

Connection between land degradation and violence/conflict

Report for WVI



Project Goals

- Analyze satellite data and conflict data
- Study IPC4 and IPC5 countries
- Get statistical insights and connection between land degradation and violence/conflict
 - Hypothesis: land degradation leads to increase of violence/conflict and vice versa
- Provide examples

Data sources:

Conflict data: UCDP Georeferenced Event Dataset (GED) Global version 22.1 downloaded from <https://ucdp.uu.se/>

NDVI data: <https://www.ncei.noaa.gov/>. Downloaded for everyday from 1981 to present.

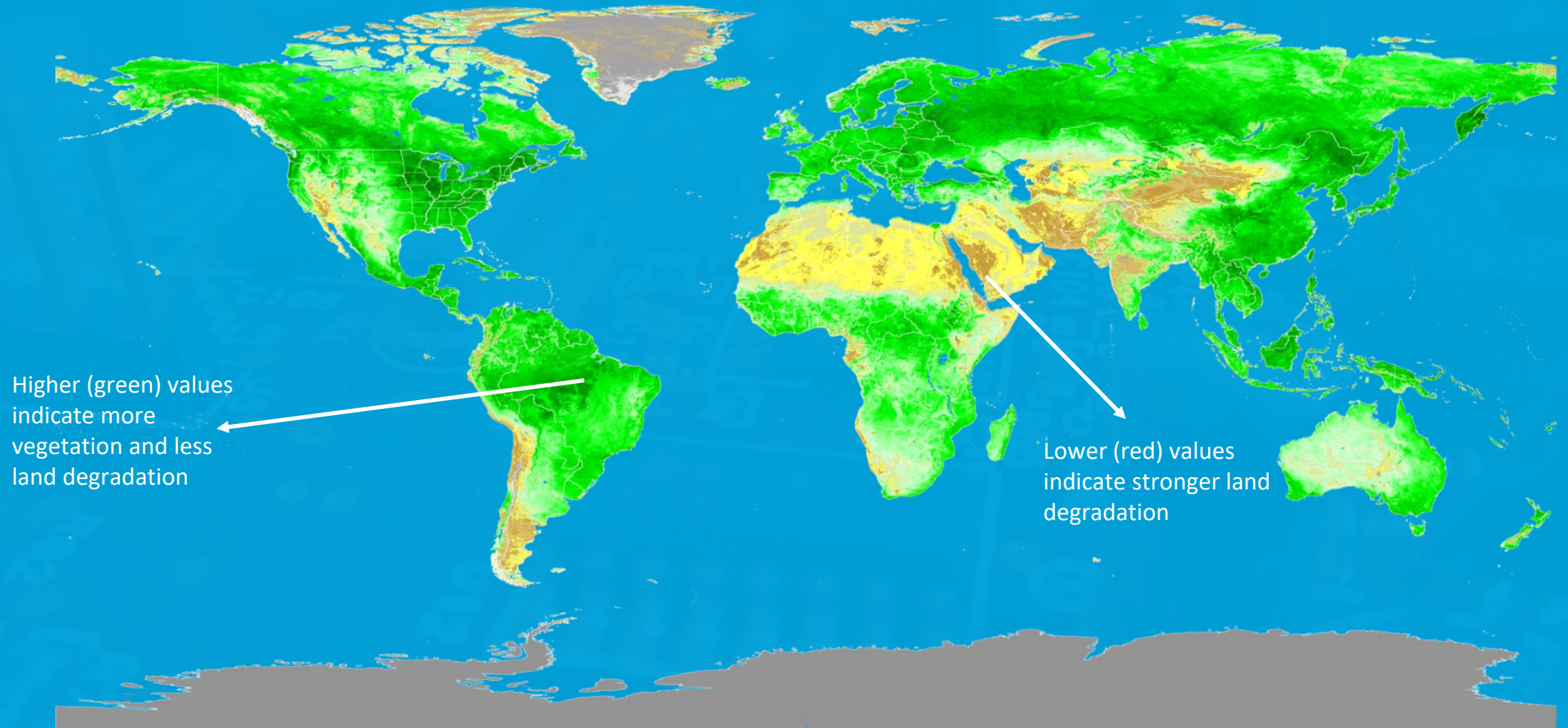
NDVI:

Commonly used index to measure the amount of healthy vegetation in a given area based on the reflectance of near-infrared and red light. NDVI is calculated by taking the difference between the reflectance values of near-infrared and red light, and then dividing this difference by their sum. Values range from -1 to +1, with negative values indicating water bodies or clouds, and positive values indicating healthy vegetation.

High NDVI values indicate an abundance of green vegetation, while low values suggest a lack of vegetation or the presence of non-photosynthetic materials like rocks, sand or soil. NDVI is widely used in various applications such as agriculture, forestry, land-use management, and environmental monitoring. It provides valuable information on vegetation cover, health and productivity, and helps in identifying areas of vegetation stress or damage.

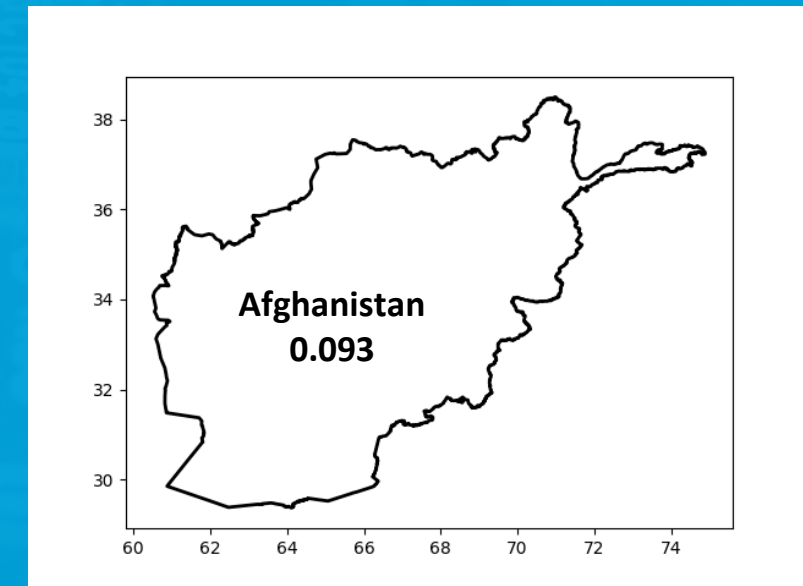
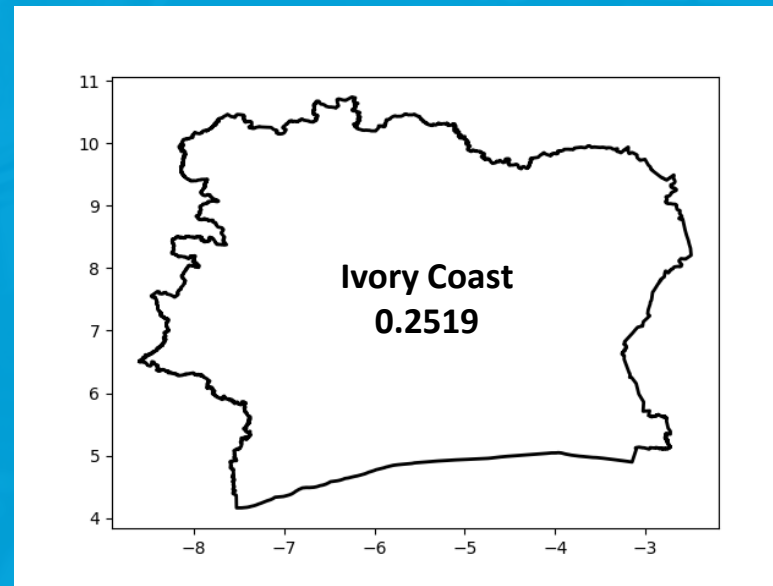
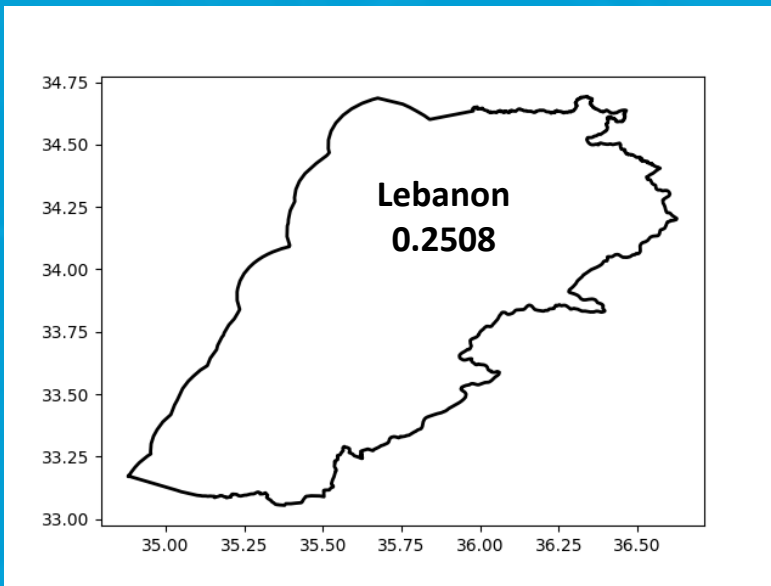
National Centers for Environmental Information (<https://www.ncei.noaa.gov/>) derives NDVI from the Surface Reflectance Climate Data Record (CDR). The data record spans from 1981 to 10 days before the present using data from NOAA polar orbiting satellites [Advanced Very High Resolution Radiometer (AVHRR) and the Visible Infrared Imaging Radiometer Suite (VIIRS)]. Output is generated daily on a 0.05° by 0.05° global grid.

