Interannual variability of atmospheric carbon dioxide over Central Siberia from ZOTTO database (2009 – 2015)

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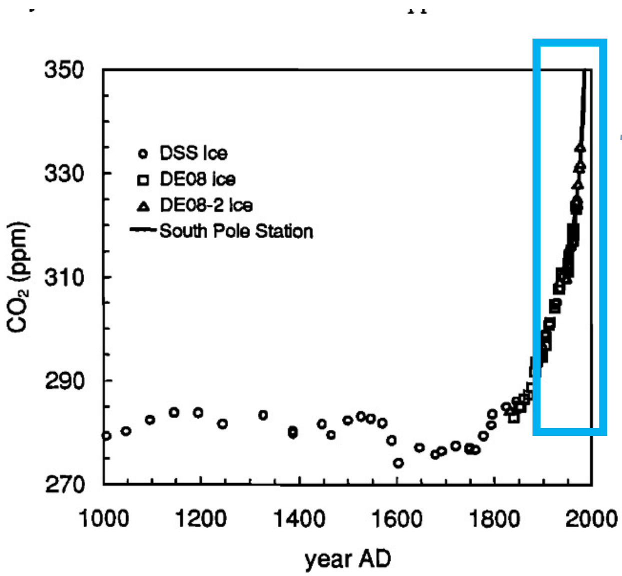
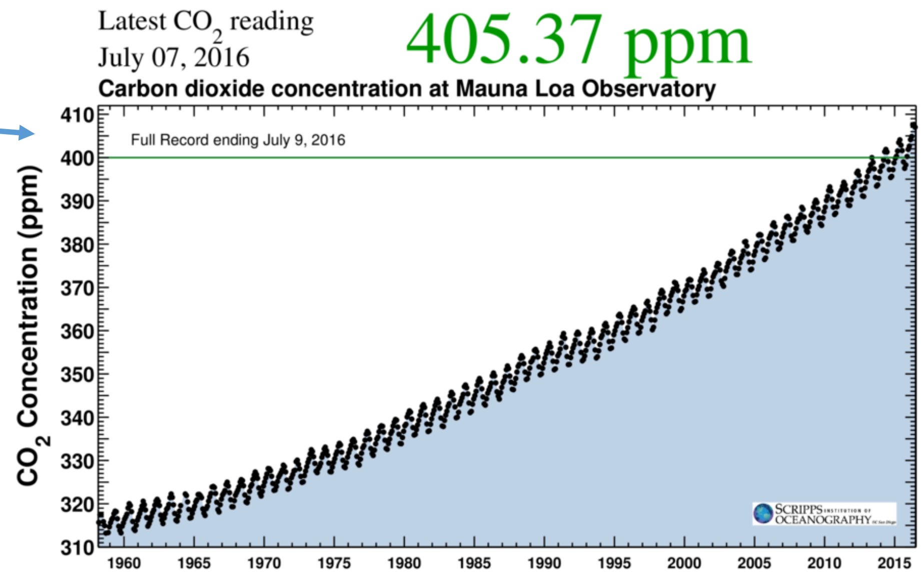
Global growth of CO_2 concentration in atmosphere

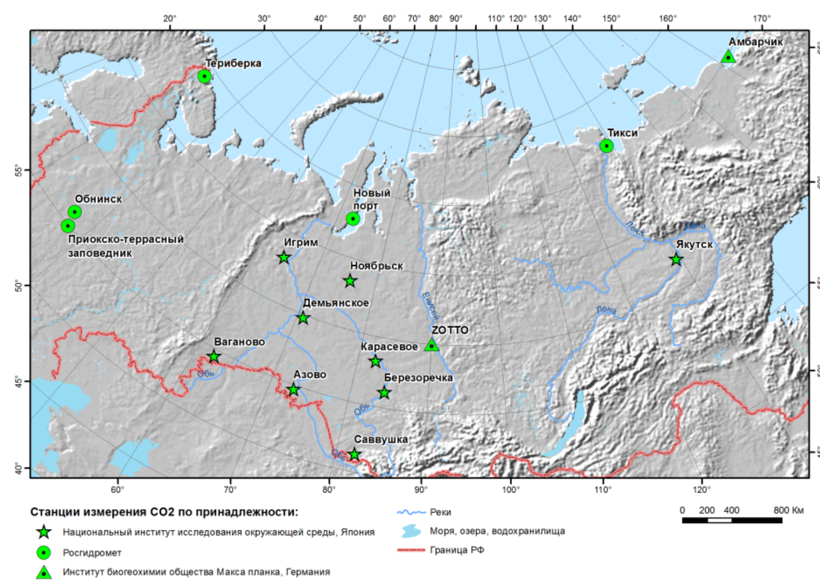


CO_2 mixing ratios from the Law Dome ice cores (Etheridge D.M. et al., 1996)



