Towards a 6m TanDEM-X DEM:
Non-local Methods for InSAR Filtering

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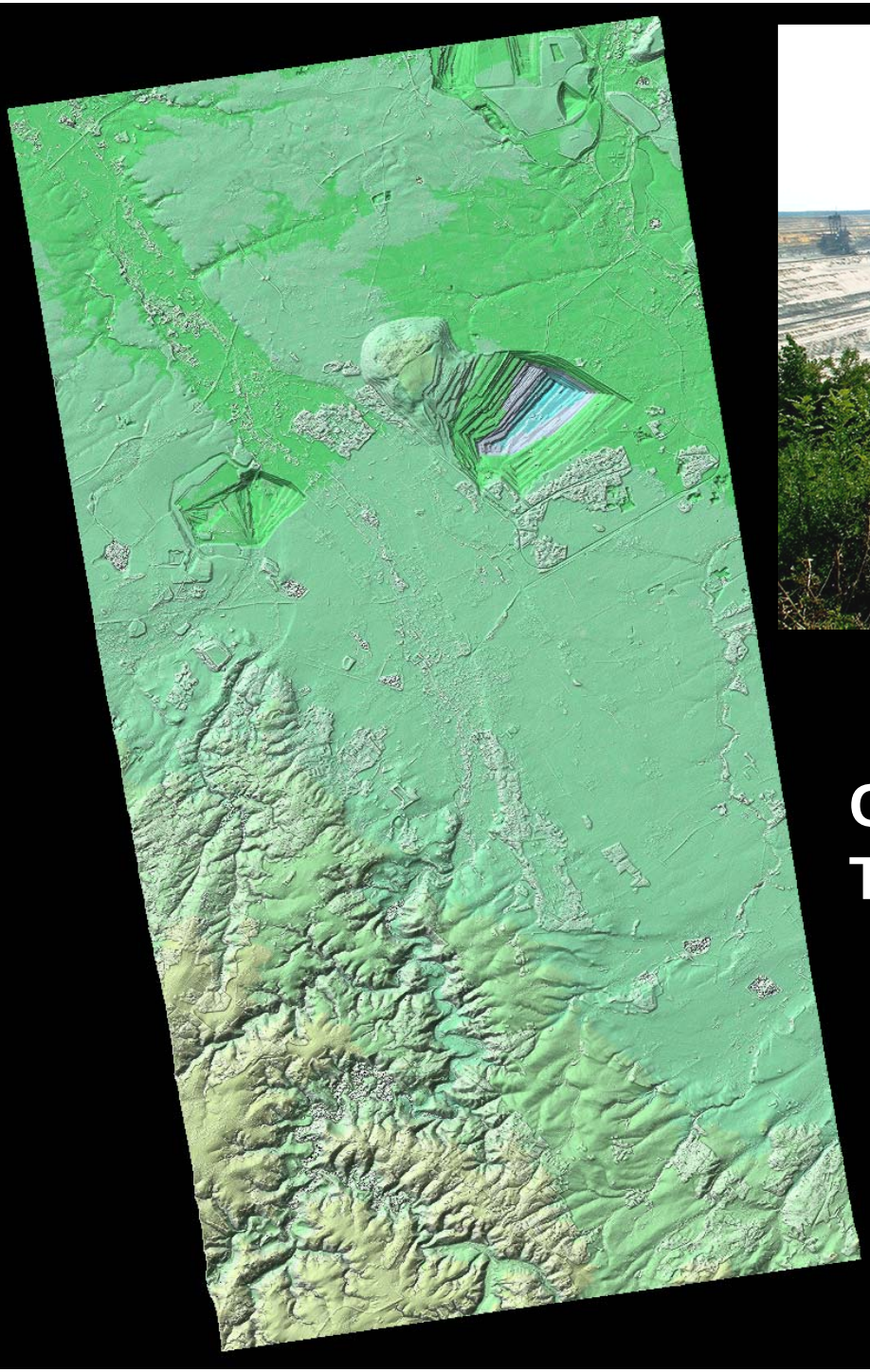
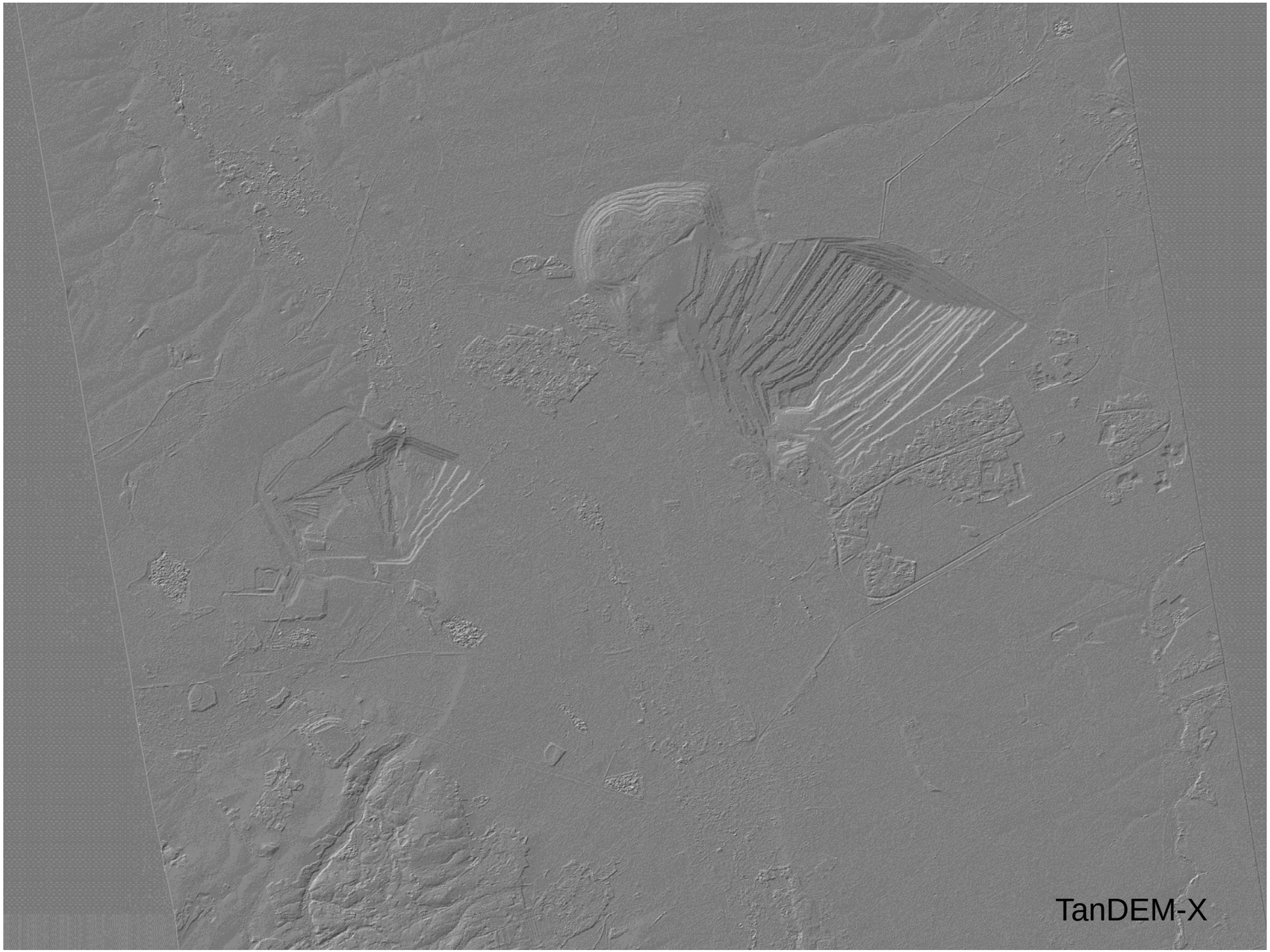
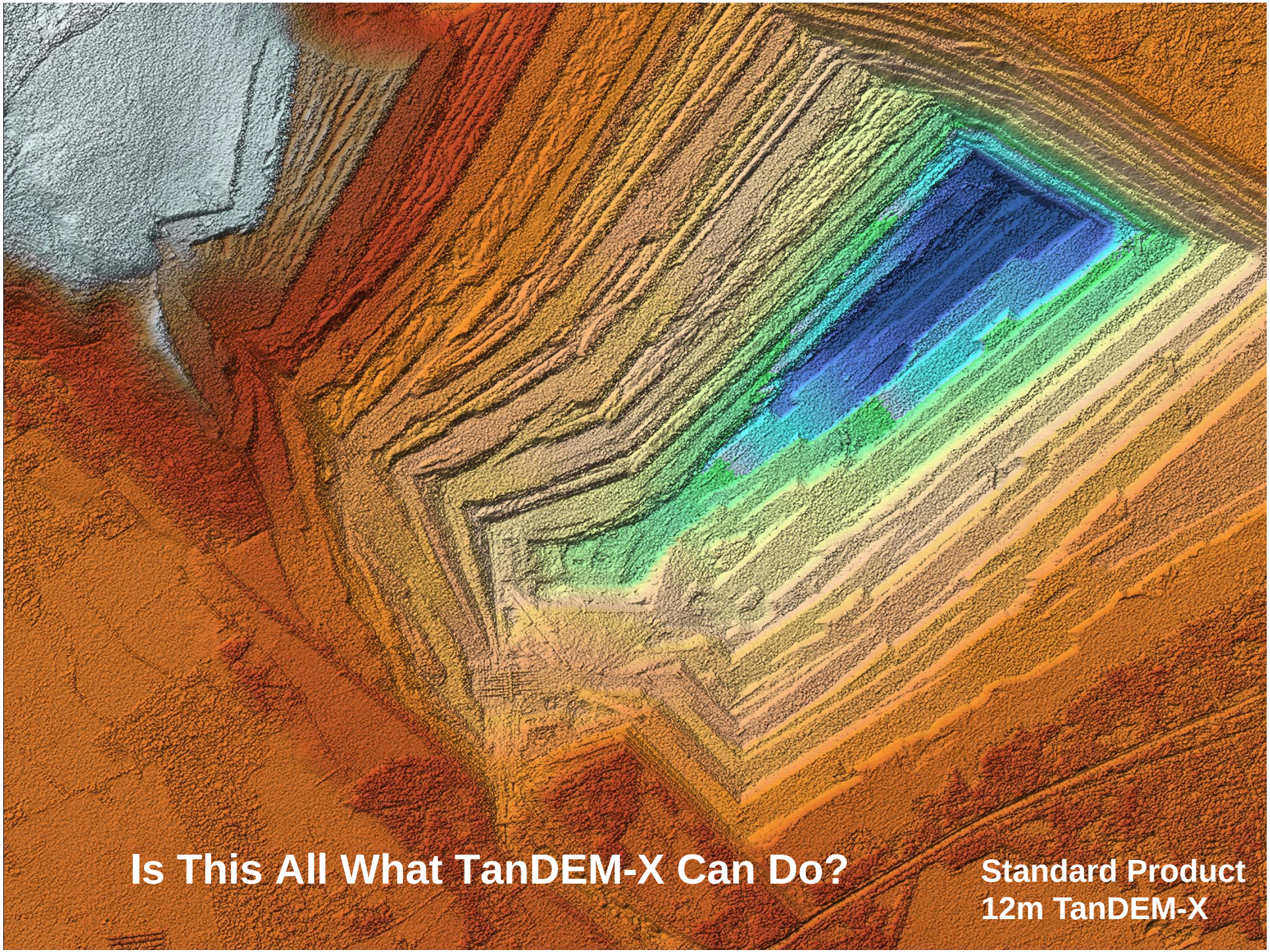
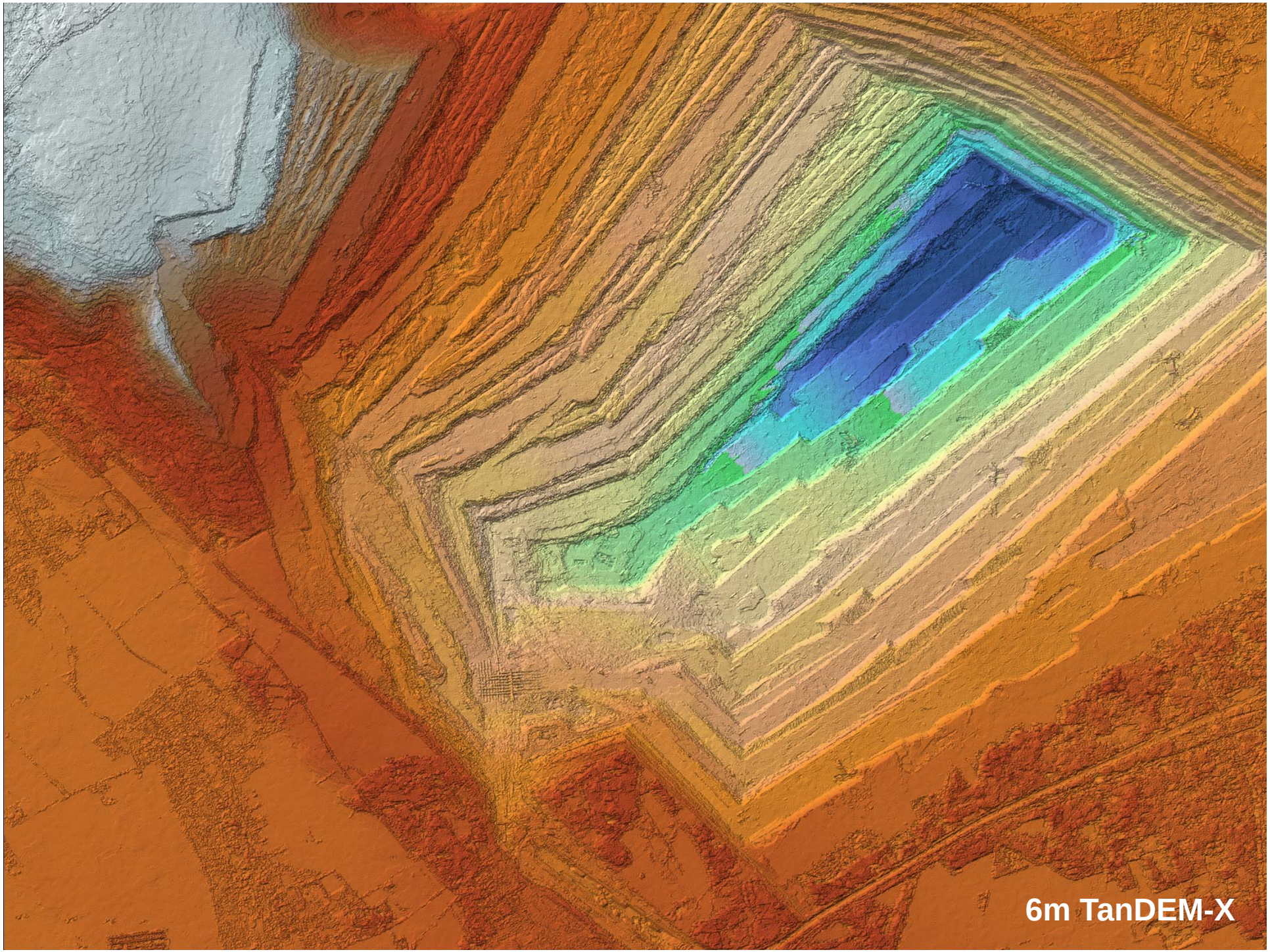


