Lecture 22: Final Exam Review

Final Exam Format: Choose the best answer. 100 multiple choice questions (1 point each).

- Exam will be available on Wednesday Dec. 6, 2023 between 6-9pm.
- **Students are required to finish it <u>within 2 hours</u>.**
- Students will be able to see their scores immediately after the exam.
- **Students can only have one attempt.**

Note: there will be about 50% of questions from previous quizzes and the mid-term exam.

<u>Module 1:</u>

LECTURE 1: Overview of remote sensing

1. In-situ vs. remote sensor: Definition of each; difference between them; Examples. Slide #3-5.
2. Active vs. passive remote sensor: Definition of each; difference between them; Examples. Slide #11-12.
3. Remote sensing sensors vs. platforms: Examples. Slide #8.

LECTURE 2: Brief history of radar & satellite meteorology

4. Which year was the first U.S. Doppler weather radar network built in? Slide #17.

<u>Module 2:</u>

LECTURE 3: Atmospheric radiation basics

5. Definitions of shortwave and longwave radiation; their frequency bands. Slide #4-5.
6. Definition and characteristics of EM waves. Slide #7-8.
7. Definitions of frequency, wavelength, and wavenumber. Slide #9-10.
8. Understanding Planck-Einstein equation E=hf. Slide #11.
9. Solid angle: definition & understanding of it, the value of solid angle for a whole sphere. Slide #15-16.
10. Measures of energy (definition & unit): radiant energy, power, flux, & intensity. Slide #13, 19-20.
11. Broadband/incoherent vs. monochamatic/coherent radiation: what about natural radiation? Slide #21.
12. What is the most fundamental radiation unit for satellite meteorology? Slide #22.
13. What is polarization? What type of polarization in the radiation that standard weather radar equipment typically transmits? Slide #25-27.

LECTURE 4: EM spectrum

14. EM bands that are important to remote sensing in meteorology. Need to know different usages of different wavelength bands: UV, Visible, IR, microwave, and radio bands. Slide #14, 15, 18, 25, &30.
15. Factors important to total insolation. Slide #4-9.

<u>Module 3:</u>

LECTURE 5: Emission

16. Know what is emission. At what temperature emission occurs. Page #1.
17. Definition of blackbody & its properties. Page #1.
18. Know the physical interpretation of the Planck Function (Page #1-2), Wien's law (Page #3), Stefan-Boltzmann's law (Page #4), & Rayleigh-Jeans approximation (Page #5).
19. Definition of emissivity & graybody emissivity. Page #5-6.
20. Definition of brightness temperature Tb. Characteristics of Tb at IR and microwave bands, respectively. Page #6.

LECTURE 6: Absorption

21. Definition of absorption, absorptivity, absorption coefficient, mass absorption coefficient, optical path length, and transmissivity. Page #1-4.
22. Lambert's law: understand what it tells us. Page #4.

LECTURE 7: Scattering

23. Definitions of scattering. Know when to use reflection/refraction and when to use scattering. Page #1-2.
24. Size parameter. Define Rayleigh, Mie, and Optics scattering regimes using the size parameter. Page #2-3.
25. Difference of the angular distribution of scattering for Rayleigh and Mie regimes. Page #3.
26. Definition of extinction. Page #5.

Module 4:

LECTURE 8: Radiative transfer equation

27. Know which processes we need to consider in getting the radiative transfer equation, i.e., what are terms A, B, C, and D. Which are depletion terms, and which are source terms. Page #1.
28. Non-scattering radiative transfer equation: valid in which regime, need to know an example. Page #4.
29. Non-emission radiative transfer equation: valid in which regime, need to know an example. Page #4.

LECTURE 9: Reflection and refraction

30. Definition of the complex index of refraction. What is the real part describing? What is the imaginary part describing? Which part is responsible for reflection and refraction? Which part is responsible for absorption?
31. When to use the rules of reflection & refraction in the atmosphere?
32. Know the relationship between incident angle and reflection angle
33. Know Snell's law
34. Explain rainbow: what are responsible for the primary rainbow & secondary rainbow, respectively?

LECTURE 10: Rayleigh and Mie scattering

35. Definitions of extinction coefficient, mass extinction coefficient, extinction cross-section, extinction efficiency. Page #1-2.
36. Understand the 3 key facts derived from Rayleigh solution: Page #2-3.
    a. For a fixed wavelength, larger particle will scattering more strongly (6 power of the radius or diameter). This is the basis of weather radar.
    b. Explain why the sky is blue.
    c. The fact relevant to passive microwave remote sensing of cloud water: absorption is proportional to mass path, independent on particle size.
37. Mie solution: understand Petty's book Fig. 12.4. Page #4.

