Global atmospheric methane and ethane: Updated mixing ratios and trends (1983-2009)

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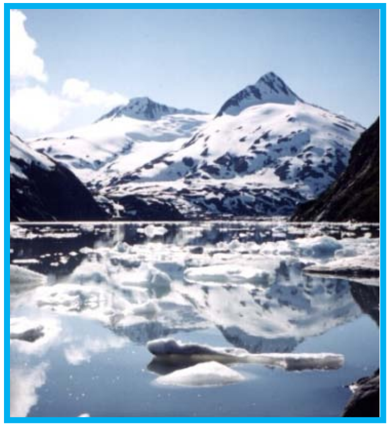

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Funding: NASA, Gary Comer Foundation

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Discussions: Murat Aydin, Jim Butler, Lori Bruhwiler, Ed Dlugokencky, Jens Mühle, Michael Prather, James Wang, and many others

UC-Irvine Global Monitoring Program

1978, 1979

- CH_4, CFCs, CCl_4, CH_3CCl_3
- North and South America
- 2% more CH_4 in Sep'79 than Jan'78

1982

- NASA funding begins
- Regular seasonal sampling in Pacific Basin

Present

- 80 canisters per season
- 45 locations in Pacific Basin
- Sampling period: 1 minute
- Sampling pressure: ambient

Canisters

- 2-L stainless steel
- Conditioned
- Bellows valve
- Evacuated

Graduate student Nermine Batniji collecting a sample in New Zealand

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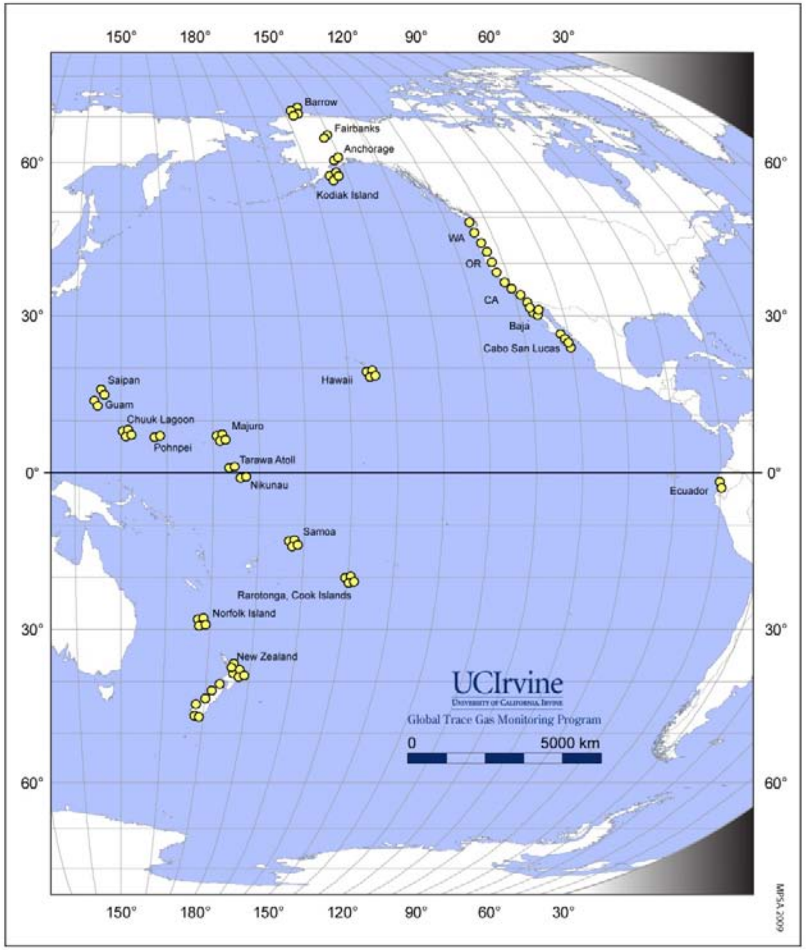
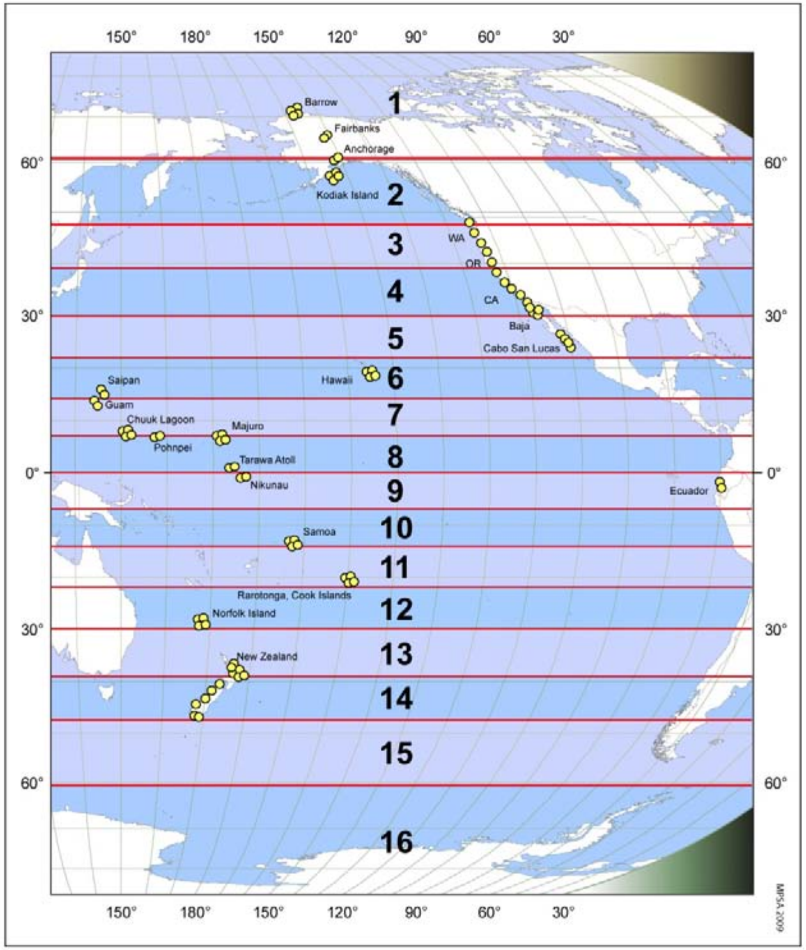
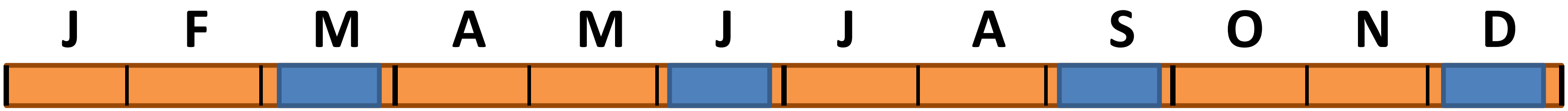
Seasonal Sampling in the Pacific Basin







