

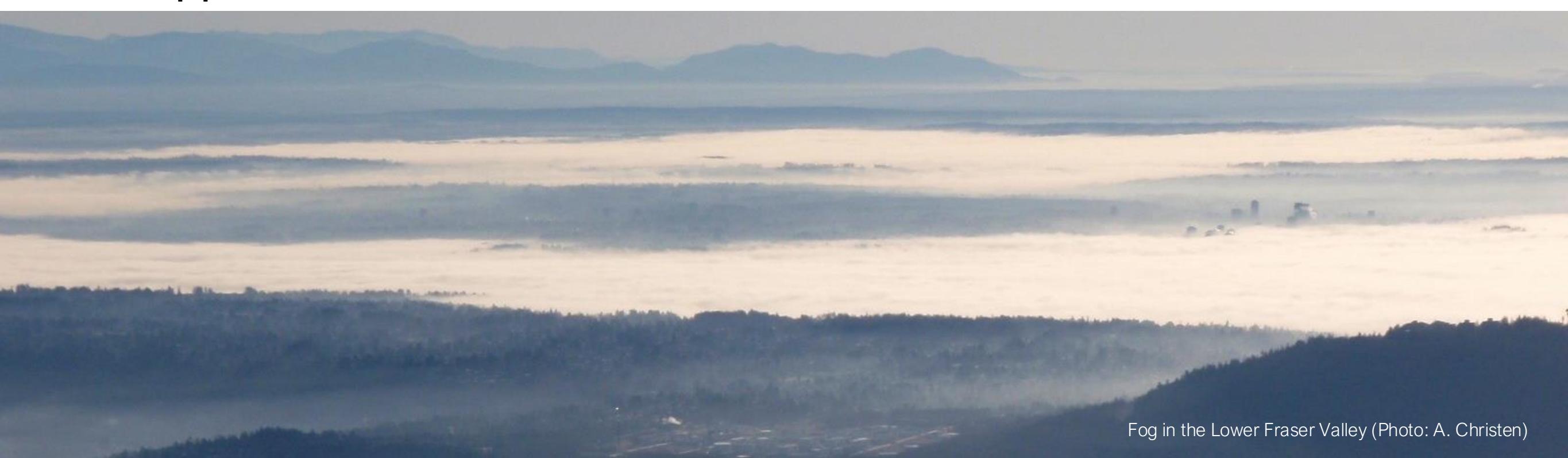


## GEOG 321 | Climatic Environments

# Topic outline

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- 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

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## Instructor

**Dr. Sara Knox**

Assistant Professor

Department of Geography

[sara.knox@mcgill.ca](mailto:sara.knox@mcgill.ca)

## Weekly office hours

BH 619 or Virtual (Zoom – please contact me ahead  
of time if you’re planning on attending via Zoom)

Mondays 10:00-11:00 am (or by appointment)

# Dr. Sara Knox

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- 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 TA

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**Camille Jones**  
Graduate student  
Department of Geography

**Office hours will be posted on the website shortly**

# Introduce yourself – in small groups & as a class

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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.

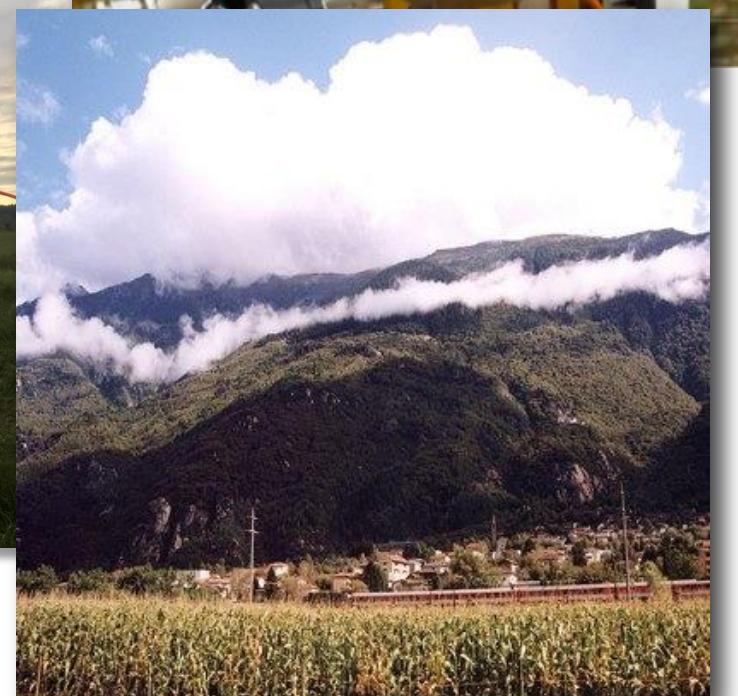
Measuring wetland trace gas exchange.



Measuring CO<sub>2</sub>-exchange of a pine shoot.



Clouds and circulation patterns in a deep mountain valley.



Photos: S. Knox, A. Christen



~ 1 cm - 1 m

~ 1 m - 100 m



Photo: S. Dengel

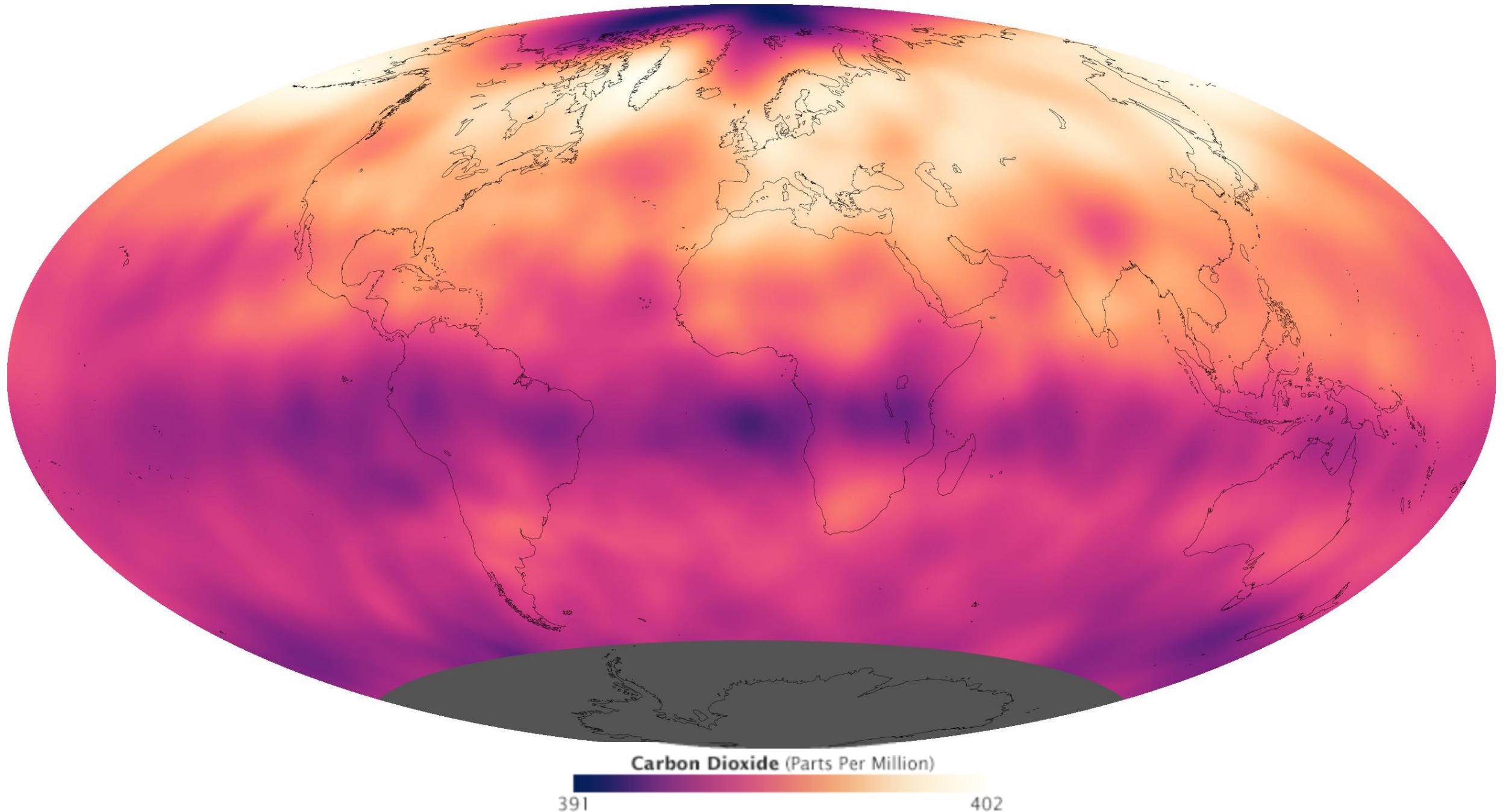
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~ 100 m - 10 km

