



El futuro  
es de todos

Gobierno  
de Colombia



# Use of NDVI as a tool to estimate N<sub>2</sub>O emissions in sugarcane crops.

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## Virtual Symposium in Plant Omics Science 2020

### CONTENT

- Introduction
- Materials and methods
- Results



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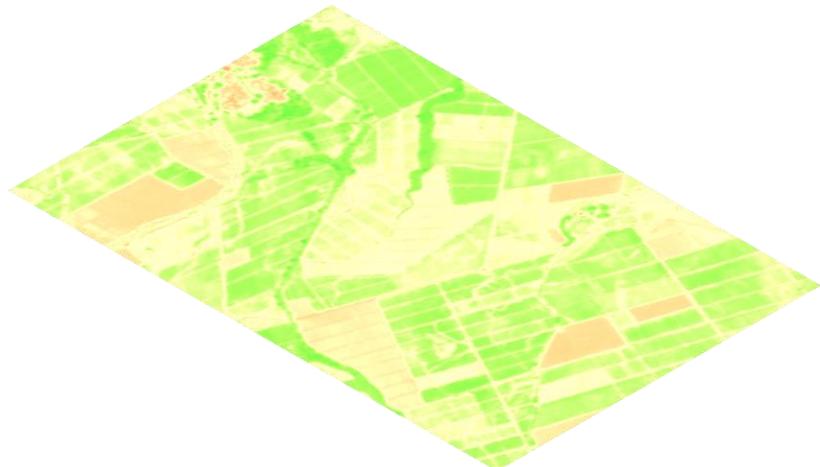
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## Introduction.

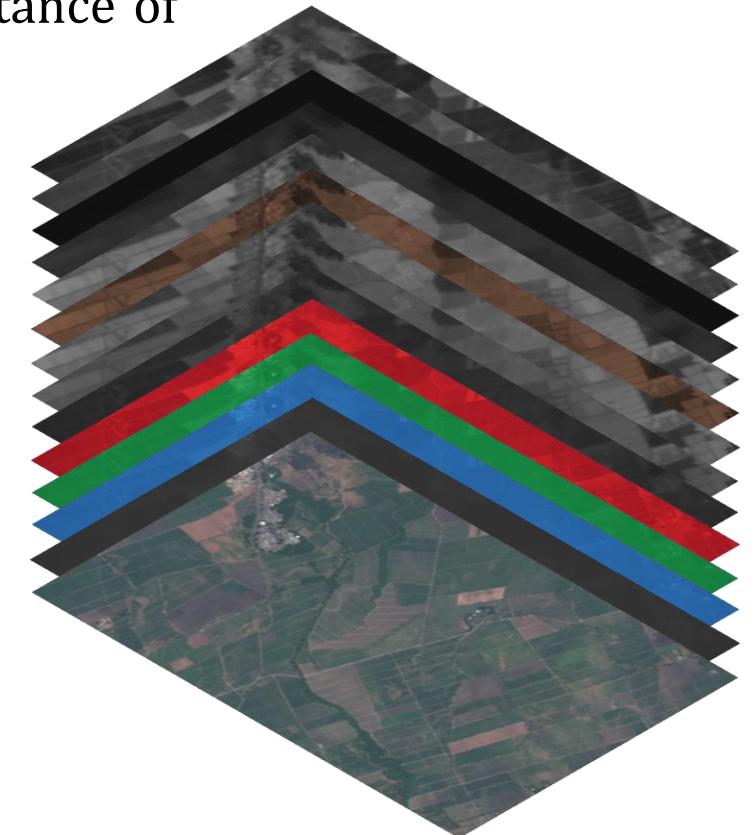
# Which is the Normalized difference vegetation index (NDVI)?

