

***Remote Sensing in the North American Carbon Program
Summary of Workshop Held at the University Center, University of Montana
Missoula, Montana, August 20-21, 2004***

I. Background

The Carbon Cycle Interagency Working Group (CCIWG) of the Climate Change Science Program (CCSP) approved planning for this workshop in April, 2004 as one element toward implementation of the North American Carbon Program (NACP). CCIWG members (representatives from the National Aeronautics and Space Administration (NASA), the Department of Energy (DOE), the National Oceanic and Atmospheric Administration (NOAA), the US Department of Agriculture (USDA), the US Geological Survey (USGS), the National Science Foundation (NSF), the National Institute of Standards and Technology (NIST), and the Office of Naval Research (ONR)) nominated workshop participants. The Office of Earth Science (now the Earth-Sun System Division) of NASA provided core funding and led the organization for this workshop on behalf of the CCIWG. The Numerical Terradynamic Simulation Group (NTSG) of the University of Montana hosted the workshop and made logistical arrangements.

Attachment 1 lists the Workshop attendees. Approximately 65 people accepted invitations. The participants represented the remote sensing, modeling and data management and assimilation communities.

The invitation letter to the workshop included the following information about objectives and goals. The purpose of the workshop was to:

- a) Review the goals and objectives of the NACP and the current use of remote sensing to meet those goals, e.g., how remote sensing technology will be employed to characterize sources and sinks of CO₂, CH₄ and CO in North America and adjacent ocean basins;
- b) Identify key issues related to remote sensing in the NACP including observations and measurements to be acquired, remote sensing inputs to models, data and data product access, etc.; and,
- c) Compile recommendations on key issues

In addition, a stated goal of the workshop was to prepare a report for the Carbon Cycle Science website and other publications (i.e., AGU EOS) on action plans for identifying/organizing existing data, mechanism(s) for scheduling targeted acquisitions, and needs for new products from, or analyses of, existing observational data sets for the NACP.

The CCIWG reviewed and approved the agenda, goals and objectives and invitation list for the workshop. The final agenda (see Attachment 2) called for a workshop of one and a half days. The primary element of the workshop was three break-out sessions planned for the afternoon of the first day. The break-out sessions focused on three topics: 1) aircraft observations for intensives, scheduled remote sensing requirements; 2) regularly available satellite remote sensing datasets – public and commercial, continuous times

series; and 3) data systems, data assimilation and modeling requirements. Each workshop invitee was assigned to a breakout session as listed in Attachment 1. Presentations on critical topics for the NACP preceded the break-out sessions and provided background information for the participants. The chairpersons of the break-out sessions were asked to summarize the session discussions and present recommendations from the break-out sessions at a plenary meeting that concluded the workshop.

The workshop followed the agenda although some details changed: Roger Dahlman did not attend, and DOE did not give a presentation; the presentation order was switched between Denning and Wickland to accommodate Denning's late arrival; the break-out groups were allowed an extra hour the morning of the second day to review the results of the previous afternoon and to obtain concurrence from the participants in each group before the results were presented at the workshop plenary. These changes did not have a significant impact on the workshop results as indicated below, and the event met, if not exceeded, the intentions and expectations of the organizers.

II. Summary of the presentations (PowerPoint slides from all presentations are in Attachment 3.)

- A. **Diane Wickland**, representing the CCIWG, described the science questions that are driving the US climate change and carbon cycle programs and the rationale for the carbon cycle program. She summarized the approach and implementation strategy of the carbon cycle science program and the issues in the overall approach that will be addressed by the NACP. She also described the management structure for the CCSP and the place of the NACP in that structure. Wickland emphasized how projects and tasks, those selected through the just completed multi-agency solicitation for carbon cycle science, and other science projects and tasks relevant to the NACP (e.g., FIA and Ameriflux) must be coordinated and stressed the urgent need to begin that coordination. In that regard, she noted that the CCIWG has established an NACP program management plan and will identify an NACP office and full time director in the near future. Wickland discussed the intention of the CCIWG to include Canadian and Mexican scientists, projects and capabilities in the NACP and the current status of the CCIWG implementation, such as the status of the State of the Carbon Cycle Report (SOCCR) and a review of the role of remote sensing in the NACP. She described how this workshop fit in with other workshops related to the NACP and planned for the coming year including the workshop on *in situ* science for the NACP mid-continent intensive, scheduled for September 13-15, and the workshop on data management and assimilation for the NACP in January 2005 (see the Wickland presentation in Attachment 3 for list of workshops). She concluded with a list of issues or questions she hoped the workshop would address:
- a. Is the ongoing work enough?
 - b. What's missing on the NACP plan, especially regarding use of remote sensing?
 - c. Are the right remote sensing products available?
 - d. What can be done to coordinate individual tasks?

