Gateway Pages to Large Data Sets for Atmospheric Trace Species

T.J. Blasing

Carbon Dioxide Information Analysis Center

“Information” is our middle name

Presented at the NOAA, GMD, ESRL, GMAC, May, 21, 2013
Global Change Master Directory (GCMD) - Earth Science data

gcmd.gsfc.nasa.gov/records/GCMD_CDIAC_CO2_CMDL.html

gcmd.nasa.gov/records/GCMD_CDIAC_CO2_SIO.html

CEOS International Directory Network Portals

Atmospheric Carbon Isotope (C-13) Concentrations from the CSIRO GASLAB Flask Sampling Network, in CDIAC Online Trends

Entry ID: CDIAC_TRENDS_C13_CSIRO_GASLAB
Obtaining and organizing atmospheric chemistry data from several institutions.
Present data sets to the public, along with some explanation of how the data were obtained and comments about trends.

"First, they do an on-line search."
Objectives:

Understandable to:

Statistician

Statistician’s teenage children

Anyone with at least as much scientific training as either of the above.

*Thanks to Greg Evans
GATEWAY PAGES -- Objectives:
Comprehensive coverage of “greenhouse” gases in:

Institutions (e.g., NOAA, CSIRO, AGAGE, SCRIPPS)
http://cdiac.ornl.gov/home.html

About CDIAC  Data  Observing Programs  Resources  News

Select one of these Data Focus Areas to find data of interest, use the CDIAC Data Search or Submit Ocean Data

- Fossil-Fuel CO₂ Emissions
- Trace Gas Emissions
- Atmospheric Trace Gases
- Oceanic Trace Gases
- Carbon Cycle
- Terrestrial Carbon Management
- Vegetation Response to CO₂ & Climate
- Climate
- Land Use & Ecosystems
Atmospheric Measurements of Climate-Relevant Species

CDIAC's data collection includes measurements of the following climate-relevant chemical species. A summary of recent greenhouse gas concentrations is also available. To determine how compounds are named, see the CDIAC “Name that compound” page.

**Butane** (C\(_4\)H\(_{10}\))
**Carbon Dioxide** (CO\(_2\))
**Carbon Isotopes**
**Carbon Monoxide** (CO)
**Carbon Tetrachloride** (CCl\(_4\))
**Chlorofluorocarbons**

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**Methane** (CH\(_4\))

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**Sulfur Hexafluoride** (SF\(_6\))
**Tetrachloroethane** (C\(_2\)Cl\(_4\))
**Trifluoromethyl Sulfur Pentafluoride** (SF\(_5\)CF\(_3\))

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**Recent Greenhouse Gas Concentrations**

T. J. Blasing
DOI: 10.3334/CDIAC/AG037
Updated February 2012

Gases typically measured in parts per million (ppm), parts per billion (ppb) or parts per trillion (ppt) by volume are presented separately to facilitate comparison of numbers. Global Warming Potentials (GWP\(_s\)) and atmospheric lifetimes are from the Intergovernmental Panel on Climate Change (IPCC, 2007, Table 2.14), except for the atmospheric lifetime of carbon dioxide (CO\(_2\)), which is explained in footnote 4. Additional material on greenhouse gases can be found in CDIAC's Reference Tools. To find out how CH\(_4\), HCFC, HFC, and CIRs are named, see Name that compound: The numbers game for CH\(_4\), HCFC, HFCs, and CIRs. Concentrations given apply to the lower 75-80 percent of the atmosphere, known as the troposphere.

