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Problems in the fusion of commercial high-resolution satellite images as well as Landsat 7 images and Initial solutions

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Existing fusion algorithms

- **IHS fusion**
- **PCA fusion**
- **Ratio fusion**
- **Wavelet fusion**

Images fused with different methods

Shanghai

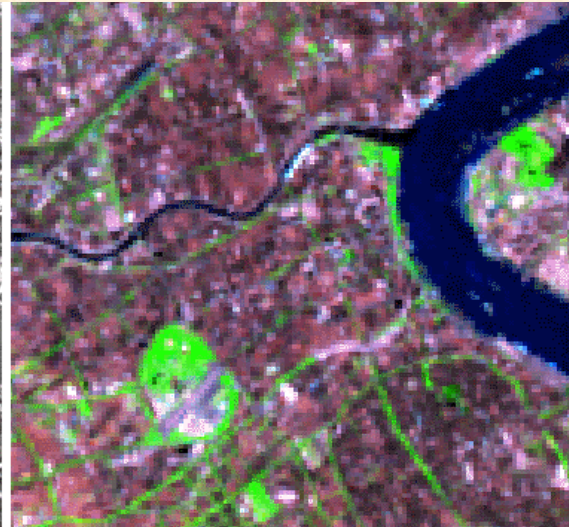
RVS method

(Regression Variable Substitution)

Original SPOT pan data



Original TM bands 3, 4 and 7



IHS method
(Intensity Hue Saturation)



SVR method
(Synthetic Variable Ratio)

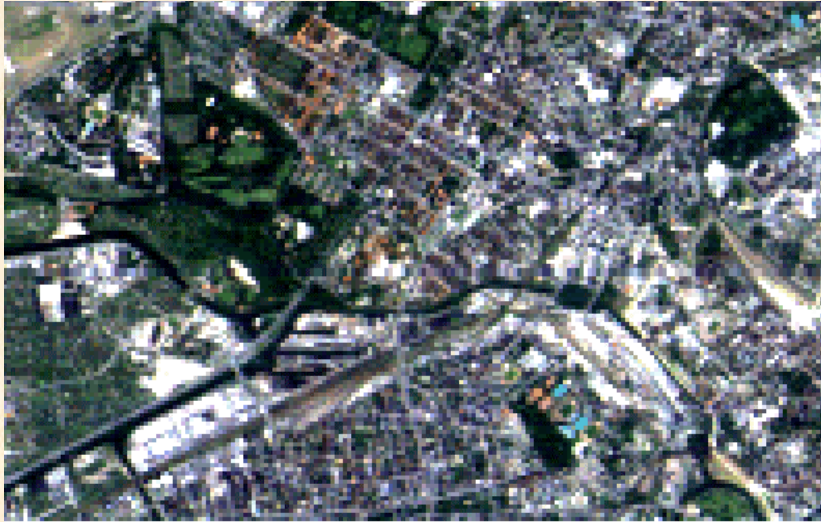


PCS method
(Principal Component Substitution)

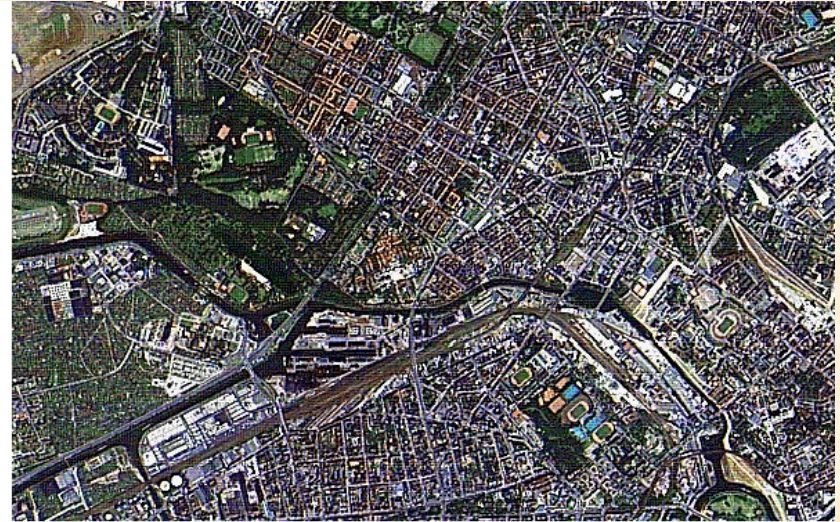
Images fused with different methods

Berlin

Original TM bands 1, 2 and 3



PCS method (Principal Component Substitution)



SVR method (Synthetic Variable Ratio)



IHS method (Intensity Hue Saturation)

