AMERIFLUX STRATEGIC PLAN

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The AmeriFlux Network

The AmeriFlux network, established in 1996, includes more than 120 independently funded sites operating across North, Central, and South America. AmeriFlux sites include tundra, grassland, agricultural crops, tropical forests and temperate coniferous and deciduous forests. The diversity of AmeriFlux sites greatly expands upon the contributions of other regional networks. AmeriFlux sites have provided a sustained set of detailed observations of ecosystem level exchanges of CO_2, water, energy and momentum on an hourly basis, spanning diurnal, synoptic, seasonal, and interannual time scales. These data have provided a wealth of information on how diverse ecosystems respond to changes in their physical environment, and how they affect their environments in turn. Contributions to carbon cycle science include understanding variation in net carbon uptake with inter-annual variation in climate, and the influence of disturbance on carbon storage and fluxes.

The sites are primarily funded through competitive grants programs. A Science Chair is responsible for leading scientific activities of the AmeriFlux network, which includes the coordination and quality assurance of measurements across sites, leading cross-network data analysis and synthesis of results, and communicating AmeriFlux results to the scientific community and other users. A Steering Committee of scientists and agency program managers works with the Science Chair by providing technical and policy advice to help meet network goals.

Purpose

The purpose of this strategic plan is to provide a framework for meeting the challenges that AmeriFlux will encounter over the next decade. Each challenge that we face offers an opportunity to better serve the scientific community and provide scientific guidance to our sponsors. In this plan we describe our vision, goals, and strategic directions.

Vision

Nations of the world face challenges in developing sound policies and directions for addressing global change. The scientific community has the responsibility to provide the scientific basis for those policies. This includes developing the understanding of the influence of land, ocean and atmospheric processes in climate change. The goal of AmeriFlux is to develop a coordinated research network of long-term flux sites in the Americas for quantifying and understanding the role of the terrestrial biosphere in global climate change. Specifically, we aim to provide reliable estimates of carbon storage, carbon dioxide and water vapor exchange, and improve our description and understanding of variation, and its causes at relevant temporal and spatial scales. We expect to provide the quantitative information to adequately predict large-scale long-term responses to changing environmental conditions. This will be accomplished using micrometeorological and biological measurements at the intensive flux sites coupled with extensive measurements (e.g. surveys and remote sensing) and modeling.

Unique Features of AmeriFlux

AmeriFlux is uniquely positioned to quantify and understand controls on carbon storage and the exchanges of energy, water and carbon across a broad range of vegetation types, disturbance histories, and climatic conditions that exist in the Americas. Biomes include boreal, temperate and tropical evergreen forests, temperate deciduous forests, woodlands, grasslands, shrublands, and agricultural crops. Climatic conditions range from tundra, to temperate, tropical, and arid regions. AmeriFlux has a pivotal role in development, testing, and application of ecosystem, atmospheric, and weather models. The network can produce a full suite of long-term measurements of meteorological variables, exchange rates of CO_2, latent heat, and sensible heat, and biogeochemical pools and flux rates of component processes with local knowledge of ecosystem functioning and history of changes in land use and land cover. The network can conduct *in situ* experiments, gradient studies, and comparative studies to improve understanding of plant and microbial processes contributing to fluxes, and the effects of vegetation type, climate, and disturbance on pools and fluxes. Complete sets of micrometeorological, meteorological, and biological measurements across sites, quality control of data, and inter-calibration of flux data with roving systems allow comparisons to elucidate general principles among biomes and disturbance histories, and to test a range of models.

Science Questions

The network role is to address the scientific uncertainties associated with global change. Our focus is to address these scientific questions:

1. What are the magnitudes of carbon storage and the exchanges of energy, CO_2 and water vapor in terrestrial systems? What is the spatial and temporal variability?

2. How is this variability influenced by vegetation type, phenology, changes in land use, management, and disturbance history, and what is the relative effect of these factors?

3. What is the causal link between climate and the exchanges of energy, CO_2 and water vapor for major vegetation types, and how does seasonal and inter-annual climate variability and anomalies influence fluxes?

4. What is the spatial and temporal variation of boundary layer CO_2 concentrations, and how does this vary with topography, climatic zone and vegetation?

Objectives

Our general objective is to seek general principles through comparisons within and among functional groups of vegetation, and to use this knowledge to scale up from site to landscape and region. To do so, we will improve the network comparability among sites through standardization of measurements and calibrations, while ensuring the flexibility to adapt to new methods or technologies that have been demonstrated to be effective, and to allow for basic research that contributes to the knowledge base.

