UV light induces methane emission from plant biomass

Mechanism and isotope studies

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- Introduction on methane from plants
- UV radiation studies
- Isotopic studies, evidence of the mechanism
- Living plants issue

Methane from plants

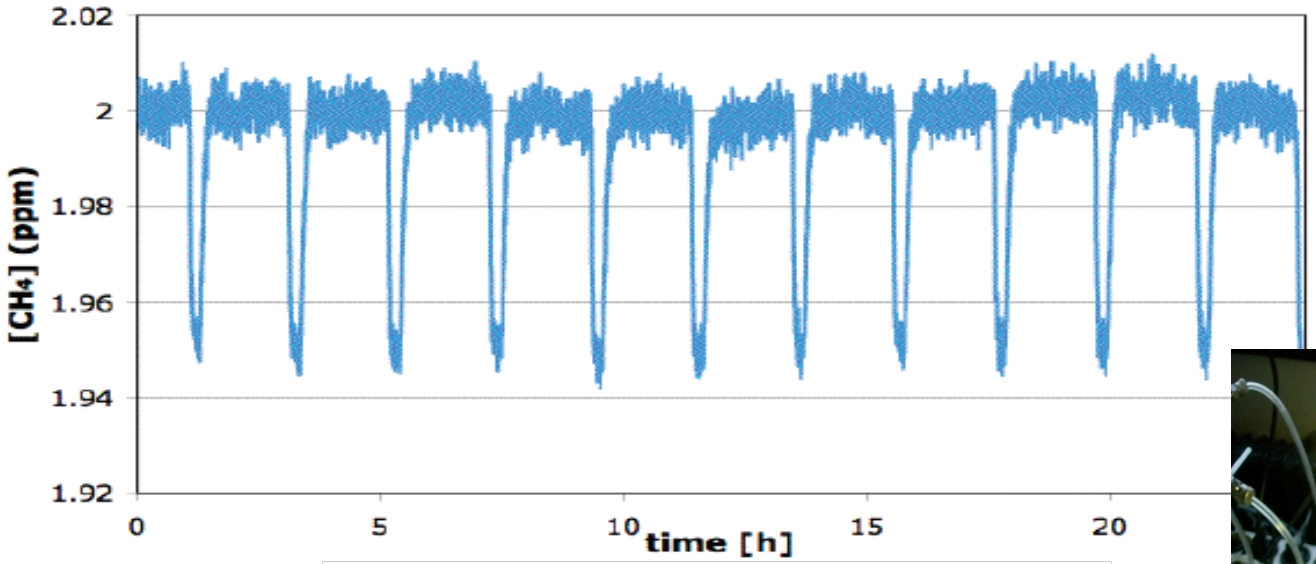
- Keppler et al. 2006, 62-236 Tg/yr
- Houweling et al. 2006, 85-125 Tg/yr
- Butenhoff & Khalil 2007, 20-69 Tg/yr
- Dueck et al. 2007, no emission!
- Kirschbaum 2008, ER 1000 times lower!
- Wang et al. 2008 some species are emitting other not
- Cao et al. 2008, alpine plant emissions (some data in agreement with Keppler values)

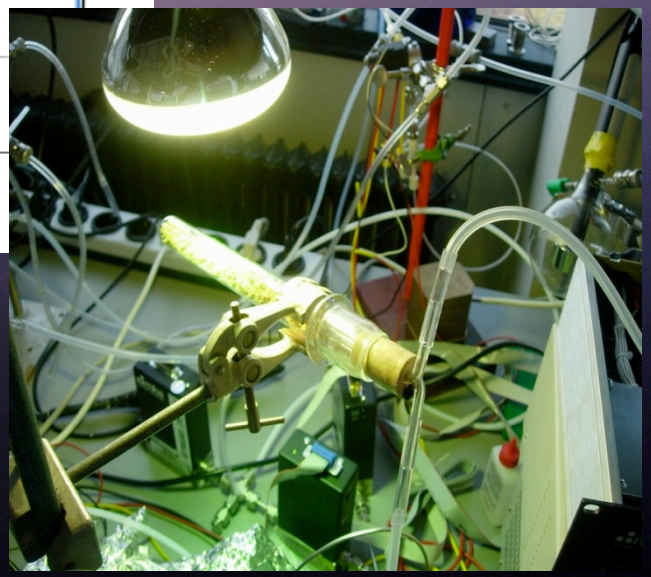
Methane emission from UV interaction with plant material

