# NEW TOOLS FOR A COMPREHENSIVE TIME- & SPACE-SYNCHRONIZED FLUX, WEATHER, SOIL & OPTICAL SENSOR NETWORKS

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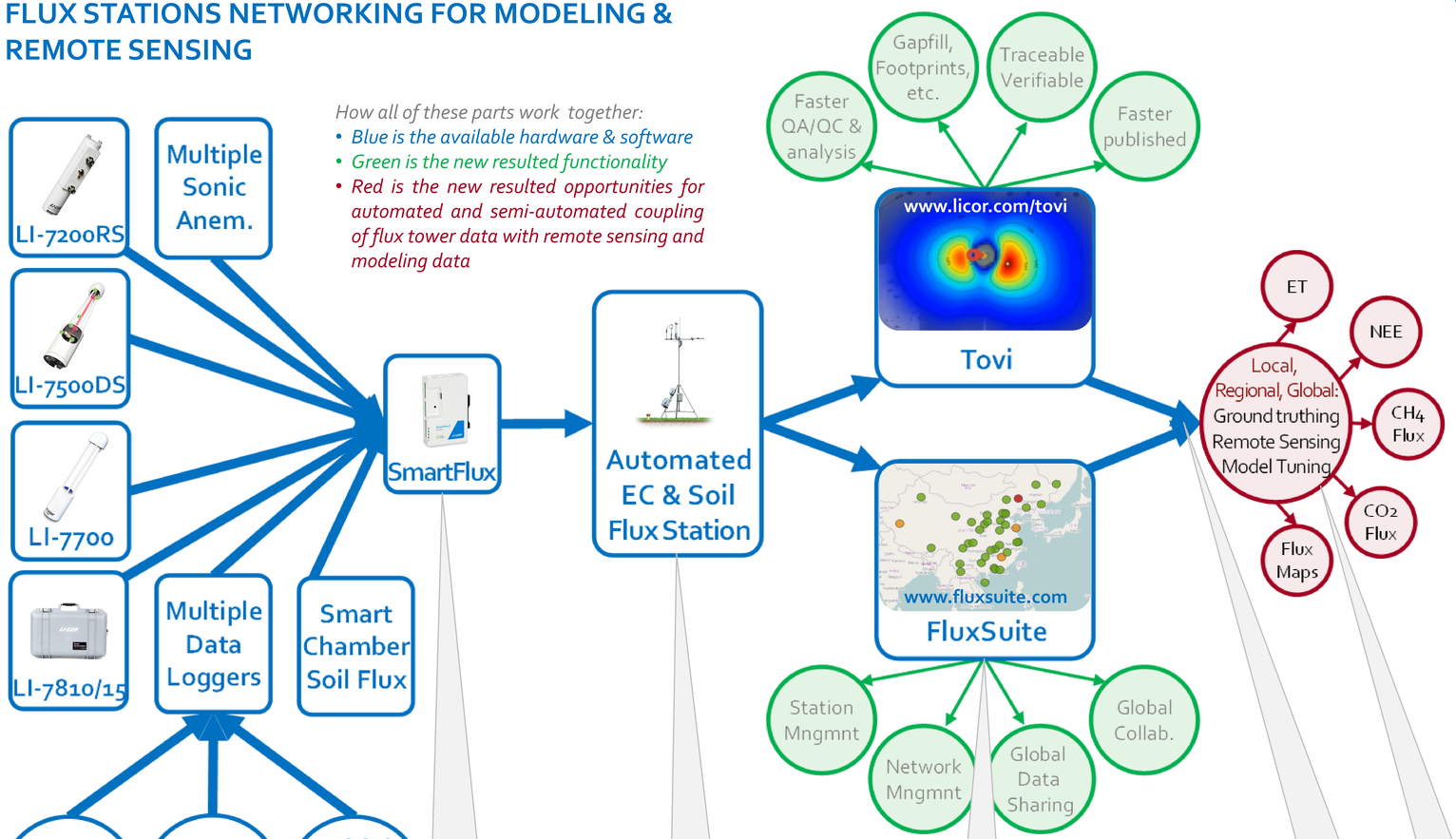
## INTRODUCTION

- Hundreds of flux stations presently operate standalone and as parts of flux networks [1,2,3]
- The value of coupling flux station data and remote sensing data has been outlined over the years in multiple publications [4,5,6,7,8,9]
- Yet, most of the stations do not allow straight-forward coupling with remote sensing data, and very few have optical sensors for validation of products and upscaling from field levels [4-12]
- A new system to collect, process, and share flux data from multiple stations [13]; can substantially help in coupling flux, proximal & remote sensing data [14]

