

# Bayan-Unjuul's Analysis

Alberto Tarroni

# Index

## 1 Introduction

## 2 Winter

- TrueColor
- NDSI

## 3 Summer

- TrueColor
- NDVI
- NDMI

## 4 Spring

- TrueColor
- NDVI
- NDMI

## 5 Conclusions

# Bayan-Unjuul



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

# Bayan-Unjuul



4790 km<sup>2</sup>

Grassland and Shrubs  
vegetation

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

# Bayan-Unjuul



4790 km<sup>2</sup>

Grassland and Shrubs  
vegetation

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

# Bayan-Unjuul



4790 km<sup>2</sup>

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

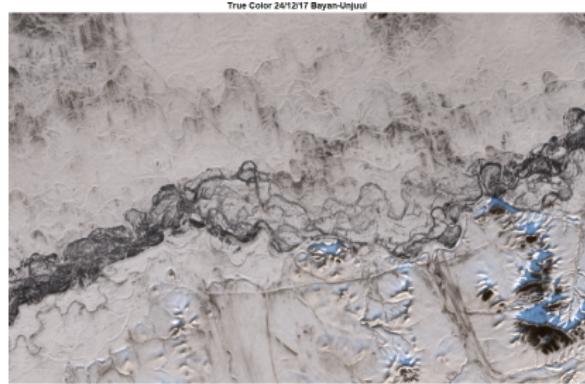
Winter Analysis using NDSI (Normalized Difference Snow Index)

Summer Analysis using NDVI (Normalized Difference Vegetation Index)

Spring Analysis using NDVI (Normalized Difference Vegetation Index)

# Winter

December 2017



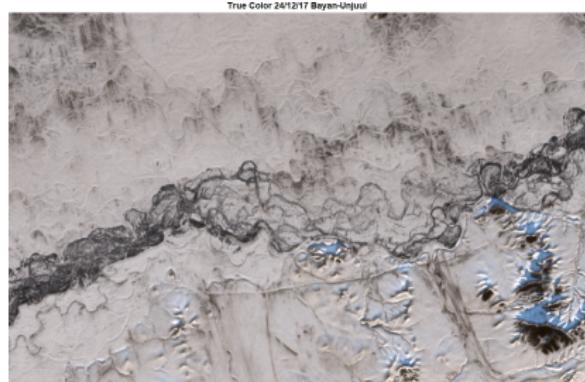
True Color by RGB (red = b4,  
green = b3, blue = b2)

Perennial snow throughout the  
winter

Frozen lakes and ponds

# Winter

December 2017



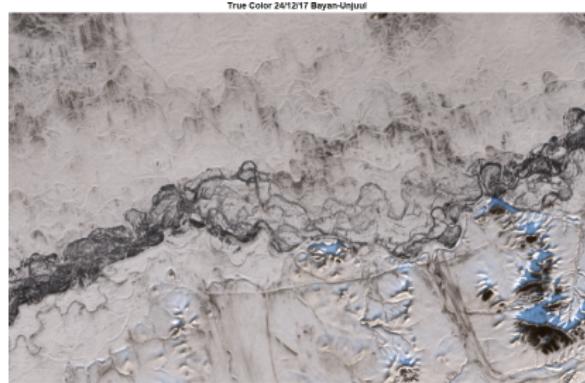
True Color by RGB (red = b4,  
green = b3, blue = b2)

Perennial snow throughout the  
winter

Frozen lakes and ponds

# Winter

December 2017



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

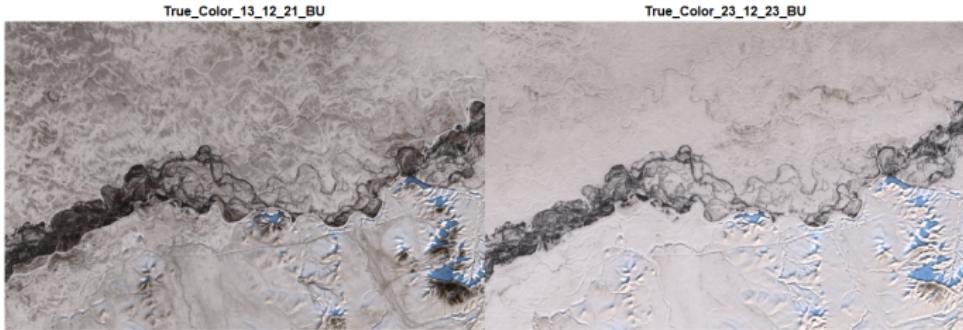
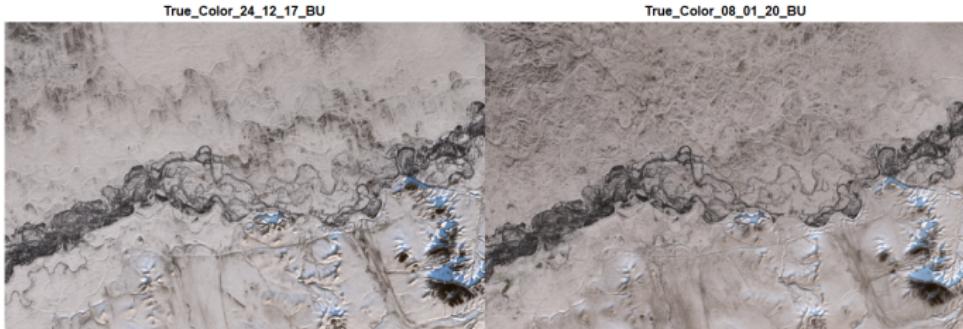
Perennial snow throughout the  
winter

Frozen lakes and ponds

# True Color Script Example

```
1 #Carico il vettore contenente le differenti bande
2
3     true_color_2017 <- c(b4_17,b3_17,b2_17)
4
5 #Creo il plot RGB con rosso=b4,verde=b3,blu=b2
6
7     tc_17 <- plotRGB(true_color_2017, 1, 2, 3, main = "TrueColor 24/12/17 Bayan-Unjuul")
```

# Winter True Color Comparison



# True Color Script Example

```
1 #Dispongo i miei plot 2 per riga e su due colonne,
2 #Con oma() do dei margini dalla cornice rispetto i punti
3 #cardinali
4 par(mfrow=c(2,2), oma=c(3,3,3,3))
5
6 tc_17 <- plotRGB(true_color_2017, 1, 2, 3, main = "True_
7     Color_24_12_17_BU")
8 tc_20 <- plotRGB(true_color_2020, 1, 2, 3, main = "True_
9     Color_08_01_20_BU")
10 tc_21 <- plotRGB(true_color_2021, 1, 2, 3, main = "True_
11     Color_13_12_21_BU")
12 tc_23 <- plotRGB(true_color_2023, 1, 2, 3, main = "True_
13     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

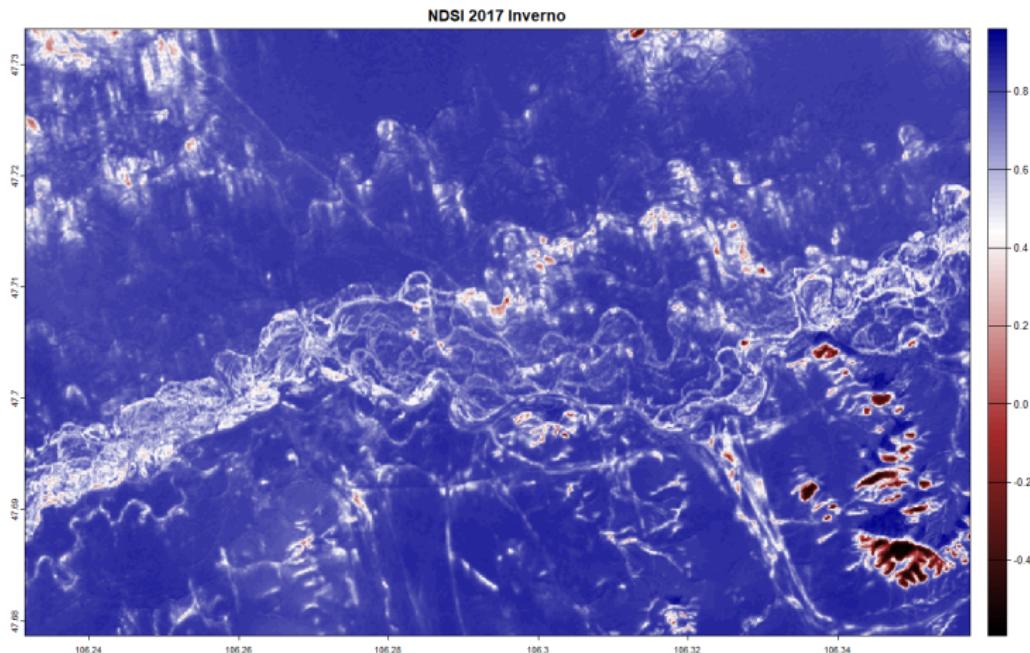
$$NDSI = \frac{Green - SWIR}{Green + SWIR}$$

SWIR: short-wave infrared light

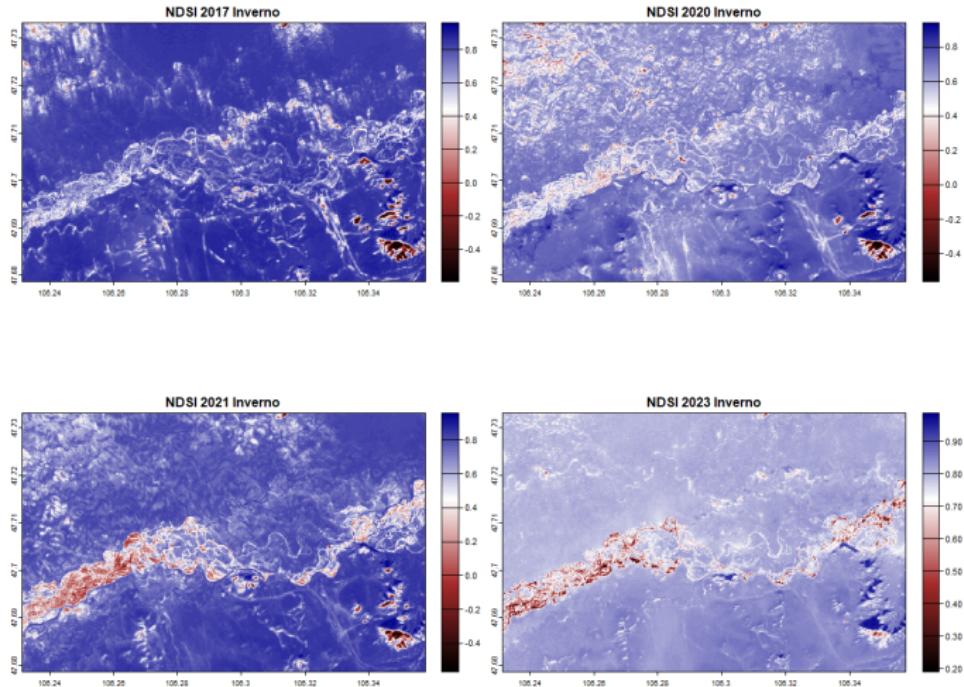
# NDSI Script Dec 2017

