research into impacts & safety in CO_2 storage

The RISCS project aims to provide guidance regarding potential impacts of an unlikely CO_2 leak on a full range of the types of environments where CCS may occur throughout the EU region. For that reason the impact and safety of CO_2 storage is being studied by conducting field studies in **terrestrial environments** representative of such environments. These include the artificial sites ASGARD (Artificial Soil Gassing and Response Detection) and Grimsrud in UK and Norway, respectively and the natural CO_2 leaking sites of Florina field (Greece), Latera and San Vittorino (Italy) and Montmiral (France).

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SEVENTH FRAMEWORK PROGRAMME

Artificial Terrestrial Sites

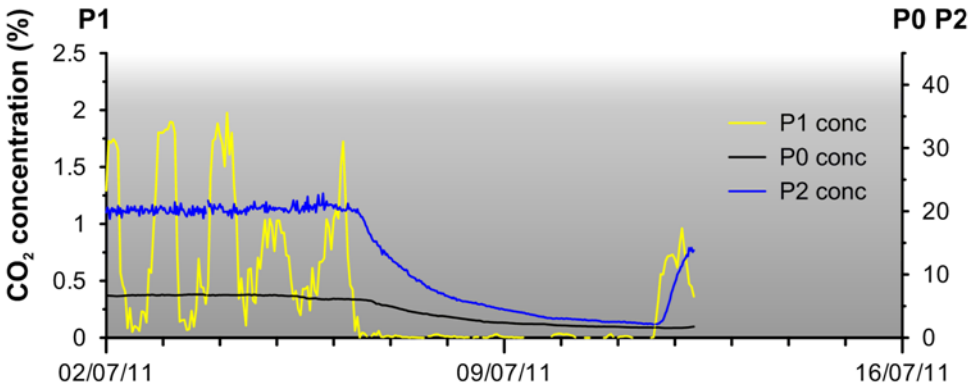
ASGARD, Nottingham, UK

At the University of Nottingham's ASGARD facility CO_2 gas is injected into the soil at a depth of 60 cm so that a range of responses of vegetation and soil ecology can be studied. Within the RISCS project, the University of Nottingham, British Geological Survey (BGS) and Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) have been studying the impacts of elevated CO_2 soil gas, injected at 1 L/minute on plots containing different crops, a grass/clover mix and existing pasture. Results to date have shown that plant stress can be observed within a few days of CO_2 gas injection.

ASGARD: Images of grass and clover plots showing a gassed plot (left) and a control plot (right).

In the pasture plots, grasses become predominant after 2 years of gassing. For all the plots, microbial numbers appear to decline with depth although analyses are not yet complete. Gassing of the plots has now finished and a final visit to the site in October 2012 will evaluate responses following a period of recovery.

Moreover, an autonomous station (designed and built by UniRoma1) was installed (together with BGS) to continuously monitor CO_2 concentrations in the soil (at two locations) and at ground surface during the CO_2 injection experiment. CO_2 concentration ranges and exposure times were determined and compared with other environmental parameters (e.g. wind, rain).



CO_2 concentration (%) over time at the ASGARD field

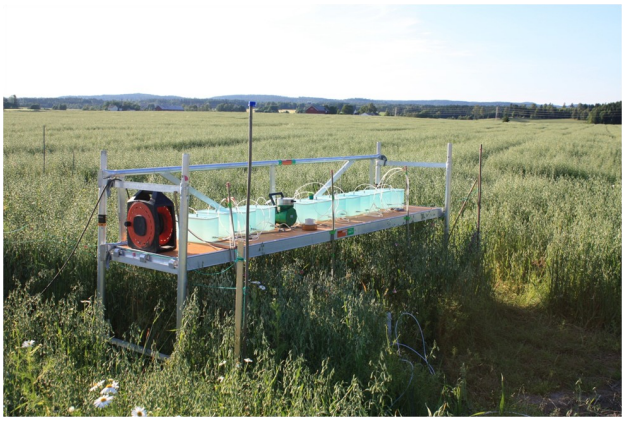
In the above figure, a two week block of time is reported which shows the levels and trends of the buried (P0 and P2) and surface (P1) probes before and during a gas shut-down and re-start. These results show the usefulness of this type of monitoring approach, particularly in terms of defining subsurface gas transmissivity and transient exposure rates.

