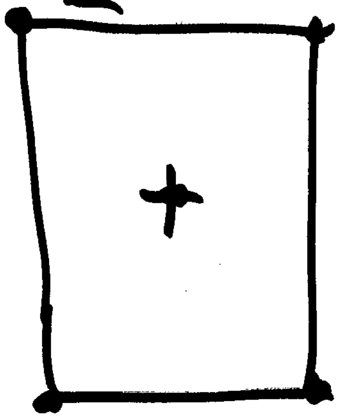


40.4928 deg
−86.9835 deg
181.53 m

40.3290 deg
−86.7788 deg
189.11 m

$\bar{\phi} = 40.4111$

$\bar{\lambda} = -86.8809$

$\bar{h} = 200\,\text{m}$

lat_off
lon_off
h_off

RPC

NITF doc.

$\phi \lambda h \rightarrow l s$

$\phi \lambda h \rightarrow PLH$

decimal degrees

normalized

<u>NITF</u> spec.

$$r_n = \frac{\sum \text{line-num-coeff}(P, L, H)}{\sum \text{line-den-coeff}(P, L, H)}$$

* for denominators $C_1 = 1$

$$c_n = \frac{\sum \text{sample-num-coeff}(P, L, H)}{\sum \text{sample-den-coeff}(P, L, H)}$$

*

$$C_1 + C_2 L + C_3 P + C_4 H + C_5 LP + C_6 LH + C_7 PH +$$
$$C_8 L^2 + C_9 P^2 + C_{10} H^2 + C_{11} PLH + C_{12} L^3 +$$
$$C_{13} LP^2 + C_{14} LH^2 + C_{15} L^2 P + C_{16} P^3 +$$
$$C_{17} PH^2 + C_{18} L^2 H + C_{19} P^2 H + C_{20} H^3$$

$P = (lat_{dd} - lat\_off) / lat\_scale$

$L = (lon_{dd} - lon\_off) / lon\_scale$

$H = (h_m - h\_off) / h\_scale$

h
ellip's
ht.

H
ortho
ht.

$r_n = (r - r\_off) / r\_scale$

$c_n = (c - c\_off) / c\_scale$

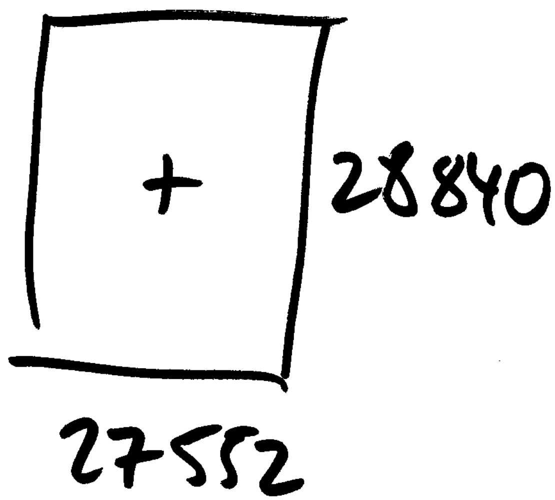
lat range $\approx$ 0.1638 deg : lat_scale = ½ · range

lon range $\approx$ 0.2055 deg : " "

h range $\approx$ 200 : " "

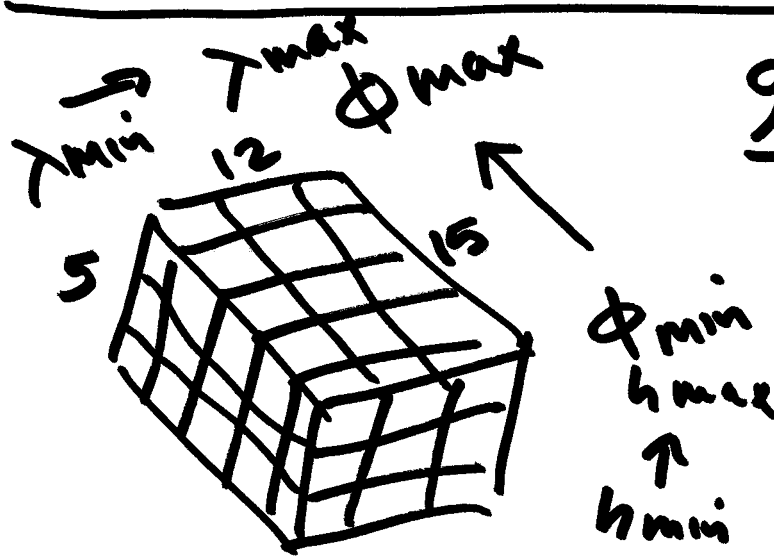
effect of applying normalization constants