NDVI explained



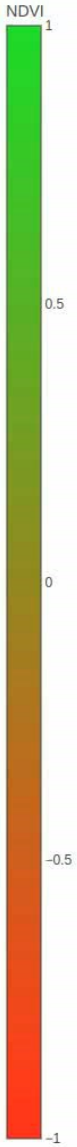
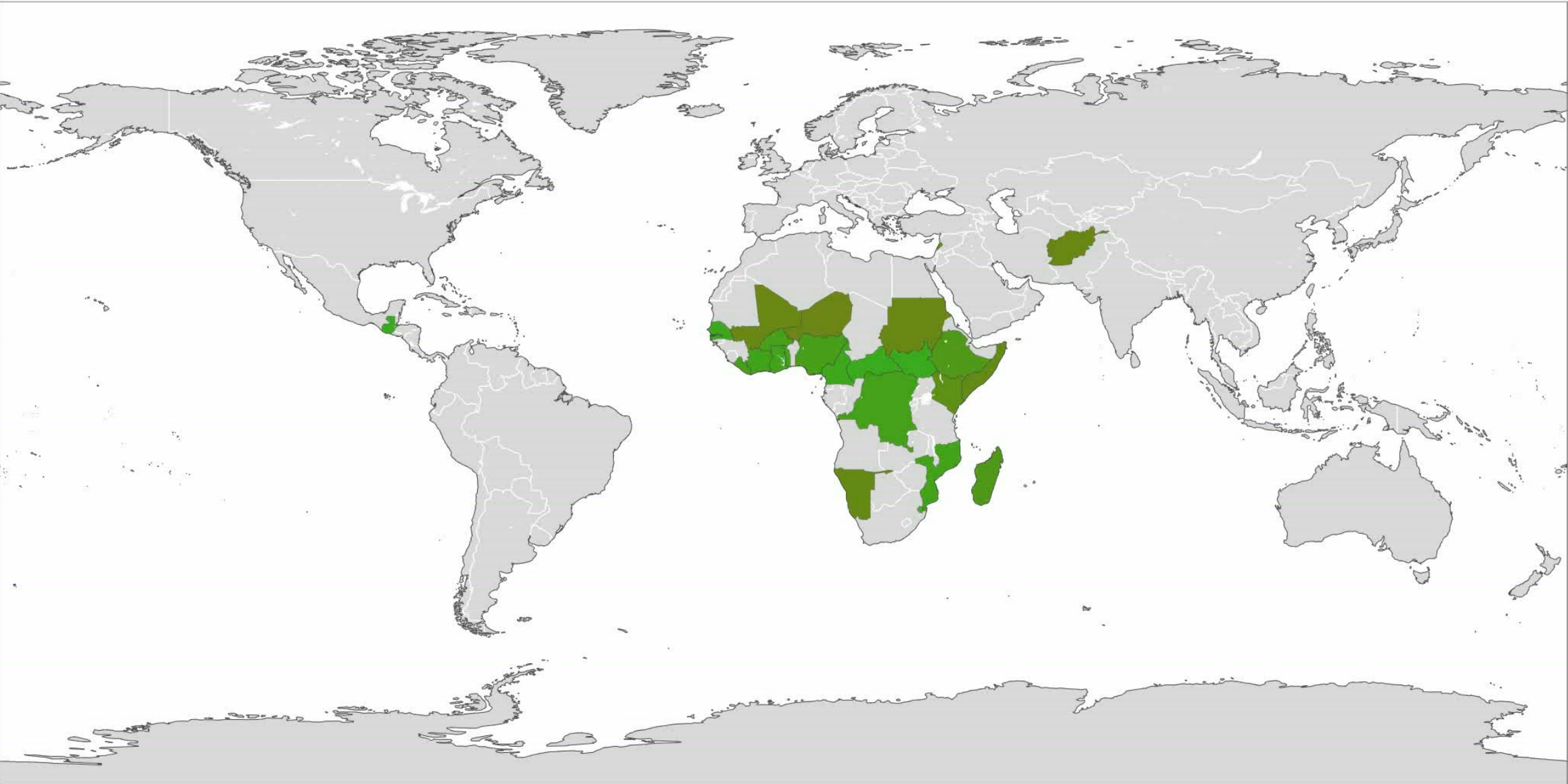
NDVI usage and examples

NDVI data we use contains world latitude and longitude coordinates with its corresponding value. For each country in IPC4 and IPC5, geographical borders were estimated and the median NDVI for each day was taken. For example, on June 16th, 2001 registered NDVI was:



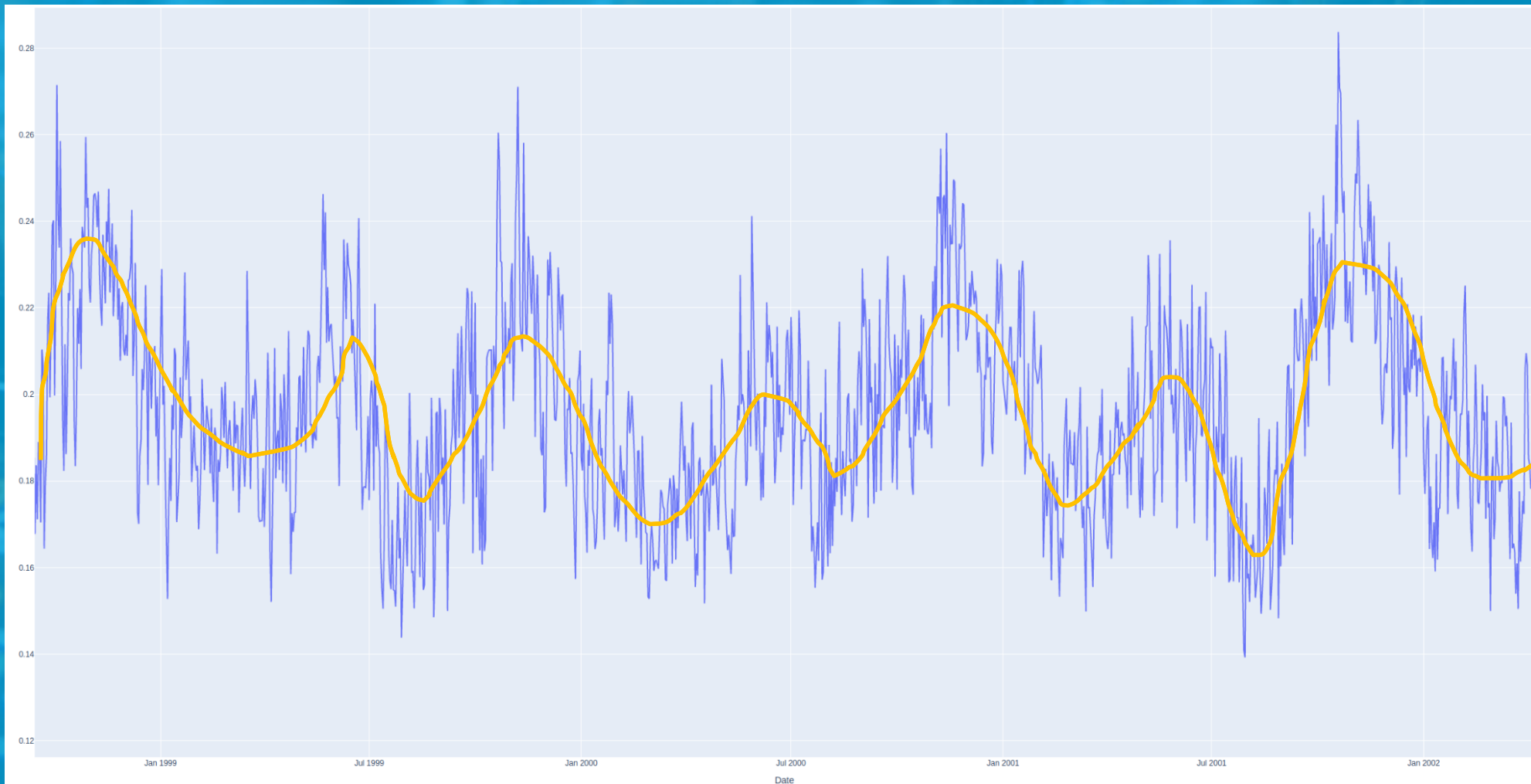
See video in the delivery folder!

