

ACCURACY, PRECISION, ERRORS

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Accuracy & Precision

Accuracy v. Precision

Accuracy is the closeness of a measurement to reality (external accuracy)

Precision is the closeness of measurements to each other (internal accuracy)

1. Low accuracy/Low precision



2. Low accuracy/High precision



3. High accuracy/Low precision



4. High accuracy/High precision



General statement of Accuracy

- Taking all of the error sources into account, GPS accuracy will be approximately 10m for most GPS units. However, any given position may result in accuracy as low as 5m or up to 40m
 - Assuming that Selective Availability is turned off, no post-processing, or no real-time differential correction

Gaussian error model



The average of the collection of measurements is more accurate than any individual measurement by a factor equal to the square root of the number of measurements, provided the data follow the Gauss model and are normally distributed

Accuracy

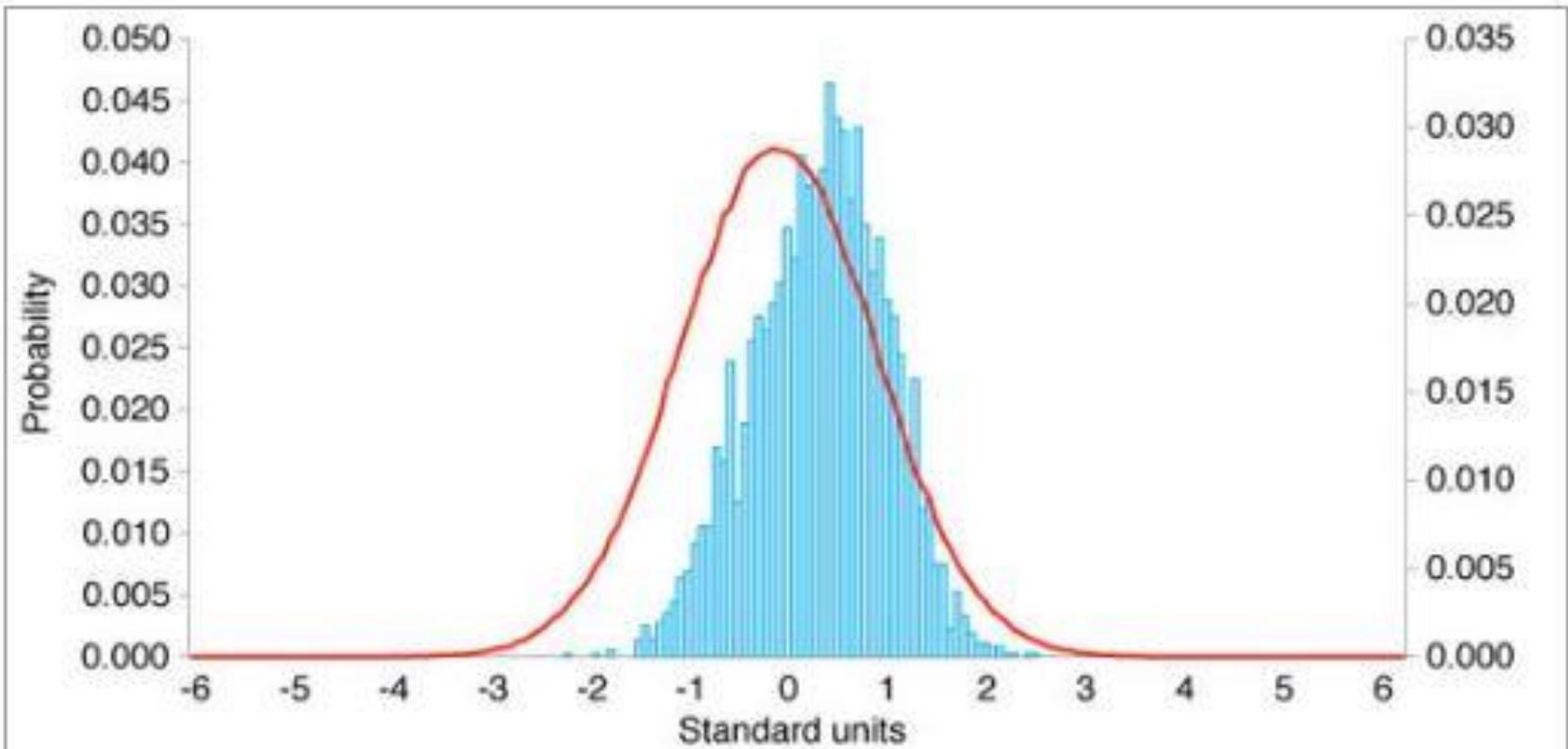
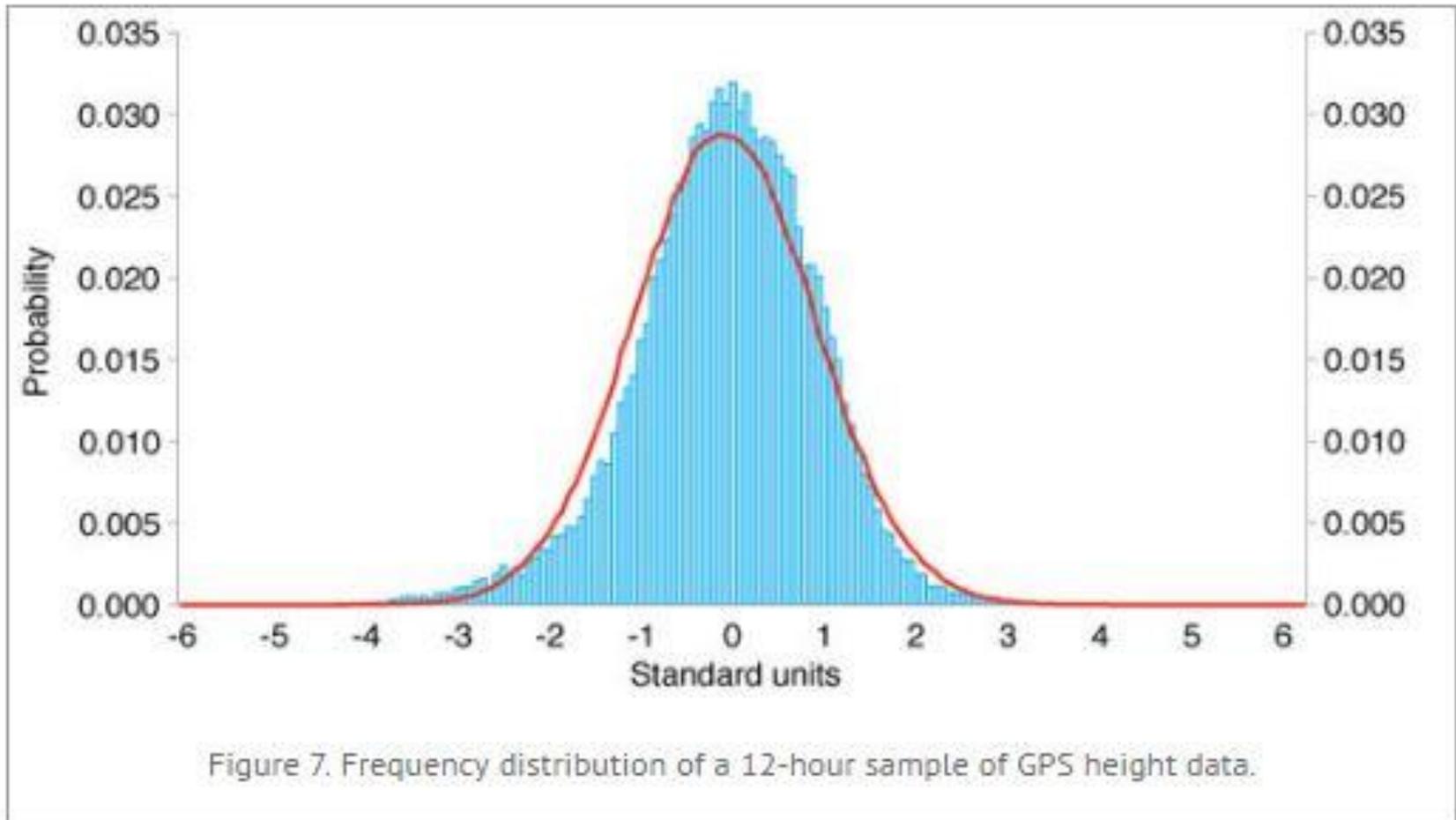
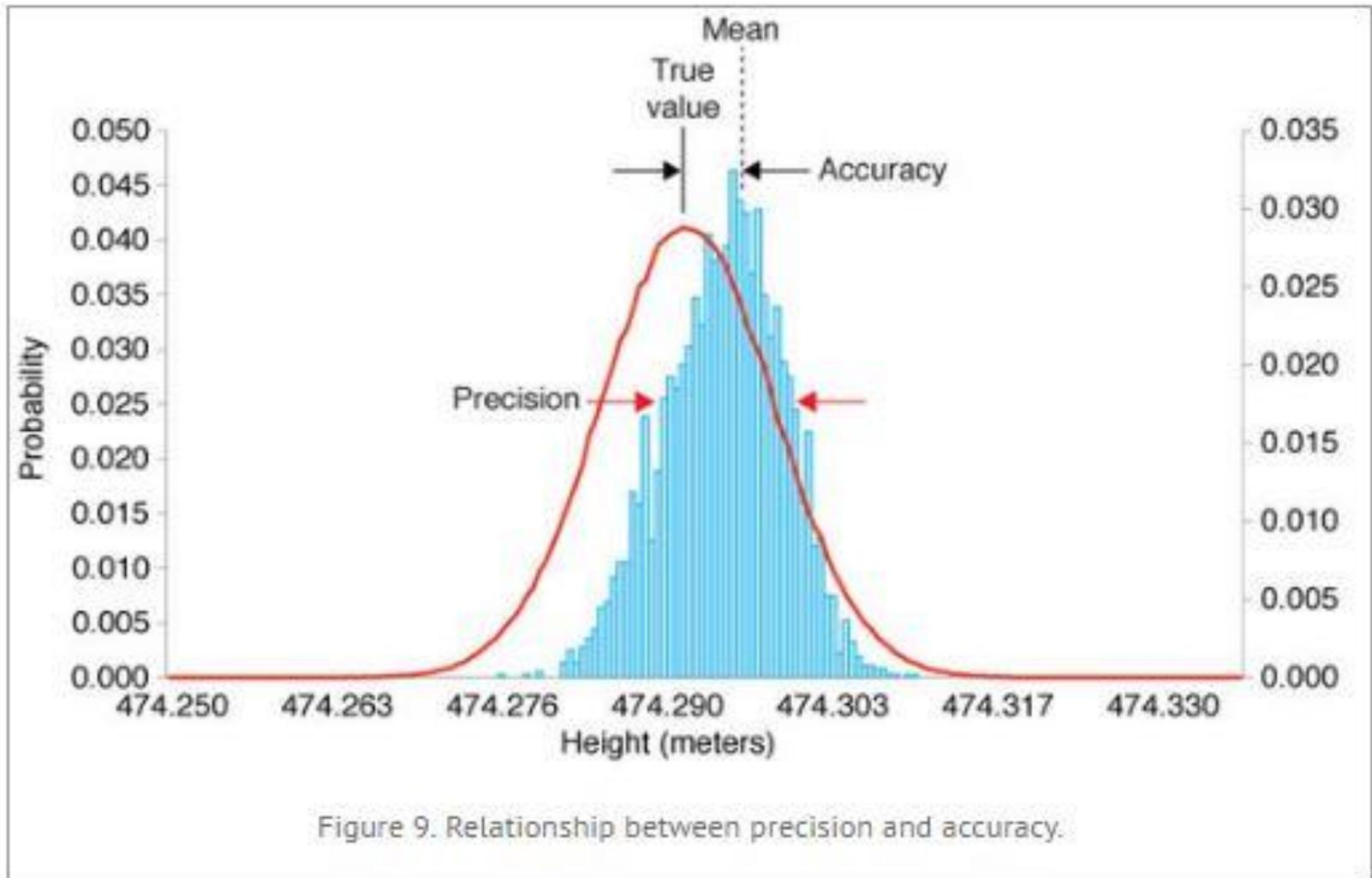


