THE MYSTERY OF LUNAR WATER

HELP SCIENTISTS UNCOVER WATER ICE ON THE MOON

PART 1

STUDENT GUIDE
AGES 9 AND UP.

STUDENT GUIDE

INTRODUCTION

We want to send astronauts back to the Moon to areas near the south pole that have frozen water (referred to as water ice in this guide). But first, we need to discover where water ice is the most plentiful. To do this, we need to compare information from many of the instruments on the Lunar Reconnaissance Orbiter (LRO) to find out which areas show water ice in all the datasets. Scientists are doing studies very similar to this to answer the same question! Help scientists locate where water ice exists on the surface in the form of surface frost. Locations of surface frost will help scientists search for water ice and other frozen resources that are buried beneath the surface.

BACKGROUND INFORMATION

There are regions near the Moon's poles that never receive sunlight (Figure 1). Such regions, known as permanently shadowed regions (PSRs), can maintain very cold temperatures (down to -415°F or -248°C!). At these cold temperatures, there can be ice made from many frozen substances, including water, carbon dioxide (CO^2), sulfur, and hydrogen.

INSTRUCTIONS

Supplies:

- ***Colored pencils, markers, or other writing tools.***
- ***Printouts of the Coloring Page - Hillshade to color on for each student***
- ***Digital or Printouts of the maps***

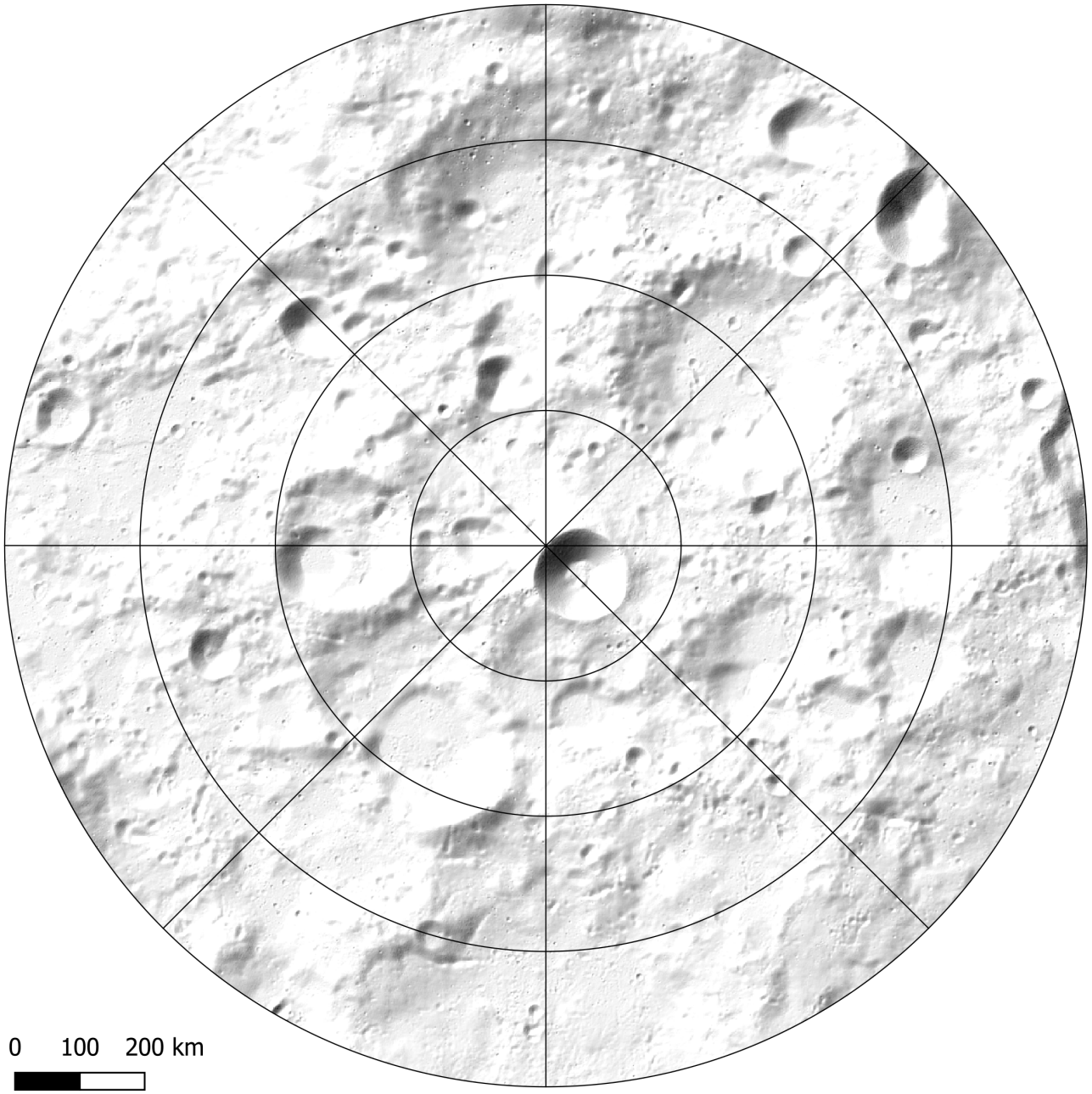
The goal of this activity is to help scientists figure out where water ice might be on the surface. Compare each of the maps to find where all four maps (WAC Summer Mosaic with PSRs, Diviner Maximum Temperature, LOLA 1064 nm albedo, and LAMP UV off/on-band ratio albedo) show results consistent with surface water ice.