**Mathematical model** to determine the quantity, **quality and development of vegetation**, from the relationship between absorbance and reflectance of bands of the **electromagnetic spectrum** on a surface



$$NDVI = \frac{(IR_{Near} - Red)}{(IR_{Near} + Red)}$$

$IR_{Near}$  = spectrum near infrared, Red = spectrum of red



## Introduction.

### Why Oxide nitrous ( $N_2O$ )?



- Greenhouse gas.
- Capacity to absorb infrared radiation is ~310 times greater than that of  $CO_2$  over a period of 100 years.
- It degrades stratospheric ozone.

It is a chemical compound that can be stable in the atmosphere for up to ~114 years.

**~27 % of direct  $N_2O$  emissions are of anthropogenic origin.**

**~80 % of anthropogenic emissions are the result of inefficient use of nitrogen fertilizers.**

### Why Sugarcane?



in 2018, ~27'684.787 hectares of sugarcane were cultivated in the world (FAO, 2020).

In 2019, ~500,100 hectares were reported in Colombia (MinAgriculture, 2020).

50% of the area (~250.000 ha) is planted in the Cuaca River Valley. In this region an intensive model predominates in which it is recommended to apply, generally, **> 100 N kg ha<sup>-1</sup> cultivated.**

## Materials and methods.



### Ubication

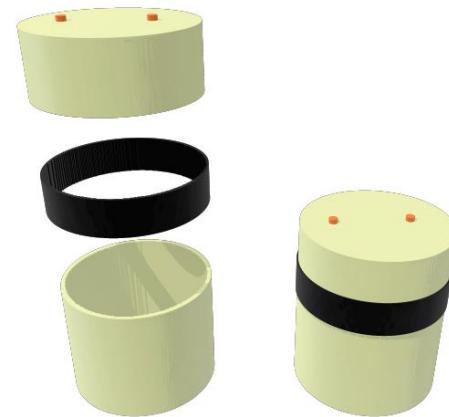
("-76.28315 W-3.67431 N" and  
"-76.28450 W-3.67039 N")

### Time period

August 20, 2019 -  
March 30, 2020

Software  
**QGIS®**  
trademark

### N<sub>2</sub>O cumulative emission data



**Direct field measurement**  
(Manual Static Chambers)



**Laboratory analysis**  
(Gas chromatograph)

# Materials and methods.

## Multispectral data.

# COPERNICUS AND ITS SENTINELS



Known as **GMES** until  
2012 - Global Monitoring  
for Environment and Security



30 Public and Private  
missions are also  
contributing data



16 years  
of development  
and testing



Sentinel-Missions  
at the heart of the  
space component



**Civil Security.**  
Allowing early warning  
and crisis prevention in  
conflict and disaster areas



**Emergency Management.**  
Accurate and timely data for  
emergency plans and rescue  
for disaster management



**Land Surface Monitoring.**  
Geographical information on land  
cover, related variables and urban  
development



**Marine Environmental Monitoring.**  
Observations and forecasts on the state  
of the physical oceans and regional seas



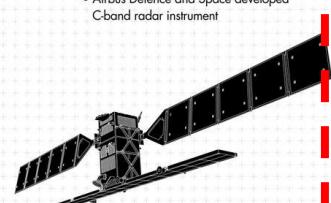
**Climate Change Monitoring.**  
Helps to understand the reason  
for climate change, rising sea levels  
and melting ice caps



**Earth Atmosphere Monitoring.**  
Daily information on the global atmospheric  
composition and when Sentinel-4 is in service  
this will be hourly

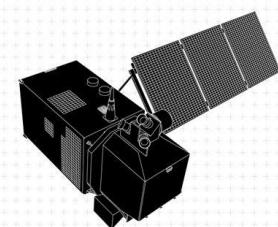
### **SENTINEL-1**

- All-weather, day-and-night radar imaging satellite for land and ocean services
- Able to "see" through clouds and rain
- Data delivery within 1 hour of acquisition
- Airbus Defence and Space developed C-band radar instrument