```
1  ### NDSI 1 = NEVE/GHIACCIO , 0 = SUOLO VEG, -1 = ACQUA 0
2      SIMILI ###
3
4  ## Palette colori ##
5
6  col_ndsi <- colorRampPalette(c("black", "brown", "white", "
7      darkblue")) (100)
8
9  ### 2017 ###
10
11 ndsi_2017 <- (b3_17 - b11_17) / (b3_17 + b11_17)
12 plot(ndsi_2017, col = col_ndsi, main = "NDSI_2017_Inverno")
```

# NDSI Dec 2017



# NDSI Comparison

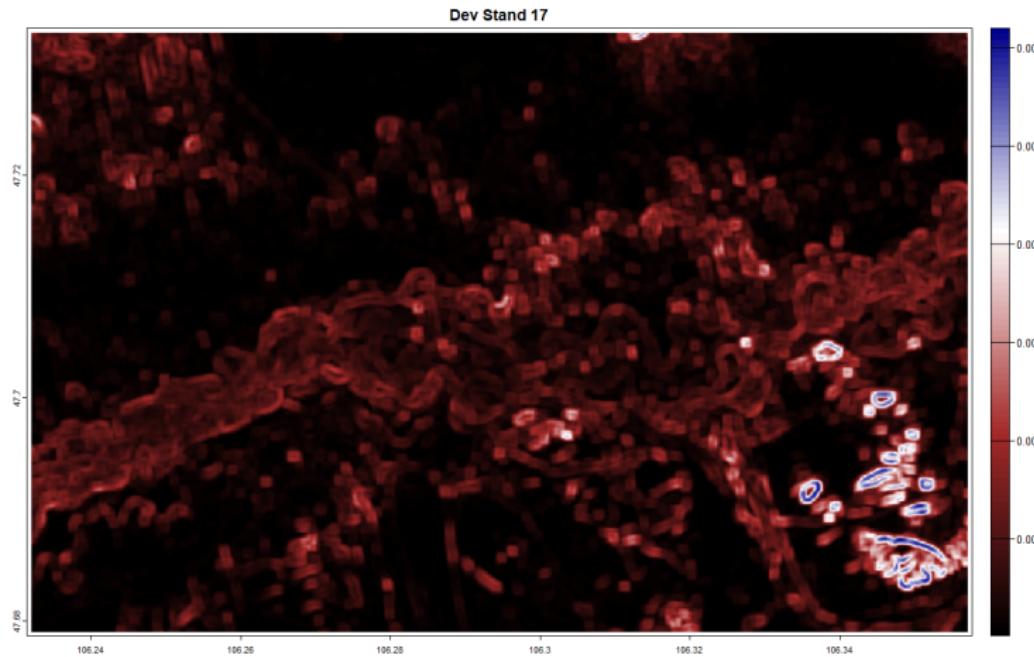


# NDSI Comparison Script

```
1 #Confronto
2
3 par(mfrow=c(2,2), oma=c(3,3,3,3))
4
5 plot(ndsi_2017, col = col_ndsi, main = "NDSI\u201d2017\u201dInverno")
6 plot(ndsi_2020, col = col_ndsi, main = "NDSI\u201d2020\u201dInverno")
7 plot(ndsi_2021, col = col_ndsi, main = "NDSI\u201d2021\u201dInverno")
8 plot(ndsi_2023, col = col_ndsi, main = "NDSI\u201d2023\u201dInverno")
```

# Standard Deviation

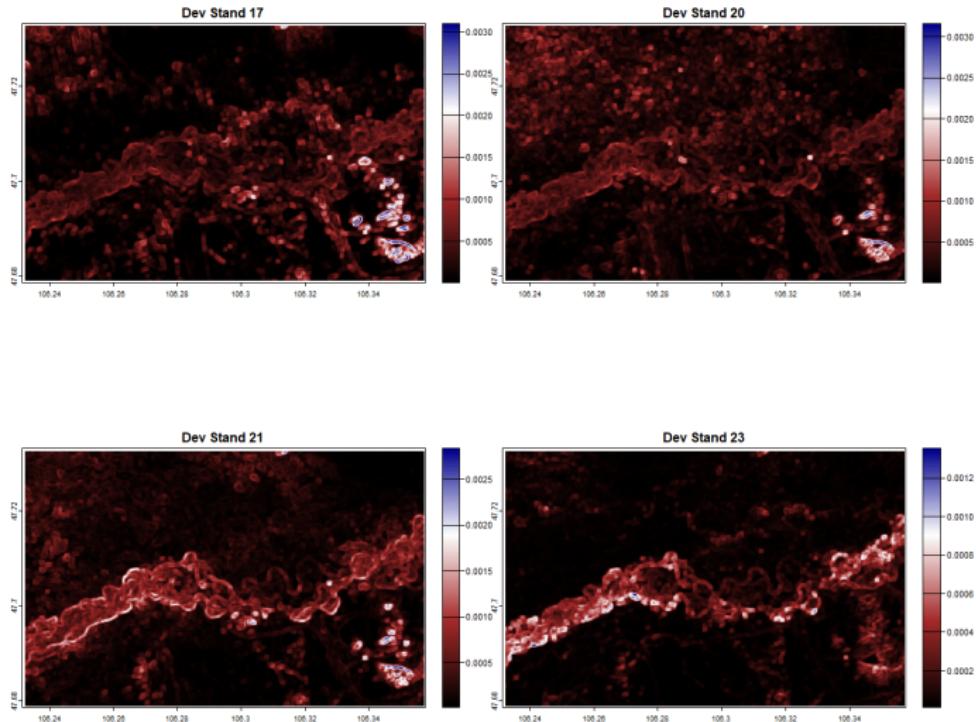
Example: 2017



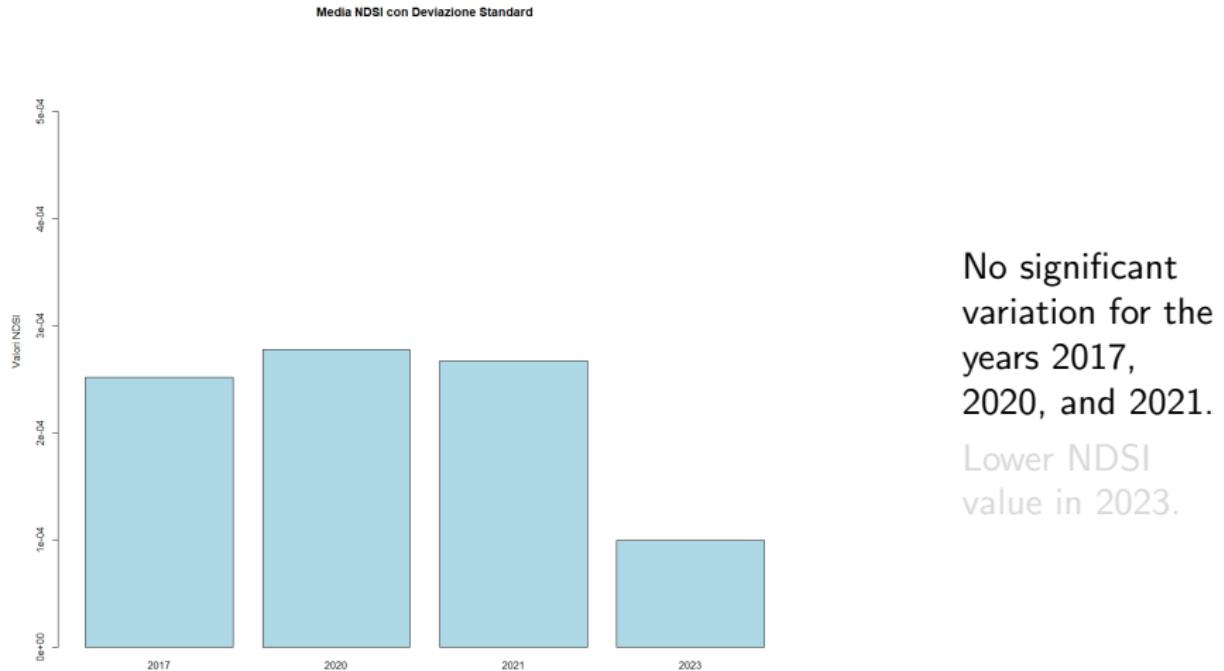
# Standard Deviation Script

