

Biogenic Emissions Inventory System (BEIS4) summary

JULY 30, 2025

Outline

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- ▶ Summary
- ▶ Input data
- ▶ Source Category Codes in NEI
- ▶ Future plans

BEIS version 4

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- ▶ BEIS4 creates gridded, hourly, model-species emissions from vegetation and soils. It estimates CO, VOC (most notably isoprene, terpene, and sesquiterpene), and soil NO emissions for the contiguous U.S. and for portions of Mexico and Canada.
- ▶ Part of Sparse Matrix Operator Kernel Emissions (SMOKE) modeling system and Community Multiscale Air Quality (CMAQ) model
- ▶ Used to produce emissions for the 2022 Emissions Modeling Platform and the 2023 National Emissions Inventory (2023NEI)
- ▶ Uses Biogenic Emissions Landuse Database (BELD) version 6
- ▶ Continues to calculate Nitric Oxide from soils (fertilized and non-fertilized)
 - ▶ J.J. Yienger and H. Levy II, Journal of Geophysical Research, vol 100, 11447-11464, 1995
- ▶ Hourly meteorological data from WRF-MCIP

Biogenic Emissions Landcover Database version 6 (BELD6)

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- High resolution tree species and biomass data from Wilson et al. 2013a, and Wilson et al. 2013b for which species names were changed from non-specific common names to scientific names
 - 220 different species at 1km resolution covering most of North America
- Tree species biogenic volatile organic carbon (BVOC) emission factors for tree species were taken from the NCAR Enclosure database (Wiedinmyer, 2001)
 - <https://www.sciencedirect.com/science/article/pii/S1352231001004290>
- Agricultural land use from [US Department of Agriculture \(USDA\) crop data layer](#)
- Global Moderate Resolution Imaging Spectroradiometer (MODIS) 20 category data with enhanced lakes and Fraction of Photosynthetically Active Radiation (FPAR) for vegetation coverage from [National Center for Atmospheric Research \(NCAR\)](#)
- Canadian BELD land use, updates to Version 4 of the Biogenic Emissions Landuse Database (BELD4) for Canada and Impacts on Biogenic VOC Emissions (https://www.epa.gov/sites/default/files/2019-08/documents/800am_zhang_2_0.pdf).

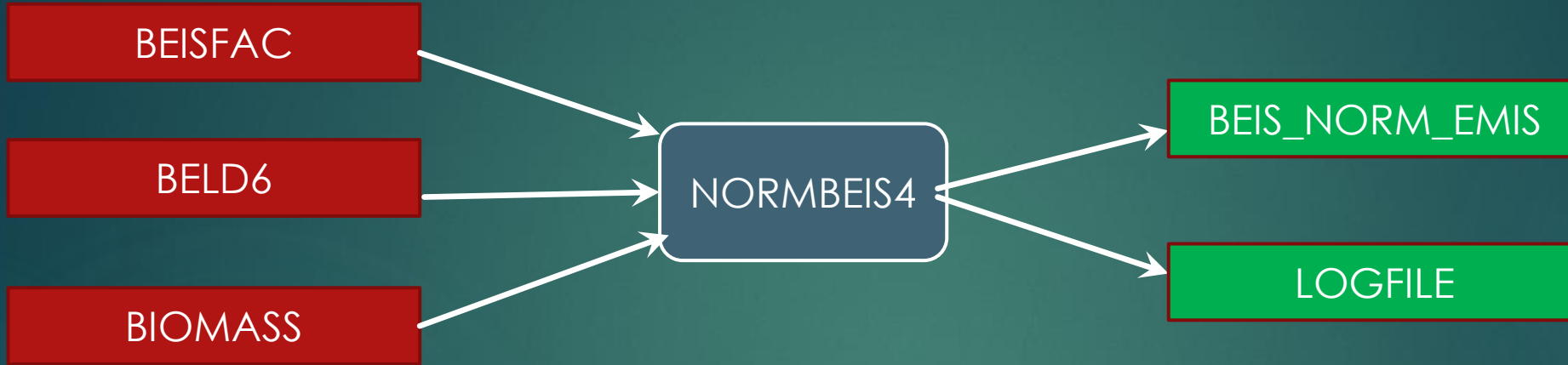
BELD6 Agricultural land types

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- ▶ Specific agricultural land types:
 - ▶ Alfalfa, Barley, Beans, Canola, CornGrain, Cotton, Hay, Oats, Peanuts, Potatoes, Rice, Rye, SorghumGrain, Soybeans, Wheat (Spring and Winter)
- ▶ Non-specific agricultural land types:
 - ▶ MODIS_12: USDA cropland subtracted out
 - ▶ Other_crop: includes berries, tomatoes, lettuce, cucumbers, sugarcane, onions, peppers, etc
 - ▶ Other_grass: USDA; hay, silage, haylage, switchgrass, some grazed/pasture
 - ▶ Some grasses in suburban and urban areas are included

BEIS4 Dataflows: NORMBEIS4

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- BEISFAC = Emissions factors table
- BELD6 = Gridded landuse in percent
- BIOMASS = Gridded biomass in grams/meter**2
- BEIS_NORM_EMIS = Normalized emissions based on temperature=30C and Photosynthetically active radiation (PAR)=1000 $\mu\text{mol}/\text{m}^2\text{s}$

PROGRAM

FILE

Meteorological variables required by BEIS4

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Variable	Description
LAI	leaf-area index
PRSFC	surface pressure
Q2	mixing ratio at 2 m
RC	convective precipitation per met TSTEP
RGRND	solar radiation reaching surface
RN	Non-convective precipitation per met TSTEP
RSTOMI	inverse of bulk stomatal resistance
SLYTP	soil texture type by USDA category
SOIM1	volumetric soil moisture in top cm
SOIT1	soil temperature in top cm
TEMPG	skin temperature at ground
USTAR	cell averaged friction velocity
RADYNI	inverse of aerodynamic resistance
TEMP2	temperature at 2 m
WSAT_PX	soil saturation from (Pleim-Xiu Land Surface Model) PX-LSM

