Total and ground water storage variation from 10-year GRACE observations in Canada

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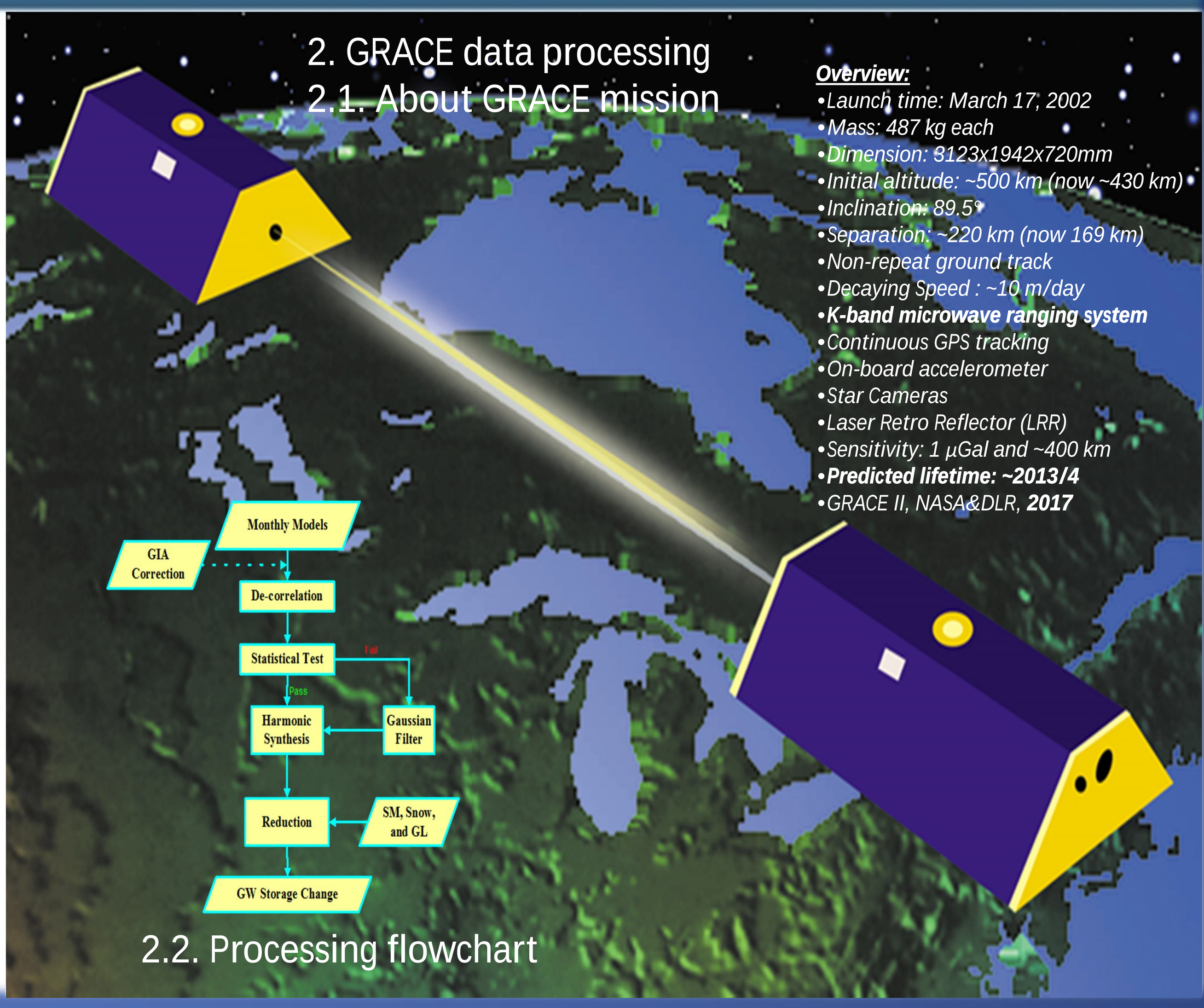
1. Objectives

