

NASA Cold Land Processes (CLPX) Workshop  
November 7-9, 2001  
Boulder, Colorado

Notes from the CLPX Workshop.

An effort was made to summarize the discussions, and the resulting action items, without duplicating the information provided in the presentation materials (PowerPoint and viewgraphs). The presentation materials are now available on the web at [www.nohrsc.nws.gov/~cline/clp.html](http://www.nohrsc.nws.gov/~cline/clp.html). Times noted in the left column are in Boulder local time, 24 hour clock format.

References:

CLPX web page at <http://www.nohrsc.nws.gov/~cline/clp.html>  
NASA Earth Science Enterprise web page at <http://www.earth.nasa.gov/>.  
AIRSAR web page at <http://southport.jpl.nasa.gov/airsar/>  
NSIDC web page at <http://www.nsidc.org/>  
USDA, NRCS SNOTEL info at [http://www.wcc.nrcs.usda.gov/water/w\\_data.html](http://www.wcc.nrcs.usda.gov/water/w_data.html)  
NASA Earth System Science Pathfinder (ESSP) web page: <http://essp.gsfc.nasa.gov/>.

Wednesday, November 7, 2001

- 0830 Short introductions were made by all participants. Approximately 58 people were in attendance from various federal government agencies (NASA, DOD CRREL, NOAA - National Weather Service and Office of Oceanic and Atmospheric Research (OAR), US Forest Service, Bureau of Reclamation, U.S. Geological Service), several Universities (University of Colorado, University of Michigan, Colorado State University, University of Wales, and University of California Santa Barbara), and the National Snow and Ice Data Center (NSIDC) which hosted the workshop.
- 0840 Mike Jasinski (NASA, CPLX Program Manager) provided an overview of the CLPX project. \$2.1M is available for the first two years of the field experiment in the Colorado Rockies.
- 0844 Don Cline, (NOAA, NWS, National Operational Hydrologic Remote Sensing Center (NOHRSC)), Experiment Coordinator, provided an overview of the Cold Land Processes mission. The CLP working group task is to assess, plan, implement the science and technology and application infrastructure necessary to address snow, ice, and free-thaw cycles.

The CLPX project began in Irvine, CA in April 1998.

0848 Don Cline provided an overview of the workshop agenda:

- Wednesday - CLPX Data Collection - review status.
- Thursday - CLPX Data Management - planning.
- Friday - CLPX Science and Technology, develop a Road Map/Strategic Plan.
- Saturday - field trip to the three Mesoscale Study Areas (MSA's).

0852 Don reviewed the purpose of the CLP experiment: who, what, where, when, and summarized the players in the game.

What: collection of comprehensive in situ and remote sensing data set to support a wide variety of cold region hydrologic science objectives.

When: Two intensive observing period (IOP's) in 2002: February 16-27, 2002 and March 25-April 2, 2002. Two additional IOP's are planned for 2003. Experiment will be completed in 2004.

Where: North Central Colorado. Large Regional Study Area, nested within it is Small Regional Study Area, nested within it are three mesoscale study areas (MSA's) 25km on a side: Fraser, Rabbit Ears, and North Park. Within the three MSA's are nine intensive study areas (ISA's) and one Local Scale Study Area (LSOS).

Why: NASA Earth Science Enterprise (ESE) Strategic Plan to answer four major science questions. See <http://www.earth.nasa.gov/>.

0910 Don Cline (NOHRSC) provided an overview of the CLPX Budget. \$2.1M is available for core data collection coming from NASA Land Surface Hydrology (LSH) Program, NASA Earth Science Enterprise, and EOS/AMSR calibration/validation. An estimated \$2.5M has been allocated so far for the Science/Analysis portion of the experiment. Sources are: NASA LSH, NASA Global Water and Energy Cycle (GWEC) Initiative, and EOS/AMSR calibration/validation program.

0912 Paul Houser (NASA) added another spin on the mission and emphasized NASA's global mission and importance of snow on global climate predictions. He asked who is in charge of looking at how the CLPX field experiment applies to the global environment. Glen Liston (Colorado State University) noted that the 3 ISA's were selected because they represent 86% of the earth's snow covered areas. Don Cline added that no one has written a proposal to determine how this experiment will/can apply to the global environment, but someone in this working group should do so.

0920 Don Cline provided a detailed break down of the budget including aircraft operations, ground operations, and data management. The planned budget for these activities is for

\$2,043k with a contingency of \$2,182k.

