Natural Resources Canada | Ressources naturelles Canada

NATIONAL DIALOGUE ON GROUNDWATER (NDGW)

DIALOGUE NATIONAL SUR LES EAUX SOUTERRAINES (DNES)

September 8, 2021

Canada

OVERVIEW

1. Greetings (Éric Boisvert) – 5 minutes
2. Breaking News or New development (all) – 5 minutes
3. Presentation – 30 minutes (15 minutes each)
   – Dr. John Crowley, Sr. Geodetic Engineer, Surveyor General Branch, NRCan – Canada’s Changing Water: the gravity of the situation.
   – Dr. Kevin Parks, Chair of UNFC-UNRMS Groundwater Working Group, UNECE Expert Group on Resource Management - UNFC and UNRMS for Groundwater.
4. Questions (all) – 10 minutes
5. Wrap-up and next meeting on November 3 from 1 to 2 p.m. (ET)

Canada's Changing Water: the gravity of the situation

Dr. John W. Crowley

Canadian Geodetic Survey, Natural Resources Canada
Dept. of Earth and Environmental Sciences, U. of Ottawa

Collaborators: Jianliang Huang, Marc Véronneau, Goran Pavlic, Alfonso Rivera, Hazen Russell, Steven Frey

National Dialogue on Groundwater
September 8th, 2021

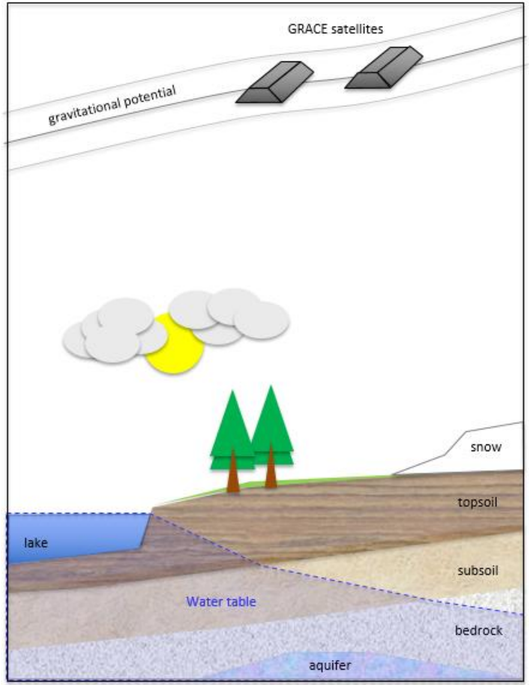
Motivation

- Water storage is changing across Canada
  - natural variability and climate change
- Observations are sparse
- Need to understand current state
- Model future state

Motivation

- Water storage is changing across Canada
  - natural variability and climate change
- Observations are sparse
- Need to understand current state
- Model future state
- Why me? gravity and water

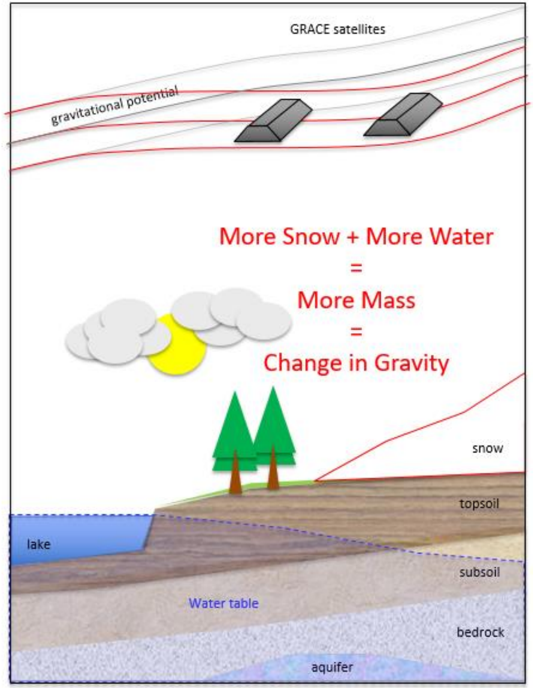
The Gravity Recovery and Climate Experiment (GRACE): How it Works



changes in water, ice, snow, etc. produce changes in local gravity

> 200 km

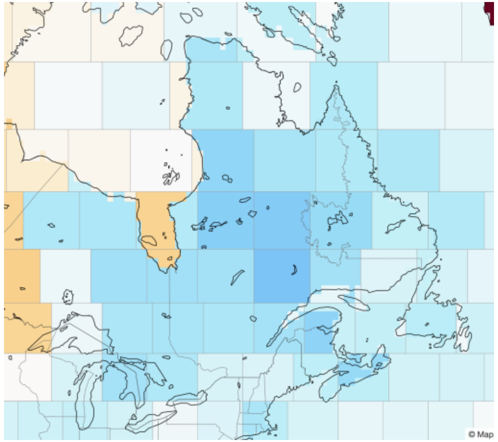
≥ monthly



GRACE at NRCan

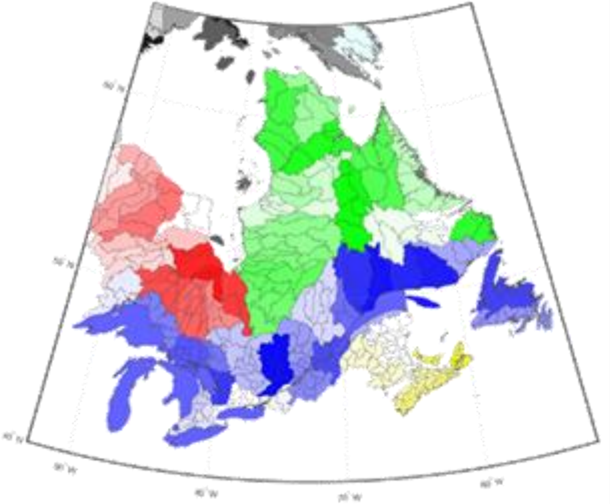
- We have developed state of the art methods for processing and analysis (e.g. Crowley et al. [2006, 2008], Huang et al. [2012, 2016], Crowley and Huang [2020])
- We contribute to leading edge international studies (e.g. Argus et al. [2020])
- We produce solutions that are developed and optimized for Canadian studies (e.g. geography)

