

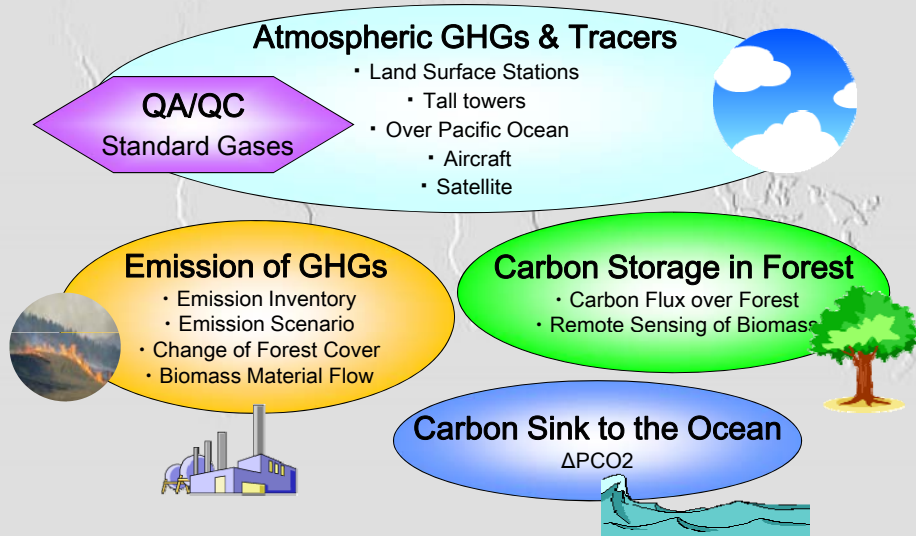
# Validation / verification capabilities of ambient mixing ratio measurements and inverse modeling

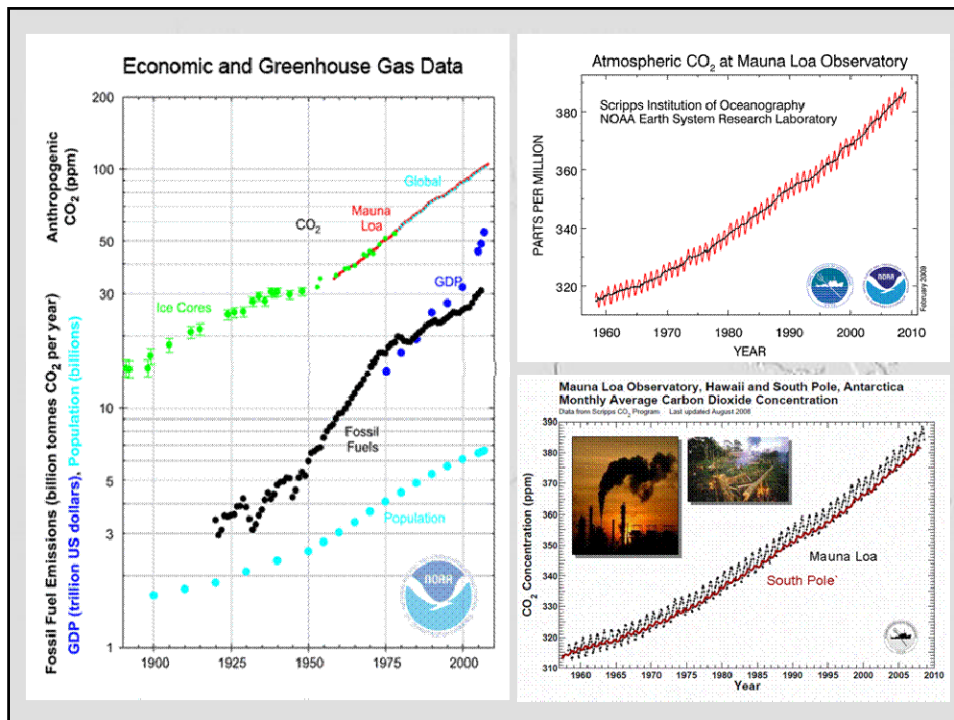
Lingxi ZHOU

Chinese Academy of Meteorological Sciences (CAMS)  
China Meteorological Administration (CMA)

