Scientific Solutions for Protecting and Restoring Water Resources

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UN/ Austria/ ESA Symposium “Space Systems: Protecting and Restoring Water Resources”

IAEA

Water Resources Programme

Overview

- IAEA Water Resources Programme
- Solutions Through Science: Ex. Isotope Hydrology
- Science in Practice: Selected Case Studies
- Future Perspectives: Potential Link with Space Technologies

Rationale for IAEA's Work in Water

- United Nations Agency
- Mandate has 3 pillars
- Non-proliferation and nuclear safety are well-known
- 3rd Pillar: Peaceful uses of nuclear science
  - Agriculture, Human Health, Industrial Applications and…………….Water!

The Basics

- About 25 Staff
- Regular Budget (over 3 million USD)
- Technical Cooperation projects (84 projects, 4 million USD)
- Member of UN Water
- It is focussed on Isotope Hydrology

Programme Objectives

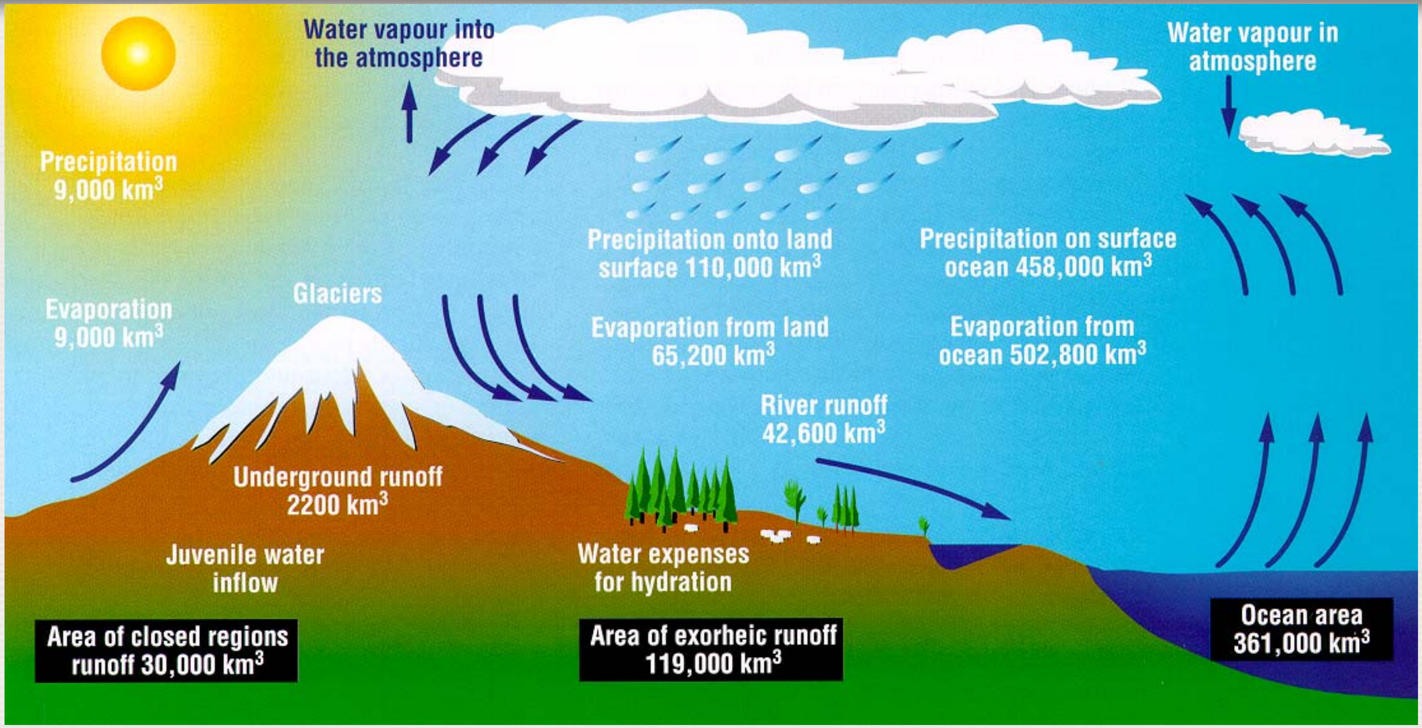
To improve the management of water resources by Member States with the use of isotope technologies

Key Features

- Responds to scientific aspects of the “Global Water Agenda”
- Millenium Development Goals, World Summit on Sustainable Development, Decade for Action:
  - Improved understanding of the water cycle
  - Sustainable exploitation of water resources
  - Improved data and capacity for monitoring the quantity and quality of water resources

The Role of Science

- Solid science is the necessary underpinning of sound water resources management



… water is in permanent motion, constantly changing from liquid to solid or gaseous phase, and back again...

