Evaluation of New Technology in-situ Greenhouse Gas Analysers for CSIRO Atmospheric Observation Network

The 6th Asia-Pacific GAW
Workshop on Greenhouse Gases
20-22 October 2014
Daejeon, Republic of Korea

www.cawcr.gov.au

Marcel van der Schoot

Australian Government
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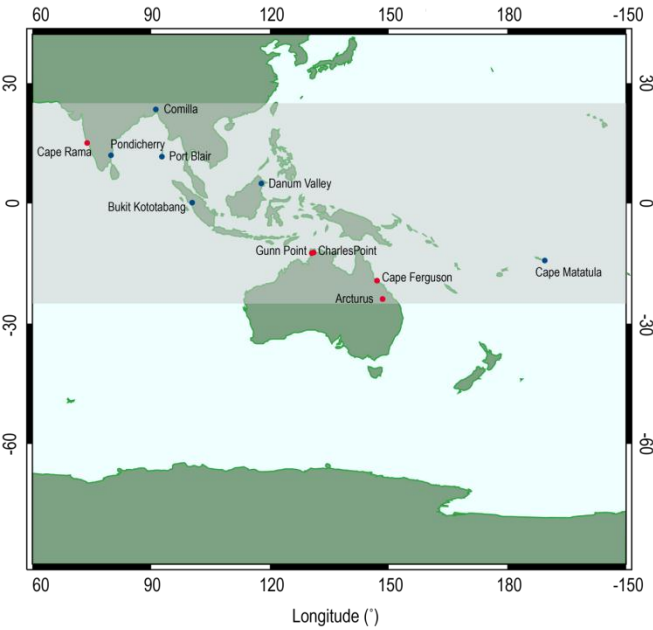
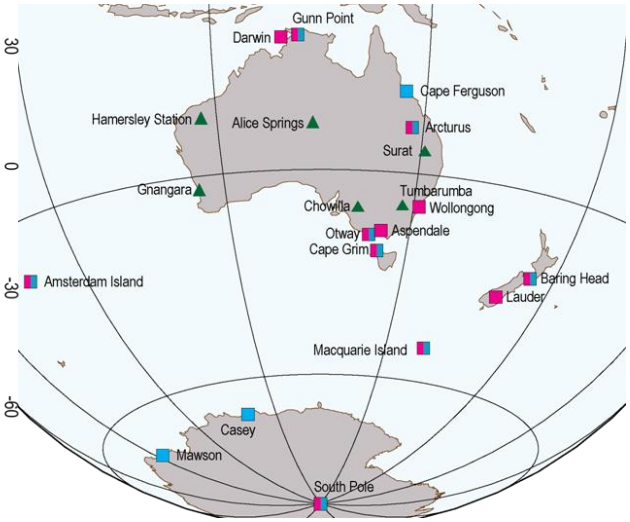
Presentation Outline

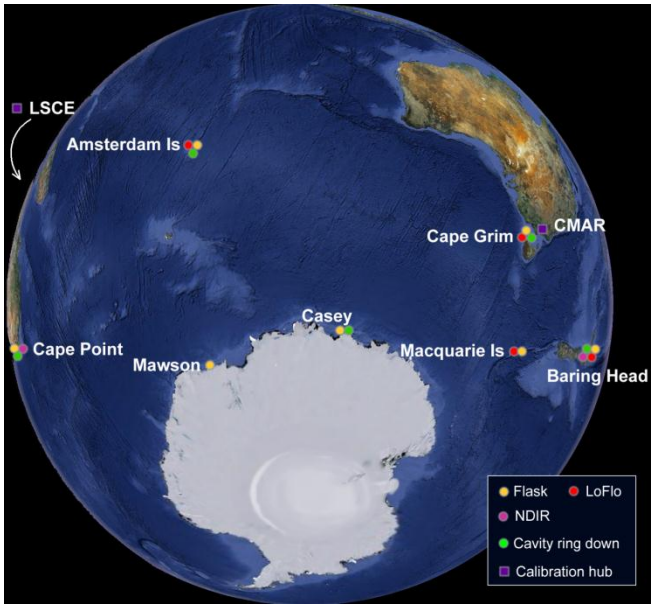
CSIRO Australian Greenhouse Gas Observation Network (AGGON)

- Cape Grim update
- Gunn Pt tropical station update
- Australia's future research vessel (RV Investigator)

AGGON Network & Research Applications







AGGON Research Applications

Objectives of AGGON expansion:

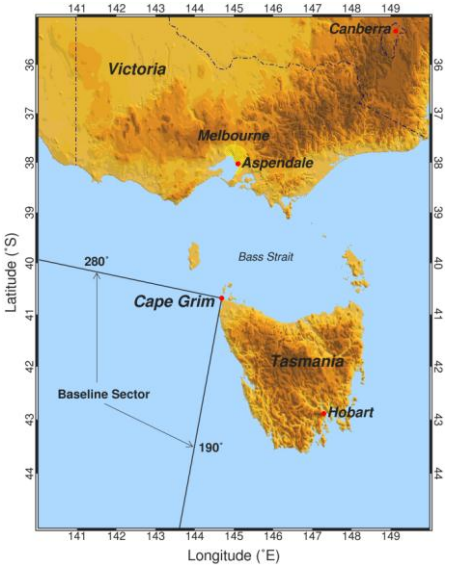
1. Continental Australian network to develop “top-down” emission verification tools (eg Australian Coal Seam Gas fugitive emissions applications - Arcturus GAW station, QLD)
2. Quantifying the changing Southern Ocean CO_2 sink (from an atmospheric perspective)
3. Understanding key atmospheric processes in the Southeast Asian - Australian tropical region
4. New research platforms - blue water research vessel RV Investigator (operational 2015)

Cape Grim Baseline Air Pollution Station

- 12-14 Nov 2014 CGBAPS Annual science meeting & ACCOM

(Atmospheric Composition & Chemistry Observations and Modelling Conference)

- GC-WERKS control software (CO_2/CH_4 Picarro)
- New GHG instruments:
  - In-situ N_2O/CO QCL (Aerodyne) (July 2014)
  - In-situ $^{13}CO_2$/$^{12}CO_2$ QCL (Aerodyne) (July 2014)



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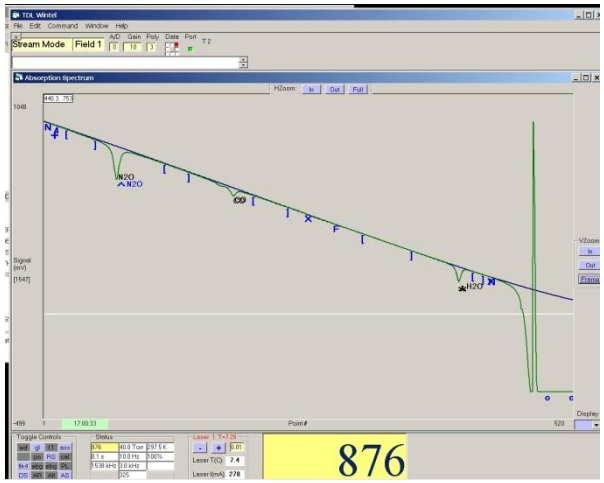
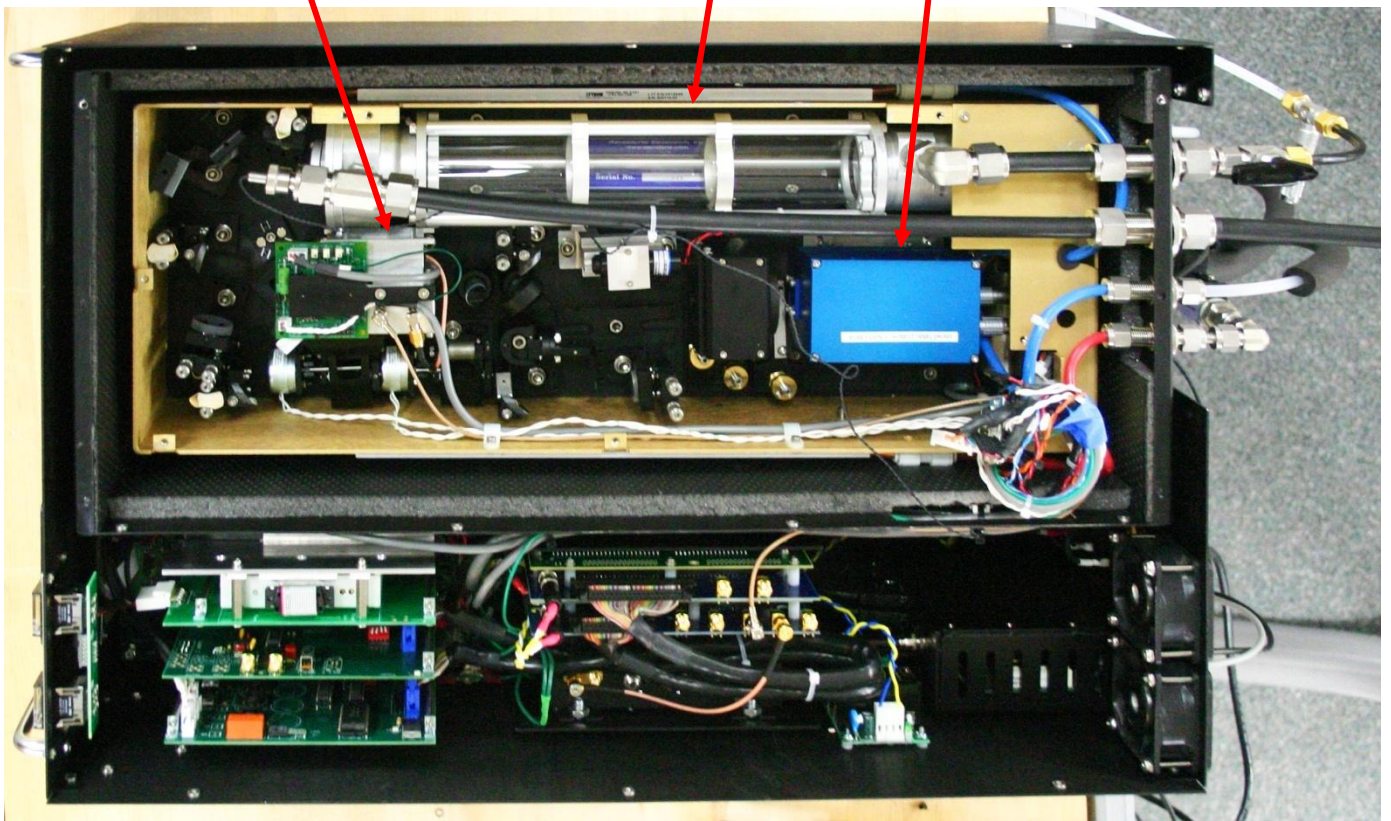
Aerodyne QCL-mini

