

# Updates to Version 4 of the Biogenic Emissions Landuse Database (BELD4) for Canada and Impacts on Biogenic VOC Emissions

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# Overview

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- Terrestrial vegetation accounts for 80-90% of global VOC emissions
- The Biogenic Emissions Landuse Database, Version 3 (BELD3) was compiled for most of North America based on early 1990's satellite imagery (Pierce et al., 2000). **Issues were noticed for Canada.**
- In 2013 the U.S. EPA updated BELD from V3 to V4 with **286** landuse categories for the contiguous United States, but only **17** broad landuse types based on MODIS satellite retrievals for Canada and Mexico
- In 2018 a U.S.-equivalent BELD4 database was extended to Canada to address the issues found in BELD3; **this database has now been updated based on a newer forest inventory**
- **Impacts on biogenic emissions using the BELD4 database**
- **Issue with discontinuity of isoprene emissions at the international border between Canada and the U.S.**



# Extension of Version 4 of the Biogenic Emissions Landuse Database (BELD4) to Canada

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## INTRODUCTION AND MOTIVATION

- Terrestrial vegetation is an important source of VOC emissions to the atmosphere, accounting for 80-90% of total global VOC emissions.
- Landuse data with detailed vegetation types at relatively high resolution are needed to accurately estimate biogenic VOC emissions.
- The Biogenic Emissions Landuse Database, Version 3 (BELD3), which contains 230 vegetation classes at 1-km resolution, was compiled for most of North America based on early 1990's satellite imagery (Pierce et al., 2000) and has been used widely for estimating biogenic emissions.
- Issues with BELD3 have been identified for Canada, such as less detailed crop species, large region of unknown tree species with zero emissions in eastern Canada, and discontinuities at the international and provincial borders for some species (Fig. 1).
- The U.S. EPA recently updated BELD from V3 to V4 with 286 landuse categories for the contiguous United States (<https://www.epa.gov/air-emissions-modeling/biogenic-emission-sources>). However, this new database only contains 17 broad landuse types based on MODIS satellite retrievals for Canada and Mexico (Fig. 2).
- A U.S.-equivalent of the BELD4 dataset has now been extended to Canada.

## Limitations of EPA BELD4 for Canada and Mexico: Examples

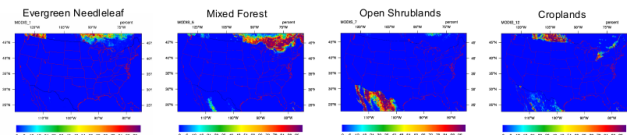


Figure 2. Examples of non-specific vegetation classes in the current EPA BELD4 database over the CMAQ CONUS 12km domain. Broad MODIS-based tree and crop classes are used for Canada and Mexico, which will result in incorrect biogenic emissions for Canadian and Mexican parts of the domain.

## INPUT DATA SETS

### > Canadian Annual Crop Inventory (ACI)

- Compiled by Agriculture and Agri-Food Canada (AAFC) (<http://www.aqr.gc.ca/atlas/ac/>); includes 71 codes/species, of which 66 are for crops
- Annual data available from 2013 to present for all provinces of Canada at 30m resolution; uses dominant species, does not cover entire country

### > Canadian National Forest Inventory (NFI)

- Compiled collaboratively by federal, provincial and territorial government agencies (<https://nfi.nfis.org/en>)
- Canada-wide inventory was created using Nearest Neighbour (KNN) mapping method based on 2001 MODIS imagery at a resolution of 250m x 250m (Beaudoin et al., 2014); considers multiple species per grid cell, does not consider non-treed areas

## METHODOLOGY AND RESULTS

- Original ACI data at 30m resolution were aggregated to 990m resolution and then resampled to 1km resolution to be consistent with the EPA BELD4 resolution
- Original NFI data at 250m resolution were aggregated to 1km resolution
- Sums of processed 1km resolution ACI and NFI data are larger than unity for some grid cells due to "double counting" of ACI and NFI databases (Fig. 3)
- Merged ACI and NFI data were finalized by renormalizing the grid cells with total fractional coverage larger than unity of summed ACI and NFI species (Fig. 4)
- Example plots of individual species fields are shown in Fig. 5