Problems in IKONOS and Landsat 7 Fusion

Popular IHS Technique for IKONOS Fusion

IKONOS 4m
Multispectral



+



=

IHS Fused 1m IKONOS Image



• Significant Colour Distortion

IKONOS 1m Panchromatic

Further Examples of IHS for IKONOS Fusion



• Significant colour distortion

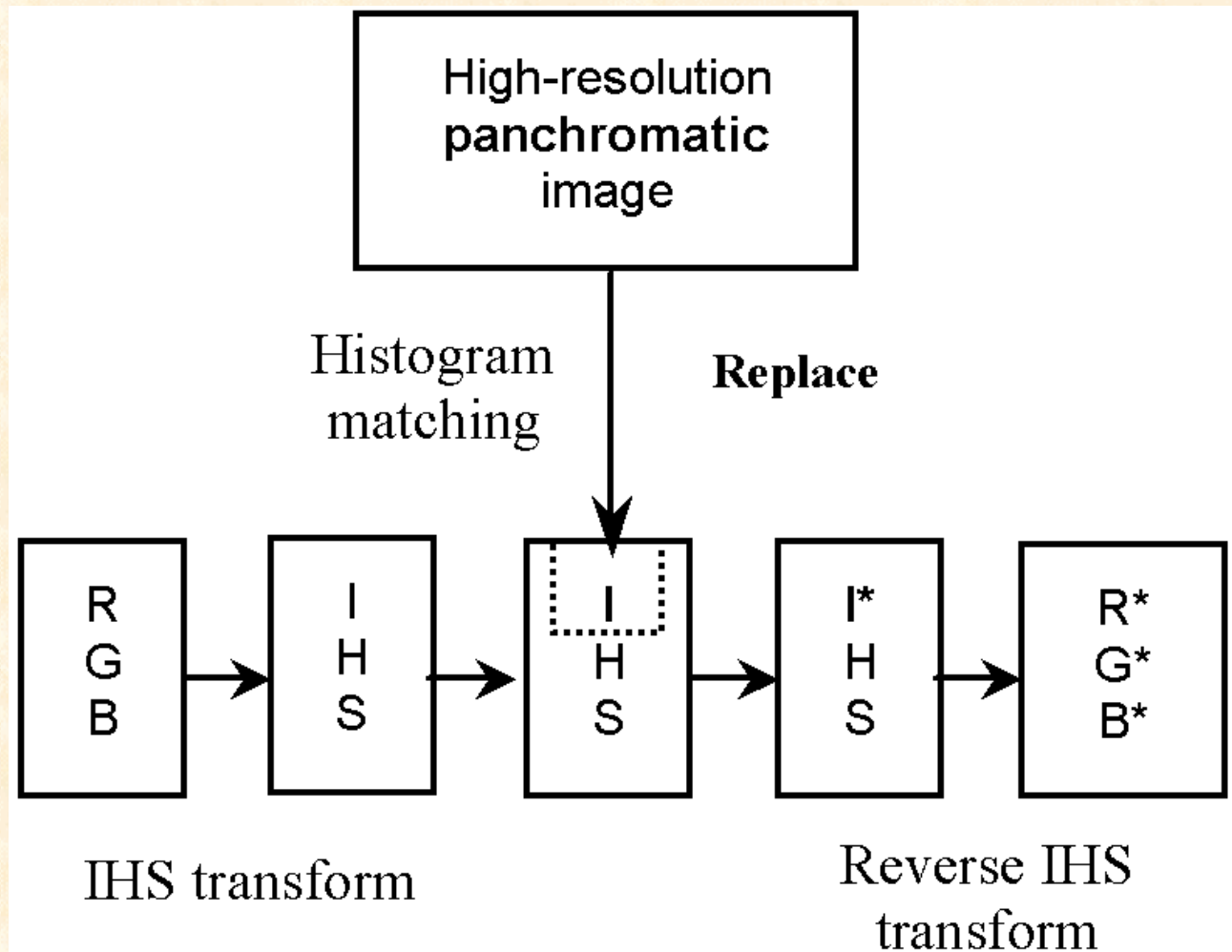