JPL analysis geometry



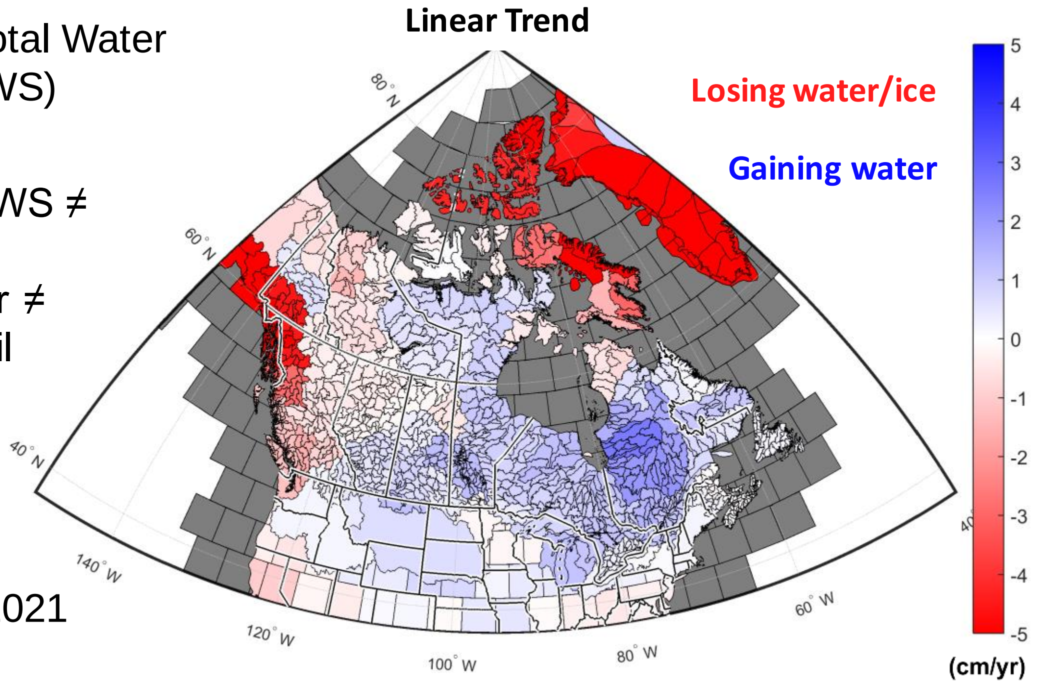
Example Analysis Regions

Our analysis geometry
-> built using drainage basins



National Scale Changes: Trends

- Trends in Total Water Storage (TWS)
- Trends in TWS ≠ trends in groundwater ≠ trends in soil moisture
- Trend calculated over 2002-2021



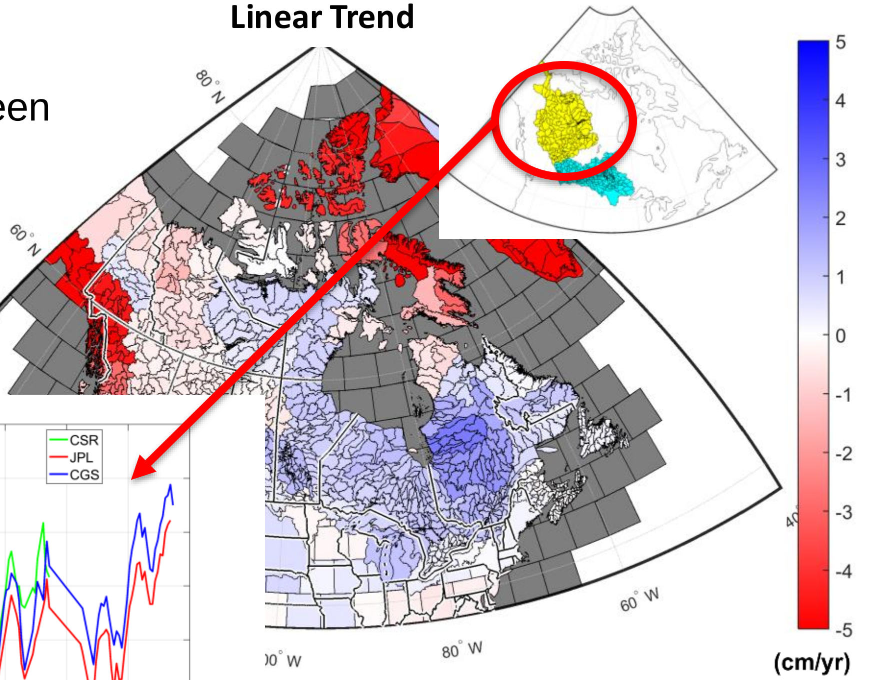
- Trends change over different periods of time

