The importance of reference standards in atmospheric GHG monitoring networks

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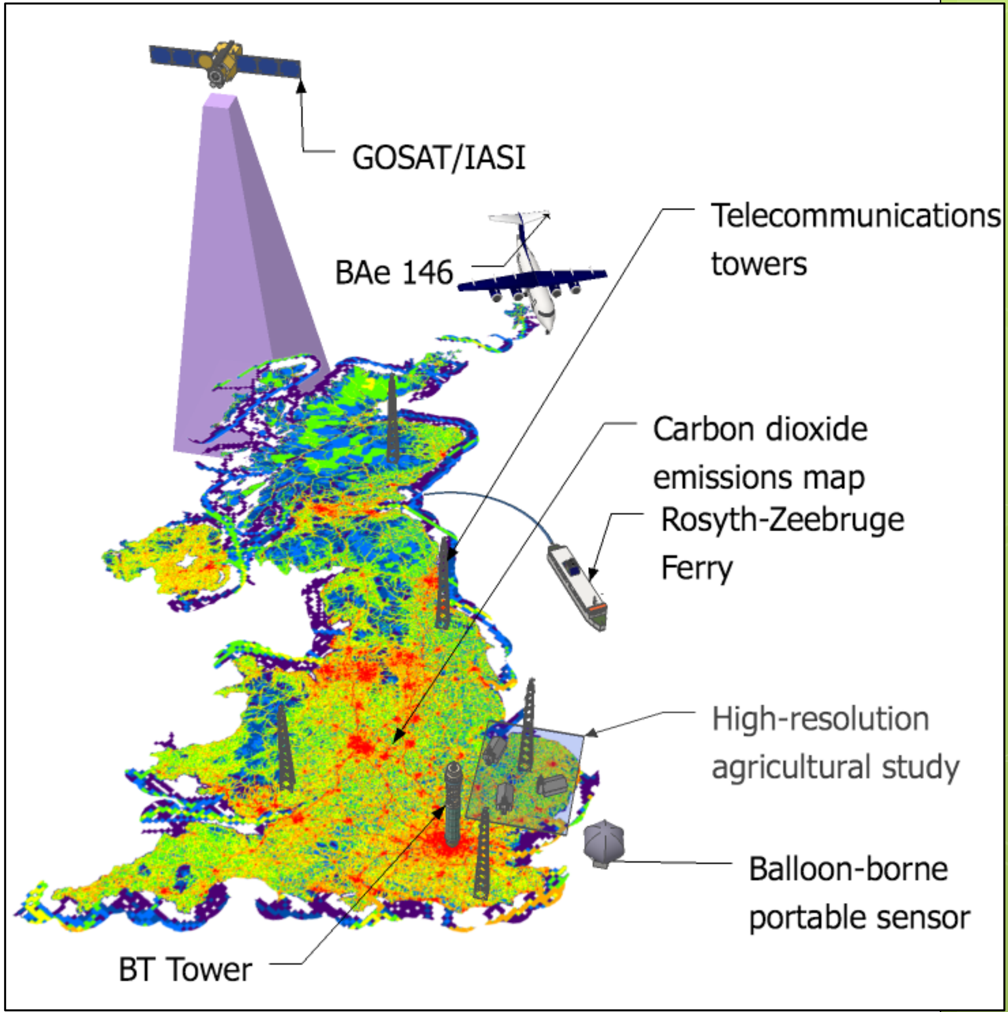
GAUGE Project

- To quantify the UK GHG budget → Emission reduction policies.
- Put the UK GHG budget into a global context.

- Integrating multi-platform and multi-scale (temporal and spatial) data sources.
- Include new sensor technology
- Interpret this new data set using inverse modelling.



Combining data

- Different gases
- Different instruments
- Di ob pl
- Different spatial scales
- Different temporal scales