https://scripps.ucsd.edu/programs/keelingcurve/

	CO_2
Global abundance in 2014	397.7±0.1 ppm
2014 abundance relative to 1750	143%
2013-2014 absolute increase	1.9 ppm
Mean annual absolute increase during last 10 years	2.06 ppm/yr

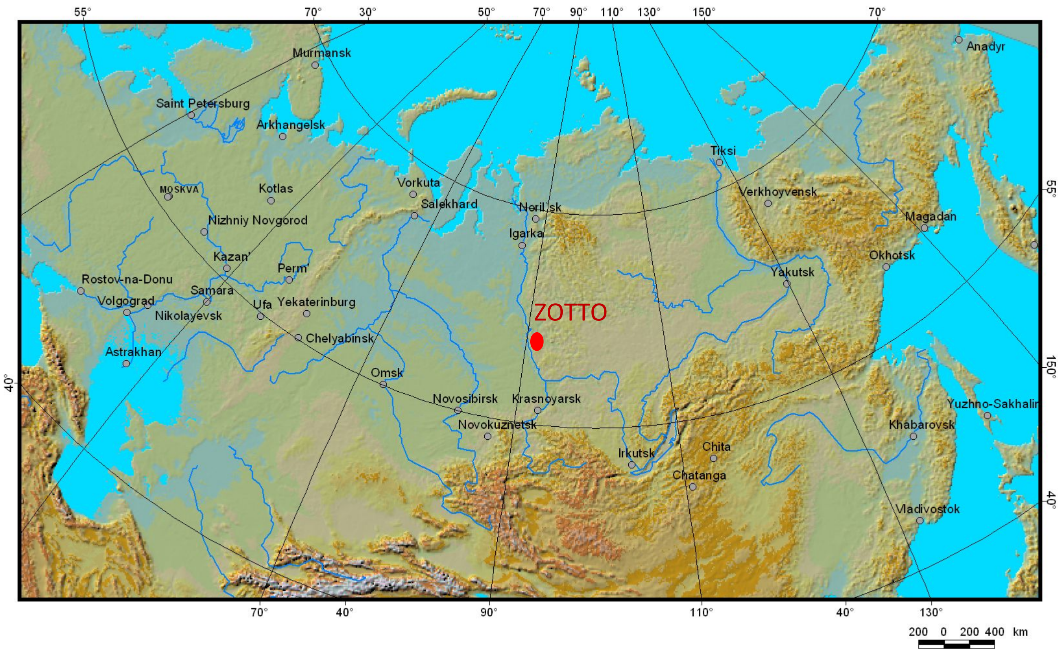


The aim of study was

to estimate the interannual variability of carbon dioxide in the atmosphere over Central Siberia from ZOTTO dataset (2009-2015).

Zotino **T**all **T**ower **O**bservatory (**ZOTTO**) http://www.zottoproject.org/

The station is located in Central Siberia at **60°48' N, 89°21'E**, about 30 km west of the Yenisei River (114 m a.s.l.).



Air temperature of January is **-26°C**.
Air temperature of July is **22° C.**

The annual precipitation sum ranges from **500 to 600 mm**.







