Seasonal Variations of Water Radiometric Indices in Soil Moisture Content Estimation in Arid Environment, Saudi Arabia

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جمعية علوم وتقنية المياه

Water Sciences and Technology Association

Overview

- Introduction
- Objectives
- Study area
- Methodological framework
- Findings
- Conclusions

Introduction

Remote Sensing Data

- Satellite images offer a large amount of data that could be analyzed
- Convenient source to perform several water indices
- Spectral reflectance variabilities tend to estimate different soil water relationships

Spectral Indices

- Spectral radiometrics indices are mathematical combinations of different spectral bands mostly in the visible and near-infrared regions of the electromagnetic spectrum
- Water radiometrics indices can be measured comprehensively through semi-analytical methods of spectral band ratios

Introduction

Remote Sensing

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Water Indices

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Soil Moisture Content

Objectives

Regression Analysis

Ground Truth Data

Radiometric Water Indices

Realization of GTD/RWI relationship

Monitoring of Soil Moisture Content

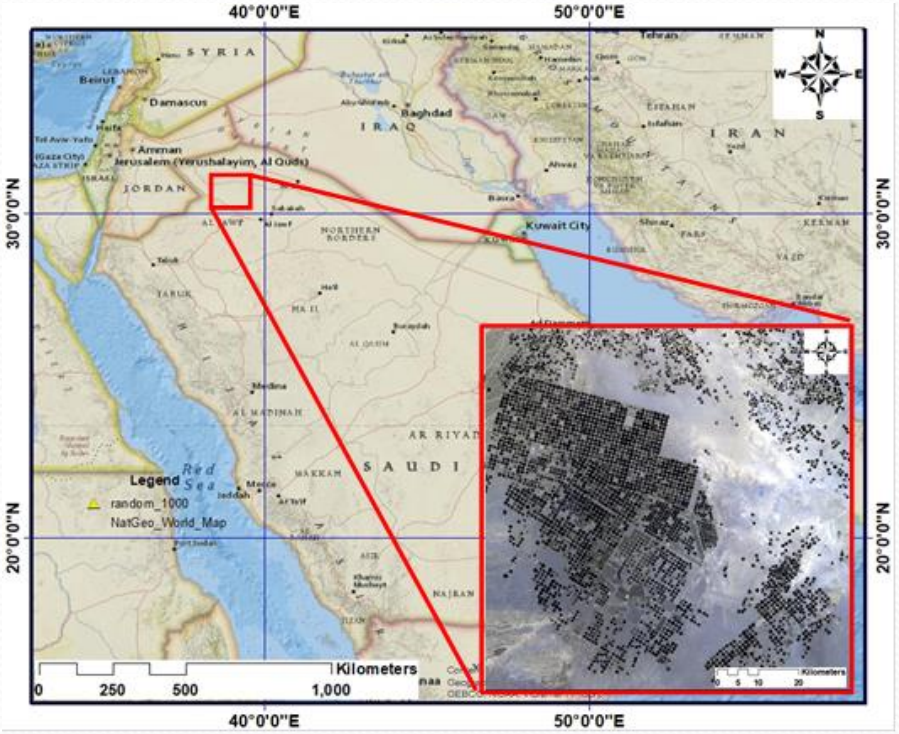
Study area

Agriculture in Wadi Al Sirhan area consists of technically highly developed farm enterprises that operate with modern pivot irrigation system.

All year fodder consists of alfalfa, which is cut up to 10 times a year for food.

The shallow alluvial aquifers could not sustain the high groundwater abstraction rates for a long time.

The groundwater level declined dramatically in most areas from 120 to almost 400 m deep.



