Recent increase of ethane detected in the remote atmosphere of the Northern Hemisphere

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Abstract (1/3) *Next* ⇨

Ethane (C_2H_6) has a large impact on tropospheric composition and air quality because of its involvement in the global chemistry responsible for generating and destroying tropospheric ozone. The abundance of C_2H_6 influences the atmospheric content of carbon monoxide and impacts the lifetime of methane. It is an important source of PAN, a thermally unstable reservoir for NO_x radicals.

On a global scale, the main sources of C_2H_6 are **leakage from the production, transport of natural gas loss**, biofuel consumption and biomass burning, mainly located in the Northern Hemisphere. Due to its relatively long lifetime of approximately two months, C_2H_6 is a sensitive indicator of tropospheric pollution and transport.

C_2H_6 from FTIR at Jungfraujoch: Recent burden increase

Click on these links to obtain more information

C_2H_6 in the Southern Hemisphere: No recent upturn

Cause of the C_2H_6 renewal: Shale gas exploitation?

Comparison with GEOS-Chem: Underestimation in the inventories

EGU General Assembly 2015, April 13th, Vienna, Austria

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Previous

Abstract (2/3)

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Using an optimized retrieval strategy (Franco et al., 2015, *JQSRT*), we present here a 20-year long-term time series of C_2H_6 column abundance retrieved from **ground-based Fourier Transform InfraRed (FTIR) solar spectra** recorded from 1994 onwards at the high-altitude station of Jungfraujoch (Swiss Alps, 3580m), part of the Network for the Detection of Atmospheric Composition Change (NDACC, see http://www.ndacc.org).

After a regular 1994-2008 decrease of the C_2H_6 amounts, which is very consistent with prior major studies (e.g., Aydin et al., 2011, *Nature*; Simpson et al., 2012, *Nature*) and our understanding of global C_2H_6 emissions, trend analysis using a bootstrap resampling tool reveals a **C_2H_6 upturn** and a statistically-significant **sharp burden increase from 2009 onwards**.

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⇦ Previous

Abstract (3/3)

We hypothesize that the C_2H_6 increase could affect the whole Northern Hemisphere and may be related to the recent massive growth in the **exploitation of shale gas and tight oil reservoirs**. This hypothesis is supported by measurements derived from solar occultation observations performed from space by the ACE-FTS instrument and at other NDACC sites. The recent rates of changes characterizing these data sets are consistent in magnitude and sign with the one derived at Jungfraujoch. In contrast, the atmospheric C_2H_6 burden in the Southern Hemisphere shows a monotonic decrease over the last two decades.

An ongoing work focuses on combining an analysis of C_2H_6 measurements from ground-based FTIR and ACE-FTS observations with dedicated GEOS-Chem simulations with updated inventories to identify the cause of the C_2H_6 renewal.

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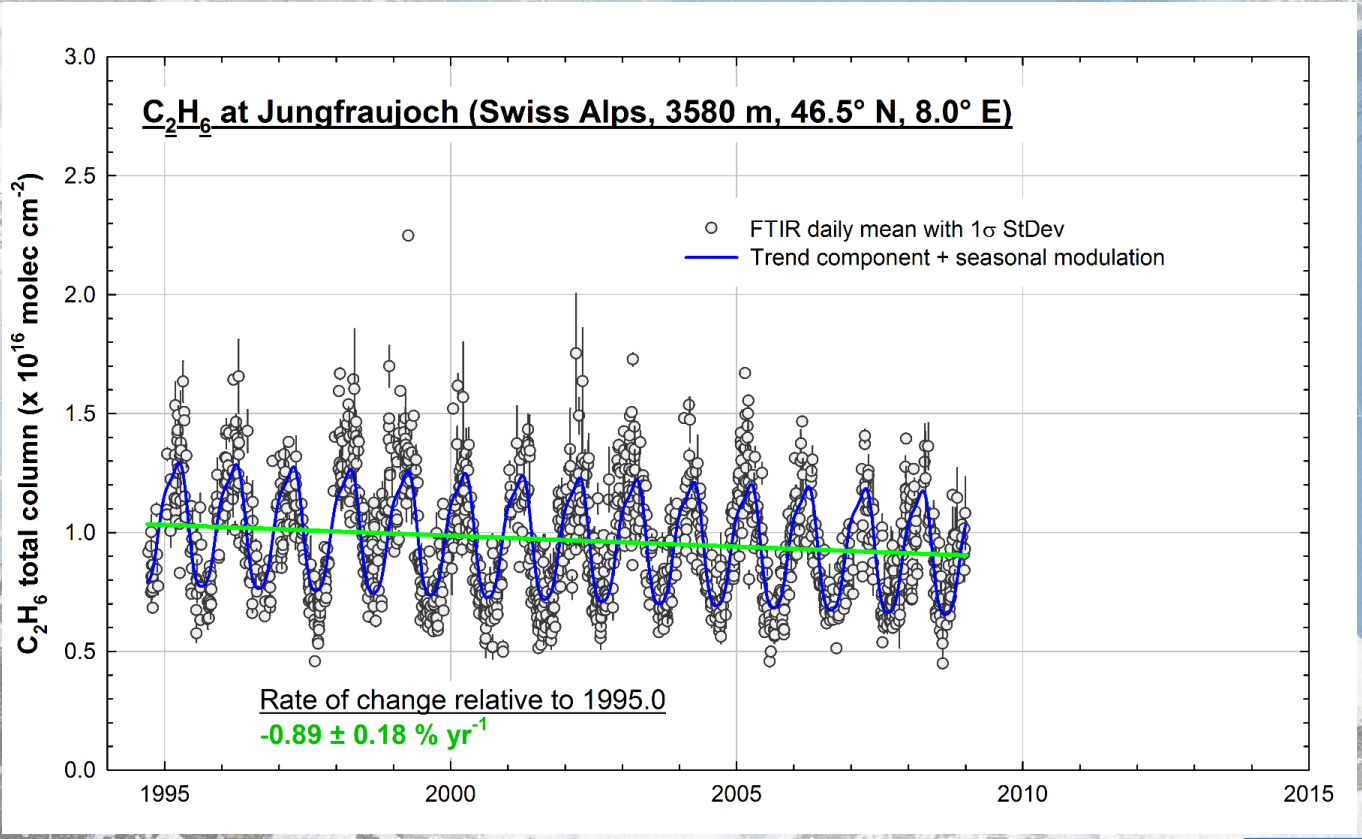
Regular decrease of atmospheric C_2H_6 burden consistent with the global decline of fugitive emissions from fossil fuel sources from the mid-1980s (Aydin et al., 2011, *Nature*; Simpson et al., 2012, *Nature*)