- CW-QCL (mid-IR) absorption spectroscopy
- Astigmatic multi-pass Herriot cell (0.5L) (76m)
- HITRAN database
- Custom TDLWINTEL instrument control software & data acquisition/processsing
- Good temperature control (double box)
- No active pressure control

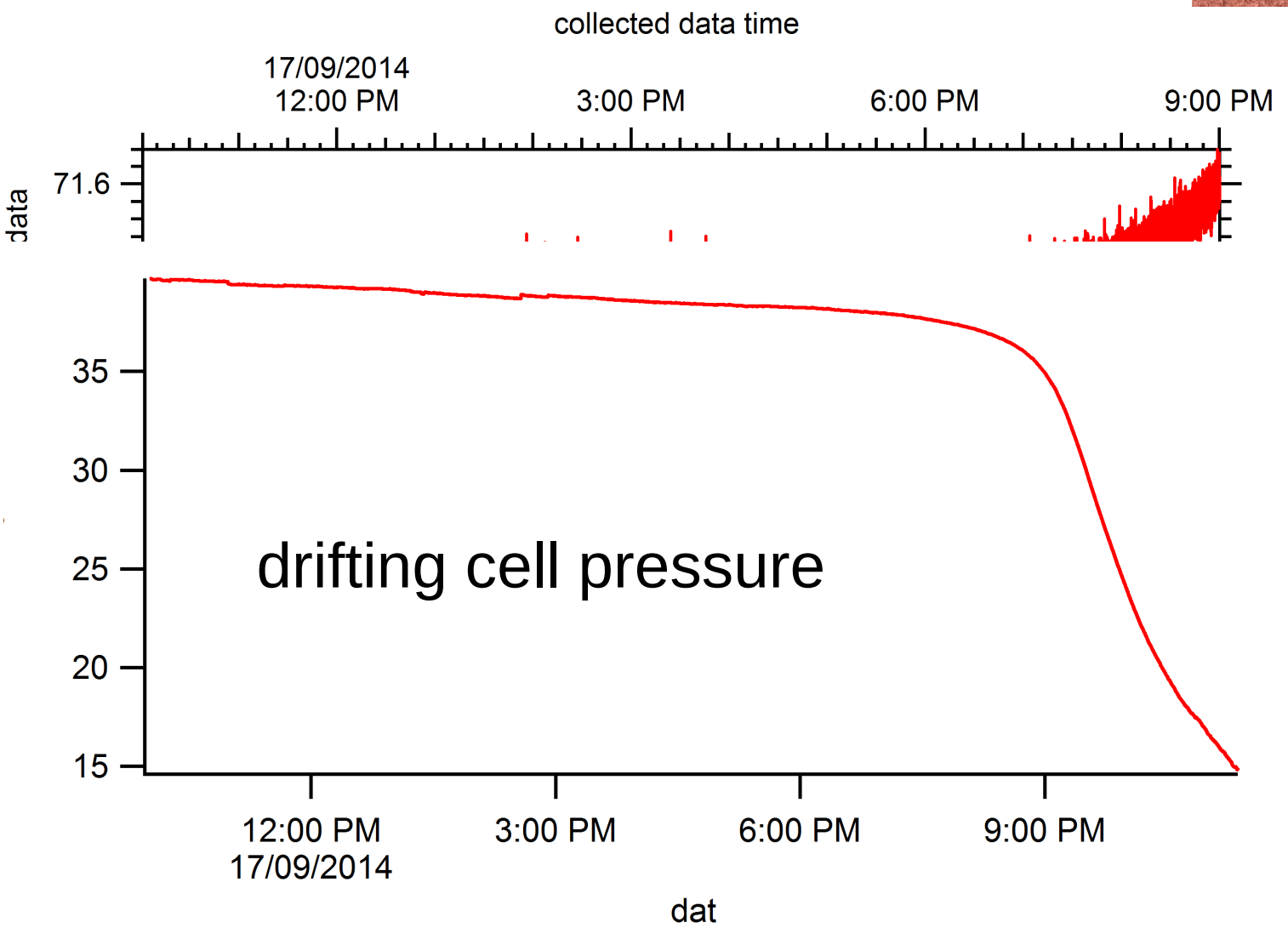


Aerodyne QCL-mini

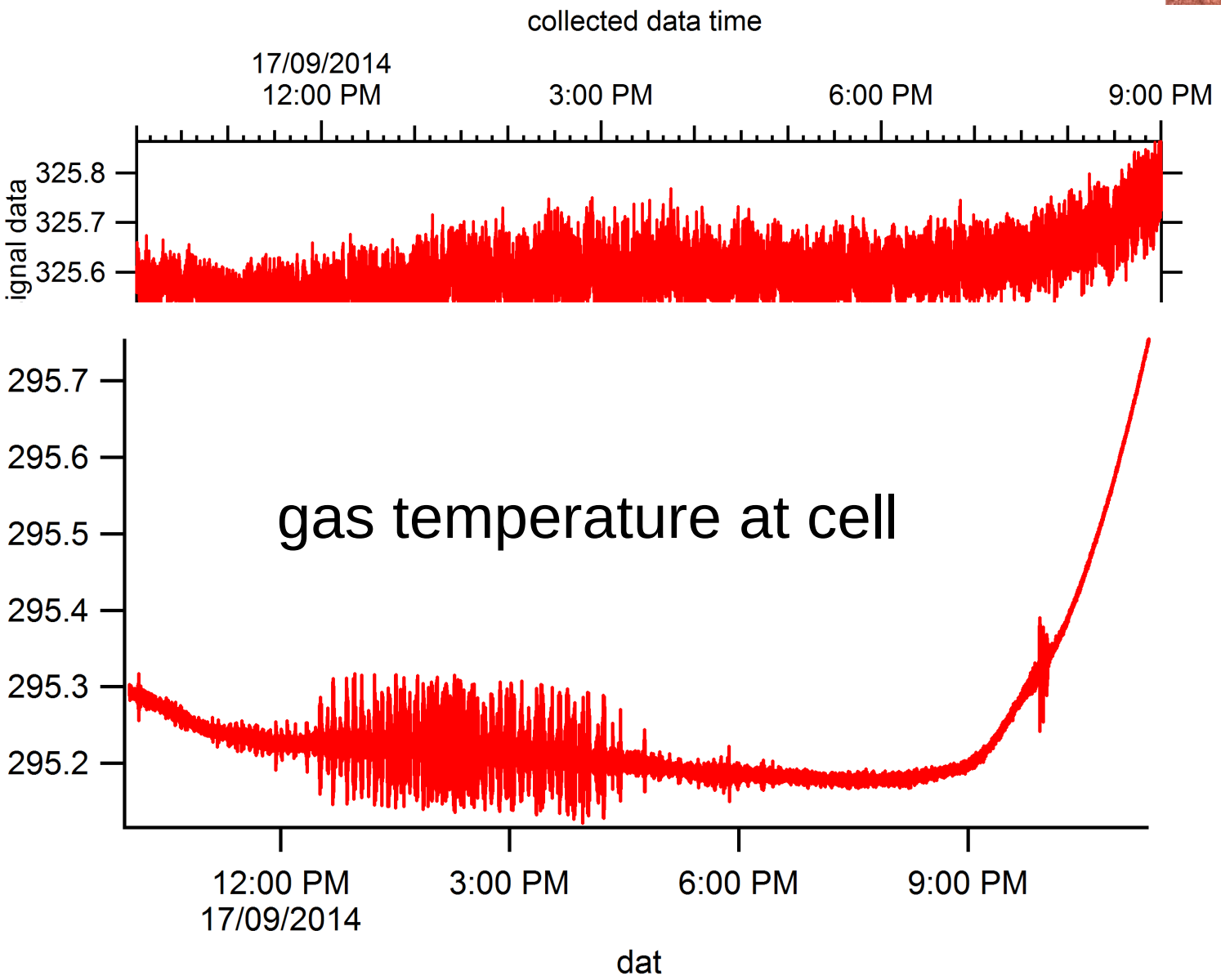
Instrument top view, outer and inner covers removed



