Observing Atmospheric Heights: DISCOVER-AQ Activity

Overview

Lesson Introduction: Students will develop an understanding of how various data platforms are used together to collect information for NASA's DISCOVER-AQ mission. Students will also develop an understanding of the vertical profile of the atmosphere. Students will be able to utilize charts to plot the heights of DISCOVER-AQ platforms and the layers of the atmosphere (troposphere, stratosphere, mesosphere, thermosphere, and exosphere).

Audience: 5-12th Grade

Resource Type: Activity

Learning Time: 45-60 minutes

Learning Objectives:

- To understand the vertical profile of the Earth's atmosphere
- To be able to recognize the DISCOVER-AQ platforms and their uses
- To be able to plot heights on charts

Materials:

- Six blank pages representing the vertical profile of the atmosphere
- Clear tape
- DISCOVER-AQ platforms picture sheet
- Glue sticks
- Notecards
- Scissors
- Vertical profile sheet
- Information sheet

Instructional strategies: Cooperative learning groups, Discussion

Educational Standards:

National Science Education Standards: Yes
Math Standards: No
Technology Standards: No
Geography Standards: No

Observing Atmospheric Heights: DISCOVER-AQ Activity

Lesson Plan

Students will:

- Understand the vertical profile of the Earth's atmosphere
- Recognize the DISCOVER-AQ platforms and their uses
- Plot heights appropriately on graphs

Materials Needed:

- Vertical profile of the atmosphere sheets
- Clear tape
- DISCOVER-AQ platforms picture sheet
- Scissors (one pair per group)
- Glue sticks (one per group)
- Notecards (14 per group)
- Vertical profile sheet (one for each student)
- Information sheet (one for each group)

Background:

DISCOVER-AQ stands for Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality. It is a four-year campaign led by NASA to improve the use of satellites to monitor air quality for public health and environmental benefit. Through targeted airborne and ground-based observations, DISCOVER-AQ will enable more effective use of current and future satellites to diagnose ground level conditions influencing air quality.

The campaign will employ NASA aircraft to make a series of flights, with scientific instruments on board to measure gaseous and particulate pollution. The series of flights commenced over Baltimore-Washington, D.C. in 2011 and continued in the summer of 2012 with flights over the Central Valley in California. Future flights include Houston, TX in September 2013 and a final site in 2014 with a location that is to be determined. The measurements will be taken in concert with ground observations and other atmospheric measurements in order to shed light on how satellites could be used to make similar, consistent measurements over time, with the ultimate goal of putting better data in the hands of policymakers and elected officials.

An important piece of this research lies within various ground monitors. Lidar attached to various platforms measure air quality in its surrounding area. Lidar is a remote sensing method that uses light to measure variable distances to the Earth. In combination with other systems, they help to give three-dimensional information of surface characteristics. Ground monitors are not limited to stationary buildings; instead they can be affixed to light poles as well as moving vehicles. In the Baltimore, MD region a lidar was placed on top of a car, which was then driven

up and down the highway as planes were taking measurements overhead. In the Houston, TX area lidar will be placed on ships as they pass through to the Gulf.

Engagement:

- Download and play the "Full Animation" video found at http://DISCOVER-aq.larc.nasa.gov/multimedia-videos.php
- Identify each DISCOVER-AQ platform as it appears on the screen (e.g. King Air air plane, ozonesonde, etc.).
- Describe how each platform is set to measure a different level of the atmosphere (other DISCOVER-AQ videos that mention heights may be used for visual purposes). http://www.nasa.gov/multimedia/podcasting/nasaedge/NE00091611_at31_DISCOVER-AQ.html
- Ask students what the purpose of measuring data at different heights in the atmosphere may be.

Exploration:

- Have students break out into small groups (3-5 students per group).
- Each student should receive a vertical profile sheet.
- Each group should have an information sheet, a set of notecards, scissors, and glue sticks.
- Explain that each group will have to utilize the information sheet provided to determine the order and heights of each layer of the atmosphere, as well as the heights of the DISCOVER-AQ platforms.
- Have the groups cut and paste the information sheets to notecards and read through the information cards aloud.
- The students will then work together to determine the order.
- Each student should record the information individually by marking locations on their vertical profile sheets.

Explanation:

- Have a representative from each group share with the class their group's determined order.
- Record each group's answer for the whole class to see.
- Discuss with the class any discrepancies in the order.
- Using the discussion, determine the accepted order.
- Select volunteers to create the classroom DISCOVER-AQ vertical profile using the vertical profile sheets, platform picture sheets, scissors, and tape.

