Earth Science Applications of Space Based Geodesy

DES-7355

Tu-Th 9:40-11:05

Seminar Room in 3892 Central Ave. (Long building)

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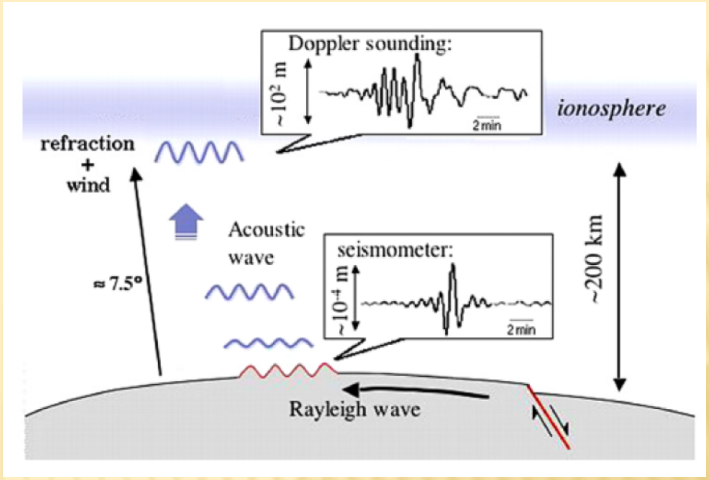
Office: 3892 Central Ave, Room 103
678-4929

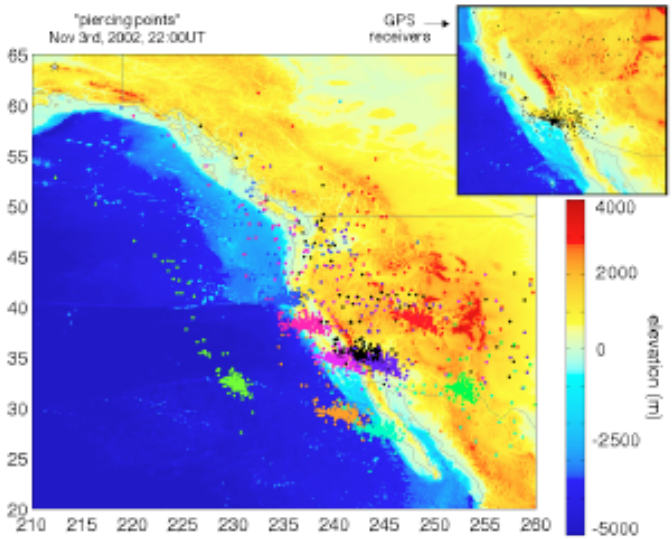
Office Hours – Wed 14:00-16:00 or if I' m in my office.

http://www.ceri.memphis.edu/people/smalley/ESCI7355/ESCI_7355_Applications_of_Space_Based_Geodesy.html

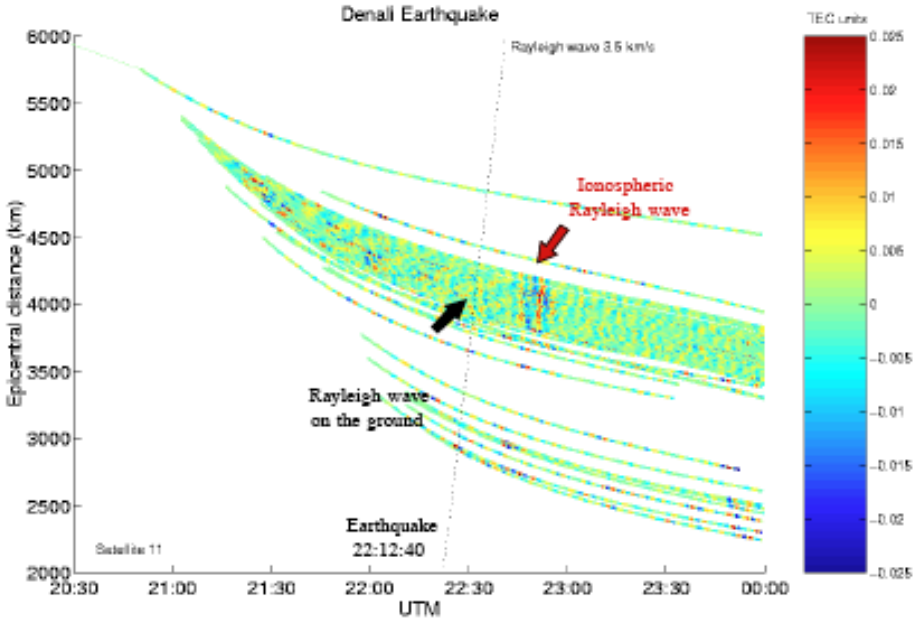
Class 16



- **Signal observed after Alaska Denali fault earthquake (M_S=7.9, Nov. 3 2002)**



Piercing points for ionospheric measurements from all receivers in California (SCIGN + IGS). Different satellites are shown with different colors. The black star shows the epicenter location for Denali earthquake.



Band-pass filtered TEC time series between 150 and 350 seconds from satellite 11, plotted as a function of time and distance to the epicenter. The black dashed line represent a typical Rayleigh wave on the ground.

