

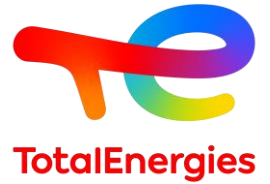
# Satellite Flaring Measurement

---

Louise Oatey & Leo Turon  
Decarbonisation Conference  
October 2023



# Remote sensing R&D overview at Total Energies



Anywhere on the Earth



Spatial resolution



Temporal resolution



Spectral resolution



Big data



Open data



**Machine learning & deep learning = AI for satellite image**



Cloud computing

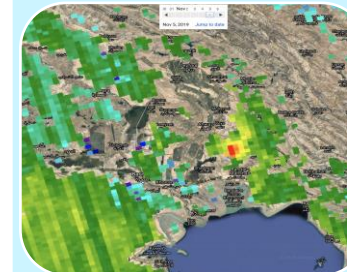
## Environment

- Vegetations classification
- Carbon sinks
- Water



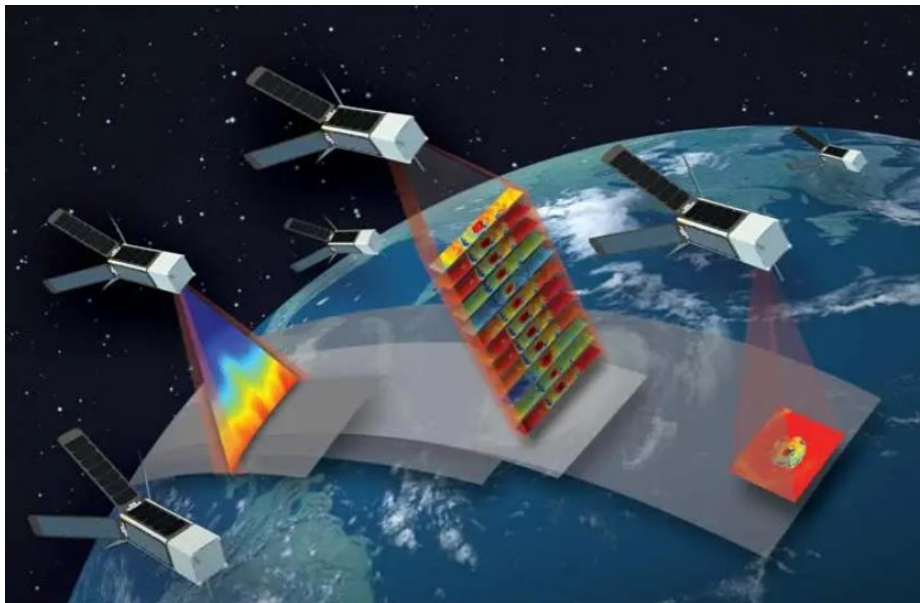
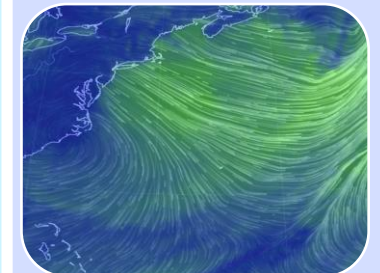
## GHG

- CH<sub>4</sub> / CO<sub>2</sub> monitoring
- Flaring
- Assimilation

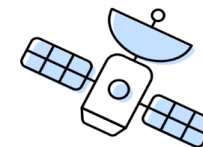


## Renewables

- Solar, wind prospection
- Agrivoltaics
- Floating PV

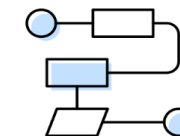


Credit: NASA (2023)



