

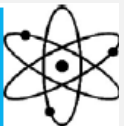
Salar de Atacama Hydrology and Water Resources

Brendan Moran, Ph.D.

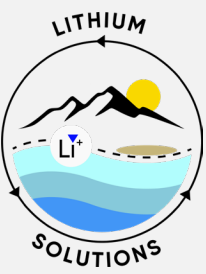
Hydrogeologist

University of Massachusetts Amherst

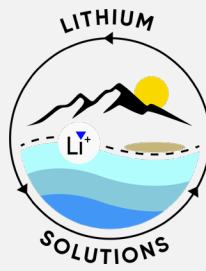
August 19, 2022



Motivations of this Work



- The amazing complexity & uniqueness of this place and its hydrology - coupled with preciousness of water
- Requires a rigorous, comprehensive assessment of the whole system from all angles
- Goal is to describe the natural system in detail and observed changes – to discern human caused impacts
- Openly communicate this knowledge for the benefit of all



Earth's Future

RESEARCH ARTICLE

10.1029/2021EF002555

Key Points:

- Freshwater inflows and the modern water budget at Salar de Atacama are dominated by relic groundwater
- A drought coincident with increases in groundwater extraction complicates the attribution of specific anthropogenic environmental impacts
- Freshwater use and allocated water rights at Salar de Atacama appear to not meet sustainable metrics

Relic Groundwater and Prolonged Drought Confound Interpretations of Water Sustainability and Lithium Extraction in Arid Lands

Brendan J. Moran¹ , David F. Boutt¹ , Sarah V. McKnight¹ , Jordan Jenckes² ,
Lee Ann Munk² , Daniel Corkran¹ , and Alexander Kirshen¹ 

¹Department of Geosciences, University of Massachusetts Amherst, Amherst, MA, USA, ²Department of Geological Sciences, University of Alaska Anchorage, Anchorage, AK, USA

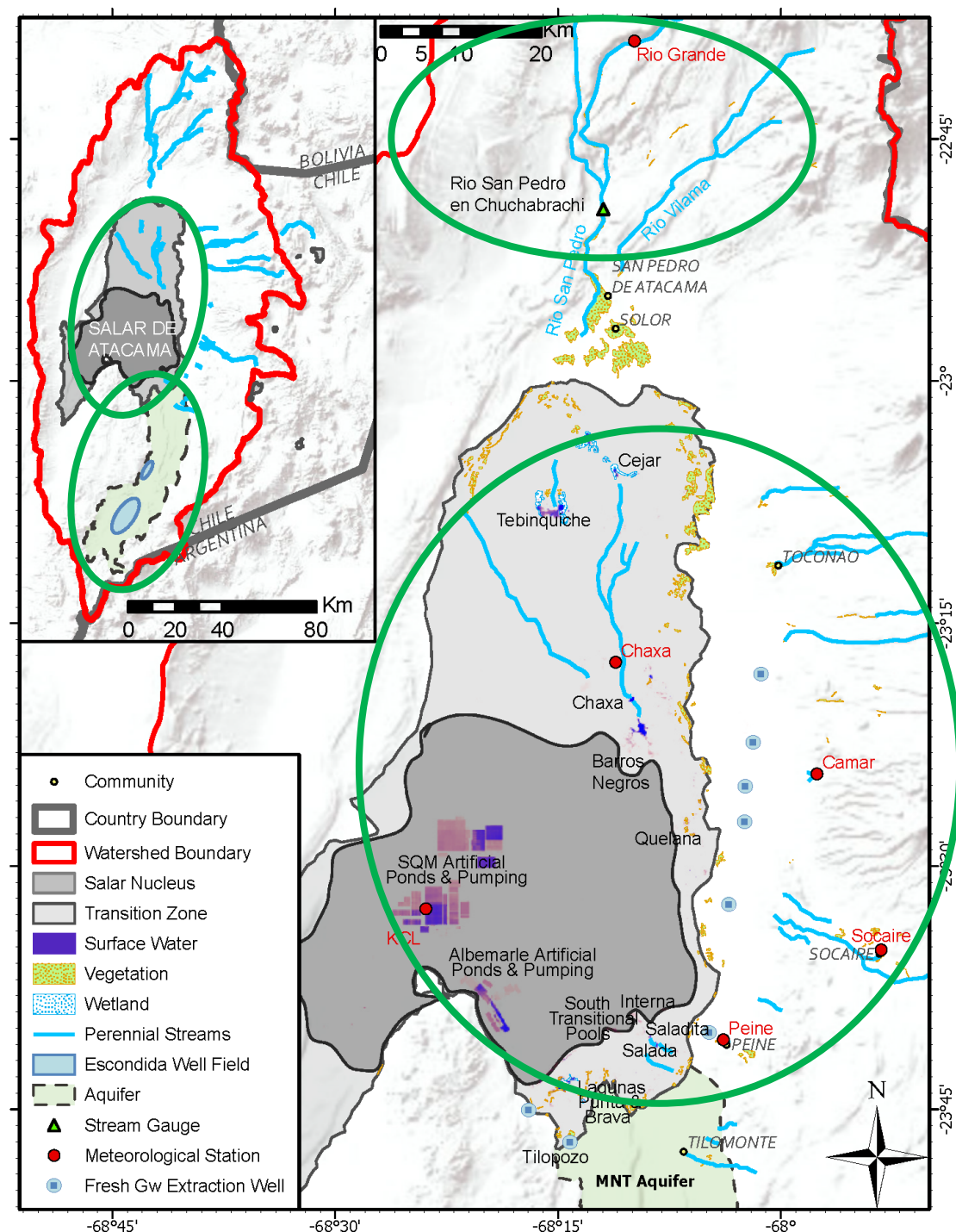
Abstract Demand for lithium for batteries is growing rapidly with the global push to decarbonize energy

<https://onlinelibrary.wiley.com/doi/10.1029/2021EF002555>

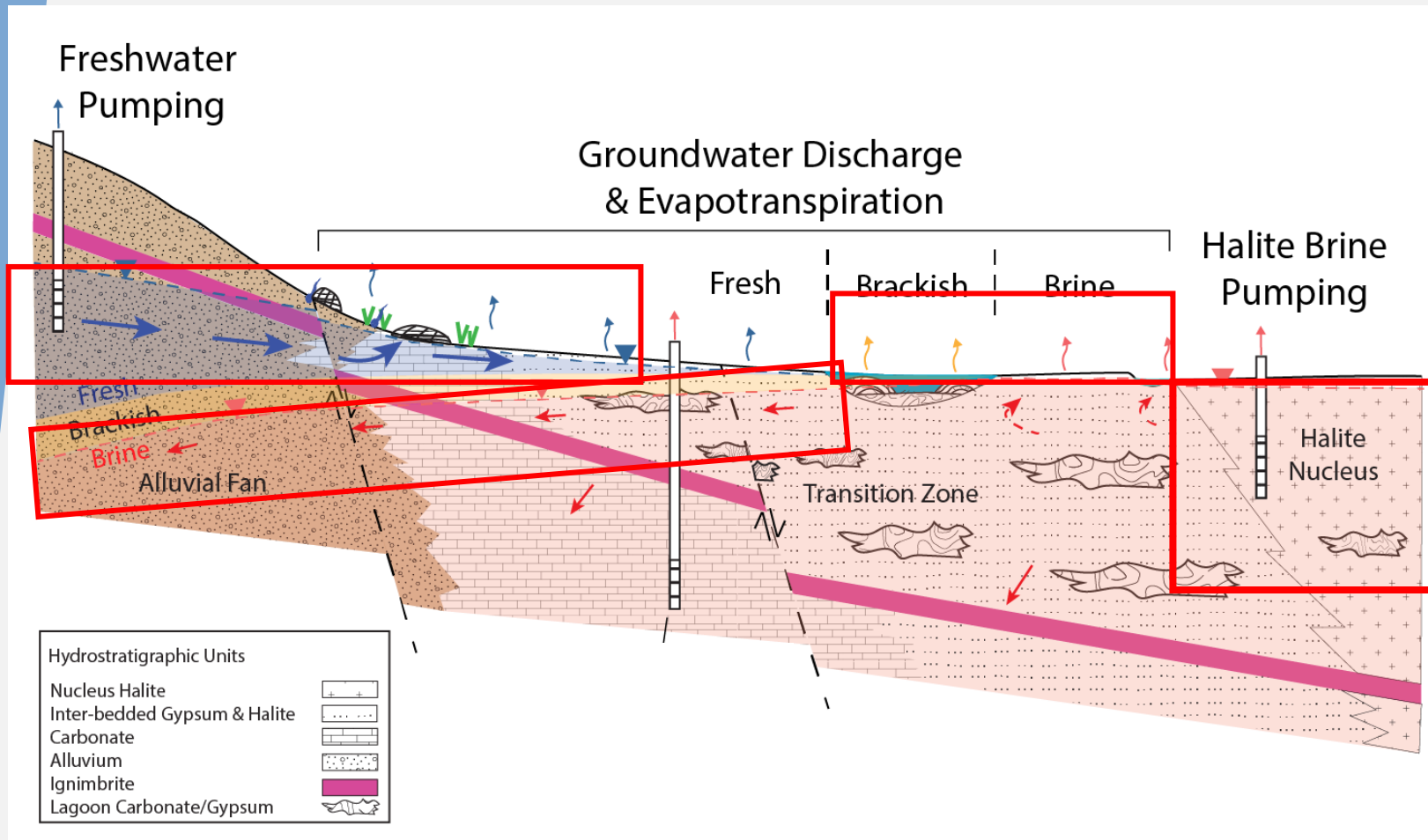
Open, free access – all raw data available for download

