GEOL 695: Geophysical Geodesy - Day 11 Sept 29 ,2009

Preliminaries

New Reading:

required:
http://www.kowoma.de/en/gps/history.htm

optional:
http://science.nasa.gov/RealTime/JTrack/3D/JTrack3D.html
(if it doesn't work on your system try upgrading Java)

The GPS System: How it works

Satellite Orbits

GPS constellation, >24 satellites. Medium high orbits, ~26,000 km. Earth looks small from the perspective of a GPS satellite. Six separate orbital planes inclined 55 from the Earth equatorial plane, with 4 satellites per plane arranged equidistantly around the orbit. 12 hour repeat time.

The purpose of this configuration is to provide an as even-as-possible distribution of satellites visible in the sky at all times. Means that there is an inherent "hole" to the north where the sky contains no satellites.

GPS is a Ranging system. Time at receiver, time at satellite, speed of light = distance. Analogous to location of a seismic source.

The basic message sent by each satellite is its location, time, identity.

$$\rho = c(t_{receiver} - t_{satellite})$$

is the *psuedorange.* This is the raw number inferred from the time difference, however it is not the true geometric range because of certain other impacts on the propagation of the signal.
- ionosphere
- troposphere
- clock errors (receiver)
- clock errors (satellites)
- satellite orbit error

Collecting data from numerous satellites, on two frequencies, helps mitigate these errors since some cancel out, and some

Double differencing vs. clock estimation.

How many satellites need to be available, at minimum, to get a position?

Signals

Two frequencies, L1 (1575.42 Mhz = ~19.0 cm) and L2 (1227.60 MHz =24.4 cm)

Codes
A binary phase modulated code signal that is cross correlated at the receiver.

Coded message sent continuously by all satellites at once. Receiver uses cross-correllation and uniqueness of the code to separate the signals from the individual satellites into separate psuedorange estimates.

Phase of the carrier wave

For high-precision studies, the real constraint on position comes from the phase of the signal rather than the estimate of ranges from the code. Dual frequency receivers now record the phase as well as the code-estimated psuedorange. More on this later.

Other GPS systems going up, or partially up

Galileo (Europe) under construction, 30 satellites planned.

Glonass (Russian), 24 satellites in original constellation, 5 are down, 3 in maintenance

Compass (China)

Someday receivers will be available that can access signals from these other constellations as well as GPS.

Dilution of Precision

Various factors control how well (to what precision) a position can be estimated. These factors include how many satellites are visible, and where they are in the sky.

A basic linear inverse problem can be set up to infer the position of the receiver based on the various range estiamtes provided for each satellite.

GDOP
PDOP
VDOP
HDOP
TDOP

Multipath

Improvements in satellite antennas reduce the effects of multipath by suppressing signals that come from beneath the antenna ground plane.

Precision can also be affected by the choice of “elevation cutoff angle”, which is

Daily high precision solutions for crustal deformation

A somewhat different set of data processing steps is used to estimate high precision daily solutions using special softwares:

GIPYS/OASIS II (Jet Propulsion Laboratory)
Gammit/Globk (MIT)
Bernese (Swiss group: http://www.bernese.unibe.ch/)

Some Signals that are accounted for in daily positioning:

Ionosphere
- Use linear combination of two frequencies to remove effects of dispersion.

Atmosphere
- dry delay (function of station height only)
- zenith wet delay (solve for)
- horizontal gradients (solved for)

Tides
- Solid Earth deformation owing to attraction of moon
- Ocean tidal loading effects large enough near coast to worry about

RINEX file structure