Chapter 8: Daily IHOP_2002 Forecasting and Nowcasting Support

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8.1. Introduction

Forecasting and nowcasting support for the International H2O Project (IHOP) will be provided jointly by the NOAA/NCEP/Storm Prediction Center (SPC), the NSSL, and the NOAA/Forecast Systems Laboratory (FSL), as described in this chapter. The IHOP_2002 forecasts and nowcasts will be provided from 13 May to 25 June, 2002. The primary forecast domain will include the body of Oklahoma, the Texas and Oklahoma Panhandles, and southern Kansas. The project support forecasting and nowcasting will be part of a larger scale cooperative effort to be conducted at the Science Support Area (SSA) of the SPC aimed at real-time evaluation of the operational utility of both operational and experimental models.

Three working groups contribute distinct scientific emphases under the broader IHOP_2002 objective to effect more comprehensive water vapor measurements and to combine these with conventional measurements to improve mesoscale weather prediction. The Quantitative Precipitation Forecasting (QPF) group explores techniques for assimilating water vapor data into operational forecast models to improve numerical predictions and QPF. The Atmospheric Boundary Layer (ABL) Group explores ABL processes that govern water vapor and other constituents. The Convection Initiation (CI) group provides a third IHOP_2002 focus, emphasizing convection initiation in relation to the morphology of surface boundaries.

For the purposes of IHOP, "convection initiation" is defined as the initial development of surface-based deep, moist convective clouds with anvils and precipitation at the surface. "Convection initiation" herein does not include new convection initiated by outflows from neighboring storms. Verification of convection initiation can be effected by comparing cloud-to-ground (CG) lightning, WSR-88D mosaic, and satellite displays with convective probability forecasts using N-AWIPS and other workstations. Some deep convection can produce anvils and precipitation aloft without electrifying sufficiently to produce CGs (though this is somewhat rare). For IHOP_2002 we will be interested in the character of convection initiation: e.g. anvil with or without CGs and surface precipitation, requiring the more comprehensive validation involving lightning, radar, and satellite data.

The term "boundary" is defined as a zone of transition between airmasses of dissimilar temperature, humidity, and/or horizontal winds, the latter delineation by horizontal convergence and shear (deformation). Different boundary types tend to have differing strengths of these three contrasts. For example, drylines tend to be especially pronounced in water vapor mixing ratio, but not infrequently have marked wind speed and direction and sometimes also temperature gradients as well. It is possible that we may encounter some boundaries of importance for convection initiation that are characterized by strong wind convergence and weak or absent thermal contrasts (e.g. widely spaced or "large aspect ratio" horizontal convective rolls or HCRs). For IHOP_2002 purposes, "significant" boundaries must be targetable (i.e. slow-moving) and also must be forecastable. Thus, significant boundaries include drylines, synoptic fronts, and decayed (e.g. greater than ~ 12 hr old) thunderstorm cold pool boundaries.

8.2. Locations of Forecasting, Briefings, and Nowcasting Support

The Norman, OK-based IHOP_2002 operations center (NOC), which will be located in trailer space adjacent to NSSL and SPC facilities, will be available for PIs and IHOP_2002 staff use. Forecasting will take place mainly in the SPC/NSSL Science Support Area (SSA), while nowcasting and very short-range forecasting will occur in both the SSA and the NOC. The SSA may be used for briefing small PI groups, but larger briefings will be conducted in the NSSL main conference room.

It is appropriate to define the forecasting and nowcasting functions and their locations for the purposes of

IHOP_2002 support. We define "short term forecasting" as the generation of 0-6 hour guidance based on observations, model output, and forecaster intuition. Longer term forecast products include forecasts beyond 6 hours, as well as outlooks for general planning purposes that could extend out to perhaps one week. In contrast, "nowcasting" is defined as the assessment and very short-range (0-1 hour) extrapolation of mesoscale weather conditions primarily based on real-time observations and also experimental forecast model output.

As noted above, nowcasting functions will be performed primarily in the NOC, but if staffing permits personnel will also remain in the SSA to monitor observations and model output that may only be available there, as well as to permit potential informal interaction with SPC forecasters.