Salar de Atacama Basin

- The **whole** basin needs to be assessed as one system, not separately
- Monitoring data and field observations were indispensable

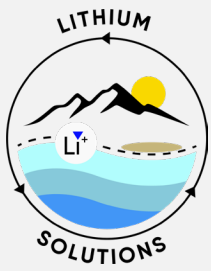


Conceptual Framework

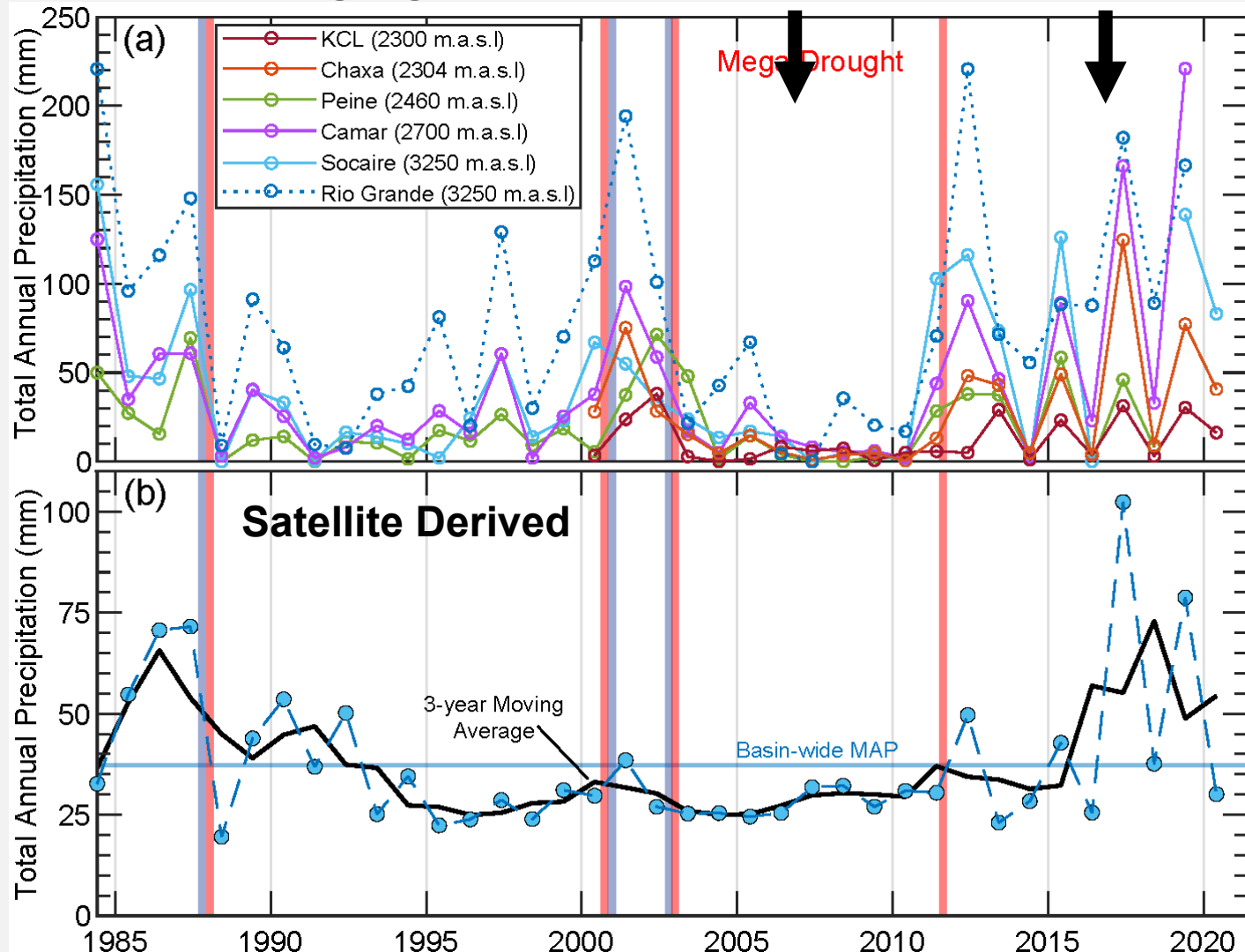


- Complex but key to ecosystems and water impacts
- How we understand the system-interactions
- Where and how much water (fresh, brackish, brine) extracted is important
- Modeling shows impacts from extraction \gg for freshwater than brine

Modern Water Cycle



Rain gauge data

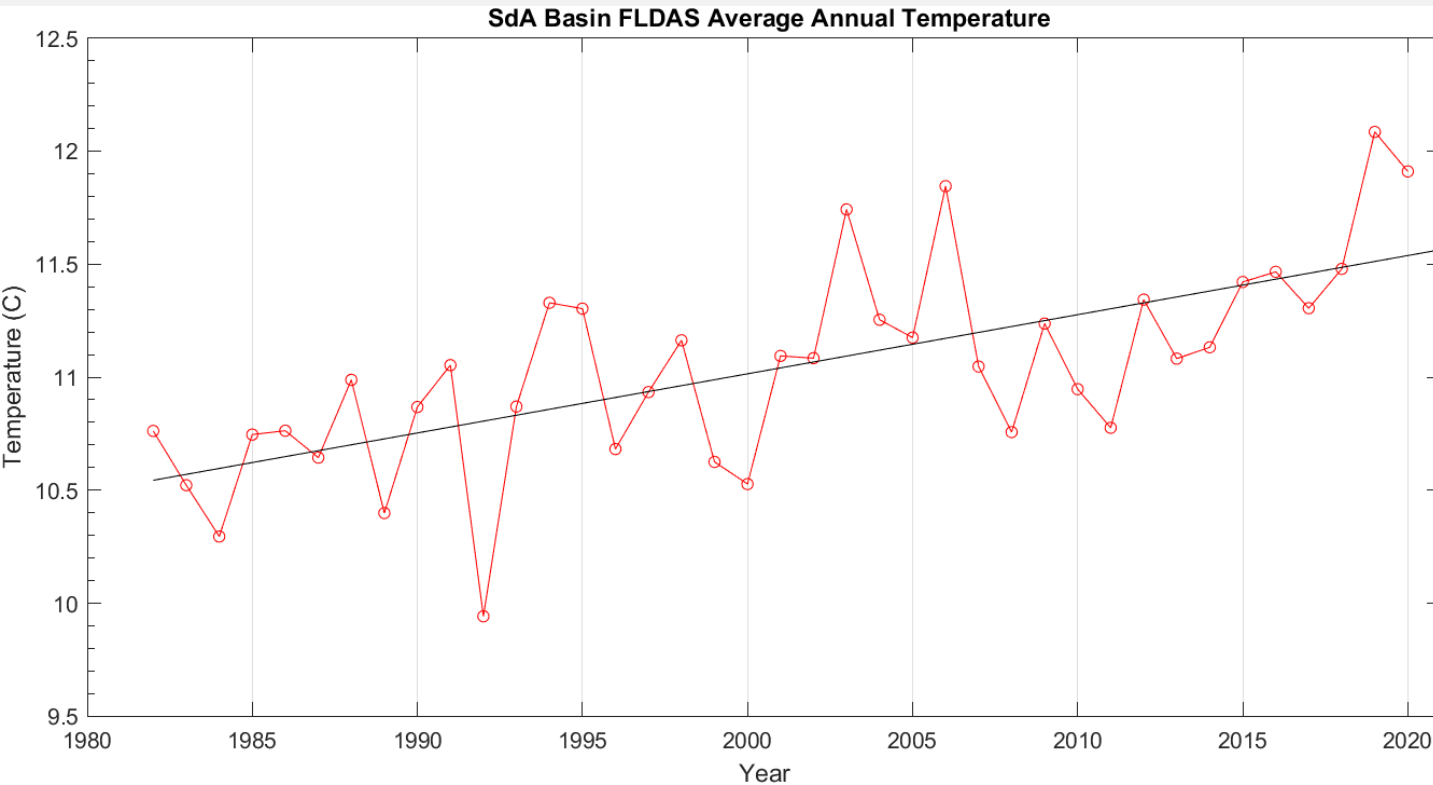


- Defined major climate regimes since 1950s
- Major multi-year precipitation deficits
- Region-wide major drought
- Anomalous recent period
- Very dry → very wet
- Likely global Climate Change signals