⇒ −1 → +1 normalized value



r_off : 14420
c_off : 13776

r_scale : 14420
c_scale : 13776



900 grid locations

in object space

for each of 900 points

$\phi \lambda h \xrightarrow[\text{6 par}]{} l_0, s_0$

$\phi \lambda h \longrightarrow l, s$

2x2 newton iteration

end

exactly consistent with physical model

ϕ_1	λ_1	h_1	l_1	s_1
ϕ_2	λ_2	h_2	l_2	s_2
$\vdots$				
ϕ_{900}	λ_{900}	h_{900}	l_{900}	s_{900}

$$r_n = \frac{A_1 + A_2 L + A_3 P + A_4 H + A_5 LP + A_6 LH + \dots}{1 + B_2 L + B_3 P + B_4 H + B_5 LP + B_6 LH + \dots}$$

$$c_n = \frac{C_1 + C_2 L + C_3 P + C_4 H + \dots}{1 + D_2 L + D_3 P + D_4 H + \dots}$$

$$\nu + B_0 = f$$

$$r_n + \Big[\overbrace{-1 - L - P - H - LP - LH \;\cdots\; - H^3}^{A} + \underbrace{r_n L \quad r_n P \quad r_n H \;\cdots\; r_n H^3}_{B} \quad \underbrace{0\ 0 \cdots 0}_{C} \quad \underbrace{0\ 0 \cdots 0}_{D} \Big]$$

$$\begin{bmatrix} A_1 \\ \vdots \\ A_{20} \\ B_2 \\ \vdots \\ B_{20} \end{bmatrix} \quad \begin{bmatrix} C_1 \\ \vdots \\ C_{20} \\ D_2 \\ \vdots \\ D_{20} \end{bmatrix} \longleftarrow \text{78 term unknown vector}$$

$$v + B\delta = f \qquad f = -\ell \; (r \text{ or } c)$$

$$\underbrace{\begin{bmatrix} v_{r_1} \\ v_{c_1} \\ \vdots \\ \vdots \\ v_{r_{900}} \\ v_{c_{900}} \end{bmatrix}}_{1800,1} + \underbrace{\begin{bmatrix} \\ \\ \\ \\ \\ \\ \end{bmatrix}}_{1800 \times 78} \underbrace{\begin{bmatrix} A \\ B \\ C \\ D \end{bmatrix}}_{78,1} = \underbrace{\begin{bmatrix} -r_1 \\ -c_1 \\ \vdots \\ \vdots \\ -r_{900} \\ -c_{900} \end{bmatrix}}_{1800,1}$$

solve LS problem for A, B, C, D

$\Delta = (B^T W B)^{-1} B^T W f$ regular LS

$v = f - B\Delta$

---

but $(B^T W B)$ order 78×78

rank < 78

select from inf. # of solutions — the solution vector with <u>shortest</u> <u>length</u>

$\Delta = (B^T W B)^{+} B^T W f$

"+" pseudo inverse

$N = B^T W B$

N^{-1} : inv(N)

N^{+} : pinv(N)

$$\begin{bmatrix} B^TWB & \\ & 0 \end{bmatrix}$$

$(\text{basis of NS})^T$

N

$x : Nx = 0$

nullspace

basis of null space

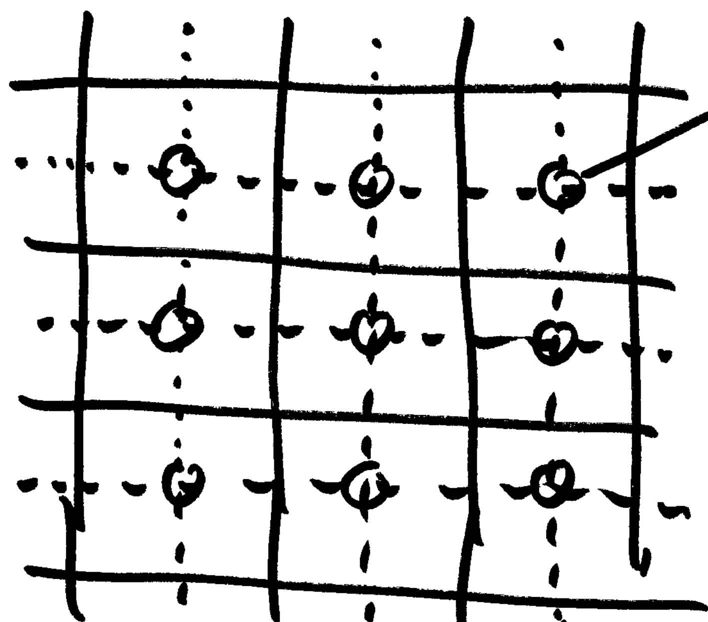
look @ eigenvector + eigenvalues of $B^T W B$
if select eigenvectors correspond to zero eigenvalues $\Rightarrow$ basis of N.S.

