R Scripts for Eddy Covariance and Storage Flux Systems

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Preface

- Workshop requirements
  - Attended the *Statistical Analyses using R* course.
  - PC or Mac installed with R (and RStudio).
  - Internet
- Workshop schedule (tentative)
  - 9 – 10 AM: PC/Mac basic setup (*Version control* – GitHub; R and RStudio)
  - 10 – 1 PM: Data analysis of Eddy Covariance and Biomet Systems (including tea break if any)
  - 1 – 2 PM: Lunch
  - 2 – 3 PM: Data analysis of Storage Flux systems
  - 3 – 4 PM: Data analysis of Soil Chamber systems (including tea break if any)

Workshop Outcomes

- By the end of this workshop, you will be able to,
  - Understand the developed R script.
  - Use the R scripts.
  - Modify the R scripts.

PC/Mac Basic Setup

- Make sure you have R and RStudio installed.
- Now, we are going to download the scripts stored in an *online repository* called GitHub (a *version control* software system).
  - Go to the website: http://github.com/yusriy/fluxMPOB
  - Download the ZIP file by clicking the *Download ZIP* button.
  - Unzip and place the downloaded folder *fluxMPOB-master* into your *Documents* folder.
  - Double-click the *fluxMPOB.Rproj* file, RStudio should run.

R Folder Structure

- Within the R Project folder there are sub-folders:
  - *Data*
    - Where you should store your data.
  - *R*
    - Where you should keep your R scripts.
  - Extra: *Figs*
    - Where the output in the form of figures should be written to.
  - *Docs*
    - Where you should keep the relevant documents or manuscripts.
  - *README.md*
    - A *Markdown readme* file to explain about the Project to users. Recommended to have for every project, especially in GitHub.

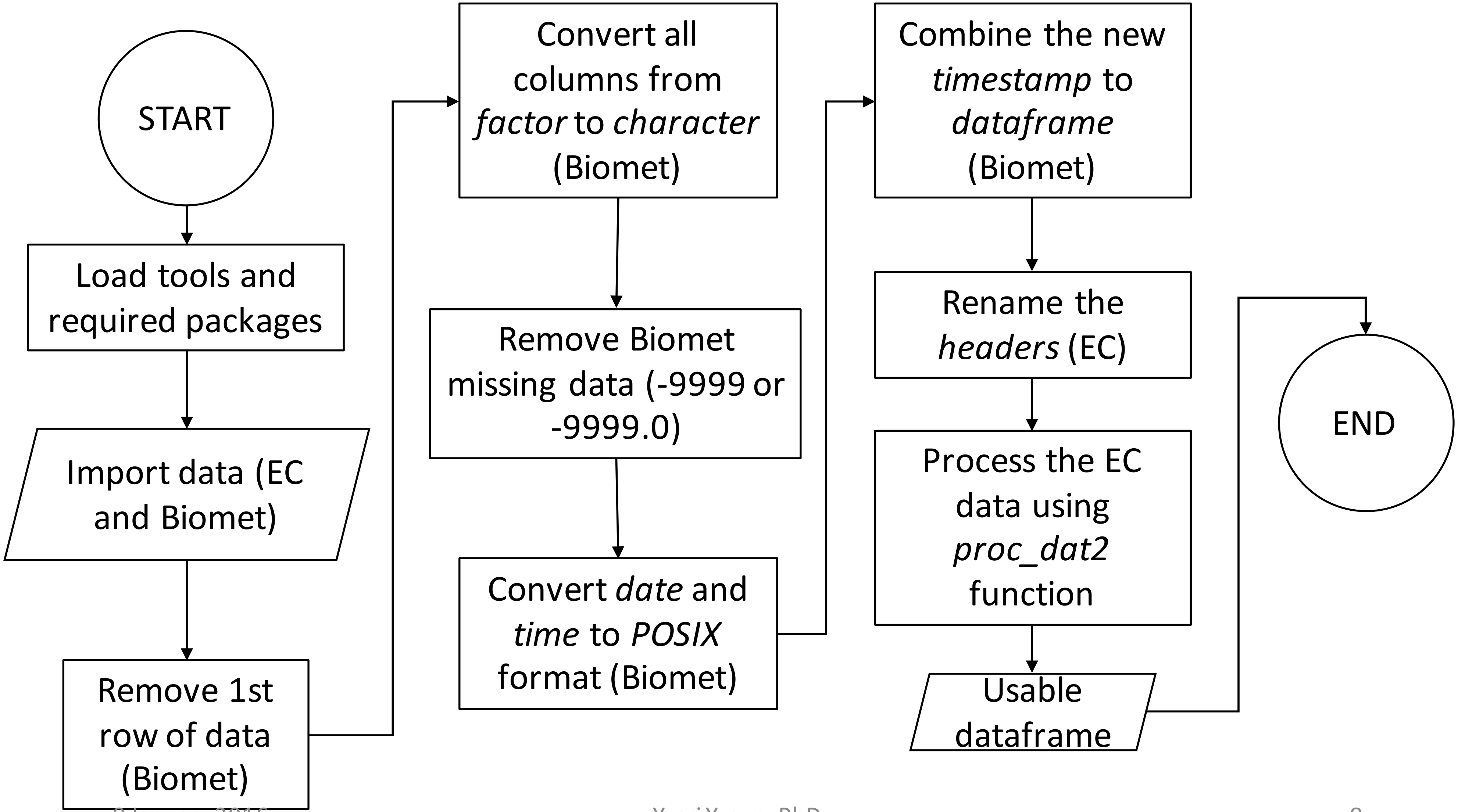
Eddy Covariance and Biomet Systems

- Output from EddyPro
  - Within (usually) *RESULTS* folder of the *Result_EDDYPRO* folder.
  - EC – *Full Output* – contains all measured and calculated parameters of EC (many of them you will not use)
  - Meteorological data – *Biomet* – contains only meteorological data.
  - The *timestamp* of both EC and Biomet should be the same. – the function of the *Sutron* datalogger.
    - Very important because this is how we can merge both datasets together.

EC and Biomet Parameters

- Open the *Full Output* data file in the *data* folder.
- A **<u>LOT</u>** of parameters/variables with many of them unimportant but I recommend using this dataset instead of the *Essential* dataset because you never know when you might want to refer to a any of the variables for troubleshooting, e.g., qc (quality control), etc.
- Now, we **<u>discuss</u>** on some of the variables in detail.
- … and **<u>study</u>** the EC data import and processing R script.

