NOAA Global Monitoring Laboratory
Virtual Global Monitoring Annual Conference (eGMAC)

Updates on Carbon Cycle Research by GML Partners in Asia, Australia, and New Zealand

July 21, 2020 1730 – 1930 (MDT)

Session Overview: Rather than having a specific scientific focus, the session is organized at a time convenient for partners in Asia and Oceania to participate. While the focus will be carbon cycle research, the presentations will cover a range of topics including New Zealand's Carbowatch program, biomass burning in Australia, results from NIES's CONTRAIL program, $^{14}CO_2$ measurements in Korea, CMA's GHG monitoring program, and more.

TIME	TITLE	PRESENTER
1730-1735	Introduction	Jocelyn Turnbull
1735-1750	CO Measurements as a Biomass Burning Carbon Emission Tracer at the Amazon Basin	Lucas Domingues National Isotope Centre, GNS Science, Lower Hutt, New Zealand
1750-1805	CarbonWatchNZ: Regional to National Scale Inverse Modelling of New Zealand's Carbon Balance	Beata Bukosa NIWA
1805-1820	The 2019/20 Australian Bushfires	Ray Langenfelds CSIRO
1820-1835	The CONTRAIL commercial aircraft monitoring CO2 emissions from cities	Taku Umezawa NIES
1835-1850	^{14}C observations of atmospheric CO_2 at Anmyeondo GAW station, Korea: Implications for fossil fuel CO_2 and emission ratios	Haeyoung Lee KMA
1850-1905	High precision greenhouse gases measurement in China	Yao Bo CMA
1905-1920	Measurements of major greenhouse gases at three background sites in the East Asia	Chang-Feng Ou-Yang Department of Atmospheric Sciences, National Central University

Session Abstracts

1735-1750 **L.G. Domingues[1,3], L. V. Gatti[2,3], J. B. Miller[4], M. Gloor[5], W. Peters[6], A. Aquino[3], C. Correia[2], J. Turnbull[1], A. Sánches[2], L. Basso[2], G. Tejada[2], L. Marani[2] and H. Cassol[2]**

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[4]Global Monitoring Laboratory, National Oceanic and Atmospheric Administration, Boulder, USA;
[5]University of Leeds, Leeds, UK;
[6]Wageningen University, Dept of Meteorology & Air Quality, Wageningen, The Netherlands

Title: **CO Measurements as a Biomass Burning Carbon Emission Tracer at the Amazon Basin**

Abstract: The tropical rainforests have an amount of carbon stored into its plants and soil comparable to half of the amount of atmospheric carbon contained at the atmosphere before the start of industrialization at the 18th century. Among the tropical regions, the Amazon forest covers the largest area and hosts the largest carbon pool (~200 PgC), corresponding for 50% of its biome globally. Considering the capability of rapid release and the amount of storage carbon, there are surprisingly few studies of emission ratios and, in order to elucidate the actual contribution and the carbon emission from biomass burning in the Amazon Basin, measurements of carbon monoxide are an important tool.

The Amazon Basin biomass burning carbon emissions have been determined by applying a mass balance technique to carbon monoxide (CO) measured from vertical profiles at four sites (ALF, SAN, RBA and TAB) over the Amazon Basin, which is compared with carbon dioxide (CO_2) emissions when the vertical profile indicates a clear biomass-burning plume. During the studied period, the average contribution from the Amazon's biomass burning is equal to 0.32 ± 0.15 PgC/year, which can represent up to one third of LULUCF global emissions.

Figure 1 –Brazilian Legal Amazon highlighted in green, showing the measurement sites location with each respective CO:CO_2 ratio.

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1750-1810 **Beata Bukosa[1], Sara Mikaloff Fletcher[1], Gordon Brailsford[1], Colin Nankivell, Dan Smale[1], Elizabeth Keller[2], Jocelyn Turnbull[2], Kay Steinkamp[1], Mike Harvey[1], Peter Sperlich[1], Rowena Moss[1], Sally Gray[1], Stuart Moore[1], Sylvia Nichol[1], and Zoe Buxton[1]**

[1]NIWA, National Institute of Water and Atmospheric Research , New Zealand
[2]GNS Science, Lower Hutt, New Zealand

Title: **CarbonWatchNZ: Regional to National Scale Inverse Modelling of New Zealand's Carbon Balance**

Abstract: Atmospheric observations of CO_2 and other greenhouse gases have been widely used to constrain estimates of terrestrial and oceanic CO_2 fluxes through atmospheric inverse modelling. Yet, applying these methods at national scale to verify and improve the National Inventory Report (NIR) and support the Paris agreement remains at the frontier of CO_2 science.

We use inverse modelling to estimate New Zealand's carbon uptake and emissions using atmospheric measurements and model. This effort is part of a five year CarbonWatch-NZ research programme, which aims to develop a complete top-down picture of New Zealand's carbon balance using national inverse modelling and targeted studies of New Zealand's forest, grassland and urban environments. In addition to quantifying New Zealand's carbon emissions on a national scale, we also focus on identifying the prevailing processes driving CO_2 changes in New Zealand to support climate mitigation.