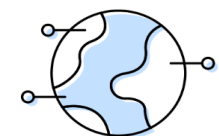
Satellite imagery

+



R&D

+

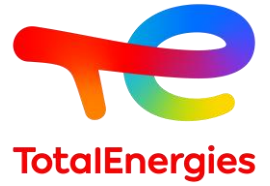


Industrialization

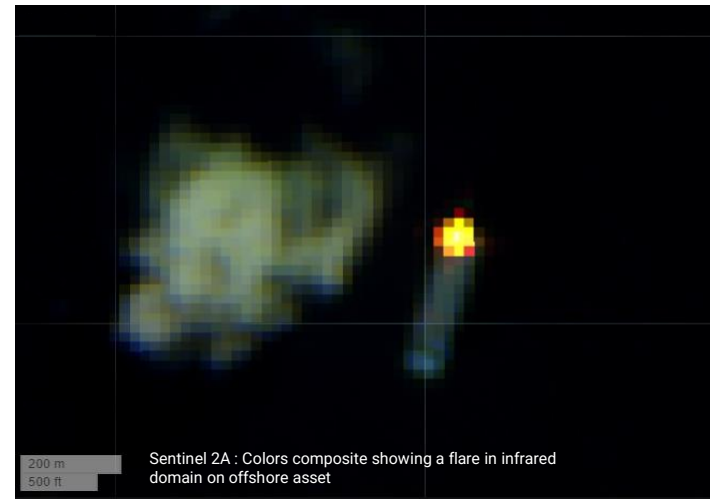
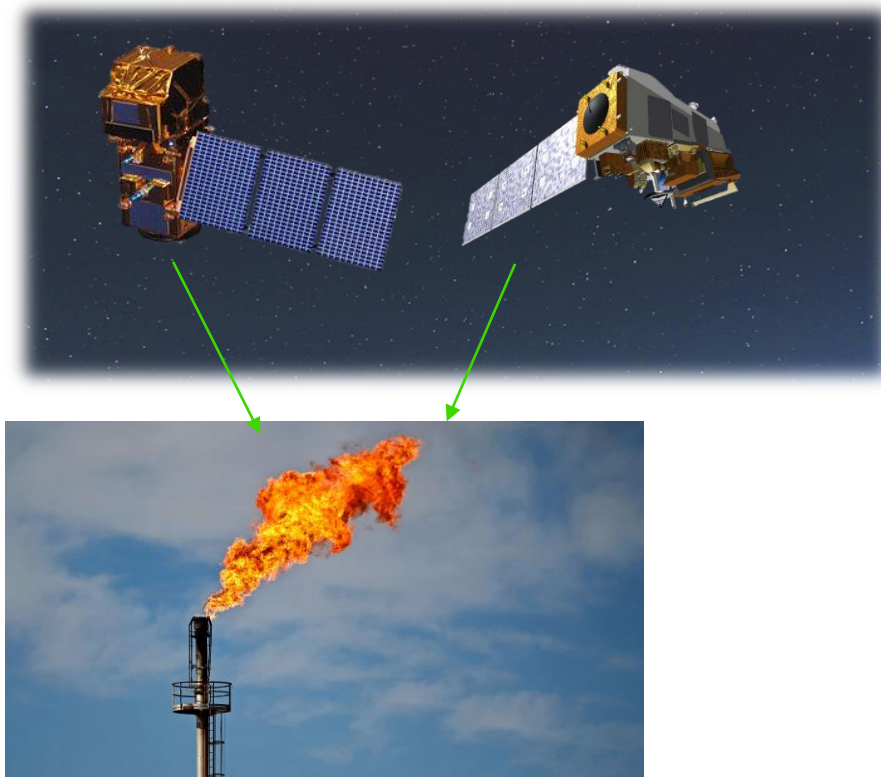
Credit: Google Earth Engine



