

AD-A242 669



CR-91-0034-3

DTIC
ELECTE
NOV 21 1991
S C D

AD

Reports Control Symbol
OSD - 1366

(2)

DEVELOPMENT OF ADVANCED COMPUTING TECHNOLOGY FOR OPTIMIZING
THE USE OF METEOROLOGICAL DATABASES:

MERCURY EVALUATION

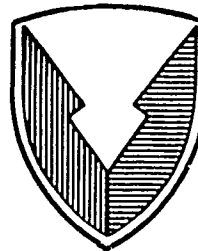
October 1991

C. A. Fields
Principal Investigator

Knowledge Systems Group
Computing Research Laboratory
New Mexico State University
Las Cruces, NM 88003-0001

Under Contract DAAD07-86-C-0034
Contract Monitor Gary McWilliams

Approved for public release;
distribution is unlimited.



US ARMY
LABORATORY COMMAND

91-15959



ATMOSPHERIC SCIENCES LABORATORY
White Sands Missile Range, NM 88002-5501

91 1119 085

NOTICES

Disclaimers

The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

The citation of trade names and names of manufacturers in this report is not to be construed as official Government indorsement or approval of commercial products or services referenced herein.

Destruction Notice

When this document is no longer needed, destroy it by any method that will prevent disclosure of its contents or reconstruction of the document.

REPORT DOCUMENTATION PAGE			Form Approved OMB No 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE October 1991	3. REPORT TYPE AND DATES COVERED Final		
4. TITLE AND SUBTITLE Development of Advanced Computing Technology for Optimizing the Use of Meteorological Databases: MERCURY Evaluation		5. FUNDING NUMBERS		
6. AUTHOR(S) C. A. Fields, principal investigator		TA: 62784AH71		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Knowledge Systems Group New Mexico State University Las Cruces, NM 88003-0001		8. PERFORMING ORGANIZATION REPORT NUMBER		
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Atmospheric Sciences Laboratory White Sands Missile Range, NM 88002-5501/ U.S. Army Laboratory Command Adelphi, MD 20783-1145		10. SPONSORING / MONITORING AGENCY REPORT NUMBER ASL-CR-91-0034-3		
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.		12b. DISTRIBUTION CODE		
13. ABSTRACT (Maximum 200 words) This document reports the development of the MERCURY mesoscale meteorological data fusion system between 1 October 1989 and 30 September 1990. MERCURY will function as an intelligent, autonomous software interface between the data ingestion and management facilities of a future version of the integrated meteorological system, or a similar system, and tactical decision aids that require meteorological data as input. This report describes the current state of MERCURY and the procedures being used for evaluation. It also presents representative test results obtained in the Los Angeles basin area during July 1990.				
14. SUBJECT TERMS artificial intelligence, mesoscale meteorology, data fusion, geographic information system, battlefield weather, expert system heuristics		15. NUMBER OF PAGES 60		
17. SECURITY CLASSIFICATION OF REPORT Unclassified		18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	16. PRICE CODE
20. LIMITATION OF ABSTRACT SAR				

GENERAL INSTRUCTIONS FOR COMPLETING SF 298

The Report Documentation Page (RDP) is used in announcing and cataloging reports. It is important that this information be consistent with the rest of the report, particularly the cover and title page. Instructions for filling in each block of the form follow. It is important to *stay within the lines* to meet optical scanning requirements.

Block 1. Agency Use Only (Leave blank)

Block 2. Report Date Full publication date including day, month, and year, if available (e.g. 1 Jan 88). Must cite at least the year.

Block 3. Type of Report and Dates Covered. State whether report is interim, final, etc. If applicable, enter inclusive report dates (e.g. 10 Jun 87 - 30 Jun 88).

Block 4. Title and Subtitle. A title is taken from the part of the report that provides the most meaningful and complete information. When a report is prepared in more than one volume, repeat the primary title, add volume number, and include subtitle for the specific volume. On classified documents enter the title classification in parentheses.

Block 5. Funding Numbers. To include contract and grant numbers; may include program element number(s), project number(s), task number(s), and work unit number(s). Use the following labels:

C - Contract	PR - Project
G - Grant	TA - Task
PE - Program Element	WU - Work Unit Accession No.

Block 6. Author(s). Name(s) of person(s) responsible for writing the report, performing the research, or credited with the content of the report. If editor or compiler, this should follow the name(s).

Block 7. Performing Organization Name(s) and Address(es). Self-explanatory.

Block 8. Performing Organization Report Number. Enter the unique alphanumeric report number(s) assigned by the organization performing the report.

Block 9. Sponsoring/Monitoring Agency Name(s) and Address(es). Self-explanatory.

Block 10. Sponsoring/Monitoring Agency Report Number. (If known)

Block 11. Supplementary Notes. Enter information not included elsewhere such as: Prepared in cooperation with .; Trans. of. .; To be published in . . When a report is revised, include a statement whether the new report supersedes or supplements the older report.

Block 12a. Distribution/Availability Statement. Denotes public availability or limitations. Cite any availability to the public. Enter additional limitations or special markings in all capitals (e.g. NOFORN, REL, ITAR).

DOD - See DoDD 5230.24, "Distribution Statements on Technical Documents."

DOE - See authorities.

NASA - See Handbook NHB 2200.2.

NTIS - Leave blank.

Block 12b. Distribution Code

DOD - Leave blank.

DOE - Enter DOE distribution categories from the Standard Distribution for Unclassified Scientific and Technical Reports.

NASA - Leave blank.

NTIS - Leave blank.

Block 13. Abstract. Include a brief (Maximum 200 words) factual summary of the most significant information contained in the report.

Block 14. Subject Terms. Keywords or phrases identifying major subjects in the report.

Block 15. Number of Pages. Enter the total number of pages.

Block 16. Price Code. Enter appropriate price code (NTIS only).

Blocks 17. - 19. Security Classifications. Self-explanatory. Enter U.S. Security Classification in accordance with U.S. Security Regulations (i.e., UNCLASSIFIED). If form contains classified information, stamp classification on the top and bottom of the page.

Block 20. Limitation of Abstract. This block must be completed to assign a limitation to the abstract. Enter either UL (unlimited) or SAR (same as report). An entry in this block is necessary if the abstract is to be limited. If blank, the abstract is assumed to be unlimited.

CONTENTS

I.	OVERVIEW	1
II.	WEATHER DATA INGESTION AND ARCHIVING	1
III.	GEOGRAPHIC INFORMATION SYSTEM	2
IV.	ANALYSIS SYSTEM	2
V.	PERFORMANCE EVALUATION	3
VI.	RECOMMENDATIONS	4
VII.	REFERENCES	5
APPENDIX A.	MERCURY: A HETEROGENEOUS SYSTEM FOR SPATIAL EXTRAPOLATION OF MESOSCALE METEOROLOGICAL DATA.....	7
APPENDIX B.	ARCHIVE FORMAT	29
APPENDIX C.	REPRESENTATIVE STATION SELECTION	33
APPENDIX D.	ESTIMATION FUNCTIONS	35
APPENDIX E.	1A BASIN TEST RESULTS	39

Accumulation Per	
NTIS ORGAL	☒
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	



I. Overview

The objective of the MERCURY project is the development of a software system for assimilating meteorological data for a mesoscale region from a number of sources, and fusing these data as necessary to generate reliable values for standard meteorological parameters at locations for which measurements are not available. MERCURY will assimilate data from a quality-assured, real-time database of measurements and numerical predictions maintained by the Integrated Meteorological System (IMETS) or a similar system. MERCURY's outputs will include conventional three-dimensional (3D) grids and point values of meteorological parameters, as well as qualitative descriptions of spatially-located meteorological features such as front boundaries. These outputs will serve as input to a variety of tactical decision aids (TDAs), including TDAs designed to aid a Staff Weather Officer (SWO). Use of MERCURY in both prognostic and diagnostic modes is anticipated.

An initial MERCURY prototype, MERCURY-1 was developed in 1988 in order to refine a requirements statement for MERCURY that had been developed from a consideration of the task environment (Coombs et al., 1988). The design, implementation, and evaluation of MERCURY-1 is described in U. S. Army Atmospheric Sciences Laboratory (ASL) Report CR-88-0034-4 (Fields, 1988). This report also outlines a high-level design for a second prototype, MERCURY-2, to meet an expanded set of requirements generated on the basis of experience with MERCURY-1. The architecture of MERCURY-2 is described in ASL Report CR-90-0034-1 (Fields, 1990), and its implementation is described in Fields et al. (1991), which is included in the Appendix. The present report describes the current status of MERCURY (the designation "MERCURY-2" has been discontinued), and the methods being used to evaluate its performance. The development of cloud image analysis algorithms for implementation in MERCURY is described by Pfeiffer (1990).

The current MERCURY implementation is being used to provide weather and terrain data for two application systems: the AIMS intentions analysis system (Coombs et al., 1990), and the WADIF environmental effects prediction system (Eskridge, 1990). These systems provide a testbed for evaluating the software and user interface tools provided by MERCURY.

II. Weather Data Ingestion and Archiving

MERCURY ingests weather data broadcast in real time via a satellite downlink, using the Scientific Data Management (SDM) software developed by the UniData program of the University Corporation for Atmospheric Research (Campbell and Rew, 1988). Functions for ingesting cloud image data in the visible and near infrared channels obtained from the Geosynchronous Operational Environmental Satellites (GOES) have been added to the system in the last year. Full-resolution GOES images have approximately 5 km resolution at mid-latitudes, so these data are adequate for analyzing cloud cover over mesoscale regions. Analysis of these images is discussed in Pfeiffer (1990).

A hardware and software upgrade that will allow MERCURY to ingest gridded numerical predictions generated by the U.S. National Weather Service, and surface and upper-air data from non-U.S. stations, is in progress. These upgrades will allow MERCURY to be used in a prognostic mode for the Continental U.S., and to be used diagnostically in any areas of the world for which adequate weather and terrain data are available.

An automated archiving system, which records all data for an indicated area that is received during a specified time interval, has also been implemented in the last year. This

system allows MERCURY to build its own archival data sets. Weather data from any source can be used as a MERCURY archive, provided that it is written in the file format used by the MERCURY archiver, which is derived from the format used in the satellite transmissions received by MERCURY. An example record showing this format is included in the Appendix.

III. Geographic Information System

MERCURY employs a high-resolution geographic information system (GIS) to provide terrain elevation and land-use data for the region of interest. This system can also be used to maintain information about other aspects of the terrain, e.g. the presence of roads or buildings, and to locate objects, such as weather stations, with respect to the terrain.

A terrain elevation database for the Continental U.S. with 30 second resolution in both latitude and longitude (approximately 600 m $\times$ 900 m resolution at mid-latitudes), which was obtained from the U.S. Geological Survey, has been implemented in MERCURY in the last year. This elevation database provides the underlying coordinate grid for the GIS component of MERCURY. Implementation of a surface cover database, also obtained from the U.S. Geological Survey, is in progress. These databases will allow MERCURY to be tested at a wide range of locations, which exhibit a variety of weather patterns, in the Continental United States. Digitized terrain databases for central Germany have also been obtained, and implemented in the GIS (Coombs et al., 1990; Eskridge, 1990).

The MERCURY user - developer interface allows any data in the GIS to be displayed graphically on a console or terminal running an X-Windows, version 11 server. Functions for retrieving and displaying data for any location for which data are available have been added to the interface this year. Functions for zooming and unzooming on a region, and for overlaying multiple data types have also been added.

Graphic editors that allow the contents of the terrain elevation and land use databases to be altered by the user have also been implemented in the last year. These editors allow data for new regions to be created; hence they can be used to develop terrain data sets for regions for which digitized map data are not available. They also allow the data to be edited as necessary to update features that have changed since a map was generated. The editors will be integrated into MERCURY in the next year.

IV. Analysis System

The current MERCURY analysis algorithm generates two-dimensional terrain-following grids of standard meteorological parameters for the region of interest, as well as point values for standard parameters, cloud cover, and present weather. The grid resolution is specified by the user. The analysis algorithm employed in the current MERCURY implementation is as follows.

1. Grid points within at most one grid spacing from at least one station that has reported surface data in the last two hours are classed as "nonisolated." All other grid points are classed as "isolated."
2. Heuristics are used to identify representative reporting stations, if any are available, for the isolated stations. "Representativeness" is defined in terms of both distance, and similarity of location with respect to the surrounding terrain. The heuristics being used are listed in the Appendix.

3. Data for the isolated grid points for which representative stations are available are estimated from the data obtained at the representative stations. The functions used for this estimation step are listed in the Appendix.
4. Conventional exponentially-weighted objective analysis is used to calculate values for the nonisolated grid points, and for the isolated grid points for which no representative stations could be identified. Both the measured data and the estimated values calculated in step 3 are used as data values in this calculation.
5. Values for points not on the specified grid are estimated by exponentially-weighted averaging of the values from the four closest grid points.
6. Present weather values are taken to be those reported by the nearest reporting station.

This algorithm can provide estimates for any point in the region of interest. The quality of the estimate varies, depending on the proximity of the point to one or more reporting stations, the local terrain, and the current weather pattern.

It is expected that the performance of this algorithm can be improved substantially by developing heuristics that use cloud image data to assess representativeness. Some of the estimation functions can also be made more realistic. These issues are discussed in Sect. VI below.

V. Performance Evaluation

A self-testing algorithm has been implemented that allows MERCURY to be tested continuously, in real time, in any region for which data are available. This algorithm is as follows.

1. A region of interest and grid resolution for testing are defined by the user.
2. On every reporting cycle (each hour for the surface station reports currently ingested by MERCURY), a grid is calculated for each reporting station S , using all of the data available to the system except that reported by S . Values of all parameters for the location of station S are estimated from this grid.
3. Errors for each parameter are calculated as the difference between the estimated value for the location of S and the measured value reported by S .

This algorithm can be used with archived data, in which case error values for an interval spanning many reporting cycles can be calculated. The algorithm can also be easily modified to assess the rate of degradation of performance as data from progressively greater numbers of stations are left out of the grid and estimate calculations.

This self-testing algorithm has been run for several testing intervals in a $300 \times 300 \text{ km}^2$ region surrounding the Los Angeles basin (Fields et al., 1991). The Los Angeles basin is a difficult test case, since it includes both complex mountainous terrain and seacoast. The tests were run both for MERCURY, and for an objective analysis procedure alone. The results of these tests indicate that the performance of MERCURY is substantially better than the performance of objective analysis alone in this region. The extent to which MERCURY outperforms objective analysis alone increases as data from additional stations are left out of the calculations, indicating that the performance degradation of MERCURY is less drastic than that of objective analysis in data-sparse environments. Representative data from these tests are included in the Appendix.

Some tests have also been performed for the White Sands Missile Range (WSMR) area, using data collected by Atmospheric Sciences Laboratory personnel. The land use data used in these tests are low resolution; however, the results of the tests show that MERCURY provides some improvement over objective analysis alone.

VI. Recommendations

The current MERCURY implementation provides a working basis for developing a robust, general meteorological data interpolation system. The principal tasks that need to be pursued are as follows.

1. Complete implementation of high-resolution digitized land use database for the Continental U.S., and for other areas as data become available.
2. Implement the cloud image analysis algorithms described by Pfeiffer (1990), and integrate them into the analysis system.
3. Improve the other heuristics and estimation procedures used in the analysis system, using testing to assess improvements in performance.
4. Compare the performance of the system to that of objective analysis alone for multiple regions in the Continental U.S., over the span of a year so that all seasons will be represented.

Completion of these tasks should enable MERCURY to perform with the accuracy and reliability needed to provide adequate data to TDAs and other client systems.

VII. References

- Campbell, D. and R. Rew (1988) Design issues in the UniData local data management system. *Preprints of the Fourth Int. Conf. on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology*. American Meteorological Society, Anaheim, CA, 1 - 5 February, 1988. pp. 208-212.
- Coombs, M., C. Fields, and G. McWilliams (1988) Artificial intelligence methods for optimizing the use of meteorological databases: Recommendations for implementing the MERCURY system. U. S. Army Atmospheric Sciences Laboratory Report CR-88-0034-2.
- Coombs, M., R. Hartley, and H. Pfeiffer (1990) Developing computer technology for modeling enemy intentions: Final report. U.S. Army Atmospheric Sciences Laboratory Report.
- Eskridge T. (1990) WADIF: An expert system for fusing weather and doctrinal information used in the intelligence preparation of the battlefield. U.S. Army Atmospheric Sciences Laboratory Report.
- Fields, C. (1988) Artificial intelligence methods for optimizing the use of meteorological databases: Architecture of the MERCURY system. U. S. Army Atmospheric Sciences Laboratory Report CR-88-0034-4.
- Fields, C. (1990) Development of advanced computing technology for optimizing the use of meteorological databases: The MERCURY-2 system. U. S. Army Atmospheric Sciences Laboratory Report CR-90-0034-1.
- Fields, C., J. Newberry, H. Pfeiffer, C. Soderlund, S. Kirby, and G. McWilliams (1991) MERCURY: A heterogeneous system for spatial extrapolation of mesoscale meteorological data. *International Journal of Man-Machine Studies* (in press).
- Pfeiffer, J. J. Jr. (1990) Development of advanced computing technology for optimizing the use of meteorological databases: Cloud detection, classification, and tracking from time-varying satellite imagery. U.S. Army Atmospheric Sciences Laboratory Report.

APPENDIX A. MERCURY: A HETEROGENEOUS SYSTEM FOR SPATIAL
EXTRAPOLATION OF MESOSCALE METEOROLOGICAL DATA

C. A. Fields, J. E. Newberry, H. D. Pfeiffer, and C. A. Soderlund

Computing Research Laboratory, New Mexico State University, Las Cruces, NM 88003-0001,
USA

S. F. Kirby and G. B. McWilliams

U. S. Army Atmospheric Sciences Laboratory, White Sands Missile Range, NM 88002-5501,
USA

Keywords: Scientific data analysis, Real time, Knowledge representation, Meteorology

Running head: MERCURY: A heterogeneous system

Correspondence to: Chris Fields, Computing Research Laboratory, Box 30001/3CRL, New Mexico State University, Las Cruces, NM 88003-0001, USA. Phone: (+1) 505-646-2848, email: cfields@nmsu.edu

This work was supported in part by U.S. Army Contract DAAD07-86-C-0034 to New Mexico State University. The views expressed in this paper are those of the authors, and are not to be construed as an official U.S. Department of the Army position. The citation of trade names or names of manufacturers in this paper is not to be construed as official U.S. Government endorsement or approval of the commercial products or services referenced.