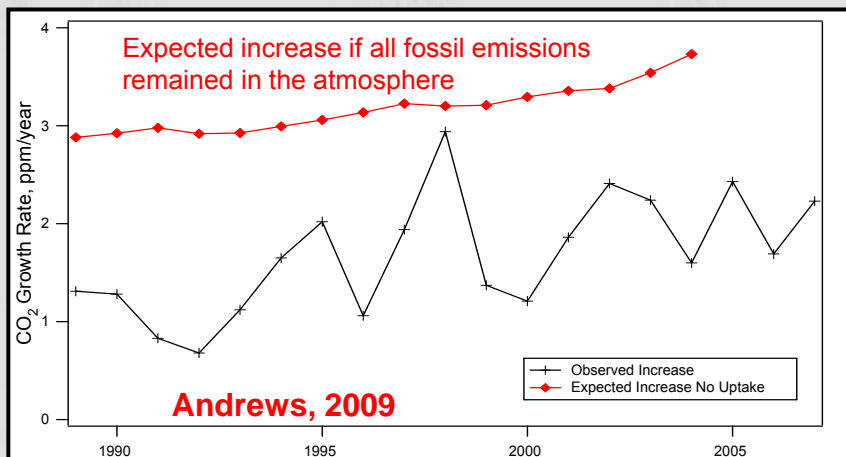
IPCC Expert Meeting on  
Uncertainty and Validation of Emission Inventories  
23-25 March 2010, Utrecht, The Netherlands

## Monitoring & Data-base of GHGs





## CO<sub>2</sub>: Land and ocean are large sinks



• 2001-2004: 58% of emissions stayed in atmosphere  
 22.5% absorbed by ocean 19.5% taken up by land biosphere  
**Emissions inventories don't tell the whole story**  
**Inventories are insufficient for predicting atm. CO<sub>2</sub> abundance**

## Atmospheric CO<sub>2</sub> *in situ* measurements

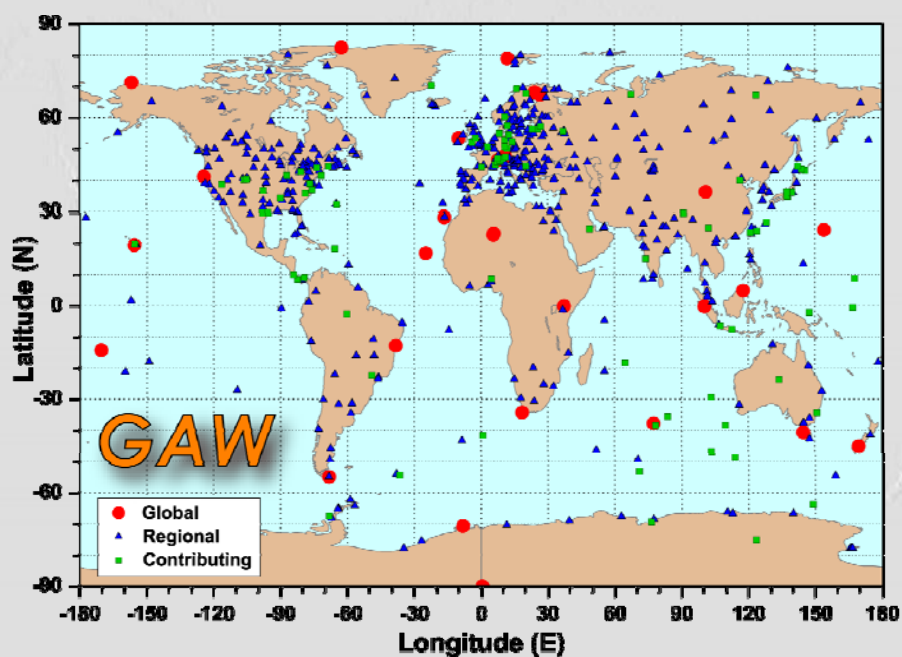
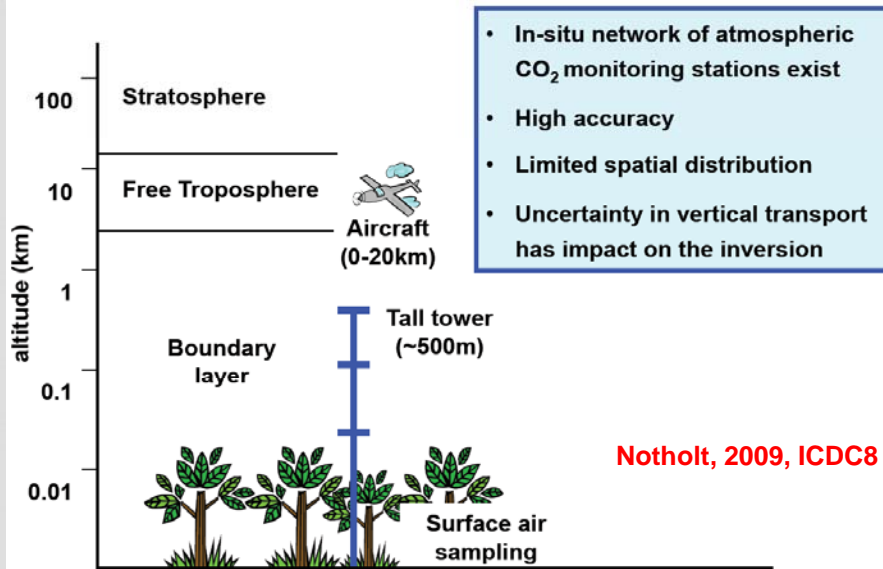
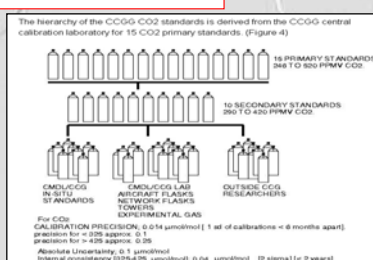
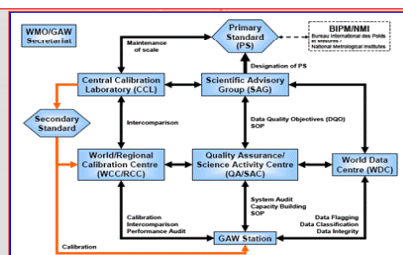


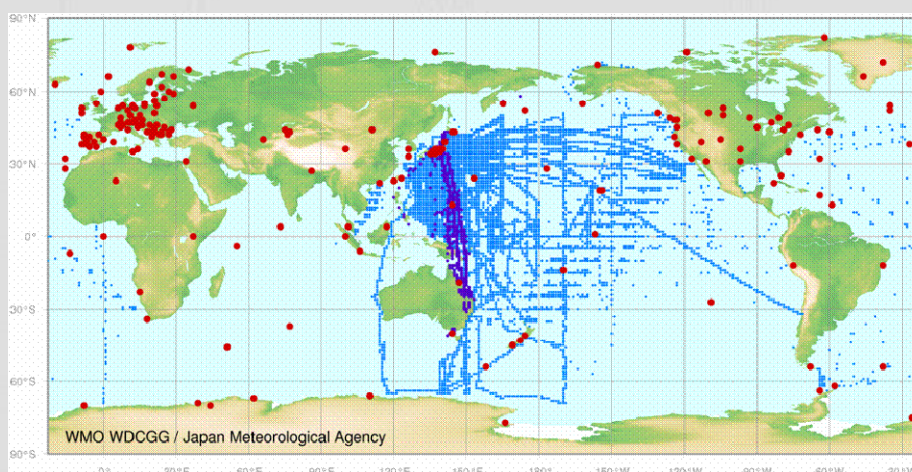
Table 1: Recommended inter-laboratory (network) comparability of components discussed.

Component	Inter-Laboratory comparability
CO <sub>2</sub>	± 0.1 ppm (± 0.05 ppm in the southern hemisphere)
δ <sup>13</sup> C-CO <sub>2</sub>	± 0.01 ‰
δ <sup>18</sup> O-CO <sub>2</sub>	± 0.05 ‰
Λ <sup>14</sup> C-CO <sub>2</sub>	+ 1 ‰
O <sub>2</sub> /N <sub>2</sub>	± 1 per meg
CH <sub>4</sub>	± 2 ppb
CO	± 2 ppb
N <sub>2</sub> O	± 0.1 ppb
H <sub>2</sub>	± 2 ppb
SF <sub>6</sub>	± 0.02 ppt