See Franco et al., 2015, *JQSRT* for more information on the FTIR retrievals

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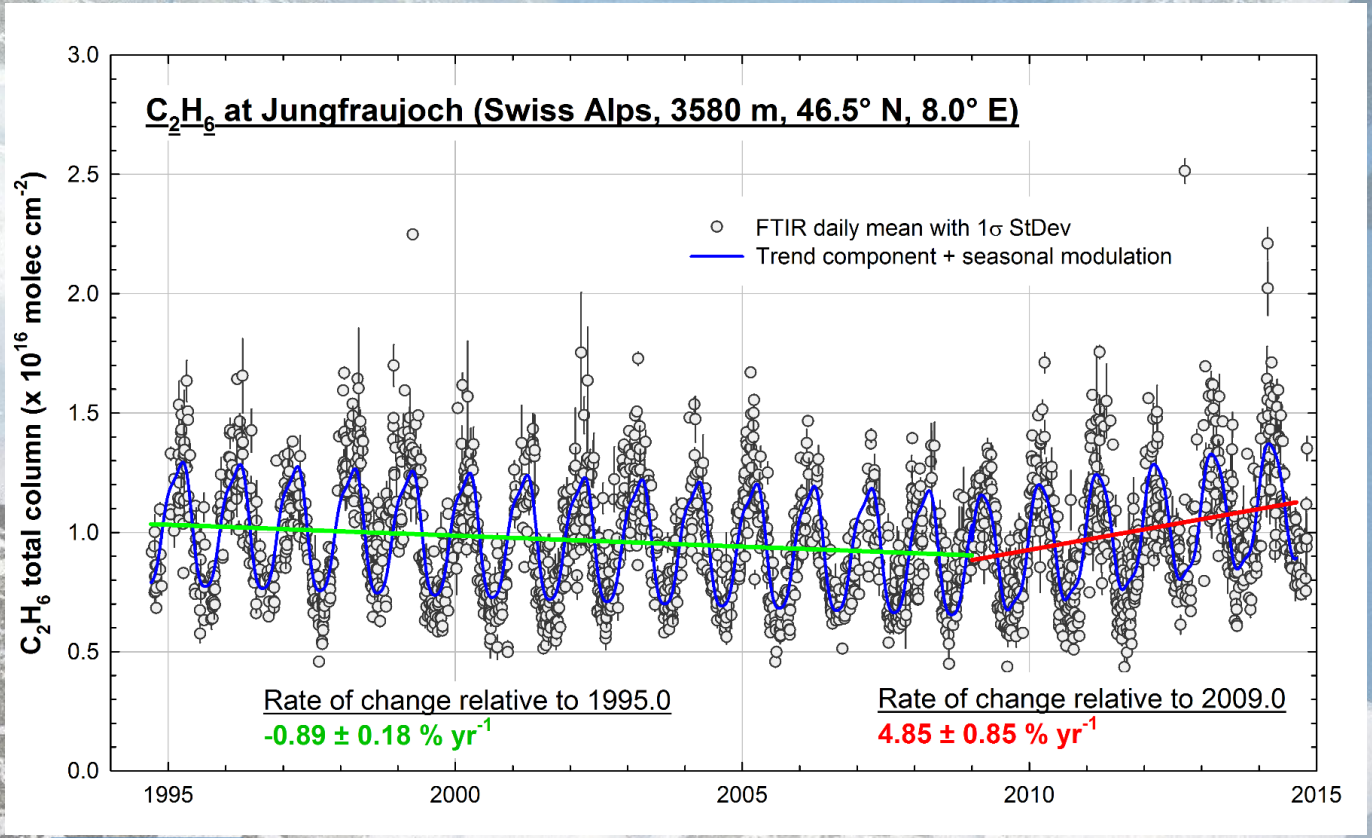
But since 2009, the atmospheric C_2H_6 burden is increasing at a rate of **5 % yr^{-1}**



