Integrated Global GHG Information System (IG³IS): Evidence Based Policy Support and Evaluation

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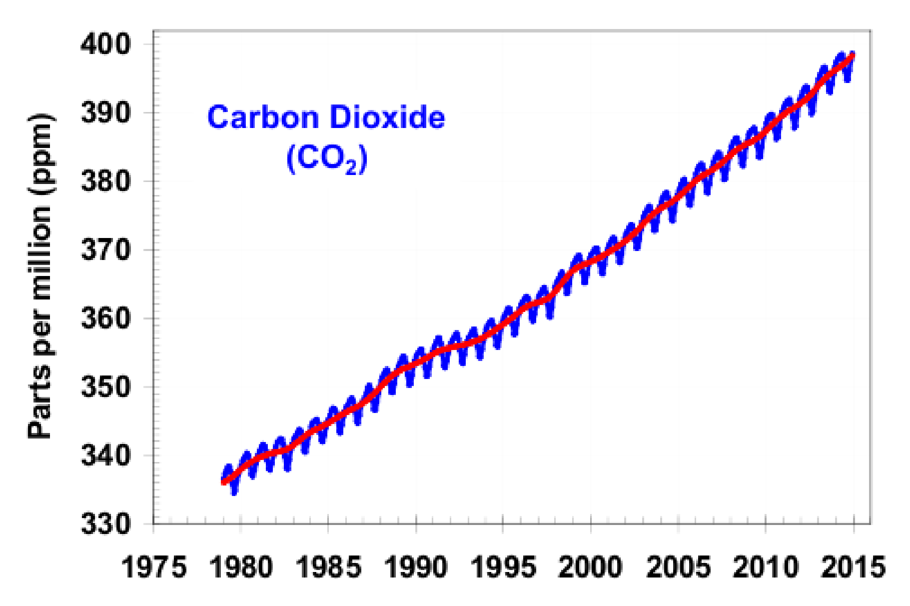
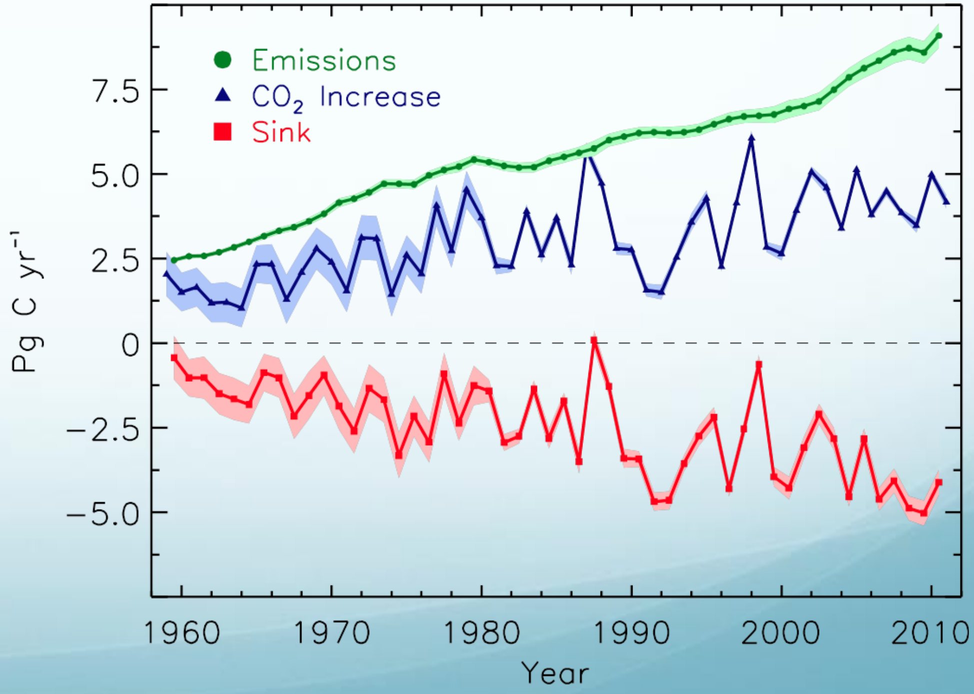
The Integrated Greenhouse Gas Information Systems (IG^{3}IS)

Context
Added Value
Principles
Objectives

Atmospheric GHGs - The Primary Driver of Climate Change

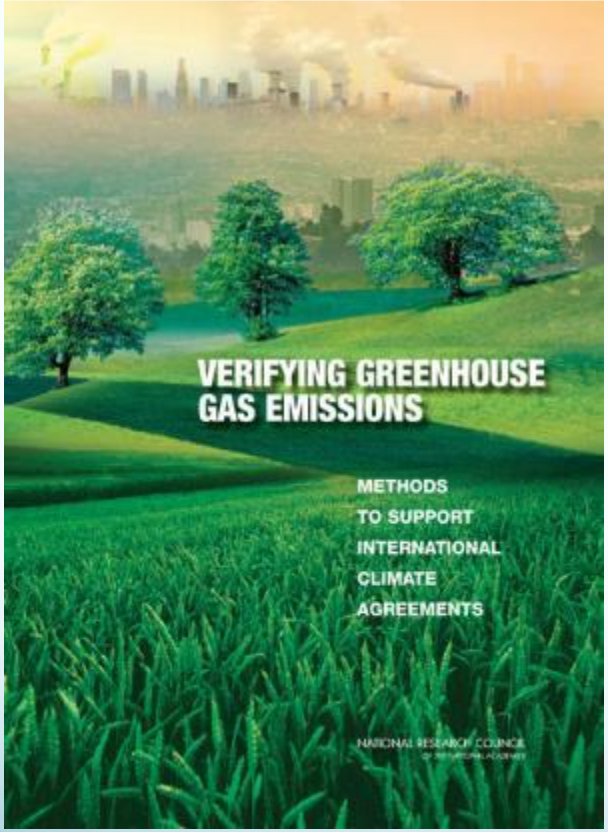
- Atmospheric CO_2 continues to increase every year
  - The trend is largely driven by fossil fuel emissions
- The growth rate increases every decade
  - Variability is largely driven by the Earth System
- The Earth System continues to capture 50% of emissions
  - Despite the increase in emissions
  - Our job is to do our best to understand the carbon cycle

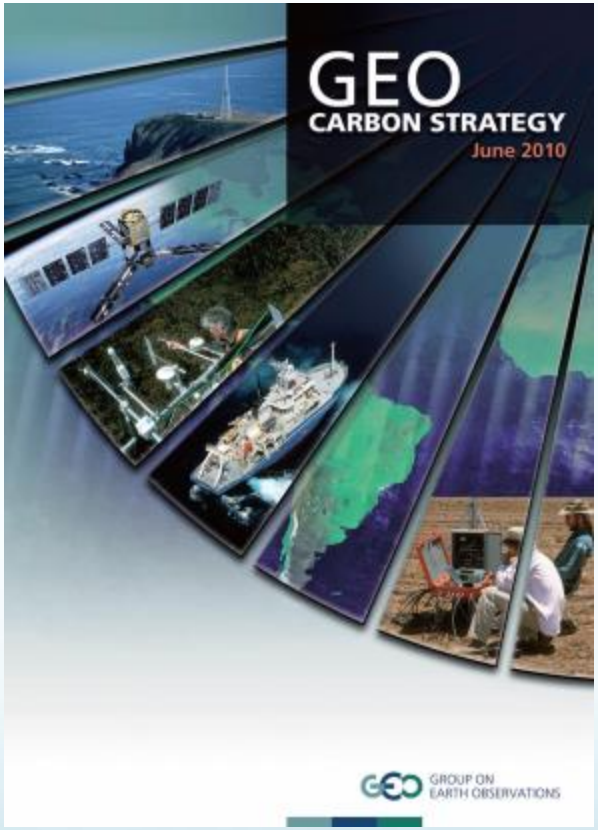


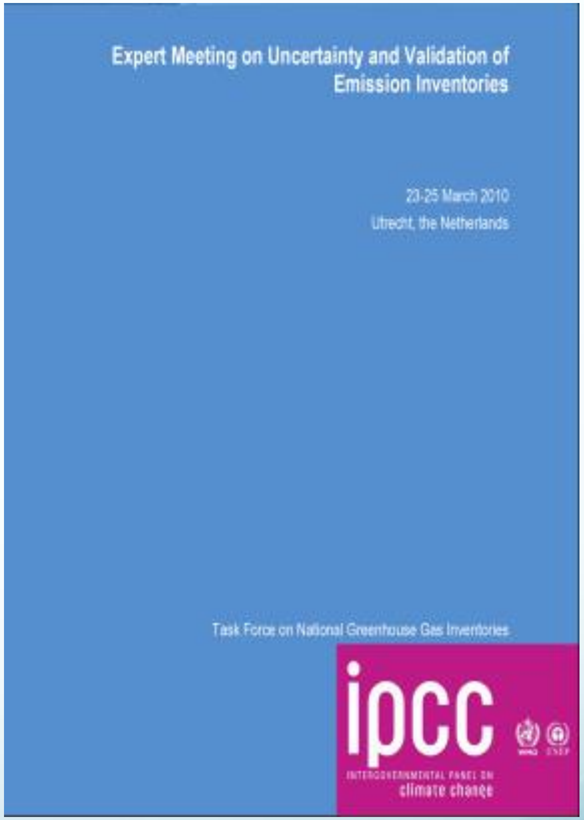


GHG monitoring and reporting in 2010: atmospheric "top-down" and inventory "bottom-up"

Can atmospheric measurements and models "verify" inventories?







UNFCCC Process and GHG Monitoring: Both evolving from "Top Down" to "Bottom Up"

Then (2010)

Binding Multi-national Treaty Commitments

"we will <u>verify</u> your reported emissions"

A grand, top-down GHG Information System

GHGIS > $5 Billion delivered 2025

Advocates: Science Community!!!

Now (2016)

Nationally Determined Contributions

"we will <u>help</u> you <u>improve</u> your data"

Federation of focused monitoring systems

IG^3IS < $1B delivered ~2018

Advocates: WMO (191 countries), States (eg, CA), Cities (eg, C40), NGOs, Industry (eg, Oil Companies)

The IG³IS Goals and Principles

Goal: Support the success of post-COP21 actions of nations, sub-national governments, and the private sector to reduce climate-disrupting GHG emissions through a sound-scientific, measurement-based approach that**:**

- **reduces uncertainty of national emission inventory reporting**,
- **identifies large and additional emission reduction opportunities**, and
- **provides nations with timely and quantified guidance on progress towards their emission reduction strategies and pledges (e.g., NDCs)**

Principles

- IG³IS will serve as an international coordinating mechanism and establish and propagate consistent methods and standards.
- Diverse measurement and analysis approaches will fit within a common framework.
- Stakeholders are entrained from the beginning to ensure that information products meet user priorities and deliver on the foreseen value proposition.
- Objectives must be practical and focused.
- Success-criteria are that the information guides additional and valuable emission-reduction actions.
- IG³IS must mature in concert with evolution of user-needs and policy.

