On the way to developing northern greenhouses adapted to population and climate: energy issues

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Wakeham bay (photo: D. Haillot)

Introduction

Energetic insecurity and food sovereignty in Nunavik

Kuujjuaq greenhouse

- **Isolated territory and off-grid**
- **Harsh climate**
- **Strong dependency to petroleum products**

- **Increased difficulty to access traditional food**
- **Expensive imported food**
- **Demand of fresh vegetables**

→<u>Considered solution</u>: development of the greenhouse cultivation

Creation of a French-Canadian team to work on this thematic integrated in the OHMI

<u>4 laboratories involved:</u>

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<u>Partners:</u>

Community greenhouse of Kuujjuaq

UMR 5175 CENTRE D'ÉCOLOGIE FONCTIONNELLE & EVOLUTIVE

INRA SCIENCE & IMPACT

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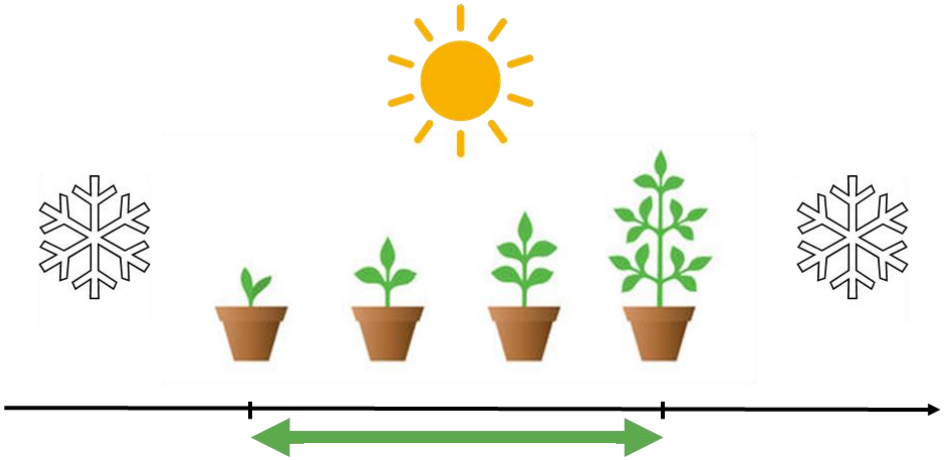
Université de Montréal

Introduction

Objectives



4 months

How to increase the growing season ?