```
1 ndsi_sd_17 <- focal(ndsi_2017, w = matrix(1/169,13,13), fun  
2      = sd)  
plot(ndsi_sd_17, col = col_ndsi, main = "DevStand17")
```

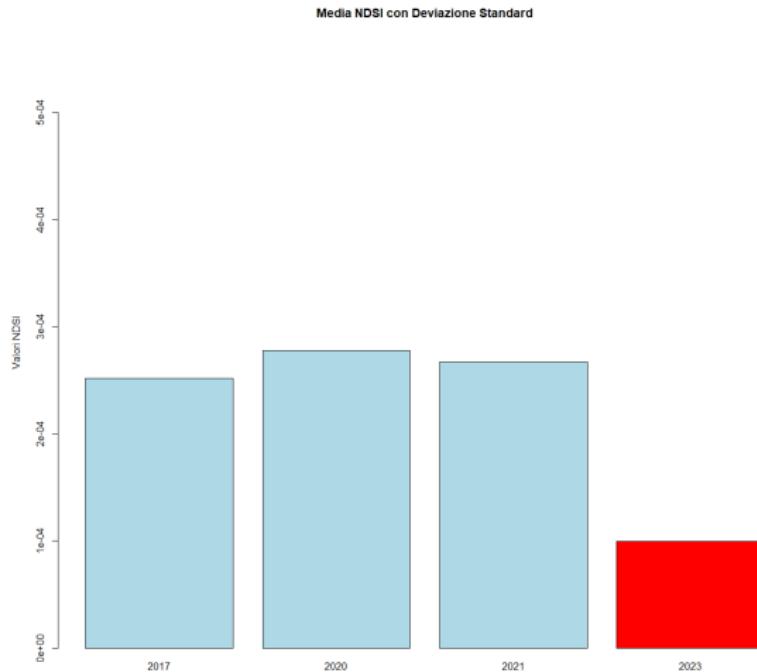
# Standard Deviation Comparison



# Plot Mean NDSI with SD (Standard Deviation)

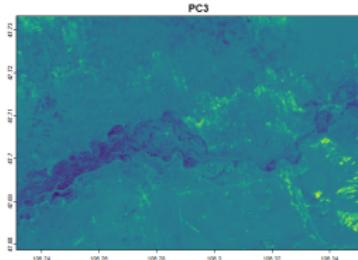
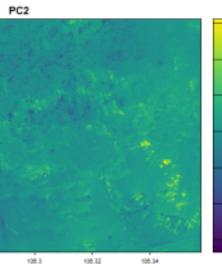
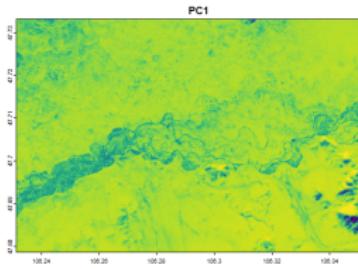


# Plot Mean NDSI with SD (Standard Deviation)



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

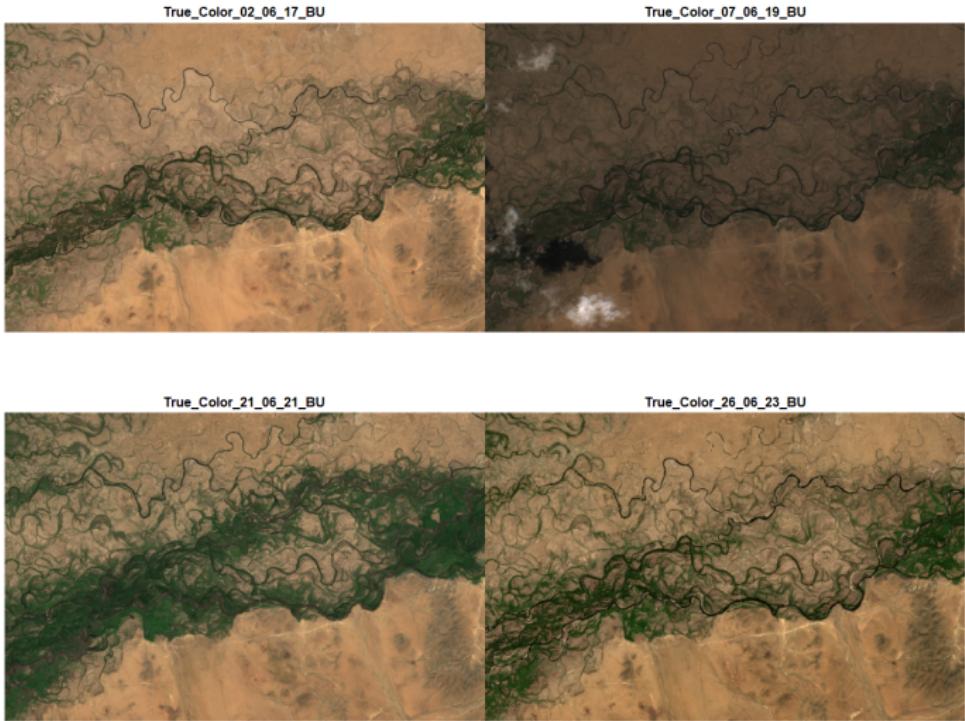
# Summer

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

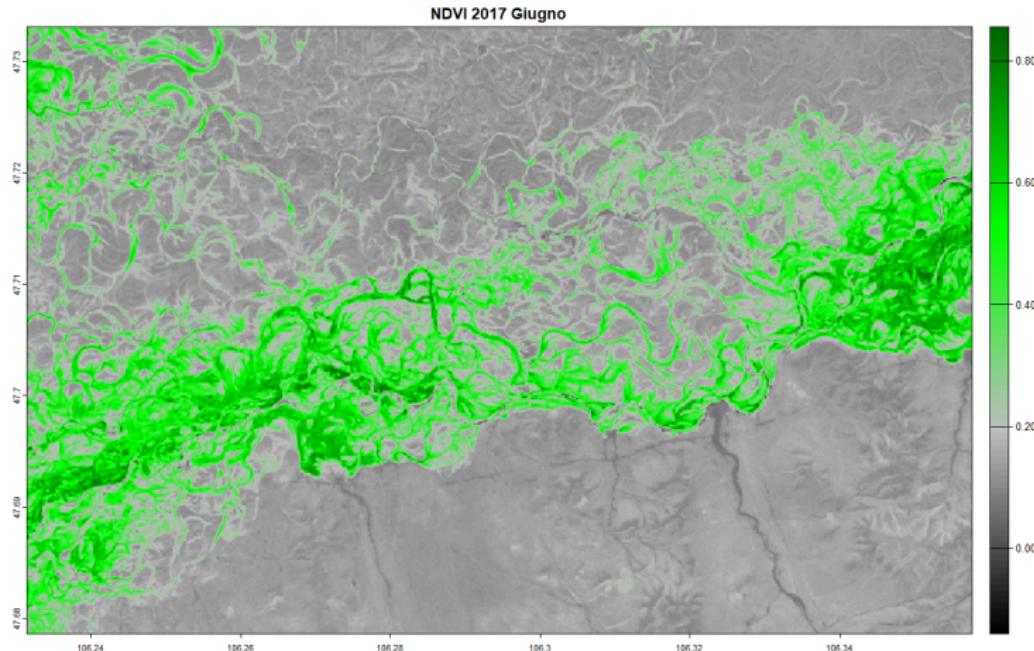
$$NDVI = \frac{NIR(b8) - Red(b4)}{NIR(b8) + Red(b4)}$$

NIR: near-infrared band,  
vegetation strongly reflects.

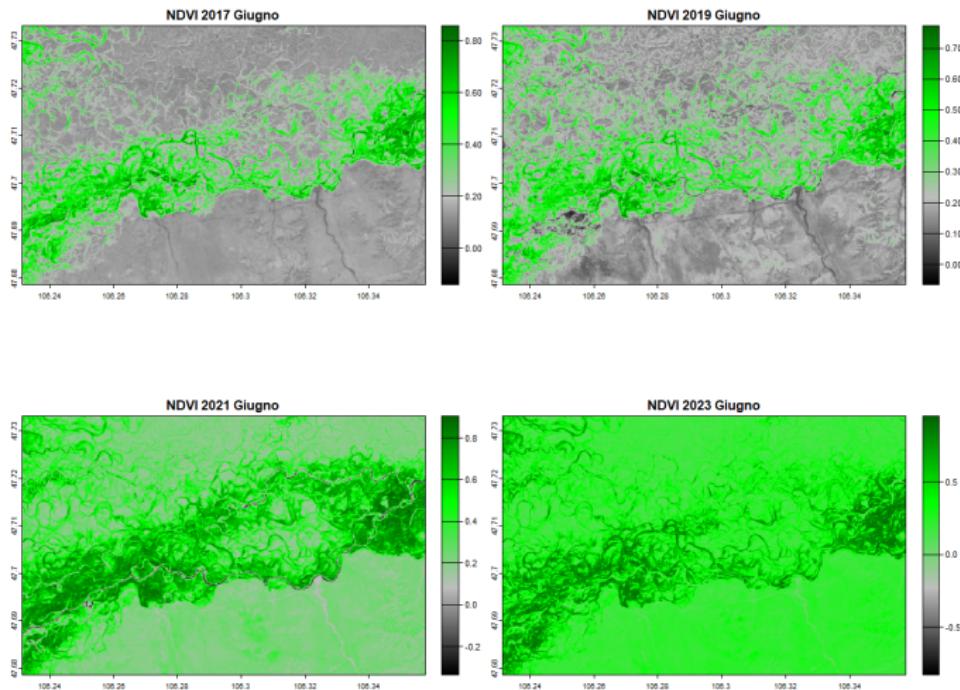
# NDVI Script Dec 2017

