An Integrated Global Atmospheric Chemistry Observations Strategy & WMOs Leading Role: GAW & IGACO

Leonard Barrie
Chief, Environment Division, WMO
Lbarrie@wmo.int

Search Engine “GAW” →
www.wmo.ch/web/arep/gaw/gaw_home.html
GAW: What is it?

- The Global Atmosphere Watch programme of WMO
- *Established* in 1989 by merging the Global Ozone Observing System (GO3OS) and Background Monitoring of Air Pollution (BAPMoN) programmes
- *Coordinated* by the Environment Division of WMO’s Atmospheric Research and Environment Programme (AREP) department under the Commission for Atmospheric Science (CAS) and its Working Group on Environmental Pollution and Atmospheric Chemistry.
The GAW Mission

- **Systematic Global Monitoring** Of Chemical Composition of the Atmosphere.
- **Analysis and Assessment** in Support of *International Conventions*.
- **Development Of Air Pollution and Climate Predictive Capability**
Motivation

- **Improved Weather Forecasting**: By Including Aerosols, Ozone and Reactive Gas Observations
- **Air Pollution** Forecasting, Health Effects, Long Range Transport and Deposition Effects
- **Climate**, Climate Change and Climate Prediction
- **Oxidizing Power**: The Atmosphere As A Waste Processor. Key to Global Hg and some POPs
- **Stratospheric Ozone Depletion** and Surface UV Enhancement: Are Halocarbon controls working? Effects of UV on biosphere?
GLOBAL STATIONS IN GAW

March 2005
### Central Calibration Laboratories

{Hosts of WMO World Reference Standards}

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Host</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂, CH₄, N₂O, CO</td>
<td>NOAA CMDL USA</td>
</tr>
<tr>
<td>Total Ozone</td>
<td>NOAA CMDL USA Dobson</td>
</tr>
<tr>
<td></td>
<td>MSC, Canada Brewer</td>
</tr>
<tr>
<td></td>
<td>MGO, Russia M124</td>
</tr>
<tr>
<td>Ozone Sondes</td>
<td>FZ-Juelich, Germany</td>
</tr>
<tr>
<td>In Situ Ozone</td>
<td>NIST USA</td>
</tr>
<tr>
<td>Aerosol Optical Depth</td>
<td>WORCC, Davos, CH</td>
</tr>
</tbody>
</table>
### World or Regional Calibration Centres

{Linking Observations to World Reference Standards and Ensuring Network Comparability}

<table>
<thead>
<tr>
<th>Category</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Ozone</td>
<td>6 Regional Dobson Centres</td>
</tr>
<tr>
<td></td>
<td>1 Regional EU Brewer Centre</td>
</tr>
<tr>
<td></td>
<td>1 Brewer travelling standard</td>
</tr>
<tr>
<td>Ozone Sondes</td>
<td>FZ-Julich, Germany</td>
</tr>
<tr>
<td>In Situ O$_3$, CO, CH$_4$</td>
<td>EMPA, Switzerland</td>
</tr>
<tr>
<td>CO$_2$, CH$_4$, N$_2$O</td>
<td>NOAA CMDL USA</td>
</tr>
<tr>
<td>N$_2$O, VOC</td>
<td>IMK-IFU Garmisch Germany</td>
</tr>
<tr>
<td>Aerosol Optical Depth</td>
<td>WORCC, Davos, CH</td>
</tr>
<tr>
<td>Aerosol physical</td>
<td>IFT, Leipzig, Germany</td>
</tr>
<tr>
<td>Precip. Chemistry</td>
<td>SUNY Albany USA</td>
</tr>
</tbody>
</table>
GAW Station Information System...

GAWSIS Online - comprehensive information on all GAW stations

- Database
- Search / Update
- Inventory / Audit

(Supported by Switzerland)
Quality Assurance Linking Observations to PS

An Observational Network With Global Coverage

A World Data Archive/Analysis Centre

Oversight Advisory Groups Of Experts For All Aspects of the Network

PS Primary Standard

Variable

← → BIPM/CIPM
GAW GLOBAL TOTAL COLUMN OZONE NETWORK: 2001-2004
Stations Submitting Data

The symbols represent different instrument types.

Compliments of WOUDC, MSC, Toronto {Ed Hare Manager}. 
GAW GLOBAL OZONE SONDE NETWORK: 2001-2004
Stations Submitting Data To WOUDC

The red triangles represent sites of GAW Contributing partner NASA/SHADOZ.

Compliments of WOUDC, MSC, Toronto {Ed Hare Manager}. 
WMO Ozone Bulletins
Every Two Weeks Aug to Nov

Antarctic Ozone Bulletin
No 2/2005

Executive summary
Since the last WMO Antarctic Ozone Bulletin, which was published on 23 August, temperatures have remained cool inside the south polar vortex, and at middle altitude ECMWF data show a cooling of a few Kelvin during the last week. Minimum total ozone columns are around 160–180 DU, which is very slightly lower than 0 days ago. However, the area where the total ozone column is less than 220 DU has increased from 12 to 22 million km² during the 10-day period since the previous Bulletin. A forecast by the past 7 days indicates a further increase to about 25 million km². Although the development of the ozone hole of 2005 is similar to what was observed in 2003, it is still too early to make a statement about the maximum size of this year’s ozone hole.