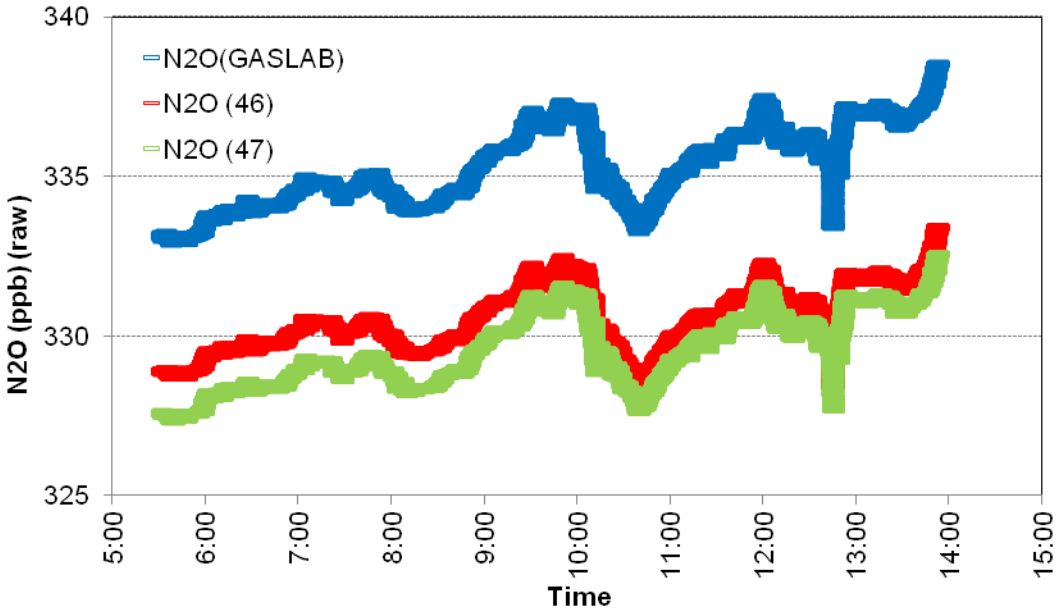
Aerodyne mini-QCL noise/drift (CO)



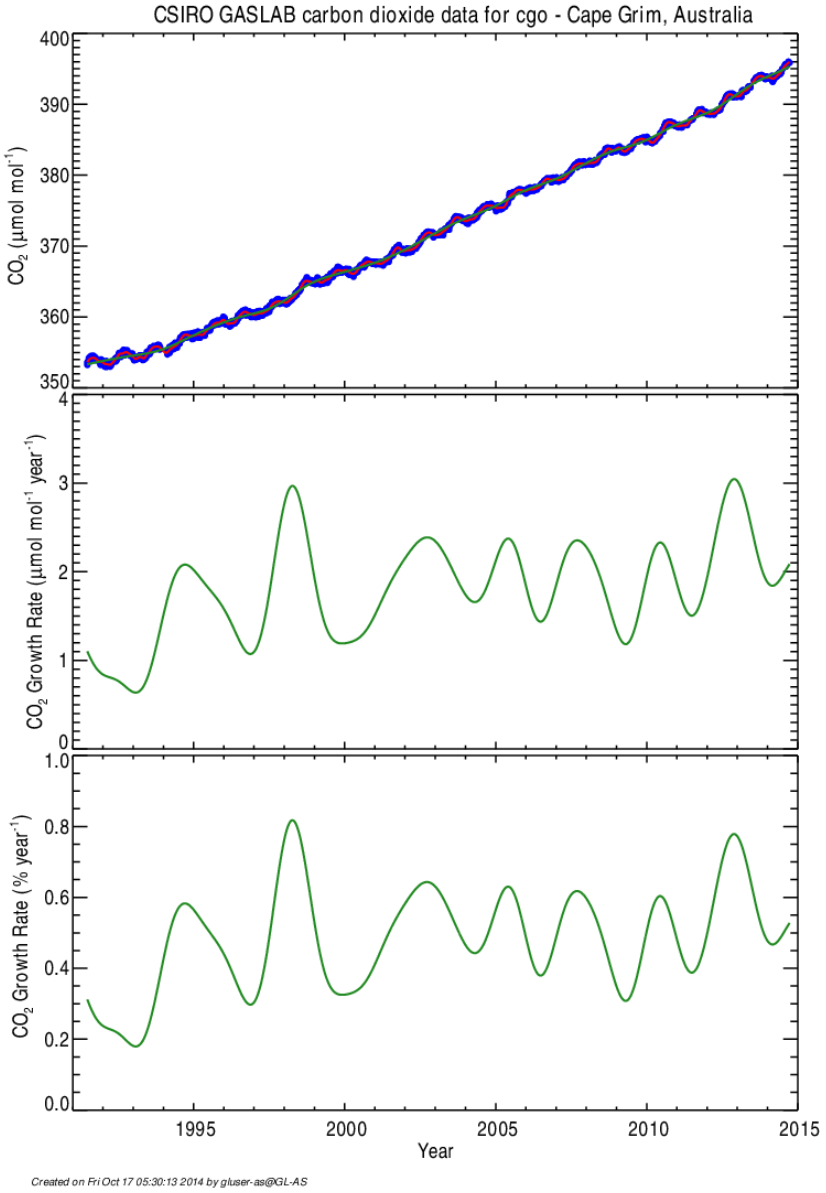
Aerodyne mini-QCL noise/drift (N2O)



Aerodyne overlap experiment



SH CO_2 2014 update - Cape Grim *(flask CO_2)*



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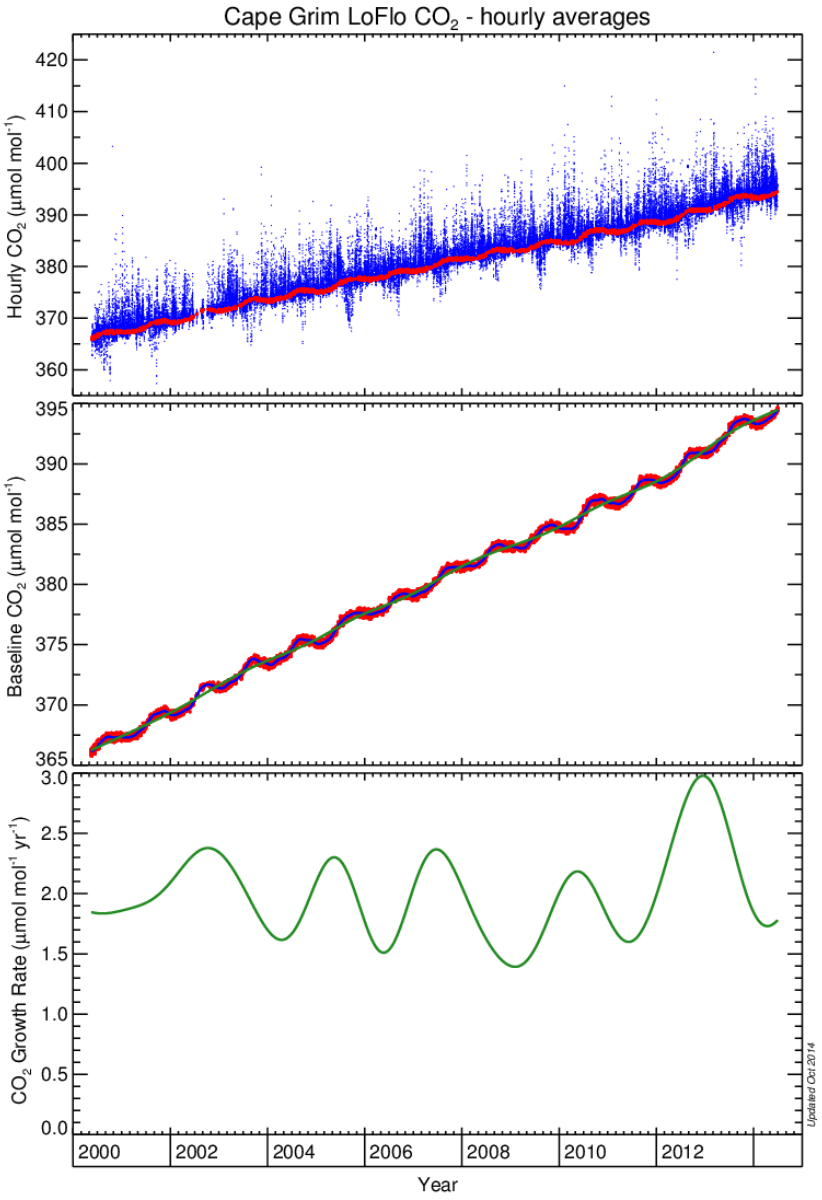
SH CO_2 2014 update - Cape Grim
(LoFlo in-situ CO_2)