Coal Mine of Hambach
TanDEM-X, 12/2010


TanDEM-X


Is This All What TanDEM-X Can Do?
Standard Product
12m TanDEM-X


6m TanDEM-X

InSAR Filters

- boxcar filter
- Lee filter [Lee et al., 1999]
- Goldstein filter [Goldstein et al., 1997]
- nonlocal means filter [Deledalle et al., 2011]

InSAR Filters

- boxcar filter
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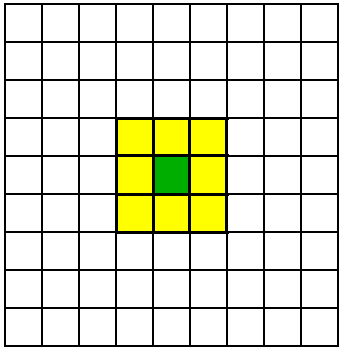
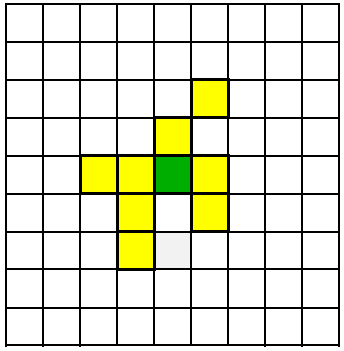
Non-local Concept

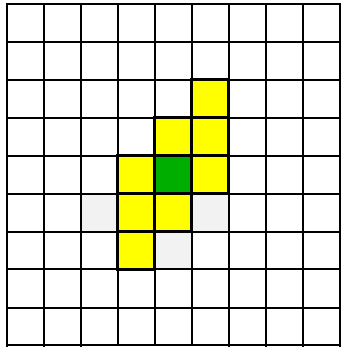
- Local filters



boxcar window,
e.g. boxcar and Goldstein

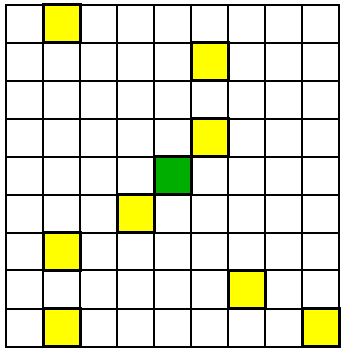


adaptive window



directional window,
e.g. Lee filter

- Non-local concept [Buades, 2005]

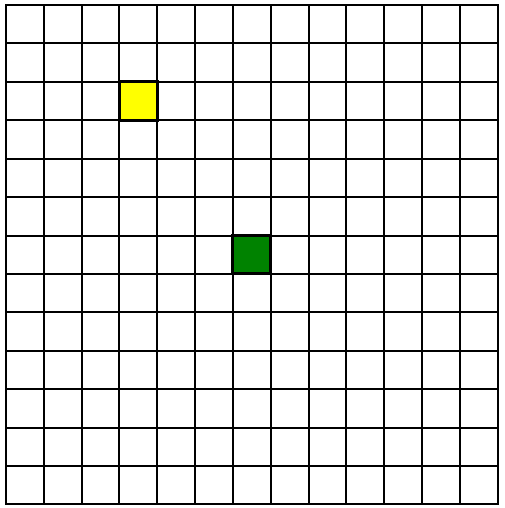


non-local concept

Likelihood as the Similarity Measure

Likelihood of InSAR measurements:

$$p\left(\Theta\middle|\Sigma\right)=\frac{2\left|u_1\right|\left|u_2\right|}{\pi I^2\left(1-\gamma^2\right)}\times\exp\left(\frac{\left|u_1\right|^2+\left|u_2\right|^2-\gamma 2\left|u_1\right|\left|u_2\right|\cos\left(\varphi-\varphi_0\right)}{I\left(1-\gamma^2\right)}\right)$$



target pixel i

pixel j

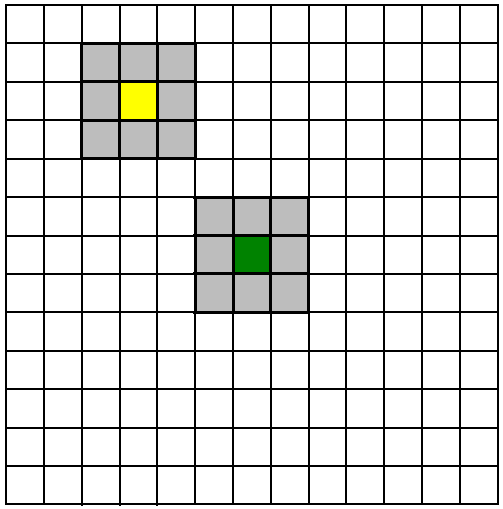
Likelihood of pixel i and j sharing identical InSAR parameters :

$$p\left(\Theta_i,\Theta_j\middle|\Sigma_i=\Sigma_j\right)=\int p\left(\Theta_i\middle|\Sigma_i=\Sigma\right)p\left(\Theta_j\middle|\Sigma_j=\Sigma\right)d\Sigma$$

Patch Based Similarity Measure

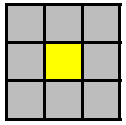
Similarity of pixel i and j :

$$w(i,j) = \prod_k p\left(\Theta_{i,k}, \Theta_{j,k} \middle| \Sigma_{i,k} = \Sigma_{j,k}\right)$$

