Validation of TES Methane with HIPPO Observations

For Application to Adjoint Inverse Modeling of Methane Sources

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Adjoint Inverse Modeling of Methane Sources

HIPPO QCLS Methane (Kort, Daube, Wofsy) provides:
- Large number of profiles
- Wide latitudinal coverage
- Remote from sources (reduces colocation error)

GEOS-Chem CTM

GEOS-Chem Adjoint

TES Methane (Worden, Kulawik)

Adjoint inverse analysis

OPTIMIZATION OF SOURCES
**TES Methane**

- Thermal IR, sun-synchronous orbit
- Observations since Sept 2004
- One global survey (GS) = 16 orbits, 26 h
- One 5x8 km² observation every 182 km
- 15-16 GS each month

**V004**

- Methane retrieval 7.658 – 7.740 μm
- Degrees of Freedom for Signal 0.6-1.6
- Averaging kernels peak 200-400 hPa

**VNEW**

- Expanded window, N₂O correction
- Degrees of Freedom for Signal 1.0-2.0
- Averaging kernels peak 200 & 500 hPa

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**Rows of Averaging Kernel**

- **Pressure**
- **DOFS = 1.54**
- RTVMR

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**Rows of Averaging Kernel**

- **Pressure**
- **DOFS = 1.99**
- RTVMR-lo
- RTVMR-hi
The Benefits of HIPPO Methane

- HIPPO I & II only
- QCLS error << TES error
- Many, high profiles
- Latitudinal coverage
- Remote from local methane sources
- Dominant variability with latitude
- Little vertical variability
- Apply TES operator & RTVMR

**HIPPO I Southbound interpolated methane**

![Map and graph showing HIPPO I and HIPPO II routes and methane data](image)
Using HIPPO and TES V004 to Define Coincidence Criteria

Validation characterizes mean bias and residual error. Residual error contains contributions from:
1) error in the retrieval
2) colocation error

Coincidence requirements of ±750 km, ±24 h are sufficient. Consistent with remote Pacific.
Positive bias and significant noise, but latitudinal gradient roughly captured. Bias and error appear constant with latitude. Error larger than self-reported!
Bias and error reduced compared with V004 methane. RTVMR-hi bias is a function of latitude.
The Ability of TES V004 to Capture Latitudinal Gradients

TES V004 captures HIPPO lat. gradients on a scale of ~20°. Informative for inverse modeling.
Model Comparison – NOAA GMD
2008 Annual Average

• GEOS-Chem provides good simulation in the annual average
• Missing northern hemisphere sources?

TES provides far greater spatial and temporal coverage than NOAA GMD
VNEW reveals information not captured by V004.
Old TES CH$_4$ - Most recent public release

- TES is biased high and residual instrument error is > self-reported range
- Colocation error in VOLD validation is negligible
- TES captures latitudinal gradient in HIPPO data at ~20° resolution
- Enabling Inverse Modeling:
  - Characterization of bias and error
  - Robust latitudinal gradient with greater coverage than surface stations

New TES CH$_4$

- Sensitivity lower in troposphere (important for inverse modeling)
- Error < old TES CH$_4$

Future Work

- **Validation of TES over source region**
- Adjoint Inversion with new TES CH$_4$
- Combine with total column measurement (SCIAMACHY, GOSAT)
- Focus on N.A. with GEOS-Chem nested-grid capability