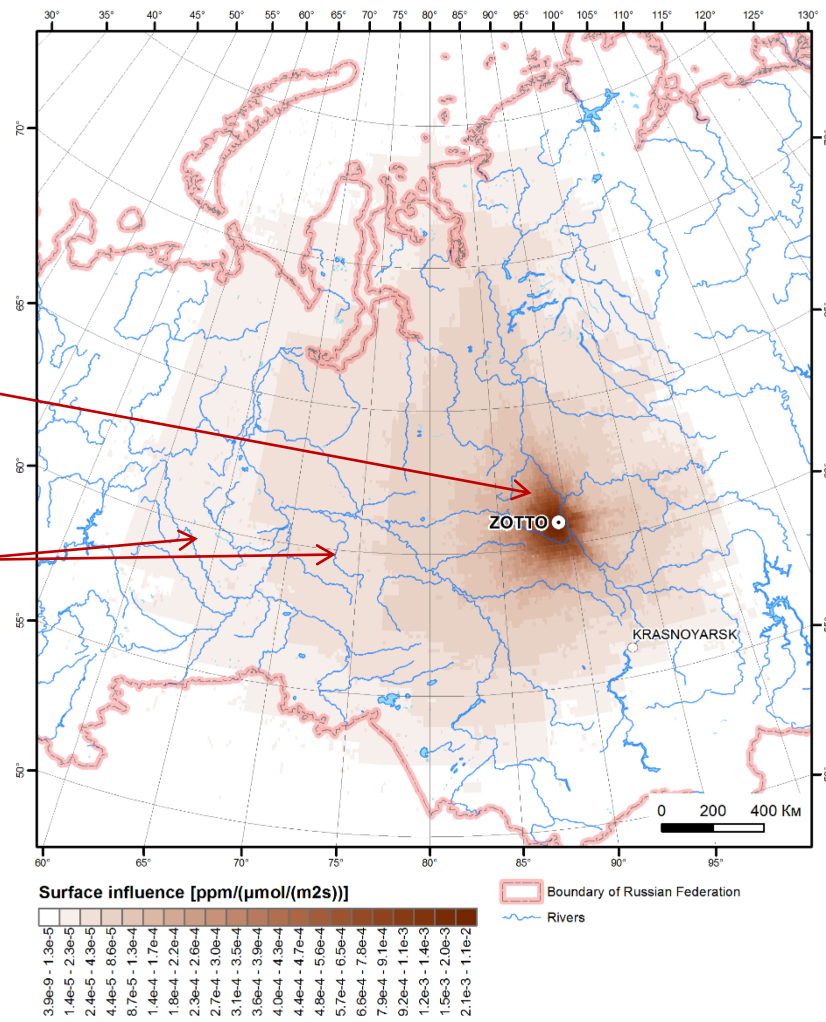
Mean cumulative seasonal footprint climatology for the 301-m height of ZOTTO made from 10 days back trajectories for every three hour from 1st of May to 30th of September for four years (2008, 2009, 2010, and 2012) applied STILT model.

- The area of ZOTTO seasonal footprint covers about of 6.9×10^6 km^2.

- The near-field of the station has the main influence on GHG measurement at ZOTTO.

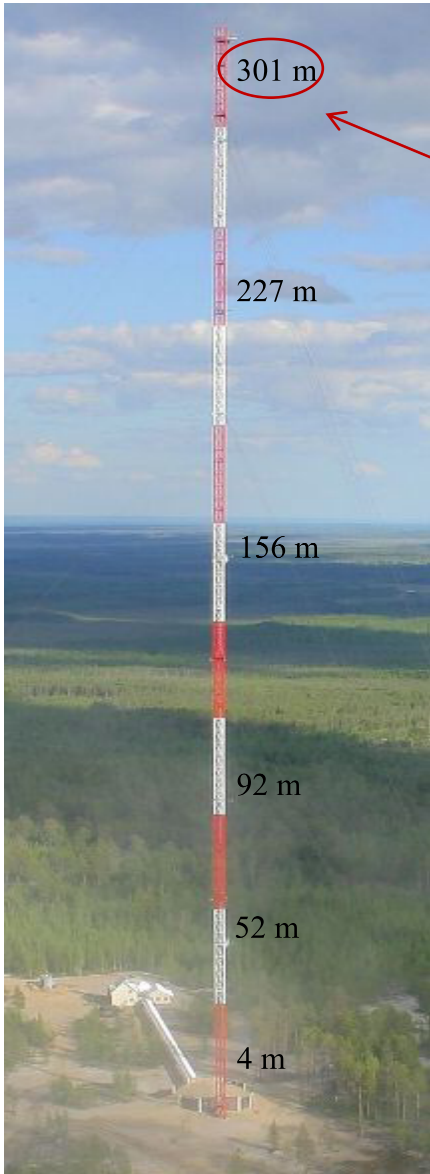
- The contribution of land cover decrease with distance and time away from the tower.