```
1  ### NDVI 1 = temperate/tropicali ; 0.2 - 0.4 = shrub/
2    grassland ; -0.1 - 0.1 = roccia, sabbia, neve ; -1 =
3    acqua ####
4
5  ## Palette colori ##
6
7  col_ndvi <- colorRampPalette(c("black", "grey", "green", "darkgreen"))(100)
8
9  ### 2017 ###
10 ndvi_2017_g <- (b8_17_ndvi - b4_17_ndvi) / (b8_17_ndvi + b4_17_ndvi)
11 plot(ndvi_2017_g, col = col_ndvi, main = "NDVI_2017_Giugno")
```

# NDVI Jun 2017

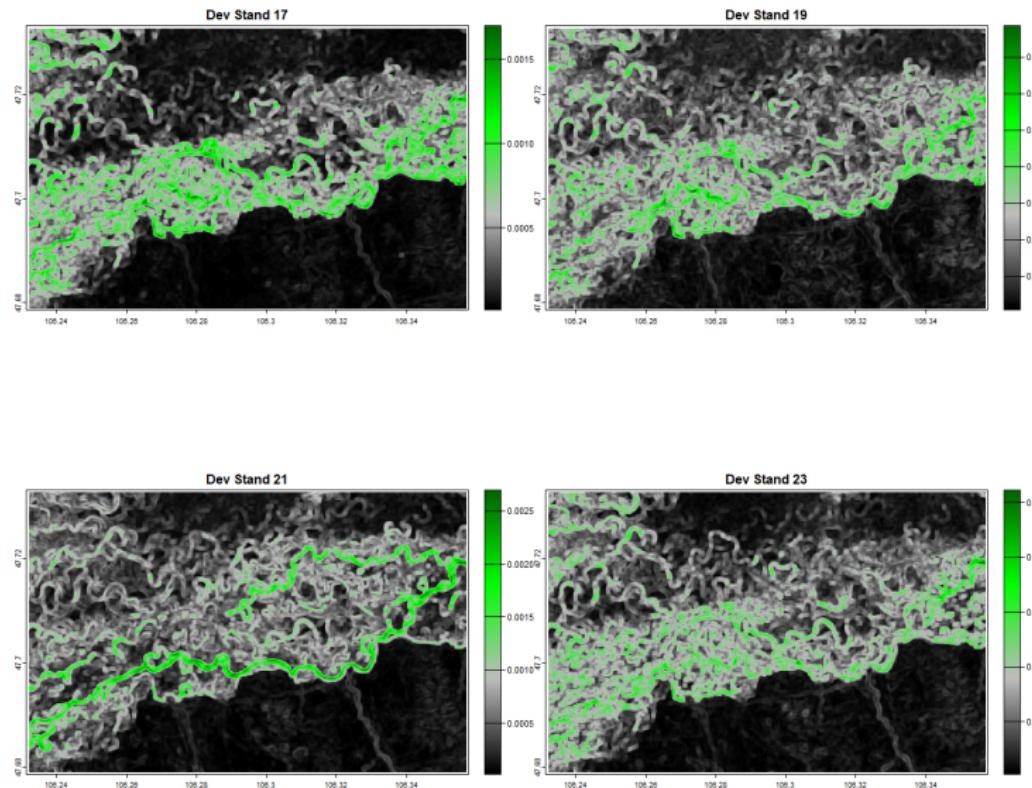


# NDVI Comparison

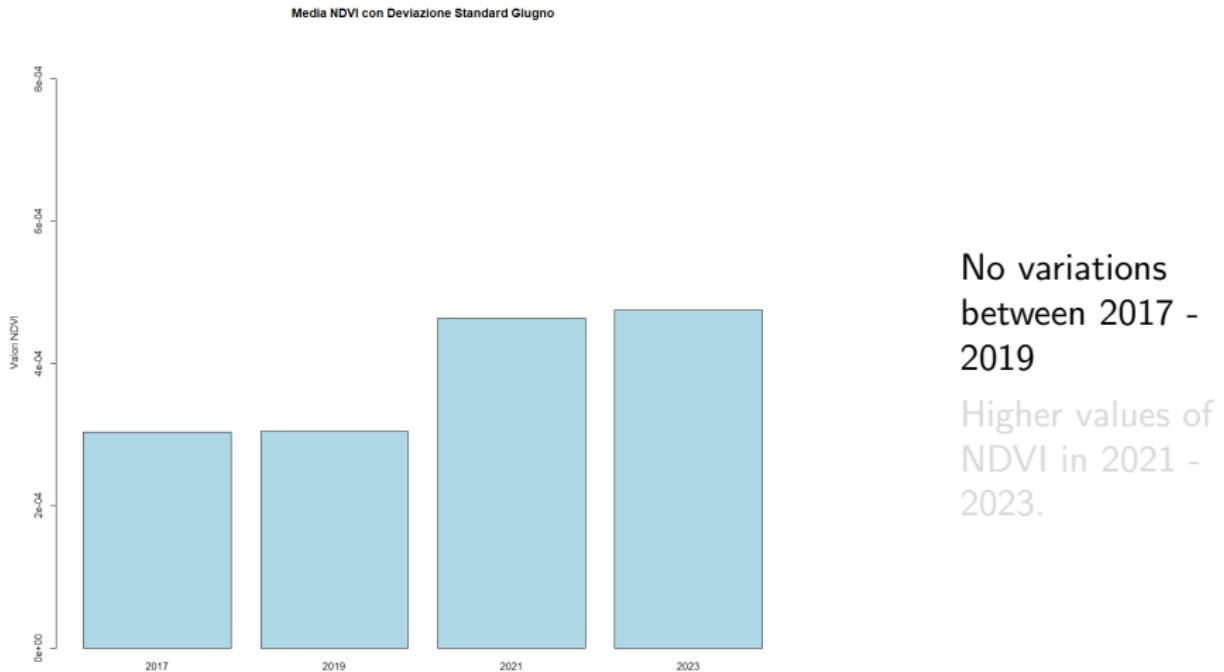


# Standard Deviation

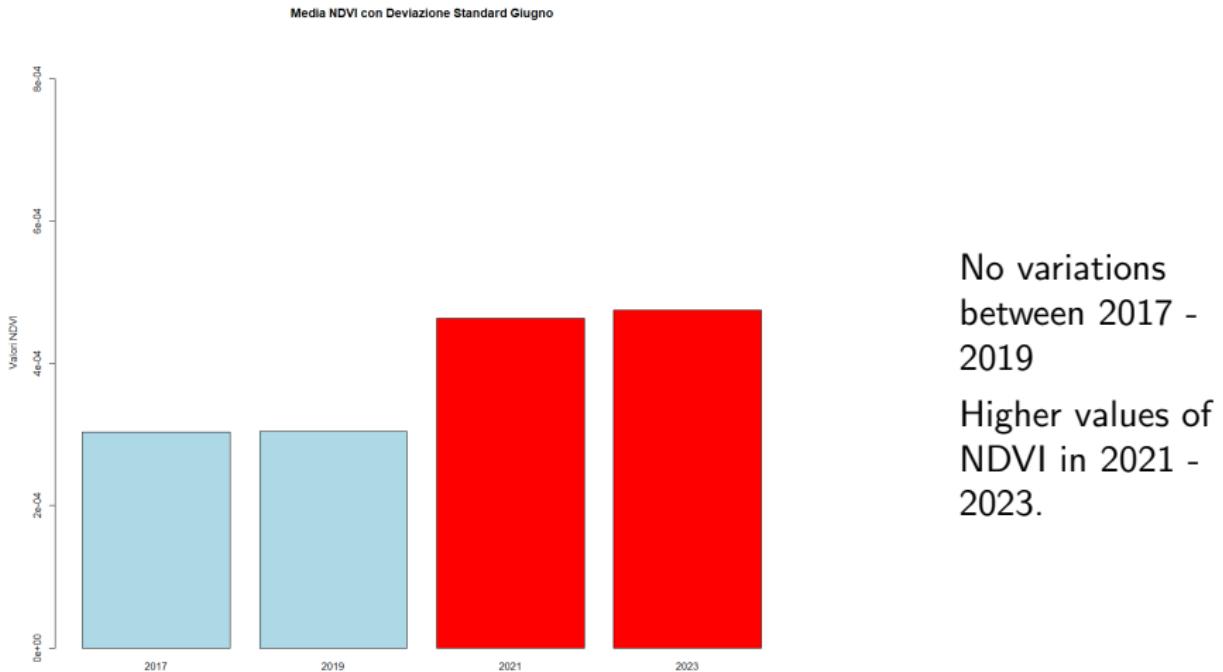
## Summer Standard Deviation Comparison



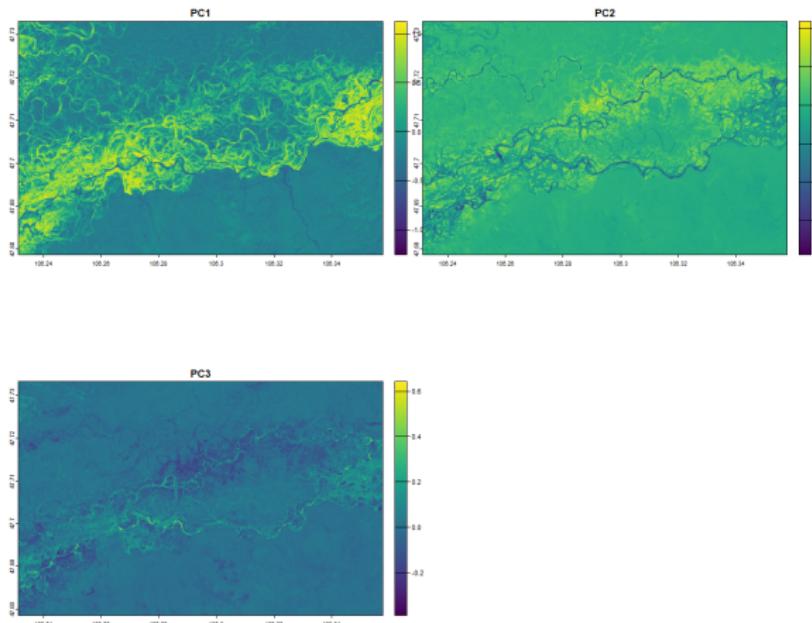
# Plot Mean NDVI with SD (Standard Deviation)



# Plot Mean NDVI with SD (Standard Deviation)



# 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

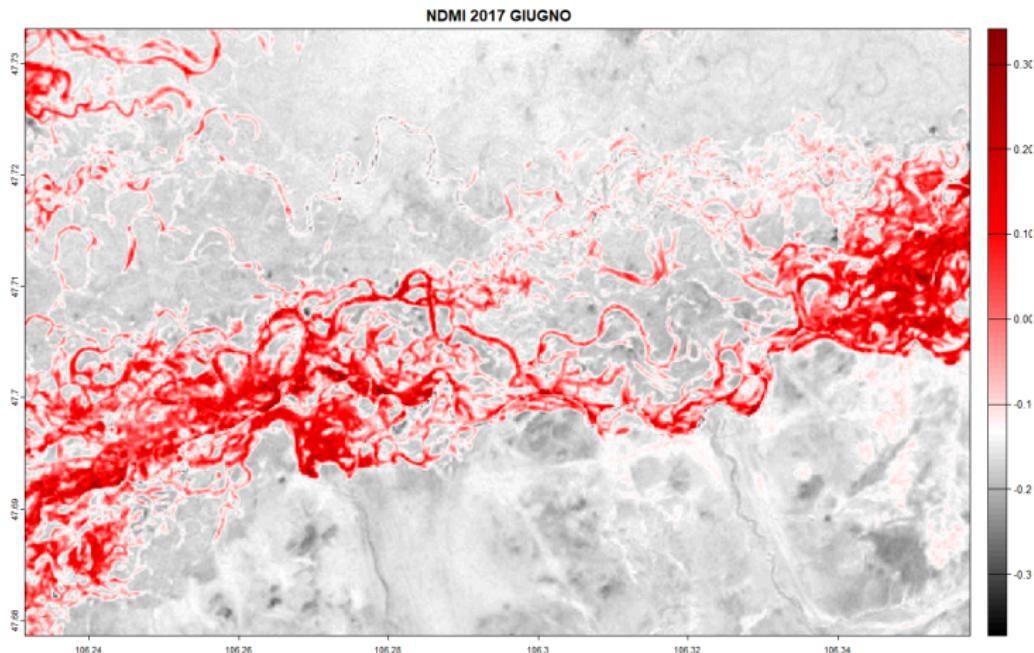
-1 : Very dry conditions

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

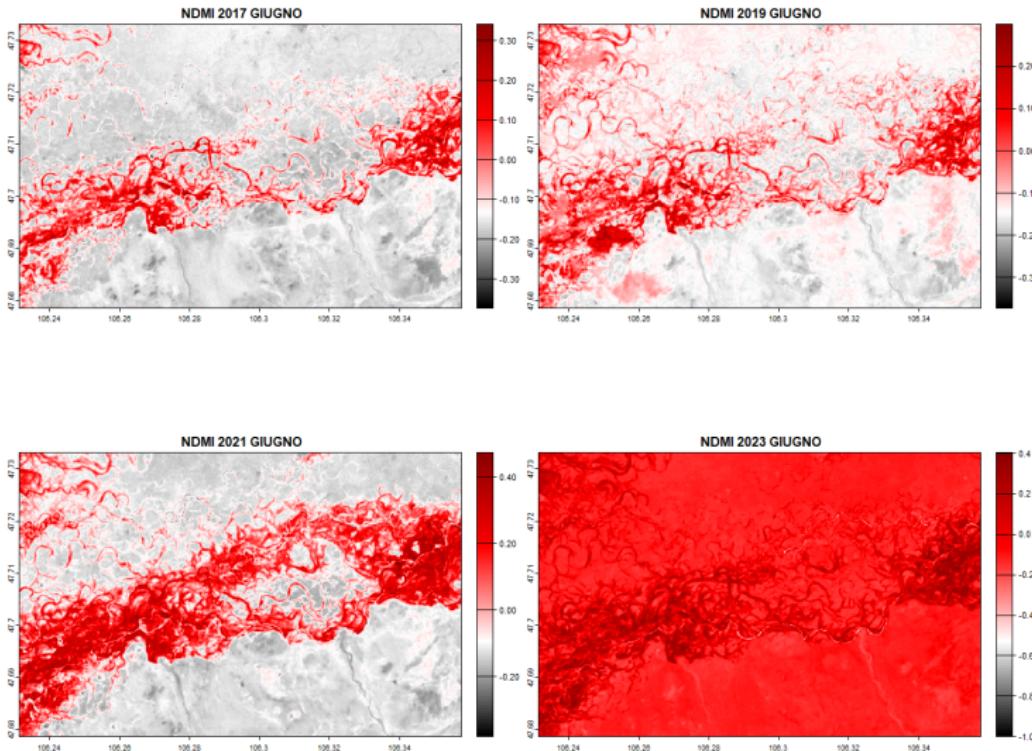
# NDMI Script June 2017

