

**U.S. EPA's 2015
International Emission Inventory Conference**

**Implementation of a MODIS Aerosol Algorithm
for Air Pollution Detection**

**By
Alvaro Cáceres**

16.04.2015

Introduction

MODIS

Aerosol Algorithm

Implementation

Results

PM10 Comparison

Validation

Summary

Air Pollution



source: la.streetsblog.org



source: coldfusion3.com

Introduction of harmful particles in atmosphere

Problems to Human health

Damage to living organisms

Direct contribution to **climate change**

Air Pollution Detection

Continuous Air Monitoring Station CAMS

Introduction

MODIS

Aerosol Algorithm

Implementation

Results

PM10 Comparison

Validation

Summary

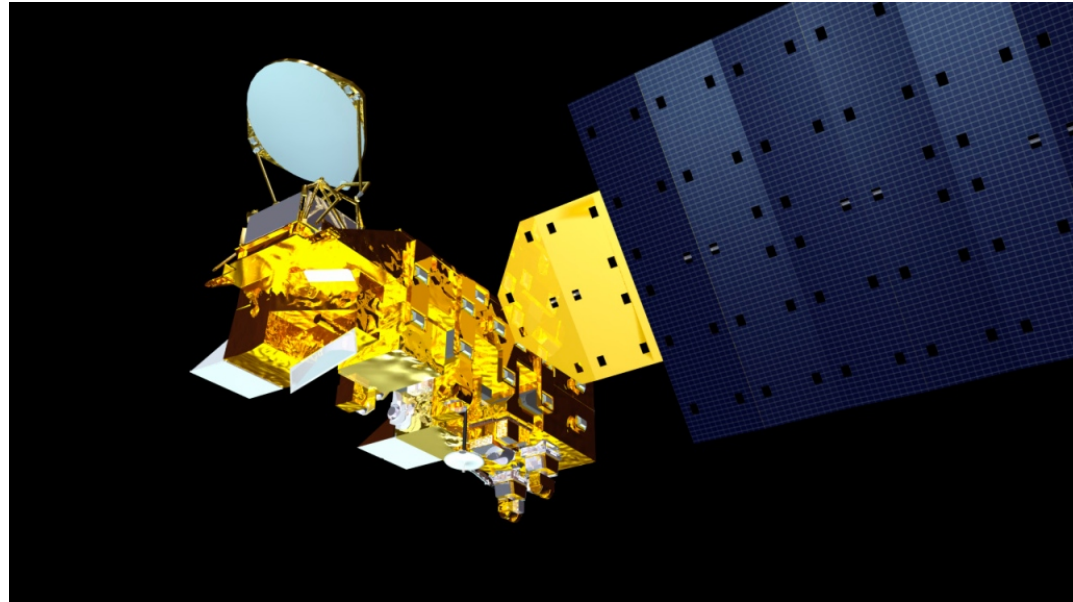


source: wycokck.org

Calculates the concentration of
particle matter in the ambient

Remote Sensing

Moderate Resolution Imaging Spectroradiometer MODIS



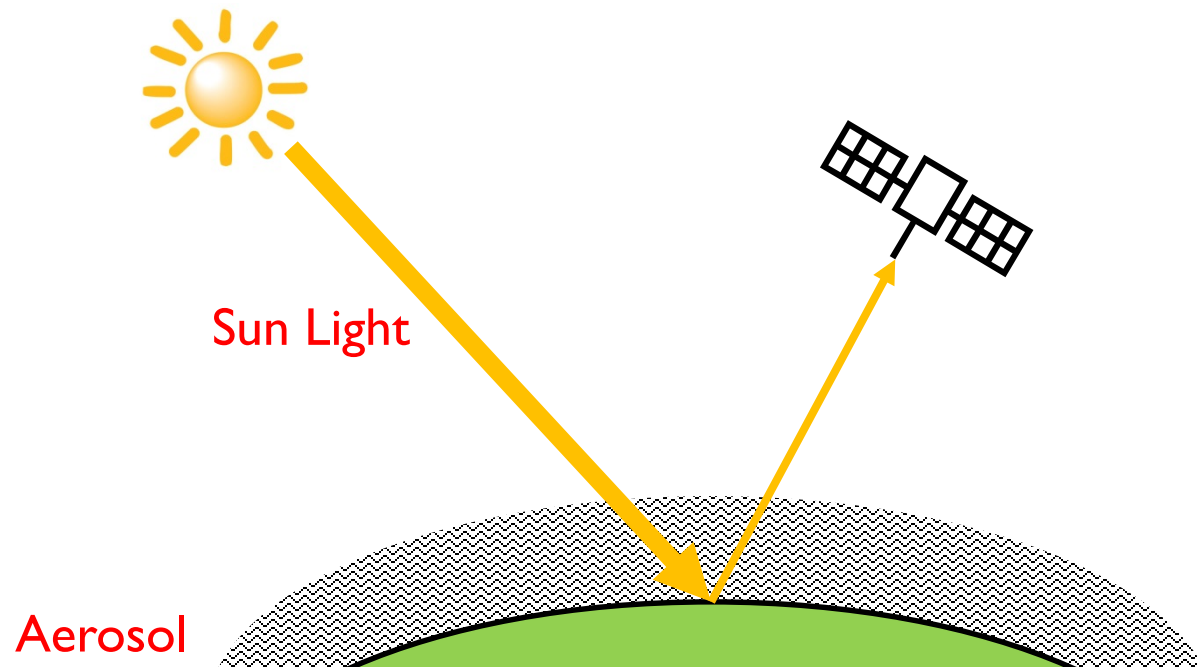
source: smhi.se

NASA **Terra** Satellite
Sun synchronous
Public domain

Aerosol Optical Thicknes (AOT)

"Degree to which aerosols prevent the transmission of light by absorption or scattering of light"

<http://disc.sci.gsfc.nasa.gov/>



Introduction

MODIS

Aerosol Algorithm

Implementation

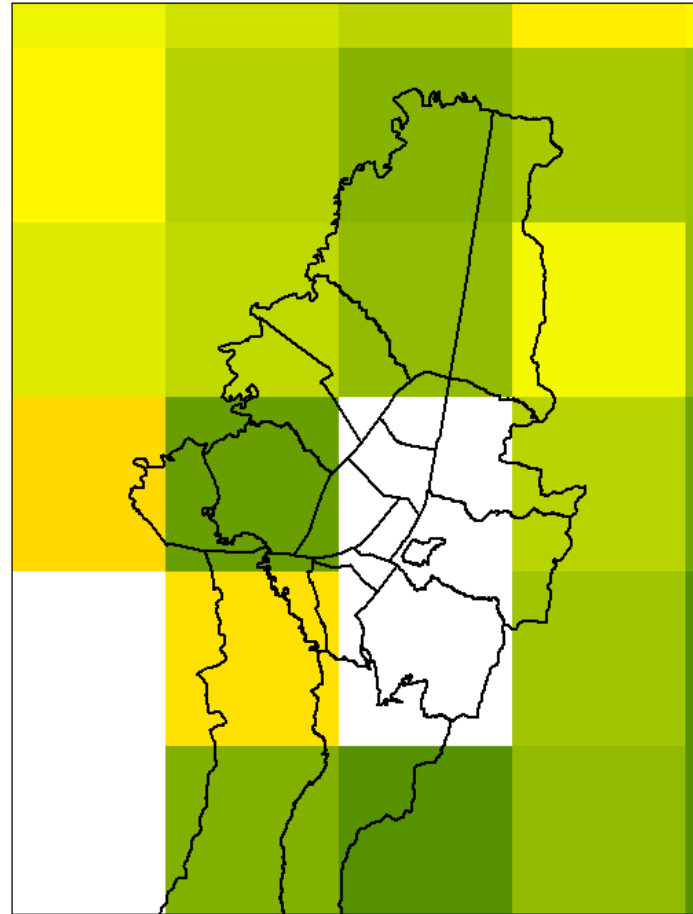
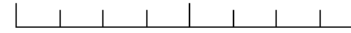
Results

