PROPOSED COORDINATION OF MOBILE GROUND-BASED PLATFORMS WITH AIRCRAFT IN IHOP-2002
Focus: Boundaries and Convection Initiation

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A. INTRODUCTION

The objective of mobile, ground-based sampling in IHOP is to improve understanding of surface-based boundaries and the convection initiation (CI) process. The proposed field strategy emphasizes a nesting of finescale in-situ measurements in that region of the boundary layer sampled by ground-based and airborne radars. The overarching philosophy is to obtain time series of radar-based 3-D airflow analyses and detailed in-situ measurements. Objectives are as follows:

(1) facilitate computation of air trajectories;

(2) obtain data suitable for retrievals/assimilation and analysis of the boundary layer;

(3) probe finescale structure of water vapor mixing ratio, virtual potential temperature, and winds along boundaries in regions of convective initiation and/or cloud suppression.

Other related objectives are presently being defined via collaboration of the ABL and CI groups, and will soon be added to the above list of objectives.

Of particular interest to the CI group are any trajectories that feed moisture up to and through the bases of developing convective clouds -- though the family of all trajectories is of interest. The 3-D airflow analyses should be sufficient to test a common argument of the convective initiation hypotheses, namely that the character of the resolvable (small mesoscale) airflow (especially vertical motion) is a key factor in the timing and location of convective initiation. The measurement of the horizontal variability of water vapor mixing ratio in the Doppler analysis domain via DIAL lidar, other remote sensors, and in-situ sampling is a second key factor. A third key factor is the stratification of water vapor mixing ratio, virtual potential temperature, and horizontal winds in the Doppler analysis domain, requiring concentrated sounding, dropsonde, profiler, and UAV stacked traverse measurements.

The following sections discuss some aspects of the field strategy and special considerations believed to be important for testing hypotheses related to surface-based boundaries and the convection initiation (CI) process. A set of notes was also compiled during the Boundaries/CI Break-out session at the IHOP meeting at NCAR in April 2001. These CI Break-out session notes (see "IHOP_CI_mtg.notes.pdf") touch on several aspects of the operations plan for the field work in IHOP-2002.

B. FIELD STRATEGY

A group of ground-based mobile platforms (armada) and research aircraft would obtain closely coordinated measurements of boundaries under conditions conducive to CI. Plans call for the following **mobile ground-based** platforms to be deployed by the CI group:

(1) Field Coordination (FC) vehicle;
(2) 3-5 cm pulse Doppler radars;
(3) NSSL and NCAR sounding systems;
(4) UAH MIPS;
(5) DRI radiometer;
(6) ground-based mobile mesonet;
(7) airborne UAV mesonet.

Additionally, a mobile 3-mm radar will participate with the armada on some boundary deployments by the CI group during IHOP. The CI group has also requested use of the following **aircraft** platforms:

(1) NRL P-3 with ELDORA and DIAL;
(2) Univ. of Wyoming King Air (UWKA) with WCR;
(3) DLR Falcon with downward-pointing DIAL;
(4) dropsonde aircraft.

Planning is underway by the ABL and CI groups to conduct several missions combining ABL and CI platforms to probe phenomena of interest to both groups.

It is highly desirable to array four mobile ground-based 3-5 cm radars along the targeted boundary segment. We could achieve the following benefits by coordinating data collection from 2 SMART-radars and 2 DOWs:

(1) decrease theoretical errors of derived vector wind field with triple-Doppler or over-determined analysis (4 radars);
(2) temporally continuous coverage of moving boundaries;
(3) increased areal coverage;
(4) minimum of dual-Doppler coverage given possible system failures in the field (ie. redundant coverage).

The 4 radar configuration provides the optimal coverage of minimum wind analysis error, assuming *over-determined* 4 radar dual-Doppler analysis with upward integration of mass continuity. Note that the over-determined 2-radar solution with 3-4 radars is superior to direct 3-radar solution near ground, the latter having vertical velocity error increasing to infinity with decreasing altitude (ie. decreasing elevation angle).

