Stand Alone
GPS Position Errors

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Several Notes on GPS Accuracy Can Be Found At:

www.oc.nps.navy.mil/~jclynch
SOLUTION TYPES

Navigation

Pseudorange Position
Phase Velocity
Dynamics Built In
Kalman Estimator (8 State)

Relative Navigation

Differential Range Correction each SV
Standard Formats
Solution as in Navigation
1-2 m Broad Area Systems
10 cm – 50 cm Special Purpose Systems

Kinematic

Differential Phase
Determine Phase Bias (Ambiguity Resolution)
Dynamic / Must Keep 4 or More Common Satellites
3 – 10 cm
One Beach Lab Data Set
Blue Real Time PPS
Showing Two Scenarios

Green Kinematic
Tracks Taken On 9 Different Days
Raw Data on Left, Adjusted Data on Right
Components of GPS Range Measurement
Refraction at L1

\[ N = 10^8 (n - 1) \]
Area That Affects Measurements
Surface
T = 18.8 deg C
p = 1014 mb
rh = 60%
Dry = 2.45 m
Wet = 0.11 m

Note Surface Duct
Surface RH 60%
200 m To 88%

Balloon Data Monterey Bay
1998 Antenna Array
Numerous Multipath Sources
GPS Experiment Antennas
Broadcast Ephemeris Generation
- GPS Reference Sites For Broadcast Ephemeris
  - NIMA Sites
Broadcast Ephemeris Parameters
4 Hours of Predicted Trajectory
17 15 minute K-points
Fit 15 parameters

Clock - 24 Hours Used
Linear Fit to Cs
Quadratic Fit to Rb
Orbit Estimation Considerations

Force Model
- Gravity 8x8 to 12x12
- Solar and Lunar Gravity
- Solid Earth Tides
- Radiation Pressure
  (Thrusts, Momentum Dumps)

Frame
- Done in Inertial Frame
- Lunar-Solar, Planetary precession
- Nutation
- Polar Motion
- UT1-UTC (irregular rotation rate)
- Spacecraft Center Gravity Offset
  From Antenna Phase Center

Measurement Adjustments
- Ionospheric - two frequency adj.
- Tropospheric - Saastamoinen Dry
  Neill Wet
- Periodic Relativistic Terms
- Station Displacement
  Earth Tides
  Crustal Motion
One arc second is about 30 m
Yearly Average
Deviation of Length of Day From Nominal Value
Accumulated Earth Clock Error
From 1800 - IERS Measurements / Analysis
Radial And Clock Errors  5 BCE's
Three Surfaces of Geodesy