G3E – Geostationary Emission Explorer for Europe

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

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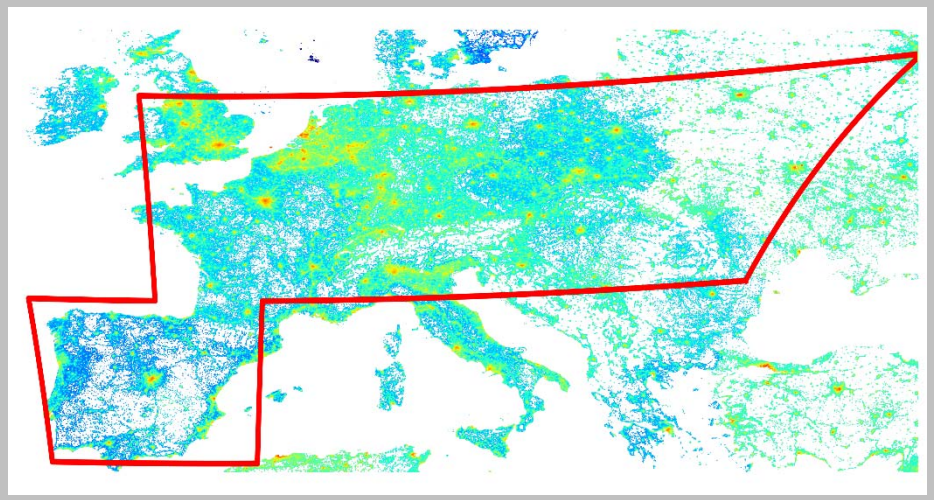

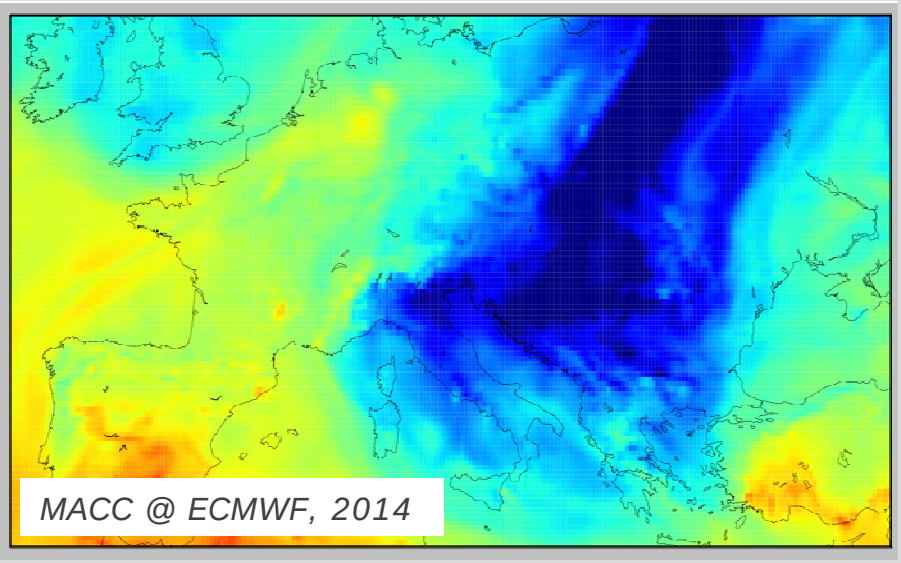

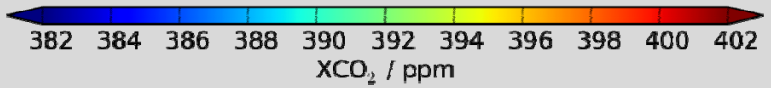

G3E: greenhouse gases from GEO

Current systematic carbon-cycle observations and the need for implementing a policy-relevant carbon observing system

P. Ciais[1], A. J. Dolman[2], A. Bombelli[3], R. Duren[4], A. Peregon[1], P. J. Rayner[5], C. Miller[4], N. Gobron[6], G. Kinderman[7], G. Marland[8], N. Gruber[9], F. Chevallier[1], R. J. Andres[10], G. Balsamo[11], L. Bopp[1], F.-M. Bréon[1], G. Broquet[1], R. Dargaville[5], T. J. Battin[12], A. Borges[13], H. Bovensmann[14], M. Buchwitz[14], J. Butler[15], J. G. Canadell[16], R. B. Cook[10], R. DeFries[17], R. Engelen[11], K. R. Gurney[18], C. Heinze[19,20,21], M. Heimann[22], A. Held[23], M. Henry[24], B. Law[25], S. Luyssaert[1], J. Miller[15,26], T. Moriyama[27], C. Moulin[1], R. B. Myneni[28], C. Nussli[29], M. Obersteiner[7], D. Ojima[30], Y. Pan[31], J.-D. Paris[1], S. L. Piao[32], B. Poulter[1], S. Plummer[33], S. Quegan[34], P. Raymond[35], M. Reichstein[22], L. Rivier[1], C. Sabine[36], D. Schimel[37], O. Tarasova[38], R. Valentini[3], R. Wang[1], G. van der Werf[2], D. Wickland[39], M. Williams[40], and C. Zehner[41]

→ Investigate the potential of geostationary platforms.

[Ciais et al., BG, 2014]

Study funded via DLR Emmy Noether-Programm DFG

G3E: greenhouse gases from GEO

Current systematic carbon-cycle observations and the need for implementing a policy-relevant carbon observing system

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[Ciais et al., BG, 2014]

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]

Study funded via DLR Emmy Noether-Programm DFG

G3E: greenhouse gases from GEO

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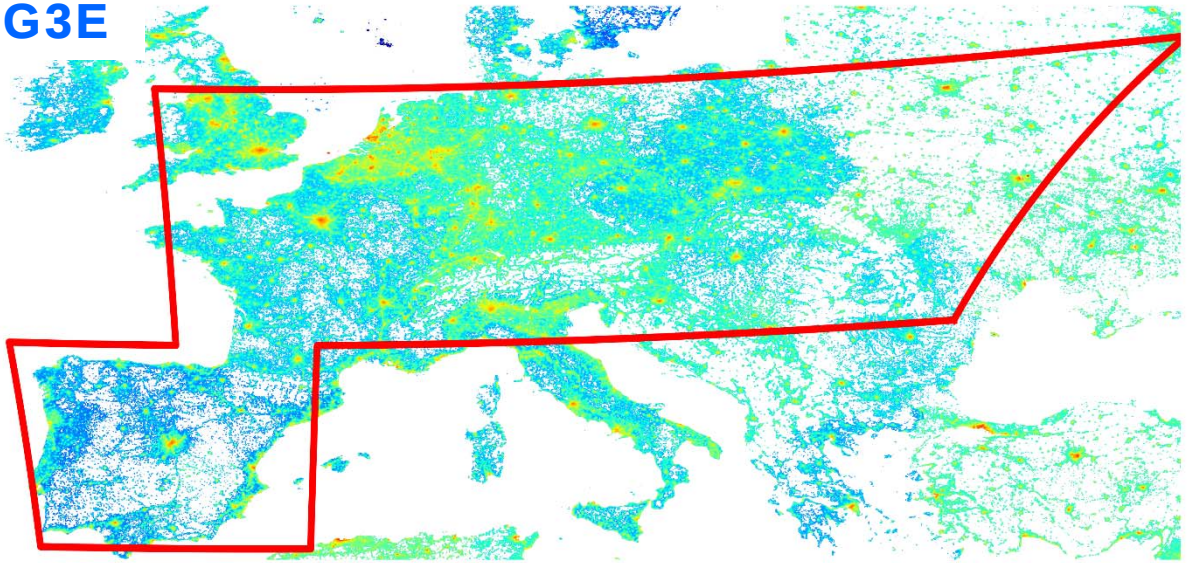
G3E



…ms.
…14]

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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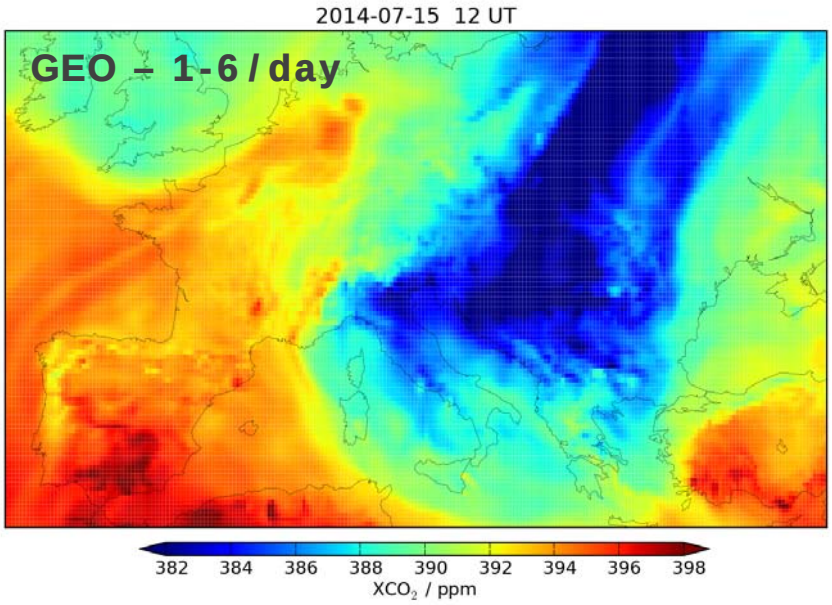
Study funded via DLR, Emmy Noether-Programm, Deutsche Forschungsgemeinschaft DFG

G3E: 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).



