

Comparison of Sentinel-2 and Landsat-8 in Assessing Vegetation Response to Soil Moisture Variation in Droughty Environments


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Introduction

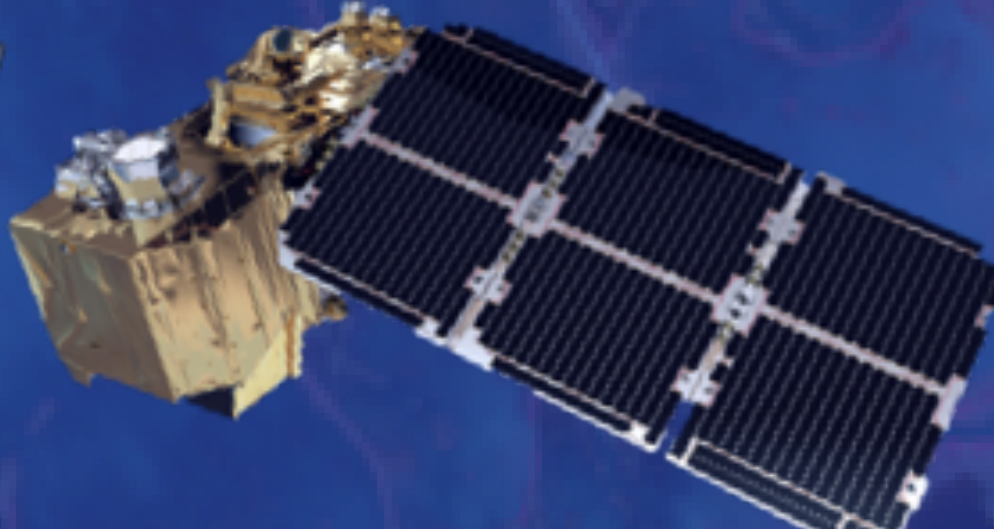
Initial indications are that the enhanced spatial and spectral resolution of Sentinel-2 MSI would allow for better assessment of vegetation condition, and consequently improved application in conditions of drought.

Although NDVI and other indices are well established methods in drought monitoring, little research has examined the suitability of Sentinel-2 (S2). While the utility of Landsat-8 (LS8) NDVI in revealing local scale plant-soil dynamics has been explored, challenges around resolution have emerged.



