REQUEST FOR SPOLKA, CHILL, PAWNEE, ISS, MGAUS, ISFS & DOW SUPPORT

Front Range Observational Network Testbed - Precipitation Observations and Research on Convection and Hydrometeorology 2013 (FRONT-PORCH 2013)

NCAR/EOL - MAY 2012 OFAP MEETING

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PART I: GENERAL INFORMATION

A. Corresponding Principal Investigator(s)

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B. Project Description

Project Title	FRONT-PORCH 2013
Location of Project	Colorado Front Range between Denver and Fort Collins within FRONT domain
Start and End Dates of Field Deployment Phase	15 May – 15 August 2013
NSF Facilities requested	CHILL, Pawnee, S-PolKa, MGAUS, ISS, ISFS, DOWs (DOW6, DOW7, rapid-scan DOW)
Funding Agency and Program Officer Name(s)	NSF-PDM; Brad Smull (Division of Atmospheric and Geospace Sciences, Physical and Dynamic Meteorology) 703.292.8524
Proposal(s) affiliated with this request	• NCAR-led proposal describing science objectives will be submitted to Brigitte Baeuerle by 13 February 2012 • Additional science proposals may be

	submitted from individual PIs in the future
Proposal Status	In preparation (x), submitted (), funded ()
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

C. Abstract of Proposed Project

The *Front Range Observational Network Testbed - Precipitation Observations and Research on Convection and Hydrometeorology* (FRONT-PORCH) experiment is an investigation of meteorological and hydrological processes that are important to accurately predict the location and intensity of orographic and convective precipitation and its hydrological response in complex terrain. Although much has been learned about hydrometeorological processes in recent years, accurate measurement and prediction of multi-scale motions, humidity, and hydrometeorological parameters remains elusive. The multi-organizational FRONT-PORCH experiment in May-August of 2013 will provide critical insight on the most extensive-to-date range of processes contributing to convective and orographic precipitation over the mountains, foothills and plains in the FRONT domain. The FRONT-PORCH 2013 experiment and its related research focuses on three main objectives:

1. Conduct fundamental hydrometeorological process research in the physical controls on warm season convective initiation, evolution and its hydrological responses in a complex terrain region
2. Perform fundamental research with state-of-the-art multi-parameter microwave radar systems on the spatially and temporally continuous retrieval of precipitation, wind, humidity and hydrometeor structure (e.g., rain, hail, graupel, mixed-phase particles, etc.)
3. Accelerate numerical-weather-prediction-based and extrapolation-based data assimilation and prediction system development through continuous and case study simulation and forecast of warm season precipitation and streamflow events

Essential in addressing the research objectives is the usage of the FRONT radar network, the two polarimetric and the rapid-scan Doppler on Wheels radars, the mobile GPS advanced upper air system (MGAUS), the integrated sounding system (ISS-449), and the integrated surface flux system (ISFS). The experiment also leverages upon many state-of-the-art research instruments and operational networks deployed along the Front Range such as Lightning Mapping Array, GPS and microwave radiometer networks, and regional ALERT stations.

Intellectual merit: Accurate prediction of the location and amount of precipitation over complex terrain continue to be a grand meteorological challenge as it depends on a wide range of time and space scales and complex processes ranging from orographic airflow dynamics, to atmospheric thermodynamics to cloud microphysics. The proposed measurements in FRONT-PORCH 2013 are the first to track both meteorological and hydrological connections between the ‘output’ (location and amount of precipitation and hydrological runoff) and the ‘input’ (upstream flow, humidity temperature and surface fluxes) through study of the intermediate transformational steps (orographic flow modification, condensation and transformation of condensate to precipitation). By integrating data from novel observation systems with sophisticated data assimilation and modeling systems we will create an unprecedented opportunity to test the validity of existing hypotheses on orographic-convective processes and we will be able to quantify principal sources of error in the hydrometeorological

prediction chain. These discoveries will act as a guide towards answering the most fundamental question: "What is the predictability of the location and amount of convective and orographic precipitation and hydrologic responses over mountainous terrain?"

Broader Impacts: Improving the ability to predict the location and amount of convective and orographic precipitation will have a direct impact on flood prediction skill and on a wide range of human activities including water management, agriculture, commerce, transportation and recreation. One of the most important scientific impacts will be on hydrological modeling and forecasting since uncertainty in the location and amount of precipitation is one of the greatest sources error in hydrological predictions. Knowledge of the predictability limits has important implications for coupled atmospheric-hydrological modeling as well as for the communication of forecast information/uncertainty to the end users. It is also expected that results of the field campaign will yield new information on a) the dynamics of moist airflow over complex three-dimensional topography, especially in cases involving precipitating convection and attendant features such as cold pools, b) the interactions between turbulent convection and microphysical processes leading to precipitation, and c) the impact of various datasets into data assimilation systems to improve the predictability of these features. It is expected that the findings from the proposed research will have relevance to orographic precipitation in other regions around the world.

D. Experiment Design

1. Location, time, and instrumentation within the observational domain

The experiment will be conducted along the Colorado Front Range between 15 May and 15 August 2013. The observational domain is centered at the National Science Foundation (NSF) Front Range Observational Network Testbed (FRONT) consisting of the Colorado State University (CSU) radars CSU-CHILL and CSU-Pawnee, the NCAR S-PolKa radar, and the National Weather Service (NWS) radars at Cheyenne and Denver (Fig. 1a). The proximity of the radars allows for deriving wind vector fields almost across the entire observational domain.

The experiment will also leverage upon existing stationary surface instrumentations (Fig. 1b) measuring hydrometeorological parameters (rain gauges, disdrometers, hotplates, vertically pointing radars, soil moisture streamflow and surface flux stations) and atmospheric humidity (Denver sounding, microwave radiometers, GPS receivers). A large variety of collocated hydrometeorological and humidity sensors are already operated at the three main instrument sites at the Skywatch Observatory on the U. of Colorado Campus[1] (CU), NCAR Marshall field site[2] (Marshall), and the Boulder Atmospheric Observatory[3] (BAO). Additional hydrometeorlogical sites are operated by CU and NCAR at the CU Mountain Research Station (MRS) and the Fourmile Canyon burn area, respectively. The experiment will also use observations from the Denver Urban Drainage, Loveland and Fort Collins ALERT stations, Community Collaborative Rain, Hail & Snow Network (CoCoRas), Global Positioning System (GPS) network, microwave radiometer network, and the NWS surface observation network (Fig. 1b, Table 1).

FRONT will be augmented by a few additional observing networks to help accelerate closely-aligned scientific and technological research. One of these additional networks is a VHF 3-D lightning network. The Lightning Mapping Array (LMA) is a three-dimensional total lightning location system, which will

[1] http://skywatch.colorado.edu/
[2] http://www.rap.ucar.edu/projects/winter/sites/marshall/
[3] http://www.esrl.noaa.gov/psd/technology/bao/

be installed by Paul Krehbiel and colleagues as part of the NSF DC3 (Deep Convective Clouds and Chemistry) project. At the conclusion of DC3, the LMA network will become part of FRONT. Figure 2 shows the planned locations of the individual LMA receivers.

