CO_2 PLUME DETECTION USING NEURAL NETWORKS: APPLICATION TO SYNTHETIC IMAGES OF CITIES AND POWER PLANTS

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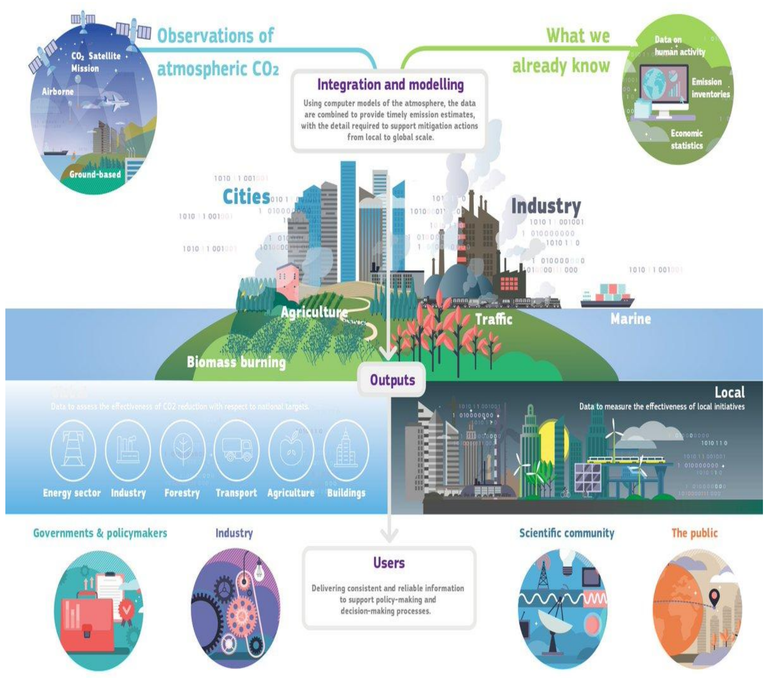
co-funded with esa

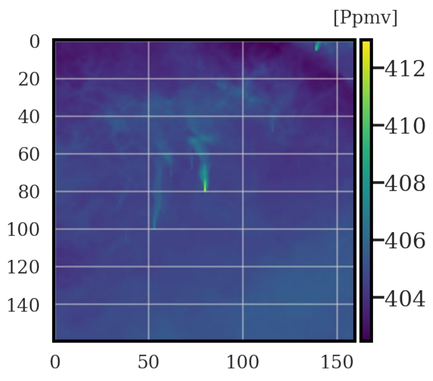
Copernicus CoCO2 project, prototype of a CO_2 monitoring service which aims, in particular, to improve the estimation of CO_2 emissions from new satellites launched from 2025 onwards.

Our aim:
Focus on CO_2 emissions from cities and power plants based on the spaceborne imagery of the CO_2 atmospheric plumes from these sources.



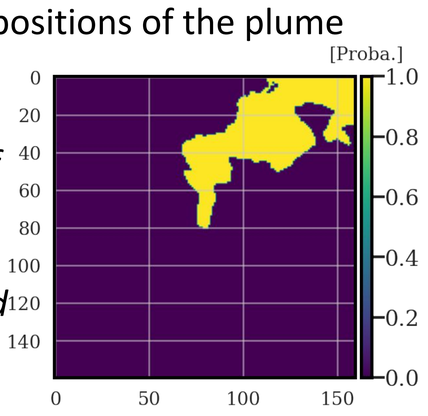
Motivation and objectives

Inversion:
From a given satellite image:
-> estimate emission rates from a point source

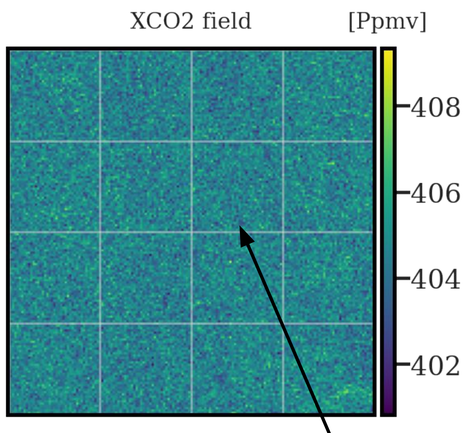


Emissions and "consequences" of the emissions: the plume, are directly related

Segmentation:
-> find map of probabilities (pixel values between 0 and 1) describing potential positions of the plume



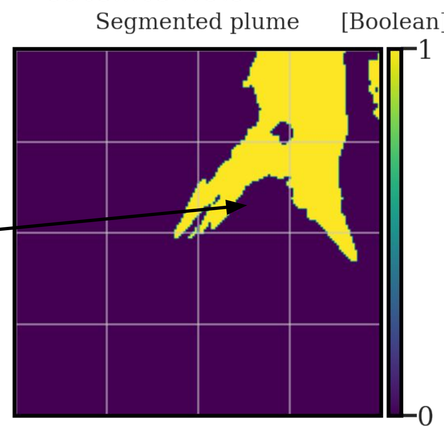
Simulated dataset



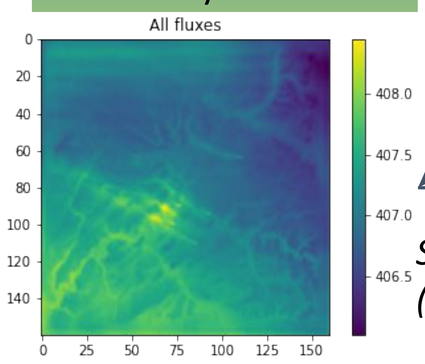
Low SNR

- Signal: rarely exceeds values of a few ppm
- Perturbed by variable regional CO2 background signals and satellite noise