She hoped the workshop would develop a list of recommendations for the CCIWG, help the CCIWG prepare for the mid-continent intensive and stimulate dialogue within the community to assure acceptance of the goals, objectives and approach of the NACP and the success of the program.

- B. **Scott Denning** focused on the science questions for the NACP and what it will take to address those questions.
- a. What is the carbon balance of North America?
 - b. What processes control the sources and sinks of CO₂, CH₄ and CO and how do the controls change with time?
 - c. Are there potential surprises?
 - d. How can we enhance and manage long-lived carbon sinks and provide resources to support decision makers?

Denning discussed how diagnostic and predictive models will help answer those four questions. He noted the requirements for modeling and the observational and measurement gaps that must be filled in order to improve the utility of the models. He described the NACP integration strategy, how the output from experiments will be input to diagnostic and predictive models, both of which will lead to improved understanding of fluxes and stocks and decision support. He noted that development and evaluation models for the NACP will be based on a hierarchy of terrestrial measurements, scaling up from intensive studies of local sites, to understanding carbon cycle processes at the regional scale, to use of extensive sampling (FIA, NRI) and, finally, to “wall-to-wall” measurements using satellite remote sensing. Denning noted the importance of including coastal ocean observations because of the very large changes in pCO₂ concentrations over short distances off shore. He identified major gaps in the observational and measurement records that need to be filled: 1) high resolution weather data, 2) historic land use land management data, 3) carbon flux and storage data for urban/suburban landscapes, 4) irrigation quantified in space and time. He noted the current paucity of atmospheric measurements and stressed the need for improvement in sampling that will accrue assuming planned programs are funded. Approval of those sampling plans will still leave much of Canada without adequate measurements. Denning concluded by describing the likely impact of the NACP on the SOCCR, our understanding of the longevity of carbon sinks, assessment of sequestration options, management of the carbon cycle and development of scenarios for future climate.

- C. **Steve Running** presented a summary of the regularly available, satellite based remote sensing data sets. He encouraged the workshop participants to identify the sensors and measurements needed to meet the requirements of the NACP and to note gaps in the inventory of currently available satellite observations. Running described the initial considerations for reviewing the NACP remote sensing requirements including the time, spatial and disciplinary domains. He outlined the sensors and sensor suites available, and he described in greater detail MODIS data products – the products that will be of use to the NACP and the characteristics of those products.

D. **Bob Cook**, in a presentation prepared with input from Eric Sundquist, Tom Boden, and Peter Thornton, posed two questions regarding data management issues for the workshop to consider: what data products are needed to meet NACP goals and objectives, and what data management functions must be in place to assure NACP scientists access to data and information products in a timely and accurate manner. Cook noted the need to identify data and information management requirements early and to consider both the products that are known to meet NACP needs and those products which do not meet existing needs but may be modified to do so. He described the NACP data management workshop now being planned for winter 2005 and noted the intention to discuss then the overall strategy of the NACP toward data management. The intention of that workshop is to issue a report on the NACP data management system, resources required, interfaces between agencies and data centers and a plan for oversight and management of NACP data requirements. Cook concluded with the following thoughts and recommendations:

- a. Dedicated financial support for data management is essential for both individual projects and NACP
- b. Communication among those making measurements, data managers, modelers, and other users is critical
- c. Data manager(s) must be an integral part of the team leading NACP
- d. Team leading NACP needs to establish:
 - Data coordinating agreements between NACP, NACP investigators, and the agencies and data centers
 - NACP Data Policy (data sharing, coordination, and enforcement)
- e. Periodic data management coordination through annual or semi-annual modeling / analysis workshops conducted by NACP

E. **Scott Denning's** second presentation focused on diagnostic modeling of atmospheric carbon concentrations in North America and the use of such models to identify sources and sinks of carbon. Denning reviewed the current global network of atmospheric observations of carbon and how the network is too sparse to understand regional carbon distributions. He described the impact of airborne measurements from the COBRA 2000 flights and discussed the uncertainties in understanding of the interaction between the atmosphere and land processes affecting carbon distribution. These uncertainties are significant in tracking the distribution of carbon and carbon flux from day to day. Denning also described the data set expected from the Orbiting Carbon Observatory (OCO) mission and the limitations of that data set. He concluded with the following:

