The role of non-CO_2 mitigation options within the dairy industry for pursuing climate change targets

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Take Home Message

Objective:
We determine how global implementation of better farming practices can further reduce non-CO_2 emissions and assist in reaching temperature goals set by international policy.

Plausible Emission Reductions:
Between 2020 and 2050, the global dairy industry can reduce a cumulative 10 to 13 Gt CO_2-eq using the 100-year GWP (21 to 26 Gt CO_2-eq using the 20-year GWP), at an average rate of 0.35 Gt CO_2-eq per year, if dairy farms improve management practices involving manure, enteric fermentation, and soils.
The whole agricultural sector (excluding land use changes) can avoid 78 to 110 Gt CO_2-eq (177-221 Gt CO_2-eq using the 20-year GWP) emissions if there is an emphasis on reducing methane and nitrous oxide emissions.

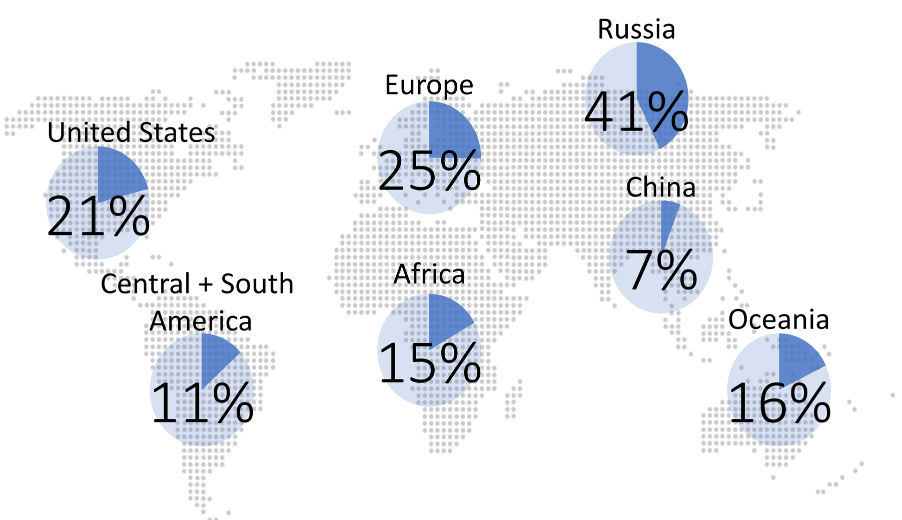
Advantages:
(1) Our future emissions scenarios are informed by GHG reductions on two US dairy farms.
(2) We use a coupled Earth system model of intermediate complexity containing full atmospheric chemistry and an interactive carbon cycle to project GHG concentrations.

Conclusions:
If better management practices are globally implemented within the next three decades, projected warming by the end of the century can be reduced by 0.21 ºC on average or 6% of total warming, with dairy mitigation contributing to 0.03 ºC of the temperature reduction. However, abatement of non-CO_2 agricultural GHG emissions alone could not reach a target of 2 ºC above the preindustrial level. Supplemental reductions in CO_2 from the fossil fuel industry are still necessary to reach a stringent temperature target.

Method

As a component of a USDA coordinated project, our study supplements the results of Veltman *et al.* (2018); which identified and tested better management practices (BMPs) on US dairy farms. BMPs improved farming practices related to cow feed, field application, and manure management for two farm sizes - a small 150 cow dairy farm and a large 1500 cow farm. We can assume that the average sized farm would fall somewhere between the two. Both US farms differed in their mitigation potential due to the differences in implemented practices and production size.

Figure 1: Methane emissions from dairy as a fraction of total agricultural emissions. Source: FAOSTAT



To reflect the differences in farming styles across the globe, we collected FAO data which showed the fraction of dairy emissions to total agricultural emissions for several economic regions, averaged over a 10 year period (**Fig. 1**).

In our study, we use the reduction estimates from the two dairy farms studied by the USDA to develop emission projection scenarios. We applied the reductions to the whole global dairy sector, weighted by the FAO data.

We develop five plausible future emission scenarios: (1) a no mitigation scenario, a reduction scenario where we apply (2) low and (3) high emission reductions to the global dairy subsector, and (4) low and (5) high emission reductions to the whole agricultural sector. (**See Table below**).

