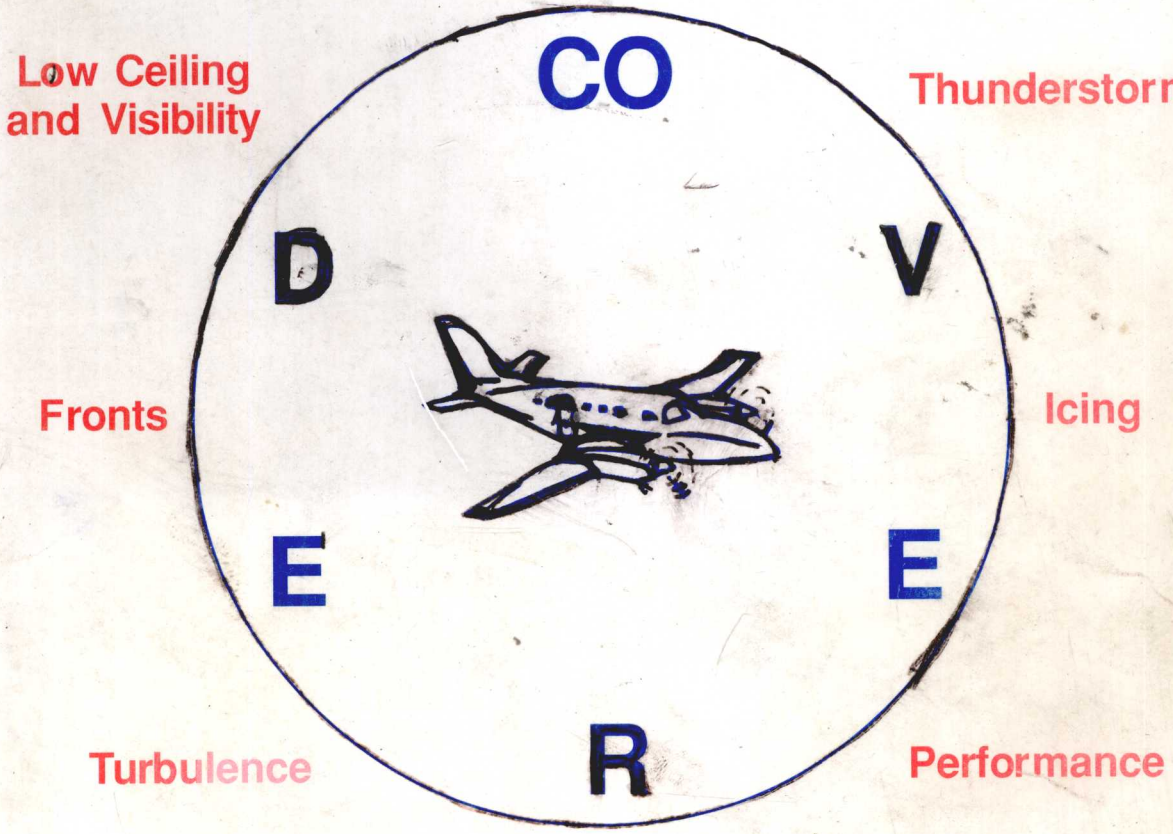
AVIATION METEOROLOGY UNSCRAMBLED:

For VFR and IFR Operations/
Certificates and Ratings



COmprehend weather principles;
Visualize weather patterns;
Evaluate in-flight weather effects;
Respond to changing weather;
re-Evaluate: evaulate in-flight response;
Determine new action, as needed.

KENNETH B. McCOOL

SIXTH EDITION

AVIATION METEOROLOGY UNSCRAMBLED:

For VFR and IFR Operations Certificates and Ratings

By Kenneth B. McCool

International Standard Book Number 0-9621387-9-7

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Gainesville, TX 76240
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Sixth Edition

Printed in the United States of America

First Printing — November, 1995
Second Printing — September, 1996
Third Printing — January, 2000

Notes on the second printing of the sixth edition...