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

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

Study funded via DLR Emmy Noether-Programm DFG

G3E: instrument design

G3E: 4-channel grating spectrometer (lots of design choices borrowed from S5, S4, CarbonSat ...)

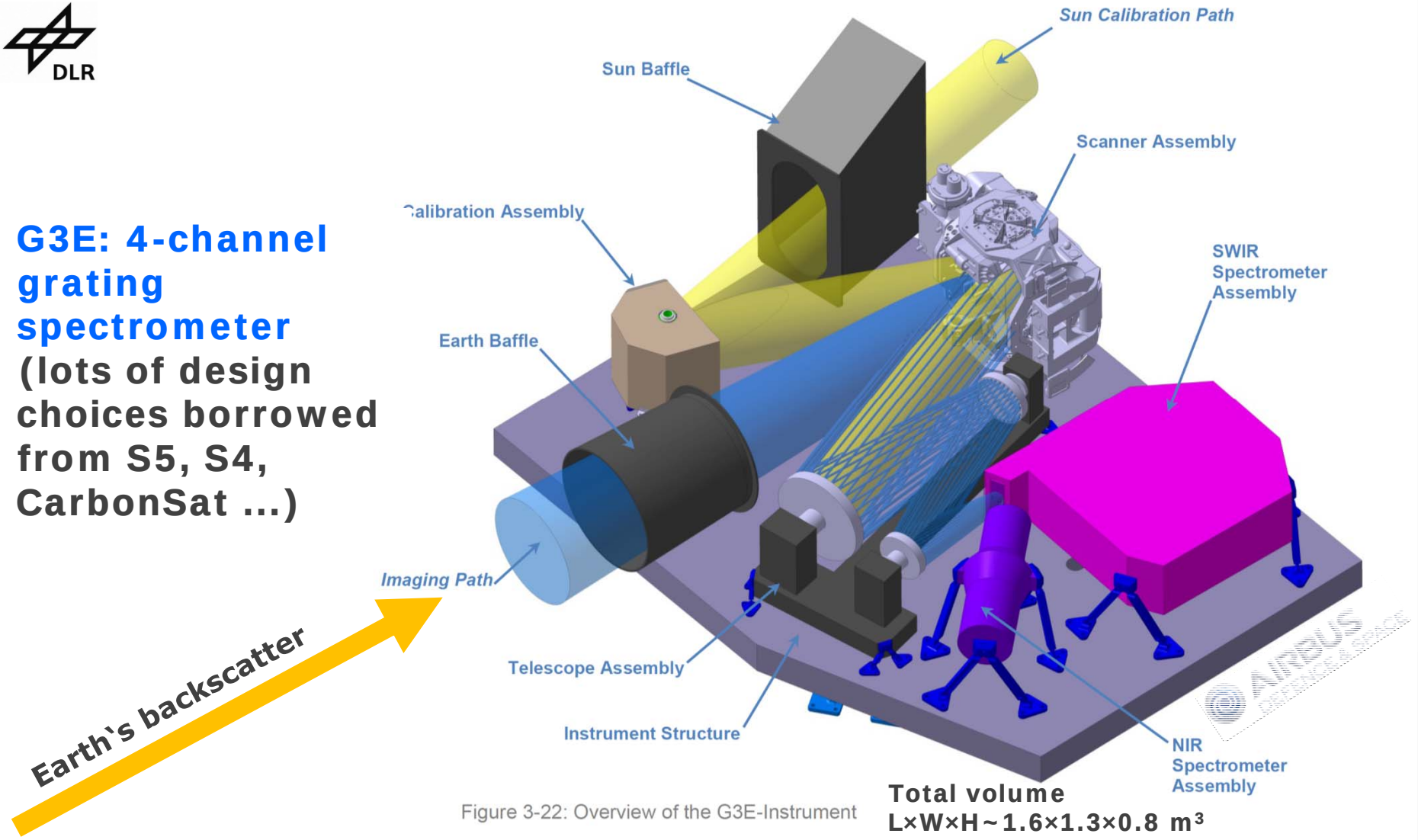


Figure 3-22: Overview of the G3E-Instrument

Total volume
L×W×H ~ 1.6×1.3×0.8 m³

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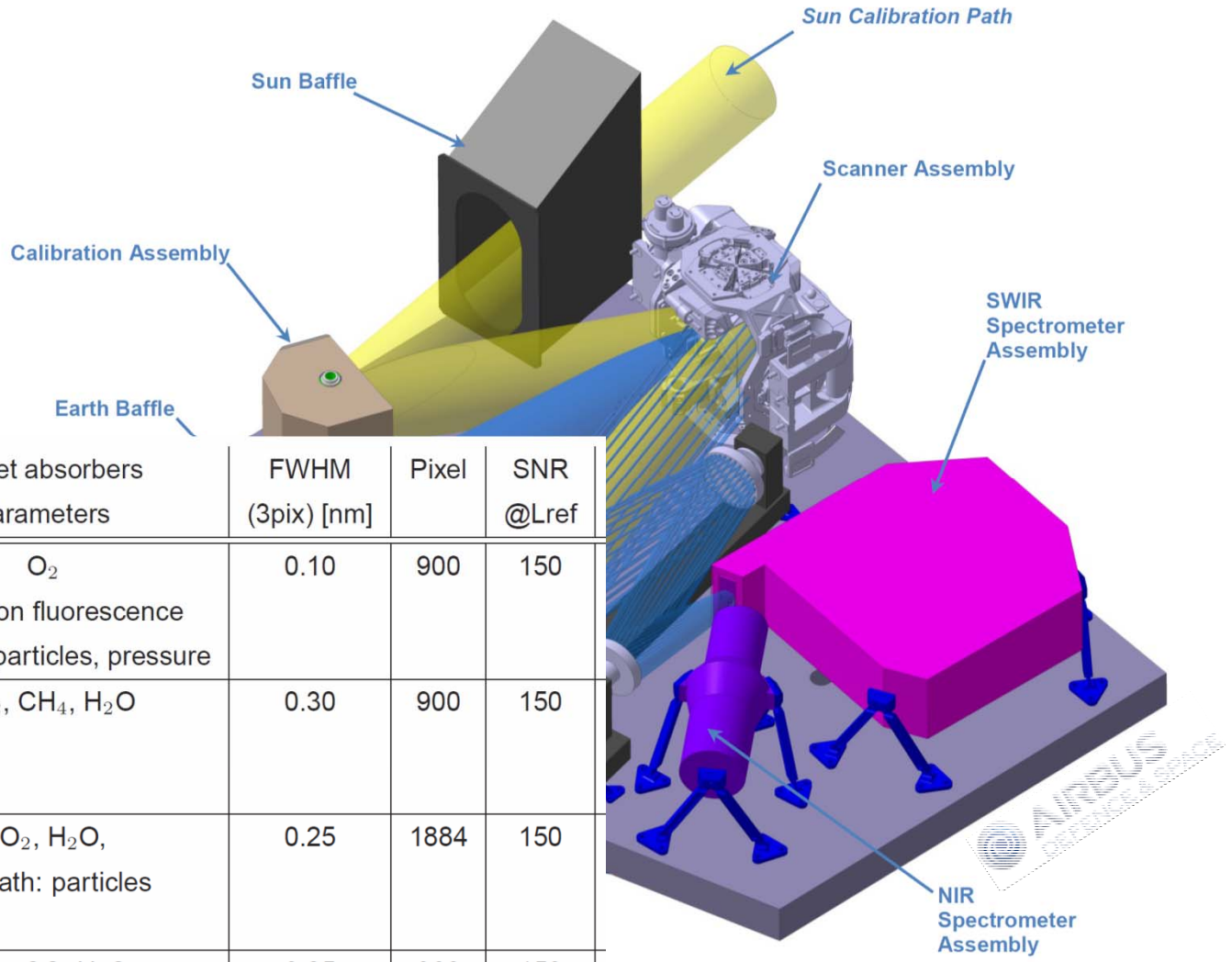
G3E: instrument design

