How observations and modelling of greenhouse gases can support the Paris Agreement: An integrated global greenhouse gas information system (IG^{3}IS)

WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

Deon Terblanche, Phil de Cola
and
the rest of the IG^{3}IS Team

WMO OMM

World Meteorological Organization
Organisation météorologique mondiale

International IG^{3}IS Planning Team Members

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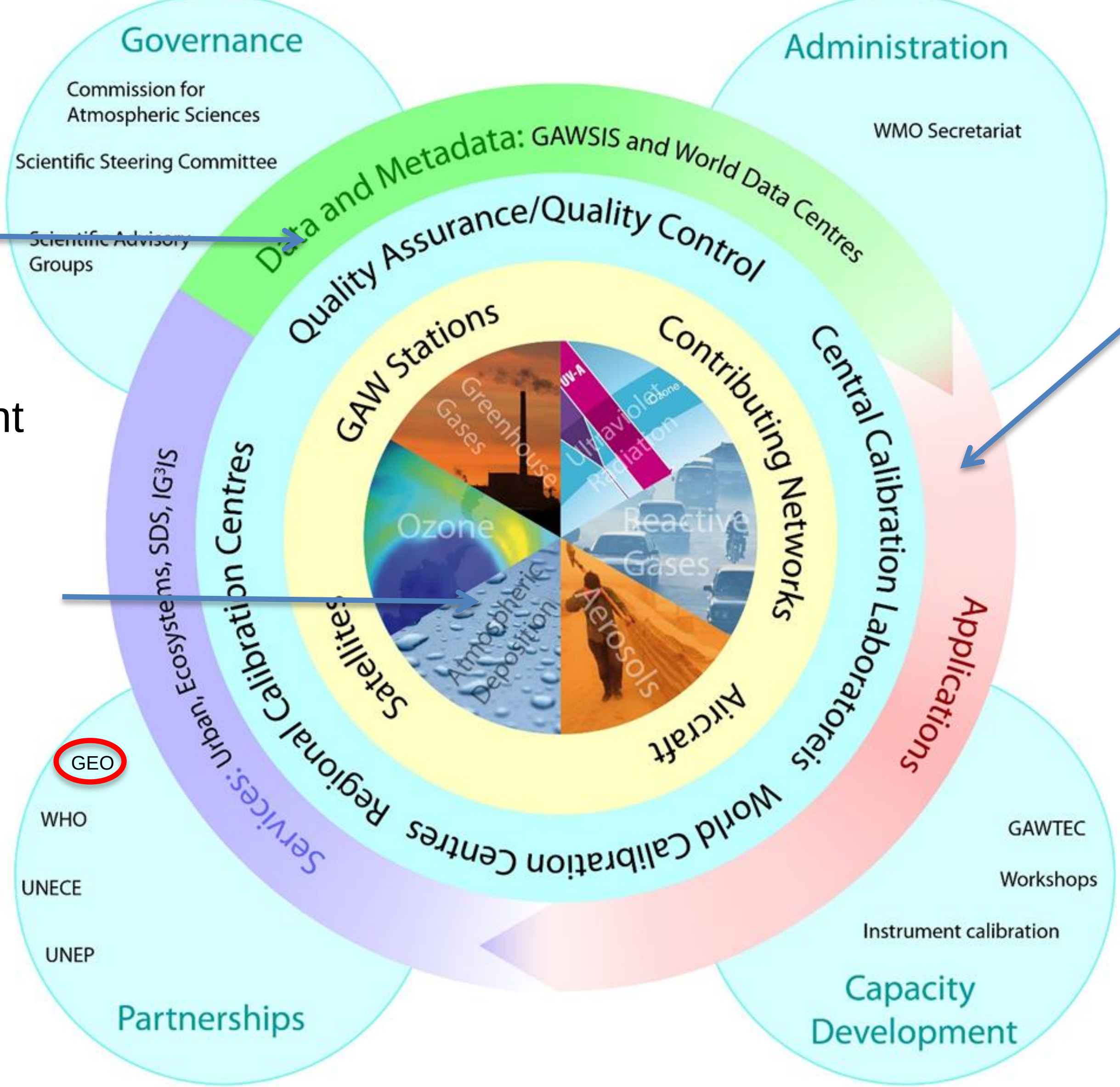
The WMO Global Atmosphere Watch Programme (since 1989)

