Office of the Registrar
FORM 40G REV. 07/13

PURDUE UNIVERSITY

REQUEST FOR ADDITION, EXPIRATION,
OR REVISION OF A GRADUATE COURSE
(50000-60000 LEVEL)

Print Form

DEPARTMENT Aeronautics and Astronautics   EFFECTIVE SESSION 2015 Spring

INSTRUCTIONS: Please check the items below which describe the purpose of this request.

- [X] 1. New course with supporting documents (complete proposal form)
- [ ] 2. Add existing course offered at another campus
- [ ] 3. Expiration of a course
- [ ] 4. Change in course number
- [ ] 5. Change in course title
- [ ] 6. Change in course credit/type
- [ ] 7. Change in course attributes
- [ ] 8. Change in instructional hours
- [ ] 9. Change in course description
- [ ] 10. Change in course requisites
- [ ] 11. Change in semesters offered
- [ ] 12. Transfer from one department to another

PROPOSED:		EXISTING:	
Subject Abbreviation	AAE	Subject Abbreviation	AAE
Course Number	52300	Course Number	59000

Long Title Introduction to Remote Sensing

Short Title Intro. Remote Sens.

Abbreviated title will be entered by the Office of the Registrar if omitted. (30 CHARACTERS ONLY)

TERMS OFFERED
Check All That Apply:
[ ] Fall [X] Spring [ ] Summer

CAMPUS(ES) INVOLVED
[ ] Calumet [X] Cont Ed [ ] Ft. Wayne [ ] Indianapolis [ ] N. Central [ ] Tech Statewide [X] W. Lafayette

CREDIT TYPE

1. Fixed Credit: Cr. Hrs. 3
2. Variable Credit Range:
   Minimum Cr. Hrs
   (Check One) To [ ] Or [ ]
   Maximum Cr. Hrs.
3. Equivalent Credit: Yes [ ] No [X]
4. Thesis Credit: Yes [ ] No [X]

COURSE ATTRIBUTES: Check All That Apply

1. Pass/Not Pass Only [ ]
2. Satisfactory/Unsatisfactory Only [ ]
3. Repeatable [ ]
   Maximum Repeatable Credit: [ ]
4. Credit by Examination [ ]
5. Fees: [ ] Coop [ ] Lab [ ] Rate Request
   Include comment to explain fee
6. Registration Approval Type
   Department [ ] Instructor [ ]
7. Variable Title [ ]
8. Honors [ ]
9. Full Time Privilege [ ]
10. Off Campus Experience [ ]

Schedule Type	Minutes Per Mtg	Meetings Per Week	Weeks Offered	% of Credit Allocated
Lecture	50	3	15	100
Recitation				
Presentation				
Laboratory				
Lab Prep				
Studio				
Distance				
Clinic				
Experiential				
Research				
Ind. Study				
Pract/Observ				

Cross-Listed Courses

COURSE DESCRIPTION (INCLUDE REQUISITES/RESTRICTIONS):

Fundamentals of satellite and airborne remote sensing. Basic physical principles of electromagnetic wave propagation will be introduced. From this foundation, the phenomenologies enabling properties of the atmosphere, ocean and land surface to be measured at a distance will be developed. These principles will be applied to the design of instruments and satellite missions for Earth observation. Microwave instruments will be emphasized, although there will also be discussion of optical systems

*COURSE LEARNING OUTCOMES

On completing this course the student shall be able to: Understand the basic physical principles of microwave and optical remote sensing. Explain the principle geophysical quantities that can be measured using remote sensing methods. Evaluate a mission design for a remote sensing application.

Calumet Department Head	Date	Calumet School Dean	Date	Calumet Director of Graduate Studies	Date
Fort Wayne Department Head	Date	Fort Wayne School Dean	Date	Fort Wayne Director of Graduate Studies	Date
Indianapolis Department Head	Date	Indianapolis School Dean	Date	IUPUI Associate Dean for Graduate Education	Date
North Central Department Head	Date	North Central School Dean	Date	North Central Director of Graduate Studies	Date
West Lafayette Department Head	Date 4/20/14	West Lafayette College/School Dean	Date 9/25/14	Date Approved by Graduate Council	Date
Graduate Area Committee Convener	Date	Graduate Dean	Date	Graduate Council Secretary	Date
				West Lafayette Registrar	Date