- 0923 Don Cline reported on the status of Airborne Remote Sensing efforts. Three aircraft will be used: NASA DC-8, NASA P3-B, and NOAA Turbo Commander. The NASA aircraft will be based out of Colorado Springs for the experiment and the NOAA aircraft will be based out of Grand Junction. Don reported on the AIRSAR flight plan.
- 0940 Question: Will flights need to be flown simultaneously? They should be but we've got some latitude.
- 0941 Bert Davis (CRREL) reported on Remote Sensing Data Collection. Planned optical satellite data sets include: LandsAT, ASTR, MODIS, AVHRR, and AVIRIS. Microwave satellite data includes: RadarSAT, ASAR, QuickSCAT, SSMI, and AMSR-E.
- 0950 Question: Do we have good knowledge of the terrain? We've got GIS-based terrain information in the form of USGS 30 meter DEM's (digital elevation models).
- 0955 Don discussed loose ends on HIF airborne radar data collection. Discussion followed on POLSCAT with Snow Water Equivalent (SWE) derived from SIR-C/X-SAR.
- 0957 JC Shi (UCSB) discussed the importance of the Ku-band. Ku provides much better measurements of snow pack. He provided an update on a proposal to ESA's Explore Program (PI is Rott).
- 1002 Simon Yeuh (NASA JPL) reported on the Polarimetric Scatterometer (POLSCAT).
- 1016 Don Cline opened the floor to comments on the benefits of Ku band. He noted that the group said that it needed an HF sensor but asked if this is the Ku we want... it is low resolution 1 Km data. Simon noted that Ku could be flown at lower altitudes for improved resolution. Ku was not fully budgeted for but could be squeezed in if the group feels it is important to the experiment.
- 1030 Break.
- 1046 Don Cline reviewed the airborne issues. Consensus was that Ku should be incorporated into the plan even though it was not fully budgeted for. All agreed that opportunistic data takes with SAR from Wisconsin to California, on March 25, should be obtained from NASA aircraft during the transit to the NASA Dryden Research Facility. All agreed that PSR should be added to the instrument suite for the '02 campaign, though it is not in the original budget.
- 1049 Paul Houser requested a summary table be provided of measurements planned for each site organized by wavelength and satellite in addition to the instrument-based summary.

Action: Don Cline agreed to provide this.

- 1051 Don Cline reported on the NOHRSC gamma background radiation survey that was completed in September '01. The soil moisture data set is good to go for the three survey areas: Rabbit Ears, Fraser, and North Park.
- 1056 Don Cline introduced the Status of Ground-based Remote Sensing (GRS). We now have four GRS instruments in the plan: FMCW from CRREL, active radar from UM, passive radiometer from UM, and the NASDA AMSR simulator.
- 1059 Gary Koh (CRREL) provided an FMCW radar overview. FMCW = Frequency Modulated Continuous Wave. Gary provided answers to the question, why use FMCW?

It is cheap, easy, field portable, robust, and has wide broadband capability which enables identification of more significant features. It is mounted on a truck. Recent experiment with it worked well. Gary advised that when the radar frequency gets too high, it is possible to receive too much scatter data to process and data overload can result.

Question: how high off the ground is the FMCW instrument? It can be flexible. It can be mounted to towers, tripods, trucks, etc. It was recommended that Gary participate in the field experiments.

- 1117 Roger DeRoo (UM) reported on the UM radar plans. The radar is mounted on a 19 meter hydraulic arm, on a truck. The truck is gas powered with a 80 gallon capacity and burns 15 gals per 24 hours. The radar has Ku, C, X, L band capability. Roger noted that the UM radar will be ready for the 2003 campaigns. He also noted that the data should be ready for NSIDC approximately four months after the observation period is completed.
- 1130 Paul Houser (NASA) asked about the location of the Micromet network and eddy correlation measurements. It was noted that the best spot for eddy covariance is probably two miles from the LSOS site.
- 1142 Tony England (UM) reported on UM's passive radiometer plans. This is also a truck-mounted system on a 35 foot hydraulic arm. The truck is diesel powered with a 7.5 kW diesel generator. The data can be made available to NSIDC about two months after completion of data collection. Measurements are taken every 30 minutes.
- 1151 Richard Armstrong (NSIDC) reviewed the NASDA AMSR simulator. It is a Japanese ground-based AMSR simulator. Ed Kim (NASA GSFC) added additional comments on L-band radiometer, called "L-rad." He noted that it should be available to CLPX in 2002, and may be available to CLPX in '03 if desired.