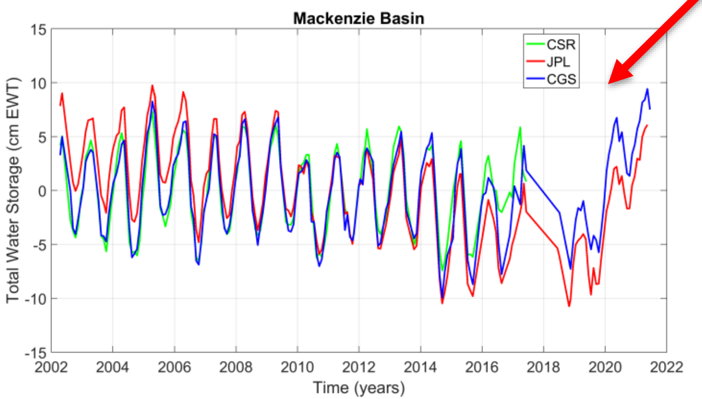
1 cm EWT
≈ 1 km^3

National Scale Changes: Trends

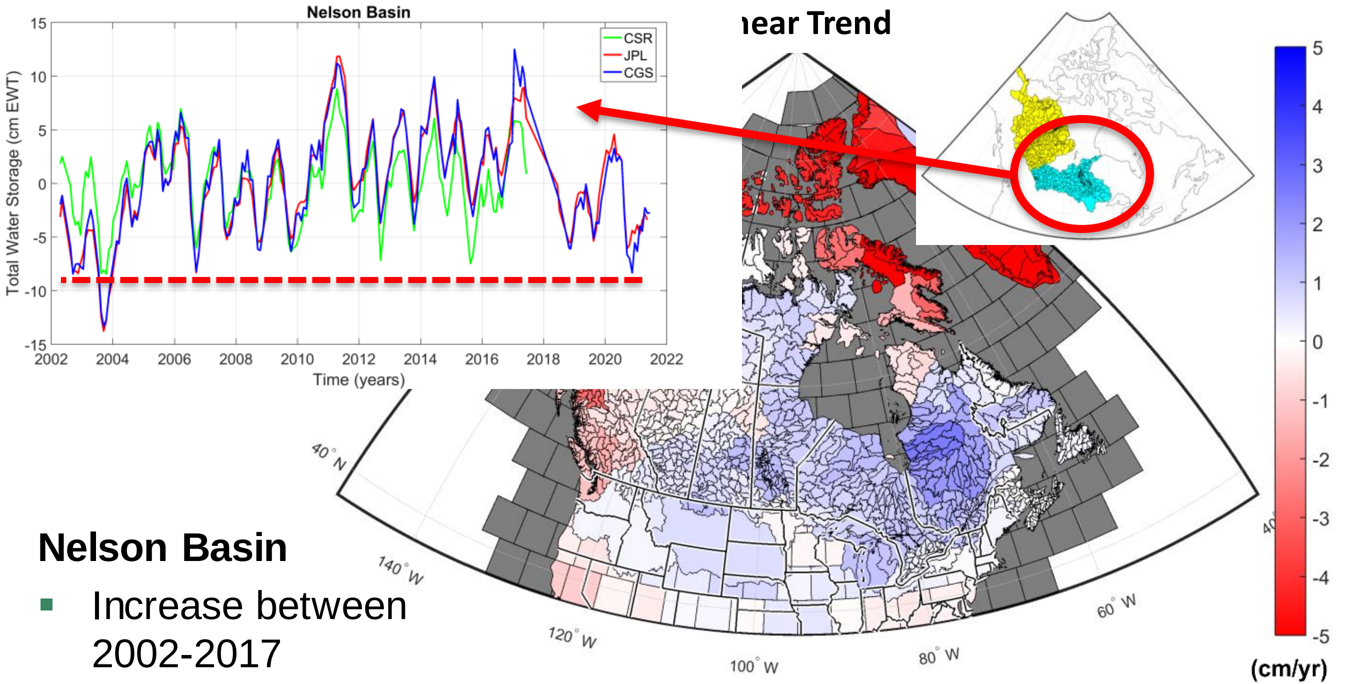
Mackenzie Basin

- Drop in storage between 2002-2017
- Increase since 2018
- Annual change of ~ 300 km³ water





National Scale Changes: Trends



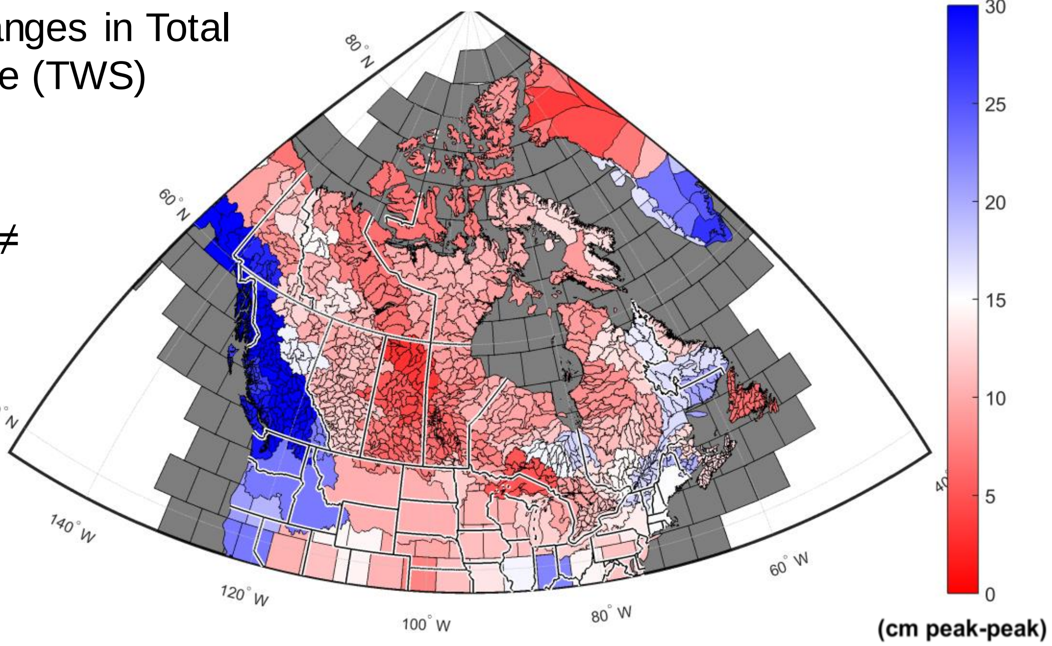
Nelson Basin

- Increase between 2002-2017
- Decrease in storage since 2018 of ~ 50-100 km^3 water
- Water storage at its lowest in two decades

