Physical resources

Groundwater depletion measured from orbit (***September 2009***)

The NASA and German Aerospace Centre Gravity Recovery and Climate Experiment (GRACE) launched in 2002 aims to measure variations over time in the gravity field by gauging tiny changes in distance between two satellites using radar. The only significant changes in the short term are due to movements of water in one form or another. The best-known result from GRACE is its assessment of shrinking ice caps, and it can also detect shifting ocean currents and the drainage of lakes. The GRACE science team has noted a major change in gravity since launch over a nearly 3 million km^2 area of NW India centred on Delhi. The only conceivable mechanism is gradual loss of groundwater though irrigation of the Gangetic plains (Rodell, M. *et al*. 2009. Satellite-based estimates of groundwater depletion in India. *Nature*, v. **460**, p.999-1002; DOI:10.1038/nature08238). The authors estimate a decline of around 109 km^3 of groundwater since 2002 – more than twice the storage capacity of India's largest reservoir. In places local farmers are reportedly having to sink deeper and deeper wells as the water table sinks by over 6 m each year. The area is one of Asia's largest producer of food grains and occupied by 600 million people. Most likely there has been a surge in withdrawal for irrigation during poor monsoons in the early 21st century, for pumping rates seem to be 70% greater than they were in the 1990s.

Gas hydrates soon to come on stream? (*September 2009*)

The looming prospects of petroleum production outside of Arabia passing its peak and flexing of Russian economic power that stems from its control of the largest untapped natural gas reserves are spurring evaluation of methane production from gas hydrates in onshore frozen peat mires and marine sediments. Gas hydrates are more equitably distributed than are geologically older petroleum reservoirs: even Japan, which is currently entirely dependent on foreign supplies, has what appear to be huge offshore reserves of gas hydrates. Estimates of the world's potential resources are enormous, at around 2 x 10^{16} m^3 (annual US natural gas consumption is ~ 6 x 10^{11} m^3) but in a variety of sands and muds at different concentrations (Boswell, R. 2009. Is gas hydrate energy within reach? *Science*, v. **325**, p. 957-958; DOI: 10.1126/science.1175074). Experiments in northern Canada (see Onshore gas hydrate reserves close to recovery March 2004) indicates that drilling to induce lower pressure in gas hydrate bearing sediments induces dissociation of the hydrate crystals to release methane while retaining also present within their structure. Injection of CO_2 into deposits should displace methane while CO_2 enters the crystalline structure: killing two birds, including carbon sequestration, with one stone. The main technical stumbling block is that gas hydrates occur in unconsolidated sediments that may be destabilised during production, resulting in uncontrollable release of the powerful greenhouse gases as well as collapse of surface structures. From an environmental standpoint, all gas hydrates do is sustain reliance on carbon-based fossil fuels and continue emissions of greenhouse gases, though burning methane is a good deal 'cleaner' than coal or oil.