Hybrid Learning in Earth and Space Science

BOULDER CREEK CZO

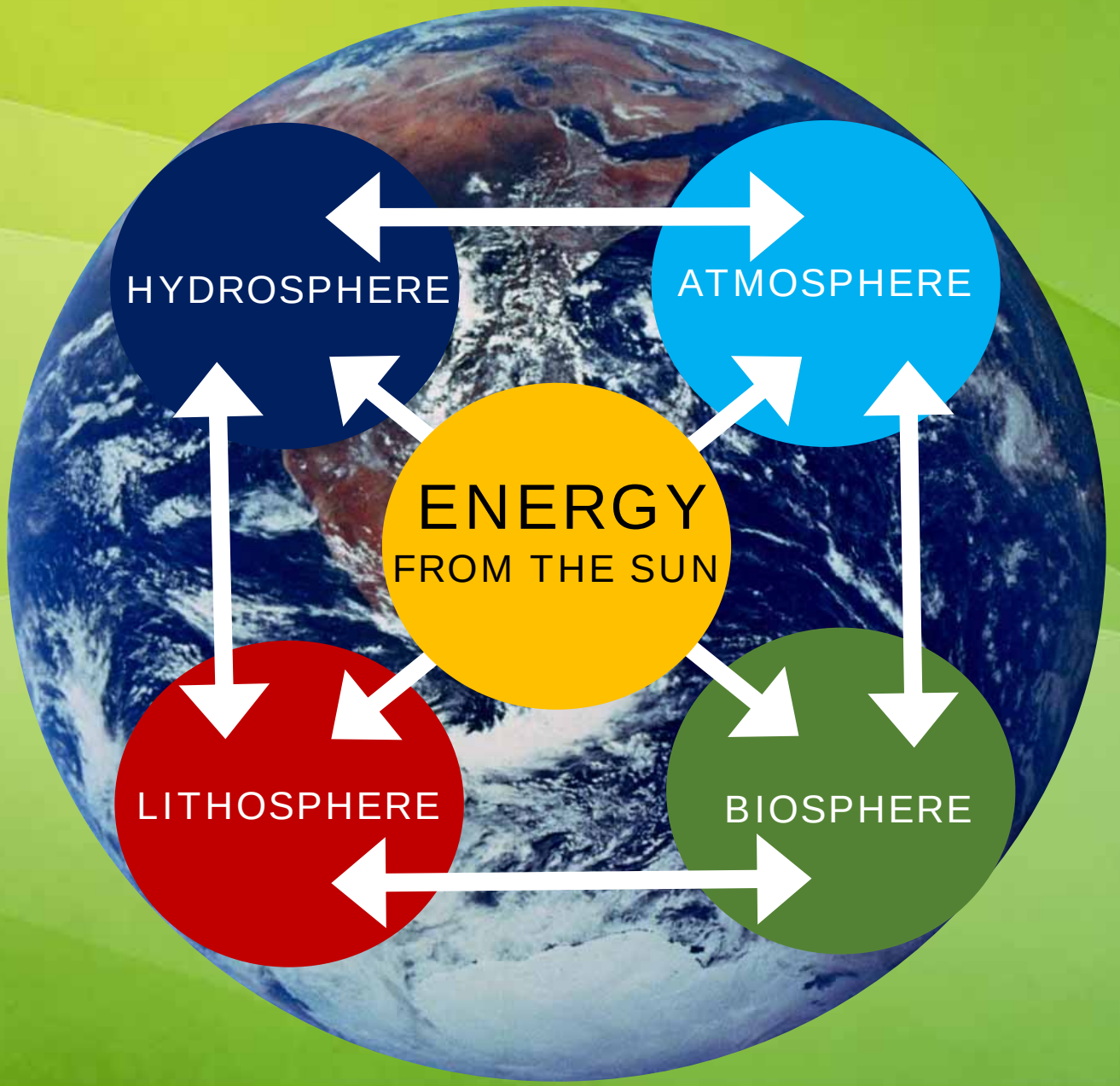
NSF

NATIONAL SCIENCE FOUNDATION

LTER NETWORK

LONG TERM ECOLOGICAL RESEARCH

Energy and Earth's Systems



NATIONAL SCIENCE FOUNDATION

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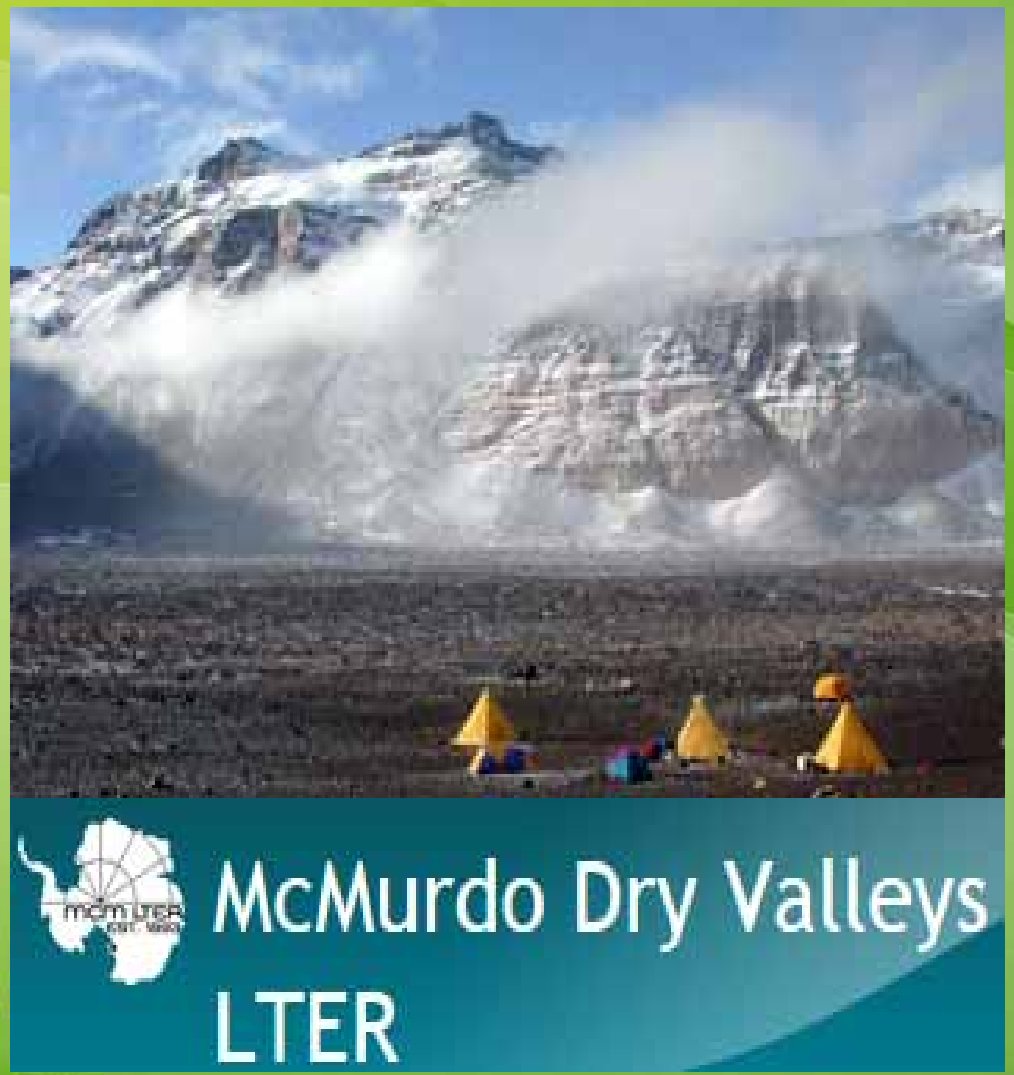
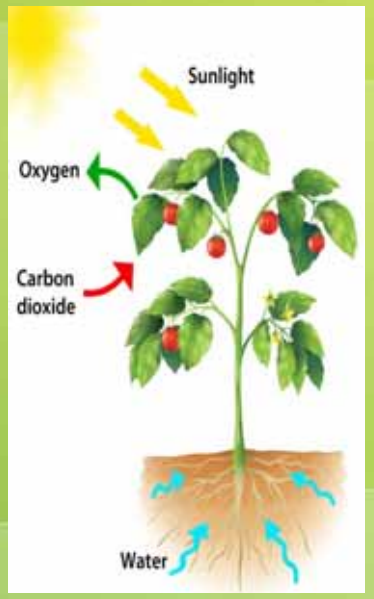
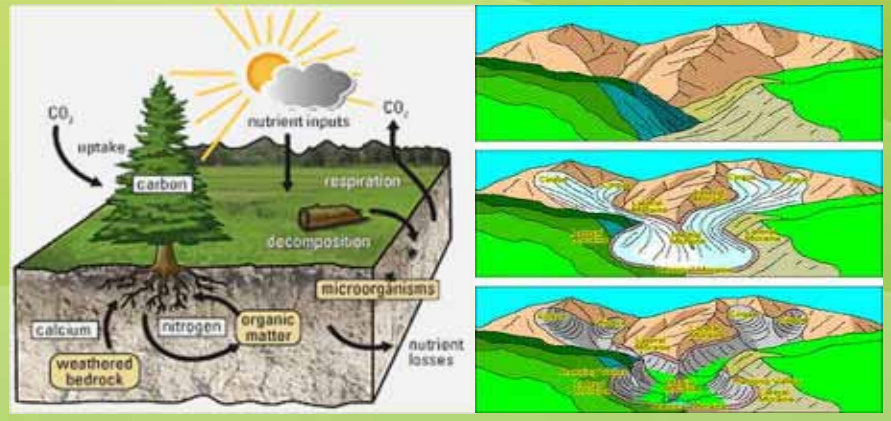


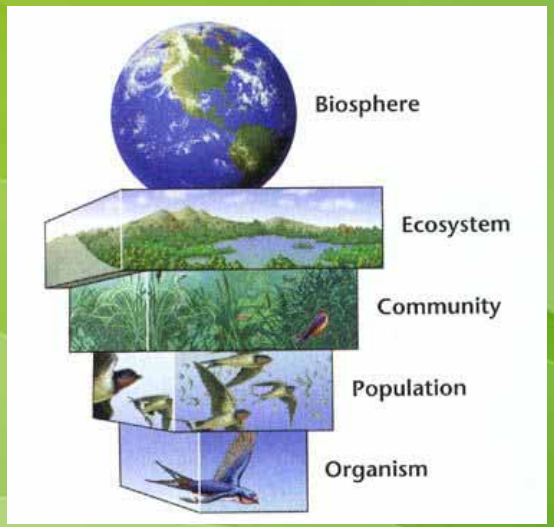
Long-Term Ecological Research ~ Core Areas



