

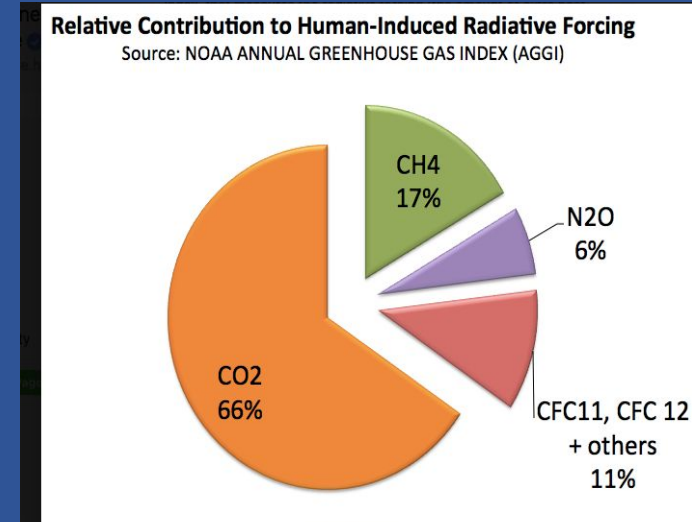
Quantifying Atmospheric Methane Growth Rates from AIRS with Giovanni

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Motivation

- Methane is a strong greenhouse gas.
- Use methane emission estimates to better understand trends in atmospheric methane growth rates.
 - ⇒ Link the bottom-up and top-down perspectives



Goal

1. Use Giovanni and GES DISC data to study the distributions and trends of trace gases.
 - Example: AIRS methane growth rates and CMS methane emissions data.
2. Demonstrate how to use Giovanni to expedite the exploration of data.

Outline






1. Introduce Carbon Monitoring System data
2. Show AIRS methane growth rates
3. Can we use emissions data to understand the causes of AIRS methane growth rate trends?
 - Spoiler alert: I don't know, but you might.
4. Potential for box-modeling?
 - Discuss caveats and challenges

GES DISC CMS data

- NASA Carbon Monitoring System (CMS)
 - Quantify carbon reservoirs and fluxes
 - Uses numerous instruments and models to collect data
- 10 datasets CMS datasets for various carbon cycling processes (fires, transportation, terrestrial and oceanic NPP, fossil fuel sources)
 - Bulk carbon fluxes
 - Global domain with varying temporal resolutions and time periods
- CMS methane emission data for:
 - North America, Mexico, Canada
 - resolution of 0.5x0.667 (NA) and 0.1x0.1 (CA,MX)

GES DISC Data Collections

Showing 1 - 11 of 11 datasets associated with cms

Image	Dataset	Source	Temporal Resolution	Spatial Resolution	Process Level	Begin Date	End Date
 Hover	Carbon Monitoring System Flux for Posterior Fire Carbon L4 V1 (CMSFluxFirepost.1) - Ocean Chemistry	Models/Analyses CMS-Flux-V1	1 month	4° x 5°	4	2010-01-01	2013-01-01
 Hover	Carbon Monitoring System Flux for Shipping, Aviation, and Chemical Sources L4 V1 (CMSFluxMISC.1) - Ocean Chemistry	Models/Analyses CMS-Flux-V1	1 month	4° x 5°	4	2000-01-01	2013-01-01
 Hover	Carbon Monitoring System Flux from the Net Ecosystem Exchange L4 V1 (CMSFluxNEE.1) - Ocean Chemistry	Models/Analyses CMS-Flux-V1	1 month	4° x 5°	4	2010-01-01	2013-01-01
 Hover	Carbon Monitoring System Flux for Posterior Total Carbon L4 V1 (CMSFluxTotalpost.1) - Ocean Chemistry	Models/Analyses CMS-Flux-V1	1 month	4° x 5°	4	2010-01-01	2017-01-01
 Hover	Carbon Monitoring System Flux for Prior Total Carbon L4 V1 (CMSFluxTotalprior.1) - Ocean Chemistry	Models/Analyses CMS-Flux-V1	1 month	4° x 5°	4	2010-01-01	2017-01-01

<https://disc.gsfc.nasa.gov/>

Compute atmospheric methane growth rates with Giovanni

The screenshot shows the Giovanni web interface with several key elements highlighted by red boxes and numbers 1 through 4:

