Sentinel-2 Pan Sharpening Comparative Analysis

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2nd International Electronic Conference on Remote Sensing

22 Mart – 5 April 2018

ANADOLU UNIVERSITY

Overview

- Introduction
- Literature Review
- Data
- Methods
- Results
- Conclusion and Discussion

Pan-Sharpening

- Pan-sharpening is a technique of merging high-resolution panchromatic and lower resolution multispectral imagery to create a single high-resolution multispectral image.

- The panchromatic band is a grayscale image that covers/combines the visible portions of the electromagnetic spectrum.
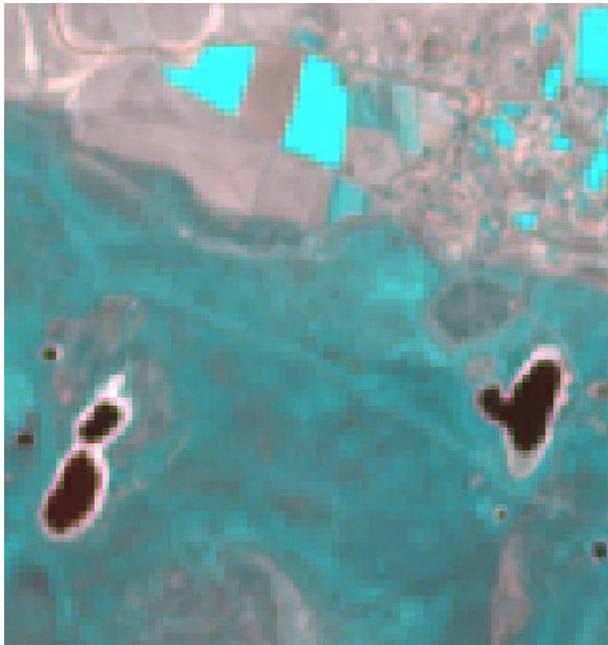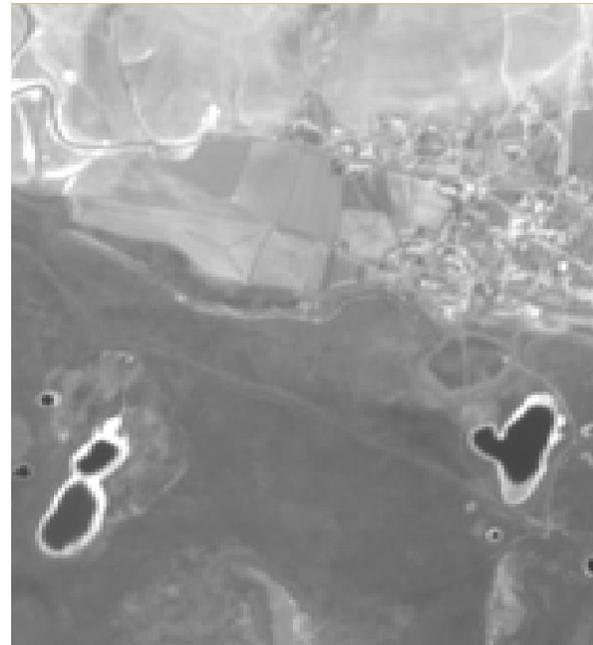
20-meters   10-meters   10-meters

Sentinel-2

Sentinel-2 Bands	Central Wavelength (µm)	Resolution (m)
Band 1 - Coastal aerosol	0.443	60
Band 2 - Blue	0.490	10
Band 3 - Green	0.560	10
Band 4 - Red	0.665	10
Band 5 - Vegetation Red Edge	0.705	20
Band 6 - Vegetation Red Edge	0.740	20
Band 7 - Vegetation Red Edge	0.783	20
Band 8 - NIR	0.842	10
Band 8A - Vegetation Red Edge	0.865	20
Band 9 - Water vapour	0.945	60
Band 10 - SWIR - Cirrius	1.375	60
Band 11 - SWIR	1.610	20
Band 12 - SWIR	2.190	20