OFFICE OF THE REGISTRAR

Supporting Document
to accompany the Registrar's FORM 40G when:

1. Requesting a New Graduate Course (Complete Section I)
or
2. Adding Distance as an Additional Schedule Type (Complete Section II)

For Reviewer's comments only (Select One)
Reviewer:
Comments:

To: Purdue University Graduate Council

From:
Faculty Member: James L Garrison
Department: School of Aeronautics and Astronautics
Campus: West Lafayette

Date:

Subject: Supporting Document to the Registrar's Form 40G

Contact for information if questions arise:

Name: Prof. James L Garrison

Phone Number: (765)-486-7482 (X67482)

E-mail: jgarriso@ecn.purdue.edu

Campus Address: 701. West Stadium Ave.

Course Subject Abbreviation and Number: AAE52300

Course Title: Introduction to Remote Sensing

SECTION I

A. Justification for the Course:

- Provide a complete and detailed explanation of the need for the course (e. g., in the preparation of students, in providing new knowledge/training in one or more topics, in meeting degree requirements, etc.), how the course contributes to existing majors and/or concentrations, and how the course relates to other graduate courses offered by the department, other departments, or interdisciplinary programs.

Observing changes in the Earth's oceans, atmosphere and land masses is a very important activity for understanding both the long-term evolution of our planet and its climate, near-term prediction of weather and natural disasters, and monitoring agricultural production and environmental damage. Although some variables describing these processes can be measured directly, with "in situ" sensors, frequent global or regional sampling will require indirect observation using electromagnetic radiation. Exploration of the solar system also makes use of remote sensing techniques for fundamental scientific research on the structure and evolution of the other planets.

- Justify the level of the proposed graduate course (50000- or 60000-level) including statements on, but not limited to: (1) the target audience, including the anticipated number of undergraduate and graduate students who will enroll in the course; and (2) the rigor of the course.

This course is proposed at the 50000-level as it is intended for advanced undergraduates, Master's degree seeking students, and early doctoral students, in engineering or the sciences. The enrollment history of the AAE 59000 experimental course in the four semesters that is was offered was as follows: Fall 2009: 6 (including 4 – AAE, 1 – ECE, 1 – Civil), Spring 2010: 5 (4 – Civil, 2 – AAE); Spring 2012: 15 (6 on campus 1 – EEE, 3 – Civil – 2, 2 - AAE, 9 Pro Ed: 3 – AAE, 1- ME, 5 - IDE), Spring 2014: 11 (6 on campus, all AAE, 5 Pro Ed, 2 – AAE, 3 - IDE). Based upon this history, the enrollment in future offerings of AAE 59000 is expected to be 10-18 students, divided approximately equally between on-campus and EPE. Approximately one half of the on-campus students are expected to be undergraduates.

B. Learning Outcomes and Method of Evaluation or Assessment:

- Describe the course objectives and student learning outcomes that address the objectives (i.e., knowledge, communication, critical thinking, ethical research, etc.).

See attached document.

- Describe the methods of evaluation or assessment of student learning outcomes. (Include evidence for both direct and indirect methods.)

See attached document.

- Grading criteria (select from drop down boxes); include a statement describing the criteria that will be used to assess students and how the final grade will be determined.

Criteria: Homework	Criteria: Papers and Projects	Criteria:
Criteria:	Criteria:	Criteria:

- Identify the method(s) of instruction (select from drop down box) and describe how the methods promote the likely success of the desired student learning outcomes.

Method of Instruction: Lecture	Method of Instruction: Distance	Method of Instruction:
Method of Instruction:	Method of Instruction:	Method of Instruction:
Method of Instruction:	Method of Instruction:	Method of Instruction:

C. Prerequisite(s):

- List prerequisite courses by subject abbreviation, number, and title.

AAE30100 , Signal Analysis for Aerospace Engineering or ECE30100, Signals and Systems, or equivalent
AAE20300, Aeromechanics, or equivalent

- List other prerequisites and/or experiences/background required. If no prerequisites are indicated, provide an explanation for their absence.

Students should be competent with a computer language (MATLAB preferred).

D. Course Instructor(s):

- Provide the name, rank, and department/program affiliation of the instructor(s).

James L. Garrison, Associate Professor, AAE

- Is the instructor currently a member of the Graduate Faculty? X Yes — No
  (If the answer is no, indicate when it is expected that a request will be submitted.)

