The use of isotopic observations of the major greenhouse gases for the source attribution

Oksana Tarasova
WMO Research Department

WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

WMO OMM
World Meteorological Organization
Organisation météorologique mondiale

GAW

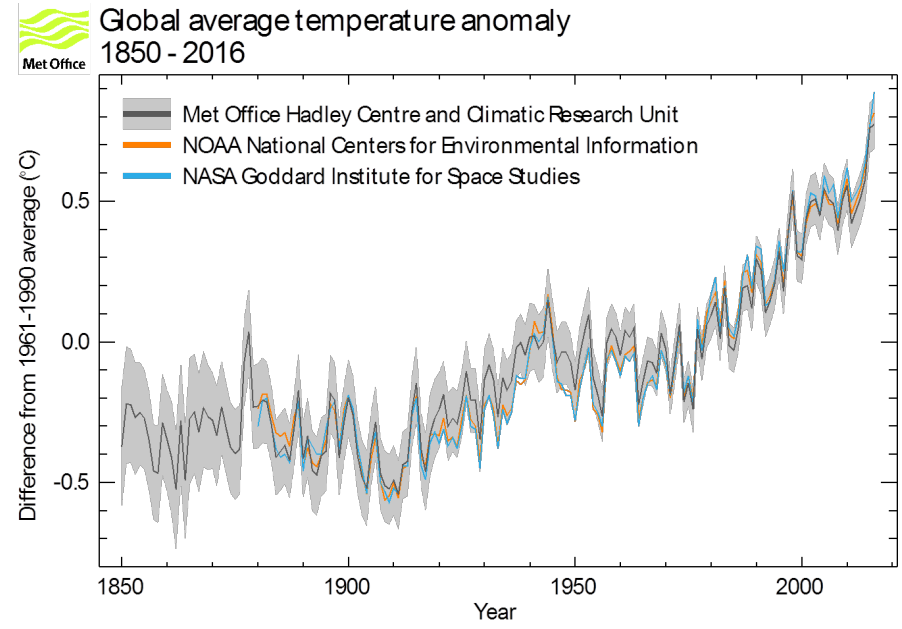
Paris agreement to address climate change

- Ambition to limit warming **to well below 2 °C above pre-industrial levels** while **pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels**
- Builds on **Nationally Determined Contributions** (NDCs) from Parties to the UNFCCC, a crucial step towards common objective
- Countries invited to update emission targets by 2020 and every five years
- **Transparency** and reporting on national progress

Players: state stakeholders (national governments), non-state stakeholders (private sector, city governments)

COP21 · CMP11
PARIS 2015
UN CLIMATE CHANGE CONFERENCE

The stakeholders need information **what** emissions to cut, **where, how much**, and if they did so was there any desirable **effect** achieved



2016 was the warmest on record – a remarkable **1.1 °C** above the pre-industrial period

WMO OMM

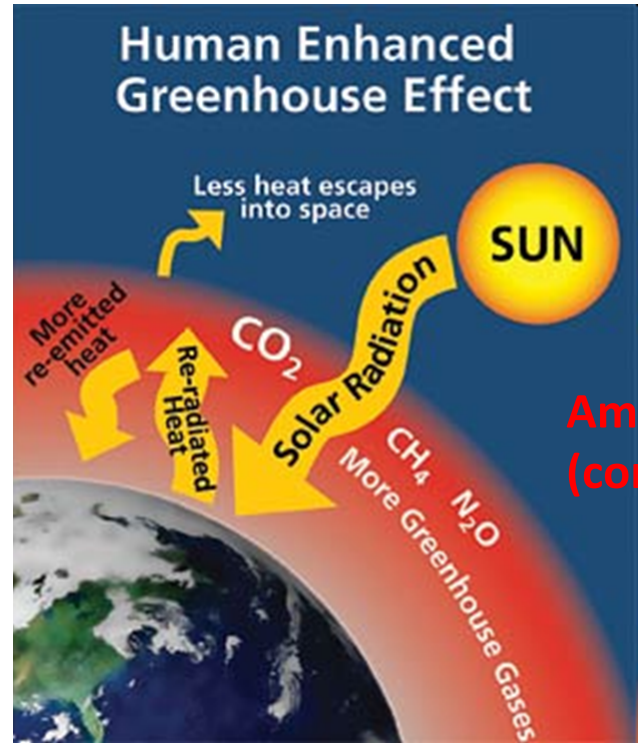
Emissions and concentrations

Paris Agreement aims to achieve 2C by controlling **emissions**

National emissions are calculated following IPCC Guidelines

category	number	Total per category
transport	NN	XX Gt
Energy	NN	XX Gt
Agriculture	NN	XX Gt
….	…	…
Total		YY Gt

Commitments (e.g. NDC):
e.g x**% of YY Gt**



temperature

radiation

Amount of gases (concentrations!!!)

