TEACHER ANSWER KEY

Field Project Student Sheet

Project #1 HIPPO: HIAPER Pole-to-Pole Observations

Team Members:

Our Scenario:

Greenhouse Gases: What are really up there?

Research:

1. *What research questions could you ask in order to learn what you need to know for your scenario? What do you want to know?* (Hint: look at the scenario titles.)

   Students would need to collect a baseline data set of green house gases, on a global scale.

2. *Which field project will help you answer your research question and learn more about your scenario?* Once you have filled this out, check with your teacher to make sure you've selected the correct field project.

   HIPPO - HIAPER (High-performance Instrumented Platform for Environmental Research, or the NSF/NCAR Gulfstream V) Pole-to-Pole Observations field project.

3. *Which research equipment have you selected to conduct your field project?* First, select one or more platforms, and then select instruments to go on the platforms. Check off these items from the list below.

Platforms:

- ○ Research Ship
- ✓ High-flying Research Aircraft
- ○ Low-flying Research Aircraft
- ○ Research Truck

Instruments:

- ✓ Greenhouse Gas Sensors
- ○ Truck-mounted Radar
- ○ Fixed Ground-based Radar
- ○ Weather Balloon
- ○ Lightning Map Array
- ○ Buoy System
- ✓ Cloud Droplet Sensor
- ○ Dropsonde
- ○ Ship-based Radar
- ○ Solar Radiation Sensor
- ○ Ocean Salinity & Temperature Sensor
- ✓ Particle Sensor

4. Summarize the types of data produced by this field project. (Hint: look at the graphs and titles/captions for the graphs.)

   Seasonal profiles of CO_2 from HIPPO mission 1-5; approximately the North Pole to the South Pole over the Pacific Basin

UPDATED: AUG 2021

Field Project Worksheet

Project #1 HIPPO: HIAPER Pole-to-Pole Observations

5. After discussing the Data Discussion Questions with your group, record answers to the three questions here:

1. What global seasonal process do you think causes the change in CO_2 concentration in the Northern Hemisphere?

Photosynthesis causes the global change in CO_2 from the Spring to Fall months.

2. Why do you think there are similar levels of CO_2 in lower latitudes year-round? (Hint: What major producer of CO_2 is not prevalent in Antarctica?)

There are constant levels of CO_2 in the lower latitudes because there is less photosyntheses occurring. Algae produce $CO2_2$, but the vegetation on the land masses in the Northern Hemisphere produce much more.

3. Why do you think there is a constant mid-level concentration (green) of CO_2 near the equator, or 0 on the x-axis? (Hint: think about the type of vegetation found in the tropics)

There is a more consistent level of CO_2 in the tropical regions because most vegetation there is not deciduous and produces CO_2 throughout the year.

Conclusions:

6. Scientists are still analyzing the data from this field project and scientific conclusions of this research aren't available yet. Read the research summary on the Field Project Fact Sheet and look over everything you've written about the field project on this worksheet. *What has this activity taught you about the process of science?*

7. *How has the research from this field project benefitted society? Why do these findings matter to you and your future?*

Societal benefits are that scientists can better see beneficial and harmful changes in the global distribution of greenhouse gases.

8. *Do these findings help address the real-world scenario you started with? What is the evidence to support your findings?*

Yes, a baseline dataset for global greenhouse gases or CO_2 is now available.

Activity by Becca Hatheway, UCAR Center for Science Education and Alison Rockwell, Earth Observing Laboratory, NCAR

UPDATED: AUG 2021

TEACHER ANSWER KEY

Field Project Student Sheet

Project #2 DYNAMO: Dynamics of the Madden-Julian Oscillation

Team Members:

Our Scenario:

Global Climate & Weather: The Domino Effect

Research:

1. *What research questions could you ask in order to learn what you need to know for your scenario? What do you want to know?* (Hint: look at the scenario titles.)

   What type of weather or climate phenomena is large enough to effect weather and climate around the world, and what would make it start, creating the "domino effect"?

2. *Which field project will help you answer your research question and learn more about your scenario?* Once you have filled this out, check with your teacher to make sure you've selected the correct field project.

   DYNAMO - Dynamics of the Madden-Julian Oscillation

3. *Which research equipment have you selected to conduct your field project?* First, select one or more platforms, and then select instruments to go on the platforms. Check off these items from the list below.

Platforms:

- [x] Research Ship
- [x] High-flying Research Aircraft
- [x] Low-flying Research Aircraft
- [ ] Research Truck

Instruments:

- [ ] Greenhouse Gas Sensors
- [ ] Lightning Map Array
- [x] Ship-based Radar
- [ ] Truck-mounted Radar
- [x] Buoy System
- [x] Solar Radiation Sensor
- [x] Fixed Ground-based Radar
- [x] Cloud Droplet Sensor
- [x] Ocean Salinity & Temperature Sensor
- [x] Weather Balloon
- [x] Dropsonde
- [x] Particle Sensor

4. Summarize the types of data produced by this field project. (Hint: look at the graphs and titles/captions for the graphs.)