National Scale Changes: Seasonal

- Seasonal changes in Total Water Storage (TWS)
- TWS ≠ groundwater ≠ soil moisture, etc.
- Seasonal calculated over 2002-2021

Mean Seasonal Amplitude

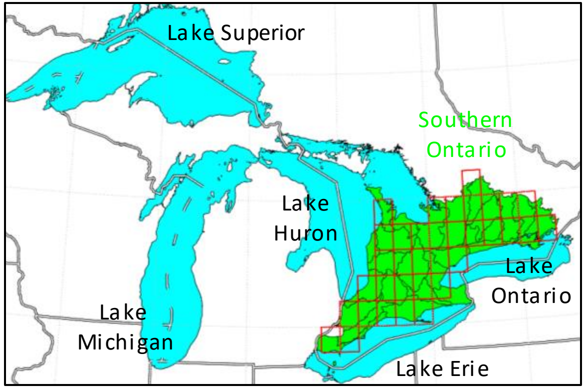


1 cm EWT ≈ 1 km³

- Seasonal amplitudes change over different periods of time

Comparison and Validation in the Great Lakes Region

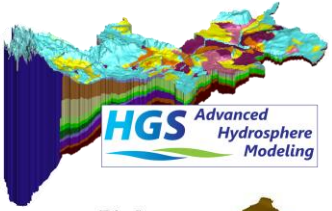
- How accurate is GRACE?
- The Great Lakes region is an ideal test site
  - Size – limits of GRACE
  - Change in mass (water)
- The area is closely monitored as it is
  - a shared Canadian/US resource
  - one of Canada's most populous regions
- Good models exist for comparison



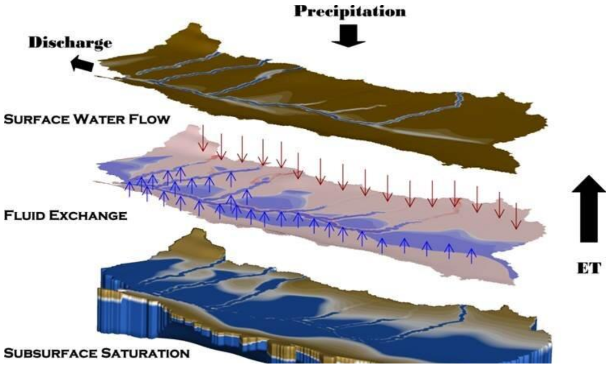
The green region shows the study area of Southern Ontario. The red squares show the location of grid elements from the CSR and JPL regions that are averaged over for comparison. The analysis region has a surface area of ~80,000 km^2.

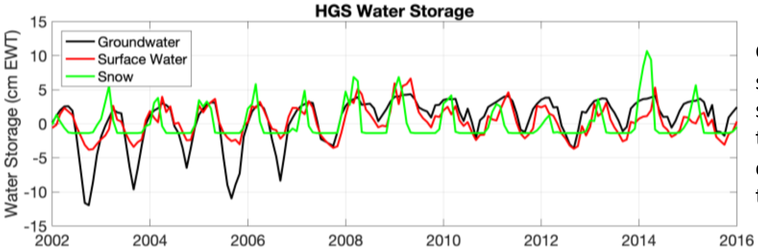
Comparison and Validation in the Great Lakes Region

- Total water storage variations for Southern Ontario were calculated by Aquanty using their software Hydrogeosphere (HGS).
- This software combines
  - The most detailed 3D geological information available
  - A dense network of groundwater wells
  - Surface water observations (e.g. streamflow)
  - Weather forcing (snow, precipitation, evapotranspiration)
- The software provides
  - Soil moisture
  - Groundwater
  - Surface Water



Aquanty Hydrogeosphere

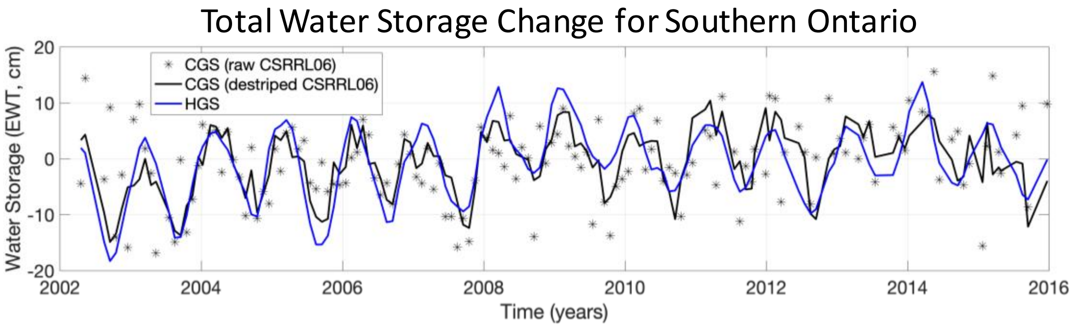




Groundwater, surface water, and snow from HGS. The total water storage change is the sum of these components.

Comparison in the Great Lakes Region

Water storage changes for Southern Ontario from GRACE using the raw CSRRL06 solution (stars) and the CGS destriped solution (black). Water storage changes from HGS (blue) for comparison.

