

**New applications of continuous atmospheric O₂ measurements:
meridional transects across the Atlantic Ocean, and improved
quantification of fossil fuel-derived CO₂**

By

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In Memory of Greg Pickers (1949-2016)

Abstract

High precision, continuous measurements of atmospheric O₂ and CO₂ are a valuable tool for gaining insight into carbon cycle processes, and for separating land biospheric, oceanic and fossil fuel fluxes of CO₂. This thesis presents a new atmospheric O₂ and CO₂ measurement system that has been deployed on board a commercial container ship, travelling continuously between Germany (~55°N) and Argentina (~35°S). These data are the first ongoing atmospheric O₂ measurements across the Atlantic Ocean, closing a gap in the global atmospheric O₂ network.

The Atlantic meridional transects of atmospheric O₂ and CO₂ display latitudinally-varying seasonality. The annual mean latitudinal gradient in APO (Atmospheric Potential Oxygen; a tracer derived from O₂ and CO₂ measurements) does not show a pronounced bulge at the equator, in contrast to observations across the Pacific Ocean.

Atmospheric O₂ and CO₂ measurements from Norfolk, UK are used to demonstrate a novel method for quantifying fossil fuel derived CO₂ (ffCO₂), using APO data. This APO ffCO₂ quantification method is more precise than the frequently-used CO tracer method, owing to a smaller range of APO:CO₂ fossil fuel emission ratios compared to the CO:CO₂ range. A sensitivity analysis of the fossil fuel emission ratios also indicates that the APO method is very likely more accurate than the CO method, and can therefore be used independently of ¹⁴CO₂ measurements (unlike the CO method), which are costly and highly unreliable in many UK regions, owing to nuclear power plant influences.

These new applications of atmospheric O₂ measurements have significant future potential. The shipboard data can be used to test and improve global climate model estimates of meridional oceanic heat and carbon transport in the Atlantic. Using APO to quantify ffCO₂ has significant policy relevance, with the potential to provide more accurate and more precise top-down verification of fossil fuel emissions.

List of Contents

List of figures	xi
List of tables	xxiii
Acknowledgements	xxv
1 Introduction	1
1.1 Climate change and the carbon cycle	2
1.2 Atmospheric oxygen measurements as a tool for understanding the carbon cycle	8
1.3 The historical and current atmospheric oxygen measurement network	15
1.4 Objective and specific aims of this research	24
1.5 Outline of thesis	25
References	25
2 Methodology of atmospheric O₂ and CO₂ measurement	35
2.1 Introduction and outline of chapter	36
2.2 Measurement system design	40
2.2.1 Overview	40
2.2.2 O ₂ and CO ₂ analysers	41
2.2.3 Gas handling procedures	47
2.2.3.1 Air inlets	47
2.2.3.2 Drying system and diaphragm pumps	48
2.2.3.3 Flow and pressure control	53
2.2.3.4 Temperature considerations and leaks	54
2.3 Calibration procedures	56
2.3.1 Calibration gas handling	56
2.3.2 Analyser calibration procedures	57
2.3.3 High pressure cylinder standards	64
2.3.4 The role of the Zero Tank and Target Tank	66
2.4 Repeatability and compatibility of measurement system	71
2.5 Data acquisition and system software control	74
2.6 Improvements implemented	77
2.7 Experimental testing	79
2.8 Future improvements	82
2.9 Summary	84

References	86
3 Measurements of atmospheric O₂ and CO₂ in the North Atlantic Ocean on board the RRS James Cook	89
3.1 Introduction	90
3.1.1 Scientific background and chapter outline	90
3.1.2 Motivation for research cruise	91
3.1.3 Location of the cruise	92
3.2 Measurement system description, technical setbacks and complementary data	93
3.2.1 Description of O ₂ and CO ₂ measurement system	93
3.2.2 Technical issues that arose during the JC090 cruise	94
3.2.3 Complementary data used in analyses	97
3.3 Data flagging	98
3.3.1 Preliminary results	98
3.3.2 Flagging of CO ₂ , O ₂ and APO data based on analysis of diagnostic parameters	99
3.3.3 Flagging of CO ₂ , O ₂ and APO data contaminated by the ship's exhaust fumes	99
3.4 Results and data analysis	102
3.4.1 Comparison of CO ₂ mole fractions with those measured by PML, and consequences for CO ₂ flux estimates	102
3.4.2 Baseline data	105
3.4.3 Short-term events: correlations with meteorological parameters	107
3.4.4 Short-term events: NAME footprints	111
3.4.5 Short-term events: oxidative ratios	114
3.4.6 Short-term events: correlations with the JC090 underway data	115
3.4.7 Short-term events: evidence of eddies from satellite derived altimetry and sea surface temperature data	117
3.4.8 Short-term events: O ₂ flux estimate associated with a typical cold-core cyclonic eddy	120

