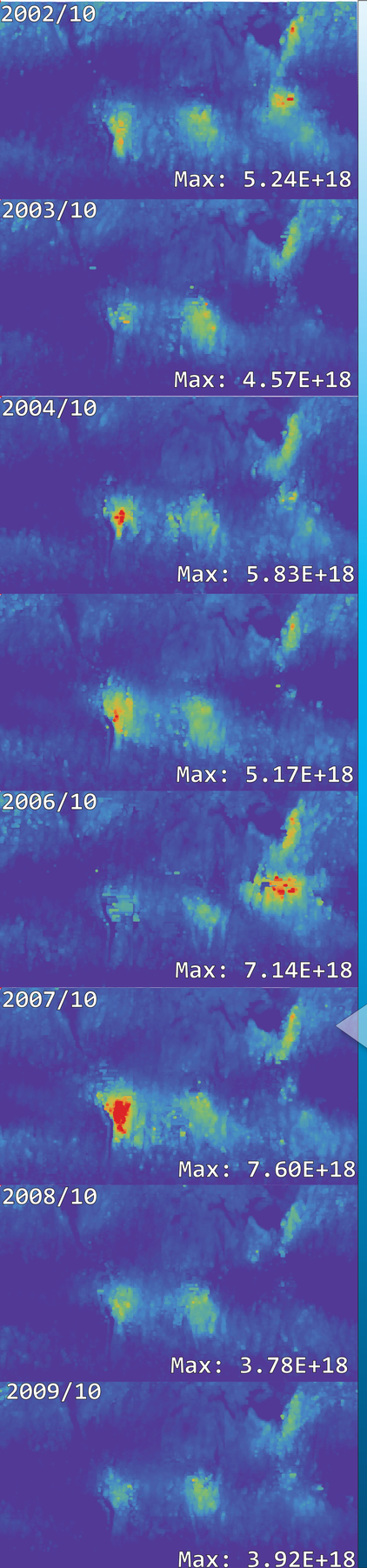

Satellite Evidence of Decreased Carbon-Monoxide Production in Brazil: 2007-2009

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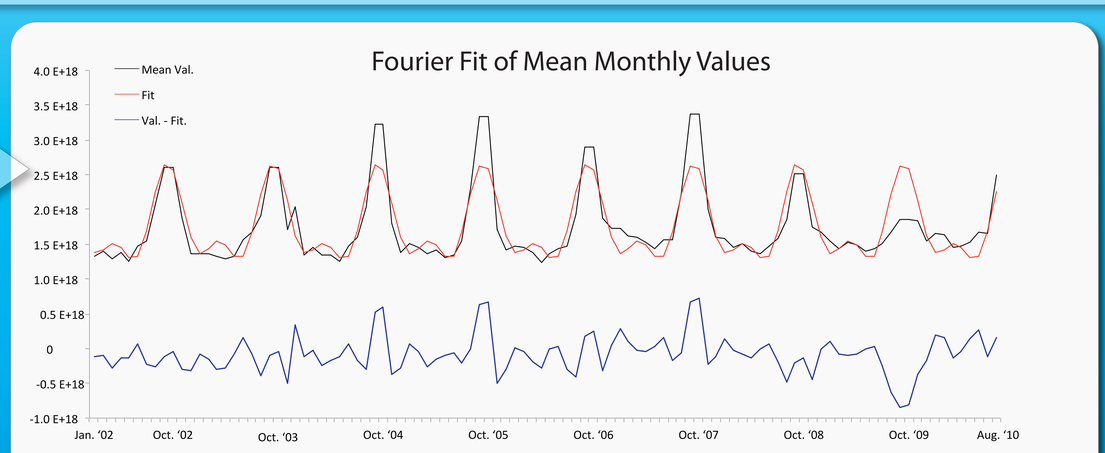
Introduction

It is well established that rising levels of greenhouse gasses, primarily CO2, are forcing climate change and contributing to rising Earth-surface temperatures. However, complex source/sink processes and natural cycling confound the precise measurement of human sources of CO2, and the long half-life of this species complicates the precise spatial and temporal identification of sources. The correlation between CO2 and other gasses was first demonstrated in 2002 [1]. Because trace atmospheric gassesshare many source/sink processes with CO2, multi-species analysis provides additional information. Further, having half life of 1.5 – 3 mo., CO lends itself to studies concerning short-term variations and specific emissions sources. Fossil fuels are often cited as a significant contributor to greenhouse gas enrichment, but scientists [1] propose that biomass burning is the only exchange process that can account for the magnitude of inter-annual variability (IAV) observed for all species. Brazil's government recently imposed regulations on rainforest-clearing, and reports that the rate of rainforest destruction has decreased. However, the strong economic motivation for farmers to clear land for agriculture, and challenges to enforcing policy in remote areas, leads skeptics to question these claims.

Fig. 1: Plotting the time series of Brazil's monthly mean values (black) reveals a sine curve reflecting seasonal variations in CO emission. To isolate a non-seasonal signal, we fit these data using a Fourier Fit containing 6 terms (red). [2] We subtract this fit from the raw values to obtain an approximation of non-seasonal signal (blue). There is a clear upward trend among seasonal peak levels through 2007. In 2008 and 2009, levels fell below the seasonal fit curve . This shift strongly suggests a change in a non-seasonal variable driving IAV in Brazil's CO levels.



