The Nile Basin and El Nino Southern Oscillation (ENSO) Climate Teleconnection – The 2023 El Nino Development and Impending Drought in Ethiopia

Food Supply and Grand Ethiopian Renaissance Dam (GERD) Operation

Nile Webinar, FIU

June 26, 2023

Wossenu Abtew, Ph.D., P.E., D.WRE

Principal Engineer

Water and Environment Consulting

Outline of Presentation

- El Nino Southern Oscillation (ENSO) and Climate Teleconnection, ENSO Tracking
- Global Impact of La Nina and El Nino – South Florida and Ethiopia
- El Nino and Historical Famine in Ethiopia
- Dam Operation and Drought (Lake Okeechobee) - Water Management Skills
- Transboundary Water Agreements and Droughts and Operation of GERD (ex. Colorado River)

Warnings - Prepare for Unprecedented Drought

FARMINGPORTAL

El Niño set to break heat records in 2024 farmers warned.

South Africa's agriculture sector must prepare for unprecedented drought in 2024 on the back of a year of record flooding and rainfall, particularly along the Eastern seaboard of the country, experts warn (4/17/203).

Cape Town - South Africa's grain and livestock farmers have been told they must adapt in the face of changing weather patterns, including a predicted drier El Niño expected in the 2023/24 summer season. https://www.iol.co.za/authors/mwangi-githahu 6/21/23

WMO Update: Prepare for El Niño

Weather Alert in South Africa – Does Ethiopia Know this?

DAILY MAVERICK

OUR BURNING PLANET

HOT TOPIC

Weather experts issue alert over looming El Niño as sea surface temperatures hit record highs

(Photo: Unsplash / Oleksandr Sushko)

Adverts on/off? You choose.

By Onke Ngcuka Follow 22 Jun 2023 0

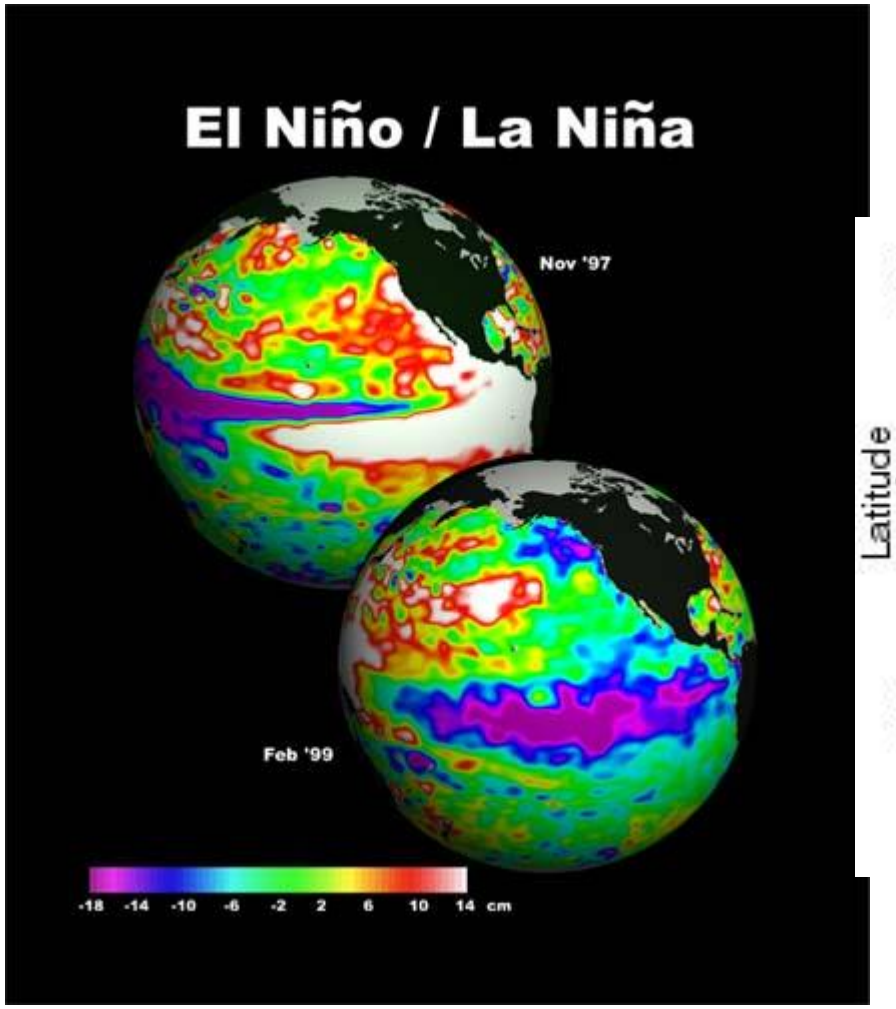
Experts warned this week that the weather phenomenon El Niño is likely to soon affect southern Africa, but whether it will cause a drought is yet to be determined.

The 1997/98 Super El Nino warning and survey in South Africa

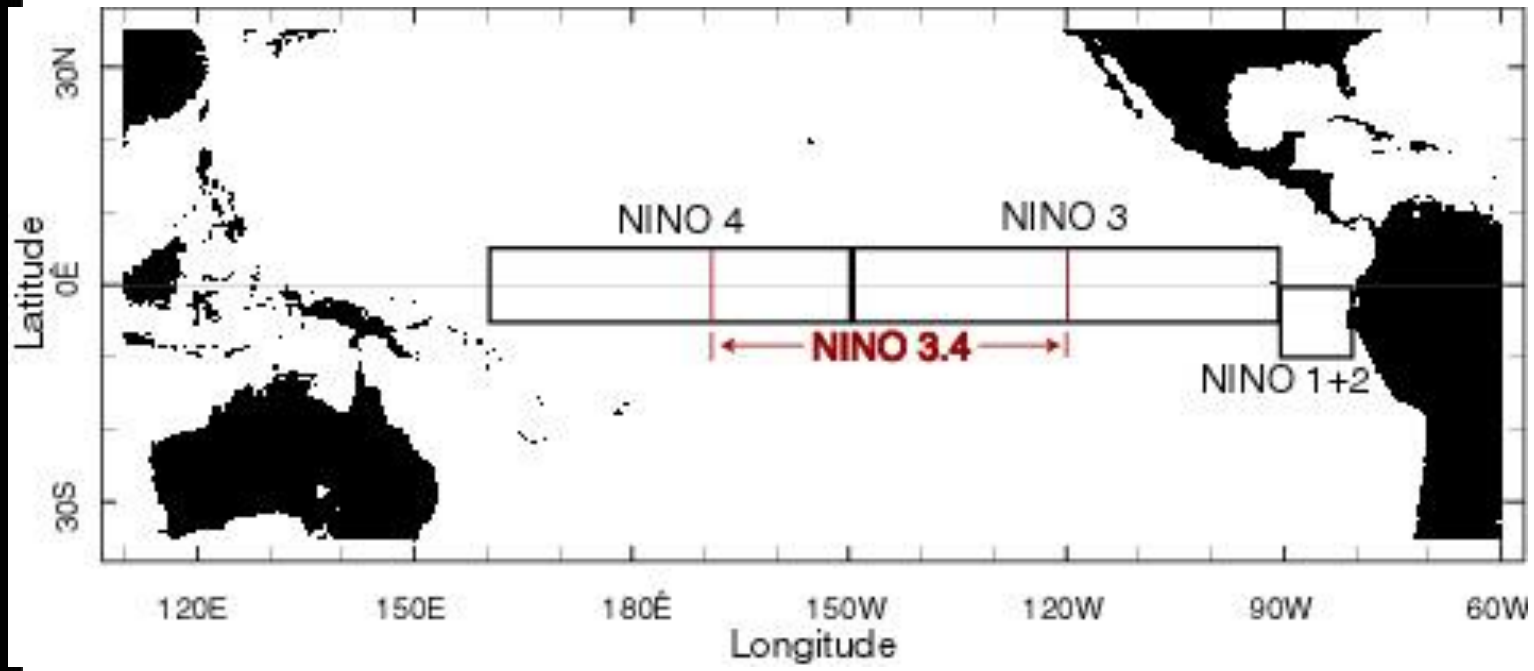
Abtew, W and A. Melesse. 2014. *Chapter 33: Climate Teleconnections and Water Management*. In: Melesse, A., Abtew, W. and Setegn, S (eds.). Nile River Basin: Ecohydrological Challenges, Climate Change and Hydropolitics, Springer, New York

Ocean-Land-Atmospheric Connection - Solar Energy, Temperature and Pressure Gradient, Wind, Mass and Energy Transfer

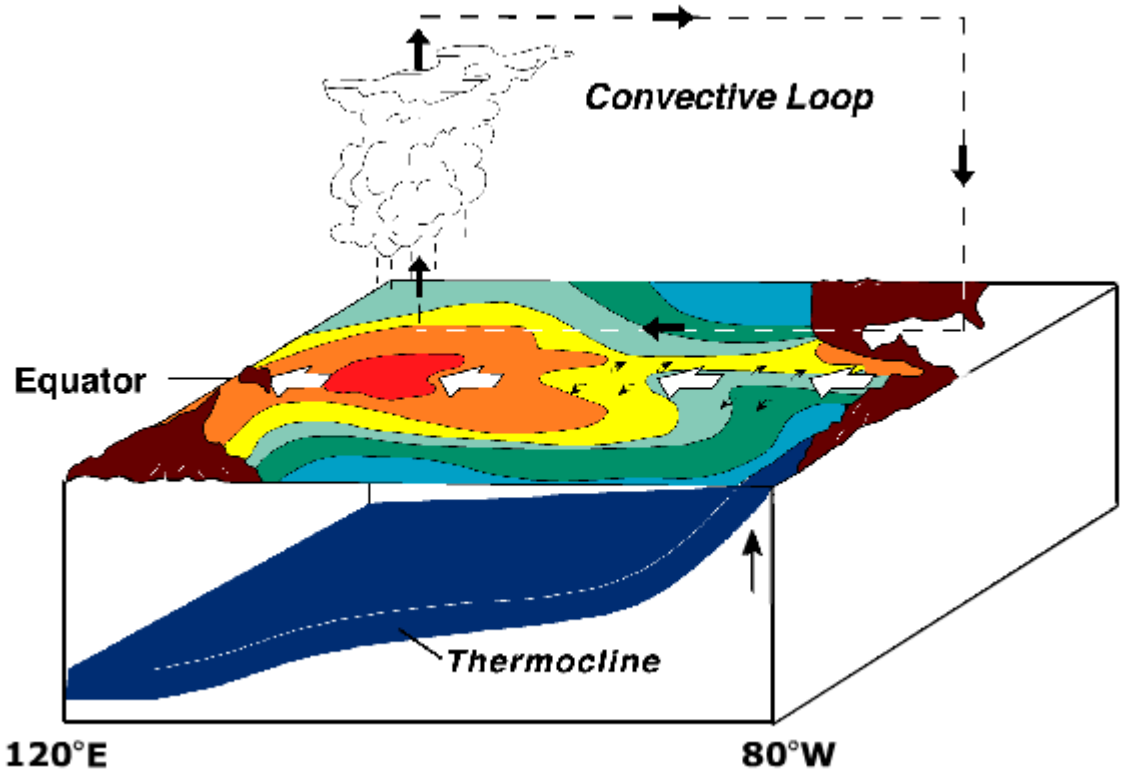
Surface Temperature and Air Pressure Anomaly



