# REQUEST FOR LAOF FACILITY SUPPORT
# *ASP SUMMER COLLOQUIUM*
# NCAR/EOL – 15 JANUARY 2009

*Submitted on 15 January 2009*

## PART I: GENERAL INFORMATION

### A. Corresponding Principal Investigator(s)

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### B. Project Description

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| Project Title | **ASP Summer Colloquium** |
| Location of Project | Front Range, CO |
| Start and End Dates of Field Deployment Phase | **4-7 June, 2009** |
| NSF Facilities requested | **S-Pol, C-130, ISS, ISFS, UW King-Air, CSU-CHILL** |
| Funding Agency and Program Officer Name(s) | **NCAR/ASP (Maura Hagan)** |
| Proposal(s) affiliated with this request | **See attached** |
| Proposal Status | In preparation (), submitted (), funded (x) |
| Do you expect other, non-NSF support? If yes, from whom? | NO |
| Is this a resubmission of a previous request? | NO |
| Is this a multi-year request or a request for continuation? | NO |
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### C. Abstract of Proposed Project

Observations of the atmosphere and its physical and chemical processes underpin even the most sophisticated atmospheric computer models, yet many students passing through graduate university degree programs have only a limited practical exposure to instruments and techniques for observing the atmosphere. NCAR/ASP has funded a 2-week summer colloquium “Exploring the Atmosphere using Observational Instruments and Techniques”. The summer colloquium will be attended by about 25 funded graduate students during a 2-week

period in the Front Range of Colorado and Wyoming. The EOL/CSU/UWyo Summer Colloquium proposal is designed around three main goals:

1. To introduce advanced graduate students to principles and operation of the NSF Lower Atmosphere Observational Facilities (NCAR C-130 and University of Wyoming King Air research aircraft; CSU CHILL and NCAR SPOL ground-based radars; University of Wyoming airborne radar; NCAR/EOL surface flux, sounding and wind-profiling instruments; and selected NCAR/EOL and NCAR/ACD chemical tracer instruments).

2. To teach graduate students how to plan and conduct limited experiments using the aircraft, radars, surface station and related instruments. All the participants will design and execute a 2-day measurement campaign using the above facilities, as selected by smaller groups of students. We expect groups of 3-4 students to each focus on a research subject of their choice, see examples below.

3. To guide the graduate student participants in the analysis of the observations they collect. EOL, CSU and UWyo staff will instruct the students to use standard tools used for observational research from the above platforms. Each group of students will work on their research project, with the results of the analysis to be presented at the end of the second week of the colloquium.

Students will be encouraged to use combinations of platforms to study a particular atmospheric phenomenon, e.g. boundary-layer fluxes using both surface, balloon-borne and airborne measurements, or precipitation development using both airborne in-situ instrumentation and ground based radars, or other phenomena as chosen by the students. Whereas students are encouraged to form smaller research teams to investigate a particular subject of their own choice, colloquium staff will also have prepared a selection of smaller research projects for those student groups that do not have a pre-defined objective in mind.

While understanding of instruments is important, the focus of the colloquium is on allowing the students to gain a deeper insight into the atmosphere and its processes through practical research projects.  It is also a major colloquium focus to teach the participants how to plan for and execute an observational campaign.

## D. Experiment Design

The final experiment design will be a product of the first week of the Colloquium and will reflect the interests and ideas of the participants. However, our condensed schedule requires that much of the measurement infrastructure be in place before the Colloquium starts. Thus, the Organizing Committee has developed a pedagogical set of science questions that would take advantage of the available facilities. We then design an experiment that can address these questions, anticipating that some aspects might change. Figure 1 shows the proposed locations of all of the ground-based facilities.

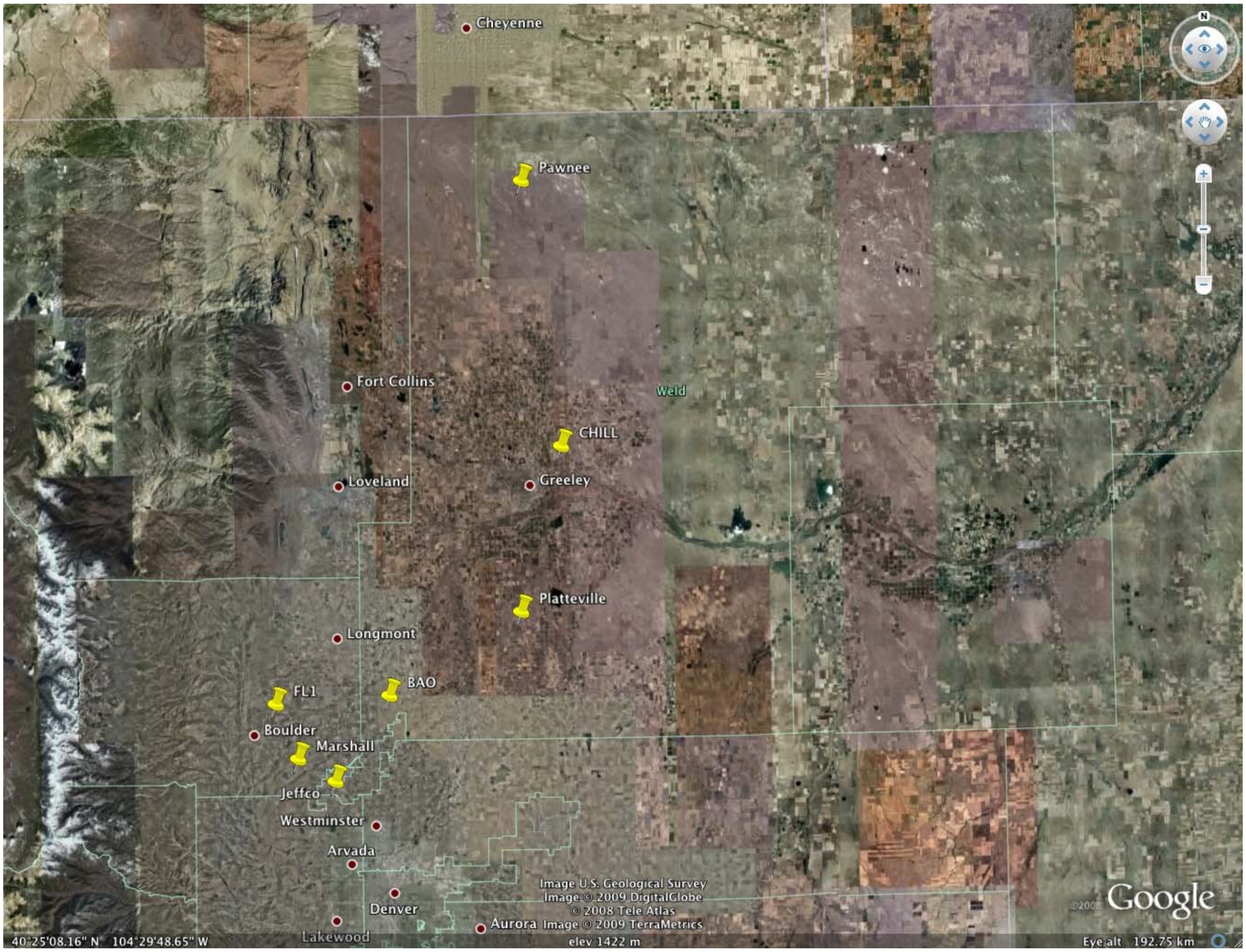



Figure 1. A Google Earth image of NE Colorado, with locations of the CHILL and Pawnee radars marked. S-Pol would be located at the NCAR Marshall Field Site, along with ISFS. MISS would be located at either Marshall, the NOAA Boulder Atmospheric Observatory (BAO), or at the NOAA Platteville radar. If MISS is not available, data from an ISS at NCAR's Foothills Lab (FL1) would be used. Both the C-130 and Univ. of Wyoming King-Air would be operated out of the Rocky Mountain Regional Airport (Jeffco).

