How Much Water Do We Have and Where: using naturally occurring isotopes to understand the water cycle and map groundwater resources

Pradeep Aggarwal

Water Resources Programme

The Earth's Water Cycle

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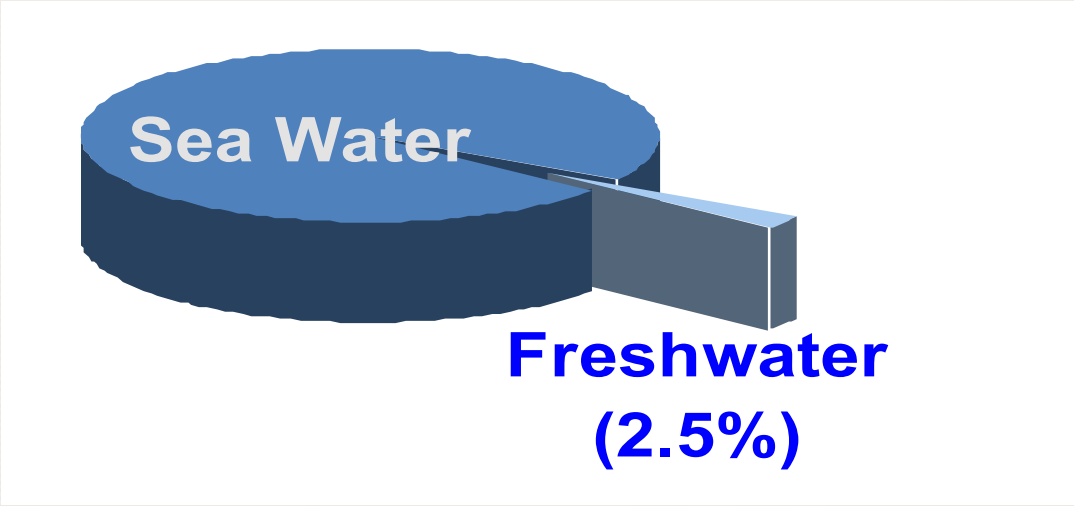
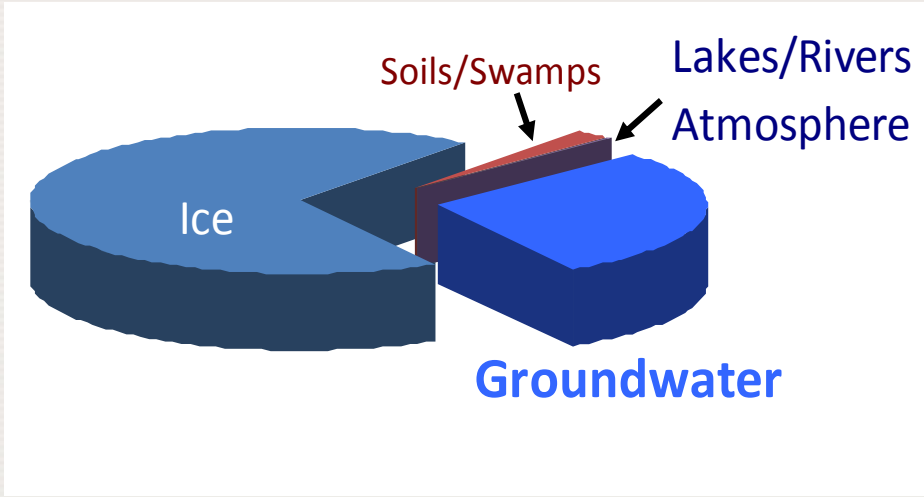
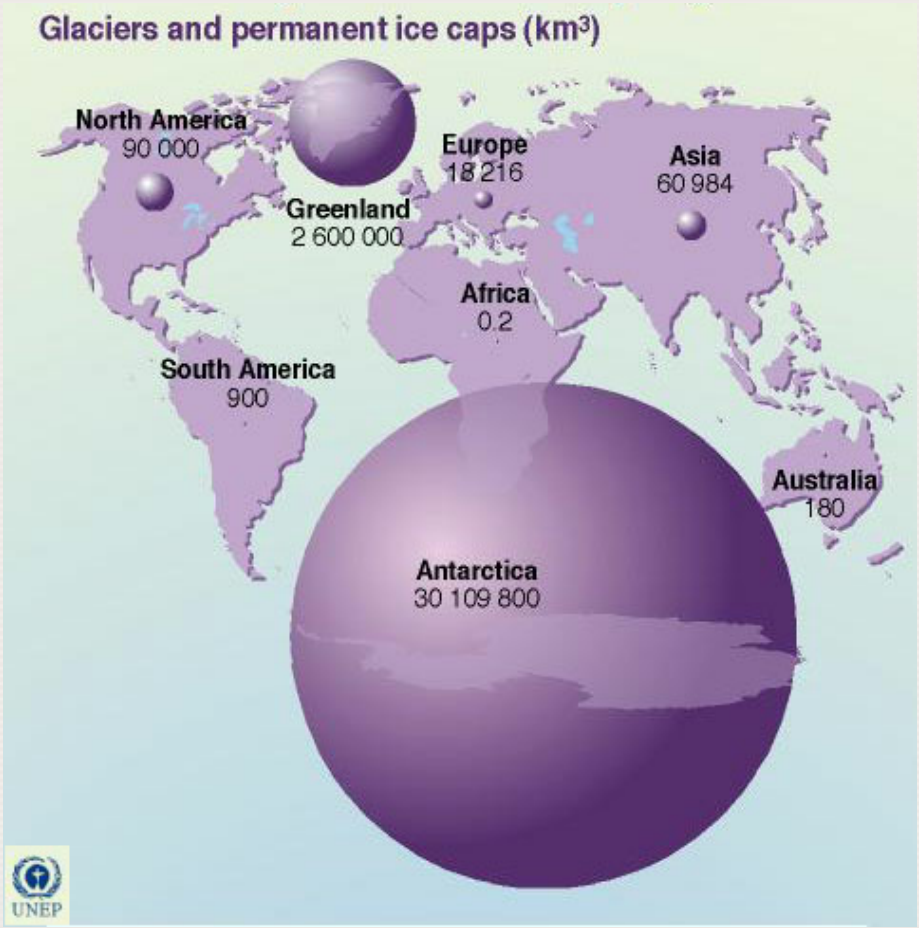
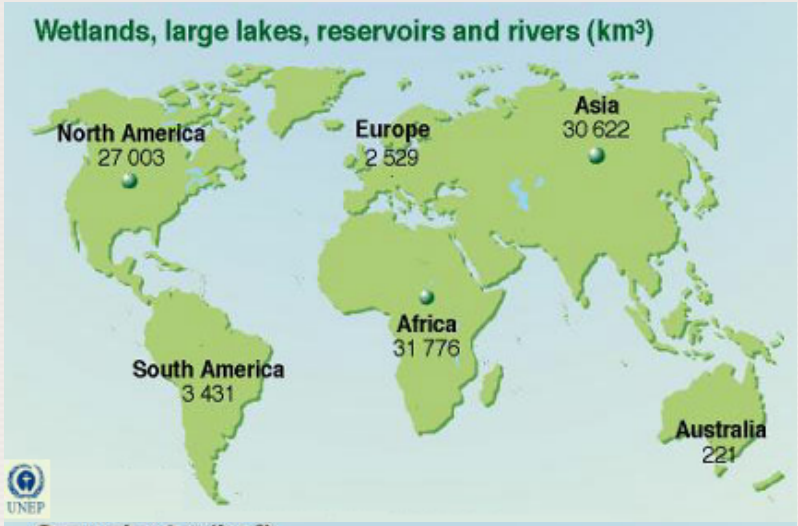
Less than 1% of all water on Earth is freshwater, and most of it (>95%) is groundwater used from wells!

