



Oct 8: Major Consequences of Climate Change: **Water Crisis**

Update

Quiz #3

Foci of the Day

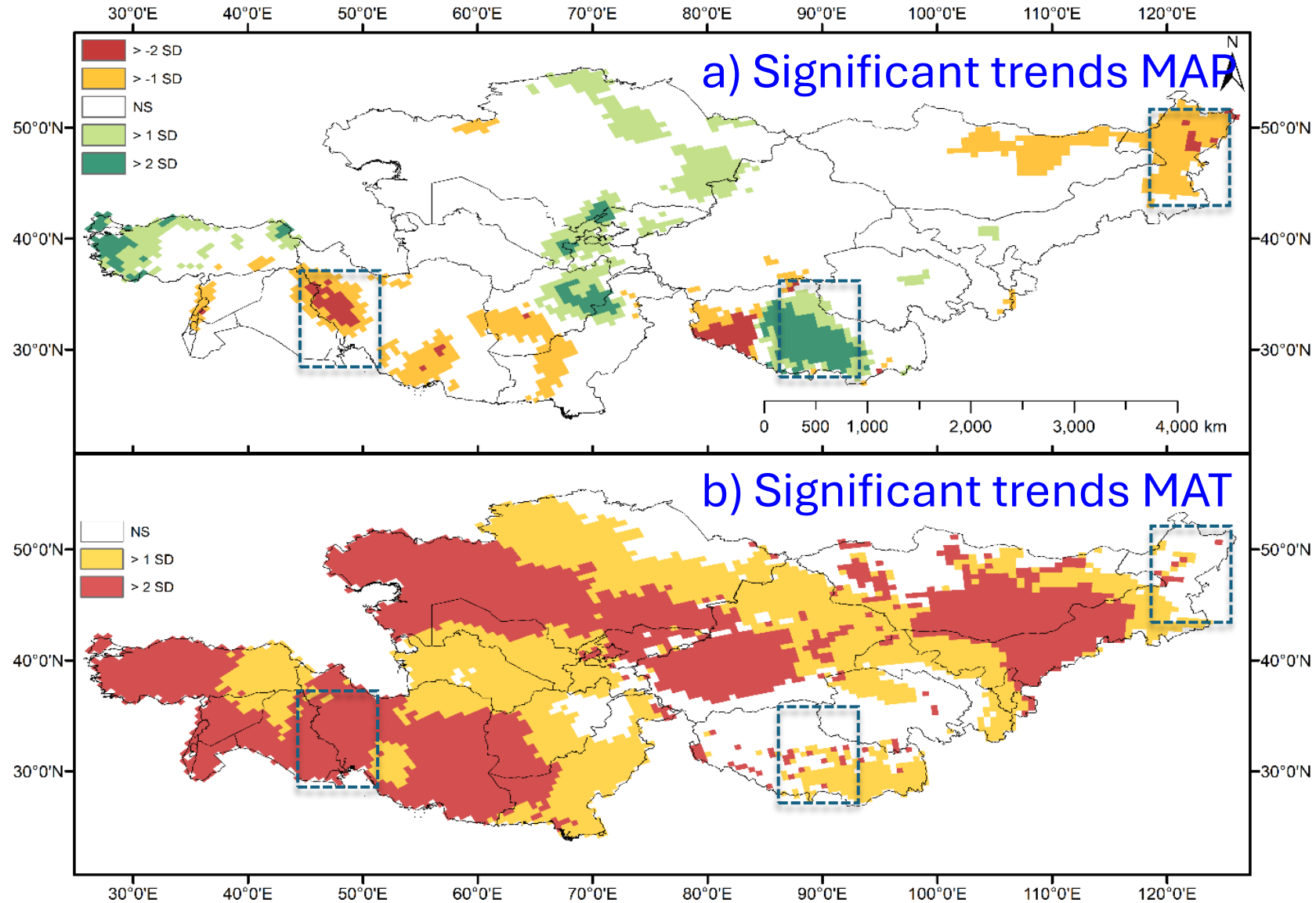
- Large regional variations and high uncertainty in projections.
- Thirsty Globe: emerging global water challenges.
- Evapotranspiration (ET) and water use efficiency (WUE).
- The Aral Sea continues to shrink.



Climate Change: high spatial variation

- Long term changes in mean annual precipitation (MAP) and mean annual temperature (MAT) across the Asian Drylands Belt (ADB)

