# ATOC/ASEN 5235
# REMOTE SENSING OF THE ATMOSPHERE AND OCEANS

**Instructor:** Prof. Irina N. Sokolik Duane D215 303-492-5724
sokolik@lasp.colorado.edu
http://irina.colorado.edu

**Office Hours**: Mon 4:00-5:00 PM (or by appointment)

**Course Website:** http://irina.colorado.edu/ATOC5235.htm

## Lecture 1

## Introduction and Logistics

**Objectives:**

1. What this course is about
2. How the course is organized:
   - Lectures
   - Computer Modeling Laboratories
   - Class Research Project
   - Homeworks
   - Midterm Exams
3. Required/additional reading.
4. Grading
5. Course outline, lecture schedule, and reading assignments.

## 1. What this course is about

***General definition:***

**Remote sensing** is the collection of information about an object without coming into physical contact with it.

***Definition used in this course:***

**Remote sensing** is characterization of an object based on measurement of electromagnetic radiation.

- This course provides a foundation for understanding the physical principles of remote sensing of the atmosphere and oceans.

- The main goal of the course is to build a broad conceptual framework for physical understanding the methodology and applications of remote sensing in studying the atmosphere and oceans.

NOTE: This course does NOT include remote sensing of land and vegetation, image processing, or instrumentation development.

- The course is designed as a collection of lectures and computer modeling laboratories.
- The lectures focus on the fundamentals of the interactions between electromagnetic radiation and atmospheric gases, aerosols and clouds, and ocean surfaces, covering the spectrum from the ultraviolet through the microwave.
- The labs provide hands-on experience in using remote sensing data for various applications in atmospheric and oceanic sciences. Topics to be covered include aerosol and cloud property retrievals, ozone and air pollution characterization, vertical temperature and humidity profile retrievals, sea ice characterization, and retrievals of ocean color and sea surface temperature.

## 2. How this course is organized:

- **Lectures:**

Lectures are developed to provide the most critical material and to complement the textbooks.

Lecture notes will be posted (in PDF format) at the course website:

**http://irina.colorado.edu/ATOC5235.htm**

!!!!! Please review lecture materials before coming to the class.

- **Computer Modeling Laboratories**

**Meeting place:**

**Physics Computer Lab, Duane G130 (next to the Math Physics Library)**

**Time: Each Friday, 10 AM - 1 PM**

Schedule of computer modeling labs

| *Date* | *Lab* | *Written report due* |
|---|---|---|
| ***January 18*** | Laboratory 1 | January 25 |
| ***January 25*** | Laboratory 2 | February 1 |
| ***February 1*** | Laboratory 3 | February 8 |
| ***February 8*** | Laboratory 4 | February 15 |
| ***February 15*** | Laboratory 5 | February 22 |
| ***February 22*** | Laboratory 6 | March 1 |
| ***March 1*** | Laboratory 7 | March 8 |
| ***March 8*** | Laboratory 8 | March 15 |
| ***March 15*** | Laboratory 9 | March 22 |
| ***March 22*** | Laboratory 10 | April 5 |
| ***April 5*** | Laboratory 11 | April 12 |
| ***April 12*** | Laboratory 12 | April 19 |
| ***April 19*** | Laboratory 13 | April 26 |
| ***April 26*** | **Laboratory 14 (Student project presentations)** | - |

- **Class Research Project**

**Goal** is to perform the analysis of remote sensing data in a well-defined problem.

Plan of a research project must be prepared by a student but discussed with and approved by me. The research project is required in lieu of a final exam. Try to select a topic of your class project as close as possible to your research.

Research project must be prepared as a web presentation.
Presentation of student's projects is scheduled for April 26 (during Laboratory 14).

**General guidelines for preparing your class project**

1) Define a topic of your project by selecting a specific atmospheric or oceanic parameter and remote sensing technique(s) used to retrieve this parameter.
*For instance, characterization of ozone from TOMS observations.*
2) Identify and study at least 3-5 papers dealing with the selected topic.
3) Perform an original analysis of the remote sensing data in a well-defined problem.
*For instance, interannual variability of* $O_3$ *over the Northern America.*
4) Your paper (about 10-15 pages) should show

the importance of the atmospheric or oceanic parameter selected;
brief description of the remote sensor;
explanation of the retrieval algorithm;
results of your analysis;
validation of retrieved data against independent measurements and/or modeling;
brief summary (e.g., advantages and disadvantages of the retrieval technique)

- **Homeworks**

will be posted (in PDF format) at the course website.
**Please turn in your homework on time.**

- **Exams:**

Two midterm exams, but no final exam.

## 3. Required/additional/advanced reading.

**Required Text:**

***Remote Sensing of the Lower Atmosphere: An Introduction.***
**G. Stephens.** Oxford Univ. Press 1994.

**Online tutorials:**

***Canada Centre for Remote Sensing (CCRS) remote sensing tutorial:***
http://www.ccrs.nrcan.gc.ca/ccrs/eduref/tutorial/indexe.html

***NASA remote sensing tutorial:***
http://rst.gsfc.nasa.gov/Front/tofc.html

***Committee on Earth Observation Satellites (CEOS) remote sensing tutorial:***
http://ceos.cnes.fr:8100/cdrom-00/astart.htm

***Univ. of Illinois tutorial: remote sensing for meteorology:***
http://ww2010.atmos.uiuc.edu/(Gh)/guides/rs/home.rxml

**Additional Text:**

***Satellite Meteorology: An Introduction.***
**Kidder S.Q. and Vonder Haar T.H.,** Academic Press, 1995.

***Physical principles of remote sensing.***
**Rees W.G**., Cambridge Univ. Press, 1990.

***Remote sensing: Principles and interpretation.***
**F.F. Sabins**, 1997.

**NOTE**: The various textbooks might have somewhat different terminology and very different notations.

## 4. Grading.

| | |
|---|---|
| Mid-term exams (2) | 30% |
| Homeworks | 20% |
| Computer modeling labs | 25% |
| Research Project | 25% |

