Course Details

Course Rationale	Freshwater is a finite resource with increasing demands. However, we have yet to completely close the freshwater mass balance, which complicates our efforts at preserving and managing this vital resource. With the advent of new technology – particularly space-based instrumentation – remote sensing has transformed the study of freshwater from a data "poor" to a data "rich" field. This course discusses the fundamental principles of remote sensing of the Earth's hydrologic cycle and includes application of ground-, airplane-, and space-based remote sensing measurements.
Course Description	Introduction to basic concepts of remote sensing in water resource management. Discussion of measurements related to hydrologically-relevant variables such as soil moisture, snow, groundwater, precipitation, and river discharge. Application of remote sensing datasets in the characterization and quantification of available freshwater resources.
Prerequisites	Basic hydrology and/or fluid mechanics; basic statistics and differential calculus.
Course Schedule	Tuesday and Thursday 4:00-5:15 PM Math 0106 (Mathematics Bldg.)
Instructor	Professor Barton Forman 1159 Glenn L. Martin Hall Office Hours: Monday and Wednesday 4:30-5:30 PM (or by appt.) Email: `baforman@umd.edu` Blackboard: `https://bb.eng.umd.edu/`
Recommended Reference	Jensen, *Remote Sensing of the Environment* (on reserve in the Engineering and Physical Science Library)
Additional On-Reserve References	Campbell and Wynne, *Introduction to Remote Sensing* Margulis, *Introduction to Hydrology* (posted on-line @ `http://aqua.seas.ucla.edu/margulis_intro_to_hydro_textbook.html`) Rees, *Physical Principles of Remote Sensing* (on reserve in the Engineering and Physical Science Library) Rees, *Remote Sensing of Snow and Ice* Wilks, *Statistical Methods in the Atmospheric Sciences*
Grading Basis	Homework: 60% (undergraduate students) / 45% (graduate students) Reading Assignment: 15% (graduate students only) Final Project: 40% (undergraduate and graduate students) **Homework is due by the start of lecture.**[1]

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[1] unless due to extenuating circumstances

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Honor Pledge	The university has a nationally recognized Honor Pledge, administered by the Student Honor Council. The Student Honor Council proposed and the university Senate approved an Honor Pledge. The University of Maryland Honor Pledge reads: *"I pledge on my honor that I have not given or received any unauthorized assistance on this assignment/examination."* This pledge was designed to promote academic integrity within the student body and emphasize importance of the university academic policies.
Class Logistics	The tentative class schedule, including topics to be covered, is listed below. The course is organized into three parts: 1) lecture-based survey of the basics of remote sensing of the natural environment, 2) application of remote sensing measurements during regular homework assignments, and 3) a literature-based survey of state-of-the-art techniques of environmental remote sensing. The background lectures will be the focus of the first part of the course. The remaining class periods will consist of: 1) brief, student-led presentations of application papers from literature, and 2) final project presentations by students at the end of the semester.

Tentative Course Schedule (subject to change)

#	Lecture Date	Topics Covered
1	Tuesday, September 2	Course motivation, history and scope of remote sensing; [Read Cha. 1; Skim Cha. 3]
2	Thursday, September 4	Introduction to electromagnetic radiation; [Read Cha. 2]
3	Tuesday, September 9	Overview of energy interactions in the atmosphere;
4	Thursday, September 11	Electromagnetic waves in free space; angular distribution of radiation; [Read Cha. 7, pages 243–254]
5	Tuesday, September 16	Interaction of electromagnetic radiation with matter; dielectric constants of real materials;
6	Thursday, September 18	Absorption and scattering by macroscopic particles;
7	Tuesday, September 23	Refection / emission from real materials; spectral signature; emissivity in thermal IR and microwave radiation;
8	Thursday, September 25	Remote sensing systems; visible, near infrared, and thermal infrared imaging;
9	Tuesday, September 30	Passive microwave systems; antenna theory; introduction to radiation incident on Earth's surface;

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#	Lecture Date	Topics Covered
10	Thursday, October 2	Simple longwave and shortwave radiative flux models;
11	Tuesday, October 7	Precipitation development; drop size distribution; ground-based radar;
12	Thursday, October 9	Satellite-based remote sensing of precipitation;
13	Tuesday, October 14	Visible remote sensing of vegetation; Landsat mission and spectral bands; [Read Cha. 6, pages 177–196]
14	Thursday, October 16	BRDF of vegetation; vegetation indices; [Read Cha. 10, pages 357–395]
15	Tuesday, October 21	Visible / IR remote sensing of snow covered area and snow grain size;
16	Thursday, October 23	Introduction to passive microwave remote sensing; PMW remote sensing of snow;
17	Tuesday, October 28	LIDAR and gamma radiation remote sensing of snow; introduction to soil moisture remote sensing;
18	Thursday, October 30	Passive and active microwave remote sensing of soil moisture; thermal / IR soil moisture retrieval;
19	Tuesday, November 4	Soil moisture retrieval using cosmic rays;
20	Thursday, November 6	Gravimetric retrieval of water storage anomalies; spherical harmonics; applications in groundwater, snow, and soil moisture using GRACE;
21	Tuesday, November 11	GRACE enhancement via data assimilation; real aperture RADAR; synthetic aperture RADAR;
22	Thursday, November 13	Radar altimetry of water surfaces; SWOT mission overview; [Read Cha. 9, pages 287–313]
23	Tuesday, November 18	Land surface temperature remote sensing;
24	Thursday, November 20	Remote sensing of net radiation and land surface heat fluxes;
25	Tuesday, November 25	Course conclusion; future direction(s) of water resource remote sensing;
–	Thursday, November 27	No Lecture (Thanksgiving Holiday)
26	Tuesday, December 2	Student Project Presentations
27	Thursday, December 4	Student Project Presentations
28	Tuesday, December 9	Student Project Presentations
29	Thursday, December 11	Student Project Presentations

