Greenhouse gAs Uk and Global Emissions (GAUGE): Quantifying UK anthropogenic GHG emissions

GAUGE objective: Quantify UK GHG budget, in the context of European and global scales, to underpin the development of effective emission reduction policies.

Challenge: Development of a comprehensive, multi-year and interlinked measurement and data analysis programme.

http://www.greenhouse-gases.org.uk/

Greenhouse gAs Uk and Global Emissions (GAUGE): Quantifying UK anthropogenic GHG emissions

Inter-calibrated atmospheric GHG measurements

From air

From sea

From space
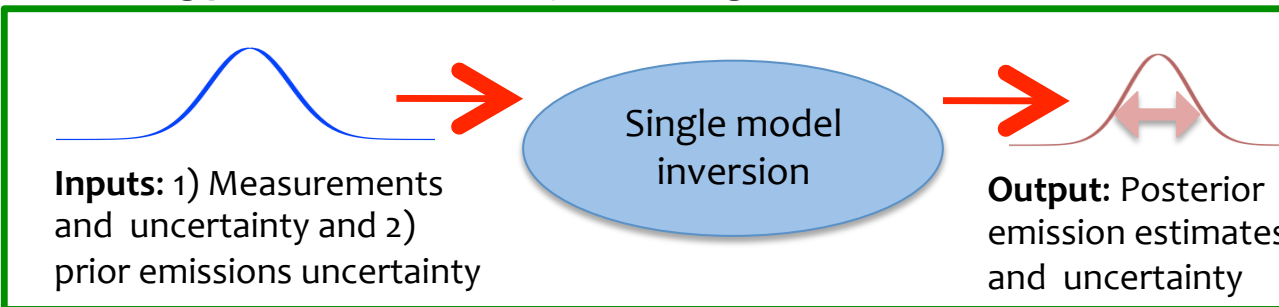
Using new technology

From the ground

● Old
● New
✳ Isotopes

Wick
Ullapool
Inverness
Aberdeen
Oban
Perth
Dundee
Stirling
Glasgow
Edinburgh
Stranraer
Newcastle
Belfast
Carlisle
Dublin
Liverpool
Hull
Manchester
Norwich
Birmingham
London
Cardiff
Dover
Plymouth

Scotland
England
Wales
Northern Ireland
Republic of Ireland

## Cutting-edge models of atmospheric transport

Global

Regional

Using the world-class meteorological analyses and the latest prior emission inventories