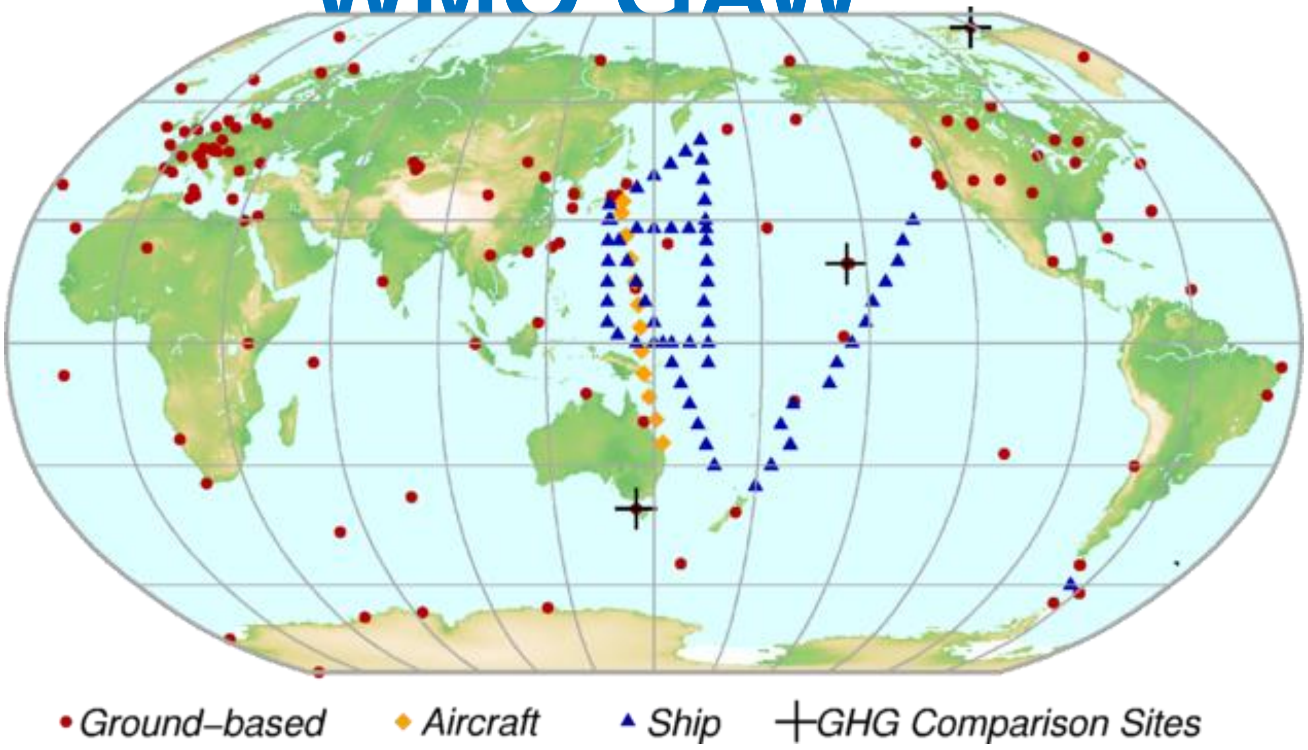
New GAW Data Management strategy

New focal area – total deposition

New Scientific Advisory Group on Applications



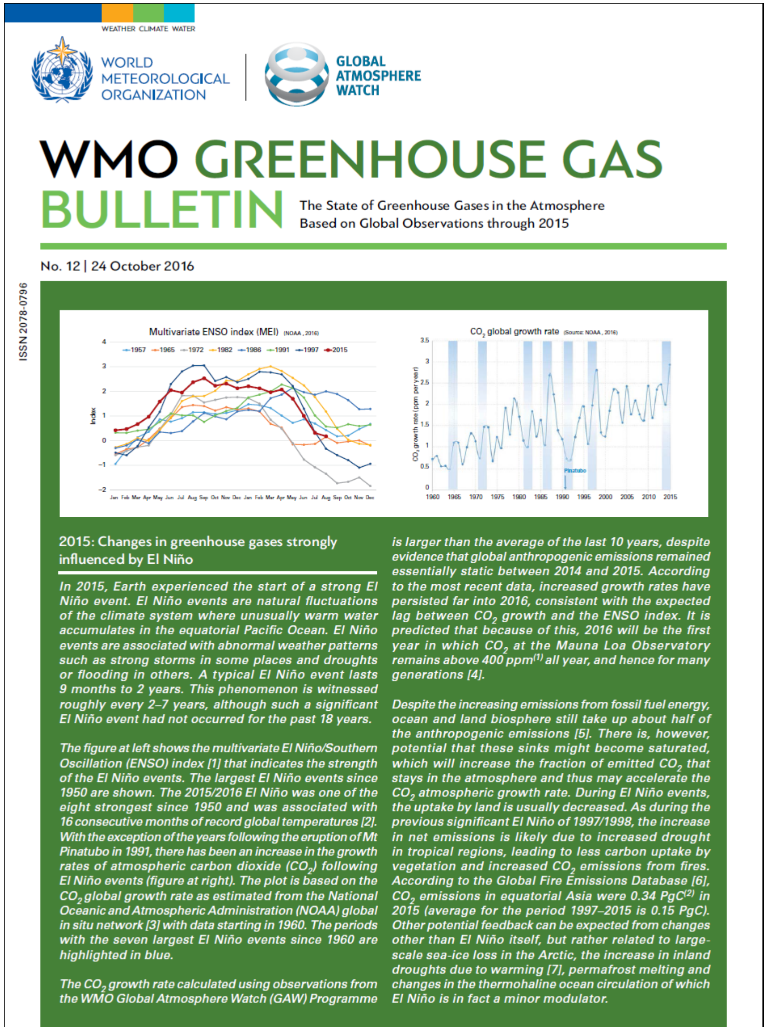
Status of greenhouse gas observations in WMO GAW



Component	Number of stations
CO_2	125
CH_4	123
N_2O	33
CFC-11	23
CFC-12	24

- **12th annual Greenhouse Gas Bulletin was released on 24 October 2016**
- Cover story is on the impact of El Nino on GHG growth rates
- Annual global CO_2 reached 400 ppm

GHG Bulletin


WEATHER CLIMATE WATER

WORLD METEOROLOGICAL ORGANIZATION

GLOBAL ATMOSPHERE WATCH

ISSN 2078-0796

WMO GREENHOUSE GAS BULLETIN

The State of Greenhouse Gases in the Atmosphere
Based on Global Observations through 2015

No. 12 | 24 October 2016

2015: Changes in greenhouse gases strongly influenced by El Niño

In 2015, Earth experienced the start of a strong El Niño event. El Niño events are natural fluctuations of the climate system where unusually warm water accumulates in the equatorial Pacific Ocean. El Niño events are associated with abnormal weather patterns such as strong storms in some places and droughts or flooding in others. A typical El Niño event lasts 9 months to 2 years. This phenomenon is witnessed roughly every 2–7 years, although such a significant El Niño event had not occurred for the past 18 years.

The figure at left shows the multivariate El Niño/Southern Oscillation (ENSO) index [1] that indicates the strength of the El Niño events. The largest El Niño events since 1950 are shown. The 2015/2016 El Niño was one of the eight strongest since 1950 and was associated with 16 consecutive months of record global temperatures [2]. With the exception of the years following the eruption of Mt Pinatubo in 1991, there has been an increase in the growth rates of atmospheric carbon dioxide (CO_2) following El Niño events (figure at right). The plot is based on the CO_2 global growth rate as estimated from the National Oceanic and Atmospheric Administration (NOAA) global in situ network [3] with data starting in 1960. The periods with the seven largest El Niño events since 1960 are highlighted in blue.

The CO_2 growth rate calculated using observations from the WMO Global Atmosphere Watch (GAW) Programme is larger than the average of the last 10 years, despite evidence that global anthropogenic emissions remained essentially static between 2014 and 2015. According to the most recent data, increased growth rates have persisted far into 2016, consistent with the expected lag between CO_2 growth and the ENSO index. It is predicted that because of this, 2016 will be the first year in which CO_2 at the Mauna Loa Observatory remains above 400 ppm(1) all year, and hence for many generations [4].

Despite the increasing emissions from fossil fuel energy, ocean and land biosphere still take up about half of the anthropogenic emissions [5]. There is, however, potential that these sinks might become saturated, which will increase the fraction of emitted CO_2 that stays in the atmosphere and thus may accelerate the CO_2 atmospheric growth rate. During El Niño events, the uptake by land is usually decreased. As during the previous significant El Niño of 1997/1998, the increase in net emissions is likely due to increased drought in tropical regions, leading to less carbon uptake by vegetation and increased CO_2 emissions from fires. According to the Global Fire Emissions Database [6], CO_2 emissions in equatorial Asia were 0.34 PgC(2) in 2015 (average for the period 1997–2015 is 0.15 PgC). Other potential feedback can be expected from changes other than El Niño itself, but rather related to large-scale sea-ice loss in the Arctic, the increase in inland droughts due to warming [7], permafrost melting and changes in the thermohaline ocean circulation of which El Niño is in fact a minor modulator.

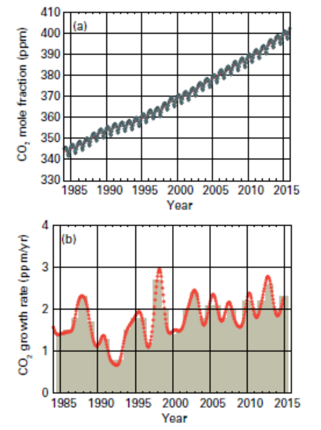


Figure 3. Globally averaged CO_2 mole fraction (a) and its growth rate (b) from 1984 to 2015. Increases in successive annual means are shown as columns in (b).