SVR Method for IKONOS Fusion

- Significant colour distortion

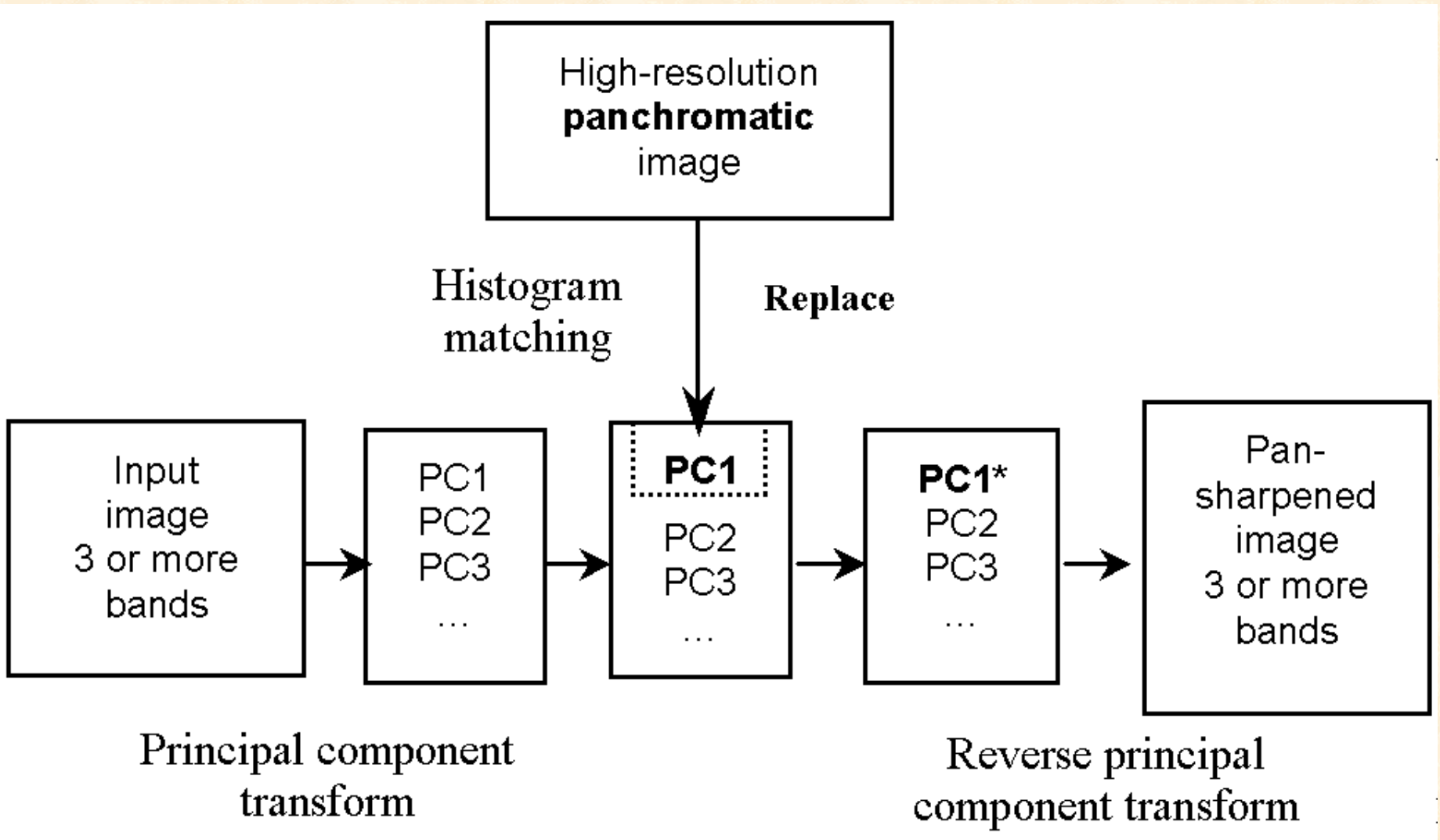


Algorithms Review

IHS Fusion



PCA Fusion (Principal Component Analysis)

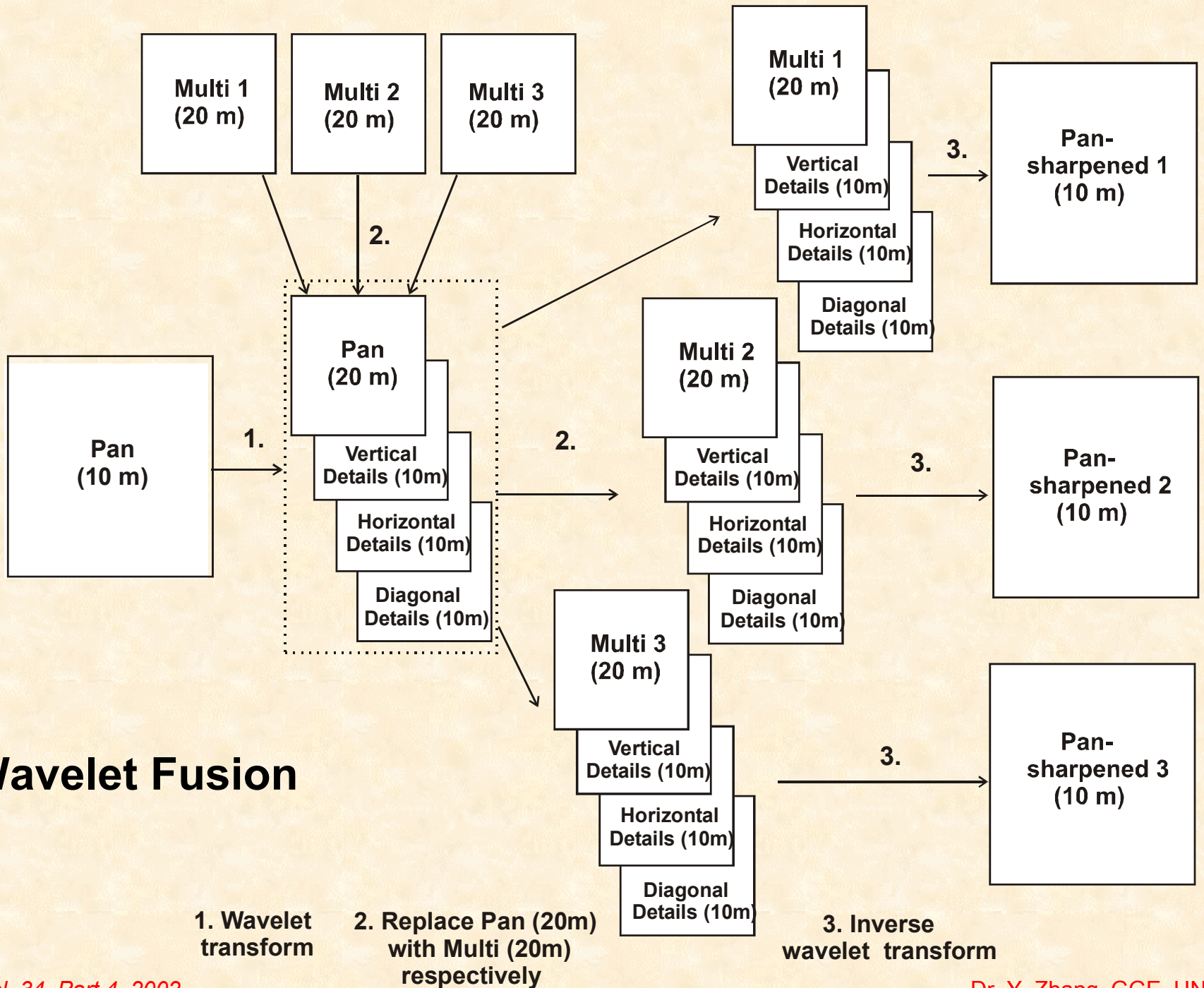


Ratio Fusion

Brovoy Transform (ERDAS 1999), SVR (Synthetic Variable Ratio), and RE (Ratio Enhancement) techniques

