POLITECNICO DI MILANO

The Impact of Temporal Decorrelation on P-Band Interferometric Ground Notching for Forest AGB Retrieval

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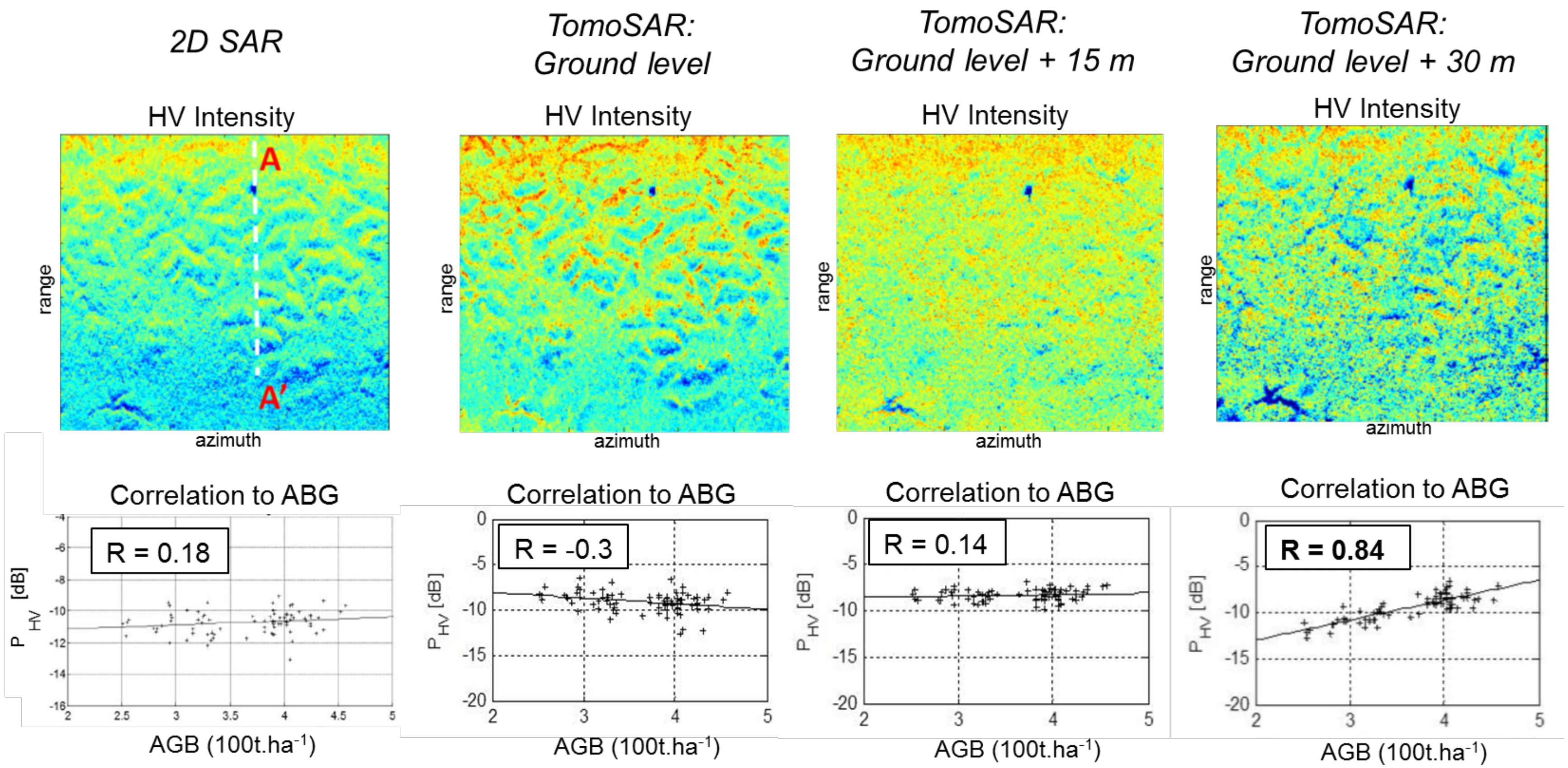
Outline

- Introduction
- Ground notching on BioSAR1 and AfriSAR
- Temopral decorrelation analysis
- Conclusions

Forest AGB retrieval using P-band tomography

Different TomoSAR layers exhibit different correlation to forest biomass

- The best correlation is found at 30 m above the ground
- The ground layer is poorly or negatively correlated to forest biomass, and strongly varying with topographic slopes



Ho Tong Minh *et al., 2013*

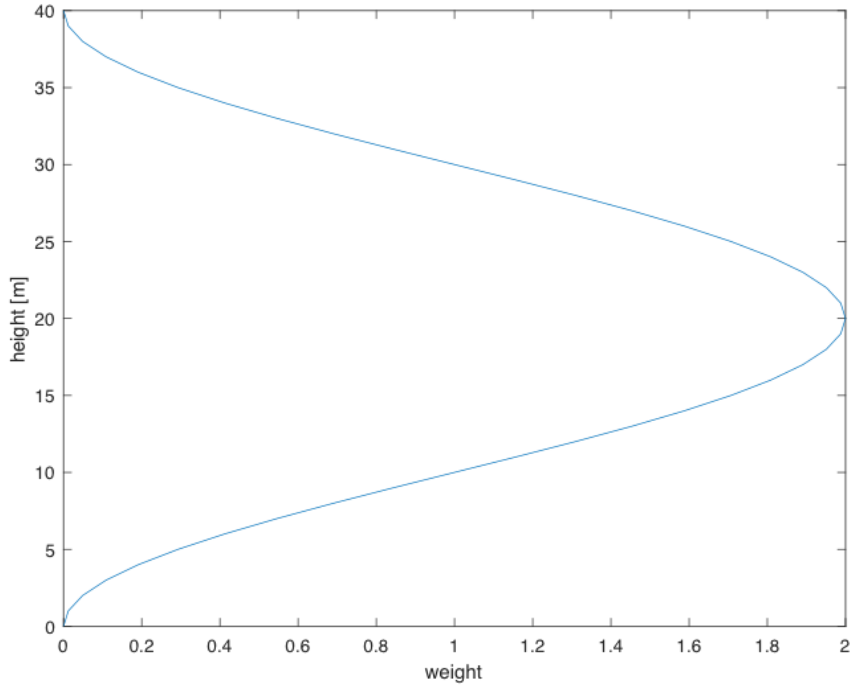
Ground notching

Master: $y_M = \int s(z)dz$,Slave: $y_S = \int s(z) \cdot e^{j \cdot k_z \cdot z} dz$

$y_{notch} = y_M - y_S$

Notch power: $E[|y_{notch}|^2] = 2 \int \sigma_S^2(z) \cdot \left(1 - cos(k_z \cdot z)\right) \cdot dz$

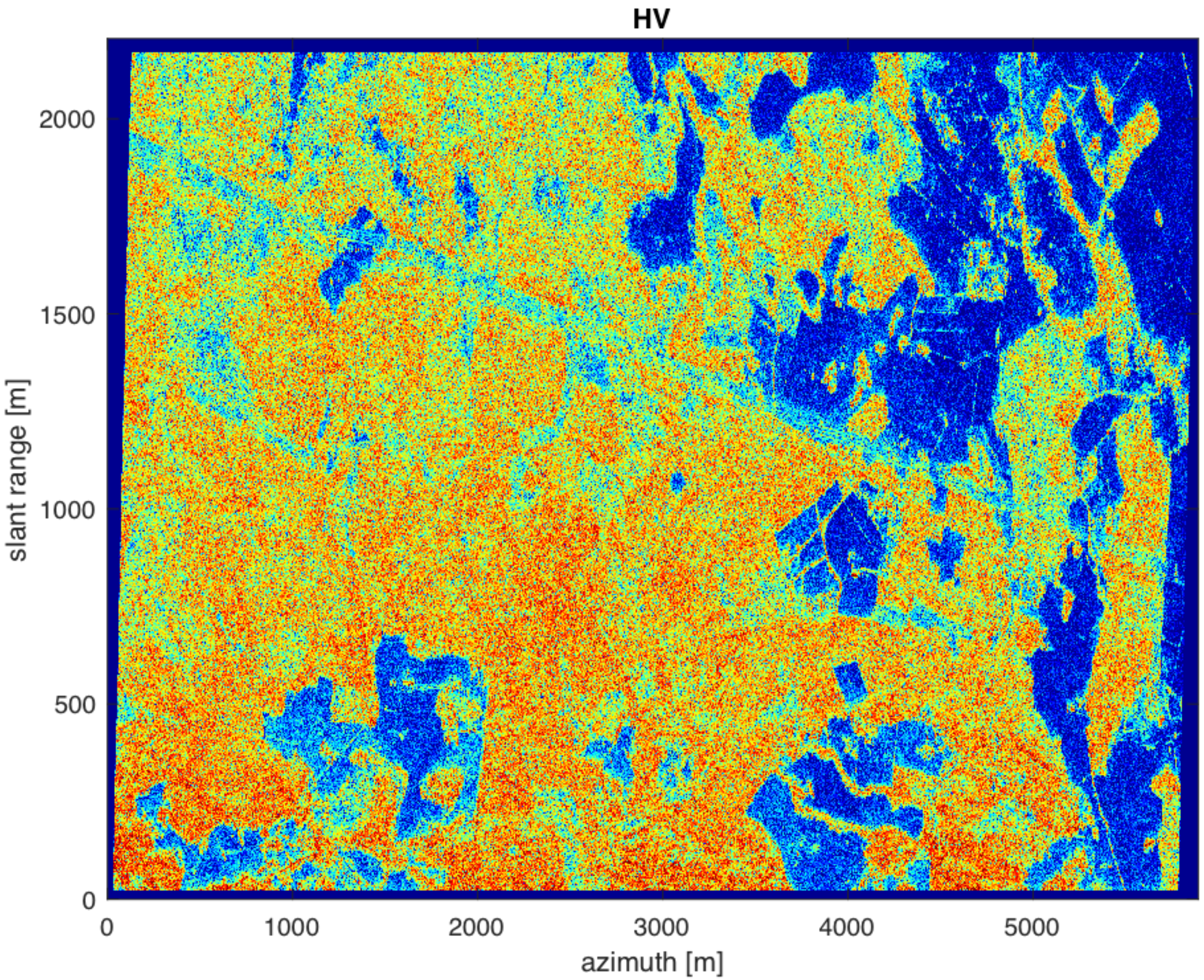
The vertical reflectivity profile is weighted by function $1 - cos(k_z \cdot z)$, it kills the echo coming from the ground and emphasize the power coming from half of the ambiguity of height.