Due to some new information in the Aeronautical Information Manual, formerly known as the Airman's Information Manual, there is an addition to the Wake Turbulence section in Chapter XI and a revised section on Meteorology is contained in Chapter XV. In Chapter XIV, the METAR and TAF definitions of ceiling are included (p. 14-6). During the preparation for this printing, the METAR and TAF codes were scheduled to be implemented on July 1, 1996. Questions on SAs and FTs are still contained in this text (Appendix C) since these codes are still described in the recently released Aviation Weather Services (AC 00-45D) in Appendix B and in the event that the METAR and TAF implementation is not made everywhere or if there is a future change back to the old formats. Question 2400 (p. 15-58) has been deleted from Chapter XV due to a change in in-flight weather broadcast requirements. Finally, the objectives to Chapter XVII which were missing in the first printing are now at the beginning of that chapter.

Preface to the sixth edition . . .

The major change in this edition is the replacement of the old Aviation Weather Services (AC 00-45C) with its updated version (AC 00-45D). About twenty percent of the old version has changed. Whether or not the new codes and formats (METAR and TAF) are fully implemented remains to be seen. An indication of this is the mere fact that the old sequence report format is still present in AC 00-45D.

Another significant change is the inclusion of all of the meteorology portion of the Airman's Information Manual in Chapter XV, rather than just a part of that document in previous editions. Other changes include updated sections on altimeter setting procedures (now in Chapter V rather than the Appendix), on wake turbulence in Chapter XI, and on airspace in Chapter XIV.

Other than a few editorial changes in content, the only other significant change is in the organization of the text, primarily in chapters XIV, XV and XVII, and in the appendices. In particular, the supplemental questions from former FAA Question Books on chapters I through XVII which were in the Appendix have now been added to the end of each chapter. In this book the 1000 numbers are questions for private and recreational pilots, the 2000 numbers for commercial, the 7000 numbers for instrument, the 3000 numbers for instructor, and the 6000 numbers for ATP/dispatcher exams. Of course, questions which were on an instrument exam, for example, may appear on a private exam in the future (and vice versa). The four-response questions from the earlier FAA Written Test Guides have been retained, since they act as review questions over the material and they may well appear on future airman exams. The author's answers are not guaranteed to be the same as the FAA's answers in all cases. Finally, a former appendix on the relationship between several atmospheric variables is now in Chapter XVII (which is itself now in the main body of the text).

About the author. . .

EDUCATION: U.S. Air Force Certificate in Meteorology. B.S., M.S., Mathematics. Ph.D., College Teaching.

AVIATION CERTIFICATES: Commercial Pilot, Instrument Rating. Certified Flight Instructor. Ground Instructor, Advanced and Instrument.

EXPERIENCE: Military Weather Officer (Captain, USAF) – briefer, wing weather officer, detachment commander; Civil Weather Forecaster – television and radio weathercaster (American Meteorological Society Seal of Approval for Television Weathercasting, 1976); Educator, in Aviation, Meteorology, Environmental Science, Physical Science, Mathematics, and Computer Science – college chief ground instructor, taught aviation weather and aviation education courses (including CFI revalidation courses); Meteorological Consultant (approved as a Certified Consulting Meteorologist, CCM, by the American Meteorological Society) – provide industrial meteorological services (President, Meteorological Associates).

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Book designed to be used. . .

1) as information for aviation personnel at all levels of experience who wish to develop a greater understanding of meteorological principles and their effects on aviation, and

2) as a textbook for aviation students working toward certificates and/or ratings. The text is suitable for the formal classroom setting or for self-study; the material presented provides the background necessary to answer questions asked by the FAA for private through airline transport certificates, and for instructor certificates. In fact, almost three hundred questions from FAA Written Study Guides (private through ATP and flight instructor) are included at the end of the first fifteen chapters, and over three hundred additional questions are in Appendix C (from FAA question books).