Heating system, artificial light…

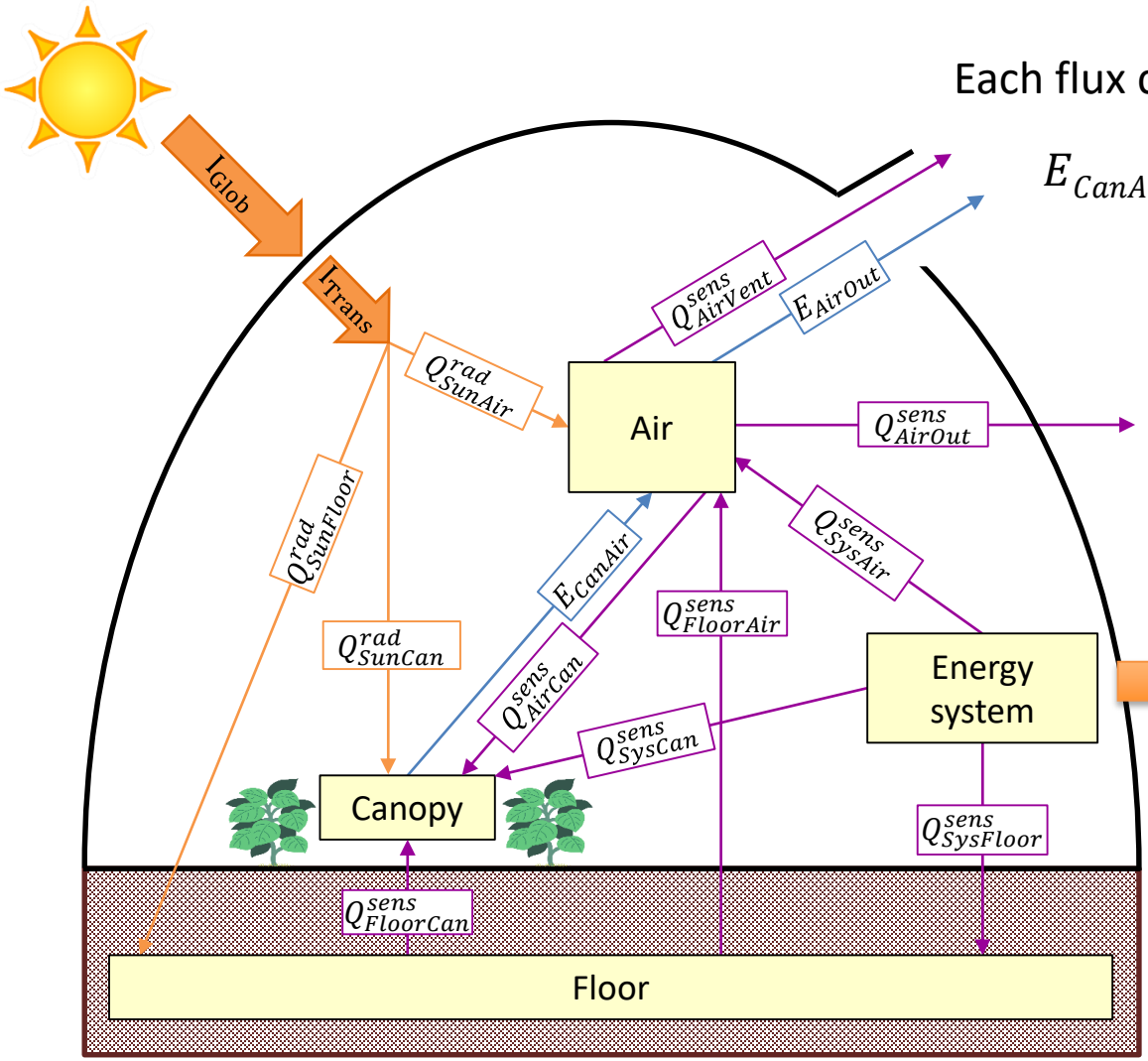
How to do the best choice ?

$

CO_2

1) Numerical tool

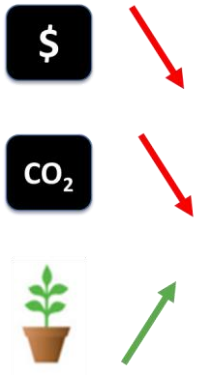
Why a model ?



Each flux can have a complex expression:

$$E_{CanAir} = K_{CanAir}(P^{Sat}_{H_2O,Can} - P_{H_2O,Air})$$

With : $$K_{CanAir} = \frac{2\rho_{Air} c_{p\_AirLAI}}{\Delta H \gamma (r_a + r_s)}$$



- Radiation flux
- Material flow (water, CO_2)
- Conduction and convective flow

1) Numerical tool

How a model work ?

Conduction, convection, radiation, evapotranspiration

Input data

T_{out}
RH_{out}
I_{glob}
Plant species
Wind speed
Greenhouse geometry and thermal characteristics

