Installation of a greenhouse gas baseline atmospheric monitoring station

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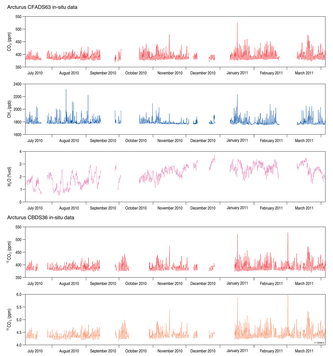
Arcturus (ARA)

In July 2010 Geoscience Australia and CSIRO Marine & Atmospheric Research jointly commissioned a new atmospheric composition monitoring station ("Arcturus") in central Queensland. The facility is designed as a proto-type remotely operated 'baseline monitoring station' such as could be deployed in areas that are likely targets for commercial scale carbon capture and geological storage (CCS). It is envisaged that such a station could act as a high quality reference point for later in-fill, site based, atmospheric monitoring associated with geological storage of CO_2.

The site is in the locality of Arcturus approximately 50 km south-east of the town of Emerald in sub-tropical Queensland. It is likely that CO_2 and CH_4 fluxes in the region are driven by the natural ecosystems and activities such as cropping, grazing, feedlotting, coal mining and gas production. This type of environment is typical of sites being considered for onshore geological storage of CO2 in Australia.. This type of environment is typical of sites being considered for geological storage of CO_2 in Australia.

Two wavelength scanned cavity ringdown instruments (Picarro) installed in the station measure continuous concentrations of CO_2, CH_4, water vapour and the



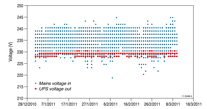
isotopic composition ($\delta^{13}C$) of CO_2. Meteorological sensors located on the 10 m fibre-glass mast measure wind speed/ direction, temperature and relative humidity. A 5.5 m tall eddy covariance flux tower has been recently installed to measure CO_2 and CH_4 fluxes.

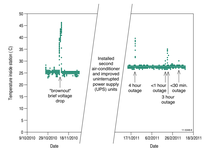
The graphs show time series of CO_2, CH_4, H_2O and CO_2 isotopes data from Arcturus. Gaps in the data are predominantly due to power problems and inaccessibility to the site due to wet weather and road closure. Ongoing modification to the station has seen a significant improvement in reliability.

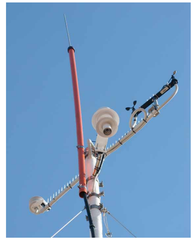
Technical Issues/Solutions:

- Electricity was not available during installation and testing—a petrol electric generator was used during up deployment
- Periodic brownouts and occasional blackouts—replaced UPS with top of the line model to maintain power supply to analysers for up to 4 hours.
- Air conditioner failed to reliaby self-start after power failures (but instruments and computers did start) resulting in a rapid increase in temperature in the container (each analyser uses ~300 watts)—installed thermal cut-offs on analysers and eventually installed a more reliable second air-conditioning system. Excessive temperature could potentially damage computers, instruments and calibration gas tanks.
- Mobile communication was not reliable to enable remote instrument control, required for calibrations—the telecommunications company undertook capacity extension on the nearest tower (35 km away) which improved communication tremendously.
- Container survived widespread flooding in region; however, heavy rains caused water ingress which destroyed some equipment. Roads were unpassable after rains (for up to 2 weeks) and delayed equipment maintenance and repair.
- Excessive humidity led to an accumulation of water in the in-take—the line was remotely dried by using a high flow of calibration gas
- A significant overriding technical issue is the challenge of running continuous unattended operation of the instruments.

10 m (fibre-glass mast) being winched up/down; aspiration inlets at 5 m and 10 m heights; and meteorological sensors at 10 m.







Top of 10m fibre-glass mast showing aspiration inlet; meteorological sensors and lightening rod. (The other inlet is at 5 m).

Understanding the measurements

Coal mines in the Bowen Basin area are situated within 100 km of Arcturus, as shown in the map to the right. The windrose of observed wind data indicates that air is most often transported to Arcturus from the north-east and southeast. This places several of the operating coal mines upwind of Arcturus. Therefore, we expect that CH_4 emissions from coal mining are likely to make a contribution to the signal we measure at Arcturus.

Estimates of emissions from coal mines in the region were used in CSIRO's TAPM (The Air Pollution Model), a mesoscale atmospheric transport model, to generate time series of CH_4 concentrations at Arcturus expected to be contributed from the coal mine emissions. This enabled the comparison of modelled CH_4 concentrations from coal mines in the region, with data measured at Arcturus.

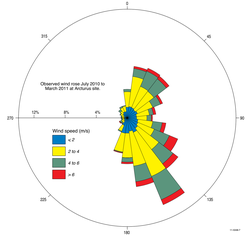
The figure below shows measured and modelled CH_4 during a three week period in spring 2010. Both traces show diurnal cycles that reflect typically well-mixed atmospheric conditions during the daytime when CH_4 concentrations normally fall to background levels, followed by more stable conditions at night that result in the build up of CH_4 in the boundary layer.

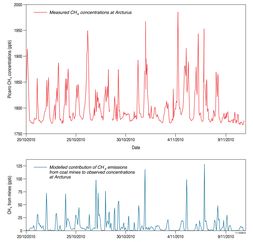
While the modelled contribution does not perfectly match the observed concentrations, predicted excursions of 20–100 ppb are frequently coincident with measured enhancements of similar magnitude, structure and duration. This suggests that some component of the measured CH_4 is coming from coal mining operations.

Mismatches between the modelled and observed CH_4 may be due to a number of factors including:

- constant emissions from coal mining operations were assumed in the model using coarse emission factors per tonne of raw coal extracted; in reality time varying emissions would be expected.
- additional regional and local sources of CH_4, including gas production, enteric fermentation from the nearby cattle feedlot and soils (not yet modelled)

Emissions modelling of CO_2 from coal mining demonstrated that the contribution from this source to the measured concentration of CO_2 at Arcturus was very small (1–2 ppm).





Future work

We will continue to refine our understanding of the variability in the observed CH_4 and CO_2 at Arcturus, aided by our new flux measurements which should help resolve the contribution of local CH_4 and CO_2 sources. In addition, we will also improve our understanding of the CO_2 climatology. The largest contribution to CO_2 variations is likely to be due to agricultural crops and natural vegetation in the area. For this work, we will use an atmospheric transport model coupled to CABLE (the CSIRO Atmosphere/Biosphere Land Exchange model) to understand the CO_2 variability at this site.

A growing network

Arcturus is the latest addition to CSIRO's growing national greenhouse gas monitoring network, sampling different air masses to those measured at the Cape Grim, Gunn Point and Otway sites. In addition to being a proto-type 'baseline monitoring station' such as could be deployed in areas that are likely targets for commercial scale geological storage of CO_2, Arcturus addresses a regional gap in the GHG network. The current data will be used to understand the measured variations in CO_2 and CH_4 in the sub-tropical location and the contributions of natural and anthropogenic sources in the area to this variability. There are future plans to expand the network further and use all data to help constrain national and regional scale greenhouse gas budgets.

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