A derivation of optimum coherent Digital Elevation Models from interferometric SAR data

Workshop September 6-7 2004
Aberdeen Scotland

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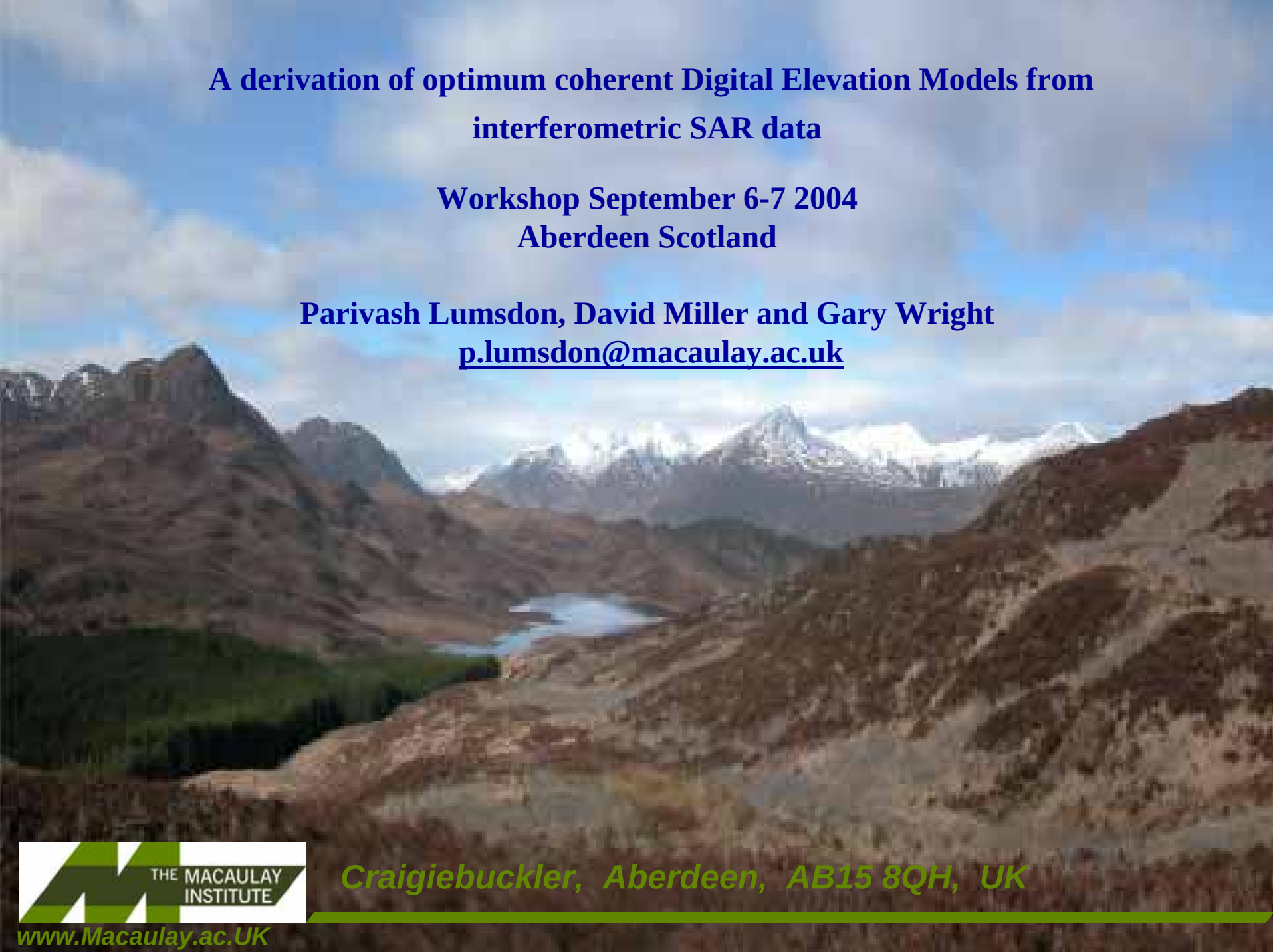

