Geostationary CO2 concepts: G3E – Geostationary Emission Explorer for Europe

A. Butz[1], J. Orphal[2], H. Bovensmann[3], T. von Clarmann[2], F. Friedl-Vallon[2], F. Hase[2], G. Hechenblaikner[4], T. Knigge[4], R. Münzenmayer[4], O. Sqalli Houssini[4], F. Schmülling[5]

[1]Deutsches Zentrum für Luft- und Raumfahrt (DLR) e. V., Oberpfaffenhofen, Germany
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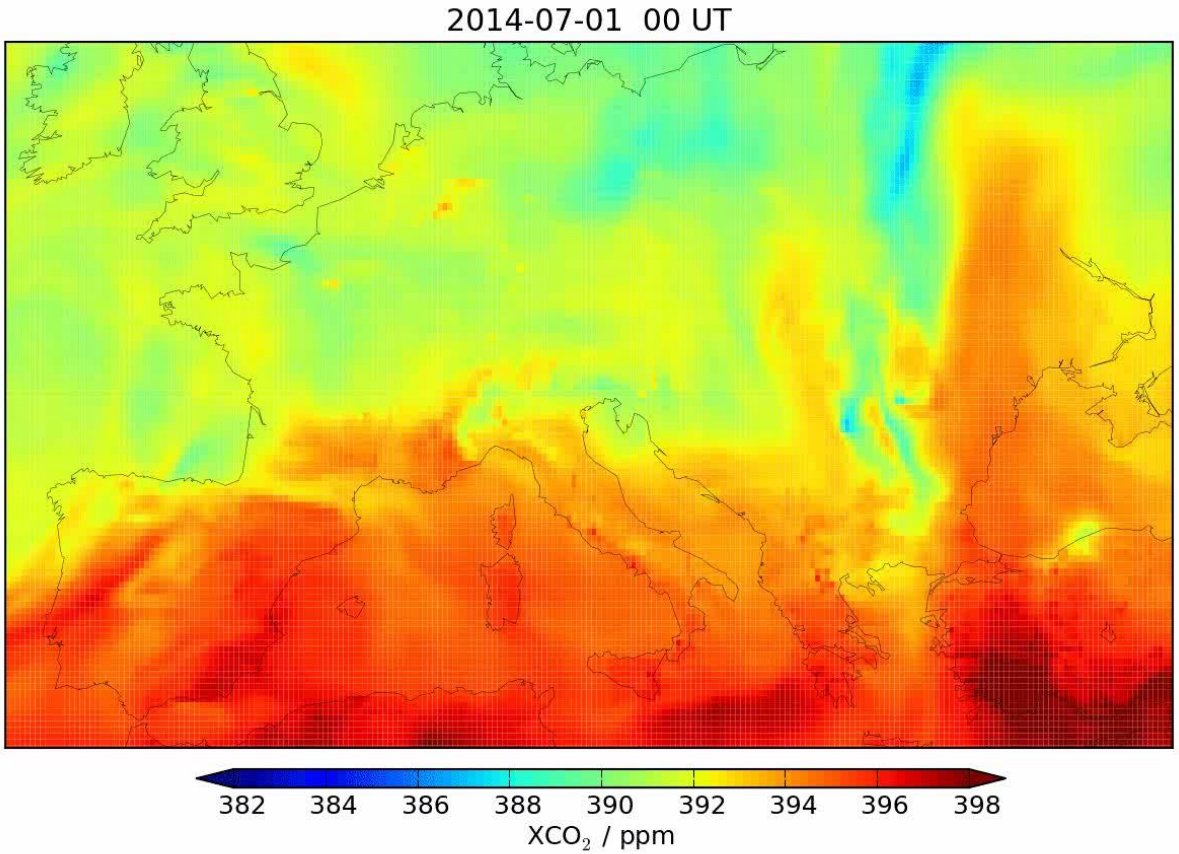
Benefit of a geostationary observer

Contiguous spatial and temporal imaging



XCO_2 fields from MACC @ ECMWF, 0.2°x0.2°, 3h

Courtesy by V.-H. Peuch, M. Razinger, A. Agusti-Panareda

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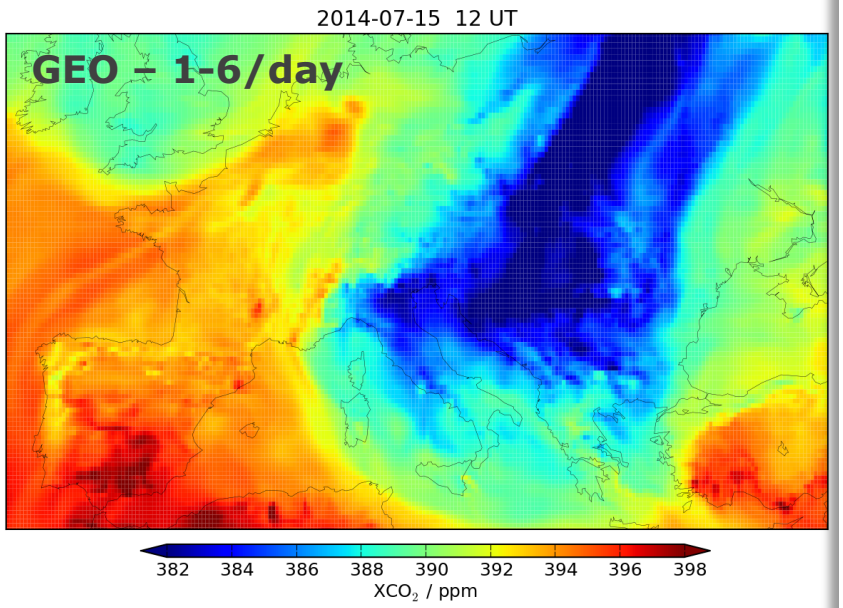

- **Spatiotemporal context**: **disentangle** transport, boundary conditions and sources/sinks
- **Local horizontal contrast**: emissions of localized sources
- **Local temporal contrast**: diurnal cycle, source specification
- **Sampling density**: less sampling bias (Don't miss events).