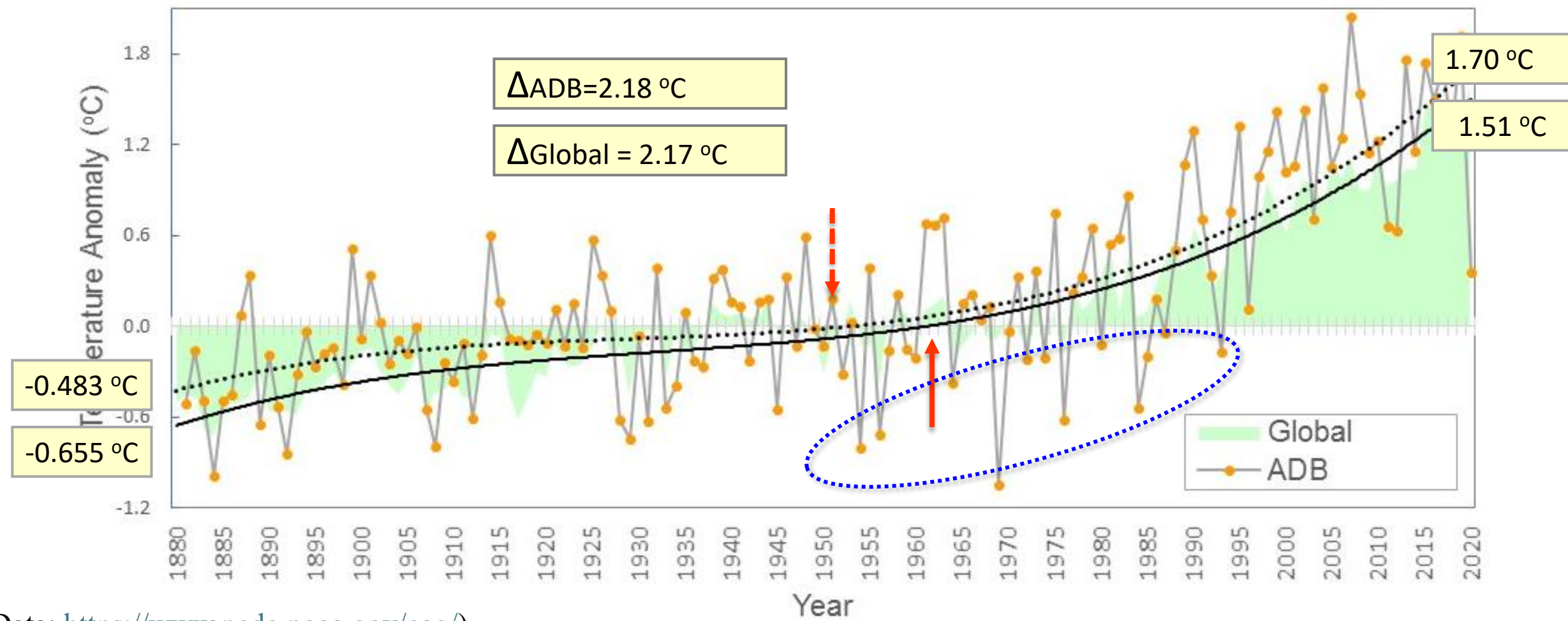
- **Spatial Variability:** not homogeneous and with hotspots



Climate Change: high interannual variation

(Extremes are often related to different physical processes than those that govern long-term means!)

Change in anomalies of land surface air temperature (°C) for global land and ADB region during 1880-2000



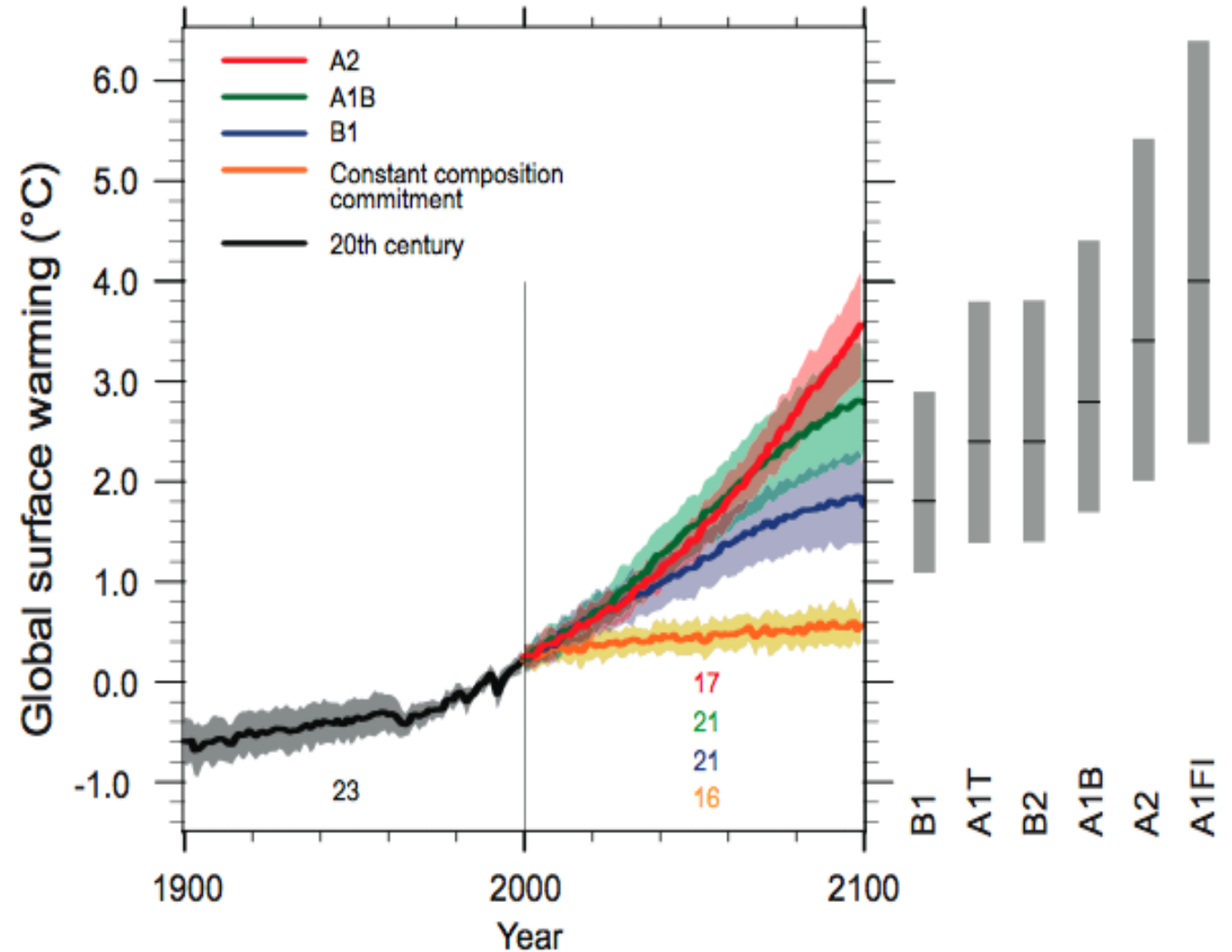
(Data: <https://www.ncdc.noaa.gov/cag/>).



