Single Station GPS Ionospheric Corrections

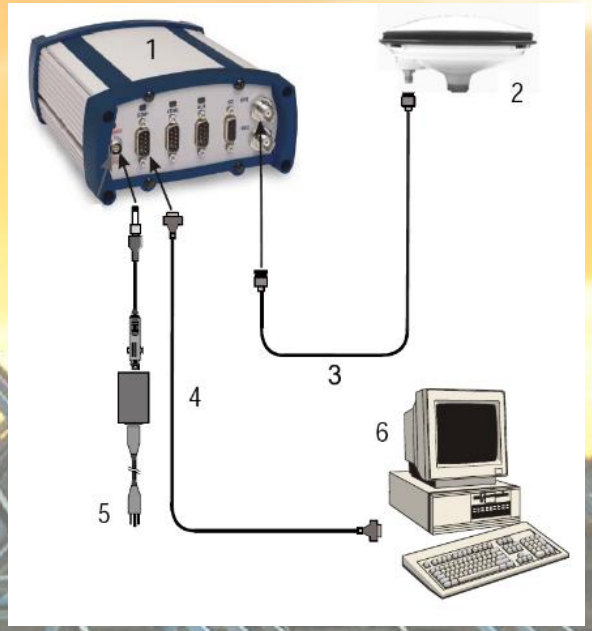
Joe Malins

Low Frequency Interferometry

LWA

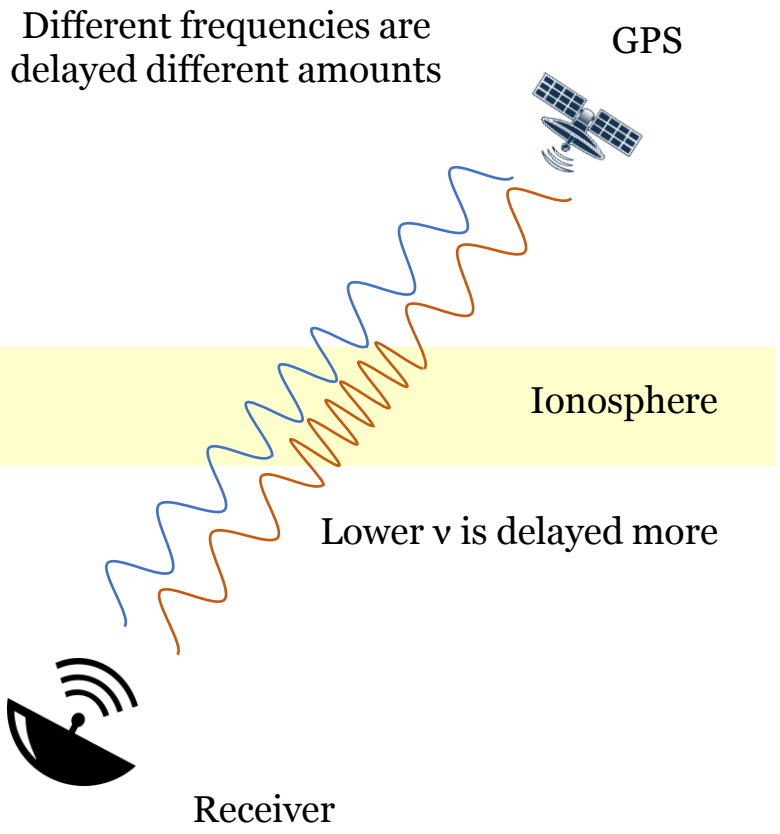
- 2x 256 Antenna Dual polarization Arrays:
  - 1 collocated with VLA,
  - 1 on Sevilleta Wildlife Refuge
- 10 MHz to 88 MHz
- 110m x 100m collection area at each site

Dual Frequency GPS Antenna



- NovAtel 4004B Dual Frequency GPS
- Borrowed from Air Force Research Lab Scintillation Network Decision Aid (SCINDA) program
- Self-biasing, 10s resolution, Plasmasphere correction

