Sensitivity of the Canadian Regional Climate Model (CRCM5) to the Improvement of Soil Database

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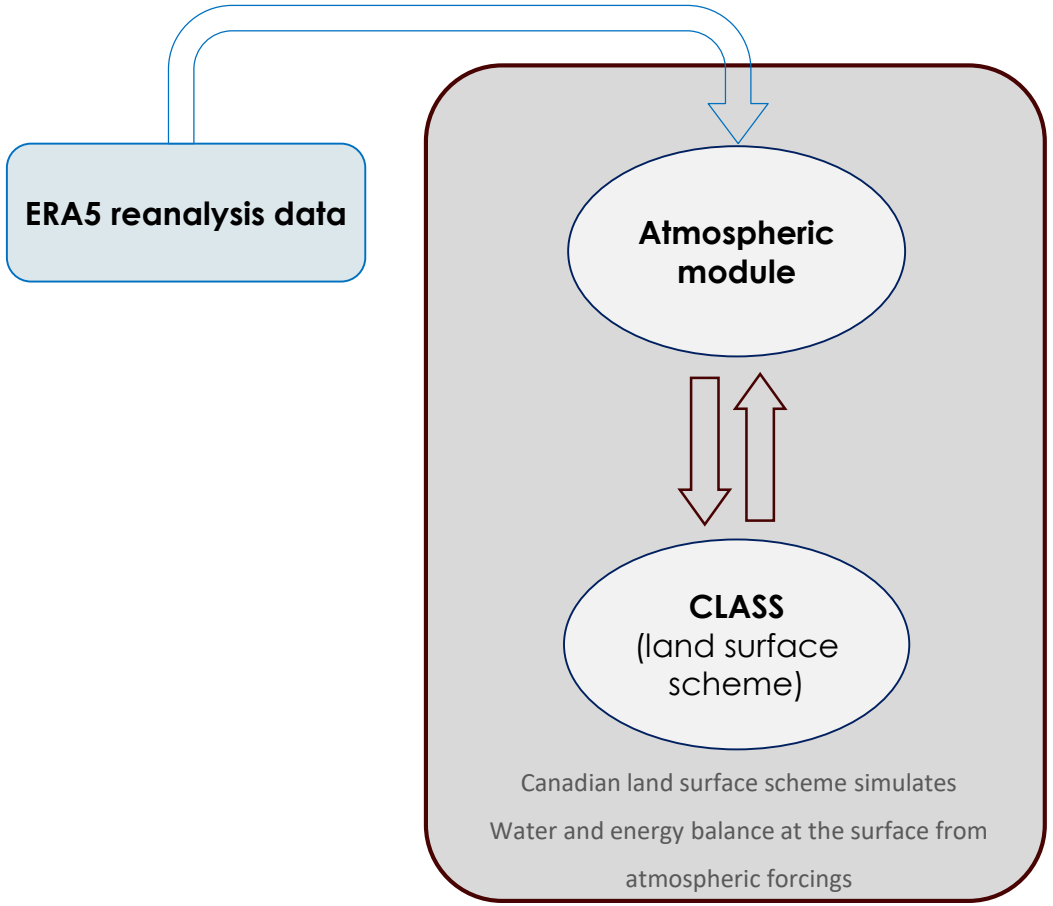
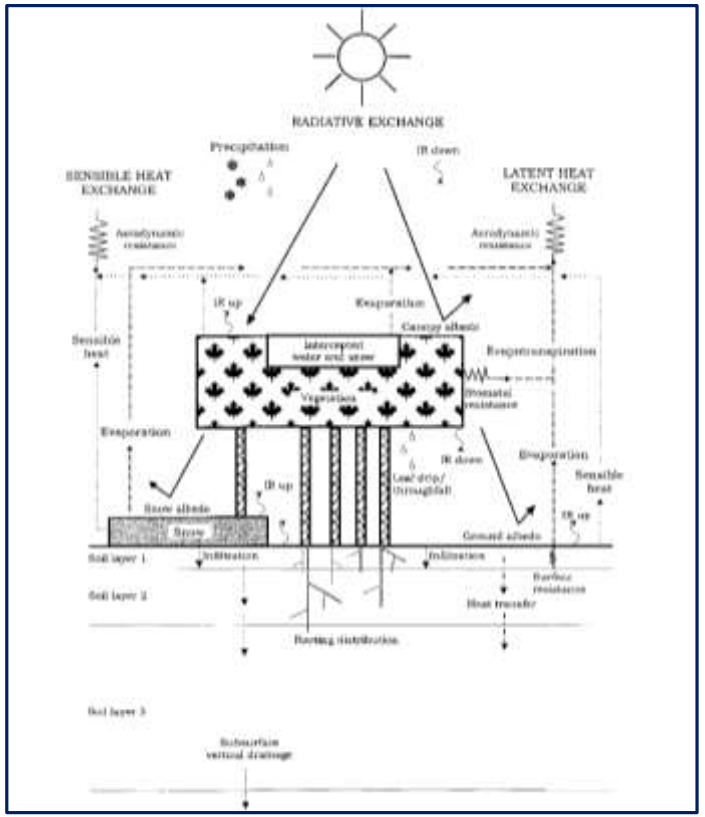
Canadian Regional Climate Model (CRCM)





Schematic diagram of CLASS (Verseghy, 2000)

Soil databases

ECOCLIMAP (Masson et al., 2003)

- Old database
- Used in Ouranos simulations for decades

cbs simulation

SIIGSOL (Sylvain et al., 2021)