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Organisation

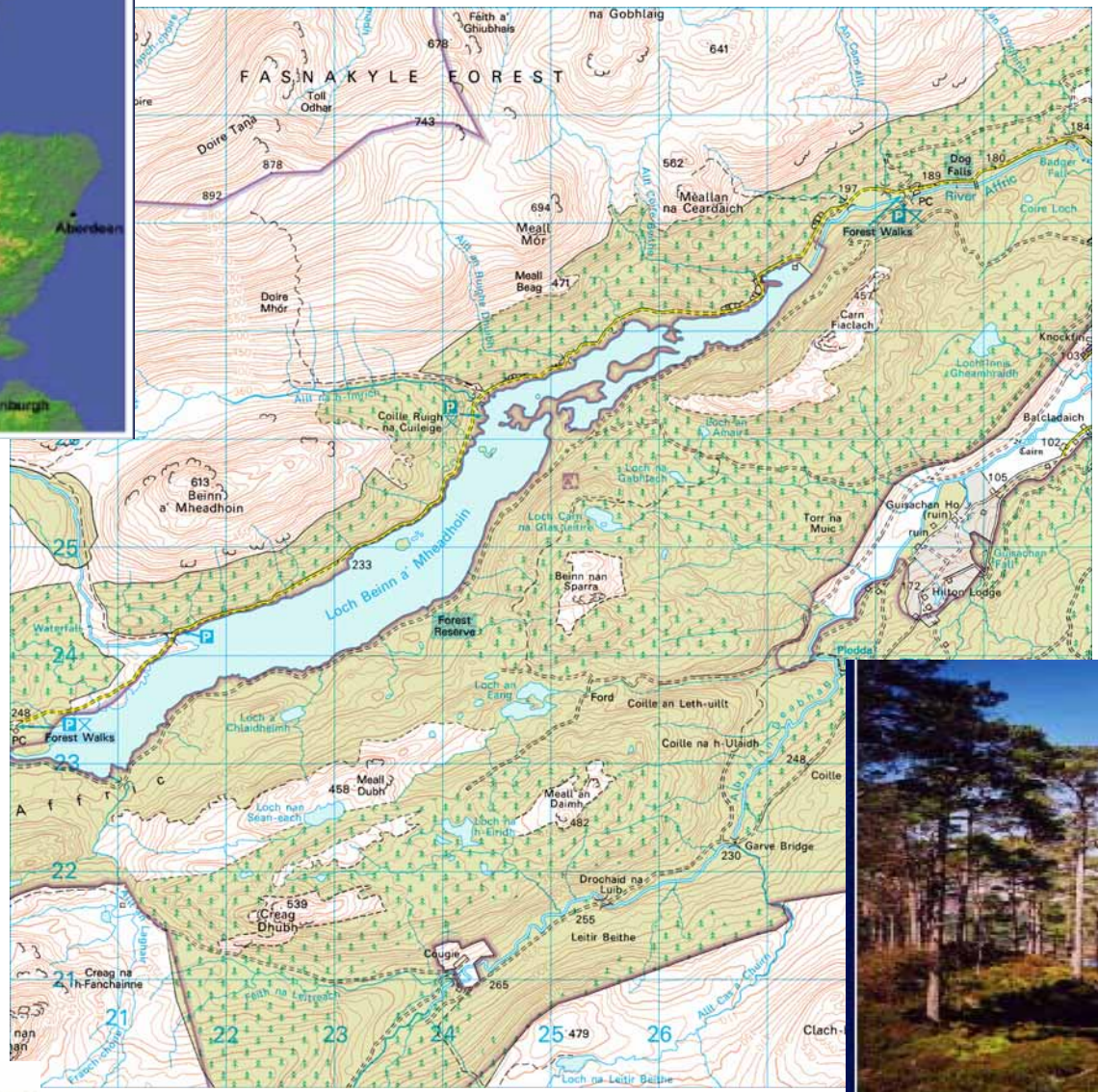
Results obtained from application of fully Polarimetric Classification and Interferometric Parameter estimation algorithms onto GlenAffric L-band radar data are presented.

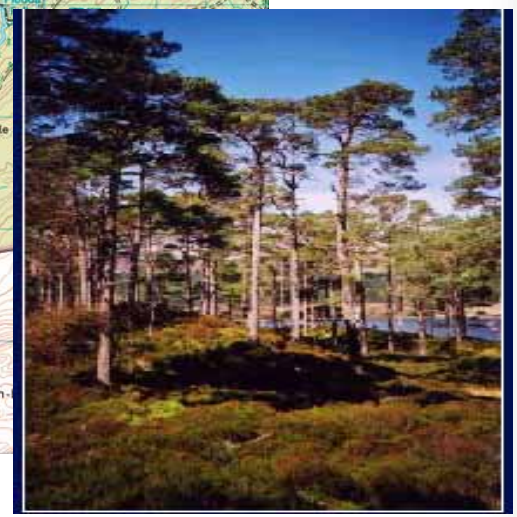
-Estimation of Interferogram from high resolution Parameter Estimation algorithm (ESPRIT)

-Despeckled Interferogram (Edge aligned Lee Filter)

-Digital Elevation Model based on local Reion Grow algorithm

GlenAffric Test Site





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Test Site

GlenAffric in Scotland

Holds one of the Largest & Oldest Semi-Natural Caledonian Pine forests

Typical species Scots Pines

Topographically Challenging site

Vast areas of Peat/Heather lands and Woodlands

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Semi Natural woodlands of GlenAffric, Scotland

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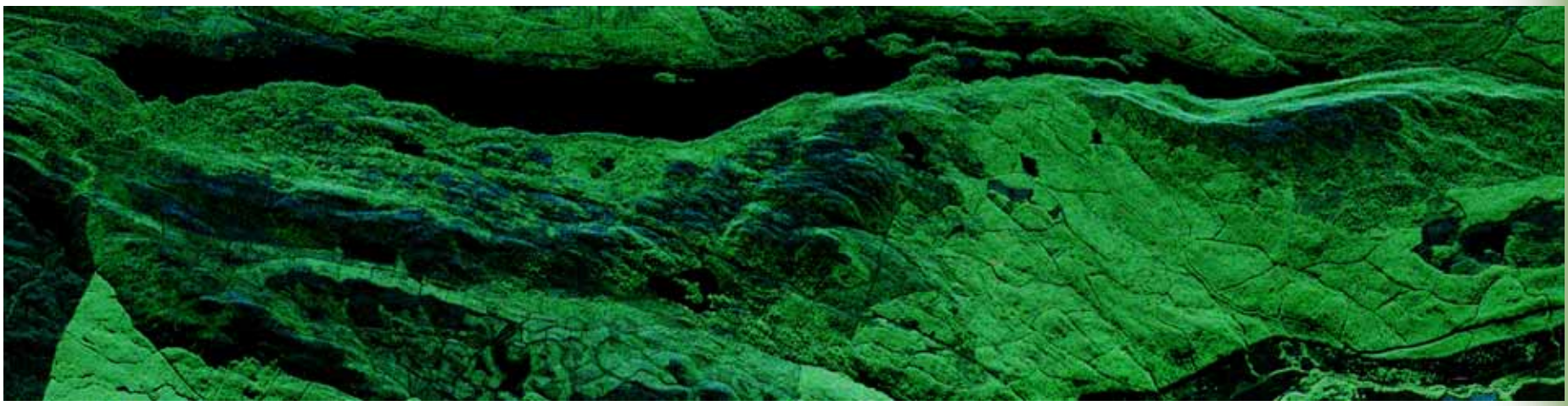
Radar Data