Data from: Veltman *et al.* (2018)

Scenario	Description	Global Emission Reduction		
		CH_4	N_2O	CO_2
No Mitigation	Business as usual projection. No BMPs implemented.	0%	0%	0%
Dairy Low Mitigation	Applies maximum emission reductions for a large 1500 cow farm to the global dairy sector.	43%	4%	10%
Dairy High Mitigation	Applies maximum emission reductions for a small 150 cow farm to the global dairy sector.	53%	56%	20%
Agr Low Mitigation	Same percent emission reductions as the Dairy-Low Mitigation but applied to whole agricultural sector.	43%	4%	10%
Agr High Mitigation	Same percent emission reductions as the Dairy-Low Mitigation but applied to whole agricultural sector.	53%	56%	20%

We use the fully coupled earth system model of intermediate complexity, the MIT Earth System Model (MESM), to compare the performance of the mitigation strategies under future climate change. The MESM includes a detailed representation of the carbon-cycle with interactive chemistry, and is capable of capturing the time-evolving chemical feedbacks of important atmospheric species (Sokolov *et al.*, 2018)

Results

The scenarios assume whole-farm BMPs begin to be globally implemented in 2020 and fully employed within 30 years (**Fig. 2**). Because it is unlikely all farms would abruptly implement BMPs, we use a linear trend in emissions reductions to broadly represent a wide range of pathways for economies to adjust to new farming technologies.

Global Emission Scenarios

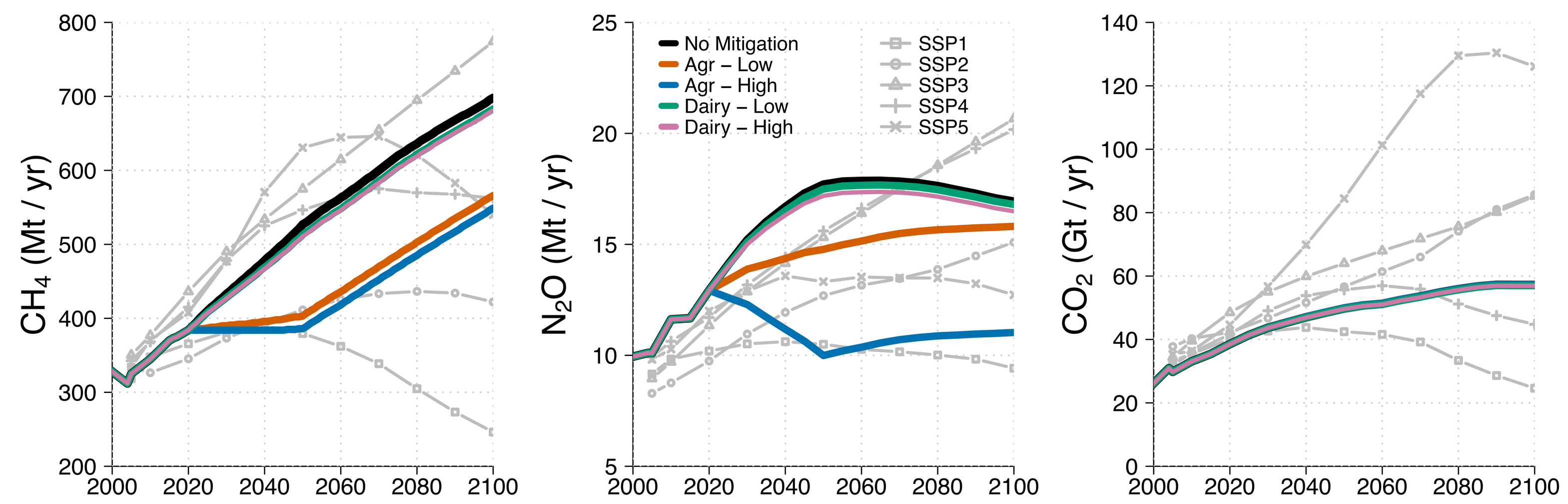


Figure 2: Net global emissions of CH_4, N_2O, and CO_2 for the five emission scenarios. The shaded light gray lines indicate the range in the IPPC share socioeconomic pathways (SSP).