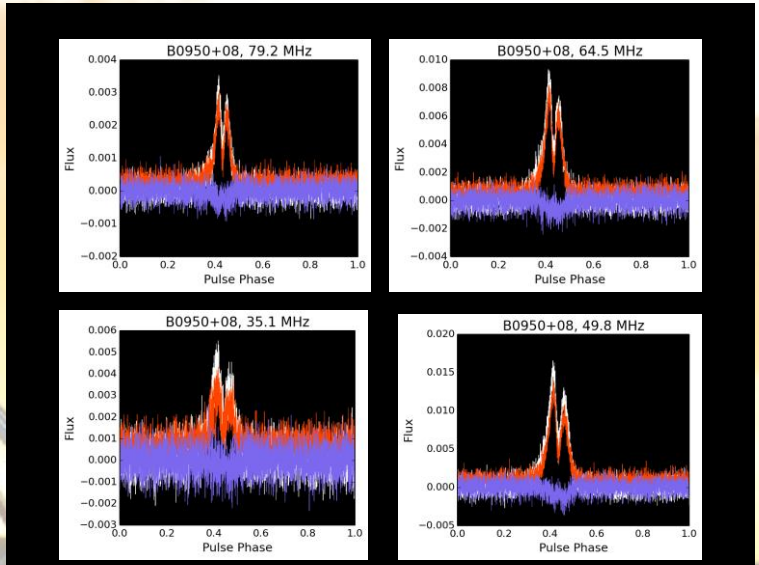
Ionosphere Measurement



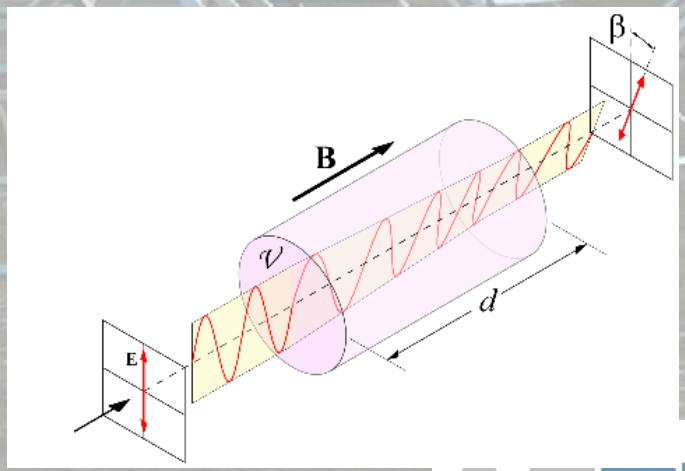
- Dual Frequency: 1575.42 MHz and 1227.60 MHz
- Ionosphere is plasma sheathe surrounding Earth
- Plasmas causes group velocity delay, phase velocity increase in EM waves
- Delays are strongly frequency dependent
- By measuring group delay difference, can measure Total Electron Content (TEC)
- Measured in n_e/m^2 or TEC units (TECU) 1 TECU = 10^{16} n_e/m^2
- No profile information

RM measurement

- LWA can use Faraday Rotation to measure magnetic fields of solar phenomena
- Faraday Rotation, caused by difference in r-wave and l-wave propagation through plasma with B-field
- Frequency dependent $RM \propto \frac{\phi_1 - \phi_2}{\lambda^2}$
- Causes dispersion of low frequency wave of incoming pulsar pulses
- Three contributions to rotation measure:
  - Material surrounding pulsar
  - Interstellar/Interplanetary Medium
  - Ionosphere and near earth plasma
- We assume near constant interstellar medium and material surrounding pulsar, or at least changing on long time scales
- At large sun angles Short time scale change only due to ionosphere
- Find rotation measure, measure ionospheric contribution, fit RM curve to ionosphere