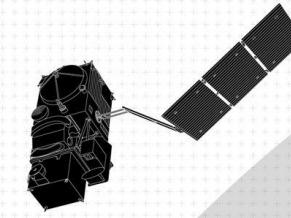
### **SENTINEL-2**

- Medium Res Multispectral optical satellite for observation of land, vegetation and water
- 13 spectral bands with 10, 20 or 60 m resolution and 290 km swath width
- Global coverage of the Earth's land surface every 5 days
- Airbus Defence and Space prime contractor for satellites and instruments



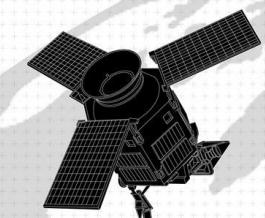
### **SENTINEL-3**

- Measures sea-surface topography with a resolution of 300 m, sea and land surface temperature and colour with a resolution of 1 km
- Measures water vapour, cloud water content and thermal radiation emitted by the Earth
- Determines global sea surface temperatures with an accuracy greater than 0.3 K
- Airbus Defence and Space supplies Microwave Radiometer



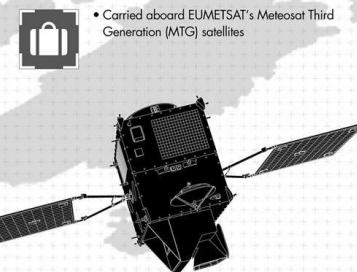
### **SENTINEL-5P**

- Global observation of key atmospheric constituents, including ozone, nitrogen dioxide, sulphur dioxide and other environmental pollutants
- Improves climate models and weather forecasts
- Provides data continuously during five-year gap between the retirement of Envisat and the launch of Sentinel-5
- Airbus Defence and Space prime contractor for TROPOMI instrument



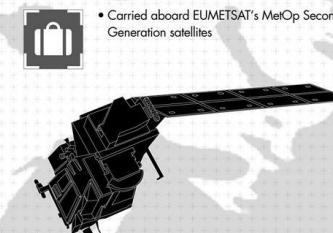
### **SENTINEL-4**

- Provides hourly updates on air quality with data on atmospheric aerosol and traces gas concentrations
- Spatial sampling is 8 km and spectral resolution between 0.12 nm and 0.5 nm
- Airbus Defence and Space prime contractor for spectrometer
- Carried aboard EUMETSAT's Meteosat Third Generation (MTG) satellites



### **SENTINEL-5**

- Measures air quality and solar radiation, monitors stratospheric ozone and the climate
- Global coverage of Earth's atmosphere with an unprecedented spatial resolution
- Airbus Defence and Space prime contractor for instrument
- Carried aboard EUMETSAT's MetOp Second Generation satellites



### **SENTINEL-6**

- Observes changes in sea surface height with an accuracy of a few centimeters
- Global mapping of the sea surface topography every 10 days
- Enables precise observation of ocean currents and ocean heat storage; vital for predicting rises in sea levels
- Airbus Defence and Space prime contractor for satellite