The FC vehicle would be deployed to facilitate mobile field observations by the armada and aircraft. Deployment would concentrate the armada inside an "Intensive Observing

Region", or "IOR", nested inside the Doppler lobe and straddling the target boundary. The IOR would have an along-boundary dimension of ~ 15 km or less (details presently being determined). The Doppler radars and probes would be deployed as follows:

(B.1) Two multiple Doppler deployment strategies are favored: "Box" (diagram "IHOP_CI.plan_outer_box.pdf") and "T" (diagram "IHOP_CI.plan_outer_tform.pdf") arrangements. The chosen deployment would depend on the relative arrangement of weather features and available roads. Two dual-Doppler baselines would be used if roads are insufficient for the "Box" or "T" deployments. Individual radars would be spaced about 15-20 km apart. The scan rates of the radars would be adjusted for local conditions, based on the lowest sampling rate that yields acceptable radial velocity estimates while achieving synchronous volume scans. Prior to the experiment, the mobile radars could perform statistical intercomparison tests of horizontal velocity around a suitable tall tower (e.g. ARM CF?). During the experiment, the radar radial velocities could be statistically validated with all available sources of in-situ horizontal wind measurements (e.g. MM, UAV, a/c traverses, mobile soundings, dropsondes). It is important for subsequent error analysis to quantify the radial velocity standard error for radars providing clear air radial velocity measurements. Other radar options have been considered. If one or two of the radars are "down", operate as a 3- or 2-radar network respectively.

(B.2) Two mobile CLASS or GLASS sounding systems should be deployed inside the ground-based radar coverage in the IOR (see diagram "IHOP_CI.plan_inner.pdf"), one unit on the cool/moist side of the boundary in question. The other unit would either be near or on the warm/dry side of the boundary. Mobile soundings could be obtained from a combination of the NCAR and NSSL sounding systems. An aircraft flying either normal to or across the boundary in the Doppler lobe(s) would deploy frequent dropsondes over legs much longer than one Doppler lobe diameter. To address possible frequency allocation problems, combine periodic deep tropospheric soundings with more frequent shallow soundings. Shallow upsondes use cut-off devices. Coordination of sonde frequencies with frequency bands of ARM sondes and the dropsonde band is required.

(B.3) The mobile mesonet (MM) and Unassisted Aerial Vehicle (UAV) airborne mesonet would be deployed within the IOR. MMs and UAVs would perform multiple transects ~ normal to the target boundary and ~ normal to the BL wind. Up to 9 MMs working on 3 roughly parallel roads spaced 5-10 km apart along the boundary. To infer details, 3 boundary-crossing MMs have short legs at low speed. To map larger scale "quasihomogeneous" BL structure (eg. detect formation of new boundaries), remaining 6 MMs have longer, faster legs on either side of the target boundary. UAVs arrayed in shallow (~ 1000 m depth) "flying tower" profile above central boundary-crossing MM. Optionally, UAV could be deployed in horizontal (along-boundary) array flying traverses. UAV leg lengths are variable (~ 5-20 km) and may be configured in the field. In-situ data will be mapped on short forward- and backward Lagrangian trajectories, adjusting histories based on matching front- and back-ends of overlapping trajectories, to improve interpretation of spatial boundary layer structure. MM and UAV water vapor mixing ratio and wind data are also critically important to provide in-situ validation of measurements of DIAL water vapor mixing ratio and clear air radial velocity from ELDORA and the ground-based radars.

(B.4) The DRI ground-based Mobile Radiometer would execute a series of traverses along the target boundary through the IOR (ie. "horizontal picket-fence" maneuver). The UAH MIPS profiler would be deployed to a fixed site on the moist/cool side of the target boundary centered in the IOR.

(B.5) Mobile Field Coordination (FC) vehicle would deploy inside the Doppler coverage and IOR near the boundary. The FC will be a large SUV or ambulance-type vehicle or multi-passenger van. FC will deploy on a local maximum in terrain. FC will be outfitted with a quick-deploy telescoping antenna mast allowing for maximum line-of-sight communications around 163 MHz (VHF voice in assigned "NSSL frequency" band) and 900 MHZ (mobile digital network). The NRL P-3 could be equipped with the NSSL repeater and a separate tunable VHF radio to facilitate VHF voice communications when it is in the area. FC should acquire large mesoscale real-time weather data and guidance from the Operations Center via satellite if possible. Ingest via 900 MHz packet system & display of mobile radar and in-situ data to assist mobile operations. Satellite capability is planned for FC, enabling real-time uplink of digital data and images to a base facility which will integrate selected field data with satellite imagery and provide data and enhanced images over the Internet to NCEP/SPC, regional NWSFOs, and IHOP Control. FC workstations will feature real-time data synthesis & display and graphical mesoscale analysis function, including: (1) ability to subjectively analyze target boundary segment; (2) automatically transmit (lat/lon) coordinates to ground-based and airborne field platforms.

