# Uncertainties in Preliminary Estimates of $CO_2$ and $CH_4$ Trends

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## Introduction

- Trends in globally averaged and Mauna Loa $CO_2$ are updated on the NOAA/GMD website monthly.
- The trends website is viewed ~35,000 times per month.
- Monthly means, annual means, and annual increases are available.
- For more information, visit: http://www.esrl.noaa.gov/gmd/ccgg/trends/
- $CH_4$ trends page is in development.
- In this presentation we've looked at two methods for calculating globally averaged $CO_2$ trends.

## Conclusions

- **NOAA/GMD's trends website is a popular way for the public and scientists to track the latest trends in $CO_2$.**
- **There can be significant biases in early, preliminary estimates of the parameters presented.**
  - **$CO_2$ bias: monthly mean = up to 0.9 ppm, annual increase = ±0.4 ppm**
  - **$CH_4$ bias: monthly mean = up to 7.6 ppb, annual increase = ±3 ppb**
- **Curve fitting end effects are a large contribution to potential bias.**
- **Changes to network distribution can have significant impacts on estimates for up to two years.**
- **Two trend methods were tested; neither has a clear advantage over the other.**

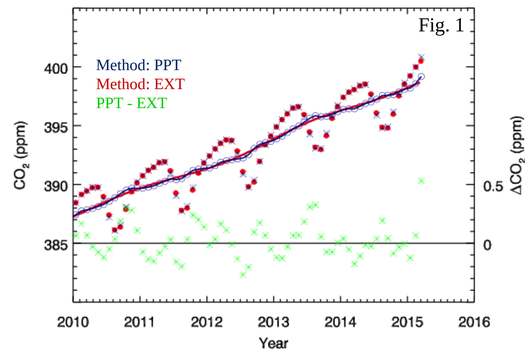
## Trend Methods

### Extension Method (EXT)

- This method will be used for the $CH_4$ trends website.
- Starts with standard weekly global averages.
- Calculates monthly means using only those values that fall within the month (Fig. 1, red symbols).
- De-seasonalized trend is similar to 12-month running mean (red trend line).
- Annual increase calculated from de-seasonalized trend as:
  Jan 1 (year) - Jan 1 (year-1).
- This is the method used to smooth discreet air samples to calculate weekly zonal averages.

### Alternate Method (PPT)

- This method is used for the $CO_2$ trends website.
- Starts with standard weekly global averages.
- Calculates monthly means using a 5-value weighted average that overlaps with previous and following months (blue symbols).
- De-seasonalized trend curve determined by subtracting 7 adjacent seasonal cycles centered on the month to be corrected (blue trend line). This result is less-smoothed than with EXT.
- Larger IAV than EXT in the de-seasonalized trend.
- Annual increase calculated from monthly means as:
  (Dec (yr)+Jan(yr+1))/2 - (Dec (yr-1)+Jan(yr))/2

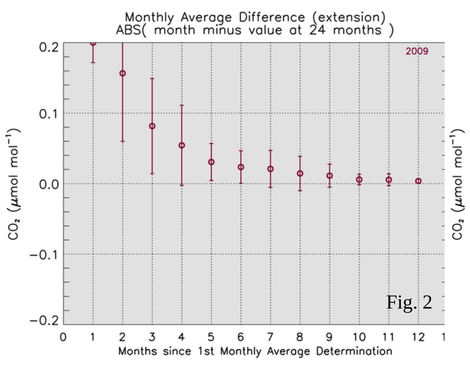


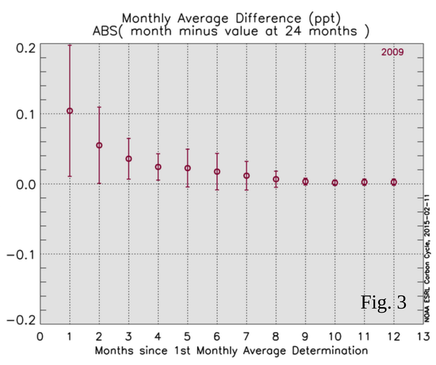

Comparison of EXT and PPT methods. Difference between the two trend methods is shown in green, RH scale.

