Bayan-Unjuul's Analysis

Alberto Tarroni

Index

Bayan-Unjuul

Figure: Bayan-Unjuul from the top of a mountain (photo by: Alberto Tarroni)

Bayan-Unjuul

4790 km^2

Grassland and Shrubs vegetation

-30°C to -10°C (Winter);
+10°C to +35°C (Summer)

Bayan-Unjuul

4790 km^2

Grassland and Shrubs vegetation

-30°C to -10°C (Winter); +10°C to +35°C (Summer)

Bayan-Unjuul

4790 km^2

Grassland and Shrubs vegetation

-30°C to -10°C (Winter); +10°C to +35°C (Summer)

Main topics

2017 - 2019 - 2021 - 2023 Analysis

Winter Analysis using NDSI (Normalized Difference Snow Index)

Summer Analysis using NDVI (Normalized Difference Vegetation Index)

Spring Analysis using NDVI (Normalized Difference Vegetation Index)

Main topics

2017 - 2019 - 2021 - 2023 Analysis

Winter Analysis using NDSI (Normalized Difference Snow Index)

Summer Analysis using NDVI (Normalized Difference Vegetation Index)

Spring Analysis using NDVI (Normalized Difference Vegetation Index)

Main topics

2017 - 2019 - 2021 - 2023 Analysis

Winter Analysis using NDSI (Normalized Difference Snow Index)

Summer Analysis using NDVI (Normalized Difference Vegetation Index)

Spring Analysis using NDVI (Normalized Difference Vegetation Index)

Main topics

2017 - 2019 - 2021 - 2023 Analysis

Winter Analysis using NDSI (Normalized Difference Snow Index)

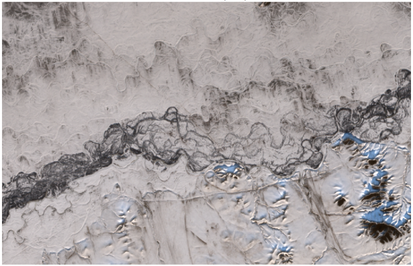
Summer Analysis using NDVI (Normalized Difference Vegetation Index)

Spring Analysis using NDVI (Normalized Difference Vegetation Index)

Winter

December 2017

True Color 24/12/17 Bayan-Unjuul



True Color by RGB (red = b4, green = b3, blue = b2)

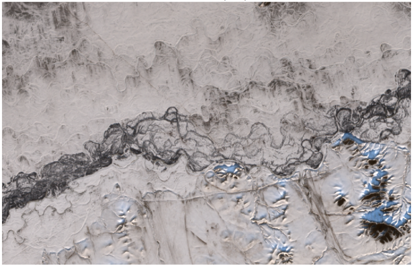
Perennial snow troughtout the winter

Frozen lakes and ponds

Winter

December 2017

True Color 24/12/17 Bayan-Unjuul



True Color by RGB (red = b4, green = b3, blue = b2)

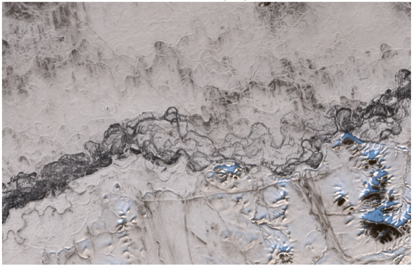
Perennial snow troughtout the winter

Frozen lakes and ponds

Winter

December 2017

True Color 24/12/17 Bayan-Unjuul



True Color by RGB (red = b4, green = b3, blue = b2)

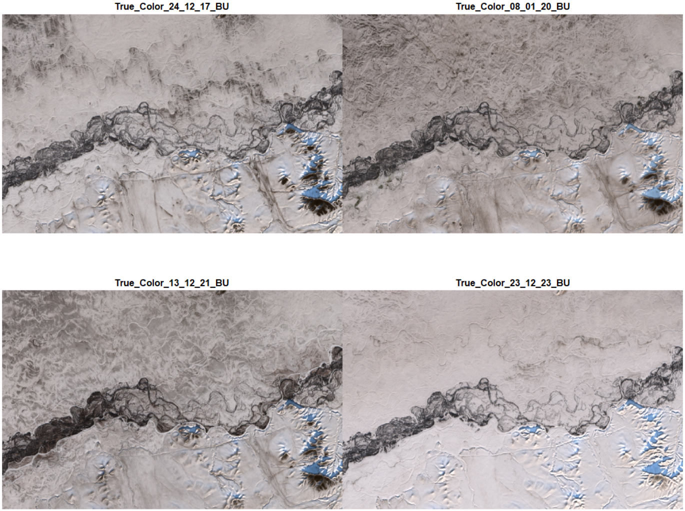
Perennial snow troughtout the winter

Frozen lakes and ponds

True Color Script Example

```
#Carico il vettore contente le differenti bande

    true_color_2017 <- c(b4_17,b3_17,b2_17)

#Creo il plot RGB con rosso=b4,verde=b3,blu=b2

    tc_17 <- plotRGB(true_color_2017, 1, 2, 3, main = "True Color 24/12/17 Bayan-Unjuul")
```

Winter True Color Comparison



True Color Script Example

```
#Dispongo i miei plot 2 per riga e su due colonne,
#Con oma() do dei margini dalla cornice rispetto i punti
    cardinali
    par(mfrow=c(2,2), oma=c(3,3,3,3))

    tc_17 <- plotRGB(true_color_2017, 1, 2, 3, main = "True_
        Color_24_12_17_BU")
    tc_20 <- plotRGB(true_color_2020, 1, 2, 3, main = "True_
        Color_08_01_20_BU")
    tc_21 <- plotRGB(true_color_2021, 1, 2, 3, main = "True_
        Color_13_12_21_BU")
    tc_23 <- plotRGB(true_color_2023, 1, 2, 3, main = "True_
        Color_23_12_23_BU")
```

NDSI

To identify snow cover by distinguishing snow from other surfaces like clouds and water

Range:

$+1$: Snow or Ice

0 : Rocks, Sand

-1 : Water

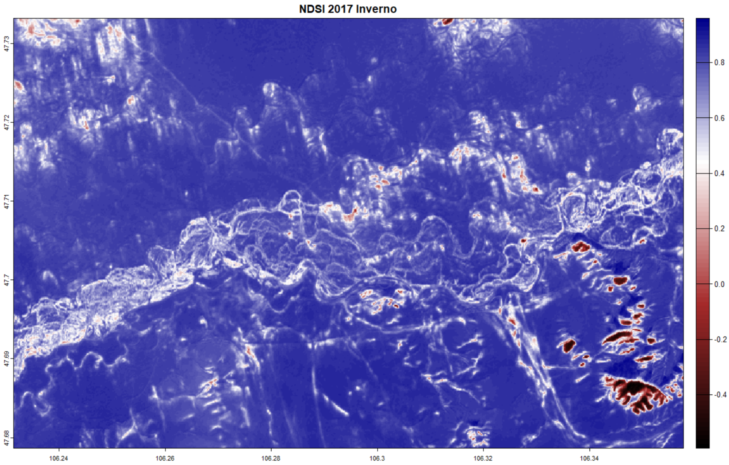
$$NDSI = \frac{Green - SWIR}{Green + SWIR}$$

SWIR: short-wave infrared light

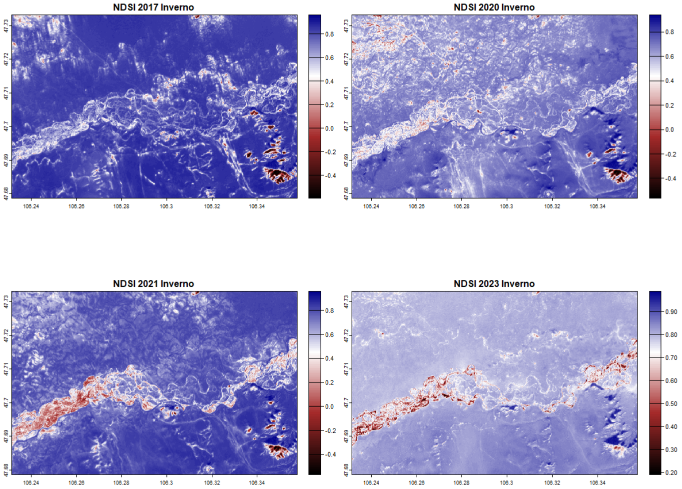
NDSI Script Dec 2017

```r
### NDSI 1 = NEVE/GHIACCIO , 0 = SUOLO  VEG, -1 = ACQUA O SIMILI ###
## Palette colori ##

col_ndsi <- colorRampPalette(c("black", "brown", "white", "darkblue")) (100)

### 2017 ###

ndsi_2017 <- (b3_17 - b11_17) / (b3_17 + b11_17)
plot(ndsi_2017, col = col_ndsi, main = "NDSI 2017 Inverno")
```

NDSI Dec 2017



NDSI Comparison

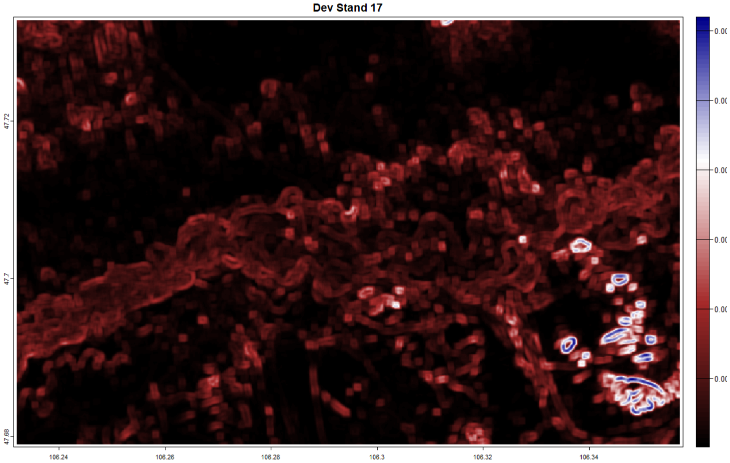


NDSI Comparison Script

```r
#Confronto

par(mfrow=c(2,2), oma=c(3,3,3,3))

plot(ndsi_2017, col = col_ndsi, main = "NDSI 2017 Inverno")
plot(ndsi_2020, col = col_ndsi, main = "NDSI 2020 Inverno")
plot(ndsi_2021, col = col_ndsi, main = "NDSI 2021 Inverno")
plot(ndsi_2023, col = col_ndsi, main = "NDSI 2023 Inverno")
```

Standard Deviation

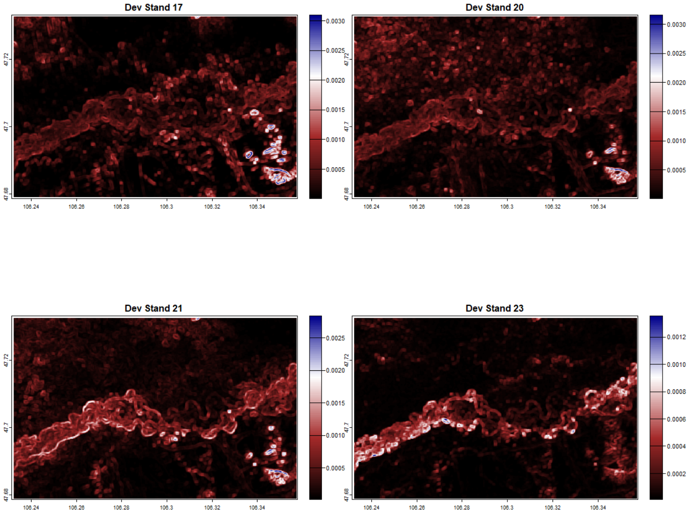
Example: 2017



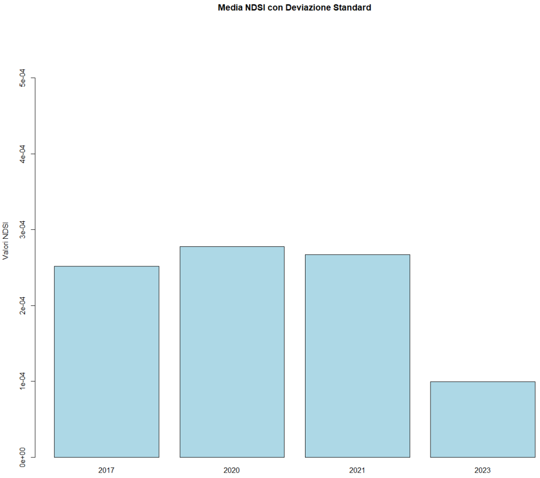
Standard Deviation Script

```
ndsi_sd_17 <- focal(ndsi_2017, w = matrix(1/169,13,13), fun
    = sd)
plot(ndsi_sd_17, col = col_ndsi, main = "Dev Stand 17")
```