20-meters Multispectral Image **+** 10-meters Panchromatic Image **=** 10-meters Multispectral Image
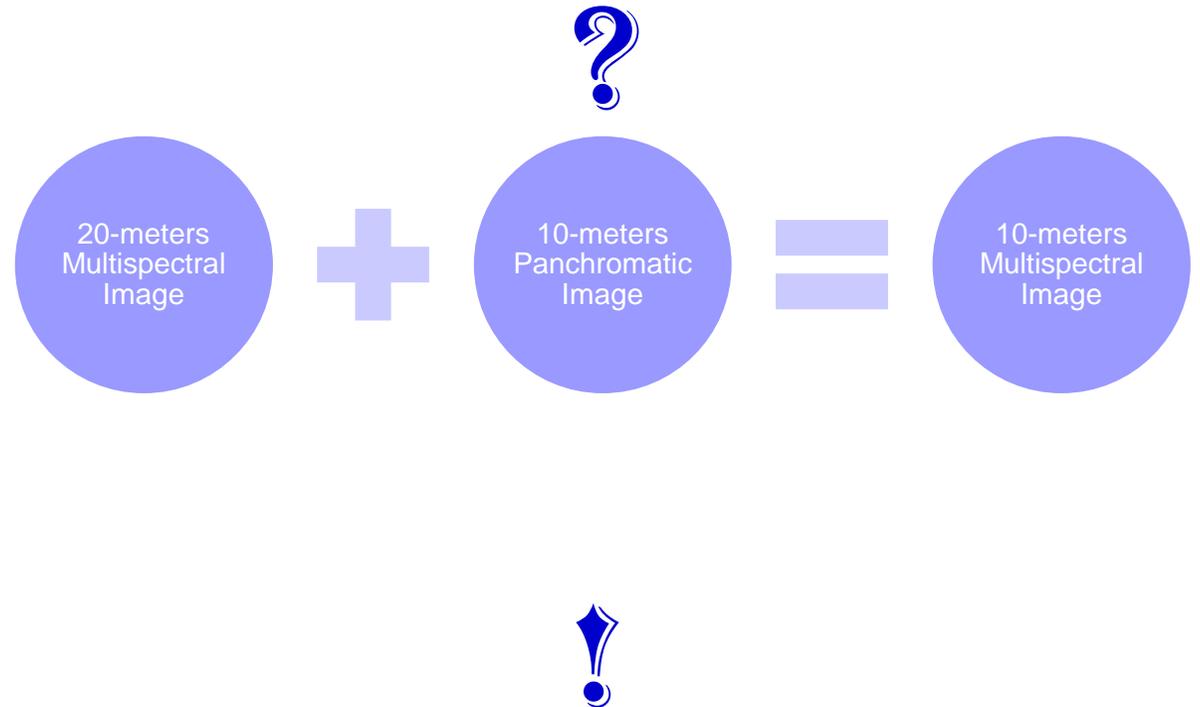
➢ Sentinel-2 does not offer panchromatic image.
➢ However, it does offer four 10-meter bands!

Sentinel-2 Panchromatic Band!!!

- Taking an advantage of the four fine spectral resolution bands, panchromatic band can be produced and used in the Sentinel-2 image fusion for producing ten fine spatial resolution bands!

I.   Selva et al. proposed averaging all four fine resolution bands in order to create a panchromatic band (Pan1).

II.   Gasparovic and Jogun used Band 8 for fusing Band 8A, 11 and 12, and used the average of Band 4 and Band 8 for the 5-7 Vegetation Red Edge bands (Pan2).

III. Weng at al. used Band 8 for fusing Band 6,7 and 8a, and Band 4 for fusing Band 5, 11 and 12 (Pan3).

Methods

■ In order to compare the three methods for producing panchromatic band, three different image fusion/pan Sharpening techniques have been performed on two Sentinel-2 images.