Understanding the Basics of Water

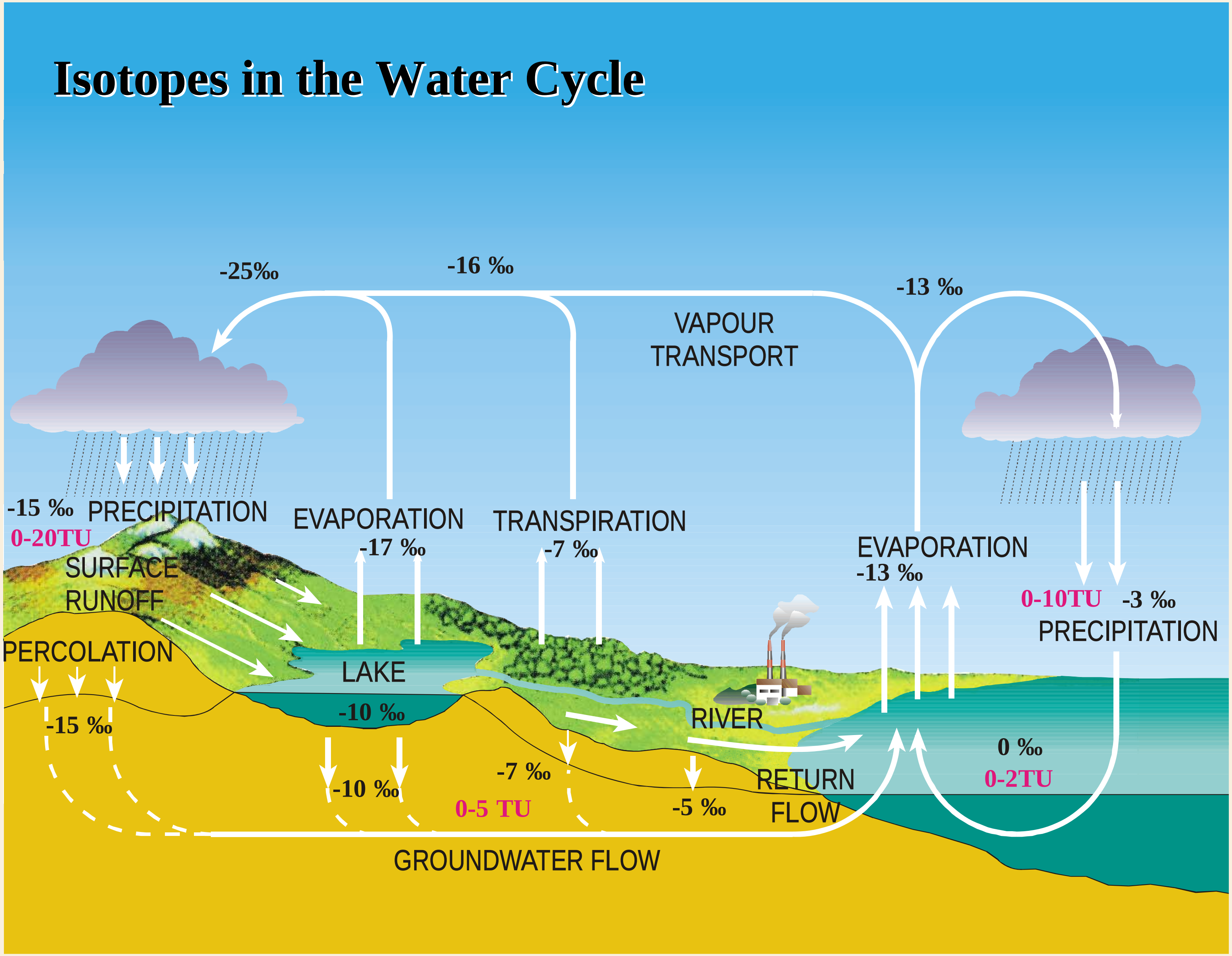
- Water consists of atoms of different mass called isotopes, which are distributed by natural processes through the water cycle
- History and journey of each drop cause it to undergo small, significant changes
- Water in different environments develops characteristic isotopic labels

Isotope Hydrology- Principles

- **Water Fingerprints”**
  During evaporation and condensation of water, the concentration of O and H isotopes (naturally-occurring atoms of different mass) in a water molecule change.

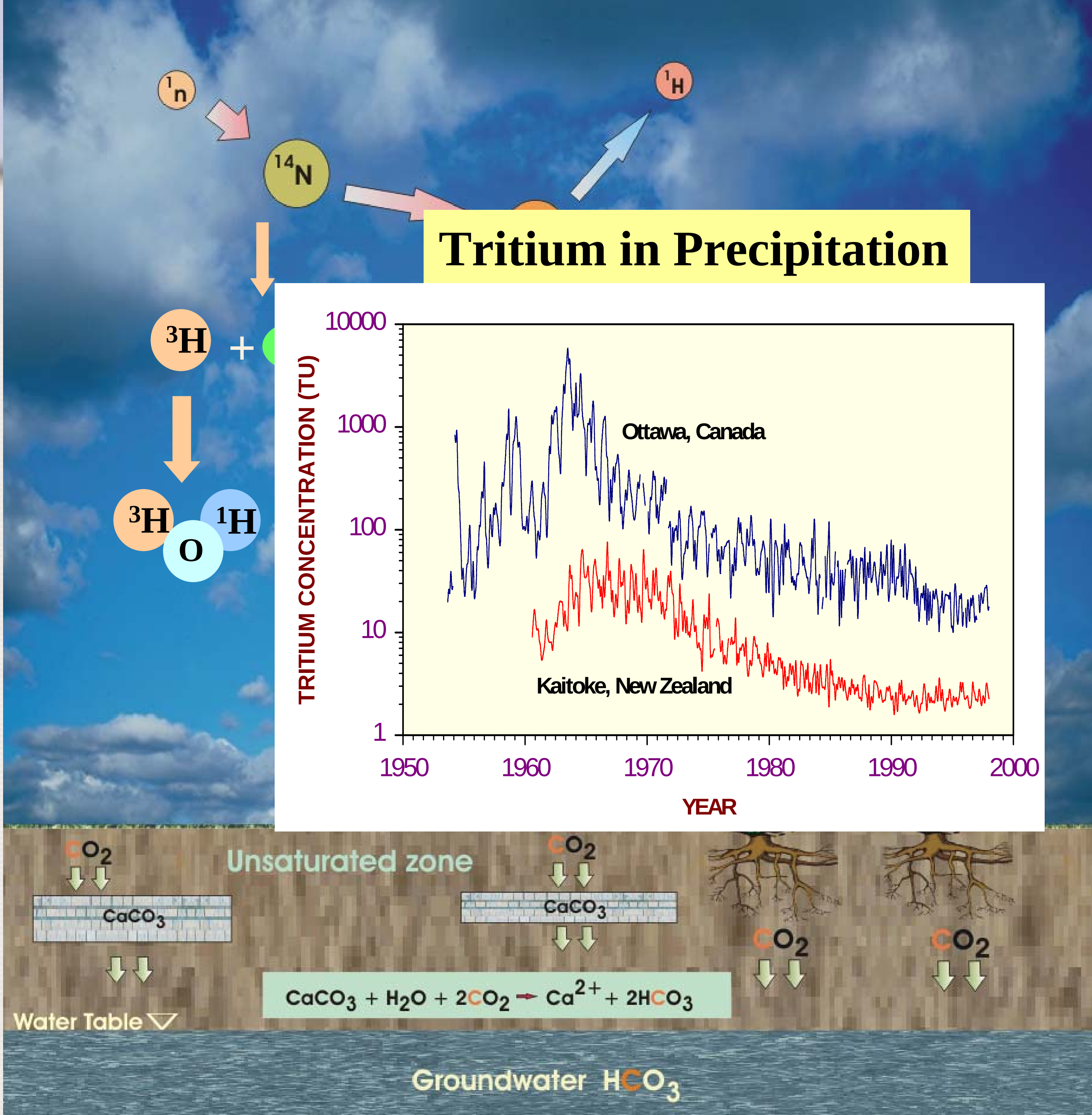
Isotope Hydrology- Principles (2)

- **Tracing"** Other isotopes in rainwater, such as tritium and carbon-14, in which concentration decreases with time. These isotopes in surface or groundwater can be measured to determine the "age" or residence time of water within a particular water body.



