CH$_4$ profile retrievals from GOSAT thermal infrared measurements

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Why methane?
Near-surface CH$_4$ concentrations

**TIR**
- CH$_4$ profile information
- Sensitivity peaks ~8 km

**SWIR**
- Total CH$_4$ column

**SWIR + TIR**
- Partial columns

GOSAT has both SWIR and TIR channels
GOSAT in a nutshell
PROBLEM
Synergistic SWIR + TIR CH$_4$ retrievals – profiles

Overestimation by TIR

Underestimation by SWIR + TIR
Global positive bias
Land/sea differences
Day/night differences (not shown)
Bias correction attempts

Spectroscopy
• Integrated X-section
• Line width

Radiometric
• Intensity scaling
• Polynomial offset

Soft calibration
• Pixel mask
• Subtraction average residue

Investigate what spectral structures causes CH$_4$ bias
⇒ Need very good estimate of the atmosphere
⇒ Aircraft campaign: HIPPO
Aircraft campaign: HIPPO
HIPPO: HIAPER Pole-to-Pole Observations

Profiles: 0-15 km

http://hippo.ornl.gov/
GOSAT TIR spectrum vs ‘1st guess’
Spectral residues
Average residue
Average residue and 1st principal component

- Strong H₂O peaks

![Diagram showing average residue and 1st principal component with strong H₂O peaks.]
Impact of fitting 1st principal component component

Huge reduction in bias
Remaining bias is smooth
Standard deviation almost identical
Conclusion and outlook

CH$_4$ TIR retrieval is extremely sensitive to small spectral features

Therefore biases are easily introduced

CH$_4$ from GOSAT TIR

- Positive bias in retrieved CH$_4$ profile up to 10%
- Global effect, with regional differences
- Land/sea and day/night transitions not smooth

Bias correction

- Straightforward bias correction schemes do not work
- Principal component analysis of spectral residuals is promising:
  - Over TCCON station Wollongong bias is reduced by factor of 10

Next steps

- Other TCCON stations
- Global map ➔ check land/sea and day/night transitions
Thank you
Radiative transfer: SWIR vs. TIR

Albedo 30%

Reflected Solar Radiation 101.9 W m\(^{-2}\)

Incoming Solar Radiation 341.3 W m\(^{-2}\)

OLR

Emitted by Atmosphere 169

Latent Heat 80

Absorbed by Surface

MERRA R1 ERA40* CFSR
JRA25 R2 ERA-I C20R

*1990s

Net absorbed 0.9 W m\(^{-2}\)

SFC
GOSAT TIR spectrum with Planck curves

\[ I = B + (I_0 - B)e^{-\sigma \rho l} \]

GOSAT spectrum
Lamont, US - cloud free

Radiance [W/m² sr cm⁻¹]

Wavenumber [cm⁻¹]

CO₂, O₃, CH₄, H₂O