Sources of the current concentrations are given in the footnotes. The concentrations given are mostly derived from data available via the CDIAC website. These data are contributed to CDIAC by various investigators, and represent considerable effort on their part. We ask as a basic professional courtesy that you acknowledge the primary sources when you refer to data from any of these sites. Guidelines for proper acknowledgment are found at each site, except for the ALL/GGAP/AGAC database where acknowledgment guidelines are given in the "readme" files; links to those "readme" files are given in footnote 9, below. Concentrations of ozone and water vapor are spatially and temporally variable due to their short atmospheric lifetimes. A vertically and horizontally averaged water vapor concentration is about 5,000 ppm. Column-averaged water vapor concentration is difficult to measure precisely because it varies from one place to another and from one season to the next. This precludes a precise determination of changes in water vapor since pre-industrial time. However, a warmer atmosphere will likely contain more water vapor than at present. For a somewhat more detailed statement on water vapor from the National Oceanic and Atmospheric Administration, see http://www.ncdc.noaa.gov/oa/climate/gases.html

### Table: Concentrations of Some Gases

<table>
<thead>
<tr>
<th>Gas</th>
<th>Pre-1750 tropospheric concentration(^1)</th>
<th>Recent tropospheric concentration(^2)</th>
<th>GWP(^3) (100-yr time horizon)</th>
<th>Atmospheric lifetime(^4) (years)</th>
<th>Increased radiative forcing(^5) (W/m(^2))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide (CO(_2))</td>
<td>397 ± 6(^6)</td>
<td>397 ± 6(^6)</td>
<td>1</td>
<td>~ 100</td>
<td>1.85</td>
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<tr>
<td>Methane (CH(_4))</td>
<td>1774/1778</td>
<td>1774/1778</td>
<td>75</td>
<td>12(^7)</td>
<td>0.51</td>
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<tr>
<td>Nitrous oxide (N(_2)O)</td>
<td>324/328</td>
<td>324/328</td>
<td>290</td>
<td>114(^8)</td>
<td>0.18</td>
</tr>
<tr>
<td>Tropospheric ozone (O(_3))</td>
<td>25</td>
<td>34(^9)</td>
<td>n.a.</td>
<td>hours days</td>
<td>0.35(^5)</td>
</tr>
</tbody>
</table>

\(^1\) Pre-1750 tropospheric concentration, unless otherwise noted.
\(^2\) Recent tropospheric concentration.
\(^3\) GWP = Global Warming Potential.
\(^4\) Atmospheric lifetime = Time required for a gas to reduce to 1/e of its initial concentration.

**Concentrations of Other Gases**

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**Other Halocarbons**

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**Mace Head, Ireland (Northern Hemisphere)**  
**Cape Grim, Tasmania (Southern Hemisphere)**  
2011 average
Methane (CH4)

Gateway Pages to Methane Data
Modern Records of Atmospheric Methane (CH₄) and a 2000-year Ice-core Record from Law Dome, Antarctica
800,000-year Ice-Core Records of Atmospheric Methane (CH₄)

Continuous Measurements
Advanced Global Atmospheric Gases Experiment (AGAGE, Prinn et al.)
Cape Meares, Oregon (Khalil & Rasmussen)

Flask Measurements
Methane, Nonmethane Hydrocarbons, Alkyl Nitrates, and Chlorinated Carbon Compounds including 3
Chlorofluorocarbons (CFC-11, CFC-12, and CFC-113) in Whole-air Samples (Blake)
CSIRO GASLAB Network (Steele et al.)
   GASLAB Flask Sampling Network Data (overview)
Measurements from Niwot Ridge, Colorado and Montana de Oro, California (Tyler)
Northern and Southern Hemisphere Sites (Quay & Stutsman)
Northern & Southern Hemisphere Sites (Stevens)

Other Relevant Links ...
Halons

Halon-1211 (CF$_2$ClBr)

Advanced Global Atmospheric Gases Experiment (AGAGE, Prinn et al.)

Methane, Nonmethane Hydrocarbons, Alkyl Nitrates, and Chlorinated Carbon Compounds including 3 Chlorofluorocarbons (CFC-11, CFC-12 and CFC-113) in Whole-air Samples (Blake)

HATS–Halocarbons and other Atmospheric Trace Species Group (Elkins et al.)

Halon-1301 (CF$_3$Br)

Advanced Global Atmospheric Gases Experiment (AGAGE, Prinn et al.)

HATS–Halocarbons and other Atmospheric Trace Species Group (Elkins et al.)