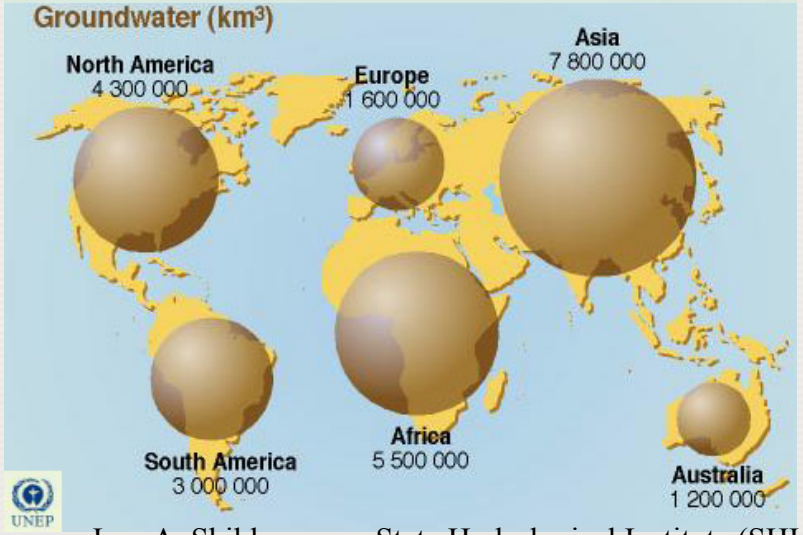




Regionally, freshwater resources are unevenly distributed







Source: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and UNESCO (Paris), 1999.

Decreasing Freshwater Availability and Scarcity

Beneath Booming Cities, China's Future Is Drying Up

Du Bin for The New York Times

A construction team works an underground tunnel that will allow water to flow beneath a local highway.

By JIM YARDLEY
Published: September 28, 200

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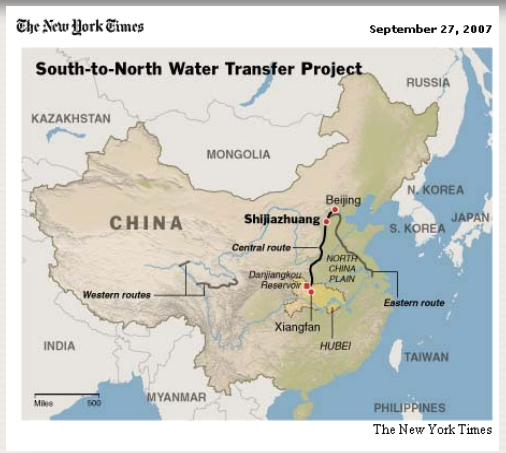

The New York Times

THIRSTY GIANT

India Digs Deeper, but Wells Are Drying Up

Ruth Fremson/The New York Times

Women draw water from a well near Dudu, Rajasthan. In Rajasthan, a heavily agricultural state, up to 80 percent of the groundwater areas are in danger of running out.

THIRSTY GIANT

In Teeming India, Water Crisis Means Dry Pipes and Foul Sludge

By SOMINI SENGUPTA
Published: September 29, 2006

E-MAIL
PRINT
SINGLE PAGE
REPRINTS

NEW DELHI, Sept. 28 — The quest for water can drive a woman mad.

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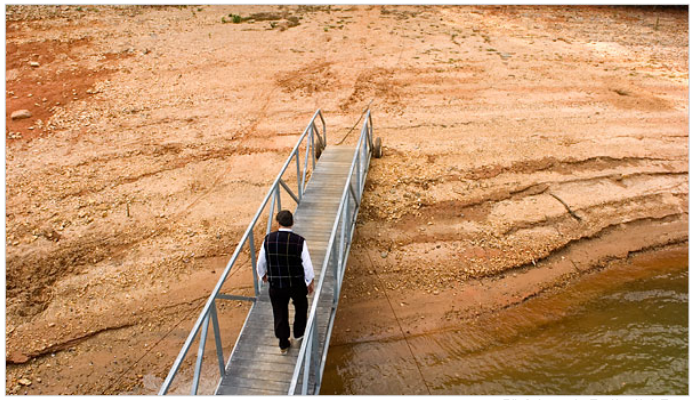
Decreasing Freshwater Availability and Scarcity – North America

New to Being Dry, the South Struggles to Adapt



Erik S. Lesser for The New York Times

Val Perry of the Lake Lanier Association walking from his dock last week. The governor of Georgia wants the Army Corps of Engineers to reduce the amount of water it releases from the lake.

By SHAILA [illegible]
Published: [illegible]

The Future Is Drying Up

Water Levels in 3 Great Lakes Dip Far Below Normal

John Flesher/Associated Press

Part of Lake Superior, Keweenaw Bay near Baraga, Mich., has dried up as the lake nears its record low, set in 1926.