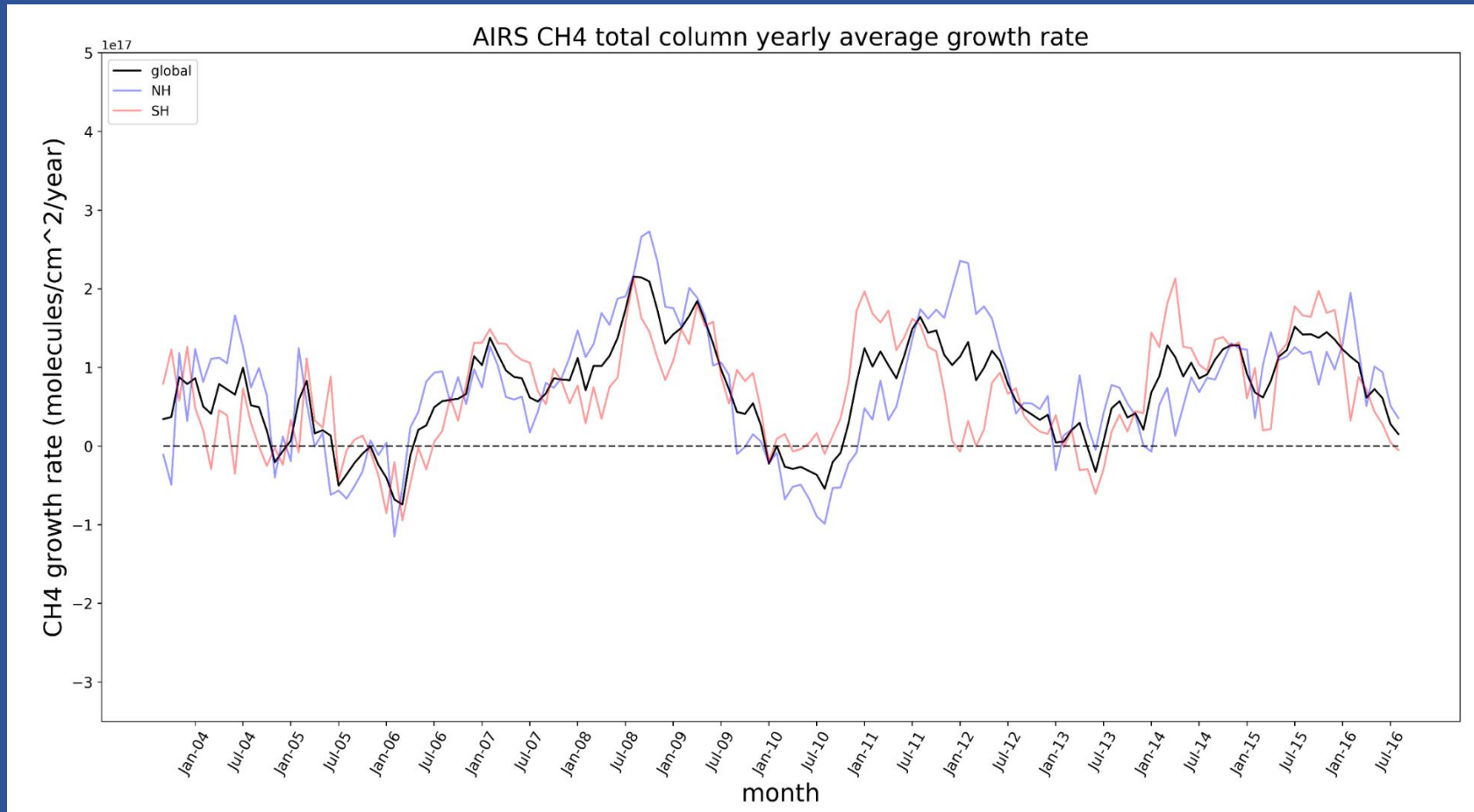
- 1**: A red box highlights the "Select Variables" section, specifically the table of available variables. The first row, "Methane Total Column (Daytime/Ascending) (AIRX3STM v006)", is selected with a checkmark.
- 2**: A red box highlights the "Select Date Range (UTC)" and "Select Region (Bounding Box or Shape)" fields. The date range is set from "2002 - 09 - 01" to "2016 - 09 - 30".
- 3**: A red box highlights the "Select Plot" section, where "Time Series: Area-Averaged" is selected.
- 4**: A red box highlights the "Plot Data" button at the bottom right of the interface.

