# User's Manual
# Earth-Centered Earth-Fixed in WGS84
# by Hydrometronics LLC

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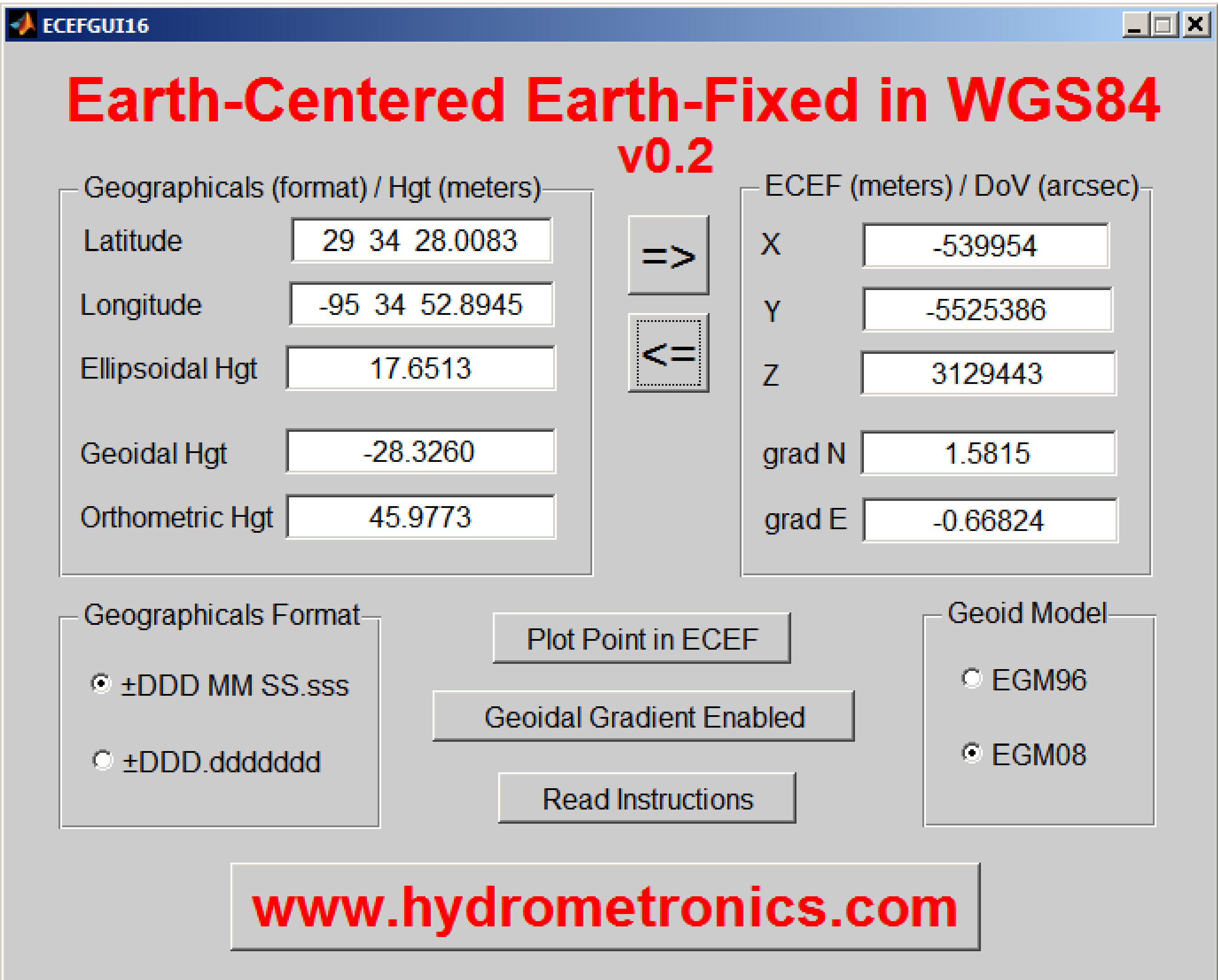