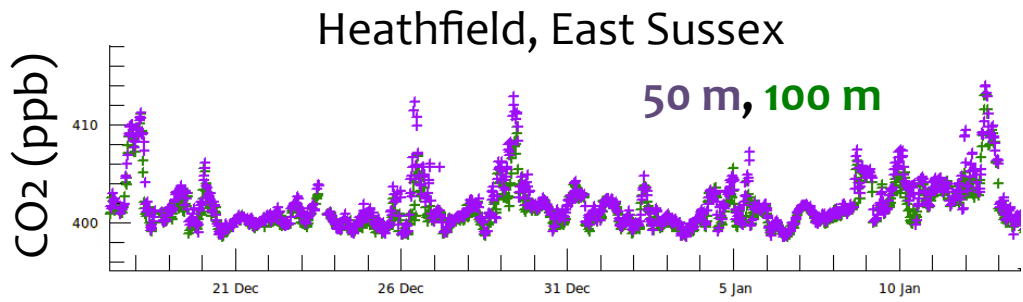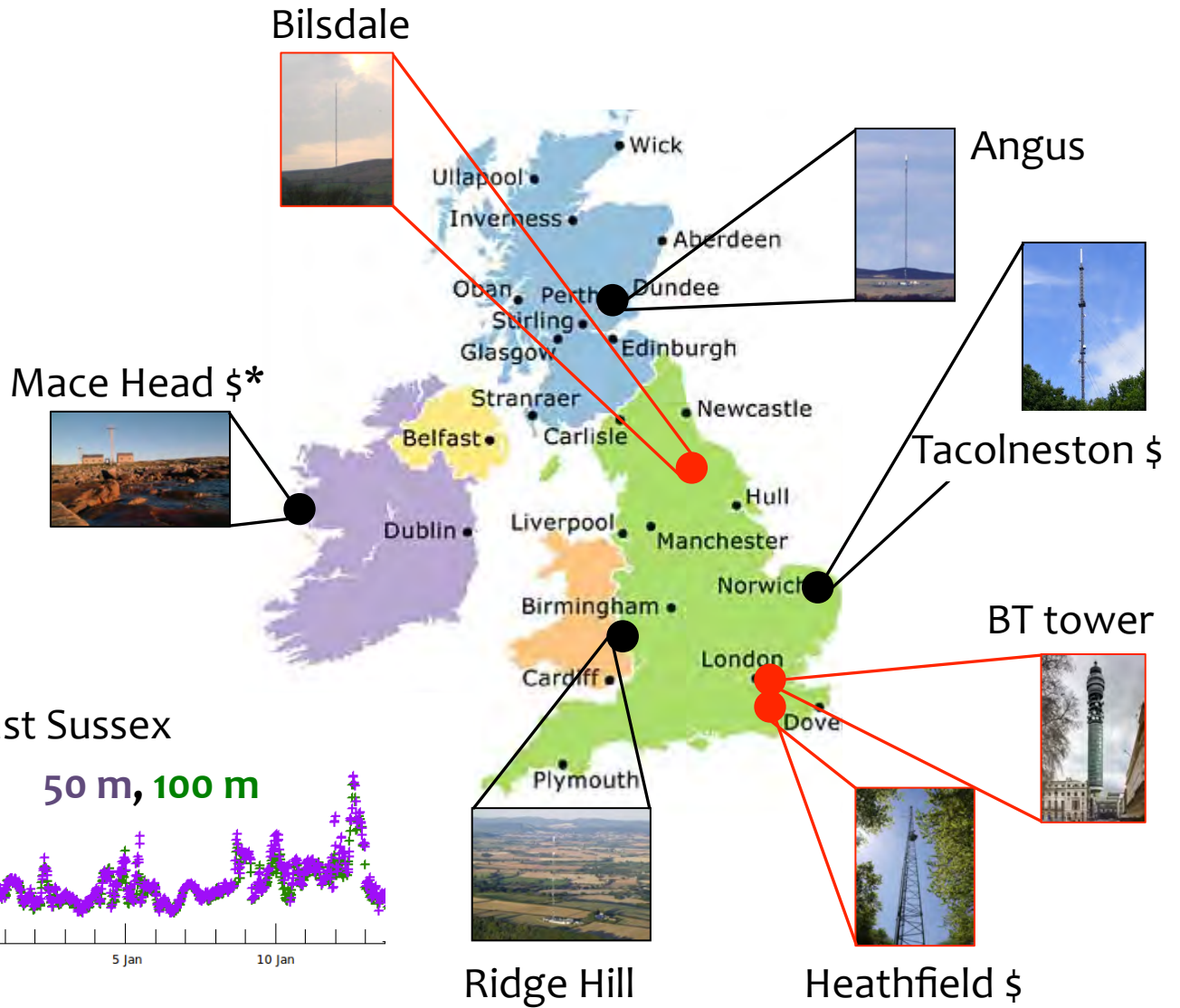## Estimating posterior emissions by combining measurements and models

Single model inversion

Inputs: 1) Measurements and uncertainty and 2) prior emissions uncertainty

Output: Posterior emission estimates and uncertainty

Facilitating better decisions: ensemble of emissions estimates provide uncertainty
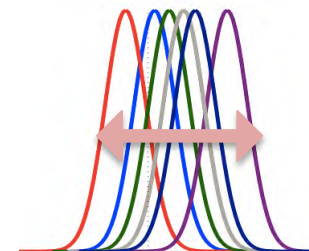
Tall towers: enhancing resolution of existing measurement network