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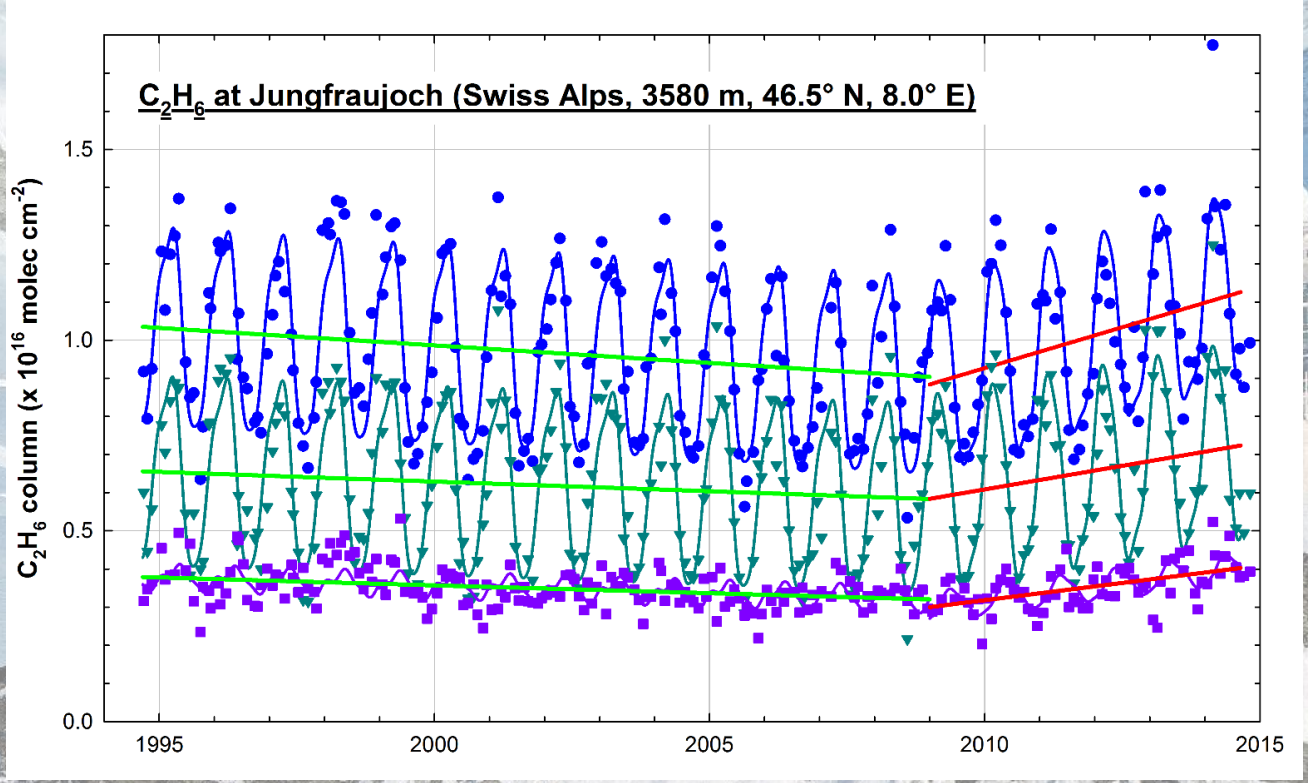
- Two independent partial columns may be deduced from the FTIR retrievals (DOFS ≈ 2.1)
- **Vertically-homogeneous** increase of C_2H_6 throughout the troposphere and lower stratosphere



Rates of change relative to 2009.0

- **Total column**
  4.85 ± 0.85 % yr^{-1}
- **Lower troposphere (3.6-8 km)**
  4.23 ± 1.06 % yr^{-1}
- **Upper trop. – lower strat. (8-21 km)**
  6.05 ± 1.09 % yr^{-1}

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Cause of the C_2H_6 renewal since 2009?

- **Sharp fluctuations of OH concentration in the atmosphere?**
  - ✓ The gobal OH levels have not exhibited large interannual variability since the end of the 20th century (Montzka et al., 2011, *Science*)
  - ✓ Neither CO nor other species that have oxidation by OH as their major removal pathway such as HCN and C_2H_2, do not present an upturn in their retrieved columns

=> hence this hypothesis should be rejected

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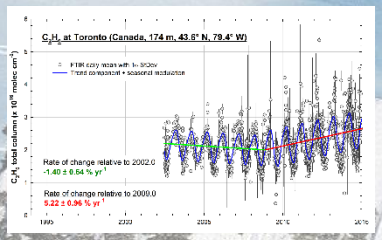
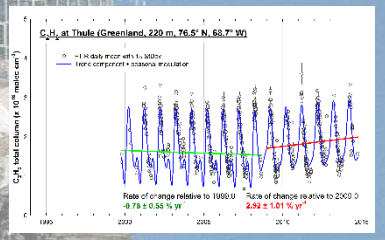
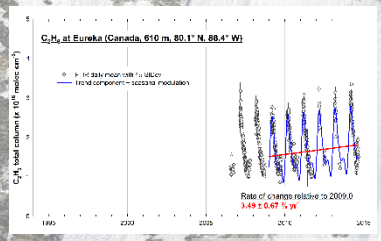
Cause of the C_2H_6 renewal since 2009?

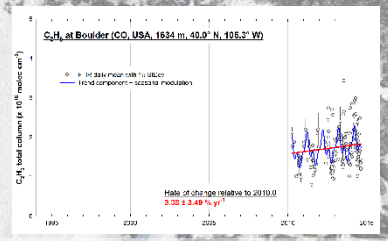
- **Product of enhanced fugitive emissions?**
  - ✓ May be linked to the recent massive growth in the **exploitation of shale gas and tight oil reservoirs**, especially in North America
  - ✓ Increases of hydrocarbons related to oil and gas industries are detected over North American regions where the drilling productivity began to grow rapidly after 2009
  - ✓ Could represent a change in C_2H_6 throughout the Northern Hemisphere
  - ✓ **FTIR and ACE-FTS** measurements over North America support this hypothesis

