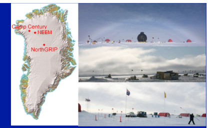

Natural & anthropogenic variations in CH_4 sources over the last 2 millennia

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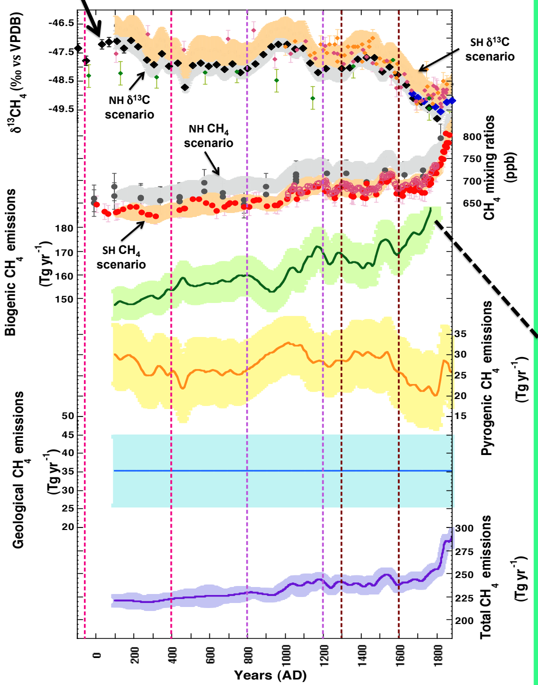
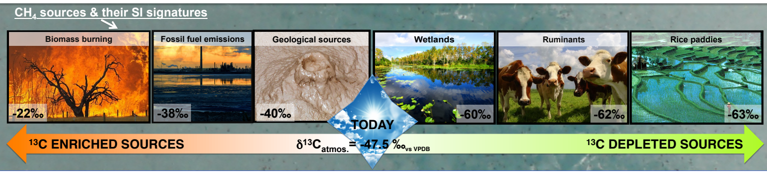
New $\delta^{13}C$ data and CH_4 emission scenarios



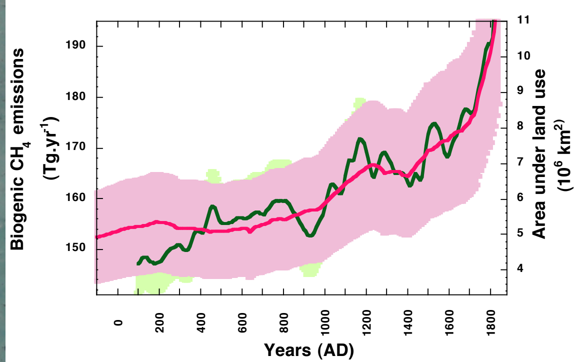
- 47 ice core samples from NEEM (black diamonds) and EUROCORE (blue diamonds) were analyzed following a dry extraction method described in Sapart et al., 2011.
- Our $\delta^{13}C$ data, together with $\delta^{13}C$ data from GISP2 (Sowers, 2010: green diamonds), Law Dome (Ferretti et al., 2005: red diamonds) and WAIS (Mischler et al., 2009: orange diamonds) and CH_4 data from GRIP (Blunier et al., 1995: black circles), Law Dome (MacFarling Meure et al., 2006: red circles) and WAIS (Mitchell et al, 2011: pink circles) were used as input to our 2-box model to calculate the most probable CH_4 emission scenarios presented in the figure above.

RESEARCH AIMS

- Investigating the changes in CH_4 sources over the last 2 millennia using stable isotope (SI) analysis from air trapped in Greenland ice cores (NEEM & EUROCORE). Each source category produces CH_4 with specific isotopic composition, thus SI analysis is an excellent tool to understand the underlying processes leading to CH_4 emissions
- Calculating the most probable source scenarios able to explain the $\delta^{13}C$ and CH_4 observations with a 2BOX-model.
- Comparing our data and scenarios to paleo-proxies and historical records in order to understand the impact of climate variability and of anthropogenic activity on the CH_4 budget.