By FELICITY BARRINGER
Published: August 14, 2007

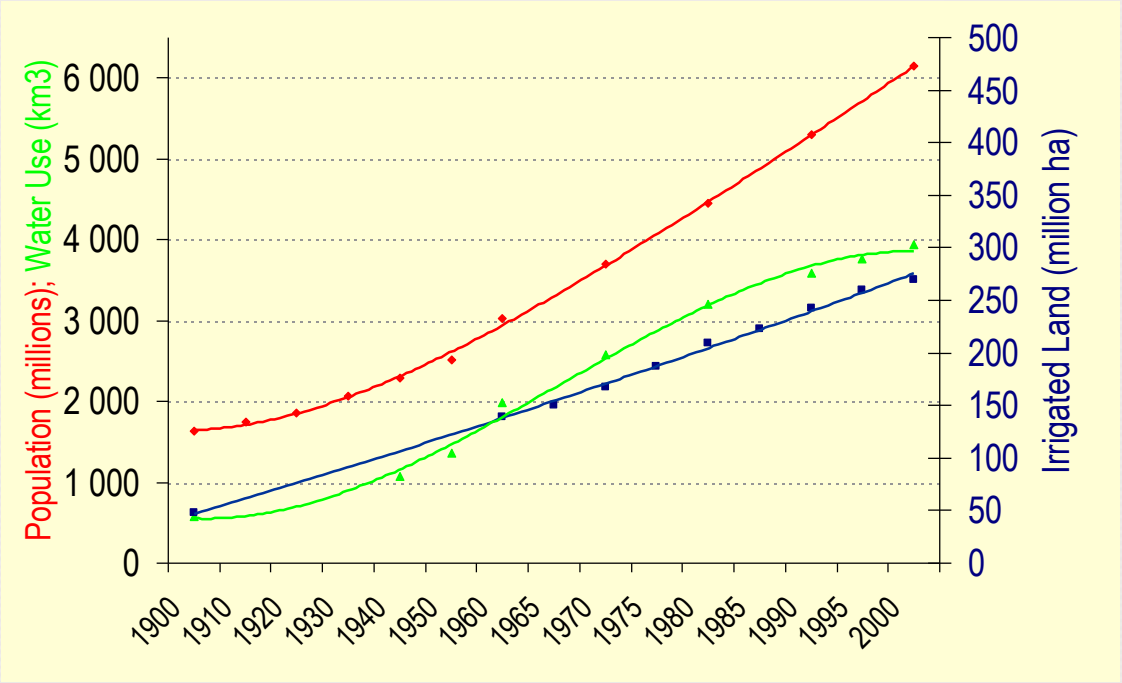
E-MAIL

An Arid West No Longer Waits for Rain

Jim Wilson/The New York Times

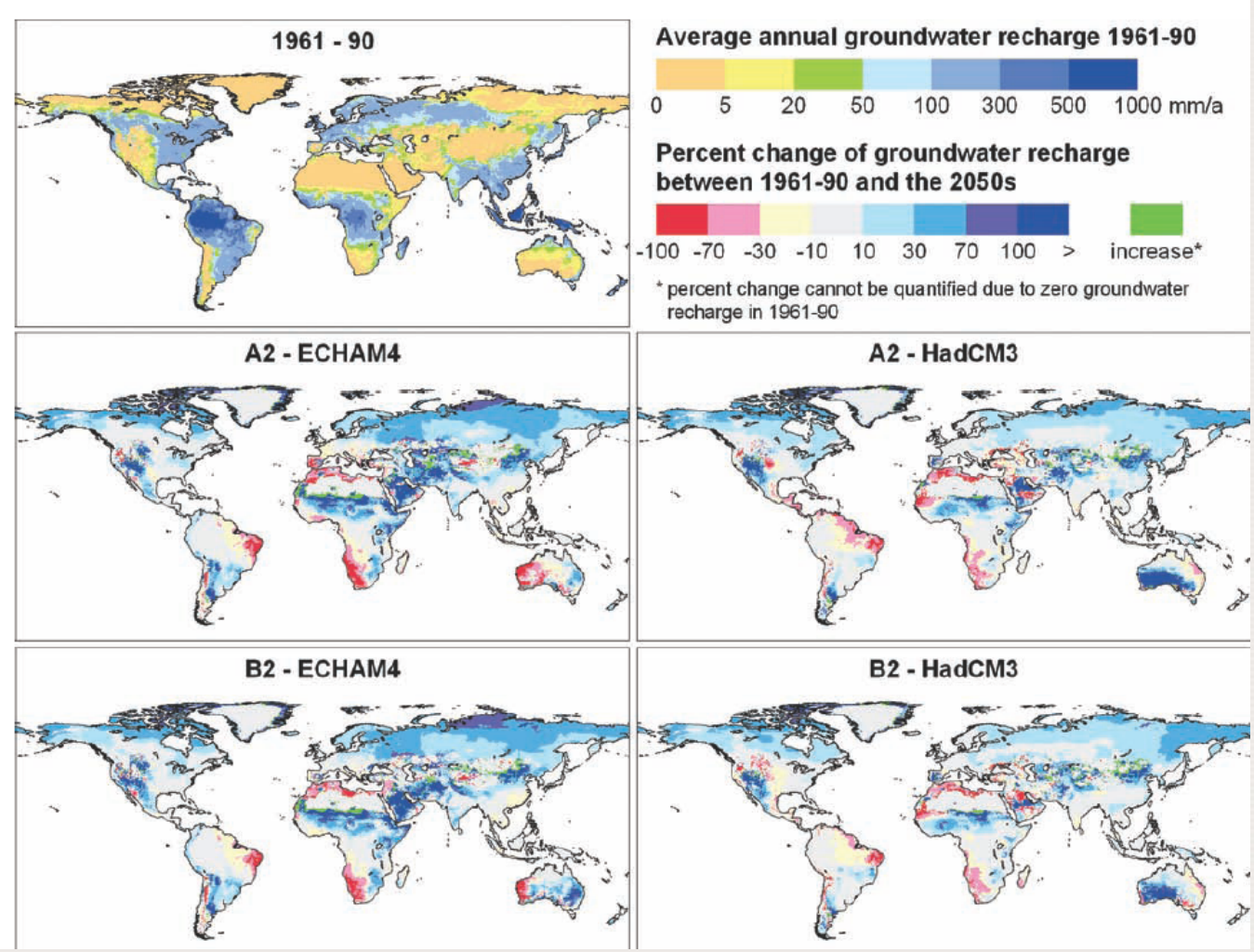
Drivers of stress on water resources

- Population growth -- (*certain*)
- Agricultural and Industrial demand, including energy production -- (*somewhat certain)*
- Climate change – (*effects unpredictable*)