Abstract: MERCURY is an integrated software system for acquiring, analyzing, and extrapolating meteorological data in real time for regions a few hundred square kilometers in size. MERCURY employs a variety of data structures, including real scalars and vectors, three-dimensional models, chords, grids, and qualitative descriptions to represent its input data, and both procedural and declarative methods to represent meteorological knowledge. MERCURY employs the extrapolation method that it is designed to improve upon, mesoscale objective analysis, when it is likely to be sufficient, and supplements this method with additional heuristic and analytic methods when necessary. Initial performance comparisons indicate that MERCURY's extrapolations are better than those obtained with objective analysis alone in regions of complex terrain and surface cover. MERCURY is implemented in C, with graphics in X-windows, and runs on a Sun 3/60 workstation under Unix 4.2 bsd.

INTRODUCTION

Meteorologists are often called upon to solve a spatial extrapolation problem: given the weather conditions observed at one or a small number of locations, what are the weather conditions at some other location in the same region, for which data are not available? The weather conditions of interest when solving this problem are typically either mesoscale or smaller, i.e. have a maximum horizontal dimension of a hundred kilometers or less and a duration of less than a day (Orlanski, 1975); examples include snowstorms, thunderstorms, fog, or strong winds. Such weather conditions may be influenced strongly by the local terrain; hence knowledge of the terrain, and of its likely meteorological effects, is essential for successful extrapolation. Even given such knowledge, however, the extrapolation problem is often very difficult, in part because the available data may not be representative of the location to which the extrapolation is being made. The difficulty of the problem is increased significantly when it must be solved for an unfamiliar location, with fragmentary data, and under severe time constraints, as is typically the case in emergency response situations such as hazardous materials accidents, and in military situations. Significant computer support for, and if feasible complete automation of, meteorological data extrapolation would be very beneficial in such situations.

This paper describes MERCURY, a proof-of-concept system being developed to test methods for representing meteorological and terrain data, and for performing spatial extrapolation. The fundamental requirements placed on MERCURY are that it i) accept actual meteorological data as input, ii) perform data extrapolation adequately in any geographical region, iii) be usable by a nonexpert, iv) answer queries in at most a few minutes, and v) run on a relatively inexpensive workstation (McWilliams et al., 1989). The approach that we have taken to meeting these requirements represents a compromise in which accuracy has been traded for speed: MERCURY is designed to make informed guesses, based on heuristic knowledge, in difficult cases instead of calculating an exact answer from a detailed physical model of the atmosphere. MERCURY does not, however, rely on "shallow" heuristic knowledge alone; it also employs explicit geographical information, and relatively simple analytical extrapolation methods, in situations in which these can be expected to yield useful results. This use of multiple computational techniques requires a heterogeneous architecture capable of supporting a variety of data structures and their associated operations. MERCURY thus departs significantly from conventional meteorological expert systems, which typically employ declaratively-encoded heuristics alone to forecast events of a particular type, such as thunderstorms or fog, in a particular location or type of location, and which are generally intended for interactive use by an expert forecaster (e.g. Zubrick and Riese, 1985; Swetnam, et al., 1986; Elio and De Hann, 1986; Elio et al., 1987; Jasperson et al., 1987; McArthur et al., 1987; Roberts, 1988; Dyer, 1989; Stunder and Sletten, 1989; surveyed by Moninger and Dyer, 1988; Moninger et al., 1989). MERCURY is somewhat similar to the expert forecasting system of Zwack et al. (1989), which employs both heuristic and numerical techniques to predict low-altitude cloudiness.

The next section describes the task environment in which MERCURY operates. Like most scientific data analysis task environments, the MERCURY task environment is open, in the sense that the system must be able to perform adequately in an arbitrarily large set of distinct situations, most of which cannot be characterized explicitly in a specification (Hewitt, 1985; Partridge, 1987). System performance in such task environments can only be judged as adequate or inadequate by comparison with measurements of actual events; it is not possible,

for example, to construct artificial test cases for a weather system. The third section describes the data and knowledge representation strategies employed in MERCURY, and the tradeoffs entailed by the use of these strategies. MERCURY employs latitude/longitude grids, real scalars and vectors, three-dimensional geometric models, spanning chords of areas, and qualitative descriptions to represent its input data, and both procedural and declarative constructs to represent meteorological knowledge. The fourth section describes the MERCURY design, and the implementation of each of the software modules. The fifth section discusses the performance of the current MERCURY system. The final section reviews the MERCURY project from the perspective of the general issue of designing intelligent systems for analyzing scientific data.

THE TASK ENVIRONMENT

Meteorological phenomena occur at a variety of spatial and temporal scales, ranging from that of long-term variations in global climate to that of transient air turbulence around individual surface features such as buildings or trees. A rough classification of the relevant scales is given in Table 1; Orlanski (1975) provides a much more detailed classification. The weather occurring at particular locations in a region may be due to phenomena at any or all of these scales; one part of a city, for example, may experience an intense thunderstorm during the passage of a low-pressure system, while another part of the same city experiences only light rain. Such local variations may be due primarily to intrinsic inhomogeneities in the larger scale system, or to the effects of the local terrain. Regional terrain features such as mountains, coastlines, deserts, or large urban areas can have strong effects on local weather under some larger-scale conditions, while having very little influence under other conditions (e.g. Retallack, 1984).

<i>Scale</i>	<i>Typical Horizontal Length Scale</i>	<i>Duration</i>	<i>Example</i>
Microscale	0.1 km	Minutes	Dust Devil
Mesoscale	10 km	Hours	Thunderstorm
Synoptic	100 km	Days	Low-pressure System

Table 1: Scales of meteorological phenomena relevant to the MERCURY project.

A meteorologist responsible for a region typically has access to a fixed set of instruments for measuring temperature, wind velocity, and so forth, which are located at particular positions within the region, and which obtain data for their positions at particular times. Data for a larger area containing the region, e.g. for the country or continent, may also be available. The scale of phenomena that the meteorologist will be able to observe is primarily determined by the spatial and temporal resolution of these data. The meteorologist's task consists largely of constructing a representation, either mentally, on paper, or using a computer workstation, of the present weather conditions in the region by extrapolating from the available data, and then generating predictions from this representation. The accuracy of the representation that is

constructed, and of the predictions generated from it, is strongly dependent on the representativeness as well as the resolution of the data that are collected; very accurate but nonrepresentative data can lead to a completely inaccurate representation of regional weather. The quality of the representation also depends on the accuracy and robustness of the available extrapolation methods.

The standard method for constructing a representation of the weather pattern over a given region from a set of measurements is a radially-weighted, linear numerical interpolation from the available data to a regular rectangular grid (e.g. Barnes, 1964). This "objective analysis" method provides the baseline performance on which MERCURY must improve to be a useful operational system. In practice, objective analysis has two serious weaknesses, both of which are due to nonideal data resolution and representativeness. First, closeness in space is a good indicator of similarity in weather only in situations in which the weather pattern varies smoothly as a function of distance, and local effects are relatively unimportant. If the weather pattern does not satisfy these conditions, the values of the wind velocity components, in particular, calculated for grid points even relatively near one or more measurement sites may be grossly inaccurate. In any case, the values for grid points located far from any measurement sites are generally highly uncertain. Second, most objective analysis procedures represent terrain at the resolution of the interpolation grid, usually simply as an elevation value at each grid point. This procedure effectively smooths the terrain to the resolution of the grid. The interpolation is thus blind to smaller-scale terrain features, which may nonetheless have a significant effect on the weather pattern. These problems can, in principle, be solved by acquiring data at more sites and interpolating on a finer grid, as is being attempted for example in the U.S. Program for Regional Observing and Forecasting Services (PROFS), but this solution is impractical for many operational systems.

It is the responsibility of the meteorologist to judge the reasonableness of an objective analysis of a set of measurements, using knowledge of the local terrain and large scale meteorological conditions, qualitative observations of local or regional conditions, and any other available information. This requires considerable expertise, which is usually gained by experience in a particular locale. Such expertise is often very region-specific, and relatively nonportable; even experienced forecasters may require significant time to become familiar enough with a new location to perform well. These problems are exacerbated when the meteorologist is a novice, is faced with fragmentary or otherwise unreliable data, or is placed under severe time constraints in a situation, such as an emergency response, in which lives are potentially at stake. The standard approach to this problem is to provide the meteorologist with additional data, the computer resources to compute analyses over finer grids, and interactive graphic capabilities for merging or otherwise manipulating displays of data or analysis results. This solution is embodied in a number of military and civilian initiatives, including the U.S. Advanced Weather Interactive Processing System (AWIPS) effort to develop a next-generation workstation for operational forecasters. We have taken a different approach to this problem in the MERCURY project, in part because MERCURY has been specifically designed for a military application in which expertise is both scarce and expensive, and in part because all user-intensive solutions face the problem that additional data and manipulation methods can accelerate cognitive overload, and hence decrease performance, especially in critical, stressful situations. Our goal has been, therefore, to develop a system that automates as much of the expertise-requiring reasoning as possible, using the problem-solving strategies employed by meteorologists as a guide in the design of efficient heuristic extrapolation methods.

The current MERCURY system includes a graphic user interface that displays a map of the region of interest, and provides access to data and analysis results. This interface is intended both as an aid for development and testing, and as a prototype of an interface suitable for use by a novice meteorologist working in an unfamiliar region, or by a nonmeteorologist with some meteorological knowledge who needs to use meteorological data, such as an emergency-response planner. MERCURY is not an interactive system in the usual sense; it queries its user for values of a set of parameters when it begins an execution, but after that it ingests and analyzes data, and generates extrapolations autonomously. Users can query MERCURY for extrapolated data for particular points, but cannot direct MERCURY's problem solving procedures. This style of interface avoids the delays and user biases associated with user interaction in conventional expert systems, but does not provide users with any effective control over the system. Testing of MERCURY's usability by the intended users in an operational setting will be required to evaluate this interface.

DATA AND KNOWLEDGE REPRESENTATION

Our choices of data and knowledge representations to employ in MERCURY have been guided by the input-output requirements of the system, a desire for the representations to appear natural and familiar to a meteorologist, and the need for generality and extensibility. It became clear early in the project that a single knowledge representation strategy would not easily satisfy these guidelines. We decided, therefore, to employ the most natural representation available for each type of data or knowledge, and to develop algorithms as necessary to handle multiple representations.

A sample surface observation report of the type used by MERCURY is shown in Fig. 1. The report contains both quantitative data, e.g. values of temperature and pressure, and qualitative data, e.g. estimates of cloud type and descriptions of present weather. MERCURY's task is to produce reports of this type, and similar reports of extrapolated upper-air conditions, for locations at which data are not available. The need to generate both quantitative estimates of real-valued variables and qualitative estimates of discrete, descriptive variables requires the use of both quantitative and qualitative data representations and reasoning methods. MERCURY employs procedurally-encoded continuous-valued functions for quantitative reasoning, and declaratively-encoded heuristic rules for qualitative reasoning. Control is encoded declaratively in the analysis subsystem, which applies meteorological knowledge, and procedurally in the lower-lying data acquisition, management, and representation subsystems.

Meteorologists use many relatively simple, analytical models, often encoded by single algebraic formulae, to estimate unknown values of real-valued variables from measured values. These models are compact representations of meteorological knowledge that can be applied in particular circumstances. They are both "compiled" and "deep" in the senses defined by Chandrasekaran and Mittal (1983): knowledge encoded by such models can only be accessed for certain tasks, but both the models and the tasks they support are general enough that the knowledge has wide applicability. Models of this type can be applied directly to data encoded as real scalars or vectors to produce real-valued results; the use of such models thus avoids the need to represent continuous variables by arbitrarily selected discrete ranges, as must often be done in conventional expert systems. Moreover, because such models are used on an everyday basis by meteorologists, they satisfy the requirement of familiarity to the intended user population. A number of these models have been implemented in the MERCURY analysis subsystem

(see below), either as extrapolation methods for particular variables, or to calculate values of parameters for use in qualitative reasoning.

Meteorologists make extensive use of maps, both of terrain elevation and surface cover, and of the state of the upper atmosphere. Weather prediction expert systems designed to work in particular geographic regions typically represent the local terrain implicitly, by encoding terrain effects directly in prediction heuristics. This approach is not practical in a system, such as MERCURY, intended for use in many distinct geographic regions that may have very different terrain. A more explicit approach to spatial information was taken by Elio and de Haan (1986) in the design of METEOR, which employed labeled, two-dimensional (2D) regions to represent areas - corresponding to contours - of significant cloudiness or upper-atmosphere convective activity (but not terrain) on a map. Heuristic knowledge of storm potential, represented by a set of rules, was used to predict storm severity from this spatial information. A representation of this type is feasible for terrain, but does not explicitly include the slope information needed to calculate terrain effects on, for example, wind patterns. In order to provide a more natural, higher-resolution representation of elevation, slope, and aspect, we have adopted a full three-dimensional (3D) geometric representation for both terrain and upper-atmosphere features such as low-pressure systems. In each case, the 3D representation is constructed over a gridded point representation of the data set; information about a single point can, therefore, be retrieved without having to traverse a 3D model. Models of individual terrain or atmospheric features are constructed as separate, named entities that can be accessed and manipulated as independent objects. The 3D representation has the additional advantage of being visualizable in perspective, allowing the user to gain an intuitive understanding of the shape of both the local terrain and the overlying upper-air features.

The boundaries of areas overlaid by significant terrain, and of areas with particular surface cover, are also represented by sets of endpoints of chords traversing the areas. Marine, inland lake, agricultural, forest, desert, suburban, low-density urban, and high-density urban areas are represented in this way. The chord representation allows efficient calculations of whether a point is in a named area, of the distance from a point to a named area, and of the direction from a point to the nearest boundary segment of a named area.

Heuristic rules are employed in MERCURY both to select analytical models or other rules to execute, and to perform qualitative extrapolation. The selection rules encode information about the applicability of particular approximations, models, or heuristics, and can be considered metarules (Clancey and Bock, 1988). They provide high-level declarative control in the MERCURY analysis subsystem. The extrapolation rules encode qualitative physical knowledge. Only relatively general rules of either type are used, in order to avoid having a very large knowledge base of situation- or location-specific heuristics. This strategy maintains generality, but at the cost of having no natural encoding for the local heuristics that experienced meteorologists use in particular locations. We hope to compensate for this lack by implementing methods for using information from additional data sources, such as cloud images obtained from satellites, and improved analytical models in future versions of MERCURY.

DESIGN AND IMPLEMENTATION

MERCURY comprises a set of subsystems, which perform i) data acquisition and management, ii) feature identification, 3D model generation, and area representation, iii) data analysis, iv) user interface functions, and v) automated self-testing. MERCURY has been implemented in C for speed and portability; the graphic user interface is based on X-windows (Scheifler and Gettys, 1986). MERCURY has been tested on a Sun 3/60 workstation running Unix 4.2 bsd.

Data Acquisition and Management

The data acquisition subsystem of MERCURY is shown in Fig. 2. Surface and upper-air data from the regularly-reporting National Weather Service civilian observation network in the continental U. S. are received in real time, via a communications satellite downlink, from the Domestic Data Plus (DD+) broadcast of the Zephyr Weather Information Service, Inc. of Westborough, MA. These data are ingested in real time and filtered from other, unused products in the DD+ data stream by the programs `txing` and `txdig`, which are components of the Scientific Data Management (SDM) system developed and distributed by the University Corporation for Atmospheric Research (UCAR) Unidata program (Campbell and Rew, 1988). `txing` and `txdig` run continuously in background on the workstation that serves as both the data acquisition system and the execution platform for MERCURY.

Following digestion, the data are written into hourly surface and 12-hourly upper-air data files by the programs `convert` (surface data) and `uacvt` (upper-air data), which are components of the Weather Processor (WXP) system developed by the Department of Earth and Atmospheric Sciences, Purdue University, and distributed by Unidata. `convert` is automatically invoked hourly by an execution shell that runs in background; `uacvt` is automatically invoked every 12 hours. Both the surface and upper-air data are filtered to remove errors by Zephyr Weather Services prior to the rebroadcast; no additional data quality checking is done by MERCURY.

The converted surface and upper-air data files are available for processing by the local data management software described below as soon as they are written, i.e. hourly for surface data, and 12-hourly for upper-air data. The 500 millibar (mb) height and temperature data present in the upper-air data files are automatically gridded at 230 kilometer (km) horizontal resolution by the `upcalc` program, which is a component of WXP, whenever a new upper-air data file is created. Additional data fields may be gridded; this only requires altering the automatic execution shell that controls `upcalc`. These gridded data files are also available to the local data management software when written. The gridded data are, in addition, automatically processed by the 3D model generator described below each time a new file of gridded data is written.

The MERCURY data management subsystem maintains and provides access to both the continuously-updated meteorological data files and the static terrain elevation and surface cover data files used by the MERCURY analysis subsystem. When MERCURY is executed, the user is asked to provide latitude and longitude (lat/long) coordinates of a box bounding the region of interest. The data management subsystem reads a permanent data file that specifies the lat/long locations of all U.S. weather stations from which data are available, and selects those stations that are within the region of interest. The most recent data reported by each of these

stations, together with all previous data from these stations back to six hours before the current time, are read from the available meteorological data files into local surface and upper-air data files. The contents of these files are continuously updated using a first-in-first-out (FIFO) protocol as new data become available. The creation of local data files allows the maintenance of multiple reports for each local station, and greatly increases the speed with which local data may be retrieved.

The only terrain database currently implemented as part of MERCURY contains $1 \text{ km} \times 1 \text{ km}$ horizontal resolution elevation data for a $100 \times 100 \text{ km}$ region of the Los Angeles, California basin area, together with digitized surface cover data created using a specialized editor. The local data management subsystem currently only provides access to these data to the analysis subsystem; once additional terrain data are available, data for the region of interest will be selected in response to a user specification of lat/long coordinates in the same way that the meteorological data are currently selected. Implementation of a digitized terrain database for the continental U.S. is currently in progress.