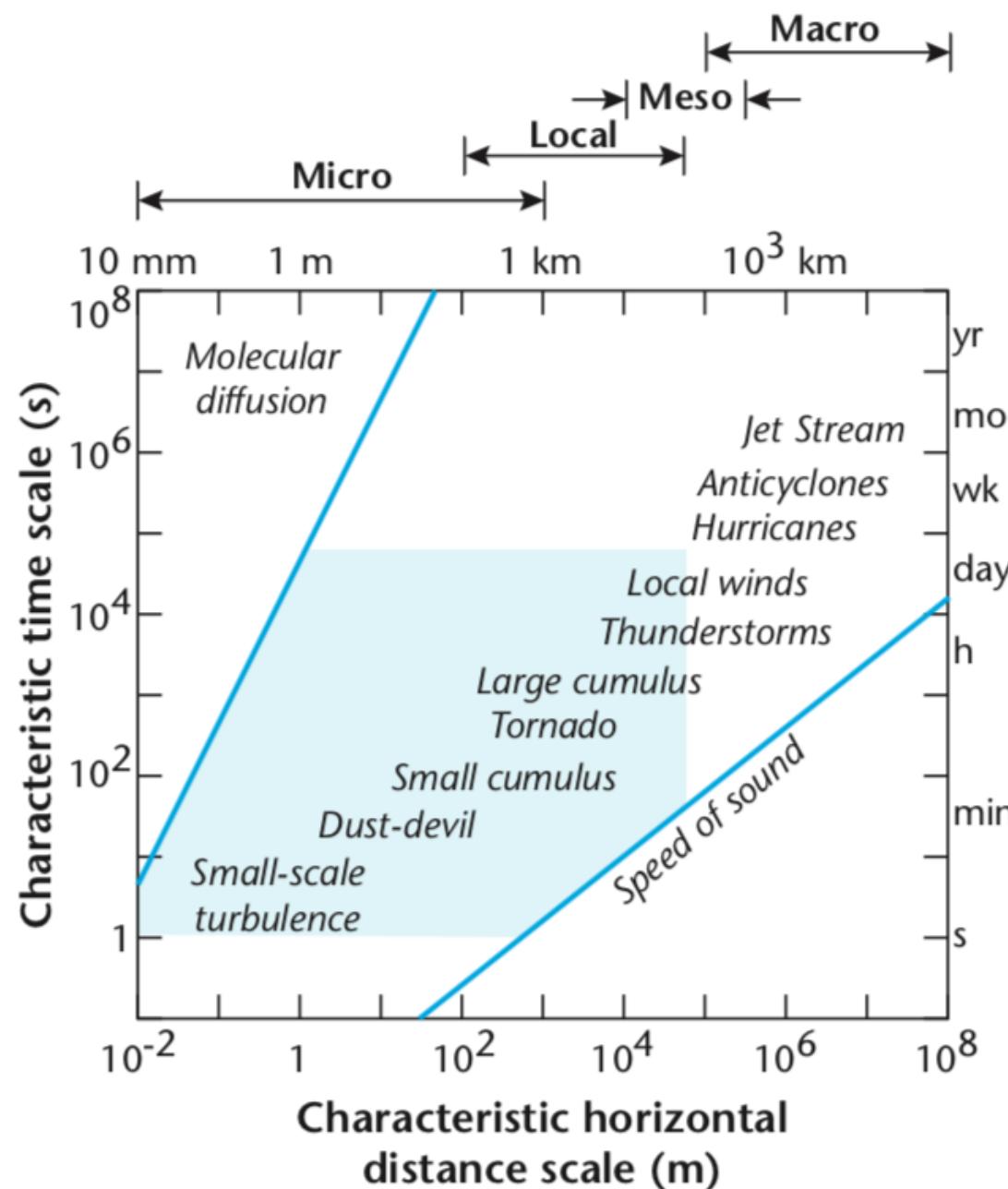


Photo: A. Christen

# 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 $5 \times 10^4$ m
Meso-scale	$10^4$ to $2 \times 10^5$ m
Macro-scale	$10^5$ to $10^8$ m



Micro-scale



Meso-scale



Macro-scale

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

# Weather vs climate?

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What is the difference between weather & climate? (Slido discussion)



Join at  
**slido.com**  
**#1937 422**



# 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

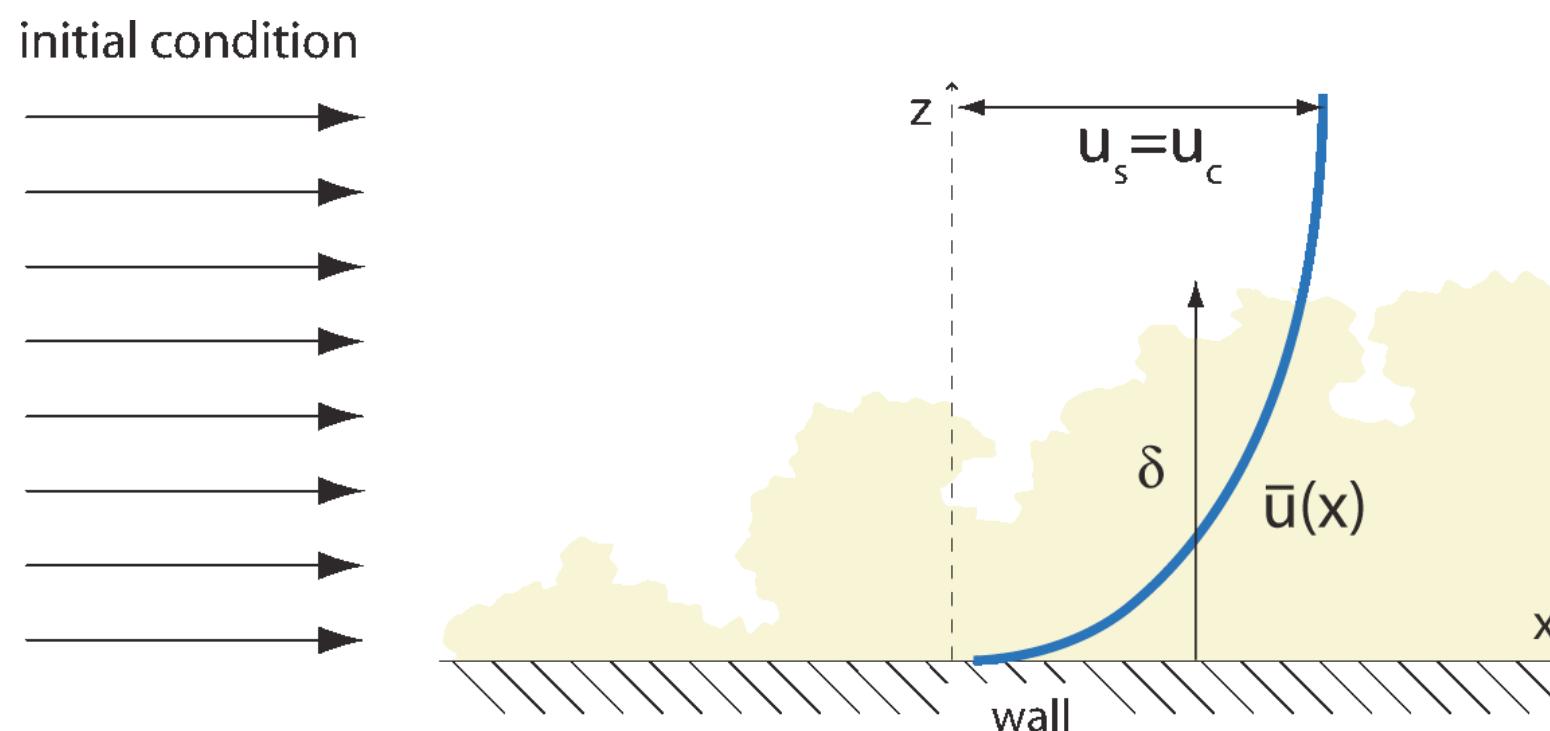
Microclimatology deals with **long-term integral effects** (from hours to decades) namely, the average and variability of specific climates near the surface with respect to different geographic settings.