Example: oxygen-18 and tritium in the water cycle

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



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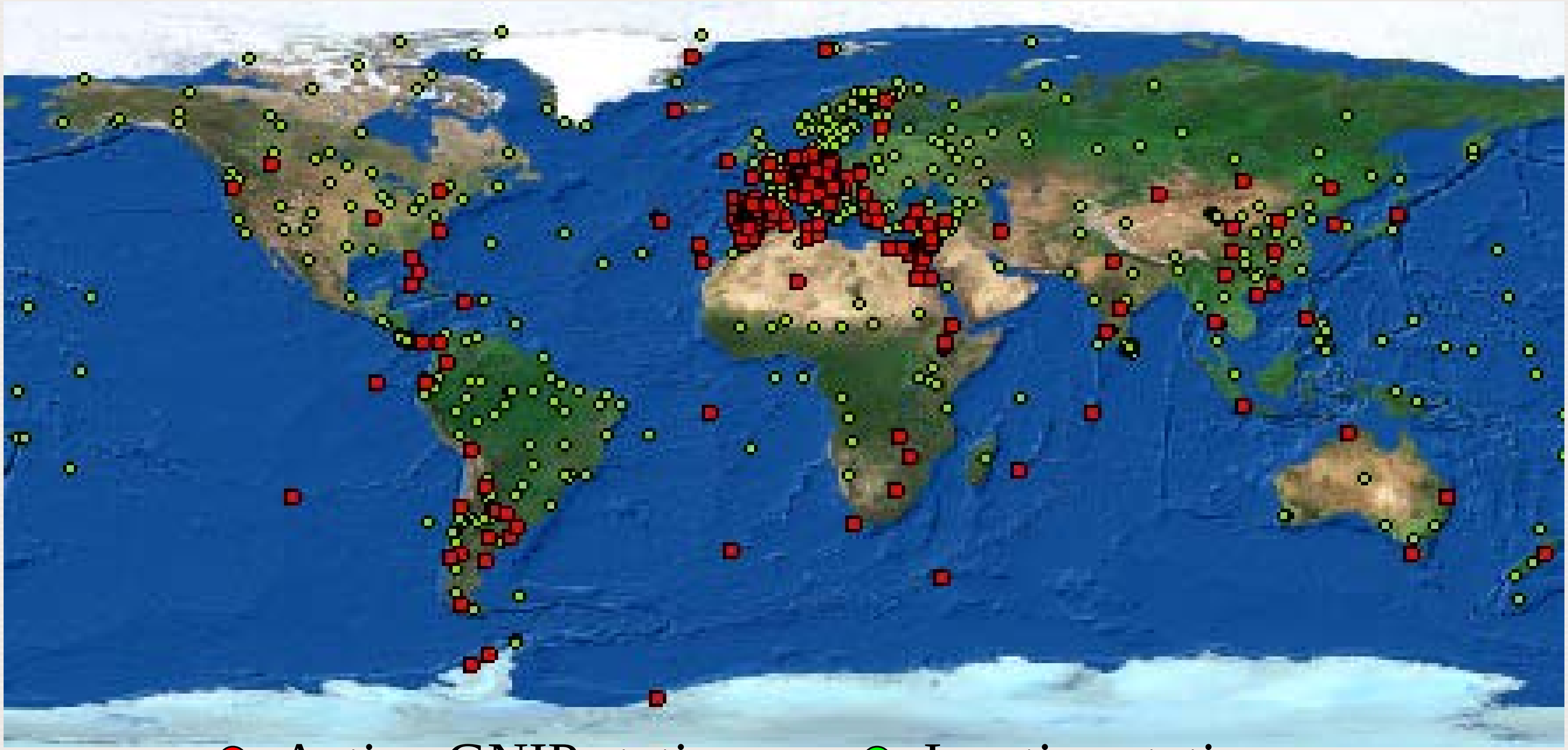
Providing Tools and Support Services

- Isotope Hydrology Laboratory (analytical services, reference materials, experts)

- Global Data Networks (GNIP etc.)

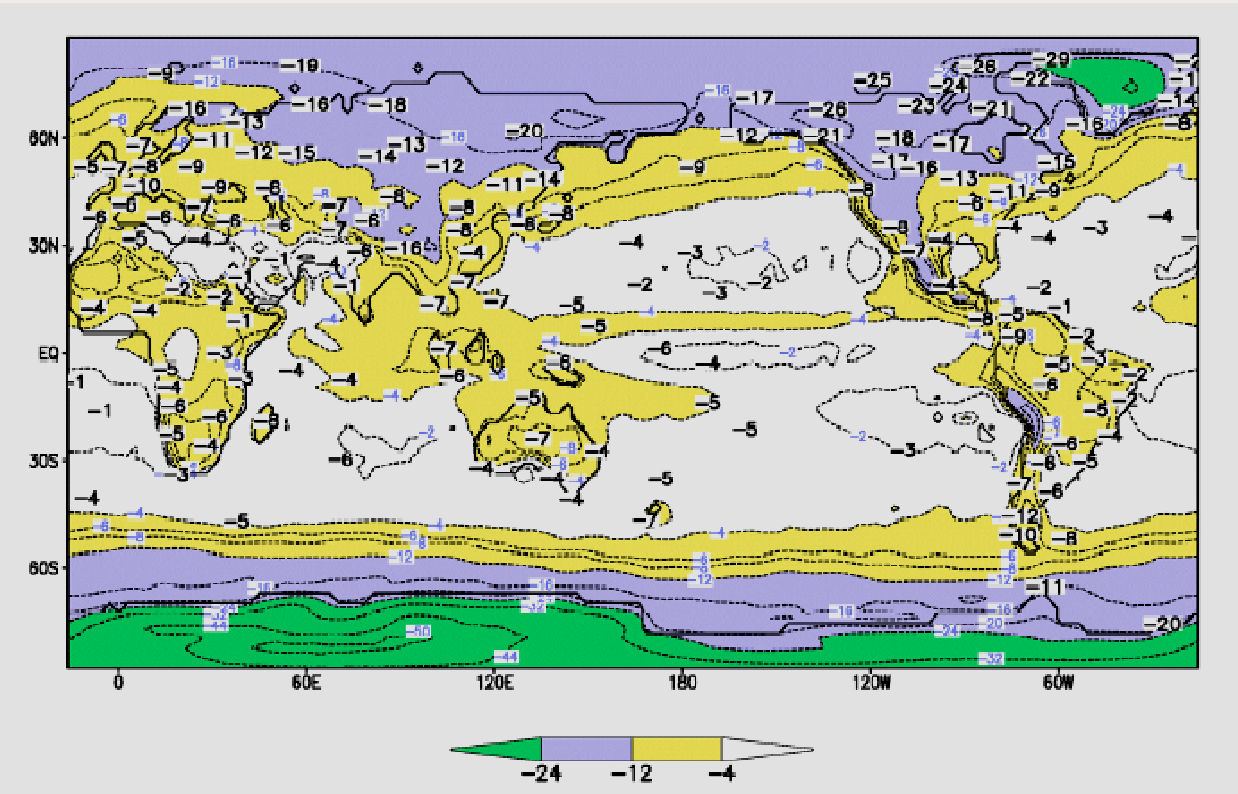
- ISOHIS Map (isotope hydrology GIS)

