Holos as a Greenhouse Gas Estimation Tool for Animal Agriculture in Northern Utah

Authors: Kathryn Slebodnik[1], Anthony Whaley[1], Jennifer Reeve[1], Roland Kröbel[2], Karen Beauchemin[2], Jennifer MacAdam[1], Jeanette Norton[1], Juan Villalba[3].

1. Utah State University Department of Plants, Soils and Climate, Logan, UT, United States of America
2. Agriculture and Agri-Food Canada, Lethbridge, AB, Canada
3. Utah State University Department of Wildland Resources, Logan, UT, United States of America

What is Holos?

Holos is a whole-farm software program developed by Agriculture and Agri-Food Canada to help users estimate greenhouse gas emissions from animal agriculture operations. It is designed to model beef, dairy, swine, sheep, poultry systems, and several other types of livestock systems. Greenhouse gases (GHG) are gases that trap heat in the earth's atmosphere. Understanding management options for reducing GHG emissions represents a method for assessing sustainability on your farm. Holos can be used to achieve a wide variety of objectives, including tracking complex systems and activities, assessing economic and environmental outcomes, optimizing resource use, comparing effects of management strategies, and serving as a platform to test experimental findings. Emission predications in Holos are driven by algorithms based on extensive farm research conducted by Agriculture and Agri-Food Canada, IPCC methodology, and peer reviewed literature (Agriculture and Agri-Food Canada, 2020; Intergovernmental Panel on Climate Change, 2020).

Holos is unique because it can be customized based on the amount of information available to the user. Holos is suitable for modeling both confined and pasture-based livestock operations, encompassing a wide variety of annual, perennial, and grassland cropping systems. Within each operation, users can customize farm inputs such as diet and feed quality. This versatility makes it a suitable tool for both producers and researchers by offering a streamlined "standard" interface and fully customizable "research" interface in version 3. Both interfaces allow the user to create farm scenarios and change management choices to understand how each decision affects net GHG emissions from the entire operation and choose best management practices. However, all models come with inherent degrees of uncertainty, so Holos is best used for exploring potential management strategies rather than strictly as a GHG accounting tool (Agriculture and Agri-Food Canada, 2020).

The whole-systems approach

Unlike other software tools, Holos estimates GHGs based on activities of the entire operation by using a "whole-systems" approach. A whole-systems perspective sees components as not only individual parts, but as part of a complex, integrated system with

emergent qualities (Hammond, 2005). When management of one part is changed, it cascades throughout the system, affecting several others, and changes the net emissions of the entire operation. Holos not only accounts for emissions from animals, but also emissions from feed production (fertilizer application, tillage, pesticides, etc.) and manure management. Holos also accounts for practices that could sequester carbon such as planting trees to create shelterbelts, or transitioning from annual to perennial crops.

As management recommendations are made to reduce the emission of one particular GHG at the expense of increasing emissions of another GHG (Janzen et al., 2006), Holos can be used to test these recommendations and determine the effect on the net emissions of the operation. To model your whole-farm system and understand the net emissions over the life cycle of the animal, you will need to create several scenarios as one Holos scenario can only model 12 months at a time.

An example of whole-systems thinking can be illustrated with the example of a beef producer who switches from planting an annual grass forage to a perennial legume forage. Although this appears to be a simple change, its effects cascade throughout the entire operation. As a result, the producer has decreased their net emissions in several ways:

- They have reduced their need for nitrogen fertilizer as legumes are nitrogen-fixing crops, eliminating energy that goes into fertilizer production (and a large quantity of CO_2 emissions from its production) and decreased nitrogen losses to the environment in air and water sources (Soussana & Lemaire, 2014).
- They have reduced the need for fuel and machine usage, as perennials do not require yearly re-seeding, or other implement use.
- Legumes can have a higher nutritional quality than grasses, which increases the herd's average daily gains. This decreases the time cattle need to spend grazing to reach their finishing weight, so they will produce less GHG from enteric methane and manure (Phelan et al., 2015).
- Bioactive compounds like tannins found in certain legume forages can provide additional benefits such as decreased volatile N losses through cattle urine and decreased enteric methane production (Waghorn, 2008).
- Transitioning annual crops to perennial forages incorporates carbon into soil (Smith, 2004).

To assess this management change in Holos, users would first design an annual grass-based system as their starting point. Then, they could create their legume-based system and note the difference in net emissions between the annual and perennial systems.

What can Holos do for me?

Through its whole systems approach and large degree of customization, Holos can be a useful tool for exploring the effect of management changes on a livestock operation's

environmental and economic outcomes for both producers and researchers. Scenario results are reported as net emissions of carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4), as well as normalized carbon dioxide equivalents (CO_2-eq). Carbon dioxide equivalents measure the collective impact of all GHGs based on their global warming potential relative to CO_2 (Hausfather, 2009). For example, the global warming potential of CH_4 is 25. This means that its ability to store heat in the atmosphere is 25 times larger than the ability of CO_2. Nitrous oxide has an even higher global warming potential of 265 (Intergovernmental Panel on Climate Change, 2014). In addition to providing results in tables, Holos helps users visualize results in charts and graphs (Figure 1).