Two-layer canopy model and seasonality

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- In the BEIS4 two-layer canopy model, the layer structure varies with light intensity and solar zenith angle (Pouliot and Bash, 2015).
- Both layers include estimates of sunlit and shaded leaf area based on solar zenith angle and light intensity, direct and diffuse solar radiation, and leaf temperature (Bash et al., 2015).
- BEIS4 computes the seasonality of emissions using the 1-meter soil temperature (SOIT2) instead of the BIOSEASON file, and canopy temperature and radiation environments are now modeled using the driving meteorological model's (WRF) representation of leaf-area index (LAI) rather than the estimated LAI values from BELD data alone.
- See [these CMAQ Release Notes](https://github.com/USEPA/CMAQ/wiki/CMAQ-Release-Notes:-Emissions-Updates:-BEIS-Biogenic-Emissions) for technical information on BEIS4:
<https://github.com/USEPA/CMAQ/wiki/CMAQ-Release-Notes:-Emissions-Updates:-BEIS-Biogenic-Emissions>

BEIS4: Nitric Oxide emissions

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▶ Nitric Oxide Sources in BEIS4

▶ Non-agricultural

- ▶ Dependent on 2m temperature

▶ Agricultural

▶ Growing season

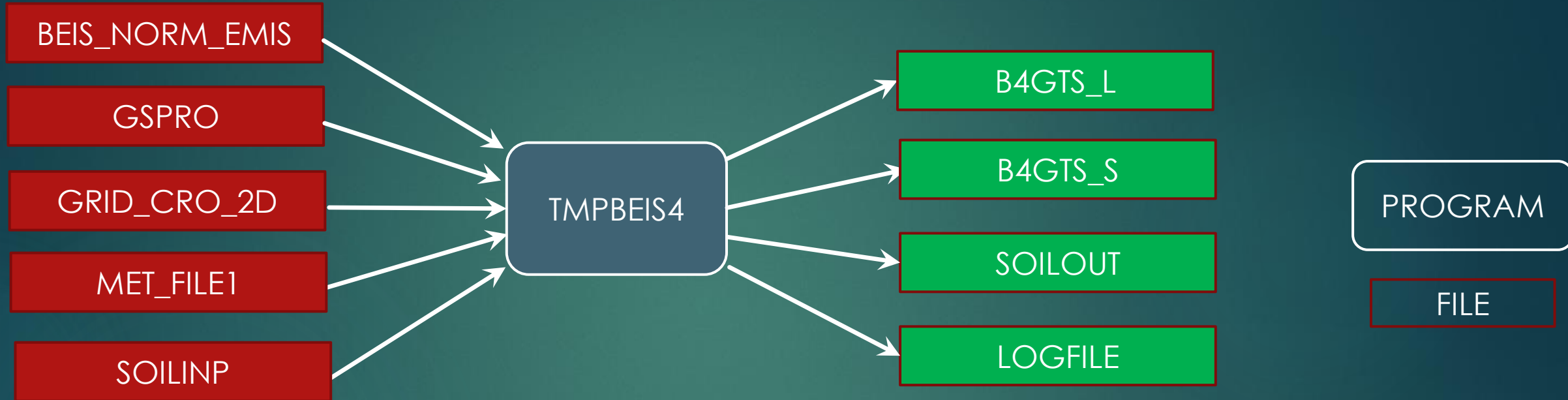
- ▶ Currently defined as Apr-Oct
- ▶ Dependent on 2m temperature, soil temperature and moisture at 1cm, precipitation, soil type
- ▶ Fertilizer adjustment beginning in April

▶ Non-growing season

- ▶ Currently defined as Jan-Mar, Nov and Dec
- ▶ Dependent on 2m temperature

BEIS4 Dataflows: TMPBEIS4

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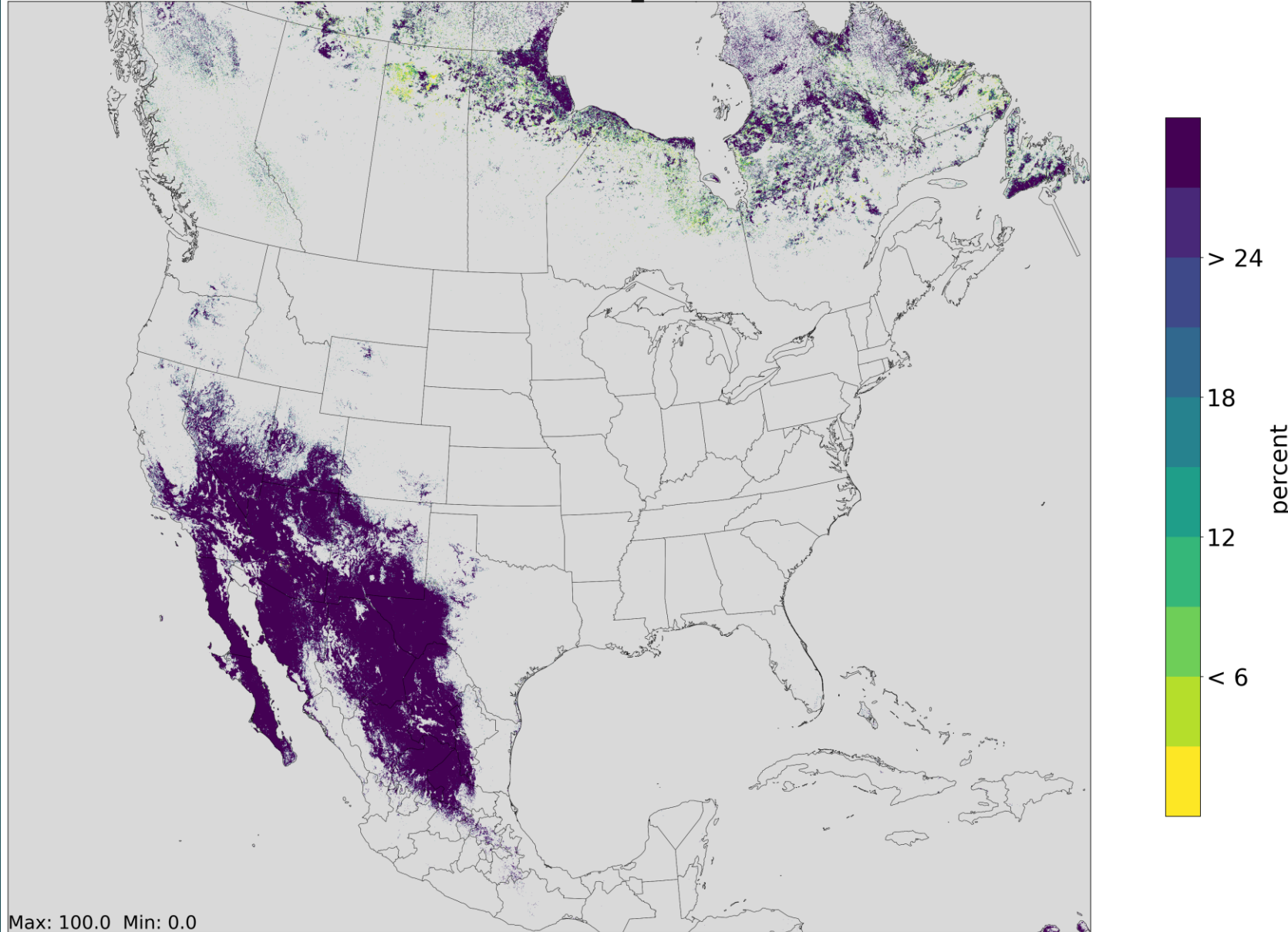