PM10 Comparison

Validation

Summary

0 5 10 20 Kilometers



How to improve resolution to make a better analysis?

Introduction

MODIS

Aerosol Algorithm

Implementation

Results

PM10 Comparison

Validation

Summary

Aerosol Algorithm

Simplified High Resolution MODIS **A**erosol
Retrieval **A**lgorithm
SARA

(Bilal, M., Nichol, J. et al.)

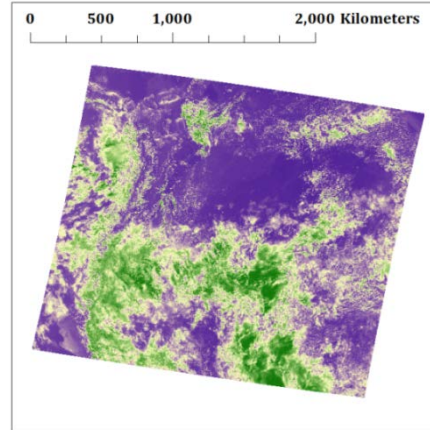
Remote **S**ensing of **E**nvironment
September 2013

10 km to 500 m!

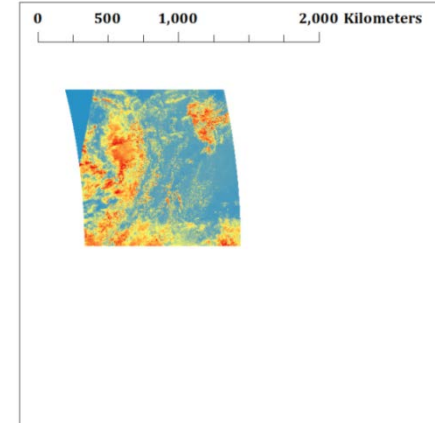
Input Data

Input Data

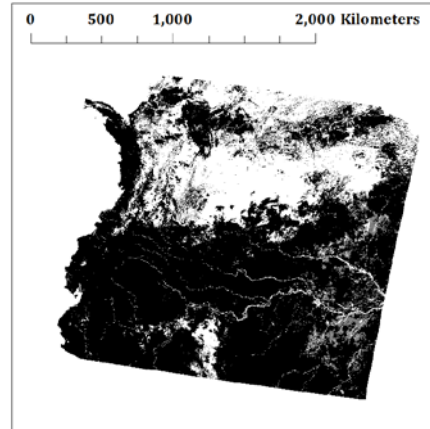
8 Initial variables



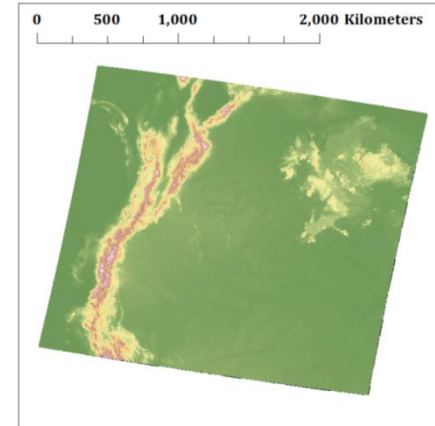
Radiance **500m**



Surface Reflectance **500m**



Cloud Mask **1km**



Geolocation **500m**

Reprojection

Input Data



Reprojection

Introduction

MODIS

Aerosol Algorithm

Implementation

Results

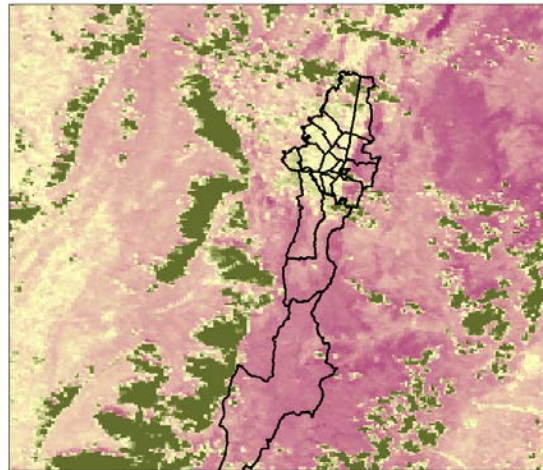
PM10 Comparison

Validation

Summary

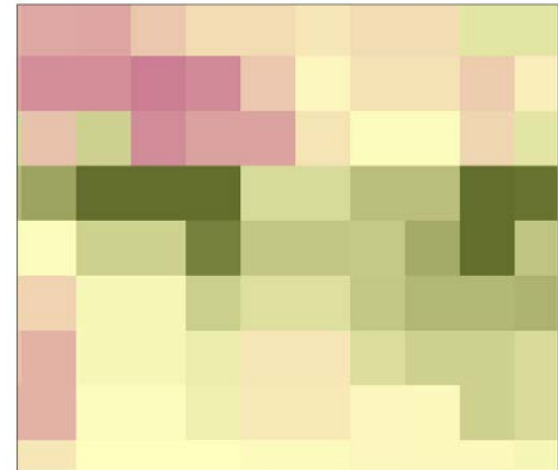
Sinusoidal to WGS84

0 15 30 60 Kilometers



Swath to regular grid

0 0.5 1 2 Kilometers

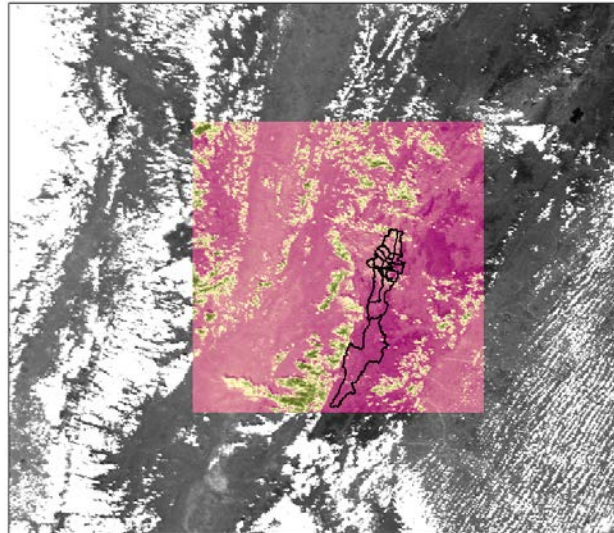


MODIS Reprojection Tool Swath

Join values

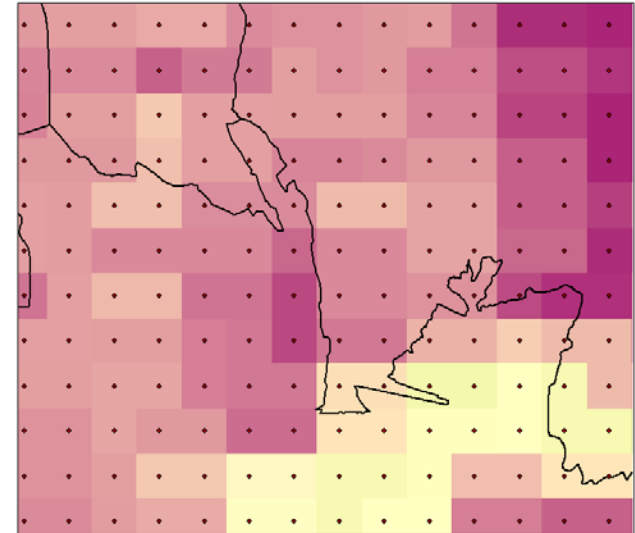


0 62.5 125 250 Kilometers



500 m resolution

0 1 2 4 Kilometers



Raster to point