- Seasonal footprint asymmetrically distributed around ZOTTO (slightly towards the westnorth)



Continuous measurements

301-m tall measurement mast for continuous high-precision monitoring of the concentrations

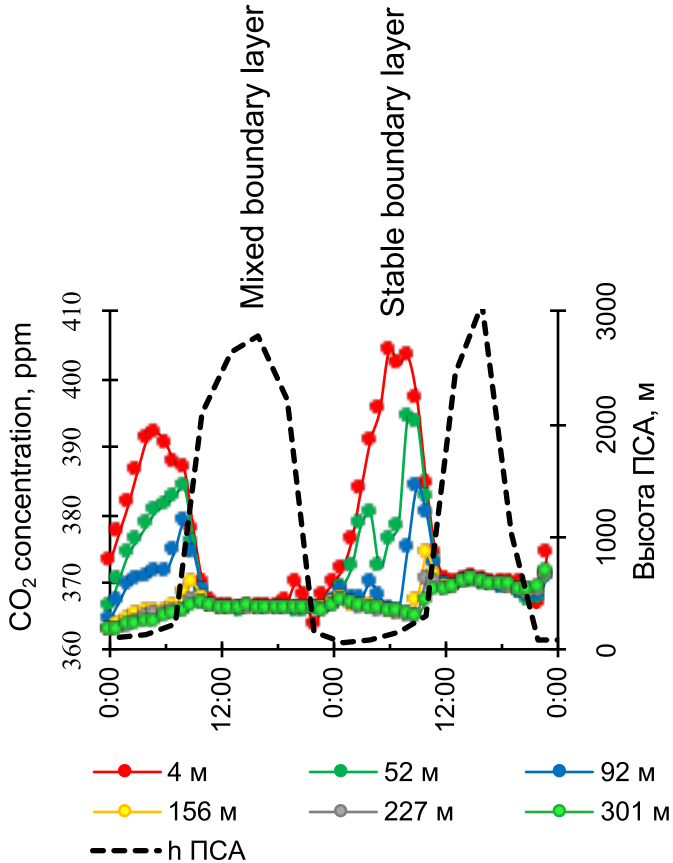


1. Samples of air are analyzed from 301 m).

2. CO_2 concentration is measured by Envirosense 3000I Multi-Species Atmospheric Monitor (Picarro, USA) established in container near bottom of tower with measuring frequency of twice per minute.