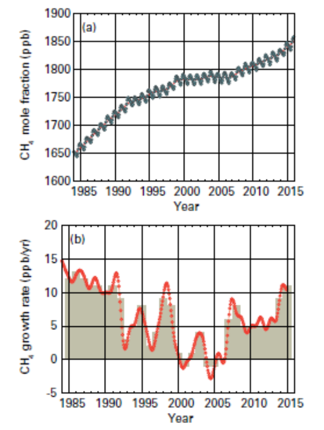


Figure 4. Globally averaged CH_4 mole fraction (a) and its growth rate (b) from 1984 to 2015. Increases in successive annual means are shown as columns in (b).

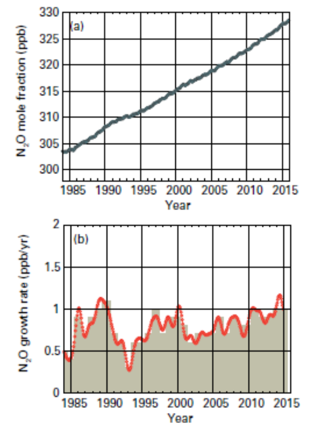
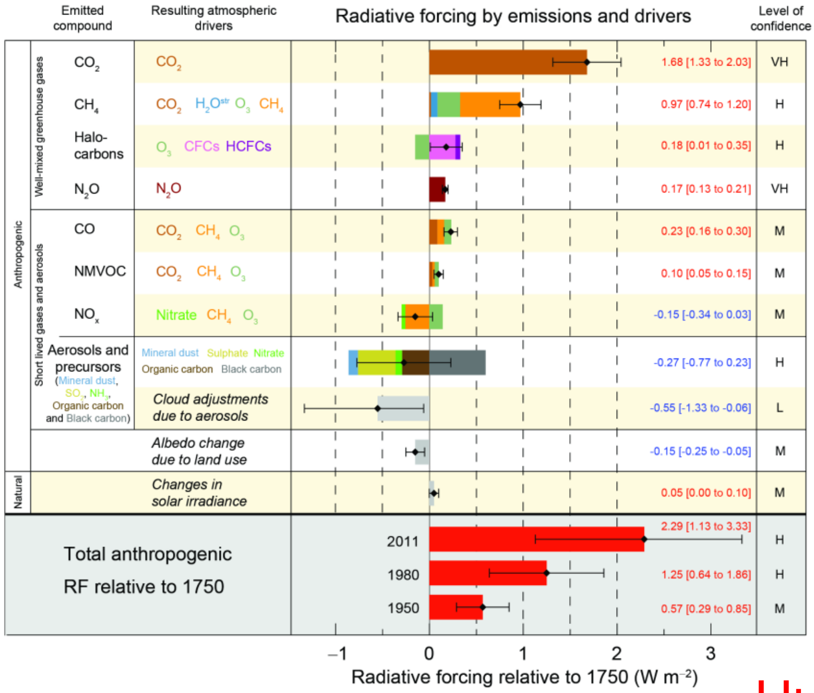
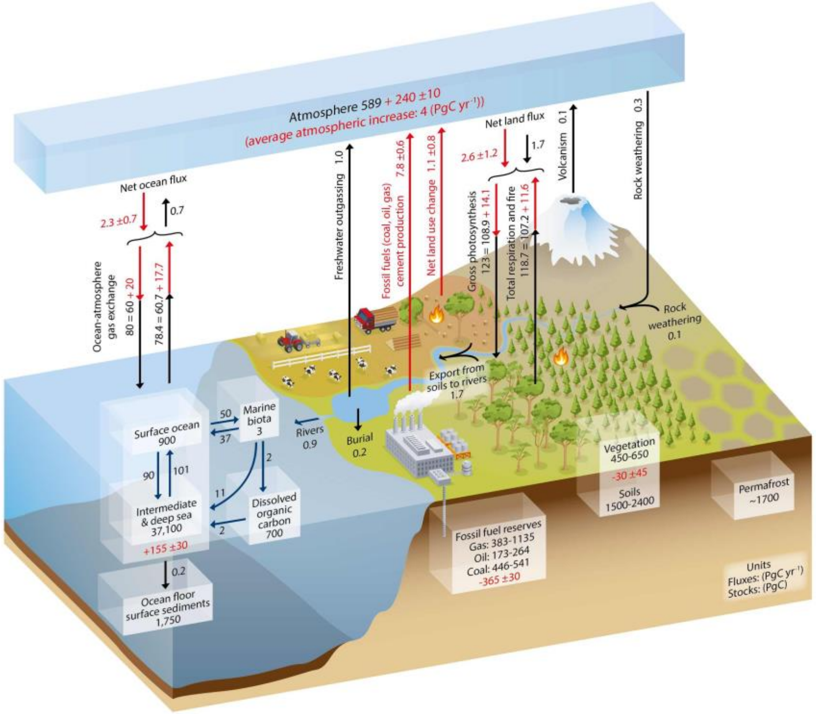


Figure 5. Globally averaged N_2O mole fraction (a) and its growth rate (b) from 1984 to 2015. Increases in successive annual means are shown as columns in (b).

Paris Agreement – limit the temperature increase by 2C by limiting emissions

Fundamental issue – it is what you **HAVE** in the atmosphere, not what you **PUT** in the atmosphere, that controls the temperature





Calculations are for year in 2011

Human (9.9GtC in) – ocean (2.6 GtC out)

land (3 GtC out) (GCP)

Avg 41%, 2015 65% remains (NOAA)