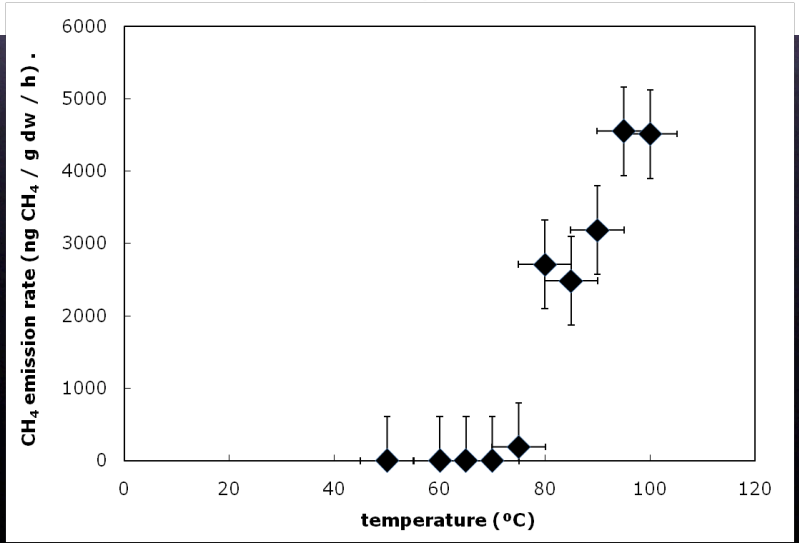
- Vigano et al.,Keppler et al. 2008, clear evidence of production with UV and temperature
- McLeod et al. 2008, experiments on UV and pectin
- Messenger et al. 2009, ROS and methane generation
- Nisbet et al. 2009: no evidence of a metabolic pathway
- Bruggemann 2009, CH4 emission from sterile plants under low light (ER 1000 times lower then Keppler values)

In more then 300 tests with ambient air (20%O_2)