High Uncertainty: Projections of Future Changes in Climate

Best estimate for low scenario (B1) is 1.8°C (*likely* range is 1.1°C to 2.9°C), and for high scenario (A1FI) is 4.0°C (*likely* range is 2.4°C to 6.4°C).

(Credit: Dr. Ying-Ping Wang, CSIRO, Australia)

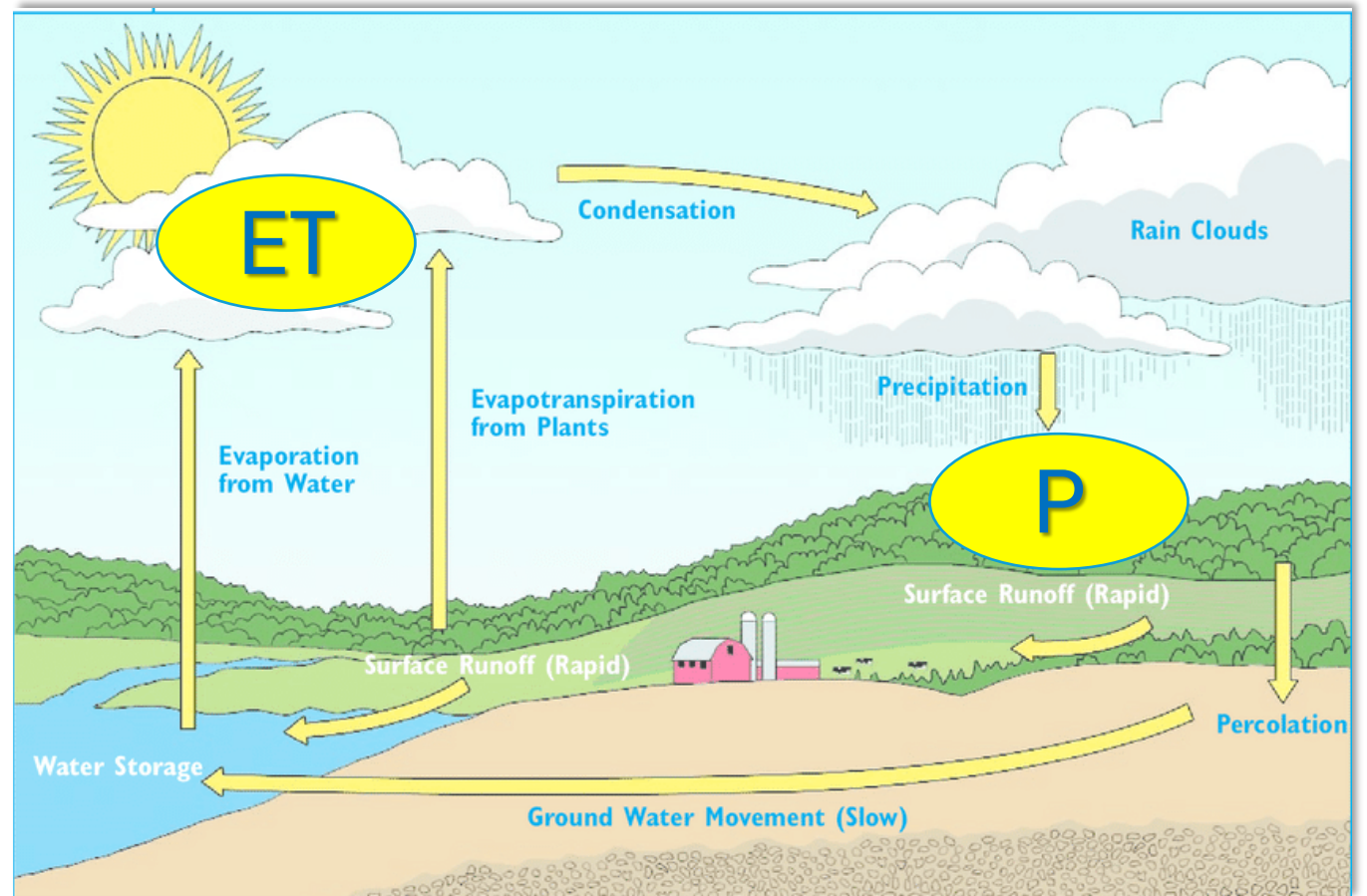




A Thirsty Globe!

