WMO/GAW温室効果ガス観測スケールの現況と気象庁の取り組みについて

発表者：坪井一寛　（気象研究所）

気象庁
地球環境・海洋部　環境気象管理官
気象研究所　海洋・地球化学研究部

WMO/GAW温室効果ガス観測

WORLD METEOROLOGICAL ORGANIZATION
（世界気象機関）

GLOBAL ATMOSPHERE WATCH
（全球大気監視）

（気象庁訳）

WMO 温室効果ガス年報

2015 年 12 月までの世界の観測結果に基づく
大気中の温室効果ガスの状況

第 12 号 | 2016 年 10 月 24 日

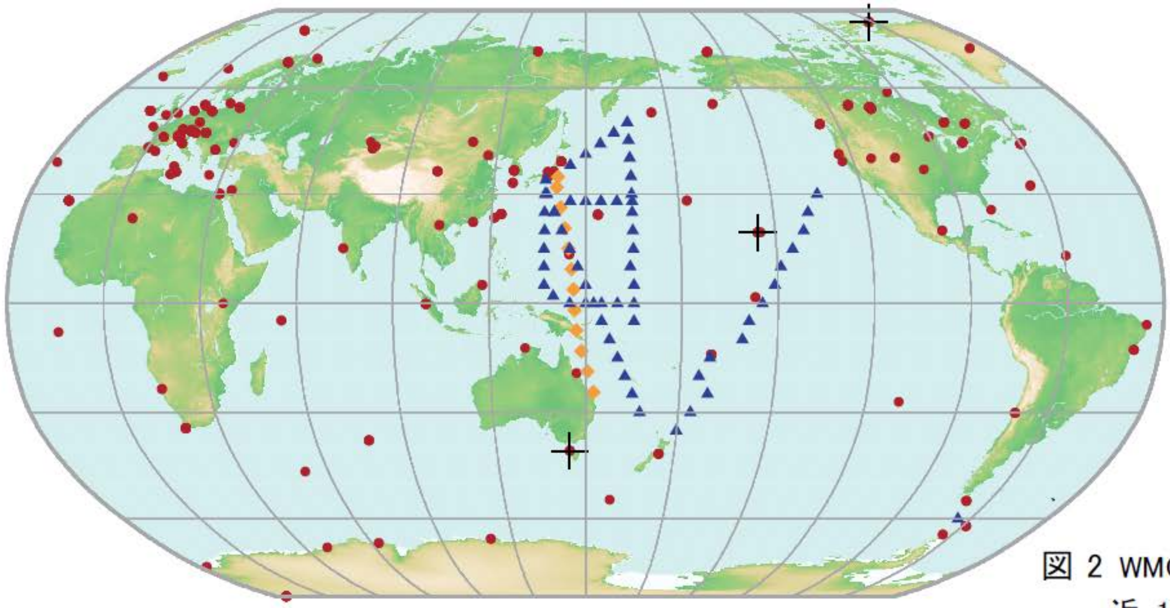


図 2 WMO/GAW 世界監視ネットワークを構成する最近 10 年間の二酸化炭素観測地点。メタンの観測ネットワークもこれと同様である。

http://www.data.jma.go.jp/gmd/env/info/wdcgg/wdcgg_bulletin.html

温室効果ガスの世界平均濃度と増加量