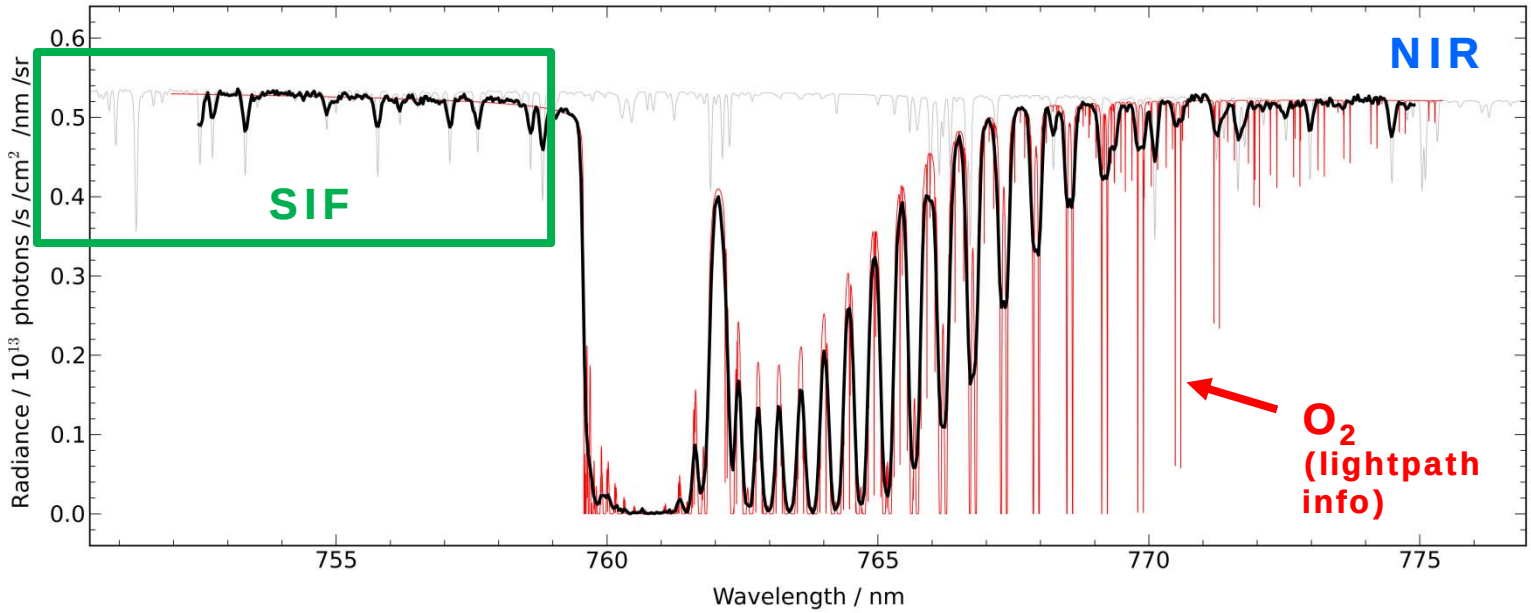
G3E: 4-channel grating spectrometer



Band ID	Spectral range [nm]	Target absorbers parameters	FWHM (3pix) [nm]	Pixel	SNR @Lref
NIR	745 - 775	O_2 vegetation fluorescence lightpath: particles, pressure	0.10	900	150
SWIR-1	1585 - 1675	CO_2, CH_4, H_2O	0.30	900	150
SWIR-2	1925 - 2082	CO_2, H_2O, lightpath: particles	0.25	1884	150
SWIR-3	2305 - 2385	CH_4, CO, H_2O lightpath: particles	0.25	960	150

Study funded via DLR Emmy Noether-Programm DFG

G3E: simulated soundings



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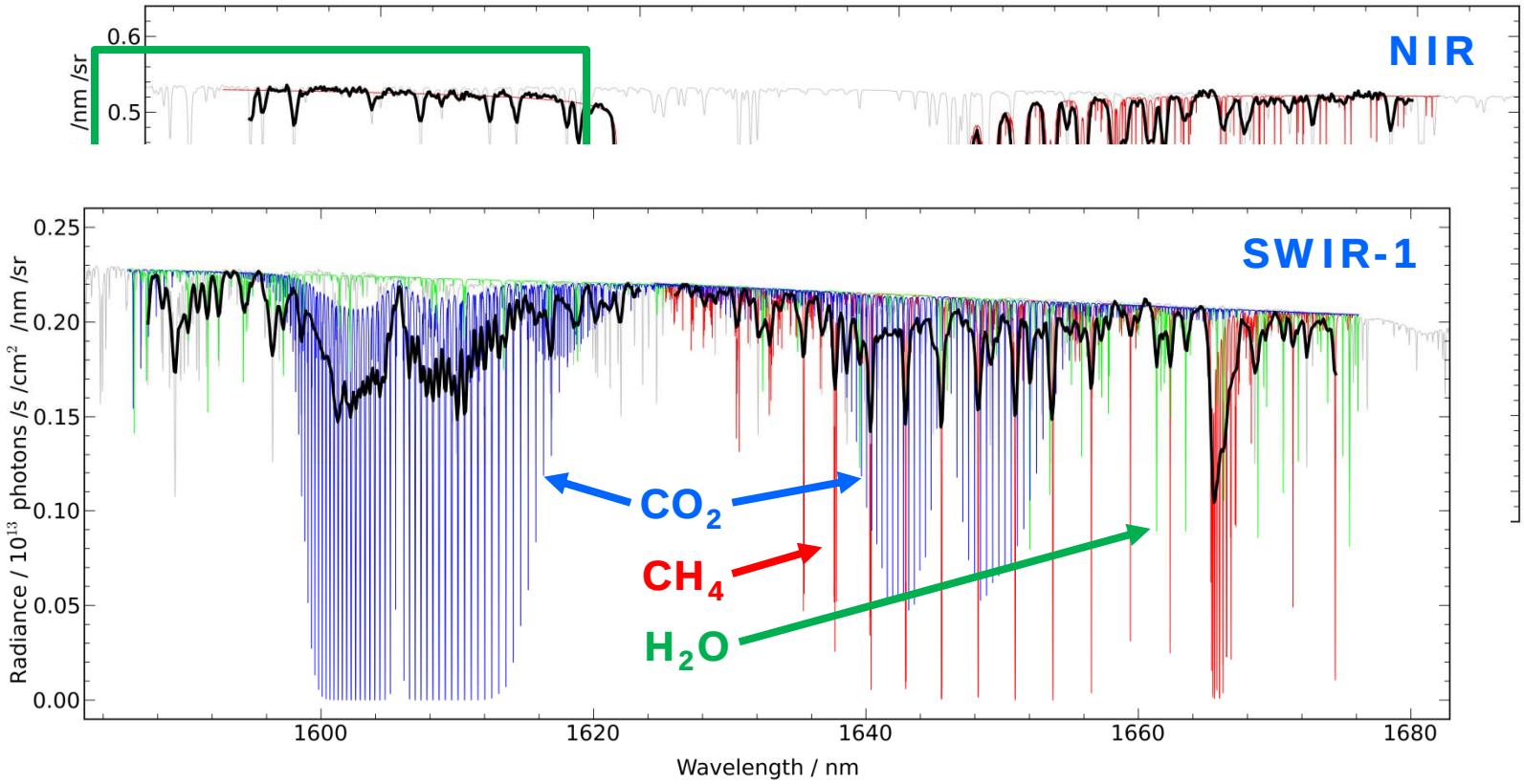
G3E: simulated soundings