Some of the science questions are:

1. How do the components of the surface energy balance change over the diurnal cycle? Do measurements of these components close?
2. How do the fluxes of momentum, temperature, and moisture change with height in the Planetary Boundary Layer (PBL)?
3. What characteristics of the interfaces between mesoscale flows enhance convective initiation?
4. What is the impact of shear on cloud growth and what are the dominant circulations in small to medium cumulus clouds?
5. How do water droplets evolve in clouds?
6. What conditions lead to initiation of precipitation in medium-sized summer-time cumuli?
7. How are tracers processed by entrainment and mixing in clouds?
8. What are the momentum and energy fluxes of orographically-induced gravity waves, and what is the impact of the vertical stability?

Question 1 is readily addressed with a surface flux station at any site with reasonable horizontal homogeneity. We request that an ISFS station be set up at NCAR's Marshall field site for this purpose. ISFS would be deployed with instruments at several heights to allow students also to look at flux-gradient relationships. Fast-response carbon dioxide sensors also would be used with ISFS to allow students to observe the diurnal cycle of CO2 respiration and assimilation. ISFS would operate continuously, starting a few days before the primary field campaign, to provide additional diurnal cycle examples.

Question 2 would be answered by flying stacks within and just above the PBL over the surface sites (e.g. over ISFS) and probably other locations using either the University of Wyoming King-Air (UWKA) or the C-130. MISS could be deployed at Marshall to provide continuous monitoring of PBL height and radiosondes launched from MISS would measure the strength of the (daytime) temperature inversion. Measurements would be made several times (morning, midday, and afternoon) during the daytime with one sounding at night to characterize the PBL without daytime heating. See Example Flight Plan 1, below.

Question 3 would rely on Dual-Doppler wind fields measured by a combination of data from the CSU-CHILL, Pawnee, and S-Pol radars. If available, S-Pol would be operated at the Marshall site. (Other radars exist in the Front Range, but obtaining their data and performing a dual-Doppler analysis in the last week of the Colloquium is unrealistic.) The CHILL-Pawnee baseline is 48 km and the CHILL-S-Pol baseline is 72 km. Convective initiation can be detected by any of these radars. This analysis will be performed for all of the periods that the radars are operating. See Example Flight Plan 2, below.

Question 4 requires in-situ measurements by the C-130 or, preferably, by the UWKA with the cloud radar. Larger cloud systems will be better observed with the ground-based radars. See flight plans 4 and 6 below.

Question 5 requires cloud particle measurements from either the C-130 or the UWKA. In addition the course participants will be provided with a droplet growth parcel model to let them compare simple predictions with observations. Example flight plans 3 and 4, see below, can be used to provide the necessary data.

Questions 6 requires a combination of radar measurements (CSU-CHILL and/or S-Pol) and cloud microphysics measured in situ by the C-130 or the UWKA. In typical summertime convective conditions, clouds would be expected to form in the afternoon, thus afternoon aircraft flights (at least half of the flight time), would be devoted primarily to this questions.  See Example Flight Plans 4 and 6, below.

Question 7 requires in-situ measurements by the C-130 or the UWKA. Thermodynamic tracers can be measured on both aircraft, the chemical high-rate tracer measurements can only be done from the C-130. See Flight plan 3 below.

Question 8 requires the velocity measurements by MISS, stability profiles from the radiosondes, and radar-derived 3-D wind fields.  In addition, either the C-130 or UWKA would penetrate the gravity waves and use measurements of wind and pressure-perturbations (incl. differential GPS) to characterize the waves.  See Example Flight Plan 5.

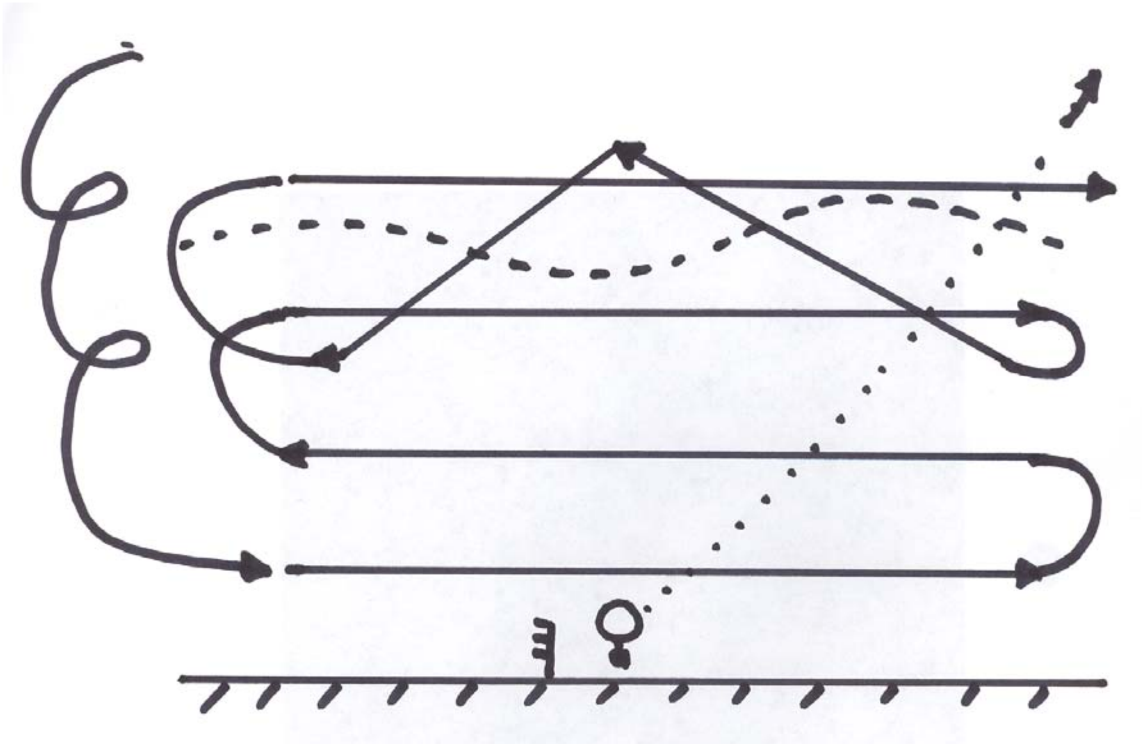
We note that, with the Wyoming Cloud Radar (WCR), the UWKA is preferred for flights requiring cloud penetration as part of cloud dynamics studies.  The C-130 can carry many more people and would allow students working on several different science questions to participate on the same flight.  Thus, these aircraft are complementary in meeting our educational objectives.

The six flight plans shown below can in principle be done with either the King Air or the C-130. For some there is a distinct advantage by using the C-130 or the King Air due to their instrumention differences.

**Example flight plan 1:  Boundary-layer fluxes**

A complete description of the structure and evolution of the planetary boundary layer throughout the diurnal cycle is still needed to characterize the transfer of e.g. heat, water, and carbon dioxide from the Earth's surface to the atmosphere.  In this study, we study the dynamics of the relatively well understood convective boundary layer and then investigate morning and/or evening transistions to the nocturnal boundary layer.  Since we are interested in dynamics, we measure fluxes of the above quantities both at the surface, using an ISFS flux station, and at several levels within and just above the boundary layer using constant-level aircraft flight legs.  Periodically, the aircraft would “porpoise” through the top of the boundary layer to track the change in height and to determine the strength of the temperature inversion and change in concentration of scalar quantities.  MISS radiosondes would be launched to give additional sampling of the inversion height (in addition to identifying the atmospheric structure higher up).  The MISS profiler would provide continuous observations of the PBL height through its backscatter and perhaps wind fields.