Extension:

- In each group, have the students use their information sheets to re-address the purpose of the platforms being at different heights. (Why is it important that they are at different

levels? Is there any correlation between their heights and the composition of the atmospheric level in which they are located?)
- Provide additional resources so students can make connections between the levels in the atmosphere and the platforms found within them.

Evaluation:

- Engage in a classroom discussion to compile all ideas.
- Utilize http://DISCOVER-aq.larc.nasa.gov/ for videos, pictures, and an interactive look at the instruments onboard P-3B.

Sources:

http://www.nasa.gov/mission_pages/calipso/news/f_calipso-cloudsat_prt.htm
http://www.aeronautics.nasa.gov/atp/facilities/support_aircraft/characteristics.html
http://geo.arc.nasa.gov/sgg/ARCTAS/presentation/RussellAGUposter_Dec2009z.pdf
http://www.livescience.com/27111-air-pollution-monitoring.html
http://discover-aq.larc.nasa.gov/instruments.php
http://science-edu.larc.nasa.gov/SCOOL/cumulus.html
http://science-edu.larc.nasa.gov/SCOOL/cirrus.html
http://espo.nasa.gov/missions/seac4rs/content/SEAC4RS_Balloon
http://www.nasa.gov/centers/goddard/news/topstory/2008/lunar_telescopes.html
http://virtualastronaut.tietronix.com/teacherportal/pdfs/How.High.Is.It.Educator.Guide.pdf

Troposphere	The troposphere is the lowest level of Earth's atmosphere. It is where the majority of weather occurs as well as where most of the gases are located. **Altitude: Extends to 17km (over the equator)**
Stratosphere	The stratosphere is the second lowest level of Earth's atmosphere. Temperature in this layer increases with altitude. This layer also contains the ozone layer. The ozone causes the temperature stratification. **Altitude: Extends to 50km**
Mesosphere	The mesosphere is the middle layer of Earth's atmosphere. In the mesosphere temperature decreases with altitude. This temperature inversion is due to increased cooling by CO_2 radiative emission. **Altitude: Extends to 80km**
Thermosphere	The troposphere is the outer layer of the Earth's atmosphere. The gases in this layer are highly diluted, but due to intense solar radiation, they can reach temperatures up to 2,500^{o}C during the day. **Altitude: Extends to 500km**

Tethered Balloon

The tethered balloon lifts a small payload to measure ozone, aerosols and meteorology in the lowest portion of the atmosphere.

Altitude: 0-0.05km

Ozonesonde

The ozonesonde is on a small balloon that is released into the atmosphere. As it rises, it measures real time concentrations of ozone, temperature, and humidity.

Altitude: Up to 30km

King Air

The King Air flies at a high altitude above the ground stations collecting data with remote sensors. It contains the High Spectral Resolution Lidar (HSRL) and the Airborne Compound Atmospheric Mapper. These two instruments provide data replicating what might be obtained from a satellite.

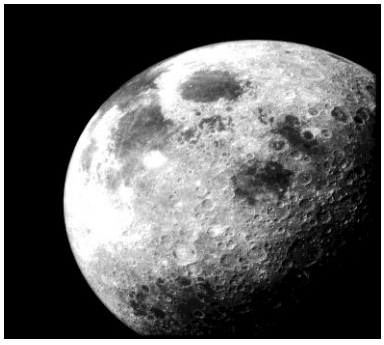
Altitude: 7.92km

P-3B

The P-3B flies up and down around the ground stations profiling the air at different heights. It collects data on ozone, carbon monoxide, and other gases and aerosols in the lower atmosphere

Altitude: 0.3-3km

Exosphere	The exosphere is the highest layer of the Earth's atmosphere. This layer is thin and gradually merges with outer space. There is no clear boundary between the two. **Altitude: Extends to anywhere between 500-1000km**
Cumulus Clouds 	Cumulus clouds are puffy or cotton-like in appearance and generally have flat bases. Normally they do not produce precipitation; however they can grow into precipitation bearing cumulonimbus clouds. Cumulus clouds are low level clouds. **Altitude: 0-2km**
Cirrus Clouds 	Cirrus clouds appear to be thin, wispy strands. They tend to be white or gray in color. They arrive in advance of a frontal system and indicate that weather may deteriorate. Cirrus clouds are high level clouds. **Altitude: 5-15km**
Ground Monitors 	Ground monitors include sun photometers and spectrometers which look through the column of the atmosphere directly at the sun. They measure the spectrum of energy reaching the surface after having passed through the atmosphere. Changes in the energy spectrum can be related to different loadings of atmospheric particles and polluting gases. **Altitude: 0km**

