Intra-annual variability of CH_4

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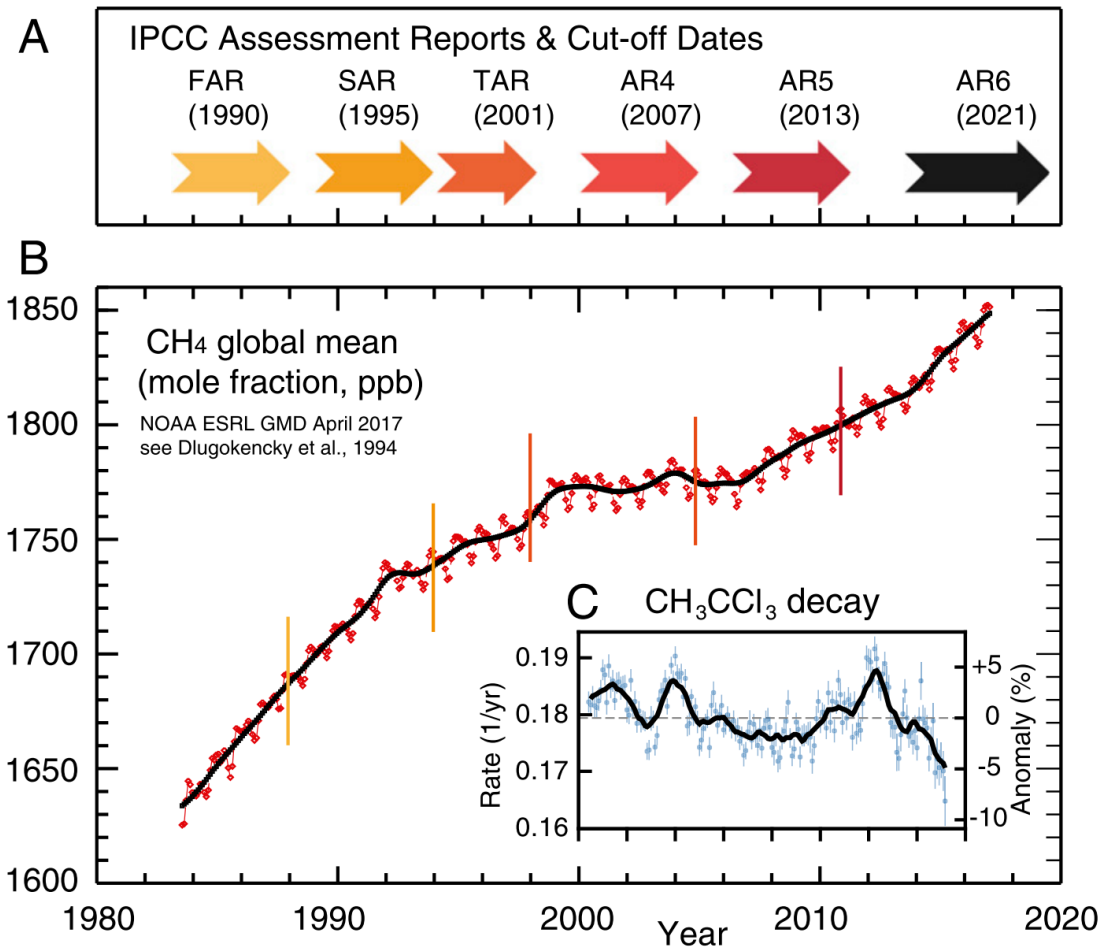
December 2, 2019