RGB Image of Glenaffric SAR Data- Pauli Decomposition

Even Bounce

Tilted Even Bounce

Odd Bounce

- **Acquired as part of the Scottish-SHAC**

in April 2000,
Airborne, Repeat pass,
Fully Polarimetric
Dual Base Line,
L Band SAR data
With Baselines 10&20m
Total of 6 Tracks
SHAC info web-site :
http://www.bnsc.gov.uk

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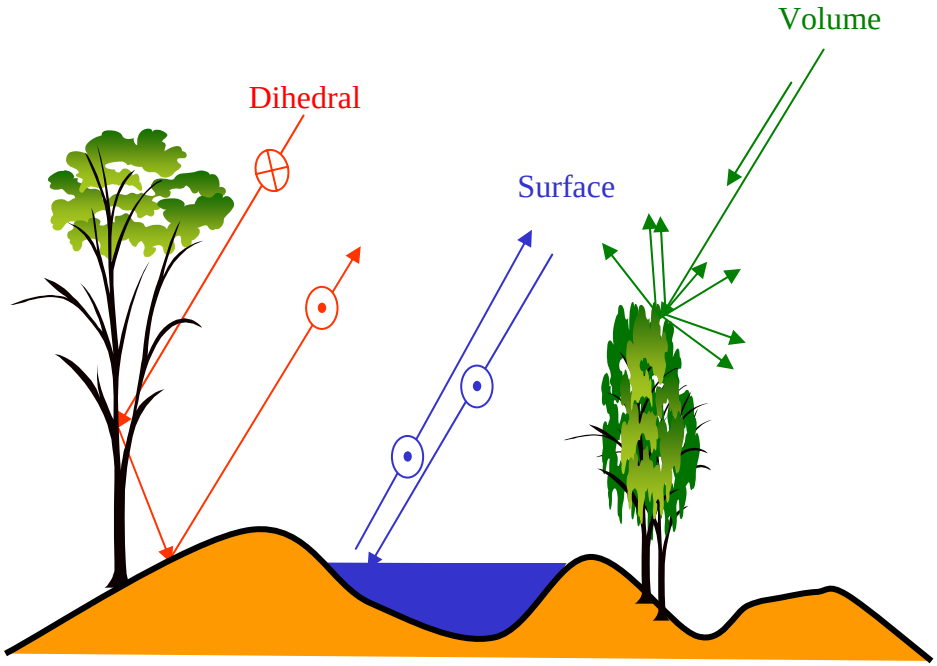
Land Cover Classification

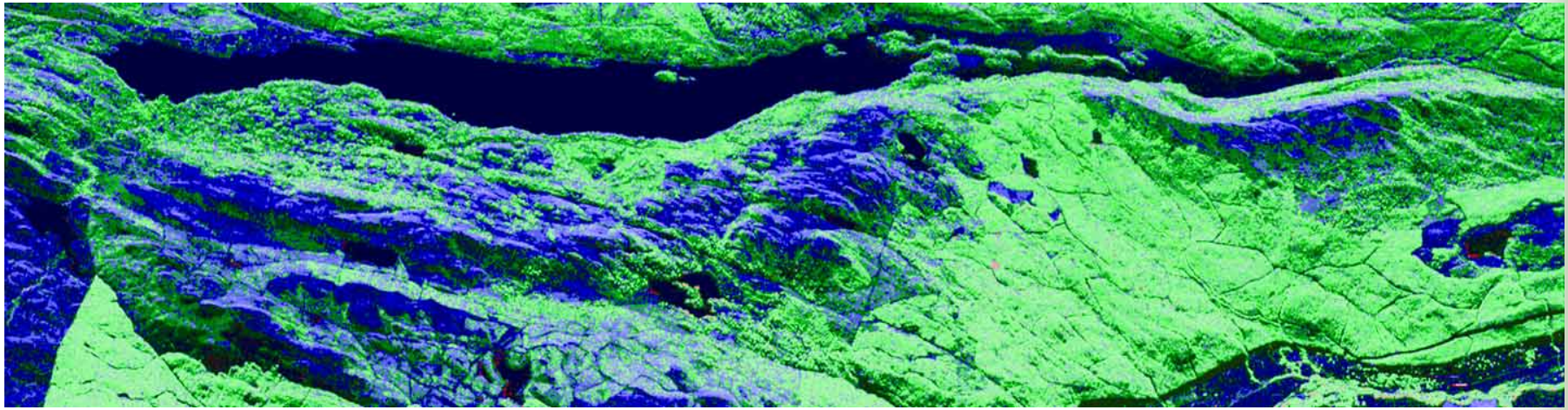
Freeman-Durden 3D Component Classification of