3.4.9	Short-term events: modelling short-term variability in APO using NAME and NEMO-PlankTOM	125
3.5	Summary and conclusions	129
	References	131
4	Latitudinal variability in atmospheric O₂, CO₂ and APO across the Atlantic Ocean	135
4.1	Introduction	136
4.1.1	Installation of the shipboard atmospheric measurement system on board the Cap San Lorenzo	138
4.2	Meridional transects of atmospheric O ₂ , CO ₂ and APO across the Atlantic Ocean	140
4.2.1	Short-term variability: equator and open ocean	144
4.2.2	Short-term variability: The Channel and North Sea	148
4.2.3	Short-term variability: ocean upwelling and productivity events	150
4.2.4	Variability in the position of the ITCZ	154
4.3	Seasonality in atmospheric O ₂ , CO ₂ and APO across the Atlantic Ocean at different latitudes	157
4.4	Annual mean latitudinal gradients of atmospheric O ₂ , CO ₂ and APO across the Atlantic Ocean: the missing equatorial APO bulge	170
4.5	Summary and Conclusions	182
	References	186
5	Quantifying ffCO₂ using APO: a novel approach	191
5.1	Introduction	192
5.1.1	Outline of this chapter	195
5.2	Atmospheric O ₂ and CO ₂ measured from the Environmental Sciences building, University of East Anglia	196
5.3	Fossil fuel CO ₂ quantification using APO from sites in Norfolk, UK	205
5.3.1	Using 'fixed' fossil fuel emission ratios	205
5.3.2	Baseline and measurement uncertainty analysis	209
5.3.3	Using 'time-varying' fossil fuel emission ratios	212
5.3.4	Comparison of CO and APO fossil fuel quantification methods	214

5.3.5	Comparison of ffCO ₂ from 'top-down' atmospheric measurements with ffCO ₂ from 'bottom-up' inventories	220
5.4	Summary and future work	224
	References	227
6	Conclusions	231
6.1	Outline of major research findings	232
6.1.1	Shipboard atmospheric O ₂ and CO ₂ measurement system	232
6.1.2	Detecting short-term ocean O ₂ fluxes in atmospheric O ₂ data	233
6.1.3	The position of the ITCZ in the Atlantic Ocean	234
6.1.4	Seasonality variability and annual mean latitudinal distribution of atmospheric O ₂ , CO ₂ and APO across the Atlantic Ocean	234
6.1.5	Quantifying ffCO ₂ (fossil fuel-derived CO ₂) using APO	235
6.2	Summary of thesis and future work	236
	References	239
	Abbreviations	241
	Appendices	243

List of Figures

- Figure 1.1.** Radiative forcing estimates in 2011 relative to 1750, from IPCC (2013). Confidence level indicators correspond to: VH – very high, H – high, M – medium, L – low, VL – very low. Radiative forcing, in $W m^{-2}$, is defined as the change in energy flux caused by a driver, calculated either at the tropopause or the top of the atmosphere. 3
- Figure 1.2.** Model projections of (a) global mean surface temperature change relative to 1986-2005, (b) Arctic September sea-ice extent, and (c) global ocean surface pH, from 1950 to 2100 for the Representative Concentration Pathway (RCP) scenarios 2.6 and 8.5 of van Vuuren et al. (2011), with bars on the right indicating the 2081-2100 predictions for RCP4.5 and RCP6.0. Model projections are from the Coupled Model Intercomparison Project Phase 5 (CMIP5) multi-model ensemble simulations (Taylor et al., 2011). Black lines with grey shading represent modelled historical evolution of each parameter and its uncertainty, respectively. Likewise, for RCP2.6 and RCP 8.5, the uncertainty is shown by the blue and red shading, respectively. The black dashed line in (b) represents nearly ice-free conditions, while the dotted lines indicate the CMIP5 multi-model means. 4
- Figure 1.3.** A schematic of the global carbon cycle, from Ciais et al. (2013). Black numbers and arrows represent natural reservoirs and fluxes of carbon prior to 1750, and red numbers and arrows represent anthropogenic reservoirs and fluxes of carbon averaged over the 2000 – 2009 time period. Reservoir and flux values are given in units of PgC and $PgC yr^{-1}$ respectively. 5
- Figure 1.4.** The atmospheric CO_2 record measured at Mauna Loa Observatory, Hawaii, by Pieter Tans, NOAA/ESRL (National Oceanic and Atmospheric Administration/Earth System Research Laboratory, USA; www.esrl.noaa.gov/gmd/ccgg/trends/) and Ralph Keeling, Scripps Institution of Oceanography, USA (www.scrippsco2.ucsd.edu/). The red line shows the entire record, with the long-term trend represented by the black line. 7
- Figure 1.5.** Atmospheric O_2 and CO_2 time series data from Mauna Loa, Hawaii, USA, and the South Pole, Antarctica; northern hemisphere data are shown in green, while southern hemisphere data are shown in blue. CO_2 data are from Keeling et al. (2001) and O_2/N_2 data are from Ralph Keeling (personal communication; <http://scrippsco2.ucsd.edu/>). 11
- Figure 1.6.** A graphical representation of calculating the land and ocean carbon sinks using the method of Keeling and Manning (2014). Black dots are 6-monthly averages of $\delta(O_2/N_2)$ and CO_2 from Alert, Canada, La Jolla, California, USA, and Cape Grim, Tasmania, Australia. 13

