Simulated CO_2 pipeline networks for CCS in France

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The study

France has practically no CO_2 pipeline infrastructure today. Using *SimCCS*, a CO_2 system model developed by Middleton and Bielicki (2009), we asked:

- Considering a couple of plausible scenarios for the future of the technology in the country, do we find any **common pipeline corridors** to all solutions?
- How does an optimal network changes when **doubling the storage** goals?

Simulations consider storage goals varying from 10 to 60 $MtCO_2$/yr, include the forty largest CO_2 sources in France, which together emit 80 $MtCO_2$ /yr, and contrast two storage policies:

- An ”onshore scenario”, where storage is permitted only in the Paris basin aquifers;
- An “offshore scenario” exports CO_2 towards the North sea through Normandy and toward an hypothetical storage option reachable off the Mediterranean shore.

Summary of results

The model builds about 2 500 km of pipelines for the 60 $MtCO_2$/yr target. Reaching this number in 30 years would require about 83 km of new pipeline per year. We found that the average system cost in the “onshore scenario” is about 52 $/t$CO_2$.

The qualitative optimal strategy is to call the sources in the order of increasing capture cost, and connect those to the available sinks. This is because capture costs represent 70% to 90% of capture costs.

Three pipeline corridors are common in all cases if CCS is deployed in France. Small-scale network layouts are compatible with larger-scale ones, altough the capacities (i.e. pipeline diameters) differ: it may be socially interesting to oversize some corridors at the early stages.

Figure 1 compares the two scenarios for a common 30 $MtCO_2$/yr target, while **Figure 2** compares two targets (30 $MtCO_2$/yr and 60 $MtCO_2$/yr) for the same “onshore scenario” (left on Figure 1). Three segments of network are always apparent: one is in the East of France (Lorraine region – **A** on figure 1), another one is in the North of France (Nord–Pas de Calais region – **B**). Also, scenarios with targets over 20 $MtCO_2$/yr use a corridor along the Seine river between Paris and Le Havre (**C**).