The table of variables includes the following columns: Variable, Source, Temp. Res., Spat. Res., Begin Date, End Date, Units, and Vert. Slice.

Variable	Source	Temp. Res.	Spat. Res.	Begin Date	End Date	Units	Vert. Slice
<input checked="" type="checkbox"/> Methane Total Column (Daytime/Ascending) (AIRX3STM v006)	AIRS	Monthly	1°	2002-09-01	2016-09-30	mol/cm2	-
<input type="checkbox"/> Methane Total Column (Daytime/Ascending) (AIRX3STD v006)	AIRS	Daily	1°	2002-08-31	2016-09-24	mol/cm2	-
<input type="checkbox"/> Methane Total Column (Nighttime/Descending) (AIRX3STD v006)	AIRS	Daily	1°	2002-08-31	2016-09-24	mol/cm2	-
<input type="checkbox"/> Methane Total Column (Nighttime/Descending) (AIRX3STM v006)	AIRS	Monthly	1°	2002-09-01	2016-09-30	mol/cm2	-
<input type="checkbox"/> Methane Mole Fraction in Air (Daytime/Ascending) (AIRX3STD v006)	AIRS	Daily	1°	2002-08-31	2016-09-24	ppv	1000 hPa
<input type="checkbox"/> Methane Mole Fraction in Air (Nighttime/Descending) (AIRX3STD v006)	AIRS	Daily	1°	2002-08-31	2016-09-24	ppv	1000 hPa
<input type="checkbox"/> Methane Mole Fraction in Air (Daytime/Ascending) (AIRX3STM v006)	AIRS	Monthly	1°	2002-09-01	2016-09-30	ppbv	1000 hPa
<input type="checkbox"/> Methane Mole Fraction in Air (Nighttime/Descending) (AIRX3STM v006)	AIRS	Monthly	1°	2002-09-01	2016-09-30	ppbv	1000 hPa
<input type="checkbox"/> Methane Mole Fraction in Air (Daytime/Ascending, AIRS-only) (AIRS3STM v006)	AIRS	Monthly	1°	2002-09-01	2017-09-30	ppbv	1000 hPa
<input type="checkbox"/> Methane Mole Fraction in Air (Nighttime/Descending, AIRS-only) (AIRS3STM v006)	AIRS	Monthly	1°	2002-09-01	2017-09-30	ppbv	1000 hPa
<input type="checkbox"/> Methane Total Column (Daytime/Ascending, AIRS-only) (AIRS3STM v006)	AIRS	Monthly	1°	2002-09-01	2017-09-30	ppbv	1000 hPa
<input type="checkbox"/> Methane Total Column (Nighttime/Descending, AIRS-only) (AIRS3STM v006)	AIRS	Monthly	1°	2002-09-01	2017-09-30	ppbv	1000 hPa

1. Select variable (methane total column- AIRX3STM v6)
2. Subset temporal and spatial domains.
3. Select service (Time Series: Area-Averaged)
4. Hit "Plot Data" and wait ~2 minutes
5. Download .csv file
 - Total time is ~10 minutes.
 - Monthly products only