(B.6) The NRL P-3 with ELDORA and DIAL would fly a narrow box pattern at low level (~ 150-200 m AGL) along the target boundary centered relative to the IOR. Along-boundary legs would be ~ 80 km (shorter if possible) to extend slightly beyond ground based multiple Doppler coverage. To utilize DIAL measurements effectively (depending on sampling characteristics) and to adequately sample boundary circulations with ELDORA, legs would be close to (and probably pass through) target boundary (eg. well within ~ 5-6 km range).

(B. 7) The UWKA with WCR would fly a combination of traverses directed both across and along the target boundary and cengered relative to the IOR. Across-boundary traverses would be at regularly spaced interval along the boundary (ie. horizontal "picket-fence" maneuver).

(B.8) The dropsonde aircraft and DLR Falcon would each fly long traverses approximately normal to the target boundary and centered relative to the IOR. Dropsondes would be released at the effective maximum rate, factoring deployment of upward soundings from NSSL and NCAR platforms.

C. GENERAL COMMENTS

The following discussion highlights selected aspects of the proposed mobile ground-based field observations in the context of the overall IHOP objective to study boundaries and the convective initiation process. The following recommendations are made:

(C.1) IHOP should commit to target boundaries, then perform dense sampling for long periods up to several hours duration in the same location. Long time-duration sampling is required for overlapping and redundant measurements and to achieve specific science goals (eg. derive air trajectories in detailed context of other measurements). If a boundary persists, sampling should continue at original location. If original target boundary dissipates, and a new boundary begins to form nearby (ie. discrete propagation), must be ready to re-deploy. Any re-deployment must be rapid, as some key ground-based sensors do not collect data while moving, and since weather might be developing at the new location. Must be realistic about ability to re-deploy in the field -- aircraft move quickly, ground vehicles do not. Accordingly, maximum targetable re-deployment ranges should be established and closely adhered to in the field. Targeting rules should be established prior to the experiment, and should be followed for the duration of IHOP -- unless field experience dictates that specific modifications are needed to optimize performance.

(C.2) Targeting at cloud-scales will require effective integration of field observations in near real-time by the Field Coordinator (FC). It will be challenging to acquire and track target boundaries in real time. Boundary shape is likely complex, while boundaries may relocate unpredictably and also might be directly sensed only by in-situ traverses and surveillance radar thin-line signatures. This emphasizes the importance of very simple (yet adaptive) target selection strategy, as well as effective field coordination and communication. A capability is needed for FC workstation ingest and rendering of multiple data sources in near real-time to allow inference of kinematic, thermodynamic, and reflectivity boundary features. Effective field communications are needed to: (1) gather latest observations (eg. MM and UAV in-situ data, mobile soundings, mobile radar base scan image); (2) disseminate updates on subjectively analyzed boundary locations and other mesoscale weather features; (3) help coordinate sampling strategies among the various mobile field platforms.

(C.3) It is proposed to operate the SMART-radars, Mobile Mesonets, UAVs, NSSL M-CLASS, and the FC vehicle from Norman. Can reduce costs by using NSSL maintenance facilities and by using locally available staffing. Given need to get on station by ~ 2 pm LT, and ~ 4 hour to ferry from base to target, would need to leave base by ~ 10 am LT. To achieve early departure, will need to streamline forecast and targeting decisions. Best option: refine initially broad target area based on later guidance & observations, during time period armada is ferrying.

(C.4) The SPC has been formally approached to consider possible experimental forecast support for IHOP. SPC has expressed great interest in the findings of the boundaries/CI work. SPC is considering a collaborative SPC-NSSL forecast experiment for Spring 2002 that in part could provide a level of forecast support for IHOP. Better understanding of convective initiation probability is interesting to the SPC. It has been noted by SPC forecasters that understanding why "null events" occur is as important as understanding why deep convective initiation occurs. This underscores the importance of staying with initial targeting choices -- as long as potential exists for deep convective initiation -- to determine if CI or a null event will occur.