$$\mathbf{T}=\mathbf{T}_v+\mathbf{T}_s+\mathbf{T}_d$$

$$T_v = 4/3.m_v.\begin{bmatrix}2 & 0 & 0\\ 0 & 1 & 0\\ 0 & 0 & 1\end{bmatrix};T_s= m_s.\begin{bmatrix}(y+1)^2 & (y^2-1) & 0\\ (y^2-1)^* & (y-1)^2 & 0\\ 0 & 0 & 0\end{bmatrix};\text{ and } T_d=m_d.\begin{bmatrix}(x-1)^2 & (x^2-1) & 0\\ (x^2-1)^* & (x+1)^2 & 0\\ 0 & 0 & 0\end{bmatrix}$$

Land Cover Classification



Freeman-Durden 3D Component Classification of Glenaffric radar data

The Freeman classified Glen Affric radar data

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

Volume Surface Dihedral

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EStimation of **P**arameters via **R**otational **I**nvariance **T**echniques (ESPRIT)

Interferometric Target vector = $\mathbf{S} = \begin{bmatrix} S_{HH_1} & S_{HV_1} & S_{VV_1} & S_{VH_1} & S_{HH_2} & S_{HV_2} & S_{VV_2} & S_{VH_2} \end{bmatrix}^T$

Covariance Matrix= $\mathbf{C}_{8x8} = \mathbf{S}.\mathbf{S}^* = \mathbf{E}.\Lambda_c.\mathbf{E}^*$, $\mathbf{E} = [\mathbf{E}_s, \mathbf{E}_n]$

$\mathbf{E}_s = \begin{bmatrix} E_1 \\ E_2 \end{bmatrix}$, $\mathbf{E}_2 = \Phi.\mathbf{E}_1$

TLS ESPRIT $\mathbf{E}_{12} = [\mathbf{E}_1, \mathbf{E}_2]$

$\mathbf{E}_{12}^*.\mathbf{E}_{12} = \mathbf{G}.\Lambda_G.\mathbf{G}^*$

$\mathbf{G} = \begin{bmatrix} [G_{1s}] & [G_{1n}] \\ [G_{2s}] & [G_{2n}] \end{bmatrix}$

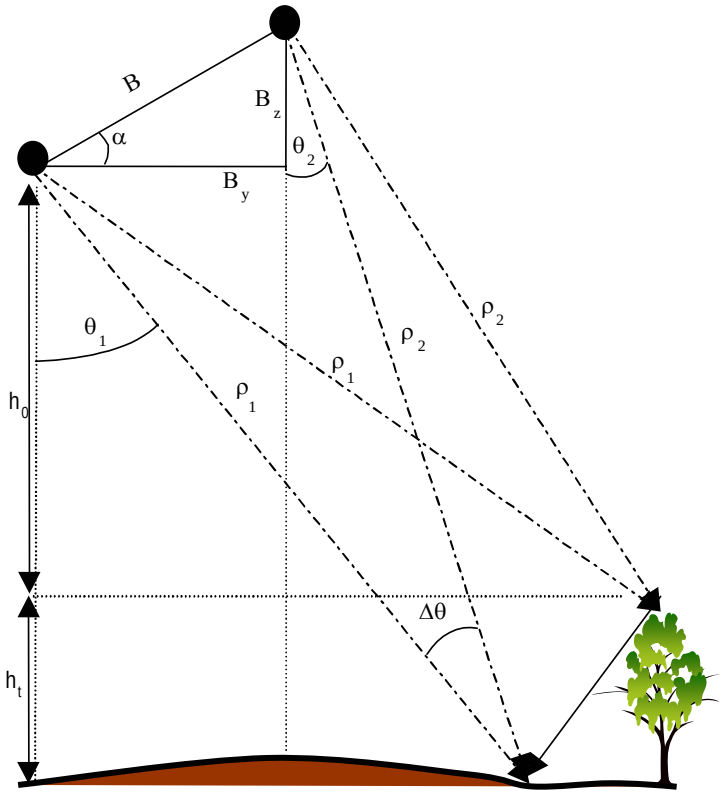
$\psi = -\mathbf{G}_{1n}.(\mathbf{G}_{2n})^{-1}$, $\Phi =$ **arg**(Eigen values of ψ **)**

$\Delta\Phi$ = Phase difference

Path difference = $\Delta\rho = \rho_1 - \rho_2$

Phase difference = $\dfrac{4.\pi.\Delta\rho}{\lambda} = \dfrac{4.\pi}{\lambda}.\Delta\theta.\dfrac{h_t}{\sin(\theta_0)}$