Idealized Modeling Class

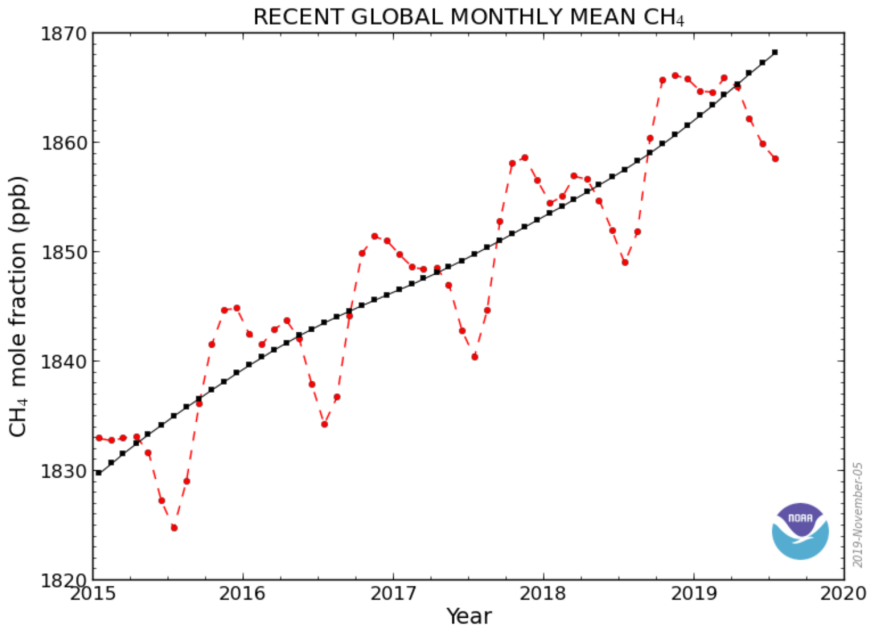
Overview

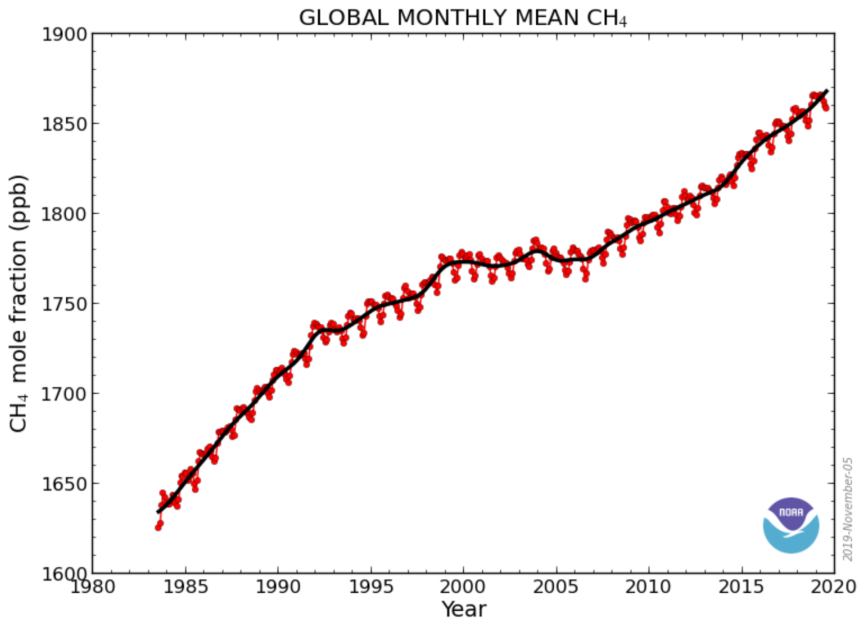
Introduction



Prather et al. 2017

Introduction

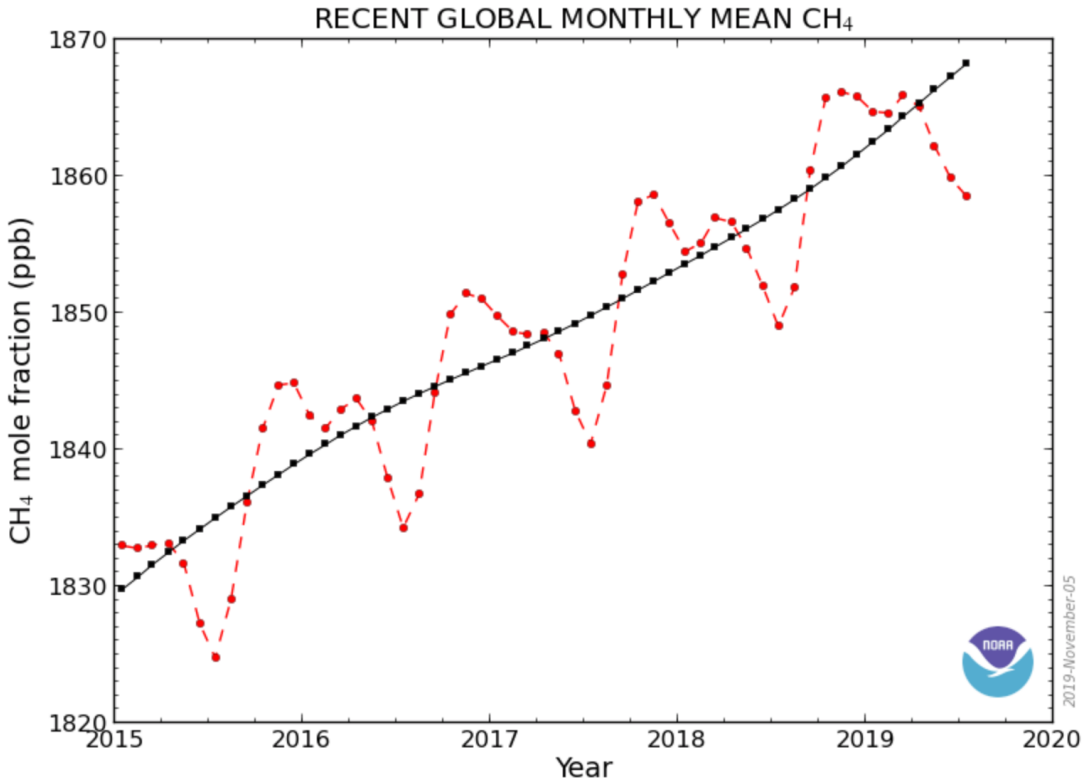




CH_4 concentration measurements from NOAA.

