GEOG 321 | Climatic Environments

Topic outline

- Introduction to the course
- Meet your teaching team, introduce yourself and meet your peers
- What does this course cover?
- How do I make effective use of the course website and myCourses? How is GEOG 321 evaluated? How are course components integrated?
- Applications

Fog in the Lower Fraser Valley (Photo: A. Christen)

Welcome to GEOG 321

Instructor

Dr. Sara Knox
Assistant Professor
Department of Geography
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Weekly office hours

BH 619 or Virtual (Zoom – please contact me ahead of time if you're planning on attending via Zoom)
Mondays 1:00-2:00 pm (or by appointment)

Dr. Sara Knox

- Born and raised in Montreal!
- B.Sc. McGill University (ESS)
- Ph.D. University of California, Berkeley
- Professor at UBC Jan 2019-June 2023
- Professor at McGill since July 2023
- Environmental scientist studying land-based solutions to climate change

Meet your TAs

Steffy Velosa
PhD student
Department of Geography

Hugo Baraer
MSc student
Department of Geography

Office hours will be posted on the website shortly

Introduce yourself – in small groups & as a class

Introduce yourself:

- Name
- Major
- Your favorite spot in Montreal

What is GEOG 321 about?

GEOS 300 is an introduction to micrometeorology and land-atmosphere interactions. The course covers the nature of atmospheric processes **at and close to the Earth's surface** on **small scales**, extending in space from those of a leaf up to that of a large valley.

Measuring CO_2-exchange of a pine shoot.

Measuring wetland trace gas exchange.

Clouds and circulation patterns in a deep mountain valley.

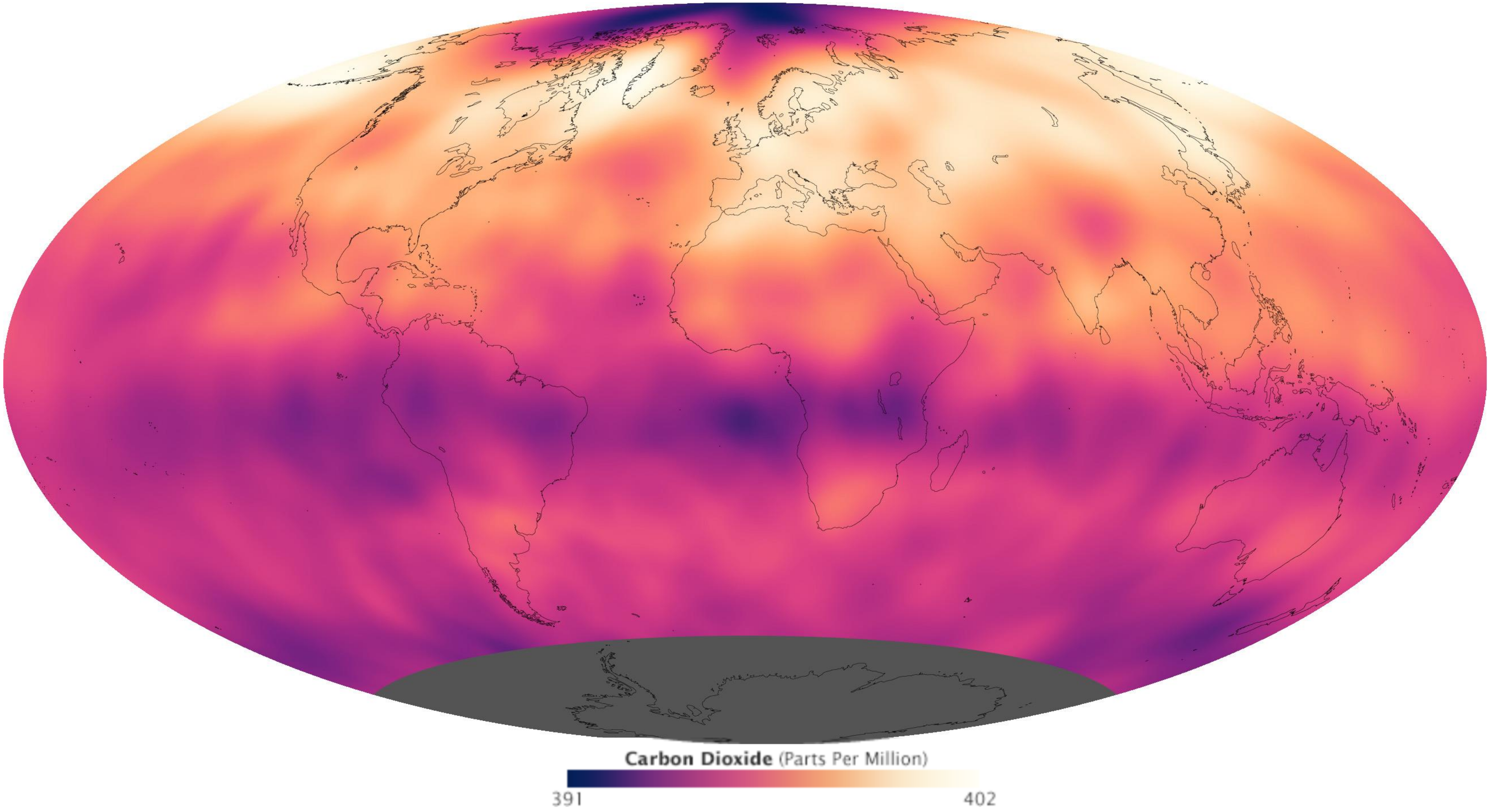
Photos: S. Knox, A. Christen


Photo: A. Christen
~ 1 cm - 1 m

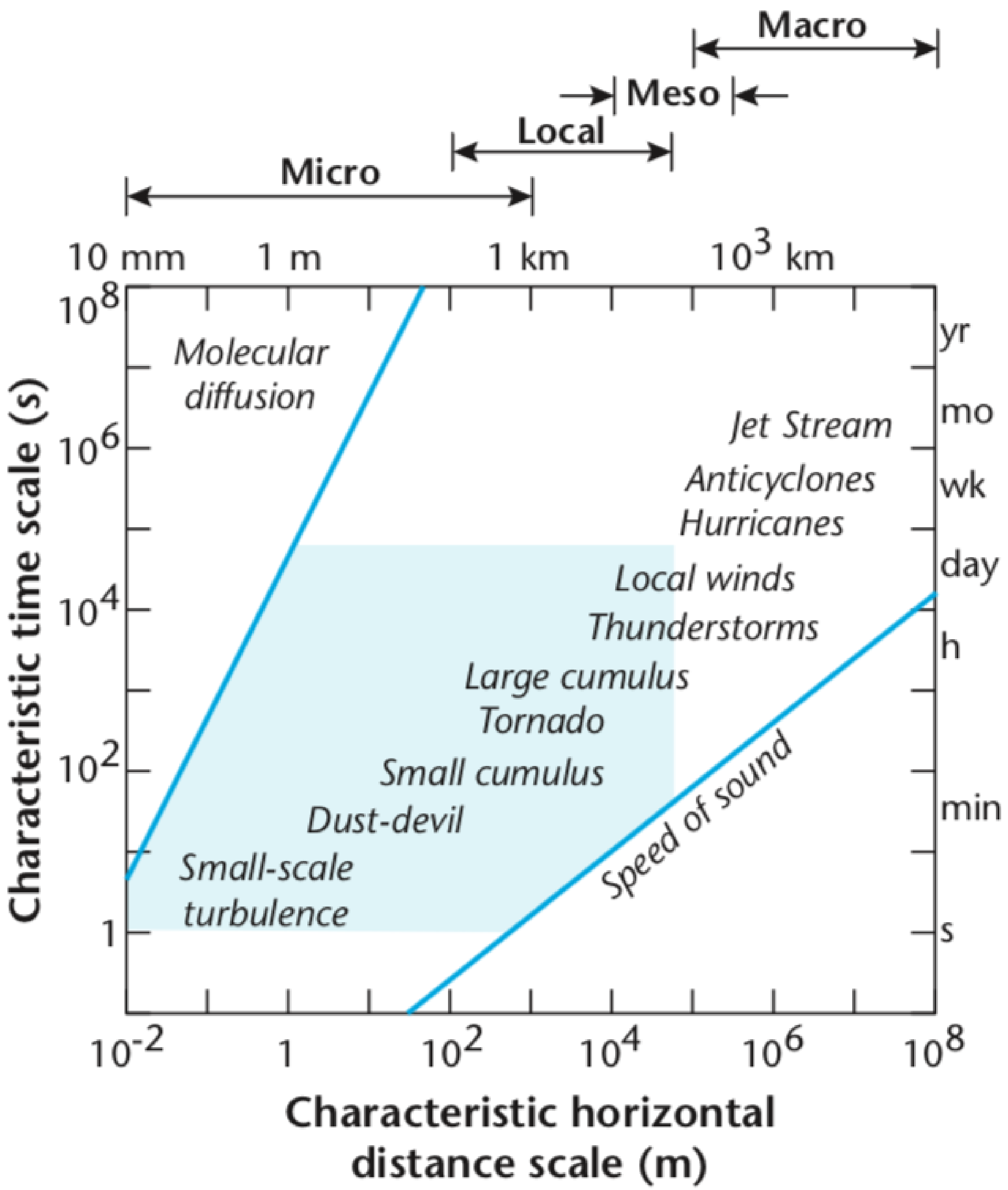

~ 1 m - 100 m
Photo: S. Dengel


~ 100 m - 10 km
Photo: A. Christen

Global scale implications



Atmospheric time and space scales



GEOG 321

Atmospheric time and space scales

Micro-scale	10^{-2} to 10^{3} m
Local scale	10^{2} to 5×10^{4} m
Meso-scale	10^{4} to 2×10^{5} m
Macro-scale	10^{5} to 10^{8} m