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.

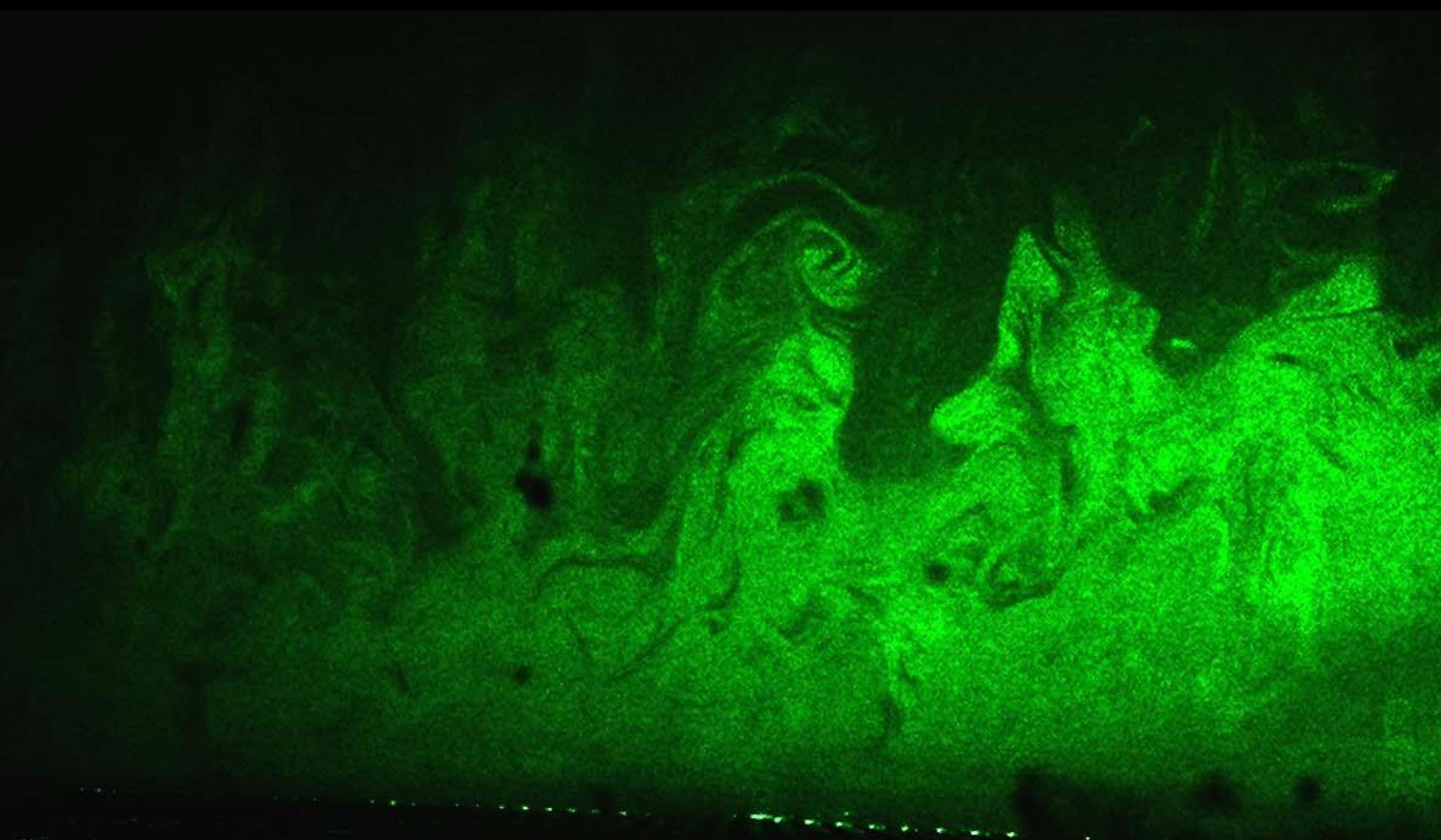
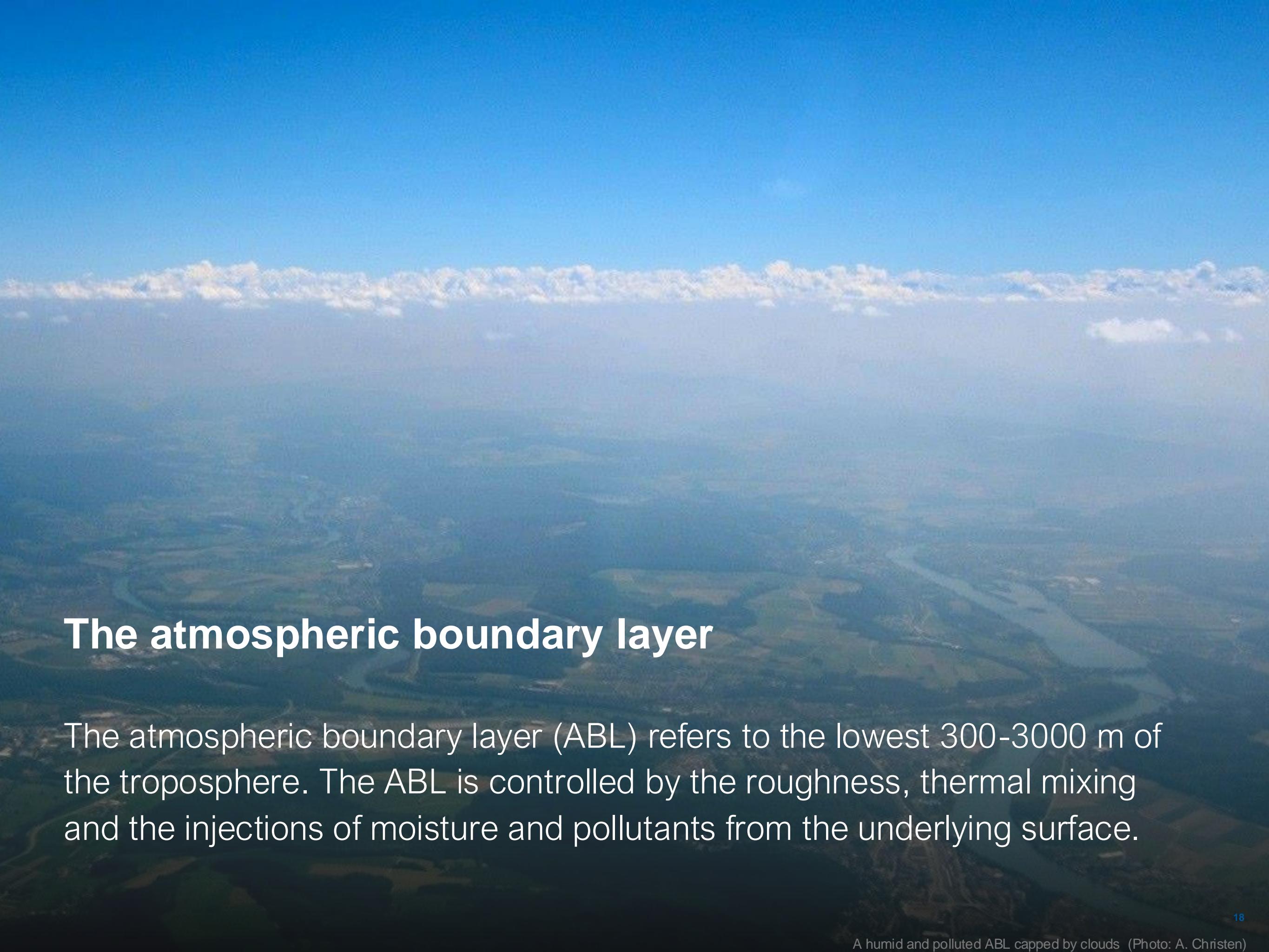


Photo: Visualisation of a boundary layer in a wind tunnel (M. A. Carper, Saint Anthony Falls Laboratory, University of Minnesota)

The background image shows an aerial view of a rural landscape with green fields and roads, transitioning into a hazy, blue-tinted area. Above this, a thin, horizontal layer of white and yellow clouds stretches across the frame, representing the atmospheric boundary layer.