Inter-annual and seasonal variations in total and ground water storage (TWS and GWS) are functions of rainfall, rates of runoff and evapotranspiration as well as soil moisture and GWS capacity. TWS changes are indicative of the magnitudes of the annual and inter-annual water cycles in Canada and its major river basins. In this study, we aim to quantify inter-annual TWS and GWS variations in three Canadian river basins (Mackenzie, Saskatchewan and Assiniboine), and seasonal variation in Canada using Release 5's monthly Earth's gravity models derived from GRACE (Gravity Recovery And Climate Experiment satellite mission) observations by the CSR, University of Texas, USA for the period of 2003-2012. The national TWS and GWS variations are shown as four seasonal maps of the GRACE-only and the GRACE combined with a land surface model for Jan.-Mar., Apr.-Jun., Jul.-Sep., and Oct.-Dec. averaged over 2003-2012. The inter-annual TWS and GWS variations for the three basins are shown as 10-year water-thickness-equivalent time series representing average water storage anomalies over the respective basins. The GRACE satellites do not directly observe the GWS variation, which needs to be separated from the GRACE TWS variation by removing surface water (SW) storage components: soil moisture, snow and ice, lake and river water storage variations. For the GWS separation, we use the SW storage variation predicted by the US NASA's Global Land Data Assimilation System (GLDAS) NOAH model and the NRCAN's Ecological Assimilation of Land and Climate Observations (EALCO) model.

2. GRACE data processing

2.1. About GRACE mission



2.2. Processing flowchart

3. Seasonal total water storage variation

3.1 10-year mean seasonal GRACE total water storage variation maps

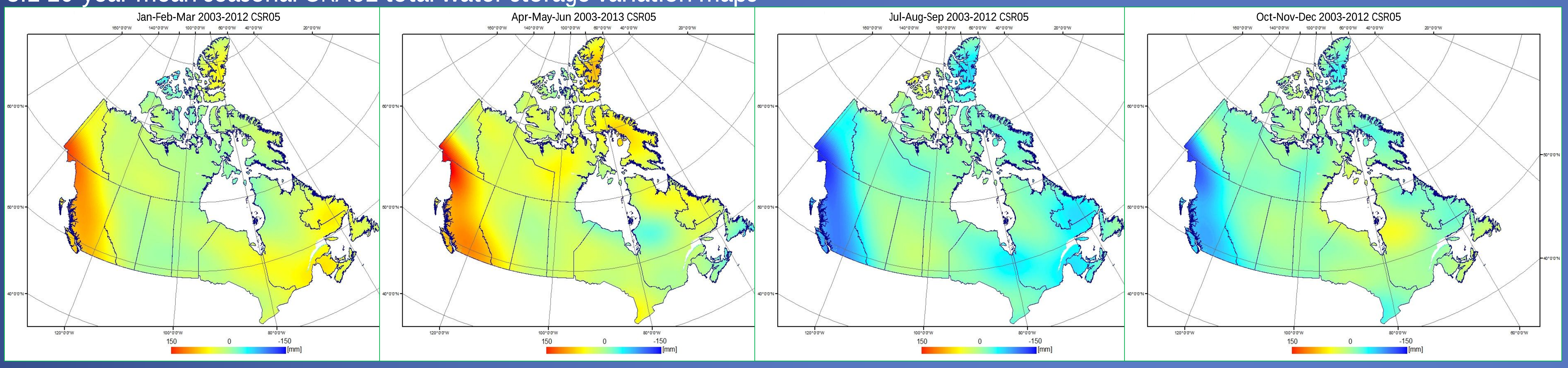


Figure 3.1 The GRACE-only TWS variations with respect to the mean storage state over 2003-2012 in four seasons: Jan.-Mar.; Apr.-Jun.; Jul.-Sep.; Oct.-Dec.. Each seasonal variation map represents the average for the corresponding season over 2003-2012. The range of the TWS variations is 60 mm in water-thickness-equivalent, or 597 cubic kilometres in volume.