Micro-scale


Meso-scale


Macro-scale

Table: T. R. Oke (1987): 'Boundary Layer Climates' 2nd Edition, Photos: CSIRO (left), Australian Bureau of Meteorology (center), NASA (right)

Micrometeorology vs. microclimatology

Microscale **Weather**

Micrometeorology focuses on **short-term fluctuations** of atmospheric variables (up to one hour) and the detailed physical processes (e.g. turbulence) that drive exchange at small scales.

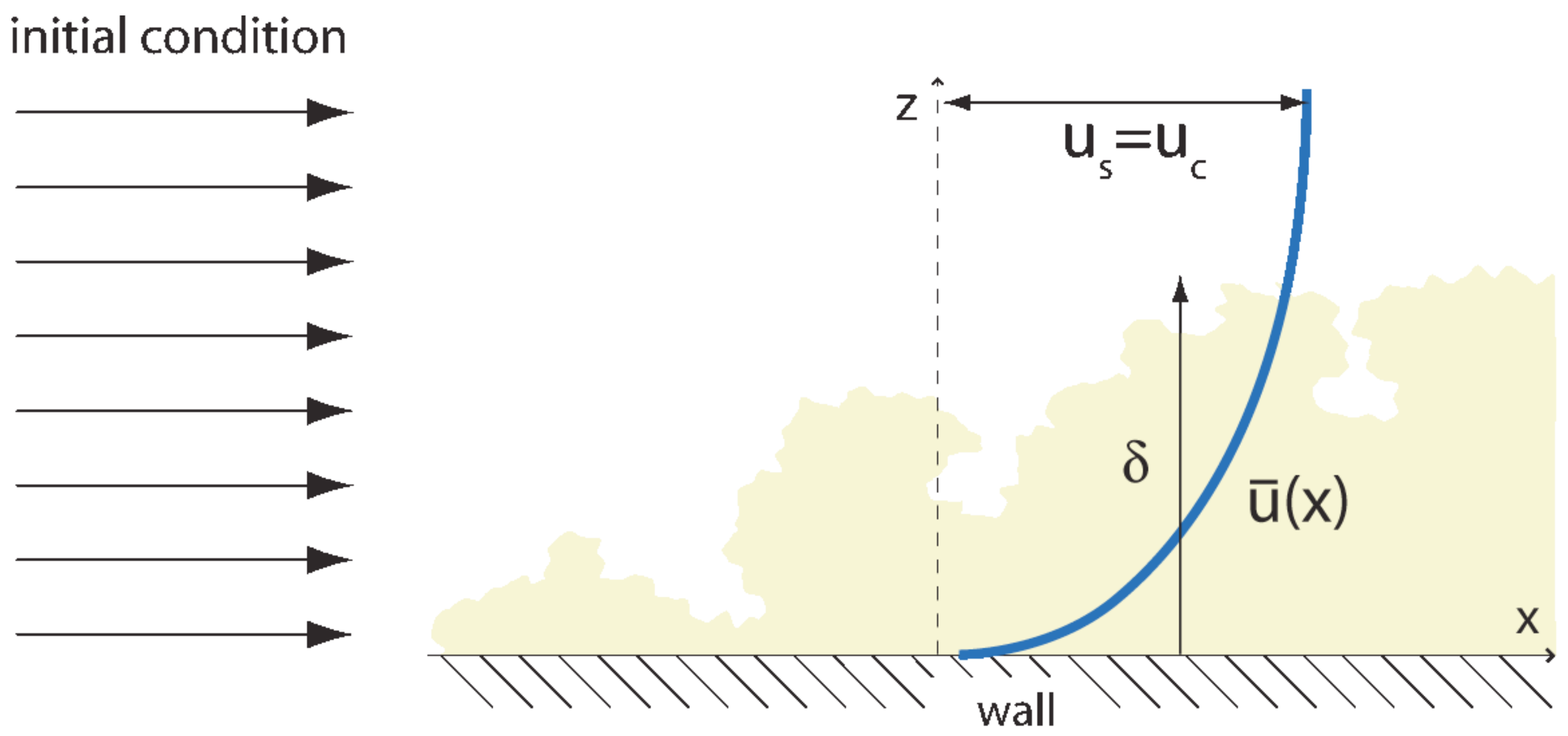
Microscale **Climate**

Microclimatology deals with **long-term integral effects** (from hours to decades) namely, the average and variability of specific climates near the surface with respect to different geographic settings.

UBC experiences specific micro-scale weather effects causing its distinctly different climate than the city further east - here fog patches in winter (Photo: A. Christen)

Boundary layers

In a fluid, a boundary layer refers to the region immediately above a material surface (usually solid) where the flow is **significantly influenced by the surface**'s energy and mass exchange and surface friction.



What is a boundary layer?

The presence of a solid surface causes flow to be slowed, sometimes associated with turbulent motions.