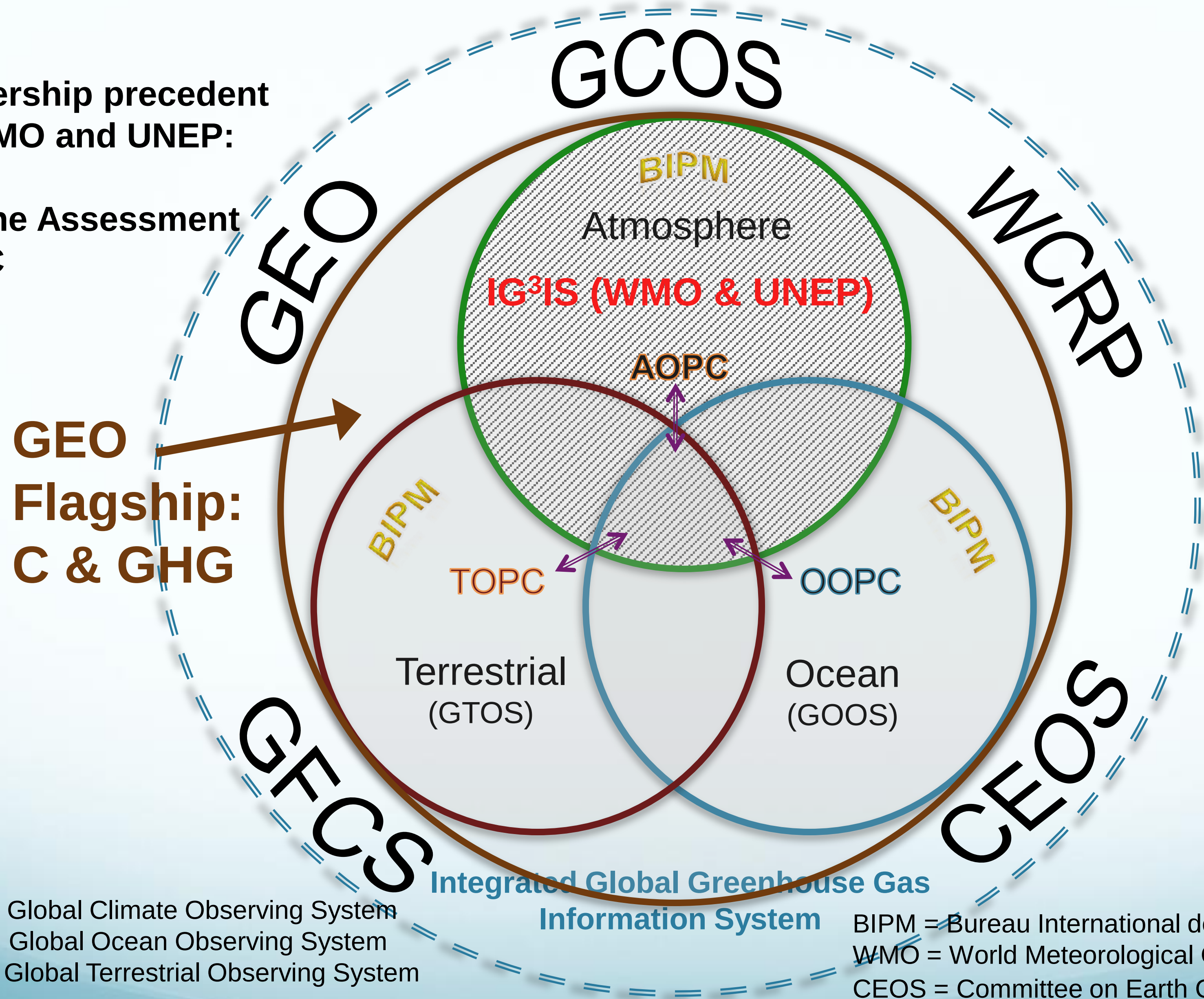
Added Value of an IG^3IS

- IG^3IS is a broad international effort with mandate starting with WMO and now partnering with UNEP
- Focuses on where skill and use cases exist, and where users are ready to engage based on where there is confidence, trust and value in doing so
- Brings together atmospheric composition information with socioeconomic activity data and emission factors…
- …..thereby, delivering information that is more timely, accurate, and consistent, with better temporal and spatial resolution
- Propagate standards and methods to establish fairness and efficiency that encourages increasing participation

IG³IS: WMO Initiative – Partners and Context

Partnership precedent for WMO and UNEP:

- Ozone Assessment
- IPCC



GCOS = Global Climate Observing System
GOOS = Global Ocean Observing System
GTOS = Global Terrestrial Observing System

AOPC = Atmospheric Observation Panel for Climate
OOPC = Ocean Observation Panel for Climate
TOPC = Terrestrial Observation Panel for Climate

BIPM = Bureau International des Poids et Mesures
WMO = World Meteorological Organization
CEOS = Committee on Earth Observation Satellites
GEO = Group on Earth Observations
GFCS = Global Framework for Climate Services
WCRP = World Climate Research Programme

Near-term IG^3IS Objectives (5-year horizon)

Support of UNFCCC Paris Agreement:

- Guide Nations to use atmospheric composition and inverse modeling (e.g., UK example) in UNFCCC inventory reporting
- "Global Stocktaking" in the context of the Paris Agreement:
  - More frequent and low latency trend assessment of NDCs are possible by combining atmospheric composition and socioeconomic data. This will be in support of the Paris Agreement's desire to revisit the progress of countries' NDCs. [e.g., FFDAS]
- Enhancing FFDAS for support of developing country inventories and Global Carbon Project methodology by increasing use of atmospheric composition data.

Key sub-national efforts and new mitigation:

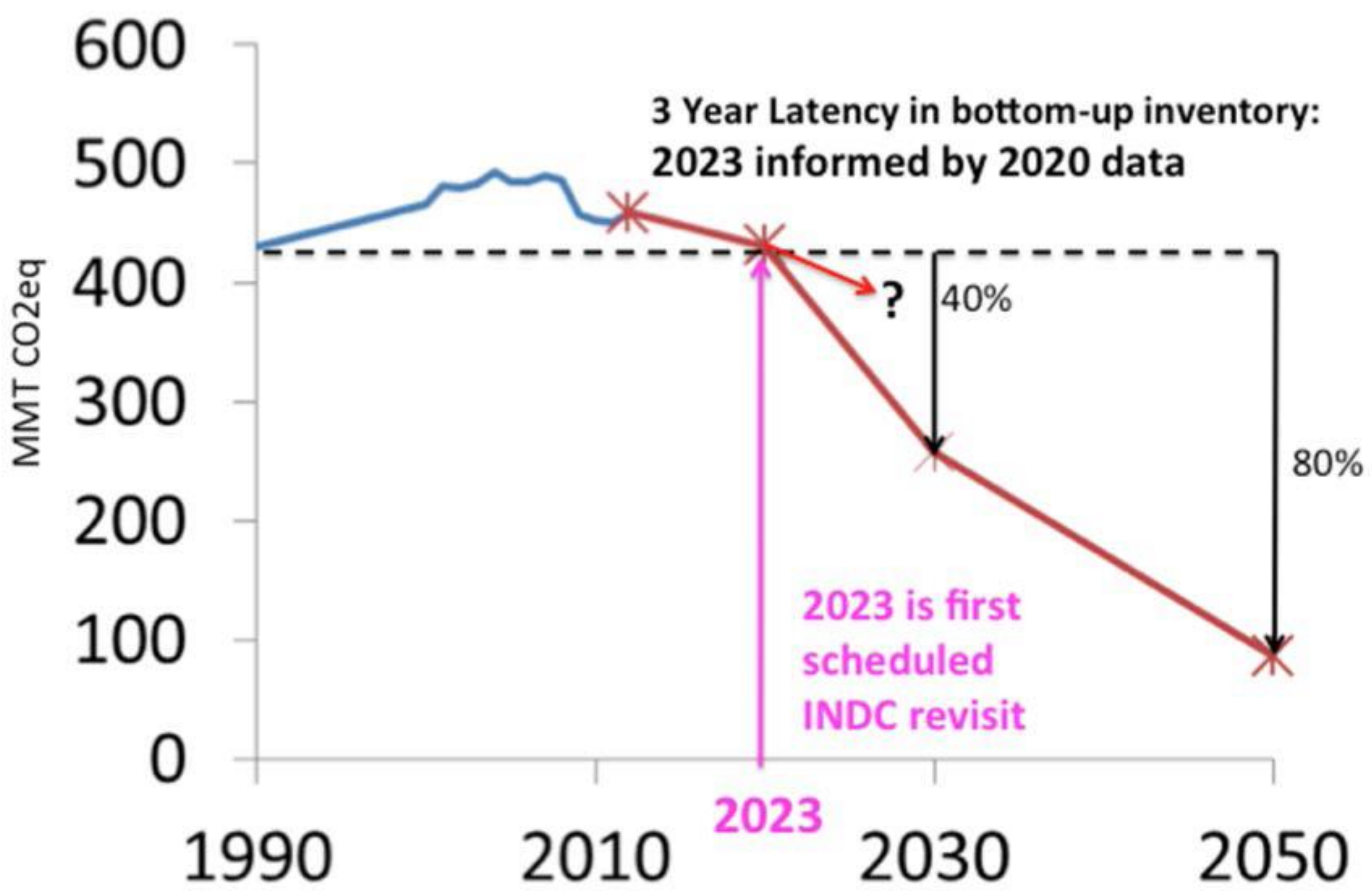
- GHG monitoring in large urban areas (megacities)
- Detection and attribution of CH_4 emissions from oil and gas sector

Improved Tools:

- Commercial aviation partnership to dramatically increase vertical profiles (e.g. extend IAGOS to intra-continental measurements)
- Isotopic top-down validation for fossil fuel CO_2 emissions (e.g., 13C, 14C)

Paris Agreement "Global Stocktaking":

A combination of top-down and bottom-up methods can deliver higher-frequency assessments of national emission trends and with rigorously quantified uncertainties



