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Using Isotope Hydrology Tools to Support Conjunctive Water Management

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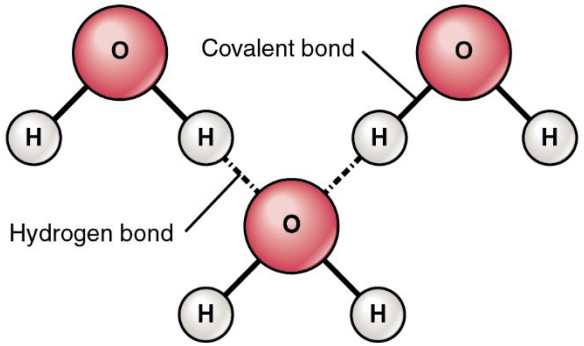
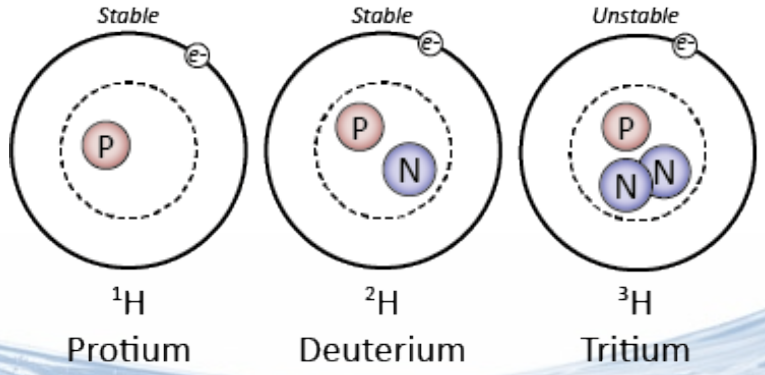
The Water Molecule

- Water is a polar inorganic compound that is at room temperature a tasteless and odorless liquid, nearly colorless with a hint of blue.
- Density: 997 kg/m³
- Boiling point: 212°F (100°C)
- Molar mass: 18.01528 g/mol.
- Melting point: 32°F (0°C)

- What happens when we consider water in terms of an isotopic molecule?

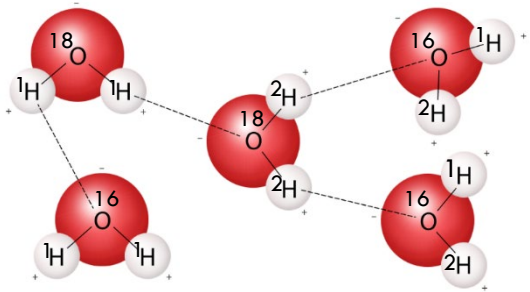




Tools We Can Use: Isotope Hydrology

Stable Isotopes

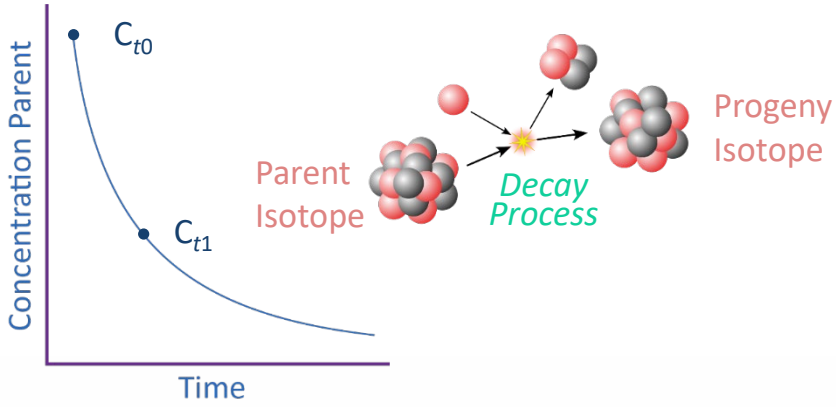
- Abundance constant, but distribution changes
- Used to quantify interactions between different reservoirs



$\delta^{18}O$ **How we report the water fingerprint:**
A measure of the relative proportion of the heavy to the light isotopes in each water sample

Radioactive Isotopes

- Concentration affected by radioactive decay
- Used to examine the duration of processes

