Project Report
ATC-242

Selected Abstracts on Aviation Weather Hazard Research

L. R. Mahn

2 January 1996

Lincoln Laboratory
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASSACHUSETTS

Prepared for the Federal Aviation Administration,
Washington, D.C. 20591

This document is available to the public through
the National Technical Information Service,
Springfield, VA 22161

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
ATC-242		

4. Title and Subtitle	5. Report Date
Selected Abstracts on Aviation Weather Hazard Research	2 January 1996
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Leslie R. Mahn	ATC-242
9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Lincoln Laboratory, MIT 244 Wood Street Lexington, MA 02173-9108	11. Contract or Grant No. DTFA01-93-Z-02012
12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Department of Transportation Federal Aviation Administration Washington, DC 20591	Project Report
	14. Sponsoring Agency Code

15. Supplementary Notes

This report is based on studies performed at Lincoln Laboratory, a center for research operated by Massachusetts Institute of Technology under Air Force Contract F19628-95-C-0002.

16. Abstract

This paper consists of bibliographic information and abstracts for literature on the topics of weather-related aviation hazards. These abstracts were selected from reports written for the ASR-9, ITWS, TDWR programs, sponsored by the Federal Aviation Administration (FAA), and the Wake Vortex program, sponsored by NASA Langley Research Center. All research was performed by MIT Lincoln Laboratory; some research was performed in collaboration with other organizations. These abstracts were compiled to allow participants in the ASR-9 program to conduct research related to their design, development, and production effort. The abstracts and bibliographic information were retrieved from several commercial databases (INSPEC, Ei Compendex*Plus, Aerospace Database, and NTIS) through an open literature search at the Lincoln Laboratory library. Sufficient information is included for readers to obtain documents of interest to them, but documents will not be provided directly by Lincoln Laboratory.

The Table of Contents allows readers to locate specific abstracts, either by topic or by author. The bibliographic information appears first, followed by the abstract (when one is included in the original document). A Keyword/Text Locator Table is included at the end of the document to allow readers to reference abstracts by specific keywords.

All documents referenced herein are under copyright by the publishing organization. Therefore, fees may be charged by those organizations for providing copies of documents.

17. Key Words		18. Distribution Statement
Airport Surveillance Radar (ASR) Weather System Processor (WSP) Weather Hazard Research Low Altitude Wind Shear Microburst	WSP Development Prototype Aviation Hazard Thunderstorm Gust Front	This document is available to the public through the National Technical Information Service, Springfield, VA 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified		

FORM DOT F 1700.7 (8-72) Reproduction of completed page authorized

ABSTRACT

This paper consists of bibliographic information and abstracts for literature on the topics of weather-related aviation hazards. These abstracts were selected from reports written for the ASR-9, ITWS, TDWR programs, sponsored by the Federal Aviation Administration (FAA), and the Wake Vortex program, sponsored by NASA Langley Research Center. All research was performed by M.I.T. Lincoln Laboratory; some research was performed in collaboration with other organizations. These abstracts were compiled to allow participants in the ASR-9 program to conduct research related to their design, development, and production effort. The abstracts and bibliographic information were retrieved from several commercial databases (INSPEC, Ei Compendex*Plus, Aerospace Database, and NTIS) through an open literature search at the Lincoln Laboratory library. Sufficient information is included for readers to obtain documents of interest to them, but documents will not be provided directly by Lincoln Laboratory.

The Table of Contents allows readers to locate specific abstracts, either by topic or by author. The bibliographic information appears first, followed by the abstract (when one is included in the original document). A Keyword Index is included at the end of the document to allow readers to reference abstracts by specific keywords.

All documents referenced herein are under copyright by the publishing organization Therefore, fees may be charged by those organizations for providing copies of documents.

PREFACE

This bibliography was generated to provide reference material pertinent to the manufacture of the Weather System Processor (WSP) that is hosted on the Airport Surveillance Radar, model 9 (ASR-9). The functional capabilities of the WSP are microburst detection, gust front detection and tracking, and storm movement estimation. These capabilities are similar to those of the Terminal Doppler Weather Radar (TDWR) system whose development was commenced at M.I.T. Lincoln Laboratory in 1984. The TDWR system is currently in operation at airports around the U.S. Work on the WSP commenced in 1985. A functional prototype has been evaluated in operational testing from 1990 through 1995. Both the WSP and the stand-alone TDWR provide improved safety and efficiency at equipped airports.

The meteorological background for the development of the TDWR and WSP systems was initiated in part by the pioneering work of Dr. T. Theodore Fujita of the University of Chicago who recognized the aircraft hazard of low-altitude wind shear due to microbursts. Dr. Fujita's work prompted the pursuit of a microburst wind shear study, the Joint Airport Weather Studies (JAWS). The co-principal investigators on the JAWS study were Dr. Fujita of the University of Chicago and Dr. John McCarthy and Mr. Jim Wilson of the National Center for Atmospheric Research (NCAR).

Dr. John Anderson of the University of Wisconsin Space Science and Engineering Center, Department of Meteorology, proposed in 1985 that it would be possible to detect low-altitude wind shear in the immediate vicinity of an airport using a suitably modified airport surveillance radar. Mr. Carmine Primeggia of the Federal Aviation Administration (FAA) provided the initial support for Lincoln Laboratory to investigate this concept in the ASR-9 program, which focused on the study and development of a fully-automated detection and warning capability for deployment at airports. The WSP work has progressed to the point that the FAA has released a procurement notice indicating immediate need for full-scale development activity, leading to the add-on WSP.

ACKNOWLEDGMENTS

The author would like to thank Bob Hall at M.I.T. Lincoln Laboratory Library and Information Services for his diligence in retrieving the abstracts and bibliographic information. Thanks also to Mary Murphy in Archives for providing a copy of the reports.

CONTENTS

CONTENTS
(Continued)

CONTENTS
(Continued)

CONTENTS
(Continued)

CONTENTS
(Continued)

CONTENTS
(Continued)

CONTENTS
(Continued)

CONTENTS
(Continued)

SECTION I. BACKGROUND
1. THUNDERSTORMS: MICROBURST AND GUST FRONT PHENOMENA

Title:	The Relationship Between Lightning Type and Convective State of Thunderclouds
Author(s):	Williams, E. R. (MIT, Cambridge, MA); Weber, M. E. (MIT, Lexington, MA); Orville, R. E. (New York, State University, Albany)
Conference Title:	International Conference on Atmospheric Electricity, 8th, Uppsala, Sweden, June 13-16, 1988, Proceedings (A89-26201 09-47). Uppsala, Sweden, Institute of High Voltage Research, 1988, p. 235-244.
Sponsor:	Research sponsored by USAF.
Publication Date:	1988
Availability:	Documents available from AIAA Technical Library

Thunderstorm case studies and earlier observations are described which illuminate the relationship between the cloud vertical development and the prevalence of intracloud (IC) and cloud-to-ground (CG) lightning. A consistent temporal evolution starting with peak IC activity changing to predominant CG activity and concluding with strong outflow (microburst) suggests that ice is responsible for both the electrical (i.e., lightning) and dynamical (i.e., microburst) phenomena. A tripole electrical structure is supported by the observations.

E.I. Monthly No:	EIM8711-079768
Title:	Case History of FAA/SRI Wind Shear Models.
Author:	Schlickenmaier, Herbert
Author Affiliation:	FAA
Conference Title:	Wind Shear/Turbulence Inputs to Flight Simulation and Systems Certification.
Conference Location:	Hampton, VA, USA
Conference Date:	1984 May 30-Jun 1
Sponsor:	NASA, Washington, DC
E.I. Conference No.:	10251
Source:	NASA Conference Publication 2474. Publ by NASA, Washington, DC, USA p 3-10
Publication Year:	1987

Abstract

The primary user of the wind shear modeling during the FAA's program was airborne simulation. The project requirement was to use wind shear models that resulted from accidents so that effective procedures and/or equipment could be found for hazardous wind shear encounters. Data sources in 1975 and 1976 were basically of two varieties: typically those that were recreated from actual accidents; and, at the other extreme, what might be considered untried models from tower measurements, and models that were mathematically synthesized. The simple case of a 4-channel flight data recorder that collects airspeed, heading, altitude, and normal acceleration versus time was taken. The author has called the first phase of this 'Recreation.' It is primarily concerned with the flight dynamics of the aircraft and results in a number of wind models that approximate the data recorded on the flight data recorder.

Title:	Electrical Activity Related to Storm Cells Development
Author(s):	LaRoche, P.; Bondiou, A.; Malherbe, C.; Pigere, J. (ONERA, Chatillon, France); Weber, M.; Engholm, C.; Coel, V. (MIT, Lexington, MA) ONERA, TP no. 1993-67, 1993, 5 p.
Conference Title:	International Conference on Atmospheric Electricity, 9th, St. Petersburg, Russia, June 15-19, 1992).
Sponsor:	Research supported by DRET, Direction Generale de l'Aviation Civile, and FAA.
Publication Date:	1993 4 Refs.
Report No.:	ONERA, TP NO. 1993-67
Availability:	Documents available from AIAA Technical Library

Abstract

Simultaneous multiple-Doppler and VHF lightning measurements were performed in the framework of a joint ONERA-Lincoln Laboratory experiment. Data obtained in 91 percent of the events confirm the results of Williams et al. (1988) that the peak in intra-cloud activity precedes the maximum value of the outflow. For several cases a correlation between the onset of the IC electrical activity and the development of slantwise divergence at mid and upper levels was observed. Three peaks were found for the distribution of time intervals between successive bursts: 1 - 3 ms for M-changes, 10 - 30 ms corresponding to the mean interval between successive recoil streamers, and 100 - 200 ms corresponding to a dart leader preceding the return stroke process.

NTIS Accession Number:	N93-19605/3/XAB
Title:	Microburst Characteristics Determined from 1988-1991 TDWR Testbed Measurements
Author(s):	Biron, P. J. ; Isaminger, M. A.
Author Affiliation:	Massachusetts Inst. of Tech., Cambridge.
Sponsor:	National Aeronautics and Space Administration, Washington, DC. Sep 92 38p
Conference Title:	NASA Langley Research Center, Airborne Wind Shear Detection and Warning Systems: Fourth Combined Manufacturers' and Technologists' Conference, Part 1 p 417-455.

Abstract

This paper presents some recent results germane to airborne windshear system design and certification. We first discuss the data analysis procedure and the associated caveats. The relative frequency, severity, and duration of microburst hazards at the various locations is important for determining the tradeoffs between safety and operational impact of false alerts which are encompassed in detection system thresholds. We then consider radar/lidar design issues such as reflective in microbursts and the vertical structure of outflows. Finally, we provide recent surface thermodynamic data associated with microbursts.

NTIS Accession Number:	AD-A250 863/8/XAB
Title:	Summary of Triple Doppler Data Orlando 1991
Author(s):	Keohan, C. F. ; Liepins, M. C. ; Meuse, C. A. ; Wolfson, M. M.
Author Affiliation:	Massachusetts Inst. of Tech., Cambridge.
Report No.:	ATC-186; DOT/FAA/NR-92/2 7
Publication Date:	Apr 92 150p

Abstract

Under Federal Aviation Administration (FAA) sponsorship, Lincoln Laboratory conducted an aviation weather hazard measurement and operational demonstration program during the summer of 1991 near the Orlando International Airport. Three Doppler radars were sited in a triangle around the airport, allowing triple Doppler coverage of thunderstorms and microbursts occurring there. This report contains a summary of all the microburst-producing thunderstorms that occurred within the triple Doppler region that were scanned in a coordinated fashion, during the months of June, July, August, and September 1991. Statistics on the microburst events are presented to give an overall picture of the available data for use in analysis. The bulk of the report consists of detailed information about each triple Doppler day, including the time, location, and strength of microbursts within the triple Doppler period as well as the availability of data from supporting sensors, including the ASR-9-WSP Doppler radar, radiosondes, LLWAS, Mesonet, AWOS, instrumented aircraft, ACARS, interferometer, and corona points. Triple Doppler weather radar data, TASS, three-dimensional wind synthesis, ASR-9, thunderstorm data, ITWS, TDWR.

Title:	Characteristics of Gust Fronts
Author(s):	Klingle-Wilson, Diana; Donovan, Michael F. (MIT, Lexington, MA)
Conference Title:	International Conference on Aviation Weather Systems, 4th, Paris, France, June 24-28, 1991, Preprints (A93-22101 07-47). Boston, MA, American Meteorological Society, 1991, p. 387-392. Research sponsored by FAA.
Publication Date:	1991 11 Refs.
Availability:	Documents available from AIAA Technical Library

Abstract

The thermodynamic characteristics and radar characteristics of gust fronts from three climatic regimes are discussed, with regional differences and similarities of gust fronts highlighted. Propagation speeds, estimated by two techniques, are compared to measured propagation speeds. Ten Denver, nine Kansas City, and 13 Orlando gust fronts were chosen. Mesonet data were used to determine the surface thermodynamic and kinematic characteristics of gust fronts, while reflectivity thin line characteristics were derived from the Terminal Doppler Weather Radar testbed radar. The thermodynamic structure and radar reflectivity thin line signatures of gust fronts are characterized on the basis of the different climatic regimes. It is shown that the Kansas City outflows are colder than Denver and Orlando outflows, and that Denver outflows are driest. The ambient-outflow temperature and relative humidity differences are greatest in Orlando.

Title:	Lightning Activity in Microburst Producing Storm Cells
Author(s):	LaRoche, P.; Malherbe, C.; Bondiou, A. (ONERA, Chatillon, France); Weber, M.; Engholm, C.; Coel, V. (MIT, Lexington, MA)
Conference Title:	(International Conference on Radar Meteorology, 25th, Paris, France, June 24-28, 1991) ONERA, TP no. 1991-98, 1991, 5 p. Research supported by DRET, Direction Generale de l'Aviation Civile, and FAA.
Publication Date:	1991 13 Refs.
Report No.:	ONERA, TP NO. 1991-98
Availability:	Documents available from AIAA Technical Library

Abstract

The paper describes an experiment performed in Orlando (Florida) during the summer of 1990 to investigate the relationships between lightning and weather conditions that are hazardous to aircraft (such as wind shear, turbulence, and heavy precipitation). The experiment used Doppler radars and a two-station lightning detection system. Preliminary results relating the lightning measurements to the cloud evolution are presented.

Title:	VHF Discharges in Storm Cells Producing Microbursts
Author(s):	LaRoche, P.; Malherbe, C.; Bondiou, A.; Office National d'Etudes et de Recherches Aerospatiales, Paris (France); Weber, M.; Engholm, C.; Coel, V. (Massachusetts Inst. of Tech., Lexington.)
Conference Title:	NASA Kennedy Space Center, The 1991 International Aerospace and Ground Conference on Lightning and Static Electricity, Volume 1 13 p (SEE N91-32599 24-47)
Publication Date:	Aug. 1991
Publication Note:	Sponsored in part by DRET and FAA
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC/MF A99

Abstract

An experiment was carried out in which 3-D mapping of VHF sources was compared to a 3-D description of the reflectivity and dynamics of associated cloud cells observed by a radar network. Data from 61 microbursts were analyzed and it was found that, in 93 pct. of the cases, electrical activity precedes outflow development. The results confirm that the peak in intracloud activity precedes the maximum value of the outflow.

Title:	High Resolution Microburst Outflow Vertical Profile Data from Huntsville, Alabama, and Denver, Colorado
Author(s):	Biron, P. J.; Isaminger, M. A.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Publication Date:	Apr. 1991 214P.
Report No.:	AD-A236486; DOD/FAA/PS-88-17
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC/MF A10

Abstract

Detailed data is presented on microburst outflows recorded by the TDWR testbed radar (FL-2). Whenever possible, a microburst detected within 10 km of the radar was scanned in a vertical direction (RHI) at 1 to 2 degree azimuthal intervals about the center of divergence. The vertical profile of the outflow is pertinent to the detection capability and siting strategy of a single Doppler radar observing the microburst from a horizontal viewing angle. Additionally, outflow features are important in assessing the hazard associated with microbursts as well as the capability of other wind shear detection (LLWAS or ASR). Of particular interest is the variability of outflow depths from case to case and site to site. If the depth across the maximum velocity differential is shallow, an outflow might go undetected or underestimated by a radar, the beam of which was not viewing the axis of peak divergence. Previous research projects in Denver reported the highest winds in a microburst typically occur near the surface with an average outflow depth (1/2 peak velocity) ranging between 500 and 600 meters; however, the vertical resolution of these data was fairly crude due to the scan strategies utilized. Detailed high resolution microburst outflow vertical profile data is provided which is pertinent to TDWR system studies based on RHI and closely spaced PPI scans.

Title:	Aspect Angle Dependence of Outflow Strength in Denver Microbursts - Spatial and Temporal Variations
Author(s):	Hallowell, Robert G. (MIT, Lexington, MA)
Conference Title:	Conference on Severe Local Storms, 16th and Conference on Atmospheric Electricity, Kananaskis Park, Canada, Oct. 22-26, 1990, Preprints (A92-27926 10-47). Boston, MA, American Meteorological Society, 1990, p. 397-402. Research sponsored by FAA.
Publication Date:	1990 8 Refs.
Availability:	Documents available from AIAA Technical Library

Abstract

Results from a detailed study of 96 individual observations from 27 microburst events to develop and test the Terminal Doppler Weather Radar (TDWR) wind shear surveillance system are presented. As part of this study MIT Lincoln Laboratory has developed algorithms for automatically detecting microbursts, or thunderstorm outflows utilizing the radial velocity data gathered from a single TDWR. The data show that microbursts, on average, have maximum strengths and extents that are 1.9:1 and 1.5:1 asymmetric, respectively.

Title:	A Case Study of The Claycomo, Missouri Microburst on July 30, 1989
Author(s):	Biron, Paul J.; Isaminger, Mark A.; Flemming, Kevin J. (MIT, Lexington, MA); Borho, Alan A. (North Dakota, University, Grand Forks)
Conference Title:	Conference on Severe Local Storms, 16th and Conference on Atmospheric Electricity, Kananaskis Park, Canada, Oct. 22-26, 1990, Preprints (A92-27926 10-47). Boston, MA, American Meteorological Society, 1990, p. 388-392. Research sponsored by FAA.
Publication Date:	1990 7 Refs.
Availability:	Documents available from AIAA Technical Library

Abstract

The strong multicell thunderstorm of July 30, 1989 near Claycomo generated a microburst with a maximum differential velocity of 45 m/sec. This microburst was preceded by mid- and upper-level velocity features as well as a descending, high reflectivity core. Each surface velocity differential pulse was preceded by a descent in center-of-mass altitude; this microburst would have been a considerable hazard to an aircraft penetrating the outflow.