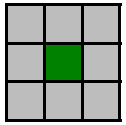


Weighted MLE estimator:

$$\hat{\Sigma}_i = \arg\max_{\Sigma} \sum_j w(i,j) \log p\left(\Theta_j \middle| \Sigma\right)$$



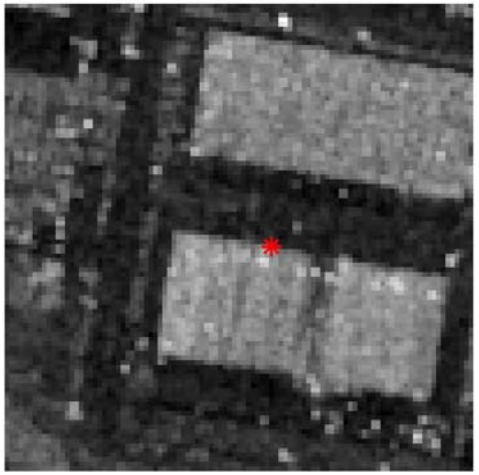
patch surrounding target pixel i



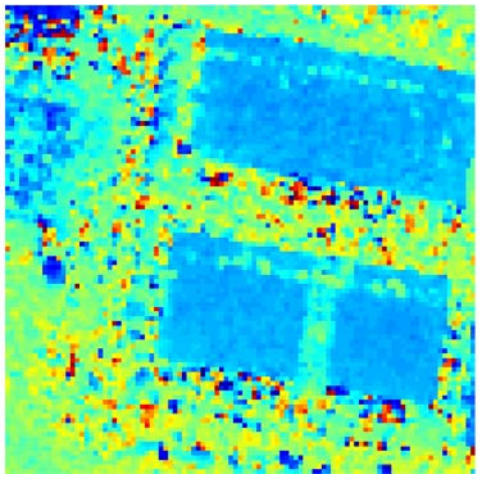
patch surrounding pixel j

$k = 1, \ldots, K$

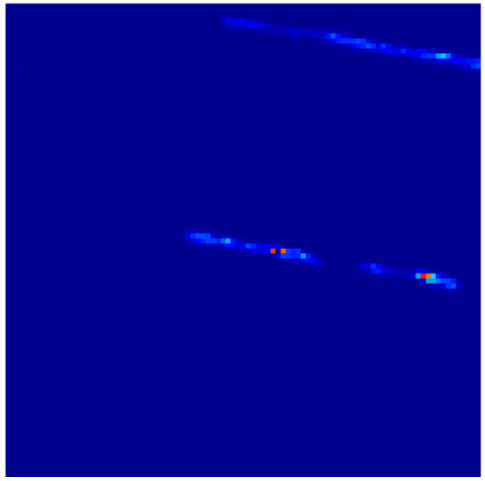
Similarity Measure – Symmetry of Patches



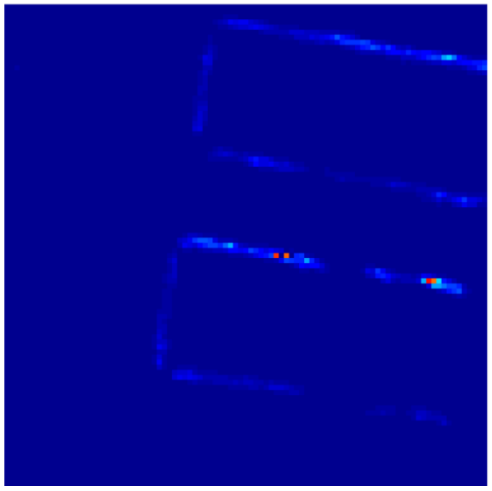
the test pixel



noisy interferogram



similarity measure w/o consider the symmetry properties



similarity measure with consider the symmetry properties

What We Expect From a Perfect Filter

- Better noise reduction, in particular for flat areas
- Better resolution
- Better coherence estimation for phase unwrapping, in particular less bias in low coherence areas

Parameter Settings for InSAR Filters

- box car filter: window size 5×5
  (used for TanDEM stanard product)
- Lee filter: window size 9×9, 24~27 pixels used for average
- Goldstein filter: window size 16×16; Overlap 12
- nonlocal means filter: patch size 5×5; nonlocal window 20×20

What We Expect From a Perfect Filter

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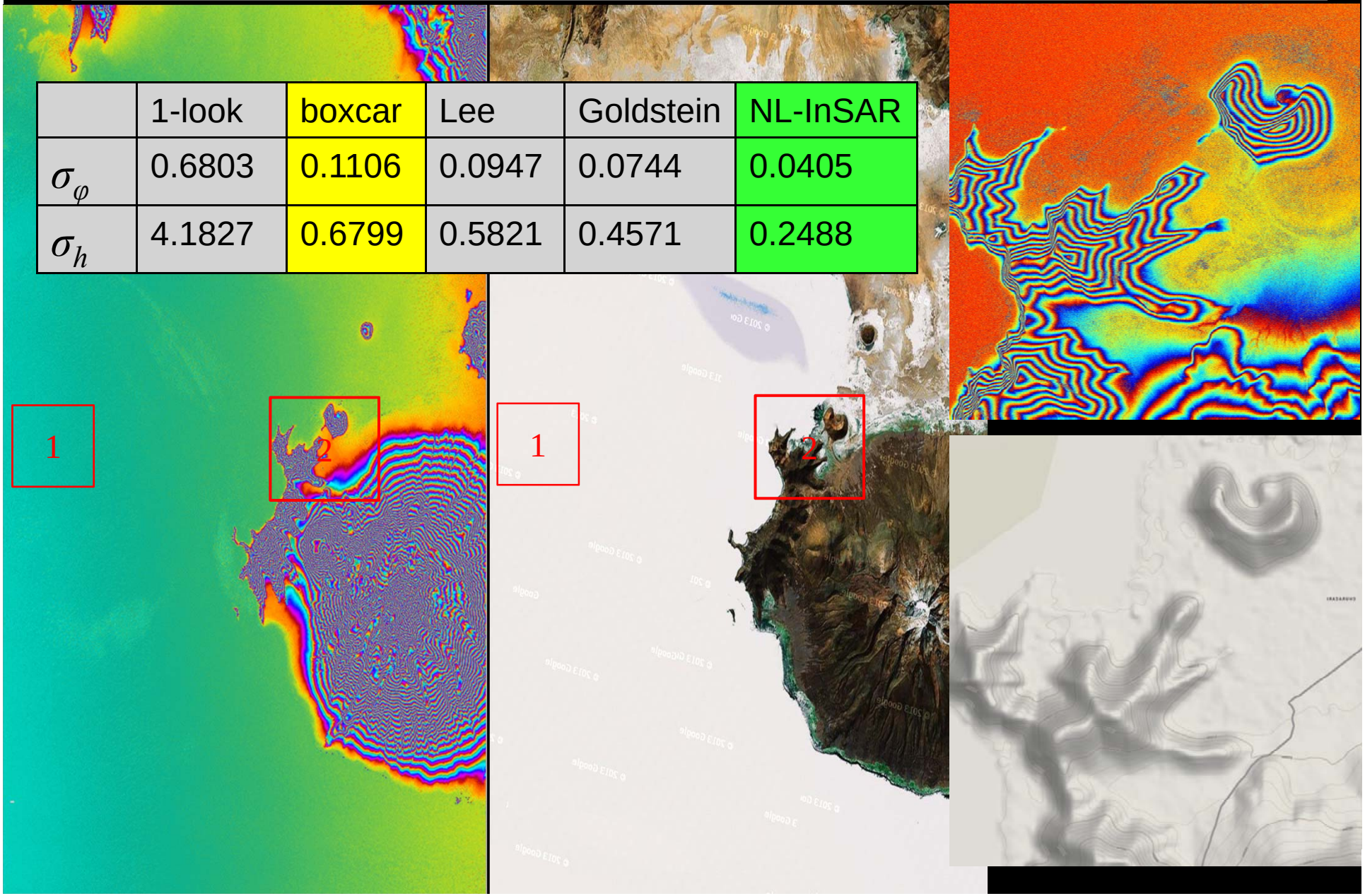
Test Site – Salar de Uyuni

	1-look	boxcar	Lee	Goldstein	NL-InSAR
σ_φ	0.6803	0.1106	0.0947	0.0744	0.0405
σ_h	4.1827	0.6799	0.5821	0.4571	0.2488