```
1 ## Palette colori ##
2
3 col_ndmi <- colorRampPalette(c("black", "white", "red", "darkred"))(100)
4
5 #NDMI#
6 ndmi_2017_g <- (b8a_17_g - b11_17_g) / (b8a_17_g + b11_17_g)
```

# NDMI June 2017

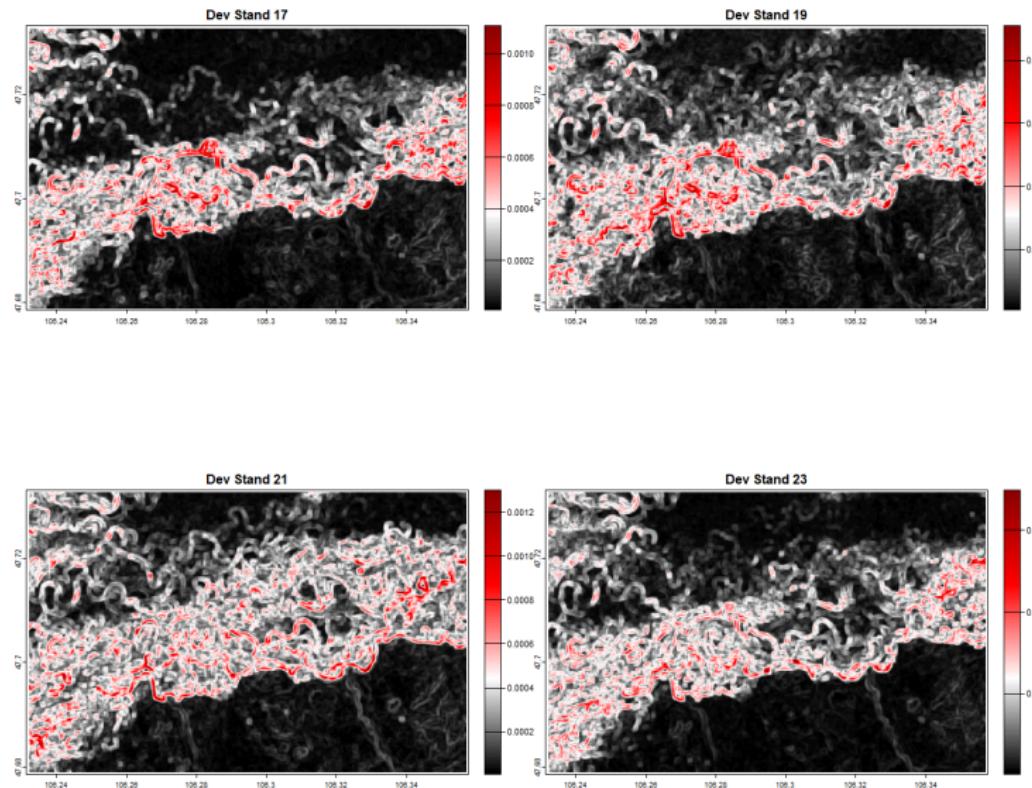


# NDMI Comparison

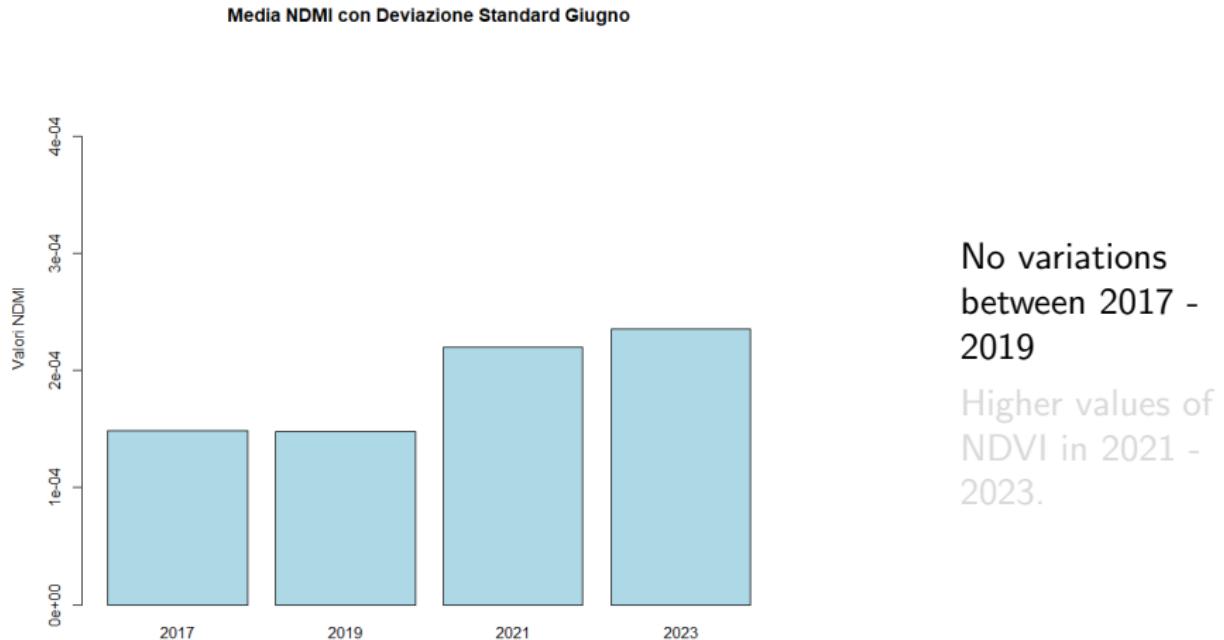


# Standard Deviation

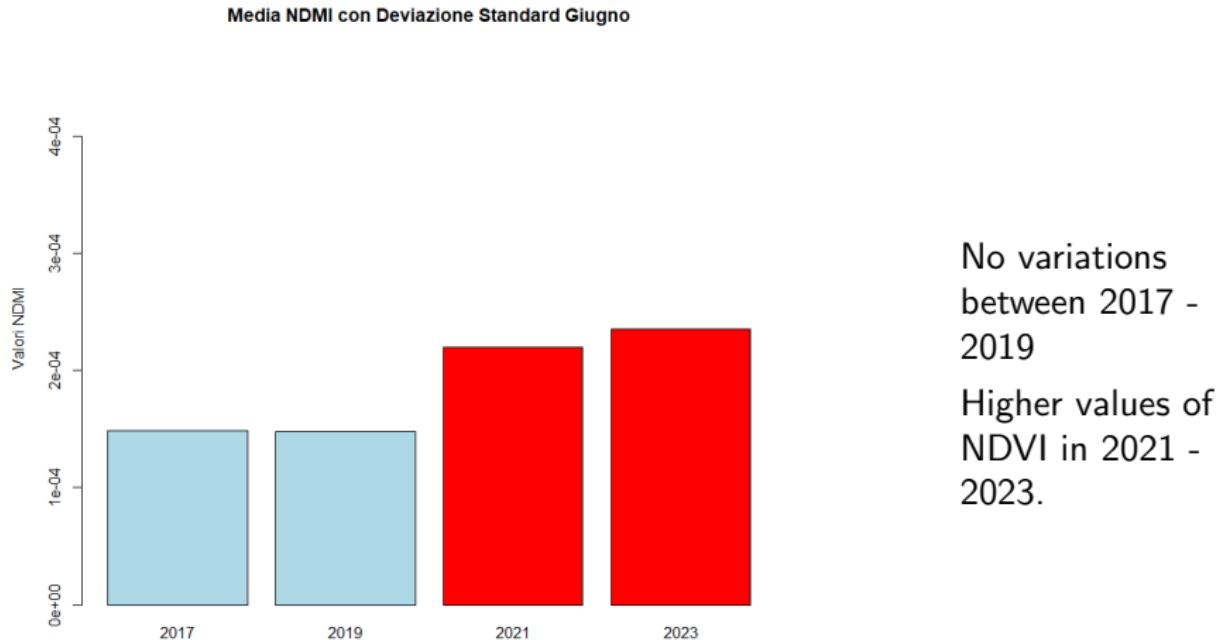
## Summer Standard Deviation Comparison



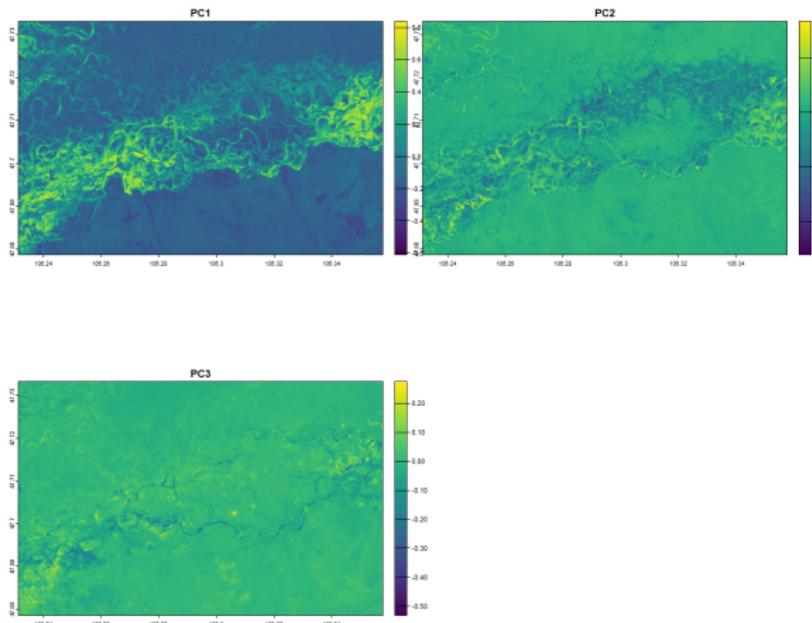