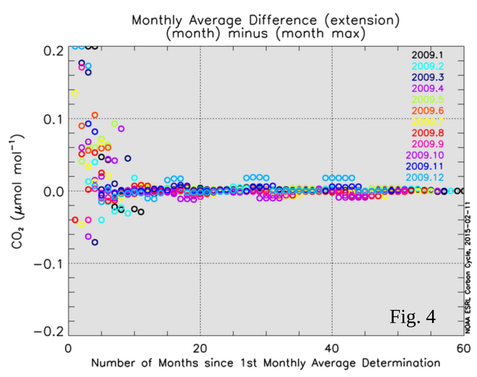
## Results and Discussion

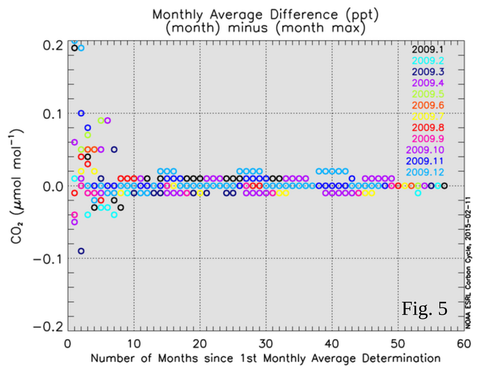
### Global Monthly Means

- Monthly means are updated on the ~5th of each month with a lag of two months (e.g., May 5th update adds March mean).
- Monthly means can change considerably after first calculation (e.g., March mean will change when recalculated on June 5th)..
- Figures 2 (EXT) and 3 (PPT) show the average difference between each updated estimate and the monthly mean estimated at 24 months for $CO_2$.
- Actual changes (Figs. 4 and 5) for any month can vary significantly from average changes.
- Despite that both methods start from the same weekly global averages, there are significant differences in their performance.



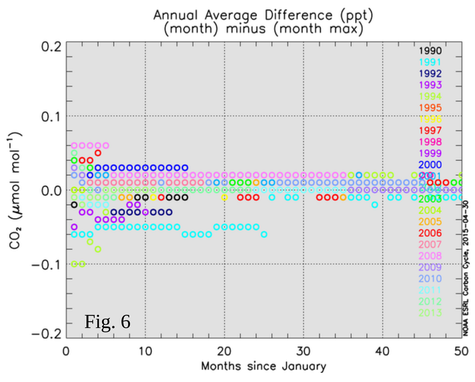



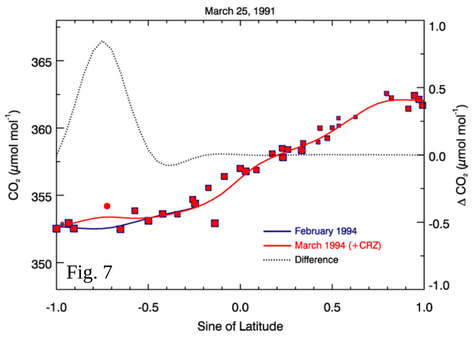




### Global Annual Means

- Annual means typically change little after the first estimate.
- Methods show similar results and are similarly influenced by network distribution.
- Changes in the network distribution can affect annual means as shown in Figure 6.
- $CO_2$ annual mean changed by 0.06 ppm after 2 years in 1991 (cyan).
- A new site is only added to the calculation of global averages after two years of samples are analyzed.
- The above condition was satisfied in March 1994. Figure 7 shows the latitude gradient for February and March 1994. Between these calculations, CRZ was added. Difference is plotted as black dotted line.




### Global Annual Increase

- There is considerable public interest in preliminary estimates of global annual increase which can have significant bias.
- Figure 8 realistically represents changes in annual increase as reported on the trends webpage. It includes "network" and curve fit end effects.
- Initial estimate of annual increase can be biased by "true" value (i.e., that made after multiple years) by ±0.5 ppm.
- Figure 9 excludes "network" effects by using all data available through February, 2015. Bias is slightly reduced to ±0.4 ppm suggesting end effects are a major contribution to bias.
- Figure 10 illustrates how adding successive months of data to the analysis affects the end point in a given year while the beginning of that year is unaffected.