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by

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(Vancouver)

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Abstract

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Preface

This thesis is original work completed by the author. Guidance was given by the supervisory committee and field assistance was provided by PERSON1, PERSON1, PERSON1, PERSON1, PERSON1, PERSON1, PERSON1, PERSON1, PERSON1, and PERSON1.

The ACTIVITY described in **??** was completed in collaboration with PERSON1 (ROLE/TITLE), PERSON1, and PERSON1.

Photos were provided by PERSON1 andPERSON1.

A version of the work in **??** and **??** has been published as a poster [Last Name, First Initial., Last Name, First Initial., Last Name, First Initial. Title of the Poster]. The author acted as lead investigator, composing and presenting the poster at the CONFERENCE NAME YYYY, CITY, STATE/COUNTRY.

A version of the work in **??** and **??** has been published as a TALK [Last Name, First Initial., Last Name, First Initial., Last Name, First Initial. Title of the Poster]. The author acted as lead investigator, composing and presenting the TALK at the CONFERENCE NAME YYYY, CITY, STATE/COUNTRY.

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Acronyms

List of Symbols and Acronyms

Symbol	Definition	Units
b_a	factor for converting m^{-2} to ha^{-1}	i.e. $b_a = 10^4\,m^2\,ha^{-1}$
b_m	factor for converting g to kg	i.e. $b_m = 10^{-3}\,kg\,g^{-1}$
b_o	factor for converting μmol to mol	i.e. $b_m = 10^{-6}\,\mu mol\,mol^{-1}$
b_t	factor for converting s^{-1} to hr^{-1}	i.e. $b_t = 3600\,s\,hr^{-1}$
C	Rate of combustion	$\mu mol\,m^{-2}\,s^{-1}$
C_{air}	heat capacity of air	J kg^{-1} m^{-3}
c	molar concentration of CO_2	µmol m^{-3}
c_{tower}	c at the height of the climate tower (24 m)	µmol m^{-3}
c_{mobile}	c at screen level height (2 m)	µmol m^{-3}
EC	eddy covariance	
F_c	the mass flux of CO_2 for a given area and time	$kg\,CO_2\,ha^{-1}\,hr^{-1}$
GHG	greenhouse gas	

GIS	geographic information systems	
H	sensible heat flux	$\mathrm{W\,m^{-2}}$
HVAC	heating hentilation and air conditioning	
IRGA	infrared gas analyzer	
LCZ	local climate zone	
LIDAR	light detection and ranging	
M_a	molecular mass of dry air	28.97 g $\mathrm{mol^{-1}}$
M_c	molecular mass of CO_2	44.01 g $\mathrm{mol^{--1}}$
OSM	OpenStreetMap	
P	Rate of photosytnesis	$\mathrm{\mu mol\,m^{-2}\,s^{-1}}$
PDT	Pacific Daylight Savings Time	
PST	Pacific Standard Time	
R	Rate of respiration	$\mathrm{\mu mol\,m^{-2}\,s^{-1}}$
r	the molar density of CO_2; mole of a CO_2 per mole dry air or " molar mixing ratio"	μmol $\mathrm{m^{-1}}$ or ppm
RSL	roughness sublayer	
r_{aC}	aerodynamic resistance of CO_2	$\mathrm{s\,m^{-1}}$
r_{aH}	aerodynamic resistance of sensible heat	$\mathrm{s\,m^{-1}}$

S_c	volumetric source or sink strength, describes the mass of CO_2 emitted per volume and time - the c that is injected or removed; normalized per ground area in this study	$\mu mol\,m^{-3}\,s^{-1}$
T_0	surface temperature (0 m)	$^\circ C$
T_{mobile}	temperature at the height of the mobile sensors (2 m)	$^\circ C$
T_{tower}	temperature at the height of the climate tower (24 m)	$^\circ C$
t	time	s
u	horizontal wind speed in West-East direction	$m\,s^{-1}$
UBL	urban boundary layer	
UCL	urban canopy layer	
v	horizontal wind speed in South-North direction	$m\,s^{-1}$
w	vertical wind speed	$m\,s^{-1}$
$\overline{w'c'}$	molar flux	$\mu mol\,m^{-2}\,s^{-1}$
x	horizontal distance (Easting)	m
y	horizontal distance (Northing)	m
z	vertical distance (Northing)	m
ρ_a	(dry) air density	$g\ m^{-3}$
ρCO_2	mass density of CO_2	$g\,CO_2\,m^{-3}$

θ	potential air temperature	K
$\overline{\cdots}$	average over a given time	
$'$	indicates a turblent deviation from the average	

Acknowledgments

Make sure to thank your friends, family, people who helped you along the way, funding agencies, etc.