In an initial study based on the inversion system used in CarbonWatch-NZ, a significantly stronger (30-60 %) sink was found relative to the NIR (Steinkamp et al., 2017), suggesting a strong CO_2 uptake in Fiordland, a region covered by indigenous temperate rainforest in New Zealand's South Island. Here, we present new results of CarbonWatch-NZ by expanding the studied time period from 2011-2013 to 2020, expanding our atmospheric observing network from two (Baring Head, 41.41°S, 174.87°E and Lauder, 38.33°S, 176.38°E) to a total of eleven in situ greenhouse gas measurement sites, and improving our atmospheric model resolution by roughly a factor of ten (NAME model, 1.5 km).

Our new results suggest that the strong sink observed in 2011-2013 did not diminish, but for recent years we have found an even stronger sink than for before. Additional measurements collected in the Fiordland region (i.e., CO_2 isotopes, carbonyl sulphide) also suggest a stronger CO_2 uptake, supporting our inversion results. Implementing observations from an additional site in the North Island (Maunga Kakaramea, 45.034°S, 169.68°E) have additionally increased the strength of the sink, pointing to additional strong sink region at the top of the North Island.

Reference: Kay Steinkamp, Sara E. Mikaloff Fletcher, Gordon Brailsford, Dan Smale, Stuart Moore, Elizabeth D. Keller, W. Troy Baisden, Hitoshi Mukai and Britton B. Stephens, Atmospheric CO2 observations and models suggest strong carbon uptake by forests in New Zealand, Atmospheric Chemistry and Physics, 2017.

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1805-1820 **Ray Langenfelds, Paul Krummel, Zoe Loh and Elise-Andree Guerette**
Climate Science Centre, CSIRO Oceans & Atmosphere, Aspendale, Australia

Title: **The 2019/20 Australian Bushfires**

Abstract: Australia experienced a severe bushfire season in 2019/20. Large areas of forest and farmland were burned across five states, taking in the length of the eastern seaboard and the south-east corner of the continent.

Emissions of combustion products were observed throughout CSIRO's Southern Hemisphere atmospheric measurement network. Fresh smoke plumes were encountered at sites close to fire-affected regions. Hemispheric-scale perturbations in background air were evident for some trace gases, e.g. CO and H_2.

This talk will discuss the nature of these fires, and what can be inferred from atmospheric data, including a preliminary top-down evaluation of the magnitude of the emissions.

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1820-1835 **Taku Umezawa**
National Institute for Environmental Studies
Center for Environmental Measurement and Analysis

Title: **The CONTRAIL commercial aircraft monitoring CO2 emissions from cities**

Abstract: CONTRAIL is the ongoing program that measures atmospheric trace gases using Japan Airlines' commercial airliners (http://www.cger.nies.go.jp/contrail/). We install Continuous CO2 Measuring Equipment (CME) and Automatic air Sampling Equipment (ASE) onboard JAL's Boeing 777-200ER and -300ER aircraft for trace gas observations over airports and in the upper troposphere/lower stratosphere. We present our recent study on CO2 variability over airports worldwide (https://rdcu.be/b4aiX). We analyzed 10+ year CO2 data by CME to address short-term variations in the lowermost part of the troposphere at airport proximity, in which long-term trend and seasonal variation were effectively removed. At many airports, CO2 enhancement varied from flight to flight downwind of neighboring cities. We calculated variability of CO2 at 36 airports worldwide, which increased with decreasing altitude. It was found that the magnitude of CO2 variability near the ground (~1 km) was correlated with the intensity of CO2 from a nearby city. This study well demonstrated the usefulness of commercial aircraft data for city-scale anthropogenic CO2 emission studies. If time allows, we also talk about CONTRAIL's recent activities.

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1835-1850 **Haeyoung Lee[1*], Edward J. Dlugokencky[2], Jocelyn C Turnbull [3,4], Sepyo Lee[1], John B Miller[2], Scott J. Lehman[5], Gabrielle Petron[2,4], Jeongsik Lim[6,7], Gang-Woong Lee[8]** (* *leehy80@korea.kr*)

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[8]Atmospheric Chemistry Laboratory, Hankuk University of Foreign Studies, Gyeonggi-do, 17035, Republic of Korea

Title: **^{14}C observations of atmospheric CO_2 at Anmyeondo GAW station, Korea: Implications for fossil fuel CO_2 and emission ratios**