Homework Assignments

Eight (8) homework problem sets will be assigned as indicated below. These assignments are designed to reinforce your basic understanding of the theory covered in the lectures. Due to limited lecture time, some concepts and applications may be introduced in the homework assignments. It is your responsibility to know the material covered not only in lectures, but in all assignments. Several of these assignments will contain problems involving numerical computing using Excel, Matlab, IDL, Python, or a suitable equivalent. Matlab access is provided through the Virtual Computing Lab (`http://www.eit.umd.edu/vcl`) and is available for remote use. Additionally, Matlab is found on the workstations housed in the CEE Design Laboratory located in 1156 Martin Hall or via individual download on TERPware (see "Matlab Primer" document for further details)

Homework Assignment Schedule

#	Subject Matter	Assigned Date	Due Date
1	Hydrologic modeling (Introduction to Matlab©); hydrologic cycle;	September 4	September 11
2	General concepts of remote sensing; underlying physical principles;	September 11	September 18
3	Monochromatic and polychromatic radiation; land surface temperature; dielectric constant of water;	September 18	September 25
4	Rayleigh-Jean approximation; land surface classification; scattering by rain drops;	September 25	October 9
5	Downwelling solar radiation; ground-based precipitation radar; satellite-derived precipitation estimates;	October 9	October 16
6	Remote sensing of vegetation; Landsat-derived vegetation indices;	October 16	October 30
7	Remote sensing of snow covered area, snow depth, and snow water equivalent;	October 30	November 6
8	Passive and active soil moisture remote sensing retrievals;	November 6	November 20

Remote Sensing Project

A primary component of this class is an individual project employing real-world remote sensing products. For this project you will choose a topic (see Table 1 for list of possible topics) relevant to global water sustainability. Next, you will propose a study based on measurements of one (or more) components of the Earth's hydrologic cycle using one (or more) of the remote sensing techniques discussed in class. The goal of this project is to have each of you become familiar with particular methods by applying them to a specific topic of your design. **NOTE:** Your proposed topic and experimental design should be done in consultation with the instructor.

Table 1: Potential subjects for individual projects.

Number	**Topic**
#1	Radiation
#2	Precipitation
#3	Vegetation
#4	Snow
#5	Soil Moisture
#6	Terrestrial Water Storage

Remote Sensing Project Schedule

Item (% of the total project grade)	**Due Date**
Topic selection and motivation: List your top three (3) choices for a topic of study. Turn in a brief description (2 pages or less) of the project motivation and rationale for studying this portion of the Earth's hydrologic cycle (10%).	October 2
Project proposal: Turn in a brief description (5 pages or less) of the proposed set of experiments you will conduct for your project, including a clear description of the remotely-sensed observations that you will use, what hypotheses you will examine, and what statistical analyses you will perform (10%).	October 23
In-class project presentation: Present the model background and remote sensing products used in your study. Discuss the major findings of your study, including what worked and what did not. Summarize the experimental results and present (briefly) ideas for future study. Limit the presentation to 15 minutes plus 5 minutes for questions and answers (40%).	December 2 – 11
Written project report: Summarize the material discussed in your in-class project presentation. Limit yourself to 10 pages (excluding title page and bibliography) using standard margins, single line spacing, and 12-point font. The 10-page limit will force you to focus on the most relevant details of your study and to succinctly describe them (40%).	December 12

Literature Reading Assignment (Graduate Students Only)

For the reading assignment you are asked to choose one (1) paper from the literature on a particular aspect/application of environmental remote sensing. Potential topics for discussion are provided in Table 2. Once chosen, everyone in class will read the paper and you will be responsible for presenting the paper and leading the class discussion of it as part of a 15-minute presentation.

Table 2: Potential topics for graduate student-led discussions.

Number	**Topic**
#1	Radiation
#2	Precipitation
#3	Vegetation
#4	Snow
#5	Soil Moisture
#6	Terrestrial Water Storage
#7	Surface Water Elevation

Literature Reading Assignment Schedule

Item	**Due Date**
Submit paper selection (List of top 3-5 choices)	September 11
Present paper and lead in-class discussion session	TBD (dependent on topic selected)