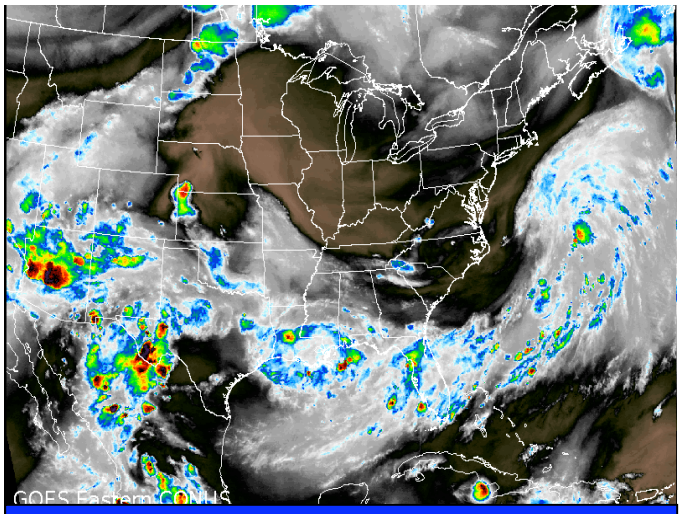
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

A Comparison Study of Water Vapor data To Precipitation over North America


Enhanced Water Vapor Image

Purpose: To provide students with the opportunity to use NASA satellite data to compare and contrast water vapor (precipitable water) data with precipitation over the United States (Jan 1994 – Jun 2005)

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Grade Level: Grades 10 – 12

Estimated Time for Completing Activity: 3 - 50 minute periods / 2 - 90 minutes blocks

Vocabulary: water vapor, precipitation, radar, weather, climate, clouds, precipitable water, centimeter, millimeter, troposphere, evaporation, condensation, transpiration, sublimation, deposition and greenhouse effect.

Prerequisite: Familiarity with Excel spreadsheet program, MY NASA DATA website, and water vapor satellite imagery.

Tools: Laptop Computers, Excel software, printer, calculators – optional, water vapor imagery tutorial.

Outcomes:

- Understand the relationship between atmospheric moisture (precipitable water) and precipitation
- Basic understanding and interpretation of Water Vapor imagery
- Basic understanding and use of Excel spreadsheets
- How different earthly spheres interact

National Standards of Learning: TEACHING STANDARD D

Teachers of science design and manage learning environments that provide students with the time, space, and resources needed for learning science. In doing this, teachers

- Structure the time available so that students are able to engage in extended investigations.
- Create a setting for student work that is flexible and supportive of science inquiry.
- Ensure a safe working environment.
- Make the available science tools, materials, media, and technological resources accessible to students.
- Identify and use resources outside the school.
- Engage students in designing the learning environment.

Pennsylvania Standards of Learning:

3.1 Unifying Themes
- A. Systems
- B. Models
- C. Patterns
- D. Scale
- E. Change

3.2 Inquiry and Design
- B. Process Knowledge
- D. Problem Solving in Technology

3.5 Earth Sciences
- C. Meteorology

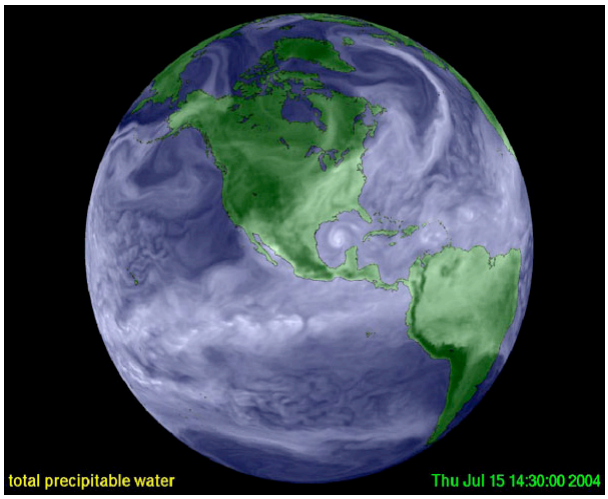
3.6 Technological Devices
- A. Tools
- B. Instruments
- C. Computer Operations
- D. Computer Software