Tree height = $h_t = \Delta\phi/(\sin(\theta_0)\lambda/(4.\pi.\Delta\theta))$



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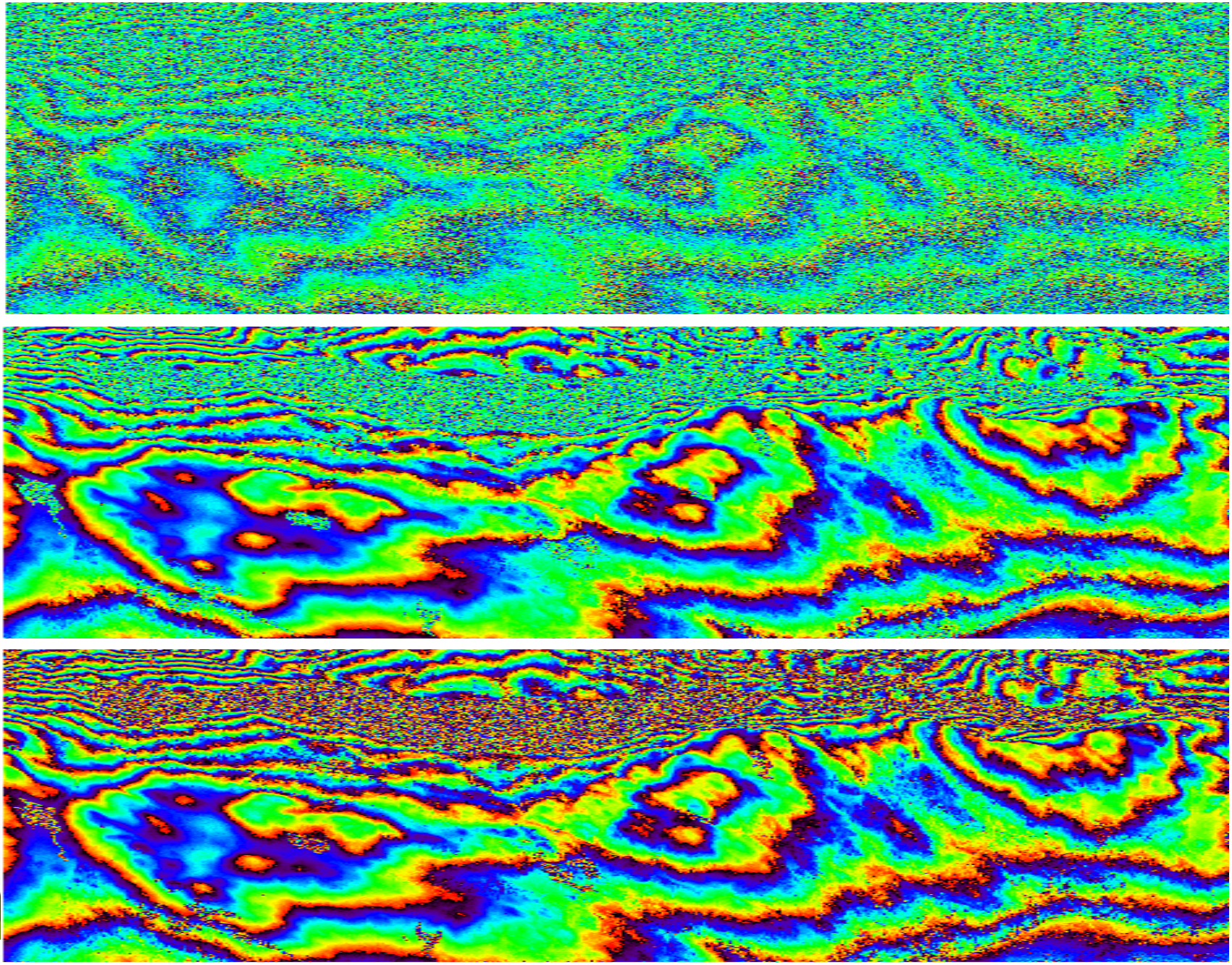
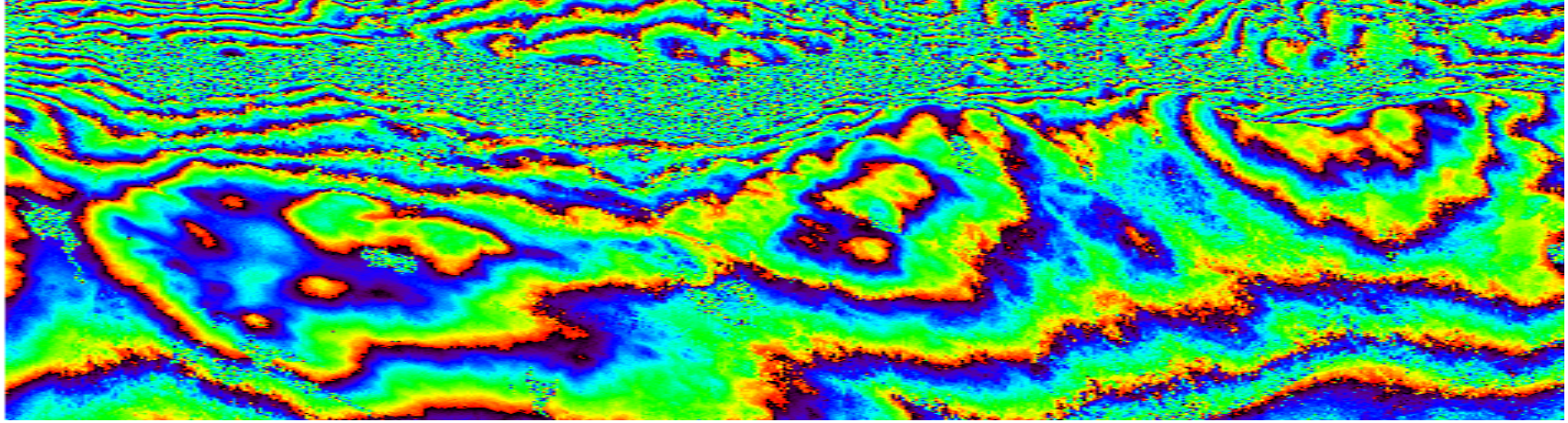
Interferogram maps





