University of Valladolid

ECAS 2017 — 2nd International Electronic Conference on Atmospheric Sciences
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chaired by Prof. Dr. Anthony R. Lupo

Air pollution Research Group

Trend assessment for a CO_2 and CH_4 data series in northern Spain

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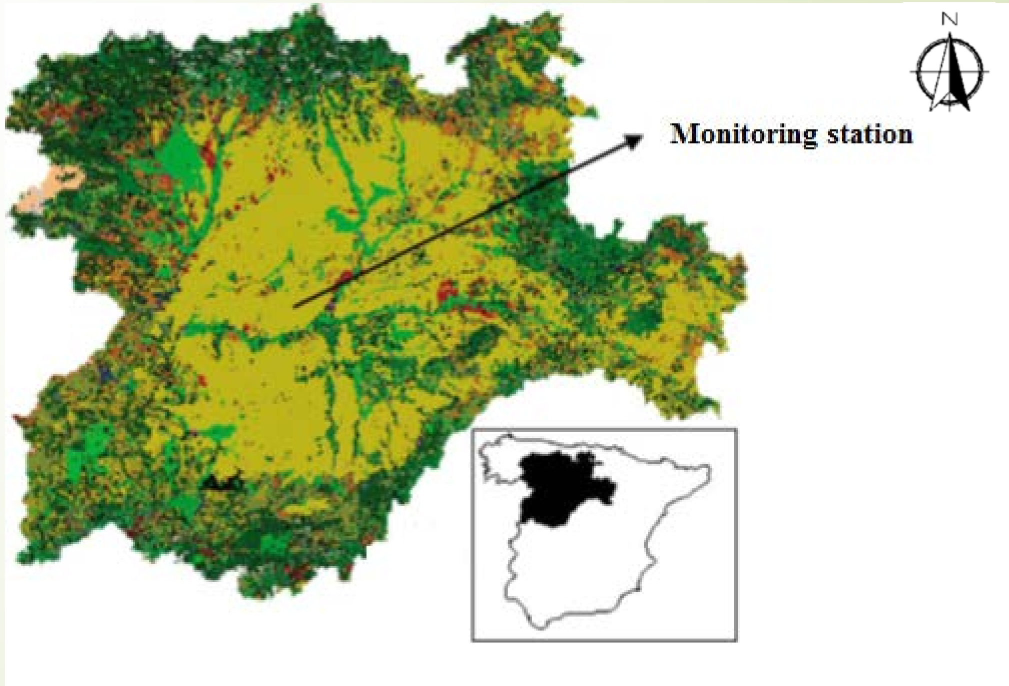
3. Results and discussion
4. Conclusions



1. Introduction

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Background information

Atmospheric time series = TREND + SEASONALITY + RANDOM COMPONENT

To separate this components we need fit the data to

Mathematical functions

Our purpose

To quantify the trend evolution of a CO_2 and CH_4 data series by applying:

- Harmonic functions
- Kernel functions
- Weighted Local linear functions

Literature

Harmonic functions:
- Anderson-Cook, 2000
- Artuso et al., 2009
- Sánchez et al., 2010

Kernel functions:
- Lorimer, 1986
- de Haan, 1999

Weighted Local linear functions:
- Cleveland, 1979

2. Data and methods

2.1. Data

Measuring campaign: from 15 Oct 2010 to 29 Feb 2016

CIBA station

(41°48′49″ N, 4°55′59″ W)