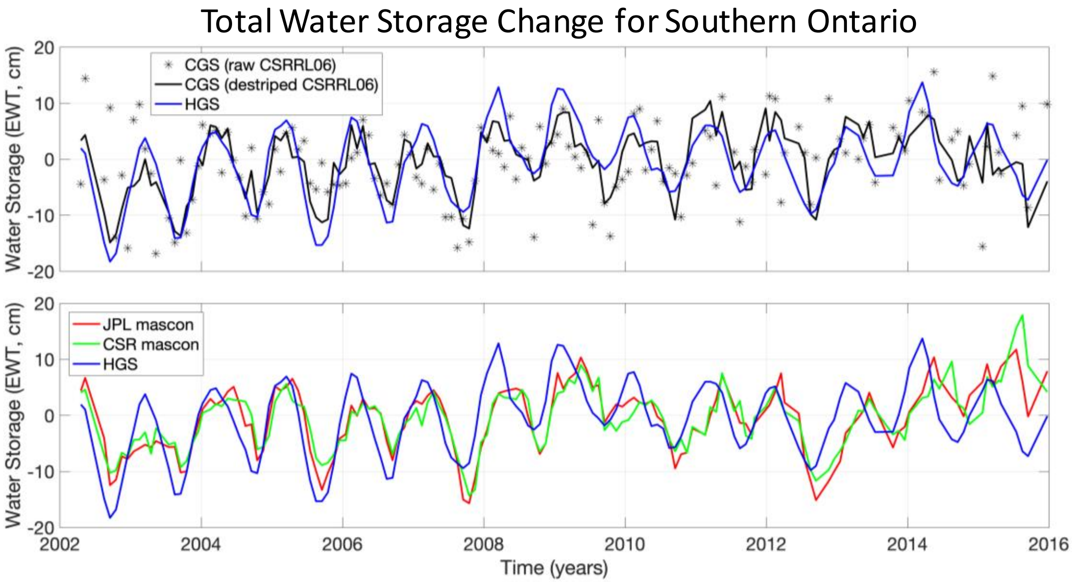


- The destriped solution using the method of Crowley and Huang (2020) is significantly improved over the raw CSRRL06 spherical harmonic solution.

Comparison in the Great Lakes Region

Water storage changes for Southern Ontario from GRACE using the raw CSRRL06 solution (stars) and the CGS destriped solution (black). Water storage changes from HGS (blue) for comparison.

Water storage changes for Southern Ontario from the CSR (green) and JPL (red) mascon solutions. Water storage changes from HGS (blue) for comparison.



Correlation between HGS and GRACE solutions

Correlation	HGS
CGS Raw	0.44
CGS Destriped	0.82
CSR Mascon	0.56
JPL Mascon	0.51

- The destriped solution using the method of Crowley and Huang (2020) is significantly improved over the raw CSRRL06 spherical harmonic solution.
- The CGS destriped solution agrees much better with the water storage changes modelled through the 3D hydrogeology model (which amalgamates many water storage observations).
- A slight phase shift is present in both the CSR and JPL solutions. This is likely the result of coarse mascons covering parts of the Great Lakes themselves (which are delayed in phase).

Canada 1 Water

To develop a national scale groundwater-surface-water modelling platform for the continental portion of Canada to support sustainable economic development under climate change adaptation

- Collaboration between government, private sector, and academia
- Led by Steven Frey (Aquanty) and Hazen Russell (GSC/NRCan)
- Funded by Defense Research and Development Canada (DRDC)
- It will:
  - Model and forecast national scale groundwater and surface-water
  - Prototype a decision support system for various groundwater indices
  - Produce tools and datasets for the public domain to encourage wide use
  - Support strategic and operational decisions related to water quantity and climate impacts
  - Help address specific research questions related to groundwater, transboundary aquifers, hydroclimatology, and risk assessment

Summary:

- Water storage variations observed in gravity change
- Methods were developed and optimized for Canada
- GRACE can effectively monitor trends and seasonal variability in water storage
- Excellent agreement between observed/modelled water variations in southern Ontario and GRACE results
  - Validation
- Canada 1 Water: Characterize (large scale) state of Canadian water and model future scenarios
- Continue work using future gravity data

QUESTIONS?

john.crowley@canada.ca

The United Nations Framework Classification for Resources: New Draft Supplemental Specifications for Groundwater.

Dr. Kevin Parks, Canada;

On behalf of the Groundwater Working Group,
UNECE Expert Group on Resource Management

National Dialogue on Groundwater
September 8, 2021

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What is the UNFC?

“A Project-Based, Present View of Future Resource-Supply”

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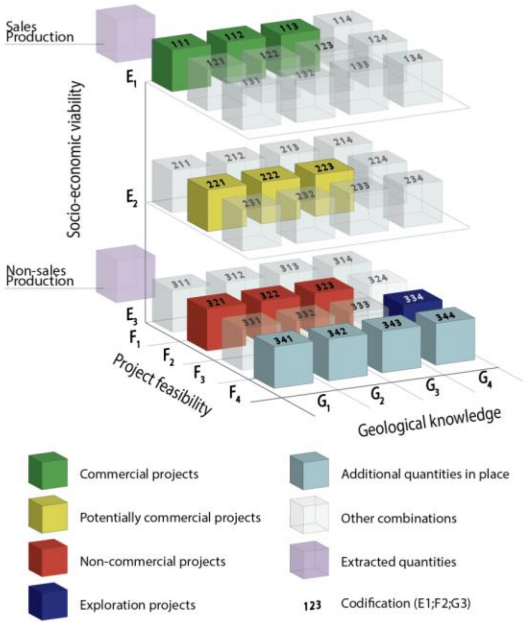

UNFC (2019) Supports the SDGs

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13 CLIMATE ACTION

6 CLEAN WATER AND SANITATION

1 NO POVERTY

2 ZERO HUNGER

10 REDUCED INEQUALITIES

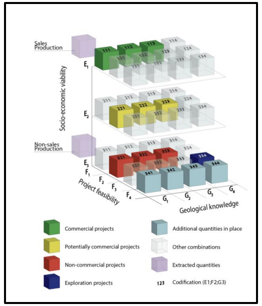
7 AFFORDABLE AND CLEAN ENERGY

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

11 SUSTAINABLE CITIES AND COMMUNITIES

17 PARTNERSHIPS FOR THE GOALS



Petroleum, Coal, Minerals, Metals, Geothermal, Solar, Wind, Nuclear

UNFC is a Key Enabler for Responsible Consumption and Production

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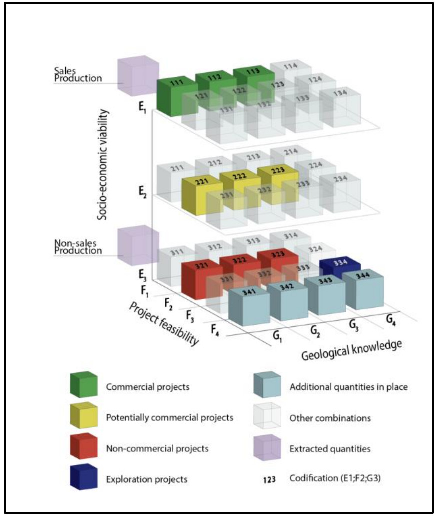

But What About Groundwater and the SDGs?