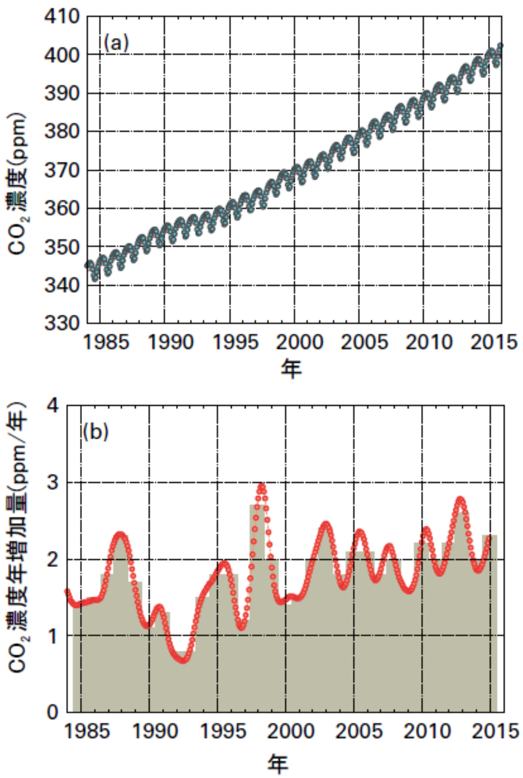


図3　二酸化炭素の1984年から2015年までの(a)世界平均濃度と(b)その一年あたりの増加量。(b)の背景の棒グラフは前年からの濃度差。

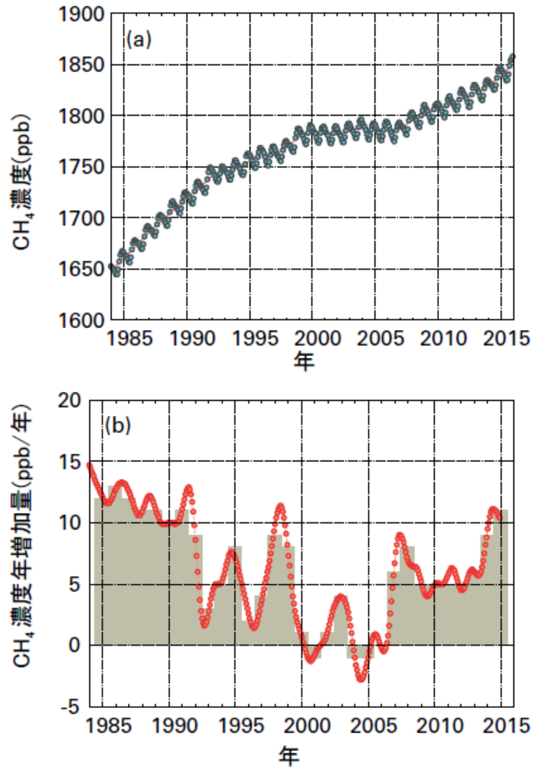


図4　メタンの1984年から2015年までの(a)世界平均濃度と(b)その一年あたりの増加量。(b)の背景の棒グラフは前年からの濃度差。

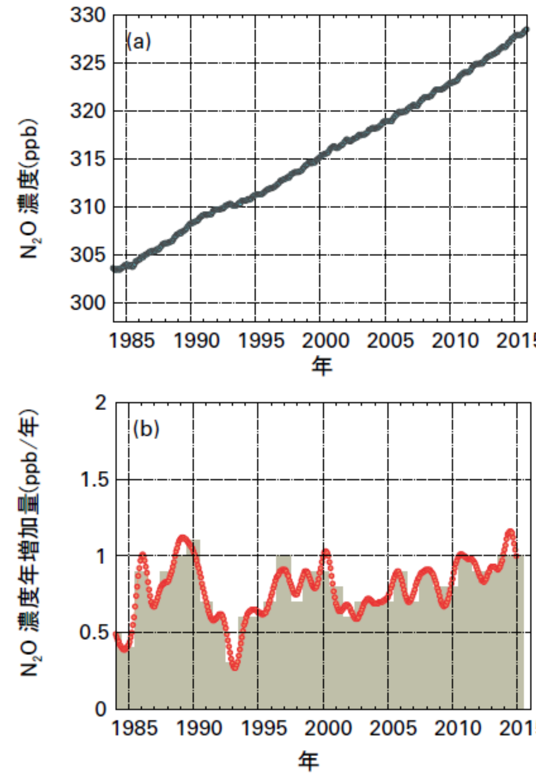


図5　一酸化二窒素の1984年から2015年までの(a)世界平均濃度と(b)その一年あたりの増加量。(b)の背景の棒グラフは前年からの濃度差。

ＷＭＯ温室効果ガス年報第１２号（２０１６年１０月２４日）

WMO/GAW 枠組

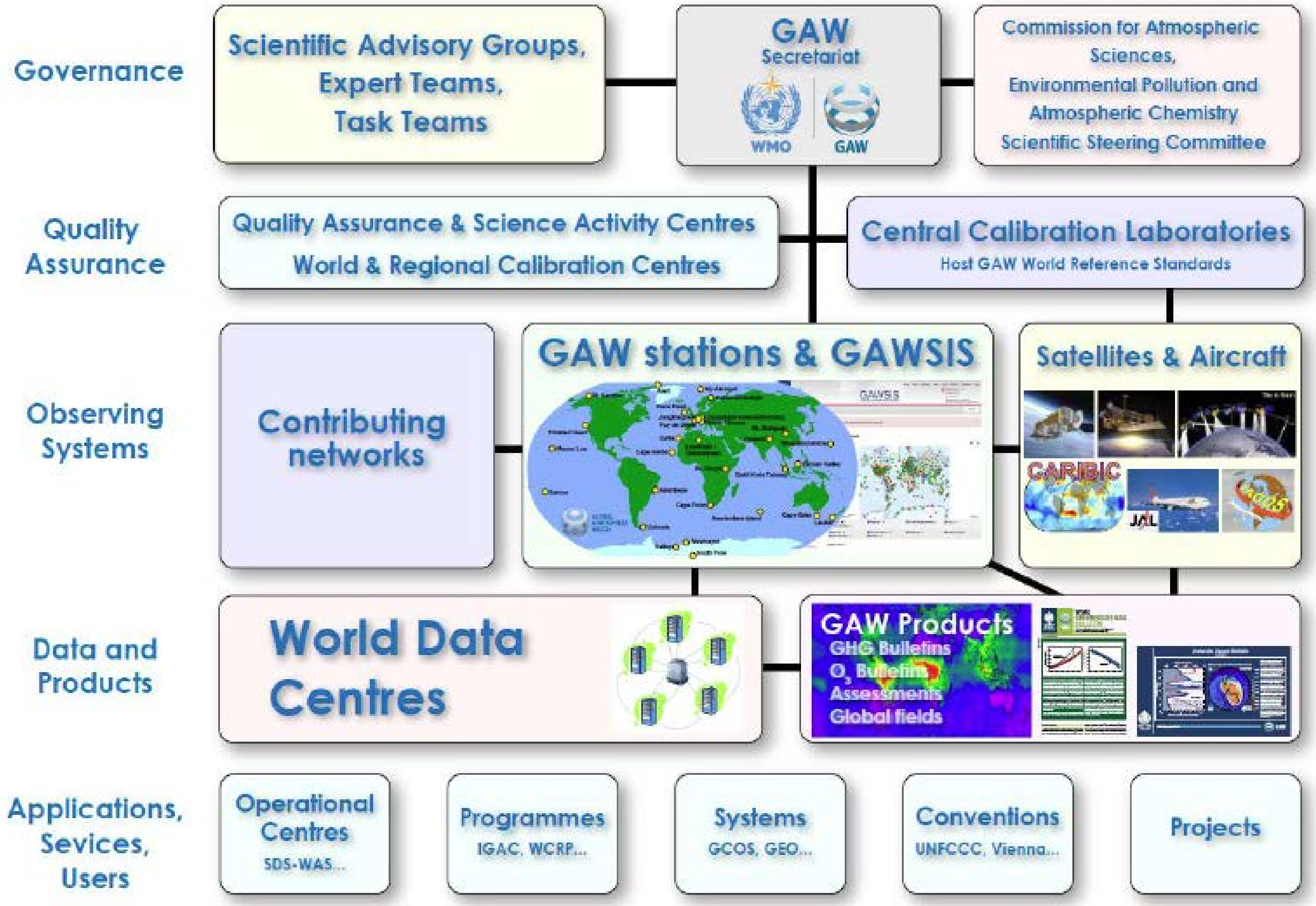


Figure 3 - Components of the WMO/GAW Programme.

