State Parameter Measurements, NSF/NCAR GV

State parameter measurements include those of pressure, temperature, humidity and wind. All are measured at 100 Hz but are normally filtered and subsampled at 1 Hz in standard data files. Special processing can produce high-rate (25 Hz) data files.

Pressure

Pressure is measured using this transducer: Parascientific Sensor, Model 1000. Accuracy 0.1 mb, precision <0.01 mb, time response <0.05 s. The transducer is based on the pressure sensitivity of a quartz-crystal resonator. Output is digital via RS-232 and is recorded by the GV central data system. Calibrations are performed regularly and data processing incorporates the latest calibration for each project. In addition, tests to determine the accuracy of the "static button" pressure sources on the GV have been used to determine corrections that are dependent on angle of attack, pressure, and dynamic pressure. These corrections have been determined in three ways: (1) via tests using a trailing-cone pressure port; (2) via comparisons to the standard avionics pressure measurement on the aircraft (which has been demonstrated to meet Reduced Vertical Separation Minima (RVSM) standards; and (3) measurements from a laser air motion sensing system, which is used to calibrate dynamic pressure and hence, under the assumption that static pressure is measured with high accuracy, total pressure. Overall accuracy is estimated at <0.3 mb.

The primary variable recording static pressure is PSXC. Other variables include the pressure provided by the aircraft avionics system, PS_A, and two alternate measurements, PSFR and PSFL, one of which is always selected as the primary variable for producing PSXC and other derived variables in the data files.

A brochure from the manufacturer that describes the pressure transducer can be downloaded at this link.

Temperature

Temperature is measured using two HARCO heated total air temperature sensors, with estimated accuracy (including all measurement uncertainties) of about 0.5°C, precision <0.01°C, response time 0.1 s. The measurement of temperature involves not only this sensor but also the measurements of dynamic and static pressure, required to correct for dynamic heating. The "recovery factor" for this sensor is estimated to be about 0.98 on the basis of flight maneuvers during which the airspeed varied. The absolute calibration has been checked by integration of the hydrostatic equation between various levels where pressure and geometric height are measured accurately; these tests lead to an overall uncertainty estimate of about 0.5°C in the measured temperature. Additional

errors occur in cloud because the sensor becomes wet and experiences evaporative cooling in the dynamically heated airflow entering the sensor.

The primary variable recording air temperature is ATX. Other variables are denoted by ATy where "y" may refer to location or other characteristic of the source. One of these variables is selected by the project manager to be ATX for each project and flight, and this is the temperature that then enters the calculation of derived variables in the data files.

Humidity

There are three primary measurements of humidity on the GV, two Buck Research 1011C dew/frost-point sensors and a Vertical Cavity Surface Emitting Laser hygrometer, described separately. The dew/frost-point sensors use housings mounted outside the fuselage, so pressure is also measured inside those housings for conversion of the measurements to ambient vapor pressure. The instrument operates by maintaining the mirrors at the threshold temperature where condensate forms on the mirror surfaces, so the direct measurement is usually the frost point at temperature less than 0^{o}C but the dew point at temperature above 0^{o}C. Because the mirror temperature must be controlled by a feedback circuit, there is a lag in response that may be several seconds or even longer at low temperature. The estimated accuracy is about 1^{o}C under stable conditions but depends on the rate of change and humidity level during transients.

The primary output variables are dew point DPXC and vapor pressure EDPC. DPXC represents the ambient dew point, even below 0^{o}C, as related to temperature by the Murphy and Koop (2006) equilibrium vapor-pressure relationship (without enhancement of the equilibrium vapor pressure by the presence of air). It is corrected for the difference in pressure between the sensor housing and the ambient air and for the enhancement factor that arises from the presence of air in addition to water vapor. DPXC is selected by the project manager on the basis of which sensor (right or left) appears to provide the best measurement in a particular project and flight.

Wind

Wind is measured by measuring separately the air motion relative to the aircraft and the motion of the aircraft relative to the ground. Air relative to the aircraft is determined from dynamic pressure and from flow angles measured by pressure ports in the nose radome on the aircraft, while motion relative to the ground is determined by inertial reference systems and global positioning systems. Wind measurements are considered to have about 1 m/s accuracy for horizontal wind and 0.5 m/s accuracy for vertical wind. Airspeed measurements are available at rates up to 50 Hz, but line lengths connecting pressure ports to sensors limit the response above about 20 Hz.

Data Products

These measurements are included in the standard data files produced by NCAR/RAF. Measurements are provided in netCDF files, normally at 1 Hz data rate; on special request, files with higher data rates (typically 25 Hz) can be produced. For all these variables, redundant measurements are available, so one of those normally is selected by the project manager to be used as the preferred variable and this is used to produce derived products like equivalent potential temperature or mixing ratio from the basic measurements. Derived variables in data files include water vapor pressure, water vapor mixing ratio, dewpoint (corrected for instrumental effects of the sensors and the enhancement factor arising from air pressure), relative humidity, pressure altitude, potential temperature, virtual temperature, pseudo-adiabatic equivalent potential temperature, wet-equivalent potential temperature, and virtual potential temperature. In addition, there are measurements that determine the state of the aircraft, including position (latitude and longitude), ground speed, true airspeed, Mach number, and attitude angles (pitch, roll, and heading).

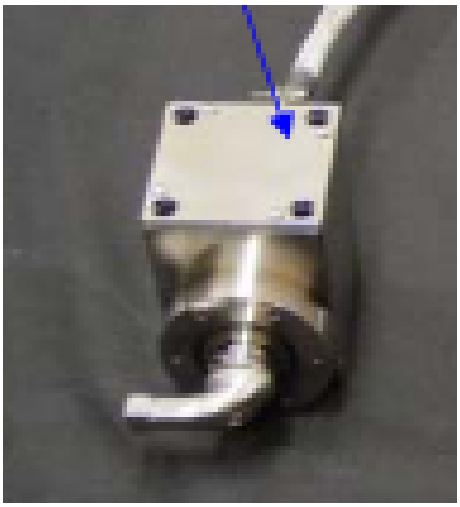
Photos

(temperature probes; dew-point housings; pitot-tube, static buttons, radome ports)

Temperature Sensor:

GV 1011C dewpoint sensor (red arrow) and temperature sensor:

Buck Research 1011C Dew Point Sensor (from Buck Research):



Photograph of the nose radome of the GV, showing three of the five pressure ports used to determine flow angles as part of the gust-measuring system: