Report from SIRS and STELLAR

Isotope ratio Working Group Meeting

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Partners

Climate Change

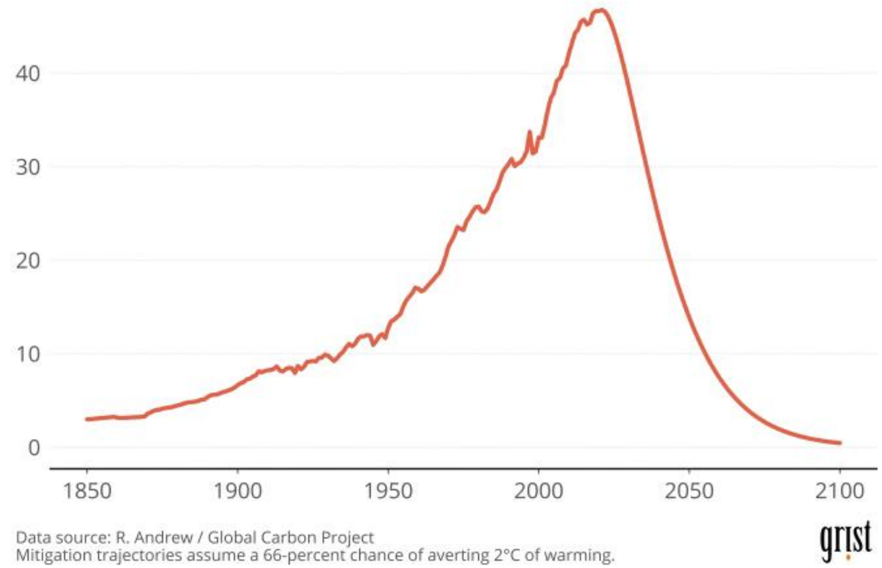
- Mathematical illustration - pain brought on society by delaying climate action
- Constrained by a budget - every year of over-emitting requires sharper curtailing in following years
- Taking action lowers the peak and makes for a more gentle decline over the rest of the century
- If emissions had peaked a little after the turn of the millennium, reductions of around 2 % annually
- But they're still rising…
- Annual reduction required now closer to 8 % (on par with lockdown emission decrease)

The importance of scientific intervention

- Coronavirus curve shows what happens over time due to policy responses
- If communities limit virus spread and distribute incidence over time, hospitals not overwhelmed
- Climate mitigation curves tell a similar story but it is about more than health systems
- The steeper curve generated by delaying climate action overwhelms whole economies and imaginations (implement what it would take to cut emissions by, e.g. 20 % per year)

Carbon dioxide emissions, in gigatons, required to limit warming to 2°C, if climate action were taken in 2019

Situation more stark for 1.5 °C



https://grist.org/climate/flatten-the-curve-coronavirus-climate-emissions/

Metrology for isotopes to underpin source apportionment

Why?

- To enable government to verify emissions (discriminate between natural and anthropogenic sources of greenhouse gases) requires information on isotopic composition
- No infrastructure to deliver gas reference materials for CO_2 and CH_4 with uncertainties to meet demand and underpin isotope ratio measurements

Why now?

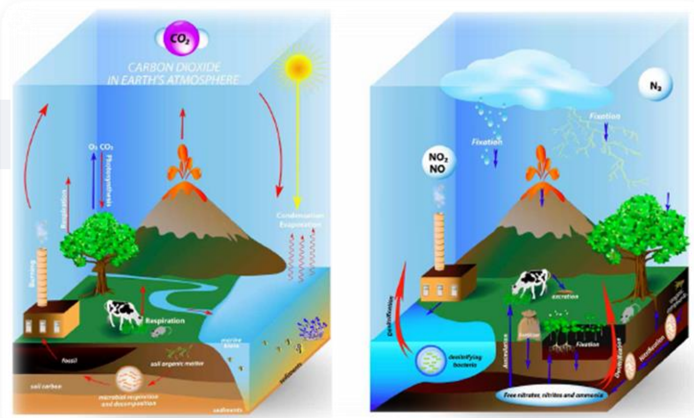
- New measurement technologies and applications
- Changes in primary reference materials
- Conventional vs. absolute (SI traceable) measurements