- A new database introduced by Quebec government
- Higher resolution

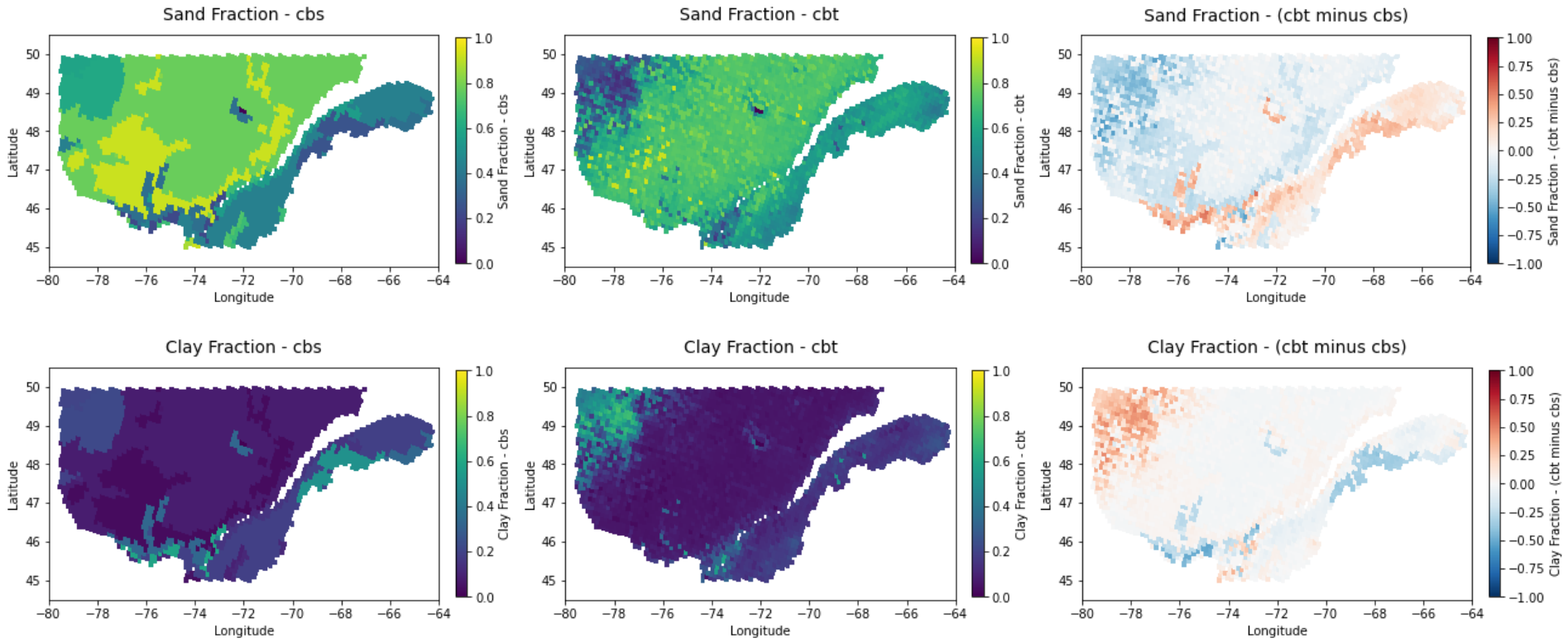
cbt simulation

Soil particles distribution and their spatial differences in Southern Quebec

ECOCLIMAP (cbs)

SIIGSOL (cbt)

The difference (cbt minus cbs)



Soil hydraulic properties and surface albedo

The role of soil texture in climate-hydrology dynamics

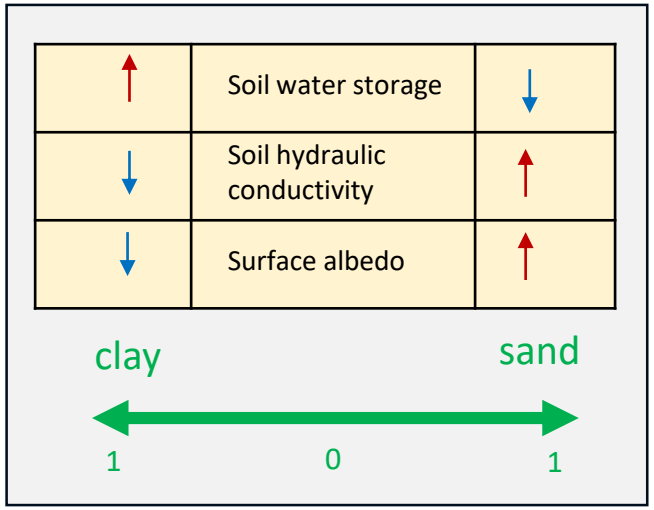
Changes in **soil porosity** and **saturated hydraulic conductivity.**

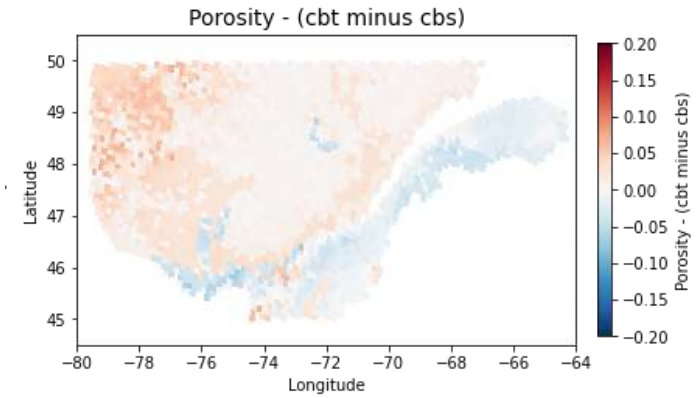
Thus, affecting soil water infiltration and retention capacity, root water update etc.