Figure 6. Frequency distribution of a 1-hour sample of GPS height data.

Accuracy



Accuracy v. Precision





Errors in GPS measurement

Errors and biases

Errors occur when there are random issues

Biases occur when there are systematic issues

- ▣ Satellite

- ▣ Orbital errors, satellite clock errors

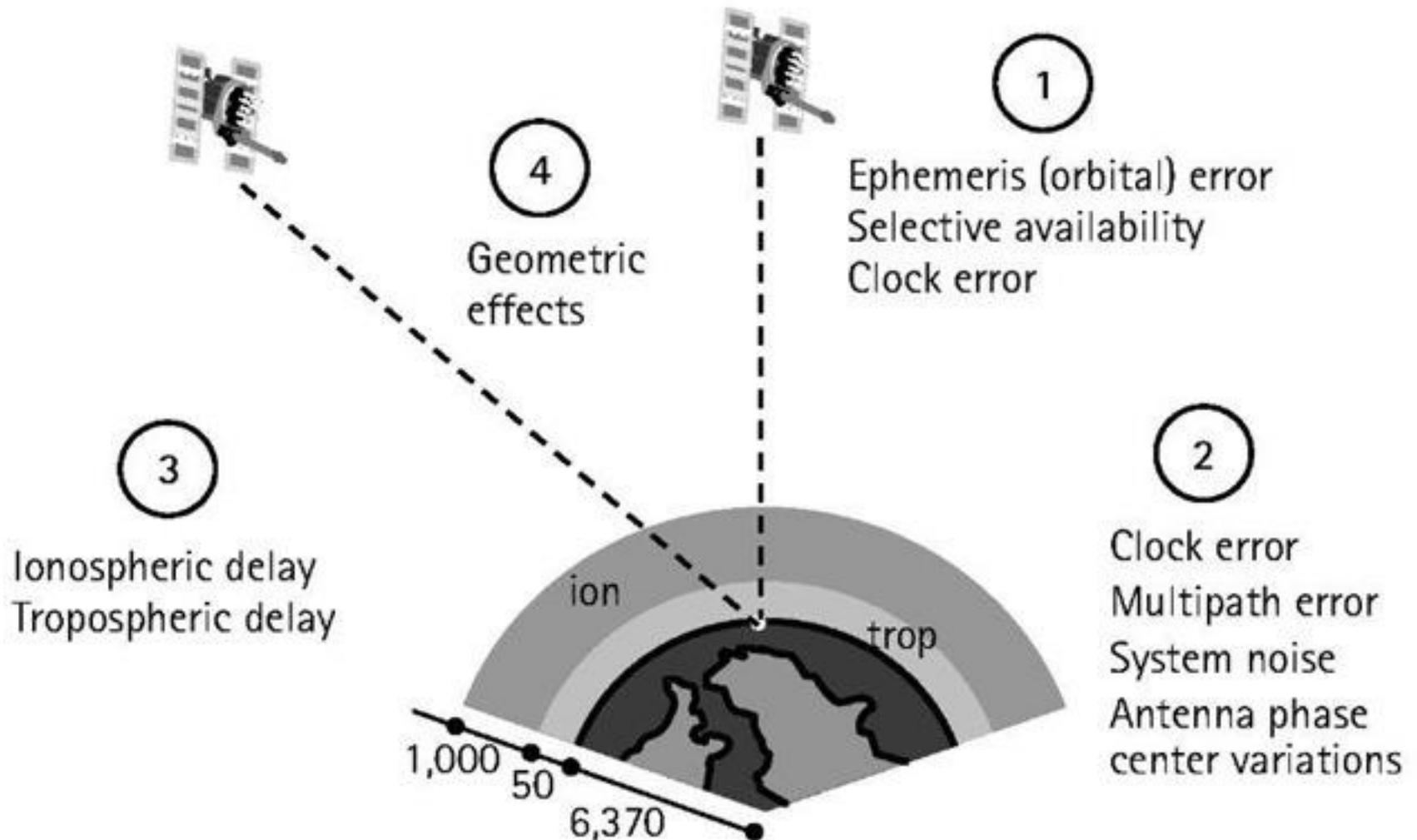
- ▣ Receiver

- ▣ Receiver clock errors, multipath error, receiver noise, antenna phase center variations