Another such observing network is the Cosmic ray Soil Moisture Observing System (COSMOS) operated by Profs. Marek Zreda and Xubin Zeng and their colleagues at the University of Arizona. Presently, the COSMOS team operates two field COSMOS observing sites in the Front Range region and developed plans to contribute data from their network to help improve characterization of antecedent land surface hydrology conditions and their relationships to diurnal convective precipitation activity.

2. Experimental design and instrument operation

The principal objective of the FRONT-PORCH 2013 field campaign is to make fundamental advances in understanding and prediction of diurnal, thermally-modulating orographic convection through the utilization of state of the art, lower atmosphere observing technology, data assimilation and numerical modeling. The three main research tasks to be completed during FRONT-PORCH 2013 are as follows:

Task 1: Conduct fundamental hydrometeorological process research in the physical controls on warm season convective initiation, evolution and its hydrological responses in a complex terrain region

Task 2: Perform fundamental research with state-of-the-art multi-parameter microwave radar systems on the spatially and temporally continuous retrieval of precipitation, wind, humidity and hydrometeor structure (e.g. rain, hail, graupel, mixed-phase particles, etc.)

Task 3: Accelerate NWP-based and extrapolation-based data assimilation and prediction system development through continuous and case study simulation and forecast of warm season precipitation and streamflow events

The NSF FRONT facility offers a unique opportunity to fulfill our objectives given the juxtaposition of existing polarimetric radars and the steep escarpment of the Colorado Front Range. Additions to the FRONT radar facilities are needed, however, and the following NSF facilities are requested to address specific research objectives that cannot be addressed with the existing instrumentation (Fig. 1c):

- **GAUS – GPS Advanced Upper Air System**: The mobile sounding system will be used to characterize the environmental and inflow region 2 hours prior and every 2 hours during the precipitation event (research Tasks 1 and 3). The mobility allows for targeted observations in the vicinity of the storm, which might not be optimally covered by the stationary instruments. The GAUS system will additionally be used to provide a daily 11 am LT sounding. This will be used in conjunction with the radiometers and the GPS network to compare and contrast the stability profiles on the days in which convection formed and those when it did not.
- **ISS – Integrated Sounding System**: The system will be used to address research Task 2. Measurements of vertical velocities are necessary to validate the vertical velocities derived from multiple Doppler retrieval techniques.
- **ISFS – Integrated Surface Flux System**: The ISFS will be used to address research objective Tasks 1, 2 and 3, which requires the measurement of local precipitation, sensible and latent heat fluxes (via the eddy covariance technique), and soil moisture, temperature and heat flux. Specifically, an enhanced surface observing network will be deployed under FRONT-PORCH 2013 to help improve a) ground-validation of quantitative precipitation measurements (Tasks 1 and 2), b) characterization of surface meteorological conditions (Tasks 1 and 3), and c) representation of the co-evolution of regional land-surface fluxes and convective precipitation

(Task 1). As stated above, a core network of surface meteorology and land surface flux instrumentation already is in place through the region. Modest enhancements to the existing surface observing network within the FRONT domain will help fill gaps in elevational sampling thereby allowing for a more spatially and topographically-continuous set of observations.

- **DOW – Doppler on Wheels radars**: The three mobile DOW radars (DOW6, DOW7, Rapid-scan DOW) will be deployed along the Foothills in an area with a concentration of hydrometeorological stations, which is not well covered by FRONT radars (Fig. 1c). The mobile radars will provide low-level wind fields and precipitation characteristics close to the surface along the Front Range slope ranging between 1600 – 3200 m. This facility will be used to address Tasks 1 and 2.

The NSF FRONT facilities (CSU-CHILL, CSU-Pawnee, NCAR S-Pol) together with the ISS, ISFS, and partially MGAUS will be operated continuously throughout the experiment:

- The **ISS** will be deployed on the CSU campus, which is within the dual-Doppler loop between the CHILL and S-Pol radar (Fig. 1c). The instrument will be deployed at the beginning of the experiment and will remain at its location throughout the experiment.
- The **ISFS** stations will be deployed shortly before commencement of radar operations and will be arrayed in two longitudinal transect that broadly sample the regional scale surface topographic gradient (see Fig. 1c). Emphasis will be placed on siting the ISFS stations where there is currently a lack of an equivalently representative long-term measurement platform. In the FRONT domain, there are specific deficiencies in the foothill-pediment regions and in the sparsely populated eastern portions of the radar coverage umbrella. In total we propose to deploy 8 total energy and water flux stations and approximately 10 basic meteorological stations. The surface energy and moisture flux and basic meteorological stations are fully automated thereby permitting continuous and unattended operations with minimal ongoing maintenance.
- An 11am LT **MGAUS sounding** will be launched throughout the experiment from the CSU-CHILL or S-PolKa site. The sounding will be launched by students or CSU-CHILL/S-PolKa staff. This will provide atmospheric stability information to assess the convective potential for each day. A total of 110 soundings (99 days = 99 soundings + ~10% failure soundings = 110 soundings) will be requested for the daily launches.

The instruments will be maintained during regular office hours (Mo-Fr. 8am-4pm). If the instruments stop operating outside the office hours, they will be maintained on the next office day.

3. Intensive observation periods within FRONT-PORCH 2013

The three month experiment is subdivided into two observational periods (OP), which are characterized by a) synoptically-linked, transient convective storms (OP I: 15 May – 15 June) and b) comparatively 'weakly-forced', diurnal convective storm events related to the onset of the North American Monsoon (OP II: 15 July – 15 August). Each observational period will have ~5 intensive observation periods (IOPs) of about 6-18 hours each, which accumulated to a total of 10 IOPs (max. 180 hrs). An IOP will start 1-2 hours prior to the arrival or formation of precipitation in order to monitor the antecedent air temperature, humidity, wind and land surface hydrology conditions and will last until most of the precipitation has moved out of the S-PolKa and CHILL radar range, typically from 6-18 hours.
All instruments need to be fully maintained during the IOPs. Additionally, the semi-operational NSF facilities (CSU-CHILL, S-Pol, ISS, ISFS), sondes from the mobile GAUS, the Ka-band radar system of S-Pol and the Doppler on Wheels radar will be deployed as follows:

- The **MGAUS sondes** will be launched during the IOP every 2 hours within the inflow region of the storm. Additional soundings (2-3) will be launched several hours prior to the beginning of an IOP and an hour after the IOP ends. The specific deployment location will be specified during the daily weather meeting and coordinated by S-Pol radar operator. For the FRONT-PORCH IOPs, a total of 120 soundings will be requested (18 hours = 11 soundings x 10 IOPs = 110 soundings + ~10% failure rate = 120 soundings).
- The **Ka-band radar** will be operated by the S-Pol radar operator during the duration of the IOP. The Ka-band radar is not requested for the entire experiment due to the limited lifetime of its transmitter.
- The **Doppler on Wheels radars** will be operated during the IOPs by the Center for Severe Weather Research. The radars will be deployed in the Front Range mountains in order to obtain low-level wind and reflectivity fields (Fig. 3).

