

Water Spotters

Tracking the hydrologic cycle from atoms to the globe

David Noone

Department of Atmospheric and Oceanic Sciences and
Cooperative Institute for Research in Environmental Sciences
University of Colorado, Boulder



Supported by National Science Foundation
Climate and Large-scale Dynamics
Arctic System Science, and Paleoclimate

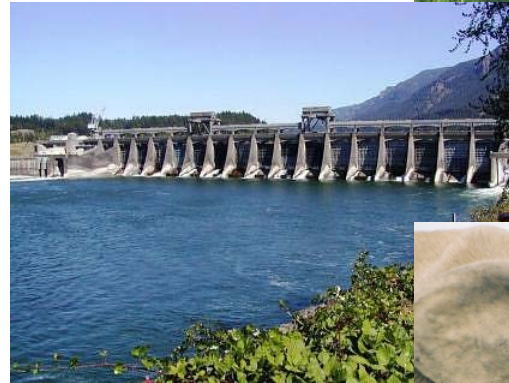


Why does water matter?

- Agriculture
(In Colorado 90% of water is used for agriculture)
- Power generation
(hydroelectric, steam for coal, cooling for nuclear)
- Ecosystem nutrient supply/export
- Recreation

Also, water...

- *Is the ocean*
- *Is a potent greenhouse gas*
- *Heats the atmosphere*

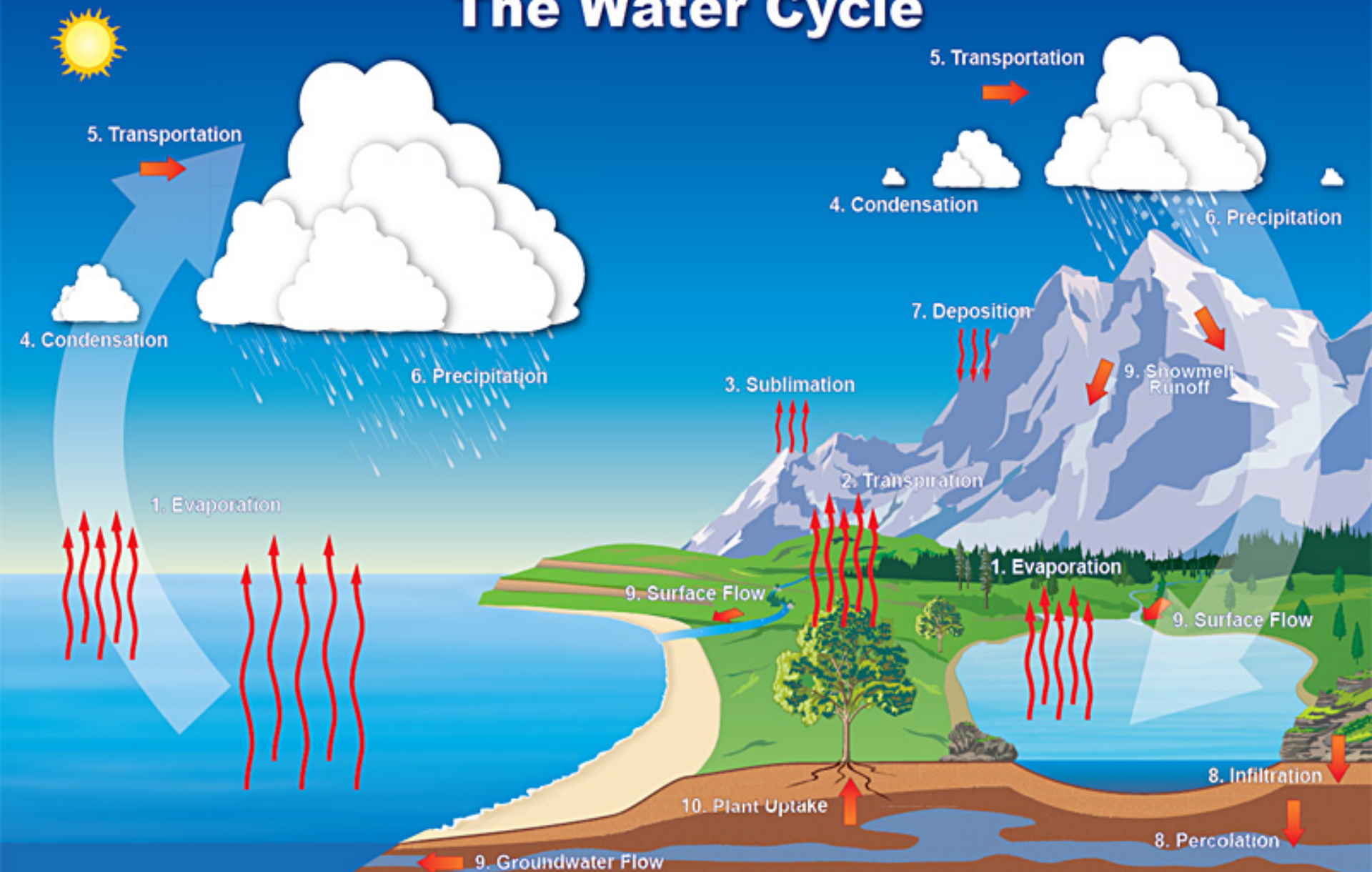


Photos of Earth
shows us the water cycle



Apollo 17, 1972

The Water Cycle



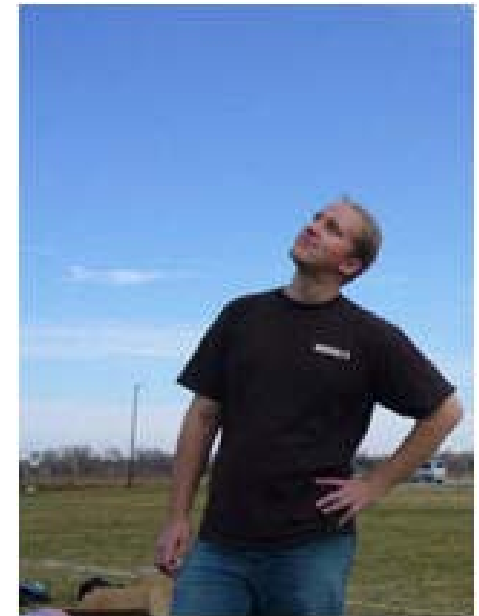
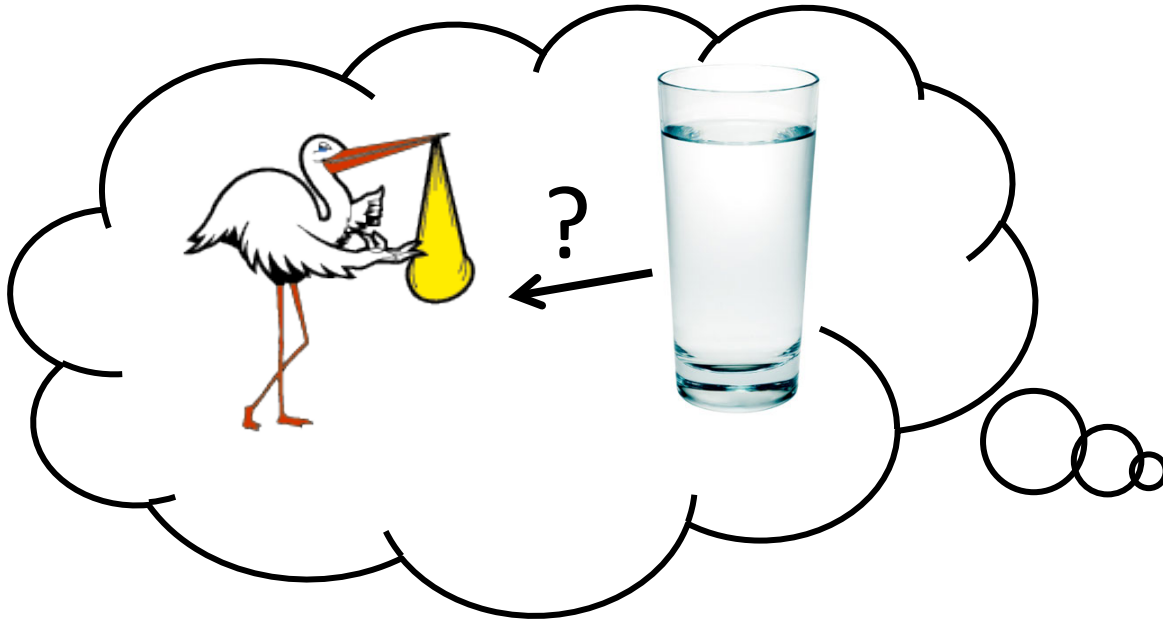
1. Evaporation is the change of state of water (a liquid) to water vapor (a gas). On average, about 47 inches (120 cm) is evaporated into the atmosphere from the ocean each year.
2. Transpiration is evaporation of liquid water from plants and trees into the atmosphere. Nearly all (99%) of all water that enters the roots transpires into the atmosphere.
3. Sublimation is the process where ice and snow (a solid) changes into water vapor (a gas) without moving through the liquid phase.
4. Condensation is the process where water vapor (a gas) changes back into water droplets (a liquid). This is when we begin to see clouds.
5. Transportation is the movement of solid, liquid and gaseous water through the atmosphere. Without this movement, the water evaporated over the ocean would not precipitate over land.
6. Precipitation is water that falls to the earth. Most precipitation falls as rain but includes snow, sleet, drizzle, and hail. On average, about 39 inches (100 mm) of rain, snow and sleet fall each year around the world.
7. Deposition is the reverse of sublimation. Water vapor (a gas) changes into ice (a solid) without going through the liquid phase. This is most often seen on clear, cold nights when frost forms on the ground.
8. Infiltration is the movement of water into the ground from the surface. Percolation is movement of water past the soil going deep into the groundwater.
9. Surface flow is the river, lake, and stream transport of water to the oceans. Groundwater is the flow of water underground in aquifers. The water may return to the surface in springs or eventually seep into the oceans.
10. Plant uptake is water taken from the groundwater flow and soil moisture. Only 1% of water the plant draws up is used by the plant. The remaining 99% is passed back into the atmosphere.





