Geostationary CO2 concepts:
G3E – Geostationary Emission Explorer for Europe

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Benefit of a geostationary observer

Contiguous spatial and temporal imaging

2014-07-01 00 UT

XCO$_2$ fields from MACC @ ECMWF, 0.2°x0.2°, 3h

Courtesy by V.-H. Peuch, M. Razinger, A. Agusti-Panareda
Benefit of a geostationary observer

Contiguous spatial and temporal imaging

- **Spatiotemporal context**: disentangle transport, boundary conditions and sources/sinks

- **Local horizontal contrast**: emissions of localized sources

- **Local temporal contrast**: diurnal cycle, source specification

- **Sampling density**: less sampling bias (Don’t miss events).
Benefit of a geostationary observer

Contiguous spatial and temporal imaging

**Performance of a geostationary mission, geoCARB, to measure CO₂, CH₄ and CO column-averaged concentrations**

I. N. Polonsky¹, D. M. O'Brien², J. B. Kumer³, C. W. O'Dell⁴, and the geoCARB Team⁵

[Polonsky et al., AMT, 2013]

**Constraining regional greenhouse gas emissions using geostationary concentration measurements: a theoretical study**

P. J. Rayner¹, S. R. Utembe¹, and S. Crowell²

[Rayner et al., AMT, 2014]

**Geostationary Emission Explorer for Europe (G3E): mission concept and initial performance assessment**

A. Butz¹, J. Orphal¹, R. Checa-Garcia¹, F. Friedl-Vallon¹, T. von Clarin², H. Bovensmann², O. Hasekamp³, J. Landgraf³, T. Knipp³, D. Weile³, O. Sqalli-Houssini³, and D. Kemper³

[Butz et al., AMT, 2015]

**Potential of a geostationary geoCARB mission to estimate surface emissions of CO₂, CH₄ and CO in a polluted urban environment: case study Shanghai**

Denis M. O’Brien¹, Igor N. Polonsky², Steven R. Utembe³, and Peter J. Rayner³

[O’Brien et al., AMT, 2016]
Geostationary Emissions Explorer for Europe (G3E)

G3E: 4-channel grating spectrometer

(lots of design choices borrowed from S5, S4, CarbonSat ...)

Total volume \(L \times W \times H \sim 1.6 \times 1.3 \times 0.8 \text{ m}^3\)

[Butz et al., AMT, 2015]
Geostationary Emissions Explorer for Europe (G3E)

[Butz et al., AMT, 2015]

Basic G3E specs:

- **Geostationary** orbit
- 2h per scan over Europe
- 2 x 3 km² ground pixels (at ~50° N/10°E, 1.7 x 1.7 km² at sub-satellite)
- $XCO_2$, $XCH_4$: anthropogenic (precision <0.5%) + biogenic (accuracy <0.5%)
- $XCO$: source/transport attribution (precision/accuracy < 10%)
- Support: aerosols, fluorescence
Alternative instrument concept investigated: imaging FTS

- **Geostationary** orbit
- 2h per scan over Europe, 900s dwell time for each zone x 8 zones
- 375 (NS) x 313 (EW) effective detector pixels
- 2 x 3 km\(^2\) ground pixels (at ~50° N/10°E, 1.7 x 1.7 km\(^2\) at sub-satellite)
- \(\text{XCO}_2, \text{XCH}_4\): anthropogenic (precision <0.5%) + biogenic (accuracy <0.x%)
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[Butz et al., AMT, 2015]
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Major issues with iFTS concept:

- Pointing must be stable during 900s dwell time, at least during single-shots to be coadded.
- Read-out frequency of 2D detector array in the order of ~1kHz.
- Data rate of ~1 Gbyte/s requires smart onboard processing

Therefore: priority to grating concept.
G3E: simulated soundings

[Butz et al., AMT, 2015]

<table>
<thead>
<tr>
<th>Band ID</th>
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<tbody>
<tr>
<td>NIR</td>
<td>745 - 775</td>
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<tr>
<td>SWIR-1</td>
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<tr>
<td>SWIR-2</td>
<td>1925 - 2082</td>
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<td>2305 - 2385</td>
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![Graph showing spectral range for NIR with bands NIR, SWIR-1, SWIR-2, and SWIR-3 with their respective spectral ranges.]
G3E: simulated soundings

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Trial ensemble: MODIS albedo (500 m x 500 m) sampled at 0.1° x 0.1° for a European albedo ensemble

G3E: simulated noise performance

[Butz et al., AMT, 2015]
Trial ensemble:
MODIS albedo (500 m x 500 m) sampled at 0.1° x 0.1° for a European albedo ensemble G3E: simulated noise performance

[Butz et al., AMT, 2015]
Trial ensemble:
MODIS aerosol/albedo
+ Calipso cirrus
+ ECHAM5-HAM aerosol types/heights

If G3E was in LEO at 12UT
Pretend GEO-view (VZA, SZA) on Europe

Analogue to our retrieval simulations for OCO-2, GOSAT, S5P, S5 [e.g. Butz et al., RSE, 2012]
- **Goal:** contiguous imaging of GHG (+support: XCO, aerosols, fluorescence) to disentangle and quantify anthropogenic and biogenic sources and sinks, disentangle transport

- **Mission concept:** 4-channel grating spectrometer in GEO (extensive LEO/GEO heritage: S5, S4, CarbonSat, ...; data reduction)

- **It is feasible with accuracies comparable to LEO.**

- **Synergies:** MTG-FCI/IRS/S4 – clouds, aerosols, SWIR-TIR CO, process markers ($\text{NO}_2$, $\text{SO}_2$, ...)