$$Fusion_i = \frac{Multi_i}{Multi_{Sum}} \times Pan$$

with $i = 1, 2$ and 3 , and $Multi_{Sum} = Multi_1 + Multi_2 + Multi_3$



Wavelet Fusion

1. Wavelet transform

2. Replace Pan (20m) with Multi (20m) respectively

3. Inverse wavelet transform

Reasons for Colour Distortion

Intensity (I) Image of IHS vs. Panchromatic Images



SPOT pan



IKONOS pan



I from IKONOS Bands 123

IKONOS PC1 and PC2 vs. Panchromatic Image



PC2 from IK bands 123



IKONOS Pan



PC1 from IK bands 123

Spectral Difference between conventional and new panchromatic images

Satellite sensor	Spectral range (μm)
SPOT 1, 2, 3 (HRV)	0.51 – 0.73
SPOT 5 (HRG)	0.51 – 0.73
IRS 1C, 1D (PAN)	0.50 – 0.75
Landsat 7 (ETM+)	0.52 – 0.90
IKONOS	0.45 – 0.90
QuickBird	0.45 – 0.90

Initial New Algorithms for Fusing IKONOS Images

- Statistics based
- Standardized
- No manual interaction

Initial new Technique for IKONOS Fusion

**IKONOS 4m
Multispectral**



+



IKONOS 1m Panchromatic

=

New 1 mIKONOS Fusion Image



• **Minimized Colour Distortion**

Initial New Technique for IKONOS Fusion



4m Multi-spectral

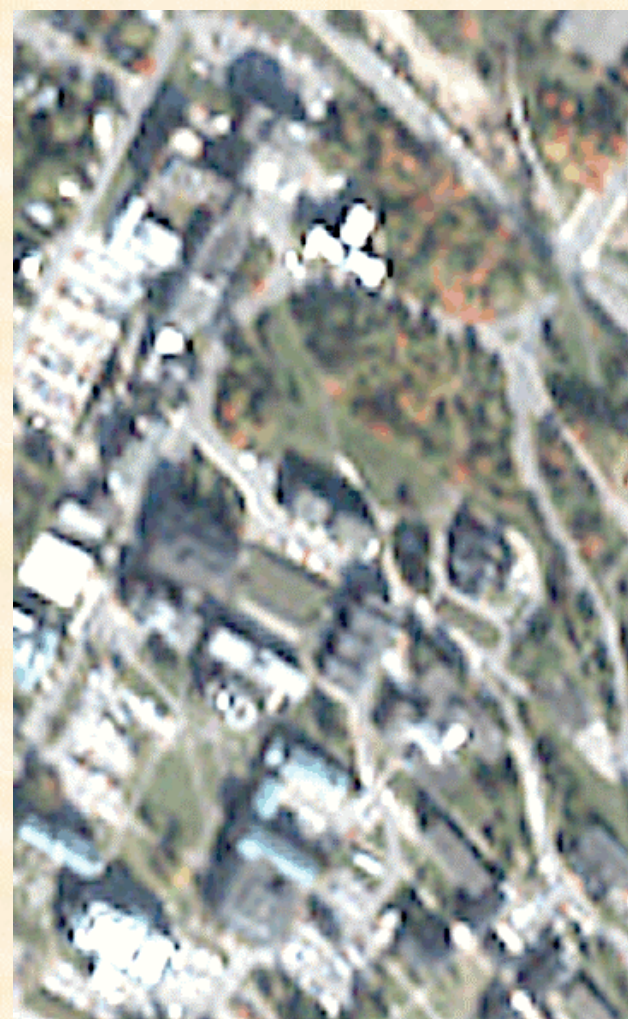


1m Panchromatic



New Fusion 1m Result

Automatic Fusion of Satellite Images



**IKONOS multispectral image
(4m resolution)**



**IKONOS panchromatic image
(1m resolution)**



**Fused IKONOS image
(1m resolution)**

Different Fusion Results of this Method



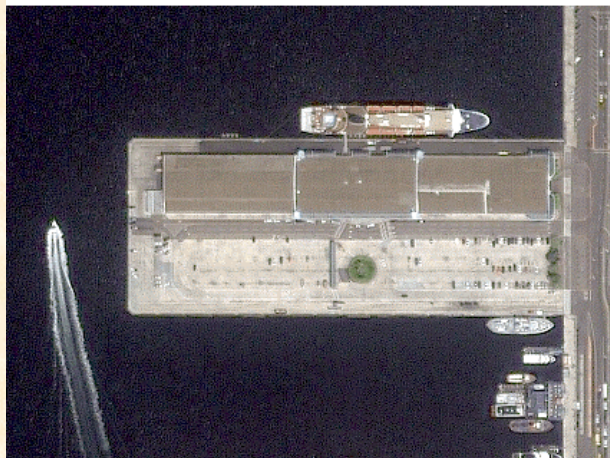
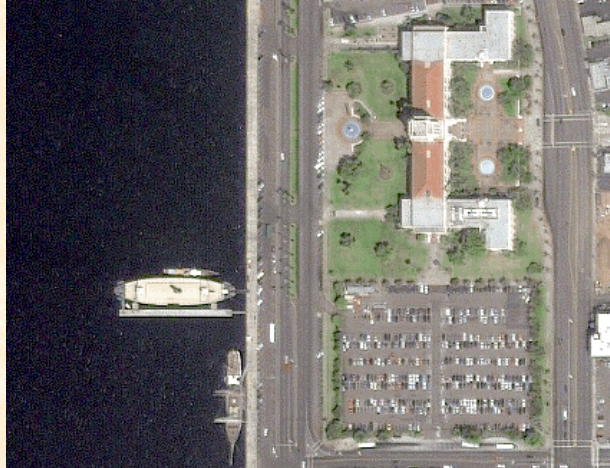
An Example of the New IKONOS Fusion