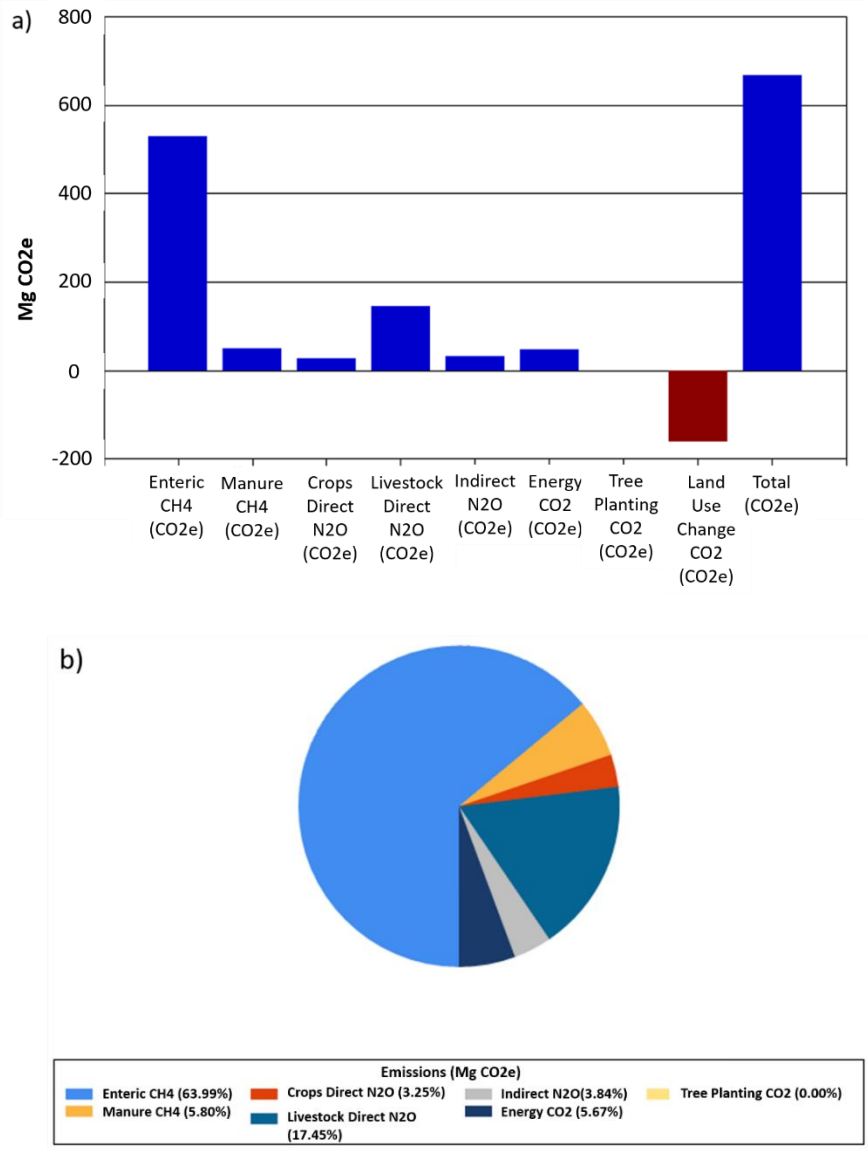

Figure 1: Example output of net emissions as a bar chart (panel a) and a pie chart (panel b) from an example beef production system in Saskatchewan, Canada modeled in Holos.

Holos is highly adaptable to a variety of locations, climates, livestock types, and management systems and sizes. While Holos was designed for use in Canada, it can be applied to regions with similar climates in the United States such as northern Utah by manually overriding soil and climatic parameters when used with a proper understanding of its design and limitations. Local soil and climate data can be found through the Utah Climate Center (https://climate.usu.edu/) and the USDA Web Soil Survey (https://websoilsurvey.sc.egov.usda.gov/). Using Holos may be beneficial for both farmers and researchers by documenting the potential environmental benefits of a particular management change when applying for or managing grants.

Application at Utah State University

At Utah State University, researchers are using Holos to help assess the effects of different pasture-based finishing systems for beef production in northern Utah to minimize nitrogen losses through ground and surface waters as well as GHG emissions. Researchers are designing scenarios in Holos based on data collected from field experiments at the Utah Agricultural Experiment Station in Lewiston, Utah. The scenarios include traditional grass- and feedlot-finished beef as well as alternative scenarios using legume forages. Legume-based systems, particularly tannin-containing legumes such as birdsfoot trefoil and sainfoin, can decrease the environmental impact of pasture-finished beef through a combination of the following:

- Complexation of tannins with organic soil nitrogen (Waghorn, 2008) or microbial inhibition by tannins that reduce nitrogen losses to the environment.
- Increased use of perennial rather than annual crops.
- Reduced nitrogen fertilization requirements due to legume nitrogen fixation
- Higher nutritional quality than traditional grass forages (Phelan et al., 2015).
- Reductions in nitrogen and carbon lost from urine and enteric methane (Soussana & Lemaire, 2014).

More information

You can download Holos for free and view supporting documentation at www.agr.gc.ca/holos-ghg. Note that Holos version 3 is currently compatible with Windows-PC operating systems only. You can find Holos training documents here.

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