Figure 1.7. The current status of the global high-precision O ₂ measurement network, as of May 2016. Note that aircraft and shipboard measurements are not shown for clarity. Stations where flask samples are collected are indicated by the red symbols, while continuous measurement stations are shown in blue. Stations that collect flask samples and make continuous measurements are shown as continuous stations (blue). Note that all atmospheric O ₂ stations also make concurrent measurements of CO ₂ .	23
Figure 2.1. Gas handling diagram of shipboard O ₂ and CO ₂ measurement system. 'Red' and 'blue' inlet lines are coloured accordingly in Unit 1, and the green colouring in Unit 2 denotes electrical cables.	42
Figure 2.2. Photograph showing the inside of the Li-6252 CO ₂ analyser.	43
Figure 2.3. Photograph showing the inside of the Oxzilla II O ₂ analyser. The MAX-250 fuel cells were originally housed inside the electronics box in the centre of the photograph, but were later moved to facilitate easier leak checking. The fuel cells have been insulated using glass wool. The inlet tubing shown in this photograph is 1/8" (external diameter), however, this was later replaced with 1/16" tubing to reduce the residence time of air in the tubing between V11 and the fuel cells (see Section 2.6 for details).	44
Figure 2.4 Top plot: Cell 1 (blue circles) and cell 2 (red triangles) O ₂ responses in [%] (uncalibrated Oxzilla II response units). Unfilled symbols represent data that are swept out and therefore ignored, while filled symbols represent data that are retained. 'WT' denotes periods when each cell is measuring the Working Tank, and 'S' denotes periods when each cell is measuring the air sample. Bottom plot: ΔO ₂ , in [%] *10 ⁴ (uncalibrated Oxzilla II response units), where unfilled symbols represent data that are swept out and ignored, while filled symbols represent data that are retained. 'WT-S' denotes periods when ΔO ₂ represents the Working Tank – air sample differential O ₂ signal, and 'S-WT' denotes periods when ΔO ₂ represents the air sample – Working Tank differential O ₂ signal. ΔΔO ₂ is calculated every minute from three V11 switch periods of ΔO ₂ (denoted by 'jog 1' and 'jog 2'), using Eq. 2.4. Note that ΔΔO ₂ could be calculated every 30 seconds, instead of every minute, however, this is not recommended, since successive jogs will share two thirds of the same data, instead of one third, and will therefore be less independent from each other.	46
Figure 2.5. Photograph (top) and annotated diagram (bottom) of the 'blue line' Aspirated Air Inlet (AAI) on board the Cap San Lorenzo Hamburg Süd container ship. The air to be measured (red arrows; 'sample air') is sampled from a moving air stream (blue arrows), which is generated by a waterproof blower. The blower prevents temperature gradients forming at the air inlet, and thus minimises fractionation of O ₂ relative to N ₂ at the inlet (Blaine et al., 2006).	47

Figure 2.6. Photograph of Unit 1, the drying unit of the O ₂ and CO ₂ measurement system.	50
Figure 2.7. Annotated diagram of the chiller trap, showing the dip tube, glass beads, and Swagelok Company quick connect stem and body fittings, which prevent the trap mistakenly being replaced the wrong way around in the chiller.	51
Figure 2.8. Drifts in the A and B coefficients of the quadratic CO ₂ fit (top and middle panels, respectively), and drift in the B coefficient of the linear O ₂ fit (bottom panel). Drifts represent the maximum possible drift in the calibration scales of CO ₂ and O ₂ . These data were constructed using a -8.9 mV ΔCO ₂ analyser response, equating to approximately 400 ppm, and using a 0.00444 % ΔO ₂ analyser response, equating to approximately -125 ppmEq (-700 per meg). Linear regression fits have been added to the plots to highlight the direction of the drift. Gaps in the time series are when the measurement system stopped working and could not be restarted until the next time the Cap San Lorenzo visited the London port.	62
Figure 2.9. Stability of the CO ₂ mole fraction (top panel) and O ₂ mole fraction (bottom panel) in the WTs over time. Each point represents the WT CO ₂ or O ₂ mole fraction as defined during a WSS calibration, minus the average WT CO ₂ or O ₂ mole fraction for each WT. Different coloured symbols represent different WTs. Typically, the lifetime of the air in a WT cylinder is about 18 days, with a starting pressure of about 300 bar and a final pressure of about 5 bar. Gaps in the time series in this figure, and Figures 2.11 and 2.12 below, are caused by system faults, predominantly drying problems, which could only be fixed each time the Cap San Lorenzo visited the London port.	63
Figure 2.10. Short-term drift in the ZT CO ₂ mole fraction, from the Cap San Lorenzo system for four days in Feb 2015. Blue symbols indicate ZT CO ₂ measurements that immediately follow a WSS calibration, and green symbols indicate the subsequent ZT CO ₂ measurements between WSS calibrations. Red symbols show the temperature measured in the room. Each ZT measurement is the mean of 11 one-minute averages of CO ₂ and O ₂ .	68
Figure 2.11. Stability of ZT CO ₂ and O ₂ mole fractions during deployment on board the Cap San Lorenzo between Sep 2014 and Sep 2015. Red and green symbols denote the CO ₂ and O ₂ mole fractions of ZTs D169300 and D064564 respectively. The red and green lines are linear regressions to the data, and indicate the direction of the long-term drift.	69
Figure 2.12. CO ₂ (top panel) and O ₂ (bottom panel) measurements of the TT cylinder on the Cap San Lorenzo. Data are shown as differences in mole fraction from the declared TT values. TT measurements that were made when the measurement system was experiencing known technical difficulties have been excluded. Each TT measurement shown is the mean of 13 consecutive one-minute averages of O ₂ and CO ₂ measurements.	70

