ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

Comparing spectral characteristics of Landsat-8 and Sentinel-2 data for Arctic permafrost regions

A. Runge[1,2], G. Grosse[1,2]

[1]Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Potsdam, Germany,
[2] Institute of Earth and Environmental Sciences, University of Potsdam, Potsdam, Germany

Background

Optical remote sensing in the Arctic is highly restricted by frequent cloud cover and low illumination angles. Hence, only few useable optical images are acquired by the Landsat mission during the short vegetation period every year.
The new ESA Copernicus Sentinel-2 mission, containing two satellites with a revisit time < 5 days, enhances data availability in the Arctic and the chance of useable images.
Combining Landsat-8 (L8) and Sentinel-2 (S2) images will increase data coverage and enable dense time-series analysis which will allow for:

- ✓ Mapping and monitoring of vegetation
- ✓ Change detection
- ✓ Differentiating between gradual and rapid changes
- ✓ Trend analysis

This will help tremendously in describing permafrost regions, their changes, disturbance schemes and the effects on the carbon cycle in a warming Arctic.

Method

❖ **All data related and processing steps were conducted in Google Earth Engine (GEE)**

Data selection: Image filtering by point location with a clover cover < 80 % and selecting same-day acquisition image-pairs of Landsat-8 and Sentinel-2

Data processing: Images were either already corrected to surface reflectance (L8 = GEE) or were corrected individually (S2 = SNAP) before they were cloud masked, reprojected to WGS 84 /UTM zone 52 and then resampled to a common resolution of 60 m

Comparisons: Single band comparisons on a pixel-by-pixel basis and multispectral index (NDVI) calculation as well as the temporal sensor response of the NDVI over summer based on three same-day acquisition image-pairs

Analysis: Applying the globally available Harmonized Landsat-8 Sentinel-2 product (**HLS**) (Claverie et al., 2016) to the same-day acquisition image-pairs while also deriving a own locally applicable linear regression band adjustment for the dataset (abbr. **LOC**).

Objectives

- ❖ Compare spectral characteristics and check compatibility of Landsat-8 and Sentinel-2 in Arctic permafrost regions.
- ❖ Assess the sensor-signal responses of Landsat-8 and Sentinel-2 and define spectral adjustments for a combined use in North-eastern Siberia.

Data

The study area is the Central Lena Delta, including Samoylov island. Samoylov island coordinates where used for point image filtering. The below dataset combines images from several satellite paths and rows, all covering the Central Lena Delta.

	Landsat-8 Band	Landsat-8 Wavelength [µm]	Landsat-8 Resolution [m]	Sentinel-2 Band	Sentinel-2 Wavelength [µm]	Sentinel-2 Resolution [m]
Coastal Aerosol	1	0.43-0.45	30	1	0.43-0.46	60
Blue	2	0.45-0.51	30	2	0.45-0.55	10
Green	3	0.53-0.59	30	3	0.53-0.58	10
Red	4	0.64-0.67	30	4	0.65-0.68	10
NIR	5	0.85-0.88	30	8A	0.85-0.88	20
SWIR 1	6	1.57-1.65	30	11	1.54-1.69	20
SWIR 2	7	2.11-2.29	30	12	2.08-2.32	20
Cirrus	9	1.36-1.38	30	10	1.34-1.41	60

Tab. 1: Landsat-8 and Sentinel-2 specifications. Adapted from Claverie et al. (2016) and ESA (2018).

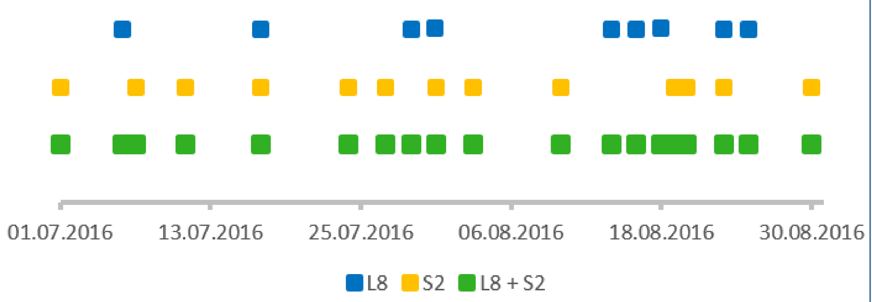


Fig. 1: Temporal coverage of Landsat-8 and Sentinel-2 during summer 2016.