Data from Gleick

Climate impacts: significant variability in models
Predicted groundwater recharge (vs 1961-90)

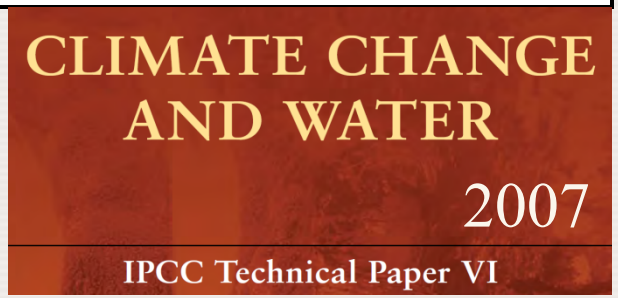


Lack data
for validation

IPCC 2007

Continued recognition of the need for water resources data and comprehensive assessments

1977 UN Water Conference
Mar del Plata, Argentina



...incomplete and incompatible data for managing water

…need scientific understanding and monitoring of aquifers…

Why isotopes?

Historical Perspective on isotope hydrology

1930s – Hydrology emerged as a scientific discipline; Horton (1931) *"..the core of hydrologic science was tracing and accounting for water cycle processes"*

1920s-1930s – Discovery of deuterium and oxygen-18

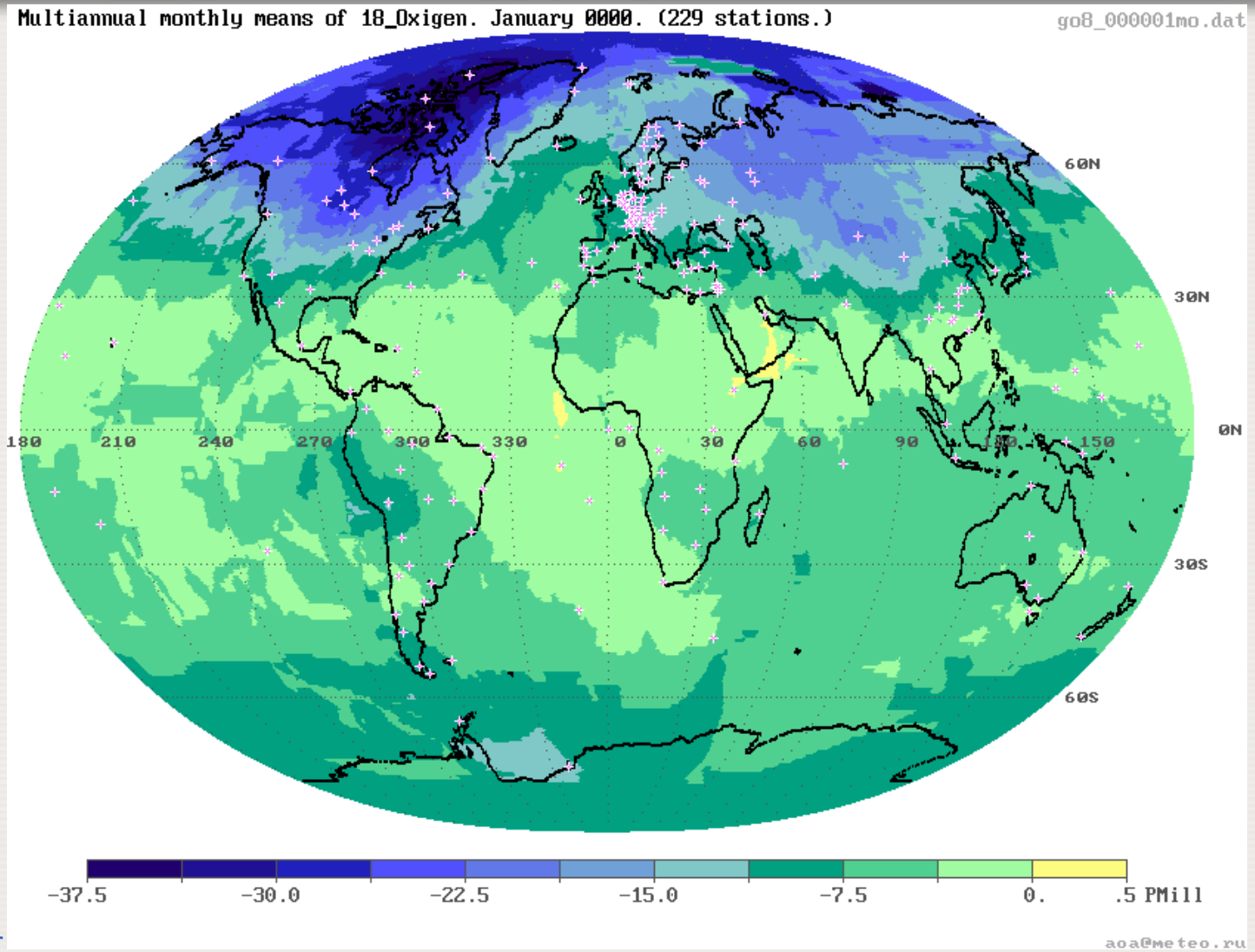
- Density differences in freshwater vs seawater indicate wide variations
- Possible use of isotopes to trace evaporation/condensation processes – *hence, tracing of the water cycle* – proposed