Standard Deviation Comparison



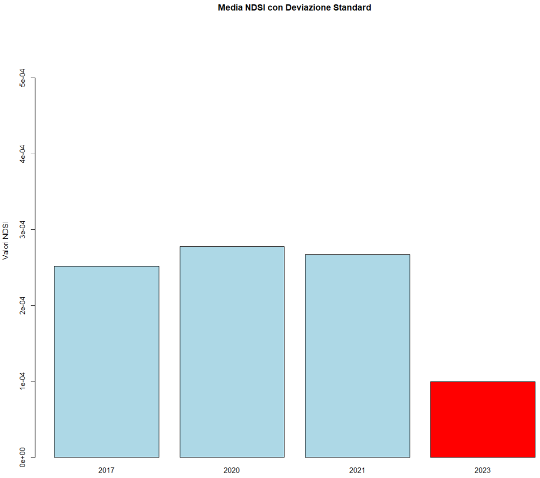
Plot Mean NDSI with SD (Standard Deviation)



No significant variation for the years 2017, 2020, and 2021.

Lower NDSI value in 2023.

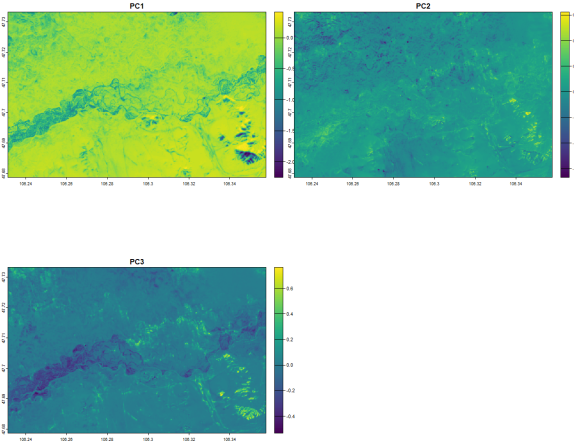
Plot Mean NDSI with SD (Standard Deviation)



No significant variation for the years 2017, 2020, and 2021.

Lower NDSI value in 2023.

PCA (Principal Component Analysis)



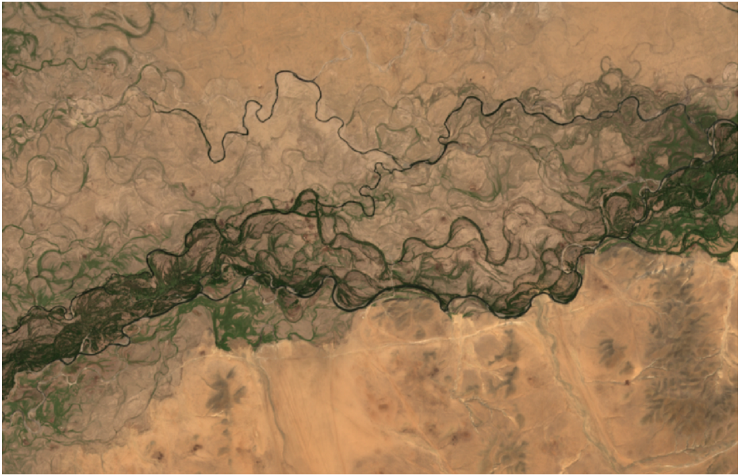
PC1: Strong contrast between lighter (yellow) and darker (purple) areas, likely indicating regions with the most significant NDSI variations

PC2 - PC3: No significant variations captured

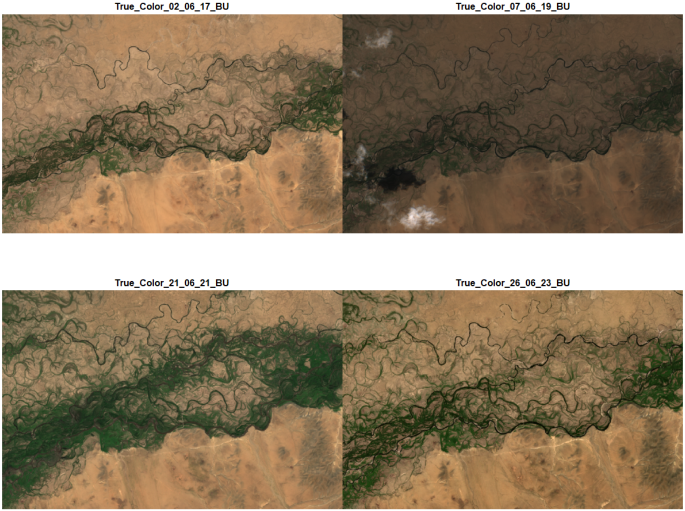
Summer

June 2017

True Color 02/06/17 Bayan-Unjuul



Summer True Color Comparison



NDVI (Normalized Difference Vegetation Index))

Index that measures the density and health of vegetation

Range:

$+1$: Dense, healthy vegetation

0 : Sparse vegetation or soil

-1 : Non-vegetated surfaces like water, snow, or ice

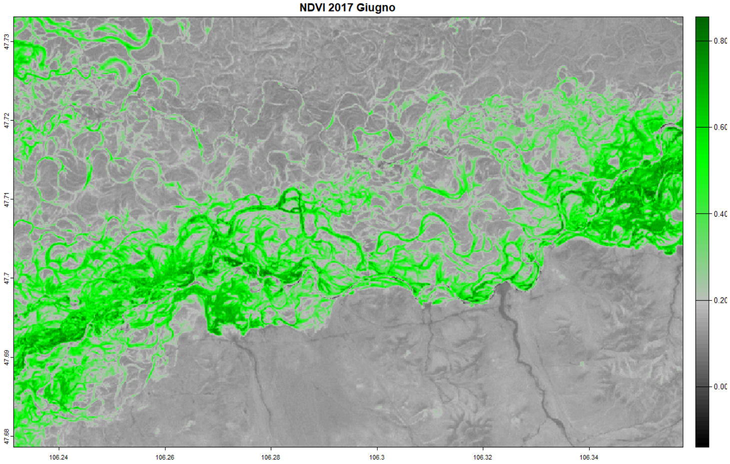
$$NDVI = \frac{NIR(b8) - Red(b4)}{NIR(b8) + Red(b4)}$$

NIR: near-infrared band, vegetation strongly reflects.

