Thursday Oct 23
Sit with your Group again to finish up G-3
Topic # 9 Systems & Feedbacks (cont.)
+ Intro to Topic #10 How Climate Works
ANNOUNCEMENTS

- Self Test & RQ-6 on Natural Climate Processes & Forcing are now available.
- RQ-6 is due NEXT Tuesday. (For RQ-6, there's a fair amount of reading – plus the I-2 Tutorial– to prepare, so you are encouraged to get started early)
- The ANSWER SHEETS for Assignments I-2, 1-3, and I-4 will be posted tonight & the I-2 Dropbox will open
  I-2 is DUE before Midnight a week from today.
- Exam grading continues . . . To be returned next week

TOPIC # 9

UNDERSTANDING SYSTEMS & FEEDBACKS (cont.)

Class notes pp 57-61

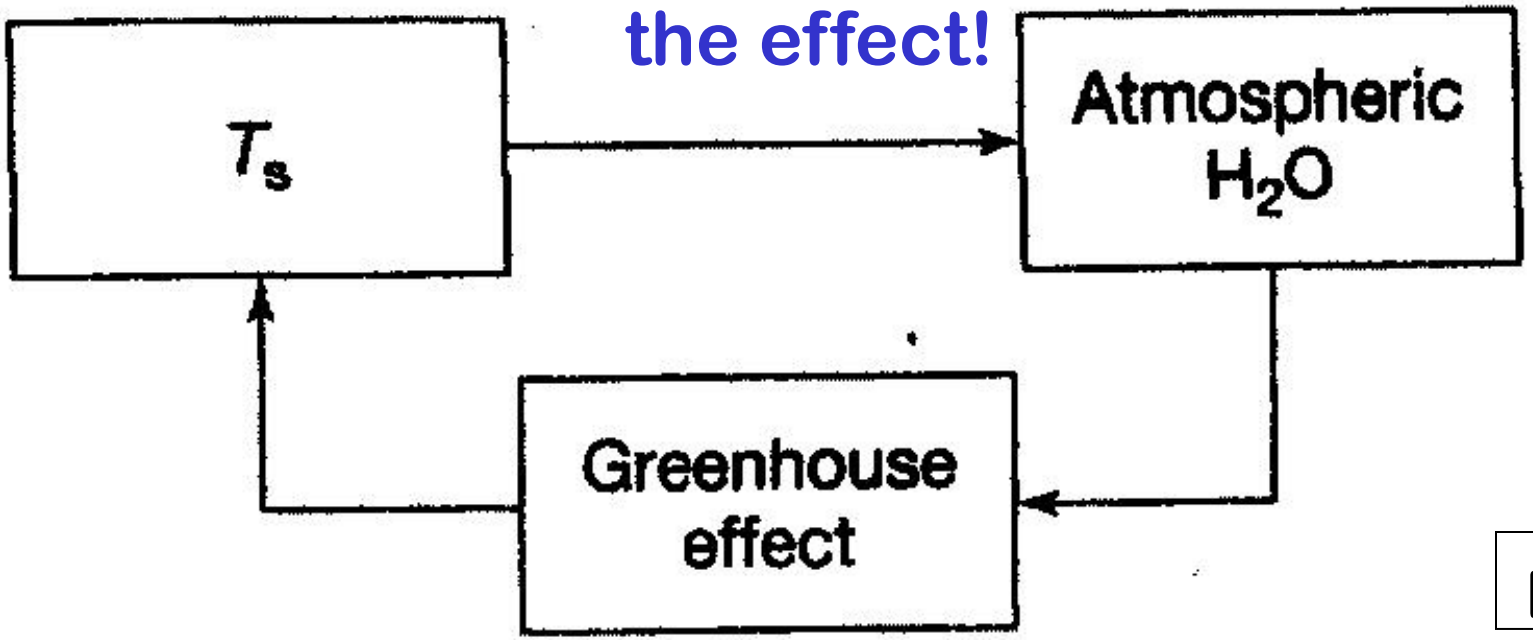
Review:

WATER VAPOR Feedback in the Earth-Atmosphere

What kind of FEEDBACK LOOP IS THIS?

Positive + OR Negative -

POSITIVE FEEDBACK LOOP that amplifies the effect!



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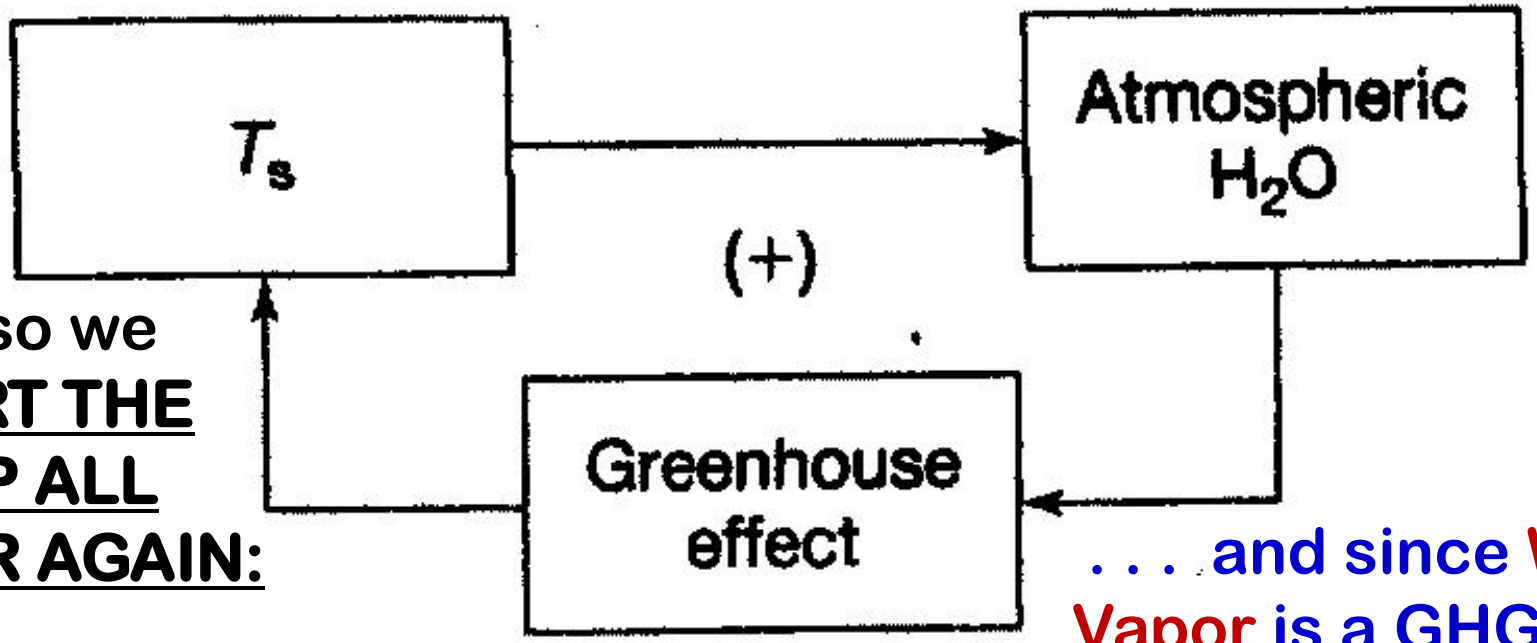
START HERE:

If the temperature of the Earth's surface (Ts) DECREASES ↓. . . .

. . . the colder temperatures will reduce evaporation, which will result in a DECREASE ↓ in the amount of Water Vapor in the atmosphere . . . . .



And so we **START THE LOOP ALL OVER AGAIN:**

. . . and since Water Vapor is a GHG, the Greenhouse Effect will then DECREASE ↓ . . . .

. . . and with a weaker GHE, the temperature (Ts) will DECREASE further ↓

AMPLYFYING the initial perturbation!!

FEEDBACK LOOPS CAN BE "IN EQUILIBRIUM" . . . . or NOT

Defined:

EQUILIBRIUM STATE:

the state in which the system will remain UNLESS something disturbs it.

An equilibrium state can be:

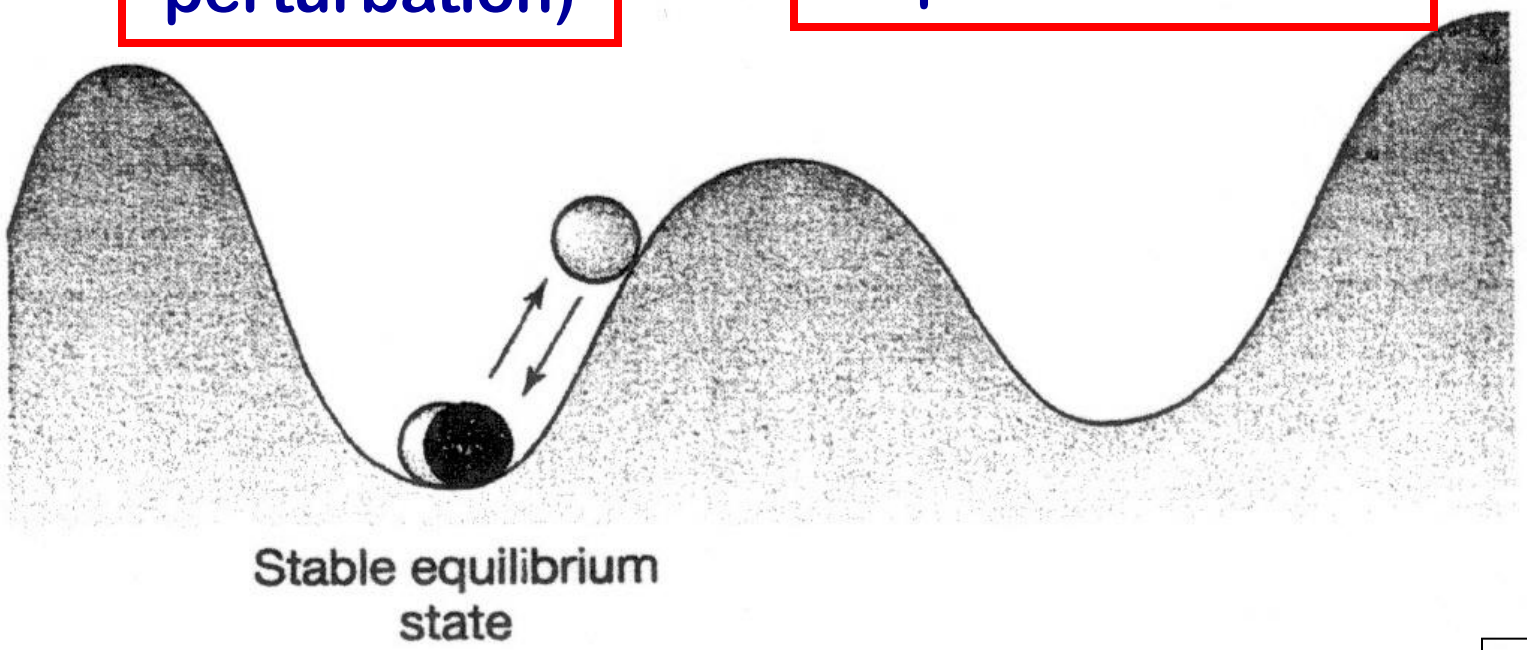
stable or unstable.

A negative feedback loop
(can also be described as)
a STABLE EQUILIBRIUM STATE :

A modest disturbance (short-term perturbation)