NDVI - 1981-12-31



NDVI Seasonality

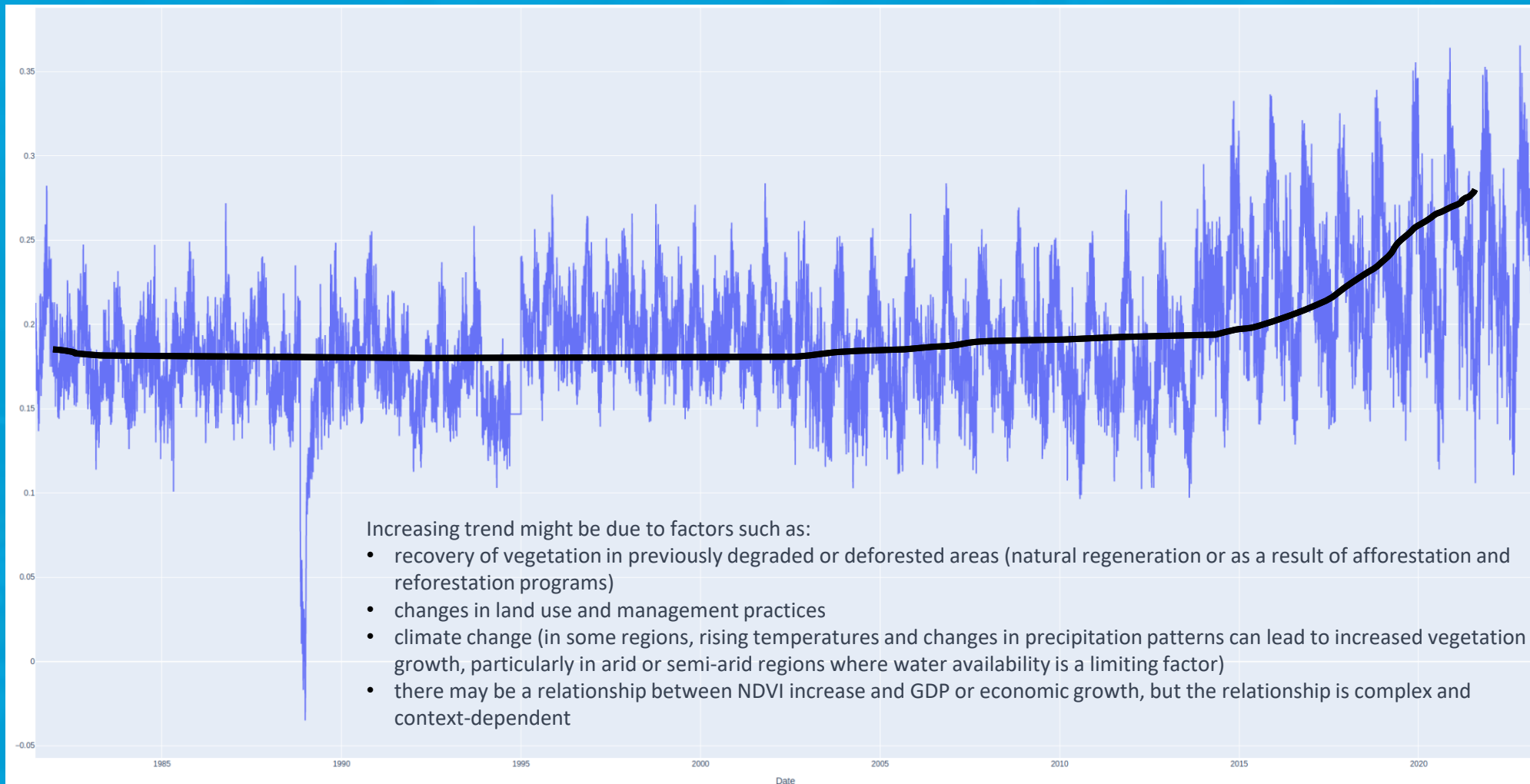
Vegetation growth and health are strongly influenced by seasonal changes in climate, particularly temperature and precipitation. These changes affect the availability of soil moisture, which is critical for plant growth, and the amount and intensity of solar radiation that drives photosynthesis. This leads to a cyclical pattern in NDVI values, with high values during the growing season and low values during the dormant season.



NDVI Trend

There is an increasing trend in NDVI in general. From 1989 to 2020, NDVI during the month of November has increased 78.96%.

Date	NDVI
Nov 1989	0.2035
Nov 1995	0.2102
Nov 2000	0.2455
Nov 2005	0.2656
Nov 2010	0.2554
Nov 2015	0.3365
Nov 2020	0.3642





Approach

Approach

- Studies were conducted to see relationship between conflicts and NDVI, aggregating over periods of 1 day, 1 week, 2 weeks, 1 month, 3 months, etc. for all available countries.
- Conflict variables taken into account for each period: total days of conflict, total conflicts, total deaths, severity of conflict.
- Important to see if there are relationships between:
 1. conflicts in a given time frame and land degradation in the next time frame (how do conflicts impact land degradation)
 2. conflicts in a given time frame and land degradation in the previous time frame (how does land degradation impact conflicts)
- Expected to see strong **positive correlations** between:
 - total days of conflict
 - total conflicts
 - total deaths
 - severity of conflict

that is, **if one of these variables increases, the others are expected to increase as well.**