3.2 Correlation between the GRACE total water storage variation and the soil moisture variation

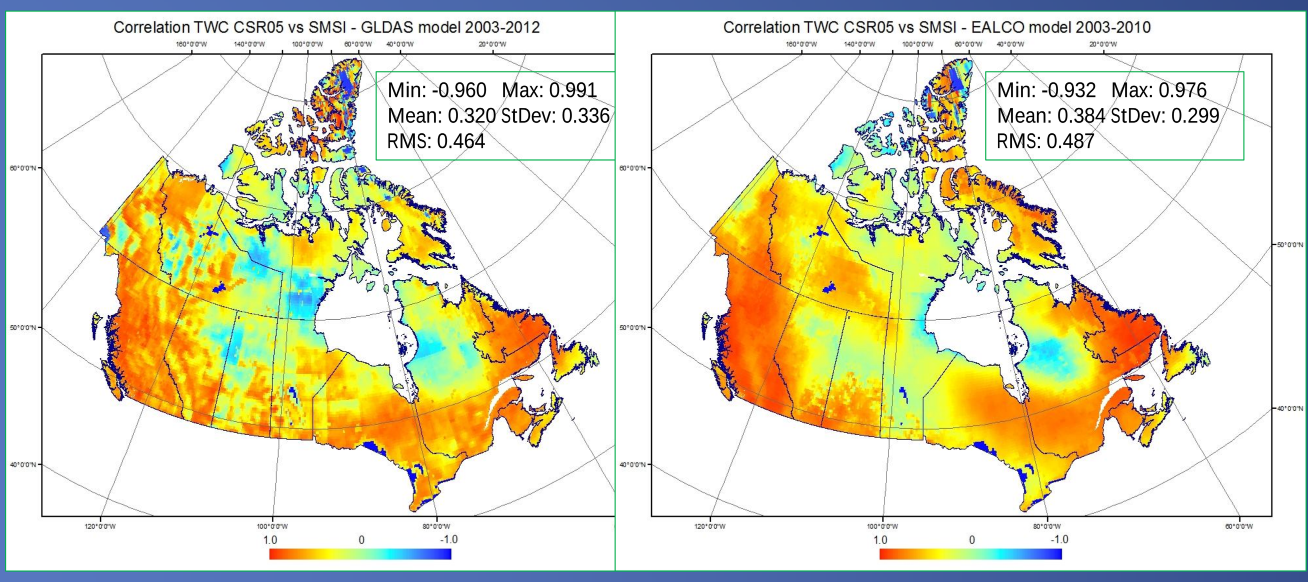


Figure 3.2 Correlation between the GRACE TWS variation and the GLDAS NOAH SW storage variation (left), and between the GRACE TWS variation and the EALCO SW storage variation (right). The EALCO SW storage shows slightly higher correlation with the GRACE TWS than the GLDAS NOAH SW.

3.4 Combined GRACE and GLDAS NOAH total water storage variation

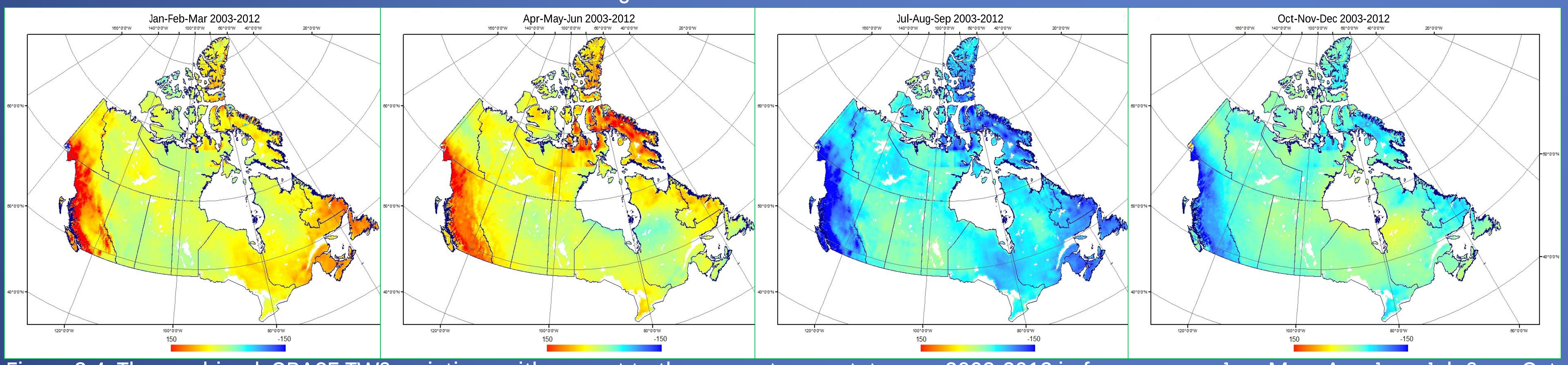


Figure 3.4 The combined GRACE TWS variations with respect to the mean storage state over 2003-2012 in four seasons: Jan.-Mar.; Apr.-Jun.; Jul.-Sep.; Oct.-Dec.. Each seasonal variation map represents the average for the corresponding season over 2003-2012. The range of the TWS variation is 99 mm in water-thickness-equivalent, or 980 cubic kilometres in volume.