DECC and GAUGE tall towers:
1) CO_2, CH_4, N_2O, CO + additional tracers
2) \$ denotes $\delta^{13}CH_4$ and $\Delta^{14}C_{CO2}$
3) * denotes N_2O isotopes)

Bilsdale

Angus

Mace Head \$*

Tacolneston \$

BT tower

Heathfield, East Sussex

50 m, **100 m**

CO_2 (ppb)

410

400

21 Dec   26 Dec   31 Dec   5 Jan   10 Jan

Ridge Hill

Heathfield \$

Aside: TT site at Divis, NI, run by Airbus Defence and Space/NPL since 9/13
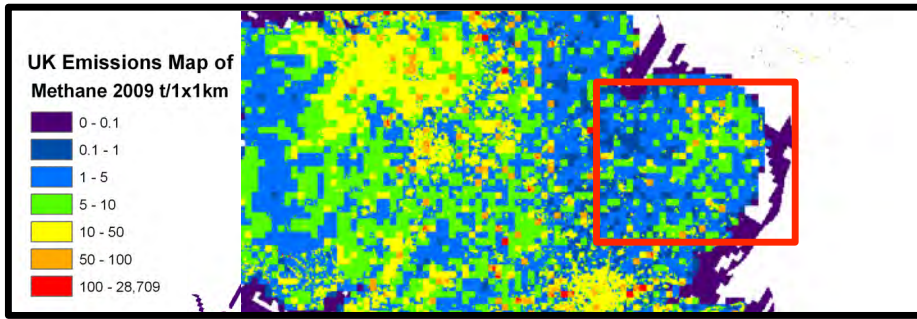
Sampling UK outflow from the North Sea