Feature Identification, 3D Model Generation, and Area Representation

Point values of meteorological variables or terrain characteristics, whether in isolation or in the context of a regular grid, are of limited use in much of the qualitative reasoning that is used by expert meteorologists to understand the behavior of weather patterns in complex terrain. The locations and characteristics of identified features, such as front boundaries, mountain ranges, or coastlines, are much more useful for this type of reasoning. MERCURY employs a feature detection and 3D model generation subsystem to construct 3D representations of terrain elevation and upper-air conditions. It uses boundaries as well as the underlying point data to represent surface-cover characteristics in 2D.

The 3D model generator is based on the Electric Tinkertoys (ET) system developed by Soderlund and Pfeiffer (1989), which provides a library of functions for constructing and manipulating data structures representing geometric entities (Pfeiffer and Soderlund, 1988). It is used to build 3D geometric models of both the gridded upper-air height fields produced by **upcalc**, and the digitized terrain elevation data. The model generator includes a graphics display facility based on X-windows, which forms part of the MERCURY user interface.

The model generator is invoked automatically whenever a new gridded upper-air data file is written. 3D models are constructed using all grid points having height values above or below user specified cutoff values; this thresholding procedure produces a segmentation of the field into individual high- or low-pressure features, respectively, to be represented as objects by the modeler. The resulting models represent pressure ridges and troughs, respectively. Plots showing typical height-field models both with and without segmentation are shown in Fig. 3.

The model generator is invoked to build models of significant terrain whenever MERCURY is executed with a new terrain data file. Two measures, of elevation with respect to sea level and local slope, are used to segment the terrain elevation data into regions of significant terrain; cutoff values for these measures are obtained from the user. The local slope is calculated at each grid point by calculating the cross product of the vectors linking the point to its south and east neighbors; the angle between this vector and the horizontal is the local slope. A grid point is taken to be inside a region of significant terrain if its elevation and slope values are both above the user-specified cutoff values. A plot showing significant terrain models generated from the gridded elevation data for the Los Angeles basin is shown in Fig. 4.

Boundary representations are also generated for each area overlaid by significant terrain, and for each area with identified surface cover, when MERCURY is executed with a terrain data file. A boundary is represented by the set of pairs of endpoints of all of the North-South and East-West chords spanning the area. This representation is suitable for concave as well as convex areas, and allows a rapid calculation of the size of the area.

Data Analysis

The MERCURY data analysis subsystem returns values of standard meteorological parameters - temperature, dew point, pressure, wind speed and direction, and visibility - either for a point specified by its lat/long coordinates, or for all points on a grid with user-specified horizontal resolution (default = 25 km $\times$ 25 km). A qualitative description of cloud type is also returned in response to queries for point data. A hierarchy of metarules is used to determine how these values are to be calculated, based on features of the region, and of the large-scale weather pattern. The basic decision implemented by these rules is between situations in which local effects are likely to be important in determining regional weather, and situations in which such effects are likely to be unimportant. If the region contains either significant terrain features, or any marine area, the region is classified as having local effects regardless of its present weather. If a region is covered by a low-pressure system, or if any station in the region reports severe weather, the region is classified as having local effects. Otherwise the region is classified as free of local effects. The mesoscale objective analysis code OASYS developed by the U.S. Army Atmospheric Sciences Laboratory (Henmi and Kirby, 1990) is used to calculate a grid of values from the available data in regions with no local effects. OASYS is based in part on the KRISSY objective analysis system developed by the U.S. Forest Service (Fosberg and Sestak, 1986), which was initially used with MERCURY. A $(1/r^2)$ weighting is employed for both surface and upper-air analyses in OASYS. A radius of influence can be specified, as well as a minimum number of stations to affect each grid point. Upper-air analyses are improved by using a cubic-spline fit to the measured upper-air data from each station; this procedure yields a uniform spread of points in the vertical dimension. Horizontal interpolation is performed at whatever vertical levels are designated by the user. Only data from stations reporting within the last two hours are included in surface analyses; stations reporting in the last 12 hours are used for upper-air analyses. Queries for point data at a point P not on the grid are answered by linear, distance-weighted interpolation between the data values at all grid points less than or equal to one grid spacing away from P. Because the qualitative cloud type value is not gridded, this value is always returned as the same as the value for the nearest reporting station.

Both objective and heuristic extrapolation methods are used in regions classified as having local effects. Grid points more than one grid spacing away from any station that has reported data in the last two hours are first classified as isolated. MERCURY estimates data for an isolated grid point heuristically if one or more stations are available that are representative of that grid point. A station is classified as representative of a grid point if it satisfies a set of criteria, encoded by rules, that measure distance and direction to terrain features, coastlines, and upper-air weather features. Data from stations representative of a point P are corrected, using either physical models or heuristic factors, for differences between the elevation and surrounding surface cover at the station and P. The corrected data from all stations representative of P that are no more than twice as far from P as the nearest such station are averaged, with linear distance weighting, to yield the estimated data for P. Once data for all isolated points for which

representative stations are available have been calculated, MERCURY executes OASYS to calculate a surface objective analysis, using both the data measured at stations reporting in the last two hours, and the estimates obtained for isolated grid points, as input to calculate data for both the remaining isolated grid points, and for the nonisolated grid points. Queries for point data are answered by distance-weighted interpolation between grid points, as in the previous case.

Because MERCURY is implemented in C, rules are encoded by if-then-else conditionals. The working memory of the rule base is a set of binary-valued flag variables that are set and passed between these conditionals. The result of executing a rule is, in many cases, the execution of one or more numerical functions, e.g. for correcting temperature data for altitude. The distinction between procedural and declarative encodings of knowledge and control is, therefore, largely a matter of interpretation by the designer in MERCURY; the distinction is not reflected in any explicit way in the software. Updating the knowledge base requires direct modification of the code in this implementation, but it has the advantage of a very straightforward relation between the rules and the numerical functions that they control.

OASYS and the smoke screen program *obskur*, which is a component of the user interface, are the only components of the MERCURY system not implemented in C; they have been left in the original FORTRAN and PASCAL, respectively. The analysis subsystem writes an input file for OASYS, and calls OASYS as an external routine; it then reads the output grid file written by OASYS as necessary to answer queries for point data. The interface with *obskur* is handled similarly, except that *obskur* is called by the user interface, not the analysis subsystem.

The analysis subsystem is in an early stage of development, with only relatively simple extrapolation methods implemented thus far. Our current effort is focussed on testing and incrementally improving the extrapolation methods, and on adding functions to allow cloud images and numerical weather predictions to be used as input.

User Interface

User interaction with MERCURY is supported by a graphic user interface implemented using X-windows. This interface supports both color and monochrome graphics displays of the region of interest, provides access to both meteorological and terrain data via interactive menus and fill-in forms, and allows user control of MERCURY via a command menu. The interface also incorporates a smoke-screen prediction program *obskur*, which demonstrates the capability of linking MERCURY directly to a client application program that requires extrapolated meteorological data. A typical interface screen is shown in Fig. 5.

The interface allows the user to display and edit parameter values from any measurement station, to scroll through stored measurements for any station, to create additional stations, and to enter data for these additional stations. The latter options are useful for porting historical data sets to MERCURY for testing purposes. Data are displayed in pop-up forms, which may be scrolled and edited directly. Edited station data are written to the relevant files by the data management subsystem. Data for stations created by the user are treated in the same way as real data by the data management component; however, such added stations are marked to distinguish them from real, and hence continuously updated, stations.

The interface also supports specialized graphic editors for creating and altering terrain elevation and land-use data. These editors require a color or grey-scale display capability.

Both allow editing of maps by a painting process, in which the mouse is used both to select elevation or land-use values from a menu, and to assign these values to either individual pixels or to areas. The assigned values are mapped from pixels to lat/long coordinates by the data management subsystem.

The smoke-screen prediction program **obskur** developed at the U.S. Army Atmospheric Sciences Laboratory has been partially ported to the interface to demonstrate the feasibility of two-way communication between MERCURY and client applications. When **obskur** is invoked from a command button on the MERCURY interface, it requests the user to select the lat/long location for which smoke-screen prediction is to be performed. **obskur** sends the lat/long coordinates of the selected location, together with the current time, to MERCURY. The MERCURY analysis subsystem calculates the values of all meteorological parameters for the location and time of interest, and returns these to **obskur**. **obskur** then calculates a downwind smoke plume from these data, and displays the result either as a triangle representing the predicted smoke plume on the map, or as a text output to the screen.

Self Testing

MERCURY includes a real-time self-testing subsystem, which may be executed continuously as data arrive. This subsystem tests MERCURY's performance in extrapolating values of surface meteorological variables to locations for which measurements are available. When invoked, the self-test system cycles once per hour through the set of stations reporting data. At each station S, it executes the analysis subsystem to calculate a set of data values for the location of S, using all available data except the data from S. The differences between the measured and calculated data for S are then written to a test log. Because self tests can be run continuously, MERCURY's performance at night and at other inconvenient times can be logged without user intervention. However, the present system does not provide adequate testing of MERCURY's performance in areas having no stations. This can currently be done only using historical data sets obtained by placing temporary measurement stations in such locations.

PERFORMANCE

MERCURY's performance in the Los Angeles basin region is currently being evaluated by comparing the magnitudes of MERCURY's extrapolation errors with those of OASYS run independently. Example results for two stations in the Los Angeles region, tested at 16:00 GTM, 8 March 1990, are shown in Table 2. While both systems suffer prediction errors, MERCURY consistently outperforms OASYS in this region.

While the performance results that have been obtained to date are from only a single region, and are not representative of all weather conditions within that region, they suggest that MERCURY is already capable of some improvements over objective analysis alone. Extended testing in different regions and seasons will be needed to determine whether this improvement is statistically significant, and to rationally refine the methods used by MERCURY.

<i>Station</i>	<i>Variable</i>	<i>MERCURY Error</i>	<i>OASYS Error</i>
LAX	Temperature	6.7%	63%
LAX	Dew Point	18%	67%
LAX	Wind Speed	0.0%	>100%
LAX	Wind Dir.	0.0%	>100%
FUL	Temperature	9.8%	28%
FUL	Dew Point	7.4%	44%
FUL	Wind Speed	36%	49%
FUL	Wind Dir.	43%	47%

Table 2: Comparison of MERCURY and OASYS errors for extrapolations of meteorological data at stations LAX (Los Angeles Airport) and FUL (Fullerton).

DISCUSSION

MERCURY is an artificial intelligence system designed to solve a complex, but relatively well-circumscribed scientific problem. Such problems share a number of characteristics:

- They are formally unspecifiable. The problems for which an AI system is needed are precisely those for which the correct answer is unknown, and for which it will not be known until the system has done its work. The only problems for which an input-output specification can be given in advance are those for which the system is unnecessary.
- The system needs to be able to work with uninterpreted physical data. The complexity, tedium, and time requirements of data interpretation are often the major motivations for automation; requiring the user to interpret the data in order to render it useful to the system is self-defeating.
- The data and the required results are very often real-valued. Reducing the data to a low-resolution discrete representation is usually unacceptable.
- The system's performance must degrade gracefully. An inaccurate answer, preferably with some estimate of the error, can nonetheless be useful; a failure to process certain data altogether because they violate some expectation is unacceptable.
- A well-defined strategy for evaluating and incrementally improving the system's performance is needed. Such a strategy will often require use of experimental data as it arrives for evaluation.

The idealized knowledge systems methodology, with its requirement that all domain knowledge be encoded in an explicit, declarative form (e.g. Hayes-Roth et al., 1983) is inadequate in task environments with these characteristics (e.g. Partridge, 1987; Fields and Dietrich, 1990), and expert systems designers are routinely warned away from such task environments (e.g. Bobrow et al., 1988). The demand for, and the potential scientific and economic consequences of, such applications are, however, very large. Methods for developing systems that will perform adequately in task environments with these characteristics are needed.

The approach we have taken in MERCURY combines elements of standard scientific computing with elements of knowledge-based AI. Viewed at the knowledge level, MERCURY is an automated tool-user; its task is to select and apply an analysis method that is appropriate to the region and data at hand. MERCURY's strategies for applying the available tools are explicitly patterned on those of an expert meteorologist. This approach has the advantage that scientific computing tools actually used by meteorologists, such as OASYS, can be incorporated directly into the system; the knowledge that these tools encode does not have to be re-represented in a different, and quite possibly less appropriate, notation to be used. Rules are used to encode strategic knowledge of how the available tools are to be used, for which the knowledge-engineering methodology and the declarative representation are very appropriate.

The use of geometric data structures, such as grids, 3D models, and area representations, is also modeled directly on the use of such representations by meteorologists. These data structures support spatial reasoning in a very natural way. While the spatial reasoning methods implemented in MERCURY thus far are relatively straightforward, they are similar in spirit to the methods for automated visualization-driven problem solving advocated by Abelson et al. (1989). As additional three dimensional information, such as 3D models of cloud masses, is introduced into MERCURY, the sophistication of these methods will increase.

We believe that heterogeneous designs such as that employed in MERCURY will prove useful for building AI systems for other scientific data analysis tasks. In particular, we expect both the explicit 3D spatial reasoning methods and the strategy of building automated users of available scientific computing tools demonstrated in MERCURY to be generally useful in building expert geographic information systems.

STATION ID	:LAX
TYPE	:SURFACE
LATITUDE (NORTH)	:33.93
LONGITUDE (WEST)	:118.40
ELEVATION (METERS)	:30.0
TIME (YYMMDDHH)	:89082916
TEMPERATURE (F)	:64.0
DEW POINT (F)	:58.0
WIND DIRECTION (DEG)	:9.0
WIND SPEED (KNOTS)	:4.0
PRESSURE (MB)	:113.20
VISIBILITY (MILES)	:2.5
CLOUD COVER {C, S, B, O}	:B
CLOUD BASE (FT)	:1300.0
PRESENT WEATHER	:F

Fig. 1: Typical surface meteorological station report,
of the type used as input by MERCURY.

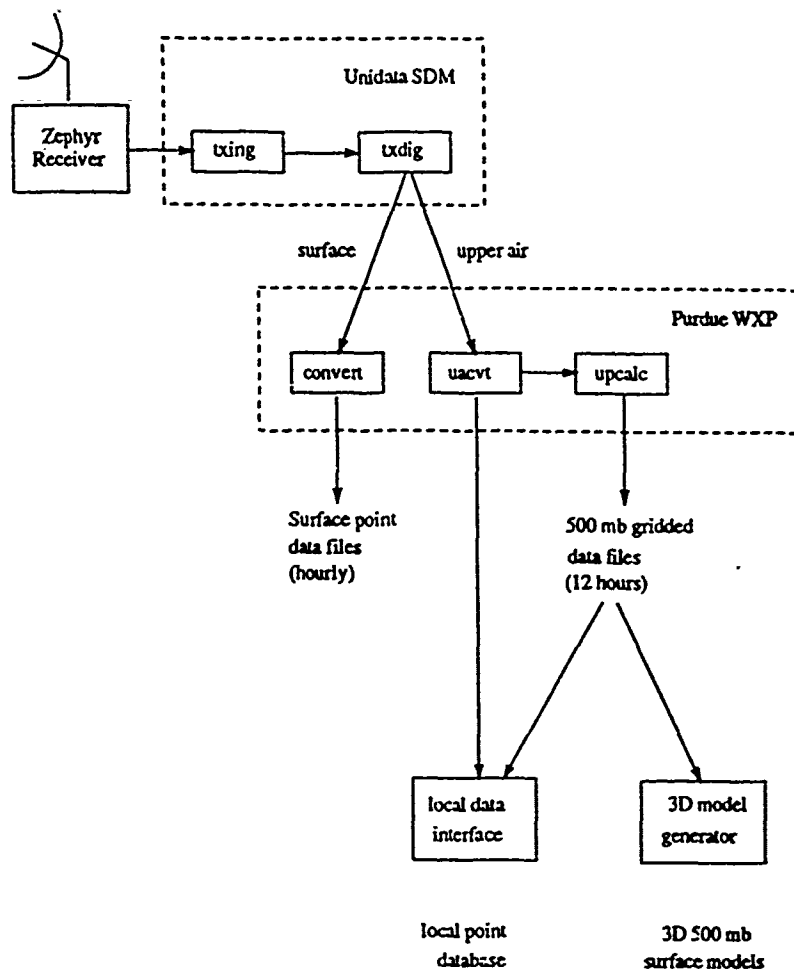


Fig. 2: Block diagram of the data acquisition system underlying MERCURY. All programs are executed automatically whenever appropriate input data are available.

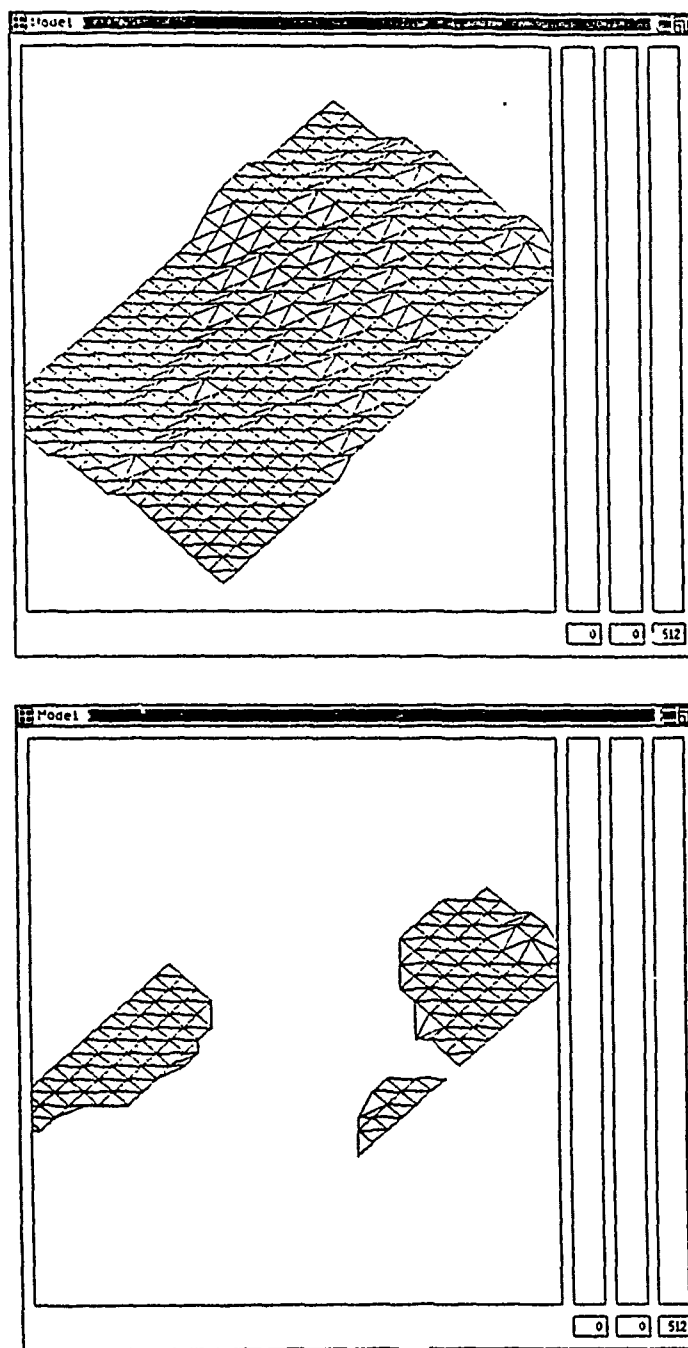


Fig. 3: (Upper) Plot showing an unsegmented model of a 500 mb height field at 230 x 230 km horizontal resolution. (Lower) Plot showing 3D models of low (left) and high (right) pressure features generated from this height field, using segmentation cutoffs of (upper level) 5800 m and (lower level) 5400 m.