The location of the study area in false color composite

Methodological framework

Estimation of soil water content

- *Volumetric method*
- *Gravimetric method*

Estimation of soil water indices

- *Normalized Difference Water Index (NDWI)*
- *Modified Normalized Difference Water Index (MNDWI)*
- *Normalized Difference Pond Index (NDPI)*
- *Normalized Difference Turbidity Index (NDTI)*

Regression Analysis

- *Principle Component Analysis (PCA)*
- *Artificial Neural Network (ANN)*

Validation

- *Stratified Random Sampling was adopted to create the ground truth data location*
- *To avoid data clumping, minimum distance of 600 meters was set as a rule for the SRS*
- *150 soil samples were analyzed for gravimetric soil water content*

Water Indices

Normalized Difference Water Index (NDWI)

$$NDWI = \frac{NIR - SWIR}{NIR + SWIR}$$

Modified Normalized Difference Water Index (MNDWI)

$$MNDWI = \frac{Green - SWIR}{Green + SWIR}$$

Normalized Difference Pond Index (NDPI)

$$NDPI = \frac{SWIR - Green}{SWIR + Green}$$

Normalized Difference Turbidity Index (NDTI)

$$NDTI = \frac{Red - Green}{Red + Green}$$

Soil Water Content

Weight approach

$$\theta_d = \frac{wt\ of\ wet\ soil - wt\ of\ dry\ soil}{wt\ of\ dry\ soil}$$

Mass approach

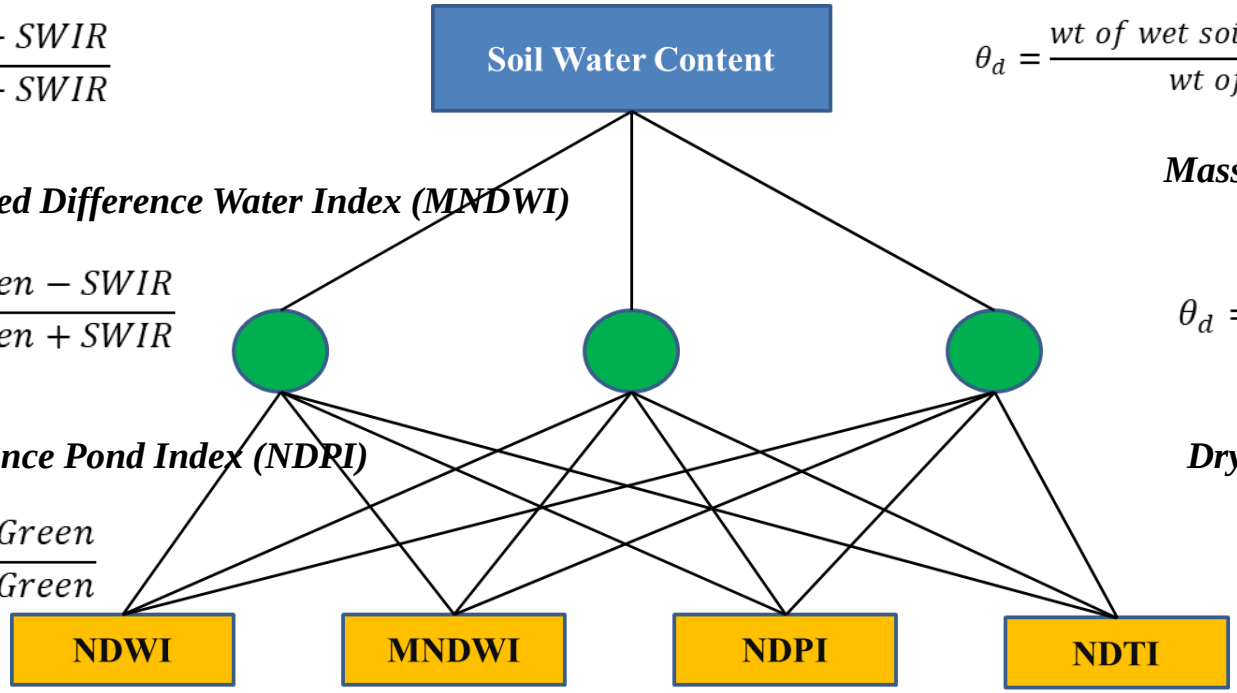
$$\theta_d = \frac{wt\ of\ water}{wt\ of\ dry\ soil}$$