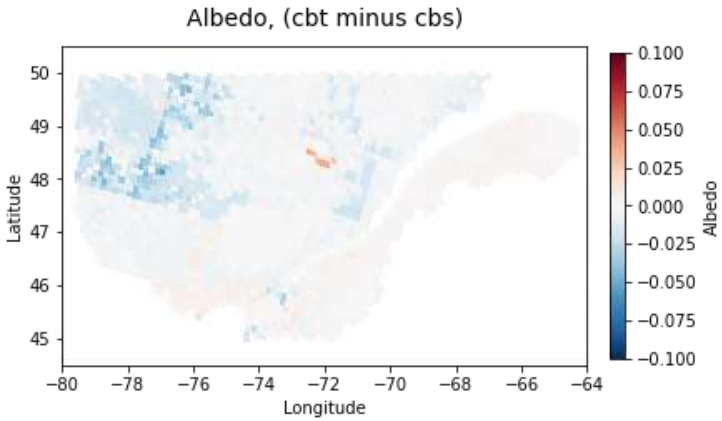
Resulting changes in soil moisture and partitioning of runoff and evaporation.

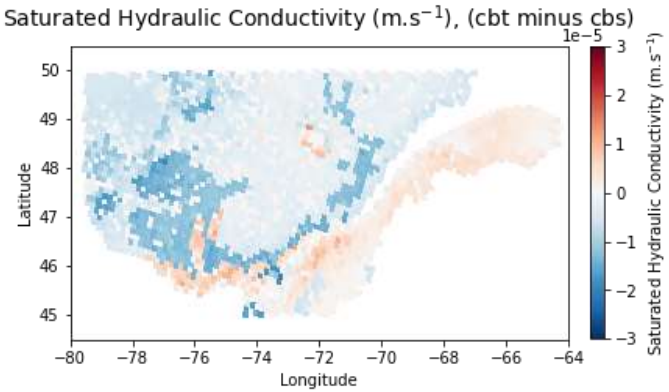
Different surface **albedo** due to different fraction of each soil particle in the two databases.

These changes could be reflected in the amount of energy received at the surface and its subsequent partitioning.









Summary of Studies on the effect of Soil Data

Category	Focus	Studies
Hydrological outputs	Evaluating the effect of soil data on hydrological outputs (e.g., runoff,	Gagnon et al., 2020; Steiner et al., 2014; Li et al., 2022; Laprise et al., 2020; Roy et al., 2014
Climate simulation	Examining how soil moisture initialization and soil moisture variations affect short-term climate outputs	Whidden et al., 2018; Seneviratne et al., 2019
	Addressing the effect of soil properties on daily climate outputs during short-term simulations	Tawfik & Dirmeyer, 2021 (WRF-CLM, USA); Zhang et al., 2023 (WRF-Hydro, Southern Africa)

Data analysis

- A large area in Southern Quebec with a total area of 427,066 km^2 was chosen for this analysis.
- Calculation of differences (**cbt minus cbs**) between the two simulations for each variable.
- Exploring the connection between the difference in climate outputs with the difference in soil (i.e. sand/clay fraction).
- What will be the magnitude of change in each output variable and their temporal variability solely as a result of change in soil database?

Studied variables

- Evapotranspiration
- Sensible heat flux
- Latent heat flux
- Net radiation
- Surface temperature
- Air temperature

Results

Evapotranspiration

(mm.day^{-1}), cbt minus cbs

Annual mean (1982-2021)

Southern Quebec

Total number of grid cells: 2,728

Annual differences of up to

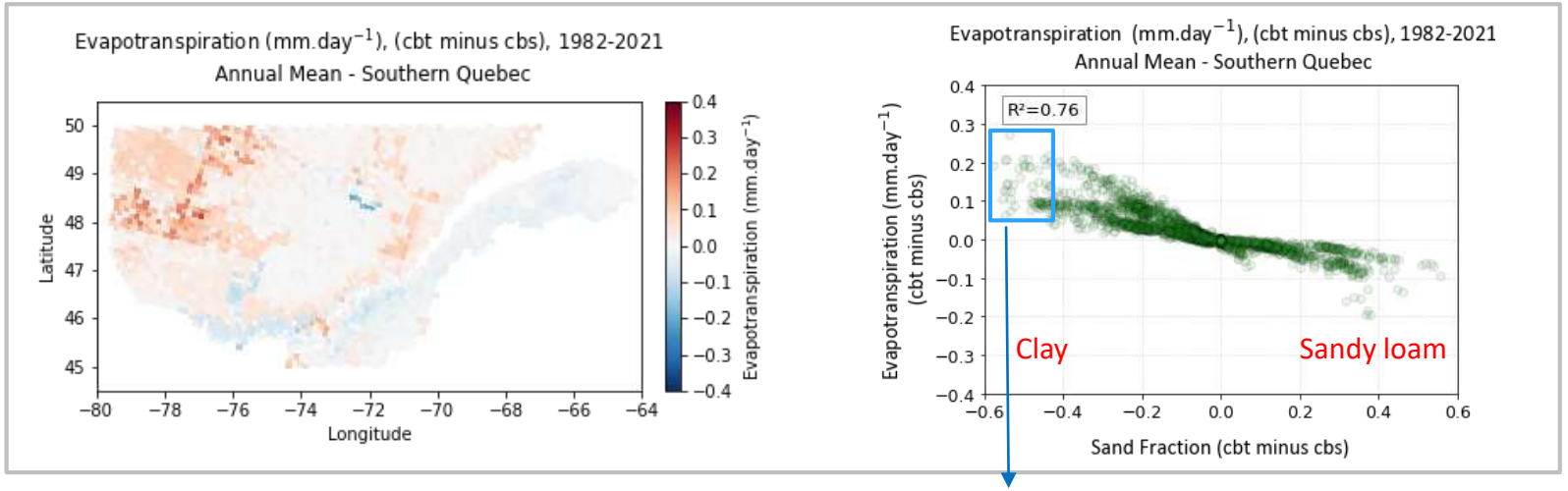
0.2 (mm.day^{-1})

Spatio-temporal mean (cbs):

1.5 (mm.day^{-1})

ECOCLIMAP → cbs

SIIGSOL → cbt



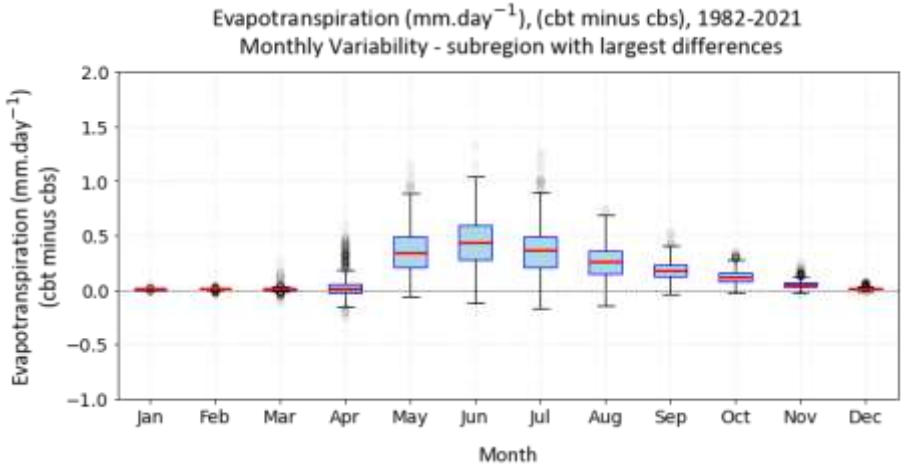
Subregion with largest differences

Number of grid cells: 50

Monthly mean (1982-2021)

Differences of up to **1 (mm.day^{-1})** in June

With a median of **0.4 (mm.day^{-1})** in this month



Results

Sensible Heat Flux

($W.m^{-2}$), cbt minus cbs

Annual mean (1982-2021)

Southern Quebec

Total number of grid cells: 2,728

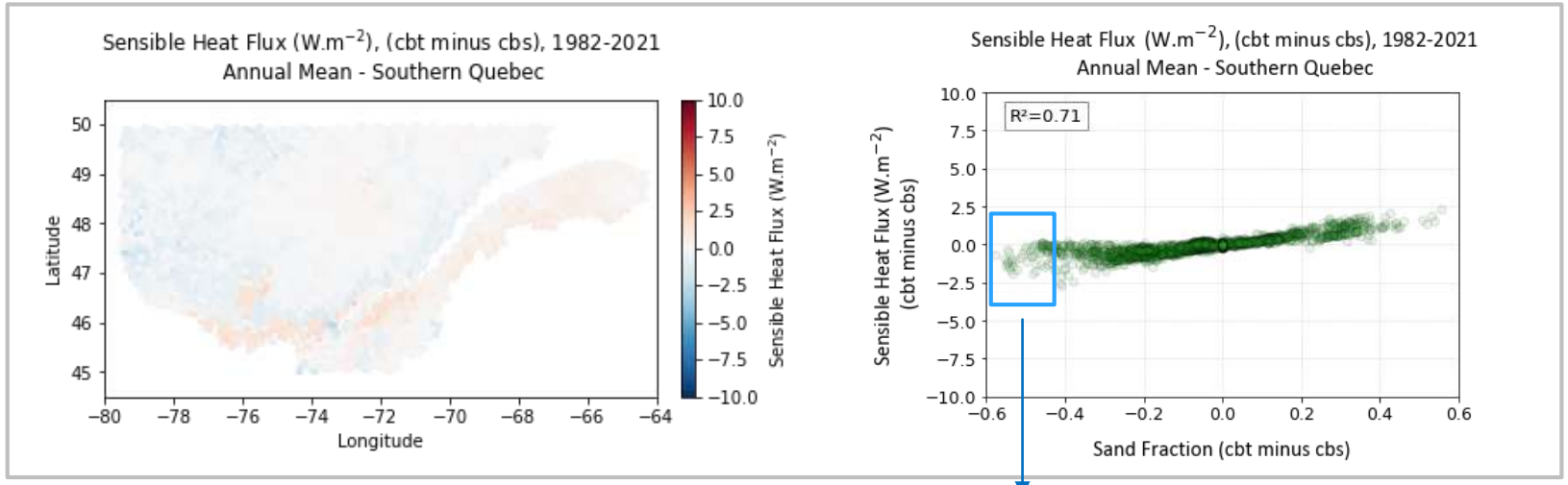
Annual differences of up to **-2 ($W.m^{-2}$)**

Spatio-temporal mean (cbs):

18 ($W.m^{-2}$)

ECOCLIMAP → cbs

SIIGSOL → cbt



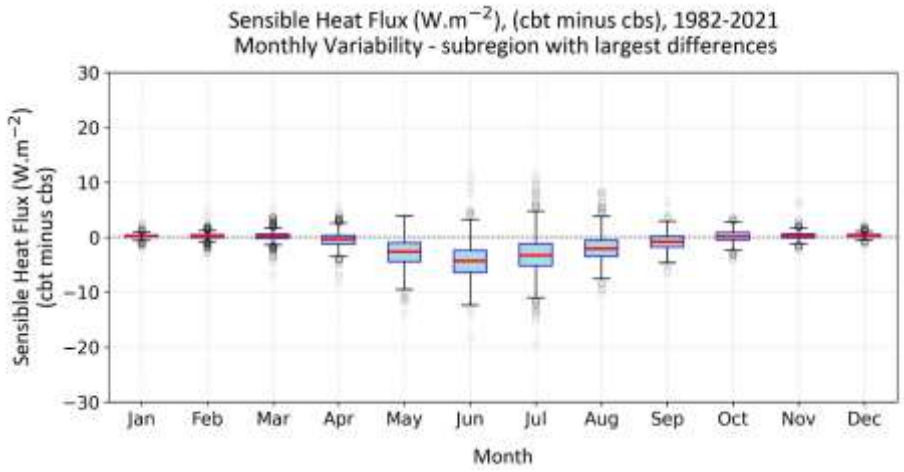
Subregion with largest differences

Number of grid cells: 50

Monthly mean (1982-2021)

