Prospectus – IASOA's Atmosphere-Surface Coupling Working Group

http://www.esrl.noaa.gov/psd/iasoa/

Background

Detailed observation of energetic, hydrological and chemical fluxes at the surface-atmosphere interface are necessary to understand and model coupling within the Arctic climate system (Figure 1). Global and regional models may represent Arctic state variables with relative accuracy, but it has been observed that they consistently fail to represent the observed magnitude and direction of energetic fluxes within the Arctic system (ref). The results of this failure are poorly constrained processes in forecast and reanalysis models (ref), highly uncertain projections about the future state of the Arctic cryosphere and biosphere (ref) and highly uncertain fate of cryospheric carbon in the global atmosphere (ref). Closing the terms of the surface energy balance (SEB) requires sustained, high quality observations of key physical parameters. Integrating these observations with biogeochemical exchanges requires additional expertise and interdisciplinary coordination. Making accurate and sustained observations of these types in the Arctic requires specialized technology and techniques.

International Arctic Systems for Observing the Atmosphere (IASOA) recognizes these challenges and seeks to contribute to the development of robust technologies and methodologies, adapted to the unique conditions of the Arctic. It also seeks to advance the joint understanding of coupled Arctic systems between different disciplinary communities. While the broad subject of Arctic flux observations exceeds the bounds of the IASOA focus, IASOA can lead a coordinating effort among the large observatories to identify measurement limitations; to enable data sharing and promote common documentation formats; to advocate for sustained and expanded observations; to coordinate forums for interdisciplinary science.

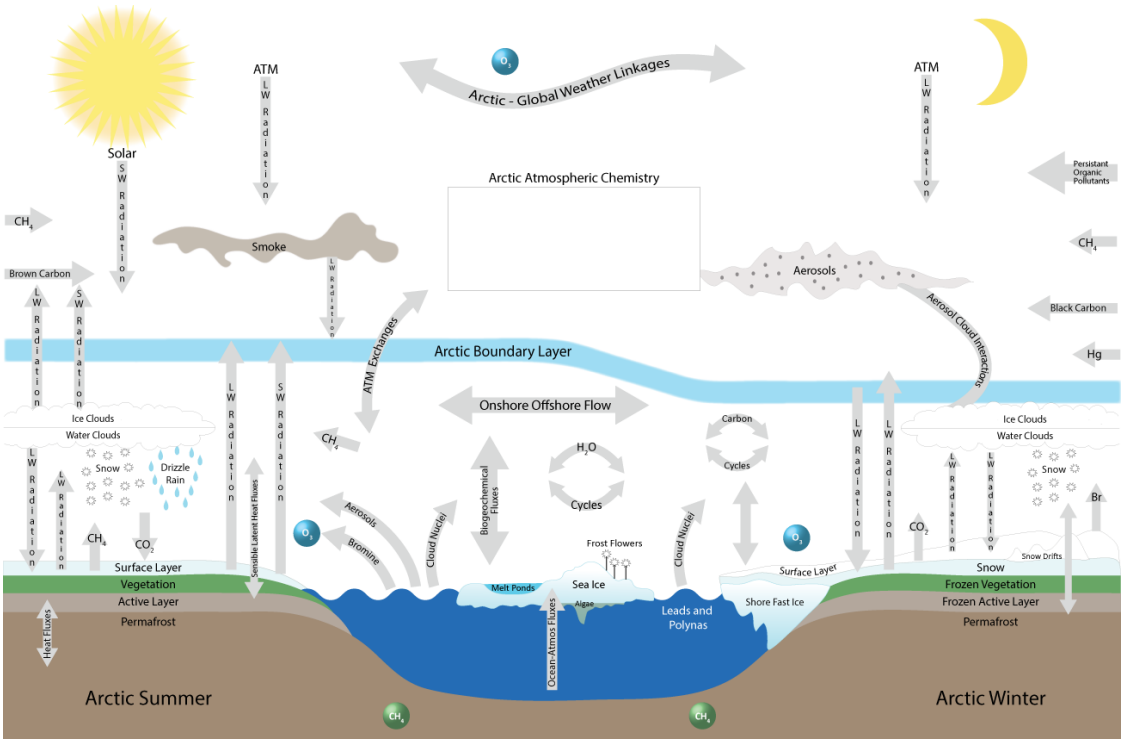

Figure 1. Energetic, hydrological and chemical exchanges within in the Arctic climate system are tightly coupled and must be understood through system-wide observations (courtesy T. Uttal).