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See legal notice on first and last pages

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# Installation

- Two files are required for the installation of ECEF in WGS84:
  - MCRInstaller.exe (almost 200MB)
  - ECEFGIUxx.exe (almost 180MB)
- The installer (supplied by The MathWorks without royalty) is large because it will support all of Matlab on your computer.
- The application is large because it contains two geoidal models. EGM08 alone is almost 140MB.
- Get the software at ftp://www.hydrometronics.com
  - UserID: ECEFinWGS84
  - Password: 3edc#EDC
- ECEF in WGS84 is complied Matlab software that requires the installation of the Matlab Compiler Runtime (MCR). Like the .NET framework for Visual Studio languages or the Java Virtual Machine (JVM) for Java, the MCR supports compiled Matlab programs.
  - ECEF in WGS84 is compiled in 32 bits for compatibility with a range of target machines
  - Execute the MCR installer on the target machine.
- Launch ECEF in WGS84 by double clicking on the executable
- Give it time to launch the first time

- Troubleshooting: If the MCR is not “seen” add MCR path to the PATH variable within Environment variables. The way to do that is Right Click on “My Computer” -> Properties -> Advanced System Settings -> Click on “Environment Variables”. In the “System Variables” dialog box, click on Path variable and add the MCR path to it which is typically “C:\Program Files (x86)\MATLAB\MATLAB Compiler Runtime \v715\runtime\win32;” for a 64 bit Windows system.

