Human Factors Division
Institute of Aviation

University of Illinois
at Urbana-Champaign
1 Airport Road
Savoy, Illinois 61874

Redesigning Weather-Related Training and Testing of General Aviation Pilots: Applying Traditional Curriculum Evaluation and Advanced Simulation-Based Methods

Douglas A. Wiegmann,
Donald A. Talleur, &
Christopher M. Johnson

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ABSTRACT

Weather-related accidents, particularly accidents due to visual flight rules (VFR) flight into instrument meteorological conditions (IMC), are associated with the highest fatality rate within general aviation (GA). Previous research indicates that accidents related to VFR flight into IMC most often involve inexperienced pilots who lack the appropriate skills to properly plan VFR cross-country flights, effectively assess changes in weather conditions during flight and appropriately evaluate and eliminate risks associated with adverse weather. Together, these findings point to a need to reevaluate weather-related instruction currently provided to pilots during *ab initio* training. The primary goal of this report is to present the findings of an analysis of (1) the content of weather-related source material disseminated by the Federal Aviation Administration (FAA), (2) the content of weather-related test questions contained in the FAA private pilot written exam, (3) the performance of pilots on weather-related exam questions and (4) the relationship between performance on the written exam and performance on the private pilot oral exam. Results are discussed in terms of improving weather-related training and testing, with the goal of reducing VFR flight into IMC accidents.

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INTRODUCTION

Previous analyses of accidents and incidents involving VFR flight into IMC have revealed several common trends or "accident profiles." Specifically, there is converging evidence (Goh & Wiegmann, 2001, 2002; Detwiler et al., 2005; Knecht, 2006) indicating that accidents involving VFR flight into IMC often include a combination of factors including a lack of basic knowledge of weather and preflight planning procedures, poor assessment of in-flight changes in weather cues, failure to adequately assess risks related to changes in weather conditions, inability to perform effective in-flight planning procedures to avoid IMC and a lack of skill in executing escape maneuvers when IMC is encountered. Although few accidents contain all of these variables, many accidents are associated with a combination of issues. Therefore, these factors can be used as criteria for evaluating the current weather-related training and testing requirements.

There are several approaches for evaluating curriculum and training/testing programs. Fundamentally, all of these methods address at least two basic questions. The first involves the ***content*** of instruction, such as the major learning objectives and topics covered. With regards to weather knowledge, such topics may include basic meteorology, reading/interpreting METARS, pre-flight planning, etc. When evaluating training programs based on ***"content"*** criteria, the goal is to determine whether the breath or scope of the training/testing is broad enough to cover the relevant domain of interest. With regards to VFR flight into IMC, the goal is to determine the extent to which the content of *ab initio* weather-related training/testing actually targets the major "causes" behind these events (e.g., preflight planning, in-flight planning, weather assessment, escape procedures, etc.).

The second basic criterion for evaluating training/testing programs involves assessing the ***nature*** of knowledge/learning that is acquired. For over thirty years, the FAA's study material on levels of learning has been based on a four-level hierarchy of rote, understanding, application, and correlation (U.S. DOT, 1977). In recent years, while retaining the original hierarchy, the FAA has further refined the classifications for learning and now also refers to **domains** of learning: affective, psychomotor, and cognitive (U.S. DOT, 1999). Each domain or dimension supports a taxonomy that leads to an educational objective.

The affective dimension is concerned with the circumstances in which the material is learned, specifically the emotional state, and how the state of the applicant's basic needs will affect his or her ability to learn. The psychomotor dimension is concerned with both the physical actions needed for control of the aircraft and the cues necessary to support physical feedback to pilots as they carry out these actions. The ***cognitive*** dimension essentially encompasses the original four levels of learning listed previously (rote, understanding, application, and correlations; U.S. DOT, 1977). The cognitive dimension is therefore most relevant in terms of classifying the level of knowledge that must be obtained in order to successfully answer weather-related questions on a private pilot written or oral exam.

The primary goal of this report is to present the results from analyses of (1) the content of weather-related source material disseminated by the FAA, (2) the content of weather-related test questions contained in the FAA private pilot written exam, (3) the performance of pilots on weather-related exam questions and (4) the relationship between

performance on the written exam and performance on the private pilot oral exam. Results will be discussed in terms of improving weather-related training and testing, with the goal of reducing VFR flight into IMC accidents.