Primary Production

Movement of Organic & Inorganic Materials

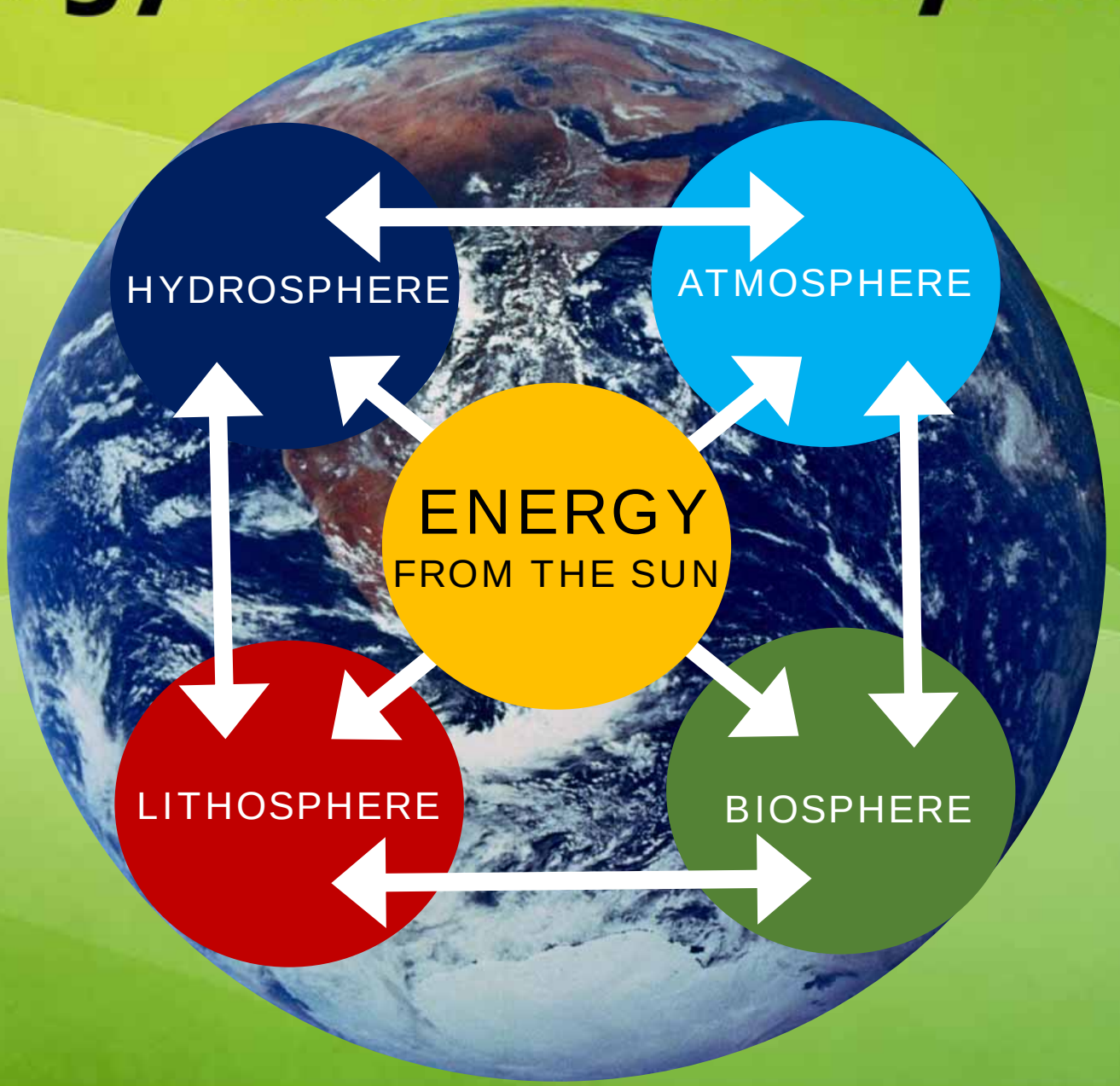




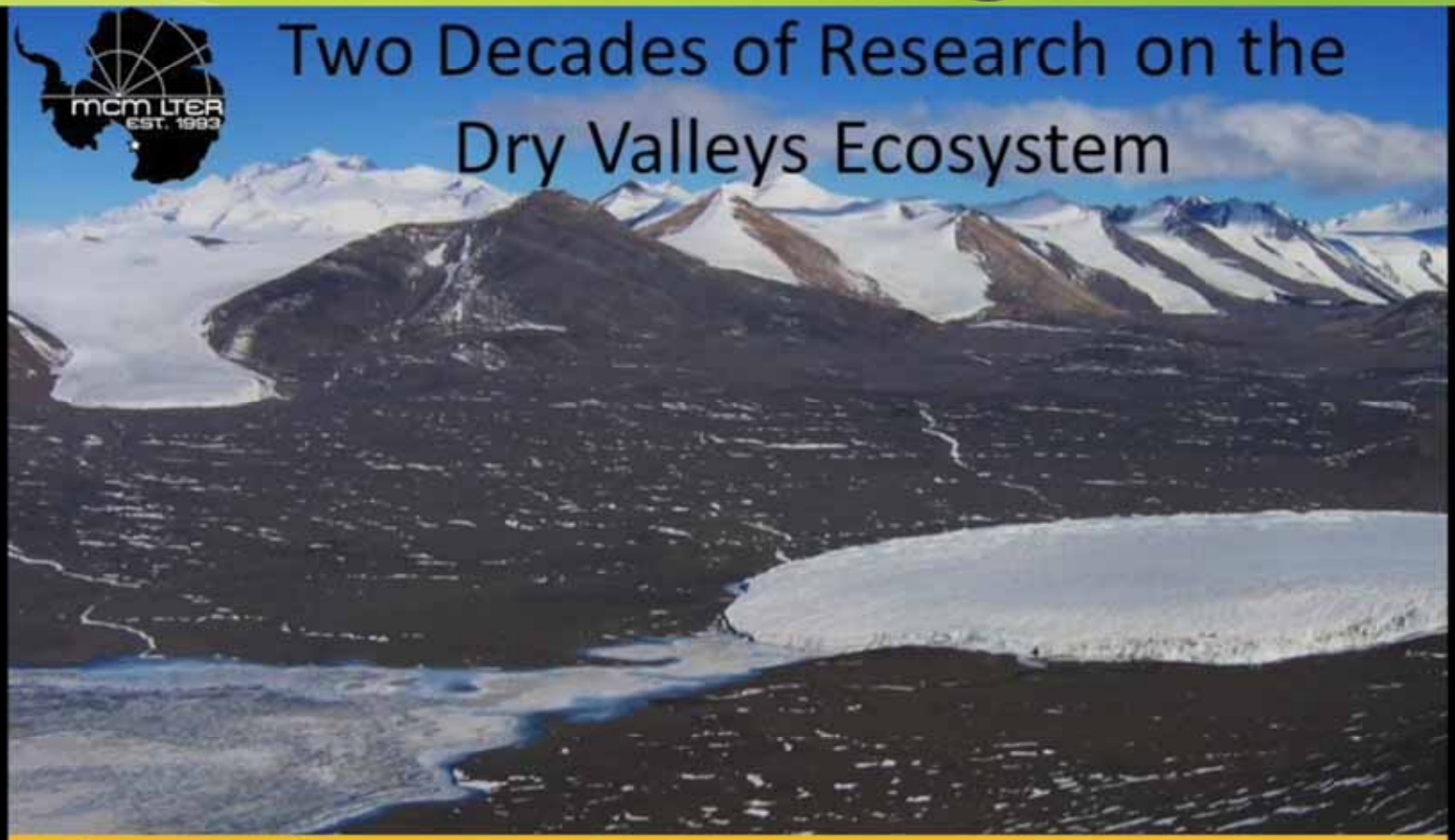
Communities & Populations

Disturbances and Change

Energy and Earth's Systems

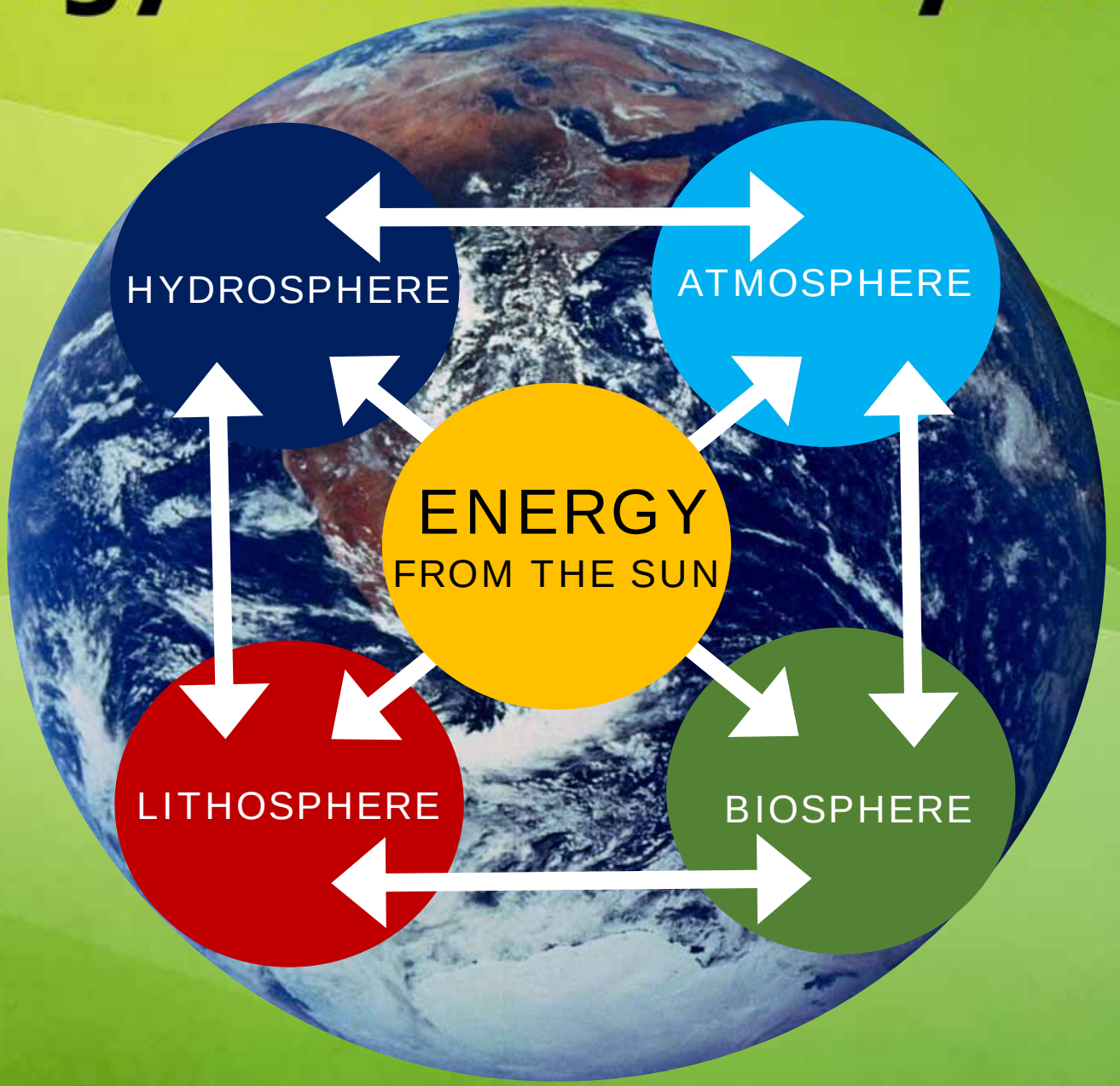


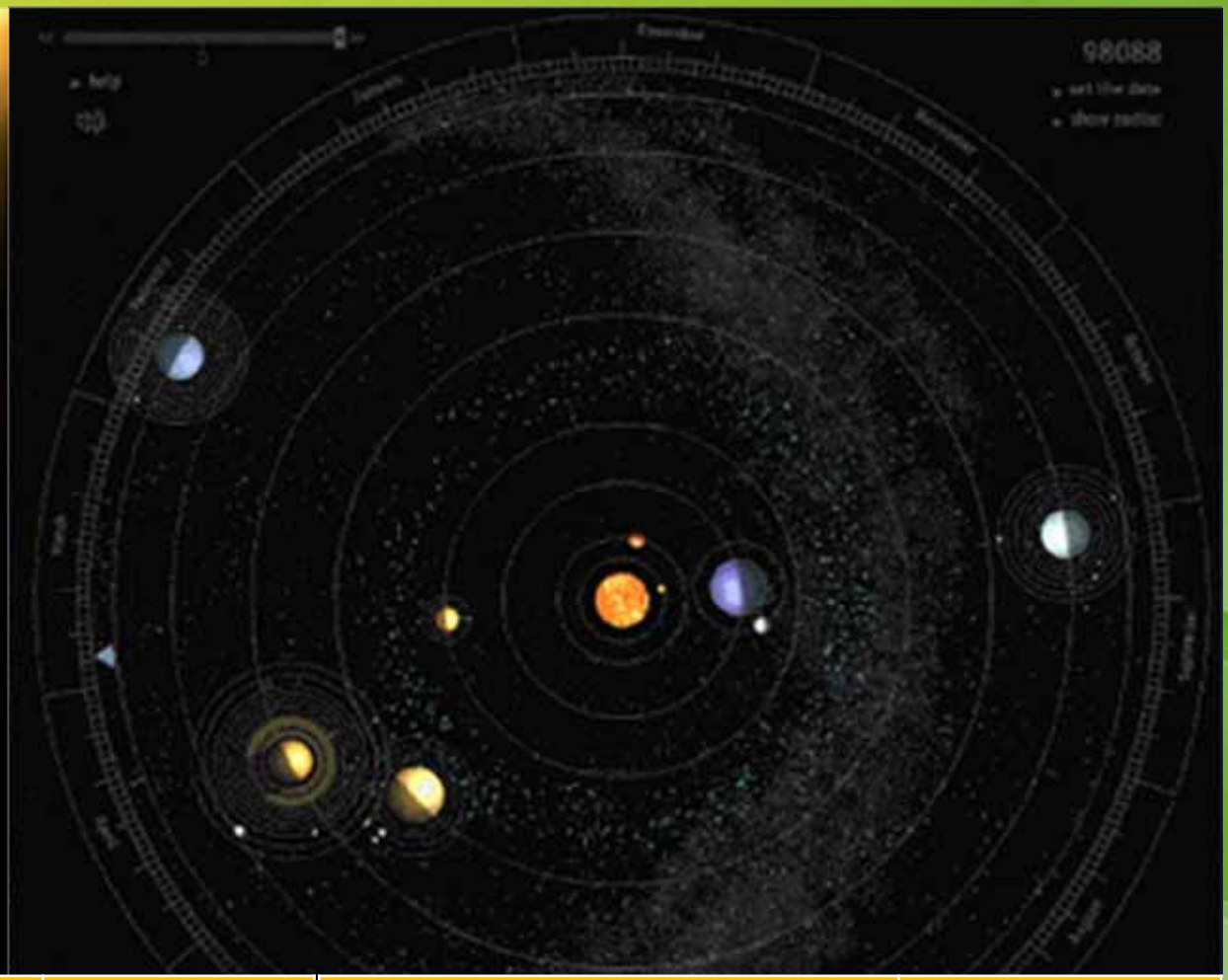
Long-Term Ecological Research Program



Mike Gooseff
Institute of Arctic & Alpine Research, University of Colorado

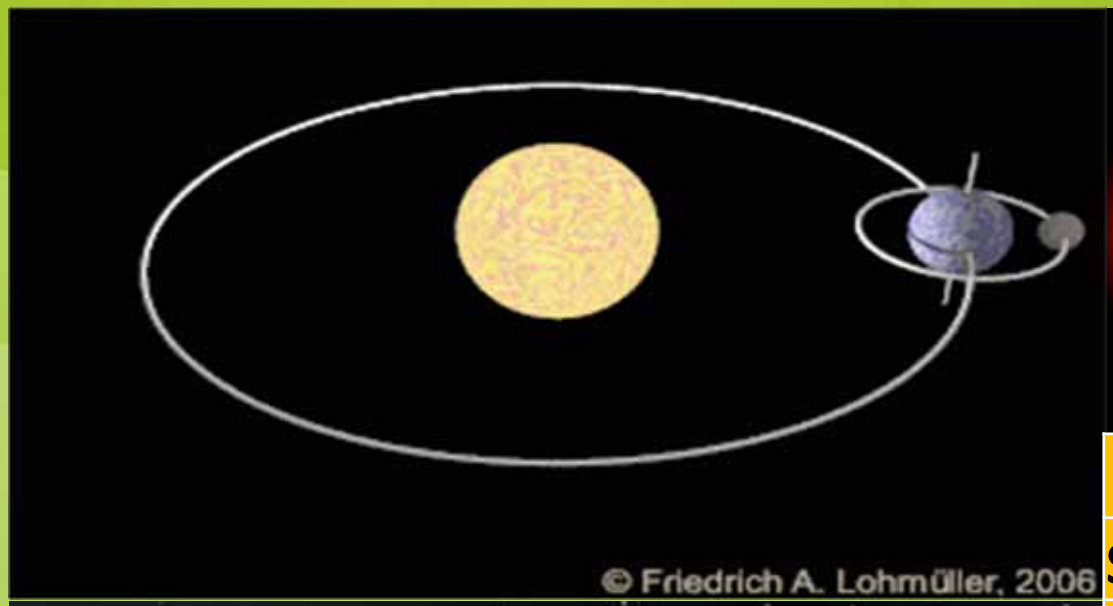
Energy and Earth's Systems

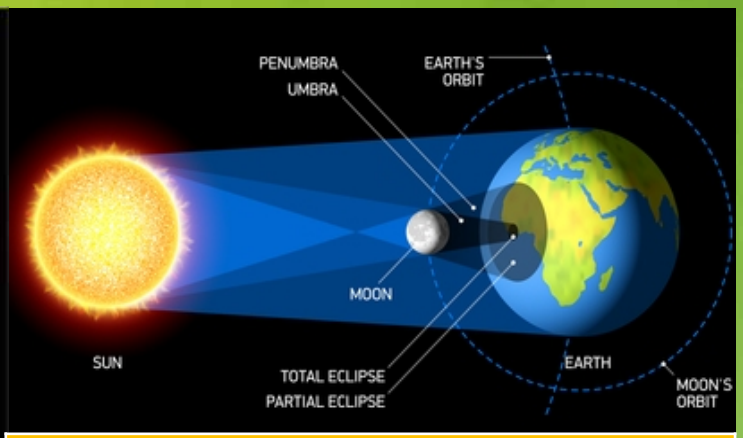


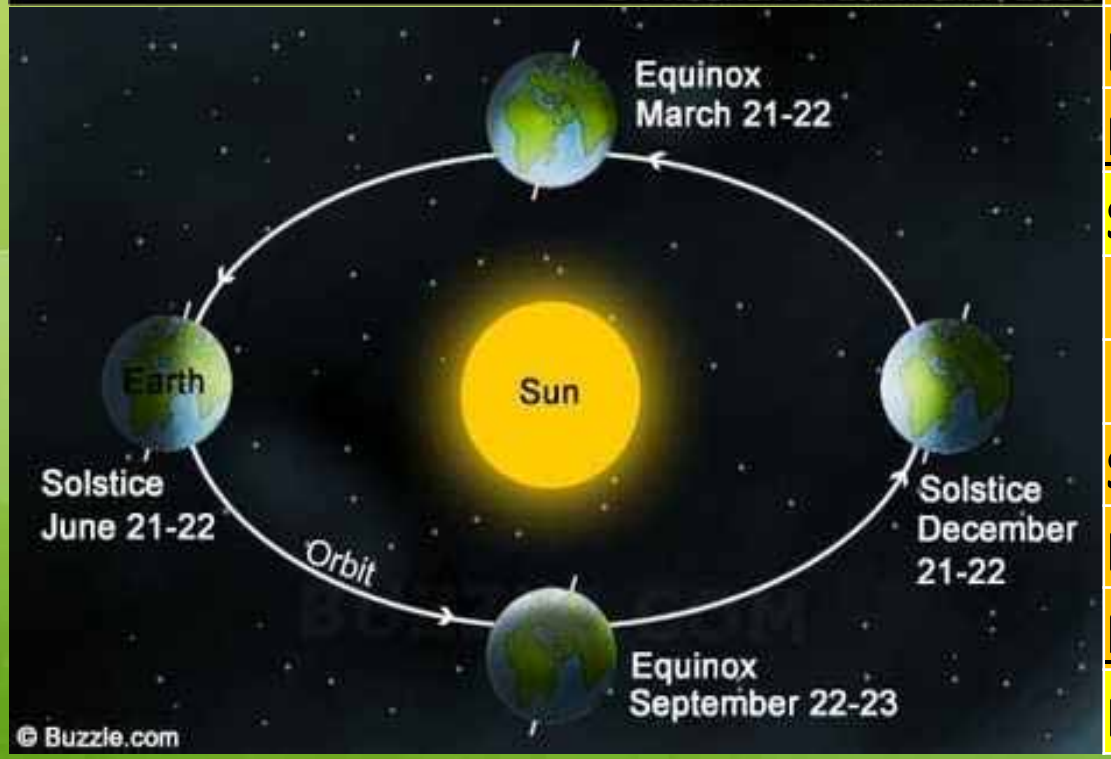


Planets Diameter (km)		Scale
Sun	1,392,000	145 Feet
Earth	12,756	16 inches
Moon	3,476	4.4 Inches

Planets Orbit (km)		Scale
Earth	150,000,000	15,700 Feet
Moon	384,000	145 Feet

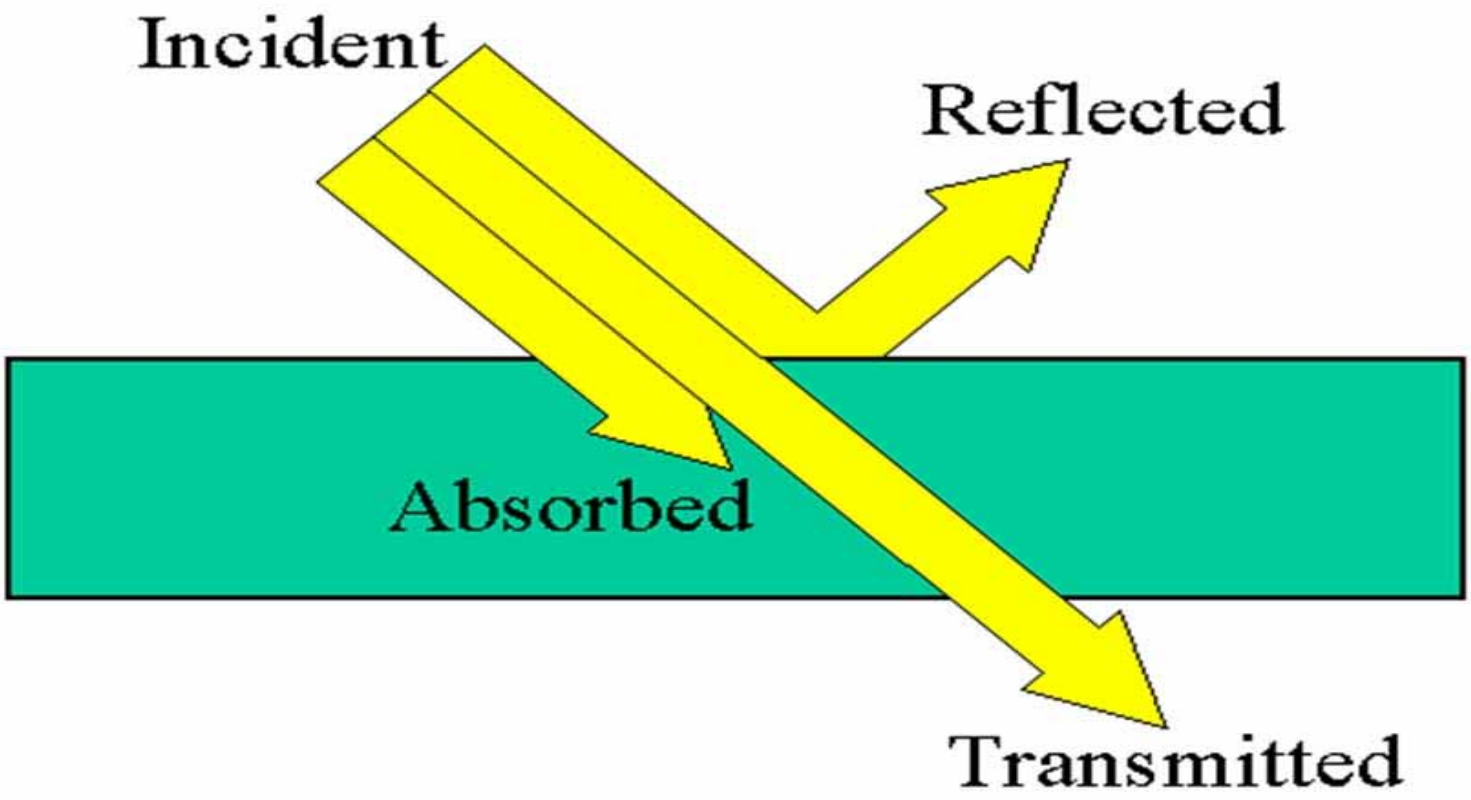


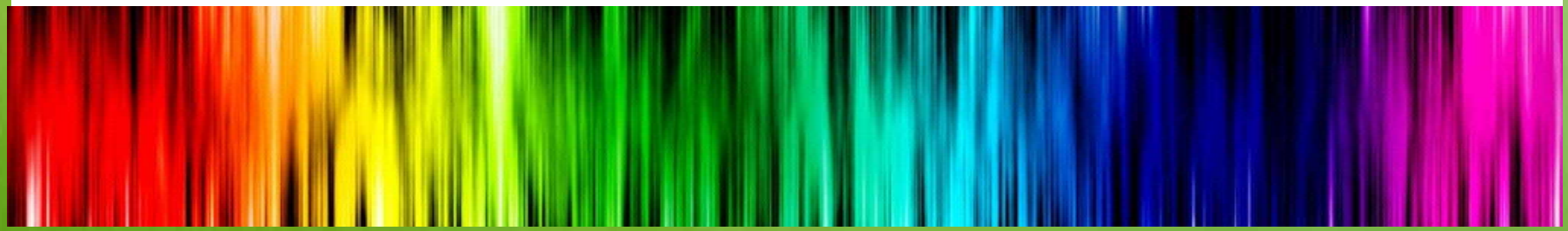




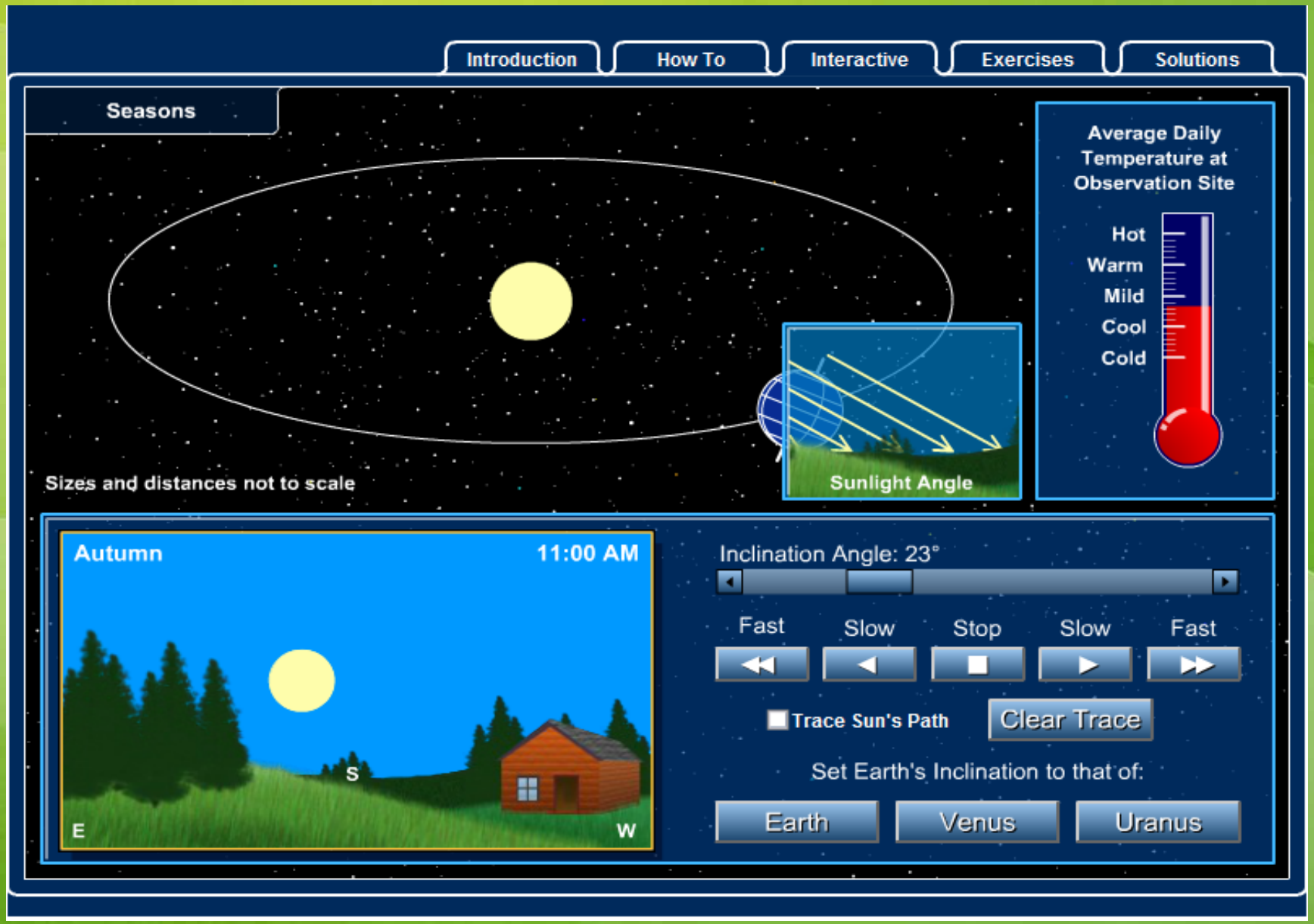
Planets Diameter (km)	
Sun	1,392,000
Earth	12,756
Moon	3,476
Sun/Moon	400
Planets Orbit (km)	
Sun	
Earth	150,000,000
Moon	384,000
Earth/Moon	390