GAW Report 228. WMO Global Atmosphere Watch (GAW) Implementation Plan: 2016-2023

温室効果ガス観測スケールとは

- 標準ガスセットによる維持
- 相対測定を基本
- 測定対象範囲のモル分率
- 不確かさ、長期的安定性
- 実大気の測定に適用可能
- SIトレーサブル（NMIとの比較を含む）
- 手法に依存

WMO mole fraction scale

The current scales are (as of June 2016):

WMO CO_2 X2007	246-521μmol/mol (15)
WMO CH_4 X2004A	300-5900nmol/mol (22)
WMO CO X2014A	30-500,988nmol/mol (14)
WMO N_2O X2006A	261-371nmol/mol (13)
WMO SF_6 X2014	2.4-20.3pmol/mol (17)
WMO H_2 X2009	140-1225nmol/mol (13)

The "X" stands for mole fraction.

WMOスケールは、ガス消費だけでなく測定対象の拡大(都市大気、発生源など)や技術進歩(分析計性能向上)を反映し、適宜更新され続けている。最新スケールによる観測データ発表を勧告。

GAW Report No.229

WMO CO2 X2017

April 2016
the NDIR system +
a new CO_2 calibration system
based on laser spectroscopic techniques
CRDS instrument for $^{16}O^{12}C^{16}O$
the off-axis ICOS or the QC-TILDAS
for the $^{16}O^{13}C^{16}O$ and $^{18}O^{12}C^{16}O$

the total CO_2 → individual isotopologue mole fractions

November 2016 ～
a new CO_2 calibration system (+the NDIR system)

mid-2017
NOAA will be releasing a revised CO2 in air scale (X2017)

https://www.esrl.noaa.gov/gmd/ccl/co2_calsystem.html

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Earth System Research Laboratory
Global Monitoring Division
325 Broadway - David Skaggs Research Center
Boulder, CO 80305-3328

Certificate of Analysis

NOAA Global Monitoring Division (GMD)

Certificate Number:	CQB09471-B
Issue Date:	26 January 2017
Material:	Air, compressed, in an aluminum gas cylinder, nominal pressure 13.6 MPa (2000 psi)
Intended Use:	For the calibration of instruments for determining the mole fraction of trace gases in air. Experience has shown that high flow applications may lead to changes in CO_2 mole fraction. For high precision measurement, flow should be less than 0.5 liters per min.
Use and Storage:	Cylinders should be used under normal laboratory conditions (room temperature). For storage, we recommend -30 to 40 deg C.
Period of Analysis:	July 2016
Prepared by:	Thomas Mefford