- ▣ Atmospheric interference

- ▣ Ionospheric & tropospheric interference

Errors and biases



Satellite errors

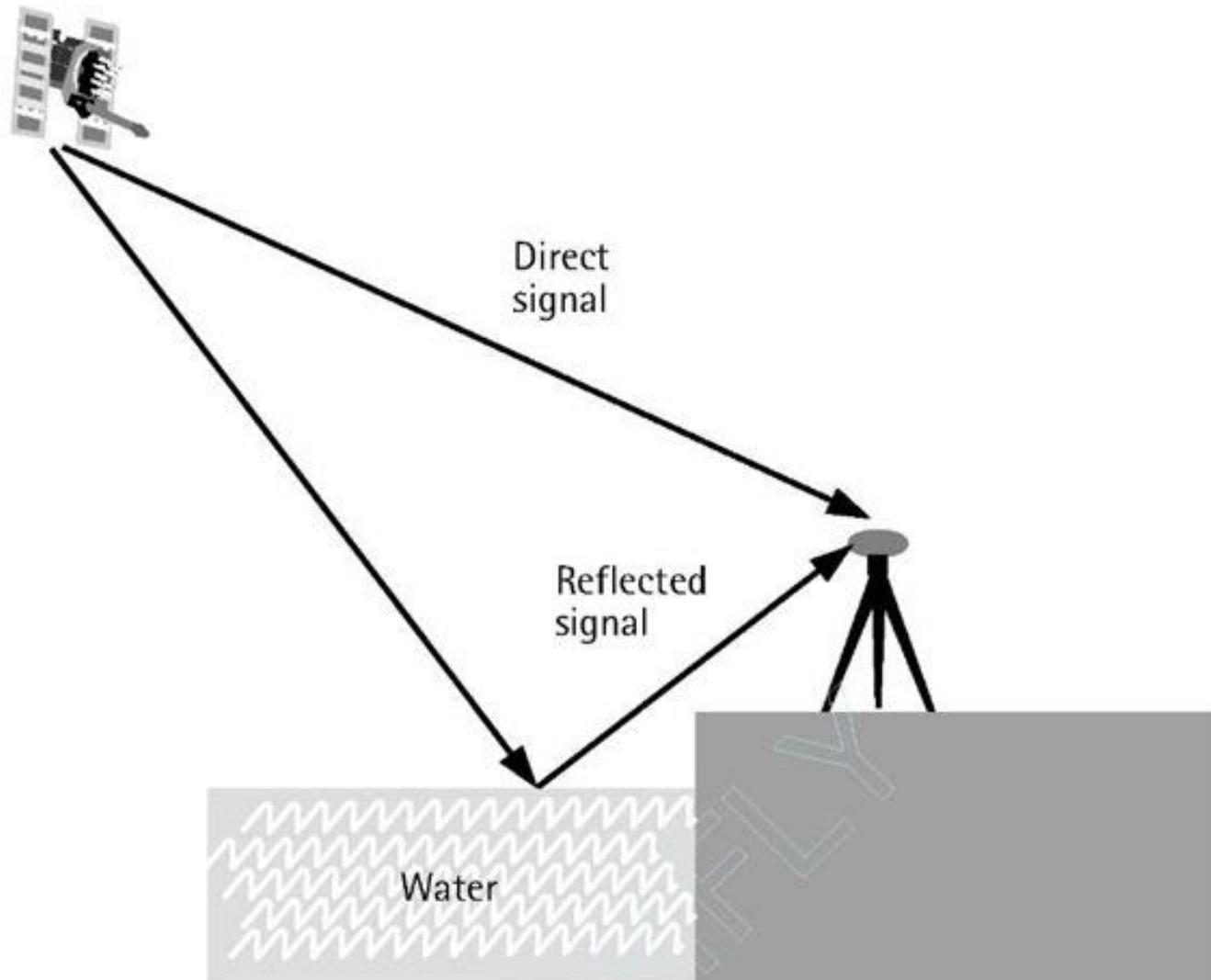
- Ephemeris error (2-5m)
 - ▣ Satellite position as a function of time, are predicted from previous GPS observations & ground control stations
 - ▣ Estimating satellite positions will not be perfect
- Clock error (2-5m)
 - ▣ Highly accurate, but not perfect; error is about 8-18ns per day

Receiver errors

- Clock error (2-20m)
 - ▣ Much less accurate than Satellite's atomic clock, therefore receiver clock error is much larger than with the satellite
- Multipath error (varies)
 - ▣ Occurs when GPS signals arrive at the receiver antenna through different paths
 - ▣ Select an observation point with no reflecting objects
 - ▣ Use a choke ring antenna (has several concentric metal hoops, which reduce the reflected signals)



Receiver error



Receiver error

- Antenna phase center variation (<1 m)
 - ▣ Antenna phase center is the point at which the GPS signal is received
 - ▣ Generally, the antenna phase center does not coincide with the physical (geometrical) center of the antenna
 - ▣ Dependent on the elevation & angle of the GPS satellite, as well as the intensity of the signal

Receiver error

- Receiver noise
 - ▣ Results from the limitations of the GPS receiver's electronics
 - ▣ Use a better receiver (more \$) or use two receivers simultaneously