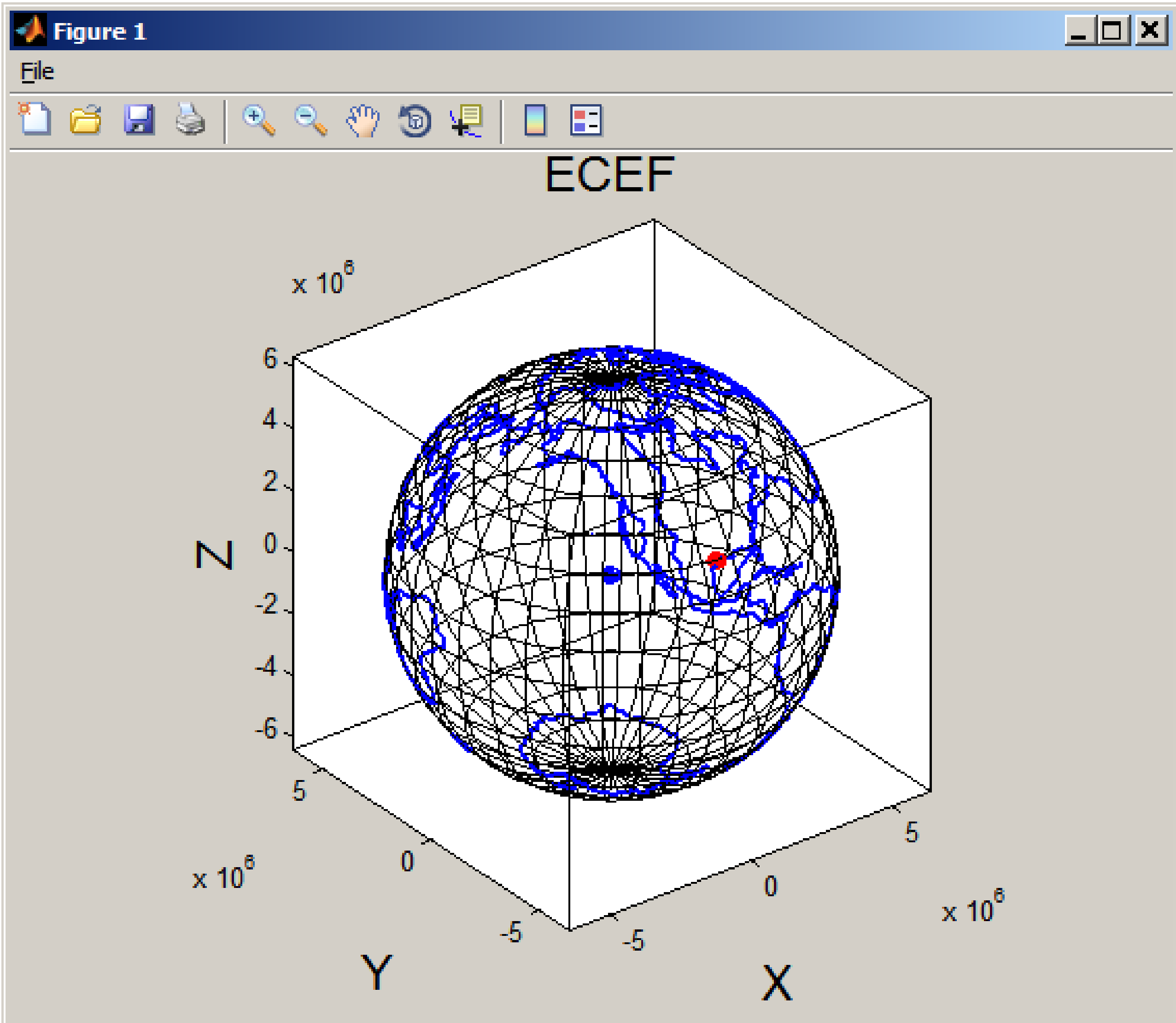
# Overview of ECEF, EGM and Deflection

- Earth-Centered Earth-Fixed (ECEF) is the geocentric Cartesian coordinate system used by GPS
- A useful Wikipedia article on ECEF is here:
  - http://en.wikipedia.org/wiki/ECEF
- ECEF supports visualization in 3D without cartographic distortion
- Earth Gravitational Models (EGM) of 1996 and 2008 provide the separation between the geoid and the WGS84 ellipsoid
- In 3D ECEF visualization EGM is important as a reference to the geoid (level surface) and the vertical
- Useful articles on EGM96, EGM08 and the geoid are here:
  - http://en.wikipedia.org/wiki/EGM96
  - http://earth-info.nga.mil/GandG/wgs84/gravitymod/egm2008/egm08_wgs84.html
  - http://en.wikipedia.org/wiki/Geoid
- The deflection of the vertical is the difference between the normal to the ellipsoid and "up" as defined by gravity. A useful article on the deflection of the vertical is here:
  - http://en.wikipedia.org/wiki/Vertical_deflection
- Deflection of the vertical (DoV) is emulated in ECEF in WGS84 by computing the gradient of the geoidal undulation and changing the sign. Gradient and DoV agree within 0.1 seconds 67% of the time and within 0.3 seconds 90% of the time, but extreme outliers can occur in mountainous areas.
- A brief user's guide for the software follows

# Overview of the Software

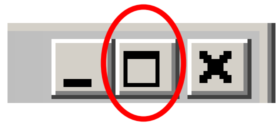
- To begin you must click on “Read Instructions”. This flashes the annoying legal disclaimer. Read the following user’s guide at least once. Close the user’s guide.
- You may choose one of two geographicals formats in the lower left. DMS requires three entries, zeros if necessary.
- You may choose one of two geoidal models in the lower right.
- Latitude, Longitude and Ellipsoidal height are converted to ECEF X, Y, Z and geoid height with “=>”
- ECEF X, Y and Z are converted to Latitude, Longitude, Ellipsoidal Height and Geoid Height with “<=”
- The above conversions also compute a modeled geoidal height. Geoidal height transforms ellipsoidal height into an approximation of orthometric height (elevation).
- Geoidal computations (especially EGM08) are slower than the ECEF conversions.
- The Deviation of the Vertical (D0V) is currently emulated with the geoidal gradient computed by differentiating N/S and E/W polynomials fitting a selection uniformly-spaced geoidal heights. It’s slow and is disabled by default.
- Red numbers indicate that the computation is incomplete. Therefore, the point cannot not yet be plotted in ECEF.
- After “=>” or “<=“ the numbers will be black and the “Plot Point in ECEF” button is enabled.
- There is no error checking for latitudes crossing the poles (e.g. 95N) or longitudes wrapping the globe (e.g. 400E). They will compute normally. So, beware.
- Slightly bizarre behavior occurs at the pole. Mathematically, X and Y should be 0. But then longitude is lost in the reverse computation. I’ve purposely preserved the numeric noise, which almost recovers longitude.
- See the plotted point in ECEF on the next page.