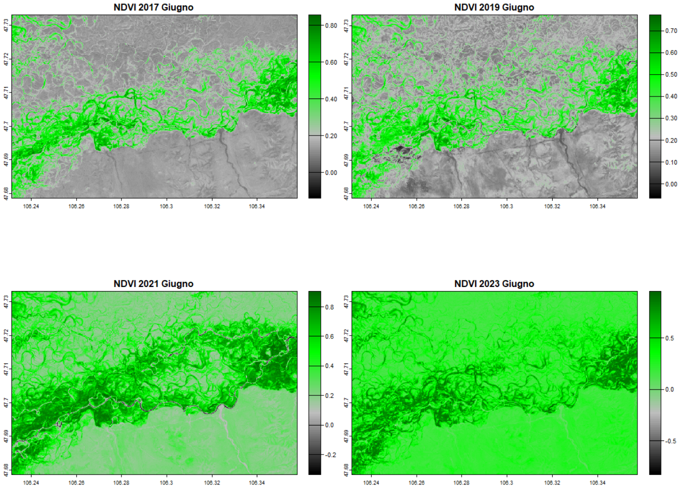
NDVI Script Dec 2017

```r
### NDVI 1 = temperate/tropicali ; 0.2 - 0.4 = shrub/grassland ; -0.1 - 0.1 = roccia, sabbia, neve ; -1 = acqua ###

## Palette colori ##

col_ndvi <- colorRampPalette(c("black", "grey", "green", "darkgreen")) (100)

### 2017 ###
ndvi_2017_g <- (b8_17_ndvi - b4_17_ndvi) / (b8_17_ndvi + b4_17_ndvi)
plot(ndvi_2017_g, col = col_ndvi, main = "NDVI 2017 Giugno")
```

NDVI Jun 2017

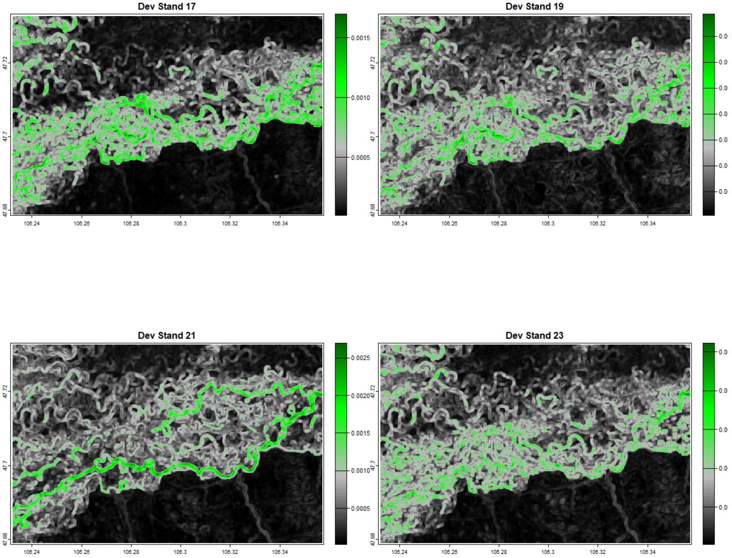


NDVI Comparison

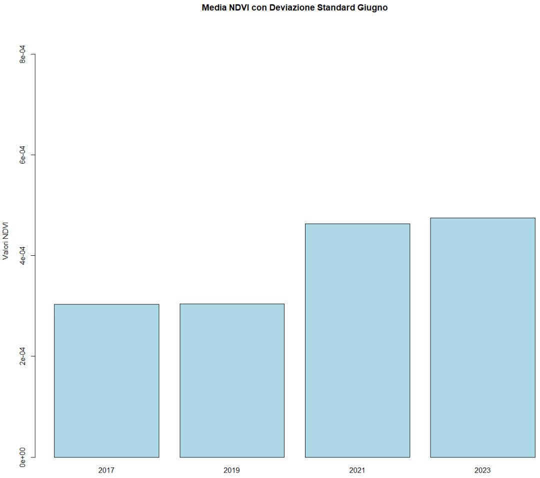


Standard Deviation

Summer Standard Deviation Comparison



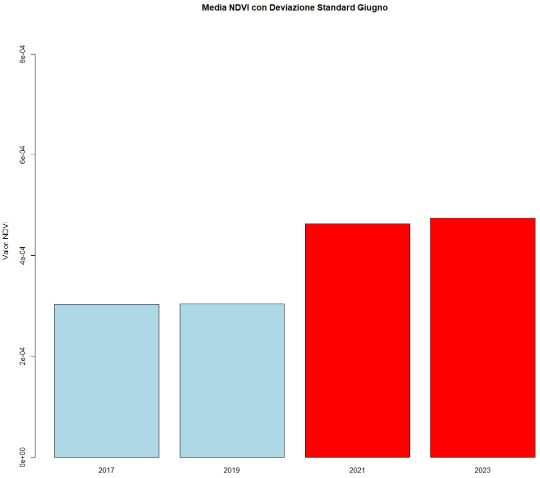
Plot Mean NDVI with SD (Standard Deviation)



No variations between 2017 - 2019

Higher values of NDVI in 2021 - 2023.