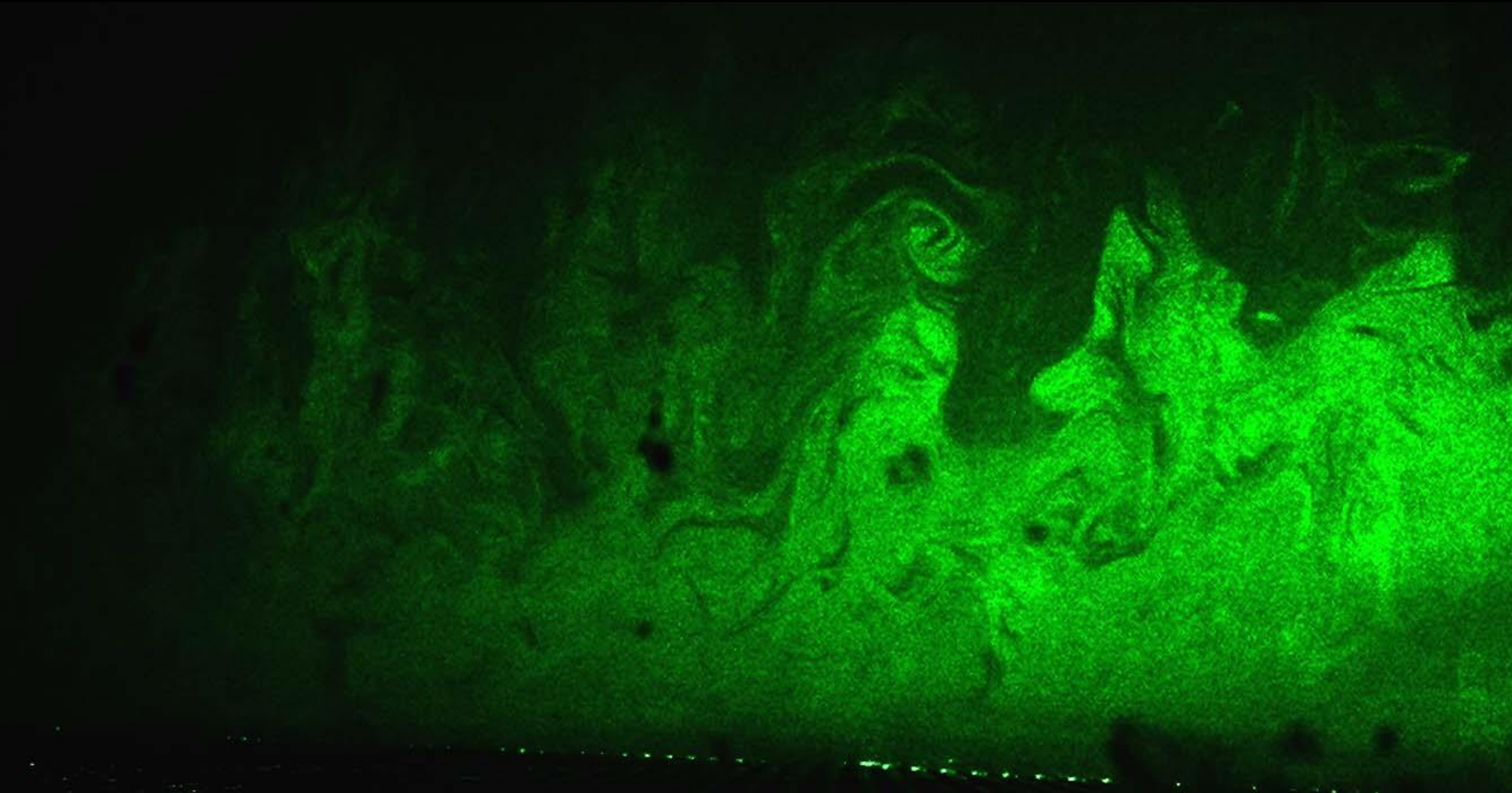
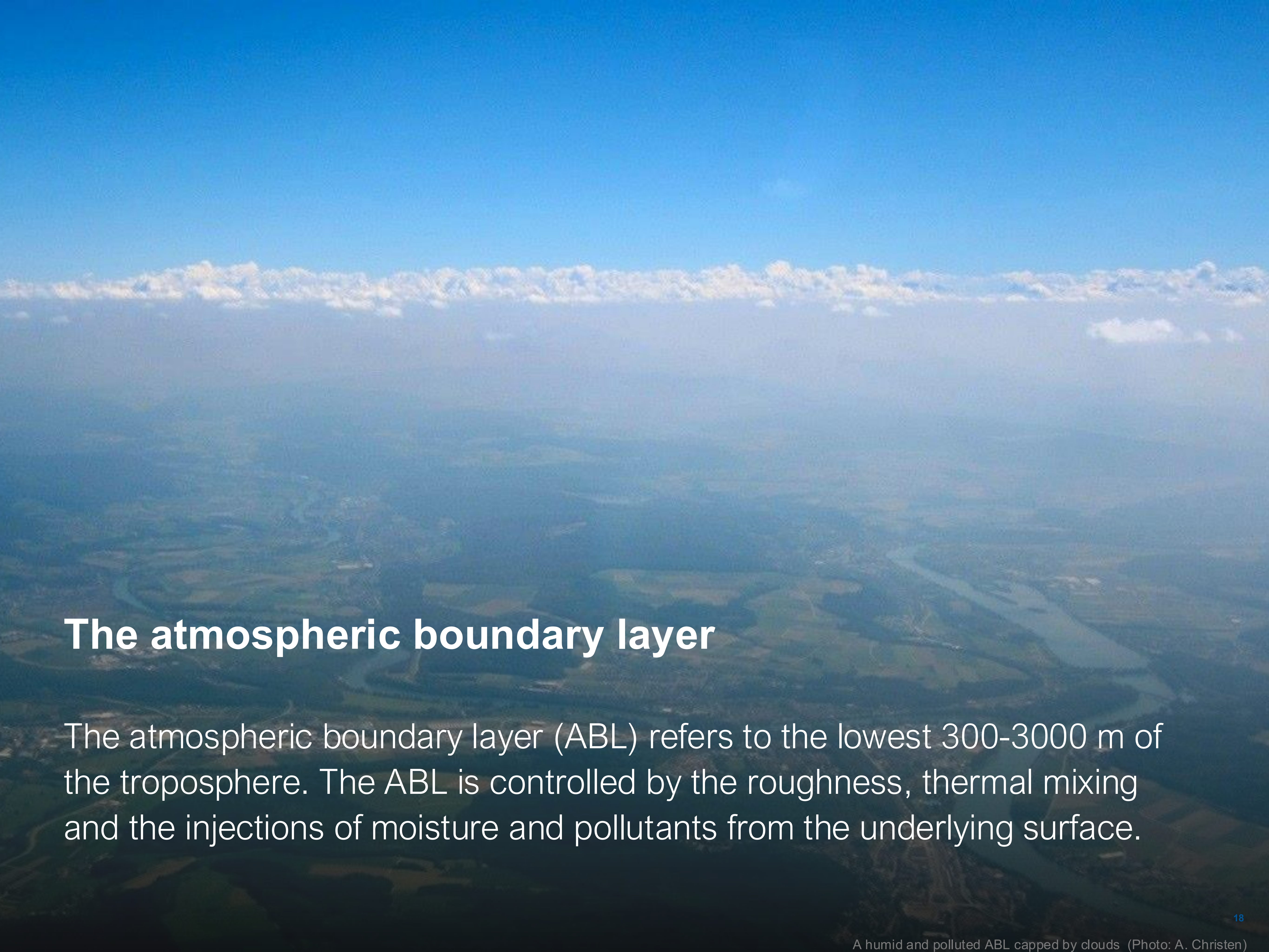


Photo: Visualisation of a boundary layer in a wind tunnel (M. A. Carper, Saint Anthony Falls Laboratory, University of Minnesota)



The atmospheric boundary layer

The atmospheric boundary layer (ABL) refers to the lowest 300-3000 m of the troposphere. The ABL is controlled by the roughness, thermal mixing and the injections of moisture and pollutants from the underlying surface.

A humid and polluted ABL capped by clouds (Photo: A. Christen)

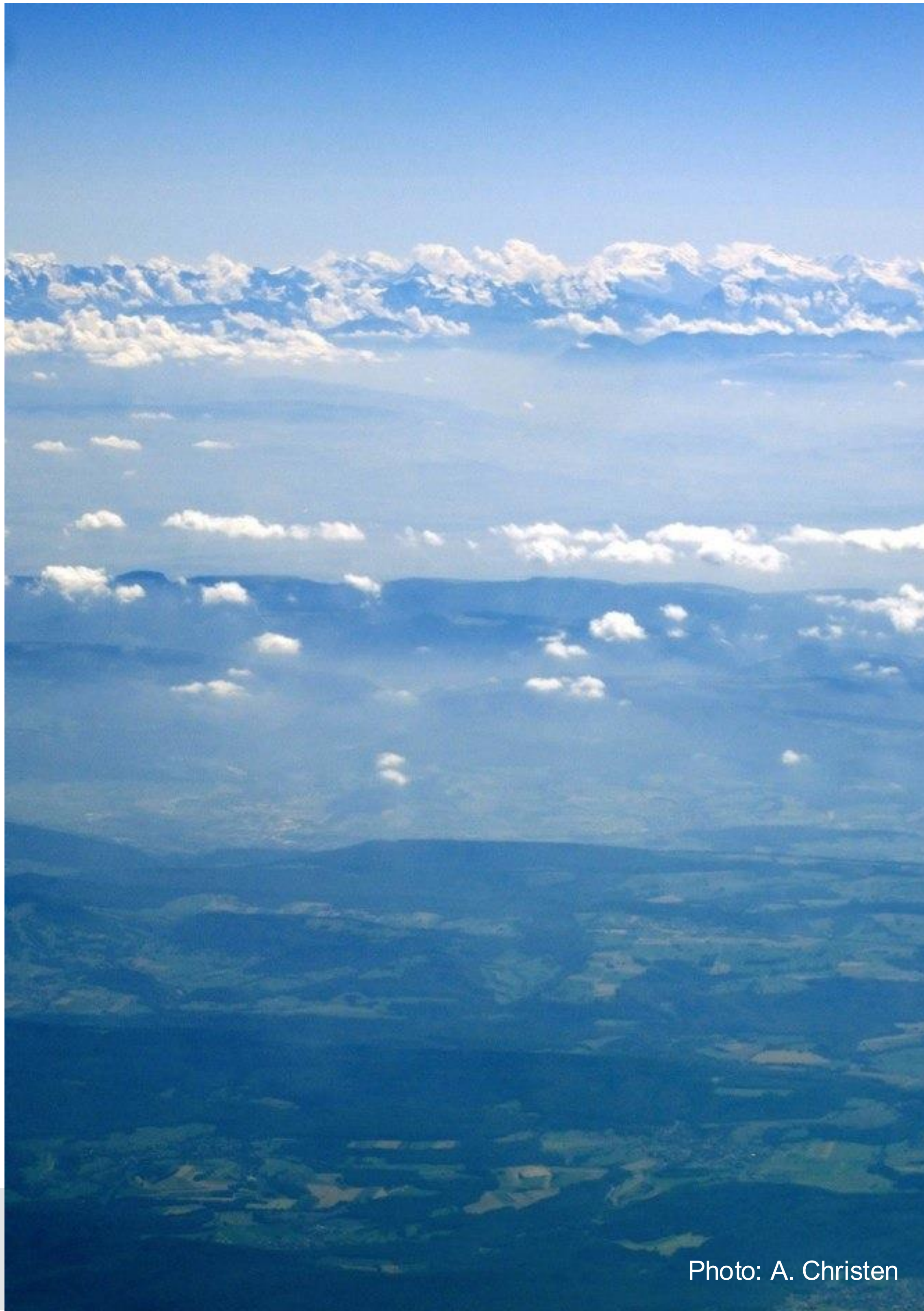

Free atmosphere
ABL depth
z_i
The ABL over Vancouver (Photo: A. Christen)

The atmospheric boundary layer

The ABL reacts **within several hours** (< 1 day) to changes at the surface.