Title:	Predicting Summer Microburst Hazard from Thunderstorm Day Statistics
Author(s):	Cullen, Joseph A.; Wolfson, Marilyn M. (MIT, Lexington, MA)
Conference Title:	Conference on Severe Local Storms, 16th and Conference on Atmospheric Electricity, Kananaskis Park, Canada, Oct. 22-26, 1990, Preprints (A92-27926 10-47). Boston, MA, American Meteorological Society, 1990, p. 383-387. Research sponsored by FAA.
Publication Date:	1990 22 Refs.
Availability:	Documents available from AIAA Technical Library

Abstract

A major contributor to the determination of benefits derivable from advanced wind shear detection equipment is a knowledge of the average relative microburst threat at each major airport. Thunderstorm day statistics are presently used in conjunction with measurements by the FAA's Terminal Doppler Weather Radar testbed systems to predict microburst threats. The equations thus derived for relating microbursts to thunderstorm days are noted to be suitable only for summer.

Title:	Meteorological and Electrical Conditions Associated with Positive Cloud-to-Ground Lightning
Author(s):	Engholm, Cynthia D.; Williams, Earle R.; Dole, Randall M. (MIT, Cambridge, MA)
Journal:	Monthly Weather Review (ISSN 0027-0644), vol. 118, Feb. 1990, p. 470-487.
Publication Date:	Feb. 1990 33 Refs.
Availability:	Documents available from AIAA Technical Library

Abstract

Meteorological and electrical conditions associated with the occurrence of positive cloud-to-ground lightning (i.e., lightning that lowers positive charge to ground) are examined. Results from case studies in winter and summer storms reveal common features and lend support to the tilted dipole hypothesis. Lightning bipoles, whose lengths range from the convective scale to the mesoscale, are aligned with the vertical wind shear, with a predominance of negative locations in proximity to the deepest convection and a mixture of positive and negative locations displaced downshear from the deepest convection. Comparisons with radar data show that all lightning events are located within a distance of 10-20 km of precipitations extending from the surface to several kilometers above the 0 C isotherm. Electrostatic field measurements beneath precipitation removed from the deepest convection indicate a positive dipole structure and a tilting deformation by vertical wind shear. These observations suggest that the principal contributor to positive lightning downshear of the deepest convection is mesoscale change separation by differential particle motions rather than mesoscale advection over distances of 100 km or more.

Title:	Characteristics of Thunderstorm-Generated Low Altitude Wind Shear: A Survey Based on Nationwide Terminal Doppler Weather Radar Testbed Measurements
Author(s):	Wolfson, M.; Klingle-Wilson, D.; Donovan, M.; Cullen, J.; Neilley, D.; Liepins, M.; Hallowell, R.; DiStefano, J.; Clark, D.; Isaminger, M.; Biron, P.; Forman, B.
Author Affiliation:	Lincoln Lab., MIT, Lexington, MA, USA
Conference Title:	Proceedings of the 29th IEEE Conference on Decision and Control (Cat. No. 90CH2917-3) p.682-8 vol. 2.
Publisher:	IEEE, New York, NY, USA
Publication Date:	1990; 6 vol. 3671 pp.
Conference Sponsor:	IEEE
Conference Date:	5-7 Dec. 1990
Conference Location:	Honolulu, HI, USA

Abstract

The characteristics of microbursts and gust fronts, two forms of aviation-hazardous low altitude wind shear, are presented. Data were collected with a prototype terminal Doppler weather radar and a network of surface weather stations in Memphis, Huntsville, Denver, Kansas City, and Orlando. Regional differences and features that could be exploited in detection systems such as the associated reflectivity, surface wind shear, and temperature change are emphasized.

Title:	A Case Study of the 24 August 1986 FLOWS Microburst
Author(s):	Isaminger, Mark A.; Biron, Paul J.; Hallowell, Robert G.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Publication Date:	Nov. 1989 83P.
Report No.:	AD-A216939
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC A05/MF A01

Abstract

From 1984 to 1986, Lincoln Laboratory collected wind shear measurements in the southeastern United States using a pulsed Doppler radar. The major emphasis of the measurement program and subsequent analyses is the development and testing of algorithms that will enable the Terminal Doppler Weather Radar (TDWR) to provide wind shear warnings to the aviation community by detection and tracking gust fronts and microbursts. An important phase of the program involves determining appropriate scan strategies and algorithms to detect other radar measurable features which precede or accompany the surface outflows of microbursts. The detection of features aloft such as convergence, rotation, divergence, storm cells, and descending reflectivity cores may permit advanced recognition of the wind shear while it is less than 10 m/s. A microburst on 24 August 1986 in Huntsville is analyzed with single and dual-Doppler techniques to assess microburst precursors, asymmetry, and forcing mechanisms which could be used for future algorithm development. The microburst producing storm formed within a moist adiabatic, unstable air-mass with weak wind shear at low to mid-levels of the atmosphere. Rotation, convergence, divergent tops, and a descending core were detected prior to the outflow attaining a divergence of 10 m/s. This storm is similar to other Huntsville microburst producing cells in exhibiting upper-level divergence prior to the initial microburst outflow.

Title:	An Analysis of Microburst Characteristics Related to Automatic Detection from Huntsville, Alabama and Denver, Colorado
Author(s):	Biron, Paul J.; Isaminger, Mark A. (MIT, Lexington, MA)
Conference Title:	Conference on Radar Meteorology, 24th, Tallahassee, FL, Mar. 27-31, 1989, Preprints (A90-28576 11-47). Boston, MA, American Meteorological Society, 1989, p. 269-273. Research supported by FAA.
Publication Date:	1989 16 Refs.
Availability:	Documents available from AIAA Technical Library

Abstract

Microburst measurements from the Terminal Doppler Weather Radar (TDWR) system testbed are presently analyzed in order to characterize and compare outflow types in an environment possessing a typically dry subcloud layer, as in Denver, Colorado, and a typically moist subcloud layer, as in Huntsville, Alabama, and then correlate these characteristics with observable features which emerge when the TDWR system is used for microburst detection. The evidence obtained suggests that the reflectivity and intensity of the outflow are important to the microburst detection system's performance, while the frequency and intensity of features aloft may provide for an earlier microburst detection.

Title:	Electrical Characteristics of Microburst-Producing Storms in Denver
Author(s):	Williams, Earle R. (MIT, Cambridge, MA); Weber, Mark E.; Engholm, Cynthia D. (MIT, Lexington, MA)
Conference Title:	Conference on Radar Meteorology, 24th, Tallahassee, FL, Mar. 27-31, 1989, Preprints (A90-28576 11-47). Boston, MA, American Meteorological Society, 1989, p. 89-92. Research sponsored by FAA.
Publication Date:	1989 8 Refs.
Availability:	Documents available from AIAA Technical Library

Abstract

Radar and electrical observations of microbursts-producing storms in Denver from June-September 1988 are studied and compared with electrical data obtained in Huntsville, Alabama in 1987 and 1988. It is observed that: all Denver clouds that produce microburst are electrified; the lightning rates for dry microbursts in Denver are an order of magnitude smaller than the wet microbursts of Huntsville; peak lightning rates occur several minutes prior to the time of maximum outflow for both cases; the maximum corona current in Denver is 50-100 percent greater than that of Huntsville; and storms in both cases may produce active lightning, but no symmetrical outflow. It is noted that the electrical data are useful for determining convective development and assessing microburst hazards.

Title:	A Preliminary Study of Precursors to Huntsville Microbursts
Author(s):	Isaminger, M. A.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Publication Date:	Oct. 1988 29P.
Report No.:	AD-A200914; ATC-153; DOT/FAA/PM-87/35
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC A03/MF A01

Abstract

Automated algorithms are being developed for the detection of wind shears such as microbursts and gust fronts. Previous studies have shown that these outflows can be hazardous to an airplane during takeoffs and landings. The ultimate goal of a microburst detection algorithm is the timely warning of potentially hazardous wind shears through the detection of reliable precursors. Research in Colorado and Oklahoma documented the significance of precursors such as descending reflectivity cores, convergence, rotation, and reflectivity notching as indicators that a microburst will occur in the very near future. The overall importance of an individual feature varies between regions. This investigation will focus on those precursors which play a dominant role in the formation of wet microbursts in the southeastern United States. The data analyzed in this report was gathered by the FAA TDWR S-band Doppler radar during 1985 and 1986 in Memphis, Tennessee, and Huntsville, Alabama.

Title:	The Downburst: Microburst and Macroburst
Author(s):	Fujita, T. Theodore
Author Affiliation:	The University of Chicago,
Publication Date:	1985, 131P.; Published by Satellite and Mesometeorology Research Project (SMRP), Department of the Geophysical Sciences, The University of Chicago, 4734 Ellis Avenue, Chicago, IL 60637.
Report No.:	PB85-148880; SMRP-RP-210; LC-85-50115
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC A07/MF A01 National Technical Information Service PB-148880

Abstract

Until several years ago, microbursts and tornadoes were regarded as being unrelated. An amazing similarity between these severe storms is presented. A tornado is an intense mesocyclone in which the swirling air rushes upward, while a microburst, at inflow and downflow levels, is surrounded by a mesocyclone in which the swirling air rushes downward. The history of downburst identification is presented, as are some observations of macrobursts and microbursts. How the microburst is related to some aircraft accidents is also studied.

NTIS Accession Number:	AD-A163 277/7/XAB
Title:	A Gust Front Case Studies Handbook
Author(s):	Klingle, D.L.
Author Affiliation:	MIT Lincoln Lab., Lexington, MA
Publication Date:	10 Jan. 1985 96p
Report No.:	ATC-129; DOT/FAA/PM-84/15
Sponsor:	Federal Aviation Administration, Washington, DC. Program Engineering and Maintenance Service.
Availability:	DTIC and NTIS
Note:	Original contains color plates: All DTIC and NTIS reproductions will be in black and white. Prepared in cooperation with Purdue Univ., West Lafayette, IN. Dept. of Geosciences.

Abstract

Gust fronts produce low altitude wind shear that can be hazardous to aircraft operations, especially during takeoff and landing. Radar meterologists have long been able to identify gust front signatures in Doppler radar data, but in order to use the radars efficiently, automatic detection of such hazards is essential. Eight gust front case studies are presented. The data include photographs of the Doppler weather radar displays, thermodynamic and wind measurements from a 440 m high tower, environmental soundings and tables of gust front characteristics. The tabulated characteristics are those though to be the most important in developing rules for automatic gust front detection such as length and height, maximum and minimum values of reflectivity, velocity and spectrum width, and estimates of radial shear. For the cases studied, outflows could be detected most reliably in the velocity field, but useful information also could be gleaned from the spectrum width and reflectivity fields. The signal-to-noise ratio threshold was found to be a major factor in the ability of an observer to discern the gust front signature in the Doppler radar displays. Detection within the spectrum width field required a higher SNR than did the radial velocity field.

2. FAA TERMINAL WEATHER DETECTION SYSTEMS OVERVIEWS

Title:	Development of an Automated Windshear Detection System Using Doppler Weather Radar
AuthAvailability:or(s):	Evans, J.; Turnbull, D.
Author Affiliation:	MIT Lincoln Lab., Lexington, MA, USA
Journal:	Proceedings of the IEEE vol. 77, no. 11 p.1661-73
Publication Date:	Nov. 1989
ISSN:	0018-9219

Abstract

The US Federal Aviation Administration (FAA) is developing the Terminal Doppler Weather Radar (TDWR) system to determine the location and severity of LAWS (low-altitude windshear) phenomena and other weather hazards (e.g., tornadoes and turbulence) and to provide the pertinent information to real-time air traffic control users. The FAA program for developing and evaluating the TDWR is described, with emphasis on the resolution of key technical issues such as separation of the radar return due to the low-altitude weather phenomena from that caused by various clutter sources and the automatic detection of the phenomena by means of pattern recognition applied to images depicting the weather reflectivity and Doppler shift. These technical issues have been addressed using experimental data obtained using a testbed radar in representative meteorological regimes. The system performance has been assessed using numerous experimental windshear data sets with corresponding 'truth' developed by experienced radar meteorologists from a number of organizations. It is shown that the system provides very reliable detection of strong microbursts in a variety of environments with a gust-front detection capability that supports effective planning of airport runway use.

Title:	FAA/M.I.T. Lincoln Laboratory Doppler Weather Radar Program
Author:	Evans, James E.
Author Affiliation:	MIT, Cambridge, MA, USA
Conference Title:	Meteorological and Environmental Inputs to Aviation Systems, Proceedings
Conference Location:	Tullahoma, TN, USA
Conference Date:	1985 Mar 12-14
Sponsor:	NASA, Washington, DC, USA; NOAA, Dep of Commerce, USA; FAA, DOT, USA; US Dep of Defense, USA; Office of the Federal Coordinator for Meteorology, USA
Source:	NASA Conference Publication n 2498. Publ by NASA, Washington, DC, USA. p 155-166
Publication Year:	1988
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC A11/MF A01
ISSN:	0191-7811

Abstract

The Federal Aviation Administration (FAA)-sponsored Doppler weather radar program at M.I.T. Lincoln Laboratory focuses on providing real-time information on hazardous aviation weather to end users such as air traffic control (ATC) and pilots. The existing Weather Surveillance Radar/Air Route Surveillance Radar (WSR/ARSR) network which provides real-time reflectivity data via the Remote Radar Weather Display System (RRWDS) will be replace by Next Generation Weather Radar (NEXRAD).

Title:	Doppler Radar for Warning of Weather Hazards Around Air Terminals
Author:	Evans, James E.
Author Affiliation:	MIT, Lexington, MA, USA
Conference Title:	IGARSS '87. Remote Sensing: Understanding the Earth as a System.
Conference Location:	Ann Arbor, MI, USA
Conference Date:	1987 May 18-21
Sponsor:	IEEE Geoscience & Remote Sensing Soc, New York, NY, USA; Int Union of Radio Science, Commission F, Brussels, Belg
Source:	Digest - International Geoscience and Remote Sensing Symposium (IGARSS) 1987. Publ by IEEE, New York, NY, USA. Available from IEEE Service Cent (Cat n 98CH2434-9), Piscataway, NJ, USA p 601
Publication Year:	1987

Abstract

Hazardous weather, especially wind shear, in the vicinity of airports is of serious concern to the air traffic control system as a result of weather caused accidents and adverse impact on efficient airport operations. Doppler weather radar had been chosen as a principal sensor for detecting the weather phenomena due to its capability for remotely sensing the precipitation and (radial) winds within the hazard generating storms. Automated detection is essential due to the transitory nature of a principal hazard (the microburst) and the nature of the air traffic control system. Progress towards fully automated detection of terminal hazards is reported, with emphasis on microburst and gust front detection using a Doppler radar similar to the NEXRAD program sensors. Topics addressed include signal processing techniques to provide high-quality weather estimates, pattern analysis techniques to identify characteristic signatures in the radar generated images and the spatial/temporal association of features observed at various altitudes within a storm. Experimental testing results were obtained from Huntsville, AL and Memphis, TN.

Title:	Status of the Terminal Doppler Weather Radar One Year Before Deployment
Author:	Evans, James E. (MIT, Lexington, MA)
Conference Title:	International Conference on Aviation Weather Systems, 4th, Paris, France, June 24-28, 1991, Preprints (A9-22101 07-47). Boston, MA, American Meteorological Society, 1991, p. J1-J6.
Sponsor:	FAA
Publication Date:	1991 18 Refs.
Availability:	Documents available from AIAA Technical Library

Abstract

The current status and deployment strategy for the operational systems of the Terminal Doppler Weather Radar are described, and recent results from extensive testing of the radar system concept and weather information dissemination approach are presented. Tables show microburst detection performance, gust front detection performance as a function of gust front strength, and gust front/wind shift planning product performance.

Title:	The Cooperative Huntsville Meteorological Experiment (COHMEX)
Author(s):	Dodge, J. (NASA, Washington, DC); Arnold, J.; Wilson, G. (NASA, Marshall Space Flight Center, Huntsville, AL); Evans, J. (MIT, Lexington, MA); Fujita, T. (Chicago, University, IL)
Sponsor:	National Aeronautics and Space Administration, Washington, D.C.
Journal:	American Meteorological Society, Bulletin (ISSN 0003-0007), vol. 67, April 1986, p. 417-419.
Publication Date:	Apr. 1986
Availability:	Documents available from AIAA Technical Library

Abstract

The Satellite Precipitation and Cloud Experiment, the Microburst and Severe Thunderstorm, and the FAA Lincoln Laboratories Operational Weather Studies of the COHMEX are described. The precipitation and cloud experiment focuses on the prestorm period in order to observe the physical processes leading to the formation of small convective systems. Aircraft, remote sensing and rawinsonde data are utilized to determine various storm/environment characteristics. Doppler velocity and reflectivity of microburst clouds are studied to evaluate the three-dimensional structure of microbursts from thunderstorms. The weather studies are designed to develop and test automatic algorithms for wind shear detection using Doppler weather radars. The application of satellite systems to data collection for these experiments is discussed.

Title:	Airborne Wind Shear Detection and Warning Systems: Third Combined Manufacturers' and Technologists' Conference, part 1
Author(s):	Vicroy, Dan D.; Bowles, Roland L.; Schlickenmaier, Herbert (Federal Aviation Administration, Washington, DC.), comps.
Author Affiliation:	National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
Publication Date:	Jan. 1991 490P.
Note:	Conference held in Hampton, VA, 16-18 Oct. 1990
Report No.:	NASA-CP-10060-PT-1; NAS 1.55:10060-PT-1; DOT/FAA/RD-91/2-PT-1
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC/MF A21

Abstract

Papers presented at the conference on airborne wind shear detection and warning systems are compiled. The following subject areas are covered: terms of reference; case study; flight management; sensor fusion and flight evaluation; Terminal Doppler Weather Radar data link/display; heavy rain aerodynamics; and second generation reactive systems.