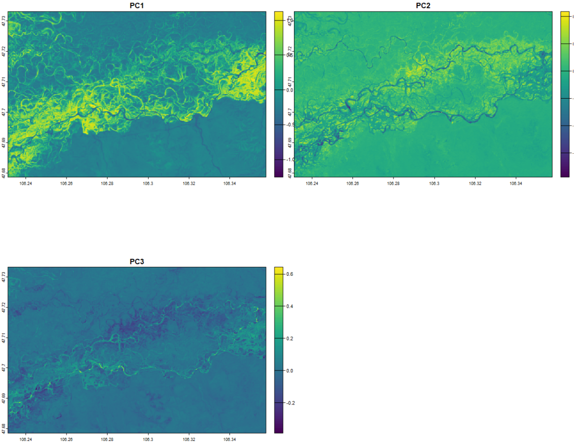
Plot Mean NDVI with SD (Standard Deviation)



No variations between 2017 - 2019

Higher values of NDVI in 2021 - 2023.

PCA (Principal Component Analysis) NDVI



PC1: There are clear patterns, possibly representing rivers, forests, or dense vegetation areas

PC2: Might reflect inter-annual variations in vegetation

PC3: Captures residual variation that isn't as visually significant

NDMI (Normalized Difference Moisture Index))

Index used to assess vegetation moisture content, especially in relation to soil and plant water stress

Range:

$+1$: High moisture content, typically seen in well-hydrated, healthy vegetation.

0 : Lower vegetation moisture or dry conditions

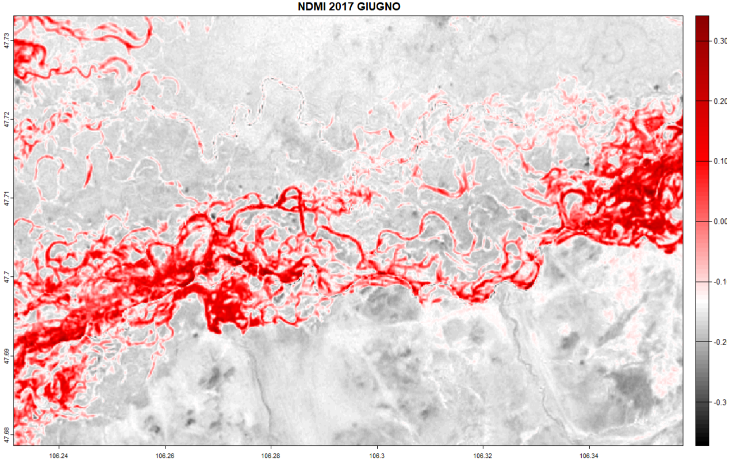
-1 : Very dry conditions

$$NDMI = \frac{NIR(b8A) - SWIR(b11)}{NIR(b8A) - SWIR(b11)}$$

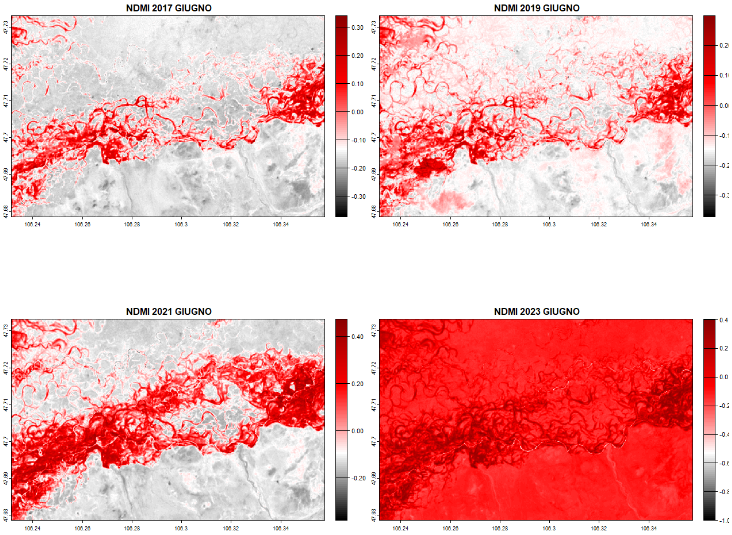
NDMI Script June 2017

```
## Palette colori ##

col_ndmi <- colorRampPalette(c("black", "white", "red", "
    darkred")) (100)

#NDMI#
ndmi_2017_g <- (b8a_17_g - b11_17_g) / (b8a_17_g + b11_17_g)
```