Instrument operations, in particular the MGAUS and DOW radars, will be assisted by students from the North Carolina State University, Colorado State University, University of Arizona, and University of Colorado.

Once the IOP is defined, there will be three major foci:

– Determining upstream and local environmental conditions by monitoring 3-dimensional structure of water vapor, temperature and wind

–Mapping the co-evolution of cloud, precipitation, and lightning structure, surface precipitation amount together with 3-dimensional wind field along the Front Range and in mountainous regions

– Measuring the land surface response to precipitation events, in the form of streamflow and soil moisture, and inter-storm dry-down behavior, in the form of changes in the partitioning of available energy to sensible and latent heat flux components

4. Logistics and weather forecast during IOPs

The deployment and operation of the FRONT-PORCH 2013 instruments will be coordinated by the instrument PIs at EOL/NCAR and/or CSU-CHILL. A key aspect of IOP planning is the forecast of the formation of precipitation and the arrival of precipitation in the observational domain. The nominal timing of the IOP will be determined at the daily planning meeting at the NCAR Operations Center the day before the intensive observations are expected to begin. Due to the episodic nature of active precipitation periods, decisions to stand-up or stand-down will be made on a quasi-weekly basis. Besides operational model output, FRONT-PORCH will use nowcasting tools such as the Variational Doppler Radar Assimilation System (VDRAS) and AutoNowcaster, which are proposed to be operated at NCAR in real-time.

5. Data Management

Data management activities during and following the FRONT-PORCH-2013 project will be addressed in two separate manners. First, real-time operational and subsets FRONT-PORCH-2013 ‘project’ or ‘research’ data will be made available to the NCAR FRONT field catalog. A template of this field catalog was established by the NCAR Earth Observing Laboratory (EOL) during the summer of 2011 (http://catalog1.eol.ucar.edu/front/). Example data sets to be included in the field data catalog include operational satellite imagery, operational radar imagery, routine surface meteorological observations, regional and local real-time hydrometeorological observing networks, operational sounding data, etc. During FRONT-PORCH-2013 this Field Data Catalog will serve as the principal data portal for most operational as well as available research products and will be used in day-to-day mission decision-making such as the planning of intensive observing periods.

The second data management activity pertains to the long-term archival and access of project data. A long-term project data archive will be coordinated by EOL as part of FRONT-PORCH-2013. The long-term archive will have NCAR-local and distributed (i.e. links to offsite locations) repositories. Internally at NCAR, EOL project data is primarily stored on the NCAR High Performance Storage System (HPSS) and accessed through the EOL Data Management System (EMDAC). EOL provides "one-stop shopping" for all centralized and related distributed project datasets through a web-based "Master Project Dataset List" that provides links to access all data and metadata. As such data repositories will be accessed via this common data portal which will contain basic dataset descriptions and pertinent, high-level (e.g. location, measurement description and periods of record) meta-data. The long-term archive portal will have basic query functionality for compliant data sets and basic full record extraction functionality for all data. The interfaces to the Field Data Catalog and the long-term data archive will be supported through a separate NSF request by members of EOL (Steve Williams, personal communication) and will be coordinated with all NCAR-internal and external project investigators. Examples of previous project web pages and data management links can be found at: http://www.eol.ucar.edu/projects/.

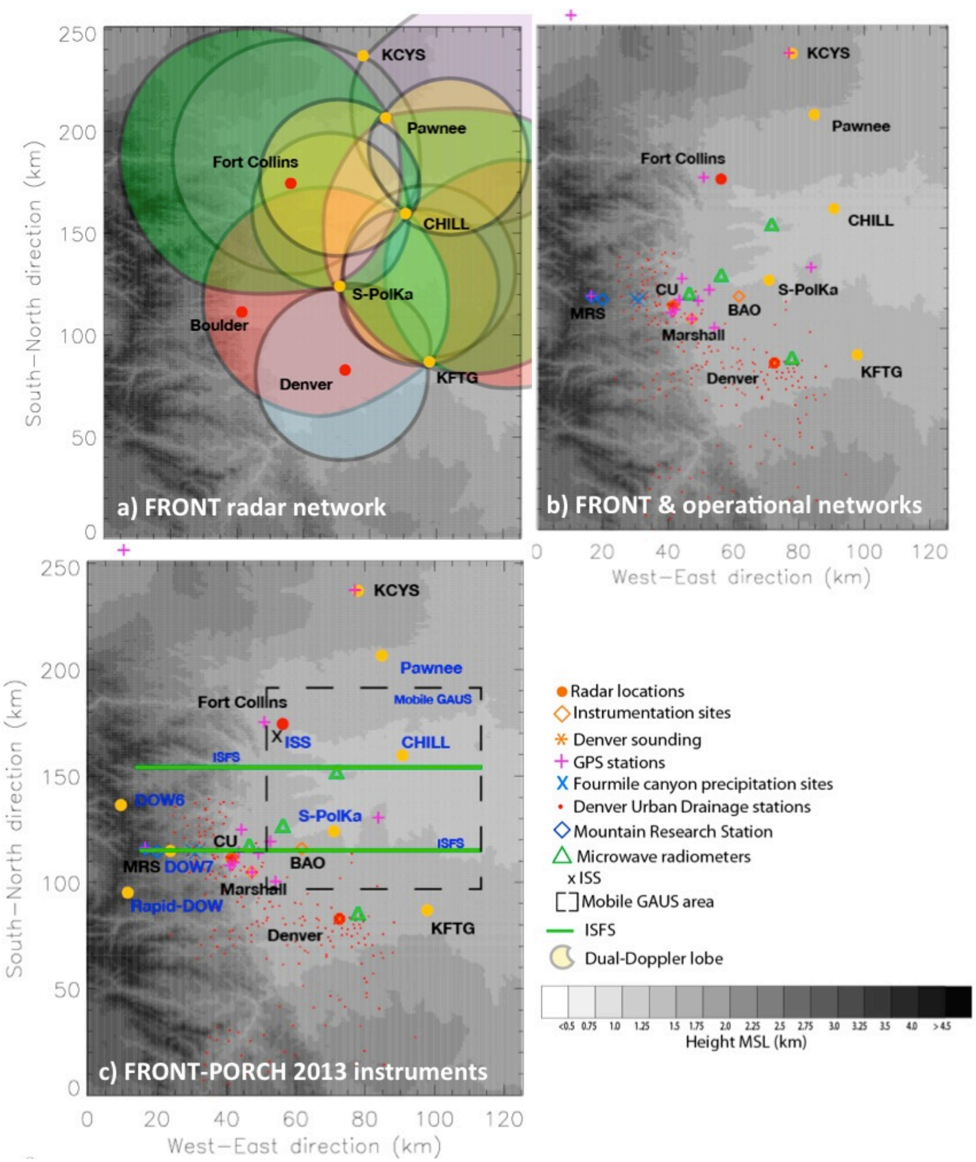

Figure 1: FRONT radar network and surface instruments for the FRONT-PORCH 2013 experiment. a) NSF FRONT radar network including the WSR-88D weather service radars at Denver, CO and Cheyenne, WY. Dual-Doppler lobes between the individual radars are indicated in color. b) FRONT and existing hydrometeorological and humidity stations within the observational domain. c) FRONT-PORCH instrumentations with requested NSF facilities indicated in blue. The basic orientation of the surface instrument transects from the ISFS is shown with a green line.