Hypothesis

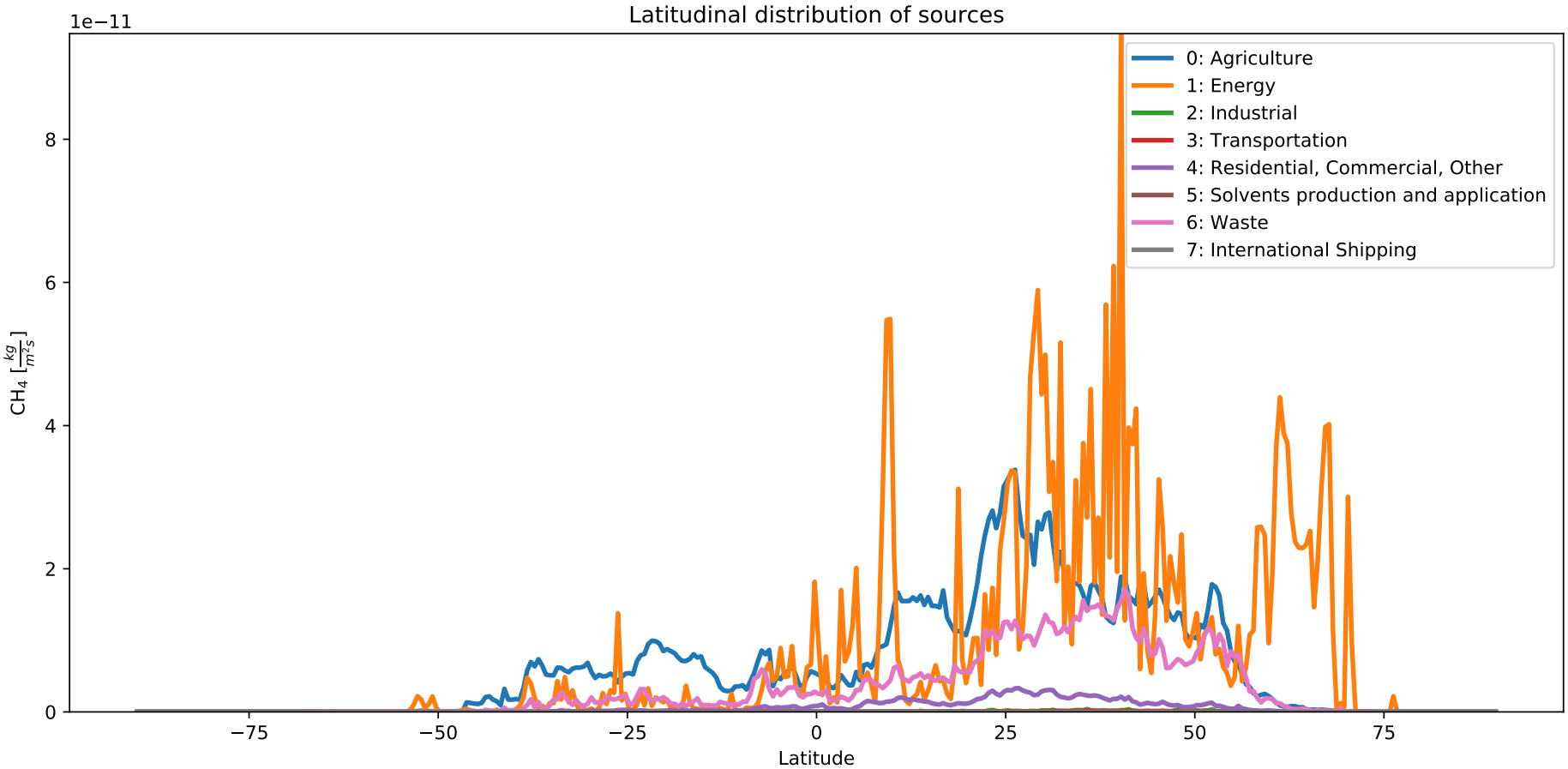
- Wetlands are the major source for methane seasonal variability