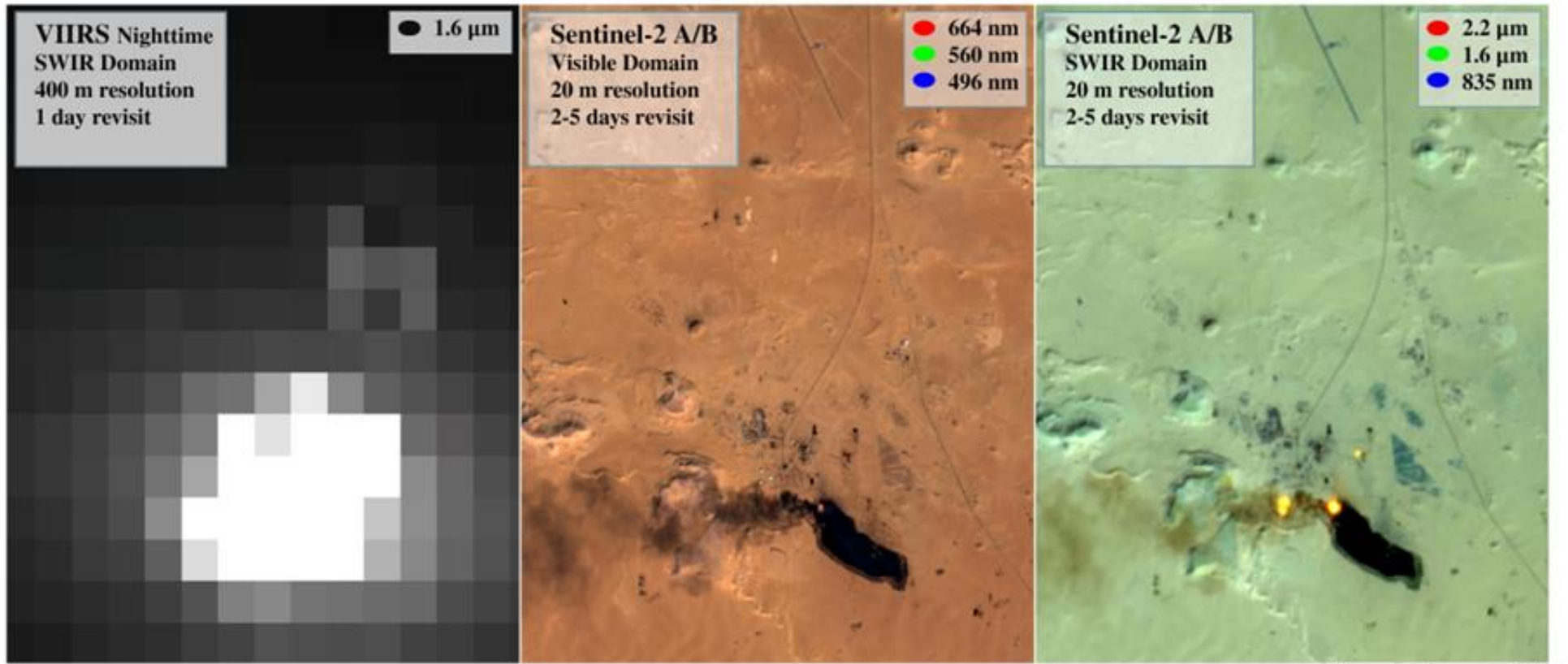
# Observation of flaring from space



- Satellite imagery is able to monitor these events worldwide.
- It detects active flaring on multispectral images. **Short-Wave Infra-red** bands are the most relevant to highlight flaring.