1939-1945 – Hiatus due to WW-II

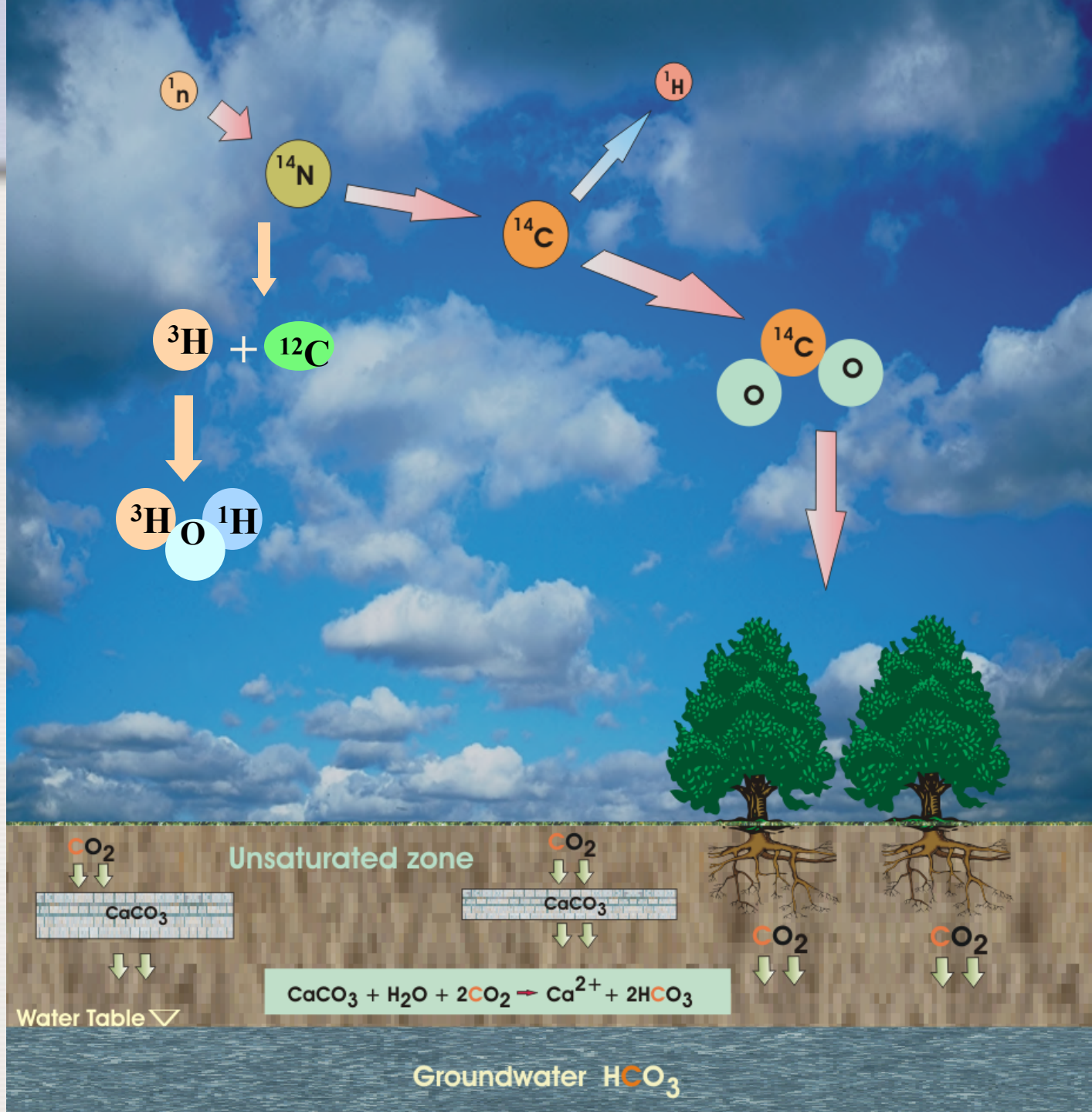
Late 1940s – discovery of natural radioactivity (tritium/C-14)

1950s - present – Application of stable and radioactive isotopes to understand hydrological and climatic processes; advances in measurement techniques

GNIP – IAEA's global network of isotopes in precipitation - since 1961 (jointly with WMO)