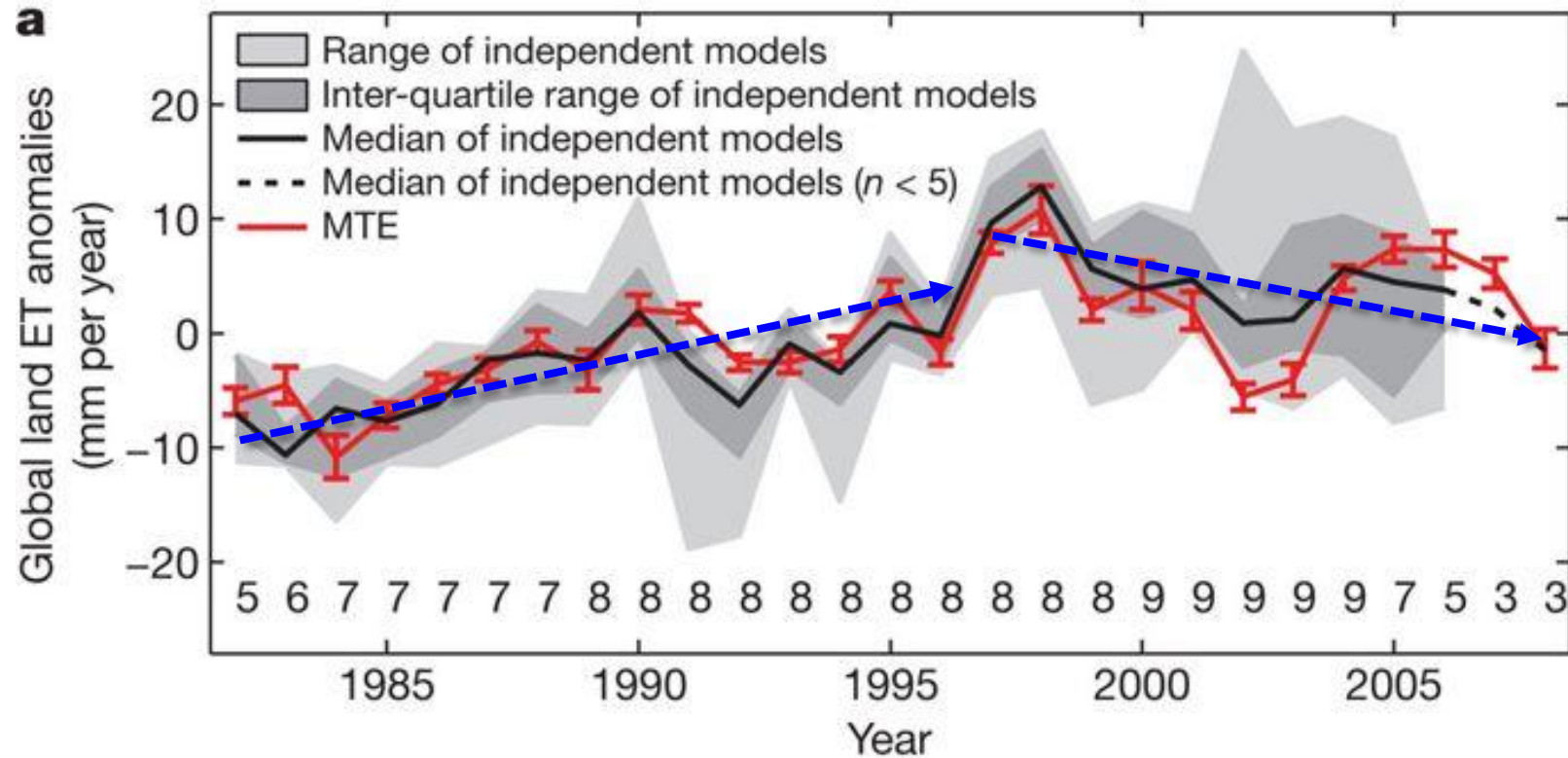
- Evapotranspiration (**ET**): the total amount of water transferred from the land surface to the atmosphere through evaporation and plant transpiration.

- Although total global precipitation (**P**) remains relatively constant over time, changes in **ET** influence the availability of water in soils, rivers, and groundwater systems.



A Thirsty Globe!

- ET has been increasing with warming climate until ~1998, but decreasing since then;
- We may have more freshwater;





A Thirsty Globe!

Unfortunately

- This change was driven primarily by **moisture limitation** in the Southern Hemisphere, particularly **Africa** and **Australia**.
- In these regions, soil moisture decreased from 1998 to 2008.
- Hence, increasing soil-moisture limitations on ET, largely explain the recent decline of the global ET.

