LAOF GROUND-BASED INSTRUMENTATION

Overview

NCAR's Earth Observing Laboratory (EOL) manages ground-based remote and in-situ sensing facilities that provide researchers with unparalleled observing capabilities.

A suite of surface, sounding, and profiling instruments provide flexible, state-of-the-art backbone measurement capabilities applicable to a wide range of experimental needs - emphasizing advanced sensor capabilities, sensor integration, system mobility, and the ability to deploy to remote or difficult locations.

NCAR ISFS

The NCAR Integrated Surface Flux System is a versatile and scalable observing system that is designed to study exchange processes between the atmosphere and the Earth's surface with in-situ sensors mounted on towers at variable heights.

NCAR ISS

The NCAR Integrated Sounding System is a meteorological observing system that combines surface, sounding, and remote sensing instrumentation to provide a comprehensive description of the boundary layer and free troposphere.

EOL provides a cutting-edge lidar network to continuously monitor water vapor, temperature, and quantitative cloud and aerosol properties in the lower troposphere; and a research-grade, transportable S-band radar capable of describing air motion in both clear air and storms, wind structure, cloud initiation and properties, and precipitation type and amounts.

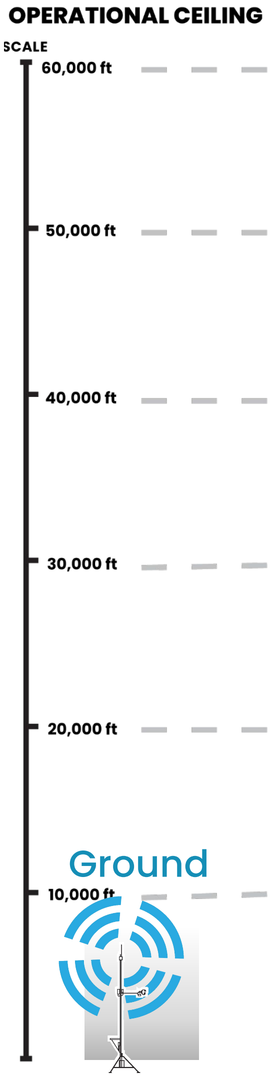
NCAR MicroPulse DIAL

The MPD is a compact, field-deployable, eye-safe lidar that that is used to monitor water vapor, temperature, and quantitative cloud and aerosol properties in the lower troposphere. A network of up to four systems is available.

NCAR S-Pol

S-Pol is a research-grade, S-band, transportable, ground-based, dual-polarized, Doppler weather radar that measures the structure, movement, and severity of precipitating cloud systems.