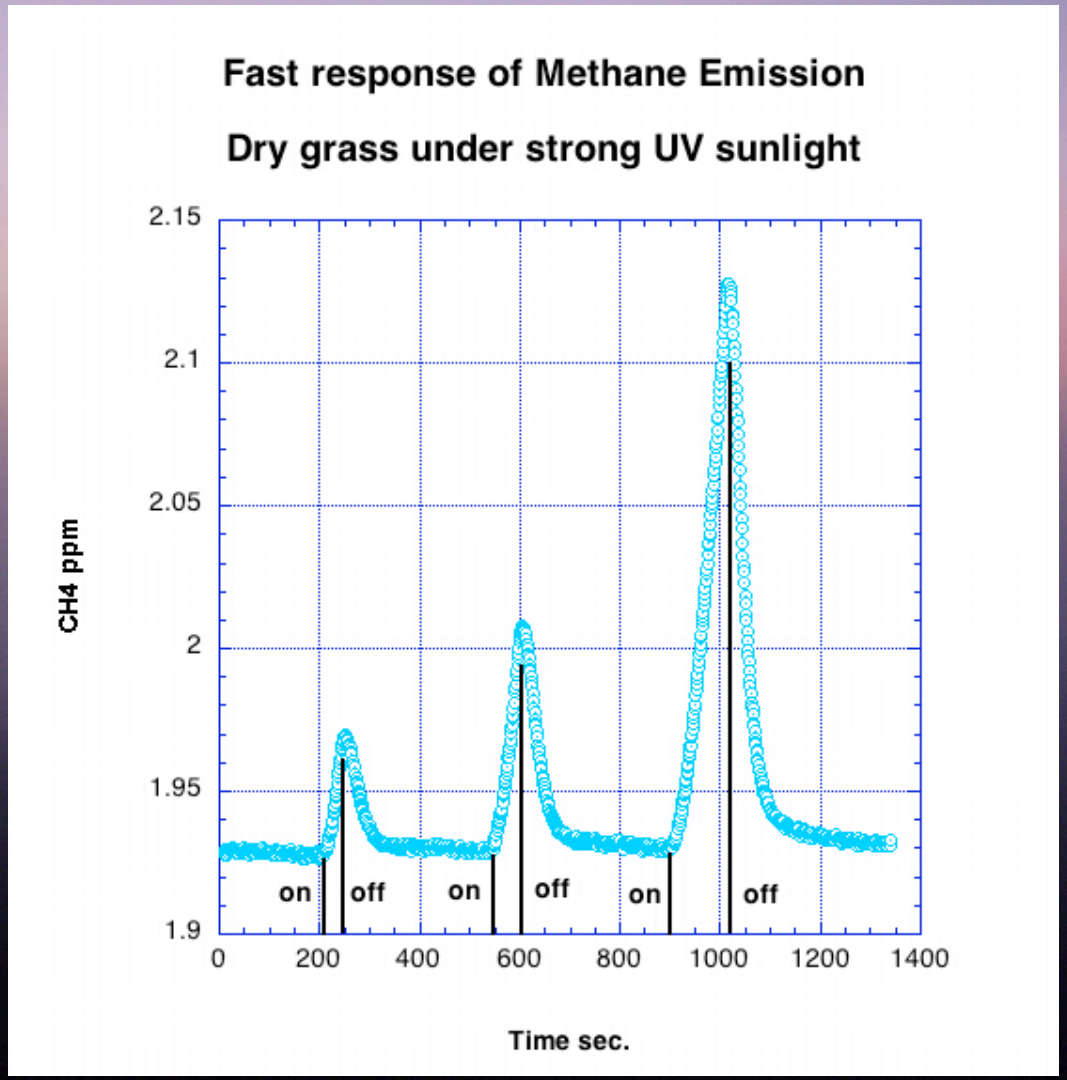
Clear evidence of CH_4 production from organic plant material by irradiation with UV and by heating