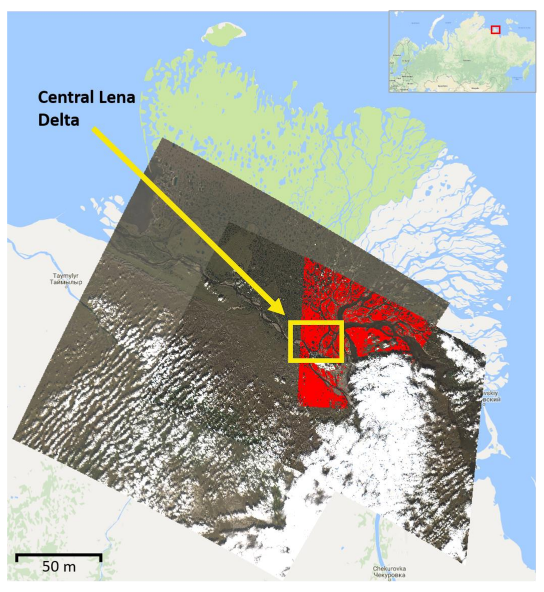


Fig. 2: Central Lena Delta L8 and S2 same-day acquisition 23.08.2016 after cloud masking in Google Earth Engine.

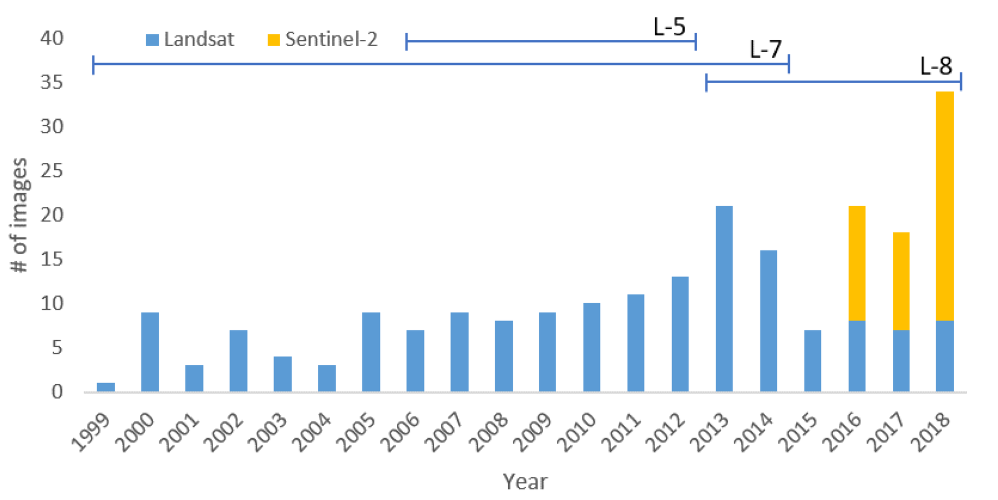
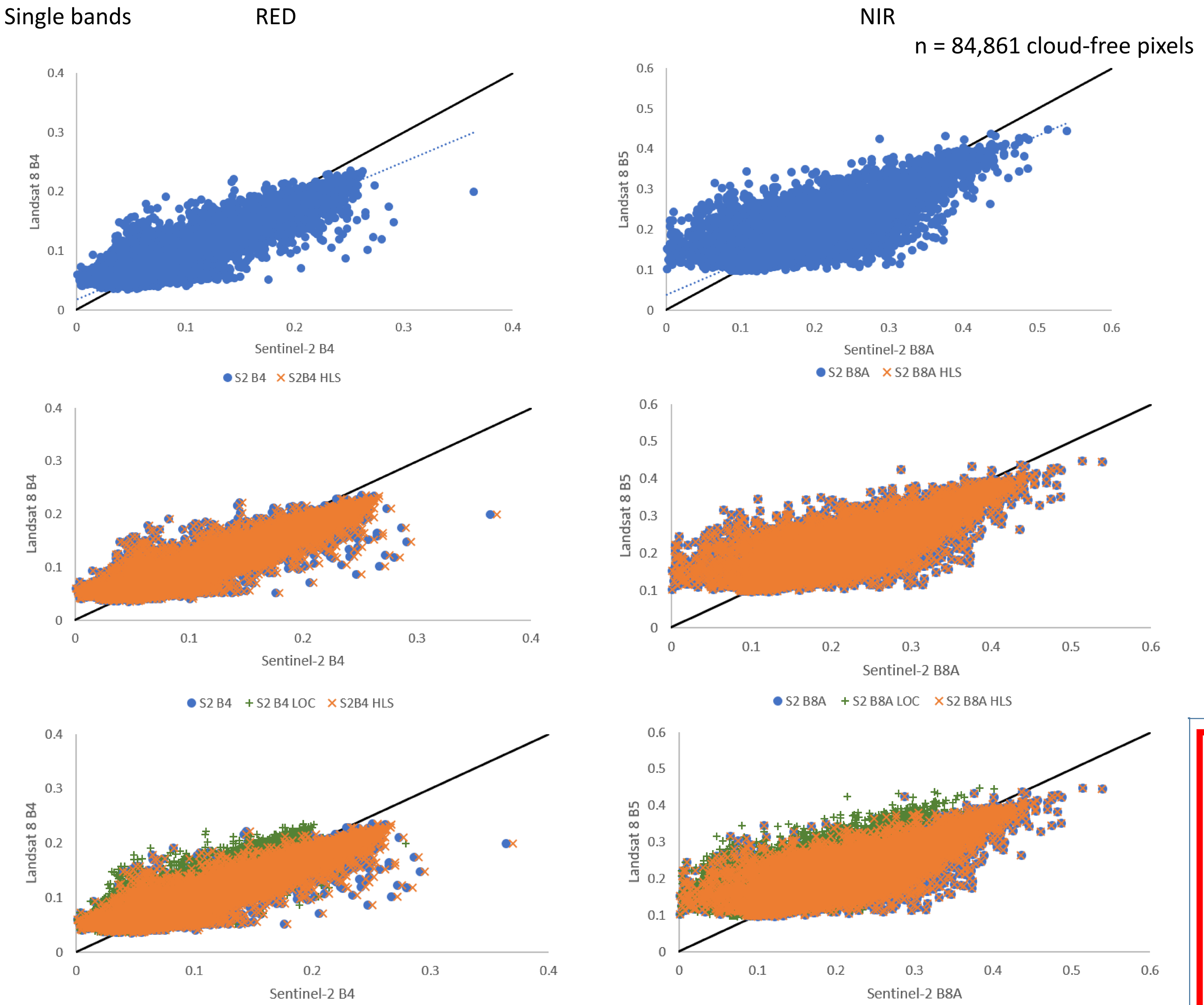