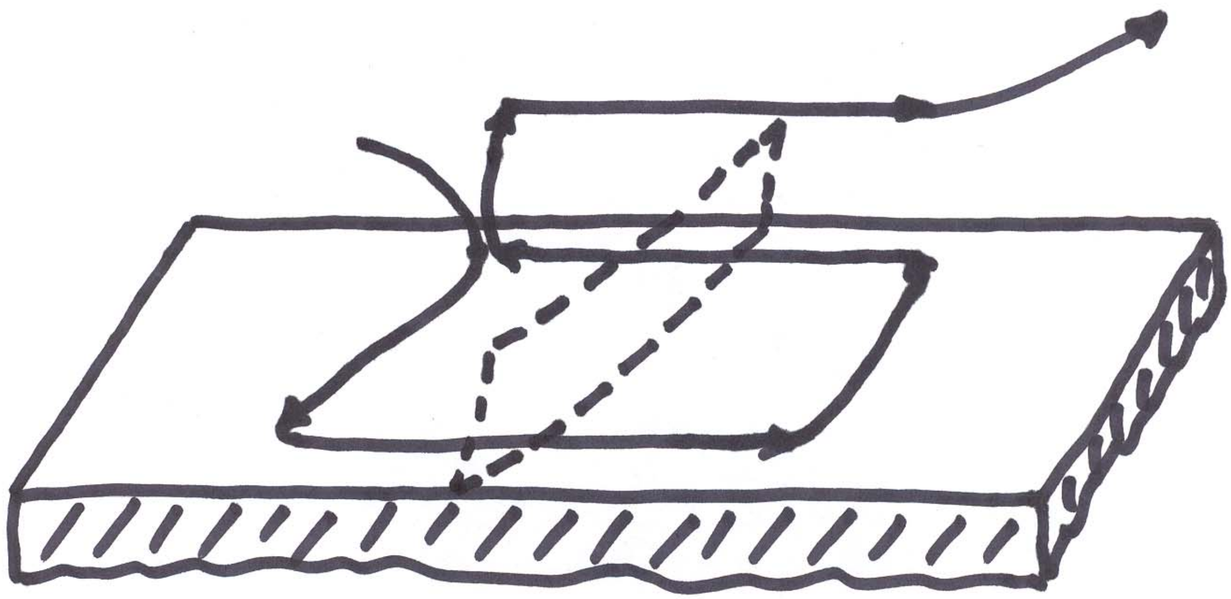
These observations could be made both at the NCAR Marshall Field Site and at a location further from the mountains (possibly near the NOAA Platteville Radar Wind Profiler site) to investigate how PBL development is affected by local, topographically forced, flow.



*Aircraft flight path above a surface station (ISFS and MISS). Assuming a mixed-layer depth of about 3-4000 ft depth, the aircraft would make (1) a descent sounding, (2) a 5-minute level leg at 1000 ft AGL, (3) a 5-minute level leg at 2000 ft AGL, (4) a 5-minute level leg at 3000 ft AGL (adjusted to be close to but below the mixed-layer top), (5) an ascent-descent pair covering approx. 1000 ft below the mixed layer top to 1000 ft above the mixed-layer top, and (6) a 5-minute level leg right above the mixed-layer top. The total flight time will be approx. 50 minutes plus ferry time*

**Example flight plan 2: Convective initiation**

Convective clouds are often observed to initiate along boundaries of different air masses, and both the "collision" of air masses as well as the temperature and humidity of the boundary-layer are important factors. The purpose of the initiation study is to (1) use radar data and surface network data to observe convergence lines, (2) to use aircraft measurements to characterize the two boundary-layer air masses involved, (3) to predict the development of the convection over the convergence line, and (4) to use the ground-based radars to verify the convective initiation forecast. In addition the lowest box flight legs can be used to calculate the convergence.



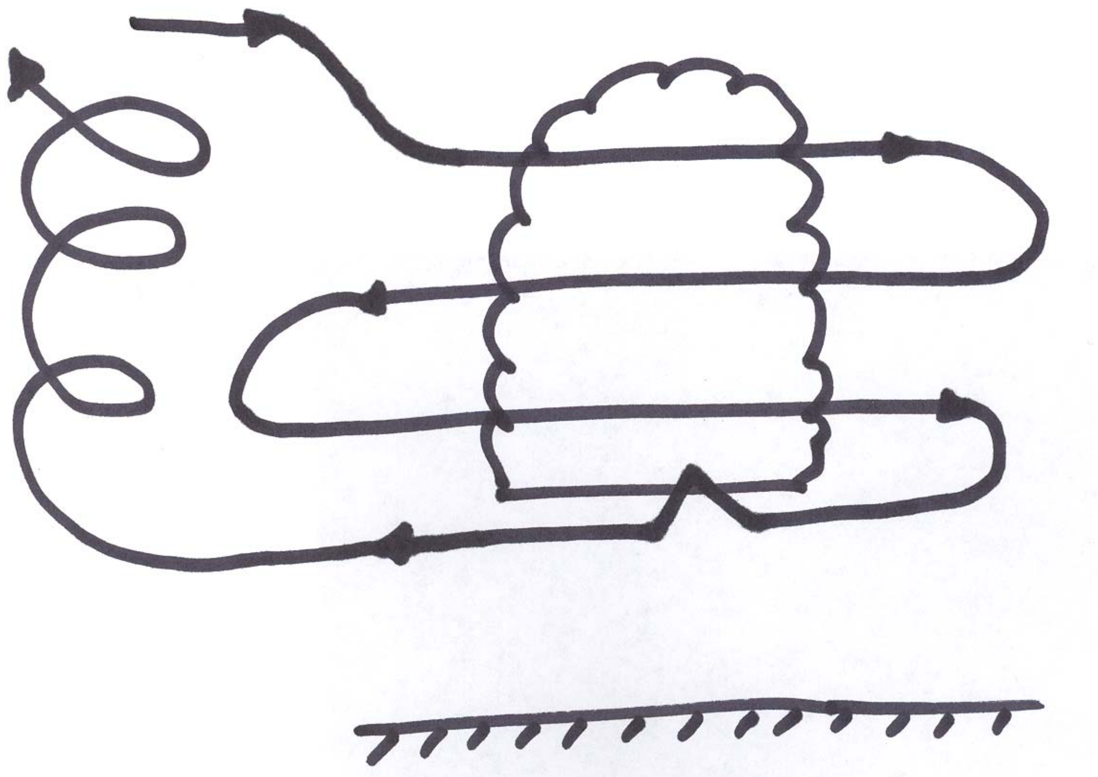
*The convective initiation flight plan calls for four 10-minute flight legs, two crossing the convergence line and two parallel to them. These four flight legs should be made at low altitude (1000 ft) to capture the humidity field in the air moving towards the convergence line. In addition one 10-minute flight leg across the convergence line should be made near the top of the mixed layer to investigate if there is divergence in the mixed-layer above the surface convergence line. Estimated flight time is 55 minutes plus ferry time.*

**Example flight plan 3: Small cumulus entrainment study**

Cumulus entrainment affects critically the growth of cloud particles. It has been postulated that entrainment may predominantly take place through the top or the sides of the cloud. The purpose of the present study is to determine the sources of entrained air and the amounts of entrained air as observed during several penetrations of a small cumulus congestus. Determination of the sources and amounts of entrained air can be done either using Paluch's (1979, JAS, **36**, 2467-2478) thermodynamic tracer method, or by using non-reactive (actually very slowly reactive) chemical tracers (e.g. ozone and CO).

Course participants should decide on a criterion for what constitutes "cloudy air" based on water saturation. Although the Paluch technique works best on non-precipitating clouds, a small amount of precipitation is nevertheless acceptable. The chemical tracers are virtually unaffected by precipitation. The participants should plot various of the conserved tracers against one another and determine if near-linear mixing patters occur (this is likely for Great Plains conditions). For linear patterns, the source and amounts of entrained air should be determined for each of the aircraft penetrations.