Differences of up to **-10 ($W.m^{-2}$)** in June

With a median of **-5 ($W.m^{-2}$)** in this month



Results

Latent Heat Flux

($W.m^{-2}$), cbt minus cbs

Annual mean (1982 - 2021)

Southern Quebec

Total number of grid cells: 2,728

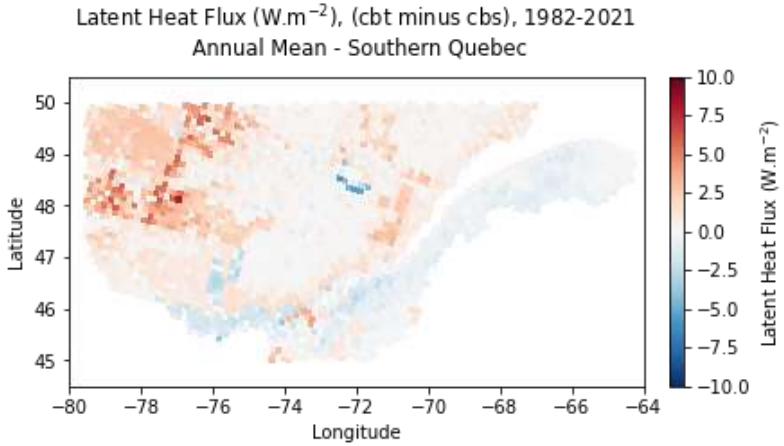
Annual differences of up to **6.5 ($W.m^{-2}$)**

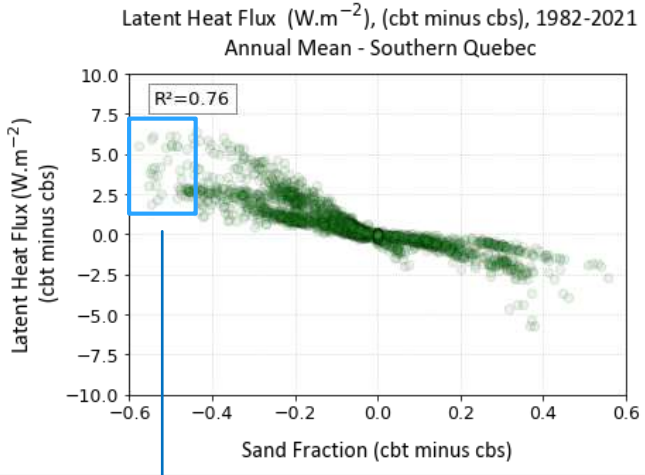
Spatio-temporal mean (cbs):

44.5 ($W.m^{-2}$)

ECOCLIMAP → cbs

SIIGSOL → cbt





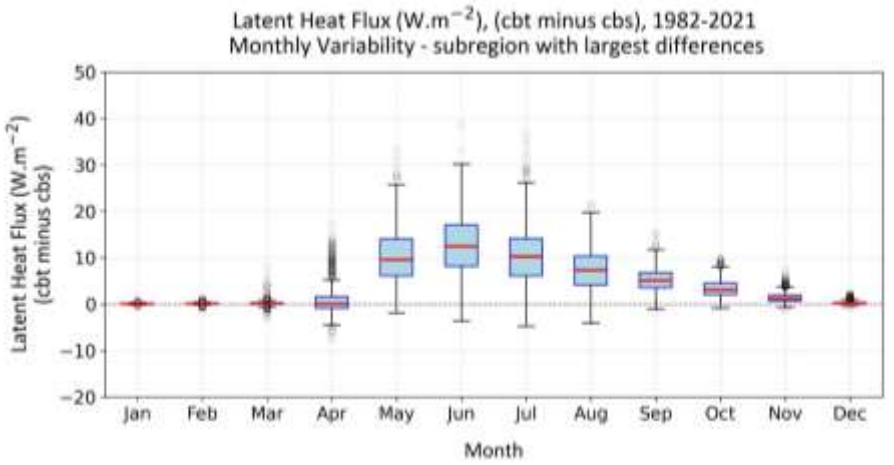
Subregion with largest differences

Number of grid cells: 50

Monthly mean (1982 - 2021)

Differences of up to **30 ($W.m^{-2}$)** in June

With a median of **12 ($W.m^{-2}$)** in this month



Results

Net Radiation

($W.m^{-2}$), cbt minus cbs

Annual mean (1982-2021)