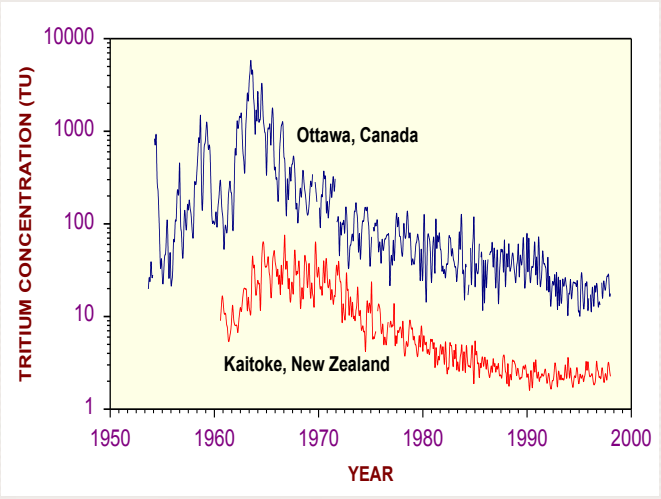


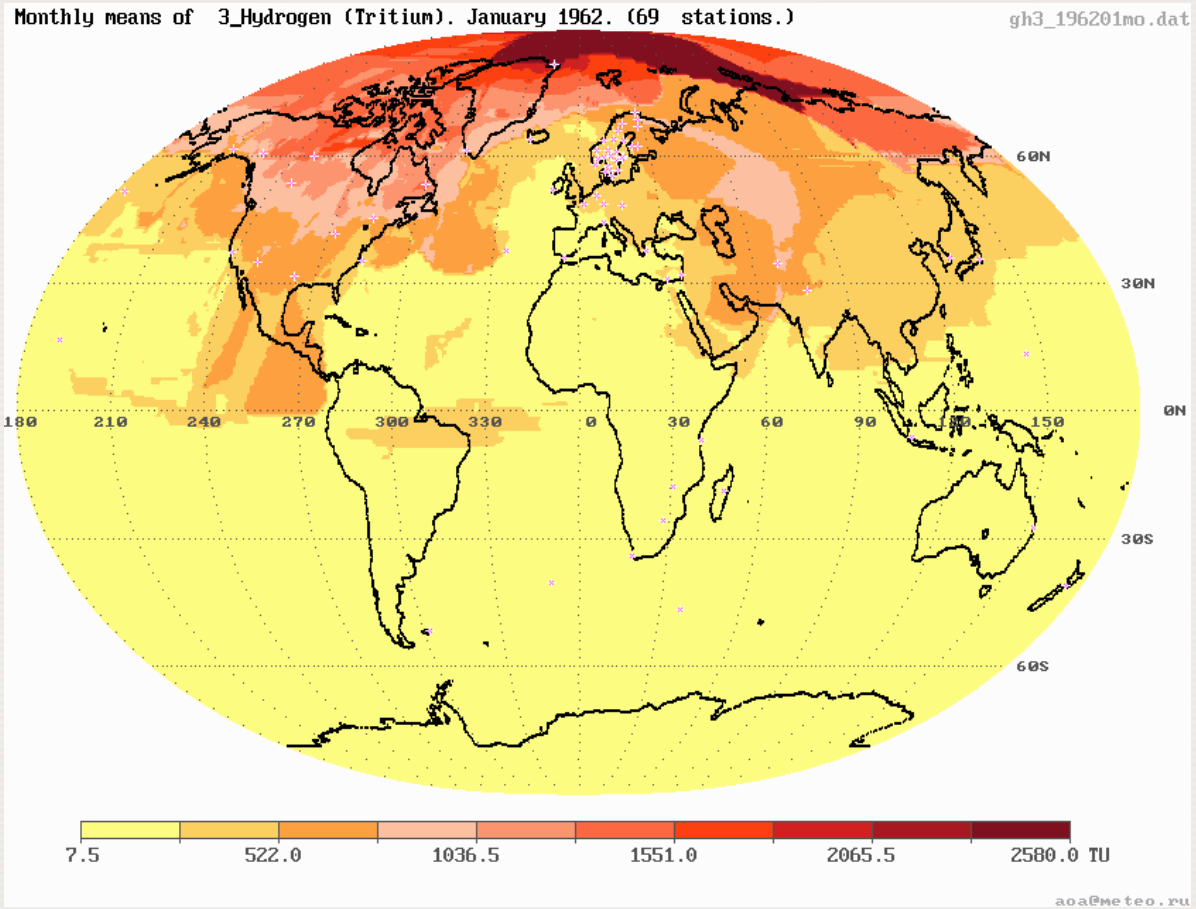
Tritium (^3H) and C-14 in Nature



Precipitation tritium content (GNIP data)

for 1962 - 1965





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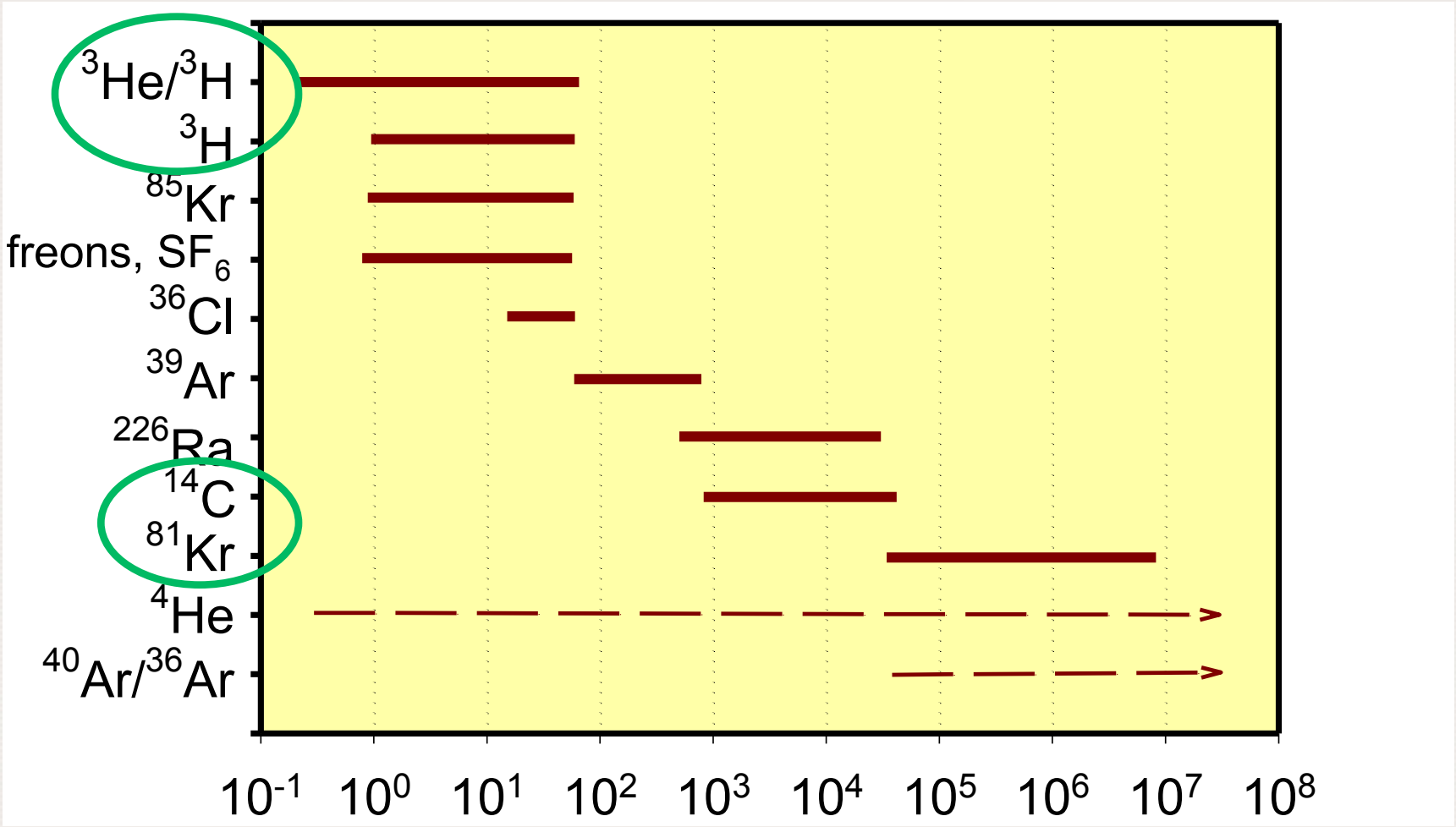
A variety of radioactive isotopes are used for determining the age of groundwater



Isotopes allow us to determine where the water comes from, how fast groundwater moves, or how old it is;

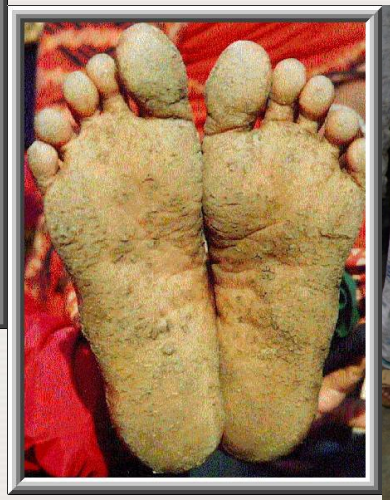
…But why do we care?