Augmented Coherence matrix

Classified Information

Dividing the image into three scattering groups

Application of Edge aligned Lee Filter to each Scattering group

ESPRIT algorithm

Interferogram for the dominant eigen parameter

Phase Unwrapping Solution

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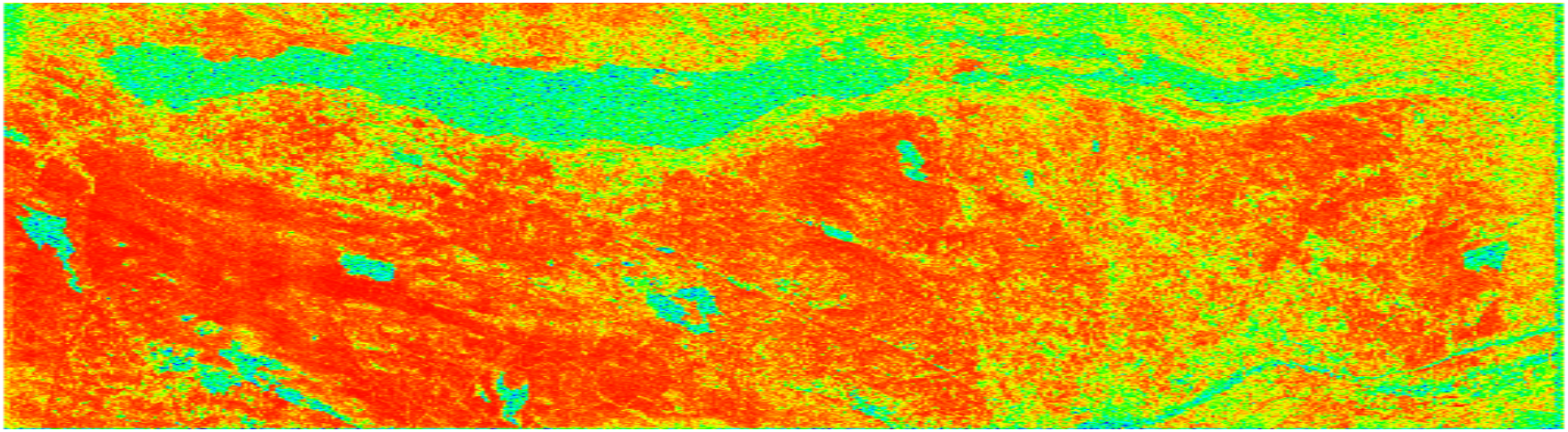