Python - ArcPy Library

Introduction

MODIS

Aerosol Algorithm

Implementation

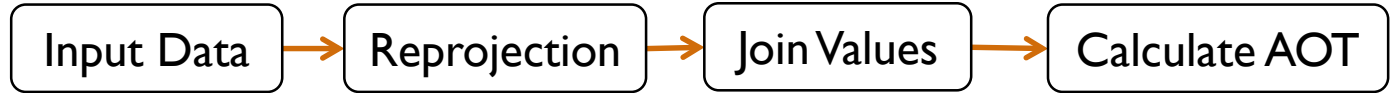
Results

PM10 Comparison

Validation

Summary

AOT Calculation

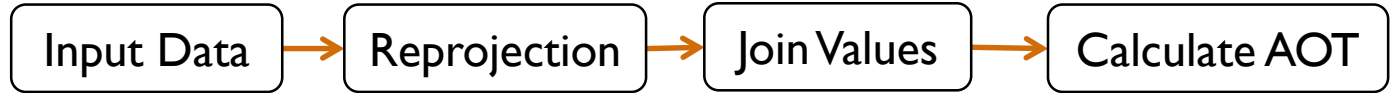


$$\rho_{\text{Aer}} = \rho_{\text{TOA}} - \rho_{\text{Ray}} - \frac{T_{(\theta_s)} T_{(\theta_v)} \rho_s}{1 - \rho_s S}$$

Symbol	Description
ρ_{TOA}	Top of Atmosphere Reflectance
ρ_{Ray}	Rayleigh Reflectance
ρ_{Aer}	Aerosol Reflectance
ρ_s	Surface Reflectance
$T_{(\theta_s)}$	Transmission of the atmosphere on sun-surface path
$T_{(\theta_v)}$	Transmission of the atmosphere on surface-sensor path
S	Atmospheric backscattering ratio

Python - SciPy Library

AOT Calculation



$$\tau_a = \frac{4\mu_s\mu_v}{\omega_0 P_a} \left[\rho_{\text{TOA}} - \rho_{\text{Ray}} - \frac{e^{-\frac{-(\tau_R+\tau_a)}{\mu_s}} e^{-\frac{-(\tau_R+\tau_a)}{\mu_v}} \rho_s}{1 - \rho_s [0.92\tau_R + (1-g)\tau_{a,\lambda}] e^{-(\tau_R+\tau_a)}} \right]$$

Symbol	Description
ρ_{TOA}	Top of Atmosphere Reflectance
ρ_{Ray}	Rayleigh Reflectance
ρ_{Aer}	Aerosol Reflectance
ρ_s	Surface Reflectance
$T_{(\theta_s)}$	Transmission of the atmosphere on sun-surface path
$T_{(\theta_v)}$	Transmission of the atmosphere on surface-sensor path
S	Atmospheric backscattering ratio

