

TEXTURE ANALYSIS OF SAR IMAGERY IN THE SPACE-SCALE-POLARIZATION DOMAIN BY WAVELET FRAMES

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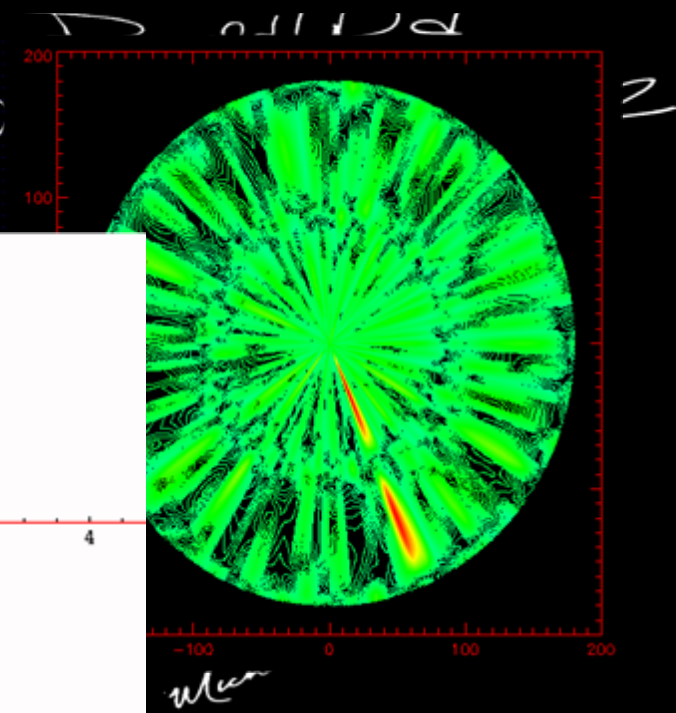
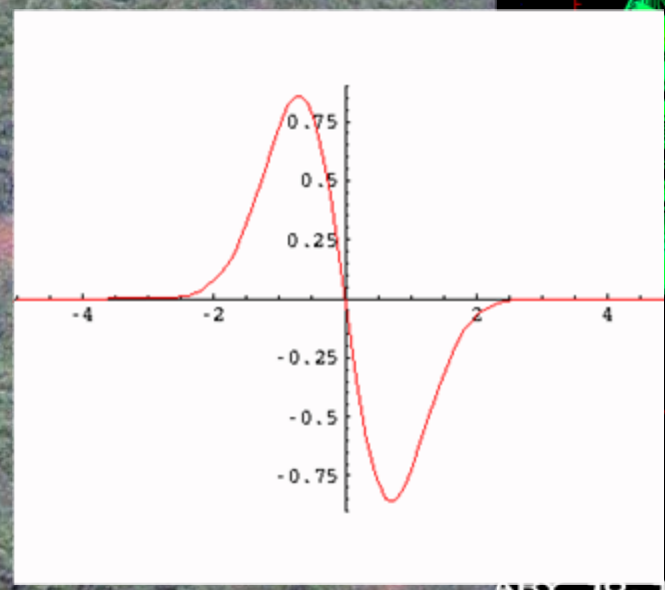
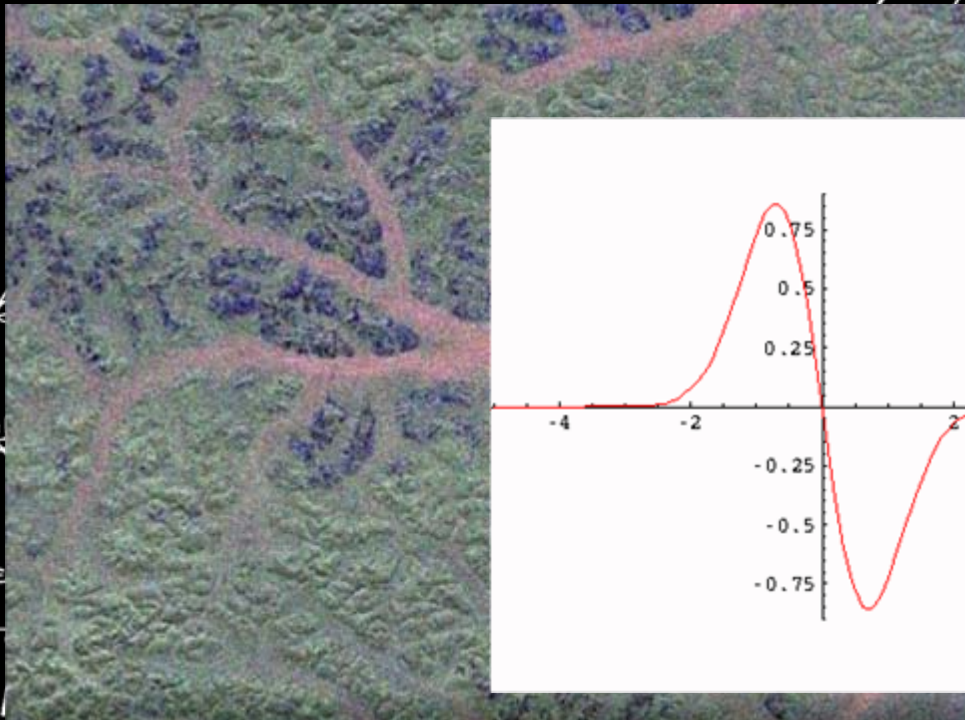
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Andrew G. Wyman

Brian Robertson

Volker Schulz



TEXTURE? WHAT TEXTURE?

'Quid est ergo
textura? Si nemo
ex me quaerat,
scio; si quaerenti
explicare velim,
nescio



G. De Grandi, J.S. Lee, D.L. Schuler,

"Target Detection and Texture Segmentation in Polarimetric SAR Images Using a Wavelet Frame: Theoretical Aspects",

IEEE Transactions on Geoscience and Remote Sensing, vol. 45, no. 11, pp. 3437-3453, Nov. 2007.

Augustine as depicted by Sandro
Botticelli, c. 1480

CAN WE EXPERIMENTALLY OBSERVE POLARIMETRIC TEXTURE?

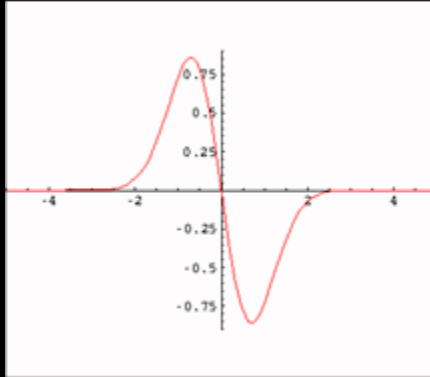


Galileo Galilei

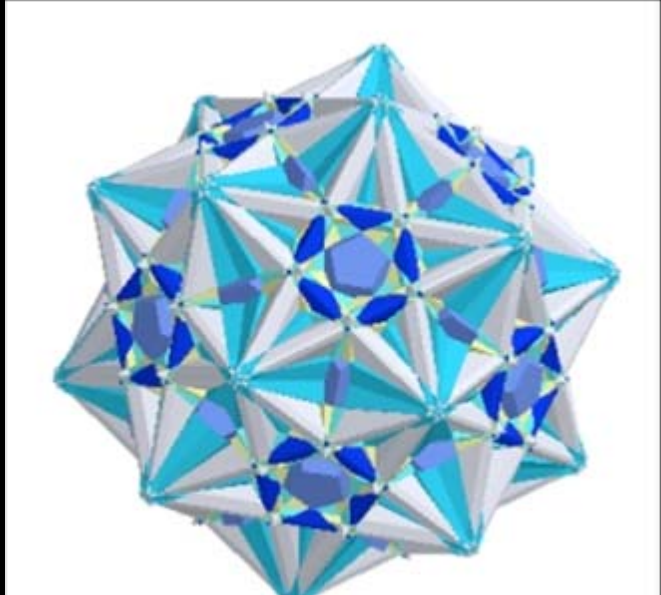
Portrait of Galileo Galilei by
Justus Sustermans (1597-1681),
ca. 1639