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Benefit of a geostationary observer

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Performance of a geostationary mission, geoCARB, to measure CO_2, CH_4 and CO column-averaged concentrations

I. N. Polonsky[1], D. M. O'Brien[2], J. B. Kumer[3], C. W. O'Dell[4], and the geoCARB Team[5]

[Polonsky et al., AMT, 2013]

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

P. J. Rayner[1], S. R. Utembe[1], and S. Crowell[2]

[Rayner et al., AMT, 2014]

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

A. Butz[1], J. Orphal[1], R. Checa-Garcia[1], F. Friedl-Vallon[1], T. von Clarmann[1], H. Bovensmann[2], O. Hasekamp[3], J. Landgraf[3], T. Knigge[4], D. Weise[4], O. Sqalli-Houssini[4], and D. Kemper[4]

[Butz et al., AMT, 2015]

Potential of a geostationary geoCARB mission to estimate surface emissions of CO_2, CH_4 and CO in a polluted urban environment: case study Shanghai

Denis M. O'Brien[1], Igor N. Polonsky[2], Steven R. Utembe[3], and Peter J. Rayner[3]

[O'Brien et al., AMT, 2016]

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Geostationary Emissions Explorer for Europe (G3E)

[Butz et al., AMT, 2015]

G3E: 4-channel grating spectrometer

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

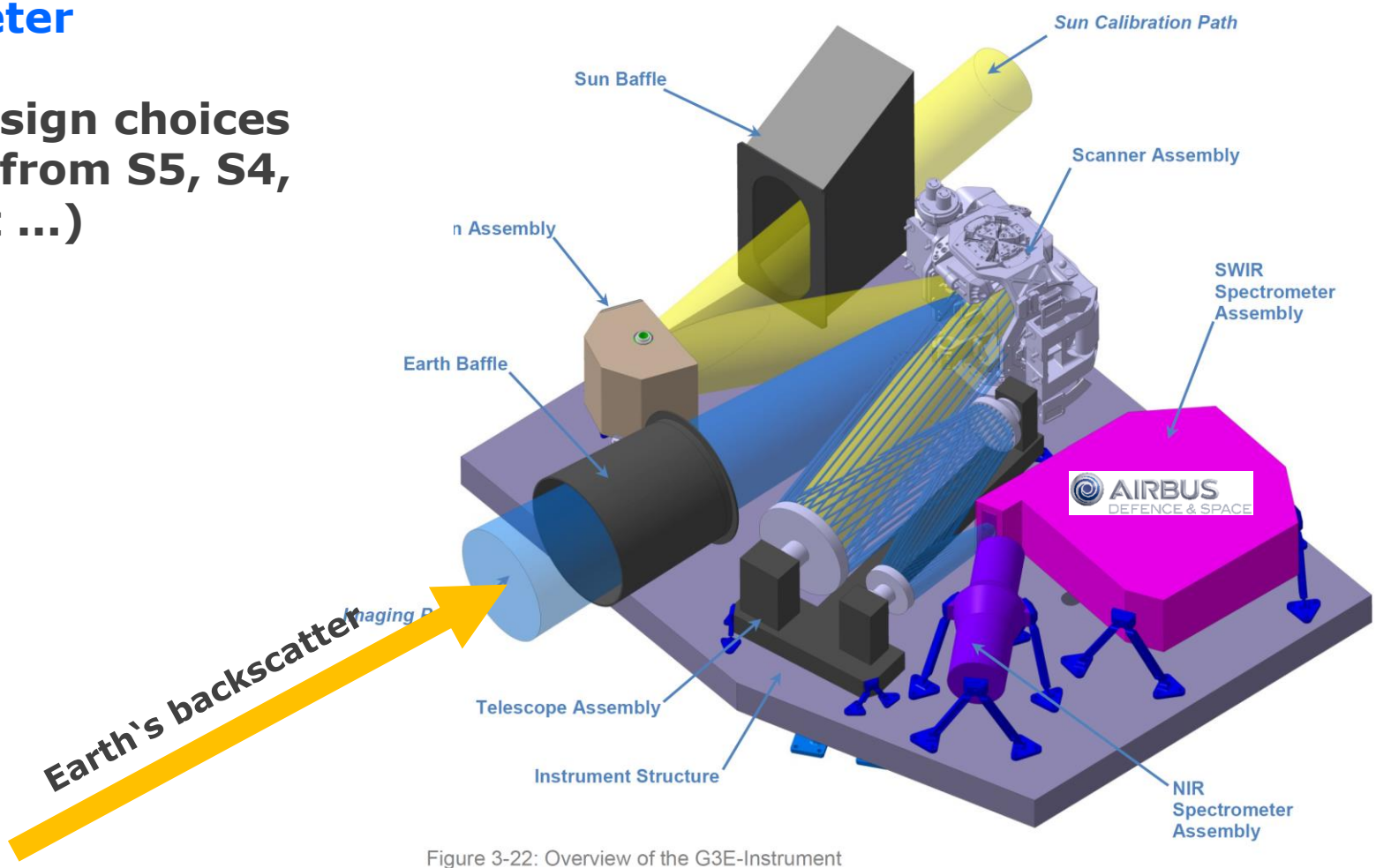


Figure 3-22: Overview of the G3E-Instrument

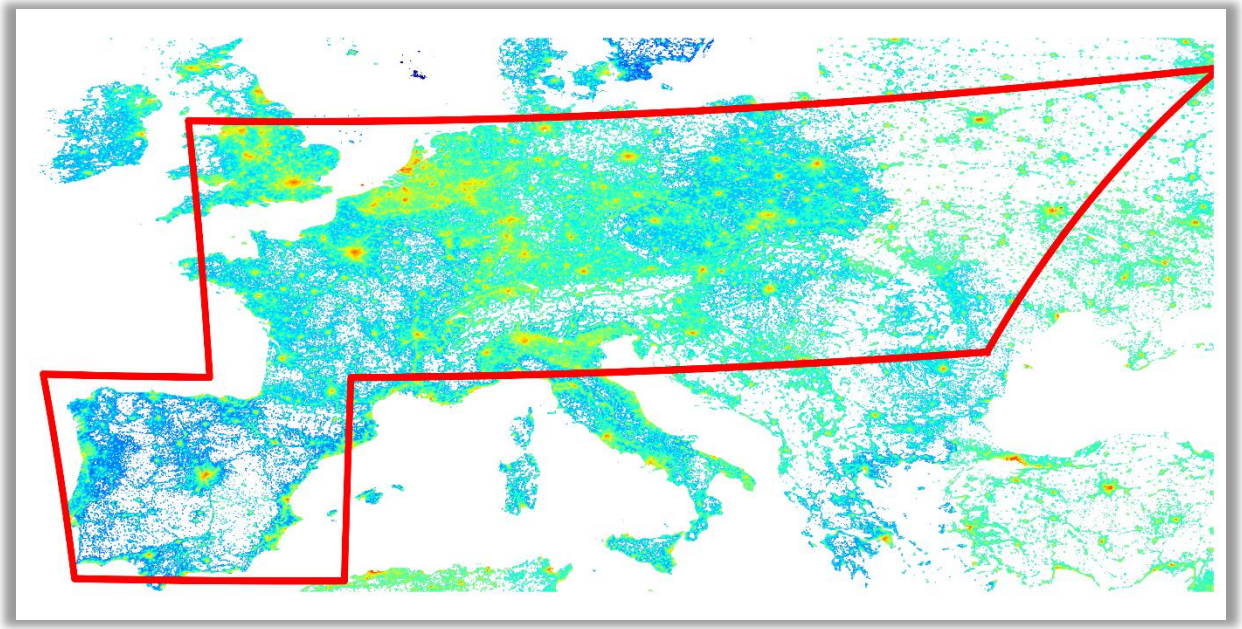
Total volume
L×W×H~1.6×1.3×0.8 m³

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.x%)**
- **XCO: source/transport attribution (precision/accuracy < 10%)**
- **Support: aerosols, fluorescence**



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Geostationary Emissions Explorer for Europe (G3E)

[Butz et al., AMT, 2015]

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)**
- **XCO_2, XCH_4: anthropogenic (precision <0.5%) + biogenic (accuracy <0.x%)**
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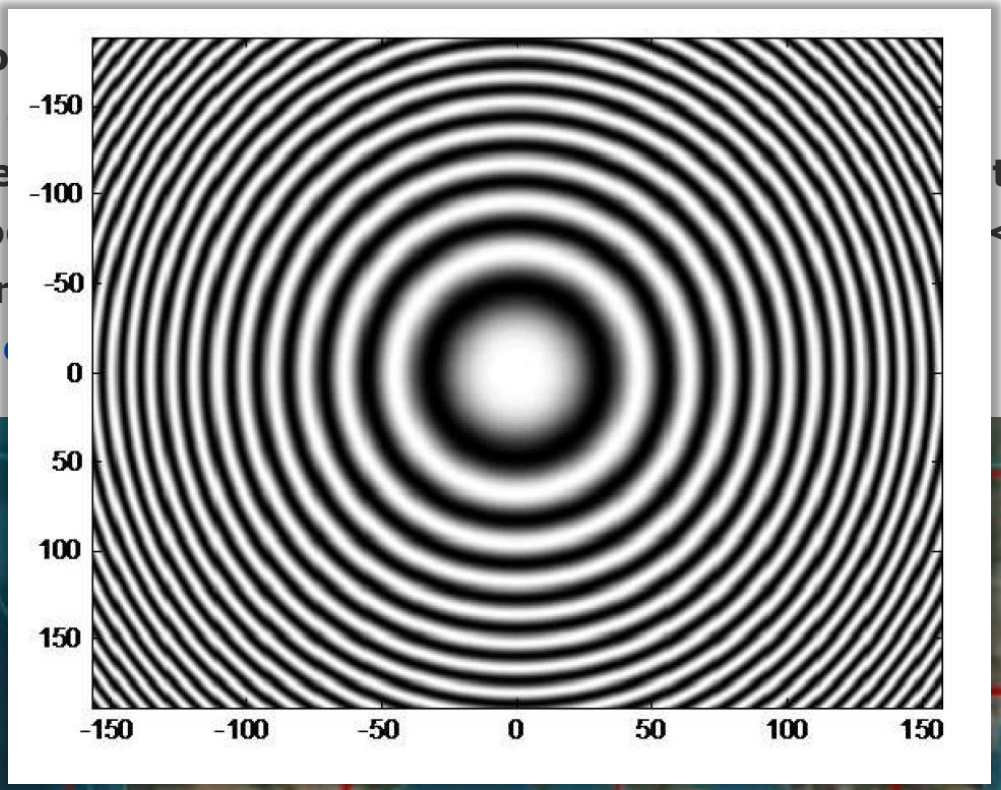
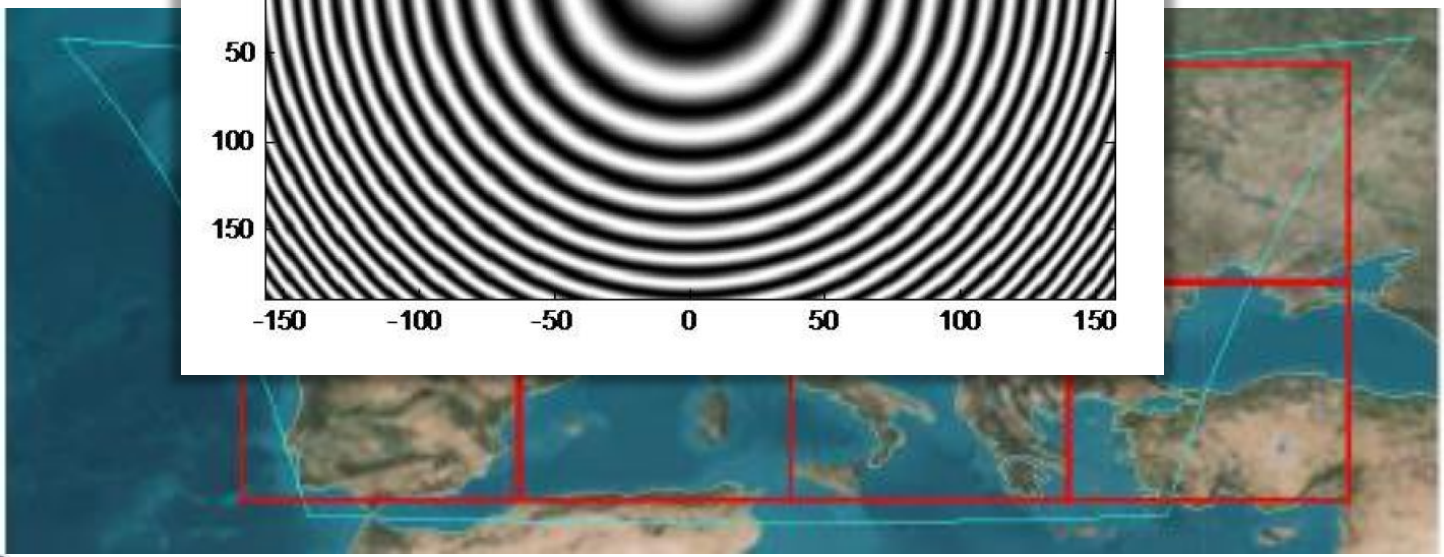
te)

<0.x%)