Needs Identified at AGU, 2013

In order to gather input and identify other experts and coordinating bodies in the Arctic flux measurement community, IASOA called an informal round-table discussion at the Fall 2013 American Geophysical Union (AGU) meeting. Attendance (see Appendix) was impressive, as was the strong interest among the Arctic terrestrial ecology community. Unfortunately, due to travel conflicts, the atmospheric community was not well represented. After introductions, a discussion followed to understand common interests. These are summarized as:

- Need to identify hi-latitude/hi-elevation best practices (extreme cold temperature operations not part of Ameriflux, NEON, ICOS, etc.)
- Need to improve cold-weather instrument performance (note: Campbell Scientific was present and interested in working with community, e.g. test sites)
- Need to improve low temperature gas sampling/analysis (e.g. cold-shifted calibrations)
- Need to improve up-scaling and integration
- Need to improve year-round operations: site communications; system power (specifically at stand-alone sites and considering Arctic-specific demands like de-icing)
- Identification of sites, parameters, datasets around the Arctic
- Identification of modeling & remote sensing communities interested in observations
- Need to develop stronger interdisciplinary efforts, leverage the large stations as sites for multi-disciplinary integration

Relevant Activities Identified at AGU and Beyond:

It was clear from the AGU discussion that IASOA scientific interests represent only a small slice of a much broader community of Arctic flux observational interest and expertise. Some interests certainly exceed the bounds (e.g. stand-alone, disciplinary experiments, sub-Arctic?) of what IASOA would rationally lead; and it is clear that other entities are already organizationally ahead of IASOA within a disciplinary community (e.g. Ameriflux) or activity (e.g. ICOS). Relevant activities (see Appendix for full description) to include/consider while scoping how IASOA could contribute to community efforts include:

Ameriflux (DOE)

NEON (NSF)

NGEE (DOE)

ABOVE (NASA)

ICOS (EU)

INTERACT (EU)

DOE-ARM (DOE)

IARPC (many teams)

GCW (WMO)

PROMICE (DK)

International Study of Carbon, Water, and Energy Balance in the Terr. Arctic (AON PI-NSF)

CLiC (WCRP)

IPA (international)

PEEX

Modeling community (RASM, CESM, etc): Phil Jones (LANL), Wieslaw Maslowski (NPS), Andrew Roberts (NPS), Jennifer Hutchings (OSU)

IASOA is ultimately interested in sustaining research collaborations within the context of the panArctic picture that can be synthesized from the individual observatories. While this synthesis and in this case system science is the objective, interim steps will relate to discovering common observing capabilities and identifying the means to compare datasets. Within IASOA context (Arctic (sub?), long-term, surface-based, year-round observations at the major sites (include new sites ?Oliktok, Toolik?), what are the parameters of interest?

- SEB
- GEP
- H2O
- CH4
- CO2
- CCN Flux from surface reservoirs (e.g. OASIS)
- Tropospheric gas flux from surface reservoirs (e.g. BROMEX)

<u>Some example science questions/objectives that could then be addressed….(provided by various)</u>

What is the fate of Arctic carbon in a warming climate?

What are the details of the mechanisms for transfer of energy and gases from the surface to the atmosphere?
How are these influenced by wind, snow/ice/ocean/surface conditions, near-surface air temperatures, magnitude of any temperature inversions, etc?
What will be the effect of a warming Arctic and/or loss of sea and land ice/snow cover on the magnitude and seasonality of the exchange?
Is there a positive or negative feedback between warming and surface-atmosphere exchange (Note: it could be +ve for some exchanges and -ve for others)?

1) From there large-scale there is one big question: What are the impacts of the aggregate-scale fluxes on large-scale atmospheric circulation? One of the proposed mechanisms that link hemispheric circulation patterns to things like decreased sea-ice is via changes in surface fluxes. And the opposite is interesting as well: Are there larger-scale (hemispheric or global) shifts that can/do/will impact aggregate scale surface fluxes in the Arctic? Global climate change will certainly impact the northward transport of energy from equator to pole, and this will impact surface fluxes…..