CO_2/CH_4/H_2O concentration high-precision monitoring

Statistical analysis



We use only daily data from 13:00 to 17:00 local time

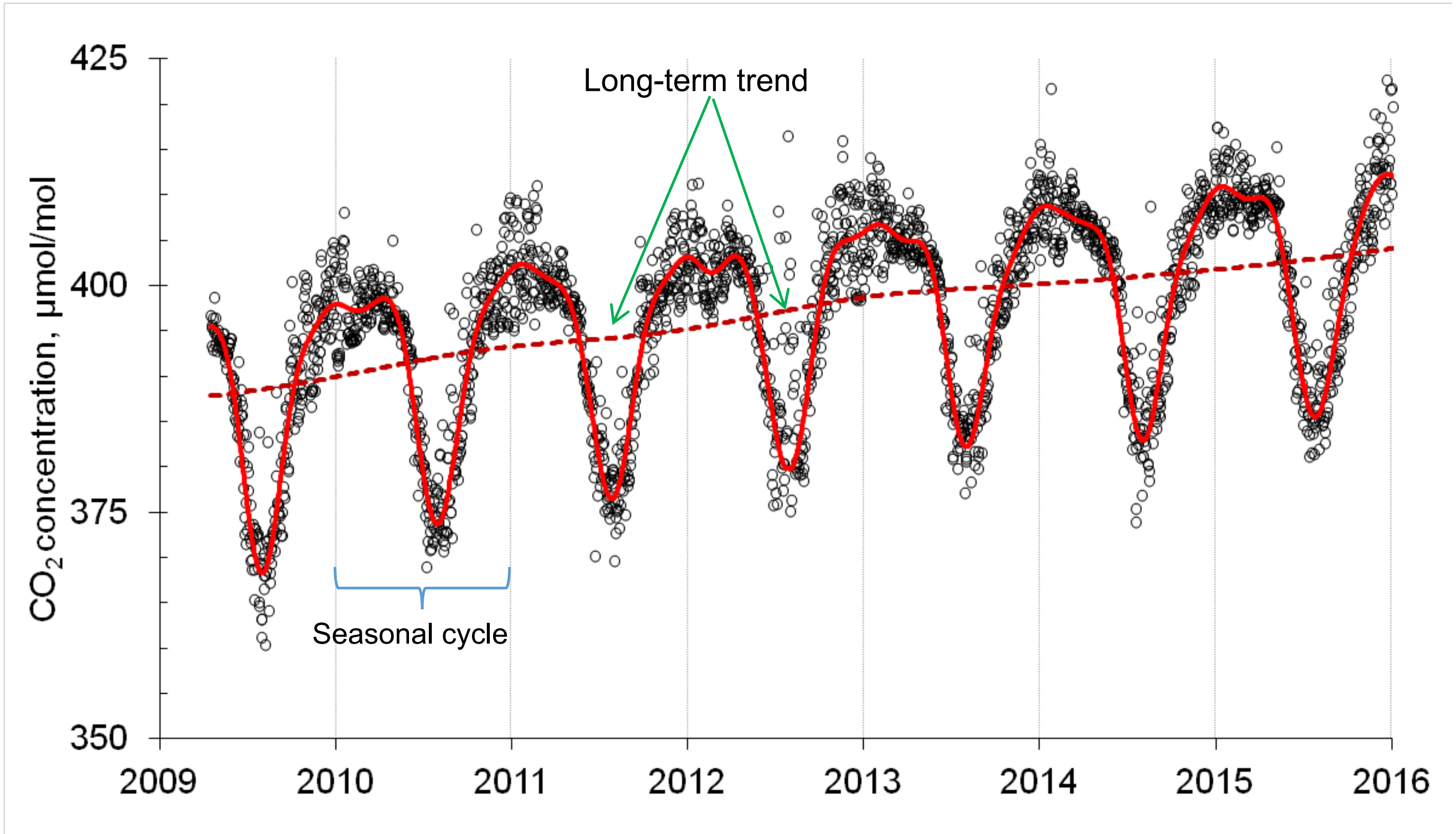
To decompose the CO_2 time series into a long-term trend and seasonal and inter-annual components, we used the curve-fitting procedures developed by Thoning et al. [1989].

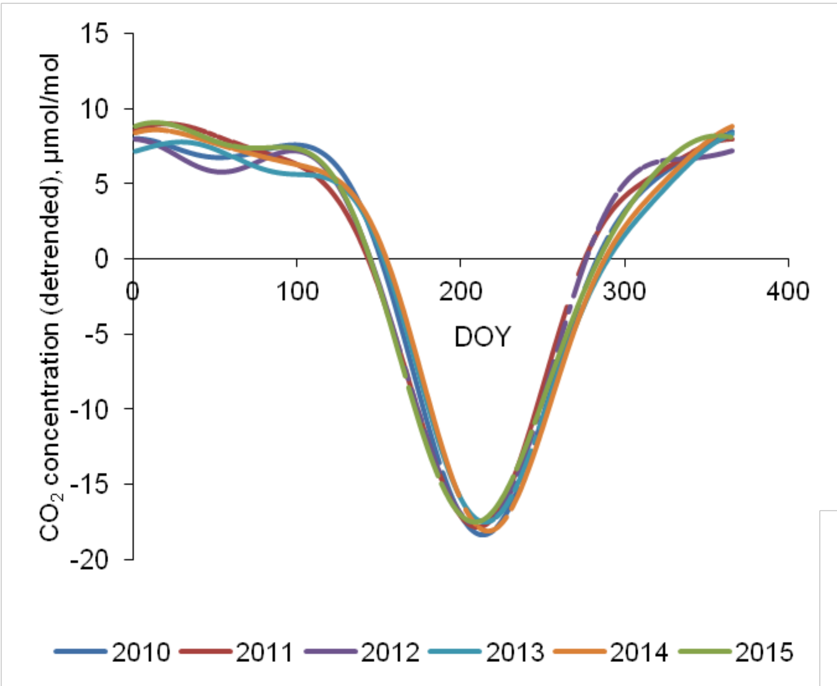
We ran the routine using a quadratic polynomial to fit the trend, four annual harmonics for the seasonal component, and short and long frequency cutoff parameters of 100 and 650 days in the Fast Fourier Transform low-pass filtering in order to remove high-frequency noise and isolate the trend component.

