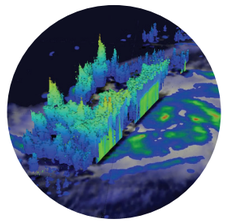
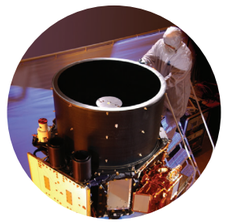
# INSTRUMENTS

## GMI

Collecting advanced precipitation measurements from space, the Global Precipitation Measurement (GPM) Microwave Imager (GPIM) is furthering our understanding of Earth's water and energy cycles and improving our ability to forecast extreme weather events. GMI is one of two instruments aboard the GPM observatory, a joint mission between NASA and the Japan Aerospace Exploration Agency (JAXA).

Ball designed, built and tested GMI and provided pre- and post-launch support for the instrument. Designed for state-of-the-art accuracy, GMI has become the calibration standard for on-orbit microwave radiometers.





*Images (Top to Bottom): GPIM; GPIM data; CALIPSO*

## CALIPSO

The Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) is dedicated to studying the impact that clouds and aerosols have on the Earth's climate. CALIPSO's active lidar instrument scans the atmosphere with green and infrared laser light and detects backscatter from clouds and aerosols. Originally designed for a life of three years, scientists continue using data from CALIPSO to construct 3D models of the atmosphere that improve our ability to predict future climate change.

Ball built CALIPSO's lidar and wide-field camera instruments, the communications equipment and integrated the payload. CALIPSO was launched in 2006 as part of the A-Train. Since then, CALIPSO has traveled more than 1.6 billion miles and produced more than 90 terabytes of data.

# ADVANCING EARTH SCIENCE

*Ball is dedicated to advancing the future of Earth Science to solve important problems for the nation. We are currently developing and maturing various technologies that fill important data gaps and help to lower program costs. These technologies include:*

## Small Spacecraft

Our flight-proven BCP-Small spacecraft offers a rapid response for meeting mission and budget requirements. We've built three spacecraft on this platform for a combined 14 years of on-orbit operations.

## Airborne Initiative

Through our airborne initiative, we design, build and demonstrate new and innovative remote sensing technologies from airborne platforms, providing the science community with new measurement capabilities for a variety of applications, from vector winds and methane to soil moisture and sea surface temperature.

## Miniaturized Science Instruments

Our close collaboration with the science community enables us to design systems that optimize science return within platform and cost constraints. For example, we built the Compact Infrared Radiometer in Space (CIRiS) instrument for integration on a cubesat platform as part of NASA's In-Space Validation of Earth Science Technologies (InVEST) program. CIRiS aims to demonstrate and validate the ability of miniaturized science instruments to effectively deliver highly-calibrated, scientifically-significant data while also reducing overall costs.

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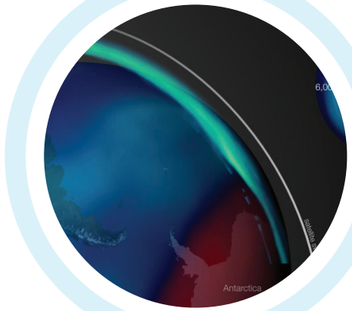
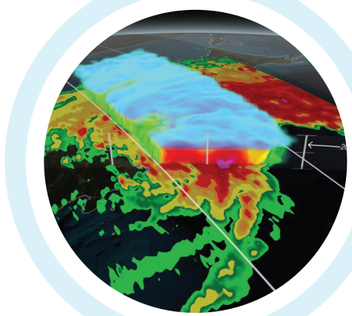
# WEATHER & ENVIRONMENT

For more than 40 years, Ball Aerospace has designed and built innovative remote sensing instruments, spacecraft and systems that support actionable environmental intelligence. From enabling more accurate weather forecasts to delivering insightful observations of our planet, we provide decision makers the information they need to protect what matters most: you, your family and our nation.

*Credits (Top Image): NOAA; (Bottom Image): USGS/NASA Landsat*



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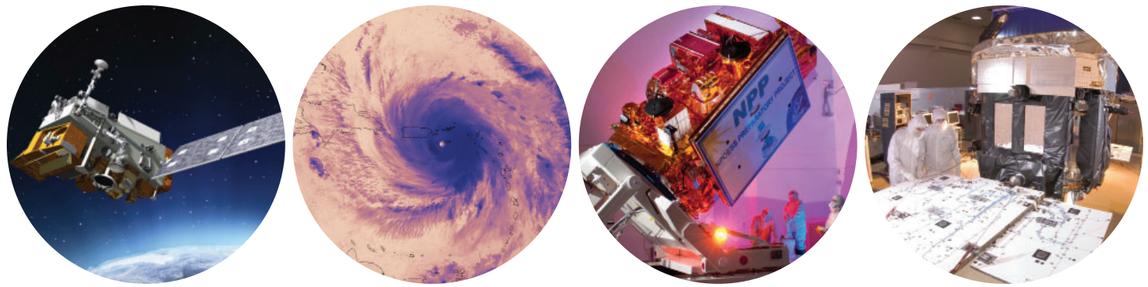
# SPACECRAFT

*Images (Left to Right): JPSS-1; Hurricane Maria captured by Suomi-NPP; Suomi-NPP; CloudSat*



*Our line of flight-proven spacecraft - the Ball Configurable Platform (BCP) – are designed for flexible, cost-effective remote sensing applications. Built on a readily configurable design with standard payload interfaces, the BCP is ideally suited for a wide range of missions, from technology demonstrations to full operational programs. The combined BCP series has flown for more than an equivalent of 85 years.*

## JPSS-1

The Joint Polar Satellite System-1 (JPSS-1), NOAA's next-generation polar orbiting weather satellite, collects critical data for weather forecasting. Data collected from JPSS-1 (known as NOAA-20) increases the timeliness and accuracy of forecasts three to seven days in advance of severe weather events, enabling emergency managers to make timely decisions to protect lives and property.