- Figure 2.13.** Schematic tab of the Nemo software. The ‘Schematic’ tab allows the user to over-ride the default valve settings by clicking on the valve symbols on the gas handling diagram, displays the measurement system pressures, temperatures and flow rates, allows the user to set the desired system flow rate, displays the current calibrated O₂ and CO₂ mole fractions, displays whether the software is in ‘auto-run’ or ‘resting-state’ mode, and displays the status of the macro control, which determines the exact sequence for how the calibration cylinders and TT cylinder are purged and measured. Note that for internal CRAM research group reasons, the numbered designators for the valves, pressure transducers and flow meters on this schematic are not consistent with the numbering used in Fig. 2.1. 76
- Figure 2.14.** Allan deviation plot showing the optimum averaging period for the Oxzilla of about 14 seconds (black dot). This optimum averaging time represents the optimum trade-off between improved precision from averaging the signal noise and reduced precision owing to the inclusion of longer-term drifts in the differential O₂ signal. The Allan deviation for ΔO_2 with a ‘standard’ switching period of 1 minute is indicated by the pink dot (i.e. a jog length of 180 seconds), and the Allan deviation for ΔO_2 with a switching period of 30 seconds is indicated by the blue dot (i.e. a jog length of 90 seconds). 78
- Figure 2.15.** Histograms of 1-minute O₂ mole fraction when cylinder air was passed through a KNF Neuberger pump (left plot) and an Air Dimensions pump (right plot). 80
- Figure 2.16.** O₂ mole fraction of a 50 L cylinder (blue, left y-axis) and a 20 L cylinder (red, right y-axis) as a function of the number of hours since the cylinder was laid horizontally. 82
- Figure 3.1.** Bathymetric map showing the route of the RRS James Cook during the research cruise, from Vigo, Portugal, to the PAP site, and returning to Santander, Spain. Colours correspond to ordinal dates (where day 242 is 30Aug2013). The inset shows a zoomed version of the ship’s route in and around the PAP site. 92
- Figure 3.2.** Schematic of the RRS James Cook, showing the locations of the meteorological lab and ship’s exhaust stack, and the position of the AAls (image adapted from <http://noc.ac.uk/research-at-sea/ships/rrs-james-cook>). 93
- Figure 3.3.** Un-calibrated Oxzilla II fuel cell data during the JC090 cruise, showing the large variations caused by the ship’s motion superimposed on the 1-minute switching of the sample and working tank. Data are from the SEC file, recorded on 10Sep2013. Vertical grid lines are shown at 30 second intervals. 96

- Figure 3.4.** CO₂, δ(O₂/N₂) and APO data from the JC090 cruise (2-minute frequency). The y-axes have been scaled to be visually comparable on a mole per mole basis (since 1 ppm CO₂ ~ 5 per meg δ(O₂/N₂)). Gaps in the data correspond to periods when calibration cylinders were being analysed. 98
- Figure 3.5.** Unpolluted (black circles), statistically flagged (red triangles) and meteorologically flagged (green diamonds) CO₂, δ(O₂/N₂), and APO data. The CO₂, δ(O₂/N₂) and APO y-axes have been scaled to be visually comparable to each other on a mole per mole basis. 100
- Figure 3.6.** O₂:CO₂ ratio plot of the statistically and meteorologically flagged pollution spike data. δ(O₂/N₂) is given in ppm equivalent units (i.e. δ(O₂/N₂) ppm equivalent units = δ(O₂/N₂) per meg/4.77) to be comparable to CO₂ and enable correct calculation of the regression slope. The red dashed line indicates the major axis regression line, which has a slope of -1.38. The regression was weighted according to the difference in measurement uncertainty associated with the δ(O₂/N₂) and CO₂ data. 101
- Figure 3.7.** Atmospheric CO₂ data from the UEA O₂ and CO₂ measurement system (blue circles) and the PML pCO₂ measurement system (red triangles) during the JC090 cruise. 103
- Figure 3.8.** Difference between air-sea CO₂ flux calculated using UEA and PML atmospheric CO₂ mole fractions from the JC090 cruise. Positive values indicate that the UEA flux from the atmosphere into the ocean is greater than the PML flux. The overall mean CO₂ flux difference is 0.1731 mol m⁻² yr⁻¹. 104
- Figure 3.9.** Hourly-averaged CO₂, δ(O₂/N₂), and APO data, plotted alongside temperature and humidity data from the RRS James Cook meteorological instruments. The CO₂ y-axis has been scaled so that the data are visually comparable to the δ(O₂/N₂) and APO data. The pink lines on the CO₂, δ(O₂/N₂) and APO plots show the background mole fractions for Weybourne, UK, calculated using the 'rfbaseline' function from the 'IDPmisc' R package. 108
- Figure 3.10.** Wind rose showing wind speed and wind direction for event 1 data (red triangles), event 2 data (green diamonds), and all other data ('no event data'; black circles). 109
- Figure 3.11.** Correlation matrices for event 1 (top plot) and event 2 (bottom plot), created using the 'corPlot' function from the 'openair' package in R (Carslaw and Ropkins, 2012). Numbers indicate the correlation coefficients values from simple linear regressions of the variables. Strong positive correlations are shaded red, and strong negative correlations are shaded blue. The ellipsoids are more round in shape for weak correlations, and more elliptical in shape for strong correlations. 110