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Laboratory analysis at UC-Irvine

Gas Chromatography (GC)

Flame Ionization Detection (FID)

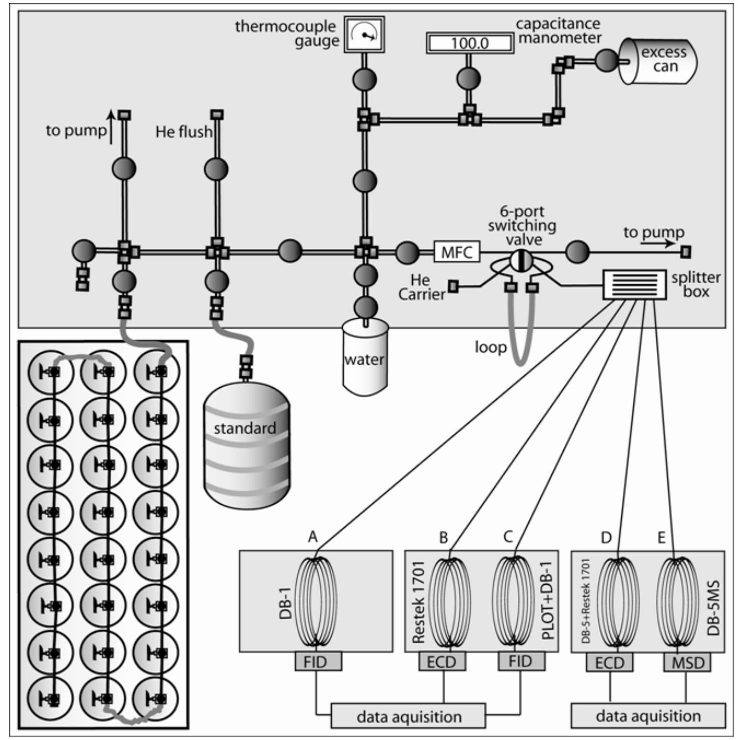
- Sensitive to hydrocarbons

Electron Capture Detection (ECD)

- Sensitive to halocarbons, $RONO_2$

Mass Spectrometer Detection (MSD)

- Unambiguous compound identification



Laboratory analysis performed by Brent Love

Compound	LOD	Precision	Accuracy
Methane		1 ppbv	1%
Ethane	3 pptv	1%	5%
CFC-11	10 pptv	1%	5%
$CHCl_3$	0.1 pptv	5%	5%
C_2Cl_4	0.01 pptv	2%	5%
$MeONO_2$	0.01 pptv	3%	10%

UC-Irvine C_1-C_{10} VOC measurements

Hydrocarbons

1. Methane
2. Ethane
3. Ethene
4. Ethyne
5. Propane
6. Propene
7. Propyne
8. *i*-Butane
9. *n*-Butane
10. 1-Butene
11. *i*-Butene
12. *t*-2-Butene
13. *c*-2-Butene
14. 1,3-Butadiene
15. *i*-Pentane
16. *n*-Pentane
17. Isoprene
18. *n*-Hexane
19. *n*-Heptane
20. *n*-Octane
21. *n*-Nonane

Hydrocarbons

22. 2,3-Dimethylbutane
23. 2+3-Methylpentane
24. Cyclopentane
25. Methylcyclopentane
26. Cyclohexane
27. Methylcyclohexane
28. Benzene
29. Toluene
30. Ethylbenzene
31. *m+p*-Xylene
32. *o*-Xylene
33. Styrene
34. *n*-Propylbenzene
35. 2-Ethyltoluene
36. 3-Ethyltoluene
37. 4-Ethyltoluene
38. 1,3,5-Trimethylbenzene
39. 1,2,4-Trimethylbenzene
40. 1,2,3-Trimethylbenzene
41. *α*-Pinene
42. *β*-Pinene