Seasons/Ecliptic Simulator

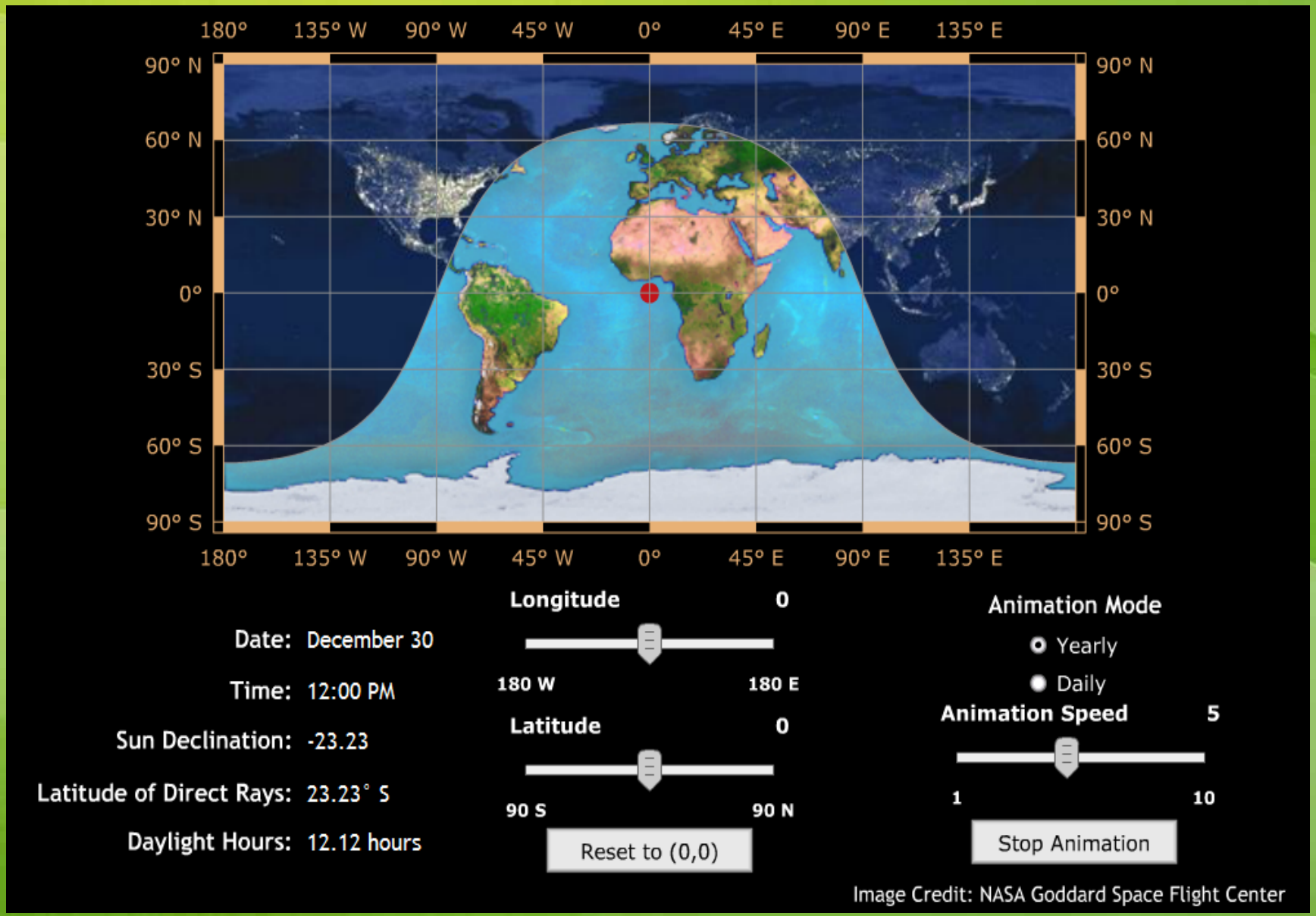




Seasons Interactive



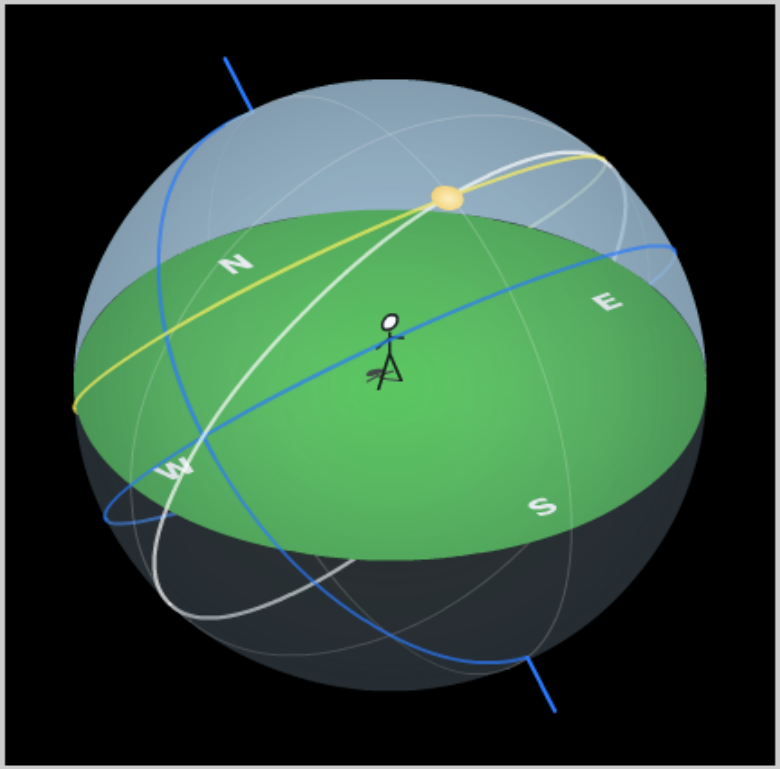
Daylight Simulator



Sun Motion Demonstrator

Motions of the Sun Simulator

reset help about



Time and Location Controls

the day of year: 27 May

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |

the time of day: 12:00

the observer's latitude: 40.8 ° N

Information

The horizon diagram is shown for an observer at latitude 40.8° N on 27 May at 12:00 (12:00 PM).

advanced

sun's hour angle: 0h 2m
sidereal time: 4h 21m
equation of time: 2:49
☐ show analemma

sun's altitude: 70.6°
sun's azimuth: 182.0°
sun's right ascension: 4h 19m
sun's declination: 21.4°

Animation Controls

start animation

animation mode:
◉ continuous ☐ loop day
○ step by day

animation speed: 3.0 hrs/sec

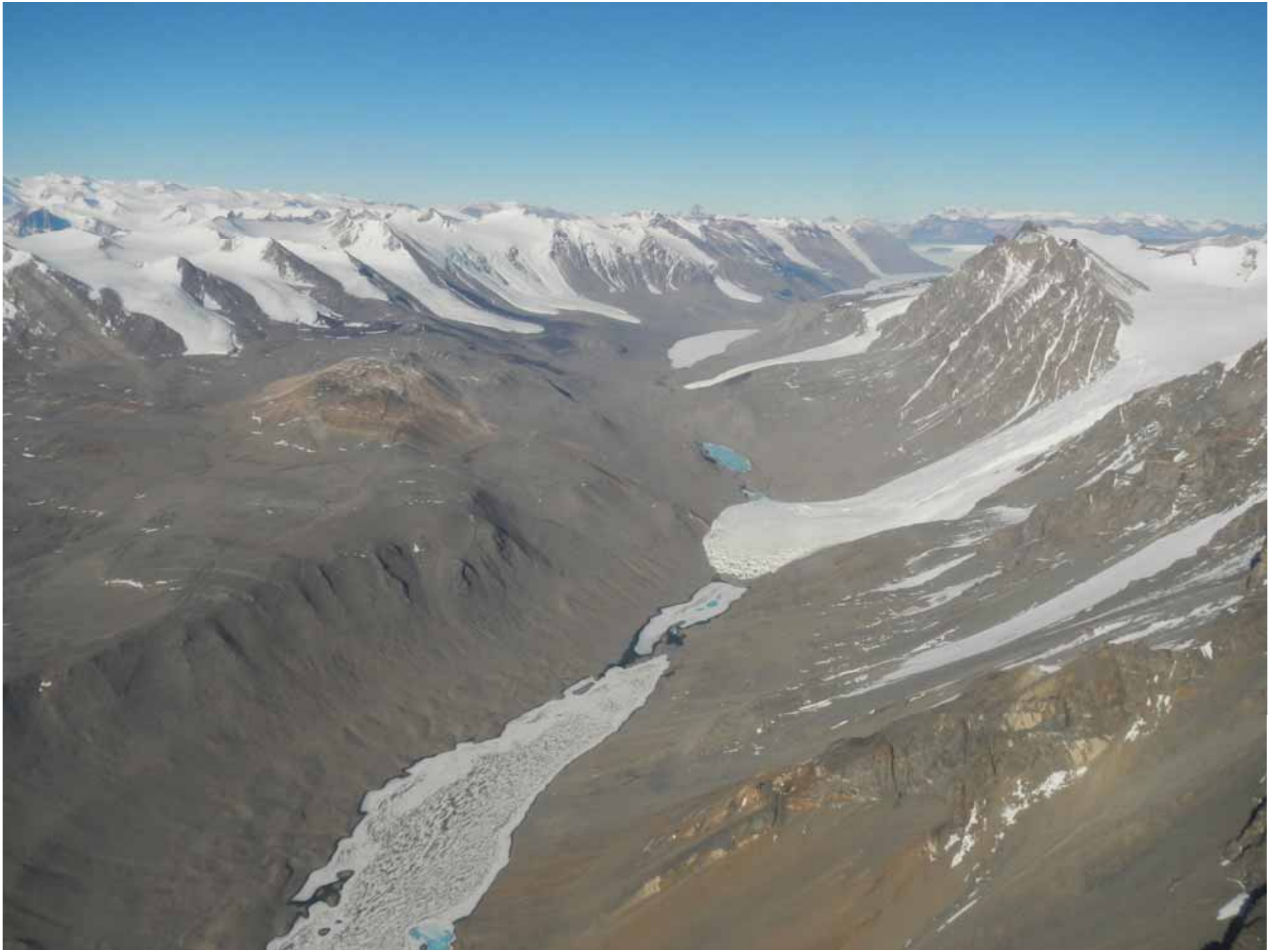
slower faster

☐ use lower quality graphics when animating to improve performance

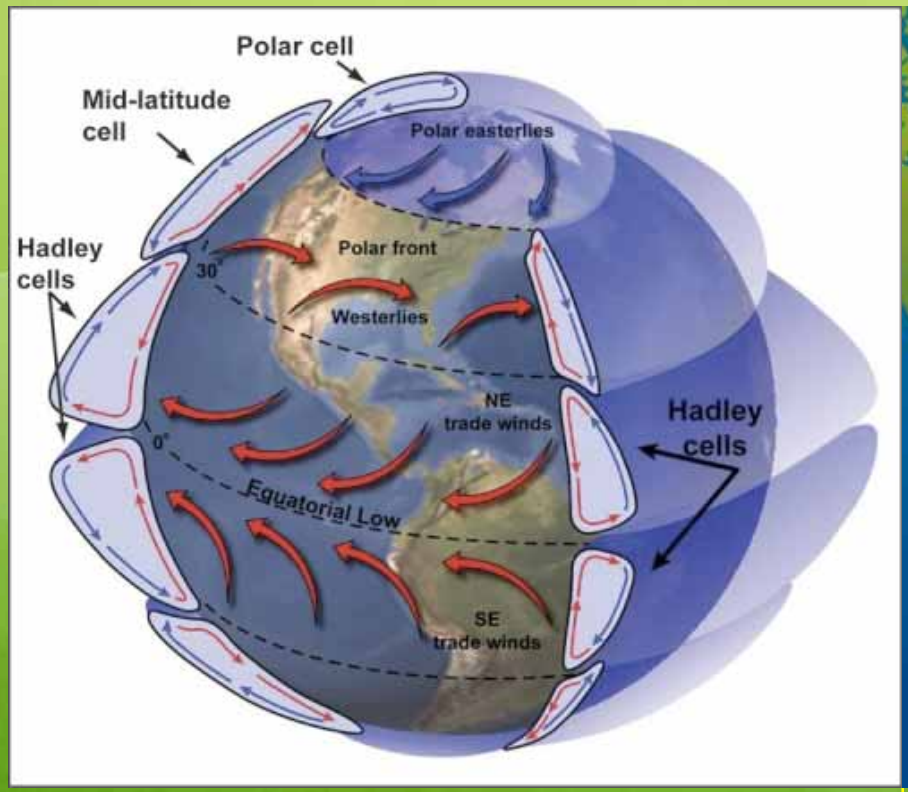
General Settings

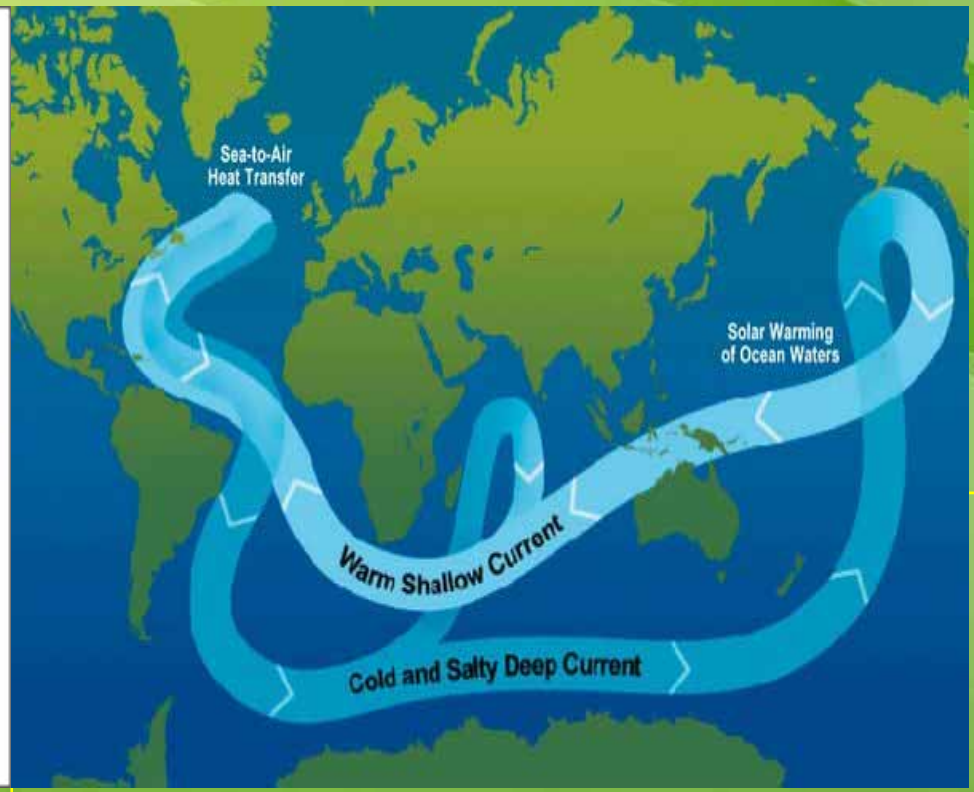
☑ show the sun's declination circle
☑ show the ecliptic
☐ show month labels
☑ show underside of celestial sphere
☑ show stickfigure and its shadow

dragging the sun's disk changes the ...
◉ time of day
○ day of year

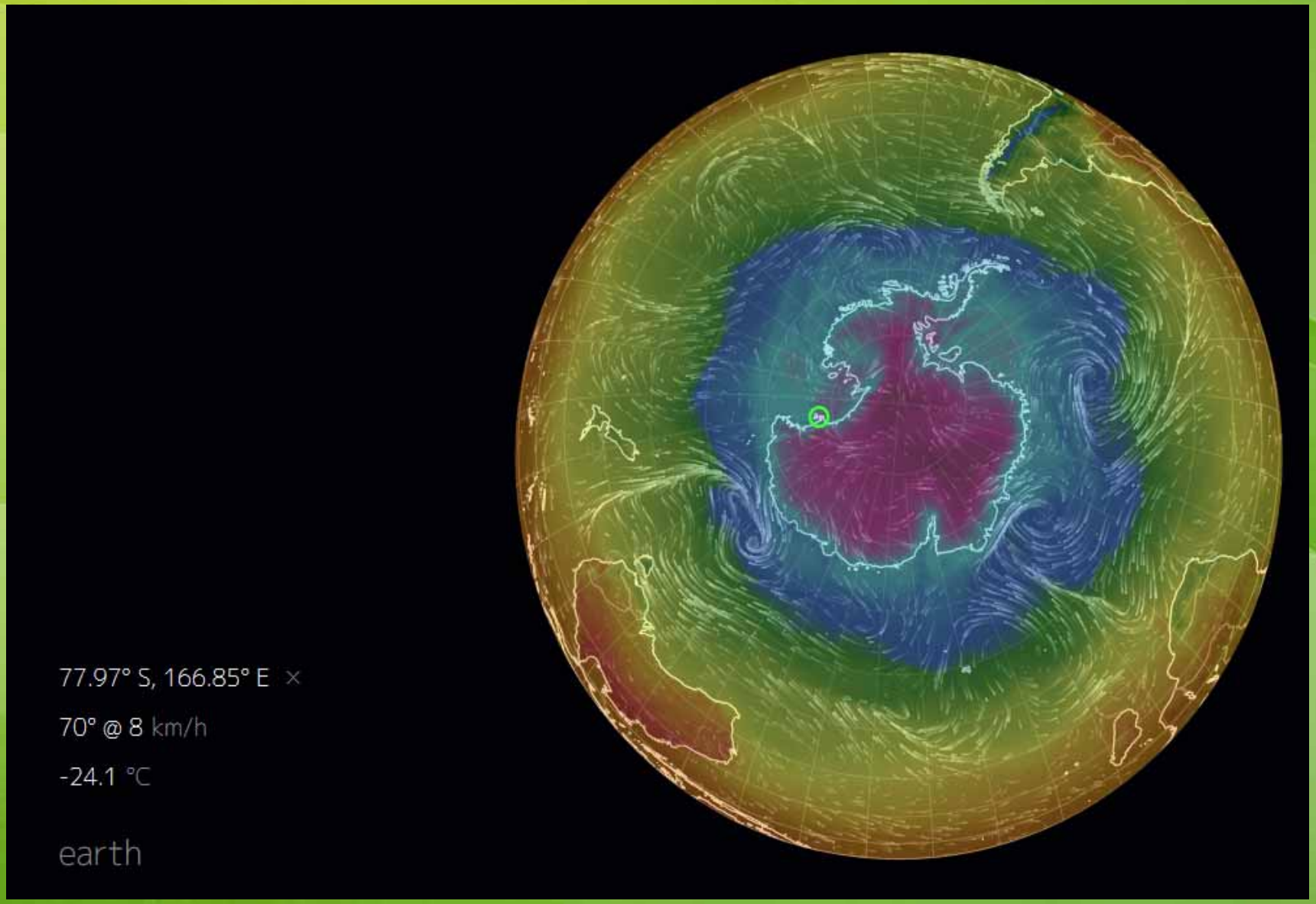


Parts of the Earth receive varying amounts of energy throughout the year. This energy is redistributed in the system to reach a balance.



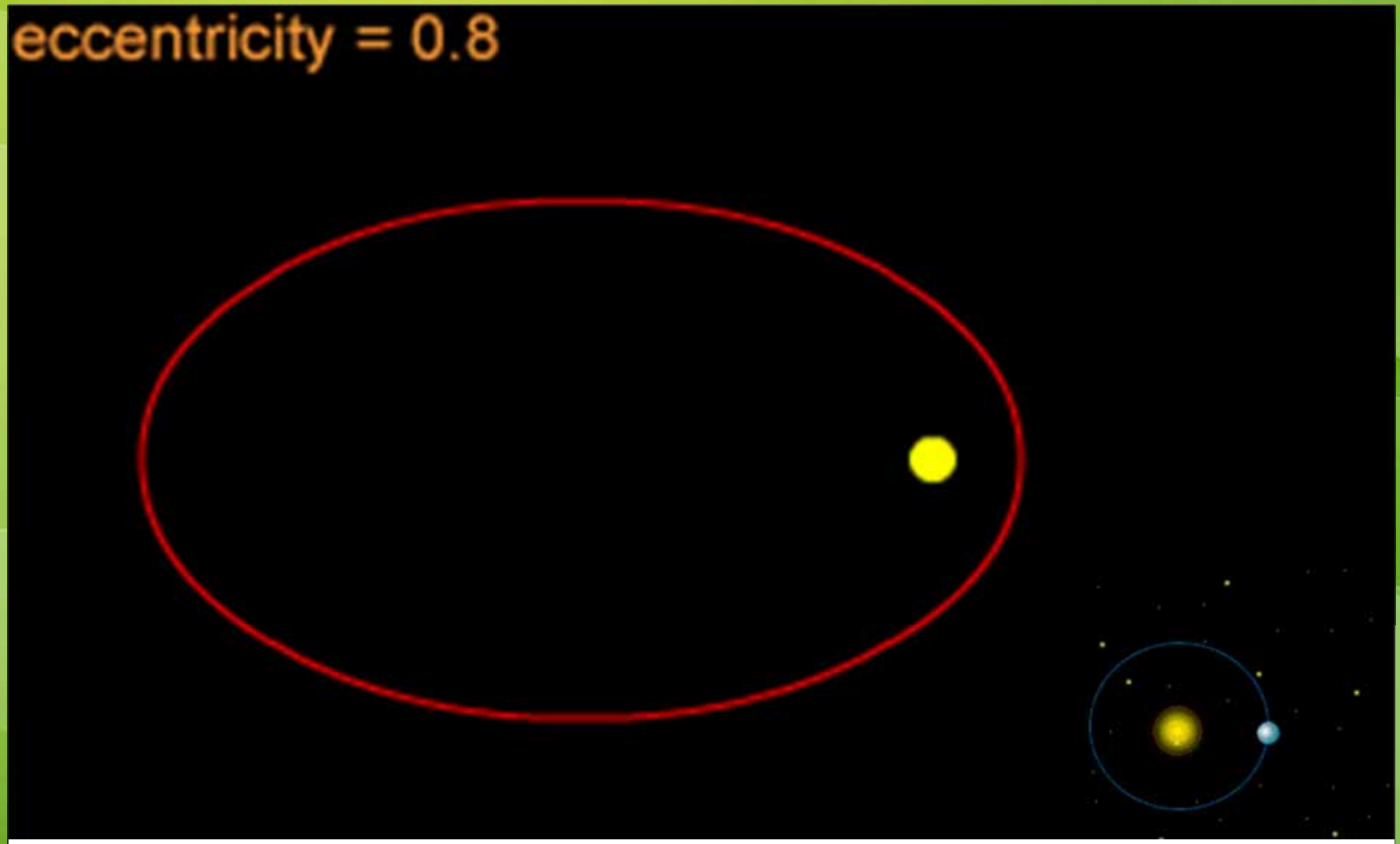


Earth Visualization Tool



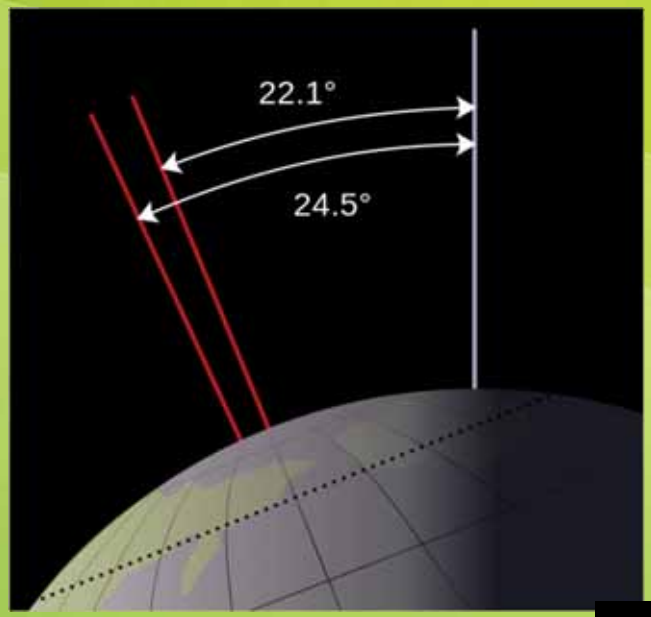
HHMI World Biome Viewer

Changes in Orbit and Angles



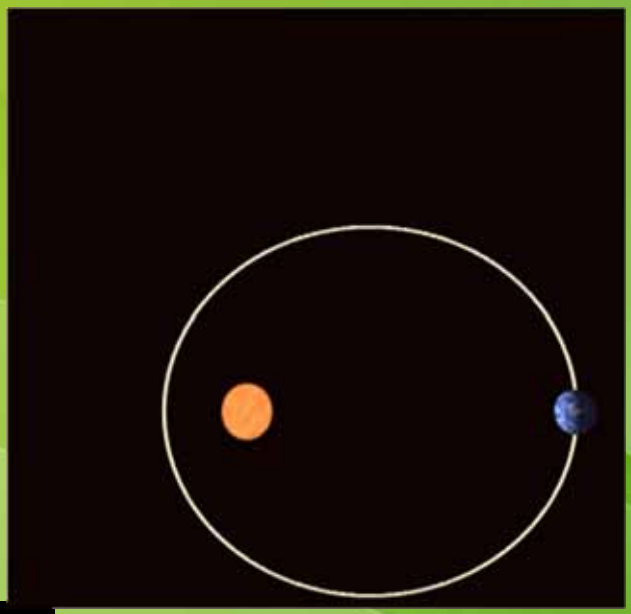
150 Mkm Average **From 139.9 to 159.8 Mkm**