Landsat-8

Visible & NIR - 30m



Sentinel-2

Visible & NIR - 10m + 4x20m Narrow NIR

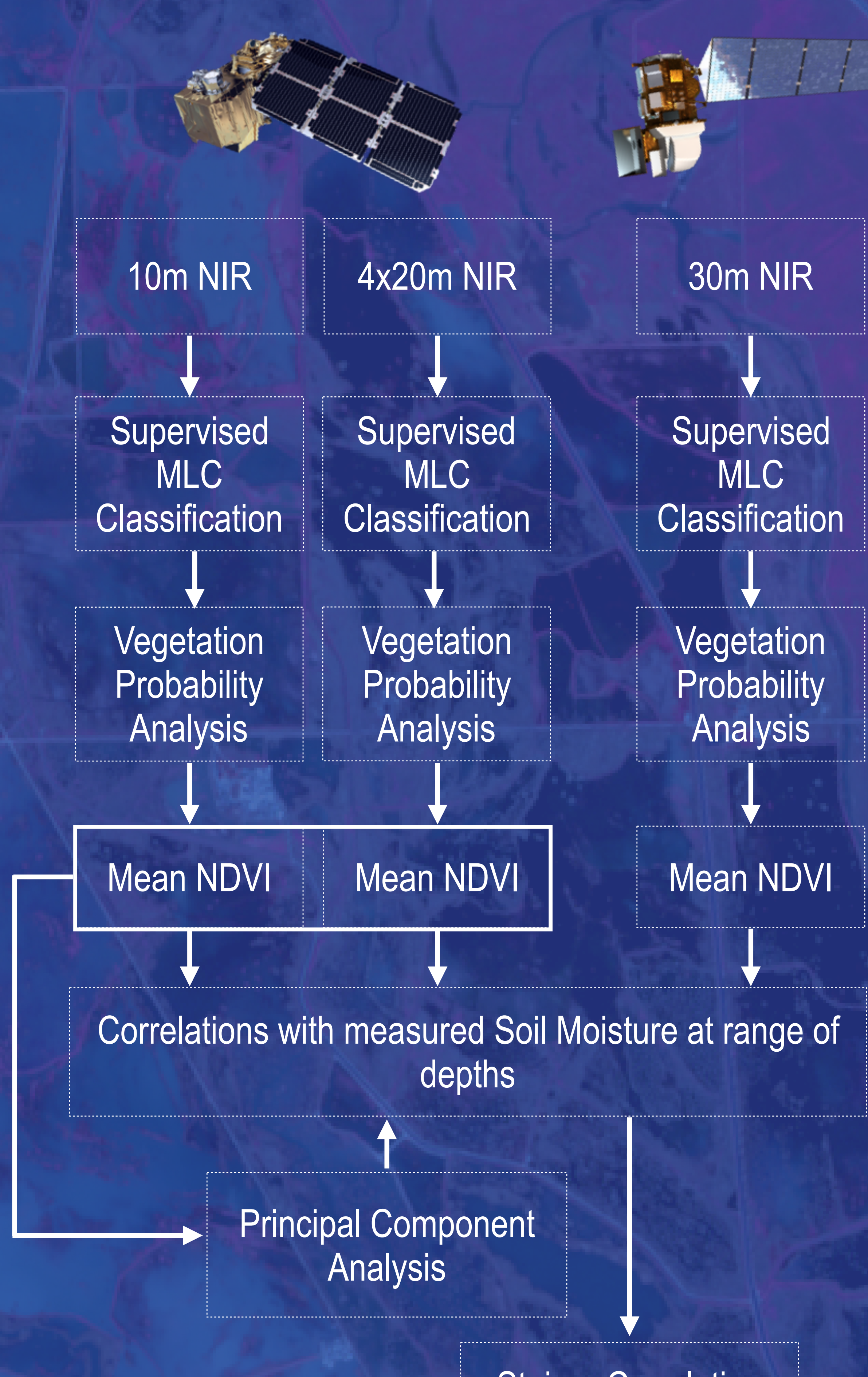
The principal aim of this study was to determine the extent to which S2 NDVI time series reflects soil moisture conditions, and whether this offers an improvement over LS8.

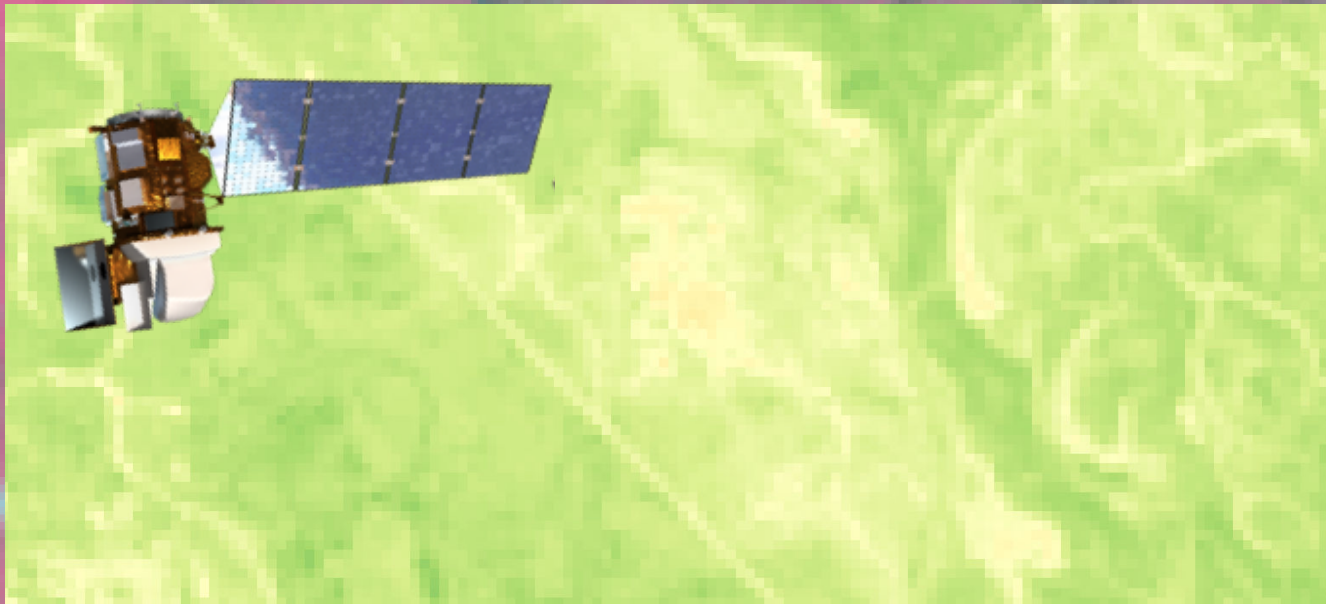
On the basis of exposure to drought over the study period (Jul 2015-Mar 2017), availability of cloud-free imagery and measured soil moisture, five sites in South-Western United States were selected. These sites, normally dry to arid, were classified as being in various states of drought, but in general this represented extension and recession of a significant drought event.

