Poster No. 50, First Conference on Atmospheric Biogeosciences, American Meteorological Society, May 27 - June 1, 2012, Boston, MA, U.S.A.

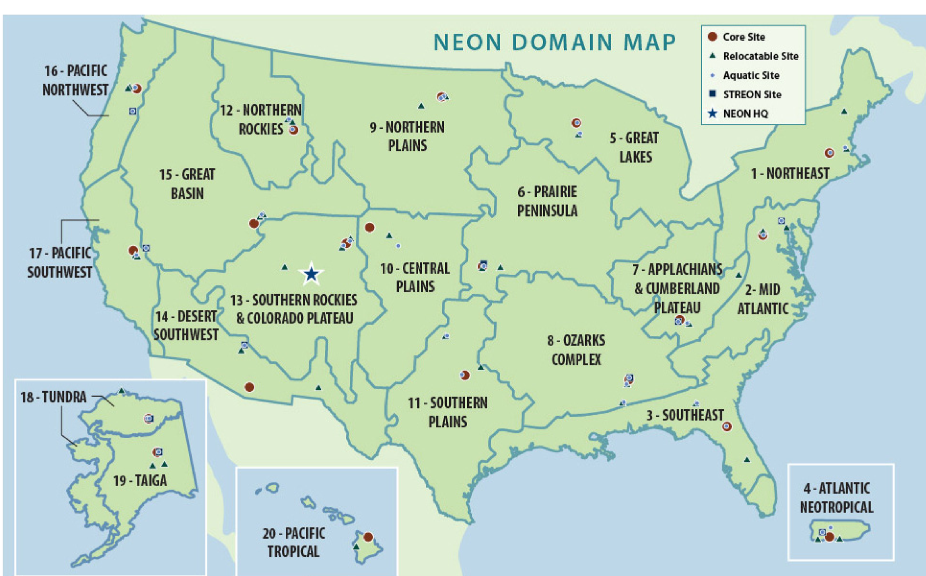
Quality assurance and quality control of NEON's eddy-covariance flux data products

Authors: Stefan Metzger[1,2], Jeffrey Taylor[1,2], Hongyan Luo[1,2], and Henry W. Loescher[1,2]
(1) National Ecological Observatory Network, Boulder, CO, U.S.A.; (2) Institute for Arctic and Alpine Research, University of Colorado, Boulder, CO, U.S.A.

neon™ National Ecological Observatory Network

Background

The National Ecological Observatory Network (NEON) is a continental-scale research platform with a projected operation of 30 years. NEON's purpose is to provide high quality data products that will facilitate discovering and understanding the impacts of climate change, land-use change, and invasive species on ecology. The eddy-covariance (EC) technique will be used to continuously monitor the exchange of sensible heat, water vapor, CO_2 and other scalars between ecosystems and the atmosphere at all 60 NEON research sites.



Map of 20 NEON domains with indicators for different sites.

Why flux QA/QC?

All data streams collected by NEON pass through an automated quality control (see companion poster No. 49). However, the EC method makes use of additional assumptions and simplifications, many of which are related to the mass balance equation:

$$F = \underbrace{\int_0^z \frac{\partial \overline{s}}{\partial t}}_{I} + \underbrace{\int_0^z \frac{\partial \overline{u's'}}{\partial x}}_{II} + \underbrace{\int_0^z \frac{\partial \overline{v's'}}{\partial y}}_{III} + \underbrace{\int_0^z \frac{\partial \overline{w's'}}{\partial z}}_{IV} + \underbrace{\int_0^z \frac{\partial \overline{u}\,\overline{s}}{\partial x}}_{V} + \underbrace{\int_0^z \frac{\partial \overline{v}\,\overline{s}}{\partial y}}_{VI} + \underbrace{\int_0^z \frac{\partial \overline{w}\,\overline{s}}{\partial z}}_{VII},$$

with the total flux F into or out of an ecosystem, a scalar quantity s such as H_2O or CO_2 mixing ratios, along-, cross-, and vertical wind speeds u, v, and w with respect to the Cartesian coordinates x, y, and z; t is time, and z is the measurement height.