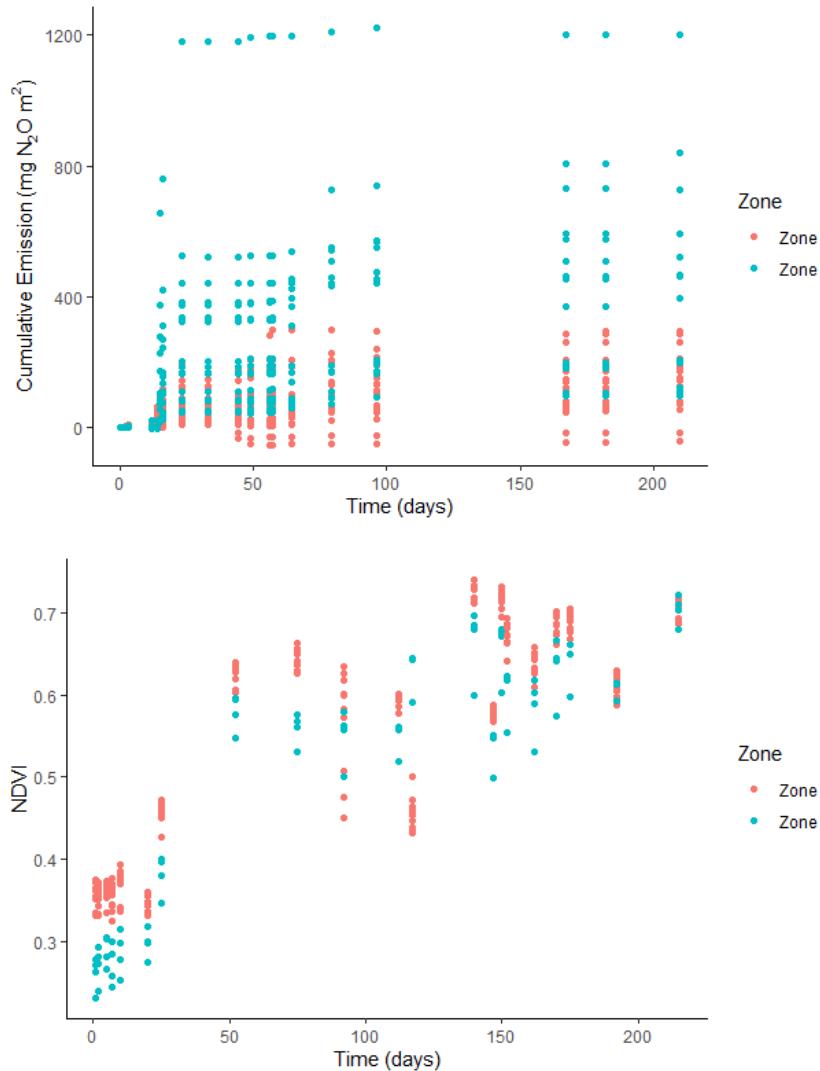
European Earth Observation Programme Copernicus: observing our planet for a safer world

2014

2020

<https://sentinel.esa.int/web/sentinel/home>

## Results.



Model for NDVI	Zone 1		Zone 2	
	R <sup>2</sup>	p-value	R <sup>2</sup>	p-value
Cubic	0.8004	< 2.22e-16	0.9212	< 2.22e-16
Quadratic	0.7873	< 2.22e-16	0.8919	< 2.22e-16
Potential	0.7661	< 2.22e-16	0.8726	< 2.22e-16
Exponential	0.7389	< 2.22e-16	0.8439	< 2.22e-16
Logarithmic	0.7339	< 2.22e-16	0.814	< 2.22e-16
Linear	0.7338	< 2.22e-16	0.7918	< 2.22e-16
Sigmoidal	0.3287	< 2.22e-16	0.4096	< 2.22e-16
Inverse	0.3067	< 2.22e-16	0.3718	< 2.22e-16