- BEIS_NORM_EMIS = Normalized emissions based on temperature of 30C and PAR 1000 $\mu\text{mol}/\text{m}^2\text{s}$
- GSPRO = Speciation profile for desired chemical mechanism
- GRID_CRO2_2D = latitude and longitude data
- MET_FILE1 = Hourly meteorological information
- SOILINP = Soil moisture accounting input file
- B4GTS_L and B4GTS_S = Hourly, gridded emissions in moles/hr and grams/hr
- SOILOUT = Soil moisture accounting output file

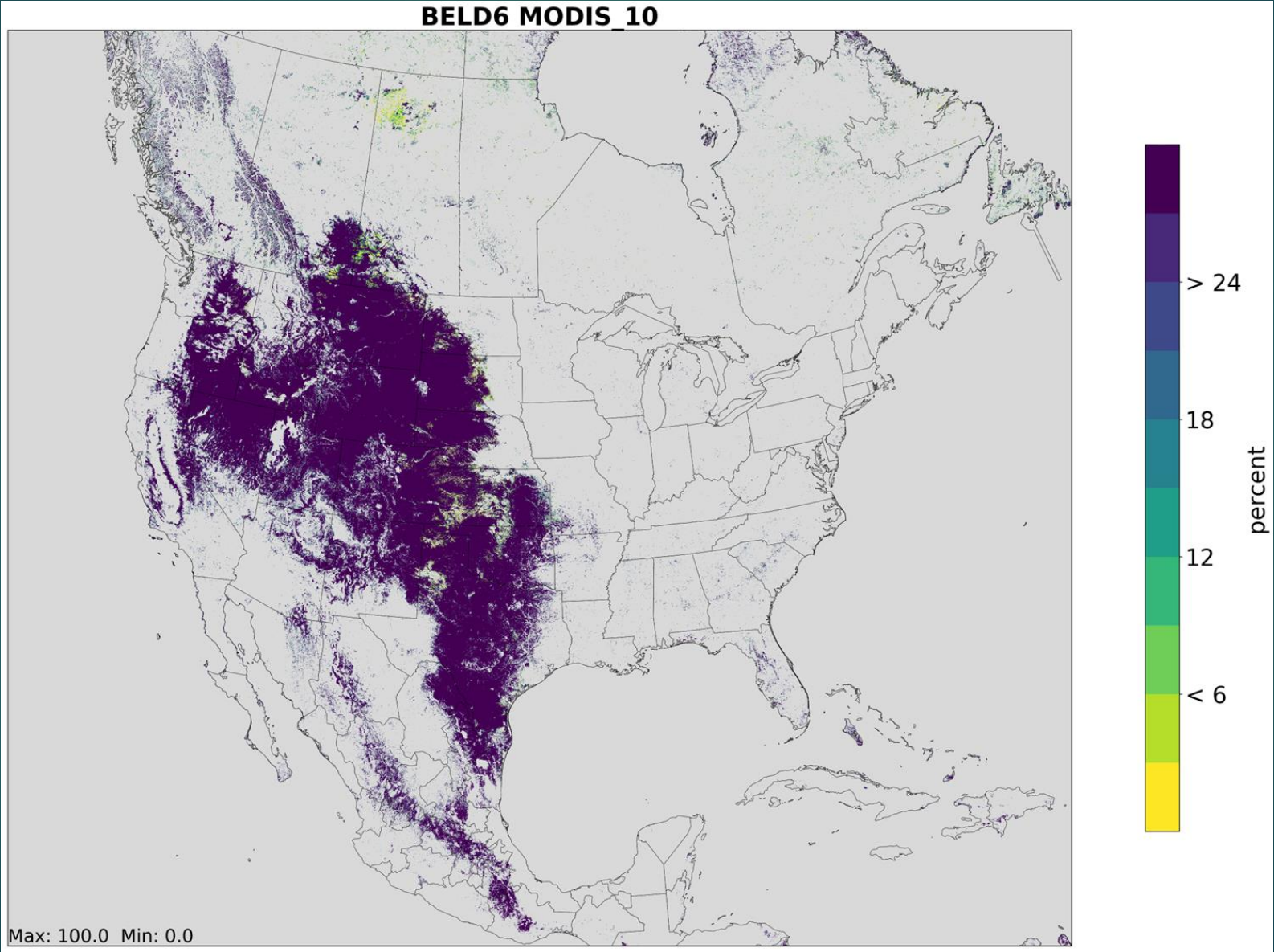
BELD6 landuse maps

MODIS shrubland

BELD6 MODIS_7

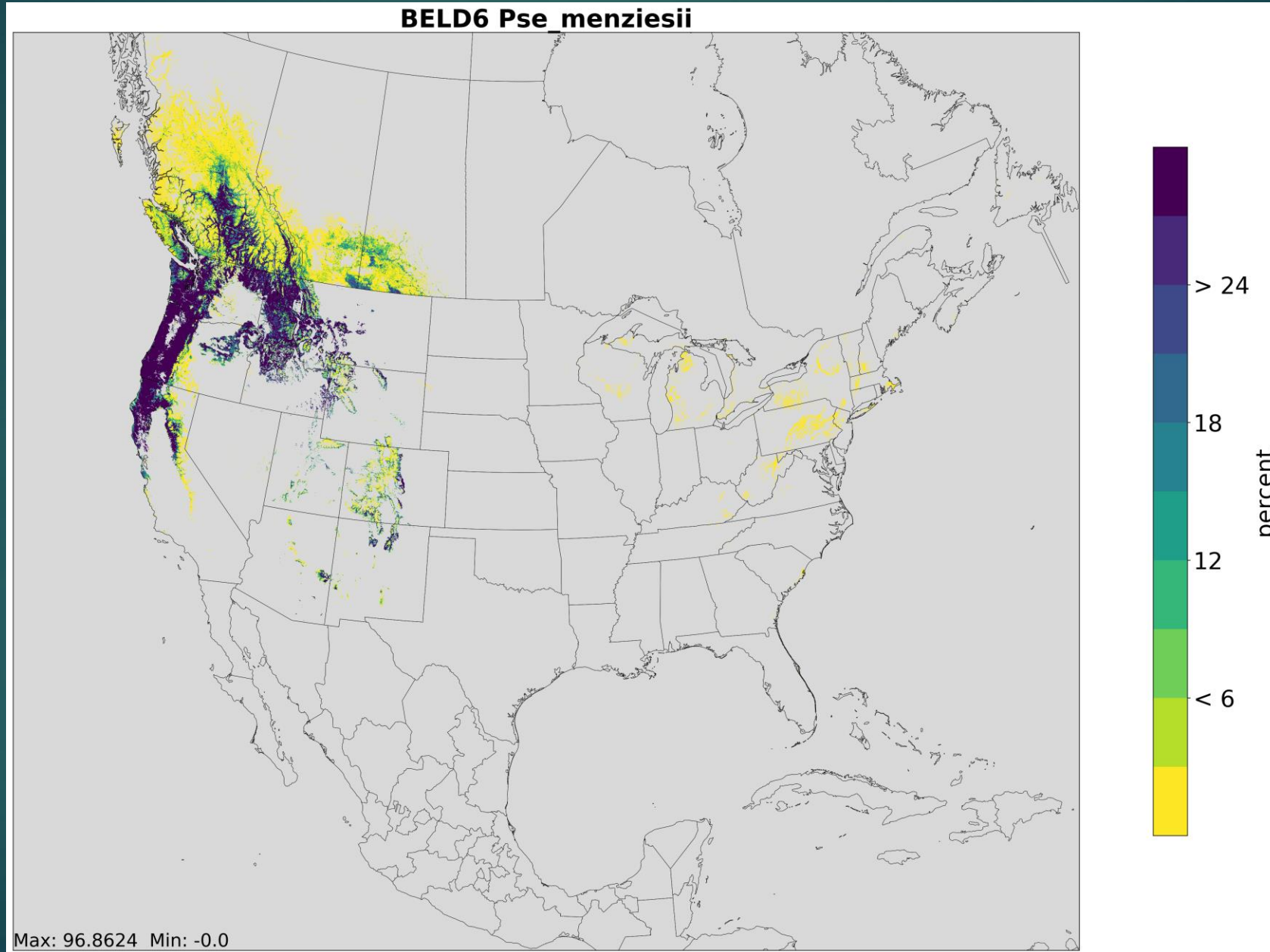


MODIS grassland



Douglas Fir

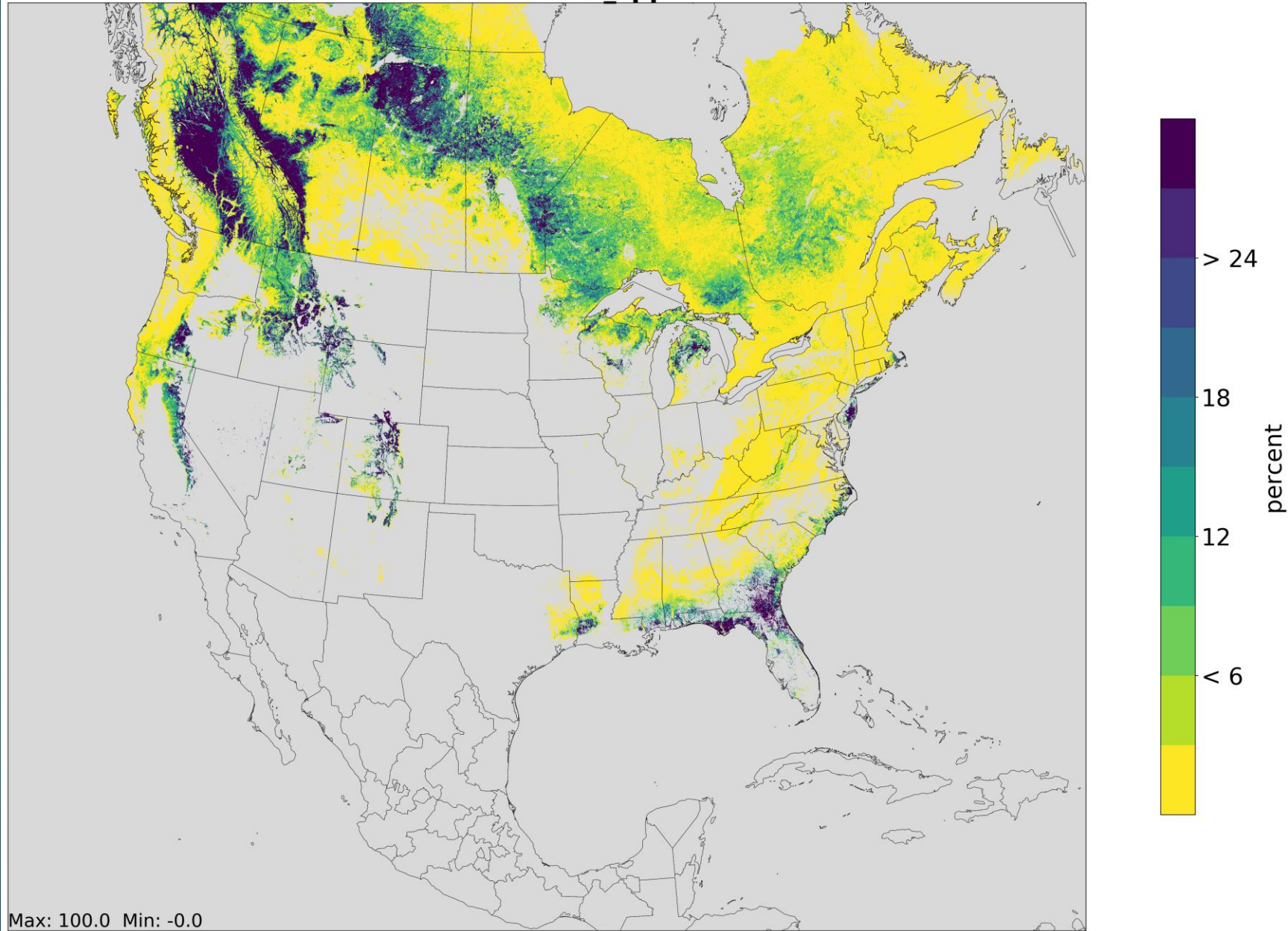
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Pine species