Nino3.4 (5N-5S; 120W-170W)



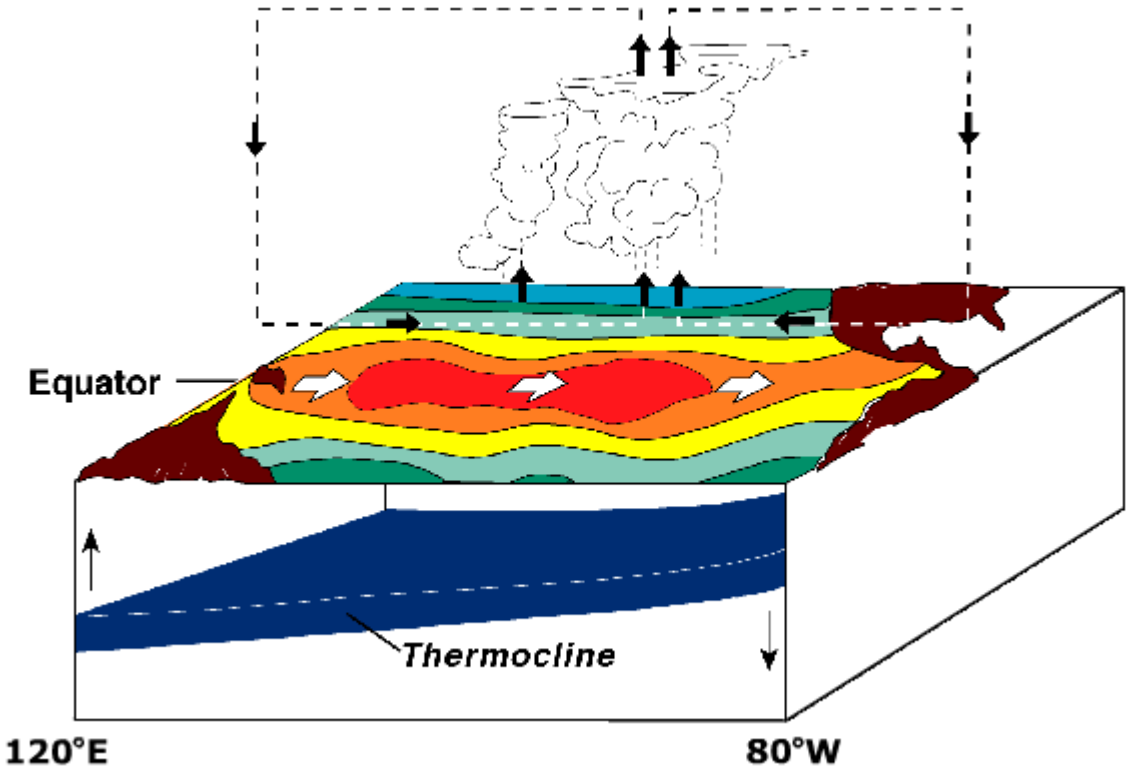
Normal Pacific Ocean Pattern



Equatorial winds gather warm water pool toward West. Coldwater upwells Along South American Coast.

NOAA

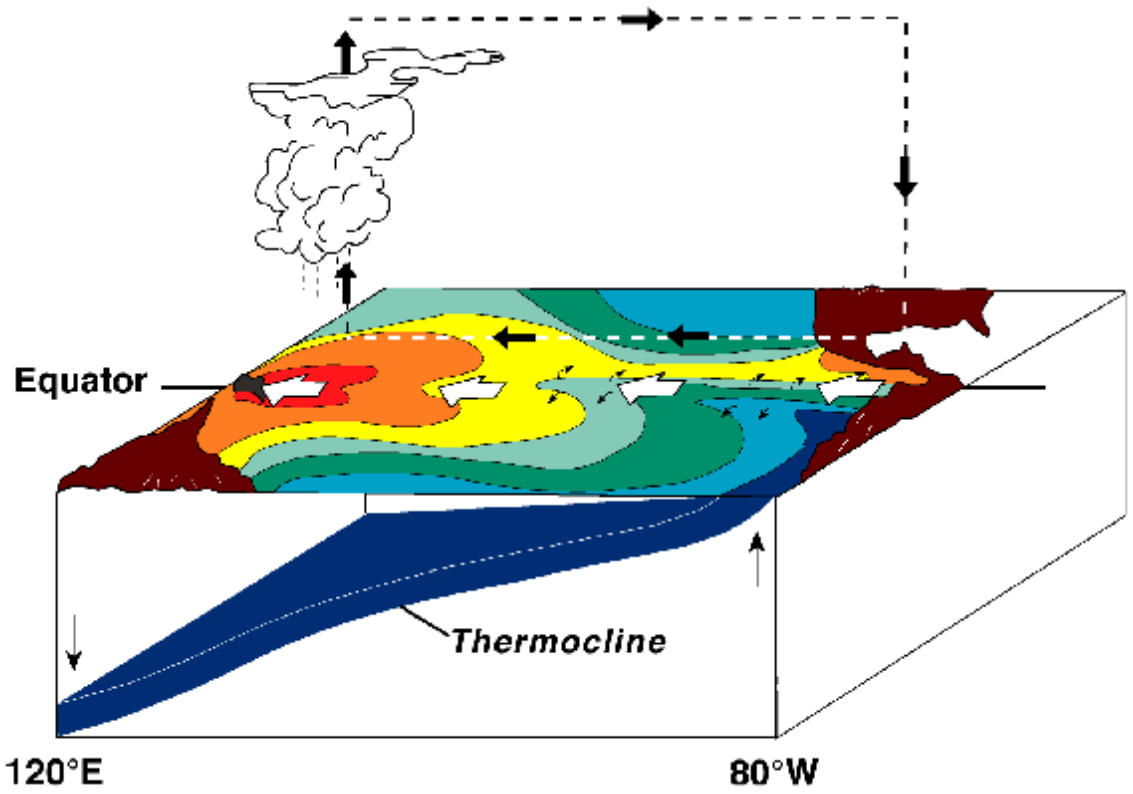
El Nino Condition



warm water pool
Approaches South American
Coast. Absence of cold
Upwelling increases warming.

NOAA

La Nina Condition

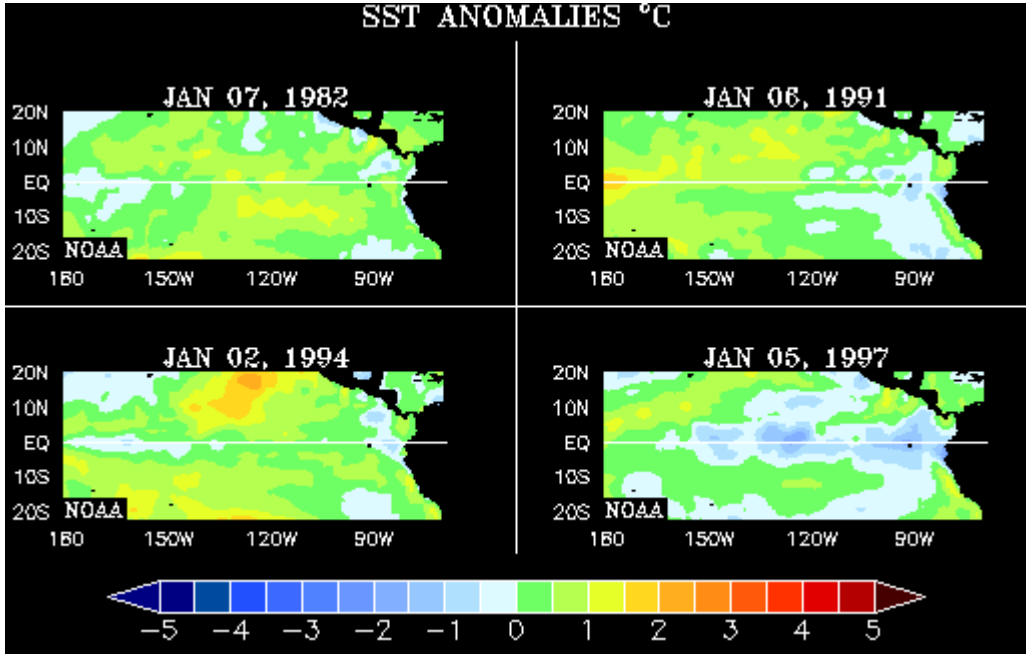


warm water is further West than usual.

NOAA

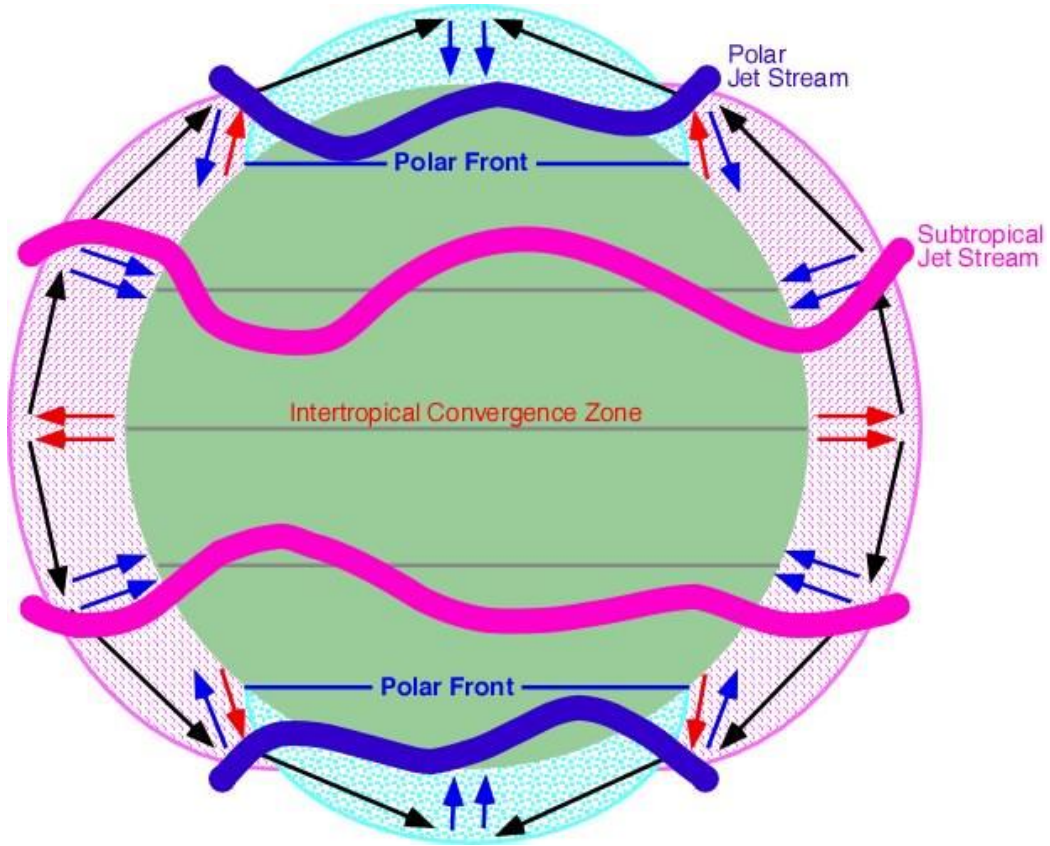
Sea Surface Temperature Anomalies – 1982 and 1997 Super El Ninos