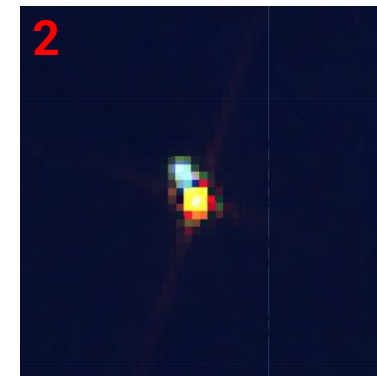
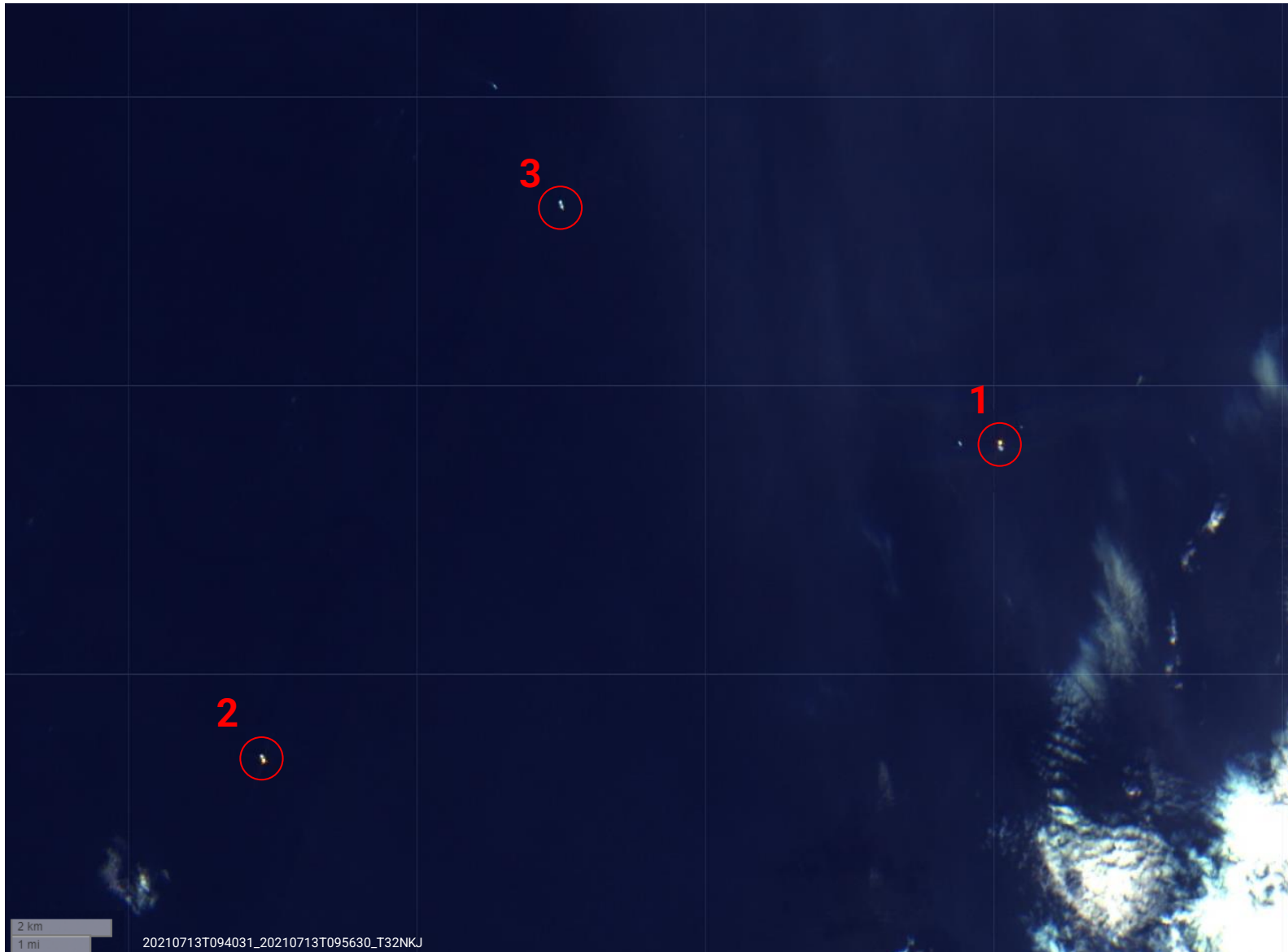
# Comparison of spatial resolution between VIIRS and Sentinel 2 images