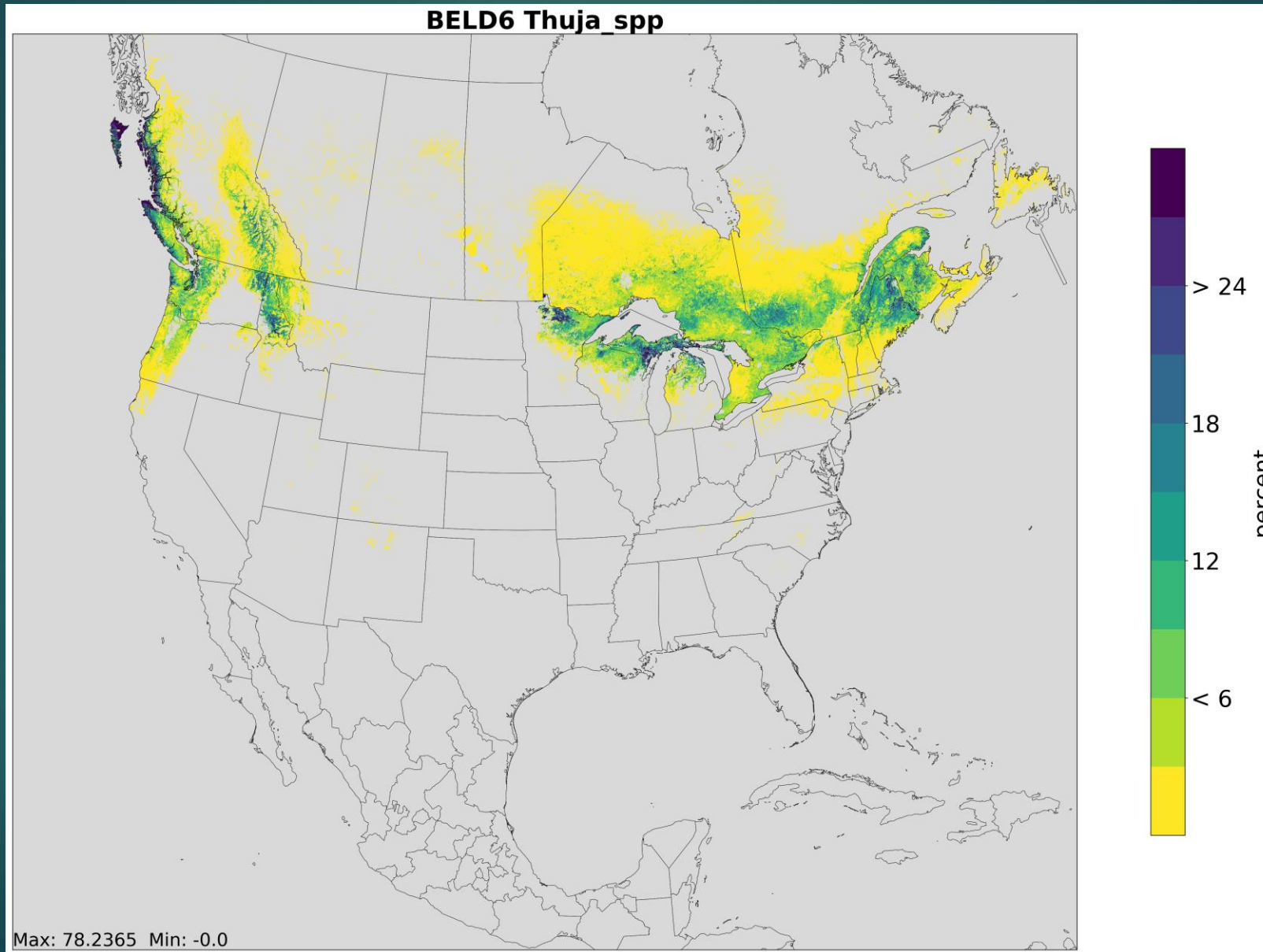
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BELD6 Pinus_spp

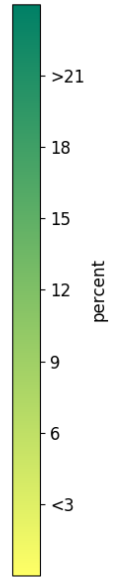
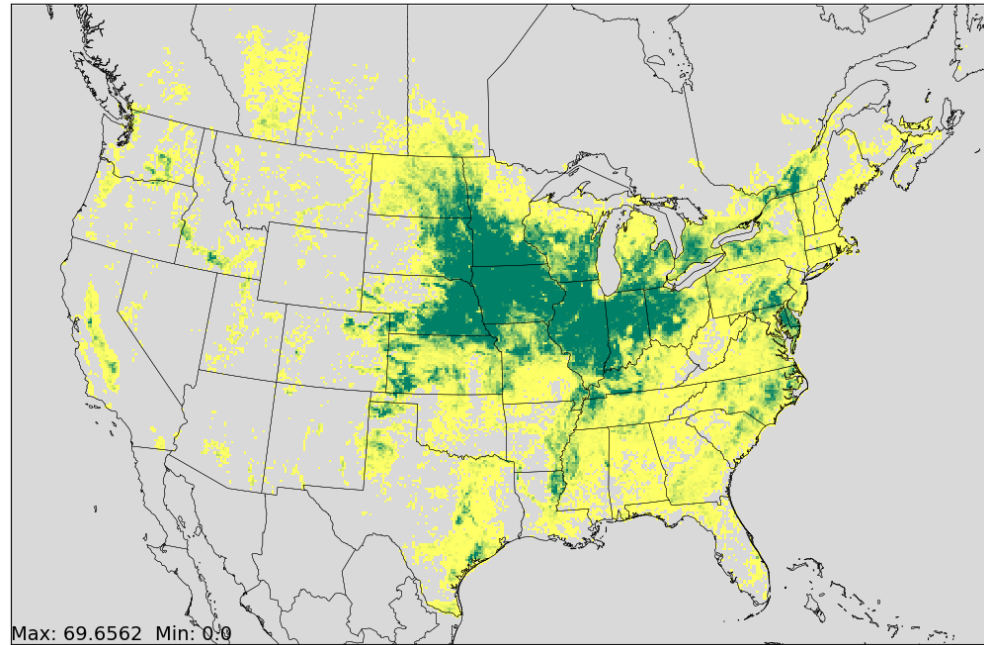