# Plotted Point in ECEF

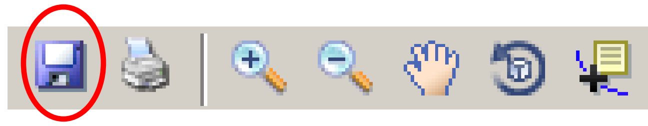


# Plot Functions

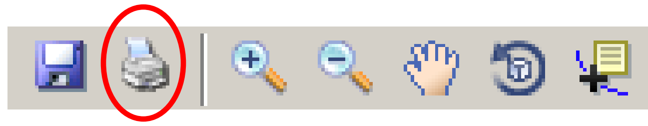
Expand to full screen



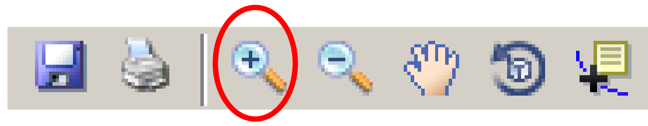
Save in 16 formats



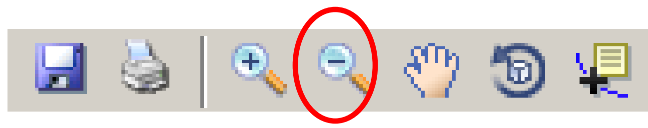
Print



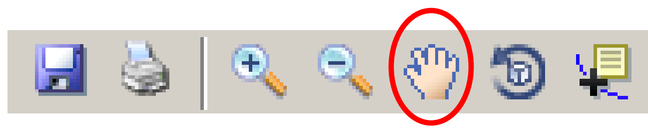
Zoom in



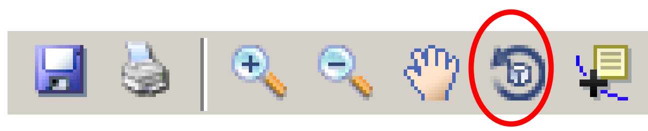
Zoom out



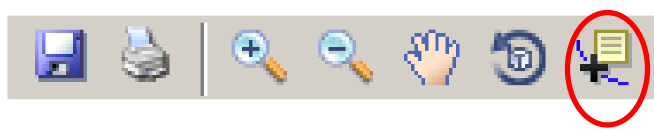
Pan



Grab & rotate figure



Mark coordinates



Reset to original view …right click with cursor in plot

NB: The plot is in true ECEF, thus presenting an ellipsoidal world, not a spherical approximation common is many graphical softwares, Matlab included. Every point has ECEF coordinates (which convert as exactly as you need into lat/lon/hgt). As the figure is rotated coordinates are recomputed for the new perspective. Thus, it's slower than rotating an image. So, take your time rotating the figure.

# Acknowledgement

The ECEF => lat/lon/hgt conversion is due to Charles Karney at:

http://geographiclib.sourceforge.net/

I have used Karney's algorithm because it is robust near the center of the earth, where other algorithms, including Matlab's, can fall over. This is of more academic than practical concern. Having translated Karney's C++ code into Matlab, I am responsible for any errors.

# Legal Notice