Rosyth to Zeebrugge freight vessel

DFDS ferry: CO_2, CH_4, N_2O*

Mobile laboratory in a shipping container

/100 ppb

- Sails 6 times/week (23 hours) at different times.
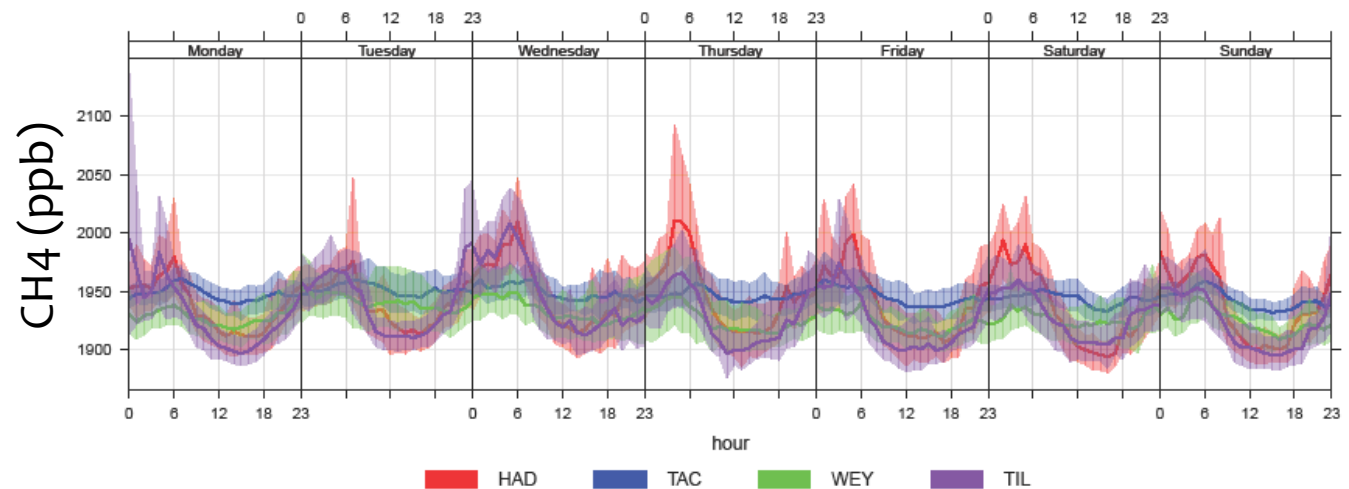- Provides continuous sampling of continental outflow over the North sea for 36 months.
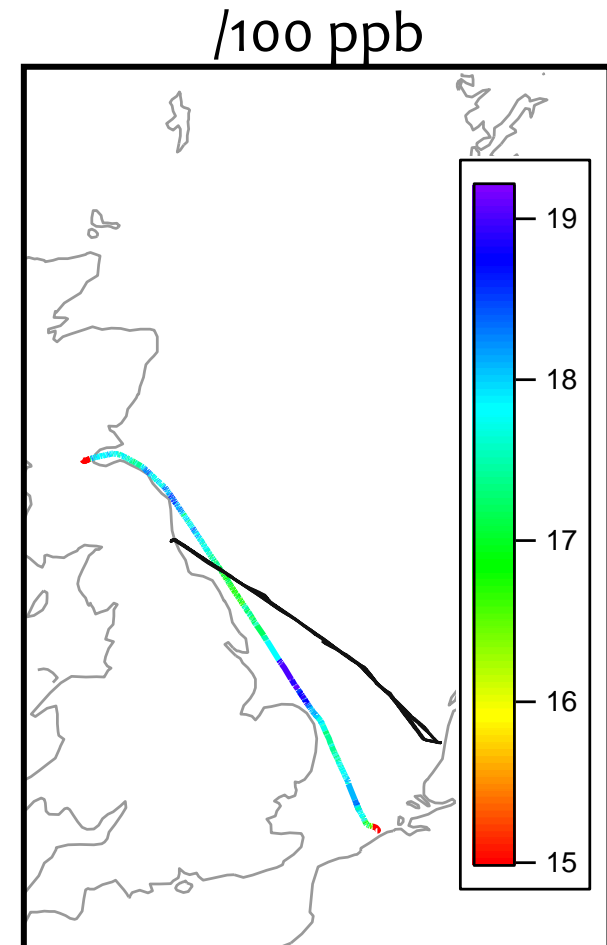
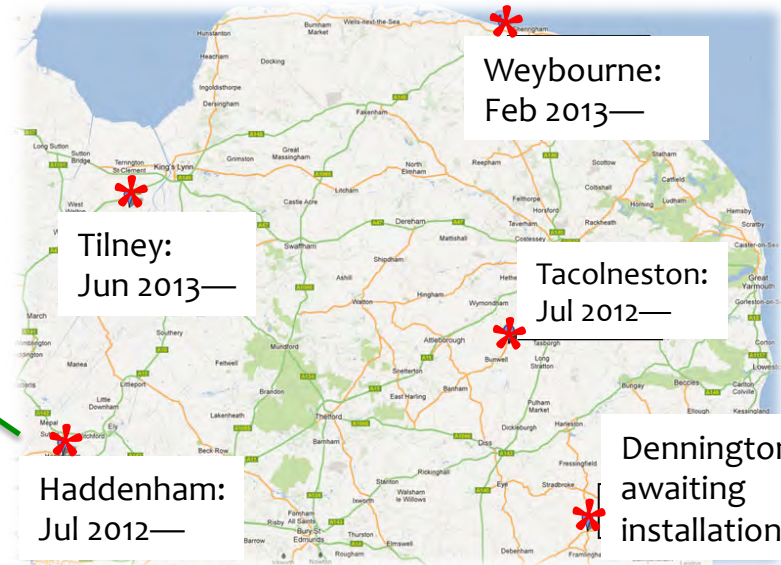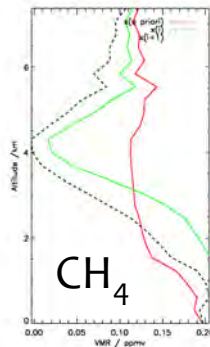Working with local communities: quantifying agricultural emissions of CH4 and N2O

UK Emissions Map of Methane 2009 t/1x1km
- 0 - 0.1
- 0.1 - 1
- 1 - 5
- 5 - 10
- 10 - 50
- 50 - 100
- 100 - 28,709