A-Train Satellites  CALIPSO	The A-Train is a coordinated group of satellites, in polar orbit, that cross northbound over the equator at 1:30pm within minutes of each other. The nearly simultaneous observations cover a wide range of parameters including atmospheric pollutants and particles. **Altitude: 690km**
Moon 	The Moon is the Earth's only natural satellite and the largest natural satellite in the Solar System. It is the fifth largest object in the Solar System that is not directly orbiting the Sun. **Altitude: 384,467km**

Vertical Profile of the Atmosphere

100km

Layer: _____

500km

Layer: _____

80km

Layer: _____

50km

Layer: _____

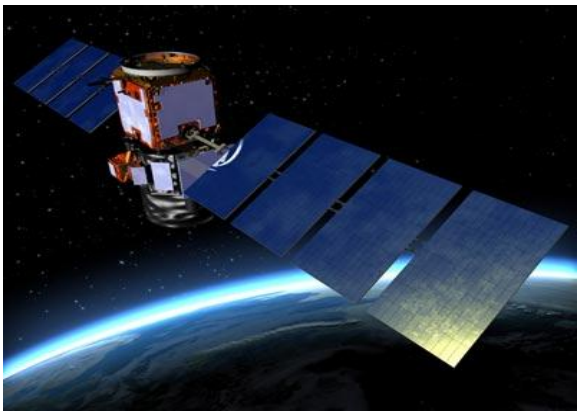
17km

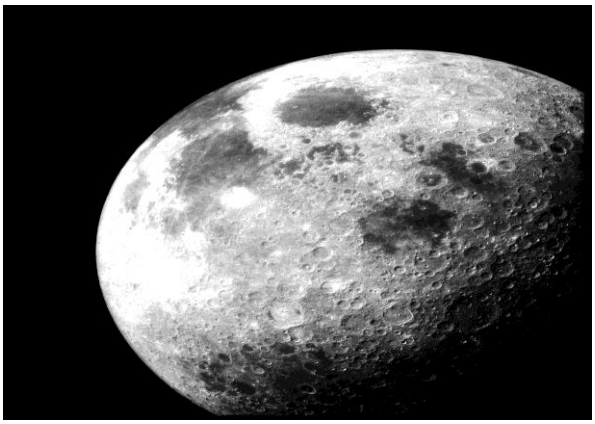
Layer: _____

Surface of the Earth

*Graphic not to scale

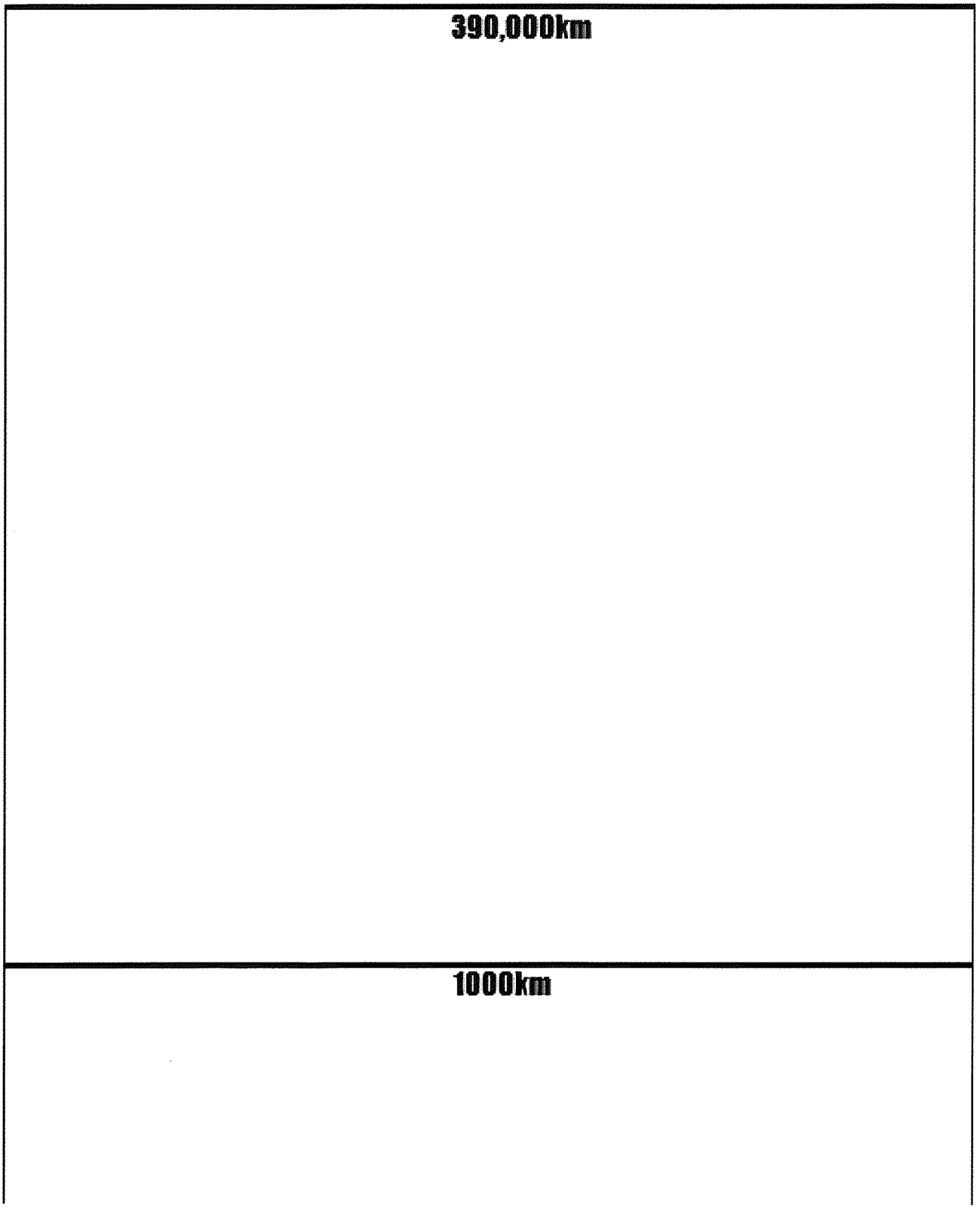
TROPOSPHERE	**STRATOSPHERE**
MESOSPHERE	**THERMOSPHERE**
EXOSPHERE	
	

