

Air Quality in the Tail-pipe of North America – Sable Island Perspective

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Introduction

Supported by the Environmental Studies Research Fund, continuous air quality monitoring on Sable Island commenced in June 2003, with the aim of obtaining baseline air quality data as offshore gas development and production become established, such as at Deep Panuke. Additionally, the island's strategic location, downwind of North American continental emission sources, makes it a prime observing site for long term trends in air quality in an otherwise pristine environment. The site is also designated as a Global Atmospheric Watch site for greenhouse gas monitoring. Funding is provided by the Canadian Association of Petroleum Producers (CAPP), Environment Canada (EC) and the Nova Scotia Department of Environment and Labour (NSEL) (Inkpen *et al.* 2006).

Summary

- Sable Island is equipped to monitor air quality from both local and long range emission sources.
- Data analysis to assess source contributions is continuing.
- Air quality data are used for air quality model validation and development.
- Maintenance and repair costs are non-trivial.
- The high humidity and high sea-salt aerosol content in the air presents monitoring challenges that have generally been overcome.
- Dedicated instrumentation to measure SO₂ and H₂S individually will increase data integrity for these pollutants.
- CO₂ monitoring verifies the global increasing trend in concentrations of this greenhouse gas.
- Biogenic contributions to particulate matter from the local environment will require investigation in future.

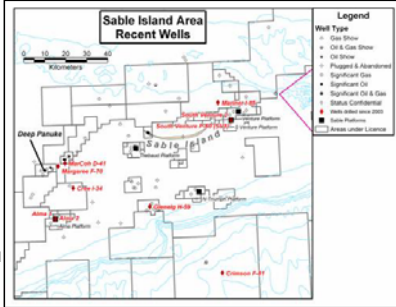


Map of Sable Island Recent Wells



Figure 1. Thebaud production platform flare (15 km west-southwest of the monitoring facility). (Courtesy: Andrew Langley)

Figure 2. Map of offshore oil and gas activity near Sable Island. (Courtesy: Canada-Nova Scotia Offshore Petroleum Board)



Air Quality Monitoring Methods

One-hour average measurements of ozone (O₃), nitric oxide (NO), nitrogen dioxide (NO₂) and fine particles (PM_{2.5}) are obtained every hour while one-hour averages of hydrogen sulphide (H₂S) are obtained every odd-hour and sulphur dioxide (SO₂) averages every even-hour. Data are transmitted every hour from the instrumentation shown below via satellite communications to Toronto, ON and then transmitted to NSEL. Thereafter the data are distributed for air quality prediction purposes and eventually archived in the National Air Pollutant Surveillance database in Ottawa. Monitoring for all components commenced in June 2003. Data encompass the period June 2003-Dec 31, 2006. Monitoring for carbon dioxide (CO₂) commenced in 1975 with flask samples with additional hourly sampling for (CO₂) that began in June 2003 (not shown).



Figure 3: Atmospheric Chemistry building and storage shed on Sable Island. (Courtesy: Sable Island Green Horse Society).



Figure 4: Monitoring equipment (l-r): Ozone (TEI-49C), NO_x (Teledyne-API), H₂S/SO₂ (Teledyne-API), PM_{2.5} (MetOne-BAM), FRM – Partisol located outside. The CO₂, CO and NH₃ monitors are not shown. (Green Horse Society)



Figure 5: Aerial view of Sable Island (Courtesy: Green Horse Society)

Monitoring Results

Air quality data are used in near-real time for air quality prediction and model validation. Time series display of air quality data assists in examining temporal variability (including seasonal patterns) and in assessing pollution events.

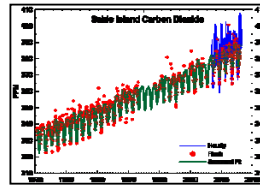


Figure 6. Sable Island Carbon Dioxide (CO₂) concentration (ppm) trends from 1975-2007 based on flask samples (in red) and hourly values in blue, illustrating the seasonal and metabolic signals from the mainland. The upward trend in CO₂ at Sable Island and other Global Atmospheric Watch (GAW) sites around the world is well documented in the literature (Worthy *et al.* 2003)

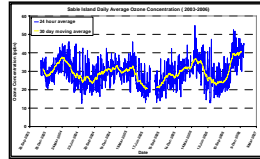


Figure 7. Sable Island daily average and 30-day running average Ozone (O₃) concentrations (ppbv) for 2003-2006 shows elevated springtime ozone. Episodic high concentrations are not significant at the site in summer, due in part to the marine inversion which restricts over-passing plumes from reaching the surface. High concentrations through Nov-Dec 2006 are being studied.