TEXTURE MEASURES OF POLARIMETRIC SAR DATA BY WAVELET FRAMES



WAVELET
FRAME
MACHINERY



WAVELET ENERGY IN A
HYPERSPACE

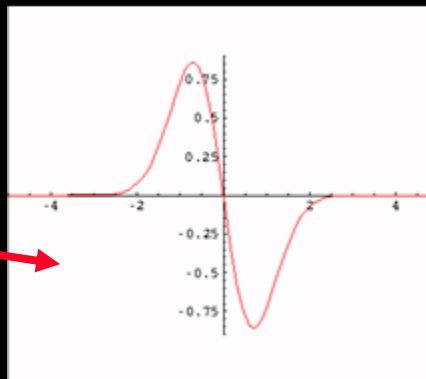
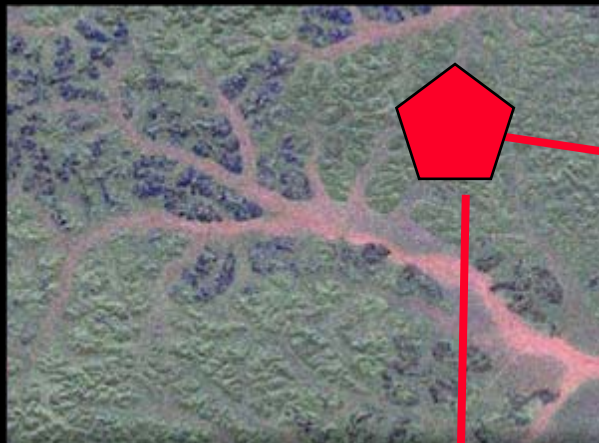
SPACE
SCALE
POLARIZATION STATE

$$[S_{HH}, \sqrt{2}S_{HV}, S_{VV}]$$

$$W_s^2(x, y)$$

TOOLS FOR TEXTURE MEASURES REPRESENTATION IN A REDUCED SPACE

WAVELET SCALING SIGNATURE (WASS)



WAVELET
FRAME
MACHINERY



$$\langle \mathbf{W}_s^2(\mathbf{x}) \rangle = \mathbf{f}(s)$$

$$\langle \mathbf{W}_s^2(\mathbf{y}) \rangle = \mathbf{f}(s)$$

$$\mathbf{P}(\bar{\psi}) = \mathbf{f}[\mathbf{S}_{HH}, \sqrt{2}\mathbf{S}_{HV}, \mathbf{S}_{VV}]$$

Power synthesis at one
polarization

Detected power data

- One polarization
- Two directions (range, azimuth)
- Dependence on scale

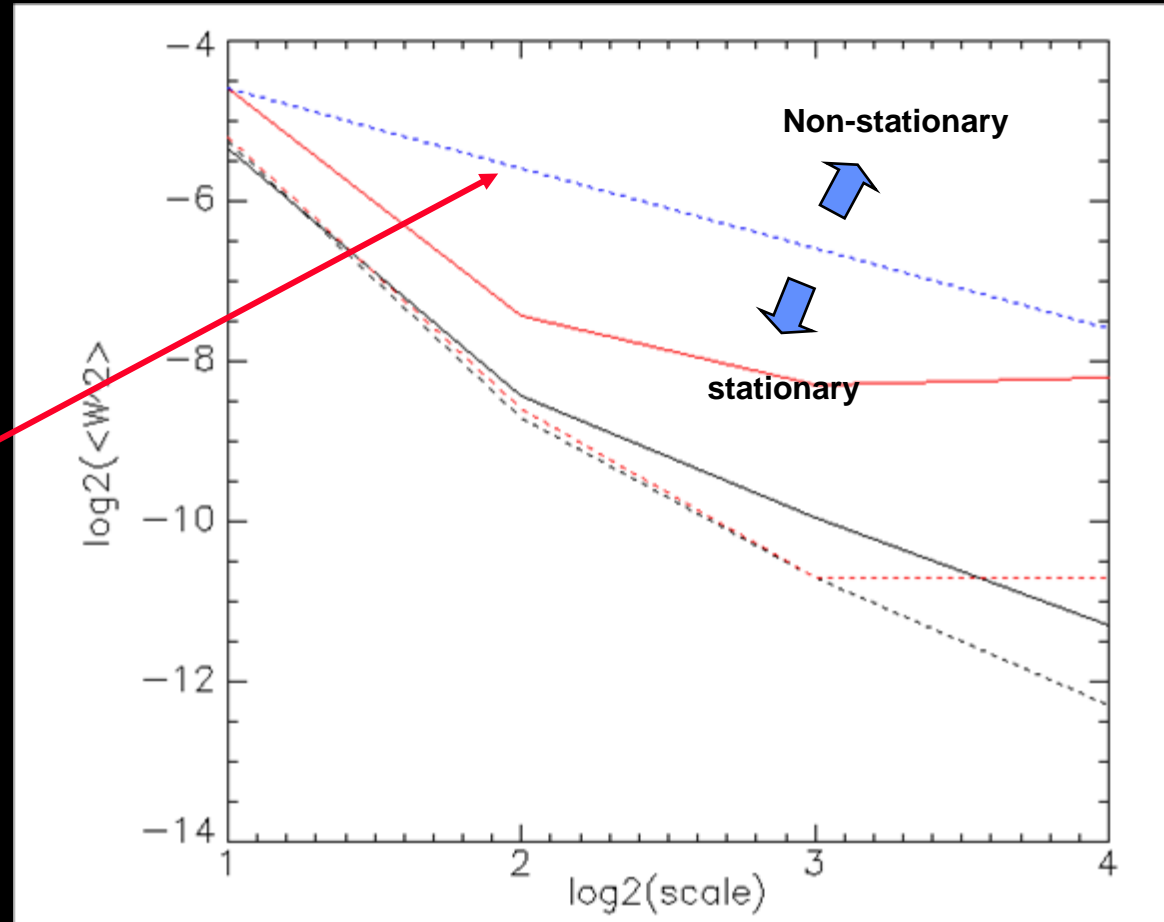
WAVELET SCALING SIGNATURE (WASS)

WASS highlights the strength of texture and at which scale texture develops

$$\log_2 \left(\frac{\langle \mathbf{W}_s^2 \rangle}{\langle \mathbf{A}_{s-1} \rangle^2} \right) = f(\log_2(s))$$

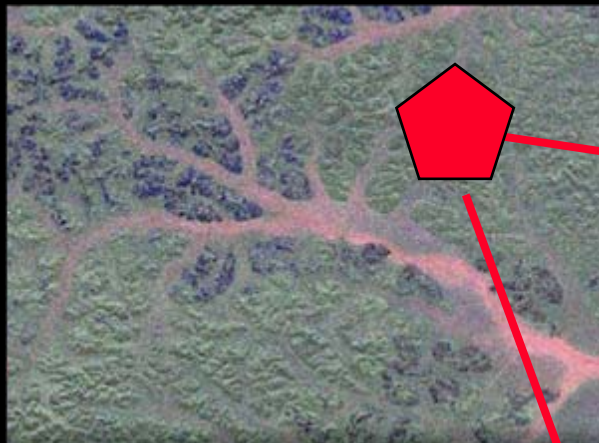
Indicates stationary non-stationary regime for an underlying scale invariant noise process

$$\mathbf{E}(\omega) \propto \omega^{-\gamma} \Leftrightarrow \langle \mathbf{W}_s^2 \rangle \propto s^{2H} \quad \gamma = 2H + 1$$



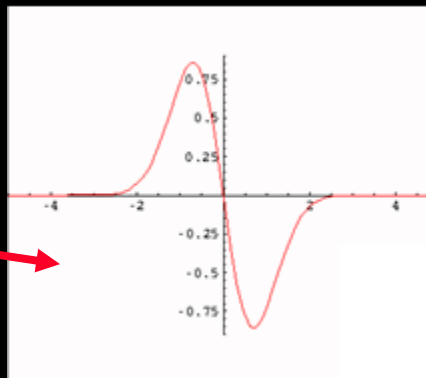
TOOLS FOR TEXTURE MEASURES REPRESENTATION IN A REDUCED SPACE

WAVELET POLARIMETRIC SIGNATURE (WASP)