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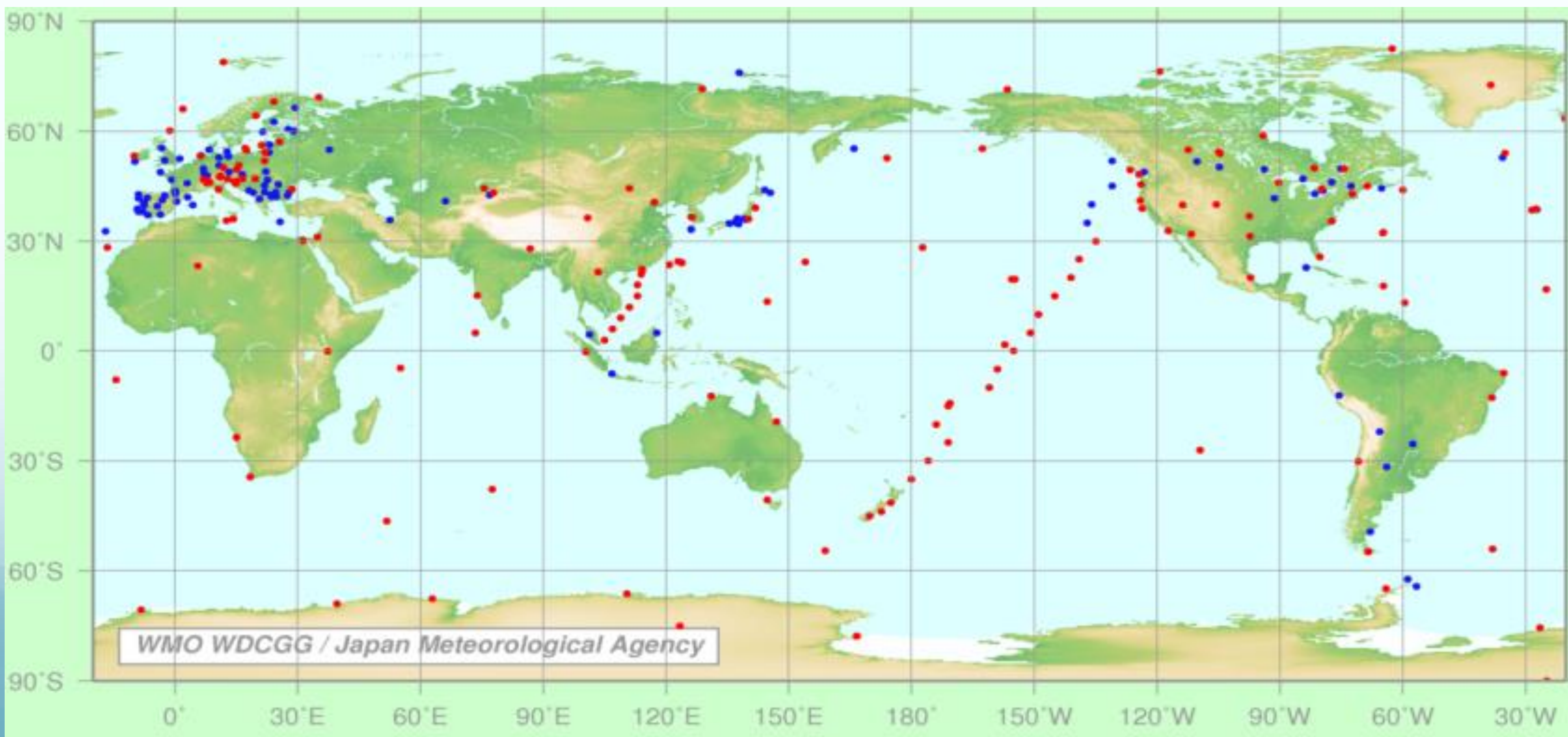
WMO Role in GHG Information and IG^{3}IS: Methods and standards for GHG Observations

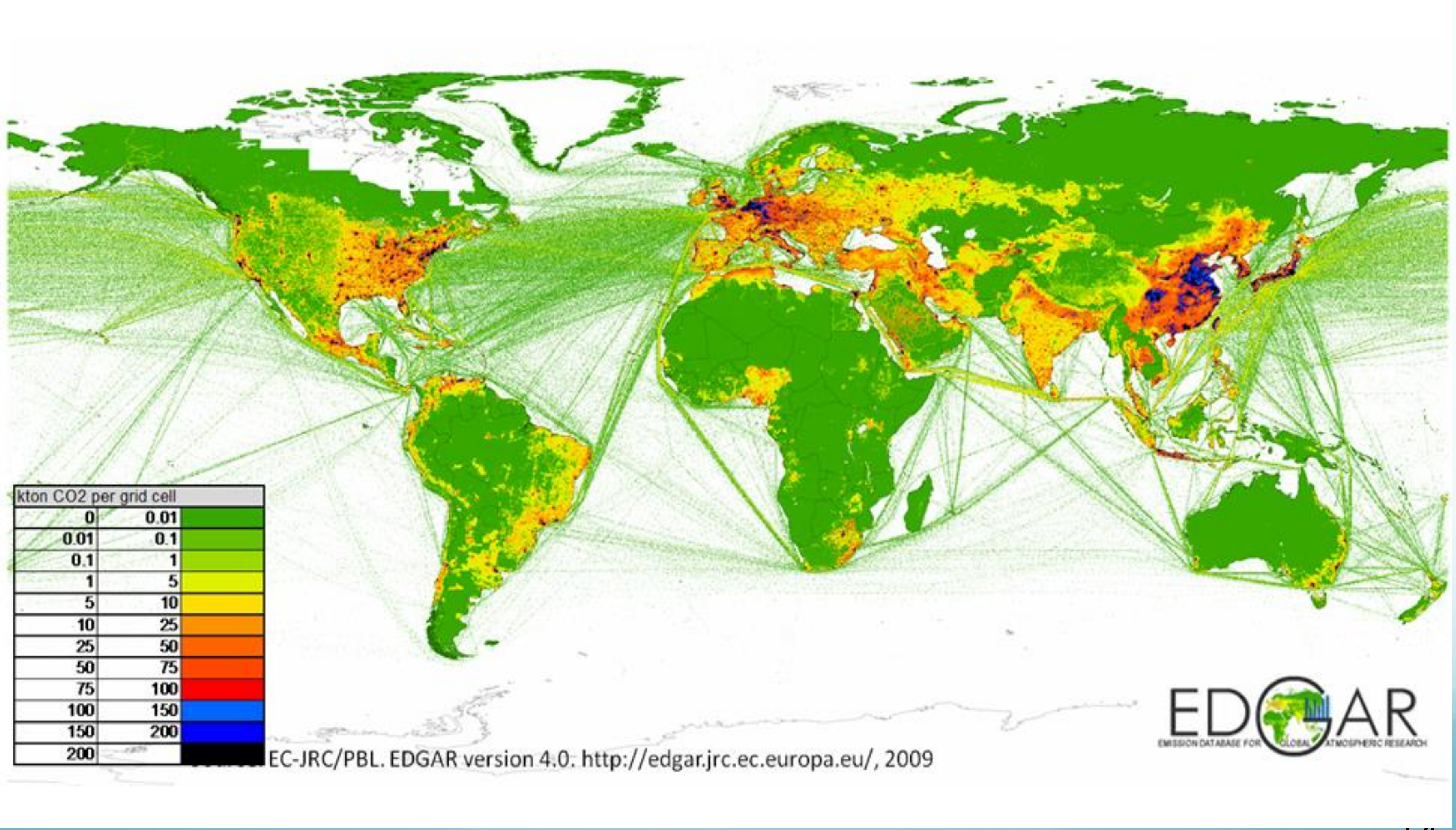
The Role of the World Meteorological Organization (WMO)

- Ensure high quality, consistent, continuous GHG and other observations of atmospheric composition
- Develop high quality atmospheric transport and data inversion models
- Coordinate global atmospheric measurements; improve models and analysis
- Leverage capabilities across programs and nations
- Build capacity in developing nations