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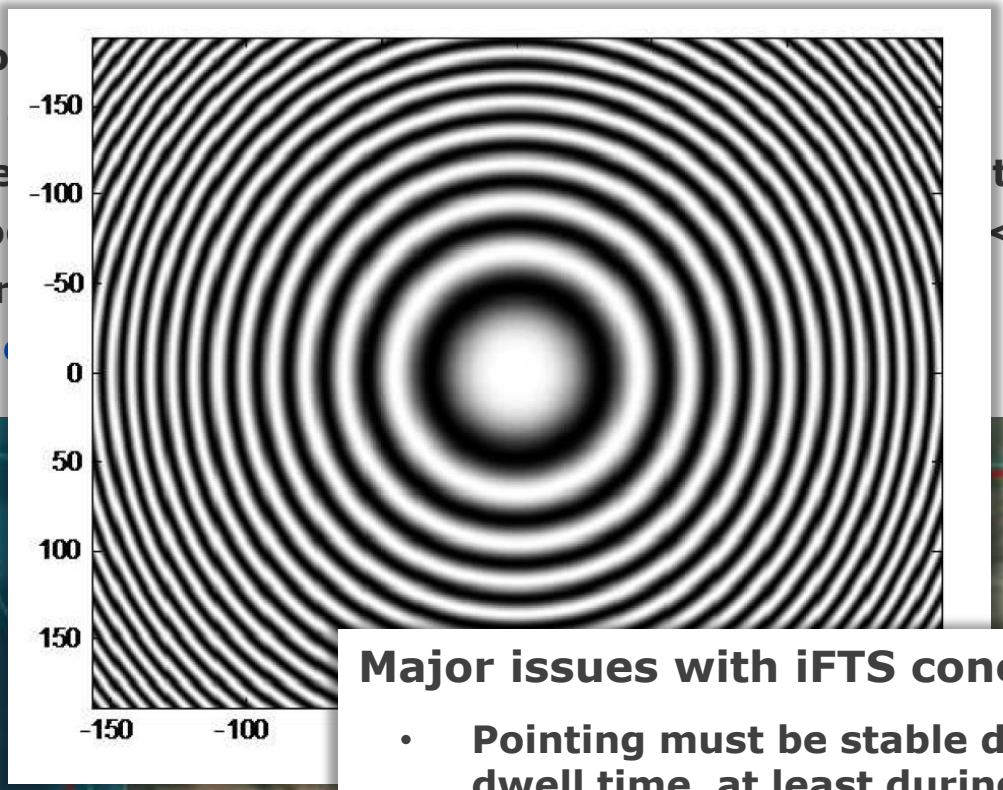

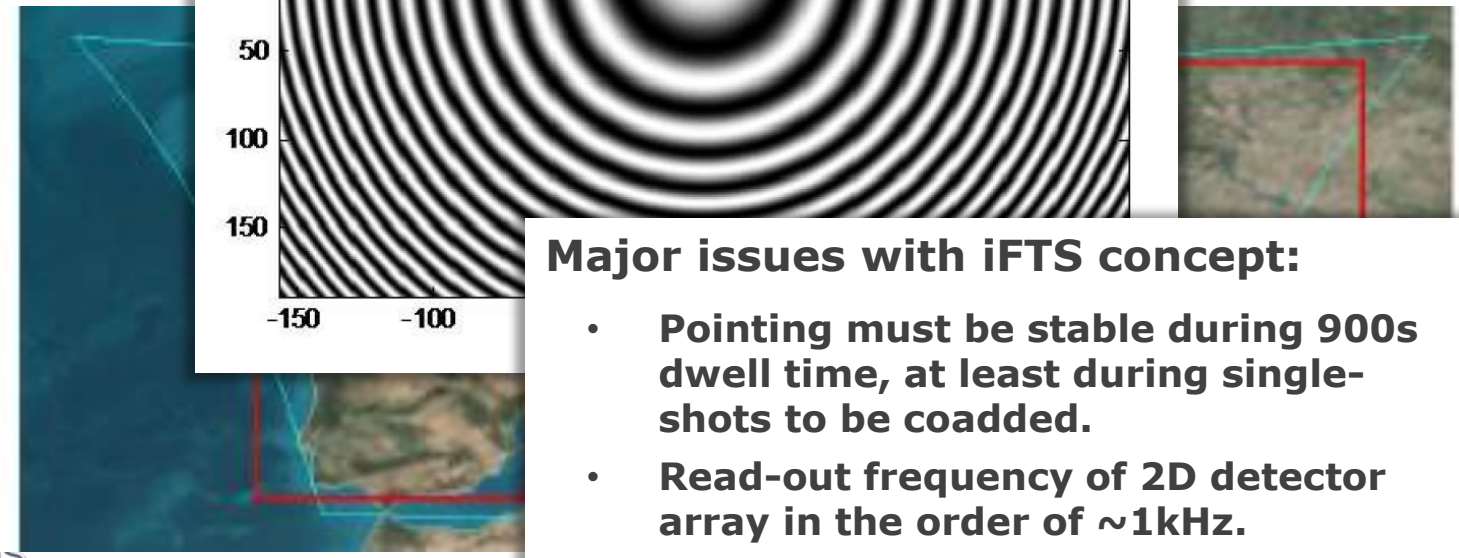

Major issues with iFTS concept:

- **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.

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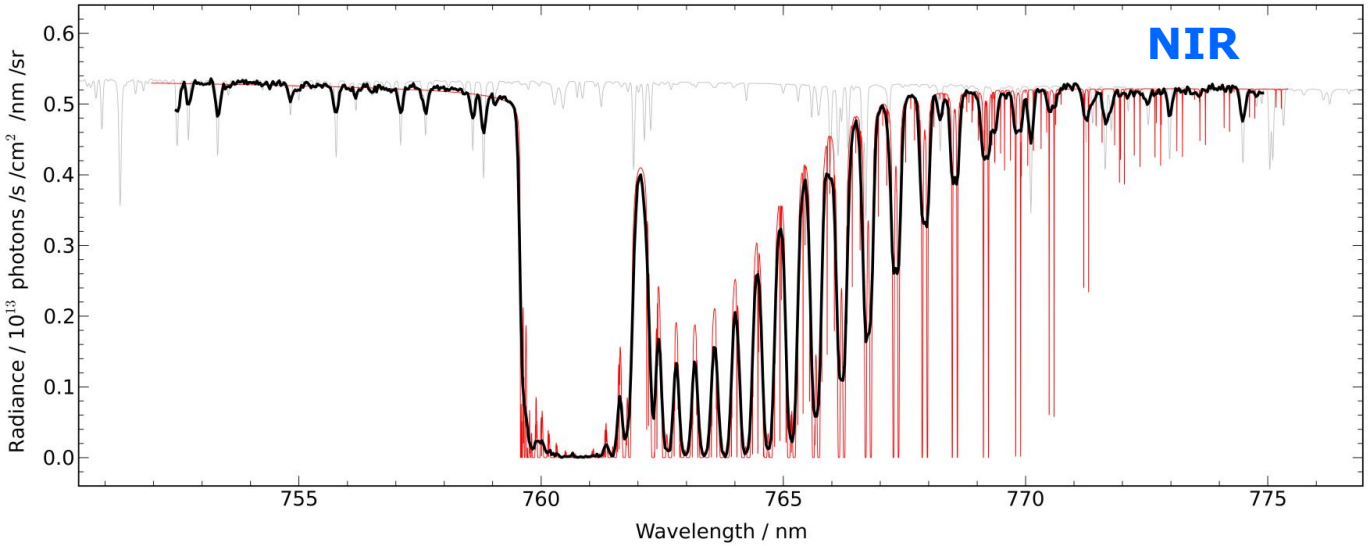
G3E: simulated soundings