Ducic et al., 2003

Ionosphere Delay

- Measured range given by $s = \int n\, ds$

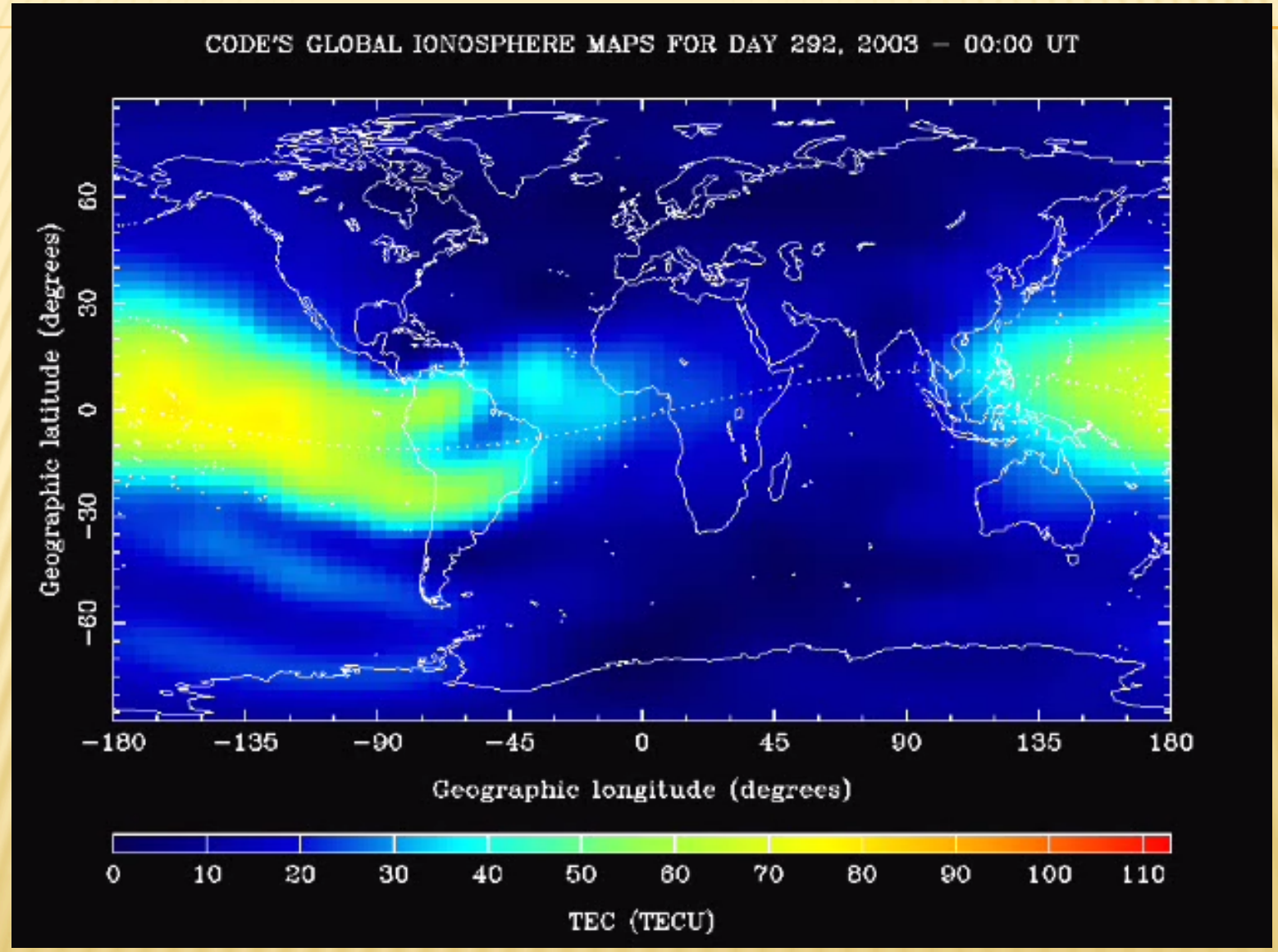
  n : refractive index

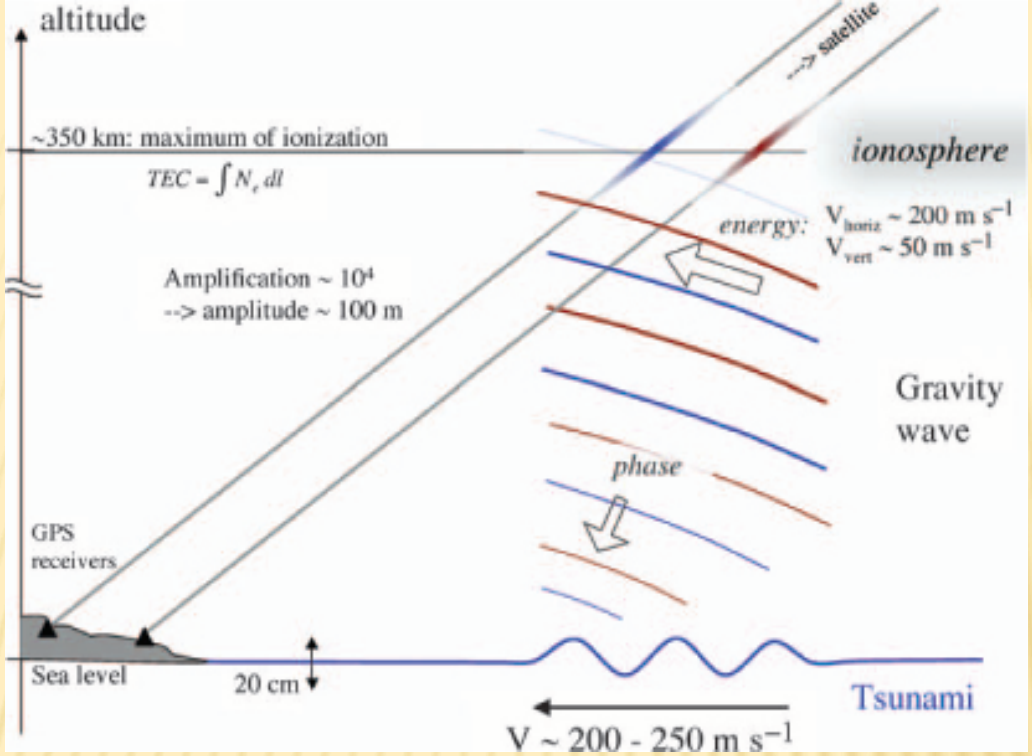
  ds : signal path