3.3 Total and ground water storage anomalies in three Canadian river basins

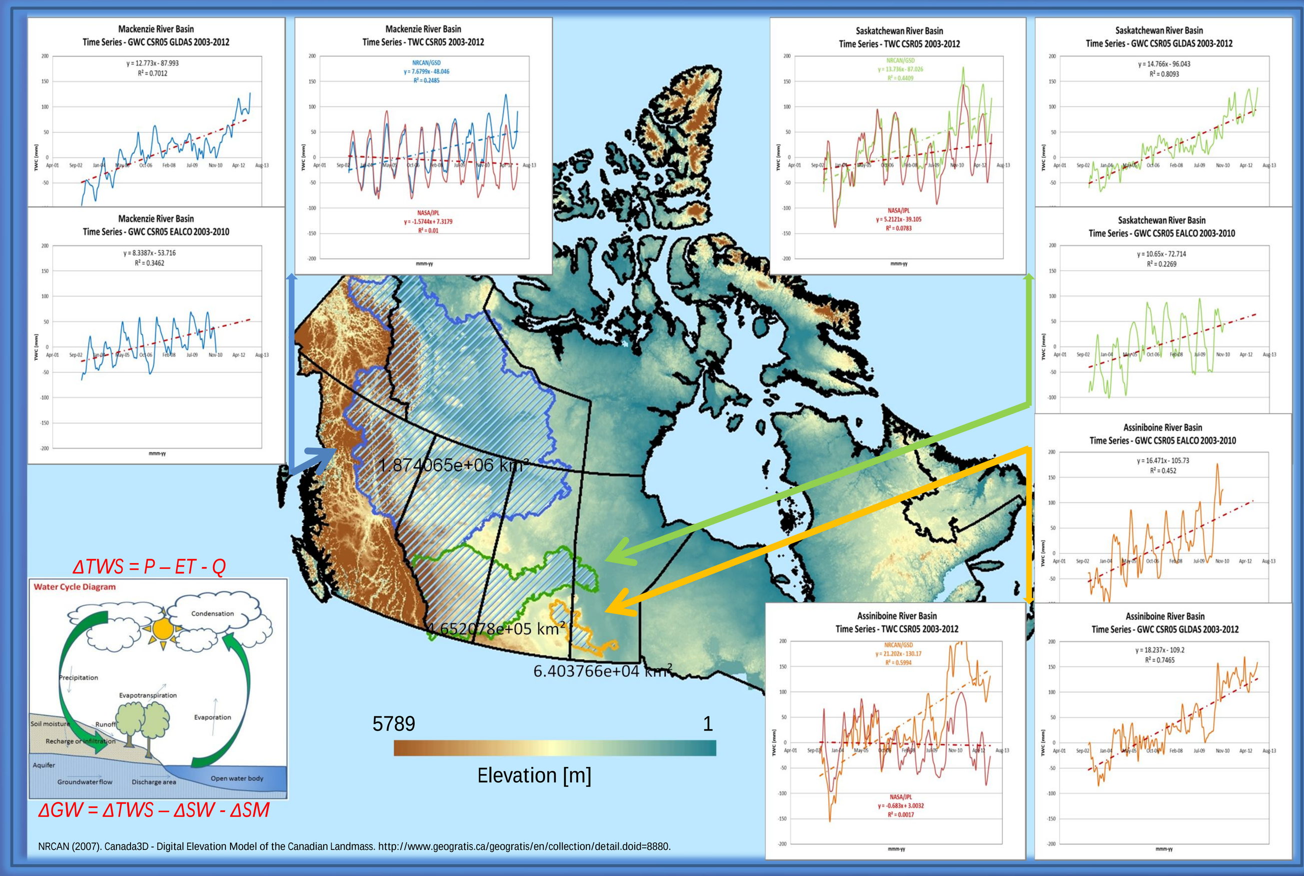


Figure 3.3 The TWS and GWS anomalies with respect to the mean storage states over 2003-2010 (using EALCO for the GW separation) and 2003-2012 (using GLDAS NOAH) in water-thickness-equivalent in the Saskatchewan, Assiniboine and Mackenzie river basins.