[Butz et al., AMT, 2015]

Band ID	Spectral range [nm]
NIR	745 - 775
SWIR-1	1585 - 1675
SWIR-2	1925 - 2082
SWIR-3	2305 - 2385



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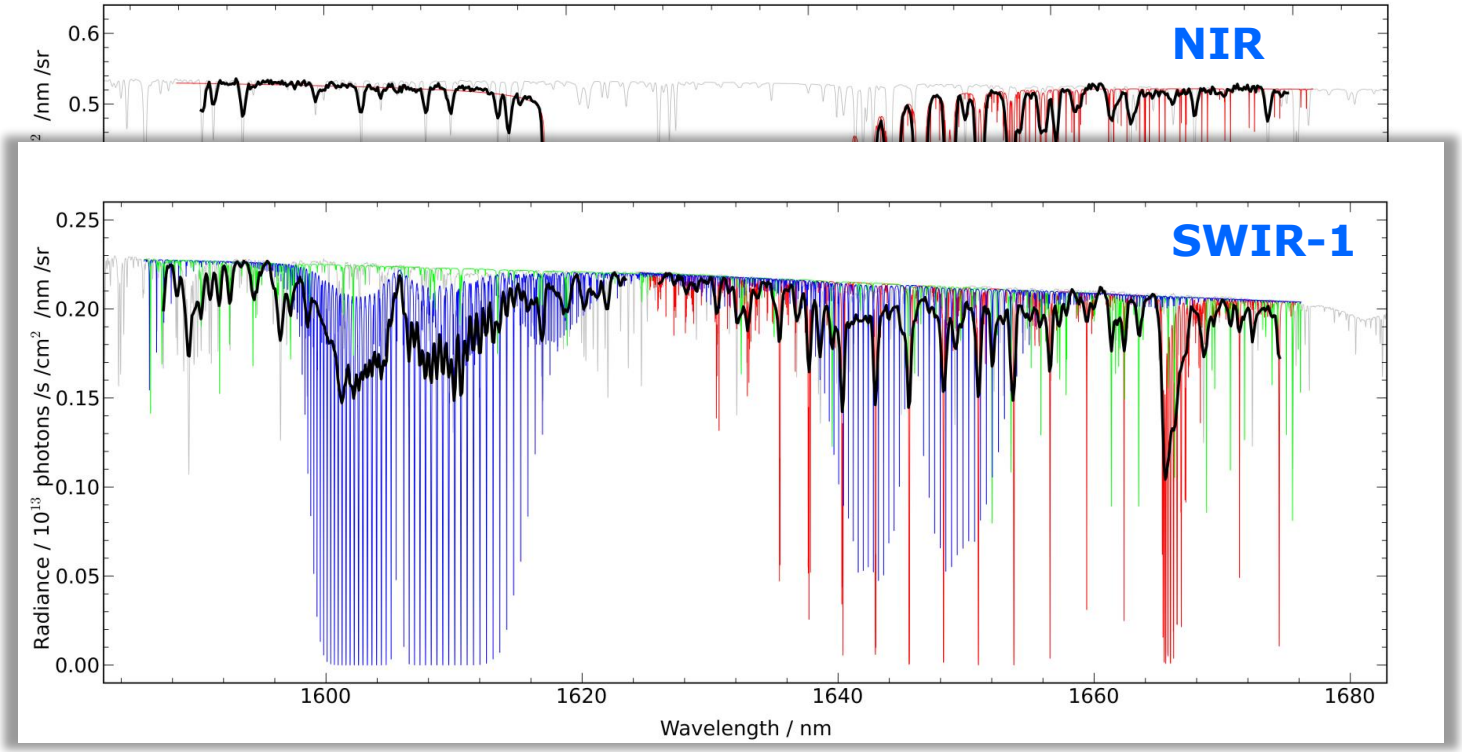