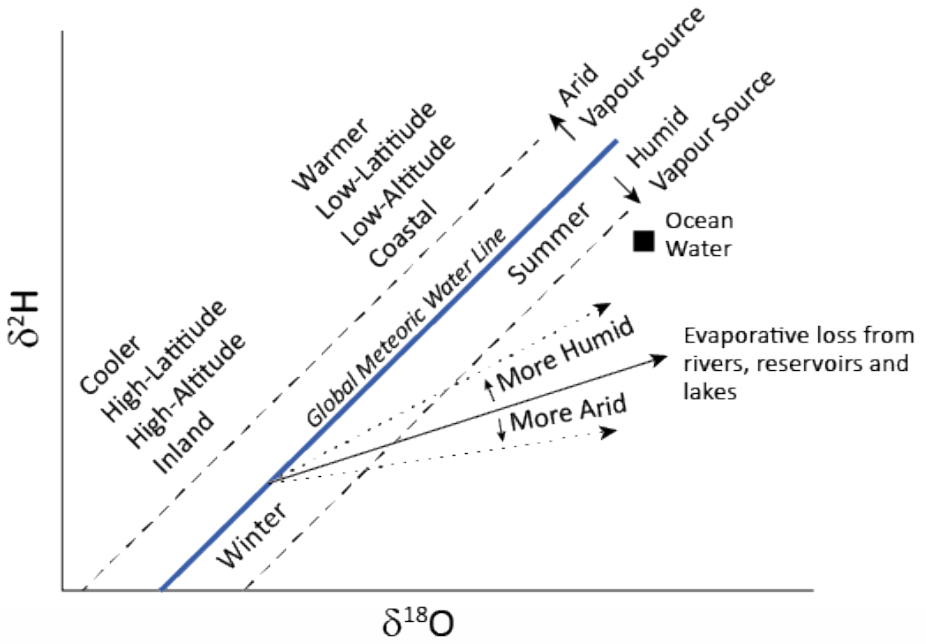


Global Meteoric Water Line

Meteoric Water Line is a way to relate the isotopes of the hydrogen and oxygen in the water molecule in precipitation.

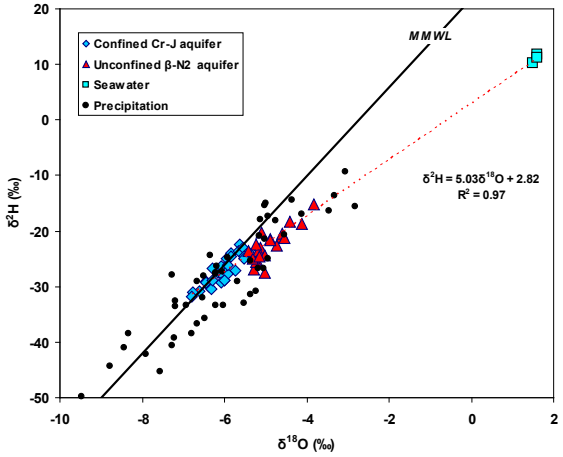
Precipitation is the source input to surface water and groundwater systems

The precipitation $\delta^{18}O$ and $\delta^{2}H$ signal is particularly sensitive to fluctuations in temperature



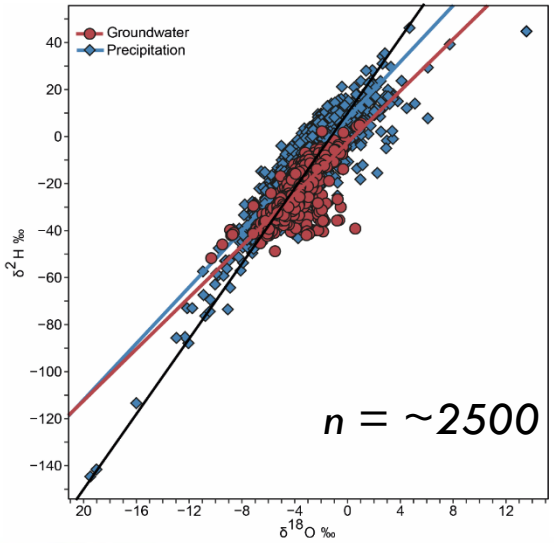
Sampling Strategies and Data Availability

$\delta^{18}O$ and $\delta^{2}H$ values of groundwater and precipitation.