NCAR ISFS



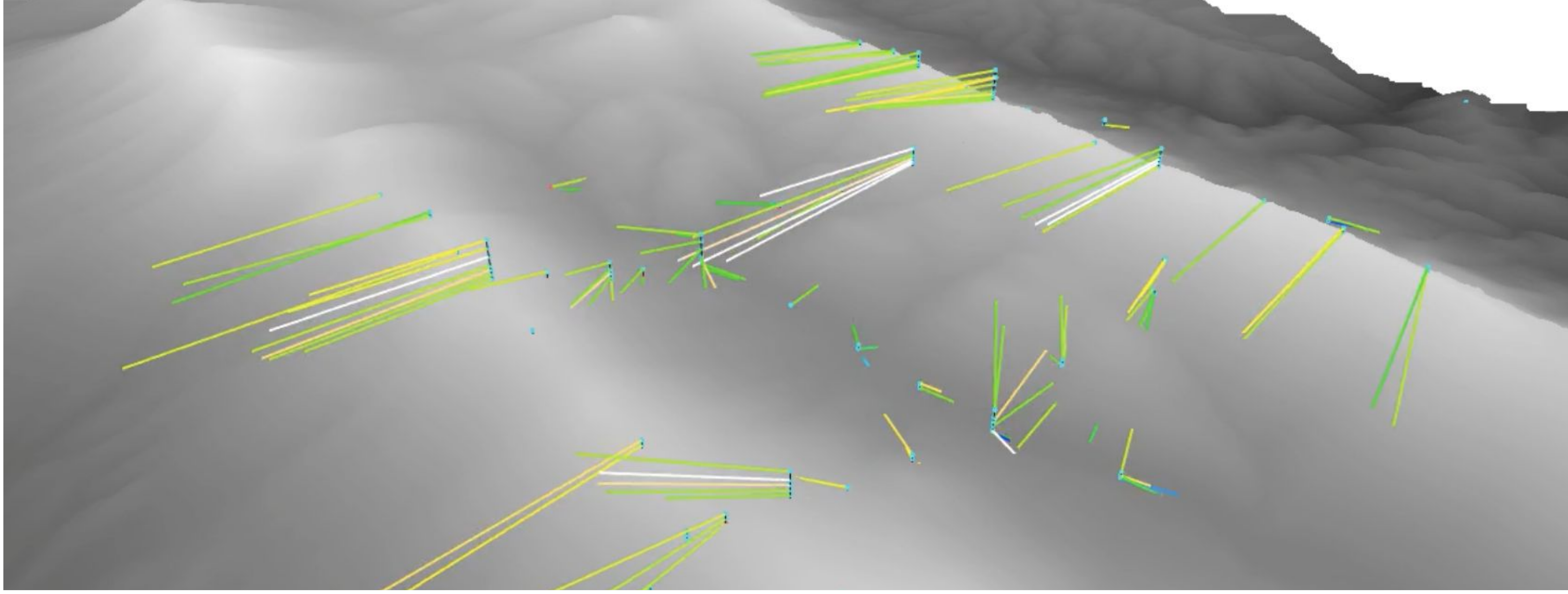
The **NCAR Integrated Surface Flux System (ISFS)** is designed to study exchange processes between the atmosphere and the Earth's surface. ISFS is versatile and scalable, combining the capabilities of a network of surface flux stations with multi-level flux towers to support intensive micro meteorological research. Investigator teams have the flexibility to configure ISFS resources to match their individual research objectives.

ISFS field deployments can range from a network of 10m surface flux towers to a scaled-up, intensive supersite of a few 30m towers that operate 2D and 3D sonic anemometers, water vapor and carbon dioxide gas analyzers, radiometers, temperature, relative humidity, and pressure sensors at multiple levels on each tower. Soil sensors can be deployed also at each towered site. Towers can be set up across a regional domain to form a network, concentrated to form a supersite, or be a combination of multi-level towers depending on scientific need.

ISFS uses the NCAR In-situ Data Acquisition Software (NIDAS) to provide data ingest, archival, and display. ISFS integrates data from both network and intensive modes with a common data ingest, archival, and display system. Solar power, cellular modems, and satellite data transmission provide the necessary flexibility for ISFS to operate in remote areas.

In a network mode, up to thirty 10m flux towers spread across multiple sites can be instrumented to measure basic weather quantities, i.e., near-surface wind, temperature, humidity, pressure and precipitation. In addition, sensors are deployed to measure momentum fluxes, sensible and latent heat fluxes, shortwave and longwave radiation, soil temperature, soil moisture, and soil heat flux at each station. These observations allow all terms of the surface energy balance to be evaluated directly.

In an intensive mode, multiple sensors are deployed on an array of multi-level flux towers (typically 30 m height) at a single site for detailed examination of the turbulence structure of the atmospheric surface layer. Generally, these involve vertical profiles of fluxes and radiative properties, as well as of basic variables such as wind, temperature, and humidity to detect changes due to the vertical structure of the lower boundary layer or canopy elements. Radiative flux divergence also has been measured due to absorption by hydrometeors close to the surface.



Average statistics of all variables, including the second-order moments needed to compute fluxes and limited third-order moments, are a standard product of ISFS and are available in real-time for display. Every data sample is archived to allow processing using spectral, wavelet, or conditional sampling methods. Average statistics of all variables, including the second-order moments needed to compute fluxes and limited third-order moments, are a standard product of ISFS and are available in real-time for display. The diagram above shows wind vectors derived from 3D sonic anemometers on multiple ISFS towers during the Peridgao campaign in 2017.