■ 60-meters Bands were not taken into consideration.

■ For the statistical comparison, Wald`s protocol was followed.

Sentinel-2
30 August 2016

Sentinel-2
10 August 2017

Layer Stack Band 5,6,7,8a,11,12

Producing Panchromatic Band

Producing Panchromatic Band

Layer Stack Band 5,6,7,8a,11,12

IHS, HPF, WPC Image Fusion Tecniques

Visual Comparison

Comparison

Statistical Comparison

Correlation Coefitient

Universal Image Quality Index

Relative Average Spectral Error

Spectral Angle Mapper

Results

Flowchart of the methodology

Results (Qualitative Analyses)

- Results for a sub-area from the 10.08.2017 image (RGB − 12, 8a, 5); a) 20 m image; b) Pan 1; c) Average value from Band 4 and Band 8; d) IHS − Pan1; e) HPF − Pan1; f) WPC − Pan1; g) IHS − Pan2; h) HPF − Pan2; i) WPC − Pan2; j) IHS − Pan1; k) HPF − Pan1; l) WPC − Pan1.

- HPF results lead to spectral distortion.

- Spectral distortion can be also noticed in the WPC results where the urban features cannot be clearly observed.

- The IHS results tend to be superior over WPC and HPF in that order.
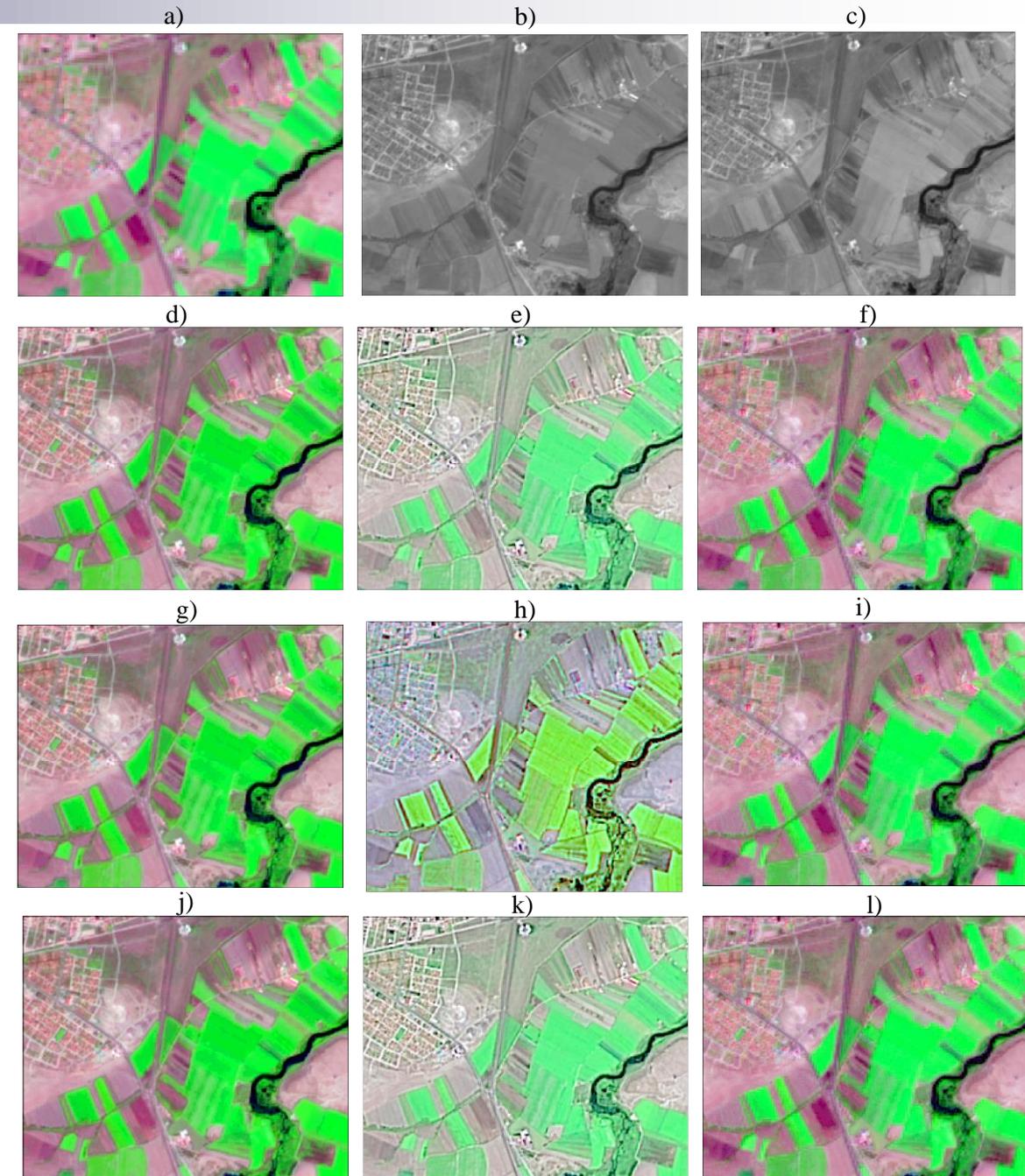
Results (Quantitative Analyses)