Therefore we measure a diurnal cycle of temperature, humidity, wind and air pollutants in the ABL.

GEOB 321 deals with the weather and climate in the ABL and the inherent linkage to the land surface



Course Learning Goals

1. Explain how the **surface radiation** and **energy budget** affects the surface climate.
2. Describe important **surface characteristics** that affect surface radiation and energy budget and surface microclimates.
3. Understand the **basics of turbulence, dispersion and local wind systems** in the atmospheric boundary layer and how they are controlled by surface processes.

Course Learning Goals (continued)

4. Provide examples of key physical, biological and chemical processes that **control trace gas, water and energy fluxes between the land surface and the atmosphere**.
5. Provide examples of how surface-atmosphere interactions **respond to environmental change**, and how this can create climate **feedbacks**.
6. Know the principles of **basic instrumentation, methods and data-analysis** (including the use of the **R programming language**) used for today's monitoring and modelling of weather and climate in the atmospheric boundary layer.

Course Learning Goals (continued)

7. **Analyze** and **interpret data** from measurement systems that are used to monitor near-surface climate and surface radiation and energy balances.
8. Explain how the principles of micrometeorology have **practical application** to society.

Structure of topics covered

Energy balance

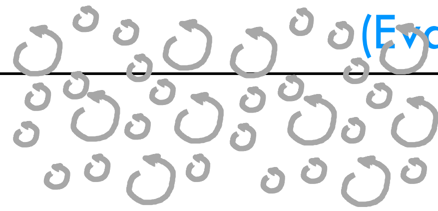
Precipitation

=

Net CO_2 flux

=

Net radiation = Sensible heat + Latent heat (Evaporation) + Soil heat + Photosynthesis



=

Short-wave irradiance

-

Short-wave reflectance

+

Long-wave irradiance

-

Long-wave emittance and reflectance

+

Runoff

+

Drainage

+

Water storage

-

Respiration

Radiation budget

Water balance

Carbon balance

Course website - https://geog321.github.io/

Climatic Environments | Syllabus | Topics Summary | Study Questions | Assignments | R Resources | Exam FAQs

Syllabus

Syllabus

GEOG 321: Winter 2025

How do feedbacks between ecosystems and the atmosphere influence microclimates and the global climate system? In this course we'll focus on the interactions between the surface, vegetation and atmosphere, and the physical processes governing the transfer of heat, mass and momentum. Through this course you'll also be exposed to the basic instrumentation and methods used in today's monitoring and modeling of microscale climate and surface-atmosphere exchange. While this course examines the behaviour of the atmosphere close to the surface, what we cover in this class implications for processes occurring at the scale of a single leaf to the entire planet!

On this page

Make sure to check the website regularly!

Course evaluation

Self-study questions	4%
Participation	4%
Written assignments (4)	42%
Mid-term exam	20%
Final exam	30%

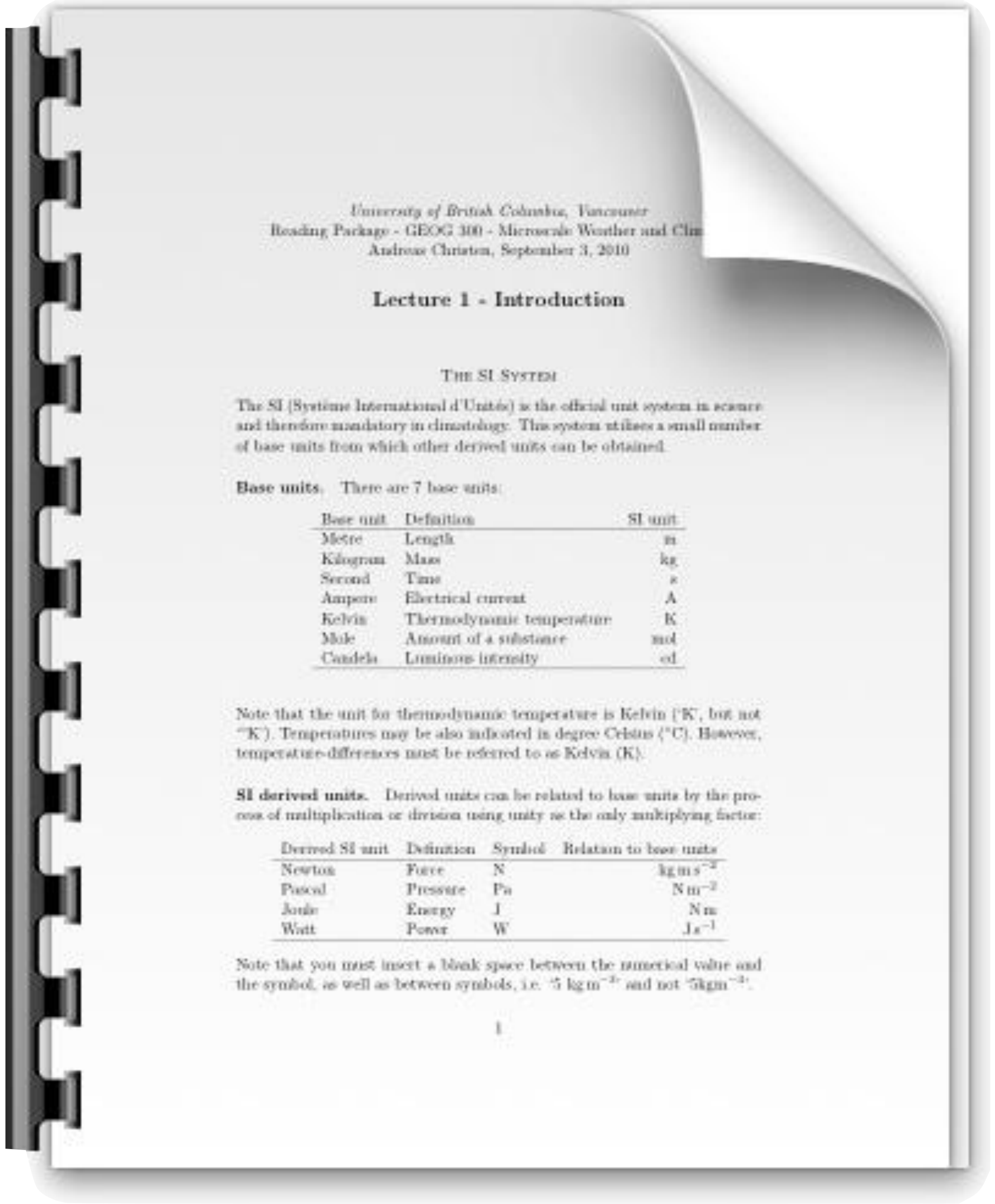
Mid-term exam is on **Feb 25**, 2026 (see **Course Schedule on Website**)

The **final exam** will be in the **scheduled exam period**. It is your responsibility to be available on both dates.

Readings

There are readings **posted on Canvas**.

They consist of draft chapters from an upcoming 3rd Edition of '*Boundary Layer Climates*' by T. R. Oke and A. Christen and a few other sources.



University of British Columbia, Vancouver
Reading Package - GEOG 300 - Microscale Weather and Clim
Andreas Christen, September 3, 2010

Lecture 1 - Introduction

THE SI SYSTEM

The SI (Système International d'Unités) is the official unit system in science and therefore mandatory in climatology. This system utilises a small number of base units from which other derived units can be obtained.

Base units. There are 7 base units:

Base unit	Definition	SI unit
Metre	Length	m
Kilogram	Mass	kg
Second	Time	s
Ampere	Electrical current	A
Kelvin	Thermodynamic temperature	K
Mole	Amount of a substance	mol
Candela	Luminous intensity	cd

Note that the unit for thermodynamic temperature is Kelvin ('K', but not '°K'). Temperatures may be also indicated in degree Celsius (°C). However, temperature-differences must be referred to as Kelvin (K).

SI derived units. Derived units can be related to base units by the process of multiplication or division using unity as the only multiplying factor:

Derived SI unit	Definition	Symbol	Relation to base units
Newton	Force	N	$\mathrm{kg\,m\,s^{-2}}$
Pascal	Pressure	Pa	$\mathrm{N\,m^{-2}}$
Joule	Energy	J	$\mathrm{N\,m}$
Watt	Power	W	$\mathrm{J\,s^{-1}}$

Note that you must insert a blank space between the numerical value and the symbol, as well as between symbols, i.e. '5 $\mathrm{kg\,m^{-3}}$' and not '5$\mathrm{kgm^{-3}}$'.