   The radar data provides a very detailed look at rain drop size and movement inside of cloud. Data from the radar and other research equipment used in the field project will help scientists determine what environmental conditions are present when the Madden-Julian Oscillation starts, or initiates.

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Field Project Student Sheet

Project #2 DYNAMO: Dynamics of the Madden-Julian Oscillation

5. After discussing the Data Discussion Questions with your group, record answers to the three questions here:

1. *Where in this data do you see the heaviest rainfall, represented by yellow and pink?*

The bottom, right corner or southeast corner of the map shows the heaviest rainfall.

2. *What do you think is the distance between the circles on the map?*

The circles on the map represent 50 kilometer spacing. The radar can see about 150 kilometers in each direction.

3. *In each cloud system, where is the rain the heaviest?*

In each rain cloud or system, the inner portions have the heaviest rainfall, depicted by yellow and orange.

Conclusions:

6. Scientists are still analyzing the data from this field project and scientific conclusions of this research aren't available yet. Read the research summary on the Field Project Fact Sheet and look over everything you've written about the field project on this worksheet. *What has this activity taught you about the process of science?*

7. *How has the research from this field project benefitted society? Why do these findings matter to you and your future?*

If scientists can determine the conditions present when the MJO initiates, weather and climate models use this data to help predict and forecast large-scale weather and climate events much more accurately and farther in advance.

The MJO is a precursor to several large scale weather climate events such as the El Niño Southern Oscillation (ENSO).

8. *Do these findings help address the real-world scenario you started with? What is the evidence to support your findings?*

Yes, knowing when the MJO will start will help determine if the cold waters form the south will bring the nutrients for a bountiful fishing season.

Activity by Becca Hatheway, UCAR Center for Science Education and Alison Rockwell, Earth Observing Laboratory, NCAR

UPDATED: AUG 2021

Field Project Student Sheet

Project #3 PREDICT: Pre-depression Investigation of Cloud Systems in the Tropics

Team Members:

Our Scenario:

Hurricanes: Why some storms turn into hurricanes and others don't

Research:

1. *What research questions could you ask in order to learn what you need to know for your scenario? What do you want to know?* (Hint: look at the scenario titles.)

   What are the environmental conditions needed in a developing storm to make it turn into a hurricane?

2. *Which field project will help you answer your research question and learn more about your scenario?* Once you have filled this out, check with your teacher to make sure you've selected the correct field project.

   PREDICT: Pre-depression Investigation of Cloud Systems in the Tropics

3. *Which research equipment have you selected to conduct your field project?* First, select one or more platforms, and then select instruments to go on the platforms. Check off these items from the list below.

Platforms:

- ○ Research Ship
- ✓ High-flying Research Aircraft
- ○ Low-flying Research Aircraft
- ○ Research Truck

Instruments:

- ○ Greenhouse Gas Sensors
- ○ Truck-mounted Radar
- ○ Fixed Ground-based Radar
- ○ Weather Balloon
- ○ Lightning Map Array
- ○ Buoy System
- ✓ Cloud Droplet Sensor
- ✓ Dropsonde
- ○ Ship-based Radar
- ○ Solar Radiation Sensor
- ○ Ocean Salinity & Temperature Sensor
- ✓ Particle Sensor

4. Summarize the types of data produced by this field project. (Hint: look at the graphs and titles/captions for the graphs.)

   A dropsonde vertical profile of atmospheric temperature, pressure, humidity, wind speed and wind direction. Scientists dropped many dropsondes into the middle of developing storms to determine the environmental conditions inside the storms with high accuracy.

   After tracking a storm to see if it turned into a hurricane or not, scientists can then go back and analyze the data of the storms that did indeed turn into hurricanes and the ones that did not.

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Field Project Student Sheet

Project #3 PREDICT: Pre-depression Investigation of Cloud Systems in the Tropics

5. After discussing the Data Discussion Questions with your group, record answers to the three questions here:

1. What is the highest speed wind recorded here in meters/second? Can you convert that to miles/hour?

Highest wind speed on graph: ~52 meters/sec or ~116 miles/hour

2. Why do you think the humidity (blue) changes so much as the dropsonde falls from the aircraft to the ocean surface? (Hint: What might the dropsonde be passing through?)