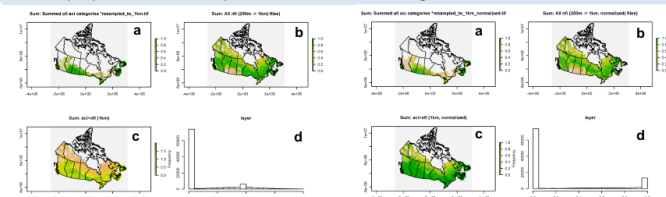


Figure 3. Sum of initial 1-km (a) ACI species, (b) NFI species, (c) total ACI and NFI species, and (d) histogram of the sum of ACI and NFI species.

Figure 4. The same as Fig. 3, but after normalization for grid cells with total fractional coverage of ACI+NFI species larger than unity.

## REFERENCES

- Pierce et al., 2000, Development of a 1-km vegetation database for modeling biogenic fluxes of hydrocarbons and nitric oxide. *Sixth International Conference on Air Surface Exchange of Gases and Particles*, July 3-7, Edinburgh, [https://www.epa.gov/sites/production/files/2015-08/beld3\\_web.pptx](https://www.epa.gov/sites/production/files/2015-08/beld3_web.pptx)
- Beaudoin, A., et al., 2014, Mapping attributes of Canada's forests at moderate resolution through KNN and MODIS imagery, *Can. J. For. Res.*, **44**, 521-532, dx.doi.org/10.1139/cjfr-2013-0401

## New Canadian + EPA BELD4: Examples

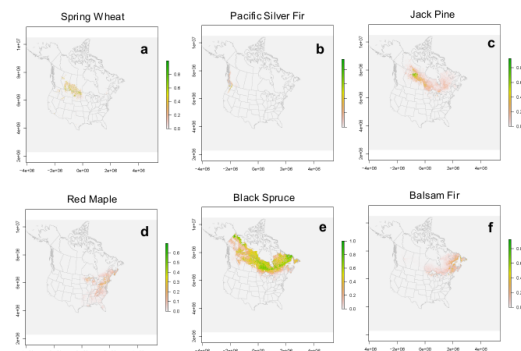


Figure 5. Examples of individual crop and tree species in the newly compiled BELD4 database with updated and improved Canadian landuse data: (i) detailed crop types match well with the EPA BELD4 data (Fig. 5a); (ii) discontinuities at international and provincial borders have largely disappeared and discontinuities within provinces are almost all entirely resolved (Figs. 5b, 5c, 5d, and 5e); (iii) significant improvement for spatial extent of Balsam Fir and Black Spruce, particularly for the province of British Columbia (Figs. 5e and 5f).

## SUMMARY

- U.S.-equivalent Canadian BELD4 database has been compiled based on the most recent Canadian crop and forest inventories
- Many existing issues with the BELD3 data for Canada were solved (Fig. 1 vs. Fig. 5)
- There are still areas for further improvement. For example, the 2001-MODIS-imagery-based Canadian national forest inventory is outdated for areas undergoing rapid development, such as the Canadian Athabasca Oil Sands area (Fig. 6)

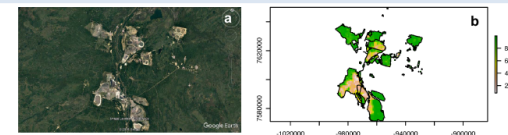


Figure 6. (a) Recent Google Earth image of the seven Athabasca Oil Sands mining facilities (light colored areas) and (b) total vegetation coverage over the same mining facilities based on the new Canadian BELD4 database which does not account for the mines opened after 2001, although it is better than BELD3 (cf. Fig. 1).