Python - SciPy Library

Introduction

MODIS

Aerosol Algorithm

Implementation

Results

PM10 Comparison

Validation

Summary

Introduction

MODIS

Aerosol Algorithm

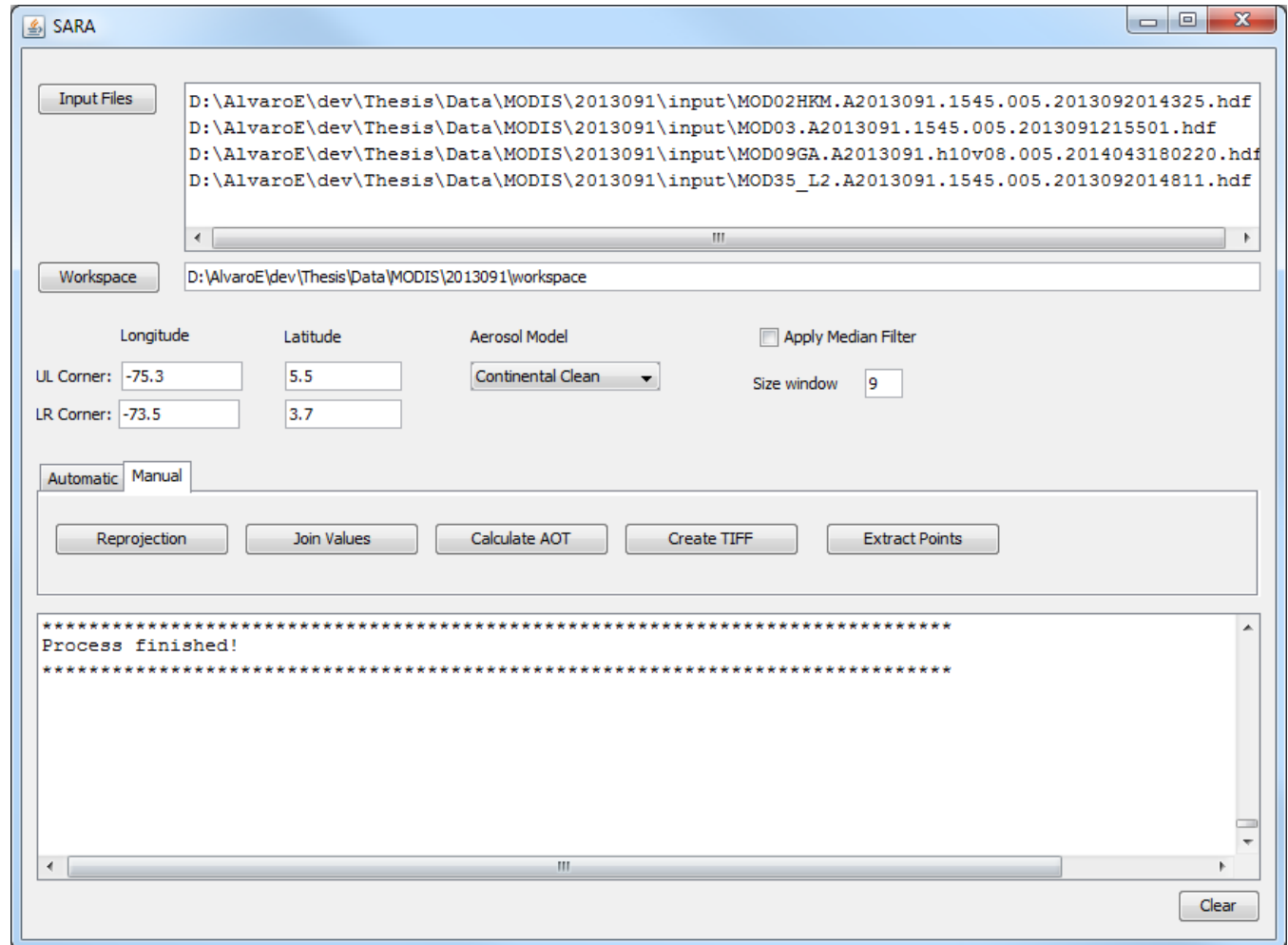
Implementation

Results

PM10 Comparison

Validation

Summary



Java Programming Language

Introduction

MODIS

Aerosol Algorithm

Implementation

Results

PM10 Comparison

Validation

Summary

Bogotá, Colombia




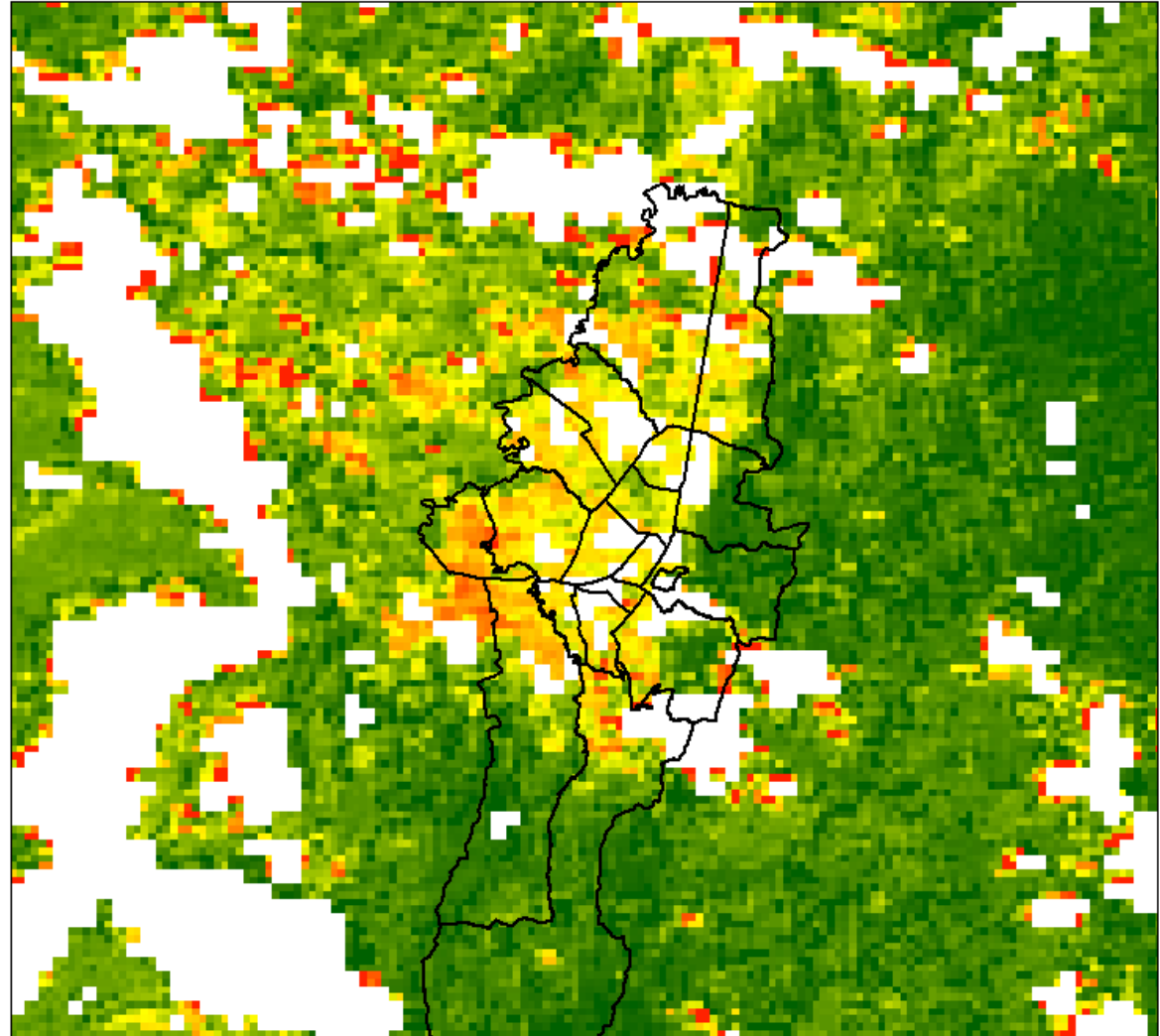
source: cdn.zmescience.com



source: [wikipedia.org](https://www.wikipedia.org)