Halon-2402 (C$_2$F$_4$Br$_2$)

HATS–Halocarbons and other Atmospheric Trace Species Group (Elkins et al.)
Modern Records of Atmospheric Carbon Dioxide (CO₂) and a 2000-year Ice-core Record from Law Dome, Antarctica

800,000-year Ice-Core Records of Atmospheric Carbon Dioxide (CO₂)

Modern Records of Atmospheric Methane (CH₄) and a 2000-year Ice-core Record from Law Dome, Antarctica

800,000-year Ice-Core Records of Atmospheric Methane (CH₄)

Modern Records of Atmospheric Nitrous Oxide (N₂O) and a 2000-year Ice-core Record from Law Dome, Antarctica

800,000 Year Ice-Core Records of Atmospheric Nitrous Oxide (N₂O)

Modern Records of Radiatively Important Halogenated Compounds in the Atmosphere
Modern Records of Atmospheric Methane (CH$_4$) and a 2000-year Ice-core Record from Law Dome, Antarctica

800,000-year Ice-Core Records of Atmospheric Methane (CH$_4$)

Introduction
This page provides an introduction and links to records of atmospheric methane (CH$_4$) concentrations over the last 2000 years, emphasizing large data bases each representing currently active stations..... The longer (2000-year) record is from the Law Dome ice core in Antarctica. The ice-core record has been merged with modern annual data from Cape Grim, Tasmania to provide a 2000-year record. A spline function has been fit to the data to provide a continuous time series of annual values. Longer-term records from Antarctic ice cores, back to 800,000 years before present, are available at (LINK)

These data have graciously been made freely available for access and distribution; the original investigators made the effort to obtain the data and assure their quality. Ice-core data are maintained by the World Data Center for Paleoclimatology, National Oceanic and Atmospheric Administration. To assure proper credit is given, please follow the instructions in the headers of the data files, in readme files, and/or at the end of this page when using any of this material. If data accessed from this site are to be used in a publication we strongly recommend some contact with the principal investigators at an early stage of the work to be sure the data are being interpreted and used correctly (NOAA insists on this; see instructions at the top of the header files). Neither the principal investigators nor CDIAC is responsible for misuse of these data.
Contributors:
The following organizations have current data from multiple sites.
(1) The Commonwealth Scientific and Industrial Research Organization (CSIRO) of Australia, particularly David Etheridge who suggested the Law Dome data be included, and who provided it.
(2) The Global Monitoring Division, Earth System Research Laboratory, National Oceanic and Atmospheric Administration (NOAA)
(3) CDIAC maintains records for additional individual locations covering limited time periods.

Period of Record: 13 C.E. - current
Graphics for organizations with current data from multiple sites can be found at:

NOAA  http://www.esrl.noaa.gov/gmd/gyd/idev/  This link gets to the visualization page for all gases, move mouse over any point on the map to get its 3-letter station code (e.g. SPO is the South Pole).

- Select Measurement Program and Plot Type
  - Carbon Cycle Gases
  - Halocarbons and Trace Gases
  - Ozone
  - Atmospheric Transport
  - Meteorology
Graphics for organizations with current data from multiple sites can be found at: 
Immediately below the graph on the left hand side you will find a selection bar, select carbon dioxide.

Research

Key greenhouse and ozone depleting gases

These graphs show changing atmospheric concentrations of key ozone depleting gases, greenhouse gases and related species, as measured at the Cape Grim Baseline Air Pollution Station in north-western Tasmania. The Cape Grim program, to monitor and study global atmospheric composition, is a joint responsibility of the Bureau of Meteorology and CSIRO. To view a large version of the graph, click on the thumbnail.
800,000 years of methane concentrations as shown in CDIAC Gateway Pages

We make our own graphics too.