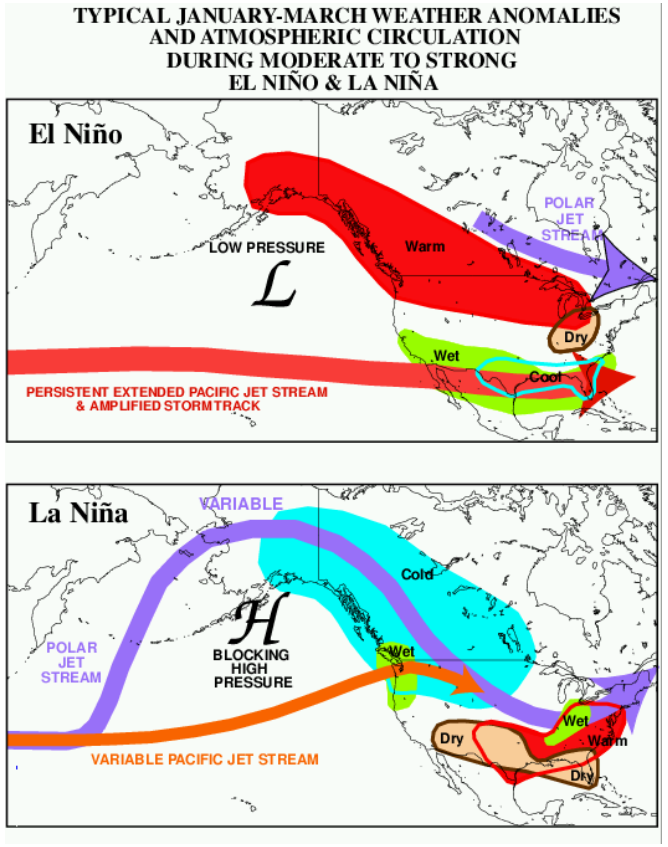
1983 Ethiopian Drought



NOAA, Earth System Research Laboratory

ESNO Impact on South Florida



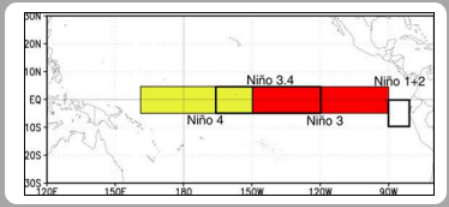


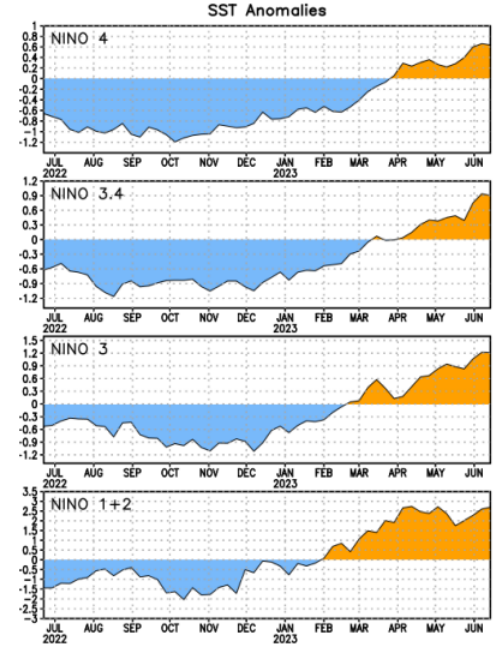
Sea Surface Departure Weekly Report

Niño Region SST Departures (°C) Recent Evolution

The latest weekly SST departures are:

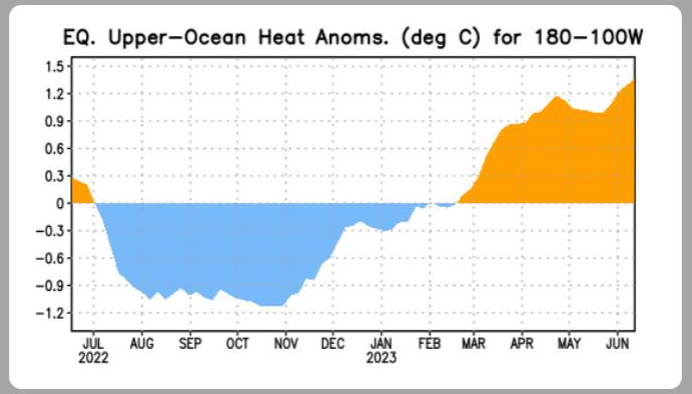
Niño 4	0.6°C
Niño 3.4	0.9°C
Niño 3	1.2°C
Niño 1+2	2.7°C





Central and Eastern Pacific Upper-Ocean (0-300 m) Weekly Average Temperature Anomalies

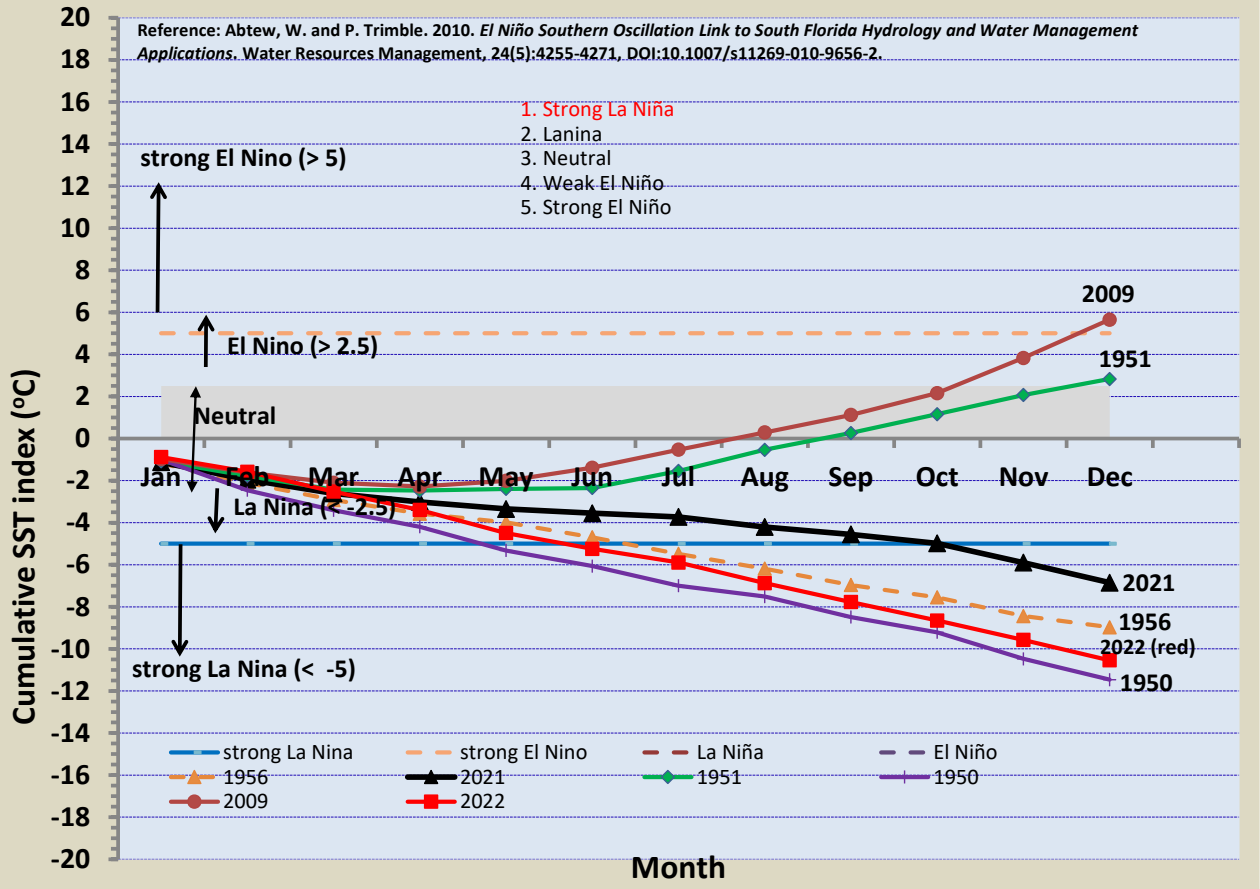
Subsurface temperature anomalies were negative until June 2022, before becoming briefly positive. From early July 2022 to mid-February 2023, anomalies were mostly negative. Subsurface anomalies became positive in February and increased through mid-April 2023 before leveling off. Since late May 2023, anomalies have increased.



Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
2011	-1.4	-1.2	-0.9	-0.7	-0.6	-0.4	-0.5	-0.6	-0.8	-1.0	-1.1	-1.0
2012	-0.9	-0.7	-0.6	-0.5	-0.3	0.0	0.2	0.4	0.4	0.3	0.1	-0.2
2013	-0.4	-0.4	-0.3	-0.3	-0.4	-0.4	-0.4	-0.3	-0.3	-0.2	-0.2	-0.3
2014	-0.4	-0.5	-0.3	0.0	0.2	0.2	0.0	0.1	0.2	0.5	0.6	0.7
2015	0.5	0.5	0.5	0.7	0.9	1.2	1.5	1.9	2.2	2.4	2.6	2.6
2016	2.5	2.1	1.6	0.9	0.4	-0.1	-0.4	-0.5	-0.6	-0.7	-0.7	-0.6
2017	-0.3	-0.2	0.1	0.2	0.3	0.3	0.1	-0.1	-0.4	-0.7	-0.8	-1.0
2018	-0.9	-0.9	-0.7	-0.5	-0.2	0.0	0.1	0.2	0.5	0.8	0.9	0.8
2019	0.7	0.7	0.7	0.7	0.5	0.5	0.3	0.1	0.2	0.3	0.5	0.5
2020	0.5	0.5	0.4	0.2	-0.1	-0.3	-0.4	-0.6	-0.9	-1.2	-1.3	-1.2
2021	-1.0	-0.9	-0.8	-0.7	-0.5	-0.4	-0.4	-0.5	-0.7	-0.8	-1.0	-1.0
2022	-1.0	-0.9	-1.0	-1.1	-1.0	-0.9	-0.8	-0.9	-1.0	-1.0	-0.9	-0.8
2023	-0.7	-0.4	-0.1	0.1								

https://www.cpc.ncep.noaa.gov/products/expert_assessment/

Monthly ENSO Tracking (Average of Weekly Data)



Abtew, W. and P. Trimble. 2010. *El Niño Southern Oscillation Link to South Florida Hydrology and Water Management Applications*. Water Resources Management, 24(5):4255-4271, DOI:10.1007/s11269-010-9656-2

Abtew, W., A. Melesse and T. Dessalegne. 2009. *El Niño Southern Oscillation link to the Blue Nile River Basin Hydrology*. Hydrological Processes. Vol. 23:3653-3660; DOI:10.1002/hyp.7367

$$CumulativeIndex = \sum_{1}^{M} I_m$$

$$\text{for } M \le 12$$

Where m is month, and I is monthly ENSO index

Strong ENSO Event

SST 0 to ±2.5 Neutral
SST 2.5 to 5 El Nino
SST > 5 Strong El Nino
SST -2.5 to -5 La Nina
SST < -5 Strong La Nina

SOI < -7 or > 7

2023 ENSO Prediction

(https://www.cpc.ncep.noaa.gov/products/analysis_monitoring/lanina/enso_evolution-status-fcsts-web.pdf/)

IRI Pacific Niño 3.4 SST Model Outlook

Nearly all models indicate El Niño will persist into the Northern Hemisphere winter 2023-24. A strong El Niño (values at or greater than 1.5°C) is indicated by the dynamical model average through December 2023-February 2024.

