



# Reconciling the carbon balance of northern Sweden using measurements and modelling.

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# Background & objectives for the project

- Boreal forest is an key component in climate mitigation strategies. Not yet known as to what extent the boreal region contribute to the global carbon sink. Hence it is necessary to provide the accurate accounting of C budgets.
- The aim of our study is to connect different carbon cycle observations to reconcile carbon fluxes and to estimate the carbon balance of northern Sweden with specific objectives

1. To compare model estimates of the fluxes and concentration with observation at site scale
2. Determine how well the atmospheric observation network can constrain the fluxes in the Nordic region.
3. To investigate how modelled and observed carbon fluxes and atmospheric concentration compare during the 2018 drought episode .

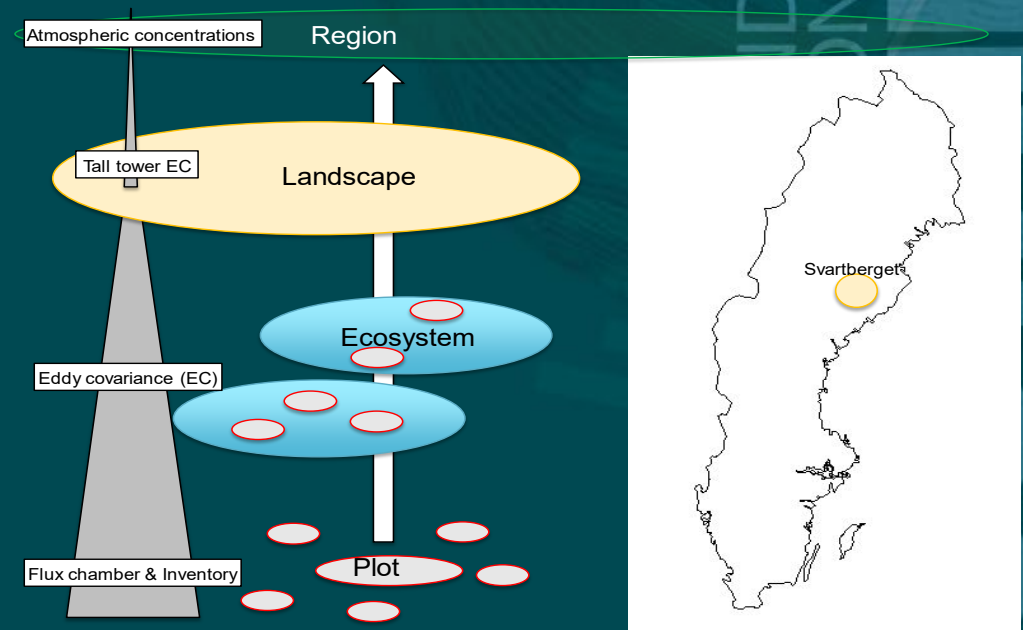


Figure 1: Schematic diagram showing a GHG emission assessment system from local to regional scale

# Materials and Methods

## 1. Local Fluxes - Observations at SVB

- The measured regional fluxes are collected from a tall tower EC system installed at 60m on the 150m ICOS tower in Svartberget measuring CO<sub>2</sub>, water vapour, and energy exchange between the boreal landscape and the atmosphere.
- It consists of a CSAT3 3-D sonic anemometer and an EC155 closed-path gas analyzer (Campbell Scientific, Inc., USA).
- The measured NEE was processed following ICOS protocol, gap-filled and source partitioned into the two flux components GPP and Reco.