By 2100, global temperature increases to 3.5 ºC in the No Mitigation scenario. Dairy farm emission reductions can reduce warming by 0.03 ºC and total agricultural emission reductions can limit warming by 0.21 ºC (**Fig. 3**).

Global Average Surface Temperature Change

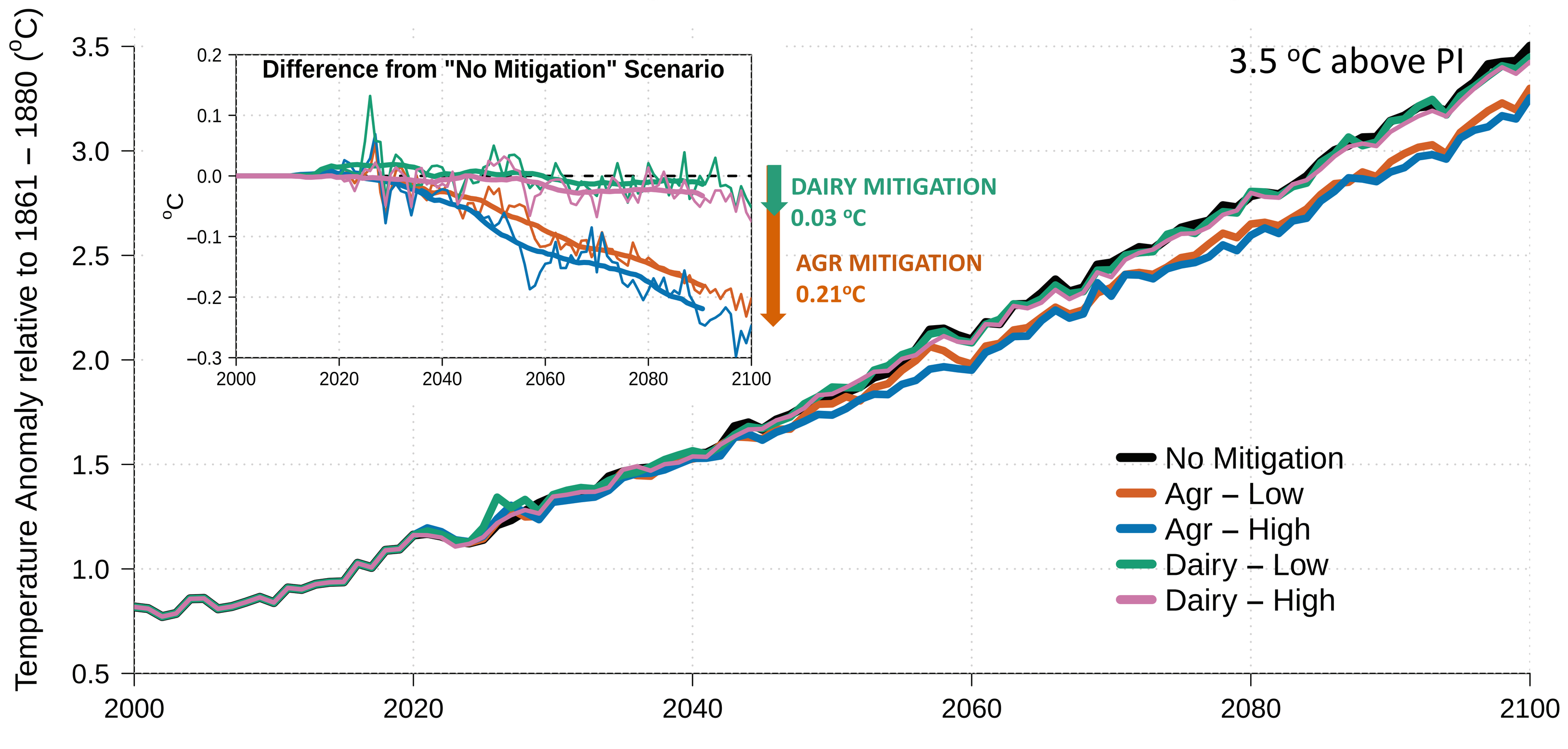


Figure 3: Projected global mean surface temperature anomaly. Inset figure – the effective temperature change as a difference from the no mitigation scenario, with 20 year running means.

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