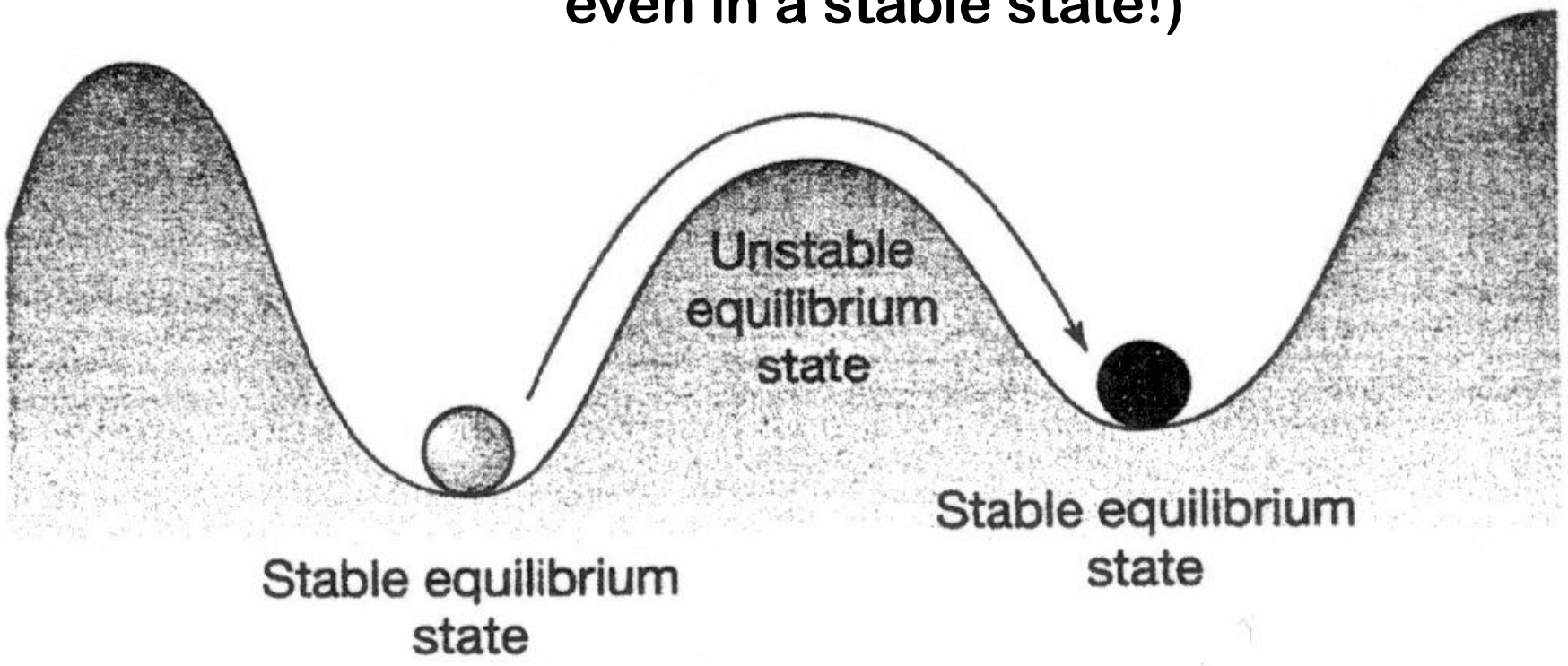
→

response that tends to return the system to its equilibrium state



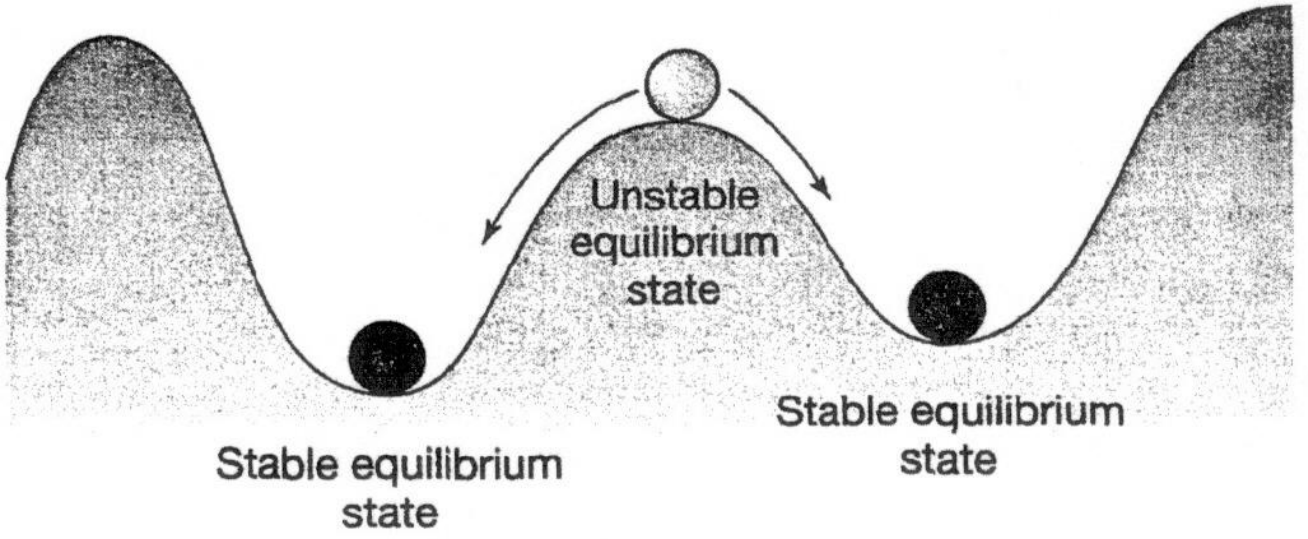
A **LARGE or more persistent** disturbance (a forcing) can carry the system to a different equilibrium state

(so there area some limits to stability, even in a stable state!)

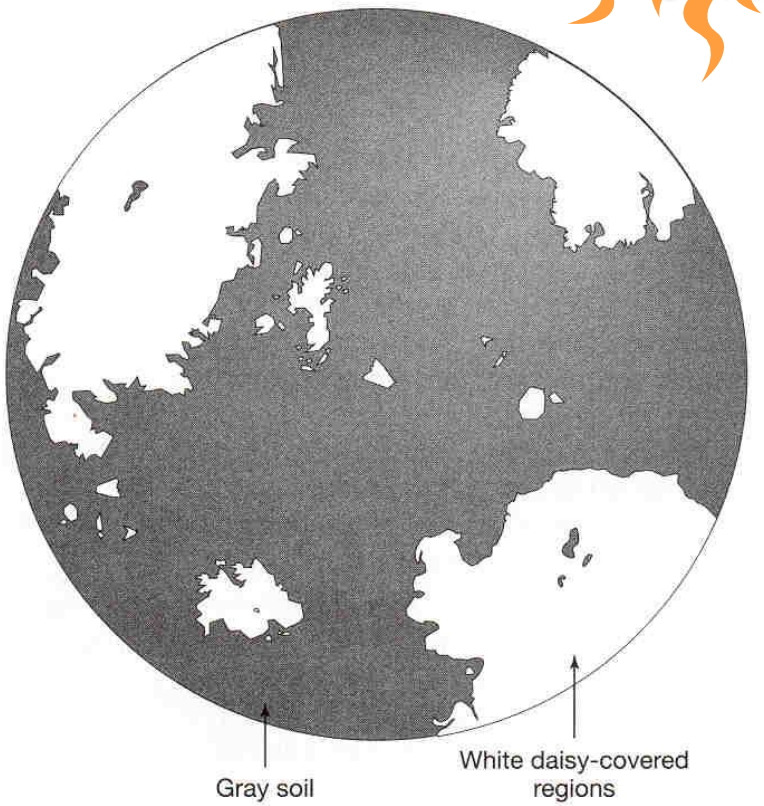


If a system is characterized by a
positive (self-amplifying) feedback loop
it is in an . . . .

➔ UNSTABLE EQUILIBRIUM STATE :



Ok, so what's this Daisyworld Climate System all about and why should I care??????



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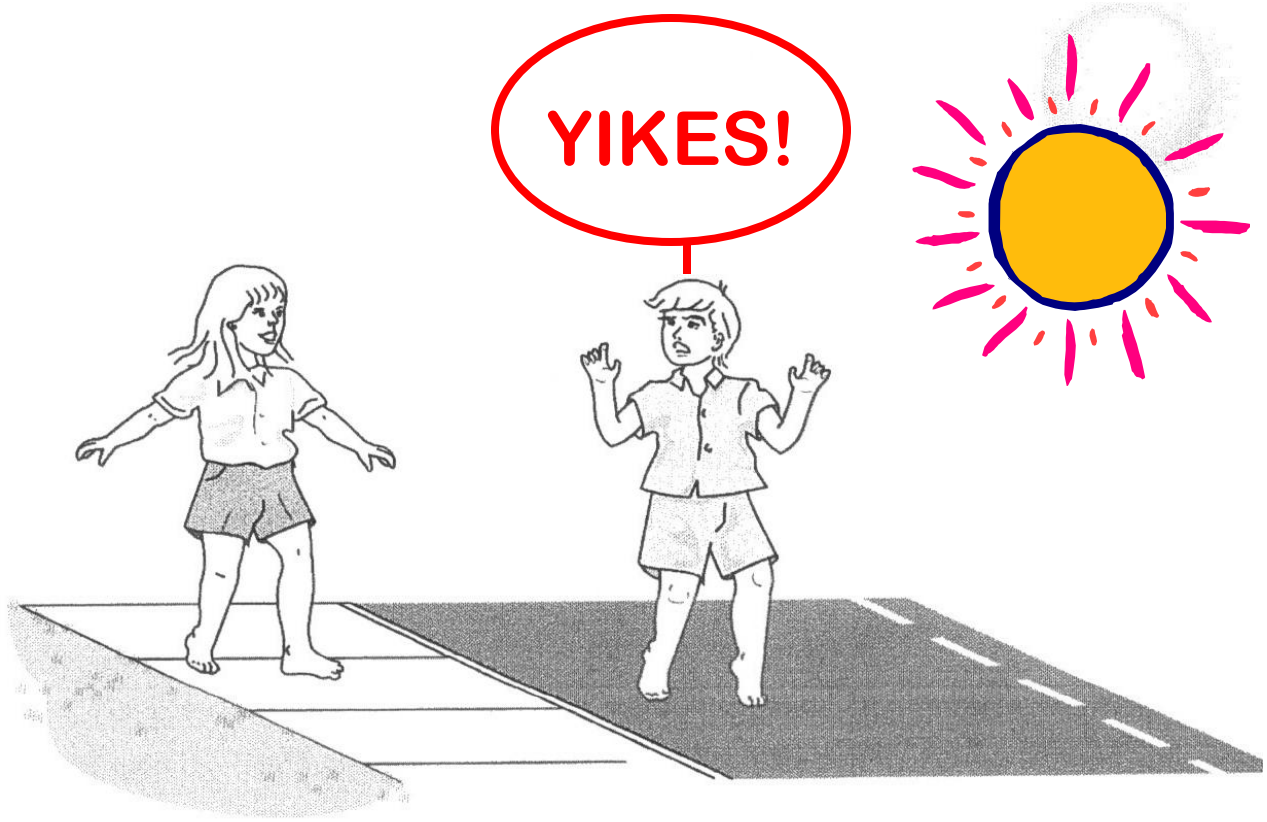


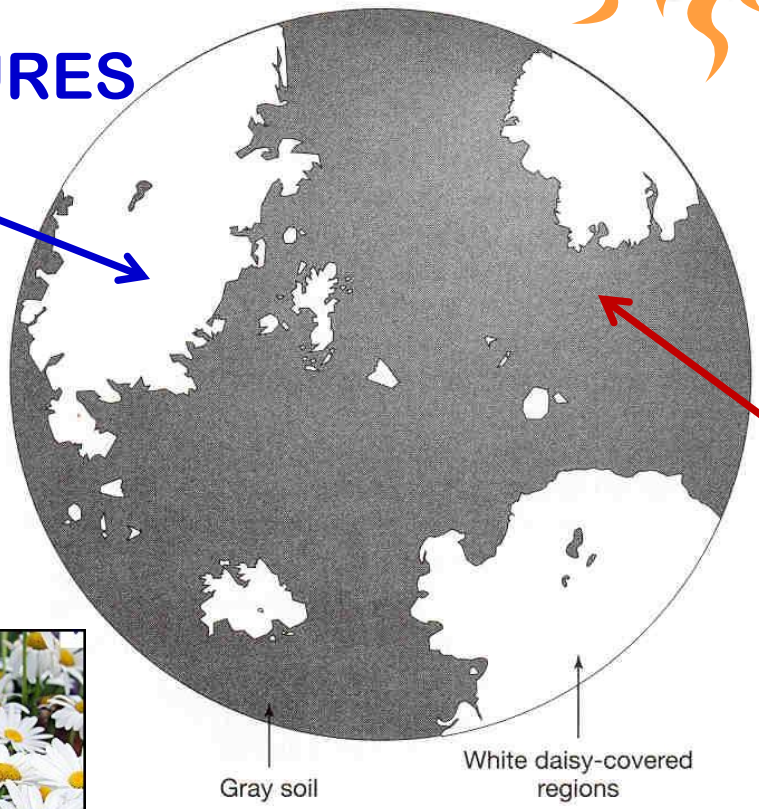
HIGH ALBEDO **LOW ALBEDO**

Review

HIGH albedo,
HIGH reflectivity,
& LOW absorption
➔ COOL TEMPERATURES

FEW or NO DAISIES

Lots of WHITE DAISIES



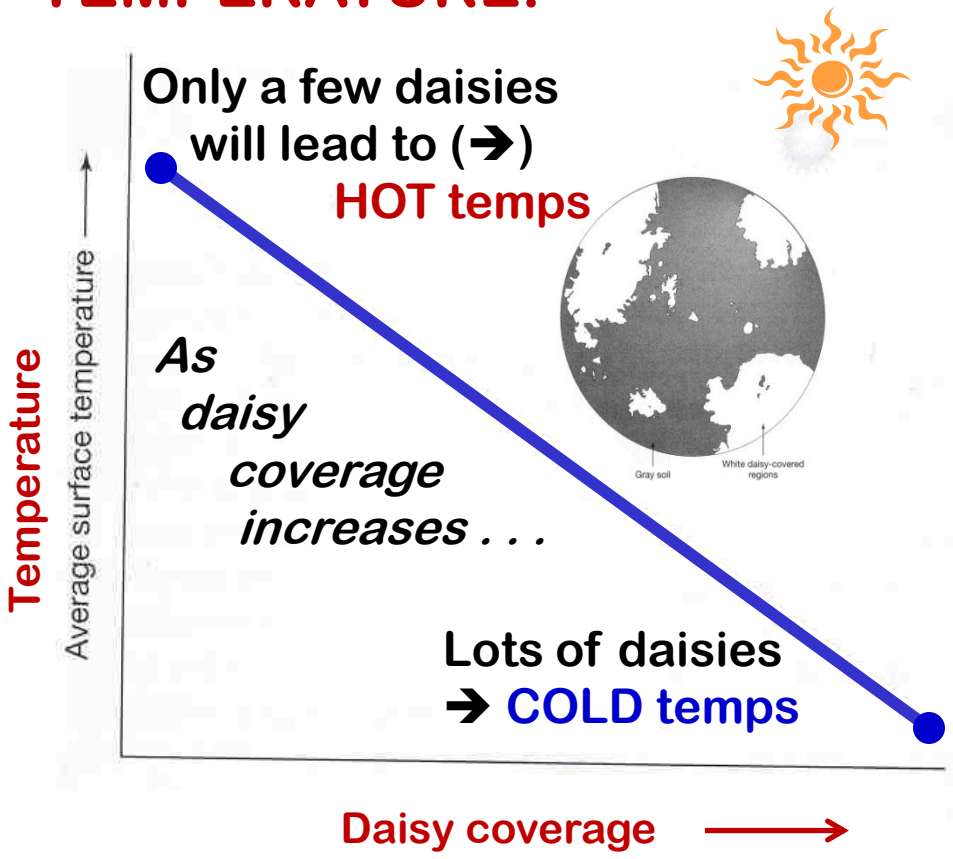
LOW albedo,
LOW reflectivity,
& HIGH absorption
Lead to ➔ HOT TEMPERATURES!

