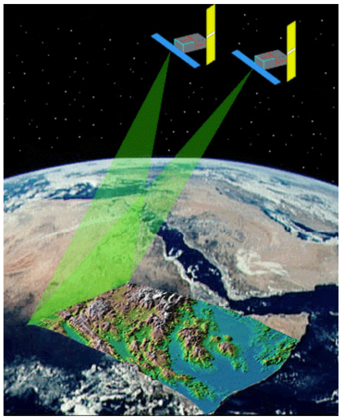
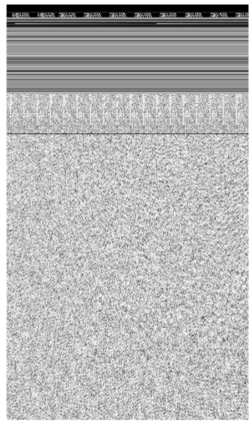
EE355/GP265- Radar Remote Sensing: Fundamentals and Geophysical Application of Imaging Radar Systems

Syllabus

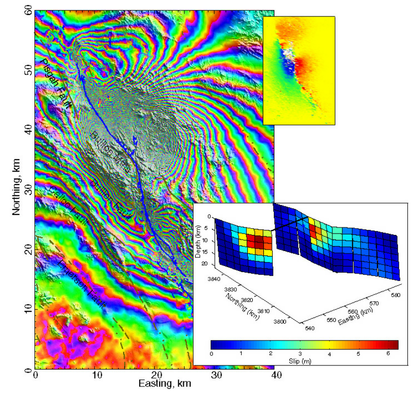
Howard Zebker



From instruments



to raw data



to images

Imaging radar views the Hector Mine earthquake of 1999. Orbiting satellite images the area before and after the earthquake, and records raw radar signals which must be processed to form an interferogram. The deformation signature, visible as the finely spaced pattern of color fringes, depicts detailed changes in the Earth's crust from motion during the earthquake. Measurement of the spatial distribution of the deformation permits solution for fault motion at depth, and may be useful in predictive studies of seismic activity. In this course we learn how to derive similar motions from spaceborne radar satellite measurements.

General Information

Lectures : Mitchell Earth Sciences Room 372; MW 10:30-11:45

Professor:	Howard Zebker
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Recommended Text

Digital processing of Synthetic Aperture Radar Data
Cumming and Wong, Artech House, 2005.

Other good text references

Title: Synthetic Aperture Radar
Authors: J.C. Curlander and R.N. McDonough
Publisher: Wiley Interscience, New York, 1991.

Title: Synthetic Aperture Radar Processing
Authors: G. Franceschetti and R. Lanari
Publisher: CRC Press, 1999.

Course goal:

By the end of this course, students will be able to derive most properties of radar echoes from first physical principles, and be able to design and implement processing code that generates high-resolution images from the raw measurements. In addition, you will be able to use multiple channel systems to produce higher order data products such as interferometric and polarimetric analyses. Finally, you will be able to apply these products to a diverse set of geophysical applications.

Course description:

Radar has evolved from a largely military detection system into a sophisticated three-dimensional imaging tool with hundreds of applications ranging from commercial aviation to fundamental research in the earth and planetary sciences. The ability to measure and map surface topography and crustal change at unprecedented levels over large areas is fundamentally altering the way in which we can measure and model the processes, natural and man-made, that effect our environment. In this course we will investigate how radar images are formed and manipulated, as well as applications of the systems to problems such as measurement of the Earth crustal deformation mm precision. We will be presenting radar as a signal processing problem, rather than the traditional approach as an instrumentation problem, acknowledging the importance of digital computer algorithms in modern radar systems. The first half of the course will be largely devoted to radar image formation, and topics will include system design, scattering from natural surfaces, range and azimuth processing algorithms, and processor design. In the second half of the course we examine polarimetric radars, which are particularly suited to the study of vegetation cover, plus the increasingly important field of radar interferometry. Interferometric radar techniques, which have formed a large part of radar-related research over the past 10 years, provide a means to characterize very small changes or motions on the Earth over large areas.