Hydrocarbons

43. Furan
44. Methanol
45. Ethanol
46. Acetone
47. Acetaldehyde
48. MEK
49. MAC
50. MVK
51. MTBE

Alkyl Nitrates

52. $MeONO_2$
53. $EtONO_2$
54. *i*-$PrONO_2$
55. *n*-$PrONO_2$
56. 2-$BuONO_2$
57. 2-$PeONO_2$
58. 3-$PeONO_2$
59. 3-Me-2-$BuONO_2$

Sulfur Species

60. OCS
61. DMS

Halocarbons

62. CFC-11
63. CFC-12
64. CFC-113
65. CFC-114
66. H-1211
67. H-1301
68. H-2402
69. HFC-134a
70. HFC-152a
71. HCFC-22
72. HCFC-141b
73. HCFC-142b
74. CCl_4
75. CH_3CCl_3
76. CH_2Cl_2
77. C_2HCl_3
78. $CHCl_3$
79. C_2Cl_4
80. CH_3Cl
81. CH_3Br
82. CH_3I
83. $CHBr_2Cl$
84. $CHBrCl_2$

Halocarbons

85. CH_2Br_2
86. $CHBr_3$
87. Ethylchloride
88. 1,2-DCE

Alkanes
Alkenes
Alkynes
Cycloalkanes
Aromatics
Monoterpenes
Oxygenates
Alkyl nitrates
Sulfur species
Halocarbons

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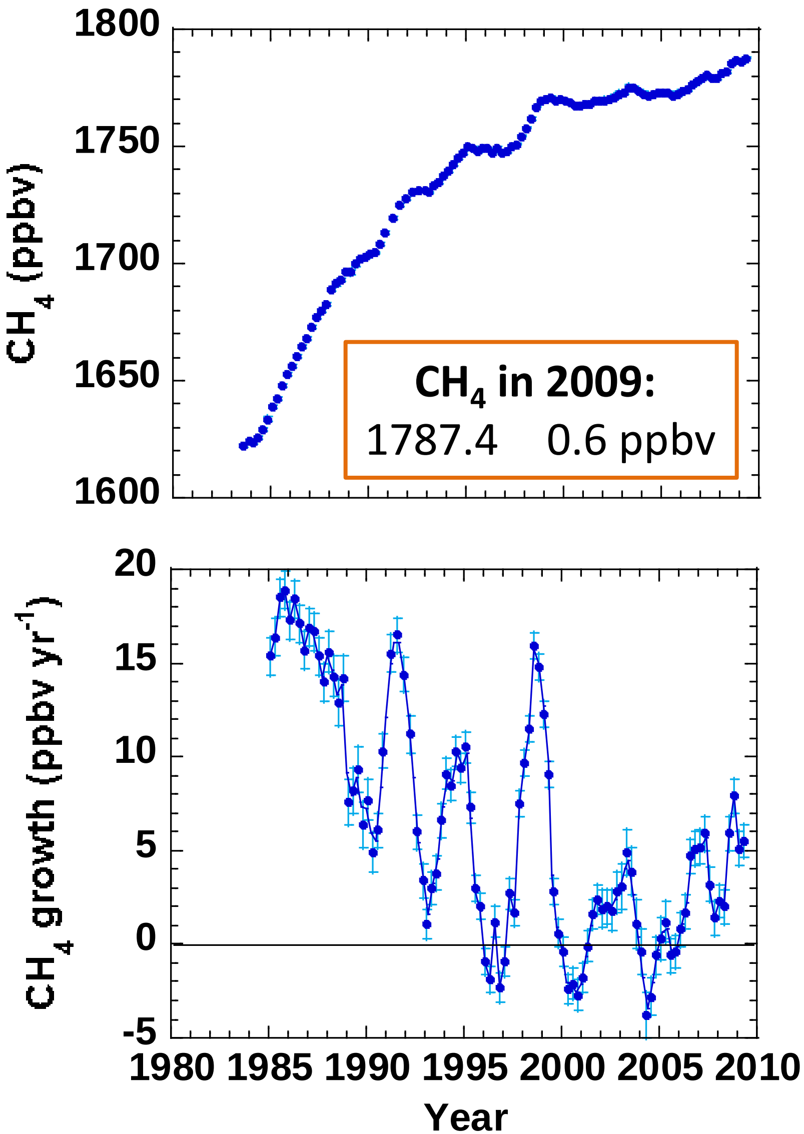
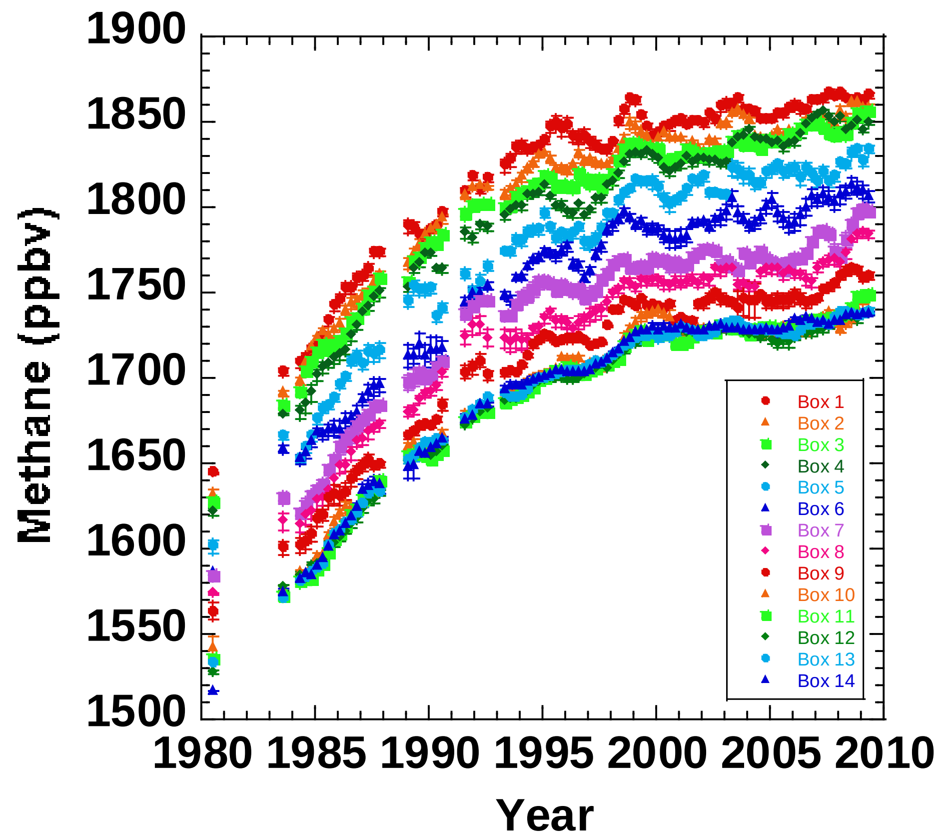
Global CH_4 mixing ratio and growth rate