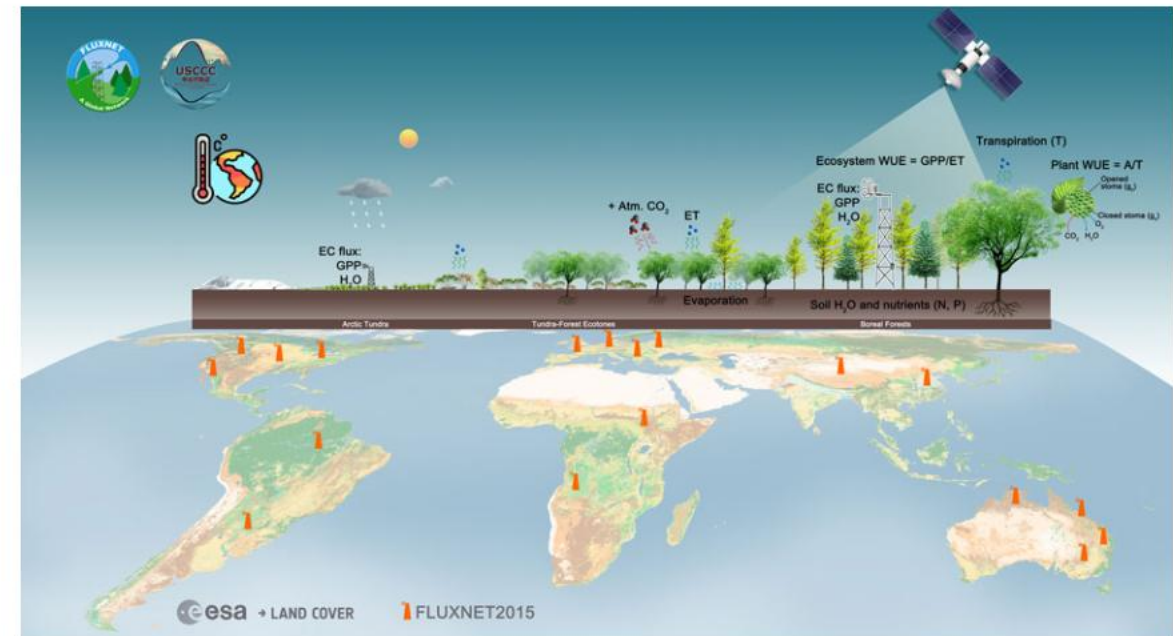
Climate Change: Full of Surprises

- Ecosystem water use efficiency ($WUE_{eco} = GPP:ET$), is widely expected to increase because of the rising atmospheric CO_2 concentration,
- Global WUE_{eco} has not risen since 2001 because of the asymmetric effects of an increased vapor pressure deficit **due to the warming**, which depressed photosynthesis (GPP) and enhanced ET.

MSU scientists find plants' ability to fight climate change is weakening

August 16, 2023 - Diane Huhn

New findings shed light on global water use efficiency in terrestrial ecosystems



Data knowledge predictions about global water use efficiency in a changing climate. (Image courtesy of Jiquan Chen/Landscape Ecology & Ecosystem Science Lab)

It's often said that you should never put all your eggs in one basket. New research indicating that plants' ability to absorb carbon dioxide (CO_2) may have stalled, just published in the journal *Science* by climate experts at Michigan State University, suggests that perhaps we shouldn't put all our climate mitigation hopes in too many plant-based strategies either, at least for the time being.

Li, F., Xiao, J., Chen, J., Ballantyne, A., Jin, K., Li, B., ... & John, R. (2023). Global water use efficiency saturation due to increased vapor pressure deficit. *Science*, 381(6658), 672-677.