Initial Results

0 5 10 20 Kilometers




0  1

Introduction

MODIS

Aerosol Algorithm

Implementation

Results

PM10 Comparison

Validation

Summary

Median Filter

Introduction

MODIS

Aerosol Algorithm

Implementation

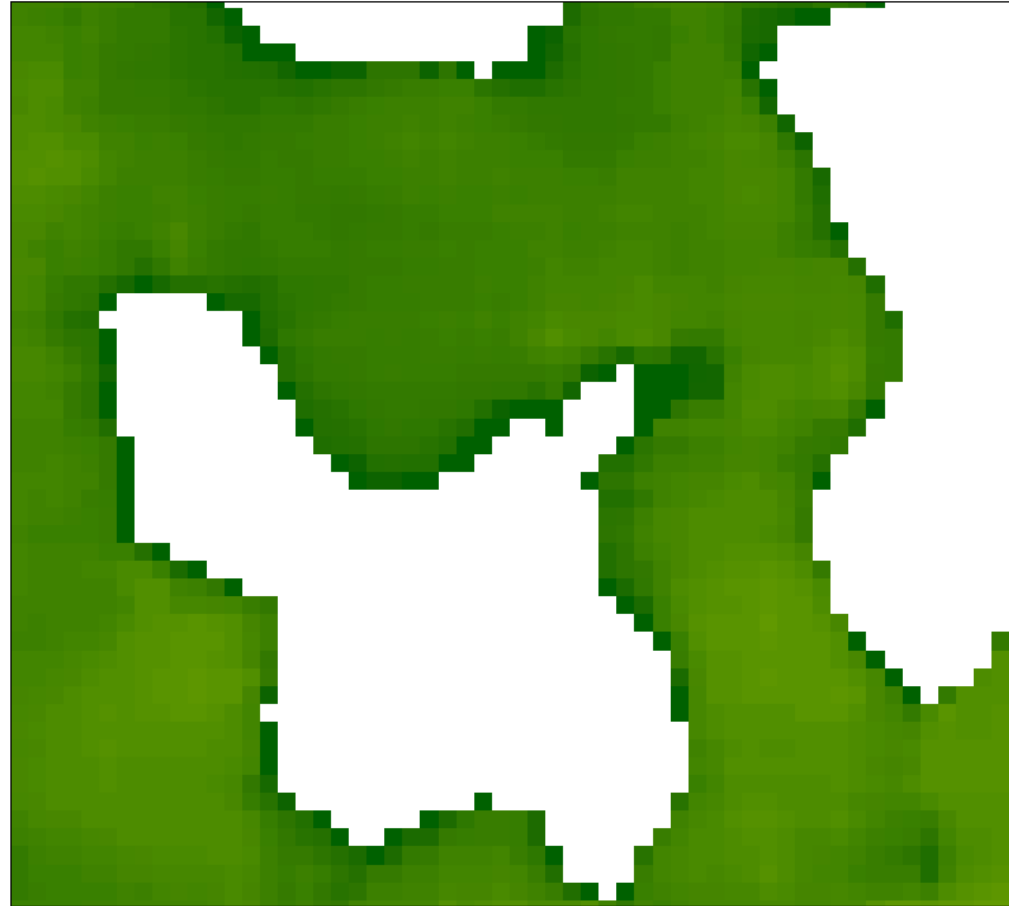
Results

PM10 Comparison

Validation

Summary

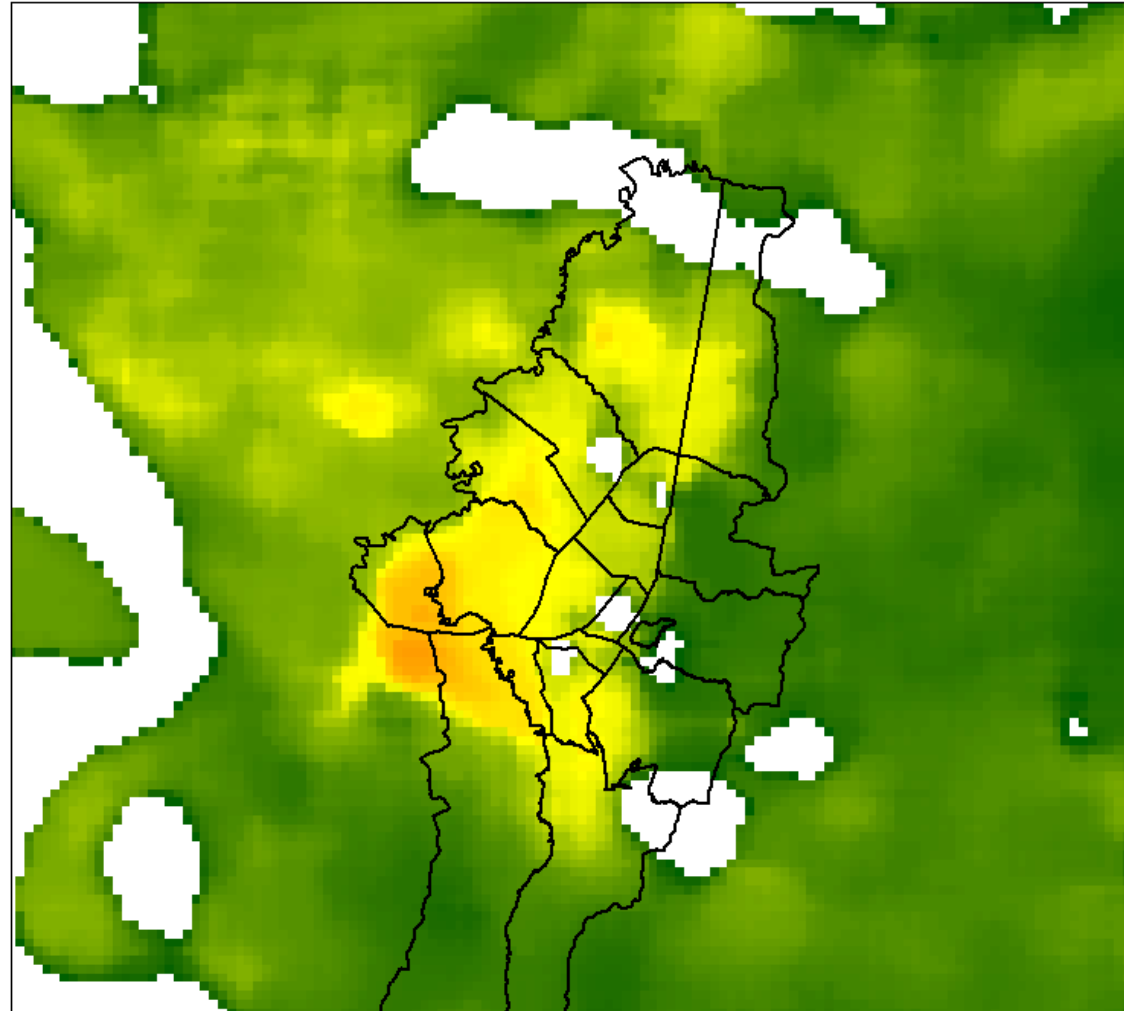
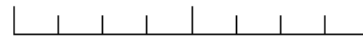
0 3.75 7.5 15 Kilometers