# 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.

Free atmosphere

ABL depth

$z_i$

# 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

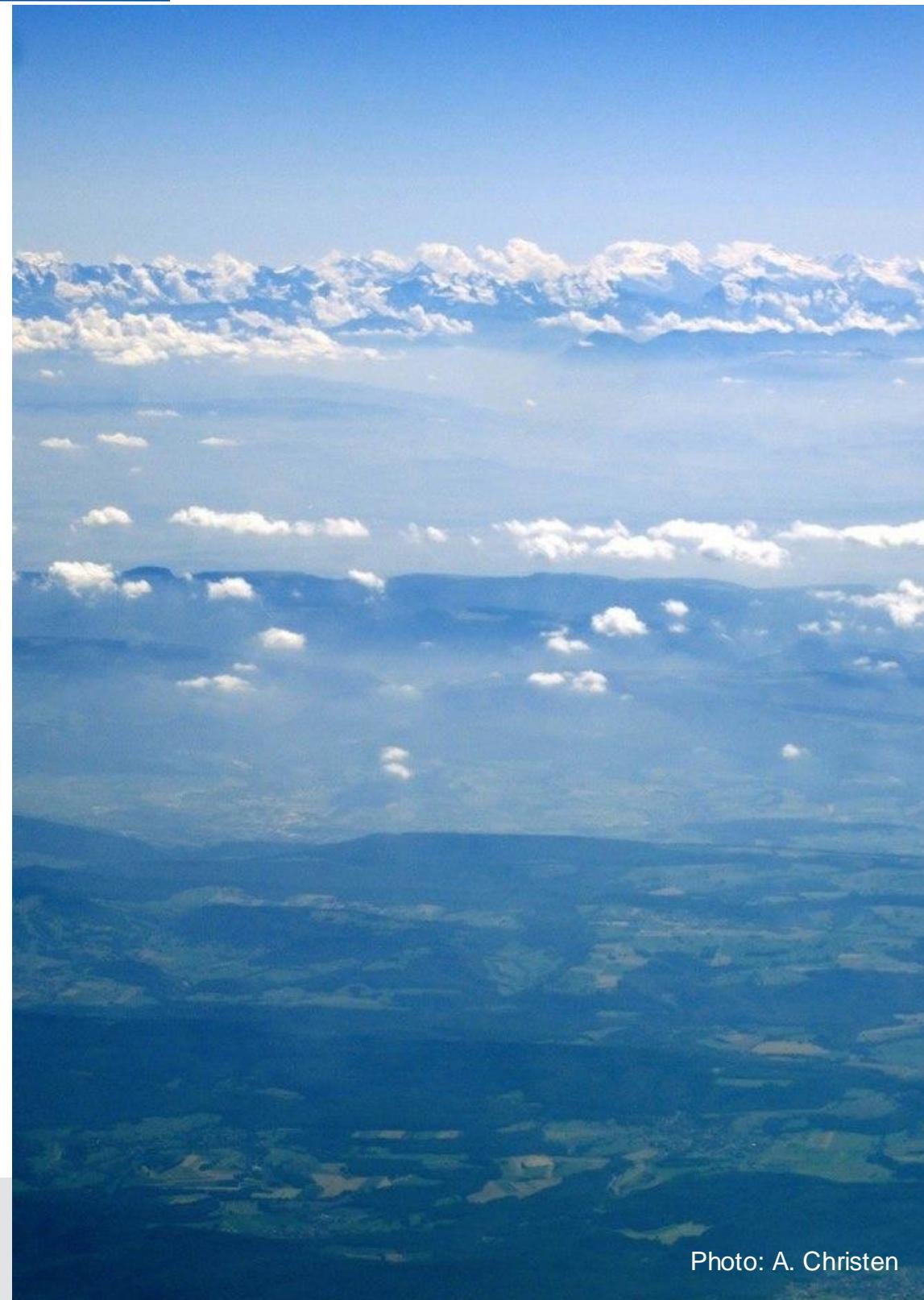


Photo: A. Christen

# Course Learning Goals

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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)

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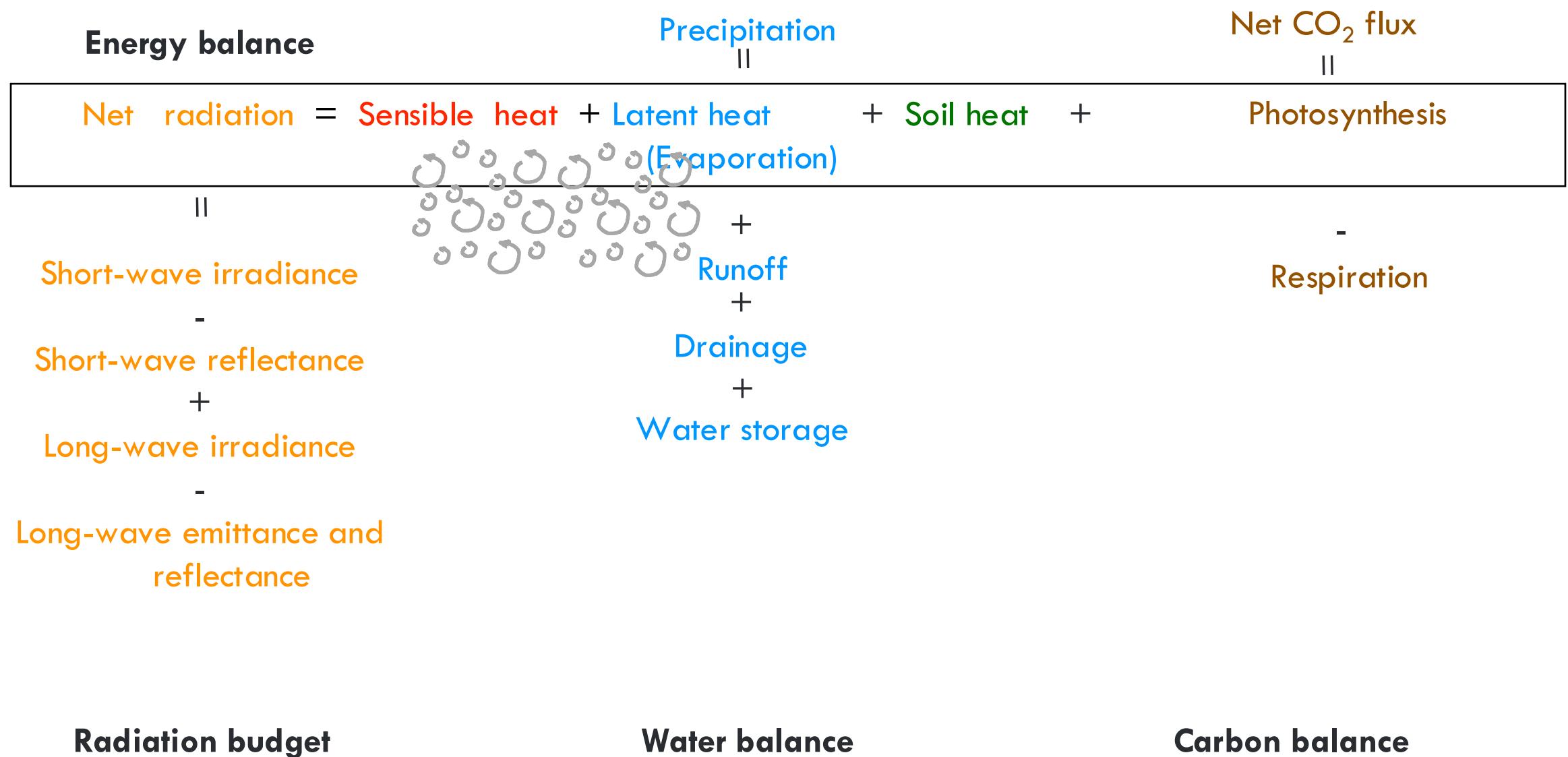
4. Provide examples of key physical, biological and chemical processes that **control trace gas, water and energy fluxes between the land surface and the atmosphere**.
5. Provide examples of how surface-atmosphere interactions **respond to environmental change**, and how this can create climate **feedbacks**.
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)

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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



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

- [Learning Outcomes](#)
- [Your Instructor](#)
- [TAs and TA office hours](#)
- [Instructional methods](#)
- [Communication Guidelines](#)
- [Required course materials](#)
- [Course content](#)
- [Evaluation](#)
- [Academic integrity](#)
- [Other statements](#)
- [Strategies for Success](#)

Make sure to check the website regularly!