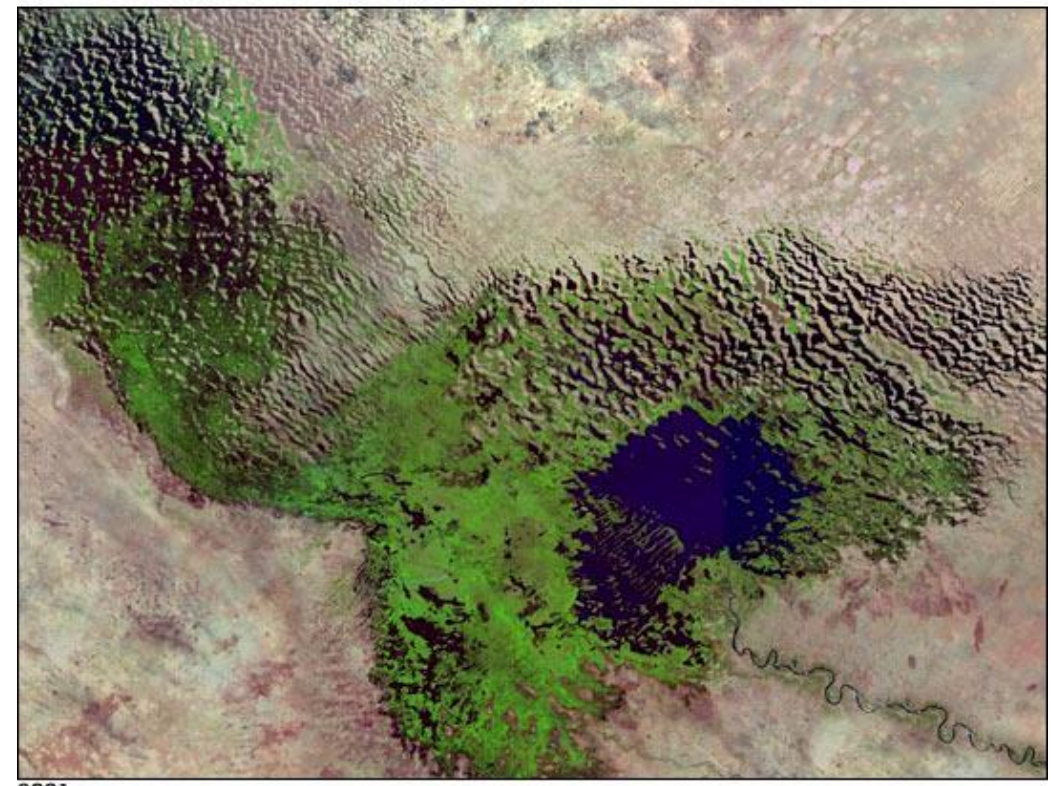




Lake Disappearance!

- Hundreds lakes across the globes disappear each year, especially in dryland regions.
- Over the last 60 years, the lake's size has decreased by 90% as a result of overuse of the water, extended drought and the impacts of climate change.
- The surface area of the lake has plummeted from 26,000 km² in 1963 to <1,500 km² today (2018) -- **shrank by 20 times.**

Lake Chad, once one of the African continent's largest bodies of fresh water, has dramatically decreased in size due to climate change and human demand for water.



List of drying lakes

From Wikipedia, the free encyclopedia

A number of lakes throughout the world are drying or completely dry due to irrigation or urban use diverting inflow.^{[1][2]}

This list is incomplete; you can help by expanding it.

- | | | |
|--|--|--|
| <ul style="list-style-type: none"> • Dead Sea in Israel, Jordan, and Palestine^[3] • Hamun Lake on the Irano-Afghan border^[4] • Salton Sea in California, U.S.^[5] • Lake Chad in Cameroon, Chad, Niger and Nigeria^[6] • Aral Sea in Kazakhstan and Uzbekistan^[7] • Tulare Lake in California, U.S.^[8] • Lake Urmia in Iran^[9] | <ul style="list-style-type: none"> • Owens Lake in California, U.S.^[10] • Walker Lake in Nevada, U.S.^[11] • Mono Lake in California, U.S.^[12] • Fucine Lake in Italy (fully drained during the 19th century) • Poyang Lake in Jiangxi, China^[13] • Qinghai Lake in China | <ul style="list-style-type: none"> • White Bear Lake in Minnesota, U.S.^[14] • Lake Meredith in Texas, U.S.^[15] • Lake Albert in South Australia^[16] • Lake Hindmarsh in Australia^[17] • Lake Poopó in Bolivia^[18] • Lake Copais, in Boeotia, Greece • Lake George, in New South Wales, A |
|--|--|--|



2001



Aral Sea: Once the fourth largest lake in the world



US Dept of State Geographer
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2020 Google
Image Landsat / Copernicus