Fig. 3: Number of Landsat and Sentinel-2 images during summer season per year.

Results



RED	Landsat 8 B4	Sentinel-2 B4	
	Intercept	Slope	R
LOC	0,019	0,766	0,95
HLS	-0,00104	1,017	0,95
NIR	**Landsat 8 B5**	**Sentinel-2 B8A**	
	Intercept	Slope	R
LOC	0,049	0,744	0,89
HLS	0,999	0,00025	0,89

Tab. 2: Linear regression band adjustment equations. HLS from Claverie et al., 2016.

Fig. 4: Band comparisons between Landsat-8 and Sentinel-2 in the Central Lena Delta on 23.08.2016.

- ➢ Band comparison for RED (left) and NIR (right)
- \+ HLS band adjustment
- \+ LOC band adjustment

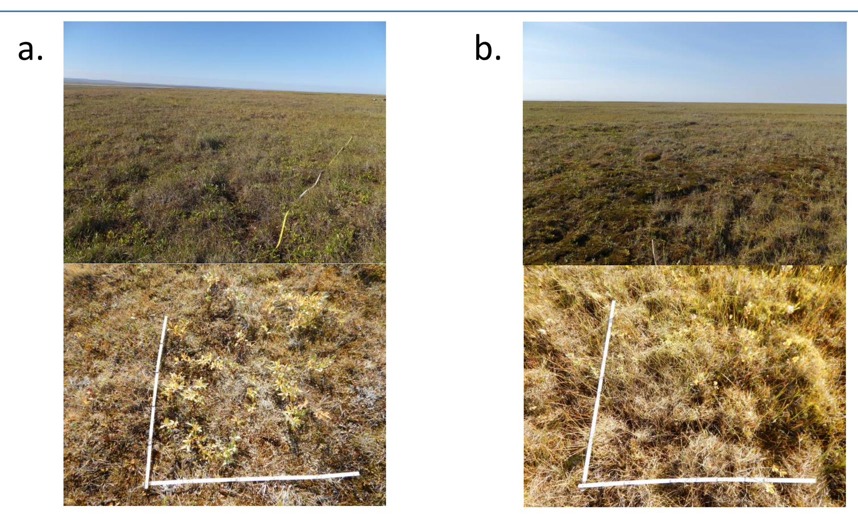


Fig. 6: Field pictures of a. Moist to dry dwarf shrub-dominated Yedoma tundra and b. wet sedge- and moss-dominated Yedoma upland tundra (M. Fuchs and A. Runge, 2018).