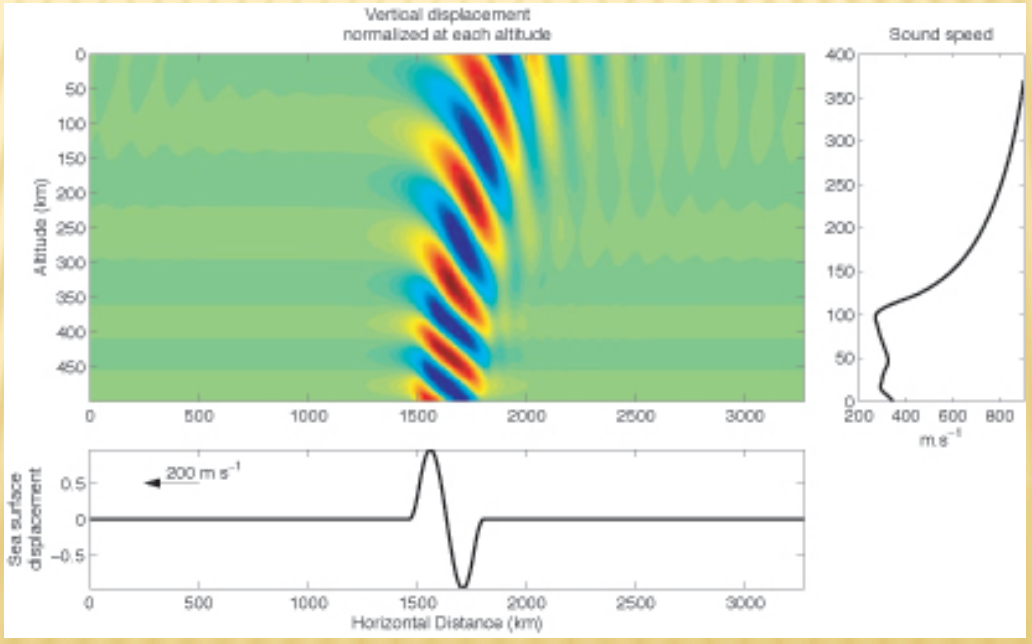
- The path delay is given by
  - $\Delta_{ph}^{iono} = -(40.3/f^2) \int N_e\, ds_0 = -40.3/f^2\ TEC$
  - $\Delta_{gr}^{iono} = (40.3/f^2) \int N_e\, ds_0 = 40.3/f^2\ TEC$