16.4 GtCO2


+34.1 GtCO2


-11.6 GtCO2

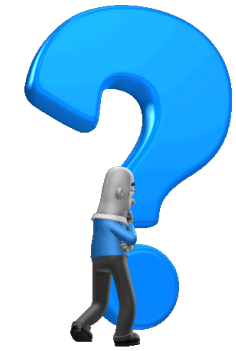

+3.5 GtCO2


-9.7 GtCO2

IN **OUT**

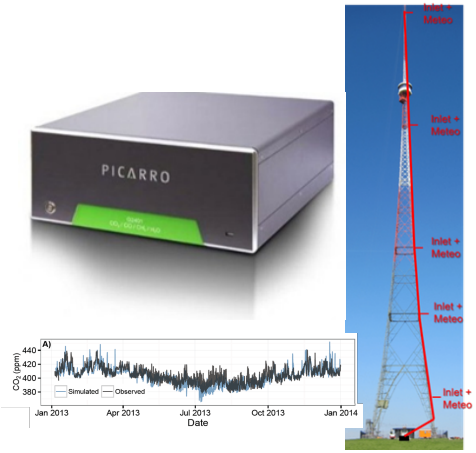
WMO OMM

Can science provide a solution?



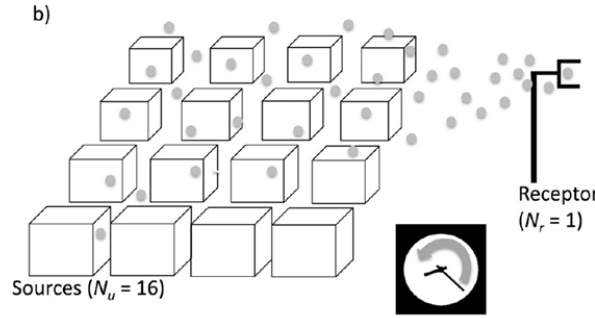
Yes! Let's add the atmosphere into the equation:

Observations of greenhouse gases



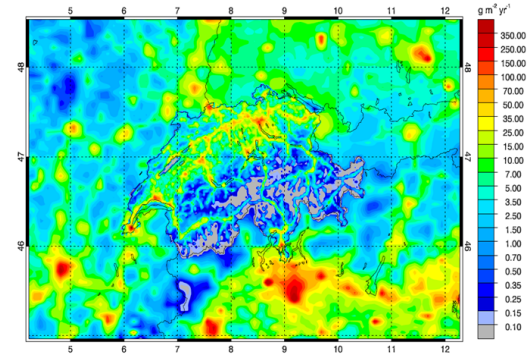
X

Transport modelling



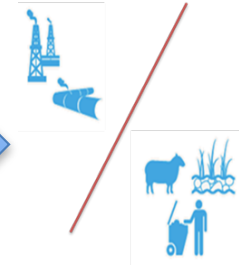
X

Emission inventory



= **ADDITIONAL information on emissions**

Attribution???



Best practices and key principles are documented in the Science Implementation Plan for the Integrated Global Greenhouse Gas Information System (IG3IS) established by the World Meteorological Organization

WMO OMM

Units

^{1}H	^{12}C	^{14}N	^{16}O
99.985%	98.9%	99.63%	99.75%
^{2}H	^{13}C	^{15}N	^{17}O
0.015%	1.1%	0.37%	0.038%
^{3}H	^{14}C		^{18}O
$< 10^{-15}$%	$< 10^{-10}$%		0.21%