# 5. Course outline, lecture schedule, and reading assignments.

| SCHEDULE FOR SPRING 2002 | | | |
|---|---|---|---|
| **Date** | **Lecture/Lab** | **Topic** | **Required reading** |
| Jan 14 | Lecture 1. | Logistic: Goals and structure of the course | |
| Jan 16 | Lecture 2. | The nature of electromagnetic radiation. Polarization. Stokes' parameters | G 2.1, 2.2.1, 2.2.2, 2.3-2.4, 4.1, App.1 |
| Jan 18 | *Lab 1.* | *Electromagnetic radiation* | |
| Jan 21 | HOLIDAY | | |
| Jan 23 | Lecture 3. | Basics of remote sensing: introductory survey | G 1.1, 1.7, p.395-398, 426-427 |
| Jan 25 | *Lab 2.* | *Learn about major NASA and NOAA satellite projects* | |
| Jan 28 | Lecture 4. | Radiation law. Blackbody emission. Brightness temperature. Sun as an energy source. | G 2.5 |
| Jan 30 | Lecture 5. | Emission and reflection from the ocean and land surfaces | G 4.3,4.4; p177-183 |
| Feb 1 | *Lab 3.* | *Planck function and emission from the surfaces. Sea-ice detection.* | |
| Feb 4 | Lecture 6. | The composition and structure of the atmosphere. Atmospheric gases | G 1.3-1.5, 3.2.1 |
| Feb 6 | Lecture 7. | Absorption/emission by atmospheric gases and effects on remote sensing | G 3.1-3.5 |
| Feb 8 | *Lab 4.* | *Absorption by gases* | |
| Feb 11 | Lecture 8. | Properties of atmospheric aerosols and clouds | G 1.6, |
| Feb 13 | Lecture 9. | Rayleigh scattering. Scattering/absorption by aerosols and clouds | G 5.1-5.7 |
| Feb 15 | *Lab 5.* | *Retrieval of aerosol optical properties from sunphotometer observations: AERONET and aircraft measurements* | G 6.1 |
| Feb 18 | Lecture 10. | Principles passive remote sensing using extinction and scattering. Scattering as a source of radiation. Multiple scattering. The two-stream approximation | G 6.3, 6.4, 6.6 |
| Feb 20 | Lecture 11. | Applications of passive remote sensing using extinction and scattering: Remote sensing of ozone in the UV region | G 6.2, 6.5 |
| Feb 22 | *Lab 6.* | *Ozone retrievals from TOMS and ground-based observations* | |
| Feb 25 | Lecture 12. | EXAM I | |
| Feb 27 | Lecture 13. | Applications of passive remote sensing using extinction and scattering: Ocean color. Reflection from ocean surfaces | |
| Mar 1 | *Lab 7.* | *Ocean color characterization* | |
| Mar 4 | Lecture 14. | Principles of passive remote sensing using emission. Radiative transfer with emission. Measurements of precipitable water vapor | G 7.1, 7.3.1, 7.3.2 |
| Mar 6 | Lecture 15. | Applications of passive remote sensing using emission: Remote sensing of sea surface temperature (SST) | G 7.2, 4.5.1 |
| Mar 8 | *Lab 8.* | *Retrievals of SST* | |
| Mar 11 | Lecture 16. | Applications of passive remote sensing using emission: Sensing of precipitation | G 7.4 |
| Mar 13 | Lecture 17. | Applications of passive remote sensing using emission: Sensing of clouds and aerosols | G 7.6 |
| Mar 15 | *Lab 9.* | *ISCCP project. Cloud detection and analysis* | |
| Mar 18 | Lecture 18. | Principles of sounding by emission. Sounding of the temperature profile | G 7.5, |
| Mar 20 | Lecture 19. | Sounding of trace gases and air pollution | |
| Mar 22 | *Lab 10.* | *Measurements of pollution in the troposphere ( MOPITT)* | |
| SPRING BREAK | | | |
| Apr 1 | Lecture 20. | Principles of active remote sensing: Radars | G 8.1, 8.2.1, |
| Apr 3 | Lecture 21. | Applications of radars: Sensing of clouds and precipitation | G 8.2.2, 8.2.3, 8.3 |
| Apr5 | *Lab 11* | *Earth radiation budget* | |
| Apr8 | Lecture 22. | Applications of the synthetic aperture radar: Sea ice mapping | |
| Apr10 | Lecture 23. | Applications of the Doppler radar: Measurements of winds | G 8.6, 8.7, 8.8 |
| Apr 12 | *Lab 12.* | *Analysis of radar sensing* | |
| Apr 15 | Lecture 24. | Principles of active remote sensing: Lidars | G 8.4.1, 8.4.2 |
| Apr 17 | Lecture 25. | Applications of lidars: Sensing of aerosols and clouds | G 8.4.3, 8.4.4 |
| Apr 19 | *Lab 13.* | *Analysis of lidar sensing* | |
| Apr 22 | Lecture 26. | Applications of lidars: Sensing of atmospheric gases | G 8.5 |
| Apr 24 | Lecture 27. | Review of remote sensing of the atmosphere | |
| Apr 26 | *Lab 14.* | *Students' project presentation* | |
| Apr 29 | Lecture 28. | Review of remote sensing of the oceans | |
| May 1 | Lecture 29. | EXAM II | |