WORLD METEOROLOGICAL ORGANIZATION

WMO GLOBAL GREENHOUSE GAS WATCH

The WMO Global Greenhouse Gas Watch aims to establish internationally coordinated top-down monitoring of greenhouse gas fluxes to support the provision of actionable information to the United Nations Framework Convention on Climate Change (UNFCCC) Parties and other stakeholders.

Key points:

- Atmospheric concentration of CO_2 and other key greenhouse gases continue to rise; the implementation of the Paris Agreement is not currently on track for the world to stay below 2.0 °C maximum warming.
- Carbon offsetting remains poorly regulated and inadequately monitored; its effectiveness as a tool for climate change mitigation is now questioned.
- Not enough is known about the reaction of natural greenhouse gas fluxes to anthropogenic emissions and induced climate change.
- Implementation of the Paris Agreement relies extensively on activities-based emission estimates – however, such estimates are not linked directly to atmospheric concentrations.
- Top-down monitoring using atmospheric observations combined with "weather-like" modelling systems can identify when and where greenhouse gases enter and exit the atmosphere; this information is critically needed to support climate mitigation.
- Top-down monitoring could be implemented by WMO and the public sector alone, but it will be slow; public-private partnerships can help substantially accelerate this.

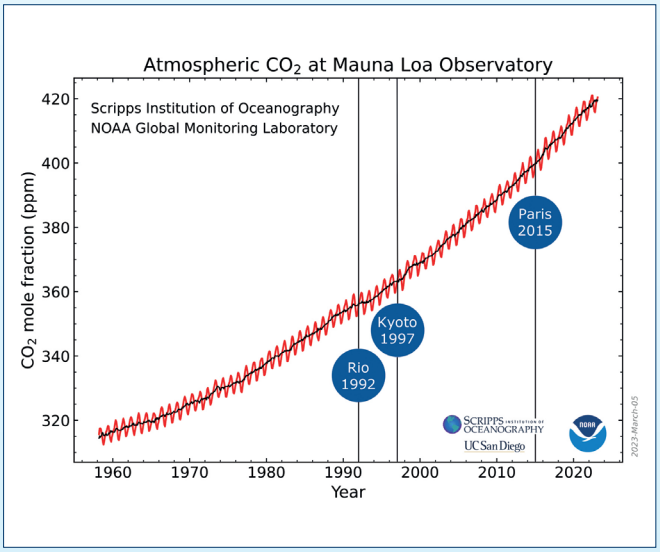


Figure 1. Sixty years of rising CO_2 background concentrations at the Mauna Loa Observatory

Background

The accelerating, unprecedented climate change seen especially over the past 50 years represents a generational challenge for all of humanity. This change is being driven primarily by increasing atmospheric concentrations of greenhouse gases due to human activity, especially fossil fuel consumption.

Climate Change Mitigation

In response, the United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1992 and amended by the Paris Agreement in 2015. It aims to keep the rise in temperature "well below" 2.0 °C, and preferably below 1.5 °C, above the baseline via a reduction of net anthropogenic greenhouse gas emissions. However, the rise in CO_2 concentrations has been steadily accelerating over the last 60 years (Figure 1), and the steps taken under UNFCCC thus have not yet led to "bending the curve".