2) From the more local-scale perspective: There are interesting questions about the interplay of local atmospheric processes (boundary layer structure, cloud properties) and surface fluxes.

Improving representation of Arctic flux terms in models

Improve methods for up-scaling

<u>What partnerships can we form to develop useful data products?</u>

Other groups could expand/tie-in where they have interests. For example, the IARC-AON project studies latitudinal gradients from sub to high Arctic; PROMICE is a geographically broad, AWS-based project that is sampling lots of points around the Greenland ice sheet. Partnering with broader sampling projects (hub-spoke model) could be a strength, provided there are common practices in sampling and data management.

Complementary activities to promote science in this topic:

1. Inventory activities/identify datasets; identify parameter & geographic sampling gaps
2. Develop recommend best practices for energetic and chemical flux sampling in extreme cold temperatures
3. Inventory datasets for inter-comparison
4. Recommend interoperable data and documentation formats
5. Identity evaluation metrics to constrain sign and magnitude of key feedbacks in the Arctic system

Who could be involved? (reviewers, please supply additional names)

Name	Affiliation	Focus	Location
Von Walden	WSU	Radiation	All, Summit
Chris Cox	CIRES	Radiation	All, Summit
Chuck Long	PNNL (ARM)	Radiation	Barrow
Marion Matrulli	AWI	Radiation	Ny-Alesund
Konrad Steffen	WSL	Radiation	Summit
Vasily Kustov	AARI	Radiation	Tiksi
Timo Hopeakoski	FMI	Radiation	Pallas-Sodankyla
Sydonia Bret-Harte	UAF	GEP[1]	Toolik/Imnaviat, Cherskii
Eugenie Euskirchen	UAF	GEP	Toolik/Imnaviat, Cherskii
Larry Hinzman	UAF	GEP	Barrow, Poker Flats, Seward Penninsula
Rommel Aulueta	NEON	GEP	Barrow
Dave Billesbach	Univ. Nebraska (NGEE)	GEP	Oliktok, Barrow
Naama Raz-Yaseef	LBNL (NGEE)	GEP	
Margart Torn	LBNL (NGEE)	GEP	
Stan Wullschleger		GEP	
Margareta Johanson	INTERACT	GEP	All
Nate Miller	CIRES	SEB[2]	Summit
Andrey Grachev	CIRES	SEB	Eureka, Tiksi
Jim Drummond	Dalhousie U.	SEB	Eureka
Glen Lesins	Dalhousie U.	SEB	Eureka
Ralf Staebler	Environment Canada	SEB	All
Ola Persson	CIRES	SEB	All
Ari Asmi	FMI, PEEX	SEB	
Sanna Sorvari	FMI, PEEX	SEB	
Alexander Makshtas	AARI	SEB	Tiksi
Irina Repina	AARI	SEB	Tiksi
Arseniy Artamanov	AARI	SEB	Tiksi
Tuomas Laurila	FMI	SEB, CO2, Methane	Pallas-Sodankyla
Ed Dlugokencky	NOAA	CO2, Methane	Barrow, Cherskii
Lori Bruhwiler	NOAA	CO2, Methane	Carbon Tracker
Wolfgang Schoener	ZAMG	SEB	GCW
Dave Cook	ANL (DOE)	SEB	Barrow
??Stephen Hudson	??	SEB	Ny-Alesund
Dave Lawrence	NCAR	Modeling	All
Bill Riley	LBNL	Modeling	All

		Modeling	All
		Modeling	All

[1] Gross Ecosystem Production (GEP)

[2] Surface Energy Balance (SEB)

Appendix

1. Participants

Attendee	Affiliation	Email	Interests
Yongwon Kim	IARC-UAF	kimyw@iarc.uaf.edu	AWS major, scientist, works with Japan
Thomas Friborg	Univ. Copenhagen	tfj@ign.ku.dk	Sweden, Greenland, (ICOS), working on getting database set-up to archive data (but not yet), ICOS consists of many stations and surfaces and towers
Sebastian Zubrzycki	Univ. Hamburg	s.zubrzycki@web.de	tree towers running (next to Tiksi), 10meter tower and 5?meter tower and cherskii tower (collaborating with NOAA) as well
Dave Billesbach	Univ. Nebraska (NGEE)	dbillesbach1@unl.edu	fluxtower DOE ARM project and NG project, Oliktok tower set-up, measurements similar to Barrow (also connected to Ameriflux)
Taneil Uttal	NOAA-ESRL	taneil.uttal@noaa.gov	

