## ARM Program Mobile Facility

# Instrument Book

***Shouxian Main Site***
***China***

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**Tropical Western Pacific/ARM Mobile Facility Management Office**

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# Contents

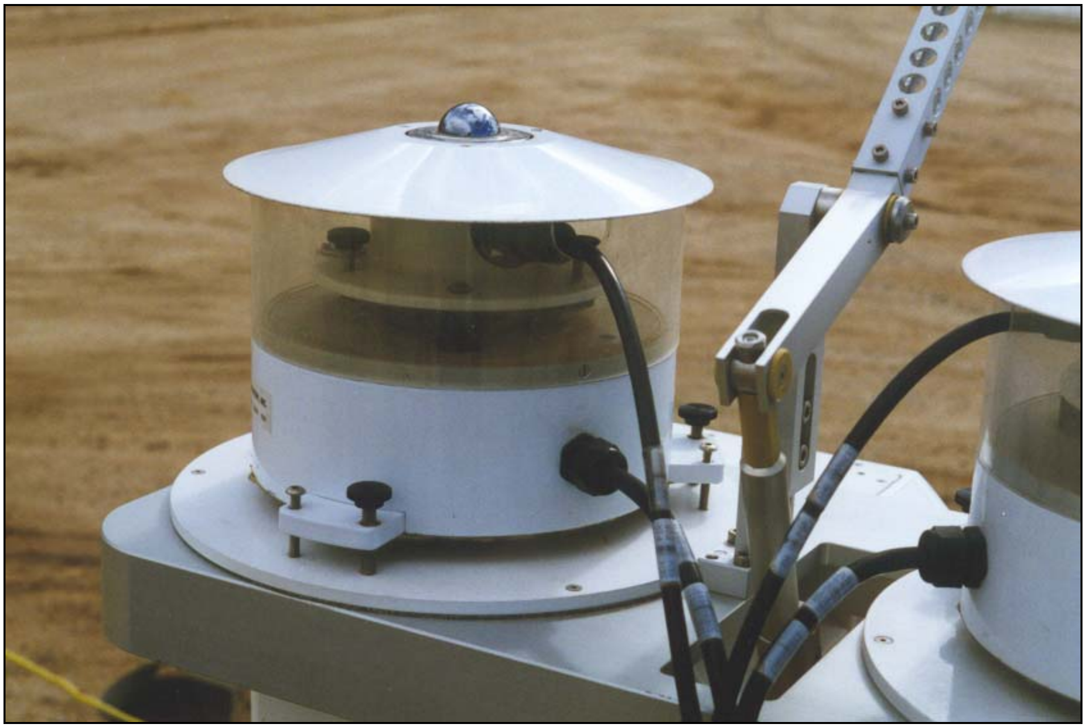
# SKYRAD Instruments

## SKYRAD Shaded Black & White (B/W) Pyranometer


The Black & White Pyranometer measures the amount of solar radiation (i.e., sunshine) that falls on the sensor under the clear dome. When the B/W is mounted on the solar tracker and shaded from the direct beam of the sun, it measures only the part of the solar radiation that is scattered downward by clouds, other material in the air, and the air itself. The value is called the “diffuse” solar irradiance. The diffuse component increases when clouds are present. The B/W is different from the unshaded Precision Spectral Pyranometer (PSP) because it is less affected by radiation cooling.

## SKYRAD Instruments:

### SKYRAD Shaded Precision Infrared Radiometer (PIR)



The PIR measures the amount of infrared (heat) energy that falls on a sensor under the shiny dome. This energy is the same kind of heat energy you feel when standing next to a campfire or cooking stove. The shiny dome reflects solar radiation but allows infrared radiation to pass through. This PIR is mounted on the solar tracker, and its sensor is shaded from the direct beam of the sun. The shading prevents heating of the dome and instrument by the direct sunlight; this heating could produce errors in the measurement.

At the AMF site, there are two shaded PIRs (#1 and #2).

## SKYRAD Instruments:
### SKYRAD Unshaded Precision Spectral Pyranometer (PSP)

The PSP measures the amount of solar radiation (sunshine) that falls on the sensor under the clear dome. When pointed upward unshaded, the PSP measures the total amount of solar radiation coming directly from the sun plus the radiation that is scattered downwards by clouds, other material in the air, and the air itself. This value is called the “total” or “global” solar irradiance. The value is reduced when clouds are present.