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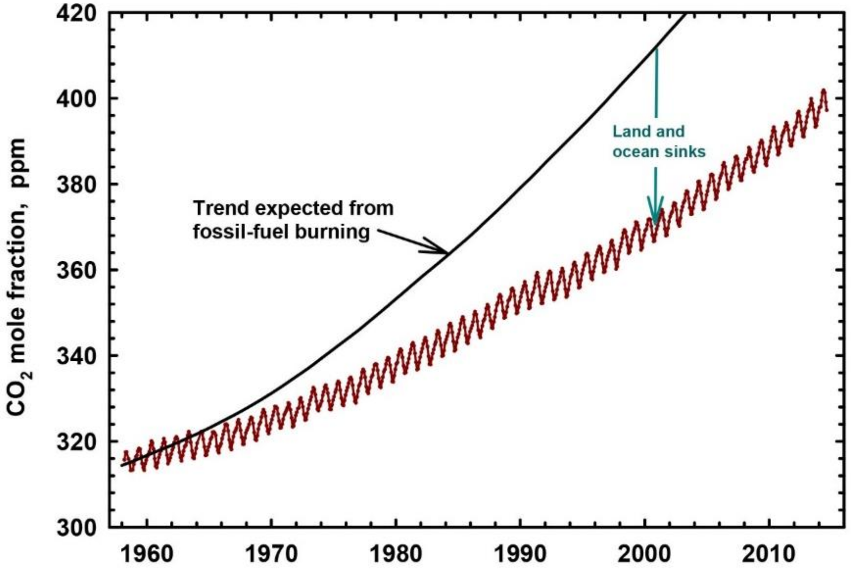
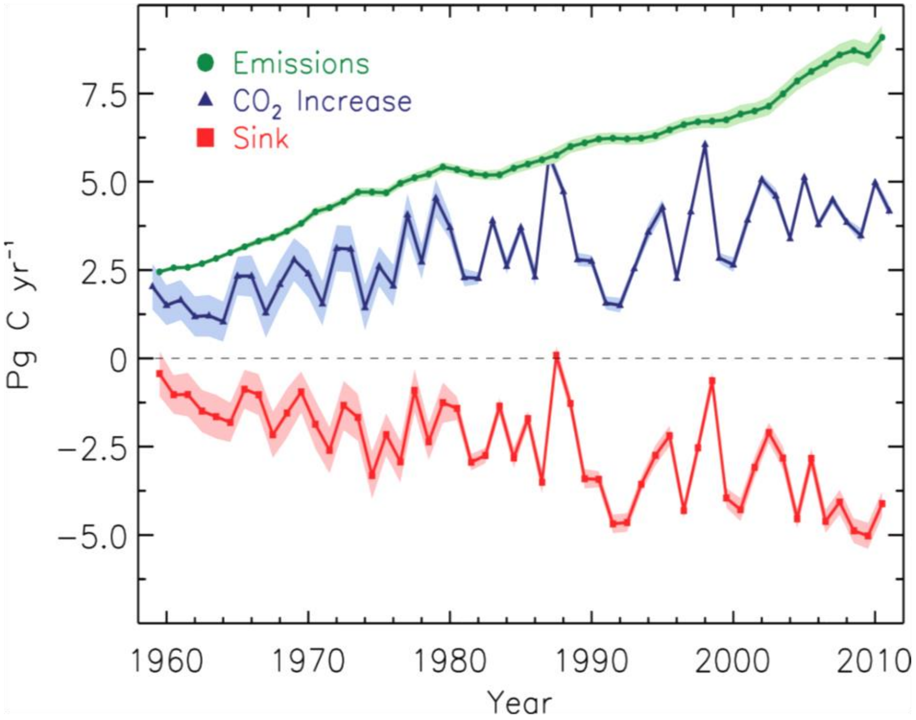
Complexity of carbon cycle





- Identification of sinks needs dedicated measurements
- CO_2 uptake by oceans lead to ocean acidification
- Knowledge of terrestrial and ocean sinks is essential for definition of **anthropogenic contribution**

How to get emissions?

“Bottom-up” measurements
(Statistical methods)

- Emissions reporting
- Reported and “verified” offsets
- Site-specific measurements

PLUS

“Top-down” measurements

- Comprehensive atmospheric observations
- Inverse modelling
- Ecosystem and ocean observations

=

Improved posterior knowledge of emissions

NDCs → **Without consideration of the ocean and land**

NDC are evaluated every 5 years -> are we on the right track?
Where can we cut more?
Are the oceans and land still working as expected?

The Integrated Global Greenhouse Gas Information System (IG^{3}IS)

Principles

- IG^{3}IS will serve as an international coordinating mechanism and establish and propagate *consistent methods and standards.*
- *Stakeholders are entrained from the beginning* to ensure that information products meet user priorities and deliver on the foreseen value proposition.
- Success-criteria are that the information *guides additional and valuable emission-reduction actions*.
- IG^{3}IS must mature *in concert with evolution of policy and technology*.

IG3IS will focus on two parallel streams of action:

- **Pilot projects to add skill and users and,**
- **End-to-end, good-practice implementation guidelines**

Support of Paris Agreement:

- Improved national inventory reporting by making use of atmospheric measurements for all countries
- Timely and quantified trend assessment of NDCs in support of “Global Stocktaking” (TBD)

Key sub-national efforts and new mitigation opportunities:

- GHG monitoring in large urban source areas (megacities)
- Detection and quantifying large unknown CH_4 emissions

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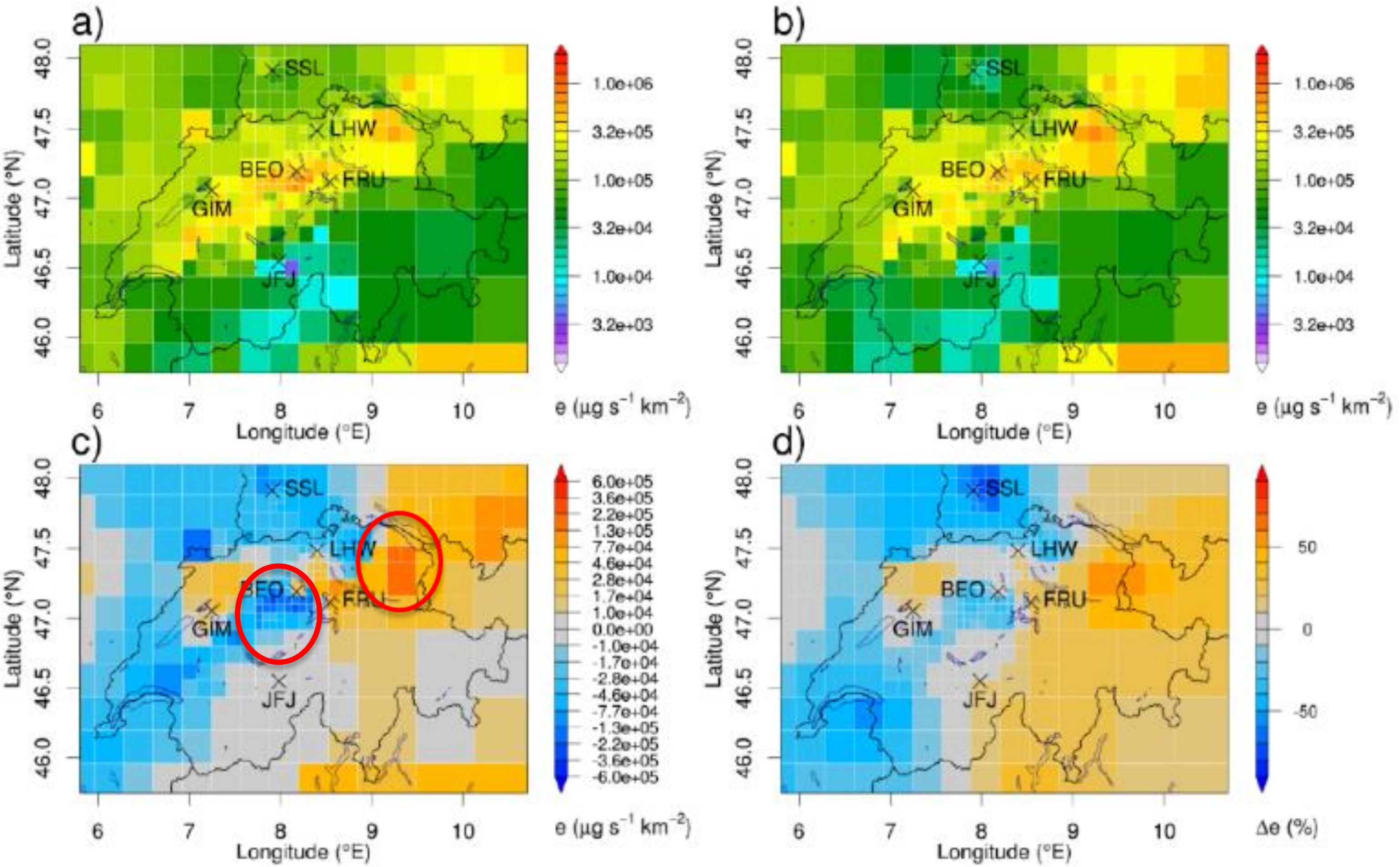
Example from Switzerland: Methane