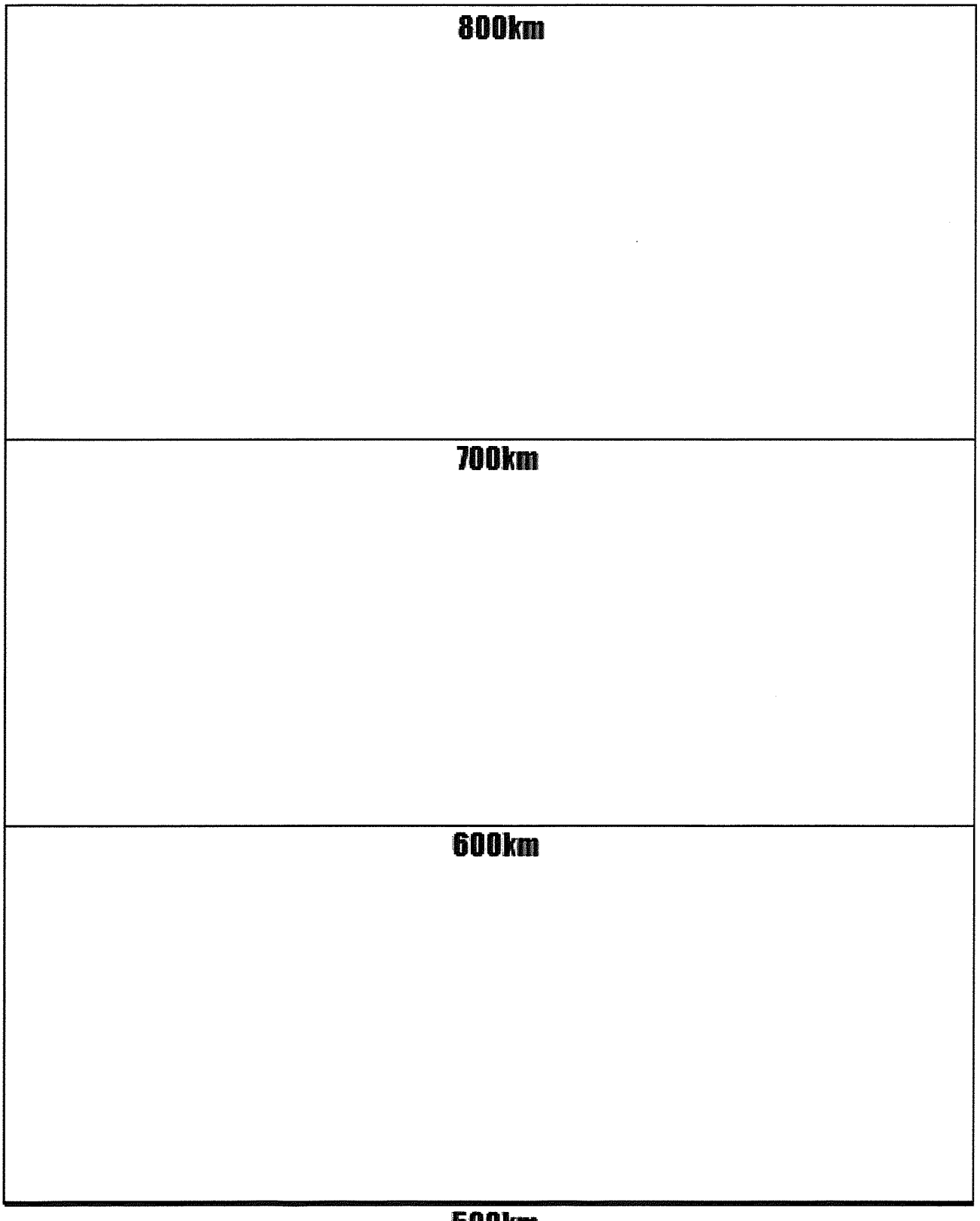


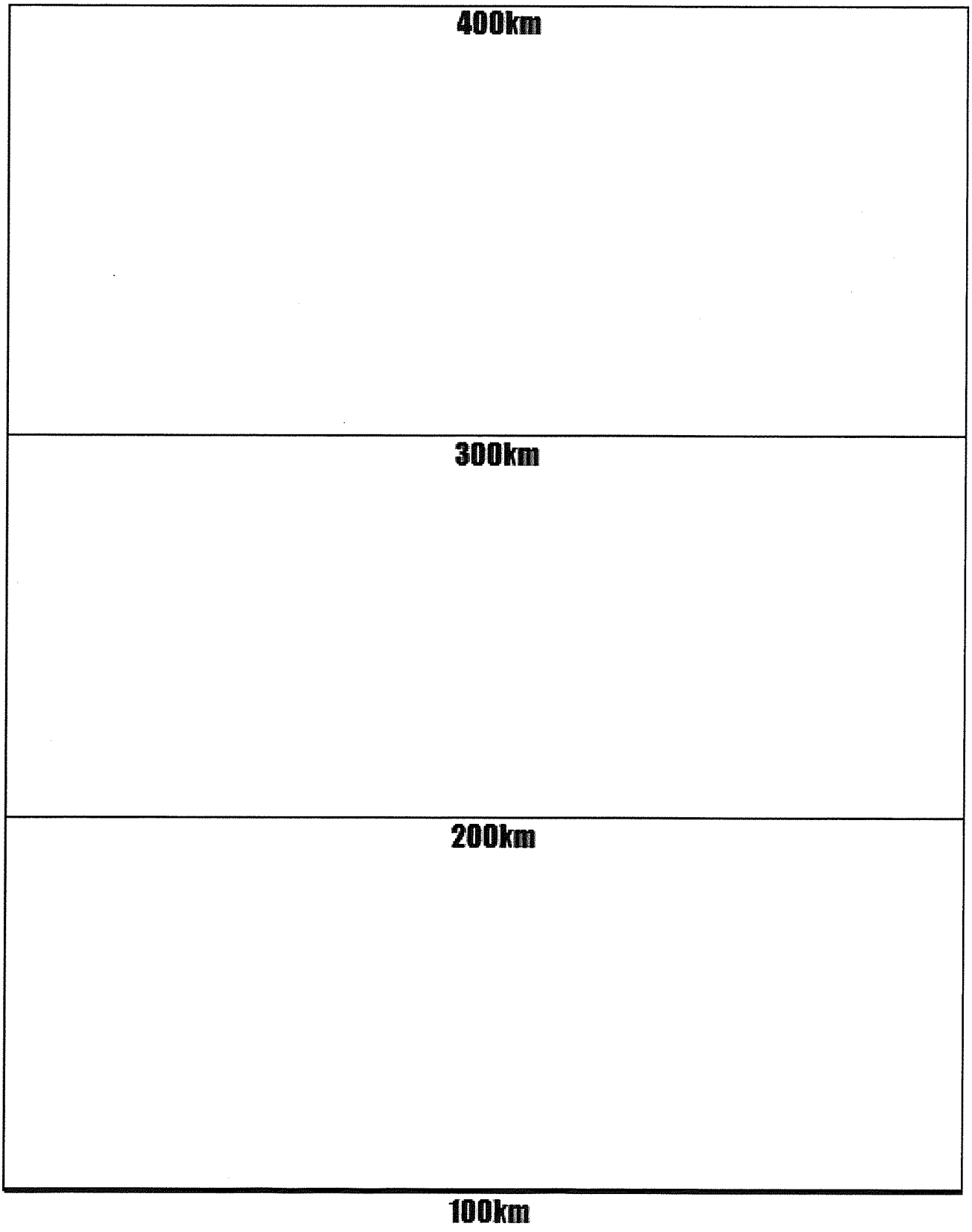