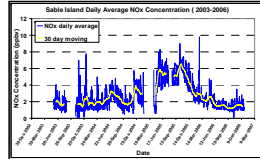


Figure 8. Sable Island daily average and 30-day running average Nitrogen Oxides (NO_x) (NO_x=NO + NO₂) concentrations (ppbv) for 2003-2006. No distinct pattern is described by the graph. NO_x is typically derived from local sources (generator, incinerator, offshore oil and gas production and passing ships). The maximum in concentrations from mid-June – Nov 2005 is being investigated.

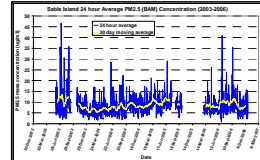


Figure 9. Sable Island daily average and 30-day running average Fine Particulate Matter (PM_{2.5}) concentrations (µg/m³) for 2003-2006. No distinct pattern is noted in the graph. The elevated PM_{2.5} concentration 'spikes' have been attributed to both local (mentioned in Figure 8 caption) and long range emissions as well as sea-salt aerosol events.

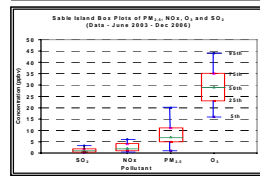


Figure 10. Sable Island box plots showing the concentration ranges for SO₂, NO_x, PM_{2.5}, and O₃ based on the data set June 2003 – December 2006.

Pollutant	Units	Sable Island	Halifax
SO ₂	ppbv	1.2	6.3
NO	ppbv	1.6	20*
NO ₂	ppbv	1.5	16*
NO _x	ppbv	3.0	36*
O ₃	ppbv	29.3	17
PM _{2.5} **	µg/m ³	8.8	4

*2006 data only ** (Lake Major)

Table 1. Comparison of average pollutant concentrations between Sable Island and Halifax for the period 2004-2006. [Data completeness criterion ≥ 75%]. The high number of local emission sources of SO₂ and NO_x in Halifax is responsible for its higher concentrations. Increased NO_x emissions in Halifax react to reduce ozone concentrations at the Halifax monitor. Higher PM_{2.5} at Sable is believed to be due to the high concentration of sea-salt aerosol.

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Air Quality Events

Elevated PM_{2.5} concentrations on Sable Island (hourly concentrations exceeding the Canada Wide Standard metric of 30 µg/m³) have been attributed to both anthropogenic long-range transport of pollution and local natural sea-salt aerosol events as seen below.



Figure 11. NOAA-MODIS satellite image of smog in the atmosphere above Sable Island, June 26, 2005. Note the 'hazy' conditions to the south of Nova Scotia and Sable Island resulting from light scattering by aerosols. (Courtesy: NASA-Rapidfire)

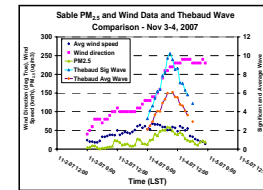


Figure 12. Sable Island PM_{2.5} concentrations during post-tropical storm Noel (Nov 3-4, 2007). PM_{2.5} concentrations (green), wind speed (dark blue), wind direction (magenta), Thebaud significant waves (orange) and maximum waves (light blue). Note the strong response the PM_{2.5} concentrations have to wave height. The extensive surf zone around Sable Island is capable of generating suspended sea-salt aerosol, much of which is larger than PM_{2.5}.

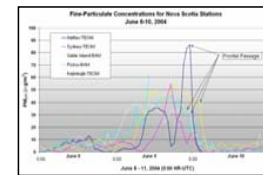


Figure 13. Time series of PM_{2.5} concentrations from a pollutant episode that originated over the Great Lakes and moved through Nova Scotia in June 2004. Concentrations declined rapidly in the wake of a cold frontal passage which ushered in cleaner air.

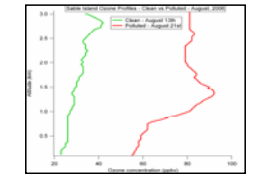


Figure 14. Sable Island ozonesonde profiles on a good air quality day and a polluted day during August of 2006. Layering/stratification of pollutants over the North Atlantic as shown in the profile for August 21st is commonly observed by these balloon ascents and during intensive field studies using aircraft (Angevine *et al.* 2006). (Courtesy: Dave Tarasick)

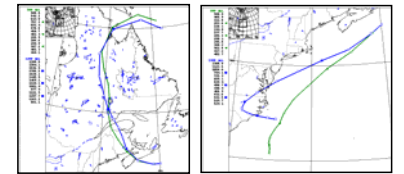


Figure 15. Sable Island air source using 3-day back-trajectories arriving at 500m (green) and 1300 m (blue) for good air quality, August 13th (left panel), show air originated from northern Quebec. For polluted air, August 21st (right panel), the air originated from along the US eastern seaboard. (CMC trajectory model)

References

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Further Information

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