Southern Quebec

Total number of grid cells: 2,728

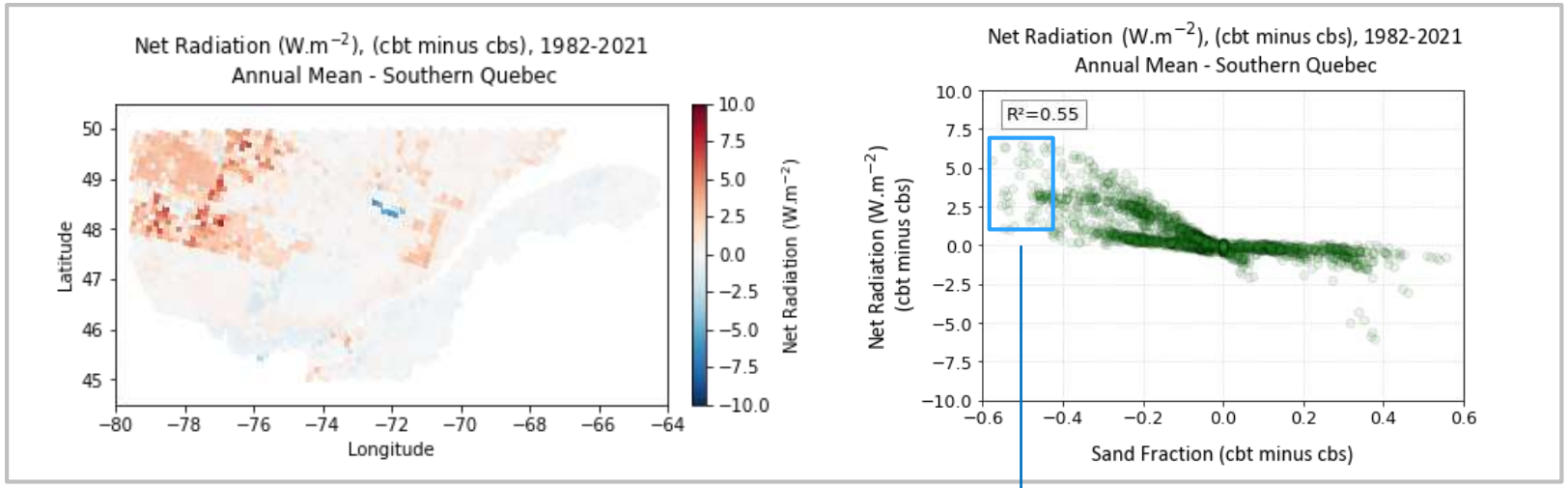
Annual differences of up to **7 ($W.m^{-2}$)**

Spatio-temporal mean (cbs):

66.5 ($W.m^{-2}$)

ECOCLIMAP → cbs

SIIGSOL → cbt



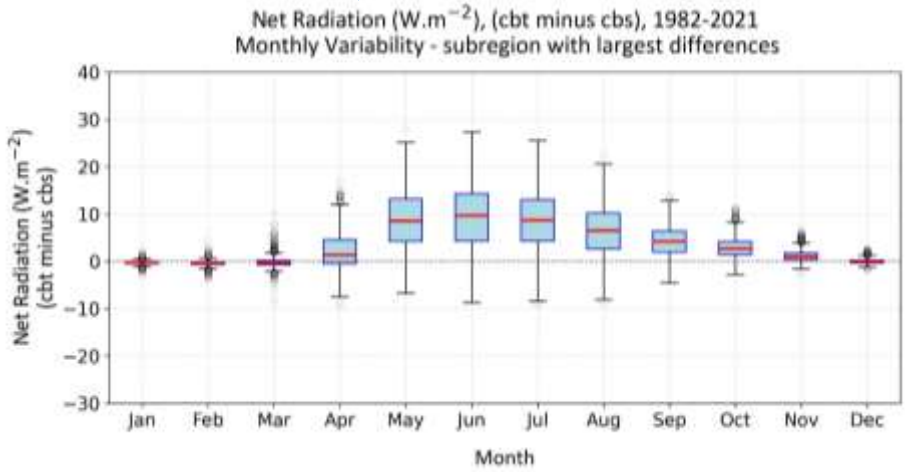
Subregion with largest differences

Number of grid cells: 50

Monthly mean (1982-2021)

Differences of up to **28 ($W.m^{-2}$)** in June

With a median of **10 ($W.m^{-2}$)** in this month



Results

Surface temperature

(°C), cbt minus cbs

Annual mean (1982-2021)

Southern Quebec

Total number of grid cells: 2,728

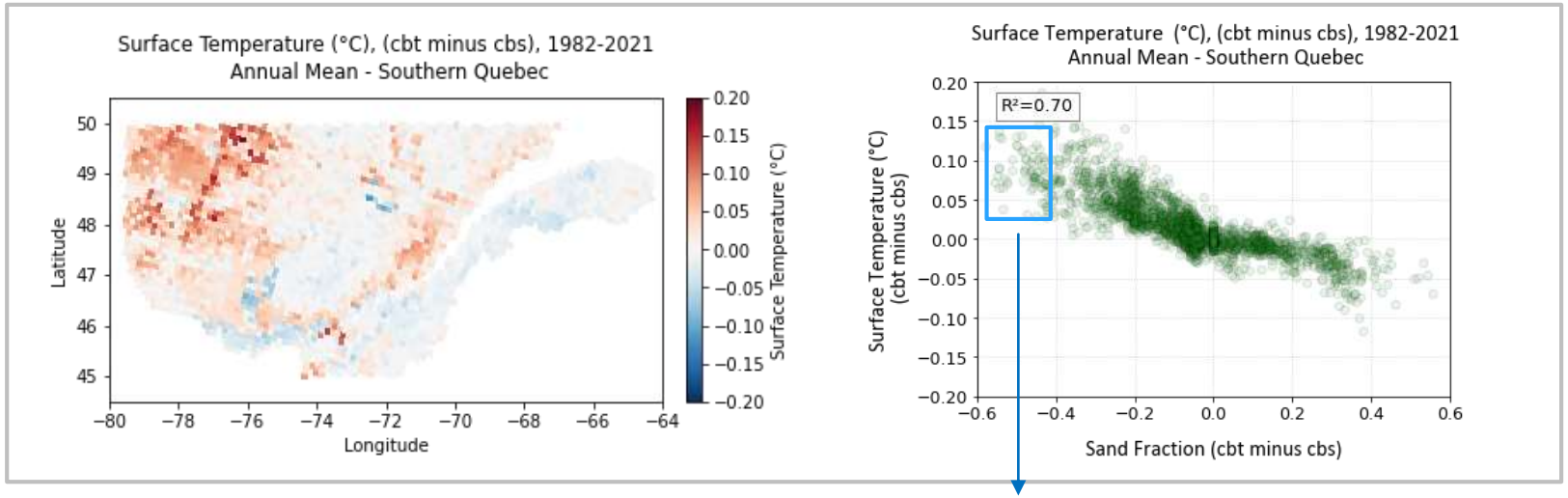
Annual differences of up to **0.15 (°C)**