- Great match between national total (“bottom-up” and “top-down”) but incorrect spatial distribution



(S. Henne et al., 2016)
Switzerland’s Greenhouse Gas Inventory 1990–2014
National Inventory Report 2016

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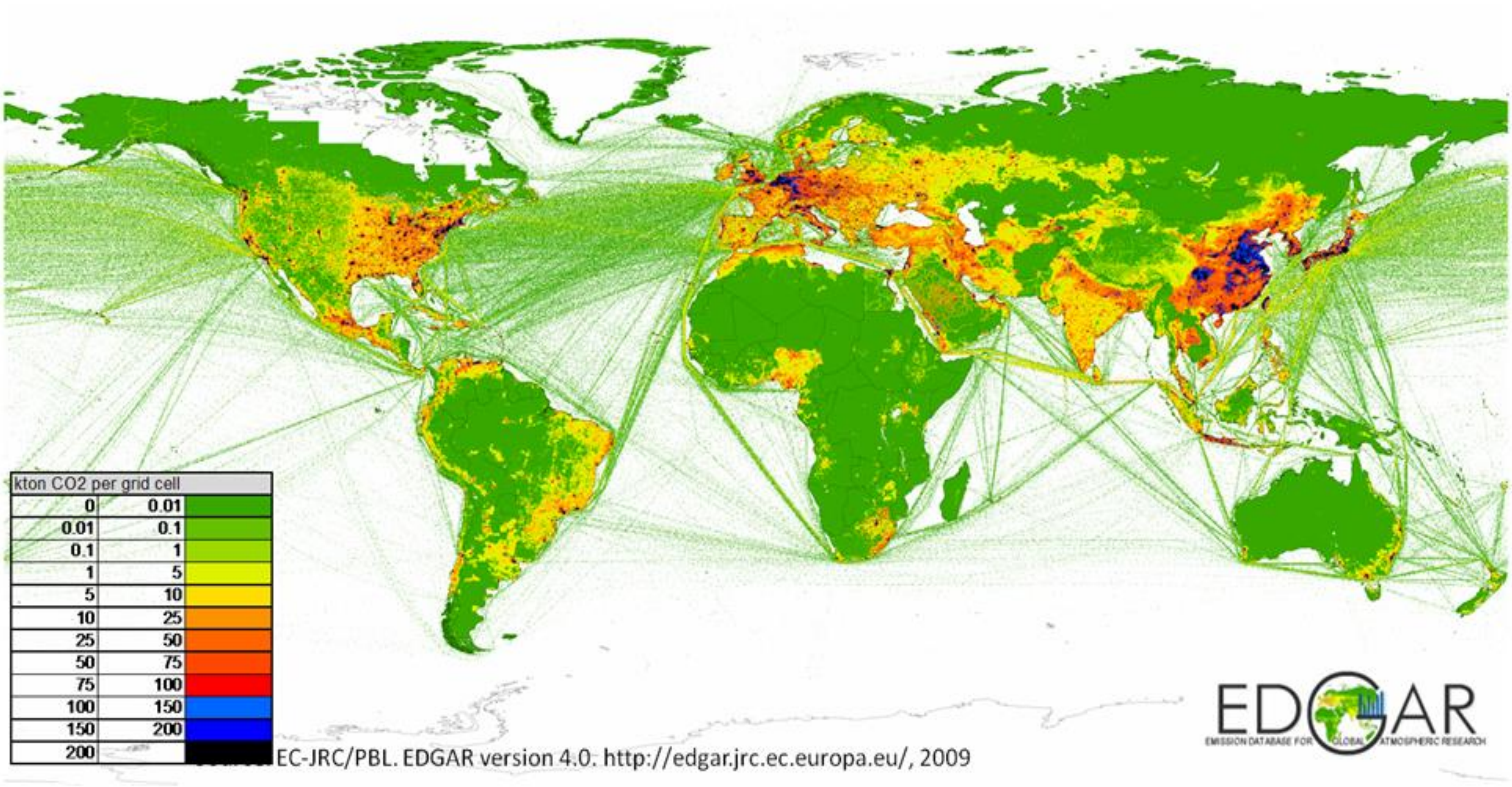
Relevance: cities matter