Tyler et al. [2007]: **Biomass burning** and **wetlands** are the two CH_4 sources most likely to influence short-term CH_4 cycles

Ethane latitudinal distribution and seasonality

Global ethane sources

- Fossil fuel: 8.0 Tg yr^{-1}
- Biofuel: 2.6 Tg yr^{-1}
- Biomass burning: 2.4 Tg yr^{-1}

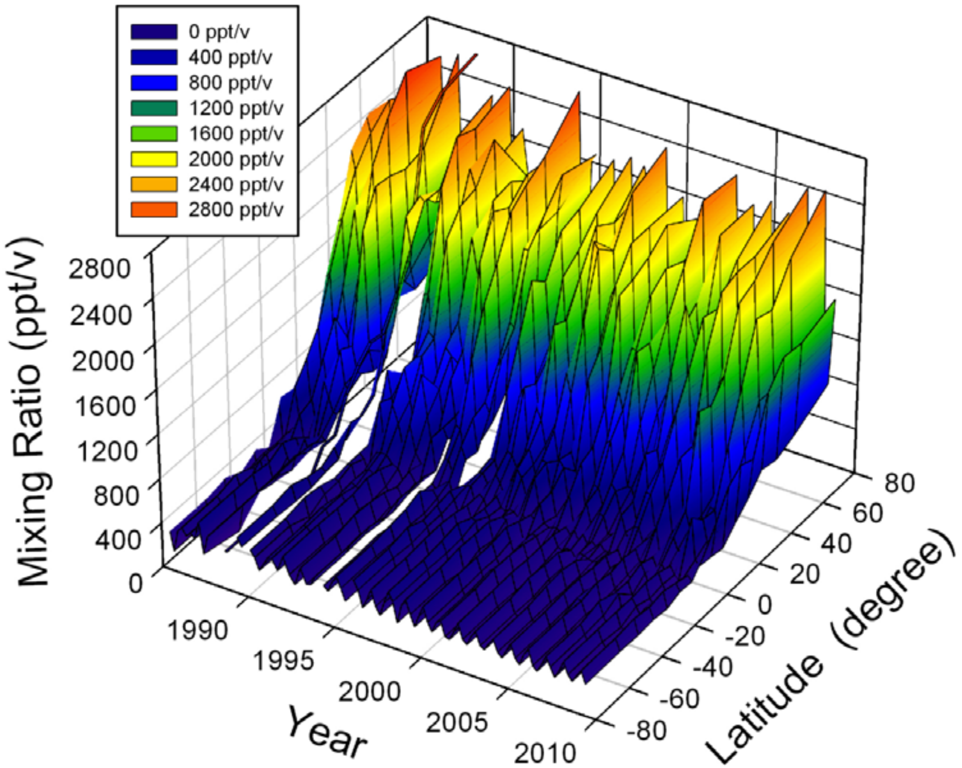
Global ethane sink

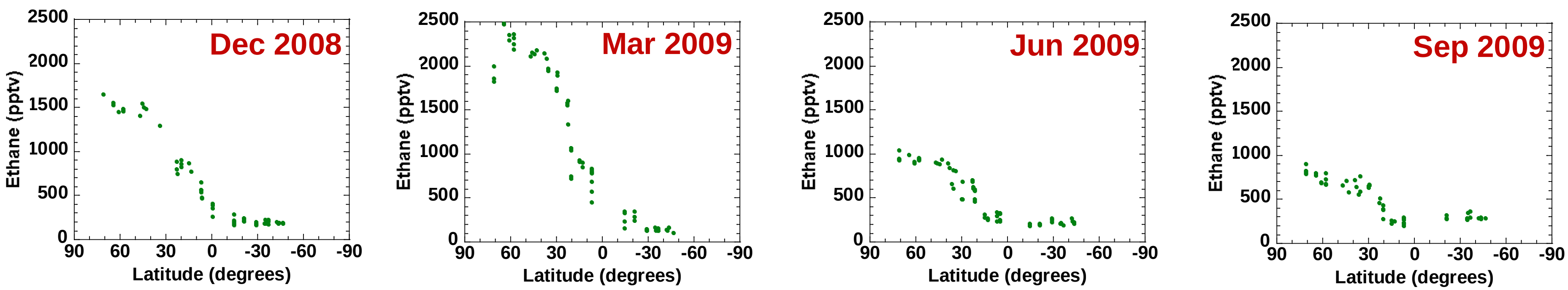
- Hydroxyl radical (OH)
- Ethane lifetime: 2-3 months