Modern Water Cycle



Basin-wide Temperature

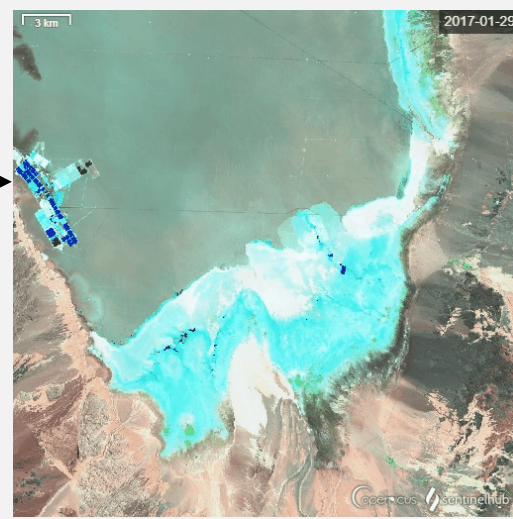
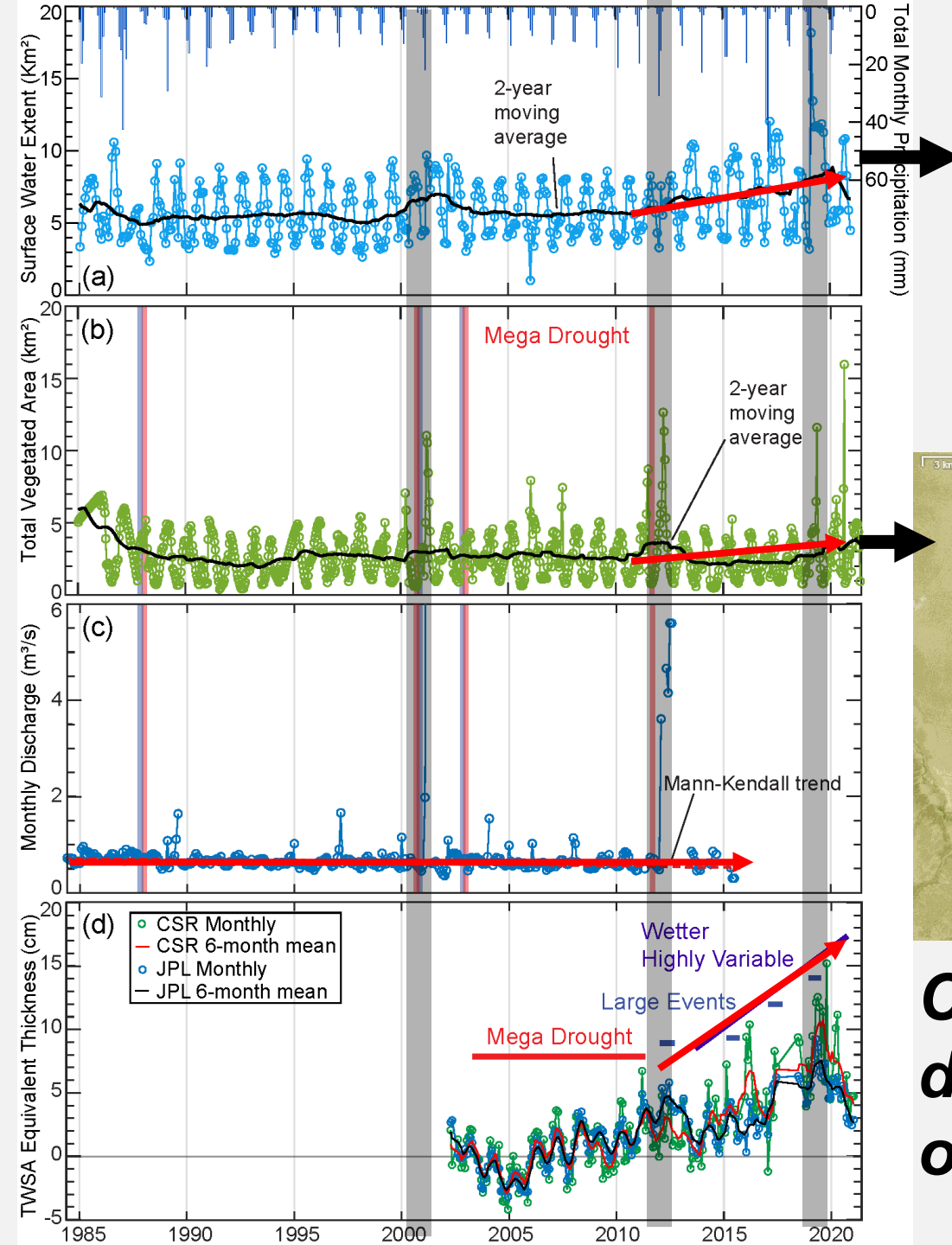


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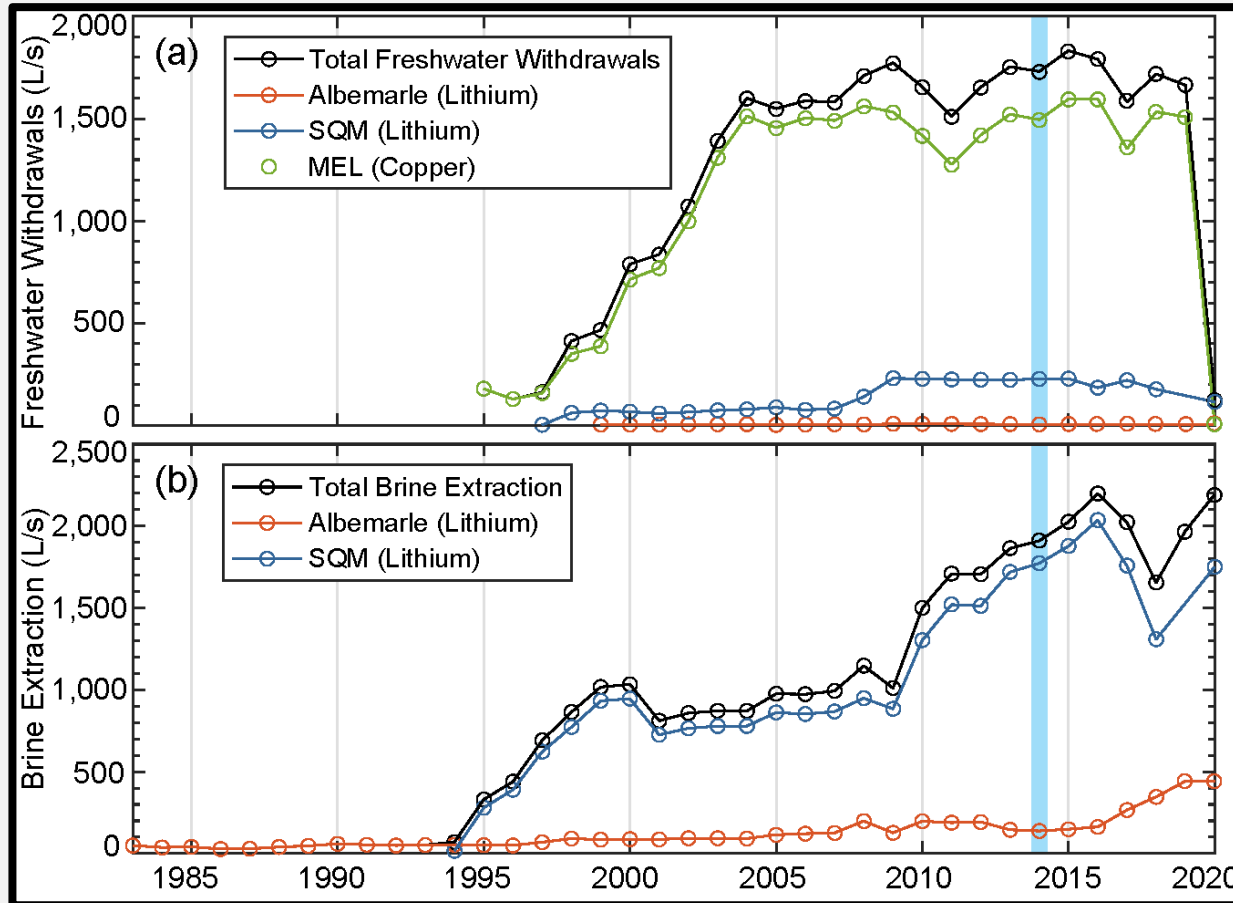
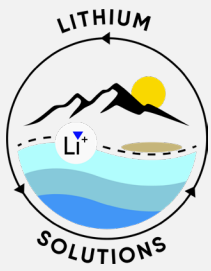
Climate-Hydrology