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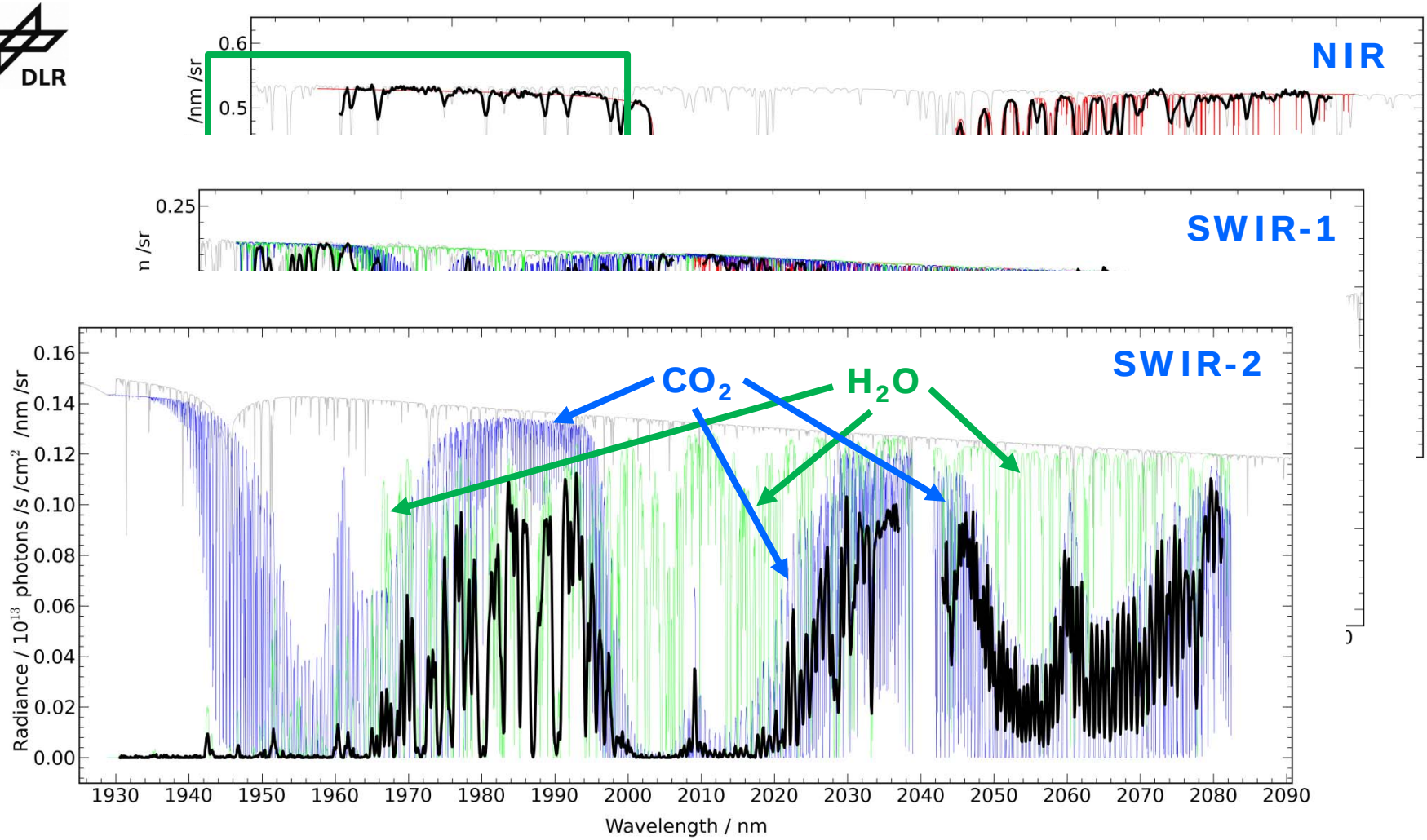

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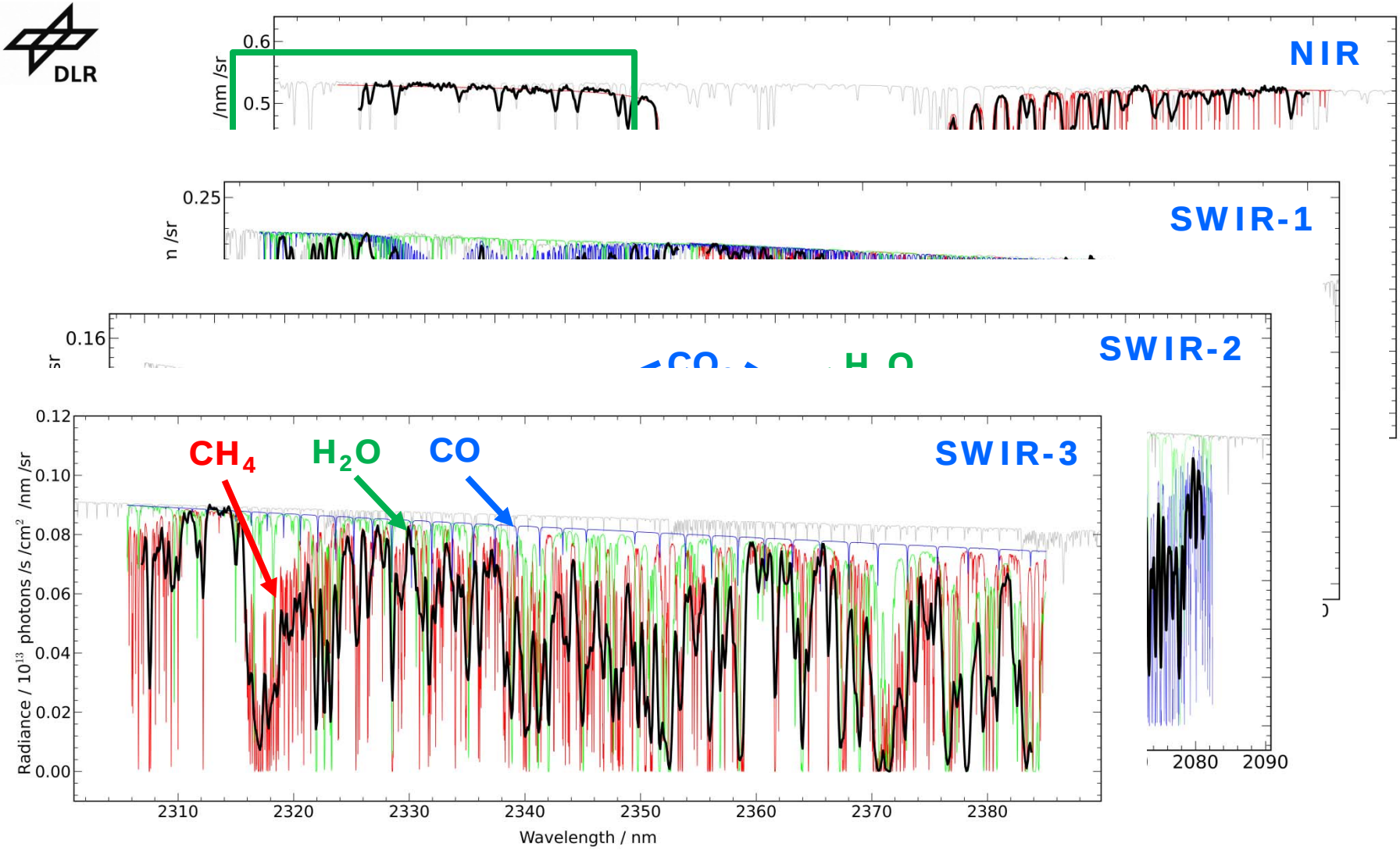
G3E: simulated soundings



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Study funded via

G3E: synergies in geostationary orbit

Meteosat Third Generation (MTG)

- Flexible Combined Imager (FCI, solar + thermal imager): spatiotemporally high-resolution (0.5-2 km, ~10 min) cloud and aerosol information

- Infrared Sounder (IRS, thermal infrared sounder, ~4 km, ~30 min): mid-tropospheric CO, O_3, H_2O, clouds, cirrus

- Sentinel-4/UVN (S4, UV/vis/NIR solar backscatter, ~8km, ~1 h): total column O_3, NO_2, SO_2, H_2CO, …, aerosols

… use for G3E's cloud screening, aerosol-driven radiative transfer …

… use for synergistic SWIR+TIR CO retrievals, source/transport attribution, cirrus screening …

… use for source attribution (NO_2 = anthro, SO_2 = volcanic), aerosol RT, cloud screening …

André Butz

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G3E: synergies in geostationary orbit

Meteosat Third Generation (MTG)

- Flexible Combined Imager (FCI,
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MTG:
~ Imaging and air quality
(+ benefits for climate gases)

G3E:
~ climate gases
(+ benefits for air quality)