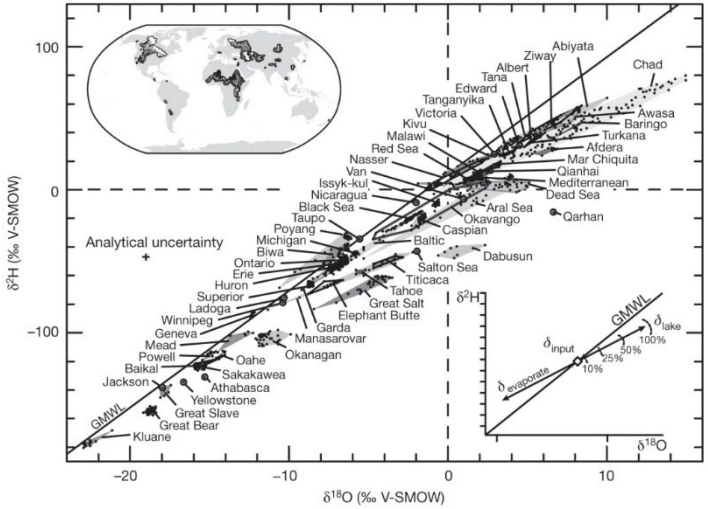
Syria
Credit A. Al-Charideh .

$\delta^{18}O$ and $\delta^{2}H$ values of precipitation vs groundwater.



South Africa
Credit Edson Ramudzuli

$\delta^{18}O$ and $\delta^{2}H$ values of large lakes and semi-enclosed seas globally.



S Jasechko *et al. Nature* **000**, 1-4 (2013) doi:10.1038/nature11983

Diversity of Water Isotope Fingerprinting

Origin
^{2}H, ^{18}O, ^{3}H, ^{87}Sr

Age
^{3}H, ^{4}He, ^{14}C, ^{85}Kr, ^{81}Kr, ^{35}S

Contamination
^{11}B, ^{13}C

Pollution
^{15}N, ^{11}B, ^{34}S

Competition in water use

Pollution legacy

Sources (multiple)

Management and governance

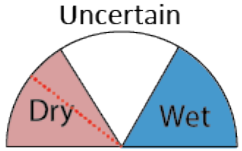
Health issues

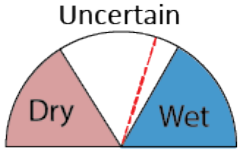
Cultural values

Making Decisions on Available Data and Information

What is the role of climate change role in extreme precipitation?

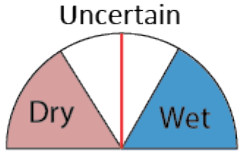
Observed trends

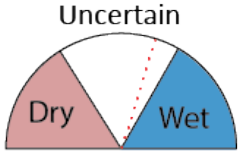




Climate projections

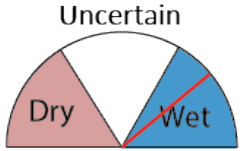
Climate change influence on weather patterns