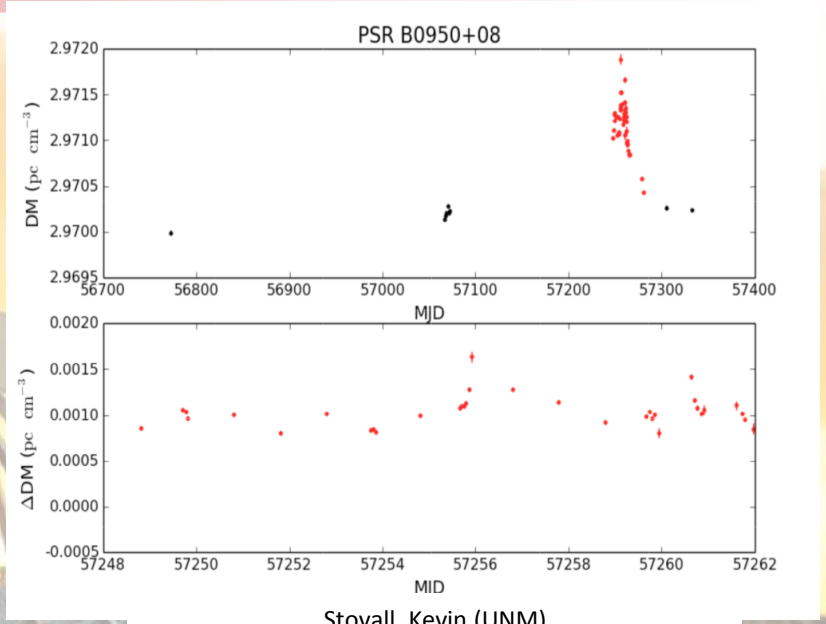


See Veronica Dike (UNM) Poster

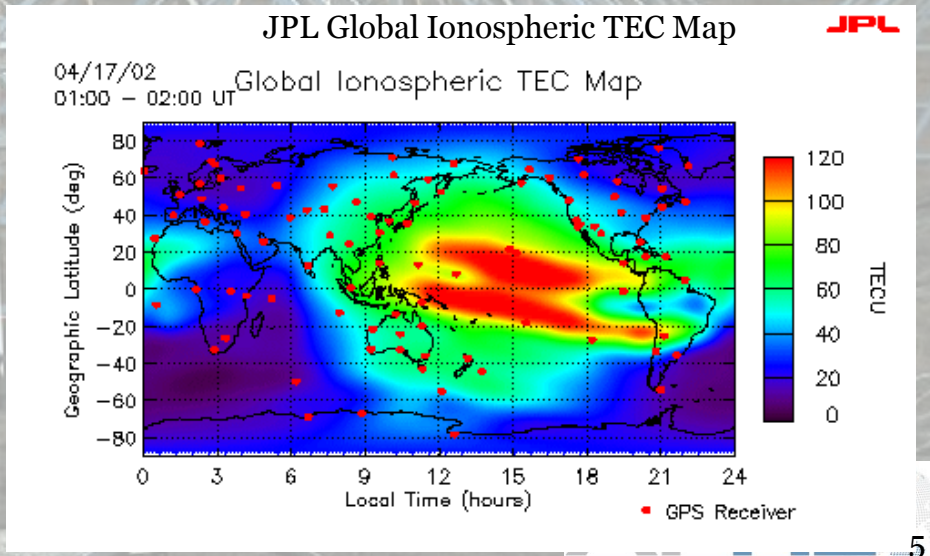


Statement of Problem

- We want to use Faraday rotation to measure magnetic field of sun and CMEs
- Currently, use global models involving hundreds of GPS stations
- Problem: not many GPS receivers located near LWA
- Problem: Global models update approximately every two hours. Time of appreciable change in ionosphere is on the order of 10 min

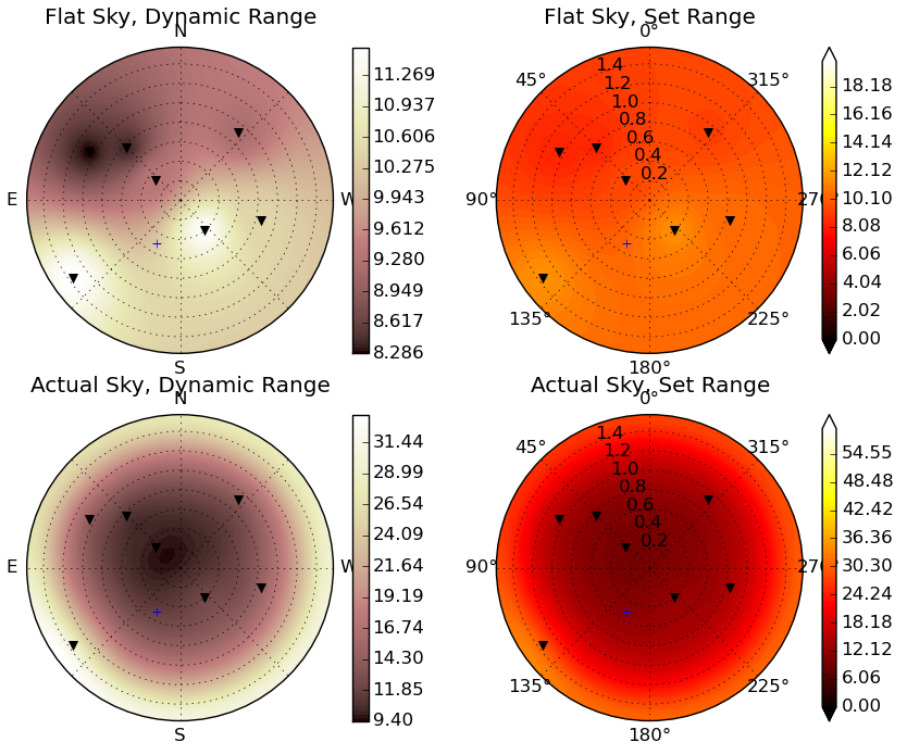


Stovall, Kevin (UNM)
Science at Low Frequencies II



Better Corrections

Interpolated Observation at LWA1
at 2016/09/23 16:00:00 UTC



- Each satellite provides accurate data to a single point on the sky
- Between 7-14 satellites at any given time
- For points between satellites, use linear weighted average of satellites