Fused 1m, result 3



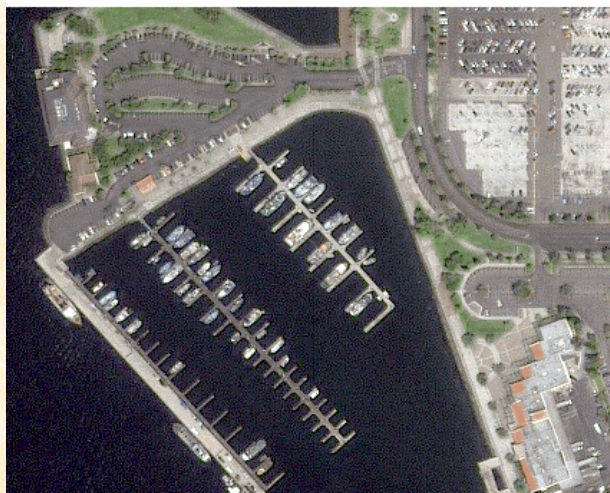
Some Highlights

Fused 1m, result 3

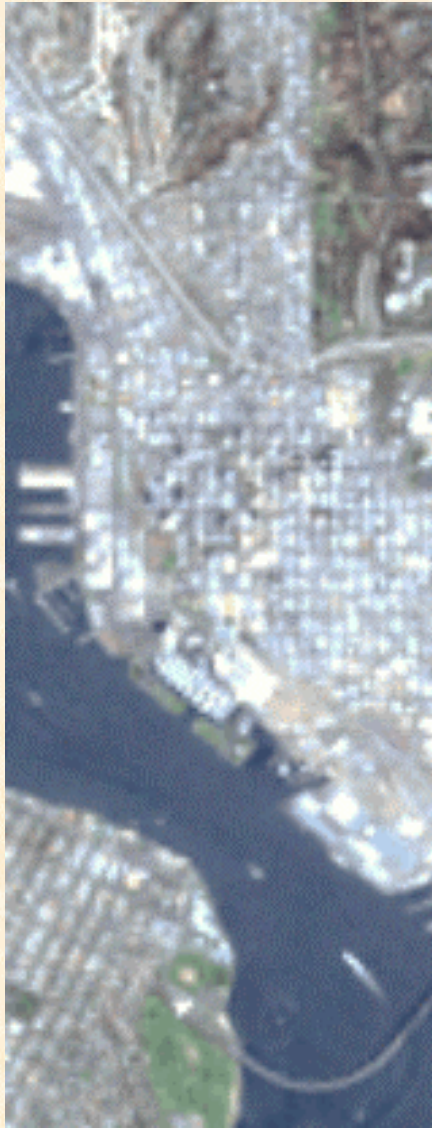


IKONOS Fusion

San Diego, USA



Landsat 7 ETM+ Image Fusion (Bands 1, 2 and 3)



30m Multispectral



15m Panchromatic



15m New Fusion Result

Landsat 7 ETM+ Image Fusion (Bands 2, 3 and 4)



30m Multispectral



15m Panchromatic



15m New Fusion Result

Landsat 7 ETM+ Image Fusion (Bands 3, 5 and 7)