Picarro G1301

30-min CO_2 and CH_4 mixing ratios

Values were corrected with

NOAA calibration gas standards

Calibration equations

$$CO_{2\,C} = 1.00341\ CO_2 - 0.17870$$

$$CH_{4\,C} = 0.99197\ CH_4 + 0.01249$$

C: corrected value

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2. Data and methods

2.2. Site location

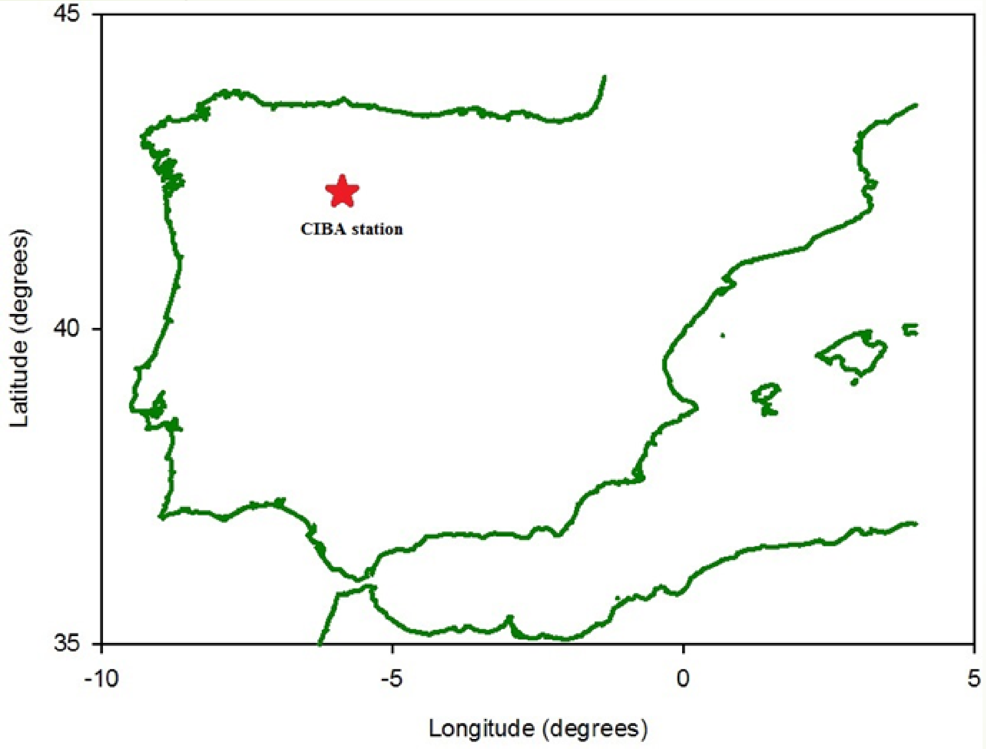

Figure 1. Monitoring site location

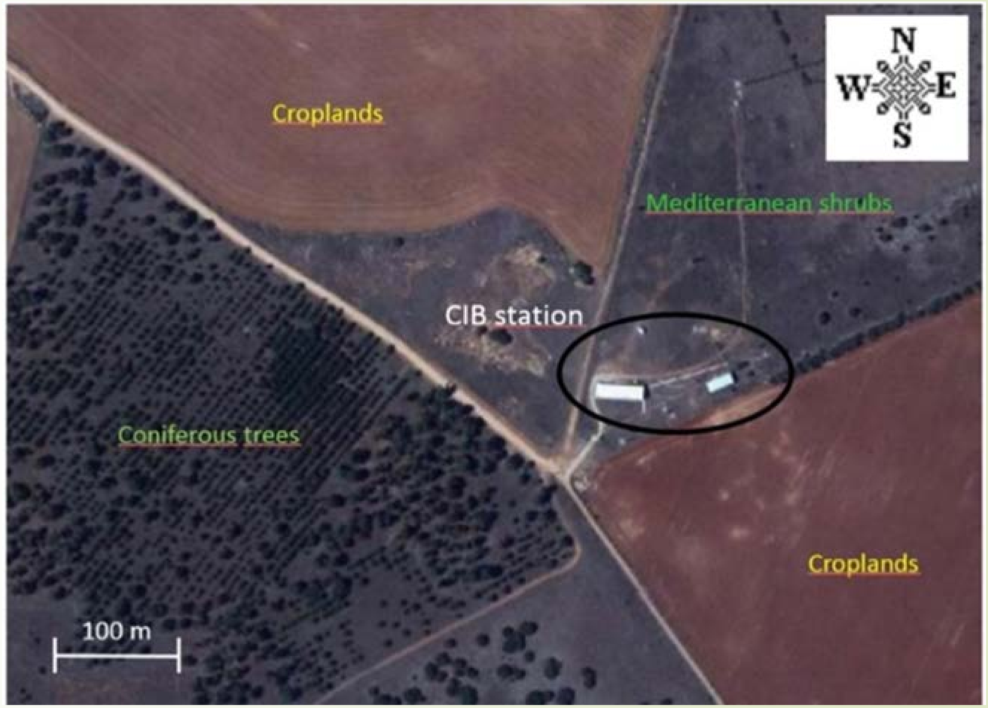

Figure 2. Vegetation ecosystems around the station (surrounded by a black line). PNOA image courtesy of ©ign.es

2. Data and methods

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2.3. Mathematical procedure

Harmonic functions

$$y = \sum_{i=0}^{3} a_i t^i + \sum_{j=1}^{4}\sum_{k=0}^{1}\left(b_{jk}\, t^k \cos(j2\pi t) + c_{jk}\, t^k \sin(j2\pi t)\right)$$

TREND | SEASONALITY

Where:

- y: mixing ratio (ppm for CO_2 and ppb for CH_4)
- t: time (years)
- j: harmonic
- K: parameter which considers the amplitude fix or variable over time
- a,b,c: unknown coefficients obtained with MATLAB ©

Kernel functions

$$\bar{y}(t,h) = \frac{\sum_{i=1}^{N} K\left(\frac{t-t_i}{h}\right) y_i}{\sum_{i=1}^{N} K\left(\frac{t-t_i}{h}\right)}$$

h chosen: 500 days

Where:

- h: smoothing parameter (days)
- N: number of data
- K: kernel function

Table 1. Kernel functions employed.

