DOUBLE DIFFERENCES

Consider two receivers, in close proximity (or possibly several kilometers apart), tracking SV (SpaceVehicle; *i.e.*, satellite) signals from the direction depicted in the accompanying sketch. The receivers don't have to be synchronized physically but their clock estimates obtained from normal GPS operation are sufficiently accurate to

- bring their observations into synchronism computationally and
- translate satellite position as received (from transmit time) to time of reception.

RECEIVERS SEPARATED by SHORT BASELINE

----- Direction of Vector S from SV to mid-baseline

Ref. Location of RCVR #0 (Origin) — O

Offset Location of RCVR # 1 — 1

|<——— baseline R ———>|

Notation :

$\mathbf{1_S} = \mathbf{S}/|\mathbf{S}|$

$B_0\ B_1$ =RCVR biases

$C_0\ C_1\ C_S$ =Clock errors

M=Multipath

N=Noise

Q=Quantiz.

Equations for pseudoranges - from -

OFFSET: $(\mathbf{R} - \mathbf{S})\cdot\mathbf{1_S} + IONO + TROPO + B_1 + C_1 - C_S + M_1 + N_1 + Q_1$

ORIGIN: $(-\mathbf{S})\cdot\mathbf{1_S} + IONO + TROPO + B_0 + C_0 - C_S + M_0 + N_0 + Q_0$

DIFF: $\mathbf{R}\cdot\mathbf{1_S} + B + C + M + N + Q$

- $\Delta(IONO) \doteq 0$
- If $\Delta(TROPO) \neq 0$ adjust for altitude & wet / dry
- Eliminate B & C by subtracting DIFFs from two SVs
- Sync requirements ⇒ knowledge (not control) of meas. timing

Since the same SV clock errors affect each receiver's measurements, C_s cancels by subtraction. Essentially the same is true of ionospheric time offsets and largely true of tropospheric delays (further compensation can be applied if a large body of water separates them). For ***double differencing*** another subtraction – across two SV's – cancels B_0, B_1, C_0, and C_1. After cancellation of so many major error sources, what remains is $\mathbf{R}\cdot\mathbf{1_s}$, the projection of baseline separation along the satellite sightline – with degradations remaining from only noise, quantization, and multipath. Perform this simple operation three times, with enough directional spread among all SV's, and you'll determine the baseline to within measurement accuracy (*e.g.*, a couple of meters for pseudoranges or, if carrier phase measurements are carefully employed, *sub-centimeter* performance is achievable).

Local area differential GPS (LADGPS) offers the benefit by broadcasting local corrections from a surveyed site. After surveying was revolutionized two decades ago the list of stunning success has continued to grow.