# Plot Mean NDMI with SD (Standard Deviation)



# Plot Mean NDMI with SD (Standard Deviation)



# 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

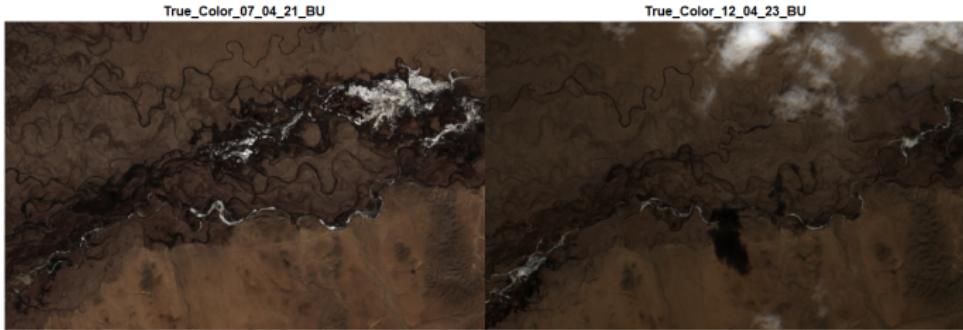
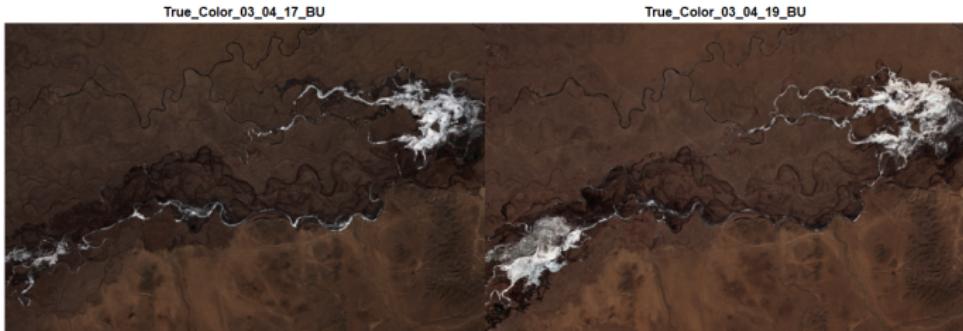
Spring

April 2017

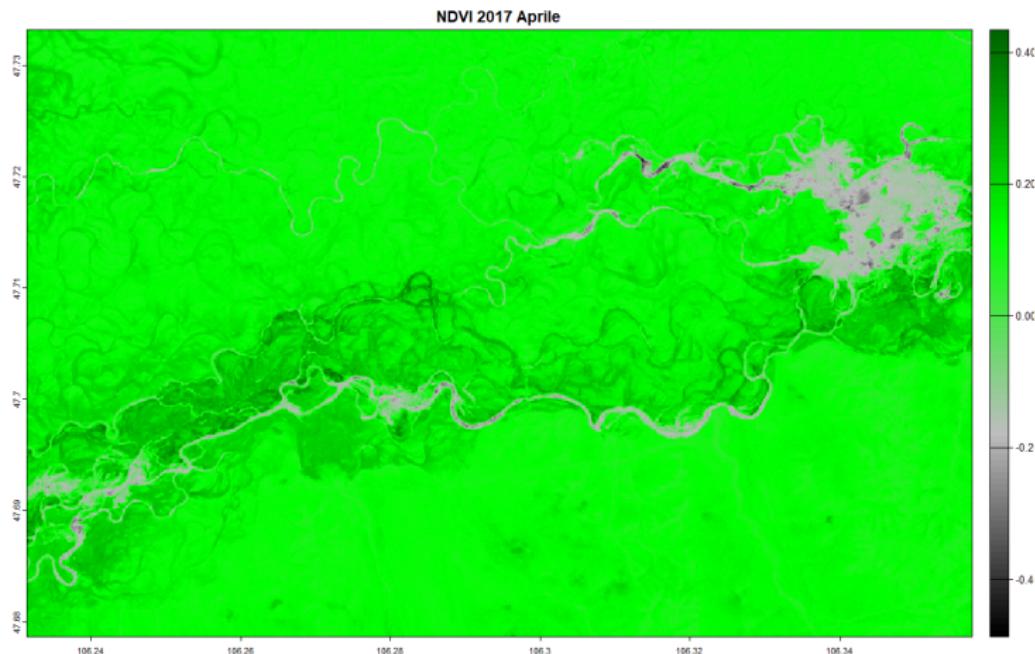
True Color 03/04/17 Bayan-Unjuul



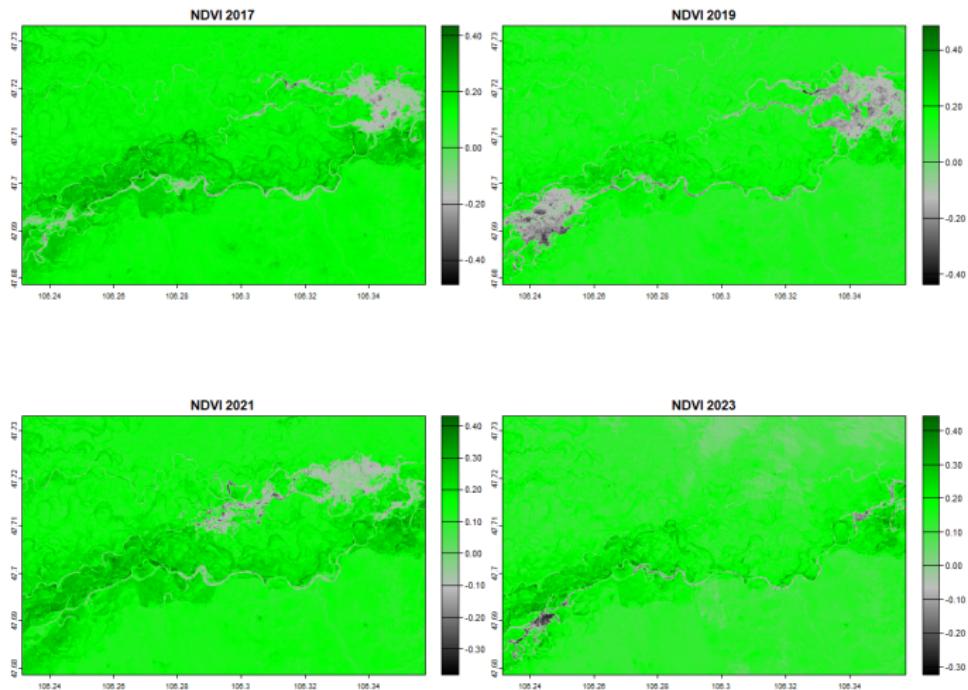
# Spring True Color Comparison



# NDVI April 2017

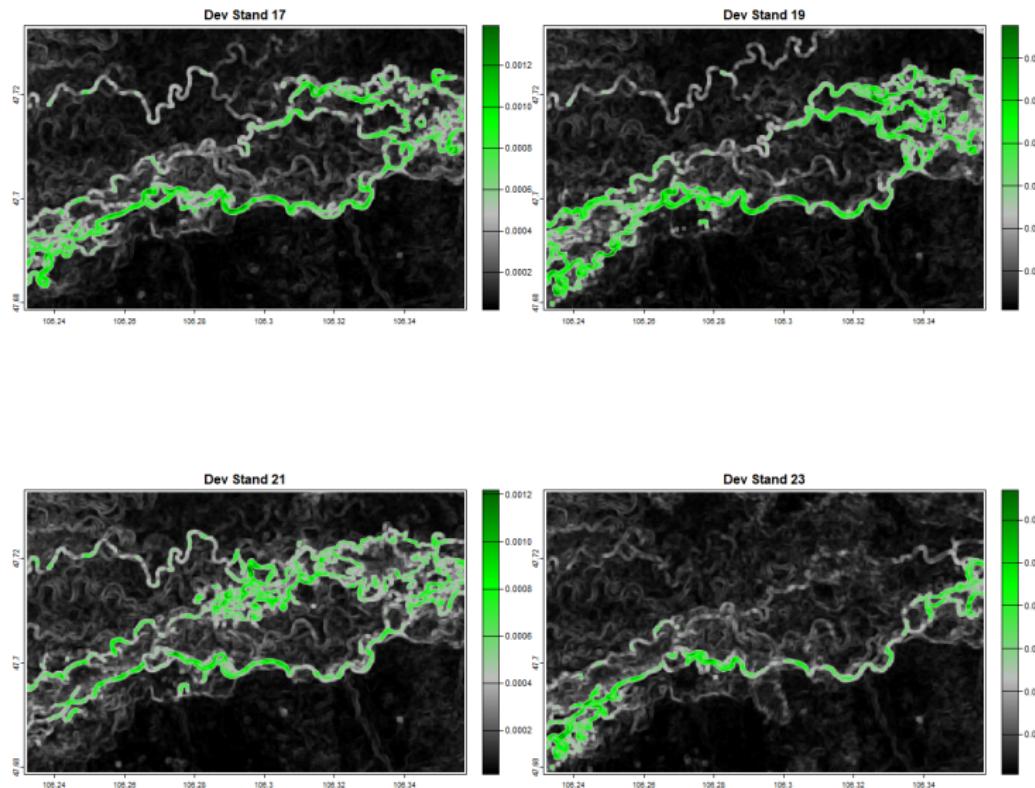


# NDVI Comparison

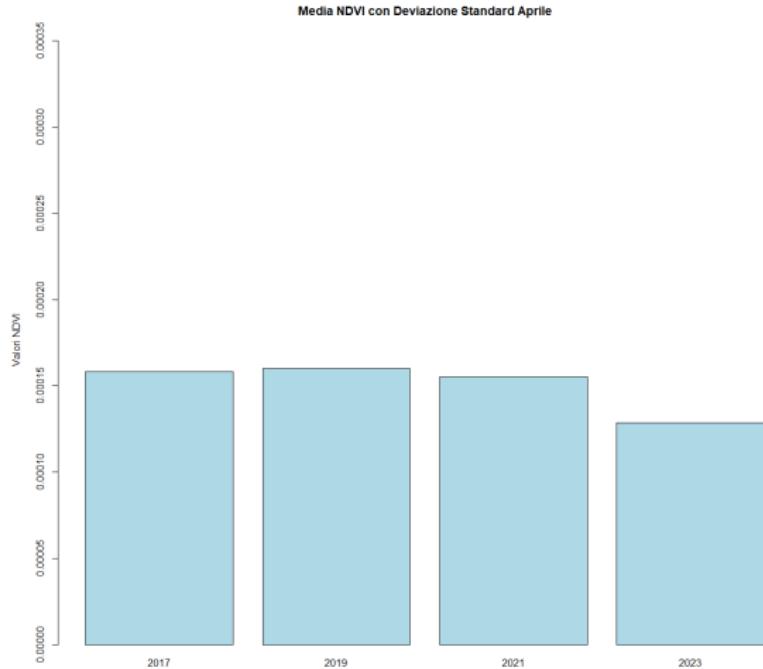


# Standard Deviation

## Spring Standard Deviation Comparison

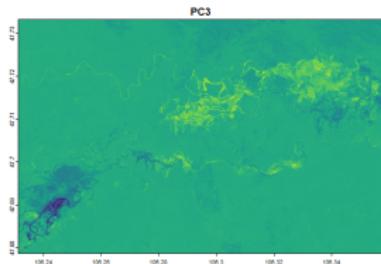