Global ethane distribution

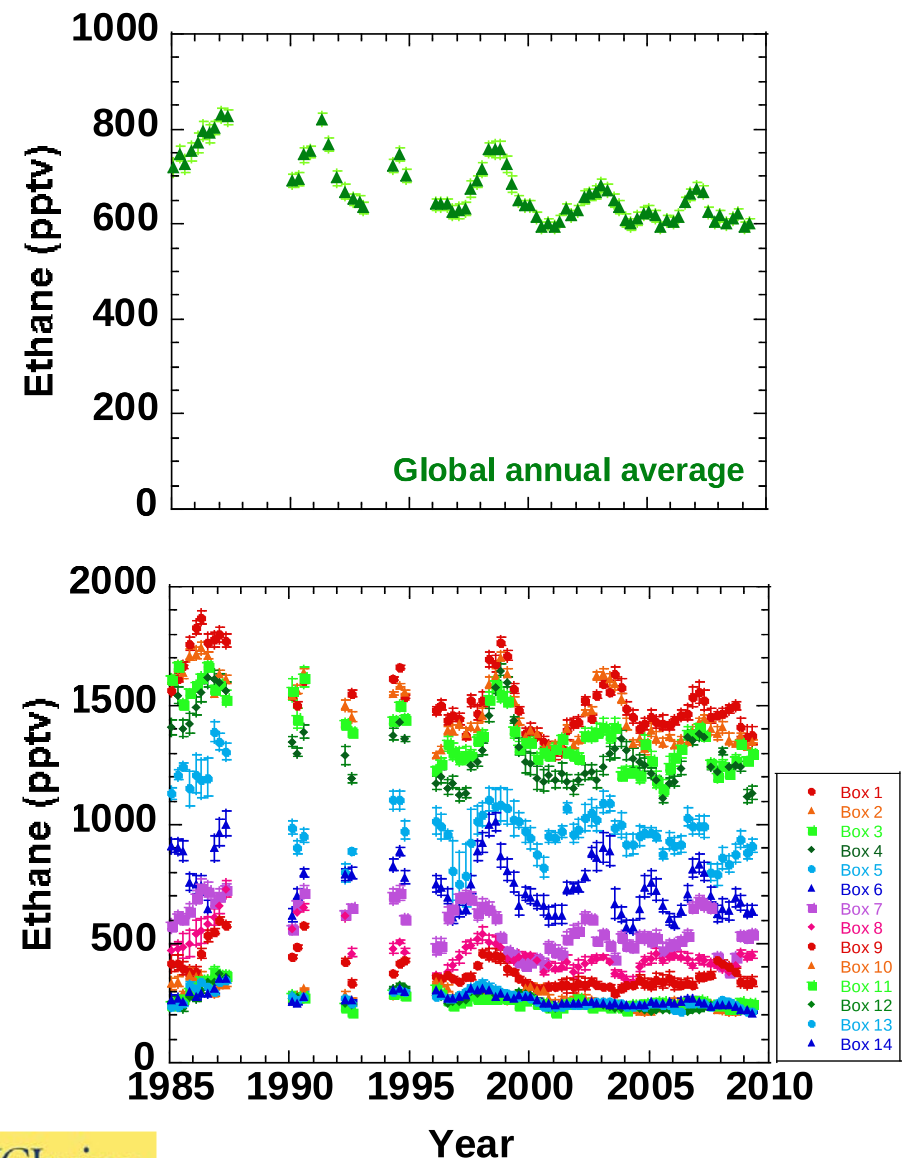
- 80% emitted in NH

Y. Xiao et al., JGR, 113, 2008





Global annual ethane mixing ratio

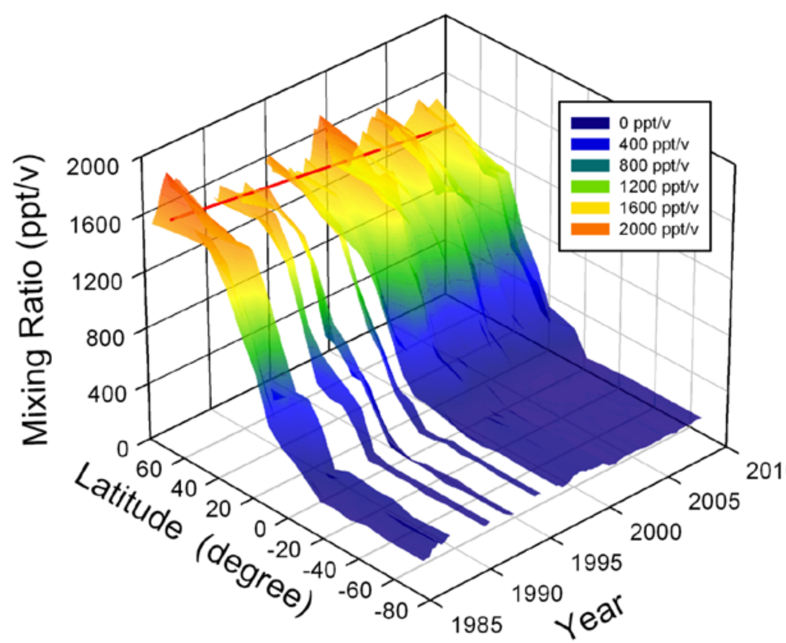


Global ethane mixing ratio

- 1986: 791 19 pptv
- 2009: 601 10 pptv

Global ethane trend

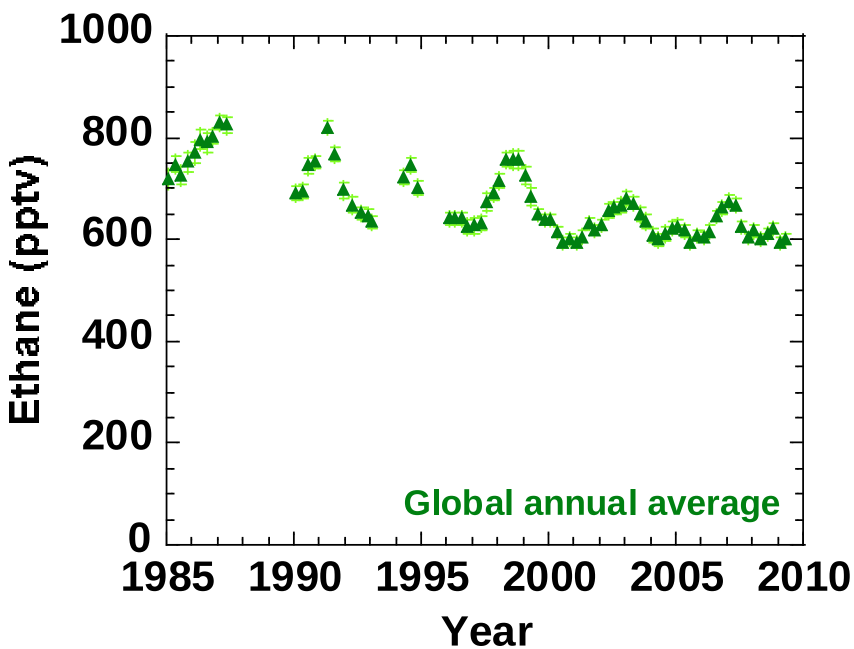
- 190 pptv (24%) decline in 23 yrs
- Average decline: −8 pptv yr^{-1}



Global ethane mixing ratio: Long-term decline

Modeling long-term ethane decline

- NOAA/ESRL CarbonTracker model
- Optimized for global ethane emissions:
  1. **Global observations**: UC-Irvine
  2. **Global atmospheric transport**: TM-5 model
  3. **Ethane sources**: POET global emissions



Global ethane levels:

800 pptv in 1986 ~ 17 Tg yr^{-1}

600 pptv in 2009 ~ 12 Tg yr^{-1}

~5 Tg yr^{-1} decrease

- Declining fossil fuel emissions?
  - Less venting & flaring?
- Consistent with declining CH_4 growth?
  - Natural gas ethane:CH_4 ~ 1:20
- Effects of OH?