It is possible that the fraction of cloud base air and environmental air can also be determined for recently detrained air (see e.g. Peter et al, 2006, QJRMS, **132**, 835-863).



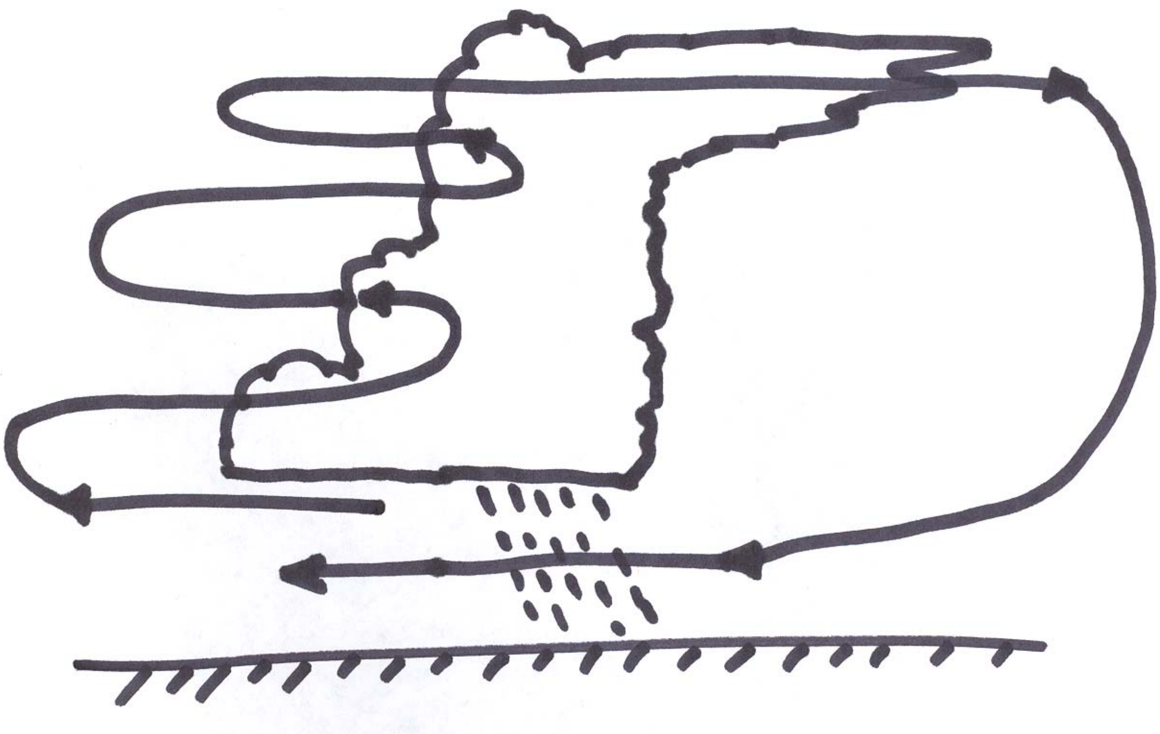
*The cumulus-entrainment study commences with a sequence (possibly three) penetrations of the cloud, followed by a pass under the cloud base (preferably with a short incursion up into a solid part of the cloud base), followed by an ascent sounding covering the altitude from 500 ft below cloud base to 1000 ft above cloud top. Course participants should decide if the cloudy legs should be made along or across the vertical shear vector for the cloud's environment. Course participants should also decide on the position of the ascent sound in relation to the cloud. Total flight time is about 35 minutes plus ferry time.*

**Example flight plan 4: Precipitation development**

Precipitation development in a moderate sized cumulus cloud should be examined using a combination of aircraft penetrations of the cloud and ground-based radar. The precipitation development study should cover (1) measurements of thermodynamic and aerosol properties in the cloud-base inflow air, (2) measurements of cloud drop sizes and concentrations a short distance above cloud base (e.g. 500 ft), (3) measurements of cloud drops and precipitation particles higher in the cloud and (4) measurements of precipitation in the precipitation shaft, e.g. 1000 ft below cloud base. For safety reasons, clouds with severe convection, hail and/or lightning should be avoided.

The aircraft measurements should be compared with ground-based radar observations to provide the dynamical context for the cloud, as well as the time-development of precipitation formation. Course participants will be provided with a simple warm-cloud microphysics parcel model that will predict droplet spectral shape and concentrations; this can be compared against the observed drop spectra. Course participants should examine where ice formation takes place, what the particle concentration is as a function of temperature, evaluate if the Hallett-Mossop criteria for ice multiplication (Hallett and

Mossop, 1974, Nature, **249**, 26-28) is fulfilled, examine the effect of shear on organization of the precipitation region, and examine the radar-observed reflectivity in the precipitation shaft in comparison to that calculated using particle-probe data from the aircraft.



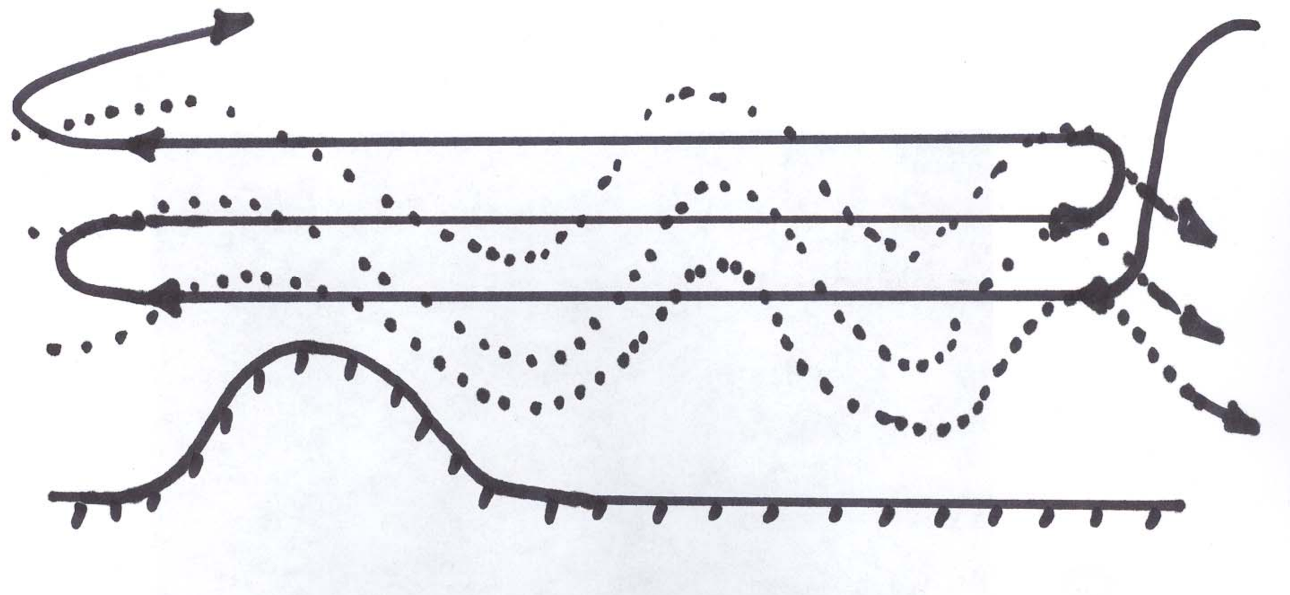
*The flight plan should include a leg below the cloud base (in the in-flow region), several penetrations through the cloud, followed by a descent to measure the precipitation below cloud base. Participants should decide if the cloudy penetrations should be done along the vertical shear vector or along the radar radial through the cloud. Estimated flight time is 50 minutes plus ferry time.*

**Example flight plan 5: Airflow over mountains and gravity waves**

With the Rocky Mountains providing a near north-south barrier, the possibility exists for generation of mountain-induced gravity waves in case of moderate or strong westerly airflow in the middle atmosphere (minimum of 7.5 – 10 m/s at ridge top, the stronger the better). The purpose of the study is to calculate the momentum flux, $\rho\int u'w'dx$ and the energy flux $\int p'w'dx$ assuming at most slowly changing background conditions (Smith et al, 2008, JAS, **65**, 2543-2562).