$$TEC = \sum \frac{\rho}{d_l} TEC_1$$

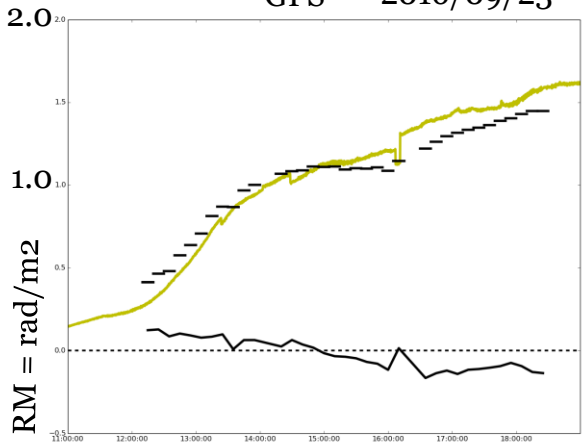
$$\rho = \frac{1}{\sum \frac{1}{d_l}}$$

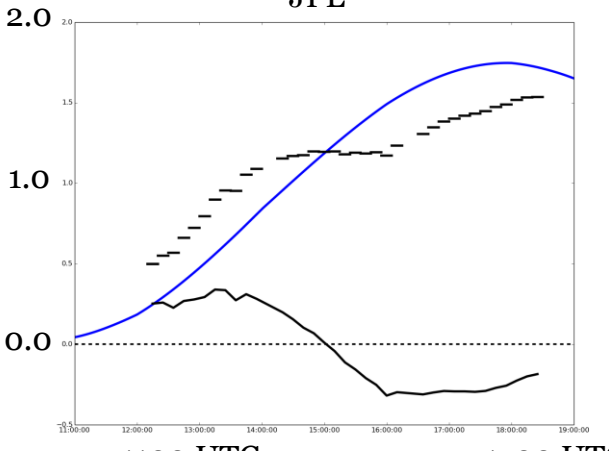
GPS 2016/09/23

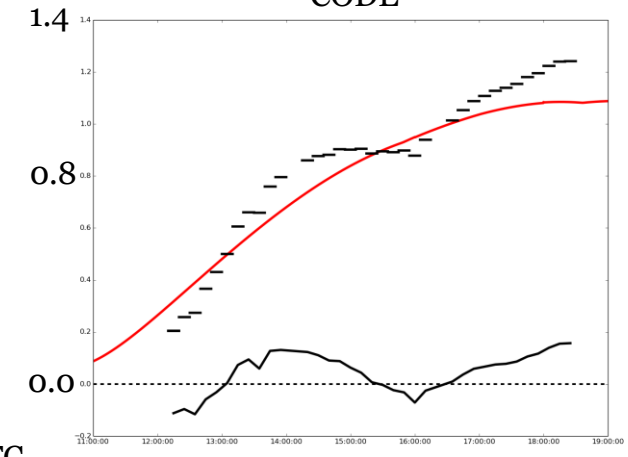
JPL

CODE

RM = rad/m2

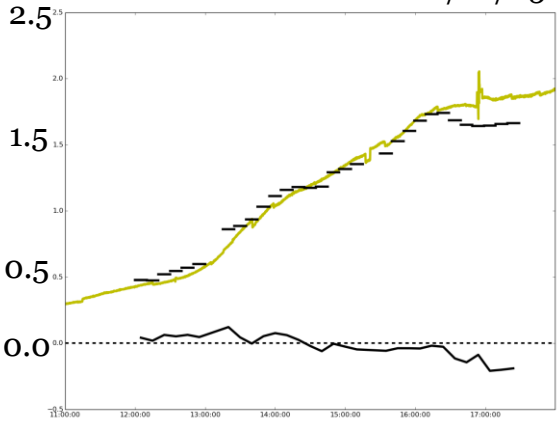


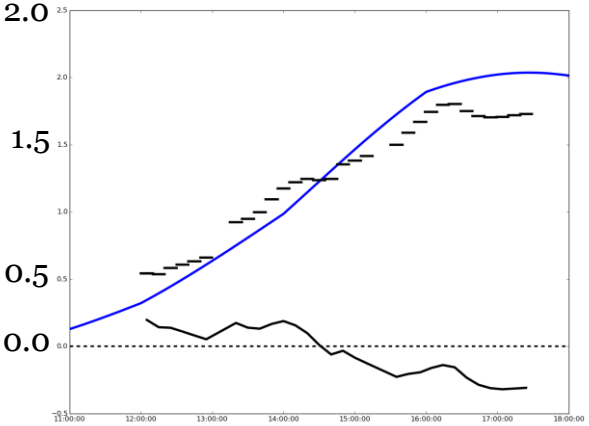