Testing these assumptions and simplifications in addition to an automated quality control is indispensable to ensure high data quality as well as representativeness of the EC flux data products for the target ecosystems.

Contact Information: smetzger@neoninc.org

www.neoninc.org

The NEON flux QA/QC plan

Four stages of scalable tests, resulting in Quality metrics (QM)

Stage 1 "Temporally explicit flux QA/QC"

- Stationarity → QM_{STA}
- Developed turbulence → QM_{ITC}
- Comparison to reference spectrum → QM_{SPE}
- Comparison to reference cospectrum → QM_{COS}
- Random error → QM_{ERR}
- Systematic error → QM_{ERS}
- Energy balance residual → QM_{RES}

Stage 2 "Spatially explicit flux QA/QC"

- Footprint modeling considering 3d dispersion
- Superimpose footprints over high-resolution remote sensing data from NEON Airborne Observation Platform
- Evaluation of target land cover in footprint → QM_{SOU}

Criteria	Eq. Term	QM_{STA}	QM_{ITC}	QM_{SPE}	QM_{COS}	QM_{ERR}	QM_{ERS}	QM_{RES}	QM_{SOU}	QM_{PUR}
Storage	I		✓					✓		
Divergence	II–III	✓	✓				✓		✓	
Divergence	IV		✓							
Advection	V–VII	✓	✓				✓		✓	
Accuracy	-							✓		
Random error	-					✓				
Flow distortion	-		✓	✓	✓					
Represen-tativeness	-							✓	✓	✓

Stage 4 "Complex terrain"

- Detailed case studies for selected sites
- Analysis of Wavelet and Hilbert spectra for intermittent turbulence, coherent structures and gravity waves
- Large eddy simulation to study advection, drainage flow, non-propagating eddies, and more realistic footprints

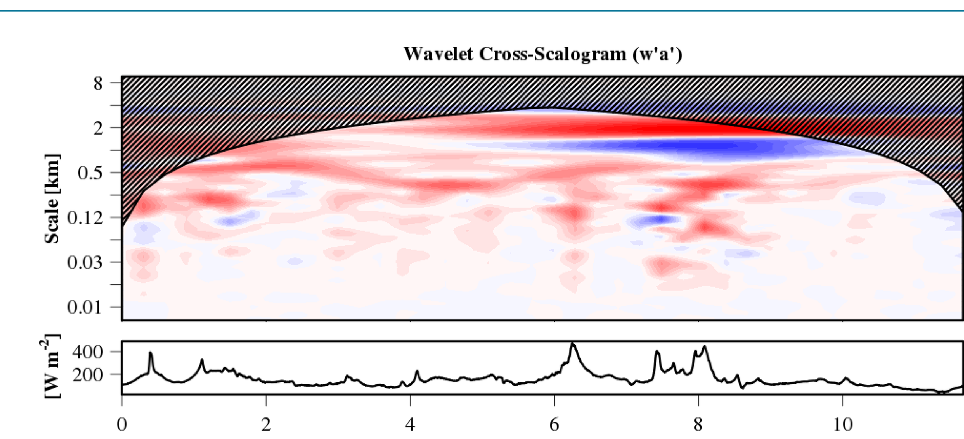
Stage 3 "Flux un-mixing in heterogeneous terrain"

- High temporal resolution of fluxes from Wavelet analysis and empirical mode decomposition
- Footprint weights for individual land covers
- Inversion of land cover specific fluxes using, e.g., support vector machines → QM_{PUR}