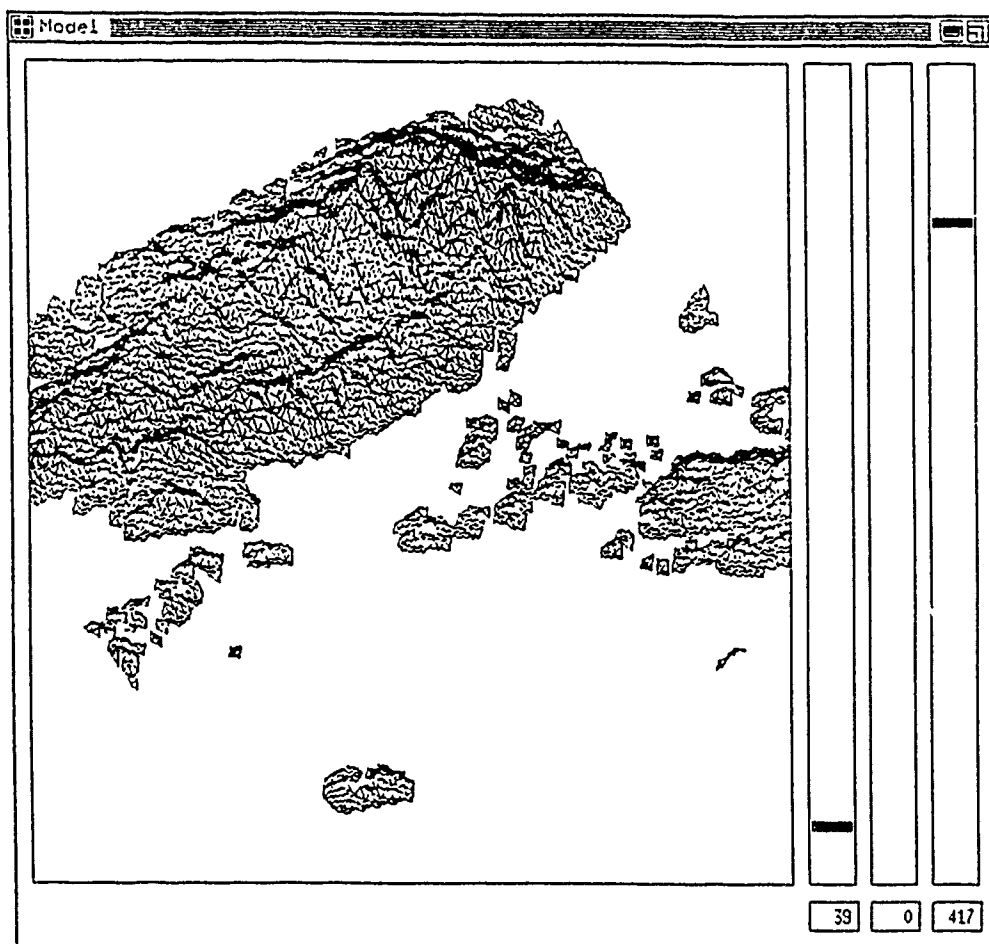


Fig. 4: Plot showing 3D significant terrain models for a 100 x 100 km region of the Los Angeles basin. The elevation cutoff value is 10 m; the slope cutoff value is 5°. The San Gabriel mountains extend across the upper part of the figure.

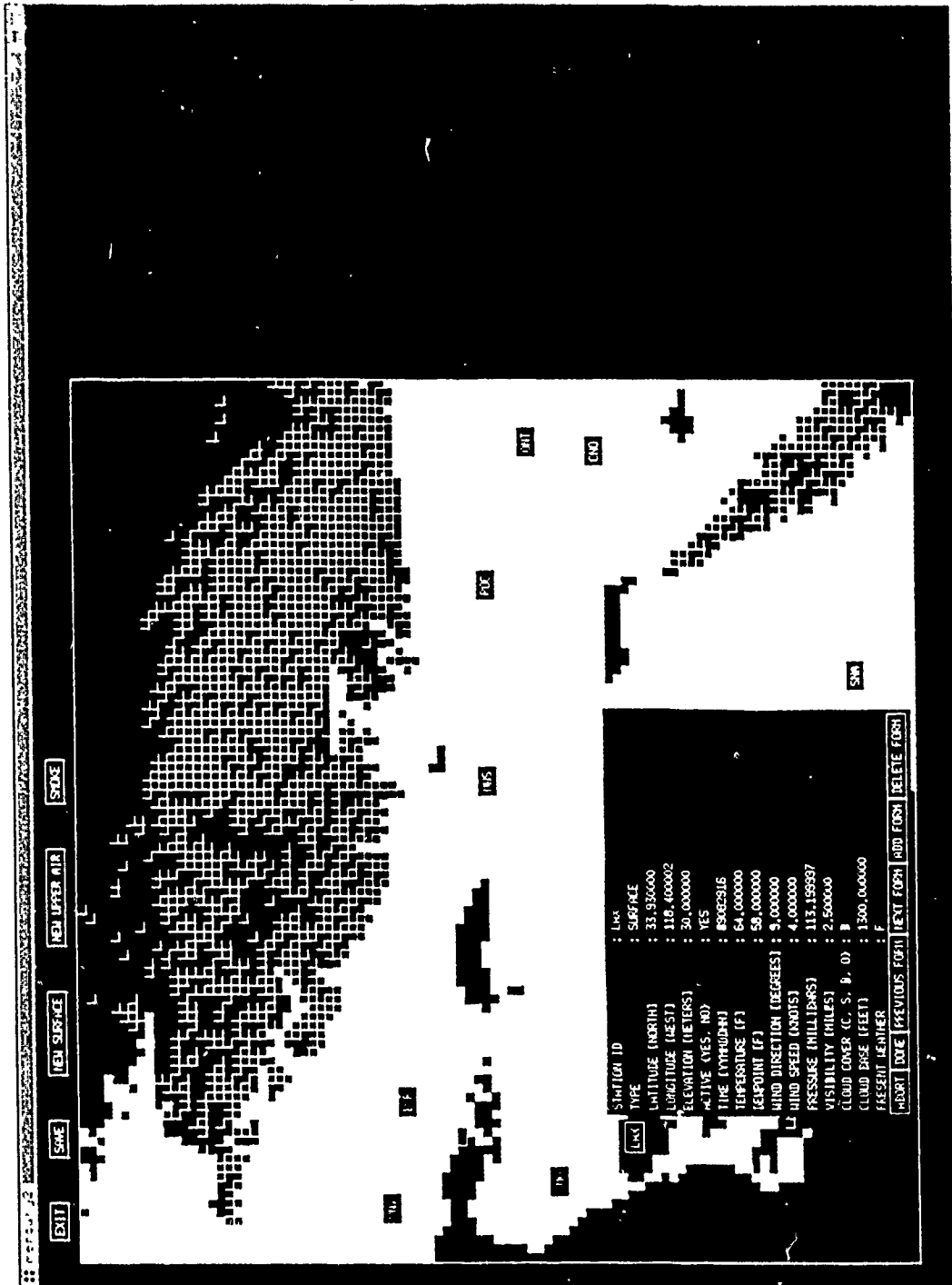


Fig. 5: Typical user interface screen, showing command menu (top panel), map display (central display area), and pop-up form for accessing and editing station data. The interface runs in a single window under the X-windows system.

REFERENCES

- Abelson, H., Eisenberg, M., Halfant, M., Katzenelson, J., Sacks, E., Sussman, G. J., Wisdom, J., and Yip, K. 1989. Intelligence in scientific computing. *Communications of the ACM* 32: 546-562.
- Barnes, S. 1964. A technique for maximizing details in numerical weather map analysis. *J. Applied Meteorology* 3: 396-409.
- Bobrow, D., Mittal, S., and Stefik, M. 1988. Expert systems: Perils and promise. In *Expert Systems in Engineering*, ed. D. Pham, pp. 19-42. Berlin: Springer Verlag.
- Campbell, D. and R. Rew (1988) Design issues in the UNIDATA local data management system. *Preprints of the Fourth Int. Conf. on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology*, American Meteorological Society, pp. 208-212, Feb 1 - 5, Anaheim, CA.
- Chandrasekaran, B. and Mittal, S. 1983. Deep versus compiled knowledge approaches to diagnostic problem solving. *Int. J. Man-Machine Studies* 19: 425-436.
- Clancey, W. and Bock, C. 1988. Representing control knowledge as abstract tasks and metarules. In *Expert System Applications*, eds. L. Bolc and M. Coombs, pp. 1-77. Berlin: Springer Verlag.
- Dyer, R. M. 1989. Adapting expert systems to multiple locations. *AI Applications in the Environmental Sciences* 3: 11-16.
- Elio, R. and De Hann, J. 1986. Representing quantitative and qualitative knowledge in a knowledge-based storm-forecasting system. *Int. J. Man-Machine Studies* 25: 523-547.
- Elio, R., De Hann, J., and Strong, G. S. 1987. METEOR: An artificial intelligence system for convective storm forecasting. *J. Atmospheric and Oceanic Technology* 4: 19-28.
- Fields, C. and Dietrich, E. 1990. Engineering artificial intelligence applications in unstructured task environments: Some methodological issues. In *Artificial Intelligence and Software Engineering*, ed. D. Partridge, in press. Norwood, NJ: Ablex.
- Fosberg, M. and Sestak, M. 1986. KRISSY: User's guide to modelling three-dimensional wind flow in complex terrain. Pacific Southwest Forest and Range Experiment Station Gen. Tech. Report PSW-92, U.S. Forest Service, Berkeley, CA.
- Hayes-Roth, F., Waterman, D., and Lenat, D. 1983. An overview of expert systems. In *Building Expert Systems*, ed. F. Hayes-Roth, D. Waterman, and D. Lenat, pp. 3-29. Reading, MA: Addison-Wesley.
- Henmi, T., and Kirby, S. 1990. OASYS: An objective analysis scheme designed for implementation in the MERCURY system. U.S. Army Atmospheric Sciences Laboratory Technical Report (in preparation).
- Hewitt, C. 1985. The challenge of open systems. *Byte* 10: 223-242.
- Jasperson, W. H., Venne, D. H., and Panton, D. J. 1987. A prototype single-station weather forecasting expert system. *Preprints Third Int. Conf. Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology*, American Meteorological Society, pp. 12-16, Jan. 12 - 16, New Orleans, LA.
- McArthur, R., Davis, J. R., and Reynolds, D. 1987. Scenario-driven automatic pattern recognition in nowcasting. *J. Atmospheric and Oceanic Technology* 4: 29-35.

- McWilliams, G., Kirby, S., Fields, C., Cavendish, C., Coombs, M., Eskridge, T., Hartley, R., Pfeiffer, H., and Soderlund, C. 1989. Army requirements for an intelligent interface to a real-time meteorological database. *Preprints Fifth Int. Conf. on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology*, American Meteorological Society, pp. 1-2, Jan. 30 - Feb. 3, Anaheim, CA.
- Moninger, W. R. and Dyer, R. M. 1988. Survey of past and current AI work in the environmental sciences. *AI Applications in the Environmental Sciences* 2: 48-52.
- Moninger, W. R. et al. (AIRIES-89 Program Committee) 1989. Third workshop on artificial intelligence research in environmental science (AIRIES). *AI Applications in the Environmental Sciences* 3: 56-63.
- Orlanski, I. 1975. A rational subdivision of scale for atmospheric processes. *Bulletin of the American Meteorological Society* 56: 527-530.
- Partridge, D. 1987. The scope and limits of first-generation expert systems. *Future Generation Computer Systems* 3: 1-10.
- Pfeiffer, J. J., Jr. and Soderlund, C. A. 1988. Solid modeling data structures for computer vision. *Proc. 22nd Asilomar Conf. on Signals, Systems, and Computers*, pp. 543-547, Oct. 31 - Nov. 2, Asilomar, CA.
- Retallack, B. J. 1984. Compendium of Lecture Notes for Training Class IV Meteorological Personnel, Volume II - Meteorology. World Meteorological Organization, WMO No. 266, Geneva.
- Roberts, W. F. 1988. Severe weather advisory program: A dynamically adjusted rule-based system for severe weather forecasting. *Preprints Fourth Int. Conf. on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology*, American Meteorological Society, pp. 276-278, Feb. 1 - 5, Anaheim, CA.
- Scheifler, R. and Gettys, J. 1986. The X Window system. *ACM Transactions on Graphics* 5: 79-109.
- Soderlund, C. and J. Pfeiffer (1989) Electric tinkertoys user's manual. Computing Research Laboratory Report MCCC-89-158, New Mexico State University, Las Cruces, NM.
- Stunder, M. J. and Sletten, T. N. 1989. POSEIDON: A frames based marine meteorological AI system. *Preprints Fifth Int. Conf. on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology*, American Meteorological Society, pp. 358-359, Jan. 30 - Feb. 3, Anaheim, CA.
- Swetnam, G. F., Dombroski, E. J., and Bunting, R. F. 1986. A demonstration expert system for weather forecasting. *Preprints Second Int. Conf. on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology*, American Meteorological Society, pp. 310-316, Jan. 14 - 17, Miami, FL.
- Zubrick, S. M. and Riese, C. E. 1985. An expert system to aid in severe thunderstorm forecasting. *Preprints 14th Conf. on Severe Local Storms*, American Meteorological Society, pp. 117-122, Oct. 29 - Nov. 1, Indianapolis, IN.
- Zwack, P., Chartier, Y., Cotnoir, A., and Newborn, M. 1989. A low cloud expert advisory terminal forecaster. *Preprints Fifth Int. Conf. on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology*, American Meteorological Society, p. 389-390, Jan. 30 - Feb. 3, Anaheim, CA.

APPENDIX B. ARCHIVE FORMAT

WAS will write the weather data to the given output directory, but it will not be in the same format as the converted input files. The WAS output format for the surface weather data is the following:

yymm.srf - file name

yy	Last two digits of the year.
mm	Month.
.srf	Three letter extension which represents surface data.

The data is group into three lines. Each format is given below.

Line 1:

sss aa.aa bbb.bb yymmddhh

sss	Station identifier.
aa.aa	Latitude
bbb.bb	Longitude
yy	Last two digits of the year.
mm	Month.
dd	Day of month.
hh	Hour of weather observation in GMT.

Example:

SDB 34.75 118.73 89040414

Line 2:

t.t d.d w.w s.s p.p v.v

t.t	Temperature in F. (-99.0 for missing)
d.d	Dewpoint in F. (-99.0 for missing)
w.w	Wind direction in degrees. (-99.0 for missing)
s.s	Wind speed in knots. (-99.0 for missing)
p.p	Pressure in millibars. (-99.0 for missing)
v.v	Visibility in miles. (-99.0 for missing)

Example:

57.0 36.0 34.0 10.0 -99.0 -99.0

Note: The numbers do not take up a specific amount of space. There will

always be a space between each number.

line 3:

c Cloud cover (1 letter) (' ' for missing).
b.b Cloud base (ceiling) (-99.0 for missing).
p Present weather (may be more than one character) (' ' for
 missing).

Example:

Note: Cloud base does not take up a specific amount of space. There will always be a space on both sides of the cloud base.

Example WAS file follows:

LGB 33.81 118.15 90110100
69.00 53.00 270.00 13.00 1014.80 20.00

MWS 34.10 118.00 90110100
50.00 45.00 190.00 7.00 -99.00 -99.00

LAX 33.93 118.40 90110100
66.00 56.00 250.00 14.00 1015.40 15.00

EDW 34.90 117.87 90110100
69.00 31.00 290.00 10.00 1012.40 25.00

RIV 33.90 117.25 90110100
71.00 54.00 300.00 9.00 1014.50 10.00

EDW 34.90 117.87 90110100
69.00 31.00 290.00 10.00 1012.40 25.00

BUR 34.20 118.36 90110100
68.00 52.00 160.00 10.00 -99.00 -99.00

CRQ 33.13 117.28 90110100
-99.00 -99.00 270.00 6.00 -99.00 -99.00

ENT 34.10 118.03 90110100
-99.00 -99.00 210.00 7.00 -99.00 -99.00

ONT 34.05 117.62 90110100

75.00 50.00 260.00 14.00 -99.00 -99.00

PMD 34.63 118.08 90110100
-99.00 -99.00 240.00 16.00 -99.00 -99.00

POC 34.10 117.78 90110100
-99.00 -99.00 220.00 6.00 -99.00 -99.00

RAI 33.95 117.45 90110100
-99.00 -99.00 310.00 15.00 -99.00 -99.00

TOA 33.80 118.33 90110100
66.00 56.00 280.00 10.00 -99.00 -99.00

VNY 34.22 118.48 90110100
69.00 48.00 140.00 6.00 -99.00 -99.00

WJF 34.73 118.22 90110100
67.00 42.00 240.00 16.00 1013.10 40.00

NZJ 33.67 117.73 90110100
69.00 53.00 230.00 2.00 1014.10 7.00

SBD 34.10 117.23 90110100
71.00 48.00 260.00 8.00 1013.30 20.00

VCV 34.58 117.38 90110100
70.00 33.00 180.00 12.00 1011.80 20.00

APPENDIX C. REPRESENTATIVE STATION SELECTION

For each isolated point P, we find the representative stations S using the following heuristics.