Each map has a different legend, but results that are consistent with surface water ice are indicated by the Dark Blue color in each map. The PSRs are also outlined in Dark Blue.

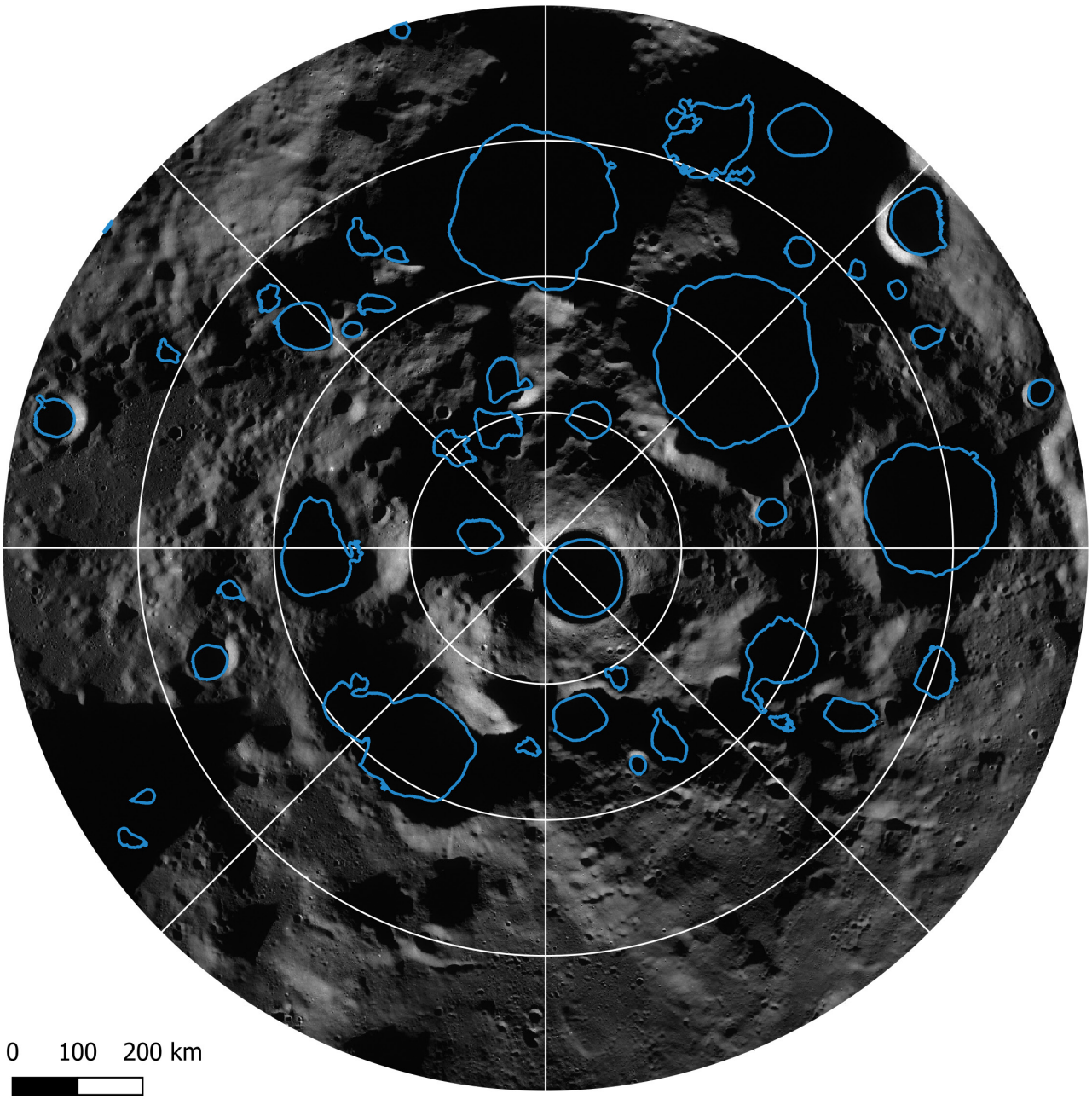
Try to find at least one location where astronauts should go to search for water ice. There are several locations that might contain water ice, so to make the activity more challenging, identify multiple locations where scientists suspect water ice may be. Colored pencils can be used to shade in the area(s) most likely to have water ice on the Coloring Page.