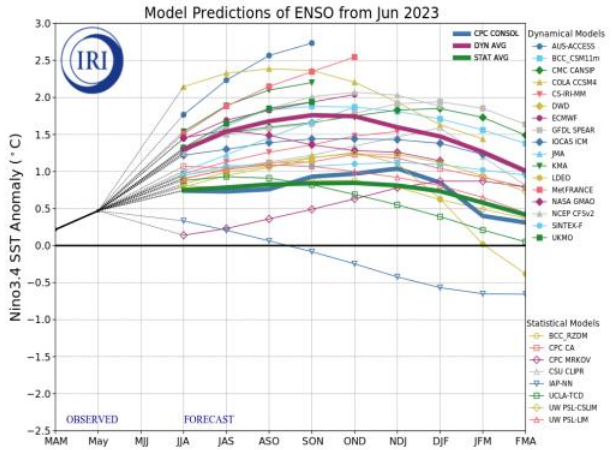
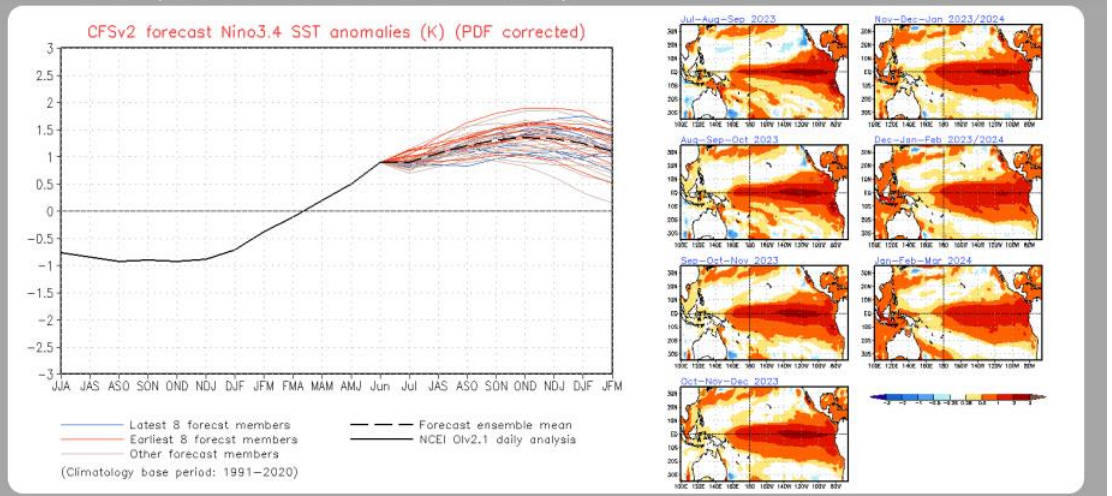


Figure provided by the International Research Institute (IRI) for Climate and Society (updated 16 June 2023).

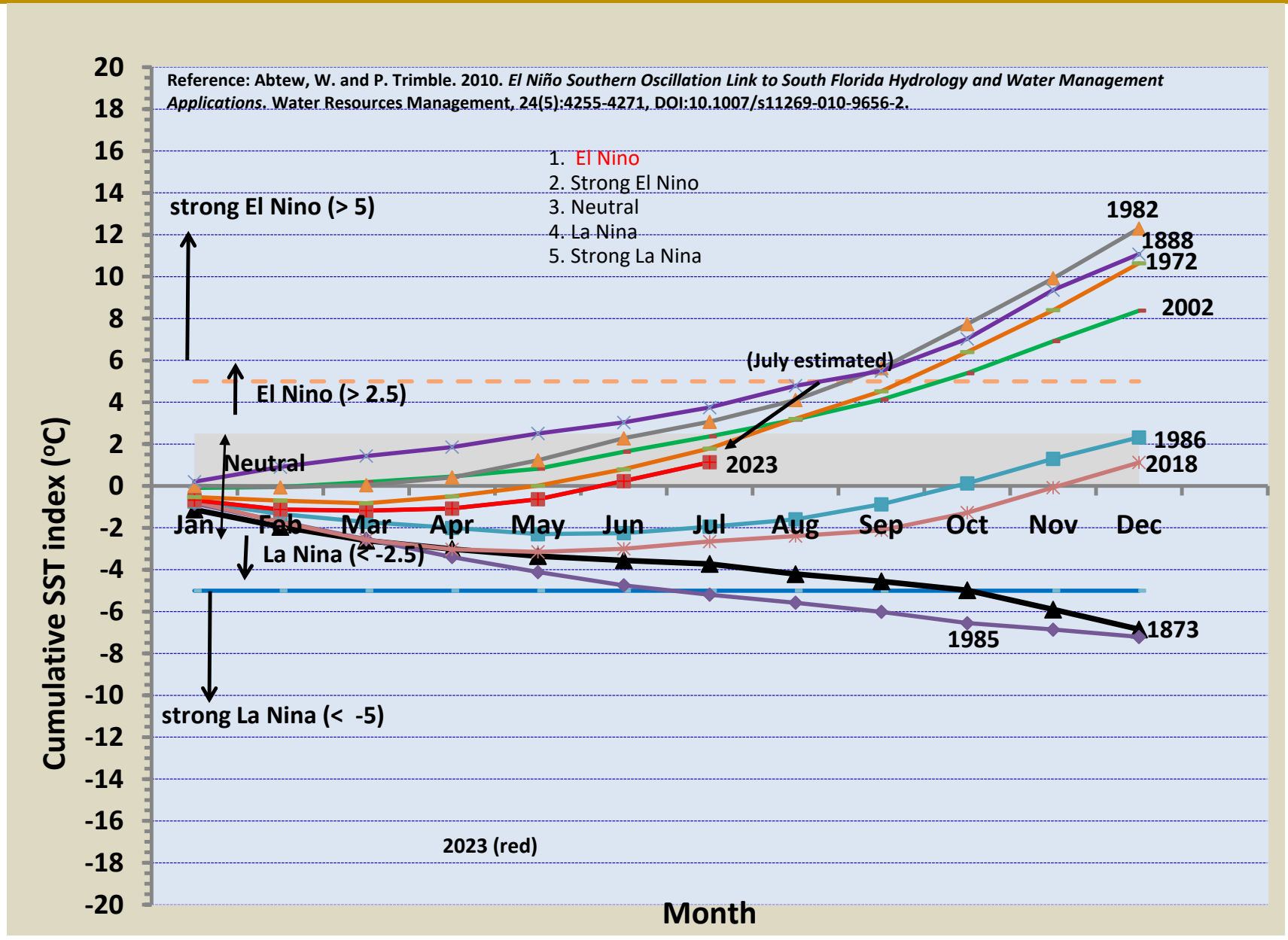
SST Outlook: NCEP CFS.v2 Forecast (PDF corrected)

Issued: 20 June 2023

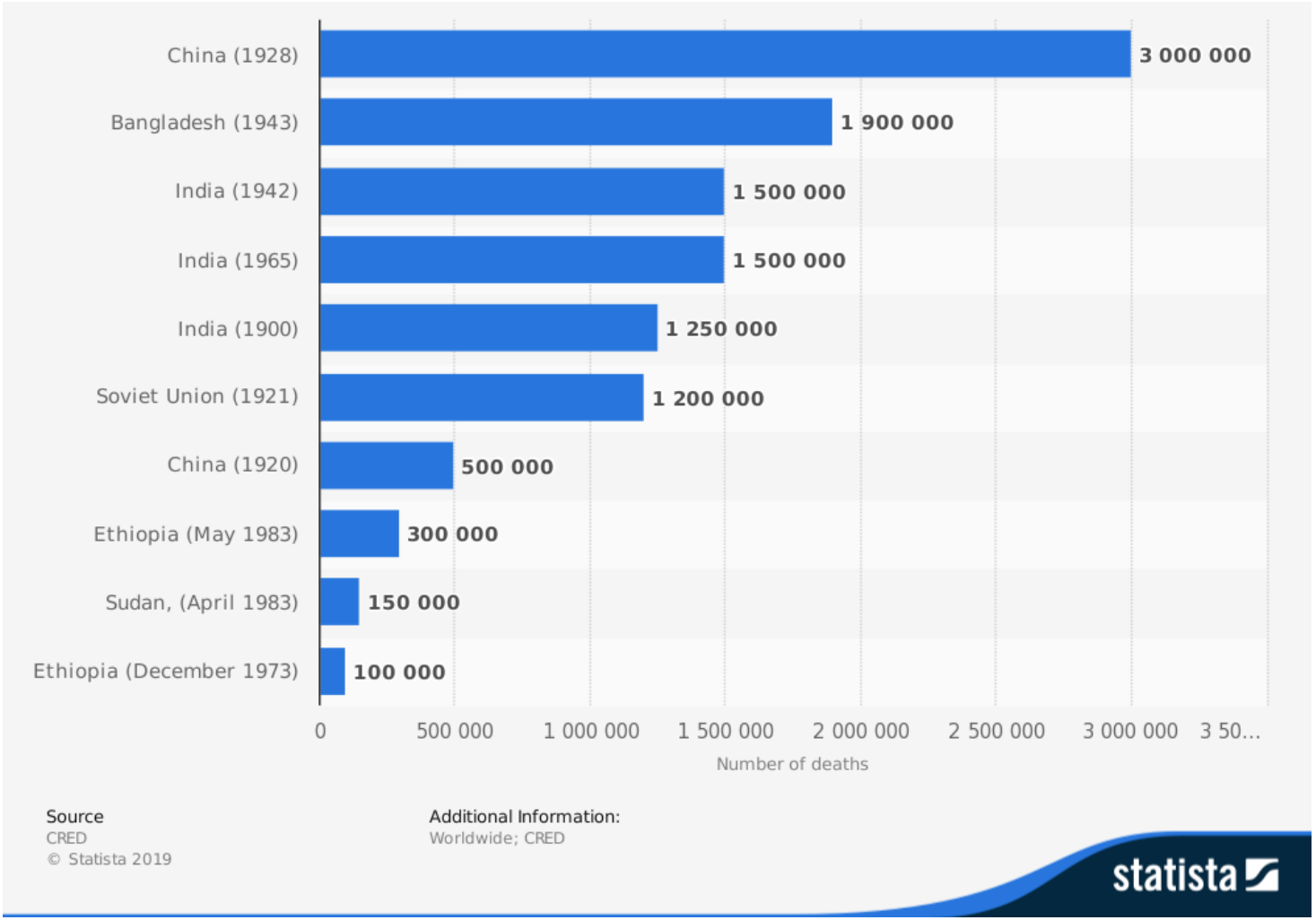
The CFS.v2 ensemble mean (black dashed line) indicates El Niño will continue through the Northern Hemisphere winter 2023-24. A moderate-strength El Niño is favored (ONI between 1.0°C and 1.5°C).