Relevance: cities matter

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



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

Urgency: cities are changing rapidly

http://*www.c40cities.org*

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

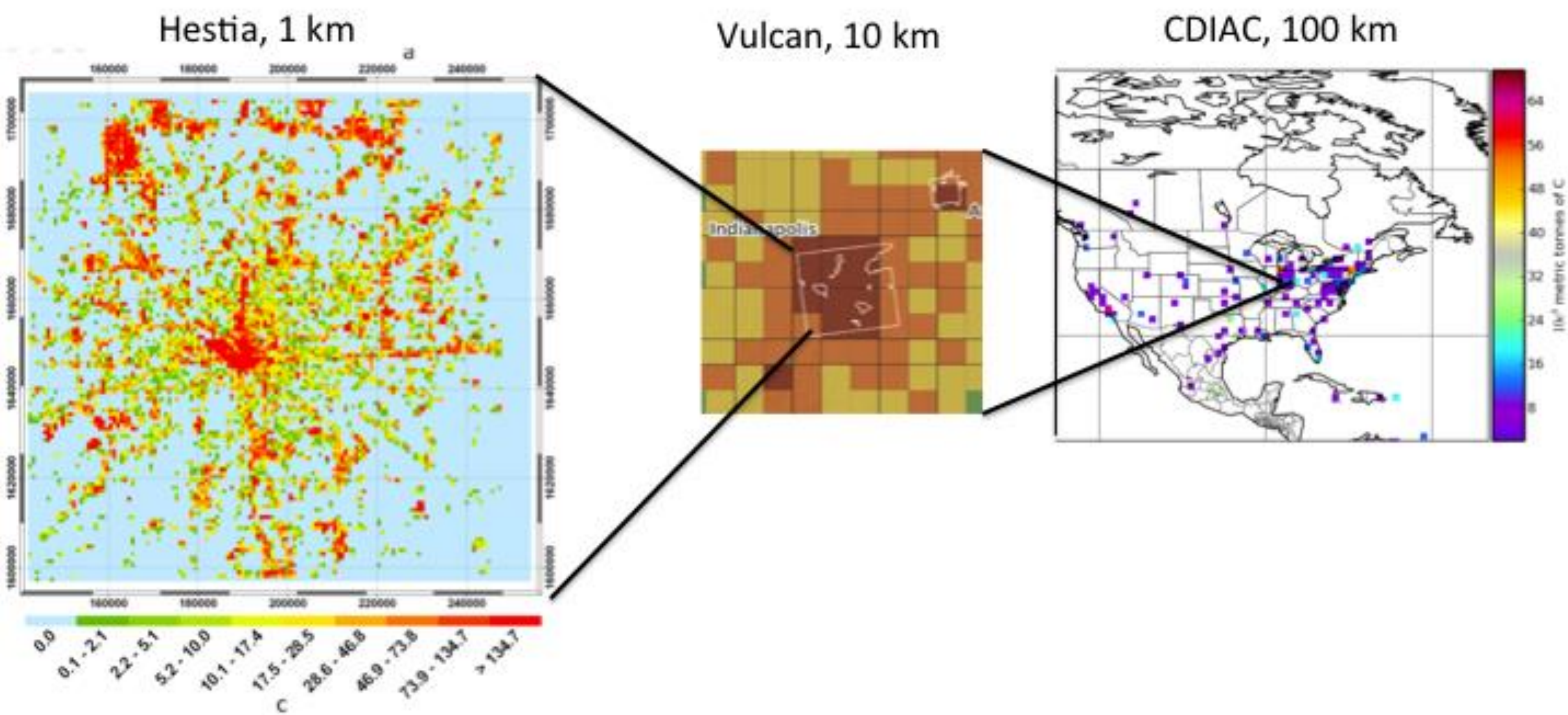
and **Growth**

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

population >4%/year
emissions >10%/year

Pragmatic: monitoring cities is a tractable problem

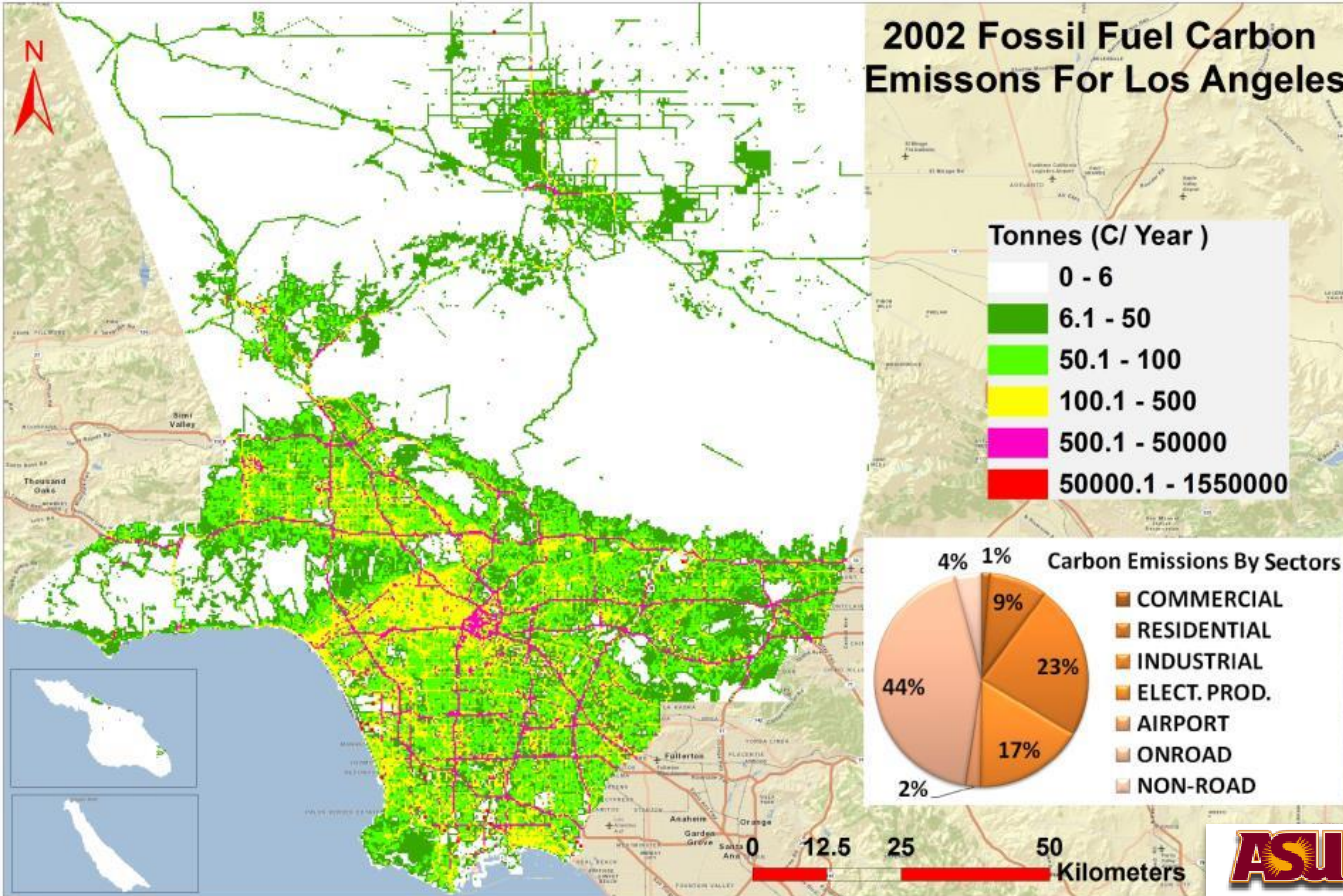
CO_2 at local (human) scales is more intense than at larger scales



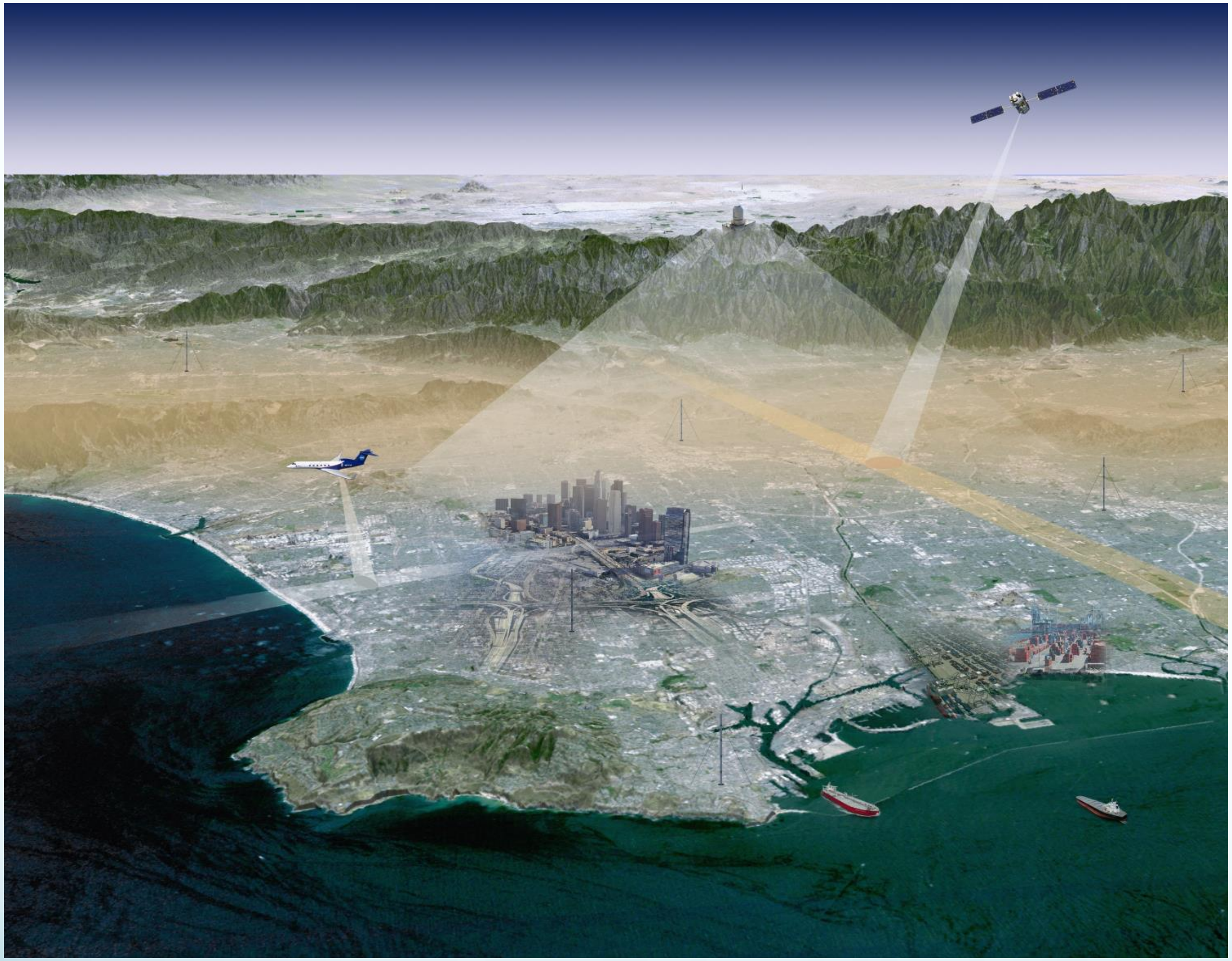
Right: Gridded annual fossil fuel CO2 emissions from a medium-size city (Indianapolis) show distinct gradients at different spatial scales. Right: CDIAC 2006 emissions for the CONUS plotted on a 1° (~100 km) show avg flux 200-600 gC/m2/yr. Middle: Vulcan 2002 emissions for the ~10,000 km2 area centered 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).

The Hestia Project:

Quantifies all fossil fuel CO2 emissions at building and street



Megacity Project: Paris and Los Angeles



Carbon emissions from cities and their support systems represent the single largest human contribution to climate change.

The Megacity Project provides a strategy, methodology and roadmap for an international framework to assess directly the carbon emission trends of the world's megacities.

http://megacities.jpl.nasa.gov

LSCE

Earth Networks

Taking the Pulse of the Planet

SigmaSpace

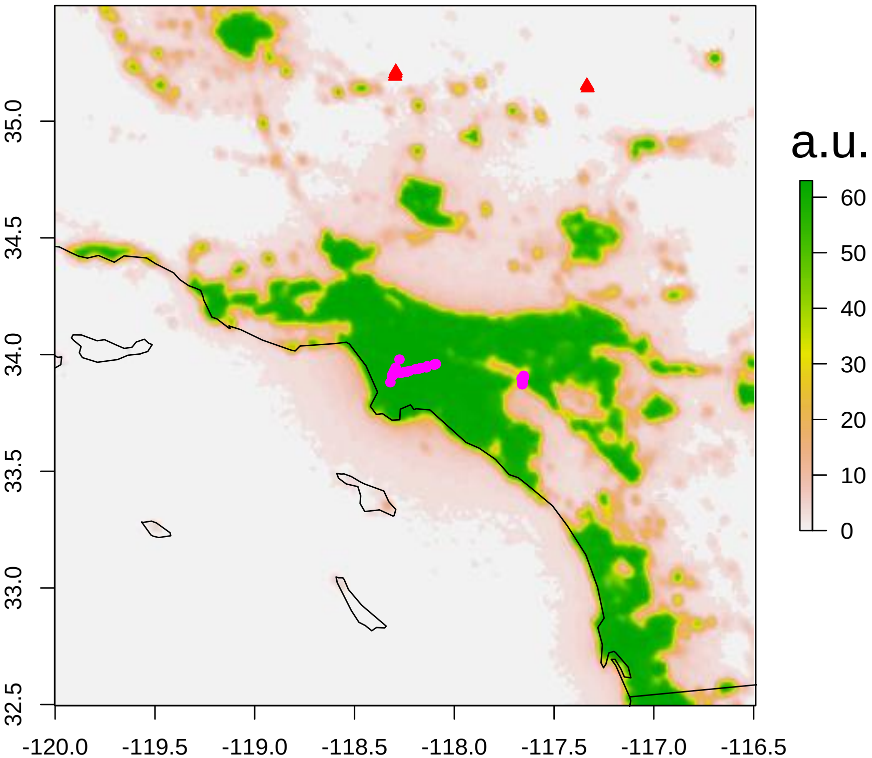
BERKELEY LAB

RESOURCES FOR THE FUTURE

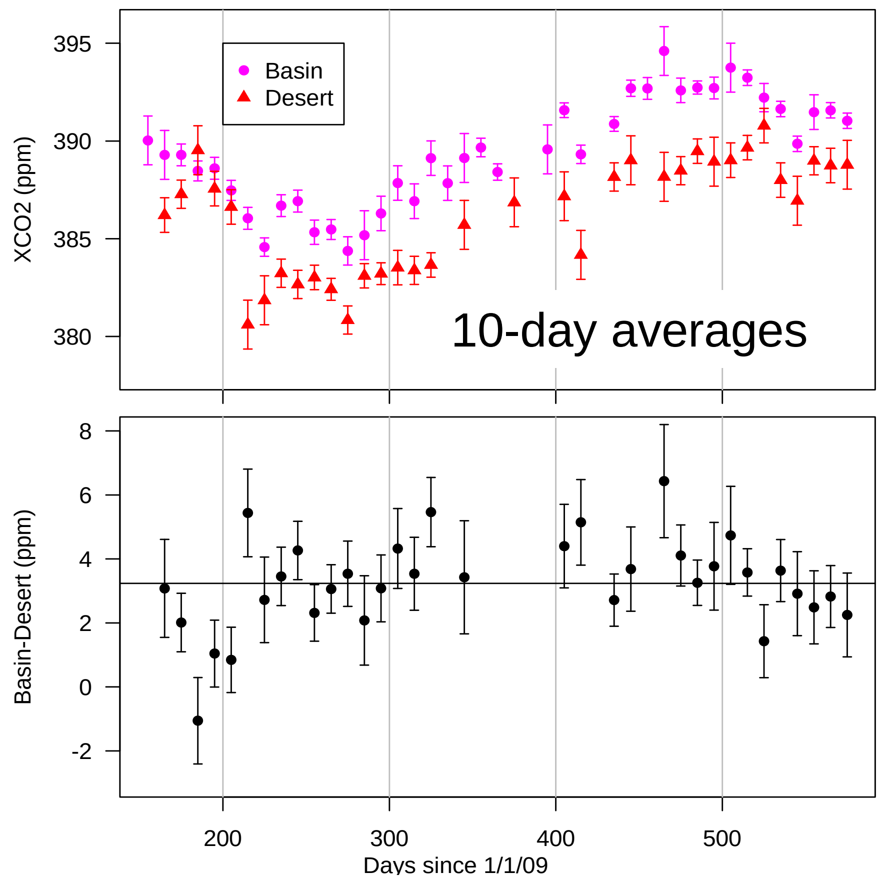
ARIZONA STATE UNIVERSITY

GOSAT Observations Demonstrate Space-based Detection of Megacity XCO2

Selecting observations over LA & 'Background' Location



Selected GOSAT footprint locations over LA nightlights



Kort et al., GRL (2012)