HOW DAISY COVERAGE AFFECTS TEMPERATURE:

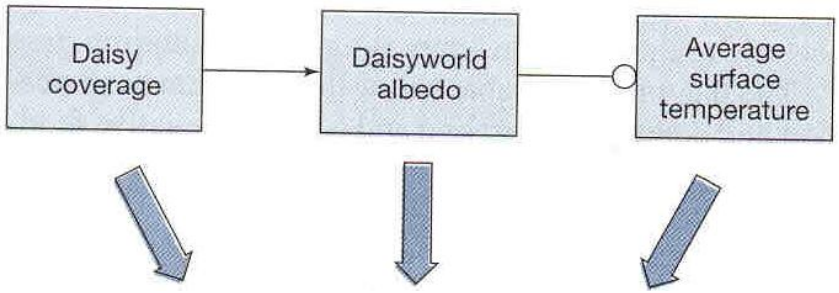
An increase in daisy coverage . . .

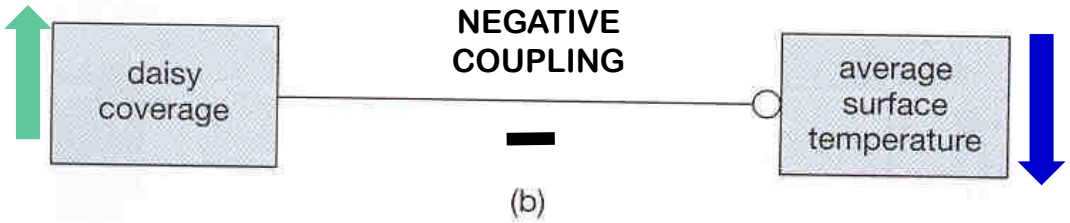
➔ a decrease in surface temperature

WHY? If albedo increases, more sunlight is reflected,
➔ less sunlight is absorbed
➔ cooler temps



These "in between" processes





← Explain this coupling

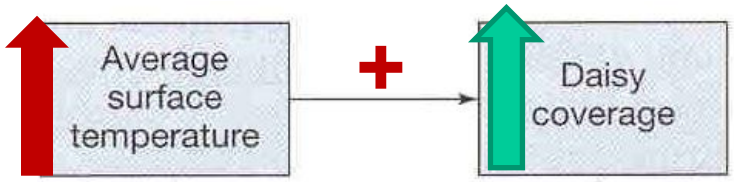
Now, let's think about the relationship between temperature & daisies in the OTHER direction and make a LOOP!

After :

Daisy coverage → (affects) Temperature

How does:

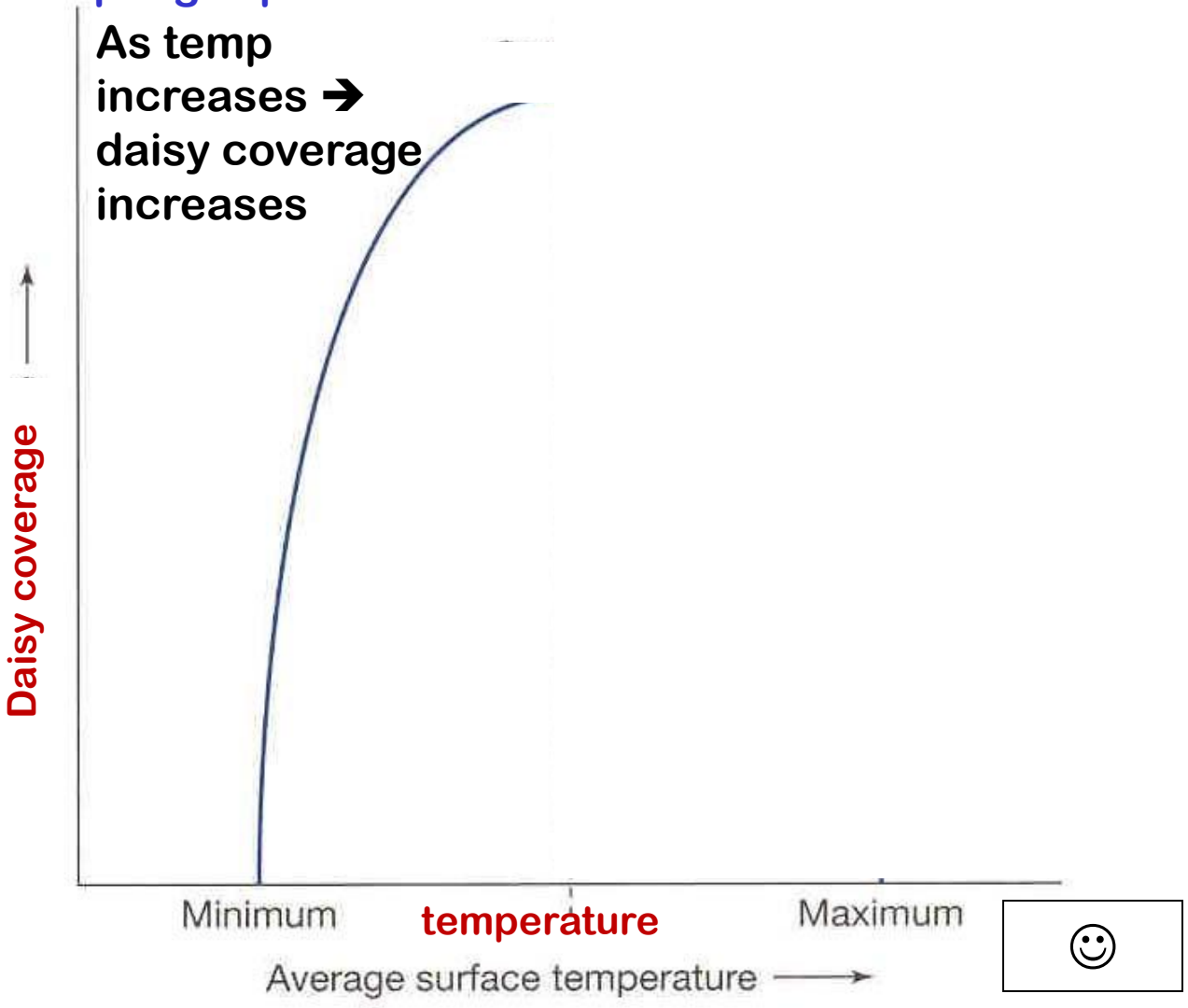
Temperature →(affect) Daisy coverage ?

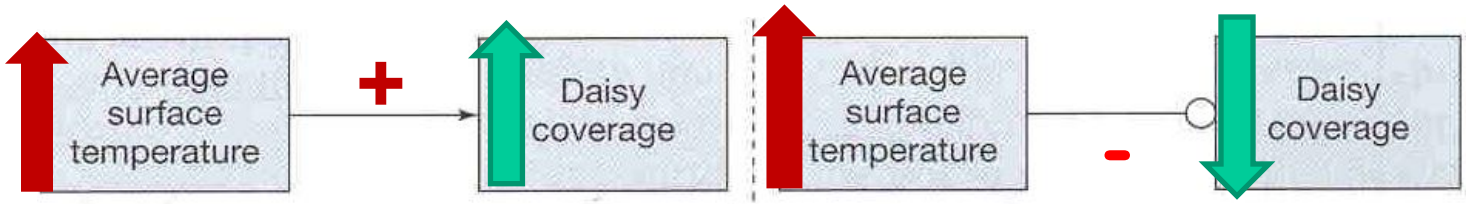


HOW DOES TEMPERATURE AFFECT DAISY COVERAGE?

Daisies thrive in warm temperatures . . .

. . . until they reach some threshold temperature, then they start dying if it gets TOO HOT!





HOW DOES TEMPERATURE AFFECT DAISY COVERAGE?

Daisies thrive in warm temperatures . . .

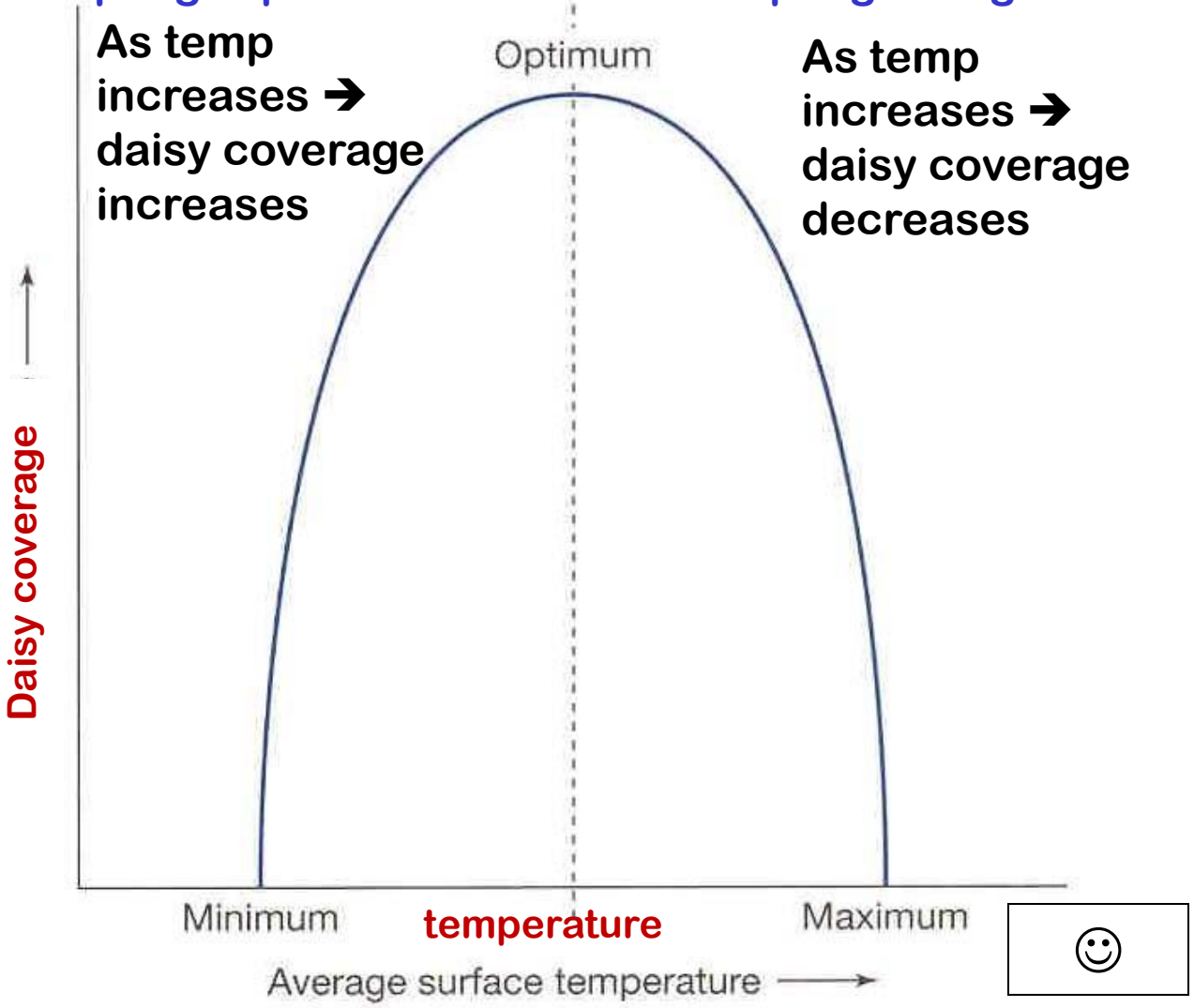
. . . until they reach some threshold temperature, then they start dying if it gets TOO HOT!