Changes in Orbit and Angles



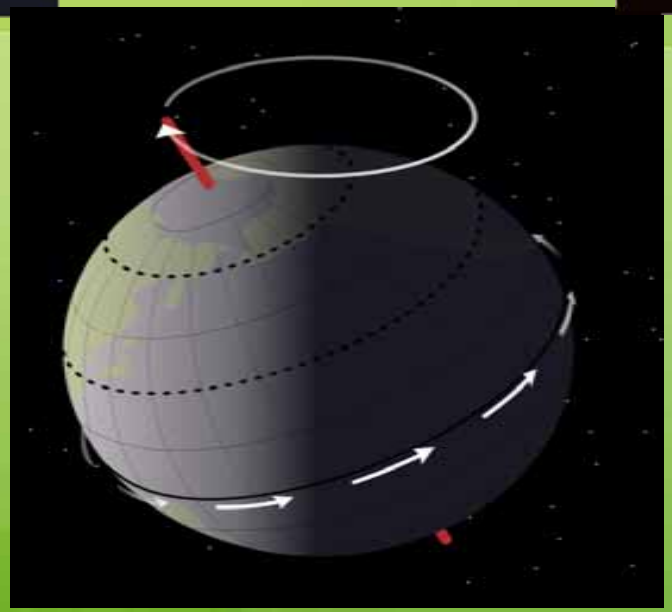
Axial Precession 23K Year Cycle

North Pole in Canada in 13K



Axial Tilt: 23.44°

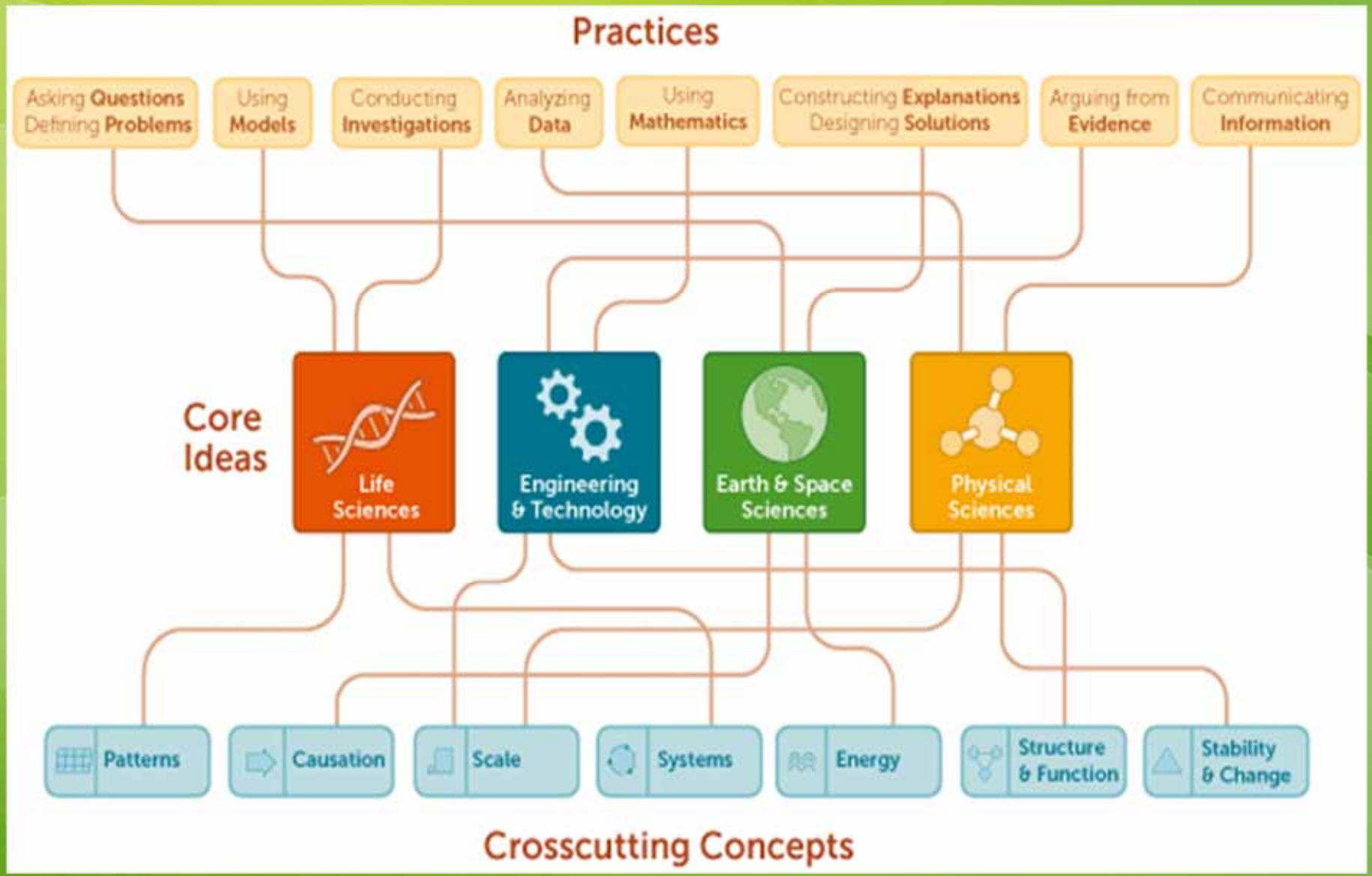
41K Year Cycle and Decreasing



Orbital Precession

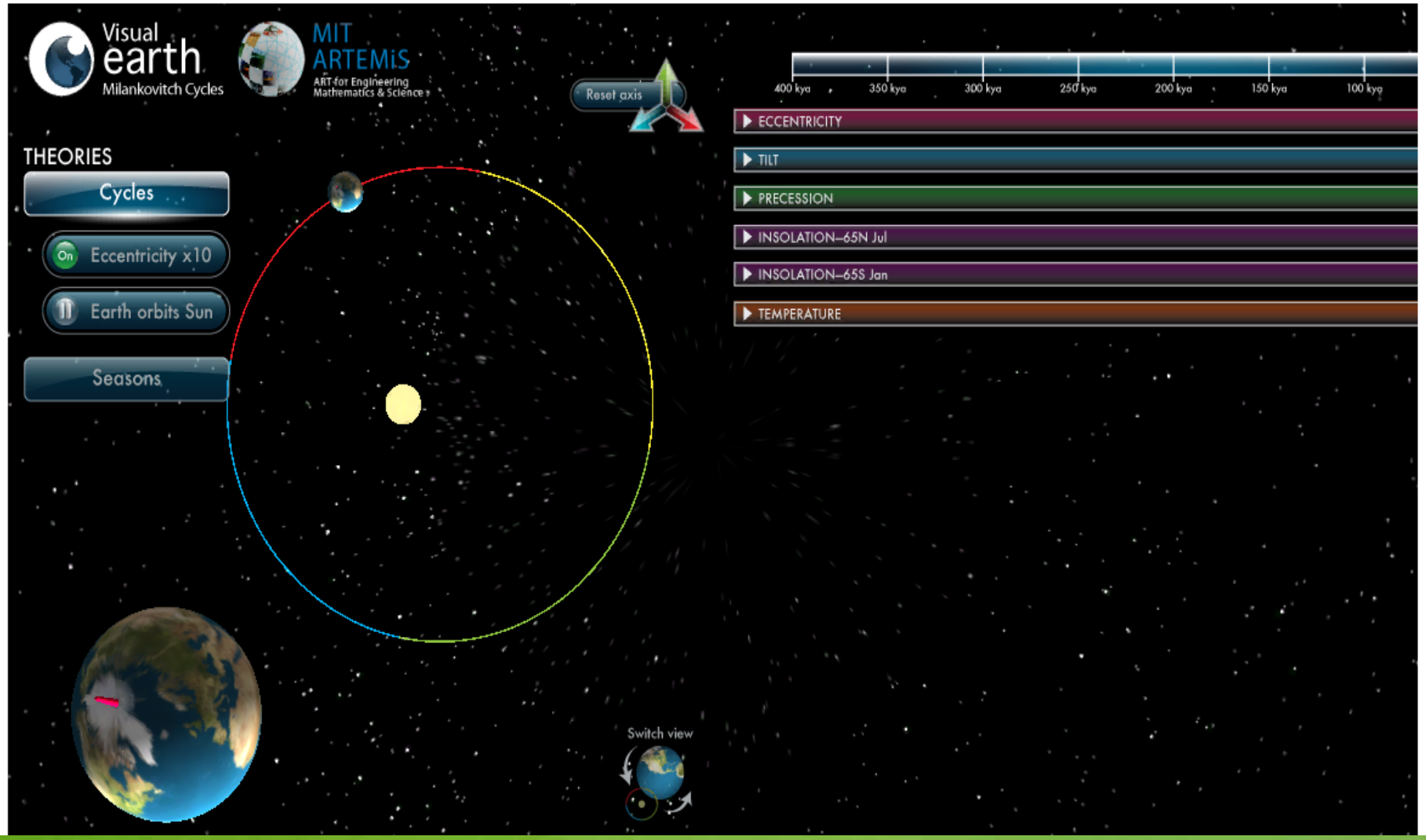
112K Year Cycle Changes Seasons 2 ways

Changes in Orbit and Angles

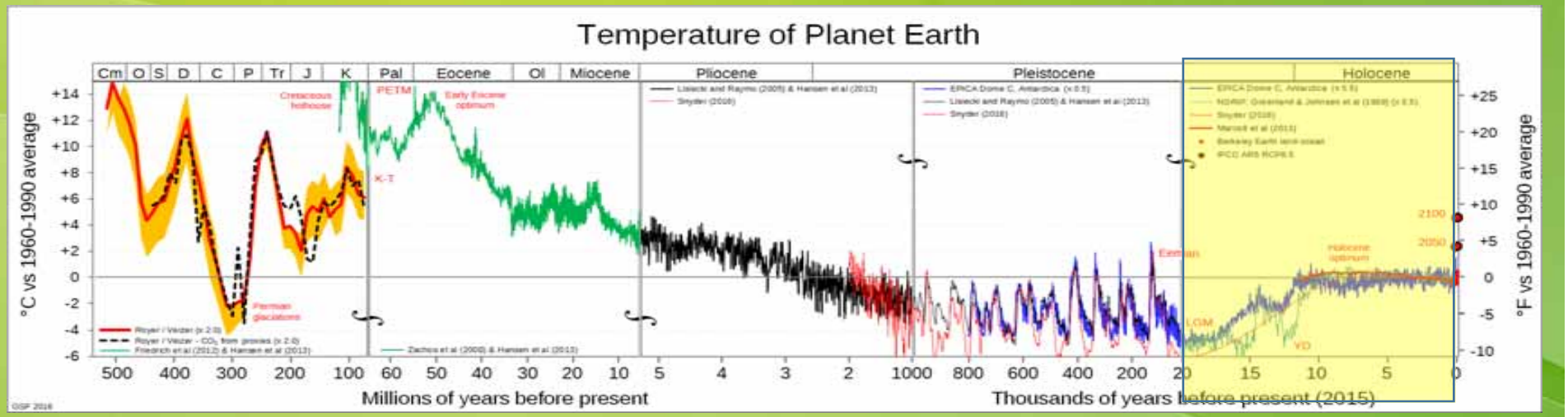


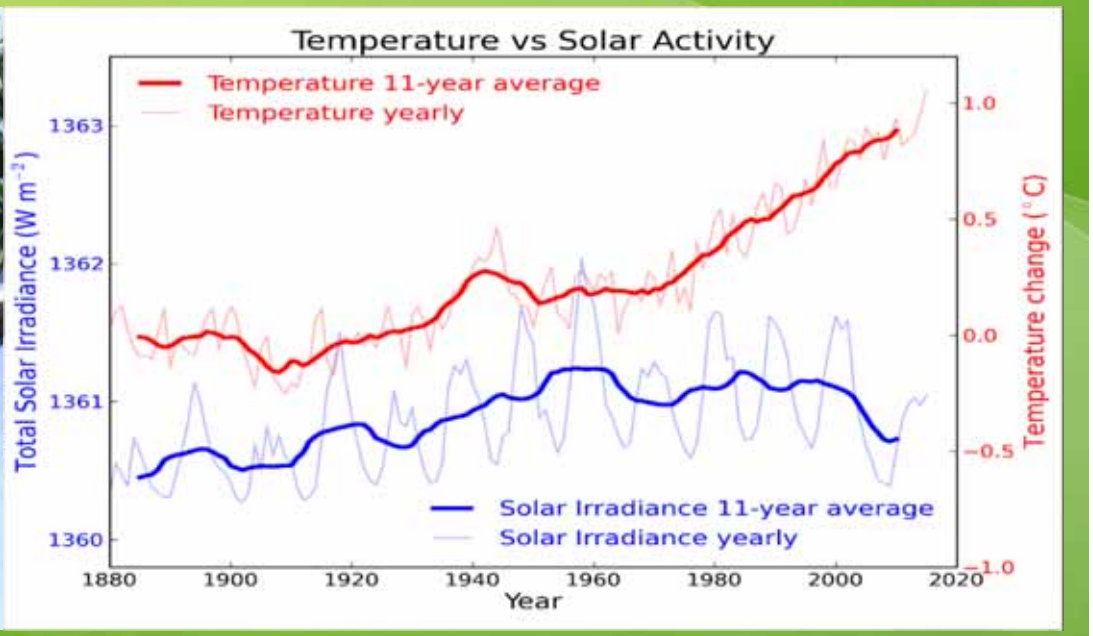
Visual Earth: Milankovitch

MIT ARTEMiS | Visual Earth: Milankovitch Cycles

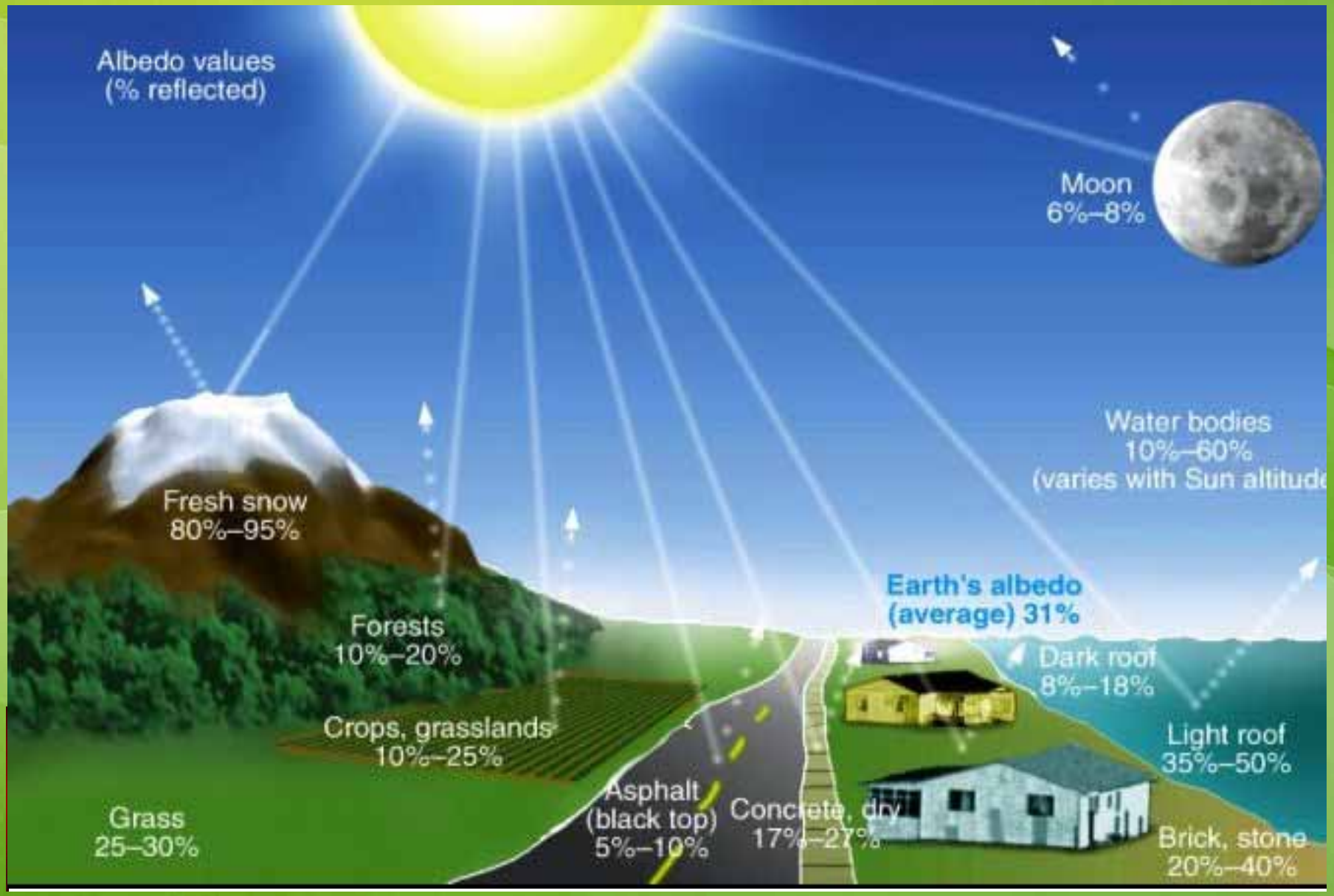


Milankovitch Cycles-Patterns

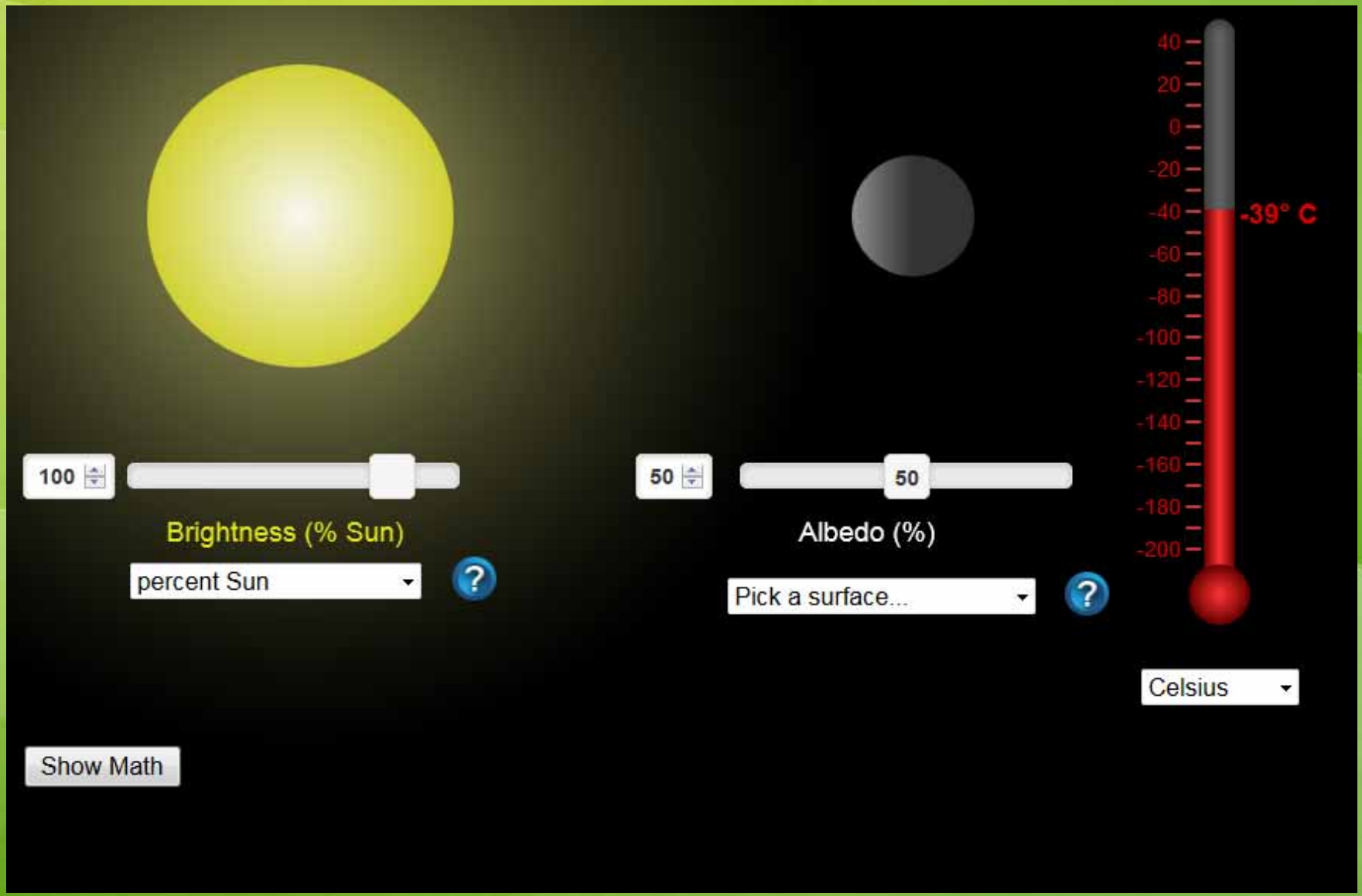


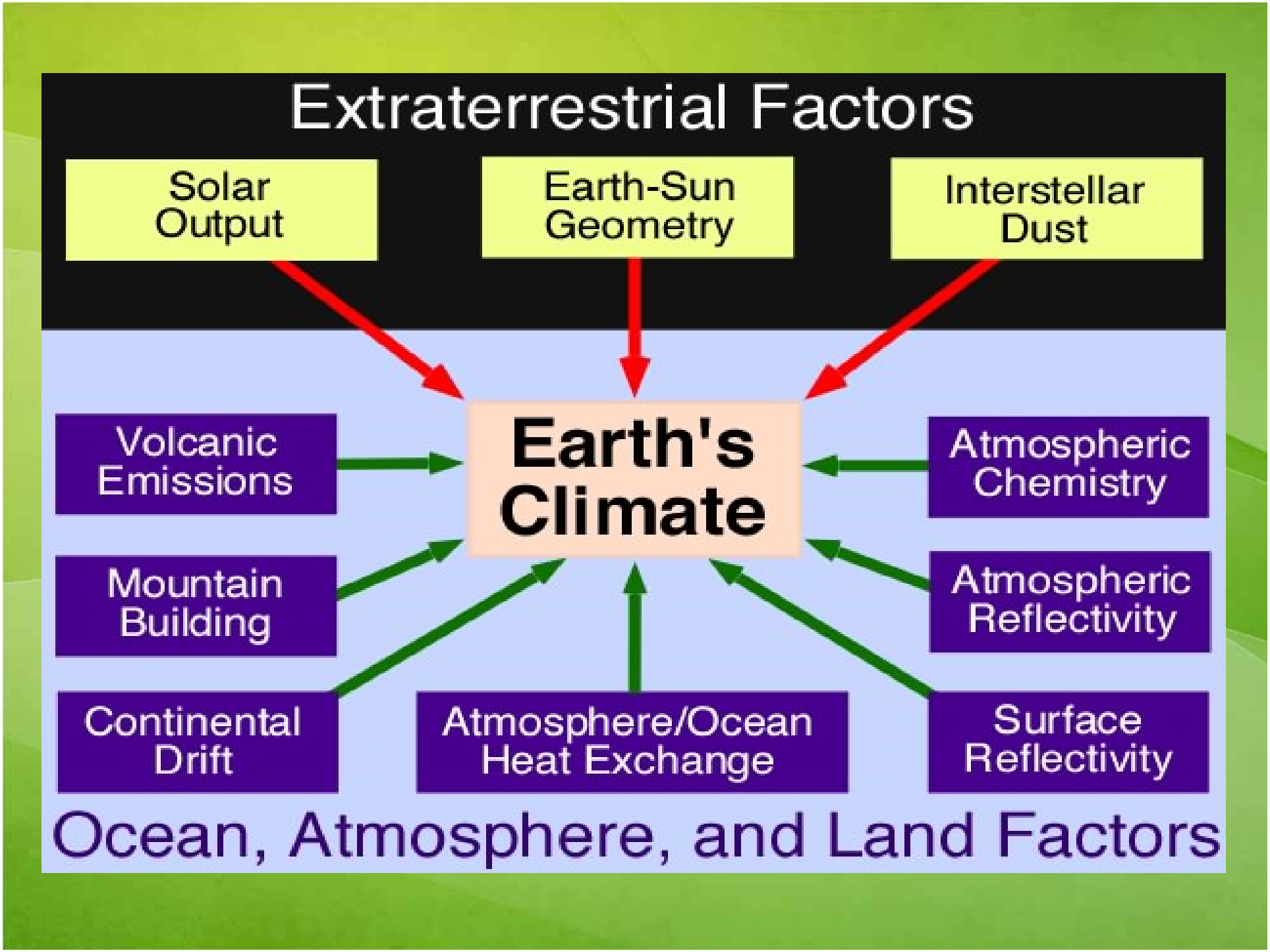


Albedo and Absorption

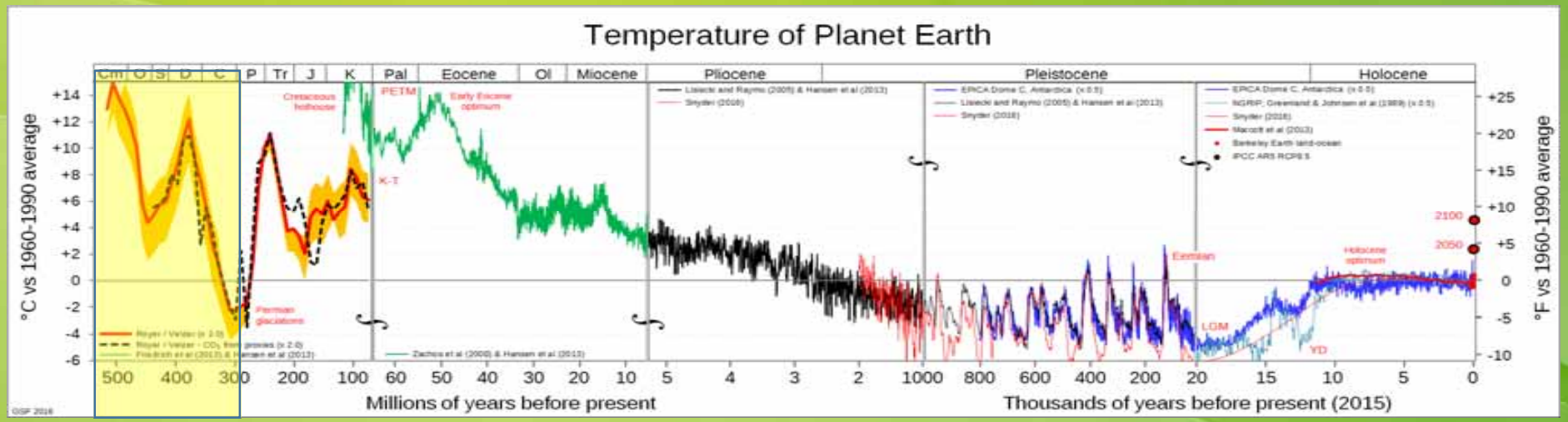


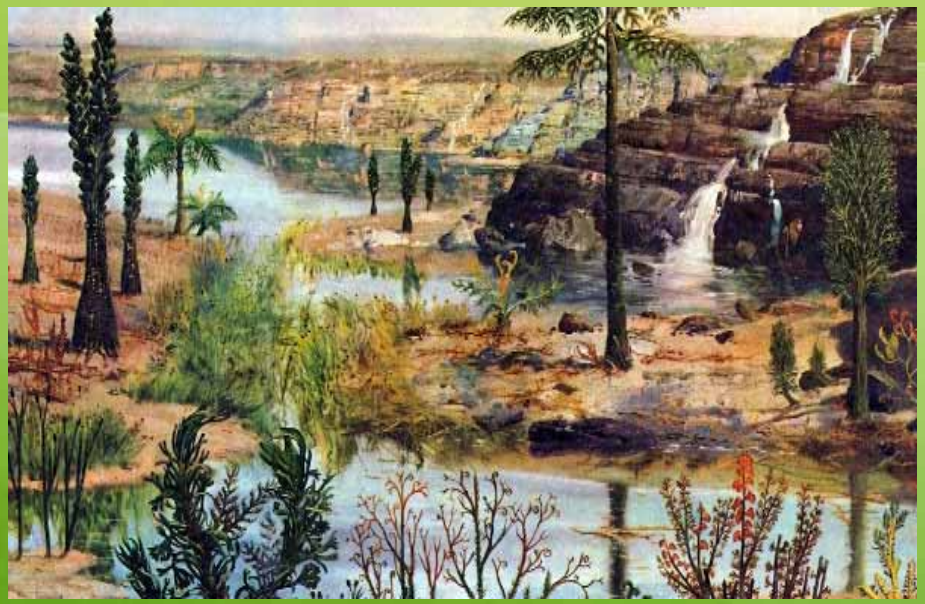
Earth's Energy Balance

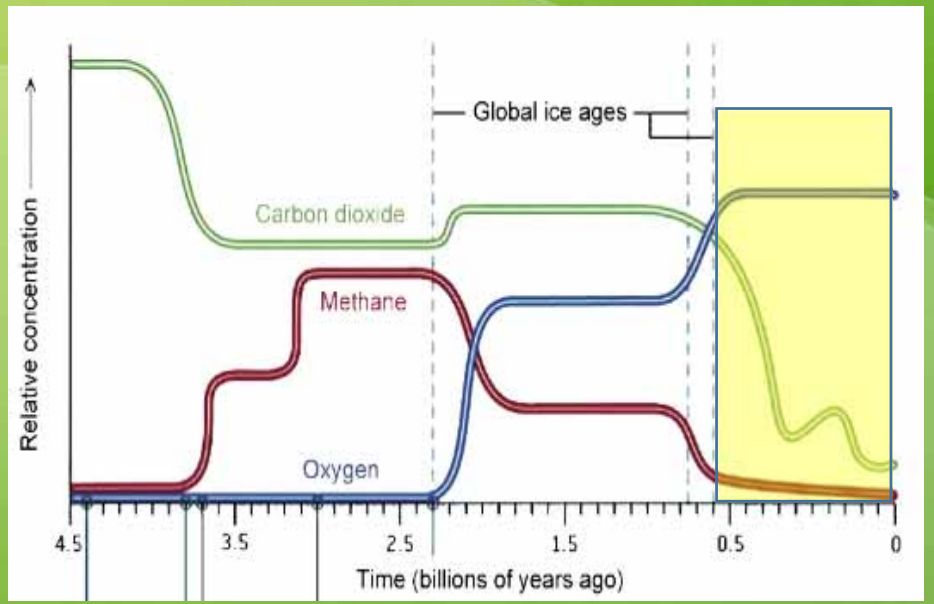



Extraterrestrial Factors
Solar Output
Earth-Sun Geometry
Interstellar Dust
Earth's Climate
Volcanic Emissions
Mountain Building
Continental Drift
Atmosphere/Ocean Heat Exchange
Atmospheric Chemistry
Atmospheric Reflectivity
Surface Reflectivity
Ocean, Atmosphere, and Land Factors