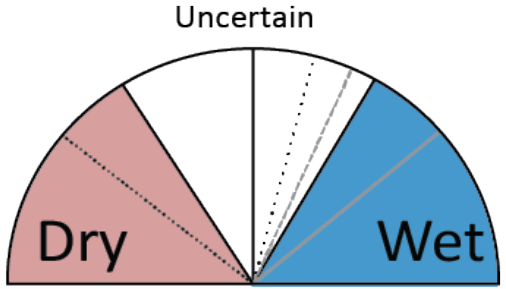




Past event attribute studies

Climate change influences on thermodynmics



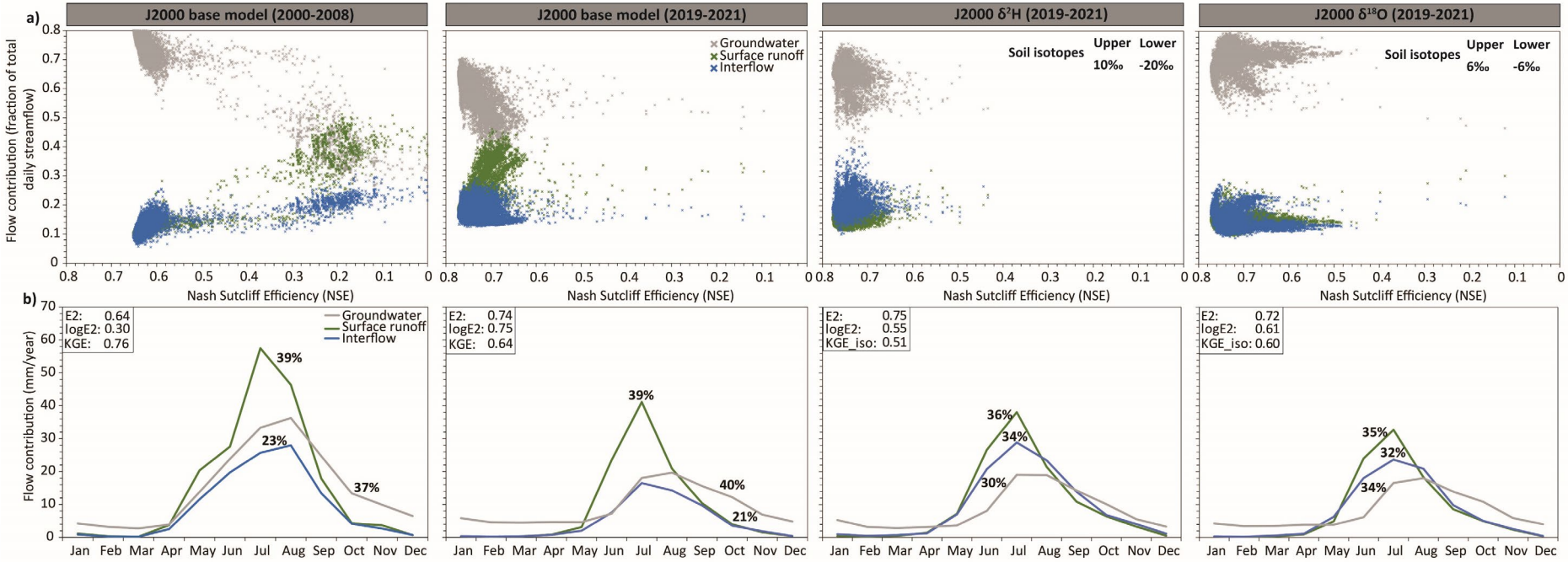


Multiple different potential interpretations

King et al., 2023, Nature Geoscience

Case Study 1: South Africa

Gauging data long term | Gauging data short term | δ^2H | $\delta^{18}O$



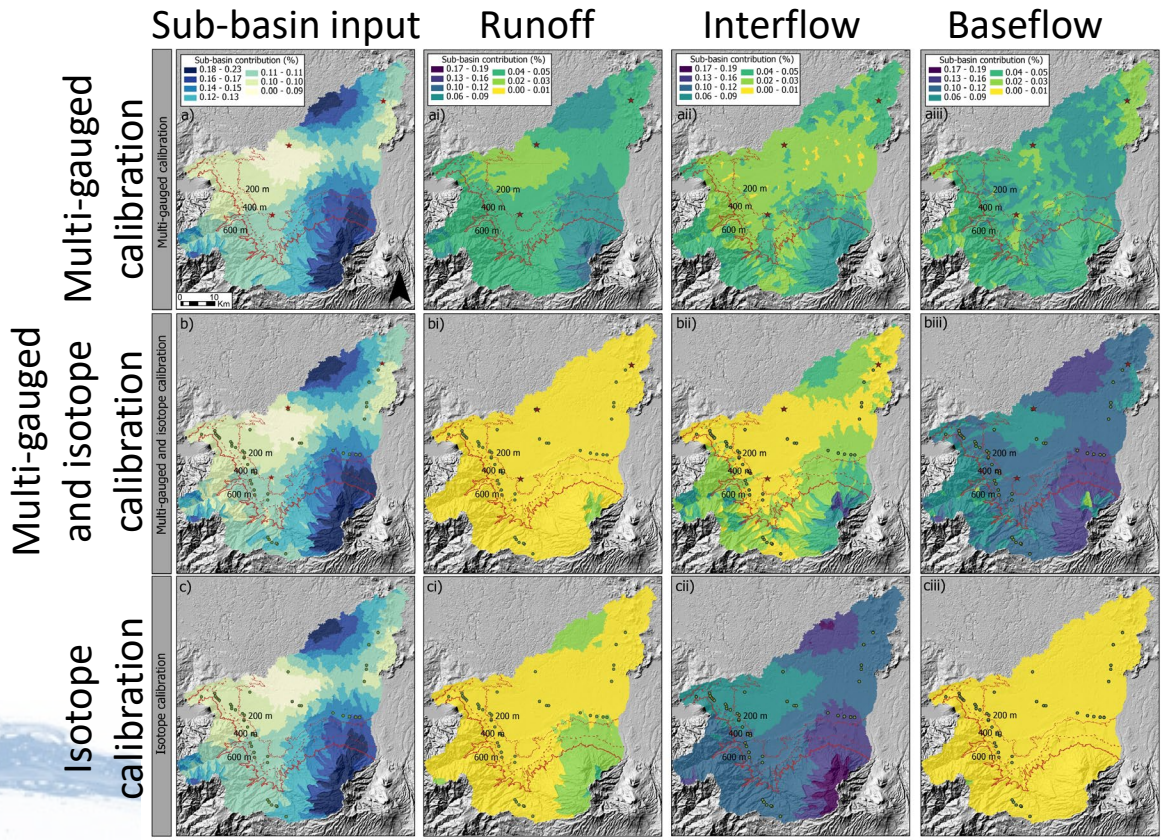
Surface runoff | interflow | Groundwater