8.3. Spatial and Temporal Domains of Interest for IHOP_2002 Working Groups

The QPF and ABL groups will coordinate observations mainly from long aircraft legs with fixed ground-based platforms that cover the full IHOP_2002 domain. The spatial domain for the CI study is smaller than the full domain, bounded as follows:

- On the west, by the eastern Texas and Oklahoma Panhandles and extreme southwest Kansas;
- On the east, by I-35 through central Oklahoma;
- On the south, by the Red River and westward from Childress, Texas;
- On the north, by extreme southern Kansas.

These are somewhat flexible boundaries, although the limited effective range of ground-based mobile teams strongly limits operating outside the indicated spatial domain.

Within the greater region of interest, the CI study will further concentrate its airborne and mobile ground-based observational assets within a small area of order 20 km x 20 km horizontally along a target boundary. This small target boundary area is called the "intensive observing region" or IOR. Aircraft legs on CI missions extend beyond, but remain centered on and frequently sample within, the IOR. The location of the IOR will change from day to day as the pattern of CI threat shifts. Additionally, the IOR may be relocated slightly with time on a given day, depending on the movement of the primary boundary and the location of the highest CI threat. However, any IOR relocation will be no faster than the speed of the ground-based mobile armada. On a few mission days, the CI group will collaborate with the ABL group to probe fixed or slowly moving target areas chosen jointly by the two groups.

The daily time periods of interest in which the three IHOP_2002 groups would conduct their data collections are as follows:

- QPF studies: 12-24 hours per operating day, day and/or night missions;
- ABL studies: sunrise to early afternoon (~ 6 am - 1 pm CDT or 11-18 UTC);
- CI studies: early afternoon to early evening (~ 2-8 pm CDT or 19-01 UTC).

The experimental forecasts to be proposed in support of IHOP_2002 are aimed at two regimes: (1) meso-beta to meso-alpha scales (~ 20-2000 km) out to 1-2 days (ALL groups); (2) meso-beta scale (~ 20-200 km) out to 6-12 hours (CI and ABL groups).

Note the distinctive focus of the CI group on boundaries, which develop on 6-12 hour time scales but typically contract to scales from 100s of meters to ~ 1-10 km in width. Hence, experimental boundary forecasts cannot be handled entirely by deterministic approaches. As described below, these boundary forecasts could be treated in a semi-statistical fashion based on the conditions predicted by mesoscale forecast models.

8.4. Daily Operations Schedule

A team composed of IHOP (FSL), NSSL, SPC, and visiting staff scientists will create forecast products, lead two IHOP_2002 weather briefings, and provide nowcasting. As noted in the following discussions, the SPC and NSSL staff scientists would have specific responsibilities during a portion of the day and on certain days of the week. IHOP_2002 and other visiting scientists are expected to fill out the weekly duty rotation to insure that forecasting and nowcasting services are not interrupted. It is proposed that the SSA forecasts would be produced by a team of three forecasters.

DAILY SCHEDULE (local time):

- ~6:00 am - 1:30 pm: Nowcasting support for any early operations (starting time variable). Location: SSA and NOC.
- 7:00 am - 9:00 am: Prepare Day 1 Forecast #1 (preliminary mesoscale discussion and thunderstorm outlook) for small, early IHOP_2002 weather briefing.
- 9:00 am - 9:20 am: Lead small, early IHOP_2002 weather briefing. Location: SSA.
- 9:20 am - 12 pm: Preparation of Day 1 Forecast #2, Day 2 Forecast, and 7-10 day outlook, and prepare main IHOP_2002 weather briefing.
- 12 pm: Complete posting of all forecast products on the web.
- 12 pm - 12:30 pm: Lead main IHOP_2002 weather briefing. Location: NSSL conference room or Norman IHOP_2002 Operations Center (NOC).
- 1:30 pm - 7:00 pm: Nowcasting support (NOC main area for this). These hours are highly variable, nowcasting could extend quite late into the night, depending on operations. Location: SSA and NOC.

8.5. Forecast Products

The common forecast needs of the CI, ABL, and QPF groups in IHOP_2002 are an extrapolation of mesoscale weather conditions over the full IHOP_2002 domain through 48 hours. These forecasts would include general flow and stability regimes, main airmasses and mesoscale boundaries, and general convective weather conditions. The IHOP_2002 forecast component emphasizes mesoscale sized graphical and text convective forecast products in the IHOP_2002 domain (valid for Day 1 and Day 2 time periods). Longer range (up to 7-10 day) verbal/text outlooks on larger scale flow and stability regimes, based on MRF and other longer range models, as well as operational ensemble runs, would be very useful for general IHOP_2002 planning purposes.