- Basin-wide assessment
- Strong responses to climate variations
- Overall wetland extents have increased since the drought
- River flow decline (~33% since 1984)
- Water extraction has continued



Climate is dominant driver of change

Climate- Hydrology

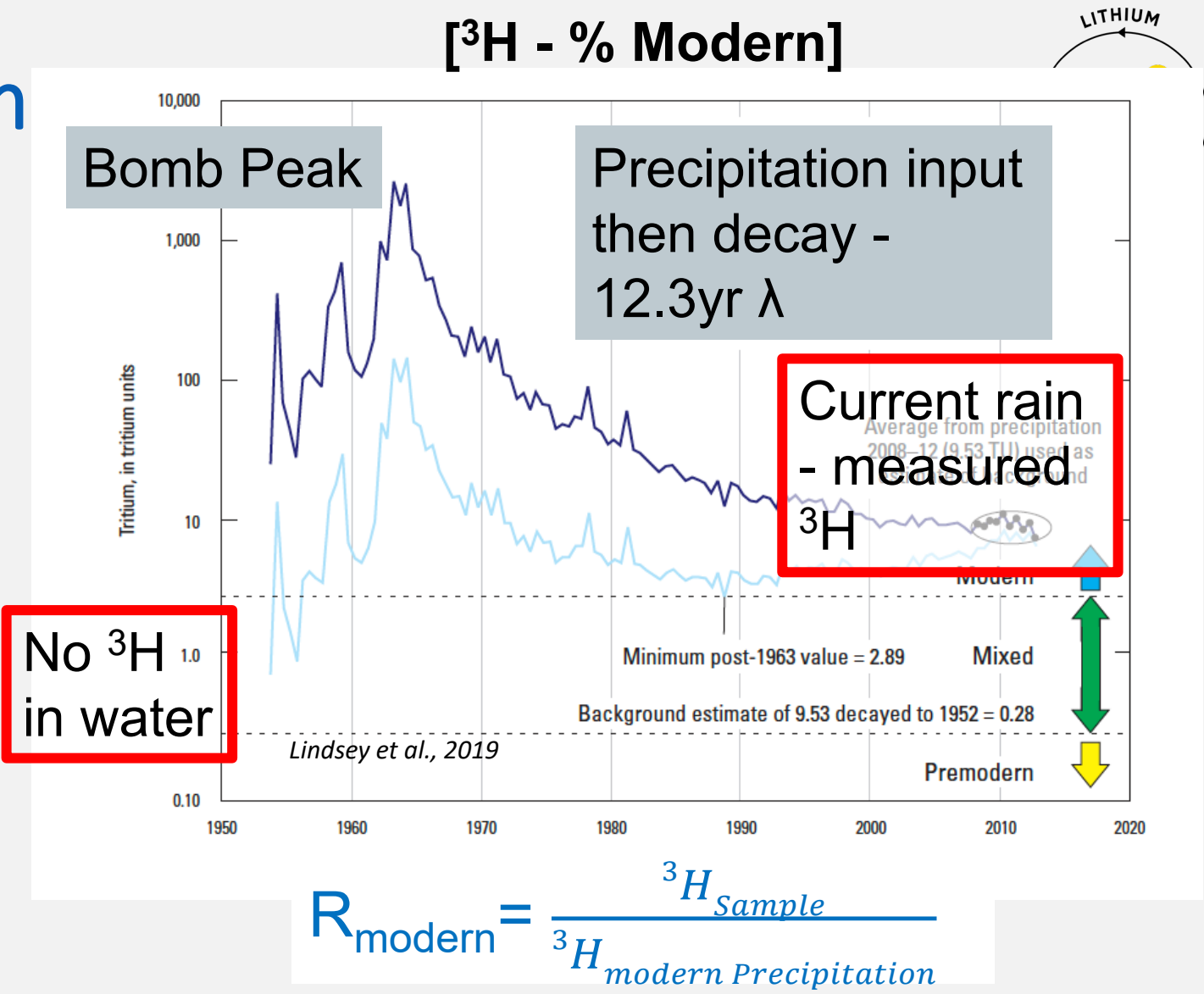


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Water Age Dating - Tritium

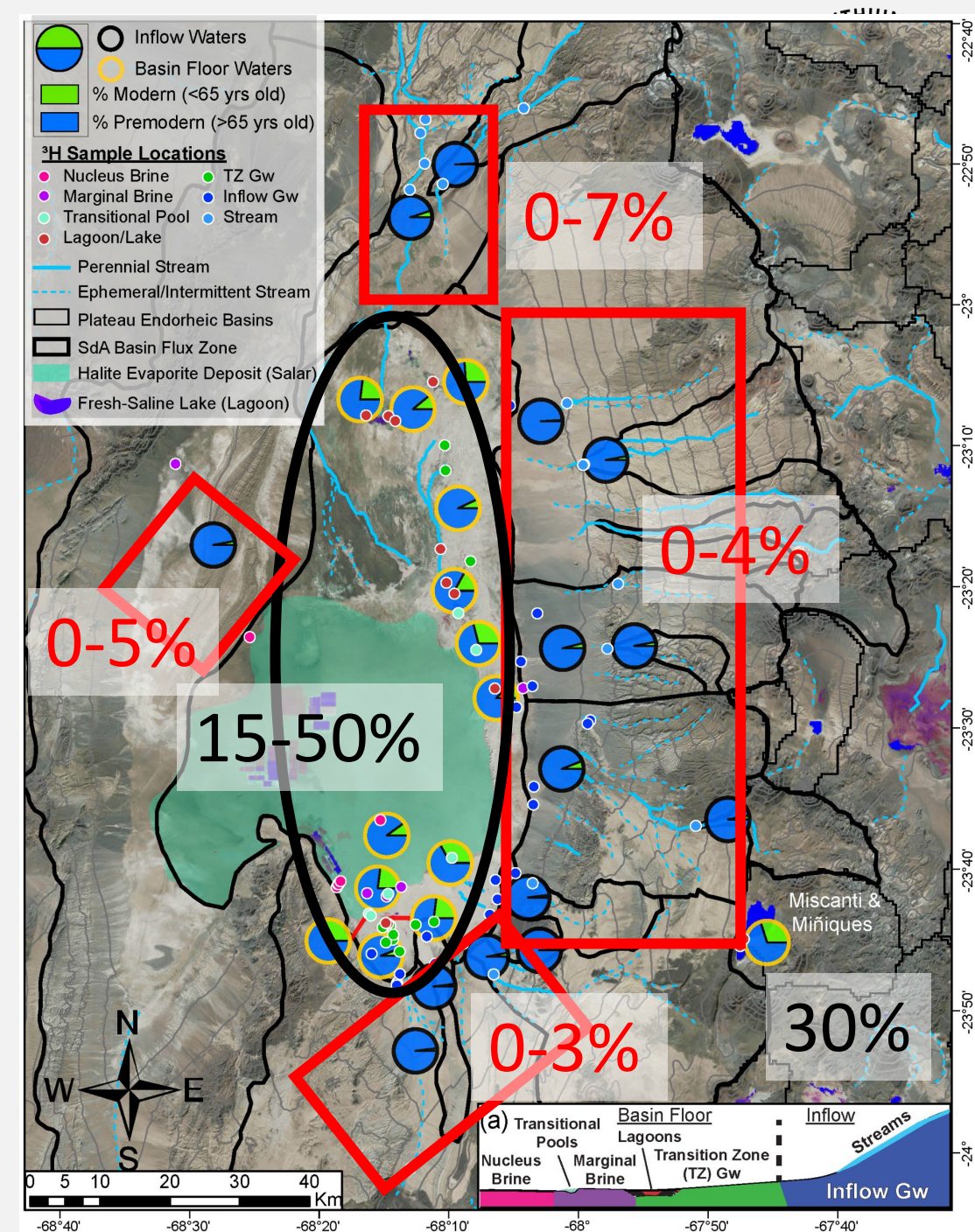
- Water age tracing with ^3H
- Water source signature is **conserved**
- Water with very small ^3H amounts must be **old**