30m Multispectral



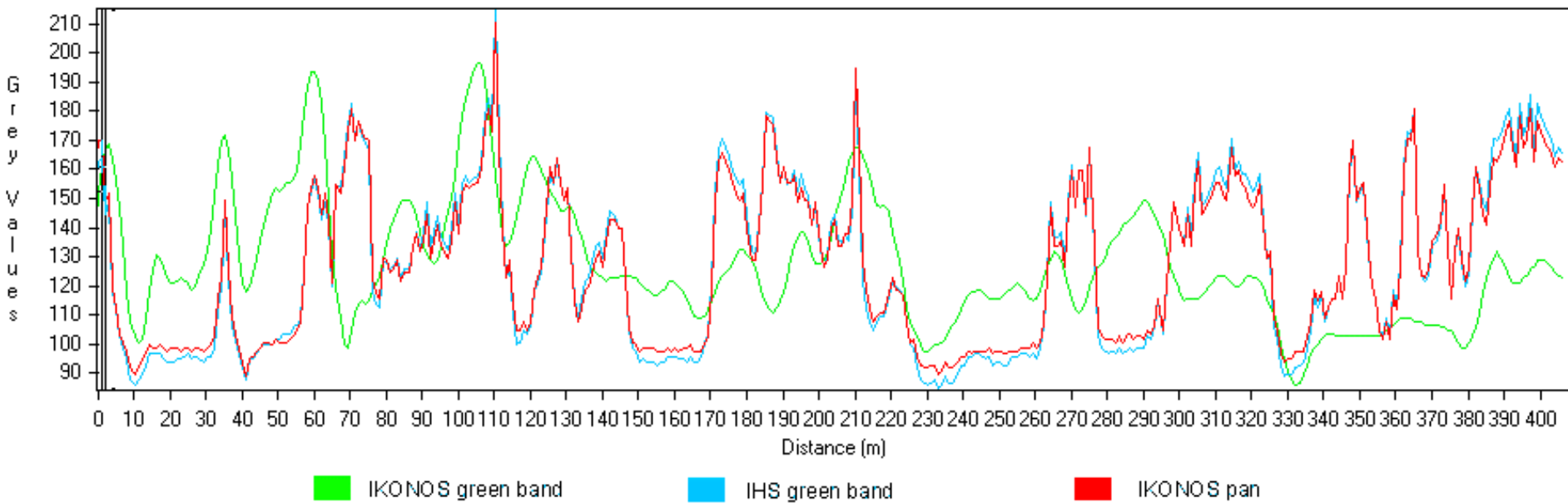
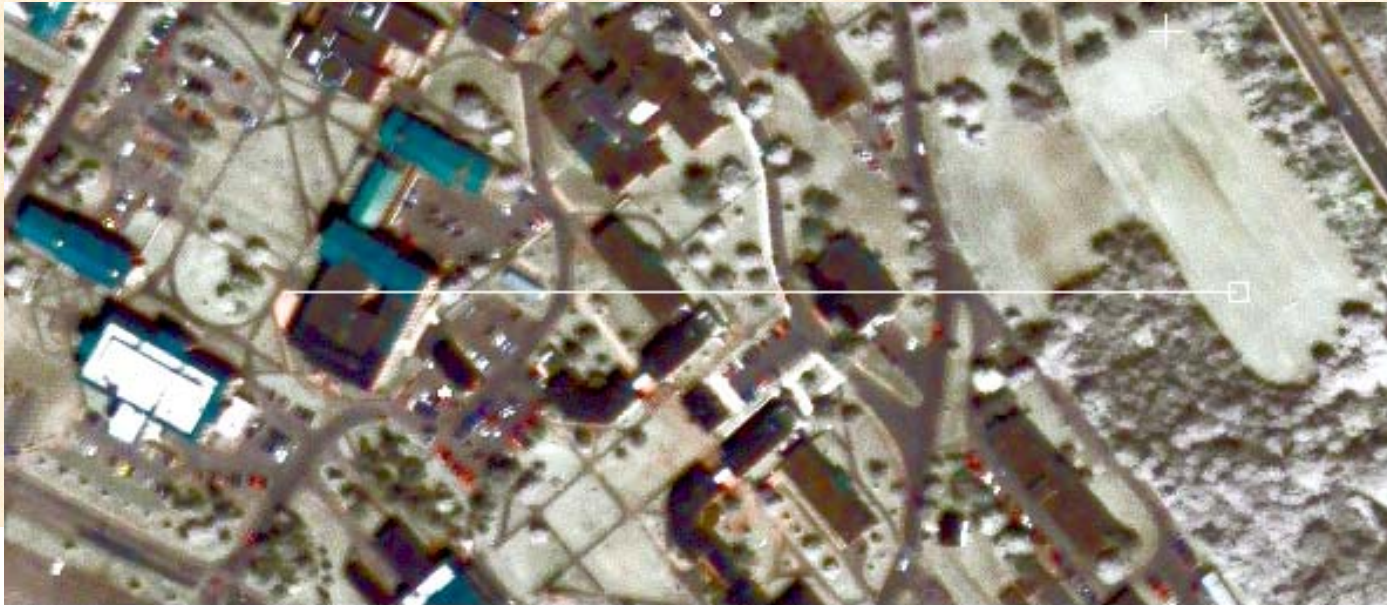
15m Panchromatic