Out in Colorado...

Where does our precipitation come from?



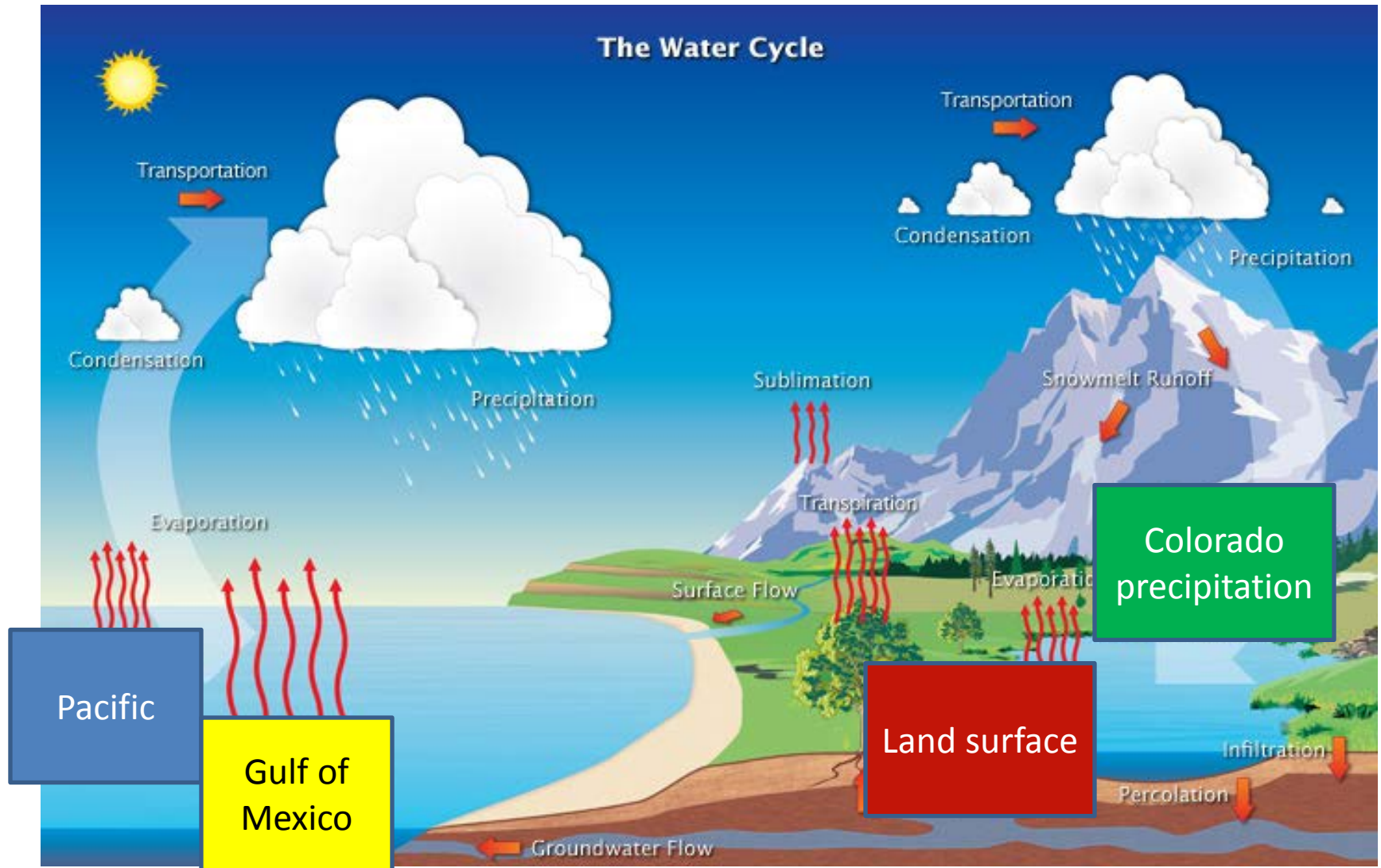
Graduate student Jesse Nusbaumer ponders the origin of precipitation

Boulderado hotel, corner of Spruce and 13th street in Boulder



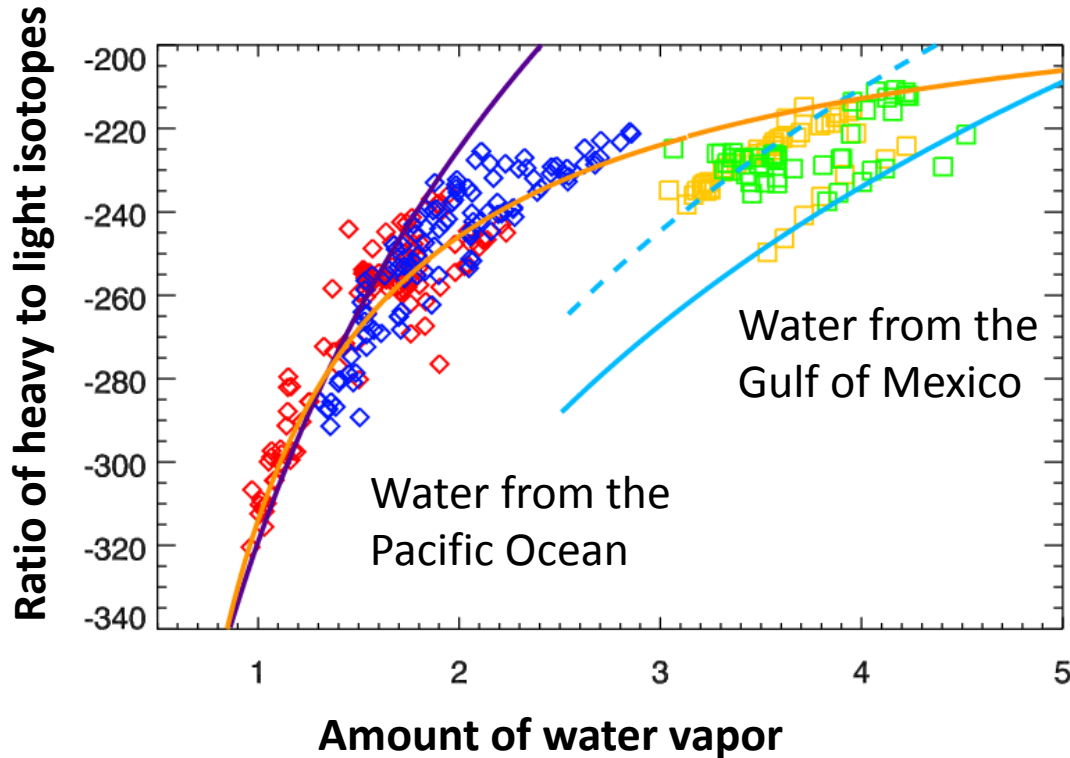


What fraction of Colorado precipitation comes from different places?



Back in Colorado

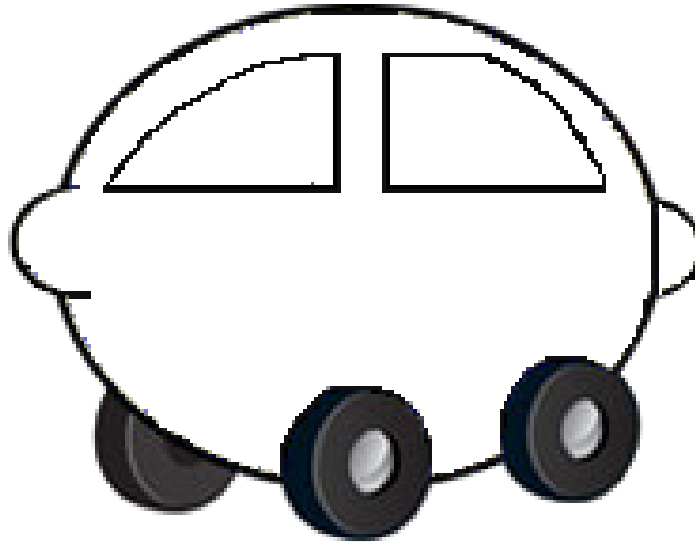
Where does our precipitation come from?



I know water is H_2O .
And I know H and O have
different isotopes,
which are a label.



Jesse has a hypothesis!



Lemona

Tyler DeWitt

Oxygen atoms and isotopes

- ^{16}O

p: 8

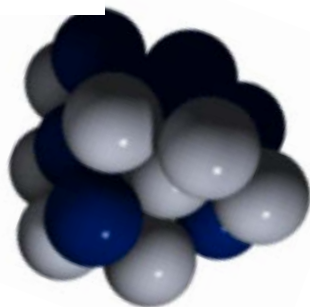
n: 8



- ^{17}O

p: 8

n: 9



- ^{18}O

p: 8

n: 10



Lemona - G



Radio
Leather seats
yellow

Lemona - GX



CD Player
cloth seats
red

Lemona - GXL

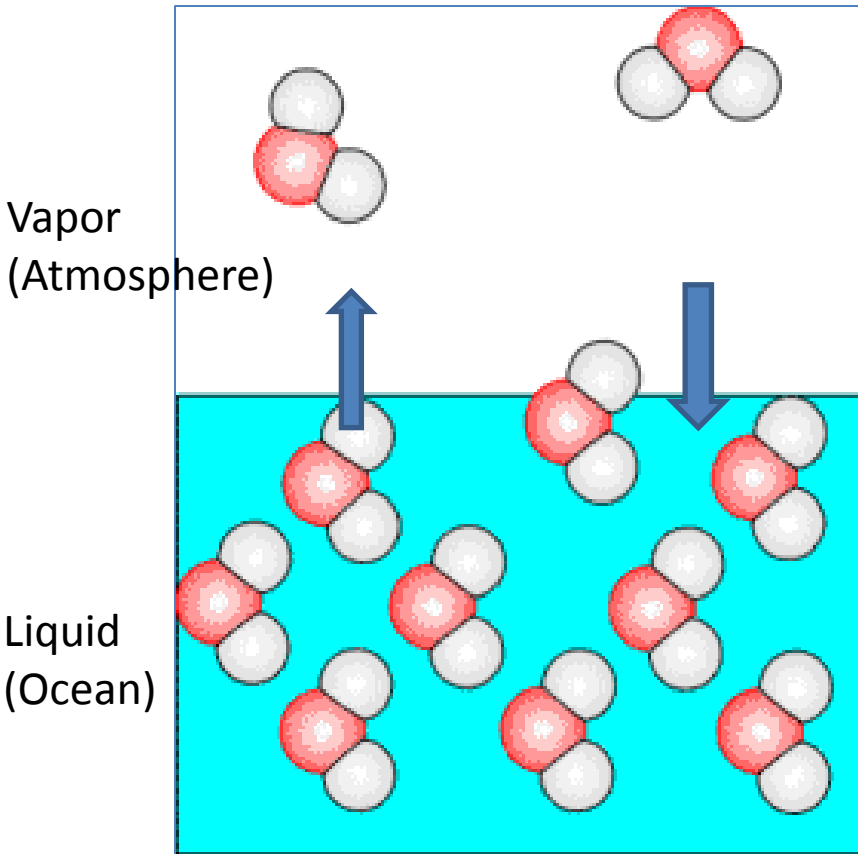


Chrome wheels
Heated seats
blue

Where does rain in Colorado come from?



A closer look at evaporation



Water molecules continually moving

Occasionally,

a molecule will escape the liquid

Occasionally,

a molecule to plunge into the liquid

If more go out than in,

we call it **evaporation**

If more go in than out,

we call it **condensation**

It is more likely that lighter isotopes jump out of the liquid.

So, ratio of heavy to light isotopes can be used to figure out what fraction of water remains in ocean or atmosphere

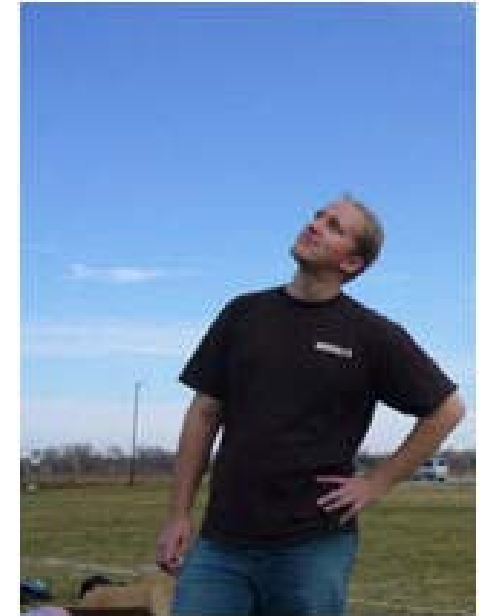
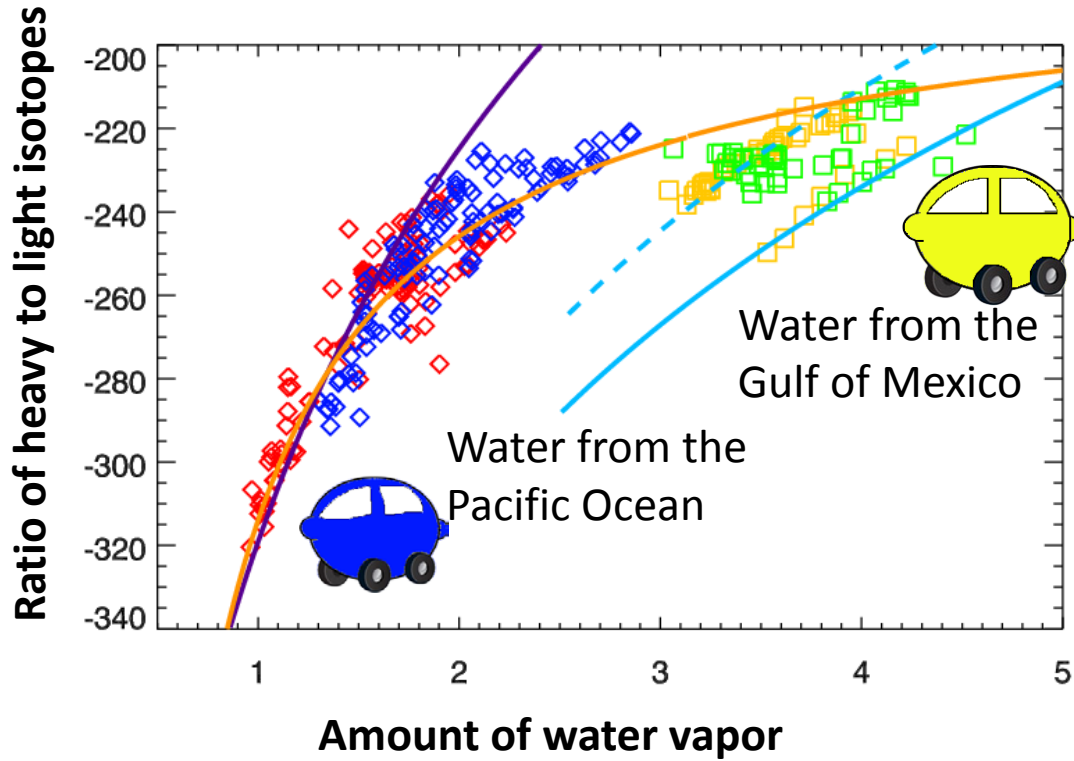
A little bit of physics....