Clouds, the humidity increases in a cloud

3. Why does the pressure in millibars decrease as altitude increases?

Pressure at the surface of the Earth is 1 Atmosphere or ~1000 millibars (mb). Pressure decreases with altitude as there are less particles and molecules pushing down from above

Conclusions:

6. Scientists are still analyzing the data from this field project and scientific conclusions of this research aren't available yet. Read the research summary on the Field Project Fact Sheet and look over everything you've written about the field project on this worksheet. *What has this activity taught you about the process of science?*

7. *How has the research from this field project benefitted society? Why do these findings matter to you and your future?*

The ability to predict the development of a hurricane would have huge benefits to coastal communities in preparation and evacuation precautions.

8. *Do these findings help address the real-world scenario you started with? What is the evidence to support your findings?*

Preliminary findings show that a moist column of air that is "protected" by swirling winds is needed for a storm to develop. In the future, as storms develop, scientists can determine if the same environmental conditions are present and better determine if that storm will develop into a hurricane or not.

Activity by Becca Hatheway, UCAR Center for Science Education and Alison Rockwell, Earth Observing Laboratory, NCAR

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TEACHER ANSWER KEY

Field Project Student Sheet

Project #4 DC3: Deep Convective Clouds & Chemistry

Team Members:

Our Scenario:

Thunderstorms: Earth's Vacuum Cleaners

Research:

1. *What research questions could you ask in order to learn what you need to know for your scenario? What do you want to know?* (Hint: look at the scenario titles.)

   How are ground level pollutant "vacuumed" up by thunderstorms, and what happens to them?

2. *Which field project will help you answer your research question and learn more about your scenario?* Once you have filled this out, check with your teacher to make sure you've selected the correct field project.

   DC3: Deep Convective Clouds & Chemistry

3. *Which research equipment have you selected to conduct your field project?* First, select one or more platforms, and then select instruments to go on the platforms. Check off these items from the list below.

Platforms:

- ○ Research Ship
- ✓ High-flying Research Aircraft
- ✓ Low-flying Research Aircraft
- ✓ Research Truck

Instruments:

- ✓ Greenhouse Gas Sensors
- ✓ Truck-mounted Radar
- ✓ Fixed Ground-based Radar
- ✓ Weather Balloon
- ✓ Lightning Map Array
- ○ Buoy System
- ✓ Cloud Droplet Sensor
- ○ Dropsonde
- ○ Ship-based Radar
- ○ Solar Radiation Sensor
- ○ Ocean Salinity & Temperature Sensor
- ✓ Particle Sensor

4. Summarize the types of data produced by this field project. (Hint: look at the graphs and titles/captions for the graphs.)

   The ozone data shows ground level ozone over a three-day period, confirming that ozone is present. This data combined with data from other research equipment, especially from the aircraft, will determine the rates at which ozone is drawn up into a thunderstorm and see how it is chemically altered within the thunderstorm and then emitted from the thunderstorm.

   NOTE: Since dropsondes are not typically released over land, weather balloons were used throughout this land-based field project. Both collect atmospheric temperature, pressure, humidity, wind speed and wind direction. Weather balloons are easier to launch for land, dropsondes are easier to launch from an aircraft and are costlier. An aircraft can cover a greater region. Neither are recovered, it is not cost effective to do so.

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Field Project Student Sheet

Project #4 DC3: Deep Convective Clouds & Chemistry

5. After discussing the Data Discussion Questions with your group, record answers to the three questions here:

1. What time of day are ozone concentrations the highest?

Ozone concentrations are highest around 6:00pm. Sunlight has had been radiating throughout the day, reacting with ground level pollutants to create ozone. UV rays are at their highest concentrations when the sun is overhead in the mid- to late-afternoon.

2. At what altitudes are ozone concentration the highest and why do you think that is?

Ozone concentrations are highest closest to the ground, because that is where most of the pollution (from vehicle emissions) is generated.

3. Why are ozone levels low at night?

Ozone levels are lowest at night, because there is no sunlight, or UV radiation, to react with pollution to generate ozone.

Conclusions:

6. Scientists are still analyzing the data from this field project and scientific conclusions of this research aren't available yet. Read the research summary on the Field Project Fact Sheet and look over everything you've written about the field project on this worksheet. *What has this activity taught you about the process of science?*

7. *How has the research from this field project benefitted society? Why do these findings matter to you and your future?*

The data collected during DC3 will help scientists and researchers develop more accurate climate and weather models. Knowing how ground level pollutants affects the upper troposphere will have great impact on weather prediction, as well as establishing regulations for vehicle and power plant emission levels.

8. *Do these findings help address the real-world scenario you started with? What is the evidence to support your findings?*

Yes, scientists now have a better understanding of the role that ground level pollutants (ozone) has on the upper troposphere, a region that is critical in cloud production. If the effects are harmful, stricter regulations can be made on offending producers of pollutants. Climate models will also be better able to predict the seasonal rainfall levels so early season water storage can be addressed.

Activity by Becca Hatheway, UCAR Center for Science Education and Alison Rockwell, Earth Observing Laboratory, NCAR

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