The fitting procedure was repeated four times in order to remove daily averages lying outside three standard deviations.

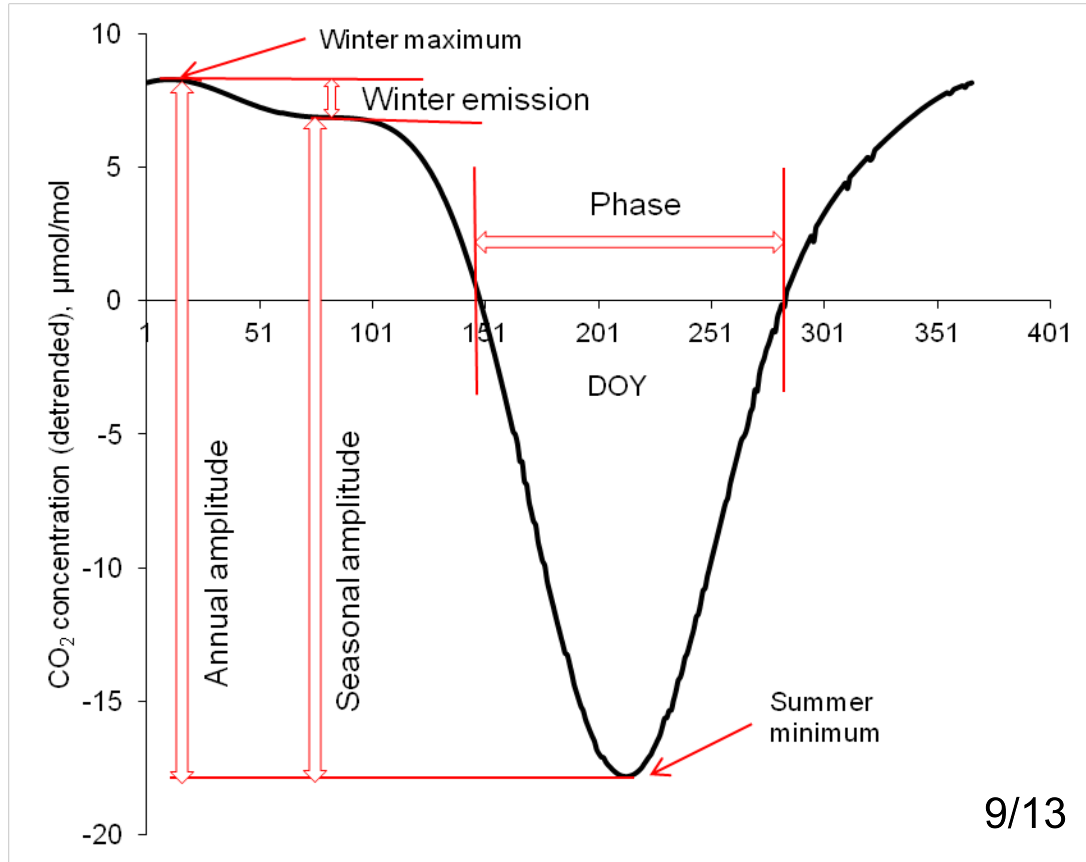
The previous result:

Daily CO_2 concentration time series obtained at ZOTTO from 1st of May 2009 to 31st of December 2015 with fitting curve





15
10
5
0
-5
-10
-15
-20
0
100
200
300
400
DOY
CO_2 concentration (detrended), µmol/mol
2010
2011
2012
2013
2014
2015