Given the lower-to-mid maximum flight altitudes of the C-130 and the King Air, and the available time (implying likely lower flight altitudes), flight legs of about 100 km can be positioned with only a small part upwind of the main barrier (to account for the up-stream tilt of the wave crest).

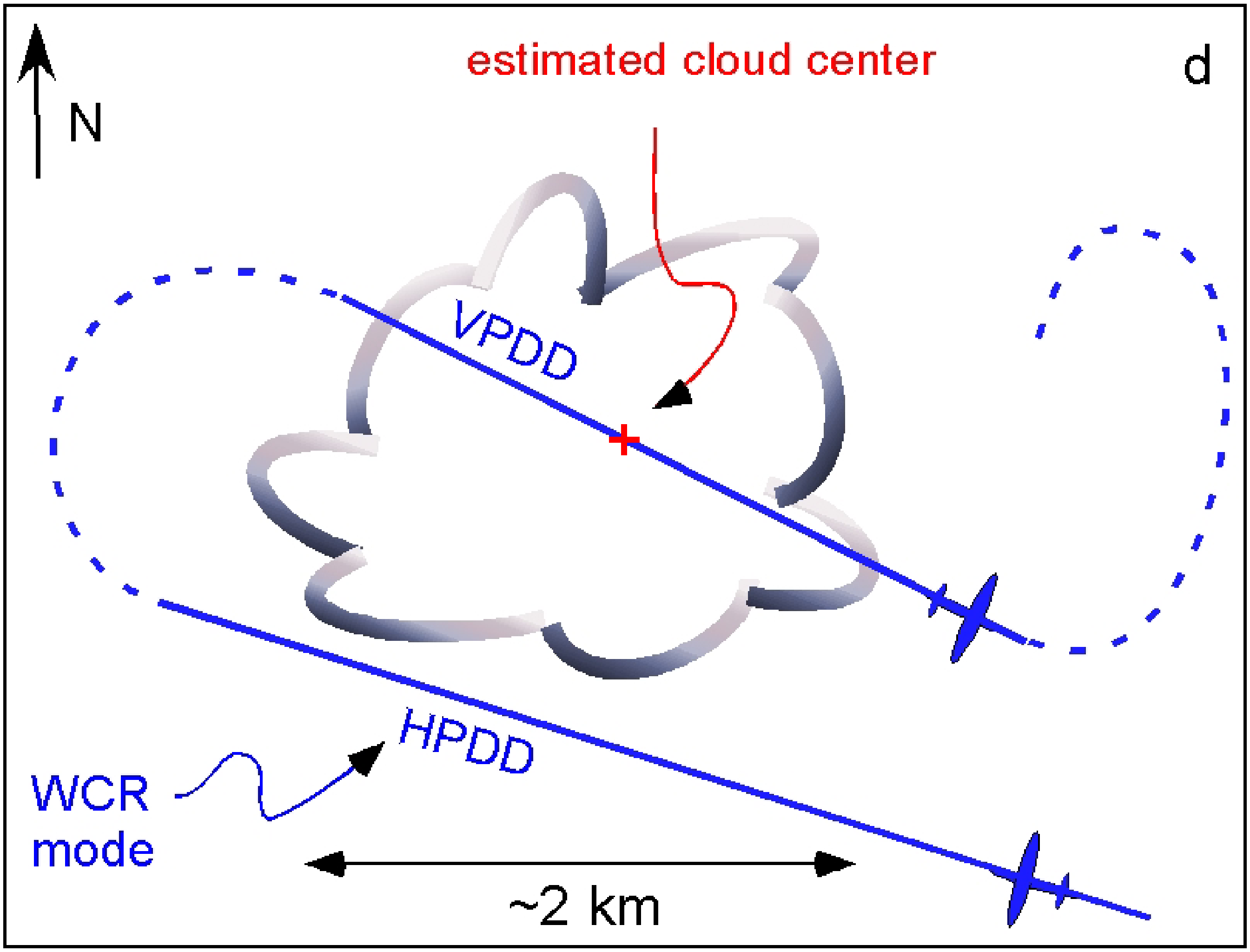
A critical part of the accurate evaluation of the energy flux is the use of the difference between aircraft pressure altitude and the geometric altitude to estimate p'. The geometric altitude over topography can only be precisely determined using very high accuracy (+/- 0.2 m) differential GPS measurements.



*The flight plan consists of three 100-km long flight legs along the wind. The upwind leg starts about 10 km upstream of the ridge top and extends 90 km downwind. The flight legs are positioned from 2000 ft above the ridge to as high as practical. Total flight time is estimated at 60 minutes plus ferry time. The vertical stacked legs will have to be located well north of the Denver area, and the ridge system can consist of e.g. the Continental Divide or the Medicine Bow range, depending on wind conditions.*

**Example flight plan 6: Air motions in small and medium cumuli**

The Great Plains region often has wind shear with boundary-layer air moving from the south and air above the mixed layer having passed over the Rocky Mountains. Thus cumulus clouds often grow in a sheared environment and this impacts the organization of elements within cumulus clouds. The UWKA WCR radar is ideally suited to determine both the horizontal and the vertical motions in cumuli through observations from below, above or outside the clouds. The WCR can be configured to change the beam directions in several ways, thus allowing for the calculation of Doppler wind fields in even small congestus clouds.




*The flight plan consists of flying outside the cloud with the radar beams looking horizontally towards the cloud, followed by one or more flight legs through the cloud center with the beams facing either up or down.*

If this is a re-submittal of a request, please address all concerns and questions raised in the "Confidential Comments and Feedback to PI" portion that was provided with the notification letter.

N/A.

If this is a second year request for continuation of a program, please provide a summary or highlights describing the results of the first field phase.

N/A.

**Publications resulting from EOL support (including EOL-managed data) within the last five years:**

| Project Name and Year | Facilities used | Publication Citation |
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|---|---|---|
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| | | |
|---|---|---|
| NAME, 2004 | S-Pol | Lang, T.J., A. Ahijevych, S.W. Nesbitt, R.E. Carbone, **S.A. Rutledge**, and R. Cifelli, 2007: Radar-Observed Characteristics of Precipitating systems during NAME 2004, *Journal of Climate*, **20**(9), 1713-1733.<br><br>Rowe, A.K., **S.A. Rutledge**, T.J. Lang, P.E. Ciesielski, and S.M. Saleeby, 2008: Elevation-dependant trends in precipitation observed during NAME, *Monthly Weather Review*, **136** (12), 4962-4979. |
| TRMM-LBA, 1999 | S-Pol | Cifelli, R., L. D. Carey, W. A. Petersen, and **S. A. Rutledge,** 2004: An Ensemble Study of Wet Season Convection in the South West Amazon: Kinematics and Implications for Diabatic Heating, *Journal of Climate*, **17**, 4692–4707. |
| ROLLS, GPS, GOA, 2004 | U. Wyo. King Air | Parish, T.R., M.D. Burkhart, **A.R. Rodi**, 2007: Determination of the horizontal pressure gradient force using Global Positioning System onboard an instrumented aircraft. J. *Atmos. Ocean. Tech.*, **24**, 521-528. |

## E. Educational Activities

Please list anticipated number of graduate and undergraduate students who will be involved directly and in a meaningful way in field work and/or data analysis related to this project, how you plan to enhance undergraduate or graduate classes with hands-on activities and observations related to this project; and if you will conduct outreach activities for K-12 and the public.

25 graduate students will be fully supported by NCAR/ASP to participate directly with all aspects of this experiment, including experiment planning, field operations, data analysis and, in some cases, equipment preparation.