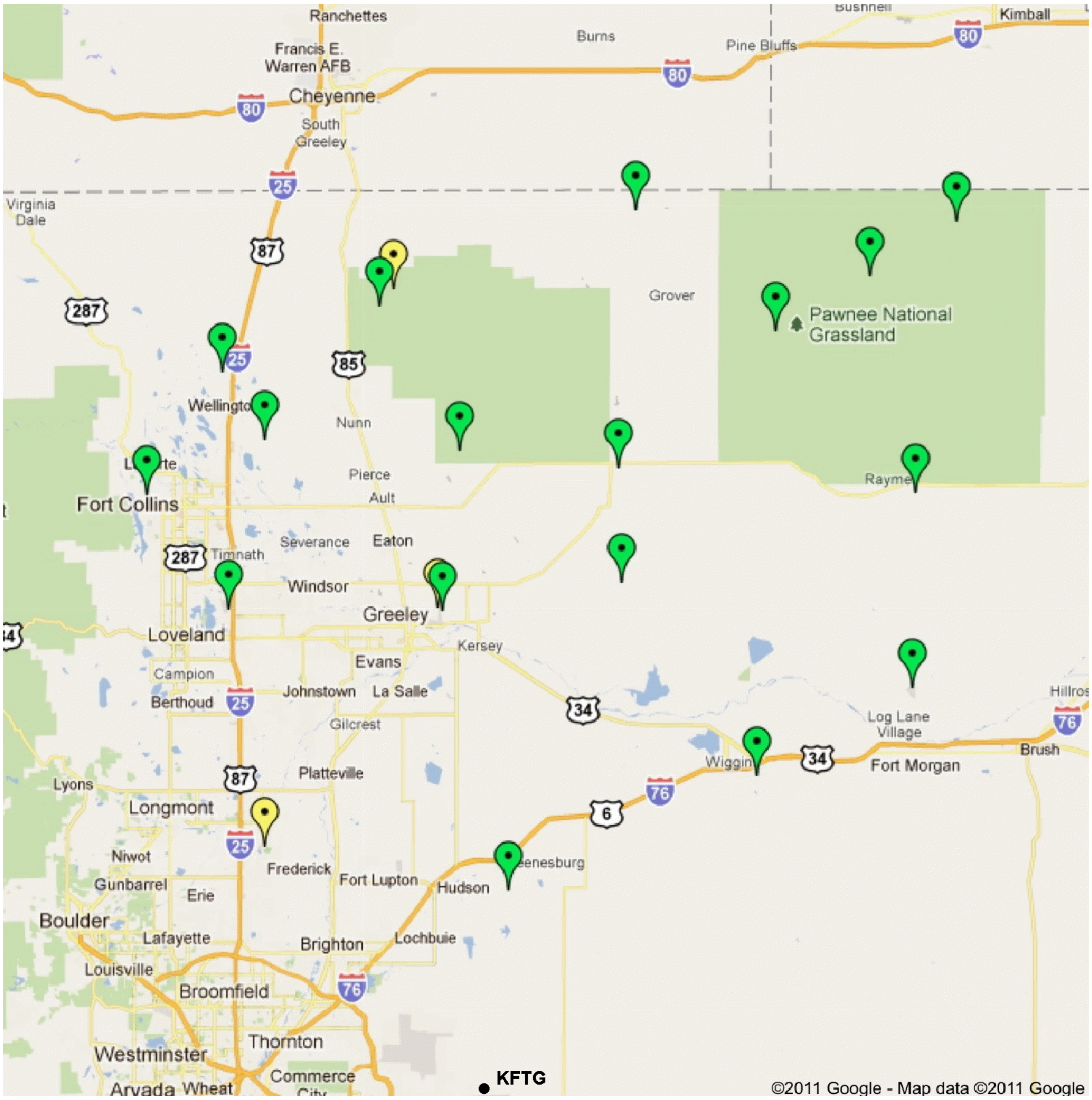

Fig. 2: The locations, marked in green, of the receivers for the LMA to be deployed in the FRONT domain. The yellow markers, from top to bottom, show the location of the Pawnee, CSU-CHILL and S-Pol radars. The CSU-CHILL marker is located close to Greeley and is obscured by a LMA marker (Figure supplied by New Mexico Tech).

Table 1: List of instruments used for the FRONT-PORCH 2013 experiment.

Site name	**Sub-sites**	**Instrumentation**
Precipitation Stations		
Mountain Research Station	Soddie C1	Disdrometer, MRR, precip. Gauges, streamflow
Fourmile Canyon burn area	BASESTN_Pars3 USGS2_Pars2 Melvina_Pars4	Precip/wx/disdrometer, streamflow
Denver Urban Drainage ALERT stations	~90 stations	Precip and streamflow Gauges
BAO		Disdrometer, soil moisture
Marshall field site		Precip. Gauges, disdrometer, hotplates, wx, MRR, ceilometer, GPS, COSMO soil moisture
NCAR Foothills, Mesa labs		Rain gauges
CU Campus		Gauge, disdrometer, weather, MRR, ceilometer
CSU CHILL site		2DVD
CoCoRas[4]	Several stations	Gauges
Humidity profiles		
CU radiometer	TBA	Microwave radiometer
Radiometrics		Microwave radiometer
NWS Denver[5]		Microwave radiometer
Honeywell (Detect)[6]	Longmont	Microwave radiometer
Denver sounding		Operational sounding
NRL tower[7]		Tower (sfc, 50, 80m)
BAO tower		Tower (sfc, 10, 100, 300m)
Radar reflectivity and wind fields		
KFTG, KCYS		S-band: single-pol
NCAR S-Polka		S-band: dual-pol, K-band: single-pol
CSU CHILL		S-band: dual-pol X-band
CSU Pawnee		S-band: single-pol
Surface stations		
NRL		
NCAR	Marshall, Foothills, Mesa lab	
CU	MRS, Campus	
BAO		
Other networks		
GPS receivers[8]		Precipitable water vapor
CSU Lightning Mapping Array	See Fig. 2	3D lightning characteristics

[4] http://www.cocorahs.org/
[5] http://rucsoundings.noaa.gov/, http://madis.noaa.gov/rdmtr_stations.html
[6] http://madis.noaa.gov/rdmtr_stations.html
[7] http://www.nrel.gov/midc/nwtc_m2/
[8] http://www.suominet.ucar.edu/index.html