Chapter 1

hello

Lamport [4]

Bringhurst [1]

Crawford et al. [3]

Lietzke [5]

Alex wrote a paper that says he's got big muscles 2

Cam wrote a paper that says Deirdre can eat 10 pies [6]

Chapter 2

Introduction

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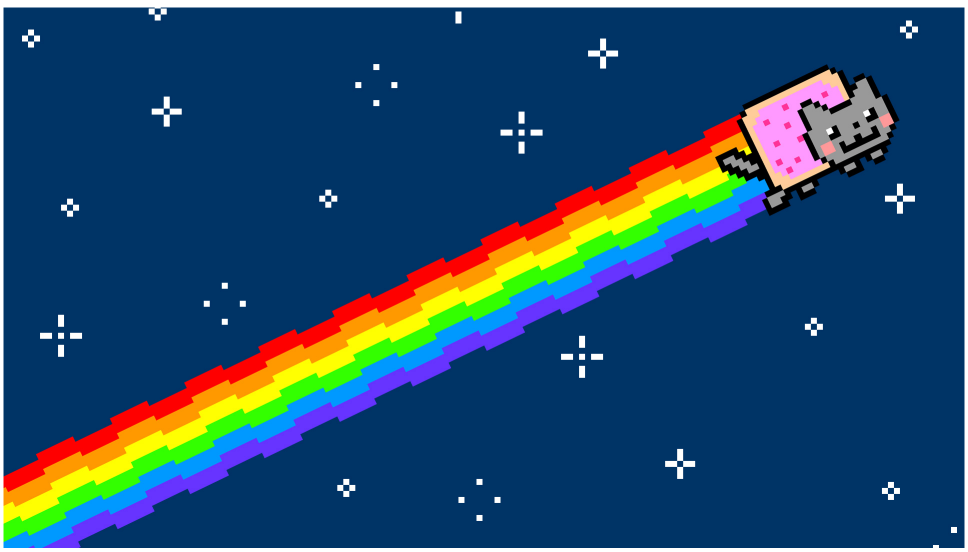

Figure 2.1: Insert figure caption here.

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2.1 State of the Art

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2.1.1 This is a subsection

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Table 2.1: Relevant scales and monitoring methods in urban settings. Adapted from []

Scale (Systems studies)	Spatial Dimension	Atmospheric Layer Studied	Temporal Resolution	Common Measurement Approaches
Micro-scale (buildings, roads, industry, greenspace)	1-100 m	urban canopy layer, roughness sublayer	One-time measurements at specific locations or along transects, in some cases long-term observations (5 min to years).	Traverse and vertical profile measurements in canyons, ecophysiological measurements using closed-chambers (vegetation, soils).
Local-scale (neighborhoods, land-use zones)	100 - 10 km	internal sublayer	Continuous measurements that resovle diurnal and seasonal dynamics (30 min to years).	Direct eddy-covariance flux measurements on towers above the city.
Meso-scale (cities, urban regions)	10 - 100 km	urban boundary layer	Short-term campaigns or continuous measurements at selected sites that resolve day-today variations and seasonal differences.	Boundary-layer budgets, upwind-downwind mixing ratio differences, regional inverse modelling, isotopic ratios.

2.1.2 This is a subsection

This is a sub subsection

Objectives

In order to address the research question, five major objectives were outlined and developed:

1. Sensor Development: Develop and test a compact, mobile, and multi-modal CO_2 sensor for bikes and cars.
2. Measurement Campaign: Deploy the sensors in a targeted measurement campaign.
3. Physical Concept: Develop a methodology to calculate emissions from measurements of CO_2 mixing ratios using knowledge about atmospheric conditions.
4. Analysis and Evaluation: Compare the mixing ratio measurements and measured emissions to traffic and building emissions inventories.

Chapter 3

Methods

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Chapter 4

Results

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Chapter 5

Conclusion

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Chapter 6

Conclusion

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Appendix A

Supporting Materials

This would be any supporting material not central to the dissertation. For example:

- additional details of methodology and/or data;
- diagrams of specialized equipment developed.;
- copies of questionnaires and survey instruments.