Aviation Meteorology Unscrambled and *Aviation Weather Services* (Appendix A), with some topics omitted, provide enough material for a full course of study (approximately forty-eight hours), and when treated very thoroughly, provide enough material for two courses in aviation weather, particularly if laboratory sessions are held for data and chart analysis and application. The author knows that many individuals and aviation schools use *Aviation Weather* in conjunction with *Aviation Weather Services* for a basic course in aviation weather. In fact, this author used that combination for several years. *Aviation Weather* is good information; it, like *Aviation Weather Services,* is an advisory circular and is published by the FAA and NOAA. The author wrote *Aviation Meteorology Unscrambled* partially as an alternative to *Aviation Weather* for weather study, feeling that objectives, questions from written exams, more depth and coverage, etc., were desirable. In these regards, the author believes that *Aviation Meteorology Unscrambled* is far superior – individual readers/instructors will need to decide for themselves. Of course, in addition, the text contains a reprint of *Aviation Weather Services* (future changes should be slight, but Appendix A will be updated to reflect any significant changes). The text also contains many of the features of a workbook due to the objectives and questions in both the body of the text and the appendices. Thus the text is essentially three publications, all in one book.

The reader of the text has a good comprehension of the material when he can answer all of the questions at the beginning and end of each chapter, and in Appendices B and C. The author has prepared other multiple-choice questions for examination purposes that will test the reader's comprehension of the material, both for the text and for *Aviation Weather Services.* As was mentioned in the preface, other instructor supplements are also available (answers to the objectives in the text and Appendix B, and to the multiple-choice questions from FAA Question Books in Appendix C).

NOTE: In the Sixth Edition, Appendices A and B have been interchanged, that is, Objectives for AWS are now in Appendix A and AWS is in Appendix B. Also, the answers to all of the questions in Appendix C are listed following that appendix.

INTRODUCTION

To be a successful pilot one must develop good flying habits. For example, a pilot on final approach to a runway who encounters a sudden wind gust as he is about to touch down must react, for there is no time to think through the problem. However, I believe that it is extremely important for pilots to develop proper flying habits through understanding.

When a pilot understands why a habit is necessary and how it resolves a problem, then proper habits will stick with him longer and he will react more quickly when encountering the problem. It is impossible, in the time usually devoted to pilot training, for a pilot to understand the why and how of everything he does in aviation at a given instant. However, that is no excuse not to try; the burden is on both the student and the instructor in such an effort. It is much more efficient (and less expensive) to understand "why and how" on the ground than it is to learn by "trial and error" in the air. And more importantly, the why and how might save lives at a later date.

This text is designed for all aviation personnel who wish to understand why weather behaves as it does. I have emphasized the COVERED concept throughout — COmprehend, Visualize, Evaluate, Respond, re-Evaluate, and Determine. It is my opinion that too much emphasis has been placed on Respond. The response will be more appropriate and effective when the pilot, in his learning, has first COmprehended, Visualized, and Evaluated the flying situation. Then after a pilot Responds, he is better prepared to re-Evaluate and, if necessary, Determine a new course of action.

Before I discuss the content of the book, I would like to emphasize that I myself am at best an average pilot, in terms of ability. Despite my training and experience, I have been humbled on numerous occasions. Each person who reads this book has certain talents and abilities which far exceed mine; in all probability you will be a much better pilot than me. Thus, please forget that I have advanced degrees and read and study the material as information from me to you in the sincere hope that you will find flying more enjoyable. I hope that you will become more knowledgeable and, hence, more confident, and at the same time increase your safety margin.

My approach has been to "start at the beginning" in my presentation of atmospheric principles. The first five chapters are somewhat technical, compared to most aviation books of this nature. However, no background in physics or mathematics is necessary. Of more importance is tenacity, the discipline to read and re-read certain areas many times. The technical level is no more than that for liberal arts (non-science) college students who take an elementary course in meteorology as a science elective. The more experienced pilot will spend less time gaining an understanding of the principles discussed in the early chapters. The remaining chapters are more straightforward. However, the first five chapters are essential for understanding and will prepare the student for further studies in aerophysics, engine performance, etc.