3.7 Science, Technology and Human Endeavors
- A. Constraints
- B. Meeting Human Needs
- C. Consequences and Impacts

Background:

Water Vapor - aqueous vapor, is the gas phase of water. Water vapor can be produced from the evaporation of liquid water or from the sublimation of ice. Under normal atmospheric conditions water vapor is continuously evaporating and condensing. Gaseous water

represents a small but environmentally significant constituent of the atmosphere. Most of it is contained in the troposphere. Besides accounting for most of Earth's natural greenhouse effect, which warms the planet, gaseous water also condenses to form clouds, which may act to warm or cool, depending on the circumstances. In general terms, atmospheric water strongly influences, and is strongly influenced by weather, and weather is modified by climate.



The average residence time of water molecules in the troposphere is about 10 days. Water depleted by precipitation is replenished by evaporation from the seas, lakes, rivers and the transpiration of plants, and other biological and geological processes.

The annual mean global concentration of water vapor would yield about 25 mm of liquid water over the entire surface of the Earth if it were to instantly condense. However, the mean annual precipitation for the planet is about 1 meter, which indicates a rapid turnover of water in the air.

Precipitation - Precipitation is any form of liquid or solid water particles that fall from the atmosphere and reach the surface of the Earth. Different seasons and geographic locations see varying amounts of precipitation in amount and intensity. Precipitation is caused when a mass of warm, moist air hits a mass of cold air. Condensation causes the moisture to form droplets that become rain or crystals (deposition) that become snow or ice. When these droplets or crystals become too heavy to be suspended in the atmosphere, they fall to Earth as precipitation.

Symbol	Meaning
R	Rain
RW	Rain Shower
HAIL	Hail
S	Snow
IP	Ice Pellets
SW	Snow Shower
L	Drizzle
T	Thunderstorm
ZR, ZL	Freezing Precipitation

Procedure: Part I – Generating a Comparison Graph

1. Have students open the MY NASA DATA website using the following URL address: http://mynasadata.larc.nasa.gov/data.html
2. At this point under Features, students should click on the 'Live Access Server' (Advanced Edition)
3. Then click on 'Atmosphere' under Select Dataset
4. Choose Atmospheric Water Vapor

5. Under Dataset variable(s): 'Check' **both** boxes - Monthly Lower & Upper Troposphere Precipitable Water
6. On Left-hand side, click on blue tab – compare two
7. Under **data set 2** – in gray block near top of page – click on >atmosphere>
8. Choose precipitation and click in the radio button to the left
9. Click on 'red' **next >** on the right hand side of screen
10. **Follow the next steps very carefully** – under Select View choose time series (t)
11. Under Select Output choose Overlay Plot
12. Under Select Region choose North America
13. Scroll down and enter the following dates – **January 15, 1994** and **June 15, 2005**
14. Click Variable 2 radio button in the gray bar
15. Finally, click on the 'red' **next**
16. **Wait a few seconds**, a comparison graph should appear – study the graph carefully. Answer the Question listed below and save data to a file on your desktop for later use – label file – "MYNASADATA".

Questions: According to the graph generated, *what correlation, if any, can you make about atmospheric water vapor (precipitable water) and precipitation?* Please explain – be specific and use details.

Procedure: Part II – Raw Data Comparison Study

1. Again, have students open the MY NASA DATA website using the following URL address: http://mynasadata.larc.nasa.gov/data.html
2. At this point under Features, students should click on the 'Live Access Server' (Advanced Edition)
3. Then click on 'Atmosphere' under Select Dataset
4. Choose: Atmospheric Water Vapor
5. Under Dataset variable(s): 'Check' **both** boxes - Monthly Lower & Upper Troposphere Precipitable Water
6. Click on 'red' **next >** right hand side of screen
7. **Follow the next steps very carefully** – under Select View choose time series (t)
8. Under Select Output choose Table of Values (text)