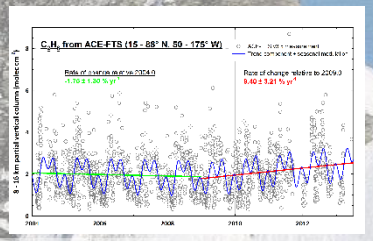


Click on a frame to enlarge the figure









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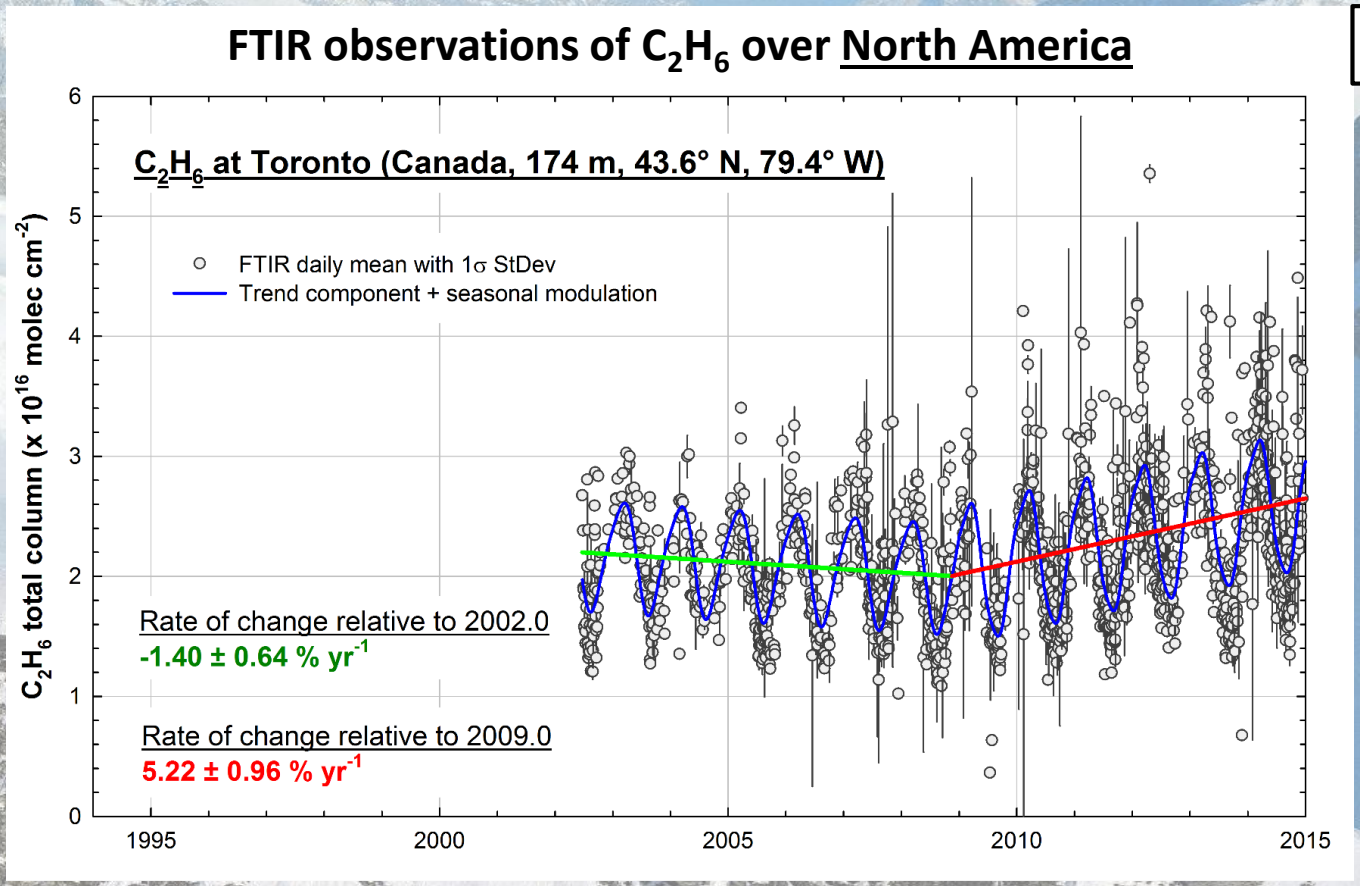
FTIR observations of C_2H_6 over North America



Note: the same a priori and variability profiles as Jungfraujoch are used for all ground-based FTIR retrievals

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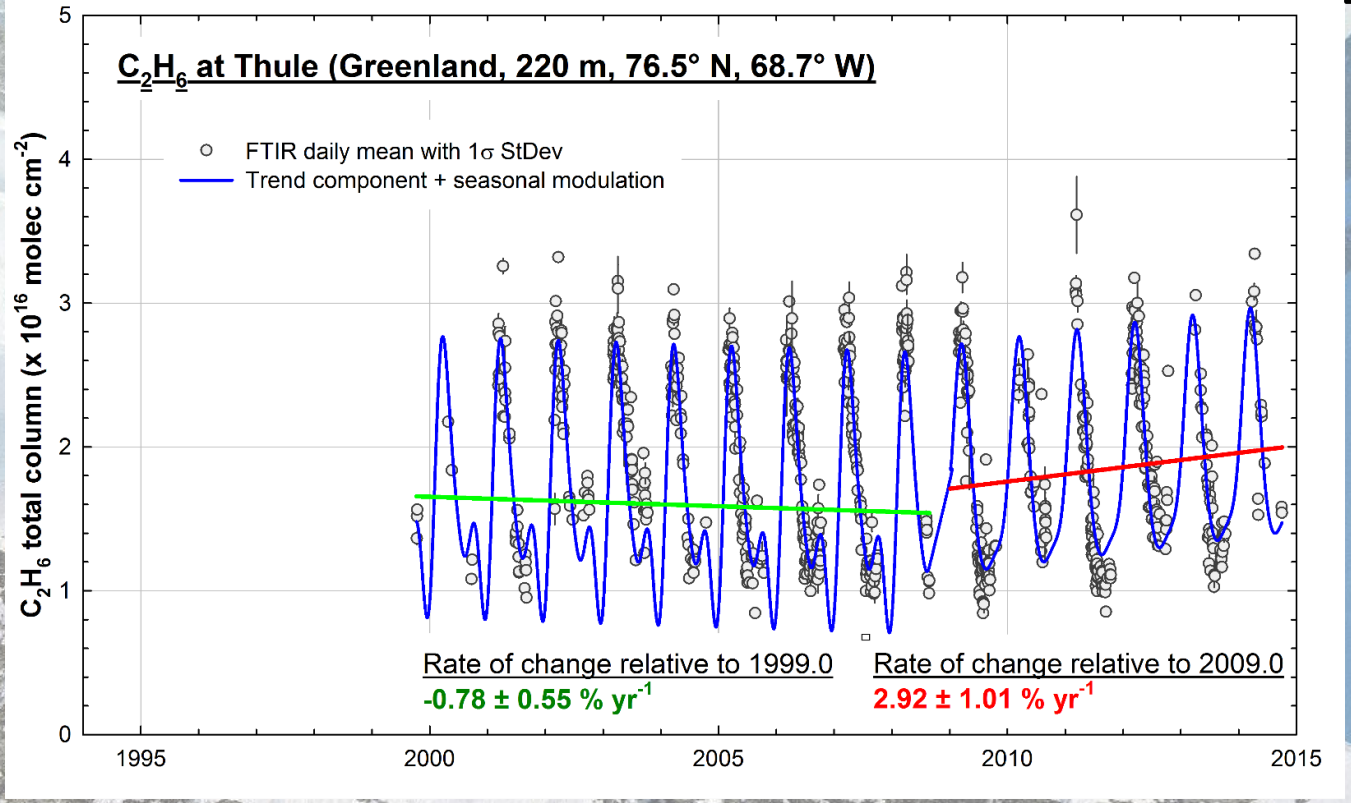