Energy balance: $\rho_j . h_j . c_{p,j} . \frac{dT_j}{dt}(t) = \sum_i Q_i(t)$

Mass balance : $C_{P_{H_2O}} . \frac{dP_{H_2O}}{dt}(t) = \sum_i E_i(t)$

$C_{CO_2} . \frac{d[CO_2]}{dt}(t) = \sum_i MC_i(t)$

Growing model

Run the model

Need instrumentation

Validate the model

Output data

T_{in}
RH_{in}
$[CO_2]_{in}$
Energy needed
Plant production

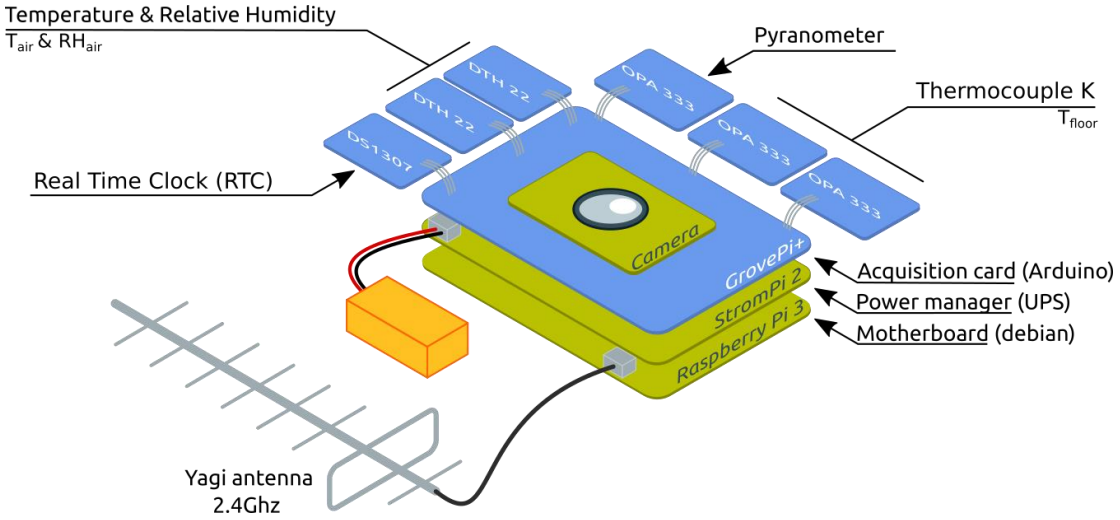
2) Data acquisition and analysis

Instrumentation

- **Constraints:** weather (humidity, low temperature), cost, distance between the greenhouse and the internet connection (300m)