GNIP - Global Network of Isotopes in Precipitation (jointly with WMO)



Active GNIP stations   Inactive stations

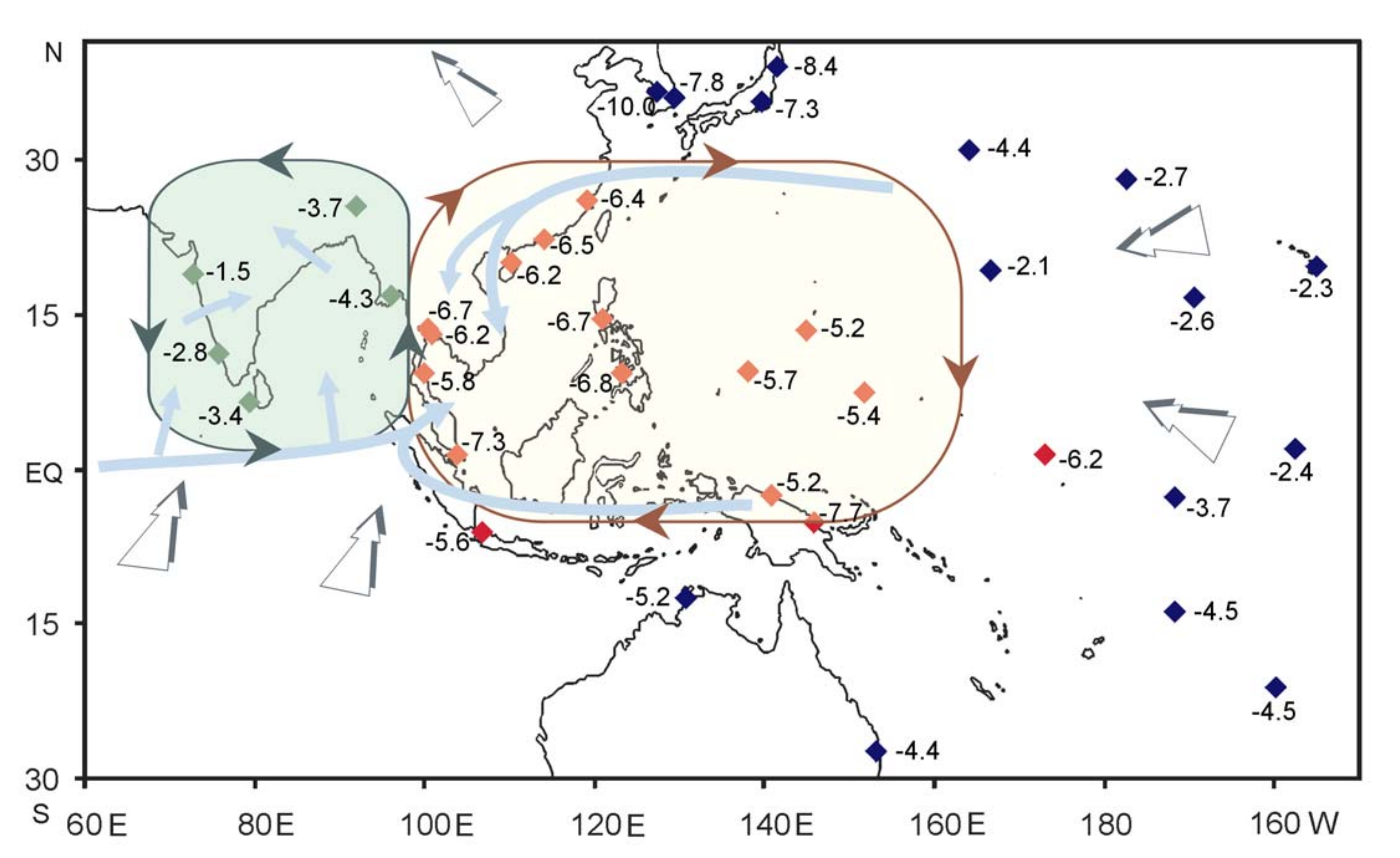
Improving Global Climate Models



ECHAM-3 Output (Hoffman et al.)

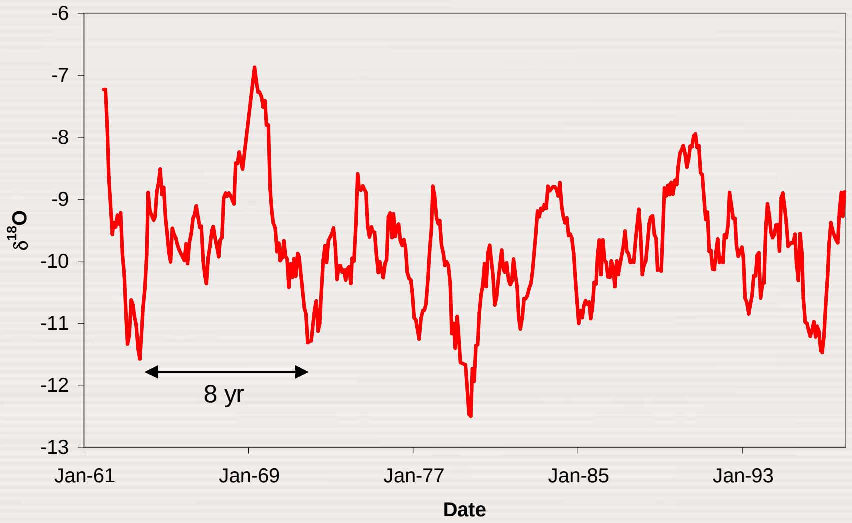
Also included in GISS and NCAR models (Jouzel et al)