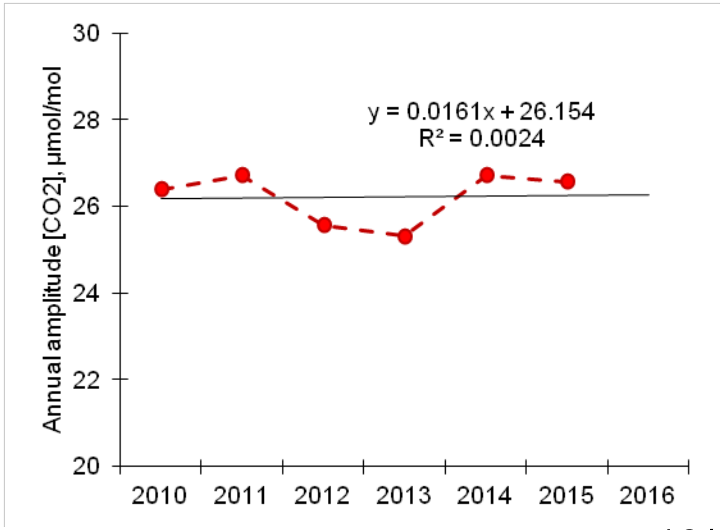


10
5
0
-5
-10
-15
-20
1
51
101
151
201
251
301
351
401
DOY
CO_2 concentration (detrended), µmol/mol
Winter maximum
Winter emission
Phase
Annual amplitude
Seasonal amplitude
Summer minimum

Annual amplitude of CO_2 concentration

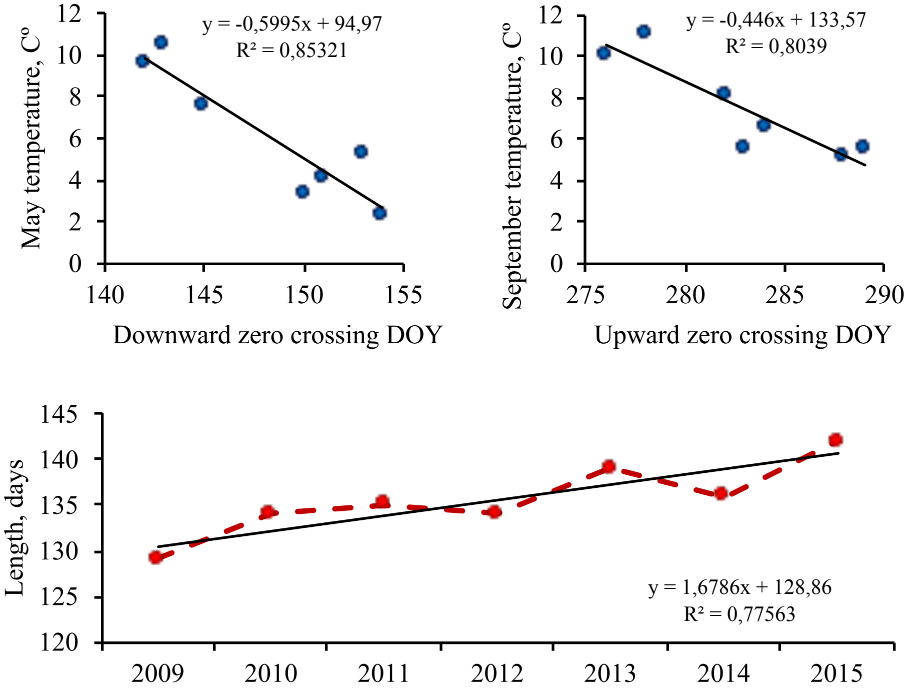
Year	Summer Minimum, µmol/mol	Winter Maximum, µmol/mol	Annual amplitude, µmol/mol
2010	-18.4	8.0	26.4
2011	-17.7	9.0	26.7
2012	-17.6	7.9	25.2
2013	-17.5	7.8	25.3
2014	-18.1	8.6	26.7
2015	-17.5	9.1	26.6
average	-17.8±0.4	8.4±0.6	26.2±0.6

