Combining MISR and MODIS data to automatically catalog smoke plumes in North America

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The Environmental Protection Agency (EPA) is seeking to better understand the effects of wildfires on air quality. This objective is approached through a fusion of data from NASA's Multi-angle Imaging Spectro-Radiometer (MISR) and Moderate resolution Imaging Spectroradiometer (MODIS) instruments, in tandem with innovative data-mining techniques. The MISR and MODIS data are used to automatically identify and classify thousands of smoke plumes over North America. Together the instruments can classify smoke plumes with higher precision and accuracy than with either instrument alone. Additional information on smoke plume heights, when combined with global models, can enable a better assessment of the regional/global impact of forest fires.

MISR has a unique ability to determine the height of smoke plumes using stereoscopic techniques, and the heights are automatically computed at 1.1-km spatial resolution as part of standard MISR processing. Smoke-plume rise is an important component of emissions transport because plume-injection height determines where in the vertical structure of the atmosphere dispersion will begin. In addition, MISR's oblique view angles cause thin smoke to appear more opaque, and the retrieved angular signature helps distinguish smoke from clouds and other aerosols.

MODIS's thermal-infrared sensing capabilities give it the unique ability to detect active fires with high temporal resolution. The MODIS Thermal Anomalies data product uses the 4-µm brightness temperature and the difference between the 4-µm and 11-µm brightness temperatures, in comparison to nearby pixels for context, to detect fires and other thermal anomalies. Support Vector Machines (SVM), a form of supervised classification, are used to detect MISR pixels that are smoky based on color, texture, and angular features. An SVM classifier was trained using dozens of hand-labelled scenes containing smoke, clouds, land, water, and/or ice and snow. Algorithms that involve techniques from the field of machine vision are used to examine those blocks that are found to contain smoke and search for distinctive plume-like shapes. This helps to reject images that contain smoke but no smoke plumes, and often allows the automatic extraction of the plume orientation. Heuristics to order all of the blocks combine the number of MISR smoky pixels, the number of MISR plume shapes, and the number of MODIS thermal anomalies.

This work is probably the largest research project to date in terms of the volume of MISR and MODIS data jointly analyzed and combined for a science research problem. Although MISR and MODIS are both on the Terra platform, their data are organized in different formats, and data splitting is performed differently for each instrument, so manually combining the products to create a robust global classifier would be time-consuming and difficult. However, the early results from this automated fusion approach are promising.

Statistics on the geographic distribution, extent, orientation, and injection height of plumes are being mined from terabytes of MISR and MODIS data from the summer of 2004, and will be delivered by the end of 2005. In 2006 the same analysis will be applied to several years' worth of data.

The summer of 2004 was selected for initial study because of the record setting fires in Alaska and the adjacent Yukon Territory of Canada. In Alaska more than 6.6 million acres were burnt during the summer of 2004, and records were also set for the number of days of reduced visibility due to wildfire smoke—poor visibility was recorded in Fairbanks on 42 of the 92 days of summer. This shatters the previous record of 19 days in 1977.

Smoke plumes from these fires were intercepted by the DC-8 on the Intercontinental Chemical Transport Experiment (INTEX) field campaign during July and August, 2004, and were evident in the Measurements Of Pollution In The Troposphere (MOPITT) Carbon Monoxide (CO) observations as a continental-scale plume over North America. Knowledge of the injection heights of the emissions from these fires is required for quantitative assessment of their effects on atmospheric composition. We are collaborating with members of the INTEX science team in analyzing the plumes from the Alaskan fires.

Several techniques to mine through the multiple years and terabytes worth of data have been tested. Current

methods operate at the granularity of one MISR block, which is approximately 400 x 140 km. The goal is to find all blocks containing smoke plumes and reject all others. It is preferable to err on the side of more false positives because it is easy to eliminate cases with no plumes, but is impractical to manually examine the entire data set to find missed plumes.

Of the ~22,000 blocks of data from ~460 Terra orbits analyzed so far, there were 635 cases in which smoke was identified in the MISR image and an active fire was present in the MODIS thermal anomalies product. Manually, it was determined that 44 of these contain distinct smoke plumes. A system is being developed to automatically flag all 44 of these blocks as worth pursuing, while flagging the least number of false positives.

For the smoke-plume heights, preliminary work indicates a mean plume height of approximately 1.7 km for the Alaskan fires in the summer of 2004. Further work will improve this estimate and relate it to fire size. ■

Announcement

ESIP Federation Elects 6 New Partners

November 14, 2005—The Federation of Earth Science Information Partners ("Federation") has elected six new partners for full membership. The following projects and organizations represent the latest class of Federation members:

- *The Earth Observing System (EOS) Clearinghouse (ECHO)*, Robin Pfister, NASA Goddard Space Flight Center, Greenbelt, Maryland
- *Environmental Systems Research Institute (ESRI)*, Jack Dangermond, Redlands, California
- *Global Change Master Directory (GCMD)*, Lola Olsen, NASA Goddard Space Flight Center, Greenbelt, Maryland
- *Pacific Disaster Center*, Christopher Chiesa, Kihei, Hawaii
- *Pacific Northwest Regional Collaboratory*, Roger Anderson, Pacific Northwest Laboratory/Battelle, Seattle, Washington
- *A 0.05 Degree Global Climate/Interdisciplinary Long Term Data Set from AVHRR, MODIS and VIIRS Instruments*, Edward Masuoka, NASA Goddard Space Flight Center, Greenbelt, Maryland

"The latest class of membership will propel the Federation toward its goal of providing improved access to the wealth of data, tools, and products available through Federation members," says **Thomas Yunck**, Federation President. "The steady growth of the Federation is attributed to its position as a leader in the field of Earth observation data, information, and products and the distribution of them into the hands of users. The Federation is developing the Earth Information Exchange, a centralized portal where member data products and tools will be available to researchers, decision makers, educators, and anyone else seeking Earth observation information."

The Federation now has 89 partners, representing a wide range of Earth science data interests. Federation partners include science data centers, environmental research groups, innovators in the application of environmental data, educators, and technologists. Across these diverse interests, public, private, and non-profit organizations are represented.

The Federation is a consortium of Earth science data centers, researchers, scientists, technologists, educators, and applications developers. The Federation promotes increased accessibility, interoperability, and usability for Earth science data and derivative products. Initiated by NASA in 1997, the Federation provides data, products, and services to decision makers and researchers in public and private settings. The Foundation for Earth Science provides administrative and staff support to the Federation of Earth Science Information Partners. For more information, call *877-870-3747*.