Isotope ratio

$$R^{18} = \frac{^{18}O}{^{16}O}$$

$$R^{15} = \frac{^{15}N}{^{14}N}$$

δ-notation

$$\delta^{18}O = \left[\frac{R^{18}_{SA}}{R^{18}_{STD}} - 1\right] * 1000\ ‰$$

$$\delta^{15}N = \left[\frac{R^{15}_{SA}}{R^{15}_{STD}} - 1\right]$$

Goals of isotope measurements

Information on sources

… and sinks

OH Cl UV

… and transport

Deposition

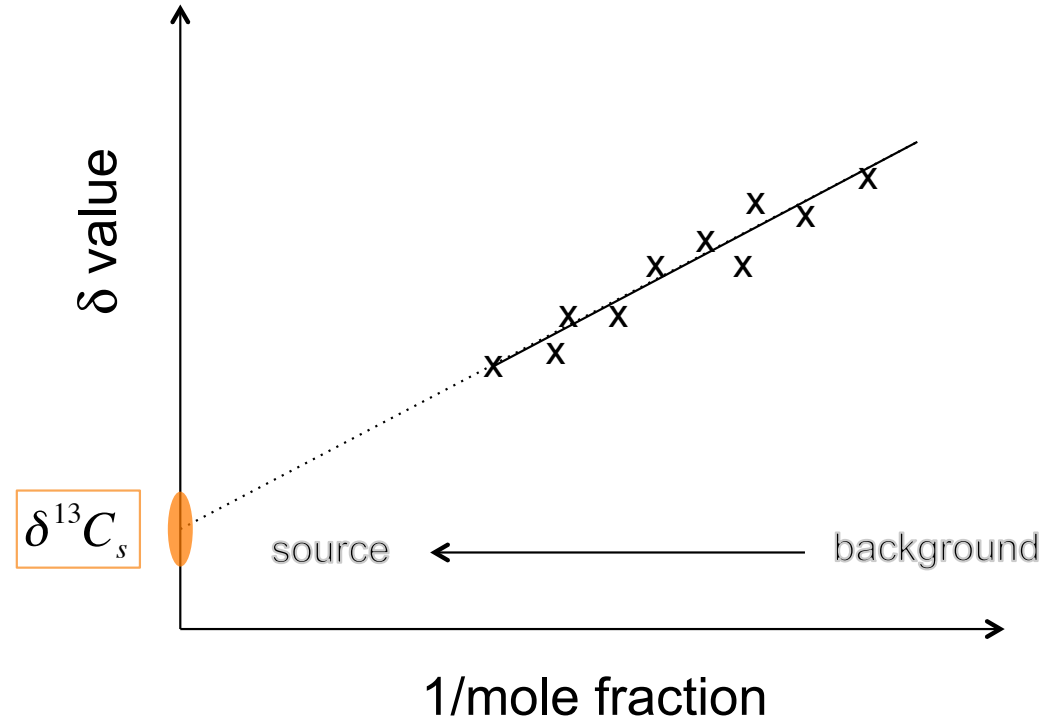
Loss to stratosphere

Global cycles of H, C, N, O – containing compounds in the atmosphere

CO_2 : ^{13}C, ^{14}C, ^{18}O, ^{17}O

CH_4 : ^{13}C, ^{2}H

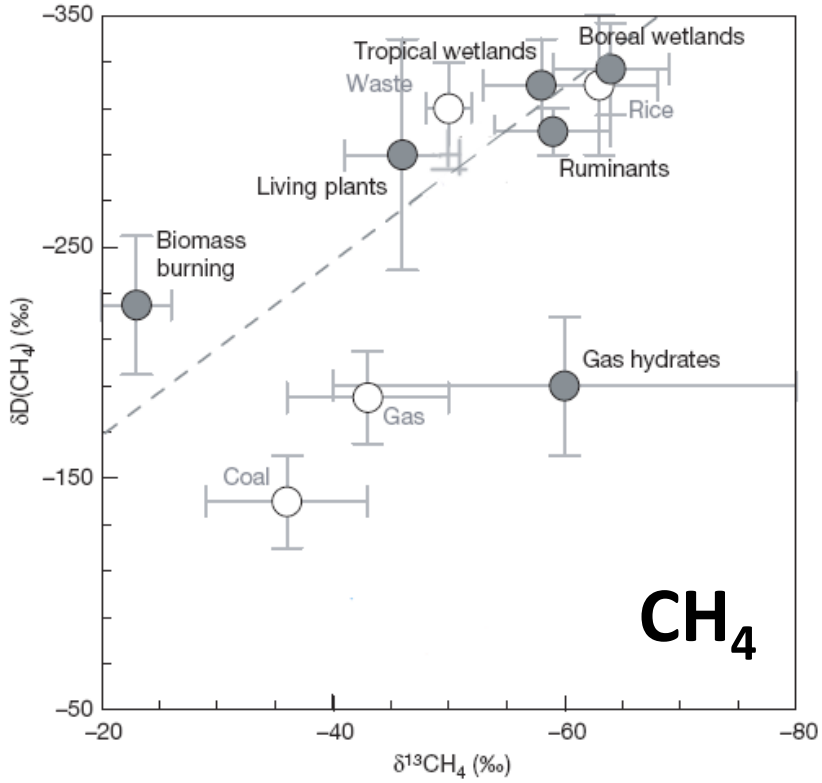
N_2O : ^{15}N, ^{18}O



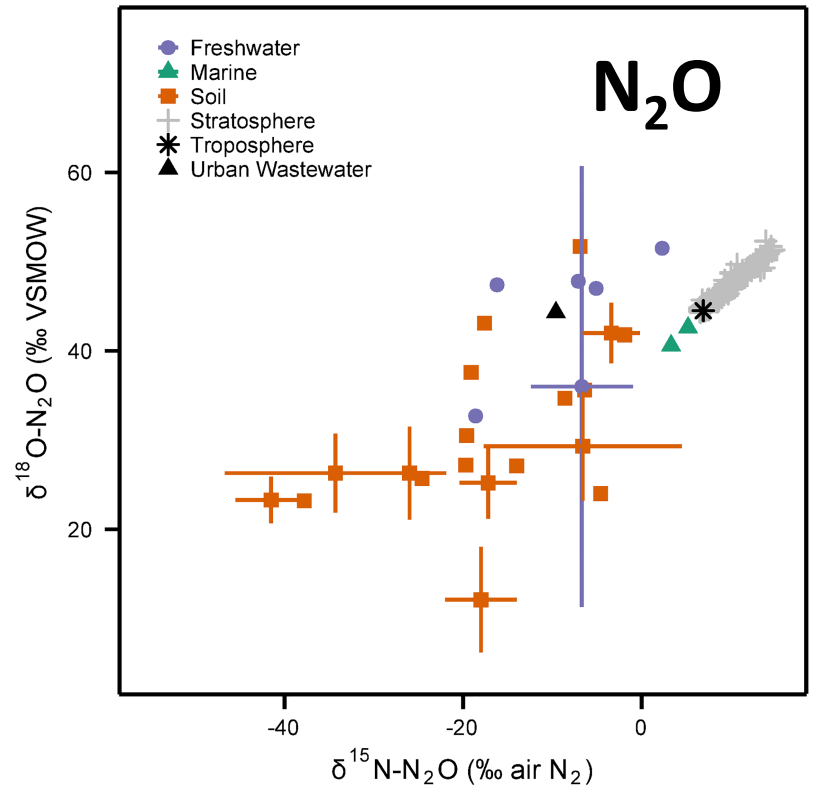
Two components mixture approach

WMO OMM

How to distinguish the sources?