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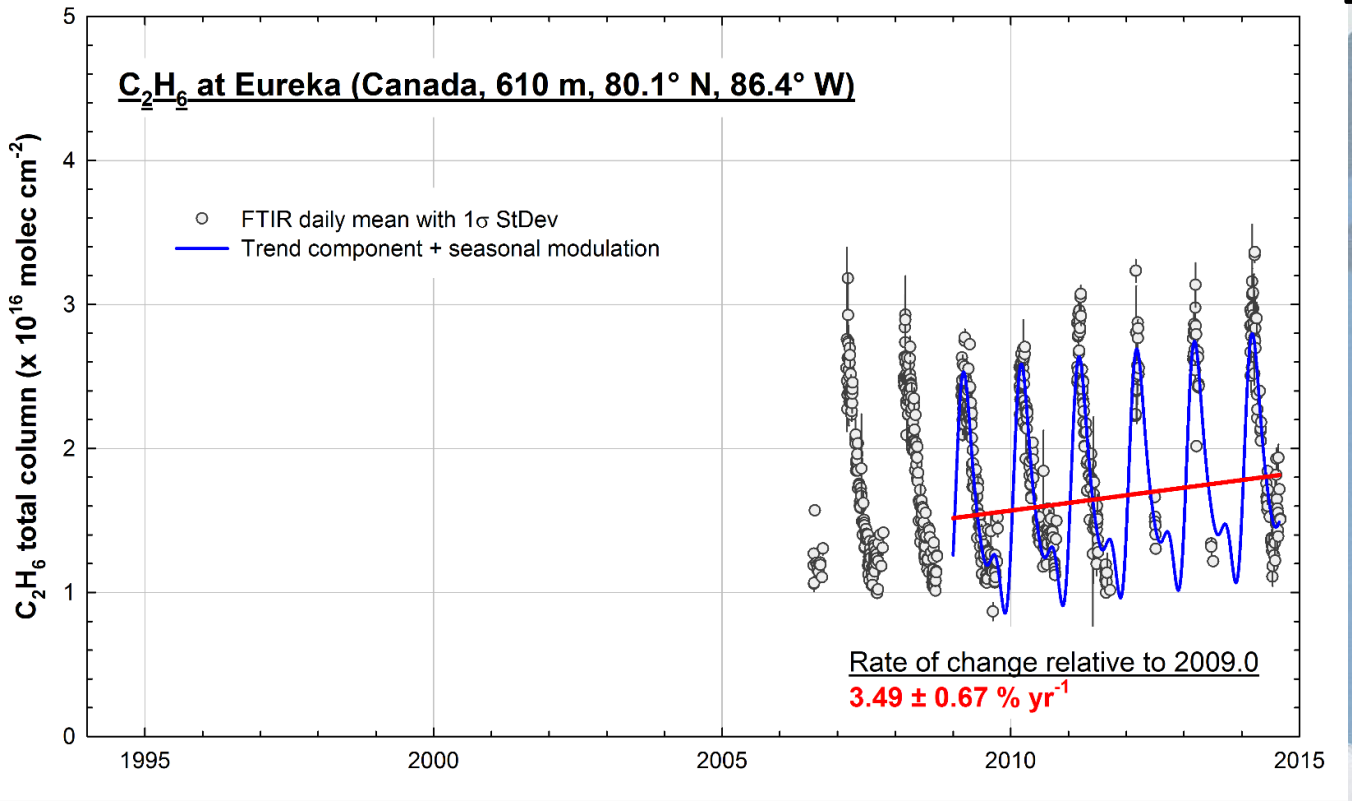