Grimsrud, Norway

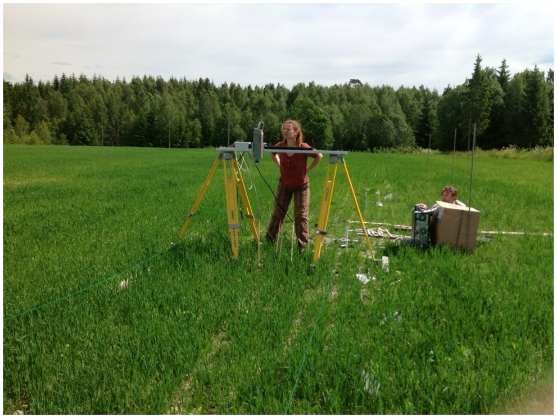
The Grimsrud CO_2 field experiment was designed to be complementary to that of ASGARD. The objectives were to simulate a CO_2 leakage, to track the leaking gas in the soil-atmosphere continuum within an oat crop, to monitor the possible induced impacts on the vegetation and to test the usefulness of isotopic measurements to fulfill the previous tasks.

The concept of the experiment was to create a CO_2 gradient within the soil and in the near surface to test different levels of exposure in a cropped field. To create this CO_2 gradient CO_2 was injected at 85cm depth in a permeable sand layer buried under a less permeable topsoil layer.

Four subsurface experimental injection plots (6m x 3m) were set up and gassed with labeled CO_2 ($\delta^{13}C$= -46,2‰) at rates ranging between 1 and 2 $l.min^{-1}$ in 2011 and 2012, respectively.



Mapping of the CO_2 within the canopy of the experimental plot



Mapping the reflectance of the crop canopy with an hyperspectral camera

Activities that were undertaken included:

* Continuous monitoring and punctual recoding of the soil CO_2 concentration and isotopic signature
* Recording of soil CO_2 fluxes and isotopic signature
* Estimation of the gas impact on vegetation

Results clearly showed that it was possible to track the injected CO_2 in the soil-canopy-atmosphere continuum and that it had an impact on the overlying vegetation. In addition, isotopic monitoring proved useful to detect the presence of leaking CO_2 in the soil and the atmosphere.

Naturally Leaking Terrestrial Sites

Florina, Greece

The Florina CO_2 field has been a producing field for many years. The gas accumulation occurs close to the surface (top of the reservoir at 300m depth). This naturally produced CO_2 leaks to the surface in various locations, with one specific field being chosen for detailed biological and chemical research.

Botanical studies have shown that at concentrations between 20-99% only dicotyledonous plants (Minurtia glomerata) were observed – this can be used as a bioindicator of high CO_2 soil gas. At concentrations below 20% monocots are dominant. Two indicator species were identified.

A semi-regional soil-gas and gas-flux survey was conducted in and around the studied site at Florina, Greece. Soil gas CO_2 concentrations range from normal background values less than 3% up to highly anomalous values in the centre of gas vents which can reach almost 100% at 70cm depth.

From the figure below it is clear that gas leakage occurs as a series of isolated "spots" that are aligned in a general NE-SW direction, which parallels one of the main fault directions in the region.

CO_2 flux and other measured soil gas species (not shown) define smaller anomalies due to their restricted occurrence within the central, high-flux core of the more significant gas vents.

CO_2 soil-gas and gas-flux survey outside Florina city.

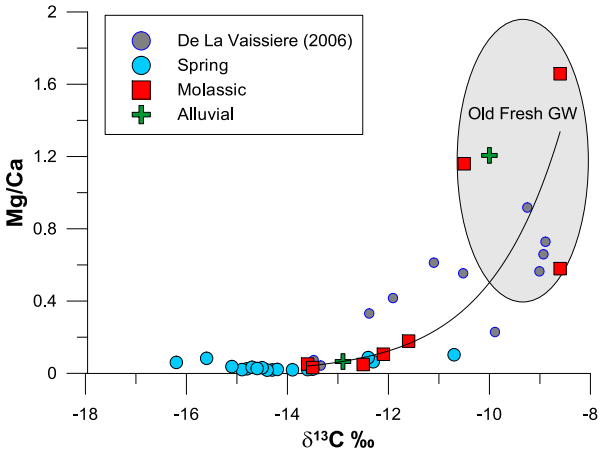
CO_2 gas and botanical measurements along a 25m transect.

Additionally, potential metabolic rates of e.g. anaerobic methane production in soil incubations and the microbial community composition using quantitative real time PCR (qPCR) and sequencing were investigated. Different CO_2 concentrations influence the CH_4 production rates. Trends of increasing copy numbers of Bacteria and Archaea along the transect correspond with decreasing CO_2 concentrations. The results so far show changes in the activity and community composition as a consequence of continuous CO_2 release.