Kernel function	$^aK(u)$
Epanechnikov	$(3/4)\,(1-u^2)$
Biweight	$(15/16)\,(1-u^2)^2$
Gaussian	$(2\pi)^{-1/2}\exp(-0.5u^2)$
Rectangular	1/2
Triangular	$1-\lvert u\rvert$
Tricubic	$(70/81)\,(1-\lvert u\rvert^3)^3$

$^a u = [(t-t_i)/h]$

2.3. Mathematical procedure (Cont.)

Weighted Local linear functions $y = a_0 + a_1 t$

$$a_1 = \frac{\sum_{i=1}^{N} w_i (t_i - \overline{t_w})(y_i - \overline{y_w})}{\sum_{i=1}^{N} w_i (t_i - \overline{t_w})^2}$$

$$a_0 = \overline{y_w} - a_1 \overline{t_w}$$

h chosen: 500 days
Kernel chosen: Epanechnikov

Where:

- W_i: weights
- $\overline{t_w}$ and $\overline{y_w}$: weighted mean values

3. Results and discussion

3.1. CO_2 and CH_4 mixing ratio evolution

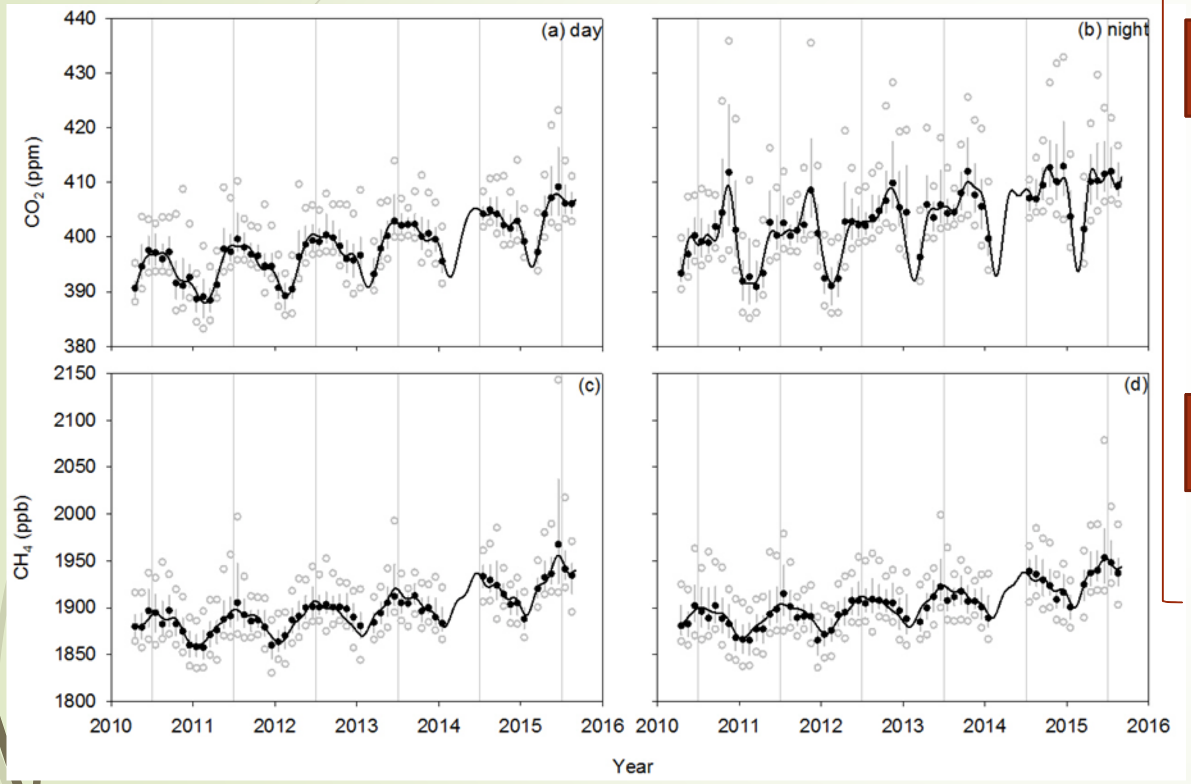

Figure 3. CO_2 (a, b) and CH_4 evolution (c, d).