Our general strategy is to use integrated approaches that include long-term micrometeorological, meteorological, and biological measurements, modeling, remote sensing, and innovative analytical techniques to improve estimates of storage and fluxes at relevant scales. The approach is to work at multiple scales of integration, and to develop measurement strategies for addressing scaling issues and to evaluate process models for large-scale applications. Long-term measurements at a representative subset of sites are essential to elucidate trends and general principals and to serve as anchor points for focused regional studies to examine spatial variability, response to disturbances or management strategies, and successional trends. At some sites, additional measurements in the surrounding landscape will allow investigation of spatial and temporal variation in carbon storage, CO_2 and water vapor exchange associate with climate, vegetation type, topography, geomorphology, and disturbance history. Some sites will be better for integrated carbon budgets, others for investigating processes regulating storage and fluxes, timing, and phenology on shorter time scales. Both roles are important to the overall AmeriFlux objectives. In our synthesis and analysis across sites, it is important to collaborate with other observatory networks.

Objective 1: Quantify spatial and temporal variation in carbon storage in plants and soils, and exchanges of carbon, water and energy in major vegetation types across a range of disturbance histories and climatic conditions in the Americas

Strategy

1. Expand network of flux sites to include under-represented vegetation types or functional groups
2. Develop cluster sites with a gradient of disturbance histories within several climatic zones and vegetation types
3. Conduct long-term measurements at appropriate sites
4. Enhance a subset of flux sites in appropriate locations for atmospheric CO_2 concentration measurements and atmospheric modeling (e.g. inverse modeling of carbon sources and sinks)
5. Develop efficient *integrated* strategies to quantify storage and fluxes over a range of scales, from stand to landscape, region, and continent, using biological and micrometeorological measurements, tower and aircraft measurements of atmospheric CO_2 concentrations, footprint modeling, ecosystem modeling, regional biosphere-atmosphere modeling, and remote sensing.

Objective 2: Advance understanding of processes regulating carbon assimilation, respiration, and storage, and linkages between carbon, water, energy, and nitrogen through measurements and modeling

Strategy

1. Develop intensive flux sites where a full suite of measurements are made of meteorology, component processes (e.g. sapflow, photosynthesis, automated soil CO_2 efflux, phenology), and key model variables for integrative measurement/modeling studies
2. Test ecosystem models across flux sites on disturbance and climatic gradients to improve assumptions on the effects of disturbance and physiological differences associated with age on carbon, water and nitrogen cycling (e.g. short-term and long-term processes, effects of inter-annual variation in climate on processes)
3. Identify a research priority in requests for proposals that encourages collaborative studies between modelers and site investigators to conduct truly integrative studies with shared products.

Objective 3: Produce high quality data for site-level analyses, synthesis activities, and the data archive

Strategy

1. Develop and apply innovative approaches to quantifying CO_2 and water vapor exchange in complex terrain and patchy landscapes
2. Develop a uniform measurement and analysis scheme to detect and correct errors in flux data
3. Provide standard programs for screening and gap-filling flux data
4. Improve micrometeorological and soil respiration instrumentation
5. Produce robust biometric estimates of carbon storage and fluxes, including soil carbon storage and transport, and resolve discrepancies between biometric estimates, and those from the eddy covariance method and process models
6. Develop procedures to ensure long-term quality of ancillary data (sonic u/v/w/Tv, PAR, temperature, humidity, CO_2 concentration).
7. Strengthen approach to site calibrations of CO_2, water and energy exchange (e.g. deploy two roving systems, extend period of site visit, exchange raw data in a standard format, expand data diagnostics).
8. Require AmeriFlux sites to adhere to data quality standards, and require resolution of discrepancies at the funding-agency level if needed
9. Require repeated exchange of “golden” data sets, whereby all sites compare results from their data analysis routines with those of the standard data sets, and resolve discrepancies
10. For sites that cannot produce reliable annual estimates from eddy flux data, a clear explanation should be provided in the meta data of the archive
11. Ensure that the investigators and sponsors elevate the importance of information management, and that appropriate levels of funding are obtained to meet this need

12. Build expertise in micrometeorological measurements and analysis to meet the growing demands for these specialized skills (training sessions and web-based programs on theory, and measurement and analysis methodologies)

Major Products

Regional NEP and carbon storage. The integrated strategies that combine flux data, atmospheric CO_2 measurements, various analysis methods, and modeling will be used to quantify regional NEP and carbon storage. These products should also be archived in the database. An example is the MODIS/model validation activity that uses near real-time meteorological data from core validation sites to drive models, with the intent of evaluating model output and remote sensing data products with flux site data.

General principles of controls on NEP and carbon storage. A concerted effort in synthesis across sites from measurements and modeling will elucidate causes of variation in magnitudes of C storage and net exchange of CO_2, and lead to general principles that can be applied broadly. The results of these synthesis activities will be useful to expanded efforts such as those outlined in the North American Carbon Plan. Synthesis data sets should be included in the data archive, and citations provided in the metadata for these datasets.

Database. Measurement data (micrometeorological, meteorological, biological, site history), remote sensing products, and model outputs need to be archived in a central database (CDIAC) for synthesis activities. Data management includes several important steps: Processing, quality assurance, and synthesis at the research sites. It is important to streamline data archiving methods, and to update contributions to CDIAC in a reasonable timeframe.