NPL setting the international metrology agenda

SIRS

δ^2H $\delta^{13}C$ STELLAR

CCQM IRWG



Metrology for isotopes to underpin source apportionment

Fundamental metrology

Initiate SI traceability of the international CO_2 isotope ratio scale by re-measuring the absolute isotope ratios by high-resolution gas-source isotope ratio mass spectrometry, combined with gravimetric mixing

Traceability

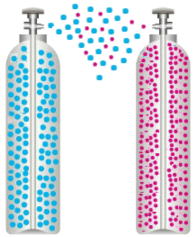
New mechanisms to disseminate and maintain continuity to the existing primary scale for CO_2 and CH_4

Enabling innovation

Provide reliable field-based measurements, develop new generation field-deployable optical spectroscopy, characterise uncertainty and traceability linked to isotopic measurements

Provide the scientific information to enable government to develop accurate emission inventories and models to challenge and inform new policy, improve abatement strategies and ensure government funding is directed more efficiently to achieve net zero

Objectives



WP1

RMs pure CO_2 for $\delta^{13}C$-CO_2 and $\delta^{18}O$-CO_2

Static and dynamic RMs of CO_2 at 400 µmol mol^{-1}

Validation of RMs and comparisons (VPDB)

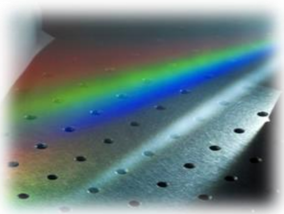
Absolute measurements

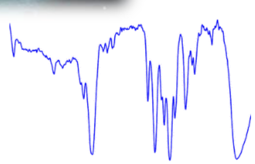
WP2

Link $\delta^{15}N$, $\delta^{18}O$ and ^{15}N site preference in N_2O to the international stable isotope ratio scales

RMs for $\delta^{15}N$, $\delta^{18}O$ and ^{15}N site preference in N_2O

Static and dynamic mixtures at 300 to 1000 nmol mol^{-1} for instrument calibration



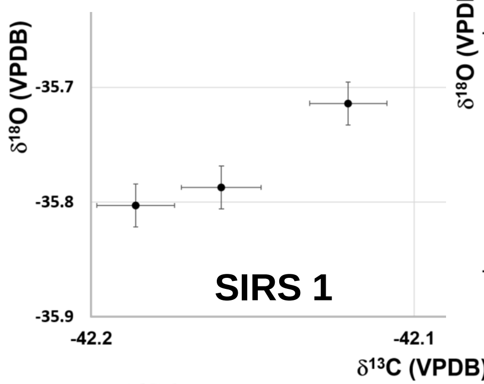


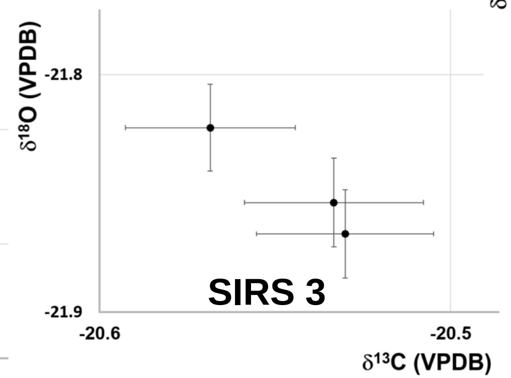
WP3

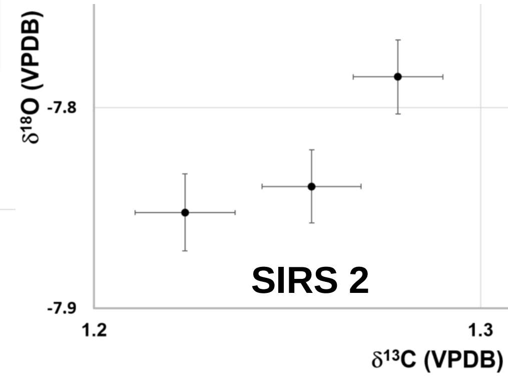
Spectroscopic methods for isotope ratio measurements