EC and Biomet R Script Flowchart



Understanding the EC and Biomet data

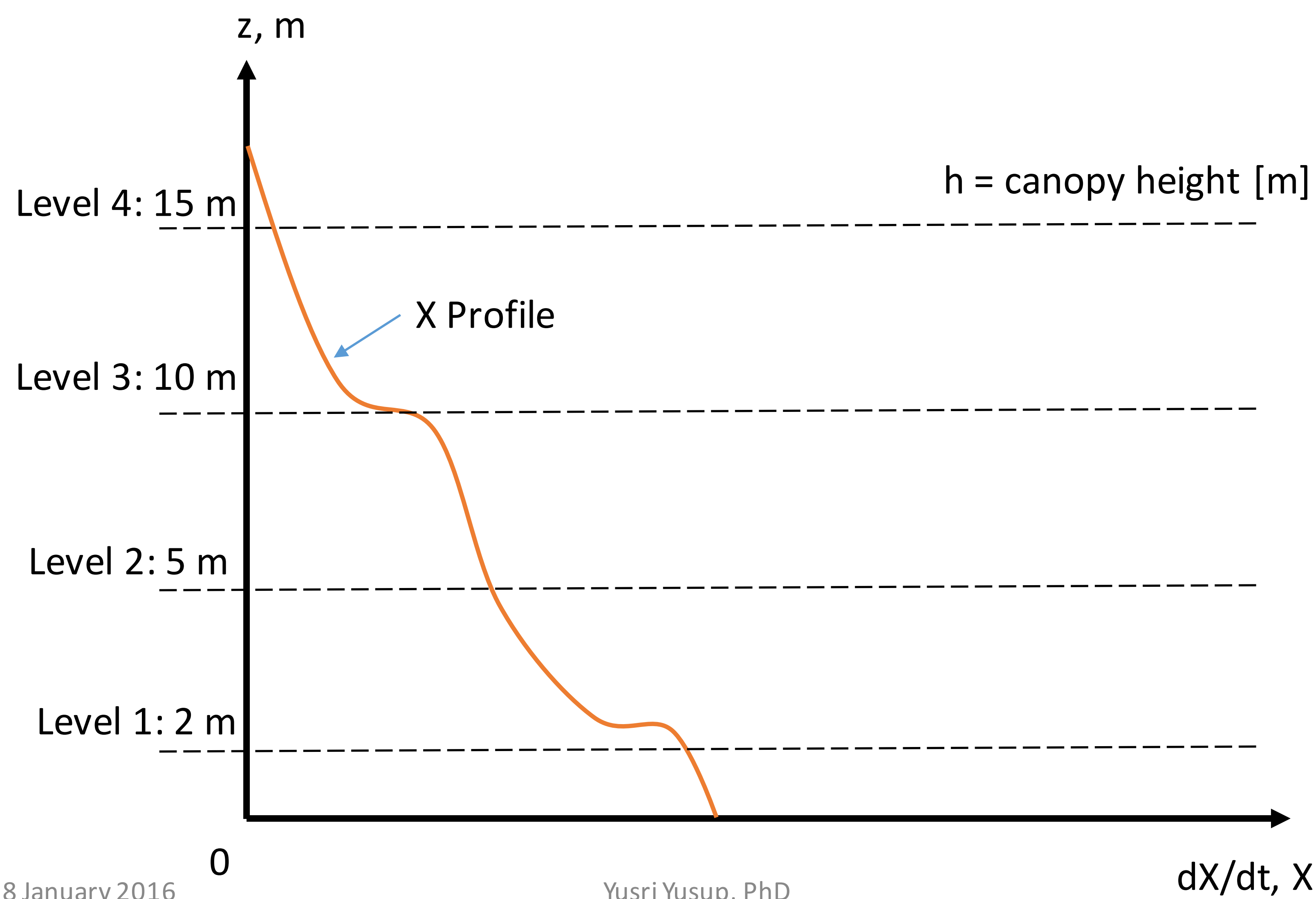
- Start with `summary()`, `plot()`, `hist()`, etc.

Storage Fluxes (LE, H, CO2) Parameters (Profiler)

- Storage flux equations for LE, H, and CO_2 *(Finnigan, 2006) used are the same as the ones employed by LI-COR.
- The units of LE, H, and CO_2 are the same as given by EC [W m^{-2}].
- Multi-level measurements of H_2O, T, and CO_2 are needed to calculated amount of energy/concentration flux stored in the canopy.
- H and LE storage fluxes can also be calculated from the EC dataset since multi-level T and RH were also collected.

*Finnigan, J. (2006). The storage term in eddy flux calculations. *Agricultural and Forest Meteorology*. 136, 108-113.

Multi-level Measurements



Note: Heights are based on the Keratong EC tower

Storage Flux Equations

$$LE\ storage\ flux = \frac{\lambda}{MW}\int_0^h \frac{dH_2O}{dt}dz$$ [W m^{-2}]