Title:	Airborne Wind Shear Detection and Warning Systems: Third Combined Manufacturers' and Technologists' Conference, part 2
Author(s):	Vicroy, Dan D.; Bowles, Roland L.; Schlickenmaier, Herbert (Federal Aviation Administration, Washington, DC.), comps.
Author Affiliation:	National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
Publication Date:	Jan. 1991 464P.
Presentation Note:	Conference held in Hampton, VA, 16-18 Oct. 1990
Report No.:	NASA-CP-10060-PT-2; NAS 1.55:10060-PT-2; DOT/FAA/RD-91/2-PT-2
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC/MF A20

Abstract

The Third Combined Manufacturers' and Technologists' Conference was held in Hampton, Va., on October 16-18, 1990. The purpose of the meeting was to transfer significant on-going results of the NASA/FAA joint Airborne Wind Shear Program to the technical industry and to pose problems of current concern to the combined group. It also provided a forum for manufacturers to review forward-look technology concepts and for technologists to gain an understanding of the problems encountered by the manufacturers during the development of airborne equipment and the FAA

Title:	Airborne Wind Shear Detection and Warning Systems. Second Combined Manufacturers' and Technologists' Conference, part 2
Author(s):	Spady, Amos A., Jr.; Bowles, Roland L.; Schlickenmaier, Herbert (Federal Aviation Administration, Washington, DC.), comps.
Author Affiliation:	National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
Publication Date:	Jul. 1990 452P.
Presentation Note:	Conference held in Williamsburg, VA, 18-20 Oct. 1988
Report No.:	NASA-CP-10050-PT-2; NAS 1.55:10050-PT-2
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC/MF A20

Abstract

The Second Combined Manufacturers' and Technologists' Conference was hosted jointly by NASA Langley (LaRC) and the Federal Aviation Administration (FAA) in Williamsburg, Virginia, on October 18 to 20, 1988.

The meeting was co-chaired by Dr. Roland Bowles of LaRC and Herbert Schlickenmaier of the FAA. The purpose of the meeting was to transfer significant, ongoing results gained during the second year of the joint NASA/FAA Airborne Wind Shear Program to the technical industry and to pose problems of current concern to the combined group. It also provided a forum for manufacturers to review forward-look technology concepts and for technologists to gain an understanding of the problems encountered by the manufacturers during the development of airborne equipment and the FAA

Title:	Airborne Wind Shear Detection and Warning Systems. Second Combined Manufacturers' and Technologists' Conference, part 1
Author(s):	Spady, Amos A., Jr.; Bowles, Roland L.; Schlickenmaier, Herbert (Federal Aviation Administration, Washington, DC.), comps.
Author Affiliation:	National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
Publication Date:	Jul. 1990 347P.
Presentation Note:	Conference held in Williamsburg, VA, 18-20 Oct. 1988 Report No.: NASA-CP-10050-PT-1; NAS 1.55:10050-PT-1
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC/MF A15

Abstract

The Second Combined Manufacturers' and Technologists' Conference hosted jointly by NASA Langley (LaRC) and the Federal Aviation Administration (FAA) was held in Williamsburg, Virginia, on October 18 to 20, 1988. The purpose of the meeting was to transfer significant, ongoing results gained during the second year of the joint NASA/AA Airborne Wind Shear Program to the technical industry and to pose problems of current concern to the combined group. It also provided a forum for manufacturers to review forward-look technology concepts and for technologists to gain an understanding of the problems encountered by the manufacturers during the development of airborne equipment and the FAA certification requirements.

Title:	Windshear Case Study: Denver, Colorado, July 11, 1988 Final Report
Author:	Schlickenmaier, Herbert W.
Author Affiliation:	Federal Aviation Administration, Washington, DC. Flightcrew Systems Research Branch.
Publication Date:	Nov. 1989 470P.
Report No.:	DOT/FAA/DS-89/19
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC A20/MF A03

Abstract

On Monday 11 July 1988 between 2207 and 2213 UTC (16:07 to 16:13 MDT), four successive United flights had inadvertent wind shear encounters with microburst windshear conditions while on final approach to Denver Stapleton Airport (DEN), each resulting in a missed approach, subsequent delay, and uneventful arrival. A fifth flight executed a missed approach without encountering the phenomena. All of the flight crews were trained utilizing the resources of the Windshear Training Aid. There was no damage to aircraft and no passenger injuries. At the time the aircraft encountered the microburst, the Terminal Doppler Weather Radar (TDWR) Operations Test and Experiment (OT&E) was in progress and detected divergent flow that intersected the operating zones for the approach runways. The radar used to test the TDWR algorithm was the Massachusetts Institute of Technology Lincoln Laboratory 10 cm Doppler radar. This Windshear Case Study outlines the technical details of the encounter, as well as describes insights gained from this confrontation that should be applied to future investigations of aircraft encountering windshear. Information was summarized from several sources including flight crew comments, air traffic control (ATC) operations and surveillance radar data, flight data recorders, data from the TDWR and the Low-Level Wind Shear Alert System (LLWAS), technical details of the event meteorology, and data from the Terminal Area Simulation System (TASS).

Title:	Airborne Wind Shear Detection and Warning Systems: First Combined Manufacturers' and Technologists' Conference
Author(s):	Spady, Amos A., Jr.; Bowles, Roland L.; Schlickenmaier, Herbert (Federal Aviation Administration, Washington, D.C.), comps.
Author Affiliation:	National Aeronautics and Space Administration. Langley Research Center, Hampton, VA
Publication Date:	Jan. 1988 558P.
Presentation Note:	Conference held in Hampton, Va., 22-23 Oct. 1987
Report No.:	NASA-CP-10006; NAS 1.55:10006; DOT/FAA/PS-88/7
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC A24/MF A01

Abstract

The purpose of the meeting was to transfer significant, ongoing results gained during the first year of the joint NASA/FAA Airborne Wind Shear Program to the technical industry and to pose problems of current concern to the combined group. It also provided a forum for manufacturers to review forward-looking technology concepts and for technologists to gain an understanding of FAA certification requirements and the problems encountered by the manufacturers during the development of airborne equipment.

E.I. Monthly No:	EIM8711-079795
Title:	Simulator Manufacture Committee: Subcommittee A.
Author(s):	Kosydar, Gerald M.; Copeland, Jim; Hall, John; Lindeman, George; McCarthy, John; Reilly, Dave; Schlickenmaier, Herb; Schoenman, Dick; Stoer, Ray
Conference Title:	Wind Shear/Turbulence Inputs to Flight Simulation and Systems Certification.
Conference Location:	Hampton, VA, USA
Conference Date:	1984 May 30-Jun 1
Sponsor:	NASA, Washington, DC, USA
E.I. Conference No.:	10251
Source:	NASA Conference Publication 2474. Publ by NASA, Washington, DC, USA p 253-254
Publication Year:	1987

Abstract

In the Simulator Manufacture session, we tried to concentrate on the main issues as they relate to simulators when used for crew training. The first issue was: Do we now have the meteorological data that we need? For microbursts, the consensus was that we do; however, there were important exceptions to this statement. In particular, there is still a need for pressure and temperature data, and getting pressure and temperature data at all the grid points is, in fact, a very, very large job. This, therefore, raises questions that the simulator manufacture session recommends be addressed by the ad hoc committee. Namely, what accuracy and resolution can we expect for parameters such as pressure and temperature? What quality of simulation can we expect based on those parameters; and will it be adequate to meet current regulations? Finally, in what time frame can this type of data be expected?

E.I. Monthly No:	EIM8711-079791
Title:	Main Airframe Manufacture Committee: Subcommittee A.
Author(s):	Rickard, William W.; Copeland, Jim; Kosydar, Jerry; Lindeman, George; McCarthy, John; McKinzie, Gordon; Reilly, Dave; Saint, Sam; Schlickenmaier, Herb; Usry, Jim; Stoer, Ray
Conference Title:	Wind Shear/Turbulence Inputs to Flight Simulation and Systems Certification.
Conference Location:	Hampton, VA, USA Conference Date: 1984 May 30-Jun 1
Sponsor:	NASA, Washington, DC, USA
E.I. Conference No.:	10251
Source:	NASA Conference Publication 2474. Publ by NASA, Washington, DC, USA p 245-246
Publication Year:	1987

Abstract

This working group addressed the large airframe manufacturers' interest in the JAWS data process. We talked about the large airframe manufacturers' needs and the development process to meet those needs. We identified the needs of the manufacturer in three areas. First is the design of equipment - the aircraft and its onboard equipment, its avionics. There are also training needs. We are required to provide data for training simulators. Finally, there is a certification need. These are three different areas, but they may end up requiring essentially the same things.

Title:	Wind Shear Hazard Definition for a Wide Body Jet (low level wind shear and control simulation) Final Report
Author:	Schlickenmaier, H. W.
Author Affiliation:	Federal Aviation Administration, Washington, D.C. Systems Research and Development Service.
Publication Date:	Jun. 1979 80P. 1 Refs.
Report No.:	FAA-RD-79-90
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC A05/MF A01

Abstract

A computer program is developed to simulate the flight dynamics and automatic flight control system (AFCS) of a three engine jumbo jet following a 3 deg glideslope during final approach. Wind shear profiles representative of actual encounters are used. The simulation uses both autopilot and autothrottle. An initial effort is made to define specific wind shear conditions that pose hazards to aircraft. Parameter values are analyzed for each of four categorized wind shear environments and performance scores achieved on computer simulations are assigned for each of the four wind shear types. The most severe situations that can be accommodated by a jumbo tri-jet with current configuration are described for each of the four wind shear types. Conservative controllability criteria is applied and a hazardous condition is presumed to exist when the control action demanded and provided by the simulator exceeds the control limits of the actual aircraft, or when the airspeed and/or touchdown dispersion exceed limit values. Definition of these criteria provide a basis for the formulation of procedures allowing aircraft to anticipate and avoid hazardous wind shear conditions.

Title:	Dissemination of Terminal Weather Products to the Flight Deck Via Data Link
Author(s):	Campbell, Steven D. (MIT, Lexington, MA); Martin, Ronald C. (Aeronautical Radio, Inc., Annapolis, MD)
Conference Title:	International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993, Preprints (A95-29398 07-47), Boston, MA, American Meteorological Society, 1993, p. 348-352.
Publication Date:	1993 2 Refs.
Availability:	Documents available from AIAA Technical Library

Abstract

A new concept for providing up-to-the-minute terminal weather information based on ground radar and other information is presented. These proposed Terminal Weather Data Link Service would provide near real-time information about (1) runaway wind shear and precipitation impact, (2) microburst, gust front, and storm cell location and motion near the airport, and (3) forecasted wind shear, precipitation, and wind shift impact at the airport. The service makes use of the existing ACARS (Aircraft Communications, Addressing, and Reporting System) data link capability found in many air carrier aircraft and the new ground-based weather sensing systems such as TDWR currently being deployed. A demonstration of the system at Orlando is discussed, including an operational overview, prototype message formats, and plans for gauging pilot reactions to the proposed service. Short-term plans for operational systems and longer-term plans for delivering graphical weather products to the flight deck via data link are discussed.

Title:	Operational Concept for the Terminal Weather Data Link Service
Author(s):	Matthews, Michael P.; Campbell, Steven D. (MIT, Lexington, MA)
Conference Title:	AIAA, Aircraft Design, Systems and Operations Meeting, Monterey, CA, Aug. 11-13, 1993, 8 p..
Publication Date:	Aug. 1993 3 Refs.
Report No.:	AIAA Paper 93-4003
Availability:	Documents available from AIAA Technical Library

Abstract

The Terminal Doppler Weather Radar (TDWR) FAA program will automatically detect microburst and gust front wind shear hazard, forecasting of wind shifts and depiction of precipitation levels. The TDWR system is being installed at 45 major airports in the U.S. The Integrated Terminal Weather System (ITWS) is under development to extend the capabilities of the TDWR system by integrating multiple sensors, including the Low Level Windshear Alerting System, Next Generation Radar, and other weather detection sensors employed or being deployed by the National Weather Service or the FAA. Along with integrating various sensors, ITWS will extend the operational usefulness of weather information by predicting microbursts, forecasting ceiling and visibility conditions, and supplying this information to the users in the quickest most reliable format possible. This paper will discuss a proposed method of data linking terminal weather information to pilots via new and existing data link systems.

Title:	Integrated Terminal Weather System (ITWS) Annual Report, 1992
Author(s):	Evans, James E. (Massachusetts Inst. of Tech., Lexington)
Publication Date:	Sep. 1993 104P.
Note:	Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
Report No.:	AD-A269884; ATC-203; DOT/FAA/RD-93/27
Availability:	Documents available from AIAA Technical Library
Other Availability:	CASI HC A06

Abstract

Hazardous weather in the terminal area is the major cause of aviation system delays as well as a principal cause of air carrier accidents. Several systems presently under development will provide significant increases in terminal safety. However, these systems will not make a major impact on weather-induced delays in the terminal area, meet a number of the safety needs (such as information to support ground deicing decisions), or reduce the workload of the terminal controller. The Integrated Terminal Weather System (ITWS) will provide improved aviation weather information in the allocated TRACON area (up to 50 nmi from the airport) by integrating data and products from various Federal Aviation Administration (FAA) and National Weather Service (NWS) sensors and weather information systems. The data from these sources will be combined to provide a unified set of safety and planning weather products for pilots, controllers, and terminal area traffic managers. By using data from multiple sensors, ITWS can generate important new products where no individual sensor alone could generate a single, reliable product. In other instances, use of data from several sources can compensate for erroneous data from one sensor and thus improve the overall integrity of existing products. Major objectives of the ITWS program are to increase the effective airport acceptance rate in adverse weather by providing information to support terminal automation systems, better terminal route planning, and wake vortex advisory services, and to reduce the need for controllers to communicate weather information to pilots via VHF voice.

Title:	Status of FAA Terminal Doppler Weather Radar Programs
Author(s):	Merritt, Mark W.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington.
Conference Title:	NASA. Langley Research Center, Airborne Wind Shear Detection and Warning Systems: First Combined Manufacturers and Technologists Conference p 411-444 (SEE N88-17616 10-03)
Publication Date:	Jan. 1988
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC A24/MF A01

Abstract

The status of the Federal Aviation Administration (FAA) Doppler weather radar programs are presented in vugraph form. Abstracts of relevant reports are given.

Title:	The FAA/M.I.T. Lincoln Laboratory Doppler Weather Radar program
Author(s):	Evans, J. E. (MIT, Lexington, MA); Turnbull, D. H. (FAA, Washington, DC)
Conference Title:	International Conference on the Aviation Weather System, 2nd, Montreal, Canada, June 19-21, 1985, Preprints (A86-37451 17-47). Boston, MA, American Meteorological Society, 1985, p. 76-79. FAA-sponsored research.
Publication Date:	1985
Availability:	Documents available from AIAA Technical Library

Abstract

Attention is given to the development status of a Next Generation Weather Radar-like transportable weather radar support facility which is being used to validate and refine scanning strategies, data processing methods, and weather detection algorithms applicable to the FAA's Terminal Doppler Weather Radar. Among the operational issues to be resolved by these research efforts are siting, optimum scanning strategy, optimum update rate, and interfacing with ATC facilities. Emphasis will be given to the development of a microburst-detection algorithm.

3. TERMINAL DOPPLER WEATHER RADAR/INTEGRATED TERMINAL WEATHER SYSTEM ALGORITHMS

Title:	A Microburst Prediction Algorithm for the FAA Integrated Terminal Weather System
Author(s):	Wolfson, M.M.; Delanoy, R.L.; Pawlak, M.L.; Forman, B.E.; Hallowell, R.G.; Smith, P.D.
Author Affiliation:	Lincoln Lab., MIT, Lexington, MA, USA
Journal:	Proceedings of the SPIE - The International Society for Optical Engineering, vol. 2220 p.194-204
Publication Date:	1994
Country of Publication:	USA
ISSN:	0277-786X
Conference Title:	Sensing, Imaging, and Vision for Control and Guidance of Aerospace Vehicles
Conference Sponsor:	SPIE
Conference Date:	4-5 April 1994
Conference Location:	Orlando, FL, USA

Abstract

Lincoln Laboratory is developing a prototype of the Federal Aviation Administration (FAA) Integrated Terminal Weather System (ITWS) to provide improved aviation weather information in the terminal area by integrating data and products from various FAA and National Weather Service(NWS) sensors and weather information systems. The ITWS Microburst Prediction product is intended to provide an additional margin of safety for pilots in avoiding microburst wind shear hazards. The product is envisioned for use by traffic managers, supervisors, controllers, and pilots (directly via data link). Our objective is to accurately predict the onset of microburst wind shear several minutes in advance. The approach we have chosen in developing the ITWS Microburst Prediction algorithm emphasizes fundamental physical principles of thunderstorm evolution and downdraft development, incorporating heuristic and/or statistical methods as needed for refinement. Results from off-line testing on 17 days of data from Orlando are also presented.

Title:	Machine Intelligent Approach to Automated Gust Front Detection for Doppler Weather Radars
Author(s):	Troxel, S.W.; Delanoy, R.L.
Author Affiliation:	Lincoln Lab., MIT, Lexington, MA, USA
Journal:	Proceedings of the SPIE - The International Society for Optical Engineering vol. 2220 p.182-93
Publication Date:	1994
ISSN:	0277-786X
Conference Title:	Sensing, Imaging, and Vision for Control and Guidance of Aerospace Vehicles
Conference Sponsor:	SPIE
Conference Date:	4-5 April 1994
Conference Location:	Orlando, FL, USA

Abstract

Automated gust front detection is an important component of the Airport Surveillance Radar with Wind Shear Processor (ASR-9 WSP) and Terminal Doppler Weather Radar (TDWR) systems being developed for airport terminal areas. Gust fronts produce signatures in Doppler radar imagery which are often weak, ambiguous, or conditional, making detection and continuous tracking of gust fronts challenging. Previous algorithms designed for these systems have provided only modest performance when compared against human observations. A Machine intelligent gust front algorithm (MIGFA) has been developed that makes use of two new techniques of knowledge-based signal processing originally developed in the context of automatic target recognition. The first of these, functional template correlation (FTC), is a generalized matched filter incorporating aspects of fuzzy set theory. The second technique is the use of "interest" as a medium for pixel-level data fusion. MIGFA was first developed for the ASR-9 WSP system. Its design and performance have been documented in a number of earlier reports. This paper focuses on the TDWR MIGFA, describing the signal-processing techniques used and general algorithm design. A quantitative performance analysis using data collected during recent real-time testing of the TDWR MIGFA in Orlando, Florida is also presented. Results show that MIGFA substantially outperforms the gust front detection algorithm used in current TDWR systems.

Title:	Initialization for Improved IIR Filter Performance
Author(s):	Chornoboy, E.S.
Author Affiliation:	MIT Lincoln Lab., Lexington, MA, USA
Journal:	IEEE Transactions on Signal Processing vol. 40, no. 3 p. 543-50
Publication Date:	March 1992
ISSN:	1053-587X

Abstract

A new method for initializing the memory registers of infinite impulse response (IIR) filters is introduced. In addition to providing improved performance as compared to other methods of initialization, this method is unique in that it makes no prior assumptions regarding the input-signal content. Therefore, the method applies equally well to a variety of IIR filter designs and applications. The method is best suited for signal processing applications in which 'batch' processing of the data is used. However, sequential processing, can be accommodated when delays at the beginning of a processing segment can be tolerated.