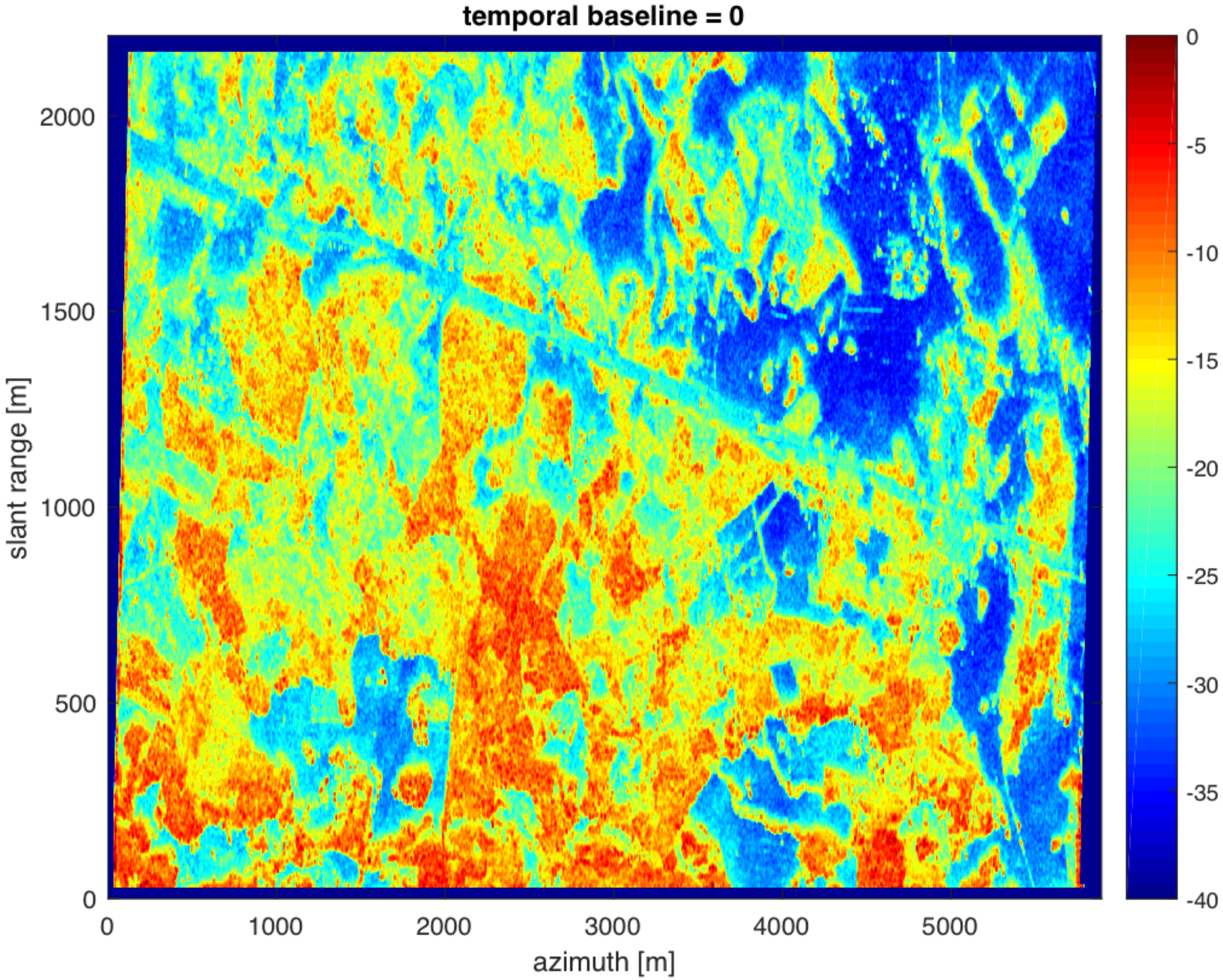
BioSAR1

Time span: 0, 23, 30, 53 days

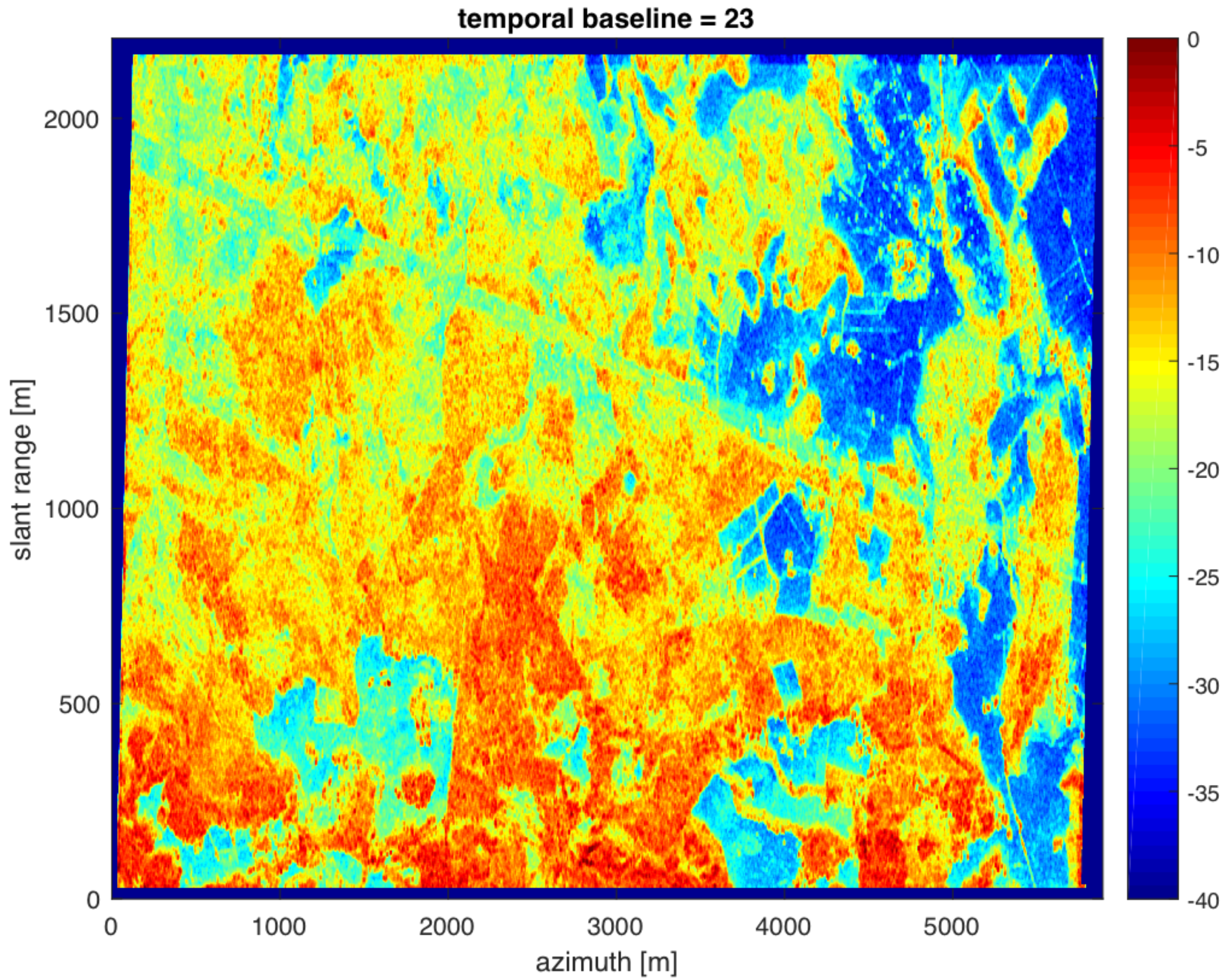
Image pairs with height ambiguity around 40 meters are selected.