## Issues with BELD3 for Canada: Examples

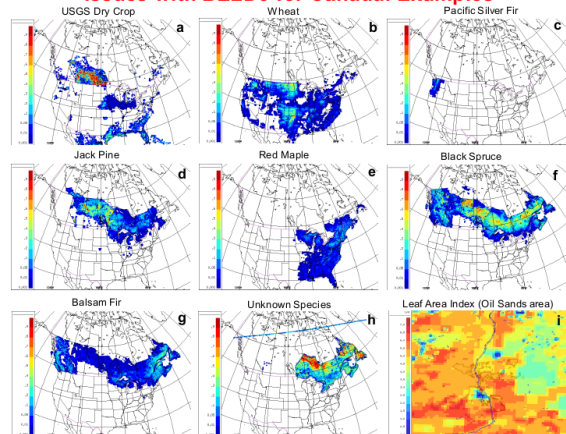


Figure 1. Examples of issues with the BELD3 data for Canada: (i) detailed crop types not available for some Canadian provinces (Panels 1a and 1b); (ii) discontinuities at international and provincial borders (Panels 1c, 1d, 1e, and 1f) and discontinuities within provinces (Panel 1f); (iii) unrealistic coverage of some tree species for some areas, such as Balsam Fir and Black Spruce for the province of British Columbia (Panels 1f and 1g); (iv) large fraction of unknown species in eastern Canada with zero emissions (Panel 1h); and (v) vegetation outdated for the Cc

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# U.S.-EPA-BELD4-Equivalent Landuse Database for Canada

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Volatile organic compounds (VOCs) released from terrestrial vegetation are an important source of VOC emissions to the atmosphere. Globally, natural sources of VOC emissions have been estimated to be much larger than anthropogenic sources and to account for 80-90% of total global VOC emissions. The accurate estimation of biogenic VOC emissions requires input of landuse data with a detailed description of vegetation types at high resolution. The Biogenic Emissions Landuse Database, Version 3 (BELD3), which contains 230 vegetation classes at 1-km resolution, was compiled by the U.S. Environmental Protection Agency (EPA) for most of North America (Pierce et al., 2000) and has been widely used by many regional air quality models for the last two decades to estimate biogenic emissions. However, some of the BELD3 vegetation fields were based on satellite imagery from the early 1990s and are now outdated for many parts of North America, particularly for areas undergoing rapid, large-scale development. In addition, since the release of the BELD3 database a few issues have been identified for the Canadian part of the BELD3 database, such as (1) detailed crop types not being available for some Canadian provinces, (2) discontinuities at international and provincial borders and discontinuities within Canadian provinces, (3) unrealistically large coverage of some tree species for some areas, such as balsam fir and black spruce for the province of British Columbia, and (4) a large and questionable fraction of unknown tree species in eastern Canada that will have zero emissions.

Recently, the U.S. EPA updated BELD from Version 3 to Version 4 (BELD4), with 286 landuse categories at 1-km resolution (see <https://www.epa.gov/air-emissions-modeling/biogenic-emission-sources>). However, these updates were mostly

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December 12, 2018

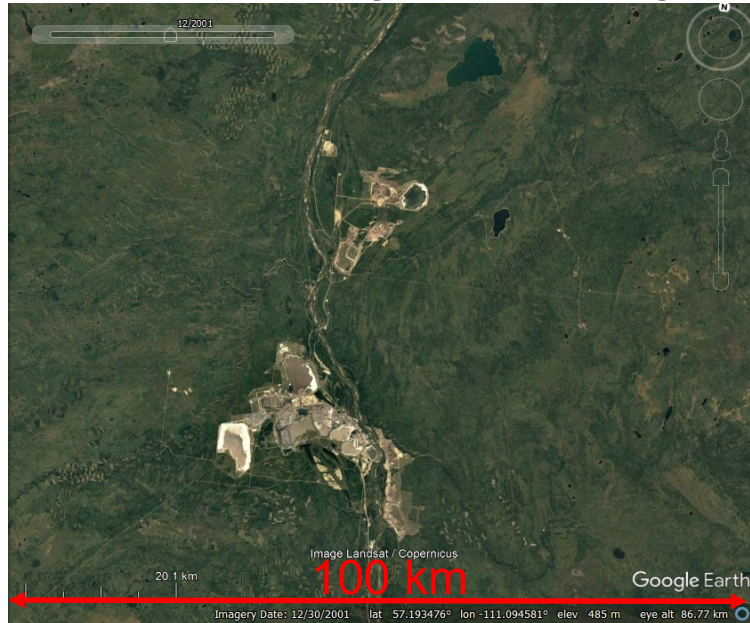
**DOI:**DOI [10.5281/zenodo.2231047](https://doi.org/10.5281/zenodo.2231047)**Keyword(s):**