- 1201 Lunch.
- 1300 Kelly Elder (US Forest Service) reported on the status of the Field Site Preparations. He noted that these are the sites where we actually poke holes in the snow. He noted that there could be as many as 60 people in the field during the IOP's in February and March, and that SAFETY is a major concern. Each intensive study area (ISA) will have 100 snow depth sample locations and 16 snow pit locations. Kelly noted that he had removed some trees and deadfall from the LSOS site. He reported that 588 soil moisture measurements were made this fall in conjunction with the NOHRSC gamma radiation soil moisture survey.
- 1318 Question: Mike Jasinski asked about the status of the 1400 posts? They should all be deployed by November 20, 2001.
- 1331 Question: JC Shi asked about surface roughness. The question was tabled for further discussion later in the agenda.
- 1333 Kelly Elder reported on Ground Data Collection plans. He reviewed the schedule for IOP-1 and IOP-2. He reported that mandatory safety training will be held on February 16 and 17, probably at the Fraser site. The safety instructors will be experts on the subject, primarily from within the CLPX work group. Safety training will include basic avalanche concepts, terrain, transceiver use, avalanche rescue techniques, working in cold weather, and winter survival.
- Action: identify and notify the nearest hospitals, police, fire departments, etc. regarding the field experiment. Provide them with an executive summary.
- 1340 Kelly Elder reviewed the sampling strategy: three ISA's in each MSA, four teams per ISA, for a total of 12 ground-based field survey teams. Each team will have 2 to 4 members. Each ISA will have 4 quadrants and one team per quadrant.
- 1346 Kelly reviewed transportation between MSA's and ISA's, into ISA's, and within ISA's. He noted that Buffalo Pass is 12 km uphill from the road and the "Cat Company" has offered transportation with their new, \$180,000 over-snow vehicle. This was viewed as a good thing.
- 1350 Kelly reviewed the IOP-1 and IOP-2 field rosters. He noted two major issues: (1) Safety and (2) data quantity and quality.
- 1359 Kelly reviewed the daily schedule of operations: morning briefing and assignments, transportation to ISA's, field exercises, return from ISA's, debriefing, data entry, data QC, data distribution and safe-guarding, equipment check and maintenance, coordination with aircraft, and planning for next day. Field teams will stay in hotels in Walden,

Steamboat Springs, and the dorms at Fraser.

1405 Kelly reported on the snow measuring equipment. Each team will be issued snow probes (cm graduated) and daily field books. At snow depth sites they will record snow depth, snow wetness, and snow surface roughness. The snow pit teams will be issued shovels, small GPS, radios, snow density samplers, scale, scraper, fiberglass ruler, snow probes, pencils, field notebooks, spare 9v batteries, snow thermometers, stratigraphy monocular device, and brushes.

JC Shi expressed concern about grain size variability in the snow pits. It was noted that the pits will be available to others for additional study after the field work is completed for the day. It was also emphasized that we cannot impact logistics, funding, time or our primary objectives with additional, unplanned activities. It was also noted that most of the snow pits will be filled in due to safety concerns and potential impact on nearby snow measurements.

1433 Question: Will snow grain size be used? Several folks answered in the affirmative.

1434 Wetness measurements were discussed. In snow pits temperatures will be taken every 10 cm from the top down. Snow density will be measured in several layers. We will do surface wetness at snow depth sites also, but just a surface sample which will be categorized as dry, moist, wet, very wet, slush. These categories can be converted into numbers in accordance with international snow measurement criteria.

Bert Davis noted that CRREL will also use SNTherm and SLTherm models to interpolate and make maps of surface moisture.

1440 Question: Will we have vegetation data? We will at snow pit sites but not at snow depth sites, though aerial photography could be used.

1445 Following more discussion of extra, unplanned work, Kelly and Don stated that we are already at the limit of our capabilities and resources with the field sampling effort. So, we cannot add much, if any, additional sampling activities to the plan. They noted that the 12 team leaders need to be experienced, skilled, back woods, data collectors with outstanding leadership and judgement skills.

1451 Janet Hardy (CRREL), LSOS coordinator, reported on the status of the LSOS site. She noted that there are 78 plots of 10 x10 meters each in the LSOS. There are continuous canopy plots, discontinuous canopy plots and open sites. LSOS key players include: UM Roger DeRoo and Tony England, CRREL Gary Koh and Janet, JPL McDonald, University of Montana, and the Japanese Space Agency for the ground-based AMSR simulator.

1507 Bert Davis (CRREL) noted that the UM trucks should be positioned prior to snowfall.

CRREL plans to create a 3-D map of every tree and DEM at the LSOS site.

1510 Break.

1535 Soil Moisture issues: Don Cline noted that this is a snow and freeze/thaw project, and, therefore, soil moisture is an important part of the project. There was talk of soil moisture sensors on the Micromet suite. Tony England noted he will have soil temperature profiles and heat flux disks at the LSOS site in '03. Much discussion followed on various techniques of measuring soil temperature and moisture profiles. Don asked what the remote sensors need. Answer was difficult to articulate but was, basically, the freeze depth, temperature, and moisture content down to 60 cm.

1555 Mark Seyfield (US Department of Agriculture, Agriculture Research Service) discussed automated ways to make an abundance of soil moisture measurements at low cost. Mark noted that you run into a cost problem fairly quickly with just about any method. There was further discussion of the pro's and con's of the various instruments: Stevens-Vitel hydra probes, theta probes, gravimetric measurements, TDR's, capacitor probes with instrument leads, and others. The issue of frozen soil was noted and that sensors must be deployed prior to freeze-up. A work group member asked if soil moisture and temperature measurements could be added to the Micromet suite. This appeared to be possible. It was noted that gravimetric measurements are simple and affordable but require bulk snow density which can be difficult to obtain.