Common Calibration Scales

Examining Compatibility

Calibration scales

Table: Status of CO_2 Calibration Scales and Intercomparison as of June 2002

Laboratory	Sites (WDCGG Site Index)	Reported Standard Scale	Most Recent Calibration	WMO Round Robin
CSIRO	CGR540S0, CSIRO Flask Network**	WMO	2001-11 at CMDL	91/92, 95/97, 99/00
NIWA	BAR541S0	SIO 1995	1995-11 at SIO	91/92, 95/97, 99/00
CAMS	WLG236N0	X93	1994-01 at SIO	95/97, 99/00
METRI/SNU	KSN233N0	X97	SIO	95/97
JMA	NMN224N0, RYO239N0, YON224N0, ALG99990, EOM99990, RYF99990	WMO	1999-03 at CMDL	91/92, 95/97, 99/00
MRI	TKB236N0, INS9999A, HKH99990, KIY99990, NTU99990, RFM99990, WLT99990	MRI 1997		91/92, 95/97, 99/00
NIES	COI243N0, HAT224N0	NIES 95		95/97, 99/00
Tohoku	SYO769S0	Tohoku		91/92, 95/97, 99/00
Shizuoka	HMM234N0		Nippon Sanso	
Aichi	MKW234N0	WMO	JMA	
Saitama	DDR236N0, URW235N0	WMO	JMA	
CMDL	BRW471N0, MLO519N0, SPO789S0, SMO514S0, CMDL flask network*	WMO	2001-01 at CMDL	91/92, 95/97, 99/00
NIST		NIST		91/92, 95/97, 99/00
SIO		SIO		91/92, 95/97, 99/00
MSC	ALT482N0, CSJ451N0, SBL443N0	SIO 1991	2000-03 at CMDL	91/92, 95/97, 99/00
IGP	HUA312S0	X81		
MGO	BER255N0, KOT276N0, KYZ240N0, STC652N0, TER669N0	X97	1991 at SIO	
KSNU	ISK242N0		MGO	
INM	IZA128N0	X87, X93	1997-01 at CMDL	91/92, 95/97, 99/00
LSCE	AMS137S0, MCH653N0	X93	1998-08 at CMDL	91/92, 95/97, 99/00
IMS	CMN644N0	X93	1998-10 at CMDL	91/92, 95/97
ENEA	LMP635N0	X93	2000-08 at CMDL	91/92, 95/97, 99/00
CNR	JBN762S0	WMO	ENEA	
CESI	PLR645N00	X85	1997-07 at CMDL	99/00
UBA	BRT648N0, DEU649N0, NGL653N0, SSL647N0, LGB652N0, WST654N0, ZGT654N0, ZGP647N0	WMO	1998-10 at CMDL	91/92, 95/97, 99/00
Heidelberg		WMO	1998-10 at CMDL	95/97, 99/00
IFU	WNK647N0, ZSP647N00	SIO 1974		99/00
ZAMG	SNB647N00	WMO	UBA	
RIVM	KMW653N0	NIST		
MISU/NILU	ZEP678N0	X93	1996-07 at CMDL	95/97, 99/00
HMS	KPS646N0	WMO 1985	2000-03 at CMDL	91/92, 95/97, 99/00
NIMH	FDT645N20		SIAD SpA, Italy	
SAWS	CPO134S0	WMO	1997-06 at CMDL	99/00

Calibration scales

Fixed set of reference standards to which the measurements can be traced

Typically manometrically or gravimetrically produced

CO_2	CH_4	N_2O
WMOx2007	WMOx2004A	WMOx2006A
BOC	WMOx2004	AGAGE SIO-98
	NPL	
	BOC	

Calibrated through two intermediary laboratories (MPI & EMPA)

Determining scaling factors

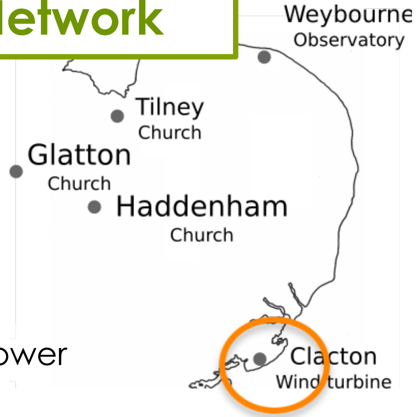
Examining compatibility

Intercomparison program (ICP)

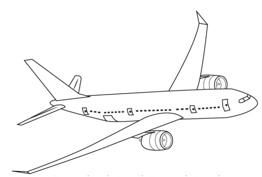
- Three cylinders
- Concentration range
- Measured at each location
- Same tubing and regulators
- Quantifying instrumental & calibration differences