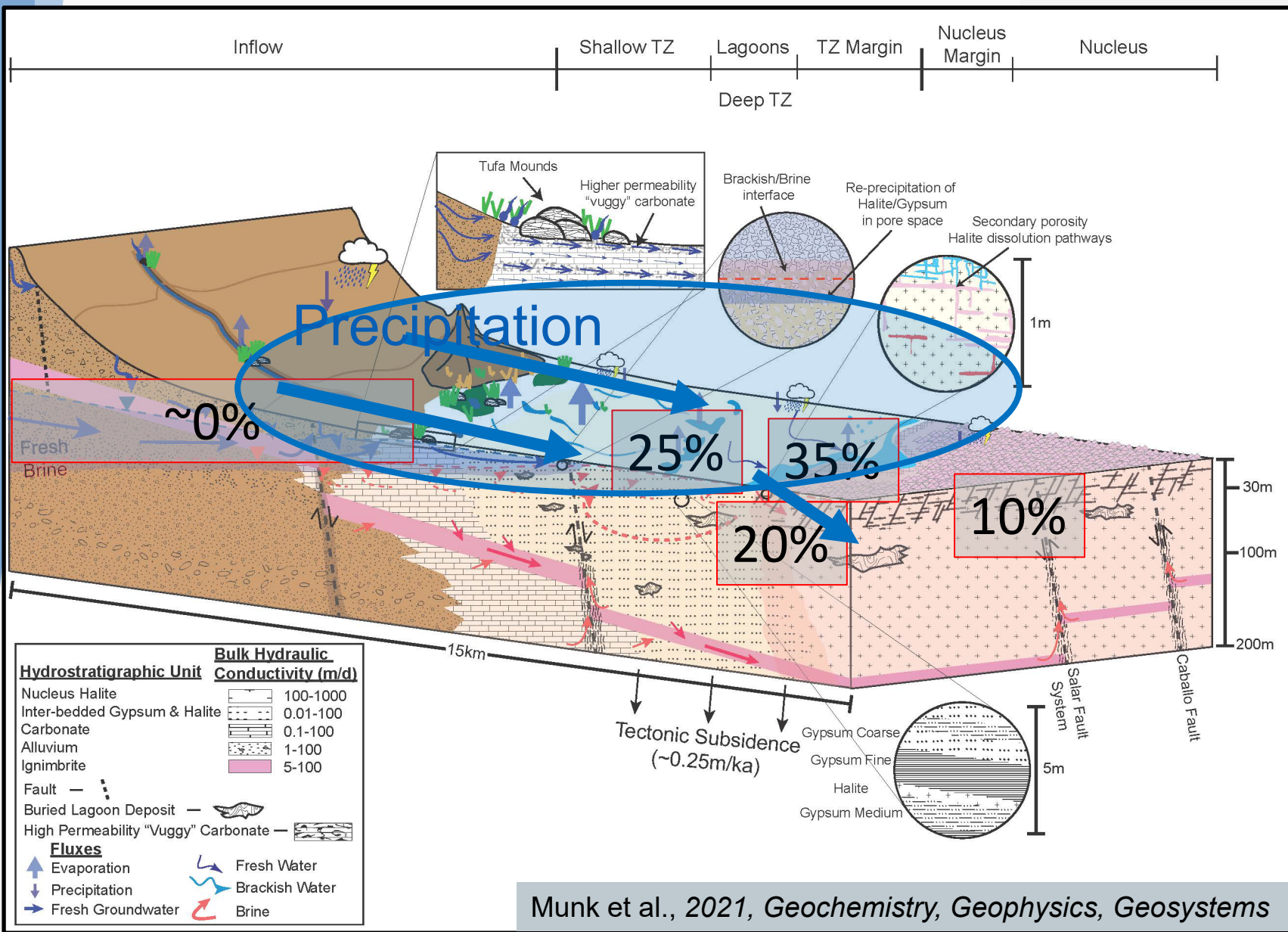
Differentiate water that is **Pre-modern** (>65 yrs) from that with substantial **Modern** component

Water Age Assessment

- 112 samples - ^3H analysis of springs, streams, lagunas and groundwater (communities = instrumental)
- Very consistent signatures.
- **Nearly all inflow** to the basin is $\gg 65$ years old
- Logic and modelling suggests that it is likely much older



Relic Water – Recent Water



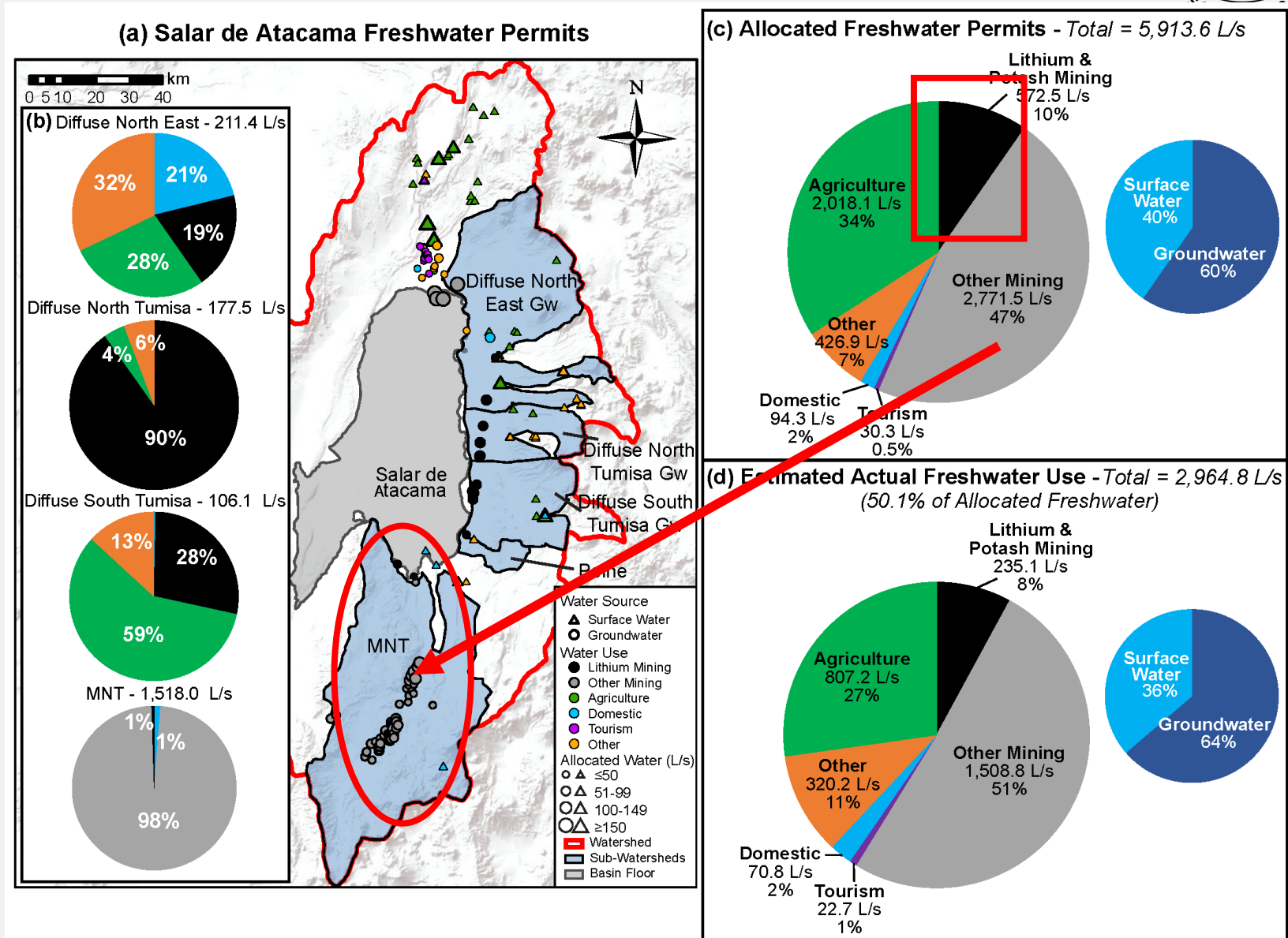
Munk et al., 2021, *Geochemistry, Geophysics, Geosystems*

- How water moves through TZ
- Old water abounds but short-term climate has major impact but affecting recent water component – very focused

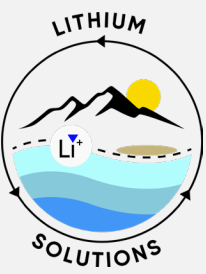


Freshwater Allocations-Use

- Water was **allocated** under flawed hydrological assumptions
- **Not in balance** - water evaporating is not recent precipitation
- **Copper mines** extracted most freshwater since 1980s

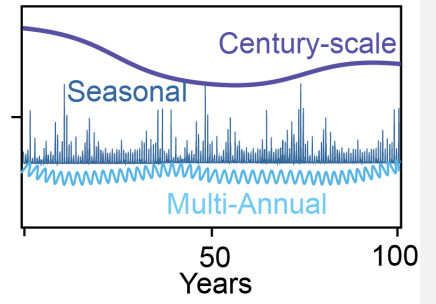
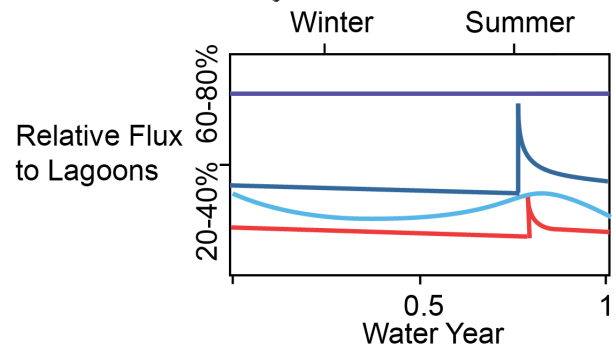
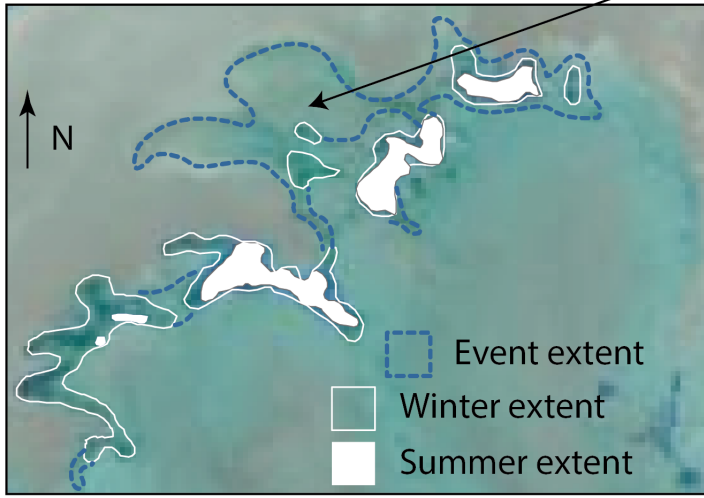
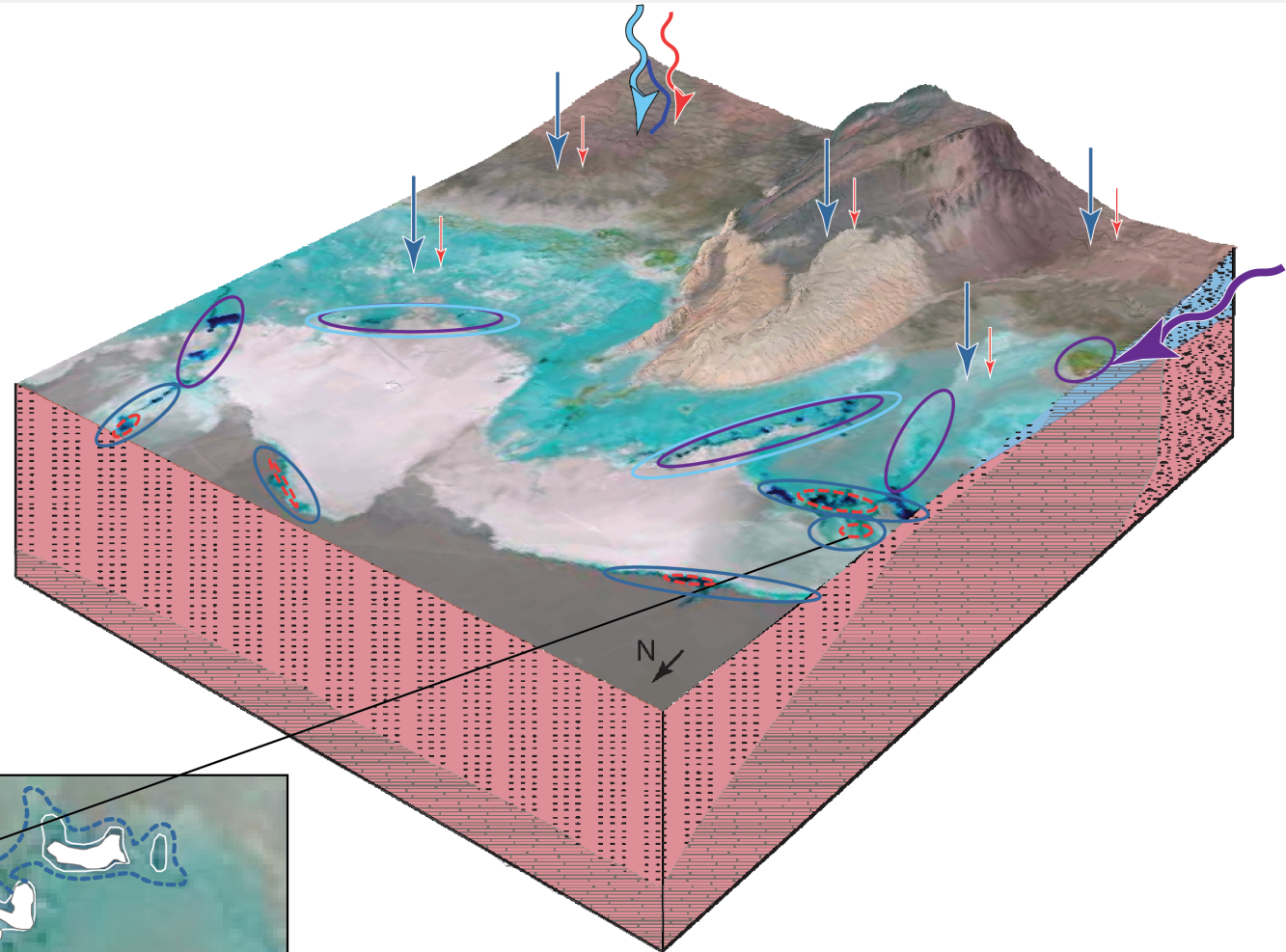
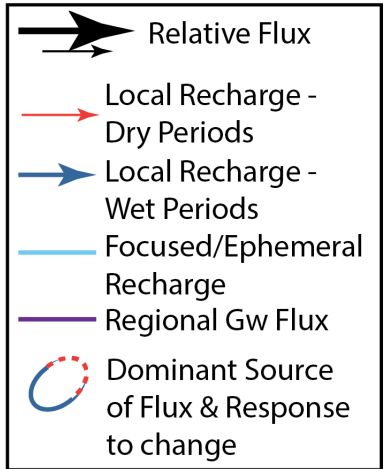
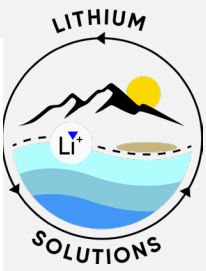