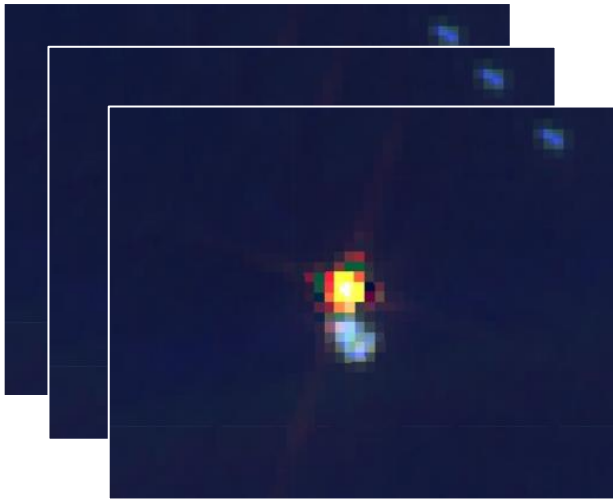
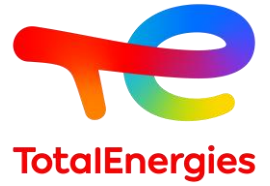
Increase of spatial resolution



# Sentinel 2 offshore capabilities



# Gas flow rate prediction



Sentinel 2 time series analysis



Google Earth Engine

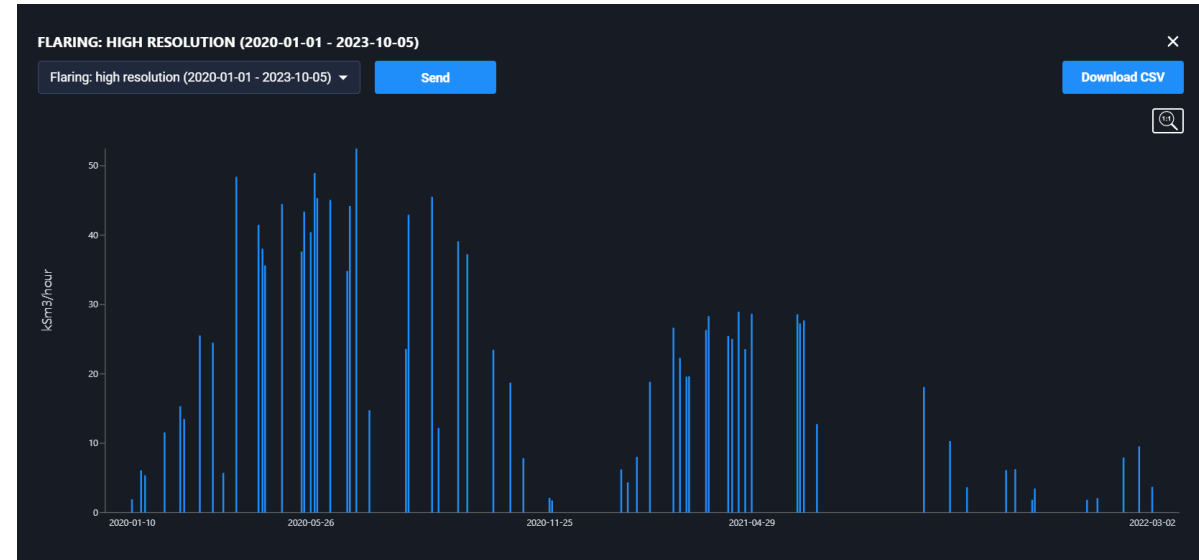
Pre-processing to get required data in correct format