IR
:
), ...,

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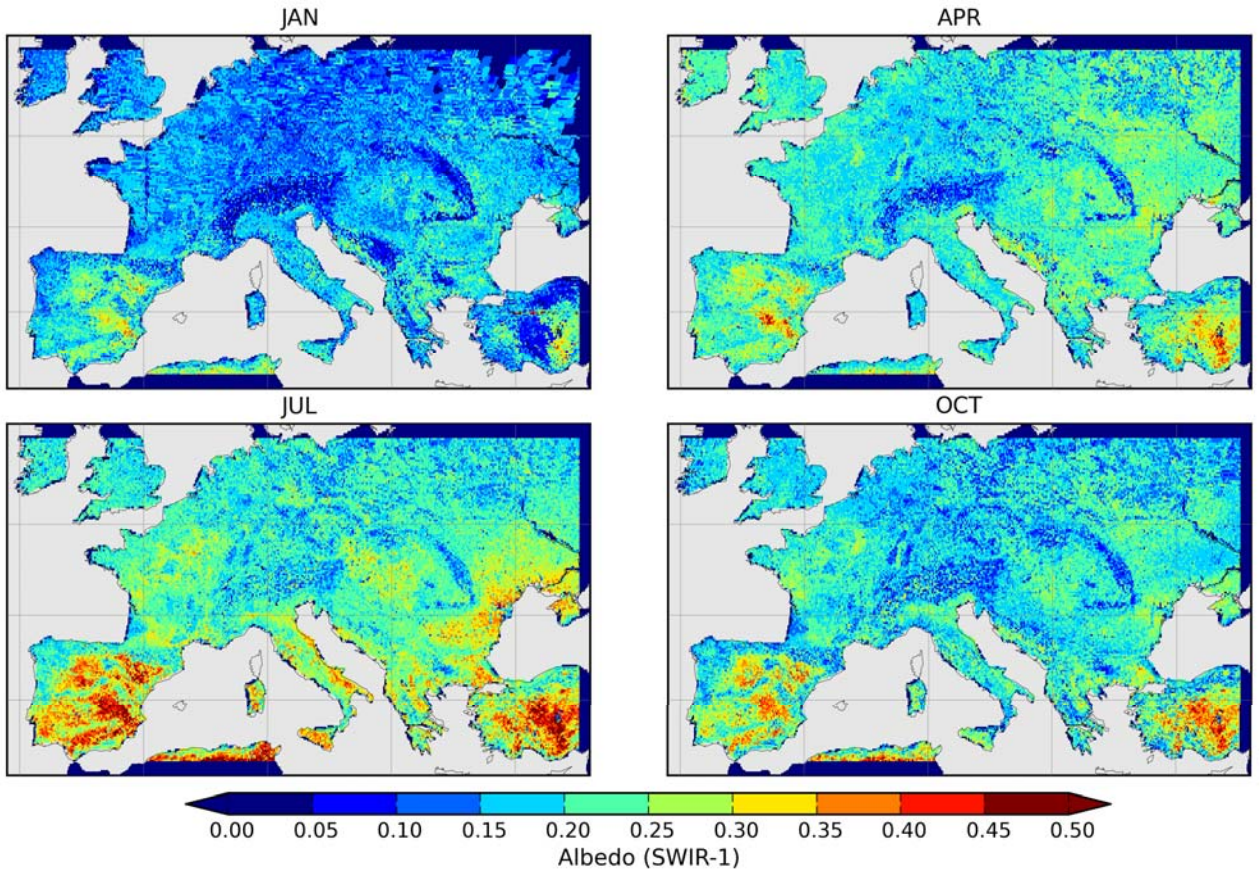
G3E: performance simulations

SNR – random errors



Sample MODIS albedo (500 m x 500 m) at 0.1° x 0.1° for a European albedo ensemble

Acknowledgement: MODIS land albedo product at http://modis-atmos.gsfc.nasa.gov/index.html

Study funded via DLR Emmy Noether-Programm DFG

G3E: performance simulations

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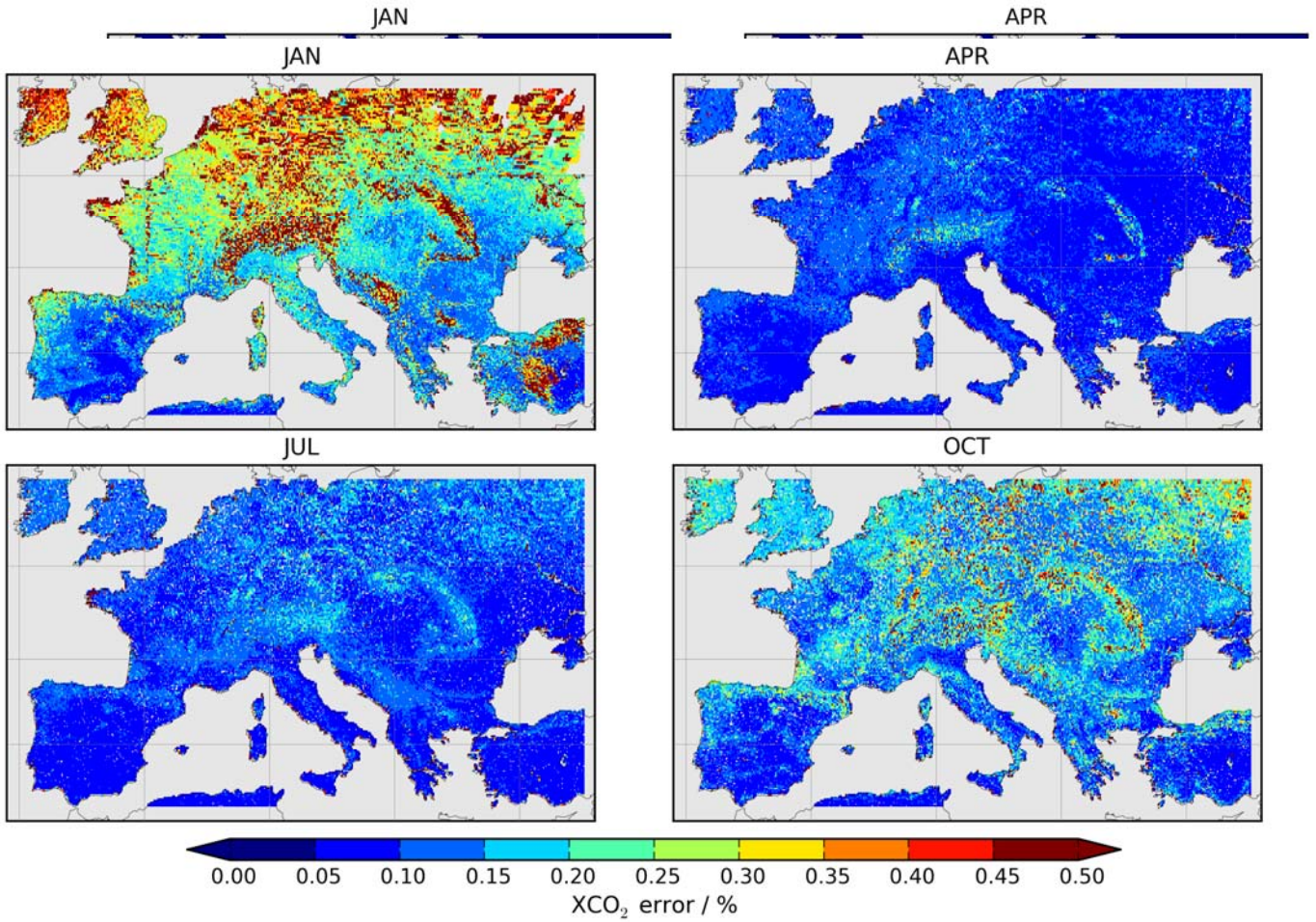

Sample MOI
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G3E: performance simulations

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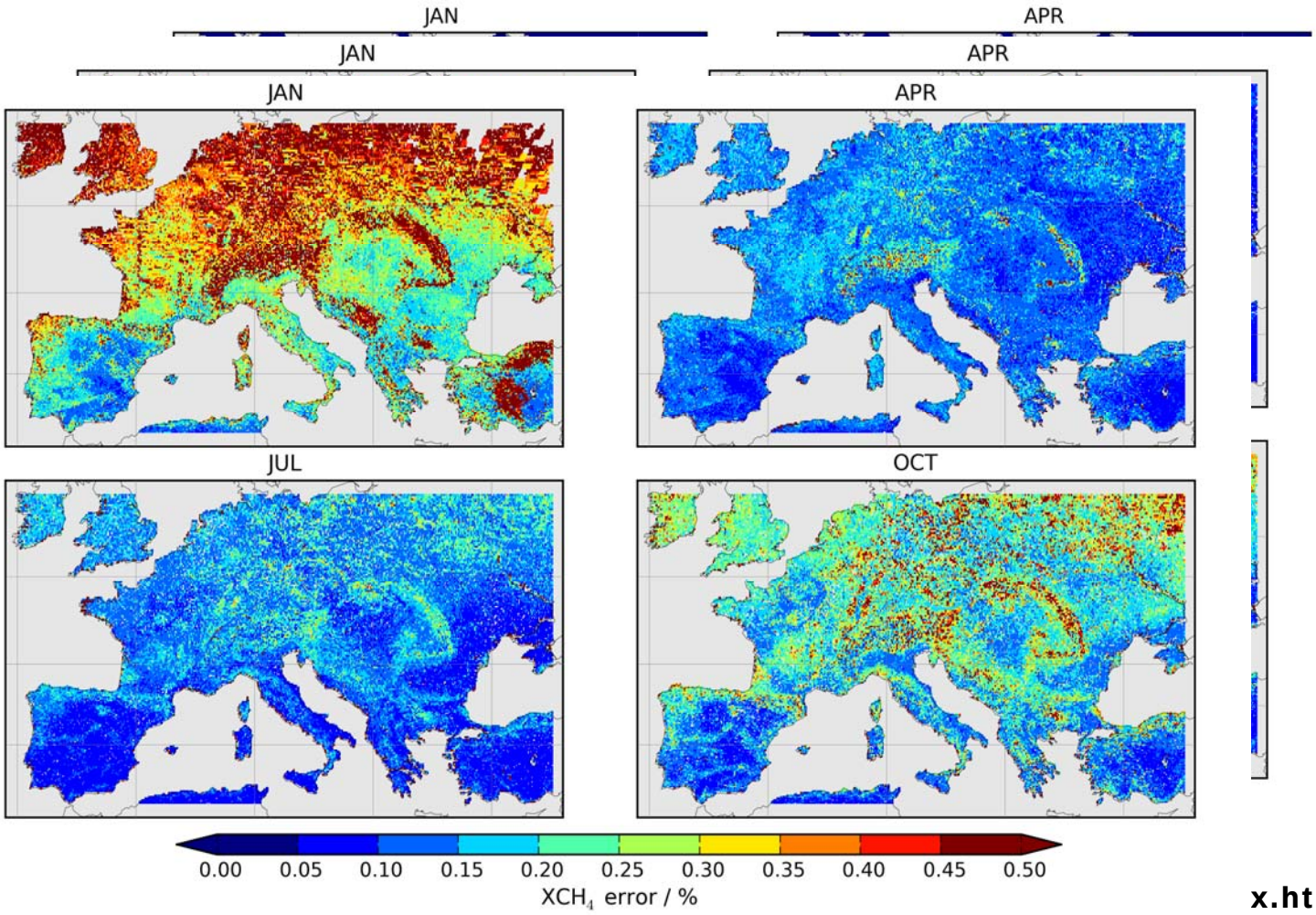