Figure 3.12. NAME footprint showing the origin of the air particles that were measured from the ship before event 1. At this time, NAME shows that the majority of the air particles originated from the northwest. Time-integrated particle concentrations are in units of gs m^{-3} .	112
Figure 3.13. NAME footprint showing the origin of the air particles that were measured from the ship during event 1. At this time, NAME shows that the majority of air particles originated from the west and southwest. Time-integrated particle concentrations are in units of gs m^{-3} .	112
Figure 3.14. NAME footprint showing the origin of the air particles that were measured from the ship after event 1, and before event 2. At this time, NAME shows that the majority of the air particles originate from the northwest. Time-integrated particle concentrations are in units of gs m^{-3} .	113
Figure 3.15. NAME footprint showing the origin of the air particles that were measured from the ship during event 2. This figure shows that the air particles were either very local at this time, or from the southwest. Time-integrated particle concentrations are in units of gs m^{-3} .	113
Figure 3.16. NAME footprint showing the origin of the air particles measured from the ship after event 2. NAME shows that most of the air particles originated from the north/northwest and west during this time. Time-integrated particle concentrations are in units of gs m^{-3} .	114
Figure 3.17. $\text{O}_2:\text{CO}_2$ ratio plot of background (i.e. non-event) data (black circles), event 1 data (red triangles), and event 2 data (green diamonds). As before, $\delta(\text{O}_2/\text{N}_2)$ is given in ppm equivalent units to be comparable to CO_2 and enable correct calculation of the regression slopes. The three lines indicates the major axis regression lines for background (black solid), event 1 (red dashed) and event 2 (green dashed-dotted) data. The regressions were weighted according to the difference in measurement uncertainty associated with the $\delta(\text{O}_2/\text{N}_2)$ and CO_2 data.	115
Figure 3.18. The top three panels show hourly averages of atmospheric CO_2 , $\delta(\text{O}_2/\text{N}_2)$ and APO, respectively. The bottom three panels show sea surface temperature, salinity and chlorophyll fluorescence data, respectively, measured by the James Cook underway system.	116
Figure 3.19. Gridded Sea Surface Height anomalies on 01Jan2014, produced from merged Jason-2/OSTM (Ocean Surface Topography Mission) and Cryosat-2 satellite data products (from: http://eddy.colorado.edu/ccar/ssh/nrt_global_grid_viewer). Blue areas are depressions in the mean sea surface height, which indicate cold core eddies, and red areas are elevations in the mean sea surface, which indicate warm core eddies.	119
Figure 3.20. Gridded Sea Surface Height anomalies on 13Sep2013 (from: http://eddy.colorado.edu/ccar/ssh/nrt_global_grid_viewer). The pink star indicates the position of the James Cook on this day.	119

Figure 3.21. A 7-day composite of SST from the MODIS aqua satellite (4 km resolution), centred around 13Sep2013 (from: http://eddy.colorado.edu/ccar/ssh/nrt_global_grid_viewer). The dashed lines indicate the contours of the sea surface height anomalies on 13Sep2013, as shown in figure 3.20. The pink ellipsoid indicates the location of the cyclonic cold-core eddy located to the east of the James Cook on the 13Sep2013. The SST colour scale has been limited to the range of 15 – 21 °C in order to visually emphasis temperature variations in the region of the cold-core eddy.	120
Figure 3.22. CTD cast dissolved O ₂ from the JC090 cruise (black circles). The CTD casts just before, during, and after event 2 are indicated by the yellow, orange and red triangles respectively. The pale blue and dark blue diamonds show dissolved O ₂ from an Argo float located southwest of the James Cook (at 44.5°N, 8.3°E), measured on 01Sep2013 and 11Sep2013, respectively.	123
Figure 3.23. A comparison of the 3-hourly-averaged detrended and deseasonalised measured Δ APO (blue circles) and modelled Δ APO (red triangles) for the JC090 cruise (where the Δ notation indicates that the APO values represent the difference from the APO baseline).	127
Figure 3.24. Modelled APO with all three variables changing as shown in Fig. 3.23 (red triangles), modelled APO with only the atmospheric footprint varying (green squares), modelled APO with only the BLH varying (pink diamonds), and modelled APO with only the O ₂ and N ₂ fluxes varying (cyan hexagons).	128
Figure 4.1. Schematic of the Cap San Lorenzo container ship, showing the location of the O ₂ and CO ₂ measurement system on G deck, the Aspirated Air Inlets, and the ship's engine exhaust stack.	139
Figure 4.2. Route of the Cap San Lorenzo from Hamburg to Buenos Aires and back.	140
Figure 4.3. Meridional transects of hourly-averaged atmospheric CO ₂ , δ (O ₂ /N ₂) and APO across the Atlantic Ocean. The equator is represented by the dashed line. Different northwards and southwards crossing are represented by the symbols and colours in the figure legend. Y-axes have been scaled to be visually comparable on a mole per mole basis.	142
Figure 4.4. Meridional transects of hourly-averaged atmospheric CO ₂ , δ (O ₂ /N ₂) and APO across the Atlantic Ocean, with polluted 'port air' data excluded. Y-axes have been scaled to be visually comparable on a mole per mole basis.	143
Figure 4.5. Atlantic equatorial variability in CO ₂ (top panel), δ (O ₂ /N ₂) (middle panel) and APO (bottom panel). Note that the y-axes have been scaled so that the APO and CO ₂ axes are 1.5 times and 2 times zoomed, respectively, compared to the δ (O ₂ /N ₂) axis on a mole per mole basis.	145