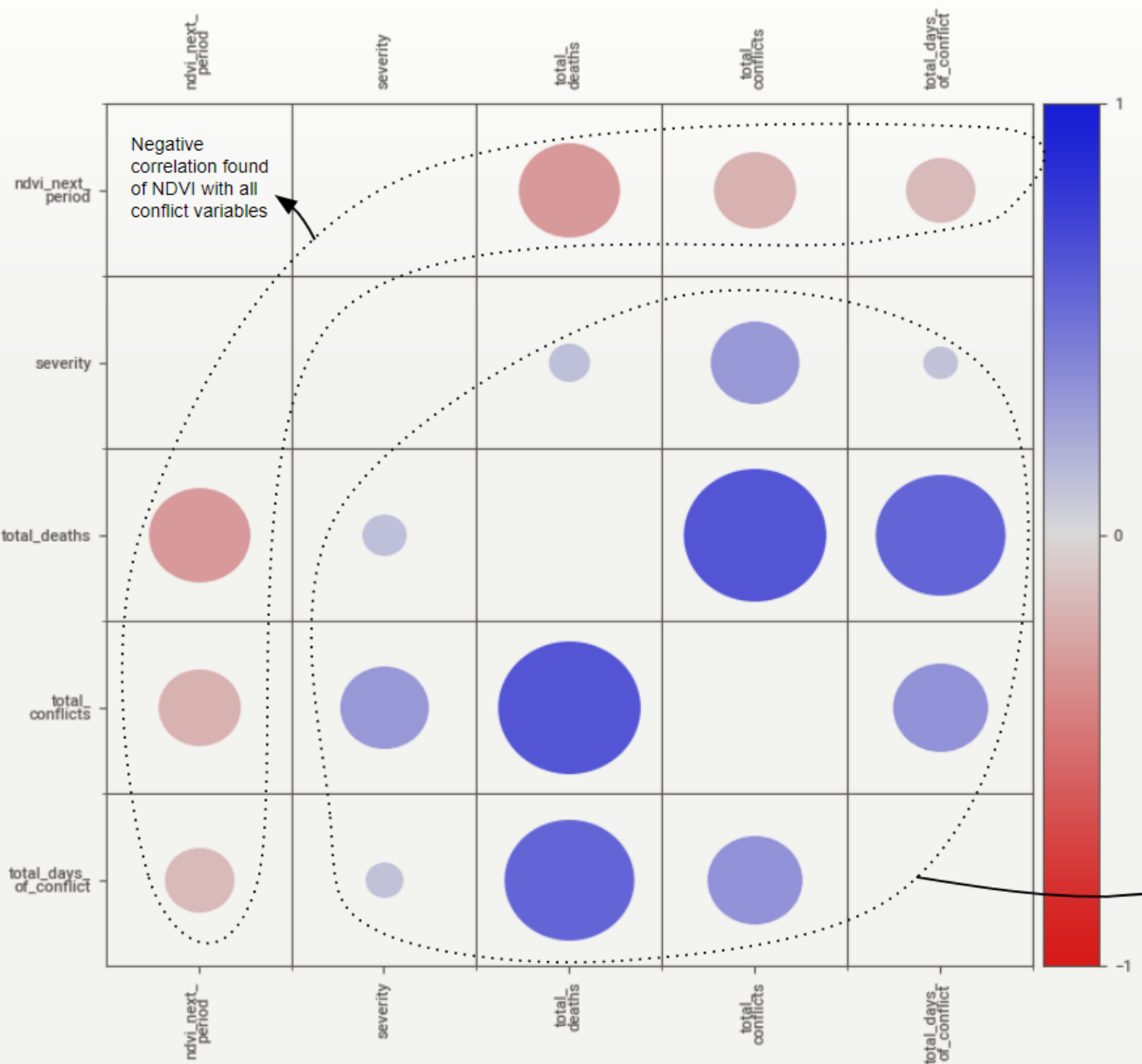
If land degradation (as measured by NDVI) and conflicts are related, **negative correlation** values are expected. The lower the NDVI, the more degraded the land is, and the higher the NDVI, the healthier it is.

A negative correlation would imply that when NDVI decreases (land degrades) conflict variables increase, and when NDVI increases (land gets healthier) conflict variables decrease.

Approach I: correlation study

For Afghanistan, Burkina Faso, Cameroon, Central African Republic, Ethiopia, Gambia, Ghana, Guatemala, Ivory Coast, Kenya, Lebanon, Liberia, Mali, Mozambique, Namibia, Niger, Nigeria, Senegal, Somalia, South Sudan, Sudan, Togo, Uganda (averaged conflicts and NDVI) for 6 months time periods:

Correlations (blue is positive and red is negative) of conflict variables with land degradation in the upcoming 6 months:



How do conflicts impact land degradation in the upcoming 6 months?
Correlation of NDVI with conflict variables:

NUMERICAL ASSOCIATIONS

(PEARSON, -1 to 1)

total_deaths	-0.35
total_conflicts	-0.24
total_days_of_conflict	-0.19
severity	-0.00

Conflict records are correlated with land degradation in the upcoming 6 months. All studied conflict variables have negative correlation with NDVI. When they increase, NDVI decreases in the upcoming 6 months (land degrades).

P-values

	ndvi_next period	severity	total deaths	total_conflicts	total_days of conflict
ndvi_next period	1.000000	0.963583	3.811488e-06	2.126125e-03	1.514421e-02
severity	0.963583	1.000000	3.784519e-01	3.656188e-03	4.933288e-01
total deaths	0.000004	0.378452	1.000000e+00	3.624366e-19	7.674859e-14
total_conflicts	0.002126	0.003656	3.624366e-19	1.000000e+00	6.302680e-05
total days of conflict	0.015144	0.493329	7.674859e-14	6.302680e-05	1.000000e+00

All conflict variables are positively correlated with each other, and negatively correlated with NDVI in the next 6 months.

NUMERICAL ASSOCIATIONS

(PEARSON, -1 to 1)

total_conflicts	0.62
total_days_of_conflict	0.54
ndvi_next_period	-0.35
severity	0.08

NUMERICAL ASSOCIATIONS

(PEARSON, -1 to 1)

total_conflicts	0.27
total_deaths	0.08
total_days_of_conflict	0.06
ndvi_next_period	-0.00

NUMERICAL ASSOCIATIONS

(PEARSON, -1 to 1)

total_deaths	0.62
total_days_of_conflict	0.30
severity	0.27
ndvi_next_period	-0.24

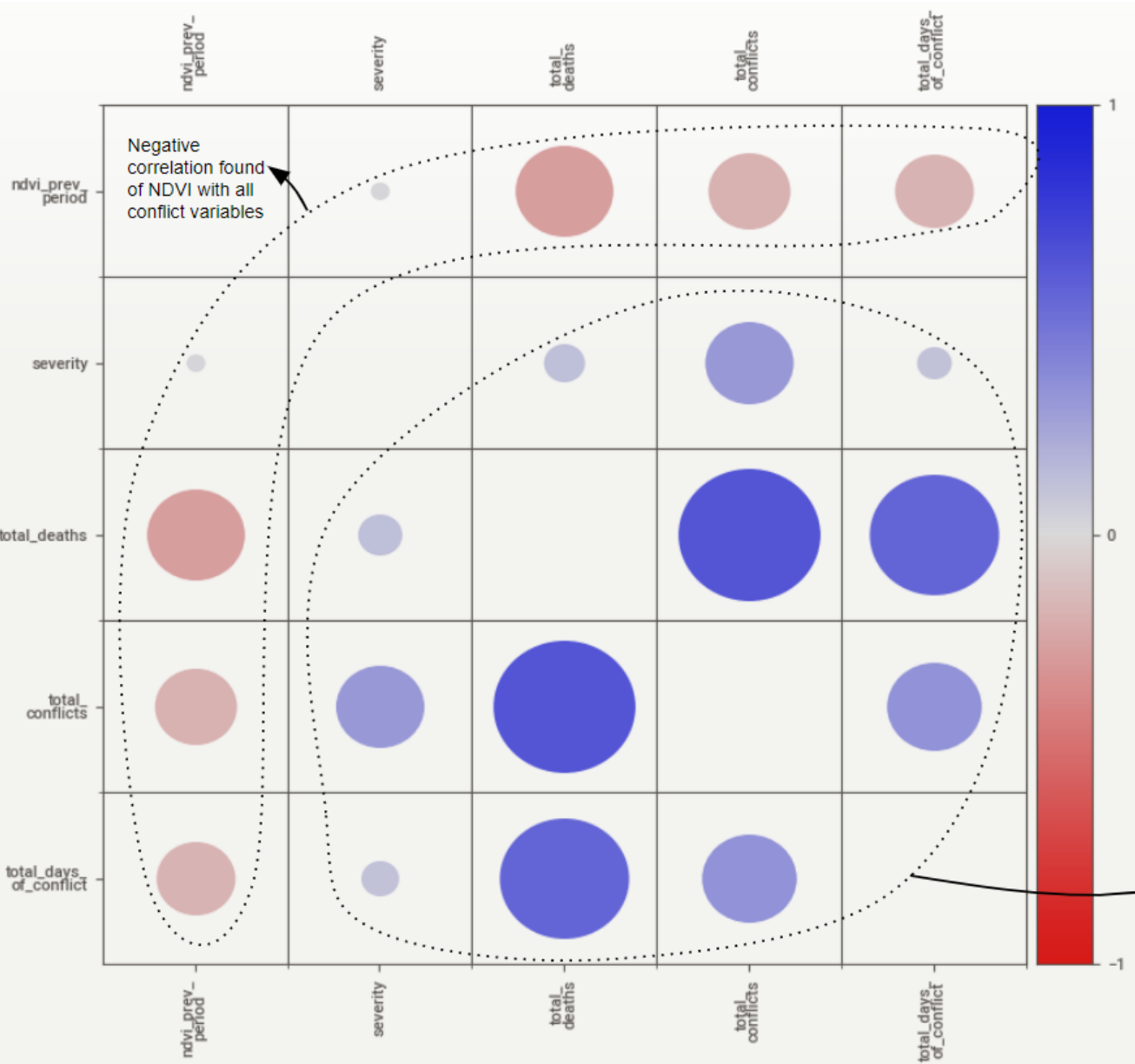
NUMERICAL ASSOCIATIONS

(PEARSON, -1 to 1)

total_deaths	0.54
total_conflicts	0.30
ndvi_next_period	-0.19
severity	0.06

For Afghanistan, Burkina Faso, Cameroon, Central African Republic, Ethiopia, Gambia, Ghana, Guatemala, Ivory Coast, Kenya, Lebanon, Liberia, Mali, Mozambique, Namibia, Niger, Nigeria, Senegal, Somalia, South Sudan, Sudan, Togo, Uganda (averaged conflicts and NDVI) for 6 months time periods:

Correlations (blue is positive and red is negative) of conflict variables with land degradation in the previous 6 months:



How does land degradation impact conflicts in the upcoming 6 months?
Correlation of NDVI with conflict variables:

NUMERICAL ASSOCIATIONS
(PEARSON, -1 to 1)

total_deaths	-0.32
total_conflicts	-0.24
total_days_of_conflict	-0.23
severity	-0.03

Land degradation is correlated with conflict records in the upcoming 6 months. NDVI has negative correlation with all studied conflict variables. When NDVI decreases (land degrades), conflict variables increase.

P-values

	ndvi_prev period	severity	total deaths	total conflicts	total_days of conflict
ndvi_prev period	1.000000	0.760072	2.514357e-05	1.733471e-03	3.070151e-03
severity	0.760072	1.000000	3.784519e-01	3.656188e-03	4.933288e-01
total deaths	0.000025	0.378452	1.000000e+00	3.624366e-19	7.674859e-14
total conflicts	0.001733	0.003656	3.624366e-19	1.000000e+00	6.302680e-05
total_days of conflict	0.003070	0.493329	7.674859e-14	6.302680e-05	1.000000e+00

All conflict variables are positively correlated with each other, and negatively correlated with NDVI of the previous 6 months.

NUMERICAL ASSOCIATIONS
(PEARSON, -1 to 1)

total_conflicts	0.27
total_deaths	0.08
total_days_of_conflict	0.06
ndvi_prev_period	-0.03

NUMERICAL ASSOCIATIONS
(PEARSON, -1 to 1)

total_deaths	0.62
total_days_of_conflict	0.30
severity	0.27
ndvi_prev_period	-0.24

NUMERICAL ASSOCIATIONS
(PEARSON, -1 to 1)

total_conflicts	0.62
total_days_of_conflict	0.54
ndvi_prev_period	-0.32
severity	0.08

NUMERICAL ASSOCIATIONS
(PEARSON, -1 to 1)

total_deaths	0.54
total_conflicts	0.30
ndvi_prev_period	-0.23
severity	0.06

Approach II: training a classifier

Predicting if there will be a severe conflict or not in the upcoming 6 months with a Logistic Regression Classifier

- Using NDVI values (ndvi), NDVI changes from one period to another (ndvi_change) and NDVI with trend removed (non_trend_ndvi) as features.

For Burkina Faso, Nigeria, Somalia and South Sudan (IPC 4 countries):

Accuracy: 0.65
Precision: 0.67
Recall: 0.91
F1: 0.77

Coefficient weights:
ndvi_change: 0.89
ndvi: 6.7
non_trend_ndvi: -3.28

For Afghanistan, Burkina Faso, Cameroon, Central African Republic, Ethiopia, Gambia, Ghana, Guatemala, Ivory Coast, Kenya, Lebanon, Liberia, Mali, Mozambique, Namibia, Niger, Senegal, Somalia, South Sudan, Sudan, Togo, Uganda (IPC 5 countries):

Accuracy: 0.59
Precision: 0.59
Recall: 0.84
F1: 0.70

Coefficient weights:
ndvi_change: 0.29
ndvi: -1.70
non_trend_ndvi: 0.85

For Afghanistan, Burkina Faso, Cameroon, Central African Republic, Ethiopia, Gambia, Ghana, Guatemala, Ivory Coast, Kenya, Lebanon, Liberia, Mali, Mozambique, Namibia, Niger, Nigeria, Senegal, Somalia, South Sudan, Sudan, Togo, Uganda :

Accuracy: 0.59
Precision: 0.63
Recall: 0.63
F1: 0.63

Coefficient weights:
ndvi_change: 1.18
ndvi: -3.56
non_trend_ndvi: 0.85

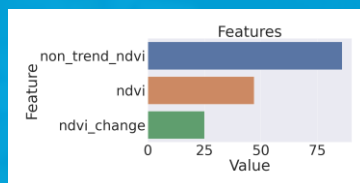
Predicting if there will be a severe conflict or not in the upcoming 6 months with a complex Classifier

- Using NDVI values, NDVI changes from one period to another and NDVI with trend removed as features.

For Burkina Faso, Nigeria, Somalia and South Sudan (IPC 4 countries):

Accuracy: 0.59
Precision: 0.67
Recall: 0.73
F1: 0.70

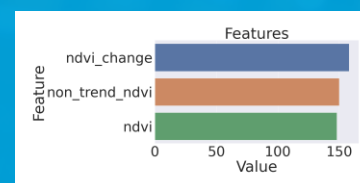
Feature importance:



For Afghanistan, Burkina Faso, Cameroon, Central African Republic, Ethiopia, Gambia, Ghana, Guatemala, Ivory Coast, Kenya, Lebanon, Liberia, Mali, Mozambique, Namibia, Niger, Senegal, Somalia, South Sudan, Sudan, Togo, Uganda (IPC 5 countries):

Accuracy: 0.68
Precision: 0.68
Recall: 0.79
F1: 0.73

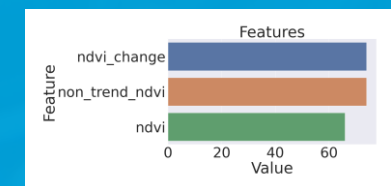
Feature importance:



For Afghanistan, Burkina Faso, Cameroon, Central African Republic, Ethiopia, Gambia, Ghana, Guatemala, Ivory Coast, Kenya, Lebanon, Liberia, Mali, Mozambique, Namibia, Niger, Nigeria, Senegal, Somalia, South Sudan, Sudan, Togo, Uganda :