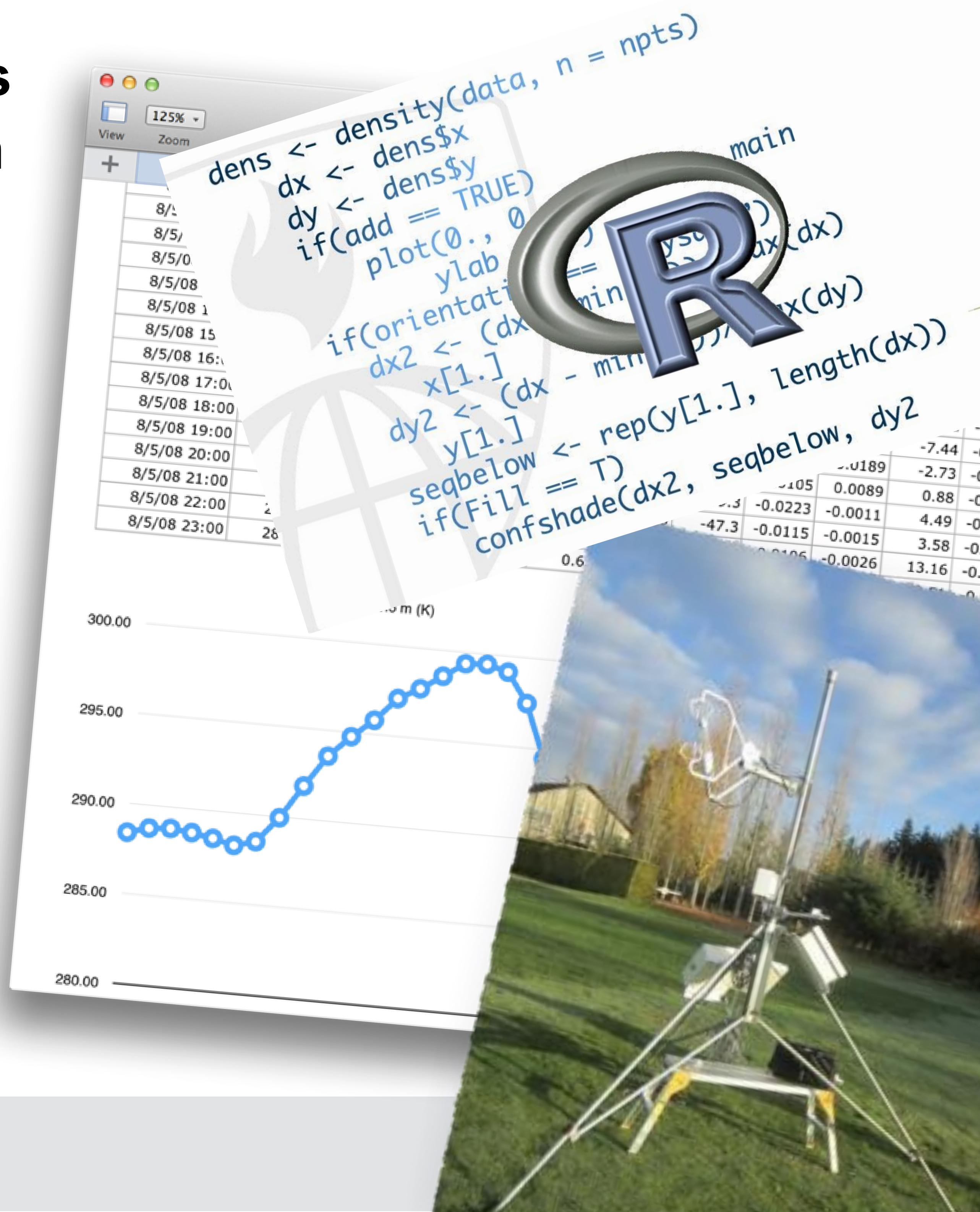
1

Study questions and assignments

Many lectures have **self-study questions <u>with answer keys</u>**. Please solve those on a regular basis after each lecture & submit them to myCourses for points.

There are a total of 3 **numeric assignments***. Collaboration on homework is encouraged. However, **write-ups must be done independently**. Note that you are not required to use R for assignments, however, it is encouraged.

*Assignments will be available on the website



Assignments

A1 **Feb 16, 2026** - **Radiation** instrumentation. Each student visualize and analyze a different dataset of radiometer measurements from a climate station. Predict and model **heat transfer in soils** using measurements of soil climates.

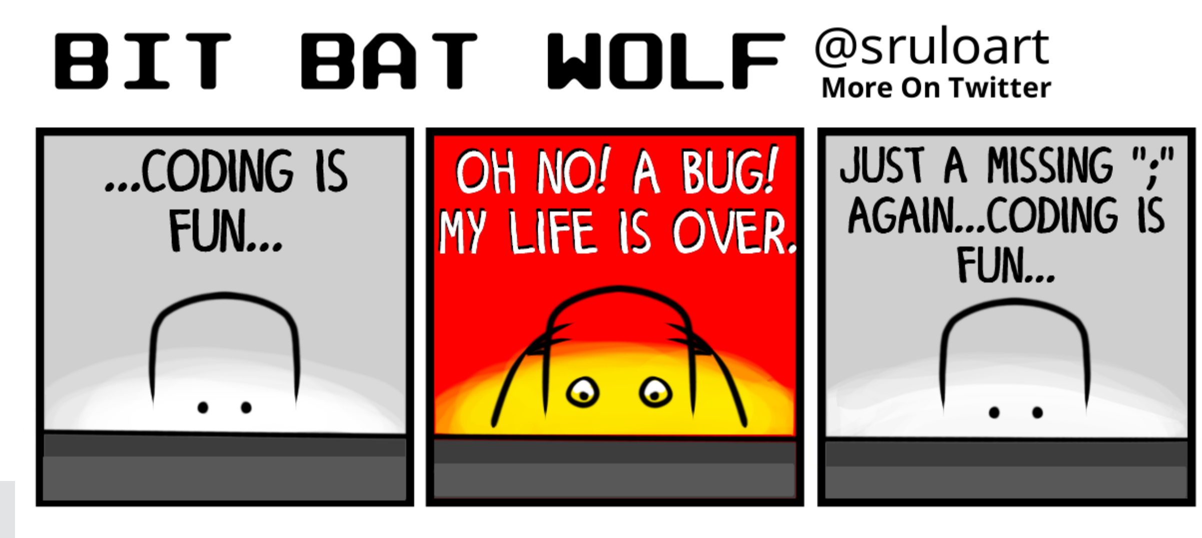
A2 **Mar 25, 2026 –** Determine whether **wind measurements** at different heights above a flat surface fit the theoretical equations.

A3 **Apr 13, 2026 –** hands on instrumentation to measure **land-atmosphere exchange of trace gases and energy** relevant for global climate change (Lab visit on Mar 23, 2026).

A note on programming and R

Should a humanities major learn to code?

Can a humanities student learn coding? Absolutely. Coding is not strictly for STEM students – it can benefit you no matter your degree.



How I can support you in learning to code

- Lots of examples!
- Demos & tutorials in class
- Resources on Website
- Office hours
- TA office hours
- Peer learning

Are you interested in using R (a programming language) in this course?

Join at:
vevox.app

ID:
433-971-976

Questions about the Syllabus/Course?

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vevox.app

ID:
433-971-976

Applications

- Global climate change
- Food and water resources
- Air pollution and industry
- Clean energy

