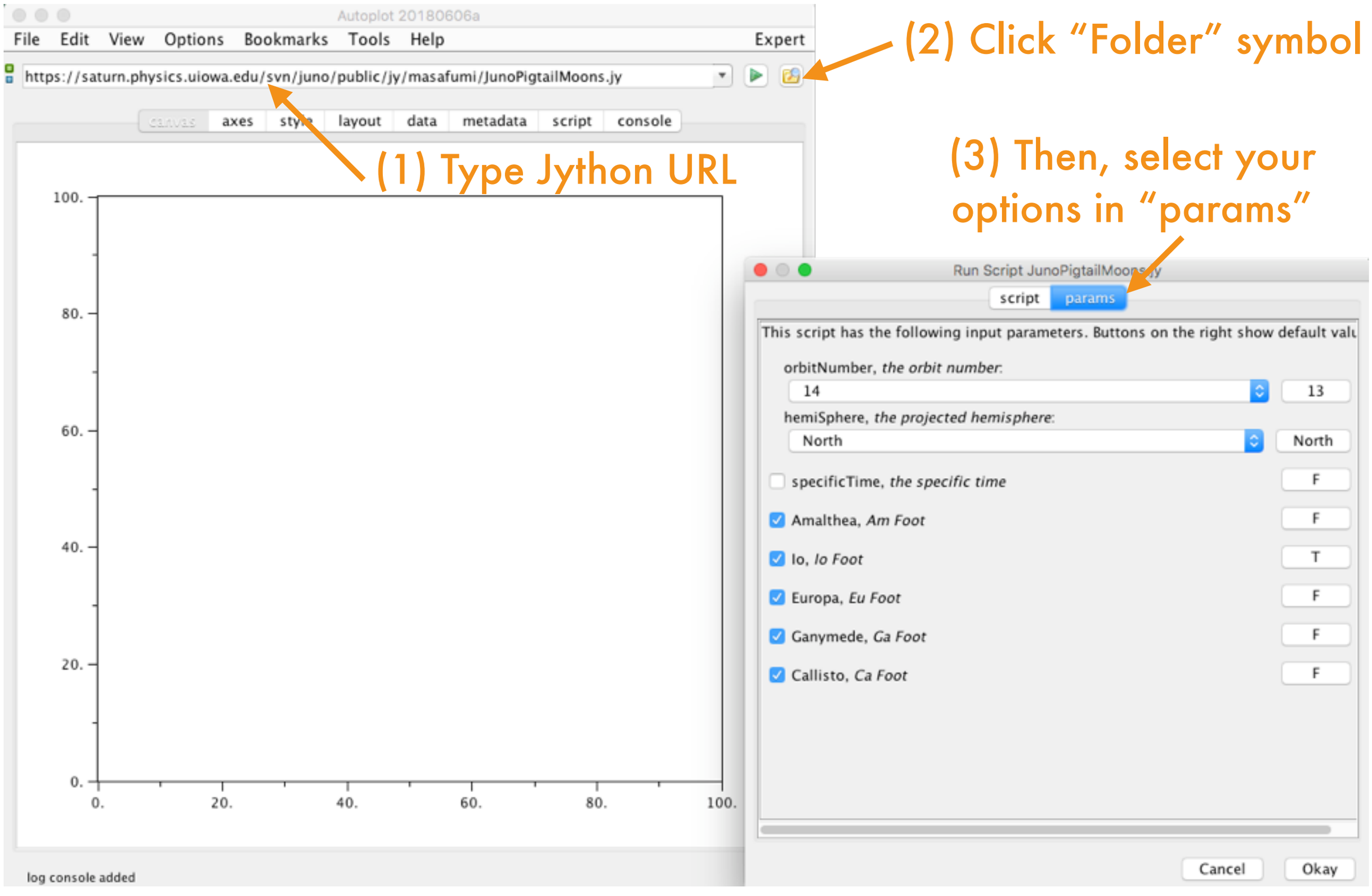
```
IDL>
h5=h5_browser('JunoFoot_PJ18_20190408_all.hdf5')
% Compiled module: H5_BROWSER.
% Compiled module: CW_TREESTRUCTURE.
```

- -999.0 means undetermined data due to largest M-shell.



Demonstration on JunoPigtailMoons.jy (1/2)

- Please download the recent Autoplot software (http://autoplot.org).
- https://saturn.physics.uiowa.edu/svn/juno/public/jy/masafumi/JunoPigtailMoons.jy



Demonstration on JunoPigtailMoons.jy (2/2)