There is an answer sheet provided in the instructor packet so you can check your work.

COLORING PAGE - HILLSHADE

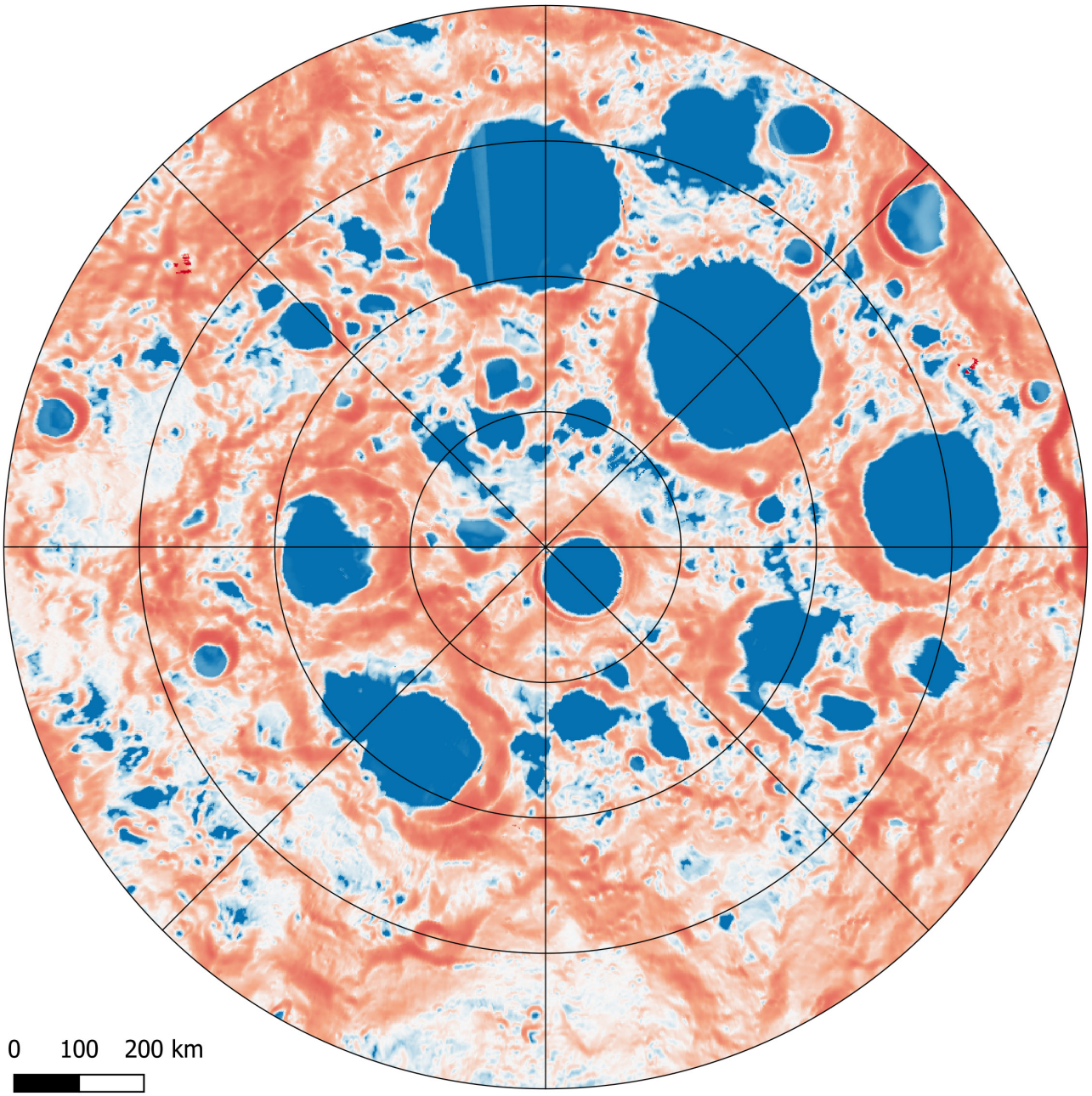


LROC WAC SUMMER MOSAIC WITH PSRs



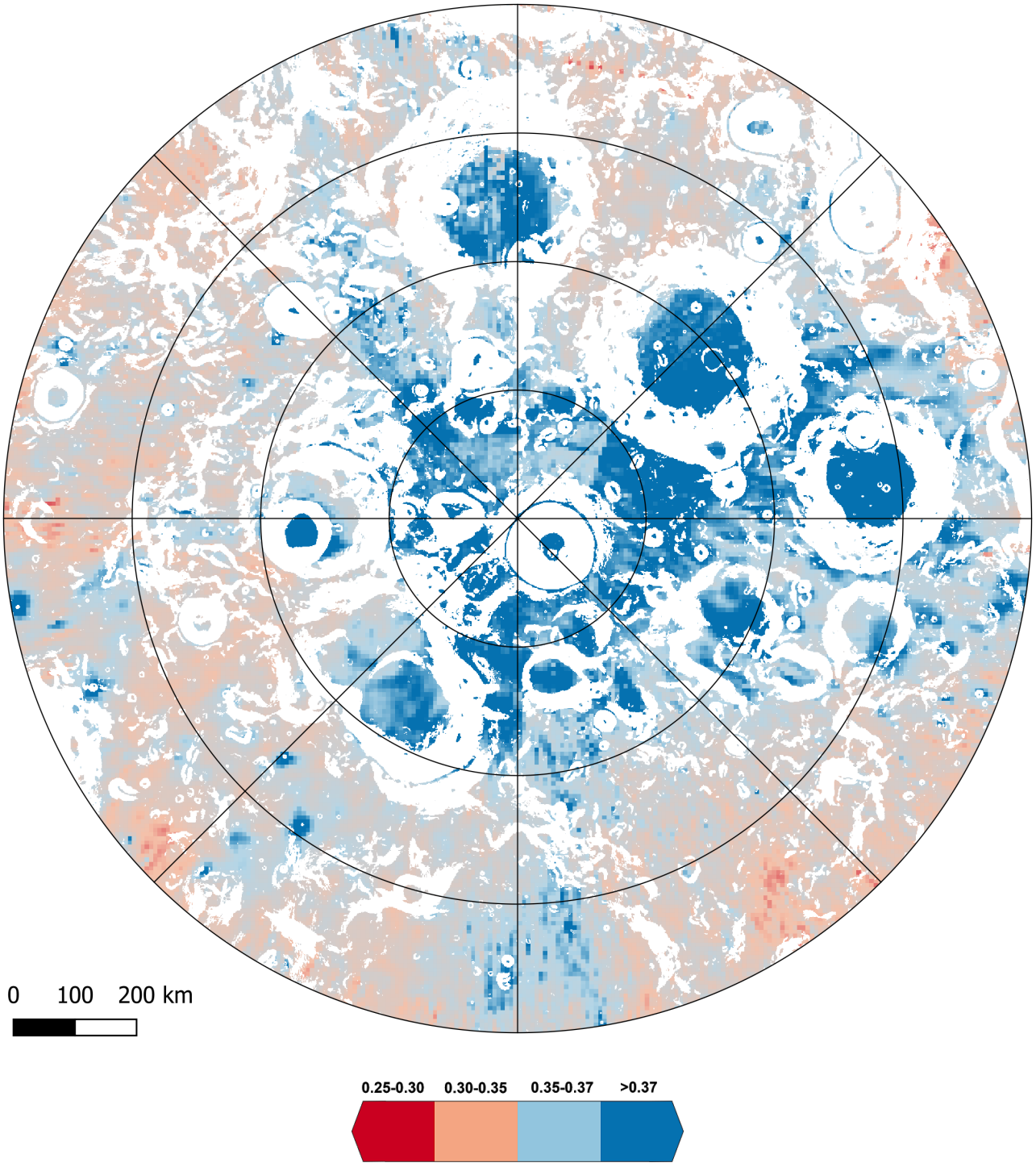
This is a mosaic of images from the Lunar Reconnaissance Orbiter Camera (LROC) Wide Angle Camera (WAC) taken during the summer (from 21 September 2010 to 23 October 2010). The summer is when the south pole receives the maximum amount of sunlight, but still not enough to light up the insides of most craters. Outlined in dark blue are the areas which are permanently shadowed. Because these areas never receive direct sunlight, it is possible that there might be water in the form of ice there.