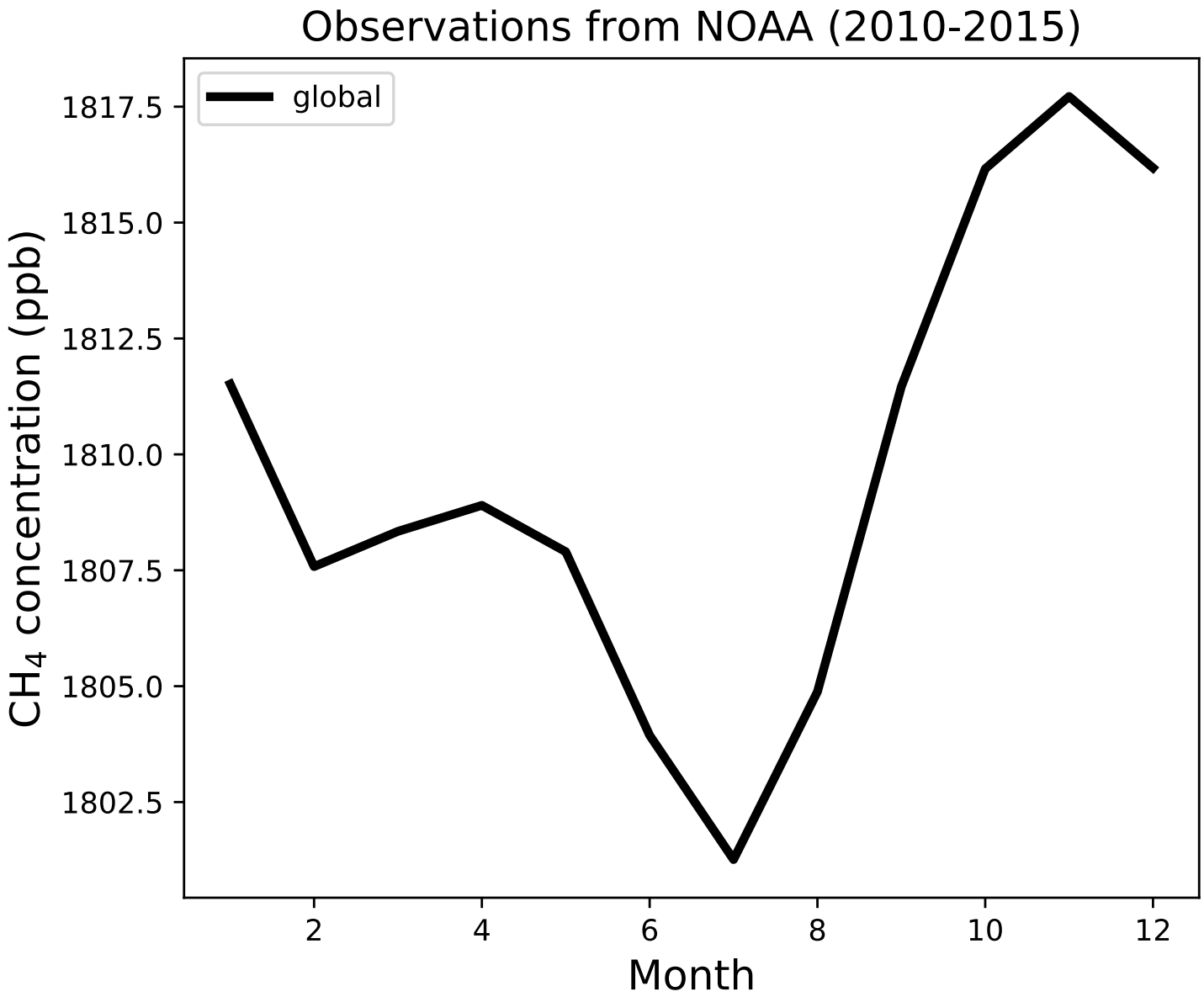
Monthly CH_4 data used

- **NOAA observations**
- **Wetland** emissions from WetCHARTs version 1.0 (JPL) averaged over 18 models
- **Anthropogenic** emissions from Community Emissions Data System (CEDS) for Historical Emissions. Data averaged monthly over all sectors: 0:Agriculture; 1: Energy; 2: Industrial; 3: Transportation; 4: Residential, Commercial, Other; 5: Solvents production and application; 6: Waste; 7: International Shipping
- **OH** data from GFDL model taken as average over 2012-2017 model run