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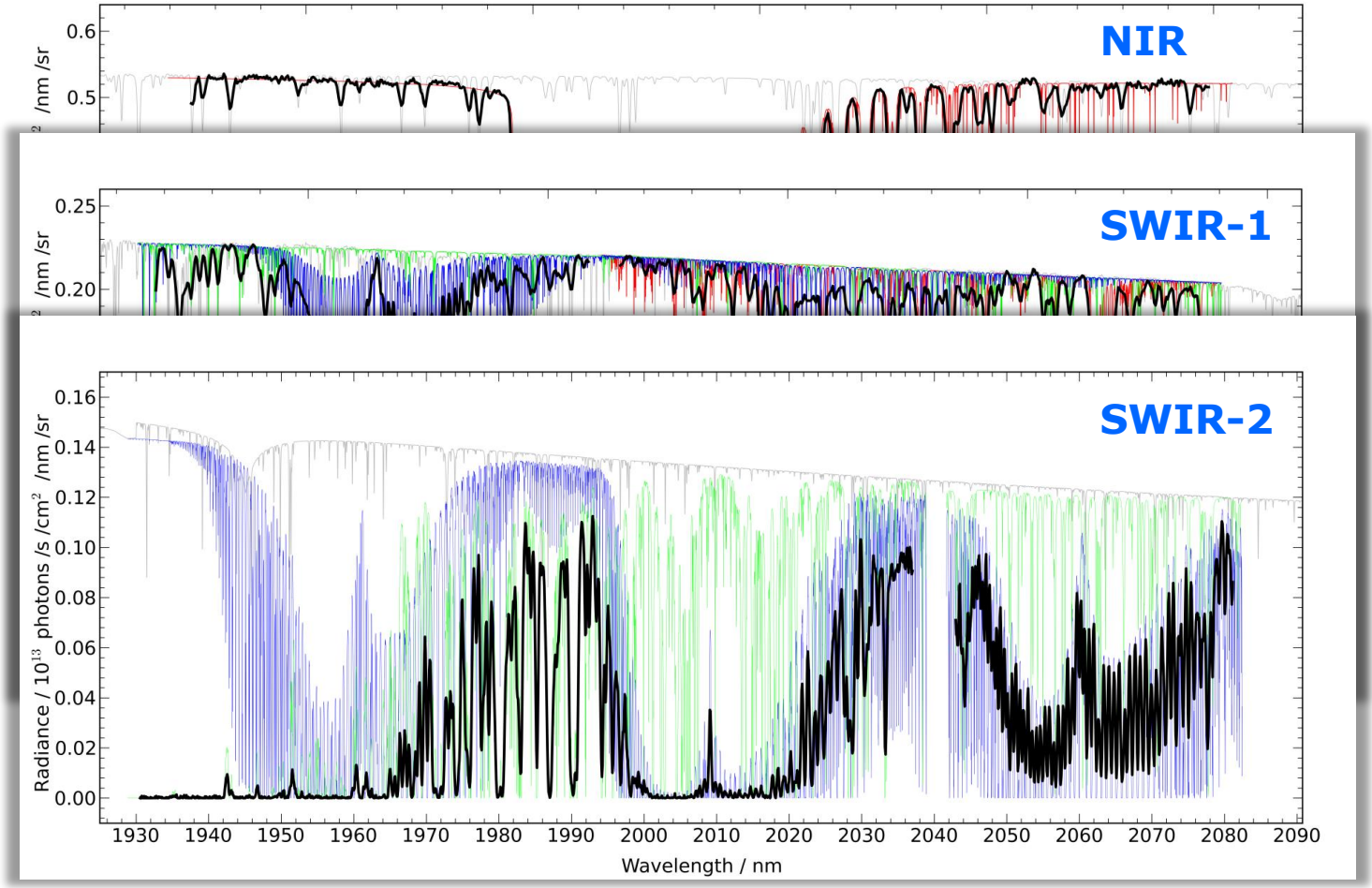

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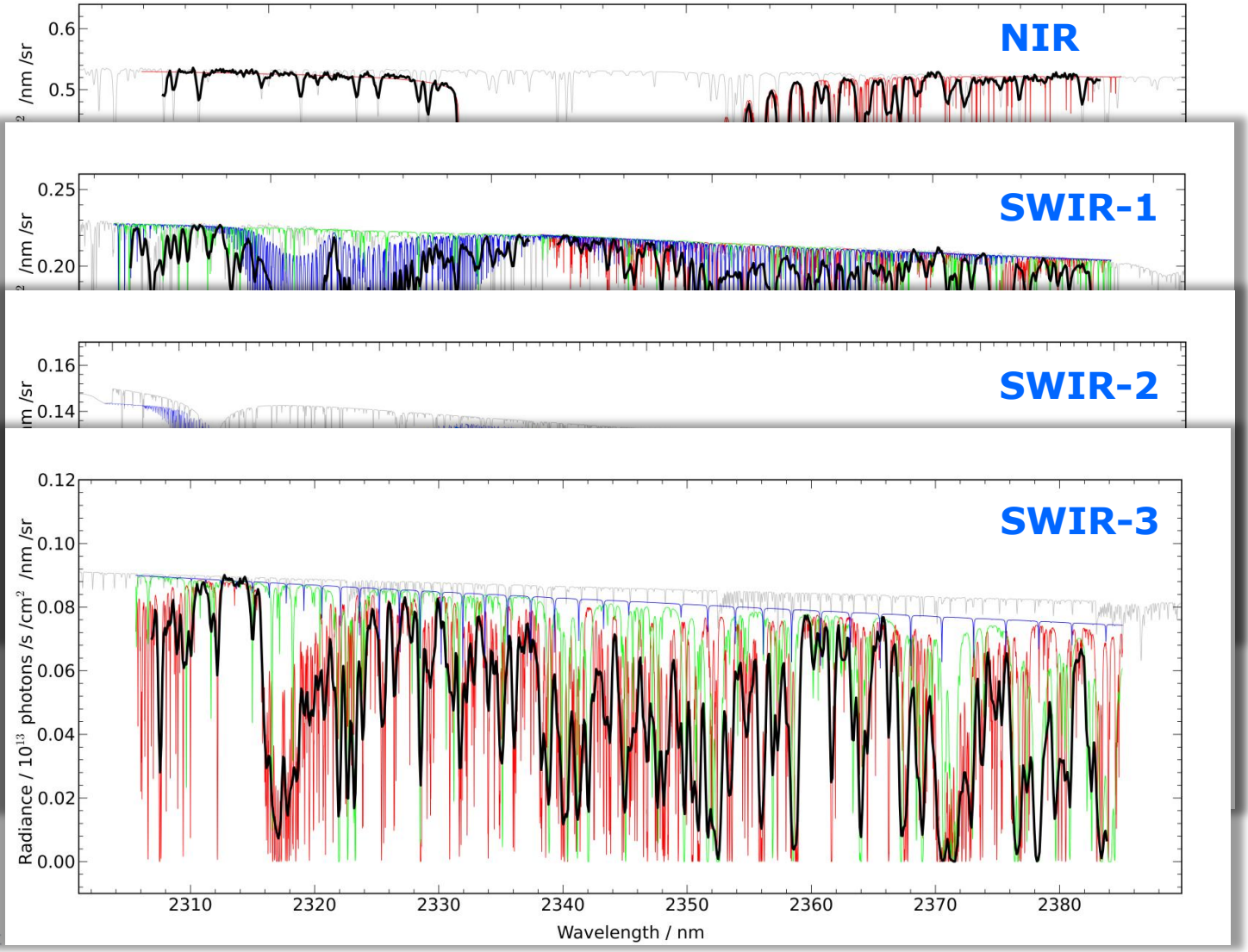
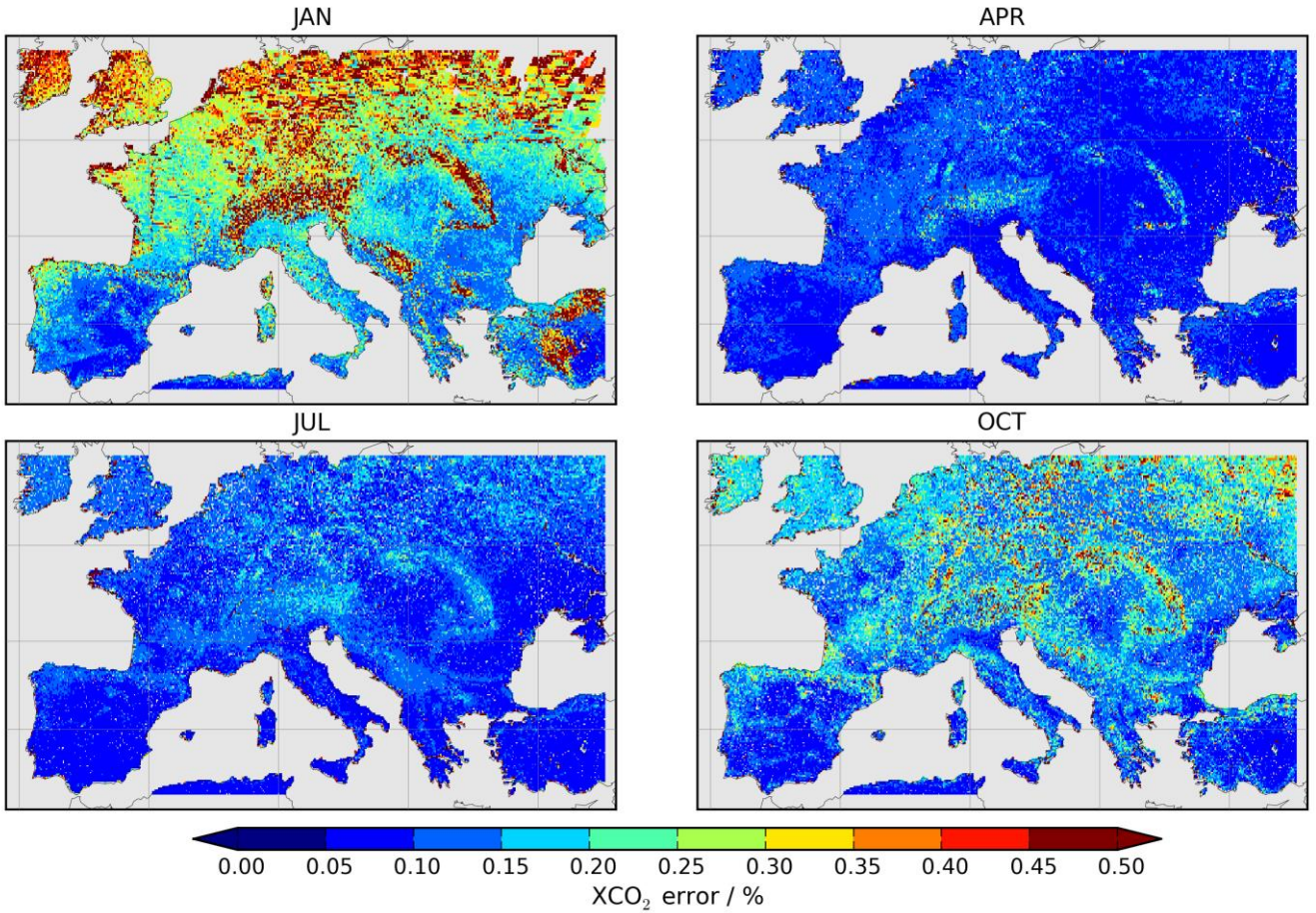