IF ...

#1 : Point P and Station S are both in the same significant terrain object or both P and S are outside of all significant terrain objects.

AND

#2 : There is no point P' between P and S with
 $\text{elevation}(P') > \max(\text{elevation}(P), \text{elevation}(S))$

AND

#3 : Point P and Station S are both in the same low pressure object or both P and S are outside of all low pressure objects.

AND

#4 : Both P and S are within 2 grid spacings from an area of marine land use or both P and S are more than 2 grid spacings from an area of marine land use.

THEN ...

Station S is representative of point P.

APPENDIX D. ESTIMATION FUNCTIONS

The following is the estimation functions used in the MERCURY analysis system for isolated point P and station S.

1. Changes due to elevation

The estimated temperature at P is

$$\text{temperature}(P) = \text{temperature}(S) + (\text{elevation}(S) - \text{elevation}(P)) / 500\text{m} * 1 \text{ degree C}$$

The estimated pressure at P is

$$\text{pressure}(P) = \text{pressure}(S) + (\text{elevation}(S) - \text{elevation}(P)) / 8\text{m} * 1 \text{ millibar}$$

2. Changes due to land use

if landuse(P) is one of {forest} and
landuse(S) is one of {agricultural, low_urban, suburban}
then

$$\text{temperature}(P) = 0.95 * \text{temperature}(S)$$

if landuse(P) is one of {forest} and
landuse(S) is one of {high_urban, desert}
then

$$\text{temperature}(P) = 0.90 * \text{temperature}(S)$$

if landuse(P) is one of {agricultural, low_urban, suburban} and
landuse(S) is one of {high_urban, desert}
then

$$\text{temperature}(P) = 0.95 * \text{temperature}(S)$$

if landuse(P) is one of {agricultural, low_urban, suburban} and
landuse(S) is one of {forest}
then

$$\text{temperature}(P) = 1.05 * \text{temperature}(S)$$

if landuse(P) is one of {high_urban, desert} and
landuse(S) is one of {agricultural, low_urban, suburban}
then

$$\text{temperature}(P) = 1.05 * \text{temperature}(S)$$

if landuse(P) is one of {high_urban, desert} and
landuse(S) is one of {forest}
then

temperature(P) = 1.10 * temperature(S)

3. Changes for wind speed due to land use when P is outside of any significant terrain objects.

```
if landuse(P) is one of {forest} and
  landuse(S) is one of {agricultural, desert, suburban}
then
  wind_speed(P) = 0.50 * wind_speed(S)
```

```
if landuse(P) is one of {low_urban, high_urban}
  landuse(S) is one of {agricultural, desert, suburban}
then
  wind_speed(P) = 0.75 * wind_speed(S)
```

```
if landuse(P) is one of {forest} and
  landuse(S) is one of {low_urban, high_urban}
then
  wind_speed(P) = 0.75 * wind_speed(S)
```

```
if landuse(P) is one of {low_urban, high_urban}
  landuse(S) is one of {forest}
then
  wind_speed(P) = 1.25 * wind_speed(S)
```

```
if landuse(P) is one of {agricultural, desert, suburban} and
  landuse(S) is one of {forest}
then
  wind_speed(P) = 1.50 * wind_speed(S)
```

```
if landuse(P) is one of {agricultural, desert, suburban} and
  landuse(S) is one of {low_urban, high_urban}
then
  wind_speed(P) = 1.25 * wind_speed(S)
```

4. Changes in wind speed and wind direction when P is inside a significant terrain object.

[A] if no upper air data are available for the region and S is lower in altitude than P, estimate wind direction at P is eastward (Northern Hemisphere) or westward (Southern Hemisphere). Estimate wind speed as 5 m/s per 500m altitude difference, added as a vector to value from S.

[B] if upper air data are available for the region, calculate wind speed and direction at P as functions of altitude from sounding data. If

more than one sounding are available, do for each sounding, then do distance weighted average of the results based on distances to the sounding stations.

- if landuse(P) is forest

then

wind_speed(P) = 0.75 * (estimate from [A] or [B])

.

APPENDIX E. LA BASIN TEST RESULTS

Los Angeles Basin Self Test Results

There are two columns of numbers under each category. The first is the observed reading at the NWS weather station. The second is the error between the observed reading and the analysis systems output. For example, in the first row of data, the temperature at LAX was 75.0 F. The error between 75.0 F and the output from Mercury's analysis system is -2.3 F. Therefore, the output from the analysis system was 72.7 F. A blank in the data column indicates missing data. A blank in the results columns only indicates a location for which the tested version of MERCURY produced no result, due to insufficient input.

Station	Date	Temperature		Dewpoint		Hor. Wind		Ver. Wind	
LAX	90071616	75.0	-2.3	62.0	1.9	-4.0	2.3	6.9	-5.6
LGB	90071616	72.0	0.6	64.0	-1.0	1.6	-3.9	8.9	-4.7
NUC	90071616								
NZJ	90071616	72.0	1.4	61.0	2.6	2.6	-1.9	3.1	2.2
RIV	90071616	75.0	-1.0	63.0	-0.8	1.5	-2.0	-1.3	1.4
SBD	90071616	73.0		63.0		-0.0		-0.0	
VCV	90071616	77.0		56.0		-0.0		-0.0	
BUR	90071616	73.0	-0.5	64.0	-0.9	0.0	-1.3	4.0	-2.7
CNO	90071616					-0.0	-1.8	-0.0	1.3
CRQ	90071616					5.2	-8.4	3.0	2.3
EMT	90071616					-0.0	0.4	-0.0	2.1
FUL	90071616	74.0	-1.3	63.0	0.1	1.2	-1.6	6.9	-2.9
HHH	90071616					-0.0	-4.0	-0.0	5.9
PMD	90071616					-4.0	0.3	6.9	-4.6
POC	90071616					-0.0	-1.0	-0.0	1.8
RAI	90071616					-0.0	-0.3	-0.0	0.4
SNA	90071616	73.0	-0.5	64.0	-2.3	1.2	-0.1	6.9	-2.8
TOA	90071616	70.0	3.6			-8.7	7.8	5.0	-0.8
VNY	90071616	72.0	1.2	63.0	0.8	-0.0	-1.3	-0.0	3.5
EDW	90071616	79.0		59.0		0.9	-4.9	4.9	2.0
ONT	90071616	77.0	-3.5	60.0	2.8	-3.8	3.9	1.4	-1.0
SMO	90071616	74.0	-0.3	64.0	-1.4	-4.7	2.5	1.7	2.5
WJF	90071616	78.0	1.0	52.0	7.0	-4.7	1.5	1.7	4.9
NUC	90071617								
LGB	90071617	73.0	1.0	65.0	-1.6	1.4	-2.8	7.9	-2.5
LAX	90071617	76.0	-1.0	63.0	1.5	-3.5	3.0	6.1	-0.1
NZJ	90071617	75.0	0.2	62.0	2.4	0.0	1.6	4.0	3.1
RIV	90071617	79.0	-0.5	62.0	1.0	1.7	-1.1	-1.0	1.5
SBD	90071617	78.0		64.0		-0.0		-0.0	
BUR	90071617	76.0	-0.1	63.0	-0.2	0.0	-5.0	5.0	-0.2
CNO	90071617					-0.0	4.0	-0.0	3.1

CRQ 90071617					5.0	-6.2	0.0	7.1
EMT 90071617					3.8	0.7	1.4	0.5
FUL 90071617	75.0	-0.6	63.0	1.0	-1.2	2.6	6.9	-1.9
HHR 90071617					-0.9	-1.8	4.9	1.2
ONT 90071617	80.0	-3.4	60.0	3.1	5.4	-3.8	4.5	-4.0
PMD 90071617					-1.4	1.4	3.8	-3.8
POC 90071617					8.0	-5.5	0.0	3.2
RAL 90071617					-0.0	2.1	-0.0	1.2
SMO 90071617	77.0	-1.6	65.0	-2.0	3.8	-6.6	10.3	-5.1
SNA 90071617	75.0	-0.3	65.0	-2.5	1.7	-1.5	9.8	-5.3
TOA 90071617	71.0	4.0			-6.1	5.4	3.5	2.8
VNY 90071617	76.0	-0.0	62.0	1.4	-9.4	9.6	3.4	2.3
EDW 90071617	83.0		59.0		-0.0	-1.4	-0.0	3.8
VCV 90071617	81.0		58.0		-0.0		-0.0	
WJF 90071617								
LGB 90071618	75.0	0.4	64.0	-1.6	0.0	-0.5	5.0	-3.0
LAX 90071618	76.0	-0.2	63.0	1.1	11.8	-11.8	2.1	0.0
RIV 90071618	84.0	-0.7	62.0	1.0	4.3	1.0	-2.5	1.2
EDW 90071618	88.0		57.0		2.6	-3.9	3.1	0.7
BUR 90071618								
CNO 90071618					-0.0	4.7	-0.0	2.7
CRQ 90071618					4.5	-3.1	5.4	-1.9
EMT 90071618					2.5	-1.0	4.3	-1.8
FUL 90071618	76.0	0.5	63.0	-1.1	-0.0	1.2	-0.0	3.4
HHR 90071618					-0.0	6.3	-0.0	2.9
ONT 90071618	84.0	-4.5	60.0	1.3	5.1	-3.2	6.1	-6.7
PMD 90071618					5.9	-3.3	-1.0	4.1
POC 90071618					4.3	-1.8	-2.5	5.5
RAL 90071618					7.8	-5.0	-4.5	5.2
SMO 90071618	77.0	-1.1	65.0	-2.4	4.0	0.8	6.9	-4.3
SNA 90071618	76.0	3.0	64.0	-1.0	0.0	-0.4	10.0	-8.2
TOA 90071618	73.0	2.9			-8.9	12.0	1.6	1.2
VNY 90071618	78.0	-1.8	63.0	-0.1	0.0	3.3	10.0	-6.1
NUC 90071618								
NZJ 90071618	81.0	-4.5	63.0	0.6	-0.7	1.7	1.9	4.0
SRD 90071618	83.0		64.0		4.0		0.0	
VCV 90071618	84.0		57.0		0.8		-0.6	
MWS 90071618	76.0	1.1	54.0	8.9	1.5	1.0	2.6	1.5
WJF 90071618								
NUC 90071619								
NZJ 90071619	81.0	-2.4	63.0	1.5	-0.7	3.9	1.9	5.8
VCV 90071619	84.0		57.0		0.8		-0.6	
MWS 90071619	76.0	3.9	54.0	9.2	1.5	2.2	2.6	-1.1
LAX 90071619	77.0	0.4	63.0	1.0	7.5	-7.7	2.7	-0.2
LGB 90071619	76.0	1.4	64.0	-1.1	2.7	-3.5	7.5	-4.0
EDW 90071619	93.0		56.0		3.9	-3.9	4.6	-4.6
RIV 90071619	87.0	0.5	62.0	2.0	6.9	-0.5	-4.0	2.5

SBD 90071619	87.0		65.0		4.9		-0.9	
BUR 90071619	84.0	-4.7	63.0	-0.9	-3.8	4.9	3.2	-1.2
CNO 90071619					6.9	-0.6	4.0	-4.1
CRQ 90071619					9.8	-8.9	1.7	3.2
EMT 90071619					3.8	-2.2	1.4	1.2
FUL 90071619	78.0	-0.1	64.0	-1.9	0.7	1.8	3.9	0.2
HHR 90071619					-0.0	3.6	-0.0	3.7
ONT 90071619	89.0	-7.6	61.0	0.8	8.0	-2.2	0.0	2.0
PMD 90071619					-0.0	1.5	-0.0	-1.4
POC 90071619					5.0	-0.1	0.0	2.0
RAL 90071619					6.9	-0.7	-4.0	4.4
SMO 90071619	77.0	1.3	65.0	-2.4	3.1	-0.8	8.5	-6.3
SNA 90071619	78.0	1.9	65.0	-1.8	2.1	-1.6	11.8	-8.9
TOA 90071619	76.0	1.2			-9.4	12.0	3.4	0.1
VNY 90071619	81.0	0.7	62.0	1.0	-0.0	-1.4	-0.0	3.7
WJF 90071619	90.0	3.0	50.0	6.0	1.0	-0.4	-2.8	3.6
MWS 90071620	76.0	4.8	54.0	9.1	1.5	2.4	2.6	0.6
LGB 90071620	78.0	-0.8	64.0	-1.4	4.6	-3.2	3.9	0.0
LAX 90071620	76.0	2.0	63.0	0.9	8.5	-2.9	3.1	-0.6
NZJ 90071620	79.0	0.1	63.0	1.4	8.0	-4.2	0.0	7.9
RIV 90071620	90.0	-1.2	63.0	1.2	6.9	-0.3	-1.2	-0.4
SBD 90071620	88.0		65.0		2.0		0.0	
VCV 90071620	92.0		54.0		1.7		-1.0	
BUR 90071620	84.0	-2.7	63.0	-0.9	-3.0	5.2	5.2	-3.2
CNO 90071620					8.7	0.7	5.0	-2.8
CRQ 90071620					6.1	-5.1	-3.5	8.4
EMT 90071620					3.8	-2.2	3.2	-0.6
FUL 90071620	79.0	-0.7	63.0	-0.8	0.0	4.7	6.0	-2.4
HHR 90071620					9.0	-4.3	0.0	3.7
ONT 90071620	91.0	-9.0	62.0	-0.2	13.2	-6.3	4.8	-2.4
PMD 90071620					5.2	-0.4	-3.0	2.2
POC 90071620					5.0	2.0	0.0	3.7
RAL 90071620					7.7	0.2	-6.4	8.9
SMO 90071620	78.0	0.2	65.0	-2.4	5.0	-0.2	8.7	-6.2
SNA 90071620	78.0	1.2	65.0	-1.9	2.1	3.5	11.8	-9.7
TOA 90071620	75.0	2.8			-7.5	13.7	2.7	0.3
VNY 90071620	84.0	-2.3	62.0	1.0	-0.0	0.0	-0.0	5.0
EDW 90071620	93.0		54.0		-0.0	5.2	-0.0	-3.0
NUC 90071620								
WJF 90071620	93.0	-3.9	52.0	2.8	5.9	-2.5	-1.0	0.2
SDB 90071620	83.0		56.0		-5.1		14.1	
LGB 90071621	78.0	0.8	64.0	-0.2	0.0	6.2	8.0	-6.0
LAX 90071621	77.0	1.4	64.0	0.5	6.4	0.7	7.7	-5.5
NZJ 90071621	80.0	-0.7	64.0	0.4	5.6	-1.4	-2.1	8.4
RIV 90071621	92.0	0.0	65.0	-0.0	7.9	0.6	-1.4	0.7
SBD 90071621	92.0		66.0		4.7		1.7	
VCV 90071621	92.0		53.0		-0.7		1.9	

BUR 90071621	85.0	-2.7	64.0	-0.5	-1.4	2.8	7.9	-1.8
CNO 90071621					9.8	0.8	1.7	-1.9
CRQ 90071621					7.0	-0.8	0.0	4.0
EMT 90071621					3.9	-1.3	4.6	-3.2
FUL 90071621	80.0	-0.7	63.0	1.1	6.1	-1.2	3.5	0.3
HHR 90071621					7.9	-1.9	1.4	4.1
ONT 90071621	92.0	-6.6	62.0	2.6	14.0	-5.8	0.0	0.8
PMD 90071621					1.7	3.8	9.8	0.4
POC 90071621					4.9	4.2	-0.9	2.6
RAL 90071621					9.4	-0.3	-3.4	3.8
SMO 90071621	77.0	2.4	65.0	-1.2	8.7	-4.0	5.0	0.3
TOA 90071621	78.0	0.2			7.8	-2.7	-4.5	9.8
VNY 90071621	85.0	-2.3	63.0	1.2	-2.7	4.6	7.5	-1.1
SNA 90071621	78.0	2.2	65.0	-1.3	1.7	4.0	9.8	-9.6
EDW 90071621	97.0		53.0		1.0	0.7	5.9	3.9
NUC 90071621								
WJF 90071621	94.0	-2.8	51.0	3.6	6.5	-5.6	11.3	-1.3
SDB 90071621	82.0		57.0		-6.2		16.9	
LAX 90071622	76.0	3.2	64.0	1.2	11.3	-3.8	6.5	-2.4
LGB 90071622	78.0	1.4	64.0	-0.3	0.0	7.0	10.0	-7.5
NZJ 90071622	81.0	-1.5	63.0	0.6	8.0	-4.0	0.0	5.9
EDW 90071622	100.0		55.0		0.0	1.7	6.0	3.8
NUC 90071622								
RIV 90071622	92.0	0.3	65.0	-1.0	9.4	2.8	-3.4	2.1
SBD 90071622	92.0		65.0		8.0		0.0	
VCV 90071622	94.0		53.0		0.0		5.0	
BUR 90071622	85.0	-2.6	64.0	-0.3	-1.7	1.7	9.8	-3.9
CNO 90071622					14.1	-1.9	5.1	-4.2
CRQ 90071622					6.9	0.5	4.0	1.1
EMT 90071622					3.0	1.1	5.2	-3.6
FUL 90071622	81.0	-1.4	63.0	0.7	4.5	1.3	5.4	-0.7
HHR 90071622					9.4	-0.6	3.4	1.7
ONT 90071622	93.0	-7.2	61.0	3.1	14.8	-3.1	2.6	-0.3
PMD 90071622					16.5	-8.3	9.5	5.7
POC 90071622					7.9	2.5	-1.4	5.0
RAL 90071622					14.1	-2.7	-5.1	6.5
SNA 90071622	78.0	3.1	64.0	-1.0	0.0	7.3	8.0	-5.9
TOA 90071622	79.0	-0.9			10.4	-4.2	-6.0	12.4
VNY 90071622	85.0	-2.2	63.0	1.4	-5.1	6.7	6.1	2.2
WJF 90071622	93.0	0.0	53.0	3.2	10.0	1.7	17.3	-7.8
SMO 90071622	78.0	1.0	66.0	-2.2	5.0	1.9	8.7	-3.3
SDB 90071622	82.0		58.0		-5.5		15.0	
VNY 90071623	85.0	-2.7	63.0	0.8	-5.1	7.1	6.1	-1.2
LAX 90071623	75.0	3.0	64.0	1.9	9.5	-1.2	5.5	-2.4
LGB 90071623	79.0	-0.7	65.0	-1.2	0.0	6.7	12.0	-8.4
NZJ 90071623	78.0	1.5	63.0	0.7	9.0	-4.9	0.0	9.7
RIV 90071623	92.0	1.3	66.0	-1.3	11.3	1.8	-6.5	3.4