# PART II – OPERATIONAL CONSIDERATIONS & LOGISTICS

| | |
|---|---|
| Approx. how many people will be involved in the field campaign? *Please specify number of participants and location(s).* | 45 (25 students, 10 mentors, 10 EOL staff), more-or-less evenly distributed with each facility |
| What other facilities/platforms outside the EOL suite will be deployed? Are any of them non-US facilities? | Univ. Wyo King-Air, CSU-CHILL |
| Are complex inter-facility or inter-agency permissions required for flight operations and/or other facility operations that would benefit from EOL leadership and experience? | No |
| Is there a need for integrated diplomatic arrangements? *(e.g., customs, immigration, focal point with local hosts/governments)* | No |
| If there are multiple instrumentation/operations sites, is there a need for operational coordination? | Yes. Operations center will be in COMET classroom at FLAB. |
| What kind of real-time data display and project coordination needs do you anticipate? | See answer in Data Management section, below. |
| Is forecasting support required for project operations? | Forecasts for daily weather briefings will be needed, but we will arrange this. |
| What kind of communications capabilities do you expect on site? *(e.g., bandwidth)* | Standard T1 internet at the Ops Center and Marshall Site. Satcom to aircraft (for chat and flight status). DSL-speed internet to MISS. |
| Will operations center and real-time display and coordination services be required? [1] | Yes. See Data Management, below. |
| Will you require work space? *(e.g., office, lab and storage space)* | We have arranged for space at Foothills Lab |
| Will you require system administration support on site? | Yes. We need to have computing facilities for participant data analysis and exercises. We are working with EOL/CDS. |
| Is there a need for coordinated shipping, lodging or transportation? *(especially if this is an international project)* | No |
| Will you be shipping hazardous/radioactive material? | No |
| Will you be shipping expendables? (e.g., radiosondes to local NWS offices) | No |
| Do you require assistance with various activities/services? | Yes. We will need an |

[1] *A basic data/analysis center with LAN connections to the EOL computers and access to the Internet will be provided in the field by EOL. Support will include real-time communications links to the facility via "chat" and real-time display of selected variables via web site links. Access to forecasting tools and preparations of operational forecasts are not usually included as part of this service. These services are presently not supported by the NSF Deployment Pool. Funds to support its deployment currently must be obtained from separate sources, such as NSF Special Funds. For more information, please contact the CDS Facility Manager.*

| | |
|---|---|
| *(e.g., help with Air Traffic Control, organizing of workshops, meetings, site surveys, leases, permits)* | operations center (located at NCAR/FLAB) and logistics support transporting participants to field locations. We are working with NCAR/FPS. |

# Part III: Data Management

| | |
|---|---|
| What operational data do you need? *(e.g., satellite, upper air, radar, surface, oceanographic, hydrological, land characterization, model products)* | Standard forecast products for daily weather briefing (first week only). |
| Do you have any specific real-time data needs to aid in your data collection activities? | Displays of data should be brought to the operations center if possible, to allow all participants to monitor progress of the field activities and to make operational decisions. |
| Is there a requirement for a local satellite receiver to acquire local or real time polar orbiter or high resolution geostationary satellite data? | No |
| Beyond the EOL dataset, will you or your Co-PIs provide additional research data to the project? | No (other than UW KingAir and CSU CHILL) |
| What data analysis products will you provide during the deployment? | N/A |
| What other research data and products do you need? | Access to data from NWS radars and surface met data in the Front Range is desirable, but not essential. |
| Is an EOL Field Catalog needed to provide real-time information management, reporting, decision dissemination, data exchange and resource monitoring? | We will want all data to be centrally collected, both for Colloquium use and later archive (along with educational materials) to facilitate follow-on educational activities. A field catalog would be ideal for this purpose. EOL/FPS has been contacted. |
| Do you plan on moving a large amount of data back to your home institution during the project? | No |
| What arrangements have been made for a comprehensive data archive, including the management and distribution of data from non-EOL platforms? | See Field Catalog needs, above. |
| Do you intend to request restricted data access? [2] | No |

[2] *Please note that EOL policy will make all EOL data publicly available once the data are quality controlled. If a PI wants to have exclusive access to these data for the first year, s/he has to officially request such a restriction via email from the EOL Division Director (wakimoto@ucar.edu) eight weeks prior to the start of an experiment. The burden will fall on the requesting PI to request the restriction and also to "police" data distribution and access to the data once the restrictions are in place.*

# PART IV: FACILITY SPECIFIC REQUEST FORMS

**The following forms are available:**

ISS – Integrated Sounding System
ISFS – Integrated Surface Flux System
SPOL – S-band Dual Polarization Doppler Radar
NSF/NCAR C130

## Integrated Sounding System (ISS) - fixed & mobile

*Contact: Dr. William "Bill" Brown*
*Email: wbrown@ucar.edu; Phone: (303) 497-8774*
*http://www.eol.ucar.edu/facilities/iss.html*

**Operational Requirements:**

| | |
|---|---|
| Number of systems requested: | 1 |
| Geographic location: | Front range (options are Boulder FLAB, Marshall Field Site, BAO [Erie], Platteville), CO |
| Will you conduct Intensive Observing Periods (IOPs)? If yes, under which circumstances? How long does each IOP last? | Entire project is essentially a 48-hour IOP |
| Will you require sonde launches? If yes, what's the total number of sondes needed? | Yes. 8. |
| At what frequency will sondes be released? | About 4 hours (0000,0800,1200,1600 local) |
| Is the RASS needed? If yes, will noise be an issue? | Desirable, but not necessary. Should be operable either at FLAB or Marshall |
| Is the MAPR system required? If yes, describe why. | No |
| Is the mobile ISS (MISS) required? If yes, describe why. | Preferred, to allow deployment in locations that would overlap CHILL and S-Pol domains |
| Do you have any special sampling requirements? | No |
| Do you have experience in the analysis of profiler data and appropriate software tools? | We will bring in this expertise, but also need support from EOL staff. |
| Please specify your data access needs. Do you need data in real-time? | It is highly desirable to get data to the OPS center at the COMET classroom. Field partipants also will be at ISS. |
| How many of your staff will be available full time to help with ISS operations? | We expect about 8 students and lecturers to particpate with ISS in the field. |
| Do you have any special requirements that pertain to EOL support? | QC'd data will be needed within 2 days of the experiment.<br>CHAT to ISS required. |
| Which EOL staff was consulted to help complete this request? | Bill Brown |

## Integrated Surface Flux System (ISFS)

*Contact: Dr. Steven Oncley (oncley@ucar.edu, (303 497-8757) or Tom Horst (horst@ucar.edu, 303 497-8838)*
*http://www.eol.ucar.edu/rtf/facilities/isff/isff.html*

### Measurements

| | |
|---|---|
| Number of measurement sites: | 2 (NCAR Marshall Field site and NOAA Platteville Profiler site) |
| Minimum/maximum separation of these sites: | 47km |
| Number and type of measurement at each site (e.g., 2 moisture flux, 5-level temperature profile) | 5-level profile of fluxes+energy balance at Marshall, 1-level flux station+energy balance at Platteville |
| Number and description of NCAR-supplied nonstandard sensors: *(www.eol.ucar.edu/sssf/facilities/isff/sensors)* | None |
| Number and description of user-supplied sensors: *Provide power requirements, data output (e.g., RS232 ASCII or 0-1V analog), and data handling (e.g., sampling rate, sorting by valve position). Note: Providing user-supplied sensors to EOL for pre-experiment testing is highly desirable.* | None |