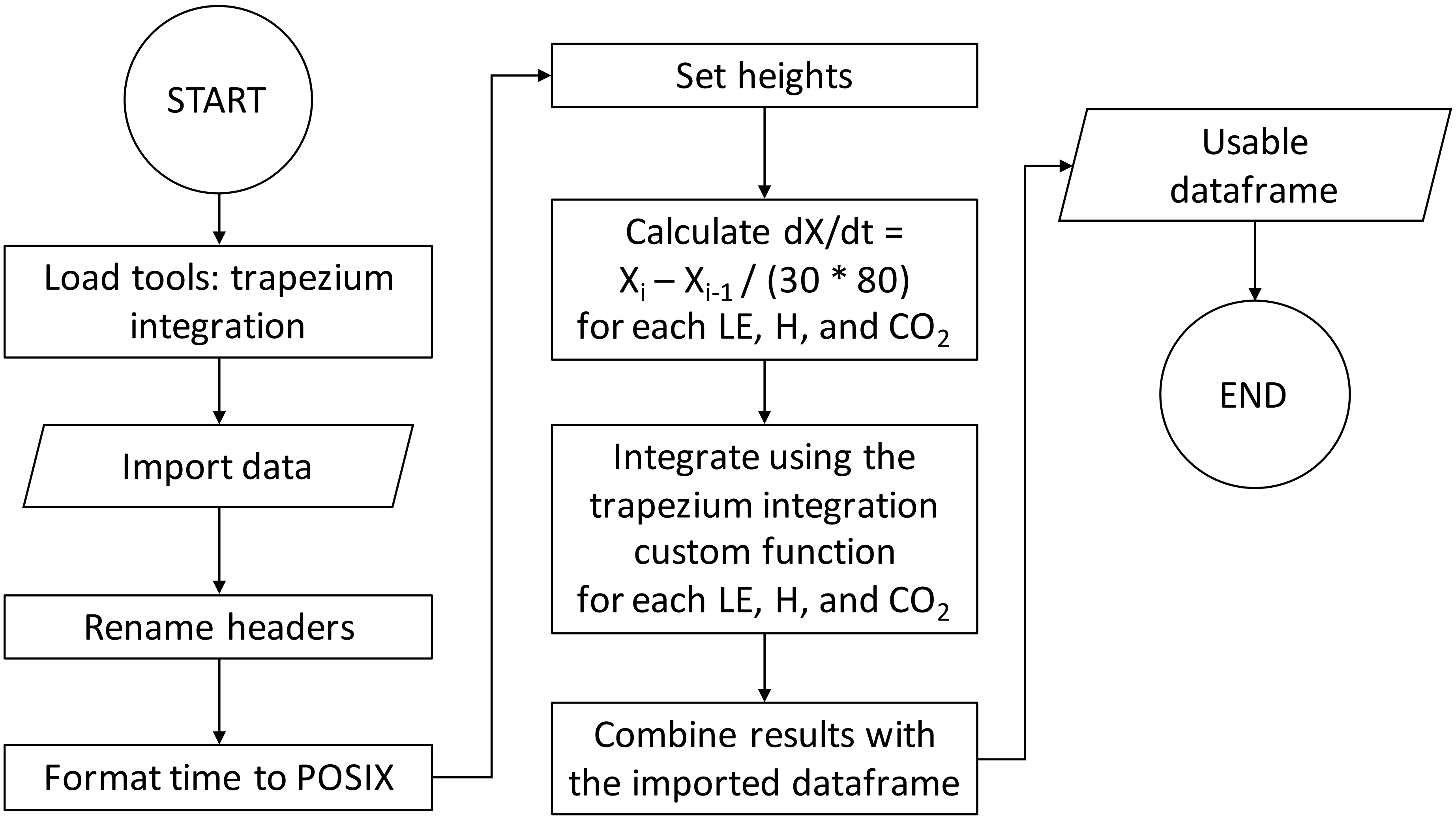
λ = latent heat of vaporization = 2540000 J kg^{-1}
MW = 18 kg mol H_2O^{-1}

$$H\ storage\ flux = \rho_{dry\ air}\ c_{p,dry\ air}\int_0^h \frac{dT}{dt}dz$$ [W m^{-2}]

ρdry air = density of dry air = 1.2754 kg m-3
$c_{p,\ dry\ air}$ = heat capacity of dry air = 1005 J kg^{-1} K^{-1}

$$CO_2\ storage\ flux = \int_0^h \frac{dCO_2}{dt}dz$$ [µmol m^{-2} s^{-1}]