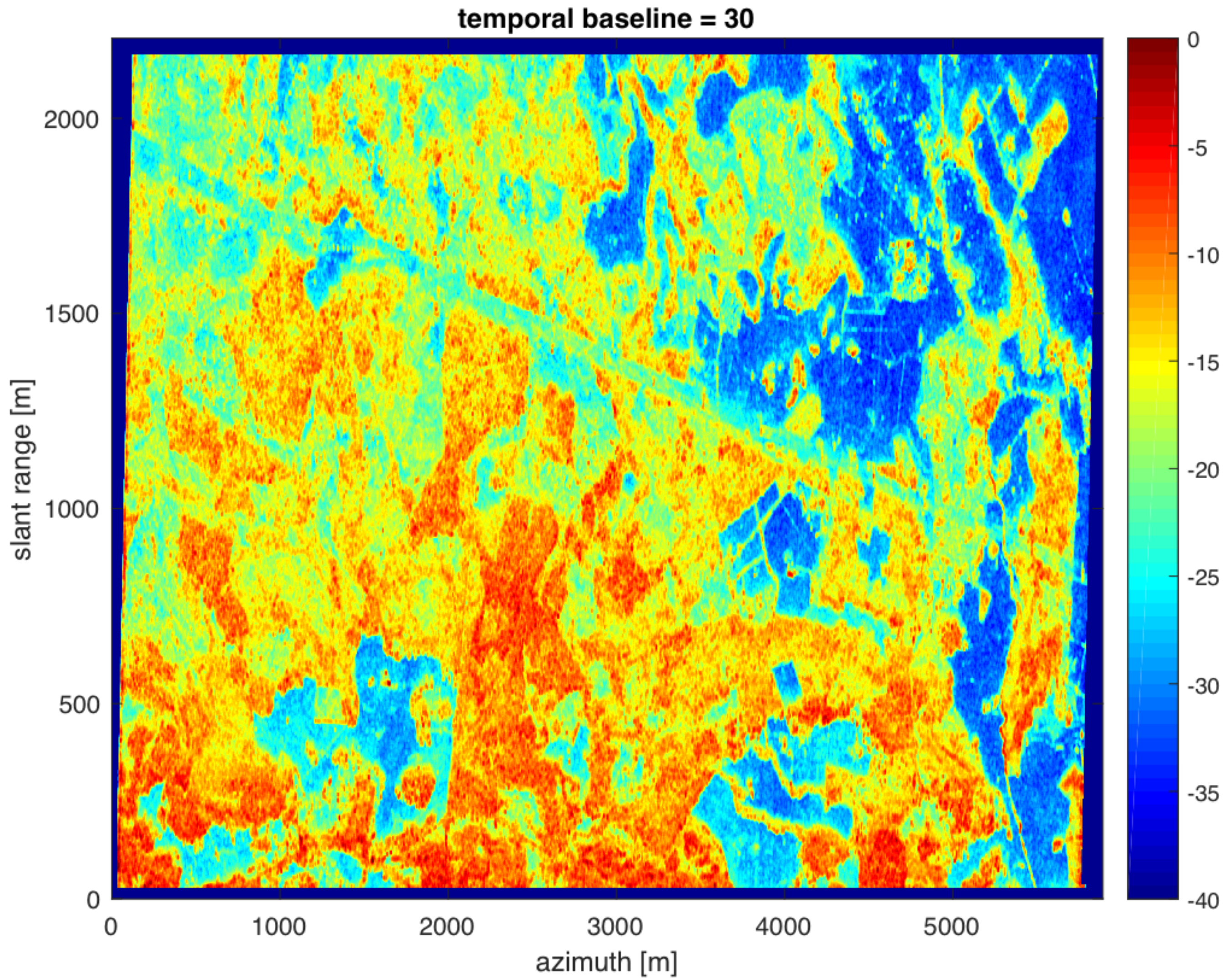
Notch power 0



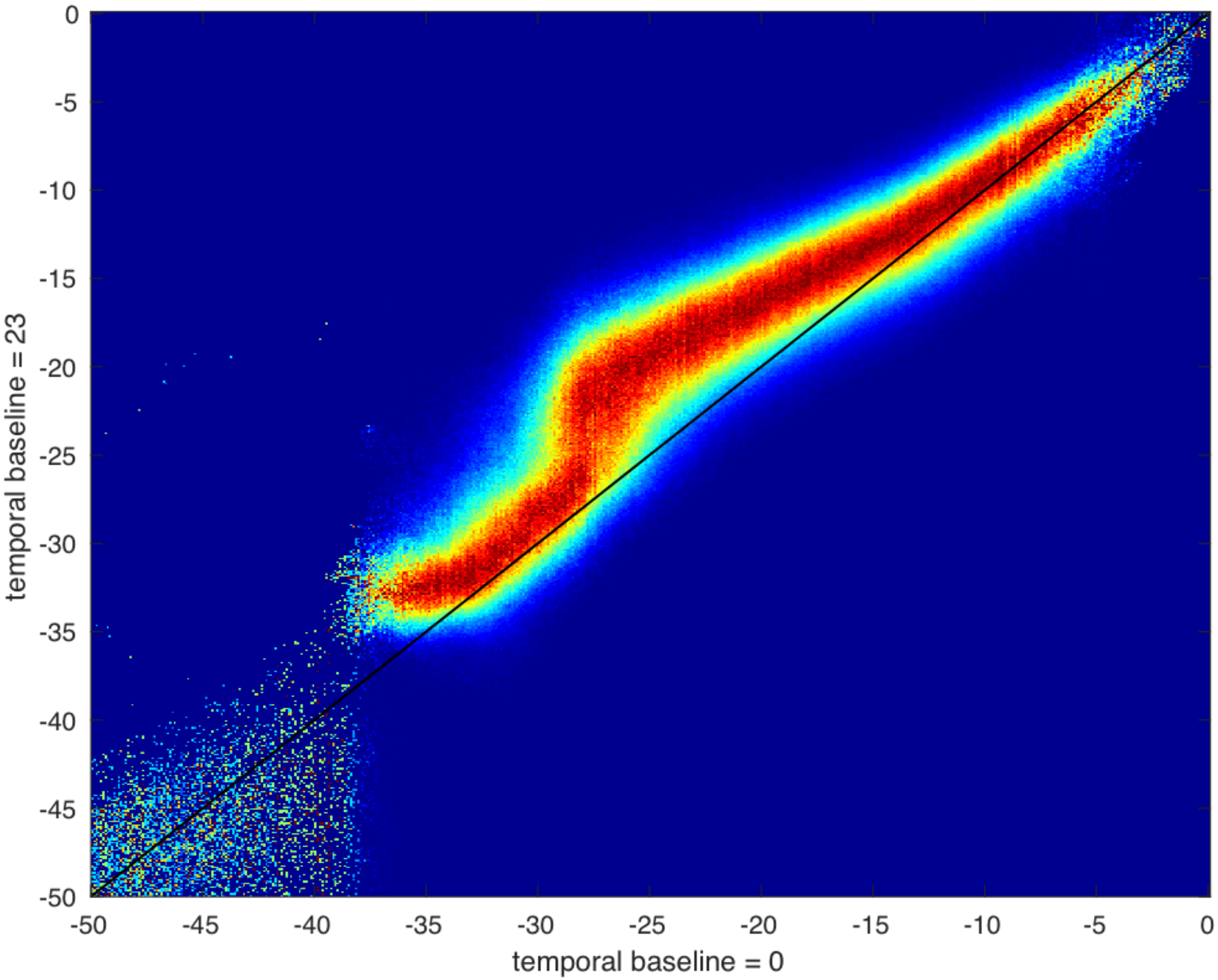
Notch power 23



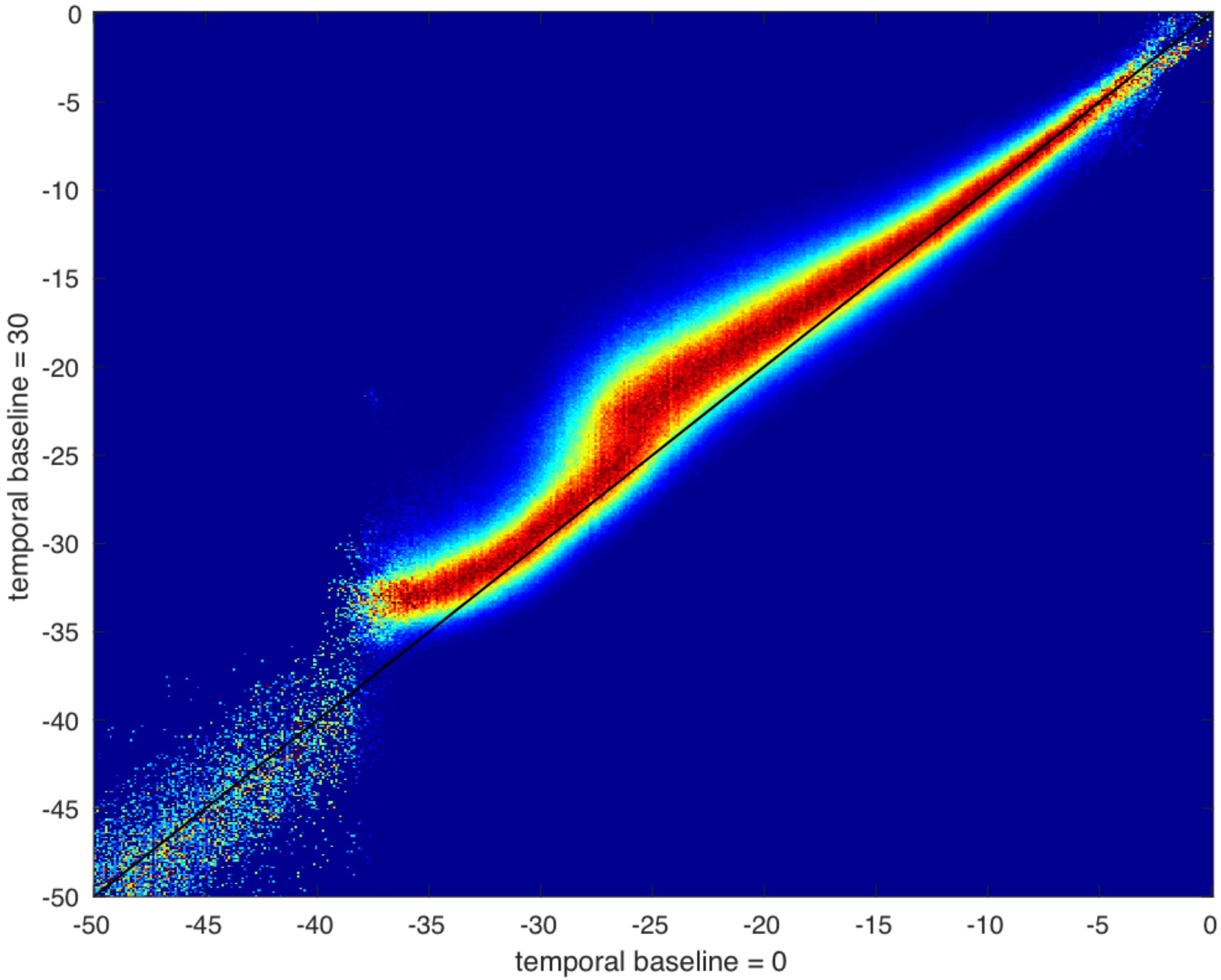
Notch power 30



Cross plot 0 vs 23



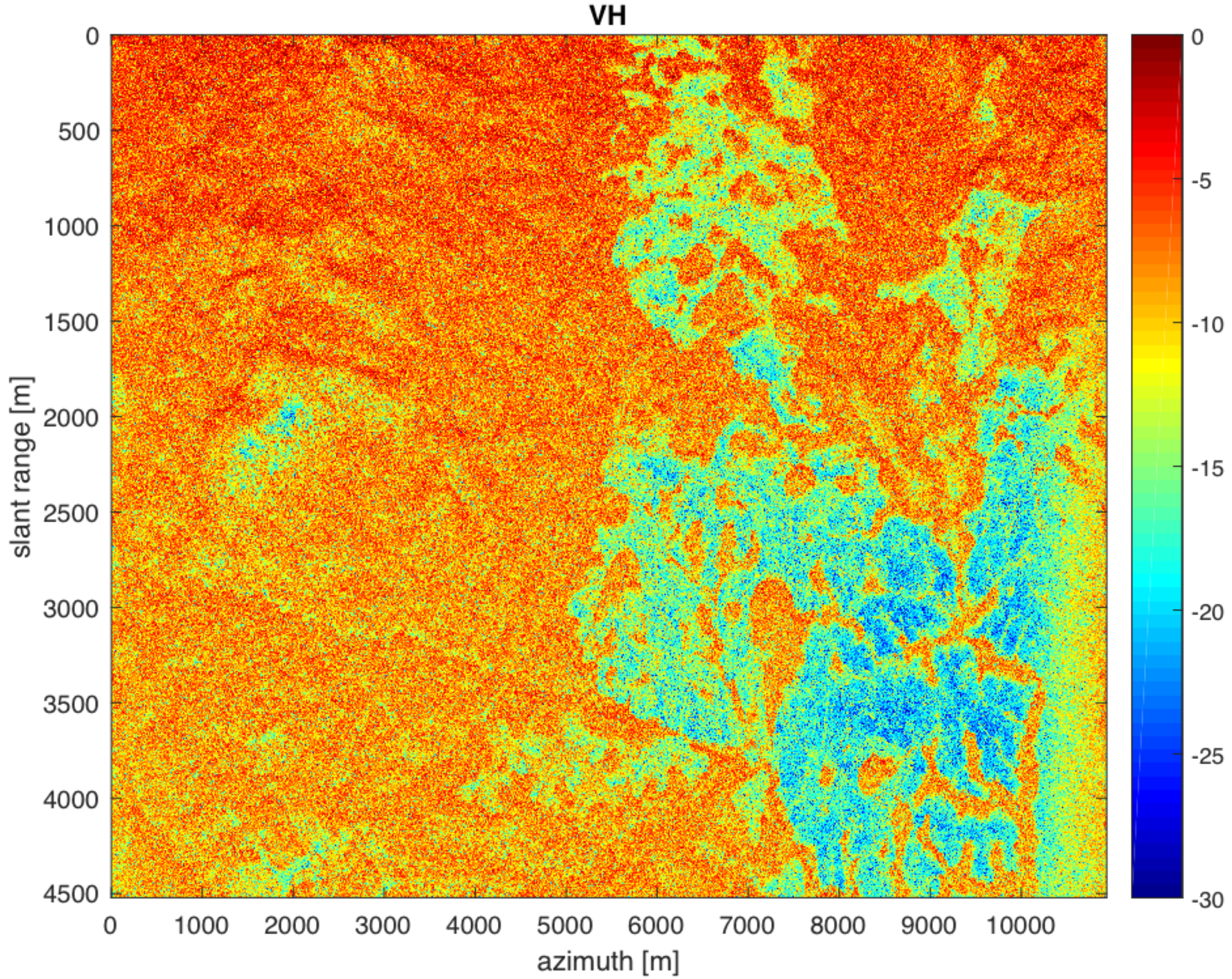