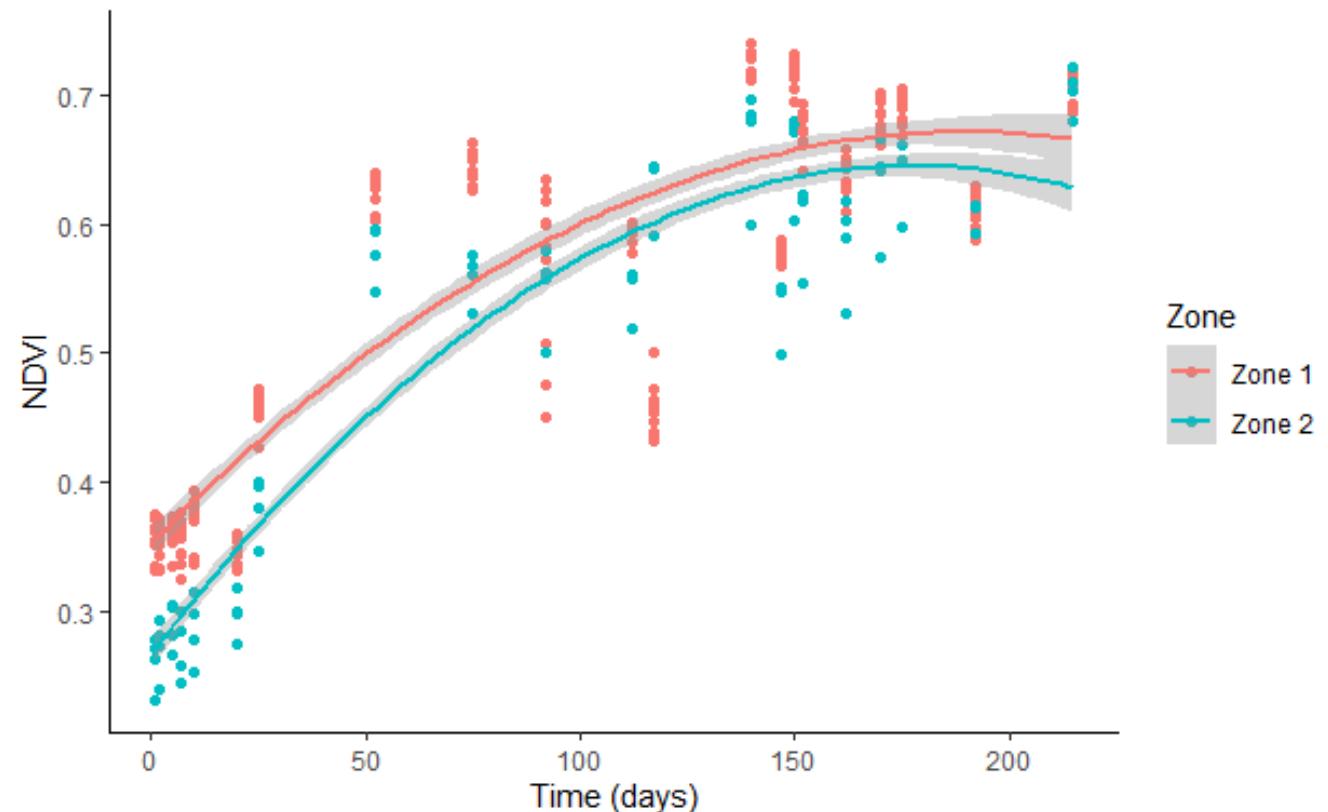
## Results.

$$NDVI_{(Zone1)} = 0.35 + (3.35^{-3} * Time) + (-8.85^{-6} * Time^2)$$

$$NDVI_{(Zone2)} = 0.27 + (4.25^{-3} * Time) + (-1.2^{-5} * Time^2)$$

Zone	R <sup>2</sup>	R <sup>2</sup> adjusted	Statistician-F	p-value
1	0.79	0.79	849.6	5.09E-155
2	0.89	0.89	1373.9	1.321E-161