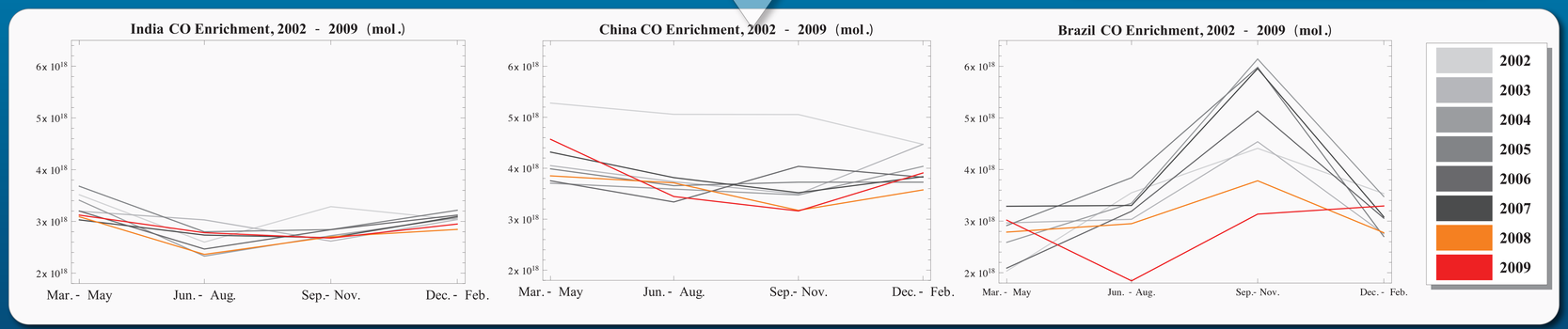
f(x)=a0+a1*cos(x*w)+b1*sin(x*w)+a2*cos(2*x*w)+b2*sin(2*x*w)+ a3*cos(3*x*w)+b3*sin (3*x*w)+ a4*cos(4*x*w)+b4 *sin (4*x*w)

Fig. 4 Color-enhanced visualizations of CO maxima values across the global grid. IAV were most pronounced in Aug.-Sep. Oct. High- and low-pass filters were applied to enhance color contrast in the range of interest, namely high CO values.

With the exception of 2006, Brazil produced the global maximum value each year through 2007. The year 2006 appeared to be an outlier, having CO values much lower than the trend established among adjacent years. We did not attribute this outlying value to a specific cause, but consider the possibility that trace gas enrichment from 2006 peat fires in Malaysia may convolute CO observations.

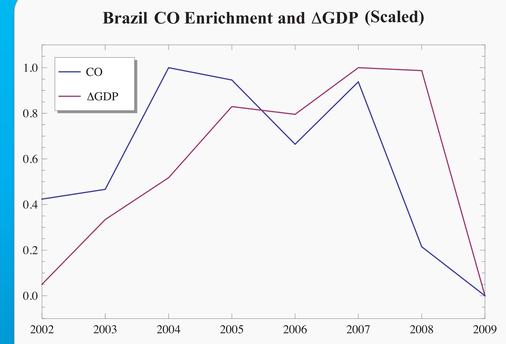
Fig. 2: comparison between seasonal maxima in Brazil to those in India and China. Brazil's seasonal maxima trend strongly upward through 2007, dropping sharply in '08 and '09. The relatively small IAV observed for China and India establishes Brazil's CO profile as region-specific, eliminating the possibility that the observed IAV results from a global process or phenomenon. It is noteworthy that Brazil's levels exceed China's in all but these most recent two years. This is consistent with theory that biomass burning is a key contributor to IAV among trace gas species [1]. (The only other sources common to all species are fossil fuels and oceans, both of which lack magnitudes sufficient to explain the observed flux in some species.)

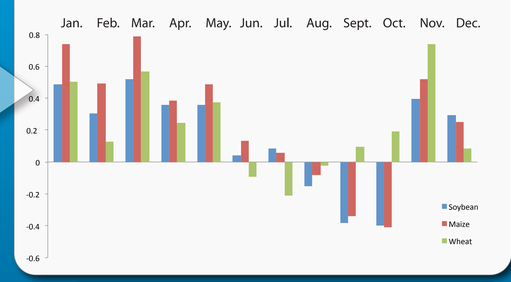
Fig. 3: (Above) Comparison of the GDP growth with annual CO maxima. The rate of GDP growth appears to correlate with CO production, lagging by one year. The short timescale of our observations limits the statistical significance of correlation. (Below) Correlation between CO levels and prices of agricultural commodities soybean, maize, and wheat. The correlation was weak, and reversed sign in August - October. As these months also correspond to seasonal maxima, we believe correlations are dominated by seasonal variation rather than an underlying economic cause(commodity prices from MundiIndex.com as of 11/12/10).



Conclusion

Analysis of NASA MOPITT data revealed a clear drop in Brazil's CO emissions in 2008 and 2009. Our findings agree with previous research implicating biomass burning as the most significant source of IAV in trace gasses [1]. If this theory is correct, and deforestation through biomass burning is the primary source of IAV in Brazil's CO levels, our results provide evidence that rainforest destruction in Brazil may have slowed in recent years.
It remains to be established whether this decline is simply the short-term result of recent economic phenomena, such as the 2007 economic recession and reduced commodity prices, or the beginning of a measurable, long-term trend arising from Brazil's improvements in environmental policy.





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