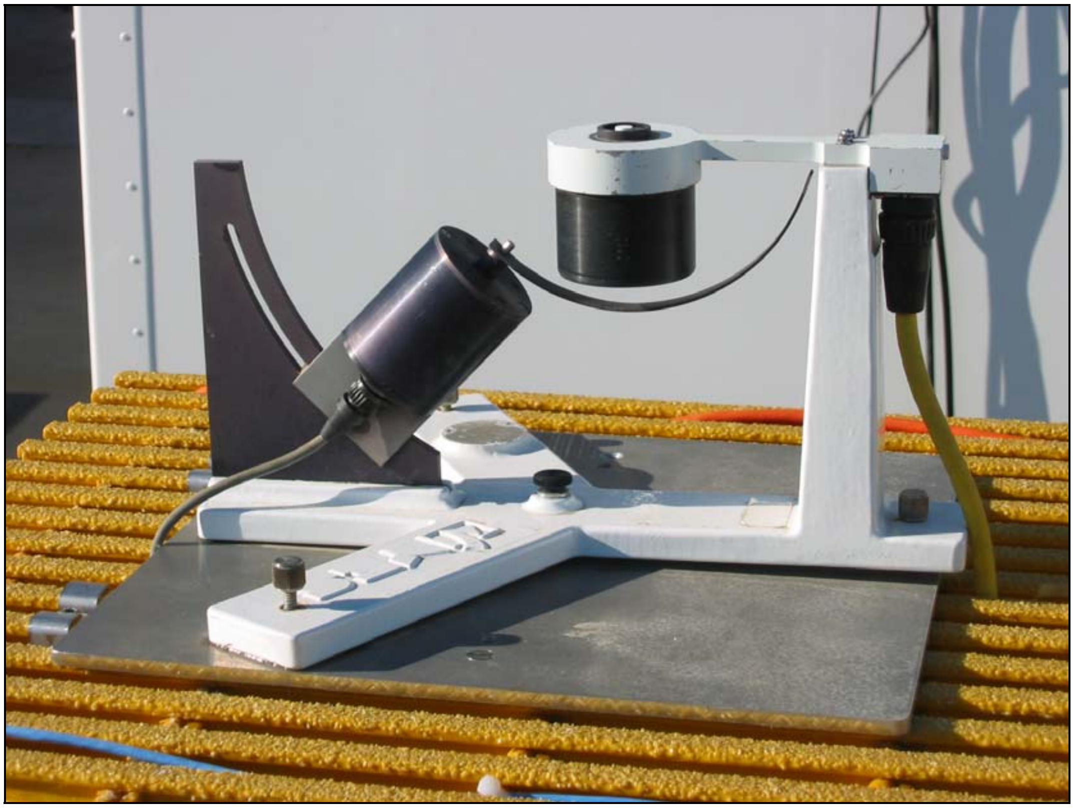
## SKYRAD Instruments:
### Normal Incidence Pyrheliometer (NIP)


The NIP is like a narrow view telescope. It has a sensor at the viewing end that measures the amount of solar radiation that falls on it. The NIP is mounted on the solar tracker so that it is always pointing directly at the sun. The value is called the “direct” solar irradiance. This value decreases when the sun is lower in the sky. When thick clouds are present (that is when the solar disk cannot be seen), the NIP should measure approximately zero.

## SKYRAD Instruments:
### UP-looking Infrared Thermometer (IRT)

The IRT measures the temperature of an object at which it is pointing by quantifying the infrared radiation coming from the object. If you pointed it at a cooking fire it would tell you the temperature of the fire. When the IRT is pointed upward, it measures the radiation temperature of the atmosphere, also known as “sky temperature.” When there is a low cloud overhead, the IRT measures the temperature of the bottom (or base) of the cloud. Low clouds might have a base temperature of +10$^{o}$ C. When there is a higher cloud, the IRT measures a combination of the radiation temperature of the atmosphere and the high cloud.