Cypress

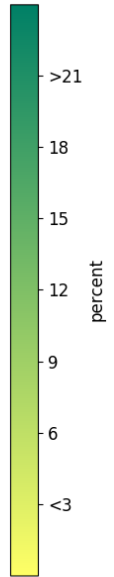
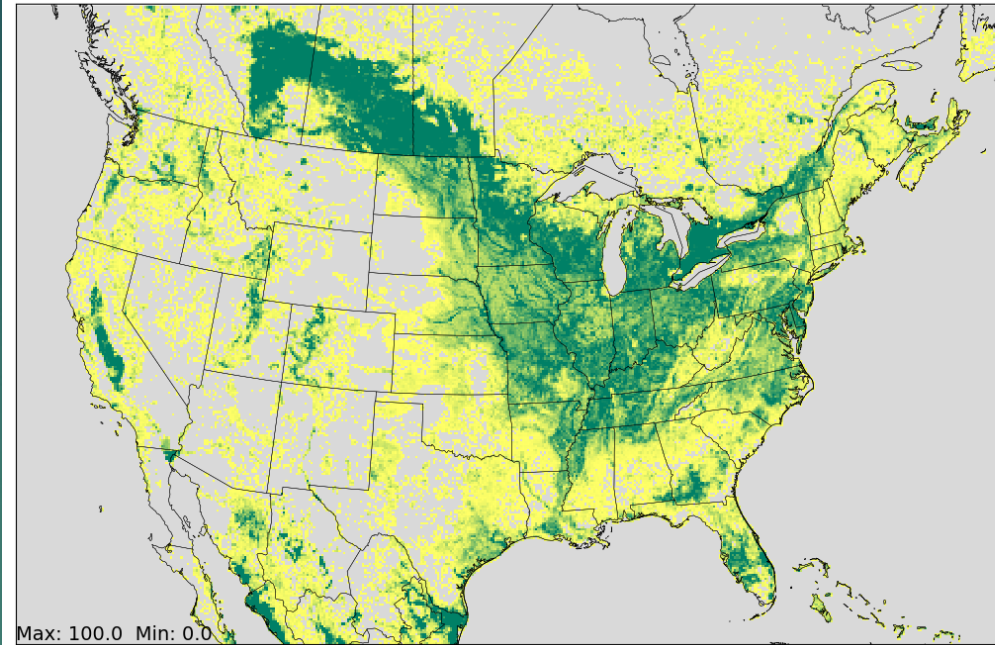
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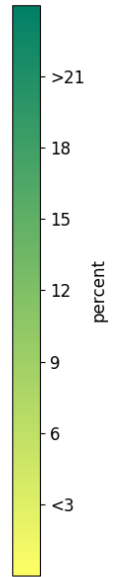
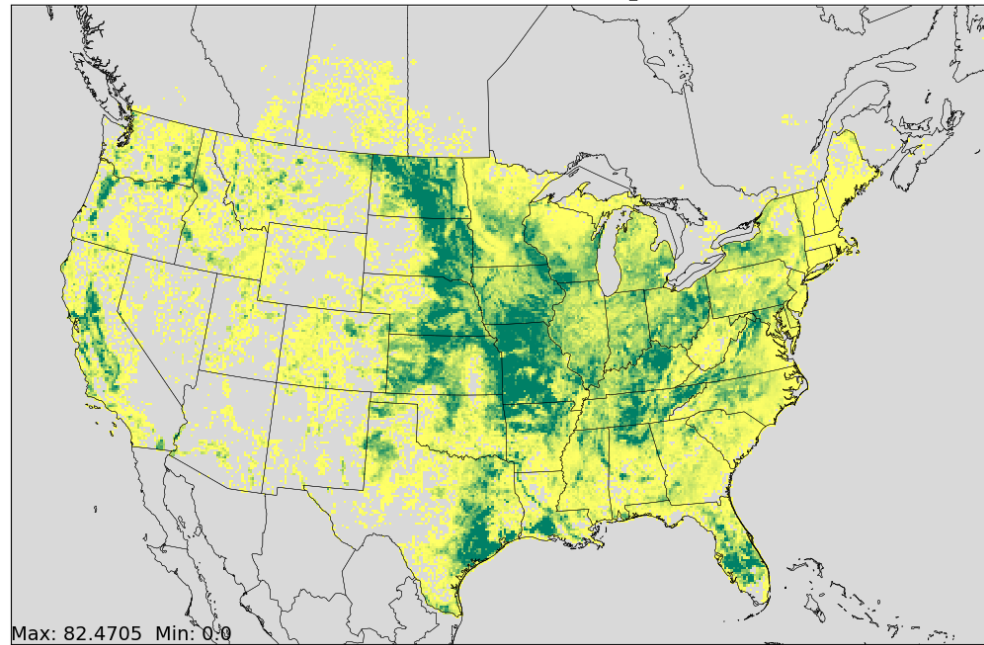
BELD6 2020 12US1 landuse: CornGrain