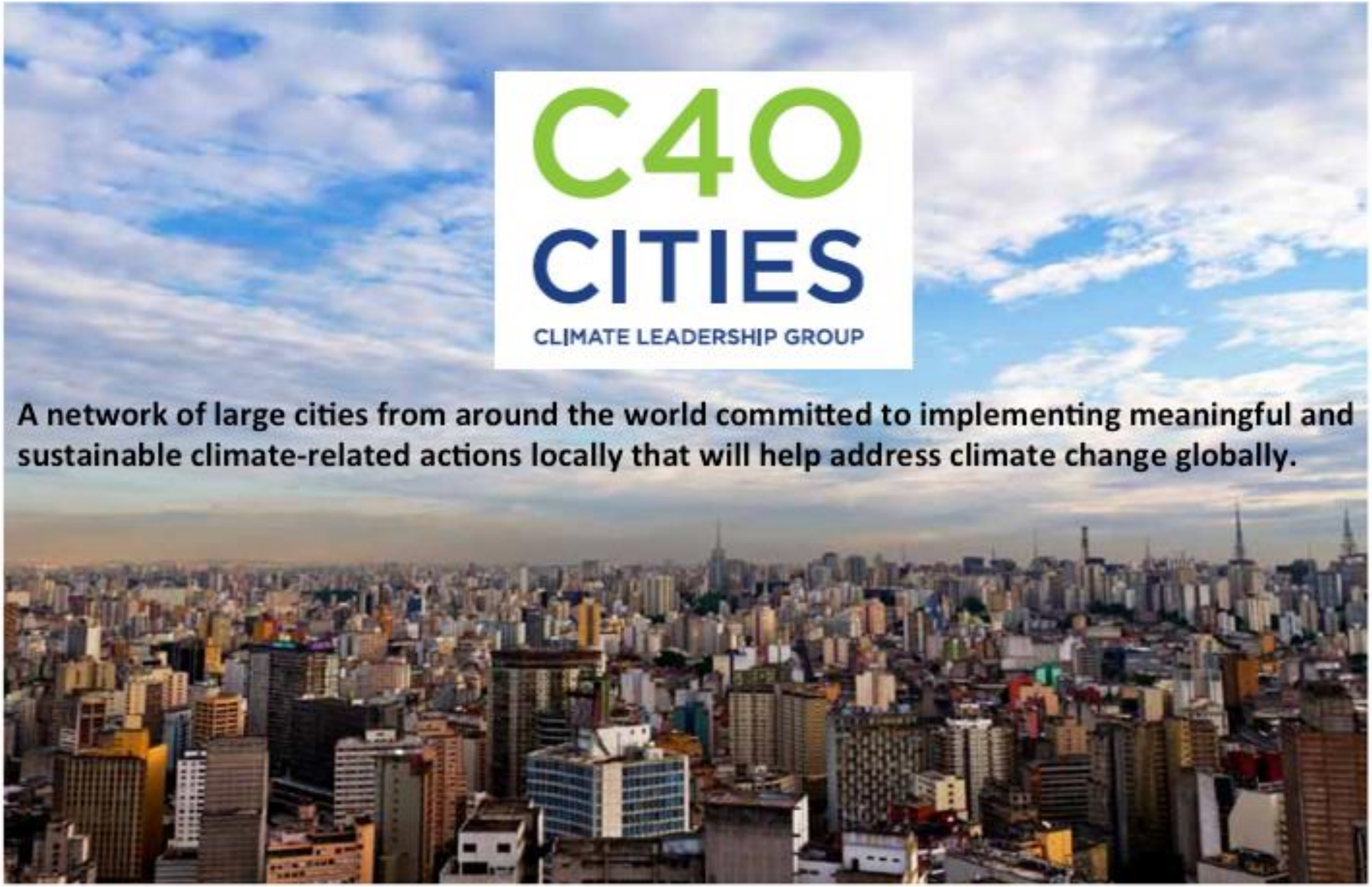
> 70% of global fossil-fuel CO_2 (about half of that from megacities)



EC-JRC/PBL. EDGAR version 4.0. http://edgar.jrc.ec.europa.eu/, 2009

Source: *Cities and Climate Change: an urgent agenda*, World Bank, 2010

Cities are demonstrating the political will for climate action and increasingly possess the needed economic strength



C40
CITIES
CLIMATE LEADERSHIP GROUP

A network of large cities from around the world committed to implementing meaningful and sustainable climate-related actions locally that will help address climate change globally.

Urgency: cities are changing rapidly

http://*www.c40cities.o*

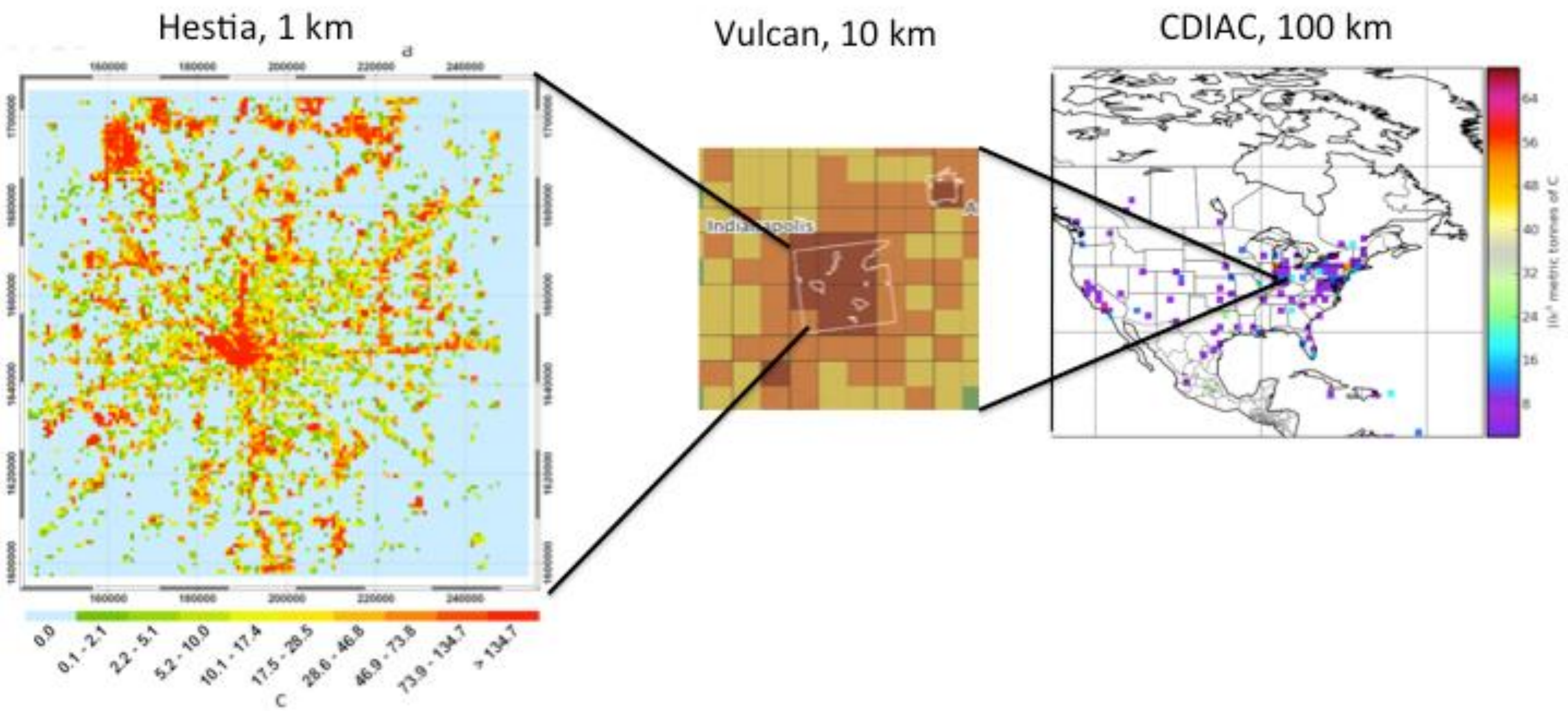
- Both with **Stabilization**
  - Green LA Plan (2007)
    - 35% (vs 1990) by 2030
  - Paris Climate Plan (2007)
    - 25% (vs 2004) by 2020

and **Growth**

- Global urbanization will ***double*** by 2050
- Explosive growth in developing megacities