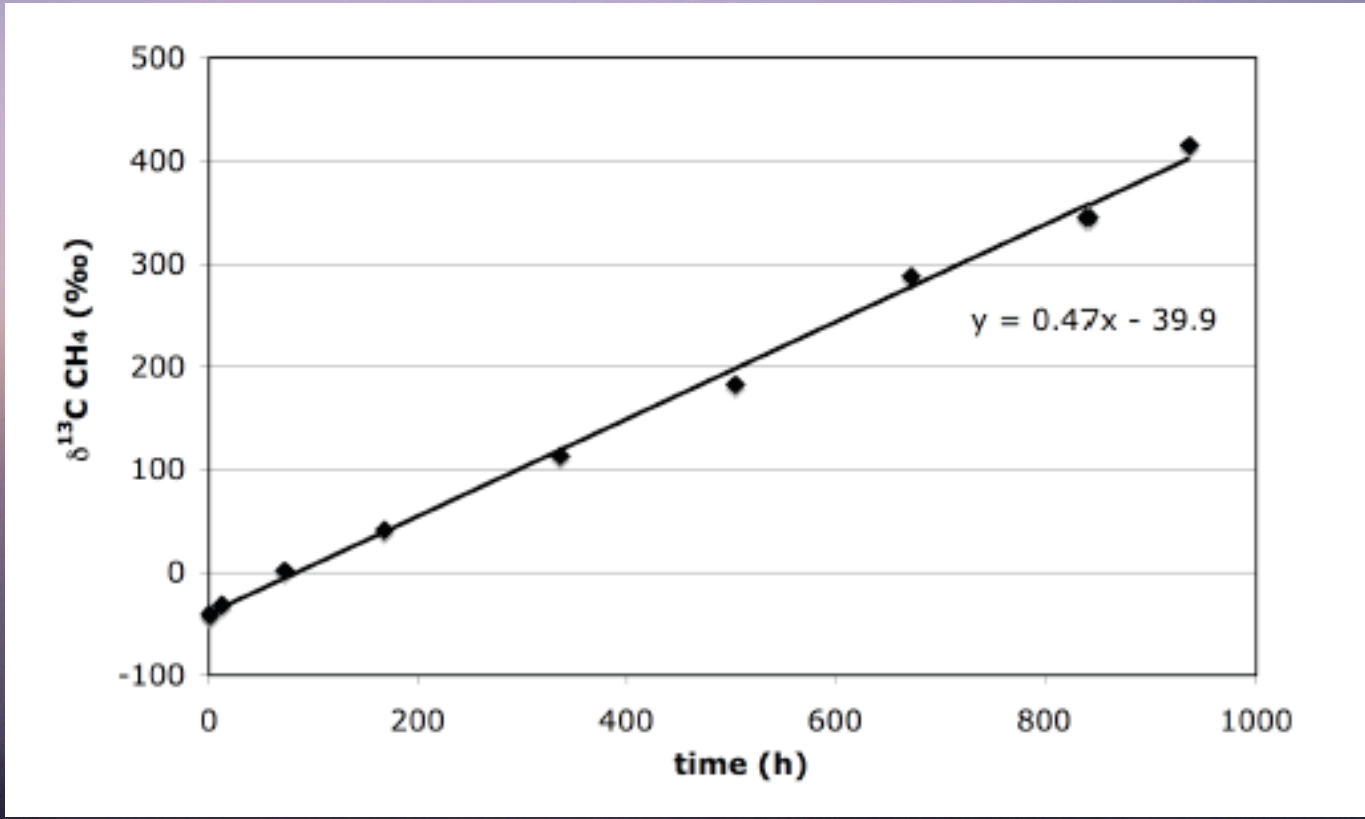
Photochemistry
The fast reaction rules out any biological activity