0 1

AOT 500m

0 5 10 20 Kilometers



0 1

Introduction

MODIS

Aerosol Algorithm

Implementation

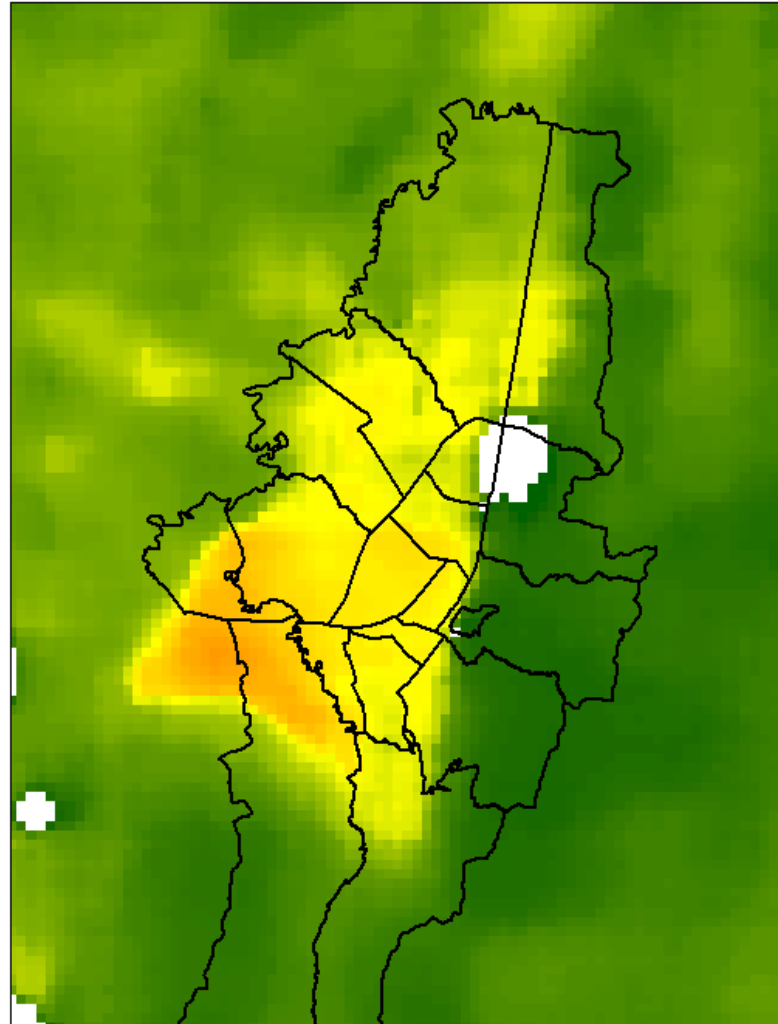
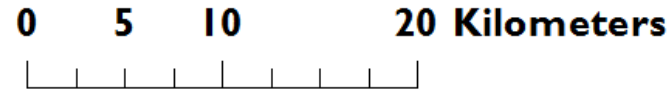
Results