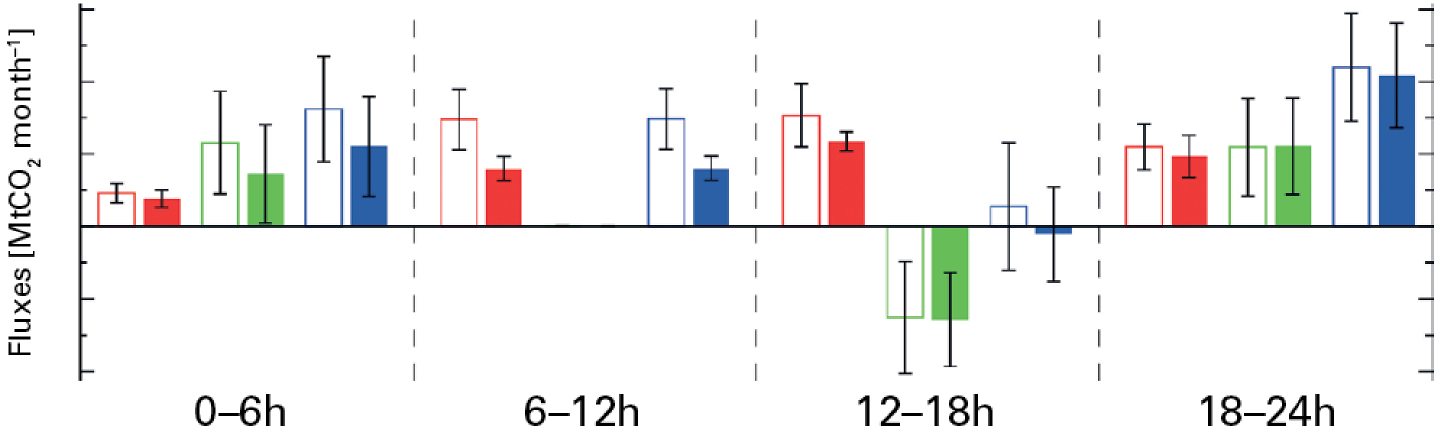
Pragmatic: monitoring cities is a tractable problem

CO_2 at local (human) scales is more intense than at larger scales



Right: Gridded annual fossil fuel CO2 emissions from a medium-size city (Indianapolis) show distinct gradients at different spatial scales. Right: CDIAC 2006 emissions for the CONUS plotted on a 1° (~100 km) show avg flux 200-600 gC/m2/yr. Middle: Vulcan 2002 emissions for the ~10,000 km2 area centered on Indianapolis on a 10 km grid. Left: Hestia 2002 emissions for the urban core on a 1 km grid. The Vulcan and Hestia plots use log-normal scales (typically >20,000 gC/m2/yr).

by combining inverse model analysis of a sufficiently dense and well-distributed network of measurements with spatially explicit prior knowledge of sources, urban emissions of FFCO2 can be better quantified



Total flux estimates over a 30-day period, for the four 6-hour periods, for anthropogenic emissions (red), biogenic fluxes (green) and the total (blue). The prior estimates are shown as open rectangles, while the posterior is shown as filled rectangles. Uncertainty reduction is evident for the morning and afternoon time periods (source: taken from [25]).

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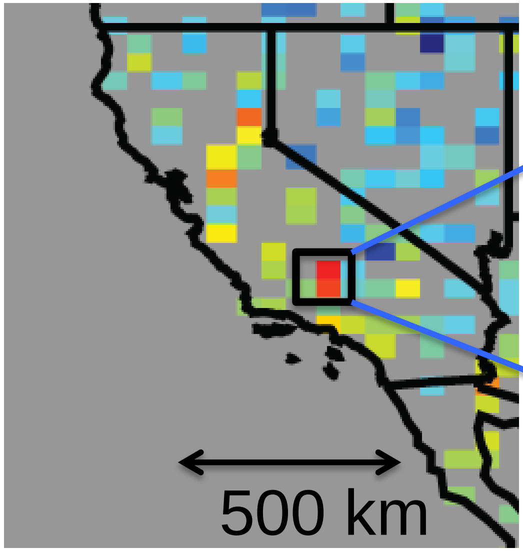
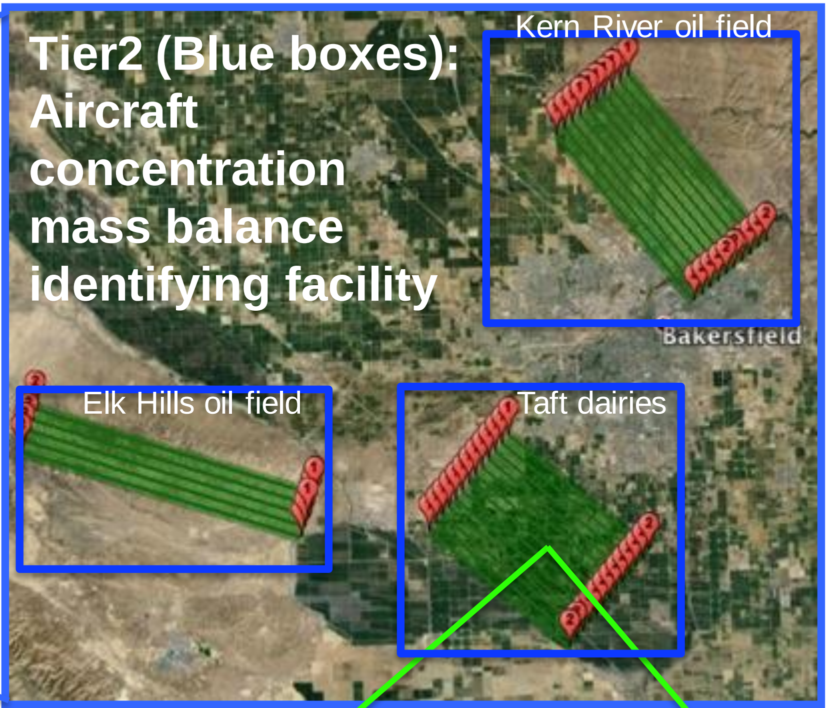
Example of additional emission reduction opportunities