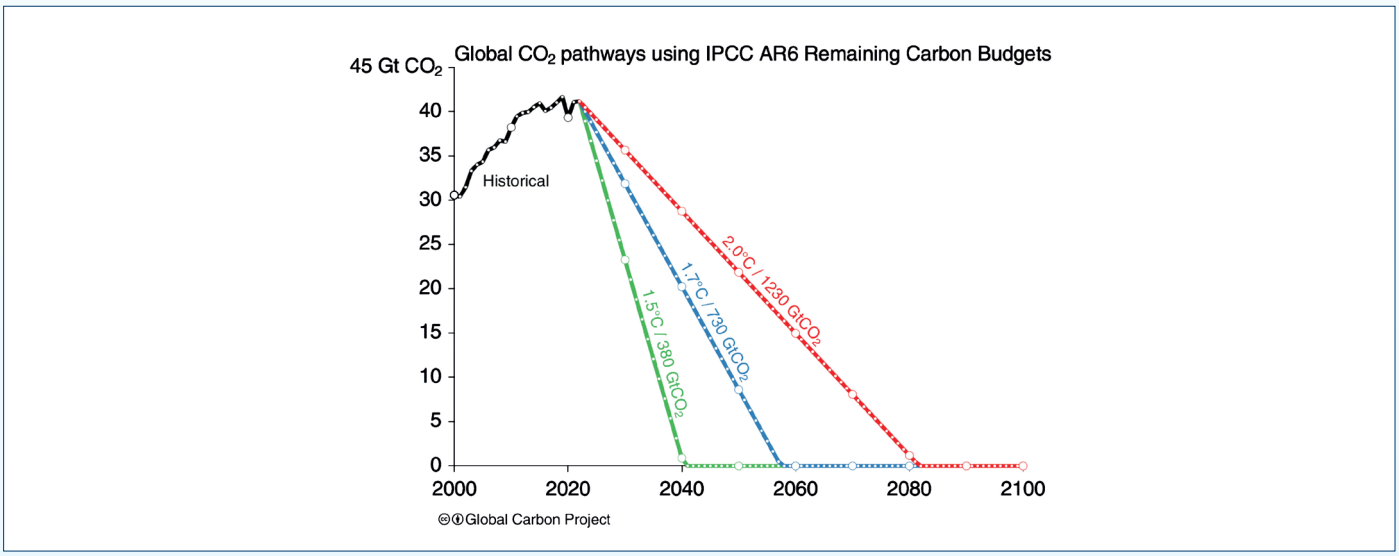


Figure 2. Anthropogenic emissions since 2000 (black). Emissions must follow the green line to stay within 1.5 °C.
Source: Global Carbon Project

In order to stay within a warming of max 1.5 °C, future anthropogenic emissions need to follow the green line in Figure 2, reaching zero in 2040. The consequences of the warming experienced to date are already devastating, e.g. rising sea levels threatening island nations and low-lying coastal cities, shifting precipitation patterns impacting food security, and a higher frequency of severe weather, causing increasing numbers of weather disasters.

The lack of success to date in curbing emissions may be linked to a lack of actionable information. Emissions from fossil fuel burning are well documented in the developed world, but that is not the case for emissions due to biomass burning, agriculture, landfills, etc. "Negative emissions" or sinks claimed in offsetting approaches are poorly defined, largely unregulated and unmonitored, and there is no centralized accounting in place to help prevent double counting.

Equally problematic is our lack of knowledge about natural sources and sinks of greenhouse gases. In the pre-industrial era, natural sources and sinks were largely in balance, leading to relatively stable greenhouse gas concentrations for three million years. However, in the industrial era, sources and sinks have been changing, partly in response to human emissions, partly due to induced climate change, and we do not fully understand how, why or where this is happening.

