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Fog Studies for University Students and High School Teachers

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Abstract

Over the past few years, fog studies have been introduced as part of courses in Earth system science for both university students and high school teachers. In the undergraduate course, about three hours are devoted to the study of fog starting with a discussion of sustainable water systems. This is followed by presentations on types of fog, the role of fog in the biosphere, biogeochemical cycles and fog, human influences on fog, fog intensity, and remote sensing of fog. We end with a description of fog collection. Fog education efforts increased for students when we were able to obtain fog collecting equipment from Richard Jagels at the University of Maine. The equipment included active and passive fog collectors as well as infrared-beam fog detectors. Two graduating students took on fog collection as their senior project. After setting up the donated equipment, the students designed a fog collection project for the University's Whidbey Island location on Puget Sound. They built a passive fog collector and determined where to place it on the Island. Future projects planned include implementing a water system based upon fog collection on Whidbey Island. We have also implemented a new module on fog for the Earth System Science Education Alliance – The Camanchaca: Fog in the Earth System. Aspects of fog in the Earth system are discussed and teachers are led to see the important role fog has throughout the Earth system. This module was successfully piloted as part of an Earth system science course for teachers in June-July, 2009.

1. INTRODUCTION

Fog as an academic topic can be incorporated on different levels and as part of courses in different disciplines. At Seattle Pacific University, fog studies have been incorporated into senior engineering projects, undergraduate general education courses and specialized graduate problem-based learning courses for teachers. Earth system science studies the Earth by examining interactions between the various components of the Earth system - the atmosphere, hydrosphere, biosphere and lithosphere. The effect of human activities is also included. In the undergraduate course, the role of fog in the Earth system is studied along with its importance in all of Earth's spheres – biosphere, atmosphere, hydrosphere and lithosphere. As an aide to studying Earth's spheres, Earth system science also incorporates remotely sensed data, mainly from satellites. The module on fog ends with a description of fog collection activities. For the teachers' course, problem –based learning is used and the module on fog can be incorporated into a course that typically will use three content-based modules.

2. BACKGROUND

During the 2007 Fog Conference, Professor Richard Jagels offered his fog collection equipment to other universities. We were fortunate to obtain the equipment and two students used it for two parts of their senior project. Initially, the equipment was used to put together an active fog collection system. Subsequently, as a follow-on project, the students built two passive fog collectors. Fog modules are now routinely incorporated into undergraduate general education courses and teacher courses in Earth system science at both Seattle Pacific and at the California State University at Los Angeles.

3. FOG COLLECTOR CONSTRUCTION

Two students with a desire to apply their engineering skills to a sustainable water project, chose the design and construction of two passive fog collectors a their engineering senior design project (Viducich, 2009). The goal was to ultimately deploy these collectors at the University's Physics Research Station on Whidbey Island. This is an island in Puget Sound and the University's property borders the Sound. The area is prone to frequent advection fog off the water with a climatological maximum of 18 days of dense fog in August.

In designing their passive fog collectors, the students made use of works on fog collector design by Schemenauer and Cereceda (1994) and the Fog water collection manual (Schemenauer, Cereceda and Osses , 2005). Some minor changes were made to the materials due to availability and cost. One of the students, although not currently working on fog collection is working on sustainable water projects in Madagascar.

Future plans for engineering projects at Seattle Pacific University include designing a water system on Whidbey Island that will make use of the new passive fog collectors.

4. UNDERGRADUATE MODULE

As part of an Earth system science course, about three hours are devoted to fog. The module begins with fog being defined as a cloud that is attached to the surface where visibility is less than 1,000 meters. Different types of fog are then discussed including steam fog, radiation fog, advection fog and upslope fog.

Fog's role in all of Earth's systems is described**.** This begins with the roles of the atmosphere and hydrosphere in the formation of fog. The role of fog in the biosphere is then discussed and references are made to locations where this is important such as the California Redwoods, wheat growing in India (Singh, Sing and Rao, 2004) and the complex roles of both fog and dew in supporting the biosphere in the the Namib desert (Henschel and Seely, 2004).

We next explore the role of fog in some of the biogeochemical cycles**.** Fog is an important part of the hydrologic cycle. It provides moisture to areas that may otherwise be dry. It can dissolve pollutants and transport them to other regions – thereby influencing the carbon, nitrogen and sulfur cycles. Numerous conference papers have addressed this function of fog; Blas, Sobik and Twarowski (2004) and Husain (2004) for example.

We look at the role humans have played in the formation and intensity of fog. In areas with heavy particulate concentrations, dense fog is common. In recent years, with a decrease in the number of particulates, we have seen the occurrence of dense fog in the Los Angeles basin greatly diminish. We then look at how fog influences human activities and discussed transportation issues, free space optics and fog collection. Emphasis was made on current fog collection efforts, the type of fog that is most readily collected, and the need for testing in certain areas before setting up large scale fog collection operations.

For the undergraduate module, students were shown an example of how fog can be detected on infrared as well as visible satellite imagery (LaDochy, 2007).

5. TEACHER MODULE

The teacher module is designed to fit a three week schedule and is usually one part of a course that contains from two to four content modules plus a module on inquiry based learning. The development of this module was described by Witiw and LaDochy (2007). Other modules in the course will cover other aspects of the Earth system. (For a complete list of modules see: http://esseacourses.strategies.org/modules.php?action=list&sort=bytitle)
The initial module which was designed for undergraduate university students was modified and expanded to fit a three week module that is part of an inquiry-based course for teachers that will include modules on other aspects of the Earth system as well. This module is now available for use by all. The three week module for the teacher course involves an initial week where some background and a scenario are provided to the teachers. In the second week, teachers develop their own Earth system models and in the last week, they develop lesson plans to be used in the classroom. As in the undergraduate course, material was drawn from resources that included papers presented at the fog conferences. Increased emphasis is placed on the remote sensing of fog by satellite. Educational resources for this module include the Digital Library for Earth System Education (2010) and the Cooperative Program for Meteorology, Education and Training (2007).

6. COMET FOG MODULES

The University Corporation for Atmospheric Research runs the Cooperative Program for Operational Meteorology, Education and Training (COMET, 2007). COMET now has over 50 modules in Spanish and 15 in French with plans for translation into Russian and Portuguese (UCAR Staff Notes, 2010). COMET currently has 14 modules on fog and low stratus; ten of which have been translated into Spanish. Although COMET modules

are designed for the professional meteorologist, they can be easily be used use in the classroom or individually (METED, 2010).

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