Sample
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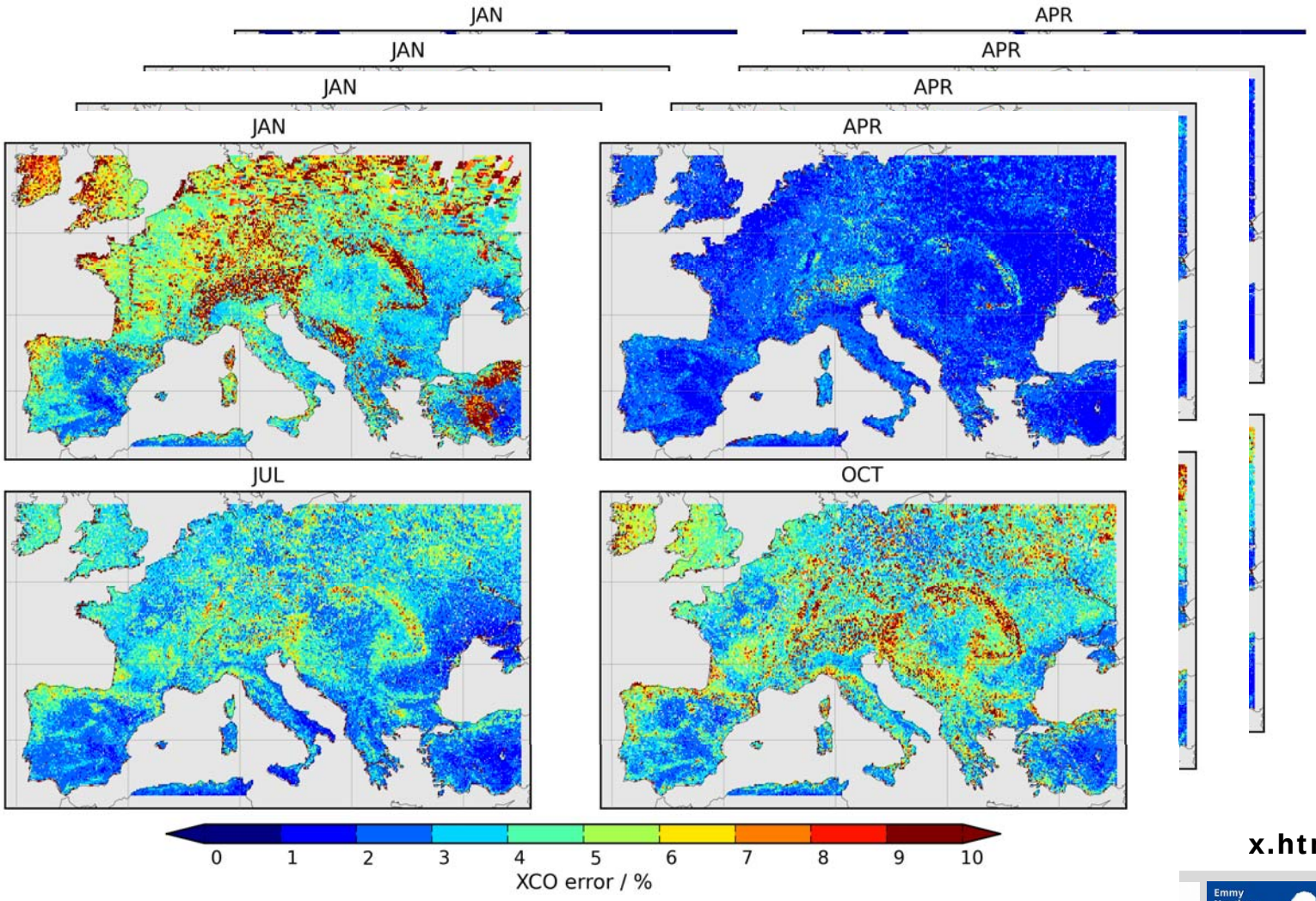
SNR – random errors



Sam
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0.1° for a
albedo

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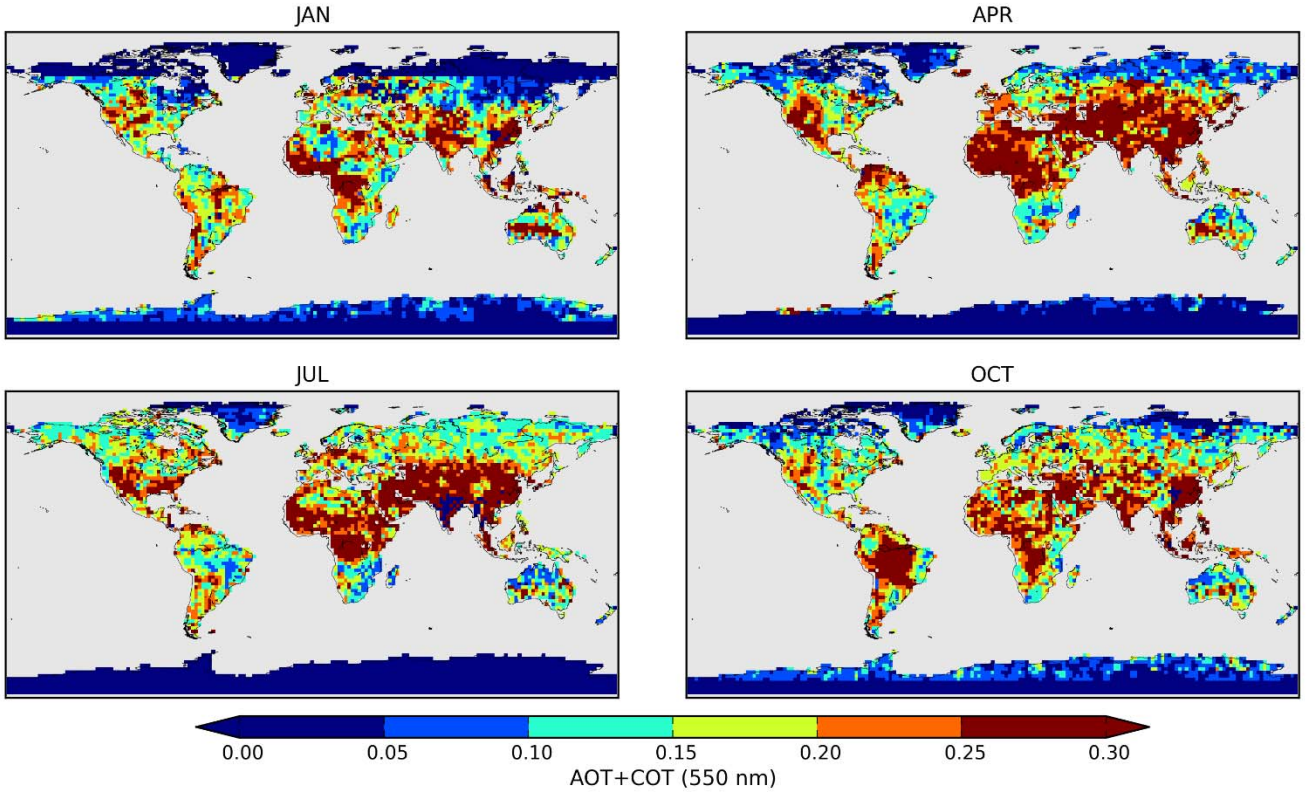
Emmy Noether-Programm
Deutsche Forschungsgemeinschaft DFG

G3E: performance simulations

Performance for aerosol/cirrus-loaded scenes

Use previously assembled global ensemble on 2° x 2°:

- **MODIS: AOT**
- **ECHAM5-HAM: aerosol type**
- **CALIOP: cirrus**
- **MODIS: albedo**
- **CarbonTracker: CO_2**
- **TM4: CH_4, CO**
- **ECHAM5-HAM: H_2O**