- a. Enhanced observations of atmospheric trace gas mixing ratio under NACP will help to quantitatively constrain area average sources and sinks by regional inversion
- b. Assumptions about temporal and spatial autocorrelations will be crucial for successful inversion, and must be reconciled with data
- c. Decomposition of total flux into "physiological" and "ecological" time scales may allow longer time average fluxes to be estimated
- d. Remotely sensed and other spatial data used in terrestrial ecosystem

- and air-sea flux models will be a central component of this effort
- e. Dedicated high-resolution meteorological reanalysis for transport diagnostics will likely be required too

F. **Chris Potter** provided a summary of issues related to modeling carbon sources and sinks in terrestrial environments. Potter reviewed how current models are used with remotely sensed data from satellites and *in situ* observations to track ecosystem processes and infer terrestrial carbon fluxes. He noted the additional information required to improve the accuracy of models and to better understand carbon storage in, and emissions from, above ground and below ground biomass. He noted the gaps between the information needed for ecosystem modeling and the current data products from MODIS. He also noted significant concerns with the NACP science implementation plan and the requirements for terrestrial carbon modeling. His concerns included the need for more detailed land cover classifications than described in the plan, the inadequacy of current plans for daily observations of vertical profiles to monitor rapid changes in land sources and sinks, and the lack of strong linkages between the NACP science community and the carbon policy community to assure use of the information from the NACP in decision support. Potter noted the potential importance of invasive species in terrestrial carbon processes and the lack of information on how control or eradication of invasive plants will impact the carbon cycle. He also described the CQUEST tool, an on-line tool for carbon management, and how that tool may be employed by NACP investigators to evaluate terrestrial carbon processes. Potter summarized the presentation with four remote sensing data requirements for terrestrial carbon cycle modeling:

- a. High resolution (250-meter or better) image products in areas of rapid change in woody biomass coverage
- b. Multi-temporal (seasonal or better) image products in areas of rapid land cover/use change
- c. Validation of high resolution surface radiation and precipitation data from remote sensing
- d. Re-projection (to conventional U.S. cartography) and accurate georectification for all the above

G. **Jeff Morisette** concluded the morning presentations with a summary of considerations for aircraft usage within the NACP. The presentation was a collaboration among Morisette, Forrest Hall and Fred Huemmerich with input from Diane Wickland, Bill Emanuel and Piers Sellers. Morisette described the science data requirements for the NACP and the effect of those requirements on the NACP implementation strategy, *in situ* measurements and satellite observations. He also described the process for planning and executing airborne data acquisition campaigns. Aircraft measurements are important to the NACP because they provide information beyond the capabilities of satellites and help scale up measurements and observations from ground sites to satellite based regional to continental scale studies. The use of aircraft is explicit in the NACP strategy. The COBRA 2000 flights are an example of the essential utility of aircraft measurements to understand

carbon fluxes and to acquire measurements at temporal and spatial resolutions adequate to scale up to satellite measurements. Morisette described the type of aircraft measurements available and their relationship to satellite measurements. He noted that *in situ* aircraft data needs for the NACP will be met by NOAA aircraft programs. The advantages of aircraft data can only be achieved with careful planning and validation of the measurements. Some considerations for advanced planning include an experimental design that incorporates the needs of all investigators who will use the data, weather forecasting for mission operations, understanding of, and compliance with FAA flight regulations, and data processing, staging and access. Morisette also reviewed use of aircraft in a possible scenario for the 2005 mid-continent intensive campaign.

III. Summary of the break-out sessions

The three break-out sessions convened early in the afternoon of the first day and continued through the remainder of the day. The three sessions were:

- 1) Aircraft observations for intensives, scheduled remote sensing requirements: chaired by Susan Ustin and Pieter Tans;
- 2) Regularly available satellite remote sensing datasets – public and commercial, continuous times series: chaired by Eric Kasischke and Jeff Masek, and
- 3) Data systems, data assimilation and modeling requirements: chaired by David Schimel and Ramakrishna Nemani.