Cross plot 0 vs 30



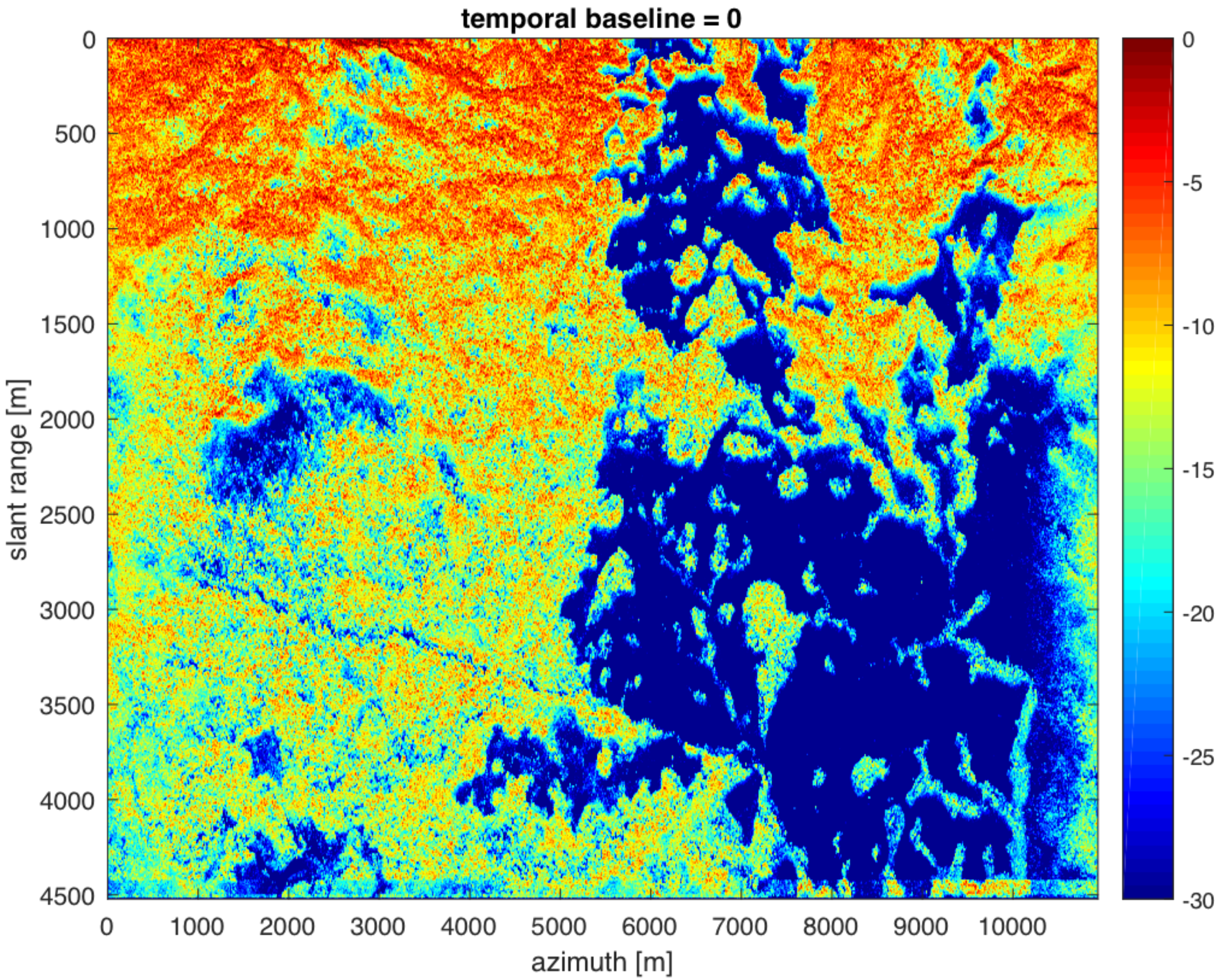
AfriSAR Lope

Time span: 0, 4, 5, 9 days

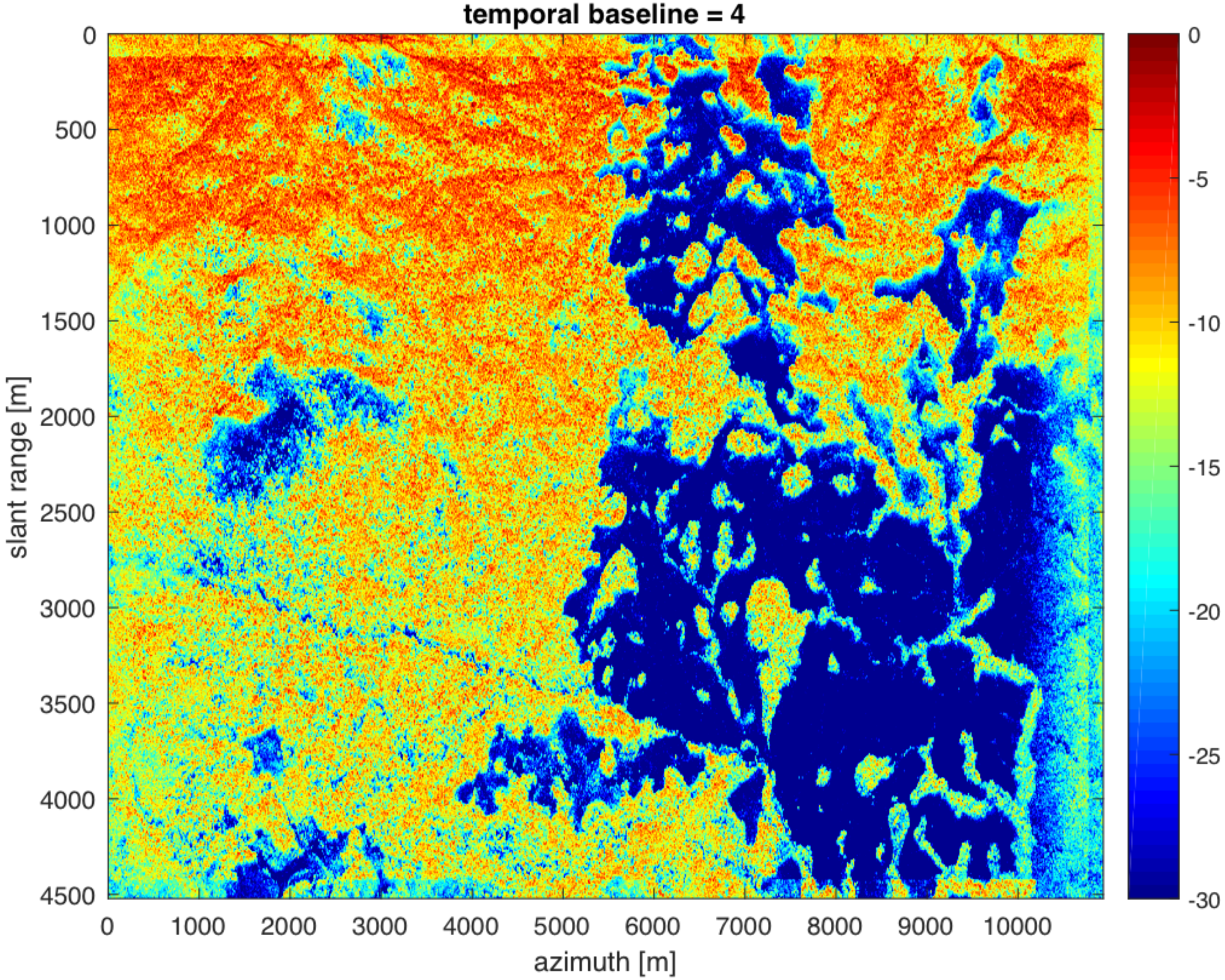
Image pairs with height ambiguity around 100 meters are selected.



