N95-23330

Computer Modeling of the Sensitivity of a Laser Water Vapor Sensor to Variations in Temperature and Air Speed

by

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Currently, there is disagreement among existing methods of determining atmospheric water vapor concentration at dew-points below -40 degrees C. A major source of error is wall effects which result from the necessity of bringing samples into the instruments. All of these instruments also have response times on the order of seconds. NASA Langley is developing a water vapor sensor which utilizes the absorption of the infrared radiation produced by a diode laser to estimate water vapor concentration. The laser beam is directed through an aircraft window to a retroreflector located on an engine. The reflected beam is detected by a infrared detector located near the laser. To maximize signal to noise, derivative signals are analyzed. By measuring the 2f/DC signal and correcting for ambient temperature, atmospheric pressure and air speed (which results in a Doppler shifting of the laser beam), the water vapor concentration can be retrieved. Since this is an in situ measurement there are no wall effects and measurements can be made at a rate of more than 20 per second. This allows small spatial variations of water vapor to be studied.

In order to study the sensitivity of the instrument to variations in temperature and air speed, a computer program which generated the 2f, 3f, 4f, DC, and 2f/DC signals of the instrument as a function of temperature, pressure and air speed was written. This model was used to determine the effect of errors in measurement of the temperature and air speed on the measured water vapor concentration. Future studies will quantify the effect of pressure measurement errors, which are expected to be very small.

As a result of these studies, a retrival algorithm has been formulated, and will be applied to data taken during the PEM-West atmospheric science field mission. Spectroscopic studies of the water vapor line used by the instrument will be used to refine this algorithm. To prepare for these studies, several lasers have been studied to determine their output frequency range and power.