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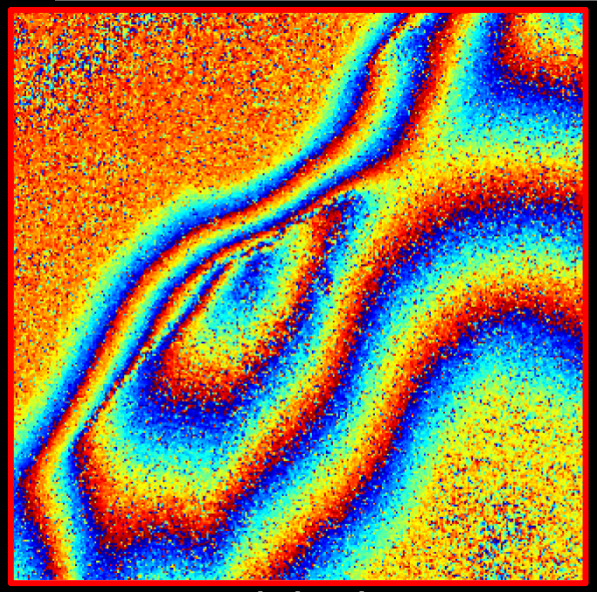
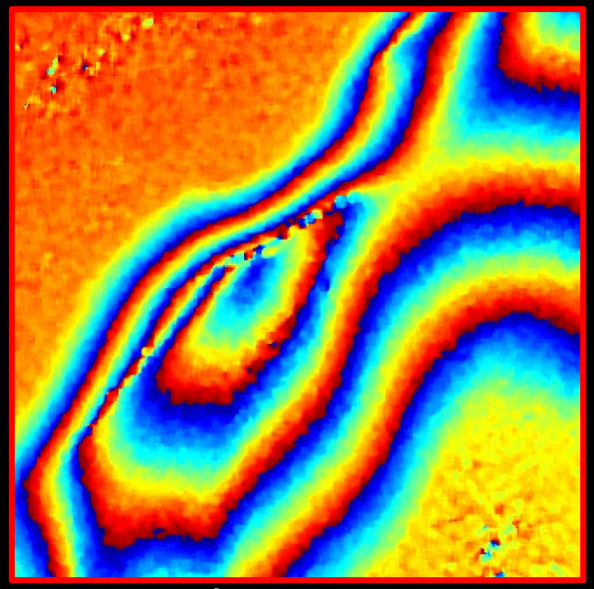
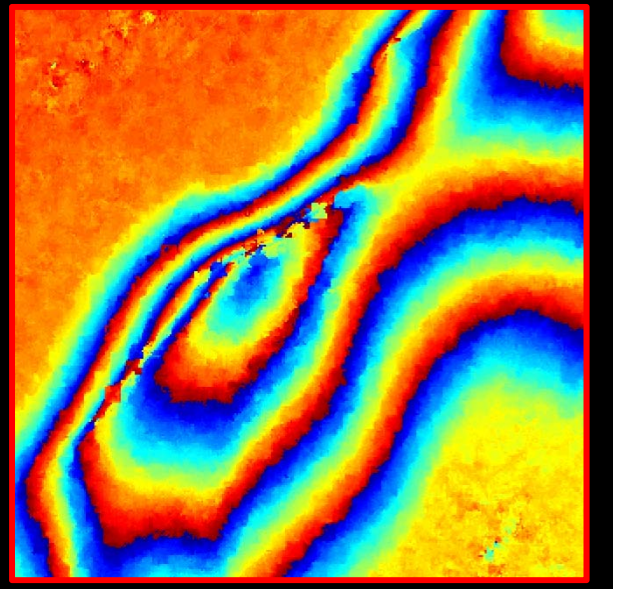
Filtered Interferogram



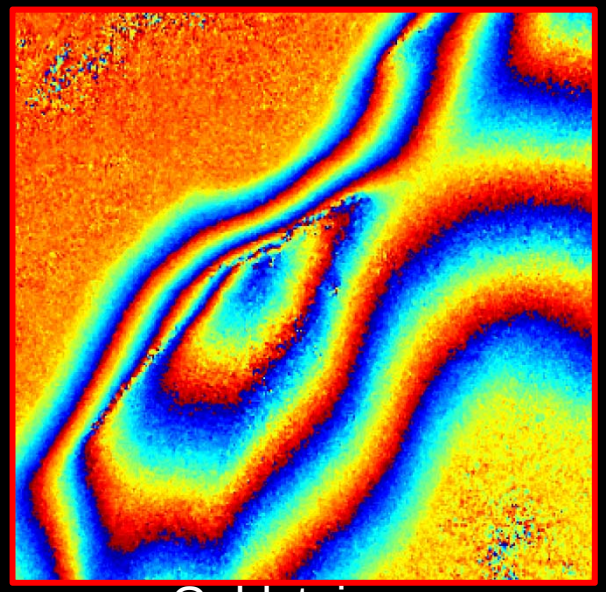
original



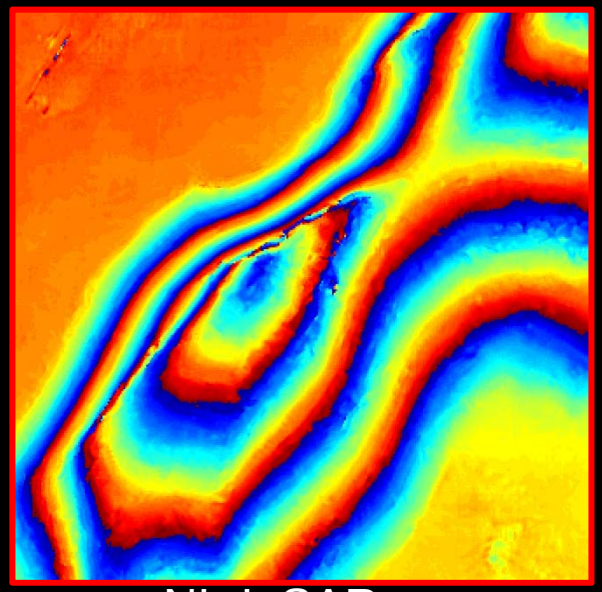
boxcar



Lee



Goldstein



NL-InSAR

What We Expect From a Perfect Filter

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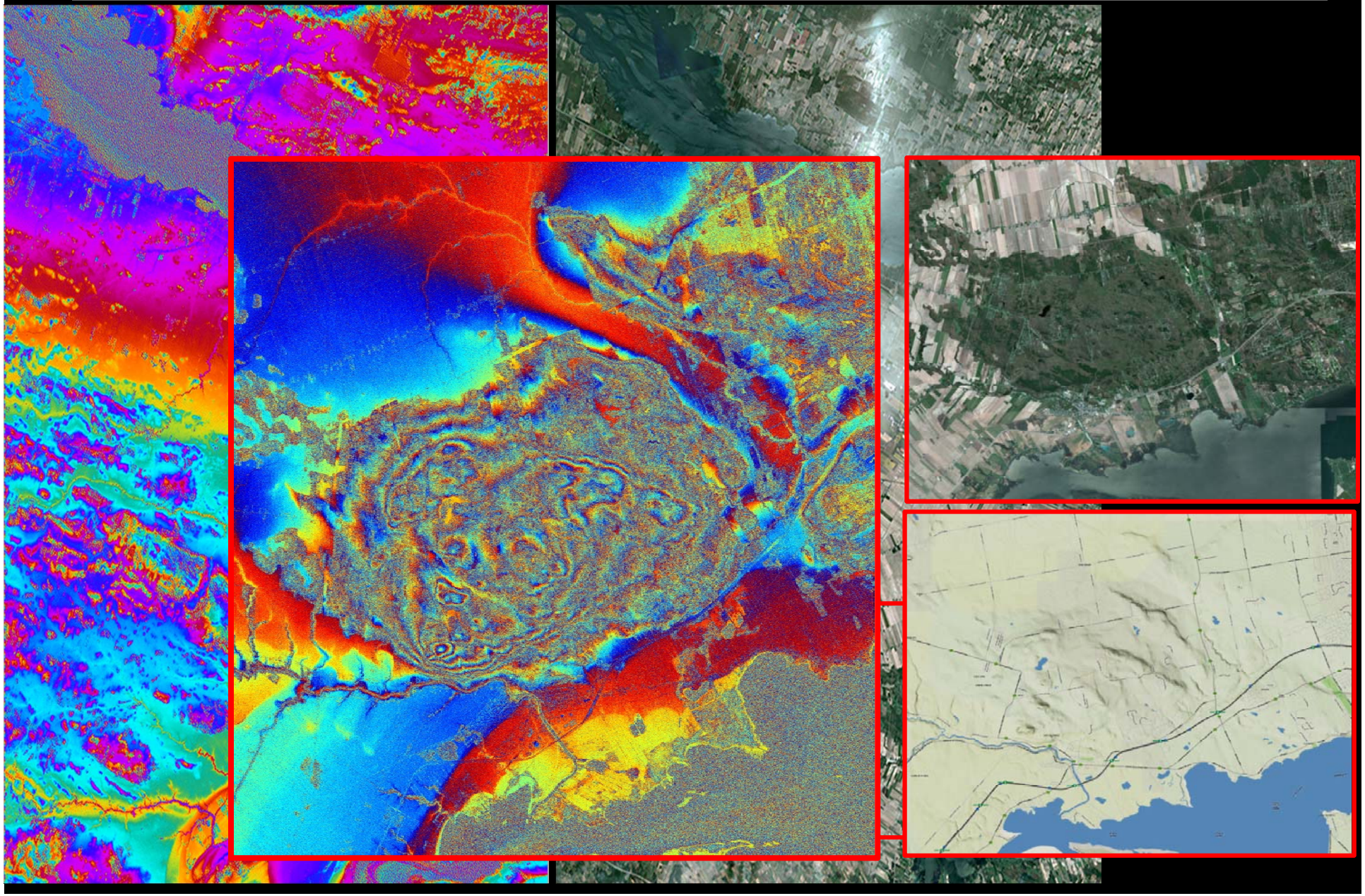
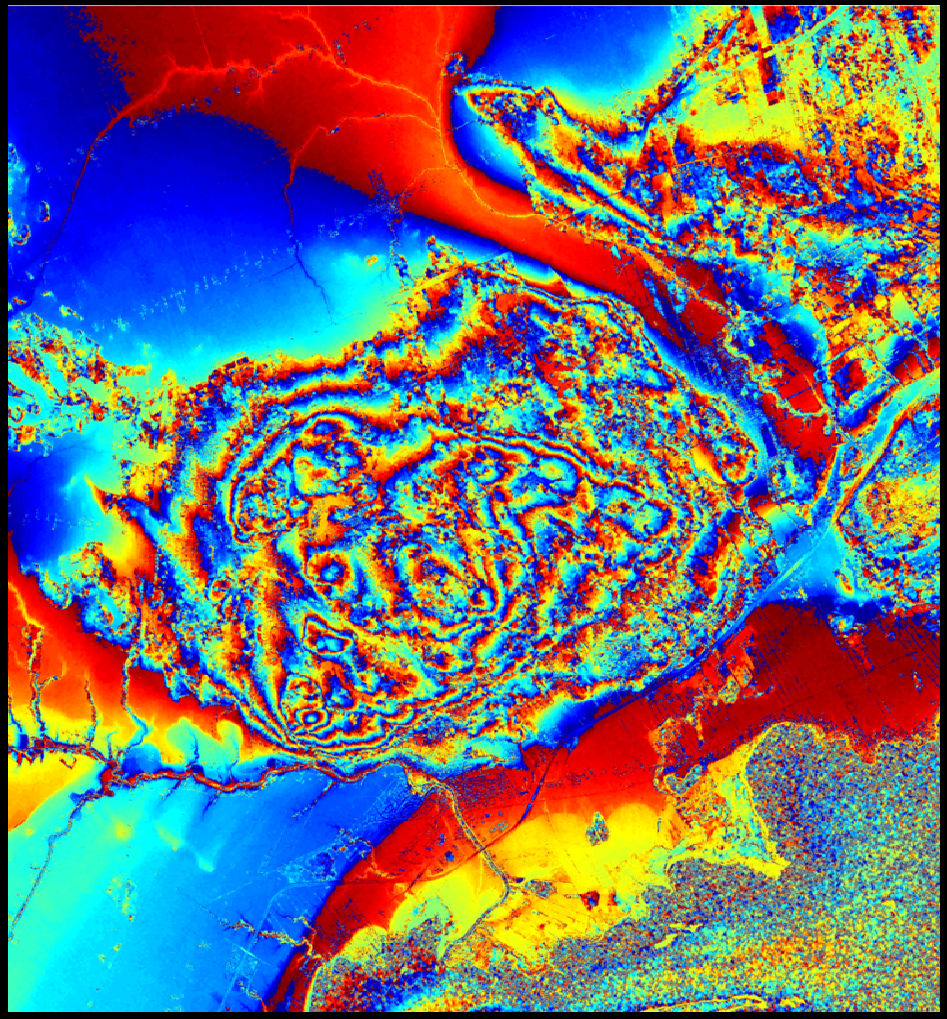
- **Better coherence estimation** for phase unwrapping, in particular less bias in low coherence areas

