The Operation of Agricultural and Forest Meteorological Observing Systems by KoFlux in the National Center for AgroMeteorology (NCAM)

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Research objectives

- Final objective to construct and provide the database from the eddy covariance technique based agricultural and forest meteorological observing systems
  - The database includes carbon/water/energy fluxes which are used to validate and improve the models in iCAMS (infrastructure of Customized AgroMeteorological support Service) and CAMS (Customized AgroMeteorological support Service) of the project.
Network of the observing systems

KoFlux / NCAM Flux monitoring network

- CRK (Cheorwon rice paddy)
- GCK (Gwangneung coniferous forest)
- HFK (Haenam farmland)
- TMK (Tahwa Mt. mixed forest)
- CFK (Cheonmicheon farmland)

• Re-constructed sites: GCK, GDK, CFK
• Newly-constructed sites: CRK, TMK

Mobile system
Eddy covariance technique based agricultural and forest meteorological observing system

Figure 1. Schematic representation of the inter-connectedness of radiation (underlined), water (in italics), carbon (normal font), energy (in CAPITAL), and entropy (bold) budgets in a biosphere (from Kim and Oki (submitted)).
Is flux observation in long-term networks actually science?  
(Schmid, 2015)

- **Difference in scientific strategy**
  - General observations: ‘controlled experiment’ to examine questions, hypotheses and predictions. "what if...?"
  - Observations in long-term networks: minimize the influence on the measurement to maximize their external validity. “what happens next?” or “how did this happen?”

- **External validity**
  - Ecosystem-Atmosphere fluxes observations in long-term networks identify trends, temporal scales of variability, spatial patterns and variations.

- **Required condition**
  - The data are comparable (comparability, compare "apples to apples")
  - A necessary condition is the compatibility of the sensors and procedures.
  - To achieve comparability and compatibility, a useful tool is standardization.
Internal validity

- **Data analysis for each site**
  - Carbon/water/energy budget quantification (Moon et al. 2015)
  - Improvement of data processing (Kang et al., 2014 and 2017)
  - To propose a new methodology for estimating gas emission (Kim et al., 2016)

- **Combined with modeling**
  - It can be enhanced if observations are combined with modeling.
    - High-resolution numerical forecasting
      (Lee et al., 2014; Song et al., 2015)
    - Remote sensing based modeling
      (BESS-Rice; Xin et al., in press)
    - Ecohydrological/Biogeochemical modeling
      (JULES with modified plant functional types and locally optimized parameter set)

(Song et al., 2016)
External validity (1): CO₂ fluxes comparison between the sites

- The adjacent two forests affected by the typhoons
  - Old natural deciduous forest vs. Fast-growing conifer plantation
  - A simple comparison of CO₂ fluxes is pointless (apples vs. oranges).
  - The deciduous forest was more resilient to the typhoon.

![Graph showing CO₂ fluxes comparison between Kompasu and Bolaven over years 2006-2015.](image-url)
External validity (2): CH$_4$ fluxes comparison between the sites

• The two rice paddies (distance: ~400 km N-S)
  - Transplanted, early-maturing cultivar vs. direct sowing, medium-maturing cultivar
  - Mid-season drainage (MSD) decreases CH$_4$ emission from an irrigated rice paddy.
  - Rainfalls during MSD period can trigger methane emissions to multiply (Kim et al., 2016)
  - Water management considering monsoon is important to reduce methane gas emission.

$$EF_i = EF_c \times SF_w \times SF_p \times SF_o \times SF_{s,r}$$

(2006 IPCC Guideline)

$EF_i$ = Adjusted daily emission factor for a particular harvested area
$EF_c$ = Baseline emission factor for continuously flooded fields without organic amendments
$SF_w$ = Scaling factor to account for the differences in water regime during the cultivation period
$SF_o$ = Scaling factor should vary for both type and amount of organic amendment applied
$SF_p$ = Scaling factor to account for the differences in water regime in the pre-season before cultivation
$SF_{s,r}$ = Scaling factor for soil type, rice cultivar, etc.
Compatibility (1): Sensors

- **Sonic anemometer**
  - Directional (e.g., CSAT3, HS-3)
  - Omin-directional (e.g., R3, 81000)

- **Gas analyzer**
  - Open –path (e.g., LI-7500, EC150)
  - Closed-path (e.g., LI-7000, TGA200)
  - Enclosed-path (e.g., LI-7200, EC155)

- **Necessity for a reference system**
  - AmeriFlux has been operated the portable eddy covariance system to evaluate data quality at sites in the network.

http://ameriflux.lbl.gov/portable-eddy-covariance-system/
Compatibility (2): Data processing

- **KoFlux standardized data processing protocol**
  - batch-process the massive flux dataset (Hong and Kim, 2001)
  - QC/QC (Kwon et al., 2007)
  - Coordinate rotation (Yuan et al., 2007 and 2011)
  - Standardization (Hong et al., 2009)
  - Nighttime CO₂ flux correction (Kang et al., 2014 and 2017)
  - Storage flux calculation (Moon et al., 2015)
  - Inter-comparison to the other networks (Takagi et al., 2008; Saigusa et al., 2013)
Summary

• Ecosystem-Atmosphere fluxes observations in long-term networks identify trends, temporal scales of variability, spatial patterns and variations of radiation, water, carbon, energy and entropy budget.

• To maximize such validity, comparability of the data and compatibility of the sensors and procedures are required.

• A useful tool to achieve comparability and compatibility is the standardization. KoFlux has been trying to standardize the eddy covariance measurement that best suits Korean agricultural lands and forests.