Dry approach

$$\theta_d = \frac{\theta_w}{1 - \theta_w}$$

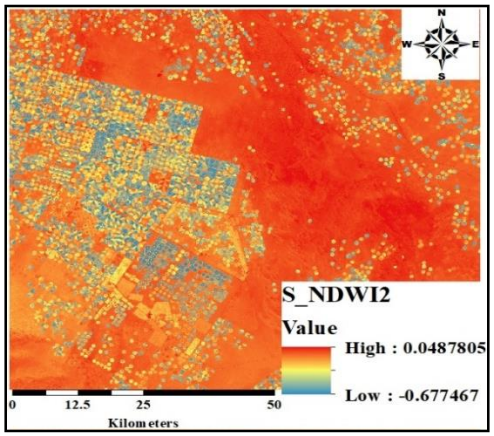
Wet approach

$$\theta_w = \frac{\theta_d}{\theta_d + 1}$$

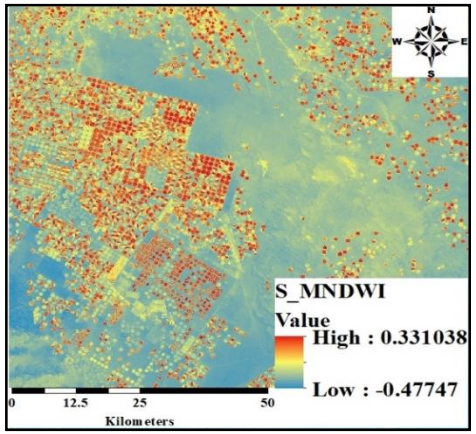


Artificial Neural Network (ANN)

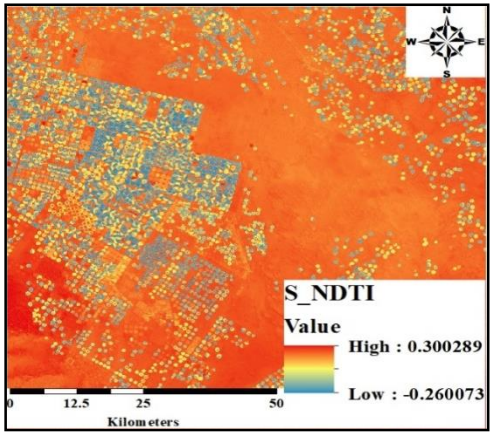
Summer Findings



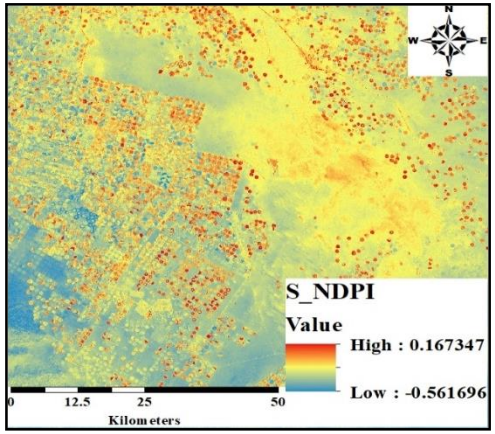
Normalized Difference Water Index (NDWI)



M-Normalized Difference Water Index (MNDWI)

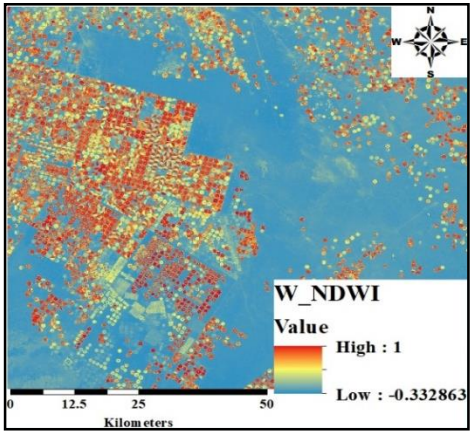


Normalized Difference Turbidity Index (NDTI)