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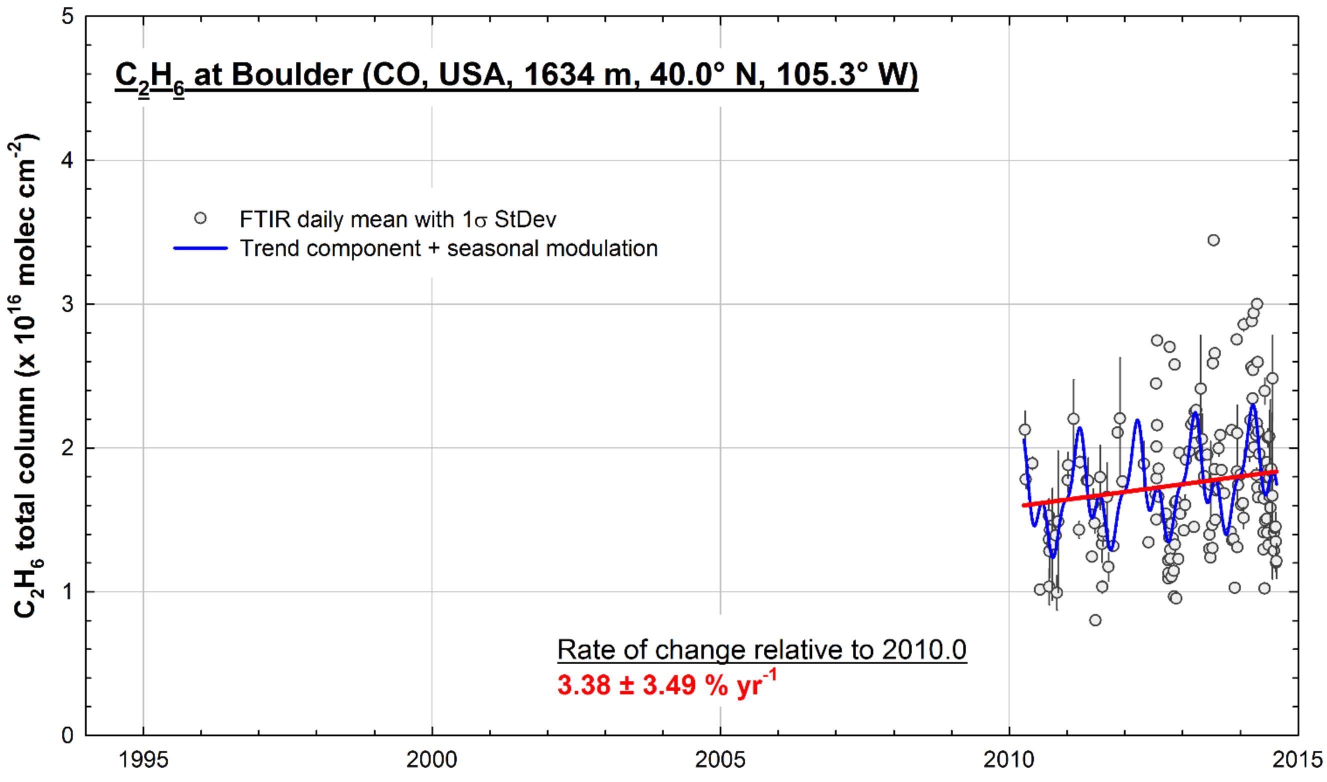

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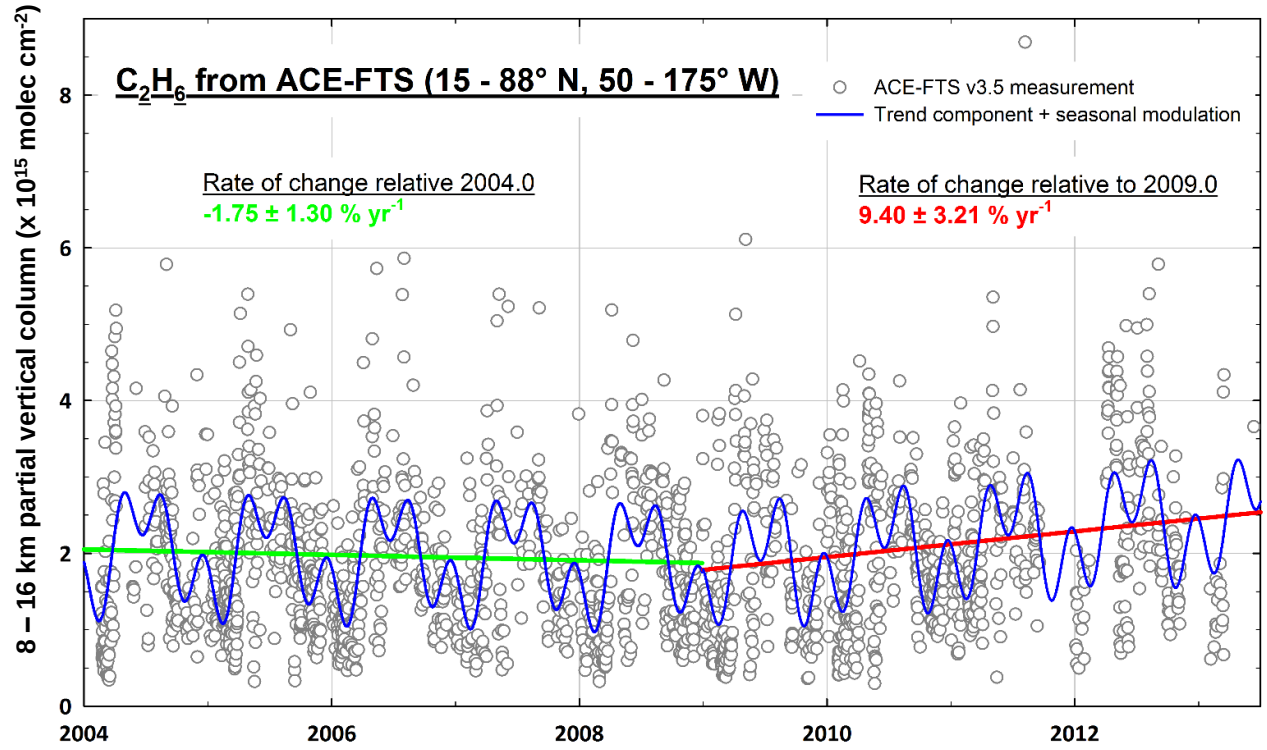
Satellite measurements of C_2H_6 over North America