Google Earth

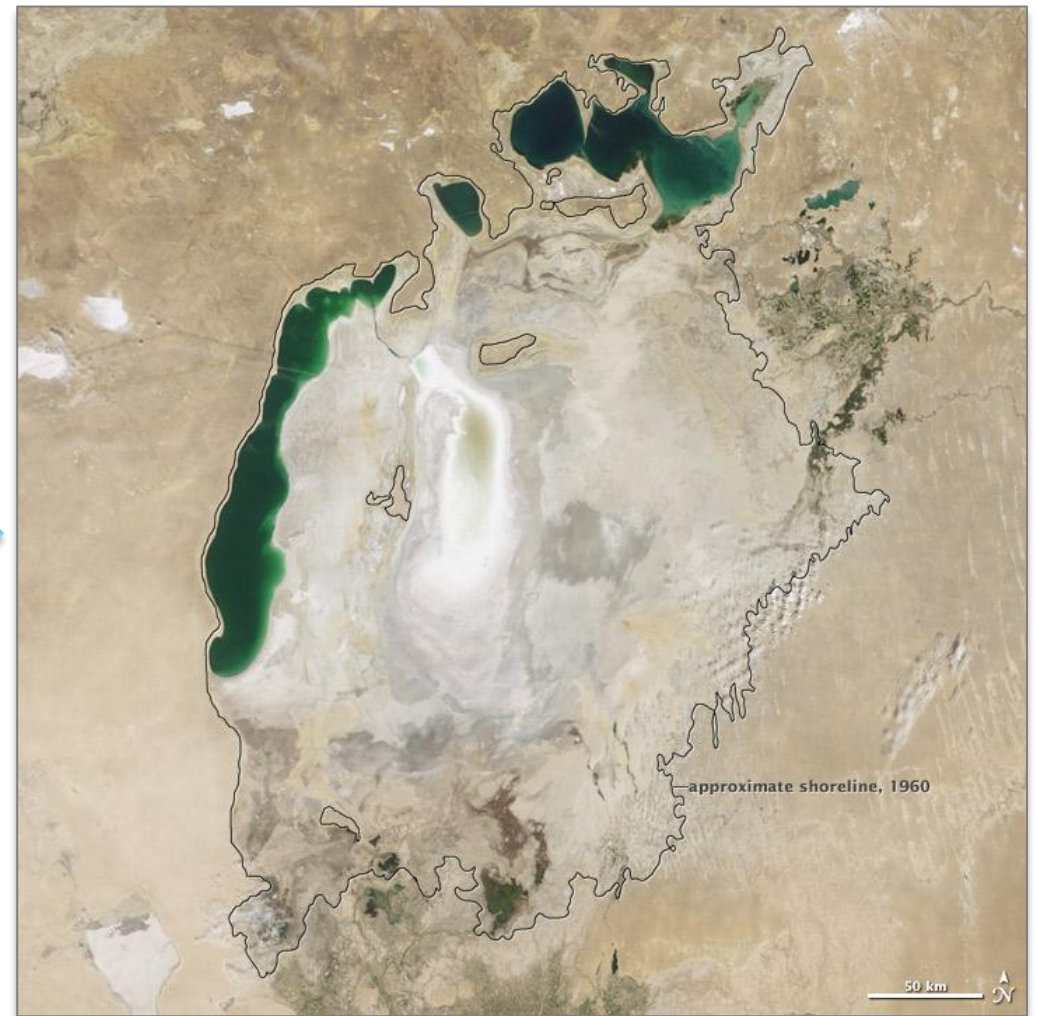
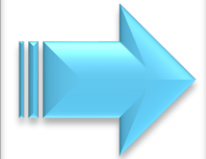
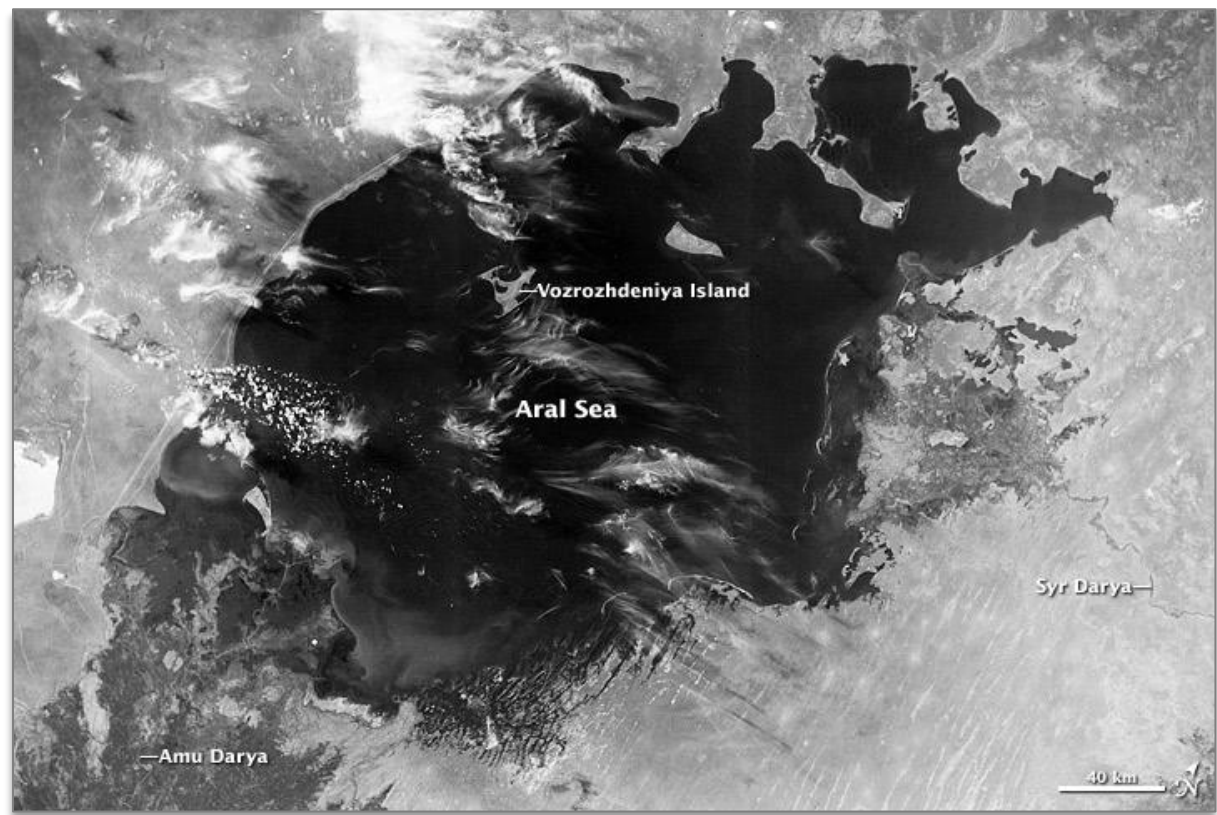
Imagery Date: 12/13/2015 48°57'55.21" N 64°14'15.06" E eye alt 13242.88 km



Aral Sea

2019

1963





What had happened?