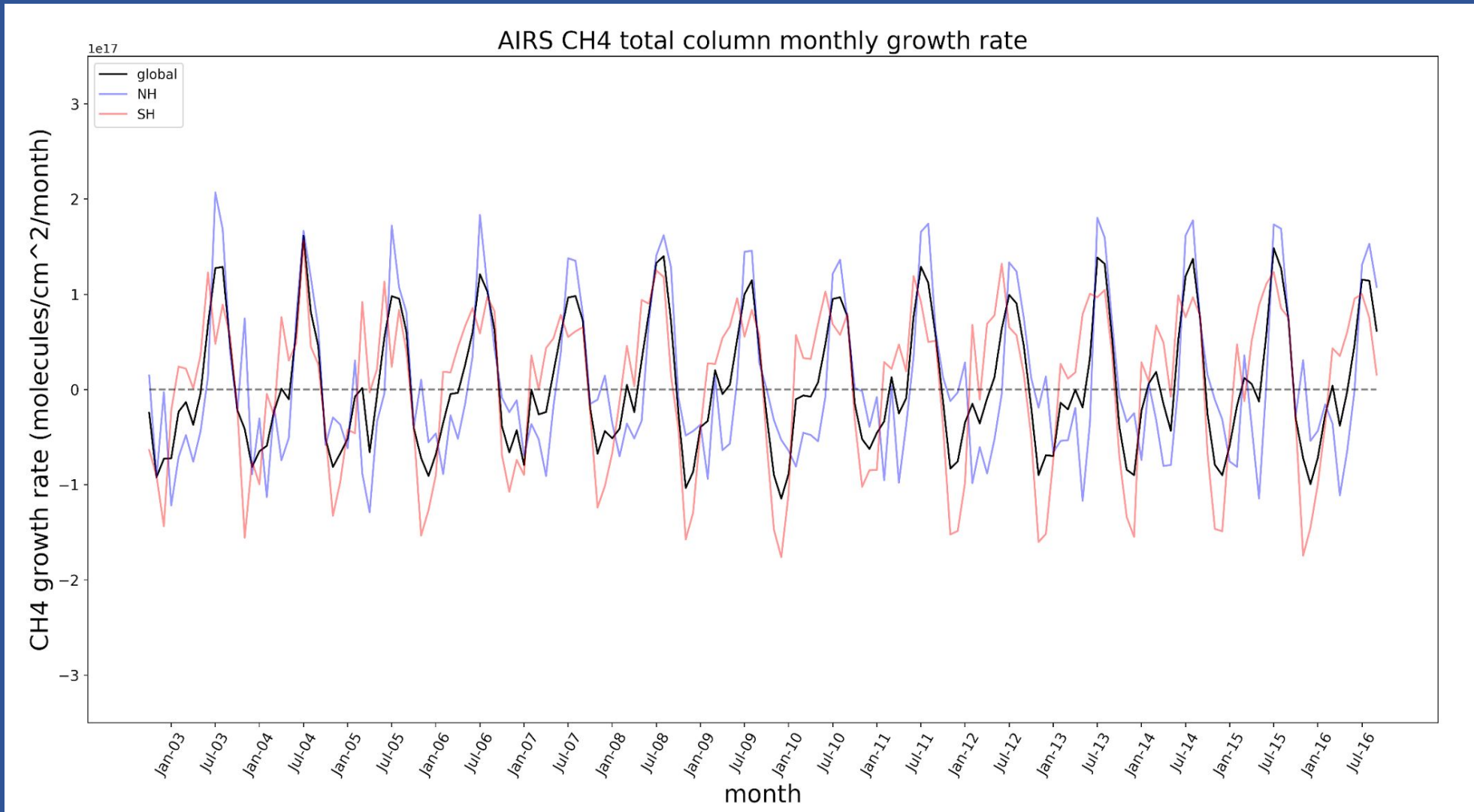
AIRS atmospheric methane growth rates



Currently do not have long enough CMS methane time series to study the trends

$$\text{CH}_4 \text{ growth rate} = \text{CH}_{4\text{month}(n)} - \text{CH}_{4\text{month}(n-12)} \quad (\text{Simpson et al. 2006; Rigby et al. 2008})$$