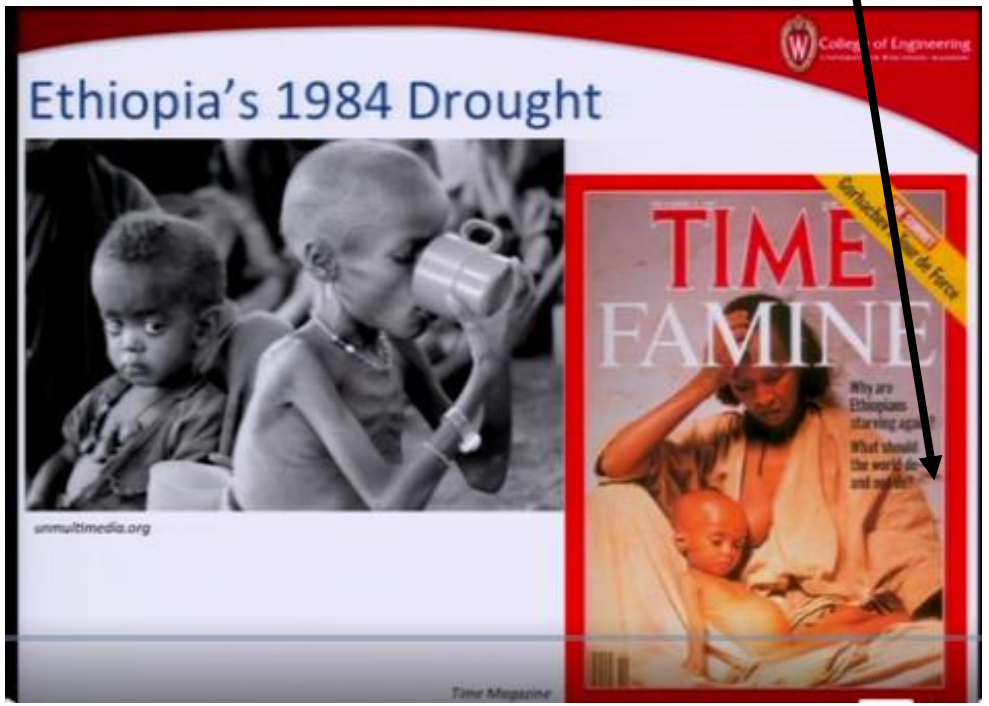
2023 ENSO Tracking (https://waterandenvironmental.com/)



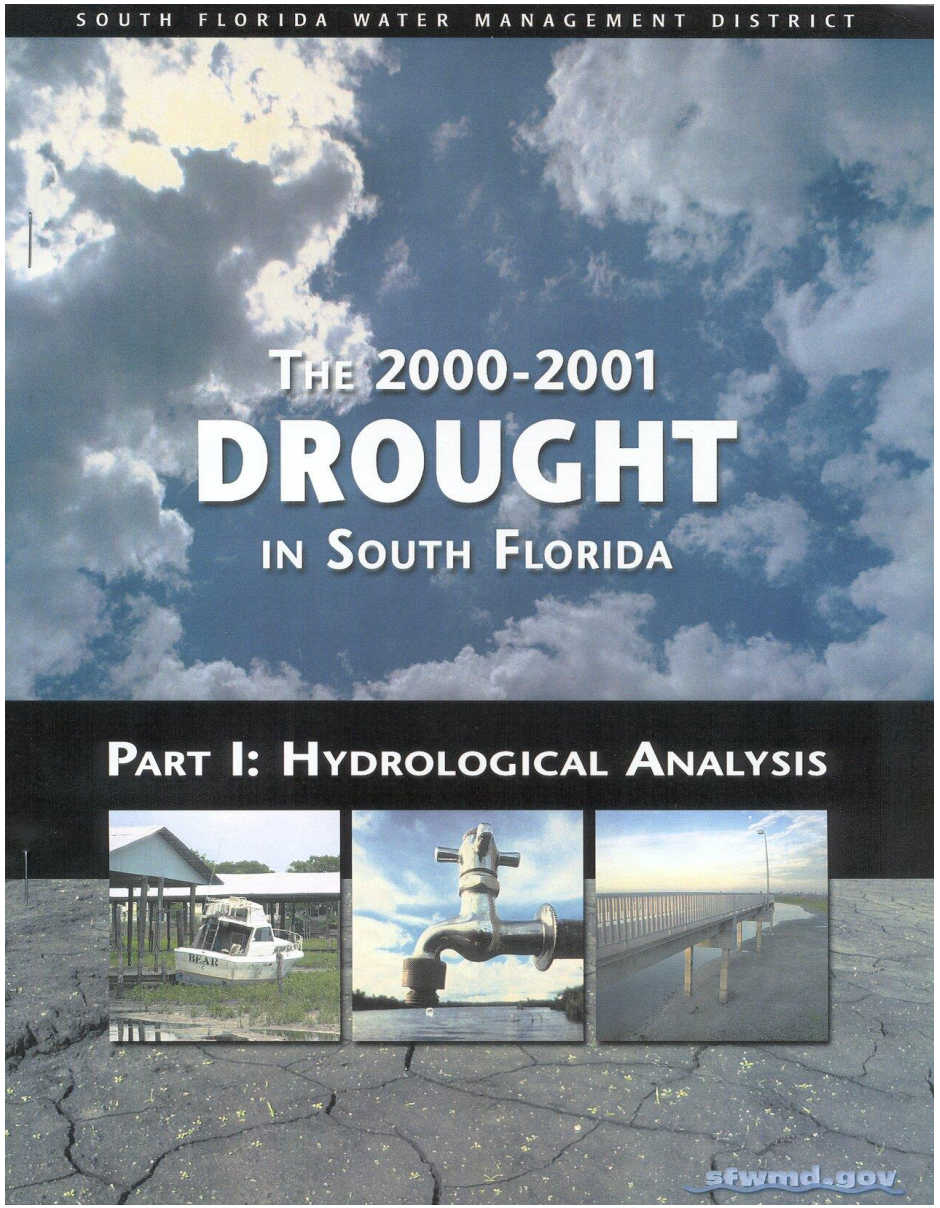
The Perils of Rainfed Agriculture and Climate Change – Ethiopia's Past Droughts Progression



Why are Ethiopians starving again? What should the world do-and not do?



South Florida Drought During La Nina Years and Water Management



Abtew, W., R. S. Huebner and S. Sunderland. 2002. *Part I: Hydrological Analysis. The 2000-2001 Drought in South Florida*. Publication # EMA-405. South Florida Water

Drought Mitigation

- National Resolve to Feed Population
- Collect Data and Use Data for Decision Making
- Remove Institutional Barriers
- Skill Based Economic Plan and Execution
- Irrigation and food Production as National Strategy
- Water Conservation
- Soil Conservation and Landscape Management
- Water Storage
- Inter-Basin Water Transfer
- Intensive Agricultural Production
- Food Diversification
- Food Storage and Inter-Country Transport
- Prepare for Drought Mitigation When Drought is Predicted

Drought and Reservoir Operation

- Range of water level of operation and river flow characteristics – seasonal variation and amount
- Lake Okeechobee Reservoir – Skilled manpower making decision and still challenging
- Net Inflow versus operation range for large reservoirs
- Refilling issue
- Drought operation, regulate water level and release
- Downstream water demand and power generation during drought (complex operation)

Lake Okeechobee Water Level Management – Rule and Decision Making

(Abtew, W., C. Qiu and V. Ciuca. 2019. Chapter 2: South Florida Hydrology and Water Management. In: 2019 South Florida Environmental Report. South Florida Water Management District, West Palm Beach, FL)