Title:	Clutter Rejection in Doppler Weather Radars Used for Airport Wind Shear Detection
Author(s):	Evans, J.E.; Hynek, D.
Author Affiliation:	MIT Lincoln Lab., Lexington, MA, USA
Conference Title:	ISNCR-89. Noise and Clutter Rejection in Radars and Imaging Sensors. Proceedings of the Second International Symposium p. 275-280
Editor(s):	Suszuki, T.; Ogura, H.; Fujimura, S.
Publisher:	North-Holland, Amsterdam, Netherlands
Publication Date:	1990
ISBN:	0 444 88585 4
Conference Sponsor:	Inst. Electron. Inf. Commun. Eng.; Inst. Electr. Eng. Japan; et al
Conference Date:	14-16 Nov. 1989
Conference Location:	Kyoto, Japan

Abstract

Low altitude wind shear has been recognized as a major cause of air carrier fatal accidents in the United States. The Federal Aviation Administration has initiated the Terminal Doppler Weather Radar (TDWR) program to develop a reliable fully automated wind shear detection system using pulse Doppler radars. The TDWR will detect low altitude wind shear phenomena such as microbursts and gust fronts in the terminal area and provide warnings that will help pilots successfully avoid wind shear on approach and departure. The techniques for the suppression of ground and storm clutter to permit the detection of low altitude wind shear are described. Novel features of the system include the use of clutter residue and range aliased weather echo editing maps which edit out the range-azimuth cells on a 'data adaptive' basis.

Title:	Extrapolating Storm Location using the Integrated Terminal Weather System (ITWS) Storm Motion Algorithm
Author(s):	Chornoboy, E. S.; Matlin, A.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Publication Date:	Mar. 1994 78P.
Note:	Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
Report No.:	AD-A278611; MIT-ATC-208; DOT/FAA/RD-94/2 Documents available from AIAA Technical Library
Other Availability:	Issuing Activity (Defense Technical Information Center (DTIC))

Abstract

Storm Motion (SM) is a planned Initial Operational Capability (IOC) algorithm of the FAA's Integrated Terminal Weather System (ITWS). As currently designed, this algorithm will track the movement of storms/cells and convey this tracking information to the ITWS user by means of a graphic display of vectors (for direction) with accompanying numeric reports of storm speed, rounded to the nearest 5 nmi/hr increment. Recognizing that there are occasions when ITWS users could benefit from a more extended product format, Storm Extrapolated Position (SEP) was conceived to supplement the SM product and thereby increase its accessibility as a planning aid. This communication describes a prototype SEP design along with an analysis of its accuracy and observed performance during 1993 ITWS demonstrations in Orlando, FL. and Dallas, TX.

Title:	Storm Tracking for TDWR: A Correlation Algorithm Design and Evaluation
Author:	Chornoboy, Edward S.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington.
Publication Date:	Jul. 1992 91P.
Report No.:	AD-A254701; ATC-182; DOT/FAA/NR-91/8
Availability:	Documents available from AIAA Technical Library
Other Availability:	CASI HC A05/MF A01

Abstract

Storm Movement Prediction (SMP) is a proposed (future) product for Terminal Doppler Weather Radar (TDWR), aiding controllers by tracking storms approaching and passing through the terminal environment. Because the scan strategy (data acquisition) of TDWR has been critically designed to meet the needs of its primary function, which is the detection of hazardous low-altitude wind shear, there is the question of whether reliable storm tracking can be obtained from the TDWR data set. The objectives of storm tracking involve a scope (spatial range) much larger than that required for the wind-shear algorithms where volume coverage is confined (in off-airport sited radars) to a sector covering the important approach and departure corridors and the only 360-degree scans are near-surface scans for gust-front detection. This report examines the application of a correlation based method of detecting storm motion, testing the notion that reliable storm motion can be inferred from existing TDWR data. In particular, storm motion derived from an analysis of the TDWR Precipitation product (PCP) is studied. A summary description of the algorithm is presented along with an analysis of its performance using data from MIT Lincoln Laboratory's TDWR testbed operations in Denver (1988) and Kansas City (1989).

Title:	Future Enhancements to Ground-Based Microburst Detection
Author(s):	Campbell, Steven D.; Matthews, Michael P.; Dasey, Timothy J.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Conference Title:	NASA. Langley Research Center, Airborne Windshear Detection and Warning Systems. Fifth and Final Combined Manufacturers' and Technologists' Conference, Part 1 p 221-239 (SEE N95-10566 01-03)
Publication Date:	Jul. 1994
Availability:	Documents available from AIAA Technical Library
Other Availability:	CASI HC A03/MF A04

Abstract

This set of viewgraphs presents the results of the Cockpit Weather Information (CWI) program at M.I.T. Lincoln Laboratory. The CWI program has been funded through NASA Langley Research Center by the joint NASA/FAA Integrated Airborne Wind Shear Program for the past four years. During this time, over 120 microburst penetrations by research aircraft have been conducted under Terminal Doppler Weather Radar (TDWR) testbed radar surveillance at Orlando, FL. The results of these in-situ measurements have been compared with ground-based detection methods. Several valuable insights were gained from this research activity. First, it was found that the current TDWR microburst shapes do not permit accurate characterization of microburst hazard in terms of the F factor hazard index, because they are based on loss value rather than shear. Second, it was found that the horizontal component of the F factor can be accurately estimated from shear, provided compensation is made for the dependence of outflow strength on altitude. Third, it was found that a simple continuity assumption for estimating the vertical component of the F factor yielded poor results. However, further research has shown that downdraft strength is correlated with features aloft detected by the TDWR radar scan strategy. The outcome of the CWI program is to move from the loss-based wind shear detection algorithm used in the TDWR to a shear-based detection scheme as proposed in the Integrated Terminal Weather System (ITWS).

Title:	Improving Aircraft Impact Assessment with the Integrated Terminal Weather System Microburst Detection Algorithm
Author(s):	Matthews, Michael P.; Dasey, Timothy J. (MIT, Lexington, MA)
Conference Title:	International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993, Preprints (A95-29398 07-47), Boston, MA, American Meteorological Society, 1993, p. 45-50.
Publication Date:	1993 11 Refs.
Availability:	Documents available from AIAA Technical Library

Abstract

A wind shear hazard index called the F Factor and its estimation from a ground-based Doppler radar are described. The estimated F Factors from the Terminal Doppler Weather Radar alert shapers are described, and direct use of TDWR base data for computing shear is explored along with the creation of that data with aircraft F Factor measurements. Estimation of the F Factor from alert shapes output from the initial Integrated Terminal Weather System Microburst Detection Algorithm is explored.

Title:	The Design and Motivation for the Integrated Terminal Weather System Microburst Detection Algorithm
Author(s):	Dasey, Timothy J. (MIT, Lexington, MA)
Conference Title:	AIAA, Aircraft Design, Systems and Operations Meeting, Monterey, CA, Aug. 11-13, 1993, 9 p..
Publication Date:	Aug. 1993 13 Refs.
Report No.:	AIAA Paper 93-3948
Availability:	Documents available from AIAA Technical Library

Abstract

This paper describes the ITWS Microburst Detection algorithm, its design, and the factors motivating its development. The ITWS Microburst Detection algorithm uses the Terminal Doppler Weather Radar (TDWR) for its primary data source. It differs from other ground based wind shear detection algorithms in its dependence on shear rather than velocity. Microburst penetration studies have indicated that shear may be a more effective measure of aircraft hazard than the traditionally used headwind/tailwind loss measure. In truth, there is merit to both measures, and the ITWS algorithm can be considered a hybrid construction where both shear and loss measures are incorporated. The new algorithm is also considered a crucial step in constructing an accurate product for predicting microburst outflow changes, needed for the ITWS Microburst Trend Algorithm currently under development. The ITWS algorithm has been tested on about 75 microburst cases from archived TDWR testbed data. It appears to provide comparable timeliness to the TDWR algorithm, and has subjectively met the performance of the TDWR algorithm. It is running off-line in real-time at the Orlando TDWR testbed in 1993, and many additions are expected before operational testing in 1994.

Title:	The Gust-Front Detection and Wind-Shift Algorithms for the Terminal Doppler Weather Radar System
Author(s):	Hermes, L.G.; Witt, A.; Smith, S.D.; Klingle-Wilson, D.; Morris, D.; Stumpf, G.J.; Eilts, M.D.
Author Affiliation:	NOAA/ERL Nat. Severe Storms Lab., Norman, OK; Massachusetts Inst. of Tech., Lexington. Lincoln Lab. USA
Journal:	Journal of Atmospheric and Oceanic Technology vol. 10, no. 5 p.693-709
Publication Date:	Oct. 1993 Country of Publication: USA

Abstract

The Federal Aviation Administration's Terminal Doppler Weather Radar (TDWR) system was primarily designed to address the operational needs of pilots in the avoidance of low-altitude wind shears upon takeoff and landing at airports. One of the primary methods of wind-shear detection for the TDWR system is the gust-front detection algorithm. The algorithm is designed to detect gust fronts that produce a wind-shear hazard and/or sustained wind shifts. It serves the hazard warning function by providing an estimate of the wind-speed gain for aircraft penetrating the gust front. The gust-front detection and wind-shift algorithms together serve a planning function by providing forecasted gust-front locations and estimates of the horizontal wind vector behind the front, respectively. This information is used by air traffic managers to determine arrival and departure runway configurations and aircraft movements to minimize the impact of wind shifts on airport capacity.

Title:	Shear-Based Microburst Detection Algorithm for the Integrated Terminal Weather System (ITWS)
Author:	Dasey, Timothy J.
Author Affiliation:	Massachusetts Inst of Technology, Lexington, MA, USA
Conference Title:	26th International Conference on Radar Meteorology
Conference Location:	Norman, OK, USA
Sponsor:	American Meteorological Society; Norman Weather Center
Source:	International Conference on Radar Meteorology 1993. Publ by American Meteorological Soc, Boston, MA, USA. p 667-669
Publication Year:	1993

Abstract

The Terminal Doppler Weather Radar (TWDR) program was the first attempt at automated microburst detection with a ground-based Doppler weather radar in the airport terminal area. The Integrated Terminal Weather System (ITWS) seeks to enhance this ability by providing earlier warnings of facilitate microburst avoidance by pilots and improved terminal planning. The TDWR alerting is fundamentally loss based, that is, the severity of the hazard is indicated by the strength of the surfaced divergence couplet. However, if this divergence is not over a small area, an aircraft will experience little or no performance deficit. The ITWS algorithm captures this information by examining the divergence shear (rate of change in velocity) as well as the loss. Ground-based Doppler radar observation has shown, and instrumented aircraft penetrations have confirmed that the shear within a microburst is highly nonuniform. The ITWS algorithm will use an additional, imbedded warning shape to indicate especially hazardous regions of a microburst. This paper explains the initial design of the ITWS microburst detection algorithm and illustrates some early results. The plans for algorithm testing and the planned enhancements to its capabilities are discussed.

Title:	TDWR Velocity Dealiasing in Operation (Terminal Doppler Weather Radar)
Author(s):	Sykes, Tymothy D. (Raytheon Co., Sudbury, MA); Stevens, Benjmin H. (MIT, Lexington, MA)
Conference Title:	International Conference on Radar Meteorology, 25th, Paris, France,
Publication Date:	June 24-28, 1991, Preprints (A93-37626 15-47). Boston, MA, American Meteorological Society, 1991, p. 350-353. Research sponsored by FAA.
Publication Date:	1991 5 Refs.
Availability:	Documents available from AIAA Technical Library

Abstract

Various features of the TDWR velocity dealiasing algorithm are described, results of the operational test and post-demonstration data analysis are discussed, and some algorithm modifications are recommended. The TDWR velocity dealiasing algorithm applies three processing steps in sequence: dual scan dealiasing, radial dealiasing, and azimuthal shear minimization. In these processing steps aliased velocities are 'corrected' by adding or subtracting one or more Nyquist intervals to produce an unambiguous velocity. Dual scan dealiasing is typically performed twice per volume scan, requiring a total of four elevation scans. Dual scan processing for a typical radial is illustrated. Radial dealiasing with samples contaminated by clutter is shown to result in incorrect velocities at range gates 40-42.

Title:	An Improved Gust Front Detection Algorithm for the TDWR
Author(s):	Eilts, Michael D. (NOAA, National Severe Storms Lab., Norman, OK); Olson, Stephen H. (MIT, Lexington, MA); Stumpf, Gregory J. (NOAA, National Severe Storms Lab.; Cooperative Inst. for Mesoscale Meteorological Studies, Norman, OK); Hermes, Laurie G. (NOAA, National Severe Storms Lab., Norman, OK); Abrevaya, Adam; Culbert, James (MIT, Lexington, MA); Thomas, Kevin W.; Hondl, Kurt (NOAA, National Severe Storms Lab.; Cooperative Inst. for Mesoscale Meteorological Stuies, Norman, OK); Klingle-Wilson, Diana (MIT, Lexington, MA)
Conference Title:	International Conference on Aviation Weather Systems, 4th, Paris, France, June 24-28, 1991, Preprints (A93-22101 07-47). Boston, MA, American Meteorological Society, 1991, p. J37-J42. Research sponsored by FAA.
Publication Date:	1991 5 Refs.
Availability:	Documents available from AIAA Technical Library

Abstract

The study describes a new algorithm which provides improved gust front detection for the TDWR using additional radar signatures of gust fronts. The novel algorithm enhances detection and prediction of gust fronts by merging radial convergence features with azimuthal shear features, thin line features, and the predicted locations of gust fronts which are passing over the radar. The rule base used to combine detections from the four components of the algorithm into single gust front detections is described. The final product of the gust front algorithm is a smooth curve representing the location of the gust front, 10- and 20-min forecasts of gust front location, an estimate of the speed and direction of the wind behind the gust front, and an estimate of the wind shear hazard.

Title:	Performance Results and Potential Operational Uses for the Prototype TDWR Microburst Prediction Product
Author(s):	Campbell, Steven D. (MIT, Lexington, MA)
Conference Title:	International Conference on Aviation Weather Systems, 4th, Paris, France, June 24-28, 1991, Preprints (A93-22101 07-47). Boston, MA, American Meteorological Society, 1991, p. J33-J36. Research sponsored by FAA.
Publication Date:	1991 3 Refs.
Availability:	Documents available from AIAA Technical Library

Abstract

The study presents a proposed new Terminal Doppler Weather Radar (TDWR) product for microburst prediction (MBP), which provides the ability to predict microbursts prior to the onset of surface outflow. The MBP product uses the ability of the TDWR to scan aloft for precursor signatures which indicate that a microburst is about to occur. The potential usefulness of the MBP product is illustrated with an example that occurred during operational testing during the summer of 1990.

Title:	An Experimental Cockpit Display for TDWR Wind Shear Alerts
Author(s):	Campbell, Steven D.; Daly, Peter M.; DeMillo, Robert J. (MIT, Lexington, MA)
Sponsor:	National Aeronautics and Space Administration, Washington, DC.
Conference Title:	International Conference on Aviation Weather Systems, 4th, Paris, France, June 24-28, 1991, Preprints (A93-22101 07-47). Boston, MA, American Meteorological Society, 1991, p. 39-44. Research sponsored by NASA.
Publication Date:	1991 3 Refs.
Availability:	Documents available from AIAA Technical Library

Abstract

The first successful ground-to-air data link and cockpit display of terminal Doppler weather radar (TDWR) wind shear warnings in real-time are reported. During the summer of 1990, wind shear warnings generated by the TDWR testbed radar at Orlando, Florida, were transmitted in real-time to a research aircraft performing microburst penetrations. Automatic delivery of TDWR wind shear warnings potentially result in decreased controller workload and improved pilot information. Pilot responses indicate that the information provided by the cockpit displays was useful in visualizing the location of wind shear hazards. The graphical display of microburst hazards provided better information than that currently provided by ATC verbal messages and pilot reports. This information was useful in assessing the microburst hazard, deciding whether to continue the approach, and planning escape maneuvers.

Title:	Microburst Divergence Detection for Terminal Doppler Weather Radar (TDWR)
Author(s):	Merritt, M. W.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Publication Date:	Sep. 1991 174P.
Report No.:	AD-A243808; ATC-181; DOT/FAA/NR-91/7
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC/MF A08

Abstract

The Terminal Doppler Weather Radar (TDWR) microburst surface divergence detection algorithm has been under development and evaluation at Lincoln Laboratory since 1983. The TDWR program is sponsored by the Federal Aviation Administration (FAA), and the algorithm described in this report is a primary algorithm component of the TDWR system. The divergence algorithm processes radar velocity measurements taken near the earth's surface to identify the strong divergent outflow characteristic of microburst wind shear hazards. The algorithm uses a complex set of pattern matching and validation test criteria to locate microburst outflow signatures and to filter out false alarms from various data contamination sources. The divergence algorithm is primarily responsible for the detection of most microbursts, although the complete TDWR microburst algorithm consists of more than a dozen distinct algorithmic components. The divergence algorithm has demonstrated a very high probability of detection (POD) for strong microburst outflows, and its performance (as well as that of the complete microburst detection algorithm) was first formally assessed in the operational test and evaluation of the TDWR in Denver, CO (1988). Subsequent evaluations were performed in Kansas City, KS (1989) and Orlando, FL (1990). These evaluations have provided insight into the algorithm and system performance in a variety of meteorological and geographical environments.

Title:	A Prototype Microburst Prediction Product for the Terminal Doppler Weather Radar
Author(s):	Campbell, Steven D.; Isaminger, Mark A. (MIT, Lexington, MA)
Conference Title:	Conference on Severe Local Storms, 16th and Conference on Atmospheric Electricity, Kananaskis Park, Canada, Oct. 22-26, 1990, Preprints (A92-27926 10-47). Boston, MA, American Meteorological Society, 1990, p. 393-396. Research sponsored by FAA.
Publication Date:	1990 7 Refs.
Availability:	Documents available from AIAA Technical Library

Abstract

The present Terminal Doppler Weather Radar (TDWR) microburst-recognition algorithm makes use of such features as reflectivity cores and convergence to recognize microburst precursors. The algorithm uses precursors to make a microburst declaration while the surface outflow remains weak, thereby improving hazard-warning time. The prototype prediction product is tuned to predict the high-reflectivity microbursts typical of humid regions of the U.S., which are expected to be most representative of TDWR installation sites.