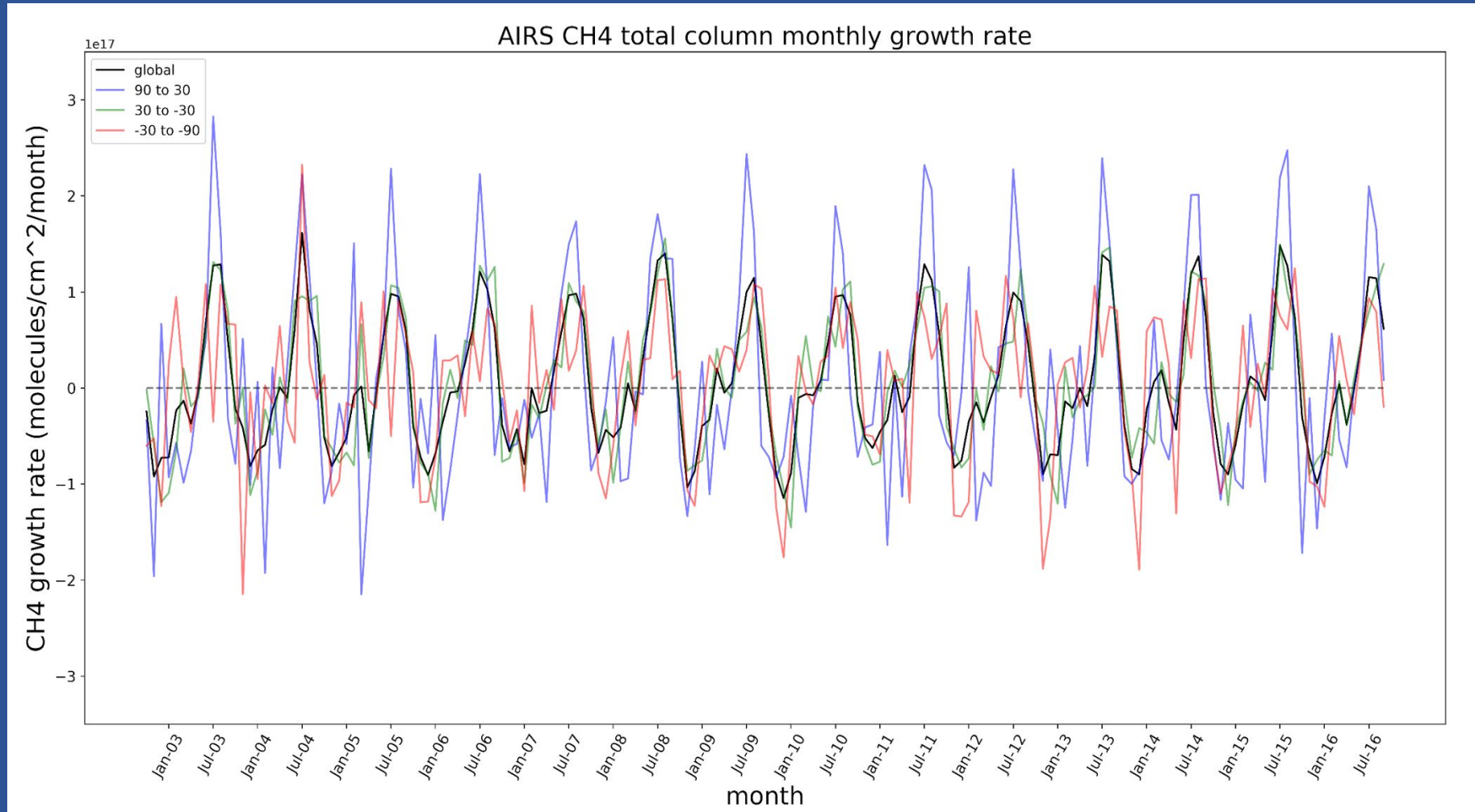
How to calculate atmospheric methane growth rates



$$\text{CH}_4 \text{ growth rate} = \text{CH}_{4\text{month}(n)} - \text{CH}_{4\text{month}(n-1)}$$

(Simpson et al. 2006; Rigby et al. 2008)

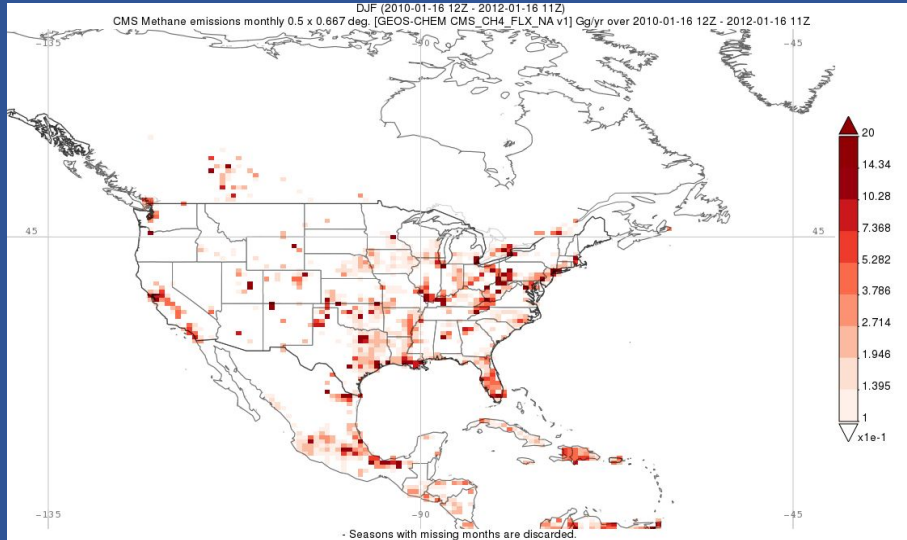
How to calculate atmospheric methane growth rates