1613 Don Cline (NOHRSC) made a recommendation that the soil moisture plan for 2002 be as follows: at snow pit sites, take dial stem temperatures at surface and 10 cm, and gravimetric sample to 20 cm. All agreed to this protocol for the 2002 field campaigns.

Action: Paul Houser agreed to head up a committee to plan the soil moisture protocol for 2003.

1620 Paul Houser, NASA, reported on the Micromet network. There will be nine Micromet sites, one at each ISA. They will provide background meteorological data including: air temperature, RH, wind speed and direction, soil moisture and temperatures, snow depth, snow temperature profile, atmospheric pressure, precipitation, shortwave radiation, longwave radiation, and a net radiometer. The Micromet system will not make measurements of: water, energy, carbon fluxes, SWE, runoff. The Micromet instruments will be attached to a standard 10 meter tower. There are \$260-290k available funds for the network. Cost per site is ~ \$25k. System shake-out is scheduled for Spring 2002, procurement in late Spring 2002, and operational by September 2002. Paul noted that the network could be turned over to another science agency in August 2004.

Questions: Micromet telemetry? Paul reviewed the options: GOES, cellular, meteorburst.

There was quite a bit of discussion regarding tipping buckets and other precipitation gauges, and

the difficulties/problems associated with all of them. It was suggested that no precipitation gages be deployed in the micromet suite if measurements are so unreliable, but this was sound defeated. Several comments indicated that this would have no credibility as a hydrology experiment if a strong effort to measure precipitation was not made.

There was additional discussion on snow temperature profiles with thermocouples and dowels. All agreed that there should be someone in charge of obtaining the met. data from existing stations such as the NRCS SNOTEL network, NWS, U.S. Forest Service.

Action: Don Cline will hire a “data wrangler.”

1715 Paul summarized the Micromet plans and budget and noted that decisions are not concluded on the instrument suite but much useful information was obtained during the discussions.

Question: Who will process the data? Paul Houser’s graduate students will.

Question: Is the eddy covariance system useful, where place it? To be determined.

Question: Who will repair and maintain the Micromet network? Paul will make site visits approximately once per month. In between, he’ll need the assistance of local help.

Question: Who will routinely look at the data for quality and reliability? Paul will.

1730 NASA DC-8 meeting was held with approximately a dozen working group members, led by Walter Klein of NASA Dryden Flight Research Center. Discussed flight and public relations logistics, funding, instruments, and schedules.

Action: NASA offered to provide a public affairs person to set up media materials and possibly a press briefing.

1850 Adjourned for the day.

Thursday, November 8, 2001

0830 Don Cline (NOHRSC) introduced the CLPX planned data sets and deliverables.

0834 Roger Barry (Director of NSIDC) introduced himself, and expressed his support of the CLPX project. He clearly stated that NSIDC is not in a position to absorb the costs of managing CLPX data, and that all CLPX data management would have to be specifically funded.

0841 Kelly Elder (USFS) provided detailed information on the expected field data sets from the ISA’s - on both the snow depth transects and snow pit sites. There will be 500 snow depth measurements per ISA, to the nearest cm, positioned in the UTM coordinate system. Each snow depth site will be characterized by snow depth, surface roughness,

and surface wetness. Data from snow pits will include snow density, snow temperatures, stratigraphy, wetness, soil moisture to 20 cm with gravimetric measurement, soil temperature at surface and 10 cm. The data will be provided in ASCII format at the end of each sampling day.

0850 Janet Hardy (CRREL) reviewed the LSOS data sets and provided a matrix on data deliverables.

0856 Tony England (UM) provided details of the UM radiometer at the LSOS site in 2003. Tony expects to collect data every 30 minutes. Data volume should be ~ 50 Kb/day. The augmented data should be ~ 200 Kb/day. The data should be available for distribution to NSIDC approximately four months after completion of the data collection period.

Action: Tony requested hourly observations of percent sky cover. Janet judged that she could provide this information - just needs an alarm clock.

0907 Roger DeRoo provided details of the UM radar data. The data will be available for distribution to NSIDC approximately four months after conclusion of data collection. He intends to place the data on his ftp site. The data will include a time stamp, incidence angle, etc.

0910 Glen Liston (CSU) reported on the NOAA Local Analysis and Prediction System (LAPS) products which are provided by NOAA's Forecast Systems Lab. See <http://laps.fsl.noaa.gov> for further information. Glen will archive the data from September 2001 through August 2004. The data/products are provided each hour on a 10 km grid and 21 vertical layers. It is a model generated product constrained by observational data sets. The data will be in NetCDF format which is an efficient, self-described, standard met. format. The group agreed that Glen should archive all the LAPS products rather than a subset.

Question: Will there be any coordinated comparison between LAPS and Micromet? not known at this point.