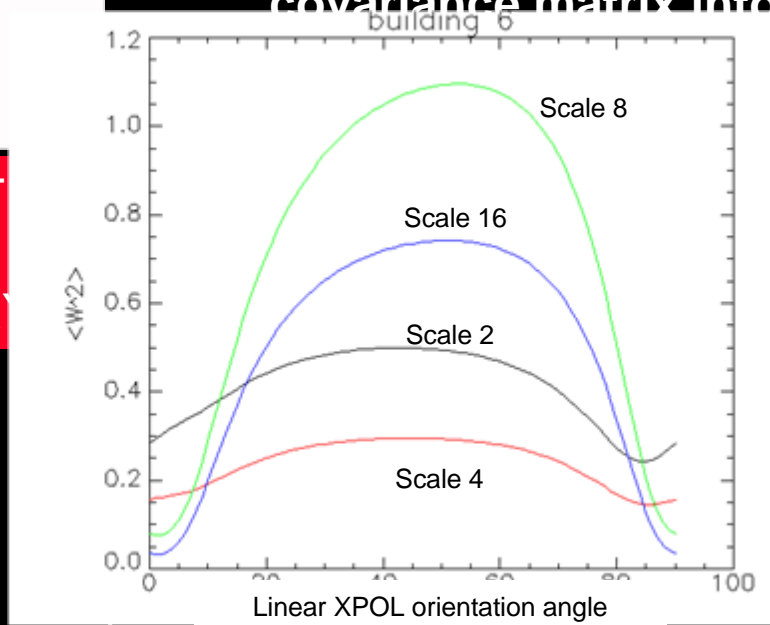
Covariance matrix representation of each element (x,y) in region of interest

$$C_{HV}(x,y)$$



WAVELET FRAME MACHINERY

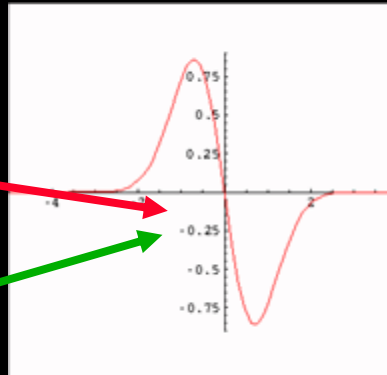
$WC_{HV}(x,y)$
Projection of each covariance matrix into the



Average wavelet energy for each polarization state and each scale $\langle WP_s^2 \rangle = f(s, \psi_1 \cdots \psi_n)$

TOOLS FOR TEXTURE MEASURES REPRESENTATION IN A REDUCED SPACE

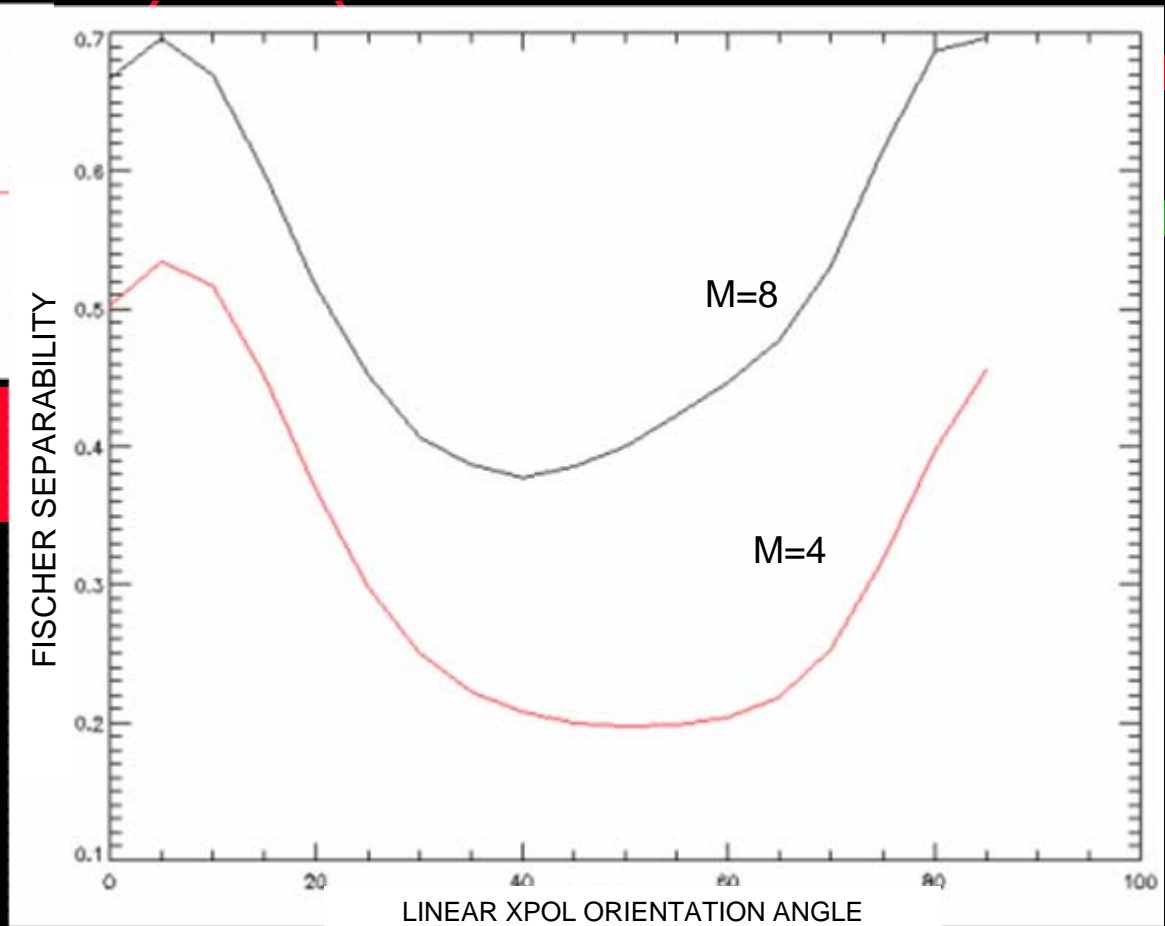
WAVELET FISCHER CLASS SEPARABILITY SIGNATURE (WASEF)