Test Site – St Lorentz



Filtered Phase and Estimated Coherence

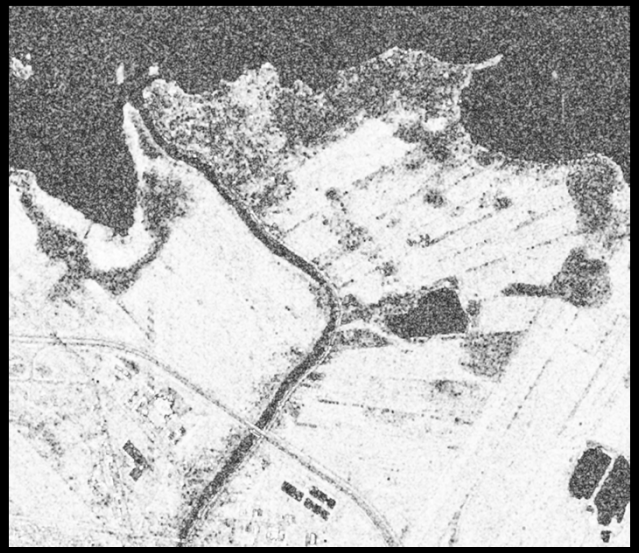


Estimated Coherence

Boxcar

NL-InSAR

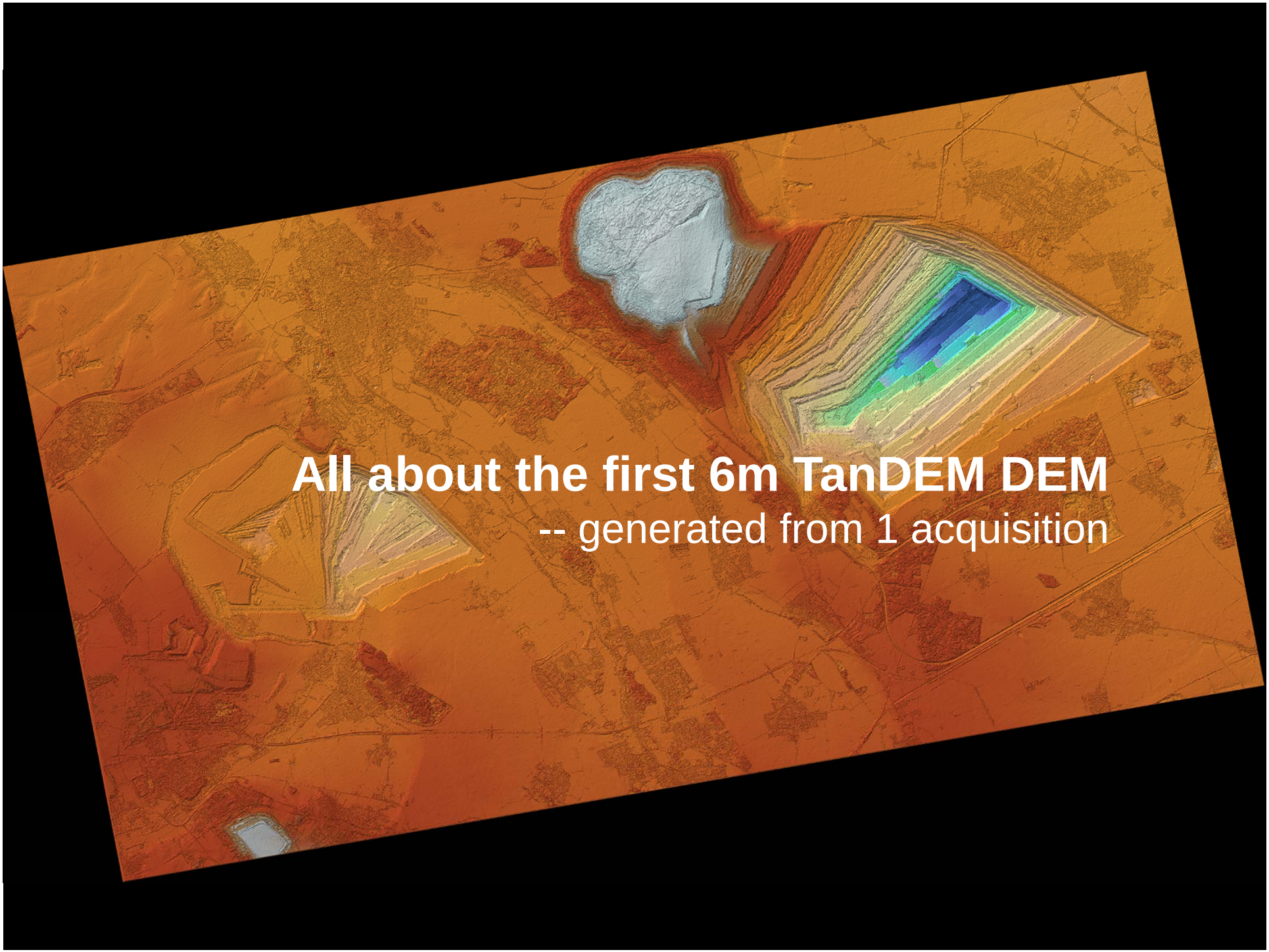
Estimated Coherence

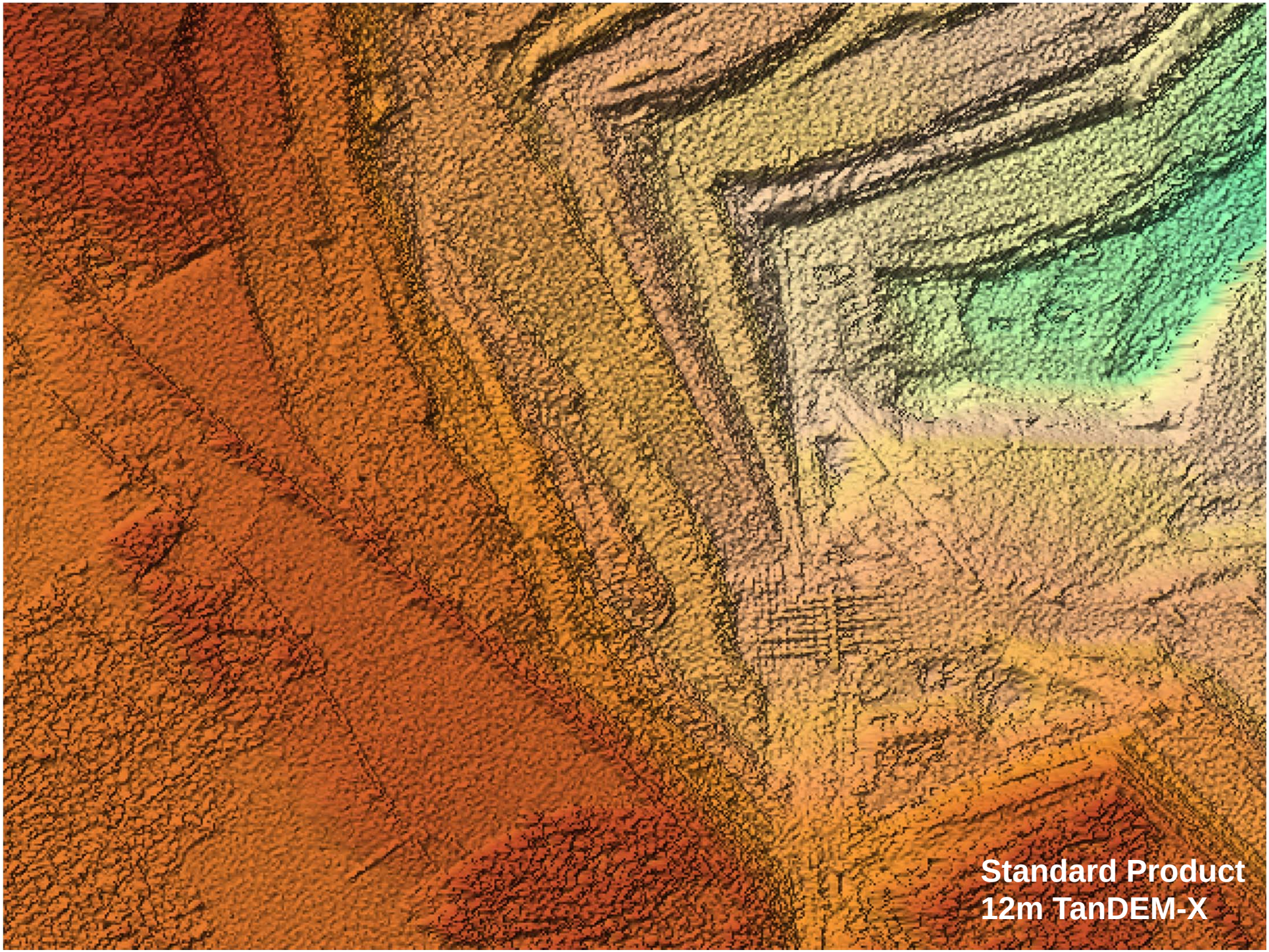


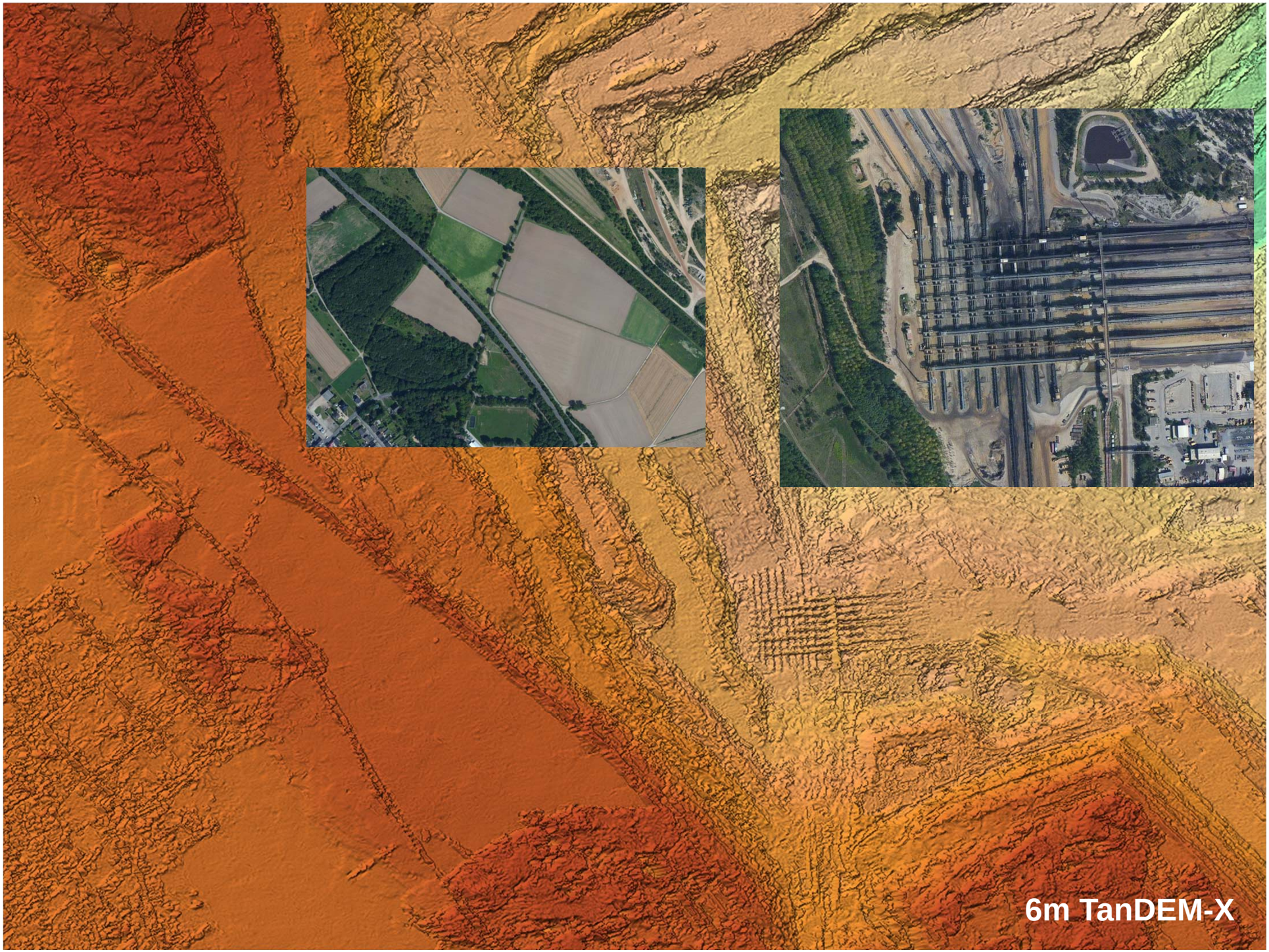