Image processing

- SWIR detection
- Feature extraction



Contouring the detections



Model  
Inversion to get the flowrate

Results :  
Time series and gas flowrate for every detection

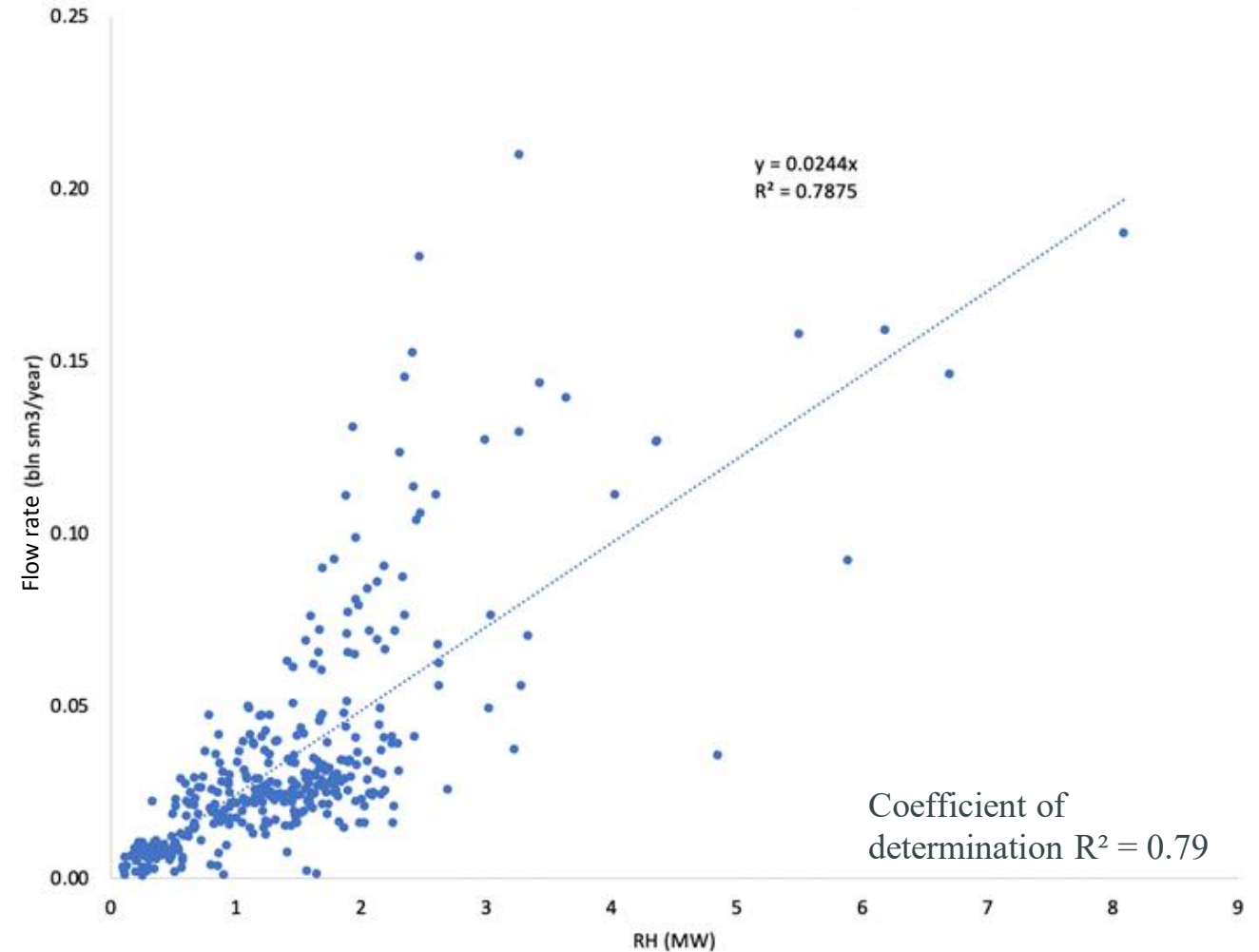
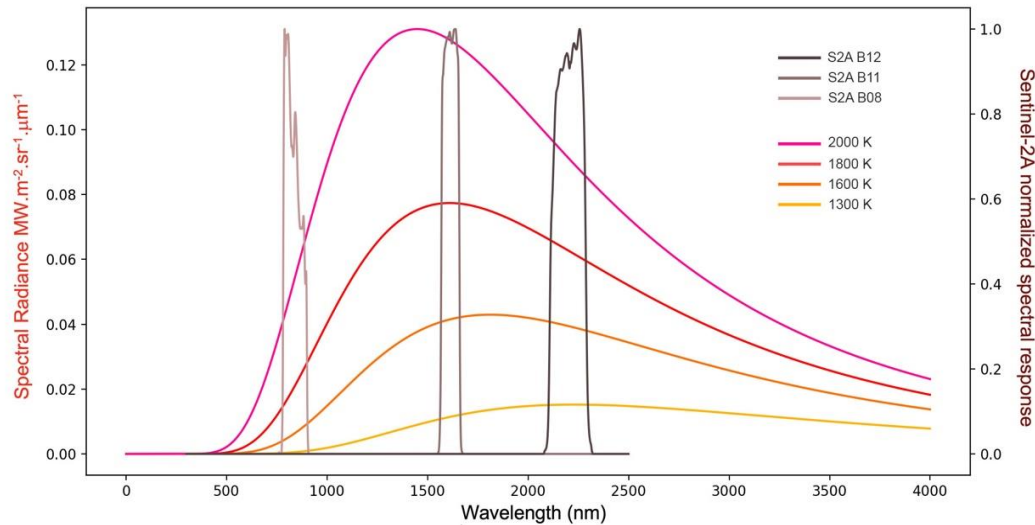