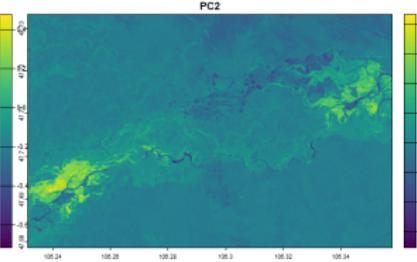
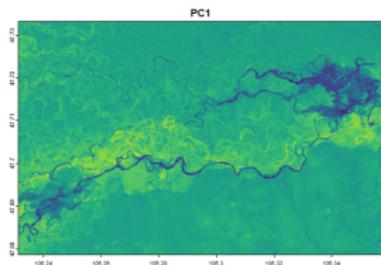


# Plot Mean NDVI with SD (Standard Deviation)



No relevant variations expect lower NDVI values for 2023

# PCA (Principal Component Analysis) NDVI

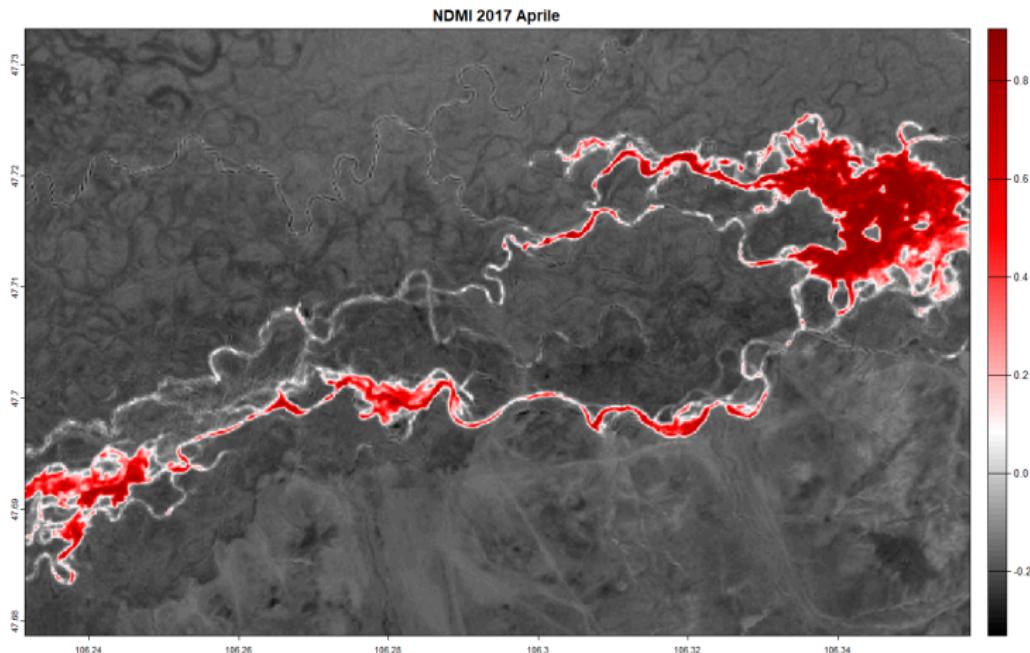


PC1: There are clear patterns, possibly representing rivers, forests, or dense vegetation areas

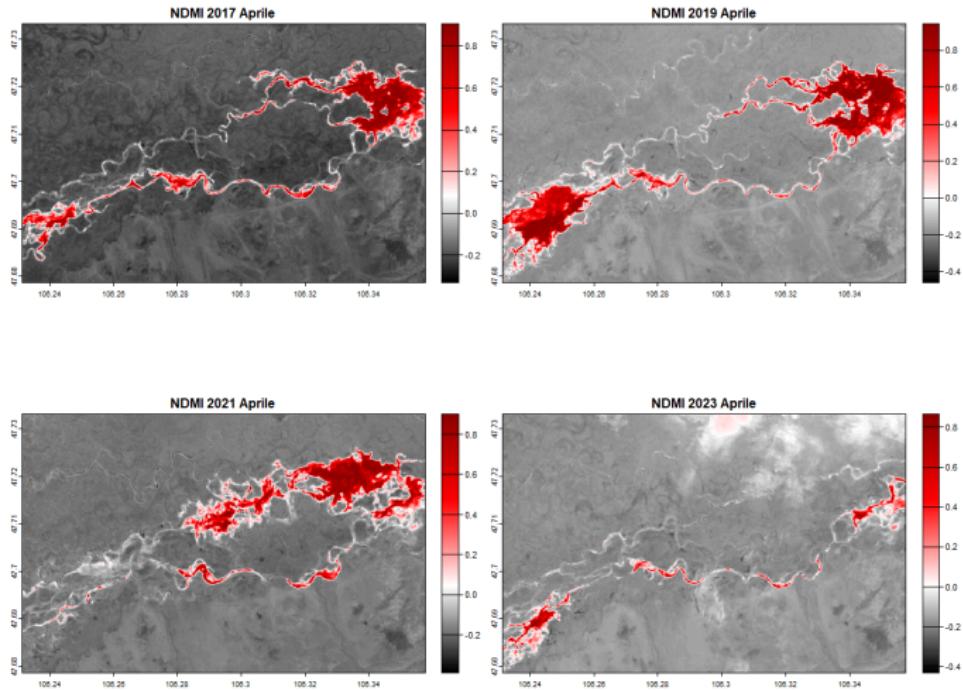
PC2: Might reflect inter-annual variations in vegetation