Persistent, robust enhancement $= 3.2 \pm 1.5$ ppm

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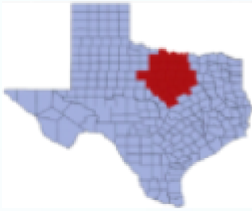
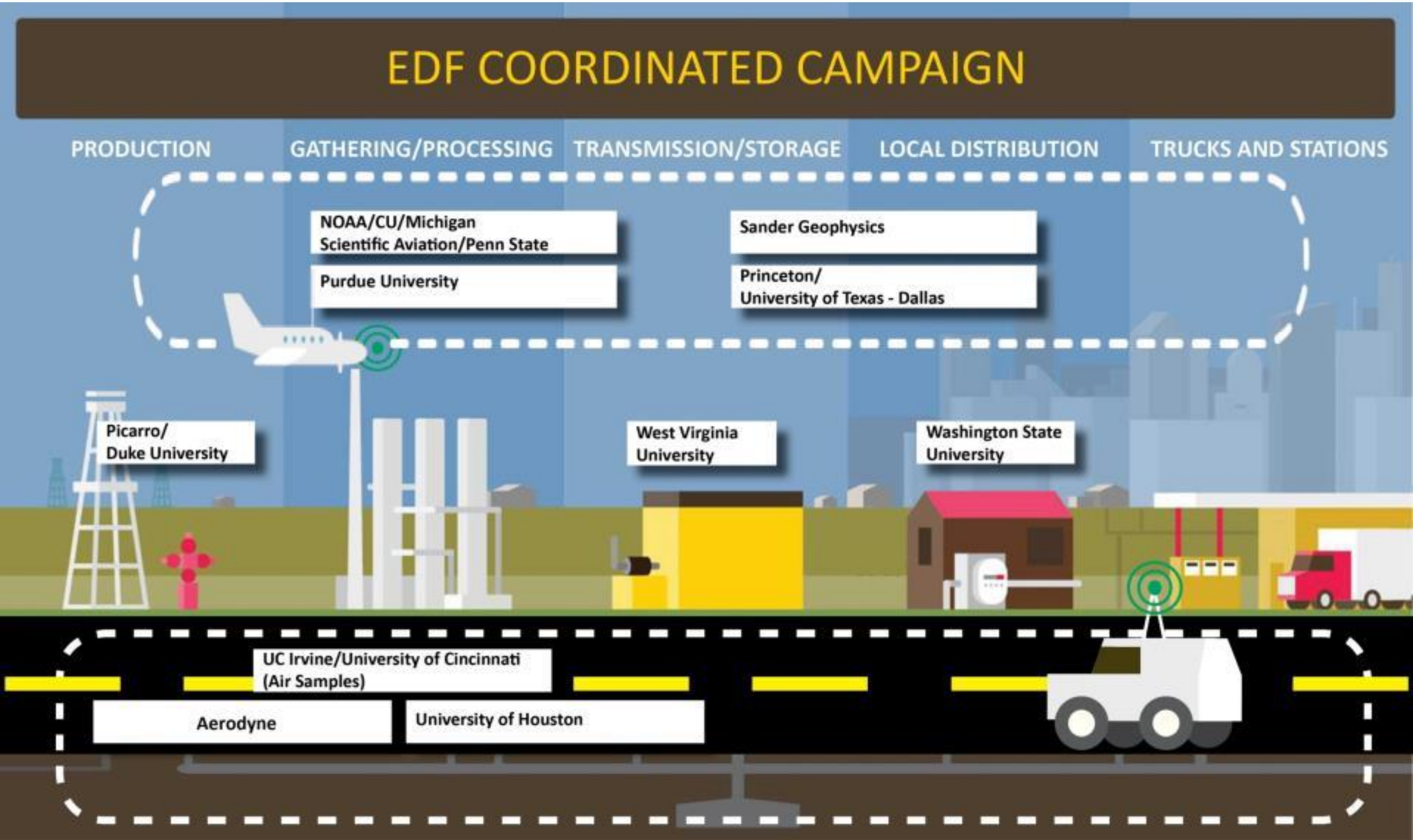
Methane from Oil and Gas Supply Chain USA Texas (Barnett Shale) Example



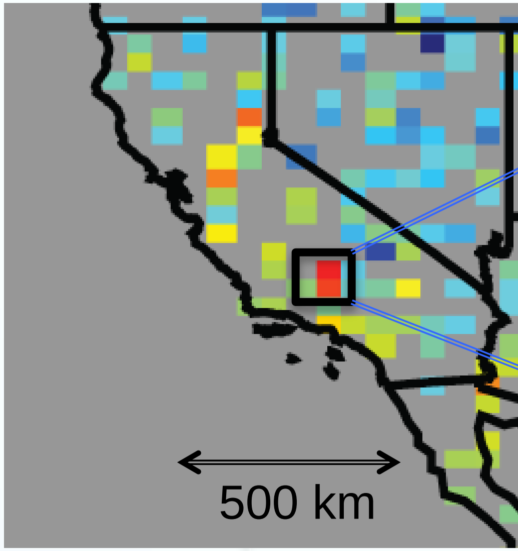
Atmospheric composition plus enhanced bottom-up activity data

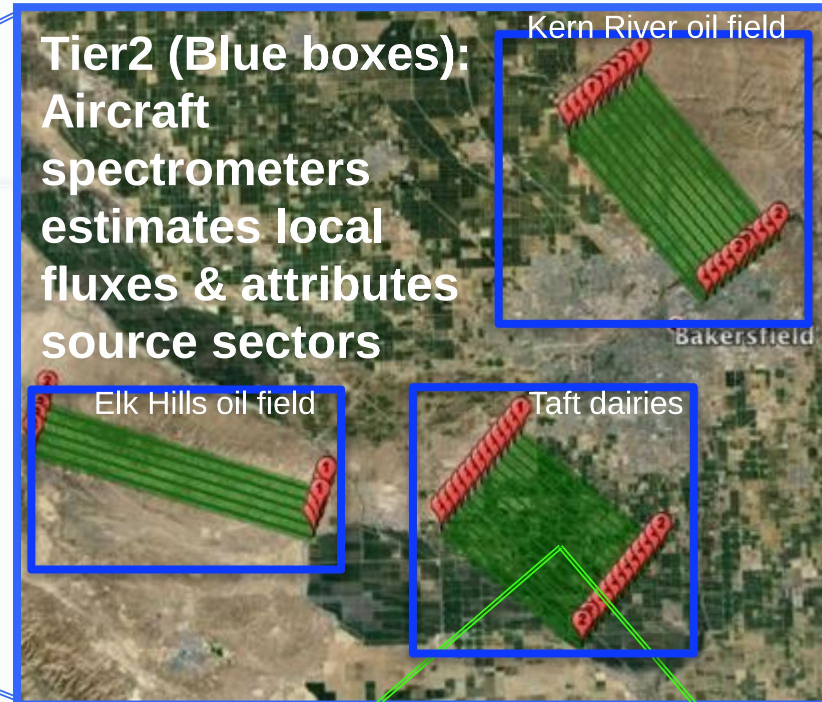


A tiered strategy for monitoring methane leaks in the US

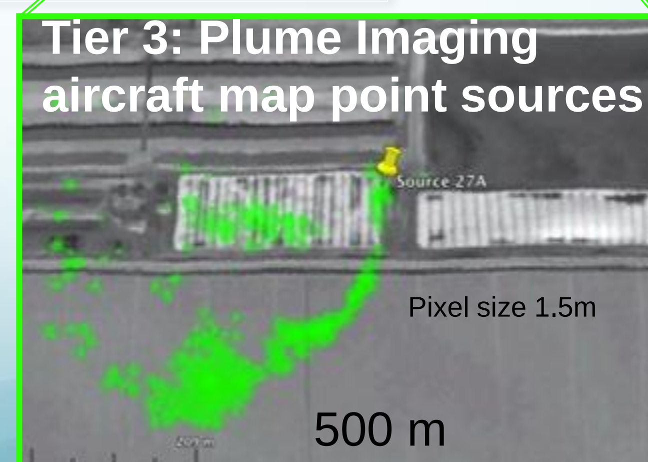
Tier 1: Satelite detects hotspot region

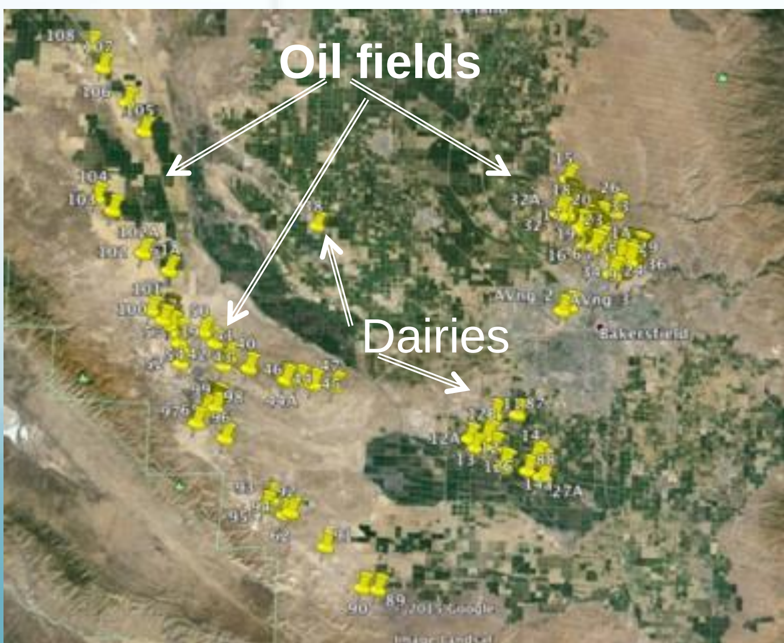
Turner et al 2015





50 km





Enhanced Activity Data

Tier 4 (not shown): Surface observations

Added Value of an IG^{3}IS

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- Focuses on where skill and use cases exist, and where users are ready to engage based on where there is confidence, trust and value in doing so
- Brings together atmospheric composition information with socioeconomic activity data and emission factors…
- …..thereby, delivering information that is more timely, accurate, and consistent, with better temporal and spatial resolution
- Propagate standards and methods to establish fairness and efficiency that encourages increasing participation