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

Study funded via DLR Emmy Noether-Programm DFG

G3E: performance simulations

Performance for aerosol/cirrus-loaded scenes

Use previously assembled global ensemble on 2° x

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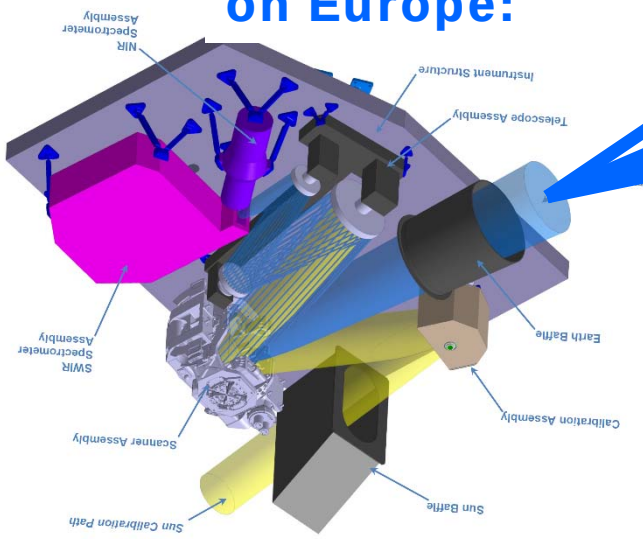
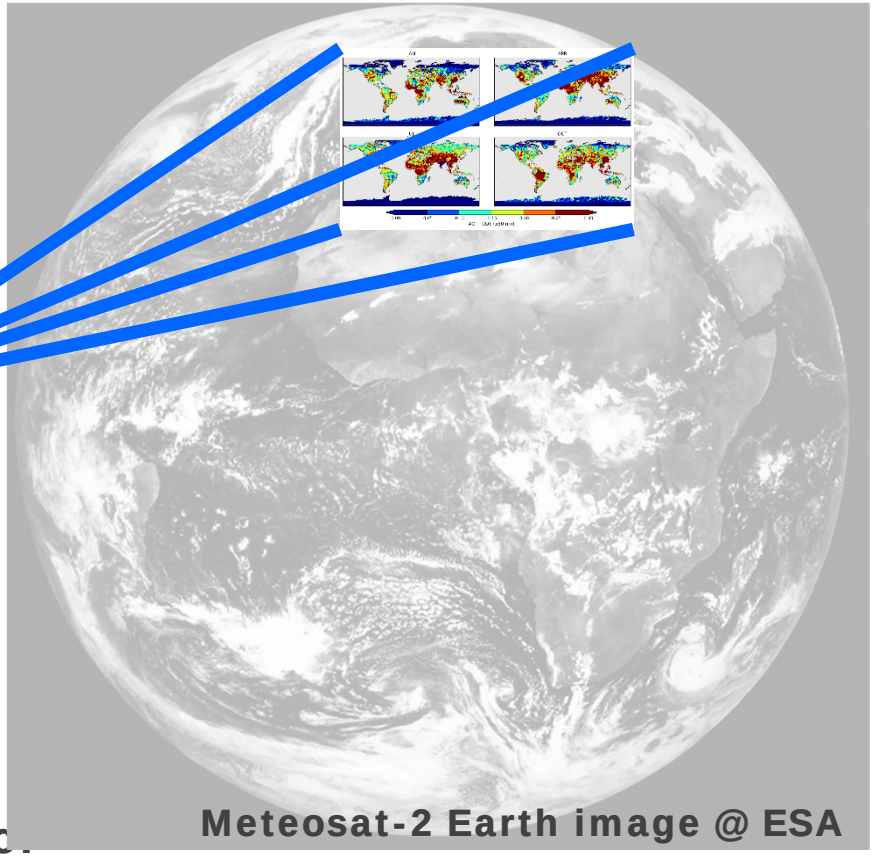
- ECHAM aeroso
- CALIO
- MODIS
- Carbo
- TM4: (
- ECHAI

Pretend GEO-view (VZA, SZA) on Europe:





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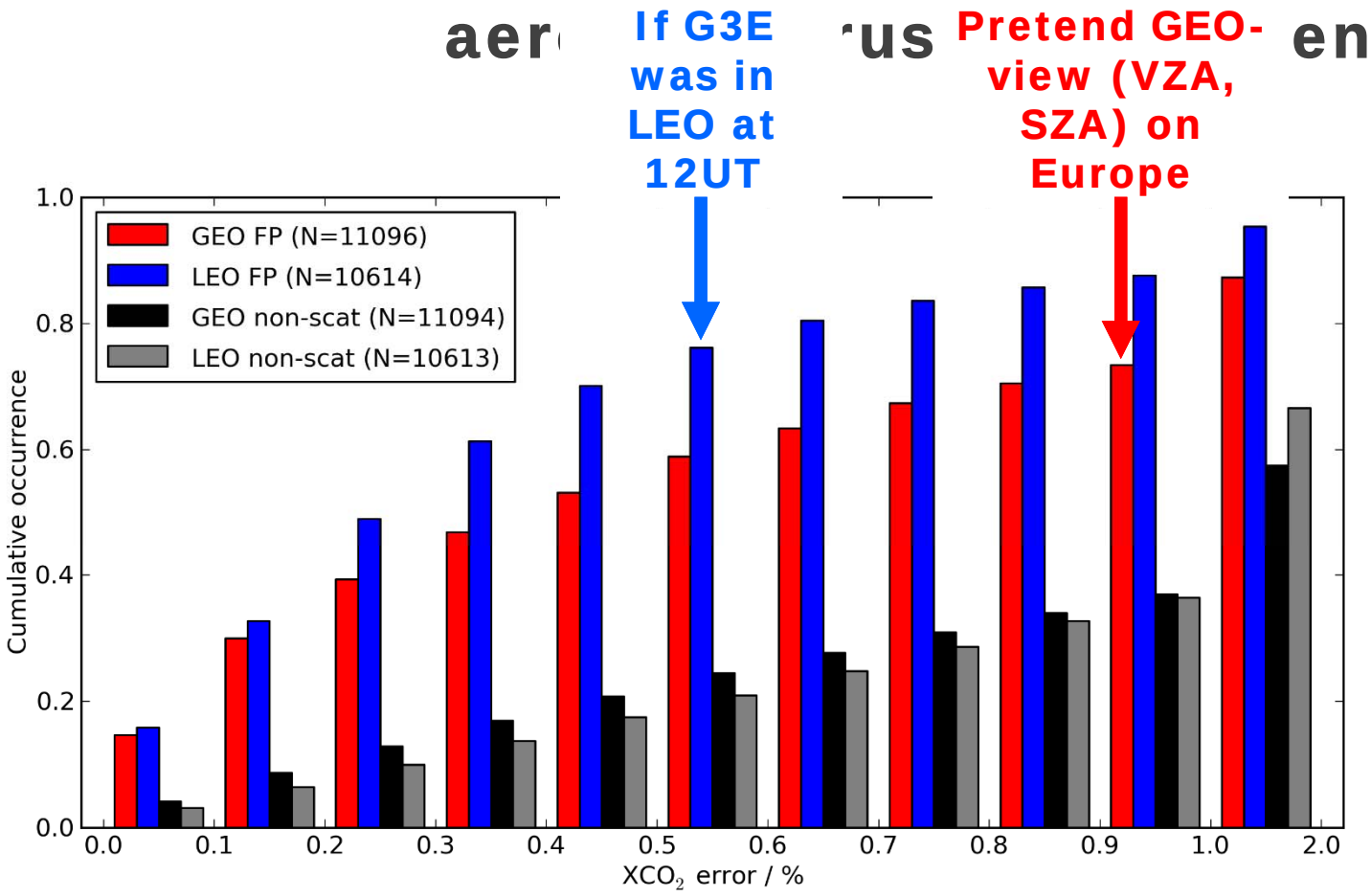
G3E: performance simulations