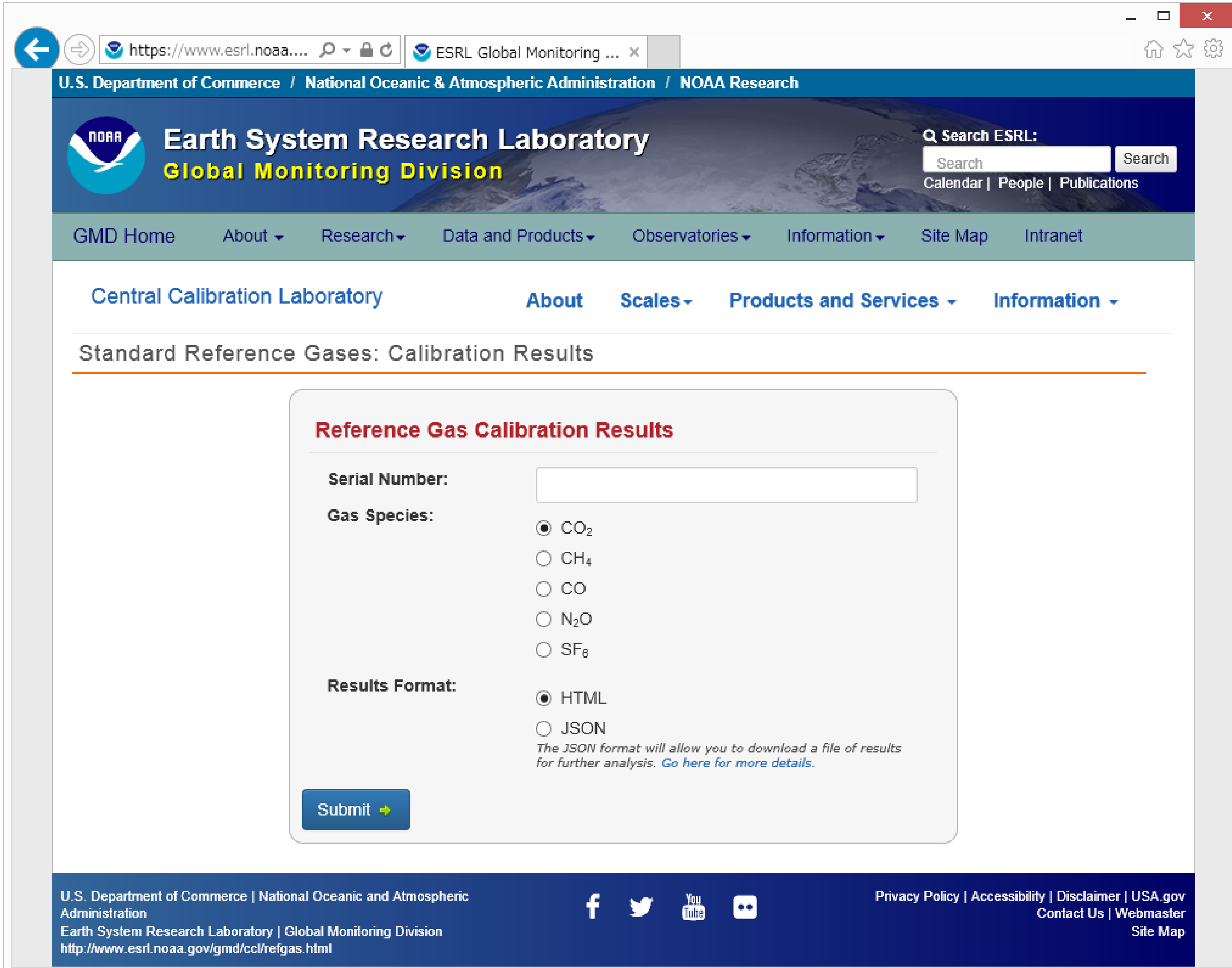
Cylinder ID: CQB09471

Results are based on analysis performed by the WMO/GAW Central Calibration Laboratories (CCL) located at the NOAA Global Monitoring Division (GMD). WMO/GAW mole fraction scales are developed and maintained by GMD in their role as CCL. Results are traceable to the SI unit "amount of substance fraction". Equipment used to develop mole fraction scales and establish traceability to the SI are traceable to national standards for mass, temperature, pressure, and amount of substance fraction (O_2 in N_2). For more information on calibration scales and analysis methods, see http://www.esrl.noaa.gov/gmd/ccl. For isotopic ratios or other informational values, if applicable, see http://www.esrl.noaa.gov/gmd/ccl/refgas.html/.

Results

	Mole Fraction[1]	Reproducibility[2]	Expanded Uncertainty[3]	Unit	Method	Calibration Scale
CO_2	294.38	0.06	0.16	$\mu mol\ mol^{-1}$	NDIR	WMO-CO_2-X2007

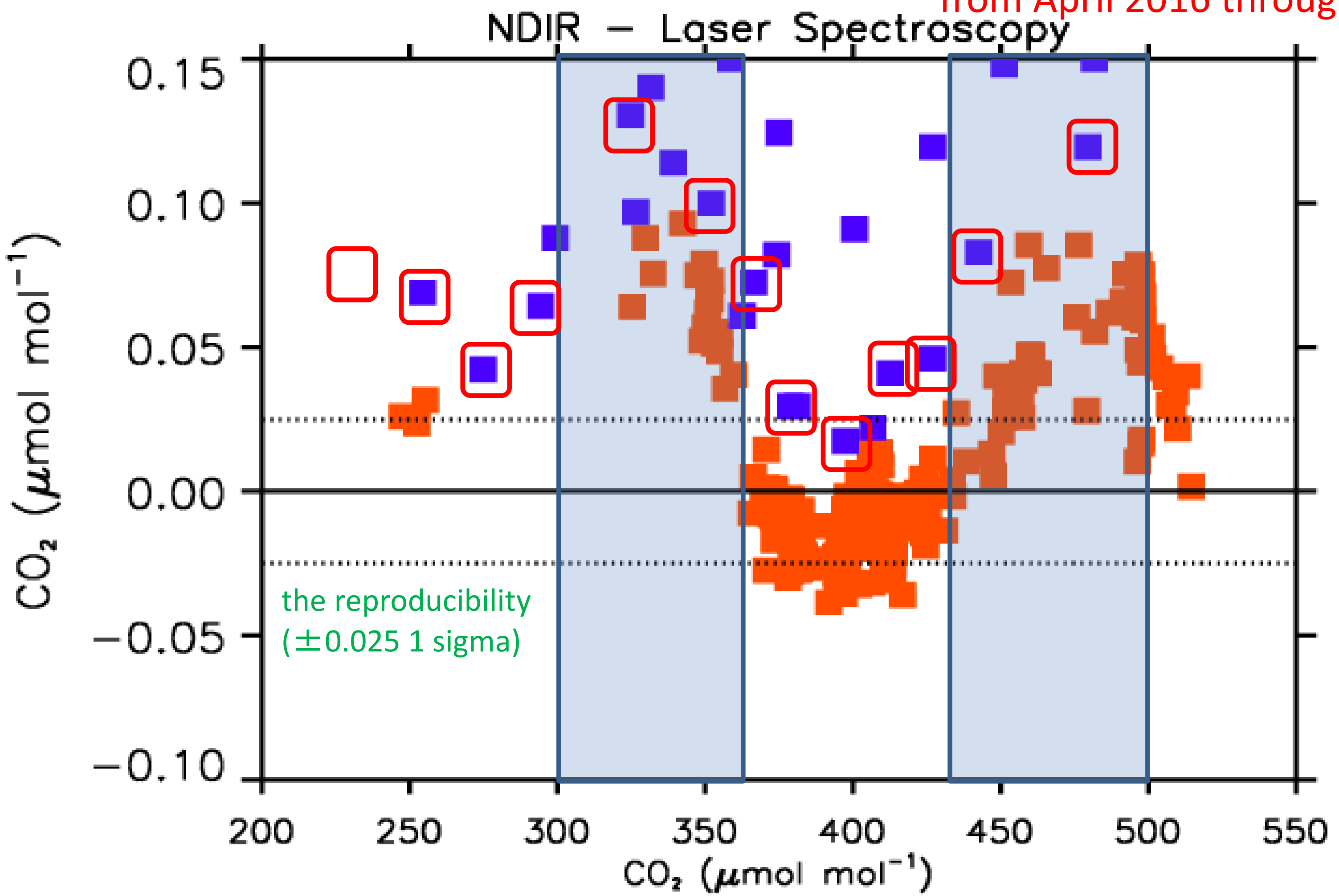
[1] mole fraction in dry air, expressed on a WMO/GAW mole fraction calibration scale ($\mu mol\ mol^{-1}$ = ppm, $nmol\ mol^{-1}$ = ppb, $pmol\ mol^{-1}$ = ppt).
[2] expected long-term variation of analysis results assuming no cylinder drift (95% confidence level)
[3] total uncertainty, estimated with coverage factor k=2, (~95% confidence level). Total uncertainty includes uncertainties associated with preparation and analysis of primary standards, as well as scale propagation. Note that we explicitly express the results with the number of significant figures corresponding to the number of significant figures in the reproducibility estimate. This is deliberate, as it provides important information to WMO/GAW end users.