Peter Griffith	NASA (ABOVE)	peter.griffith@nasa.gov	Works with NASA/ABOVE program. Interested in tower locations, inventory of where towers are by AmeriFlux and FluxNet people, definition of what is “Arctic” location
Eric Kasischke	Univ. Maryland (ABOVE)	ekasisch@umd.edu	energy exchanges and fluxes
Adrian Rocha	Univ. Notre Dame	arocha1@nd.edu	Norte Dame, heat flux, Toolik Lake, AmeriFlux, data archived in AmeriFlux database
Mats Nilsson	Swedish Univ. of Ag. Sciences	mats.b.nilsson@slu.se	Swedish, fluxtowers, ICOS,
Leif Klemedtsson	Univ. Gothenburg	lief.klemedtsson.gu.se	member of Swedish ICOS, carbon, bio-chemist gas fluxes
Torsten Sachs	GFZ Potsdam	tsachs@gfz-potsdam.de	fluxtowers in Lena river, airborne flux measurements
Stefun Metzger	NEON	smetzger@neoninc.org	NEON
Rommel Aulueta	NEON	rzulueta@neoninc.org	NEON, arctic sites building in 2015, standardized instruments, started AmeriFlux in Barrow
David Durden	NEON	ddurden@neoninc.org	NEON, Barrow and Toolik, boundary layer interest
Gerald Geerneart	U.S. DOE	gerald.geernaert@science.doe.gov	NGEE, DOE Climate and Environmental Sciences Division director, IARPC (US) Principal

Masahito Ueyama	Osaka Prefecture University	miyabi-flux@muh.biglobe.ne.jp	Eddy Covariance measurements
Kazuhito Ichii	Fukushima Univ.	kazuhito.ichii@gmail.com	Eddy Covariance measurements
Janet Jansson	LBNL	jajansson@lbl.gov	Danish center, how to measure gas fluxes
Sasha Ivans	Campbell Scientific	sasha@campbellsci.com	Interested in customer needs for instrumentation
Ivan Bogoer	Campbell Scientific	ivan@campbellsci.com	Interested in customer needs for instrumentation
Wolfgang Schoener	GCW	wolfgang.schoener@zamg.ac.at	Global Cryosphere Watch (GCW)-CryoNet, interactions with atmosphere, over-lapping interests between IASOA and GCW in the Arctic
David Lesmes	U.S. DOE	david.lesmes@science.doe.gov	
Manuel Helbig	Universite de Montreal	manuel.helbig@umontreal.ca	
Oliver Sonnentog	Universite de Montreal	oliver.sonnentag@gmail.com	Eddy Covariance measurements
Taro Nakai	Nagoya Univ.	taro.lnakai@gmail.com	
Hirohiko Nagano	IARC-UAF	hnagana@alaska.edu	
Ayaka Sakabe	Kyoto Univ.	sakabea@kasi.kyoto-u.ac.jp	Flux Towers in AK
Virginie Moreaux	SDSU	vmoreaux@mail.sdsu.edu	Works with Patrick Murphy
Patrick Mruphy	SDSU	pmurphy@mail.sdsu.edu	
Naama Raz-Yaseef	LBNL	nryaseef@lbl.gov	NG tower (works with Dave B.), contacting people (60+ people) to join flux tower network
Ulli Seibt	UCLA	useibt@ucla.edu	Greenland (Thule) gas exchange between land and atmosphere
Tuomas Laurila	FMI	tuomas.laurila@fmi.fi	finland, Tiksi, FMI, ICOS

Syndonia Bret-Harte	UAF	msbretharte@alaska.edu	NSF-AON funded work in Alaska, Cherskii
Eugenie Euskirchen	UAF	seeuskirchen@alaska.edu	NSF-AON funded work in Alaska, Cherskii
Margareeta Johanson	Lunds U.	margareta.johansson@nateko.lu.se	INTERACT program. monitoring at research stations, station catalog of parameters measured, minimum things needed to start monitoring, inventory

2. Relevant Projects (Content extracted from websites as noted)

Ameriflux (http://ameriflux.lbl.gov/Pages/default.aspx): The AmeriFlux Network, sponsored by U.S. Department of Energy, gathers data from the longest-running sites in the world measuring ecosystem CO2, water, and energy fluxes. This thriving community of tower site investigators and climate/ecosystem modelers works together with shared commitment to transparency, open access, and quality. The network's scientists gather data that assess carbon cycle exchange from land to air, and environmental measurements of local ecosystems.