Title:	TDWR (Terminal Doppler Weather Radar) Scan Strategy Requirements
Author(s):	Campbell, S. D.; Merritt, M. W.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Publication Date:	Nov. 1988 21P.
Report No.:	AD-A201785; DOT/FAA/PM-87-22
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC A03/MF A01

Abstract

The requirements for the scan strategy to be employed in the Terminal Doppler Weather Radar (TDWR) are described. The report is divided into three main sections: rationale, example scan strategy and requirements. The rationale for the TDWR scan strategy is presented in terms of: (1) detection of meteorological phenomena, and (2) minimization of range ambiguity and velocity folding ambiguity. Next, an example is provided based on an experimental scan strategy used in Denver during the summer of 1987. Finally, the requirements for the TDWR scan strategy are presented based on the preceding discussion. Also, an appendix is included describing the proposed criteria for switching between scan modes.

NTIS Accession Number:	PB92-118736/XAB
Title:	TDWR Scan Strategy Requirements, Revision 1 (Project rept)
Author(s):	Campbell, S. D. ; Merritt, M. W.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Sponsor:	Federal Aviation Administration, Washington, DC.; Department of the Air Force, Washington, DC.
Report No.:	ATC-144-REV-1; DOT/FAA/PM-87/22
Publication Date:	9 Apr 90 23p

Abstract

The report describes the requirements for the scan strategy to be employed in the Terminal Doppler Weather Radar (TDWR). The report is divided into three main sections: rationale, example scan strategy, and requirements. The rationale for the TDWR scan strategy is presented in terms of (1) detection of meteorological phenomena, and (2) minimization of range and velocity folding effects. Next, an example is provided based on an experimental scan strategy used in Denver during the summer of 1987.

Title:	Terminal Doppler Weather Radar Clutter Control
Author(s):	Evans, J.E.; Drury, W.H.; Hynek, D.P.; Lee, T.S.; Stevens, B.H., Jr.
Author Affiliation:	Lincoln Lab., MIT, Lexington, MA, USA
Conference Title:	Record of the IEEE 1990 International Radar Conference (Cat. No. 90CH2882-9) p.12-16
Publisher:	IEEE, New York, NY, USA
Publication Date:	1990; 673 pp.
Conference Sponsor:	IEEE; IEE
Conference Date:	7-10 May 1990
Conference Location:	Arlington, VA, USA

Abstract

A number of unique approaches to clutter rejection which have been validated with the terminal Doppler weather radar (TDWR) testbed radar are described. Key aspects of the detection problem are emphasized from the viewpoint of a radar engineer (as opposed to the meteorological and pattern recognition features of the problem). Attention is focused on mainlobe clutter suppression since it is a principal cause of inadequate detection performance. To provide a framework for the TDWR system discussions, the salient features of the low-altitude wind shear detection environment and the pattern recognition algorithms are first described. Some of the system features which arise from ground clutter suppression considerations are then discussed. Clutter due to out-of-trip weather returns is also an important factor in TDWR system engineering due to the trade-off between unambiguous velocity and range (coupled with the (range)/sup -2/ power law for weather echoes). Some of the radar engineering areas which warrant additional investigation are discussed.

Title:	Use of Features Aloft in The TDWR Microburst Recognition Algorithm
Author(s):	Campbell, Steven D. (MIT, Lexington, MA)
Conference Title:	Conference on Radar Meteorology, 24th, Tallahassee, FL, Mar. 27-31, 1989, Preprints (A90-28576 11-47). Boston, MA, American Meteorological Society, 1989, p. 167-170. Research sponsored by FAA.
Publication Date:	1989 8 Refs.
Language:	English
Availability:	Documents available from AIAA Technical Library

Abstract

The incorporation of features aloft into the TDWR microburst recognition algorithm is discussed. The structure of the prototype algorithm and the scan strategy are described. The algorithm recognizes features aloft related to microbursts, such as descending reflectivity cores and convergence aloft. The performance of the TDWR algorithm is evaluated by applying it to microburst events observed during the summer of 1988 at Stapleton airport in Denver, Colorado. It is noted that the ability to recognize features aloft improves the probability of detection of microbursts by 4.5 percent.

Title:	Using Features Aloft to Improve Timeliness of TDWR Hazard Warnings (Terminal Doppler Weather Radar)
Author(s):	Campbell, Steven D.; Isaminger, Mark A. (MIT, Lexington, MA)
Conference Title:	International Conference on the Aviation Weather System, 3rd, Anaheim, CA, Jan. 30-Feb. 3, 1989, Preprints (A89-54776 24-47). Boston, MA, American Meteorological Society, 1989, p. 184-189. Research supported by FAA.
Publication Date:	1989 7 Refs.
Availability:	Documents available from AIAA Technical Library

Abstract

Results are presented that demonstrate the ability of the prototype microburst recognition algorithm of the Terminal Doppler Weather Radar (TDWR) to recognize features aloft for microburst events observed at Huntsville, Alabama, in 1986 and Denver, Colorado in 1987. Five days of data from each location were used, and ground truth was established for 126 microburst events. Of these, seven high-reflectivity events were tested for the effect of using features aloft on the alarm timeliness. The average precursor warning time for the seven events was 6.2 min, which corresponds well with the conceptual model for high-reflectivity events proposed by Roberts and Wilson (1986). The use of features aloft was found to increase the alarm timeliness for these events by 1.3 minutes.

NTIS Accession Number:	PB91-185967/XAB
Title:	Gust Front/Wind Shift Detection Algorithm for the Terminal Doppler Weather Radar (Final rept)
Author(s):	Witt, A. ; Smith, S. D. ; Eilts, M. D. ; Hermes, L. G. ; Klingle-Wilson, D. L.
Author Affiliation:	National Severe Storms Lab., Norman, OK; Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Sponsor:	Prepared in cooperation with Cooperative Inst. for Mesoscale Meteorological Studies, Norman, OK.; Massachusetts Inst. of Tech., Lexington. Lincoln Lab.; Federal Aviation Administration, Washington, DC.
Report No.:	DOT/FAA/NR-91/4
Publication Date:	Nov 89 75p

Abstract

During 1987, Doppler radar data were collected in Denver, Colorado and Norman, Oklahoma to test and evaluate the Gust Front Detection Algorithm, which is designed to detect the radial convergence associated with a gust front, forecast its future location, and estimate the wind speed and direction behind the front. The paper describes the version of the gust front algorithm which will be deployed in the initial Terminal Doppler Weather Radars. The algorithm uses two 360 degrees low-elevation angle PPI's of radial velocity data. Radial convergence lines are detected and vertical continuity is used to associate detections and thus reduce false alarms. Recent enhancements to the algorithm include: (1) peak velocity difference thresholding, (2) variable thresholds for the two elevation scans, (3) connection of nearby shear features into a single shear feature, (4) a fifth-order polynomial fit to the radial convergence lines to allow more representative positioning of the gust front, (5) normal velocity component tracking and forecasting, (6) a velocity outlier rejection scheme, (7) redefinition of the data processing sector, (8) a perpendicular wind estimation technique for use with short gust fronts and as a replacement estimate when uniform wind model estimates fail error checks, and (9) rigorous error checking of wind estimates using gust front orientation and tracking information. The performance evaluation of the algorithm was completed using the 1987 Colorado and Oklahoma data sets. The most notable results were the high PODs and the low FARs. Gust front forecasts were found to be, on average, within four minutes of the actual time of frontal passage. Wind estimates were generally within 30 degrees and 3 m/s of the measured surface winds.

Title:	Wind Shear Detection with Pencil-Beam Radars
Author(s):	Merritt, M.W.; Klingle-Wilson, D.; Campbell, S.D.
Author Affiliation:	Lincoln Lab., MIT, Lexington, MA, USA
Journal:	Lincoln Laboratory Journal vol. 2, no. 3 p.483-510
Publication Date:	Fall 1989
ISSN:	0896-4130

Abstract

Abrupt changes in the winds near the ground pose serious hazards to aircraft during approach or departure operations. Doppler weather radars can measure regions of winds and precipitation around airports, and automatically provide air traffic controllers and pilots with important warnings of hazardous weather events. Lincoln Laboratory, as one of several organizations under contract to the Federal Aviation Administration, has been instrumental in the design and development of radar systems and automated weather-hazard recognition techniques for this application. The Terminal Doppler Weather Radar (TDWR) system uses automatic computer algorithms to identify hazardous weather signatures. TDWR detects and warns aviation users about low-altitude wind shear hazards caused by microbursts and gust fronts. It also provides advance warning of the arrival of wind shifts at the airport complex. Extensive weather radar observations, obtained from a Lincoln-built transportable testbed radar system operated at several sites, have validated the TDWR system. As a result, the Federal Aviation Administration has issued a procurement contract for the installation of 47 TDWR radar systems around the country.

Title:	Automated Detection of Microburst Windshear for Terminal Doppler Weather Radar
Author(s):	Merritt, Mark W. (MIT, Lincoln Laboratory, Lexington, MA)
Conference Title:	Digital Image Processing and Visual Communications Technologies in Meteorology; Proceedings of the Meeting, Cambridge, MA, Oct. 27, 28, 1987 (A89-11726 02-47). Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 61-68. FAA-sponsored research.
Publication Date:	1987 5 Refs.
Availability:	Documents available from AIAA Technical Library

Abstract

An image analysis method is presented for use in detecting strong windshear events, called microbursts, in Doppler weather radar images. This technique has been developed for use in a completely automated surveillance system being procured by the Federal Aviation Administration (FAA) for the protection of airport terminal areas. The detection system must distill the rapidly evolving radar imagery into brief textual warning messages in real time, with high reliability.

NTIS Accession Number:	PB92-118694/XAB
Title:	Advanced Microburst Recognition Algorithm
Author(s):	Campbell, S. D.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Sponsor:	Federal Aviation Administration, Washington, DC.; Department of the Air Force, Washington, DC.
Publication Date:	30 Jun 87 39p

Abstract

The report describes an advanced microburst recognition algorithm for the Terminal Doppler Weather Radar (TDWR) project. The algorithm utilizes radar information from scans aloft as well as surface scans. The use of vertical structure allows the algorithm to achieve increased reliability over an algorithm based solely on surface outflow detection. In addition, the use of features aloft allows the algorithm to produce earlier microburst hazard warnings than would otherwise be possible. The present algorithm is implemented using a rule-based expert system for low-altitude wind shear recognition.

NTIS Accession Number:	PB92-118678/XAB
Title:	Requirements for TDWR Scan Coverage Aloft
Author(s):	Merritt, M. W.; Campbell, S. D.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Sponsor:	Department of the Air Force, Washington, DC.; Federal Aviation Administration, Washington, DC.
Publication Date:	27 Jan 87 20p

Abstract

The microburst detection data requirements, and implications for scanning requirements for the Terminal Doppler Weather Radar system are discussed. While the wind shear hazard presented by a microburst is primarily a low-altitude phenomena, the reliable and timely detection of microbursts requires the observation of storm features at upper altitudes. By observing the growth of the storm reflectivity structure, and following the descent of the strong rain core of the storm, the decaying stage of the storm life cycle may be detected, and used to improve the reliability of early microburst warnings (based on surface outflow strength). The use of microburst precursors (storm features which generally precede the formation of microbursts) are a promising method for improving the warning lead time, ad their observation also requires radar scanning to the mid-levels of the storm. A basic requirement to scan to an altitude of 6 kilometers above ground level is developed for the typical TDWR siting scenario.

Title:	Recognizing Low-Altitude Wind Shear Hazards from Doppler Weather Radar: An Artificial Intelligence Approach
Author(s):	Campbell, S.D.; Olson, S.H.
Author Affiliation:	Lincoln Lab., MIT, Lexington, MA, USA
Journal:	Journal of Atmospheric and Oceanic Technology vol. 4, no. 1 p.5-18
Publication Date:	March 1987

Abstract

Describes an artificial intelligence-based approach for automated recognition of wind shear hazards. The design of a prototype system for recognizing low-altitude wind shear events from Doppler radar displays is presented. This system, called WX1, consists of a conventional expert system augmented by a specialized capability for processing radar images. The radar image processing component of the system employs numerical and computer vision techniques to extract features from radar data. The expert system carries out symbolic reasoning on these features using a set of heuristic rules expressing meteorological knowledge about wind shear recognition. Results are provided demonstrating the ability of the system to recognize microburst and gust front wind shear events.

NTIS Accession Number:	PB92-115112/XAB
Title:	Ground Clutter Cancellation for the NEXRAD System
Author(s):	Evans, J. E.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Sponsor:	National Oceanic and Atmospheric Administration, Washington, DC.; Department of the Air Force, Washington, DC.
Report No.:	ATC-122
Publication Date:	19 Oct 83 177p

Abstract

Returns from the ground and associated obstacles surrounding a NEXRAD weather radar (i.e., ground clutter) will contaminate the estimates of weather echo spectral features (e.g., reflectivity, mean velocity, and spectral width). The ground clutter returns are particularly large at low elevation angles and close range (e.g., within 40 km). Additionally, the pulse repetition frequency (PRF) values necessary to obtain the desired weather Doppler features result in ground clutter contamination at ranges that are multiples of the unambiguous range interval (e.g., 115-175 km for a typical NEXRAD). Fortunately, the ground clutter power spectrum is localized around zero velocity so that one can reduce its effect by appropriate Doppler signal processing. Automatic reduction of clutter contamination is essential if NEXRAD is to achieve the desired automatic weather product generation capability. The results of an analytical/experimental study oriented toward development of a clutter cancellation specification and associated quality assurance tests for the NEXRAD system are described.

E.I. Monthly No:	EIM8403-027126
Title:	Short-Term Prediction of High Reflectivity Contours for Aviation Safety
Author(s):	Brasunas, John C.; Merritt, Mark W.
Author Affiliation:	MIT, Lincoln Lab, Lexington, Mass, USA
Conference Title:	9th Conference - Aerospace and Aeronautical Meteorology.
Conference Location:	Omaha, Nebr, USA
Conference Date:	1983 Jun 6-9
Sponsor:	American Meteorological Soc, Boston, Mass, USA; AIAA, New York, NY, USA; Natl Weather Assoc
E.I. Conference No.:	03655
Source:	Publ by American Meteorological Soc, Boston, Mass, USA p 118-122
Publication Year:	1983

No abstract given.

4. TERMINAL DOPPLER WEATHER RADAR/INTEGRATED TERMINAL WEATHER SYSTEM MEASUREMENT PROGRAMS

Title:	Dual-Doppler Measurements of Microburst Outflow Strength Asymmetry
Author:	Hallowell, Robert G.
Author Affiliation:	Massachusetts Inst of Technology, Lexington, MA, USA
Conference Title:	26th International Conference on Radar Meteorology
Conference Location:	Norman, OK, USA
Sponsor:	American Meteorological Society; Norman Weather Center
Source:	International Conference on Radar Meteorology 1993. Publ by American Meteorological Soc, Boston, MA, USA. p 664-666
Publication Year:	1993

Abstract

Previous studies of microburst asymmetry have not considered the impact of radar configurations, thereby, introducing apparent asymmetry into the analysis. By using simulated data we are able to estimate the impact of temporal difference, vertical beam overlap, and horizontal beam intersection angle factors in processing and analyzing dual-Doppler microburst events. A total of 859 microburst observations were examined from three geographical regions. We find that overall asymmetry distributions are lower than had been found in all previous studies, and that differences in asymmetry ratios in the observation data vary from 1.1 to 4.0 (with less than 5% over 3.0) and have a median value of 1.78. In addition, estimating and removing the residual errors of apparent asymmetry from the observation data set yields a distribution of 1.0 to 3.0 and median 1.34.

Title:	Preliminary Results of the Weather Testing Component of the Terminal Doppler Weather Radar Operational Test and Evaluation
Author:	Vasiloff, Steven V.; Eilts, Michael D.; Turcich, Elizabeth; Wieler, Jim; Isaminger, Mark; Biron, Paul
Author Affiliation:	Natl Severe Storms Lab, Norman, OK, USA
Conference Title:	26th International Conference on Radar Meteorology
Conference Location:	Norman, OK, USA
Sponsor:	American Meteorological Society; Norman Weather Center
E.I. Conference No.:	19150
Source:	International Conference on Radar Meteorology 1993. Publ by American Meteorological Soc, Boston, MA, USA. p 29-31
Publication Year:	1993

Abstract

The Terminal Doppler Weather Radar (TDWR) system (Turnbull et al. 1989), which has been developed by Raytheon Co. for the Federal Aviation Administration (FAA), provides automatic detection of microbursts (Fujita 1985) and low-altitude wind shear. The second major function of TDWR is to improve air traffic management though forecasts of wind shifts, precipitation and other weather hazards. The TDWR system generates Doppler velocity, reflectivity, and spectrum width data. The base data are automatically dealiased and clutter is removed through filtering and mapping. Precipitation and windshear products, such as microbursts and gust fronts, are displayed as graphic products on the Geographic Situation Display which is intended for use by Air Traffic Control supervisors. The initial Operational Test & Evaluation (OT&E) of the Terminal Doppler Radar showed that weather detection performance was generally acceptable. A set of NASS-SS-1000 requirements was satisfied. Base data quality appears to be excellent and the two primary algorithms, microburst detection and gust front detection, are in general working well.

Title:	The Orlando TDWR Testbed and Airborne Wind Shear Date Comparison Results
Author(s):	Campbell, Steven; Berke, Anthony; Matthews, Michael (Massachusetts Inst. of Tech., Lexington)
Conference Title:	NASA Langley Research Center, Airborne Wind Shear Detection and Warning Systems. Fourth Combined Manufacturers' and Technologists' Conference, Part 2 p 811-846 (SEE N93-14844 04-03)
Publication Date:	Sep. 1992
Availability:	Documents available from AIAA Technical Library

Abstract

The focus of this talk is on comparing terminal Doppler Weather Radar (TDWR) and airborne wind shear data in computing a microburst hazard index called the F factor. The TDWR is a ground-based system for detecting wind shear hazards to aviation in the terminal area. The Federal Aviation Administration will begin deploying TDWR units near 45 airports in late 1992. As part of this development effort, M.I.T. Lincoln Laboratory operates under F.A.A. support a TDWR testbed radar in Orlando, FL. During the past two years, a series of flight tests has been conducted with instrumented aircraft penetrating microburst events while under testbed radar surveillance. These tests were carried out with a Cessna Citation 2 aircraft operated by the University of North Dakota (UND) Center for Aerospace Sciences in 1990, and a Boeing 737 operated by NASA Langley Research Center in 1991. A large data base of approximately 60 instrumented microburst penetrations has been obtained from these flights.