Watson et al., 2023

Case Study 2: Costa Rica

Objective: To evaluate changes in precipitation on surface runoff, interflow and groundwater flow and the ability of isotopes to capture these differences when gauging data were not available.

Isotopes Used: ^{2}H and ^{18}O



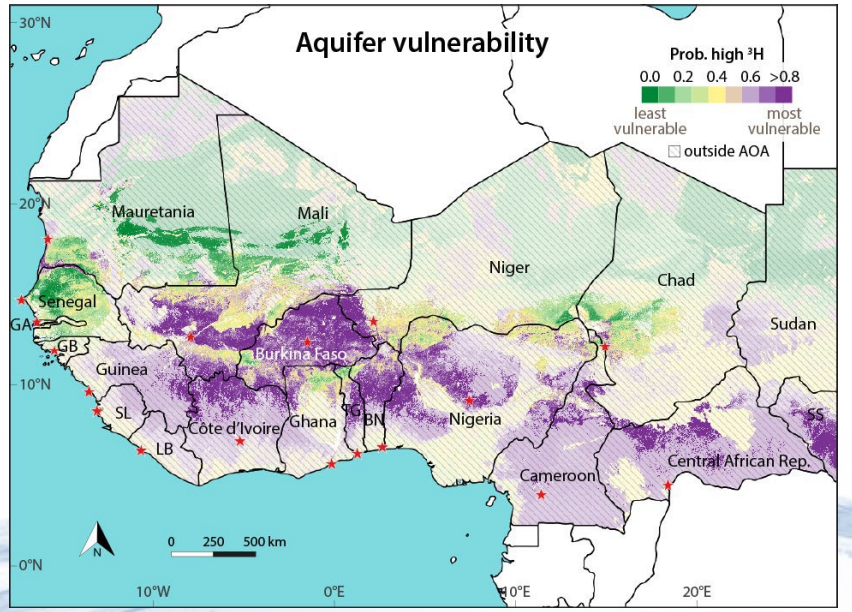
Watson et al., submitted

Case Study 2: Tritium

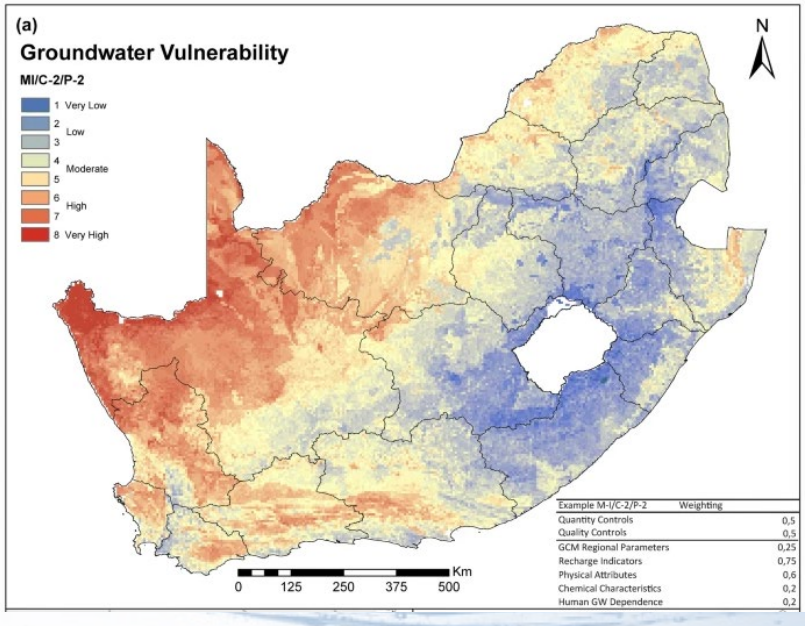
Objective: To understand the risk of groundwater vulnerability to climate change and over-abstraction