BELD4 Biogenic Emissions Landuse Canada

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# Changes to the Athabasca Oil Sand Area

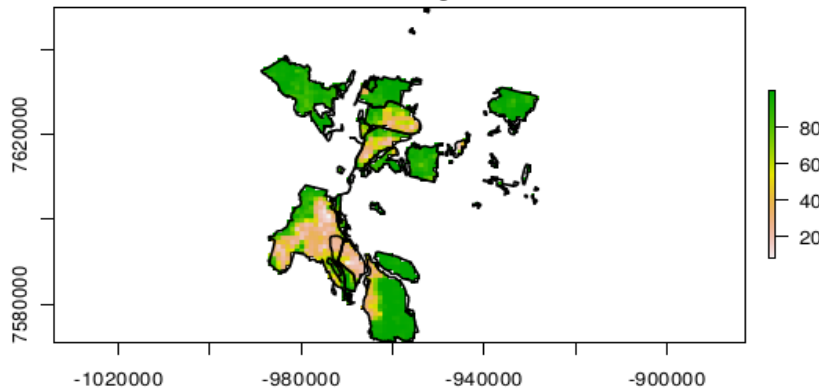
Dec. 2001 Google Earth Image



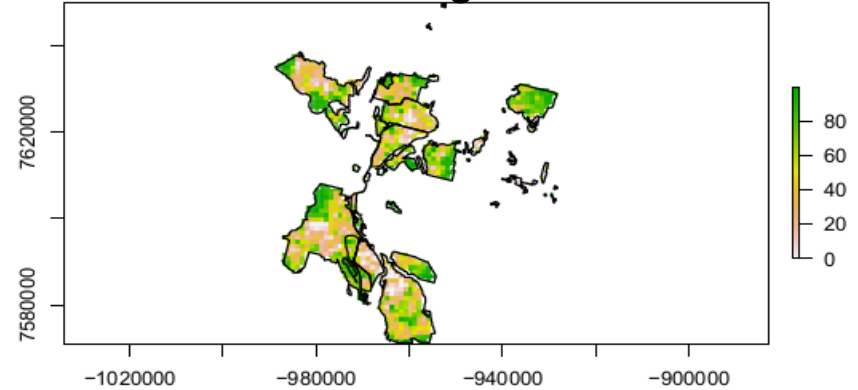
Dec. 2011 Google Earth Image



Total tree coverage: 2001 NFI

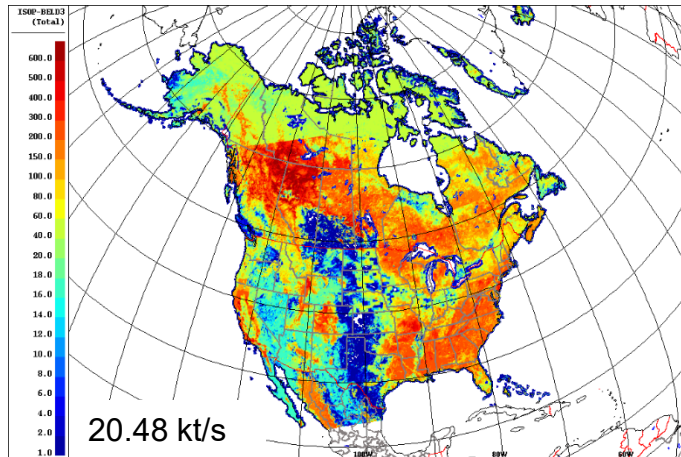


Total tree coverage: 2011 NFI