## 2. Regional Fluxes -Ecosystem and Diagnostic vegetation models

- Process based ecosystem models
  - LPJG
  - ORCHIDEE
- Diagnostic models
  - VPRM
  - SiBCASA

# Materials and Methods

## 1. Atmospheric CO<sub>2</sub> Concentration Measurements

- Continuous in situ observations of CO<sub>2</sub> concentration -GLOBALVIEWplus observation package
- For 2016-2018, observations from eight sites within our regional study domain are available.
- High frequency CO<sub>2</sub> concentration measurements at several vertical levels up to 150m using tall towers part of the European ICOS atmospheric network. Selected the observations at highest level

## 2. Transport model (LUMIA system)

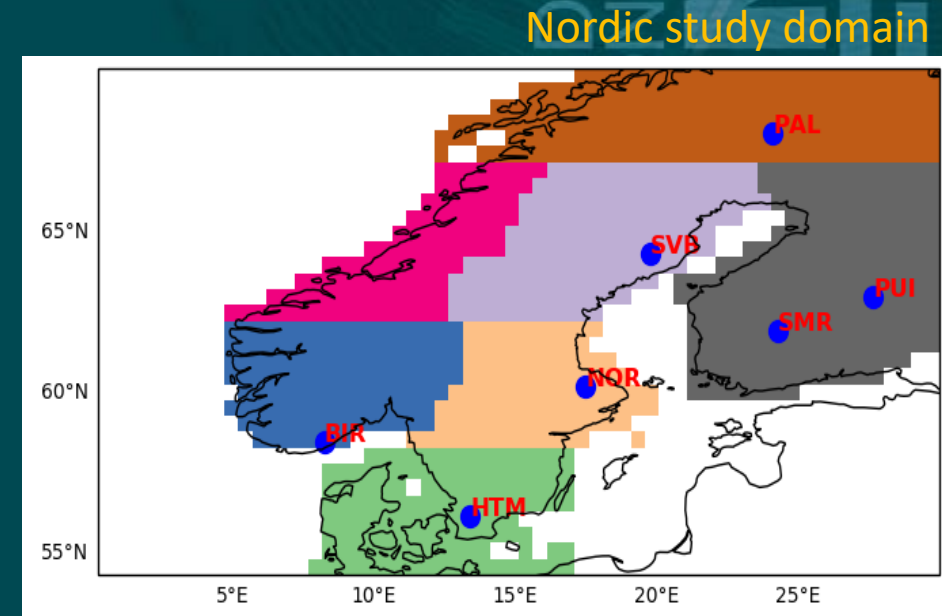
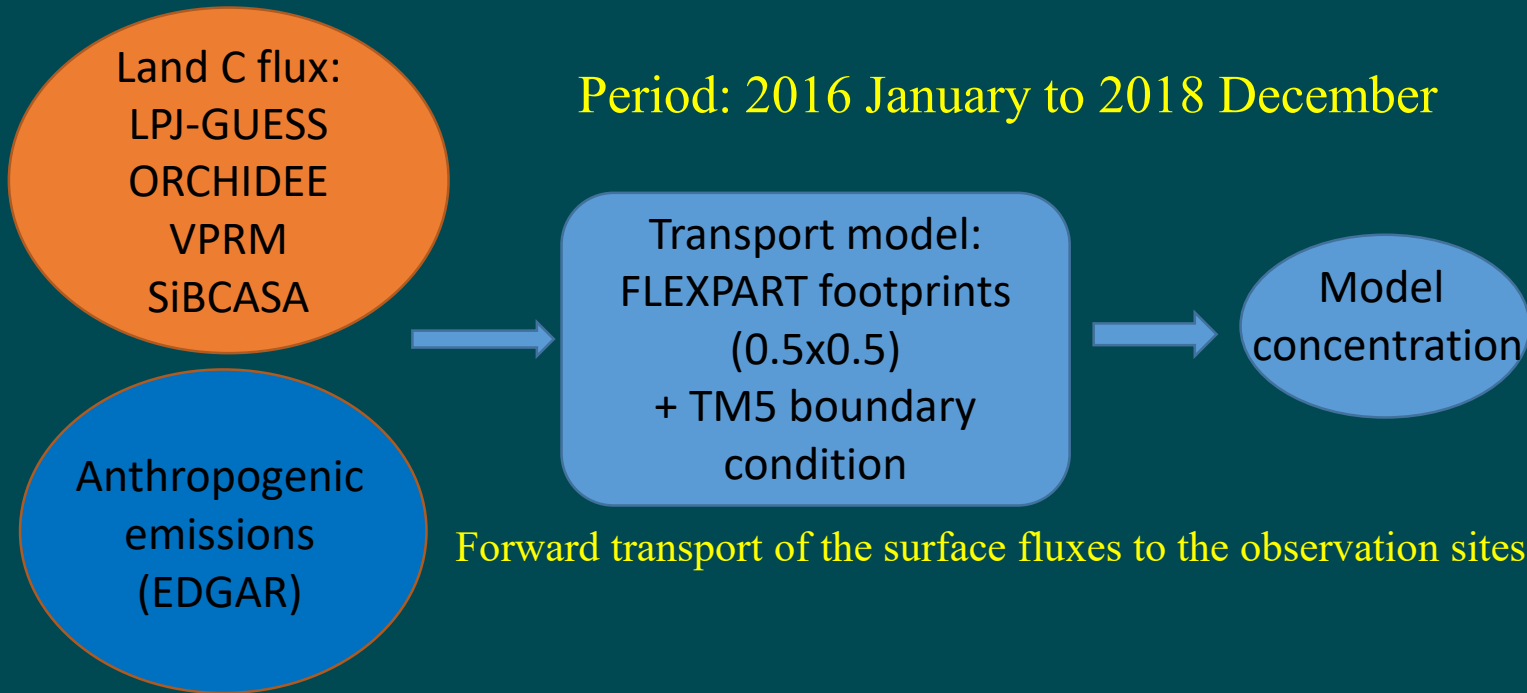