Inlet

GC-FID

Cylinders

St Mary's Church, Haddenham

Weybourne: Feb 2013—

Tilney: Jun 2013—

Tacolneston: Jul 2012—

Haddenham: Jul 2012—

Dennington: awaiting installation

CH4 (ppb)

HAD   TAC   WEY   TIL

Using the UK research aircraft to linking across scales

BAe 146

UKMO remote
sensing instrument

ARIES

CH_4

Example flight sortie

Links across spatial scales, measurement platforms, and
validate satellites
- Campaign mode: summer (2014 and/or 2015, ~60 hours)
- Piggyback mode on FAAM flights (~200 hrs/yr)

Space-borne data links UK work to larger scales
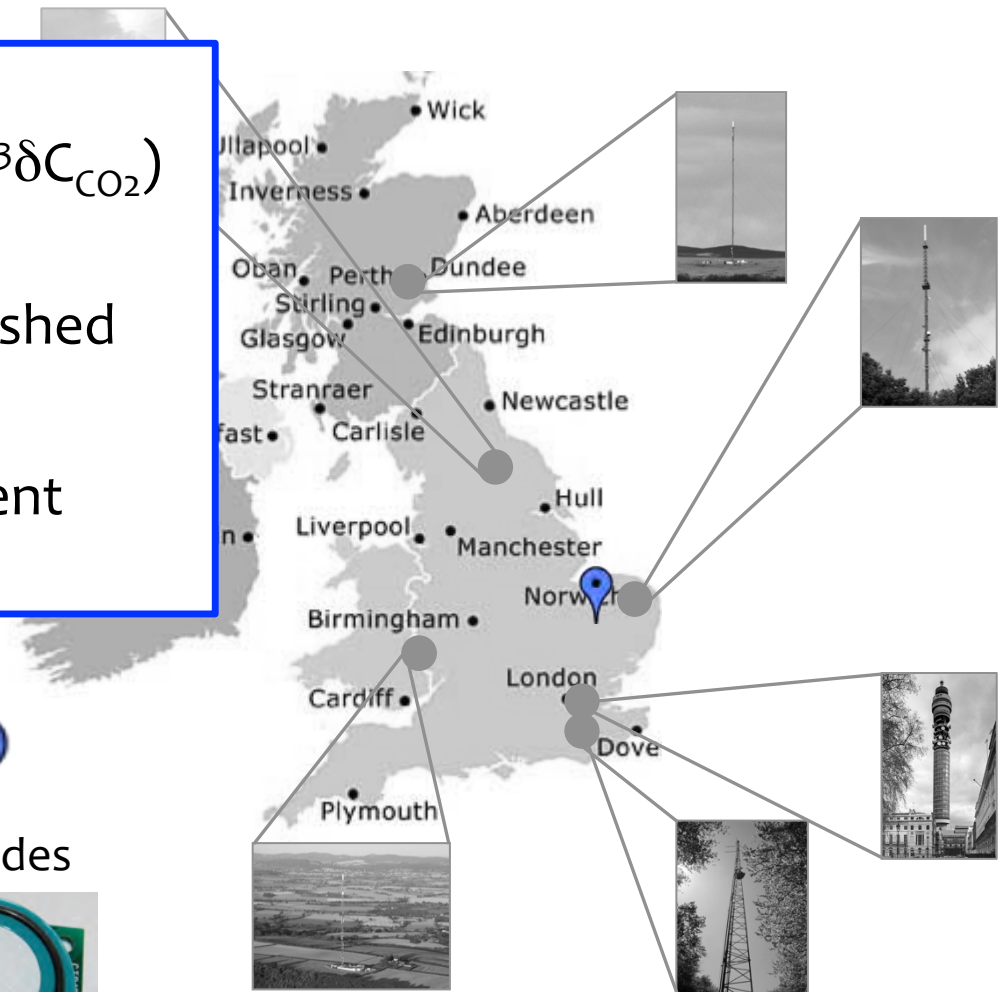
Using NASA, ESA, and Japanese instruments

- Exploiting existing NERC expertise in retrieving and interpreting space-borne data
- Global, continuous top-down constraints.
- GAUGE is developing UK-specific products (e.g., partial cloudy retrievals.)