UK Network

Regional Network



Mobile Platforms

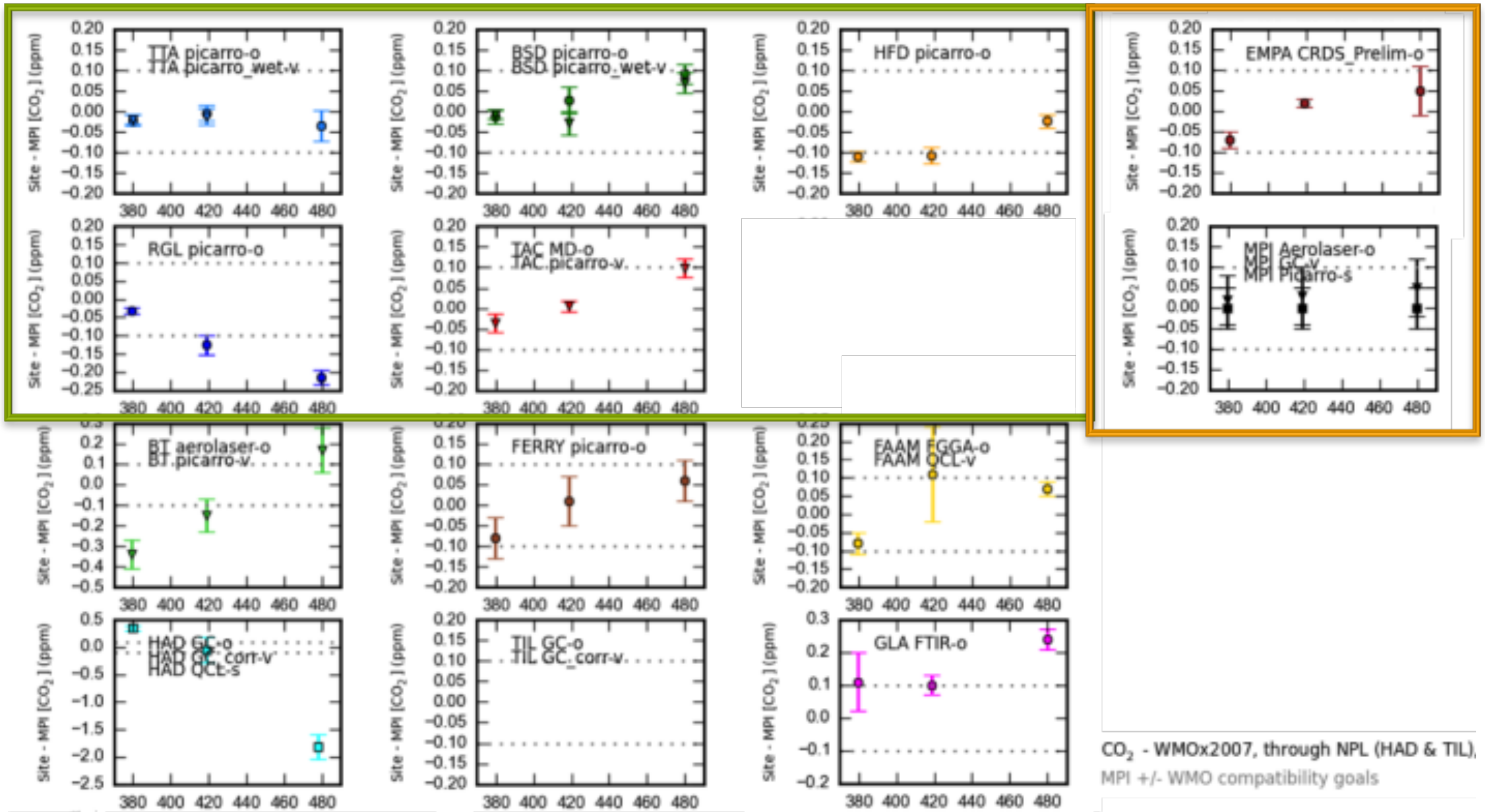


Calibration centres

EMPA

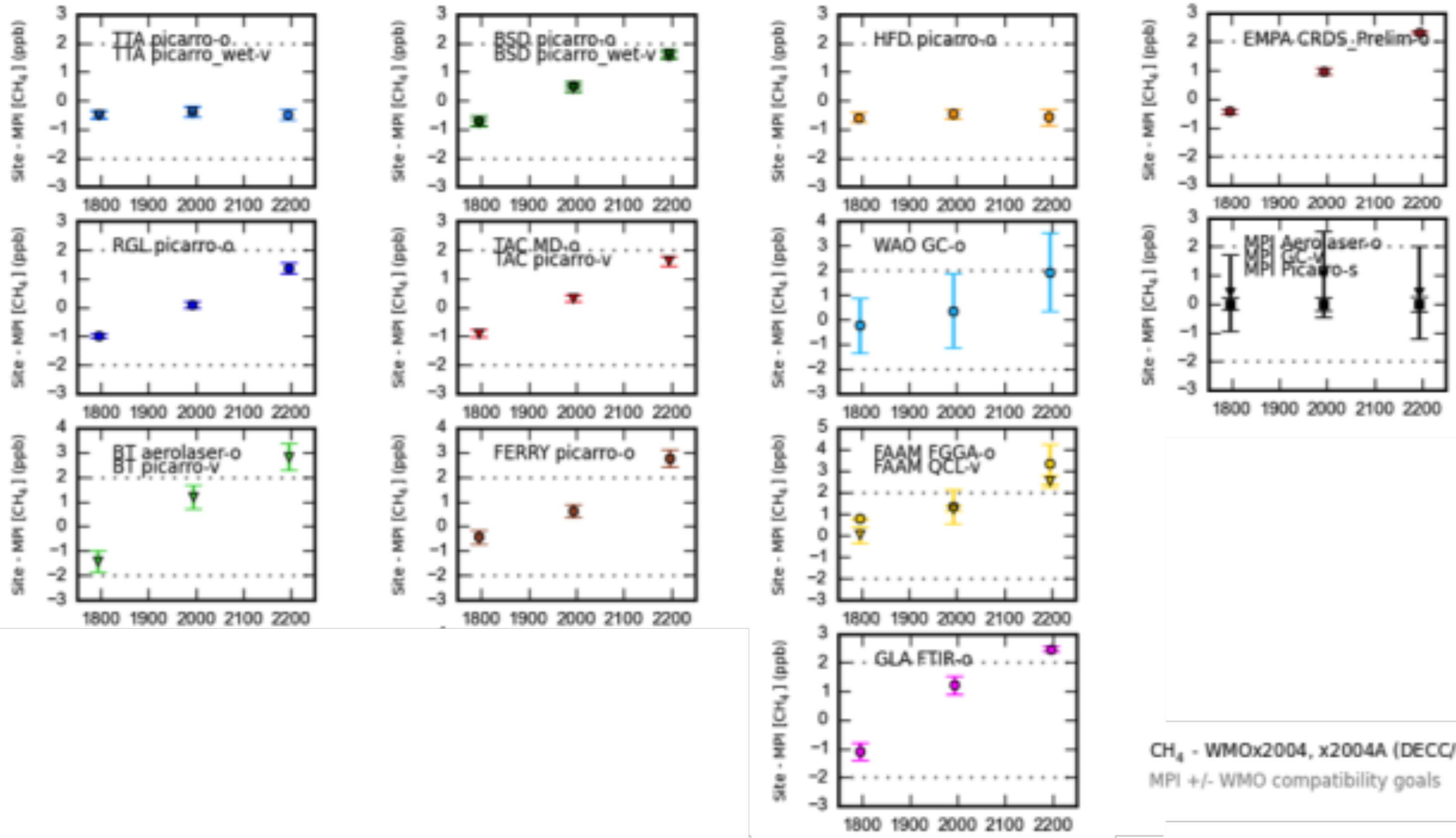
MAX-PLANCK-GESELLSCHAFT

