Methane Wetland Emissions: Influence of the El Niño Southern Oscillation

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Natural emissions from wetlands are the largest single source of methane and most of these emissions originate from tropical regions. During ENSO events, planetary-scale changes in ocean temperature occur in the tropics, producing anomalies in soil temperature and precipitation. As a result, ENSO could play a significant role in determining the inter-annual variability of wetland emissions. In this study, we use an emissions model to investigate the influence of ENSO on present-day wetland emissions.

Results from ensemble simulations indicate that significant regional differences in wetland emissions occur between El Niño and La Niña years. These differences appear to be predominantly caused by changes in wetland fraction associated with precipitation changes. Despite the large regional differences, results also suggest that ENSO does not influence wetland emissions or the atmospheric CH_4 growth rate on a global annual scale.

Introduction

Methane (CH_4) wetland emissions depend on water table depth, temperature, and the carbonaceous substrate availability. As a result, most emissions originate from tropical regions. However, the cause of inter-annual variability in emissions is uncertain, with studies showing differing temperature and precipitation sensitivities.

During El Niño Southern Oscillation (ENSO) events, planetary-scale changes in ocean temperatures occur in the tropics, leading to anomalies in soil temperature and precipitation. The purpose of this study is to investigate the influence of ENSO events on wetland emissions.

Wetland Emissions Model

We use the Gedney et al. (2004) wetland emissions model coupled to the Met Office Hadley Centre's climate model, HadGEM2. The emission flux is parameterized as:

$$F = k * f_w * C_s * Q_{10}(T_{soil})^{(T_{soil}-T_0)/10}$$

where F is the emission flux, k is a scaling factor used to give a global annual total of 180.0 Tg CH_4/year, f_w is the wetland fraction, C_s is the soil carbon, Q_{10} is a temperature sensitivity function, T_{soil} is the soil temperature, and T_0 is 273.15 K.

Methodology and Model Experiments

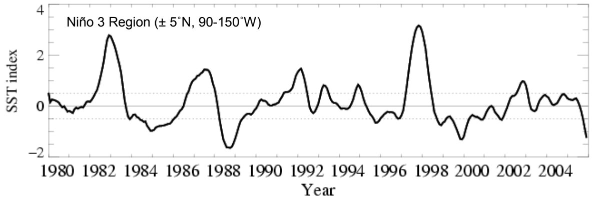

Figure 1: Time series of the Niño 3 sea surface temperature (SST) indices as 5-month running means using HadISST.

Two 7-member ensemble simulations were carried out – one for the 1997/98 El Niño year and another for the 1988/89 La Niña year. These years were chosen to maximise the potential difference in wetland behaviour (Figure 1).

Results

Figure 2 shows the seasonal cycle of global wetland emissions from all ensemble members. It indicates that ENSO events do not influence wetland emissions on a global annual scale or contribute to the inter-annual variability in atmospheric CH_4 growth rate.

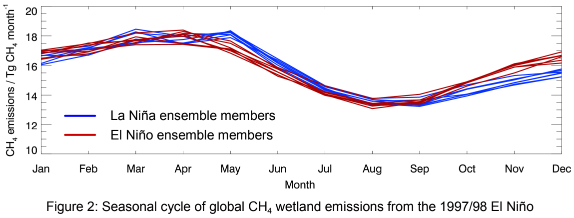

Figure 2: Seasonal cycle of global CH_4 wetland emissions from the 1997/98 El Niño ensemble (red) and the 1988/89 La Niña ensemble (blue).

Figure 3 shows the global annual distribution of wetland emissions from the La Niña ensemble mean (top left), the El Niño ensemble mean (middle left) and an absolute difference between the two (below left). It indicates that regionally, there are significant differences in the behaviour of wetland emissions between El Niño and La Niña years. This appears to be largely correlated with differences in wetland fraction, which are shown in the right of Figure 3. The Maritime Continent, for example, shows a reduction

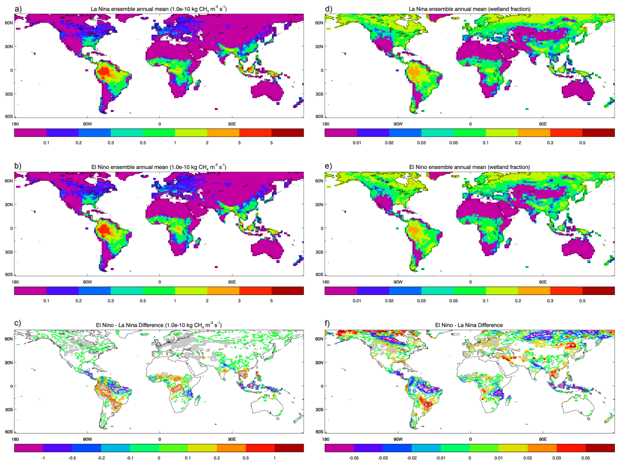

Figure 3: Global annual distributions of CH_4 wetland emissions from a) the La Niña ensemble mean b) the El Niño ensemble mean and c) the absolute difference between the two. The equivalent plots for wetland fraction are in d), e), and f). The grey shading in the difference plots indicates where the differences are statistically significant at the 90% confidence interval.

in wetland fraction for El Niño relative to La Niña, leading to a reduction in wetland emissions of ~50%. One exception is western Amazonia, where wetland emissions are higher in El Niño than La Niña despite the reduction in wetland fraction. Differences in surface precipitation (left) and surface temperature (right) between the El Niño and La Niña ensemble means are shown in Figure 4. For western Amazonia, it indicates that although there is a significant reduction in surface precipitation, this is offset by an increase in surface temperature in El Niño relative to the La Niña ensemble.

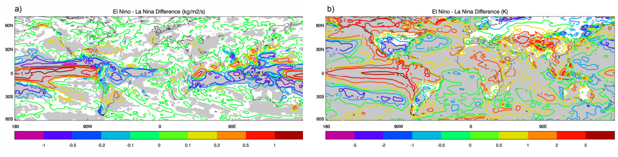

Figure 4: Global annual absolute differences in a) surface precipitation and b) surface temperature between the El Niño and La Niña ensemble means.

References
Gedney, N., P. M. Cox, and C. Huntingford (2004), Climate feedback from wetland methane emissions, *Geophys. Res. Lett.,* 31, L20503, doi:10.1029/2004GL020919.

Acknowledgements
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Conclusions

The El Niño Southern Oscillation (ENSO) gives rise to significant differences in surface precipitation and temperature between El Niño and La Niña years, particularly in the tropics. As a result, ENSO has the potential to play a significant role in determining the inter-annual variability of wetland emissions and the global atmospheric CH_4 growth rate. Results from ensemble simulations indicate that significant regional differences in wetland emissions occur between El Niño and La Niña years. These differences appear to be predominantly caused by changes in wetland fraction associated with precipitation changes.

However, results also suggest that ENSO does not influence wetland emissions or the atmosphere CH_4 growth rate on a global annual scale.

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