Moisture Sources/recycling in the Asian Summer Monsoon



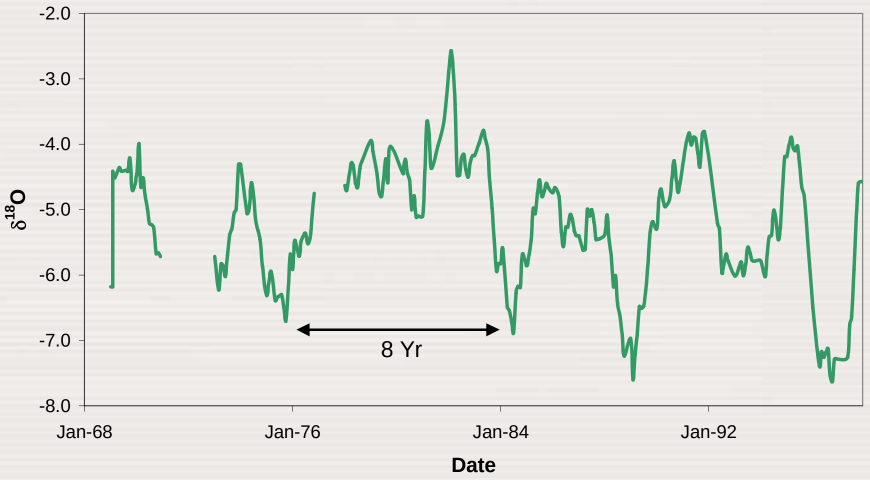
(Lau et al; Chen et al; Aggarwal et al)

Do long-term isotope data contain information on periodic changes in moisture sources?



Vienna

Bangkok



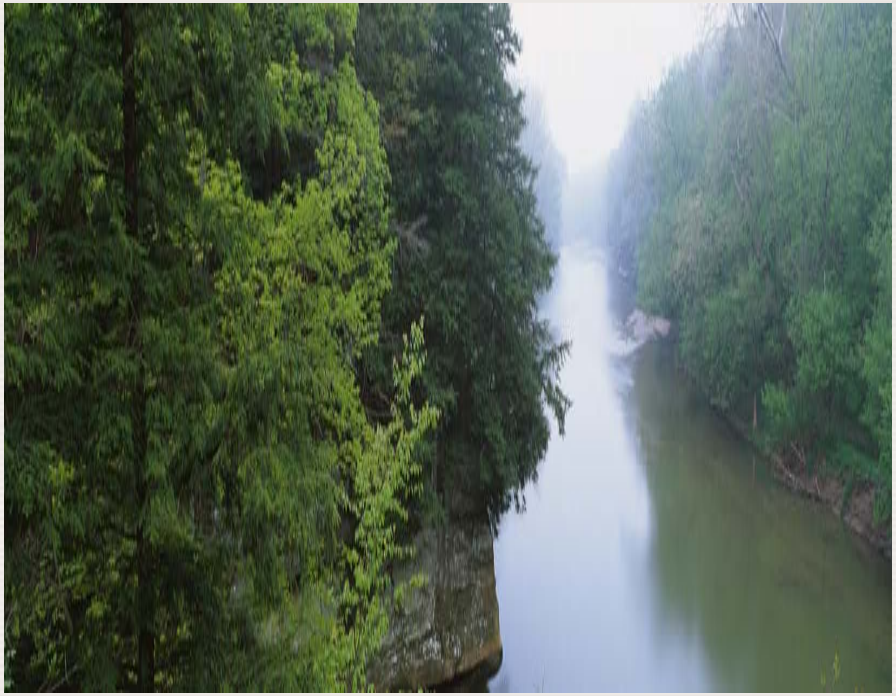
(12 monthly running avg. $\delta^{18}O$)

Advancing/ Adapting Science

- Coordinated Research Programmes
  - Base flow
  - Monitoring of isotopes in large rivers (GNIR)
  - Submarine groundwater discharge (with IAEA Monaco Lab.)
  - Moisture isotopes in the biosphere and atmosphere programme
  - (new- 2006) Assessment of hydrological processes in wetlands

Where Does River Water Come From?

- The changes in isotopic composition of a river along its length allow one to quantify inputs from GW and tributaries.
- New developments in dating techniques of groundwater will permit managers to predict the response of surface water to land use change.