0926 Gary Koh (CRREL) reviewed the FMCW radar products. He noted that the group needs to decide what frequencies to use and the angles for the mobile radar system. Gary showed a standard FMCW radar profile and discussed mobile backscatter measurements and TDR probes for soil moisture profiles.

0936 Don Cline reviewed the AIRSAR data sets, TOPSAR and POLSAR, and the NOHRSC gamma data sets. The AIRSAR data will be mosaic'd by JPL for each MSA. The gamma data are posted to the NOHRSC web page in near real-time. See [www.nohrsc.nws.gov](http://www.nohrsc.nws.gov).

- 0945 Paul Houser discussed the Micromet data. It will be stored in ASCII, with a 10 minute time-step, and should be available within a day or two on his web site. Paul will include two data sets: raw data from data logger and QC'd and cleaned up data sets. Paul re-stated the need to identify one person to gather all the met. data from all available sources in the research domain.
- 0952 Al Gasiewski (NOAA, OAR, Environment Technology Lab) reported on the PSR multi-band polarimetric data sets. He plans to provide dry snow microwave images to the field, in near real-time, in JPEG or similar format. The QC'd and cleaned up data sets should be ready for distribution to NSIDC within eight months of conclusion of data collection.
- 1010 Question: are there any known flight restrictions? No, but there was a request to give Salt Lake City a wide berth during the Olympic Games due to enhanced aviation security.
- 1011 Ed Kim (NASA - JPL) reported on the Airborne Earth Science Microwave Imaging Radiometer (AESMIR) which is designed to simulate AMSR-E. The NASA P3 is the platform for AESMIR. It collects passive microwave imagery at all six AMSR channels plus IR brightness. It is planned for both 2003 intensive observation periods (IOP's).
- 1023 Bert Davis (CRREL) discussed the satellite data deliverables. Optical satellite data sets will be provided primarily from AVHRR and LandSAT. CRREL plans to deliver a snow product which the other techniques cannot. They will provide a snow covered area (SCA) map derived from LandSAT and AVHRR imagery. Microwave satellite data sets will include SSMI and AMSR, both of which have existing operational distribution pipelines to NSIDC.
- 1041 Tom Painter (UCSB) discussed AVIRIS which is the acronym for Airborne Visible InfraRed Imaging Spectrometer (see <http://makalu.jpl.nasa.gov/html/overview.html>). Tom noted that AVIRIS could be available for the late March IOP. The filesize of the quick looks could be approximately 1 Mb in size. The quick looks should be available the same day. Tom plans to collect field data in conjunction with the AVIRIS flights. Several working group members offered up mass spectrometry resources.
- 1106 Mark Parsons (NSIDC) provided a general review of Good data Management Practices. Mark will be the CLPX data manager. Mark reviewed the data management spectrum that can be provided by NSIDC. NSIDC can offer a full range of support from the PI does almost everything to NSIDC does almost everything. Mark noted that NSIDC provides a web gateway to NASA's Earth Observing System (EOS) data and to all MODIS data and products
- 1140 Mark reviewed some specific issues including ArcIMS which is a basic GIS program that runs on a web server and provides maps in GIS format.

1145 Roger Barry (Director NSIDC) noted that we need to think long term, 20 years down the road on what scientists will need. He noted that NSIDC is university supported with a small bit of NOAA funding and soft project money. He noted that NSIDC will support the CLPX project as best it can given their limited resources.

1154 Don Cline gave a demonstration of ArcView 3.2 maps of the ISA's and MSA's.

Question: Should we provide this functionality/tool in the CLPX data management system?  
TBD.

Question: Should we consider it to be a data set for the archive? TBD.

1230 Lunch.

1338 Don Cline opened the floor to discussion of what the working group envisions for the final product, as in what do we want it to look like? Don reported that there is \$50k per year, for 3 years, for NSIDC. He noted that there is a line item in the budget for a "data wrangler" - someone to work with Don at NOHRSC and be, primarily, the facilitator to deliver data sets to NSIDC. Don noted that are four primary components to the data: field, airborne, satellite, and modeling. He asked how can we make these data sets accessible, presentable, usable, and distributable?

1350 The working group discussed data embargoes. Most members agreed that one (1) year period seemed reasonable. The group agreed that only the CLPX group should have access to the data during the embargo.

1400 Daily Field Data Management of snow depth transects and snow pit data sets was discussed. The preliminary protocol is as follows: measurements will be written in field books that are pre-printed to appear the same as the electronic spreadsheets. At the end of the day, the field teams will deliver their field books to a single point (central filter) for scanning, photo copying, and debriefing. The data will be keyed into electronic spreadsheets by the data management team. The data will be QC'd for outliers - this will be a visual QC and automated QC using a GIS-based software program (most likely ArcView) for interpolating and contouring. An ASCII file will be created for each field book. Note: 1 Field Book = 1 file and new pre-printed field books will be provided each day. The electronic spreadsheet will look just like the field book for visual QC and ease of data entry. The data wrangler will transmit the files to NSIDC that evening. NSIDC will arrange the files in a logical manner and posted to an ftp site that is password protected. The data management team will consist of three members.