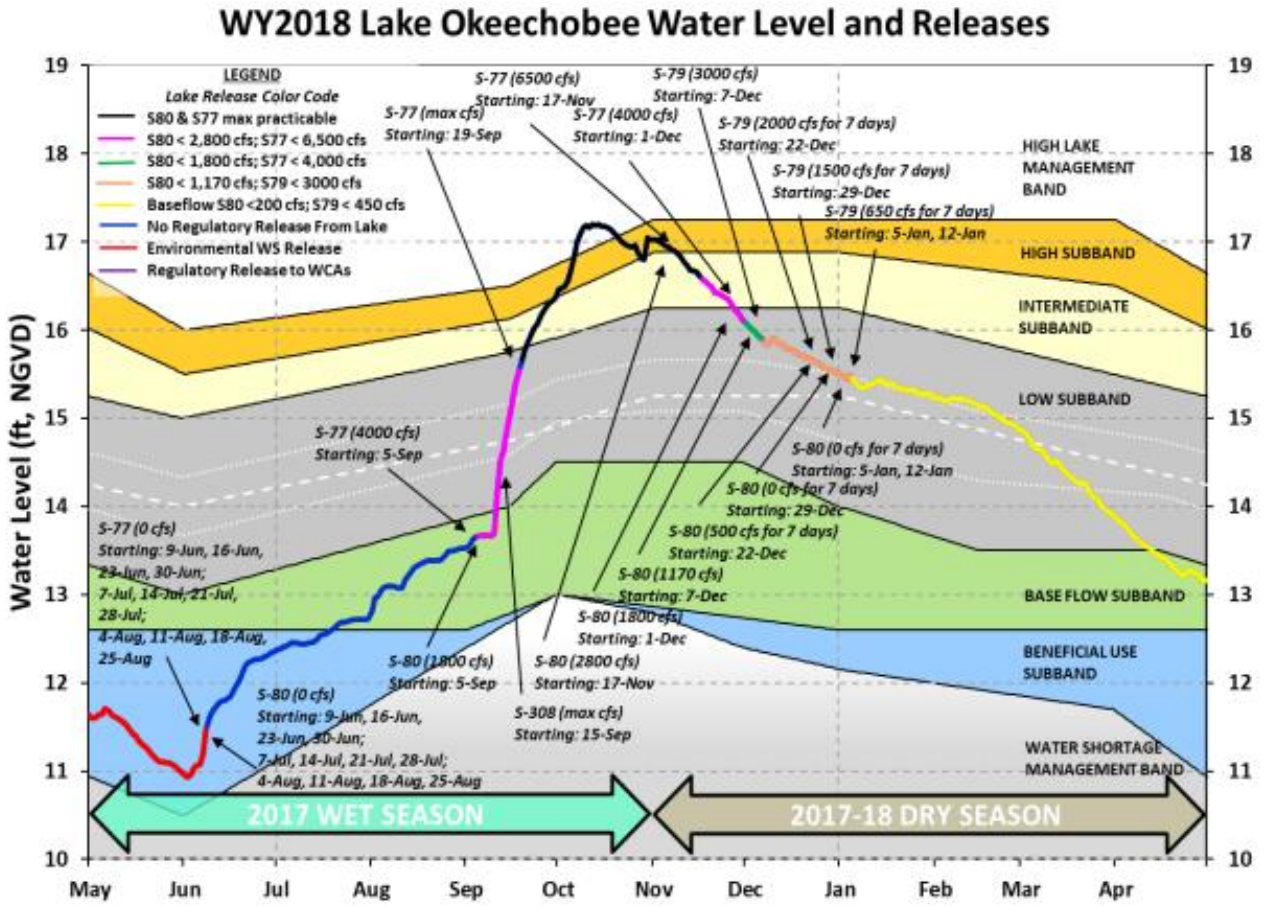
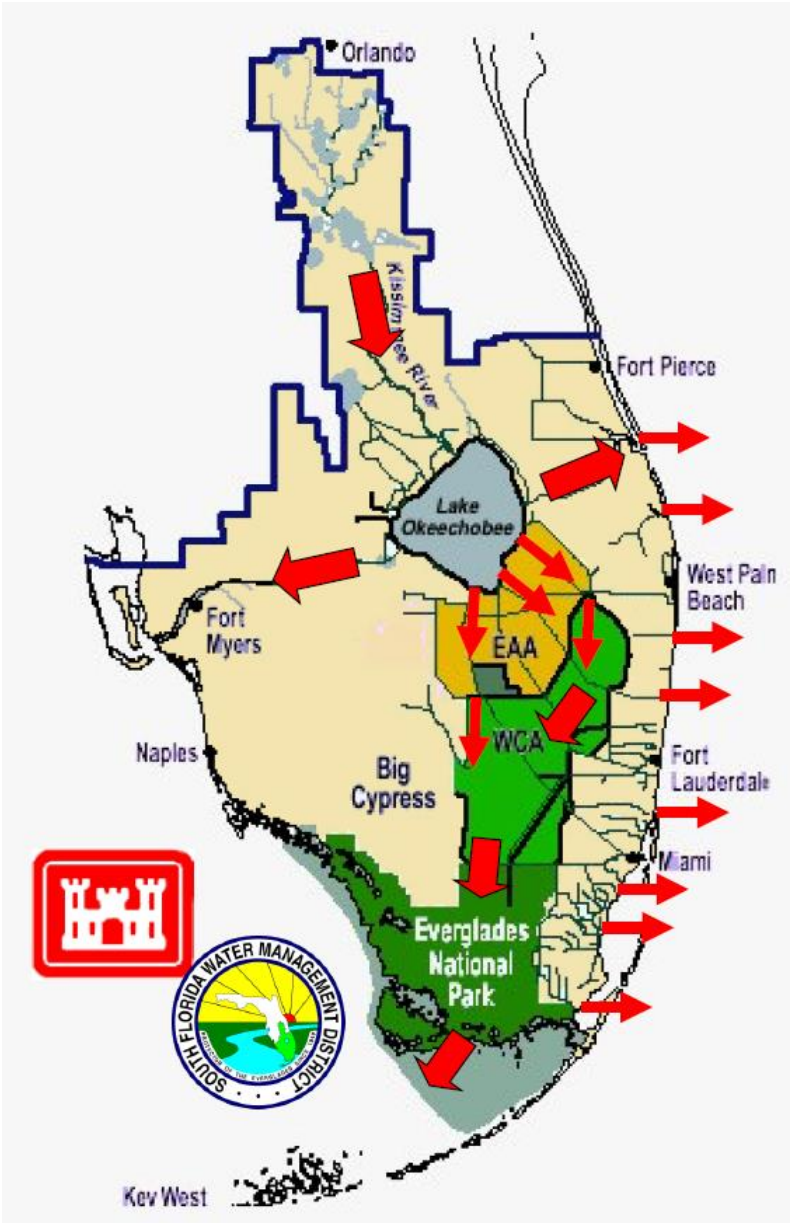


Figure 2-14. Daily Lake Okeechobee water levels, regulation schedule, and water management decisions in WY2018. (Note: Aug – August; cfs – cubic feet per second; Dec – December; Jan – January; Jul – July; Jun – June; max – maximum; ft, NGVD – feet National Geodetic Vertical Datum of 1929; Nov – November; and Sep – September.)



Reservoir Operation Weekly Decision-Making Team

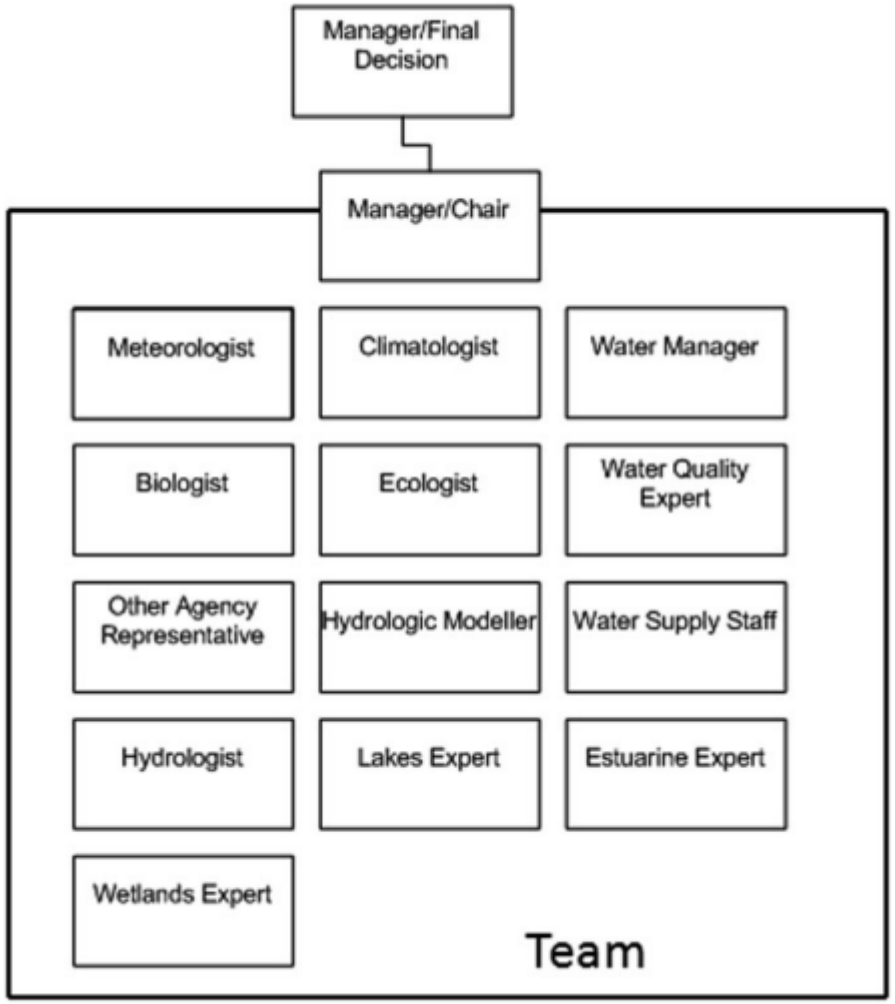
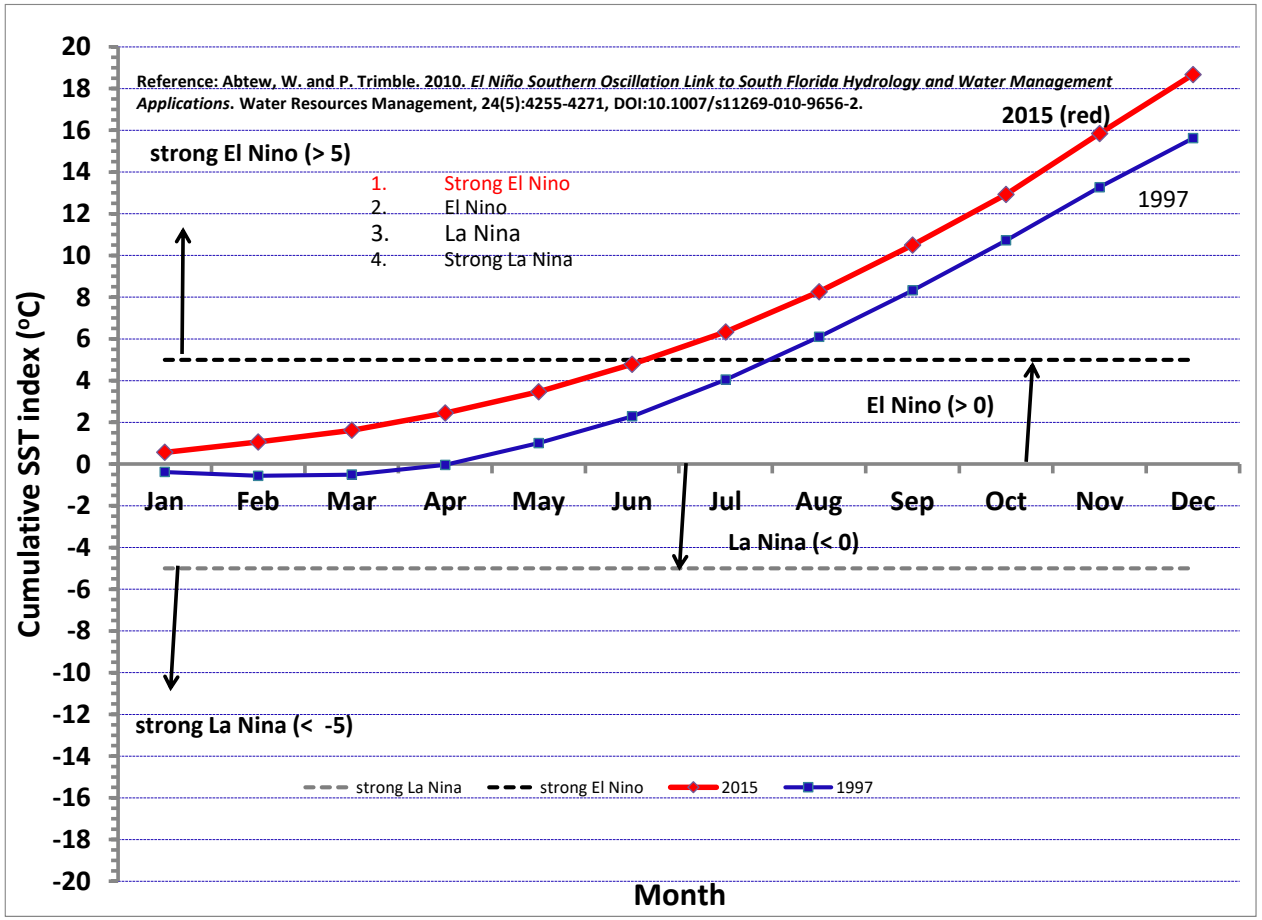


Fig. 33.8 Organizational structure for forecast based water management decision making