Antarctic Ozone Bulletins
1 Sep 2005

Contact: Geir Braathen Gbraathen@wmo.int
The WMO/GAW Global Atmospheric CO2 & CH4 Monitoring Network:

- Started as BAPMoN in the 1970s which became part of GAW in 1989
- Biennial WMO/IAEA CO₂ and Isotopes Measurements Experts Workshops (13th in Boulder 19-22 Sept 2005)
- Quadrennial International Carbon Dioxide Conference (7th in Boulder 26-30 Sept 2005)
- October 2005 GCOS Steering Committee endorses it as a Comprehensive network of GCOS.
GAW Global Carbon Dioxide Network
{Major Partner NOAA/CMDL}
All Data Available From GAW World Data Centre For Greenhouse Gases

http://gaw.kishou.go.jp/wdcgg.html
Major Partner
NOAA/CMDL
Hosts “Global View”
and has many products
&
works closely with WDCGG

Carbon Dioxide Measurements
NOAA CMDL Carbon Cycle Greenhouse Gases

Core Aerosol Variables

- optical depth
- light scattering coefficient
- light absorption coefficient
- mass (preferably in two size fractions)
- major chemical components in two size fractions

Building A Global AOD Network Monitoring

A WMO/GAW Experts Workshop
A Global Surface-Based Network for Long Term Observations of Column Aerosol Optical Properties
hosted by C. Wehrli, WORCC PMOD
March 2004 in Davos

A Blueprint For Moving Forward:
GAW Report # 162. WMO/GAW Expert Workshop on a Global Surface-based Network for Long Term Observations of Column Aerosol Optical Properties (Davos, Switzerland, 8-10 March 2004)
The Ground-based Global AOD Network “is currently un-coordinated”

Global AOD Network Long-term Sites
4+ years in operation, >50% coverage, as of March 2004

Latitudinal distribution
Polar regions: 4
Midlatitude North: 50
Tropics: 26
Midlatitude South: 10
Total: 90

Major data gaps
Africa, Asia, India, Polar region and Oceans

International: AERONET, BSRN, GAWPFR, SKYNET
National: Australia, China, Finland, Germany, Japan, Netherlands, Russia, USA(4)

Courtesy of Chris Wehrli Davos AOD Calibration centre
GAWPFR and WORCC/Davos
The Core of Quality Assurance

2004: 9 GAW stations operational, 4 stations pending deployment & 5 additional PFRs operated by FMI, DWD, ETHZ
Operational Aerosol Satellites Are Coming: So Far Only Demonstration Missions

A best estimate of the global distribution of annual average tropospheric aerosol optical depth (AOD) compiled by combining data from six satellites (operating for limited periods between 1979 and 2004). Observations for a region were selected using ground-based AOD observations as guidance (courtesy of S. Kinne MPI, Hamburg, Germany).
A systematic approach to observations is needed
What Is The Integrated Global Observing Strategy (IGOS) Partnership?
A Consortium of 13 Partners Formed in 1999 with a secretariat that rotates lead every 2 years. They meet regularly with CEOS

- Food and Agriculture Organization (FAO)

The IGOS Partners include the:

**Global observing systems**
- Global Climate Observing System (GCOS)
- Global Ocean Observing System (GOOS)
- Global Observing System (GOS) of the WMO
- Global Atmospheric Watch (GAW) of the WMO
- Global Terrestrial Observing System (GTOS)

**Sponsors of the global observing systems**
- World Meteorological Organization (WMO)
- U.N. Educational, Scientific, and Cultural Organization (UNESCO)
- U.N. Environment Programme (UNEP)
- Intergovernmental Oceanographic Organization (IOC)
- International Council for Science (ICSU)

**Committee on Earth Observation Satellites (CEOS)**
includes all national and regional government agencies with an Earth observing satellite system

**Global change research programs**
- International Geosphere-Biosphere Programme (IGBP)
- World Climate Research Programme (WCRP)
- International Group of Funding Agencies for Global Change Research (IGFA)
IGACO
THE INTEGRATED GLOBAL ATMOSPHERIC CHEMISTRY OBSERVATIONS THEME

For the Monitoring of our Environment from Space and from Earth

September 2004
An international partnership for cooperation in Earth observations
<table>
<thead>
<tr>
<th>Chemical species</th>
<th>Air Quality</th>
<th>Oxidation Capacity</th>
<th>Climate</th>
<th>Stratospheric Ozone Depletion</th>
</tr>
</thead>
<tbody>
<tr>
<td>O$_3$</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>H$_2$O (water vapour)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>CO</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO$_2$</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>CH$_4$</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>HCHO</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VOCs</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N$_2$O</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>NO$_x$ = NO+NO$_2$</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>HNO$_3$</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO$_2$</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>BrO, ClO, OCIO</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>HCl, ClONO$_2$</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>CH$_3$Br, CF$_3$Br, CFC-11, CFC-12, HCFC-22</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>aerosol optical properties</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>actinic flux</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>
Example of a timeline diagram