Performance for aer[illegible]rus [illegible]enes



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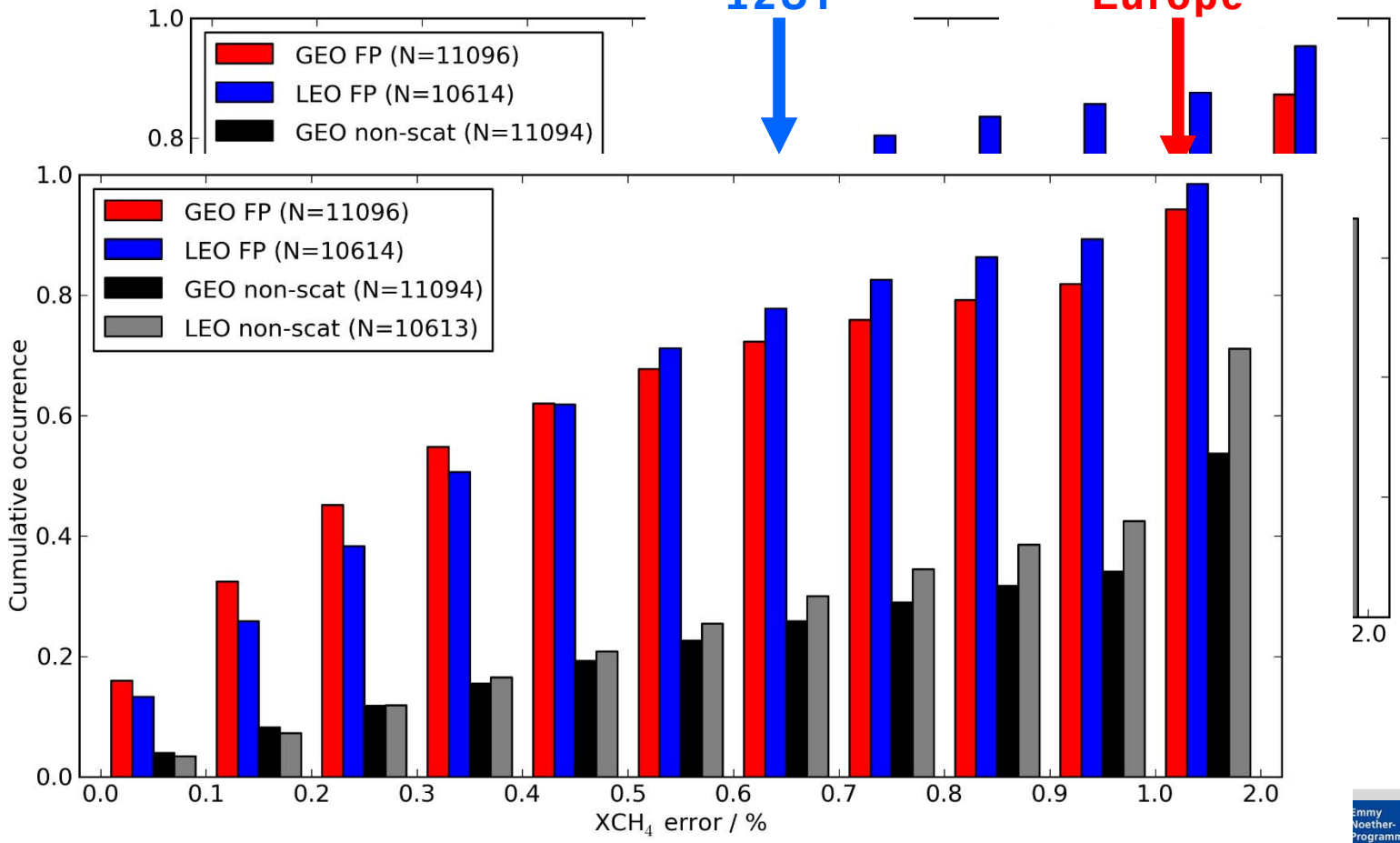
G3E: performance simulations

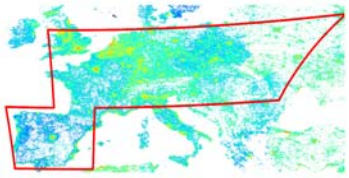
Performance for aer[illegible]rus [illegible]enes

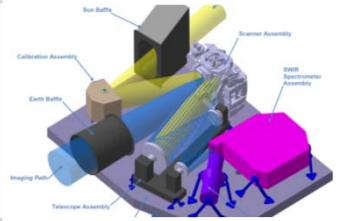
If G3E was in LEO at 12UT

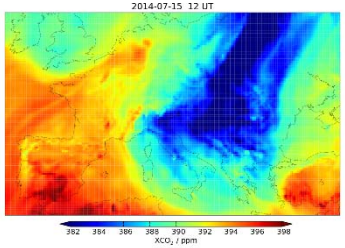
Pretend GEO-view (VZA, SZA) on Europe

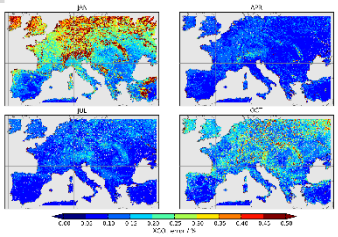


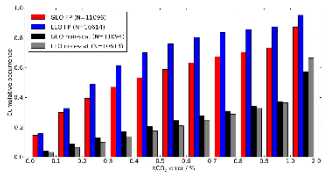
G3E – Geostationary Emission Explorer for Europe











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

- Goal: contiguous imaging of GHG (+support: XCO, aerosols, fluorescence) to disentangle and quantify anthropogenic and biogenic sources and sinks

- Synergies: MTG-FCI/IRS/S4 – clouds, aerosols, SWIR-TIR CO, process markers (NO_2, SO_2, …)

- Strategic:

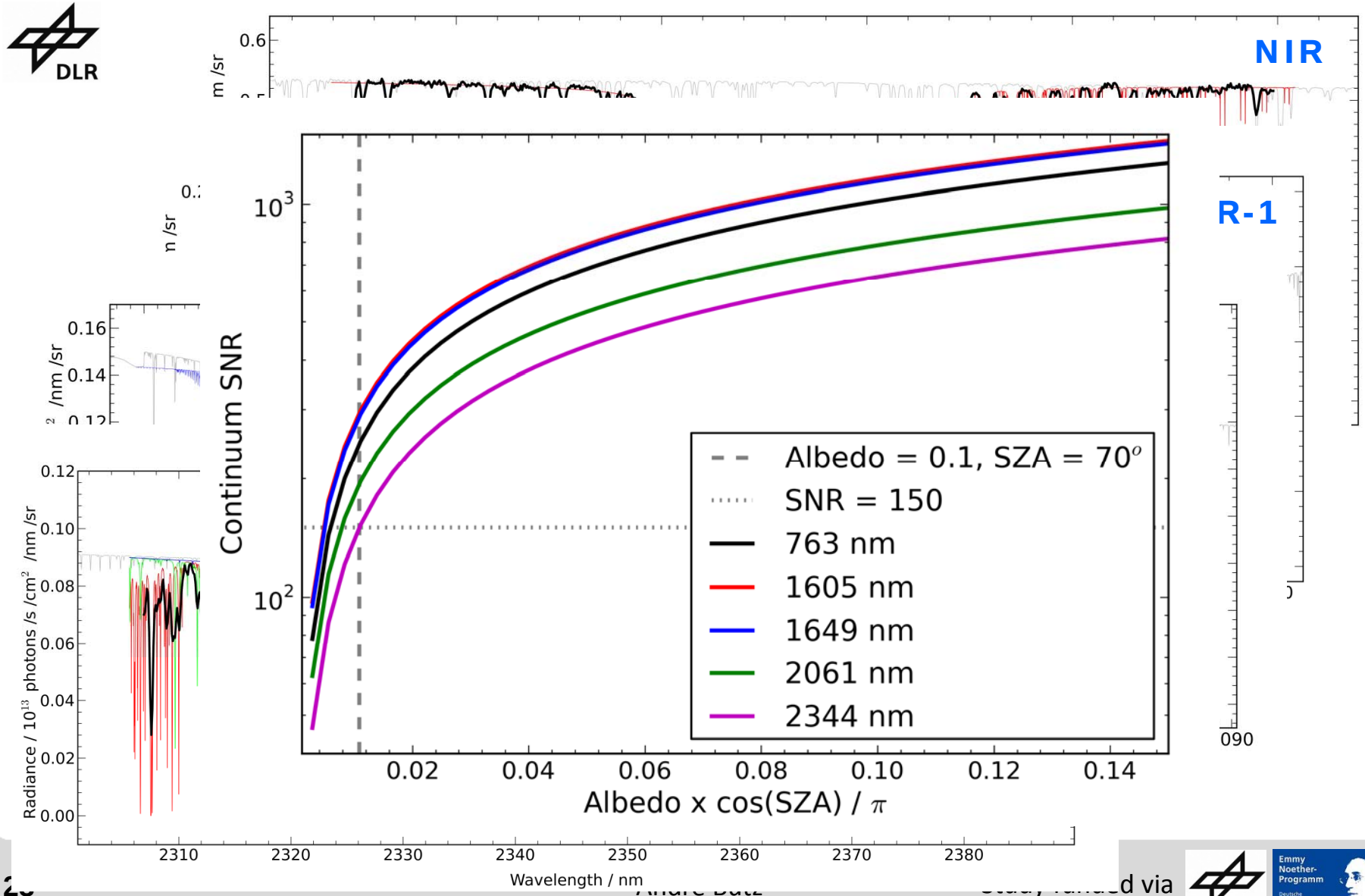
  → Complement meteorological and air quality sounders (MTG, TEMPO, …) by a/several GEO greenhouse gas mission(s)

  → Complement global view from LEO with regional spatiotemporally dense zoom from GEO

  → Constellation with other agencies: US – GEO-CARB, GCPI, ….

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

G3E: simulated soundings



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