WASP
MACHINERY

Covariance matrix
representation of
each element (x,y) in
region of interest

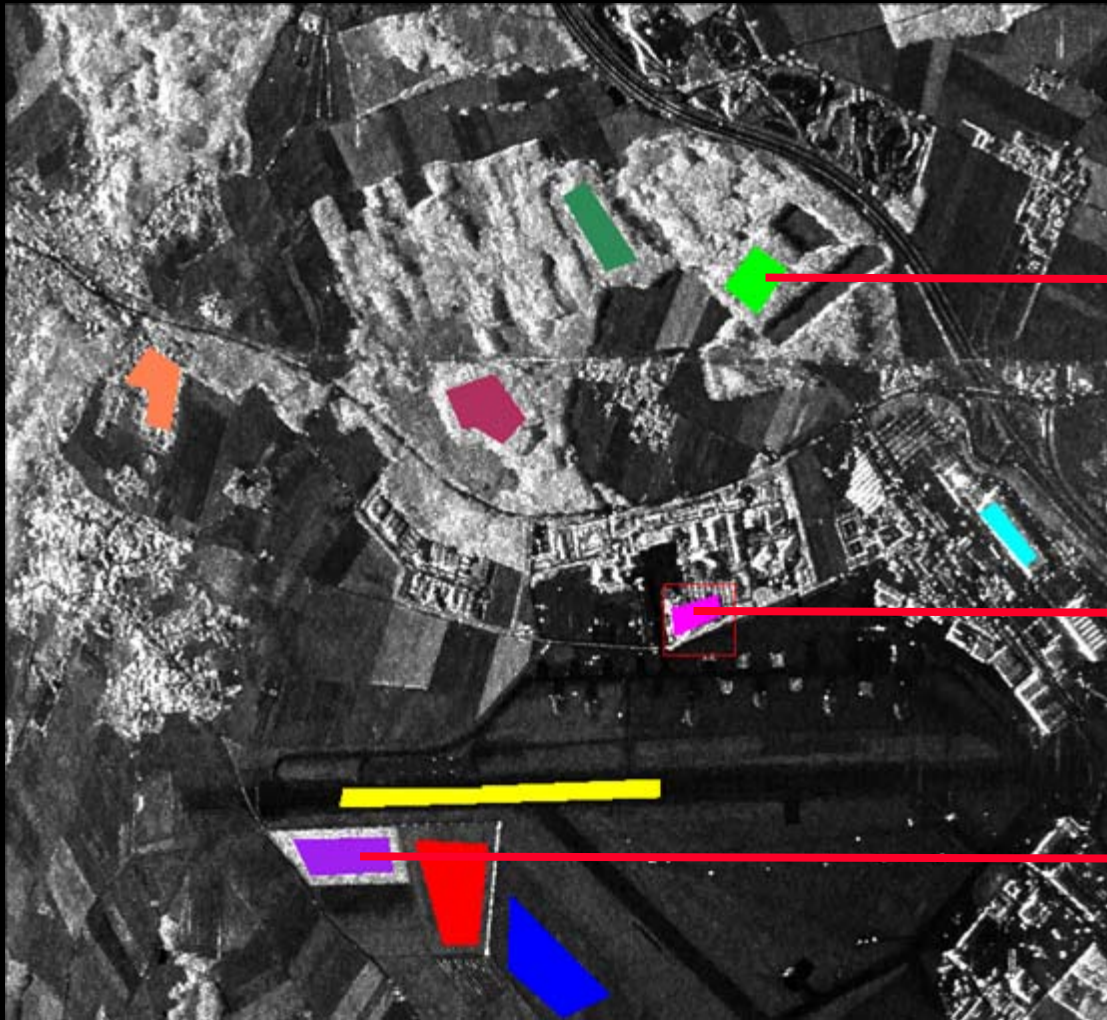
$$C_{HV}(x,y)$$



$$LDA = f(\psi_n, s)$$

WASP ANALYSIS OF HIGH RESOLUTION AIRBORNE SAR DATA

Theme: Land Cover



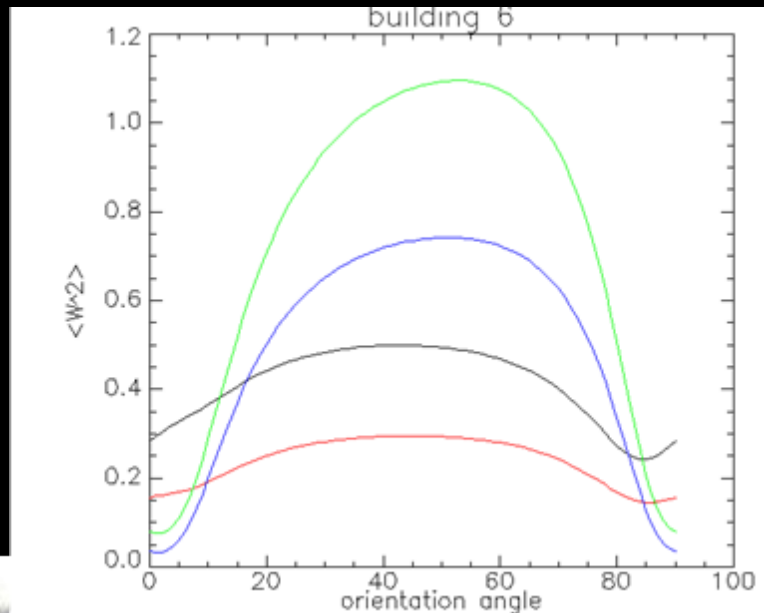
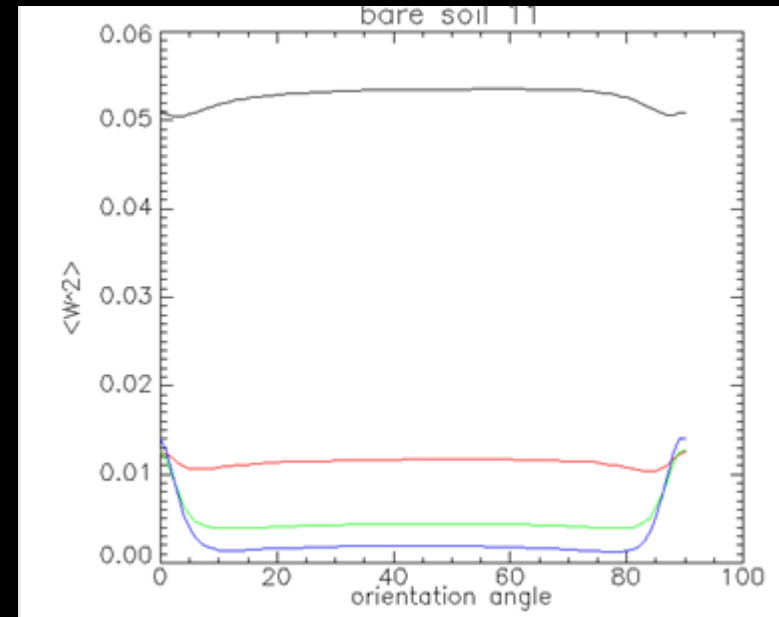
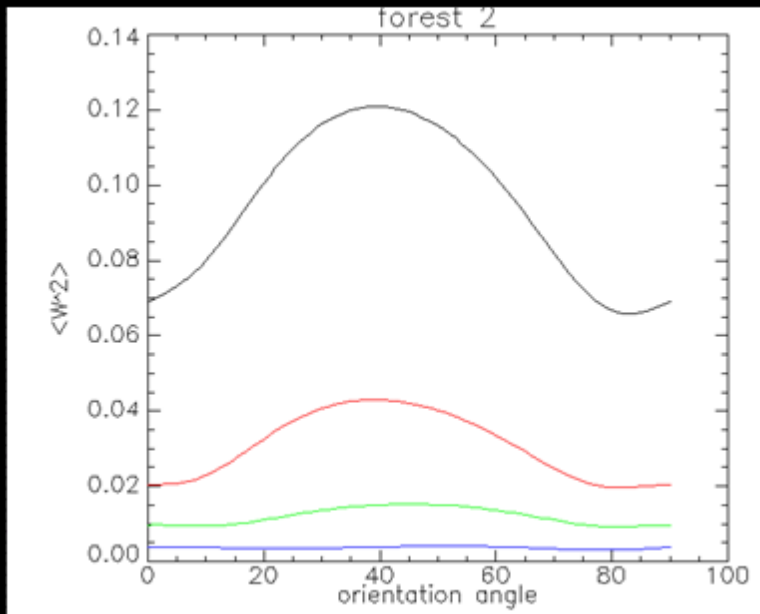
FOREST

BUILDING

BARE SOIL

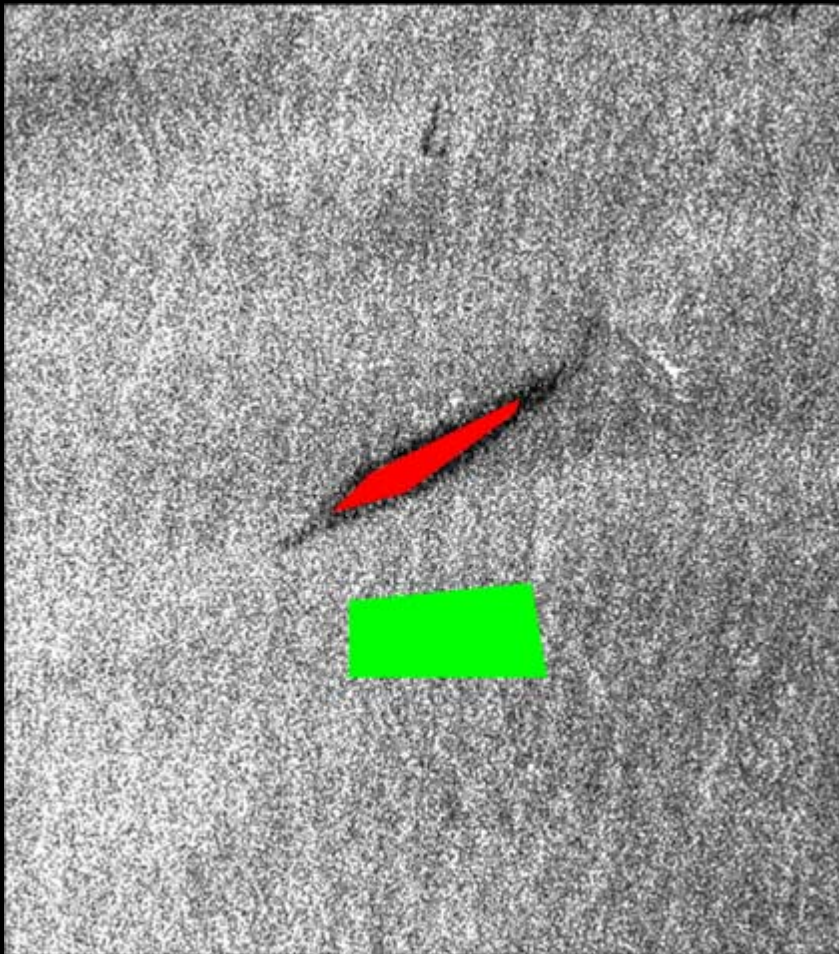
E-SAR P-band data set (courtesy DLR)

WASP ANALYSIS OF HIGH RESOLUTION AIRBORNE SAR DATA

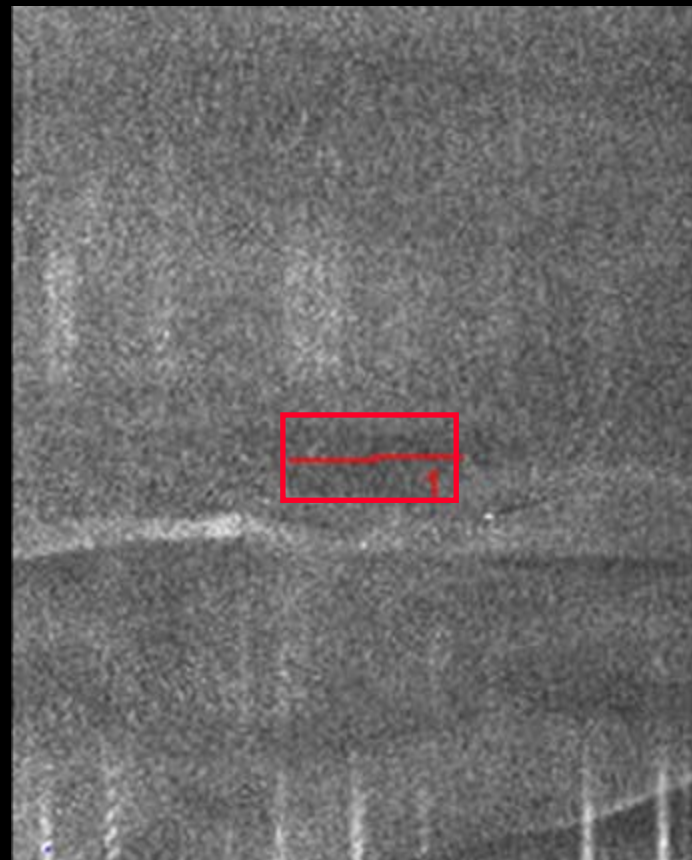


WASP ANALYSIS OF SPACE-BORNE C-BAND DATA

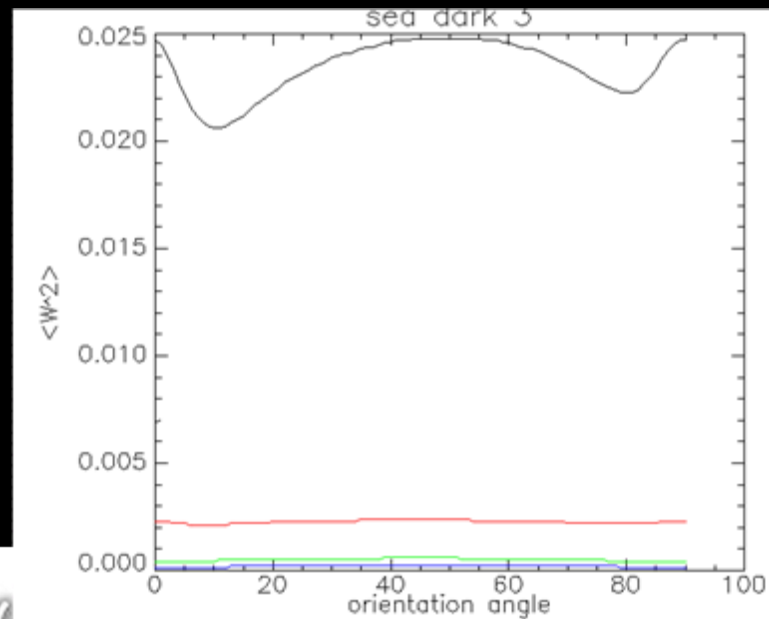
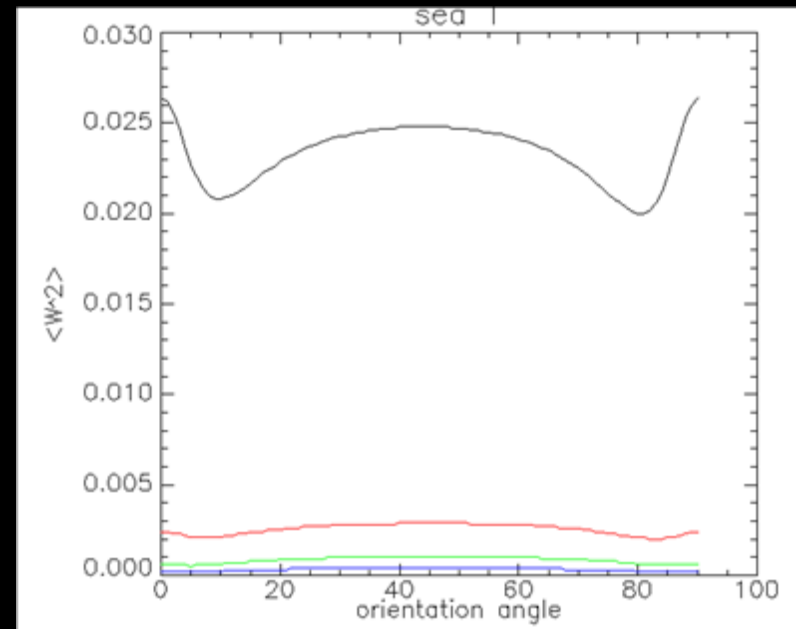
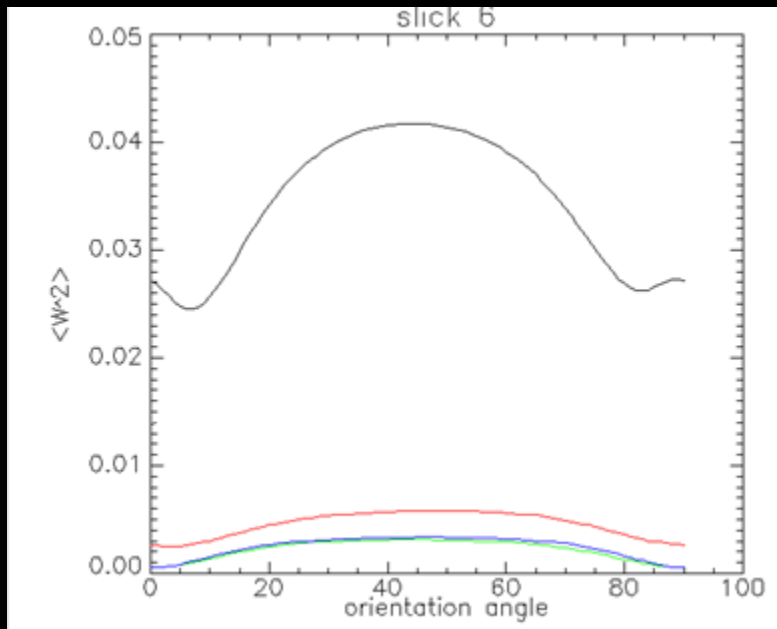
Marine Applications



