Global Monitoring: Trends and Distributions of $\text{CO}_2$ and $\text{CH}_4$

NOAA ESRL Carbon Cycle Group

ESRL Atmospheric Chemistry Review
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Scientific Motivation

• Determine budgets
  – Sources and sinks of CO$_2$ and CH$_4$ at large to regional spatial scales

Approach

• Accurately, precisely measure spatial, temporal distributions of CO$_2$ and CH$_4$
  – Resolve small spatial gradients
  – Measure trends
  – Obtain meaningful derivatives
Measurement Programs
NOAA ESRL Carbon Cycle

[Map showing measurement programs around the world with various symbols representing different types of sites and routes.]
Components of Cooperative Air Sampling and Measurement Network

- Flask prep
- Check out
- Personal contacts
- Logistics
- Check in

Sample Collection

- Standards
- Analytical
  - ~21,300 flasks (2007)
- Testing and Development

QA/QC

Products
Components of Cooperative Air Sampling and Measurement Network

- Flask prep
- Personal contacts
- Logistics
- Standardization
- Analytical testing and development

Comparisons

Test air components of Cooperative Air Sampling and Measurement Network.
Components of Cooperative Air Sampling and Measurement Network

- Flask prep
- Personal contacts
- Logistics
- Standards
- Check in
- Check out
- Sample Collection

Components of Cooperative Air Sampling and Measurement Network
Components of Cooperative Air Sampling and Measurement Network

- Flask prep
- Personal contacts
- Logistics

The Collection
- Analytical flasks (2007)
- Comparisons
- QA/QC
- Test air

Products

Graph showing residuals vs. LGR, CH₄ (nmol mol⁻¹)
Components of Cooperative Air Sampling and Measurement Network

Sample Collection

- Flask prep
- Personal contacts
- Logistics
- Check in
- Check out

~21,300 flasks (2007)

Comparisons

QA/QC

Test air

Products

Standards

Testing and Development
Trend = 2.0 ppm yr\(^{-1}\)

Trend = -0.03‰ yr\(^{-1}\)
(INSTAAR)

Trend = 1.8 ppb yr\(^{-1}\)

Trend = -1.1 ppb yr\(^{-1}\)

Trend = 0.7 ppb yr\(^{-1}\)

Trend = 0.2 ppt yr\(^{-1}\)
Le Quéré et al.  
SCIENCE, 316, 2007: S. Ocean CO$_2$ sink decreased by 0.03 Pg C yr$^{-1}$ decade$^{-1}$ from 1981-2004.

http://www.esrl.noaa.gov/gmd/ccgg/globalview/
Globally Averaged CH$_4$

Little increase since 1999.

Initially, looked like approach to steady state.

Growth rate continues to decrease.

Will this continue?
Interpolar difference

![Graph showing the difference between PNH and PSH over years from 1985 to 2005. The graph includes data points for observations and model predictions, with error bars. The data is updated from Dlugokencky et al., Geophys. Res. Lett., 30 (19), 1992, doi:10.1029/2003GL018126, 2003.]
Fiore et al., GRL, 33, 2006: Suggests significant impact of climate change (T and lightning) on CH$_4$ trend.
Scientific Payoff

• NOAA ESRL program forms core of WMO GAW and GEOSS GHG networks
  – Data used in GHG budget studies

• Sufficient coverage to establish surface boundary conditions and large scale budgets
  – Verify satellite retrievals
Future of Network

• **Enhance background network**
  – Increase sampling from ships (Atlantic, S. Ocean)
  – Improve existing methods

• **Detect changes in Arctic CH$_4$ emissions**
  – CH$_4$, CO$_2$ measurements planned for Siberia
  – New flask site in La Biche, Alberta (isotopes)
  – Discussions with USGS for Yukon Basin

• **Verify North American CH$_4$ emissions**
  – Add CH$_4$ measurements to tall towers