METHODS AND RESULTS

FAA Weather-Related Training Materials

Our initial evaluation focused on identifying the different weather-related source materials (WRSM) and their specific weather content. As listed in Appendix A, the FAA has 17 documents in its inventory of study materials that pertain to weather-related matters. These source materials cover 61 weather-related topics, including basic weather principles, aviation weather services, thunderstorms, icing, turbulence avoidance, windshear avoidance, density altitude, cold weather operations and obtaining good weather briefings. Note that VFR flight into IMC is tangentially covered in a few of these documents; however, none are specifically titled or targeted at this issue.

Written Exam Questions

Content Analysis: Analysis of the private pilot written test question bank, (FAA, 2006), found 112 WRSM questions, each having a unique subject matter code, (U.S. DOT, 2004), which indicates the weather topic addressed and the related source document (see Appendix A). There are also an additional 35 items in the text bank that could be construed as weather-related, but are not specifically labeled as such. According to the FAA aviation safety inspection (ASI) staff specialist in charge of the private pilot written exam, at least 10 questions on the 60 question exam come from WRSM, and that as many as 50% of the questions on the exam might be construed as weather-related questions, even though they do not specifically target weather knowledge or come directly from the weather study materials. This would mean that, considering only the specific weather-related study materials, an applicant could incorrectly answer all 10 weather questions and still receive a passing grade. In fact, even if there were more than 10 weather questions on the exam, an applicant could incorrectly answer 18 weather questions and still receive a passing score of 70%.

Appendix B provides a table that lists the number of weather-related exam questions that are exacted directly from each weather-related training document disseminated by the FAA. As can been seen from this table, the FAA only generates questions that draw from 4 of these sources. The sources include Aviation Weather, Aviation Weather Services, Aeronautical Information Manual, and Pilot's Handbook of Aeronautical Knowledge. While these sources are broader in nature and are likely to include information that touches on all relevant weather-related topics, some of the more specific study materials may be better equipped to elicit some of the finer details on specific issues, such as issues dealing with VFR flight into IMC.

Levels of Learning: In order to analyze the level of learning required to perform well on the exam, we used the FAA's **cognitive** domain categories, as previously described (U.S. DOT, 1999). These categories included rote, understanding, application, and correlations. We applied this taxonomy to all weather-related subject matter (WRSM) questions, as well as those that could be construed as weather-related items.

In one sense, all exam questions could be categorized as requiring only the rote or knowledge level of learning, since all questions and answers were available prior to the exam and could have been memorized by the applicant. However, if the assumption is made that an applicant will actually study the source material as opposed to simply memorizing the answers, then many questions may be categorized beyond the knowledge level. Several criteria were established to guide this subsequent categorization process:

1) Questions that directly reference information that is verbatim from FAA source material requires no more than rote memorization to answer and therefore are

categorized under the knowledge, or rote, level of learning.

2) If a question's material cannot be obtained verbatim from the FAA source material, but must be understood due to different wording from what is used to present it in that source material, then it is categorized under the comprehension, or understanding, level.
3) If a question requires understanding of the material so that it can be applied to an actual flight scenario or condition, it is categorized at the application level. For example, questions that require interpretation of charts are classified at the comprehension, or understanding, level of learning as opposed to the application level; however, if the use of the chart requires applying the answer to a specific scenario then it is categorized at the application level.
4) If a question requires material to be understood to the extent that it can be related to a previously un-discussed, or novel situation, then it is categorized at the correlation level.

As stated previously, analysis of the private pilot written test question bank found 112 WRSM questions and an additional 35 that could be construed as weather-related. Each question was reviewed and its associated FAA subject matter knowledge code was referenced to verify the level to which a student would need to learn the material in order to answer each question (see Table 1). All 112 WRSM questions' study materials were verified although one question's study material was not found under the knowledge code listed for that question. Two questions from the 35 non-WRSM questions were found to have incorrect knowledge codes as well. However, in these three cases above, the required study material was found in the same document as listed for the incorrect knowledge code. In one additional case, one of the non-WRSM questions required study material that could not be found in the listed knowledge code's reference material.

Table 1. Weather-related written exam questions categorized by level of learning required to answer the question.