- **Virgin Lands Campaign:** A Soviet initiative launched in the mid-1950s to cultivate previously uncultivated lands in Central Asia and other regions.
- Most regional renewable water resources originate in the mountains, where the major rivers of the region begin.
- Extensive irrigation systems have been developed to enhance soil fertility.

- High ET loss
- Less inflows from rivers
- More water withdraw





Take-Home-Messages

- 1) Warming has increased evapotranspiration (ET), but this trend has been constrained by reduced soil moisture since 1998.
- 2) Ecosystem water use efficiency (WUE) exhibited a noticeable shift after 2001.
- 3) The Aral Sea experienced both shrinkage and expansion due to land-use changes.

A Thirsty Globe!



Field Impressions



Field Impressions



Field Impressions



Field Impressions



Field Impressions





Field Impressions



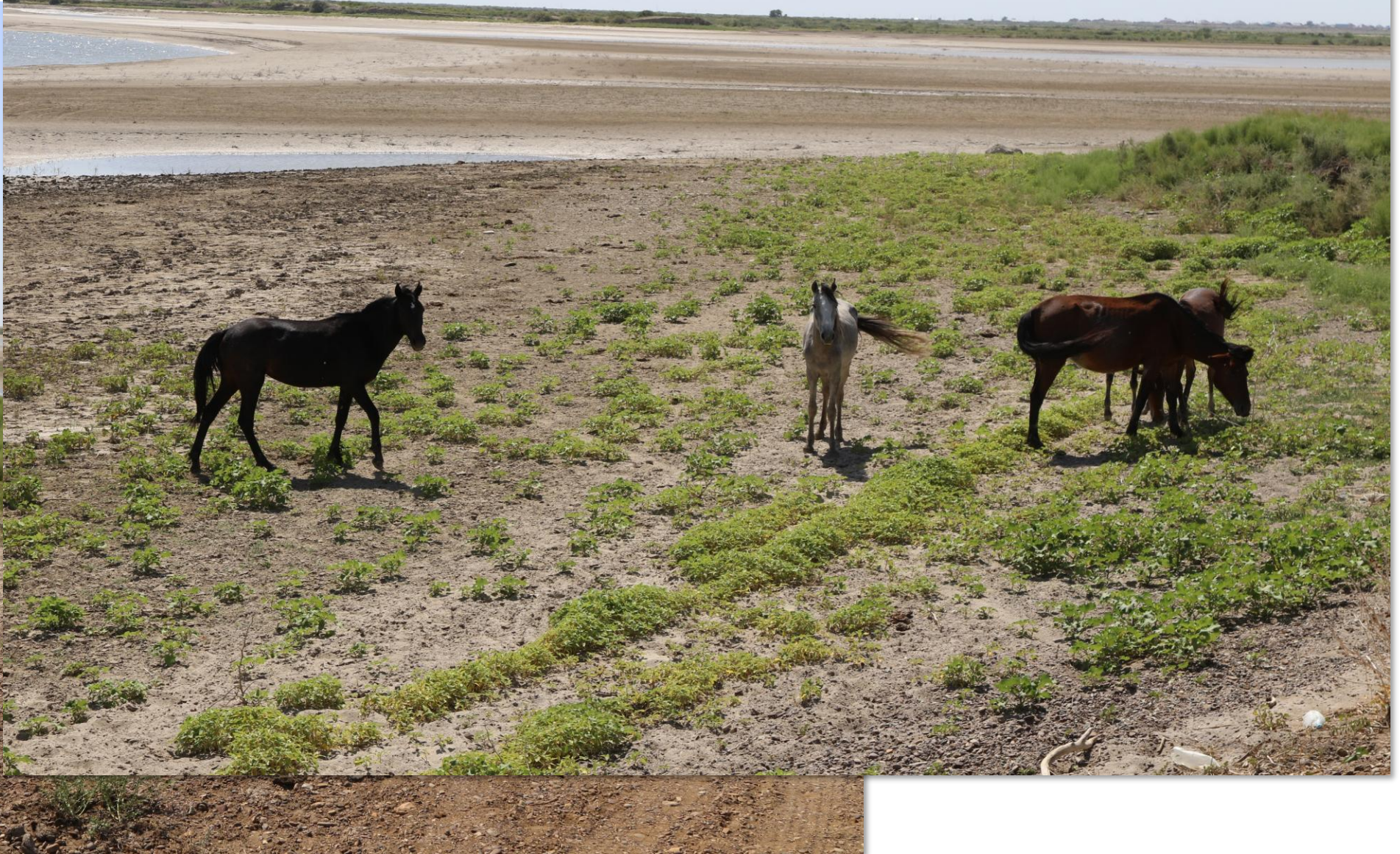


Field Impressions





Field Impressions





Field Impressions





Field Impressions





Field Impressions





Oct 13: Major Consequences of Climate Change: **sea level**