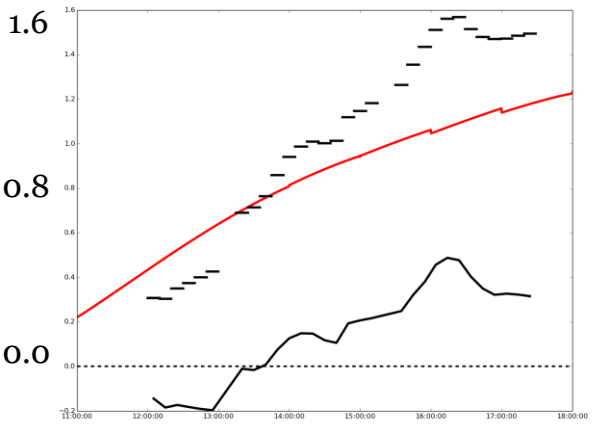


1100 UTC 1700 UTC

2016/10/05







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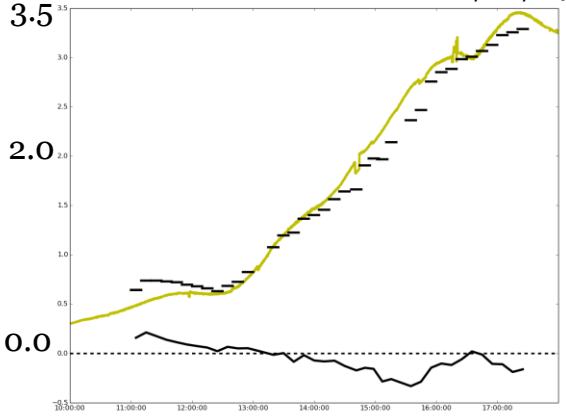
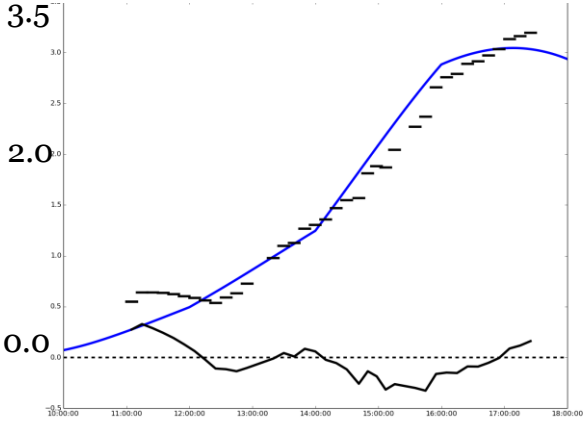
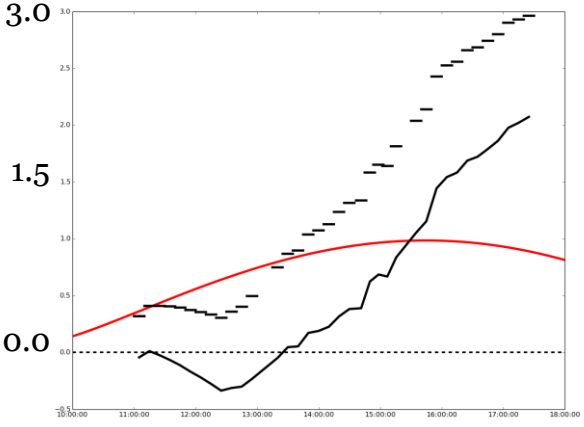
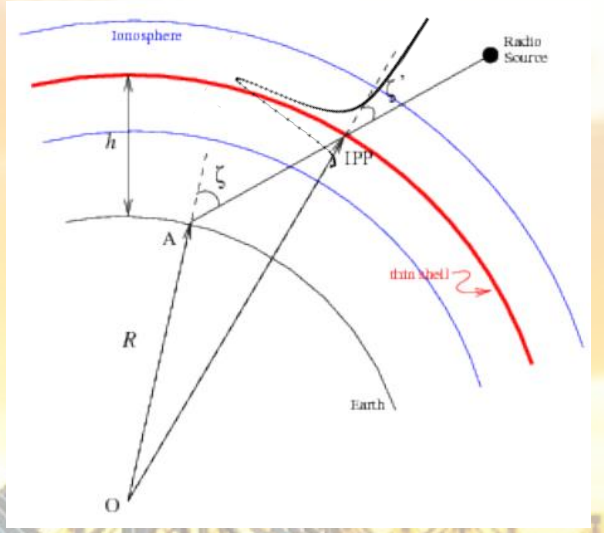