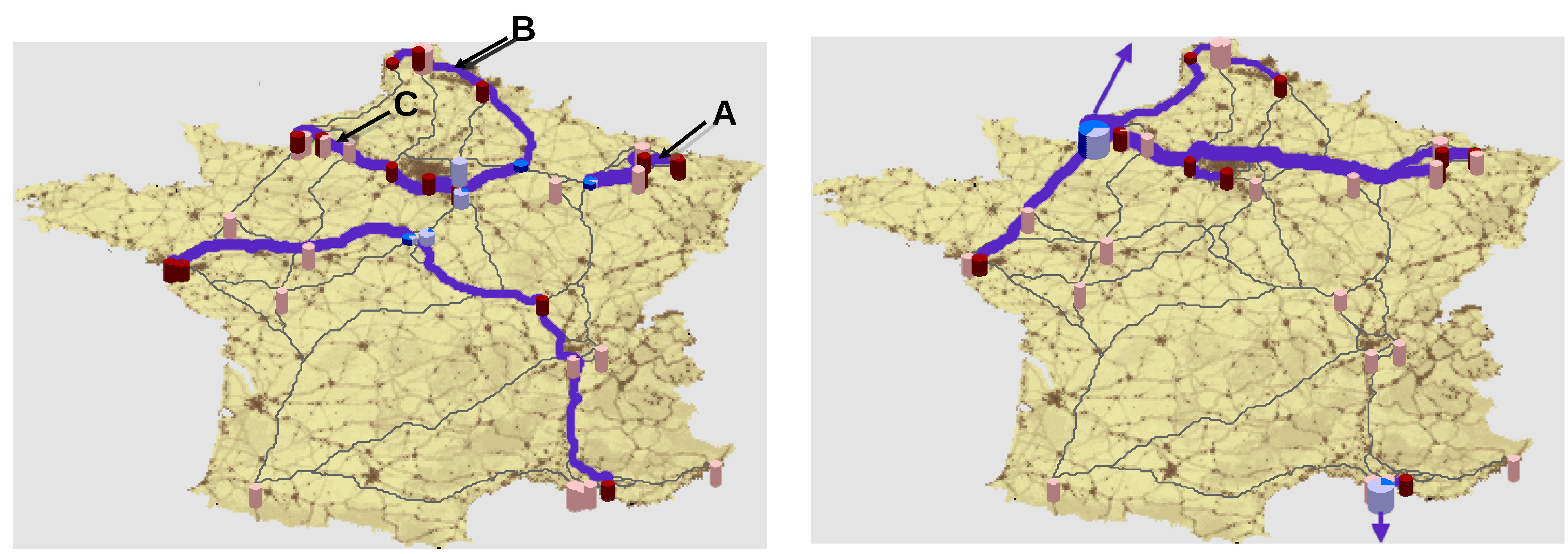


Figure 1. Optimal CCS network for 30 $MtCO_2$/yr in France for the “onshore scenario” (left) and the “offshore scenario” (right). Captured sources are in red, non-captured sources in pink, sinks in blue, unused sinks in light blue. The network is in purple. Purple arrows symbolise pipelines linking a hub to an hypothetical offshore reservoir.

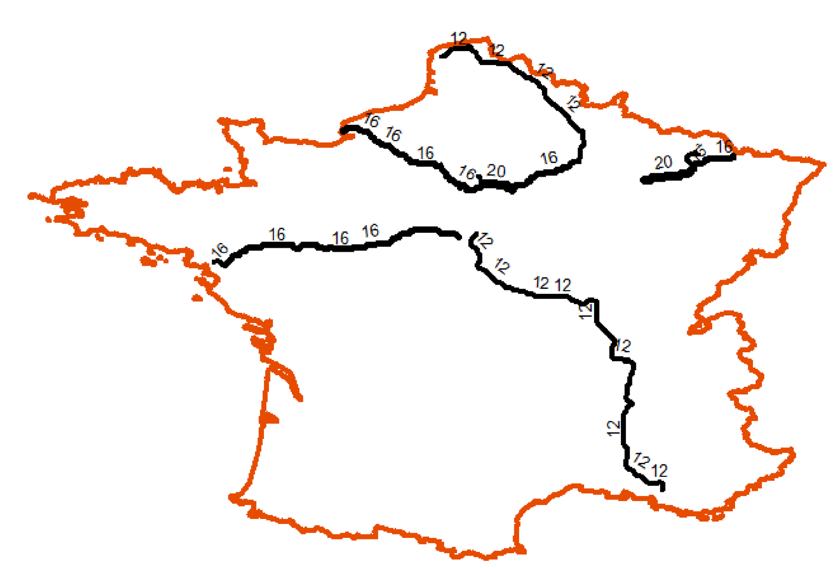
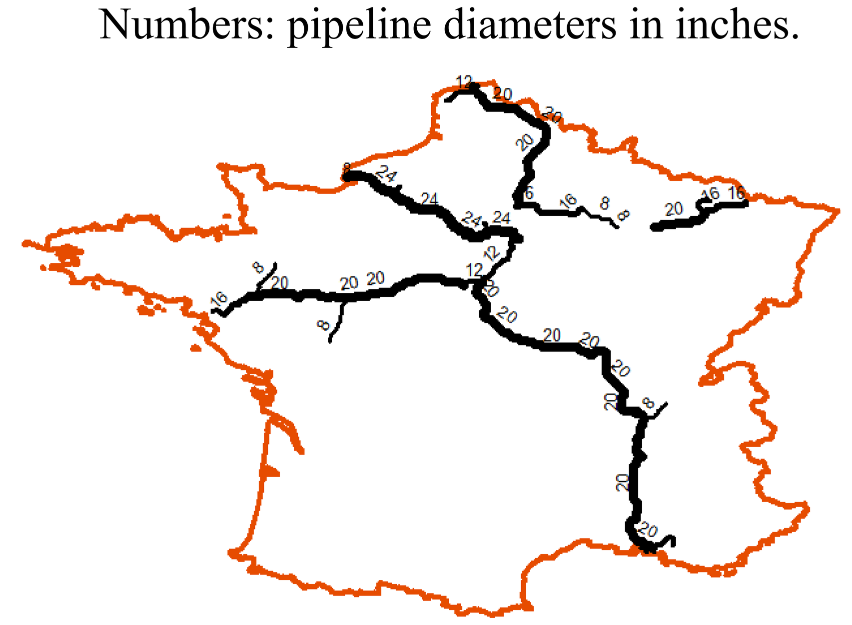


Figure 2. CCS pipeline for the “onshore scenario” for two different CO_2 targets: 30 $MtCO_2$/yr (above) and 60 $MtCO_2$/yr (below). Numbers: pipeline diameters in inches.