DIVINER MAXIMUM TEMPERATURE



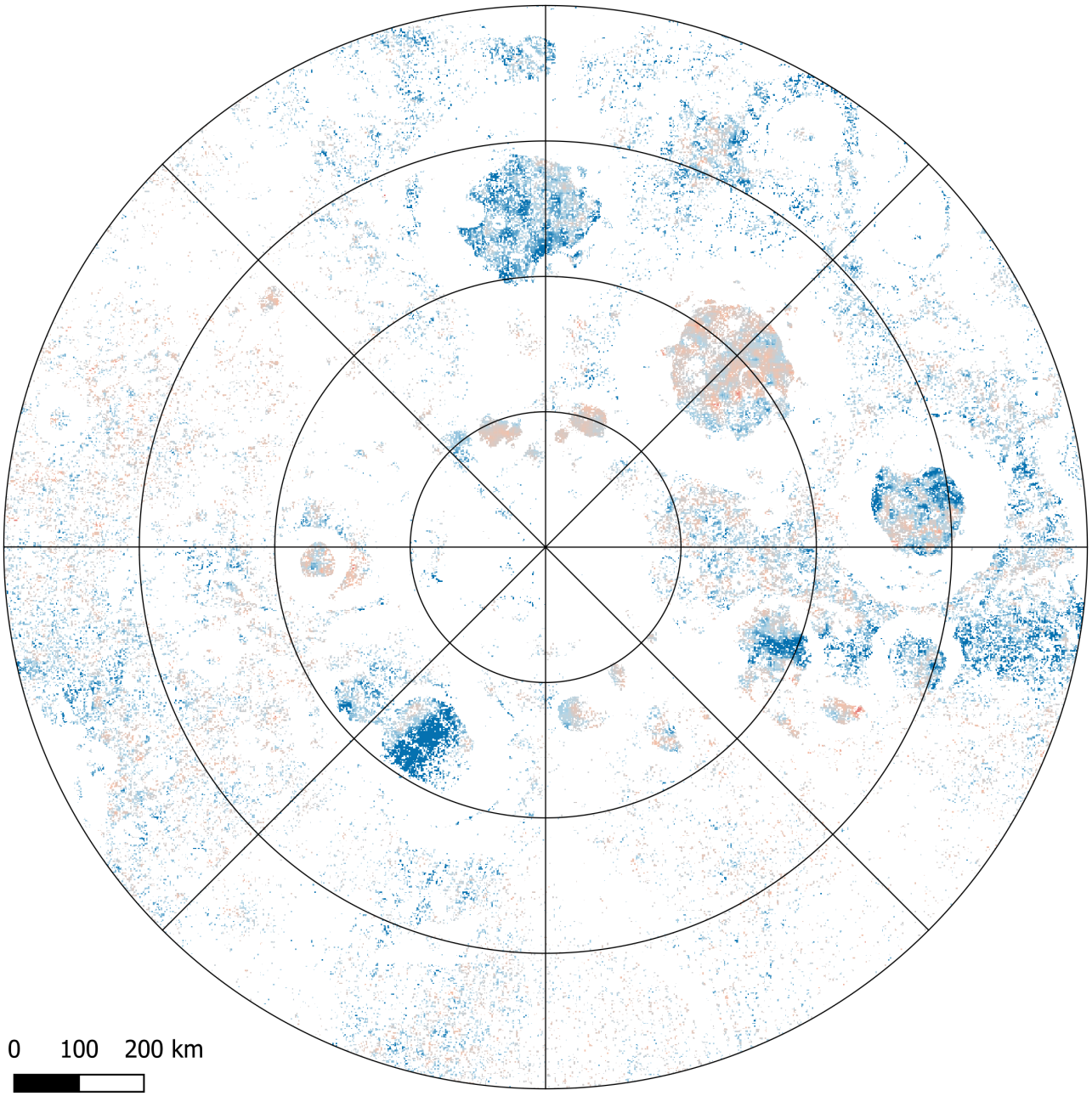
This map shows the maximum temperature in degrees Kelvin (K) over the entire year as measured by the Diviner Lunar Radiometer Experiment (Diviner, for short). Values < 110 K (dark blue) are cold enough to trap water ice.