Testing emerging technologies for measuring GHGs

- CO_2/CO sondes
- mobile FTS (CO_2, CH_4, N_2O, CO, $^{13}\delta C_{CO2}$)
- A laser instrument ($^{13}\delta C_{CO2}$)

Inter calibrated with more established instruments.
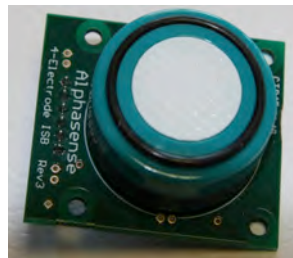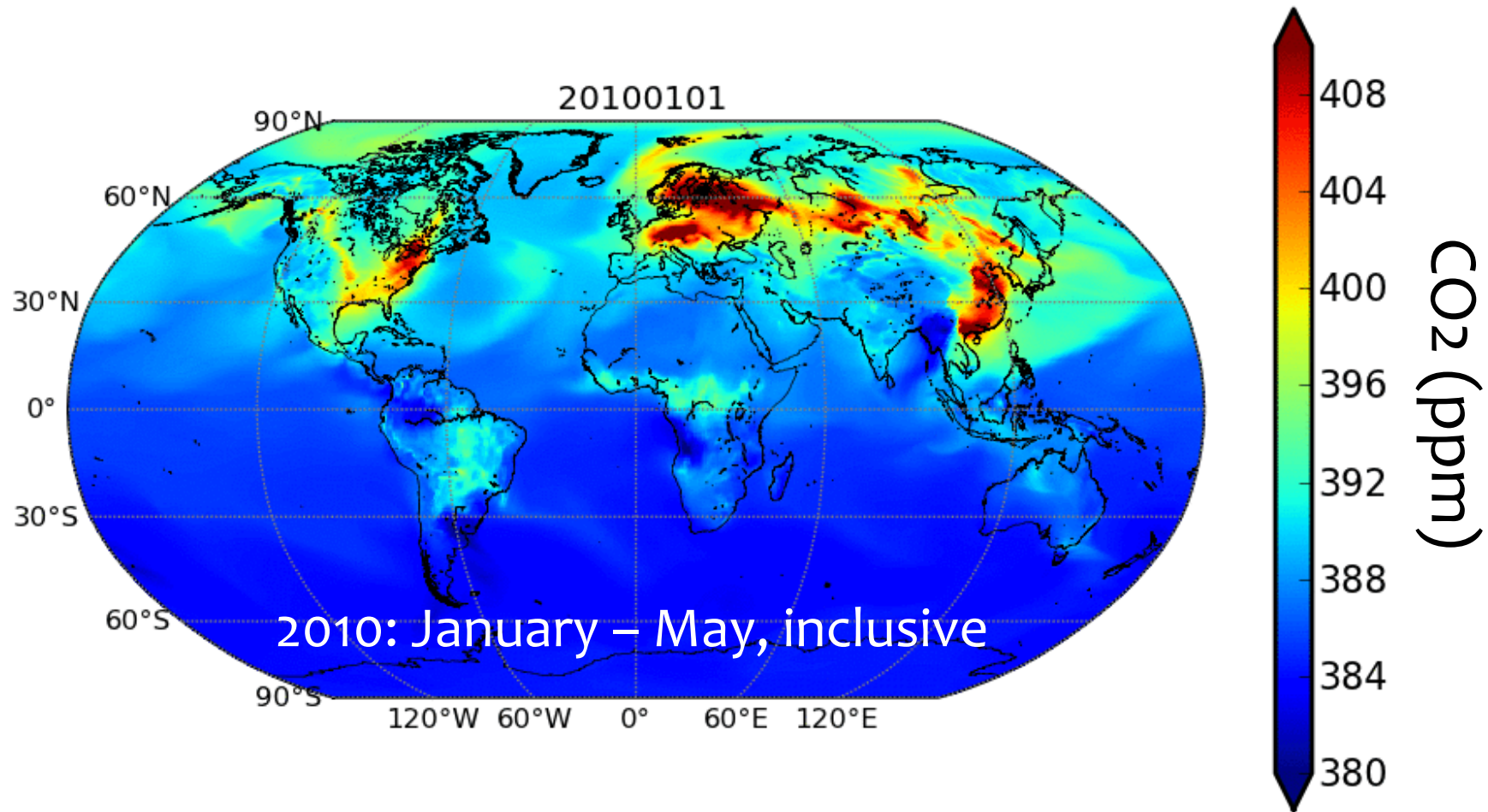
Developing post-2016 measurement activities.