Objectives

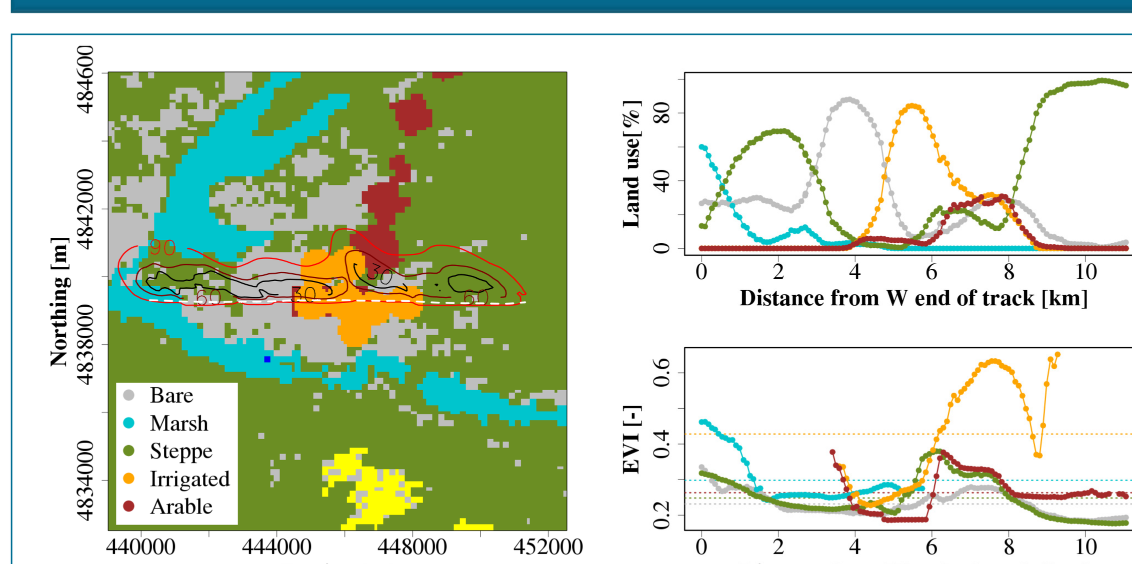
- Enable the transition of EC measurements from principal-investigator-based into observatory-based operations
- Place QA/QC approaches into a production framework
- Ensure consistent quality rating over the range of climates and ecosystems across an entire continent
- Advance established tests and data flows (e.g., AmeriFlux, CarboEurope) to new state-of-the-art functionality
- Respond to requests from the research community
- Provide research community with open source algorithms

Example I – Wavelet analysis (aircraft data*)



- Parseval's theorem: covariance of a signal can be studied equivalently in time- and frequency domain
- Integration over all frequencies of each individual flux measurement enables high temporal discretization

Example II – Footprint analysis (aircraft data*)



- Superimposing footprints over land cover maps
- Fractional land cover contribution to each individual flux measurement

Example III – Flux un-mixing

Inferring the characteristic fluxes of individual land covers, F_m, e.g. through linear numerical inversion of;

- Temporally high resolved flux measurements F_n, from wavelet analysis or empirical mode decomposition
- Fractional contribution of F_m to F_n, C_{nm}, from footprint analysis

$$\begin{matrix} C_{11}F_{11} + C_{12}F_{12} & \cdots & C_{1m}F_{1m} = F_1 \\ C_{21}F_{21} + C_{22}F_{22} & & C_{2m}F_{2m} = F_2 \\ \vdots & \ddots & \vdots \\ C_{n1}F_{n1} + C_{n2}F_{n2} & \cdots & C_{nm}F_{nm} = F_n \end{matrix},$$

with the number of flux samples N, and the number of individual land covers M.

*Courtesy of MAGIM - Matter fluxes in grasslands of Inner Mongolia as influenced by stocking rate (www.magim.net). The flight campaign was funded by the German Research Foundation, Research Group 536 MAGIM. Stipend funding by the German Academic Exchange Service, Helmholtz Association of German Research Centers, China Scholarship Council and the European Union under the Science and Technology Fellowship China is acknowledged.