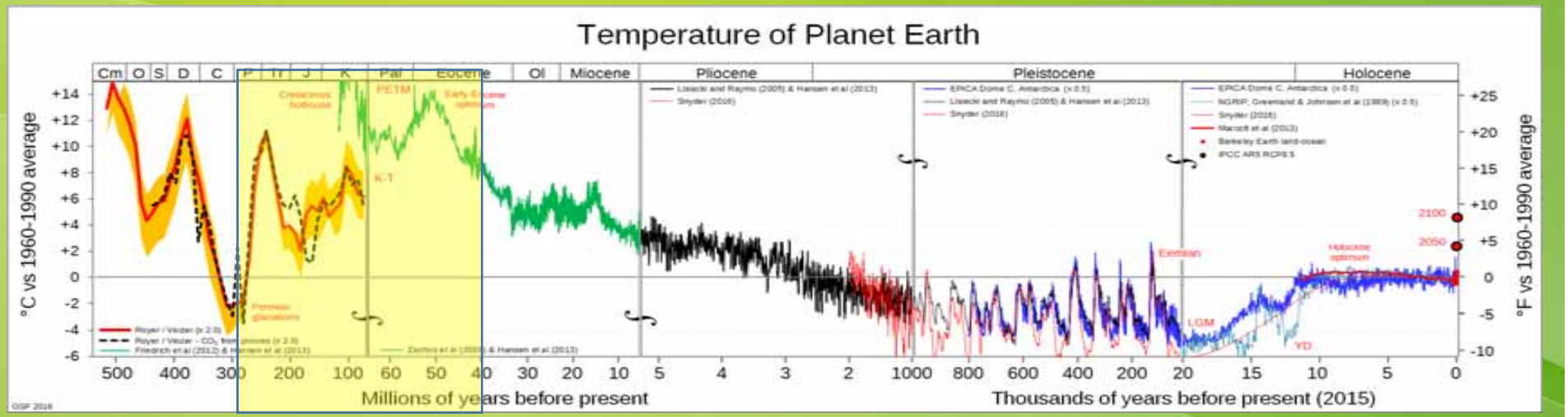
Earth's Climate - Patterns



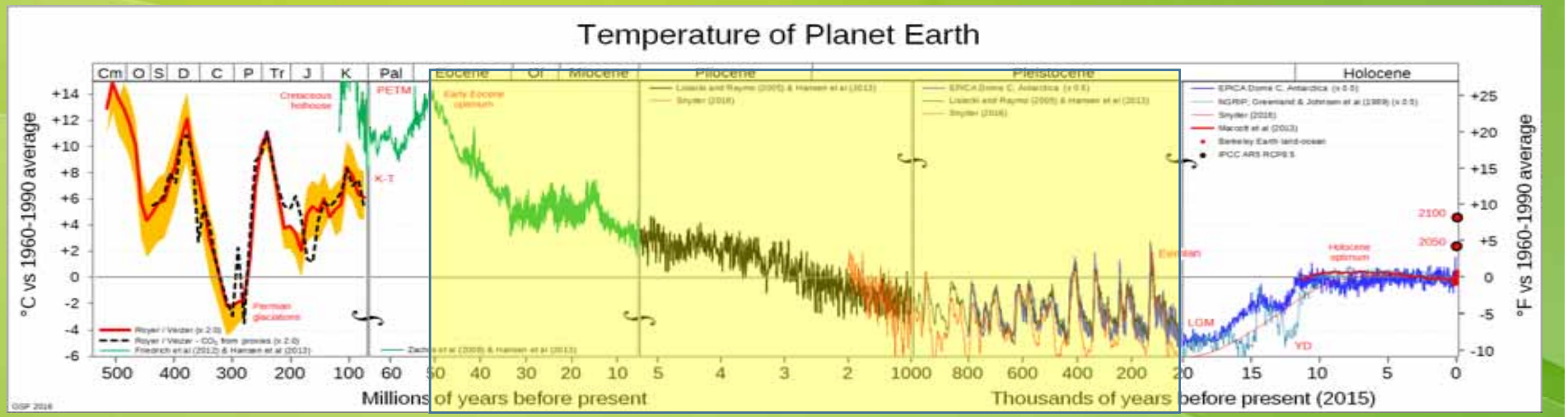


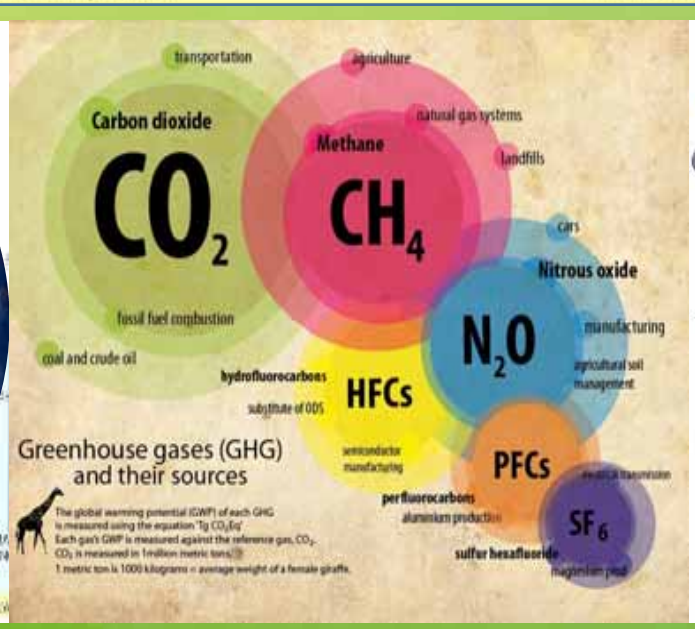


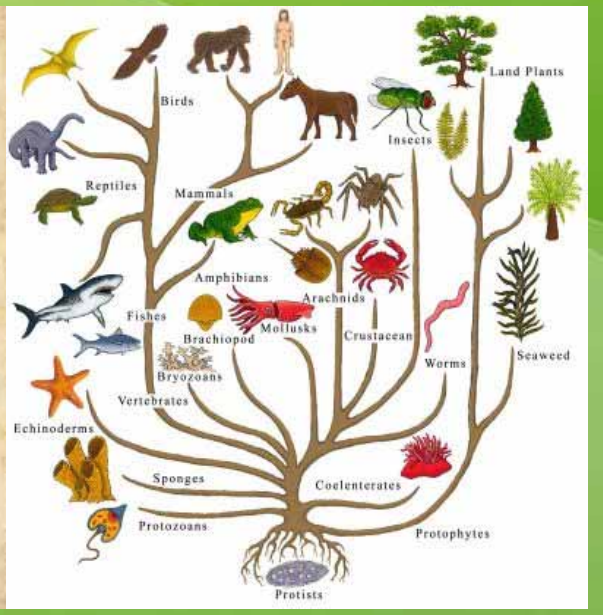
Earth's Climate - Patterns



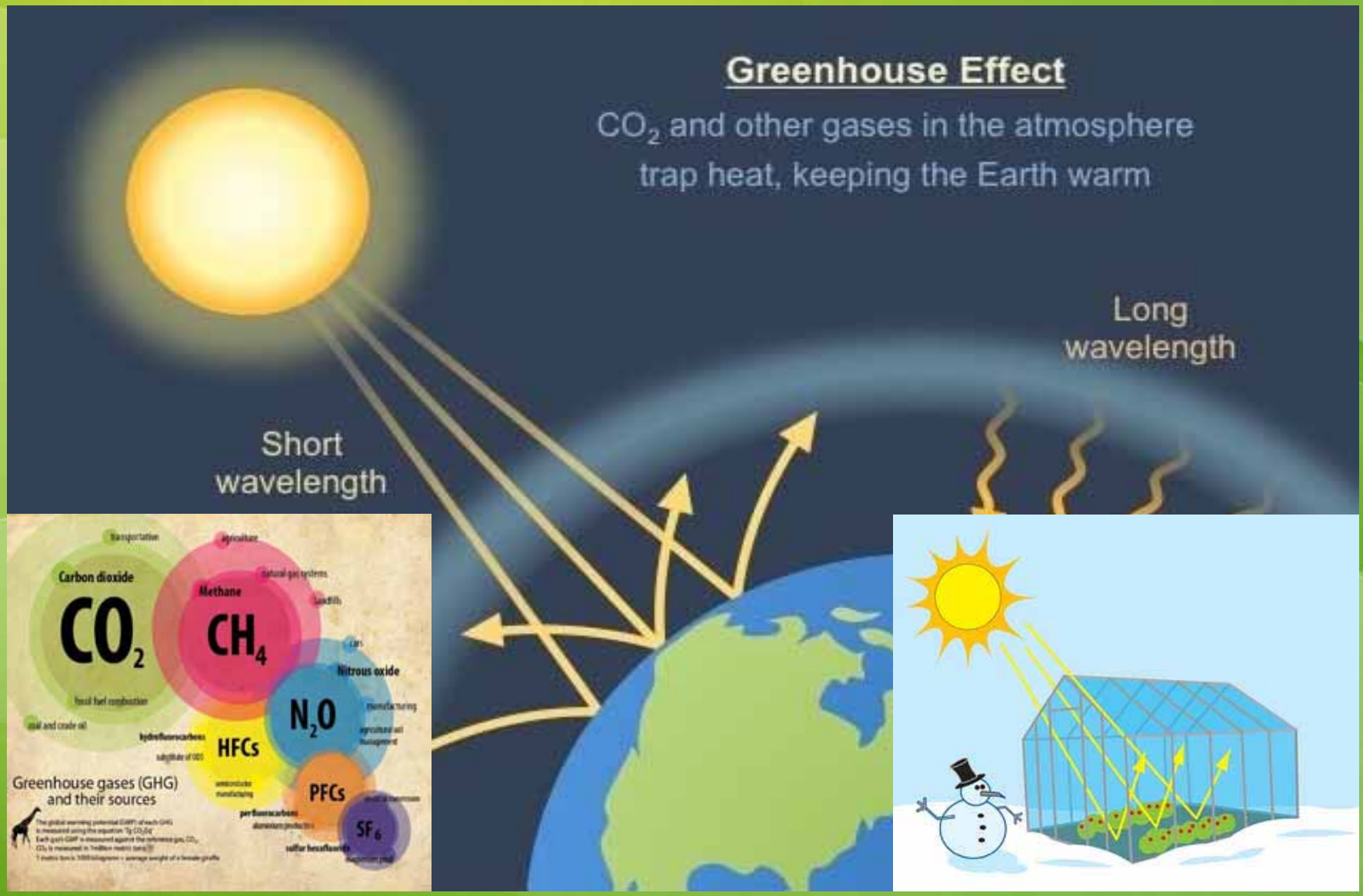
Milankovitch Cycles-Patterns



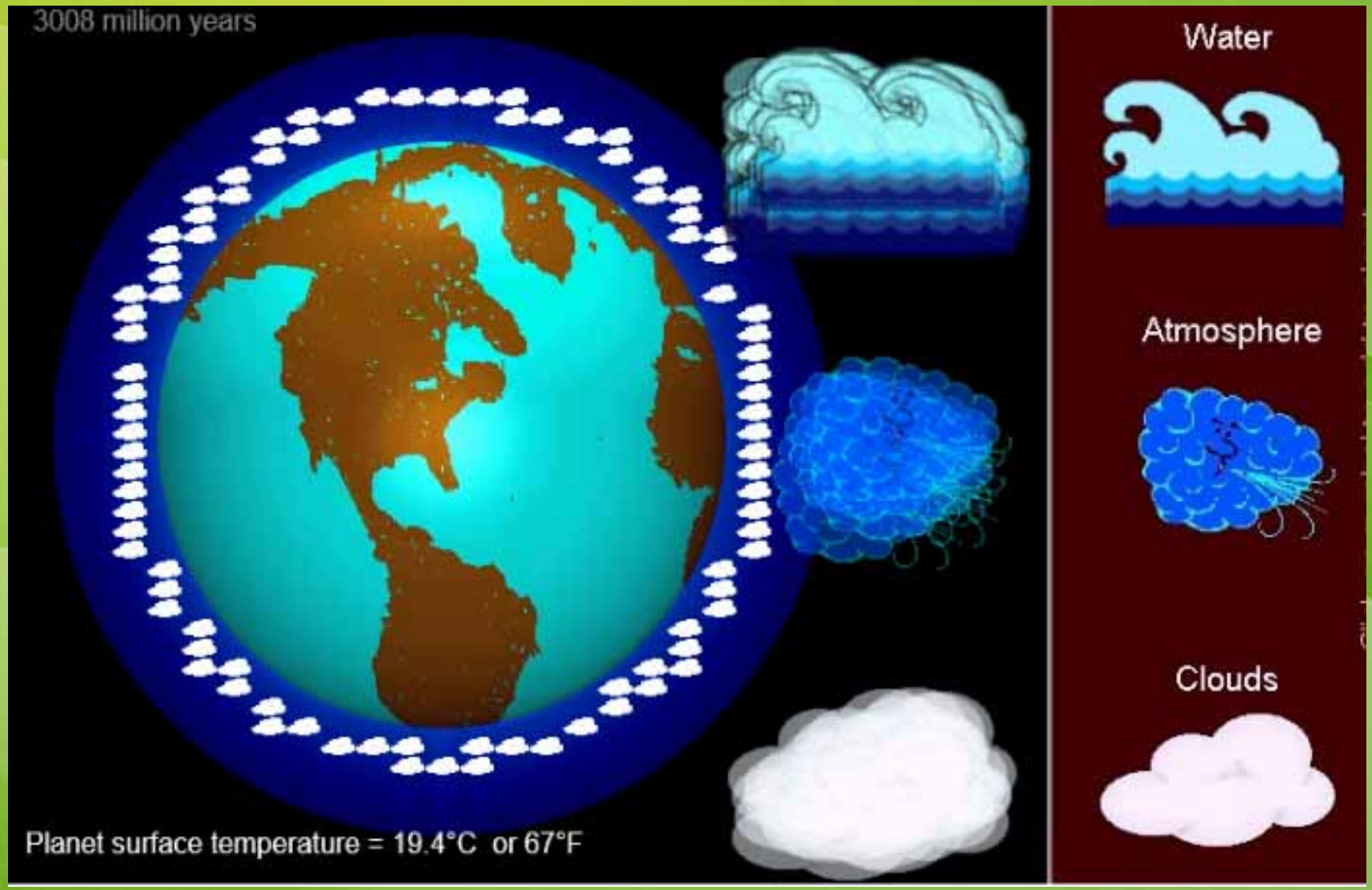




The Greenhouse Effect

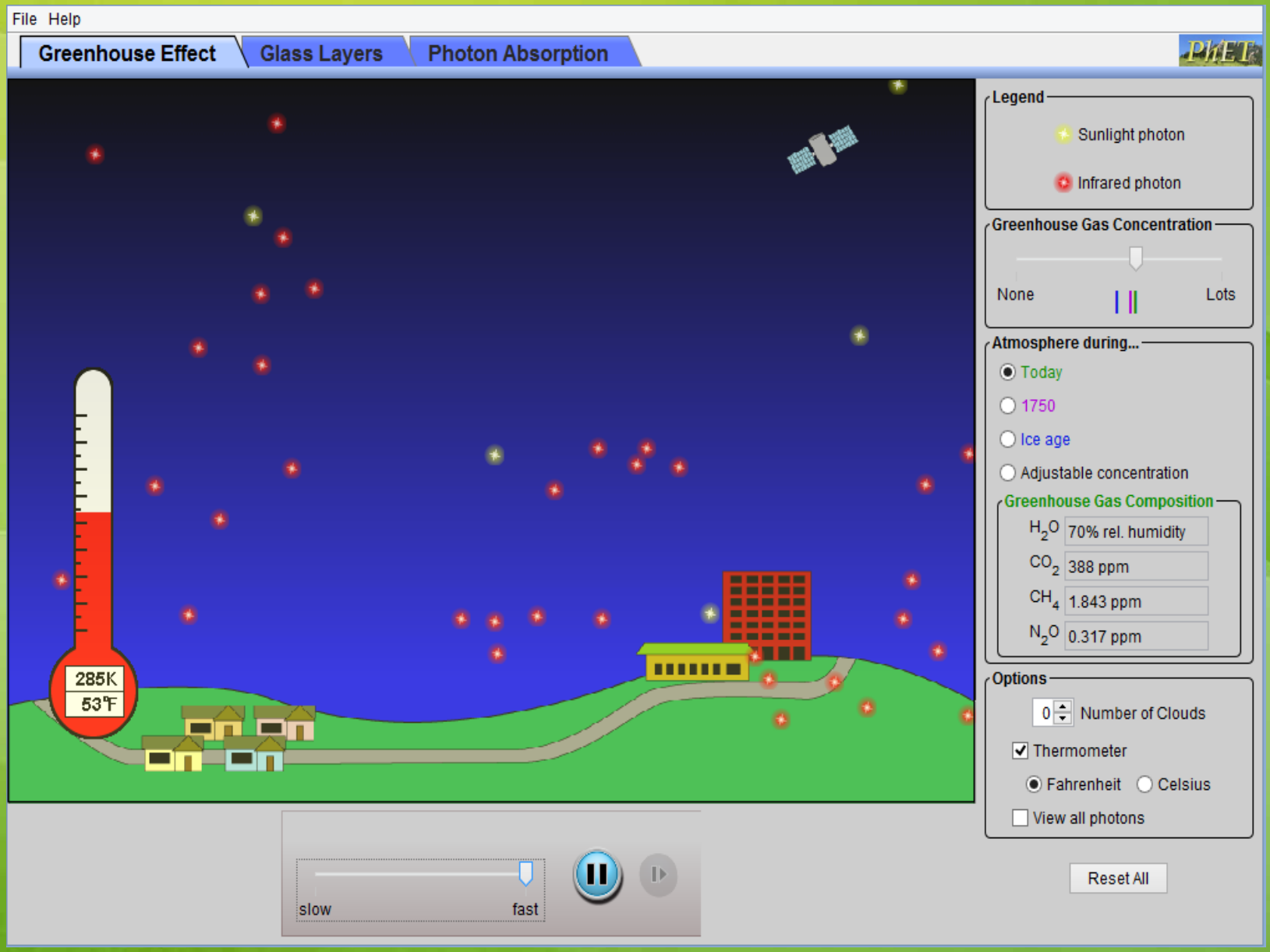


Make A Planet Simulator

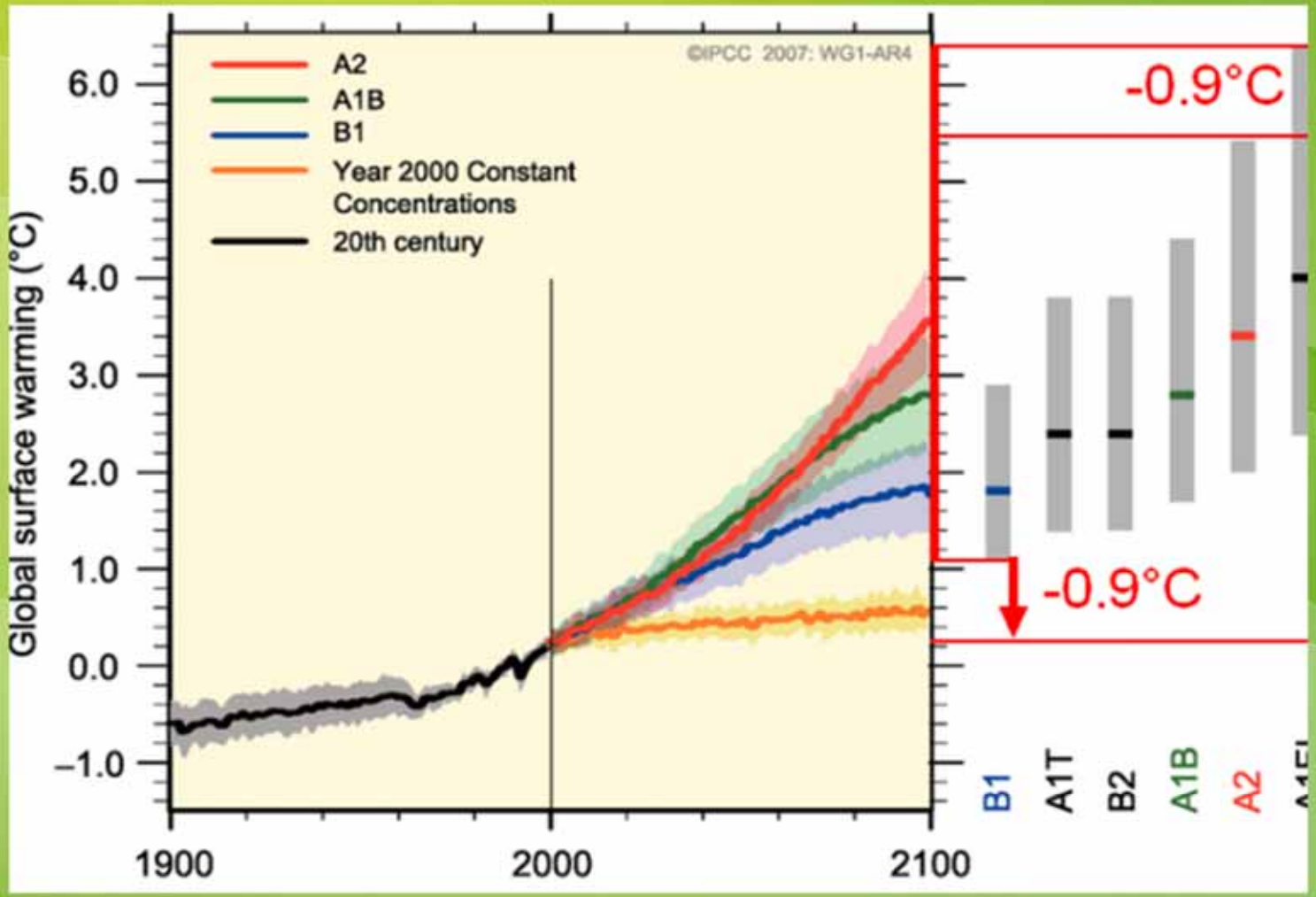


Temperature Target: 60 Degrees F or 16 C

PHET: Greenhouse Effect



IPCC Model Projections



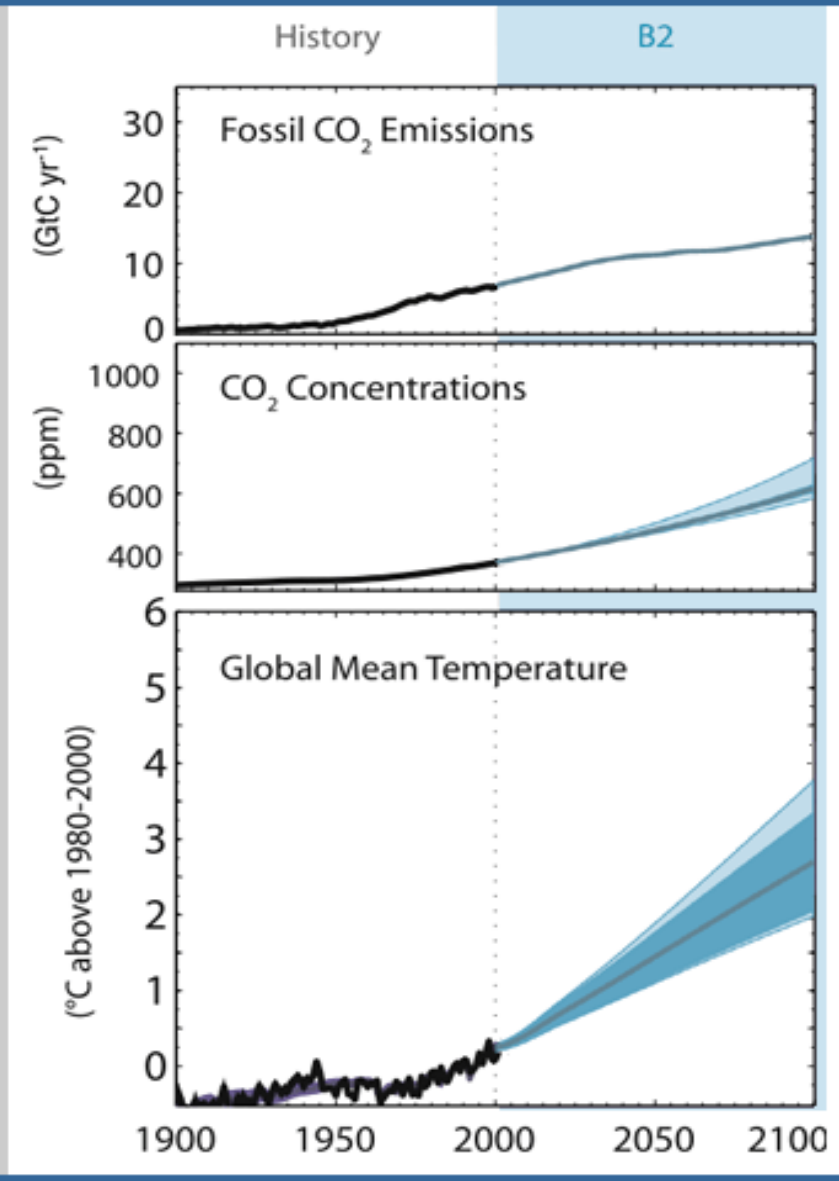
The World's Scientists Trying To Predict A Number Of "What If" Situations and Impacts

Compare IPCC Scenarios

Scenario B2 | Credits

The **B2** storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

Population: Medium (~10 billion in 2100)
Economic Growth: Medium