Local emissions (vehicles, industrial activities and domestic heating)

CO_2 maximum

DAY: winter

NIGHT: Winter and spring

Temperature inversions. Vigorous vegetation growth (↑respiration rates)

CO_2 minimum → summer

↓ Consumption of fossil fuel and photosynthetic activity

⚠ CH_4 cycle is less pronounced than CO_2 cycle.

Table 2. Monthly means statistics for the mixing ratios.

Statistic	CO_2 (ppm)		CH_4 (ppb)	
	Day	Night	Day	Night
Median	397.91	403.24	1.8966	1.9024
Interquartile range	5.01	7.98	0.0284	0.0315
10th percentile	394.34	397.87	1.8737	1.8772
90th percentile	405.72	414.74	1.9368	1.9446

3. Results and discussion

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3.2. Data trend evolution

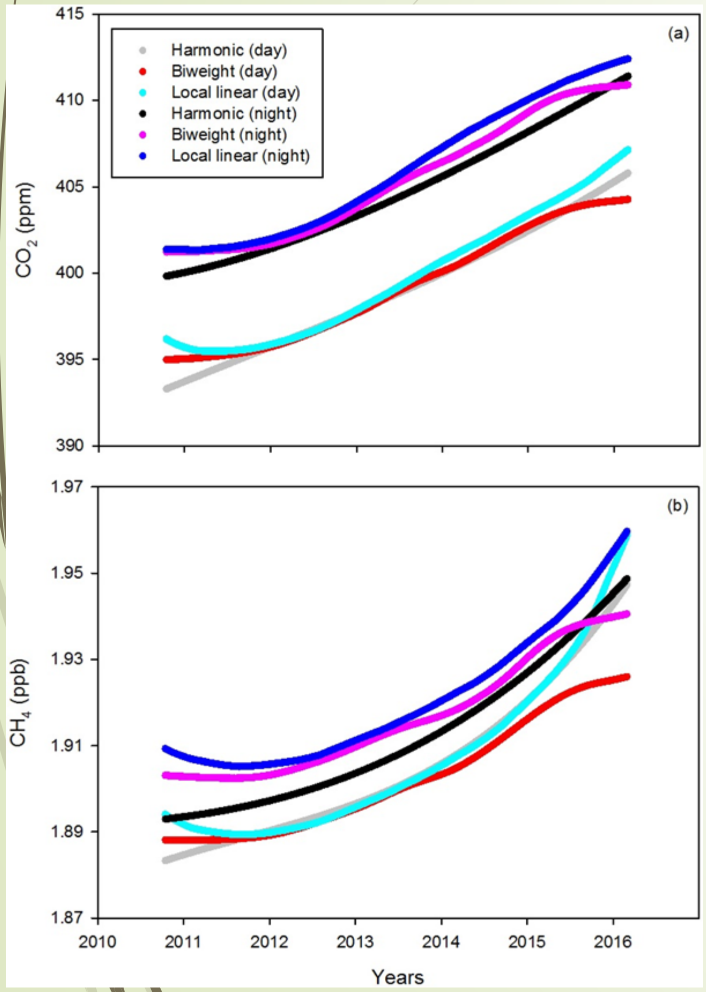

Figure 4. CO_2 (a) and CH_4 (b) trend evolution.

Increasing pattern over the years partially related with a rise in anthropogenic emissions from industrial activities and from the urban landfill as well as from farming vehicle emissions.

Harmonic functions: greater values and smoother trend curves

- All observations contribute to the calculations

Kernel and weighted local linear functions: lower values and less smooth trend curves

- Only consider the interval calculation between -1 and 1.
- Border effect → rough graphical output at the start and end of the series

Table 3. Mean growth values

Function	CO_2 (ppm year^{-1})	CH_4 (ppb year^{-1})
Harmonic	2.30	11.90
Biweight kernel	1.80	7.15
Local weighted	1.98	10.85

Values from literature:

- 1.7–3.6 ppm year^{-1} for CO_2

  Zhang et al. 2008 and Zhu et al. 2015

- 6-10 ppb year^{-1} for CH_4

  Fang et al., 2016; Nisbet et al., 2014 and Vermeulen et al., 2011

4. Conclusions

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1. We did not find major differences between the 6 kernels studied, although slightly better fits were obtained with the biweight kernel.

2. Similar CO_2 and CH_4 trends results were found regardless of the chosen function.

3. Harmonic, Kernel and local weighted functions were effective methods of describing the data trend at CIBA station for both gases.

4. These mathematical functions produced meaningful information for air quality modelling in the troposphere.

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Conflicts of interest: The authors declare no conflict of interest

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