E. Course Outline:

- Provide an outline of topics to be covered and indicate the relative amount of time or emphasis devoted to each topic. If laboratory or field experiences are used to supplement a lecture course, explain the value of the experience(s) to enhance the quality of the course and student learning. For special topics courses, include a sample outline of a course that would be offered under the proposed course.

See attached document.

F. Reading List (including course text):

- A primary reading list or bibliography should be limited to material the students will be required to read in order to successfully complete the course. It should not be a compilation of general reference material.

See attached document.

G. Library Resources

- Describe the library resources that are currently available or the resources needed to support this proposed course.

Students should have access to Purdue Library's electronic Journal collection for use in their literature review and some of the assigned readings.

H. Example of a Course Syllabus (While not a necessary component of this supporting document, an example of a course syllabus is available, for information, by clicking on the link below, which goes to the *Graduate School's Policies and Procedures Manual for Administering Graduate Student Programs*. See Appendix K.)

http://www.gradschool.purdue.edu/downloads/Graduate_School_Policies_and_Procedures_Manual.pdf

SECTION II

New graduate degree program policies and guidelines, approved by the Indiana Commission for Higher Education on August 10, 2012, require additional documentation regarding modes of delivery. Please complete Section II when adding an additional mode of delivery to an existing graduate course.

A. Justification for New Proposed Mode of Delivery (Complete)

B. Learning Outcomes and Method of Evaluation or Assessment:
(Complete if different from approved mode of delivery)

- Describe the course objectives and student learning outcomes that address the objectives (i.e., knowledge, communication, critical thinking, ethical research, etc.).

- Describe the methods of evaluation or assessment of student learning outcomes. (Include evidence for both direct and indirect methods.)

- Grading criteria (select from drop down boxes); include a statement describing the criteria that will be used to assess students and how the final grade will be determined.

Criteria | Criteria | Criteria

Criteria | Criteria | Criteria

- Identify the method(s) of instruction (select from drop down box) and describe how the methods promote the likely success of the desired student learning outcomes.

Method of Instruction | Method of Instruction | Method of Instruction

Method of Instruction | Method of Instruction | Method of Instruction

Method of Instruction | Method of Instruction | Method of Instruction

C. Prerequisite(s):

(Complete if different from approved mode of delivery)

- List prerequisite courses by subject abbreviation, number, and title.

- List other prerequisites and/or experiences /background required. If no prerequisites are indicated, provide and explanation for their absence.

D. Course Instructor(s):

- Provide the name, rank, and department/program affiliation of the instructor(s).

- Is the instructor currently a member of the Graduate Faculty? __ Yes __ No

  (If the answer is no, indicate when it is expected that a request will be submitted.)

E. Course Outline:

(Complete if different from approved mode of delivery)

- Provide an outline of topics to be covered and indicate the relative amount of time or emphasis devoted to each topic. If laboratory of field experiences are used to supplement a lecture course, explain the value of the experience(s) to enhance the quality of the course and student learning. For specials topic courses, include a sample outline of a course that would be offered under the proposed course.

F. Reading List (including course text):

(Complete if different from approved mode of delivery)

- A primary reading list or bibliography should be limited to material the students will be required to read in order to successfully complete the course. It should not be a compilation of general reference material.

- A secondary reading list or bibliography should include material students may use as background information.

G. Library Resources

(Complete if different from approved mode of delivery)

- Describe the library resources that are currently available or the resources needed to support this proposed course.

TO: The Faculty of the College of Engineering

FROM: School of Aeronautics and Astronautics

RE: New Graduate Course: AAE 52300: Introduction to Remote Sensing

The faculty of the School of Aeronautics and Astronautics have approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

AAE 52300 Introduction to Remote Sensing
Sem. 2, Lecture 3, Cr. 3
Prerequisites: AAE 20300, AAE 30100 or ECE 30100 or equivalent or graduate standing.

Description: Fundamentals of satellite and airborne remote sensing. Basic physical principles of electromagnetic wave propagation will be introduced. From this foundation, the phenomenologies enabling properties of the atmosphere, ocean and land surface to be measured at a distance will be developed. These principles will be applied to the design of instruments and satellite missions for Earth observation. Microwave instruments will be emphasized, although there will also be discussion of optical systems. Most of the material would also be applicable to remote sensing of other planets. Intended for students in engineering or the sciences.

