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 CH₄ growth rate on a global annual scale.

Introduction
Methane (CH₄) 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:

\[
F = k \cdot f_w \cdot C_s \cdot Q_{10}(T_{soil})(T_{soil} - T_0)/10
\]

where \(F\) is the emission flux, \(k\) is a scaling factor used to give a global annual total of 180.0 Tg CH₄/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
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 CH₄ growth rate.

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 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.

Conclusions
The El Niño Southern Oscillation (ENSO) gives rise to significant differences in wetland emissions on a global annual scale or contribute to the inter-annual variability in atmospheric CH₄ 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 atmospheric CH₄ growth rate on a global annual scale.

References

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