Abstract: To understand Korea's carbon dioxide (CO_2) emissions and sinks as well as those of the surrounding region, we used 70 flask-air samples collected during May 2014 to August 2016 at Anmyeondo (AMY, 36.53° N, 126.32° E; 46 m a.s.l) World Meteorological Organization (WMO) Global Atmosphere Watch (GAW) station, located on the west coast of South Korea, for analysis of observed ^{14}C in atmospheric CO_2 as a tracer of fossil fuel CO_2 contribution (C_{ff}). Observed $^{14}C/C$ ratios in CO_2 at AMY varied from -59.5 to 23.1‰ with the measurement uncertainty of ±1.8‰. The derived mean value C_{ff} of (9.7±7.8) μmol mol^{-1} (1σ) is greater than that found in earlier observations from Tae-Ahn Peninsula (TAP, 36.73° N, 126.13° E, 20 m a.s.l., 24 km away from AMY) of (4.4±5.7) μmol mol^{-1} from 2004 to 2010. The enhancement above background of sulfur hexafluoride ($\Delta x(SF_6)$) and carbon monoxide ($\Delta x(CO)$) correlate strongly with C_{ff} ($r > 0.7$) and appear to be good proxies for fossil fuel CO_2 at regional and continental scales. Samples originating from the Asian continent had greater $\Delta x(CO):C_{ff}$ (R_{CO}) values, (29±8) to (36±2) nmol μmol^{-1}, than in Korean local air ((8±2) nmol μmol^{-1}). Air masses originating in China showed (1.8±0.2) times greater R_{CO} than a bottom-up inventory suggesting that China's CO emissions are underestimated in the inventory while observed R_{SF6} are 2-3 times greater than both China and Korea inventories. However, both R_{CO} derived from inventories and observations have decreased relative to previous studies, indicating that combustion efficiency is increasing in both China and South Korea.

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1850-1905 **Bo Yao, Miao Liang, Wanqi Sun, Lixin Liu**
Meteorological Observation Centre of China Meteorological Administration (MOC/CMA)

Title: **High precision greenhouse gases measurement in China**

Abstract: High precision measurement of greenhouse gases have been conducted at seven background stations among China by China Meteorological Administration (CMA) since 1990s. Now, CO_2/CH_4 mixing ratios were measured by *in-situ* CRDS systems at 6 background stations, N_2O/SF_6 mixing ratios were measured by GC-ECD systems at 5 background stations, and $HFC/PFC/NF_3$ mixing ratios were measured by GC-MS at Shangdianzi Station. Besides, samples were collected weekly at 7 background stations and $CO_2/CH_4/N_2O/SF_6$/HFCs/PFCs/NF_3 mixing ratios were analyzed at central lab at CMA. All the *in-situ* systems are equipped with automatic calibration module and the and the measurements can trace back to the World Meteorological Organization (WMO) calibration scale for $CO_2/CH_4/N_2O/SF_6$ and Advanced Global Atmospheric Gases Experiment (AGAGE) calibration scale for $HFC/PFC/NF_3$. The atmospheric HFCs mixing ratios were used to estimate Chinese HFCs emission from 2010 to 2017.

Besides, an automatic observation system based on CRDS high precision CO_2 observation system has been established at six core stations in Beijing-Tianjin-Hebei region. The measurement at all the six core stations shares the same technique with the measurement at CMA background stations. The observations at high tower stations, mobile vehicle, aircraft, air-core sampling were conducted. CO_2 were measured at least 2 layers at the towers at 5 stations of Shangdianzi, Beijing Boundary Layer Tower, Xianghe, Luancheng and Tianjin Boundary Layer Tower. Besides, vertical CO_2 file were observed by aircraft at Shijiazhuang, Xingtai and Tangshan by using KingAir based on Shijiazhuang Airport and Y-12 Aircraft based on Tangshan Airport. At last, fine resolution CO_2 concentration in Beijing, Shijiazhuang and other places have been carried out by mobile vehicle. A state-of-art technique of air-core sampling has been developed and tested in Inner Mongolia and Qinghai to get the vertical profile up to 25 km. The integrated observation of atmospheric CO_2 was carried out by multiple research platforms in September 2018 and January 2019. The observation data will be further applied to estimate CO_2 grid emission of Beijing-Tianjin-Hebei region.

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1905-1920 **Chang-Feng Ou-Yang[1], Jia-Lin Wang[2], Neng-Huei Lin[1,3]**
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[2]Department of Chemistry, National Central University, Taoyuan 32001, Taiwan

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Title: Measurements of major greenhouse gases at three background sites in East Asia

Abstract: The measurement results of major greenhouse gases including CO_2, CH_4, N_2O, and SF_6 at the Lulin Atmospheric Background Station (LLN; 23.47°N, 120.87°E; 2,862 m a.s.l.), Dongsha Island (DSI; 20.70°N, 116.73°E; 3 m a.s.l.), and Taiping Island (TPI; 10.37°N, 114.37°E; 5 m a.s.l.) were reported in this study. These sites are located respectively in central Taiwan, northern South China Sea, and southern South China Sea as part of NOAA/ESRL/GML's Cooperative Air Sampling Network. Distinct seasonal variations were found for most greenhouse gases. For LLN in the free troposphere, seasonal maxima and minima of most greenhouse gases as well as other air pollutants were observed in March and July, respectively. Springtime vegetation growth dramatically drew down the CO_2 mixing ratios in summer. For DSI and TPI at surface level, which were mainly influenced by the Asian continental outflow, the maximum values were thus observed in winter. The seasonal patterns were much more distinct for most greenhouse gases at DSI compared to those at LLN and TPI. A minor seasonal variation of N_2O were also revealed at DSI. In summer, the oceanic influences originated from the southern South China Sea brought air masses with low mixing ratios of greenhouse gases into East Asian troposphere.