Figure 2: Map showing the Scandinavian study domain with ICOS atmospheric observation sites and different geographical regions.

## 1. Comparison of fluxes at SVB- Local Landscape scale

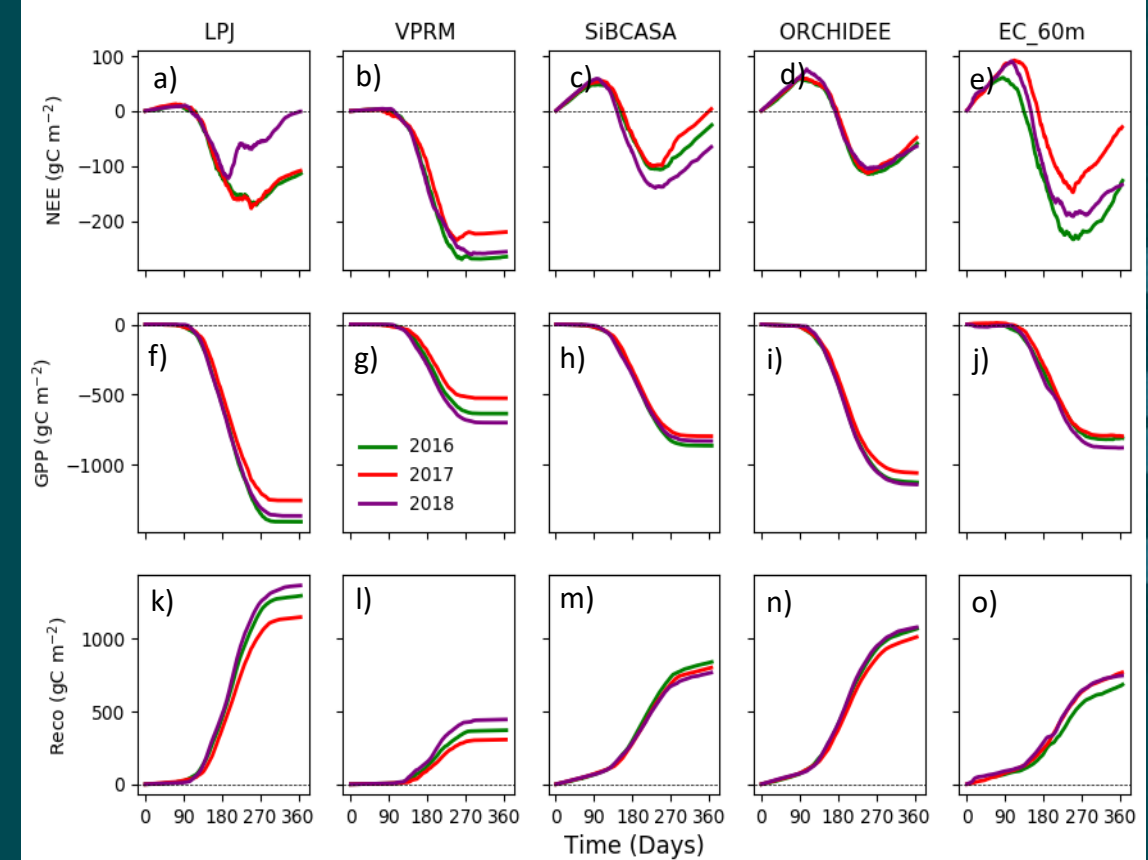