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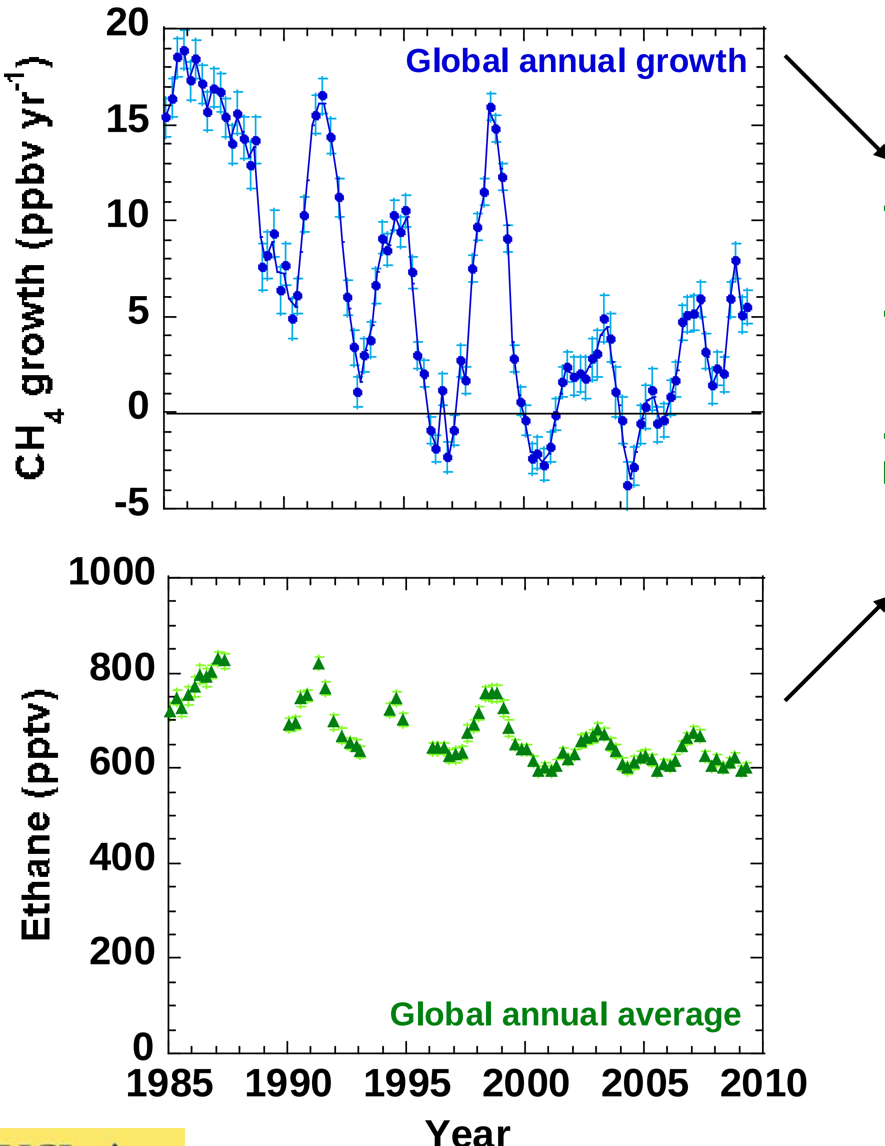
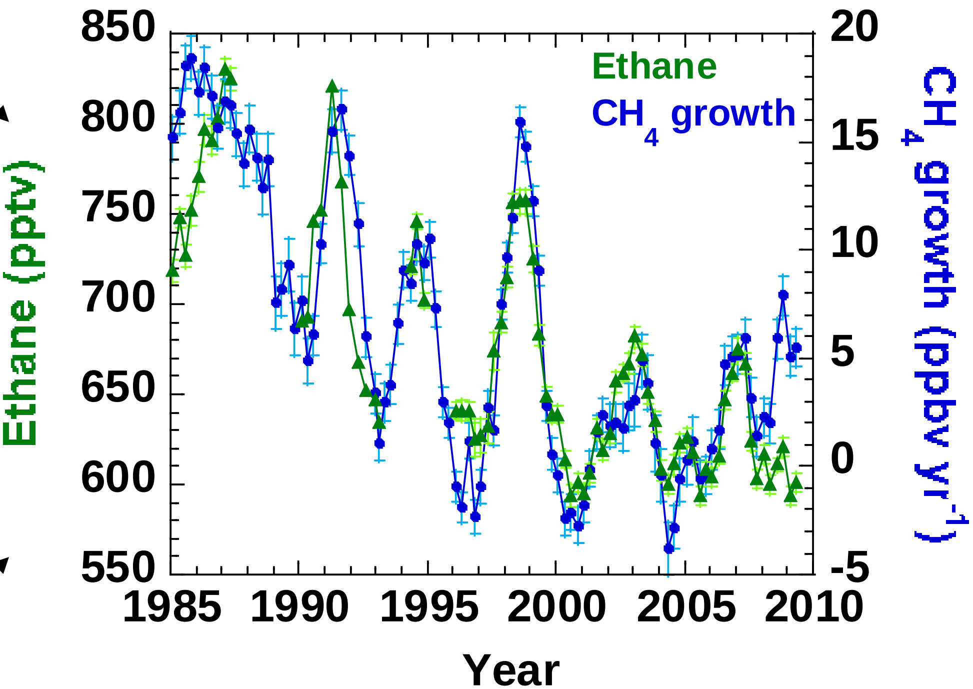
Global CH_4 and ethane: Similar trends





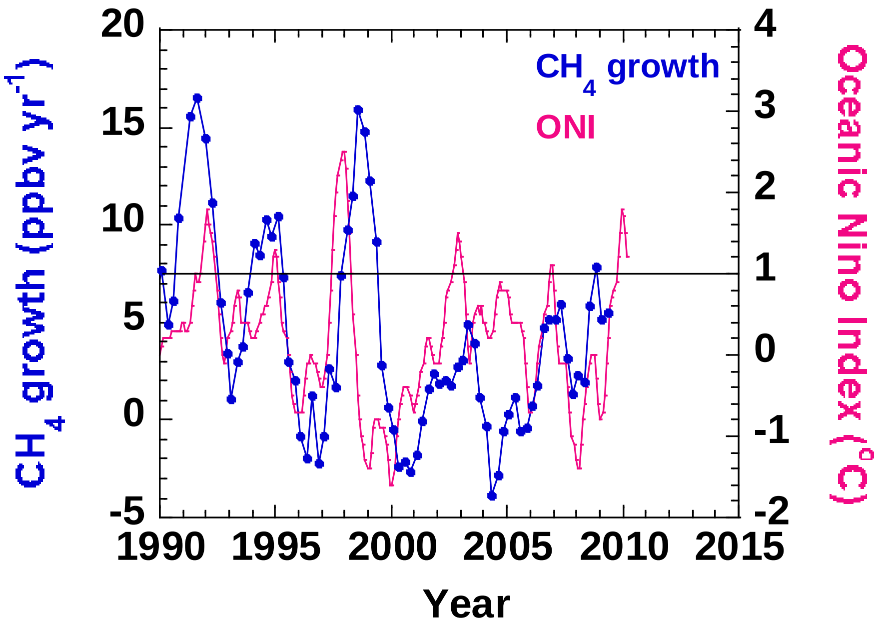
CH_4 fluctuations

- 1998: Wetlands + biomass burning
- 2003: Biomass burning (Siberia)
- 2007: Wetlands + biomass burning
- 2008: Wetlands (tropics)