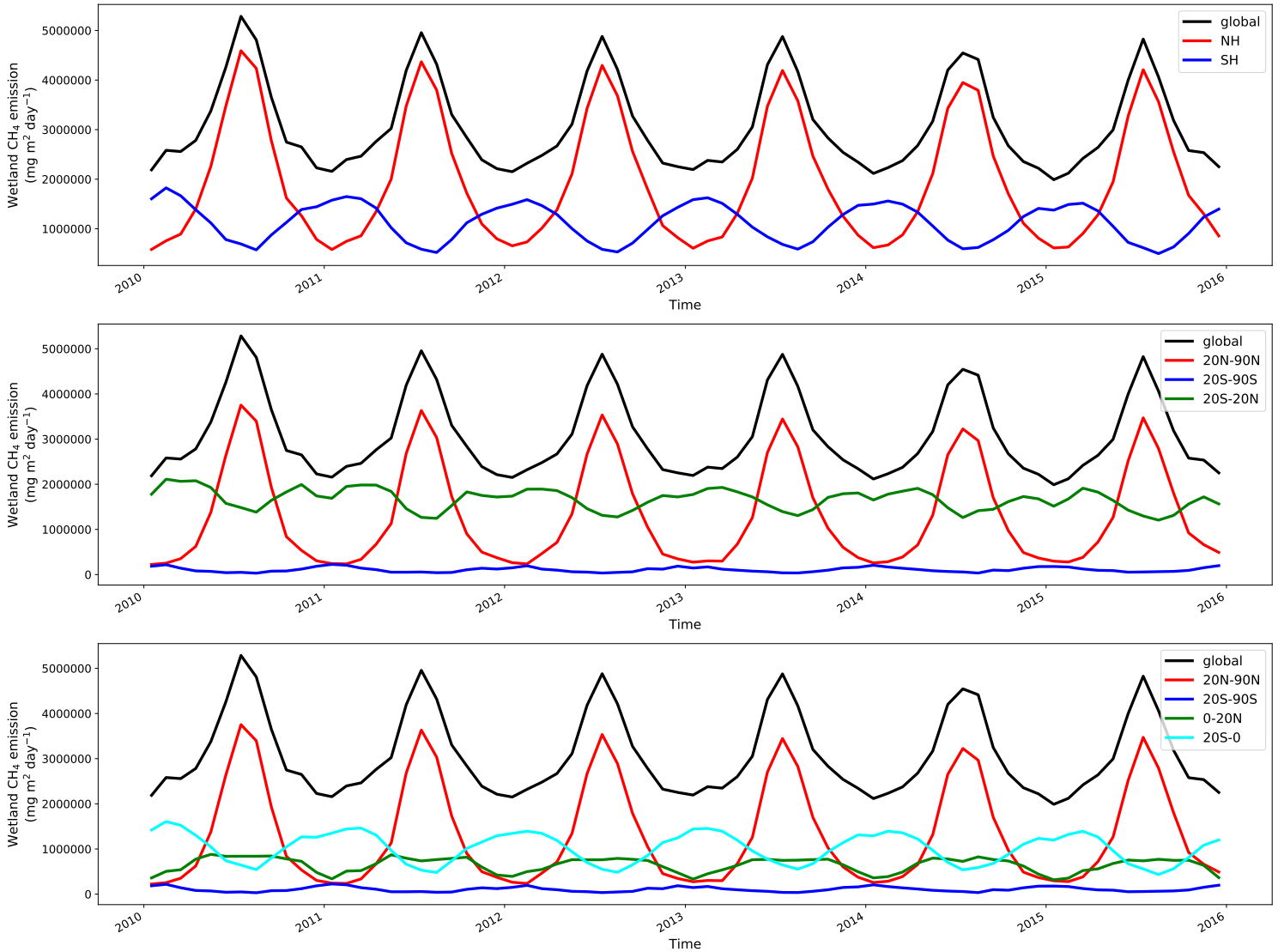
Anthropogenic sectors' latitudinal distribution