## SKYRAD Instruments:
### Multi-Filter Rotating Shadowband Radiometer (MFRSR)



The MFRSR uses measurements of the total and diffuse solar radiation to determine properties of the atmosphere. The MFRSR has a black shading arm that rotates over the sensor every 15 seconds. When the sensor is unshaded, it measures total solar irradiance. When the shading arm blocks the sun from the sensor, the MFRSR measures the diffuse solar irradiance. The direct solar irradiance can be calculated by subtracting the diffuse value from the total value.

The MFRSR actually makes seven simultaneous measurements with seven detectors. One of these detectors measures all the sunlight coming in; this value is very similar to that obtained by the unshaded upward looking PSP. The other six measurements use the same kind of detector with different filters in front of them. These filters only allow certain portions of the sunlight to pass through them and on to the detector. As with the NIP, the amount of direct solar radiation depends on the height of the sun above the horizon and the cleanliness of the atmosphere. By measuring the direct solar irradiance at different sun angles, it is possible to calculate the amount of solar radiation at the top of the atmosphere and the amount that is removed by the atmosphere before it reaches the ground.

# Total Sky Imager (TSI)


The Total Sky Imager (TSI) provides time series of hemispheric sky images during daylight hours, and retrievals of fractional sky cover for periods when the solar elevation is greater than 5 to 10 degrees.

# GNDRAD Instruments

## GNDRAD Precision Spectral Pyranometer (PSP)

The PSP measures the amount of solar radiation (sunshine) that falls on the sensor under the clear dome. When the PSP is pointed downward, it measures the amount of solar radiation reflected from the surface below. The value depends on the amount of sunshine hitting the surface and how well the underlying surface reflects the sunshine.

## GNDRAD Instruments:
### GNDRAD Precision Infrared Radiometer (PIR)

The PIR measures the amount of infrared (heat) energy that falls on a sensor under the shiny dome. This energy is the same heat energy you feel when standing next to a campfire or cook stove. The shiny dome reflects solar radiation but allows infrared radiation to pass through. When the PIR is pointed downward, it measures the upwelling infrared irradiance or heat energy given off by the surface below.

## GNDRAD Instruments:
### Down-looking Infrared Thermometer (IRT)

The IRT measures the temperature of an object that it is pointing at by measuring the infrared radiation coming from the object. If you pointed it at a cooking fire it would tell you the temperature of the fire. When the IRT is pointed downward at the grass, it measures the temperature of the grass. Similarly, if you pointed it down on the airport runway, it would measure the temperature of the runway. This value is called the “surface temperature” and depends on the surface material, general weather conditions at the site, and the time of day.

## Surface Meteorology (SMET) Instruments

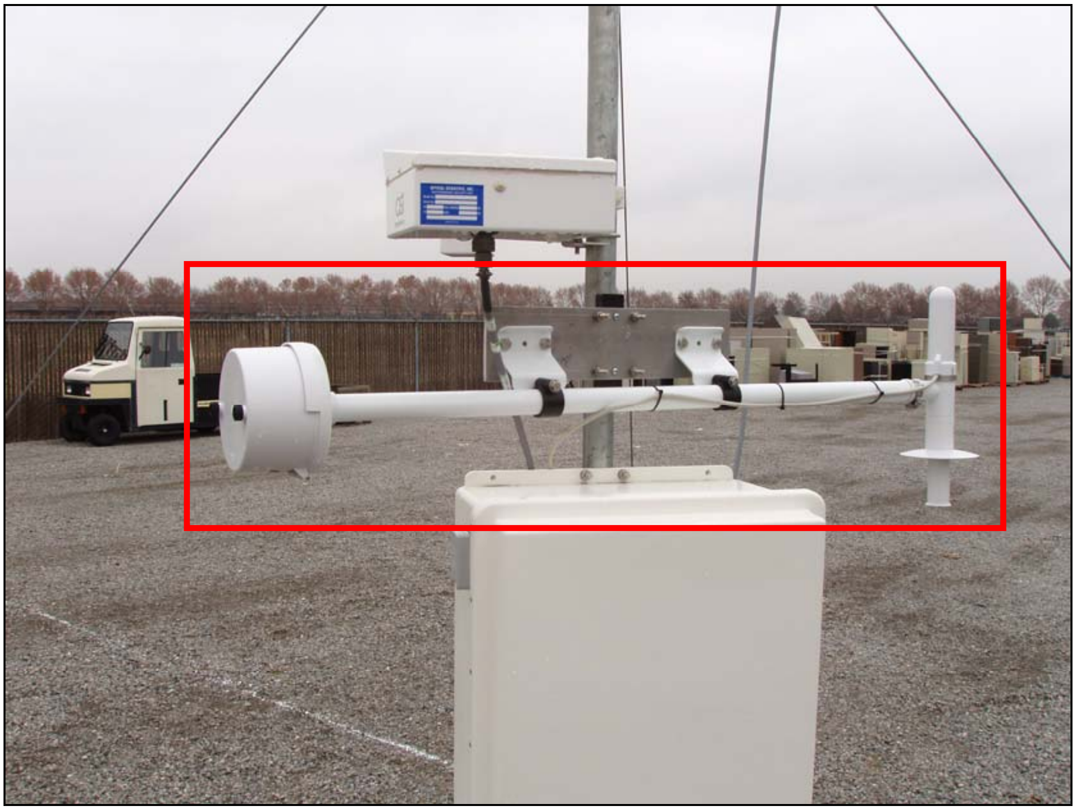
There are several instruments associated with the Meteorological Tower, which stands 3 meters tall. These measure wind speed and direction, temperature, humidity, atmospheric pressure, and rainfall.