**GAW recommendations**  
**14<sup>th</sup> WMO/IAEA expert meeting**  
**Sept. 2007, Helsinki**

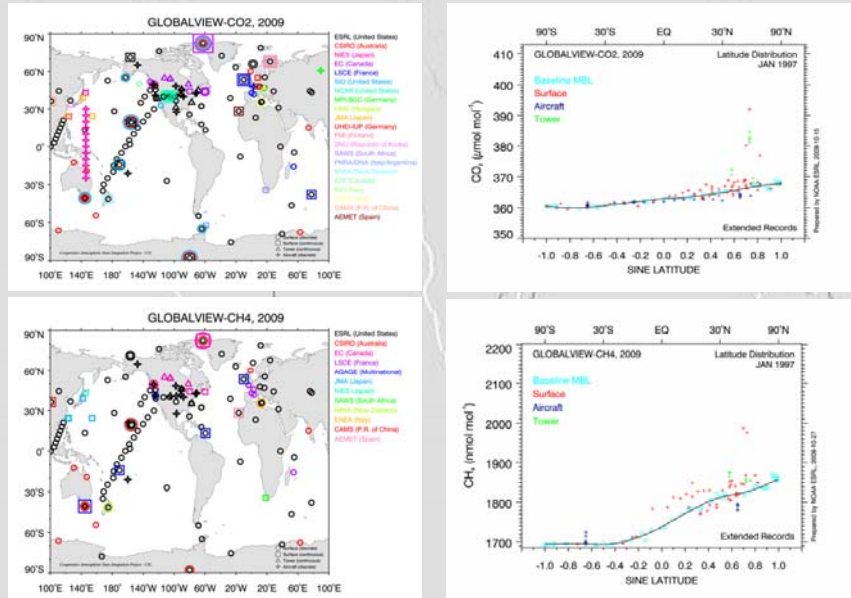


## Data reported to the WDCGG

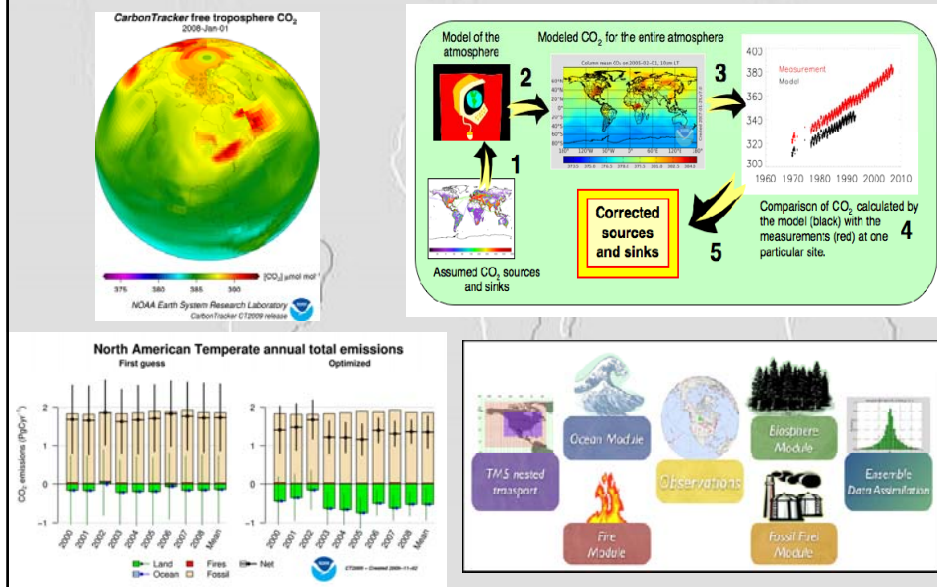


• Fixed stations, • Aircraft observations, • Ship observations  
 Up to 30 April 2009, **curtesy SUDA Kazuto (JMA)**

# Global-View



# CarbonTracker



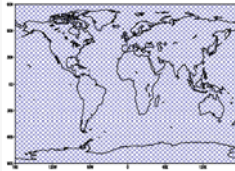


## Atmospheric inversion estimation

Prior flux information



LMDZ transport model



Atmospheric observations

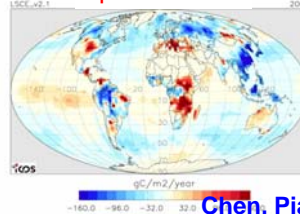


Inverse Procedure

**Limitations 1:**

sparse atmospheric measurement network (only a few sites in Asia), and uncertainty from transport model

Optimized fluxes



**Limitations 2:**

Low spatial resolution, we can only estimate CO2 flux at regional scale, can not separate each ecosystem

Chen, Piao, Zhou, 2010 Yokohama

## More sites expected in China In-situ & grab sampling Network Atmospheric GHGs & tracers




China Atmosphere Watch (14 Key regions)  
National Centre for Network Observation  
Funded by MOST Project (2005.12-2008.12)





**Data submit to the WDCGG**



**WDCGG**

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[Contributors](#)

[Data/Quick Plot](#)

[Mt. Waliguan](#)

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WMO Global Atmosphere Watch

**World Data Centre for Greenhouse Gases**

**Mt. Waliguan - CMA**

		Parameter Inventory	Parameter Metadata	Station	Contributor
Parameter (Data/Quick Plot)	Category	Period	Types of Data	Update	Parameters included
CH <sub>4</sub> <sup>***</sup> continuous	Air sampling observation	1994-01-01 - 2007-12-31	daily, monthly	2009-08-31	
CO <sub>2</sub> <sup>***</sup> continuous	Air sampling observation	1994-01-01 - 2007-12-31	daily, monthly	2009-08-31	