@ Google

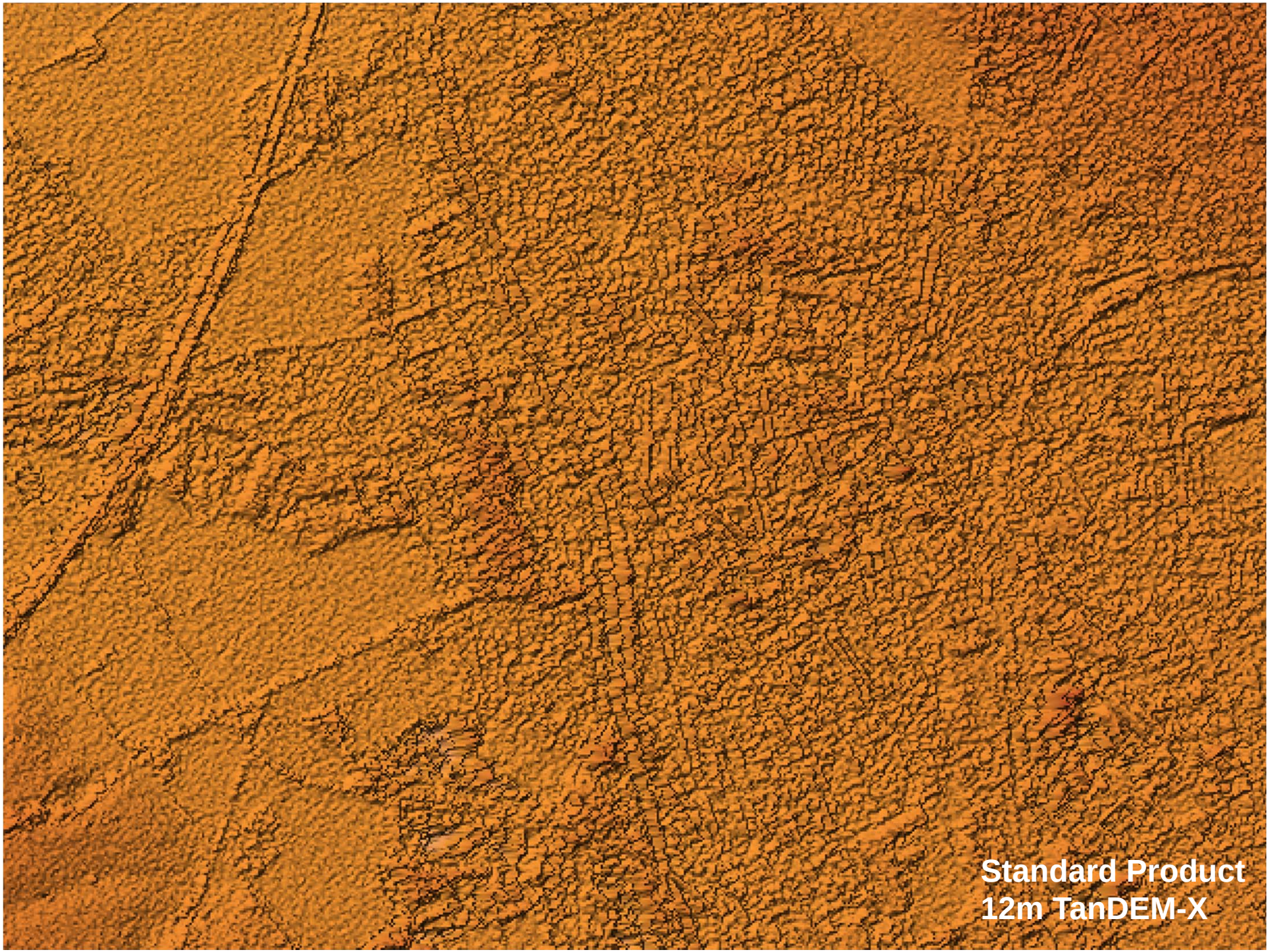
Boxcar

NL-InSAR


All about the first 6m TanDEM DEM
-- generated from 1 acquisition


Standard Product
12m TanDEM-X


6m TanDEM-X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6m TanDEM-X