    - Where $TEC = \int N_e\, ds_0$ is the total electron content

Ionosphere TEC

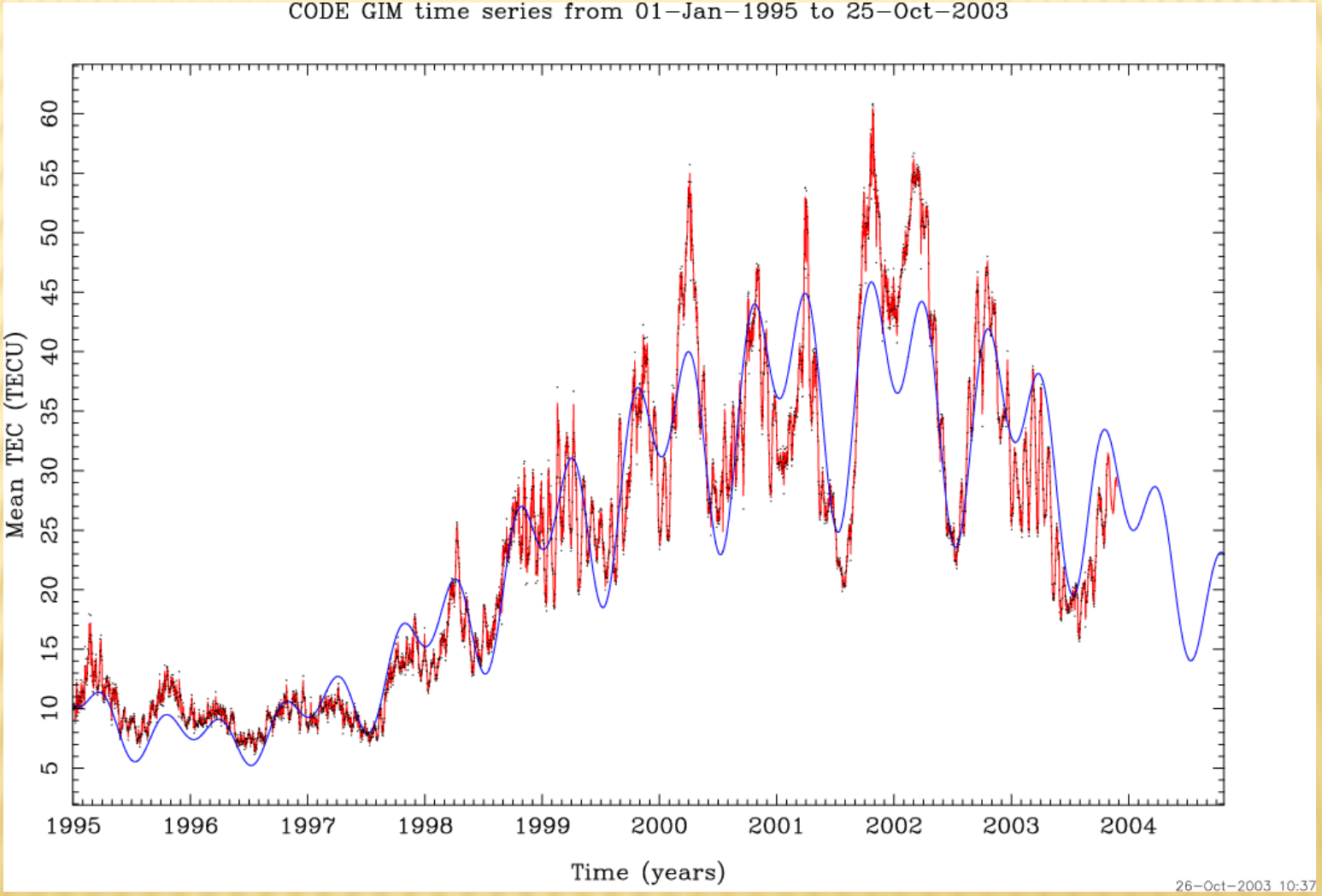






Artru et al., 2005

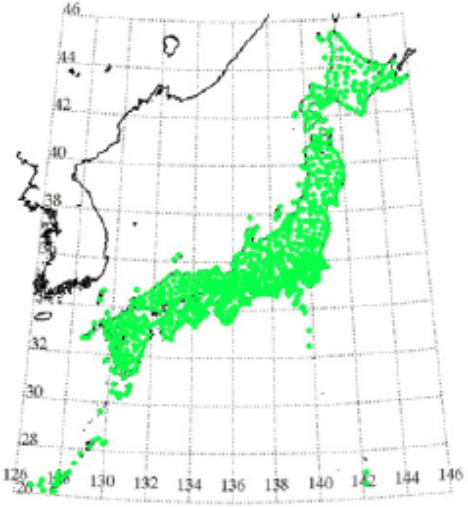
Ionosphere Variation



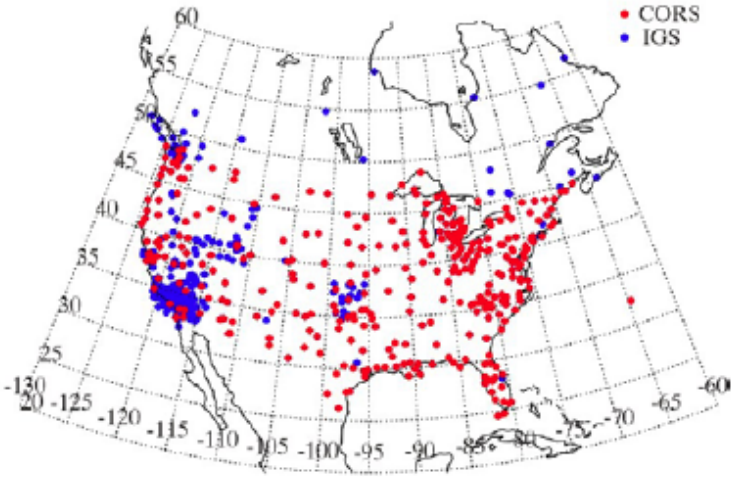
http://www.cx.unibe.ch/aiub/ionosphere.html