## Course evaluation

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

**Mid-term** exam is on **Feb 26**, 2024 (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 3<sup>rd</sup> 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 Climate  
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 utilizes 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	$\text{kg m s}^{-2}$
Pascal	Pressure	Pa	$\text{N m}^{-2}$
Joule	Energy	J	$\text{Nm}$
Watt	Power	W	$\text{J s}^{-1}$

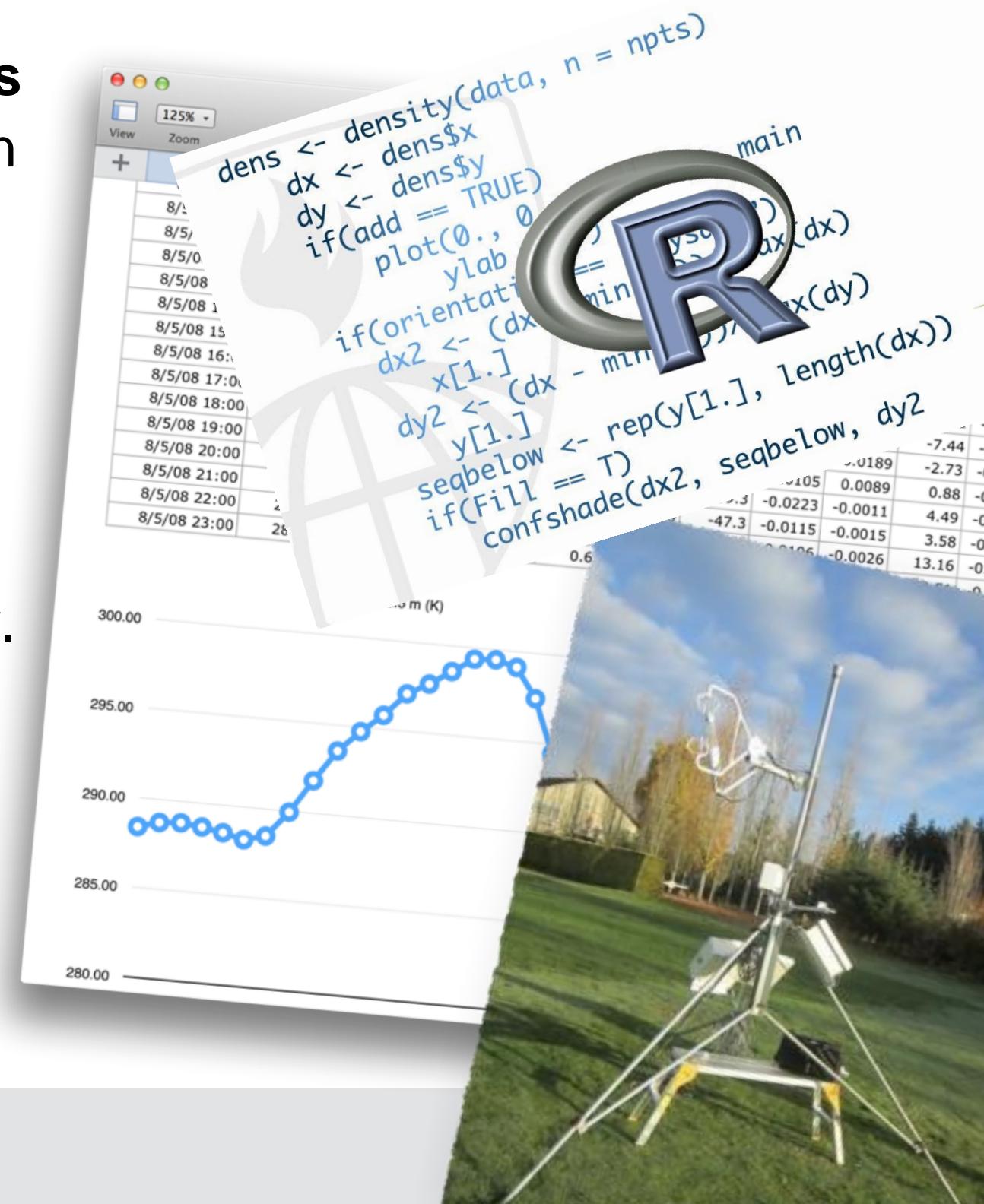
Note that you must insert a blank space between the numerical value and the symbol, as well as between symbols, i.e. '5 kgm<sup>-2</sup>' and not '5gmn<sup>-2</sup>'.

# Study questions and assignments

Many lectures have **self-study questions with answer keys**. 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

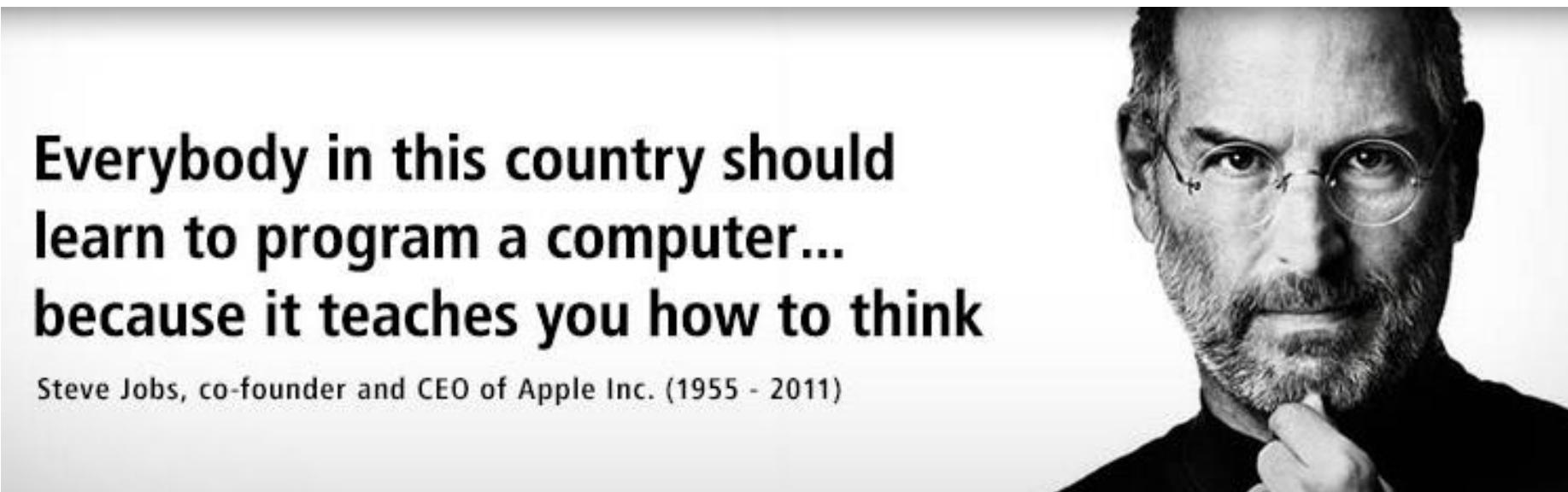


# Assignments

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- A1** Feb 12, 2025 - Hands on **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 24, 2025 – Determine whether **wind measurements** at different heights above a flat surface fit the theoretical equations.
- A3** Apr 9, 2025 – hands on instrumentation to measure **land-atmosphere exchange of trace gases and energy** relevant for global climate change (Lab visit on Mar 24, 2025).