## SMET Instruments:
### Propeller Vane Wind Sensors (WND)


The wind sensor is mounted on the top of the Meteorological Tower. The propeller measures wind speed. The direction of the wind is measured by the position of the vane.

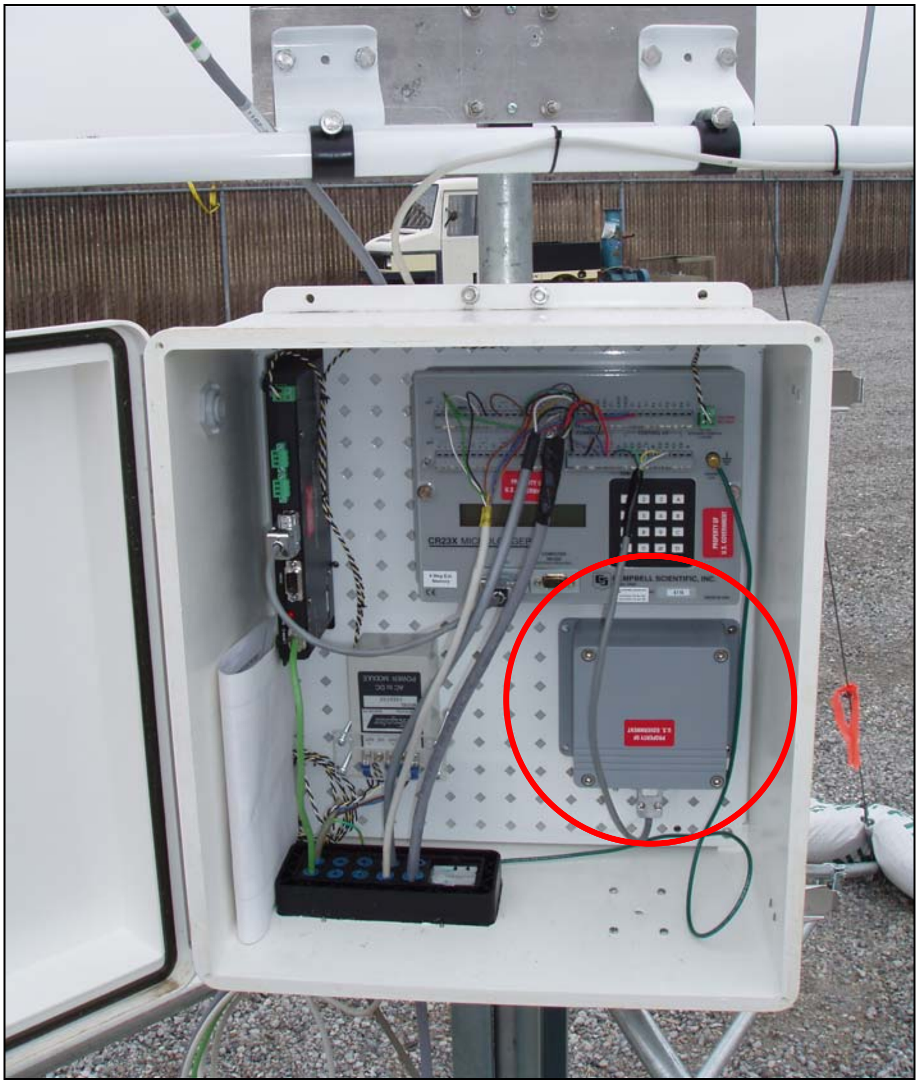
## SMET Instruments:

### Temperature and Humidity Sensors (T/RH)



The temperature and humidity sensors are mounted inside a tube to protect them from direct sunlight. The tube is attached to the Meteorological Tower near the bottom. A small fan at one end draws air into the tube and over the sensors.

## SMET Instruments:
### Barometer



A barometer measures atmospheric pressure and is housed inside the logger container on the Meteorological Tower. A tube connects the barometer to the outside.

## SMET Instruments:
### Optical Rain Gauge (ORG)


Mounted on the Meteorological Tower, the ORG measures the rate of rainfall in millimeters per hour (mm/hr). It sends an invisible beam of light from one of its ends to a detector at the other end. When raindrops fall, they break the beam. The rain rate is determined by measuring how often the beam is broken. It can be used to calculate the total amount of rain that has fallen in any given period.

## SMET Instruments:
### Present Weather Detector (PWD)

The Present weather Detector (PWD) measures the visibility near the surface by estimating the water content of precipitation and combining it with optical forward scatter and temperature measurements. The AMF is equipped with the Vaisala PWD22, which measures visibility up to 20 km depending on the weather condition.

# Eddy Correlation Flux Measurement System (ECOR)

The Eddy Correlation Flux Measurement System provides in-situ, half-hour averages of the surface vertical fluxes of momentum, sensible heat, and latent heat. The fluxes are obtained by the eddy-correlation technique; in other words, by correlating the vertical wind component with the horizontal wind component, the sonic temperature (approximately equal to the virtual temperature), and the water vapor density. A 3-dimensional sonic anemometer is used to obtain the orthogonal wind components and the sonic temperature. An infrared hygrometer is used to obtain the water vapor density.

# Microwave Radiometer (MWR)


The MWR measures time series of column-integrated amounts of water vapors and liquid water. Water vapor is just the water molecules in the air; you can't see them. Liquid water is the water droplets in the clouds. The value the MWR reports for the water vapor is what you would get if you could get all the water vapor above a rain gage to condense as liquid water in the gage. Although clouds look like they contain a lot of water, the liquid water values the MWR measures are usually a few tenths of a millimeter. The MWR does not detect ice. Clouds higher than 5 kilometers (km) are usually composed of ice particles rather than water drops, and the MWR does not detect them.

# Microwave Radiometer Profiler (MWRP)


The MWRP provides continuous profiles of water vapor, liquid water, and temperature up to 10 km height. Those profiles are obtained at 10-second intervals during clear, cloudy, and precipitating conditions. The temperature measurements are taken with the Infrared Thermometer (IRT) mounted on top.

# Microwave Radiometer – High Frequency (MWRHF)

The Microwave Radiometer - High Frequency (MWRHF) provides time-series measurements of brightness temperatures from two channels centered at 90 and 150 GHz. These two channels are sensitive to the presence of liquid water and precipitable water vapor.

# Ceilometer

The Ceilometer measures the distance from the ground to the bottom of a cloud directly overhead. This distance is called “cloud base height.” The Ceilometer can measure cloud bases up to about 8 kilometers (km) above the surface. The Ceilometer sends out a pulse (flash) of light and measures how long it takes for the light to come back after being reflected off the bottom of a cloud.