CO_2 - Compatibility



CO_2 - WMOx2007, through NPL (HAD & TIL),
MPI +/- WMO compatibility goals

CH_4 - Compatibility



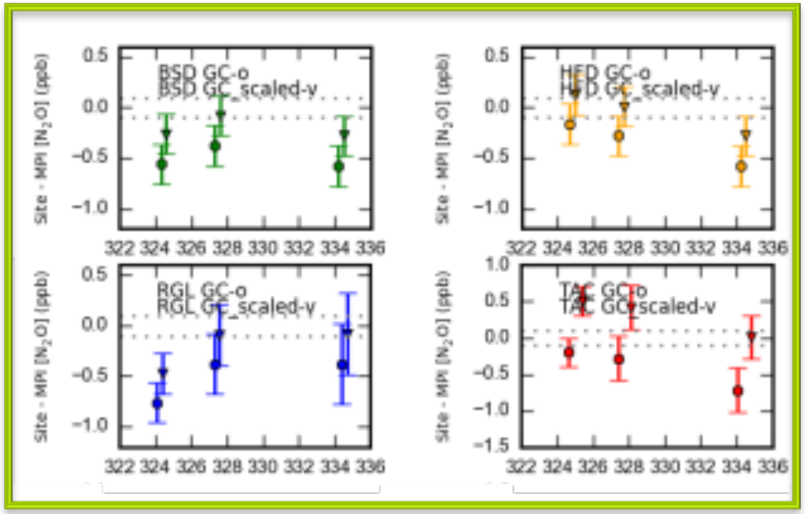
CH_4 - WMOx2004, x2004A (DECC/GAUGE/FERRY)