GPS Networks in the World

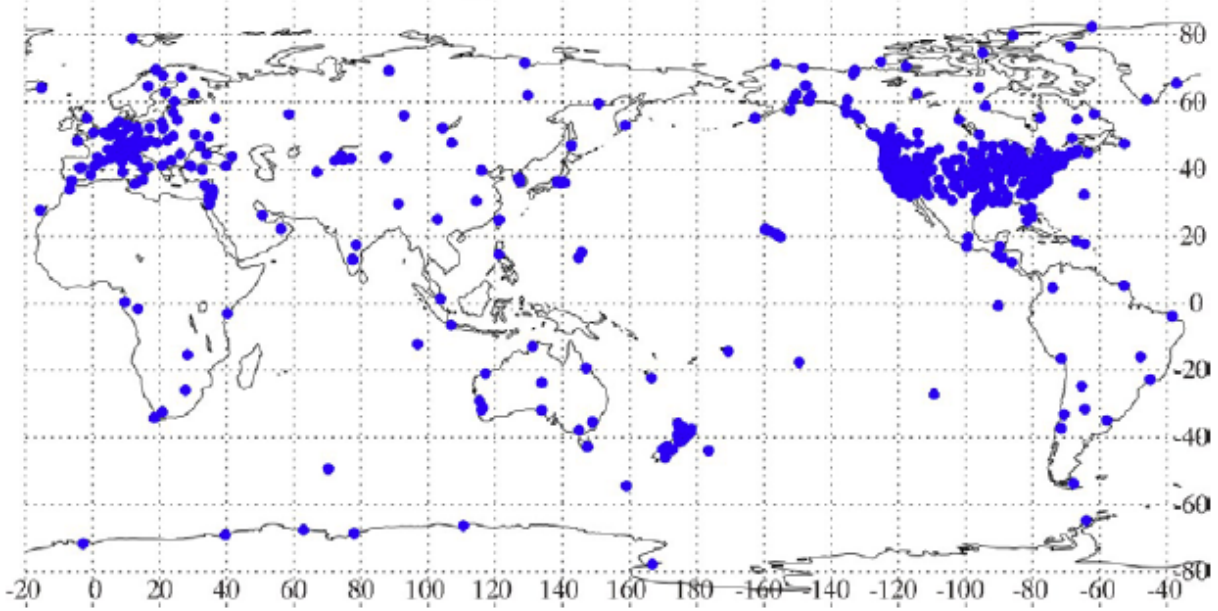
(a) GEONET GPS STATIONS



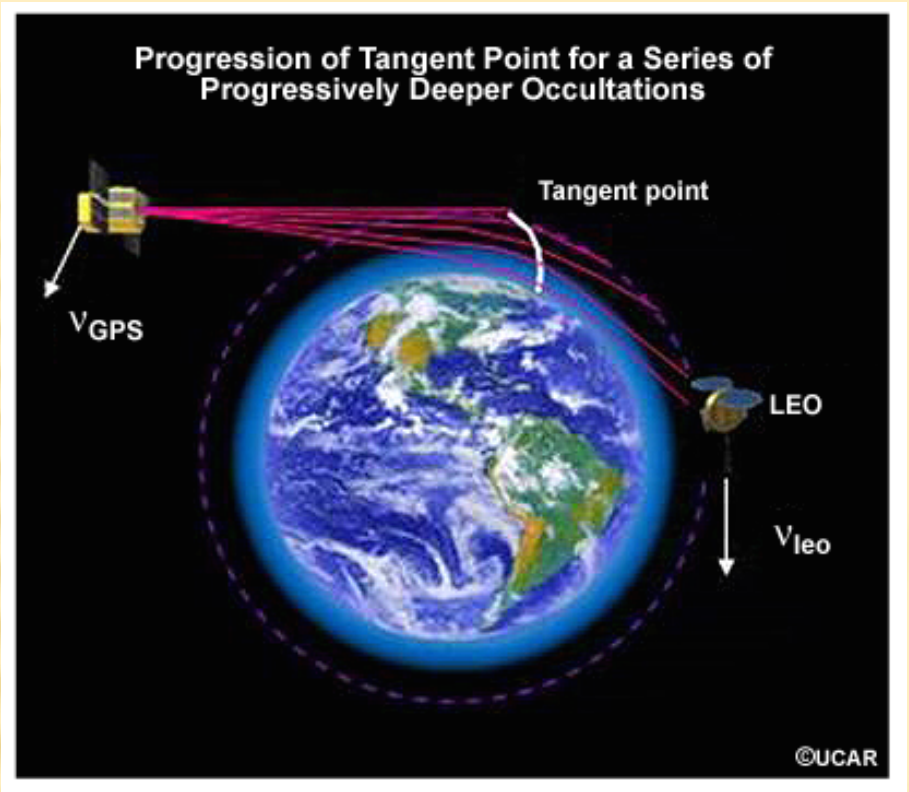
(c) CORS GPS STATIONS



(b) IGS GPS STATIONS



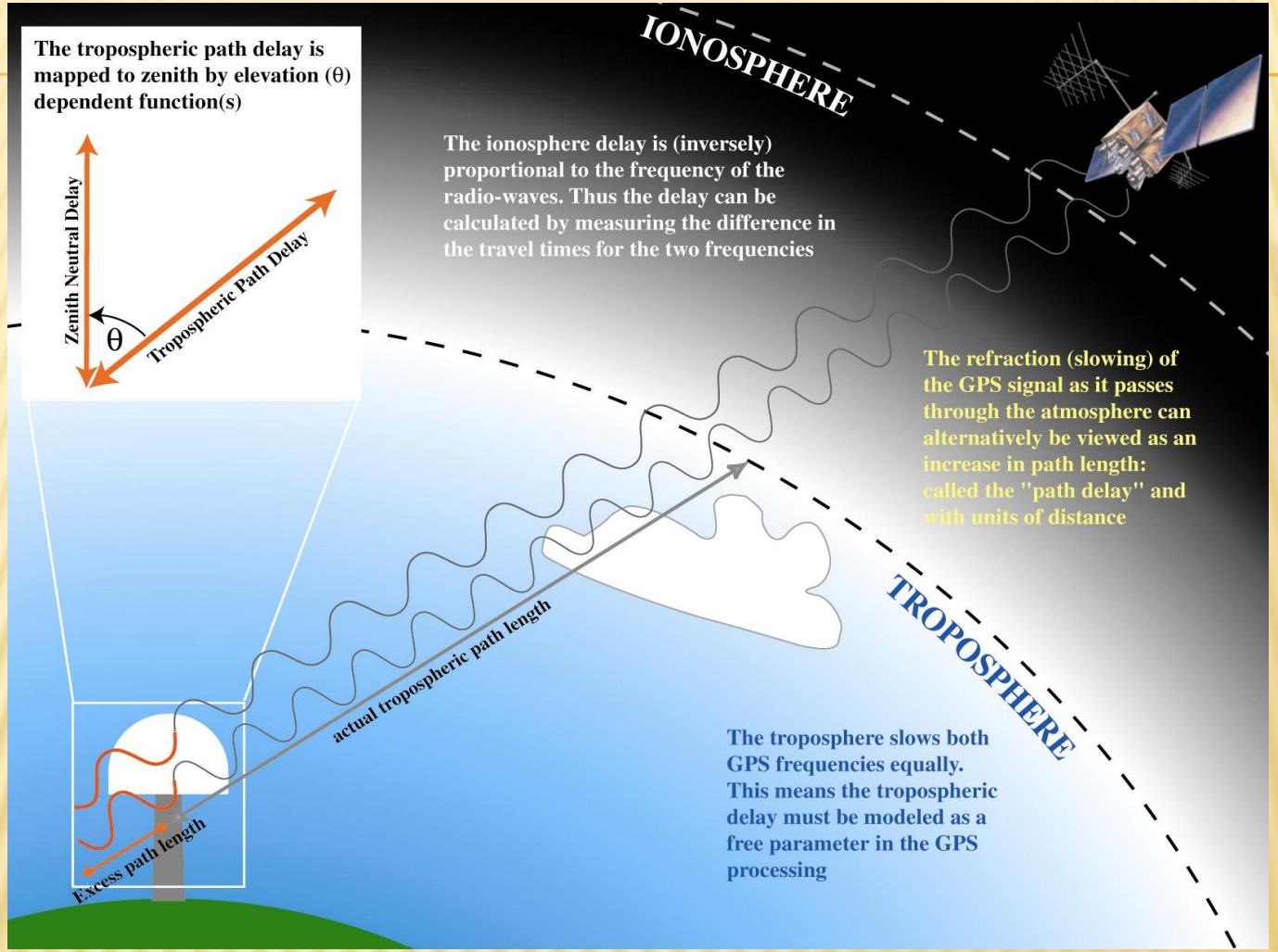
Tsugawa, 2006



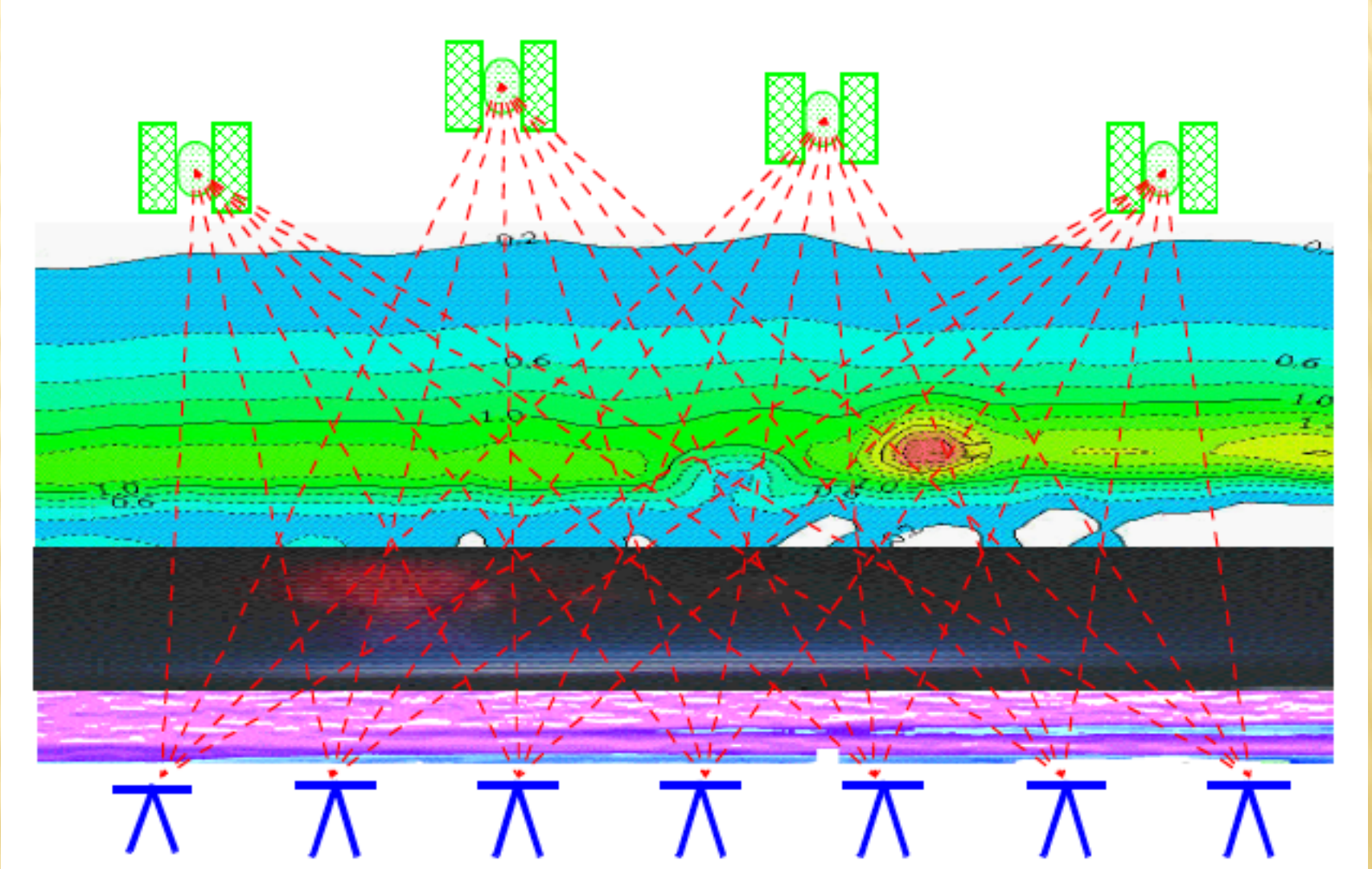
The LEO tracks the GPS phase while the signal is occulted to determine the Doppler

The velocity of GPS relative to LEO must be estimated to ~0.2 mm/sec (20 ppb) to determine precise temperature profiles

Zenith Neutral Delay



- Tropospheric delays increase with decreasing elevation angle (more atmosphere to traverse)



Ware et al., 2000

TROPOSPHERIC DELAY

- Caused by the neutral atmosphere, which is a nondispersive medium (as far as GPS is concerned)
  - Troposphere extends up to 40 km
  - Effects carrier phase and code ranges the same
- Typically separate the effect into
  - Dry component
  - Wet component
- $\Delta^{Trop} = 10^{-6} \int N_d^{Trop} ds + 10^{-6} \int N_w^{Trop} ds$
  - Where N is the refractivity
  - ds is the path length