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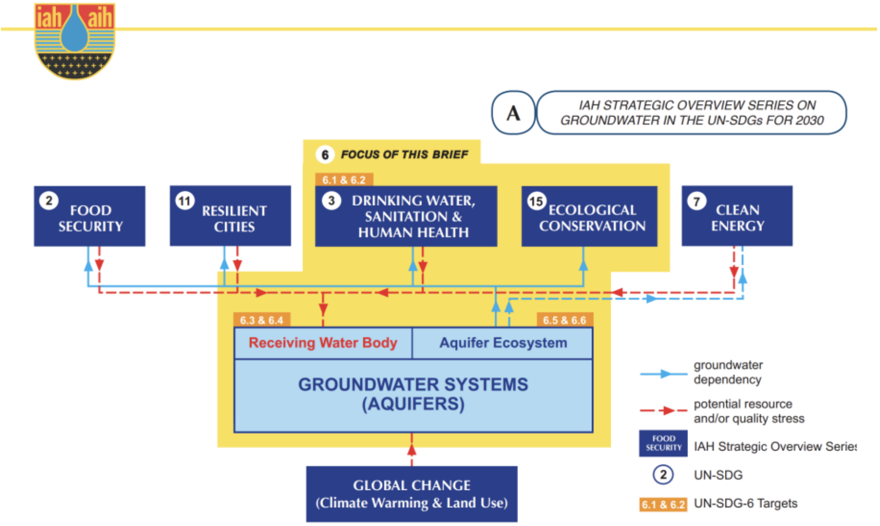
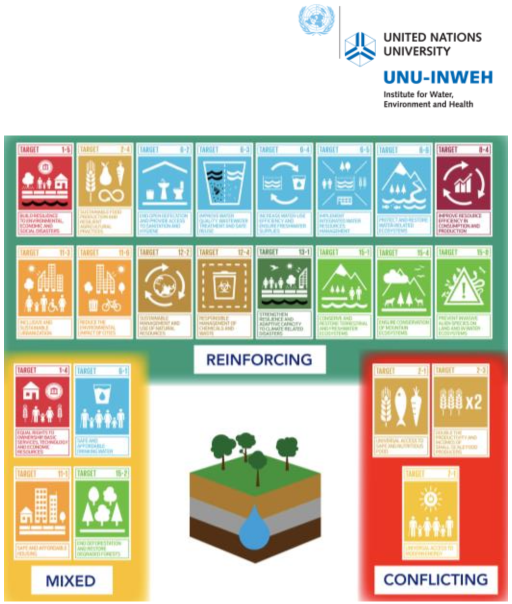


IAH : Foster et al., 2017



UNU-INWEH: Guppy et al., 2018

Groundwater is Important!

The World's Largest Extracted Raw Material by Volume

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- Groundwater is the world's most extracted raw material with withdrawal rates currently in the estimated range of 982 km^3 /year. [World oil production in comparison is ~6 km^3/year.]
- About 70% of groundwater withdrawn worldwide is used for agriculture.
- Groundwater provides almost half of all drinking water worldwide.
- Globally, about 38% of irrigated lands are equipped for irrigation with groundwater.
- The total volume of groundwater in the upper 2 km of the Earth's continental crust (not inclusive of high-latitude North America or Asia) is approximately 22.6 million km^3 , of which 0.1 million km^3 to 5.0 million km^3 is less than 50 years old (judged as "modern" or recently recharged).
- The volume of modern groundwater is equivalent to a body of water with a depth of about 3 m spread over the continents.
- Source: [Groundwater | Facts about global groundwater usage (ngwa.org)](ngwa.org) accessed 29/03/2021

Groundwater Added to UNFC Family in 2019!

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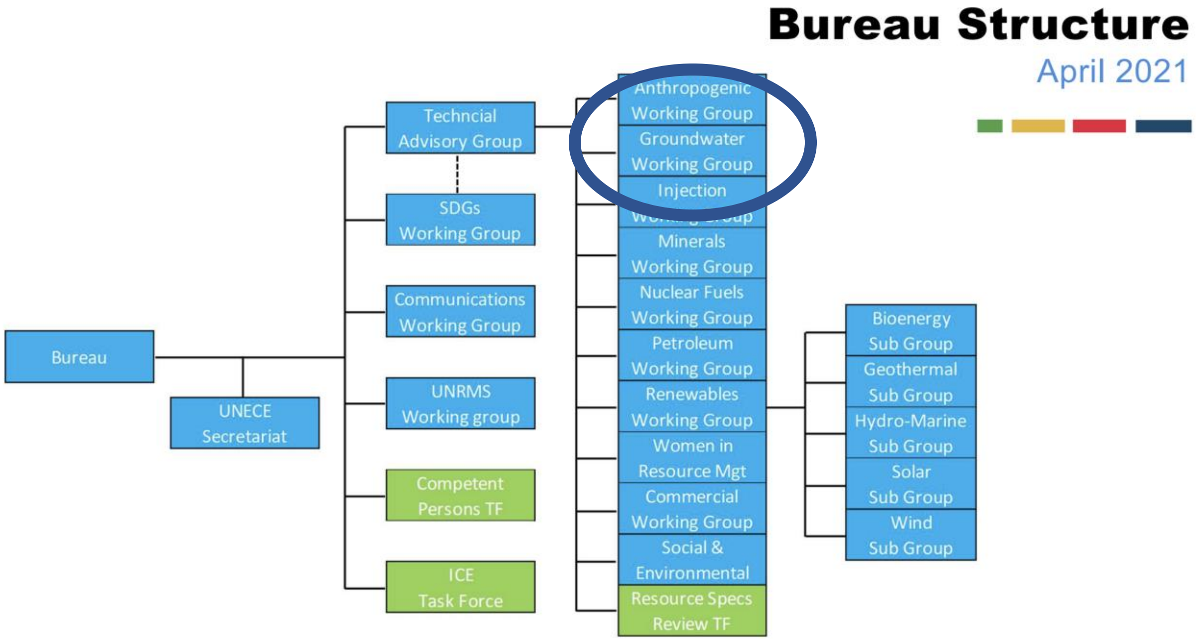