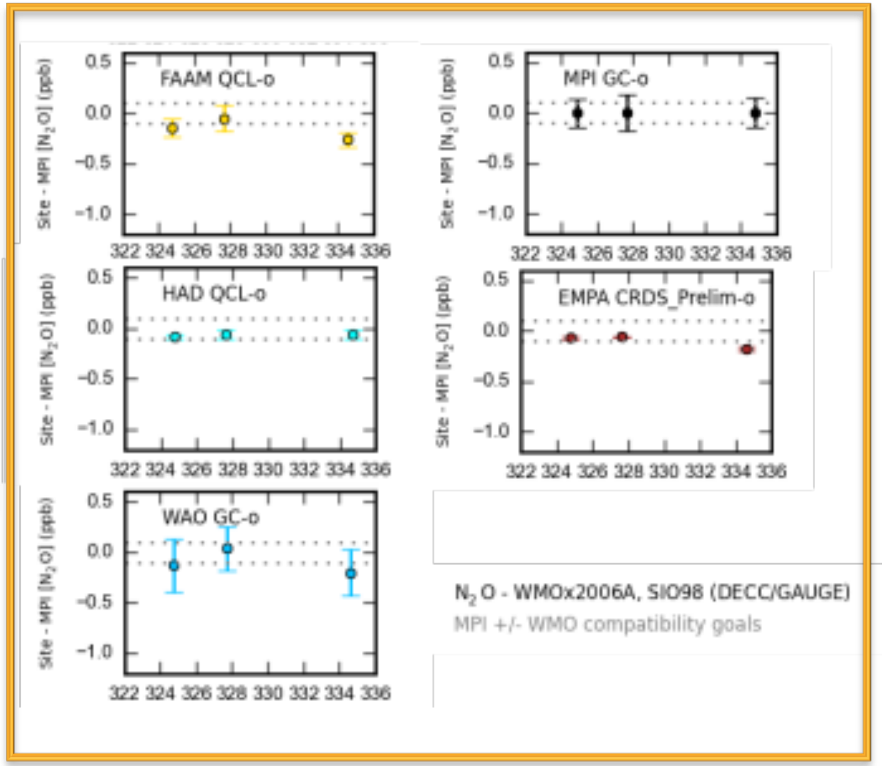
MPI +/- WMO compatibility goals

MPI & EMPA divergence?

Site	Trend	Via	Instrument	Year
TTA	No	MPI	CRDS	2014
RGL	Yes	MPI	CRDS	2011
TAC	Yes	MPI	CRDS	2011
BSD	Yes, strong	EMPA	CRDS	2015
BT	Yes, strong	EMPA	CRDS	2014
Ferry	Yes, strong	EMPA	CRDS	2014
FAAM	Yes, strong	EMPA	CRDS	2014
GLA	Yes, strong	EMPA	CRDS	2014
WAO NCAS	Yes, strong	NOAA direct	NDIR	-
ICP's	-	MPI	CRDS	2013