# Model building

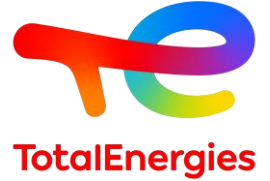
- 10 minutes resolution in-situ flow-meters on 4 sites
- Matched 364 Sentinel 2 acquisition with in-situ measurement
- Stefan – Boltzmann’s law :  $RH = \sigma T^4 S$

Where RH = radiant heat in megawatts (MW),  $\sigma$  = the Stefan–Boltzmann constant, T is temperature in K and S = source area in square meters

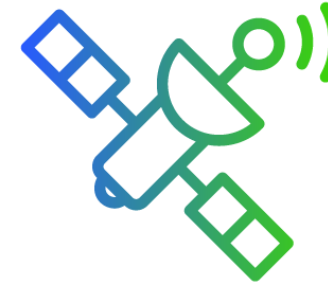
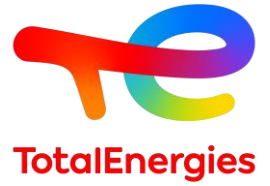
- Planck curve fitting to find T and S



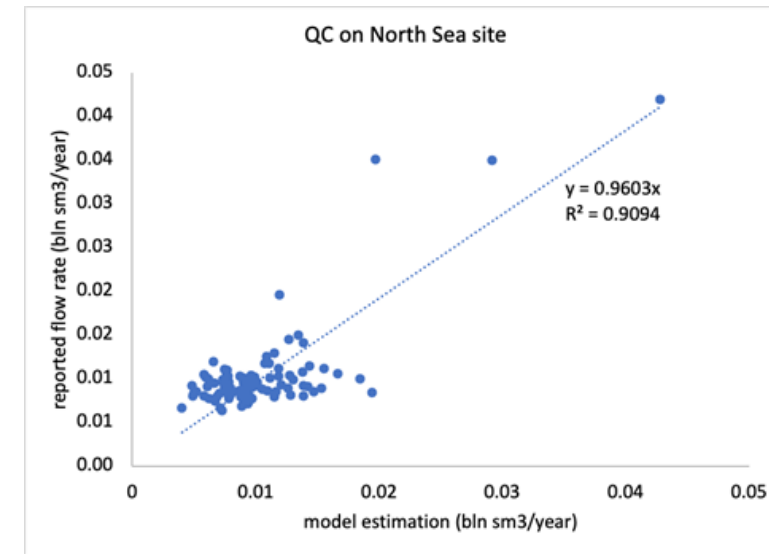