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

Project Name and Year	**Facilities used**	**Publication Citation**
VORTEX2	DOW6, 7	Friedrich et al. 2012, Kalina et al. 2012
IHOP 2002	P3-ELDORA, Dropsondes, Flight level, MMR	Friedrich et al. 2008a, 2008b (listed below)
CaPE	CP3, CP4, FL2	Friedrich et al. 2005
NAME-2004	Spol, ISS	Higgins and Gochis, 2007; Gochis et al., 2004; 2007; 2009; Nesbitt et al., 2008

Friedrich, K., S. Higgins, F. J. Masters, and C. R. Lopez, 2012: Artifacts in PARSIVEL disdrometer measurements under strong wind conditions. *J. Atmos. Oceanic Technol*. (in review)

Kalina, A. E., K. Friedrich, and S. M. Ellis, 2012: Comparison of disdrometer and X-band radar observations in convective precipitation. *J. Atmos. Oceanic Technol*. (in review)

Friedrich, K., D. E. Kingsmill, C. Flamant, H. V. Murphey, and R. M. Wakimoto, 2008a: Kinematic and moisture characteristics of a nonprecipitating cold front observed during IHOP. Part II: Along-front structures. *Mon. Wea. Rev.*, **136**, 3796-3821.

Friedrich, K., D. E. Kingsmill, C. Flamant, H. V. Murphey, and R. M. Wakimoto, 2008b: Kinematic and moisture characteristics of a nonprecipitating cold front observed during IHOP. Part I: Across-front structures. *Mon. Wea. Rev*., **136**, 147-172.

Friedrich, K., D. E. Kingsmill, and C. R. Young, 2005: Misocyclone characteristics along Florida gust fronts during CaPE. *Mon. Wea. Rev*., **133**, 3345-3367.

Gochis, D.J., A. Jimenez, C.J. Watts, J. Garatuza-Payan, and W.J. Shuttleworth, 2004: Analysis of 2002 and 2003 warm-season precipitation from the North American Monsoon Experiment (NAME) Event Rain Gauge Network (NERN). *Monthly Weather Review*, **132(12)**, 2938-2953.

Higgins, R.W. and D.J. Gochis, 2007: Synthesis of results from the North American Monsoon Experiment (NAME) Process Study. *J. Climate*, **20(9)**, 1601-1607.

Gochis, D.J., C.J. Watts, J. Garatuza-Payan, and J. Cesar-Rodriguez, 2007a: Spatial and temporal patterns of precipitation intensity as observed by the NAME Event Rain Gauge Network from 2002 to 2004. *J. Climate*, **20**, 1734-1750.

Nesbitt, S., Gochis, D.J., and T. Lang, 2008: The diurnal cycle of clouds and precipitation along the Sierra Madre Occidental observed during NAME-2004: Implications for warm season precipitation estimation in complex terrain. *J. Hydrometeorology*, **9**, 728-743.

Gochis, D.J., S. Nesbitt, W. Yu, and S.F. Williams, 2009: Assessment of quantitative precipitation estimates from space-borne platforms during the 2004 North American Monsoon Experiment. *Atmosfera*, **22**, 69-98.

E. Educational Activities

FRONT-PORCH 2013 will provide unique field research experiences to graduate students from several institutions. The one-page descriptions of research interests (see attached) express the desire for several graduate and undergraduate students from the participating U.S. universities (North Carolina State University, Colorado State University, University of Arizona, University of Colorado) to participate in FRONT-PORCH 2013. The goals of the educational part of FRONT-PORCH will be to educate students about theoretical questions and objectives motivating the field campaign, the techniques and instrumentation used to address these objectives, and the process of designing and executing a large international field campaign such as FRONT-PORCH. We plan to integrate research and education in FRONT-PORCH through the following activities:

1. **Dedicating research projects to graduate and undergraduate students** either as part of their PhD theses or an independent study.
2. Students will gain **hands-on practical experience** with instrumentation and data analysis. Students will be responsible for deploying, operating, and maintaining research instruments (e.g., FRONT radars, mobile DOW radars, MGAUS, surface meteorological, eddy-covariance and microphysical stations).
3. **Website** (hosted at NCAR, CSU or perhaps COMET) **with sets of images and movies illustrating real-world examples** of key mesoscale storm features. These examples would be used in the classroom as a focus for discussion of mesoscale kinematic and dynamical structures in conjunction with traditional schematics and idealized model output. The target audiences are senior-level undergraduates and graduate students (see proposal by Yuter et al.).
4. Instrument, data and analyzed products will be used in **graduate and undergraduate teaching courses** at NCSU, CU, CSU, and U. of Arizona. Teaching material (homework assignments, problems etc.) will be made available on the FRONT-PORCH web site and will be incorporated into the educational websites (see educational activity #3).
5. The PIs will volunteer as mentors for the **NCAR/UCAR Significant Opportunities in Atmospheric Research and Science (SOARS), the U. of Colorado Summer Multicultural Access to Research Training (SMART), and the Research Experience for Undergraduate (REU)** CHILL-Radar program. Research topics, goals, and an outline of the research related to FRONT-PORCH will be submitted to the programs at the end of 2012. The PIs will work closely with the SOARS, SMART, and REU staff to find an optimal pairing between the mentor (i.e., research topic) and the protégés area of interest.

PART II – OPERATIONAL CONSIDERATIONS & LOGISTICS

Approx. how many people will be involved in the field campaign? *Please specify number of participants and location(s).*	During IOPs: 2 studs + PI @ CSU-CHILL 2 studs +PI @ S-Polka 4 studs + PI @ DOW 2 studs MGAUS (mobile) 2 studs surface hydrometeorology and flux stations (ISFS)
What other facilities/platforms outside the EOL suite will be deployed? Are any of them non-US facilities?	Requested from NSF facility pool: - CSU-CHILL - DOWs: DOW6, DOW7, rapid-scan DOW – See experimental design for additional instruments provided by the PIs and operational networks operated by FRONT and other groups
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?	No
If there are multiple instrumentation/operations sites, is there a need for operational coordination?	Yes, operation center will be located at NCAR (Foothills) to coordinate instrument operations
What kind of real-time data display and project coordination needs do you anticipate?	Real-time CIDD or JAZZ display including CHILL, S-Polka, sat, surface obs, NEXRAD, real-time dual Doppler between CHILL, S-Polka, NEXRAD (low-level surveillance scans Z, RR, V, refractivity), VDRAS,
Is forecasting support required for project operations?	No
What kind of communications capabilities do you expect on site?	Cell phone, high-speed internet
Will operations center and real-time display and coordination services be required? [9]	Yes, real-time display as specified.
Will you require work space? *(e.g., office, lab and storage space)*	No
Will you require system administration support on site?	No
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?	We may need assistance with obtaining permits/permissions for surface flux station installations.