Accuracy: 0.74
Precision: 0.81
Recall: 0.68
F1: 0.74

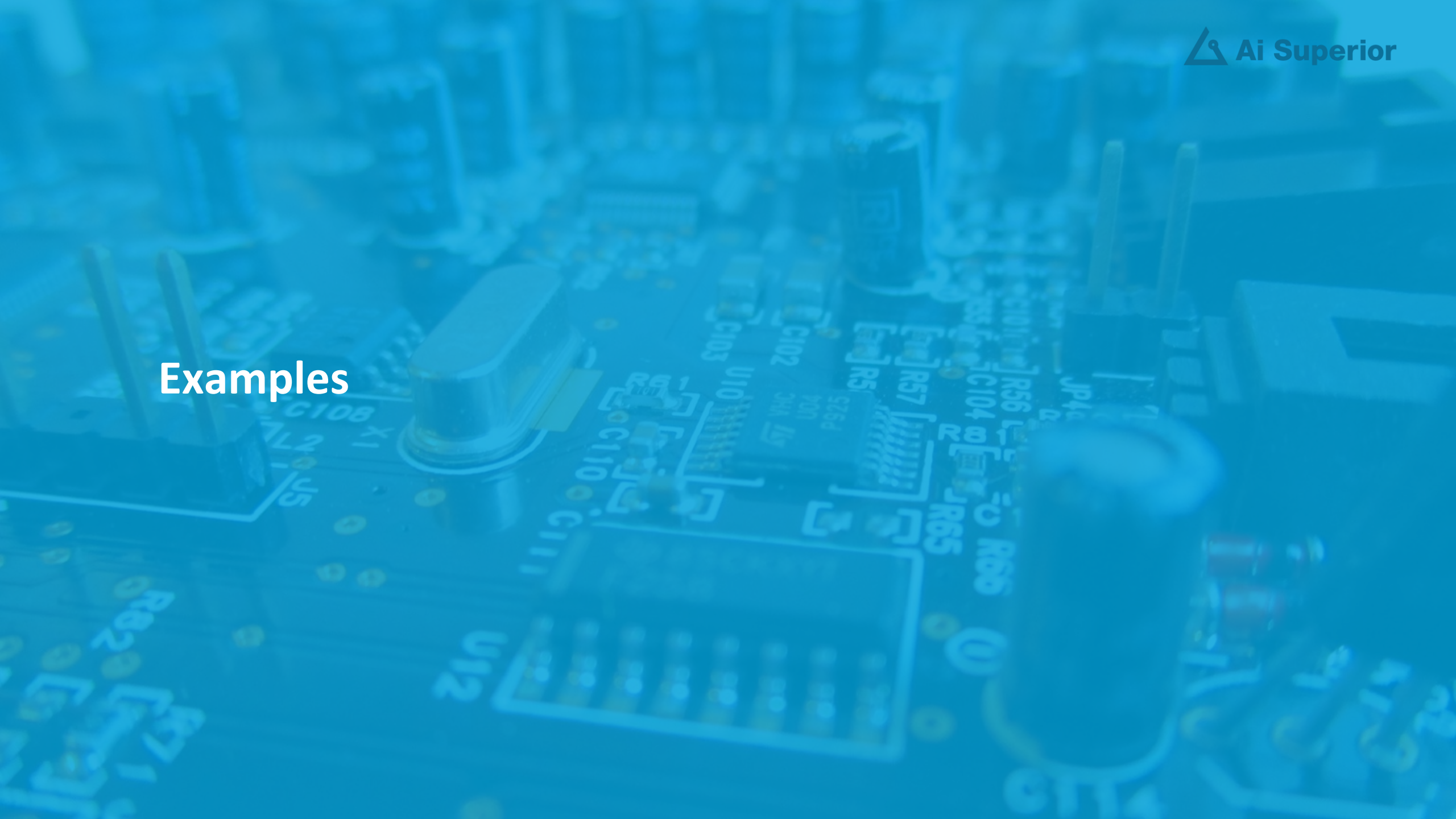
Feature importance:



Conclusion and Highlights

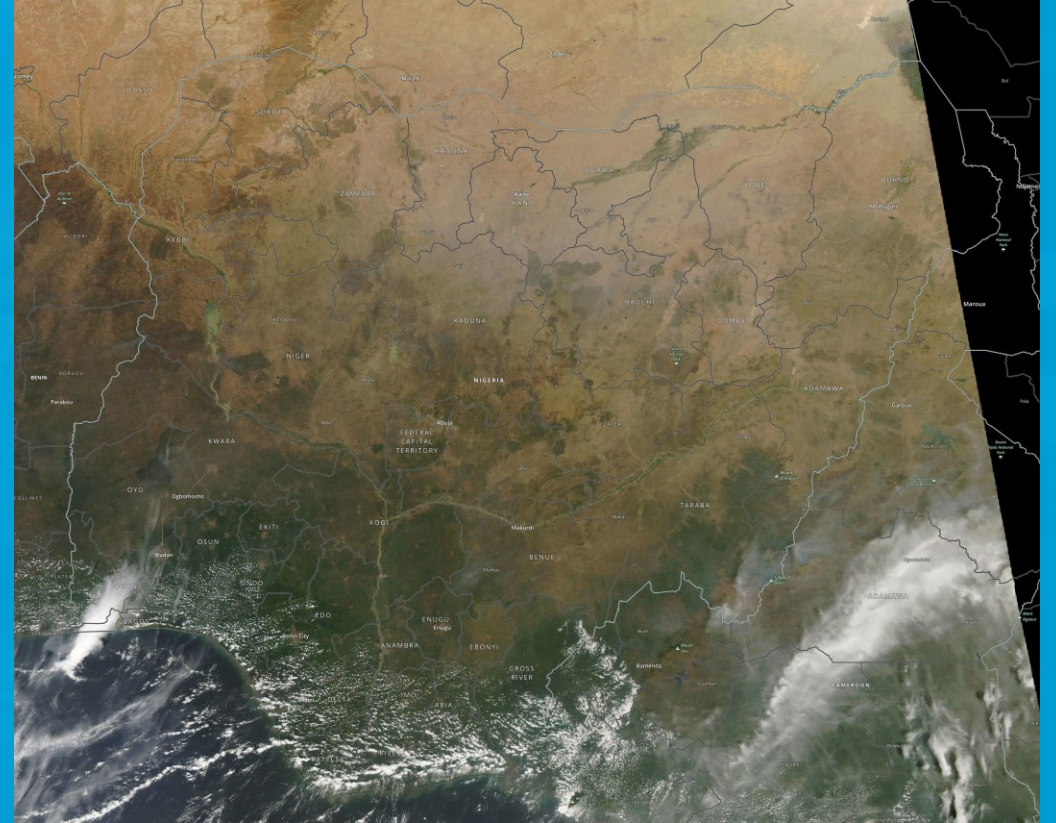
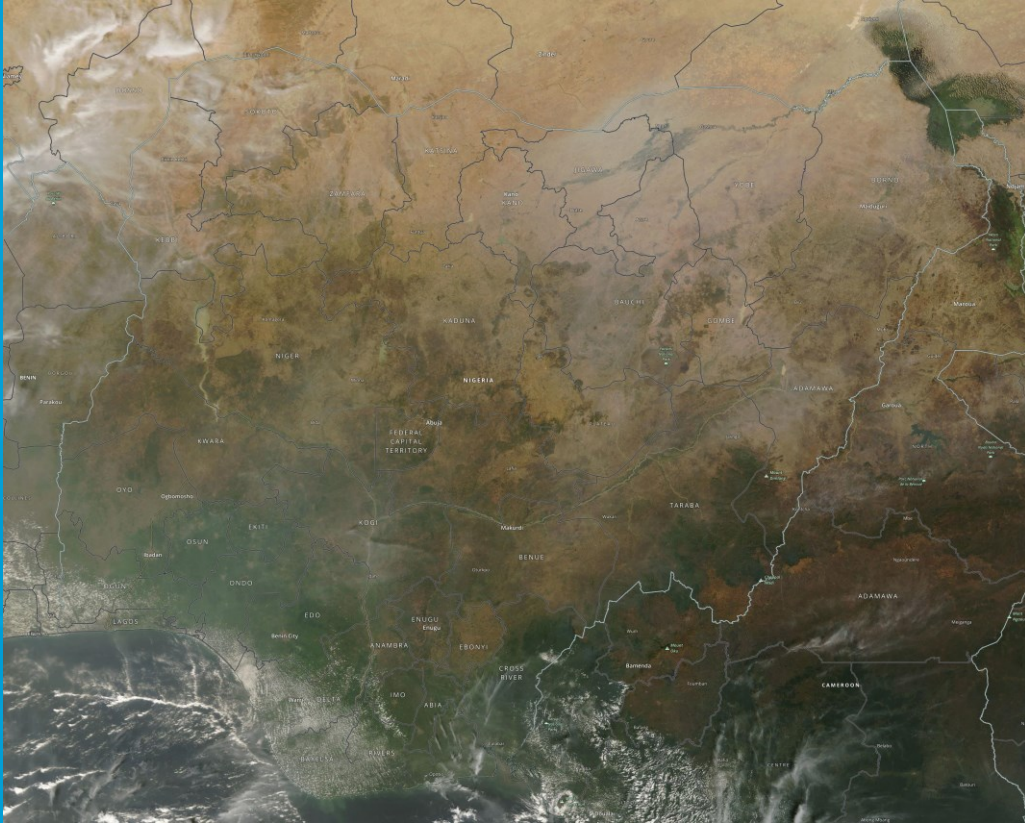
- NDVI is used to measure land degradation/regeneration. When NDVI decreases land degrades, and vice versa.
- Historical conflict records of countries can be aggregated over periods of time and analyzed with land degradation/regeneration during that period.
- For Afghanistan, Burkina Faso, Cameroon, Central African Republic, Ethiopia, Gambia, Ghana, Guatemala, Ivory Coast, Kenya, Lebanon, Liberia, Mali, Mozambique, Namibia, Niger, Nigeria, Senegal, Somalia, South Sudan, Sudan, Togo, Uganda historical data confirmed the hypothesis:
 1. Conflicts are positively correlated to land degradation in the upcoming 6 months (increases in conflicts decrease NDVI)
 2. Land degradation is positively correlated to conflicts in the upcoming 6 months (decreases in NDVI increase conflicts)
- Machine learning models can be used to predict whether or not a conflict will take place in the upcoming 6 months taking into account land degradation/regeneration with an accuracy of 74%.