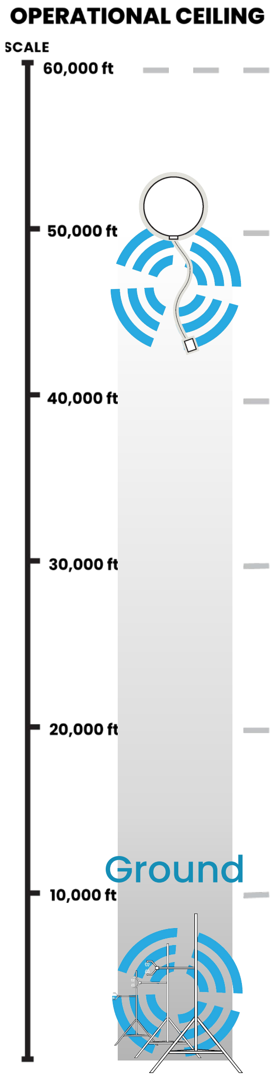
Standard ISFS Sensors

The ISFS sensors are a mix of commercial instruments and in-house developed sensors.

- 3D & 2D Sonic Anemometers
- H_2O/CO_2 Flux Open-path Gas Analyzer
- Temperature / RH sensors
- Visible & Infrared Precision Radiometers
- 4-Component Integrated Net Radiometer
- Soil Sensor Suite (Temperature, Moisture, Heat Flux, Heat Capacity)
- Nano-barometer

User-supplied or non-standard sensors can be readily accommodated by ISFS. Power and mounting are provided and the various data streams are easily integrated into the system.

NCAR ISS



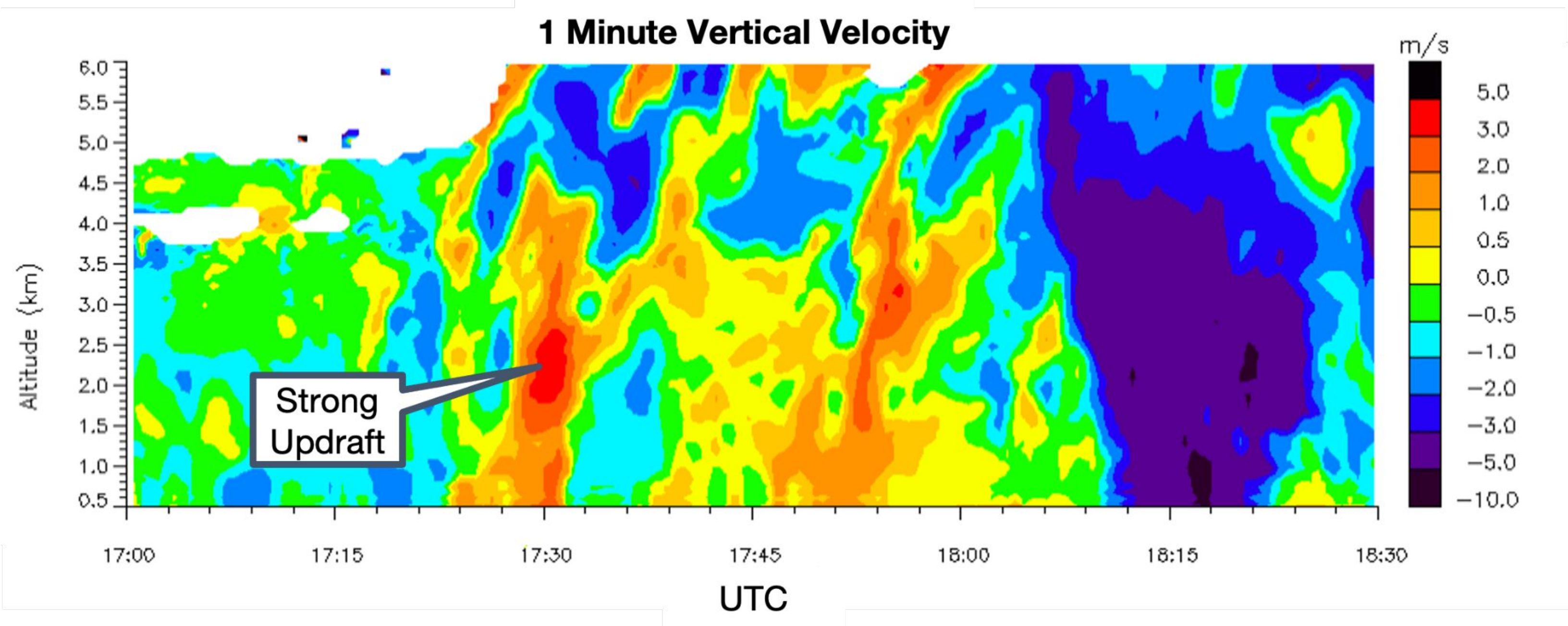
The **Integrated Sounding System (ISS)** is a meteorological observing system that combines surface, sounding, and remote sensing instrumentation to provide a comprehensive description of the boundary layer and free troposphere.