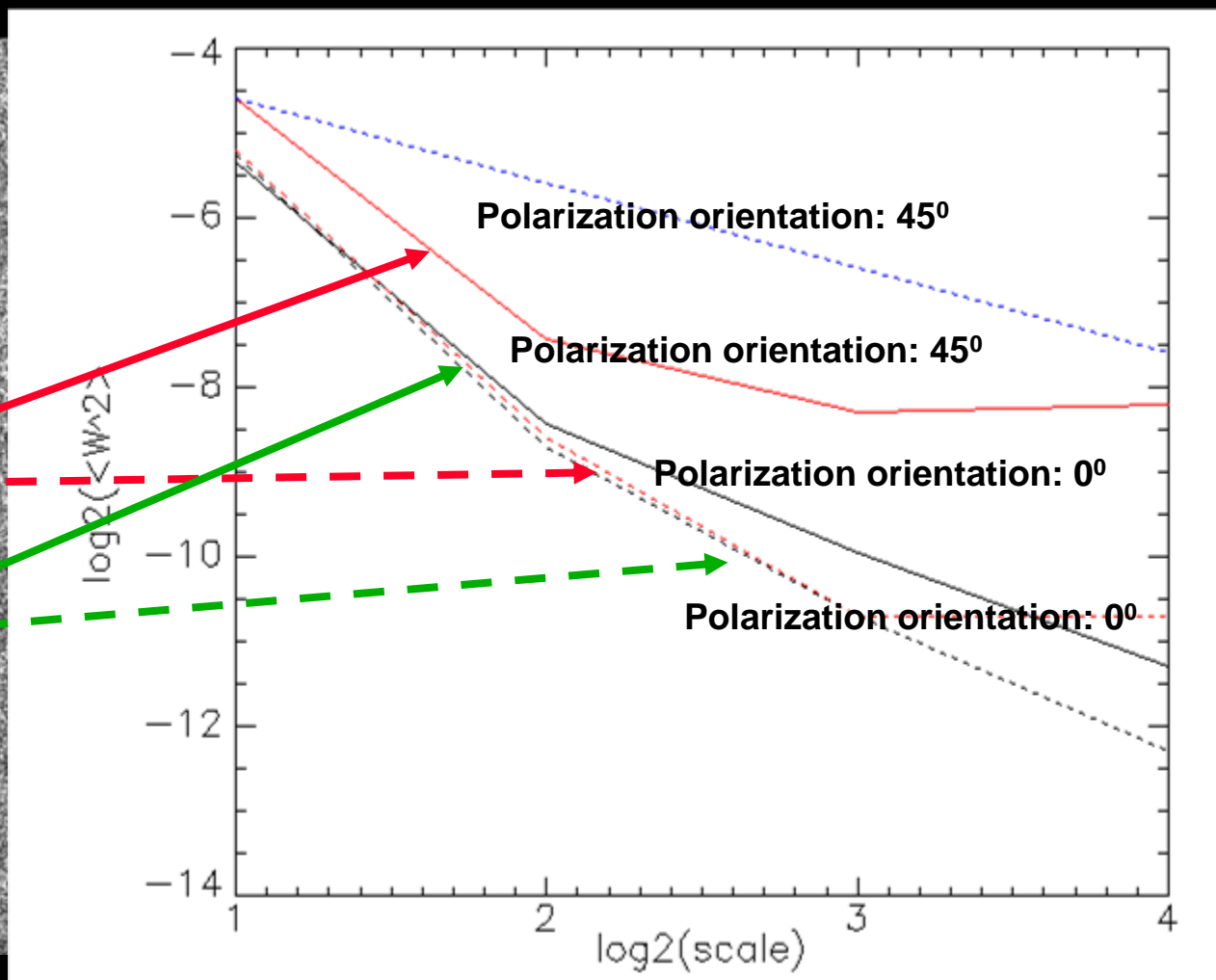
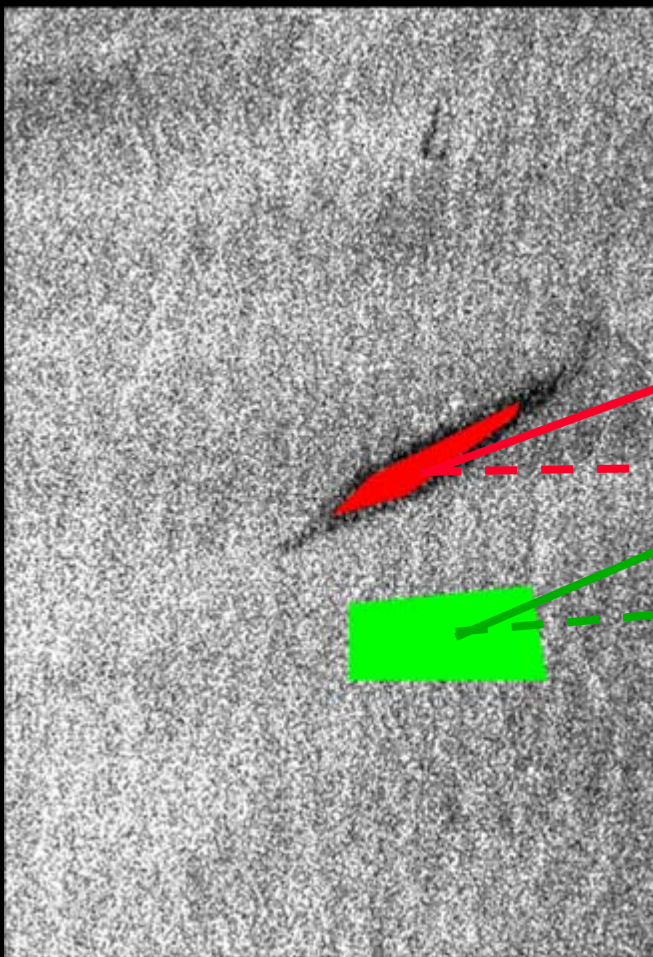
SIR-C C-band data set – English Channel
(courtesy JRC EMSL and USGS)



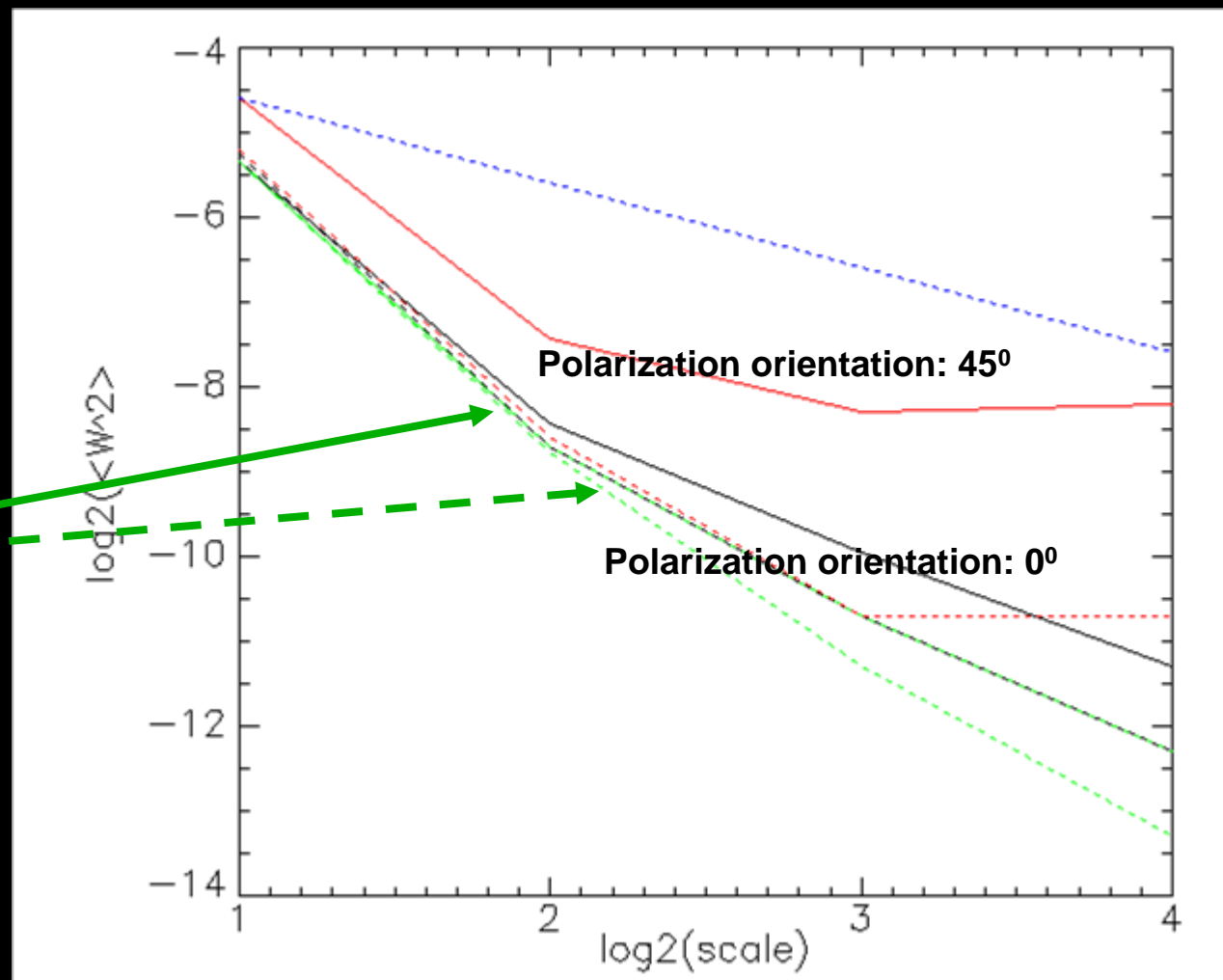
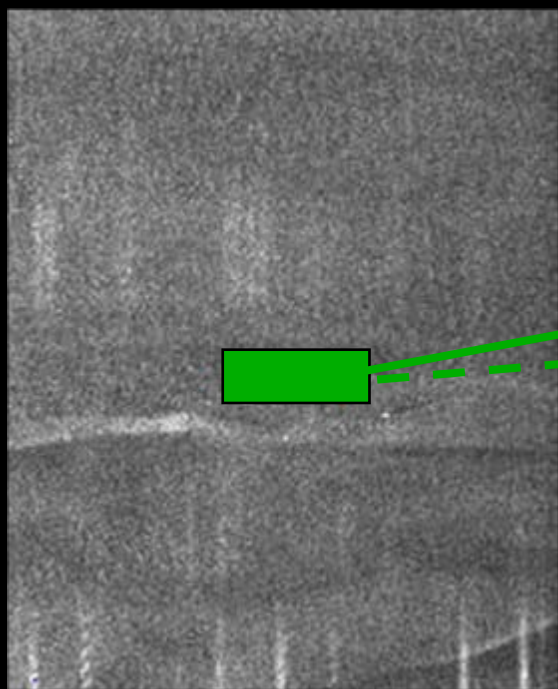
WASP ANALYSIS OF SPACE-BORNE C-BAND DATA