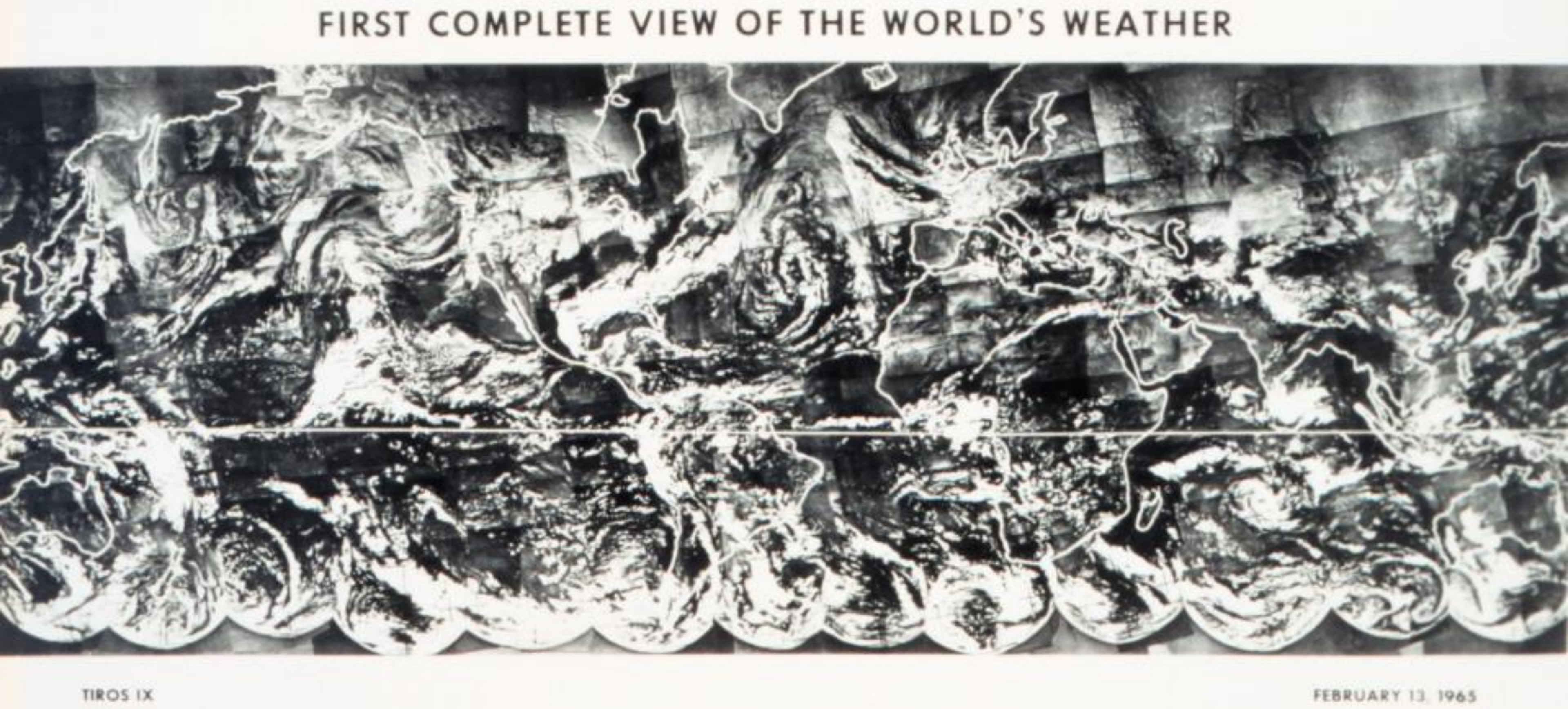
Next steps

- Develop a system for the future that will meet society's evolving needs to reduce and mitigate GHG emissions:

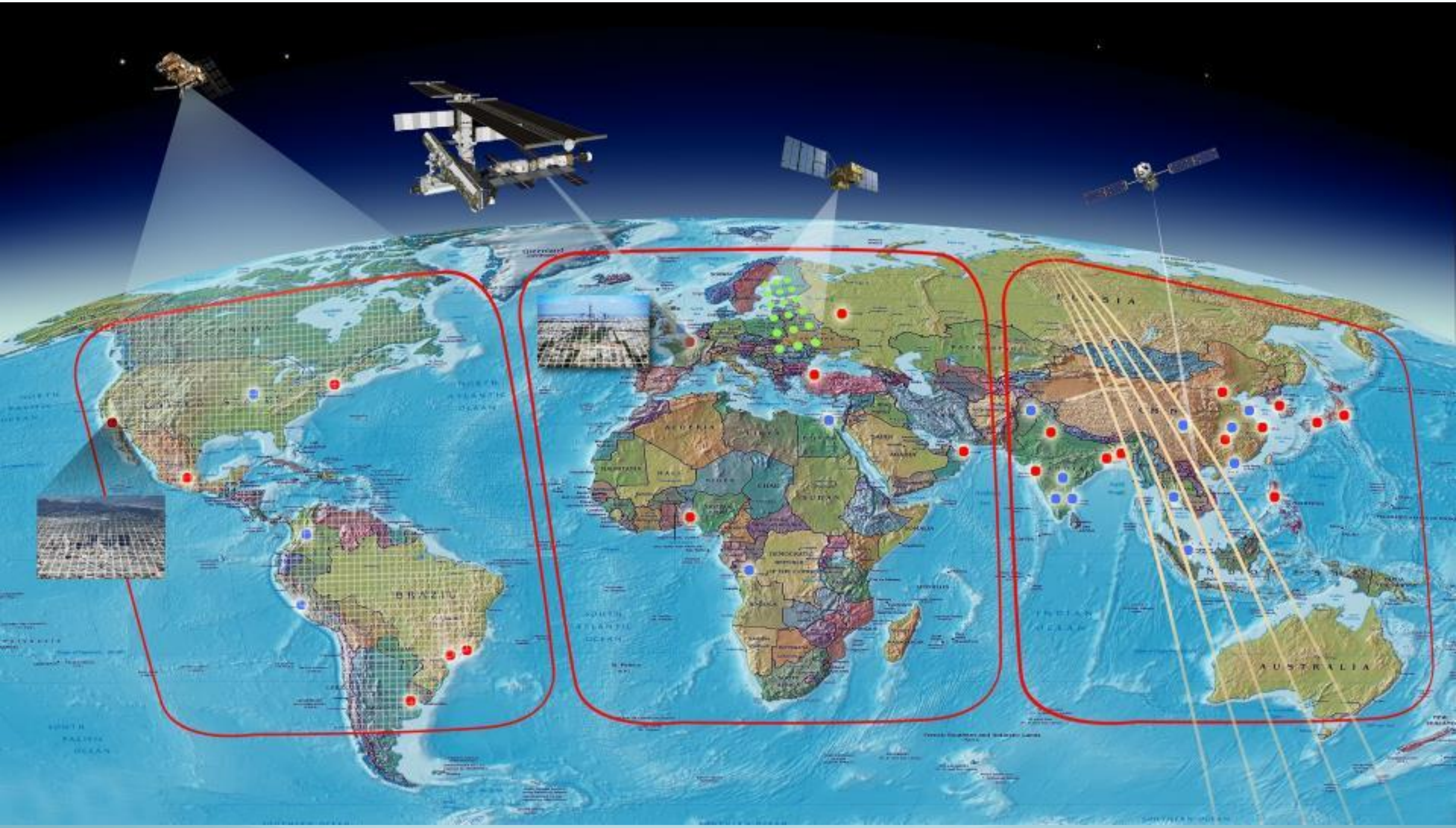
  - Complete the strategic/implementation plan for the IG^3IS and gain approval from WMO and UNEP
  - Actively entrain partners and users through all stages of development
  - Coordinate with other efforts (e.g., GCOS, GFCS, GEO Carbon Flagship)
  - Establish budgets and identify support
  - Establish a Secretariat

NWP system architecture of observations and models: an IG³IS long-term vision for "carbon weather" forecasts

Today's NWP system incorporates multiple coordinated satellites in low Earth orbit (LEO) and geostationary orbit (GEO), aircraft, balloon, and ground observing systems in a true system of systems. A similar approach could be developed for CO2 and CH4 emissions monitoring, perhaps even leveraging the existing operational meteorological infrastructure.



Future with geostationary sounders, low-Earth orbiting mapping systems and data assimilation

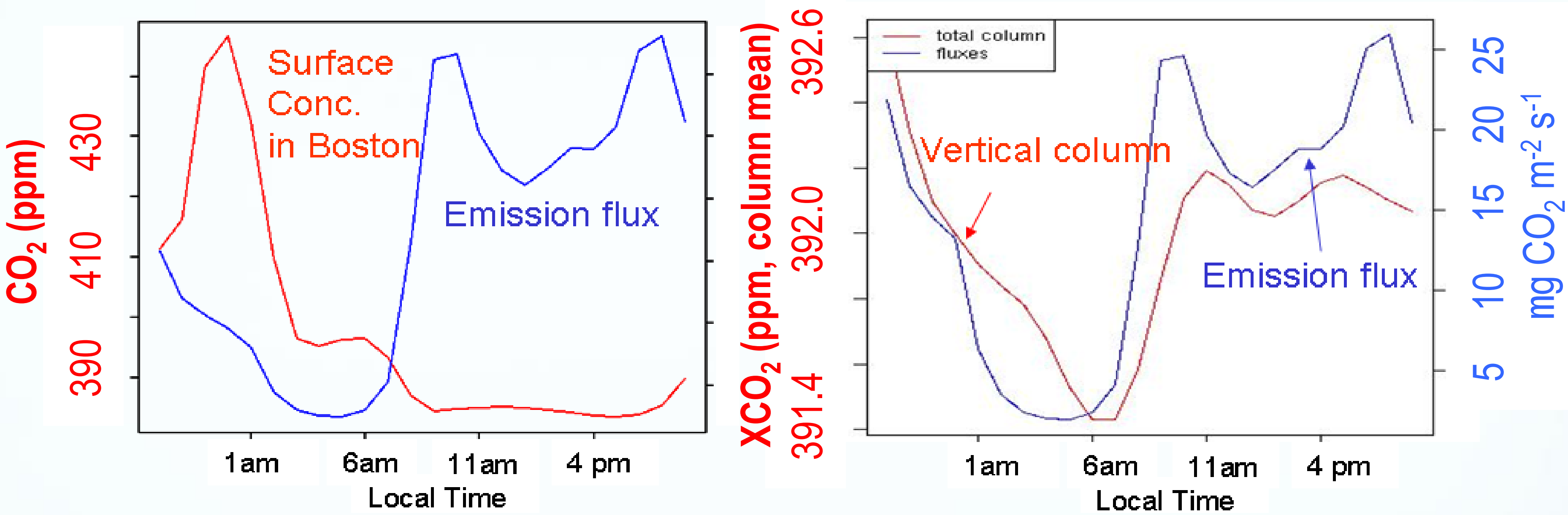


Conclusions

In order to provide GHG information that will support post COP21 action, there is need for an Integrated Global GHG Information System working at local, regional, and national scales. An IG^{3}IS combines atmospheric composition with bottom-up inventory data to better inform policy and decisions

- **Reduce uncertainty of national emission inventory reporting**,
- **Identify large and additional emission reduction opportunities**,
- **Provide nations with timely and quantified guidance on progress towards their emission reduction strategies and pledges (e.g., NDCs)**

WMO Role in GHG Information: Atmospheric Transport



The patterns in observed surface concentrations are distinctly opposite to the daily variations of emissions fluxes from human activity.