NDMI June 2017

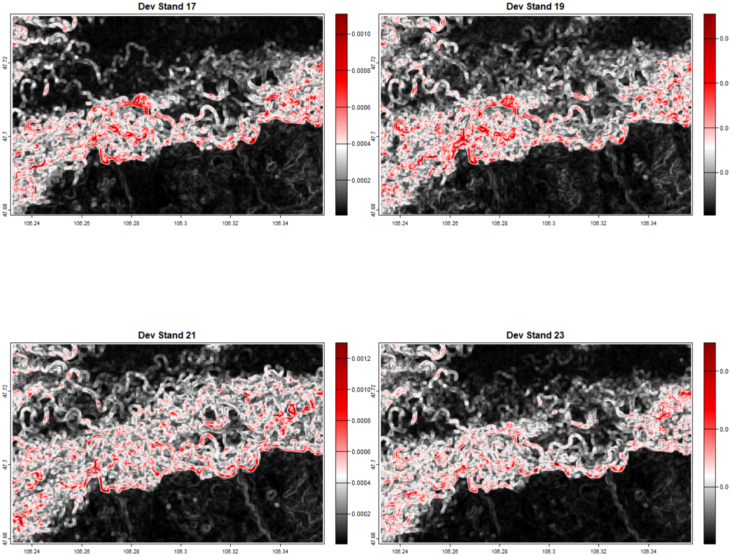


NDMI Comparison

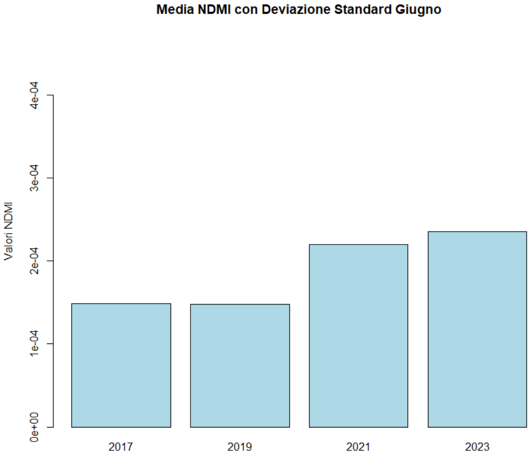


Standard Deviation

Summer Standard Deviation Comparison



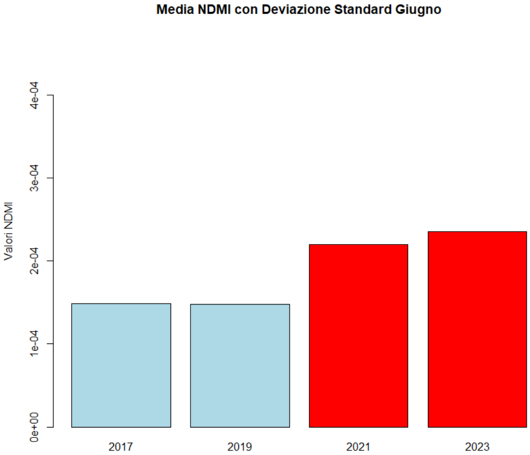
Plot Mean NDMI with SD (Standard Deviation)



No variations between 2017 - 2019

Higher values of NDVI in 2021 - 2023.

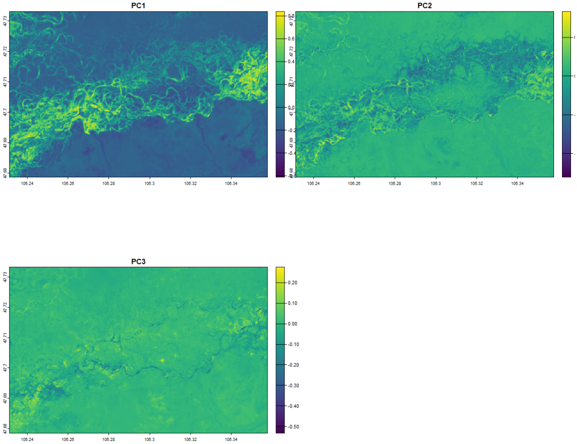
Plot Mean NDMI with SD (Standard Deviation)



No variations between 2017 - 2019

Higher values of NDVI in 2021 - 2023.

PCA (Principal Component Analysis) NDMI



PC1: There are clear patterns, possibly representing rivers, forests, or dense vegetation areas

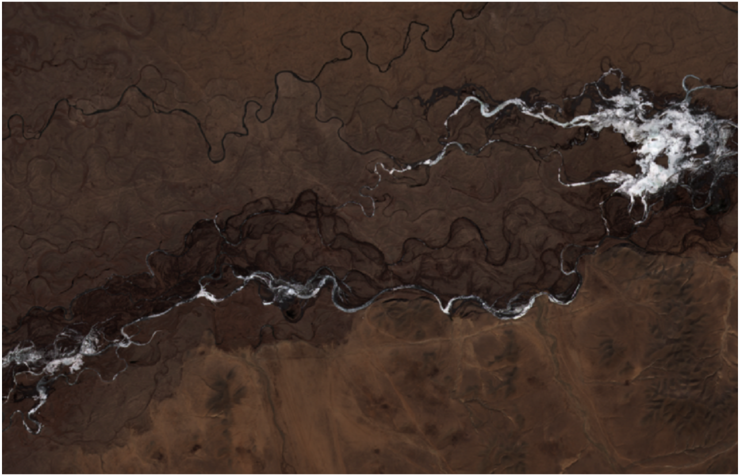
PC2: Might reflect inter-annual variations in vegetation