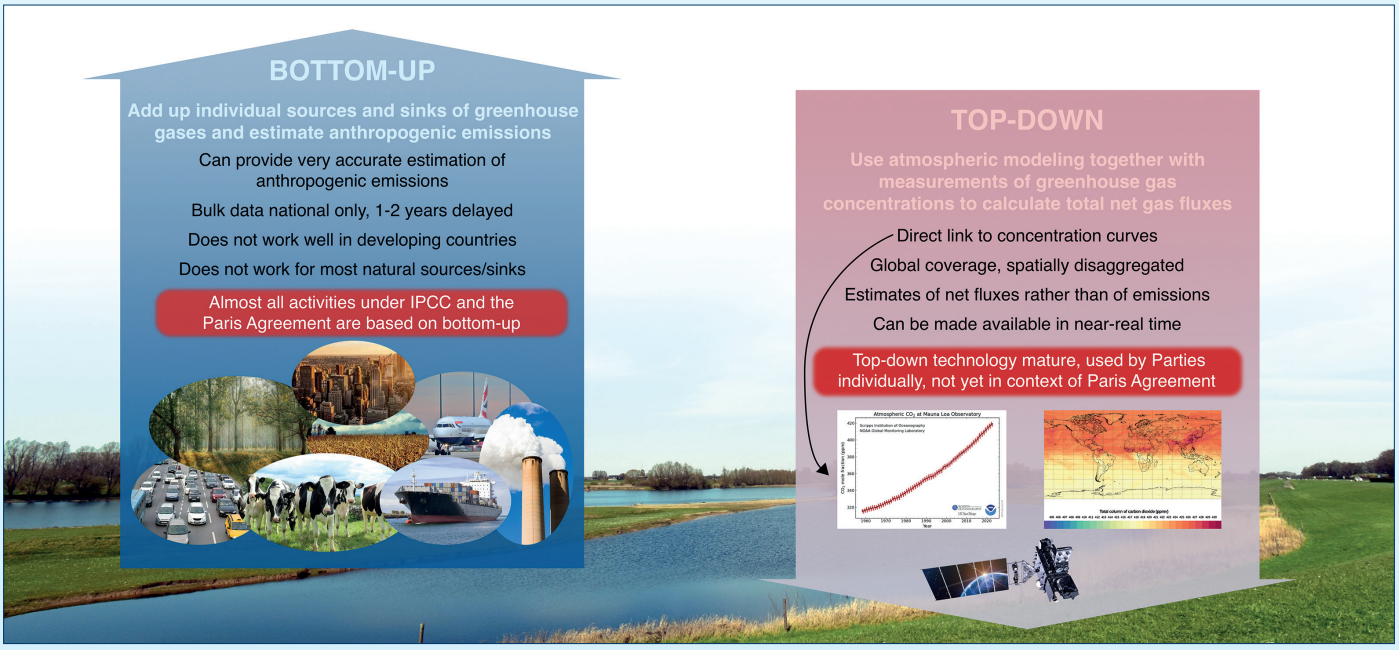


Figure 3. Bottom-up estimation focuses on anthropogenic emissions and works well where good input data are available; top-down monitoring focuses on atmospheric greenhouse gas concentrations and accounts for the net contributions to changes in concentrations from all sources.

Systematic monitoring of greenhouse gas concentrations and fluxes is needed in order to reduce uncertainties, improve our understanding of greenhouse gas budgets, and improve our ability to design and assess the effectiveness of mitigation action.

Greenhouse gas emission and sink estimates: bottom-up and top-down approaches

There are two basic approaches to estimating greenhouse emissions and sinks (see Figure 3):

Bottom-up estimation consists of adding up all the known contributions – positive as well as negative – of human activities to greenhouse gas emissions, e.g. from fossil fuel consumption and other economic activities, agriculture, ranching, forestry, etc. Bottom-up estimation works well in developed countries where the required economic data are widely available. However, it is difficult to use in developing countries due to a lack of data, and it is even more difficult to apply to the natural systems which do not report and – in the case of the ocean – partly fall outside national borders. Currently, almost all greenhouse gas reporting mandated under the Paris Agreement as well as voluntary offsetting approaches rely on bottom-up approaches.

In top-down monitoring, real-time, model-generated estimates of greenhouse gas concentrations (see Figure 4) are continuously compared to physical observations, and the discrepancy is used to calculate estimates of net greenhouse gas fluxes. Global top-down flux estimates can be linked directly to the atmospheric concentrations shown in Figure 1, which is what drives climate change. The required infrastructure – observations, modeling and data assimilation, international exchange of input and output data – closely parallels the infrastructure developed over the past 60 years under the WMO World Weather Watch which underpins all currently available weather and climate information irrespective of the delivery agent.