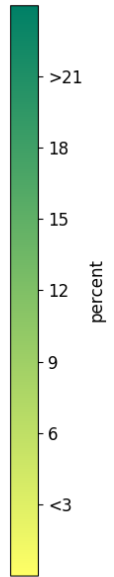
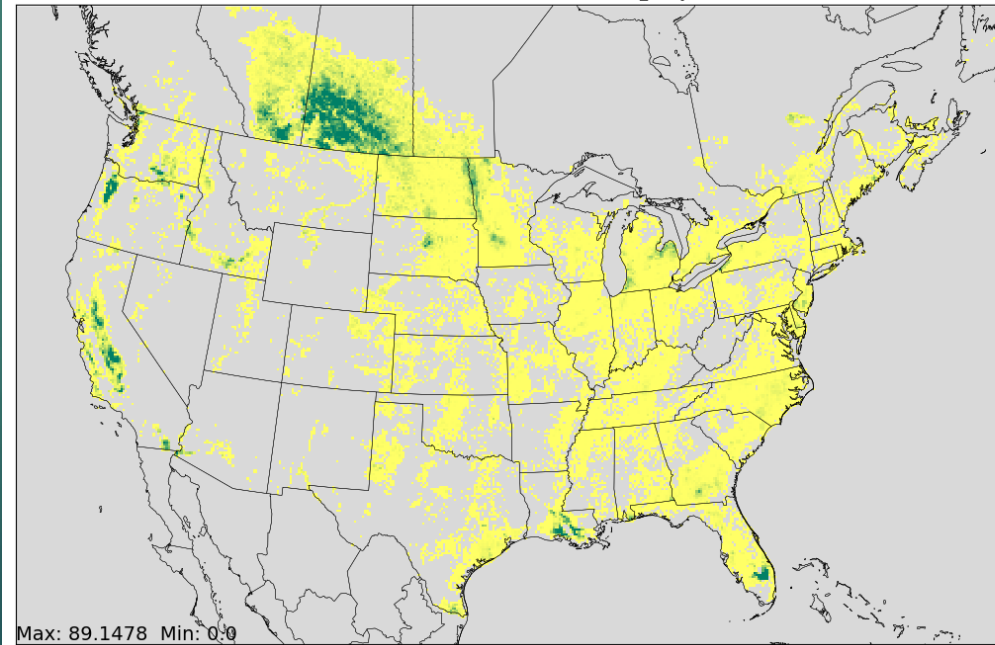
BELD6 2020 12US1 landuse: MODIS_12



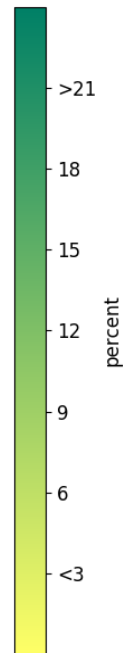
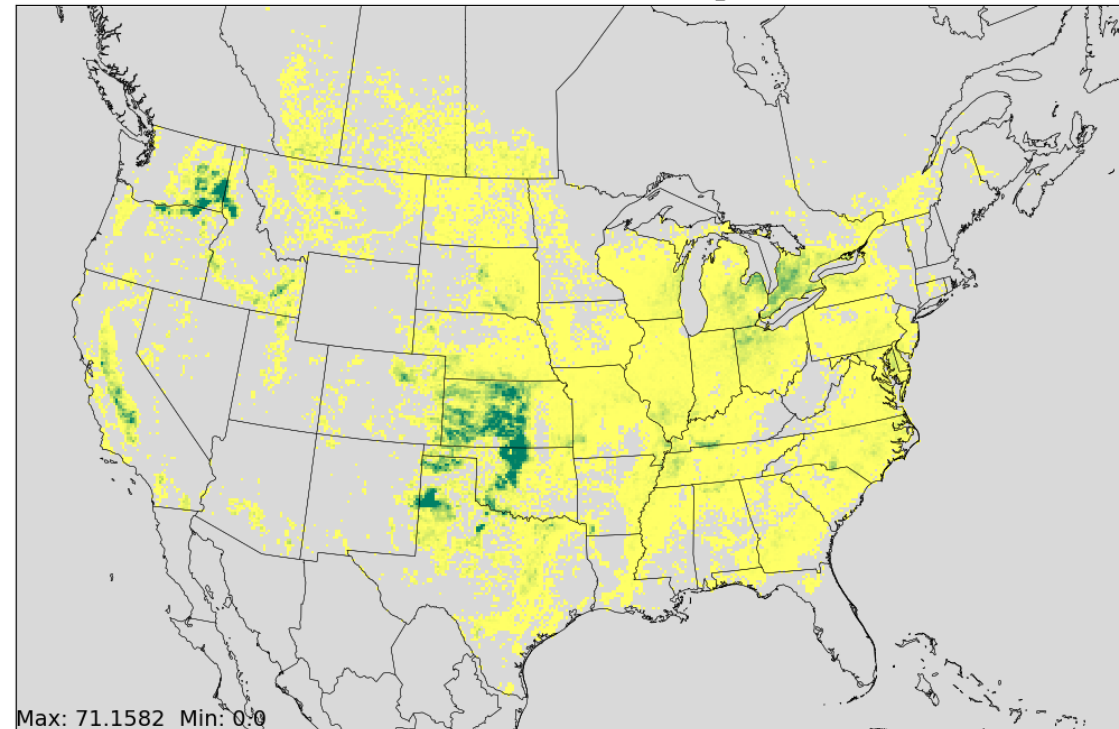
BELD6 2020 12US1 landuse: Other_Grass