Coupling is positive

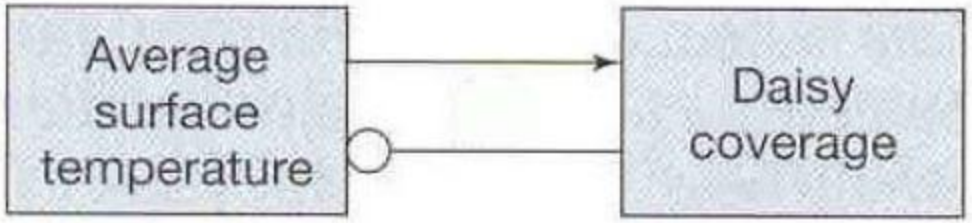
As temp increases ➔ daisy coverage increases

Coupling is negative

As temp increases ➔ daisy coverage decreases



Initial response of Daisy Coverage to Daisyworld "global warming"➔



Clicker Q1. Four choices: Which one properly describes this LOOP?

A) NEGATIVE LOOP in Stable Equilibrium

B) POSITIVE LOOP in Stable Equilibrium

C) NEGATIVE LOOP NOT in Equilibrium = UNSTABLE

D) POSITIVE LOOP NOT in Equilibrium = UNSTABLE

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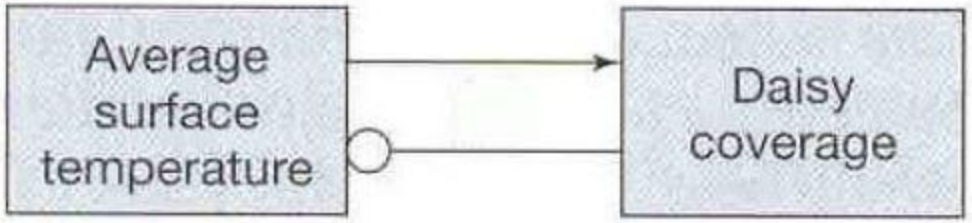

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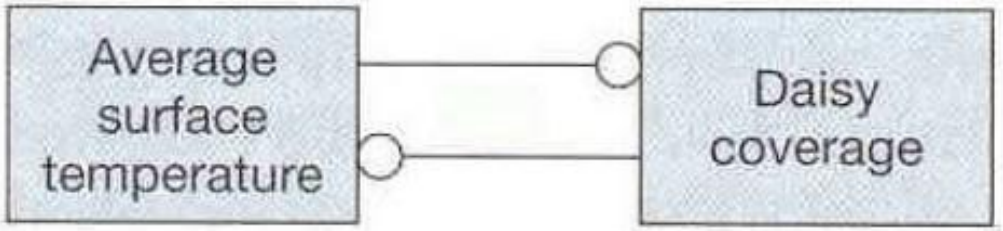
Initially, Daisyworld CAN adapt to an increase in global temperature

Later response of Daisy Coverage to Daisyworld "global warming"➔



Clicker Q2. Four choices: Which one properly describes this LOOP?

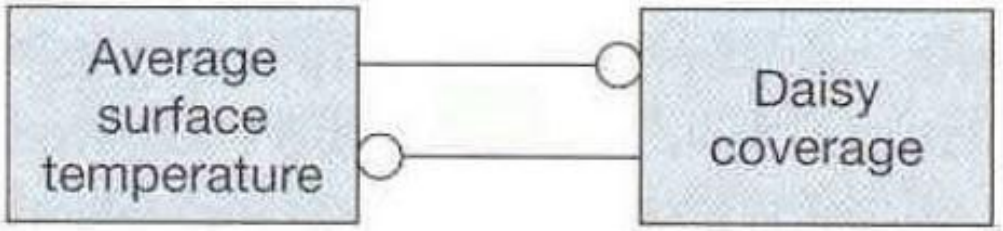
A) NEGATIVE LOOP in Stable Equilibrium

B) POSITIVE LOOP in Stable Equilibrium

C) NEGATIVE LOOP NOT in Equilibrium = UNSTABLE

D) POSITIVE LOOP NOT in Equilibrium = UNSTABLE

Later response of Daisy Coverage to Daisyworld "global warming"➔



Clicker Q2. Four choices: Which one properly describes this LOOP?

A) NEGATIVE LOOP in Stable Equilibrium

C) NEGATIVE LOOP NOT in Equilibrium = UNSTABLE

B) POSITIVE LOOP in Stable Equilibrium

D) POSITIVE LOOP NOT in Equilibrium = UNSTABLE

But with INCREASED WARMING . . . a threshold is reached (the point when it's too hot for the daisies) and they begin to die off!

MAIN LESSON OF DAISYWORLD!

If certain thresholds are crossed:

NEGATIVE FEEDBACK loops that
normally regulate temperature

Can be replaced by POSITIVE FEEDBACK loops
that amplify temperature!

THOUGHT QUESTION:

**Could this happen on
OUR PLANET EARTH??**

The final segment of:

http://www.pbs.org/wgbh/nova/solar/

So what's going on SOLAR-WISE in our own STATE?

ARIZONA
Incentives/Policies for Renewables & Efficiency

see: www.dsireusa.org

DSIRE: Database of State Incentives for Renewables & Efficiency

AZ's RENEWABLE ENERGY STANDARD:

15% Renewables by 2025!

(enacted in 2006) 30% distributed!

Prior to the 2006 rules, Arizona's original Environmental Portfolio Standard required regulated utilities to generate **0.4%** of their power from renewables in 2002 , increasing to **1.1%** in 2007-2012.

"Renewable Energy Standard"

(Renewable portfolio standard - RPS)

Require UTILITIES to use or procure RENEWABLE ENERGY
(or renewable energy credits) to account for:
-- a certain % of their retail electricity sales or
-- a certain amount of generating capacity

According to a specified schedule

So what's going on SOLAR-WISE in our own STATE?

We are currently at 3% and a bit ahead of schedule!

Most is SOLAR :

Photovoltaic (PV) (12 – 30 % efficiency)
Solar Thermal w/ storage (up to 75%)
(Plant is near Gila Bend)

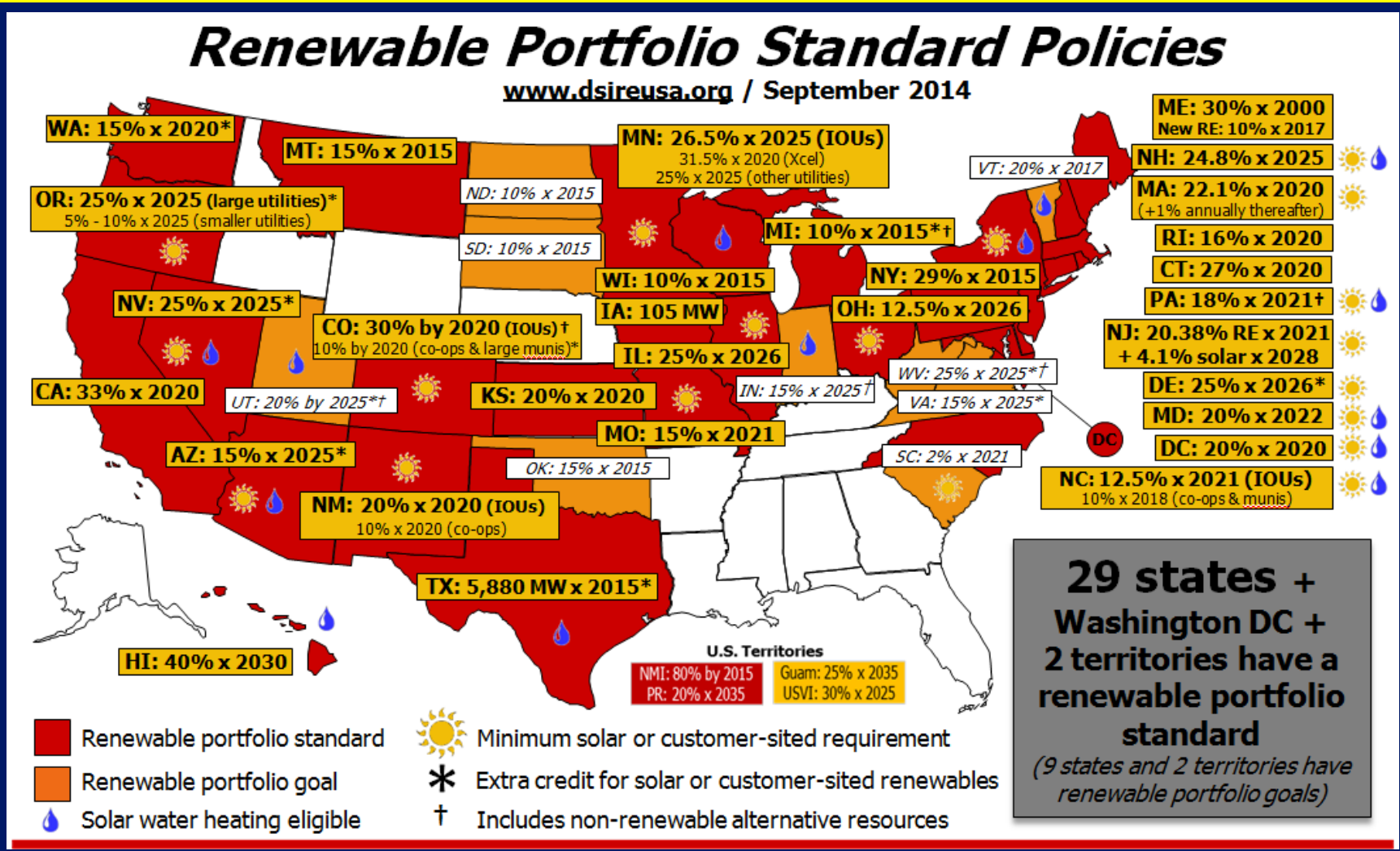
–Even though SOLAR may not be highly efficient (YET!)

SOLAR has extra benefits because **IT IS MODULAR!** (can generate electricity **CLOSE** to the point of use!)

AZ's RENEWABLE ENERGY STANDARD:

15% Renewables by 2025 ?

AZ # 2 in country on utility side, but very far behind on the consumer (US!) side! Can we do better?



LINKING TO LIFE!

Arizona Corporation Commission

http://www.azcc.gov/

In AZ we VOTE for our Corporation Commission !!

And, if you are interested in seeing **SOLAR** increase in AZ . . .

THERE IS A REASON TO VOTE!!!

Arizona Wins Back Its Renewables Standard

"Score a victory for an engaged citizenry."

(In 2013 there was an attempt by one of the commissioners to roll back the 2006 standard!)

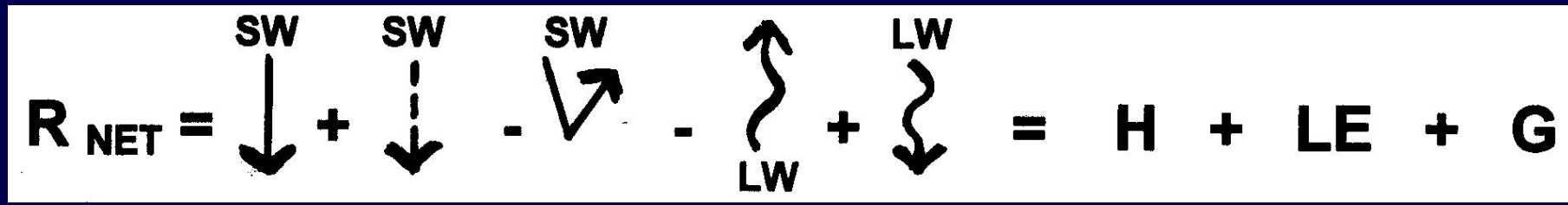
"Poll after poll shows Arizonans want more solar," former ACC policy advisor Nancy LaPlaca noted. That is equally true of polls about solar throughout the country. The surveys show that voters know, as LaPlaca put it, that "solar displaces fuel costs, which are in fact 'monstrous' because of the uncounted enormous health costs, dirty air and water, and climate change" that they also entail.

Now we'll WRAP UP G-3
and move on to

TOPIC #10
HOW CLIMATE WORKS!

More complex applications of the ENERGY BALANCE Components . . .

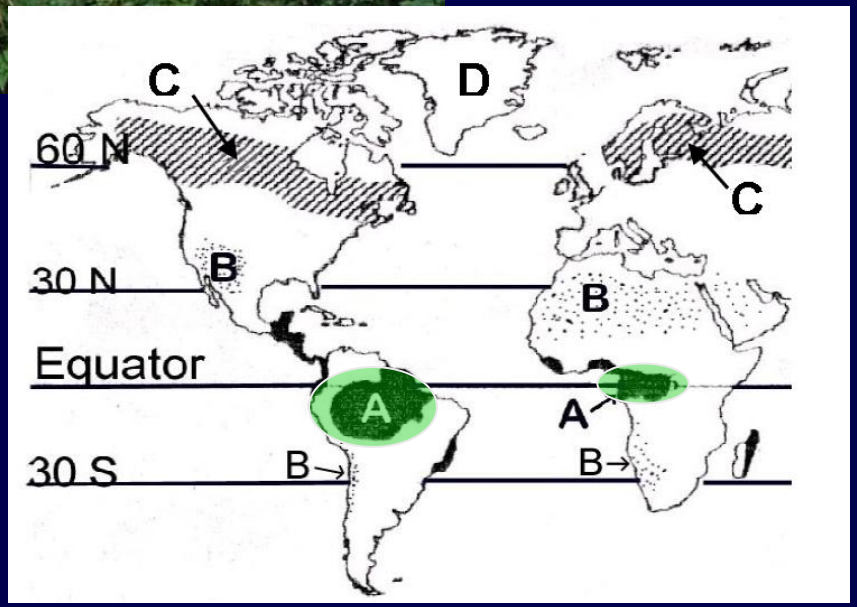
. . . and how they link to Topic #10: CLIMATE!