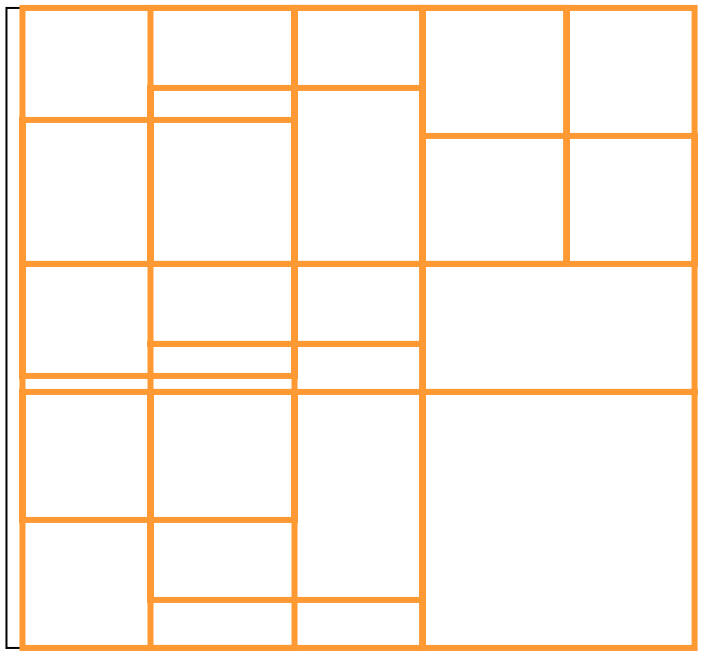

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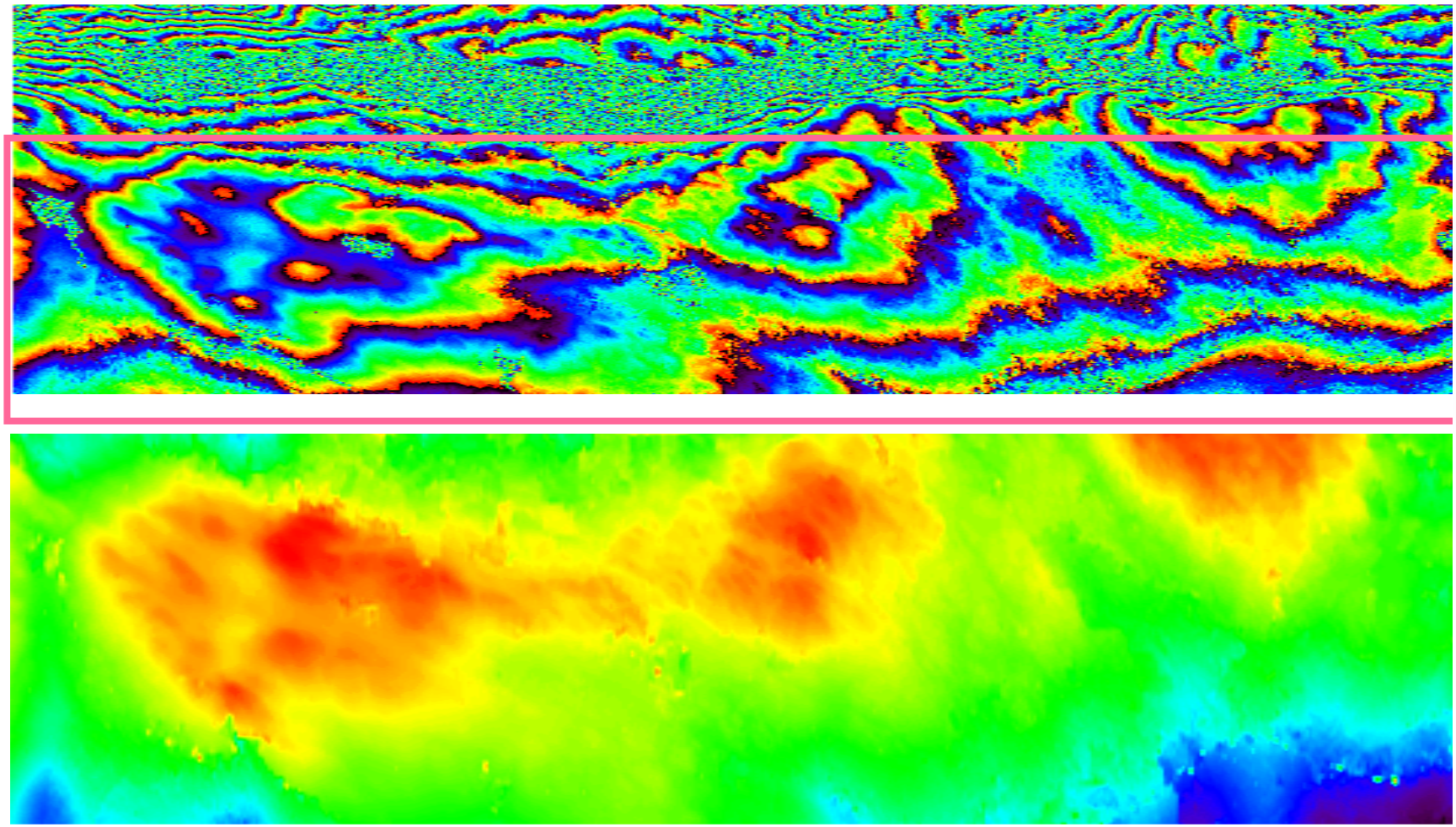
Digital Elevation Model



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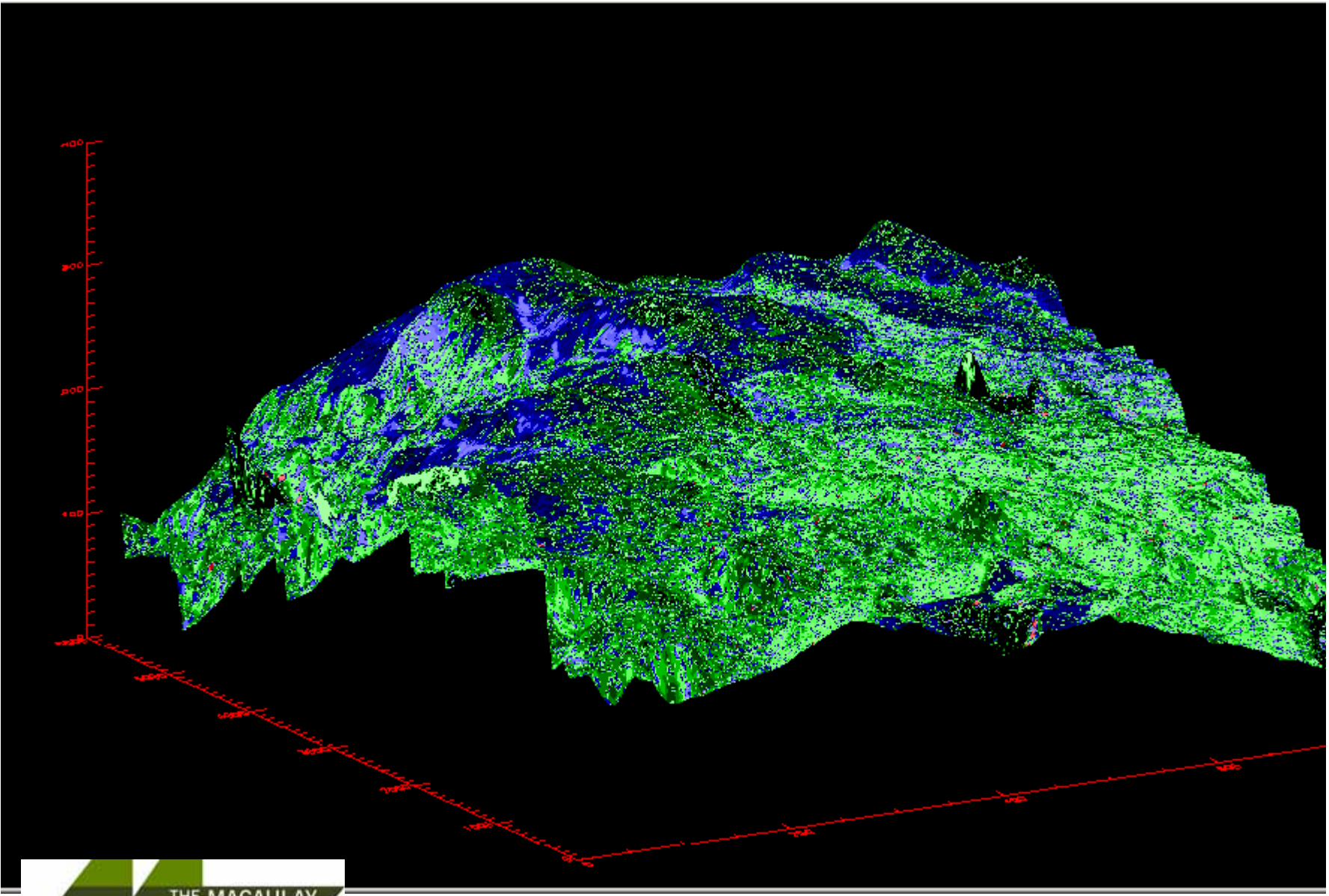
Digital Elevation Model



