Tovi, New Software for Flux Data Analysis: from Gap Filling to Flux & Footprint Partitioning

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DATA ANALYSIS PLATFORM

- Driven and guided by the Research Community; developed, implemented & supported by LI-COR.

- Research Community provides scientific competence, methods and codes, and outlines the needed tools.

- LI-COR provides software engineering, solid implementation, easy-to-use GUI, documentation, trainings, support, and continuous development: www.tovi.io
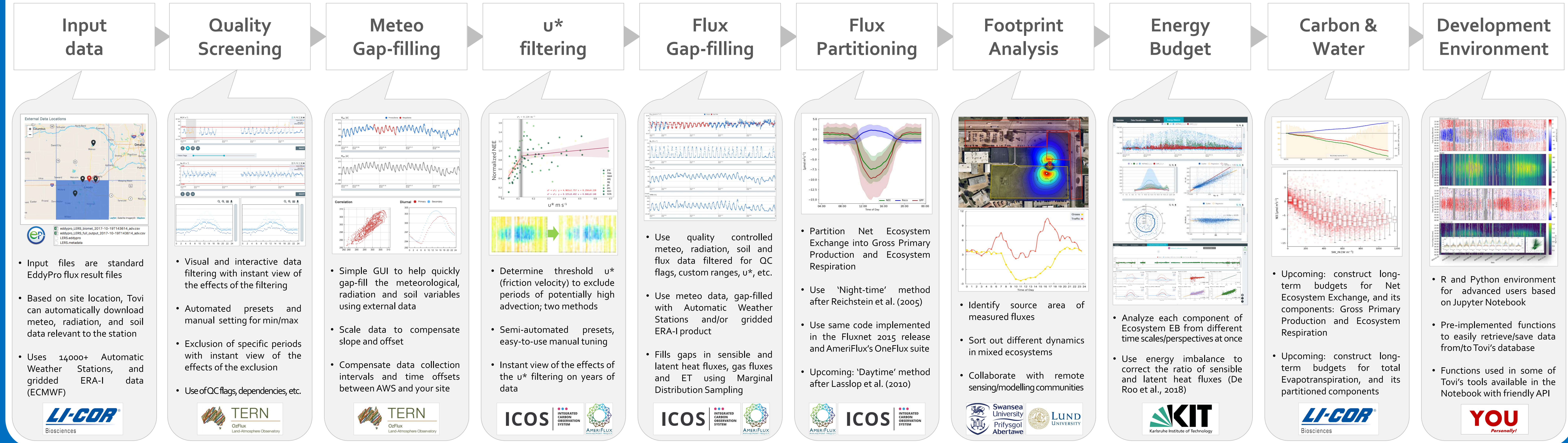
HOW DOES IT WORK?

- Scientifically sound and programmatically robust software allows seamless data retrieval, quality control, analysis, and workflow documentation.

- Shareable, traceable, and reproducible workflow uses methods available from the research community.

- Greatly enhances standardization and comparability among sites and users, and makes results defensible.

WHAT CAN IT DO?

- Automates multiple time-intensive procedures and handles large datasets

- Does automated search of 14000+ weather stations for gap-filling

- Automatically generates reproducible workflows and lists of references

- Facilitates use of proven analytical tools and cross-domain collaborations

EXAMPLE OF ONE OF MANY POSSIBLE WORKFLOWS

| Input data | Quality Screening | Meteo Gap-filling | u* filtering | Flux Gap-filling | Flux Partitioning | Footprint Analysis | Energy Budget | Carbon & Water | Development Environment |

Input data
- Input files are standard EddyPro flux result files
- Based on site location, Tovi can automatically download meteo, radiation, and soil data relevant to the station
- Uses 14000+ Automatic Weather Stations, and gridded ERA-I data (ECMWF)

Quality Screening
- Visual and interactive data filtering with instant view of the effects of the filtering
- Automated presets and manual setting for min/max
- Exclusion of specific periods with instant view of the effects of the exclusion
- Use of QC flags, dependencies, etc.

Meteo Gap-filling
- Simple GUI to help quickly gap-fill the meteorological, radiation and soil variables using external data
- Semi-automated presets, easy-to-use manual tuning

u* filtering
- Determine threshold u* (friction velocity) to exclude periods of potentially high advection; two methods
- Instant view of the effects of the u* filtering on years of data

Flux Gap-filling
- Use quality controlled meteo, radiation, soil and flux data filtered for QC flags, custom ranges, u*, etc.
- Use meteo data, gap-filled with Automatic Weather Stations and/or gridded ERA-I product
- Fills gaps in sensible and latent heat fluxes, gas fluxes and ET using Marginal Distribution Sampling

Flux Partitioning
- Partition Net Ecosystem Exchange into Gross Primary Production and Ecosystem Respiration
- Use 'Night-time' method after Reichstein et al. (2005)
- Use same code implemented in the Fluxnet 2015 release and AmeriFlux's OneFlux suite
- Upcoming: 'Daytime' method after Lasslop et al. (2010)

Footprint Analysis
- Identify source area of measured fluxes
- Sort out different dynamics in mixed ecosystems
- Collaborate with remote sensing/modelling communities

Energy Budget
- Analyze each component of Ecosystem EB from different time scales/perspectives at once
- Use energy imbalance to correct the ratio of sensible and latent heat fluxes (De Roo et al., 2018)

Carbon & Water
- Upcoming: construct long-term budgets for Net Ecosystem Exchange, and its components: Gross Primary Production and Ecosystem Respiration
- Upcoming: construct long-term budgets for total Evapotranspiration, and its partitioned components

Development Environment
- R and Python environment for advanced users based on Jupyter Notebook
- Pre-implemented functions to easily retrieve/save data from/to Tovi's database
- Functions used in some of Tovi's tools available in the Notebook with friendly API

EXAMPLE OF ONE OF MANY AVAILABLE TOOLS

1) Select the data from your own or another site

2) Format data for Tovi: EddyPro data do not need formatting

3) Import data into Tovi: current version works on 30 min EddyPro data , but will be expanded in the future to other processing programs and formats

- All known past and present flux tower locations
- Airborne flux measurements
- TCCON locations: not eddy covariance measurements

Data from over 2000 past and present EC locations can be analyzed and reanalyzed

Select perimeter around roads

1) Select two or more perimeters of interest

2) Run the footprint tool for your site

3) Try different percentage of flux footprint coming from each of the perimeters, including multiple discontiguous perimeters, to tease out the unique data

Select perimeter around lawn

Footprint tool allows selecting multiple dis-contiguous perimeters to apportion flux

Morning traffic peak

Evening traffic peak

Roads and Parking

Entire footprint

Traffic count

Green grass

NEE, umol CO_2 m^{-2} s^{-1}

US DOT traffic count: % of hourly to daily

Time of Day

Unique patterns can be discovered and new scientific products can be created much faster than before