Collaborating researchers are those who run western hemisphere carbon flux tower sites, and those who use the AmeriFlux Network's long-term, continuous environmental measurements to investigate ecosystem and climate questions.

The AmeriFlux Management Project (AMP), funded by the U.S. Department of Energy's Terrestrial Ecosystem Science program, supports the needs of the AmeriFlux Network researchers, offering data processing, quality assurance, and helping investigators to optimize and improve data collection to achieve the best long-term quality data. AMP also manages the AmeriFlux Network website, hosted at Lawrence Berkeley National Laboratory.

NEON (http://www.neoninc.org/): National Ecological Observing Network (NEON) is designed to gather and synthesize data on the impacts of climate change, land use change and invasive species on natural resources and biodiversity. Data will be collected from 106 sites (60 terrestrial, 36 aquatic and 10 aquatic experimental) across the U.S. (including Alaska, Hawaii and Puerto Rico) using instrument measurements and field sampling. The sites have been strategically selected to represent different regions of vegetation, landforms, climate, and ecosystem performance. NEON will combine site-based data with remotely sensed data and existing continental-scale data sets (e.g. satellite data) to provide a range of scaled data products that can be used to describe changes in the nation's ecosystem through space and time.

NGEE-Arctic (http://ngee-arctic.ornl.gov/mission): Increasing our confidence in climate projections for high-latitude regions of the world will require a coordinated set of investigations that target improved process understanding and model representation of important ecosystem-climate feedbacks. The Next-Generation Ecosystem Experiments (NGEE Arctic) seeks to address this challenge by quantifying the physical, chemical, and biological behavior of terrestrial ecosystems in Alaska. Initial research will focus on the highly dynamic landscapes of the North Slope (Barrow, Alaska) where thaw lakes, drained thaw lake basins, and ice-rich polygonal ground offer distinct land units for investigation and modeling. A focus on scaling based on investigations within these geomorphological units will allow us to deliver a *process-rich ecosystem model, extending from bedrock to the top of the vegetative canopy, in which the evolution of Arctic ecosystems in a changing climate can be modeled at the scale of a high resolution Earth System Model grid cell (i.e., 30x30 km grid size)*. This vision includes mechanistic studies in the field and in the laboratory; modeling of critical and interrelated water, nitrogen, carbon, and energy dynamics; and characterization of important interactions from molecular to landscape scales that drive feedbacks to the climate system.

ABOVE-NASA (http://above.nasa.gov/):Climate change in the Arctic and Boreal region is unfolding faster than anywhere else on Earth, resulting in reduced Arctic sea ice, thawing of permafrost soils, decomposition of long- frozen organic matter, widespread changes to lakes, rivers, coastlines, and alterations of ecosystem structure and function. NASA's Terrestrial Ecology Program is in the process of planning a major field campaign, the Arctic Boreal Vulnerability Experiment (ABoVE), which will take place in Alaska and western Canada during the next 5 to 8 years. ABoVE will seek a better understanding of the vulnerability and resilience of ecosystems and society to this changing environment.

INTERACT (http://www.eu-interact.org/): INTERACT is an infrastructure project under the auspices of SCANNET, a circumarctic network of 33 terrestrial field bases in northern Europe, Russia, US, Canada, Greenland, Iceland, the Faroe Islands and Scotland. INTERACT specifically seeks to build capacity for research and monitoring in the European Arctic and beyond, and is offering access to numerous research stations through the Transnational Access program.

The project, which is funded by the EU, has a main objective to build capacity for identifying, understanding, predicting and responding to diverse environmental changes throughout the wide environmental and land-use envelopes of the Arctic. This is necessary because the Arctic is so vast and so sparsely populated that environmental observing capacity is limited compared to most other latitudes.

INTERACT is multidisciplinary: together, the stations in INTERACT host thousands of scientists from around the world who work on projects within the fields of glaciology, permafrost, climate,

ecology, biodiversity and biogeochemical cycling. The INTERACT stations also host and facilitate many international single-discipline networks and aid training by hosting summer schools.