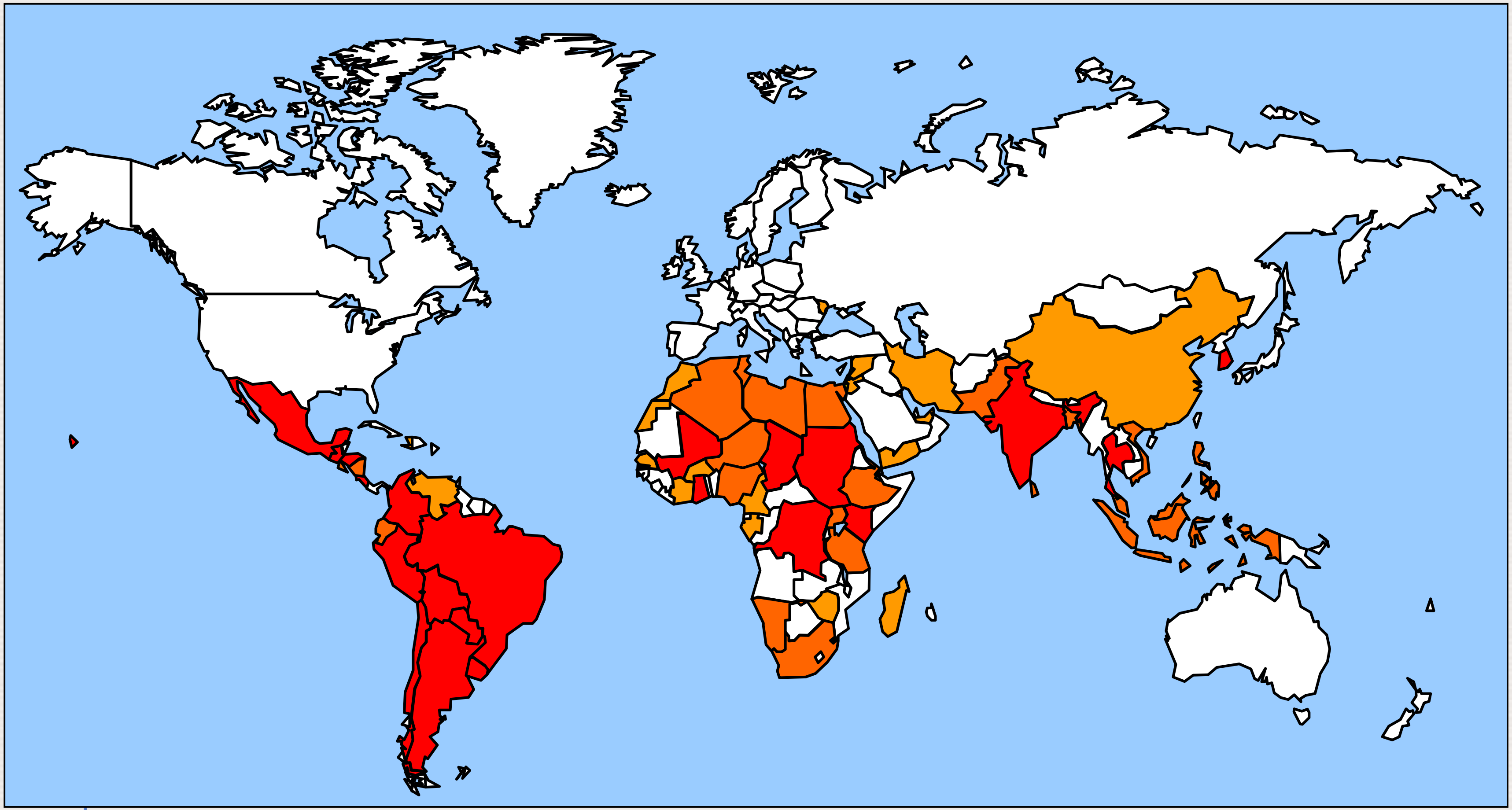


Global Network for Sampling Moisture Isotopes in the Biosphere and Atmosphere (MIBA)

- MIBA launched in 2005;
- Importance of moisture derived from terrestrial sources such as soils and plant transpiration recognized.
- Monitor the isotope composition of moisture in plants, soils and air. This effort will provide an understanding of how soil moisture availability and atmospheric humidity affect vegetation growth.

Supporting Technical Cooperation

- About 84 active projects (funding ~$8M/ cycle)



ARSENIC

A SILENT KILLER

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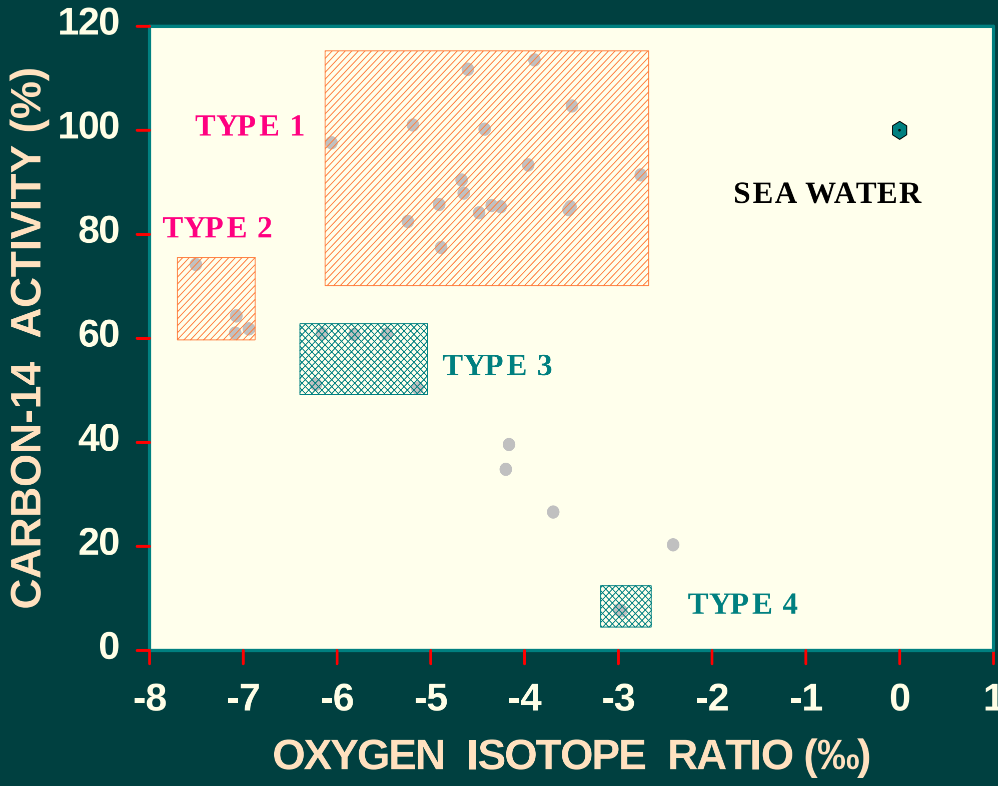
Mitigation of Arsenic Contamination of Groundwater in Bangladesh

<u>TYPE 1</u>: Arsenic-bearing, Shallow (depth < 70 m), Replenished by rain & flood waters, Modern

<u>TYPE 2</u>: Arsenic-bearing, Higher salinity, Recharge from river water, Modern

<u>TYPE 3</u>: Arsenic-free, Deeper (~ 150 m), Low salinity, Several thousand years old

<u>TYPE 4</u>: Arsenic-free, Deep (~300m), Old (~ 20000 years)



Results Used for Formulating Mitigation Policies the Government of Bangladesh

Government of the People's Republic of Bangladesh
Ministry of Local Government, Rural Development & Co-operatives