NTIS Accession Number:	AD-A255 703/1/XAB
Title:	Birds Mimicking Microbursts on 2 June 1990 in Orlando, Florida
Author:	Isaminger, M. A.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington.
Publication Date:	Jul. 1992 74P.
Report No.:	AD-A255703; ATC-184
Availability:	Documents available from AIAA Technical Library
Note:	Original contains color plates: All DTIC reproductions will be in black and white.

Abstract

During 1990 and 1991, the Terminal Doppler Weather Radar (TDWR) testbed collected Doppler radar measurements in Orlando, Florida in support of the TDWR Project. The main focus of the project is to develop algorithms that automatically detect wind shears such as microbursts and gust fronts. While the primary goal of the TDWR is to detect scattering from raindrops, the sensitivity of the system allows for the detection of biological echoes as well. Previous research has shown that under certain conditions the scattering from birds and insects will lead to divergent signatures that mimic microbursts. This type of pattern has been documented in Alabama (Rinehart, 1986), Illinois (Larkin and Quine, 1989), and Missouri (Evans, 1990). In the Alabama and Illinois events, a divergent pattern similar to a microburst was produced when a large number of birds departed in the early morning hours from an overnight roosting site. On 2 June 1990 in Orlando, Florida, there were 11 surface divergent signatures similar to microbursts detected by the TDWR testbed radar. The maximum differential velocity of these events ranged from 11 to 36 m/s, while the maximum reflectivity varied from 0 to 44 dBz. There was light rain in the area and low-reflectivity returns aloft; however, the reflectivity was more like low-reflectivity microbursts in Denver than high-reflectivity microbursts that generally are observed in Orlando. These divergences were not detected by the microburst algorithm since the TDWR site adaptation parameters have been adjusted to avoid issuing alarms for signatures such as those on 2 June. Detailed investigation was conducted of two events to verify that these were not actual microbursts.

Title:	A Comparison of the Performance of Two Gust Front Detection Algorithms Using a Length-Based Scoring Technique
Author(s):	Klingle-Wilson, D. L.; Donovan, M. F.; Olson, S. H.; Wilson, F. W.
Author Affiliation:	Massachusetts Inst. of Tech., Cambridge.
Publication Date:	May 1992 45P.
Report No.:	AD-A250862; ATC-185; DOT/FAA/NR-92/1
Availability:	Documents available from AIAA Technical Library

Abstract

The Terminal Doppler Weather Radar (TDWR) Gust Front Algorithm provides, as products, estimates of the current locations of gust fronts, their future locations, the wind speed and direction behind the gust fronts, and the wind shear hazard to landing or departing aircraft. These products are used by air traffic controllers and supervisors to warn pilots of potentially hazardous wind shears during take-off and landing and to plan runway reconfigurations. Until recently, an event-based scoring scheme was used to evaluate the performance of the algorithm. With the event-based scoring scheme, if any part of a gust front was detected, a valid detection was declared. Unfortunately, this scheme gave no indication of how much of the gust front length was detected, nor could the probabilities be easily related to the probability of issuing a wind shear alert for a specific approach or departure path which was being impacted by a gust front. To make the scoring metric more nearly reflect the operational use of the product, a new length-based scoring scheme was devised. This scheme computes the length of the gust front detected by the algorithm. When computed over a large number of gust fronts, this length-based scoring scheme yields the probability that any part of the gust front will be detected.

Title:	Orlando Experiment
Author(s):	Campbell, Steve
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Conference Title:	NASA. Langley Research Center, Airborne Wind Shear Detection and Warning Systems: Third Combined Manufacturers' and Technologists' Conference, Part 1 p 243-262 (SEE N91-24166 16-03)
Publication Date:	Jan. 1991
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC/MF A21

Abstract

FAA terminal Doppler weather radar program and NASA/FAA airborne wind shear program are presented in the form of view-graphs. The following topics are included: TDWR testbed radar performance; cockpit display system; flight operations; analysis workstation; and future work.

Title:	A Comparison of Anemometer and Doppler Radar Winds During Wind Shear Events
Author(s):	Liepins, Margita C.; Wolfson, Marilyn M.; Clark, David A.; Forman, Barbara E. (MIT, Lexington, MA)
Conference Title:	Conference on Severe Local Storms, 16th and Conference on Atmospheric Electricity, Kananaskis Park, Canada, Oct. 22-26, 1990, Preprints (A92-27926 10-47). Boston, MA, American Meteorological Society, 1990, p. 356-361. Research sponsored by FAA.
Publication Date:	1990 8 Refs.
Availability:	Documents available from AIAA Technical Library

Abstract

An effort is made to clarify the basic relationship between the wind information furnished by the Low Level Wind Shear Alert System (LLWAS) and the upcoming Terminal Doppler Weather Radar system, as well as to ascertain the effect of this relationship on integration of the two operational systems. A mathematical technique proposed for 'correcting' LLWAS wind data where required, in order to achieve a better match with radar winds, is evaluated for the cases of divergent microbursts and convergent wind-shear gust fronts.

Title:	Results of the Kansas City 1989 Terminal Doppler Weather Radar (TDWR) Operational Evaluation Testing
Author(s):	Evans, J. E., ed.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Publication Date:	Aug. 1990 87P.
Report No.:	AD-A228784; ATC-171; DOT/FAA/NR-90/1
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC/MF A05

Abstract

The Terminal Doppler Weather Radar (TDWR) testbed was used at the Kansas City International (KCI) airport during the summer of 1989. The objective was to test and refine previous tested techniques for the automatic detection of low-altitude wind shear phenomena (specifically microbursts and gust fronts) and heavy precipitation in a midwest weather environment, as well as to assess possible new products such as storm movement predictions. A successful operation evaluation of the TDWR products took place at the KCI tower and terminal radar control room (TRACON). Several supervisor and controller display refinements were assessed as effective. The system was successful in terms of aircraft at KCI avoiding wind shear encounters during the operational period, and it was assessed as very good in usefulness for continuing operation by the KCI air traffic control (ATC) personnel. The probability of detection for microbursts was substantially better than that in Denver. However, the false-alarm probability was found to be substantially higher in Kansas City due to a combination of weather and clutter phenomena. By optimizing the site-adaptation capabilities of the TDWR meteorological and data quality algorithms, the required false-alarm probability was achieved. The gust front performance was generally poorer than in Denver due to a combination of unfavorable radar-airport-gust front geometry of false alarms induced by low-level jets. Gust front algorithm refinements which should provide improved performance are discussed.

Title:	Automatic Detection of Low Altitude Wind Shear due to Gust Fronts in the Terminal Doppler Weather Radar Operational Demonstration
Author(s):	Klingle-Wilson, Diana
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Conference Title:	NASA, Langley Research Center, Airborne Wind Shear Detection and Warning Systems. Second Combined Manufacturers' and Technologists' Conference, Part 2 p 754-770 (SEE N91-11695 03-03)
Publication Date:	Jul. 1990
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC/MF A20

Abstract

A gust front is the leading edge of the cold air outflow from a thunderstorm. Wind shears and turbulence along the gust front may produce potentially hazardous conditions for an aircraft on takeoff or landing such that runway operations are significantly impacted. The Federal Aviation Administration (FAA) has therefore determined that the detection of gust fronts in the terminal environment be an integral part of the Terminal Doppler Weather Radar (TDWR) system. Detection of these shears by the Gust Front Algorithm permits the generation of warnings that can be issued to pilots on approach and departure. In addition to the detection capability, the algorithm provides an estimate of the wind speed and direction following the gust front (termed wind shift) and the forecasted location of the gust front up to 20 minutes before it impacts terminal operations. This has shown utility as a runway management tool, alerting runway supervisors to approaching wind shifts and the possible need to change runway configurations. The formation and characteristics of gust fronts and their signatures in Doppler radar data are discussed. A brief description of the algorithm and its products for use by Air Traffic Control (ATC), along with an assessment of the algorithm's performance during the 1988 Operational Test and Evaluation, is presented.

Title:	Summer 1988 TDWR Microburst Analysis
Author(s):	Merritt, Mark W.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Conference Title:	NASA, Langley Research Center, Airborne Wind Shear Detection and Warning Systems. Second Combined Manufacturers' and Technologists' Conference, Part 2 p 740-751 (SEE N91-11695 03-03)
Publication Date:	Jul. 1990
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC/MF A20

Abstract

The Terminal Doppler Weather Radar (TDWR) testbed system was operated during the months of July to August 1988 in a live operational demonstration providing microburst (and related weather hazard) protection to the Stapleton International Airport in Denver, CO. During this time period, the performance of the detection system was carefully monitored in an effort to determine the reliability of the system. Initial performance analysis indicates that the microburst detection component of TDWR satisfies the basic performance goals of 90 percent probability of detection and 10 percent probability of false alarm. An in-depth study of the system performance, based on analysis of both dual-Doppler radar observations and surface mesonet measurements, is in progress to provide a detailed understanding of the observability of microbursts by the radar, the ability of the algorithms to detect microburst observed by the radar, and the timeliness and accuracy of the microburst alarms provided to operational users.

NTIS Accession Number: PB92-118702/XAB
Title: Microburst Detection Algorithm Performance Results for Kansas City, 1989
Author(s): Neilley, D. R. ; Wolfson, M. M. ; Hallowell, R. G.
Author Affiliation: Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Sponsor: Federal Aviation Administration, Washington, DC.; Department of the Air Force, Washington, DC.
Publication Date: 19 Dec 90 39p

Abstract

The report presents performance statistics for the microburst detection algorithm based on an off-line, automatically scored evaluation of 26 days during the 1989 Terminal Doppler Weather Radar (TDWR) demonstration. The TDWR testbed was located near Kansas City and operated at the McCoy International Airport (MCI). Before site adaptation parameters were optimized for the MCI environment, the probability of detection (POD) was quite good at 94.0%, but the probability of false alarms (PFA) was also high at 12.6%. Days with extreme statistics are examined and discussed. Analysis of the causes of false alarms on 13 days in Kansas City showed that the microburst algorithm 'coast' and 'precursor' alarm declarations were together responsible for 52%, and clear air data contamination was responsible for another 35%. The storm cell validation test, provided as a site adaptation feature in the TDWR microburst algorithm, was evaluated on a subset of cases as a method for eliminating clear air false alarms. Several recommendations on how the microburst detection algorithm performance could be improved are made.

Title: Microburst Recognition Performance of TDWR Operation Testbed (Terminal Doppler Weather Radar)
Author(s): Campbell, Steven D.; Merritt, Mark W.; Distefano, John T. (MIT, Lexington, MA)
Conference Title: International Conference on the Aviation Weather System, 3rd, Anaheim, CA, Jan. 30-Feb. 3, 1989, Preprints (A89-54776 24-47). Boston, MA, American Meteorological Society, 1989, p. 25-30. Research supported by FAA.
Publication Date: 1989 8 Refs.
Availability: Documents available from AIAA Technical Library

Abstract

The microburst recognition performance of the Terminal Doppler Weather Radar (TDWR) operational testbed is assessed. The prototype TDWR microburst recognition algorithm is described. The method for evaluating the system's recognition performance is described, including the assessment of radar detectability and pattern-recognition capability. Recognition performance is assessed by comparing microburst recognition algorithm outputs with meteorological radar data. Preliminary results are presented for the 1986, 1987, and 1988 seasons.

Title:	Storm Models for End-to-End TDWR (Terminal Doppler Weather Radar) Signal Processing Simulation Tests
Author(s):	Evans, J. E.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Publication Date:	May 1989 47P.
Report No.:	AD-A209384; ATC-155; DOT/FAA/PM-87/37
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC A03/MF A01

Abstract

End-to-end qualification testing of the Terminal Doppler Weather Radar (TDWR) contractor signal processing system will be accomplished by a signal processing simulation test. Government furnished storm models will be used to provide inputs to the signal processor. The corresponding hazardous weather product results will be compared to the results determined by the detection algorithm developers. This report examines the role of the end-to-end tests in the context of overall TDWR qualification testing and concludes that the signal waveform/velocity ambiguity resolution should be the principal focus of the signal processing simulation testing. Salient characteristics of the initial pair of storm models (a high reflectivity microburst observed in Huntsville, AL, and a series of low-to-moderate reflectivity microburst storms observed in Denver, CO) are described as well as desirable characteristics of additional storm models to be provided later.

NTIS Accession Number:	PB92-118728/XAB
Title:	Quick-Look Summary Report on Microburst Detection Algorithm Performance During TDWR Operational Test and Evaluation
Author(s):	Merritt, M. W.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Sponsor:	Federal Aviation Administration, Washington, DC.; Department of the Air Force, Washington, DC.
Publication Date:	21 Oct 88 25p

Abstract

During July and August, 1988 the testbed Terminal Doppler Weather Radar (TDWR) system was exercised in an operational test and evaluation at Denver's Stapleton airport. During this period, the system was operated each day from noon to 7 pm (local time) each day, with real-time warning and planning products provided to the Stapleton air traffic control users. The primary purpose of the evaluation was to demonstrate that the microburst detection function provided by the system met the TDWR System Requirements Statement goals, so that procurement of the system by the Government could proceed.

Title:	Weather Radar Studies Quarterly Technical Summary Report, 1 Apr. - 30 Jun. 1985
Author(s):	Evans, J. E.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Publication Date:	Jun. 1985 65P.
Report No.:	AD-A165221; DOT/FAA/PM-85-28
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC A04/MF A01

Abstract

FAA-funded Doppler weather radar activities during the period 1 April to 30 June 1985 are reported. The test-bed Doppler weather radar system making measurements in Olive Branch, Mississippi, was fully operational. Additionally, the University of North Dakota C-band Doppler weather radar commenced measurements. Weather measurements were conducted on a number of cold front passages with attendant prefrontal lines of showers and thunderstorms and on scattered air mass thunderstorms. Some 17 microbursts were observed during the radar operation with the bulk of the microburst occurring in late June. Thirty-one gust fronts were observed as well. The University of North Dakota Citation aircraft made airborne turbulence measurements on eight days in the period mid-May to mid-June. The Lincoln mesonet was fully operational throughout the period. The 1984 peak wind speed data from the mesonet and the Memphis International Airport LLWAS data have been analyzed to determine ground level wind-shear characteristics in the Memphis area. Doppler weather radar data from the National Center for Atmospheric Research JAWS program and the National Severe Storms Laboratory are being analyzed to develop low-altitude wind-shear detection algorithms. Analysis continued of the data collected in the 1983 Boston area coordinated aircraft-Doppler weather radar turbulence experiment. Work continued on the development of weather radar products for the Central Weather Processor.

NTIS Accession Number:	AD-A161 622/6/XAB
Title:	Weather Radar Studies Quarterly Technical Summary Report January 1 - March 31, 1985
Author(s):	Evans, James E.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Sponsor:	Federal Aviation Administration, Washington, DC. Program Engineering and Maintenance Service.
Report No.:	DOT/FAA/PM-85-16
Publication Date:	31 Mar 85 42p

Abstract

FAA-funded Doppler weather radar activities during the period 1 January to 31 March 1985 are reported. The test-bed Doppler weather radar system measurements in Olive Branch, Mississippi, commenced following the installation of an improved lightning protection system. Clutter suppression testing showed that the objective of 50-dB suppression was obtained in the field against appropriate fixed targets. Weather measurements were conducted on a number of cold front passages with attendant prefrontal lines of showers and thunderstorms. The Lincoln mesonet was recalibrated at Lincoln in January and February and then installed at the site in late February. The mesonet was fully operational in March. The 1984 peak wind speed data from the mesonet and the Memphis International Airport LLWAS data were analyzed preliminarily to determine wind shear characteristics in the Memphis area. Doppler weather radar data from the National Center for Atmospheric Research JAWS program and the National Severe Storms Laboratory are being analyzed to develop low-altitude wind shear detection algorithms. Analysis of the data collected in the 1983 Boston area coordinated aircraft-Doppler weather radar turbulence experiment commenced. Work continued on the development of weather radar products for the Central Weather Processor with particular emphasis on the correlation tracking and extrapolated weather map algorithms. Keywords include: Weather radar; Low-altitude wind shear; NEXRAD; Central weather processor; Aviation weather products; and Turbulence.

NTIS Accession Number:	PB92-118660/XAB
Title:	Spectral Stability Test Results for Enterprise Weather Radar
Author(s):	Evans, J. E.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Sponsor:	Federal Aviation Administration, Washington, DC.; Department of the Air Force, Washington, DC.
Publication Date:	2 Feb 84 18p

Abstract

Measurements, 16 December 1983, on an Enterprise C-band radar at Enterprise Corp. show that the spectral residue when illuminating a tower with the antenna motionless consists principally of: (1) a discrete line some 29 dB down from the dc signal level at a frequency corresponding to a velocity of approximately 7.5 m/s, and (2) a wideband noise whose spectrum is approximately flat with a total power some 22 dB down from the direct signal. In the context of anticipated Lincoln Laboratory usage of the UND radar data, it appears that the Enterprise radar with Sigmet processor will be able to provide an effective clutter suppression capability of 26 to 30 dB.

SECTION II:
ASR WEATHER SYSTEM PROCESSOR (WSP)

5. BASELINE ASR-9: TARGET CHANNEL AND SIX-LEVEL WEATHER

Title:	Advances in Primary-Radar Technology
Author(s):	Stone, M.L.; Anderson, J.R.
Author Affiliation:	Lincoln Lab., MIT, Lexington, MA, USA
Journal:	Lincoln Laboratory Journal vol. 2, no. 3 p.363-80
Publication Date:	Fall 1989
ISSN:	0896-4130

Abstract

Current primary radars have difficulty detecting aircraft when ground clutter, rain, or birds interfere. To overcome such interference, the Moving Target Detector (MTD) uses adaptive digital signal and data processing techniques. MTD has provided the foundation for a new generation of primary radars called Airport Surveillance Radar-9 (ASR-9). In addition to achieving near-optimal target-detection performance, ASR-9 also provides timely weather information. The Federal Aviation Administration (FAA) is installing ASR-9 systems at more than 100 airports across the United States.