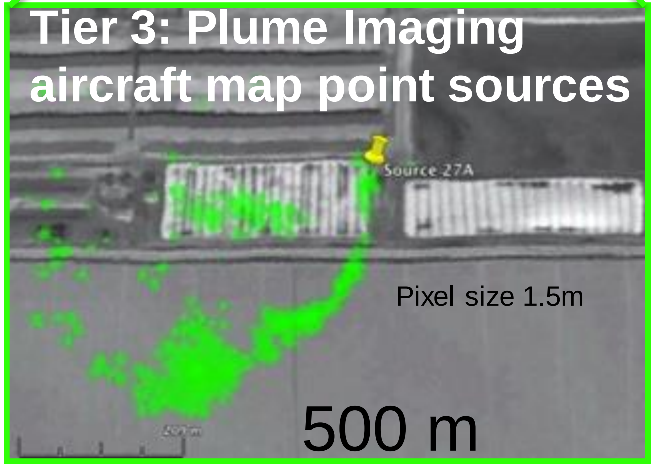
Tier 1: Satelite detects hotspot region

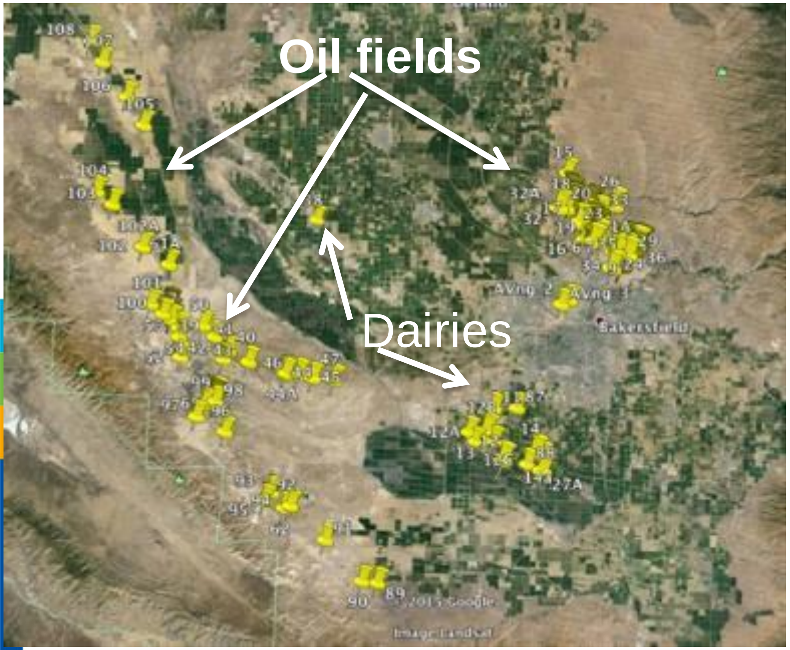


Turner et al 2015


Tier2 (Blue boxes): Aircraft concentration mass balance identifying facility

50 km


Tier 3: Plume Imaging aircraft map point sources



Enhanced Activity Data

Tier 4 (not shown): Surface observations

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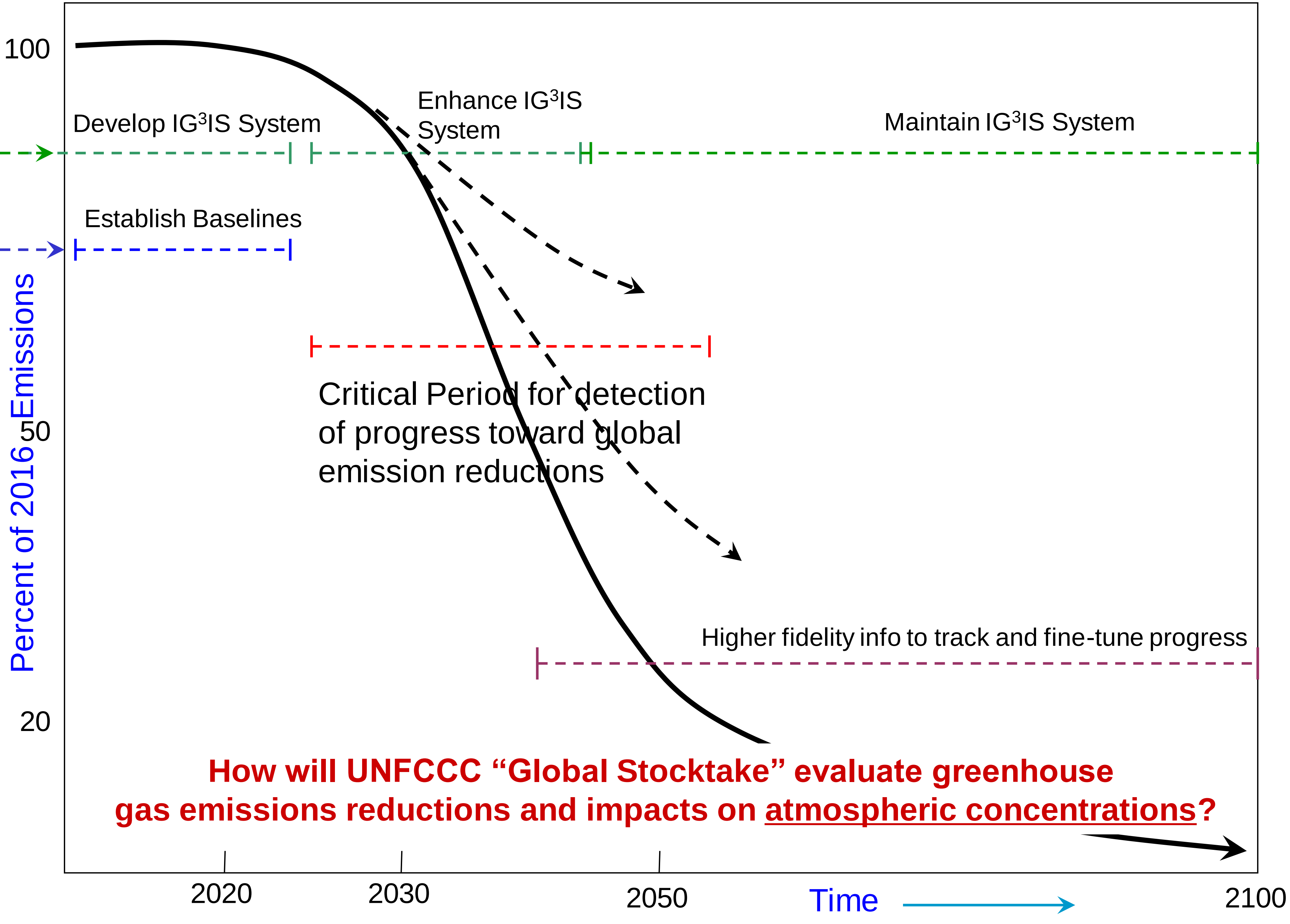

How will UNFCCC "Global Stocktake" evaluate greenhouse gas emissions reductions and impacts on atmospheric concentrations?

Why such a system/service?

- It provides a globally harmonized tool for countries to build confidence in their mitigation actions related to the Paris agreement.
- It sheds light on the highly variable and not to be taken for granted ocean and land CO_2 sinks (and sources)
- It refocuses our attention back to the atmosphere as that is where we need to dramatically bend curves before the climate system will stabilize
- It builds on previous successful observation-science-policy success stories within the UN (e.g. UNEP-WMO on stratospheric ozone, ongoing through recent Kigali ammendment)
- It will greatly enhance the global climate monitoring capacity
- Timely and quantified trend assessment of NDCs in support of “Global Stocktaking”

Side Event

Science for informed mitigation and adaptation choices

Date: 11 November, 13:15-14:45
Venue: Austral

Thank you
Merci

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