- Figure 4.6.** NAME footprint showing the air mass origin on 27Apr2015, as the Cap San Lorenzo was travelling south. The colour scale given is the log of the time-integrated concentration of air particles gs m^{-3} . 146
- Figure 4.7.** NAME footprint on 08Mar2015, showing the air mass origin as the Cap San Lorenzo crosses the ITCZ heading south. The colour scale given is the log of the time-integrated concentration of air particles gs m^{-3} . The footprint demonstrates that the air originates from both the northern and southern hemispheres simultaneously while the ship crosses the ITCZ. The ship's location is indicated by the black circle, and the position of the ITCZ is shown by the horizontal dashed black line. 148
- Figure 4.8.** Hourly-averaged atmospheric CO_2 (circles), $\delta(\text{O}_2/\text{N}_2)$ (squares) and APO (triangles) from two periods (top panel from Sep2014; bottom panel from Feb2015) when the Cap San Lorenzo was travelling between ports in Europe. Data collected when the ship's speed was less than 5 mph are shown in turquoise, bright green and yellow for CO_2 , O_2 , and APO respectively. Both plots are annotated with the names of the ports in which the ship made berth. The y-axes have been scaled to be visually comparable on a mole per mole basis. 149
- Figure 4.9.** HYSPLIT ensemble back trajectories for 08 Oct 2002 (left plot) and 25 Mar 2002 (right plot), consisting of eight 3-hourly trajectories 24 hours in length from Trinidad Head, California. The left plot corresponds to a period exhibiting low APO, and elevated CO_2 and N_2O , which was previously reported by Lueker and colleagues as being an ocean upwelling event, and the right plot corresponds to a period of little short-term variability in either APO, CO_2 or N_2O , which is of oceanic origin. 152
- Figure 4.10.** Short-term variability in N_2O (blue solid line), CFC-12 (green dashed-dotted line) and CFC-11 (red dashed line) from the AGAGE measurements at Trinidad Head. The orange shading indicates the approximate timing of the 'upwelling' events published in Lueker (2004). 153
- Figure 4.11.** Seasonal migration in the position of the ITCZ in the Atlantic Ocean. Positions obtained from the atmospheric CO_2 and O_2 from the Cap San Lorenzo (CSL) are shown in blue, positions obtained from atmospheric CO_2 and CH_4 data by Royal Holloway University of London (RHUL) on board the RRS James Clark Ross are shown in pink and cyan for 2013 and 2014 respectively, and positions obtained from rainfall maxima using NASA's Tropical Rainfall Measuring Mission (TRMM) are shown in red and green for 2014 and 2015 respectively. 155
- Figure 4.12.** Atmospheric CO_2 from the Cap San Lorenzo, binned into 5° latitude bands (black symbols). The curve fits were produced using HPspline (solid blue lines). For each latitude band, 400 ppm is shown by the dashed black horizontal line. 159

- Figure 4.13.** Atmospheric $\delta(\text{O}_2/\text{N}_2)$ from the Cap San Lorenzo, binned into 5° latitude bands (black symbols). The curve fits were produced using HPspline (solid red lines). For each latitude band, -600 per meg is shown by the dashed black horizontal line. 160
- Figure 4.14.** APO from the Cap San Lorenzo, binned into 5° latitude bands (black symbols). The curve fits were produced using HPspline (solid green lines). For each latitude band, -325 per meg is shown by the dashed black horizontal line. 161
- Figure 4.15.** CO_2 (top panel; blue circles and solid lines), $\delta(\text{O}_2/\text{N}_2)$ (bottom panel; red triangles and dashed lines) and APO (bottom panel; green squares and dash-dotted lines) seasonal amplitude as a function of latitude. Error bars show the uncertainty in the seasonal amplitude for each species, which was determined from the mean magnitude of the HPspline curve fit residuals at the seasonal inflexion points. Y-axes have been scaled to be visually comparable on a mole per mole basis. The equator is indicated by the vertical black dashed line. 166
- Figure 4.16.** Timing of the seasonal maxima (open symbols) and minima (filled symbols) in atmospheric CO_2 (top panel; blue circles and solid lines), $\delta(\text{O}_2/\text{N}_2)$ (bottom panel; red triangles and dashed lines) and APO (bottom panel; green squares and dash-dotted lines) as a function of latitude, determined from the detrended HPspline curve fits. The equator is indicated by the vertical black dashed line. 168
- Figure 4.17.** Annual mean latitudinal variability in detrended APO flask (left panel) and continuous (right panel) data from cargo ships crossing the Pacific Ocean, from Tohjima et al. (2015). Different colours correspond to data from different years, as shown in the legend, and the thick dark grey lines indicate the mean from all the years. 171
- Figure 4.18.** Latitudinally-varying annual mean CO_2 (top panel; blue circles), $\delta(\text{O}_2/\text{N}_2)$ (middle panel; red triangles) and APO (bottom panel; green diamonds) from the Cap San Lorenzo. Also shown in the top panel is the meridional variation in global annual mean CO_2 from the NOAA Marine Boundary Layer (MBL) reference product for 2015 (black squares), which was estimated by adding 2 ppm yr^{-1} to the 2014 values, because the 2015 data are not currently available. Error bars represent the mean standard error of the measurements at each latitude (see main text for justification). The vertical dashed line in each panel represents the equator. Note that y-axes for each panel have been scaled to be visually comparable on a mole per mole basis. 173
- Figure 4.19.** Latitudinal variability in annual mean APO calculated using 5° binned APO (green circles; same as in Fig. 5.17), and 2.5° binned APO (blue triangles). Error bars represent the mean standard error of the measurements at each latitude. The vertical dashed line represents the equator. 175