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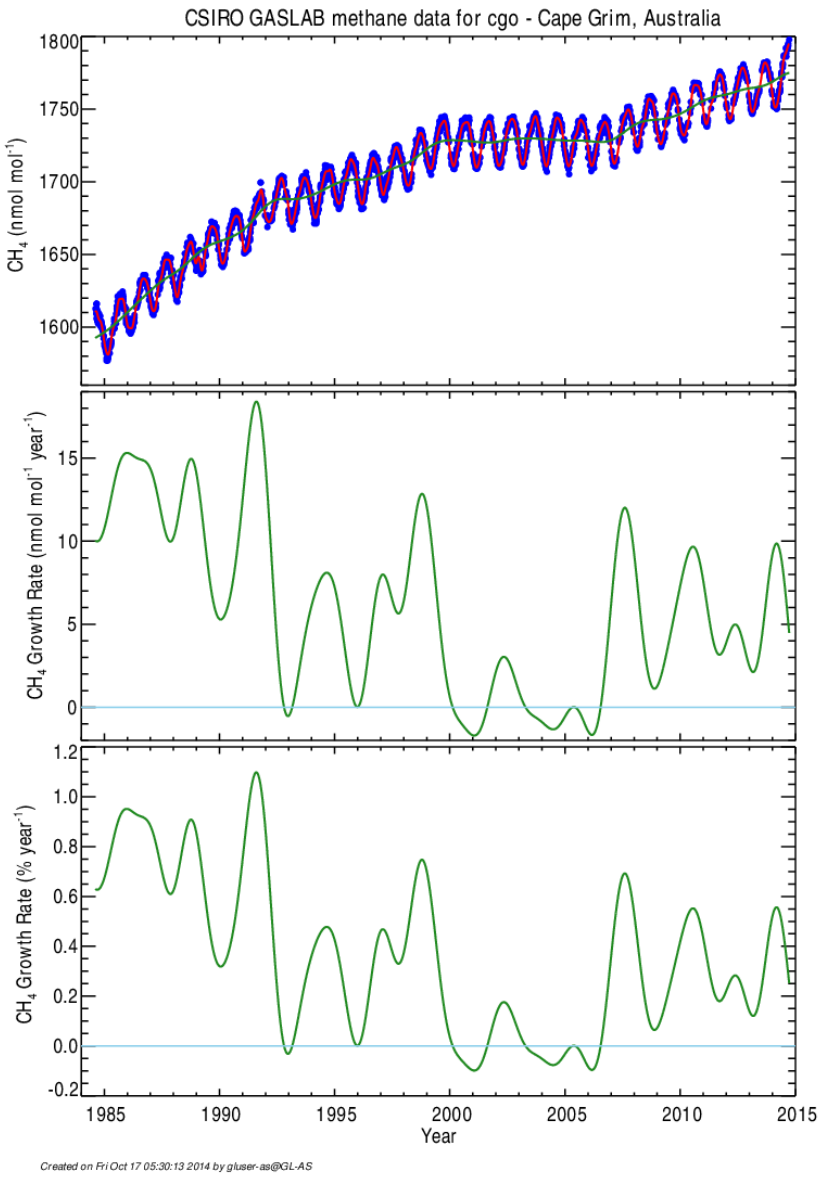
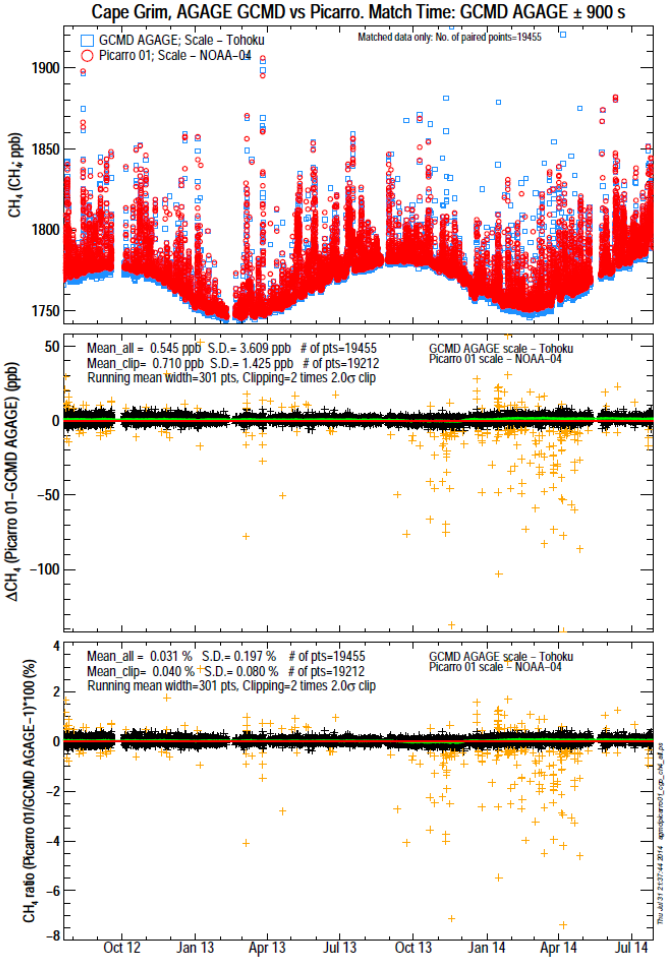
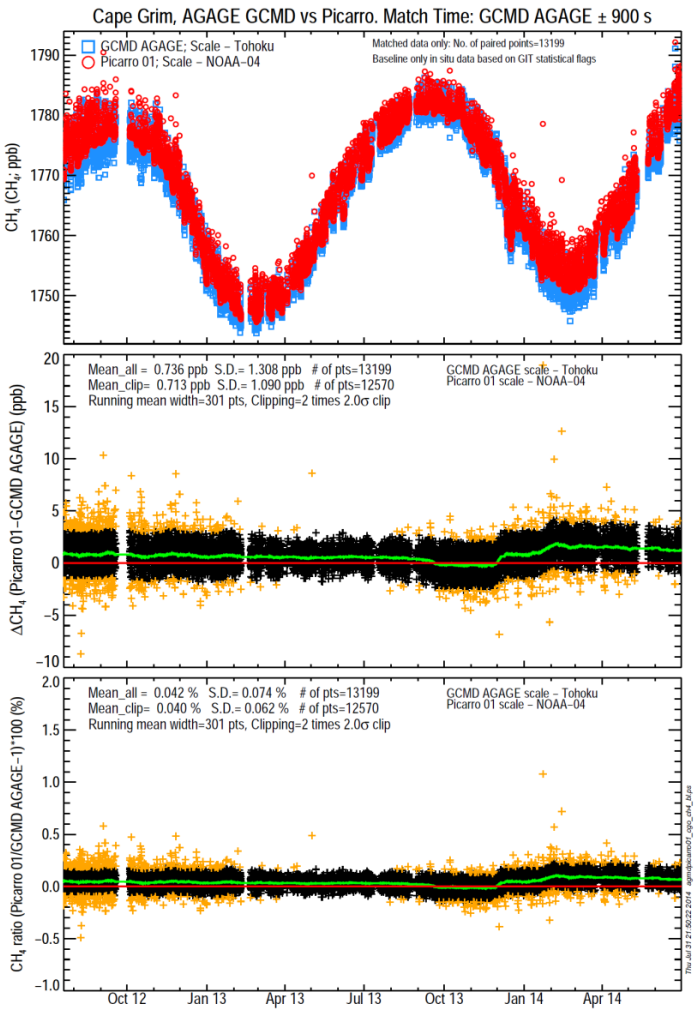
SH CO_2 2014 update - Cape Grim *(flask CH_4)*



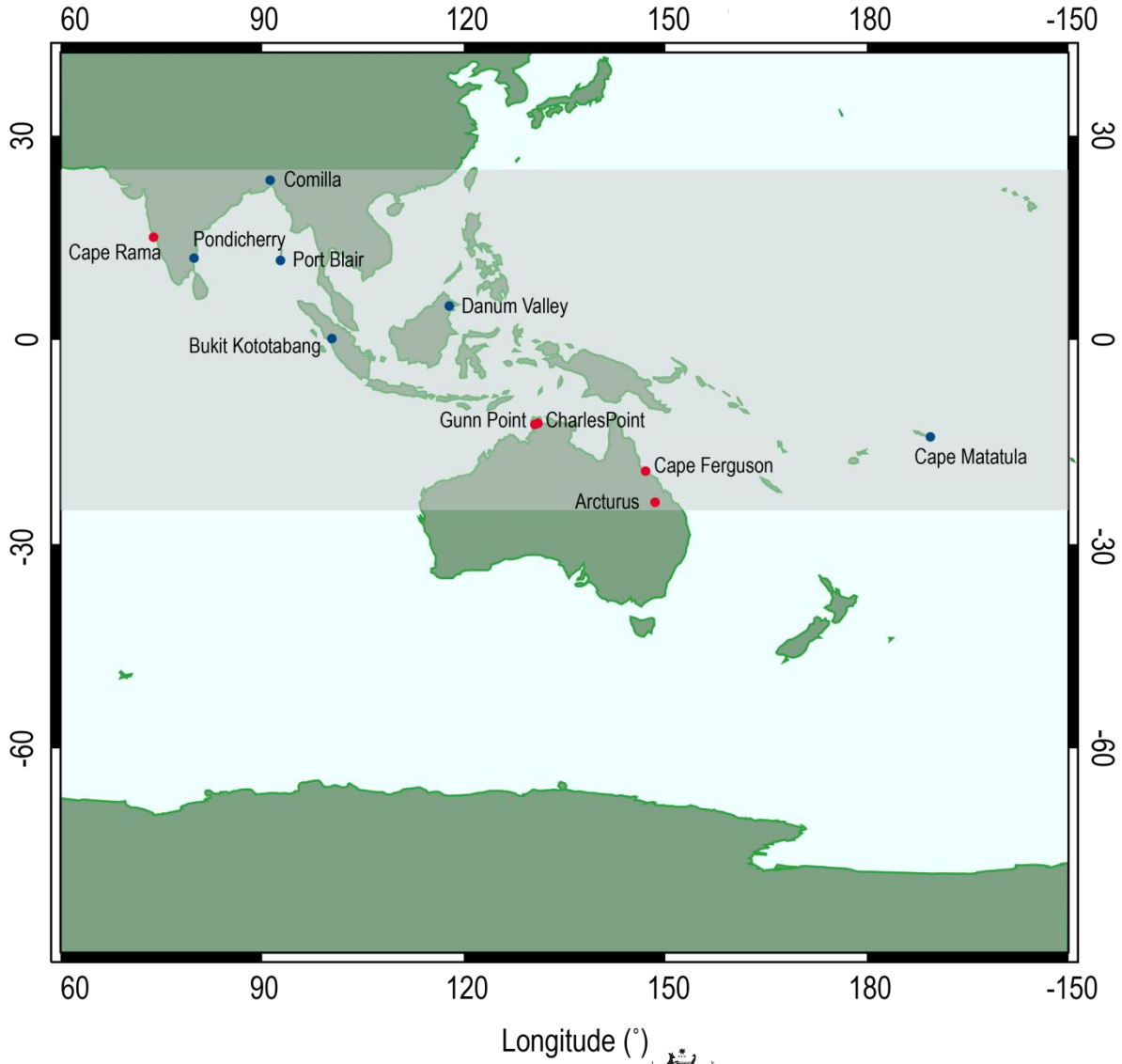
Cape Grim CH_4 comparison







Tropical Southeast Asia-Australian Regional Network



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Gunn Point Pilot Tropical Atmospheric Research Station