For continuity of established routine, it is proposed that the experimental forecast support commence somewhat prior to the beginning of IHOP, probably by the beginning of May 2002. This would allow the forecast process to be "calibrated" (e.g. interactions of forecasters and users), problems with displays to be determined, etc.

8.5.1. Day 1 Forecasts

Day 1 Boundary Forecast - The focus of the Day 1 boundary forecast is to provide guidance for IHOP's field activities via issuance of scheduled short-term forecasts of the position and movement of main mesoscale boundaries.

The forecaster would prepare two Day 1 forecasts of the expected locations of main mesoscale boundaries within the full IHOP_2002 domain. The Day 1 forecasts would map expected boundary locations in the IHOP_2002 domain, noting character (e.g. cold-, warm-, or stationary front, decayed outflow, dryline). Forecasts of expected boundary location at 18Z, 20Z, 22Z, and 00Z would be issued at 9:00 am (14Z) and 12 noon (17Z). The number of forecasts and their specific timings will be subject to change as planning proceeds. Examples of what two such Day 1 mesoscale boundary forecasts could look like are shown in Fig. 1.

Objective tools (e.g. confluence of streamlines from gridded analyses) could be combined with human forecaster intuition to prepare analyses of expected boundary locations from observations or numerical forecast output.

Temperature and water vapor mixing ratio gradients could also be factored to estimate boundary location.

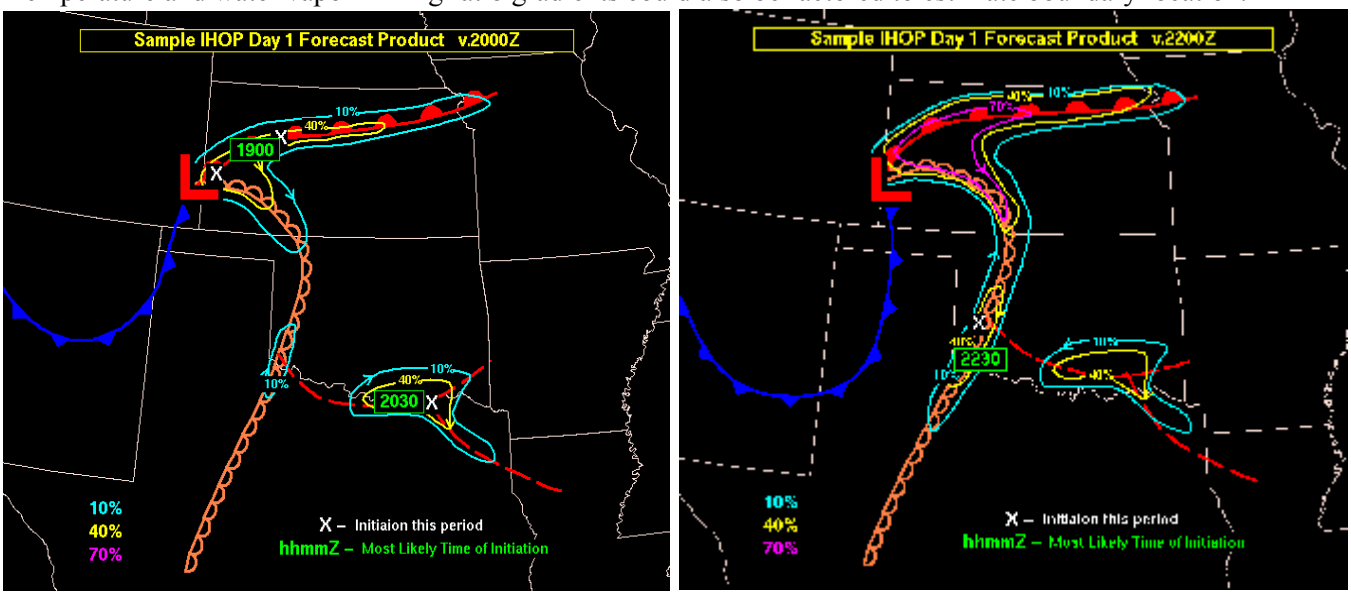


Figure 1. Examples of Day 1 forecasts for two times, 2000 UTC and 2200 UTC. Descriptions of these forecasts are discussed in the text.

