Introduction:
Greenhouse gases (GHG) have been identified as the main drivers of current climate change (IPCC, 2013) and their concentrations in the atmosphere have been continuously increasing over the last 150 years (peaking over 400 µmol/mol CO₂ during winter 2015 in the northern hemisphere). Following the evolution of the main greenhouse gases in the atmosphere as well as increasing our current knowledge of the global carbon cycle is then mandatory to better assess carbon budget at the local to global scale and to be used as input forcing in the climate models simulating our future climate. In that context, atmospheric monitoring networks have been developed since more than 50 years and a significant effort to harmonize and refine monitoring stations protocols, technics and data processing. As a contribution to this effort, the ICOS (Integrated Carbon Observation System) European research infrastructure has been established, with a significant contribution of France.

The French metropolitan GHG monitoring network:
A typical ICOS-Fr station consists of a high tower equipped with meteorological sensors and air inlets at 3 or 4 sampling levels. A shelter usually hosts (Figure 2):
- an air distribution system including a set of target and calibration cylinders;
- one or two continuous analyzers (at least enabling CO₂, CH₄, CO monitoring);
- a transmission system enabling automatic data transfer and instruments remote control.

A SNO ICOS-Fr super site: Trainou Tower (TRN)

Figure 2: Example of a ICOS-Fr station schematic

Figure 3: GHGs and Radon time series at TRN. On the left, 180m (blue), 100m (green), 50m (red) and 5m (black) record obtained by gas chromatography measurement technics. On the right, CH₄, CO and CO₂ records from CRDS measurements.

Figure 4: CO₂ Vertical gradient and mean diurnal cycle at TRN station

A spike detection algorithm:

Method:
For a given monitoring station, we consider the full temporal record at disposal (minute average concentration values). Spike selection is based on standard deviation (Sd) calculation between first and third quartile of the full data serie. Each data point with concentration Cᵢ verifying the following condition will be flagged as spike:

\[ Cᵢ > C_{\text{correct}} + α * S_d + \sqrt{α * S_d} \]

- \( C_{\text{correct}} \) is the last unflagged data point
- \( α \) is a parameter enabling to adjust the filtering threshold.

Results: case study of Pic du Midi (PDM) station

Figure 6: Because of very noisy suspicious CH₄ signals recorded at the PDM station, an inter-comparison campaign has been conducted with two CO₂/CH₄ analyzers placed in two locations at 200 m distance from each other. Our spike detection method has been applied to both data series confirming frequent local contaminations for CH₄ at site 1 (left panel) and few CO₂ contaminations at site 2 (middle panel). After investigation a small waste water treatment plant was found to be responsible for CH₄ contamination at site 1 and a correlation of CO₂ spikes for site 2 was found with the use of a diesel generator. This work conducted us to remove the monitoring instrument form site 1 and place it on site 2.

Acknowledgements - Perspectives:
The SNO ICOS-France in now entering into an operational phase. The main objectives for coming years are:
- Installation of the last remaining station in Brittany (Roch Tredudon)
- Final set up of the demonstration station from Saclay
- ICOS Labelling of French stations into ICOS-Europe
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