RAL laser system
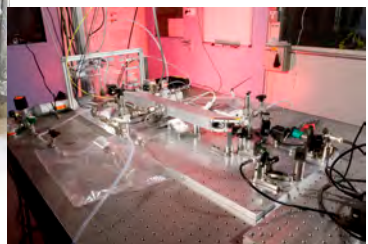
CO_2 sondes

Mobile FTS

Using numerical models to integrate data

20100101

2010: January – May, inclusive

CO₂ (ppm)

- Use prior information for emission inventories
- Model can help attribute observed variability to sources and regions
- We sample the model as observed by a particular instrument.

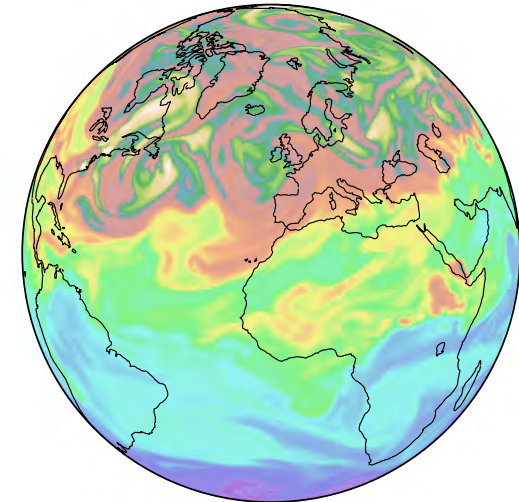# Inferring surface fluxes from atmospheric data

Fluxes

Prior flux estimates

4-D atmospheric concentrations

Atmospheric transport model
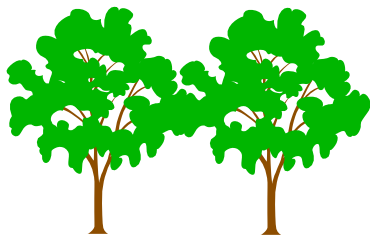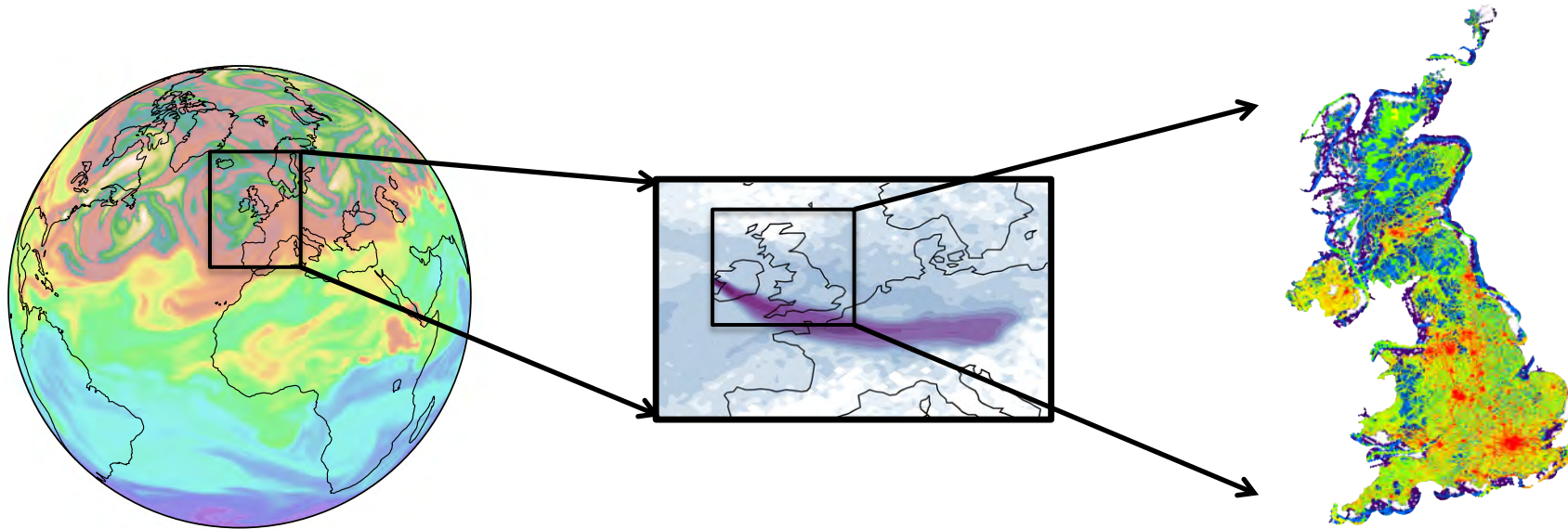
"inverse" model