VCV 90071623	93.0		55.0		-1.7		9.8	
BUR 90071623	85.0	-3.0	63.0	0.9	-1.7	2.0	4.7	1.3
CRQ 90071623					7.9	-0.3	1.4	3.9
FUL 90071623	80.0	-0.6	63.0	1.2	4.0	1.8	6.9	-0.9
HHR 90071623					9.8	-1.9	1.7	3.2
ONT 90071623	94.0	-8.7	61.0	3.5	15.0	-2.9	0.0	0.8
PMD 90071623					14.6	-2.7	12.2	5.5
SMO 90071623	76.0	2.4	67.0	-3.3	8.4	-2.3	7.1	-2.6
SNA 90071623	78.0	1.2	64.0	-0.8	0.0	7.7	15.0	-12.6
TOA 90071623	78.0	-0.3			9.4	-3.3	-3.4	9.6
WJF 90071623	92.0	-0.5	53.0	4.0	12.0	0.4	20.8	-9.8
EDW 90071623	100.0		57.0		11.3	3.3	4.1	8.1
SBD 90071623	93.0		66.0		6.6		-2.4	
CNO 90071623					14.8	-2.2	2.6	-3.2
EMT 90071623					1.7	1.7	9.8	-8.3
POC 90071623					6.6	4.0	-2.4	5.7
RAL 90071623					16.9	-5.0	-6.2	5.3
NUC 90071623								
SDB 90071623	78.0		57.0		-2.3		12.8	
LGB 90071700	79.0	-2.6	65.0	-2.3	0.0	8.2	10.0	-5.3
LAX 90071700	74.0	2.3	64.0	0.6	12.1	-1.3	7.0	-3.4
NZJ 90071700	77.0	2.1	62.0	1.6	8.9	0.2	-1.6	10.7
RIV 90071700	90.0	1.3	65.0	-1.3	10.3	3.5	-3.8	5.0
SBD 90071700	91.0		65.0		8.0		0.0	
VCV 90071700	93.0		54.0		0.0		10.0	
BUR 90071700	84.0	-2.5	63.0	-1.8	-2.7	5.8	7.5	-2.3
CNO 90071700					14.1	-2.0	5.1	-1.1
CRQ 90071700					5.9	4.6	-1.0	6.6
EMT 90071700					1.7	1.0	9.8	-5.4
FUL 90071700	78.0	-0.3	63.0	-0.6	0.0	7.1	10.0	-3.9
HHR 90071700					11.8	-1.3	2.1	3.9
ONT 90071700	92.0	-10.7	60.0	2.1	14.1	-2.4	5.1	-1.0
PMD 90071700					16.7	-1.4	19.9	-3.0
POC 90071700					6.9	1.9	4.0	1.8
RAL 90071700					18.0	-6.7	0.0	2.3
SMO 90071700	74.0	3.4	66.0	-3.0	13.9	-6.0	8.0	-2.6
SNA 90071700	78.0	0.1	64.0	-1.5	9.6	-2.6	11.5	-9.0
TOA 90071700	76.0	0.8			13.8	-6.0	-2.4	8.8
VNY 90071700	86.0	-5.3	60.0	3.3	-2.5	5.1	4.3	2.6
WJF 90071700	90.0	-1.1	53.0	5.2	16.1	-1.9	19.2	-2.2
EDW 90071700	97.0		59.0		12.1	4.6	7.0	12.9
NUC 90071700								
MWS 90071700	72.0	8.5	55.0	8.0	2.5	-0.4	4.3	5.2
SDB 90071700	76.0		57.0		-1.7		9.8	
NUC 90071701								
MWS 90071701	72.0	6.6	55.0	8.2	2.5	2.6	4.3	4.1
LAX 90071701	72.0	3.1	64.0	0.0	10.8	-1.7	1.9	1.8

LGB 90071701	80.0	-5.9	65.0	-2.2	7.9	-1.4	-1.4	5.9
NZJ 90071701	77.0	0.2	63.0	0.7	-2.1	8.0	5.6	1.2
RIV 90071701	86.0	2.0	64.0	-1.5	9.5	2.7	-5.5	5.0
VCV 90071701	90.0		54.0		0.0		15.0	
BUR 90071701	81.0	-0.4	64.0	-2.9	-2.7	5.1	7.5	-2.5
CRQ 90071701					6.1	5.2	3.5	-1.1
FUL 90071701	76.0	0.9	63.0	-0.5	0.0	7.3	8.0	-4.2
HHR 90071701					8.9	1.0	1.6	1.3
ONT 90071701	88.0	-8.6	61.0	0.6	12.2	0.2	4.4	-0.0
PMD 90071701					12.5	-1.3	21.6	-4.2
POC 90071701					6.9	1.9	5.8	-0.8
SMO 90071701	74.0	1.4	65.0	-1.9	13.0	-6.1	10.9	-8.1
SNA 90071701	76.0	1.4	64.0	-0.8	3.4	-1.2	9.4	-4.5
TOA 90071701	72.0	4.0			12.0	-4.1	0.0	2.8
VNY 90071701	85.0	-6.6	60.0	3.8	-3.9	6.2	4.6	2.4
WJF 90071701	88.0	-1.8	54.0	4.4	11.0	0.6	19.1	-0.4
EDW 90071701	94.0		60.0		12.3	0.2	10.3	11.4
SBD 90071701	88.0		63.0		7.9		1.4	
CNO 90071701					16.9	-6.9	6.2	-3.0
EMT 90071701					5.0	-2.2	8.7	-4.3
RAL 90071701					14.1	-3.1	-5.1	7.8
SDB 90071701	74.0		56.0		3.4		9.4	
NUC 90071702								
MWS 90071702	72.0	4.3	55.0	8.6	2.5	1.6	4.3	-1.1
LGB 90071702	77.0	-3.9	65.0	-2.2	7.9	-0.8	-1.4	3.3
LAX 90071702	71.0	2.1	64.0	0.3	12.1	-3.2	7.0	-5.3
NZJ 90071702	75.0	1.5	63.0	0.7	3.8	2.9	1.4	4.7
RIV 90071702	82.0	2.7	63.0	0.2	7.8	4.0	-4.5	4.6
VCV 90071702	85.0		56.0		-4.8		13.2	
EDW 90071702	89.0		60.0		10.4	2.1	6.0	15.7
BUR 90071702	78.0	-1.1	65.0	-2.0	-2.7	5.1	7.5	-3.3
CNO 90071702					9.4	1.8	3.4	-1.6
CRQ 90071702					4.7	6.2	1.7	-1.3
EMT 90071702					3.8	-1.0	3.2	1.1
FUL 90071702	75.0	0.2	63.0	-0.5	1.4	6.2	7.9	-5.9
HHR 90071702					9.8	0.4	1.7	2.1
ONT 90071702	84.0	-6.3	61.0	0.7	12.8	-3.6	2.3	0.4
PMD 90071702					14.7	-2.3	8.5	5.1
POC 90071702					9.4	-1.5	3.4	-0.3
RAL 90071702					16.7	-7.9	-3.0	4.3
SMO 90071702	72.0	1.6	65.0	-1.3	9.5	-1.9	5.5	-1.3
SNA 90071702	76.0	-0.6	64.0	-0.8	5.0	0.2	8.7	-6.8
TOA 90071702	71.0	3.1			11.5	-3.1	-9.6	13.1
VNY 90071702	80.0	-4.1	63.0	1.5	-3.0	4.9	5.2	0.8
WJF 90071702	85.0	-3.0	55.0	3.1	12.9	0.0	15.3	-7.3
SBD 90071702	85.0		64.0		5.6		2.1	
SDB 90071702	71.0		55.0		2.7		7.5	

HHR 90071703					9.8	-1.9	1.7	-0.1
LAX 90071703	69.0	1.9	63.0	0.9	9.4	-1.0	3.4	-2.1
LGB 90071703	73.0	-1.7	64.0	-0.8	5.8	-0.9	-6.9	8.7
RIV 90071703	79.0	1.7	64.0	-0.3	3.8	6.9	-3.2	3.2
VCV 90071703	82.0		53.0		2.6		14.8	
BUR 90071703	73.0	0.3	65.0	-2.0	-3.4	4.8	9.4	-6.8
CNO 90071703					8.7	1.1	5.0	-2.6
CRQ 90071703					6.6	4.3	2.4	-2.0
EMT 90071703					2.5	3.5	4.3	-5.9
FUL 90071703	73.0	-0.2	63.0	0.2	-1.2	7.2	6.9	-6.5
ONT 90071703	80.0	-3.7	60.0	3.7	11.3	-2.9	4.1	-1.3
PMD 90071703					16.9	-3.9	6.2	7.8
POC 90071703					9.0	-1.6	0.0	3.7
RAL 90071703					14.8	-7.6	-2.6	4.5
SMO 90071703	70.0	0.8			9.4	-3.4	3.4	-0.7
SNA 90071703	73.0	0.2	64.0	-1.6	0.0	2.3	8.0	-7.0
TOA 90071703	70.0	1.3			7.7	-0.6	-6.4	7.7
VNY 90071703	75.0	-3.0	63.0	1.8	-3.8	4.8	3.2	3.6
WJF 90071703	81.0	-3.0	57.0	2.1	12.9	2.2	15.3	-8.7
SBD 90071703	81.0		65.0		6.0		0.0	
EDW 90071703	85.0		61.0		13.9	3.1	8.0	-1.8
NZJ 90071703	73.0	0.5	62.0	1.6	0.2	2.9	1.0	4.4
NUC 90071703								
SDB 90071703	67.0		56.0		2.7		7.5	
HHR 90071704					9.8	-1.7	1.7	-1.2
RAL 90071704					14.8	-8.0	-2.6	3.6
TOA 90071704	70.0	0.4			7.7	-0.1	-6.4	7.2
LGB 90071704	71.0	-0.0	64.0	-0.7	6.9	-1.6	-5.8	6.9
LAX 90071704	69.0	1.0	63.0	0.2	9.8	-1.7	1.7	-0.5
NZJ 90071704	71.0	1.5	62.0	2.3	1.9	2.7	0.7	4.0
RIV 90071704	76.0	2.7	65.0	-2.0	5.2	4.5	-3.0	2.6
SBD 90071704	79.0		64.0		3.0		0.0	
VCV 90071704	80.0		53.0		0.7		1.9	
BUR 90071704	72.0	-0.3	64.0	-1.0	-0.9	4.1	4.9	-4.2
CNO 90071704					6.1	4.8	3.5	-2.2
CRQ 90071704					-0.0	8.8	-0.0	-1.5
EMT 90071704					2.5	1.7	4.3	-6.1
FUL 90071704	73.0	-1.6	63.0	0.4	0.0	6.3	5.0	-4.8
ONT 90071704	78.0	-3.3	60.0	3.8	13.8	-7.5	2.4	-0.6
PMD 90071704					16.9	-6.8	6.2	4.9
POC 90071704					4.9	3.1	-0.9	3.5
SMO 90071704	69.0	1.3	63.0	0.2	6.9	0.0	4.0	-2.8
SNA 90071704	72.0	-0.4	65.0	-2.6	2.7	0.6	7.5	-7.0
VNY 90071704	73.0	-1.9	63.0	0.7	-0.0	2.2	-0.0	3.9
WJF 90071704	78.0	-2.8	57.0	2.4	10.3	3.9	12.3	-6.1
NUC 90071704								
EDW 90071704	81.0		61.0		9.5	7.4	5.5	0.7

SDB 90071704	66.0		57.0		1.2		6.9	
RAL 90071705					14.8	-9.4	-2.6	3.7
TOA 90071705	70.0	-0.5			7.7	-0.6	-6.4	7.5
CNO 90071705					6.1	2.7	3.5	-3.6
CRQ 90071705					-0.0	9.1	-0.0	-1.3
EMT 90071705					2.5	2.0	4.3	-5.5
FUL 90071705	73.0	-2.6	63.0	0.3	0.0	6.6	5.0	-4.7
POC 90071705					4.9	1.9	-0.9	2.7
SMO 90071705	69.0	0.3	63.0	0.2	6.9	-0.6	4.0	-2.8
LGB 90071705	70.0	0.7	64.0	-0.8	8.5	-3.8	-3.1	3.8
LAX 90071705	68.0	1.7	63.0	0.2	9.8	-3.9	1.7	-0.9
RIV 90071705	75.0	0.7	65.0	-2.0	3.9	4.7	-0.7	0.2
SBD 90071705	76.0		64.0		0.9		0.5	
VCV 90071705	78.0		53.0		-0.5		3.0	
EDW 90071705	80.0		61.0		9.5	4.3	5.5	6.1
BUR 90071705	71.0	-0.7	64.0	-1.0	-0.9	3.6	4.9	-4.2
ONT 90071705	75.0	-1.6	60.0	3.6	10.0	-3.7	0.0	1.8
PMD 90071705					13.8	-3.1	11.6	0.1
SNA 90071705	71.0	-0.2	65.0	-3.3	5.4	-2.0	4.5	-3.8
WJF 90071705	77.0	-2.0	56.0	2.7	10.9	1.3	13.0	-3.4
NUC 90071705								
NZJ 90071705	70.0	1.5	61.0	3.3	1.9	4.0	0.7	2.3
VNY 90071705	71.0	-0.6	63.0	0.7	-0.0	1.7	-0.0	4.1
SDB 90071705	67.0		55.0		4.7		1.7	
CNO 90071706					6.1	-2.7	3.5	-0.9
CRQ 90071706					-0.0	7.4	-0.0	0.7
EMT 90071706					2.5	-3.3	4.3	1.3
FUL 90071706	73.0	-3.4	63.0	-2.2	0.0	3.7	5.0	-3.8
POC 90071706					4.9	-2.1	-0.9	4.6
SMO 90071706	69.0	0.1	63.0	0.2	6.9	-2.0	4.0	-1.2
BUR 90071706	71.0	-0.9	64.0	-1.9	-0.9	2.9	4.9	-3.5
LGB 90071706	70.0	0.5	64.0	-2.2	4.6	-1.9	-3.9	7.6
LAX 90071706	68.0	1.5	64.0	-1.5	8.5	-3.7	3.1	0.1
RIV 90071706	73.0		65.0		2.0		0.0	
ONT 90071706	73.0	-1.8	60.0	0.3	3.8	1.0	3.2	-0.7
PMD 90071706					9.6	0.7	11.5	0.3
SNA 90071706	71.0	-0.9	65.0	-2.6	4.9	-3.4	0.9	1.0
VNY 90071706	71.0	-0.8	63.0	0.1	-0.0	1.3	-0.0	4.6
WJF 90071706	77.0	-1.9	55.0	2.9	10.9	-0.9	13.0	-4.1
EDW 90071706	79.0		61.0		7.7	2.0	6.4	5.1
NZJ 90071706	69.0	2.3	62.0	2.3	0.3	4.0	2.0	-0.6
SBD 90071706	74.0		64.0		1.9		0.7	
VCV 90071706	76.0		55.0		-2.1		5.6	
MWS 90071706	67.0	4.2	47.0	16.0	-1.0	3.6	5.9	-1.7
NUC 90071706								
SDB 90071706	69.0		53.0		16.9		-6.2	
SNA 90071707	71.0	-1.8	65.0	-2.1	4.9	-3.3	0.9	-1.7

VNY 90071707	71.0	-0.5	63.0	0.1	-0.0	-3.8	-0.0	3.1
EDW 90071707	79.0		61.0		7.7	2.0	6.4	5.1
MWS 90071707	67.0		47.0		-1.0		5.9	
NUC 90071707								
LGB 90071707	69.0	1.4	64.0	0.3	3.9	-0.3	-4.6	5.1
LAX 90071707	68.0	1.3	64.0	-1.0	6.6	-5.9	2.4	-2.7
RIV 90071707	72.0		65.0		2.0		-0.3	
SBD 90071707	73.0		64.0		-0.0		-0.0	
VCV 90071707	74.0		55.0		0.3		0.9	
BUR 90071707	71.0	-0.7	64.0	-2.1	-5.2	6.0	3.0	-2.5
ONT 90071707	72.0		59.0		3.8		3.2	
PMD 90071707					7.7	-0.0	9.2	-0.5
NZJ 90071707	69.0	1.9	63.0	1.4	0.9	3.8	-0.3	0.9
WJF 90071707	75.0	-0.3	56.0	2.7	7.7	0.3	9.2	-2.0
SDB 90071707	68.0		55.0		11.3		-6.5	
SNA 90071708	71.0	-2.6	65.0	-2.1	4.9	-4.1	0.9	-1.5
VNY 90071708	71.0	-2.2	63.0	1.0	-0.0	-3.2	-0.0	2.5
EDW 90071708	79.0		61.0		7.7	0.1	6.4	2.8
MWS 90071708	67.0		47.0		-1.0		5.9	
LGB 90071708	69.0	1.1	64.0	0.3	3.9	-0.6	-4.6	5.2
PMD 90071708					7.7	-0.0	9.2	-0.5
LAX 90071708	68.0	0.3	64.0	-1.0	5.9	-5.9	1.0	-1.0
NZJ 90071708	68.0	2.9	63.0	1.4	-0.0	4.7	-0.0	0.4
RIV 90071708	71.0		65.0		1.0		-0.2	
SBD 90071708	72.0		64.0		-0.0		-0.0	
VCV 90071708	73.0		54.0		0.0		2.0	
BUR 90071708	69.0	1.3	65.0	-3.1	-4.3	5.0	2.5	-2.1
ONT 90071708	72.0		59.0		3.8		1.4	
NUC 90071708								
WJF 90071708	75.0	-0.7	55.0	3.3	7.7	0.7	9.2	-2.2
SDB 90071708	67.0		54.0		14.7		-8.5	
LGB 90071709	69.0	-0.7	64.0	-3.0	3.9	-3.9	-4.6	4.6
PMD 90071709					7.7	1.5	9.2	-1.5
NUC 90071709								
LAX 90071709	68.0	0.3	64.0	-3.0	6.6	-6.6	2.4	-2.4
NZJ 90071709	68.0	0.4	61.0	3.0	-0.0	5.0	-0.0	-2.5
RIV 90071709	70.0		65.0		-0.0		-0.0	
VCV 90071709	73.0		53.0		-0.7		1.9	
BUR 90071709	69.0		65.0		-0.0		-0.0	
ONT 90071709	72.0		59.0		-0.0		-0.0	
SBD 90071709	71.0		64.0		-0.0		-0.0	
WJF 90071709	74.0	-7.0	56.0	-2.0	9.2	-1.1	7.7	0.4
SDB 90071709	67.0		54.0		11.0		0.0	
NUC 90071710								
LAX 90071710	68.0	0.3	64.0	-2.0	8.0	-6.7	0.0	-0.7
NZJ 90071710	68.0	-0.3	62.0	2.0	1.7	8.3	-1.0	1.0
RIV 90071710	70.0		65.0		-0.0		-0.0	