Isotope Age of water…

http://www.youtube.com/watch?v=rLJL8Tw0Wsc

Ice

Bangladesh: drinking water from wells improved the quality of life, but also exposed nearly 70 million to high arsenic



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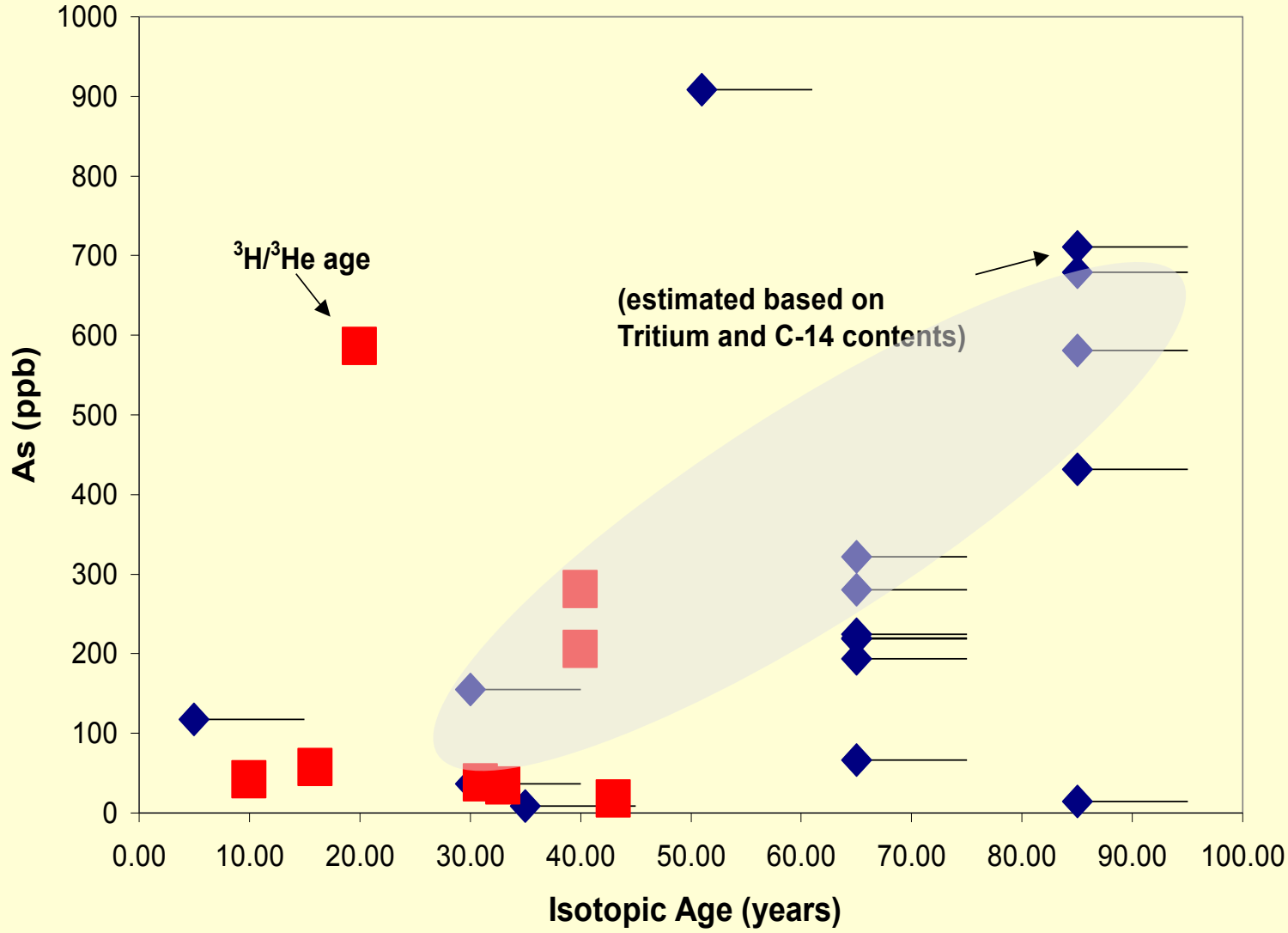
Finding arsenic-safe water

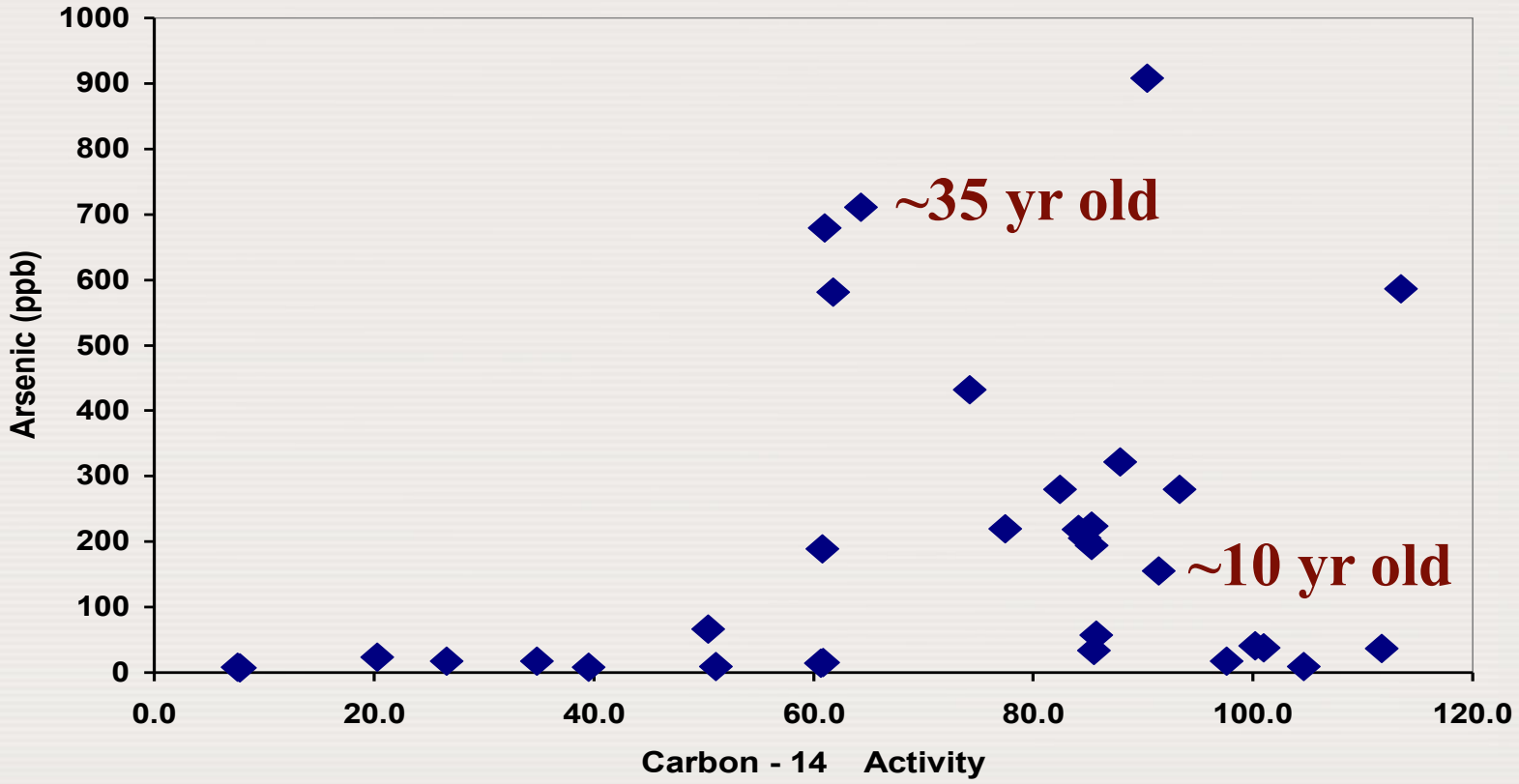
Pre-requisites for mitigation strategy:

- What are the causes of arsenic mobilization?
- Is there Arsenic in deep aquifers?
- What is the impact of past groundwater use on aquifer dynamics?
- Are deep aquifers an alternative source of safe drinking water?

Has Increased Groundwater Use Increased Arsenic Mobilization?

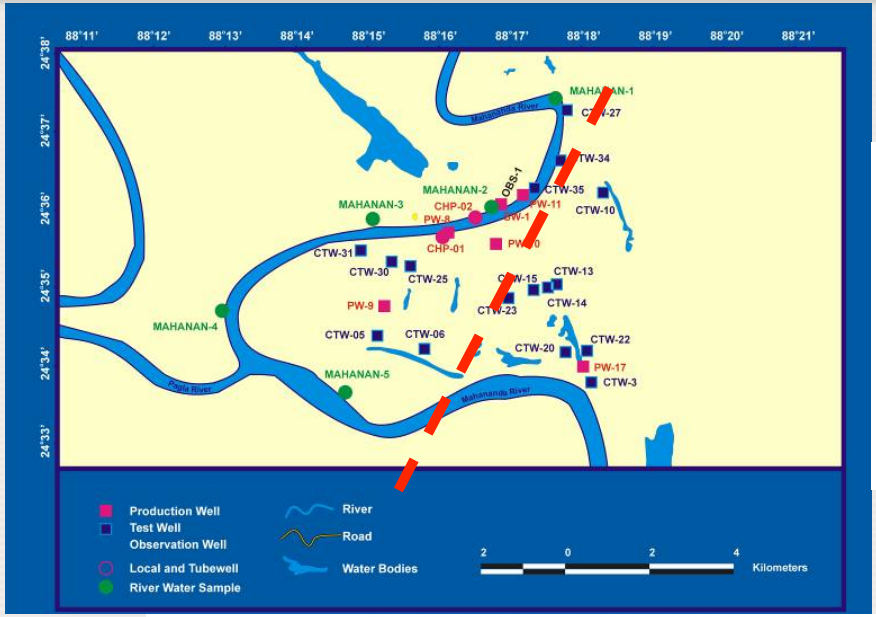


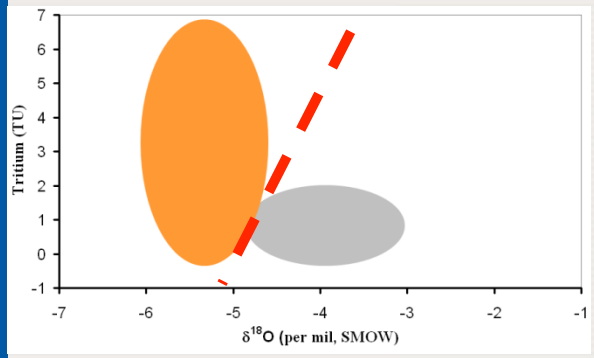
Has Increased Groundwater Use Increased Arsenic Mobilization?

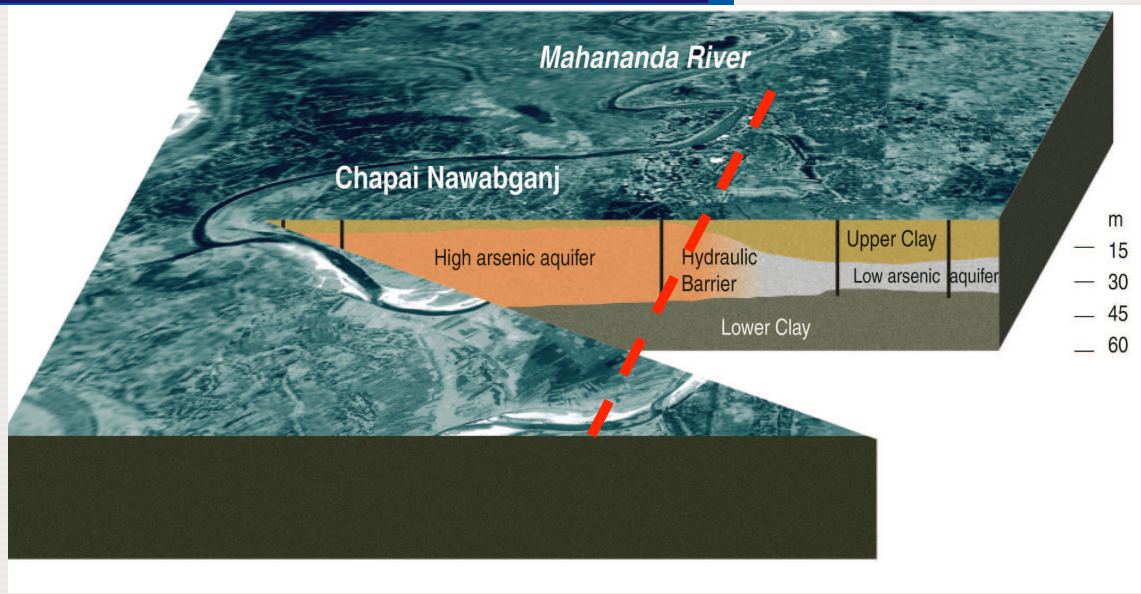


So how does this help provide safe water?

Arsenic-free water supply options – Isotopes help optimize investments







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Thank You!