4. Seasonal ground water storage variation

4.1 10-year mean seasonal ground water storage variation

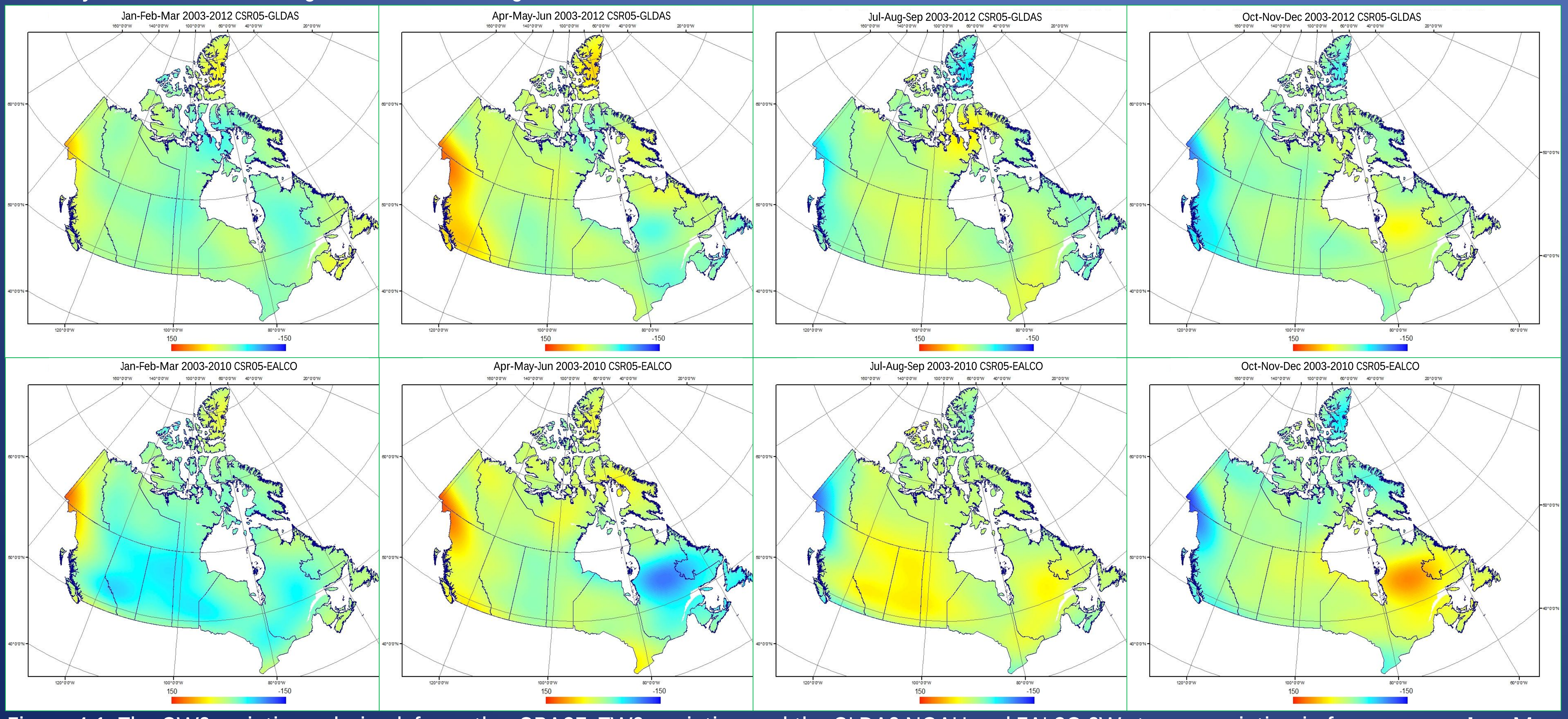


Figure 4.1 The GWS variations derived from the GRACE TWS variation and the GLDAS NOAH and EALCO SW storage variation in four seasons: Jan.-Mar.; Apr.-Jun.; Jul.-Sep.; Oct.-Dec.. Each seasonal variation map represents the average for the corresponding season over 2003-2012 (using GLDAS NOAH) and 2003-2010 (using EALCO), respectively. The range of the GWS variation is 18 mm in water-thickness-equivalent, or 174 cubic kilometres in volume using GLDAS NOAH, and 37 mm in water-thickness-equivalent, or 370 cubic kilometres in volume using EALCO in Canada.

5. Summary

We have derived the seasonal total water storage (TWS) variation maps from GRACE in Canada for the period of 2003-2012. Seasonal ground water storage (GWS) maps were further derived from the GRACE TWS by using the surface water storage components obtained from the GLDAS NOAH (2003-2012) and EALCO (2003-2010) models. We have also estimated the TWS and GWS anomalies in the Saskatchewan, Mackenzie and Assiniboine river basins for the period of 2003-2012, which show significant accumulation of water storage. A comparison with the NASA JPL's GRACE Tellus results suggests that the TWS accumulation estimates in the three river basins are largely dependent of the postglacial rebound correction.

6. References

GRACE Tellus, http://http://grace.jpl.nasa.gov/

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