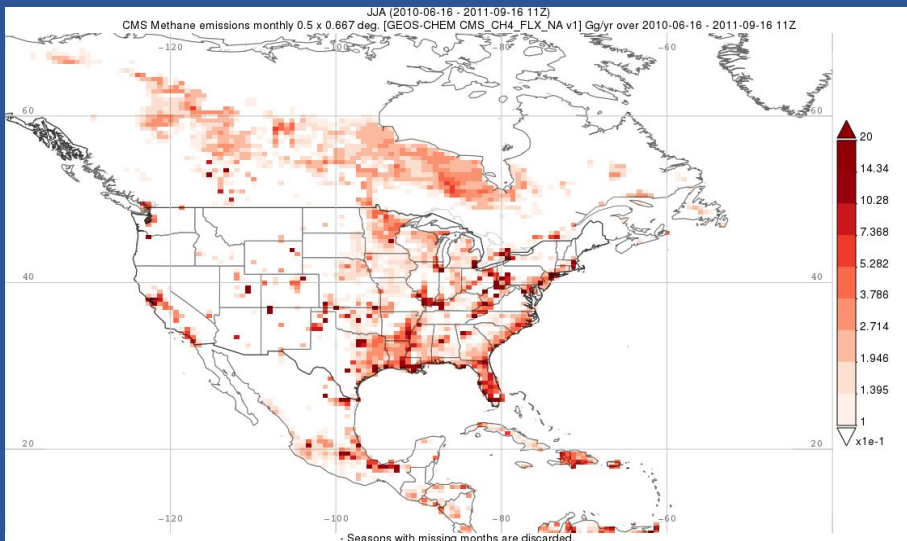
- Larger variability in the maximum growth rate for 90N to 30N than for other domains
- Can we attribute seasonal trends and variability in maximums in the northern hemisphere to source or sink processes?