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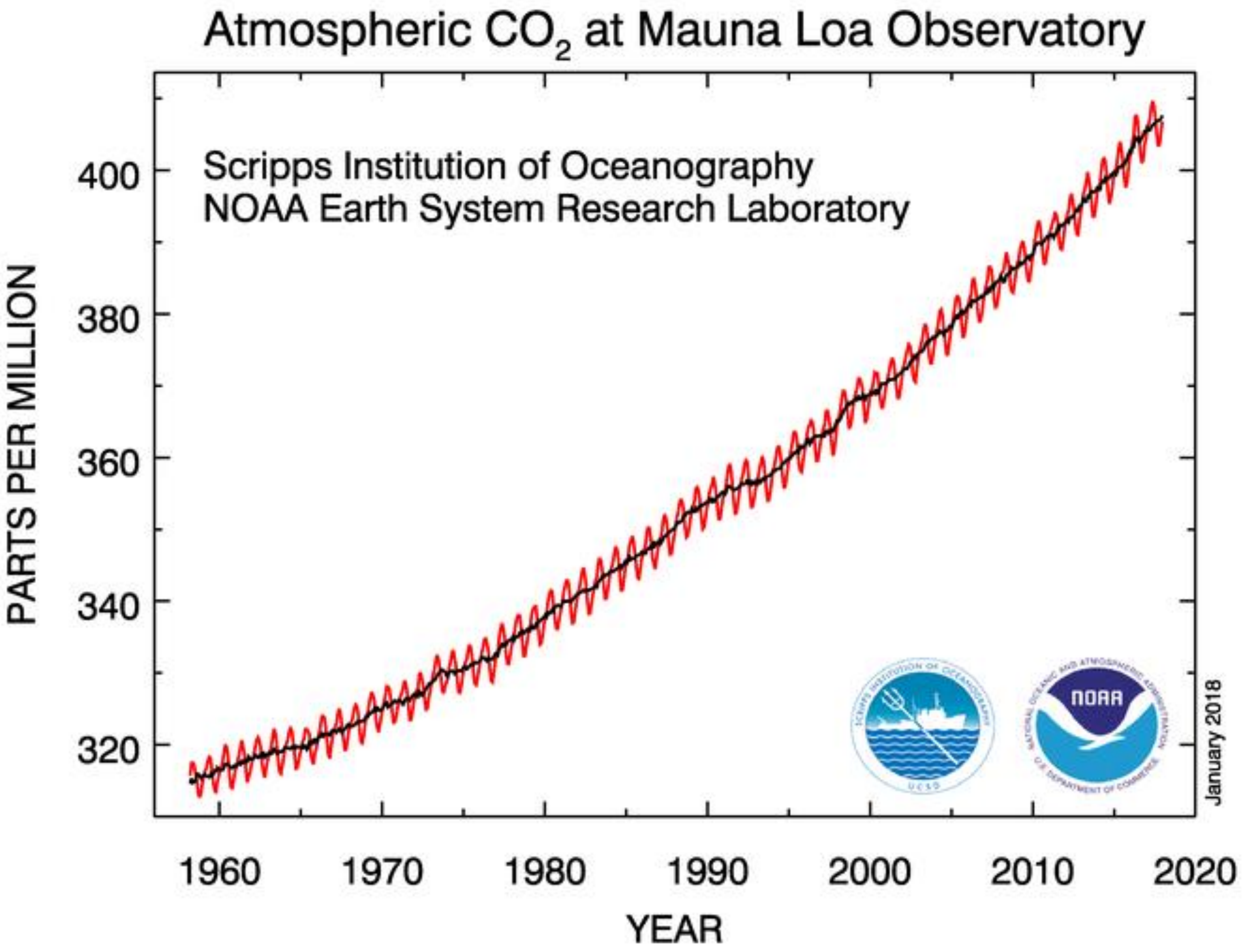
Rising CO_2 concentrations



Terrestrial ecosystems are key components of the global carbon cycle

Sources

34.4 $GtCO_2/yr$

88%

12%

4.8 $GtCO_2/yr$

Sinks

17.2 $GtCO_2/yr$

46%

24%

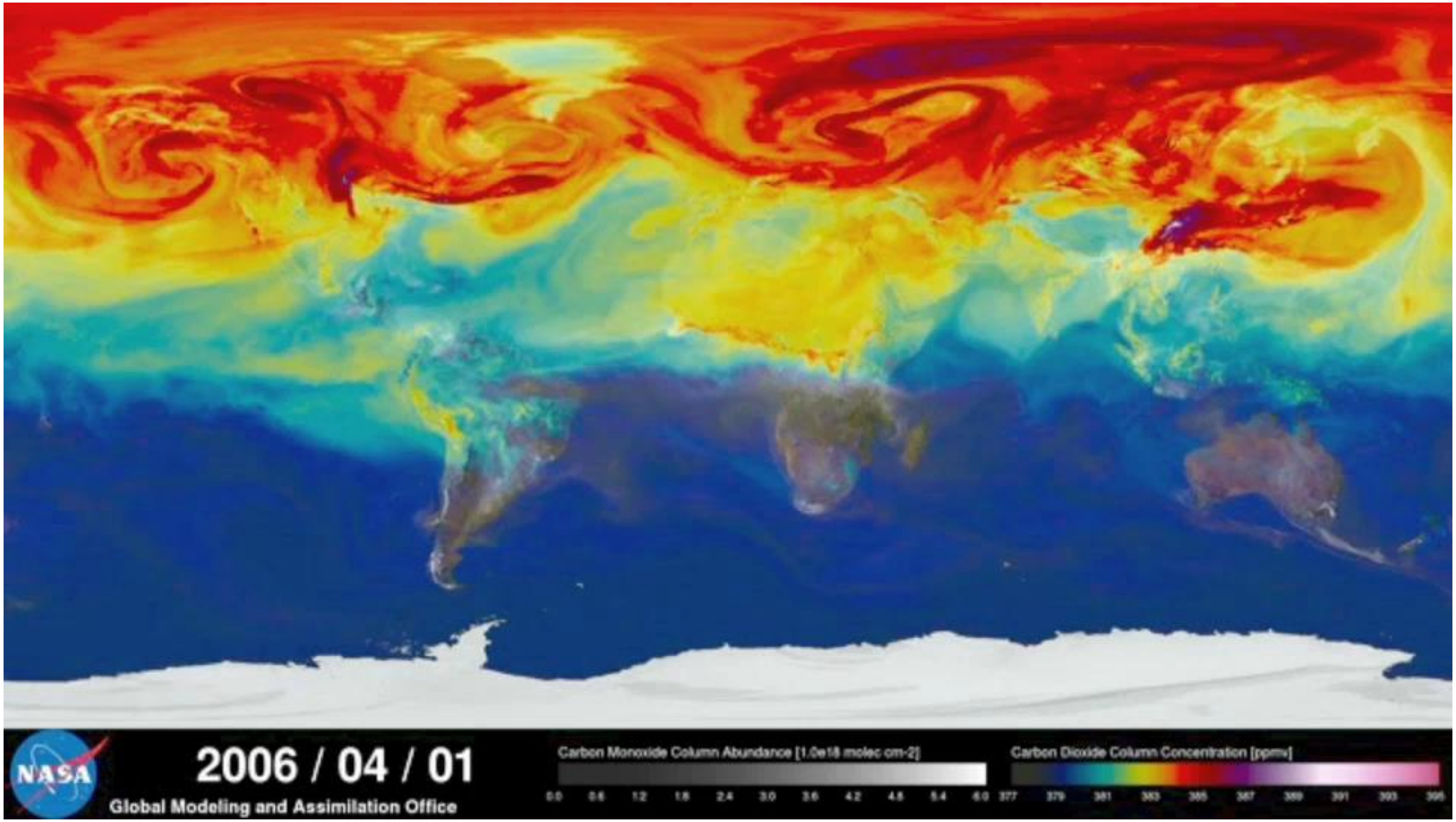
8.8 $GtCO_2/yr$

30%

11.0 $GtCO_2/yr$

GLOBAL CARBON project

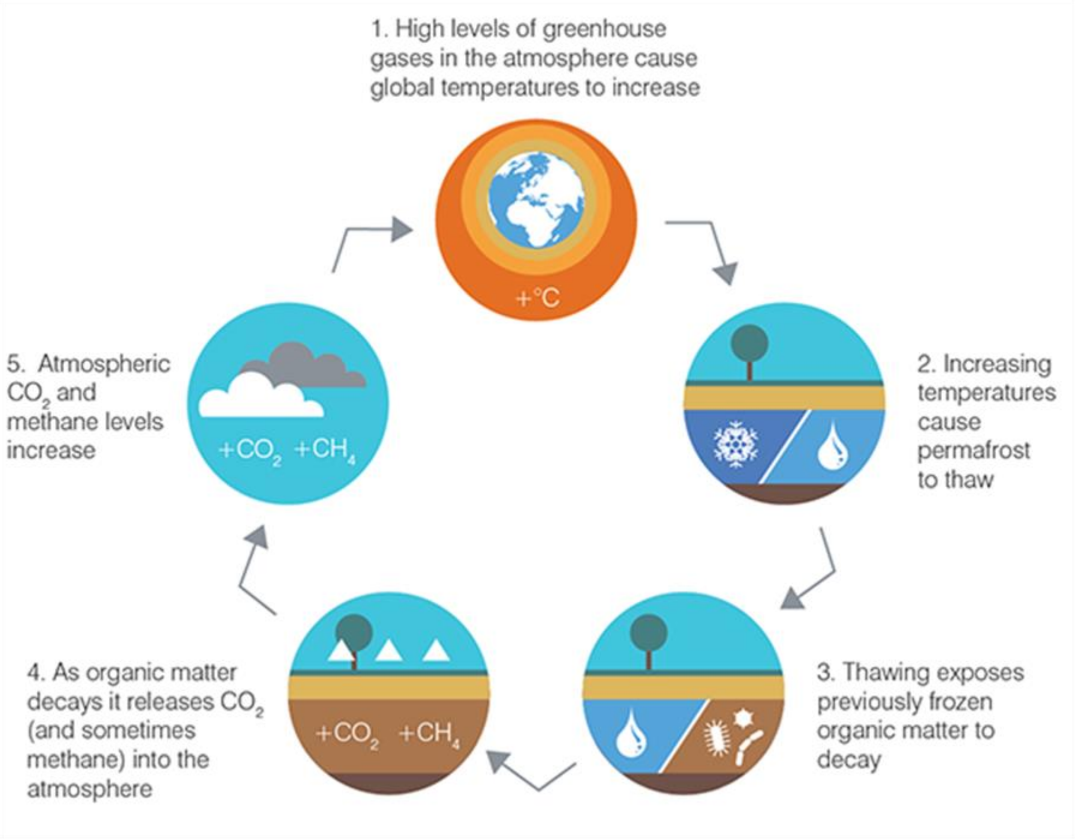
The breathing of the biosphere



Applications - Global climate change

Knowledge on micrometeorology and climatology helps to…

- Determine **greenhouse-gas** emissions and uptake between the land surface and the atmosphere.
- Study **climate-surface feedbacks** (e.g. due to thawing permafrost).
- Determine the melt rate and mass balance of **ice-sheets and glaciers**.