	Level of Learning				
FAA Code	R	U	A	C	Totals
Non-WRSM	16	16	2	1	35
WRSM	69	39	3	1	112
Totals	85	55	5	2	147

R= rote; U = understanding; A = application; C = Correlation.

Of the 112 WRSM questions, 69 (62%) were classified as requiring the **rote level** of learning to answer. These questions can be construed as coming verbatim from the WRSM material indicated by the FAA subject matter knowledge code. Simply memorizing the written subject matter material is sufficient to answer these rote-level questions. Thirty-nine questions (35%) were classified as requiring the **understanding level** of learning. For these questions, simply memorizing material as written in the subject study material is not sufficient. Three questions (2.4%) were classified at the **application level**, meaning they require material to be applied to a scenario that is similar but not specifically presented in the study materials. One question was classified as requiring the **correlation level** of learning. At this level, material must be understood well enough to be applied to a novel situation or scenario beyond that which the material is usually associated.

When considering the additional 35 questions that could be construed as weather-related but are not specifically from WRSM study materials, 16 (46%) were classified as requiring the **rote level** of learning, 16 (46%) required the **understanding level**, 2 (5.7%) required the **application level**, and 1 required the **correlation level**. In sum, considering all weather-related questions in the test bank, only 7 (5%) out of a total 147 questions require a level of learning at the application or correlation level.

Pilots' Performance on Written and Oral Exams

As a preliminary study of pilots' actual knowledge of weather-related topics, we analyzed a set of written and oral exams completed by students

enrolled in the University of Illinois, Institute of Aviation part 141 flight training program. An analysis of written exam results and corresponding oral exam results for 108 private pilot applicants was conducted from copies of written test results maintained by the Institute of Aviation for certification purposes. Approval was obtained from the University of Illinois Institutional Review Board prior to conducting this analysis.

Exam results fell into one of three categories: 1) Passed written exam score report which accompanied airman application to the FAA for the private pilot certificate, 2) Passed written exam score report not yet submitted to the FAA, 3) Failed written exam score report indicating that the applicant had not yet retaken the exam for passing score, and 4) Oral exam report indicating pass/fail status and corresponding deficiency areas.

Written Exam Results: Given exam content varies across test applications, we first analyzed the subject matter of exam items that were administered to the 108 pilots in our study. This analysis showed that there were 91 distinct subject matter areas tested across all pilots, 25 of which were WRSM areas. Again, however, each WRSM area tested came from only four of the seventeen source documents disseminated by the FAA (These sources include Aviation Weather, Aviation Weather Services, Aeronautical Information Manual, and Pilot's Handbook of Aeronautical Knowledge. See Appendix C for details).

A total of 106 of the 108 written exam score reports indicated passing scores, and two were failures with scores less than 70%. The overall passing average score was 86.98%, with a range of 70% to 100% (SD = 6.94). This score is slightly higher than the overall national average (M=84.90%, n=28,132) (FAA, 2005).

Across the 106 passing applicants, 0 to 15 distinct subject matter areas were recorded as deficient. A total of 78% (n=83) of applicants who passed the exam were found to be deficient in 1 to 6 specific weather-related subject matter areas. Considering only those applicants who were found to be deficient on weather-related material (n=83), the average passing score was 85.59% with a range of 70% to 98% (SD = 6.58).

When the total number of non-weather related deficiencies were compared between those applications who had WRSM deficiencies (n=83) and those applicants who had no WRSM deficiencies (n=23), there was no significant difference between groups. This is an important finding as it indicates that those applicants who are WRSM deficient are not necessarily more or less deficient on other subject matter areas. Specifically, this finding suggests that for WRSM-deficient applicants, it is possible that only the weather-related areas were especially weak, which is an indicator that training and/or experience in this area was also weak.

A detailed analysis of the WRSM was made, starting with a frequency analysis (see Table 2). A total of 83 applicants missed questions from one or more of the WRSM areas and, on average, missed questions from 2 WRSM areas (35%, n=29). The next most deficient number of WRSM areas was 1 (34%, n=28), followed by 3 and 4 areas (14.5%, n=12 respectively), and 5 and 6 areas (1%, n=1 respectively). None of the applicants who passed the exam missed WRSM questions from more than 6 areas.