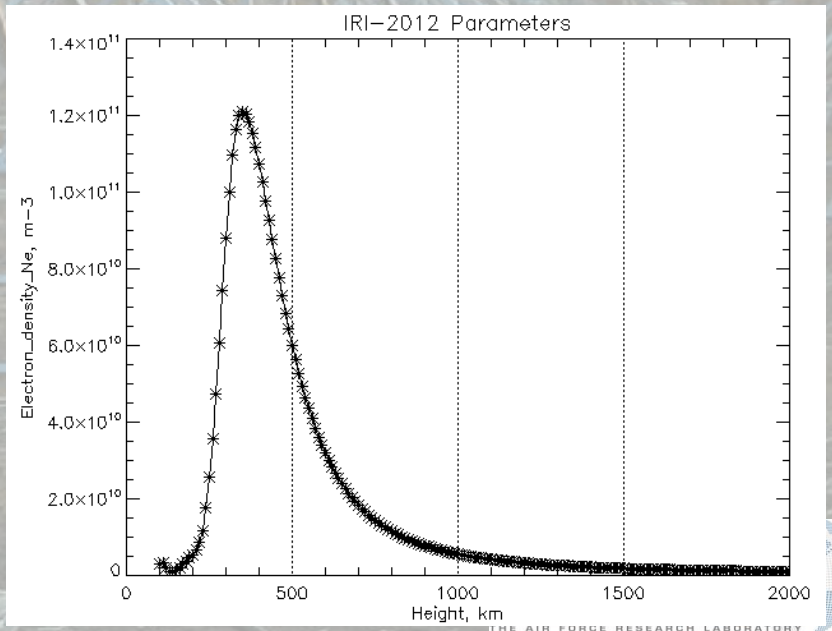


Height Dependence

- Current model uses only single Ionospheric Pierce Point (IPP)
- TEC assumed to be concentrated at that location
- Use IGRF12 to model magnetic field at various points along line of sight to satellite
- Model uses 191 points along International Reference Ionosphere (NASA/JPL) profile to determine profile of the ionosphere
- Currently not giving better results than non-height dependent



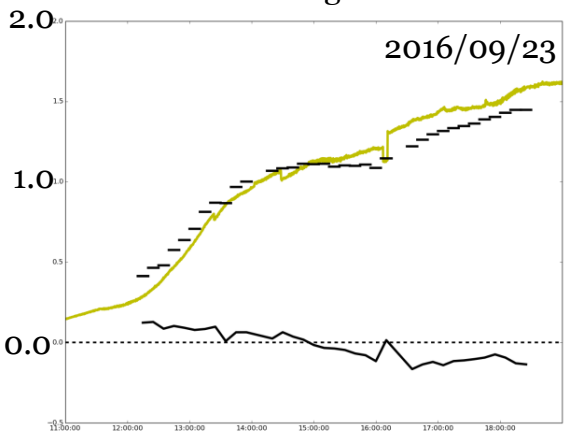
C. Sotomayor-Beltran et al.: Ionospheric Faraday rotation

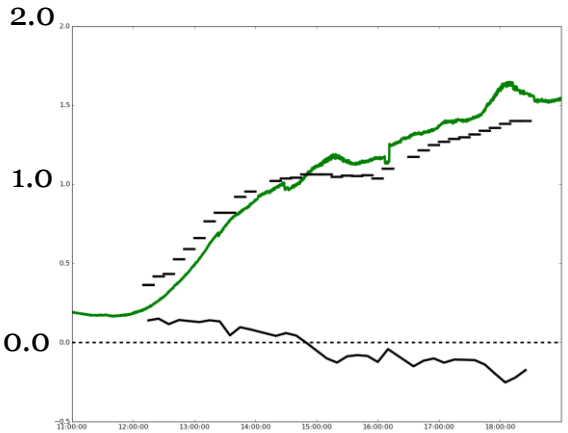


GPS without height correction

GPS with height correction

2016/09/23





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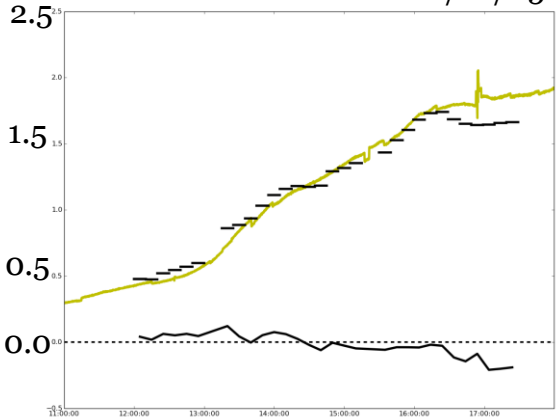