Day 1 Convection Outlook - The focus of the Day 1 convection outlook is to provide guidance for IHOP's field activities via issuance of scheduled short-term convective forecasts (initiation of general deep convection). The CI group has special forecasting needs due to its emphasis on mobile targeting of boundaries capable of initiating storms. Note that the Day 1 operational mode will have been tentatively established the day before, so the utility and application of the Day 1 guidance will be known in advance.

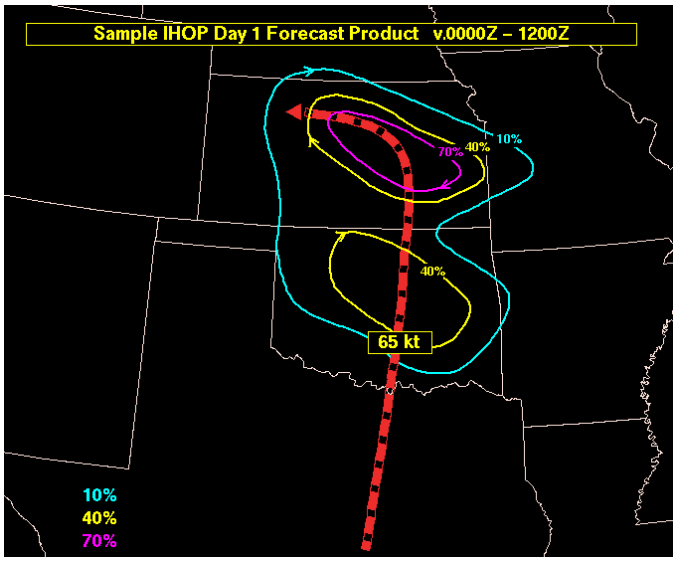
The forecaster would prepare two Day 1 forecasts of the quantitative probability of deep convection overlaid on expected boundary locations within the full IHOP_2002 domain. The Day 1 forecasts could be in the form of contour lines of equal probability overlaid directly onto a map of the IHOP_2002 domain that includes forecasted boundaries. Convective outlooks valid within ± 1 hour of 18Z, 20Z, 22Z, and 00Z would be issued at 9:00 am (14Z) and 12 noon (17Z).

The forecast would be used to identify a target region for Day 1 mobile field operations out of the set of areas with local (relative) maxima of convective probability. The forecast target would ordinarily be that boundary segment as close as possible to Norman, Oklahoma (but within the CI domain) that also possesses the highest probability of convection initiation. On some occasions, a closer or more distant target could optionally be chosen if of interest to IHOP. The forecaster would also forecast the expected time (hours UTC) and time uncertainty of CI (hours) within the forecasted target area itself.

Day 1 Boundaries/Convection Forecast Graphic- Current plans call for the Day 1 forecast graphic to integrate information about boundary location and character, convection probability, and timing of initial convection. Each graphic would include the forecasted significant boundaries, a contoured probability of deep convection within 30 miles of a point, and delineation of new convection during that forecast period by an "X" including the estimated time of initial convection.

Day 1 Mesoscale Convective System/Low Level Jet Outlook - The SPC proposes to produce a Day 1 forecast for the low level jet (LLJ) location and the probability of mesoscale convective system (MCS) activity. In support of QPF group activities, the primary concern would be a forecast of MCS activity and LLJ location between 00Z (Day 1) and 12Z (Day 2). Since the approximate location of decayed outflow boundaries from nocturnal

Fig. 2. Example of a Day 1 LLJ forecast with MCS probabilities shown.



convection could be inferred, this forecast would also be useful for IHOP_2002 planning regarding possible ABL, CI, and ABL-CI missions on Day 2.

A single graphic would contain the forecast position and strength of the LLJ valid 06Z, along with the contoured probability of an MCS within 30 miles of a point valid 00Z-12Z (Fig. 2). The graphic would also include the most likely time of convection initiation between 00Z and 12Z. The confidence in the occurrence of an MCS, the most likely location of initiation, and an approximate track of movement could be inferred from the forecast graphic.

