



## AtSc 252: Applied Weather Modification

Classroom/Hybrid Course

### Instructor & Course Information

Credits	3 Undergraduate Credits
Class Room	Odegard Hall 103, 4:00 – 5:15 p.m. CST
Pre-Requisites	AtSc 110: Meteorology
Instructor	Dr. David Delene
Office:	Clifford Hall 420
Email	david.delene@und.edu
Phone	701-777-4847 (Office), 507-533-5363 (Mobile/Text)
Student Hours	3-4 p.m. on Tuesday/Thursday or by Appointment

Email is typically the best way to reach me; however, free feel to call or text. I will respond to emails and phone calls within 48 hours. You can address me as Dr. Delene; however, simply using David is also fine with me.

### About the Professor

I would like to welcome you to AtSc 252 - Applied Weather Modification. I have been actively involved in weather modification research since 2007. I having conducted field projects in North Dakota, Mali, and Saudi Arabia; where I have flown with some of the most experienced weather modification pilots in the world. Additionally, I have done weather modification workshops for Burkina Faso, Morocco, and Saudi Arabia. I have presented invited presentations in South Korea, China, India and the United Arab Emirates on weather modification topics. I have published peer-reviewed papers on using aircraft measurements and rain-gauge data to assess weather modification projects. Research projects have included the evaluation of hygroscopic cloud seeding, glaciogenic cloud seeding, and hail suppression operations. Additionally, I have conducted research projects that involve obtaining and analyzing aircraft-based, cloud micro-physical measurements for NASA, DOD, NSF and private companies. I have been the Editor of the Journal of Weather Modification from 2012 to 2021. I have been teaching the applied weather modification class at the University of North Dakota since the Spring of 2021.

### Course Description and Objectives

This is a semester-long course designed to provided a broad understanding of applied weather modification operations as currently conducted around the world. An important component of developing a long-term, sustainable weather modification project is personnel training. Conducting an operational program that involves airborne cloud seeding program is a highly technical undertaking that combined the fields of aviation and meteorology. Without technically trained personnel with an understanding of the scientific fundamentals of weather modification it is unlikely that the program's objectives will be obtained. Having educated personnel with the necessary technical knowledge enables programs to be carried out a cost effective and productive program. A broad background in weather modification methods enables personnel to understand and adapt to technical and scientific advances, which can occur rapidly in the weather modification field. For example, new observation methods, equipment development, and computer models are continuously being developed and incorporated into weather modification programs.

## Course Objectives Goals and Learning Outcomes

Provides a comprehensive introduction to basic concepts of weather modification as currently practiced around the world. Topics include a study of cloud physics, seeding theory, a review of past and current programs, and a discussion of related legal, societal, economic, and environmental issues. The class provides students exposure to the practical aspects of weather modification operations, including operational program design and evaluation, care and use of seeding materials and equipment, identification of seeding opportunities, and methods of airborne delivery of seeding materials. The course goals are:

- To learn how cloud weather modification projects are established and conducted.
- To learn the theoretical basis for weather modification.
- To learn how weather forecasting contributes to weather modification programs.
- To learn how to effectively participate in operational programs.

By the end of this course, students should be able to demonstrate the learning outcomes:

- State why and where weather modification operations are conducted.
- Recognize the overall context and factors affecting application of cloud seeding.
- Explain the theoretical basis and assumption for weather modification.
- Explain what constitutes a seeding opportunity.
- Identify cloud seeding opportunities and select appropriate conditions for treatment.
- Describe how cloud seeding equipment works and what are its operational limitations.
- Conduct cloud seeding operations in a safe and effective manner.
- Distinguish between valid and false claims of cloud seeding success.

## Textbook and Course Materials

Applied Weather Modification is a specialized field that does not have a physical textbook available. Hence, this course makes use of open educational resources (OER). Open educational resources are freely accessible, openly licensed documents and media that are useful for teaching and learning. These required resources are available to students at no cost and will be used in place of physical textbooks.