Primary Energy Use: Medium
Land-use Change: Medium



Nature Conservancy Wizard

The Nature Conservancy
Protecting nature. Preserving life.™

ClimateWizard

University of Washington

The University of Southern Mississippi

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Analysis Area

- United States / Global
- United States

Time Period

- Past 50 Years
- Mid Century (2050s)
- End Century (2080s)

Map Options

- Map of Average
- Map of Change

Compare & Animate Models

Measurement

- Average Temperature
- Precipitation
- Annual

Resources

Case Studies
Documentation | Developer
Data and Map Image Download
ClimateWizard Custom Analysis
Printer Friendly Version

Future Climate Model

IPCC Fourth Assessment

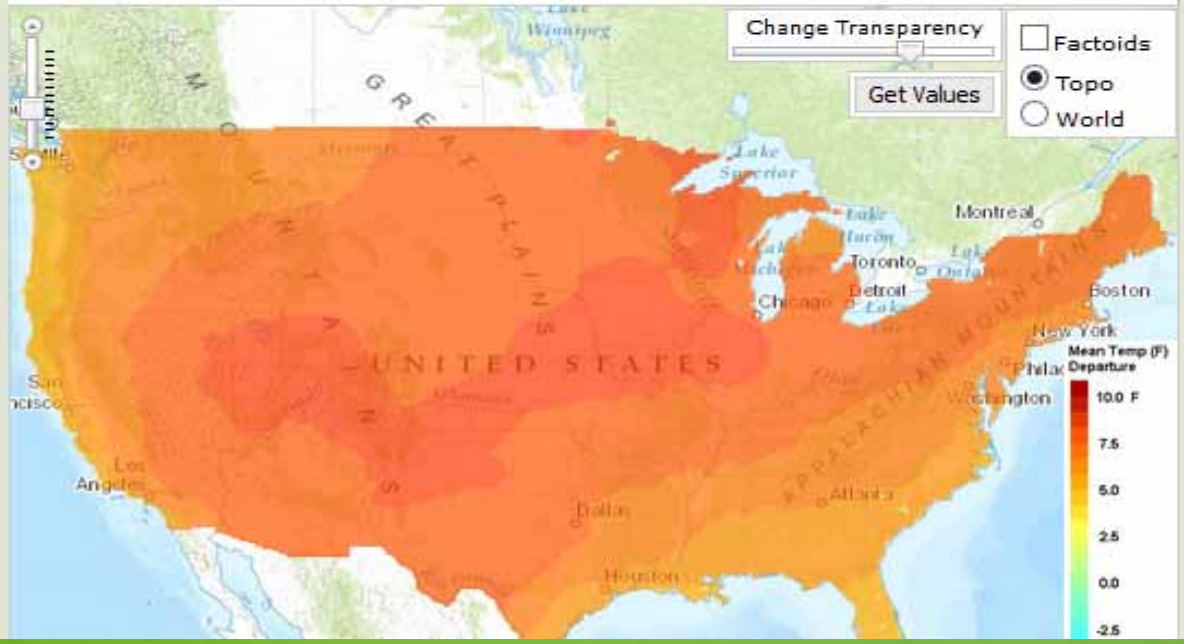
Emission Scenario: High A2

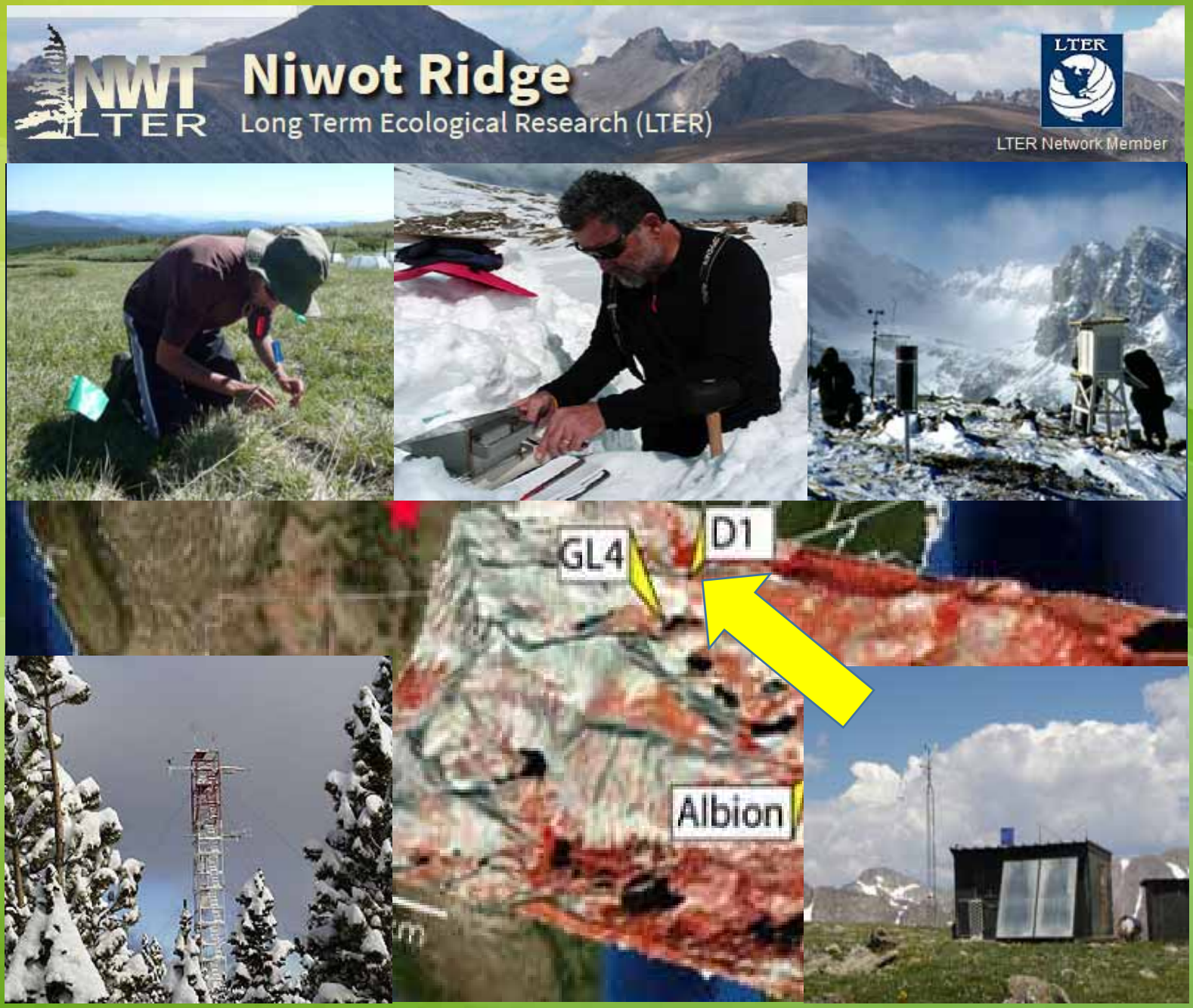
General Circulation Model: Ensemble Average