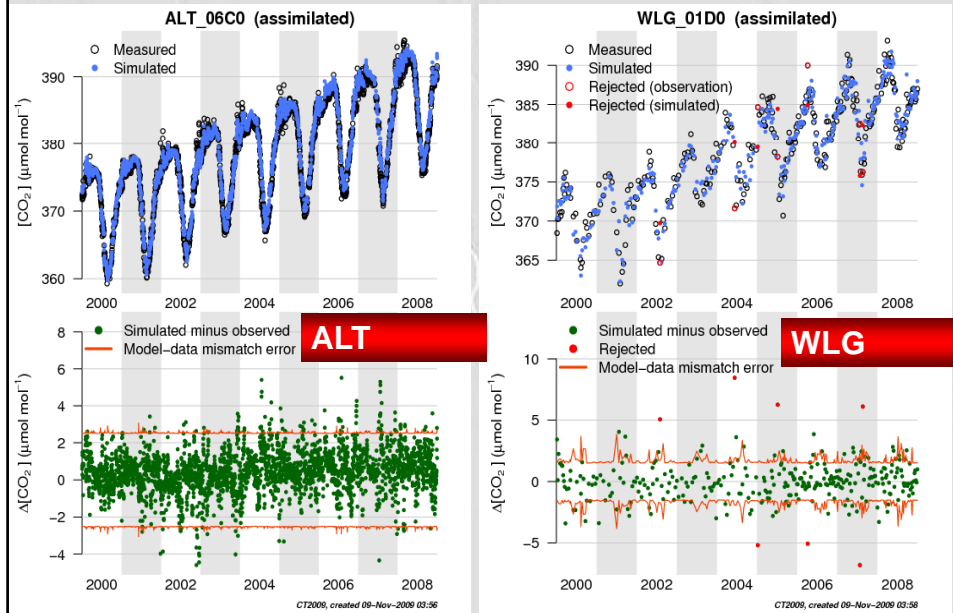
WMO Global Atmosphere Watch

**World Data Centre for Greenhouse Gases**

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CO <sub>2</sub> <sup>***</sup> continuous	Air sampling observation	1994-01-01 - 2008-12-31	daily, monthly	2009-10-14	

## Observed and simulated atmospheric CO<sub>2</sub> mixing ratios



## Joint AGAGE, SOGE and affiliated Networks

**AGAGE** Advanced Global Atmospheric Gases Experiment  
Sponsored by NASA's Atmospheric Composition Focus Area in Earth Science

**AGAGE Stations:** Mace Head, Trinidad Head, Barbados, Tsimba, Cape Grim

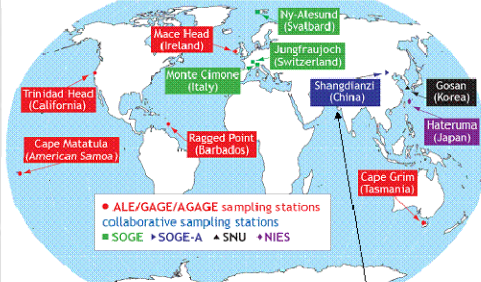
**Affiliated Stations:** Alert, Inuvik, Umanak, Shangdianzi, Gosan, Hateruma

**Shangdianzi GAW Regional Station**

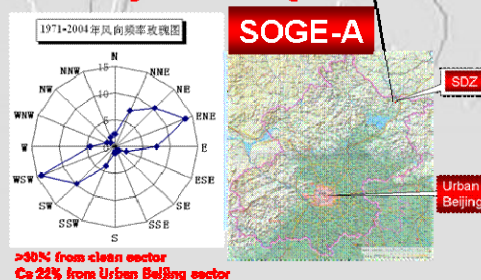
The Shangdianzi GAW Regional Station (Global Atmosphere Watch programme of the World Meteorological Organization) 150km northeast of urban Beijing is part of the domain of the China Meteorological Administration (CMA). It is jointly operated by the Beijing Meteorological Bureau (BMB) and the Chinese Academy of Meteorological Sciences (CAMS). The first in-situ measurement of CO<sub>2</sub>s and solvents in China has been performed by GC-ECDs at the Shangdianzi since 2006. As one of the partners of SOGE-A, Shangdianzi measurement is attached to the SOGE and linked to the AGAGE network. Furthermore, in-situ atmospheric CO<sub>2</sub>/CH<sub>4</sub> measurements by Picarro CRDS and in-situ CH<sub>4</sub>/CO<sub>2</sub>/N<sub>2</sub>O/SF<sub>6</sub> by GC-FID+ECD and enhanced in-situ measurements of halocarbon by the Medusa GC-MS will be implemented at the Shangdianzi in 2009.