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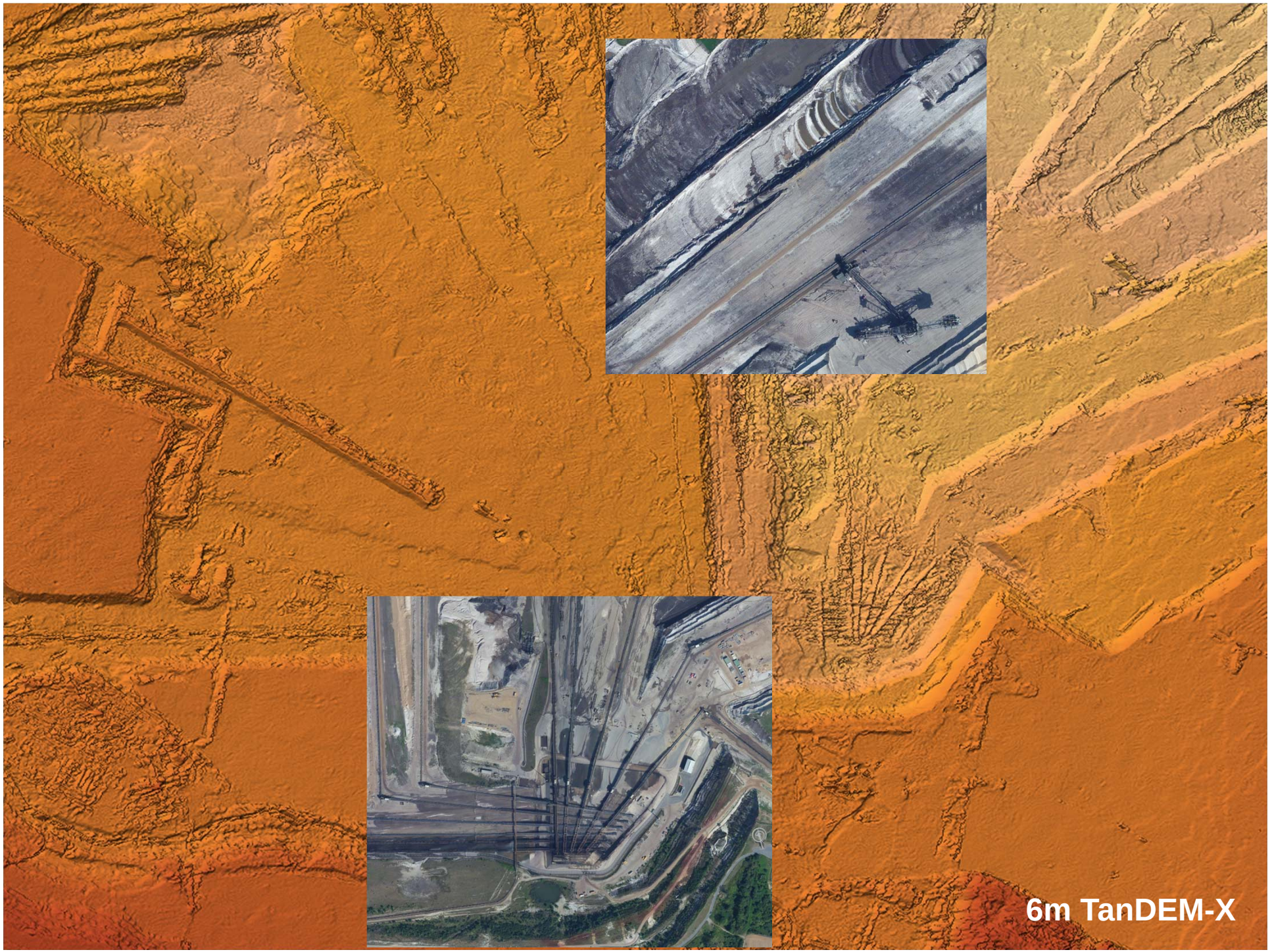
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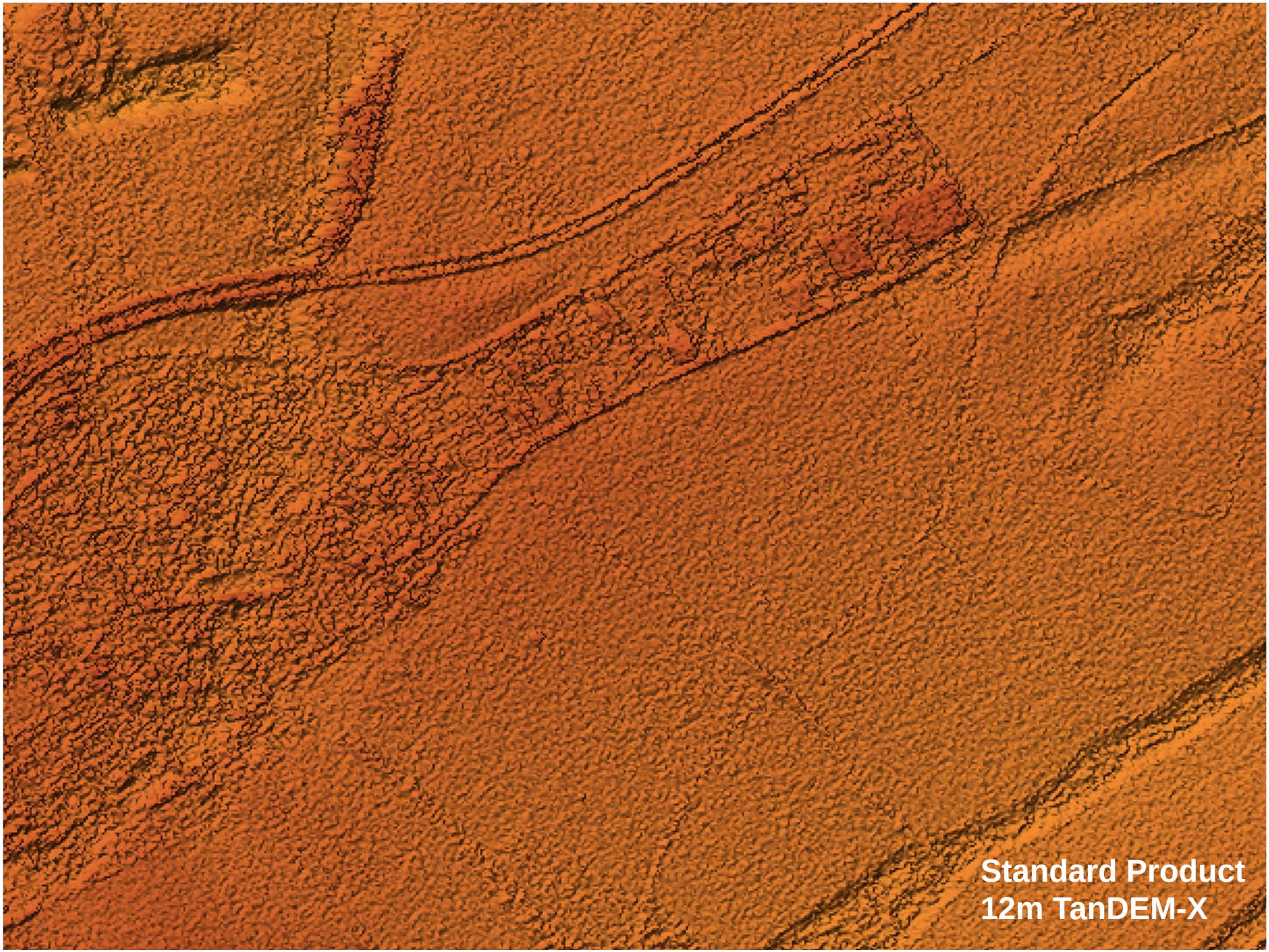
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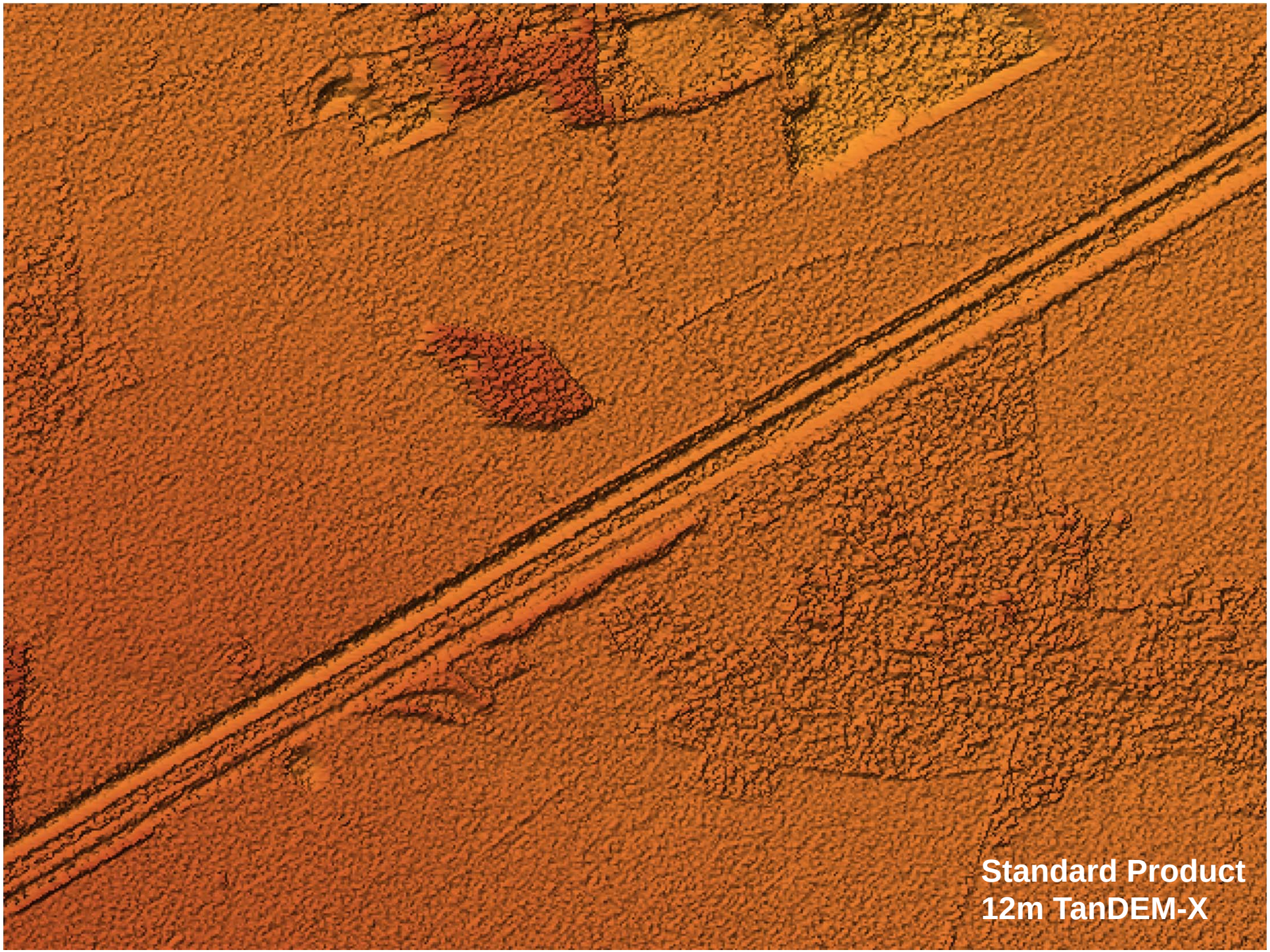