Applications

- Global climate change
- Food and water resources
- Air pollution and industry
- Clean energy

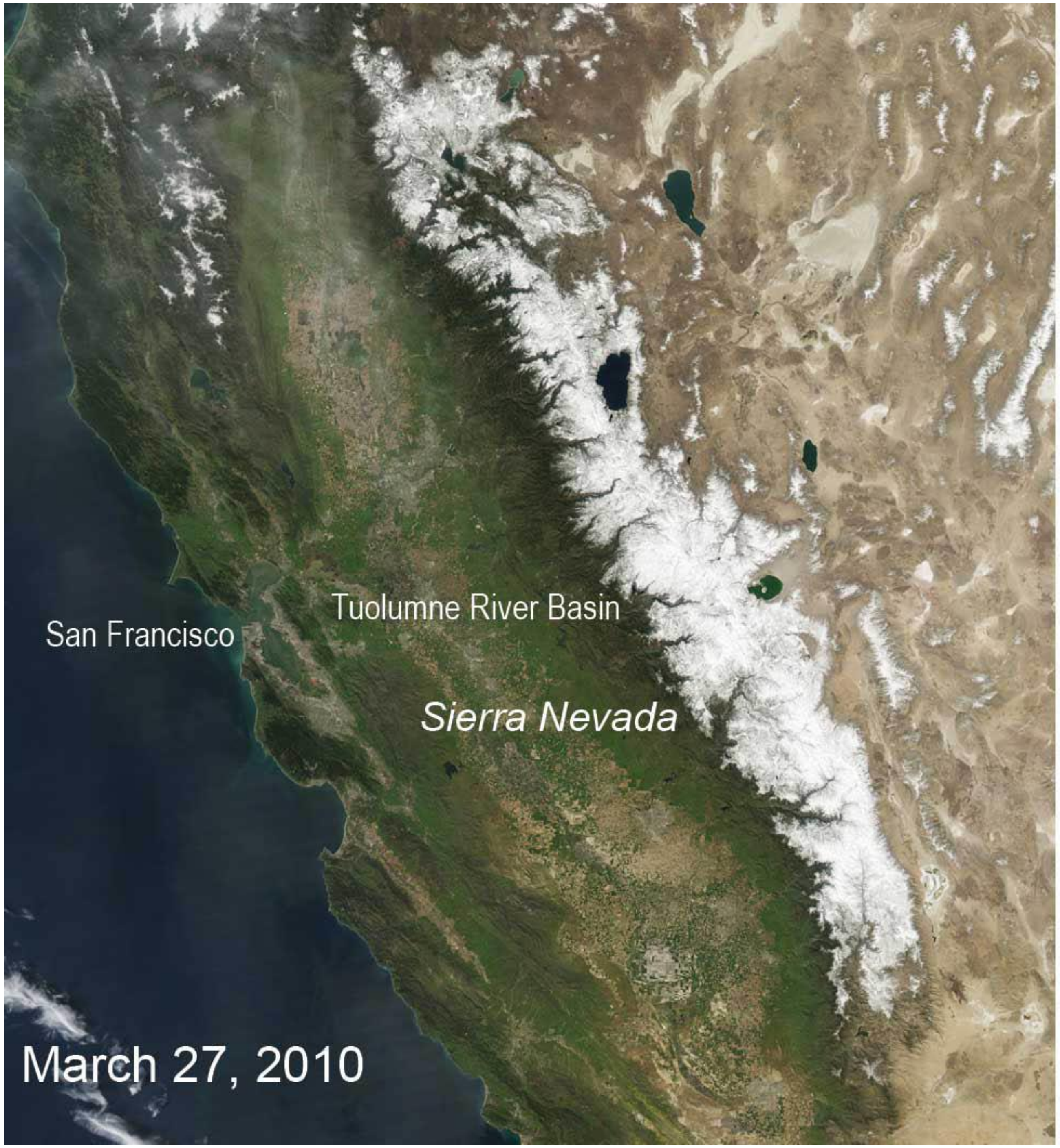
Food security

Food security is a major challenge of our century.

Photo: J. Verfaillie

Food and water resources

Food requires water for growth, in many places the availability of water is the limiting factor.



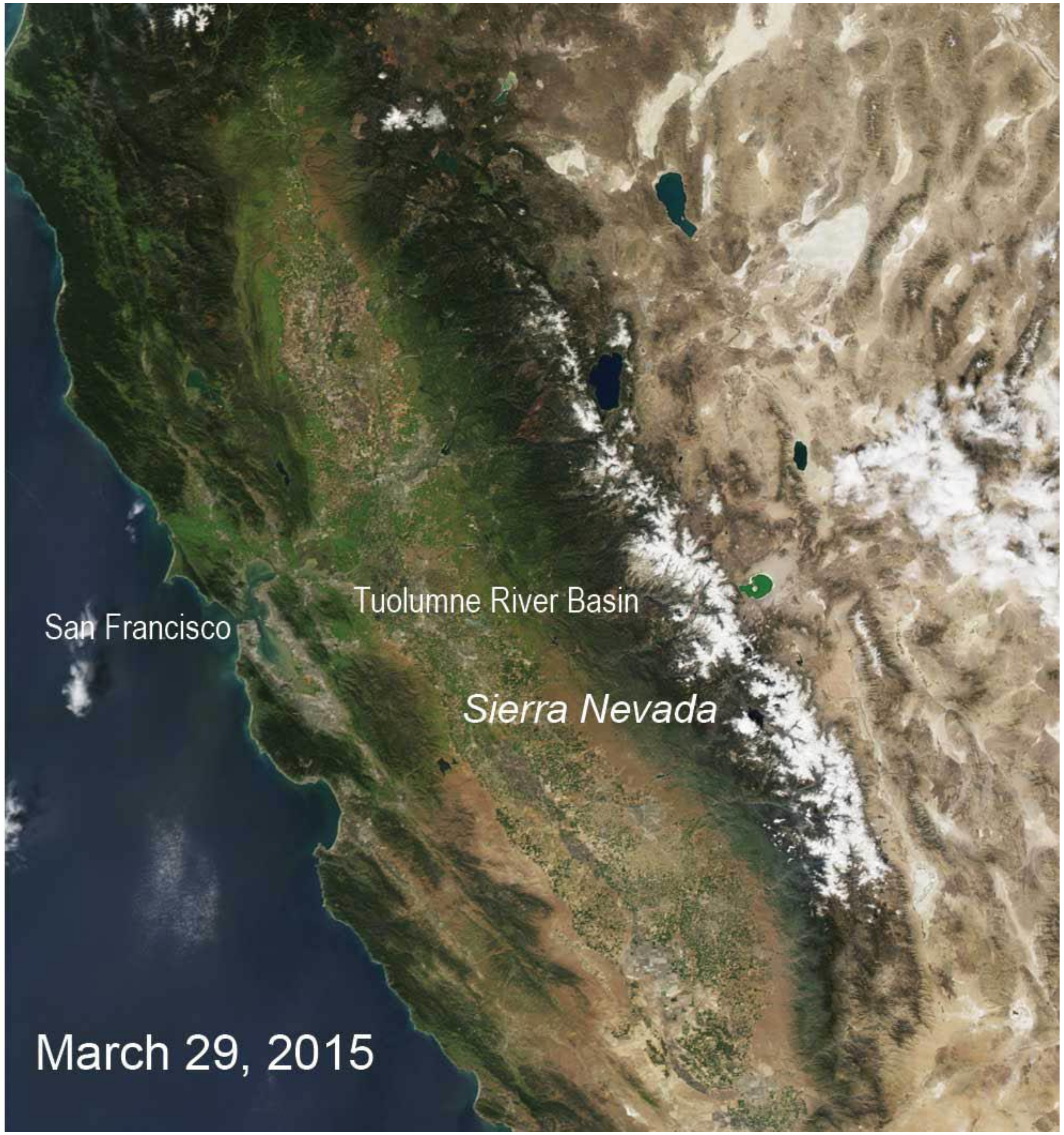


Photo: A. Christen

Food and water resources

"Warmer temperatures mean even when the rains come, evaporation can wick much of the moisture away.”