## Technical Requirements

The [UND Technical Support webpage](#) contains information on your UND email and how to download a free version of Microsoft Office.

- Students are expected to use their official UND email in the course.
- You can use Libreoffice Writer or Microsoft Word to complete assignments.
- [View the basic technical requirements](#) for every online course.

## Course Overview and Organization

This course contains 5 blocks of lessons designed to focus your study of applied weather modification and to assist you in achieving the course learning objectives and outcomes. You will work through a combination of required readings, view captioned videos, take quizzes and exams.

### 1. Block 1

Course Syllabus

Introduction

History of Weather Modification

Critical Thinking and Legal Aspects

Environmental Concerns and Sociological Issues

Economic Impacts

Unintended Weather Modification

Research – Hail Measurements with T-28 Aircraft

Exam I (Block 1)

### 2. Block 2

- Statistical Evaluations
- Atmospheric Aerosols
- Atmospheric Water Vapor
- Particle Nucleation
- Droplet Growth
- Ice Crystal Growth
- Exam II (Block 2 and 1)
- 3. Block 3
  - Basic Clouds and Cloud Formation
  - Precipitation Processes
  - Cloud Dynamics
  - Conceptual Models
  - Precipitation Conceptual Models
  - Hail Suppression Conceptual Models
  - North Dakota Cloud Modification Project (NDCMP) Model
  - Exam III (Block 3, 2 and 1)
- 4. Block 4
  - Winter-time Precipitation Enhancement
  - Fog Abatement
  - Lightning Suppression
  - Hurricane Modification
  - Seeding Materials
  - Dry Ice as Seeding Agent
  - Seeding Agent Dispersal
  - Seeding Equipment and Methods
  - Exam IV (Block 4, 3, 2 and 1)
- 5. Block 5
  - Radar for Weather Modification
  - Record Keeping and iPARS
  - Weather Forecasting and SkewT Bascis
  - Daily Operations and Opportunity Recognition
  - Flight Safety
  - Case Example: Put All Together
  - Final Exam (Block 5, 4, 3, 2 and 1)

## Assessment and Grading

This course is made up of a series of quizzes, assessments, and exams, which will be graded. Exams and the final exam are comprehensive of the class material covered, with grades determine be the following percentages:

Quizzes and Assignments:	20%
Exams:	60%
Final Exam:	20%

There will quiz for each topic. Each course block will have an exam, with the final exam covering block 5. T he exams are in class, with a sign-out sheet, using the Respondus Exam Authoring Tool.

The following grading scale is used: (updated if needed)

A	90% to 100%
B	80% to 89%
C	70% to 79%
D	60% to 69%

## Course Evaluation

Once you complete your course, you will be asked to complete an online course evaluation. Your feedback on the course is very important to me. I read all students' comments carefully and use them to improve my course.

## Netiquette

Always use professional language (no netspeak) in your assignments and emails. Please be respectful of others at all times, even if you disagree with their ideas. *Netiquette* is a set of rules for behaving properly online. Here are a few basic points to remember when communicating in this course:

- **Be scholarly.** Use proper language, grammar, and spelling. Explain your thoughts, justify opinions, and credit the ideas of others by citing or linking to scholarly resources. Avoid misinforming others when you are unsure of the answer. When discussing something and supplying a guess, clearly state that.
- **Be respectful.** Respect the privacy of others. Do not share personal or professional information about others unless permission has been granted. Respect diversity and opinions that differ from their own. Be tactful when you communicate.
- **Be professional.** Everyone should strive to give their best impression online. Truthfulness, accuracy, and running a final spell check are appropriate expectations for university students. Writing in a legible font and limiting the use of emoticons is considered professional behavior. Profanity and participation in hostile interactions, known as flaming, is unprofessional as well as disruptive.
- **Be polite.** Students should be addressing professors and instructors by the appropriate title or requested name. Students should interact online politely, just as they would be expected to do in a physical environment. Sarcasm, rudeness, and writing in all capital letters (shouting) should be avoided.