Reason: Observing changes in the Earth's oceans, atmosphere and land masses is a very important activity for understanding both the long-term evolution of our planet and its climate, near-term prediction of weather and natural disasters, and monitoring agricultural production and environmental damage. Although some variables describing these processes can be measured directly, with "in situ" sensors, frequent global or regional sampling will require indirect observation using electromagnetic radiation. Exploration of the solar system also makes use of remote sensing techniques for fundamental scientific research on the structure and evolution of the other planets.

Remote sensing from satellite or aircraft involves a complex system of interacting components, each of which can have a defined effect on the accuracy, resolution, and sampling of the desired quantities. This course is intended to provide students an overview of the key elements of Earth remote sensing systems, including instruments, satellite and airborne platforms, data processing and orbit/mission design. This course will introduce the important principles needed to understand and design EO satellite systems, including the instrument, platform, orbit selection, data reduction and calibration/validation methods.

At present, this specific material is not covered by another course at Purdue. Offering this course will introduce students in Aeronautics and Astronautics to the unique mission requirements for remote sensing and Earth observation. An understanding of the basic physical principles of remote sensing measurements, as well as science and application questions driving the need for those measurements, is a necessary requirement for the design of satellite missions for this purpose. On the other hand, scientists in a variety of fields, including oceanography, hydrology, agriculture, planetary sciences and even some social science fields, who make use of remote sensing data could benefit from taking this course, to improve their understanding of these data sources.

This course would be an elective within the Astrodynamics and Space Applications (ASA) area of AAE. It is also proposed to be listed as satisfying the requirements for the Ecosystem Analysis Tools core in the Ecological Sciences & Engineering Interdisciplinary Graduate Program (ESE-IGP). It will also be offered through the Engineering Professional Education (EPE) program.

This course is proposed at the 50000-level as it is intended for advanced undergraduates, Master's degree seeking students, and early doctoral students, in engineering or the sciences. The enrollment history of the AAE 59000 experimental course in the four semesters that is was offered was as follows: Fall 2009: 6 (including 4 – AAE, 1 – ECE, 1 – Civil), Spring 2010: 5 (4 – Civil, 2 – AAE); Spring 2012: 15 (6 on campus 1 – EEE, 3 – Civil – 2, 2 - AAE, 9 Pro Ed: 3 – AAE, 1- ME, 5 - IDE), Spring 2014: 11 (6 on campus, all AAE, 5 Pro Ed, 2 – AAE, 3 - IDE). Based upon this history, the enrollment in future offerings of AAE 59000 is expected to be 10-18 students, divided approximately equally between on-campus and EPE. Approximately one half of the on-campus students are expected to be undergraduates.

Tom I-P. Shih, Professor and Head

School of Aeronautics and Astronautics

APPROVED FOR THE FACULTY
OF THE SCHOOLS OF ENGINEERING
BY THE ENGINEERING
CURRICULUM COMMITTEE

ECC Minutes 9/19/14

Date 9/19/14

Chairman ECC

AAE 52300, Introduction to Remote Sensing

Supplemental Material for Form 40G.

B. Learning Outcomes and Method of Evaluation or Assessment:

Course Objectives: The purpose of this course is to (1) Introduce the fundamental physical principles of microwave and optical remote sensing. (2) Identify the principal geophysical quantities that can be measured using remote sensing methods and explain the application of physical principles from (1) in making these measurements. (3) Present examples of the application of remote sensing measurements to address science or engineering problems and provide students with the skills to evaluate the utility of remote sensing measurements to a specific problem within their area of interest. (4) Evaluate considerations in the design of satellite missions for remote sensing.

Student Learning Outcomes:

Student learning outcomes (knowledge, skills, communication, critical thinking, and ethical research) that address the four (4) objectives above, are listed in the following table:

- Objective 1: Introduce students to the fundamental physical principles of microwave and optical remote sensing.
  - **Knowledge**: Electromagnetic wave propagation as a solution to Maxwell's equations.
  - **Communication**: Definition of terms and quantities used in electromagnetism and remote sensing. Visualization of electromagnetic waves propagating through space and media.

- Objective 2a: Show the application of principles of electromagnetic wave propagation to sensing of the atmosphere, ocean and solid Earth.
  - **Knowledge**: Relationships between properties of media (for example: atmospheric water vapor, ocean salinity, ocean surface winds, vegetation type, biomass density, etc …) and the observed variation in properties of electromagnetic waves interacting with the media (amplitude, frequency, polarization, etc.).
  - **Skills:** Derivation of typical forward models relating geophysical variables to electromagnetic variables, applying basic principles such as wave propagation and radiative transfer.
  - **Critical Thinking:** Identifying the assumptions made in physical models to understand possible limitations in the application of those models.