Responsible Use of Groundwater is a Key

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2 ZERO HUNGER

14 LIFE BELOW WATER

3 GOOD HEALTH AND WELL-BEING

15 LIFE ON LAND

6 CLEAN WATER AND SANITATION

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

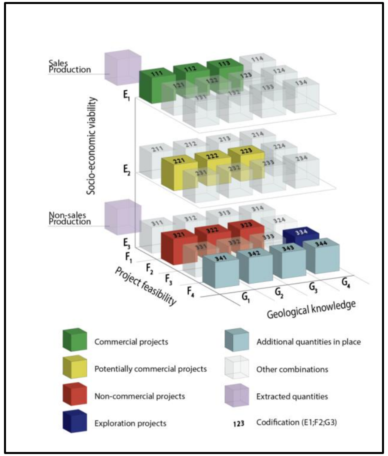
7 AFFORDABLE AND CLEAN ENERGY

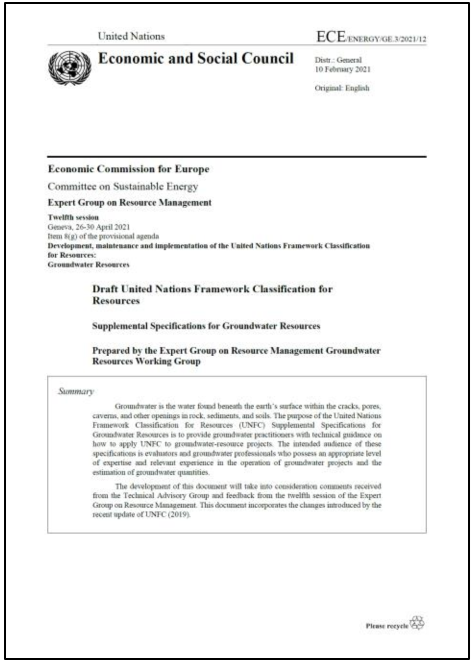
8 DECENT WORK AND ECONOMIC GROWTH

11 SUSTAINABLE CITIES AND COMMUNITIES

13 CLIMATE ACTION

Groundwater in the UNFC





United Nations

ECE/ENERGY/GE.3/2021/12

Economic and Social Council

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10 February 2021

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Economic Commission for Europe

Committee on Sustainable Energy

Expert Group on Resource Management

Twelfth session
Geneva, 26-30 April 2021
Item 8(g) of the provisional agenda
Development, maintenance and implementation of the United Nations Framework Classification for Resources:
Groundwater Resources

Draft United Nations Framework Classification for Resources

Supplemental Specifications for Groundwater Resources

Prepared by the Expert Group on Resource Management Groundwater Resources Working Group

Summary

Groundwater is the water found beneath the earth's surface within the cracks, pores, caverns, and other openings in rock, sediments, and soils. The purpose of the United Nations Framework Classification for Resources (UNFC) Supplemental Specifications for Groundwater Resources is to provide groundwater practitioners with technical guidance on how to apply UNFC to groundwater-resource projects. The intended audience of these specifications is evaluators and groundwater professionals who possess an appropriate level of expertise and relevant experience in the operation of groundwater projects and the estimation of groundwater quantities.

The development of this document will take into consideration comments received from the Technical Advisory Group and feedback from the twelfth session of the Expert Group on Resource Management. This document incorporates the changes introduced by the recent update of UNFC (2019).

Please recycle

Complicating Groundwater Aspects

Groundwater Moves, Projects Can Mutually Interfere

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- Groundwater moves. It moves naturally and under influence of climate, geology, land use, and resource development.

- Because it moves and transmits pressure change, groundwater projects interfere across both 3D space and time.

- In situ, groundwater performs valuable geotechnical and environmental services such as
  - Support to groundwater-dependent ecosystems
  - Baseflow to streams and rivers
  - Prevention of seawater encroachment
  - Prevention of land subsidence
  - Dilution, storage, and isolation of wastes.

- Groundwater quality is also an important aspect of developments. Quality is affected by natural mineral reactions, natural contaminants like iron or arsenic, and anthropogenic surface and subsurface contaminants from industrial and waste sources.

Challenges in Groundwater Governance

Highly Variable Governance and Legal Frameworks

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- Groundwater governance is very heterogeneous across and within nations.
- Project rights to groundwater may be accessed by a lease, license or commercial arrangement like other subsurface commodities, but more often is linked to social, traditional, historical, property, indigenous, or constitutional rights.
- Groundwater is described as a “common pool resource”: it is “subtractable”, meaning an extracted volume can only be used by one user at a time, and at the same time it is very difficult or expensive to deny access to its use or benefit by individuals.
- Because of interference between projects and across source, groundwater sources can be afflicted by “tragedy of the commons” where rational decisions made by individual actors acting in their own best interests can collectively harm everyone.
- Groundwater sources have a dual nature – groundwater is potentially renewable and non-renewable at the same time, depending on project parameters.

Creating UNFC for Groundwater: Our Starting Place

Groundwater is usually viewed through a resource lens, not supply.