Best guesses for CH_4 and ethane behaviour in 2010

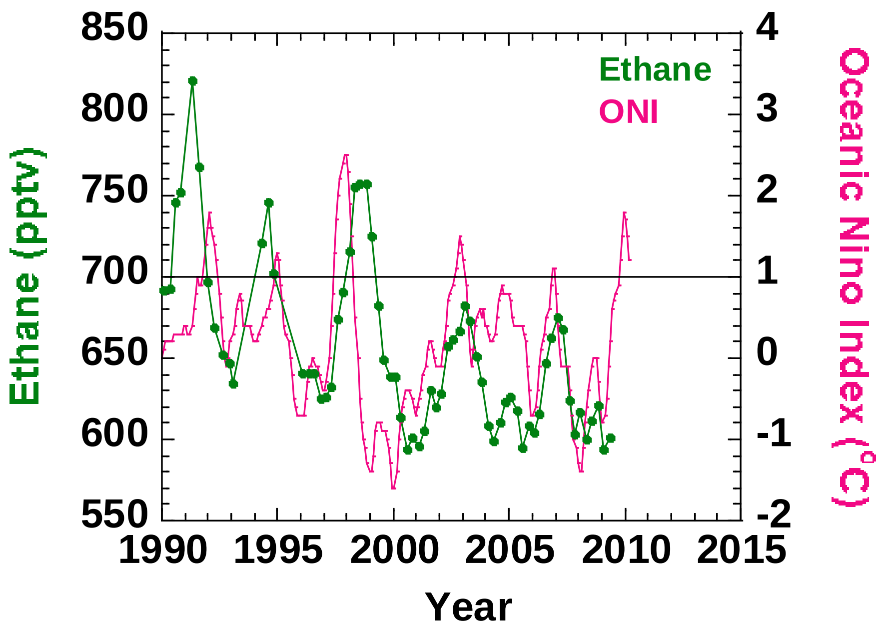
CH_4:

- Continued growth of 5-10 ppbv yr^{-1}?
- Boreal wetlands, biomass burning?



Ethane:

- Growth from 600 to 650 pptv?
- Boreal biomass burning?



The Oceanic Niño Index (ONI) is a 3 month running mean of sea surface temperature anomalies in the Niño 3.4 region (5°N-5°S, 120°-170°W), based on the 1971-2000 base period.
http://www.cpc.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml

Conclusions

Global CH_4 mixing ratio: 1787.4   0.6 ppbv
Global C_2H_6 mixing ratio: 601   10 pptv

Global CH_4 growth + ethane mixing ratio

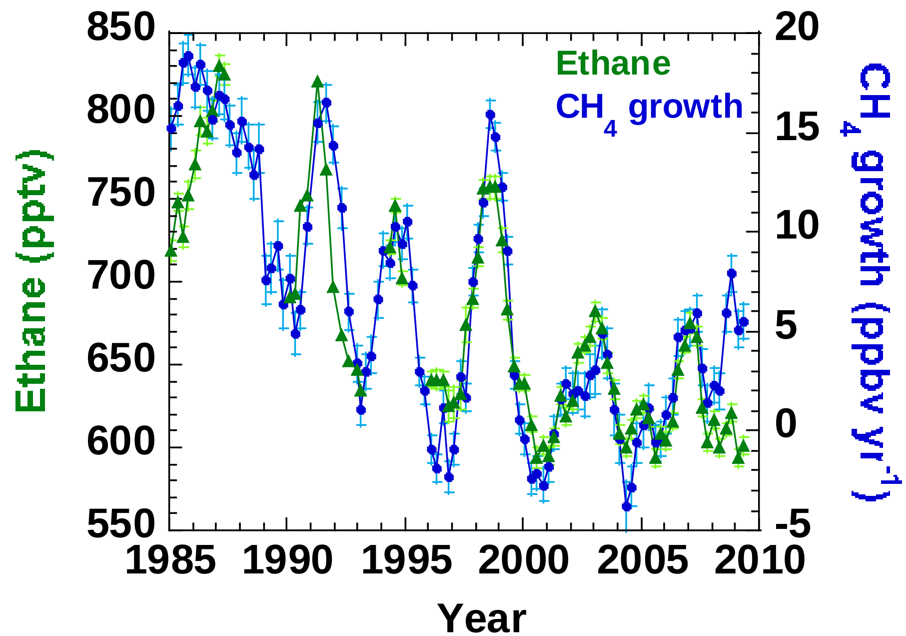
- **Long-term decline**
  - Fossil fuel?
- **Short-term anomalies**
  - **CH_4:** Wetlands + biomass burning
  - **Ethane:** Biomass burning

CH_4 peak in 2008/2009

- Growth in the tropics
- Weak ethane peak
  - Minimal biomass burning influence
- Still no evidence of CH_4 release from Arctic permafrost in our record

Expect CH_4 and ethane growth in 2010

- Following El Niño in 2009/2010



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