PART III: DATA MANAGEMENT

What operational data do you need? *(e.g., satellite, upper air, radar, surface, oceanographic, hydrological, land characterization, model products)*	Satellite, upper air, radar, surface, model products
Do you have any specific real-time data needs to aid in your data collection activities?	CHILL, S-Polka real-time data need to be displayed with VCHILL, CIDD
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?	Measurements from operational networks and other groups (see Table 1 in experimental design), NCAR auxiliary data, CHILL radar, other data (NWS, GPS network, radiometer network)
What data analysis products will you provide during the deployment?	Possibly a previous day's precipitation analysis
What other research data and products do you need?	CHILL, Pawnee, S-Polka, MGAUS, ISS, ISFS
Is an EOL Field Catalog needed to provide real-time information management, reporting, decision dissemination, data exchange and resource monitoring?	Yes, real-time operational and subsets FRONT-PORCH 2013 'project' or 'research' data will be made available to the NCAR FRONT field catalog: http://catalog1.eol.ucar.edu/front/. Please see FRONT-PORCH2013-Attachment.docx
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?	Data will be stored and maintained by the data owner (NCAR, CU, CSU, CSWR, U. of Arizona) and coordinated by NCAR-EOL. EOL (Steve Williams will prepare for this through a separate request). Please see FRONT-PORCH2013-Attachment.docx
Do you intend to request restricted data access?	No

PART IV: FACILITY SPECIFIC REQUEST FORMS
GPS Advanced Upper Air System (GAUS) fixed & mobile

Operational Requirements:

Number of systems requested:	One
Location:	Colorado Front Range
Do you need a mobile or fixed system(s)?	One mobile system
Total number of sondes requested:	230 soundings: OP: 110 soundings IOPs: 120 soundings (~12 per IOP)
Will you conduct Intensive Observing Periods (IOPs)? If yes, under which circumstances?	Soundings are required prior and during precipitation events
How long does each IOP last?	~6-18 hrs
At what frequency will sondes be released?	2-3 hrs prior; 2 hrs during
Please specify your data access needs. Do you need data in real-time?	Real-time would be nice, but not necessary
How many of your staff will be available full time to help with GAUS operations?	~ 2 students (funding for students needs to be requested through the deployment pool)
Do you have any special requirements that pertain to EOL support?	No
Which EOL staff was consulted to help complete this request?	Bill Brown

Throughout the experiment (15 May – 15 August 2013): An 11am LT MGAUS sounding will be launched throughout the experiment during from the CSU-CHILL or S-PolKa site. The sounding will be launched by students or CSU-CHILL/S-PolKa staff and no EOL staff is requested. Training of students and CSU staff at the beginning of the experiment is requested.

IOPs (Phase I: 15 May-15 June and Phase 2: 15 July-15 August): The MGAUS sondes will be launched during the IOP every 2 hours within the inflow region of the storm. Additional soundings (2-3) will be launched several hours prior to the beginning of an IOP and an hour after the IOP ends. The specific deployment location will be specified during the daily weather meeting and coordinated by S-Pol radar operator. EOL staff will be requested (1 EOL person) and a student will be provided by the PIs to assist the deployment.

Integrated Sounding System (ISS) - fixed & mobile

Operational Requirements:

Number of systems requested:	One (ISS 449)
Geographic location:	CSU Campus
Will you conduct Intensive Observing Periods (IOPs)? If yes, under which circumstances? How long does each IOP last?	ISS will be operated in a semi-operational mode throughout the experiment (15 May-15 August)
Will you require sonde launches? If yes, what's the total number of sondes needed?	No
At what frequency will sondes be released?	N/A
Is the RASS needed? If yes, will noise be an issue?	No
Is the MAPR system required? If yes, describe why.	No
Is the mobile ISS (MISS) required? If yes, describe why.	ISS 449; vertical velocities are needed
Do you have any special sampling requirements?	No
Do you have experience in the analysis of profiler data and appropriate software tools?	No
Please specify your data access needs. Do you need data in real-time?	If possible real-time but not necessary. Anticipating to use the CSU infrastructure including high-speed internet.
How many of your staff will be available full time to help with ISS operations?	One postdoc and/or student can be deployed during at least part of the project
Do you have any special requirements that pertain to EOL support?	No special requirements. Only during the deployment of the instruments at the beginning/end of the experiment and maintenance during the experiment (see experimental design) EOL support is required.
Which EOL staff was consulted to help complete this request?	Bill Brown and Scott Ellis

Integrated Surface Flux System (ISFS)

Measurements

Number of measurement sites:	18 total stations oriented along 2 west-east transects between the high peaks of the Front Range and east of principal FRONT domain (see Fig. 1c)
Minimum/maximum separation of these sites:	5-15 km
Number and type of measurement at each site (e.g., 2 moisture flux, 5-level temperature profile)	8 total energy and water flux stations and approximately 10 basic meteorological stations
Number and description of NCAR-supplied nonstandard sensors: *(www.eol.ucar.edu/sssf/facilities/isff/sensors)*	
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.*	

Operations

Will an operations base be available or should EOL supply one?	Anticipate semi-operational deployments and maintenance without operator
Location of the base station relative to measurement sites:	
Logistics requirement at base station: *(e.g., power, phone, vehicle access, owner permission)*	TBA; PIs will assist in choosing deployment sites
Logistics requirement at each measurement site:	
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*	2 students
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?	EOL flux and energy balance estimation techniques, plus PI-provided QC and analyses of other meteorological variables
Is archiving of high-rate (each sample) data needed or are time-averaged statistics sufficient?	Archival of raw 10Hz flux data is desired along with time-averaged statistics
What averaging is needed for statistics? *ISFF default is 5 minutes*	5 minutes is adequate
What data products are needed in real time? How should these be made available? *(e.g., WWW, display in base)*	Minimally, precipitation, wetness, wind, temperature and humidity would be available in real-time where communications exist. They are not strictly required though.
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?	Standard time-series of met and averaged flux variables are adequate for web products. All raw and 'composite' data will also need to be accessible.
Please specify any special data requirements:	None.

S-Band/Ka-Band Dual Polarization Doppler Radar (SPOLKA)

Operations

Weather events during which collection is desired:	Prior and during convective and orographic precipitation events
Will you conduct Intensive Observing Periods (IOPs)? If yes, under which circumstances?	anticipate continuous operation during experiment (15May-15 Aug) with ~5 IOPs between Phase I and Phase II, respectively (see experimental design)
How long does each IOP last?	~6-18 hrs
Typical operations schedule/mode (daily operation hours):	During IOPs - pre-scheduled (1-2 days ahead) attended operations; Measurements prior and during precipitation within the FRONT domain required; unattended during the non-IOPs
Estimated number of radar observation hours:	OP: 99 days x 24 hrs = 2376 hrs for S-band radar IOPs: 6-18 hrs x 10 events = 60-180 hrs for both S- and Ka-band radar
How many of your staff will be available to help with SPOL operations?	~ 1-2 students
Please specify your communication needs:	Telephone, High-speed internet
Summary of auxiliary equipment located at the radar site:	None

