MAD change detection

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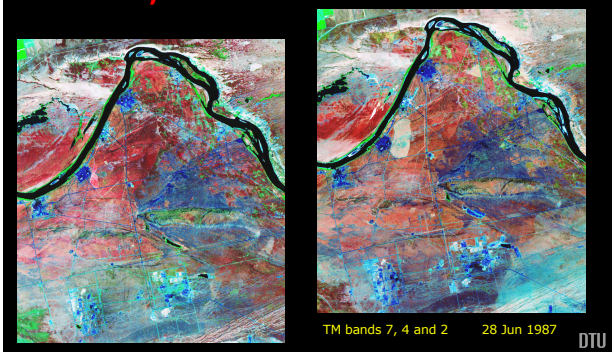
Change?

- Change occurs if differences between same spectral bands at two points in time are significantly different from zero
- Nature of noise: additive (optical) or multiplicative (radar), difference/ratio, zero/one
- Makes sense only if data are calibrated or normalized to same zero and scale
- MAD method (in a minute) invariant/insensitive to linear/affine scaling

MAD, data example

- Landsat-5 TM data from Hanford, Washington, USA
- 12 Aug 1983 and 28 Jun 1987 850 x 750 pixels (TM1 and 6 left out)
- Coregistration to rms-error of around 0.5 pixel
- Changes due to excavation and exploratory activities for waste disposal

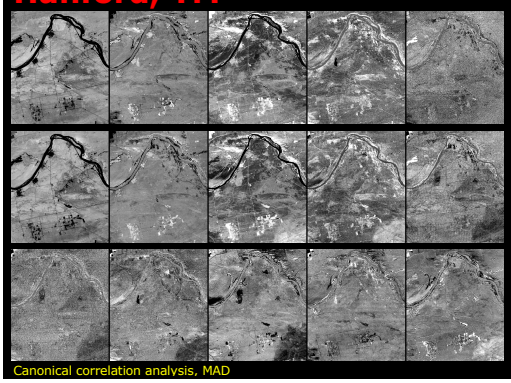
Hanford, TM



TM bands 7, 4 and 2 12 Aug 1983

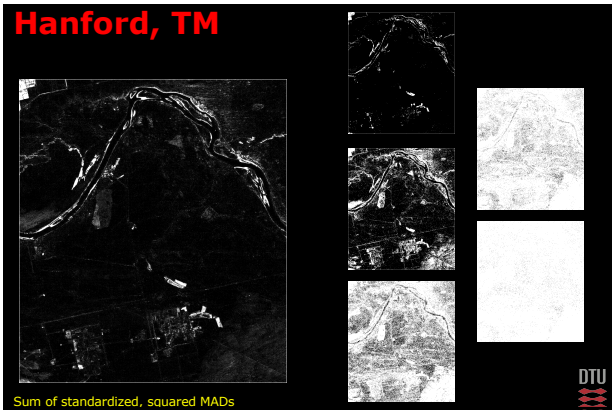
TM bands 7, 4 and 2 28 Jun 1987

Hanford, TM



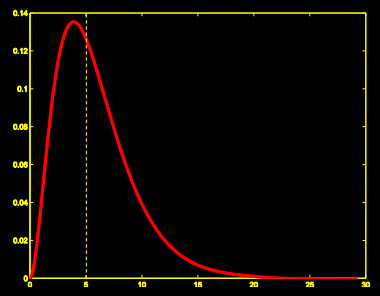
Canonical correlation analysis, MAD

Hanford, TM



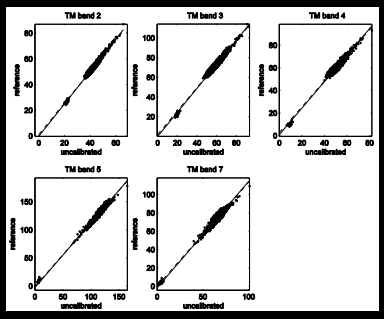
Sum of standardized, squared MADs

χ^2 pdf



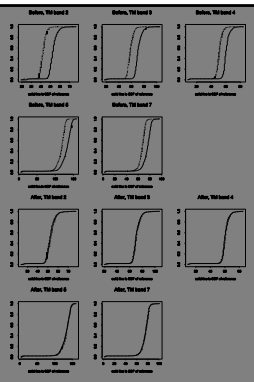
Number of degrees of freedom is 6

Hanford, TM



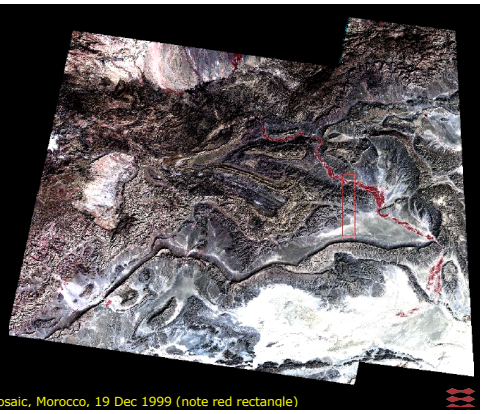
OLS and orthogonal regression of no-change (training) pixels for normalization

Hanford, TM



Orthogonal regression of no-change (test) pixels, CDFs

Mosaic



Landsat-7 ETM+ mosaic, Morocco, 19 Dec 1999 (note red rectangle)

Canonical correlation analysis

Maximize correlation between a^TX and b^TY with unit variance (px1 X and qx1 Y zero mean)

$$\begin{bmatrix} 0 & \Sigma_{12} \\ \Sigma_{21} & 0 \end{bmatrix} \begin{bmatrix} a \\ b \end{bmatrix} = \rho \begin{bmatrix} \Sigma_{11} & 0 \\ 0 & \Sigma_{22} \end{bmatrix} \begin{bmatrix} a \\ b \end{bmatrix}$$

$[a\ b]^T$ with ρ or $[a\ -b]^T$ with $-\rho$ (choose non-neg)

or

$$\Sigma_{12}\Sigma_{22}^{-1}\Sigma_{21}\ a = \rho^2\Sigma_{11}\ a$$
$$\Sigma_{21}\Sigma_{11}^{-1}\Sigma_{12}\ b = \rho^2\Sigma_{22}\ b$$

MAD analysis

- Subtract canonical variates with unit variance (in reverse order)

$$Z = a^TX - b^TY$$

- Invariant to linear and affine transformations in X and Y such as affine normalization or calibration
- Challenges
  - collinear variables (spectral data)
  - many variables (or few observations) as in hyperspectral data: (near) singular matrices
  - possible remedy: regularization or data reduction