- **Latitude :** 12º 15'S
- **Longitude :** 131º 3'E
- **Elevation:** 25 m
- **Road Access**
  - 1-2 hours from Darwin (70 km road)
  - 4WD
  - 35 km unsealed road subject to wet season flooding
- Site History
  - Ex-prison farm (closed 1990)
  - Radar Site - Bureau of Meteorology lease since 2004
  - Atmospheric Radiation Measurement Site (ARM funded US Department of Energy)
- Power
  - Town power (generally reliable but does fail in storms)
  - Backup generator for essential applications (~3 days)
- Communications
  - Land line and mobile next G reception

Gunn Pt. GAW Station

World Meteorological Organization
Weather · Climate · Water

GLOBAL ATMOSPHERE WATCH

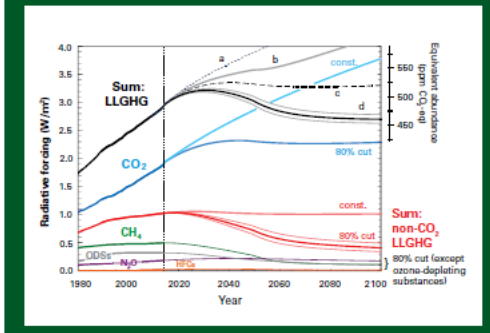
WMO GREENHOUSE GAS BULLETIN

The State of Greenhouse Gases in the Atmosphere
Based on Global Observations through 2013

No. 10 | 9 September 2014

ISSN 2078-0796

Climate Summit Edition



The WMO Global Atmosphere Watch (GAW) coordinates observations of the most important contributors to climate change: long-lived greenhouse gases (LLGHG). In the figure, their radiative forcing (RF) is plotted along with a simple illustration of the impacts on future RF of different emission reduction scenarios. Analysis of GAW observations shows that a reduction in RF from its current level (2.92 W·m^{-2} in 2013)[1] requires significant reductions in anthropogenic emissions of all major greenhouse gases (GHGs).

Long-lived GHGs (carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), substances that deplete stratospheric ozone), and remaining gases listed under the Kyoto Protocol to the United Nations Framework Convention on Climate Change (sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs)) are the main drivers of climate change, and WMO GAW monitors them all. WMO GAW atmospheric measurements of these gases are used to inform climate policy in two ways: (1) The observations are compared with determinations of LLGHG atmospheric abundances from pre-industrial times (usually 1750) from ice cores to calculate RF (defined as the change in Earth's net radiative flux); (2) For gases that do not exchange rapidly between the atmosphere and ocean or biosphere, the observations are combined with estimates of LLGHG lifetimes to quantify their emissions. The figure above uses both pieces of information. It shows the increase in RF above its pre-industrial level for the major LLGHGs from 1980 through 2013 (see plots of data and their descriptions in this bulletin) and their sum (in black), and it illustrates the change in RF that would occur from 2014–2100 based on emission reductions as follows: (a) emissions held constant at 2013 levels, (b) constant CO_2 emissions and 80% reduction in anthropogenic non-CO_2 GHG emissions, (c) 80% reduction in CO_2 emissions while non-CO_2 GHG emissions are held constant, and (d) 80% reductions in all LLGHG emissions. The projections are not based on realistic emissions scenarios; they merely illustrate that achieving reductions in RF will require significant decreases in anthropogenic emissions of both non-CO_2 LLGHGs and CO_2. The figure and description are based on an update of Montzka et al. (2011).

Executive summary

The latest analysis of observations from the WMO Global Atmosphere Watch Programme shows that the globally averaged mole fractions of CO_2, CH_4 and N_2O reached new highs in 2013, with CO_2 at 396.0±0.1 ppm[2], CH_4 at 1824±2 ppb[3] and N_2O at 325.9±0.1 ppb. These values constitute, respectively, 142%, 253% and 121% of pre-industrial (before 1750) levels. The atmospheric increase of CO_2 from 2012 to 2013 was 2.9 ppm, which is the largest year to year change from 1984 to 2013. For N_2O the increase from 2012 to 2013 is smaller than the one observed from 2011 to

T. Machida, M. Manizza, M. Rigby, S. O'Doherty, P.K. Patra, C.M. Harth, R.F. Weiss, P.B. Krummel, M. van der Schoot, P.J. Fraser, L.P. Steele, S. Aoki, T. Nakazawa, and J.W. Elkins, 2014: Global and regional emissions estimates for N_2O. *Atmos. Chem. Phys.*, 14(9):4617–4641, doi:10.5194/acp-14-4617-2014.

Thompson, R.L., F. Chevallier, A.M. Crotwell, G. Dutton, R.L. Langenfelds, R.G. Prinn, R.F. Weiss, Y. Tohjima, T. Nakazawa, P.B. Krummel, L.P. Steele, P. Fraser, S. O'Doherty, K. Ishijima and S Aoki, 2014: Nitrous oxide emissions 1999 to 2009 from a global atmospheric inversion. *Atmos. Chem. Phys.*, 14(4):1801–1817, doi:10.5194/acp-14-1801-2014.

Touratier, F. and C. Goyet, 2011: Impact of the Eastern Mediterranean Transient on the distribution of anthropogenic CO_2 and first estimate of acidification of the Mediterranean Sea. *Deep-Sea Research I*, 58(1):1–15, doi: 10.1016/j.dsr.2010.10.002.

Wakita, M., S. Watanabe, M. Honda, A. Nagano, K. Kimoto, K. Matsumoto, M. Kitamura, K. Sasaki, H. Kawakami, T. Fujiki, K. Sasaoka, Y. Nakano and A. Murata, 2013: Ocean acidification from 1997 to 2011 in the subarctic western North Pacific Ocean. *Biogeosciences*, 10:7817–7827, doi:10.5194/bg-10-7817-2013.

WMO, 2009: *Technical Report of Global Analysis Method for Major Greenhouse Gases by the World Data Centre for Greenhouse Gases* (Y. Tsutsumi, K. Mori, T. Hirahara, M. Ikegami and T.J. Conway). GAW Report No. 184 (WMO/TD-No. 1473), Geneva, 29 pp.

Wong, C.S., J.R. Christian, S.-K. Emmy Wong, J. Page, Liusen Xie and S. Johannessen, 2010: Carbon dioxide in surface seawater of the eastern North Pacific Ocean (Line P), 1973–2005. *Deep-Sea Res. I*, 57(5):687–695, doi:10.1016/j.dsr.2010.02.003.

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Website: http://ds.data.jma.go.jp/gmd/wdcgg

[1] W·m^{-2} – watts per square metre.

[2] ppm – number of molecules of the gas per million molecules of dry air.

[3] ppb – number of molecules of the gas per billion (10^9) molecules of dry air.

[4] Indicated uncertainty ranges are calculated by a bootstrap method following Conway et al. (1994). This uncertainty is calculated with a confidence interval of 68% (one sigma).

[5] This percentage is calculated as the relative contribution of the mentioned gas(es) to the increase in global radiative forcing caused by all long-lived greenhouse gases since 1750.

[6] 1 PgC = 1 billion (10^9) tonnes or 10^{15} g of carbon.

[7] TgN = teragrams of nitrogen.

[8] ppt – number of molecules of the gas per trillion (10^{12}) molecules of dry air.

Selected greenhouse gas observatories

The Australian Tropical Atmospheric Research Station (ATARS) at **Gunn Point** (12.25°S, 131.05°E, 25 m a.s.l.) is located near Darwin, in Australia's Northern Territory. The station was established in 2010 and became a GAW regional station in 2012. It is co-located with a Bureau of Meteorology (BoM) research radar station and the operation is supported by both BoM and the Commonwealth Scientific and Industrial Research Organization (CSIRO, Australia). Gunn Point complements the growing atmospheric observation network in the Asian–Australian tropical region and is an important addition to the globally under-sampled tropical regions. Measurements currently include the main greenhouse and related trace gases (in situ CO_2, CH_4 and radon; a flask air sampling programme for CO_2, CH_4, N_2O, carbon monoxide (CO), hydrogen (H_2), $^{13}CO_2$, ^{18}OCO), as well as aerosol scattering coefficient, black carbon, ozone, NO_x, gaseous elemental mercury and short-lived halocarbons of tropical coastal marine origin. In the near future, measurement programmes will expand to include in situ N_2O, CO, particle number concentrations and volatile organic compounds.

Pha Din (21.57°N 103.52°E, 1466 m a.s.l.) is a recently designated GAW regional station. It is located on a hill in north-western Viet Nam above the surrounding forests. The facility is operated by the Vietnamese National Hydrometeorological Service. The site has been a meteorological station since 2011, when a tower was built to install a future meteorological radar. The laboratory building provides air-conditioned laboratory space and also basic accommodation for station operators and guest researchers. Capacities for continuous observations of greenhouse gases and aerosol optical properties were established in early 2014 through the collaboration of two Swiss institutes (Empa and the Paul Scherrer Institute), MeteoSwiss and the Vietnamese National Hydrometeorological Service. CO_2, CH_4 and CO are measured with cavity enhanced absorption spectroscopy. The Pha Din station is the first of its kind recording greenhouse gases, surface ozone and aerosol properties in a rural setting in Viet Nam.