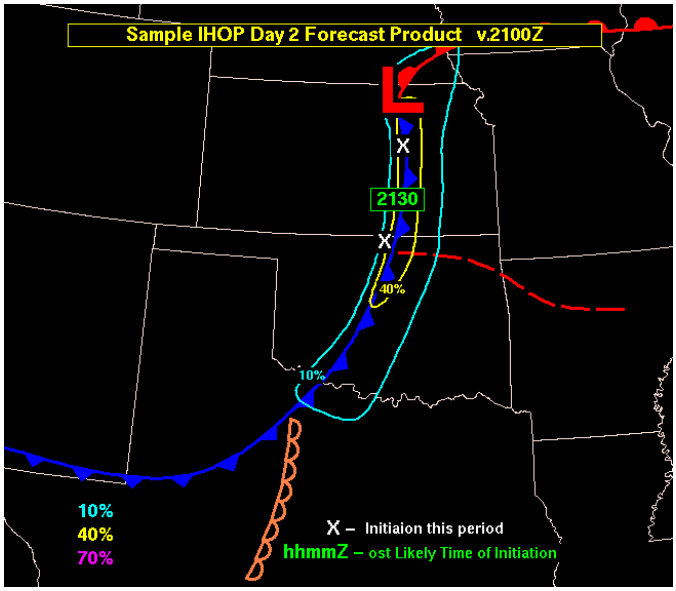
8.5.2. Day 2 Forecasts

Day 2 Boundary Forecast - The forecaster would prepare a Day 2 forecast of the expected locations of main mesoscale boundaries within the full IHOP_2002 domain. The Day 2 forecasts would map expected boundary locations in the IHOP_2002 domain, noting only the boundary character (e.g. cold-, warm-, or stationary front, decayed outflow, dryline). The Day 2 boundary forecasts would be issued at 12 noon CDT or 17Z (Day 1) and valid at 21Z (Day 2) respectively.

Day 2 Convection Outlook - The focus of the Day 2 convection outlook is to provide IHOP_2002 leaders with information that will help decide the likely mode of Day 2 field activities (if any), whether these be under the QPF, ABL, CI, or ABL-CI emphasis.

The forecaster would prepare a single Day 2 forecast of the qualitative probability of deep convection overlaid on expected boundary locations within the full IHOP_2002 domain. The Day 2 forecast could be in the form of an area or areas outlining "significant" likelihood of convection initiation. The Day 2 convective outlooks would be issued at 12 noon CDT or 17Z (Day 1) and valid in the period 18Z - 00Z (Day 2) respectively.

Fig. 3. Example of an IHOP Day 2 forecast graphic.



Day 2 Forecast Graphic - The Day 2 forecast graphic (Fig. 3) will be similar to the Day 1 forecast graphic. Each graphic would include the forecasted significant boundaries, a contoured probability of deep convection within 30 miles of a point, and delineation of new convection during that forecast period by an "X" including the estimated time of initial convection. The main difference of the Day 2 graphic is the broader valid period of convective probability in comparison to the Day 1 graphic.

8.5.3. Forecast Dissemination

The experimental forecasts will be presented in weather briefings and posted on the web, as in past NSSL-SPC forecast experiments. The convection forecasts would be in the form of a graphic, including a highly simplified text summary. Forecast products would be posted on the web by 12 noon each day.

The forecaster would present the early 6-hour Day 1 forecast (Forecast #1), along with other pertinent current weather information, at a 9 am briefing attended by a small group of key PIs. Based on the early 6-hour forecast, the IHOP leaders and PIs may make a "GO"/"NO GO" decision, and mobile ground-based teams would depart shortly thereafter given a GO status. Alternatively, depending on the mission being considered, the IHOP deployment decision may be deferred until the noon briefing.

The forecaster would present the late (second) 6-hour Day 1 forecast (Forecast #2), the 30-hour Day 2 forecast, and the 7-10 day outlook, along with other pertinent current weather information, at a 12 noon briefing attended by a larger group of Pis and other interested parties. In the event of an early GO decision for a CI or ABL-CI mission, the CI team would be in transit at the time of the 12 noon briefing. Hence, the PIs in the field would appoint a local representative of their interests at the noon briefing. The PIs in the mobile field coordination vehicle would participate in the noon briefing by studying web-based forecast products and joining the IHOP_2002 mission prioritization process via satellite telephone to NSSL.