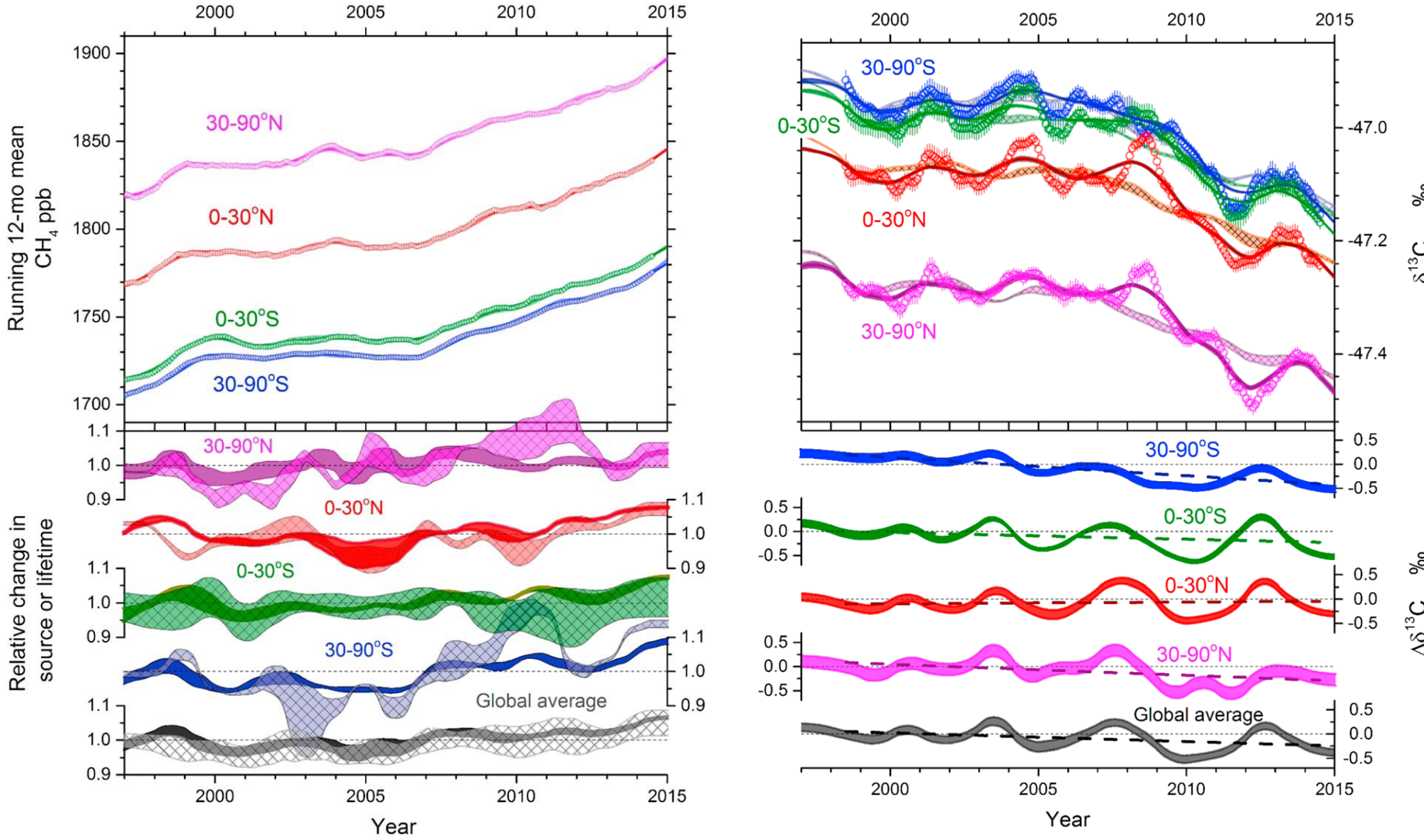
(Fischer et al., 2008)



(Emission-weighted average $\delta^{15}N\text{-}N_2O$ and $\delta^{18}O\text{-}N_2O$ from continental and marine environments from Snider et al.,2015)

The sources are mixed with each other and with a background => several samples with the different contribution of the same source can be used

Global methane changes attribution

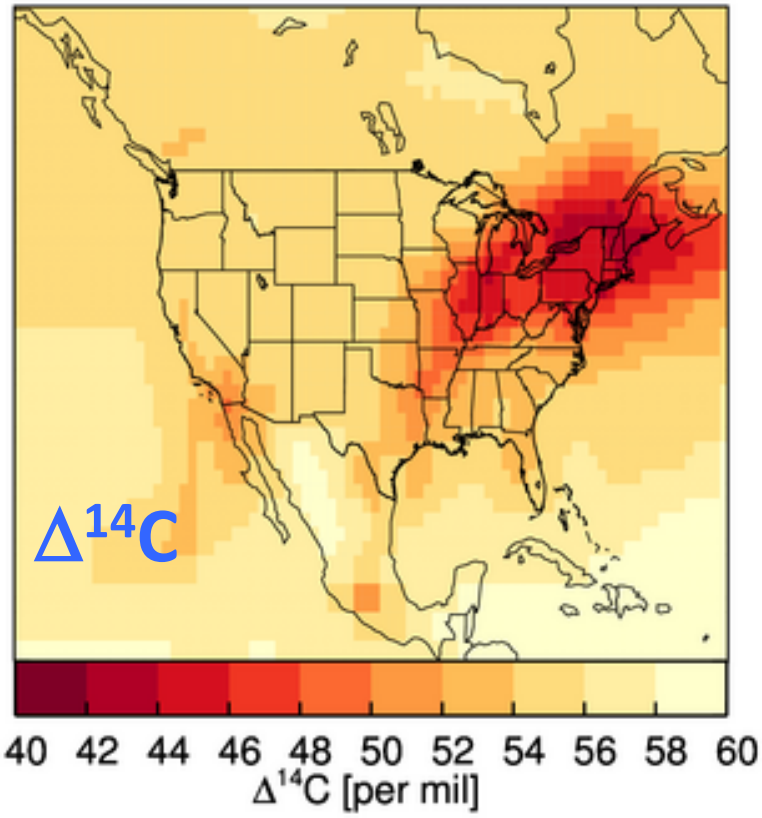


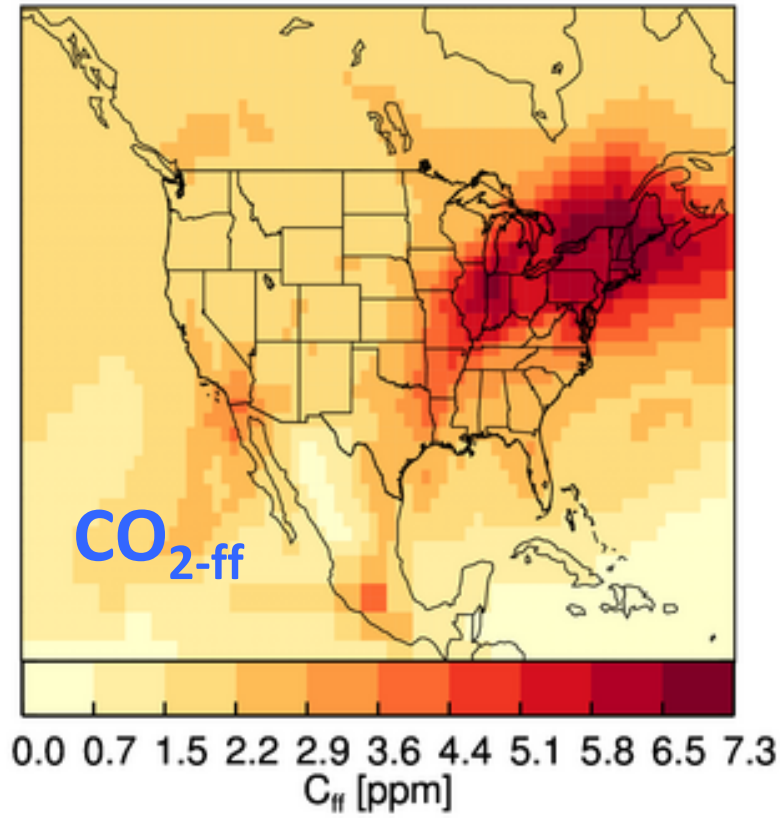
(From Nisbet et al., 2016)

Fossil fuel CO_2 emissions attribution

$^{14}CO_2$:$^{12}CO_2$ ($\Delta^{14}C$) is a robust tracer for fossil fuel fluxes:

$\Delta^{14}C_{ff}$ = -1000 per mil (i.e. zero ^{14}C)
Scaling: -2.7 per mil $\Delta^{14}C$ = 1 ppm CO_2-fossil