Isotope Used: Tritium – ^{3}H

Sahel: Podgorski et al., submitted 2023



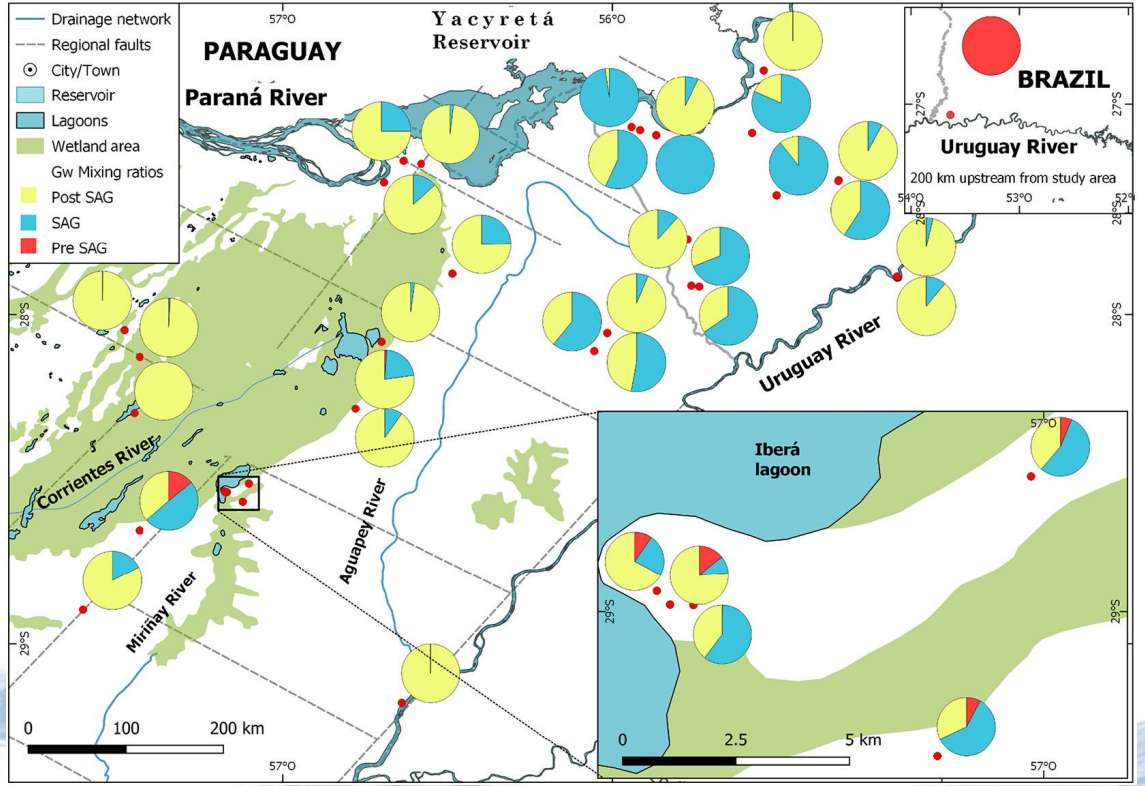
South Africa: van Rooyen et al., 2020



Case Study 3: Iberá Wetlands

Objective: To confirm if discharge from the transboundary Guarani Aquifer System is sustaining the surface water system

Isotope Used: ^{222}Radon



Ortega et al., 2023, STOTEN

Isotopic Take Aways

- Simple and inexpensive tools
- Effective at identifying different source regions and mixing relationships
- Can be used to separate atmospheric, surface water and groundwater components
- Can be customized to the situation
- IAEA provides support to Member States for adoption of isotope hydrology approaches

Thank you

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