http://www.esrl.noaa.gov/gmd/ccl/refgas.html

比較結果 (NDIR minus Laser Spectroscopy)

from April 2016 through Oct 2016



Blue points are cylinders with δ[13]C < -20‰.

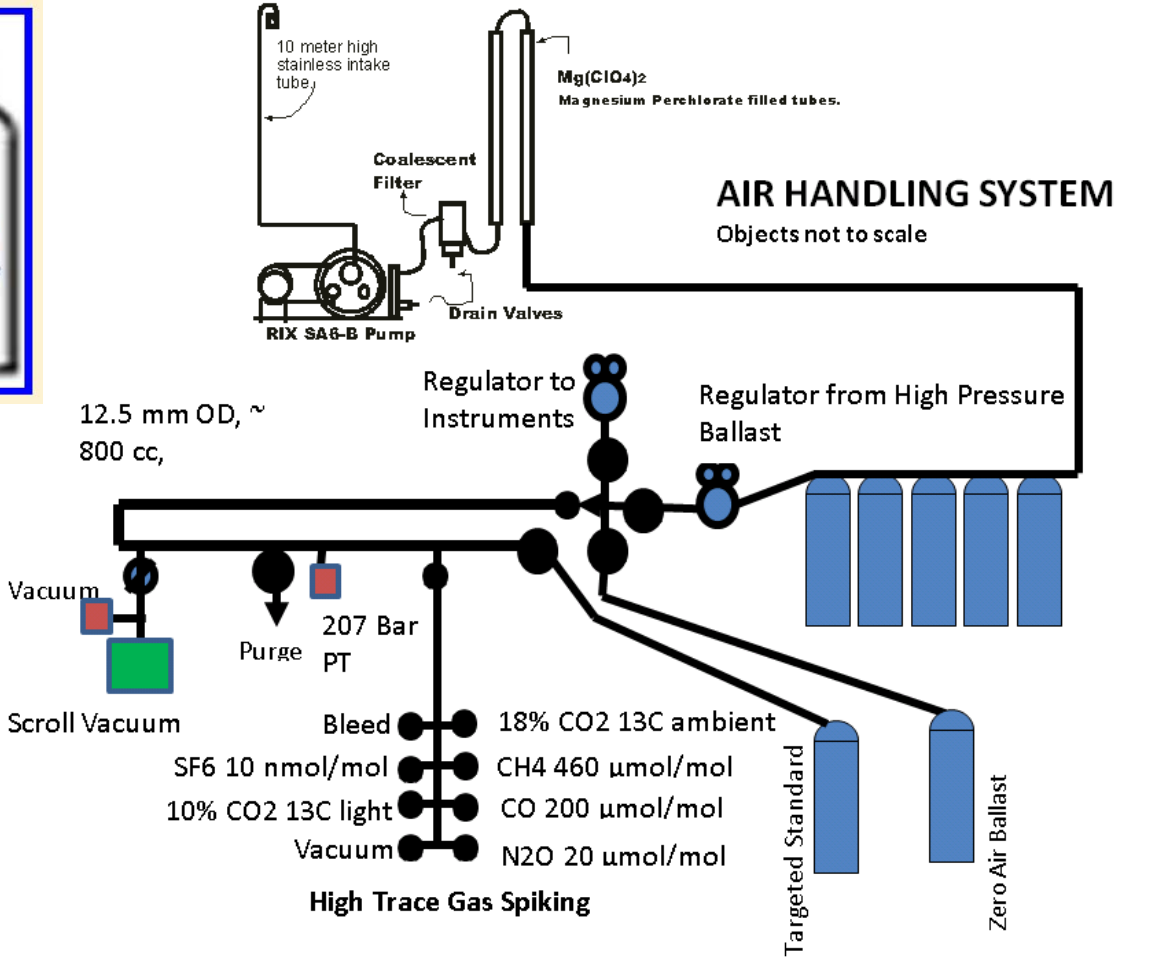
JMA_7G Primary

https://www.esrl.noaa.gov/gmd/ccl/co2_calsystem.html

Standard Reference Material (NIST,NOAA)

Anal. Chem., 2016, 88 (6), pp 3376–3385

Development of a **Northern Continental Air** Standard Reference Material（SRM1720)