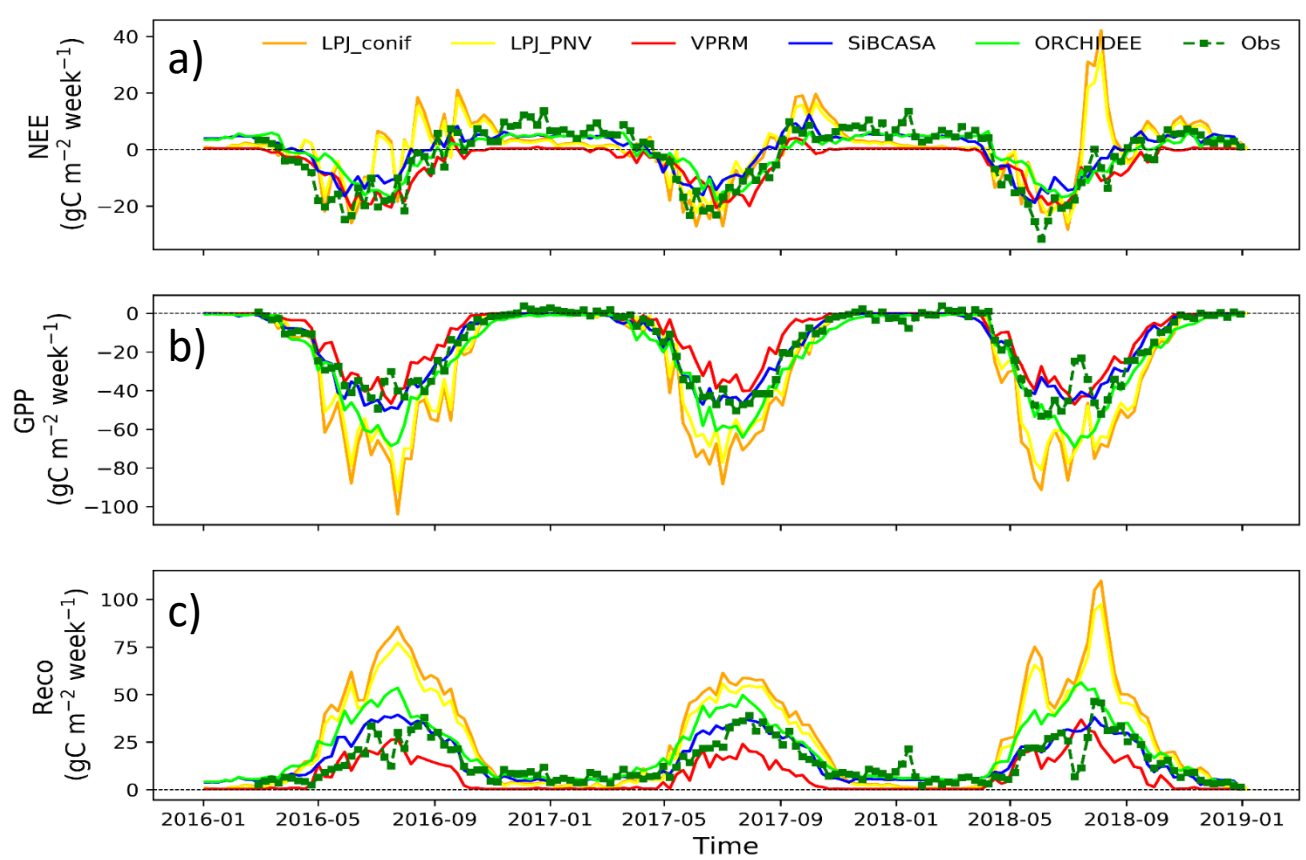
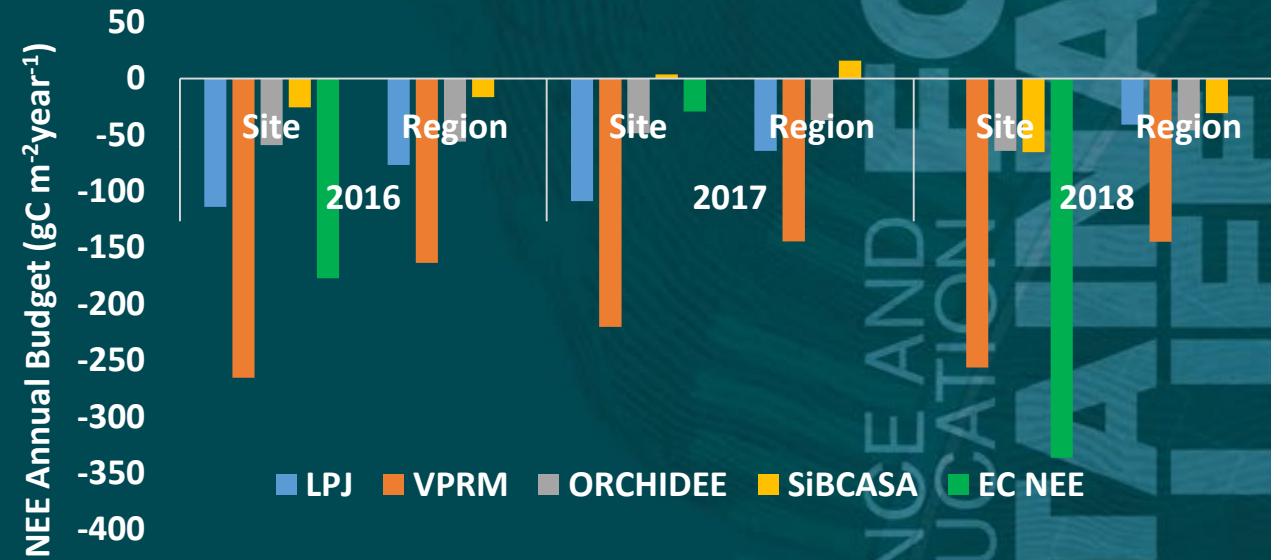
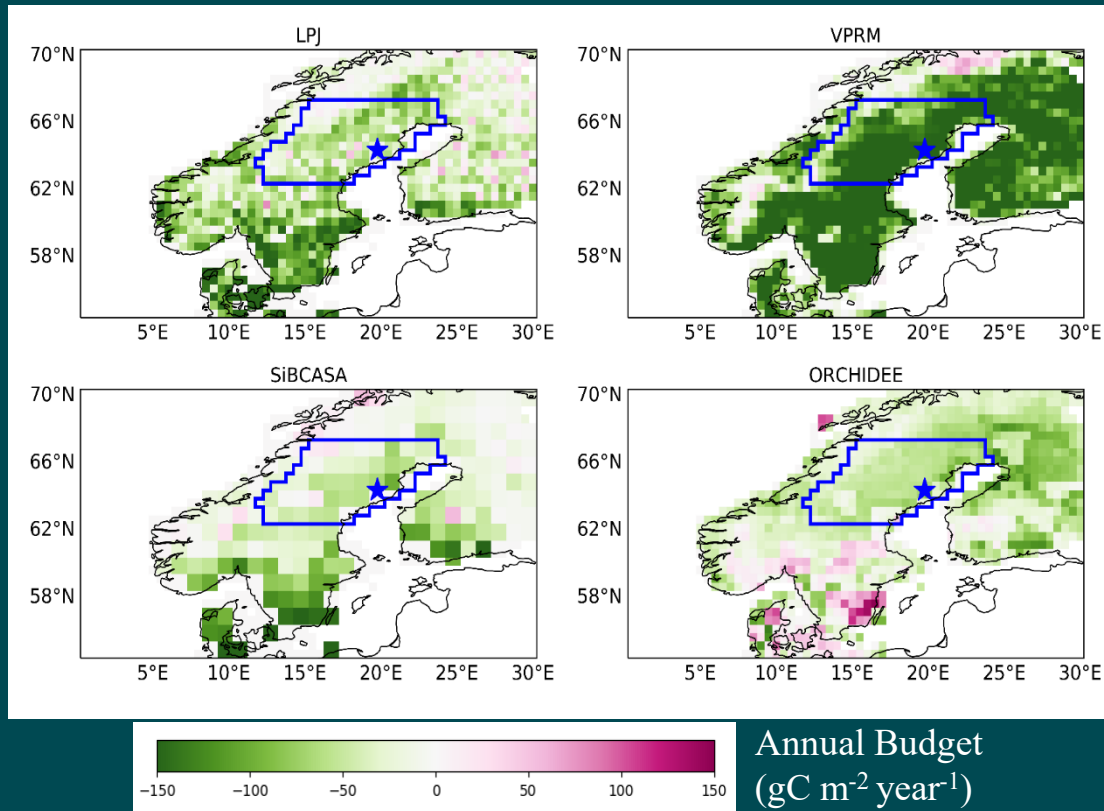