- ➢ Landsat-8 and Sentinel-2 divert from 1:1 line (black line in Fig. 4)
- ➢ **Systematic offset** between Landsat-8 and Sentinel-2, esp. NDVI
- ➢ HLS product corrects the offset a little
- ➢ LOC adjustment shows a slightly better correction of the offset
- ➢ For different land covers (Fig. 5) the spectral sensor response varies, which has to be considered

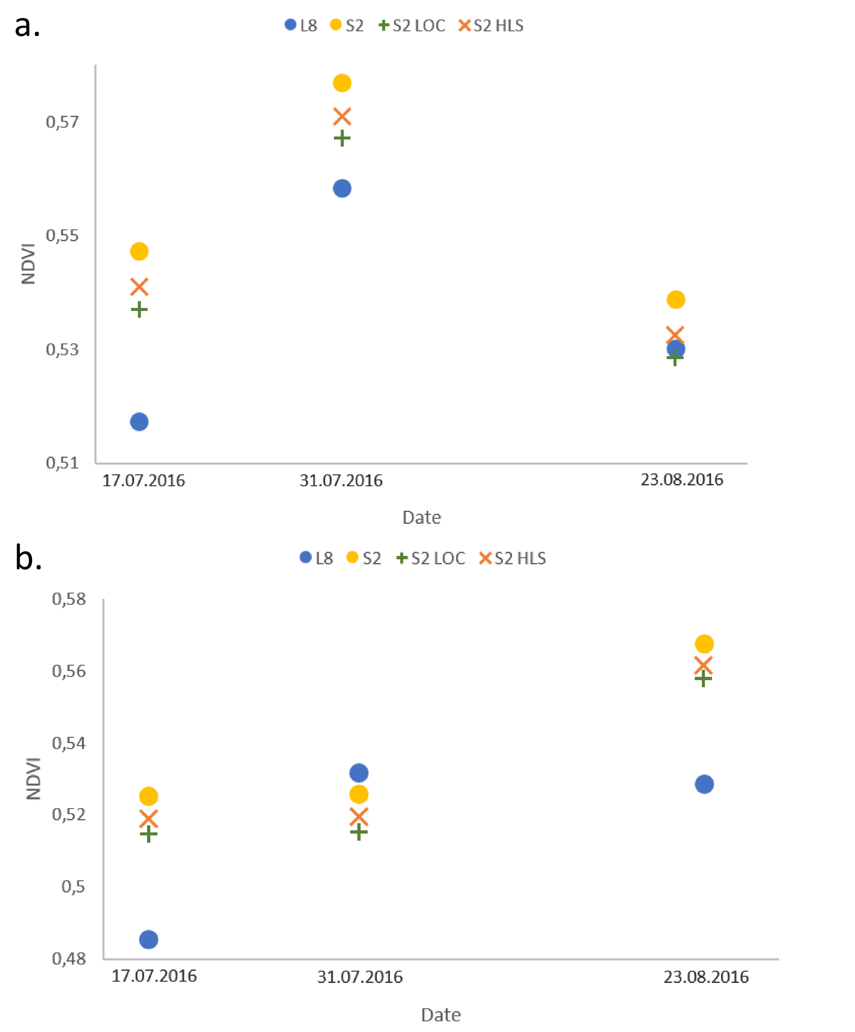


Fig. 5: Comparison of NDVI values for a. Moist to dry dwarf shrub-dominated Yedoma tundra and b. Wet Yedoma upland land cover from same-day acquisitions of Landsat-8, Sentinel-2, Sentinel-2 HLS and Sentinel-2 LOC adjusted.

Conclusion

- ❖ Band adjustment is necessary to correct for the spectral offset between Landsat-8 and Sentinel-2 images, before any combined dense time-series analysis is possible
- ❖ The Harmonized Landsat-8 Sentinel-2 product correction is not sufficient which underlines that a local and/or regional adjustment procedure is necessary

Next Steps

- ❖ Broadening the linear band adjustment approach by:
  - ❖ Looking at multiple same-day acquisition image-pairs
  - ❖ Looking at multiple sites, e.g. along a longitudinal transect in Siberia: Central Lena Delta, Batagay, Yukechi
  - ❖ Taking different types of land cover into account
- ❖ Investigating whether an Arctic band adjustment product can be derived

References
Claverie, M., Masek, J. and Ju, J., 2016. Harmonized Landsat-8 Sentinel-2 (HLS) Product User's Guide.
ESA, 2018. Sentinel-2 MSI Technical Guide.
Google Earth Engine was used for all processing steps. GEE receives the satellite images directly from USGS (Landsat) oder ESA Copernicus (Sentinel-2).

Alexandra Runge
PhD Candidate
Alfred Wegener Institute
Telegrafenberg A45
14473 Potsdam, Germany
alexandra.runge@awi.de
Phone : +49-331-288-20107