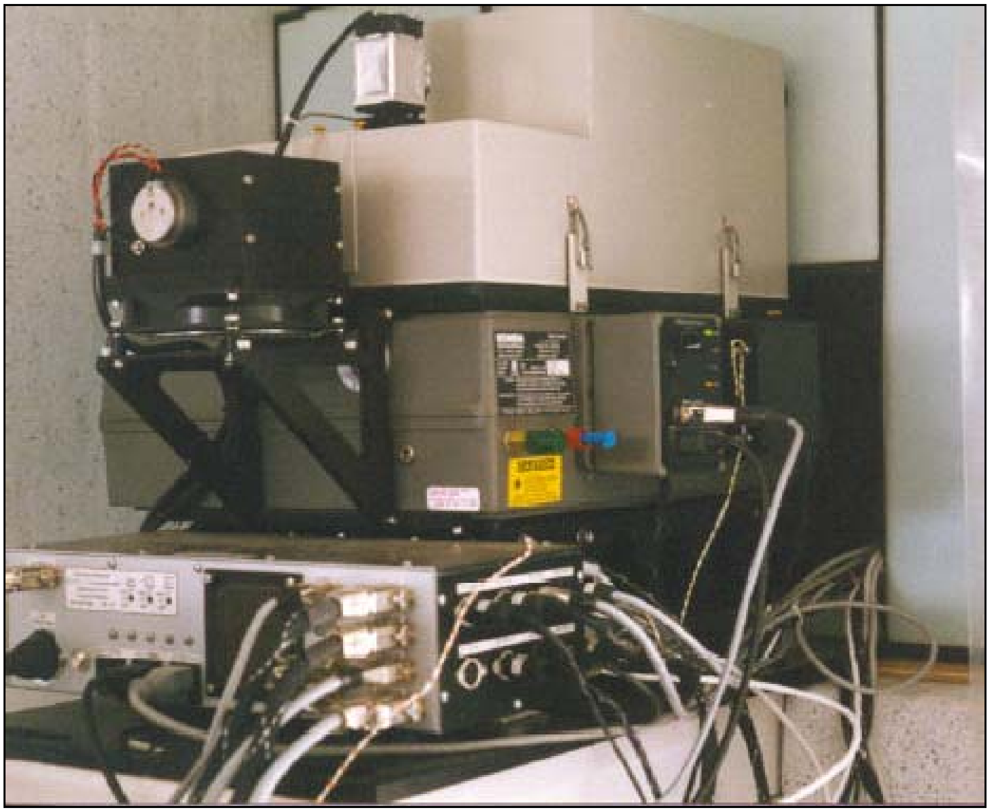
# Micro Pulsed Lidar (MPL)


The MPL works just like the Ceilometer but can see clouds that are much higher. The MPL can detect cirrus clouds, which can be as high as 16 to 17 km high.

# Balloon-Borne Sounding System (BBSS)

The Balloon-Borne Sounding System provides vertical profiles of both the thermodynamic state (i.e., temperature) of the atmosphere and the wind speed and direction. The data are collected by a radiosonde attached to a weather balloon. The main components of the BBSS are a radiosonde, a balloon, an antenna to receive data (shown above), and DigiCORA, a computer program that collects data from the radiosonde.

# Atmospheric Emitted Radiance Interferometer (AERI)



The AERI measures a spectrum of heat radiation of the sky directly above the instrument. A spectrum is a distribution of energy across a range of wavelengths. Because the AERI measures a spectrum of heat radiation, its data produce profiles of temperature and water vapor of the atmosphere above the instrument. Scientists also use the AERI data to improve models of how heat radiation behaves in the Earth's atmosphere.

# Aerosol Observation System (AOS)

The AOS takes in-situ aerosol measurements at the surface. The principal measurements are the aerosol absorption and scattering coefficients as a function of the particle size and radiation wavelength. Additional measurements include the particle number concentration, size distribution, hygroscopic growth, and inorganic chemical composition. The AOS measures aerosol optical properties to better understand how particles interact with solar radiation and influence the earth's radiation balance.

# W-band ARM Cloud Radar (WACR)


The W-band ARM Cloud Radar is a zenith-pointing radar that operates at a frequency of 95 GHz. The main purpose of this radar is to determine cloud boundaries (i.e., cloud bottoms and tops). This radar can also report radar reflectivity (dBZ) of the atmosphere up to 20 km. In addition, the WACR has a Doppler capability that allows the measurement of cloud constituent vertical velocities.