Flip to p 54

AMAZON RAIN FOREST

A = Humid Tropical Climates



Some Key Global Climate Regions

theguardian

News | US | World | Sports | Comment | Culture | Business | Money

Environment › Amazon rainforest

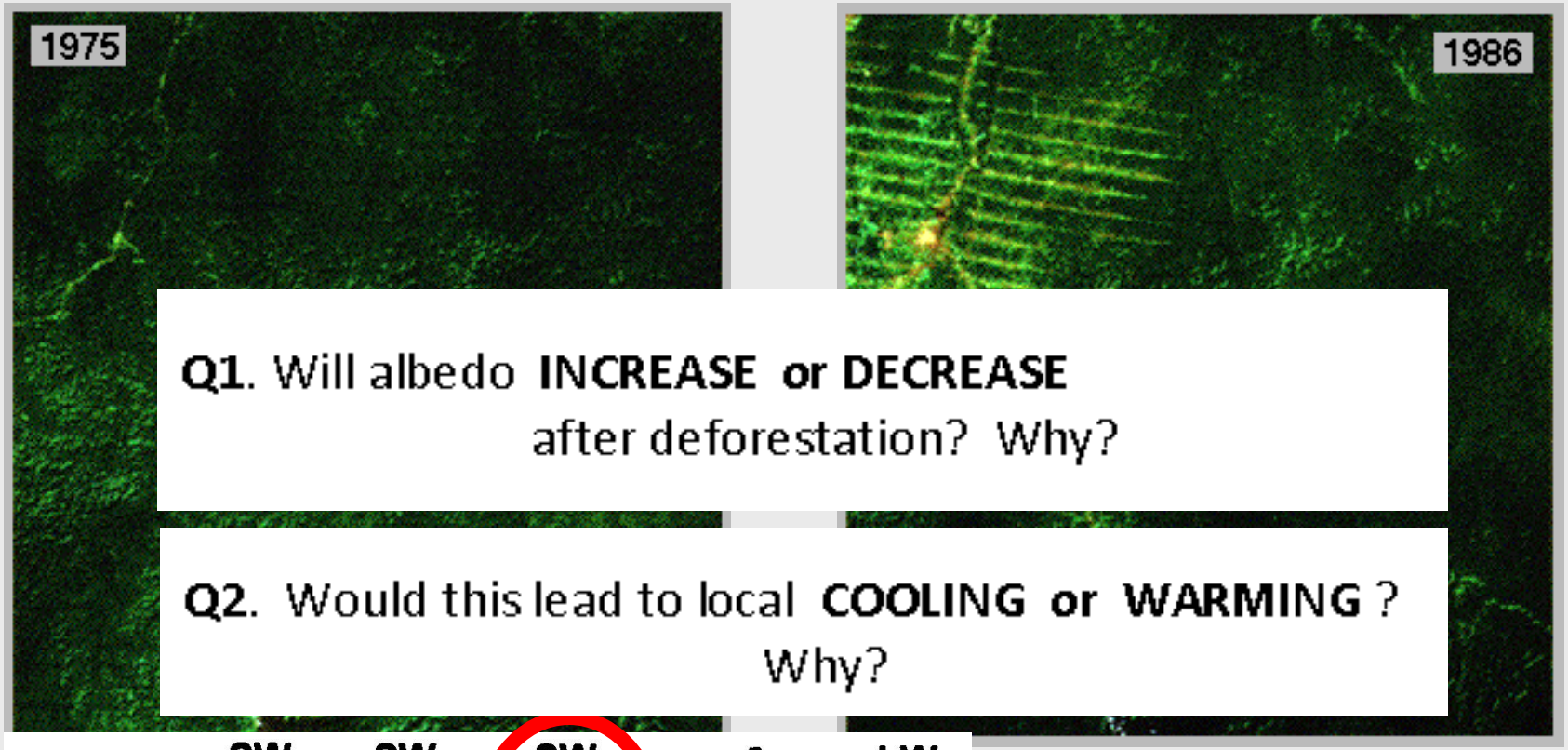
Amazon deforestation picking up pace, satellite data reveals

Data indicates 190% rise in land clearance in August and September compared with same period last year

A tree in a deforested area in the middle of the Amazon jungle. Photograph: Raphael Alves/AFP/Getty Images

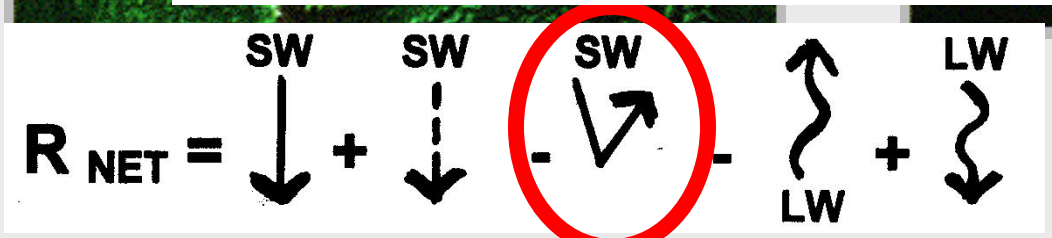
www.theguardian.com/environment/2014/oct/19/amazon-deforestation-satellite-data-brazil

How does DEFORESTATION change the LEFT SIDE of the local energy balance???



Q1. Will albedo **INCREASE or DECREASE** after deforestation? Why?

Q2. Would this lead to local **COOLING or WARMING**? Why?



More → cooler temperatures?

AMAZON RAIN FOREST:

- Warm
- Rainy
- Humid
- Lush vegetation

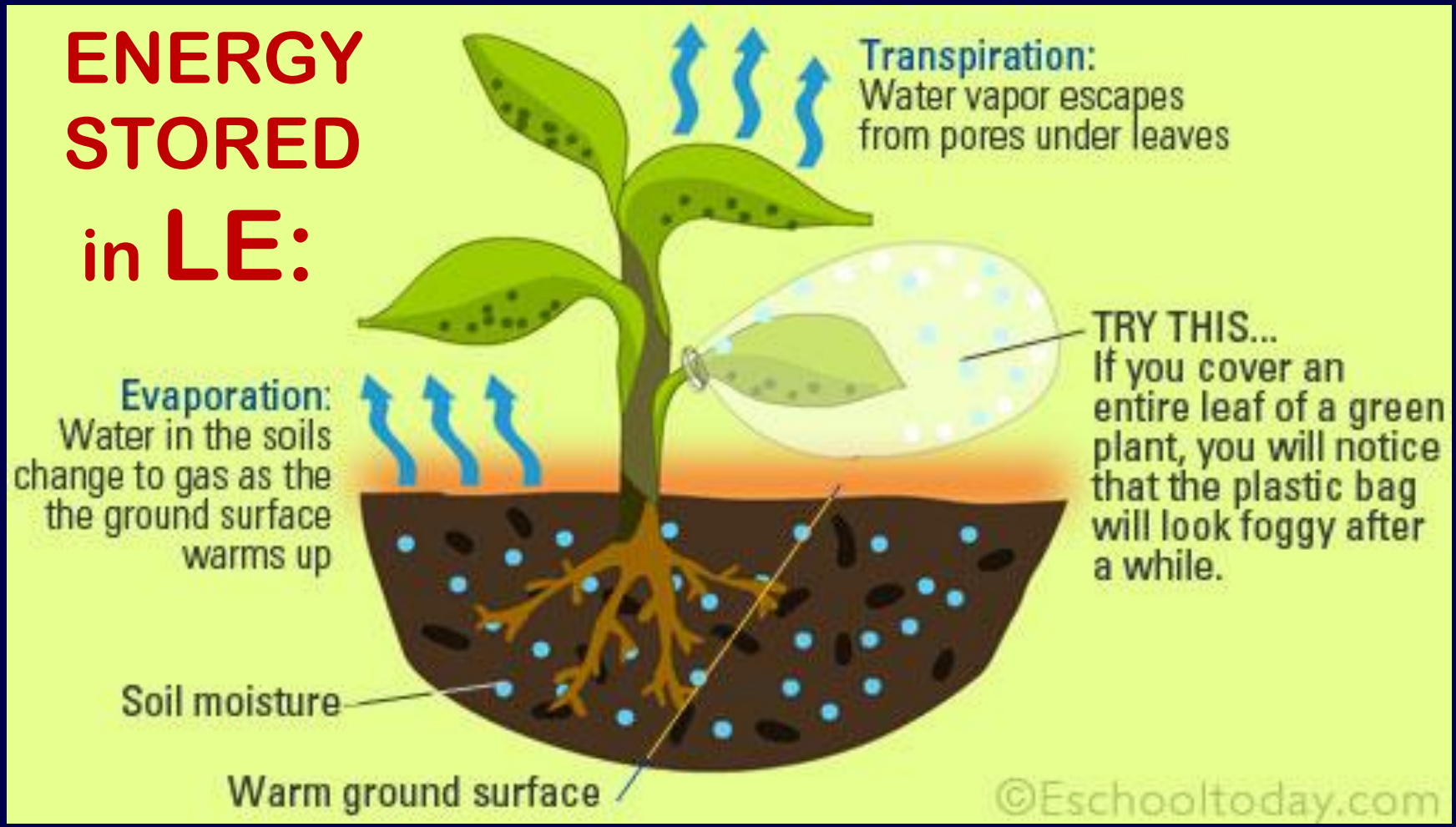
WARMTH + MOISTURE → EVAPORATION

H + water → phase change → LE + water vapor

TREES + MOISTURE → TRANSPIRATION

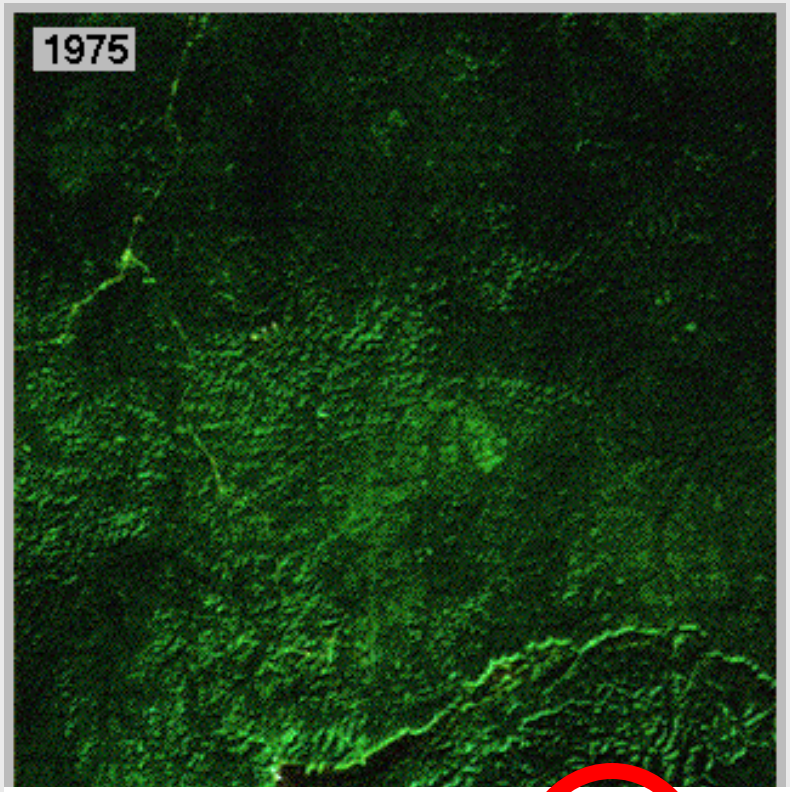
TRANSPIRATION = plants absorb water through the roots and then give off H_2O water vapor through pores ("stomates") in their leaves.

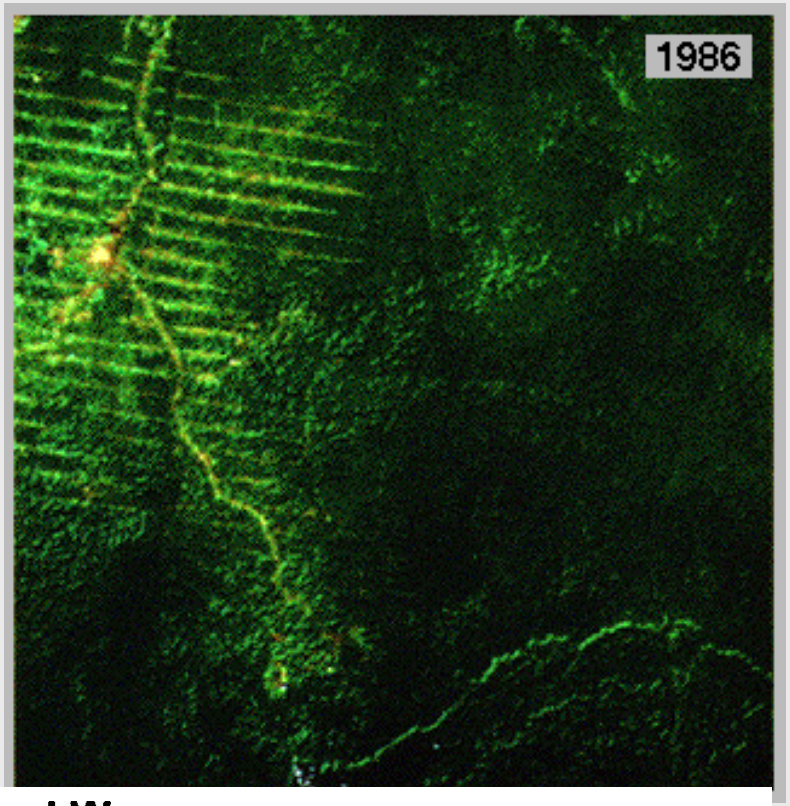
ENERGY STORED in LE:



TRANSPIRATION = plants absorb water through the roots and then give off H_2O water vapor through pores ("stomates") in their leaves.