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ICOS (http://www.icos-infrastructure.eu/): Integrated Carbon Observing System is a European research infrastructure (ESFRI) dedicated to high precision observations of greenhouse gas concentrations and fluxes. ICOS will provide the long-term observations required to understand the present state and predict future behavior of the global carbon cycle and greenhouse gas emissions. Atmospheric stations are established to measure continuously the greenhouse gas (CO_2, CH_4, N_2O) concentration variability due to regional and global fluxes. The atmospheric network will have more than 30 sites, considered as the backbone of the infrastructure.

Ecosystem Stations are built for monitoring the functioning of land ecosystems and the exchange of energy and greenhouse gases between the ecosystems and the atmosphere, The Ecosystem network will consist of 40-60 observation sites employing a standardized set of measurement techniques and instruments.

Marine ICOS will provide the long-term oceanic observations required to understand the present state and predict future behaviour of the global carbon cycle and climate-relevant gas emissions. A network of ships and fixed stations will be monitoring carbon exchange between the surface ocean and the atmosphere, acidification of oceans, surface temperature, salinity and other variables.

Initially there will be more than 70 ICOS observation stations. The ICOS National Networks will gradually extend as more stations are integrated into ICOS RI.

PROMICE (http://promice.org/home.html): Program for the monitoring of the Greenland Ice Sheet (PROMICE) In 2007 the Programme for Monitoring of the Greenland Ice Sheet (PROMICE) was initiated as an ongoing effort to assess changes in the mass budget of the Greenland ice sheet. The two major contributors to the Greenland ice sheet mass loss are a reduction in the surface mass budget through enhanced surface melt and an increasing ice calving flux through glacier acceleration. PROMICE aims to quantify both these processes. The surface mass budget is monitored by a network of weather stations

in the melt zone of the ice sheet, providing measurements that feed into models calculating ice-sheet-wide melt.

OASIS: **The Ocean – Atmosphere – Sea Ice – Snowpack (OASIS)** program was created in 2004 as an international, multidisciplinary group to study chemical and physical exchange processes among the title reservoirs, focusing on the impact on tropospheric chemistry and climate, as well as on the surface/biosphere and feedbacks in the Arctic.

During the International Polar Year (IPY), OASIS was involved in a number of large-scale field studies in both polar environments. Sea ice was of particular interest, as it plays a critical role in polar environments: it is a highly reflective surface that interacts with radiation; it provides a habitat for mammals and microorganisms alike, thus playing a key role in polar trophic processes and elemental cycles; and it creates a saline environment for chemical processes that facilitate a highly oxidizing (cleaning) atmosphere in an otherwise low-radiation environment. Ocean-air and sea ice-air interfaces also produce aerosol particles that provide cloud condensation nuclei (CCN).

Sea ice is undergoing rapid change in the Arctic, transitioning from a perenniall or multi-year ice (MYI) pack to a thinner, seasonal first-year ice (FYI) pack, thereby transforming into a more Antarctic-like system. Such changes in critical interfaces will likely have large impacts system wide – from habitat loss to dramatic changes in heat and water vapor fluxes to changes in atmospheric chemistry. OASIS scientists are deeply involved in studies aimed at understanding interactions among components of the Ocean – Atmosphere – Sea Ice – Snowpack system and potential feedbacks at their most fundamental levels.

International Study of Carbon, Water, and Energy Balance in the Terrestrial Arctic (http://aon.iab.uaf.edu/research): Our research contributes to Arctic Observatory Network (AON) goals by observing and documenting arctic environmental change through development of long-term multivariate data sets at two observatory sites in Alaska and Siberia. We are also working to integrate our findings across the network of other long-term arctic research projects, including the Arctic LTER, by building databases and cross-disciplinary collaborations.

Our primary objective is to increase understanding of carbon, water, and energy fluxes, and their interactions, in arctic landscapes.

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IARPC (Modeling, Atmosphere, Sea Ice, Terrestrial Groups) The Interagency Arctic Research Policy Committee implements its Five Year Plan for Arctic Research through a set of 12 implementation teams. The four listed here have some stake in improved understanding of and representation of surface energy balance and ecological flux processes in models.