Based on the early and/or late 6-hour Day 1 forecasts, the IHOP_2002 leaders would alert the aircraft representatives of the anticipated take-off time and initial target point for the day's mission. I.e. on some marginal days the IHOP_2002 leaders might wait until the late forecast to deploy aircraft, while on days with stronger potential the aircraft deployment decision could be made based on the early forecast. Based on the 30-hour outlook, the IHOP_2002 leaders would make a tentative "STANDBY" decision about operating on the following day, and if so in what mode.

8.6. Nowcasting

Nowcasting the positions and strengths of main boundaries and the development of deep convection will be an important component of IHOP. It would be desirable (even preferable) for the experimental forecasters to collaborate on nowcasting support with IHOP_2002 staff during IHOP's afternoon operations. However, the following discussion assumes that IHOP_2002 will provide at least one nowcaster from its pool of interested scientists. It should be noted that several SPC scientists, as well as other NWS forecasters, may wish to volunteer part-time to assist with nowcasting duties. The nowcasting function will be performed in the NOC, although if staffing permits another nowcaster will remain in the SSA, running all day and potentially well into the night. It is expected that the above forecast duties represent a full time task for at least one, but probably two individuals, and must be conducted independently of any nowcasting activities during the same (morning) time period to avoid potential staffing conflicts.

8.6.1. Tools and Approaches

The nowcasting should be divided into two parallel activities: 1) conventional mesoanalysis (surface, radar, satellite, profilers, etc.); and 2) mesoscale NWP initialization and evaluation. Each may require at least one full-time staff position to address effectively. Note that NWP evaluation is of rather limited value to field operations, but has a large potential for NWP development subsequent to IHOP. On the other hand, the conventional mesoanalysis and the mesoscale NWP initialization is essential to the success of field operations in IHOP. The planned short-range (9- to 12-hour) mesoscale NWP forecasts will provide some additional useful guidance to assist Day #1 field operations. Nowcasting elements could factor (not limited to) the following elements:

- Subjective (by hand) mesoscale analysis;
- Inspection of real-time WSR-88D and satellite imagery loops;
- Analysis of real-time mobile ground-based field observations received from mobile satellite uplink;
- NCAR Auto-Nowcaster output;
- Short-range (9-12 hour) operational NCEP mesoscale forecast model output;
- FSL 9- or 12-hour experimental mesoscale numerical forecasts.
- Other (perhaps from CAPS, NASA (Huntsville group), and the University of Wisconsin) experimental model forecasts; see Chapter 10 for further information.

The following 4 modeling systems are anticipated (resolution indicated):

- LAPS/MM5 at 12-km over a sub-synoptic domain and nested 4-km "IHOP_2002 domain" (the modeling domains are found elsewhere in this document).
- LAPS/WRF at 12-km over a sub-synoptic domain and a nested 4-km "IHOP_2002 domain".
- RUC at 12-km over a larger, "sub-CONUS domain".
- WRF at 12-km initialized with RUC analyses over sub-CONUS domain.
- RUC at 20-km over a CONUS domain.

Other short-range experimental mesoscale model forecast output could be considered as appropriate. Details of FSL's model products may be found in Chapter 10 (Model information).

Examining the various models will be accomplished primarily through the use of N-AWIPS and FX-Net workstations. Plans call for an FSL FX-Net PC-workstation to be located at the SSA, with another at the NOC, and this will provide displays of the experimental models being run at FSL, as well as the standard NCEP operational models, and a variety of radar, satellite, and point observations. Also available in the SSA will be 2 AWIPS workstations, localized to Norman, one a LINUX workstation and one an HP, and 3 N-AWIPS workstations (one will be a LINUX version), which will be able to display a variety of observational data as well as output from the standard NCEP models and from some special model runs, and output from some locally-developed applications. One N-AWIPS workstation is planned also for the NOC. Other experimental model output (for instance, from CAPS) will be viewed through web interfaces. There will also be other specialized workstations available, for example an NCAR Zebra workstation will display S-Pol radar and special soundings as well as other data at the NOC.