Figure 4.20. Annual mean latitudinal variability in APO from the Cap San Lorenzo measurements, binned into 5° latitude bands (green circles, solid lines) and 2.5° latitude bands (red triangles, dashed lines), as well as the annual mean variability in modelled APO using TM3 and low spatial resolution fluxes (blue diamonds, dotted and dashed lines) and high spatial resolution fluxes (pink squares, dotted lines). The vertical dashed line represents the equator.	176
Figure 4.21. Atlantic Ocean Air-sea O ₂ fluxes from the NEMO-PlankTOM model, binned into 10° latitude bands. The longitudinal range used in the latitudinal binning was 61°W to 20°E. Note that negative numbers indicate fluxes from the ocean to the atmosphere.	178
Figure 4.22. Comparison of annual mean latitudinal variability in Atlantic APO from the Cap San Lorenzo (green circles and solid lines; both panels) with annual mean latitudinal variability in Western Pacific APO from 2003-2012 flask data (pink squares and dashed line; top panel), 2010 only flask data (red triangles and dashed lines; top panel), and 2008-2012 continuous data (dark blue dash-dotted lines on the bottom panel, with uncertainties indicated by the turquoise dash-dotted lines). All western Pacific data are from Yasunori Tohjima (National Institute of Environmental Studies, Japan) and are published in (Tohjima et al., 2015).	179
Figure 4.23. Annual mean air-sea O ₂ flux for 2015 from the NEMO-PlankTOM model. Note that positive values indicate fluxes into the ocean (green to red shading), and negative values indicate fluxes out of the ocean (blue/purple shading). O ₂ fluxes are shown in units of mol m ⁻² s ⁻¹ .	181
Figure 4.24. NCEP2 vertical pressure velocity data (in Pa s ⁻¹) over the North Atlantic along a 22.5°E meridional transect. Note that positive values indicate downwards atmospheric transport, while negative values indicate upwards atmospheric transport.	182
Figure 5.1. Map showing the location of the University of East Anglia (UEA), and also the Tacolneston tall tower (TAC) and Weybourne Atmospheric Observatory (WAO).	196
Figure 5.2. Hourly-averaged atmospheric CO ₂ (top panel), δ(O ₂ /N ₂) (2 nd panel) and APO (3 rd panel) measured from the roof of the Environmental Sciences building at UEA. Note that the y-axes for δ(O ₂ /N ₂) and APO have been scaled to be visually comparable to the CO ₂ y-axis on a mole per mole basis, and 'bad' data caused by technical problems have been excluded prior to averaging. Also shown are 3-hourly model-derived GDAS meteorological data (NOAA): atmospheric temperature (4 th panel: dark red solid line), relative humidity (4 th panel: cyan short-dashed line), atmospheric pressure (4 th panel: pink dotted line), wind direction (bottom panel: dark navy long-dashed line), and wind speed (bottom panel: grey dashed/dotted line).	198

Figure 5.3. O ₂ :CO ₂ ratio of hourly-averaged data measured at UEA during the summer of 2014. $\delta(\text{O}_2/\text{N}_2)$ is given in ppm equivalent units to be comparable to CO ₂ on a mole per mole basis. The solid red line indicates the major axis regression line, which is weighted according to the difference in measurement precision (and therefore uncertainty) associated with the $\delta(\text{O}_2/\text{N}_2)$ and CO ₂ data, and has a slope of -1.1011. The negative value of the O ₂ :CO ₂ ratio indicates that the two species are anti-correlated.	199
Figure 5.4. Hourly-averaged CO ₂ (top panel) and $\delta(\text{O}_2/\text{N}_2)$ (bottom panel) with selected diurnal events coloured according to the O ₂ :CO ₂ ratio (see legend in figure). The y-axes have been scaled so that the $\delta(\text{O}_2/\text{N}_2)$ and CO ₂ panels are visually comparable on a mole per mole basis.	200
Figure 5.5. A polar plot of the variability in 2-minute O ₂ :CO ₂ ratios with wind speed (m s ⁻¹) and wind direction. Meteorological data are from NOAA's GDAS product. The polar plot was created in R using the 'polarPlot' function from the 'Openair' package (Carslaw and Ropkins, 2012).	201
Figure 5.6. Comparison of atmospheric CO ₂ at UEA and TAC (top panel), and comparison of atmospheric CO ₂ and $\delta(\text{O}_2/\text{N}_2)$ at UEA and WAO (middle panel and bottom panel). Y-axes have been scaled so that the $\delta(\text{O}_2/\text{N}_2)$ and CO ₂ panels are visually comparable on a mole per mole basis.	203
Figure 5.7. Comparison of hourly-averaged TAC CO and UEA APO data (top panel) and hourly-averaged WAO CO and APO data (middle panel), illustrating that a lot of the short-term variability in CO and APO is anti-correlated. Also shown is wind direction measured at WAO (bottom panel). The CO measurements at TAC are sampled from the 100 m tower inlet. It should be noted that the TAC CO data shown above are not the finalised, quality controlled data, due to an on-going calibration issue that is affecting the accuracy of the high CO values.	205
Figure 5.8. ffCO ₂ from CO at TAC and APO at UEA (top panel) and ffCO ₂ from CO and APO at WAO (bottom panel). Also shown is ffCO ₂ from ¹⁴ CO ₂ at TAC (top panel, black dots).	208
Figure 5.9. ffCO ₂ calculated from Co at TAC (top panel) and APO at UEA (bottom panel) using the moderately flexible baseline fits used in Fig. 4.8, as well as inflexible baseline fits (dashed pink and orange lines) and flexible baseline fits (dotted-dashed dark purple and dark red lines).	210
Figure 5.10. Moderately flexible, inflexible, and flexible baseline fits to CO from TAC (top panel) and APO from UEA (bottom panel).	211
Figure 5.11. ffCO ₂ (CO) and ffCO ₂ (APO) at TAC and UEA, respectively (top panel), and ffCO ₂ (CO) and ffCO ₂ (APO) at WAO (bottom panel), calculated using time-varying emission ratios and inflexible baselines. Shaded areas denote the respective uncertainties of the calculated ffCO ₂ . ffCO ₂ from ¹⁴ CO ₂ measurements at TAC are denoted by the black circles, of which the size represents the uncertainty of the ffCO ₂ (¹⁴ CO ₂) values.	216