For more information, read the [Top 12 Be-Attitudes of Netiquette for Academicians](#).

## Student Resources

Many services are available to online students such as writing assistance from the UND Writing Center, free online tutoring, and more. Visit the [Student Resources page](#) for more information. You can also access the resources webpage from the *Student Resources* link in your Blackboard course menu.

## History of Weather Modification and Cloud Physics Research at UND

UND has a long history of weather related research, including weather modification and cloud physics, which “took off” in 1974 when the school acquired its first weather radar. Additionally the State of North Dakota has a long history of funding a co-pilot internships program where UND students can be involved with North Dakota Cloud Modification Project (NDCMP) each summer. The University of North Dakota (UND) has a formal memorandum of understanding (MOU) in place where by co-pilot interns work on the NDCMP. Additionally, UND students have the opportunity to be project meteorological interns each year. While the meteorological interns are not exclusive to UND like the co-pilot interns, many non-UND meteorological interns learned about UND’s Graduate School because of the program. Several of these student have attended and graduated from the Atmospheric Sciences Graduate Program at UND. The UND co-pilot internship program has a long history, which started with a National Science Foundation grant in 1973. Since then, more than 400 UND student pilots have participated in the internship program. See the [“Leading Research IN THE CLOUDS”](#) AeroCom Summer 20219 article for additional information.

## University of North Dakota Policies & Resources

### Academic Integrity

Academic integrity is a serious matter, and any deviations from appropriate behavior will be dealt with strongly. At the discretion of the professor, situations of concern may be dealt with as a scholastic matter or a disciplinary matter.

As a scholastic matter, the professor has the discretion to determine appropriate penalties to the student's workload or grade, but the situation may be resolved without involving many individuals. An alternative is to treat the situation as a disciplinary matter, which can result in suspension from the University, or have lesser penalties. Be aware that I view this as a very serious matter, and will have little tolerance of or sympathy for questionable practices. A student who attempts to obtain credit for work that is not their own (whether that be on a paper, quiz, homework assignment, exam, etc.) will likely receive a failing grade for that item of work, and at the professor's discretion, may also receive a failing grade in the course. Read more in the [Code of Student Life](#).

### Accessibility for Students

The University of North Dakota is committed to providing equal access to students with documented disabilities. To ensure access to your classes and program, please contact [Accessibility for Students](#) (formerly known as Disability Services for Students) to engage in a confidential discussion about accommodations for the classroom, clinical and/or online course settings. Accommodations are not provided retroactively. Students are encouraged to register with the Community Standards & Accessibility for Students office at the start of their class/program. More information can be obtained by email [UND.accessibilityforstudents@UND.edu](mailto:UND.accessibilityforstudents@UND.edu) or by phone at 701.777.2664.

If you receive an exam accommodation from Community Standards & Accessibility for Students, share the letter with the Office of Extended Learning at [UND.courses@UND.edu](mailto:UND.courses@UND.edu).

### Religious Accommodations

UND offers religious accommodations, which are reasonable changes in the academic environment that enable a student to practice or observe a sincerely held religious belief without undue hardship on the University. Examples include time for prayer or the ability to attend religious events or observe a religious holiday. To request an accommodation, complete [student religious accommodation request form](#). If you have any questions, you may contact the [Equal Opportunity & Title IX Office](#).

### Pregnancy Accommodations

Students who need assistance with academic adjustments related to pregnancy or childbirth may contact the Equal Opportunity & Title IX Office to learn about your options. Additional information and services may be found at [Pregnancy Resources](#).

### Resolution of Problems

Should a problem occur, you should speak to your instructor first. If the problem continues to be unresolved, go to the department chair, and next to the college Dean. Should the problem persist, you have the right to go to the Provost next, and then to the President.

### Notice of Nondiscrimination

It is the policy of the University of North Dakota that no person shall be discriminated against because of race, religion, age, color, gender, disability, national origin, creed, sexual orientation, gender identity, genetic information, marital status, veteran's status, or political belief or affiliation and the equal opportunity and access to facilities shall be available to all. Concerns regarding Title IX, Title VI, Title VII, ADA, and Section 504 may be addressed to Donna Smith, Assistant Vice President for Equal Opportunity & Title IX and Title IX/ADA Coordinator, by calling 701.777.4171 or emailing [UND.EO.TitleIX@UND.edu](mailto:UND.EO.TitleIX@UND.edu). Concerns can also be directed to the Office for Civil Rights, U.S. Department of Education, 230 S. Dearborn St., 37<sup>th</sup> Floor, Chicago, IL 60604, or any other federal agency.

## Reporting Discrimination, Harassment, or Sexual Misconduct

If you or a friend has experienced sexual misconduct, such as sexual harassment, sexual assault, domestic violence, dating violence, or stalking, please contact the [Equal Opportunity & Title IX Office](#) or UND's Title IX Coordinator, Donna Smith, for assistance: 701.777.4171; [donna.smith@UND.edu](mailto:donna.smith@UND.edu). You may also contact the Equal Opportunity & Title IX office if you or a friend has experienced discrimination or harassment based on a protected class, such as race, color, national origin, religion, sex, age, disability, sexual orientation, gender identity, genetic information, pregnancy, marital or parental status, veteran's status, or political belief or affiliation.

## Faculty Reporting Obligations Regarding Discrimination, Harassment, and Sexual Misconduct

It is important for students to understand that faculty are required to share with UND's Title IX Coordinator any incidents of sexual misconduct or of discrimination or harassment based on a protected class they become aware of, even if those incidents occurred in the past or are disclosed as part of a class assignment. This does not mean an investigation will occur if the student does not want that, but it does allow UND to provide resources to help the student continue to be successful at UND. If you have been impacted by discrimination, harassment, or sexual misconduct, you can find information about confidential support services at the [Equal Opportunity & Title IX Office](#).

## How to Seek Help When in Distress

We know that while college is a wonderful time for most students, some students may struggle. You may experience students in distress on campus, in your classroom, in your home, and within residence halls. Distressed students may initially seek assistance from faculty, staff members, their parents, and other students. In addition to the support we can provide to each other, there are also professional support services available to students on campus through the [Community Standards & Accessibility for Students](#) office and the [University Counseling Center](#). Both staffs are available to consult with you about getting help or providing a friend with the help that he or she may need. Visit the [Office of Community Standards](#) webpage for more additional information.

## How to Recognize When a Student is in Distress

The term "distressed" can mean any of the following:

- Student has significant changes in eating, sleeping, grooming, spending, or other daily activities.
- Student has cut off or minimized contact with family or friends.
- Student has significant changes in performance or involvement in academics, sports, extracurricular, or social activities.
- Student describes problems (missing class, not remembering, destructive behavior) that result from experiences with drinking or drugs.
- Student is acting withdrawn, volatile, tearful, etc.
- Student is acting out of character or differently than usual.
- Student is talking explicitly about hopelessness or suicide.
- Student has difficulty concentrating or difficulty carrying on normal conversation.
- Student has excessive dependence on others for company or support.
- Student reports feeling out of control of one's emotions, thoughts, or behaviors.

## Land Acknowledgment Statement

Today, the University of North Dakota rests on the ancestral lands of the Pembina and Red Lake Bands of Ojibwe and the Dakota Oyate - presently existing as composite parts of the Red Lake, Turtle Mountain, White Earth Bands, and the Dakota Tribes of Minnesota and North Dakota.

We acknowledge the people who resided here for generations and recognize that the spirit of the Ojibwe and Oyate people permeates this land. As a university community, we will continue to build upon our relations with the First Nations of the State of North Dakota - the Mandan, Hidatsa, and Arikara Nation, Sisseton-Wahpeton Oyate Nation, Spirit Lake Nation, Standing Rock Sioux Tribe, and Turtle Mountain Band of Chippewa Indians.