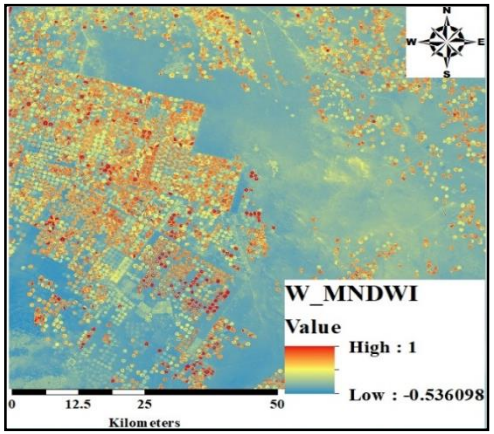


Normalized Difference Pond Index (NDII)

Winter Findings



Normalized Difference Water Index (NDWI)



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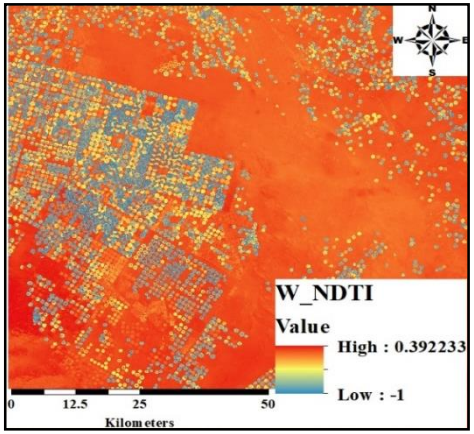
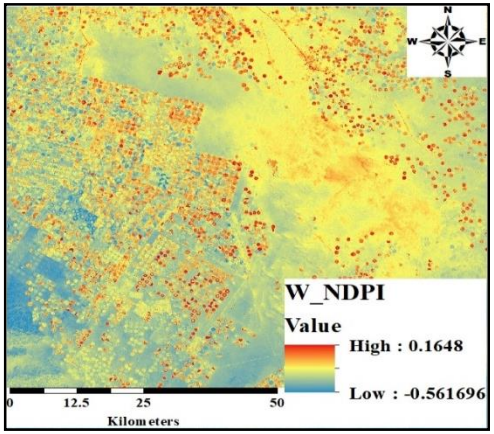


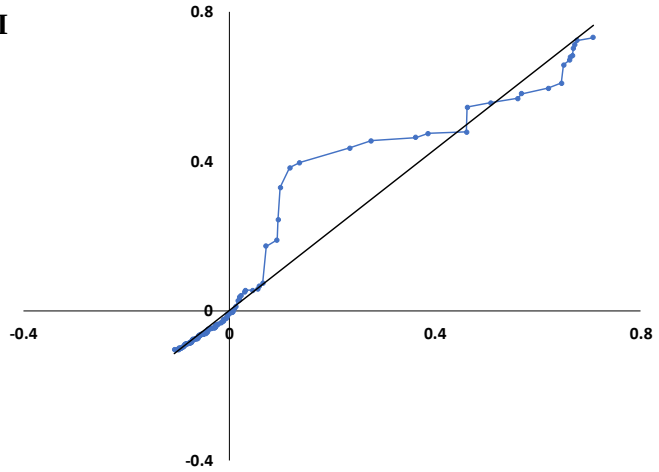
Normalized Difference Turbidity Index (NDWI)



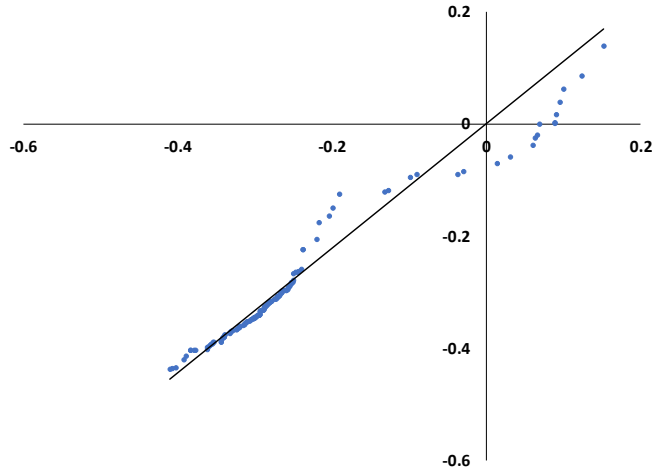
Normalized Difference Pond Index (NDPI)