Cf. IPCC AR4 (2007)
2. USE OF DATA These data are made freely available to the public and the scientific community in the belief that their wide dissemination will lead to greater understanding and new scientific insights. The availability of these data does not constitute publication of the data. NOAA relies on the ethics and integrity of the user to assure that ESRL receives fair credit for their work. **If the data are obtained for potential use in a publication or presentation, ESRL should be informed at the outset of the nature of this work. If the ESRL data are essential to the work, or if an important result or conclusion depends on the ESRL data, co-authorship may be appropriate.** This should be discussed at an early stage in the work. Manuscripts using the ESRL data should be sent to ESRL for review before they are submitted for publication so we can insure that the quality and limitations of the data are accurately represented.
NOAA [http://www.esrl.noaa.gov/gmd/dv/data/](http://www.esrl.noaa.gov/gmd/dv/data/) select carbon dioxide in the second column of the selection chart and select stations of interest. Information about station codes is at: [http://www.esrl.noaa.gov/gmd/dv/site/site_table2.html](http://www.esrl.noaa.gov/gmd/dv/site/site_table2.html)

<table>
<thead>
<tr>
<th>Greenhouse Gases (358)</th>
<th>Carbon Dioxide (358)</th>
<th>Flask (188)</th>
<th>Hourly Averages (153)</th>
<th>ABP (2)</th>
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<tr>
<td></td>
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<td>Insitu (1)</td>
<td>Dense (107)</td>
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<td>Insitu Tower (9)</td>
<td>Monthly Averages (94)</td>
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<td>Daily Averages (4)</td>
<td>MLO (42)</td>
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<td>ZEP (2)</td>
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# comment: ************ DATA DESCRIPTION ************

# comment:

# description_site-code: mlo
# description_project-abbr: ccg_surface # description_strategy-abbr: flask

# comment:

# comment: ************ DATA DOCUMENTATION ************

# comment:

# comment: Please refer to the species-specific README file in the

# comment:

# data_fields: site year month value

MLO 1969 8 322.93
MLO 1969 9 321.36
MLO 1969 10 320.71
MLO 1969 11 322.00
MLO 1969 12 323.77
MLO 1970 1 325.13
MLO 1970 2 325.54
MLO 1970 3 325.68
MLO 1970 4 326.58
MLO 1970 5 327.68
MLO 1970 6 327.30
MLO 1970 7 326.13
MLO 1970 8 324.91
MLO 1970 9 322.98
MLO 1970 10 322.61
MLO 1970 11 323.97
MLO 1970 12 325.46
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<th>Country</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Elevation (Meters)</th>
<th>Time from GMT</th>
<th>Projects</th>
</tr>
</thead>
</table>
| AAO  | Airborne Aerosol Observing, Bondville, Illinois | United States | 40.050   | -88.370   | 230.0              | 6 hours ahead | » Ozone Airborne *  
                » Carbon Cycle Airborne Flasks *  
                » Aerosol Airborne, Light Aircraft |
| ABQ  | Albuquerque New Mexico      | United States | 35.040   | -106.620  | 1617.0             | 7 hours behind| » Integrated Surface Irradiance Study |
| ALT  | Alert, Nunavut              | Canada      | 82.451   | -62.506   | 200.0              | 4 hours behind| » Aerosol Surface In-Situ  
                » Carbon Cycle Surface Flasks  
                » HATS Flask Sampling  
                » Baseline Surface Radiation Network  
                » Trajectories |
1. DATA SOURCE AND CONTACTS

National Oceanic and Atmospheric Administration (NOAA)
Earth System Research Laboratory (ESRL)
Global Monitoring Division (GMD)
Carbon Cycle Greenhouse Gases (CCGG)

Correspondence concerning these data should be directed to:

Pieter P. Tans and Thomas J. Conway
NOAA ESRL Global Monitoring Division
325 Broadway, GMD-1
Boulder, CO 80305
U.S.A.

email: Pieter.Tans@noaa.gov T
Thomas.J.Conway@noaa.gov
We recommend the detailed and readable account of the air sampling, preparation, measurement process, and calibration scales given by NOAA: http://www.esrl.noaa.gov/gmd/ccgg/about/co2_measurements.html

About CO2 Measurements

How we measure background CO2 levels on Mauna Loa.

Pieter Tans and Kirk Thoning, NOAA Earth System Research Laboratory, Boulder, Colorado
September, 2008

Topics

• Summary
• Infrared absorption.
• Mole fraction in dry air
• Calibration of the instrument.
• Target gas.
• Data selection for background air
• Auxiliary measured variables
• How we calibrate reference gases.
• Replication of the field measurements
• Observed variations of CO2 in the atmosphere.
• Further reading
Why --- So, What!