# 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.

**BIT BAT WOLF** @sruloart  
More On Twitter



# How I can support you in learning to code

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

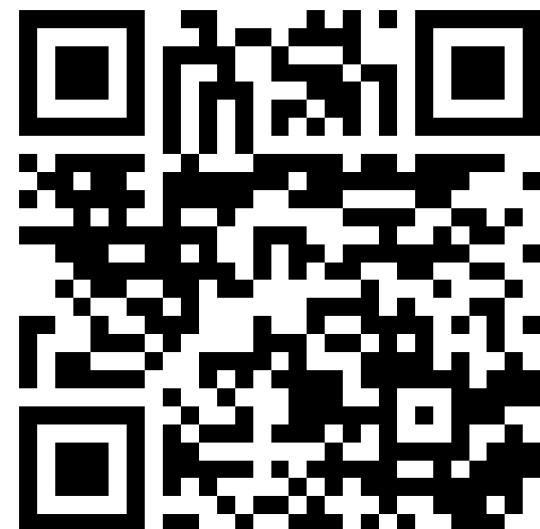
# Are you interested in using R (a programming language) in this course?

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polling

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**#1937 422**



# Other questions about the Syllabus/Course?

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polling

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# Applications

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



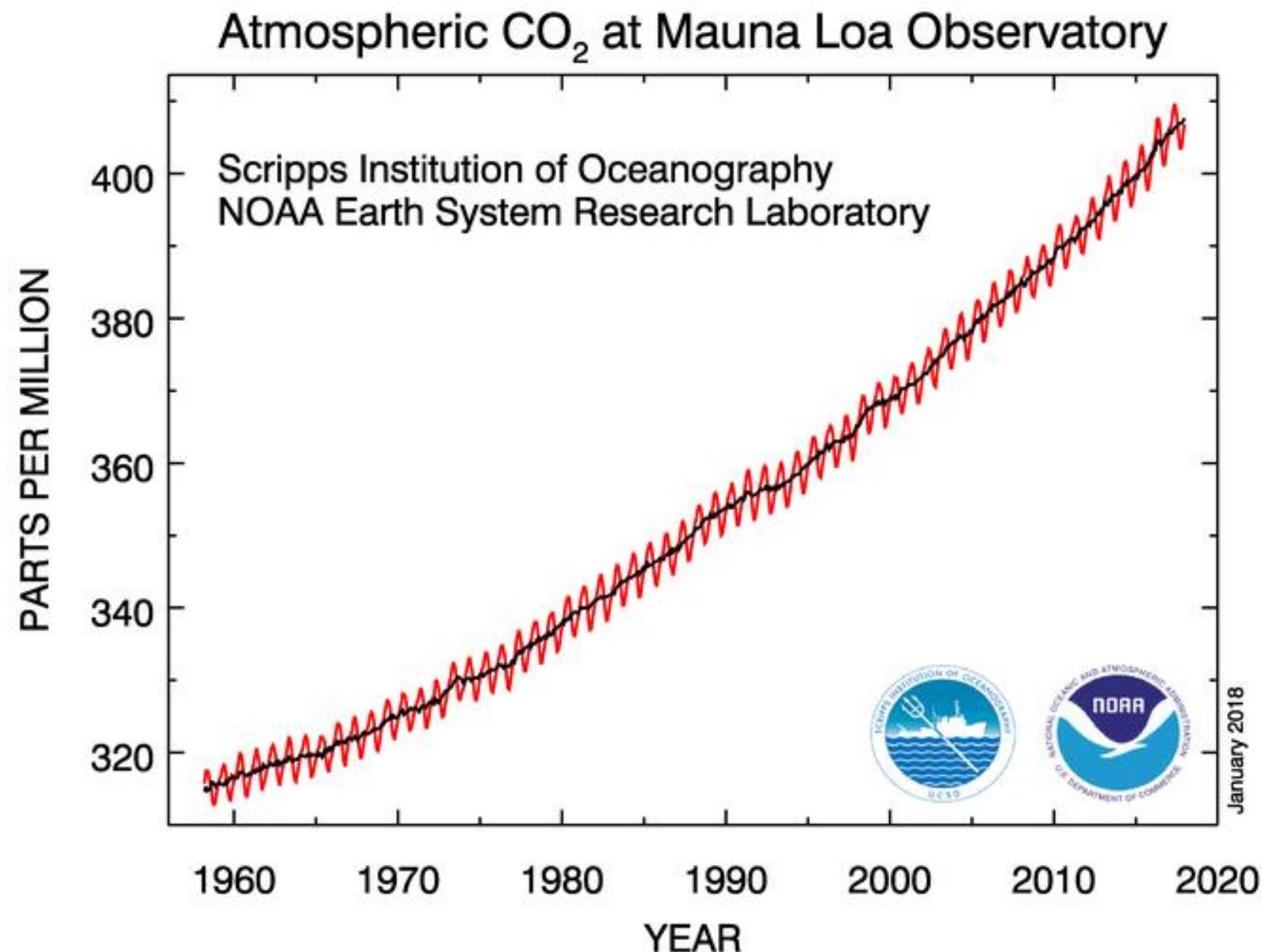