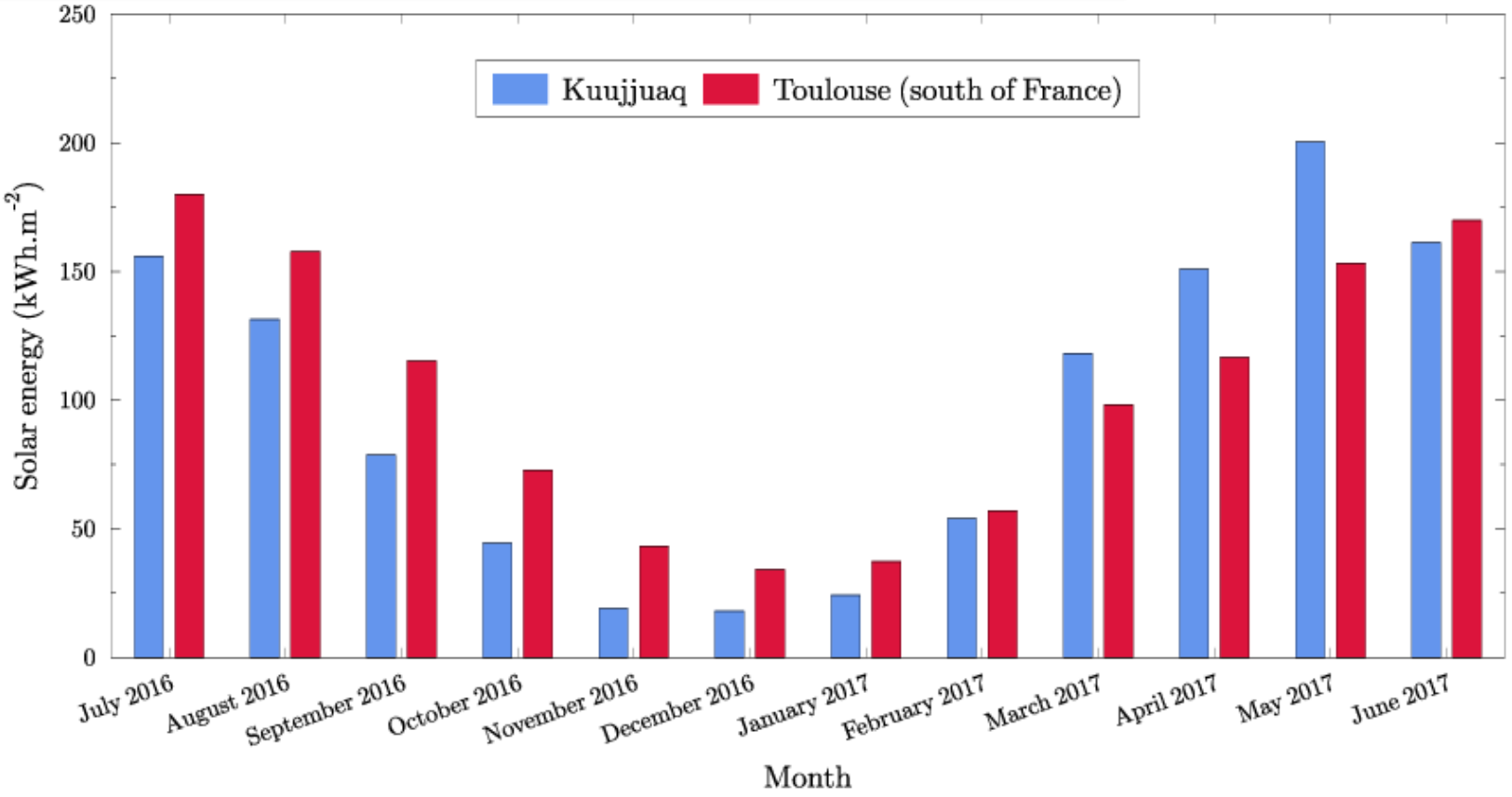
- **Acquisition** system using electronic boards which are:
  - ✓ Cheap, robust, lightweight, small and standardized
  - ✓ Connected to our website

- **Automation** in real time of the following data:
  - ✓ Solar fluxes inside and outside the greenhouse
  - ✓ External temperature and RH
  - ✓ Ambient temperature and RH
  - ✓ Soil temperature
  - ✓ One photo a day