### Operations

| | |
|---|---|
| Will an operations base be available or should EOL supply one? | ISFS Base at Marshall desirable |
| Location of the base station relative to measurement sites: | 100m |
| Logistics requirement at base station: *(e.g., power, phone, vehicle access, owner permission)* | Power, Internet |
| Logistics requirement at each measurement site: | N/A |
| Will there be intensive observation periods requiring 24-hour staffing? *(ISFF data are collected continuously in any case)* | No |
| Availability of investigator-supplied staff: *We encourage investigators and their students to participate in ISFF deployments, including reviewing data on-site* | Up to 10 students and mentors will be directly involved with ISFS operations |
| Which EOL scientist/engineer/project manager was consulted before completing this request? | Steve Oncley |

**Data Needs**

| | |
|---|---|
| What data analysis methods do you plan to use? | Flux-profiles, spectra, energy balance |
| Is archiving of high-rate (each sample) data needed or are time-averaged statistics sufficient? | Yes (at both sites) |
| What averaging is needed for statistics?<br>*ISFF default is 5 minutes* | Standard 5-min okay |
| What data products are needed in real time? How should these be made available?<br>*(e.g., WWW, display in base)* | WWW display of statistics, "cockpit" display of time series from Marshall, preferably in COMET classroom as well. GOES statistics from Platteville. |
| Post-project: EOL typically distributes statistics via the web. What additional data products (plots, high-rate data, derived products) are desired? Is web distribution acceptable? | Access to high-rate data at COMET classroom. |
| Please specify any special data requirements: | - QC'd data required 2 days after project.<br>- Prefer to have ISFS collecting data 3 days before official start of operations (I.e., starting 1 June)<br>- CHAT to ISFS base required |

# S-Band Dual Polarization Doppler Radar (SPOL)

*Contact: Dr. Jothiram Vivekanandan*
*Email: vivek@ucar.edu; Phone: (303) 497-8402*
*http://www.eol.ucar.edu/rsf/spol/spol.html*

### Operations

| | |
|---|---|
| Weather events during which collection is desired: | Boundary layer development and convection |
| Will you conduct Intensive Observing Periods (IOPs)? If yes, under which circumstances? | Entire project is essentially one 40-hour IOP |
| How long does each IOP last? | See above |
| Typical operations schedule/mode (daily operation hours): | 0500-2100 local |
| Estimated number of radar observation hours: | 32 |
| How many of your staff will be available to help with SPOL operations? | Up to 10 students and mentors would be directly involved with S-Pol |
| Please specify your communication needs: | Internet (CHAT) |
| Summary of auxiliary equipment located at the radar site: | N/A |

### Typical Radar Parameters

| | |
|---|---|
| PRF: | 1000 |
| Gate Spacing: | 150m |
| Type of Scans: | RHI/PPI/SUR |
| Scan Rate: | 6-10 degrees/s |
| Minimum Sensitivity Needs (dBZ at 50 km): | -15 dBZ @50km |
| Scientific rationale for desired radar parameters: | Optimal clear-air return in pre-convection environment. After precipitation develops, we would convert to a storm-mode scanning strategy. |
| Please specify your radar control needs: | Standard scan control |
| Please specify your radar display needs: | Standard engineering display |

### D. Data

| | |
|---|---|
| Will data distribution via ftp be sufficient? | Yes |
| Please specify your in-field real time data access needs? | None |

### E. Other

| | |
|---|---|
| Do you have any special requirements that pertain to EOL support? | No |
| Which EOL scientist/engineer/project manager was consulted to help complete this request? | Wen-Chau Lee |

# NSF/NCAR C-130

*Contact: Dr. Jorgen Jensen*
*Email: jbj@ucar.edu, Phone: (303) 497-1028*
*http://www.eol.ucar.edu/raf/Aircraft/c130.html*

**Operational Considerations:**

| | |
|---|---|
| Preferred flight period | 5-6 June 2009, +/- 2 days |
| Total number of research flight hours requested | 8 |
| Total number of flights requested | 2 |
| Estimated duration of each flight | 4 |
| Total number of flights per week | 2 |
| Particular part(s) of day for flights | Day time |
| Do you plan to fly night missions? | No |
| Preferred base of operation | JeffCo |
| Alternate base | No |
| Is JeffCo Airport (near Boulder) acceptable as your operations base? | Yes |
| Average flight radius from base | 50-200 miles |
| Desired flight altitudes(s) | 1000 ft to 20000 ft |
| Will there be operations in foreign or military airspace? | No |
| Number of scientific observers for each flight (max is 15) | 15 |
| Will you require air to ground communications? | Yes, chat and standard data download. Possible upload of satellite and radar images. |
| Will you require satellite communications above base level? (see Appendix IV) | No |

**Description of desired flight pattern(s), priorities, and estimate number of flights:**
*(Please include graphics and flight pattern images as needed.)*

Flight plans will be developed by the course participants in conjunction with course instructors and pilots. The course participants will decide on their research objectives during the first four days of the course, so we can only give indicative flight plans for various likely research subjects. Sample flight plans are detailed previously in this document, see above.

# Airborne Scientific Instrumentation

## a) Standard EOL/RAF Measurements

*Standard measurements provided automatically when the C-130 is allocated for a project are listed in Appendix II.*

## b) Additional instruments available upon request [3]

| Description | Special Consider-ations [4] | Data Rate(s) | Name | Needed Yes/no |
|---|---|---|---|---|
| Radiometric Ambient Air Temperature (Ophir III) (in cloud) | | Low | OAT | Yes |
| Radiometric Sky Temperature | | Low | RSTT | Yes |
| TDL Laser Hygrometer | B,C,D | Low | TDL | Yes |
| Gerber Probe (Liquid Water Content) | | High | PVM-100 | Yes |
| Cloud Particle Size Distribution (0.5-47µm) | | Low, High | FSPP/SPP-100 | Yes |
| Cloud Particle Size Distribution (40-640µm) | | Low, High | OAP 260X | |
| Aerosol Particle Size Distribution (0.1–3.0µm) | | Low, High | PCAS/SPP-200 | Yes |
| Aerosol Particle Size Distribution (0.3–20µm) | | Low, High | FSSP/SPP-300 | |
| PMS Cloud Particle Images (2-dimensional) | B | Auto | OAP 2D-C | Yes |
| PMS Hydrometeor Images (2-dimensional) | B | Auto | OAP 2D-P | Yes |
| Fast-Response Chemiluminecsence Ozone Concentration | A, D | High | O3FSM | Yes |
| Carbon Dioxide Concentration | C, D | Low, High | CO2C | |
| Carbon Monoxide Concentration | D, D | Low | COCAL | Yes |
| TECO Ozone Concentration | | Low | TEO3 | |
| Radial Differential Mobility Analyzer (8–130 nm) | B, D | Low | RDMA | |
| Number of RAF Air Sample Inlet(s) (standard or solid diffuser) | | | | |
| VHS Video recording (fwd) with date/time | | | | |
| VHS Video recording (side) with date/time | | | | |
| VHS Video recording (down) with date/time | | | | |
| Digital video recording (fwd or down) with date/time stamp | C, D | | | Yes |

[3] *Before requesting instruments in this section, please refer to Appendix 1 to see whether any are needed. Some instruments may require considerably more resources, special data handling and a dedicated, on-board operator.*

[4] *A – Instrument requires a dedicated operator on board the aircraft.*
*B – Special software tools required for routine data processing, display and analysis*
*C – Data recorded on separate data acquisition system, not on RAF's ADS.*
*D – Data acquired by instrument requires unique post-processing.*
*E – Instrument requires filling out a separate request form (available in this document).*

**Other instruments:**

We would like to fly the following RAF instruments that are currently under development or testing:

Cloud Droplet Probe, CDP
10-micron fast 2D-C probe
Fast hygrometer
Differential GPS and/or Omnistar GPS

Payload ground support needs for instrumentation and instruction:

| | Preflight needs | Postflight needs | Routine Maintenance |
|---|---|---|---|
| | On flight days | On flight days | On non-flight days |
| Access (hrs) | 2 | 1 | 8 AM – 5 PM |
| Power (hrs) | 2 | 1 | 8 AM – 5 PM |
| Special support needs | No | | |

**d) Instruments available by special arrangement [5]**

| Description | Special Considerations | Data Rate(s) | Name | Needed |
|---|---|---|---|---|
| Counter-flow Virtual Impactor | A, B, D | Low, High | CVI | No |
| Cloud Particle Imager | A, B, C, D | High | CPI | Yes |
| Wyoming Cloud Radar | A, B, C, D, E | High | WCR | No |

Please identify mission critical instruments in order of importance:

The short duration of the deployment implies that we will have to accept that flights go ahead even if one or more instruments malfunction. The C-130 payload has sufficient amounts of redundant sensors that we do not foresee any reason for flights to be delayed, except for major data system failure. If necessary, the course organizers will work with the course participants to change objectives in case of instrument malfunction.