LOLA 1064 NM ALBEDO MAP



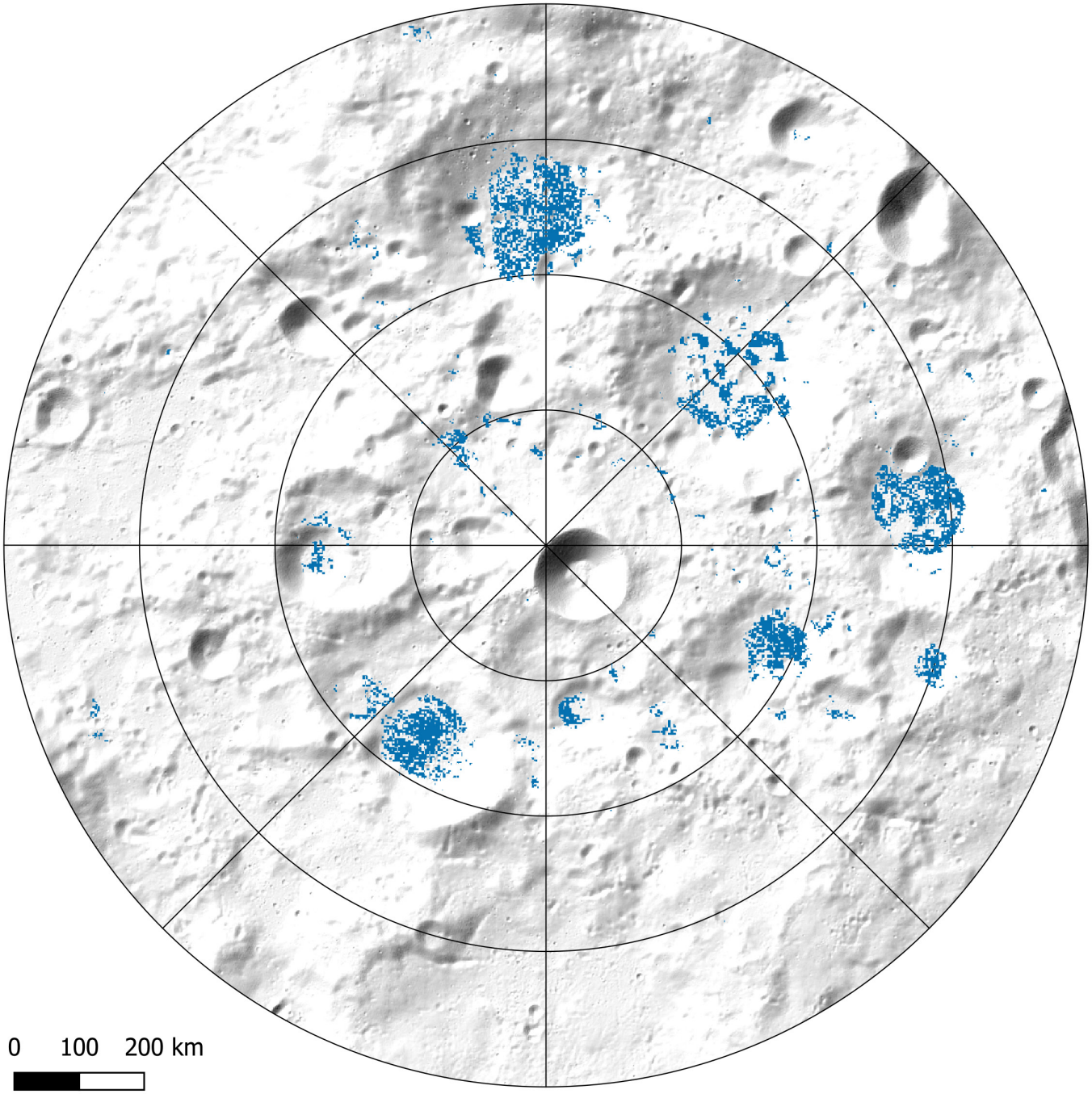
This is an albedo map from the Lunar Orbiter Laser Altimeter (LOLA) instrument. Albedo is a measure of how much a material reflects light. So, a surface that appears brighter has a higher albedo than one that appears darker. One material that is reflective and can appear bright is ice in the form of surface frost, so this map can help us tell where surface frost might be located. Another surface that appears bright is crater walls, so to help with interpretation, the steep slopes have been removed from this map (white). Values of >0.37 (dark blue) are bright enough to indicate surface frost.