TROPOSPHERIC DELAY

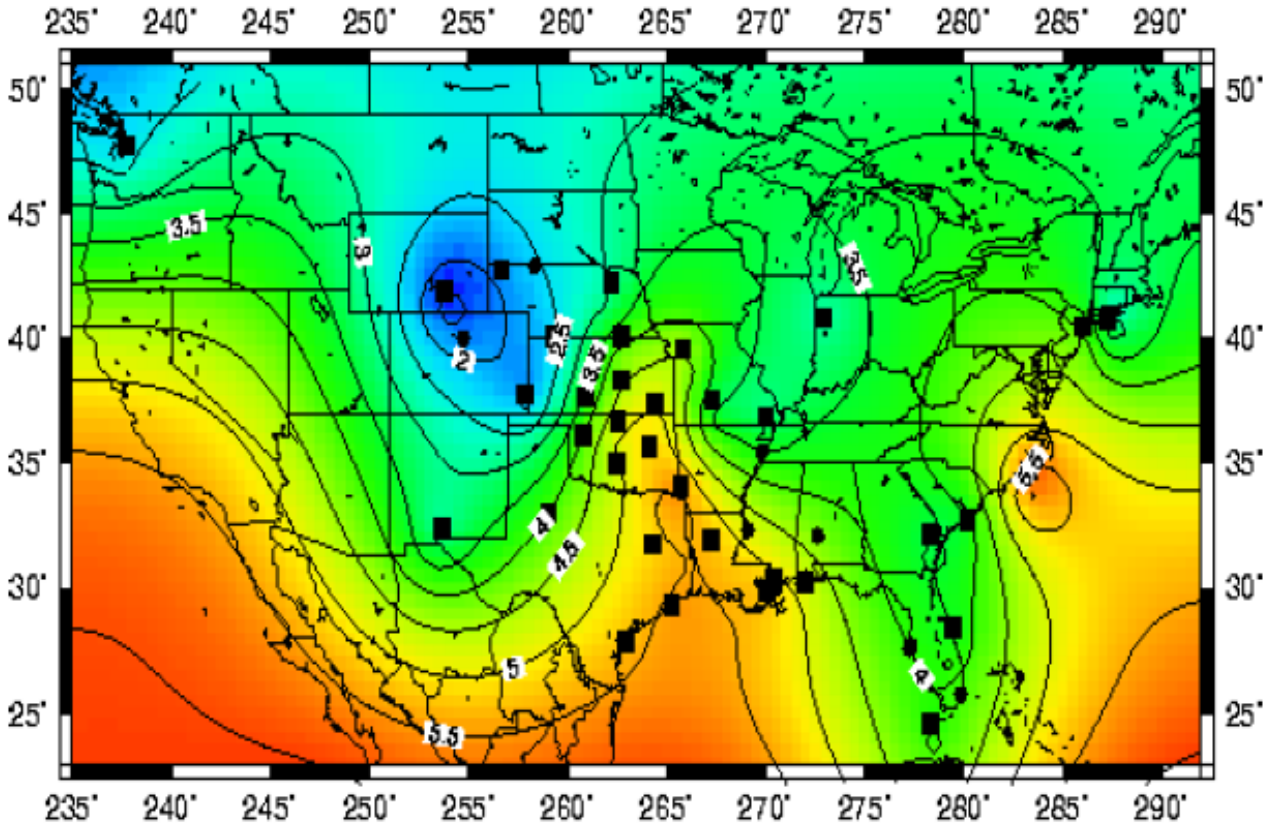
- Dry component contributes 90% of the error
  - Easily modeled
- Wet component contributes 10% of the error
  - Difficult to model because you need to know the amount of water vapor along the entire path

TROPOSPHERIC DELAY

- There are many models which estimate the wet component of the tropospheric delay
  - Hopfield Model
  - Modified Hopfield Model
  - Saastamoinen Model
  - Lanyi Model
  - NMF (Niell)
  - Many, many more

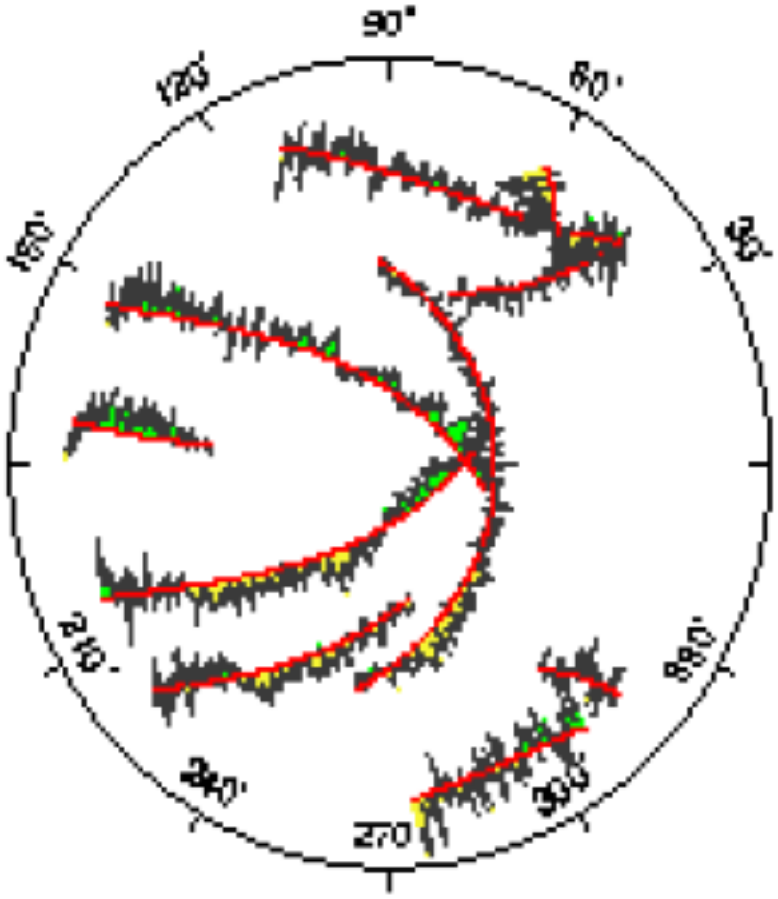
Real-Time GPS Sensing of Precipitable Water (PW)