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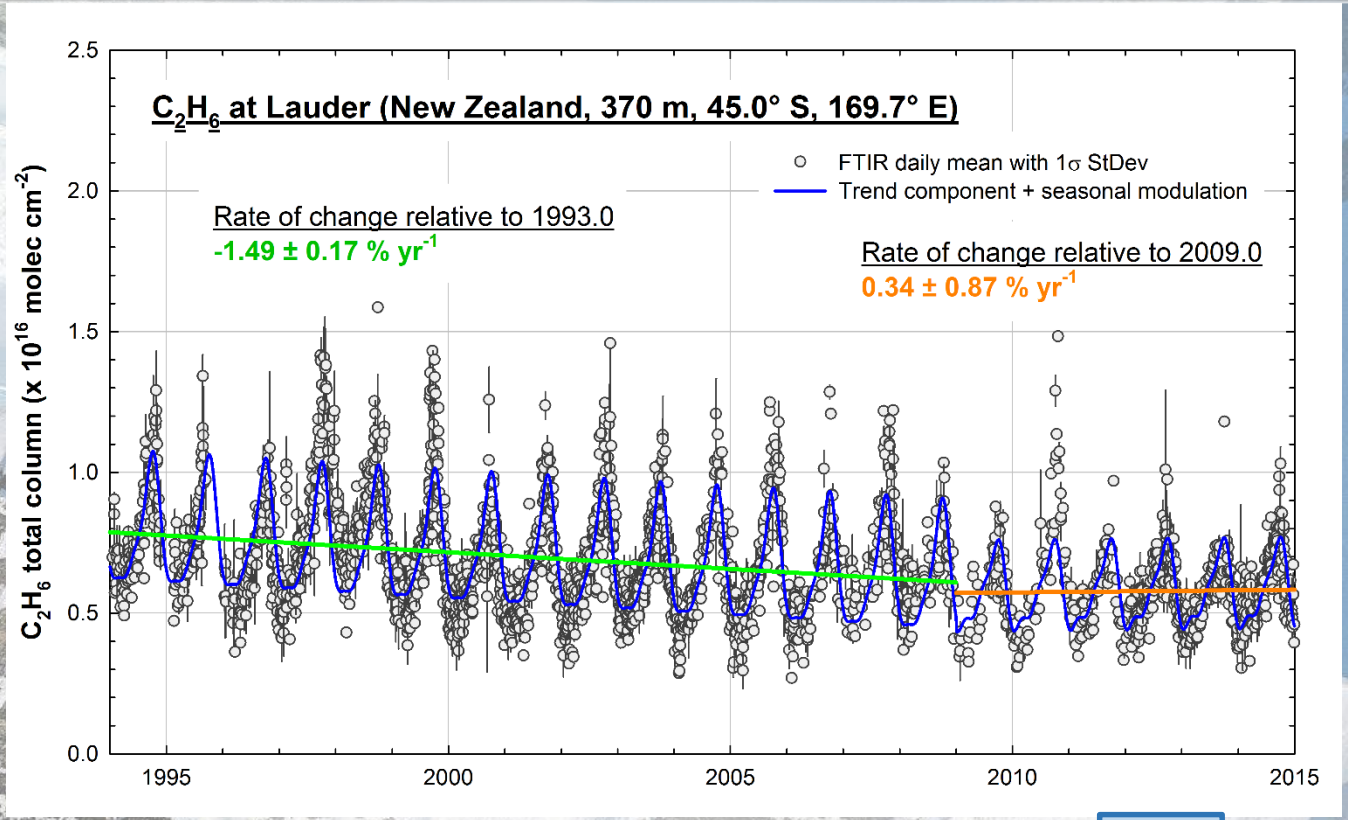
- FTIR and ACE-FTS observations in the Southern Hemisphere do not reveal any recent increase
- Latitudinal exchange of C_2H_6 between both hemispheres is weak
- The observed renewal of C_2H_6 seems to be currently **limited to the Northern Hemisphere**