Table 2. Applicant frequency of deficient WRSM areas (see Appendix A for WRSM area details).

Number of Deficient WRSM areas	Applicant Frequency (%)
1	34
2	35
3	14.5
4	14.5
5	1
6	1

Several subject matter areas stood out as problematic for applicants (see Table 3). A quartile ranking of the frequencies of applicant deficiencies in each WRSM area was conducted. For the 6 areas that fell into the upper 25% of the most highly deficient areas, deficiencies were recorded for at least 14.5% of the 83 applicants who were found to

be deficient in WRSM areas. Deficiencies occurred most often for topics related to **atmospheric pressure and altimetry** (I22), **aviation weather forecasts** (I57), **stable and unstable air** (I25), **thunderstorms** (I30), **common IFR procedures** (I31) **turbulence** (I28), **radar summary charts** (I60) **moisture cloud formation and precipitation** (I24, I26) **weather service information** (I54) and **weather depiction**. There were 6 areas where few WRSM deficiencies were recorded. Only as many as 2.4% of the 83 applicants were deficient in these areas as indicated by the lowest quartile. All other deficient WRSM areas were represented by 3.6% to 12% of the 83 applicants.

Table 3. Applicant deficiency frequency by WRSM area (see Appendix A for details).

WRSM Area	Applicant deficiency frequency (%)
I22	31.3
I57	20.5
I25	18.1
I30, I31	15.7
I28	14.5
I60	12
I24, I26, I54, I59	10.8
I21	9.6
I33	8.4
I64	7.2
I27, I55, J25	3.6
H955, H960, I23, I29, I58	2.4
I56	1.2

Oral Exam: Since knowledge deficiencies could potentially impact success on the oral examination component of the private pilot practical test, an analysis of the relationship between the written and oral exams was performed. At the time of this study, 96 of the 106 applicants who passed the written exam also took the oral exam portion of the private pilot practical test. Twenty-two (23%) of the 96 applicants who passed the written exam and took the oral exam subsequently failed the oral exam. Thirteen of the 22 (59%) oral exam failures were due at least in part to weather knowledge deficiencies. Twelve of these 13 oral failures that were due impart to weather deficiencies also showed deficiencies in WRSM areas on their written exam. However, in the context of the 96 applicants who took the oral exam, no significant effect was found to indicate that written exam deficiencies on WRSM were associated with failure of the oral exam due solely or in part to WRSM deficiencies, $\chi^2(1, \underline{N}=96)=1.77$, $p=.183$ (see Table 4).

Table 4. Weather deficiencies on oral exam and on written exam

	WRSM deficiency ?		
Oral Weather Deficiency ?	No	Yes	Totals
No	20	63	83
Yes	1	12	13
Totals	21	75	96

Since there was no indication that written exam WRSM deficiencies were associated with oral examination failures due to weather, the relationship between *total* number of subject matter areas found deficient on the written exam and oral exam pass rate was also examined. A significant effect was found, $F(1, 95)=12.11$, $p\leq.001$, indicating that the higher numbers of deficiencies on the written exam, the more likely an applicant would fail their subsequent oral exam. Since all failures of the oral exam were represented by applicants who had previously passed their written exam, this finding indicates the necessity of the oral exam as part of the testing process as well as the relative effectiveness of its current format and content.

CONCLUSION AND RECOMMENDATIONS

The review of weather-related source materials revealed that the WRSM is scattered over a large

number of documents but with most WRSM for the private pilot exam coming from just a few. Furthermore, there appears to be no discernable effort to combine or update the majority of these documents (e.g., Aviation Weather). Some of the source material is relatively outdated and sources with information on critical weather-decision issues (e.g., How to Obtain a Good Weather Briefing, Aeronautical Decision-Making, and Thunderstorms) are not included as source references for the private pilot written exam. Although the basics of weather theory have not changed dramatically over the years, with the advent of widespread computer access to weather information, our ability to predict weather and our methods for observing it have changed significantly since the publication of various documents currently in use.