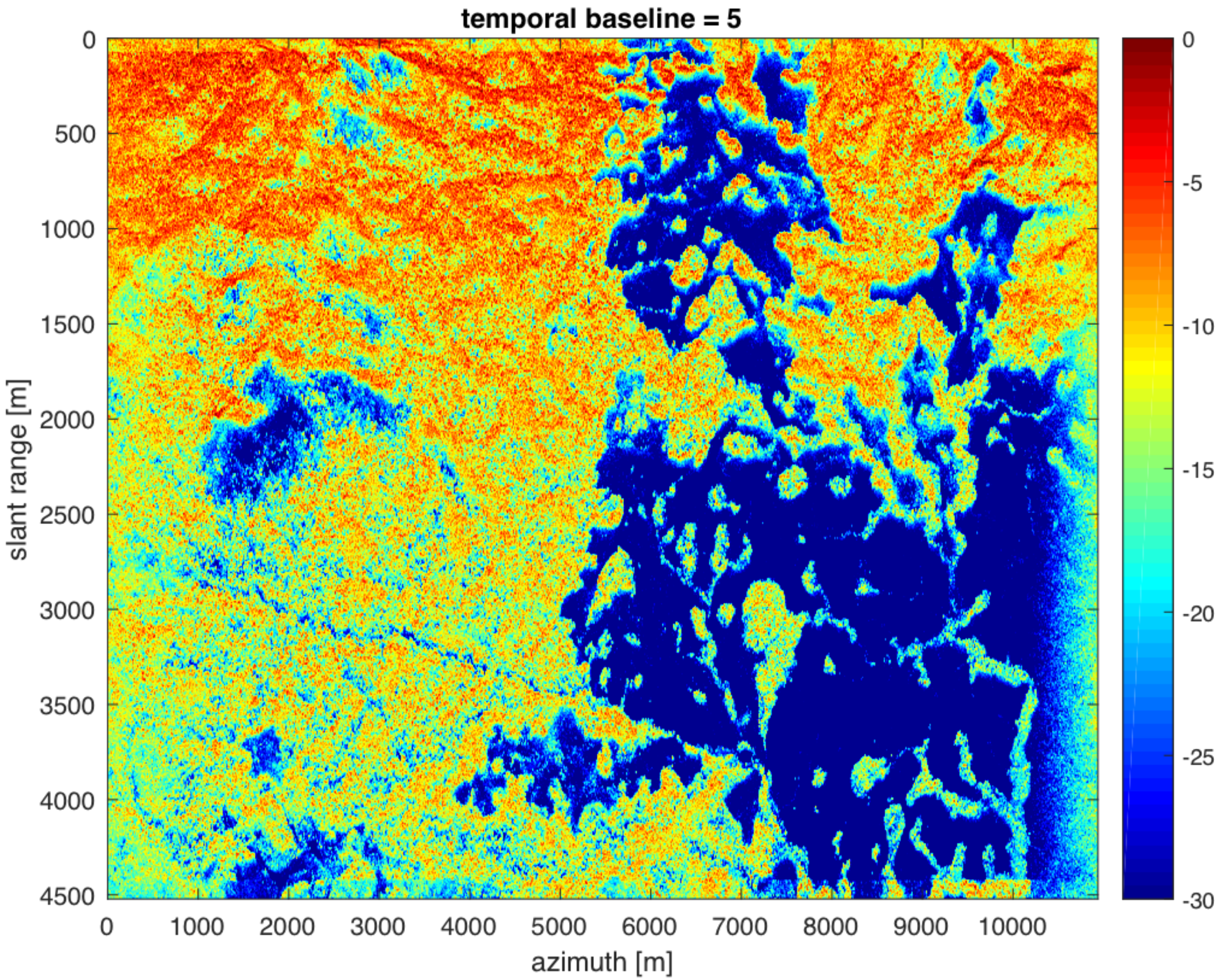
Notch power 0



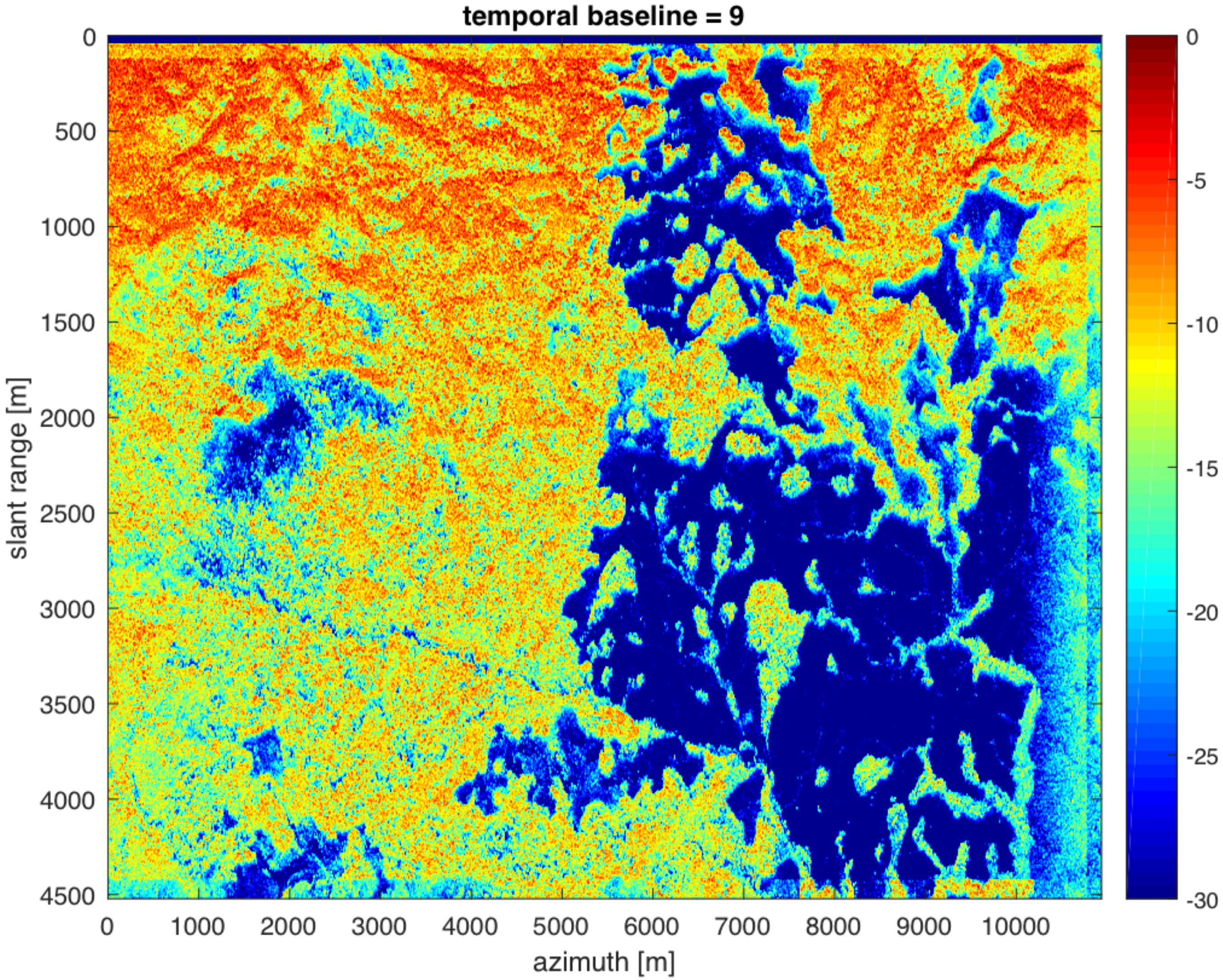
Notch power 4



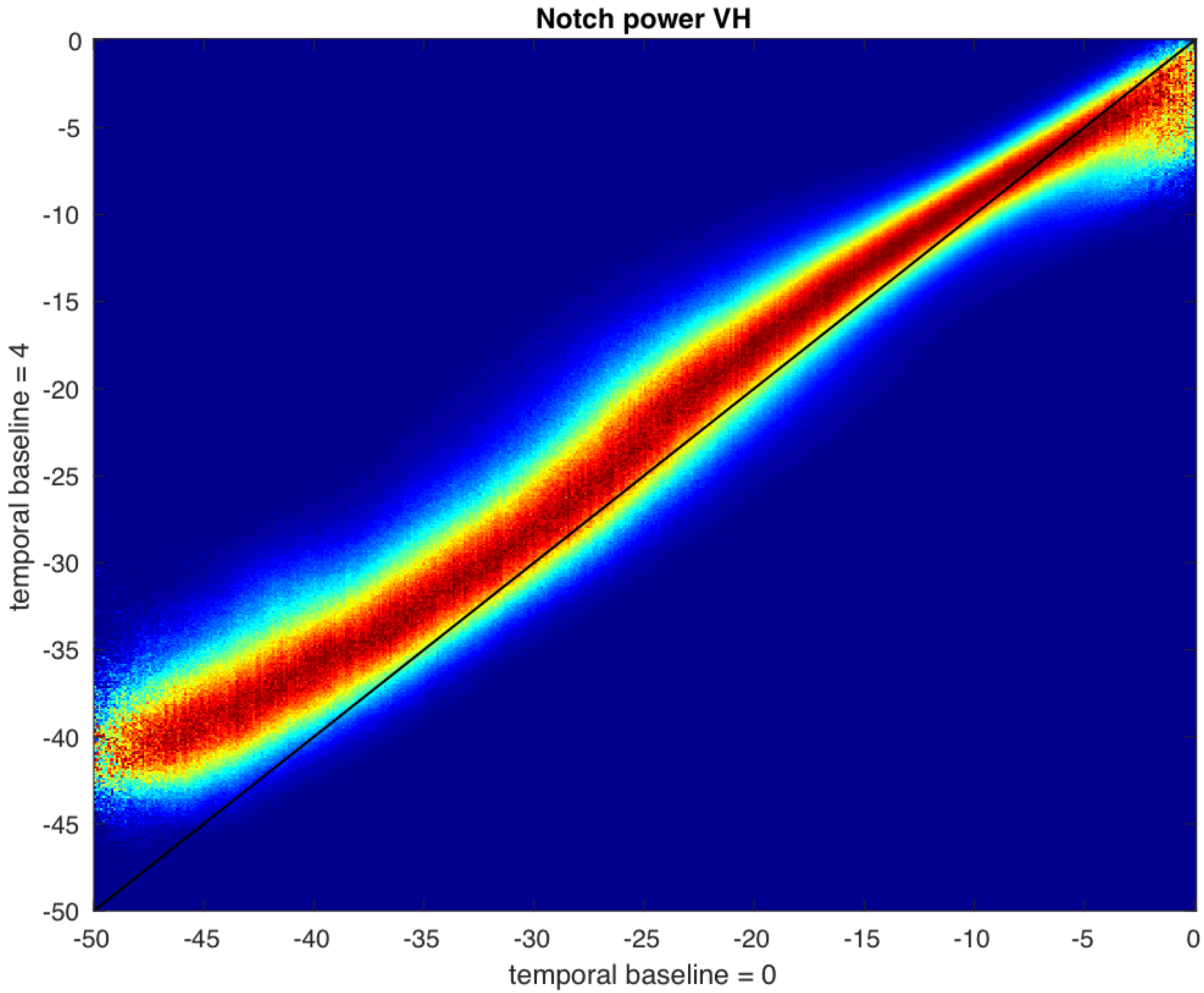
Notch power 5



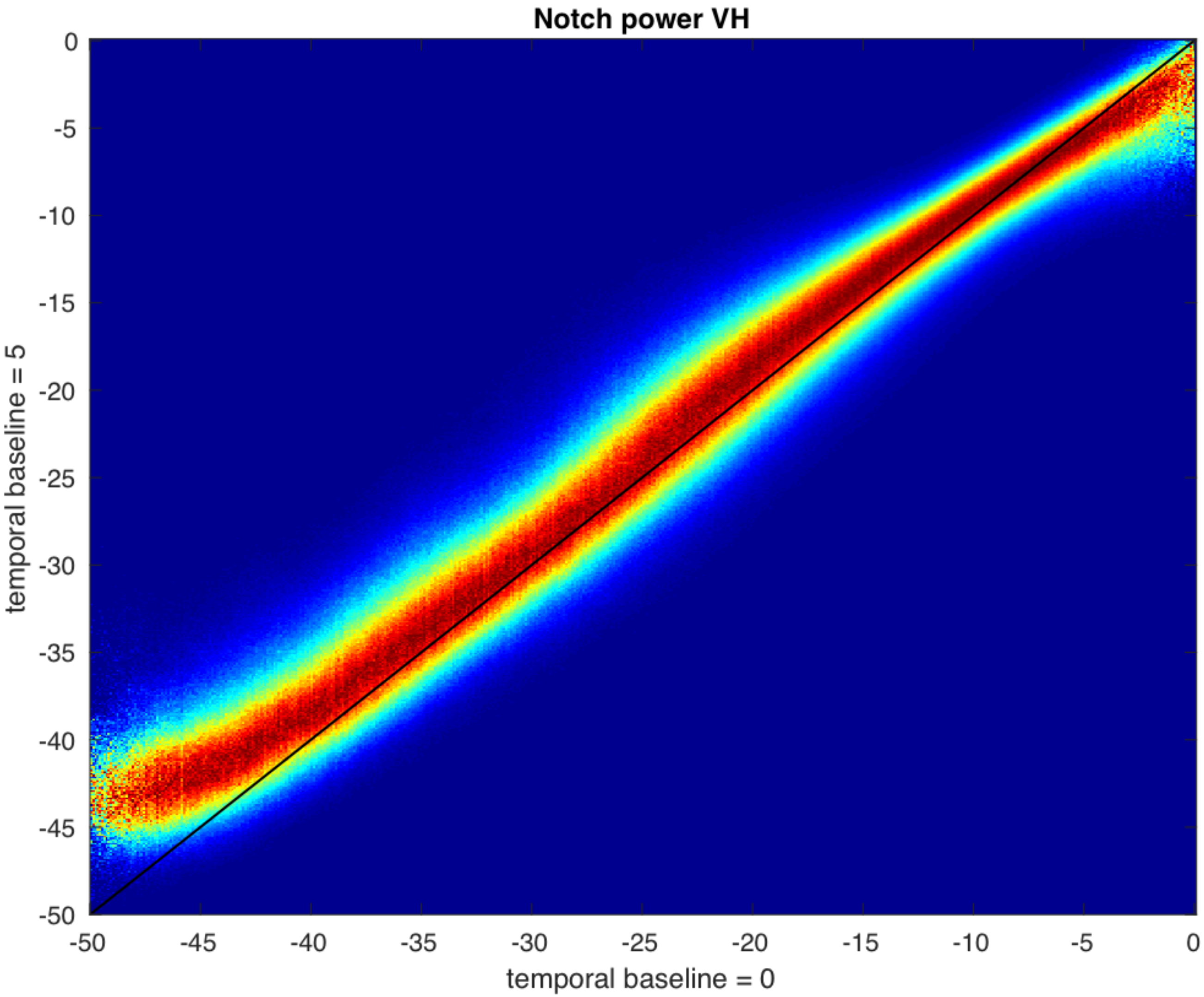
Notch power 9



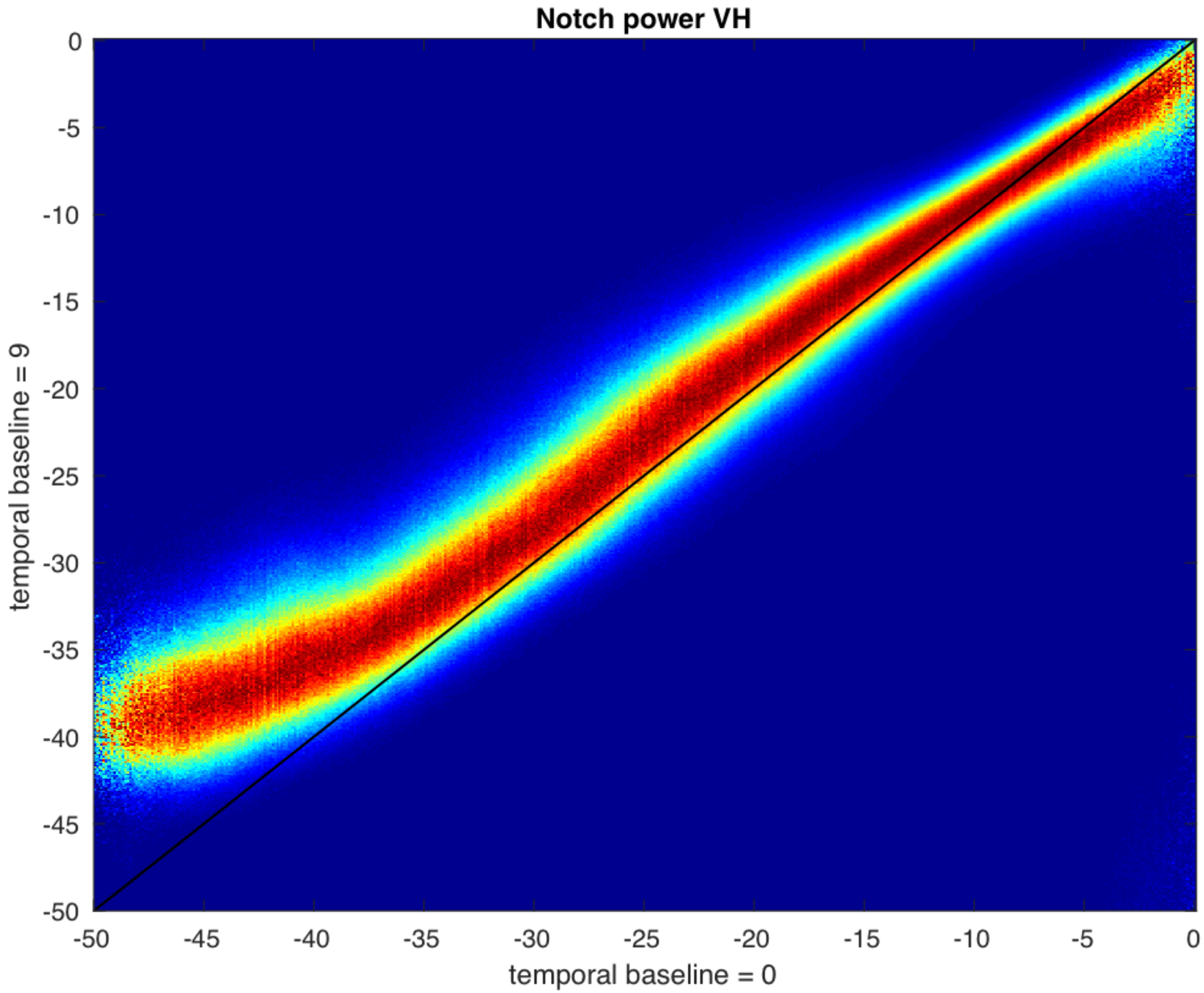
Cross plot 0 vs 4



Cross plot 0 vs 5

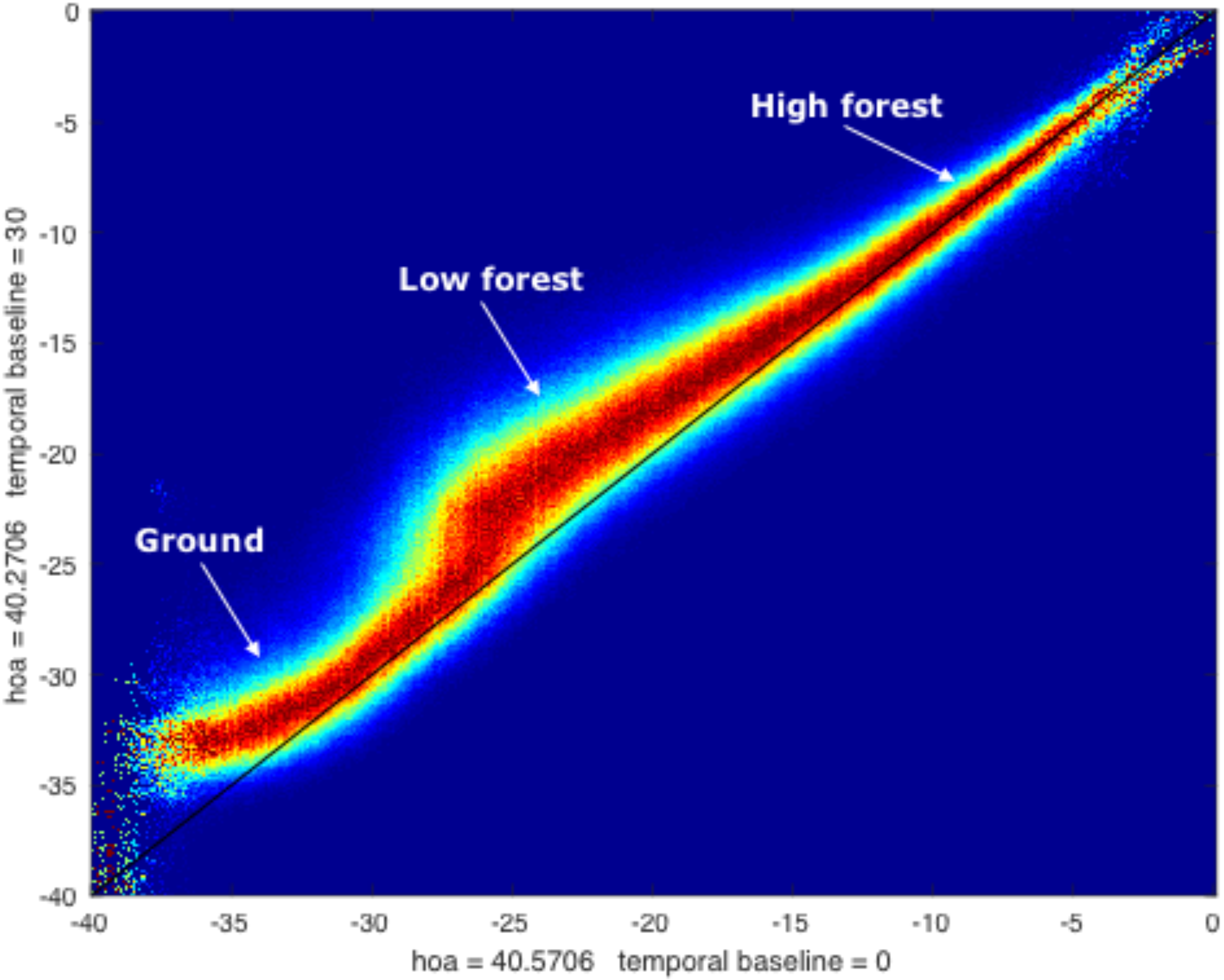


Cross plot 0 vs 9



Temporal decorrelation analysis

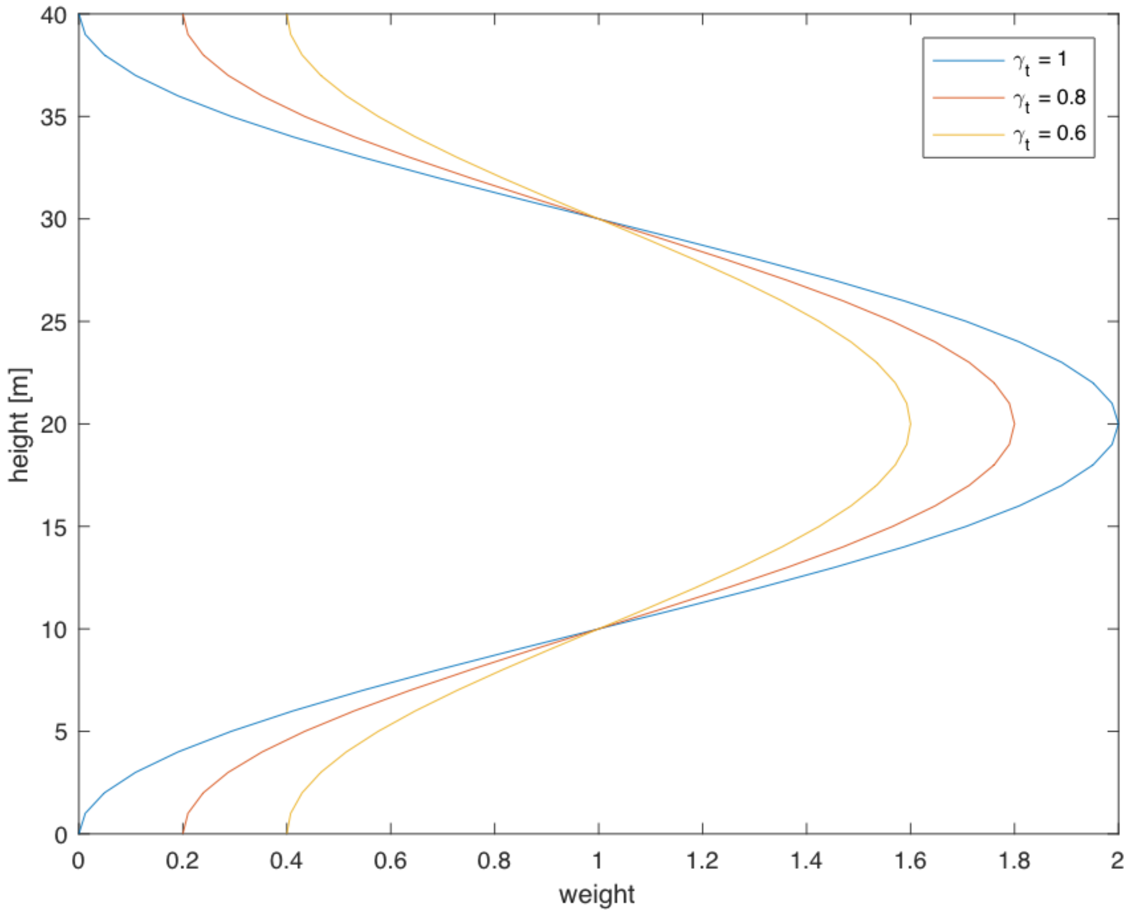
Why the intensity is more stable for tall-forested areas, whereas it's not for low vegetation?



Temporal decorrelation analysis

$$E[|y_{notch}|^2] = 2\int \sigma_s^2(z) \cdot \left(1 - \gamma_t(z) \cdot cos(k_z \cdot z)\right) \cdot dz$$