SCALING (WASS) ANALYSIS – SAME EXPERIMENT

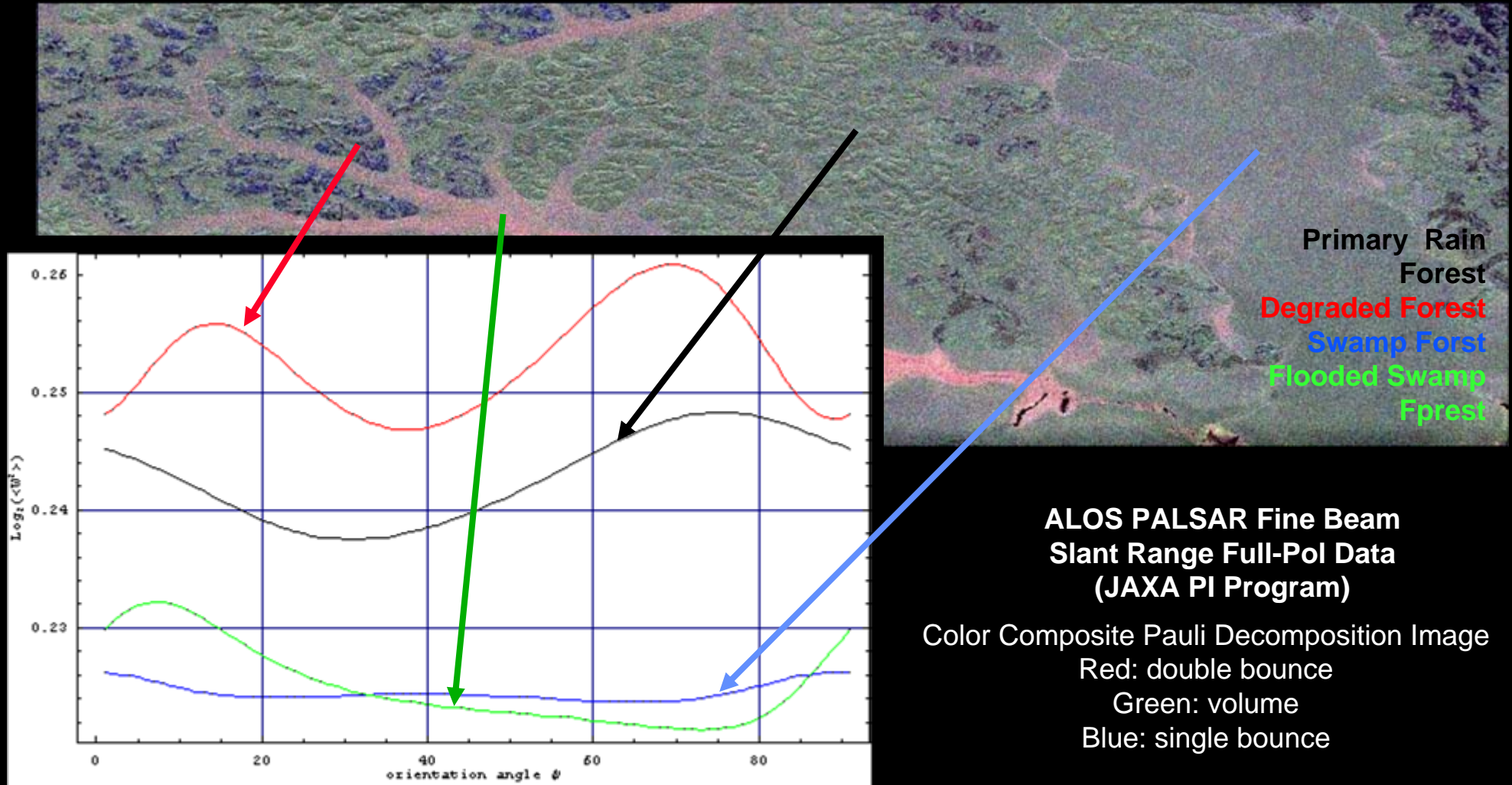


SCALING (WASS) ANALYSIS – SAME EXPERIMENT



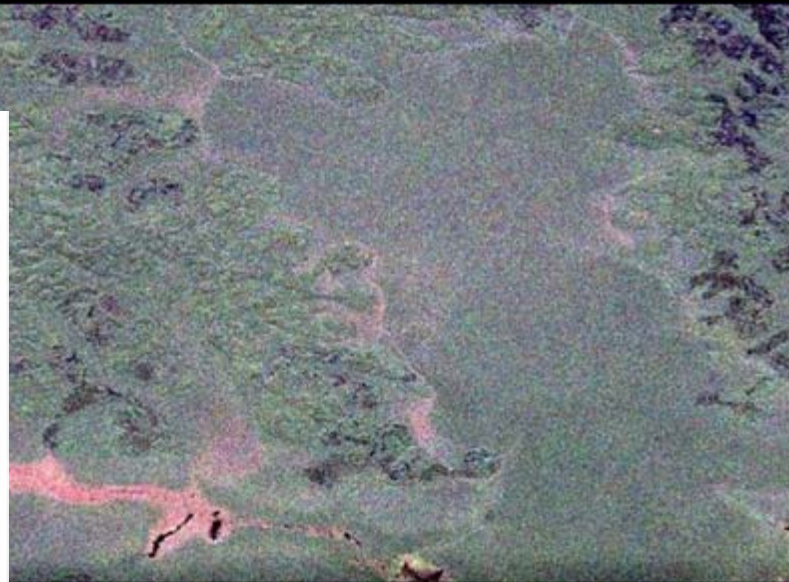
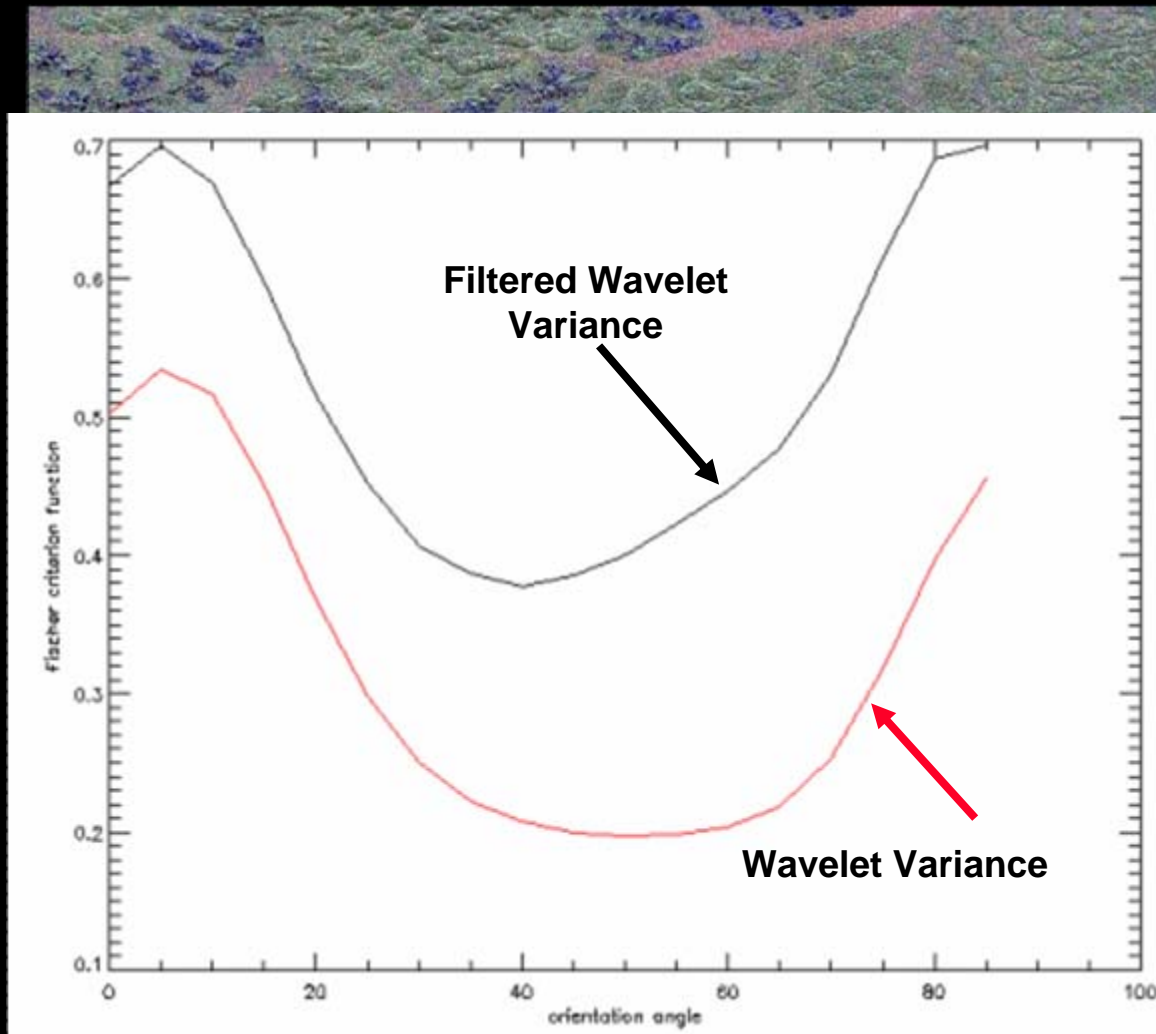
WASP ANALYSIS OF L-BAND PALSAR DATA

Theme: Swamp Forest Mapping in the Congo Floodplain



TEXTURAL FISCHER CLASS SEPARABILITY (WASPSEF)

Swamp Forest – Primary Rain Forest

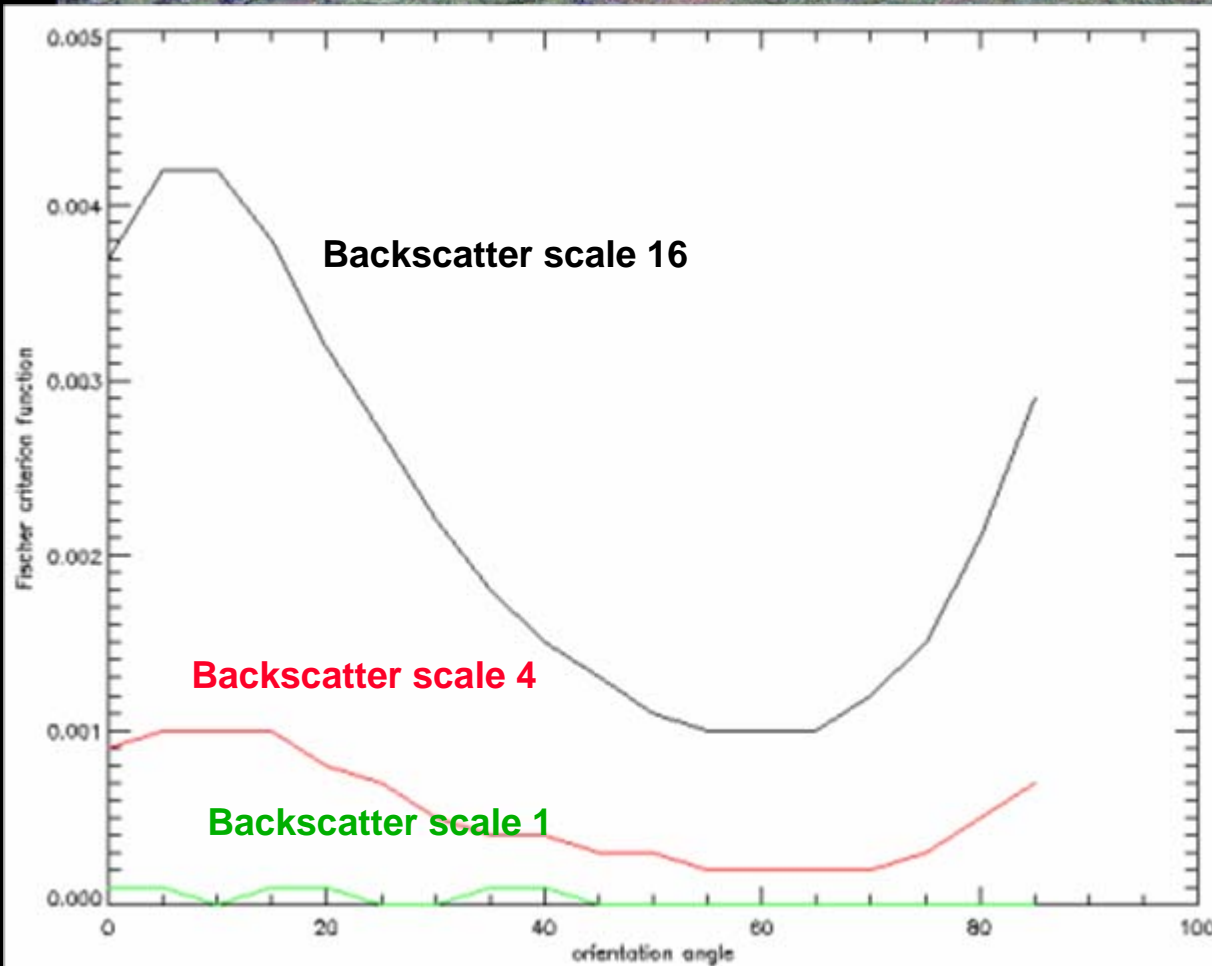


**ALOS PALSAR Fine Beam
Slant Range Full-Pol Data
(JAXA PI Program)**

Color Composite Pauli Decomposition Image
Red: double bounce
Green: volume
Blue: single bounce

BACKSCATTER FISCHER CLASS SEPARABILITY

Swamp Forest – Primary Rain Forest



ALOS PALSAR Fine Beam
Slant Range Full-Pol Data
(JAXA PI Program)

Color Composite Pauli Decomposition Image
Red: double bounce
Green: volume
Blue: single bounce

CONCLUSIONS – WEATHER FORECASTS



*È scherzo od è follia
codesta profezia....*

Is polarimetric texture
a prank or madness?

Experiments using WASP analysis indicate that indeed texture measures based on wavelet frames exhibit dependences on polarization state.

However, assessment of the usefulness of these measures in the passage from supervised analysis to segmentation problems in mapping applications still needs to be addressed in a systematic way and in different thematic contexts.

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