QC

1. check residuals

$$v = f - B\Delta \ll 1 \text{ pixel}$$

2. validation, check points



$\phi\lambda h \to PLH \to l,s$ Phy

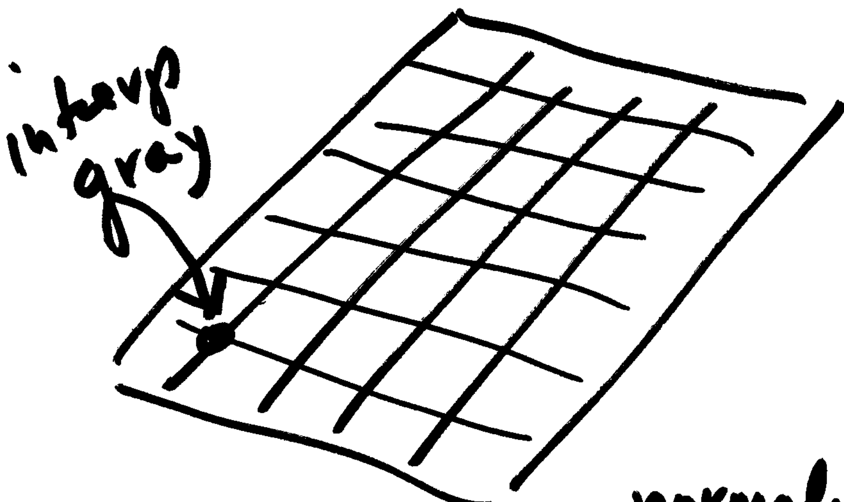
$\phi\lambda h \to l,s$ RPC

agree $\ll$ 1 pixel

replacement model

maintained accuracy
simplified

<u>rectification</u>



$$\left.\begin{array}{l} XY_{\text{ISPW}} \\ XY_{\text{UTM}} \end{array}\right\}$$

$H_{\text{SL or ortho}}$

$$XY \longrightarrow \Phi\lambda \xrightarrow{\text{normalize}} \begin{pmatrix} PL \\ H \end{pmatrix} \xrightarrow{\text{apply RPC}} \begin{pmatrix} r_n \\ c_n \end{pmatrix}$$

$H \rightarrow h$

$$(r_n, c_n) \xrightarrow{\text{un-normalize}} \underline{\underline{(r, c)}}$$

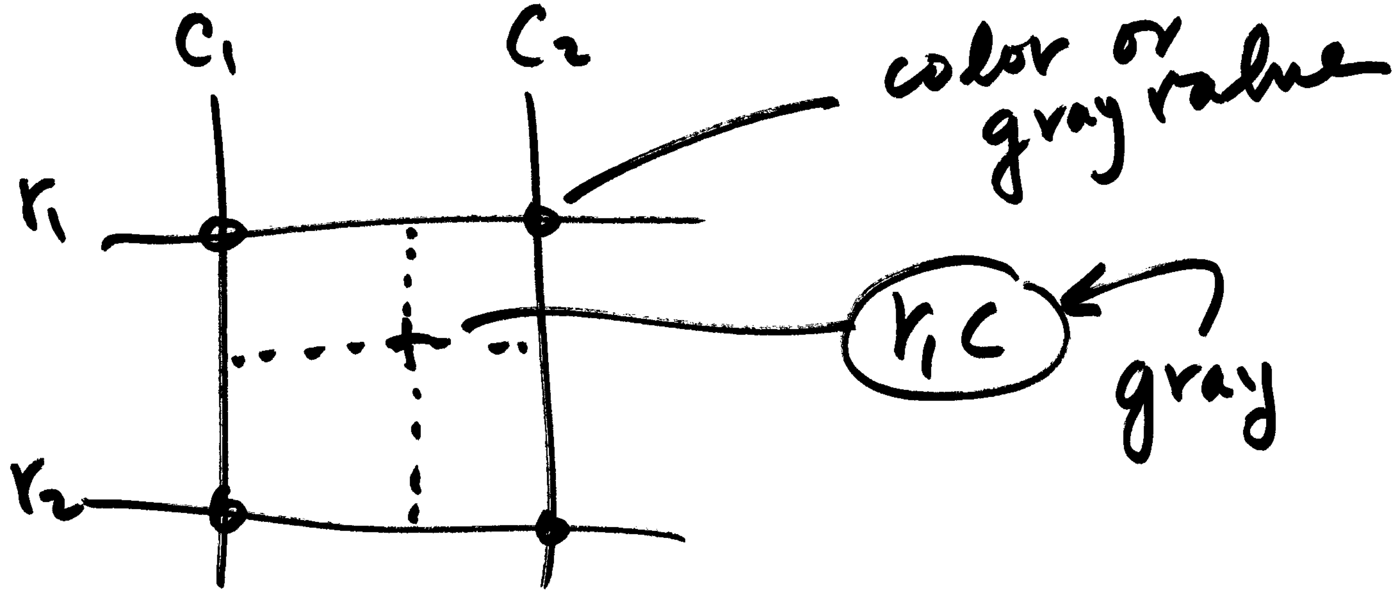
$$r_n = (r - r\_off) / \cancel{\text{[illegible]}}\; r\_scale$$

$$c_n = (c - c\_off) / c\_scale$$

$$r = (r_n \cdot r\_scale) + r\_off$$

$$\underline{\underline{c}} = (c_n \cdot c\_scale) + c\_off$$

<u>fractional</u> ⇒ interpolation



nearest neighbor
bilinear
bicubic

interpolation