Carbon Monitoring System (CMS) methane emissions data

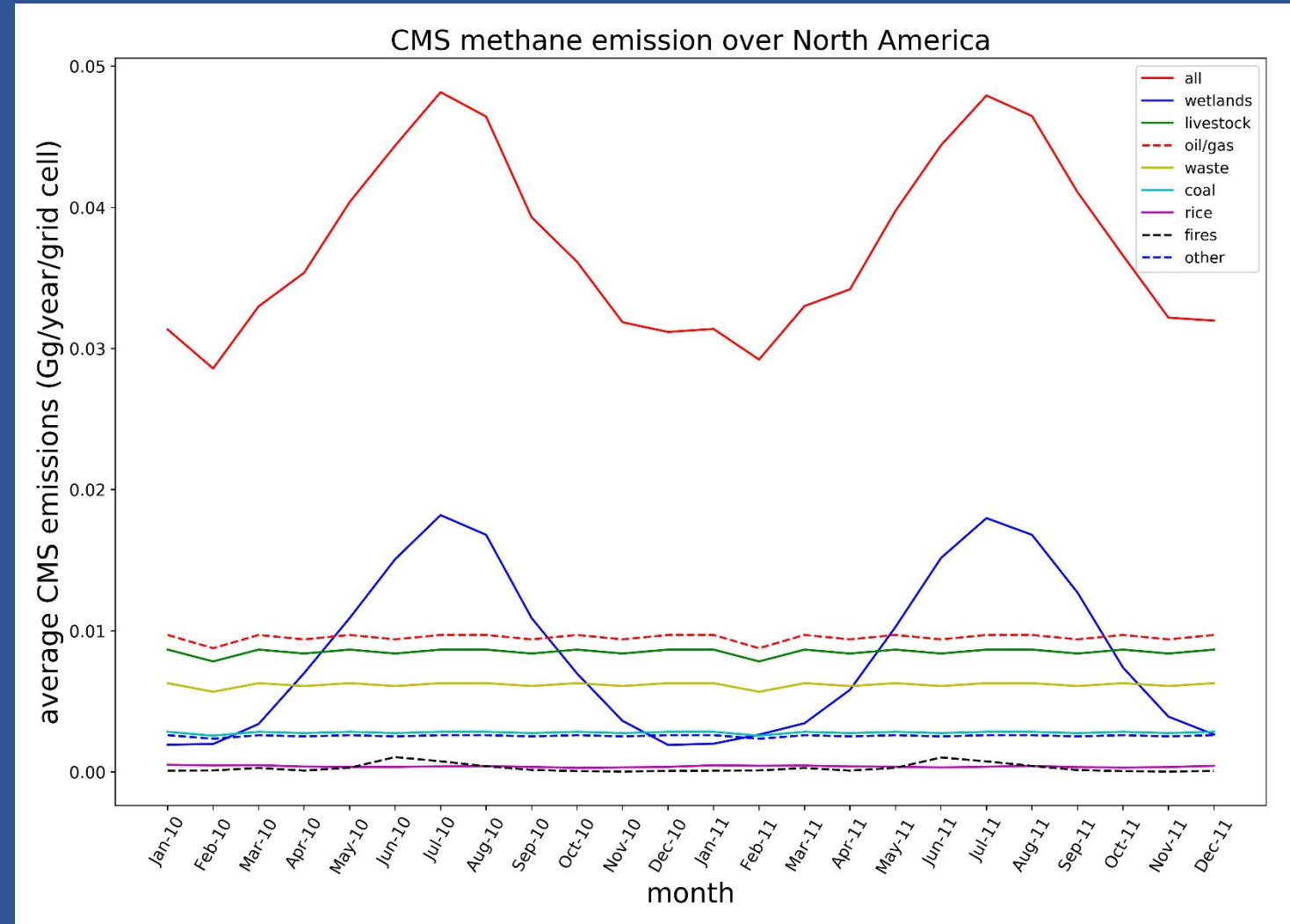
DJF 2010-2011 methane emission average (Gg/year/cell)



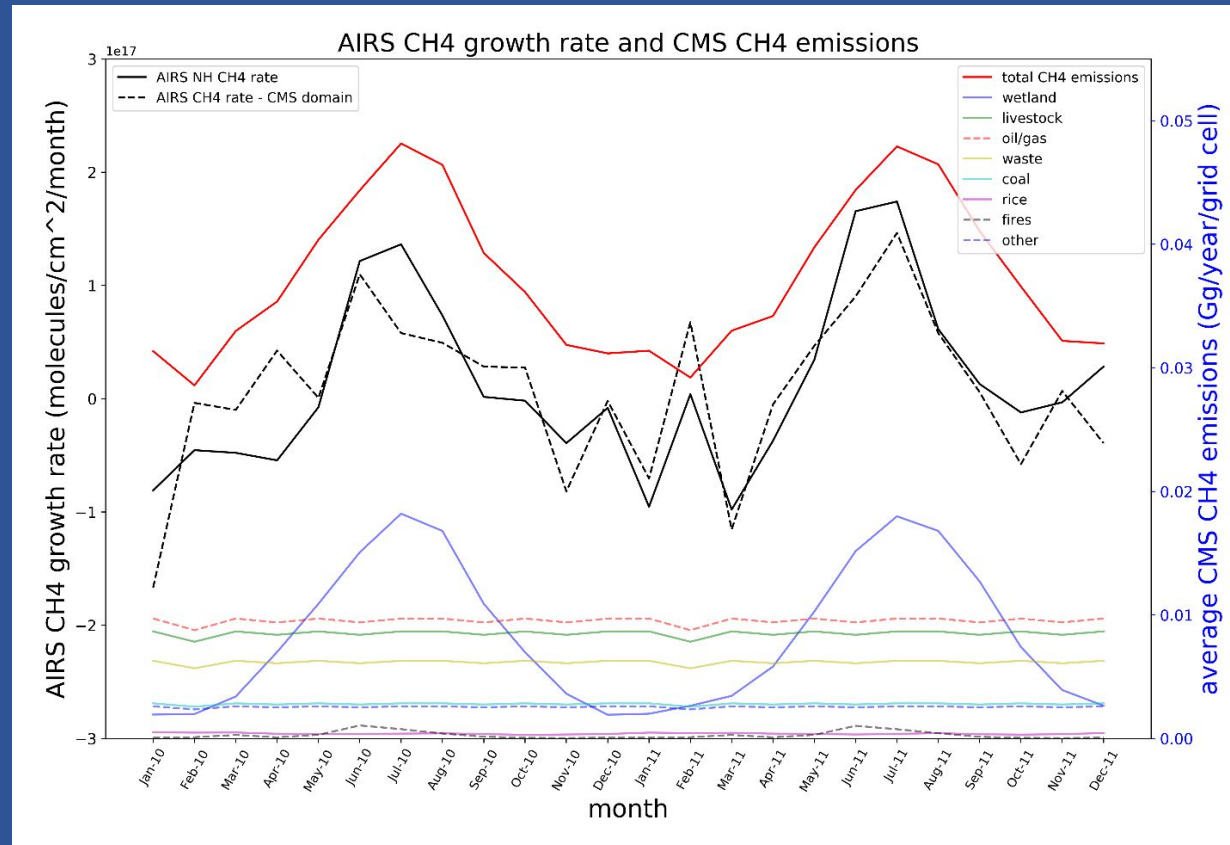
JJA 2010-2011 methane emission average (Gg/year/cell)



