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Pacific Islands Water Science Center

The Water Cycle in Hawai‘i

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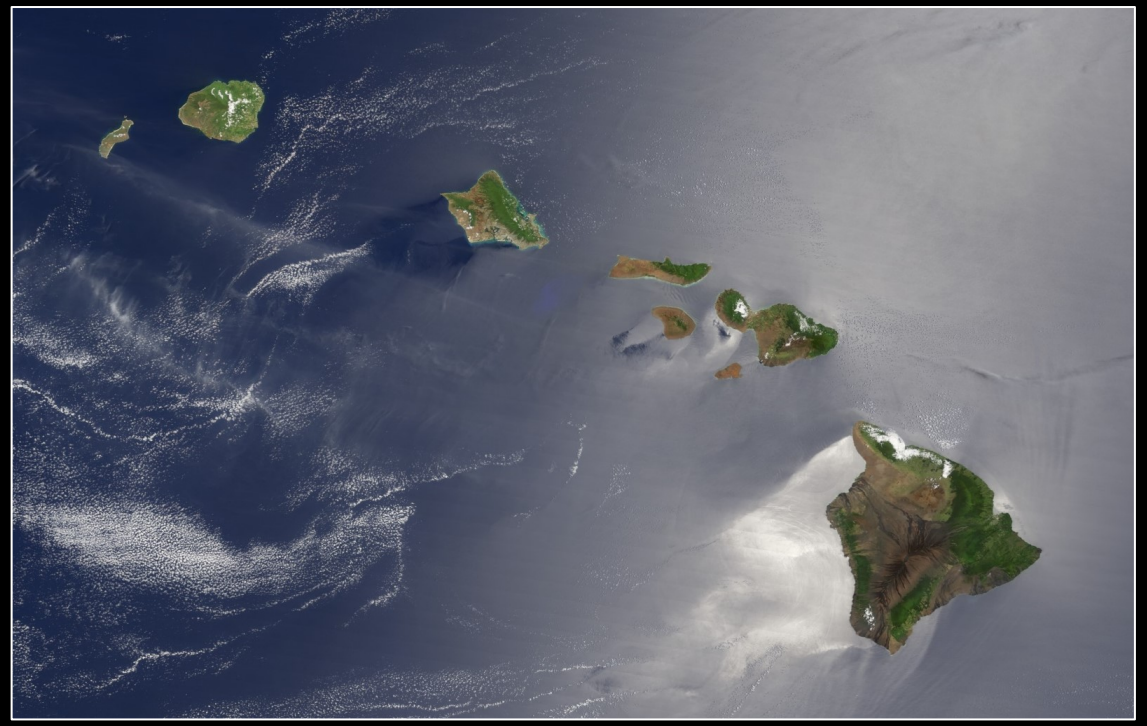
U.S. Geological Survey

EARTH 2023 Workshop
July 11, 2023



https://earthobservatory.nasa.gov/images/3510/hawaiian-islands

The Water Cycle: A Matter of Scale

The Water Cycle

COMPLETED

By Water Science School October 2, 2022

• Water Science School HOME • Water Cycle Diagrams • Glossary of Water Cycle Terms • Water Pools and Fluxes Data Tables

What is the water cycle?

The water cycle describes where water is on Earth and how it moves. Water is stored in the atmosphere, on the land surface, and below the ground. It can be a liquid, a solid, or a gas. Liquid water can be fresh or saline (salty). Water moves between the places it is stored. Water moves at large scales, through watersheds, the atmosphere, and below the Earth's surface. Water moves at very small scales too. It is in us, plants, and other organisms. Human activities impact the water cycle, affecting where water is stored, how it moves, and how clean it is.

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Viewed from space, the most striking feature of our planet is the water. In both liquid and frozen form, it covers 75% of the Earth's surface. It fills the sky with clouds. Water is practically everywhere on Earth, from inside the planet's rocky crust to inside the cells of the human body (NASA). What's important to keep in mind is that all of this water is in constant motion across our planet.

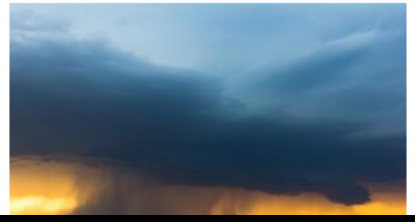
Credit: NASA

Pools store water

Oceans store 96% of all water on Earth. Ocean water is saline, meaning it's salty. On land, saline water is stored in saline lakes. The rest of the water on Earth is fresh water. Fresh water is stored in liquid form in freshwater lakes, artificial reservoirs, rivers, and wetlands. Water is stored in solid, frozen form in ice sheets and glaciers, and in snowpack at high elevations or near Earth's poles. Water vapor is a gas and is stored as atmospheric moisture over the ocean and land. In the soil, frozen water is stored as permafrost and liquid water is stored as soil moisture. Deeper below ground, liquid water is stored as groundwater in aquifers. Water in groundwater aquifers is found within cracks and pores in the rock.

Fluxes move water between pools

As it moves, water can change form between liquid, solid, and gas. Circulation mixes water in the oceans and transports water vapor in the atmosphere. Water moves between the atmosphere and the surface through evaporation, evapotranspiration, and precipitation. Water moves across the surface through snowmelt, runoff, and streamflow. Water moves into the ground through infiltration and groundwater recharge. Underground, groundwater flows within aquifers. Groundwater can return to the surface through natural discharge into rivers, the ocean, and from springs.

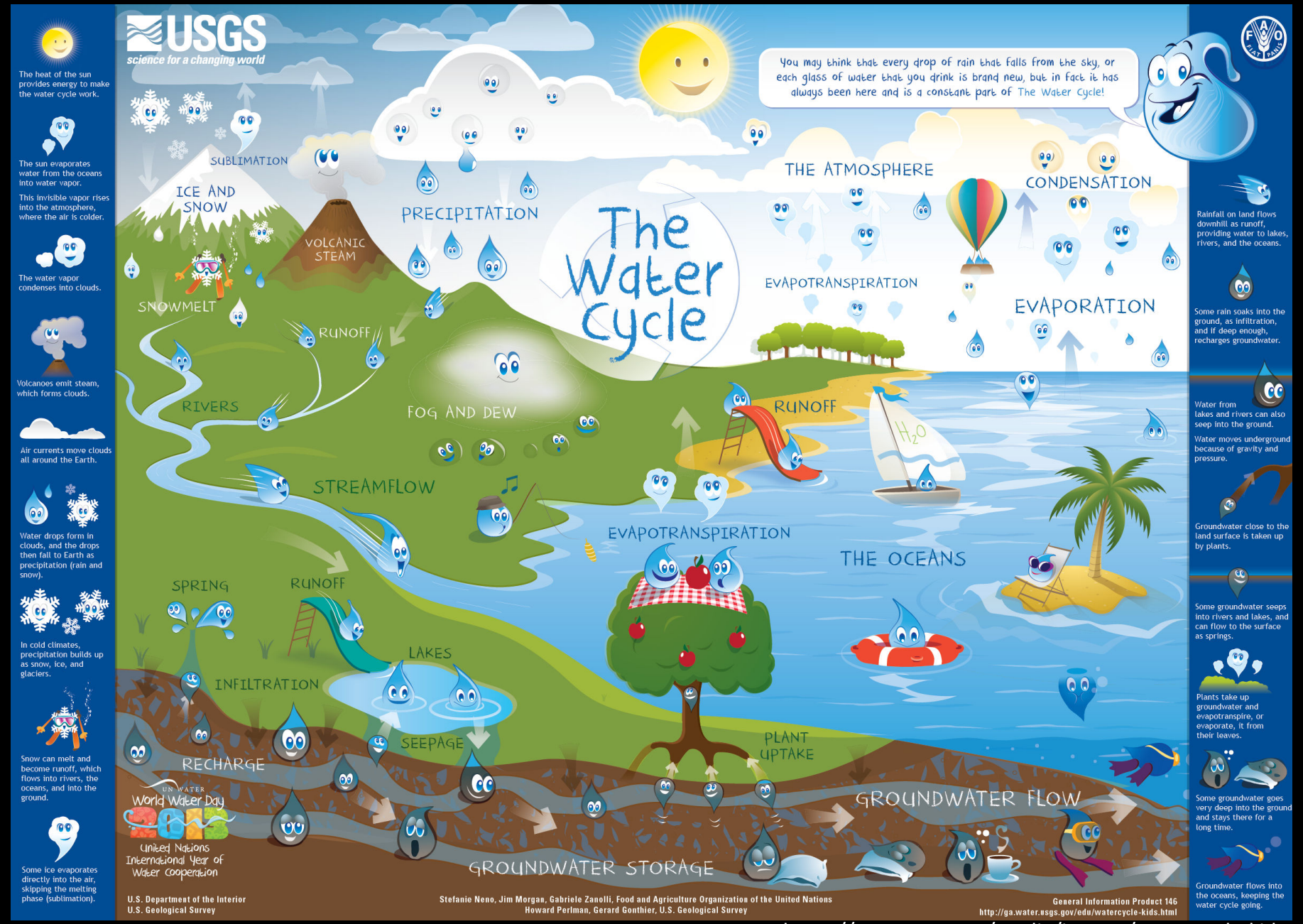


What drives the water cycle?

Water moves naturally and because of human actions. Energy from the sun and the force of gravity drive the continual movement of water between pools. The sun's energy causes liquid water to evaporate into water vapor. Evapotranspiration is the main way water moves into the atmosphere from the land surface and oceans. Gravity causes water to flow downward on land. It causes rain, snow, and hail to fall from clouds.

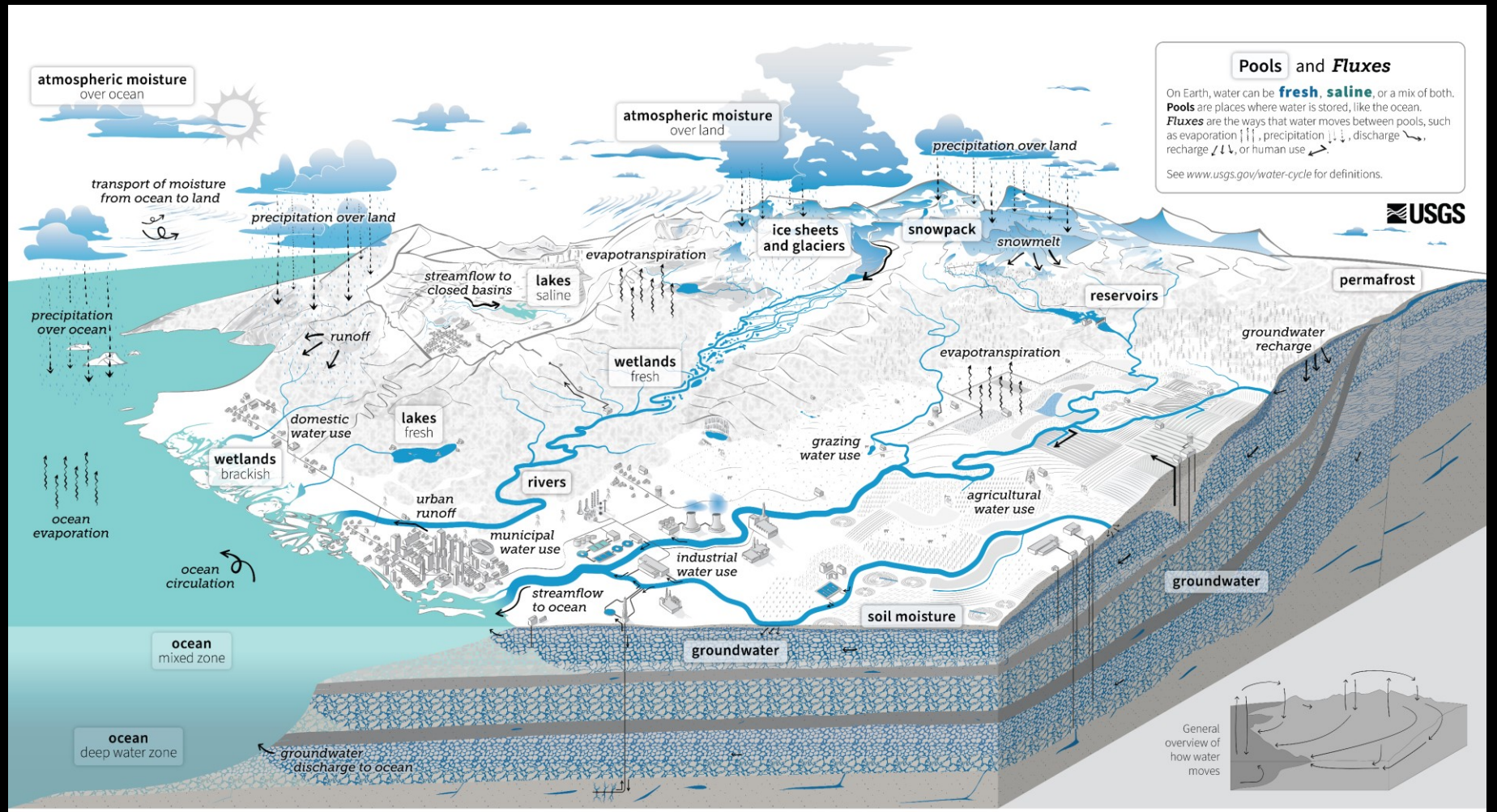
https://www.usgs.gov/special-topics/water-science-school/science/water-cycle

The Water Cycle for Kids



https://www.usgs.gov/media/images/water-cycle-kids

The Water Cycle: Continental Scale



The Water Cycle

The water cycle describes where water is found on Earth and how it moves. Water can be stored in the atmosphere, on Earth's surface, or below the ground. It can be in a liquid, solid, or gaseous state. Water moves between the places it is stored at large scales and at very small scales. Water moves naturally and because of human interaction, both of which affect where water is stored, how it moves, and how clean it is.

Liquid water can be fresh, saline (salty), or a mix (brackish). Ninety-six percent of all water is saline and stored in **oceans**. Places like the ocean, where water is stored, are called **pools**. On land, saline water is stored in **saline lakes**, whereas fresh water is stored in liquid form in **freshwater lakes**, artificial **reservoirs**, **rivers**, **wetlands**, and in soil as **soil moisture**. Deeper underground, liquid water is stored as **groundwater** in aquifers, within the cracks and pores of rock. The solid, frozen form of water is stored in **ice sheets**, **glaciers**, and **snowpack** at high elevations or near the Earth's poles. Frozen water is also found in the soil as **permafrost**. Water vapor, the gaseous form of water, is stored as **atmospheric moisture** over the ocean and land.

As it moves, water can transform into a liquid, a solid, or a gas. The different ways in which water moves between pools are known as **fluxes**. **Circulation** mixes water in the oceans and transports water vapor in the atmosphere. Water moves between the atmosphere and the Earth's surface through **evaporation**, **evapotranspiration**, and **precipitation**. Water moves across the land surface through **snowmelt**, **runoff**, and **streamflow**. Through infiltration and **groundwater recharge**, water moves into the ground. When underground, groundwater flows within aquifers and can return to the surface through **springs** or from natural **groundwater discharge** into rivers and oceans.

Humans alter the water cycle. We redirect rivers, build dams to store water, and drain water from wetlands for development. We use water from rivers, lakes, reservoirs, and groundwater aquifers. We use that water (1) to supply our **homes** and **communities**; (2) for **agricultural** irrigation and **grazing** livestock; and (3) in **industrial** activities like thermoelectric power generation, mining, and aquaculture. The amount of available water depends on how much water is in each pool (water quantity). Water availability also depends on when and how fast water moves (water timing), how much water is used (water use), and how clean the water is (water quality).

Human activities affect **water quality**. In agricultural and urban areas, irrigation and precipitation wash fertilizers and pesticides into rivers and groundwater. Power plants and factories return heated and contaminated water to rivers. Runoff carries chemicals, sediment, and sewage into rivers and lakes. Downstream from these types of sources, contaminated water can cause harmful algal blooms, spread diseases, and harm habitats. **Climate change** is also affecting the water cycle. It affects water quality, quantity, timing, and use. Climate change is also causing ocean acidification, sea level rise, and extreme weather. Understanding these impacts can allow progress toward sustainable water use.

https://www.usgs.gov/media/files/water-cycle-poster-pdf

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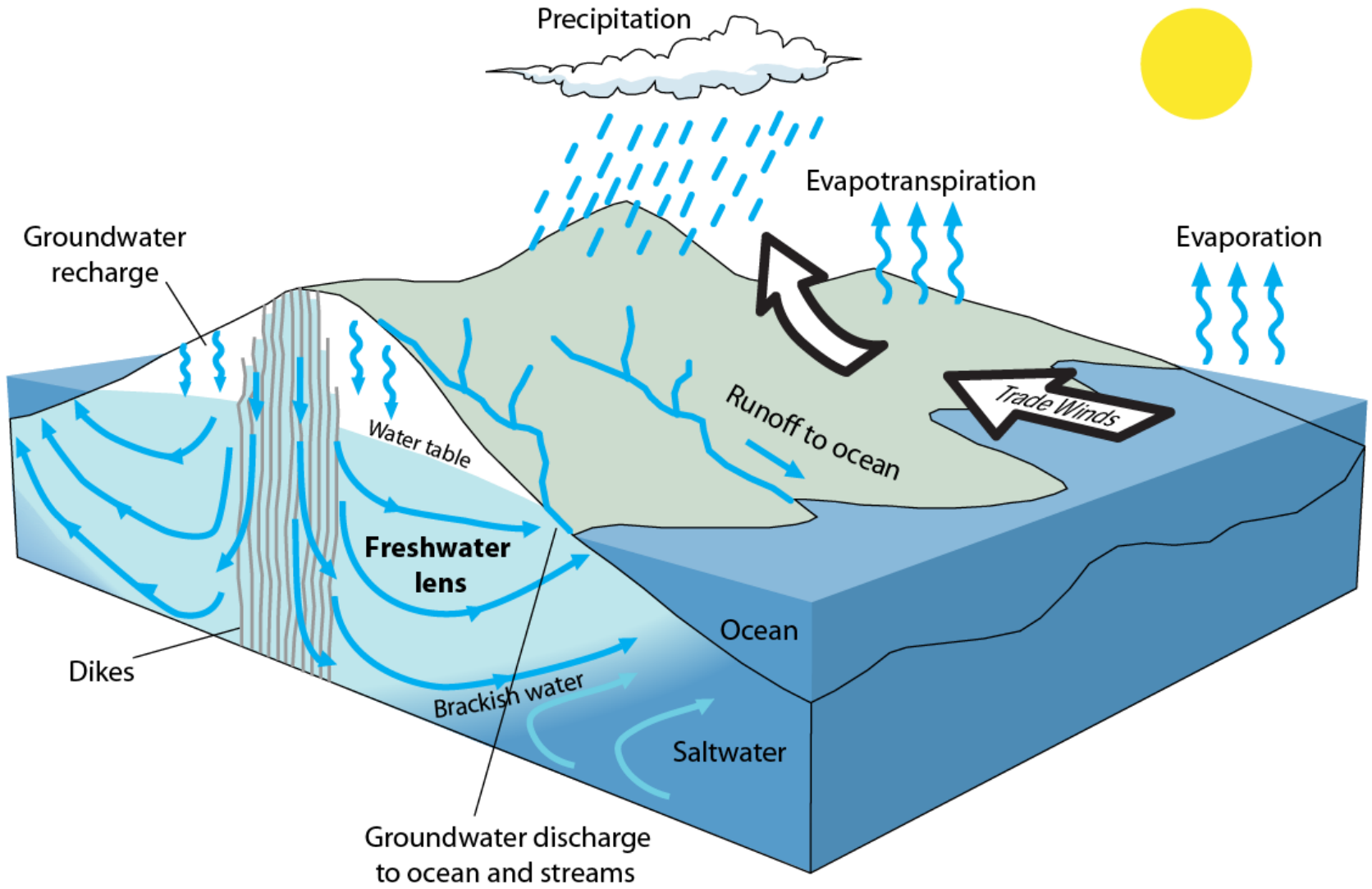
The Water Cycle in Hawai‘i: Island Scale



https://doi.org/10.3133/sir20155164

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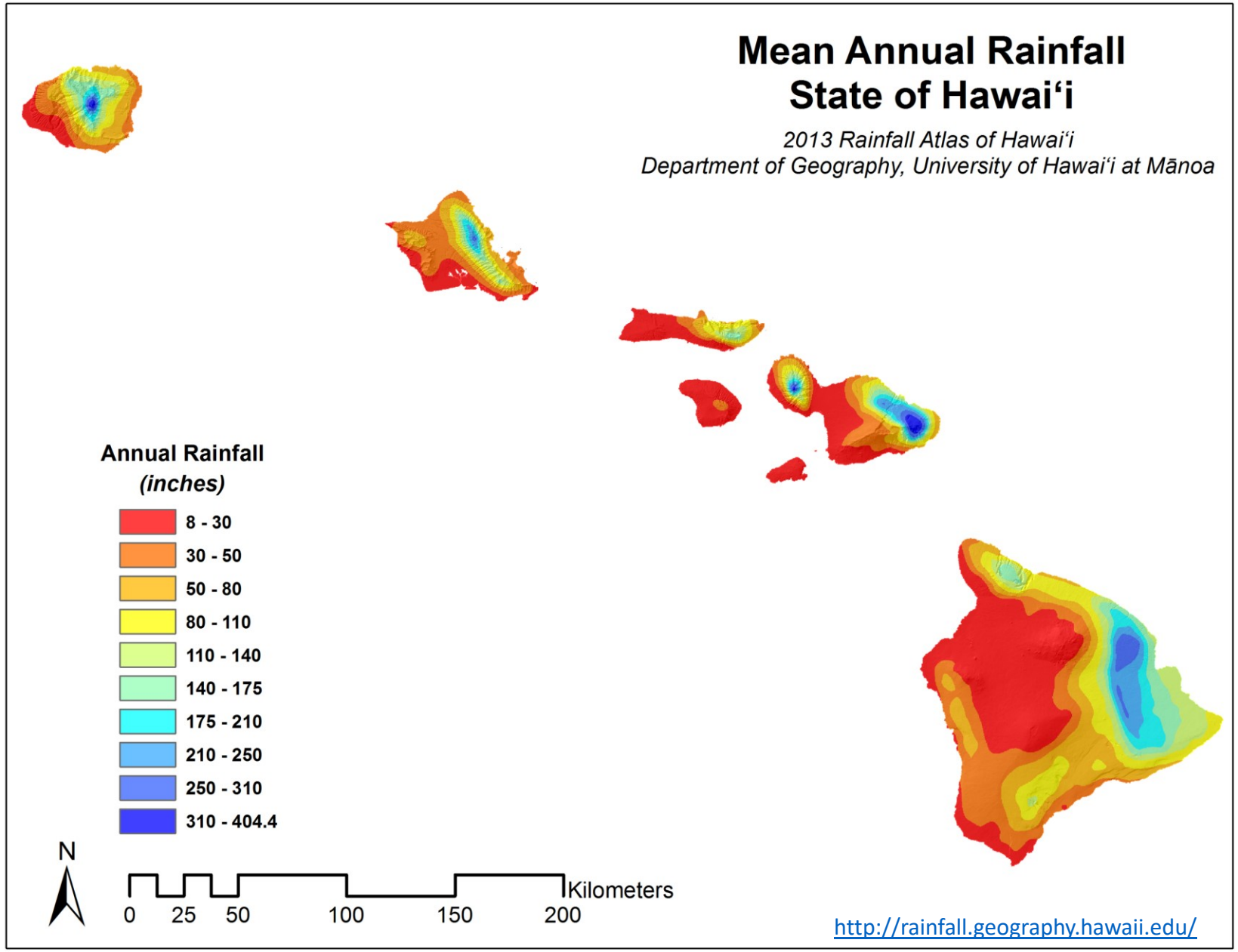
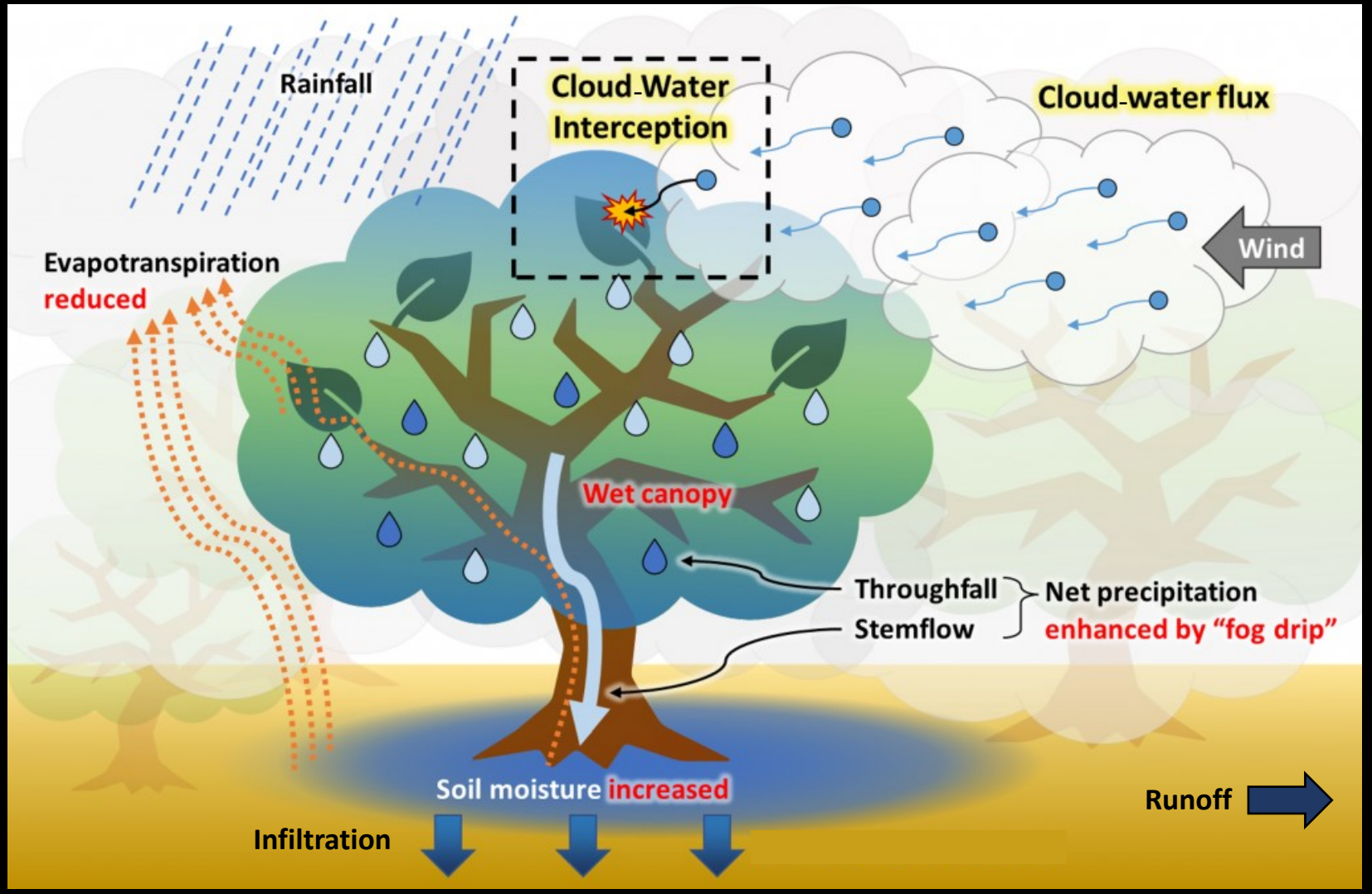

Mean Annual Rainfall
State of Hawai'i
2013 Rainfall Atlas of Hawai'i
Department of Geography, University of Hawai'i at Mānoa
Annual Rainfall
(inches)
8 - 30
30 - 50
50 - 80
80 - 110
110 - 140
140 - 175
175 - 210
210 - 250
250 - 310
310 - 404.4
N
0 25 50 100 150 200
Kilometers
http://rainfall.geography.hawaii.edu/

The Water Cycle in Hawai‘i: Forest-Plot Scale



Modified from https://www.hawaii.edu/climate-data-portal/cloud-water-interception-in-hawaii/

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Selected High Priority Non-Native Species of Concern

Himalayan ginger
(*Hedychium gardnerianum*)

Tropical ash
(*Fraxinus uhdei*)

Strawberry guava
(*Psidium cattleianum*)

Kikuyu grass
(*Pennisetum clandestinum*)

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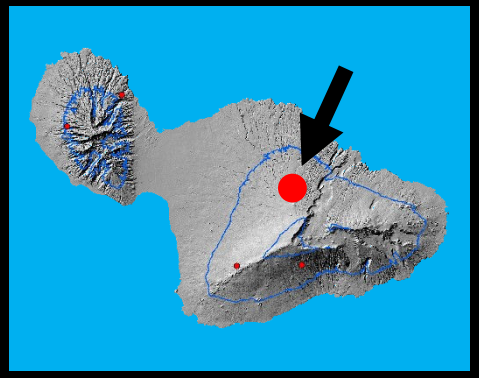
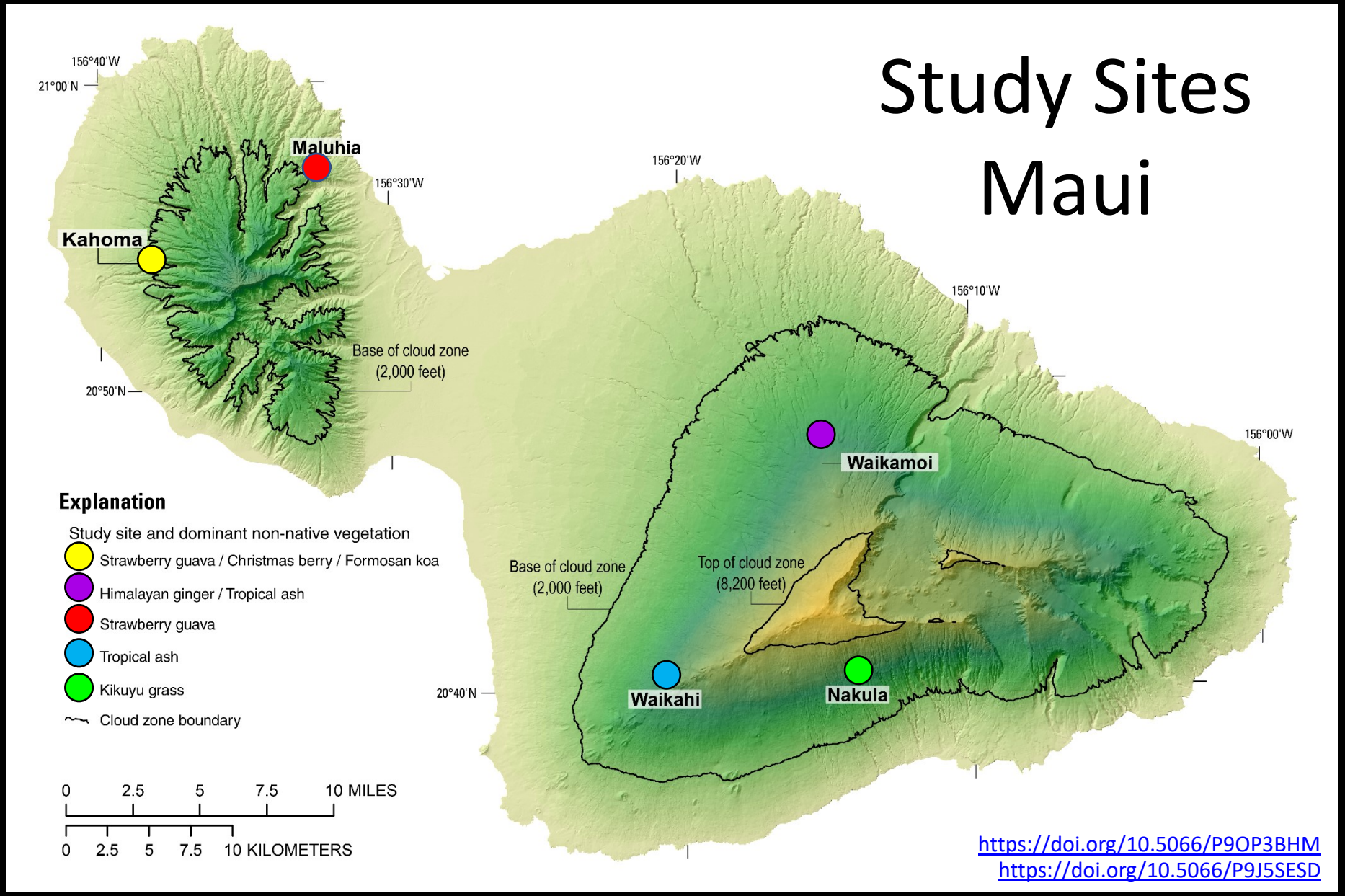
Waikamoi, Maui



Study Sites Maui

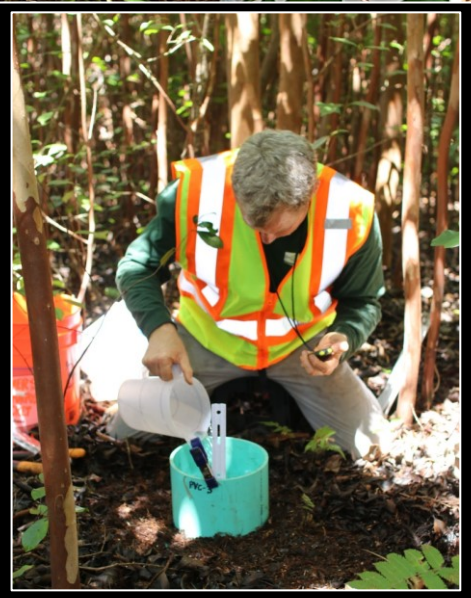


https://doi.org/10.5066/P9OP3BHM
https://doi.org/10.5066/P9J5SESD

Infiltration-Rate Testing

Single-ring infiltrometer

Himalayan ginger-Tropical ash plot
Waikamoi, Maui



Strawberry guava plot
Maluhia, Maui

Strawberry guava plot
Kahoma, Maui

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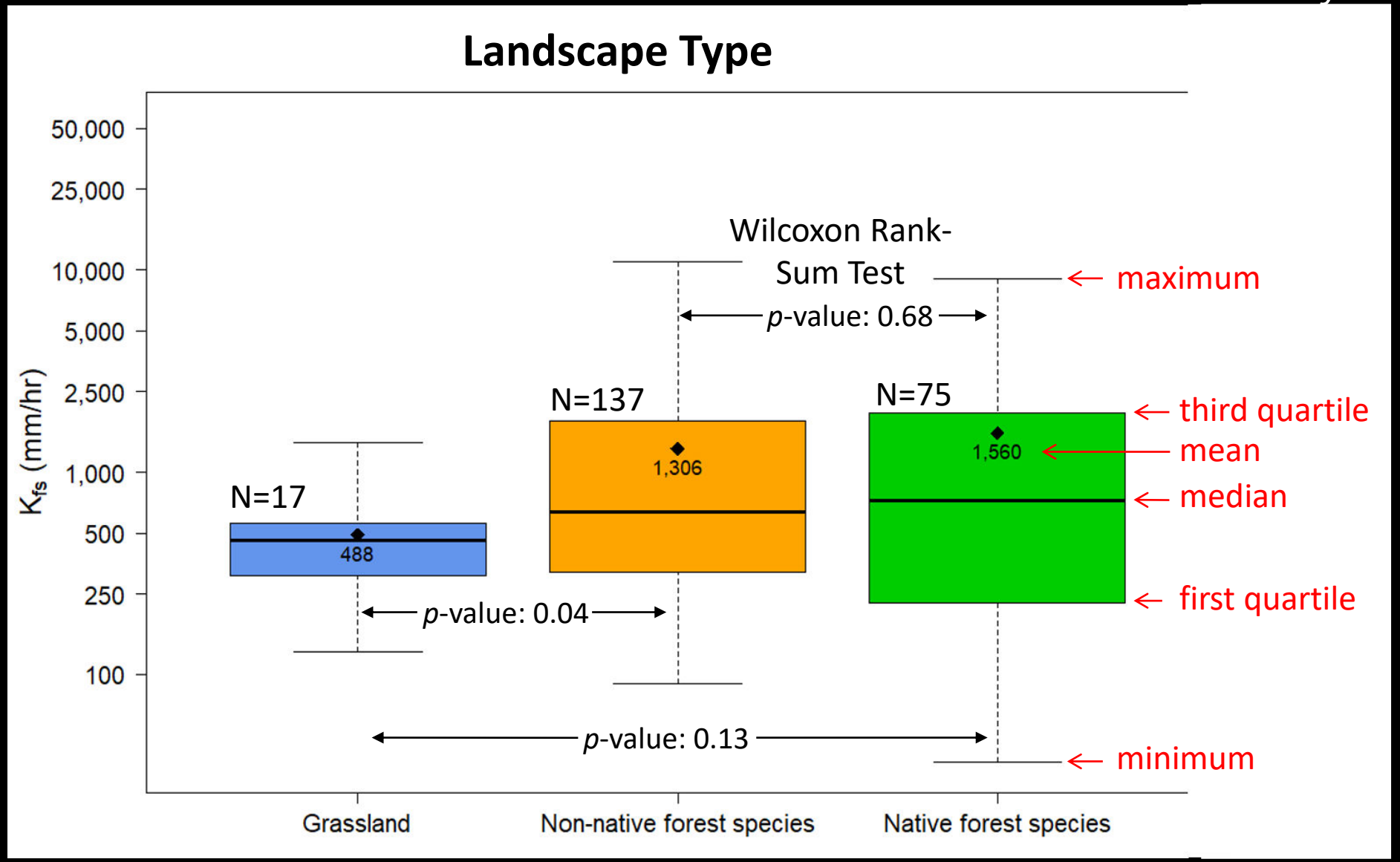
Field-Saturated Hydraulic Conductivity (K_{fs})



Excludes data collected from Maluhia plots

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Preliminary Information—Subject to Revision.
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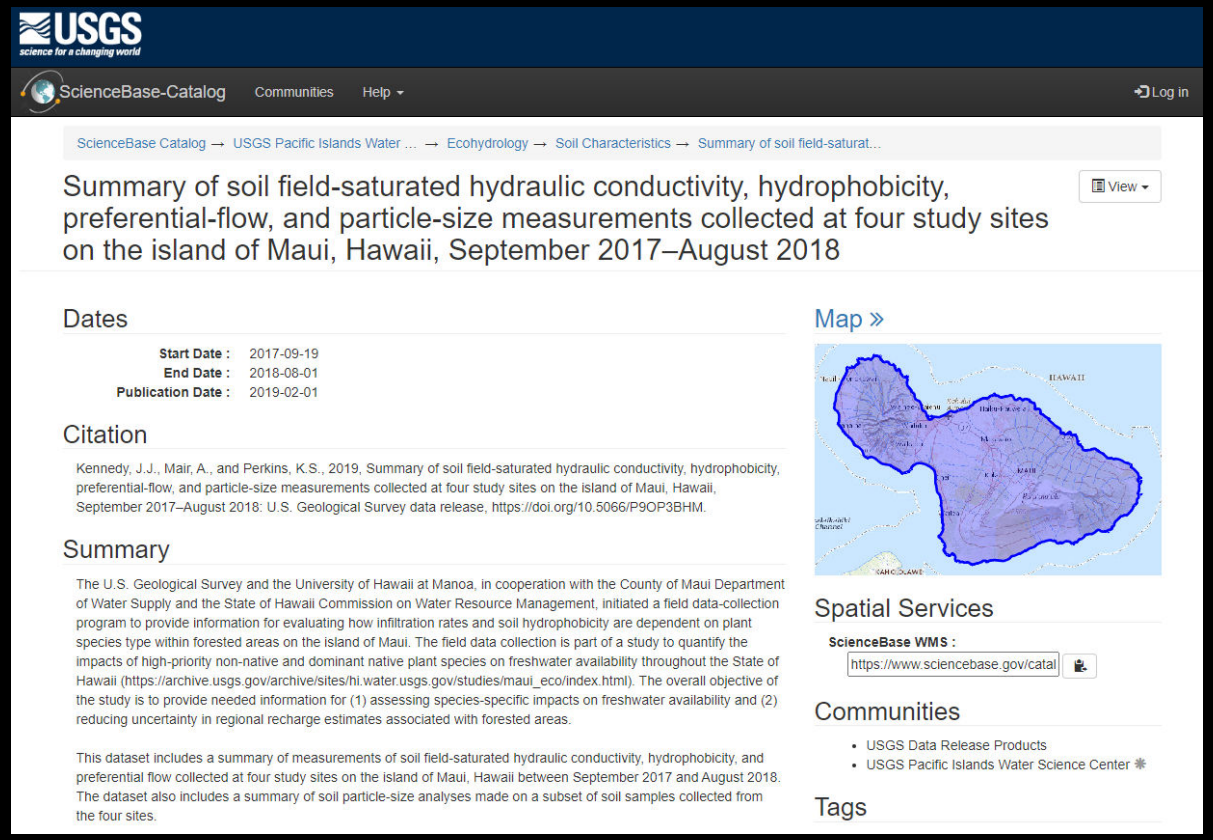
ScienceBase Digital Repository



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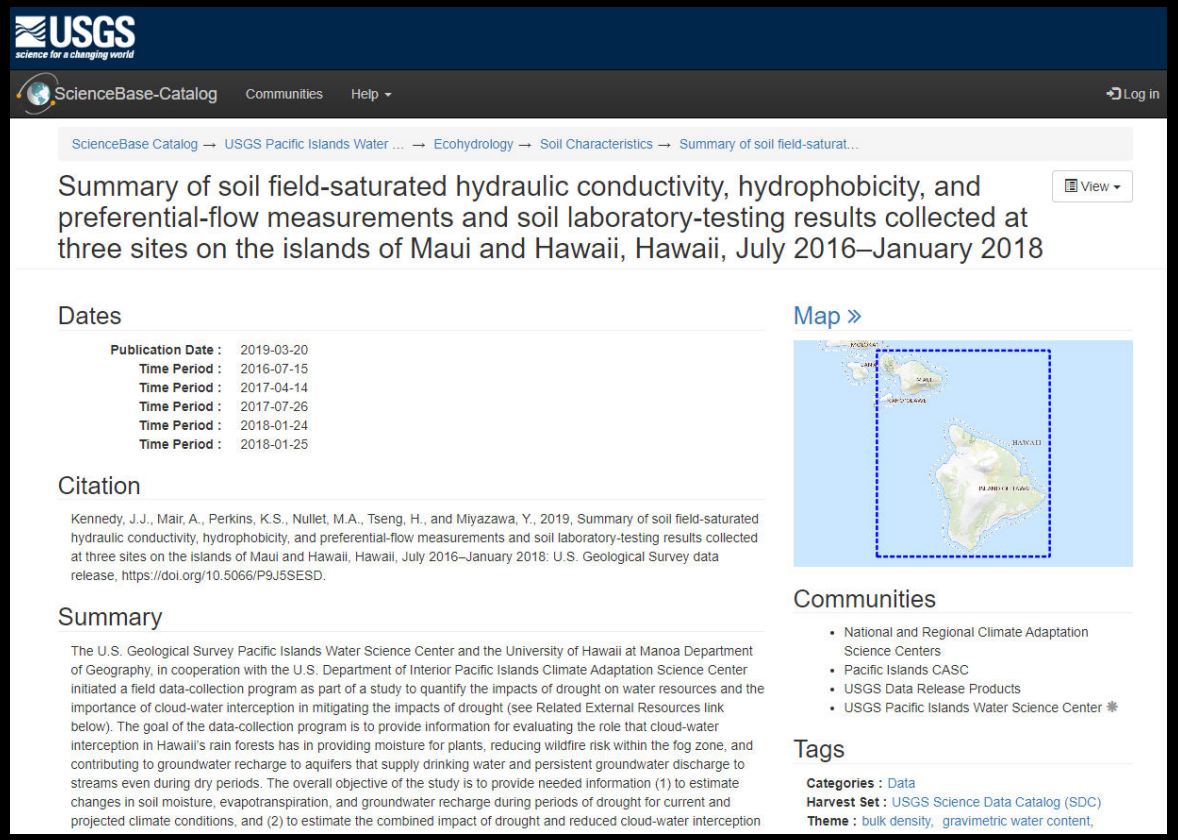

https://doi.org/10.5066/P9J5SESD

Mahalo!

Native forest plot
Kahoma, Maui

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