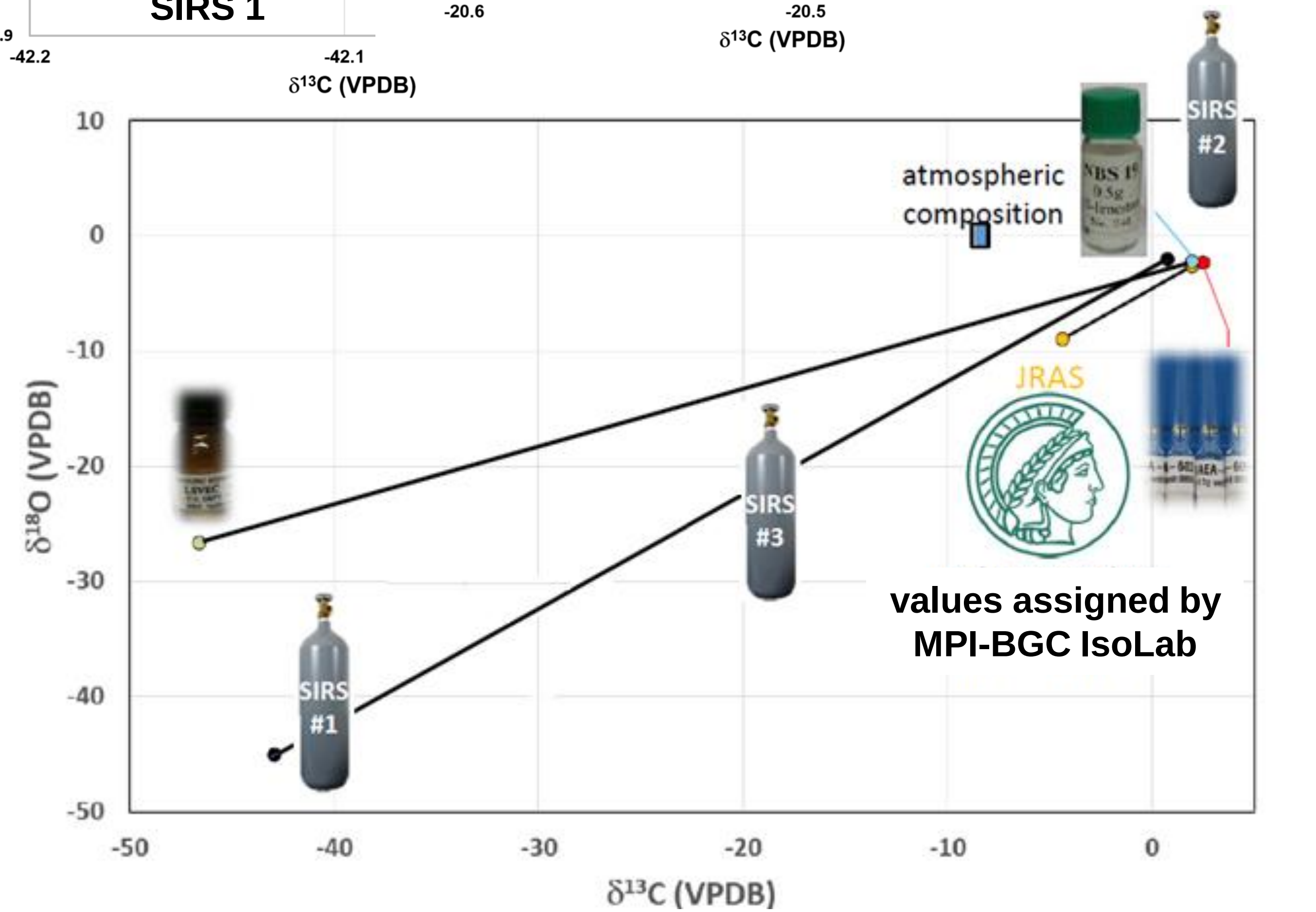
Comparison of methods

CO_2 reference materials



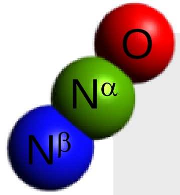


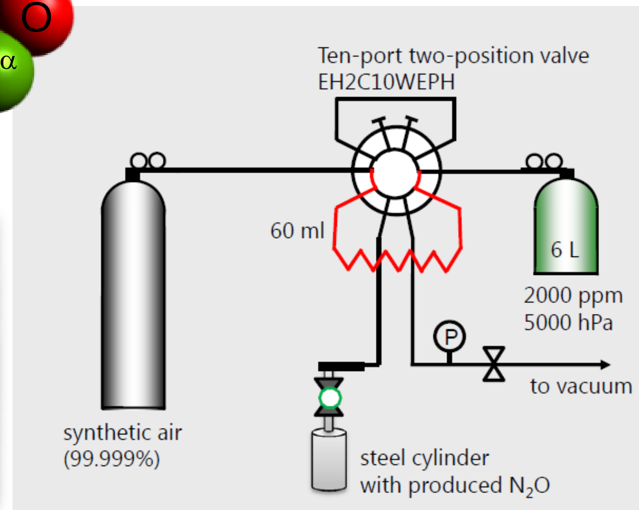


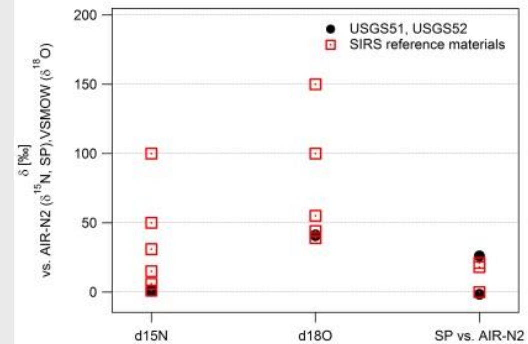


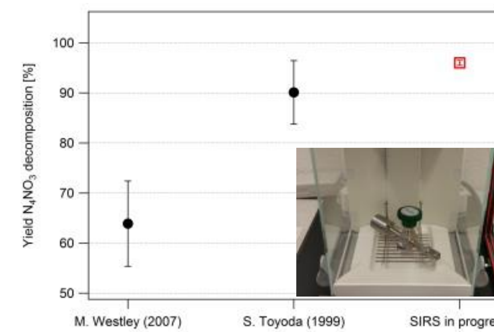
N_2O reference materials

$$NH_4NO_3 \xrightarrow{270\ °C} N^{\beta}N^{\alpha}O + 2\ H_2O$$

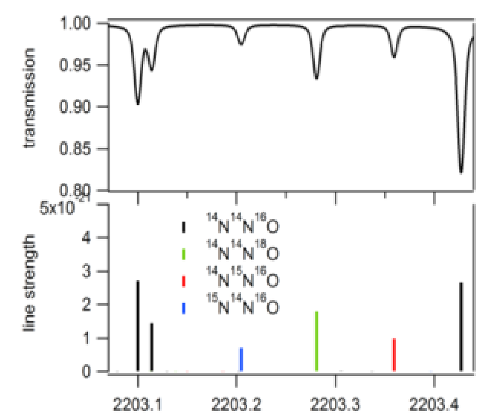






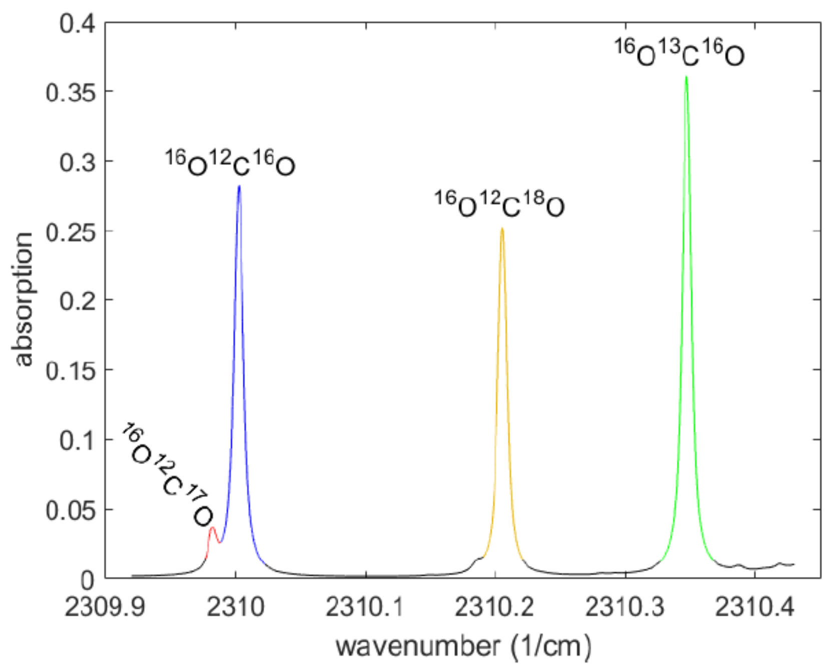


- Technique developed to characterise N_2O for $\delta^{15}N$, $\delta^{18}O$ by IRMS
- Novel technique for N_2O SP achieves higher yield / reproducibility
- 6 RMs prepared by spiking of commercial N_2O and
- currently characterised for $\delta\ ^{15}N$, $\delta\ ^{18}O$, SP by IRMS and OIRS
- Static dilution system for N_2O RMs developed for instrument calibration



Spectroscopy

- Two IR laser based commercial isotope analysers for CO_2 have been tested and characterised
- Achieved precision on the level of 0.01 ‰ for $\delta^{13}C$ and $\delta^{18}O$ in air-CO_2 samples
- Investigation of matrix gas effect has been initiated to improve accuracy