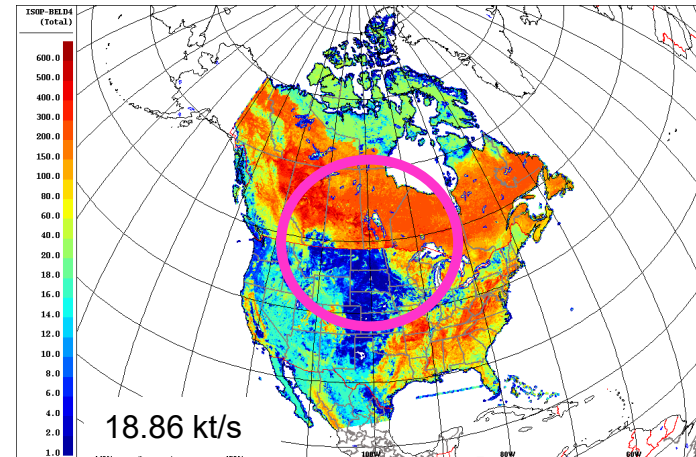


# Impacts on Isoprene Emissions

BELD3 Isoprene

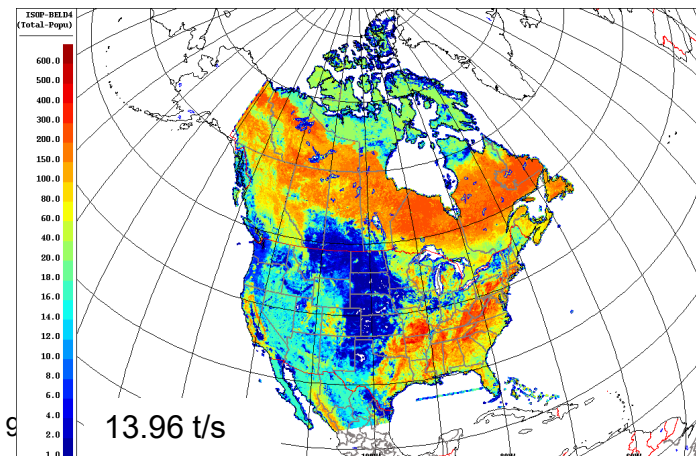


BELD4 Isoprene



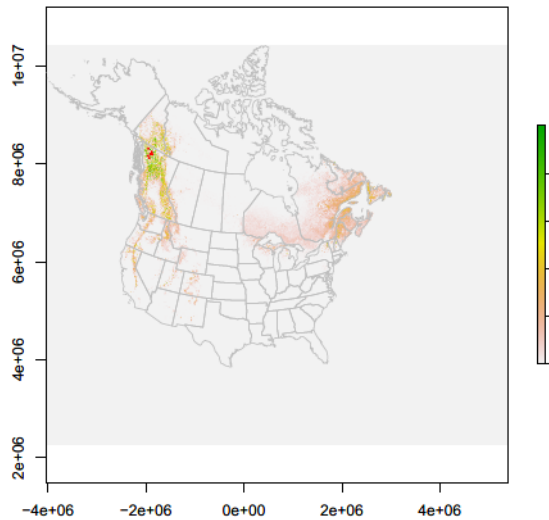
- Isoprene emissions calculated from BELD4 are higher for eastern Canada but lower for the U.S. than those calculated from BELD3
- Discontinuity for BELD4 seen at the international border is mainly due to emissions from Populus