VCV 90071710	72.0		54.0		-0.0		-0.0	
BUR 90071710	68.0		64.0		-0.0		-0.0	
ONT 90071710	71.0		59.0		-0.0		-0.0	
SBD 90071710	69.0		63.0		-0.0		-0.0	
WJF 90071710	75.0		55.0		8.4		7.1	
SDB 90071710	66.0		53.0		6.9		1.2	
LAX 90071711	68.0	0.3	64.0	-2.0	7.0	-7.0	0.0	0.0
NZJ 90071711	68.0	-0.3	62.0	2.0	-0.0	8.8	-0.0	0.0
RIV 90071711	70.0		65.0		2.0		0.0	
VCV 90071711	72.0		54.0		-0.3		2.0	
BUR 90071711	68.0		64.0		-0.0		-0.0	
ONT 90071711	69.0		59.0		3.8		1.4	
WJF 90071711	74.0		56.0		9.5		5.5	
SBD 90071711	69.0		63.0		-0.0		-0.0	
SDB 90071711	67.0		53.0		8.0		0.0	
LAX 90071712	68.0	0.3	64.0	-2.0	6.6	-4.4	-2.4	2.8
NZJ 90071712	68.0	-0.3	62.0	2.0	3.0	5.3	0.5	-3.5
RIV 90071712	69.0		64.0		2.0		-0.3	
BUR 90071712	68.0		64.0		-0.0		-0.0	
ONT 90071712	69.0		59.0		-0.0		-0.0	
MWS 90071712	67.0		47.0		-0.0		-0.0	
SBD 90071712	69.0		63.0		-0.0		-0.0	
VCV 90071712	71.0		55.0		-0.3		2.0	
WJF 90071712	73.0		55.0		7.8		4.5	
SDB 90071712	68.0		52.0		5.6		-2.1	
EDW 90071712	72.0		61.0		2.5		4.3	
MWS 90071713	67.0		47.0		-0.0		-0.0	
LGB 90071713	69.0	1.1	65.0	-1.7	4.7	-4.7	-1.7	1.7
LAX 90071713	68.0	0.3	64.0	-2.0	8.0	-8.0	0.0	0.0
NZJ 90071713	68.0	2.7	62.0	1.6	-0.0	0.4	-0.0	-0.2
RIV 90071713	68.0		65.0		2.6		-1.5	
VCV 90071713	70.0		55.0		-0.0		-0.0	
EDW 90071713	73.0		62.0		5.4		4.5	
BUR 90071713	67.0	0.2	65.0	-3.1	-0.0	1.1	-0.0	-0.1
ONT 90071713	70.0		58.0		-0.0		-0.0	
WJF 90071713	73.0		55.0		9.5		5.5	
SBD 90071713	69.0		62.0		-0.0		-0.0	
SNA 90071713	71.0	-2.7	64.0	-1.7	-0.0	0.8	-0.0	-0.3
VNY 90071713	67.0	0.1	63.0	1.0	-0.0	0.8	-0.0	0.0
CRQ 90071713					-0.0	6.8	-0.0	-1.0
SDB 90071713	68.0		52.0		5.9		1.0	
MWS 90071714	67.0	1.4	47.0	15.9	-0.0	0.1	-0.0	-0.0
LGB 90071714	70.0	-1.7	65.0	-3.5	0.0	2.3	-5.0	4.9
LAX 90071714	69.0	-0.9	64.0	-0.7	8.0	-5.2	0.0	-1.8
NZJ 90071714	68.0	2.4	63.0	0.4	2.8	-2.6	-1.0	1.0
RIV 90071714	70.0	-1.0	66.0	-4.0	0.2	-0.4	-1.0	1.2
SBD 90071714	69.0		63.0		-0.0		-0.0	

VCV 90071714	72.0		55.0		-1.9		2.3	
BUR 90071714	67.0	1.1	65.0	-2.7	-0.0	1.4	-0.0	-0.1
CNO 90071714					-0.0	-1.1	-0.0	1.1
CRQ 90071714					-0.0	6.8	-0.0	-1.0
EMT 90071714					-0.0	0.1	-0.0	-0.0
FUL 90071714	68.0	1.1	62.0	-1.0	3.5	-2.7	2.0	-3.3
HHR 90071714					3.2	2.0	-3.8	3.8
ONT 90071714	69.0	-0.3	59.0	1.2	-2.3	2.5	1.9	-1.9
PMD 90071714					6.4	-1.3	7.7	-5.0
RAL 90071714					-0.0	-0.2	-0.0	0.2
SNA 90071714	71.0	-2.7	64.0	-1.1	-0.0	2.0	-0.0	-0.7
VNY 90071714	68.0	-0.6	63.0	1.0	-0.0	1.4	-0.0	0.2
WJF 90071714	74.0	-1.0	55.0	2.5	5.6	0.0	2.1	4.4
EDW 90071714	73.0		61.0		3.0	3.4	5.2	2.5
NUC 90071714								
SMO 90071714	68.0	0.5	64.0	-0.7	4.3	-0.3	2.5	-3.4
TOA 90071714	68.0	1.0			-0.0	3.3	-0.0	-1.9
SDB 90071714	73.0		52.0		3.9		-0.7	
LGB 90071715	70.0	-1.5	65.0	-1.9	0.0	2.1	-5.0	4.7
NZJ 90071715	68.0	2.4	63.0	0.4	2.8	-2.6	-1.0	1.0
RIV 90071715	70.0	-1.0	66.0	-4.0	0.2	-0.4	-1.0	1.2
SBD 90071715	69.0		63.0		-0.0		-0.0	
VCV 90071715	72.0		55.0		-1.9		2.3	
BUR 90071715	67.0	1.3	65.0	-1.6	-0.0	1.2	-0.0	-0.3
CNO 90071715					-0.0	-1.1	-0.0	1.2
CRQ 90071715					-0.0	2.4	-0.0	-2.1
EMT 90071715					-0.0	0.0	-0.0	-3.7
FUL 90071715	68.0	1.6	62.0	1.8	3.5	-2.7	2.0	-3.6
HHR 90071715					3.2	-0.1	-3.8	2.3
ONT 90071715	69.0	0.1	59.0	4.6	-2.3	2.5	1.9	-1.9
PMD 90071715					6.4	-1.3	7.7	-5.0
RAL 90071715					-0.0	-0.2	-0.0	0.2
SNA 90071715	71.0	-2.7	64.0	-1.1	-0.0	2.0	-0.0	-0.7
VNY 90071715	68.0	-0.5	63.0	1.7	-0.0	1.2	-0.0	-0.0
WJF 90071715	74.0	-1.0	55.0	2.5	5.6	0.0	2.1	4.4
EDW 90071715	73.0		61.0		3.0	3.4	5.2	2.5
NUC 90071715								
SMO 90071715	68.0	1.1	64.0	0.0	4.3	-1.8	2.5	-4.5
TOA 90071715	68.0	1.4			-0.0	2.5	-0.0	-2.5
SDB 90071715	73.0		52.0		3.9		-0.7	
LAX 90071715	70.0	-1.9	64.0	0.0	4.3	-1.5	-2.5	0.6
LGB 90071716	70.0	-1.5	65.0	-1.9	0.0	2.1	-5.0	4.7
NZJ 90071716	68.0	2.4	63.0	0.4	2.8	-2.6	-1.0	1.0
RIV 90071716	70.0	-1.0	66.0	-4.0	0.2	-0.4	-1.0	1.2
SBD 90071716	69.0		63.0		-0.0		-0.0	
VCV 90071716	72.0		55.0		-1.9		2.3	
BUR 90071716	67.0	1.3	65.0	-1.6	-0.0	1.2	-0.0	-0.3

CNO 90071716					-0.0	-1.1	-0.0	1.2
CRQ 90071716					-0.0	2.4	-0.0	-2.1
EMT 90071716					-0.0	0.0	-0.0	-3.7
FUL 90071716	68.0	1.6	62.0	1.8	3.5	-2.7	2.0	-3.6
HHR 90071716					3.2	-0.1	-3.8	2.3
ONT 90071716	69.0	0.1	59.0	4.6	-2.3	2.5	1.9	-1.9
PMD 90071716					6.4	-1.3	7.7	-5.0
RAL 90071716					-0.0	-0.2	-0.0	0.2
SNA 90071716	71.0	-2.7	64.0	-1.1	-0.0	2.0	-0.0	-0.7
VNY 90071716	68.0	-0.5	63.0	1.7	-0.0	1.2	-0.0	-0.0
WJF 90071716	74.0	-1.0	55.0	2.5	5.6	0.0	2.1	4.4
EDW 90071716	73.0		61.0		3.0	3.4	5.2	2.5
NUC 90071716								
SMO 90071716	68.0	1.1	64.0	0.0	4.3	-1.8	2.5	-4.5
TOA 90071716	68.0	1.4			-0.0	2.5	-0.0	-2.5
SDB 90071716	73.0		52.0		3.9		-0.7	
LAX 90071716	70.0	-1.9	64.0	0.0	4.3	-1.5	-2.5	0.6
LAX 90071717	70.0		64.0		4.3		-2.5	
WJF 90071722	96.0		54.0		12.9		15.3	
SDB 90071722	86.0		55.0		-6.4		7.7	
LGB 90071723	84.0	-4.1	65.0	-1.0	10.3	-1.6	-3.8	6.1
NZJ 90071723	83.0	0.8	62.0	2.6	9.0	-0.7	0.0	7.9
LAX 90071723	74.0	3.8	64.0	0.7	15.8	-6.2	2.8	-1.3
RIV 90071723	94.0	0.3	64.0	-0.8	13.2	-1.3	-4.8	2.8
SBD 90071723	94.0		64.0		6.9		1.2	
VCV 90071723	98.0		46.0		4.7		-1.7	
BUR 90071723	87.0	-3.3	60.0	0.3	-2.7	4.6	7.5	-5.0
CNO 90071723					12.2	-2.4	4.4	-6.6
CRQ 90071723					7.5	5.4	-2.7	2.4
EMT 90071723					2.1	4.4	5.6	-7.2
FUL 90071723	87.0	-4.7	64.0	0.2	3.4	6.0	9.4	-8.3
HHR 90071723					10.0	3.0	0.0	1.9
ONT 90071723	95.0	-6.1	61.0	2.8	9.4	1.6	-3.4	5.5
PMD 90071723					17.3	-4.4	10.0	3.4
POC 90071723					7.9	0.8	-1.4	2.8
RAL 90071723					16.0	-5.6	-5.8	5.7
SMO 90071723	75.0	3.7	66.0	-3.5	10.7	-1.4	9.0	-7.1
SNA 90071723	82.0	2.0	65.0	-2.3	7.5	1.1	13.0	-12.2
TOA 90071723	75.0	4.8			13.0	-2.9	-7.5	9.3
VNY 90071723	88.0	-4.6	58.0	3.4	-4.7	7.0	1.7	4.7
EDW 90071723	104.0		59.0		13.2	4.2	4.8	5.2
WJF 90071723	96.0	0.2	54.0	3.4	12.9	1.7	15.3	-6.3
SDB 90071723	84.0		55.0		-4.5		7.8	
LGB 90071800	84.0	-4.9	65.0	-2.4	10.3	-2.1	-3.8	6.7
LAX 90071800	74.0	3.7	64.0	1.1	12.2	-3.8	4.4	-0.8
NZJ 90071800	81.0	1.8	62.0	2.2	7.5	-1.2	2.7	6.2
RIV 90071800	92.0	1.5	59.0	3.2	11.8	-0.5	-2.1	2.4

VCV 90071800	97.0		55.0		2.4		13.8	
BUR 90071800	86.0	-2.6	61.0	1.1	-2.7	3.9	7.5	-4.9
CNO 90071800					14.1	-4.3	5.1	-4.4
CRQ 90071800					8.0	3.1	0.0	1.5
EMT 90071800					5.1	-2.2	6.1	-3.1
FUL 90071800	85.0	-3.6	62.0	0.8	8.5	-0.3	3.1	-0.4
HHR 90071800					9.4	1.0	3.4	-0.2
ONT 90071800	95.0	-9.4	60.0	0.7	10.0	1.7	0.0	3.3
PMD 90071800					12.9	3.4	15.3	-2.3
POC 90071800					8.0	0.7	0.0	2.9
RAL 90071800					15.0	-4.2	0.0	1.2
SMO 90071800	75.0	3.5	67.0	-4.2	7.7	-0.0	9.2	-5.9
SNA 90071800	81.0	1.4	65.0	-2.7	2.6	6.1	14.8	-13.2
TOA 90071800	75.0	4.5			11.3	-2.4	-4.1	7.2
VNY 90071800	88.0	-5.5	61.0	1.1	-4.9	6.5	0.9	5.9
WJF 90071800	95.0	-1.6	54.0	2.9	16.9	-4.1	14.1	-2.1
EDW 90071800	100.0		60.0		13.9	-1.0	8.0	7.3
MWS 90071800	79.0	4.8	56.0	6.6	2.6	2.8	3.1	2.8
SBD 90071800	93.0		63.0		5.9		-1.0	
SDB 90071800	83.0		52.0		10.4		-6.0	
WJF 90071801	95.0	-4.6	54.0	1.9	16.9	-3.4	14.1	-5.2
MWS 90071801	79.0	3.4	56.0	7.2	2.6	-1.0	3.1	2.6
LGB 90071801	81.0	-3.0	63.0	0.1	9.4	-1.2	-3.4	4.4
LAX 90071801	72.0	4.6	65.0	0.2	12.2	-3.5	4.4	-4.2
NZJ 90071801	79.0	2.6	63.0	0.6	7.9	0.7	1.4	3.8
VCV 90071801	94.0		56.0		0.0		13.0	
BUR 90071801	86.0	-3.6	62.0	1.4	-3.4	5.3	9.4	-6.4
CNO 90071801					16.0	-4.0	5.8	-3.0
CRQ 90071801					8.0	3.1	0.0	-0.9
EMT 90071801					1.0	1.9	5.9	-2.9
FUL 90071801	84.0	-4.3	63.0	-0.8	6.1	2.4	3.5	-2.0
HHR 90071801					10.0	0.3	0.0	2.3
ONT 90071801	93.0	-8.5	61.0	-0.2	14.1	-1.3	5.1	-2.0
PMD 90071801					13.8	2.5	11.6	1.4
POC 90071801					10.0	-0.5	0.0	4.1
RAL 90071801					14.8	-2.9	-2.6	4.7
SMO 90071801	74.0	3.1	67.0	-3.3	7.5	0.2	2.7	0.2
SNA 90071801	80.0	0.5	64.0	-1.1	6.4	2.4	7.7	-6.5
TOA 90071801	74.0	3.6			12.1	-3.4	-7.0	8.5
VNY 90071801	87.0	-4.9	63.0	-0.1	-3.2	4.3	3.8	2.7
EDW 90071801	97.0		59.0		13.9	-0.1	8.0	3.6
RIV 90071801	90.0	2.3	58.0	4.5	9.4	2.9	-3.4	3.2
SBD 90071801	92.0		63.0		6.9		-1.2	
SDB 90071801	80.0		51.0		10.7		-9.0	
MWS 90071802	79.0	0.6	56.0	7.4	2.6	0.7	3.1	1.9
LGB 90071802	78.0	-2.5	65.0	-2.7	10.8	-2.7	-1.9	3.3
LAX 90071802	71.0	2.9	65.0	-0.0	11.8	-2.9	2.1	-1.2