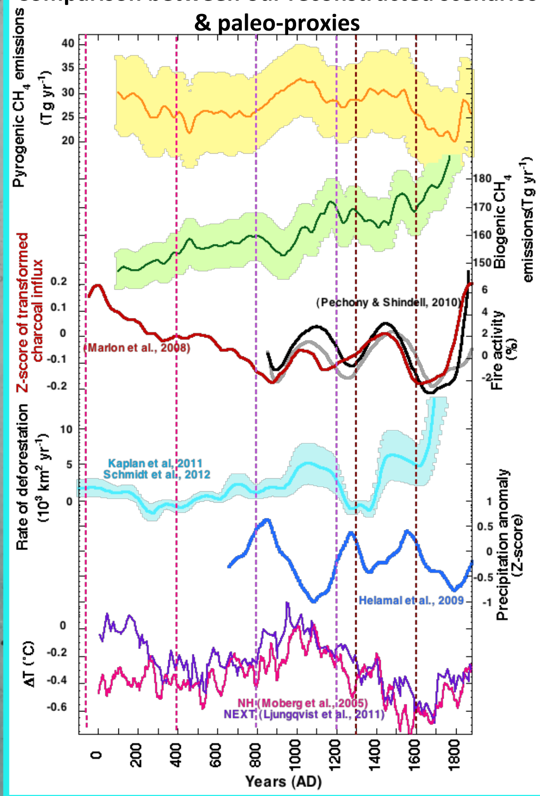
Comparison between our reconstructed biogenic CH_4 emission scenario & area under land use data



- Our model results confirm that the long-term trend in CH_4 atmospheric mixing ratio over the last millennia is mainly caused by an increase in biogenic CH_4 emissions (e.g. wetlands, agriculture).
- Several hypotheses have been suggested to explain this CH_4 increase including rising emissions from wetlands or from gas hydrate or early emissions induced by human activities.

- We show that our reconstructed biogenic CH_4 emission scenario is in good agreement with global human-induced changes in land cover from the KK10 (pink) (Kaplan et al., 2011 & Schmidt et al., 2012). This suggests that human activities, including the expansion of rice agriculture played a significant role in the observed trends over the last 2 millennia.

Comparison between our reconstructed scenarios & paleo-proxies



- In order to understand how the pyrogenic and biogenic CH_4 sources are affected by climate variability and anthropogenic activity, we compare our reconstructed CH_4 emission scenarios to charcoal, fire, temperature and precipitation data, but also to the rate of deforestation which is a good indicator of anthropogenic variations in biomass burning.

CONCLUSIONS

- Our new NH $\delta^{13}C$ record shows unexpected centennial-scale variability that was attributed in agreement with our sensitivity tests to changes in biomass burning and biogenic emissions.
- Our pyrogenic scenario is quite well correlated with the global charcoal index, with data of fire activity and with deforestation estimates. A comparison with paleoclimatic data shows that the two younger $\delta^{13}C$ excursions occur during drier periods, but no clear correlation is observed with temperature proxies. For the first excursion, less proxies are available, but we suggest that anthropogenic activities, especially during the Roman Empire/Han dynasty epoch and may have affected the CH_4 budget.
- Our model results show that the long-term increasing trend in CH_4 and decreasing in $\delta^{13}C$ over the last 2 millennia is highly likely caused by increase in biogenic sources. Comparing those data to anthropogenic land-use data suggest that humans affect significantly the CH_4 budget since 2 millennia.

*** Our biogenic scenario compare to temperature and precipitation data suggest that possible increases in the methanogenesis rates at higher temperatures are likely compensated or even overwhelmed by decreases in wetland area due to extended droughts. This also suggests that in the future CH_4 emissions from natural wetlands may decrease rather than increase in a warming climate.**