- Consider a cat in a box..



Notion of “likelihood” and “preference” essential element

Back in Colorado



Summit Camp, Greenland

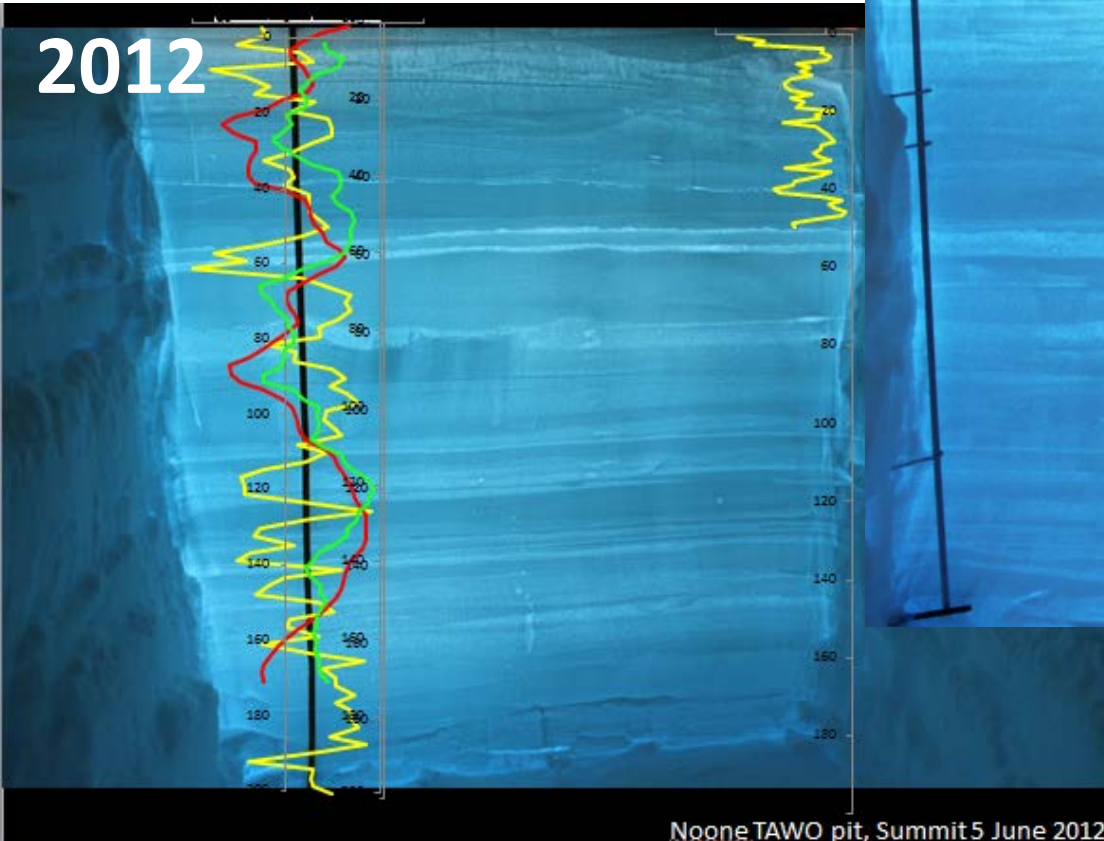




© Joe Raedle/Getty Images

Snow piles in layers

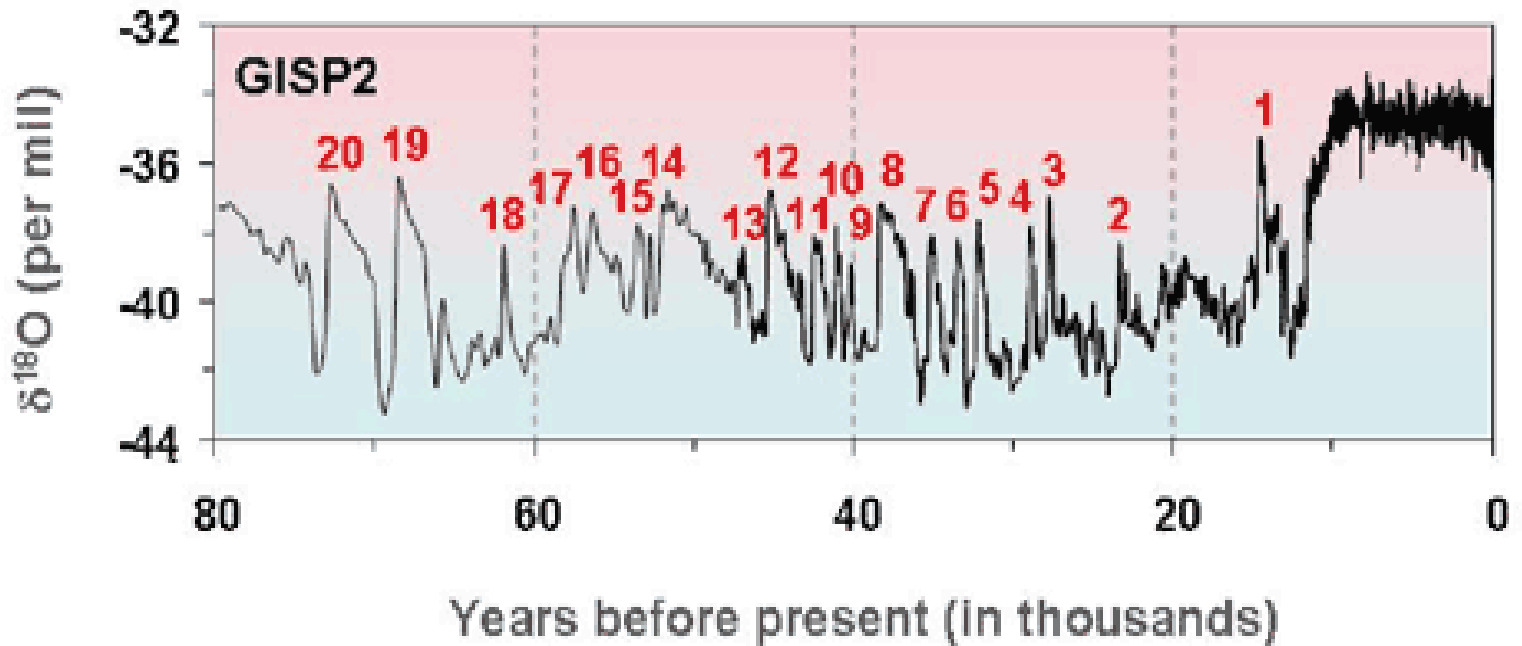
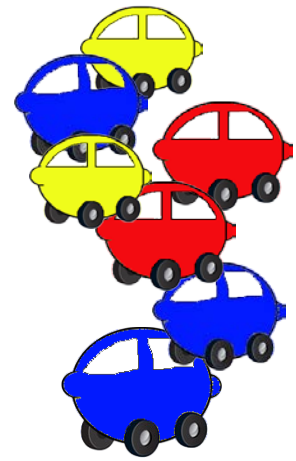
Layering gives a time history
Each snow event is the tick of a clock.





© Joe Raedle/Getty Images

Isotopes give record of past water cycles



Water spotters: what's the color of your water?

- Isotopes are a label.
- Used to figure out how water moves around (*between ocean, atmosphere, land, ice sheets*)
- The label comes from differences in evaporation and condensation in the history of the precipitation (*changes at a molecular scale influence the global scale*)
- Knowing how this works, it can be used to understand
 - changing patterns of precipitation
 - how climate has changed in the past



