Methane Retrievals in the Thermal and Short-Wave Infrared from IASI

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CH₄ Retrievals in the TIR

RAL-RSG IASI CH₄ retrieval

- Optimal estimation retrieval scheme which fits the TIR spectral range 1232-1290cm⁻¹.
- Jointly fits CH₄ with H₂O, HDO, surface temperature, cloud fraction, cloud altitude and scale factors for two systematic fit residuals.
- Retrieval of effective cloud parameters exploits information provided by N₂O absorption within the fit window.
- IASI measured spectra are fitted to a BT RMS of 0.1K; at this precision, the scheme delivers XCH₄ to a precision of 20-40 ppbv.

Recent advances

- Scheme has been extensively compared to Leicester GOSAT retrievals, models (GEOSCHEM, TOMCAT and ECMWF) and TCCON ground-based observations
- Processed Metop-A from 2007-2013 (2014 on the way)
- Scheme adapted to Metop-B (giving virtually identical performance)
TIR Retrieval Comparisons with MACC
**CH₄ Retrievals at 3.7 μm**

**Background**

- IASI measures methane lines in the **3.7-3.9 μm** (2500-2700 cm⁻¹) SWIR spectral range, where there is a significant solar component.
- AK peaks sharply near the surface at ~3.7 μm
  - Solar component provides retrieval **sensitivity to the boundary layer** where trace gas emissions peak
- **Combination of SWIR and TIR** retrievals has the potential to provide both height resolved information and surface sensitivity.

**Challenges**

- Complexity of modelling both solar and thermal terms
- Relatively **high IASI noise** in this spectral region
- RTTOV solar spectrum **missing significant solar lines** – replaced with ACE

[Diagram of Black Body Emission Curves of the Sun and Earth]

[Graph showing Transmission vs Wavelength with peaks at CH₄, HDO, N₂O]
Noise Reduction using Principal Components

Example of the noise reduction achieved by using PC reconstructed spectra (Atkinson et al., 2010).

![Raw and Reconstructed Spectra](chart.png)
SWIR XCH₄ Retrieval

Mean day a priori

Mean day MACC

Mean day retrieved

Mean day MACC_AK
SWIR XCH₄ Day vs Night

Mean day retrieved

Mean night retrieved

xCH₄ error / ppmv

xCH₄ error / ppmv

RAL Space

ESA ATMOS Workshop, 8-12th June, Heraklion, Greece.
Day-time SWIR averaging kernel shows that the solar component is delivering retrieval sensitivity that extends down to the surface.
Comparing SWIR XCH\textsubscript{4} Retrievals with MACC

MACC

Mean day MACC

Mean night MACC

MACC (AK applied)

Mean day MACC_AK

Mean night MACC_AK

RAL-RSG

Mean day retrieved

Mean night retrieved

TIR

Mean day MACC

Mean night MACC

Mean day MACC_AK

Mean night MACC_AK

Mean day retrieved

Mean night retrieved

ESA ATMOS Workshop, 8-12\textsuperscript{th} June, Heraklion, Greece.
Retrieval validation with TCCON

**SWIR (day-time)**

- Lauder 125HR
- Darwin
- Caltech
- Tsukuba 125HR
- Four Corners
- Garmisch
- Karlsruhe
- Bialystok
- Ny Alesund

**TIR (day and night)**

- Wollongong
- Saga
- JPL 2011
- Lamont
- Park Falls
- Orleans
- Bremen
- Sodankyla
- Eureka

**SWIR (night-time)**

- Lauder 125HR
- Reunion Island
- Ascension Island
- Izana
- Saga
- JPL 2011
- Lamont
- Park Falls
- Orleans
- Bremen
- Sodankyla
- Ny Alesund

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Summary and Future Work

TIR CH$_4$ retrievals

- XCH$_4$ with precision of 20-40 ppbv achieved
- Scheme has been extensively compared with GOSAT and model data (GEOSCHEM, MACC) and validated against TCCON network.
- Paper currently in preparation... publication imminent!

SWIR CH$_4$ retrievals

- Current results look extremely promising!
- Need to optimise the retrieval by...
  - improving spectral sampling and handling of systematic fit residuals
  - improving cloud modelling/filtering

Combination of TIR and SWIR retrievals
Thank you for listening

Any questions?

Mean day retrieved

Mean day MACC_AK

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