Examples



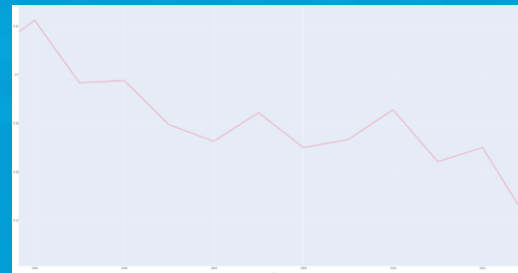
Nigeria

High res images are in the delivery folder!



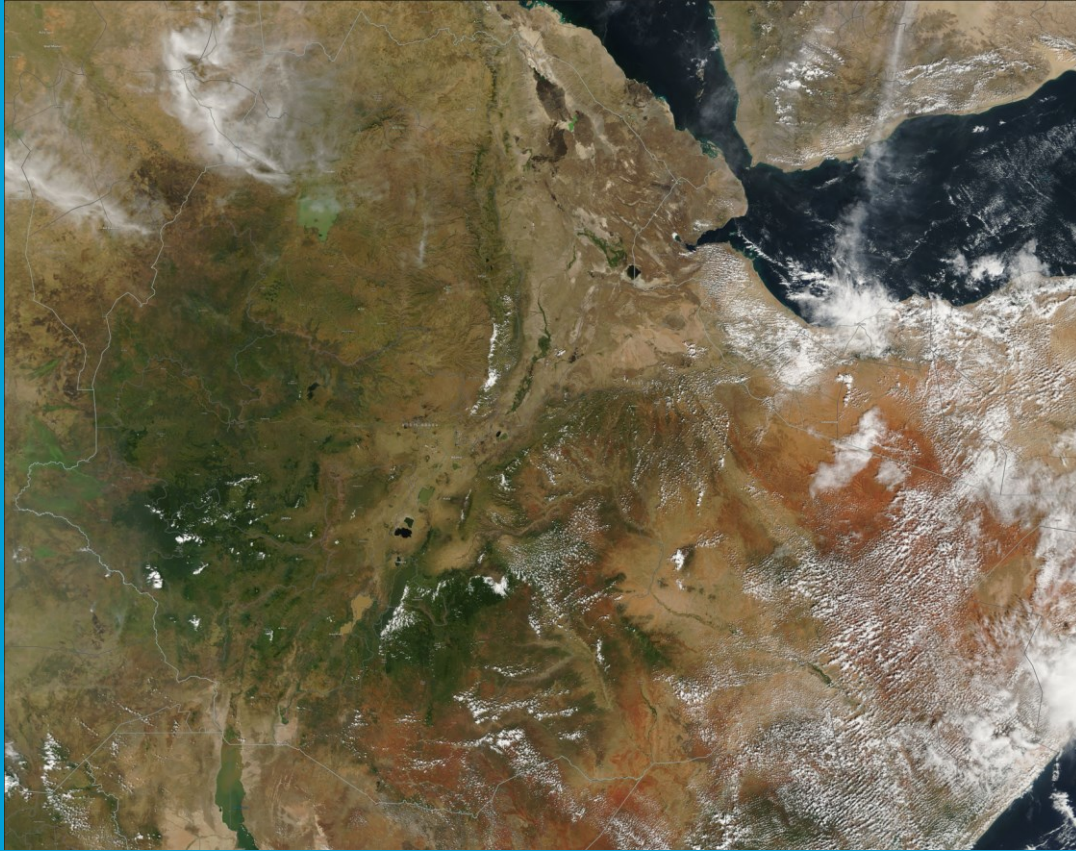
2001-12
NDVI: **0.2112**
Conflicts: 40

2012-12
NDVI: **0.1712**
Conflicts: 407

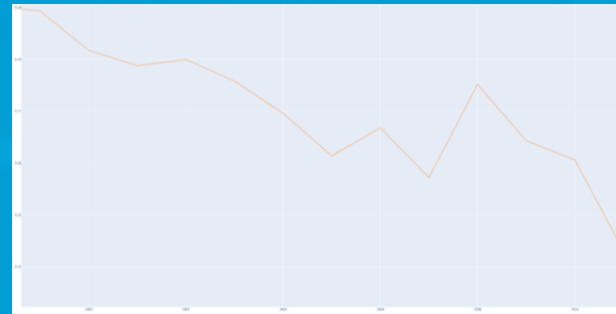


Ethiopia

High res images are in the delivery folder!



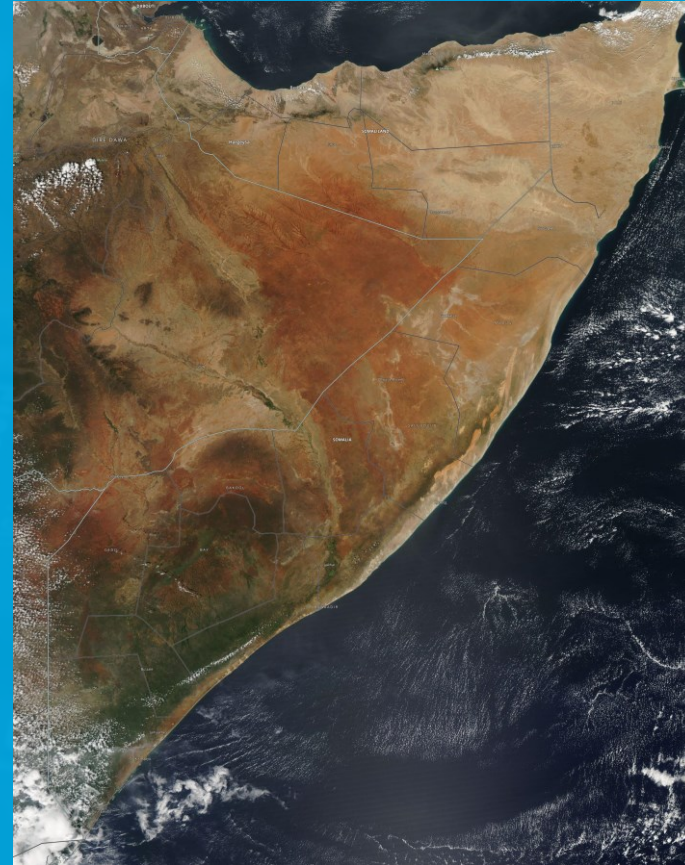
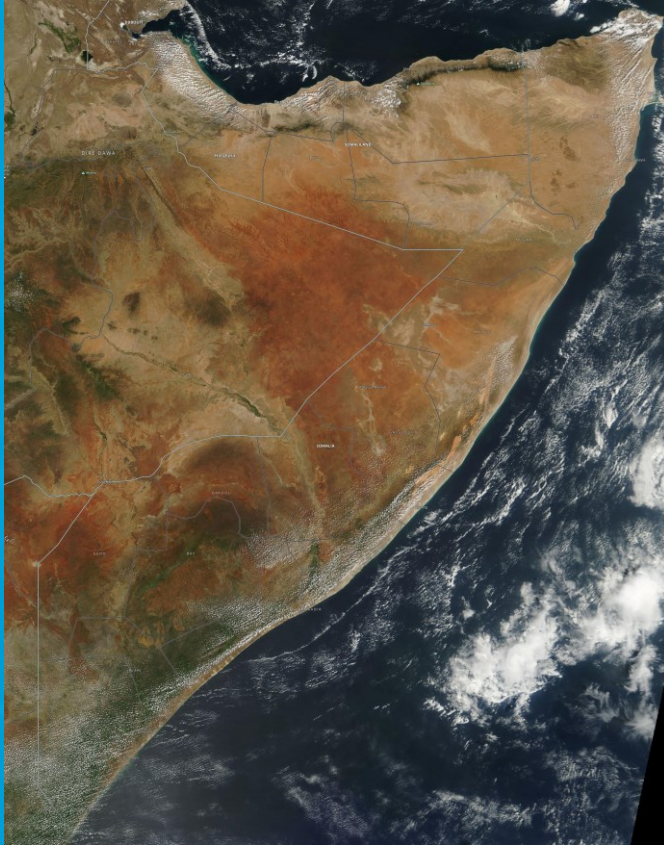
2000-12
NDVI: **0.1788**
Conflicts: 77



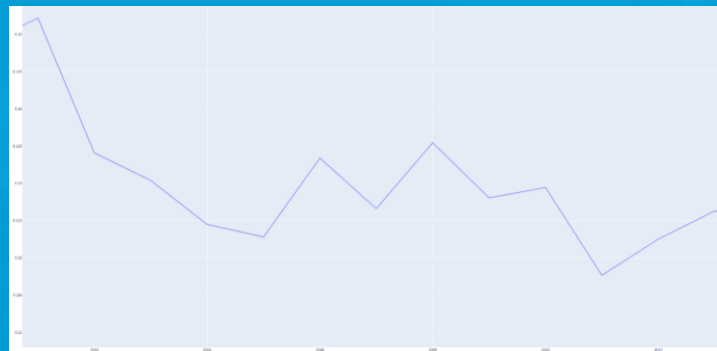
2010-12
NDVI: **0.1432**
Conflicts: 145

Somalia

High res images are in the delivery folder!