Signal of CO2 plumes induced by cities emissions is intrinsically difficult to detect



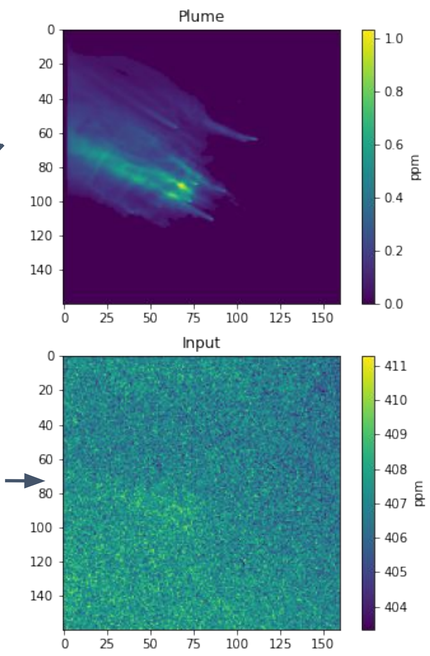
Typical hourly emissions from a city or a power plant = 17.3 Mt.yr-1



Simulated atmospheric dispersion of the plume only

Addition of the simulated background

Satellite noise (Gaussian 0.7ppm)

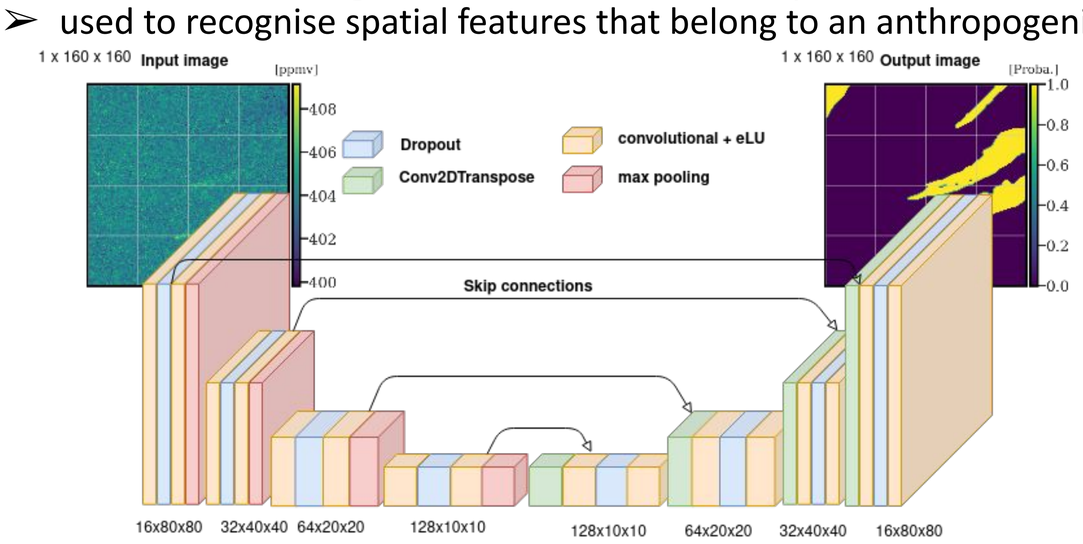


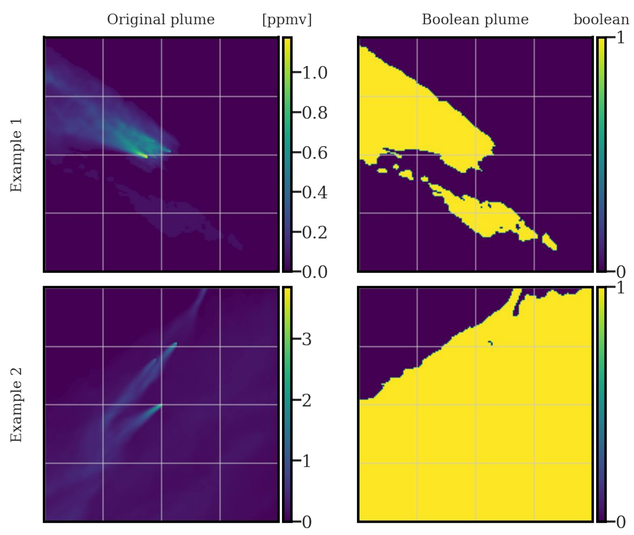
CNN trained on simulated XCO_2 fields:
Paris (WRF-Chem) and Berlin, various power plants (COSMO-GHG)

CNN methodology

Convolutional Neural Networks: U-net algorithm

- ❏ capture spatial features of the image through application of successive filters
- ❏ i.e., transform image into relevant features maps
- ➢ used to recognise spatial features that belong to an anthropogenic plume





How to mathematically define a plume ?
-> We add a weight depending on concentrations in the binary cross entropy loss function.

Segmentation results

Geographical generalisation and extrapolation on Berlin plumes