PT = Pressure Transducer

https://www.esrl.noaa.gov/gmd/ccl/airstandard.html

GGMT2015_A19_Kitzis

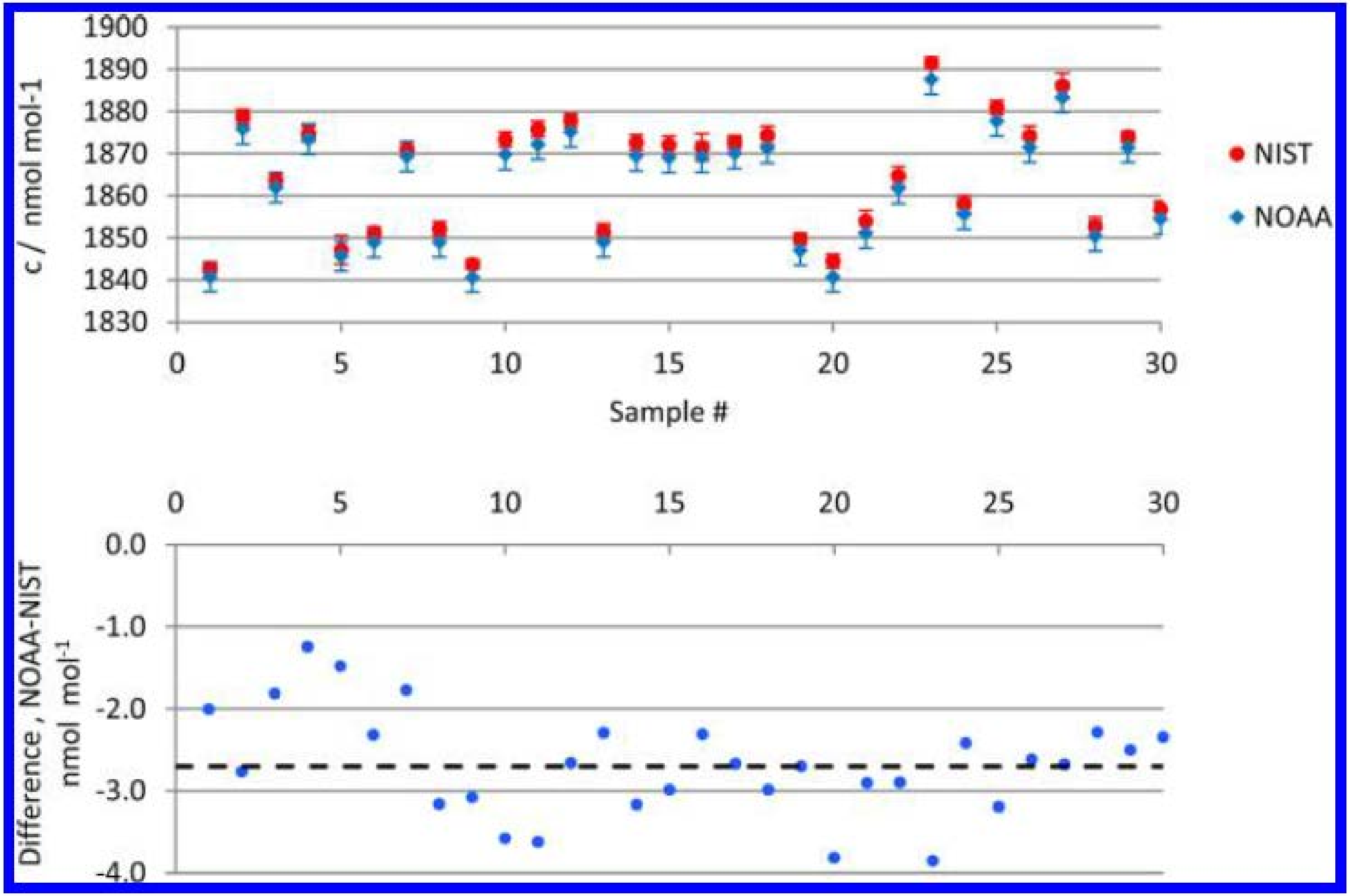
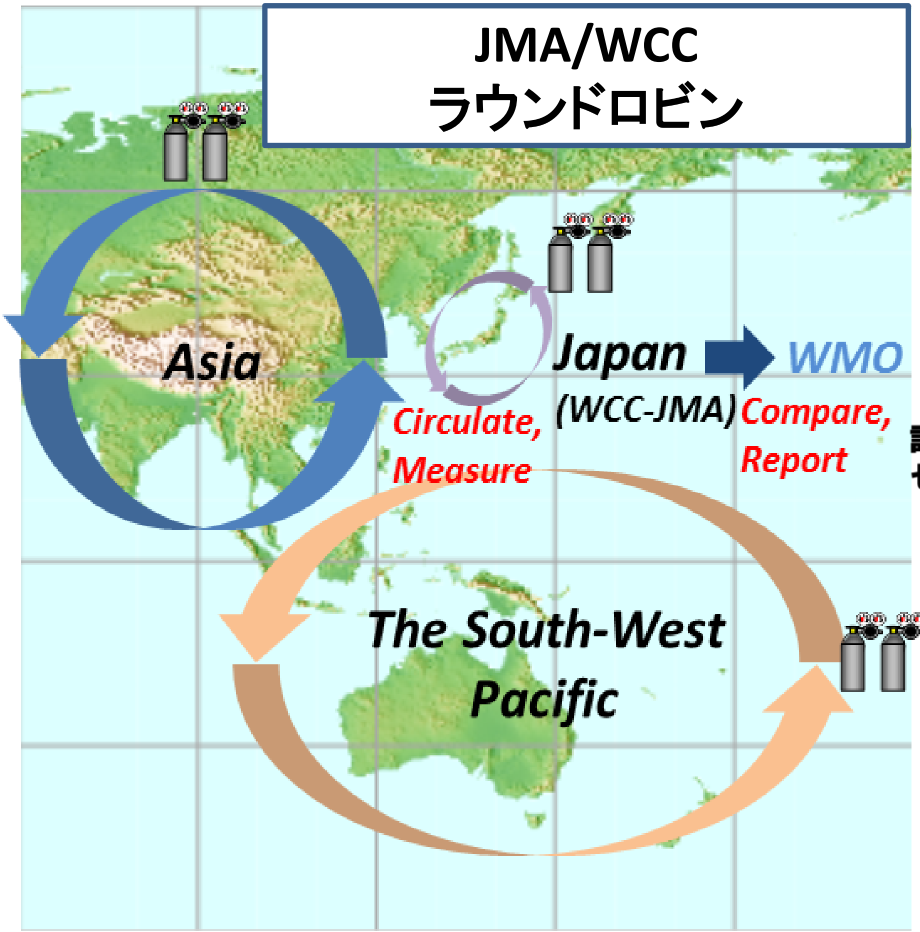


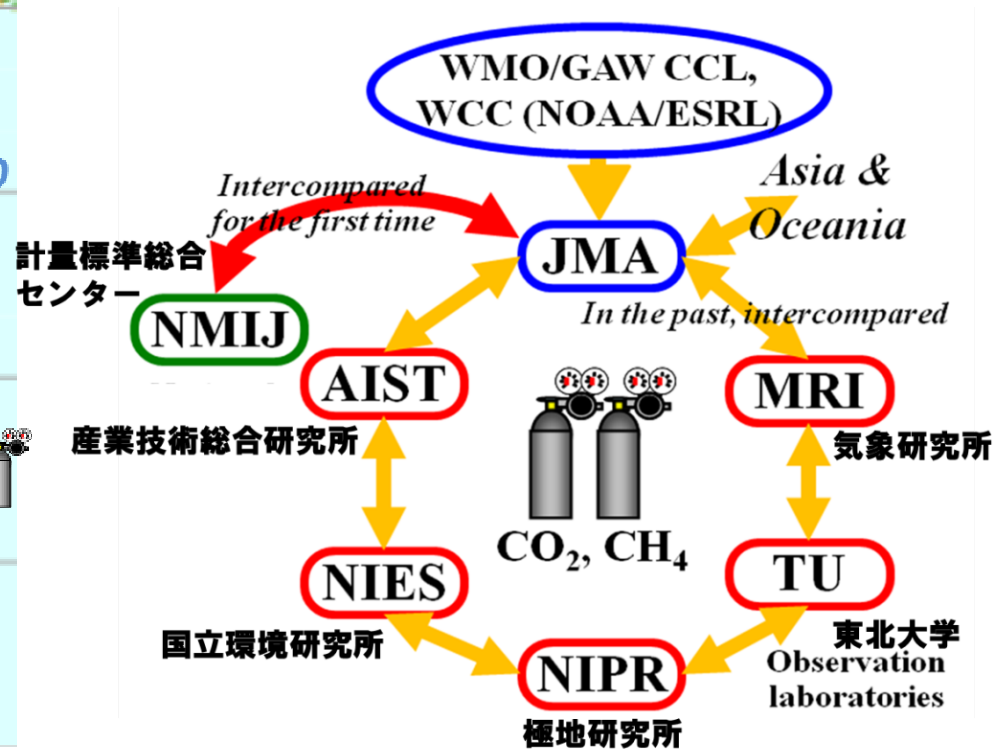
Figure 2. Comparison of NIST and NOAA CH_4 values (Error bars represent expanded uncertainties; 95% confidence interval.) and differences with black dashed line representing an average difference of −2.7 nmol mol^{-1}.