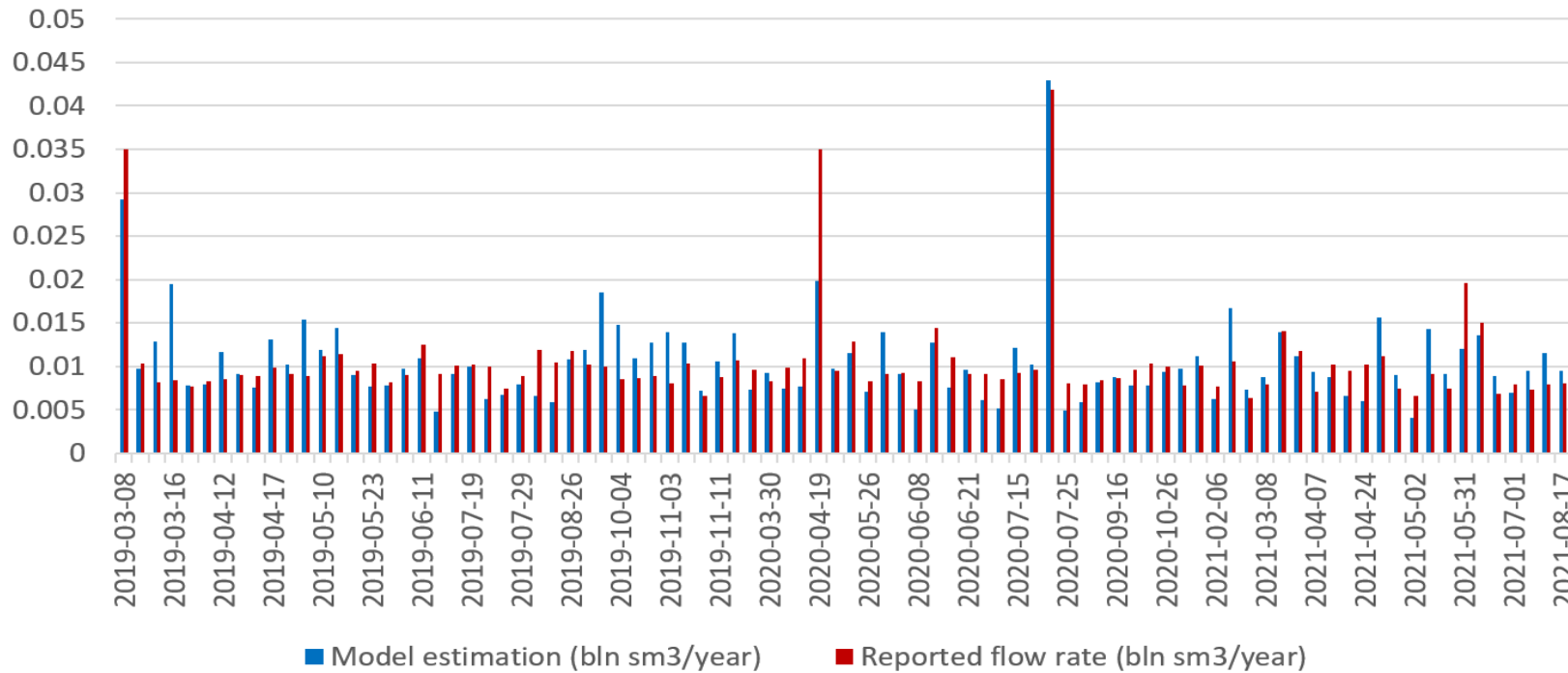
Coefficient of determination  $R^2 = 0.79$



# Results



- North Sea Site with 98 detections from Jan 2019 to Sept 2021
- Correlation between reported and model estimated flow rates is 0,91







# DEMETER for quantification of greenhouse gases emissions

### Estimate the gas flow rate from Sentinel 2 images

Works worldwide with a clear sky.  
Revisit time : 2 to 5 days.

### Decision-making app

From R&D to operations (GHG emission reduction)

### CUMULATIVE FLARING VOLUME

Using other multispectral images (VIIRS, Landsat)