The current FAA private pilot written exam does not include questions that specifically address decision-making related to VFR flight into IMC. Nonetheless, our analysis of written score reports for 106 private pilot applicants who passed the exam showed a relatively high percentage of applicants that were deficient on topics related to VFR flight into IMC accidents, including a lack of knowledge of common IFR producers, aviation weather forecasts, moisture cloud formation and precipitation, weather service information and weather depiction. Understanding of these areas would seem to be critical to the weather decision-making process. Furthermore, pilots who are deficient in these weather-related areas are not necessarily deficient in other piloting areas, indicating that they are not just "aeronautically inadaptable" individuals, but rather, their deficiency is specifically weather-related. Adequate FAA source documents exist and are readily available to applicants, so there is no clear reason why these areas are not adequately addressed.

The manner in which weather-related topics are tested may be another important issue in evaluating pilots. The majority of the questions on the written exam target a rote level of learning. This is not too surprising, given the multiple-choice format of the exam. However, currently, there are no scenario-based weather-related questions on the private pilot exam; however, other subject matter areas that address issues such as weight and balance and cross-country planning require a multitude of information to be assimilated to produce a scenario-driven answer. Yet, in no case is the applicant asked to make associations between weather products in order to make safe flight decisions, as would be the case in an actual flight-planning environment. As a result, it may be fruitful to investigate the possibility of taking a scenario-based approach toward developing questions that address weather-related knowledge on the private pilot written exam.

It is possible that assessing weather-related decision-making may be too difficult to do using multiple-choice questions. Therefore, such knowledge may need to be are assessed by other means (e.g., the private pilot practical oral exam). Interestingly, this study found no clear association between weather-related written exam results and practical oral exam results; although results were related when considering overall test scores. This finding suggests that each exam evaluates WRSM in different ways.

Perhaps the private pilot oral exam is the only potential testing point where the applicant could be required to demonstrate an application and/or correlation level of learning toward answering hypothetical questions pertaining to weather-related decision-making scenarios. However, such conclusions are beyond the scope of this study. A systematic review of the practical test standards that govern the content of the private pilot oral exam will need to performed to ascertain whether this level of testing is indeed required as part of the oral exam.

REFERENCES

Detwiler, C., Holcomb, K., Boquet, A., Wiegmann, D., & Shappell, S., (2005). Human factors analysis of general aviation accidents. *113th Annual Meeting of the American Psychological Association.*

Federal Aviation Administration. (2006). *Private pilot airman knowledge test question bank*. Downloaded on August 18, 2006 from http://www.faa.gov/education_research/testing/airmen/test_questions/media/pvt.pdf.

Federal Aviation Administration. (2005). *2005 annual statistics: total volume, pass rates, and average score*. Downloaded on August 30, 2006 from http://www.faa.gov/data_statistics/aviation_data_statistics/test_statistics/media/2005/annual/2005_Annual_Statistics_for_Airmen_Knowledge_Testing.pdf.

Goh, J. & Wiegmann, D. A. (2001). Visual flight rules flight (VFR) into adverse weather: An empirical investigation of the possible causes. *The International Journal of Aviation Psychology, 11*(4), 259-379.

Goh, J. & Wiegmann, D.A. (2002). Human factors analysis of accidents involving visual flight rules flight into adverse weather. *Aviation, Space, and Environmental Medicine, 73,* 817-822.

Knecht, WR. (2006). Use of weather information by general aviation pilots: Providers and products. *FAA Quarterly Report*. Downloaded on June 20, 2006 from http: //www.hf.faa.gov/docs/508/docs/gaFY05Wx.pdf.

U.S. Department of Transportation, Federal Aviation Administration (1977). *Aviation Instructor's Handbook* (Advisory Circular 60-14) AFS-500.

U.S. Department of Transportation, Federal Aviation Administration (1999). *Aviation Instructor's Handbook* (Handbook 8083-9). AFS-630.

U.S. Department of Transportation, Federal Aviation Administration. (2004). *Reference materials and subject matter knowledge codes for airman knowledge testing* (Advisory Circular 60-25F). AFS-630.

Washington, DC.Federal Aviation Administration. (2005). *2005 annual statistics: total volume, pass rates, and average score*. Downloaded on August 30, 2006 from http://www.faa.gov/data_statistics/aviation_data_statistics/test_statistics/media/2005/annual/2005_Annual_Statistics_for_Airmen_Knowledge_Testing.pdf

APPENDICES

Appendix A: Weather Source Material Reviewed

U.S. Department of Transportation, Federal Aviation Administration and U.S. Department of Commerce, National Weather Service. (1975). *Aviation weather* (Advisory Circular 00-6A).