**Station Information (Shangdianzi, China)**

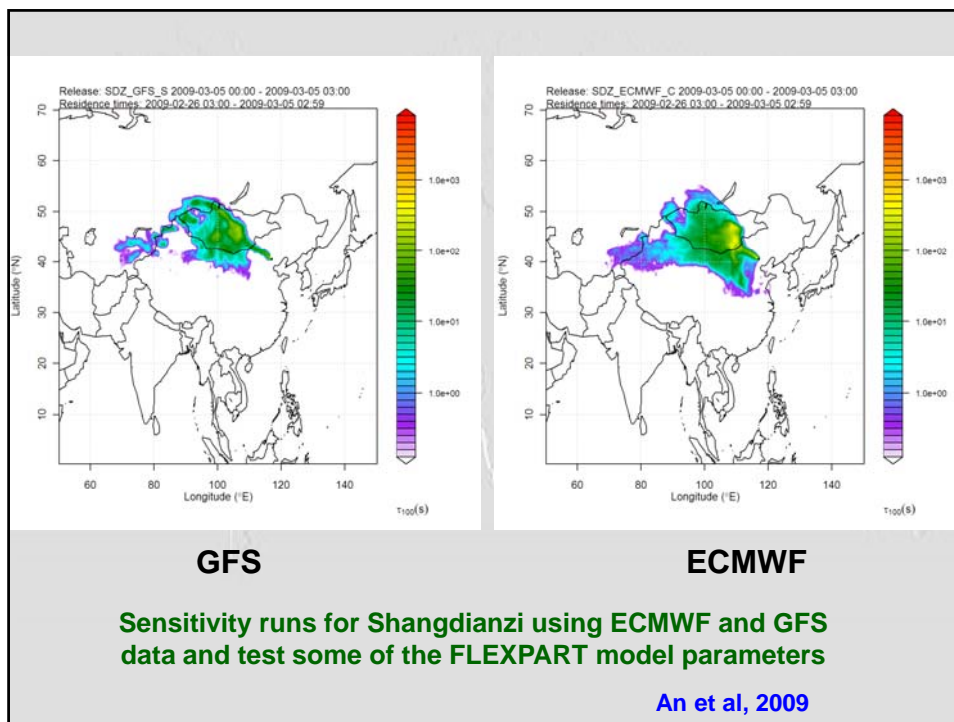
Latitude: 40° 39' N  
Longitude: 117° 7' E  
Time Zone: GMT+8  
Air sample Intake: 301.3 m (station is 293.3 m above sea level)  
Station PIs: Lingxi Zhou, zhouli@cams.cma.gov.cn  
Station manager:



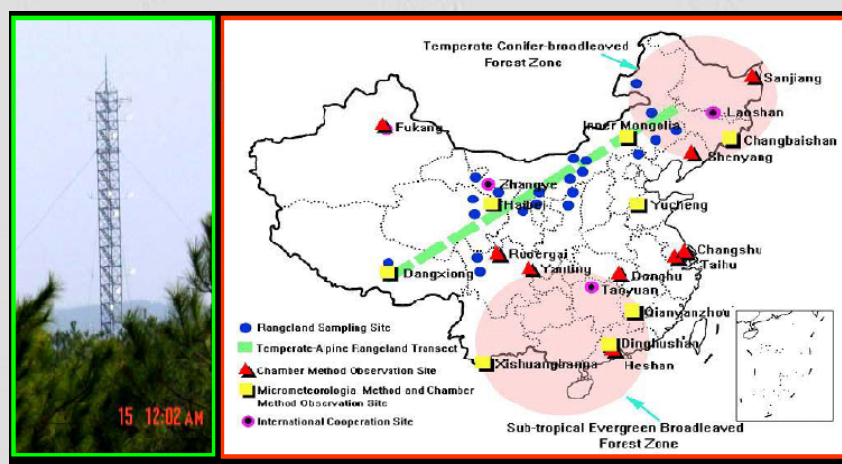
### Wind Rose (1971-2004) Shangdianzi GAW Regional Station