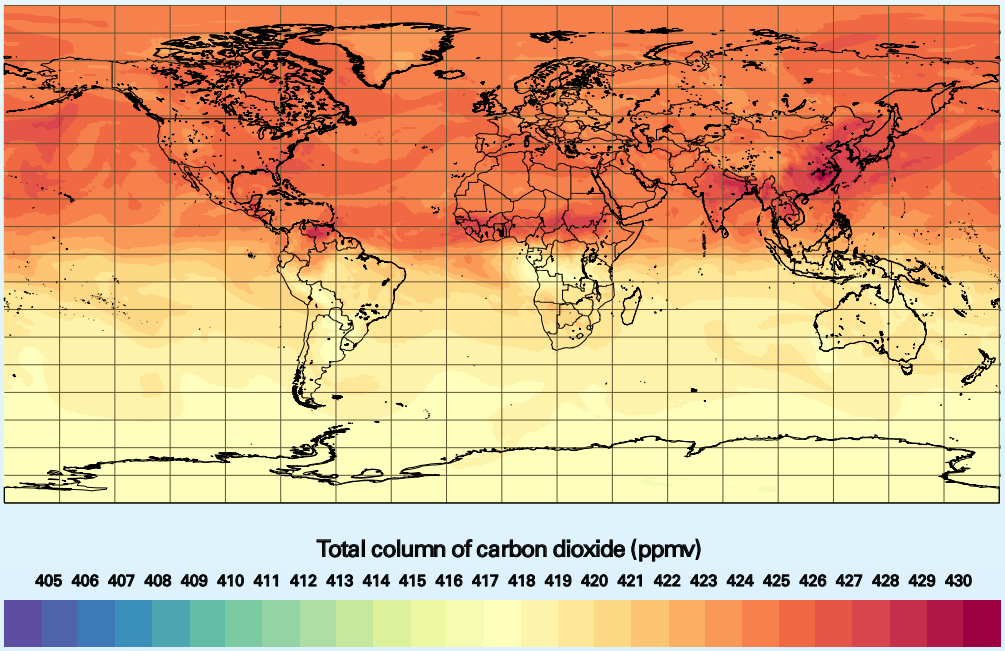


Figure 4. Global map of the Earth's CO_2 field
Source: Copernicus Atmosphere Monitoring Service, European Centre for Medium-Range Weather Forecasts (ECMWF)

WMO-coordinated greenhouse gas monitoring

In support of efforts to combat the continued increase in atmospheric greenhouse gas concentrations, WMO is launching an initiative to establish internationally coordinated, routine, top-down monitoring of greenhouse gas fluxes.

The main output will be consolidated, authoritative monthly estimates of greenhouse gas fluxes everywhere on the globe, initially at 100 km by 100 km grid resolution, aiming for 1 km by 1 km within the current decade. The goal is to provide high-quality, authoritative, timely information about greenhouse gases at spatial and temporal scales that are directly relevant for decision-making by UNFCCC Parties and other public and private sector stakeholders and to help put our scientific understanding of greenhouse gas fluxes on a more solid footing.

The monitoring system will build on existing capabilities and on WMO's experience in coordinating international activities in operational numerical weather prediction, climate analysis and greenhouse gas research. The main system components will be:

- An integrated global greenhouse gas observing system, both surface- and space-based;
- Routine modelling of greenhouse gases for flux estimations;
- Free and unrestricted international exchange of data under the WMO Unified Data Policy;
- Routine intercomparisons and quality assessments of model outputs.