[5] *CPI, CVR and WCR are not covered by NSF Deployment Pool Funds and require separate funding sources. They also require considerably more resources, need special data handling and require a dedicated on-board operator.*

# APPENDIX II: NSF / NCAR C-130

## EOL/RAF Standard Airborne Scientific Measurements

*For details about instrument type and performance, consult the RAF Bulletins on the EOL web site at* http://www.eol.ucar.edu/raf/Bulletins/

### I. TIME

| *Name* | *Units* | *Description* |
|---|---|---|
| Time | sec | Offset from Reference Start Time (units is reference time) |

### II. INERTIAL REFERENCE SYSTEM

| *Name* | *Units* | *Description* |
|---|---|---|
| LAT | degree_N | Inertial Latitude |
| LON | degree_E | Inertial Longitude |
| THDG | degree_T | Aircraft True Heading Angle |
| PITCH | degree | Aircraft Pitch Angle |
| ROLL | degree | Aircraft Roll Angle |
| ACINS | m/s2 | Aircraft Vertical Acceleration |
| VSPD | m/s | IRS-Computed Aircraft Vertical Velocity |
| ALT | m | IRS-Computed Aircraft Altitude |
| GSF | m/s | Inertial Ground Speed |
| VEW | m/s | Inertial Ground Speed Vector, East Component |
| VNS | m/s | Inertial Ground Speed Vector, North Component |

### III. GLOBAL POSITIONING SYSTEM (GPS)

| *Name* | *Units* | *Description* |
|---|---|---|
| GLAT | degree_N | GPS Latitude |
| GLON | degree_E | GPS Longitude |
| GVEW | m/s | GPS Ground Speed Vector, East Component |
| GVNS | m/s | GPS Ground Speed Vector, North Component |
| GALT | m | GPS Altitude |
| GMODE | none | GPS Mode |
| GSTAT | none | GPS Status |

### IV. ALTITUDE AND POSITION

| *Name* | *Units* | *Description* |
|---|---|---|
| HGM232 | m | Geometric (Radar) Altitude (APN-232) |
| PALT | m | NACA Pressure Altitude |
| PALTF | feet | NACA Pressure Altitude |
| GGALTC | m | GPS-Corrected Altitude |
| LATC | degree_N | GPS-Corrected Latitude |
| LONC | degree_E | GPS-Corrected Longitude |

### V. AIRCRAFT AND METEOROLOGICAL STATE PARAMETERS

| *Name* | *Units* | *Description* |
|---|---|---|
| ATTACK | degree | Attack Angle, Reference |
| SSLIP | degree | Sideslip Angle, Reference |
| PCAB | mbar | Interior Cabin Static Pressure |
| PSX | mbar | Raw Static Pressure, Reference |

| | | |
|---|---|---|
| PSXC | mbar | Corrected Static Pressure, Reference |
| QCX | mbar | Raw Dynamic Pressure, Reference |
| QCXC | mbar | Corrected Dynamic Pressure, Reference |
| TTH | deg_C | Total (Recovery) Temperature, Deiced |
| TTX | deg_C | Total (Recovery) Temperature, Reference |
| DPX | deg_C | Dew/Frost Point Temperature, Reference |
| DPXC | deg_C | Dew Point Temperature, Reference |

## VI. THERMODYNAMIC MEASUREMENTS

| *Name* | *Units* | *Description* |
|---|---|---|
| ATH | deg_C | Ambient Temperature, Deiced |
| ATX | deg_C | Ambient Temperature, Reference |
| TASX | m/s | Aircraft True Airspeed, Reference |
| TASHC | m/s | Aircraft True Airspeed, Humidity Corrected |
| EDPC | mbar | Ambient Water Vapor Pressure, Reference |
| THETA | K | Potential Temperature |
| THETAE | K | Equivalent Potential Temperature (Bolton) |
| TVIR | deg_C | Virtual Temperature |
| RHUM | % | Relative Humidity |
| RHODX | gram/m3 | Absolute Humidity, T-Electric, Reference |
| SPHUM | gram/kg | Specific Humidity |
| MR | gram/kg | Mixing Ratio, T-Electric |

## VII. WINDS

| *Name* | *Units* | *Description* |
|---|---|---|
| UI | m/s | Wind Vector, East Component |
| VI | m/s | Wind Vector, North Component |
| WI | m/s | Wind Vector, Vertical Gust Component |
| WS | m/s | Horizontal Wind Speed |
| WD | degree_T | Horizontal Wind Direction |
| UX | m/s | Wind Vector, Longitudinal Component |
| VY | m/s | Wind Vector, Lateral Component |
| UIC | m/s | GPS-Corrected Wind Vector, East Component |
| VIC | m/s | GPS-Corrected Wind Vector, North Component |
| WIC | m/s | GPS-Corrected Wind Vector, Vertical Component |
| WSC | m/s | GPS-Corrected Horizontal Wind Speed |
| WDC | degree_T | GPS-Corrected Horizontal Wind Direction |
| UXC | m/s | GPS-Corrected Wind Vector, Longitudinal Component |
| VYC | m/s | GPS-Corrected Wind Vector, Lateral Component |

## VIII. RADIATION

| *Name* | *Units* | *Description* |
|---|---|---|
| RSTB | deg_C | Radiometric Surface Temperature |
| IRB | W/m2 | Raw Infrared Irradiance, Bottom |
| IRT | W/m2 | Raw Infrared Irradiance, Top |
| IRBC | W/m2 | Corrected Infrared Irradiance, Bottom |
| IRTC | W/m2 | Corrected Infrared Irradiance, Top |
| SWB | W/m2 | Shortwave Irradiance, Bottom |
| SWT | W/m2 | Shortwave Irradiance, Top |
| SWTC | W/m2 | Shortwave Irradiance, Top (Attitude-Corrected) |
| UVB | W/m2 | Ultraviolet Irradiance, Bottom |

| | | |
|---|---|---|
| UVT | W/m2 | Ultraviolet Irradiance, Top |

## IX. CLOUD PHYSICS

| *Name* | *Units* | *Description* |
|---|---|---|
| PLWCC | gram/m3 | Corrected PMS-King Liquid Water Content |
| RICE | Volts | Raw Icing-Rate Indicator |

## XI. PARTICLES

| *Name* | *Units* | *Description* |
|---|---|---|
| FCNC | vlpm | Corrected CN Counter Sample Flow Rate |
| CONCN | count/cm3 | Condensation Nuclei (CN) Concentration |

# Appendix IV: Base Level SATCOM Support

All projects will get a base level of SATCOM support which will include "Chat" (IRC), a simple data feed to the ground and file transfer in both directions. Additional services can be arranged through CDS at extra cost. Please contact us early to discuss requirements and allow for scheduling.

The base level deployment fund allocation is currently $120 per hour. Actual cost to transfer data is 4.7 cents per kilobyte. A typical uncompressed satellite image is around 120 kilobytes (or $5 to transfer). Data feed to the ground tends to be the largest portion of data transfer involved in a project. This can be optimized by adjusting the number of variables sent and the frequency they are sent. e.g. 12 variables sent every second is the same amount of data as 36 variables sent every 3 seconds.