50%: This map shows the temperature change projected by the middle model. That is, **half of the models project a greater amount of change, and half of the models project less change as** compared to the 1961-1990 baseline

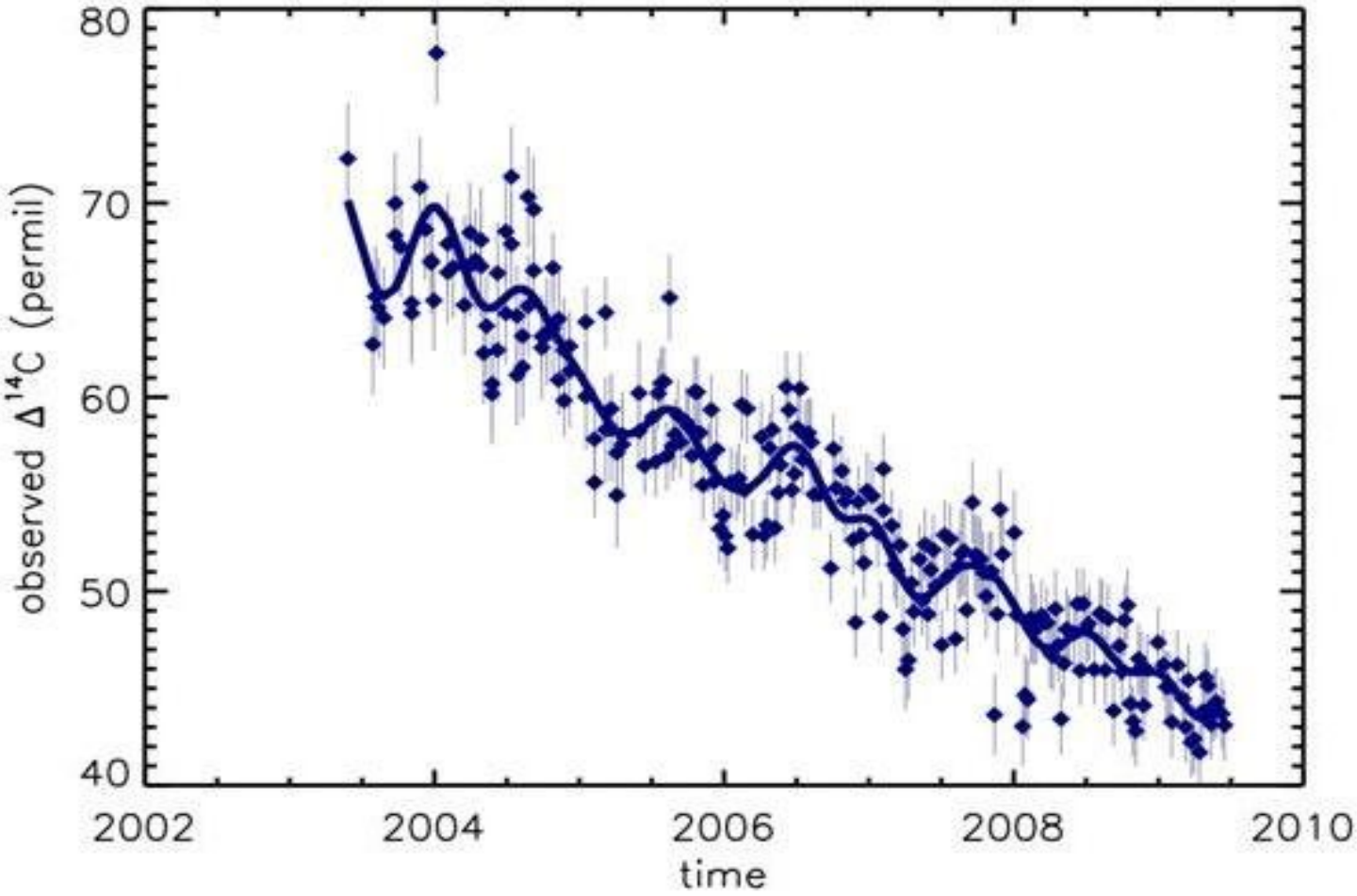
Change in Annual Temperature by the 2080s

Model: Ensemble Average, SRES emission scenario: A2



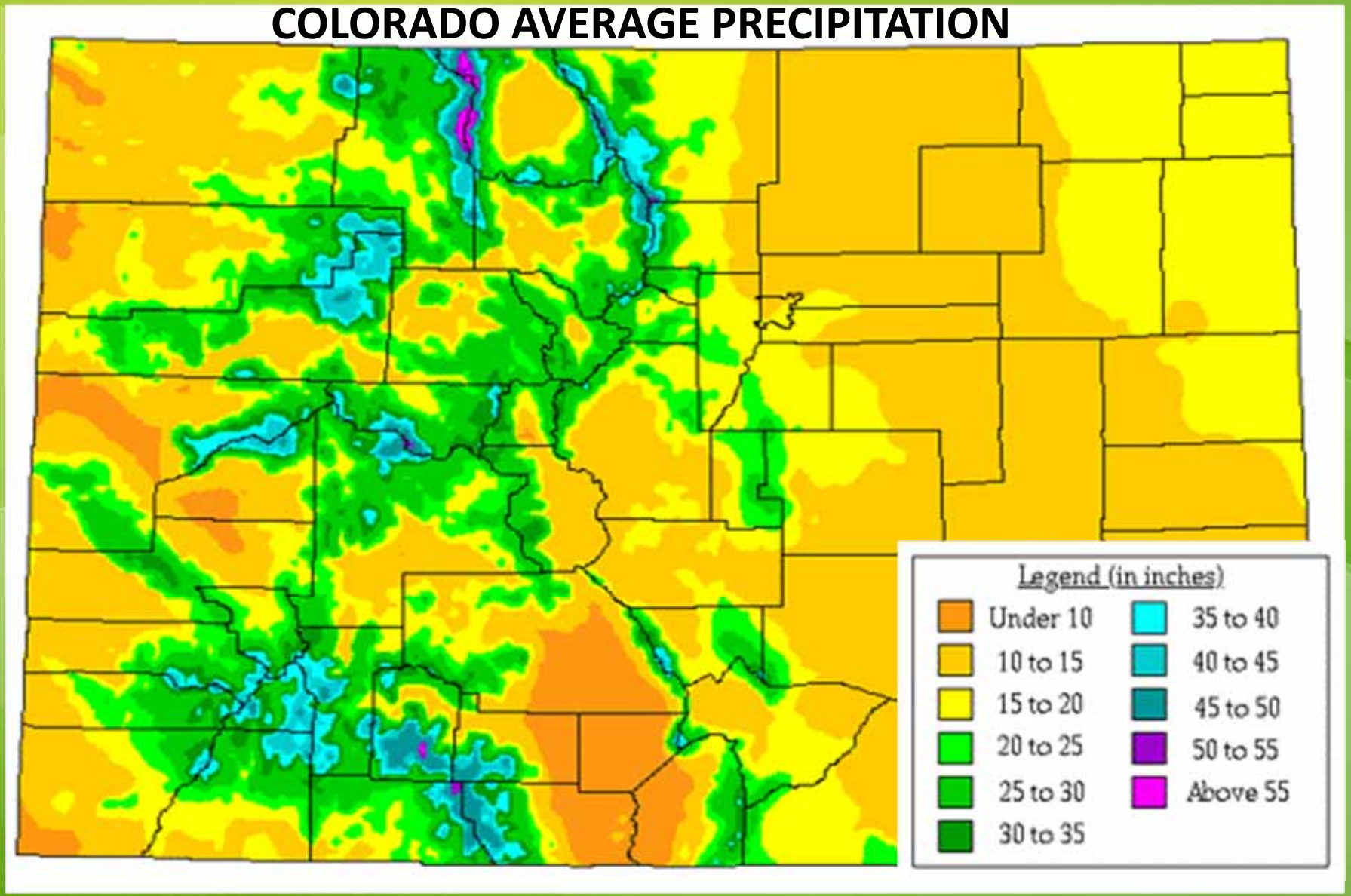

NWT LTER
Niwot Ridge
Long Term Ecological Research (LTER)
LTER
LTER Network Member
GL4
D1
Albion

Clean Air Measurements at Niwot Ridge, Colorado

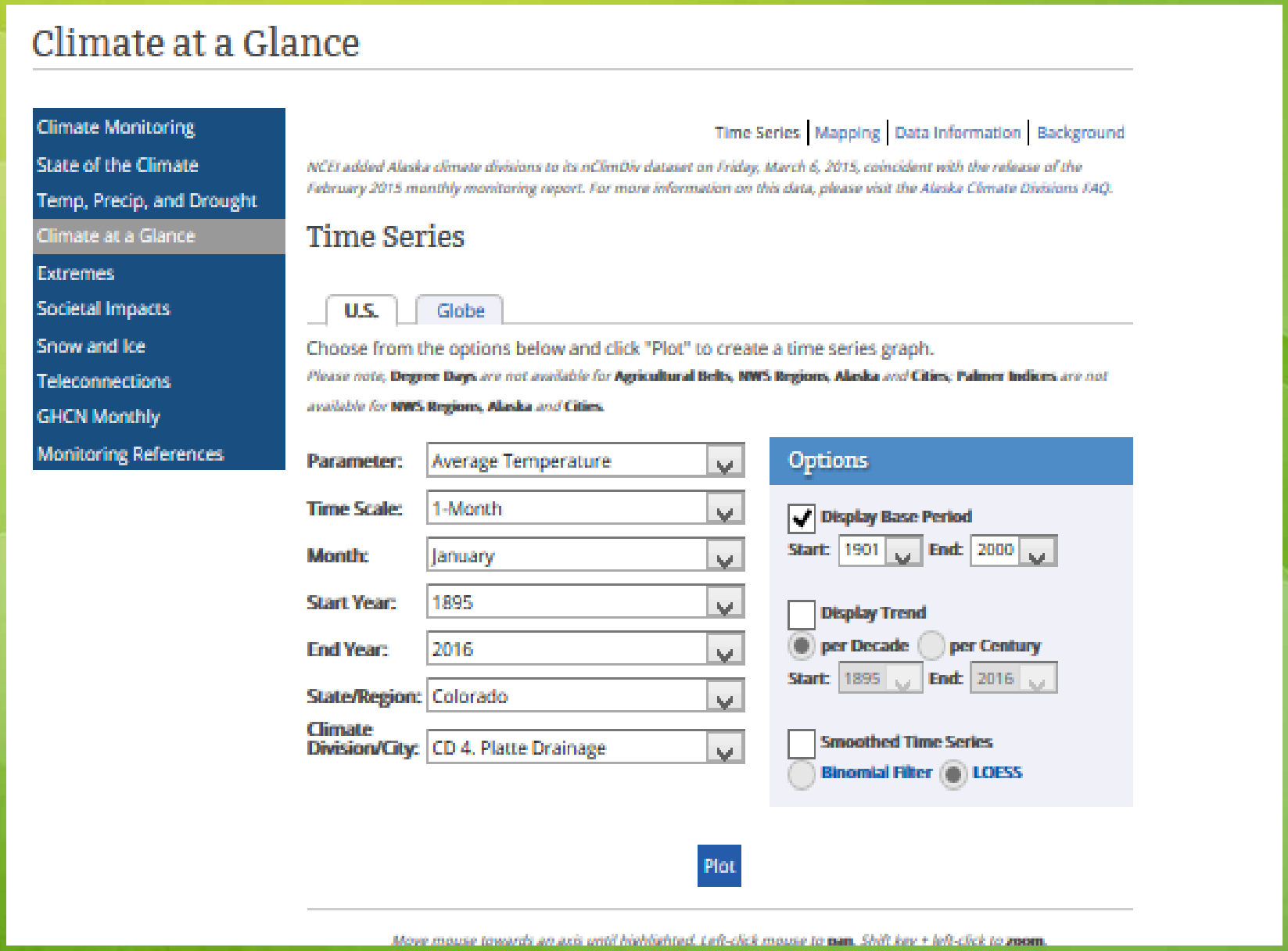


Climates Close To Home

COLORADO AVERAGE PRECIPITATION



Climate at a Glance ~ NOAA



Critical Zone Observatories

The Critical Zone is Earth's porous near-surface layer, from the tops of the trees down to the deepest groundwater. It is a living, breathing, constantly evolving boundary where rock, soil, water, air, and living organisms interact.

Resilience in Natural and Built Systems:

Opportunities and Innovations in Community Sustainability

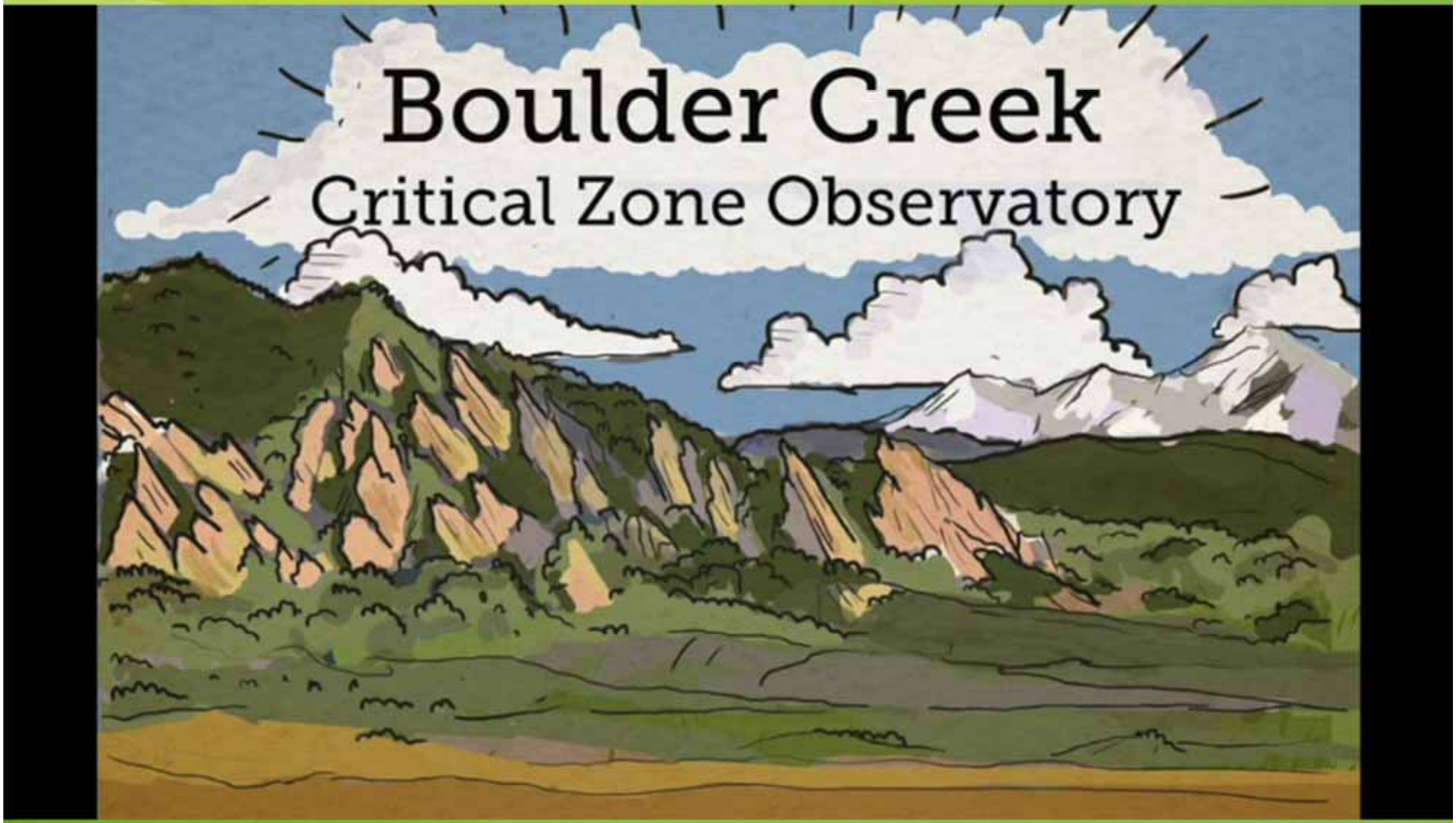
Colorado, Headweaters of the West:

Colorado Recieves 2.8 Billion Gallons of Water/Year

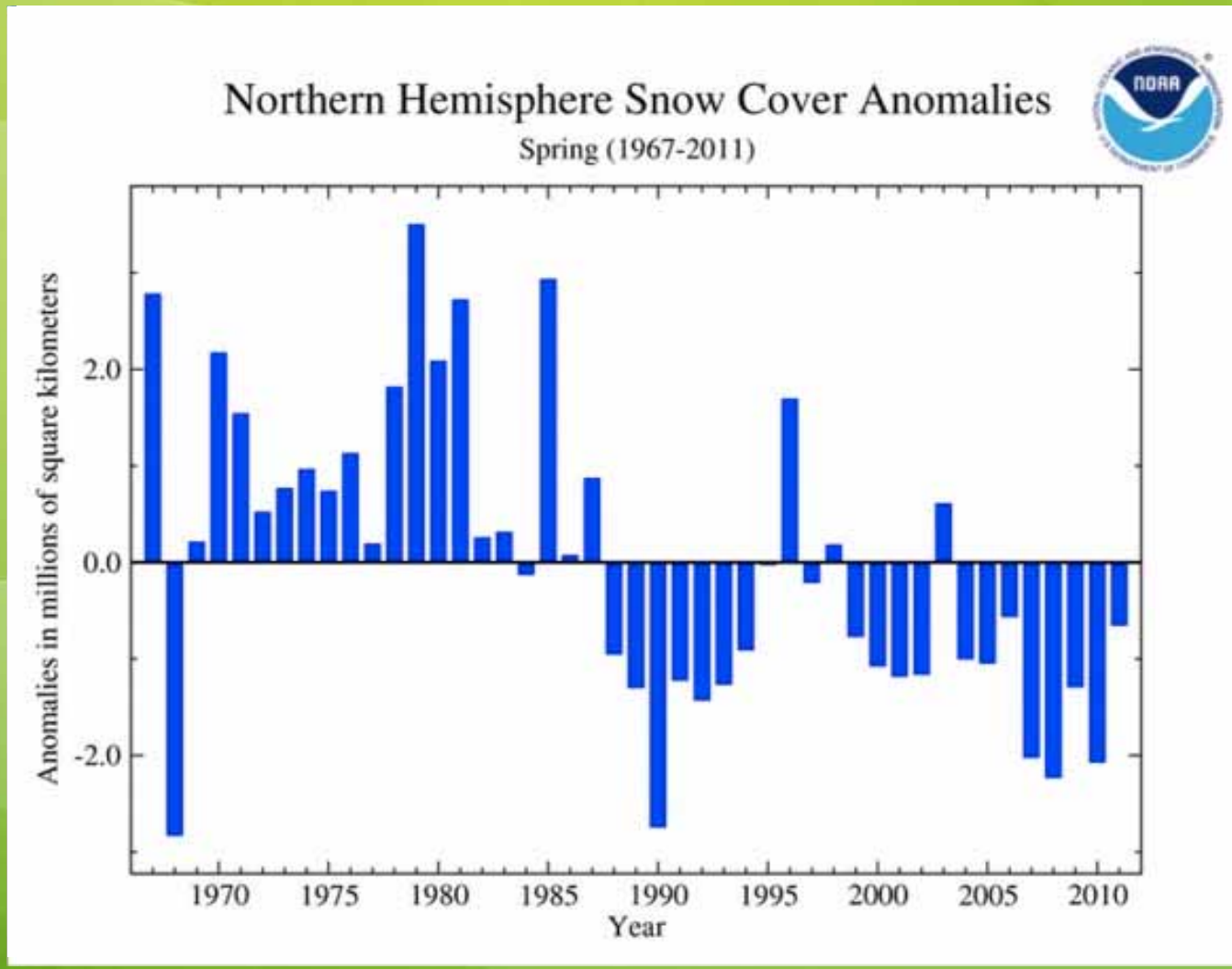
80% falls as snow, and we only use about 33%.

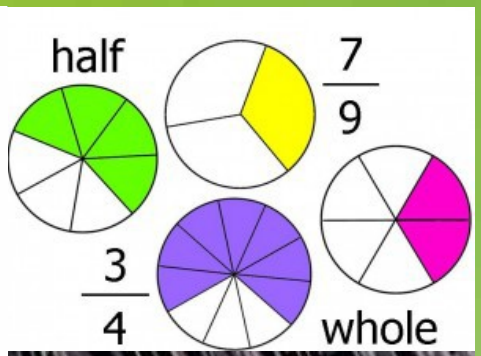
67% is passed downstream to other users.