PM10 Comparison

Validation

Summary

Resolution Improvement



Introduction

MODIS

Aerosol Algorithm

Implementation

Results

PM10 Comparison

Validation

Summary

PM10 Monitoring Stations

Bogotá Air Quality Monitoring Network

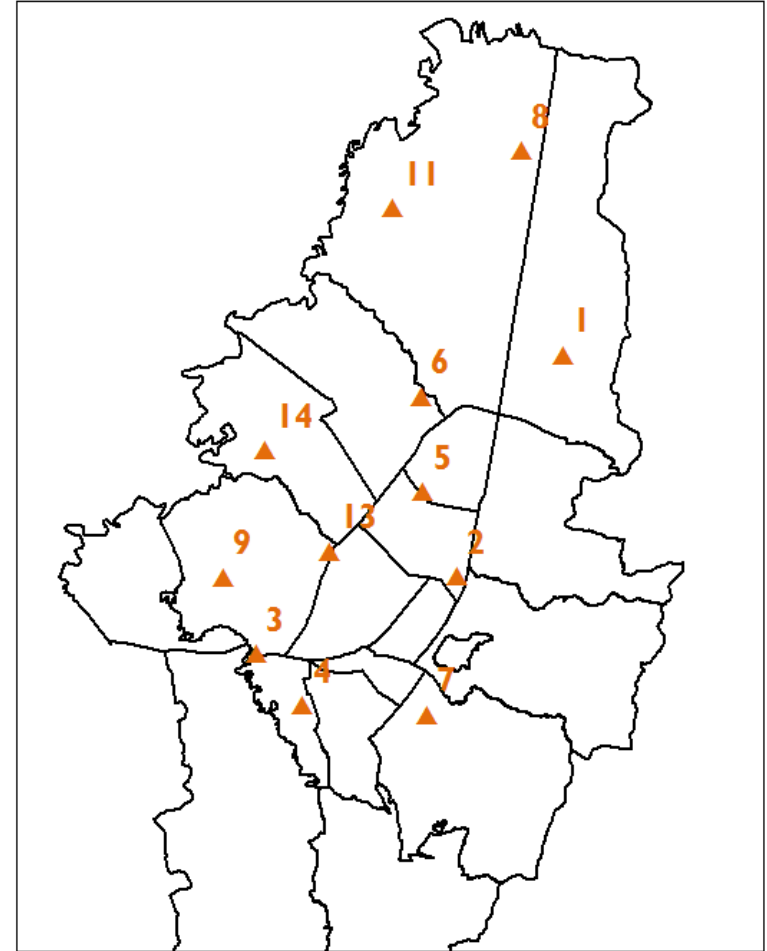
14

Air Monitoring
stations

PM10

Particle Matter less
than 10 $\mu\text{m}/\text{m}^3$

0 2.5 5 10 Kilometers



PM10 Interpolation

Introduction

MODIS

Aerosol Algorithm

Implementation

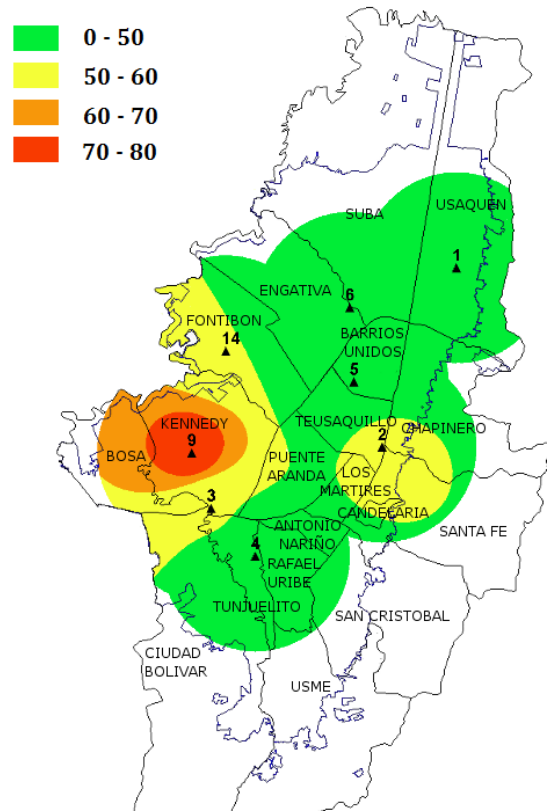
Results

PM10 Comparison

Validation

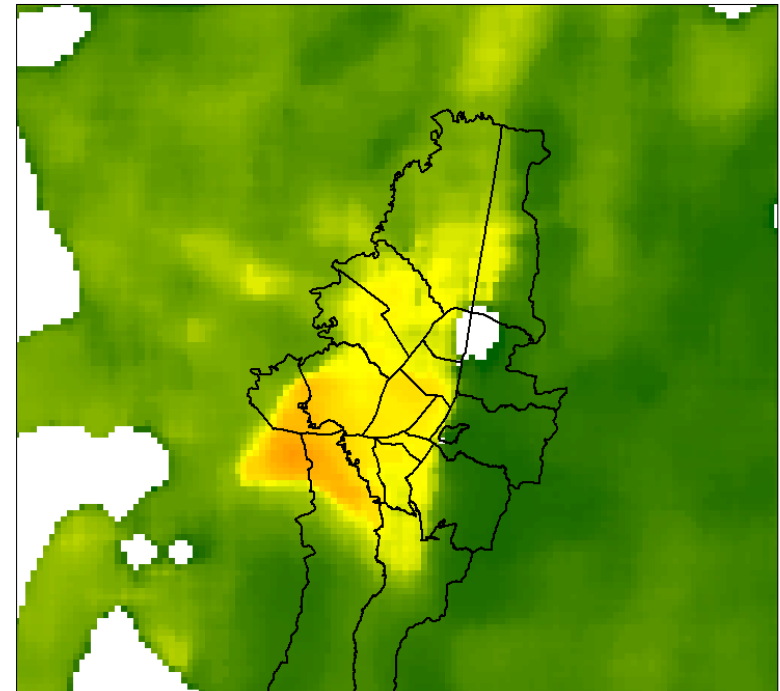
Summary

PM10



AOT

0 5 10 20 Kilometers



0 1.4

27.03.2013

Introduction

MODIS

Aerosol Algorithm

Implementation

Results

PM10 Comparison

Validation

Summary

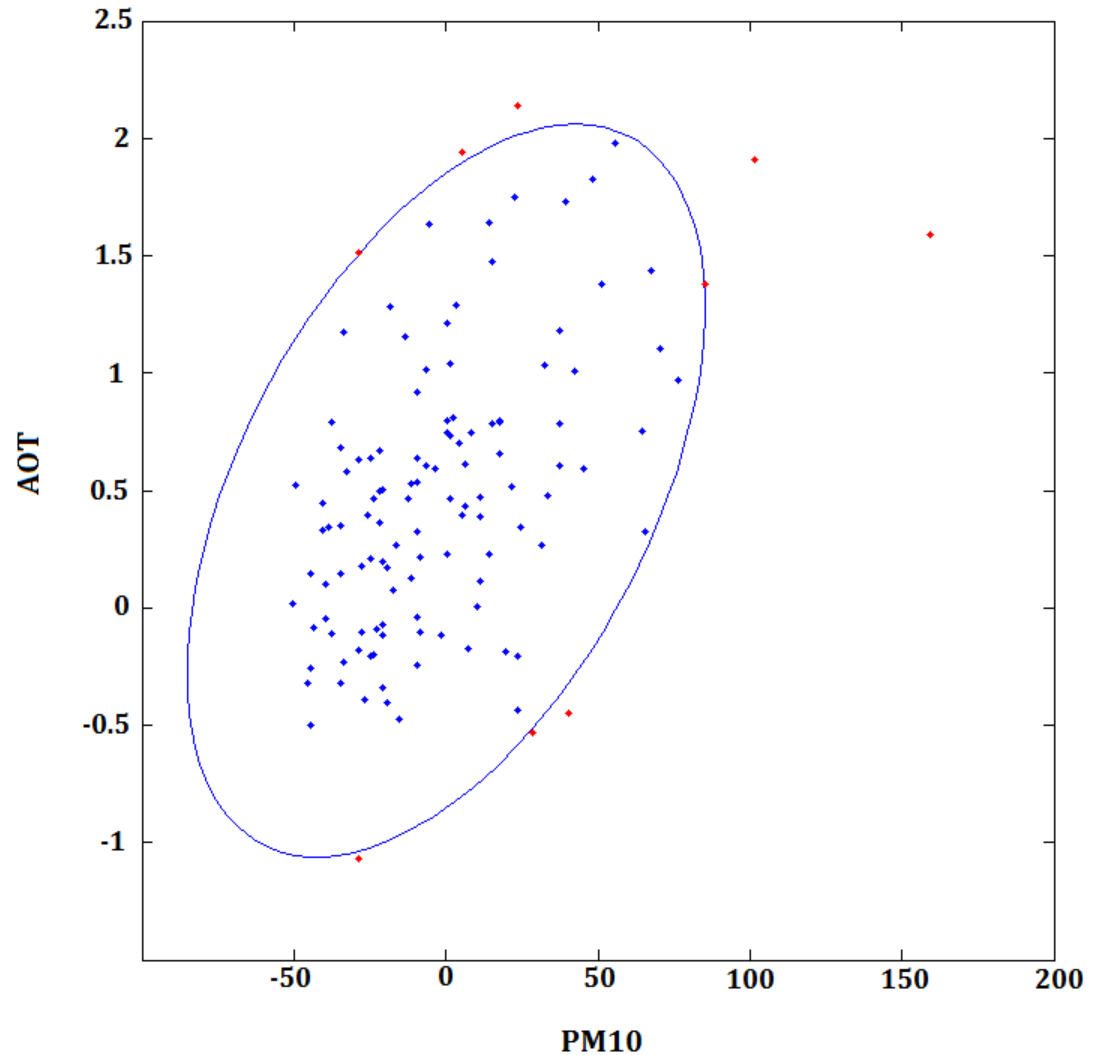
Limitations

Month	Days	Terra
Feb	28	17
Mar	31	17
Apr	30	17
May	31	17
Jun	30	17
Jul	31	18
Aug	31	17
Sep	30	19
	242	139
	100%	57%