- Objective 2b: Identify important geophysical variables that can be measured using remote sensing methods.
    - **Knowledge**: Examples of geophysical model functions. Derivation of these models from physical principles and empirical measurements.
    - **Skills:** Defining remote sensing measurements to retrieve desired geophysical variables. Basic approaches to invert forward models.
    - **Critical Thinking:** Identifying the assumptions made in physical models to understand possible limitations in the application of those models.

- Objective 3a: Show examples of the application of remote sensing measurements to solve relevant engineering or science problems.
    - **Knowledge**: Examples of the most prominent applications of remote sensing data to problems in atmospheric science, oceanography, agriculture and civil engineering, for example.
    - **Critical Thinking:** Assess the applicability of remote sensing methods for a particular problem.

- Objective 3b: Develop student skills in evaluating measurements obtained through remote sensing.
    - **Knowledge**: Basic concepts of accuracy, precision, spatial resolution, bandwidth, and sample rate. Physical basis for prediction of instrument and measurement performance.
    - **Skills:** Predict the performance in terms of precision, spatial resolution, and sample rate, for a basic microwave (active or passive) or electro-optical instrument.
    - **Critical Thinking:** Understand assumptions in models predicting measurement performance.
    - **Ethical Research:** Accurate assessment of the quality and limitation of research results based upon remote sensing data.

- Objective 3c: Independent research project on topic of student's choice
    - **Knowledge**: In depth understanding of the topic of a student's choice. Standards for scientific and technical writing. Organization of a technical paper and proper acknowledgement of sources. Available tools for literature search.
    - **Skills**: Scientific and technical writing. Literature reviews.
    - **Communication**: Writing of a technical paper in the style, format and standard of a peer-reviewed journal article.
    - **Critical Thinking:** Evaluation of published results. Inter-comparison of results from multiple authors.
    - **Ethical Research:** Proper citation and attribution of sources in publication.

- Objective 4: Introduce mission design for remote sensing.
    - **Knowledge**: Orbit dynamics for remote sensing missions: geostationary, Sun-synchronous and repetitive orbits.
    - **Skills**: Predict coverage of Earth remote sensing mission. Design orbit for remote sensing mission to meet specified coverage and revisit requirements.

Methods of Evaluation or Assessment

Grading criteria: Extended homework assignments and an individual research project.

A final numerical score will be computed by averaging the numerical scores for the homework and project, weighted equally (50% each). The distribution of numerical scores over the entire class will be used to set the thresholds for each letter grade. It is expected, however that the letter grades will not deviate much from the "uncurved" values, i.e. A=90%+, B=80-90%, C=70-80%, etc.

Task 1: Homework
4-5 homework assignments will be given for a total of 50% of the course grade.
Homework assignments are evenly spaced throughout the course, due approximately once every 3 weeks. These assignments may contain a few "text book" problems, but the majority of the work will involve some computer analysis of actual or simulated remote sensing data. Students are expected to write a complete description of the problem, in their own words, a description of their solution, and an interpretation of their results.

Homework will be graded on a scale of 100 points. Shorter, "text book" problems will count for 10-20% each. Longer problems involving computer programming and processing of data will count for 40-60% each. Approximately 10-20% of the total score will be allocated to the student's insight into the problem and interpretation of the results.

Task 2: Individual Research Project
An independent research project, completed incrementally throughout the semester and due on the last day of class, will count for 50% of the final grade.

The project will be based upon a topic selected by the student and approved by the instructor, on some problem broadly related to remote sensing, for example:

- Review of a current or planned remote sensing mission, including the instrument design, orbit selection, retrieval algorithms, and science requirements.
- An important science question that can be addressed through remote sensing methods.
- The theoretical principles and application of a class of remote sensing instruments, including comparison with alternative instruments capable of making similar measurements through different physical principles.

- Development of signal processing techniques for a particular application in remote sensing.