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Gunn Point GAW station update (NT) (12º 15’ S 131º 3’ E)

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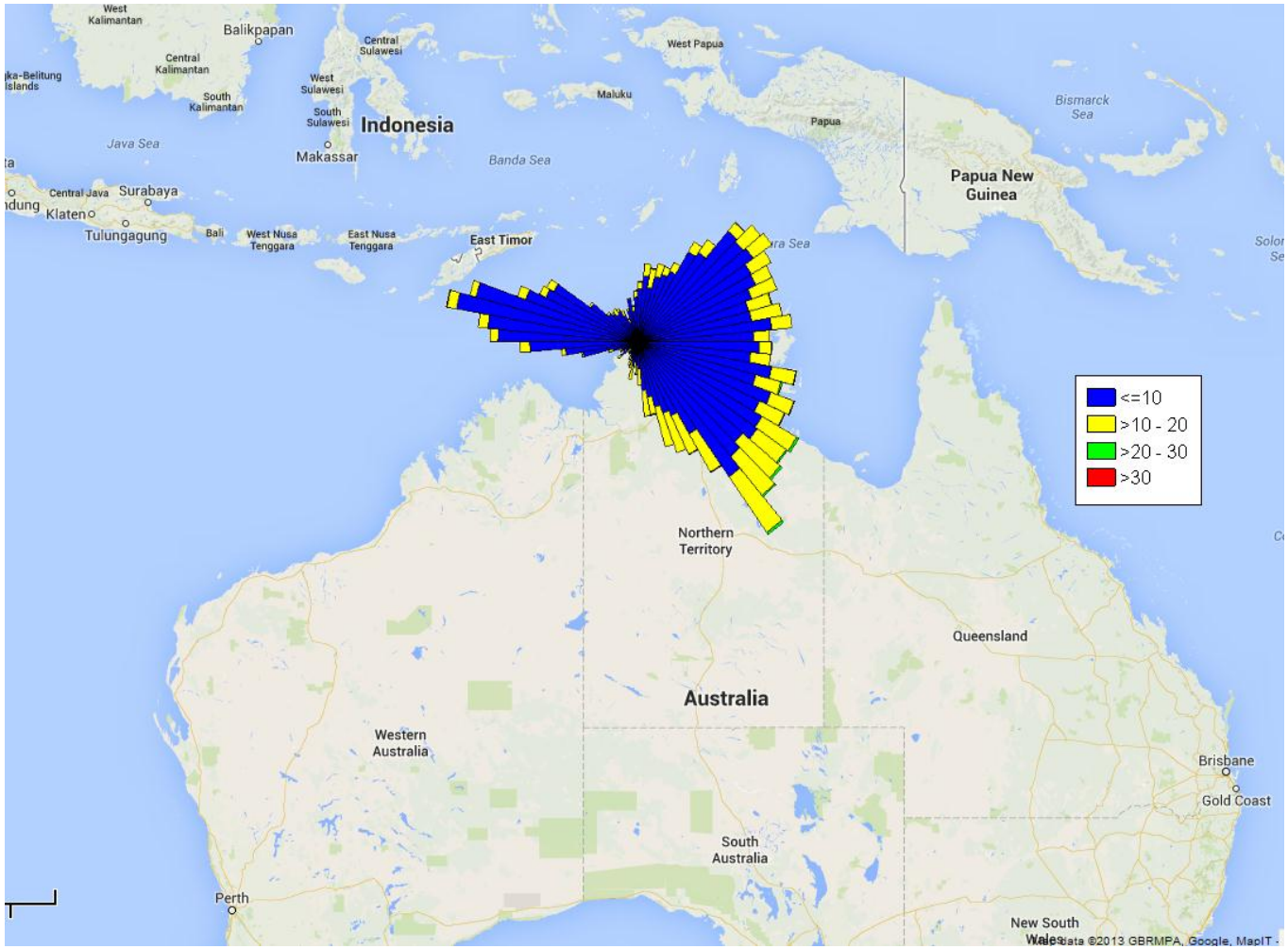
Gunn Point – atmospheric measurement program

- Current
  - *In-situ* CO_2 & CH_4 (CRDS)
  - *In-situ* $^{13}CO_2/^{12}CO_2$ *(CRDS)**
  - Flask CO_2, CH_4,$^{13}CO_2/^{12}CO_2$, N_2O, CO, H_2
  - Radon (ANSTO)
  - Short-lived halocarbons ($CHBr_3/CH_2Br_2/CHCl_3/C_2Cl_4/CH_2CCl_3/CCl_4$..): GC-ECD (N. Harris, U. Cambridge, UK) (2013)
  - AWS (Jul 2013) and tower meteorology (WS, WD)
  - O_3 (UV spectrometry) / CO (NDIR) /NO/NO_X *(chemiluminescence)*
  - *Aetholometer and nephelometer*
  - $PM_{2.5}/PM_{10}$
  - Aerosols
  - 2 campaigns completed (dry season 2010, 2014)
- Proposed measurement program
  - *In-situ* CO/N_2O (Off-axis ICOS-Los Gatos) (2014/15)

Radon at Gunn Pt.



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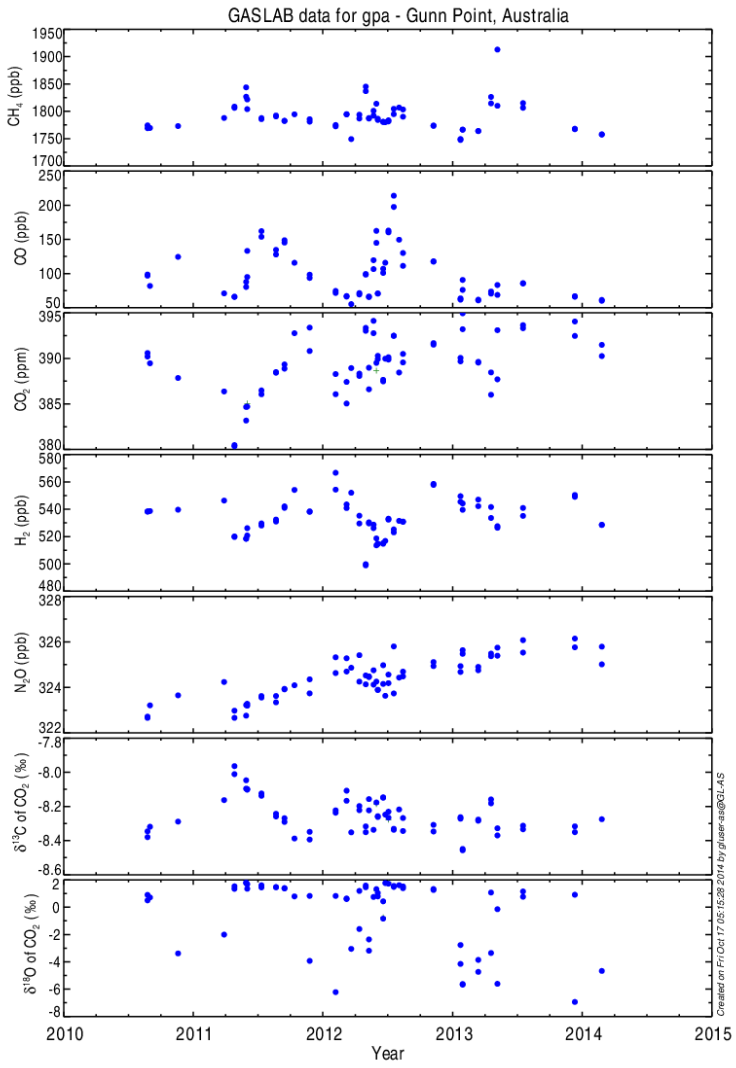
Gunn Pt. Flask Data