- An FTIR based method for $\delta^{13}C$-CO_2 determination in air-CO_2



- Construction of the field-deployable CO_2 isotope analyser for atmospheric measurements and isotope analyser for pure N_2O
- Commercial optical isotope analysers for N_2O have been characterised

From SIRS to STELLAR

	SIRS	STELLAR	BEYOND
CO_2 reference materials (scale traceability)	Uncertainties 0.1 ‰ ($\delta^{13}C$-CO_2) and 0.5 ‰ ($\delta^{18}O$-CO_2)	Uncertainties 0.05 ‰ ($\delta^{13}C$-CO_2) and 0.1 ‰ ($\delta^{18}O$-CO_2)	Uncertainties 0.01 ‰ ($\delta^{13}C$-CO_2) and 0.05 ‰ ($\delta^{18}O$-CO_2)
CH_4 reference materials (scale traceability)	-	Uncertainties 0.2 ‰ ($\delta^{13}C$-CH_4) and 5 ‰ ($\delta^{2}H$-CH_4)	Uncertainties 0.02 ‰ ($\delta^{13}C$-CH_4) and 1 ‰ ($\delta^{2}H$-CH_4)
N_2O reference materials (scale traceability)	1.0 ‰ ($\delta^{15}N^{\alpha}$ and $\delta^{15}N^{\beta}$) and 0.5 ‰ ($\delta^{18}O$)	-	-
SI traceability	Re-measure the absolute CO_2 isotope ratios	Uncertainties 0.1 ‰ ($\delta^{13}C$-CO_2) and 0.1 ‰ ($\delta^{18}O$-CO_2)	Uncertainties 0.01 ‰ ($\delta^{13}C$-CO_2) and 0.05 ‰ ($\delta^{18}O$-CO_2) Uncertainties 0.02 ‰ ($\delta^{13}C$-CH_4) and 1 ‰ ($\delta^{2}H$-CH_4)