There is no long-term change in CO_2 seasonal amplitude for six years

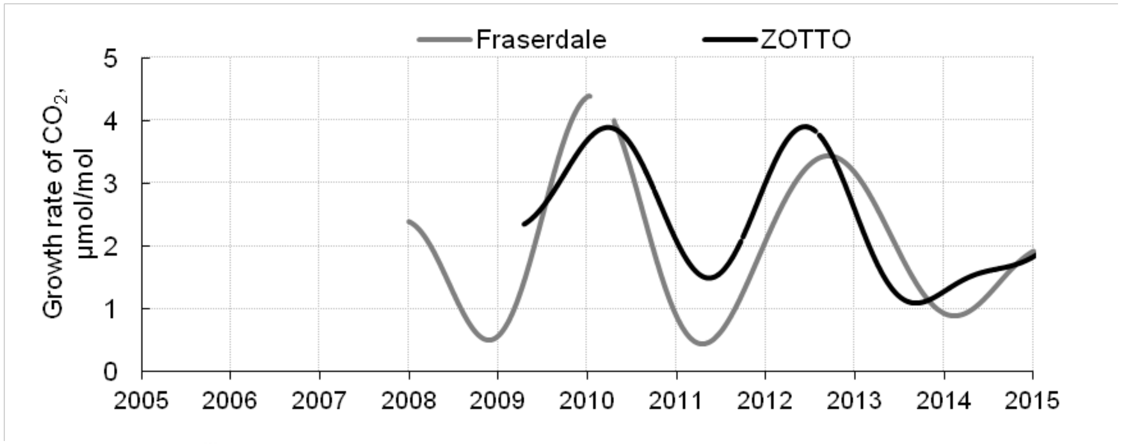


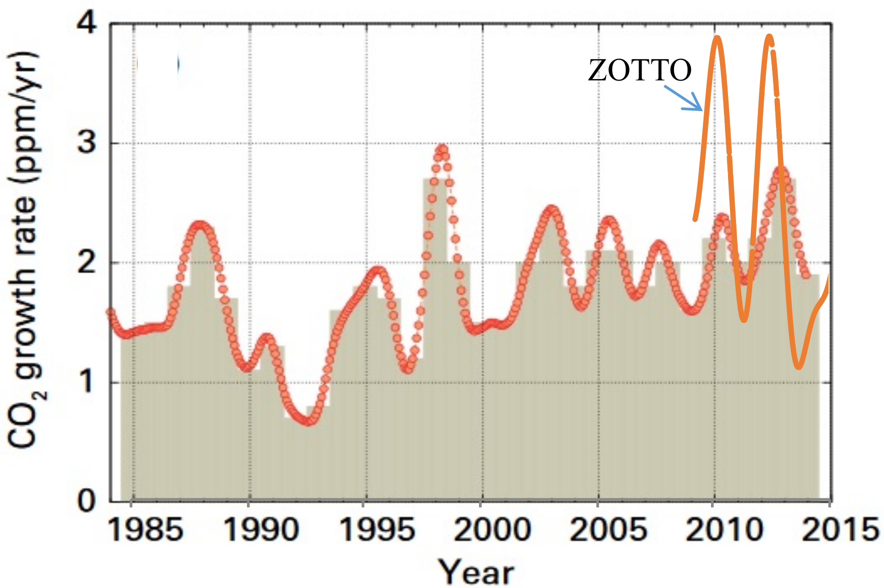
Seasonal phase of CO_2 concentration

Year	Downward zero crossing	Upward zero crossing	Length
2009	154	282	129
2010	150	283	134
2011	142	276	135
2012	145	278	134
2013	151	289	139
2014	153	288	136
2015	143	284	142
Average	148±5 May, 28	282±5 October, 9	135±4



Growth rate variability of CO_2 concentration





CO_2 concentration increases from 390.7 to 402.2 ppm for seven years at ZOTTO

About 2.3 ppm/year

3.8 µmol/mol in 2010 and 2012
1.5 µmol/mol in 2011 and 2013

The same tendency is in world and other boreal forest

Conclusions

For the period from 2009 to 2015 the seasonal cycle amplitude of carbon dioxide concentration was 26.2±0.6 μmol/mol without any long-term tendency.

At the same period the mean growth rate of carbon dioxide in atmosphere was 2.3 ppm/year. However, there was high inter-annual variability likely due to fluctuations in net ecosystem productivity and carbon dioxide emissions (e.g. from forest fires).

To detect long-term trends in amplitude and phase of atmospheric CO_2 in inland regions like ZOTTO, long periods of measurements are necessary to improve the statistical significance of the observations.

ACKNOWLEDGMENTS

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Thank you for your attention!