15m New Fusion Result

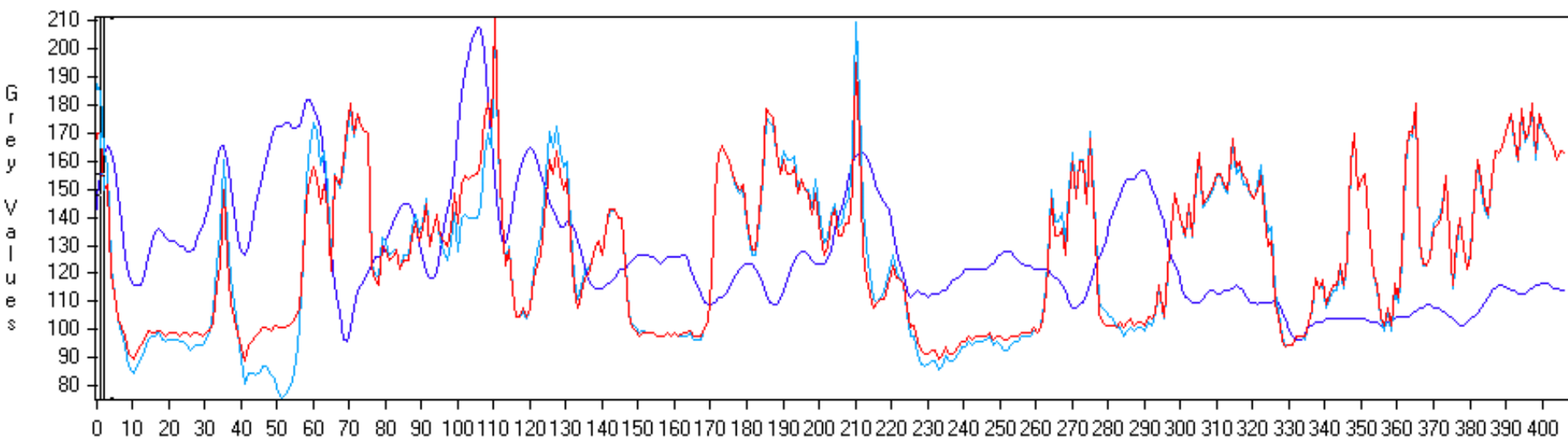
Spatial Profile Comparison

IHS fusion spatial profile

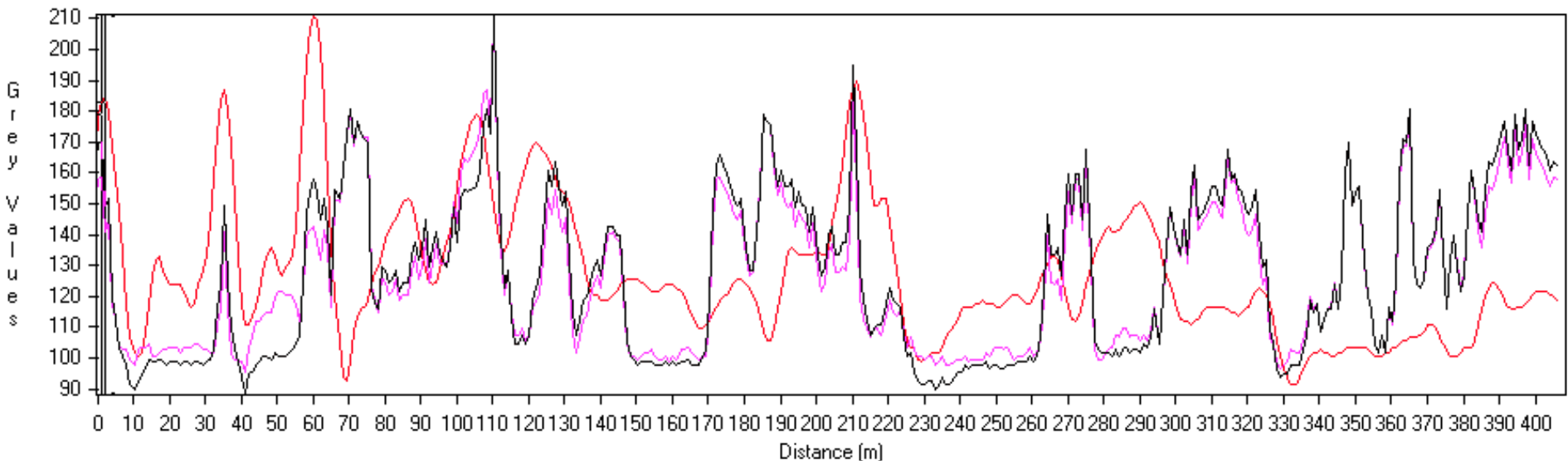


IHS fusion spatial profile

Sample Profile of Selected Channel(s)



Sample Profile of Selected Channel(s)