Spatio-temporal mean (cbs):

2.5 (°C)

ECOCLIMAP → cbs

SIIGSOL → cbt

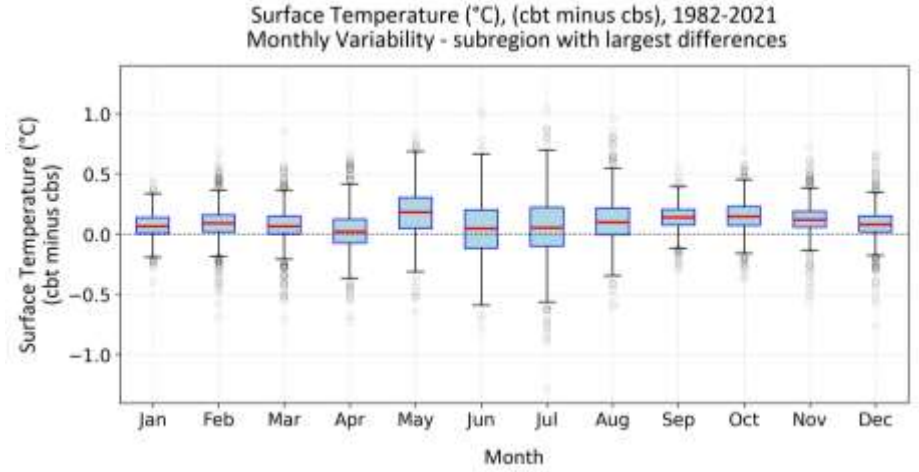


Subregion with largest differences

Number of grid cells: 50

Monthly mean (1982-2021)

Differences of up to **0.7 (°C)** in July



Results

Air temperature

(°C), cbt minus cbs

Annual mean (1982-2021)

Southern Quebec

Total number of grid cells: 2,728

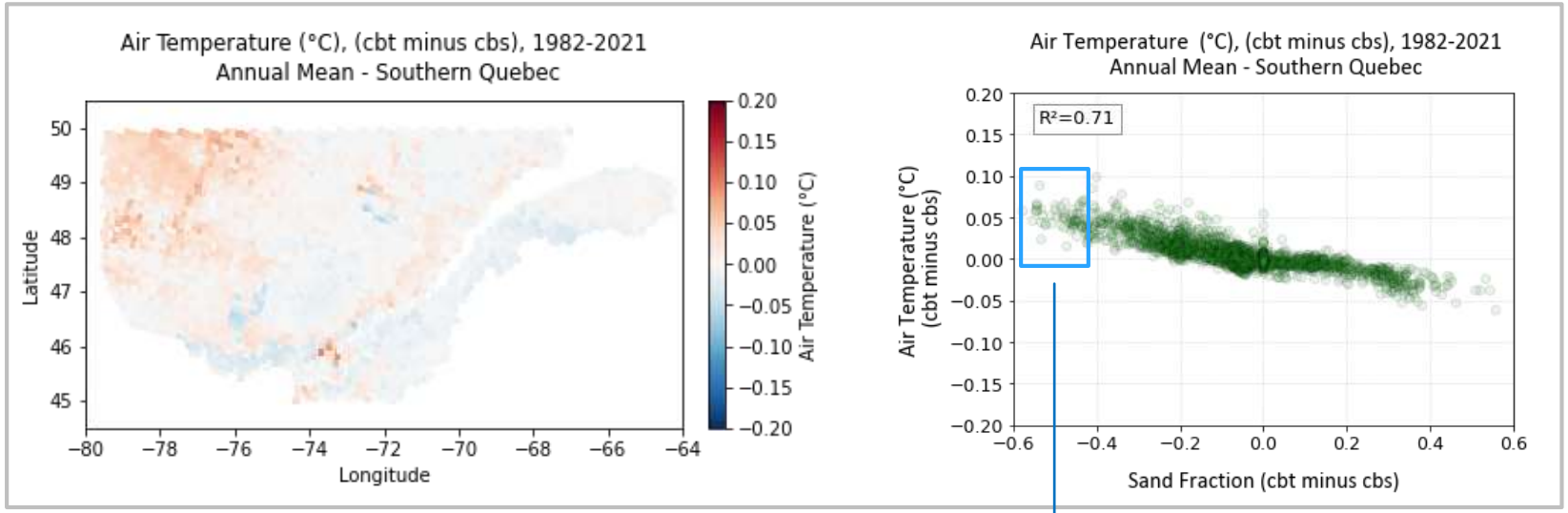
Annual differences of up to **0.1 (°C)**

Spatio-temporal mean (cbs):

2.5 (°C)

ECOCLIMAP → cbs

SIIGSOL → cbt

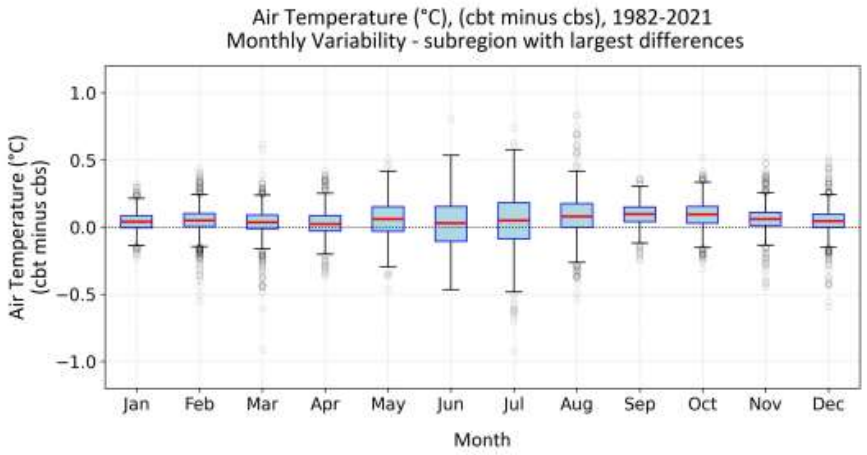


Subregion with largest differences

Number of grid cells: 50

Monthly mean (1982-2021)