BELD4 Isoprene without Populus

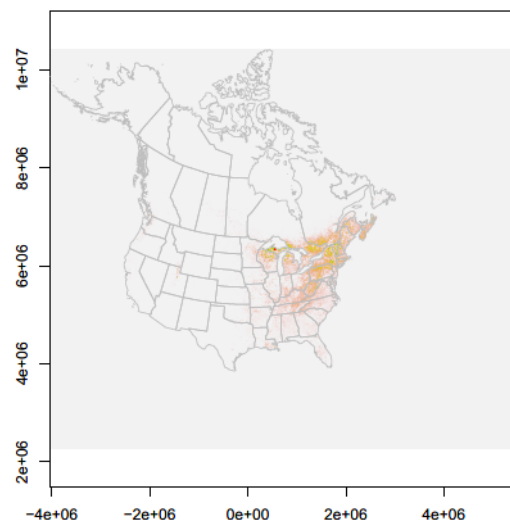


# Spatial Distribution of Tree Species, Examples

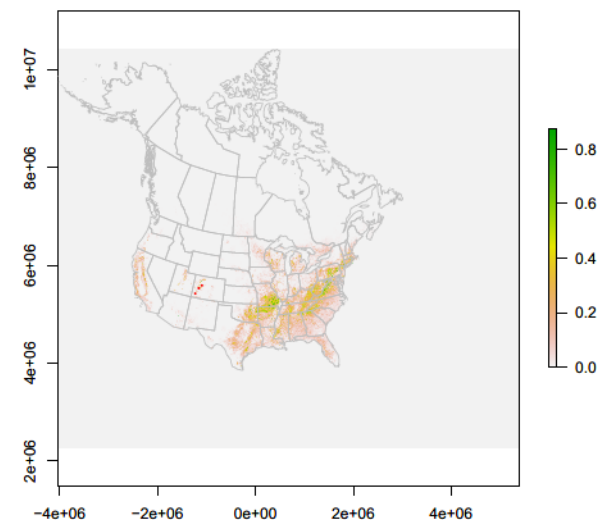
SUM\_Fir\_group\_12\_species



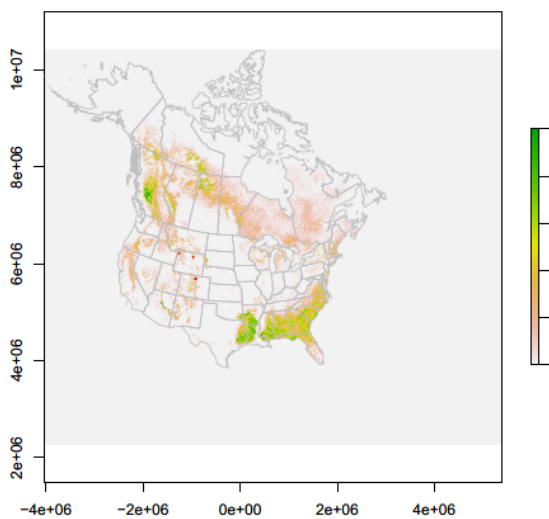
SUM\_Maple\_group\_13\_species



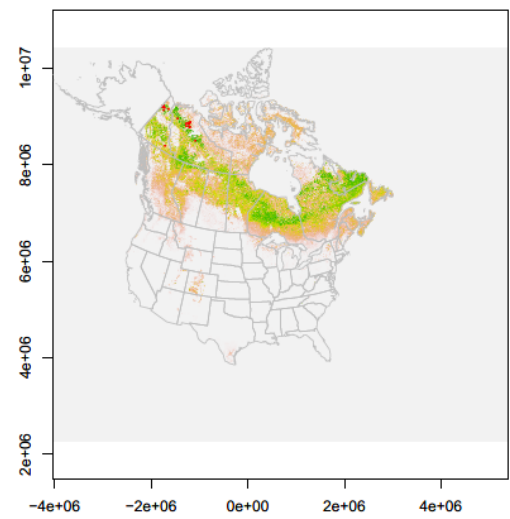
SUM\_Oak\_group\_44\_species



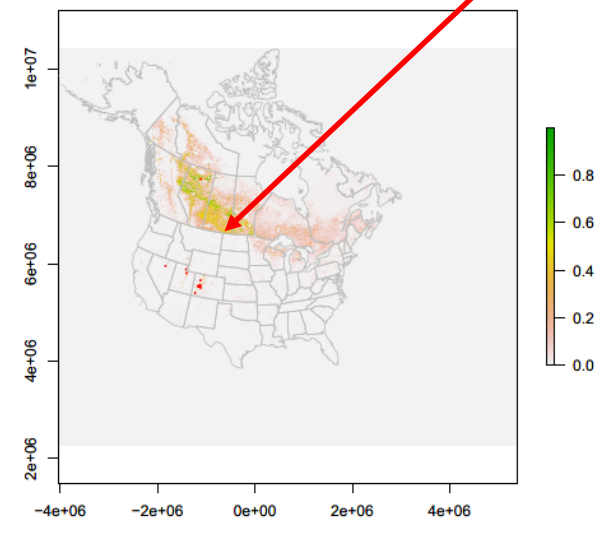
SUM\_Pine\_group\_39\_species



SUM\_Spruce\_group\_9\_species



SUM\_Populus\_group\_1\_species



**For More Details**

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**Session: Tools**

**Thursday, Aug. 01, 8:00am - 8:25am**