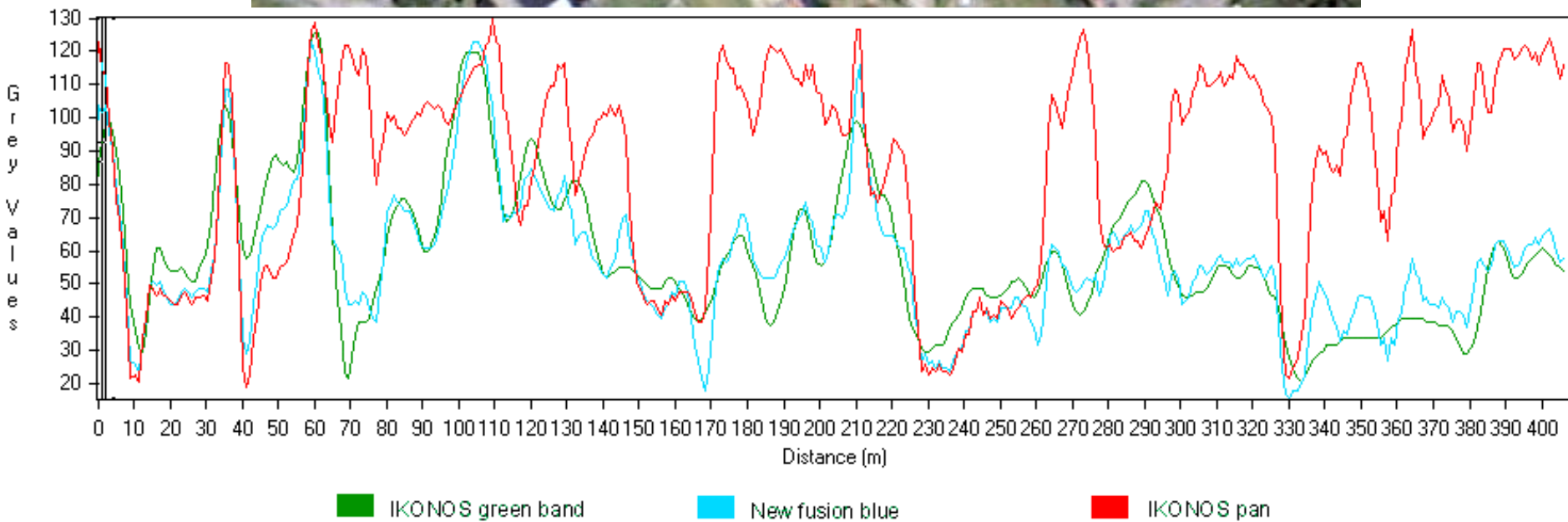


■ IKONOS red band

■ IHS fusion red band

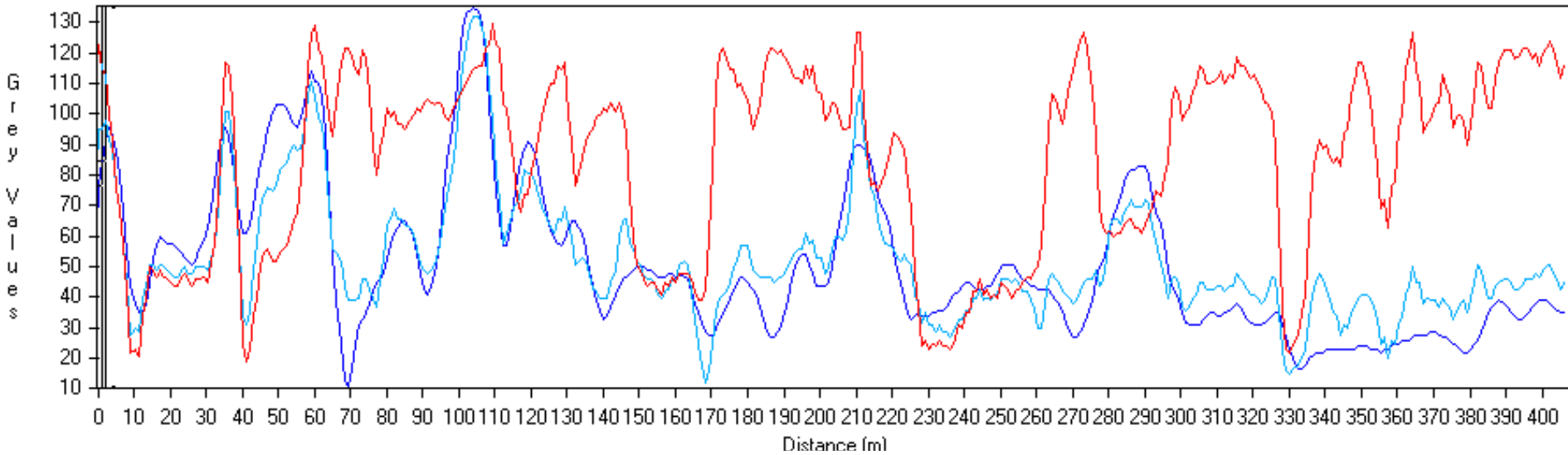
■ IKONOS pan

New fusion spatial profile

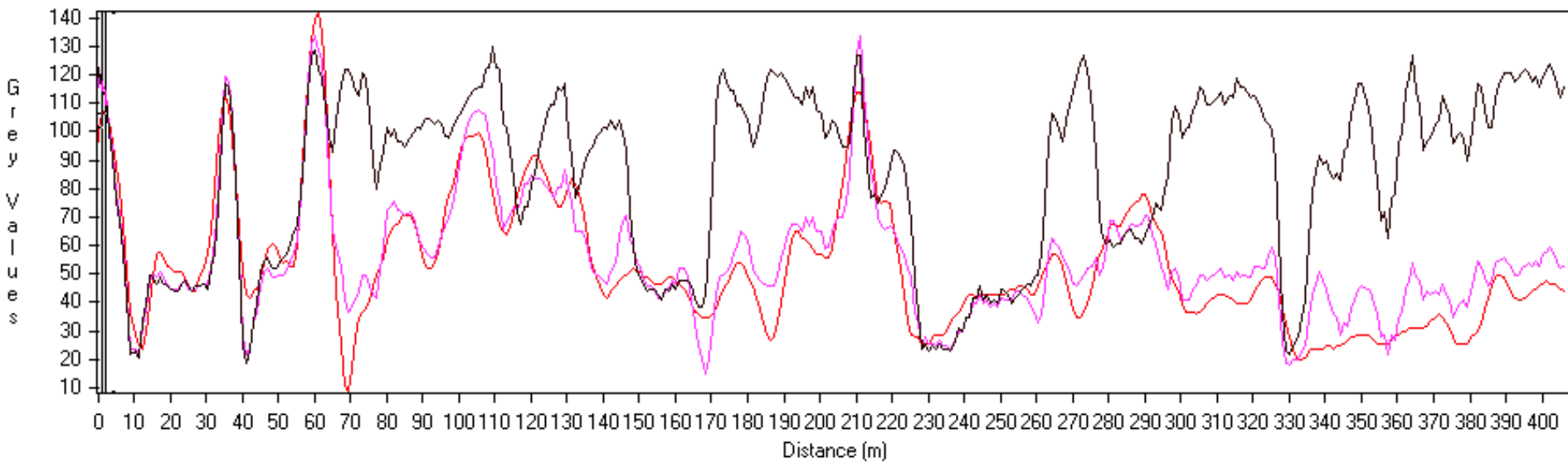



New fusion spatial profile

Sample Profile of Selected Channel(s)



Sample Profile of Selected Channel(s)



 IKONOS red band

 New fusion red band

 IKONOS pan

Conclusions

The new fusion technique has been tested with many IKONOS and Landsat 7 data sets covering different areas. The image sizes were more than 10,000 by 10,000 pixels.

All the fusions have shown a perfect result with:

- maximum detail increasing,
- minimum colour distortion, and
- natural colour and feature integration.

Acknowledgements:

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