The principal instruments that are part of the ISS include a radar wind profilers (449 MHz, 915 MHz) and a scanning Doppler wind lidar for measurements of high-resolution wind components; a balloon-borne rawinsonde sounding system; and a surface meteorological station that collects surface wind, pressure, thermodynamics, radiation and precipitation data. Other instruments such as the Radio Acoustic Sounding System (RASS) used to obtain virtual temperature profiles, a ceilometer, disdrometers, radiometers, cameras, and a GPS Water Vapor sensor can be added as needed based on the scientific objectives for a particular field campaign.

A system is typically deployed with a furnished trailer, which transports the equipment to a field site and then acts as office space and shelter for computers and other equipment.

EOL has developed a Modular 449 Wind Profiler, an advanced wind profiler with a unique modular design. This profiler utilizes the Space Array method, which offers scalability for specific experiments and enables rapid wind measurements within minutes. Compared to the 915 DBS wind profilers, the 449 profiler is approximately ten times faster. However, it is important to note that the 449 profiler is more prone to radio interference, and the measured wind data may have higher levels of noise compared to the 915 DBS profiler.

In the United States, wind profiling is conducted using two allocated frequencies: 449 MHz and 915 MHz. In most other parts of the world, the allocated frequency is 1290 MHz. This diversity in profilers allows for flexibility in operating at the frequency best suited for scientific requirements and spectrum availability at a particular location.



The data plot shows 1 min vertical velocity data from the NCAR 449 MHz wind profiler (3 panels) during the CHEESEHEAD campaign in summer 2016.

The ISS are available in a variety of configurations. The standard system is typically deployed at fixed locations for periods of weeks to months; the mobile system (MISS) is mounted to a trailer and usually used for shorter, more rapid deployment such as storm chasing and outreach activities. The ship-borne configuration is deployed on research vessels for ocean meteorology studies.

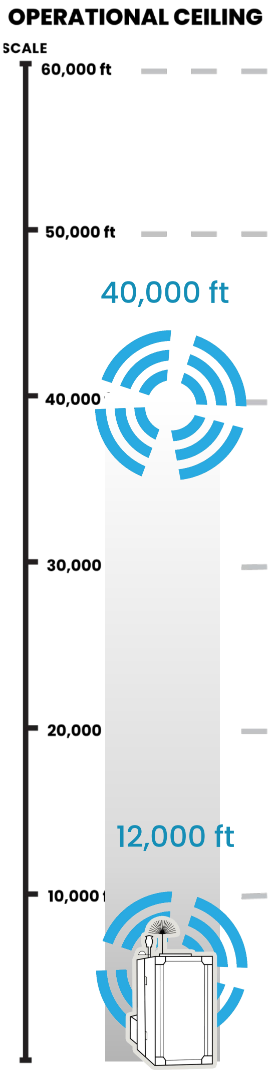
Data from all instruments are ingested into a data management, display, and communications infrastructure to provide raw data and data products in real-time or near real-time to researchers remotely or on-site.

The systems are commonly used for boundary layer studies but have also been part of field programs that focused on tropical meteorology, severe weather, mountain meteorology, ocean-atmosphere exchange, microphysics, wind energy, agriculture, atmospheric chemistry, and atmospheric gravity waves. The ISS is especially well suited for educational deployments.