Atmospheric error

- Ionospheric interference (5-150m)
 - Uppermost part of the Earth's atmosphere, UV & x-ray radiations coming from the sun interact with the has molecules & atoms, resulting in a number of free electrons, atoms, and molecules
 - A dispersive medium, which means it bends the GPS radio signal and changes its speed

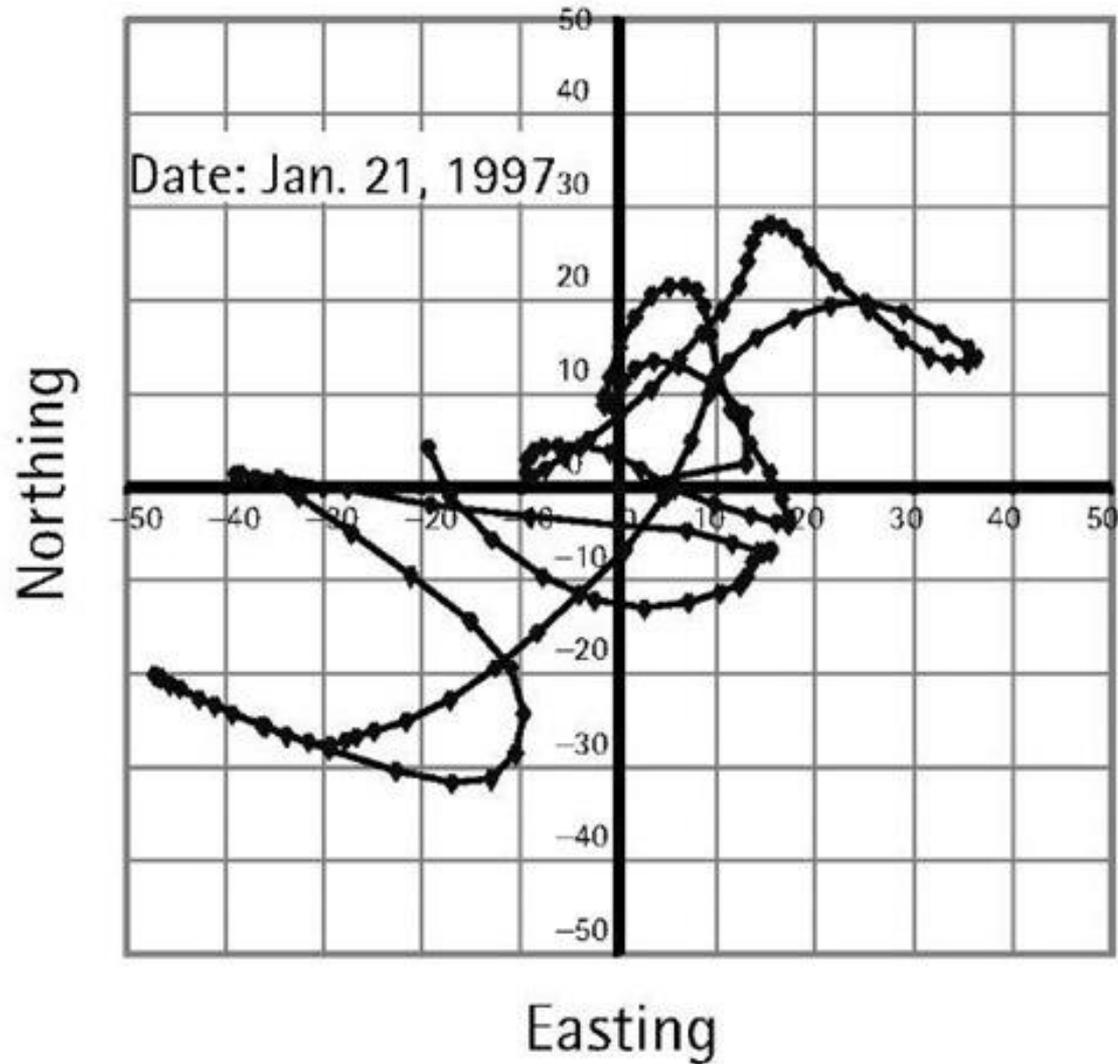
Tropospheric error

- Tropospheric delay (2-10m)
 - Troposphere is the electronically neutral atmospheric region – it is nondispersive for radio frequencies and as a result delays the GPS signal
 - Measured satellite-to-receiver range will be longer than the actual range
 - Dependent on temperature, pressure, & humidity
 - Dry component (90% of the delay) is easily modeled and can be resolved using two receivers simultaneously
 - Wet component (water vapor) is not easy to predict