Figure 3: Comparison of the weekly time series and cumulative net CO<sub>2</sub> exchange (NEE) estimated from 2016 to 2018 from four different models and landscape level eddy covariance measurements at 60m height at the ICOS-Svartberget (SVB) station.

## 2. Comparison of regional fluxes

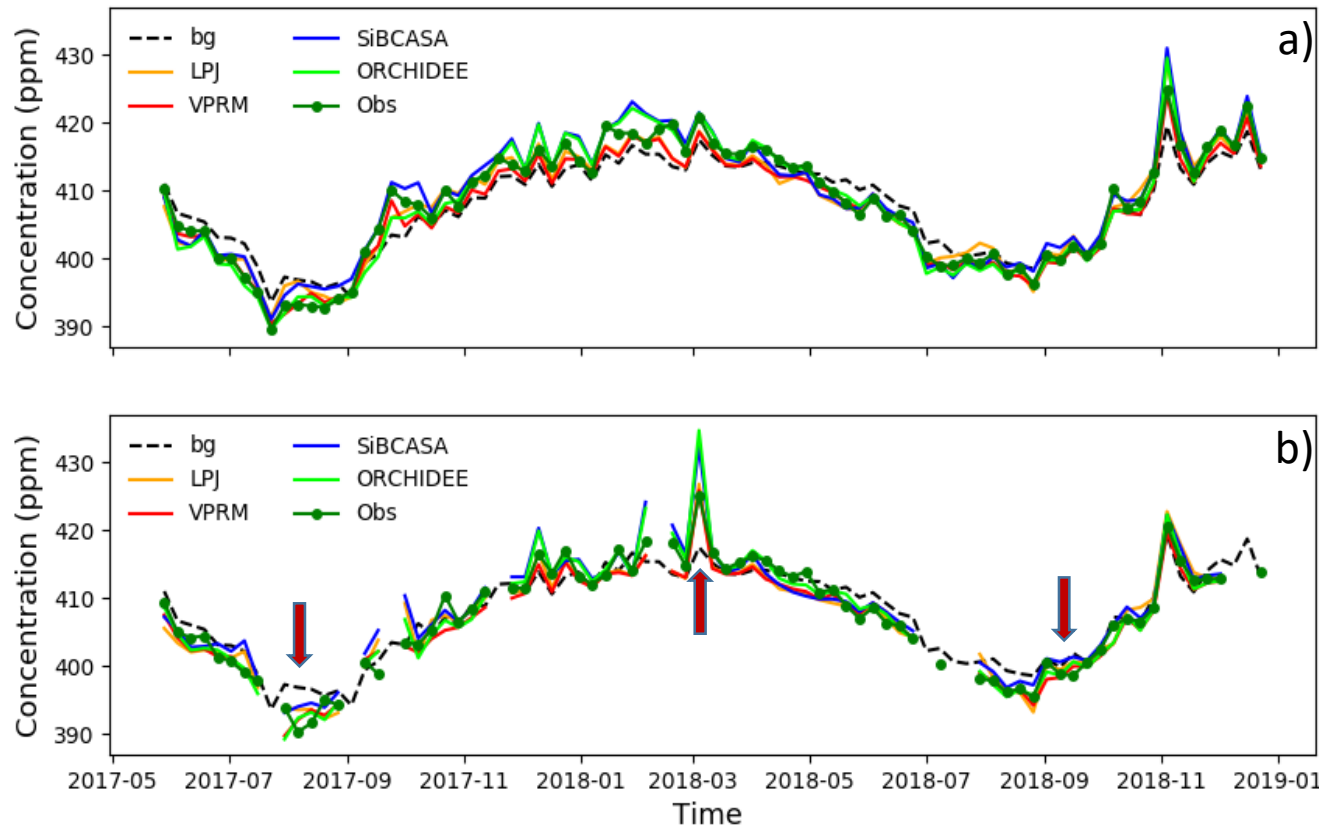
To examine **how much widespread the features seen at the local landscape level is** and how much SVB can represent the northern Sweden region