<http://cires.colorado.edu/education/outreach/waterspotters/>

http://www.nsf.gov/news/special_reports/science_nation/waterspotters.jsp

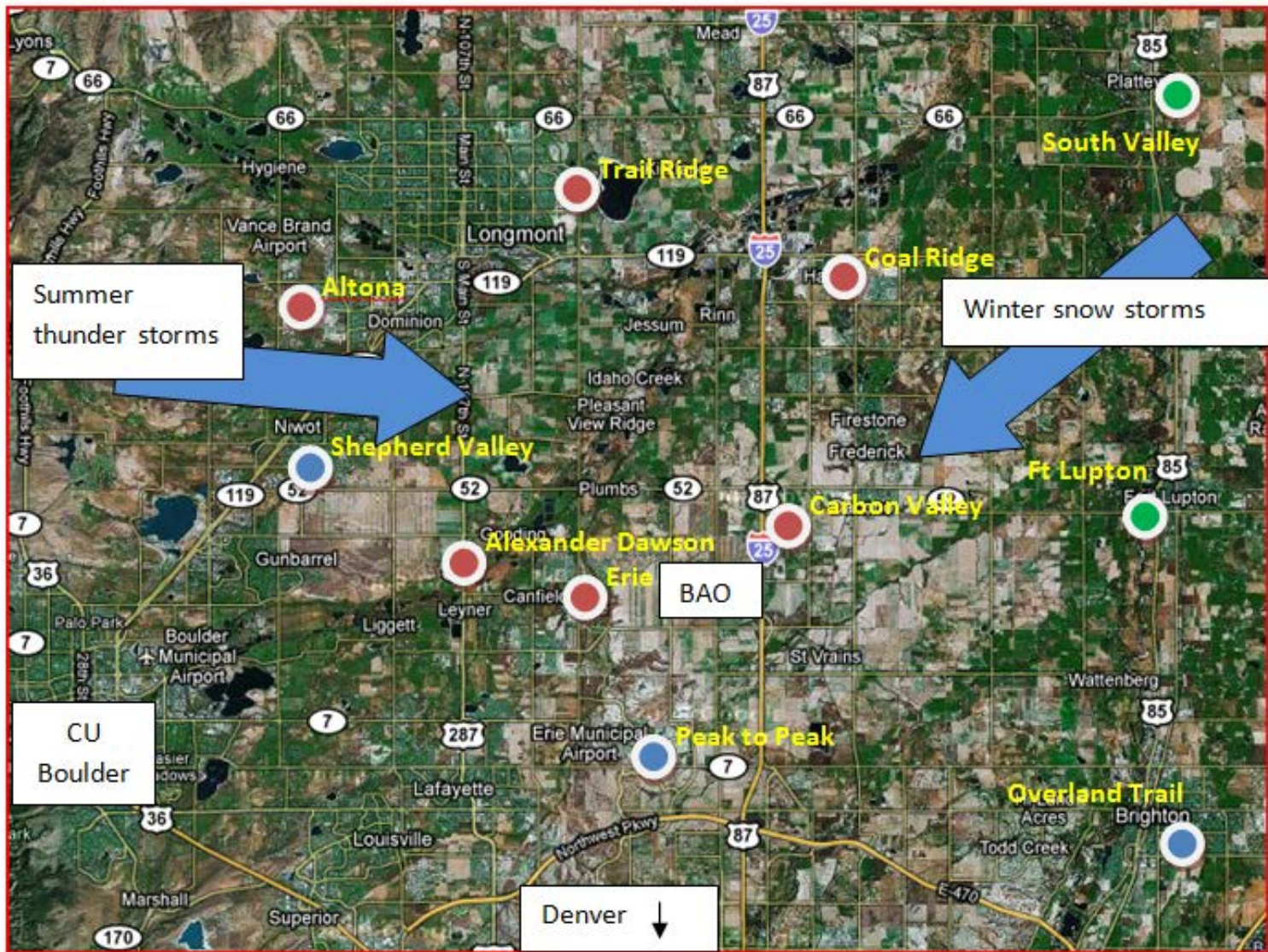
David Noone (dcn@colorado.edu) climate.colorado.edu

Water Spotters program

NSF supported study of water cycle in Colorado

- Multi level student involvement:
- Grad students
- Undergraduate students helping in lab tasks
- Middle school student helping with rain water sample collection
- (Also curriculum modules for science teachers and professional development under a MESA program)

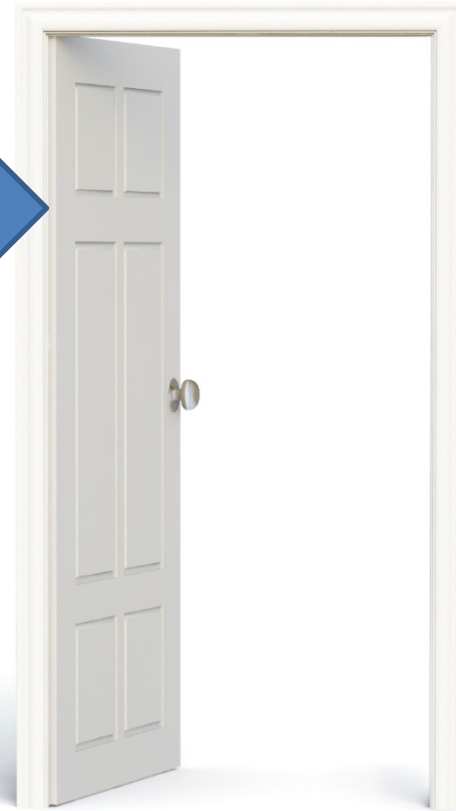
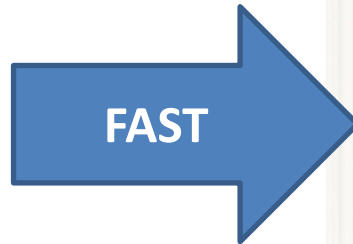




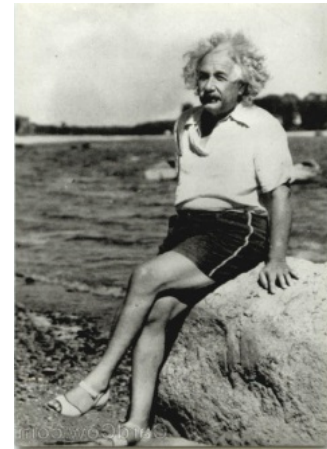
-  Schools in St Vrain Valley School District
-  Schools in Mean School District
-  Other: Boulder Valley School District, Brighton School District

Isotope physics 2

- Consider 100 small cats running out the door...



- Versus 100 big cats



Einstein, 1906