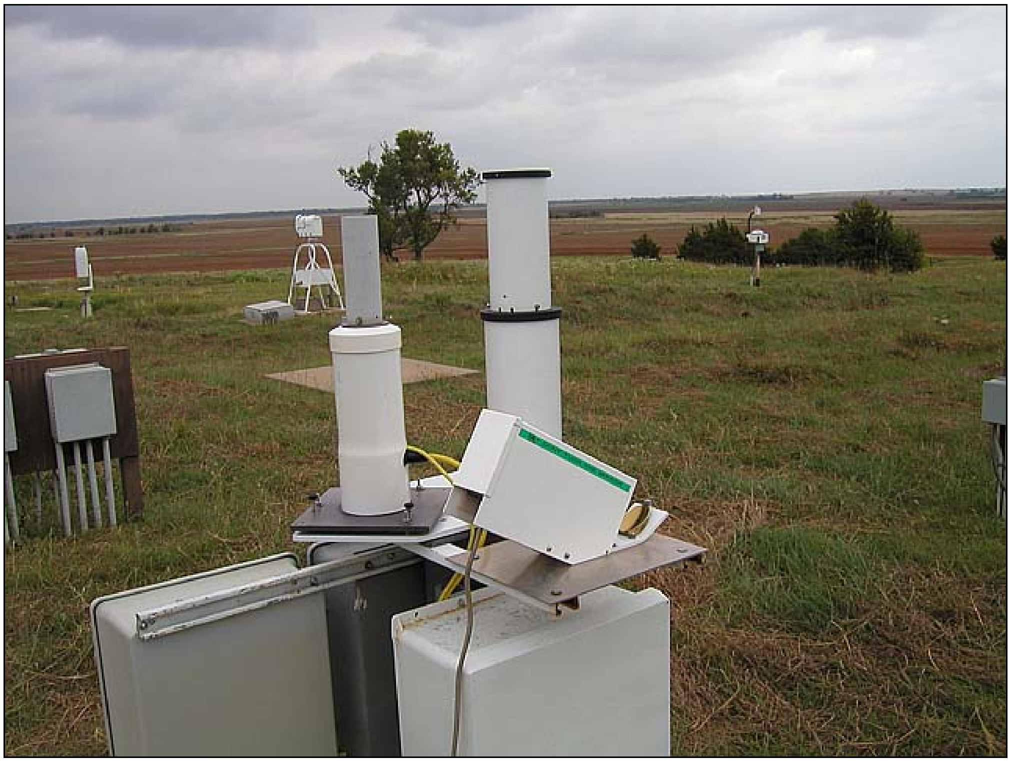
# Radar Wind Profiler (RWP)

The RWP measures wind profiles from 2 to 5 km and virtual temperature profiles from 1 to 2 km by transmitting electromagnetic energy into the atmosphere and measuring the strength and frequency of backscattered energy.

# Cimel Sunphotometer (CIMEL)

The Cimel Sunphotometer (CIMEL) is a multi-filter, automatic, sun-tracking radiometer that measures aerosol, water vapor, and ozon, as well as the direct solar radiance and reflected sky radiance at the Earth's surface. Measurements are taken at pre-determined discrete wavelengths in the visible and near-infrared parts of the spectrum to determine atmospheric transmission and scattering properties. The CIMEL operates only during daylight hours (i.e., sun above horizon).

# 2-Channel Narrow Field of View Zenith Radiometer (2NFOV)



The 2-Channel Narrow Field of View Zenith Radiometer (2NFOV) is a ground-based radiometer that looks straight up in the sky. With its narrow field of view, the 2NFOV measures the downwelling zenith radiance in a 1-second time series. The radiance is measured at a wavelength of 869 nm. One example of the uses for the data collected by this instrument is to examine the internal structure of clouds.

# Sun and Aureole Measurements (SAM)


The Sun and Aureole Measurements (SAM) system provides ground-based measurements of the radiance profile of the solar disk and the associated aureole resulting from the passage of solar radiation through atmospheric aerosols and clouds. The radiance of the solar disk measures the cloud optical depth, while the aureole measurements provide information on the forward scattering of the sunlight that is defined by the ice/water composition of the cloud along the line of sight. The aureole profile is important for understanding cloud transmissive effects as well as the particle size and ice content of cirriform clouds.