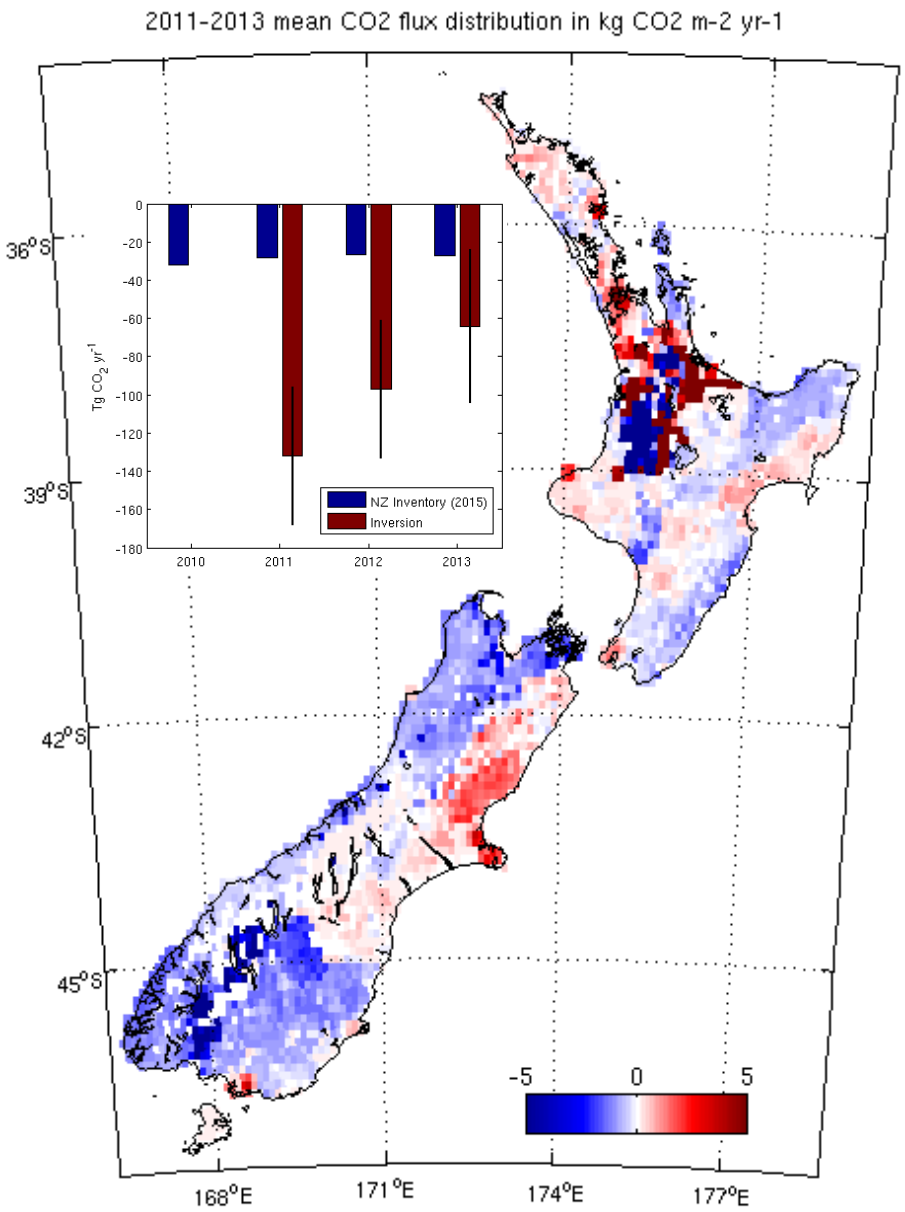


Atmospheric $\Delta^{14}C$ looks just like fossil CO_2

Includes only fossil fuel

WMO OMM

Miller et al., 2012



Land Use Land Cover Change emissions attribution

- 3 stations measuring CO_2 and ^{14}C in CO_2 are used.
- Larger uptake than prior model or bottom up accounting, particularly in forested regions.
- Differences to bottom up accounting partly due to differences between LULUCF and what the atmosphere 'sees'. These issues are still being resolved.

Slide: courtesy of Brailsford Gordon, NIWA

Collaboration between IAEA and WMO

- IAEA provides reference isotopic materials for observations of the isotopic composition of the greenhouse gases to the global community. Since 1997 IAEA co-organizes jointly with WMO the biennial meetings on Carbon Dioxide, Other Greenhouse Gases, and Related Measurement Techniques.

- As about 25% of CO_2 emitted in the atmosphere is absorbed by the ocean, WMO collaborates with IAEA on improved understanding of the ocean acidification processes.

- Other areas of collaboration include nuclear preparedness and isotope hydrology research and observations.

Thank you!
Merci!

WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

WMO OMM

World Meteorological Organization
Organisation météorologique mondiale

GLOBAL ATMOSPHERE WATCH