8.6.2. Interaction between mobile field coordinators (FC) and IHOP_2002 nowcasters

Prior to deployment of ground-based mobile platforms in mid-morning, the nowcaster must develop a strong sense of the exact location and nature of boundaries. If at all possible, the ground teams ought to be deployed (and on station if possible) well prior to the development of the first clouds on visible imagery. Both prior to and after deployment, boundaries should be identified based on wind shifts, WSR-88D finelines, and virtual temperature and humidity contrasts if these are starting to develop. The overall highest priority for CI and ABL-CI mission nowcast support is to provide the FC vehicle with any needed refinements of the target IOR based on the latest weather information.

The IHOP_2002 nowcasters will communicate with IHOP_2002 field facilities via the mobile field coordination (FC) vehicle, passing on and receiving mesoscale weather information and facilities updates. The refined Day 1 target IORs (based on the Day 1 Forecast #2), the Day 2 outlook, and the tentative Day 2 mission status will be relayed from IHOP_2002 staff nowcasters to the mobile field coordinators and aircraft.

In the early stages when the field teams are not yet in position collecting data, the boundary might be somewhat diffuse. In the event of a diffuse or rapidly evolving boundary, the nowcaster needs to monitor closely that the boundary is not sharpening up at some location outside the current IOR. Such rapid evolution might require the field teams to quickly re-deploy to a newly identified target IOR. Early warning is essential due to the limited maximum speed of ground teams.

Once the CI teams are collecting data on a boundary that can be readily identified and monitored through real-time field data, the emphasis of IHOP_2002 nowcasting should shift toward carefully monitoring the mesoscale environment just beyond the current IOR. The nowcaster should monitor adjacent areas for new boundary formation, an increasing probability of CI, the motion of secondary boundaries toward the current IOR, the movement of larger-scale mesoscale ascent toward or away from the current IOR, etc. Given a clear need to abandon the current IOR, the highest nowcasting priority should be to promptly advise field teams regarding a new target IOR.

8.6.3 Other nowcaster duties

Experience in other field programs has made it clear that comprehensive notes and summaries of the evolving weather during operations can be of great value for research efforts following the period of the experiment. The nowcasters will be expected to electronically enter notes during the nowcasting period, as well as provide a more cohesive daily summary. These descriptions will be collected by UCAR/JOSS and become part of the overall project catalog. In addition, nowcasters should feel free to save any graphics (including model snapshots, data, images, etc.), and these can also be added to a JOSS "quick look" data set. There will be easy methods for saving such imagery (gif images) on the FX-Net workstations.

8.7. Additional Planning Considerations

The IHOP_2002 planners should coordinate closely with the SPC as planning of forecasting and nowcasting support activities proceeds. A key problem for IHOP_2002 planners is to fill the weekend forecasting and nowcasting shifts. The SPC has offered the consultative assistance of its forecasters during weekend shifts, however SPC will be unable to staff these IHOP_2002 positions directly. The SPC has identified the need to establish a linkage between the forecast (morning) and nowcast (afternoon) shifts. This would be most easily addressed by assigning individuals to serve during both morning and afternoon shifts. Similarly, individuals designated by IHOP_2002 to serve as forecasters on weekend shifts would preferably assist the weekday forecasters to establish an experience base and greater continuity of the forecast product. The SSA needs to be configured to separate IHOP_2002 support from the other, non-IHOP_2002 forecast and nowcast activities being conducted by the SPC, NSSL and FSL on all weekdays during May-June 2002.

8.8. Forecast Evaluation Activities During IHOP

In addition to the forecasting and nowcasting project support activities, staff from the SPC, NSSL, and FSL will undertake a comprehensive effort to subjectively document the unprecedented number of experimental numerical models that will be run in support of IHOP. We will be using a modified set of online forms that have been developed by the SPC/NSSL in support of their last two spring programs. Modifications will be made to emphasize QPF forecast evaluation, as well as some specific pre-convective fields. One of the nowcaster duties (staffing levels permitting) will be to continue this evaluation activity into the afternoon and evening hours, at least during operational periods. A group from the HPC is also expected to be part of this model evaluation activity.