PC3: Captures residual variation that isn't as visually significant

Spring

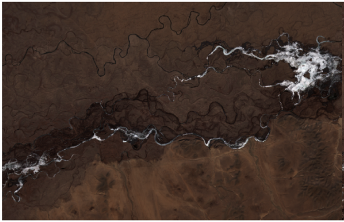
April 2017

True Color 03/04/17 Bayan-Unjuul

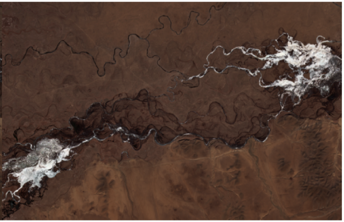


Spring True Color Comparison

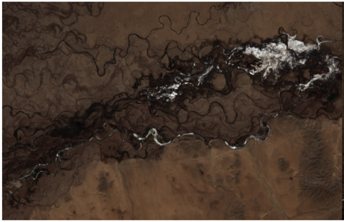
True_Color_03_04_17_BU



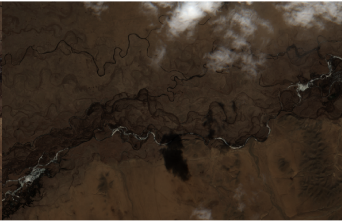
True_Color_03_04_19_BU



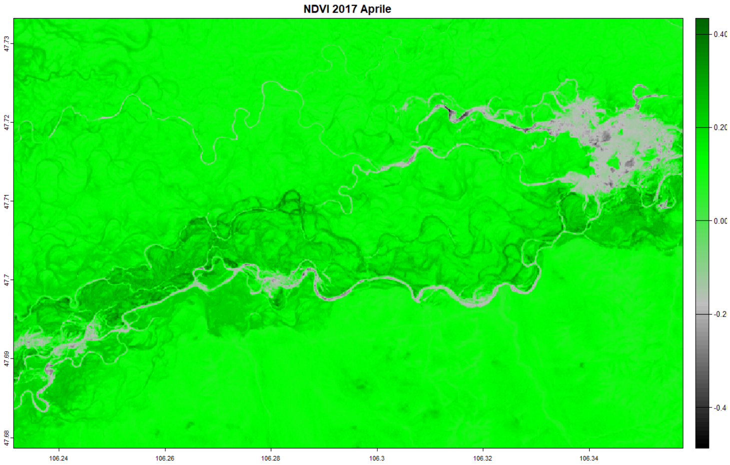
True_Color_07_04_21_BU



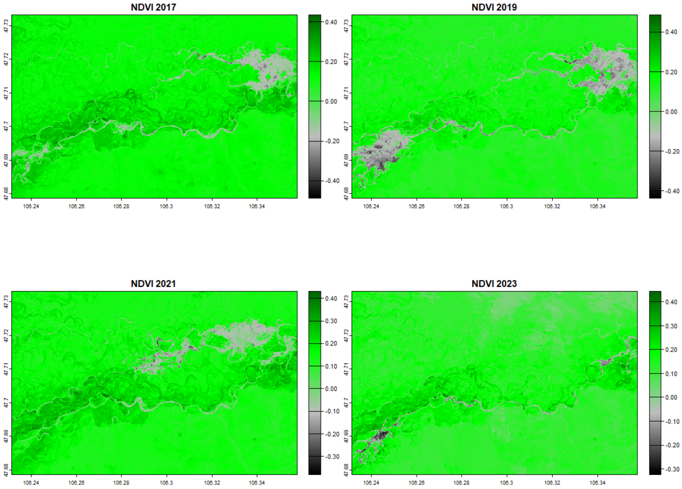
True_Color_12_04_23_BU



NDVI April 2017

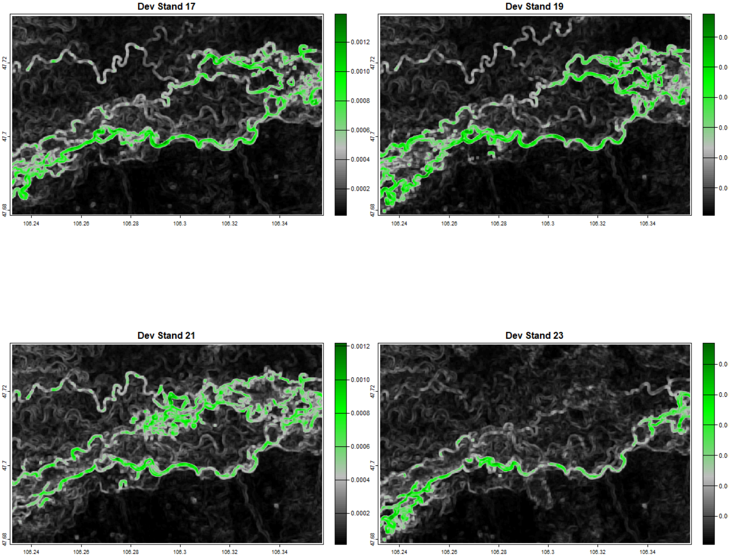


NDVI Comparison

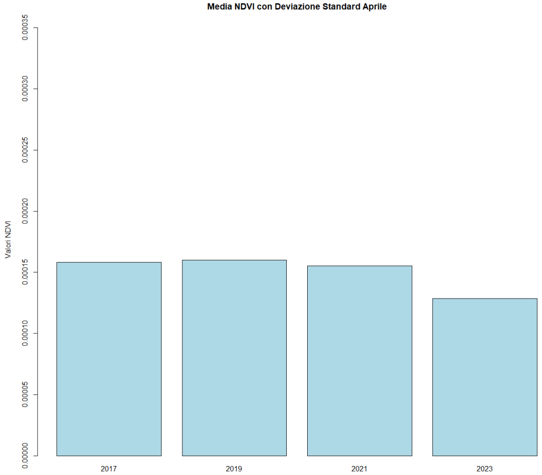


Standard Deviation

Spring Standard Deviation Comparison

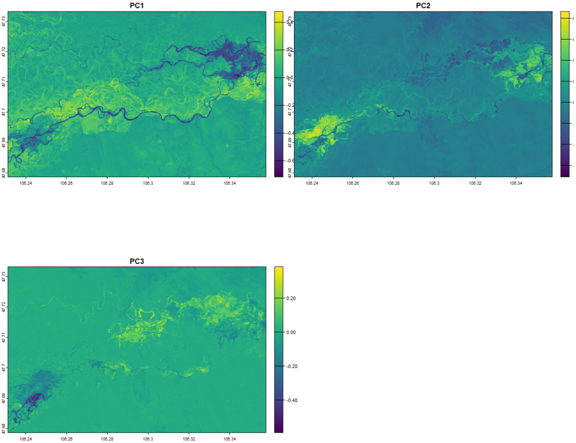


Plot Mean NDVI with SD (Standard Deviation)



No relevant variations except lower NDVI values for 2023

PCA (Principal Component Analysis) NDVI

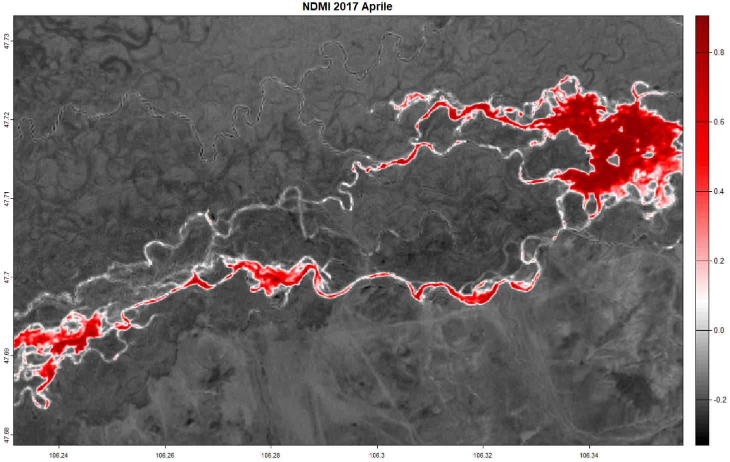


PC1: There are clear patterns, possibly representing rivers, forests, or dense vegetation areas