Figure 5.12. ffCO ₂ from APO at UEA (top panel) and CO at TAC (bottom panel) calculated using a variety of emission ratios (see text above and figure legends). The ffCO ₂ from time-varying ratios is the same as the ffCO ₂ shown in Fig. 4.11 (top panel), only without the uncertainty shading, to aid visual comparison with the ffCO ₂ calculated using the other emission ratios. Also shown is ffCO ₂ from TAC ¹⁴ CO ₂ data (black symbols).	219
Figure 5.13. ffCO ₂ (CO) at TAC (top panel) and ffCO ₂ (APO) at UEA (bottom panel) compared to modelled ffCO ₂ from COFFEE (black lines) and the UK NAEI (orange lines).	221
Figure 5.14. WAO ffCO ₂ (CO) (top panel) and ffCO ₂ (APO) (bottom panel) compared to modelled ffCO ₂ from COFFEE (black lines) and the UK NAEI (orange lines).	222
Figure 5.15. Total CO ₂ (blue solid line), biosphere CO ₂ (green dashed line) and ffCO ₂ from APO (red dashed-dotted line) at UEA. Note that left and right y-axes are scaled to be visually comparable.	223
Figure 5.16. Total CO ₂ (blue solid line), biosphere CO ₂ (green dashed line) and ffCO ₂ from APO (red dashed-dotted line) at WAO. Note that left and right y-axes are scaled to be visually comparable.	224

List of Tables

Table 1.1. A record of the historical and current high-precision atmospheric O ₂ data from flask samples, continuous measurements, and campaigns.	16-22
Table 2.1 Shipboard measurement system WSS and TT cylinders. ‘# Fills’ indicates the number of previous fills of the cylinders, and is an indication of how well ‘conditioned’ the cylinder is. Note that D596276 was evacuated between Jan 2015 and Nov 2015, owing to the air inside getting ‘wet’. Evacuating a cylinder effectively removes all conditioning from the cylinder, and re-starts the ‘# Fills’ counter. The upper values in the ‘Dec. O ₂ ’ and ‘Dec. CO ₂ ’ columns refer to the declared values when the cylinders were prepared, while the bottom values refer to the declared values at the end of the cylinder lifetimes. Due to a technical issue with the cylinder filling system, it was not possible to prepare a 4 th WSS in time for January 2016.	66
Table 2.2. Repeatability of O ₂ and CO ₂ analysers of shipboard measurement system, determined from TT analyses. Repeatability is calculated as the mean of the $\pm 1\sigma$ standard deviations from all the TT runs (where a run consists of either 7 two-minute averages or 13 one-minute averages, as mentioned above), and hence is denoted as the mean of these $\pm 1\sigma$ standard deviations, reported to $\pm 1\sigma$ standard deviation, thus demonstrating how the repeatability of the O ₂ and CO ₂ measurements varies over time.	72
Table 2.3. Compatibility of O ₂ and CO ₂ measurements, determined from TT analyses. Compatibility is calculated as the mean difference from the UEA CRAM Laboratory ‘declared value’ of the TT. Note that there is no compatibility entry for the Wolfson Lab period when JT air was pass through the drying system, as unfortunately, it was not possible to measure the JT against the UEA calibration scales. The upper values in the ‘No. of TT runs’ column refer to the CRAM Laboratory declared values when the cylinders were prepared, while the bottom values refer to the declared values at the end of the cylinder lifetimes.	74
Table 2.4. Improvements in short-term precision from reduced V11 switching frequency. Values are means of the $\pm 1\sigma$ standard deviations of the TT and ZT runs, reported with $\pm 1\sigma$ standard deviation, and are in per meg units. The improvement for TT and ZT measurements correspond to a 40% and 60% reduction, respectively.	79
Table 3.1. Sensitivity of O ₂ fluxes calculated using the Jacob (1999) ‘Puff’ model to variations in vertical mixing height, <i>e</i> -folding time, and wind fetch. Note that the O ₂ flux values are in mol m ⁻² yr ⁻¹ , and negative flux values denote air-to-sea fluxes.	124

Table 4.1. Previous O ₂ and CO ₂ measurements from commercial container ships. NDIR refers to non-dispersive infrared, and GC/TCD refers to gas chromatograph equipped with a thermal conductivity detector. Latitude and longitude ranges are approximate. The container ship O ₂ and CO ₂ flask measurements of Battle et al. (2006) were continued on board the 'Ka' imimoana', a US NOAA (National Oceanic and Atmospheric Administration) research vessel, which serviced a series of moorings between 8°N and 8°S in the Pacific, from 2001 - 2007. Cont/Flask indicates continuous and flask sample measurements.	137
Table 4.2. Comparison of Cap San Lorenzo CO ₂ , O ₂ and APO seasonal cycle amplitudes with those from other O ₂ and CO ₂ measurement stations at similar latitudes. Data are either from the literature (please refer to the citations in Table 1.1) or are from personal communication with the measurement station personnel.	170
Table 5.1. Component and total uncertainties for the CO and APO ffCO ₂ quantification methods at TAC, WAO and UEA, given to 2 significant figures for easier comparison.	214
Table 5.2. Typical ffCO ₂ ranges from the literature, shown alongside the ffCO ₂ ranges for TAC, UEA and WAO presented in this work, calculated using CO, APO and ¹⁴ CO ₂ atmospheric data.	218
Table 5.3. Comparison of TAC ffCO ₂ values using the 'top-down' CO method and 'bottom-up' inventories. All units are in ppm. Average values are given ±1σ standard deviation.	222
Table 5.4. Comparison of UEA ffCO ₂ values using the 'top-down' APO method and 'bottom-up' inventories. All units are in ppm. Average values are given ±1σ standard deviation.	222
Table 5.5. Comparison of WAO ffCO ₂ values using the 'top-down' CO and APO methods and 'bottom-up' inventories. All units are in ppm. Average values are given ±1σ standard deviation.	222

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