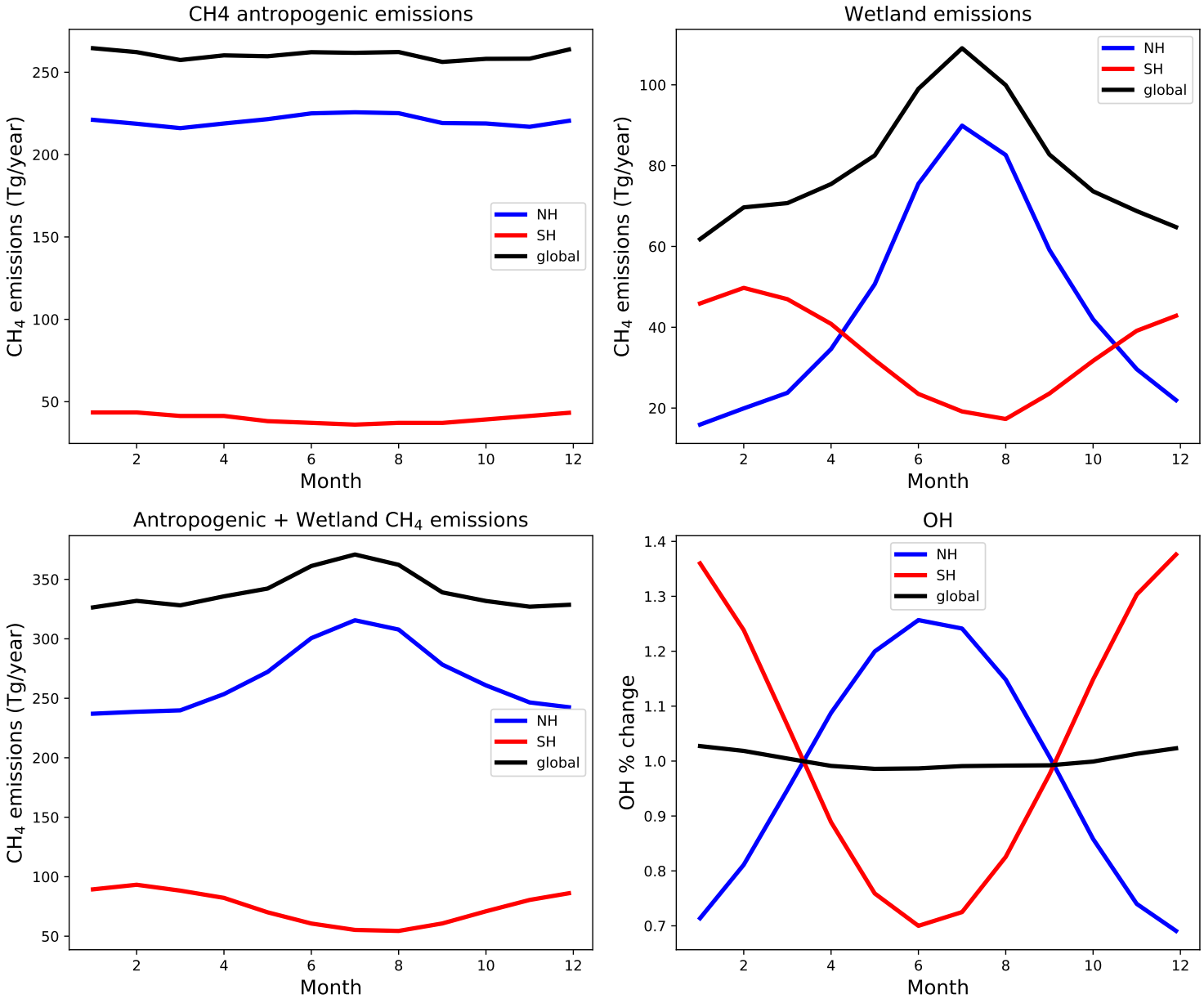
Monthly CH_4 data used



Wetland Emissions



Monthly CH_4 data used



One-box model

- Governing Equation

$$\frac{dM}{dt} = E - k[OH]M$$

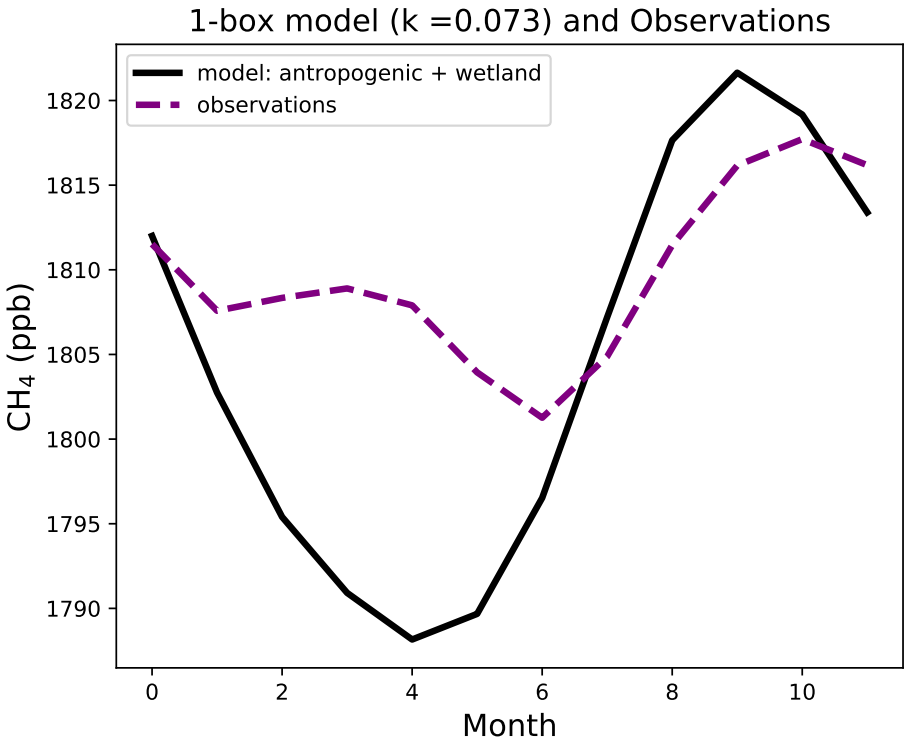
  - M: mass of methane in system in Tg
  - E: emissions in Tg
  - k: constant
  - $[OH]$: concentration of OH
- Model is run for 12 months on 4-5 year averaged monthly data