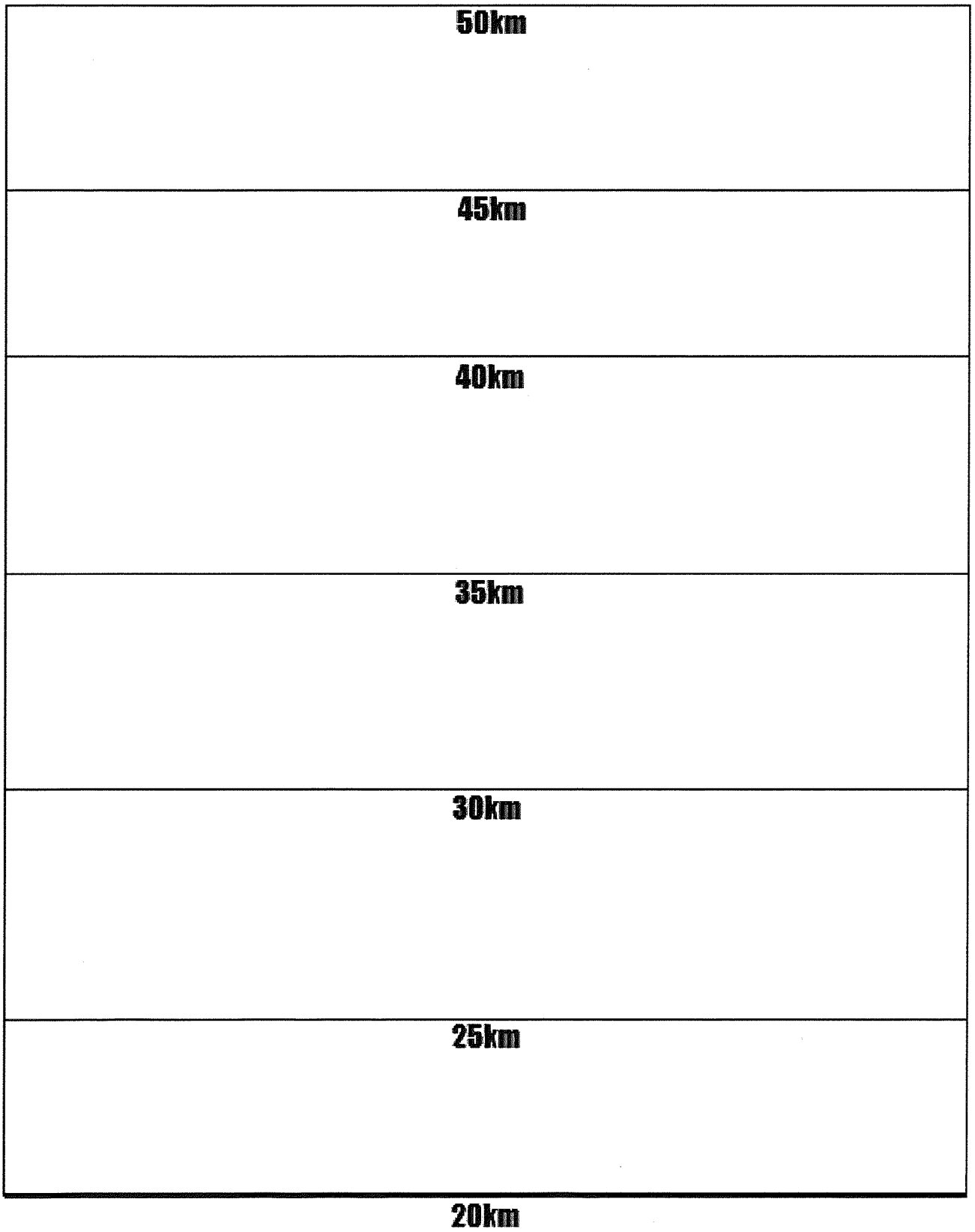
Images (from top)
Troposphere
Mesosphere
Exosphere
Cirrus Clouds
Tethered ozonesonde
King Air
A-Train satellite (CALIPSO)