Surface concentrations of CO_2 maximize at nighttime when the nocturnal PBL is shallow, but PBL height and rush hour emissions are increasing in the morning.

Must understand atmospheric transport and dynamics to quantify emissions fluxes from atmospheric concentration measurements

Atmospheric GHGs - The Primary Driver of Climate Change

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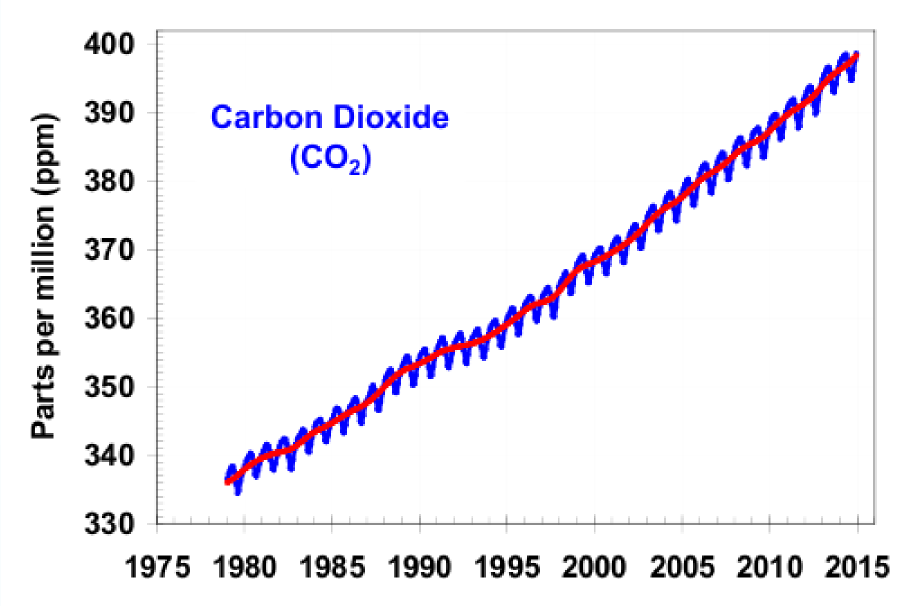
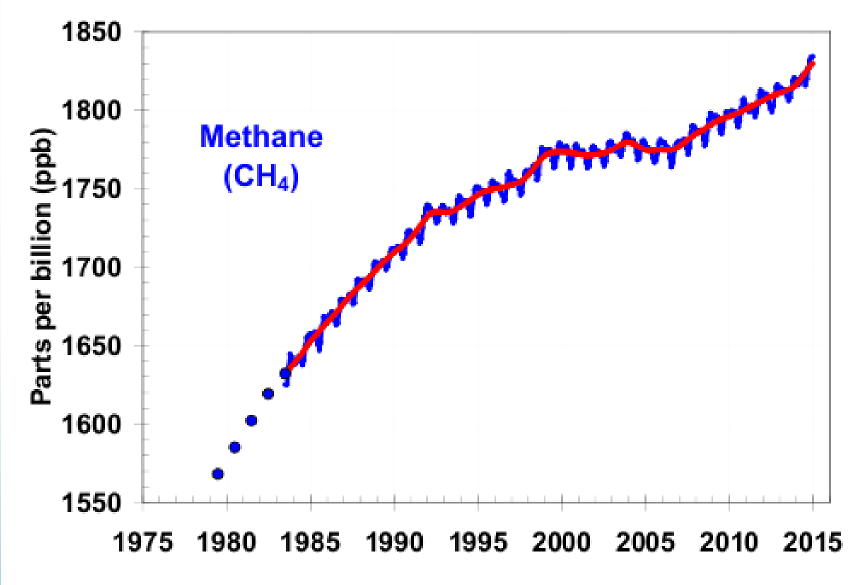
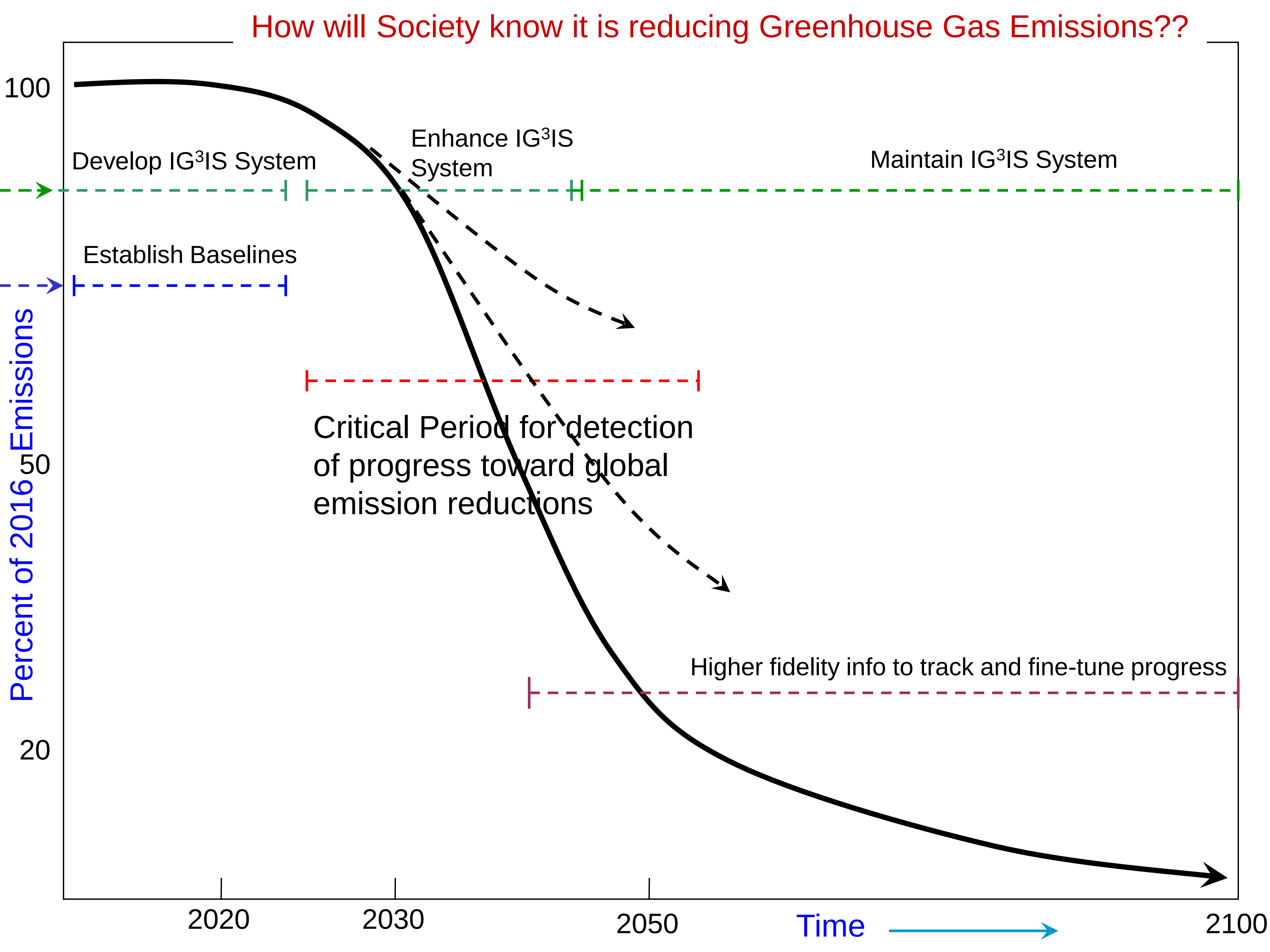






How will Society know it is reducing Greenhouse Gas Emissions??
100
50
20
Percent of 2016 Emissions
Develop IG³IS System
Enhance IG³IS System
Maintain IG³IS System
Establish Baselines
Critical Period for detection of progress toward global emission reductions
Higher fidelity info to track and fine-tune progress
2020
2030
2050
2100
Time

CLIMATE

Carbon trackers could help bolster climate vows

Projects lay groundwork for a global greenhouse monitoring system

By **Warren Cornwall**

In May, China's statistical agency quietly raised estimates of how much coal the nation has burned since 2000. That little bit of bookkeeping had big implications. It amounted to as much as 900 million metric tons of additional carbon dioxide (CO_2) emitted annually in recent years, more than the total yearly emissions of Germany. It also underscored the challenge of knowing what many countries are really pumping into the atmosphere.

After negotiators left Paris last week with vows to curb the world's climate pollution (see box, p. 1451), officials will want to know whether countries are living up to their promises. The Paris meeting addressed part of the puzzle: greenhouse gas accounting, including mechanisms for auditing emissions reports. But scientists are also in the early stages of deploying systems they hope could buttress international agreements by closely tracking greenhouse gas emissions in the air, rather than on paper.

Space-borne sensors are watching the ebb and flow of carbon around the globe, and a few experimental, city-scale monitoring systems are up and running. Ultimately, a network of instruments on satellites, commercial jets, smokestacks, and communications towers could deliver a detailed, nearly instantaneous picture of emissions in a country, city, or even a neighborhood: a global weather system for greenhouse gases.

"A carbon weather service is probably the best example of where we probably ought to get in the future," says Riley Duren, an engineer at NASA's Jet Propulsion Laboratory in Pasadena, California. He heads the Megacities Carbon Project, which is building a first-generation system in Los Angeles, California. The idea got a boost earlier this year when the United Nations World Meteorological Organization (WMO) endorsed the creation of the Integrated Global Greenhouse Gas Information System, to promote networks for tracking greenhouse gases.