Prior to meeting, participants received guidance for the sessions from Bill Emanuel. Emanuel noted that the sessions were to:

- Clarify the roles for remote sensing in NACP, specific requirements, and approaches.
- Identify existing remote sensing assets and capabilities for NACP.
 - What projects and programs are in place to take advantage of these resources?
 - What additional initiatives are needed?
 - What are the requirements for coordination, for example to take advantage of different sensors, aircraft and satellite observations?
- Clarify data management and data system requirements for remote sensing in the NACP.
- Clarify modeling and analysis approaches for using remote sensing in the NACP.
 - What are the data requirements?
 - What requirements do these impose on data acquisition, etc.?

and that the ultimate goals of the sessions were to:

- Make recommendations to the CCIWG and other agency sponsors.
- Extend the workshop dialog to the larger community.
- Adapt existing and new projects to help implement recommendations and meet NACP goals.

The break-out sessions re-convened the morning of August 21 to review the discussion from the previous day and agree upon a report to the plenary session of the workshop.

The plenary session convened approximately 9:30am. Highlights of breakout session reports include:

1. Aircraft observations – Susan Ustin reporting: The summary of the session began with a listing of the airborne science goals which included quantifying stocks and fluxes of carbon, understanding the mechanisms and controls on the carbon cycle, scaling between intensive ground sites and satellite measurements, calibration and validation of satellite data, linking the carbon, water and nitrogen cycles, and understanding and predicting the interactions between human management and the physical/biological environment. Ustin described the airborne remote sensing requirements for intensive campaigns and noted that *the group felt that 2005 was too soon to implement a large scale, integrated program*. She also noted other institutional planning needs, such as a coordination plan; the variables that should be measured by aircraft (see Attachment 4) including surface properties and atmospheric measurements; and she displayed a table compiled by the session of possible measurement requirements and the instruments that could make those measurements. She also reported on the scheduling and spatial resolution issues and recommended flight and schedule objectives.

Institutional planning issues identified by the group:

- a. *Develop coordination plan for intensives--*
 - *Who decides priorities?*
 - *Coordination among multiple PIs and agencies on aircraft missions. Notify PIs of flight status and planning.*
- b. *Scope the data acquisition capacity and start with pilot implementation. 2005 campaign is too soon to fully develop large scale integrated program.*
- c. *Develop a prioritized schedule for deployments and rationale for site prioritization and data collection.*
- d. *Identify instruments and platforms of all participating agencies to optimize deployments.*
- e. *Identify who will process the data and deliver it to participants; with deadlines. Need for quick turn-around and data/preliminary products available to the broad research community.*
- f. *Seek common format for shareable data*
- g. *Coordinate with other agencies (e.g., homeland security for urban/ag regions)*
- h. *Measure clouds concurrent with flux measurements (MODIS, GOES)*

Recommended flight and scheduling objectives for intensive sites:

- a. *~30km x 30km footprint around towers; chemistry/fluxes*
- b. *~10km x 10km for LIDAR (0.5-1m horizontal)*
- c. *Spatial resolution depends on science priorities (<1-20m suggested for different science goals).*
- d. *Min/max leaf on/off; Additional flights for bimodal precipitation regimes.*
- e. *1-5 year repeat for structure measurements.*

Synergy:

- a. *Concurrent flights (multi/HSI) with atmosphere measurements for process/physiology*

- b. *Concurrent AVIRIS, TIR desirable (physiology)*
 - c. *Concurrent LIDAR/radar or AirMISR desirable (structure)*
 - d. *AVIRIS (HSI) required to achieve many science goals*
 - e. *Coordination between field and aircraft data collections*
 - f. *Coordination between aircraft data and field calibration activities*
 - g. *Coordination between aircraft data collection and satellites*
 - h. *Experiment design needs integration with modeling community*
2. Regularly available data sets – Eric Kasischke reporting: The session reported on four areas of use of satellite data: 1) plant physiology (GPP, NPP and NEP); 2) land surface mapping; 3) forest structure characterization; and, 4) disturbance mapping and characterization. Current data sets applicable to each area were described and issues identified. Recommendations from the session:
- a. *Additional surveys are needed to more completely address objective for the workshop*
 - *Quick survey of project abstracts and phone/email contacts with selected investigators*
 - *More detailed survey of all participants (see form)*
 - *Establish online database of NACP investigations, including topic, data uses, and new products generated.*
 - b. *Linkages to establish collaborations with new NACP investigators and existing MODIS LAND teams may be useful for generation of new information products*
 - c. *NACP Mgmt needs to check on availability of high-resolution commercial data for specific study areas to support product development/validation. Ensure that SDB high-resolution archive is preserved for NACP use.*
 - d. *Data Management issues*
 - *Means for investigators to review data holdings (especially Landsat and other data sets, ALI, MISR) is needed*
 - *Access to data on local field observations that can be used in analysis of RS data*
 - *Common formatting for NACP MODIS products (NAM subsets, common projection set, etc)*
 - *Leverage existing ORNL capabilities (e.g Mercury system).*
 - e. *Establish (Recommend?) 'baseline' versions of datasets (e.g. AVHRR NDVI) for common use across NACP*
 - f. *Improve access to existing validation datasets produced by Federal Agencies; general need for more coordinated validation of NACP RS products; general need for improved characterization of uncertainty and error.*
 - g. *Coordinate NACP Intensives and Tier 2 observations with RS validation efforts*
3. Data management and assimilation; Dave Schimel reporting: The session noted that the community is moving from making data look like models to making model output look like the data. *There is a need for a standing*