| COMPONENT | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|-----------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Non-Satellite Global |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Surface in situ (GAW with NOAA CMDL) |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Surface-based Lidar profile |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Balloon vertical profile |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Aircraft |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| MOSAIC | P | UT |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| NOXAR |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| CARIBIC |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| NOAA CMDL |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Satellite |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Indirect-Subtract Stratosphere |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| TOMS | C | P |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| ERS GOME-195 |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| AURA CMI 04 |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| M. TOP 1, 2, 3 GOME-2 05 |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| NPF OMPS 05 |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| NPOESS OMPS 10 |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Direct Upper Tropospheric |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| SAGE II & III |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| SORCE POAMIII |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| SCISAT ADEOS |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| SCISAT MAESTRO |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Direct Measurement |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| ENVISAT SCIAMACHY 02 |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| AURA TES 04 |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |

Figure 4.2.1. An overview of satellite, ground-based and aircraft measurements for tropospheric $O_3$
GAW GLOBAL OZONE SONDE NETWORK: 2001- 2004
Stations Submitting Data To WOUDC

The red triangles represent sites of GAW Contributing partner
NASA/SHADOZ.

Compliments of WOUDC, MSC, Toronto {Ed Hare Manager}.
Flight routes with regular observations

MOZAIC  21000 flights
JAL  1000 flights
NOXAR  622 flights
CARIBIC  83 flights
Satellite Column Observations From Low Earth Polar Orbiting Satellites

Tropospheric ozone from combined TOMS and SBUV data, showing major source regions and large-scale transport in the Northern hemisphere. [Courtesy J. Fishman, NASA]
The IGACO System Components

**The Data Stream**
- Quality Assurance & Cal/Val
- Integrated Data Archives
- Assimilation of Real-time Data
- Forecast Models Of Weather & Air Quality

**Products & Uses**
- Reanalysis
- Global 4-D Distribution
- Uses:
  1. Atmos. Chemistry
  2. Global Change Detection
  3. Pollution Sources/Pathways
  4. Improve Forecasts
  5. Environ. Assessment

INTEGRATED GLOBAL ATMOSPHERIC CHEMISTRY OBSERVATIONS (IGACO)
Examples of IGACO-relevant national, regional, international activities:

- GEMS
- ACCENT
- AERONET
- EMEP
- EANET
- WMO/GAW
- NDSC

Satellite-Programmes

- NATCHEM
- BSRN
- IMPROVE
- IAGOS/MOZAIC
IGACO-Ozone

GAW Calibration & Quality Assurance

World Integrated Data Archive System: Includes WOUDC

Assimilation of Real-Time Data By Forecast Models

WMO Real-Time Data Distribution: Weather Information System (WIS)

Data Uses/Applications:
1. Public UV Warnings
2. Public Ozone Bulletins
3. Research
4. Scientific Assessments
5. Forecasts of Ozone Depletion
6. Improved Weather Forecast

Global Products

Secretariat at Finnish Met Institute
Leaders WMO/GAW & IO3C

Observations:
All Sources

Global Products

IGACO-Ozone

GAW Calibration & Quality Assurance

World Integrated Data Archive System: Includes WOUDC

Assimilation of Real-Time Data By Forecast Models

WMO Real-Time Data Distribution: Weather Information System (WIS)

Data Uses/Applications:
1. Public UV Warnings
2. Public Ozone Bulletins
3. Research
4. Scientific Assessments
5. Forecasts of Ozone Depletion
6. Improved Weather Forecast

Global Products

Secretariat at Finnish Met Institute
Leaders WMO/GAW & IO3C

Observations:
All Sources

Global Products

IGACO-Ozone

GAW Calibration & Quality Assurance

World Integrated Data Archive System: Includes WOUDC

Assimilation of Real-Time Data By Forecast Models

WMO Real-Time Data Distribution: Weather Information System (WIS)

Data Uses/Applications:
1. Public UV Warnings
2. Public Ozone Bulletins
3. Research
4. Scientific Assessments
5. Forecasts of Ozone Depletion
6. Improved Weather Forecast

Global Products

Secretariat at Finnish Met Institute
Leaders WMO/GAW & IO3C

Observations:
All Sources

Global Products

IGACO-Ozone

GAW Calibration & Quality Assurance

World Integrated Data Archive System: Includes WOUDC

Assimilation of Real-Time Data By Forecast Models

WMO Real-Time Data Distribution: Weather Information System (WIS)

Data Uses/Applications:
1. Public UV Warnings
2. Public Ozone Bulletins
3. Research
4. Scientific Assessments
5. Forecasts of Ozone Depletion
6. Improved Weather Forecast

Global Products

Secretariat at Finnish Met Institute
Leaders WMO/GAW & IO3C

Observations:
All Sources

Global Products
Upcoming Cross-Cutting Events

- 24-26 April 2006 WMO Geneva “Chemical Data Assimilation in Atmospheric Forecast and Re-analysis Models An ACCENT/WMO Expert Workshop in support of IGACO”, contacts are P. Borrell and L. Barrie
THANK YOU