# Applications

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



# Rising CO<sub>2</sub> concentrations



# Terrestrial ecosystems are key components of the global carbon cycle

## Sources



34.4 GtCO<sub>2</sub>/yr  
**88%**



**12%**  
4.8 GtCO<sub>2</sub>/yr

## Sinks



17.2 GtCO<sub>2</sub>/yr  
**46%**

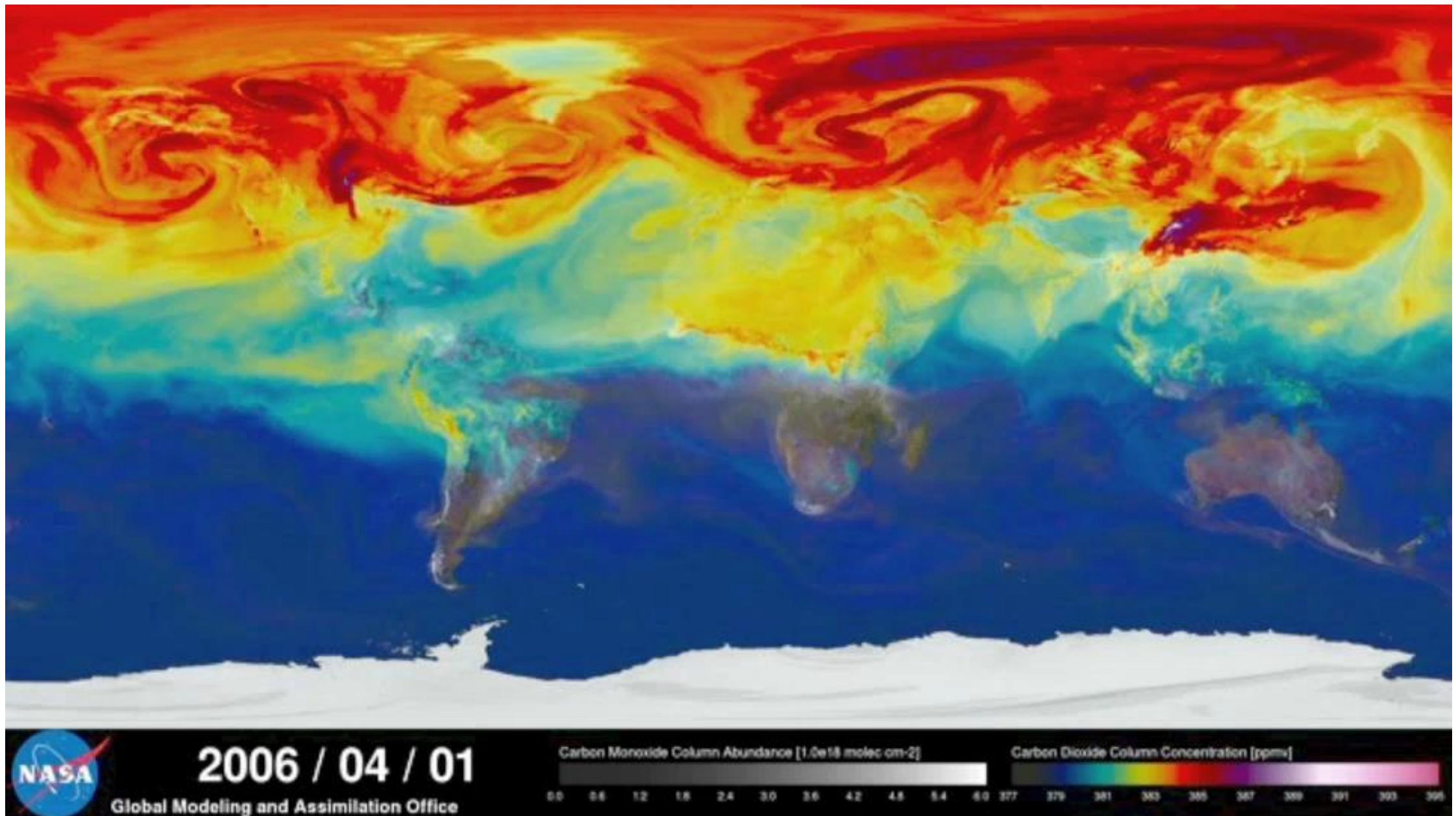


**24%**  
8.8 GtCO<sub>2</sub>/yr



**30%**  
11.0 GtCO<sub>2</sub>/yr

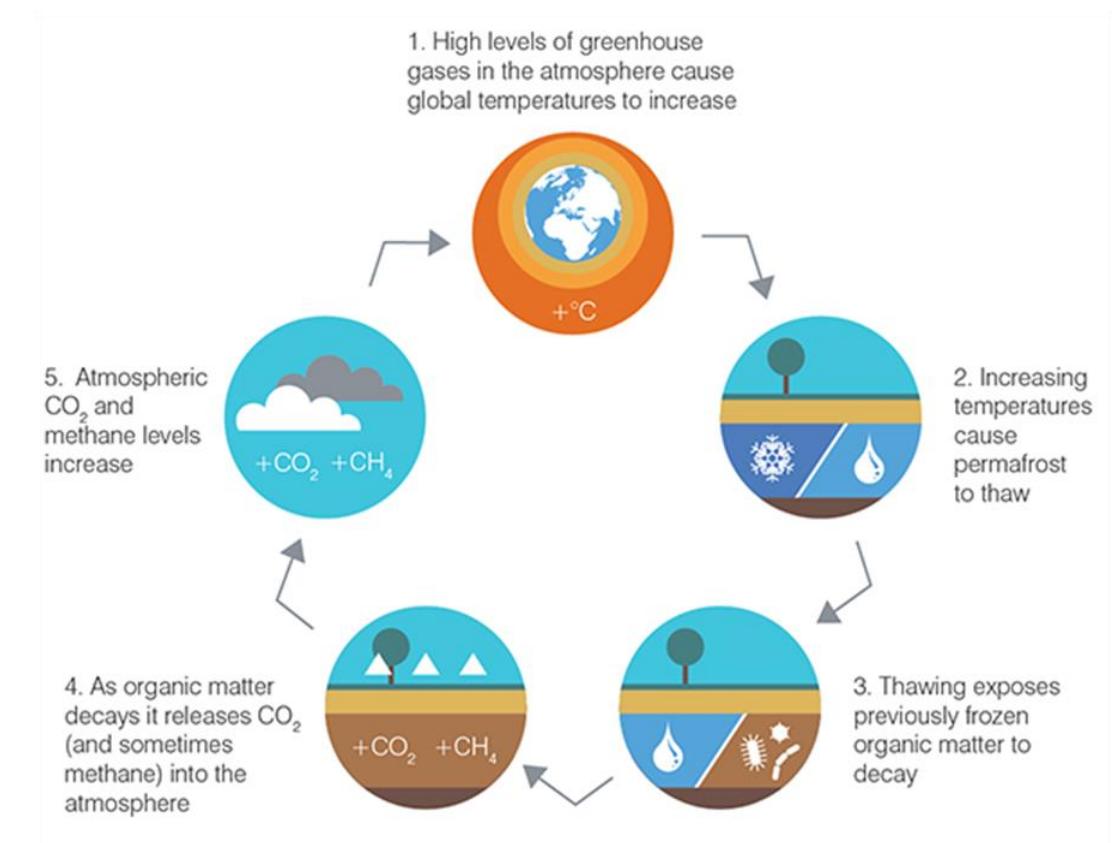
# The breathing of the biosphere



# 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

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



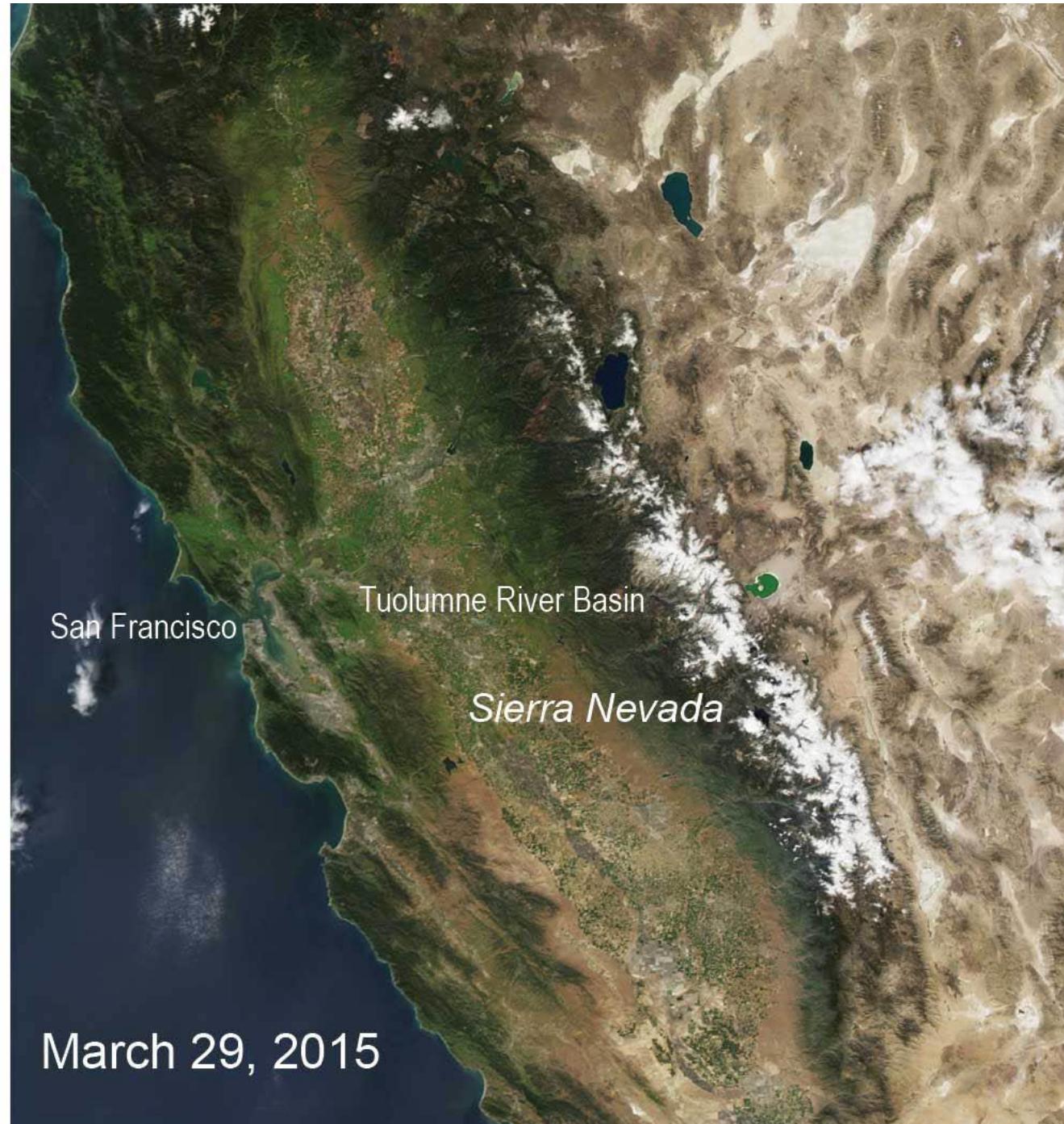
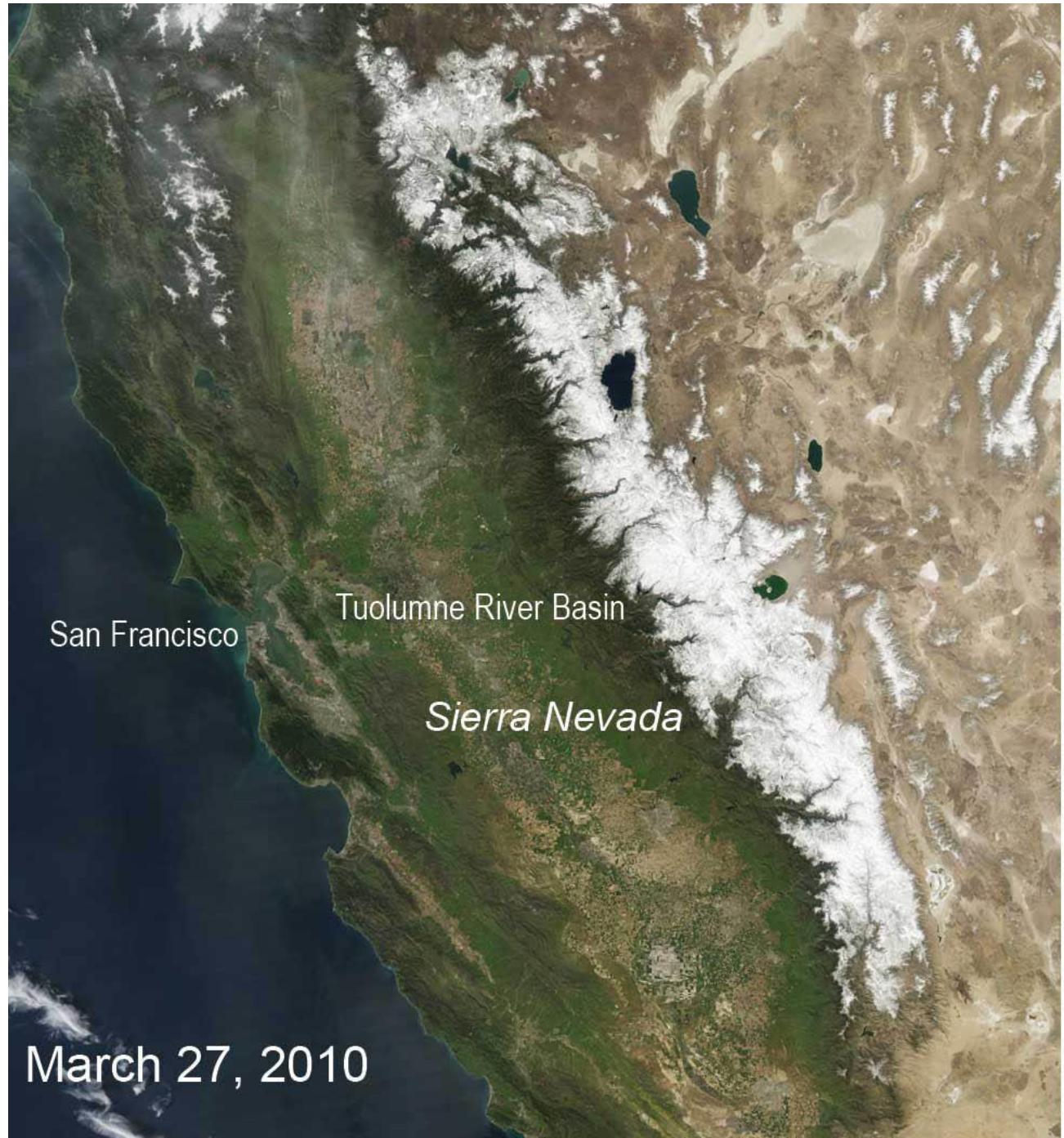