LAMP UV OFF ON-BAND RATIO UV ALBEDO MAP



This map shows the reflectance (or albedo) in the ultraviolet (UV) spectrum, measured by the LAMP instrument. LAMP's Off-band is a near-perfect reflector of water ice, so the LAMP team took the ratio of the "On-Band" and "Off-Band" maps to more easily detect water frost absorption. Values >1.2 (dark blue) are consistent with surface water ice.

ANSWER SHEET FOR PART 1



Surface Frost is overlaid in blue.

GLOSSARY

Albedo - A measure of how bright or dark materials are.

Commercial spaceflight organizations - Nongovernmental companies that provide space goods, services, or activities. Some American commercial spaceflight organizations that work with NASA include Boeing and SpaceX.

Drive system - A system that controls speed, rotation, and direction of a motor in a machine.

Earth line-of-sight communication - Communications between Earth and rover are made possible because Earth is in constant view. Only the nearside of the Moon is in constant line-of-site.

Electromagnetic spectrum – Made up of waves (wavelengths) that travel through space at the speed of light. Waves differ in frequency (long vs. short waves).

Elements – Chemical elements that are matter in the universe. Elements are atoms with a specific number of protons.

Engineering - Designing and building new products, machines, or systems using chemistry, physics, and math to solve problems. Different kinds of engineering are often used together when designing something. Building a rover for example uses a combination of electrical engineering (designing how the machine is powered), mechanical engineering (the design, construction, and use of the machine), and materials engineering (designing and building new materials).

Farside - The face of the Moon that faces away from Earth. Sometimes inaccurately called the "dark side". During a New Moon on Earth, the Farside is illuminated by the Sun.

Kelvin - K, the abbreviation for Kelvin, is the base unit of temperature in the International System of Units.

Nearside - The face of the Moon that we see from Earth is called the nearside.

Pixel scale - A pixel (short for picture element) is one of many small squares that make up a picture. The number of small squares in a picture is referred to as resolution. In a satellite image, how much ground is covered by one pixel is referred to as the pixel scale.

Power - In physics and science power refers to the rate, or how fast, energy is used. Power comes from work, or heat or energy transferring to an object.

Surface frost - On Earth, frost is a thin layer of ice on a solid surface. Frost forms when water vapor (a gas) comes into contact with a frozen surface, thus changing the water vapor into ice (a solid). On the Moon, surface frost is not only water, other elements such as sulfur and nitrogen are thought to exist as well.

Suspension system - How the wheels are connected to the rover; provides control of how the rover interacts with the terrain.

Tidal Locking - The Moon rotates about its axis in about the same time it takes to orbit the Earth, resulting in the same side of the Moon always facing towards Earth.

Traverse - Planned path that rover will travel during mission duration.

Vacuum - The vacuum of space is empty and cold; the vacuum of space is nothing.

Water ice - Frozen materials such as water can be trapped in the permanently shadowed regions on the Moon because of such cold temperatures. There is no liquid water on the Moon.

Watts - Unit used to measure how fast energy is used. Power is measured in Watts.