Title:	Vertical Reflectivity Profiles - Averaged Storm Structures and Applications to Fan-Beam Radar Weather Detection in the U.S
Author(s):	Troxel, Seth W.; Engholm, Cynthia D. (MIT, Lexington, MA)
Conference Title:	Conference on Severe Local Storms, 16th and Conference on Atmospheric Electricity, Kananaskis Park, Canada, Oct. 22-26, 1990, Preprints (A92-27926 10-47). Boston, MA, American Meteorological Society, 1990, p. 213-218. Research sponsored by FAA.
Publication Date:	1990 7 Refs.
Availability:	Documents available from AIAA Technical Library

Abstract

The ASR-9 radar furnishes ATC personnel with precipitation intensity estimates that are quantized into the NWS's six weather levels. To compensate for the possibility that fan-beam reflectivity estimates may not be representative of the storm intensity in those cases where the vertical reflectivity profile is nonuniform, the weather reflectivity thresholds may be adjusted on a regional and range basis. Weather level adjustments are presently computed by minimizing the relative error between the fan-beam reflectivity and the storm intensity. A single correction is found to be suitable for all regions and weather levels.

Title:	Beam Filling Loss Adjustments for ASR-9 Weather Channel Reflectivity Estimates
Author(s):	Engholm, Cynthia D.; Troxel, Seth W.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Publication Date:	Oct. 1990 57P.
Report No.:	AD-A228654; ATC-177; DOT/FAA/NR-90/6
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC/MF A04

Abstract

The FAA is deploying over 100 new airport surveillance radars (ASR-9) across the country. In contrast to earlier ASRs, the ASR-9 utilizes a separate digital weather processing channel to provide air traffic controllers with timely, calibrated displays of precipitation intensity. The ASR-9 utilizes dual selectable fan shaped elevation beams designed to track aircraft over a large volume. As a consequence, weather echoes received from these fan shaped beams represent vertically averaged quantities. If the precipitation only partially or nonuniformly fills the beam, then the vertically integrated reflectivity may underestimate the actual intensity of the storm. The ASR-9 weather channel corrects for this by adjusting the range dependent six level reflectivity thresholds. The appropriateness of the currently implemented correction has not been carefully examined and may require modification to take into account regional and morphological variability in storm structure. The method used to derive new beam filling loss adjustments is discussed. An extensive database of volumetric pencil beam radar data were used in conjunction with the ASR-9 simulation facility to derive adjustments aimed at calibrating the precipitation intensity reports to the maximum perceived hazard. Results from this calibration indicate that a single correction is appropriate for all sites and intensities. The new corrections yield substantially improved results over the current corrections in producing these reflectivity reports.

Accession Number:	AD-A211 749/7/XAB
Title:	ASR-9 Weather Channel Test Report
Author(s):	Puzzo, Dean C.; Troxel, Seth W.; Meister, Mark A.; Weber, Mark E.; Pieronek, James V.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Publication Date:	May 1989 140P.
Report No.:	AD-A211749; ATC-165; DOT/FAA/PS-89-3
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC A07/MF A01
Note:	Original contains color plates: All DTIC and NTIS reproductions will be in black and white.

Abstract

The ASR-9, the next generation airport surveillance radar, will be deployed by the FAA at over 100 locations throughout the U.S. The system includes a weather channel designed to provide ATC personnel with timely and accurate weather reflectivity information as a supplement to normal aircraft information. Issues addressed are: whether the ASR-9 weather channel performs according to FAA specifications and whether the ASR-9 weather channel adequately represents weather reflectivity for ATC purposes. Comparisons between data from an ASR-9 in Huntsville, AL, recorded during design qualification and testing, and data from two other reference radars, were used as the basis for the assessment. Several storm cases were analyzed, comprised of stratiform rain, isolated convective storms, squall lines, and cold fronts containing multiple simultaneous convective storms. Results suggest that, with the exception of an apparent 3 dB discrepancy between the weather products of the ASR-9 and the reference radars, the ASR-9 weather channel seems to perform according to FAA specifications. Although the ASR-9 products give a reasonable representation of the extent and severity of potentially hazardous weather in Huntsville, the results suggest that the static storm model used to determine beamfill corrections for the ASR-9 should be optimized for the particular climatic region in which an ASR-9 will be operated.

Accession Number:	AD-A208 284/0/XAB
Title:	ASR (Airport Surveillance Radar)-9 Weather Channel Test Report, Executive Summary (Project rept.)
Author:	Troxel, S. W.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Report No.:	ATC-168
Publication Date:	3 May 89 29p
Note:	Original contains color plates: All DTIC and NTIS reproductions will be in black and white.

Abstract

The ASR-9, the next generation airport surveillance radar, will be deployed by the FAA at over 100 locations throughout the United States. The system includes a weather channel designed to provide ATC personnel with timely and accurate weather reflectivity information as a supplement to normal aircraft information. Comparisons between data from an ASR-9 in Huntsville, Alabama, recorded during design qualification and testing, and data from two other reference radars, were used as the basis for assessment of ASR-9 weather channel performance. Results suggest that, with the exception of an apparent 3 dB discrepancy between the weather products of the ASR-9 and the 'reference' radars, the ASR-9 weather channel seems to perform according to FAA specifications.

Accession Number:	AD-A191 147/8/XAB
Title:	Assessment of ASR-9 Weather Channel Performance: Analysis and Simulation
Author:	Weber, M. E.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Sponsor:	Federal Aviation Administration, Washington, DC. Program Engineering and Maintenance Service.
Report No.:	ATC-138; DOT/FAA/PM-86-16
Publication Date:	31 Jul 86 108p
Note:	Original contains color plates: All DTIC and NTIS reproductions will be in black and white.

Abstract

In this report, we use pencil-beam Doppler weather radar data, combined with on-airport ground clutter measurements, to analyze the performance of the six-level weather channel in the next generation airport surveillance radar, the ASR-9. A key tool was a computer procedure that used these data to simulate the output of the ASR-9's weather channel, including effects of the radar's fan-shaped elevation beams, short coherent processing intervals and ground clutter filters. Our initial analysis indicates that: (a) the combination of high-pass Doppler filters and spatial/temporal smoothing should normally prevent ground clutter from having a significant effect on the controllers' weather display; (b) the spatial/temporal smoothing processor will result in weather contours that are statistically stable on a to-scan basis, reinforcing controller confidence in the validity of the data; (c) relative to the coarse resolution imposed by use of the NWS levels, accurate two-dimensional parameterizations of storm reflectivity can be estimated. Our assessment indicates that the ASR-9's weather reflectivity maps should be reliable. The radar will be widely deployed at significant air terminals, and will provide a combination of high update rate and large volumetric coverage not available from other sensors. These attributes should lead the ASR-9 becoming an important component of the Federal Aviation Agency's modernized weather nowcasting system.

6. WSP OVERVIEWS

Title:	Low Altitude Wind Shear Detection Using Airport Surveillance Radars
Author(s):	Weber, M.E.; Stone, M.L.
Author Affiliation:	Lincoln Lab., MIT, Lexington, MA, USA
Journal:	IEEE Aerospace and Electronics Systems Magazine vol. 10, no. 6, p.3-9
Publication Date:	June 1995
Country of Publication:	USA
ISSN:	0885-8985

Abstract

This paper describes an enhanced weather processor for the Federal Aviation Administration's Airport Surveillance Radar (ASR-9) that will include Doppler wind estimation for the detection of low altitude wind shear, scan-to-scan tracking to provide estimates of the speed and direction of storm movement and suppression' of spurious weather reports currently generated by the ASR-9's six-level weather channel during episodes of anomalous radar energy propagation (AP). This ASR-9 Wind Shear Processor (WSP) will be implemented as a retrofit to the ASR-9 through the addition of interfaces, receiving chain hardware and high-speed digital processing and display equipment. Thunderstorm activity in terminal airspace (the volume extending approximately 30 nmi from an airport and to 15,000 feet altitude) is an obvious safety issue and makes a significant overall contribution to delay in the United States commercial aviation industry. Analysis and on-line testing of the prototype ASR-9 WSP has confirmed that the system can provide operationally beneficial detection of low-altitude wind shear phenomena and enhanced weather situational awareness for Air Traffic Control teams.

Title:	Wind Shear Detection with Airport Surveillance Radars
Author(s):	Weber, M.E.; Noyes, T.A.
Author Affiliation:	Lincoln Lab., MIT, Lexington, MA, USA
Journal:	Lincoln Laboratory Journal vol. 2, no. 3 p.511-26
Publication Date:	Fall 1989
ISSN:	0896-4130

Abstract

Airport surveillance radars (ASR) utilize a broad, cosecant-squared elevation beam pattern, rapid azimuthal antenna scanning, and coherent pulsed-Doppler processing to detect and track approaching and departing aircraft. These radars, because of location, rapid scan rate, and defect air traffic control (ATC) data link, can also provide flight controllers with timely information on weather conditions that are hazardous to aircraft. With an added processing channel, an upgraded ASR can automatically detect regions of low-altitude wind shear. This upgrade can provide wind shear warnings at airports where low traffic volume or infrequent thunderstorm activity precludes the deployment of a dedicated Terminal Doppler Weather Radar (TDWR). Field measurements and analysis conducted by Lincoln Laboratory indicate that the principal technical challenges for low-altitude wind shear detection with an ASR-ground-clutter suppression, estimation of near-surface radial velocity, and automatic wind shear hazard recognition-can be successfully met for microbursts accompanied by rain at the surface.

Title:	Airport Surveillance Radar Based Wind Shear Detection
Author(s):	Weber, Mark; Stone, Melvin (MIT, Lexington, MA); Primeggia, Carmine (FAA, Washington); Anderson, John (Wisconsin Univ., Madison)
Conference Title:	International Conference on Aviation Weather Systems, 4th, Paris, France, June 24-28, 1991, Preprints (A93-22101 07-47). Boston, MA, American Meteorological Society, 1991, p. J11-J16.
Sponsor:	FAA
Publication Date:	1991
Availability:	Documents available from AIAA Technical Library

Abstract

The study provides an update on the development of a system based on airport surveillance radars (ASRs) for detection of thunderstorm-generated low-altitude wind shear. Emphasis is placed on wind shear detection using the ASR-9 radar. Background and an overview of technical issues are presented. Results of an initial operational test of ASR-based wind shear detection at Orlando International Airport are reported. Interface of a wind shear processor to the ASR-9, and the status of ongoing development activities are discussed. Analysis and on-line testing of ASR-based wind shear detection indicates that these radars are capable of supporting the detection of microbursts and gust fronts. The baseline system tested in Orlando is shown to provide an operationally useful capability A production ASR-9 is being modified to demonstrate that interfaces to the wind shear processor can be achieved without degradation of the ASR-9's aircraft detection channel..

Title:	Weather Sensing with Airport Surveillance Radars
Author:	Weber, Mark E. (MIT, Lexington, MA)
Conference Title:	International Conference on the Aviation Weather System, 3rd, Anaheim, CA, Jan. 30-Feb. 3, 1989, Preprints (A89-54776 24-47). Boston, MA, American Meteorological Society, 1989, p. 68-74. Research sponsored by FAA.
Publication Date:	1989
Availability:	Documents available from AIAA Technical Library

Abstract

The use of six-level weather reflectivity reports from the ARS-9 airport surveillance radars to control airport terminal regions is discussed. The design of the ASR-9 six-level reflectivity processor is described. Consideration is given to the statistical stability of the displayed weather regions, the ASR-9 method for ground clutter suppression, and the system's fan-shaped elevation beam pattern. A possible processor upgrade to enable airport surveillance radars to measure the velocity of precipitation wind tracers and to detect regions of hazardous low altitude wind shear. Results from experiments testing the capabilities of ARS-9 are reviewed.

7. WSP DATA PROCESSING ISSUES

Title:	Variable-PRI Processing for Meteorologic Doppler Radars
Author(s):	Chornoboy, E.S.; Weber, M.E.
Author Affiliation:	Lincoln Lab., MIT, Lexington, MA, USA p.85-90
Publisher:	IEEE, New York, NY, USA
Publication Date:	1994
ISBN:	0 7803 1438 7
Conference Title:	Proceedings of 1994 IEEE National Radar Conference
Conference Sponsor:	Atlanta Sect. & the IEEE Aerosp. & Electron. Syst. Soc
Conference Date:	29-31 March 1994 Conference Location: Atlanta, GA, USA

Abstract

In this communication e described how, with nonuniform sampling, the concept of bandlimited extrapolation can be used to obtain unambiguous Doppler velocity estimates in the supra-Nyquist region. The proposed method coherently processes a multi-PRI sample using a generalized form of periodogram analysis. The work is described in the context of meteorologic Doppler processing and includes a discussion of effective suppression for stationary ground clutter when multi-PRI schemes are used.

Title:	Machine Intelligent Gust Front Detection
Author(s):	Delanoy, R.L.; Troxel, S.W.
Author Affiliation:	Lincoln Lab., MIT, Lexington, MA, USA
Journal:	Lincoln Laboratory Journal vol. 6, no. 1, p.187-212
Publication Date:	Spring 1993
ISSN:	0896-4130

Abstract

Techniques of low-level machine intelligence, originally developed at Lincoln Laboratory to recognize military ground vehicles obscured by camouflage and foliage, are being used to detect gust fronts in Doppler weather radar imagery. This Machine Intelligent Gust Front Algorithm (MIGFA) is part of a suite of hazardous-weather-detection functions being developed under contract with the Federal Aviation Administration. Initially developed for use with the latest generation Airport Surveillance Radar equipped with a wind shear processor (ASR-9 WSP), MIGFA was deployed for operational testing in Orlando, Florida, during the summer of 1992. MIGFA has demonstrated levels of detection performance that have not only markedly exceeded the capabilities of existing gust front algorithms, but are competitive with human interpreters.

Title:	Optimal Mean Velocity Estimation for Doppler Weather Radars
Author(s):	Chornoboy, E.S.
Author Affiliation:	MIT Lincoln Lab., Lexington, MA, USA
Journal:	IEEE Transactions on Geoscience and Remote Sensing vol. 31, no. 3 p.575-86
Publication Date:	May 1993
ISSN:	0196-2892

Abstract

Optimal Doppler velocity estimation is explored for a standard Gaussian signal measurement model and thematic maximum-likelihood (ML) and Bayes estimation. Because the model considered depends on a vector parameter (velocity, spectrum width (SW), and signal-to-noise ratio (SNR)), the exact formulation of an ML or Bayes solution involves a system of coupled equations that cannot be made explicit for any of the parameters. Simple computational forms are shown to exist when SW and SNR are assumed known. An information-theoretic concept is used to extend these equations to the general case of SW and SNR unknown. A Monte Carlo simulation experiment is used to verify that the method can work, with no a priori information for either SW or SNR and a very small (20 pulse) sample size. The improved performance of this new Doppler velocity estimator is documented by comparison with derived optimal bounds and with the performance of the pulse pair (PP) method. Bayes estimator results are used to provide true performance bounds for comparison. Cramer-Rao bounds are also derived and shown to be inferior to the Bayes bounds in the small sample case considered.

Title:	Machine Intelligent Gust Front Algorithm for Doppler Weather Radars
Author:	Delanoy, Richard L.; Troxel, Seth W.
Author Affiliation:	Massachusetts Inst of Technology, Lexington, MA, USA
Conference Title:	26th International Conference on Radar Meteorology
Conference Location:	Norman, OK, USA
Sponsor:	American Meteorological Society; Norman Weather Center
Source:	International Conference on Radar Meteorology 1993. Publ by American Meteorological Soc, Boston, MA, USA. p. 654-656
Publication Year:	1993

Abstract

Lincoln Laboratory, has had a significant role in the development of two Doppler radar systems that are capable of detecting low-altitude wind shears, including gust fronts, in the airport terminal control area. These systems are the latest generation Airport Surveillance Radar, enhanced with a Wind Shear Processor (ASR-9 WSP) and the Terminal Doppler Weather Radar (TDWR). Gust fronts produce signatures that are observable to varying degrees in reflectivity and Doppler velocity data generated by these radars. In Doppler velocity images, gust fronts are recognizable as zones of converging winds. In reflectivity images, gust fronts appear as thin lines of increased intensity, which occur as the result of rain, dust, insects, or debris being lofted and concentrated at the leading edge of the front. An existing automated gust front detection and forecasting algorithm, developed principally to TDWR data and called in this paper the Advanced Gust Front Algorithm (AGFA), has achieved respectable levels of performance using these data. With clear, unambiguous radar signatures AGFA performs reasonably well. The challenge is in constructing an algorithm that can detect marginally detectable, ambiguous radar signatures without incurring unacceptable false alarm rates. A general-purpose approach to object recognition, which was originally developed in the context of automatic target recognition (ATR), has been incorporated in a Machine Intelligent Gust Front Algorithm (MIGFA). Use of the term "machine intelligence" in particular reflects the use of two new techniques of knowledge-based signal processing.

Title:	Anomalous Propagation Associated with Thunderstorm Outflows
Author:	Weber, Mark E.; Stone, Melvin L.; Cullen, Joseph A.
Author Affiliation:	Massachusetts Inst of Technology, Lexington, MA, USA
Conference Title:	26th International Conference on Radar Meteorology
Conference Location:	Norman, OK, USA
Sponsor:	American Meteorological Society; Norman Weather Center
Source:	International Conference on Radar Meteorology 1993. Publ by American Meteorological Soc, Boston, MA, USA. p 238-240
Publication Year:	1993

Abstract

Doppler radars that select the level of ground clutter suppression base on "clear day maps" may fail to suppress anomalous propagation (AP) induced ground clutter echoes. Operational Doppler radar systems known to be susceptible to this phenomena are the National Weather Service's WSR-88D and the Federal Aviation Administration's Airport Surveillance Radar (ASR-9) six-level weather channel. In this paper, characteristics of thunderstorm outflow-generated AP are documented using data from a testbed ASR-9 operated at Orlando, Florida. The testbed radar's rapid temporal updat and accurate scan-to-scan registration of radar resolution cells enabled characterization of the spatial and temporal evolution of the AP-induced clutter echoes. We discuss implications of these phenomenological characteristics on operational systems, specifically the ASR-9. Algorithms for discrimination between true precipitation echoes and AP-induced ground clutter are discussed.

Title:	Coherent Processing Across Multi-PRI Waveforms
Author:	Weber, Mark E.; Chornoboy, Edward S.
Author Affiliation:	Massachusetts Inst of Technology, Lexington, MA, USA
Conference Title:	26th International Conference on Radar Meteorology
Conference Location:	Norman, OK, USA
Sponsor:	American Meteorological Society; Norman Weather Center
Source:	International Conference on Radar Meteorology 1993. Publ by American Meteorological Soc, Boston, MA, USA. p 232-234
Publication Year:	1993

Abstract

Meteorological Doppler radars have typically utilized constant pulse-repetition intervals (PRI) Recent work by Chornoboy presents design algorithms for time-varying finite impulse response (FIR) filters that achieve Chebyshev or mean-squared error (MSE) optimality when processing multi-PRI waveforms. This paper is a follow-on to that work, treating techniques for post-clutter filter processing (e.g. periodogram estimation) that are appropriate for such waveforms. Our approach involves a least-squares fitting of the signal - sampled at a nonuniform rate - to a weighted sum of uniformly spaced sinusoids. The sinusoids or "basis functions" are chosen to span a Nyquist interval consistent with the longest PRI in the transmitted waveform, and need not be centered at zero Doppler. Determination of the sinusoid weightings - effectively a discrete Fourier transformation (DFT)- and the associated residual between the harmonic fit and the data are accomplished via multiplications of the signal vector with pre-computed matrices. The resulting spectrum estimate can be used directly for weather echo moment calculations, or can be inverse-Fourier transformed using conventional techniques to generate a time-domain signal representation.