G3E: simulated noise performance

[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



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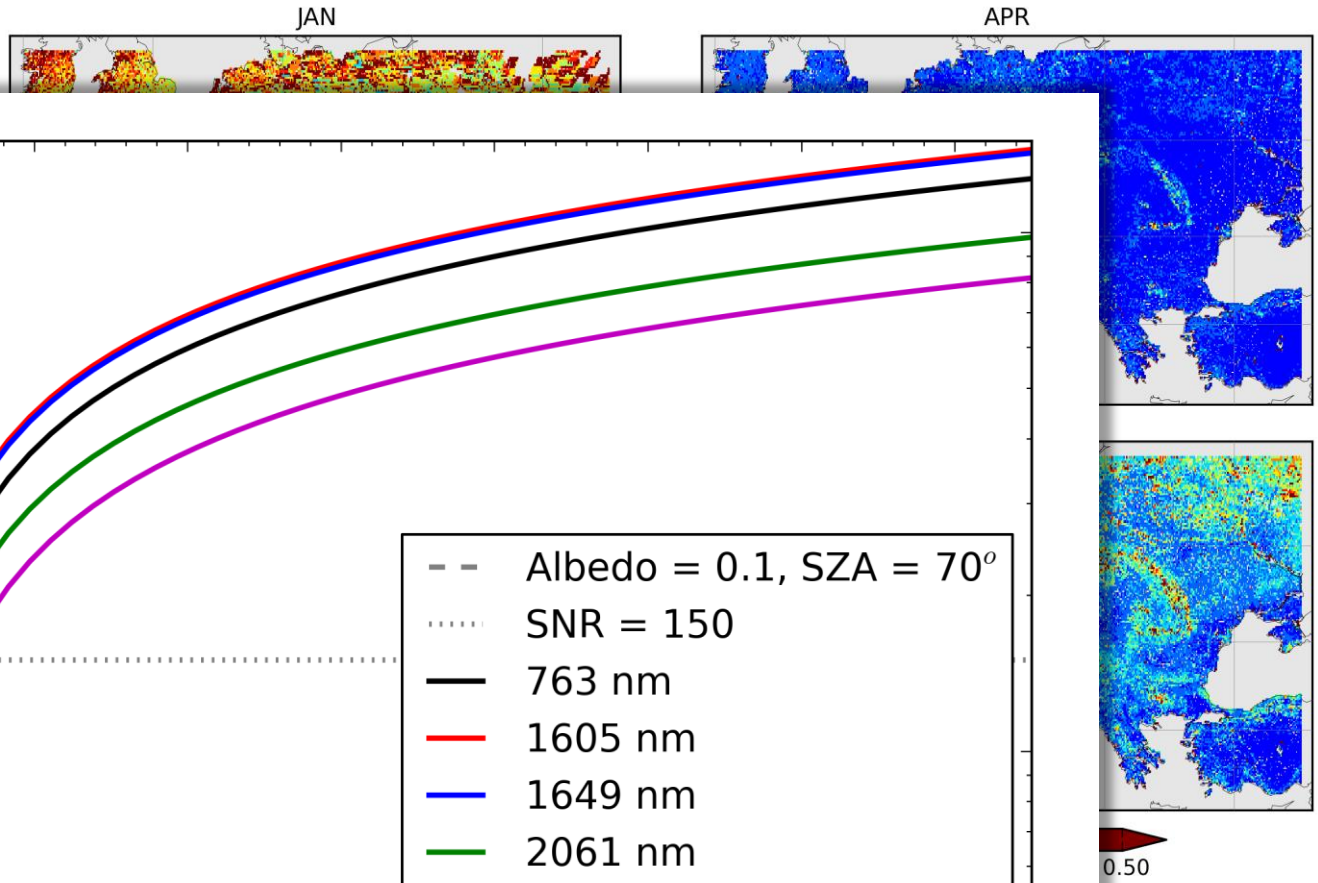
G3E: simulated noise performance