巡回比較実験



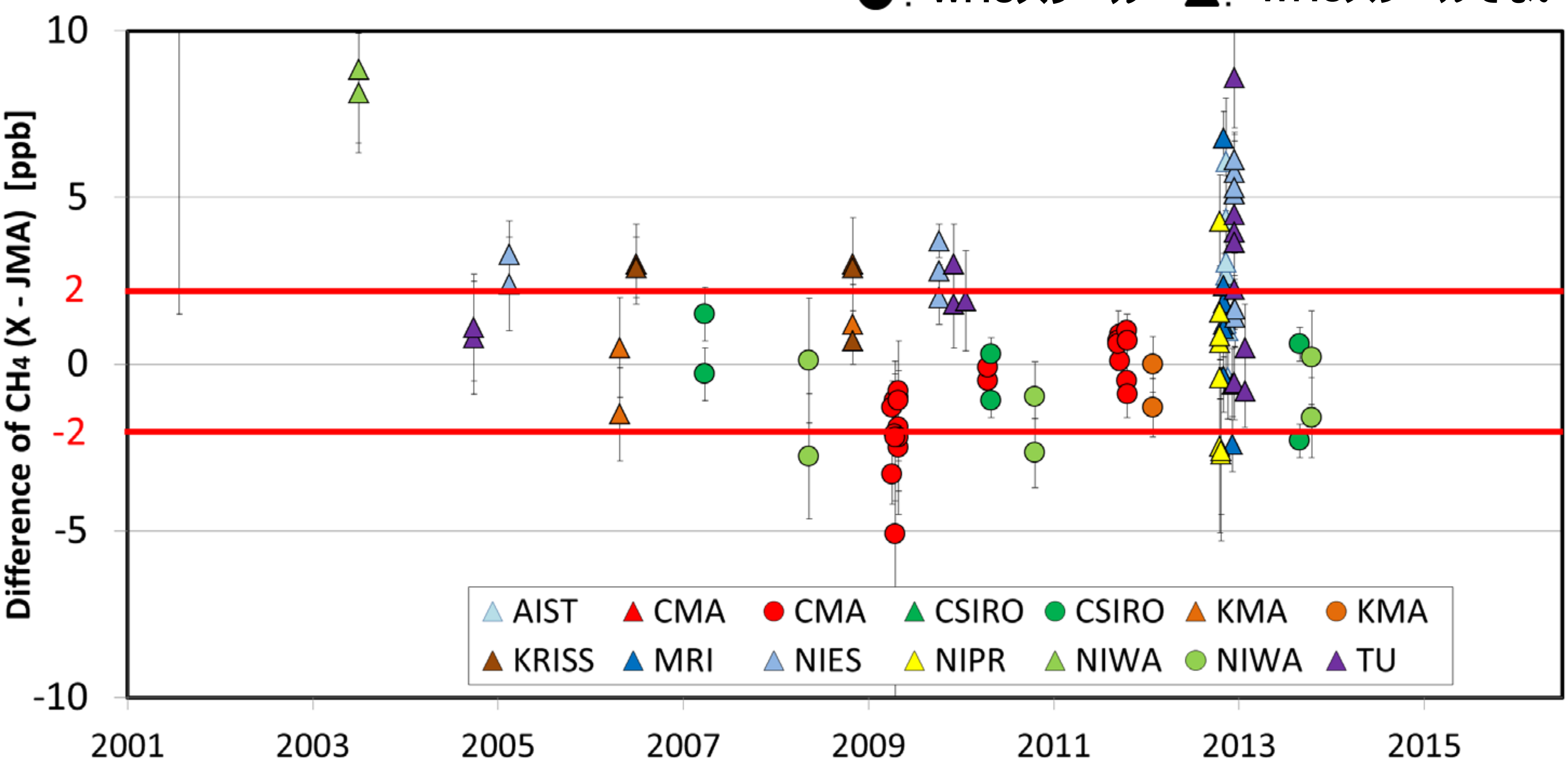
国内巡回比較：IceGGO

Inter-Comparison Experiments for Greenhouse Gases Observation



メタン巡回比較実験結果履歴

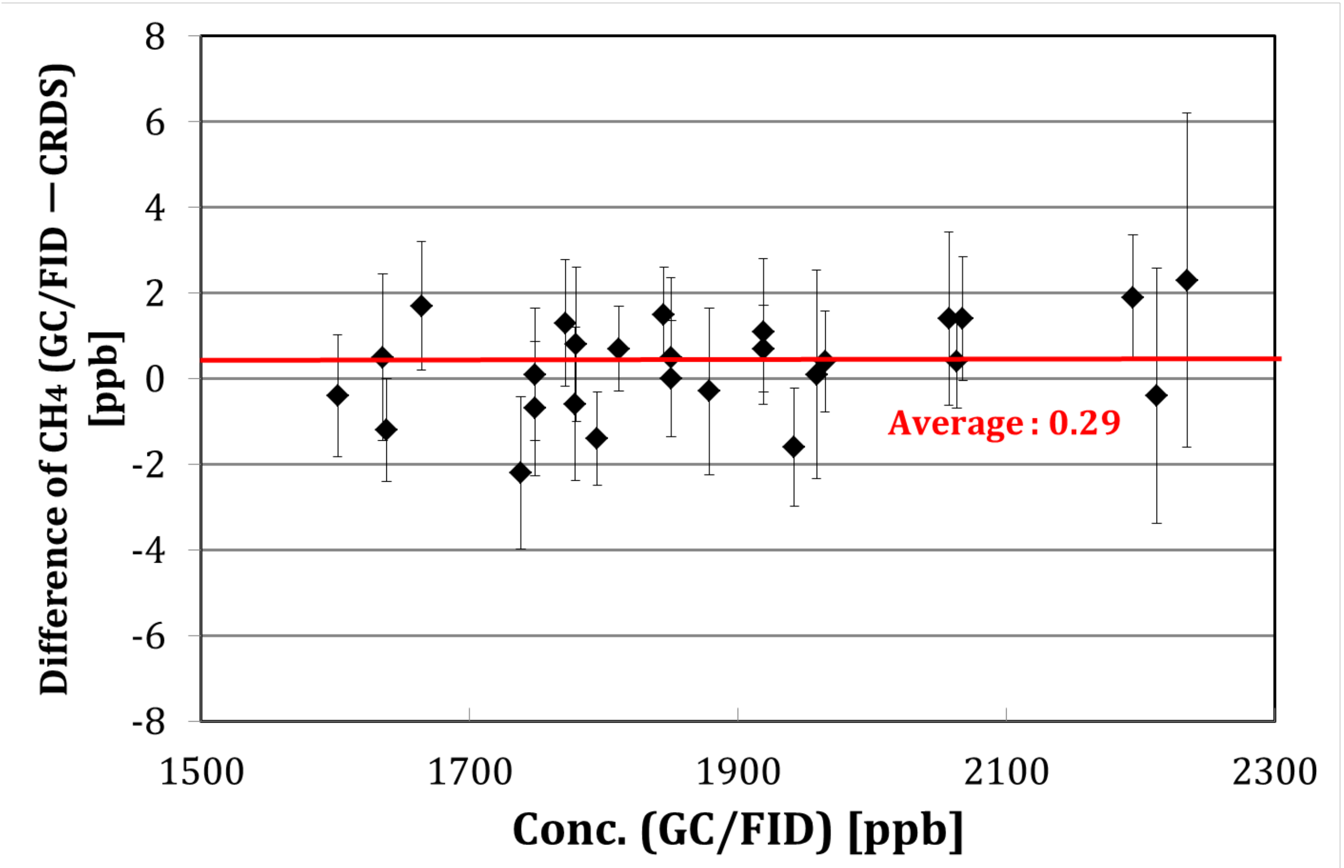
●：WMOスケール　▲：WMOスケールでない



※GAW の目標精度: ±2ppb

気象庁較正装置更新計画

平成28年度　メタン較正装置更新（GC/FID→CRDS）
次年度以降　二酸化炭素較正装置更新（NDIR→CRDS or ICOS）



まとめ

- WMO mole fraction スケール
  測定対象拡大、手法改善による更新

- 巡回比較実験
  観測スケール、測定手法の違いを把握
  継続的な実施

- 技術進歩
  レーザー分光法の普及
  標準ガスの要件（大気組成）