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

# NDMI April 2017

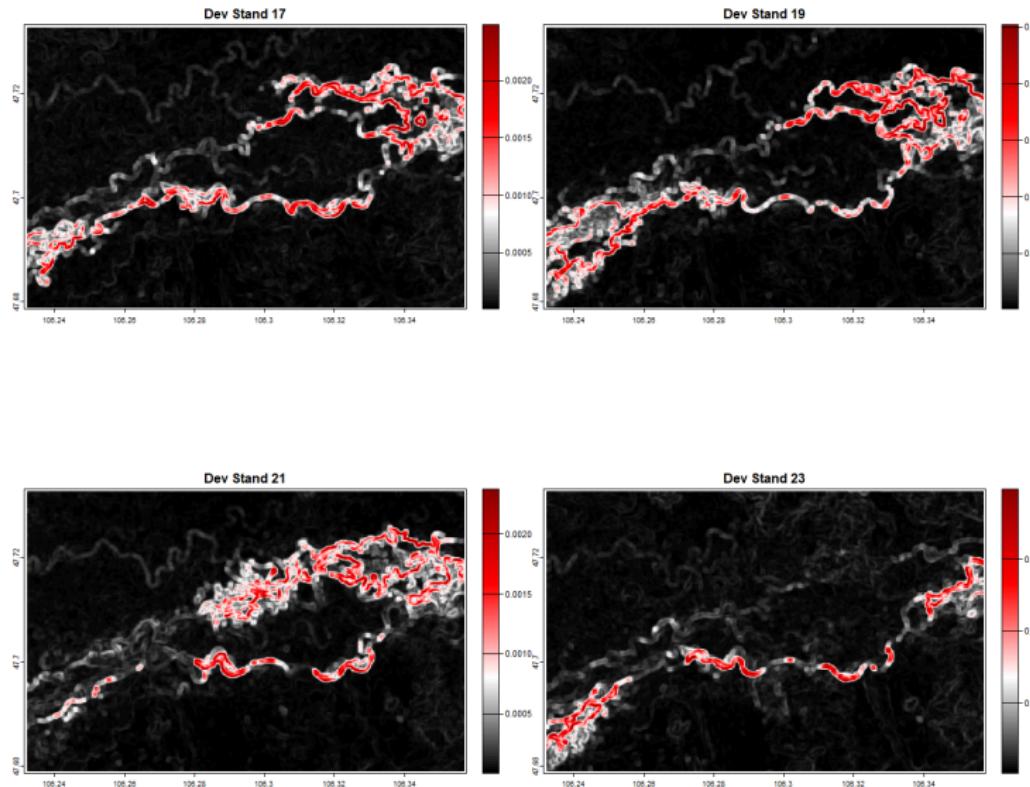


# NDMI Comparison

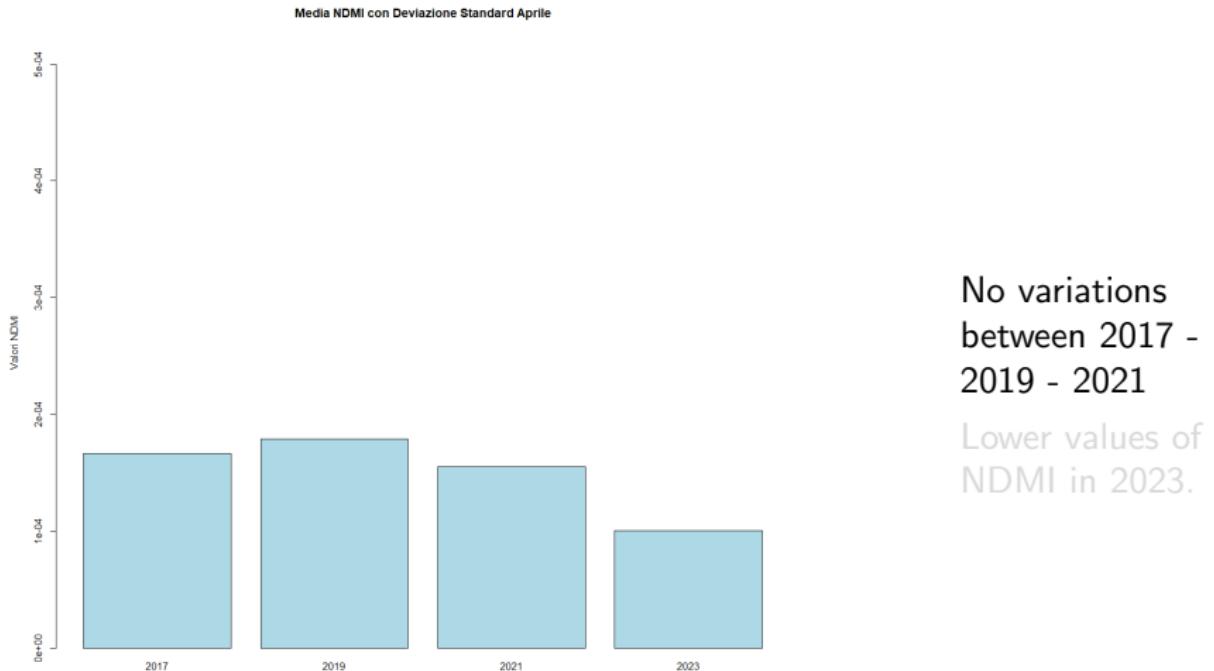


# Standard Deviation

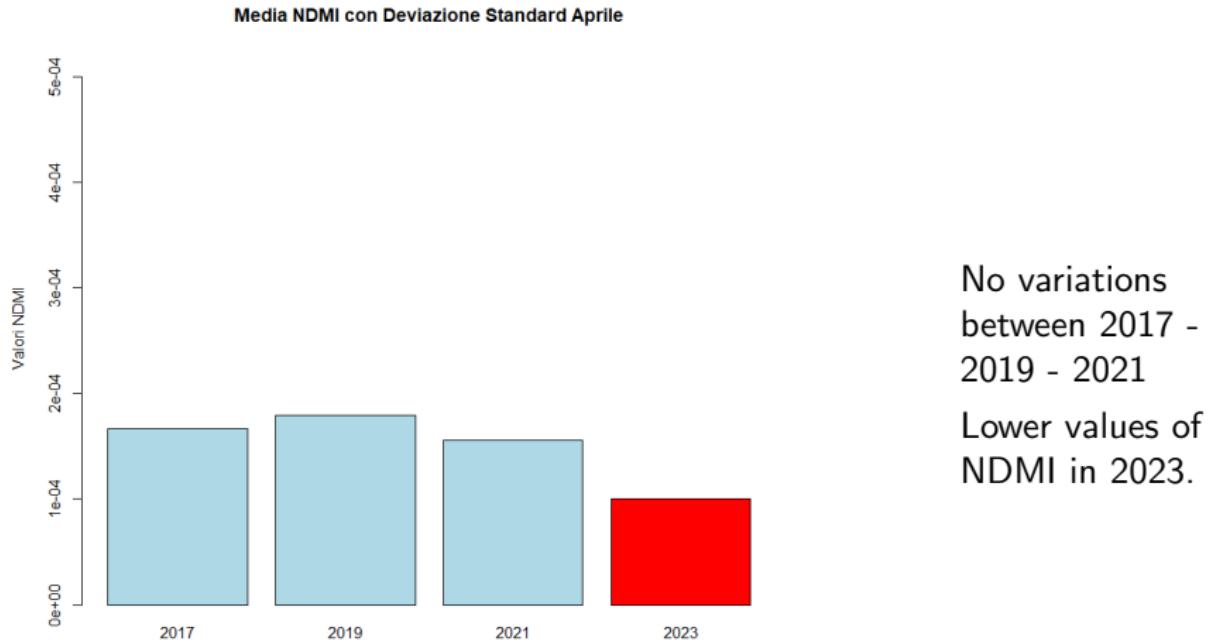
## Spring Standard Deviation Comparison



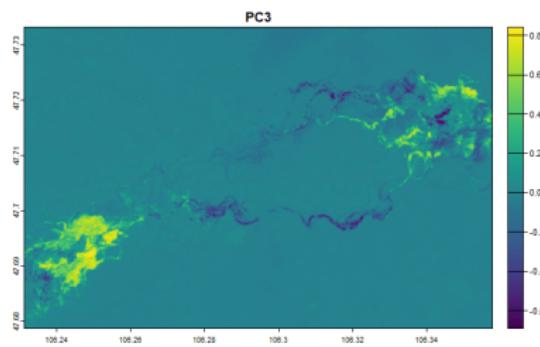
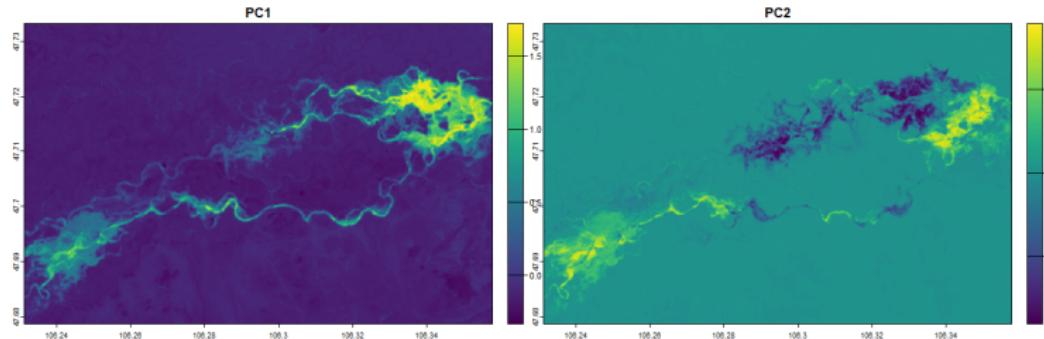
# Plot Mean NDMI with SD (Standard Deviation)



# Plot Mean NDMI with SD (Standard Deviation)



# 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.