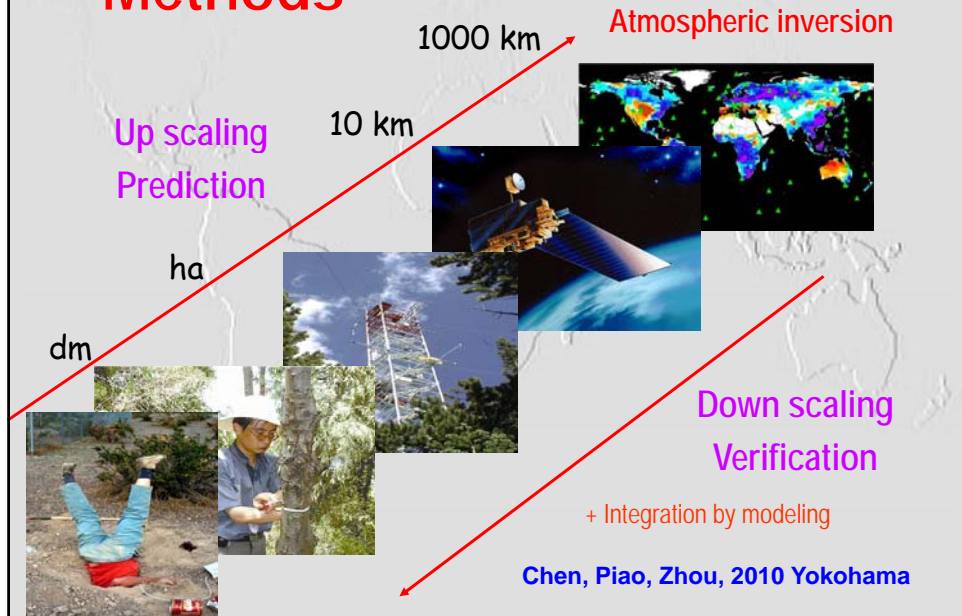


## Chamber, Flux tower measurements

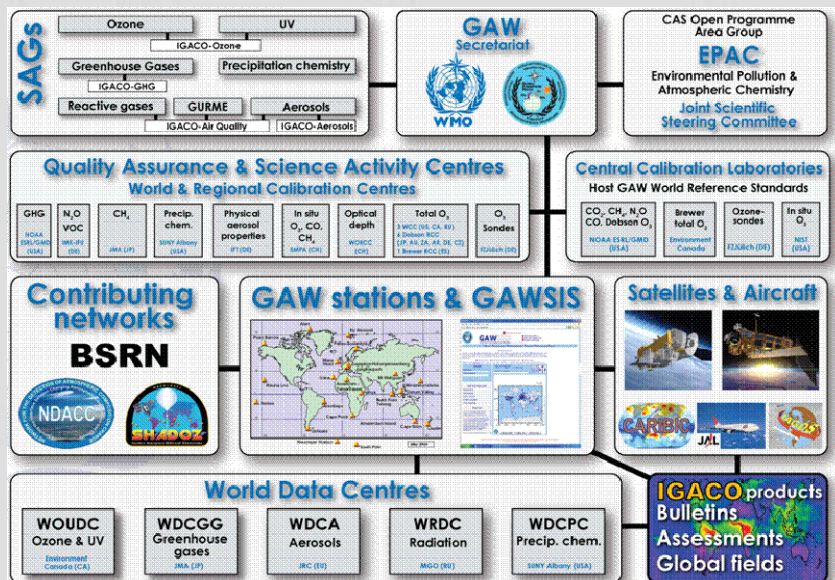


Chen, Piao, Zhou, 2010 Yokohama

# Methods



## WMO-GAW



## WMO/IAEA Meetings of Experts on CO<sub>2</sub> Concentration & Related Tracer Measurement Techniques



### 14th WMO/IAEA Meeting of Experts on Carbon Dioxide, Other Greenhouse Gases, and Related Tracers Measurement Techniques

10-13 September 2007, Helsinki, Finland



#### WORLD METEOROLOGICAL ORGANIZATION GLOBAL ATMOSPHERE WATCH



No. 972

WMO Global Atmosphere Watch (GAW)  
Strategic Plan: 2008 – 2015

A Contribution to the Implementation of the WMO Strategic Plan: 2008-2011



WMO TD NO. 1084

#### Goals

- Produce internally consistent CO<sub>2</sub>, δ<sup>13</sup>C, δ<sup>18</sup>O, Δ<sup>14</sup>C and O<sub>2</sub>/N<sub>2</sub> data sets through regular calibration and inter-comparisons of measurements, and scrutiny of archived data.
- Expand the global CO<sub>2</sub> measurement network. Emphasis should be on high-frequency measurements on the continents and increased sampling (high or low frequency) in the tropics, from vertical profiles, and from ships (though the Ship of Opportunity Programme, SOOP).
- Cooperate with process-oriented research programs including the ocean carbon cycle community (e.g., IGBP projects SOLAS, IMBER, and GLOBEC, and the WCRP project CLIVAR) and terrestrial C flux measurements (e.g., FLUXNET). Emphasis should be on the importance of the flux measurement communities rigorously calibrating their measurements to the WMO CO<sub>2</sub> mole fraction scale.
- Develop comprehensive mechanistic carbon cycle models that include soil, terrestrial ecosystem, and ocean processes. These models will be linked to GAW measurements through assimilated CO<sub>2</sub> mole fractions, flux measurements, and other auxiliary information (land cover maps, soil moisture, chlorophyll, sea surface temperatures, etc.).
- Integrate satellite and *in situ* measurements of CO<sub>2</sub>. Emphasis should be on ensuring that remotely-sensed retrievals of CO<sub>2</sub> columns are validated with vertical profiles of *in situ* measurements and surface-based column abundances determined using FTIR spectrometry.
- Expand the possibilities of archiving meteorological information needed for assimilation models.

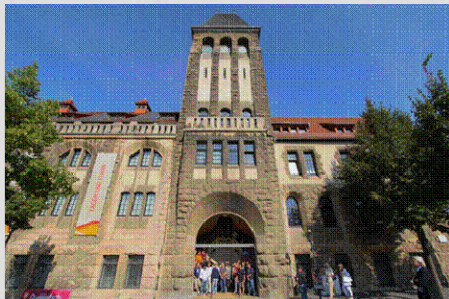
#### Goals

- Produce an internally consistent CH<sub>4</sub> data set through the use of standards regularly calibrated by the CCL, audits by the WCCs, and inter-comparisons of measurements.
- Improve coverage of the GAW network by adding sites in the tropics, in the Arctic, and on continents. Emphasis should be on high-frequency measurements and vertical profiles.
- Integrate satellite and *in situ* measurements of CH<sub>4</sub>. Emphasis should be on the validation of remotely-sensed CH<sub>4</sub> columns with vertical profiles of *in situ* measurements.

.....



