Southern Hemisphere Regional Greenhouse Gas Observation Networks

GGMT 2011, Wellington, NZ

M. V. van der Schoot¹, A. Stavert¹, L. P. Steele¹, R. J. Francey¹, D. A. Spencer¹, P. B. Krummel¹, P. J. Fraser¹, Z.M. Loh¹, R. Langenfelds¹, M. Schmidt², M. Ramonet², B. Wastine², G. Brailsford³

¹CAWCR/CSIRO Marine and Atmospheric Research, Australia
²Laboratoire des Sciences du Climat et de l'Environnement, France
³NIWA, New Zealand

www.cawcr.gov.au
Outline of today’s talk

• Southern Hemisphere measurement challenges and applications/opportunities
• Australian continental GHG observation network
• Progress with new pilot Australian Tropical Atmospheric Research Station (ATARS)
The CSIRO (GASLAB) collaborative flask network
Southern Hemisphere measurement challenges & applications

- SH far removed from large emission sources (NH)
- SH dominated by ocean effects
- Very well mixed atmosphere
- Integrated global baseline after inter-hemispheric mixing (~1 year)

- Precision requirements more critical in SH vs NH (WMO recommendation 0.05ppm vs 0.1ppm)
- Biases between sites important (sampling and calibration)
Southern Hemisphere measurement challenges & applications

- **Atmospheric verification of GLOBAL fossil fuel CO₂ emissions/reductions?**
  - Definitive global multi-year trends best measured at mid-high southern latitudes
    - Large spatial representativeness, well mixed & far from regional emission sources (NH)

- **Atmospheric-based assessment of Southern Ocean CO₂ sink?**
  - Southern Ocean CO₂ sink – decreasing efficiency?
    - Use of high precision atmospheric measurements with atm/ocean inversion modelling
    - Use of O₂/N₂ to constrain CO₂ sink partition
    - Antarctic coastal impact on CO₂ sink/Sea ice CO₂ dynamics
2000-year SH GHG records: Law Dome & Cape Grim

- Nitrous oxide
- Methane
- Carbon dioxide

Year:
- 1700
- 1750
- 1800
- 1850
- 1900
- 1950
- 2000

GHG Concentrations:
- $N_2O$ (ppb)
- $CO_2$ (ppm)
- $CH_4$ (ppb)
- MP & KP (ppb)

Legend:
- Law Dome ice/firm
- Cape Grim

Montreal & Kyoto synthetics
Spatial Representativeness

>100° longitude

~30° latitude

~8km vertically


Decadal increase in annual fossil CO2 emissions
(from Roger Francey using Marland et al., 2008; Andres, pers. comm.)
Decadal increase in annual fossil CO2 emissions (using Marland et al., 2008; Andres, pers. comm.)

Francey et al (2011) in press
Southern Ocean network

- High precision (LoFlo)
- Calibration propagation (~0.01ppm)
- Link to a regional calibration scale
- Quantify site biases
- Side-by-side comparisons
- ICP
Australian Continental GHG network (CH4, CO₂ in situ)
In-situ CH4 (all data)
Why are tropics important?

Tropics play a major role in global climate processes (not well defined):

- Home to ~1/2 of global population & rapid economic development (eg. India & China)
- Major global source and sink for CO2 and CH4
  - biomass burning
  - wetlands
  - rice production
- ~80% of global sources of N$_2$O (25% of which from Asian tropics) (Huang et al, 2008)
- ~75% of global sources & 60% global sinks H$_2$ (Xiao et al, 2007)
- Short-lived halocarbons (stratospheric influence)

- Tropics are a critically under-sampled region
Tropical Sampling Sites

Cape Ferguson, QLD
Dec 1989 –

Great Barrier Reef, QLD
Jun 1986 – Dec 1988 (sporadic)

Charles Point, NT
Sep 1990 – Dec 1990

Jabiru, NT
Jan 1987 – May 1991

Myilly Point, NT
Aug 1990 – Mar 1993 (sporadic)

Trace gas species analysed:

Before 1991/92: CO₂, CH₄, CO

After 1991/92: CO₂ and its δ¹³C and δ¹⁸O, CH₄, CO, H₂, N₂O
GASLAB flask data: CH₄

![Graph showing CH₄ levels over time for different locations including Cape Grim, Mauna Loa, Cape Ferguson, and Charles Point. The graph plots CH₄ concentrations in parts per billion (ppb) against dates from 1991 to 2010.]
GASLAB flask data: CO₂
Gunn Point (NT) - existing radar station (BoM) (Lat/Long: 12.2 S, 131.0 E)
Air mass origin maps Gunn Point
(courtesy Alistair Manning UK Met Office)
• Wet / Dry season air masses giving continental coverage with Cape Grim station, clean Indian Ocean air & SE Asian air masses
• Strategically located to reduce global scale atm. inversion CO₂ flux uncertainties
• Based at existing research radar site at Gunn Point (BoM)
• Unique opportunity to combine existing state-of-the-art physical atmospheric research facilities currently in Darwin (BoM / US DoE Atmospheric Radiation Measurement program) with high precision chemical atmospheric measurements
  - Regular field campaigns (Mctex, TRMM, Dawex, TWPICE...)
• TCCON network site at Darwin (FTS) for satellite validation (GOSAT, SCHIAMACHY) since September 2005 (University of Wollongong/Caltech)
• Extensive tropical ecosystem (Savanah) research (CSIRO, Charles Darwin University)
Gunn Point – atmospheric measurement program

• **Current (Sep 2011)**
  - *In-situ* CO₂ & CH₄ (CRDS)
  - *In-situ* ¹³CO₂/¹²CO₂ (CRDS)
  - Flask CO₂, CH₄, ¹³CO₂/¹²CO₂, N₂O, CO, H₂
  - Met (WS, WD)
  - Radon (ANSTO)
  - O₃, CO, NO/NOₓ

• **Proposed measurement program**
  - *In-situ* CO/N₂O (Aerodyne) 2012
  - PM₂.₅/PM₁₀
  - Aerosols (dry season campaign completed June 2010)
  - Short-lived halocarbons, C₄-C₁₂ HCs: GC-ECD (N. Harris, U. Cambridge, UK) (May 2012)
  - Medusa (2012/13?)
Thank you

www.cawcr.gov.au