2) Data acquisition and analysis

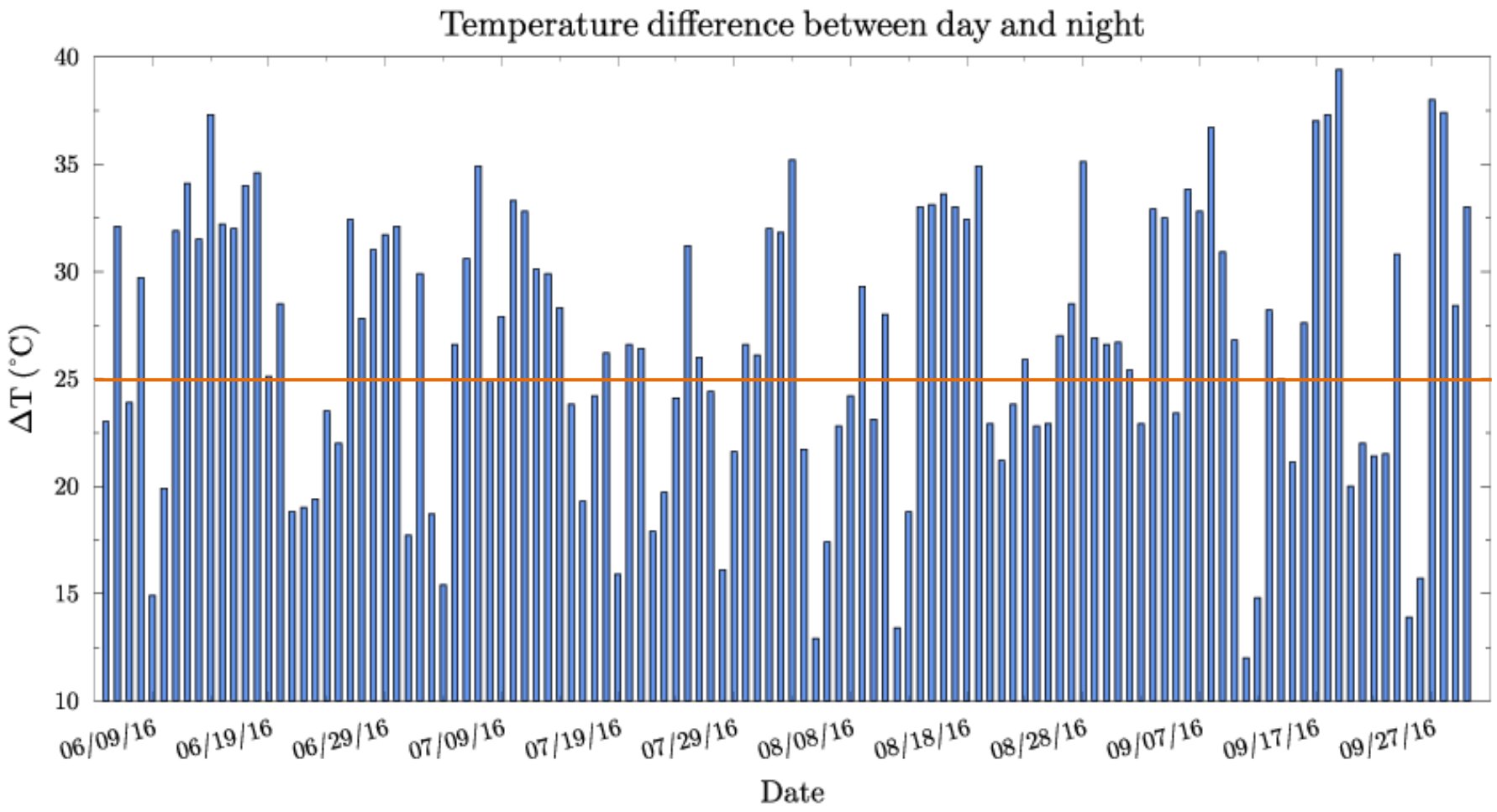
Monthly solar energy available



- Strong potential of solar energy
- New data unavailable in the literature
- Data needed to calculate ROI on any solar system (photovoltaic or thermal)