Available ISS Instruments	
Radar Wind Profilers	449 MHz Modular Wind Profiler 915 MHz Vaisala LAP3000 DBS 1290 MHz Radian LAP3000 DBS RASS (Radio Acoustic Sounding System)
Wind Lidar	Vaisala / Leosphere Windcube 200S Scanning Doppler lidar
Ceilometers	Vaisala CL31, CL51 and CL61 (with depolarization channel)
Radiosonde Soundings	Vaisala MW41 / RS41 radiosondes iMet-3050A / iMet-1 radiosondes
Surface Met	Gill WindObserver (2D sonic anemometer)* Lufft WS300 (Temp/RH/Pressure)* Vaisala PTB210 / PTB330 (Pressure)* Hukseflux NR01 4-component radiation HSA Tipping bucket rain gauge Lufft WS800 (Wind/Precip/T/RH/P)* OTT Parsivel-2 optical disdrometer
GPS Integrated Water Vapor	Trimble NetR8 with Vaisala WXT
Aerosols	PurpleAir Aerosol Sensor
Mounted on 10m or 3m towers	

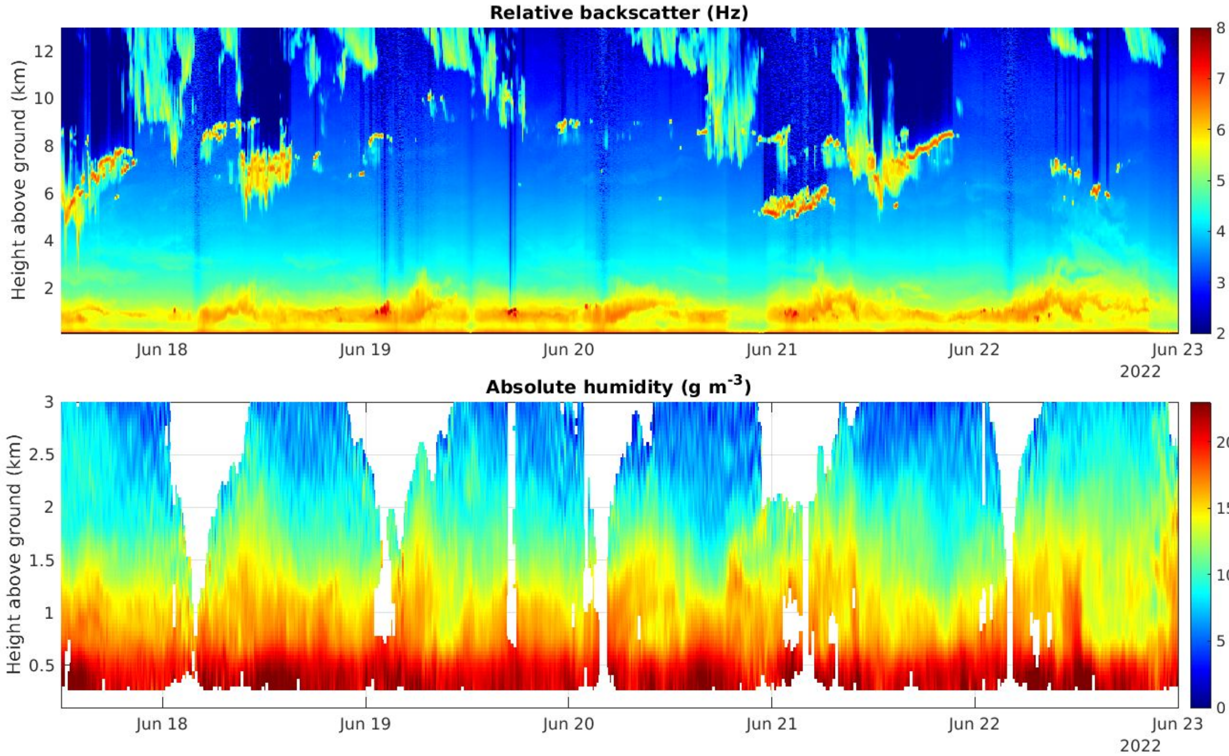
Specifications

- Nominal Wavelengths: 828.2 nm, 770 nm
- Pulse Length: 0.6-1 μs
- Pulse Repetition Rate: 7-9 kHz
- Vertical Resolution: 150 m
- Vertical Range: 250-4,000 m
- Temporal Resolution: 1-5-10 min