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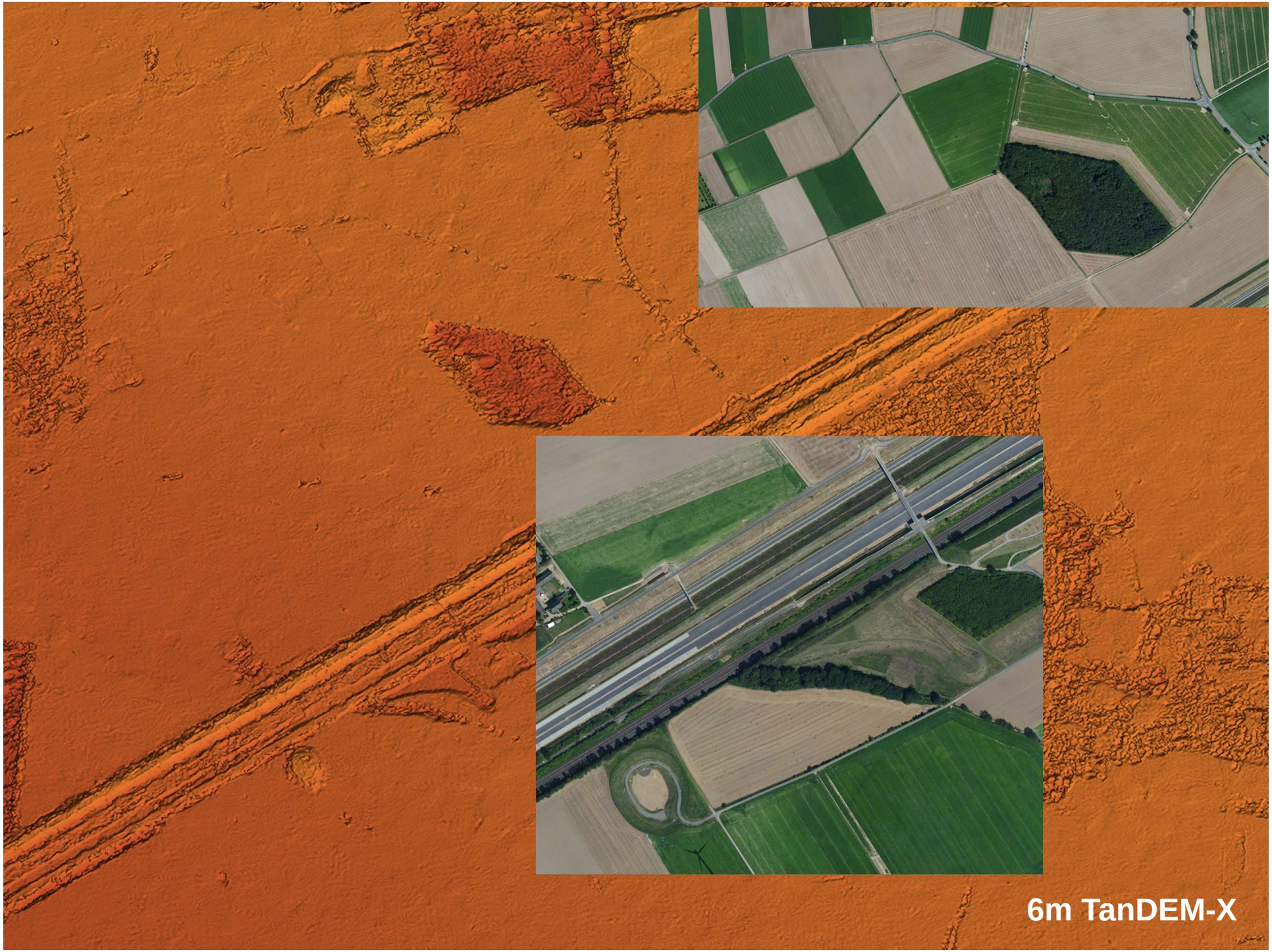
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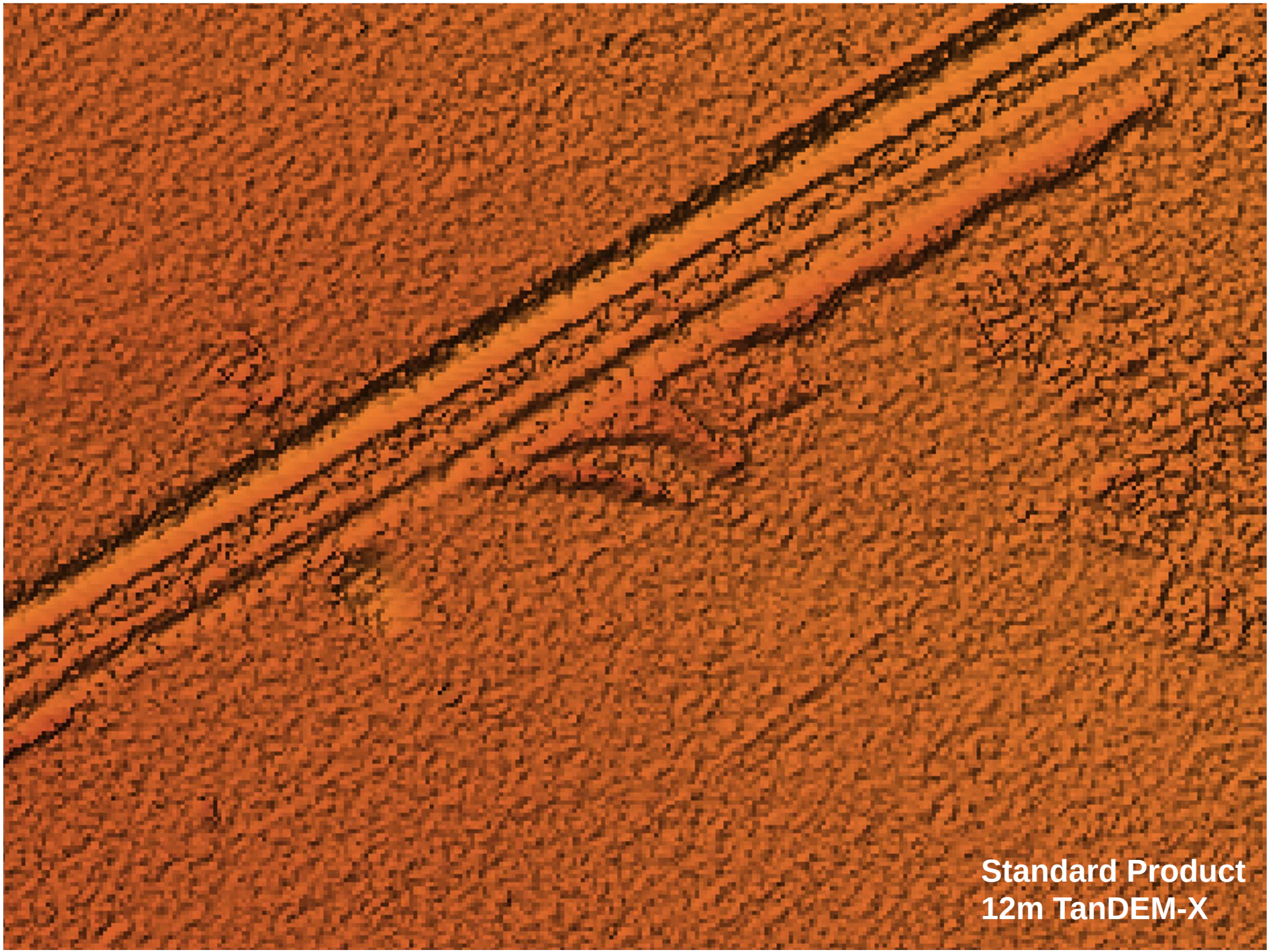
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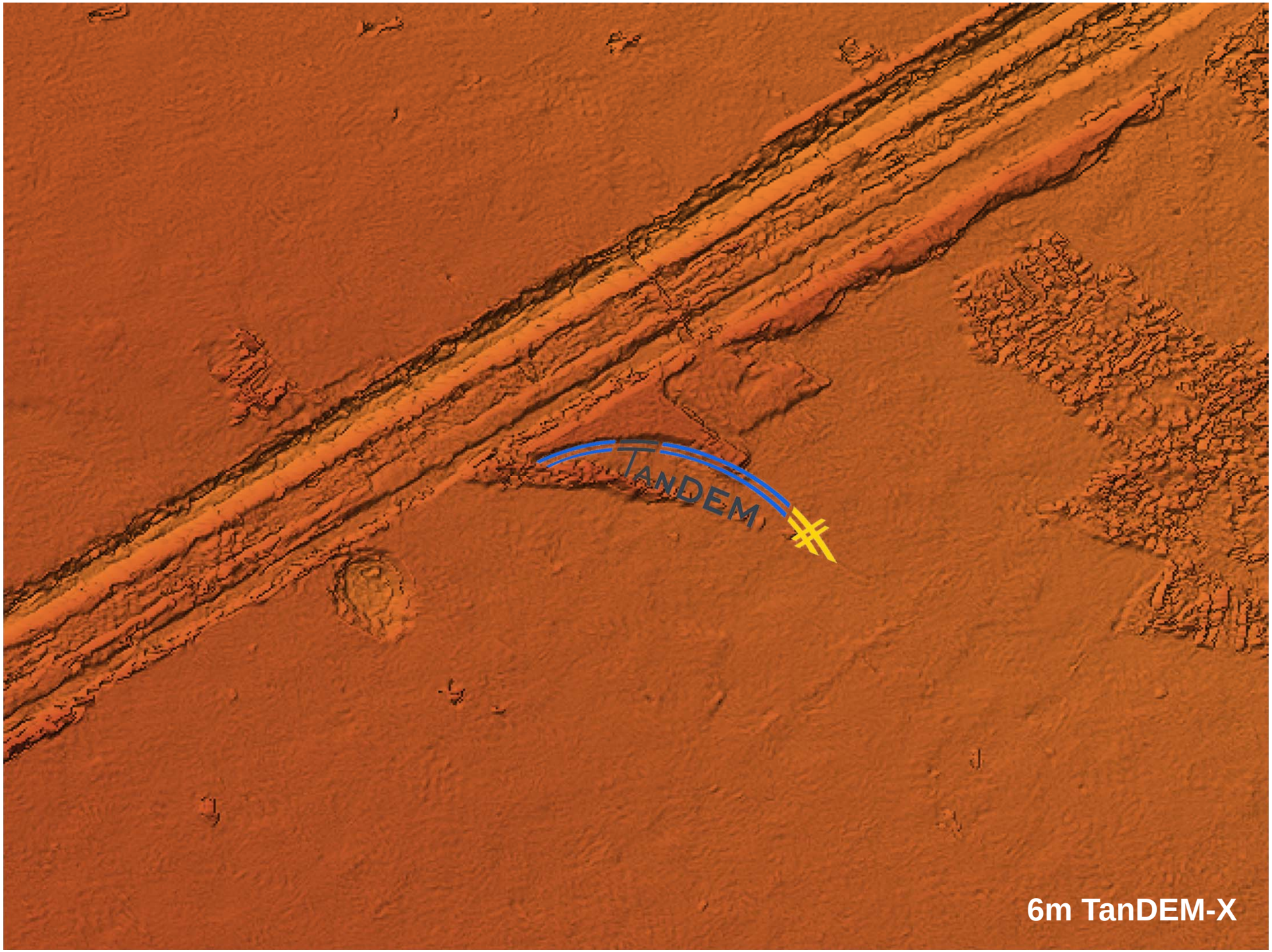
TANDEM
6m TanDEM-X