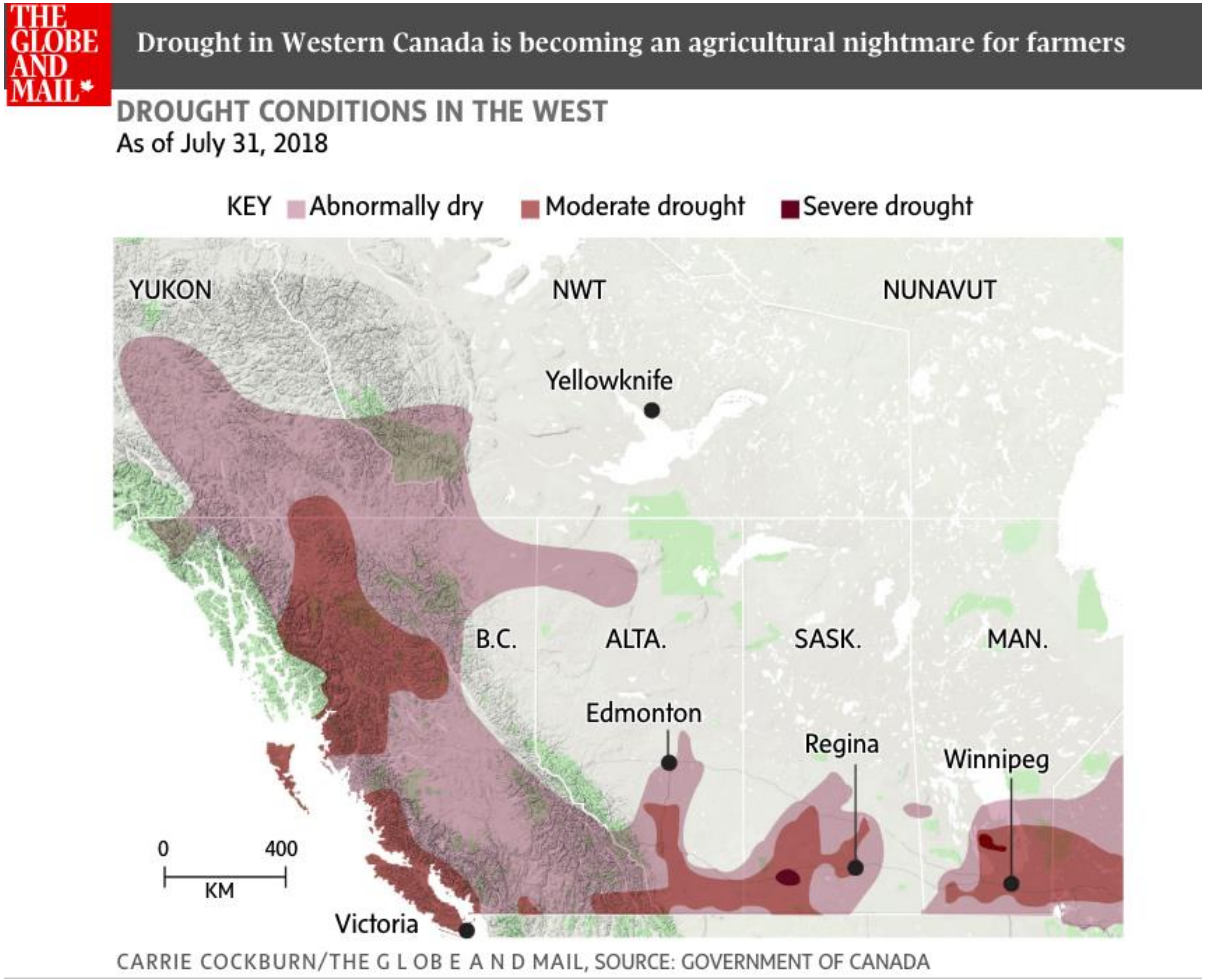


Photo: A. Christen

Applications – Food and water resources

Knowledge on micrometeorology and climatology helps to…

- Develop strategies to **use water efficiency** (soil moisture, evapotranspiration).
- Quantify and model local and regional rates of **evapotranspiration**.
- To predict **frost** and protect crops properly from frost.
- To manage **wind erosion** and sheltering.
- To efficiently plan **agricultural operations** (seeding, spraying, burning).

Applications

- Global climate change
- Food and water resources
- Air pollution and industry
- Clean energy

Applications

- Global climate change
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Energy security

Energy is a central need of growing populations and economies.
How can we secure energy without harming our climate system?

Photo: A. Christen

Clean energy

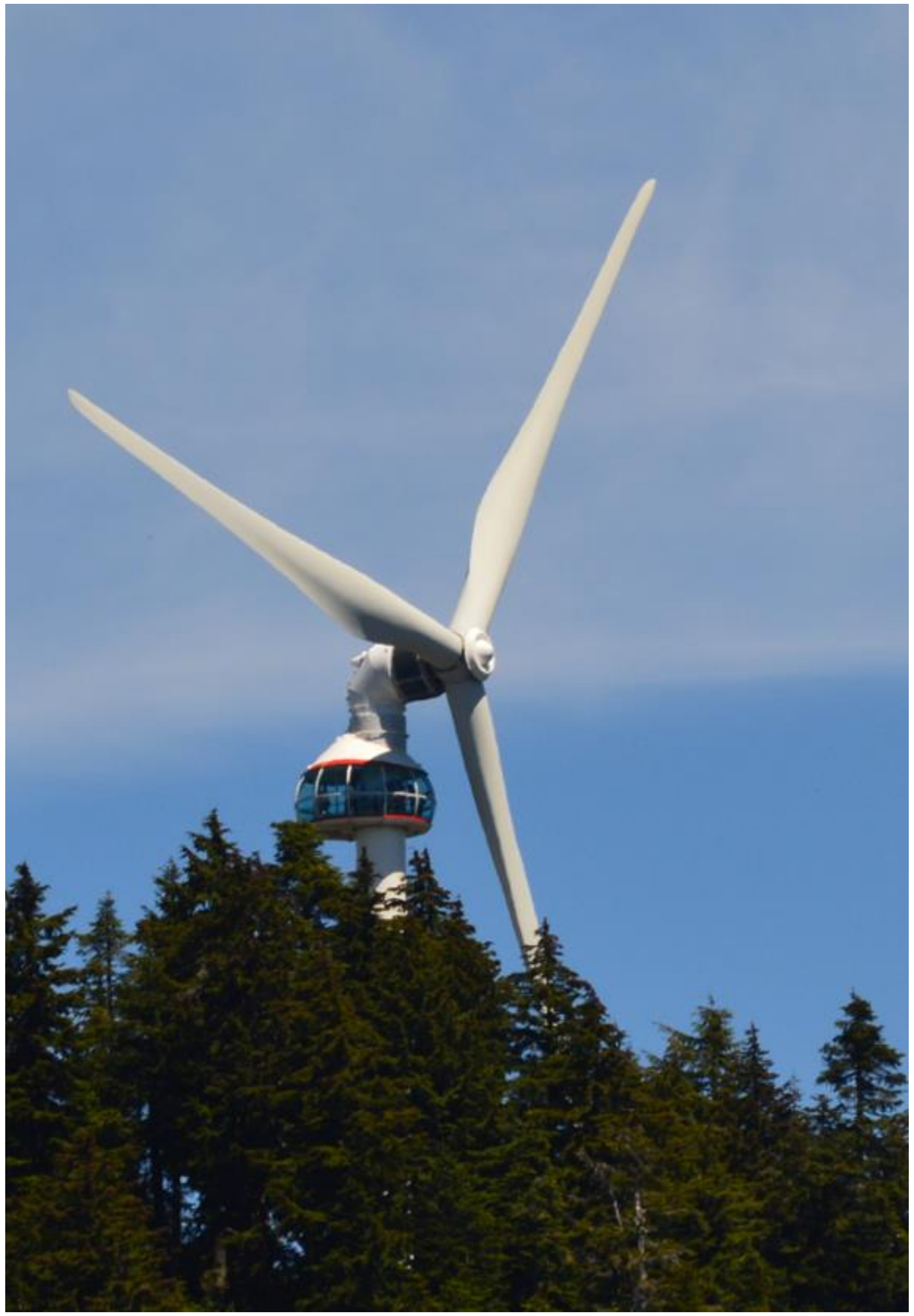
Clean energy production, along with efficient distribution and use of energy, are key tasks of moving into a more sustainable 21st century.

Photo: A. Christen

Applications – Clean energy, engineering & architecture

Knowledge on micrometeorology and climatology helps to…

- Maximize use of **renewable energies** (wind, solar).
- Optimize **thermal climate** and energetics of buildings.
- Calculate **wind loading** of buildings and structures.



Wind turbine on Grouse Mountain, Vancouver (Photo: A. Christen)