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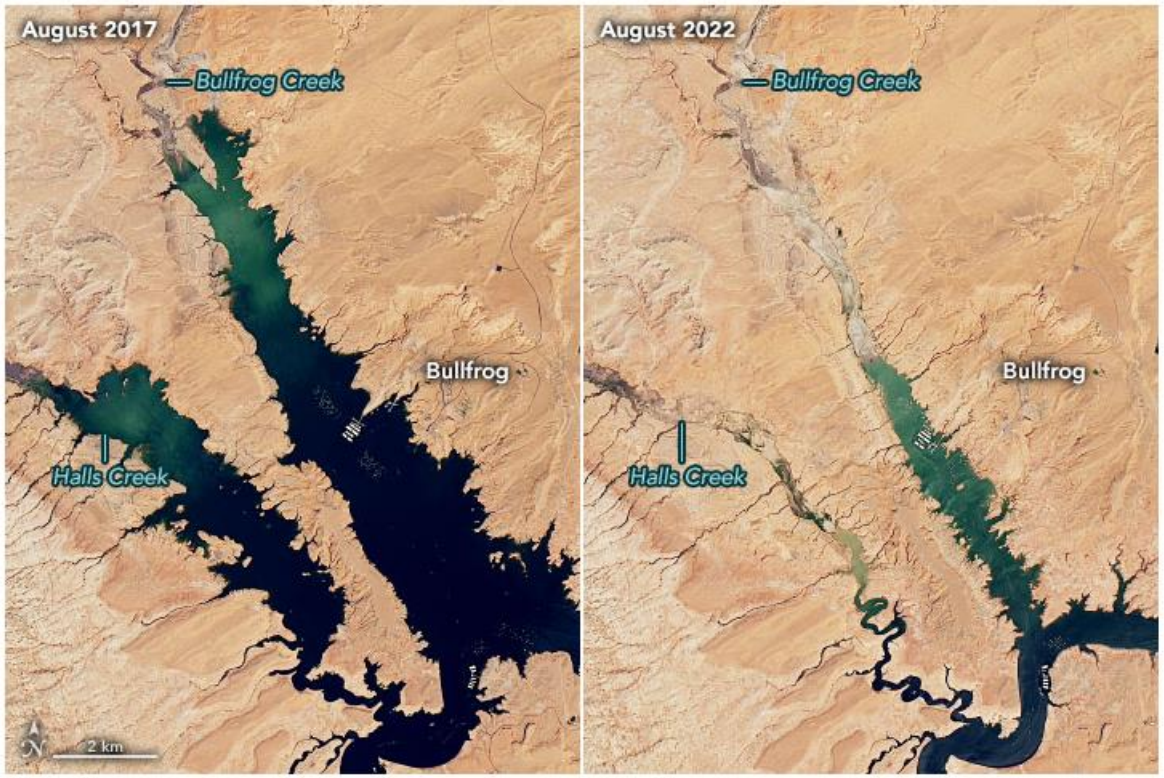
International River Agreements and the Non-stationarity of Streamflow Data

Water Treaty between USA and Mexico: The Colorado and Rio Grande Rivers

- The 1940s, however, were a time of unusual water abundance on the treaty rivers. When American and Mexican engineers drafted the 1944 water treaty, they did not foresee today's prolonged megadrought (Varady, R.G., Gerlak, A.K., Mumme, S.P. The Conversation, July 1, 2021 - https://theconversation.com/megadrought-along-border-strains-us-mexico-water-relations-160338)



August 16, 2017 - August 6, 2022

https://earthobservatory.nasa.gov/images/150249/lake-powell-still-shrinking

How a 100-year-old miscalculation drained the Colorado River

An epic drought in the West is drying up the river. But that's only part of the story.

By Benji Jones@BenjiSJones Sep 23, 2022, 8:00am EDT

As the Colorado River is stretched thin by drought, can the 100-year-old rules that divide it still work? (Arizona Republic, 23 November 2022)

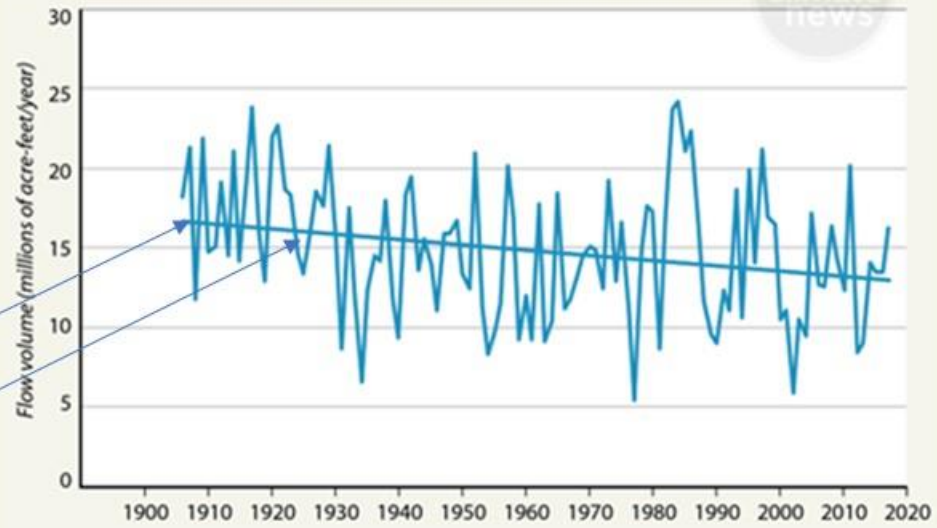
Colorado River Flows and Climate Change

Less Water, Rising Temperatures

The Colorado River's flow has diminished in the century since the states that rely on it agreed to a water-sharing compact. The average temperature in the region has risen and is projected to continue to rise.

COLORADO RIVER FLOW

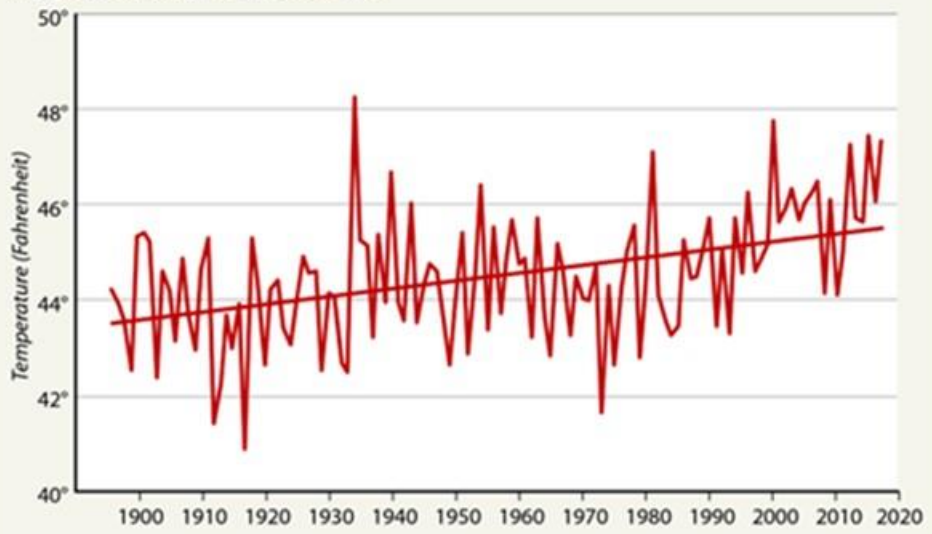
In millions of acre-feet, 1906-2017



1905-1922 flow used for water sharing agreement

UPPER COLORADO RIVER BASIN AVERAGE TEMPERATURE

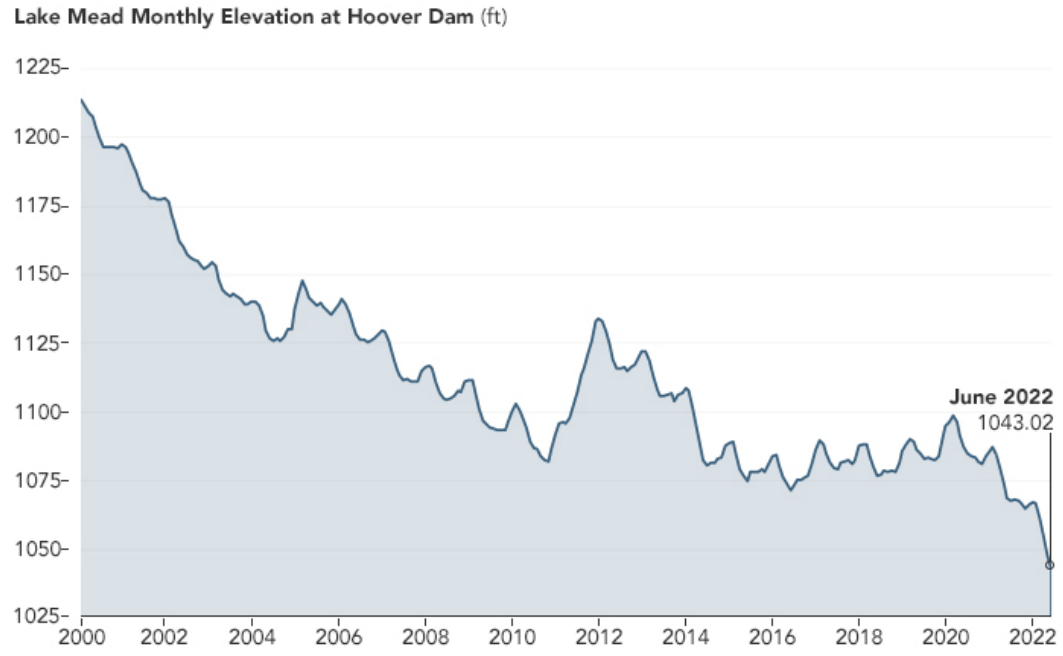
In degrees Fahrenheit, Oct. 1895-Sept. 2017