A secondary focus of the study therefore was the performance of S2 NDVI under extreme conditions. As far as we are aware, this represents the first study of this kind using S2.

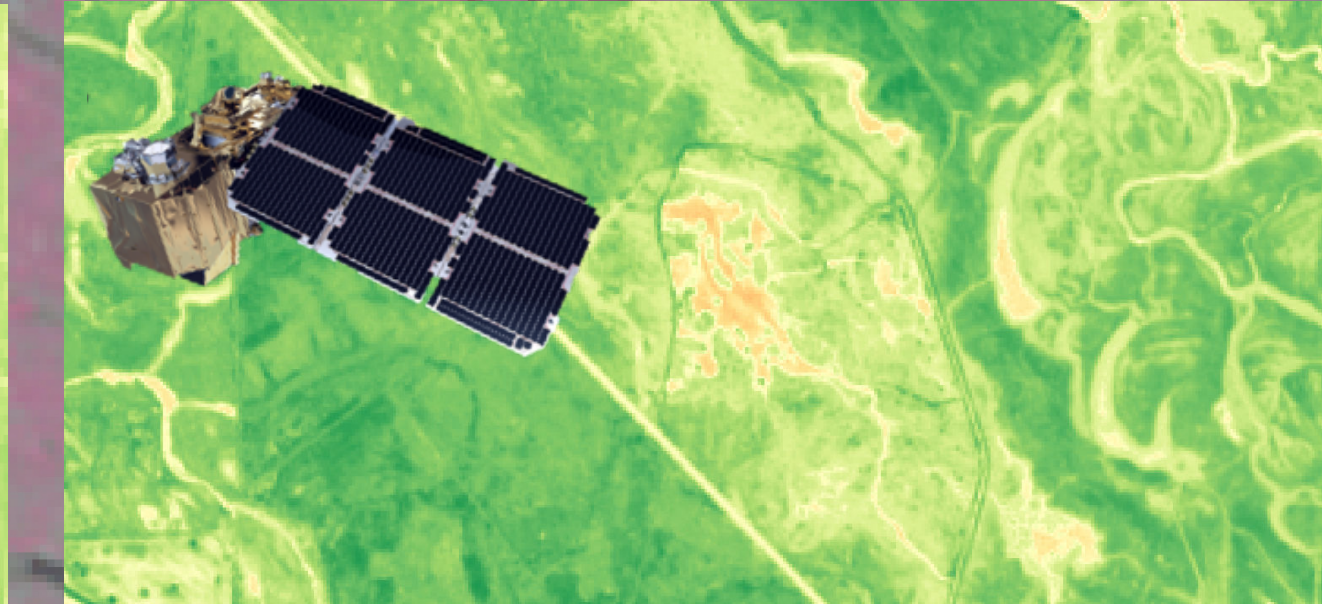
Fallbrook	Merced	Las Cruces	Ford Dry Lake	Desert Centre
Severe/Extreme Drought	Extreme/Exceptional Drought	Dry/Moderate Drought	Moderate Drought	Moderate Drought
Mediterranean Scrub (69% cover)	Freshwater Meadow Marsh (77% cover)	Warm Semi-Arid Grass (14% Cover)	Warm Semi-Arid Grass (44% Cover)	Warm Semi-Arid Grass (29% Cover)
Generally the wettest site, but extremely dry relative to normal	Generally wet, but extremely dry relative to normal	Average in terms of normal conditions	Joint driest sites on average, only in moderate drought	