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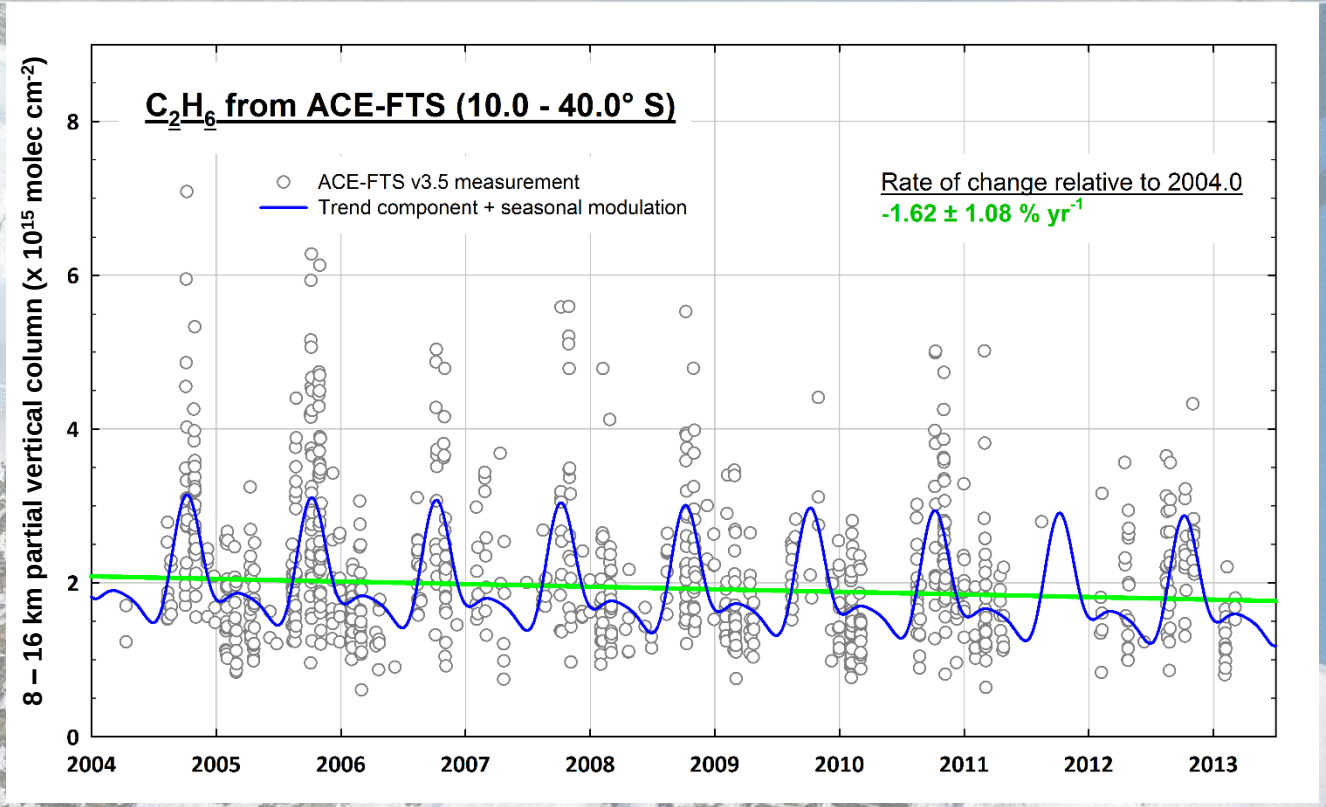

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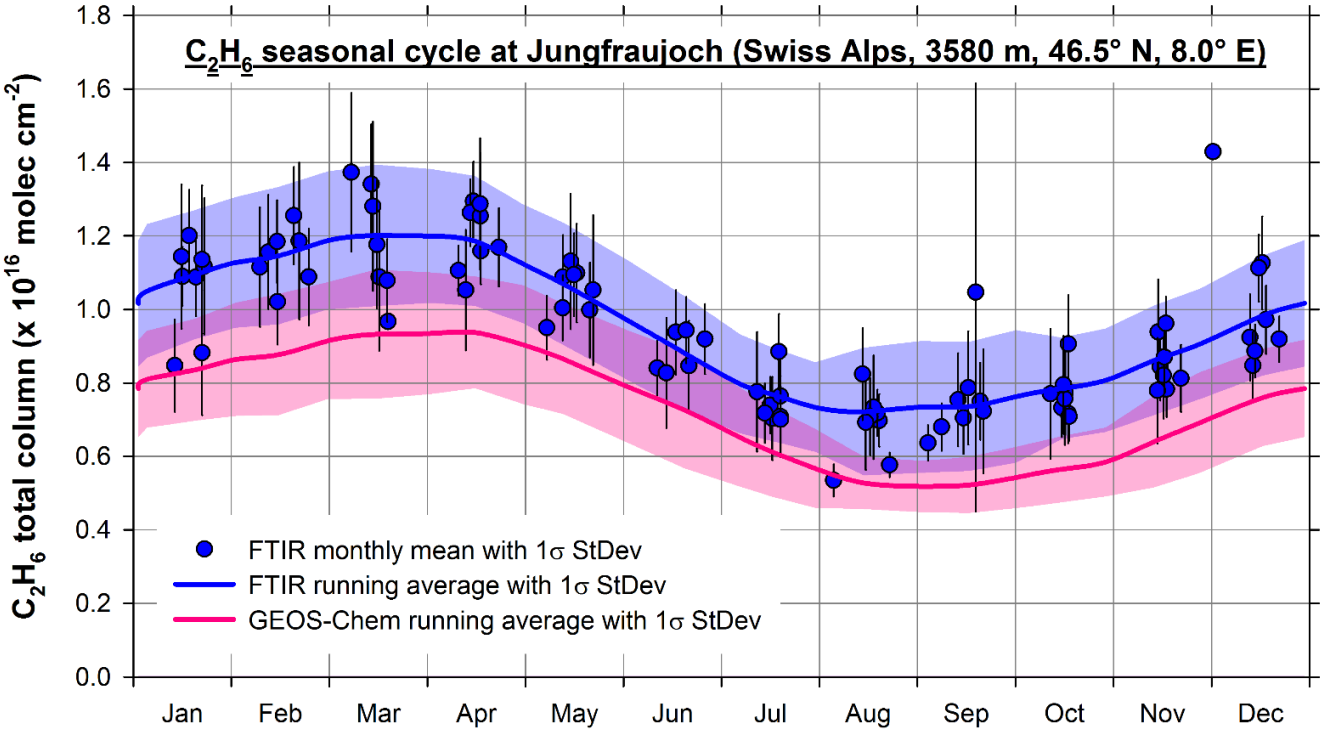
C_2H_6 derived from FTIR retrievals and GEOS-Chem simulations



- GEOS-Chem v9-02 standard full-chemistry simulation
- 2005-2013 results displayed on a 1-year time base
- The vertical resolution and specific sensitivity of the FTIR retrievals are accounted for

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- **Underestimation of C_2H_6 emissions** in the current inventories implemented by GEOS-Chem
- **Incorporating updated inventories** to reproduce the observed changes is part of an ongoing work

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Acknowledgments:

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