Differences of up to **0.6 (°C)** in July



Results

Air temperature (°C), cbt minus cbs

Subregion with largest differences

Number of grid cells: 50

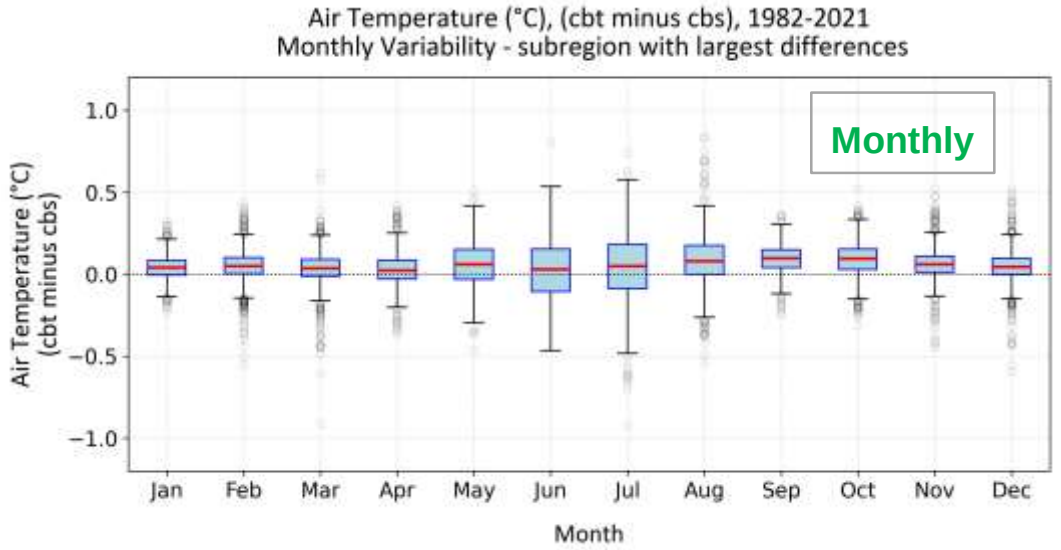
Monthly mean (1982-2021)

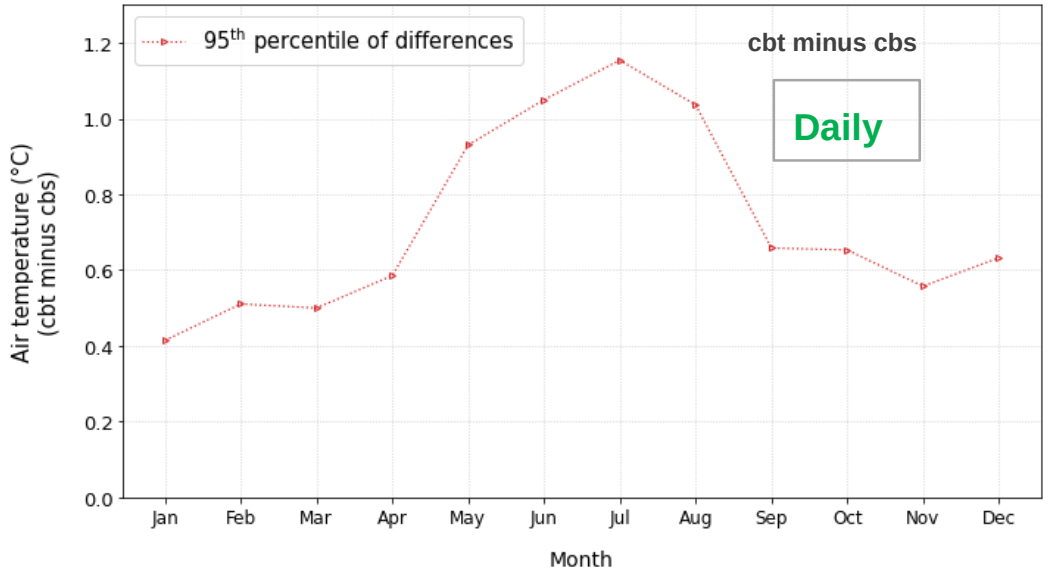
Monthly differences of up to **0.6 (°C)**.

Extreme values:

Daily differences of up to **1.2 (°C)** in July

Spatio-temporal mean (cbs): 2.5 (°C)





Conclusion

Water fluxes

A remarkable influence on the hydrologic outputs could be observed. The magnitude of effects can vary directly depending on how large the differences are between the input soil textures.

Energy fluxes

Both net radiation and heat fluxes (sensible and latent) were substantially influenced by changes in soil texture.

Climate output

Daily air temperatures changed by more than one degree Celsius due to variations in soil texture. Although the impact of soil texture on annual air temperature was relatively small, the strong correlation between air temperature differences and soil texture variations, combined with the monthly variability of these differences suggest careful consideration of soil input data in climate modelling.

Acknowledgement

- Ouranos

For their great contribution in providing the cbs and cbt simulations

- Jean-Daniel Sylvain

For the efforts they made in developing the new soil database (SIIGSOL)

Thank you for your attention

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