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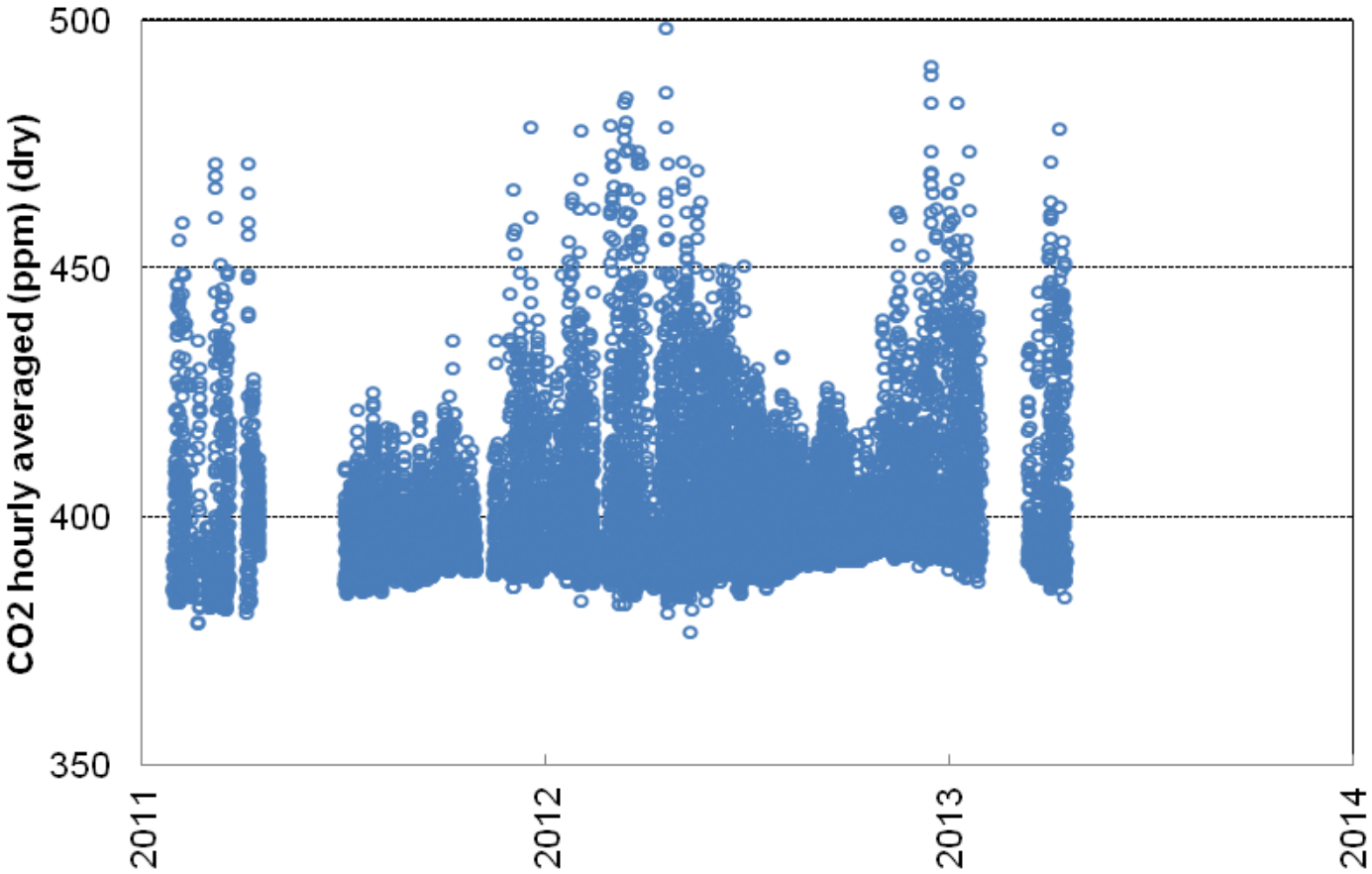
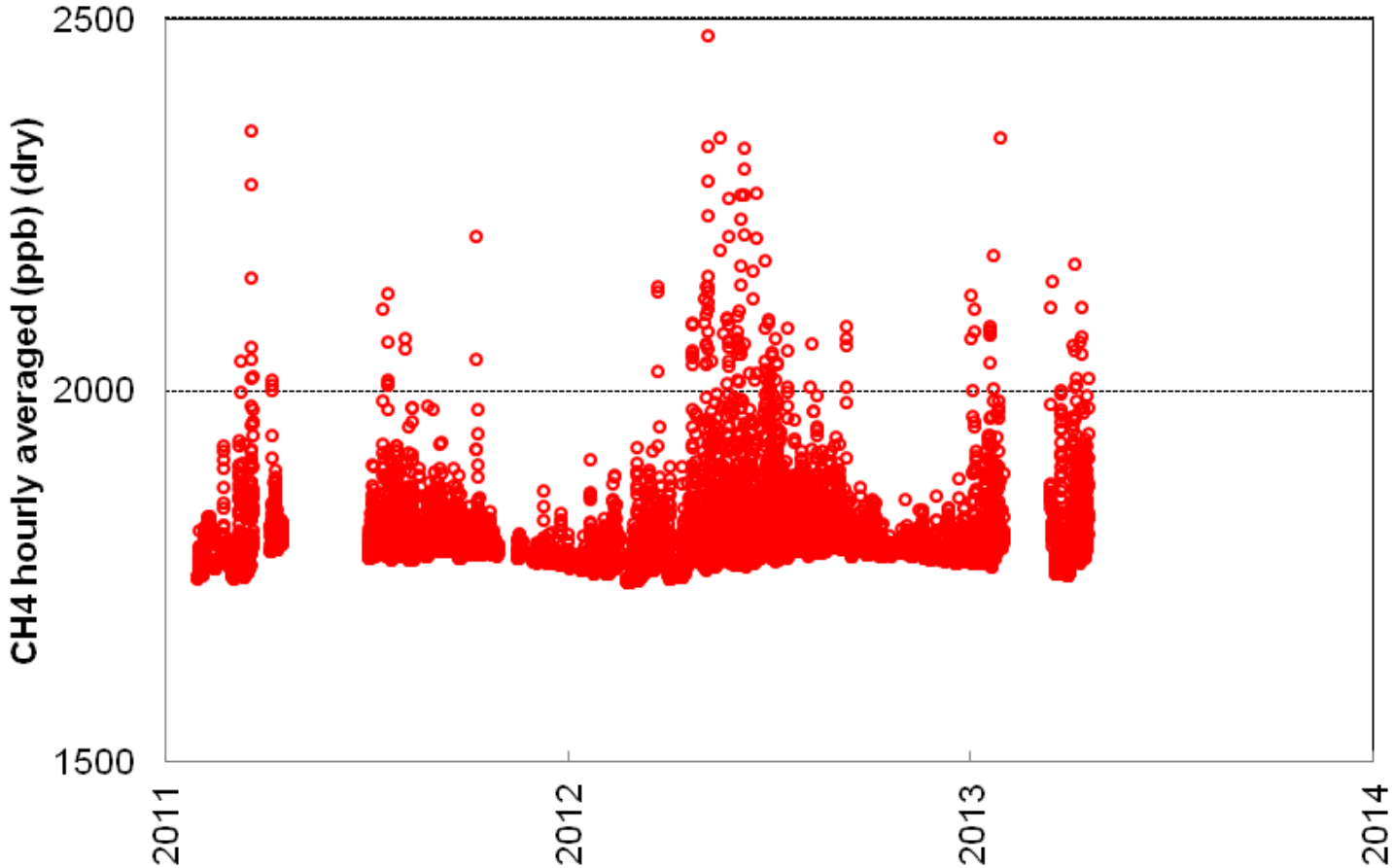
Gunn Pt in-situ CO_2 (hourly ave)



Gunn Pt in-situ CH_4 (hourly ave)



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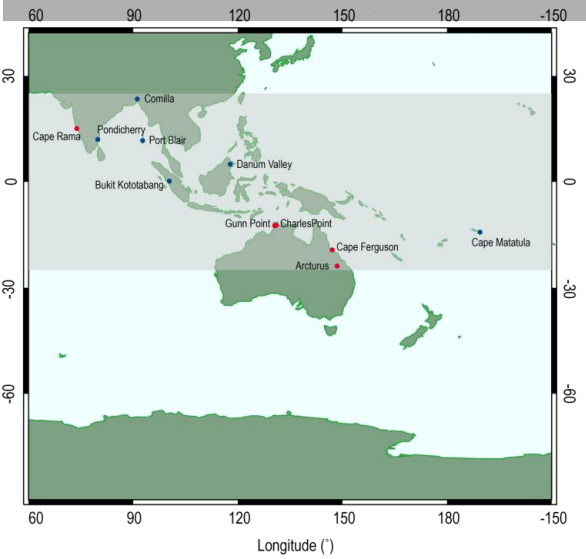
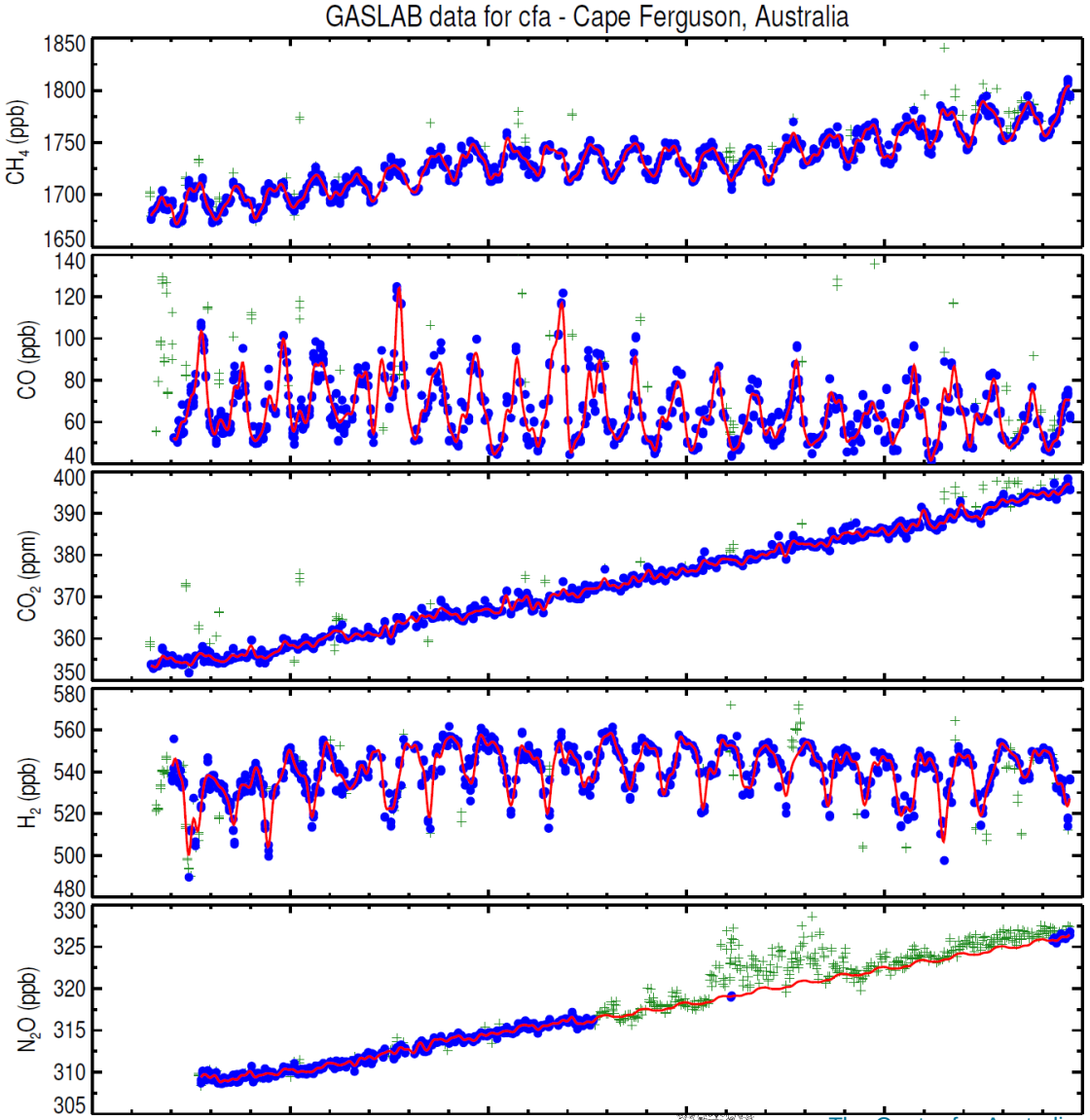
Cape Ferguson (Queensland) (19.28°S, 14.06°E)