Module 5:

LECTURE 11: Introduction of Radar and Radar hardware

38. Characteristics of radar antenna & reflector. What determines the shape of the radar antenna bean pattern? Slide #11-12.
39. What does a weather radar measure? Slide #6
40. Functions of transmitter, receiver, duplexer, signal processor. Slide #8, 17-18.

LECTURE 12: Curvature and refraction of radar beam, radar equation for point targets

41. Definition of refractivity; which parameter(s) determine how radar beam curve in the atmosphere. Slide 8-14.
42. Know how much the radar beam bends relative to the Earth surface under standard refraction, sub-refraction, and super refraction conditions. Slide #15.
43. Definition of ducting. Slide #18-19.

44. In Rayleigh, Mie, and Optics regimes, how does the radar back-scattering cross section relate to the target (particle)'s size/diameter/geometric area. Slide #26-30.

LECTURE 13: Radar pulse Characteristics and Radar equation for distributed targets

45. Definitions of pulse length, listening time, range resolution, Pulse Repetition Frequency (PRF). Page#1
46. What determines the maximum unambiguity range that radar could detect? Page#2
47. Definitions of radar reflectivity factor and radar reflectivity. Page#4
48. Definition and shape of radar sample volume. Page#2-3
49. Relationship of radar received power and reflectivity factor and the distance between radar antenna and the target. Page#4

Module 6:

LECTURE 15 Part 1 Notes: Doppler Velocity & Doppler dilemma

50. What is Doppler effect? Understand the Doppler frequency shift equation. Page#1-2
51. What is maximum unambiguous velocity? What parameters determine it? (Vmax=+/- λ (PRF)/4). Page#3
52. What is Doppler dilemma? What is the relationship between maximum unambiguous velocity (Vmax) and maximum unambiguous range (Rmax) ? Page#3

LECTURE 15 Part 2 slides: Range and velocity folding; Interpreting Doppler velocity patterns

53. What is second-trip/multi-trip echo? Understand range folding and be able to calculate the displayed distance from the real distance from radar for second trip echo. Slide #3-6.
54. Given the maximum unambiguous velocity and the actual radial velocity value, you should be able to calculate the aliased/folded velocity. Slide #10-12.

LECTURE 16: Meteorological targets of radar: cloud, rain, Z-R relationship, snow, bright-band, & hail

55. Clouds: What is the cloud drop size distribution? Which wavelength radar can detect non-precipitating clouds? Slide #2-4.
56. Which wavelength radar are the best to detect rain and precipitating clouds? Slide #5.
57. The relationships between particle diameter and rain rate/liquid water content/radar reflectivity factor: rain rate ~ D^3 or D^4, liquid water content ~ D^3, radar reflectivity factor ~ D^6. Slide #6-8.
58. What measurements are used to determine the Z-R relationships? Slide #9.
59. Why radar doesn't detect snow very well? Why the radar power received back from snow and ice is 7 dB less than it would be if a radar were looking at liquid precipitation? Slide #10-13.
60. What is bright band? Under what conditions bright-band will occur? How does bright band form? Slide #14-16.
61. How to determine hail using radar reflectivity? What is a flare echo? Slide #20-21.

LECTURE 17: Attenuation of radar echo & Spaceborne radars

62. What is attenuation? What factors is the attenuation amount dependent on? Slide #2.
63. Why are space radars more subject to attenuation problems than ground-based radars? Slide #11.

Module 7:

LECTURE 18: Satellite orbits

64. How to determine the orbit (altitude above Earth surface) of a circular geostationary satellite? (slide 5-7)
65. Differences between circular and elliptical orbits (slide 10)
66. Definition of inclination angle (slide 15). Definition of prograde orbits and retrograde orbits. (slide 15-16)
67. Definition & characteristics of Keplerian orbit (slide 19-20), sun-synchronous orbit (slide 22-23), geostationary orbit (slide 30), polar orbit (slide 23, 38), low earth orbit (slide 23, 38), and equatorial orbit (slide 38).
68. How to keep an orbit sun-synchronized? What characteristics of the earth makes the sun-synchronized orbit possible? (slide 24)

LECTURE 19: Operational Remote Sensing in Visible, IR, and Microwave Channels

69. Which parameters do visible, IR, and water vapor channels measure (slide 4-11). What is in the brightest/darkest regions in visible, IR, and water vapor images, respectively (slide 11)?
70. What is the difference between satellite imagers & sounders? (slide 30)
71. Which radiation processes are important in 1.4, 10, 19, 22, 37, 50-60, and 85 GHz? (slide 32-40).
72. Why microwave-based rainfall retrieval is better than IR-based rain retrieval? (slide 32, 50-53).

LECTURE 20: Distinguishing different image types and Identifying weather systems

73. What is the difference between visible and IR images? (slide 8)
74. What are the four properties used in the Dvorak TC intensity estimation technique? (slide 45)

LECTURE 21: Identifying clouds

No questions from this lecture