With temporal decorrelation, the weight under quarter of the height ambiguity becomes larger. Echo from the ground can't be killed completely.



Temporal decorrelation analysis

Master and slave images: $y_M = \int s_1(z)dz$, $y_S = \int s_2(z) \cdot e^{j \cdot k_z \cdot z} dz$

Ground notching: $gn = y_M - y_S$

Double ground: $dg = y_M + y_S$

Expected gn power: $E[|gn|^2] = 2\int \sigma_s^2(z) \cdot \big(1 - \gamma_t(z) \cdot cos(k_z \cdot z)\big) \cdot dz$

Expected dg power: $E[|dg|^2] = 2\int \sigma_s^2(z) \cdot \big(1 + \gamma_t(z) \cdot cos(k_z \cdot z)\big) \cdot dz$

$$\frac{E[|dg|^2] + E[|gn|^2]}{2} = 2\int \sigma_s^2(z) \cdot dz$$

$$\frac{E[|dg|^2] - E[|gn|^2]}{2} = 2\int \gamma_t(z) \cdot \sigma_s^2(z) \cdot cos(k_z \cdot z) \cdot dz$$

Assumption: $\gamma_t(z)$ is uniform along height

$$\frac{E[|dg|^2] - E[|gn|^2]}{2} = 2|\gamma| \cdot \int \sigma_s^2(z) \cdot cos(k_z \cdot z) \cdot dz$$

where $\gamma = \frac{E[y_M \cdot y_S^*]}{\sqrt{E[y_M \cdot y_M^*] \cdot E[y_S \cdot y_S^*]}}$

Temporal decorrelation analysis

From 2 pair images we can get

$$\frac{E[|dg_1|^2]+E[|gn_1|^2]}{2}=2\int\sigma_s^2(z)\cdot dz$$

$$\frac{E[|dg_1|^2]-E[|gn_1|^2]}{2}=2|\gamma_1|\cdot\int\sigma_s^2(z)\cdot cos(k_z\cdot z)\cdot dz$$