Spectrocopic methods	Precision 0.1 ‰ ($\delta^{13}C$-CO_2 and $\delta^{18}O$-CO_2), N_2O ($\delta^{15}N^{\alpha}$, $\delta^{15}N^{\beta}$ and $\delta^{18}O$) Precision N_2O ($\delta^{15}N^{\alpha}$, $\delta^{15}N^{\beta}$ and $\delta^{18}O$)	Precision 0.05 ‰ ($\delta^{13}C$-CO_2 and $\delta^{18}O$-CO_2) Precision 0.2 ‰ ($\delta^{13}C$-CH_4) and 1 ‰ ($\delta^{2}H$-CH_4)	Precision 0.01 ‰ ($\delta^{13}C$-CO_2 and $\delta^{18}O$-CO_2) Precision 0.02 ‰ ($\delta^{13}C$-CH_4) and 1 ‰ ($\delta^{2}H$-CH_4)

STELLAR: Stable Isotope Metrology to Enable Climate Action and Regulation

- To support governments to verify emissions need to discriminate between natural and anthropogenic sources of greenhouse gases
- Requires information on isotopic composition
- No infrastructure to deliver gas reference materials for CO_2 and CH_4 with uncertainties to meet demand and underpin isotope ratio measurements
- Address advances in spectroscopy and robustness of scale