Ball designed and built the JPSS-1 spacecraft and Ozone Mapping and Profiler Suite instrument (OMPS), integrated all five of the satellite's instruments, performed satellite level testing and provided launch support.

## SUOMI-NPP

The Suomi National Polar-orbiting Partnership (Suomi-NPP) mission has served as the primary polar-orbiting spacecraft for NOAA's operational weather forecasting mission since 2014, collecting critical data on Earth's atmosphere, oceans and land surface.

Ball designed and built the Suomi-NPP spacecraft and OMPS instrument, integrated all five of its instruments, performed satellite-level testing and provided launch support. We are currently under contract for continued spacecraft operations.

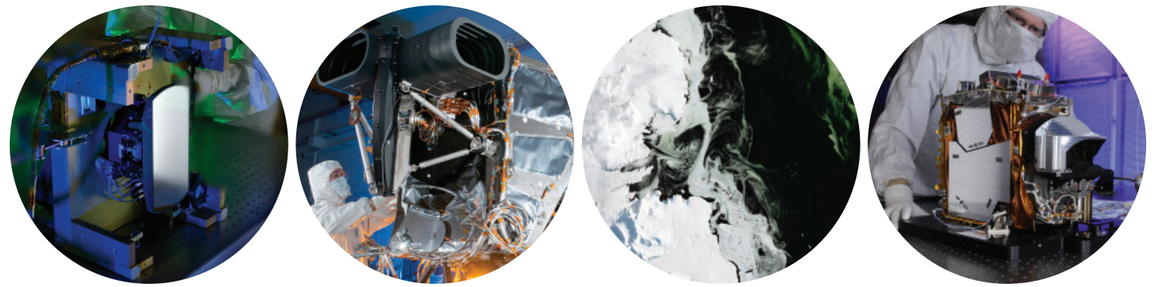
## CLOUDSAT

Collecting the first global measurements of cloud properties, the CloudSat mission has provided scientists with never-before-seen 3D perspectives of Earth's clouds, which are critical for understanding their effect on both weather and climate. Launched in 2006 as part of NASA's spacecraft constellation called the A-Train, CloudSat has gone well beyond its 2-year design life.

Ball built the CloudSat spacecraft, as well as tested and integrated the Cloud Profiling Radar payload built by the NASA Jet Propulsion Laboratory and other hardware contributions from the Canadian Space Agency.

# INSTRUMENTS

*Images (Left to Right): TEMPO; OLI-1; Antarctica captured by OLI-1 (Credit: USGS/NASA Landsat); OMPS-2*



*From air quality and precipitation to ozone and clouds, our reliable and affordable instruments are helping scientists track Earth's weather and climate trends like never before. Spanning the electromagnetic spectrum, our instruments fly on both airborne and space-based platforms and support a wide-range of Earth-sensing missions.*

## TEMPO & GEMS

NASA's Tropospheric Emission: Monitoring of Pollution (TEMPO) mission will revolutionize our understanding of air quality, providing space-based hourly measurements of major air pollutants across North America for the first time. Ball built TEMPO's spectrometer and telescope using a two-axis scan mirror. TEMPO is the first Ball instrument to be hosted on a geostationary communications satellite.

In tandem with TEMPO, Ball built the Geostationary Environmental Monitoring Spectrometer (GEMS), a joint development effort by Ball and the Korea Aerospace Research Institute (KARI), South Korea. Launched in February 2020, GEMS is the Asian element of a global air quality monitoring capability that includes TEMPO. GEMS is the first UV-visible air quality spectrometer in geostationary orbit.

## LANDSAT

The Landsat program, a series of satellites jointly managed by NASA and the U.S. Geological Survey, provides the longest continuous space-based record of Earth's surface unmatched in quality, detail and coverage.

Ball is helping to continue this record with the Operational Land Imager (OLI), a multispectral imaging instrument that enables better spatial resolution and greater sensitivity to brightness and color than any previous Landsat mission. We built the OLI-1 for Landsat 8 and delivered OLI-2 for Landsat 9. Additionally, we contributed the cryocooler for the Thermal Infrared Sensor-1 (TIRS-1) for Landsat 8 and delivered the TIRS-2 cryocooler for Landsat 9. Ball is also designing and prototyping next-generation land imaging instruments for NASA to help ensure a seamless extension of Landsat's 45-year uninterrupted data record well into the future.

## OMPS

OMPS measures the global distribution and vertical structure of Earth's ozone layer, continuing the nation's more than 40-year record of total-ozone and ozone-profile observations. OMPS is currently flying aboard the JPSS-1 and Suomi-NPP satellites.

Ball designed, built and tested both OMPS instruments, as well as supported instrument integration on both satellites. As a result of Ball's success on OMPS, we received a sole-source contract from NASA to build OMPS instruments for all three of the next JPSS follow-on missions.

Ball has more than 40 years of experience developing ozone monitoring instruments for NOAA and NASA. Ball built three Stratospheric Aerosol and Gas Experiment III (SAGE) instruments. Measuring the vertical structure of gases in the atmosphere, the SAGE instruments are critical to the study of ozone. In addition, Ball built nine Solar Backscatter Ultraviolet Radiometers, which helped to discover the ozone hole above Antarctica in 1987.