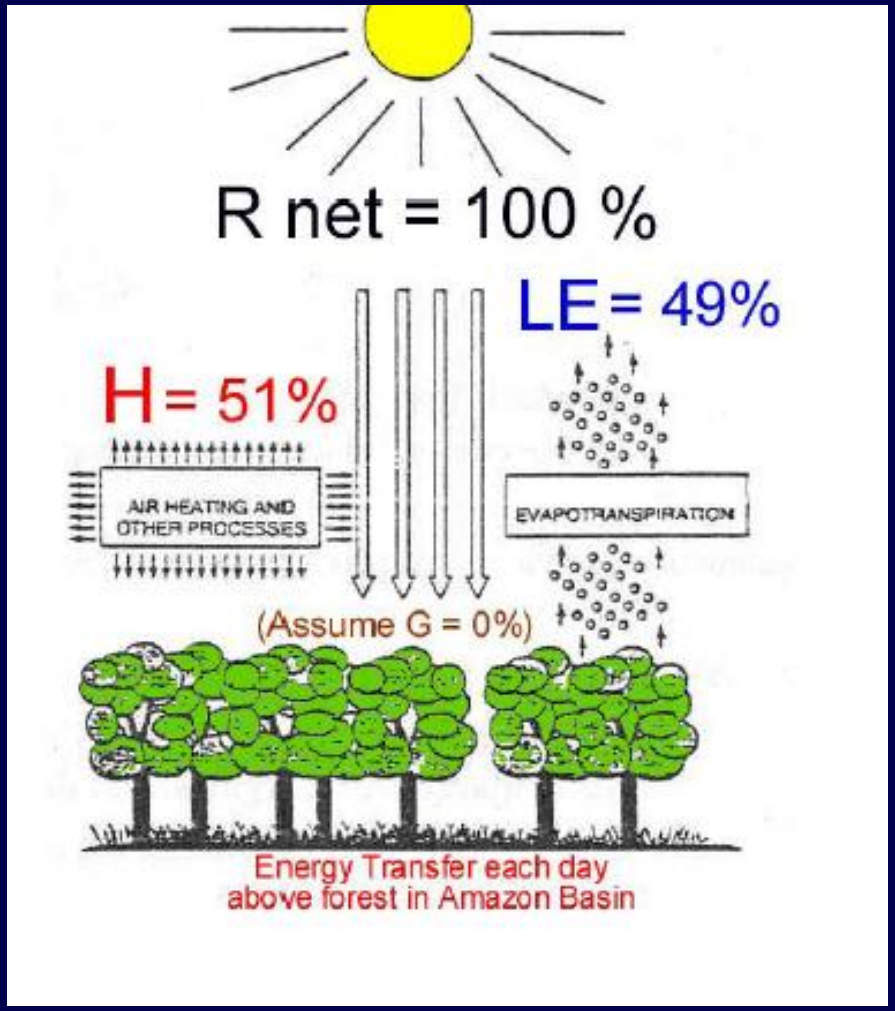
How does DEFORESTATION change the RIGHT SIDE of the local energy balance???





$$R_{NET} = SW_{\downarrow} + SW_{\downarrow} - SW_{\uparrow} - LW_{\uparrow} + LW_{\downarrow} = H + LE + G$$

More → cooler temperatures?

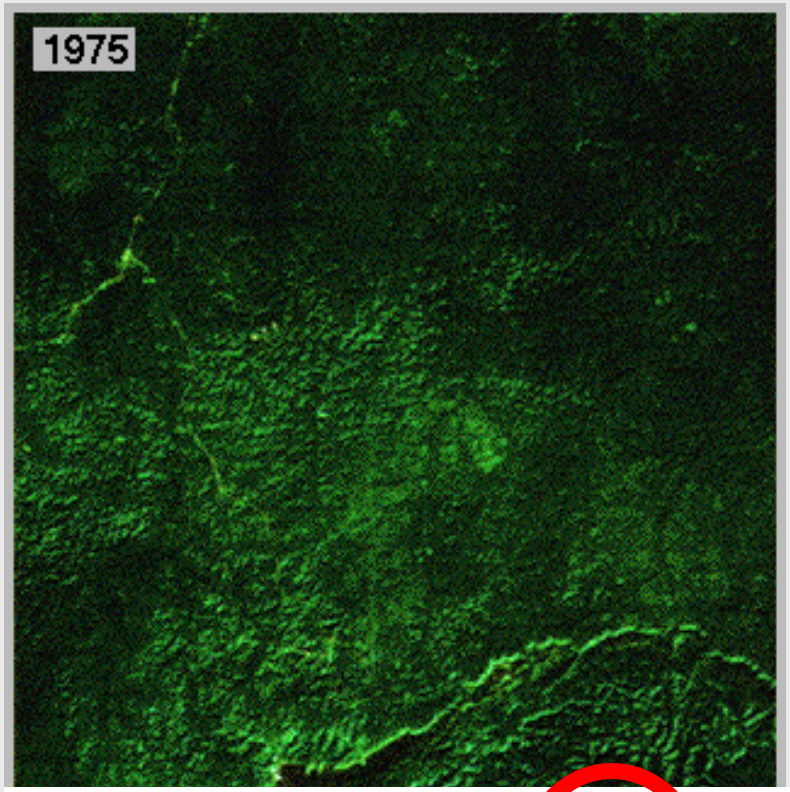


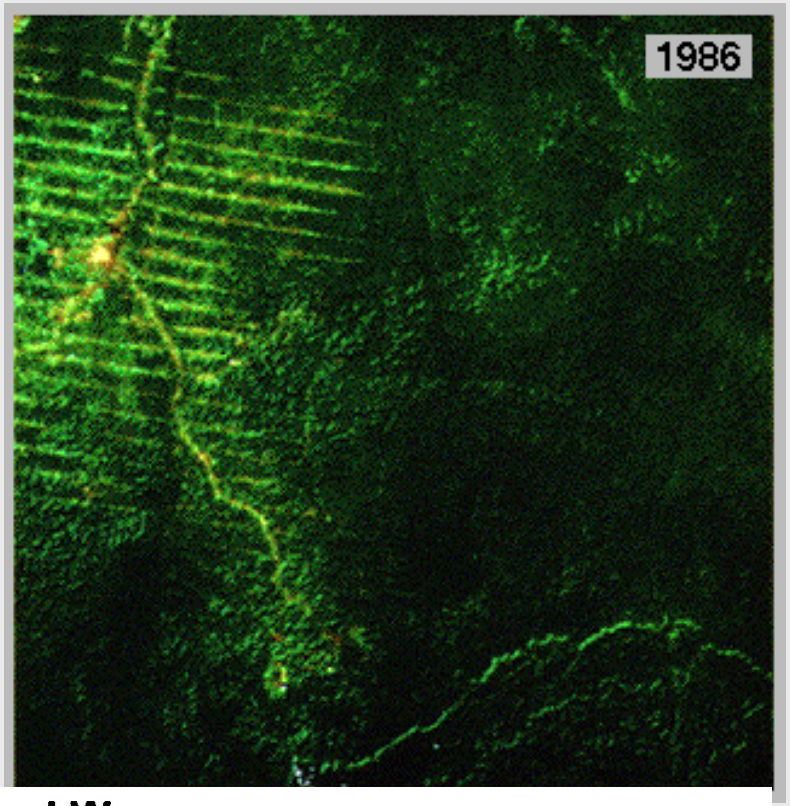
Estimates from Amazon Baisn indicate that ~1/2 of its precipitation is derived from transpiration

Q3. Will the proportion of energy stored in **LE** (at the expense of H) **INCREASE** or **DECREASE** after deforestation? Why?

Q4. Would this lead to local **COOLING or WARMING**? Why?

How does DEFORESTATION change the RIGHT SIDE of the local energy balance???





$$R_{NET} = SW_{\downarrow} + SW_{\downarrow} - SW_{\uparrow} - LW_{\uparrow} + LW_{\downarrow} = H + LE + G$$

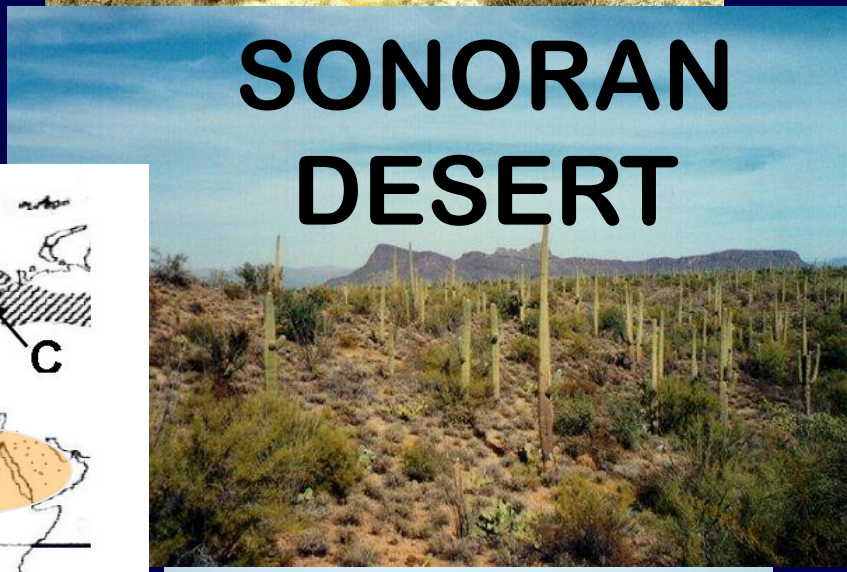
Less

More → cooler temperatures?

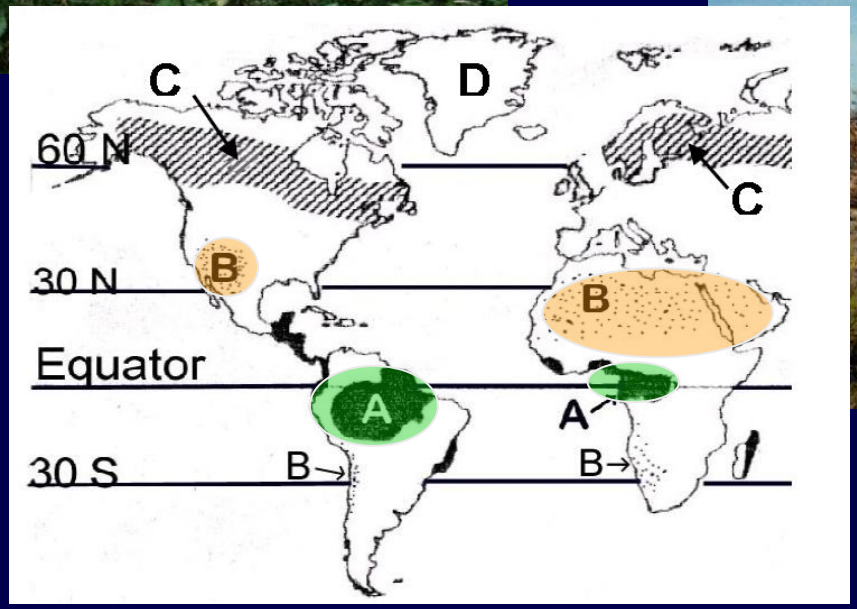
More → warmer temperatures?