working group for modeling and assimilation, related to, but not same as, the NACP data management steering committee. The NACP has to be able to subset EOS and other remote sensing and spatial data. These data sets will cookie-cut out the NACP domain (define domain first!) and supply products geo-rectified to a common base map.

Issues related to standards versus protocols for model/data interactions are:

- *Enable models to be compared to data in their original space/time form: don't interpolate point data to grids; models to predict things that are actually observed.*
- *Keep original LO/L1 data (swaths, point data) for assimilation into models*
- *Keep complete pedigree of every pixel*
- *Must include (pixel-specific) uncertainty estimates for every variable.*
- a. *There is also a need for self-consistent high resolution surface weather and atmospheric transport data set (reanalysis, not real time)*
 - *High resolution (10k?, 5km?) many levels (especially near the surface) hourly time step or shorter for transport*
 - *Tightly constrained to observations*
 - *Mass conserving transport and including cloud and turbulence transports*
 - *Open data archive with support for distribution and doc,*
- b. *Slow ecosystem data that constrain process models (even at points that constraining process models (at points or over small regions)*
 - *Link fast and slow processes*
 - *Biomass, soil C and N, litter, etc.*
- c. *Hydrologic data: deep soil water snow, permafrost*
- d. *Specialized point and remote sensing data to support detection and quantification of high-latitude carbon losses.*

Water is often the factor controlling the carbon cycle - more than temperature except where temperature affects evapotranspiration. *As a consequence, there is a need for closer coordination with hydrologic community.* Right now the major question in NACP is identification of a North American carbon sink. But ten years from now, the key question may be the carbon source in the high latitudes. *There is an opportunity for closer cooperation with the Canadian community.*

IV. Discussion and actions

A general discussion followed the break-out sessions reports. Bill Emanuel led the discussion, and he provided the workshop with a summary of the major points he gathered from the presentations and break-out sessions:

1. Core modeling group
2. Observation comparison at different resolutions/scales
 - Aircraft and satellite
 - Point measurements and RS
3. Informatics requirements
 - Science rationale
4. Data assimilation approaches
 - Implied uncertainties

5. Remote sensing directed at upper Midwest campaign
 - High resolution cloud data product
 - MODIS
 - Aircraft
 - Historical data Landsat etc.
6. Remote sensing directed at US/continental sources and sinks
 - Wall-to-wall landcover, biomass
7. Disturbance
 - Coastal
8. Emissions
9. Hydrology

Discussion comments:

- Steve Running noted that this is a good time in NACP planning for a modeling sub-group to form. About half dozen flavors of modeling. Modeling team could go far coordinating data acquisition etc.
- Scott Denning added that NACP needed an explicit strategy to link high resolution data from aircraft to the wall to wall MODIS acquisitions.
- Susan Ustin noted that if MASTER could fly with AVIRIS such comparisons could be made but there has to be an explicit plan to do that.
- Questions were asked about the timetable for implementing recommendations. It was noted that the workshop participants were a subset of the community and needed to connect with broader community.
- Dave Schimel offered that the NACP must begin now on informatics requirements derived from science requirements. Informatics requirements now are 10 years old and may not reflect needs of NACP adequately.
- Bill Emanuel asked about what specific remote sensing tasks and data sets the participants are prepared to bring to bear on the upper Midwest intensive? Some responses:
 1. High resolution cloud data product
 2. USGS EDC crop type data
 3. Goal of intensive is to prove the sampling design. (Wickland)
 4. Ames Research Center is doing 1km NPP daily product (Potter).
- Emanuel inquired if the workshop would form a team to follow this meeting and start to be more specific on data sets for intensives. Steve Running added that the team should probably focus on MODIS and that for the MODIS land data suite, the team could see what improved products, over automated global product, people would generate for NACP. Some investigators may have improved products already. Could get an idea of what could be generated for North America. Emanuel noted the need to consider what NACP can scope for upper Midwest. Jeff Morisette noted that code for MODIS collection 5 is due soon, so this is a good time to look at the MODIS products, but direction is needed from NASA HQ to Chris Justice to request products for specific tile (Midwest). Susan Ustin added that she is funded to participate in a validation campaign and that effort could involve aircraft products for the upper Midwest.
- Emanuel returned the discussion to the creation of a sub-group and reiterated the need to scope the intensives for the NACP, i.e., what can be done, where the gaps are – and develop very short report/summary. Group designation:

Steve Running will lead it up. Cook, Collatz, Morisette, Masek and Nemani will contribute. Objective is to take the identification of products for the Midwest intensive

as far as feasible by 9/13, *in situ* measurements from agricultural community; then complete for October 5-7 – meet and report prior to AmeriFlux meeting. Wickland noted that the groups should focus on products known to be useful. Running: have to be modifications of standard products. Wickland – it will cost something so it has to be of know use. Dar Roberts – consider adding historic Landsat data. Wickland – consider current REASoN projects such as TRFIC and GLCF.

- Two other subgroups emerged:

- Working group on aircraft data and scenarios for 2005/2006, including identification of data gaps: Susan Ustin will lead with support from Dave Schimel, Greg Asner, Pieter Tans and Scott Ollinger. Focus will be on surface measurements and coordination with NACP intensive.

- Core modeling group. Scott Denning would be appropriate lead. In association with that group Emanuel asked about US and continental data products, especially products that merged retrospective imagery with current imagery for wall-to-wall historical perspective on landcover and biomass. Jeff Masek noted the need to hear from the modeling community about the requirements for such a product. Masek will lead that effort working with Dave Schimel, Dennis Ojima, and Eileen Helmer.

- Emanuel called for all teams to report October 7-8 in Boulder for follow on to AmeriFlux meeting.

- Emanuel – what about fire product? Schimel – modeling group looking for 30 year perspective. Kasischke – that record exists for boreal region but not for the US; he will work on a summary of what it would take to generate that product/information. Need to look at other disturbance such as insect damage. Need to get at intensity of the defoliation and translate that to impact on carbon and nitrogen.

- Management of data products: workshop in January. The teams formed should consider providing input at that workshop such as how data sets will be integrated with other data required for NACP. Each team should designate someone to focus on data management issues and present them at the data management workshop.

V. Final comments from NASA (Diane Wickland)

Wickland, speaking on behalf of the CCIWG, acknowledged the issues identified during the workshop and recognize that there are actions for the IWG.

1. Heard strong call for coordination and integration that has yet to be put in place.
2. Much interest in the workshop on first intensive, which was appropriate, but not at cost of looking at larger goal which is continental perspective. The NACP may be focused too much on fast processes rather than slow processes that may have more impact on continental scale.
3. Data management and data servicing functions – need to think about who does it, what the costs are, etc. Should be good input to management workshop
4. Clear need for working groups. This should be an open process. Plenty of work for everyone. Should be inclusive in the approach,
5. Comments from Dave Schimel on need to track pixel pedigree was an eye-opener. If that is critical, NASA HQ has to think that through the implications, especially cost. Model working group could help define what is really needed.
6. Clear message for useful data base of on-going activities and data sets. Challenge to keep that current. NACP office will help.
7. Importance of not leaving out arctic and sub arctic systems.

Next steps:

- a. Airborne sensors and aircraft: implementation strategy for NACP did not call for a lot of aircraft. It will be difficult for NASA and other agencies to identify funds for aircraft acquisitions in '05. '06 may be easier. She acknowledged the sense of the group that the 2005 intensive might be considered a prototype or pilot activity with a full up intensive to follow in 2006.
- b. CCIWG is establishing an NACP project office which the workshop felt is a good idea. The CCIWG will move as fast as possible to do that. This workshop provided input on activities of that office.
- c. Need to work harder on interactions with land management agencies that have needed expertise and data of interest. Also with the weather data products.
- d. Need to hear from other workshops. – Iowa, AmeriFlux, etc., and input from oceanographers.

Wickland concluded by thanking participants for their time and effort.