https://disc.gsfc.nasa.gov/datasets/CMS_CH4_FLX_NA_V1/summary?keywords=ch4
DOI: 10.5067/RF3R3G9I3UVX



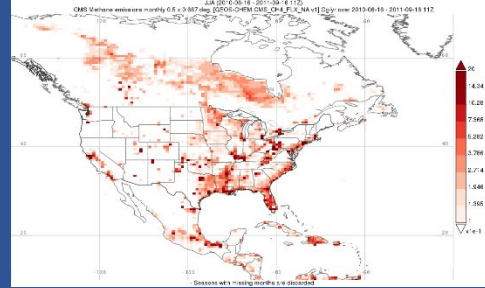
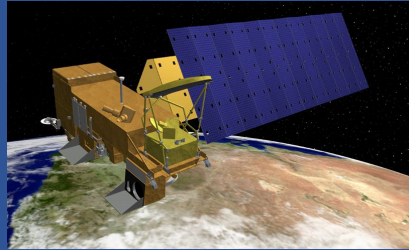
Carbon Monitoring System (CMS) methane emissions data



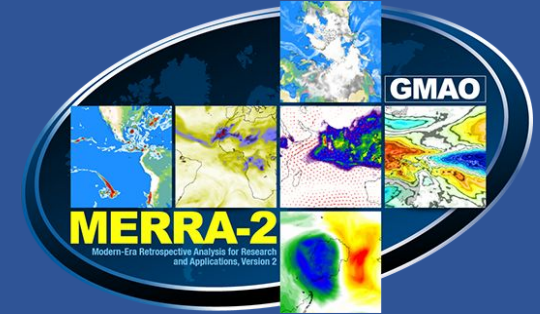
- Must also consider influence of sinks and air mass advection on methane growth rates
- compare sink and advection terms with observations

$$\frac{dCH_4}{dt} = \Sigma sources - \Sigma sinks + \nabla CH_4$$

Box modeling



?



$$\frac{dCH_4}{dt} = \Sigma sources - \Sigma sinks + \nabla CH_4$$

- Can AIRS and CMS methane data be used as a constraint for methane sinks?
- Solve for sinks, compare methane losses to other estimates.
- Must consider uncertainty and error.

Conclusions

- Interesting trends in AIRS methane growth rates exist.
- CMS data could be used in concert with AIRS data to better understand these trends.
 - Caveats: Uncertainty in the data and short CMS time period
- This analysis could be expanded to utilize other CMS datasets and AIRS variables.