Lab – Ionosphere:
Demonstration of ionospheric propagation errors retrieved from different ionospheric models as a function from geophysical and solar activity conditions

Permanently changing ionospheric ionization seriously affects accuracy and safety of radio systems used in telecommunication, navigation and remote sensing (more information will be given on Friday morning by N. Jakowski).

To get a feeling how good single frequency GNSS users are able to correct ionospheric propagation delays nowadays, a simulation tool (ionsim) is currently being under development at the German Aerospace Center (DLR) which shall be made available to users via internet at http://swaciweb.dlr.de in future.
The website of the Space Weather Application Center - ionosphere (SWACI) provides near real time information on the current state of the ionosphere. Since the first order ionospheric delay of transionospheric radio waves is proportional to TEC please have a look at the TEC maps: http://swaciweb.dlr.de/data-and-products/public/tec/tec-global/?L=1 .

In this Lab demonstration you will get an impression of correction results retrievable from different ionospheric models under geophysical and solar activity conditions you can define.
Models available:
GPS or Klobuchar model used in GPS
NeQuick correction model for Galileo
NTCM-GL ionospheric TEC model recently developed in DLR
GPS based TEC map reconstructions from SWACI

Two options for ionospheric analysis are principally available
1. Historical (1995-2010)
2. Near Real Time (fixed day 10 July 2013)

Please find the options for selecting parameters at the second page.
Real time sample is prepared for a sample day because NeQuick needs too much processing time. Therefore, in the demonstration study we can freely use only the historical data set.

Please formulate your task what kind of dependence you would like to see and what you expect to see. Please send the task (parameter set according to panel at the next page) via e-mail until lunch break to Norbert.Jakowski@dlr.de .

Panel for defining parameters for the run of models

Lab 5: Ionospheres

Introduction
This lab will use ionosphere model results for placing the Earth and it's magnetosphere/ionosphere system at different distances from the Sun.

Consider the following questions in your group:
• What are the drivers of an ionosphere model?
• How are those drivers affected by changing the location of the "Earth"?

Getting Started
This link has both the Magnetosphere and Ionosphere simulation results for the "Earth" at different distances from the Sun.
http://ccmc.gsfc.nasa.gov/support/HSS_2013/11deg.php
Be sure to use the Ionosphere Table

Start with the 1 AU case.
• *Open the 1 AU link in the middle of the table on a new tab.*
• *Choose "View 3D Ionosphere/Thermosphere (low altitude: 80-500 km)"*
• *In the "Choose Plot Area" section, set "H=Constant" to 110 and click the radio button (this altitude is roughly where we expect the "E" layer to be)*
• *Click on "Update Plot"*

• What variable are you looking at?
• What features do you observe in this plot? What are the specific drivers that generate these features?
• Where is it noon? How do you know? How can you tell from the output?
• What season is it in the Northern Hemisphere? How do you know?
• Can you explain the shape of the structure at high latitudes?

Now let's look at the "F-Layer".
• *In the "Choose Plot Area" section, set "H=Constant" to 300 and click the radio button (this altitude is roughly where we expect the "F" layer to be)*
• Now what features do you see?
• Identify the location of the maximum electron density. What is the local time of this location?
• Can you explain the shape of the structures at low latitudes?
• What do you think is driving the structures here?
Be prepared to discuss your answers to these questions.

Comparative Ionospheres
For each of the simulations, view "N_e" (the electron density) at first the E-layer and then the F-layer.

- *For the each layer, construct a table with entries for each distance from the Sun that includes: the maximum electron density, the location (including local time) of the maximum value, the relative importance of the ionosphere drivers.*

- Can you estimate the dependence of the E-layer density on distance from the Sun?
- ..... F-layer density ...?
- Are these two dependences the same or different?

F2 Layer and Radio Communications

The F2 layer can interact strongly with radio waves, sometimes making propagation possible, and sometimes preventing long distance propagation. Two important parameters for radio propagation are the F2 Layer "Maximum Density" (NmF2) and the "Height of the Maximum Density" (hmF2).

- *For one of the runs, from the quantity menu select "NmF2" (near the bottom).*
- What is the maximum value of "NmF2" and its location (or local time).
- *Do the same for "hmF2". Construct a table of these values for the different runs available.*

An Ionospheric Global Variable

The Total Electron Content (TEC) is the electron density integrated over all altitudes at a specific location. Very large TEC (100 or more) can cause significant errors in GPS systems.

First look at the 1 AU case.
- *In the "quantity" choose "TEC" which is near the bottom of the list.*
- What are the primary contributors to TEC?
- Where might you be most concerned about GPS reception?

Review the results for different distances from the Sun.
- *Construct a table for each distance of the*
    - *maximum value of TEC*
    - *it's approximate local time and latitude*
    - *identify the important driver of TEC for that simulation result*

- Which driver is most important when considering the change in TEC at different distances from the Sun?
- At which location is least likely to affect a "GPS" like system?

Ionosphere Altitude Profile
So far you have been looking at the global structure of the ionosphere either at a fixed altitude or integrated over the altitude. Now let's look at slices in altitude in a particular longitude.

First orient yourself on the map.
• At what longitude is the local time noon? ... midnight?

• *Under "Choose Plot Area", select "lon=constant" and set it to the midnight longitude. Click "Update Plot"*

• The image you see is a slice in constant longitude. Look at the axes and identify the north pole and south pole.
• Can you pick out the E-Layer, F-Layer and Auroral Zone?

• *Change to the noon longitude and plot the results.*
• Identify the regions above. Compare the density of the regions at noon and midnight.
• Compare these results to results at other longitudes.