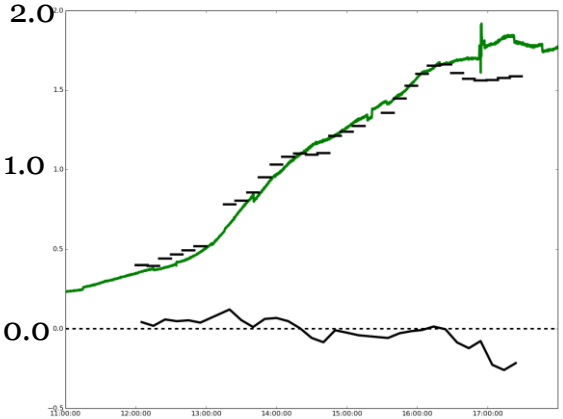

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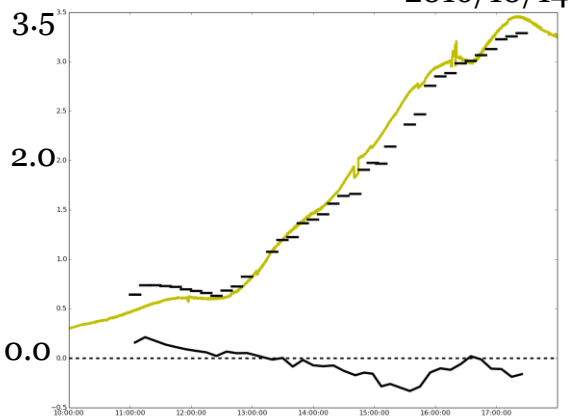
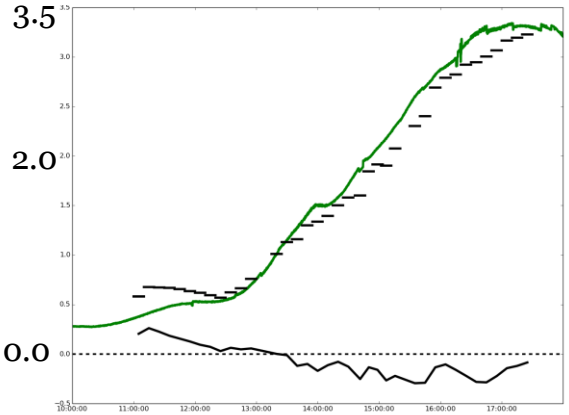
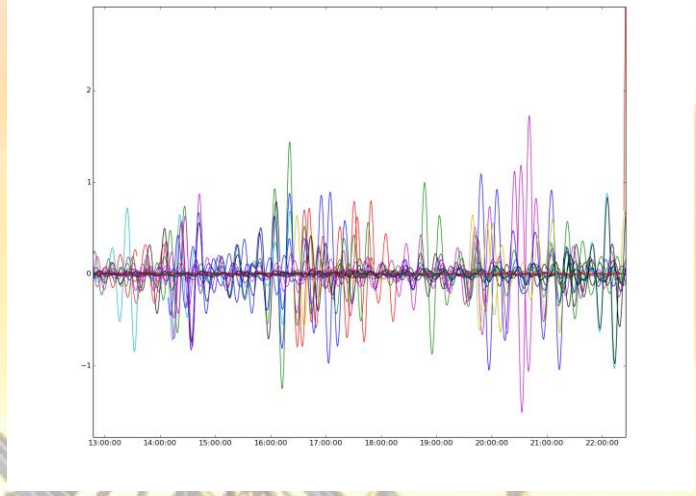
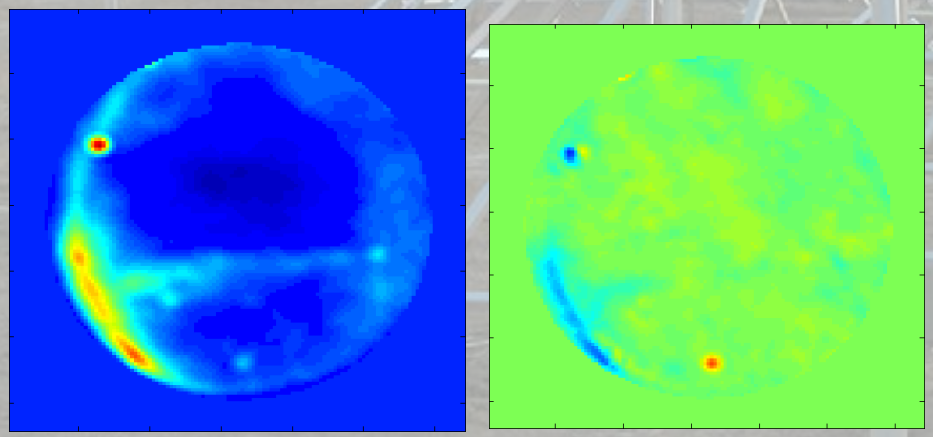