U.S. Department of Transportation, Federal Aviation Administration and U.S. Department of Commerce, National Weather Service. (1999). *Aviation weather services* (Advisory Circular 00-45E). AFS-400.

U.S. Department of Transportation, Federal Aviation Administration. (2003). *Pilots handbook of aeronautical knowledge* (Handbook 8083-25).

U.S. Department of Transportation, Federal Aviation Administration. (1983). *Thunderstorms* (Advisory Circular 00-24B). AFS-260.

U.S. Department of Transportation, Federal Aviation Administration. (1997). *Atmospheric turbulence avoidance* (Advisory Circular 00-30B). AFS-400.

U.S. Department of Transportation, Federal Aviation Administration. (1988). *Pilot windshear guide* (Advisory Circular 00-54). AFS-200.

U.S. Department of Transportation, Federal Aviation Administration. (1991). *Aeronautical decision making* (Advisory Circular 60-22). AFS-820.

U.S. Department of Transportation, Federal Aviation Administration. (1997). *Hazardous mountain winds and their visual indications* (Advisory Circular 00-57). AND-720.

U.S. Department of Transportation, Federal Aviation Administration. (1982). *Hazards following ground deicing and ground operations in conditions conducive to aircraft icing* (Advisory Circular 20-117). AWS-100.

U.S. Department of Transportation, Federal Aviation Administration. (1979). *Cold weather operation of aircraft* (Advisory Circular 91-13C). AFS-820.

U.S. Department of Transportation, Federal Aviation Administration. (1996). *Effect of icing on aircraft control and airplane deice and anti-ice systems* (Advisory Circular 91-51A). AFS-820.

U.S. Department of Transportation, Federal Aviation Administration. (2002). *Pilot guide: flight in icing conditions* (Advisory Circular 91-74). AFS-220.

U.S. Department of Transportation, Federal Aviation Administration, Accident Prevention Program. (n.d.). Wind shear (FAA-P-8740-40). AFO-800-0582.

U.S. Department of Transportation, Federal Aviation Administration, Accident Safety Program, (1999). How to obtain a good weather briefing (FAA-P-8740-30). AFS-820.

U.S. Department of Transportation, Federal Aviation Administration, Accident Safety Program, (1996). Winter Flying Tips (FAA-P-8740-24). Downloaded on October 11, 2006 from http://www.faasafety.gov/gslac/ALC/lib_tableofcontents.aspx.

U.S. Department of Transportation, Federal Aviation Administration, Accident Safety Program, (n.d.). Thunderstorms- don't flirt…skirt'em (FAA-P-8740-12). Downloaded on October 11, 2006 from http://www.faasafety.gov/gslac/ALC/lib_tableofcontents.aspx.

U.S. Department of Transportation, Federal Aviation Administration, Accident Safety Program, (n.d.). Density altitude (FAA-P-8740-2). AFS-800-0478.

Appendix B: Summary of Private Pilot Written Exam Weather Question Source Media

Written Exam Weather Question Source	Written Exam Subject Matter Codes	No. of Questions from Source
Aviation Weather (AC 00-6A)	I20- I36	57
Aviation Weather Services (AC 00-45E)	I54- I67	48
Aeronautical Information Manual	J25	2
Thunderstorms (AC 00-24)	KO1	0
Atmospheric Turbulence Avoidance (AC 00-30)	KO2	0
Pilot Windshear Guide (AC 00-54)	KO4	0
Aeronautical Decision Making (AC 60-22)	LO5	0
Cold Weather Operation of Aircraft (AC 91-13)	L52	0
Effect of Icing on Aircraft Control and Airplane Deice and Anti-ice Systems (AC 91-51)	L62	0
Hazards Following Ground Deicing and Ground Operations in Conditions Conducive to Aircraft Icing (AC 20-117)	M51	0
Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25)	H951-H963 H996-H998	5
Airplane Flying Handbook (FAA-H-8083-3A)	H1356	0
Density Altitude (FAA-P-8740-2)	VO1	0
Thunderstorms (FAA-P-8740-12)	VO3	0
Tips on Winter Flying (FAA-P-8740-24)	VO6	0
How to Obtain a Good Weather Briefing (FAA-P-8740-30)	VO8	0
Windshear (FAA-P-8740-40)	VO9	0