Typical Radar Parameters

PRF:	Standard S-PolKa scans (1000 Hz)
Gate Spacing:	To be specified (150 m)
Type of Scans:	- Rapid dual-Doppler - High-quality polarimetric - some RHIs
Scan Rate:	To be specified
Minimum Sensitivity Needs (dBZ at 50 km):	Standard
Scientific rationale for desired radar parameters:	Dual Doppler wind fields, hydrometeor, refractivity, humidity retrieval
Please specify your radar control needs:	Standard on site; remote operations are desired
Please specify your radar display needs:	On site & VCHILL type cap. (remote excess)

D. Data

Will data distribution via ftp be sufficient?	Yes & VCHILL display
Please specify your in-field real time data access needs?	Preliminary sweep fields desired asap after the mission

E. Other

Do you have any special requirements that pertain to EOL support?	If possible operational surface station and GPS receiver requested for S-Polka site
Which EOL scientist/engineer/project manager was consulted to help complete this request?	Tammy Weckwerth, John Hubbert

Request for DOW Facility Support

A. User

1. Name: **David Gochis[1], Katja Friedrich[2]**
2. Title: Drs**.**
3. Date: 15 January 2012
4. Address: [1] NCAR, PO Box 3000, Boulder, CO, 80307-3000
   [2] Dept. of Atmospheric and Oceanic Sciences; University of Colorado at Boulder; UCB 311; Boulder, CO 80309-0311
5. Affiliation: [1] Scientist III, [2]Assistant Professor
6. Phone: [1] 303.497.2809; [2] 303.492.2041 FAX: [1] 303.497.2809 [2]303.492.3524
   Email: [1] gochis@ucar.edu, [2] Katja.Friedrich@colorado.edu

7. Other Persons and Affiliations (attach list if necessary): **V. Chandrasekar (CSU), Scott Ellis (NCAR), John Hubbert (NCAR), Patrick Kennedy (CSU), Steve Rutledge (CSU), Alan Shapiro (U. of Oklahoma), Jenny Sun (NCAR), Sandra Yuter (NCSU), Tammy Weckwerth (NCAR), Morris Weisman (NCAR), Jim Wilson (NCAR), Xubin Zeng (U. Arizona)**

8. Project Title: ***FRONT-PORCH 2013***

Front Range Observational Network Testbed - Precipitation Observations and Research on Convection and Hydrometeorology 2013

Brief Abstract of Proposed Field Program: **Please see FRONT-PORCH2013-Attachment.docx**

B. General Information

10. Funding Agency: NSF-PDM Contract Office: Brad Smull (Division of Atmospheric and Geospace Sciences, Physical and Dynamic Meteorology) 703.292.8524

Proposal in Draft Form	(x)
Pending Negotiations	( )
In Review	( )
Approved	( )

11. Location of Field Program**: Colorado Front Range between Denver and Cheyenne within FRONT domain**

12. Start and End Dates of Field Program: **15 May – 15 August 2013**

13. Number of Personnel You Will Bring to the Field, can they assist with radar operations:
2-4 students

14. Typical operations (daily ops hrs, number of days per week):

The three month experiment is subdivided into two observational periods (OP), which are characterized by a) synoptically-linked, transient convective storms (OP I: 15 May – 15 June) and b) comparatively 'weakly-forced', diurnal convective storm events related to the onset and mature phase of the North American Monsoon (OP II: 15 July – 15 August). Each observational

period will have ~5 intensive observation periods (IOPs) of about 6-18 hours each, which accumulated to a total of 10 IOPs (=120 hrs). An IOP will start 1-2 hours prior to the arrival or formation of precipitation in order to monitor the antecedent air temperature, humidity, wind and land surface hydrology conditions and will last until most of the precipitation has moved out of the S-PolKa and CHILL radar range, typically from 6-12 hours. The DOWs will only be operated during IOPs: 6-18 hrs x 10 events = 60-180 hrs

15. CSWR provides a Scientific Project Manager for all field programs to assist in experiment design, site selection, field coordination and general liaison with Principal Investigators. Does the proposed project require a CSWR scientist resident at the field site for the duration of the experiment? Yes __x__ No___

16. Describe the other observational facilities involved in your program. (e.g. aircraft, surface sensors):
Requested from NSF facility pool:
- **CSU-CHILL**
- **NCAR S-Polka**
- **NCAR's MGAUS sounding system**
- **NCAR ISS**
- **NCAR ISFS**
- **DOW radars: DOW6, DOW7, rapid-scan DOW**

See experimental design for additional instruments provided by the PIs and operational networks operated by FRONT and other groups

17. What assistance will you require in locating deployment sites for the radar(s)? (Note that some logistics details will depend on how far these sites are from the personnel, whether sites are secure for DOW storage between operations, how far DOWs must be driven to sites for operations, etc. **Assistance for locating deployment sites prior to the experiment is requested.**

C. Requirements

18. Radar Parameters (be as specific as possible)

PRF: standard
Gate Spacing: 10-50 m
Types of Variable Recorded Scans: (velocity, reflectivity):
DOW6 and DOW7: ZH, VR, ZDR, RHV, LDR, KDP
Rapid-scan DOW: ZH, VR
Number of Pulses Per Integration Cycle: standard
Update rates for volumetric scans? (1 minute per volume, 3 minutes per volume?)
DOW6 and DOW7: 1 min per volume
Rapid-scan DOW: 20 s per volume
Number of tilts per volume? standard
Volumetric resolution (e.g. 100 m x 100 m x 100 m?) 50m x 50m x 100m

Do you require dual-Doppler? **Yes** If so, are you requesting multiple DOWs? **YES**
Do you require dual-polarization? **Yes** If so, are you requesting multiple DOWs? **YES**
Do you require rapid-scan capability? **Yes**

19. List of auxiliary equipment you will bring (please include description, volume, power, and voltage):
None

20. Communication Requirements (including the need for sending radar data to a remote site)
High-speed internet and radio communication; if possible real-time data transfer for real-time dual-Doppler applications, DOW data will be post-processed after each mission.