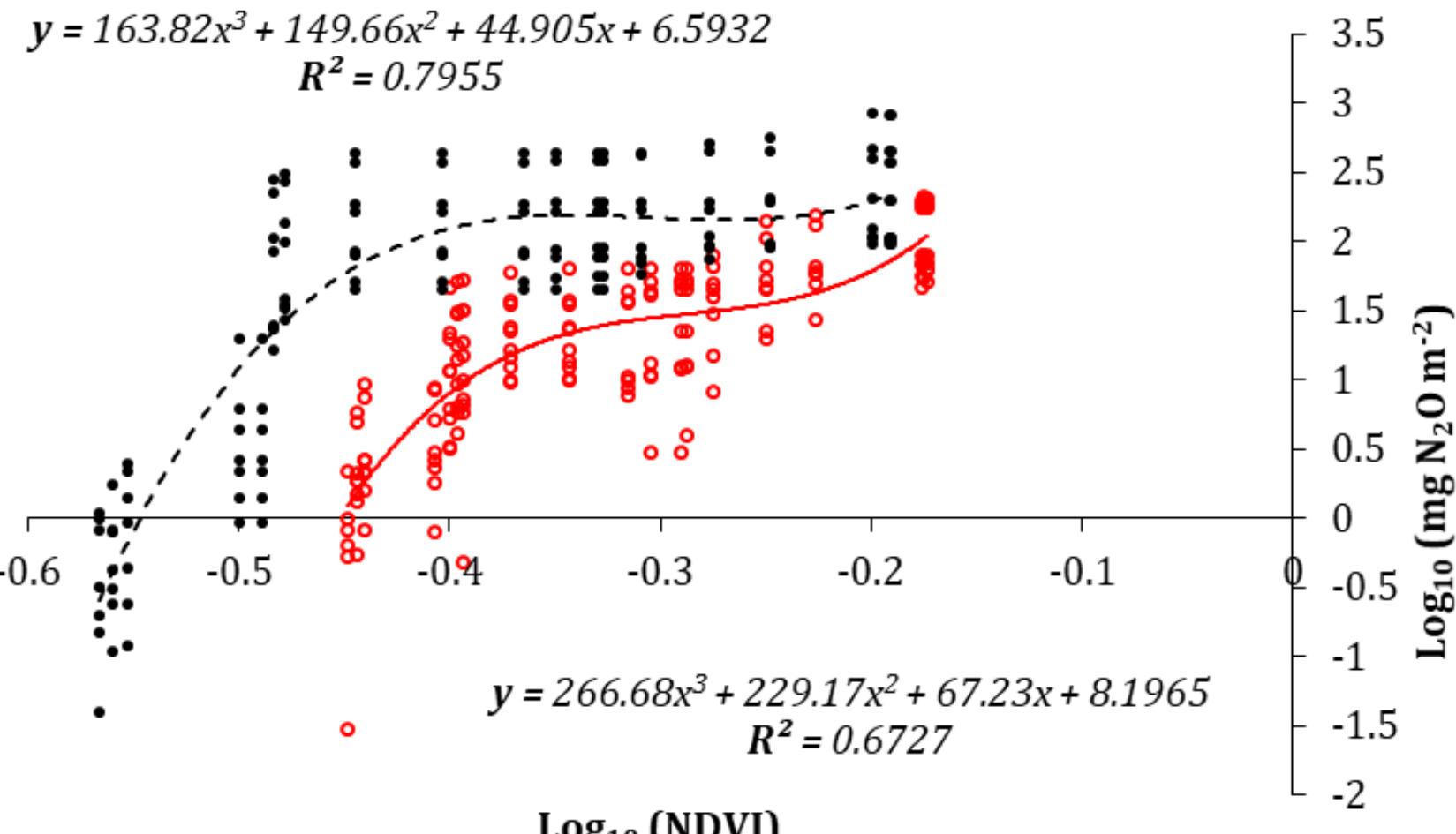
Zone	Variables	n	Spearman	p-value
1	N <sub>2</sub> O-NDVI(t)	190	0.53	<0.0001
2	N <sub>2</sub> O-NDVI(t)	152	0.75	<0.0001



## Results.

Model_Z1	R <sup>2</sup>	p-value
Cubic	0.6727	< 2.22e-16
Quadratic	0.6344	< 2.22e-16
Linear	0.6013	< 2.22e-16
Inverse	0.5018	< 2.22e-16
Sigmoidal	0.3838	< 2.22e-16

Model_Z2	R <sup>2</sup>	p-value
Cubic	0.7955	< 2.22e-16
Quadratic	0.7507	< 2.22e-16
Linear	0.5573	< 2.22e-16
Inverse	0.3555	1.6218e-15
Sigmoidal	0.1977	1.2986e-07





Aliados



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**JAVERIANA**  
Cali  
IES Ancla



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[VIGILADA MINEDUCACIÓN Rev. 42220 de 2016.]



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