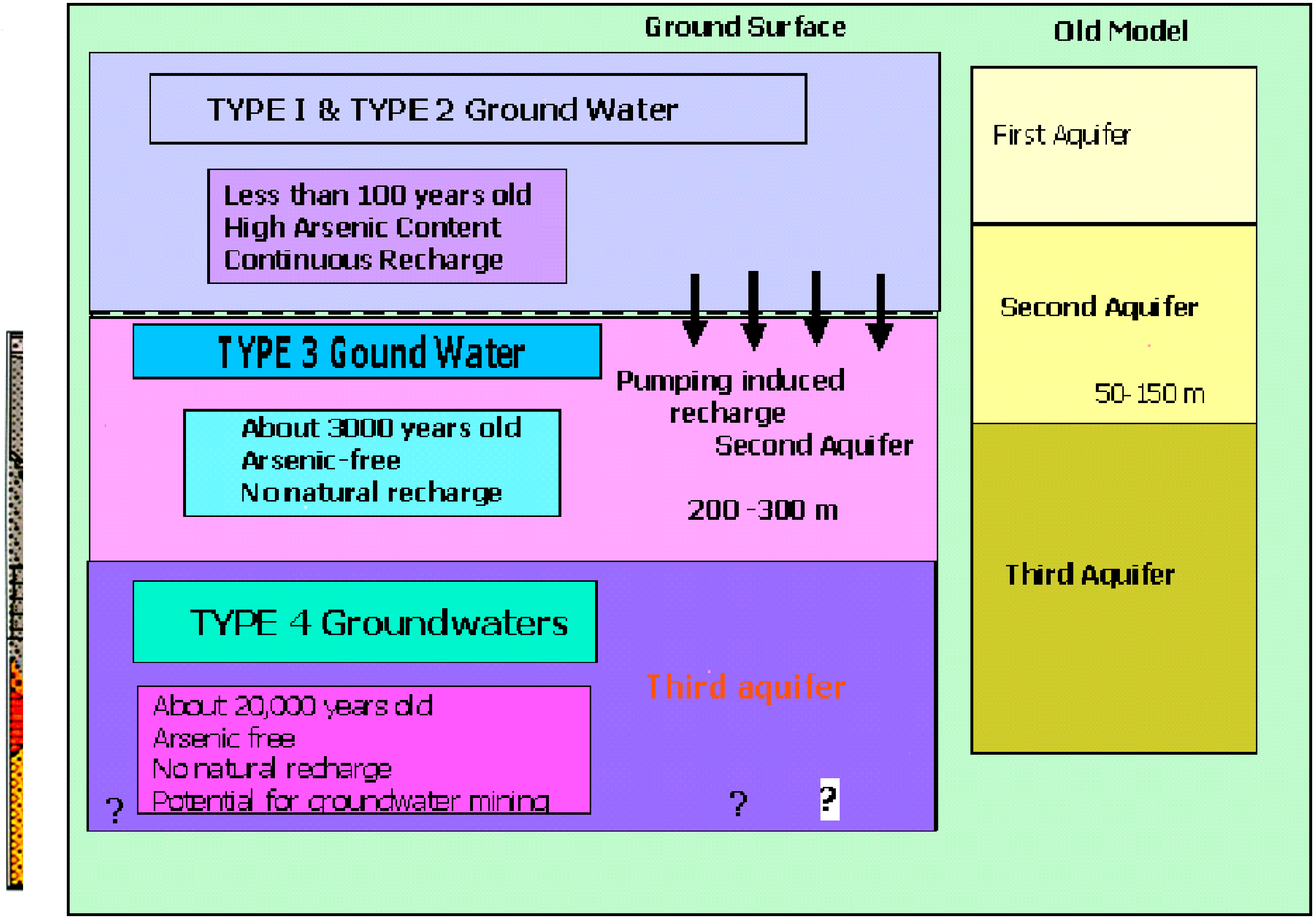


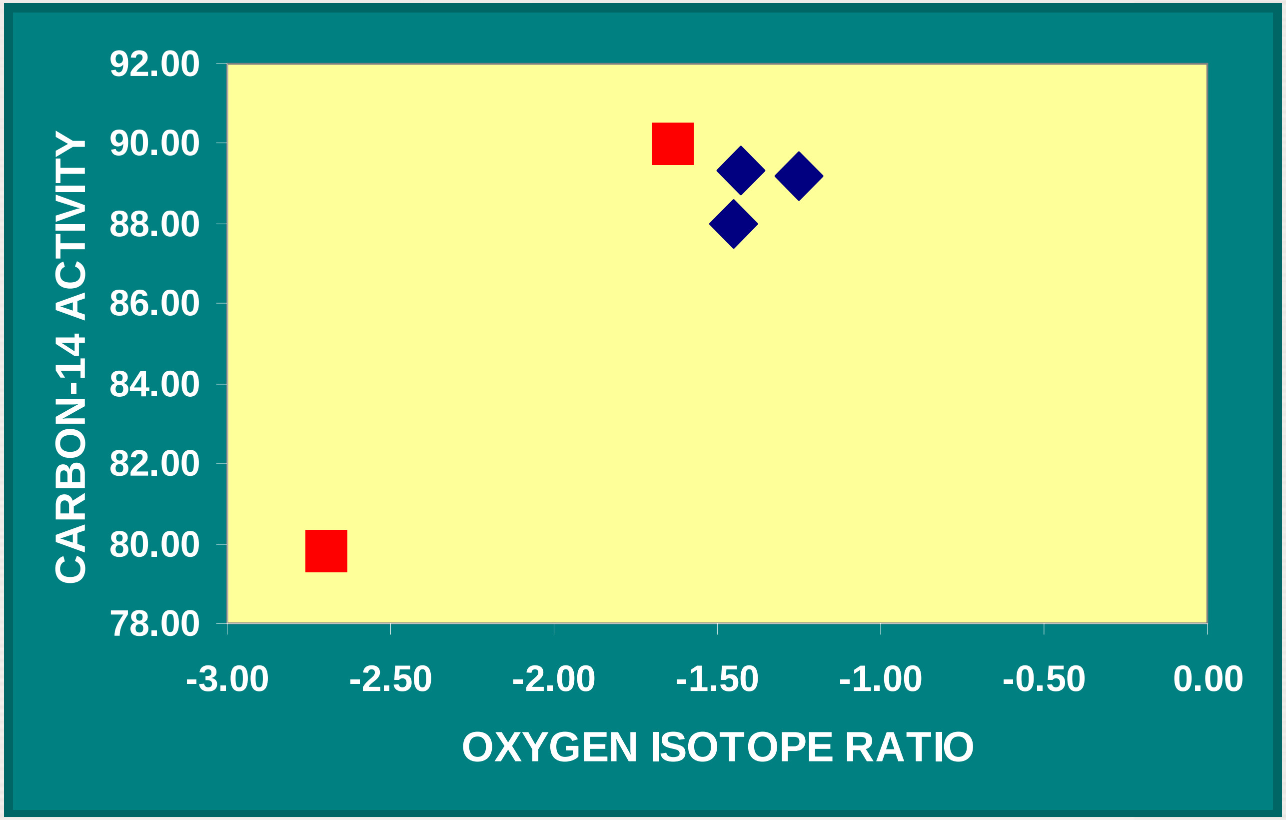
Fig. 4.3 Revised Hydro-geological Model Based on Isotopic and Hydro-chemical Data (Aggarwal, 2000)