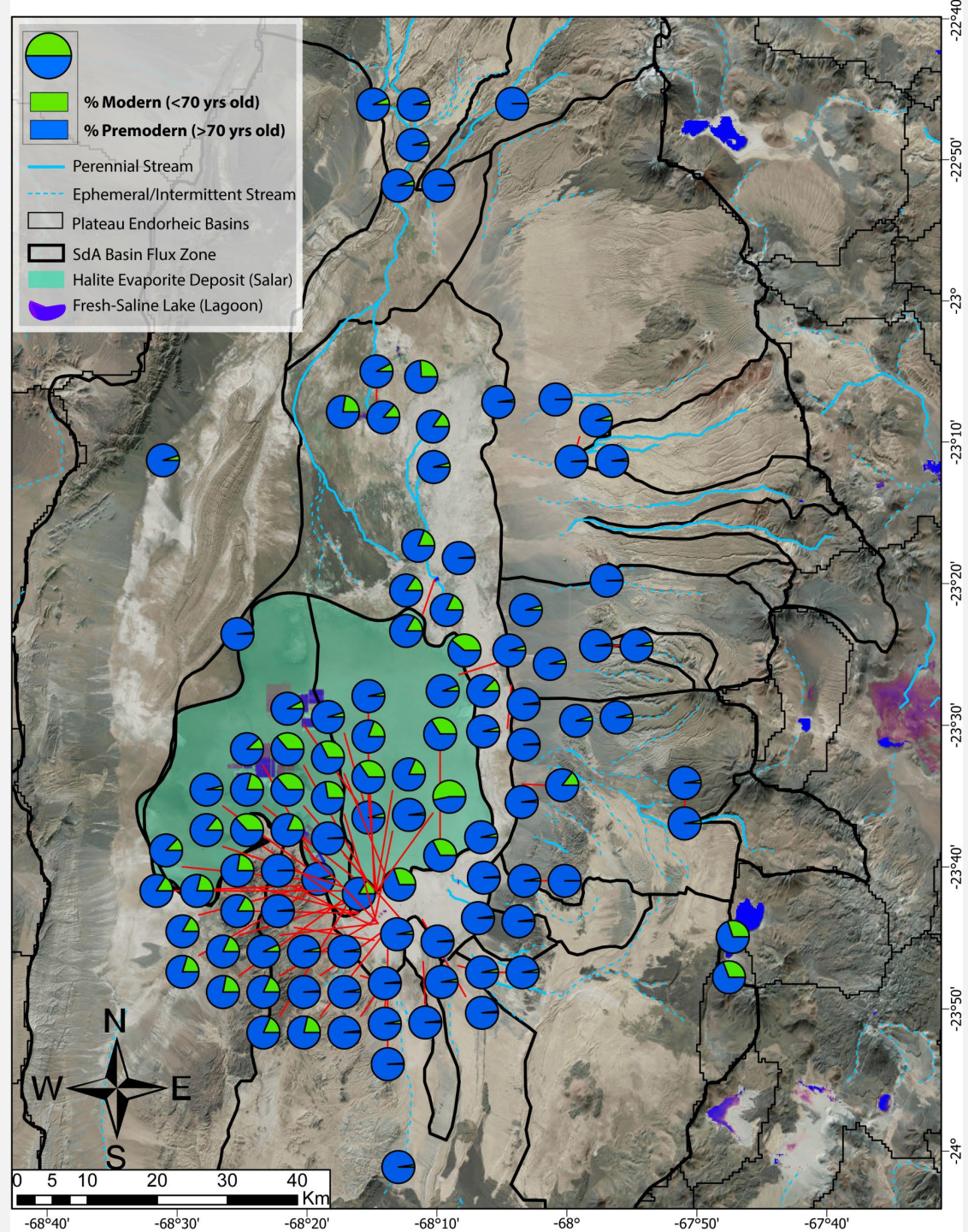
Applying Knowledge to Solve Problems

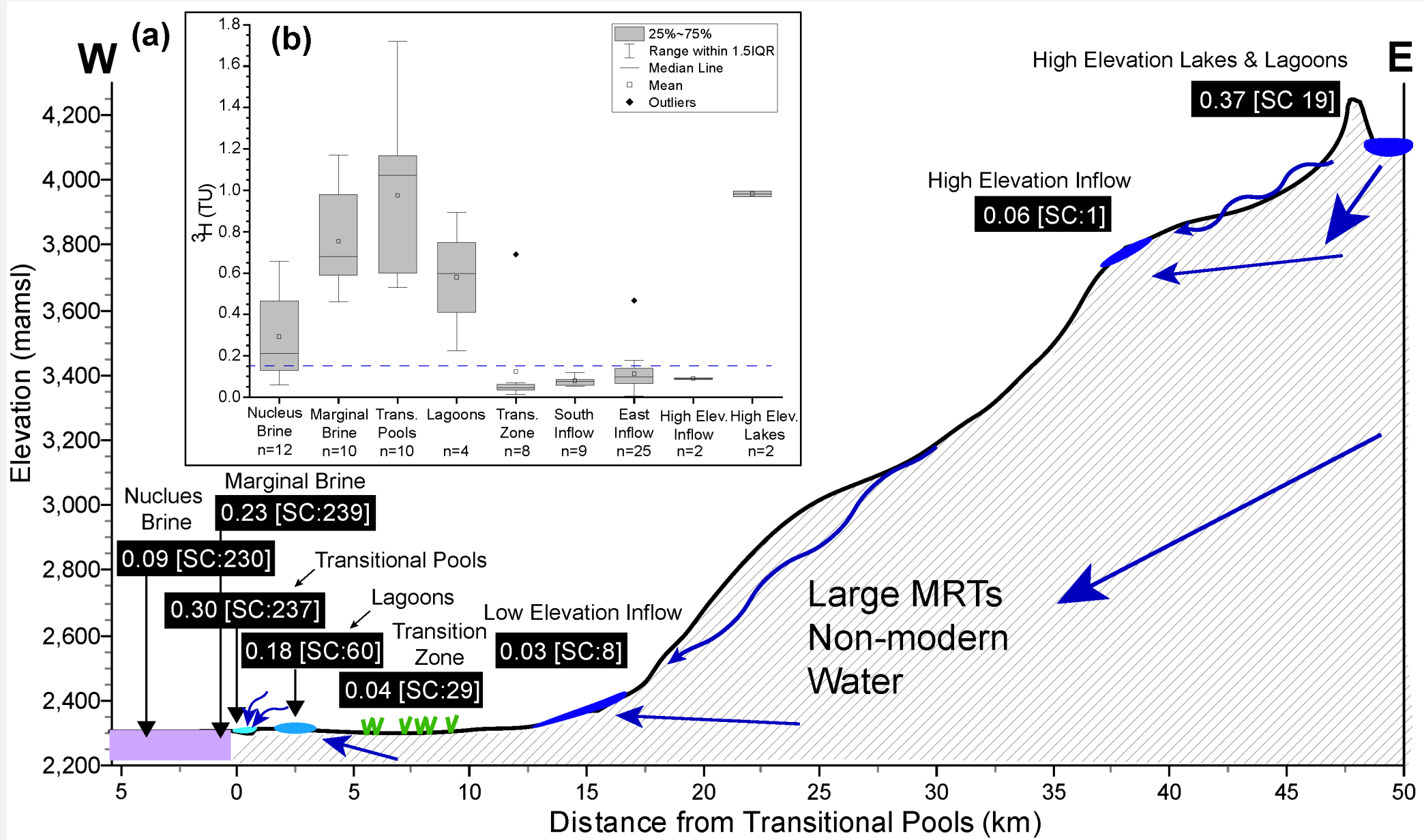


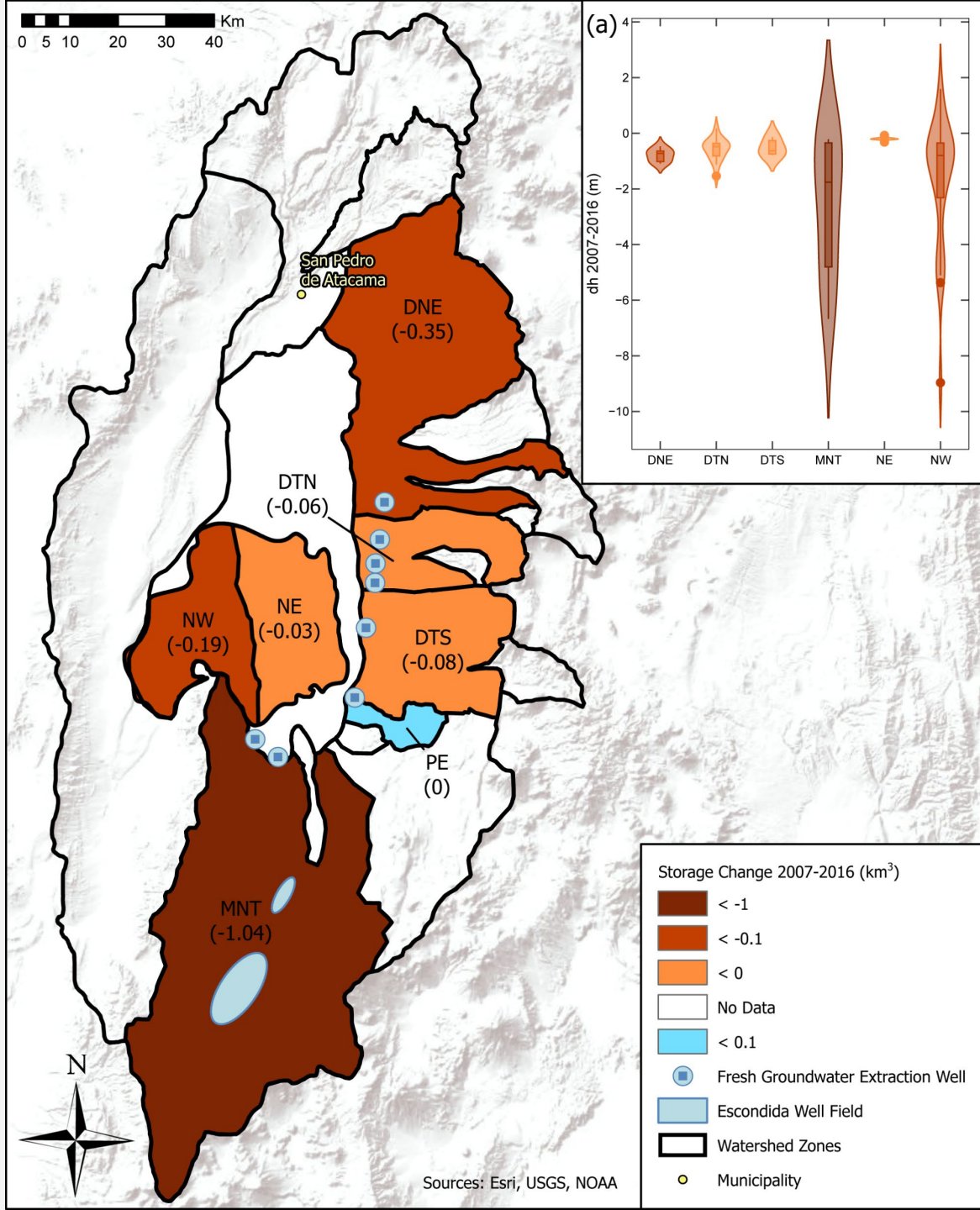
- Water management based on best science available – continue to improve knowledge
- Reduced freshwater use intensity/investments in infrastructure & agriculture
- Ongoing monitoring & assessment of natural system - critical to assessing future changes and adapting to them