9. Under Select Region choose North America
10. Scroll down and enter appropriate dates – **January 15, 1994 and June 15, 2005**
11. Finally, click on the 'red' next >
12. **Wait a few seconds** and a list of raw data by date should appear – label (**water vapor**) and save as file (format – **text file**) to desktop – *file already created in part I.*
13. Close raw data file after saving
14. Back on MYNASA DATA WEBSITE - In top gray bar after datasets – click on atmosphere
15. Click on precipitation
16. Click in box to left of precipitation
17. Click on 'red' **next >** right hand side of screen
18. **Follow the next steps very carefully** – under Select View choose time series (t)
19. Under Select Output choose Table of Values (text)
20. Under Select Region choose North America
21. Scroll down and enter appropriate dates – **Jan 1, 1994 and Jun 1, 2005**
22. Finally, click on the 'red' **next >**
23. Wait a few seconds and a list of raw data by date should appear – label (**Precipitation**) and save as file (format – **text file**) to desktop – *file already created in part I*

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24. Remainder of activity will be preformed in **Excel** or similar spreadsheet software

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25. In **Excel**, open a blank spreadsheet
26. Under Data – top menu bar, choose Get External Data - find folder created on desktop
27. Choose import text file
28. Choose 'saved' **water vapor files** to import into Excel – import both upper and lower level water vapor files
29. Follow Excel suggestions to import data into a usable format – **ex**. Fixed width, etc.
30. Repeat this procedure to import 'saved' **precipitation** file into the same spreadsheet as water vapor

IMPORTANT At this point students must place data in appropriate columns and rows to do a comparison study. This may take a fair amount of formatting work – make sure columns and rows match up as well as possible – delete data not needed. Take your time – this will save you some work later when asked - *What does the raw data show?*

31. **Proceed to the Questions portion of this activity**

Questions:

1. How much water vapor (precipitable water) is available in the atmosphere during this time period? What is the time period (duration) of this study?

2. How much precipitation falls during this time period?
3. Does all precipitable water fall as precipitation? If not, how much precipitable water still exists in the atmosphere after the precipitation amount is removed? *Convert amount into a percent*.
4. What summary statement can you now make about the relationship between water vapor (precipitable water) and precipitation? Answer should be in sentence format.

5. Real Time Study – using the Waynesboro School District weather page – log in to WeatherTap site at: http://www.weathertap.com

   - Select 'satellite' from top menu and choose 'satellite home'
   - Scroll down to second U.S. map and click on 'eastern U.S.'
   - Look at 'visible' image to find area of heavy cloud cover
   - Then change image type to 'water vapor'
   - Now, click on 'enhanced' to bring up enhanced water vapor image
   - Click on 'animate' if desired
   - From top menu again select 'satellite' and then on 'tutorial'

6. Explain how to read / interpret black and white – color enhanced images. Include Information on 'scales' for each type of image.
7. What is the value of water vapor imagery to meteorologists?

Extensions:

- Compare answers from this study (water vapor image) to another geographic location – summarize results.
- Have students work through **GLOBE** program water vapor protocol – students will need a calibrated water vapor meter.
- **MODIS** water vapor site – compare various images

Related Links:

My NASA Data website
http://mynasadata.larc.nasa.gov/data.html

WeatherTap Website – Satellite images
http://www.weathertap.com/

Satellite Finds Warming "Relative" to Humidity
http://earthobservatory.nasa.gov/Newsroom/NasaNews/2004/2004031516663.html

A Warmer World Might Not Be a Wetter One
http://www.nasa.gov/centers/goddard/news/topstory/2005/warm_wetworld_prt.htm

GOES Eastern US SECTOR Water Vapor Image
http://www.goes.noaa.gov/index.html

GOES EAST Image Search
http://www.goes.noaa.gov/srcheast.html

Precipitable Water Images
http://cimss.ssec.wisc.edu/goes/rt/viewdata.php?product=pwa_sn

Current and Anticipated Precipitation Anomalies over the U.S.
http://www.cdc.noaa.gov/Drought

Teacher notes:

Extremely Important - Measurements of water vapor amounts (*precipitable water*) will be expressed in centimeters (**cm**). Those amounts must then be converted to millimeters (**mm**) to match precipitation measurement units. This will allow for easier comparison studies in part two using the Excel program. Students may need some basic instruction on formulas to use and how to insert formulas needed to determine results.