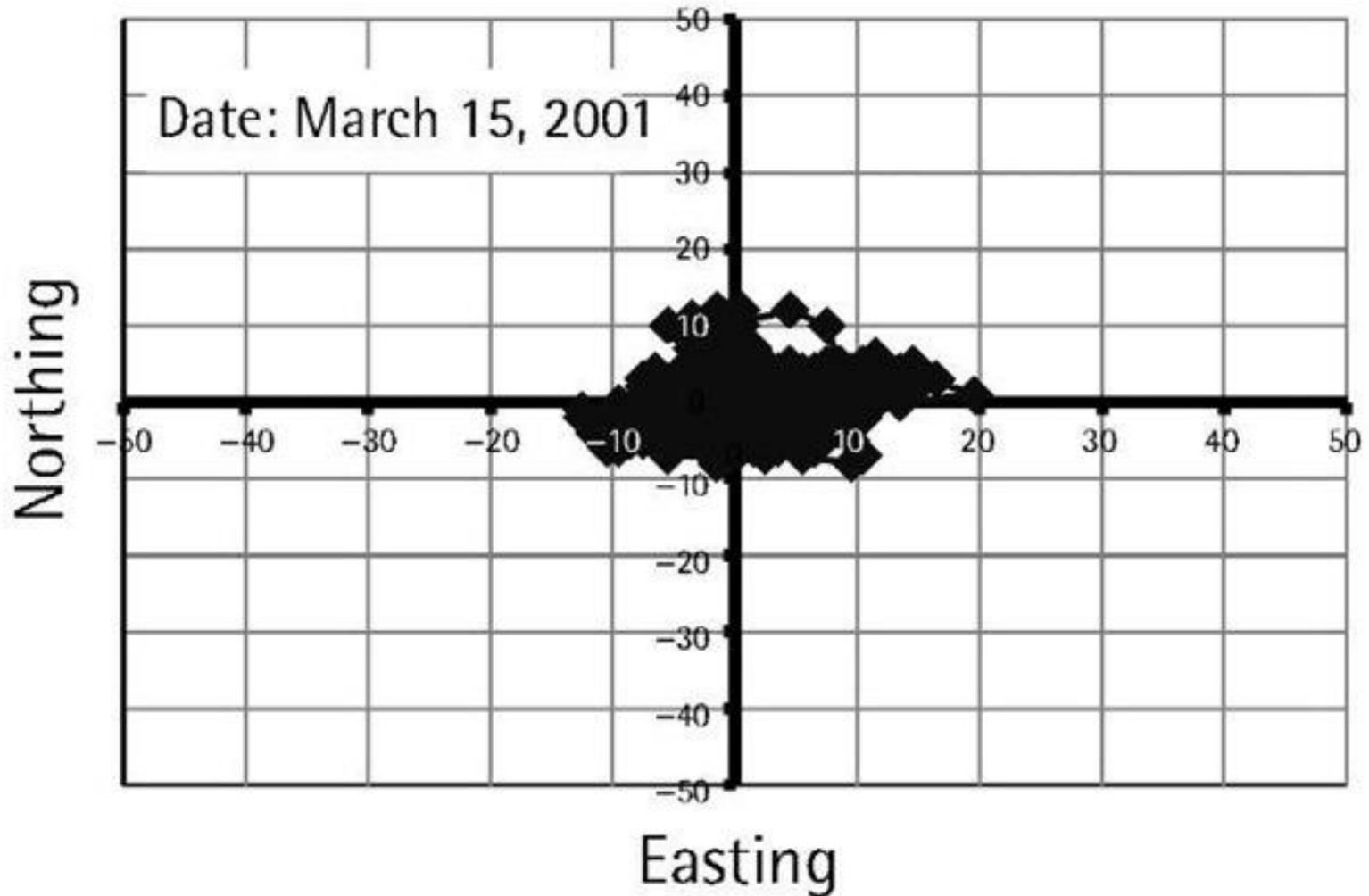
Selective Availability (SA)

- Random error to deny accurate real-time positioning to civilian users
- Discontinued in May 1, 2000

Selective availability - on



Selective availability - off



How do I avoid errors?

1. Point averaging
2. Mission planning
3. Avoid large electrical/power lines
4. Don't collect data in a downpour
5. Avoid collecting data around reflective surfaces