9/4/99 21:00 UT

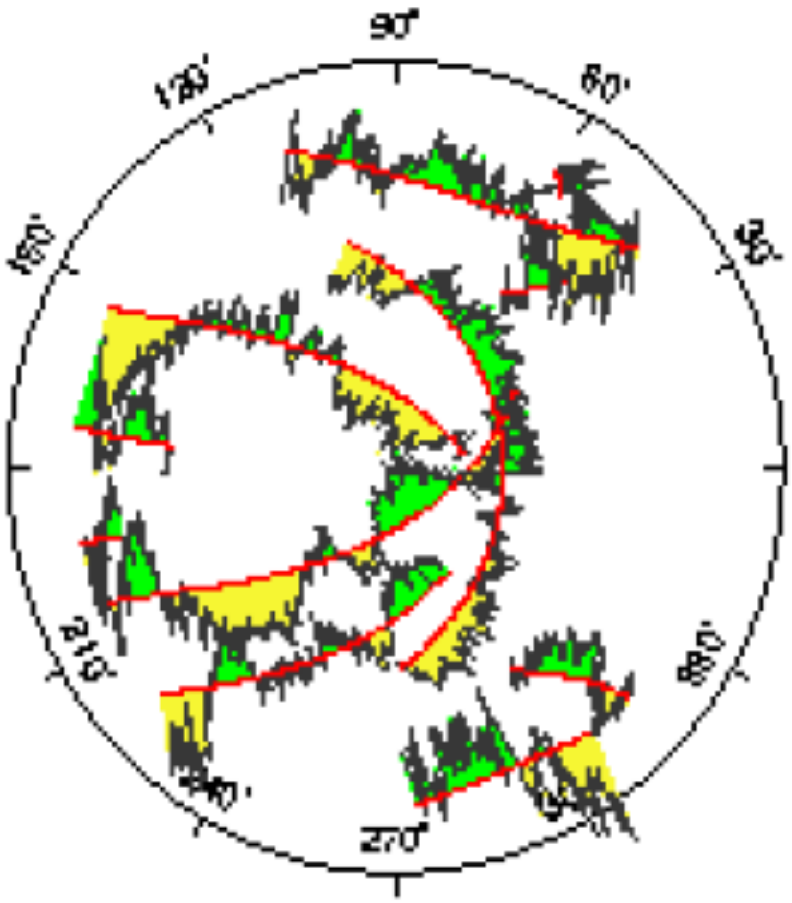


Ware et al., 2000

Atmospheric Slant Delays



Calm, 5.7 mm rms



Typhoon, 11.1 mm rms

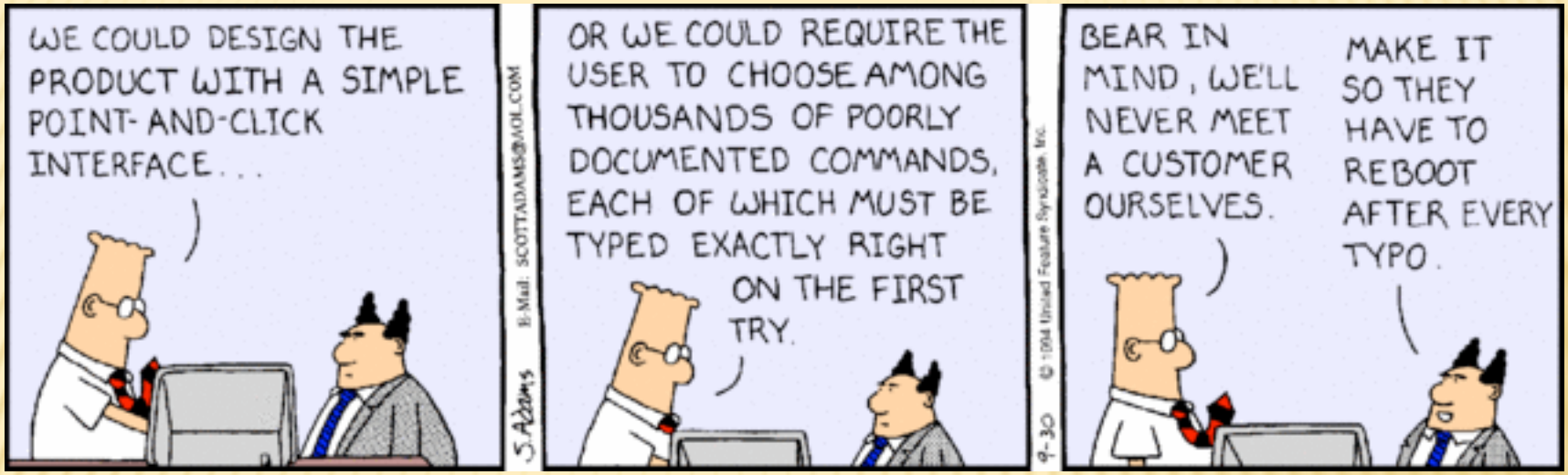
Ware et al., 2000

MULTIPATH ERRORS

- GPS assumes that the signal travels directly from the satellite to the receiver
- Multipath results from signal reflecting off of surface before entering the receiver
  - Adds additional (erroneous) path length to the signal
- Difficult to remove; best to avoid

Now we will look at a number of GAMIT/GLOBK tutorial and other resources on the web.

Intro to GPS processing with GAMIT/GLOBK



"people who have trouble with typing commands should not be using a computer."

(Response of the Unix community to criticism that Unix ignored the needs of the unsophisticated user.)

If you thought UNIX was user-hostile, you have not seen anything yet!

gamit/globk home page, documentation and tutorials

Can't get to from above, but very useful

gamit script help

Eric Calais' GAMIT overview

Andy Newman's GamitGlobk tutorial

copy of Murray and Battaglia's course from Berkeley

Tom Herring's Gamit/Globk Matlab post processing toolbox