On the spatial resolvability of superconducting gravimetry: SAGD and groundwater reservoirs

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Summary

The feasibility of resolving individual steam chamber plumes in steam-assisted gravity drainage (SAGD) reservoirs, and monitoring over-depletion of aquifers using superconducting gravimetry is investigated. Past work has shown that the iGrav superconducting gravimeter has the susceptibility (<0.5 microGal) to detect the density changes from replacing bitumen with steam in SAGD projects. Gravity and gravity gradient signals range from 3-20 microGal and 5-200 microGal/km. However, the individual steam chambers for each well pair (injection and production) can only be differentiated if the wells are at a sufficient separation and depth. SAGD operations are water-intensive, and utilizing proximate groundwater resources is preferable, as long as the water is sustainably extracted. Proper water management requires the monitoring of the water reservoirs and its depletion. Water pumping operations rely on groundwater replenishment by rivers or aquifers, and it is important to monitor the following parameters: depletion/replenishing rate, water source, and extraction rate of each source. Gravity and gravity gradient responses are forward modeled for river fed and groundwater fed aquifers, individually and in combination. This requires the incorporation of the following parameters: permeability, conductivity and depletion/replenishing rates. If a water pumping site is fed by groundwater and river, we investigate if the gravity signals for the two processes can be spatially separated, which directly contributes to an improved assessment of production sustainability. Two major obstacles have prevented the use of time-lapse gravimetry on small scale reservoirs, namely i) the need for sub-microgal sensitivity, and ii) the high noise levels in the vicinity of the reservoir. In this study, we demonstrate that both limitations can be overcome by using i) a portable superconducting gravimeter (iGrav by GWR), and ii) a pair of instruments under various baseline geometries. This will allow for the measurement of several gravity gradient components, resulting in improved spatial resolution for locating density anomalies, as well as the cancellation of common noise in both instruments. Finally, the optimal survey geometry can be determined to identify the spatial separation resolvability of two mass change events, and to resolve sub-reservoirs for SAGD and groundwater depletion.