The working group discussed the issue of photo management and the use of disposable cameras and digital cameras for a photo record of surface roughness. All agreed that photographs would be limited to the snow pits. The group agreed that the data management team would also manage the photo's. The group recommended burning CD's in the field to catalog/archive the

photographs.

Action: Need boards for snow surface roughness. Also need protocol for photo's and cameras.

JC Shi volunteered to analyze the surface roughness data.

Question: What do we want NSIDC to provide in terms of a relational database? There was general agreement that a web-based presence was required that works well and is slick and easy to use for slicing and dicing the data in any manner possible. At the end of the day, the field will transmit a file, possibly a shape-file, to NSIDC and they will provide a product that is web-based and queryable.

Action: Send URL's to Ron Weaver (NSIDC) for web sites that do this well.

Action: Identify the most common web queries for NSIDC to they can build them into the CLPX web interface.

Kelly Elder and Don Cline restated the suggestion that all data be embargoed for one (1) year from the end of the field campaign, IOP-2 in 2002 and IOP-4 in 2003. No objections were heard.

1441 Other ground data sets were discussed. The Micromet data will telemetered to Paul Houser's office at NASA Goddard Space Flight Center in Greenbelt, MD. The data will downloaded once per day from the data loggers and posted on a NASA password protected ftp site and/or web site. New data will be appended to the end of the existing file. The data will be QC'd manually and automatically. Plots of the data will be created for the past few days and posted on a password protected web site. The data will be backed up on a daily basis. Metadata will also be provided on the web site.

Question: Do we want to ship the Micromet data to NSIDC? Yes, but not in real-time. It was considered to be beyond the NSIDC resources to handle the meteorological data in real-time. It was emphasized that we will need to prioritize the NSIDC workload. Eventually, the data needs to be archived at a one-stop shop in a coherent package. Concern was expressed regarding the long-term security of the data.

1501 Field Data - Ground-based Remote Sensing

UM's two trucks with radar and radiometer capabilities were discussed. The data will be provided in ASCII format. It will take 2-4 months to QC and process the data. Tony England will send the data to NSIDC when it is ready for distribution.

Gary Koh (CRREL) noted that QC of the FMCW radar data will take a couple of months. He will send it to NSIDC when it is ready for distribution.

LSOS data was then discussed. It was generally agreed that the “data wrangler” would coordinate delivery of all the LSOS data sets to NSIDC. The data wrangler will also ensure that the GRS data sets from UM and CRREL, and the field data from the snow depth transects and snow pits, are delivered to NSIDC.

Action: Develop the data documentation required by NSIDC. Mark Parsons will start working on this with the principal data collectors.

- 1530 Tony England (UM) briefed the CLPX working group on two projects of his in the Arctic. Both projects would benefit from additional collaboration. Additional funding is not needed. The focus of the projects is on global climate change in the Arctic tundra. He is looking at surface hydrology in the active layer. Both projects are designed to run for three years: (1) NSF OPP Instrumentation Project - PI is England, and (2) NASA GEWEC project - PI's are England and Pollack.
- 1550 Data Management of Airborne Data Sets: The group discussed POLSAR, TOPSAR, and PSR. The group decided to forego the POLSAR for the upcoming field campaigns since only the C-band will be missed. TOPSAR and PSR will be flown on the DC-8 on all three scheduled sorties.
- 1555 Data Management of NOHRSC Gamma Data Sets: Don Cline reported that the gamma data are posted to the NOHRSC web site operationally in near real-time. The gamma data will remain on the NOHRSC web site for the duration of the water year. At the end of the water year, NOHRSC will send the CD-ROM's to NSIDC. The CD-ROM's contain all of the data and products generated by the NOHRSC for a given water year.
- 1600 DC-8 Data Sets: JC Shi and Don Cline reported that for AIRSAR data, quick looks of the ISA's will be delivered from Colorado Springs to the field sites on a daily basis, probably in JPEG or similar format. The quick looks will not be geo-registered but will be useful for diagnosis of data health. Delivery will be by FedEx or by anyone with some free time and a vehicle. The quick looks can probably be provided to NSIDC for posting on the web. There was some interest in doing this, especially for program managers who need to be able to point to signs of progress. The processed, geo-registered AIRSAR data sets will likely be ready for distribution to NSIDC in approximately eight months after data collection is completed. The processed data can be FedEx'd to NSIDC on a CD or ftp'd. The files are expected to be very large, perhaps 60 Mb each. JPL could process the ISA's first and then generate mosaics of the MSA's. The files will be in flat binary raster with a separate header or in NetCDF format.

PSR: same plan as AIRSAR except for the files are smaller, probably 10 Mb each.