NCAR MPD

The **Micro-pulse Differential Absorption Lidar (MicroPulse DIAL, or MPD)** is a compact, field-deployable, eye-safe lidar that offers continuous unattended monitoring of water vapor, temperature, and quantitative cloud/aerosol properties in the lower troposphere. A network of five water vapor MPD units has been constructed with four currently available to the research community. These instruments can be used to advance knowledge in a variety of areas, including the temporal and spatial distribution of boundary layer temperature and water vapor, convection initiation, and land-atmosphere exchange.



MPD data collected in June 2022 during the Taiwan-based PRECIP field program. The top panel shows relative backscatter; the bottom panel shows absolute humidity.

The multi-system MPD network can provide continuous high-vertical resolution water vapor and temperature profiling across a user-defined area of observations. Water vapor and temperature are the fundamental thermodynamic variables that define the state of the atmosphere. Water vapor is highly variable in space and time and influences many important processes related to weather and climate. The ability to continuously measure these thermodynamic variables in the lower troposphere with high vertical resolution has been identified as a priority observation needed by the weather forecasting, atmospheric science, and climate science communities.

MPD is a combination of three lidars in one unit. A water vapor Differential Absorption Lidar (DIAL) measures absolute humidity, a High Spectral Resolution Lidar (HSRL) measures calibrated aerosol backscatter coefficient, and an oxygen DIAL measures temperature. These techniques provide accurate and calibration-free measurements requiring a minimal set of assumptions.

MicroPulse DIAL Products			
Range resolved	**Resolution**	**Technique**	**References**
Absolute Water Vapor	5-10 min 250 m to 4 km	DIAL	Spuler et al. 2015 Spuler et al. 2021
Temperature	10-20 min 250 m to 4 km	DIAL	Stillwell et al. 2020
Quantitative Aerosol /Cloud Properties	1 min 50 m to 10 km	HSRL	Hayman and Spuler 2017

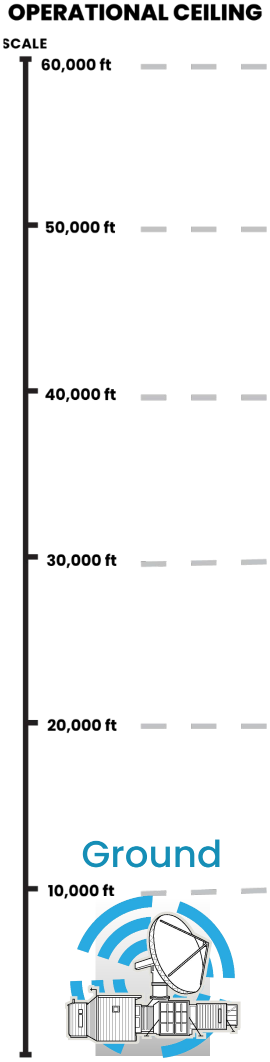
MPD Applications

MPD applications are far reaching. Detailed moisture observations aid in forecasting high-impact weather through detailed moisture observations; high-resolution continuous thermodynamic water vapor profiles can be provided for data assimilation into numerical models; long-term observations assist in assessing atmospheric moisture response to climate change and increase our understanding of the hydrological cycle; and MPDs provide excellent data to study water vapor variability and transport and can contribute to model validation.