The course will be presented in a lecture/seminar style. Each week there will be a significant computer exercise to give experience with implementation of the material presented in class. Some additional homework problems will also be assigned as appropriate. Lecture notes will be handed out routinely, and special handouts will also be distributed from time to time. Reading assignments will be given for most class meetings. These may be from the text or from other sources, most of which will be on reserve at Terman Engineering Library. Homework and computer assignments will generally be given on Wednesdays and collected on Wednesdays, with the results handed back by the following Monday or Wednesday. Cooperation on homework is encouraged, but you are expected to keep the work on an approximately equal basis. For now, plan on one midterm exam plus a final term project. Grades will be based on the totality of your work, with weightings of approximately 40% on the final project or exam, 25% on the midterm, 30% on homework, and up to 5% extra credit problems and so forth.

A course syllabus and a list of reference books are attached. Assigned readings will usually be from the text. You may also find that a different book presents material in ways you can more easily understand, although the selected text is quite good.

Weekly Topic(s)

Week 1. Overview and class procedures
Basic concepts and notation
What is an imaging radar ?
Elementary scattering theory

Week 2. Radar equation
System design principles
Image formation
Radar as a signal processing problem

Week 3. Range Modulation Processing
Range processing and matched filters
Pulse compression
FFT implementations

Week 4. Azimuth processing
Synthetic aperture technique
System impulse response
Azimuth correlator design

Week 5. Range migration processing
Focussing and autofocus algorithms
Doppler tracking and filtering
Multilook processing
Midterm Examination through Lect. 2/3

Week 6. Polarimetry
Scattering from vegetation
Radiometric calibration
Geometric distortion
Assignment and Discussion of Final Exam

Week 7. Interferometry
Interferometric radar
Interferometric processing implementation
Image registration
Baseline determination

Week 8. Measurement of surface topography
Topographic algorithms
Application examples

Week 9. Velocity measurements
Measurement of velocities
Ocean current applications
Glaciers and ice streams
Airborne and spaceborne instrumentation

Week 10. Surface deformation measurements
Two- and three-pass algorithms
Earthquakes and volcanoes

Finals week
TAKE-OUT FINAL DUE, NOON, Monday

REFERENCES

Other books which may serve as useful references are listed below. These are on reserve in Terman Engineering Library, as well as the recommended texts.

Bracewell, R. N., The Fourier Transform and Its Applications, McGraw-Hill, New York, 2nd edition, 1986.

Carrara, W.G., R.S. Goodman, and R.M. Majewski, Spotlight Synthetic Aperture Radar: Signal Processing Algorithms, Artech House, Norwood, MA, 1995.

Curlander, J.C. and R.N. McDonough, Synthetic Aperture Radar, Wiley Interscience, New York, 1991.

Elachi, C., Introduction to the physics and techniques of remote sensing, Wiley, New York, 1987.

Elachi, C., Spaceborne Radar Remote Sensing: Applications and Techniques, IEEE press, New York, 1988.

Goodman, J.W., Introduction to Fourier Optics, McGraw-Hill, New York, 1968.

Kraus, J.D. Radio Astronomy, McGraw-Hill, New York, 1966. (Later editions good also)

Peebles, P.Z, Radar Principles, Wiley Interscience, New York, 1998.

Press, W.H., B.P. Flannery, S.A. Teukolsky, and W.T. Vetterling, Numerical Recipes in C, the Art of Scientific Computing, Cambridge University Press, New York, 1988. (Any of the Numerical Recipes series will have useful algorithm information)

Sabins, F., Remote Sensing, 3rd ed., Freeman, New York, 1996. Soumekh, M., Fourier Array Imaging, Prentice Hall, Englewood Cliffs, New Jersey, 1994.

The following, though not on reserve, are also relevant and may be useful:

Cook, C.E., and M. Bernfeld, Radar Signals, Academic Press, New York, 1967.

Skolnik, M.I., Radar Handbook, McGraw-Hill, New York, 1970.