NOW LET'S COMPARE:

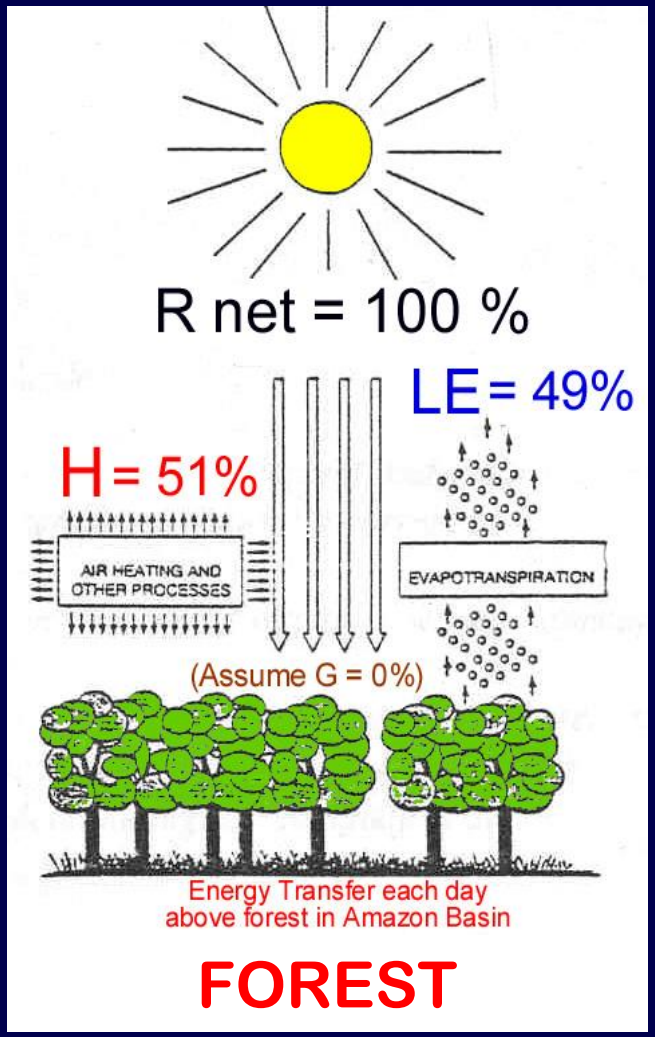
vs.

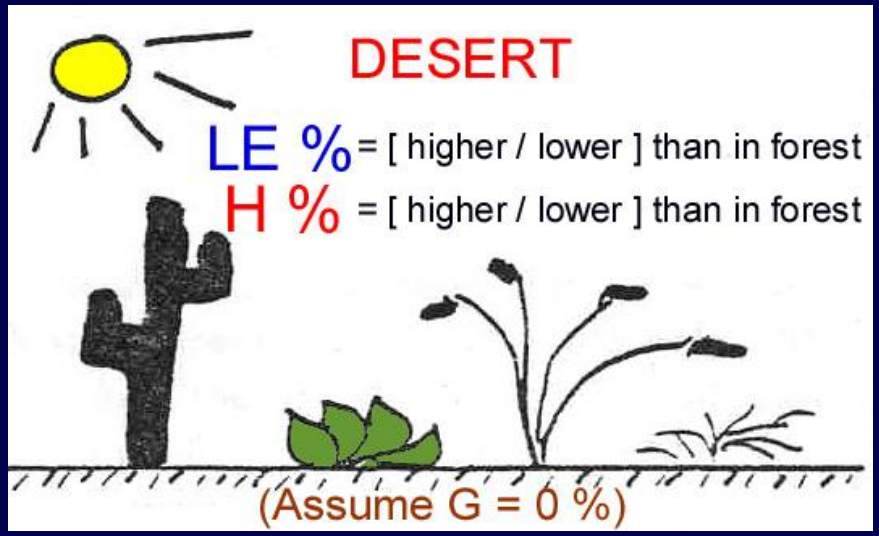


B = Subtropical Desert Climates



Some Key Global Climate Regions





H + LE + G

How would the distribution of energy in the right side of the equation differ in the Sonoran desert vs. the Amazon rainforest?

Q5. Choose the correct response below. Why?

(a) In the desert, **LE** will be **higher** and **H** will be **lower**

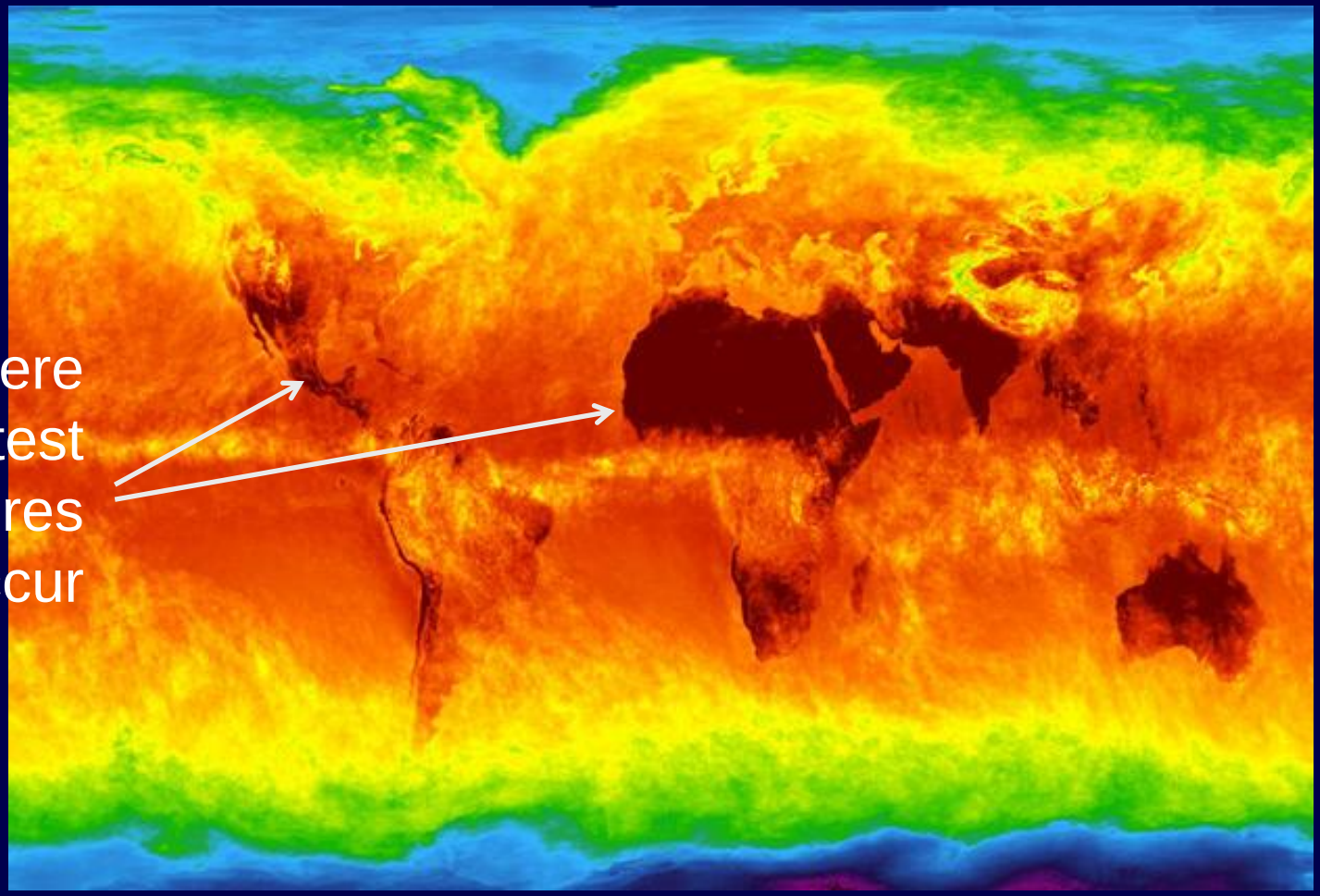
(b) In the desert, **LE** will be **lower** and **H** will be **higher**

Q6. Which environment do you think can reach the **highest temperatures** during its warm season? Why?

(a) The Amazon Rain Forest?

(b) The Sonoran Desert?

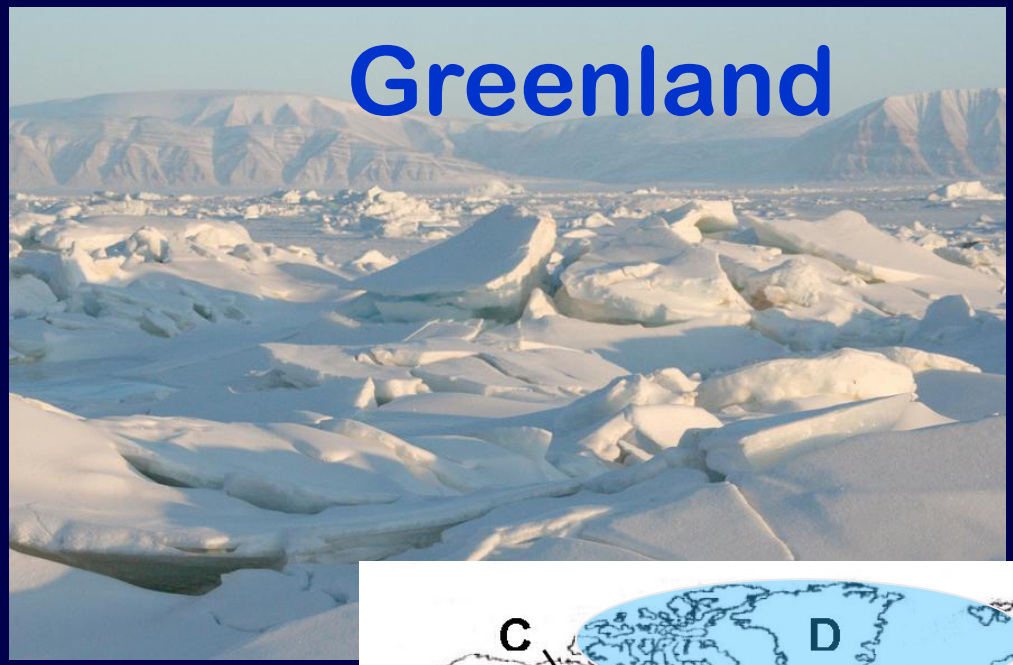
Note where the hottest temperatures occur



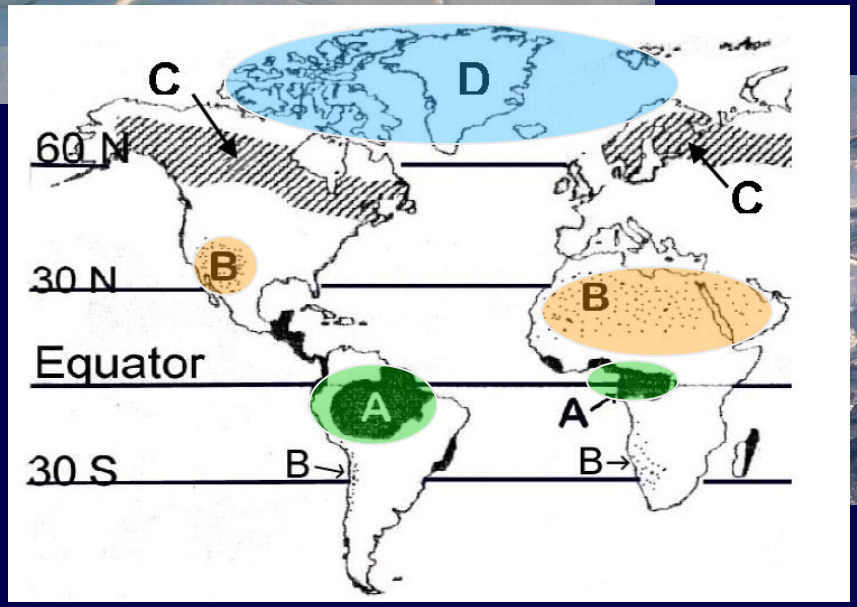
What if humans put in canals (CAP), lakes, & artificial water bodies in a desert?

More energy in H? or More energy in LE?

Let's visit one more global climate region . . . . .