“We cannot effectively plan for and manage what we do not measure.”

Trends

The merged, 2000-year record indicates that atmospheric CO₂ levels have substantially increased beyond their preindustrial values which fluctuated around 280 parts per million (ppm) for most of the period, with a slight dip from around 1600 to 1800 C.E. The Intergovernmental Panel on Climate Change defined preindustrial concentrations as those prior to 1750. Since then, atmospheric CO₂ concentrations have risen from around 277 ppm (IPCC, 2007) in 1750 to a global average of around 388 ppm in 2010 (386 ppm at Cape Grim and the South Pole; Southern Hemisphere concentrations tend to lag Northern Hemisphere values).

For more recent concentrations of radiatively active (greenhouse) gases in the atmosphere, go to Recent Greenhouse Gas Concentrations

Atmospheric methane began its modern upswing around 1800, 50-100 years before carbon dioxide or nitrous oxide did. This is possibly due to an expanding agriculture. Focusing on the last few decades, atmospheric methane was steadily increasing before leveling off temporarily during the first few years of the 21st Century. It began to increase again around 2007.

Northern Hemisphere amounts change before those in the Southern Hemisphere, suggesting the Northern Hemisphere is the net source of the overall increase. However, locations of sources and sinks and the nature of the processes involved, preclude any simple explanations. Natural sources of methane include wetlands and microorganisms in the digestive systems of animals. Recent methane increases also arise from mining, fossil-fuel extraction and processing, and from landfills as well as from expansion and intensification of agriculture. The major atmospheric sink is removal by the hydroxyl radical.
References:


Citation instructions:

CITING THE MODERN CO$_2$ DATA:

**CSIRO:** CSIRO requests that use of these data in any paper or presentation be accompanied by acknowledgement of the source of the data (CSIRO Marine and Atmospheric Research GASLAB) and that the version of the data (as specified by release date) be explicitly stated. For additional references to cite, please consult the readme file (pdf or doc) for CO2 in the list of files found at [CSIRO_gaslab_data_Aug2011.zip](http://cdiac.ornl.gov/)

**NOAA:** Citations to NOAA personnel are given in the “readme” files for each species. [ftp://ftp.cmdl.noaa.gov/ccg](ftp://ftp.cmdl.noaa.gov/ccg)

**SCRIPPS:** Scripps requests citing one of the references listed at [http://scrippsco2.ucsd.edu/data/atmospheric_co2.html](http://scrippsco2.ucsd.edu/data/atmospheric_co2.html): (scroll to bottom of page.) We also suggest the reference given at the top of each data page, for example: R. F. Keeling, S. C. Piper, A. F. Bollenbacher and S. J. Walker, Scripps CO2 Program, Scripps Institution of Oceanography, University of California, La Jolla, California USA 92093-0244.
Citation instructions -- continued:

LAW DOME ICE-CORE DATA

These records are maintained by the World Data Center for Paleoclimatology at the National Oceanic and Atmospheric Administration (NOAA). Please cite as:

We recommend also citing: MacFarling-Meure, et al. 2006 and, Etheridge 1996 from the references above.

If accessing the data from this site: please also cite: Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy.

If citing material from this page only, cite as: Modern Records of Atmospheric Carbon Dioxide (CO2) and a 2000-year Ice-core Record from Law Dome, Antarctica, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy. Path: LINK to THIS SITE
Halocarbons & other Atmospheric Trace Species Group (HATS)

The general mission of the Halocarbons and other Atmospheric Trace Species group is to quantify the distributions and magnitudes of sources and sinks for atmospheric nitrous oxide (N2O) and halogen containing compounds. HATS utilizes numerous types of platforms, including ground-based stations, towers, ocean vessels, aircraft, and balloons, to accomplish its mission. For a detailed mission statement consult our FAQ.

You can also read about CFCs and their substitutes in stratospheric ozone.
FTP directory /hats/ at ftp.cmdl.noaa.gov

To view this FTP site in Windows Explorer, click Page, and then click Open FTP Site in Windows Explorer.