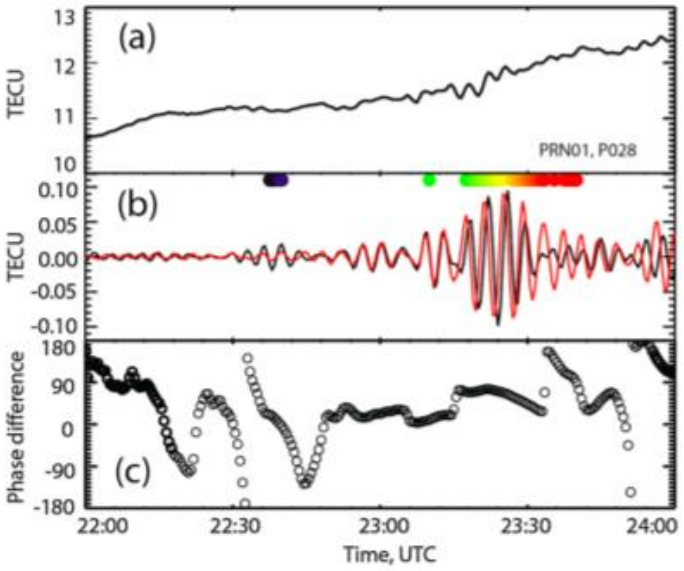


Other Research

- On June 30th, Ken Obenberger discovered wave in LWA Imaging Archive
- Waves similar to gravity infrasonic ionosphere oscillations found by Shao, X.M., and E.H. Lay
- Shao used 6-order polynomial to determine oscillations
- Looking at using FFT to isolate oscillations of proper time scale



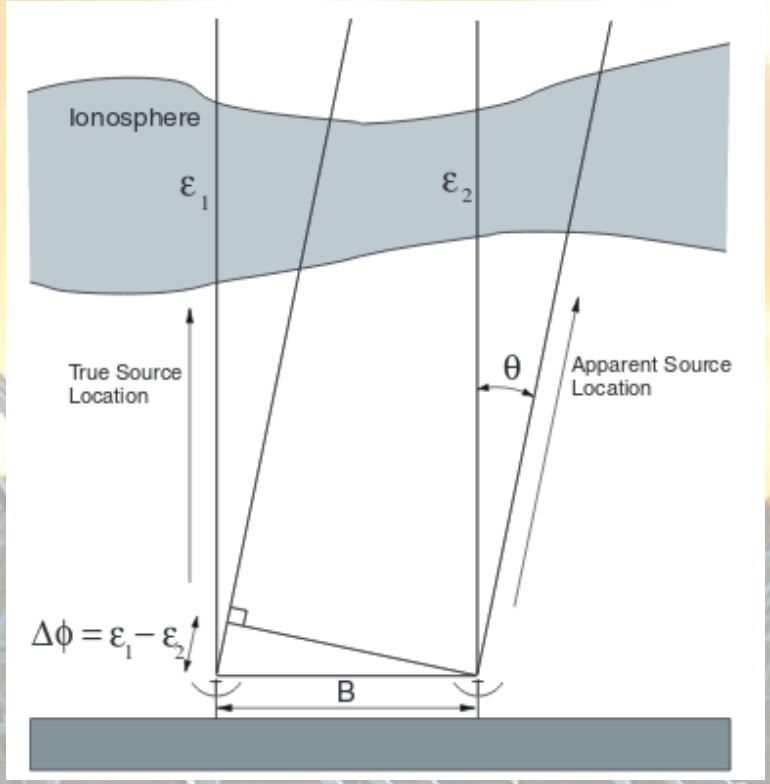




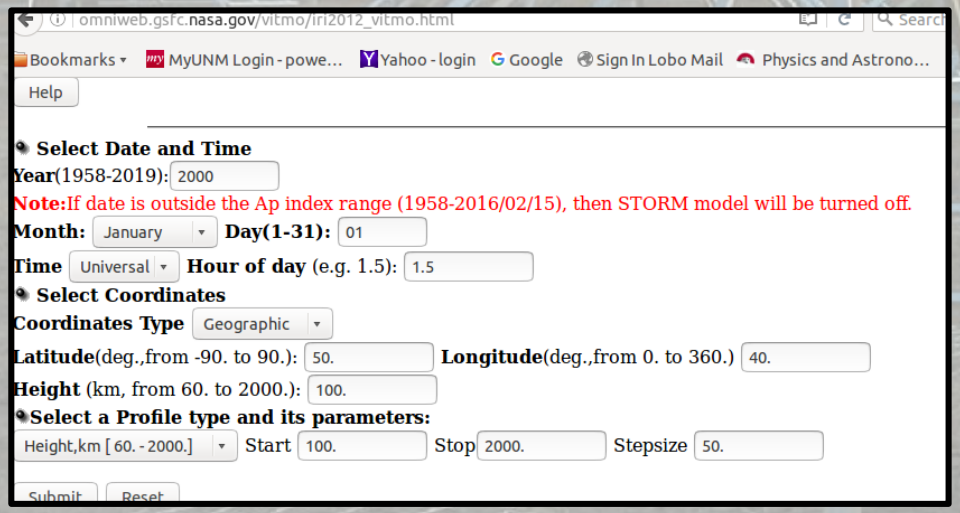
Shao, X.-M., and E. H. Lay (2016)

Near Term Plans

- Continue to use GPS to calibrate data for low frequency observations
- Eventually, want to use GPS Corrections for correlating LWA1 and LWA Sevilleta
- Can provide data universally for interested parties for VLA corrections
- Use GPS measurements to study Ionospheric phenomena



COHEN & RÖTTGERING



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