All the models showed the site as well as the region is a C sink for all the years. The year 2017 is a lesser sink (and even a small source in SiBCASA) for both site and region in all models, which is contradicted only for LPJG in 2018.

Figure 4: Spatial map of NEE Annual Budget for 2018 from all different models.

## 3. Comparison of CO<sub>2</sub> concentration



LUMIA simulated concentration using fluxes from vegetation models is compared with observed concentration at SVB. Concentration can be sensitive to fluxes from any region. In second figure concentration is plotted only when the site is more than 90 % sensitive to fluxes within north Sweden region. The background uncertainty is the same for all simulations.

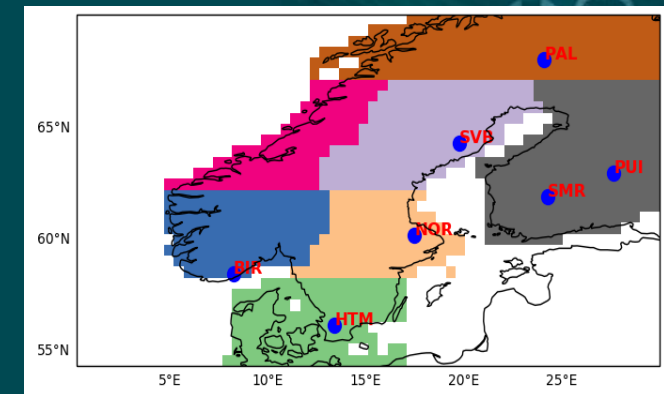


Figure 5: Time series comparison of LUMIA simulated concentrations with observed concentration at SVB. (b) Concentration is taken only when the observations are sensitivite to fluxes of northern Sweden region is more than 90%.

- we have established a framework for combining different observations (flux and concentrations) and models (vegetation and atmospheric transport) to investigate the carbon balance of northern Sweden and to explore how representative the experimental site SVB is for the northern Sweden region
- We find that the northern Swedish boreal study region was a carbon sink for all the years (2016-2018) whereas models differed in sink strength, inter and intra-annual variability as well as in the response to 2018 drought.
- The difference among modelled concentration when the observations are sensitive to N Sweden proves **the potential of observations to be used for refining the flux estimates.**
- Our study overall highlights **the need to further improve vegetation models through model-data inter-comparisons and** using inverse transport models.