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<th>Up to higher level directory</th>
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<td>06/09/2010 12:00AM 6,148 DS Store</td>
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<td>10/01/2012 07:48PM Directory INX</td>
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<td>04/11/2012 12:00AM Directory Total Cl Br</td>
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<td>02/19/2009 12:00AM Directory halons</td>
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<table>
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<td>02/19/2009 12:00AM Directory ..</td>
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<td><a href="http://cdiac.ornl.gov/home.html">http://cdiac.ornl.gov/home.html</a></td>
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file: brw_H1211_MM.dat

Halon-1211 (H1211) data from hourly in situ samples analyzed on a gas chromatograph located at Pt. Barrow (BRW), Alaska (71.3 N, 156.6 W, elevation: 8 m).
<table>
<thead>
<tr>
<th>HATS Information</th>
<th>N2O</th>
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### Chromatograph for Atmospheric Trace Species

**halon-1211 Mixing Ratio**

**Links to data files:** Hourly, Daily, Monthly, Global

**Barrow, Alaska**

- 11/02/2012 07:23PM: 9,401
- 11/02/2012 07:24PM: 9,408
- 11/02/2012 07:25PM: 9,414
- 11/02/2012 07:26PM: 9,417
- 11/02/2012 07:25PM: 9,414

Next to Barrow, Alaska:

- brw_H1211_MM.dat
- mlo_H1211_MM.dat
- nwr_H1211_MM.dat
- smo_H1211_MM.dat
- spo_H1211_MM.dat
- sum_H1211_MM.dat
Understandable to:

- Statistician?
- Statistician’s teenage children ??

Anyone with at least as much scientific training as either of the above.

cryogenic trap
colder than a lawyer’s heart -- removes
water-vapor interference

SMOW ?? Standard Mean Ocean Water

V-SMOW ?? Vienna Standard Ocean Water

V-PDB ?? Vienna PeeDee Belemnite

A Faraday Cup is device for measuring the current in a beam of charged particles.
Methods

Modern Data

**Gas chromatography (GC)** is used to separate the species of interest. A sample is injected ... the combined gases then move through an "obstacle course" ... exiting molecules are sorted according to size and solubility.

**Electron Capture (EC)** When compounds of a particular species having an enhanced affinity for electrons emerge from the gas chromatograph they enter an electron capture detector ... the reduction in current is a measure of the amount of chemical present. A discussion of how gas chromatography is used .... can be found here.

**Mass spectrometry (MS)** Molecules emerging from chromatographic sorting ..... A nontechnical introduction to mass spectrometry may be found here.

Calibration is accomplished by periodically injecting gas mixtures containing known quantities of the chemicals of interest and measuring their signals.

Information on calibration scales may be found at the following links:

**AGAGE:** [http://agage.eas.gatech.edu/data_archive/agage/gc-md/readme.scale](http://agage.eas.gatech.edu/data_archive/agage/gc-md/readme.scale)

**NOAA:** [http://www.esrl.noaa.gov/gmd/ccl/summary_table.html](http://www.esrl.noaa.gov/gmd/ccl/summary_table.html)

More detailed NOAA calibration information: [http://www.esrl.noaa.gov/gmd/ccl/](http://www.esrl.noaa.gov/gmd/ccl/)
**Electron Capture**

Electron

**Flame Ionization**

**Accelerator Mass Spectrometry**

Please spare an electron

Halogen
Why is Climate Information Lost in Very Deep Ice?

The stratigraphic record from the GISP2 and GRIP ice cores agree for most of the ice depth, indicating that the variations are indeed related to climate. However, isolated small folds can be seen below about 2400 m depth, and the records appear to become uncorrelated below about 2800 m depth. Because of irregular bedrock topography, inhomogeneities in the ice, and changes in ice flow direction, layers in the ice can be overturned and disrupted by ice flow.

Ice dynamics models are needed to predict areas and conditions of likely disruption for future ice cores. This figure shows where perturbed layers are likely to become overturned and where they are likely to be flattened. Disruptions that are larger than the ice core diameter may be detected by geophysical tools such as radar remote sensing and/or borehole sonic measurements.