## FEATURES FOR REMOTE SENSING

- Each flux station in this system outputs final fully-processed hourly fluxes of $CO_2$, $CH_4$, Evapotranspiration, Sensible Heat, Momentum, and auxiliary variables (radiation, weather, soil data, etc.)
- Actual flux footprint location and size is computed and reported by each station every 30-60 minutes
- Clocks within a station are synchronized with PTP, and clocks between multiple stations are synchronized using GPS to within fraction of a second
- Station time, coordinates, fluxes, auxiliary data, location and size of the flux footprint are stored in the form of hourly data and metadata files, and can be accessed remotely

## FLUX STATIONS NETWORKING FOR MODELING & REMOTE SENSING




## SUMMARY

- New technical tools can help connect remote sensing, modeling and flux communities to couple ground data (fluxes, proximal sensors, soil data, etc.) with the remote sensing data:
  1. GPS-driven PTP protocol synchronizes instrumentation within the flux station, different stations to each other, and all of them to remote sensing data to precisely align remote sensing and flux data in time
  2. Footprint size and coordinates computed and stored with each 30-60 minute flux data file help correctly match flux footprint to satellite, aircraft or drone motion to precisely align remote sensing and flux data in space
  3. Specific regions inside the footprint can be selected, and respective fluxes from only the selected regions can be precisely matched with modeled or remotely sensed coverage areas
  4. Remote sensing researchers can collaborate with flux researchers to easily access data from flux stations across the globe without having own stations
- In addition, other key measurements can be utilized within flux station footprint:
  4. Current flux stations can be augmented with ground-based optical sensors to deliver SIF, PRI, CCI, NDVI, *etc.*
  5. Full snapshot of the remote sensing pixel can then be constructed including leaf level, ground-based optical sensors, and fluxes from the same exact footprint
- Dozens of new stations already operate globally and can be readily adapted for the proposed workflow, and over 500 active traditional stations can be upgraded to synchronize with remote sensing datasets

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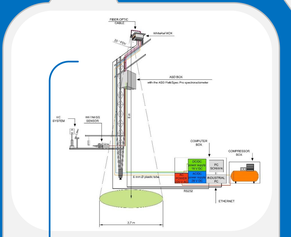
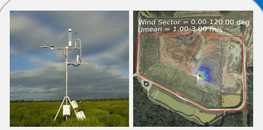
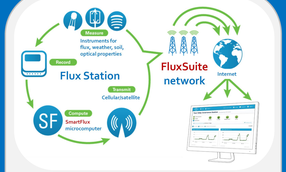
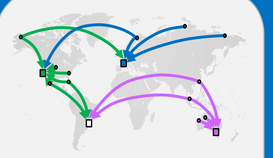


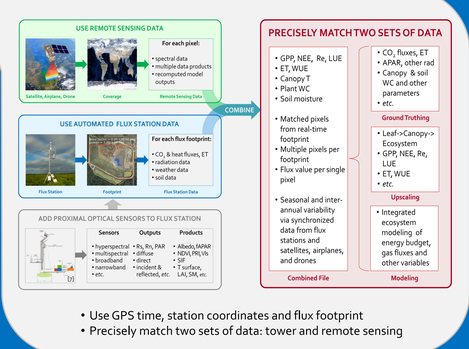

- SmartFlux is a field microcomputer for a fast logging and a complete on-site real time flux processing
- Each 30-60 mins file has exact GPS time, station coordinates, flux footprint size and location
- $CO_2$, $CH_4$, Heat fluxes, ET rates, Soil Flux, *etc.*
- Radiation and proximal optical data
- Weather and soil data, *etc.*




- The key is combining SmartFlux micro-computer with the FluxSuite on-line access tool
- GPS time-keeping, PTP clocks, patented time alignment across multiple sites and networks
- Multiple anemometer models and logger models to automatically merge virtually any auxiliary weather, soil & optical data



- FluxSuite is a new on-line system to remotely manage a station or a network of stations and collaborate with other groups
  - All stations and networks are time-synchronized and managed remotely
  - Flux, remote sensing, and modeling communities can share data rather easily
- Tovi is a new environmental data analysis software for automated and semi-automated QC, various ways of gap filling, sophisticated footprint partitioning, etc.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