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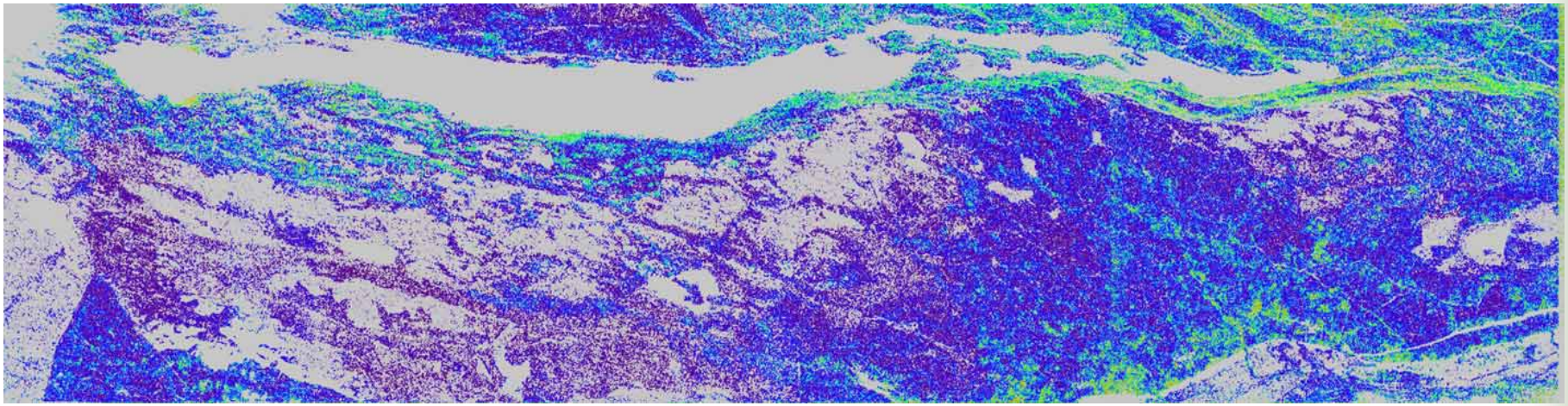
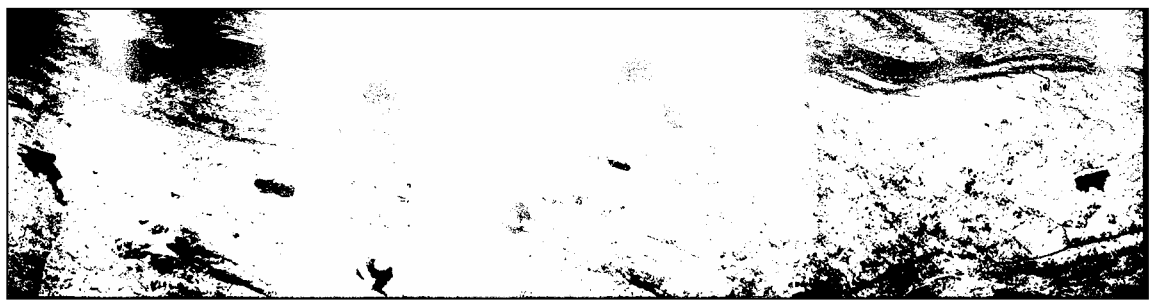
Glenaffric Tree Height

ESPRIT



Temporal de-correlation mask, 10m baseline tracks, tree heights of 45 m



Temporal de-correlation mask of Glen Affric radar data

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Summary

Land Cover classification
(Freeman-Durden, Lee Filter, Wishart Classifier)

Temporal Decorrelation mask, SNR mask and Water mask

Interferometric Target Vector and Coherence matrix

Edge aligned enhanced Lee filter

TLS ESPRIT

DEM and Tree hight