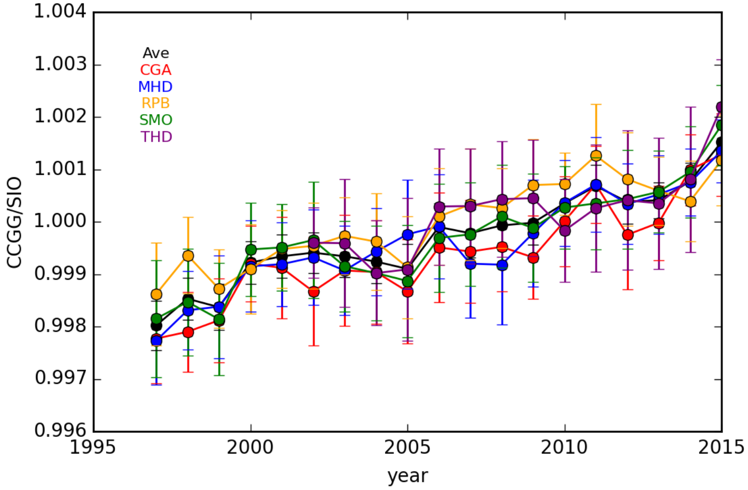
N_2O - Compatibility

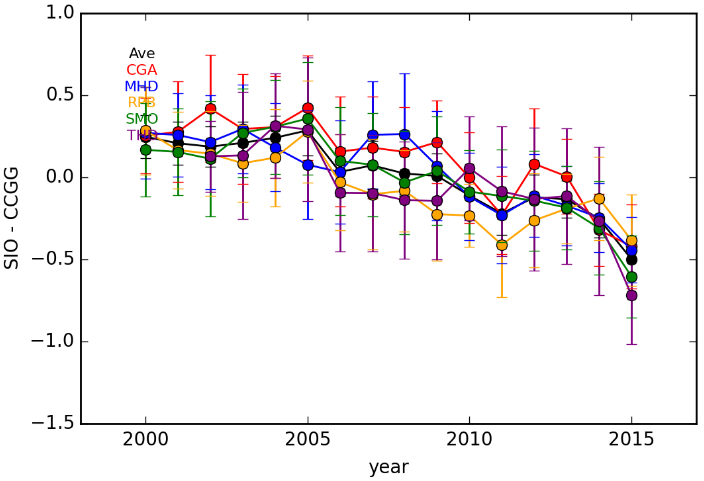




N_2O – Compatibility

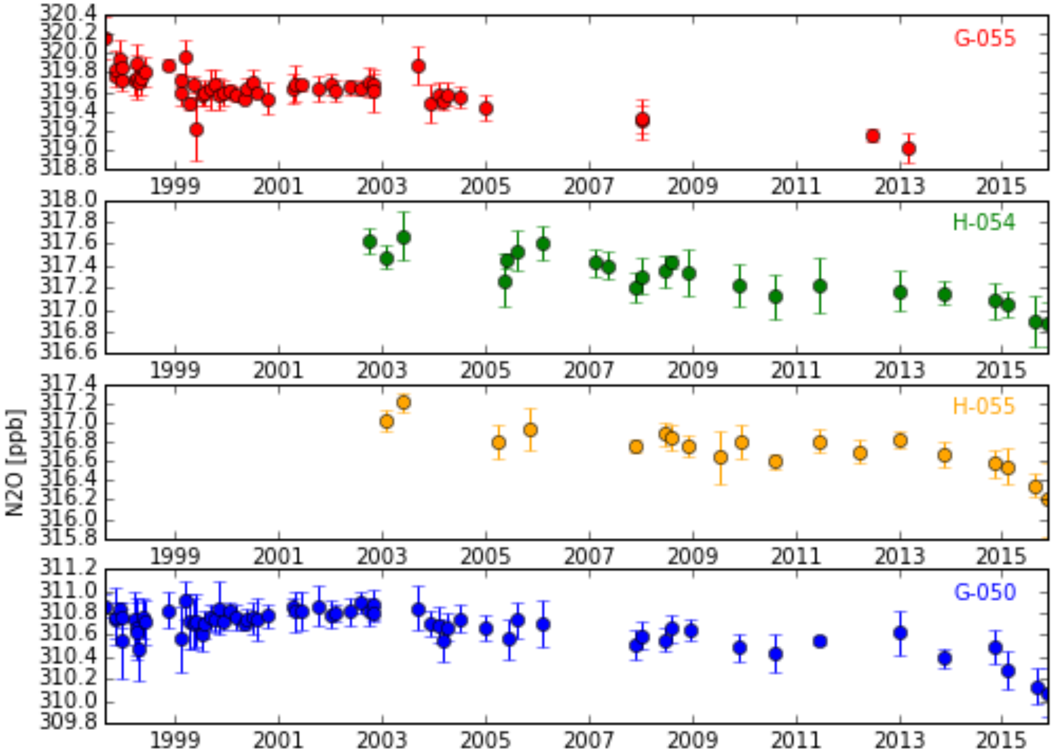
Scaling factors



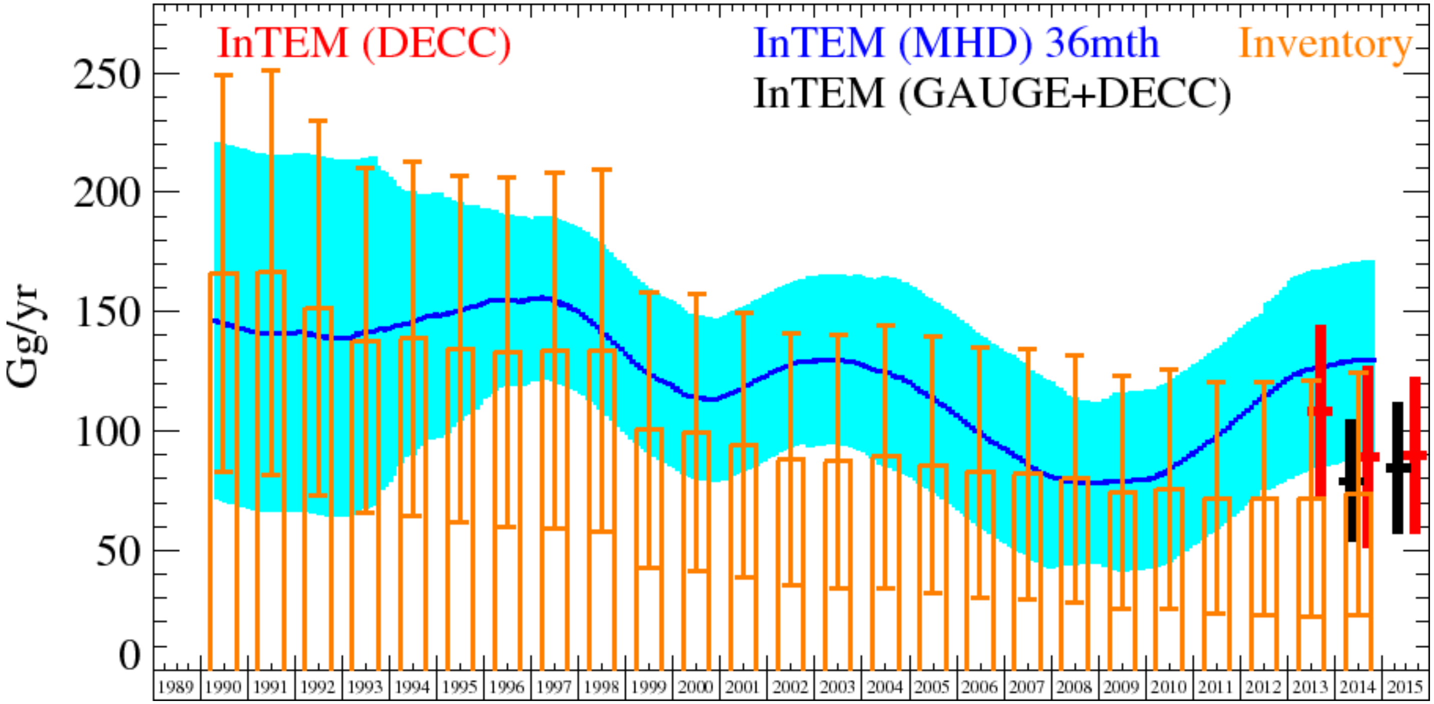


- Fixed annual factor based on flask/in situ comparison at co-located AGAGE (SIO) and CCGG (WMO) sites.
- CCGG measurements only collected in "baseline" periods so typically only looking at concentrations near ambient and the concentration is increasing over time.

N_2O – Compatibility
Scaling factors



Importance of reliable reference standards



Standard requirements

Gases & Analytical Techniques

- Bulk gases matched to natural air particularly important for optical techniques
- Useful concentration ranges – e.g. NMHC currently only 6 ppb in N_2 available need 0.5 to 6 ppb in natural air
- Isotopic composition matched to sample
- Calibration/recalibration needs to be quick!

Standard requirements

Practicalities and Multiplatform networks

- Space
  - Multispecies standards – not just CO_2, CH_4 and N_2O also CO, SF_6, HFC's CFC's…
- Cylinder size
  - Small for Ferry/Church/Aircraft
  - Large for long term trend observations at fixed sites
- Cost
  - Typically need at least 4 cylinders (up to 7 for some approaches) per site
  - Recalibrated multiple times within the life of the cylinder

- Networks
  - Known scaling factors or comparisons to link with other scales

Acknowledgments

Met Office

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