Vigano et al., *Biogeosciences* 2008

Aerobic release of methane WITHOUT LIGHT at 20ºC

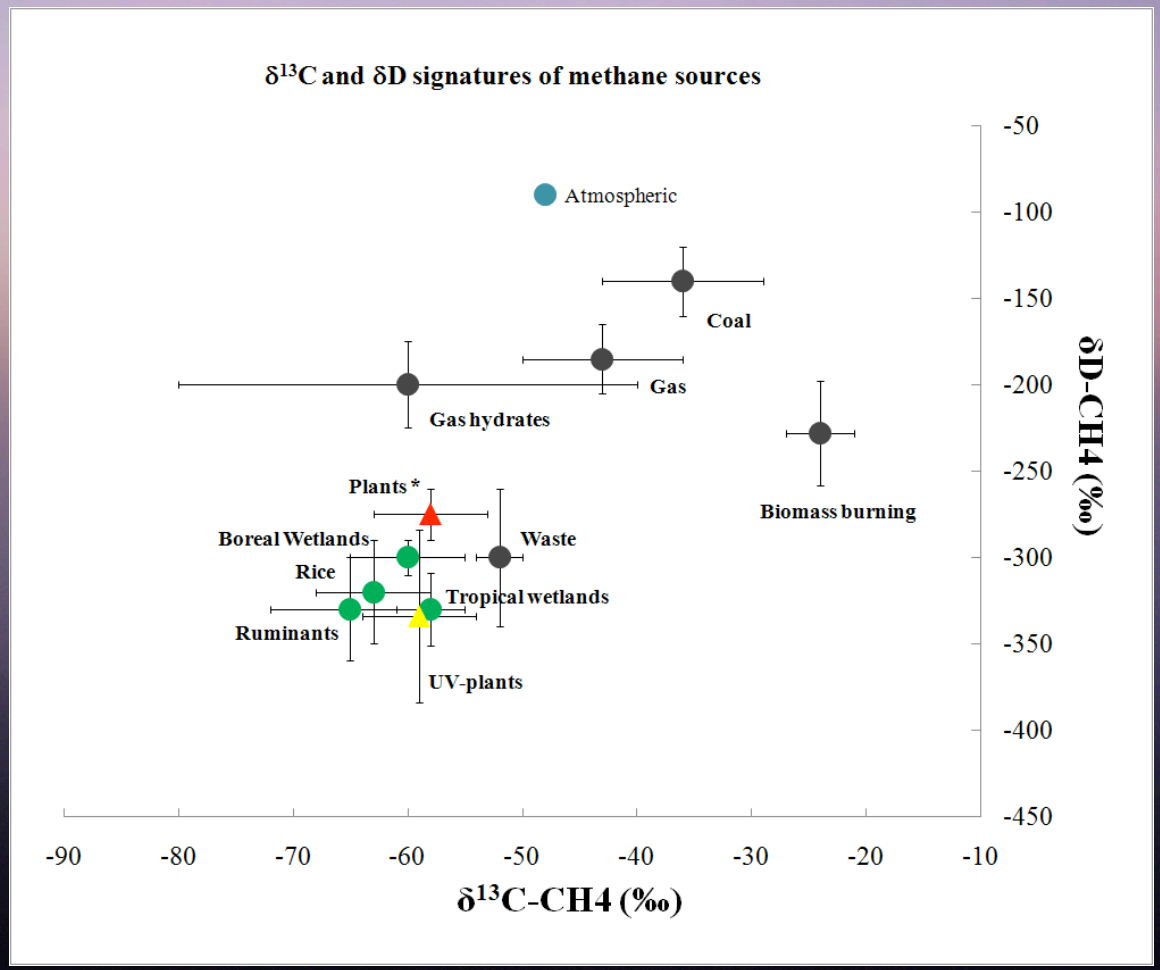
Isotopic approach



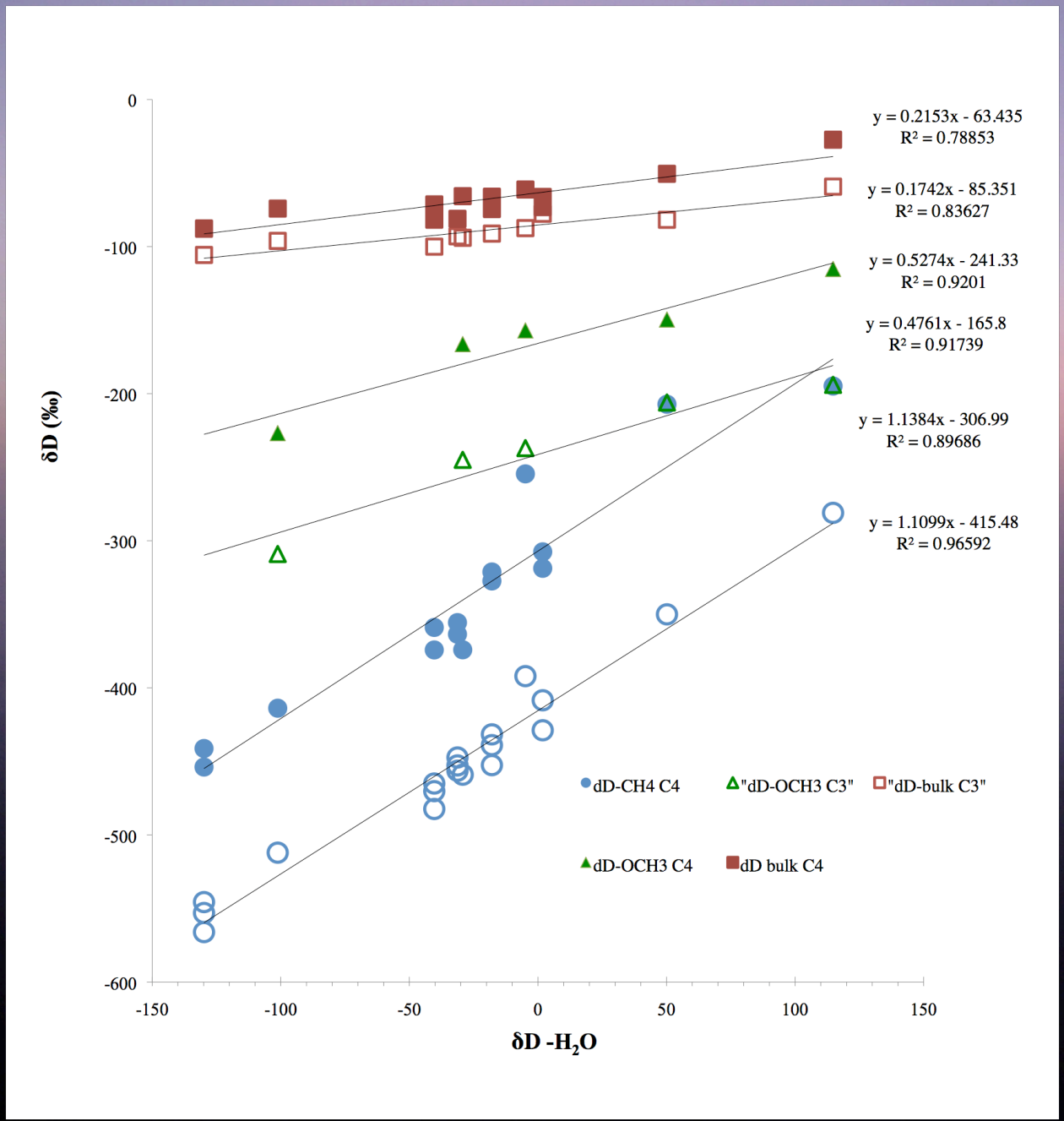
A dry leaf of pure ^{13}C from the Dueck experiment is releasing
0.03 ng/gDWh
(lowest limit ever detected for methane!)