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- Groundwater resources are usually mapped by geological surveys and environmental agencies. The traditional emphasis has been on resources in place, environmental flows, chemical quality and vulnerability to resources.

- There is no groundwater equivalent to PRMS, CRIRSCO, COGEH etc. in groundwater that would provide a picture of present and potential supply at the project level. UNFC for Groundwater has the opportunity to create this practice without reference to legacy systems, but the challenge is the international community of practice has no familiarity with this style of resource governance.

Structure of the UNFC Groundwater Specifications

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Enviro-Socio-Economic Viability

E-Score

Technical Feasibility

F-Score

The Project

Certainty in Estimates

G-Score

Groundwater Inventory

In Situ Services	• Environmental Flows • Geotechnical Functions • Cultural, Aesthetic
Socially Necessary Projects	• Domestic • Small Agriculture • Traditional
Projects linked to other commodities	• Oilfield produced waters • Mine dewatering

Innovations of the Groundwater E-Axis

Recognizing *In Situ* Services and Socially Necessary Projects

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- E-score needs to consider context of entire source because of groundwater's role in environmental flows of water, its in-situ service values, other types of development.
- E-score context has to be spatially beyond a project boundary because groundwater moves, and historical because changes in groundwater conditions propagate into the future past a project's lifespan, and then decay over long intervals of time.
- E-score needs to consider the existence and persistence of socially necessary projects that can fall outside formal licensing systems.
- Socially necessary projects are a new category that reflect the reality that small projects exist because of human need, sustainment of small farms, traditional practice, or purposely permissive or absent governance.




Implications of the Groundwater E-Axis

Why is this important for UNFC?

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- Groundwater practice everywhere is usually very sophisticated in terms of assessing environmental-social-economic impacts of groundwater projects.
- Other commodities and resources under UNFC – including wind and solar – impact groundwater.
- Other UNFC Specifications may need to defer or refer to the Groundwater Specifications to properly assess E-Scores (UNRMS).

Groundwater F-Axis

Promoting the adoption of feasibility ladders.

- Opportunities exist for better design practice in groundwater projects by using UNFC:

- Most groundwater projects have a fast path from inception to maturity in practice. This is because capital requirements of many groundwater projects tend to be small, the technology is well known, needs are immediate, and tolerance for failure is high.

- Using UNFC in Groundwater may catalyze better design, leading to better resource development, less waste of capital, and fewer project failures by promoting UNFC's use of laddered or phased approaches to groundwater development, as captured by the F-Axis score.

Implications for a Groundwater F-Axis

Moving from Least Cost to Best Available Technologies.

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- Because Feasibility ladders do not exist in groundwater practice, there is little drive to achieve anything like a BAT (best available technology) solution.
- The drive to get water at the lowest cost with old technology drives groundwater-project practice in unregulated areas and in unregulated sectors.
- Groundwater development, while celebrated by users, has an invisible footprint of environmental damage that needs better technology in projects to control and mitigate.

Challenges of the Groundwater G-Axis

G1+G2 is Recommended Reporting Level of Certainty in Estimate

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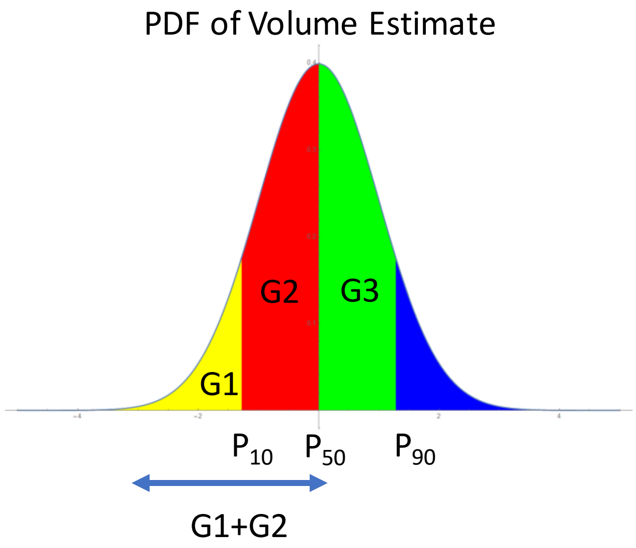
- UNFC G-Axis standard definitions use G1-G2-G3 hierarchy of certainty as derived from mineral and petroleum deposits, roughly coincident with the proven-probable-possible spectrum of reserves assignment.
- Groundwater specifications recommend use of G1+G2 (best estimate) as the standard for reporting project quantities as allowed by UNFC 2019.
- This recommendation is based on need to aggregate all claimed volumes in a groundwater source prior to setting a level for the E-axis score of a project.



Aggregation and Inventory

Need to be Embedded in Supplemental Standards for Groundwater

- Aggregation of all claimed volumes for projects in a groundwater source, socially necessary projects, and volumes need to sustain environmental flows and in situ geotechnical services need to be tracked to avoid double-counting and overdraft.
- Use of "best estimates" of G1+G2 makes high quality aggregation practical in an inventory.
- The UN's SEEA-Water schema already provides the necessary framework to support UNFC Supplemental Groundwater Specifications.

Groundwater Resources Working Group

Workplan 2021-2023

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- Groundwater Supplemental Specifications first draft delivered.
- Next steps in GRWG Workplan (2021-2023):
  - Proof of Concept/Case Studies in 4 areas:
    - Policy Formulation
    - Resource Management
    - Corporate Business Processes
    - Financial Capital Allocation.
  - Application Guidance including incorporation of SEEA-Water
  - Socialization with international communities of groundwater practice including
    - International Association of Hydrogeologists (IAH)
    - European Federation of Geologists (EFG)
    - National Roundtable on Groundwater – Canadian Geological Surveys

Thank you!

National Dialogue on Groundwater
September 8, 2021

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Thank you and see you all at the next meeting:

November 3 from 1 to 2 p.m. (ET)