Findings

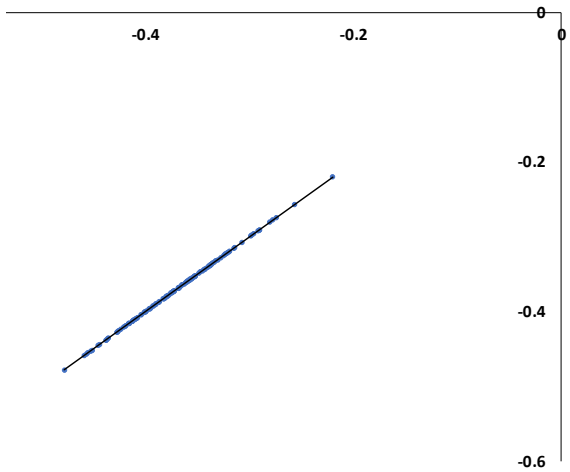
NDWI



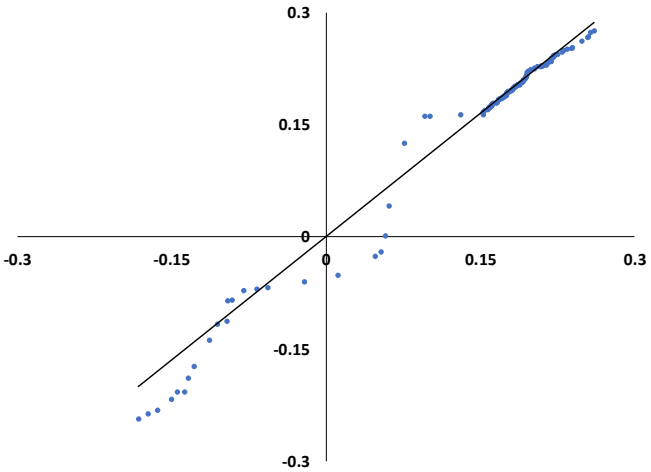
MNDWI



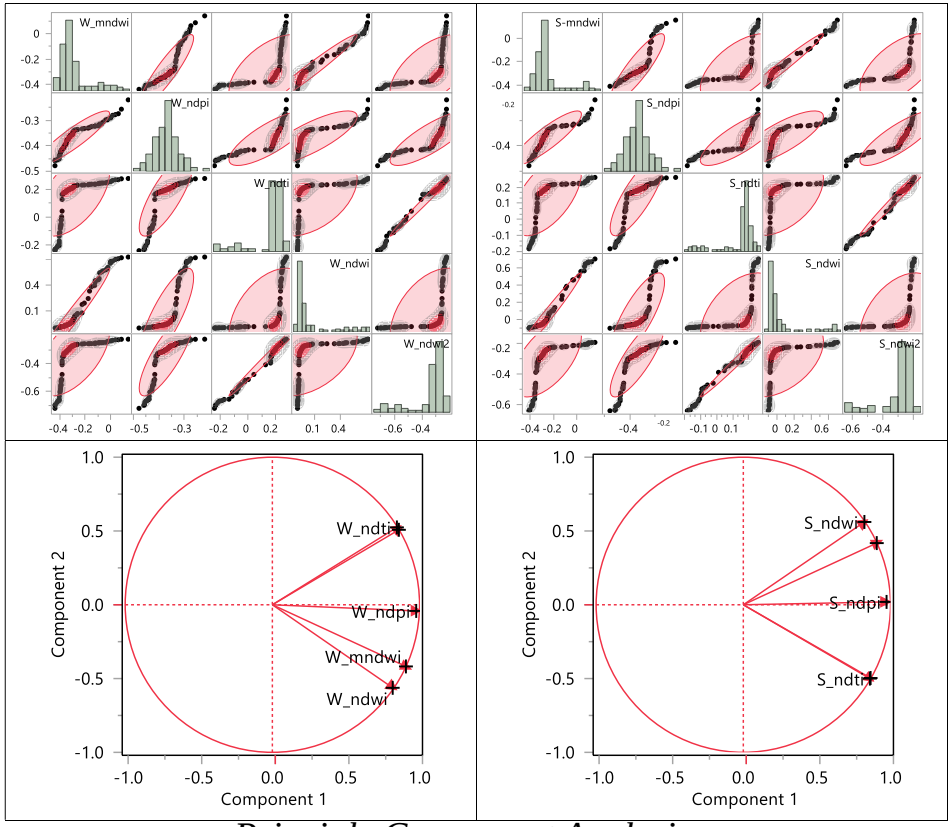
NDPI



NDTI



Findings

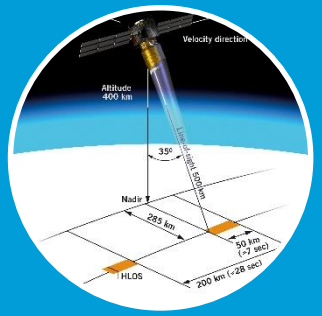


Principle Component Analysis

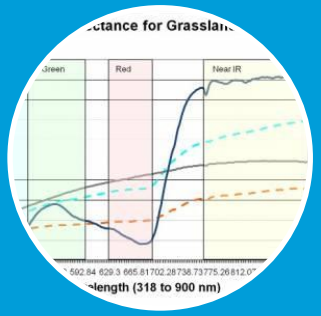
		Training Measures	Validation Measures
MNDWI	RSquare	0.7574526	0.6698156
	RMSE	**0.0999530**	0.0972931
	Mean Abs Dev	0.0571881	0.0436599
	-LogLikelihood	**-88.411680**	-45.554430
	SSE	0.9990600	0.4732975
	Sum Freq	100	50
NDWI	RSquare	0.3032101	0.0893892
	RMSE	0.2388872	0.1869959
	Mean Abs Dev	0.1203075	0.0628425
	-LogLikelihood	-1.2825260	-12.886510
	SSE	5.7067096	1.7483727
	Sum Freq	100	50
NDPI	RSquare	0.7565419	0.6698155
	RMSE	0.1499295	0.1459397
	Mean Abs Dev	0.0857822	0.0654899
	-LogLikelihood	-47.865170	-25.28115
	SSE	2.2478847	1.0649203
	Sum Freq	100	50
NDTI	RSquare	0.7533827	0.6619429
	RMSE	0.0003280	0.0003226
	Mean Abs Dev	0.0001876	0.0001451
	-LogLikelihood	-660.35100	-331.01460
	SSE	1.08E-05	5.20E-06
	Sum Freq	100	50

Neural Network Analysis

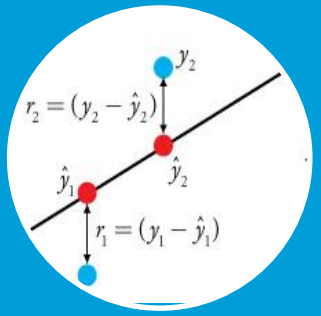
Conclusion & Recommendations



Remote Sensing techniques were satisfactorily implemented and interpreted in term of soil moisture mapping in consort with radiometric water indices



Modified Normalized Difference Water Index was statistically successful to represent soil moisture content in winter condition rather than summer condition. Normalized Difference Pond Index showed no temporal variation.



Principal Component Analysis and Artificial Neural Network Analysis are complementary tools to understand the regression pattern of the radiometric water indices in the designated study area

Time Series Analysis for better regression stability

Thanks for your attention