Title:	Machine Intelligent Gust Front Algorithm
Author(s):	Delanoy, Richard L.; Troxel, Seth W.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington.
Publication Date:	Nov. 1993 95P.
Publication Note:	Sponsored in part by AF
Note:	Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
Report No.:	AD-A273695; ATC-196; DOT/FAA/RD-93/1
Availability:	Documents available from AIAA Technical Library
Other Availability:	CASI HC A05

Abstract

The Federal Aviation Administration has sponsored research and development of algorithms for automatic gust front detection as part of a suite of hazardous weather detection capabilities for airports. These algorithms are intended for use with Doppler radar systems, specifically the Terminal Doppler Weather Radar (TDWR) and the Airport Surveillance Radar enhanced with a Wind Shear Processor (ASR-9 WSP). Although gust fronts are observable with fairly reliable signatures in TDWR data existing gust front detection algorithms have achieved only modest levels of detection performance. For smaller airports not slated to receive a dedicated TDWR, the ASR-9 WSP will provide a less expensive wind shear detection capability. Gust front detection in ASR-9 WSP data is an even more difficult problem, given the reduced sensitivity and less reliable Doppler measurements of this radar. A Machine Intelligent Gust Front Algorithm (MIGFA) has been constructed at Lincoln Laboratory. MIGFA is a radical departure from previous design strategies. Incorporating knowledge-based, signal-processing techniques initially developed at Lincoln Laboratory for automatic target recognition, MIGFA uses meteorological knowledge, spatial and temporal context, conditional data fusion, delayed thresholding, and pixel-level fusion of evidence to improve gust front detection performance significantly. In tests comparing MIGFA with an existing state-of-the-art algorithm applied to ASR-9 WSP data, MIGFA has substantially outperformed the older algorithm.

Title:	ASR-9 Microburst Detection Algorithm
Author(s):	Newell, O. J.; Cullen, J. A.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Publication Date:	Oct. 1993 68P.
Note:	Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
Report No.:	AD-A273591; ATC-197; DOT/FAA/NR-93/2
Availability:	Documents available from AIAA Technical Library
Other Availability:	Issuing Activity (Defense Technical Information Center (DTIC))

Abstract

The ASR-9 Wind Shear Processor (WSP) is intended as an economical alternative for those airports that have not been slated to receive a Terminal Doppler Weather Radar(TDWR) but have, or will be receiving, an ASR-9 radar. Lincoln Laboratory has developed a prototype ASR-9 WSP system which was demonstrated during the summer months of the past three years in Orlando, Florida. During the operational test period, microburst and gust front warnings, as well as storm motion indications, were provided to the Air Traffic Control in real time. The ASR-9 Microburst Detection Algorithm (AMDA) is based on the earlier TDWR Microburst Detection Algorithm, but has been substantially modified to better match the particular strengths and weaknesses of the ASR-9 rapid-scanning fan-beam radar. The most significant additions included a capability to detect overhead microbursts, a reflectivity processing step used to help detect velocity signatures that have been biased by overhanging precipitation, and a modification to some of the shear segment grouping and thresholding parameters to accommodate better the typical on-air siting of the ASR-9. In addition, the AMDA has been designed to be as efficient as possible to allow it to run at the radar's 4.8 seconds/scan antennas rotation rate on a single-board computer. A detailed description of AMDA, as well as the performance evaluation strategy and results, are presented in this report.

Title:	Doppler Mean Velocity Estimation: Small Sample Analysis and a New Estimator
Author:	Chornoboy, Edward S.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Publication Date:	Mar. 1992 73P.
Report No.:	AD-A249024; TR-942
Availability:	Documents available from AIAA Technical Library
Other Availability:	CASI H A04/MF A01

Abstract

Optimal Doppler velocity estimation, under the constraint of small sample size, is explored for a standard Gaussian signal measurement model and thematic maximum likelihood (ML) and Bayes estimation. Because the model considered depends on a vector parameter (velocity, spectrum width, and signal-to-noise ratio (SNR)), the exact formulation of an ML or Bayes solution involves a system of equations that is neither uncoupled nor explicit in form. Historically, iterative methods have been the most suggested approach to solving the required equations. In addition to being computationally intensive, it is unclear whether iterative methods can be constructed to perform well given a small-sample size and low signal strength. This report takes a different approach and seeks to construct approximate (ML and Bayes) estimators based on the notion of using constrained adaptive models to deal with nuisance parameter removal. A Monte Carlo simulation is used to determine small-sample estimator statistics and to demonstrate true performance bounds in the case of known nuisance values. Performance comparisons between these optimal forms and other standard estimators (pulse pair (PP) and a frequency domain wind profiler (WP)) method are presented. Performance sensitivity of the optimal algorithms, with respect to uncertainty in the values of model nuisance parameters, is explored and provides the foundation for the recommendation to seek an adaptive method.

Accession Number:	AD-A209 478/7/XAB
Title:	Dual-Beam Autocorrelation Based Wind Estimates from Airport Surveillance Radar Signals (Project rept.)
Author:	Weber, M. E.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Report No.:	ATC-167; DOT/FAA/PS-89/5
Publication Date:	21 Jun 89 51p
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC A04/MF A01
Note:	Original contains color plates: All DTIC and NTIS reproductions will be in black and white.

Abstract

This report describes an efficient, autocorrelation based algorithm for estimating low altitude radial winds using signals from the two receiving beams of an airport surveillance radar (ASR). The approach seeks to achieve the accuracy demonstrated previously for spectral domain dual beam velocity estimators with significantly reduced computational requirements. Fundamental to the technique is the assumption that the power spectrum measured with an airport surveillance radar's broad elevation beam can be fitted by a two component Gaussian model. The parameters of this model are estimated using measured low-order autocorrelation lags from the low and high beam received signals. The desired near surface radial velocity estimate is obtained directly as one of these parameters - the center frequency of the 'low altitude' Gaussian spectrum component. Simulated data and field measurements from Lincoln Lab's experimental ASR-8 in Huntsville, Al, were used to evaluate the accuracy of the autocorrelation based velocity estimates. Monte Carlo simulations indicate that biases relative to the near surface outflow velocity in a microburst would be less than 2.5 m/s unless the microburst were distant (range > 12 km) or very shallow (depth of maximum wind speed layer < 50 m). Estimate standard deviations averaged 0.5 m/s after the spatial filtering employed in our processing sequence. The algorithm's velocity estimate accuracy was sufficient to allow for automatic detection of measured microbursts during 1988 with a detection probability exceeding 0.9 and a false alarm probability less than 0.05.

Title:	A Preliminary Assessment of Thunderstorm Outflow Wind Measurement with Airport Surveillance Radars
Author(s):	Weber, Mark E.; Moser, William R.
Author Affiliation:	Massachusetts Inst. of Tech., Cambridge. Lincoln Lab.
Publication Date:	May 1987 90P.
Report No.:	AD-A189064; ATC-140; DOT/FAA/PM-86-38
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC A05/MF A01

Abstract

Modern airport surveillance radars (ASR) situated on or near most major air terminals, feature coherent pulse Doppler processing, a vertical fan beam and rapid azimuthal antenna scanning for detection and tracking of aircraft. These radars might serve an additional useful role by making radial wind measurements in the immediate vicinity of an airport so as to provide data on thunderstorm outflow winds. This report presents a preliminary analysis of the capabilities and limitations of ASRs in measuring outflow winds. Principal results are: (1) radar sensitivity is adequate to measure winds associated with weakly reflecting (5 to 20 dBZ) thunderstorm outflows at ranges less than 20 km provided that appropriate operating parameters are chosen; (2) overhanging precipitation, often moving at a markedly different radial velocity than the outflow, will be a significant source of interference owing to the vertical-fan antenna pattern. If radar reflectivity is approximately constant with altitude, this interference will limit the maximum range for reliable outflow velocity measurements to about 20 km for an outflow that extends 1000 m above the surface and to 7 km for an outflow that extends only 300 m above the surface; (3) At two example major air terminals (Memphis International and Denver Stapleton) ground clutter suppression of approximately 40 dB, combined with the use of inter-clutter visibility techniques, would result in an adequate signal-to-interference ratio for thunderstorm outflow velocity measured over the significant approach/departure corridors.

Title:	Ground Clutter Processing for Wind Measurements With Airport Surveillance Radars
Author:	Weber, Mark E.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Publication Date:	Nov. 1987 63P.
Note:	Original contains color illustrations
Report No.:	AD-A187708; ATC-143; DOT/FAA/PM-87/21
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC A04/MF A01

Abstract

Modern airport surveillance radars (ASR) are coherent pulsed-Doppler radars used for detecting and tracking aircraft in terminal area air-space. These radars might serve an additional role by making radial wind measurements in the immediate vicinity of an airport to provide data on low altitude wind shear (LAWS). One factor that will affect their capability in this role is the requirement that intense low-beam ground clutter be filtered from the signals prior to estimation of the reflectivity and radial velocity of weather scatterers. This report describes and analyzes a specific signal processing algorithm for ASR weather parameter measurements. An adaptively selected Finite Impulse Response high-pass filter, is used for ground clutter suppression, followed by pulse-pair weather reflectivity and radial velocity estimation. Measurements from a Lincoln Laboratory- developed testbed ASR in Huntsville, Alabama are used to characterize the ground clutter environment under siting conditions that are representative of operational ASRs. Temporal fluctuations in ground clutter intensity are analyzed with attention to their impact on the adaptive clutter-filter selection procedure. The performance of the signal processing algorithms is then analyzed using the testbed ASR ground clutter measurements in combination with simulated or real weather signals. We conclude that ground clutter and the requisite clutter filtering will not severely distort ASR wind shear measurements when the reflectivity factor of the microbursts or gust front is approx. 20 dBz or greater. This is typically the case for microbursts occurring in moist conditions such as prevail over the Eastern United States during summer.

Title:	Pixel-Level Fusion Using 'Interest' Images (Technical rept)
Author(s):	Delanoy, R. L. ; Verly, J. G. ; Dudgeon, D. E.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Report No.:	TR-979; ESC-TR-92-206
Publication Date:	26 Apr 93 22p

Abstract

A simple general-purpose means of representing image sensory data at the pixel level is presented in the context of target detection. One or more interest operators (i.e., feature detectors) are applied to one or more sensory images. The output of each operator is an interest image in which high pixel values are assigned to locations where features are found that are indicative of the object (or target) being sought. Any relevant sensory data that are transformed into interest images can then be fused in a pixel-wise manner by means as simple as computing averages, maxima or minima. The approach has been implemented in the detection module of an automatic target recognition system built at Lincoln Laboratory. Data fusion, Automatic target recognition, Mathematical morphology, Machine intelligence, Low-level computer vision, Fuzzy set theory, Laser radar.

Title:	Automated Gust Front Detection Using Knowledge-Based Signal Processing
Author(s):	Delanoy, R.L.; Troxel, S.W.
Author Affiliation:	MIT Lincoln Lab., Lexington, MA, USA
Conference Title:	Record of the 1993 IEEE National Radar Conference (Cat. No. 93CH3253-2) p.150-5
Publisher:	IEEE, New York, NY, USA
Publication Date:	1993 xi+291 pp.
ISBN:	0 7803 0934 0
Conference Sponsor:	IEEE
Conference Date:	20-22 April 1993
Conference Location:	Lynnfield, MA, USA

Abstract

The latest airport surveillance radar, enhanced with a wind shear processor (ASR-9 WSP), is being developed as a less expensive alternative weather radar. Although gust fronts are visible to human observers in ASR-9 WSP imagery, the lower sensitivity and less reliable Doppler measurements of this radar make automated gust front detection a much more challenging problem. Using machine intelligence and knowledge-based signal processing techniques developed in the context of automatic target recognition, a machine intelligent gust front algorithm (MIGFA) is constructed that is radically different from previous algorithms. Developed initially for use with ASR-9 WSP data, MIGFA substantially outperforms a state-of-the-art gust from detection algorithm based on earlier approaches. These results also indirectly suggest that MIGFA performance may be nearly as good as human performance. Preliminary results of an operational test period (two months, approximately 15000 scans processed) are presented.

8. WSP FIELD MEASUREMENT PROGRAMS

Title:	Airport Surveillance Radar (ASR-9) Wind Shear Processor: 1991 Test at Orlando, Florida
Author:	Weber, M. E.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Publication Date:	Jun. 1992 44P.
Report No.:	AD-A252246; ATC-189; DOT/FAA/NR-92/7
Availability:	Documents available from AIAA Technical Library
Other Availability:	CASI HC A03/MF A01

Abstract

An operational test of a Wind Shear Processor (WSP) add-on to the Federal Aviation Administration's airport surveillance radar (ASR-9) took place at Orlando International Airport during July and August 1991. The test allowed for both quantitative assessment of the WSP's signal processing and wind shear detection algorithms and for feedback from air traffic controllers and their supervisors on the strengths and weaknesses of the system. Thunderstorm activity during the test period was intense; low-altitude wind shear impacted the runways or approach/departure corridors on 40 of the 53 test days. As in previous evaluations of the WSP in the southeastern United States, microburst detection performance was very reliable. Over 95 percent of the strong microbursts that affected the Orlando airport during the test period were detected by the system. Gust front detection during the test, while operationally useful, was not as reliable as it should have been, given the quality of gust front signatures in the base reflectivity and radial velocity data from the WSP. Subsequent development of a Machine Intelligent Gust Front Algorithm has resulted in significantly improved detection capability. Results from the operational test are being utilized in ongoing refinement of the WSP.

Title:	A Study of Dry Microburst Detection with Airport Surveillance Radars
Author:	Meister, M. A.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Publication Date:	Nov. 1990 53P.
Report No.:	AD-A230060; ATC-176; DOT/FAA/NR-90/5
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC/MF A04

Abstract

This report evaluates the capability of Airport Surveillance Radars (ASRs) for the detection of low altitude wind shear associated with the outflows of dry microbursts. It describes results of simulations of dry microburst observations by the ASR. These simulations incorporated weather and clutter data collected by the FL-2 pencil-beam Doppler weather radar at Denver Stapleton Airport in 1988 and 1989 and clutter data collected by the FL-3 ASR-9 emulation radar at Huntsville, Alabama. The impact of signal strength, overhanging precipitations, and ground clutter on both observability and algorithmic performance are assessed. Principal results of study are the following: (1) Overhanging precipitation and weak signal strength do not, by themselves, prohibit detection of dry outflows; however, occurrence of false alarms and biases in velocity estimates indicate that improvements in the dual beam estimator that was evaluated would be required for reliable detection of these events. (2) Ground clutter tends to obscure dry outflows in regions where the difference between median effective clutter reflectivity and weather reflectivity exceeds 17 to 20 dB. A method for predicting the percentage of missed microburst detections due to ground clutter is used to estimate overall microburst detection probabilities for a dry environment such as Denver. Using simulated Denver clutter, overall detection probability is 91 percent.

Title:	Low-Altitude Wind Shear Detection with Airport Surveillance Radars: Evaluation of 1987 Field Measurements
Author(s):	Weber, Mark E.; Noyes, Terri A.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Publication Date:	Aug. 1988 102P.
Report No.:	AD-A199189; ATC-159; DOT/FAA/PS-88/10
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC A06/MF A01

Abstract

A field measurement program is being conducted to investigate the capabilities of airport surveillance radars (ASR) to detect low altitude wind shear (LAWS). This capability would require minor RF signal path modifications in existing ASRs and the addition of a signal processing channel to measure the radial velocity of precipitation wind tracers and automatically detect regions of hazardous velocity shear. A modified ASR-8 has been deployed in Huntsville, Alabama and is operated during periods of nearby thunderstorm activity. Data from approximately 30 wet (i.e., high radar reflectivity) microbursts during 1987 have been evaluated through comparison with simultaneous measurements from a collocated pencil beam weather radar. This report describes the 1987 approaches for LAWS detection with ASRs. Techniques are described for estimation of low altitude wind fields in the presence of interference such as ground clutter or weather aloft and for automatic detection of microburst wind shear from the resulting radial velocity fields. Evaluation of these techniques using case studies and statistical scoring of the automatic detection algorithm indicates that a suitably modified ASR could detect wet microbursts within 16 km of the radar with a detection probability in excess of 0.90 and a corresponding false alarm probability of less than 0.10. These favorable results indicate the need for careful consideration of implementation issues and the potential operational role of wind measurements from an ASR.

Title:	The 1990 Airport Surveillance Radar Wind Shear Processor (ASR-WSP) Operational Test at Orlando International Airport
Author(s):	Noyes, T. A.; Troxel, S. W.; Weber, M. E.; Newell, O. J.; Cullen, J. A.
Author Affiliation:	Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
Publication Date:	Jul. 1991 68P.
Report No.:	AD-A239852; ATC-178; DOT/FAA/NR-91/1
Availability:	Documents available from AIAA Technical Library
Other Availability:	NTIS HC/MF A04

Abstract

Lincoln Laboratory, under sponsorship from the Federal Aviation Administration (FAA), is conducting a program to evaluate the capability of the newest Airport Surveillance Radars (ASR-9) to detect hazardous weather phenomena--in particular, low-altitude wind shear created by thunderstorm-generated microbursts and gust fronts. The ASR-9 could provide coverage at airports not slated for a dedicated Terminal Doppler Weather Radar (TDWR) and could augment the TDWR at high-priority (high traffic volume, severe weather) facilities by providing a more rapid update of wind shear products, a better viewing angle for some runways, and redundancy in the event of a TDWR failure. An operational evaluation of a testbed ASR Wind Shear Processor (ASR-WSP) was conducted at the Orlando International Airport in Orlando, FL during August and September 1990. The ASR-WSP operational system issued five distinct products to Air Traffic Control: microburst detections, gust front detections, gust front movement predictions, precipitation reflectivity and storm motion. This document describes the operational system, the operational products, and the algorithms employed. An assessment of system performance is provided as one step in evaluating the operational utility of the ASR-WSP.

KEYWORD INDEX