& surrounding Arctic Sea Ice

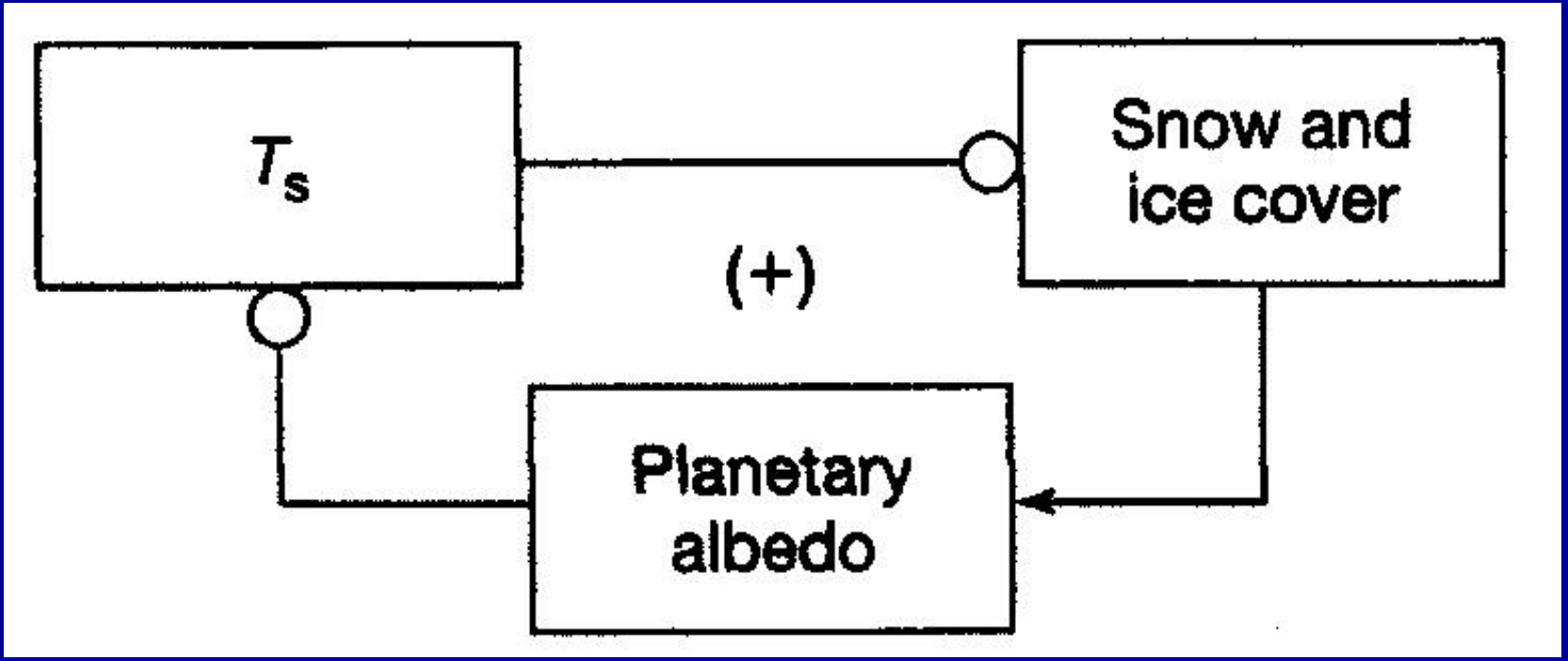


D = Polar Climates

☺

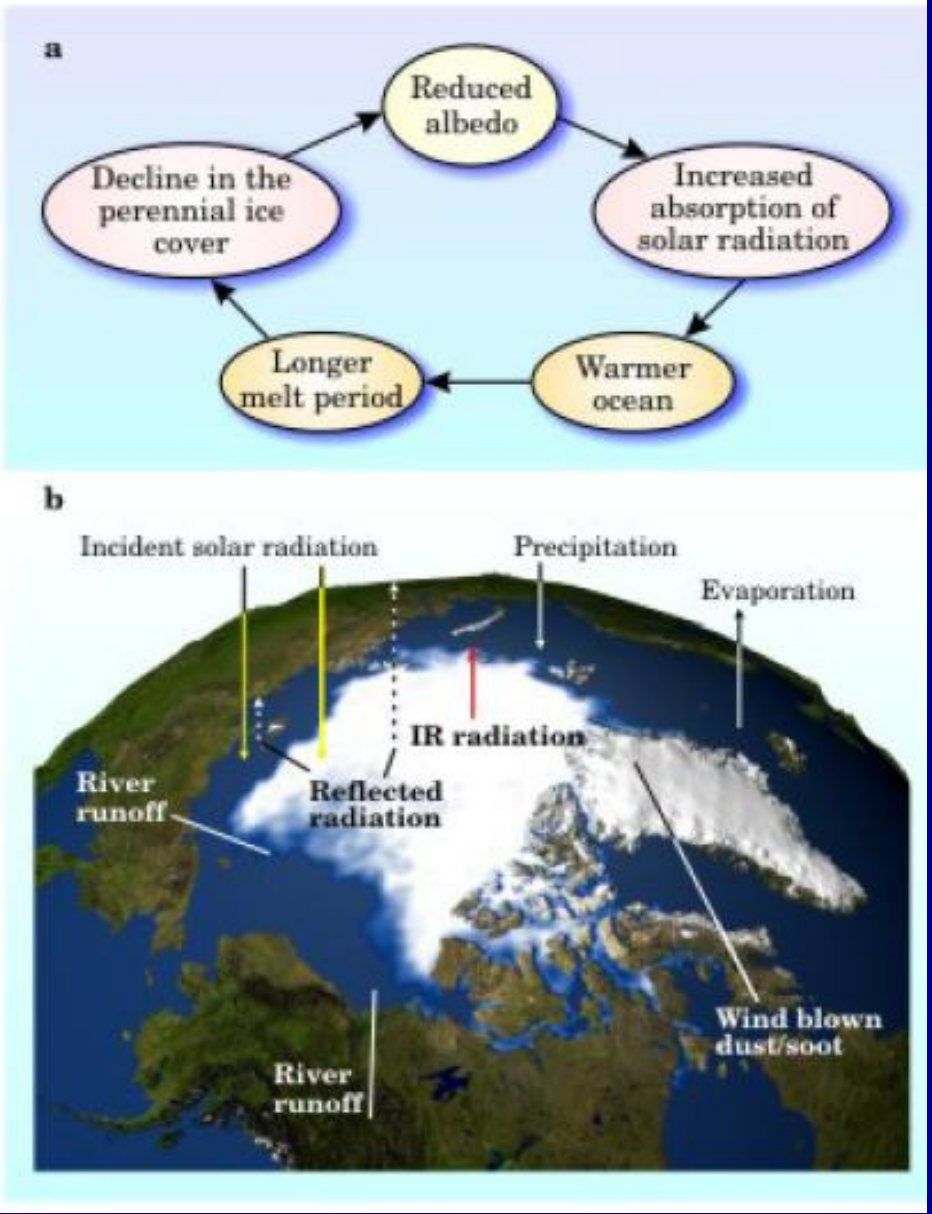
Remember this feedback . . . .

SNOW AND ICE ALBEDO Feedback



GROUP BONUS POINT CHALLENGE

REMEMBER FEEDBACK LOOPS:
Is this one positive or negative?



GROUP BONUS POINT CHALLENGE !!

As a group, complete the feedback loop on the bottom of page 61 by linking the components with the proper coupling arrow symbols as used in the SGC text.

p 61

albedo

Extent of ice cover

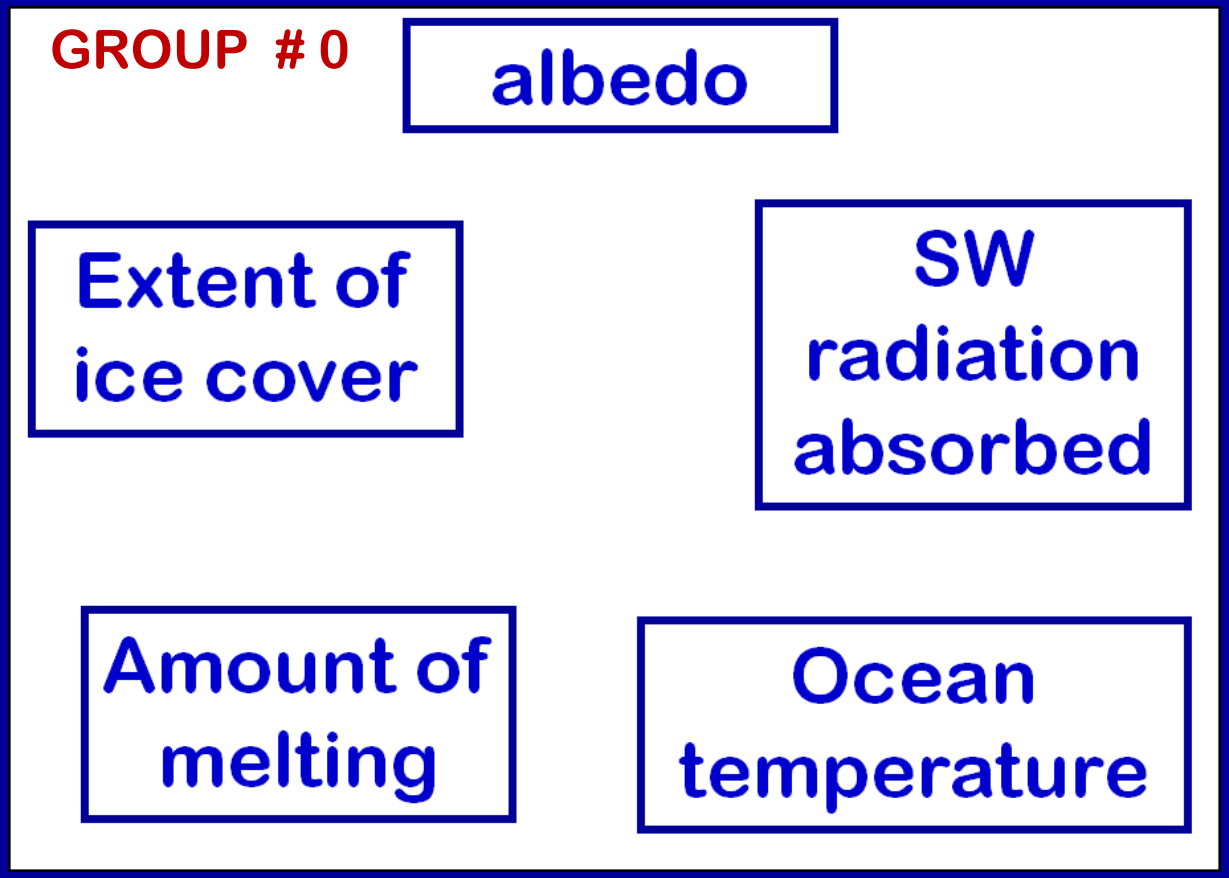
SW radiation absorbed

Amount of melting

Ocean temperature

GROUP BONUS POINT DIRECTIONS

(1) WRITE YOUR GROUP # ON CARD
(2) Sketch in the component boxes
(3) Link them with proper + or – coupling symbols
(4) State if entire loop is + POSTIVE or – NEGATIVE
(5) Give Card to Dr H



THEN GO ON
TO COMPLETE G-3

albedo

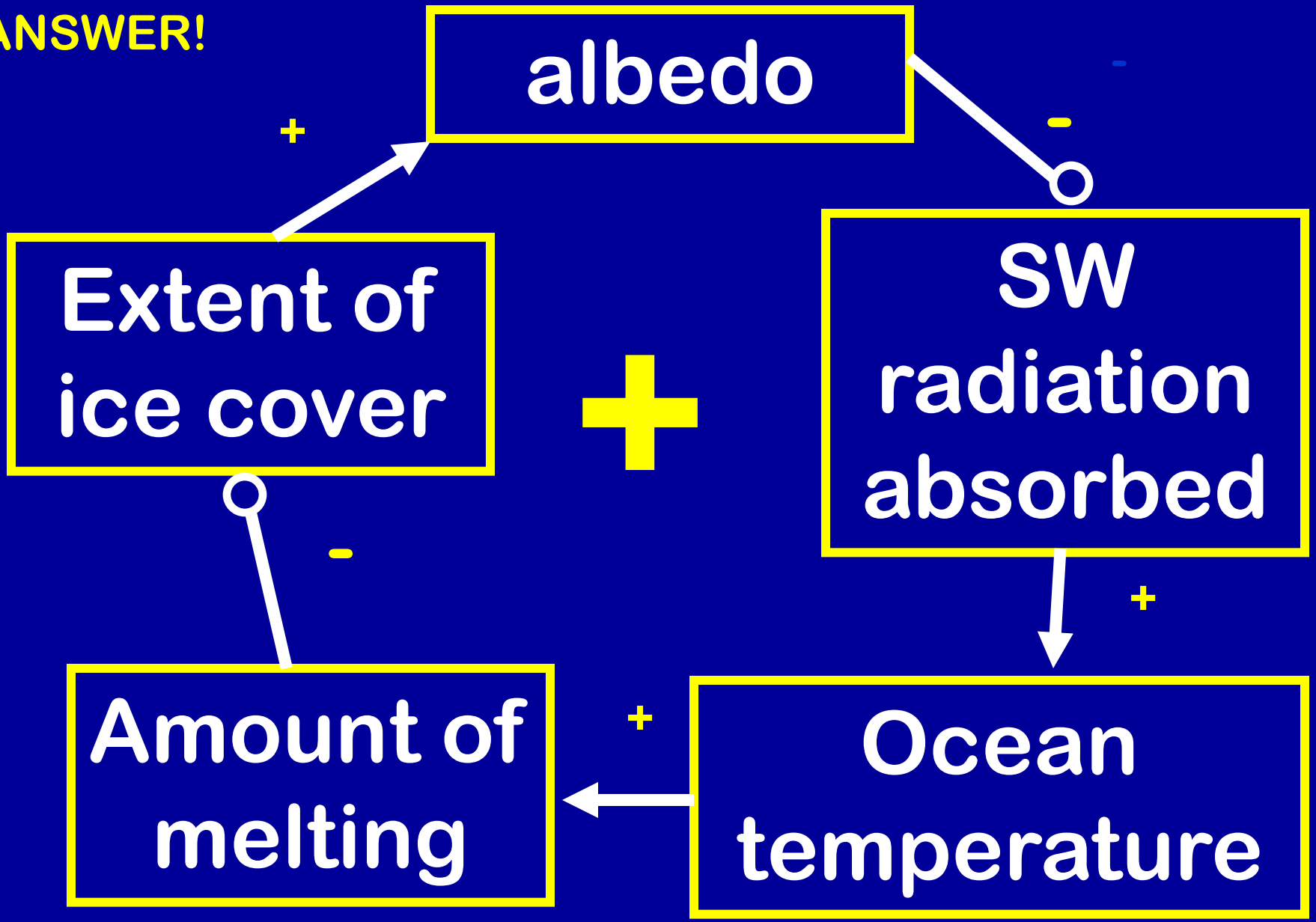
Extent of ice cover

SW radiation absorbed

Amount of melting

Ocean temperature

BONUS POINT
ANSWER!



Go CATS . . .

Beat the Cougars!