## Food security

Food security is a major challenge of our century.

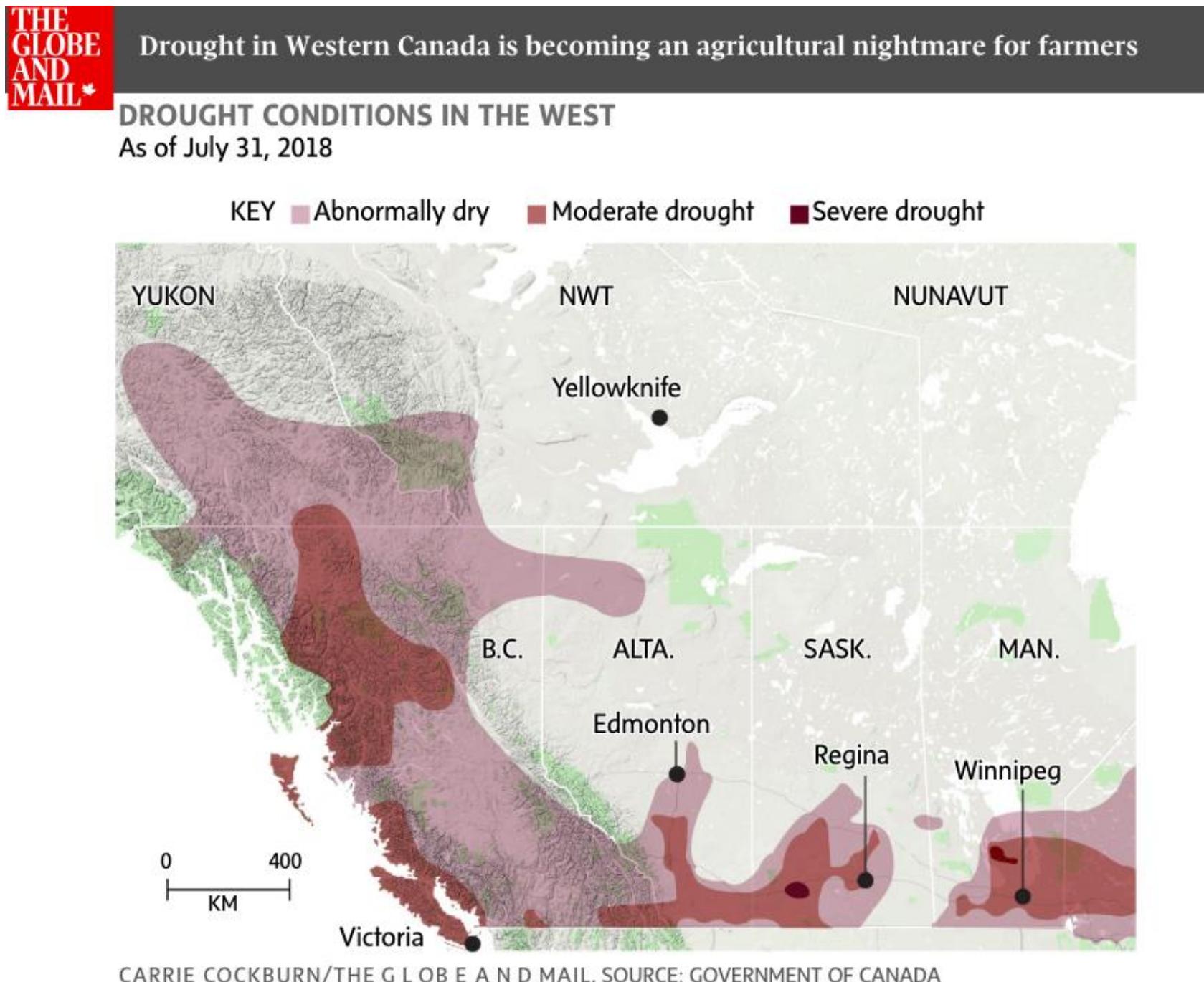
# Food and water resources

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



# Food and water resources

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



## Applications – Food and water resources

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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

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



# Applications

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





## Energy security

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

# 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)