NZJ 90071802	77.0	2.4	62.0	1.4	7.5	1.0	2.7	1.6
VCV 90071802	93.0		50.0		11.8		2.1	
EDW 90071802	93.0		59.0		13.2	0.6	4.8	6.8
BUR 90071802	81.0	-1.2	65.0	-1.1	-2.7	5.2	7.5	-4.8
CNO 90071802					7.7	3.3	9.2	-10.9
CRQ 90071802					5.0	6.3	0.0	-0.4
EMT 90071802					3.0	-0.1	5.2	-2.2
FUL 90071802	82.0	-4.5	61.0	1.7	6.9	1.4	5.8	-4.4
HHR 90071802					10.0	0.1	0.0	1.3
ONT 90071802	90.0	-7.3	61.0	0.4	12.8	-4.8	-2.3	6.5
POC 90071802					7.5	0.5	-2.7	5.3
RAL 90071802					14.1	-5.7	-5.1	6.5
SMO 90071802	72.0	2.9	66.0	-1.6	8.7	-0.9	5.0	-3.2
SNA 90071802	78.0	0.2	64.0	-1.8	7.7	0.5	6.4	-4.2
TOA 90071802	70.0	5.6			10.4	-1.2	-6.0	7.4
VNY 90071802	84.0	-5.8	64.0	0.8	-2.6	4.2	3.1	2.5
RIV 90071802	88.0	1.3	62.0	2.0	6.1	5.1	-3.5	1.7
SBD 90071802	89.0		65.0		7.9		-1.4	
WJF 90071802	89.0	-2.2	53.0	2.1	14.6	-2.9	12.2	-4.3
SDB 90071802	77.0		49.0		4.5		-5.4	
PMD 90071802					12.3	2.0	10.3	0.6
LGB 90071803	73.0	-0.0	66.0	-3.0	7.7	-0.8	-6.4	9.6
LAX 90071803	70.0	1.5	64.0	0.8	10.3	-2.9	3.8	-0.3
EDW 90071803	89.0		59.0		9.2	2.1	7.7	-1.2
BUR 90071803	78.0	-0.7	65.0	-0.7	-2.1	4.8	5.6	-3.9
CNO 90071803					6.4	4.6	7.7	-5.5
CRQ 90071803					5.0	3.6	0.0	1.1
EMT 90071803					2.1	3.8	5.6	-7.9
FUL 90071803	78.0	-4.3	61.0	3.5	6.9	-0.2	4.0	-2.8
HHR 90071803					9.4	-1.0	3.4	-0.5
ONT 90071803	85.0	-5.0	60.0	3.3	14.1	-7.3	5.1	-1.6
POC 90071803					7.9	0.7	-1.4	5.7
RAL 90071803					10.4	-2.6	-6.0	8.7
SMO 90071803	70.0	2.9	65.0	-0.8	4.0	3.1	6.9	-4.0
SNA 90071803	75.0	-0.2	66.0	-4.4	2.7	3.6	7.5	-7.0
TOA 90071803	69.0	3.6			8.0	-0.3	0.0	1.9
VNY 90071803	81.0	-5.4	64.0	0.9	-0.0	1.0	-0.0	5.4
NZJ 90071803	74.0	2.0	61.0	3.9	5.0	0.3	0.0	4.8
RIV 90071803	84.0	1.0	64.0	-0.3	6.1	2.1	-3.5	2.6
PMD 90071803					11.3	0.4	6.5	3.3
SBD 90071803	85.0		65.0		3.9		0.7	
VCV 90071803	88.0		53.0		7.8		4.5	
WJF 90071803	85.0	-1.4	55.0	-0.3	12.3	-1.9	10.3	-5.1
SDB 90071803	75.0		48.0		5.0		-8.7	
CNO 90071804					6.4	0.9	7.7	-6.2
EMT 90071804					2.1	3.8	5.6	-7.9
HHR 90071804					9.4	-0.4	3.4	-0.2

POC 90071804					7.9	-1.7	-1.4	5.3
RAL 90071804					10.4	-3.3	-6.0	8.4
TOA 90071804	69.0	2.2			8.0	0.2	0.0	2.4
LGB 90071804	72.0	-0.6	65.0	-1.4	9.4	-2.7	-3.4	6.1
LAX 90071804	69.0	1.4	64.0	0.9	11.3	-3.9	4.1	-0.6
RIV 90071804	81.0	1.0	64.0	-0.5	9.4	-2.0	-3.4	2.2
VCV 90071804	81.0		56.0		-0.3		2.0	
EDW 90071804	86.0		60.0		8.7	2.1	5.0	4.0
BUR 90071804	75.0	-0.0	66.0	-1.8	-3.8	6.7	3.2	-1.3
CRQ 90071804					-0.0	9.2	-0.0	1.9
FUL 90071804	75.0	-2.8	62.0	2.3	5.6	1.3	2.1	-0.2
ONT 90071804	82.0	-4.9	59.0	4.9	6.9	0.0	4.0	-0.5
PMD 90071804					10.7	-2.1	9.0	-4.0
SMO 90071804	69.0	2.4	65.0	-0.7	4.0	3.4	6.9	-4.1
SNA 90071804	73.0	-0.7	66.0	-3.1	2.4	5.2	6.6	-5.3
VNY 90071804	78.0	-4.8	64.0	1.6	-0.0	-0.0	-0.0	3.9
NZJ 90071804	71.0	2.9	63.0	1.9	7.9	-3.3	1.4	2.8
SBD 90071804	82.0		65.0		4.0		0.0	
WJF 90071804								
SDB 90071804	73.0		50.0		0.8		0.6	
CNO 90071805					6.4	2.7	7.7	-7.5
EMT 90071805					2.1	3.6	5.6	-7.3
HHR 90071805					9.4	-1.5	3.4	0.7
POC 90071805					7.9	-0.6	-1.4	4.3
RAL 90071805					10.4	-3.9	-6.0	8.2
TOA 90071805	69.0	2.0			8.0	-0.6	0.0	2.6
CRQ 90071805					-0.0	8.2	-0.0	2.1
FUL 90071805	75.0	-3.2	62.0	3.0	5.6	0.6	2.1	-1.1
SMO 90071805	69.0	2.2	65.0	-1.3	4.0	2.9	6.9	-3.3
LGB 90071805	71.0	0.5	66.0	-2.4	6.9	-0.4	-4.0	6.5
LAX 90071805	70.0	0.0	63.0	2.0	9.5	-2.1	5.5	-2.0
NZJ 90071805	71.0	2.7	64.0	1.6	1.9	3.9	-0.7	2.4
RIV 90071805	78.0	1.5	64.0	-1.3	5.6	1.5	-2.1	0.8
VCV 90071805	79.0		56.0		0.9		4.9	
BUR 90071805	73.0	0.1	65.0	-0.2	-0.9	3.5	4.9	-2.9
ONT 90071805	81.0	-5.3	59.0	4.9	10.8	-4.2	1.9	1.5
PMD 90071805					9.0	-2.9	10.7	-7.2
SNA 90071805	73.0	-0.9	67.0	-3.4	4.3	-0.0	2.5	-2.5
VNY 90071805	75.0	-3.1	65.0	-0.2	-0.0	1.7	-0.0	5.1
EDW 90071805	84.0		58.0		6.1	2.9	3.5	7.2
SBD 90071805	79.0		64.0		1.9		0.7	
WJF 90071805								
SDB 90071805	73.0		47.0		2.3		-1.9	
CRQ 90071806					-0.0	7.1	-0.0	1.8
FUL 90071806	75.0	-3.1	62.0	-0.2	5.6	-0.3	2.1	-3.0
SMO 90071806	69.0	2.3	65.0	-1.9	4.0	1.2	6.9	-4.8
SNA 90071806	73.0	-1.4	67.0	-2.9	4.3	1.1	2.5	-2.1

VNY 90071806	75.0	-3.7	65.0	-0.9	-0.0	-0.3	-0.0	4.3
EDW 90071806	84.0		58.0		6.1	1.6	3.5	2.9
LGB 90071806	71.0	1.5	65.0	-2.9	6.1	-1.1	-3.5	5.6
LAX 90071806	70.0	0.3	63.0	1.1	8.5	-5.1	3.1	1.3
RIV 90071806	77.0		63.0		1.9		-0.7	
SBD 90071806	77.0		63.0		0.9		0.3	
VCV 90071806	77.0		55.0		0.0		4.0	
BUR 90071806	72.0	1.2	65.0	-1.3	-2.5	4.3	4.3	-3.3
ONT 90071806	79.0		58.0		9.8		-1.7	
PMD 90071806					7.7	-1.6	6.4	-2.9
MWS 90071806	72.0		48.0		2.5		-4.3	
NZJ 90071806	70.0	3.6	65.0	0.5	4.9	0.1	0.9	0.8
WJF 90071806								
SDB 90071806	72.0		47.0		1.7		-1.0	
SNA 90071807	73.0	-2.3	67.0	-2.5	4.3	-3.3	2.5	-3.0
VNY 90071807	75.0	-4.0	65.0	-1.0	-0.0	0.3	-0.0	0.2
EDW 90071807	84.0		58.0		6.1	1.6	3.5	2.9
MWS 90071807	72.0		48.0		2.5		-4.3	
LGB 90071807	71.0	1.1	64.0	2.3	4.3	-1.5	-2.5	4.1
LAX 90071807	70.0	0.3	64.0	1.0	1.4	-1.4	3.8	-3.8
RIV 90071807	75.0		63.0		2.6		-1.5	
SBD 90071807	77.0		61.0		-0.0		-0.0	
VCV 90071807	77.0		55.0		-0.5		3.0	
BUR 90071807	71.0	3.1	65.0	-1.5	-0.0	0.5	-0.0	-0.1
ONT 90071807	78.0		60.0		4.7		-1.7	
PMD 90071807					1.7	4.3	9.8	-6.3
NZJ 90071807	70.0	3.2	65.0	1.1	-0.0	4.4	-0.0	1.7
WJF 90071807								
SDB 90071807	71.0		49.0		4.9		-0.9	
MWS 90071808	72.0		48.0		2.5		-4.3	
LGB 90071808	71.0	-0.7	64.0	1.0	4.3	-4.3	-2.5	2.5
LAX 90071808	70.0	0.3	64.0	1.0	-0.9	0.9	4.9	-4.9
RIV 90071808	74.0		63.0		2.0		0.0	
SBD 90071808	75.0		63.0		-0.0		-0.0	
VCV 90071808	76.0		54.0		-0.3		0.9	
BUR 90071808	70.0		65.0		-0.0		-0.0	
ONT 90071808	75.0		59.0		2.0		3.5	
PMD 90071808					1.7		9.8	
NZJ 90071808	70.0	0.4	65.0	-1.0	-0.0	2.9	-0.0	-0.1
WJF 90071808								
SDB 90071808	71.0		49.0		4.9		-0.9	
LGB 90071809	71.0	-0.7	64.0	-2.0	4.3	-4.3	-2.5	2.5
PMD 90071809					1.7		9.8	
LAX 90071809	69.0	1.3	64.0	-2.0	2.6	-2.6	3.1	-3.1
RIV 90071809	73.0		63.0		1.5		-1.3	
SBD 90071809	73.0		63.0		-0.0		-0.0	
VCV 90071809	75.0		53.0		-0.2		1.0	

BUR 90071809	70.0		65.0		-0.0		-0.0	
ONT 90071809	75.0		60.0		5.9		-1.0	
NZJ 90071809	70.0	0.1	62.0	2.0	-0.0	4.0	-0.0	-0.8
WJF 90071809								
SDB 90071809	69.0		53.0		4.5		-5.4	
LAX 90071810	69.0	1.3	64.0	-1.0	5.2	?	3.0	-3.0
NZJ 90071810	70.0	-1.3	63.0	1.0	-0.0	5	-0.0	3.7
RIV 90071810	72.0		63.0		-0.0		-0.0	
SBD 90071810	73.0		63.0		-0.0		-0.0	
VCV 90071810	74.0		52.0		-0.0		-0.0	
BUR 90071810	70.0		65.0		-0.0		-0.0	
ONT 90071810	74.0		60.0		-0.0		-0.0	
WJF 90071810								
SDB 90071810	69.0		52.0		7.1		-8.4	
LAX 90071811	69.0	0.3	65.0	-2.0	5.2	-5.2	3.0	-3.0
RIV 90071811	72.0		63.0		-0.0		-0.0	
SBD 90071811	71.0		63.0		-0.0		-0.0	
VCV 90071811	73.0		52.0		-3.1		2.6	
BUR 90071811	70.0		65.0		-0.0		-0.0	
ONT 90071811	72.0		59.0		-0.0		-0.0	
NZJ 90071811	69.0	-0.3	63.0	2.0	-0.0	6.5	-0.0	3.7
WJF 90071811	77.0		52.0		10.8		1.9	
SDB 90071811	69.0		50.0		6.1		-5.1	
LAX 90071812	69.0	0.3	65.0	-2.0	5.2	-5.2	3.0	-3.0
RIV 90071812	72.0		63.0		-0.0		-0.0	
SBD 90071812	71.0		63.0		-0.0		-0.0	
VCV 90071812	73.0		52.0		-3.1		2.6	
BUR 90071812	70.0		65.0		-0.0		-0.0	
ONT 90071812	72.0		59.0		-0.0		-0.0	
NZJ 90071812	69.0	-0.3	63.0	2.0	-0.0	6.5	-0.0	3.7
WJF 90071812	77.0		52.0		10.8		1.9	
SDB 90071812	69.0		50.0		6.1		-5.1	
LAX 90071813	69.0	0.3	65.0	-2.0	5.2	-5.2	3.0	-3.0
RIV 90071813	72.0		63.0		-0.0		-0.0	
SBD 90071813	71.0		63.0		-0.0		-0.0	
VCV 90071813	73.0		52.0		-3.1		2.6	
BUR 90071813	70.0		65.0		-0.0		-0.0	
ONT 90071813	72.0		59.0		-0.0		-0.0	
NZJ 90071813	69.0	-0.3	63.0	2.0	-0.0	6.5	-0.0	3.7
WJF 90071813	77.0		52.0		10.8		1.9	
SDB 90071813	69.0		50.0		6.1		-5.1	

Obs Mean	:	76.6	60.8	4.5	2.5
Error Mean	:	-0.3	0.4	0.4	0.3
Abs Error Mean:		2.0	1.9	2.9	3.5

 * Station Summary *

Station : SDB

Obs Mean	:	72.8	52.8	4.1	0.9
Error Mean	:	-999.9	-999.9	-999.9	-999.9
Abs Error Mean:		-999.9	-999.9	-999.9	-999.9

Station : MWS

Obs Mean	:	72.2	51.2	1.3	1.9
Error Mean	:	3.9	9.6	1.4	1.3
Abs Error Mean:		3.9	9.6	1.7	2.1

Station : WJF

Obs Mean	:	82.6	54.1	9.7	9.3
Error Mean	:	-1.6	3.0	-0.4	-2.3
Abs Error Mean:		2.0	3.1	1.6	4.2

Station : SMO

Obs Mean	:	72.6	65.0	6.3	6.1
Error Mean	:	1.5	-1.6	-0.9	-3.4
Abs Error Mean:		1.7	1.7	2.2	3.7

Station : ONT

Obs Mean	:	79.8	59.8	6.4	1.6
Error Mean	:	-5.3	2.4	-2.0	-0.2
Abs Error Mean:		5.3	2.4	3.2	2.0

Station : EDW

Obs Mean	:	86.5	59.1	7.0	5.3
Error Mean	:	-999.9	-999.9	1.6	4.1
Abs Error Mean:		-999.9	-999.9	2.7	4.8

Station : VNY

Obs Mean	:	77.7	62.8	-1.7	2.0
Error Mean	:	-2.6	1.1	2.6	2.4
Abs Error Mean:		2.7	1.2	3.2	2.9

Station : TOA

Obs Mean	:	72.2	-999.9	4.9	-2.2
Error Mean	:	2.2	-999.9	1.0	4.8
Abs Error Mean:		2.3	-999.9	4.0	5.4

Station : SNA

Obs Mean	:	74.8	64.8	3.1	6.6
Error Mean	:	-0.2	-2.0	1.0	-5.4

Abs Error Mean:	1.4	2.0	2.5	5.5
Station : RAL				
Obs Mean :	-999.9	-999.9	10.3	-3.2
Error Mean :	-999.9	-999.9	-3.5	4.4
Abs Error Mean:	-999.9	-999.9	3.7	4.4
Station : POC				
Obs Mean :	-999.9	-999.9	6.6	-0.2
Error Mean :	-999.9	-999.9	0.4	3.4
Abs Error Mean:	-999.9	-999.9	1.9	3.5
Station : PMD				
Obs Mean :	-999.9	-999.9	8.8	8.9
Error Mean :	-999.9	-999.9	-0.9	-0.4
Abs Error Mean:	-999.9	-999.9	2.3	3.4
Station : HHR				
Obs Mean :	-999.9	-999.9	7.1	1.0
Error Mean :	-999.9	-999.9	-0.2	2.0
Abs Error Mean:	-999.9	-999.9	1.8	2.2
Station : FUL				
Obs Mean :	76.5	62.7	2.9	4.8
Error Mean :	-1.5	0.4	2.2	-2.7
Abs Error Mean:	1.9	1.1	3.1	3.0
Station : EMT				
Obs Mean :	-999.9	-999.9	2.4	4.3
Error Mean :	-999.9	-999.9	0.6	-3.4
Abs Error Mean:	-999.9	-999.9	1.8	3.9
Station : CRQ				
Obs Mean :	-999.9	-999.9	4.0	0.6
Error Mean :	-999.9	-999.9	2.9	1.2
Abs Error Mean:	-999.9	-999.9	5.3	2.4
Station : CNO				
Obs Mean :	-999.9	-999.9	7.6	3.8
Error Mean :	-999.9	-999.9	-0.0	-2.6
Abs Error Mean:	-999.9	-999.9	2.6	3.4
Station : BUR				
Obs Mean :	74.7	64.2	-1.4	3.6
Error Mean :	-0.8	-1.1	3.3	-2.6
Abs Error Mean:	1.5	1.4	3.8	2.7

Station : VCV

Obs Mean	:	80.8	54.1	0.2	3.7
Error Mean	:	-999.9	-999.9	-999.9	-999.9
Abs Error Mean:		-999.9	-999.9	-999.9	-999.9

Station : SBD

Obs Mean	:	79.0	63.8	2.5	0.1
Error Mean	:	-999.9	-999.9	-999.9	-999.9
Abs Error Mean:		-999.9	-999.9	-999.9	-999.9

Station : RIV

Obs Mean	:	78.7	63.8	4.3	-1.8
Error Mean	:	0.7	-0.4	1.5	2.2
Abs Error Mean:		1.2	1.7	2.2	2.2

Station : NZJ

Obs Mean	:	72.8	62.7	2.8	0.6
Error Mean	:	1.0	1.5	2.1	3.0
Abs Error Mean:		1.6	1.6	3.5	3.4

Station : NUC

Obs Mean	:	-999.9	-999.9	-999.9	-999.9
Error Mean	:	-999.9	-999.9	-999.9	-999.9
Abs Error Mean:		-999.9	-999.9	-999.9	-999.9

Station : LGB

Obs Mean	:	74.0	64.5	4.6	-0.5
Error Mean	:	-0.7	-1.4	-0.7	2.5
Abs Error Mean:		1.5	1.6	2.8	5.0

Station : LAX

Obs Mean	:	71.0	63.9	7.4	2.8
Error Mean	:	1.0	-0.1	-3.6	-1.6
Abs Error Mean:		1.4	1.1	4.0	2.0