Specifications

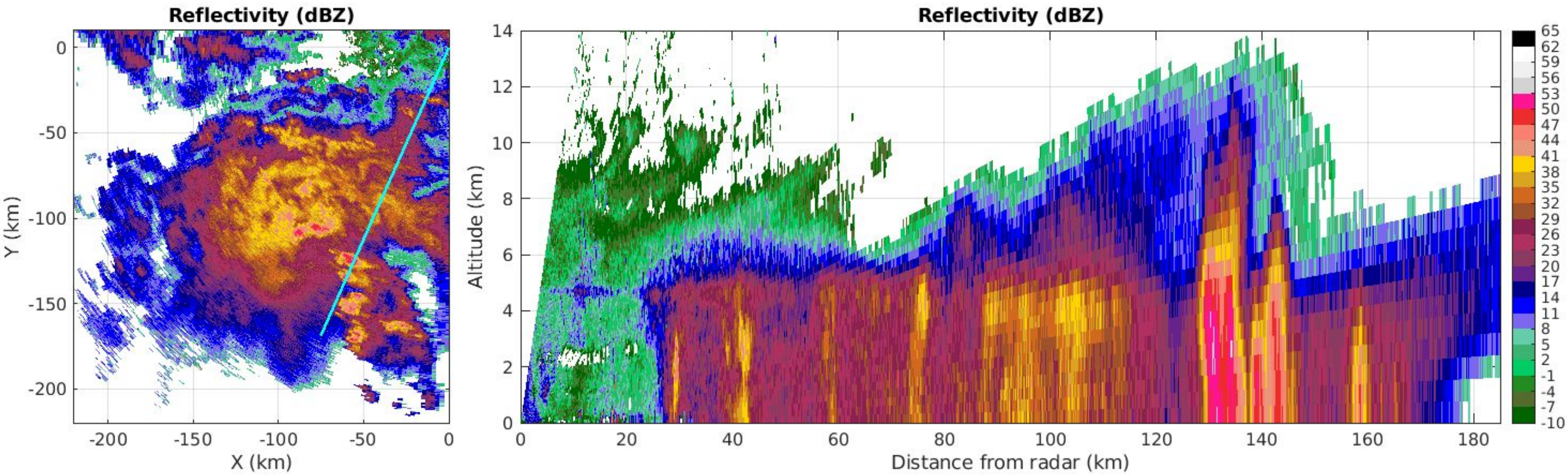
- Wavelength: 10.7 cm (S-band)
- Transmitter: Klystron
- Antenna Diameter: 8.5 m
- Range Resolution: 150 to 225 m
- Peak Power: >600 kW
- Beamwidth: 0.92°
- PRT Range: 0.8 to 12 ms
- Sensitivity: -44 dBZ at 1 km

NCAR S-Pol



The **NCAR EOL S-band Dual Polarization Doppler Radar (S-Pol)** is a research-grade, S-band (10 cm), transportable, ground-based, dual-polarized, Doppler weather radar. Once set up, the radar can be operated and monitored remotely, provided that there is sufficient high-speed internet connectivity.

As an S-band radar, S-Pol is sensitive to a wide range of echo types and particle sizes from clear air (primarily via insects) and cloud echoes to severe storms containing rain and hail. The research-quality, dual-polarization Doppler data from S-Pol provide high-resolution information about precipitation rates, microphysics, and storm structures and kinematics. The radar has been used for many types of research, including weather and climate prediction, monsoon rainfall, and convection initiation.



S-Pol has equivalent capabilities to the Doppler radars of the U.S. National Weather Service's Next Generation Weather Radar (NEXRAD) network, and is used as a test bed for development of algorithms to improve NEXRAD data quality. However, in contrast to the stationary NEXRAD radars, S-Pol is completely transportable. The radar is housed in eight sea containers, four of which are used as the foundation for the pedestal. It can be shipped to remote locations for field experiments, providing research-grade radar coverage where none would otherwise be available.

Several other characteristics make S-Pol unique. It operates without a radome. The radar operates most of the time in fast-alternating dual-polarization mode, which provides Linear Depolarization Ratio (LDR) and the cross-correlation coefficient that offers additional insight into the microphysics of the observed clouds. Real-time identification of hydrometeor types and rainrates are available along with time series recording. S-Pol's Range Height Indicator (RHI) mode provides scientists with impressive detail of the vertical structure of a storm. The absolute phase measurements from S-Pol can be used to compute and monitor in real time the low-level humidity by measuring changes in refractive index between fixed ground targets. Advanced signal processing software, along with the option to scan more slowly than surveillance radars, produces data quality that is significantly superior to standard weather radars.

NCAR EOL

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Online Resources:
www.eol.ucar.edu/research-facilities/ground-based-systems