Appendix C: Specific Private Pilot Written Exam Weather Question Source Questions

Written Exam Weather Question Source	Written Exam Subject Matter Codes	Topic Title	No. of Questions from Source
Aviation Weather (AC 00-6A)	I20	The Earth's Atmosphere	0
	I21	Temperature	5
	I22	Atmospheric Pressure and Altimetry	5
	I23	Wind	1
	I24	Moisture, Cloud Formation and Precipitation	6
	I25	Stable and Unstable Air	9
	I26	Clouds	6
	I27	Air Masses and Fronts	4
	I28	Turbulence	3
	I29	Icing	2
	I30	Thunderstorms	10
	I31	Common IFR Producers	4
	I32	High Altitude Weather	0
	I33	Arctic Weather	1
	I34	Tropical Weather	0
	I35	Soaring Weather	0
	I36	Glossary of Weather Terms	1

Aviation Weather Services (AC 00-45E)	I54	The Aviation Weather Service Program	7
	I55	Aviation Routine Weather Report (METAR)	5
	I56	Pilot and Radar Reports, Satellite Pictures, and Radiosonde Additional Data (RADATs)	5
	I57	Aviation Weather Forecasts	17
	I58	Surface Analysis Chart	2
	I59	Weather Depiction Chart	4
	I60	Radar Summary Chart	5
	I61	Constant Pressure Analysis Charts	0
	I62	Composite Moisture Stability Chart	0
	I63	Winds and Temperatures Aloft Chart	0
	I64	Significant Weather Prognostic Charts	3
	I65	Convective Outlook Chart	0
	I66	Volcanic Ash Advisory Center Products	0

	I67	Turbulence Locations, Conversion and Density Altitude Tables, Contractions and Acronyms, Station Identifiers, WSR-88D Sites, and Internet Addresses	0
Aeronautical Information Manual	J25	Meteorology	2
Thunderstorms (AC 00-24)	KO1	Thunderstorms	0
Atmospheric Turbulence Avoidance (AC 00-30)	KO2	Atmospheric Turbulence Avoidance	0
Pilot Windshear Guide (AC 00-54)	KO4	Pilot Wind Shear Guide	0
Aeronautical Decision Making (AC 60-22)	LO5	Aeronautical Decision Making	0
Cold Weather Operation of Aircraft (AC 91-13)	L52	Cold Weather Operation of Aircraft	0
Effect of Icing on Aircraft Control and Airplane Deice and Anti-ice Systems (AC 91-51)	L62	Effect of Icing on Aircraft Control and Airplane Deice and Anti-Ice Systems	0
Hazards Following Ground Deicing and Ground Operations in Conditions Conducive to Aircraft Icing (AC 20-117)	M51	Hazards Following Ground Deicing and Ground Operations in Conditions Conducive to Aircraft Icing	0

Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25)	H951	Weather Theory	2
	H952	Nature of the Atmosphere	0
	H953	The Cause of Atmosphere Circulation	0
	H954	Atmospheric Stability	0
	H955	Air Masses	1
	H956	Fronts	0
	H957	Weather Reports, Forecasts, and Charts	2
	H958	Observations	0
	H959	Service Outlets	0
	H960	Weather Briefings	0
	H961	Aviation Weather Reports	0
	H962	Aviation Forecasts	0
	H963	Weather Charts	0
	H996	The Decision Making Process	0
	H997	Risk Management	0
	H998	Factors Affecting Decision Making	0
Airplane Flying Handbook (FAA-H-8083-3A)	H1356	Inadvertent VFR Flight into IMC	0
Density Altitude (FAA-P-8740-2)	VO1	Density Altitude	0
Thunderstorms (FAA-P-8740-12)	VO3	Thunderstorms	0
Tips on Winter Flying (FAA-P-8740-24)	VO6	Tips on Winter Flying	0
How to Obtain a Good Weather Briefing (FAA-P-8740-30)	VO8	How to Obtain a Good Weather Briefing	0
Windshear (FAA-P-8740-40)	VO9	Windshear	0