- 1635 Bert Davis reported on Satellite Data Management. The AMSR and SSMI data are delivered operationally to NSIDC on a daily basis. There was discussion that NSIDC

could archive a subset of the data, perhaps for the Regional Area, for the duration of the project. The NOHRSC will provide geo-registered AVHRR data sets, all channels, all level 1B data, for a subset of the Regional Area. The group discussed LANDSAT, MODIS, AVIRIS, MISR, and ASTER data sets. All agreed to make the data centrally available at NSIDC for serving on their web page. There was a problem in that these data sets must be requested from the originators. NSIDC agreed to submit the requests and post the data sets before the project closes. There was concern expressed again about NSIDC's work load and resources to support the CLPX project. NSIDC noted that they can re-distribute these data sets if they are combined with other data and have a value added element. It was noted that MODIS data could be obtained from the NASA GSFC DAAC or the NSIDC EDG. RadarSAT and QuickSAT data sets were briefly discussed. Acquiring these data sets involves a request to ASF Fairbanks (Kyle is onboard with this?). Bert Davis noted that CRREL can purchase the LandSAT imagery, geo-register them, provide the metadata, and plot the data on a lat/lon grid, but a request is still required.

In summary, there was a good bit left to resolve regarding the satellite data sets.

1704 The working group discussed the delivery mechanism for the CLPX data sets. There was solid agreement that they should all be available at a one-stop shop type of web page at NSIDC. There was discussion of public outreach materials, identification of the CLPX audience, marketing tools, and easily digestible formats such as ArcIMS. It was re-emphasized that our primary goal is data distribution and our primary audience is research scientists. It was again noted that NSIDC has a long list of action items and the list must be prioritized.

Action: All CLPX presenters need to send their presentations to Don Cline for posting on the CLPX web page.

Friday, November 9, 2001

0832 Don Cline opened the discussion on CLP Science and Technology with a review of the relevant science/research initiatives: USGCRP, NASA Global Carbon Cycle, NASA Global Water and Energy Cycle, NOAA GEWEX, UK Snow Research, NASA Earth Science Enterprise (ESE) Research Strategy, and the NASA Strategic Plan.

0855 It was noted by the working group that snow is not discussed in the NASA Strategic Plan, nor is the freeze/thaw cycle. These omissions were viewed as problems that need to be corrected.

0910 John Kimball (University of Montana) provided a presentation on the NASA Global Carbon program, which is a NOAA ESSP (Earth System Science Pathfinder) mission to measure soil water mobility, freeze/thaw cycles, and soil moisture. John noted that

further information is available on the Hydrosphere Mission web page:  
[http://www.forestry.umn.edu/ntsg/RemoteSensing/freezethaw/proj\\_summary.html](http://www.forestry.umn.edu/ntsg/RemoteSensing/freezethaw/proj_summary.html)

- 0912 Jin Huang (NOAA/OGP) discussed how CLP and the GEWEX America's Prediction Project (GAPP) link up. Jin indicated that GAPP would provide \$75K in support of COPX data collection, and would fund future research proposals related to CLPX as long as proposals passed the review process. Jin also provided a brief overview of CEOP (Coordinated Enhanced Observing Period 2001-2003).
- 0928 John Pomeroy (University of Wales) briefed the working group on UK snow research priorities, relevant research in the UK, inventory of what they do not yet know well and where additional work is needed, and reviewed the Mackenzie GEWEX experiment in the '90's. John noted that his research has found that there is substantial snow loss in the tree canopy due to sublimation. John also found that the albedo remains low even when there is a significant snow load in the tree canopy. The ECWMF atmospheric models were corrected based on these findings. Don Cline remarked that approximately 40 research papers could be written on the subjects covered in John's presentation.
- 1018 Paul Houser (NASA) provided a presentation on the Goddard Space Flight Center (GSFC) Global Water Cycle project. Paul provided overviews of the Earth Science Enterprise (ESE) and the NASA Hydrologic Services Branch. Paul noted that knowledge of soil moisture has a greater impact on predictability of precipitation than does knowledge of sea surface temperatures (SST's), at least in mid-latitude continental areas. Paul noted that uncertainty of observations can lead to unsatisfactory uncertainty in the model outputs. Paul discussed the importance of snow cover to global water cycles and the NCEP Eta snow updating problem (melts snow during the day and puts it back at night which confuses the energy and water budgets). Paul provided an overview of NASA challenges.
- 1051 Don Cline provided an overview of the NOHRSC snow model, called SNODAS. SNODAS is a spatially distributed snow energy and mass balance model that is run each day at 1 km and 1 hour resolution (please see <http://www.nohrsc.nws.gov/98/html/pubs/techno.htm> for additional information on SNODAS). Don noted that the NOHRSC intends to use the CLPX data to verify SNODAS output. Don described the snow observing systems used by NOHRSC: ground-based measurements, optical remote sensing, passive microwave, active microwave, and airborne gamma remote sensing data sets. He noted that assimilating snow data is fraught with difficulties. The NOHRSC solution is to assimilate optical RS data, active and passive microwave RS data, airborne gamma RS data, ground observations, Doppler radar data, GOES-derived solar radiation, static gridded geophysical data sets, and NCEP model output. Please see the NOHRSC web page, Bulletin Board, for examples of SNODAS output.