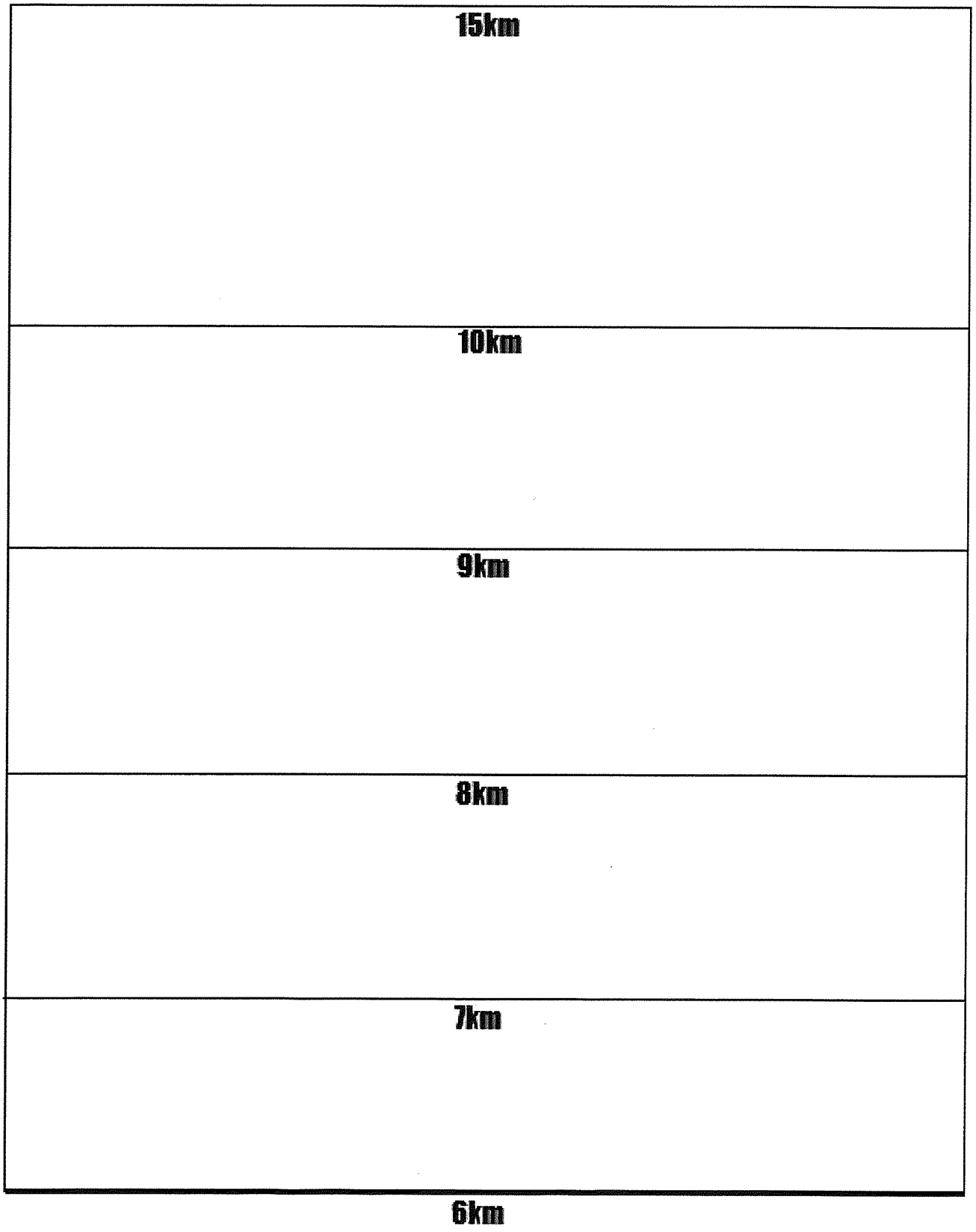
Images (from top)
Stratosphere
Thermosphere
Cumulus
Ground station
Untethered ozonesonde
P-3B
Moon