Methodology

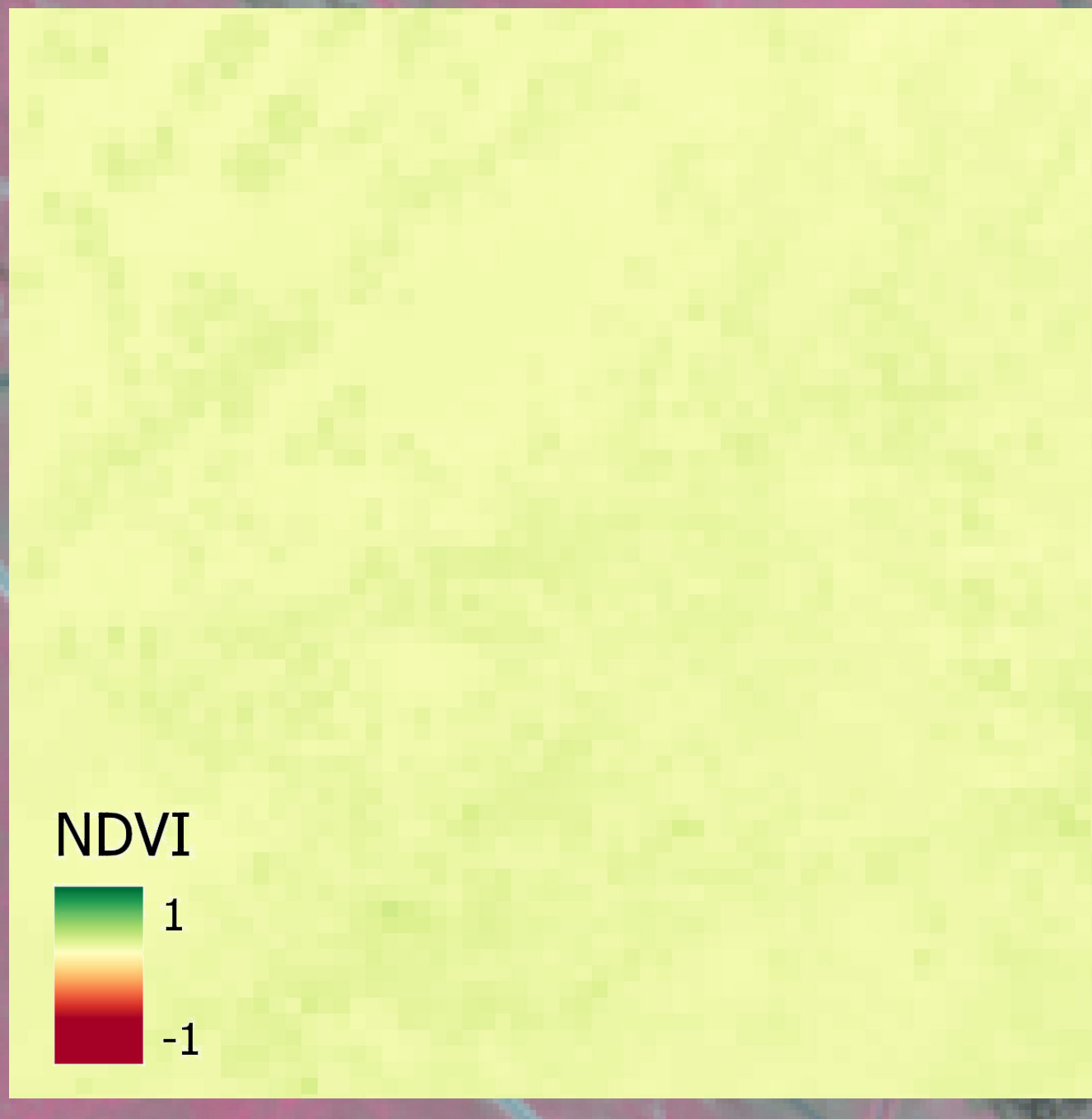




Landsat-8



Sentinel-2



NDVI
1
-1

Top Image: Merced (Feb 2016)

Bottom Image: Ford Dry Lake (Aug 2017)

- Notable differences are observed in the magnitude of NDVI values (Band 8) in the Merced image (likely a result of the enhanced spatial and spectral resolution of Sentinel-2). This is also seen on the graph opposite.
- Small patches of vegetation at Ford Dry Lake are not detected in the Landsat-8 image (due to the poorer resolution).


	Fallbrook			Merced			Las Cruces			Ford Dry Lake			Desert Centre		
	S2 (B8)	S2 (PCA)	LS8	S2 (B8)	S2 (PCA)	LS8	S2 (B8)	S2 (PCA)	LS8	S2 (B8)	S2 (PCA)	LS8	S2 (B8)	S2 (PCA)	LS8
5cm	0.61*	0.65*	0.02	0.78*	0.81*	0.31	-0.21	-0.38*	-0.61	0.39*	0.48*	0.35	-0.12	-0.03	0.33
10cm	0.72*	0.76*	0.29	0.82*	0.84*	0.39	-0.091	-0.34*	-0.59	0.51*	0.58*	0.55	0.14	0.15	-0.11
20cm	NA	NA	NA	0.49*	0.52*	0.10	0.05	0.21	-0.27	0.47*	0.55*	0.65	0.19	0.23	-0.10
50cm	NA	NA	NA	-0.29	-0.24	-0.41	0.19	0.02	0.26	-0.27	-0.24	0.23	-0.73	-0.72	-0.56
100cm	NA	NA	NA	NA	NA	NA	NA	NA	NA	-0.52*	-0.48*	-0.14	NA	NA	NA

Correlations between S2 (10m NIR), S2 PCA of 4x20m NIR and LS8

Blue highlights indicate Steiger correlation comparison significance

* denotes correlation 95% significance

Merced - Soil Moisture (10cm depth) and NDVI



Soil Moisture (Volumetric Percentage)

NDVI

Field Capacity

Wilting Point

Legend: Soil M (10cm), S2 Band 8, S2 Band 5, S2 Band 6, S2 Band 7, S2 Band 8A, LS8

Results & Conclusions

- No significant correlations between Landsat-8 NDVI and measured soil moisture were found.
- High significant correlations were present between moisture at depths of <30cm and Sentinel-2 NDVI at three sites (Merced, Fallbrook & Ford Dry Lake).
- No significant correlations between Sentinel-2 NDVI and soil moisture at two sites (Desert Centre & Las Cruces).
 - These sites were characterised by much lower vegetation cover - suggesting a minimum cover threshold of \approx 30-40% is required for NDVI values to report significant correlations with soil moisture.
- The principal component analysis (PCA) shows that at all sites of significant positive moisture/NDVI correlations, the linear combination of the red-edge bands produced stronger correlations than the poorer spectral, but higher spatial resolution band.
 - NDVI calculated using the higher spatial resolution bands may therefore be of greater use in this context than the higher spatial resolution band.
- These results suggest high potential for the application of Sentinel-2 NDVI in drought monitoring, even in extreme environments, thus allowing us to further our understanding of local scale plant-soil dynamics.

Full paper: West, H., Quinn, N., Horswell, M. and White, P. (2018) Assessing vegetation response to soil moisture fluctuation under extreme drought using Sentinel-2. Water, 10 (7). p. 838. <https://doi.org/10.3390/w10070838>