Water Resources in Ethiopia

- Nation is heavily dependent on SW
- Most SW flows to surrounding countries
- Rainfall is not uniformly distributed in space or time
- Lack of knowledge of nationwide GW resource
- Lack of a National GW database

Groundwater Mapping in Addis Ababa, Ethiopia

Isotopes allowed determination of optimal groundwater pumping rates by providing a wealth of hydrologic information with a relatively small effort

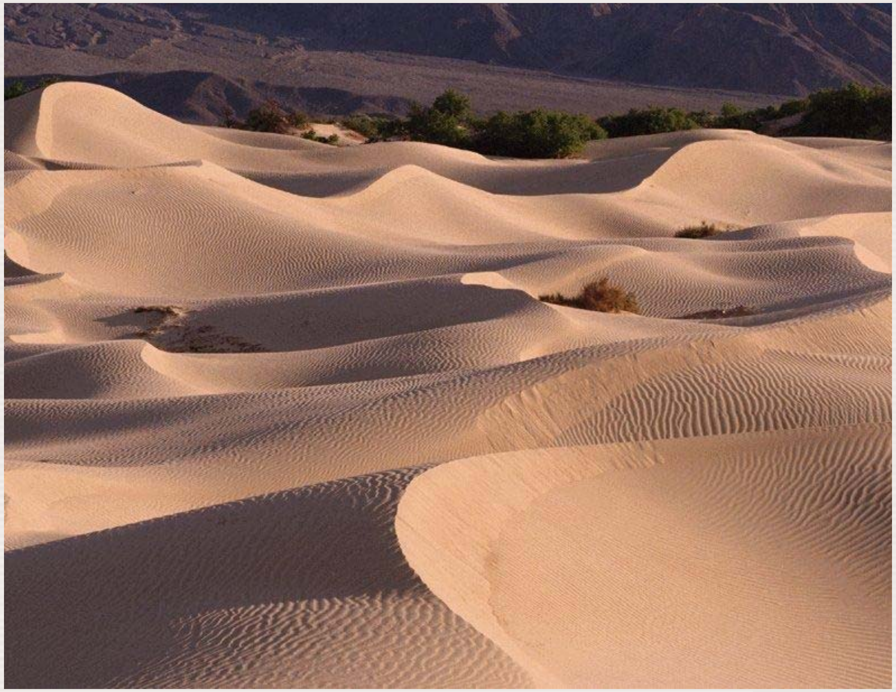


Source of Chuho Springs, Uganda

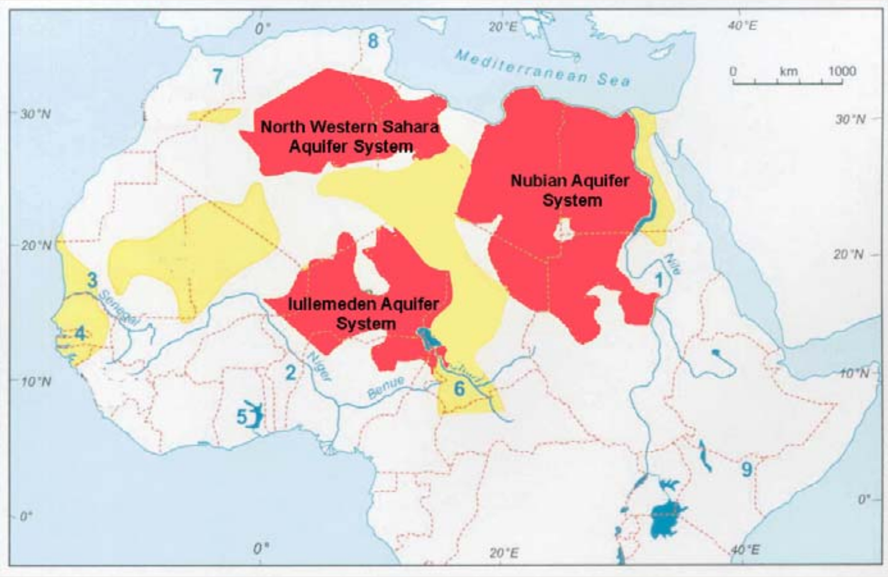
- Chuho springs, located north of the Kisoro town in Southwestern Uganda, are being tapped for local water supply. A concern had been raised about the long-term sustainability of these springs in terms of both quality and quantity of water.
- An IAEA Technical Cooperation project worked to determine the source of the springs and helped to determine groundwater protection zones.
- Implemented in cooperation with an Austrian Development Cooperation project.

Are our groundwater resources renewable?

- Many of the fresh groundwater reserves are in regions where climate is now arid or semi-arid, mostly recharged when the climate was wetter thousands of years ago.
- How do we know? Through the much lower relative concentrations of the heavy isotopes of hydrogen and oxygen in the waters (^{2}H and ^{18}O) as well as dating using natural radioisotopes such as ^{14}C. Only through the use of nuclear techniques can such information be gained and used as a warning to be judicious in exploitation of these reserves.



Science to Manage “Shared” Aquifers



- Over 400 transboundary aquifers worldwide
- Knowledge of aquifer systems needed to manage them;
- Current projects in the Nubian, NW Sahara and Iullumuden Aquifers

Isotope Hydrology and Space Technologies

- Link point source measurements (e.g. isotopes) with remote sensing to enhance models (global climate as well as gw conceptual models)
- Also efforts to measure isotopes with space technologies (e.g. NASA, Lidar)
- Potential cooperation in large transboundary aquifers