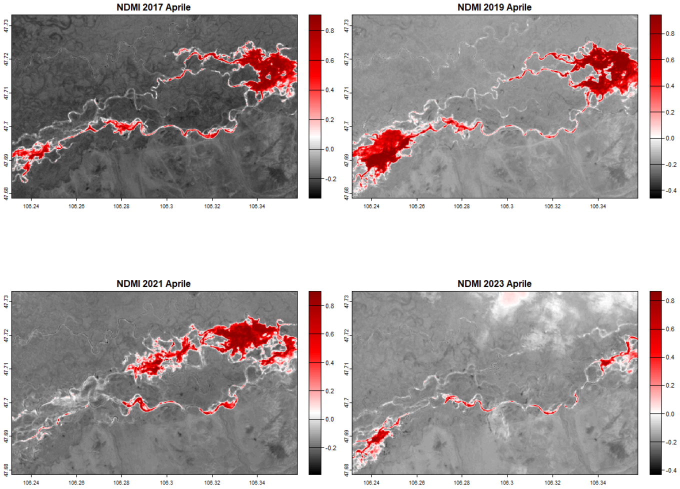
PC2: Might reflect inter-annual variations in vegetation

PC3: Captures residual variation that isn't as visually significant

NDMI April 2017

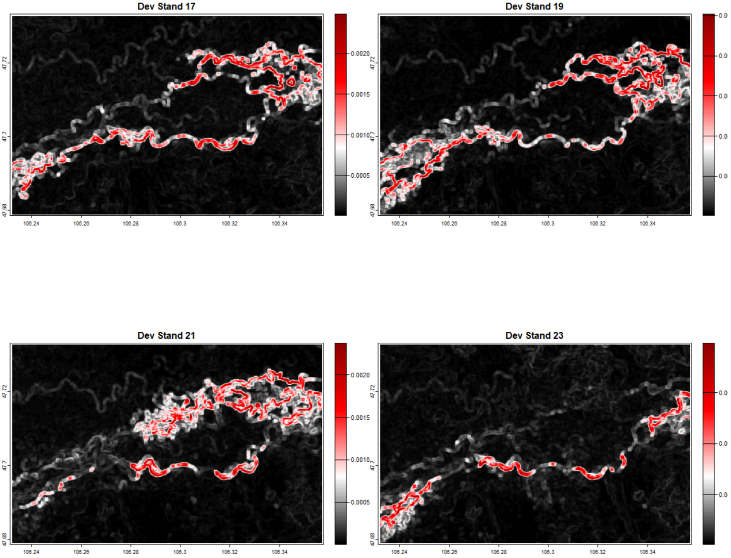


NDMI Comparison

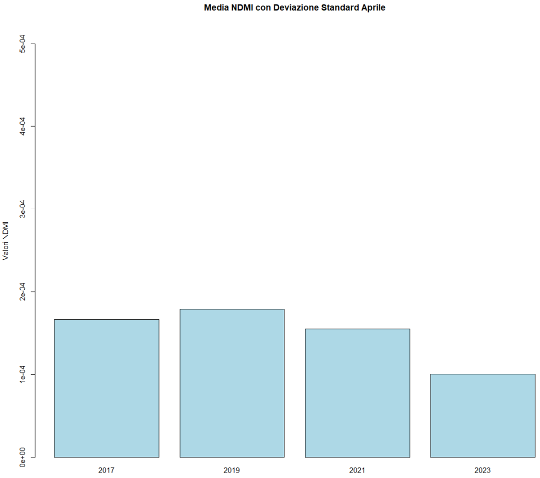


Standard Deviation

Spring Standard Deviation Comparison



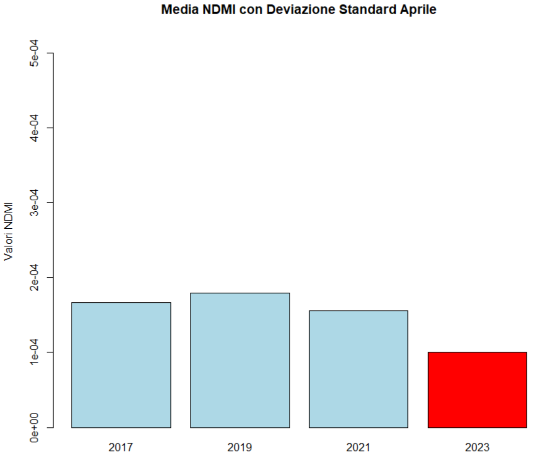
Plot Mean NDMI with SD (Standard Deviation)



No variations between 2017 - 2019 - 2021

Lower values of NDMI in 2023.

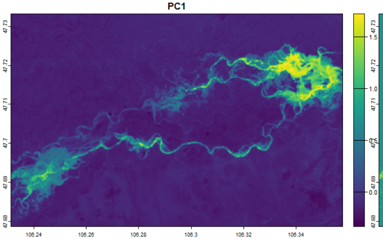
Plot Mean NDMI with SD (Standard Deviation)

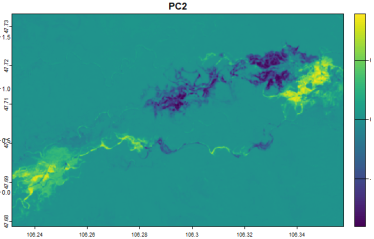


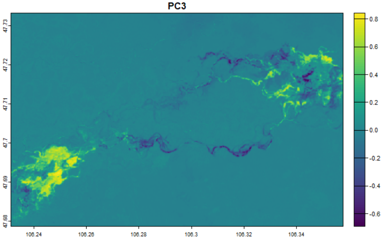
No variations between 2017 - 2019 - 2021

Lower values of NDMI in 2023.

PCA (Principal Component Analysis) NDMI







Observations

NDSI Analysis: Show a decrease in snow coverage over the years, which can have significant impacts on the ecosystem.

NDMI Spring Analysis: Less snow leads to earlier melting and reduced soil water availability in spring.

NDVI Summer Analysis: Despite the decrease in snow coverage and reduced soil moisture, an increase in vegetation is observed during summer. Moderate Water Stress (NDMI)

Conclusions

The **decrease** in snow and the resulting changes in the water cycle highlight the importance of monitoring the effects of climate change on water resource availability and vegetation.

Understanding these dynamics is **crucial** for implementing sustainable natural resource management strategies.