SH CO_2 2013 update - Cape Ferguson (19°16‘ S 147°3’E)



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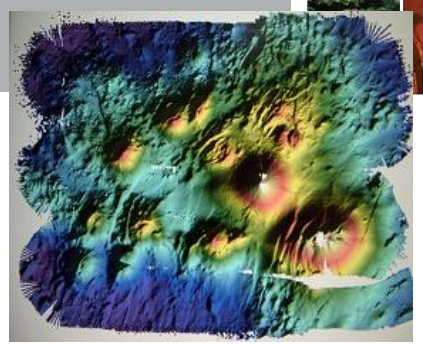
Future Research Vessel Project

RV *Investigator* – a new era in marine and atmospheric research for Australian scientists and international collaborators

RV Investigator Arrival

Vessel Capability Comparison

Capability	*Southern Surveyor*	*Investigator*
Length	66 m	93.9 m
Width	12.5 m	18.5 m
Number of scientific berths	15	40
Max distance in a single voyage	6 000 nautical miles	10 000 nautical miles
General purpose	Retro-fitted	Purpose-built scientific research vessel



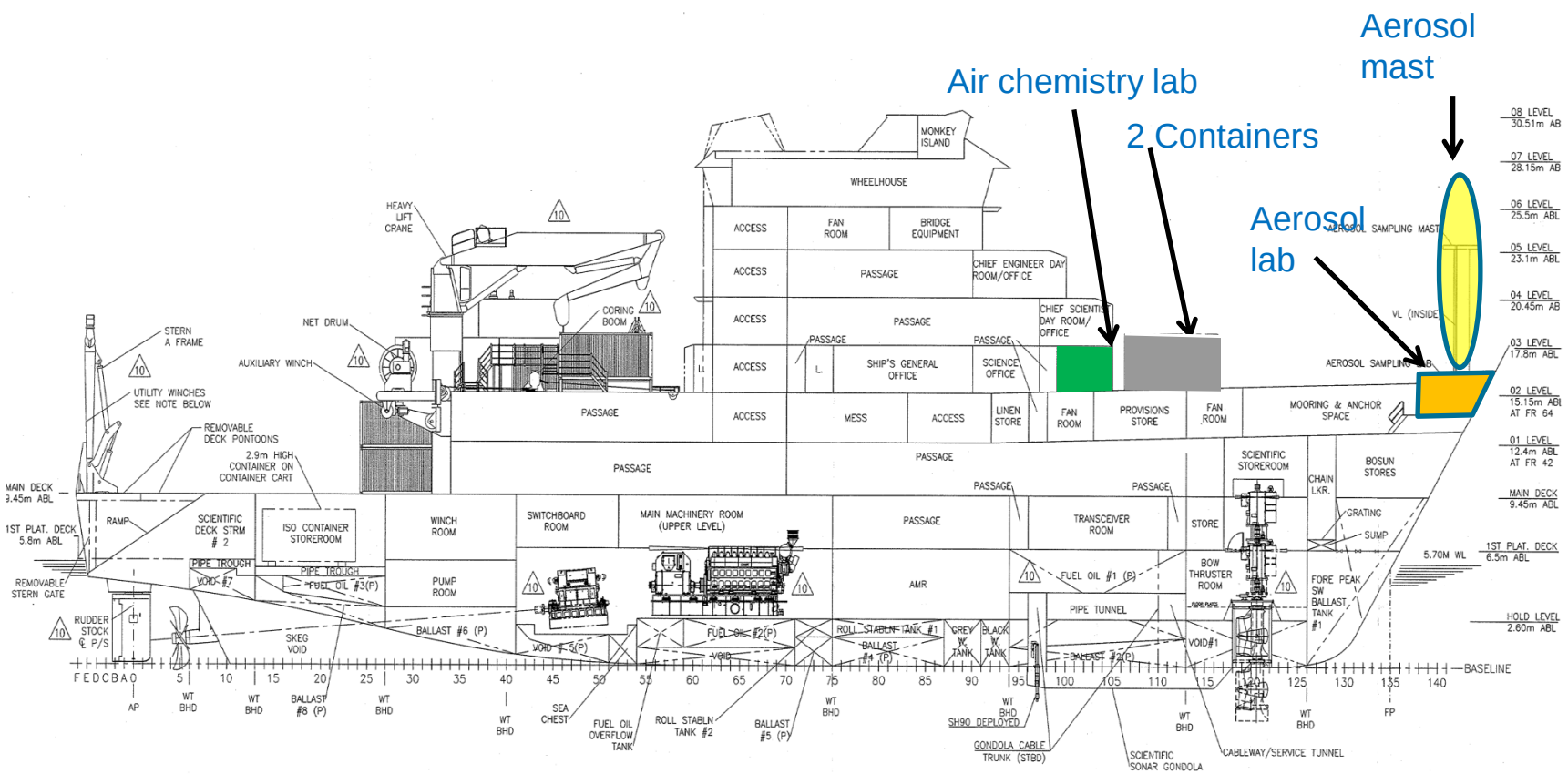
RV Investigator Research Program

- **GHG spectrometers,**
  1. **In-situ CO_2/CH_4 (CRDS) (Picarro)**
  2. **In-situ N_2O/CO (QCL) (Aerodyne)**
  3. **O_2/N_2 (fuel cell) (NCAR)**
- **Polarimetric Weather Radar**
- **Absorption photometer**
- **Nephelometer**
- **O_3 monitor**
- **NO_x monitor**

- Sea surface temperature radiometer
- Gravity meter
- Multicorer
- Towed general purpose profiling CTD
- Underway water analysis instruments
- XBT system
- CTD/O_2 Rosette System
- 24 and 36 bottle carousel & frame

Location of atmospheric chemistry labs and position of specialist containers.





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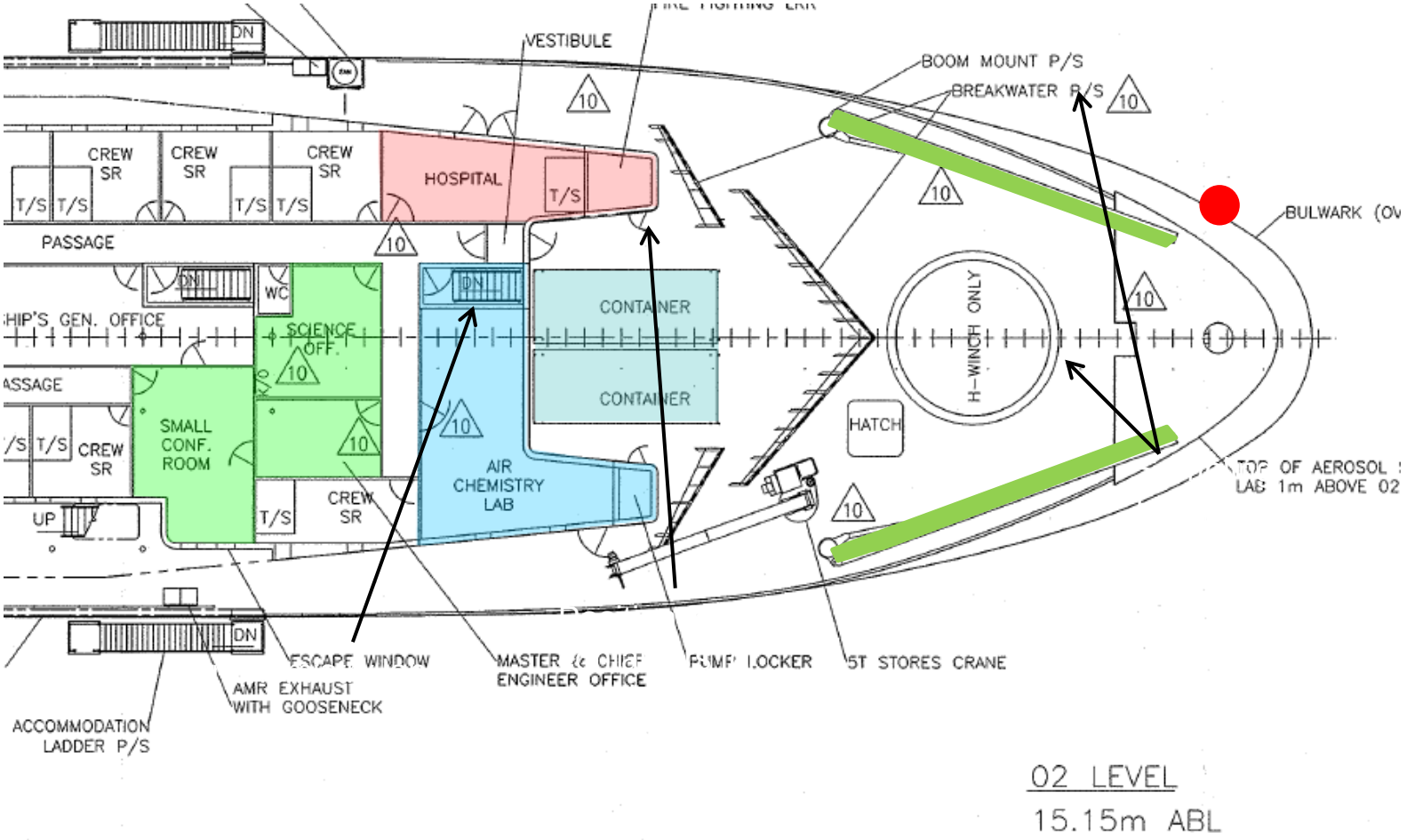
Air chemistry lab, containers and booms



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Thank you

www.cawcr.gov.au


Gunn Point
2 km
1 mi
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NH CO_2 2014 update - Alert and Mauna Loa