Snow Fractioning and Colorado's Water



Snow Fractioning and Colorado's Water

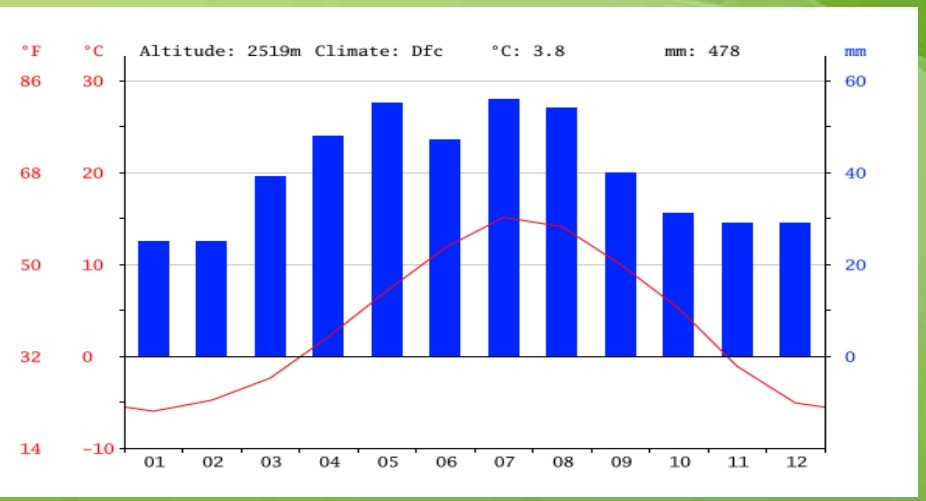




Snow Fractioning and Colorado's Water

Snow Fractioning for the Colorado Front Range in 2016-2017

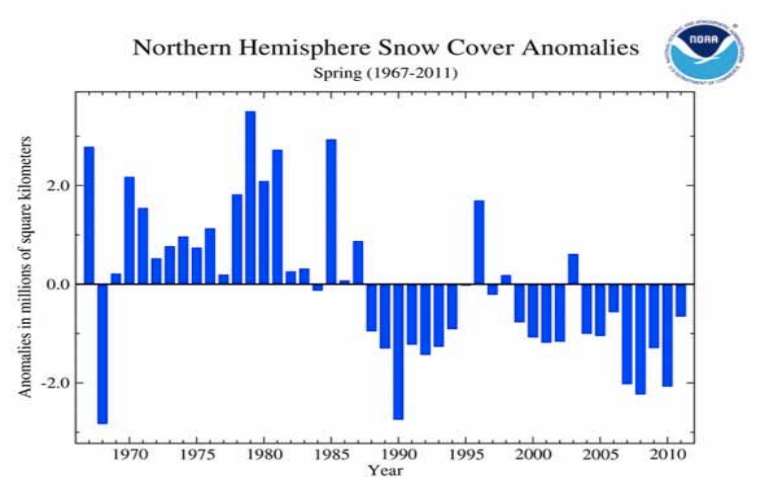
Month	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Precip. Total	40	30	20	30	30	40	20	60	40
Snow Fraction	S/R 25% 75%	S/R 66% 33%	S/R 100% 0%	S/R 100% 0%	S/R 100% 0%	S/R 100% 0%	S/R 100% 0%	S/R 75% 25%	S/R 25% 75%
Snow (ml)	10 ml	20 ml	20 ml	30 ml	30 ml	40 ml	20 ml	45 ml	10 ml
Rain (ml)	30 ml	10 ml	0 ml	0 ml	0 ml	0 ml	0 ml	15 ml	30 ml



Snow Fractioning and Colorado's Water

Snow Fractioning for the Colorado Front Range in 1990-1991

Month	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Precip. Total	40	30	20	30	30	40	20	60	40
Snow Fraction	S/R 0% 100%	S/R 33% 66%	S/R 50% 50%	S/R 66% 33%	S/R 100% 0%	S/R 100% 0%	S/R 25% 75%	S/R 50% 50%	S/R 0% 100%
Snow (ml)	0 ml	10 ml	10 ml	20 ml	30 ml	40 ml	5 ml	30 ml	0 ml
Rain (ml)	40 ml	20 ml	10 ml	10 ml	0 ml	0 ml	15 ml	30 ml	40 ml



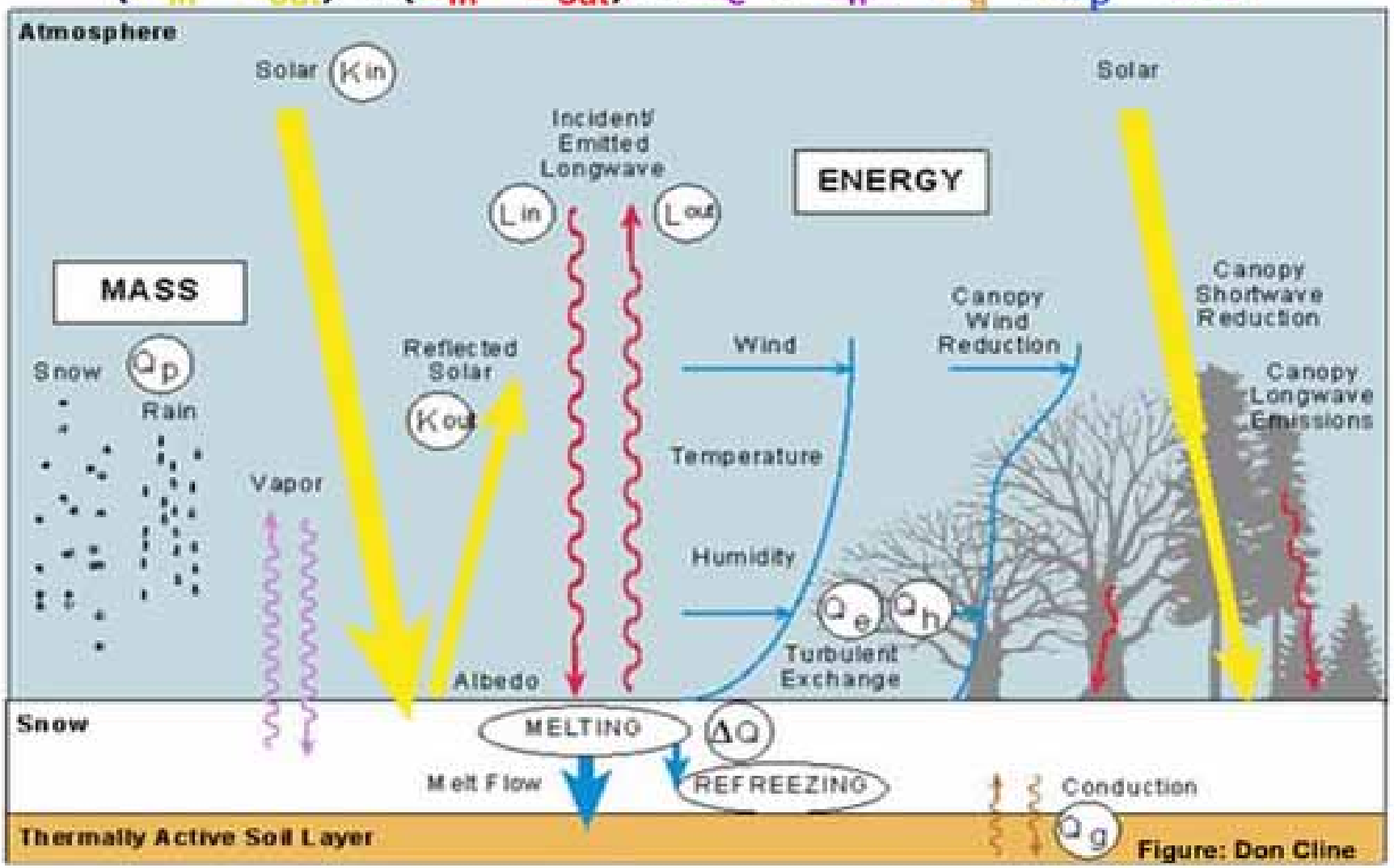
Snow Fractioning for the Colorado Front Range in 2016-2017

Month	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Precip. Total	40	30	20	30	30	40	20	60	40
Snow Fraction	S/R 25% 75%	S/R 66% 33%	S/R 100% 0%	S/R 100% 0%	S/R 100% 0%	S/R 100% 0%	S/R 100% 0%	S/R 75% 25%	S/R 25% 75%
Snow (ml)	10	20	20	30	30	40	20	45	10
Rain (ml)	30	10	0	0	0	0	0	15	40

Snow Fractioning for the Colorado Front Range in 1990-1991

Month	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Precip. Total	40	30	20	30	30	40	20	60	40
Snow Fraction	S/R 0% 100%	S/R 33% 66%	S/R 50% 50%	S/R 66% 33%	S/R 100% 0%	S/R 100% 0%	S/R 25% 75%	S/R 50% 50%	S/R 0% 100%
Snow (ml)	0 ml	10 ml	10 ml	20 ml	30 ml	40 ml	5 ml	30 ml	0 ml
Rain (ml)	40 ml	20 ml	10 ml	10 ml	0 ml	0 ml	15 ml	30 ml	40 ml

$$(K_{in} - K_{out}) + (L_{in} - L_{out}) + Q_e + Q_h + Q_g + Q_p = \Delta Q$$



K = shortwave

L = longwave

Q_e = latent heat flux

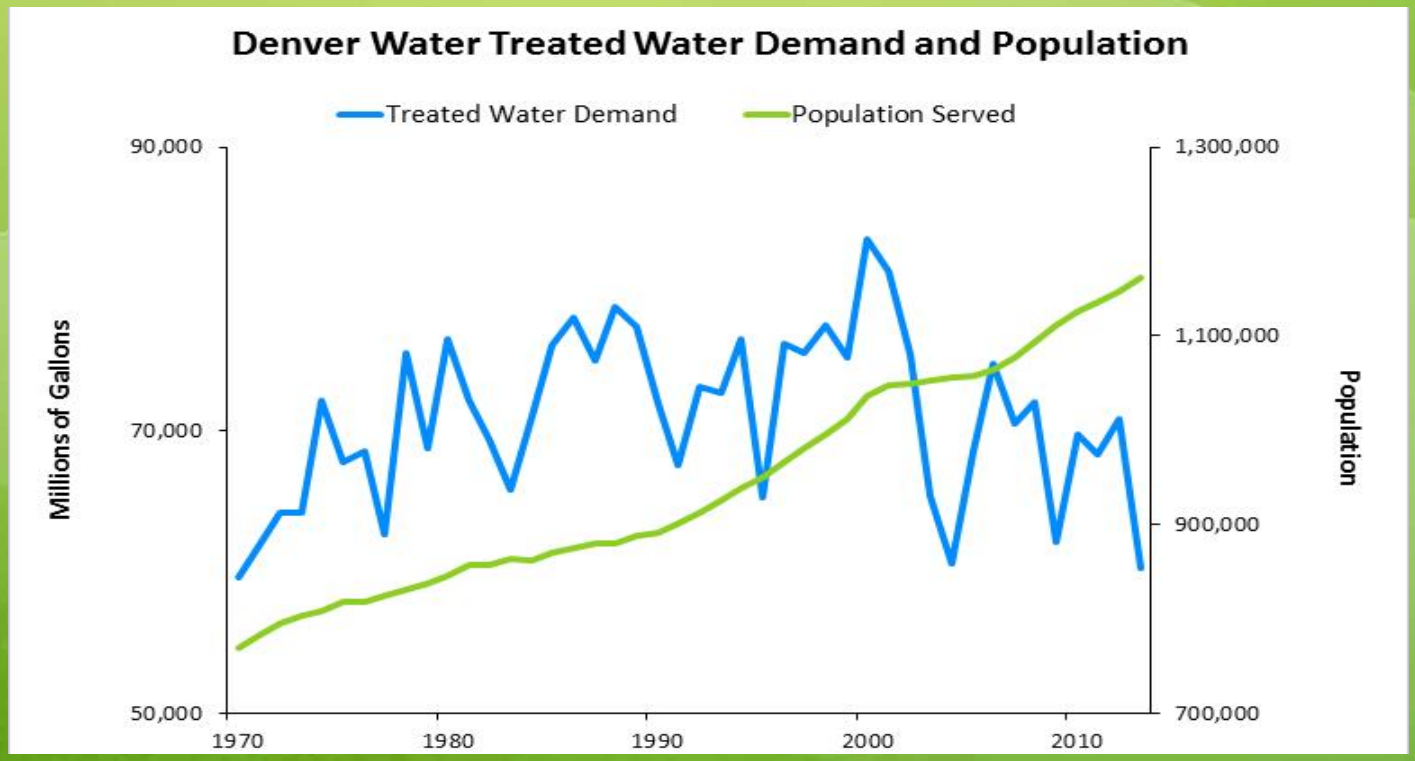
Q_h = sensible heat flux

Q_g = ground source

Q_p = precip source

Resilience in Natural and Built Systems:

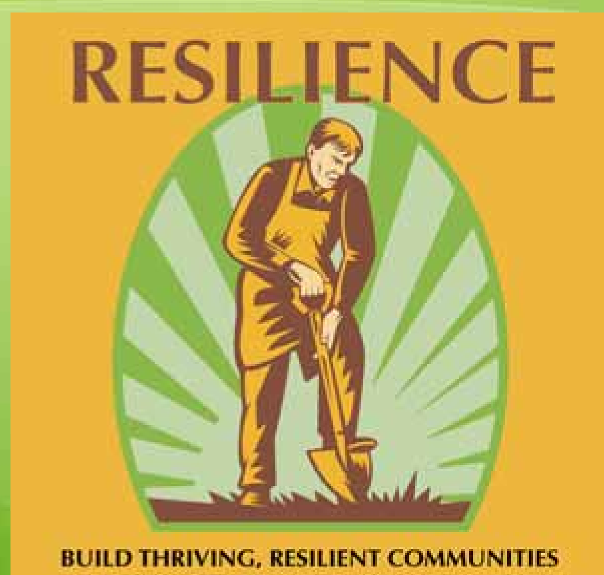
Opportunities and Innovations in Community Sustainability



Colorado's Boulder Creek CZO


resilient
Able to successfully adapt to uncertainty and plan for changing global conditions.
communities
A collection of stakeholders within a defined geography who are reliant on the shared resources and affected by the actions/choices of one another.

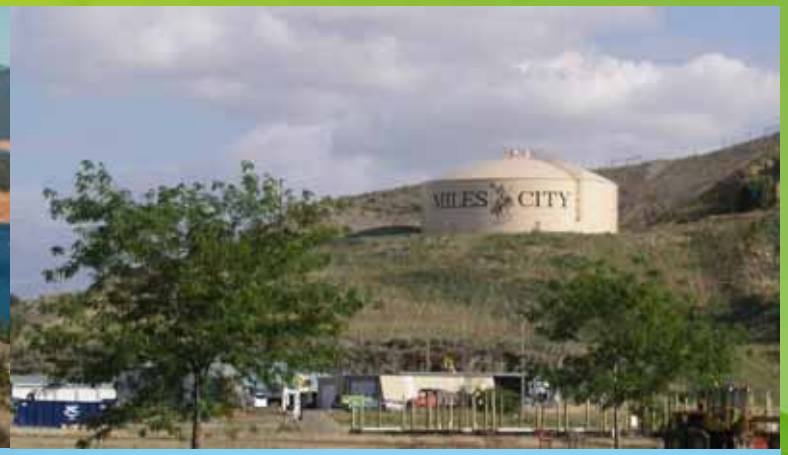

community
communities
people
resilience
local
change
many
new
example
work
one
energy
social
future
Community
support
thinking
learning
well
helps
systems
might

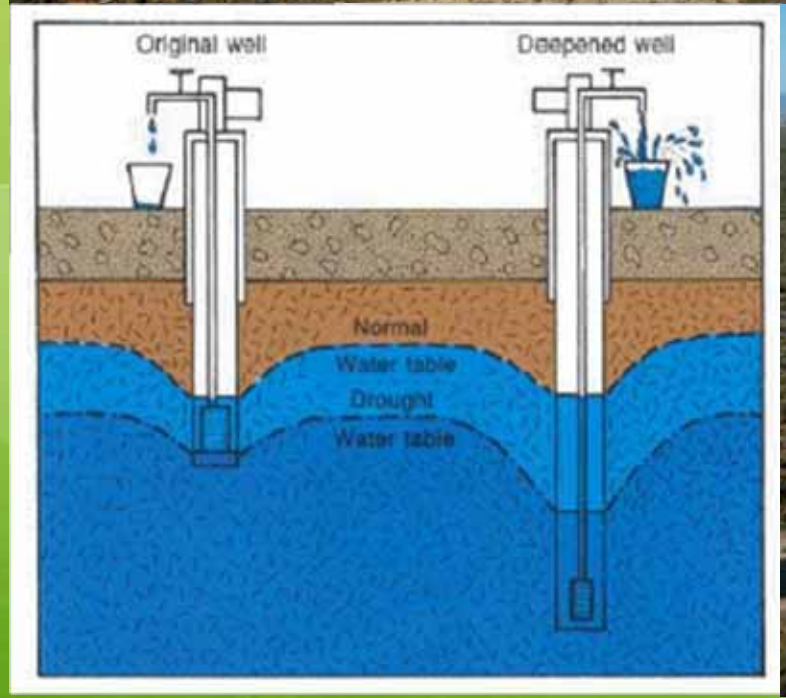

RESILIENCE
BUILD THRIVING, RESILIENT COMMUNITIES


WELLNESS
ACCESS
EDUCATION
ENGAGEMENT
SELF-SUFFICIENCY
PARTNERSHIP
QUALITY
EFFICIENCY
COMMUNITY RESILIENCE

Resilience in Natural and Built Systems:

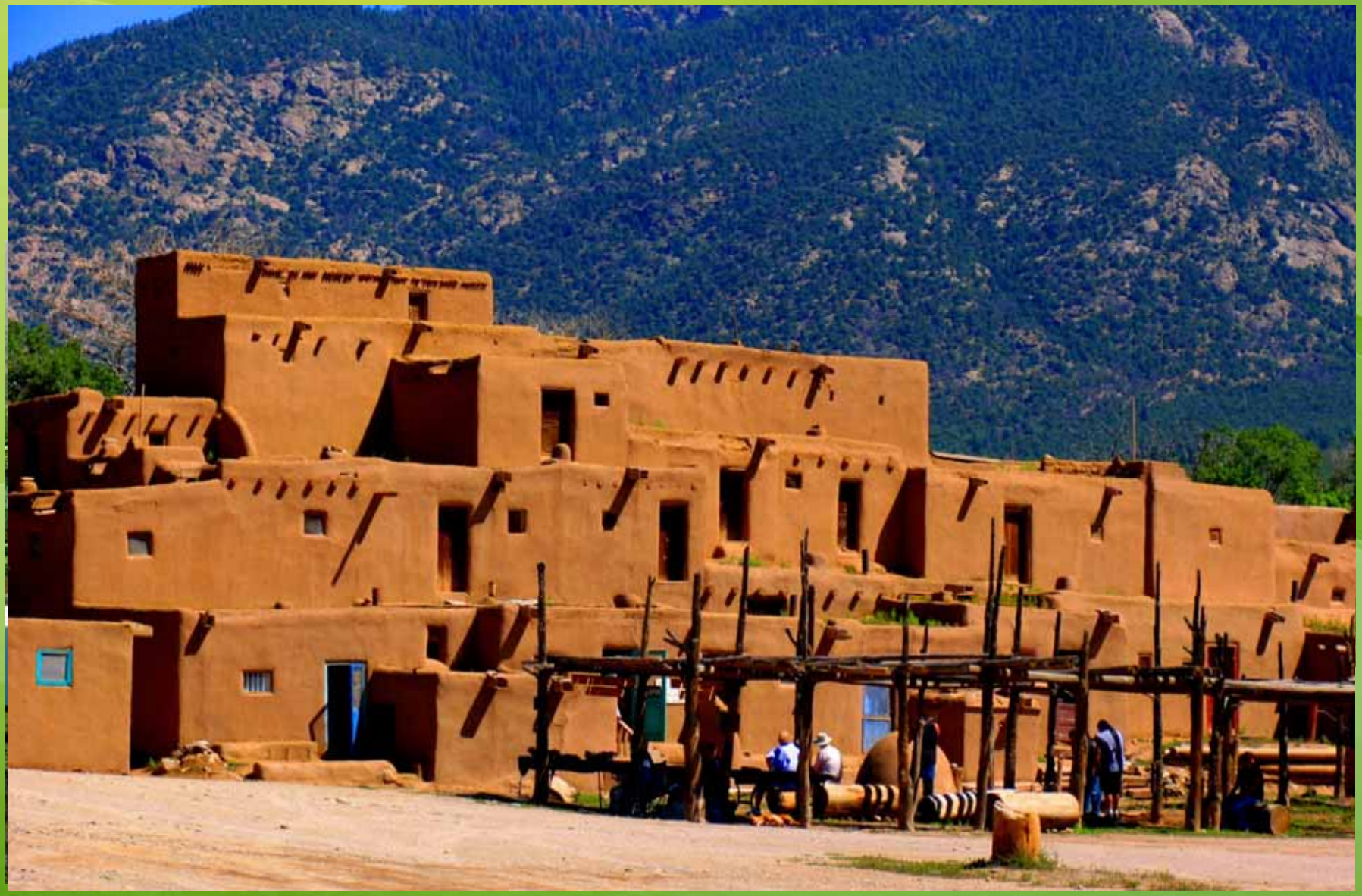
Opportunities and Innovations in Community Sustainability





Resilience in Natural and Built Systems:

Opportunities and Innovations in Community Sustainability



Resilience in Natural and Built Systems:

Opportunities and Innovations in Community Sustainability