**15th WMO/IAEA Meeting of Experts on Carbon Dioxide, Other Greenhouse Gases and Related Tracers Measurement Techniques, 7-10 Sept. 2009, Jena, Germany**



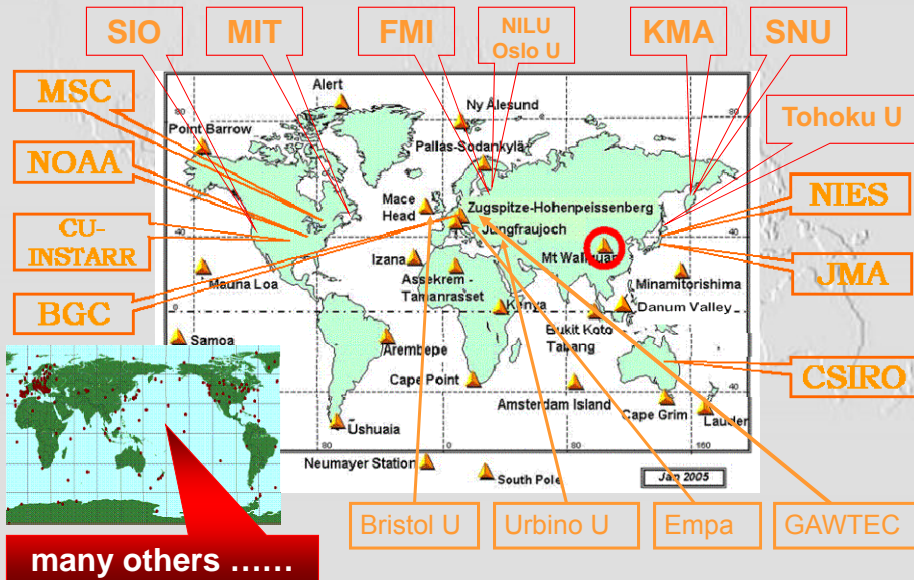
## WMO Round-robin Inter-comparison (GHGs)

### 2002 - 2005 WMO ROUND-ROBIN INTERCALIBRATION RESULTS CARBON DIOXIDE CONCENTRATIONS (Preliminary)

Lab/Institution	Analysis Date	Report Date	CO2 (ppm)	CO2 (ppm)	Other GHGs measured (Reported in ppt)	Other GHGs (Lab - NOAA CO2 (ppm))
GROUP 1 (10 countries, 14 labs, 14 sites)						
US - NOAA	Feb-Mar-2002					
US - NOAA	Apr-2002		354.91	354.34	354.81	
US - NOAA	Feb-2002					
JP - Tsukuba U.	Jan-2003	May 2004				
JP - MPE	Apr-2003	May 2004			CH4, N2O, SF6, C2H6, C2H2, HFC-125, HFC-134a	
JP - MPE	Jul-2003	May 2004				
JP - MPE	Sep-2003	May 2004			CH4	
JP - MPE	Jan-2004	May 2004				
India - IITM (Gurgaon)	May-Jun-2004	Jul 2004				
CH - CMA (Jiayu)	Jul-2004	Nov 2004				
CH - CMA (Jiayu)	Jul-2004	Nov 2004				
US - SO FIPPS	June 2005	June 2005			CH4, N2O, SF6, C2H6, C2H2, HFC-125, HFC-134a	
FR - LDC-E	Oct-Nov-2005	Dec-2005				
GROUP 2 (10 countries, 14 labs, 14 sites)						
US - NOAA	Feb-Mar-2002					
US - NOAA	Apr-2002		350.85	350.33	350.66	
US - NOAA	Feb-2002					
FR - Météo France	Oct-2002	Oct-2002				
FR - Météo France	Nov-2002	May 2003				
FR - Météo France	Dec-2002	Dec-2002				
FR - Météo France	Jan-2003	Jan-2003				
FR - Météo France	Feb-2003	Feb-2003				
FR - Météo France	Mar-2003	Mar-2003				
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FR - Météo France	May-2003	May-2003				
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FR - Météo France	Jan-2004	Jan-2004				
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FR - Météo France	Jul-2020	Jul-2020				



# International Cooperation



CMA/SST/Picarro group in the lab at CMA  
2008/11/11

China Atmosphere Watch (14 Key regions)  
National Centre for Network Observation  
Funded by MOST Project (2005.12-2008.12)

Beijing Lab and

Picarro-CH<sub>4</sub>/CO<sub>2</sub>甚高分辨率在线  
观测系统

# Summary

- **Long-term network observation of atmospheric GHG mixing ratios combine with meteorological data and modelling can provide basis for**
  - independent regional emission estimates and verifications
  - check countries' and regions' compliance with the Protocols
  - neighbourhood watch
- **Better to achieve**
  - High frequency low-cost and recognized techniques
  - Enhanced and feasible coverage (temporal / geographical)
  - Larger zoo (more GHG & related tracers measured)

Thank You