The minimum requirement for a grade of B- (75%) is a thorough, clearly written, review of the literature related to the specific topic selected, presented in the style and format of a journal article, with proper citations and a complete bibliography. In order to earn a grade of B+ or better (85%), the student project must present some "original contribution". Students should be careful to define an original contribution that could realistically be completed within the last two months of the course. Examples of successful original contributions include:

- Applying a published algorithm to a simple problem, using synthetic or actual data.
- Attempting to reproduce one example of a result published in one of the references.
- Compare multiple approaches to a problem, presenting quantitative data to support the pro's & con's of each approach.

Independent research topics, involving work with a faculty member, can be substituted for the project with approval of both the course instructor and the advising faculty member (if different).

Three incremental deadlines are provided for the instructor to provide feedback to the student throughout the term.

- Abstract with 5 references – due week 4
- Preliminary literature review (10+ peer reviewed references) and project plan – due week 8
- Project draft – due week 13
- Final project – due last day of class.

These incremental deliverables will not be used to compute the project score. Only the final project will contribute to the final grade. The incremental due dates are provided to give feedback to students to help them in developing their project.

Method of Instruction:

Lecture

Lectures will be used to provide development of the key background material necessary to understand the fundamental principles of remote sensing, namely electromagnetism and the interaction of electromagnetic waves with natural media. The subsequent development of measurement techniques based upon these fundamental principles, is also best presented in the lecture format, in which the problem geometry can be defined, the key assumptions stated, and the physical model applied.

Distance

Lectures will be designed for both in-class and distance students.

E. Course Outline:

1) Science Requirements (1 week)
2) Basics of Electromagnetism (1 week)
3) Electromagnetic waves (2 weeks)
4) Electromagnetic boundary conditions (1 week)
5) Radiative transfer (1 week)
6) Emission, black body radiation, brightness temperature (1 week)
7) Rough surface scattering (1 week)
8) Active microwave: scatterometry (1 week)
9) Passive microwave: radiometry (1 week)
10) Optical: multispectral (1 week)
11) Multispectral data: indices, transformation and classification (1 week)
12) Ranging: altimetry and lidar (1 week)
13) Earth observation mission design (2 week)

F. Reading List:

Course Text: *Physical Principles of Remote Sensing*, W.G. Rees, Cambridge University Press, 2013, Third Edition: ISBN 978-1-107-00473-3 (Hardback), ISBN 978-0-521-18116-7 (Paperback), also available in a Kindle Edition.

Assigned Readings from other texts:

National Research Council. *Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond.* Washington, DC: The National Academies Press, 2007, Executive Summary (pp 1-15).

Ulaby, F. T., R.K. Moore, and A,K. Fung, *Microwave Remote Sensing, Active and Passive, Vol I,* pp 212-245, Artech House, 1981

Ulaby, F. T., R.K. Moore, and A,K. Fung, *Microwave Remote Sensing, Active and Passive, Vol II,* pp 825-831, Artech House, 1986

Richards, A. and X. Jia, *Remote Sensing Digital Image Analysis*, Springer 2006, ISBN 978-3-540-29711-6, , Chapters 6,8, and 9 (Available as eBook through Purdue Library)

Jin, S., Estel Cardellach and F. Xie, *GNSS Remote Sensing: Theory, Methods and Applications,* Springer, ISBN 978-94-007-7482-7, Part III (Available as eBook through Purdue Library)

Assigned papers:

Wang, J.R. and Schmugge, T.J. "An Empirical Model for the Complex Dielectric Permittivity of Soils as a Function of Water Content," *IEEE Transactions on Geoscience and Remote Sensing*, Vol. GE-18 , Issue 4, Oct. 1980, pp 288-295, DOI: 10.1109/TGRS.1980.350304

Klein, L. and Swift, C.T., "An improved model for the dielectric constant of sea water at microwave frequencies," *IEEE Transactions on Antennas and Propagation,* Vol. 25, Issue 1, Jan. 1977, pp 104-111, DOI: 10.1109/TAP.1977.1141539

Koblinsky, C.J., P. Hildebrand, D. LeVine, F. Pellerano, Y. Chao, W. Wilson, S. Yueh and G. Lagerloef, "Sea surface salinity from space: Science goals and measurement approach," *Radio Science,* Vol. 38, No. 4, 8064, DOI: 10.1029/2001RS002584, 2003

Entekhabi, D., et. al., "The Soil Moisture Active Passive (SMAP) Mission," *Proceedings of the IEEE,* vol. 98, No. 5, May 2010, pp 704-716, DOI: 10.1109/JPROC.2010.2043918