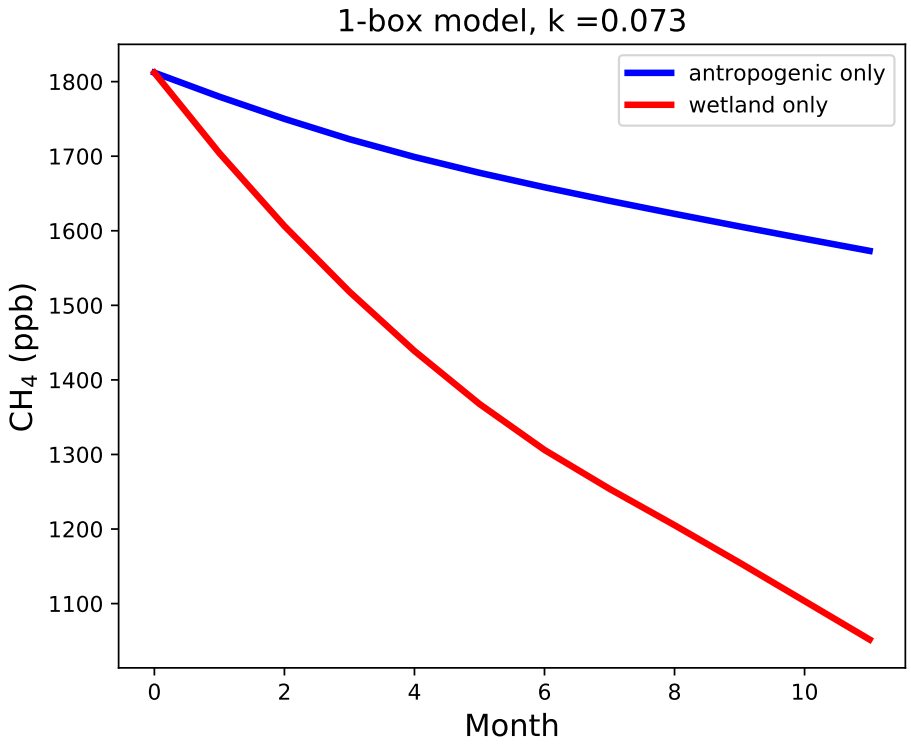
One-box model

The following scenarios are considered:

- Forcing with **only wetland** emissions
- Forcing with **only anthropogenic** emissions
- Forcing with **both** emission sources

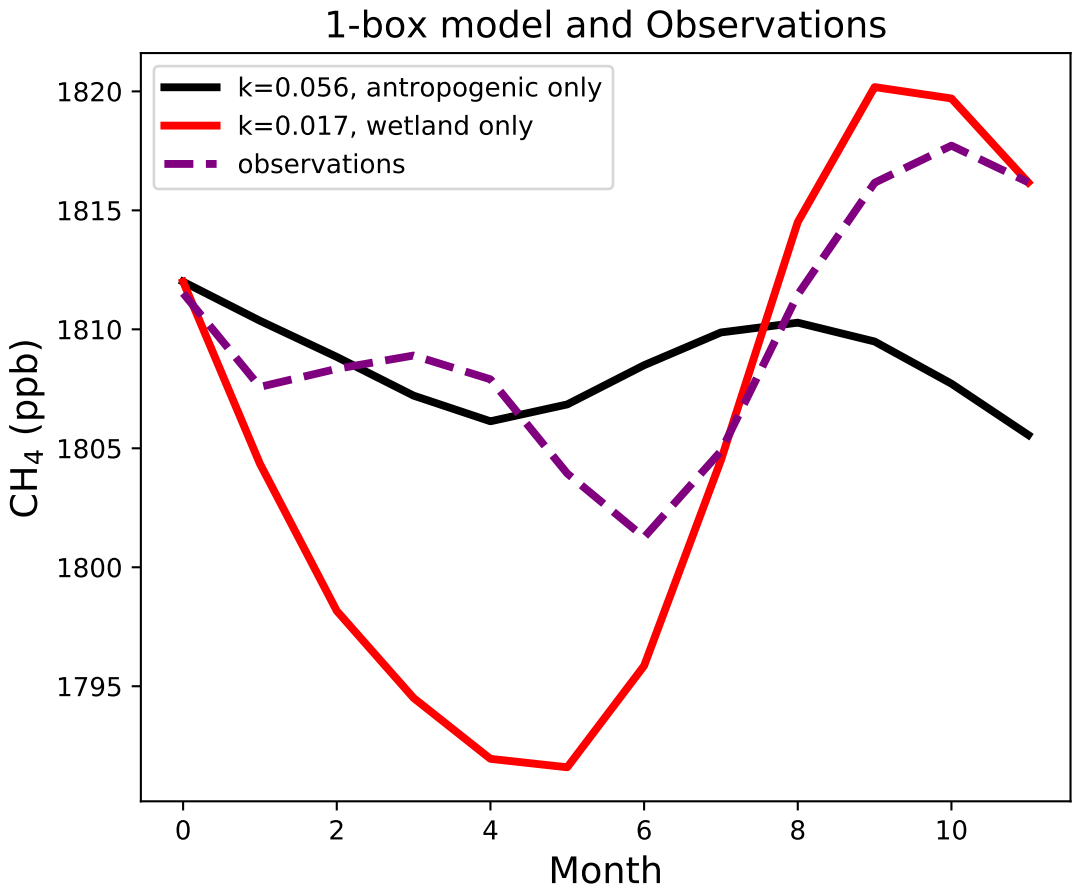
One-box model





Model shows seasonality **only when both antropogenic and wetland** emissions are considered for $k = 0.073$.

One-box model



Model shows seasonality when individually antropogenic and wetland emissions are considered for **"optimal"** k **values**.