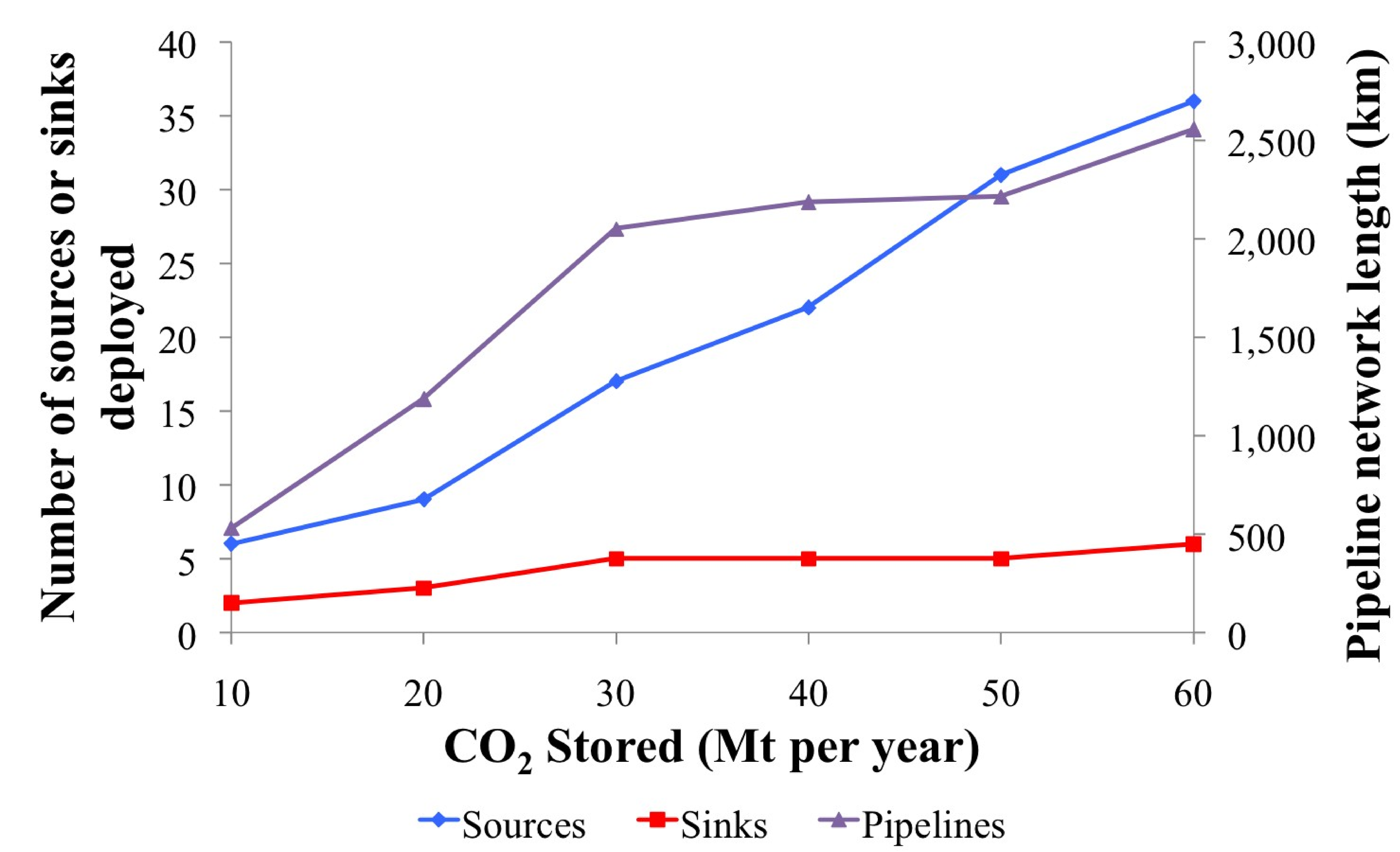
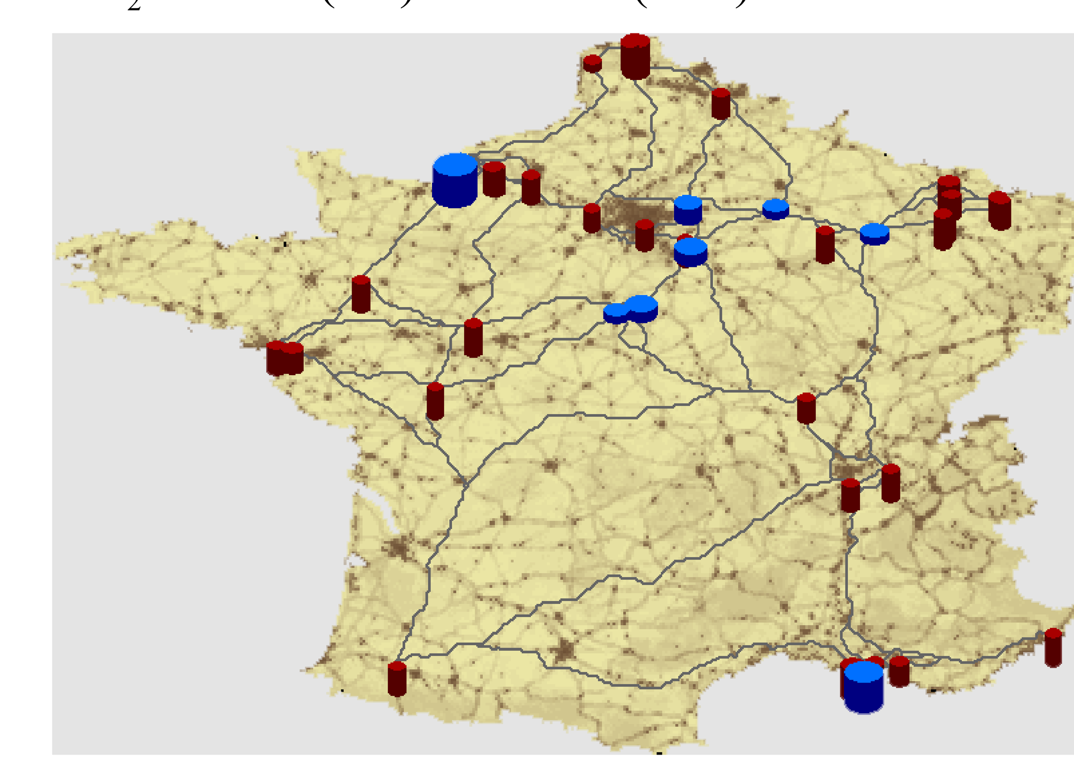


Figure 3. Comparing networks for various storage targets, from 10 to 60 $MtCO_2$/yr. Comparing 10 to 30 $MtCO_2$/yr, the bigger network is extended in length to reache more sources. Comparing 30 $MtCO_2$/yr to 50 $MtCO_2$/yr, the network extends in capacity, subnetworks merge, CO_2 flows are aggregated into 20–24 inches trunklines. Connecting additional sources appear required to go from 50 to 60 $MtCO_2$/yr.

About the SimCCS model

A cost surface, i.e. a raster grid of the cost to lay a pipeline across each grid cell, was estimated using geographical datasets including protected areas, existing gas pipelines, rivers, railroads, highways, land cover, and population densities. Given the location of sources and reservoirs as network nodes, the model generated a set of potential routes between all possible close node pairs (**Figure 4**). Based on these potential routes, given the costs of capture, building and operating pipeline, storing and exporting CO_2, the model minimized the total cost to meet a given target quantity of CO_2 stored.

Figure 4. Potential pipeline routes (grey) between CO_2 sources (red) and sinks (blue).



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