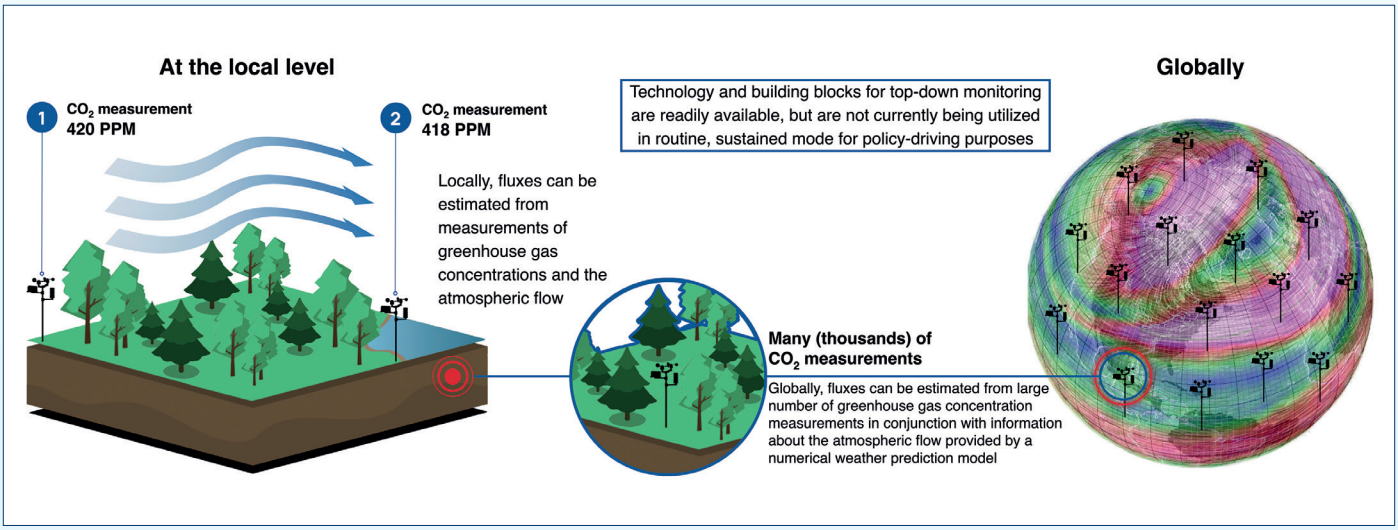
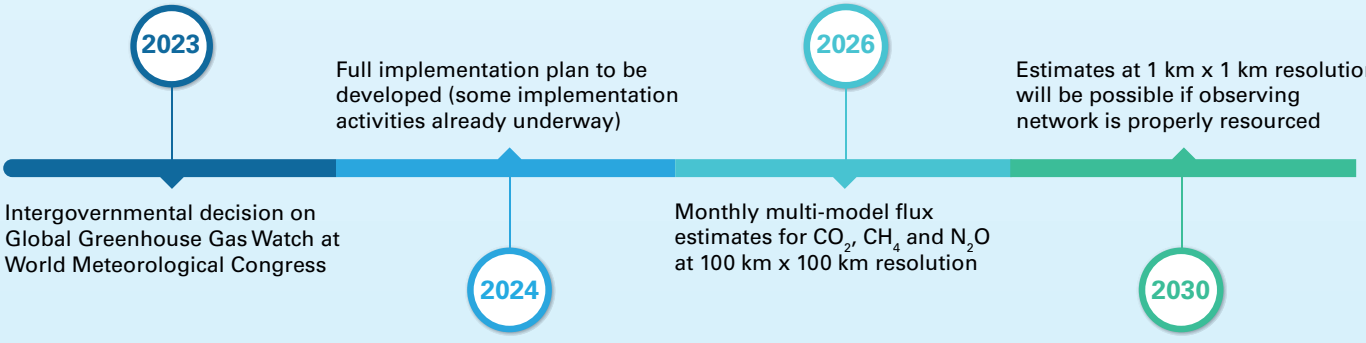


Figure 5. Estimation of greenhouse gas fluxes via the systematic comparison between model-predicted and observed greenhouse gas concentrations. The quality of the flux estimates will depend on the quality of the atmospheric transport fields and the observational data coverage.

Applications

- Support for the implementation of the UNFCCC Paris Agreement by providing input to the:
  - Global Stocktake;
  - Enhanced Transparency Framework;
  - Implementation of Article 6.
- Complementing bottom-up estimation done by national and local jurisdictions reporting on greenhouse gas emissions via downscaling, e.g. using IG^{3}IS approach.
- Voluntary and regulatory carbon markets; verification of the impact of offsets, supporting the valuation of tradeable assets.



The World Meteorological Organization is a specialized agency of the United Nations responsible for the international coordination of technical and scientific activities in weather prediction and climate monitoring. The Organization has 193 Member states and territories, and its history in international coordination of meteorology goes back to the establishment of its predecessor, the International Meteorological Organization, in 1873.