Seminar “Physics and Chemistry of the Atmosphere”,
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AI-Based Detection of Methane Plumes using Hyperspectral Satellite Observations

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Climate change and its consequences challenge us to gain a better understanding of the interactions between human activities and the atmosphere. One key element in this context is methane (CH_4), a greenhouse gas whose global warming potential is substantially higher than that of CO_2 over 20 year timescale (IPCC AR6 WGI, 2021). Its potency and short lifespan make reducing anthropogenic methane emissions a critical strategy for climate change mitigation.

While detecting these emissions is essential, resolving localized plumes in satellite retrievals remains challenging: signals are often weak and heavily contaminated by sensor noise, striping and surface-driven artifacts.

Hyperspectral missions such as EnMAP and PRISMA provide the spatial resolution needed to resolve such plumes, but their methane retrivals are embedded in complex backgrounds where simple thresholding or rule-based methods frequently fail.

Spatially informed supervised machine-learning models, such as convolutional neural networks (CNNs), offer a way to automatically detect, localize and delineate plume structures in these fields. In this talk, I present a segmentation approach based on a U-Net architecture trained on physically consistent methane plumes from WRF-LES simulations superimposed onto synthetic backgrounds with controlled noise and artifacts. I will show initial segmentation results across varying emission source strengths and background conditions, and briefly discuss how this framework can be developed toward robust plume detection using hyperspectral satellite observations.