You will find that an understanding of weather principles will help you to visualize or form a mental picture of weather systems, leading you to make the practical decision "Do I fly?" or "Do I stay on the ground?" What many pilots view as poor weather when they look outside may in fact be good flying weather or may change into good flying weather in just a short period of time. And, of course, the reverse is also true. What may appear to be beautiful flying weather may in fact be poor flying weather or may quickly become so. Having the confidence that comes with exercising judgment concerning weather factors is one of the keys that contribute to the enjoyment of flying.

Now while knowing where smooth air is on a particular flight will increase your enjoyment, certainly of much more importance is flight safety, that is, the prevention of accidents. In a study conducted by the National Transportation Safety Board, one out of every ten accidents resulted in fatalities. One out of every six accidents was weather-related. Even more alarming is the fact

that three out of every ten people who perished in an aircraft accident died as a result of a weather-related factor. Out of the three people who perished due to weather (again, this three is out of each ten aircraft fatalities), two of the three died due to continued flight into adverse weather. The following are some of the weather factors or causes relative to weather accidents: unfavorable wind, low ceiling, high density altitude, fog, updrafts and downdrafts, rain, thunderstorm activity, induction icing, snow, turbulence with clouds and thunderstorms, structural icing, and obstructions to vision. By understanding weather principles you will be better able to visualize weather patterns in order to exercise the pilot judgment necessary to prevent accidents.

I have drawn upon many years of training and experience in an effort to provide as complete a text on "understanding and applying meteorology" as possible for aviation personnel. In order to "unscramble" aviation weather for you, I may have to temporarily scramble it for you. Be patient. Read and study the material until you begin to see this presentation as a unified whole. Each chapter represents a piece of a puzzle. Only after you have completed the entire text will you realize why the material was presented as it was. Just as you must master the airplane in order to become a competent pilot, I hope that this book will enable you to become a more knowledgeable and confident pilot where weather is concerned.

In addition to drawing on my own experience and training, I have tried to include thoughts and topics from various government publications, such as Air Force Manual 51-12, the Airman's Information Manual, Exam-O-Grams, FAA Written Study Guides and Question Books, and Advisory Circulars. Some of the material would be treated differently by the meteorology purist, such as the "steady-state" thunderstorm. However, my purpose is to try to enhance understanding, not to try to change the language of aviation meteorology.

I consider the emphasis on upper levels of the atmosphere to be one of the major features of this book. Another major area of concentration has been altimetry; the book also emphasizes aircraft performance. The VFR visibility and cloud minimums have been included. There is a chapter on flight safety, including a comparison of legal flying and use of common sense. And metric units have been included — some of the conversions, in parentheses, are exact and some approximate.

Perhaps the most significant feature of the book is that it encourages the reader to visualize weather. When you receive weather information, your comprehension of weather factors should provide you with a mental image of weather along your route of flight plus potential changes. Only when you can visualize weather in your "mind's eye" are you truly a competent pilot with regard to weather considerations. Despite the inclusion of many illustrations in the book, you should develop the ability to visualize as much as possible. In fact, reference to illustrations is accomplished parenthetically, indicating that such figures or tables are usually supplementary to the paragraph containing the reference. For continuity and reinforcement, you should usually complete the entire paragraph before referring to the illustration(s). There is no firm rule as to where in a paragraph a reference is made to an illustration; in general, such illustrations correlate with the entire paragraph.

I would like to thank Dr. Eugene Wilkins, CCM, Jim Branch and Curt Callaway for their suggestions relative to the content and wording of the original transcript. I would also like to thank Ed Curtis of Mountain View College for his suggestions relative to the second edition. However, I accept full responsibility for what has been said and the manner in which it has been stated.

Kenneth McCool, President
Meteorological Associates
September 1, 1989

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