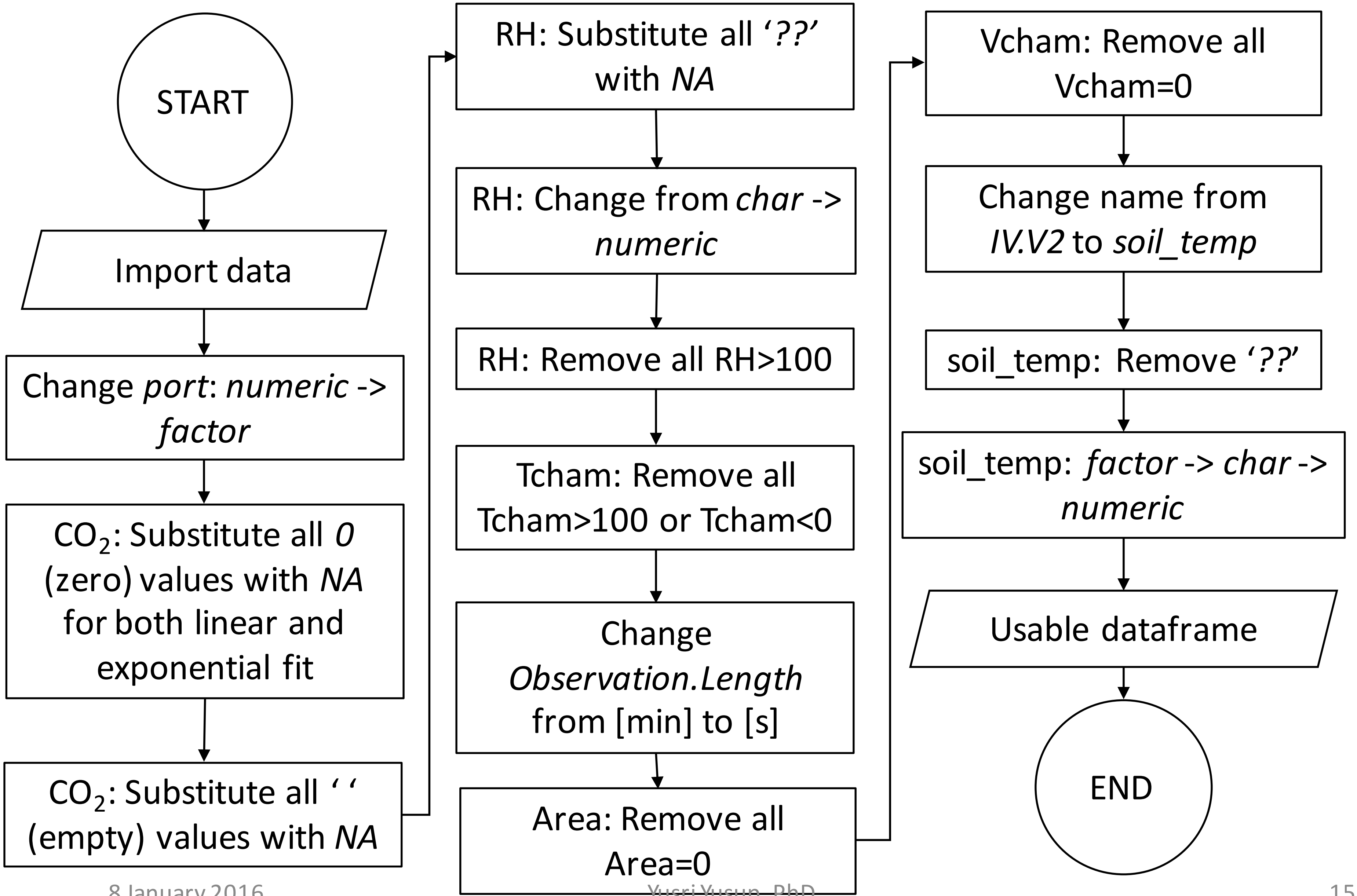
Storage Flux R Script Flowchart



Soil Chamber Flux Parameters

- Different sampling points are connected to different *ports* of the analyzer (Multiplexer).
- Four soil flux chambers:
  - Port 1: Harvest path – under palm
  - Port 2: Harvest path – open
  - Port 3: Frond pile – north
  - Port 4: Frond pile – south
  - Port 5 – 8: Profiler (not used here since the data is added to the storage flux dataset)
- Again, not all parameters/columns will be used.
- Data that we import into R is assumed to be already processed by LI-COR's *SoilFluxPro*.

Soil Chamber Flux R Script Flowchart



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