Tethered Balloon Sounding System for Vertical Radiation Profiles

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A small, tethered balloon sounding system is being developed to make broadband radiometric and meteorological profiles through the lowest 1500 m of the atmosphere. The major technical issue of this instrument development project is the construction of a stable platform that will keep the complement of radiometric instruments level, regardless of balloon motion.

A prototype stable platform, called the Sky Platform, has now been completed and is being demonstrated in the poster session of the science team meeting. The Sky Platform is an equilateral triangle approximately 65 cm on a side and formed from aluminum tubing. A mount for radiometric and horizontal sensors is supported inside the triangle, and the Sky Platform is carried on the tetherline 30 m or more below a small, helium-filled, tethered balloon.

At a point 30 m below the balloon, the main tetherline branches into a 3-m-long section of three lines, only to rejoin the main tetherline at the end of the 3-m section. The Sky Platform is carried within the 3-m-long section. One corner of the Sky Platform is attached to one of the lines at the center of the 3-m-long section, while the remaining corners of the Sky Platform are attached to the remaining two lines through pulleys driven by small electric motors. The platform is kept level by an automatic control loop which interrogates the horizontal sensors (accelerometers) on the Sky Platform and drives the motors and pulleys to keep the Sky Platform level. A flux gate magnetometer provides platform heading information.

A second airborne platform, called the Motion Sensing Platform (MSP), has been developed to fly in place of the Sky Platform to collect data on the full range of platform motions, including lateral and angular accelerations, lateral and angular velocities, and angular orientation. This platform is built on a triangular frame identical to the one on the Sky Platform, but the MSP carries no radiometric sensors, control loop, or leveling motors. Rather, the MSP is instrumented to measure the motions to which the Sky Platform will be subjected; the data provide engineering information to be used in the final design of the control loop and structural elements of the Sky Platform. An array of six miniature solid state accelerometers provides the raw data from which balloon motions are determined. Future plans call for the installation of a small attitude gyroscope on the MSP and on the Sky Platform. Gyroscope and accelerometer data will allow us to determine the accuracy of tilt determinations and to demonstrate the efficacy of the control-loop-stabilized platform.

The Sky Platform will carry any of a number of broadband radiometric sensors that are within the weight limitations imposed by the small lifting capacity of the balloon. Initial observations will be made using a modified REBS Q*6 net radiometer and/or a LiCor silicon cell pyranometer.

Calculations have been performed to estimate the radiometric influence of the balloon on the measurements made at the Sky Platform. These calculations suggest that the shortwave radiometric influence of the balloon will be small if the radiometer is not directly shaded by the balloon and if the platform is located 12 or more equivalent balloon diameters below the balloon. The infrared radiometric influence of the balloon has not yet been calculated.

A theoretical model of the performance of a tilted net radiometer has been developed to assist with the engineering specifications of the stable platform and to provide a means of correcting observations for radiometer tilt, if necessary. This model, which will be tested against observations to be collected in a special series of field

measurements, shows that a nonlevel net radiometer can be seriously in error during daytime when the shortwave radiation stream is directed, but is less susceptible to error during nighttime ascents when the longwave radiation stream is more isotropic. Oscillations of the radiometer about the horizontal are less serious than a mean tilt angle. Thus, it will be important to ensure that the platform is balanced so that wind drag will not produce a mean tilt angle. Partial theoretical correction of the errors is possible if the tilt and azimuth angles of the radiometer are recorded.

Future plans call for field testing of the prototype Sky Platform and collection of tetherline motion data with the MSP. Currently, data from the MSP are sampled using an electrical cable that hangs from the MSP. We are now designing an on-board data storage module that will allow us to dispense with the cable. In its normal operating configuration, the tethered balloon will carry a commercial meteorological sensing package that will record temperature, humidity, pressure, wind speed, and wind direction during the ascents. We plan to use the spare channels in the commercial package to provide the operator with real-time information on the radiometric measurements as the balloon ascends. At the completion of the ascent, much more detailed data will be available from the on-board data storage module.

A final stage in the instrument development program will be to harden the entire tethered balloon system so that it can be run routinely at the Cloud and Radiation Testbed sites. Operating characteristics and operating limits of the instrument system must be determined so the data can be properly interpreted and safety and operational requirements can be met.