Two-box model

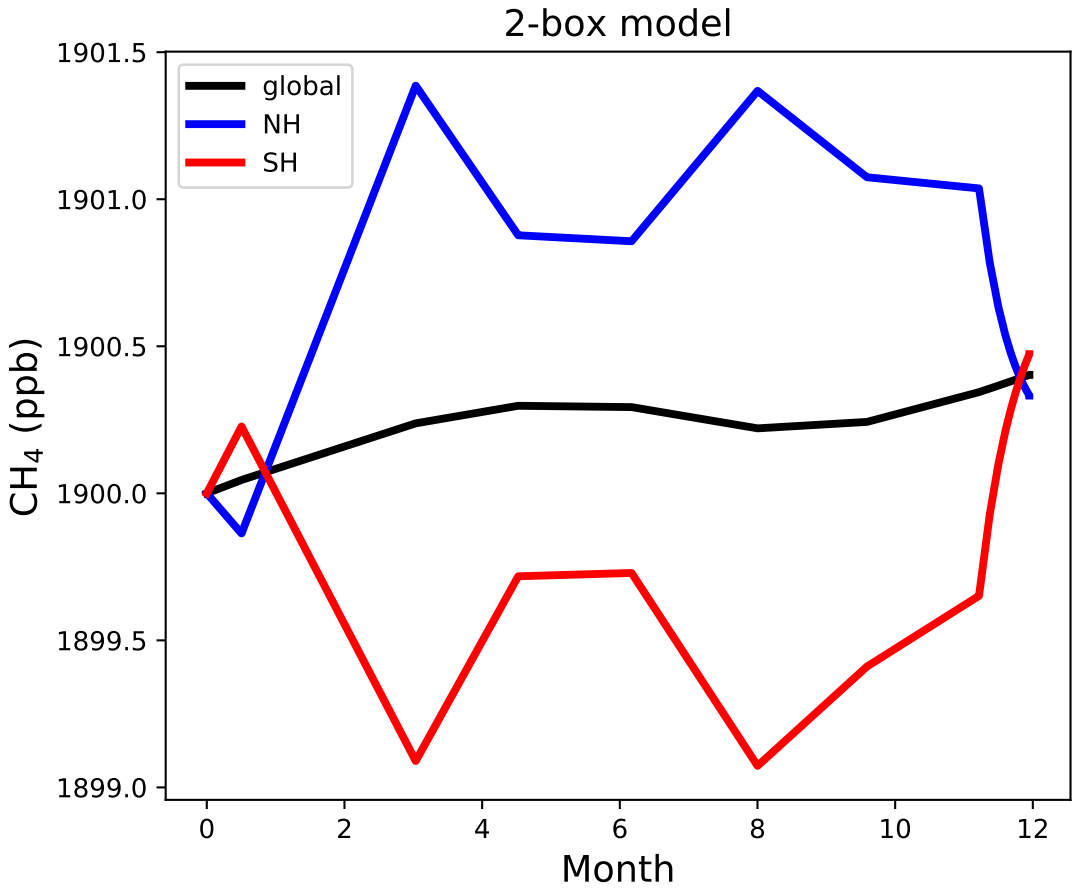
- Governing Equation

$$\frac{dM_{NH}}{dt} = E_{NH} - k[OH]_{NH} M_{NH} + \frac{M_{SH} - M_{NH}}{\tau}$$

$$\frac{dM_{SH}}{dt} = E_{SH} - k[OH]_{SH} M_{SH} + \frac{M_{NH} - M_{SH}}{\tau}$$

  - M: mass of methane in NH and SH (Tg)
  - E: emissions in NH and SH (Tg)
  - k: constant
  - $[OH]$: concentration of OH in NH and SH
  - τ: interhemispheric exchange rate
- Model is run for 12 months on 4 year averaged monthly data

Two box model (work in progress)



$$k = 2.3 \cdot 10^{-6},\ \tau = 1$$

How can Turner et al. 2017 fit CH_4 observations?

$$\frac{\partial [X]_S(t)}{\partial t} = E_{X,N}(t) - k_{[X]}[OH]_N(t)[X]_N(t) + \frac{[X]_S(t) - [X]_N(t)}{\tau_{NS}} \quad (1)$$

$$\frac{\partial [X]_S(t)}{\partial t} = E_{X,S}(t) - k_{[X]}[OH]_S(t)[X]_S(t) + \frac{[X]_S(t) - [X]_N(t)}{\tau_{NS}} \quad (2)$$

Summary

- We **cannot confirm the hypothesis** that wetland emissions of CH_4 are causing the seasonality observed
- We note that the model is highly sensitive to [OH] and k values
- With **"optimal" k values** the one and two-box models can fit observations

References

- GitHub Repository at `github.com/imitevski/ch4_box_model`
- NOAA dataset `ftp://aftp.cmdl.noaa.gov/products/trends/ch4/ch4_mm_gl.txt`
- Wetland dataset `https://daac.ornl.gov/cgi-bin/dsviewer.pl?ds_id=1502`
- Anthropogenic dataset `http://www.globalchange.umd.edu/ceds/ceds-cmip6-data/`
- OH dataset from GFDL - file provided by Jian He