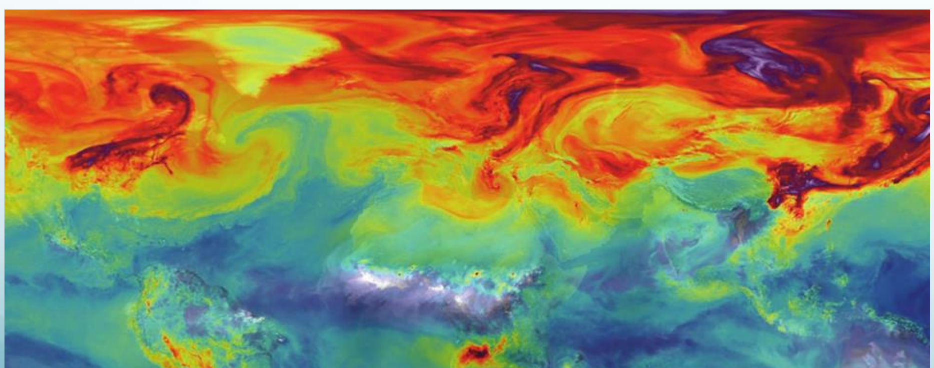
Today, the clearest data on CO_2 are the atmospheric concentrations measured at more than 40 stations around the world. Emissions for countries or cities are estimated by adding up reams of statistics about fuel consumption, deforestation, electricity generation, and other activities.

Many developed countries have honed these inventories over years of practice under the Kyoto, Japan, climate treaty. But much less is known about emissions in the developing world, which today account for an estimated 60% of climate pollution. In October, the European Union's earth observation agency, Copernicus, warned that such uncertainties "could undermine the credibility and the stability of future climate agreements."

The projects now underway in the skies and on the ground could eventually help officials determine whether their neighbors are meeting their promises and whether their own strategies are producing results. "Our goal is to say: 'Your emission reduction policies seem to be consistent with what we see in the atmosphere, although it looks like your efforts in transportation are having a bigger impact than the energy sector,'" says James Butler, director of the global monitoring division at the National Oceanic and Atmospheric Administration's Earth System Research Laboratory in Boulder, Colorado.

Cities, where a majority of human-caused greenhouse gases originate, are serving as testing grounds. Over the last 5 years, Indianapolis, Boston, Los Angeles, and Paris have been outfitted with equipment to track their carbon emissions. A similar network is being built around Washington, D.C., and it may eventually be extended up the East Coast to Boston, says James Whetstone, a scientist and manager at the National Institute of Standards and Technology in Gaithersburg, Maryland, which is helping fund several of the U.S. projects.

Los Angeles illustrates both the potential and the challenges. Today, 13 devices mounted high on tall buildings and cellphone and radio towers constantly measure CO_2 across an area of 17,000 square kilometers. Some also track methane, a potent heat-trapping gas. Atop nearby Mount Wilson, a device scans the basin every 90 minutes, detecting the gases' infrared signature. Airplanes zero in on hot spots identified by the stationary instruments. NASA's Orbiting Carbon Observatory-2 (OCO-2) satellite periodically surveys the city for a big-picture snapshot. The data



A simulation shows high CO_2 levels over Northern Hemisphere continents. New monitoring efforts aim to keep tabs on regional emissions.

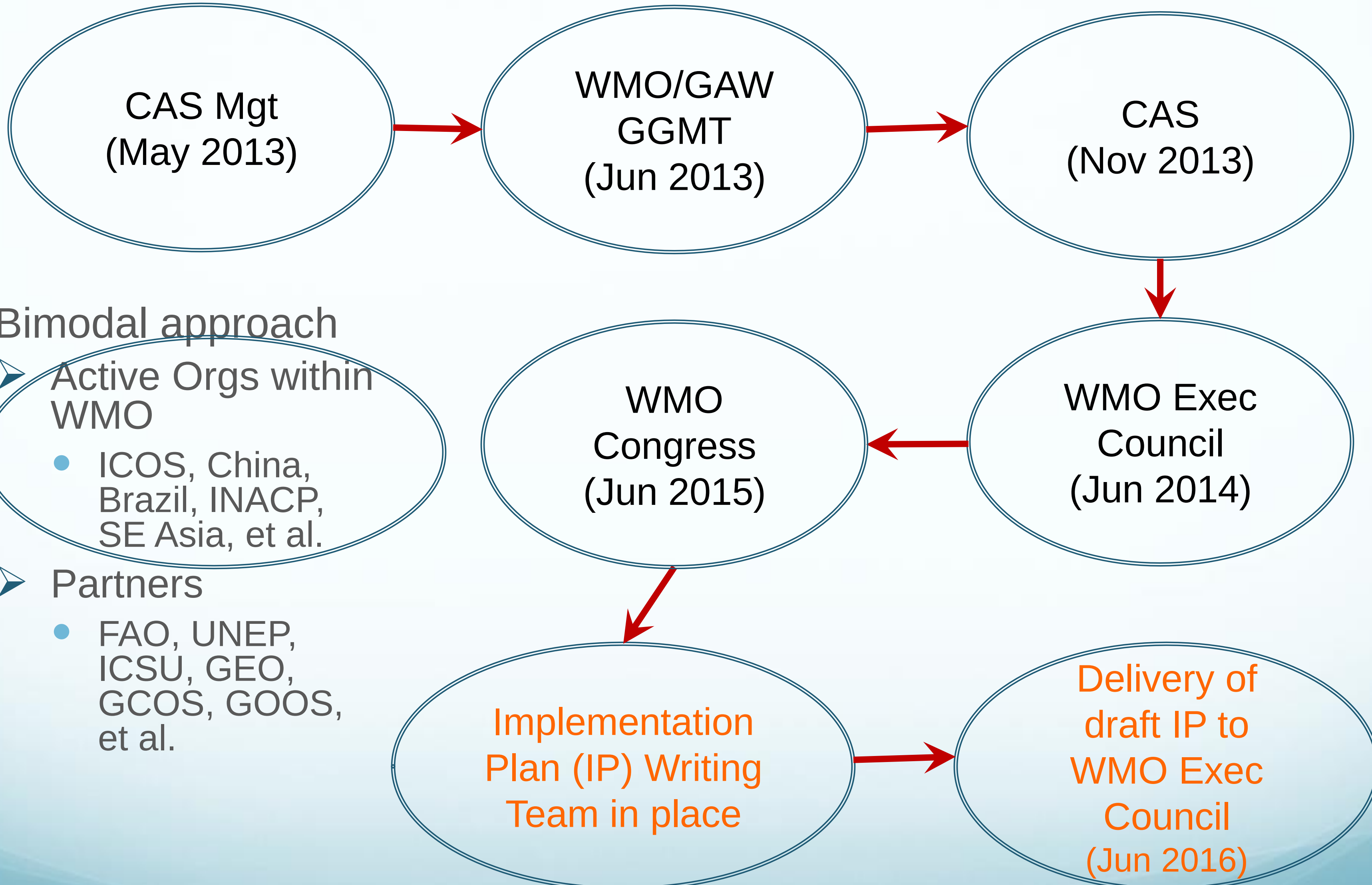
Carbon trackers could help bolster climate vows: projects lay groundwork for a global greenhouse monitoring system

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

Science 18 Dec 2015:
W Cornwall, Vol. 350, Issue 6267, pp. 1450-1451
DOI: 10.1126/science.350.6267.1450

IG³IS Implementation

(within WMO)

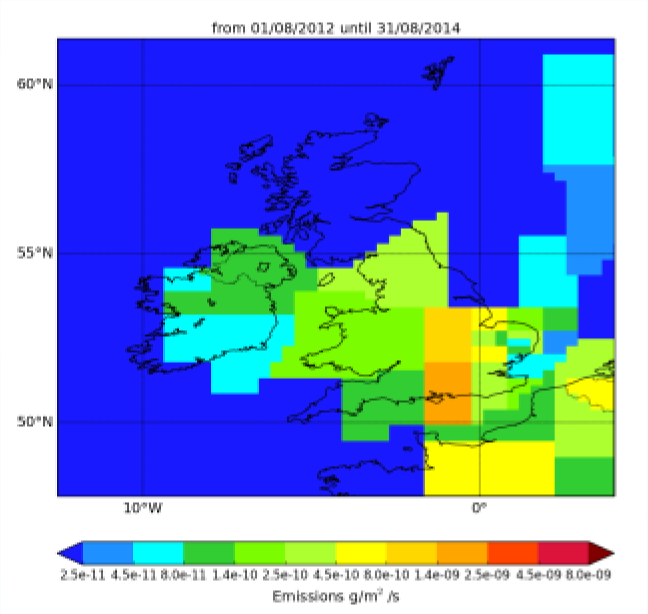


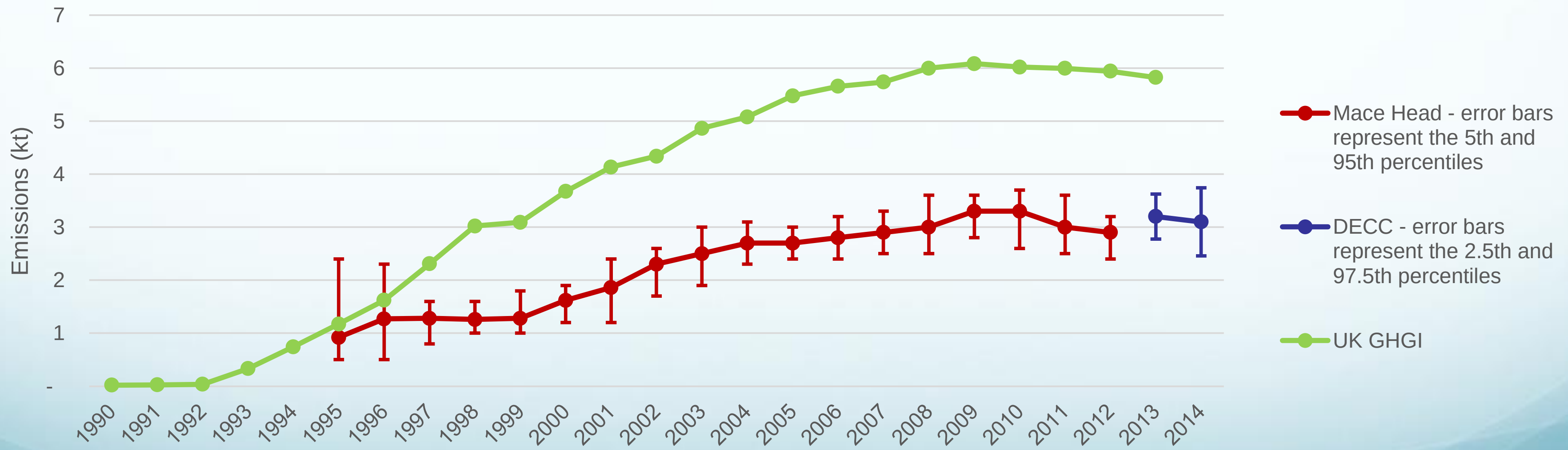
- Bimodal approach
  - Active Orgs within WMO
    - ICOS, China, Brazil, INACP, SE Asia, et al.
  - Partners
    - FAO, UNEP, ICSU, GEO, GCOS, GOOS, et al.

Example from UK report to UNFCCC: HFC-134a

- **Significant mismatch throughout the entire time-series of emissions, approximately inversion is 50% lower than inventory.**

- **Investigated the refrigeration model used by inventory compilers, key variables to be re-considered by DECC:**
  - **Refill rate**
  - **Uptake rate**





Example from UK report to UNFCCC: Methane

- Early (1990s) mismatch with the inventory.
- Difficult to understand, most likely cause is landfill emissions but retrospectively challenging to investigate.
- Inspired DECC to expand the network from 1 to 4 stations.