Groundwater sampling along the entire basin and chemical analyses (pH and Eh buffering capacity, dissolved gas concentrations, major and trace elements etc) were conducted over a 3 year period. Geochemical evaluation of the latest campaign is still on going. In general, low pH values were observed along the major fault lines with a NE-SW direction. Elevated concentrations in some elements are related to the dissolution of minerals that enrich the water. However, the prolonged interaction of the CO_2 impacted water with the host rock has resulted in chemical equilibrium.

Montmiral, France

The Montmiral reservoir is located in the Rhône valley (France) and the gas content is 97-99% CO_2. Detailed analyses (major ions, metals, REE, ^{18}O, ^{2}H, ^{13}C, $^{87}Sr/^{86}Sr$) were performed on these aquifers within the framework of other EU projects (i.e. NASCENT). Geochemical and isotopic indicators were interpreted and the data show no evidence of CO_2 leakage. The geochemical anomalies that were observed are attributed to the age of the groundwater



Negative $d^{13}C$ isotopic signature associated with high Mg-concentrations

To conclude, the oldest waters have a specific geochemical signature but they don't give any evidence of deep CO_2 intrusion. These observations confirm that CO_2 could be safely trapped by geological formations for long-term or that a CO_2 leak might have no impact on fresh groundwater quality.

San Vittorino, Italy

Previous research in San Vittorino illustrated different changes in water chemistry as a function of proximity to leakage points and associated groundwater flow patterns. Most major and trace element concentrations increased in samples located in a north-central area where known and inferred faults cross the valley, although none of the samples had concentrations that made them un-potable. Although the main inferred mechanism for these geochemical anomalies was water-rock-gas interaction, the distribution of some tracer elements appeared to imply the co-migration of deep brines together with the CO_2.

Latera, Italy

Over recent of years the Latera site has been used as a natural laboratory. Results indicate that, even at this anomalous high-flux site, the effects of the gas vent are spatially limited and that the ecosystem appears to have adapted to the different conditions through species substitution or adaptation. Extensive botanical and microbial work has been already performed at this site. The research within the RISCS project will focus on the potential impact of the leaking CO_2 on water quality.

Bubbling pool, where large volumes of primarily CO_2 are released together with spring water, San Vittorino .

Measurement profile conducted across an individual gas vent within the Latera caldera.

Past Events

Euroscience Open Forum (ESOF)

date & place: 11-15 July 2012, Dublin, Ireland

In an interactive game we pretended we were a nation whose Prime Minister needed to assess the impacts of a new promising technology for reducing emissions, carbon capture and storage (CCS). He took a very democratic approach to it and decided to get advice from a number of different sources, such as the Ministry of Environment, Industry, Journalists, Lay people, Mums, Primary schoolchildren and High school students.

RISCS's researchers first helped the group get started and then they were available to answer the participants' questions and in general for interacting with the group and providing information.

* BGS Press release
* What is the impact of sustainable energy technologies? RISCS team

The “stakeholders” are meeting the “Prime Minister” as to express their opinion regarding the new technology proposed.

Introducing the game and creating the groups.

Upcoming Events

GHGT11, 18th - 22nd November 2012, Kyoto, Japan

Accepted abstracts for poster presentations:

* *Modelling dispersion of CO_2 plumes in sea water as an aid to monitoring and understanding ecological impact*. J.C. Blackford, R. Torres
* *Hypothetical Impact Scenarios for CO_2 Leakage from Storage Sites* A. Paulley, R.Metcalfe, M. Egan, P. R. Maul, L. Limer, A. A. Grimstad, and the RISCS Project Team
* Systems analysis of field and laboratory experiments considering impacts of CO_2 leakage in terrestrial systems A.E. Bond, R. Metcalfe, N. Chittenden, P.R. Maul, P. Suckling, K. Thatcher, R. Walke, K. Smith, D. Rasse, D.G. Jones,
* *Environmental impacts of CO_2 leakage: recent results from the ASGARD facility, UK*. K.L. Smith, M.D. Steven, D.G. Jones, J.M. West, P. Coombs, K.A. Green, T.S. Barlow, N. Breward, S. Gwosdz, M. Krüger, S.E. Beaubien, A. Annunziatellis, S. Graziani and S. Lombardi
* *Simulated CO_2 leakage experiment in terrestrial environment: Monitoring and detecting the effect on a cover crop using ^{13}C analysis*. C. Moni, D.P. Rasse, and the RISCS Project Team

Accepted abstract for oral presentation:

* *Potential environmental impacts of CO_2 leakage from study of natural analogue sites in Europe* F. Ziogou, V. Gemeni, N. Koukouzas, D. de Angelis, S. Libertini, S.E. Beaubien, S. Lombardi, J.M. West, D.G. Jones, P. Coombs, T.S. Barlow, M. Krüger and S. Gwosdz