21. Data: yes (sweep files of VR, Zh, SW, NCP, dual-pol parameters)
Estimated number of radar observations hours: IOPs: 12 hrs x 10 events or 6 hrs x 20 events = 120 hrs

What level of product would you desire for a final data set (raw files or translated sweeps)?
Translated sweep files

D. Previous Experience

22. Previous Research Radar Experience of Requesting Scientist(s):

- **DOW 6 and DOW 7 data analysis for Hurricane Ike 2008 and several supercell thunderstorms during VORTEX2**
- **Polarimetric C-band Doppler research radar operated by the French weather service Meteo France at Trappes, France; studying effects of ground clutter and sample velocity on quality of polarimetric quantities; work included data analysis and radar operation (2004-2007)**
- **Analysis of ELDORA radar data from IHOP experiment 2002 (2003-2004)**
- **Analysis of CP3, CP4, and FL2 radar data from CaPE 1999 experiment (2003-2004)**
- **Wind vector field determination using bistatic Doppler radar network at DLR in Oberpfaffenhofen, Germany; work included data analysis and radar operation (1999-2003)**
- **Investigating kinematic and microphysical structures using the monostatic, polarimetric Doppler radar system, POLDIRAD operated by DLR, Oberpfaffenhofen; work included data analysis and radar operation (1999-2003)**
- **Investigation of an improved algorithm for X-band attenuation correction based on dual-polarization parameters (IHOP 2002)**
- **Investigation of an iterative algorithm for precipitation classification and rain rate estimation at X-band (IHOP 2002)**

23. List of Publications Resulting from Past Radar Programs (attach list if necessary):

Kalina, A. E., K. Friedrich, and S. M. Ellis, 2012: Comparison of disdrometer and X-band radar observations in convective precipitation. *J. Atmos. Oceanic Technol*. (in review)

Friedrich, K., S. Higgins, F. J. Masters, and C. R. Lopez, 2012: Artifacts in PARSIVEL disdrometer measurements under strong wind conditions. In review at *J. Atmos. Oceanic Technol.*

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Rudolph, J., K. Friedrich, and U. Germann, 2011: A radar-based climatology of high precipitation events in the European Alps: 2000-2007. *J. Appl. Meteor.,* **50**, 944-957.

Dotzek, N., and K. Friedrich, 2009: Downburst-producing thunderstorms in southern Germany: Radar analysis and predictability. *Atmos. Res., 93,* 457-473.

Friedrich, K., U. Germann, and P. Tabary, 2009: Influence of ground clutter contamination on the accuracy of polarimetric quantities and rainfall rate. *J. Atmos. Oceanic Technol.*, 26, 251-269.

Friedrich, K., D. E. Kingsmill, C. Flamant, H. V. Murphey, and R. M. Wakimoto, 2009: Kinematic and moisture characteristics of a nonprecipitating cold front observed during IHOP. Part II: Along-front structures. *Mon. Wea. Rev.*, 136, 3796-3821.

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Friedrich, K., and M. Hagen, 2004: Wind synthesis and quality control of dual-Doppler derived horizontal wind-fields. *J. Appl. Meteor.*, 43, 38-57.

Friedrich, K., M. Hagen, and P. Meischner, 2000: Vector wind field determination by bistatic multiple-Doppler radar. *Phys. Chem. Earth (B)*, 25, 1205-1208.

E. Experiment Description

24. Please attach a written description of the experiment. A statement of the scientific objectives, experimental design, and planned use of all major facilities should be included and discussed in detail. This includes use of research aircraft, satellite data and sounding data, etc. Two copies of the scientific proposal through which this research will be funded should be submitted if such a proposal exists. Completed forms should be sent, preferably via e-mail, to CSWR. Please ask for confirmation that the documents have been received and can be read.

Please see FRONT-PORCH2013-Attachment.docx

Request for CSU CHILL Facility Support

A. User Identification

1. Name: David Gochis[1], Katja Friedrich[2]
2. Title: Drs.
3. Date: 15 January 2012
4. Address: [1] NCAR, PO Box 3000, Boulder, CO, 80307-3000
   [2] Dept. of Atmospheric and Oceanic Sciences; University of Colorado at Boulder; UCB 311; Boulder, CO 80309-0311
5. Affiliation: [1] Scientist III [2]Assistant Professor
6. Phone: [1] 303.497.2809; [2] 303.492.2041 FAX: [1] 303.497.2809 [2]303.492.3524
   Email: [1] gochis@ucar.edu [2] Katja.Friedrich@colorado.edu
7. Other Persons and Affiliations (attach list if necessary): V. Chandrasekar (CSU), Scott Ellis (NCAR), John Hubbert (NCAR), Patrick Kennedy (CSU), Steve Rutledge (CSU), Alan Shapiro (U. of Oklahoma), Jenny Sun (NCAR), Sandra Yuter (NCSU), Tammy Weckwerth (NCAR), Morris Weisman (NCAR), Jim Wilson (NCAR), Xubin Zeng (U. Arizona)
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Pending Negotiations	( )
In Review	( )
Approved	( )

11. Location of Field Program: **Colorado Front Range between Denver and Cheyenne within FRONT domain**

12. Start and End Dates of Field Program: **15 May – 15 August 2013**

13. Number of Personnel You Will Bring to the Field: **2-3 students**

14. Typical operations (daily ops hrs):

Operation prior and during convective and orographic precipitation events only during precipitation events

Relation of Operations Hours to Weather

OP (continuous operations): 99 days x 24 hrs = 2376 hrs

IOPs: 6-18 hrs x 10 events = 60-180 hrs

18. CHILL provides a Scientific Project Manager for all field programs to assist in experiment design, site selection, field coordination and general liaison with Principal Investigators. Does the proposed project require a CHILL scientist resident at the field site for the duration of the experiment? Yes _x_ No___

19. Describe the other observational facilities involved in your program. (e.g. aircraft, surface sensors)
Requested from NSF facility pool:
- **CSU-CHILL**
- **NCAR S-Polka**
- **NCAR's MGAUS sounding system**
- **NCAR ISS**
- **NCAR ISFS**
- **DOW radars: DOW6, DOW7, rapid-scan DOW**

See experimental design for additional instruments provided by the PIs and operational networks operated by FRONT and other groups

C. Requirements

17. Radar Parameters (be as specific as possible)

PRF: standard
Gate Spacing: standard (maximum range 200 km)
Types of Variable Recorded Scans: (velocity, reflectivity, phidp, ldr, rhohv(0), differential reflectivity: VR, Zhh, Zvv, rhohv, phidp, Zdr, Kdp, LDR
Number of Pulses Per Integration Cycle: standard
Azimuth Interval for Processor Outputs (DEG): to be specified
Time Series Data Collection Mode (Y or N): no

18. List of auxiliary equipment you will bring (please include description, volume, power, and voltage):
None

20. Communication Requirements (including the need for sending radar data to a remote site)
None

20. Polarization Diversity: Yes (x) No ( )

21. Data:

Estimated number of radar observations hours:
OP (continuous operation between 15 May – 15 August): 99 days x 24 hrs = 2376 hrs for S-band radar
IOPs (Phase I: 15 May-15 June and Phase II: 15 July – 15 August): 12 hrs x 10 events or 6 hrs x 20 events = 120 hrs

What level of product would you desire for a final data set (UF tape, [9-track or 8 mm], interpolated data, etc.)? Sweep files of all radar quantities, if possible multiple Doppler retrieval including all radars

Do you want all data converted to UF or just selected time periods? all data

D. Previous Experience

22. Previous Research Radar Experience of Requesting Scientist(s):
    - **Polarimetric C-band Doppler research radar operated by the French weather service Meteo France at Trappes, France; studying effects of ground clutter and sample velocity on quality of polarimetric quantities; work included data analysis and radar operation (2004-2007)**
    - **Analysis of ELDORA radar data from IHOP experiment 2002 (2003-2004)**
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Please see FRONT-PORCH2013-Attachment.docx