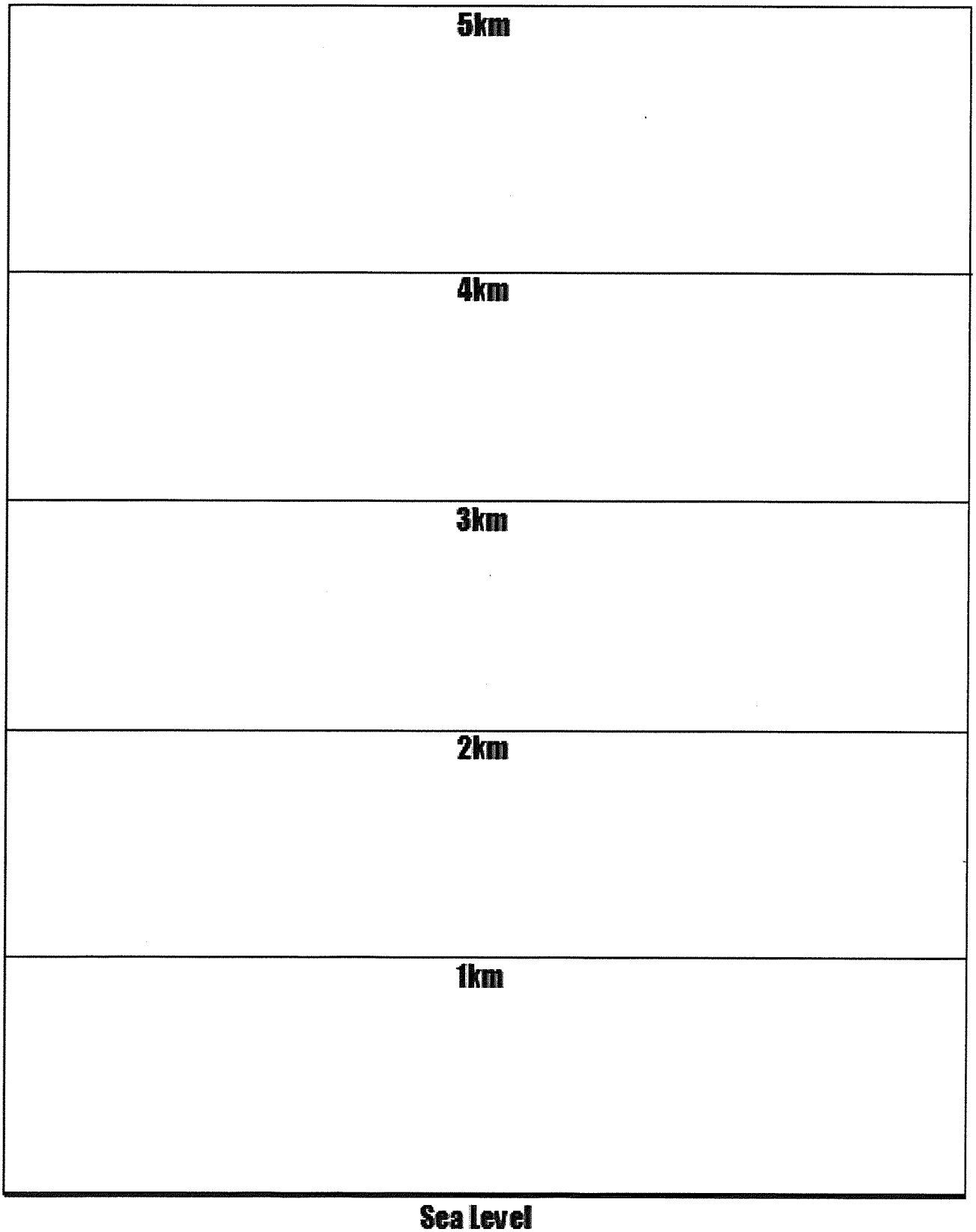

390,000km
1000km


800km
700km
600km
500km


400km
300km
200km
100km


50km
45km
40km
35km
30km
25km
20km


15km
10km
9km
8km
7km
6km


5km
4km
3km
2km
1km
Sea Level