- 1110 Richard Armstrong (NSIDC) provided an overview of AMSR snow algorithm validation. He compared the microwave algorithm to NOAA NESDIS' weekly, and now daily, snow cover extent maps. Richard reported that the algorithm performed pretty well especially with an established snow pack. It appeared to underforecast snow cover by ~25% early in the season (October, November).
- 1133 Bert Davis (CRREL) provided an overview of CRREL activities that pertain to CLPX. He remarked that CRREL meets Army requirements and their approach is to run simple models with large volumes of data as opposed to running global models which have significant uncertainty. Bert reviewed CRREL's basic research, applied research (military), and applied technology (civil works). Bert noted that model uncertainty was a function of forecast projection and volume/density of input data. Ground observations were viewed as having high certainty, and, therefore, CRREL uses lots of them in model assimilation techniques. Bert briefly discussed their new soil/snow physics model called SLTherm.
- 1150 Don Cline (NOHRSC) provided an overview of the GWEC scaling study (Global Water and Energy Cycle). He provided a review of problems with land-surface models, remotely sensed measurements, and cold land processes.
- 1201 Glen Liston (CSU) reviewed the GWEC Boundary Layer Study.
- 1209 Kelly Elder (USFS) discussed Forest Service studies that relate to CLPX at the Fraser MSA.
- 1222 Lunch.
- 1250 Don Cline discussed the need for a CLP Science and Technology Road Map. He expressed concern regarding funding for the science and analysis of the data sets. Don suggested that the working group members consider ganging up on their program managers, twist their arms, and lobby for funds.
- 1301 Don introduced numerous topics and issues that could fit into the Strategic Plan or Road Map. Examples included: forest cover, topography, vegetation, soil moisture conditions and dynamics, thin or patchy snow covers, ecosystem dynamics
- 1321 Question: Who is our audience? The general opinion was NASA program managers, NOAA/OGP, and the National Science Foundation (NSF).
- 1322 Don reviewed NASA's main science questions as a way to jump start ideas for the Road Map: variability, consequences, predictions, feedback.

Don stated that the working group needs to produce a strategic plan/road map for review by Jack

Kaye (NASA) by August 2002. The plan needs to be short, concise, flashy, and good.

John Pomeroy suggested another framework to inspire creative thinking: physical properties, interactions, and technology.

1410 The working group broke into three groups: RS, modeling, and interactions, to flush out the issues and concerns.

1536 Breakout Reports were ready.

1537 John Kimball (U Montana) reported on the input from the interactions team:

- CLPX requires long-term seasonal studies in addition to intensive study periods.
- The group didn't feel that you can do a dynamic system study like hydrology with intensive study periods alone - temporal data sets are also needed.
- The group used John Pomeroy's list from the UK meeting from a few months ago.

1546 Bert Davis provided the report from the Modeling team. He asked the question: how will new modeling efforts and measurements improve upon the inadequacies of previous efforts? Their top six questions were related to:

- fractional snow cover
- sublimation
- thin snow
- blowing snow
- vegetation
- super-stable conditions

The modeling group's top eleven measurement requirements were:

- snow fractional cover at relevant scales < 1km
- SWE
- spatial variations of atmospheric forcings
- land cover characteristics
- albedo over various land cover types
- snow sublimation - direct field measurements on a tower
- soil freeze/thaw profile
- soil hydraulic properties
- spatial variation of dry vs. wet snow
- snowmelt outflow - spatial variation
- surface temperatures

1600 Ed Kim (NASA JPL) reported for the Remote Sensing group. The group's issues included:

- spatial scale - most RS resolutions are still coarse, and noisy data can make model output worse.
- uncertainty curves
- RS community needs to interact with the modeling community
- combined active/passive synergy and combined radar/IR
- cloud cover - how much is too much?
- trees - a problem for most retrievals
- complex terrain
- retrieval issues
- need for observations that are more tailored to address frozen ground applications
- large aircraft limitations

Question: who will write up these reports? Bert Davis will write up the modeling report with assistance from his team members. John Pomeroy and Janet Hardy will write up the Interactions report. Hardy Granberg will write up the RS report.

1615 Don Cline asked the folks about the future of the working group. All agreed that a debriefing should be scheduled for late spring 2002, possibly in conjunction with the Eastern Snow Conference tentatively scheduled for June 2002 in Stowe, Vermont, and possibly a workshop in fall 2002 prior to the 2003 field campaigns. Don noted that he will add all the presentation materials to the CLPX web site. He will also email information to the group regarding the update to the CLPX plan. Please see [www.nohrsc.nws.gov/~cline/clp.html](http://www.nohrsc.nws.gov/~cline/clp.html).

1645 Workshop adjourned.