SOURCE: National Climate Assessment

PAUL HORN / InsideClimate News

Inside Climate News
1/31/2019



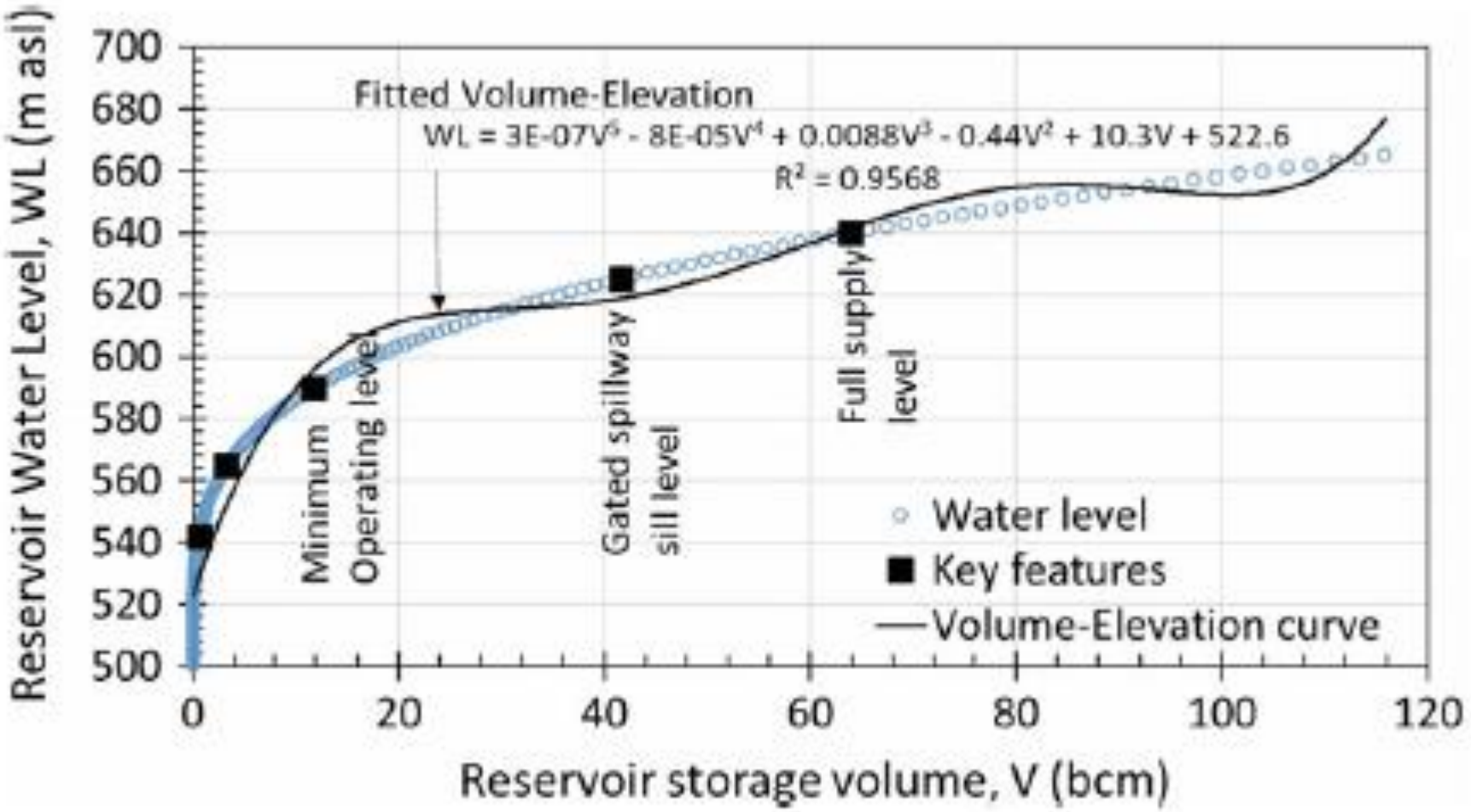
December 1, 2000 - 2022

Source: USBR/NASA

GERD Volume and Water Level

GERD surface area and mean flow

Recovery from consecutive drought



Abtew, W, Dessu S. 2018. *The Grand Ethiopian Renaissance Dam on the Blue Nile River*: Springer (https://www.springer.com/la/book/9783319970936)

GERD Operation Simulation – Water Level for a Given Release

- DC draft agreement

- No Credit for Excess Flow
- Penalty for Low Flow
- Sensitive to Minor Increase in Release

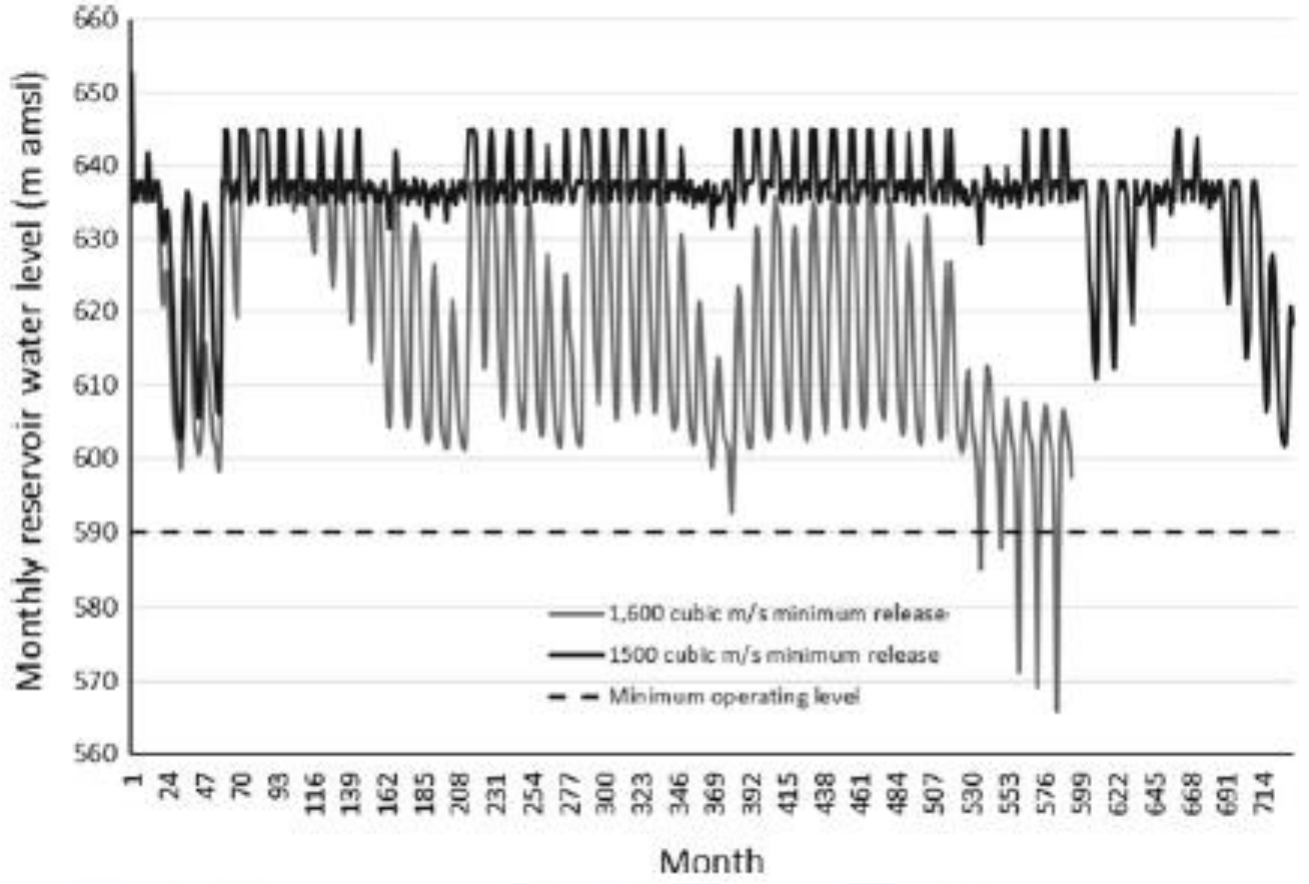


Fig. 8.9 Simulated reservoir water level for 1500 and 1600 $m^3 s^{-1}$ minimum releases after reservoir filling

Abtew, W, Dessu S. 2018. *The Grand Ethiopian Renaissance Dam on the Blue Nile River*: Springer (https://www.springer.com/la/book/9783319970936)

GERD Operation Simulation – Storage Volume for a Given Release

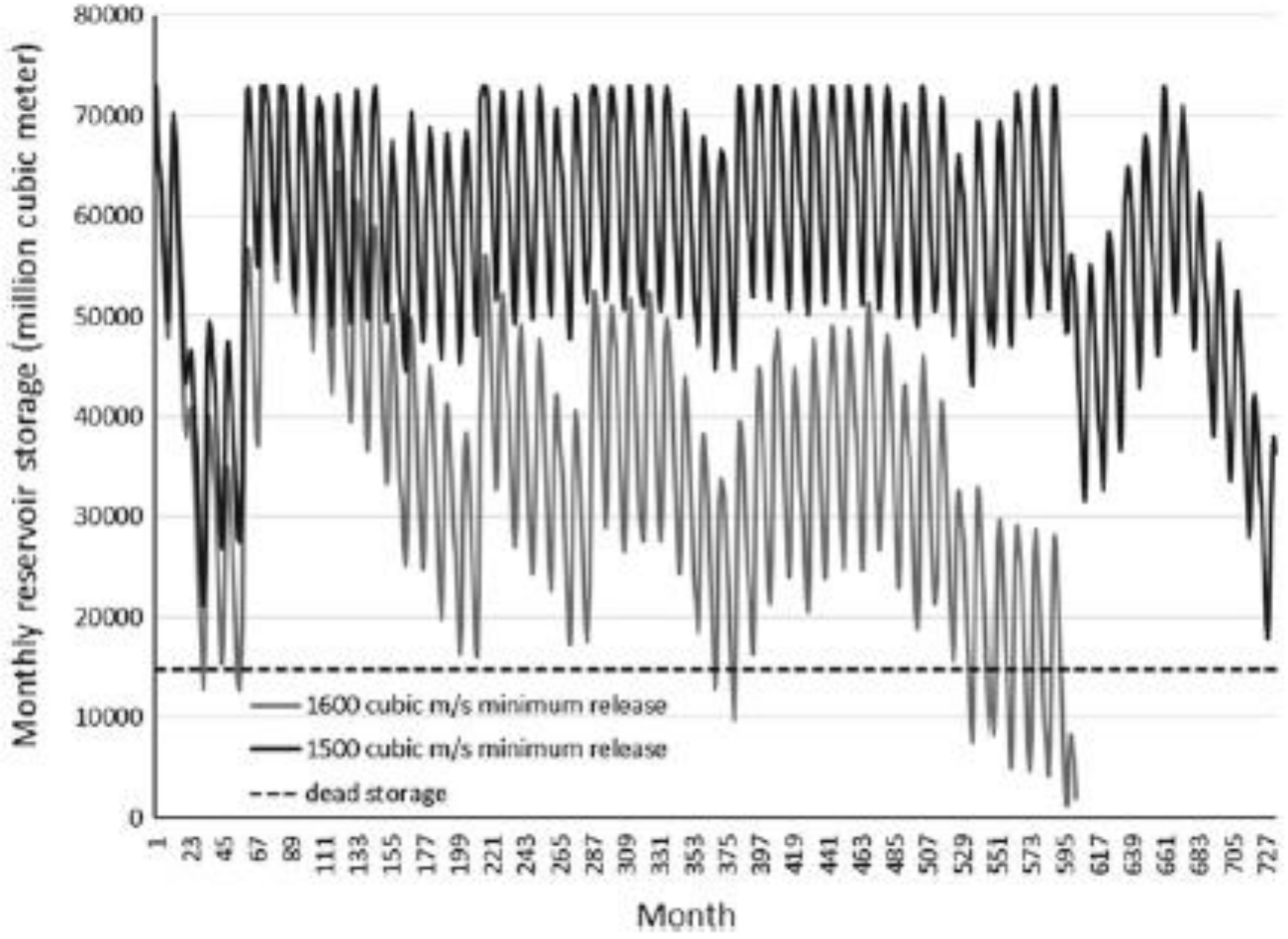


Fig. 8.10 Simulated reservoir storage for 1500 and 1600 $m^3 s^{-1}$ minimum releases after reservoir filling

Abtew, W, Dessu S. 2018. *The Grand Ethiopian Renaissance Dam on the Blue Nile River*: Springer (https://www.springer.com/la/book/9783319970936)

Thank You