Training. Web-based and on-site training in micrometeorological and biological measurements for new investigators, educators, and students.

Implementation Priorities

Conduct long-term measurements at appropriate sites

Conduct multiple site studies surrounding flux sites, particularly disturbance gradients, to investigate variation in carbon storage, and exchanges of carbon, water and energy associated with disturbance and management.

Measure atmospheric CO_2 concentrations at appropriate sites (towers and subset of flux sites) combined with atmospheric modeling.

Improve intensive measurements at flux sites to include a common suite of basic biological measurements (NPP, NEP, above and belowground C pools), physiological measurements, phenology, soil properties, and disturbance history

Conduct process studies at flux sites to improve knowledge of how processes regulate CO_2 and water vapor exchange, and as a collaborative effort to improve model representation of respiration, phenology, and disturbance

Evaluate suites of process models using data from flux sites, and advance the “real-time model comparison” that is underway

Expand flux sites as needed to fill critical gaps in biomes, developmental stages, and climate space.

Reduce uncertainties in flux measurements, improve data QA/QC and archiving standards, and require Ameriflux sites to adhere to these standards. Strive for comparability of measurements over time and across sites, augmented by calibrations with roving systems.

Scaling and integration. Collaborative studies that include spatial and temporal estimates from a combination of flux site data, cluster sites, remote sensing and modeling. This includes validation of model output, nudging of meteorological and atmospheric models, coupled modeling, remote sensing applications for scaling, and remote sensing validation.

Networking

Coordination with the North American Carbon Program (NACP). The NACP plan for research on the carbon cycle is focused on measuring and understanding the sources and sinks of CO_2, CH_4, and CO in North America and adjacent ocean regions. The plan is intended as a component of the U.S. Interagency Carbon Cycle Science Program and as a contribution to the new U.S. Climate Change Research Initiative. The NACP will provide quantitative understanding of the uptake or release of these gases attributable to natural and human activity. The Program will separate the influence of combustion and biogenic sources, and determine the sensitivity of underlying biological processes to environmental conditions (climatic variations, sunlight, temperature, soil moisture), to biophysical and ecological factors, (phenology, vegetation cover, prior land use), and to management of forests and agricultural land. The integrative framework proposed in the NACP will need to incorporate data from a wide range of sensors, locations, and processes and to connect measurements obtained at the “leaf level” with regional and continental scale data. AmeriFlux has a pivotal role in the NACP.

Cooperation within AmeriFlux, and with other research programs and groups is essential to make the most of the data collection and analysis efforts in climate change science. Interaction between research networks will be encouraged (e.g. FLUXNET, GTOS, BASIN).

Strong collaborations between modeling groups and flux sites are necessary to make strides in quantifying and understanding storage and fluxes.

Criteria for AmeriFlux Sites - Communications and Timetables

In October 2004, the AmeriFlux Steering Committee developed the following criteria to build a cohesive network that meets AmeriFlux objectives, and those of the North American Carbon Program (NACP) and the US Carbon Cycle Science Program (US CCSP). The criteria are used to evaluate site performance and determine membership status in the AmeriFlux network:

- Utility and uniqueness to the network - Site is representative of the biome or vegetation type, and helps to fulfill need of adequate coverage of biomes, disturbance classes, and climate.
- Continuous meteorological and micrometeorological measurements year-round
- Follows instrumentation and calibration guidelines posted on the AmeriFlux web site
- Conducts the core biological, meteorological and micrometeorological measurements outlined on the AmeriFlux web site at appropriate intervals, and provides biological data to the AmeriFlux archive
- Participates in calibration system comparisons and instrument calibration with AmeriFlux standards and resolves discrepancies
- Submits meteorological and micrometeorological data within one year of data collection, following submission guidelines posted on the AmeriFlux web site
- Meets data quality and data archiving standards posted on the web
- Attends annual AmeriFlux meeting
- Demonstrated output – Produces quality publications on key topics in respected professional journals and other outlets
- Network participation - Participates in synthesis activities across sites, demonstrates true availability of site data to others, and participates in the broader array of NACP research.

Additional evaluation criteria for flux sites that provide process-level understanding:

- Focal points for intensive ecological studies on biotic and abiotic controls on the exchanges of CO2 and water vapor, and changes in carbon stocks
- Conduct full carbon accounting at appropriate temporal and spatial scales (biometric estimate of NEP, carbon stocks in vegetation and soil), and provide uncertainties in these estimates
- Estimate stand structure and phenology with high resolution remote sensing

Additional evaluation criteria for carbon mixing ratios at sites:

- Sites strategically located for quantifying spatial variation in continental CO2 concentrations
- Potential to be enhanced with instrumentation for methane [CH4] and carbon monoxide [CO]