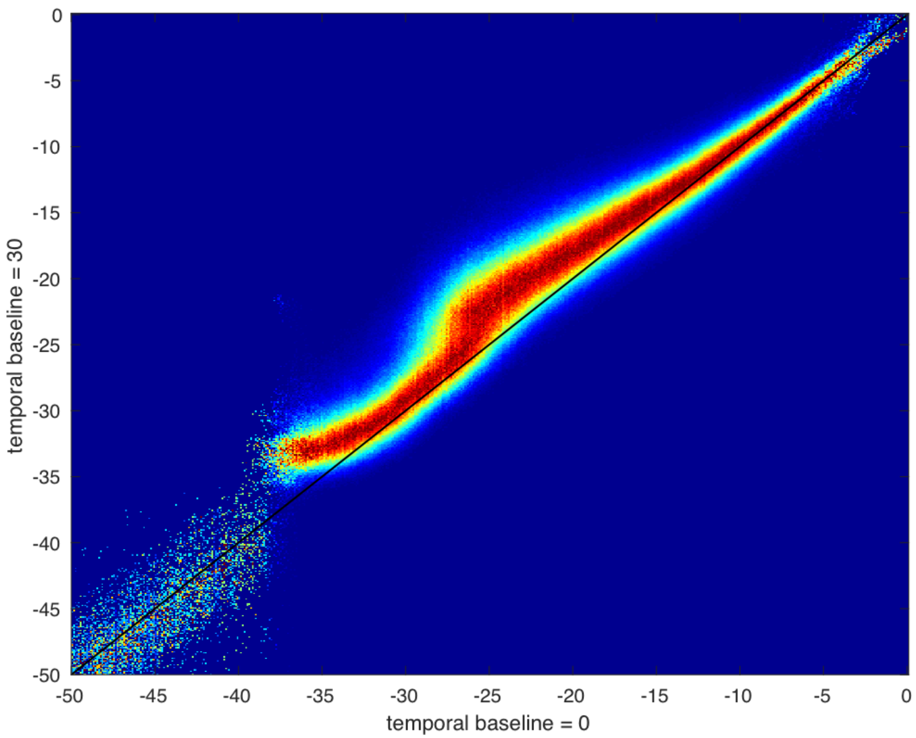
$$\frac{E[|dg_2|^2]+E[|gn_2|^2]}{2}=2\int\sigma_s^2(z)\cdot dz$$

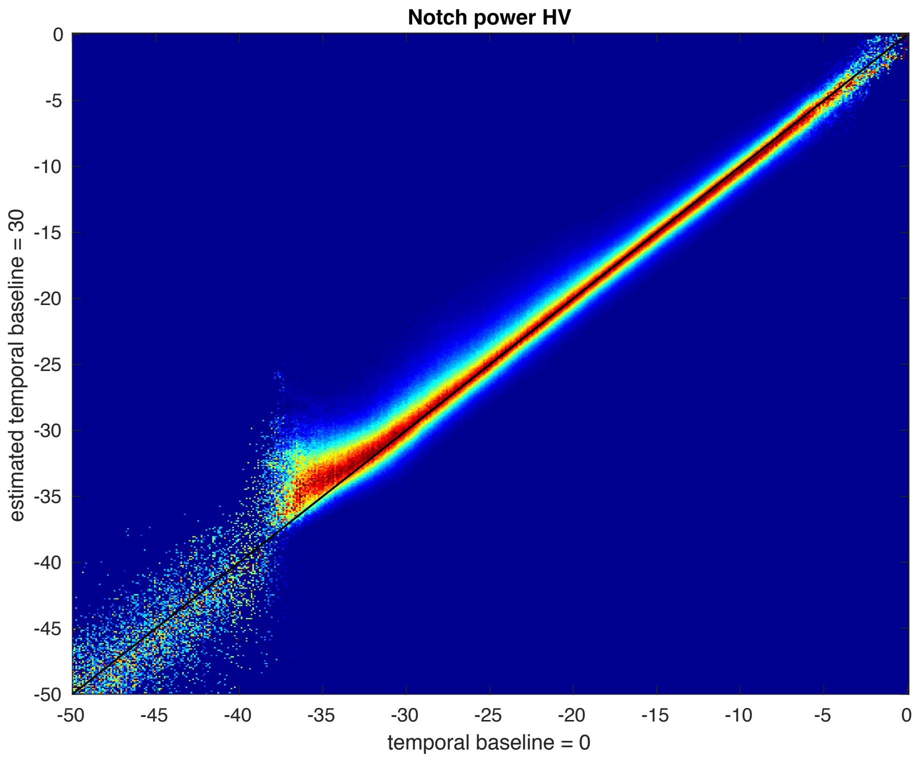
$$\frac{E[|dg_2|^2]-E[|gn_2|^2]}{2}=2|\gamma_2|\cdot\int\sigma_s^2(z)\cdot cos(k_z\cdot z)\cdot dz$$

The estimation of $E[|gn_2|^2]$ is

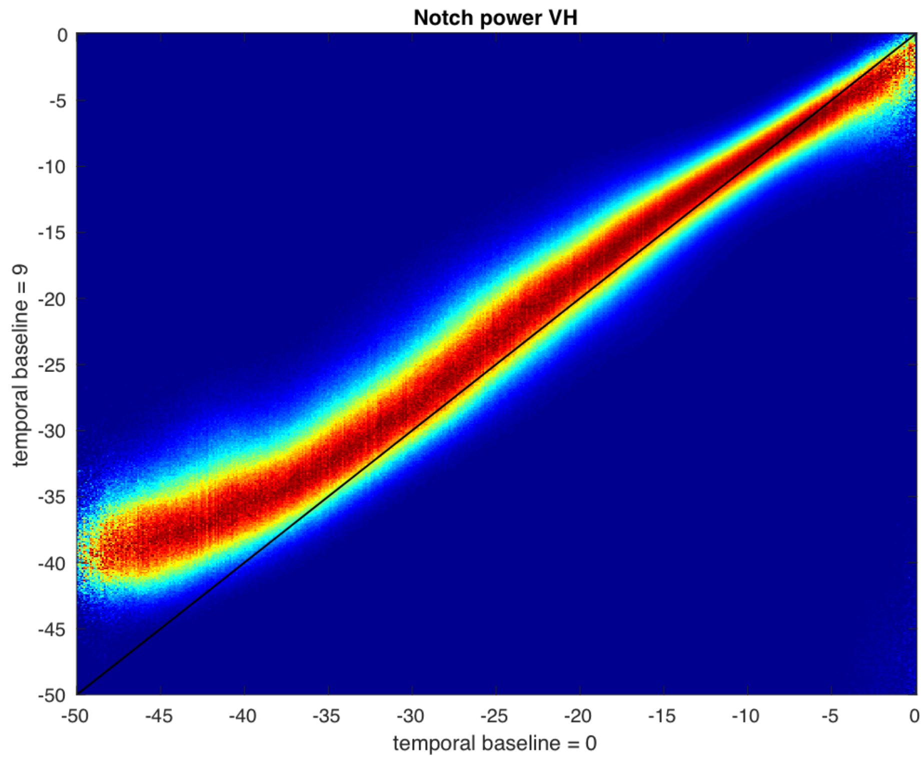
$$E[\widehat{|gn_2|^2}]=\frac{E[|dg_2|^2]+E[|gn_2|^2]}{2}-\frac{E[|dg_2|^2]-E[|gn_2|^2]}{2}\cdot\frac{|\gamma_1|}{|\gamma_2|}$$

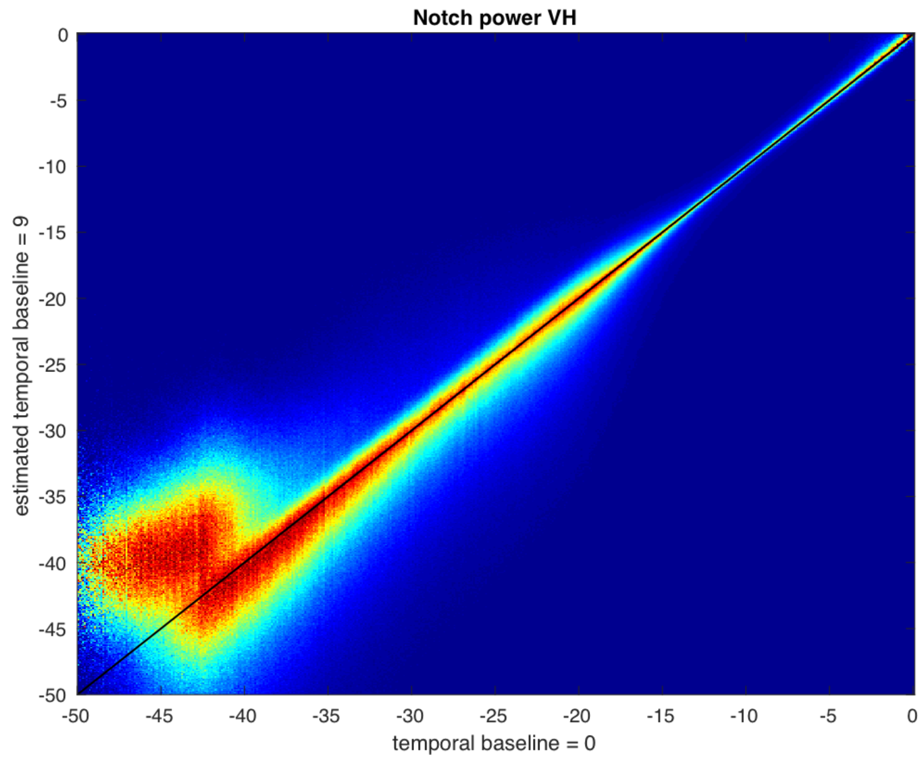
Model validation on BioSAR1





Model validation on AriSAR





Preliminary conslusions

- Ground-notched intensity is more stable for tall-forested areas
- Low vegetation is more effected by temporal decorrelation
- A model is proposed to evaluate the impact of temporal decorrelation on interferometric ground notching