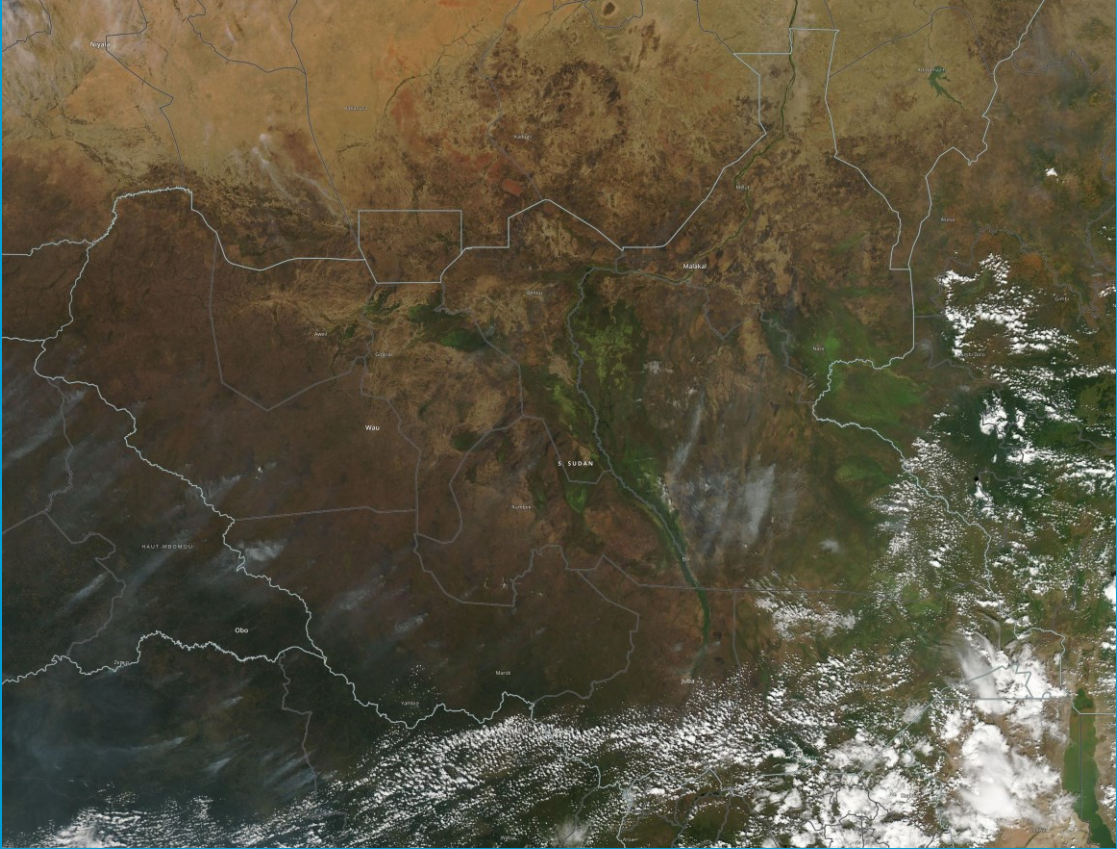
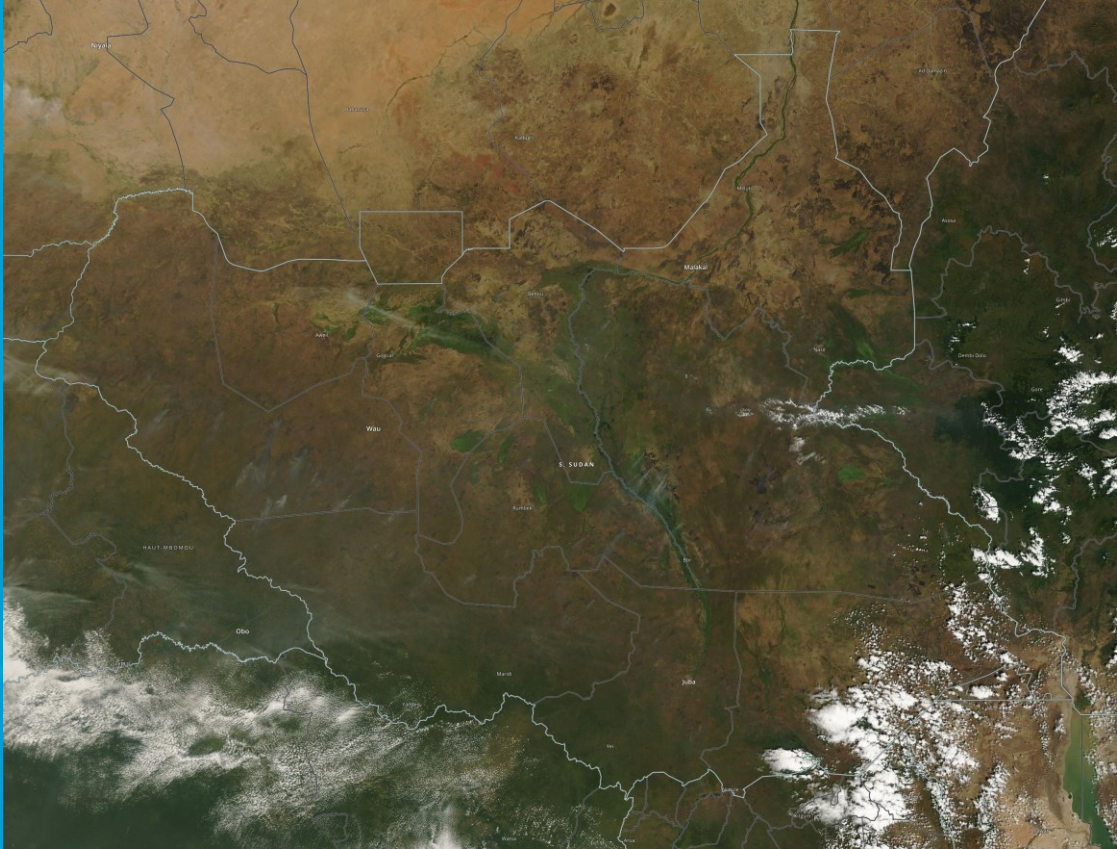
2000-12
NDVI: **0.1522**
Conflicts: 61



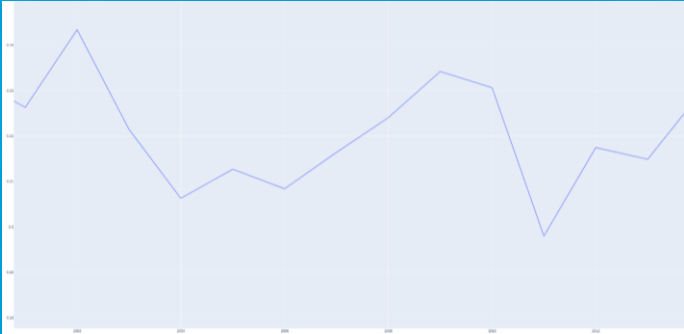
2012-12
NDVI: **0.1263**
Conflicts: 446

South Sudan

High res images are in the delivery folder!



2000-12
NDVI: **0.2263**
Conflicts: 0



2012-12
NDVI: **0.2149**
Conflicts: 59

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Thank you

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