- Improve trust, information collection & knowledge sharing fairly between all parties

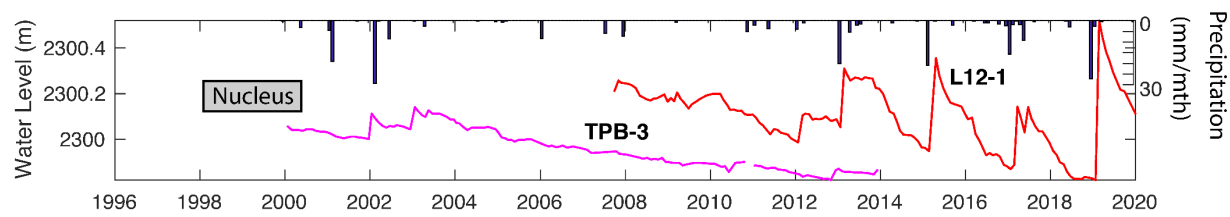
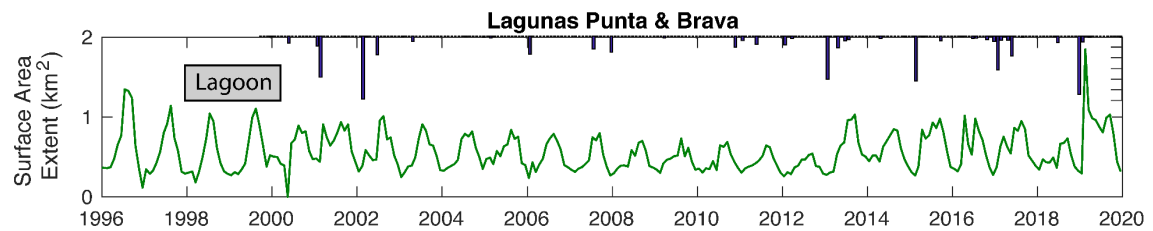
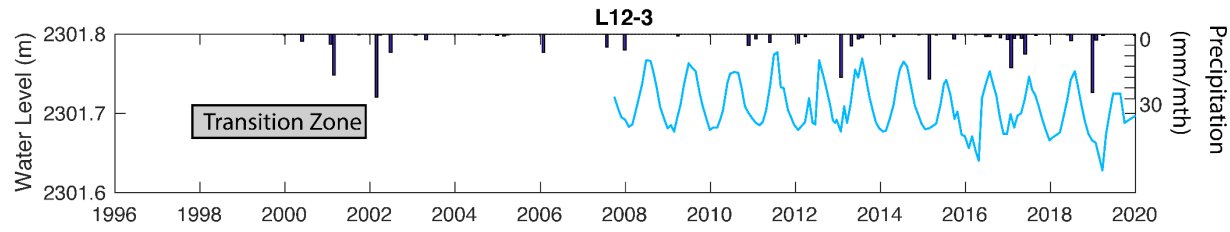
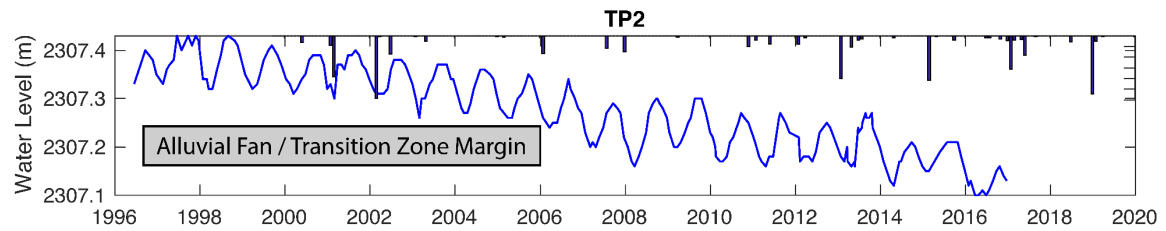
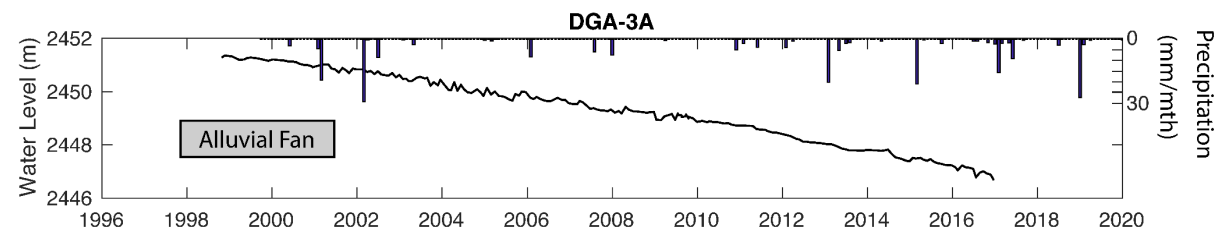
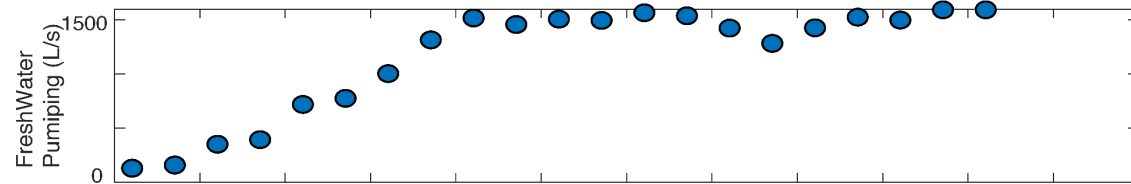
Extra Slides













Landsat 5 & 7 Derived NDVI [0.2-0.9 range] - Southern SdA Transition Zone