[Butz et al., AMT, 2015]

Trial ensemble:

MODIS albe
x 500 m)
0.1°
Europ



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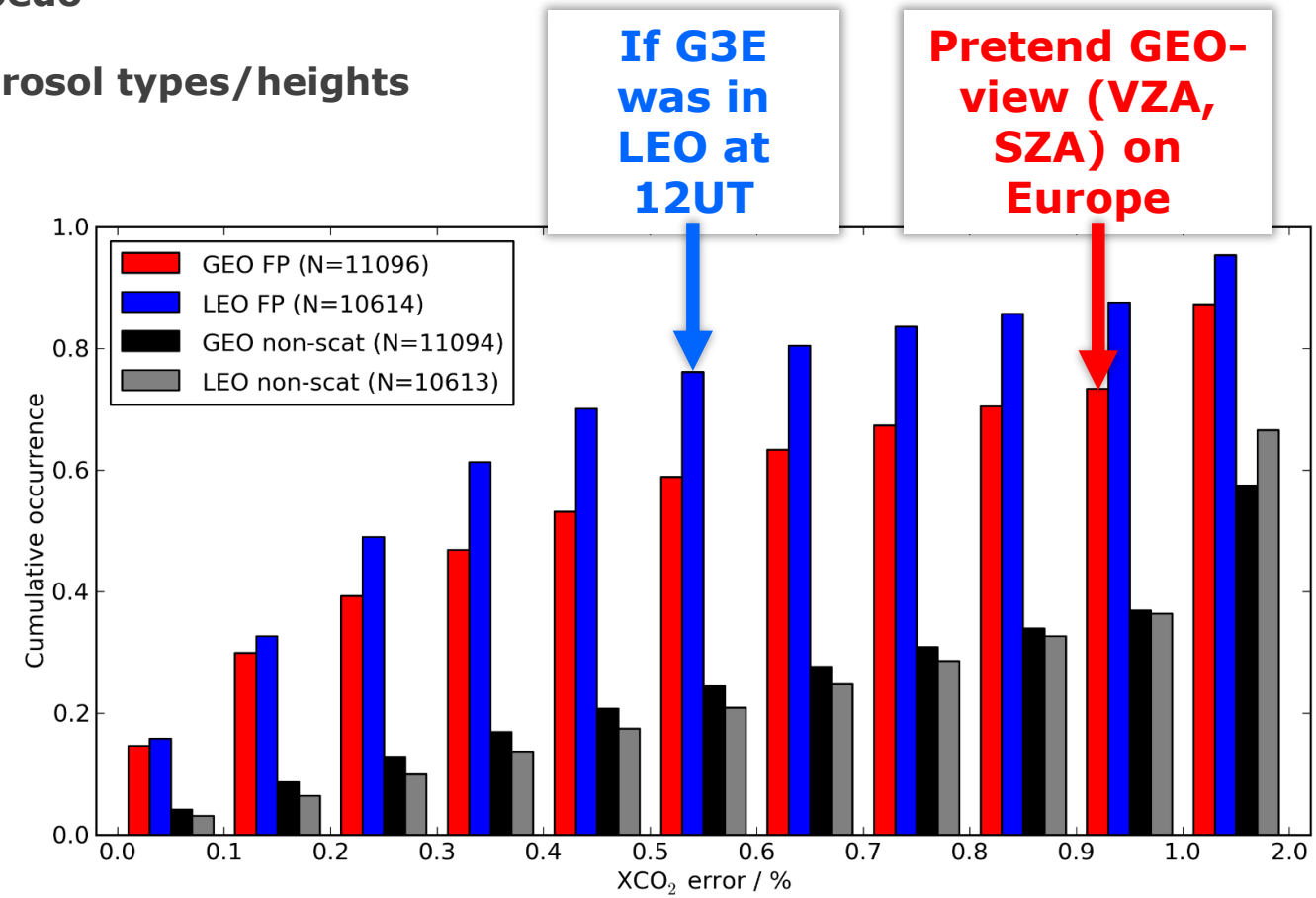
G3E: simulated performance under aerosol load

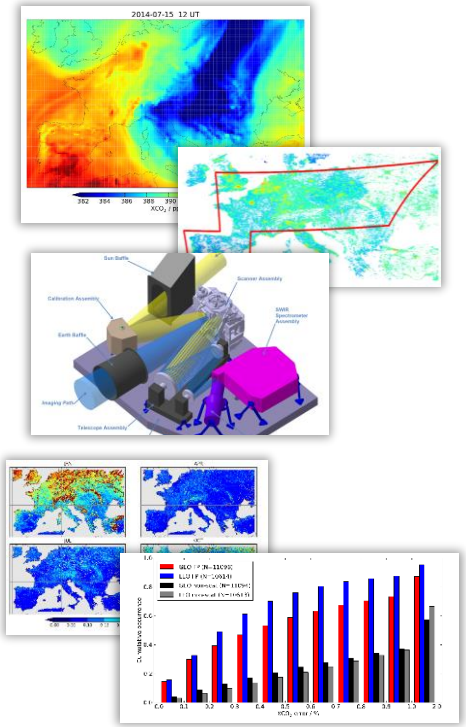
[Butz et al., AMT, 2015]

Trial ensemble:
MODIS aerosol/albedo
+ Calipso cirrus
+ ECHAM5-HAM aerosol types/heights



Analogue to our retrieval simulations for
OCO-2, GOSAT, S5P, S5 [e.g. Butz et al., RSE, 2012]

G3E



- 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 (NO_2, SO_2, …)

This study received funding from Federal Ministry for Economic Affairs and Energy Funding ID: 50 EE 1305.