Number PM10 Samples	Not covered by clouds
1473	163
100%	11%

Correlation

Median Filter: **51.19%**



Introduction

MODIS

Aerosol Algorithm

Implementation

Results

PM10 Comparison

Validation

Summary

Industrial zones

Introduction

MODIS

Aerosol Algorithm

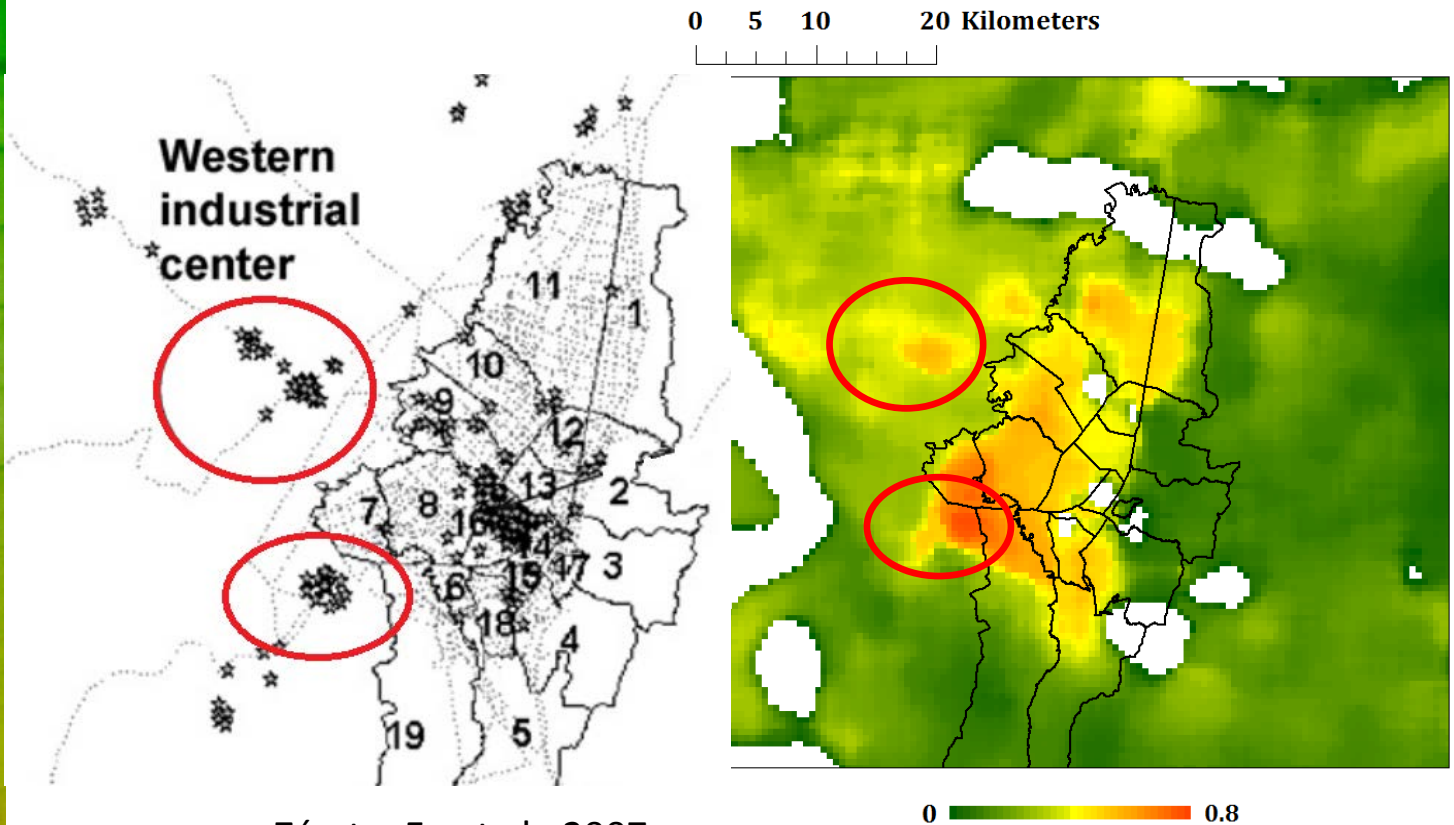
Implementation

Results

PM10 Comparison

Validation

Summary



source: Zárate, E., et al., 2007

Introduction

MODIS

Aerosol Algorithm

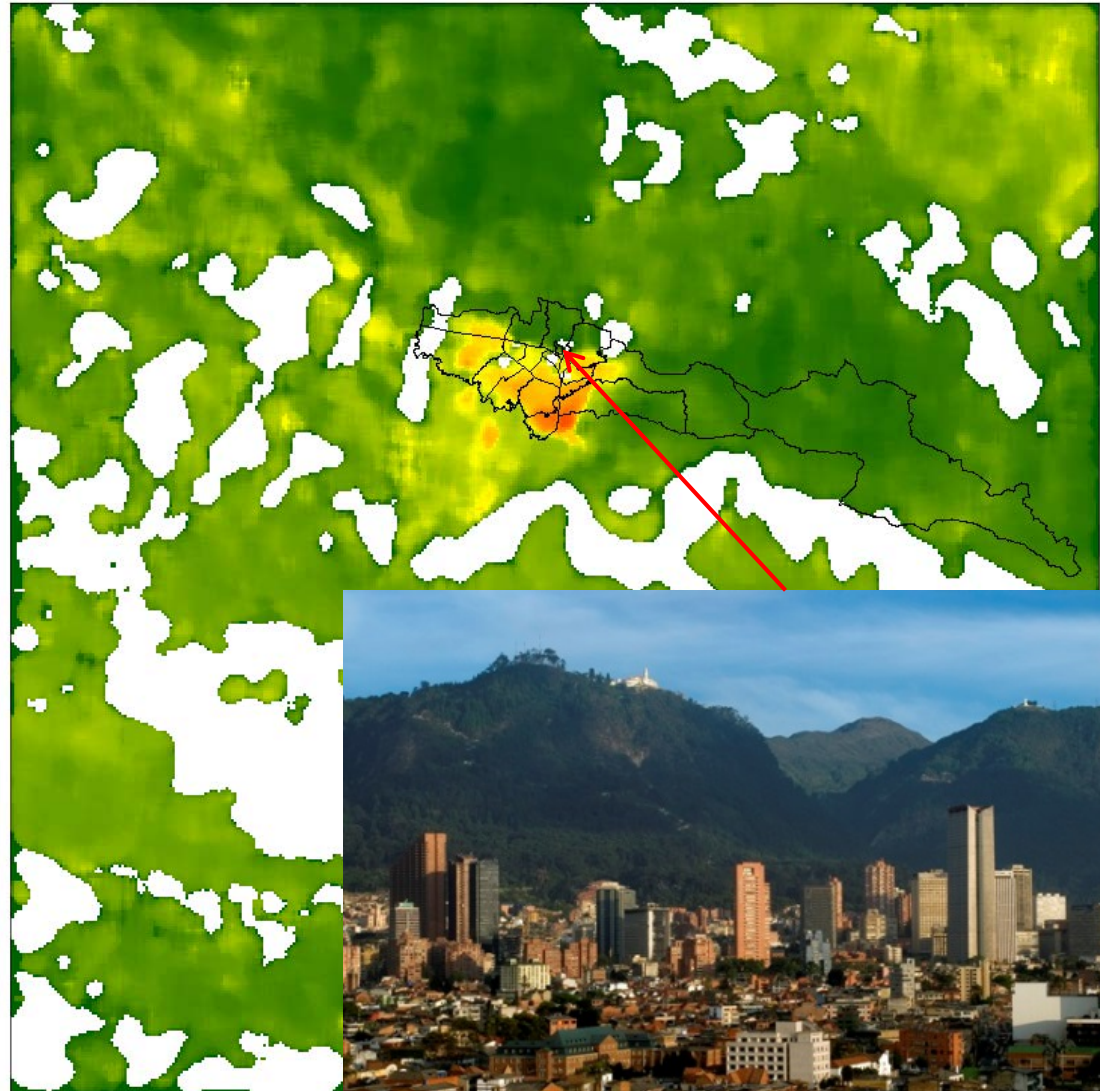
Implementation

Results

PM10 Comparison

Validation

Summary



Introduction

MODIS

Aerosol Algorithm

Implementation

Results

PM10 Comparison

Validation

Summary

Summary

It is an efficient tool to estimate the **air quality** over mixed surfaces.

It can be useful to improve the **environment**, as part of a decision support system.

References

M. Bilal, J. E. Nichol, M. P. Bleiweiss and D. Dubois, "A Simplified high resolution MODIS Aerosol Retrieval Algorithm (SARA) for use over mixed surfaces," *Remote Sensing of Environment*, vol. 136, pp. 135-145, September 2013.

E. Zárate, L. C. Belalcázar, A. Clappier, V. Manzi and H. V. den Bergh, "Air quality modelling over Bogota, Colombia: Combined techniques to estimate and evaluate emission inventories," *Atmospheric Environment*, vol. 41, no. 29, pp. 6302-6318, 2007.

Thanks for your attention!