2) Data acquisition and analysis

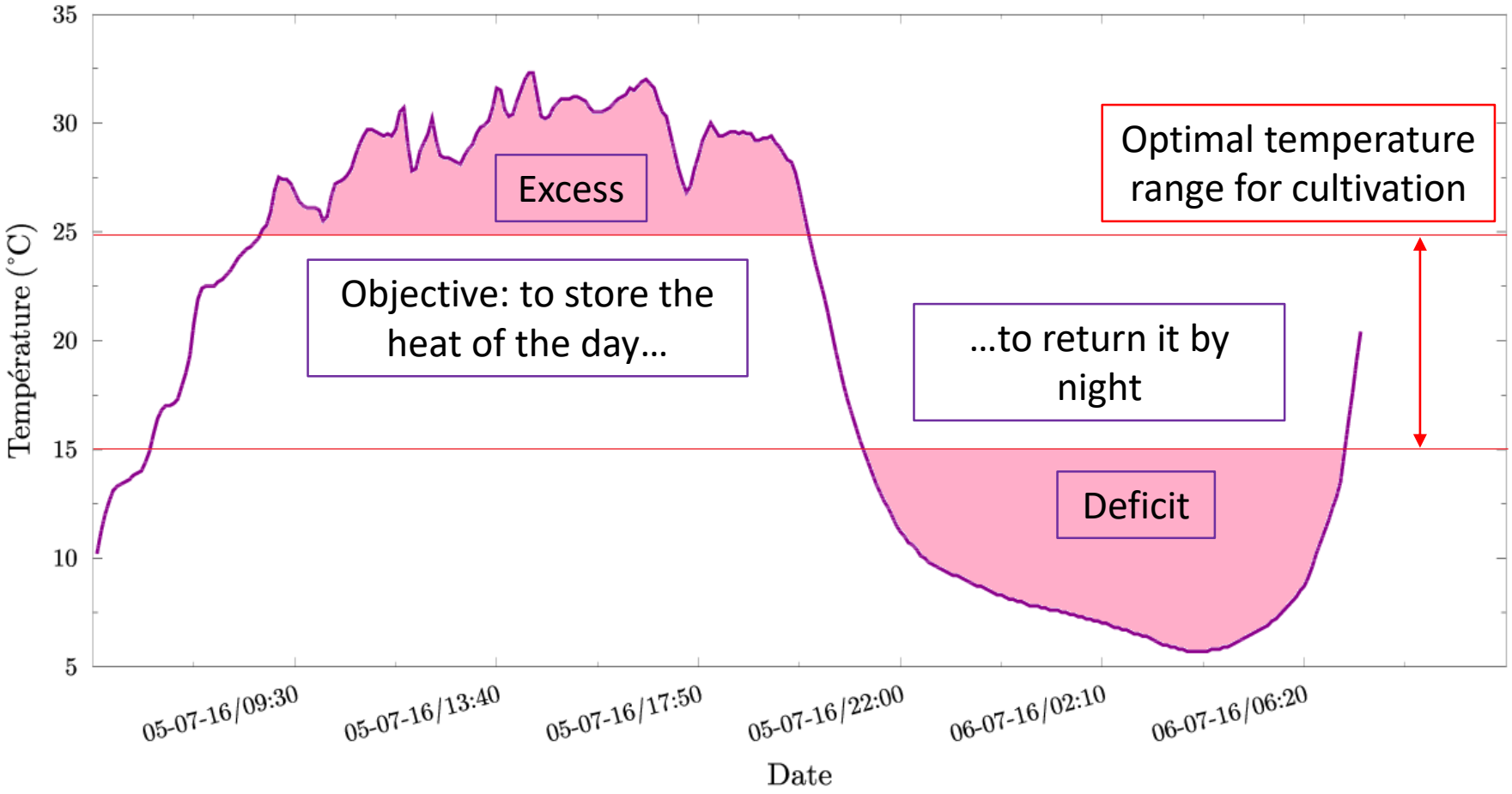
Greenhouse temperature analysis



→Strong ΔT with an average of 25°C during the growing season

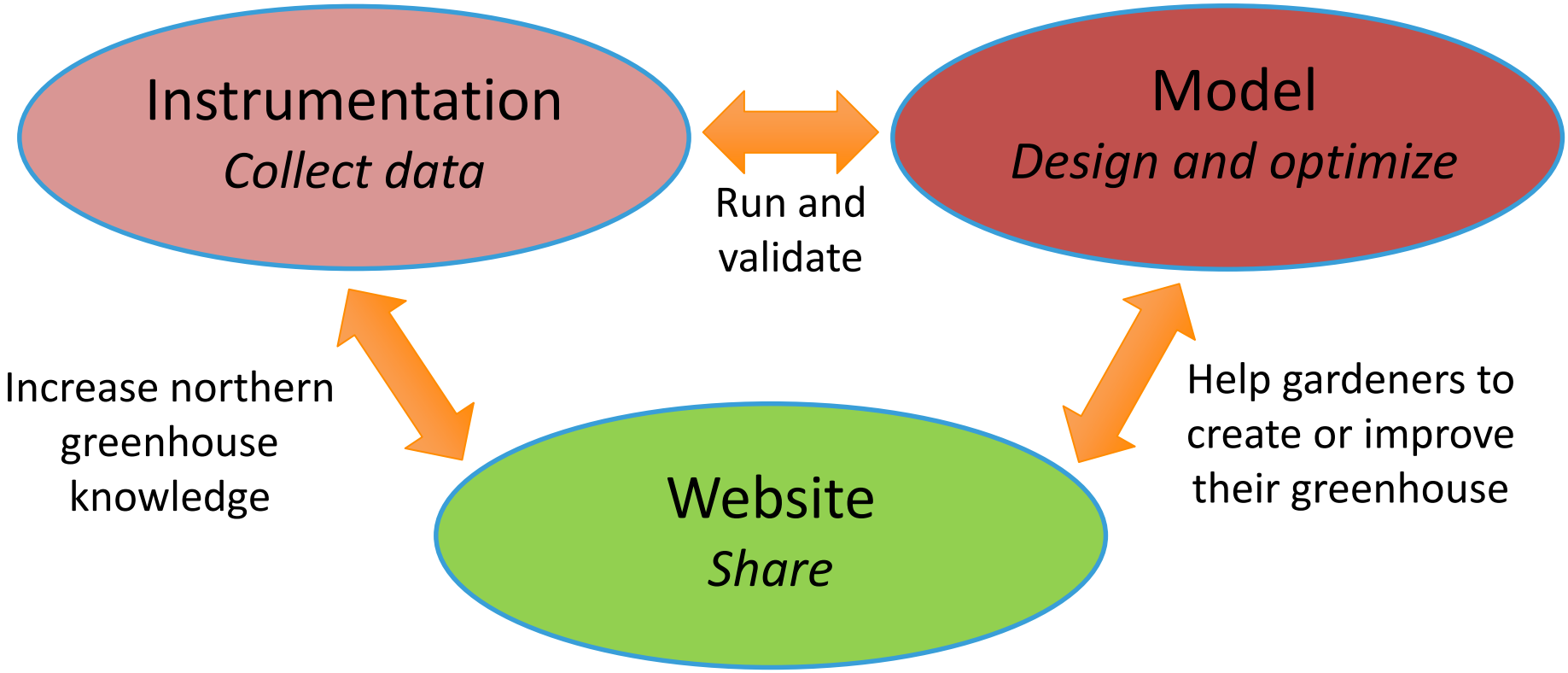
2) Data acquisition and analysis

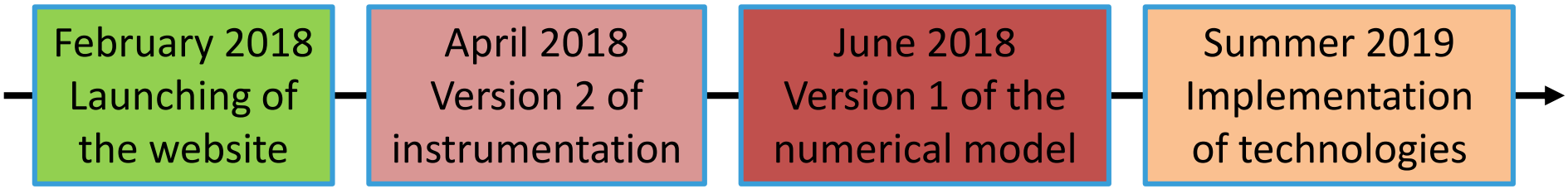
Greenhouse temperature analysis



→Use of thermal storage system (water, rock, PCM, geothermics…)

Conclusion and outlook





Arctic Change 2017

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Thank you for your attention

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