Classroom: CAS 223
Tu & Th 2PM to 3:15PM
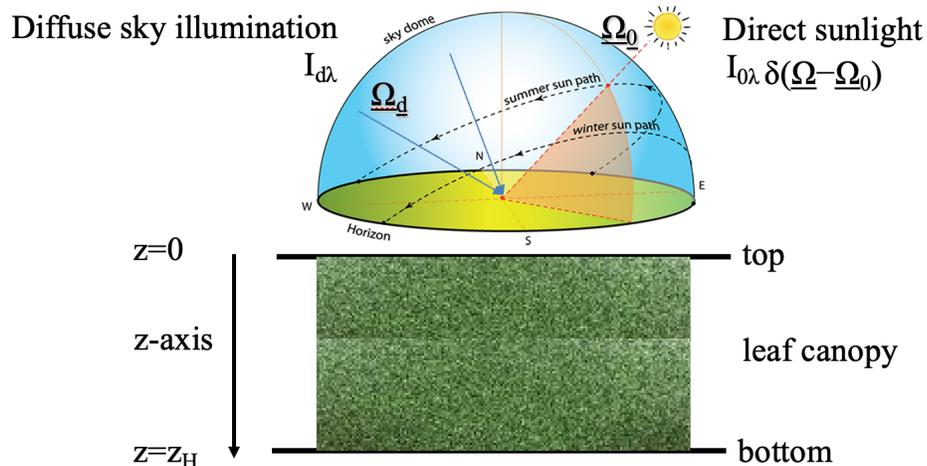Contact Hours: Anytime (Setup via Email)

Prof. Ranga B. Myneni (ranga.myneni@gmail.com)

The RT Problem (1D monochromatic RT / 1D one-speed Problem)

$$-\mu \frac{\partial}{\partial z} I_\lambda(z,\underline{\Omega}) + \sigma(z,\underline{\Omega}) I_\lambda(z,\underline{\Omega}) = \int_{4\pi} d\underline{\Omega}' \, \sigma_{s\lambda}(z,\underline{\Omega}' \to \underline{\Omega}) \, I_\lambda(z,\underline{\Omega}')$$

$$I_\lambda(z=0,\underline{\Omega}) = I_{o\lambda}\delta(\underline{\Omega}-\underline{\Omega}_o) + I_{d\lambda}(\underline{\Omega}), \quad \mu < 0,$$

$$I_\lambda(z=z_H,\underline{\Omega}) = 0, \quad \mu > 0.$$

Diffuse sky illumination $I_{d\lambda}$ $\underline{\Omega}_d$ $\underline{\Omega}_0$ Direct sunlight $I_{0\lambda}\delta(\underline{\Omega}-\underline{\Omega}_0)$

z=0 — top
z-axis — leaf canopy
z=z_H — bottom

The discipline of remote sensing involves measurements and interpretation of Electromagnetic radiation (EMR) emitted or scattered by targets such as water bodies, ice sheets, vegetation, atmosphere, etc.. The focus is typically on the properties of the targets, such as, aerosols in the atmosphere, leaf area of vegetation, organic matter in water bodies, etc. This problem is best described by invoking the wave or particle nature of EMR and mathematically characterizing the corresponding propagation and interaction physics. Solutions to resulting equations shed light on the nature and information content of remotely measured signals. This is the so-called forward problem, where the physical variables of the target are assumed known and the solution is the remotely measured signal.

The inverse of this problem, where the remote signal is assumed known and solved for physical properties of the target, is the central problem in remote sensing.

Nearly all remote sensing techniques have at their heart the inverse of the forward problem mentioned above. We will focus on remote sensing of green leaf area using vegetation as a target and invoking the particle nature of EMR. Our approach shall be sufficiently generic, that mastering this topic will easily translate to skills for solving problems in remote sensing of other media.

Thus, the goal of this course is two-fold: (1) to gain a process level physics based understanding of the measured signals, i.e., satellite data, and (2) master skills required to develop algorithms for remote sensing of physical traits of interest of any target.

The lectures will be grouped into five thematic chapters:

(1) Definitions and the Radiative Transfer Equation (RTE)
(2) The RTE Problem in Vegetation Media
(3) Physics of Photon-Vegetation Interactions
(4) Numerical Solution Methods of the RTE
(5) Advanced Methods

I will provide you lecture notes and all needed reference materials. I will assume that you have some college-level background in Calculus, Differential Equations and Numerical Methods. I have been actively researching on this material for nearly 40 years and have taught this course for the past 30 years. I will do my best to teach you all in a manner that shall make you the masters of this material by the semester's end.

Course assignments will require coding and interpretation of results. Final grade will be based on the report submitted at the semester's end. This report shall consist of results and their interpretation from solution of the 1D radiative transfer equation for a vegetation medium idealized as a turbid medium. There are no exams in this course.

The class website is (BU Login required):
https://sites.bu.edu/cliveg/ee-445-645-spring-2026/

Books and Articles: Several standard textbooks and reference books will be made available to the students by the instructor. All materials will be posted on the class website above.

Policies: Policies regarding academic honesty and incomplete grades are dictated by the College. Please consult the CAS student handbook.

Prof. Myneni's website:
https://sites.bu.edu/cliveg/

EE 445/645 Lecture Schedule for Spring 2026
(Jan-20-2026)

		Chapter 01: Definitions & Radiative Transfer Equation
1	Jan-20	Introduction to the Course
2	Jan-22	Basic definitions (C1-P1)
3	Jan-27	Particle Dist. Function & Radiative quantities – C1-P2)
4	Jan-29	Radiative interactions (C1-P3)
5	Feb-03	The Radiative Transfer Equation (C1-P4)
6	Feb-05	Integral form of the Radiative Transfer Equation (C1-P5)
7	Feb-10	Energy Balance & Reciprocity Principles (C1-P6)
		Chapter 02: Radiative Transfer Problem in Vegetation Canopies
8	Feb-12	RTE in Vegetation & Radiative Quantities of Interest (C2-P1)
		Chapter 03: Structure, Optics and Cross Sections
09	Feb-19	Canopy Structure (C3-P1)
10	Feb-24	Extinction Cross Section (C3-P2)
11	Feb-26	Leaf Optics (C3-P3)
12	Mar-03	Differential Scattering Cross Section (C3-P4)
		Chapter 04: Numerical Solution of the Radiative Transfer Equation
13	Mar-10	One dimensional RTE problem set-up (C4-P1)
14	Mar-12	Successive orders of scattering (C4-P2)
15	Mar-17	Start Discrete Ordinates method (C4-P3)
16	Mar-19	Finish Discrete Ordinates method (C4-P3)
17	Mar-24	Gauss-Seidel method (C4-P4) & Two Stream Method (C4-P5)
18	Mar-26	Hot Spot (C4-P6) & Model Inversion (C3-P7)
19	Mar-31	Start 3D Discrete Ordinates – 01 (C4-P8)
20	Apr-02	Finish 3D Discrete Ordinates – 02 (C4-P9)
		Chapter 05: Advanced Topics
21	Apr-07	Decomposition of RTE Solution (C5-P1)
22	Apr-09	Estimating LAI from RS data (C5-P2)
23	Apr-14	Spectral Invariants (C5-P3)
24	Apr-16	Stochastic RTE (C5-P4)
25	Apr-21	Light Quality in Vegetation Canopies (C5-P5)
26	Apr-23-30	Discussion Related to Coding of Assignment & Submission for Grading