We are able to perform high precision isotope measurements

The stable isotope signature of methane emitted from plant material under UV irradiation (submitted)



Detailed isotopic studies on plant emissions
Very depleted!



δD water drives δD of the plant molecules and of the gases emitted

New unpublished experiments:

My experiments	ER (ng/gDWh)	Keppler et al.	ER (ng/gDWh)
Sorghum		Sorghum	
Light (strong UV)* 3.1 (±3.8)	Dark 3.9 (±1.7)	Light 407-782	Dark 137-331
Maize		Maize	
Light (strong UV)* 0.025 (±0.6)	Dark 1.76 (±0.6)	Light 428-732	Dark 55-149
Dry plant (T~35ºC)			
7.5 (±0.2)	1.68 (±0.5)		
Wheat		Wheat	
Light (strong UV)* 3.0 (±5.5)	Dark 9.6 (±5.6)	Light 123-244	Dark 317-587

the emission from living plants are small
of the order of plant litter aerobic degradation

* ~8 W/m^2 UVB T~35-40ºC (tropics ~4 W/m^2)

Present situation:

1-Up to now high emission rates of Keppler for living plants could not be reproduced

2-UV light and temperature drive the aerobic methane emission from plant matter (and other effects, physical injury, etc)

3-Very small emissions also occur without light and at room temperature

Rough upscaling:

Global totals of detrital organic matter[1] = 2.74 *10^{18} gDW
Global terrestrial plant biomass[2] = 8.27*10^{17} gDW

1)Dark emissions:

For 0.03 ngCH_4/gDWh (tiny but involving the whole carbon matter)

➔ 1.5÷9.6 TgCH_4
~ 1,6% of global budget

2) Living plant emissions + UV induced emissions:

(5ngCH_4/gDWh, based on NPP and on leaf area index) : ~10 Tg

➔ 10-20 TgCH4

Total: ~3-4% of the actual Global Budget

[1]V.Meentemeyer et al.:BioScience, Vol. 32, No. 2 (Feb., 1982), pp. 125-128
[2] Schlesinger WH 1991, Academic Press, San Diego, CA, USA; Table 5.2

- Aerobic CH_4 emission is likely small
- There are no “hot spots”
- Smooth over the whole biosphere
- Difficult to separate from background

BUT:
isotope studies prove that they are there