Geophysical Research Abstracts, Vol. 9, 04529, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-04529

Testing and verification of remote sensing techniques on a naturally-leaking CO_2 reservoir (Latera, Italy): implications for monitoring of CO_2 geological storage sites.

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The capture of carbon dioxide (CO_2) from large-scale fixed point sources, especially fossil-fuel (coal) based power plants, and its storage in deep underground geological structures is now being demonstrated at a variety of scales throughout the world. Given appropriate site selection, site characterisation, monitoring and history matching, and performance assessment, geological storage of CO_2 is likely to be very safe. Nevertheless, monitoring techniques may be needed to ensure public safety and acceptance, and to verify storage for carbon credits. Considering that monitoring areas are likely to be large, spatial methods need to be developed and verified that can define a limited number of points on which more detailed studies can be conducted; this will eventually reduce costs and increase the potential for successful intervention. Remote sensing techniques clearly have the capability of covering large areas, and thus have the potential to be used in pre-injection site characterisation (providing an environmental baseline), to assess site performance during injection and to monitor the long term security of the site. Despite this potential, very little has been published on the application of these methods for the monitoring of CO_2 geological storage sites.

To address this issue a preliminary study was undertaken within "CO2GeoNet", an EC Network of Excellence, involving the application and testing of air-borne techniques on the extinct Latera caldera in central Italy where deep-origin, naturally-produced CO_2 is released to the atmosphere from a series of gas vents. This area has served as an excellent natural laboratory for studying gas migration, examining the environmental impact of leaking CO_2, and the testing of various monitoring techniques both within the EC-funded Nascent project and within other CO2GeoNet studies. The large database on the Latera site thus made it an ideal choice for this remote sensing study. This project involved the collection of new data during two flights conducted in May and October of 2005, the interpretation of this data together with historical airphotos collected in 1990/91 and 1998/99, and finally the “ground-truthing” of the remote-sensing-defined anomalies via soil gas and gas flux surveys. The May flight was conducted using a highly modified Dornier 228-101 research aircraft (UK - NERC) containing an Airborne Thematic Mapper (ATM), a Compact Airborne Spectrographic Imager (CASI 2) and a Light Detection And Ranging (LIDAR) sensor. The October flight was done with an AS350 B2 helicopter (Italy – OGS) containing LIDAR, a high-resolution digital camera and a Hyperspectral sensor (AISA Eagle 1K).

Interpretation of the remote sensing data was first conducted on a small field where gas vents are known to occur, to better understand the response of each tool to CO_2-impacted vegetation and surface-exposed soil. The area of study was then expanded to a large sub-set of the total flight area (approximately 25%) and polygonal anomalies were visually defined for each of the six sets of processed data (i.e. NDVI-May, NDVI-October, ATM Thermal, Hyperspectral band 41, Casi band 12, and orthophoto). Polygons were grouped where they highlighted an anomaly at the same location, and the group was assigned a class according to how many techniques showed an anomaly for that location (i.e. from 1 to 6). A structural interpretation of the LIDAR data was also performed and combined with the classified polygon anomalies to highlight the areas of greatest potential for CO_2 leakage. Finally historical airphotos were also interpreted, both semi-automatically and manually, and these results were compared with the results from the two new flights. Soil gas (CO_2, CH_4 and He) and CO_2 flux measurements conducted on approximately half of the remote-sensing-defined anomalies showed an overall success rate of 39%, although surprisingly the highest classes did not yield the highest success rates. Examination of the six individual datasets showed NDVI October to have the highest success rate (46%) and Hyperspectral band 41 the lowest (31%); interestingly the latter is one of the bands used to calculate the former, thus showing that the NDVI process provides more information.

These preliminary results indicate the potential of remote sensing, combined with soil gas geochemistry, as a screening technique applied to the search for gas release points. Future research should be conducted to address a number of unresolved questions, such as: at what level of gas flow will a gas vent be recognised using remote sensing methods; what are the best remote sensing methods and why; what is the best season to fly and collect data; and what is the influence of other trace gases?