Posterior flux estimates

$$P(A \mid B) = \frac{P(B \mid A)P(A)}{P(B)}$$

Ensemble Kalman Filter with a 3-month lag window
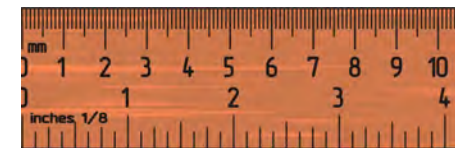
Measurement and uncertainties

Using different models to address different scales

1,000 km   100 km   10 km   1 km
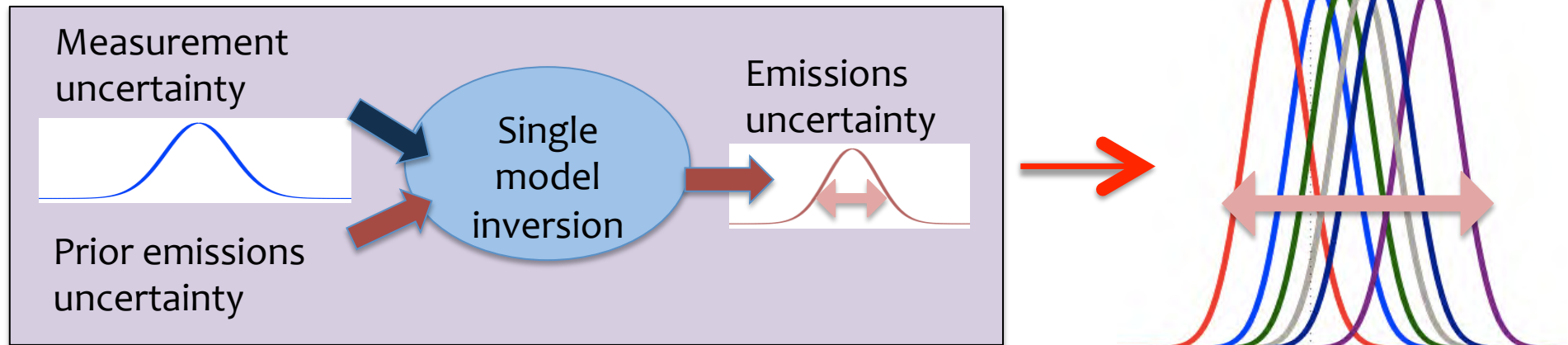
Satellites   Tall towers   Aircraft   Ship   Regional intensive   BT tower

GAUGE will deliver robust regional flux estimates of CO2, CH4 and N2O

Measurement uncertainty

Prior emissions uncertainty

Single model inversion

Emissions uncertainty

Ensemble of emission estimates provides better estimates uncertainty

◎ Different transport models
◎ Different methods to infer the fluxes
◎ This approach will lead to more robust results
◎ Regional emission estimates and uncertainties will be freely available