- **Table 1.** Quantitative analyses of the image fusion techniques for the 30.08.2016 image

		CC	UIQI	RASE	SAM
Ideal		1	1	0	0
IHS	Pan1	0.935	0.942	2.17	0.019
	Pan2	0.947	0.943	4.40	0.019
HPF	Pan1	0.943	0.933	1.49	0.020
	Pan2	0.952	0.952	4.16	0.018
WPC	Pan1	0.971	0.923	1.36	**0.001**
	Pan2	**0.987**	**0.983**	1.81	0.009

- Table 2. Quantitative analyses of the image fusion techniques for the 10.08.2017 image

		CC	UIQI	RASE	SAM
Ideal		1	1	0	0
IHS	Pan1	**0.992**	**0.990**	**2.23**	**0.029**
	Pan2	0.968	0.959	2.75	0.030
	Pan3	0.989	0.979	2.38	0.040
HPF	Pan1	**0.990**	**0.981**	**2.23**	**0.028**
	Pan2	0.966	0.956	2.70	0.191
	Pan3	0.956	0.953	2.71	0.231
WPC	Pan1	0.966	0.956	2.70	0.026
	Pan2	0.996	0.987	1.75	0.018
	Pan3	**0.998**	**0.989**	**1.64**	**0.017**

Results (Quantitative Analyses)

- **Table 3.** Quantitative analyses of the image fusion techniques for Band 6 of the 10.08.2017 image

		Bias	CC	UIQI	SAM
Ideal	Pan	0	1	1	0
IHS	Avg	28.26	0.987	0.977	0.030
	(Red+NIR)/2	29.38	**0.990**	**0.980**	**0.030**
	NIR	31.12	0.989	0.980	0.039
HPF	Avg	1.013	0.966	0.954	0.193
	(Red+NIR)/2	0.97	**0.967**	**0.953**	**0.028**
	NIR	0.81	0.966	0.953	0.205
WPC	Avg	22.66	0.997	0.989	0.020
	(Red+NIR)/2	27.01	0.998	0.987	0.018
	NIR	23.25	**0.998**	**0.990**	**0.015**

Conclusion

- All of the panchromatic bands are able to produce accurate results in downscaling Sentinel-2 20-m bands. In two out of three cases the first method was superior, while in the third case the results of the second and third methods were almost identical.
- Using a single panchromatic band is less time consuming and more practical.
- For the two images used in this paper, the superior fusion method was WPC with almost ideal CC (0.998) and SAM (0.001) values.
- Band 6 is best fused with a panchromatic band produced as an average value from Band 4 and Band 8.

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Thank you for your attention !

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