BELD6 2020 12US1 landuse: Other_Crop

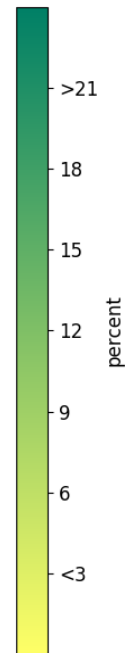
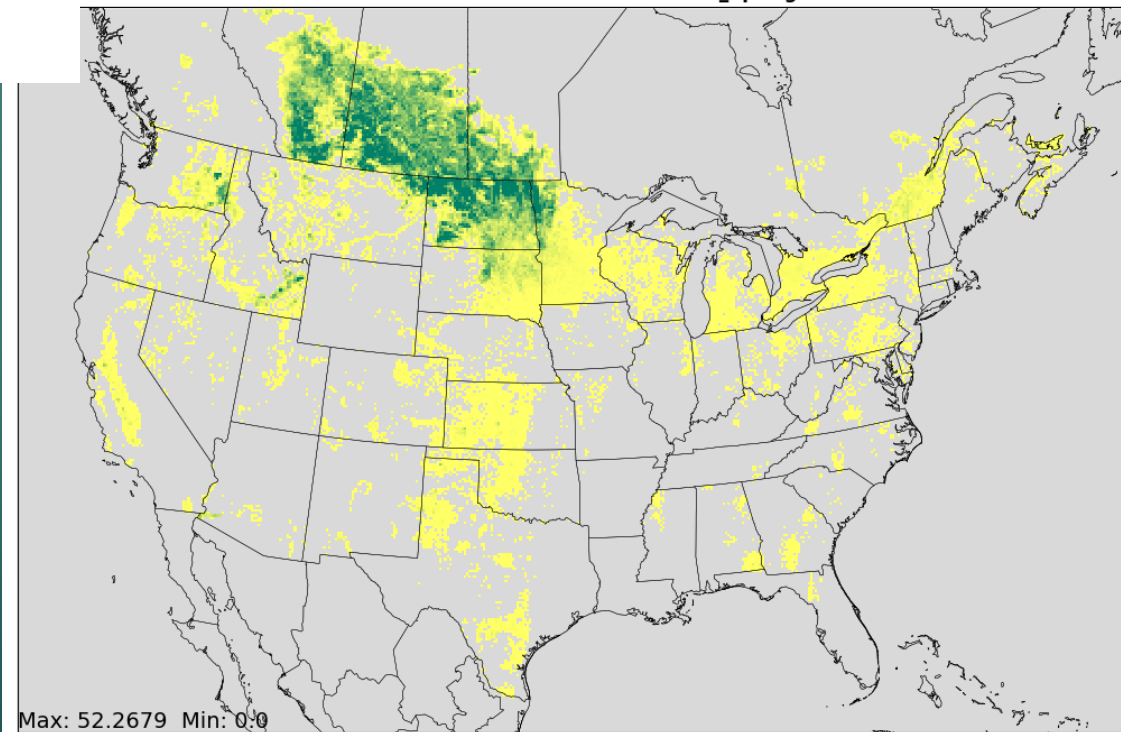


BELD6 2020 12US1 landuse: Wheat_Winter



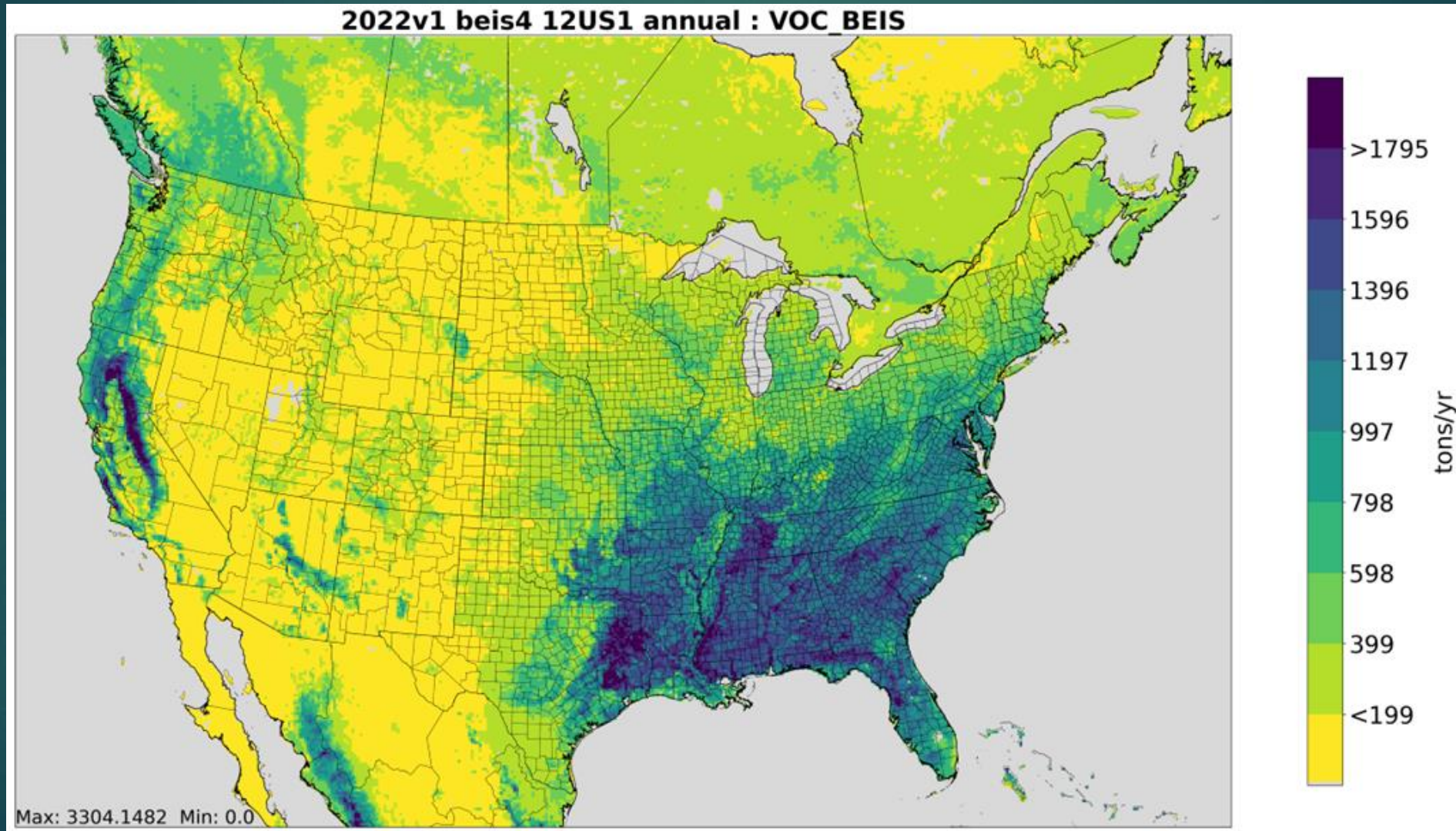
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BELD6 2020 12US1 landuse: Wheat_Spring



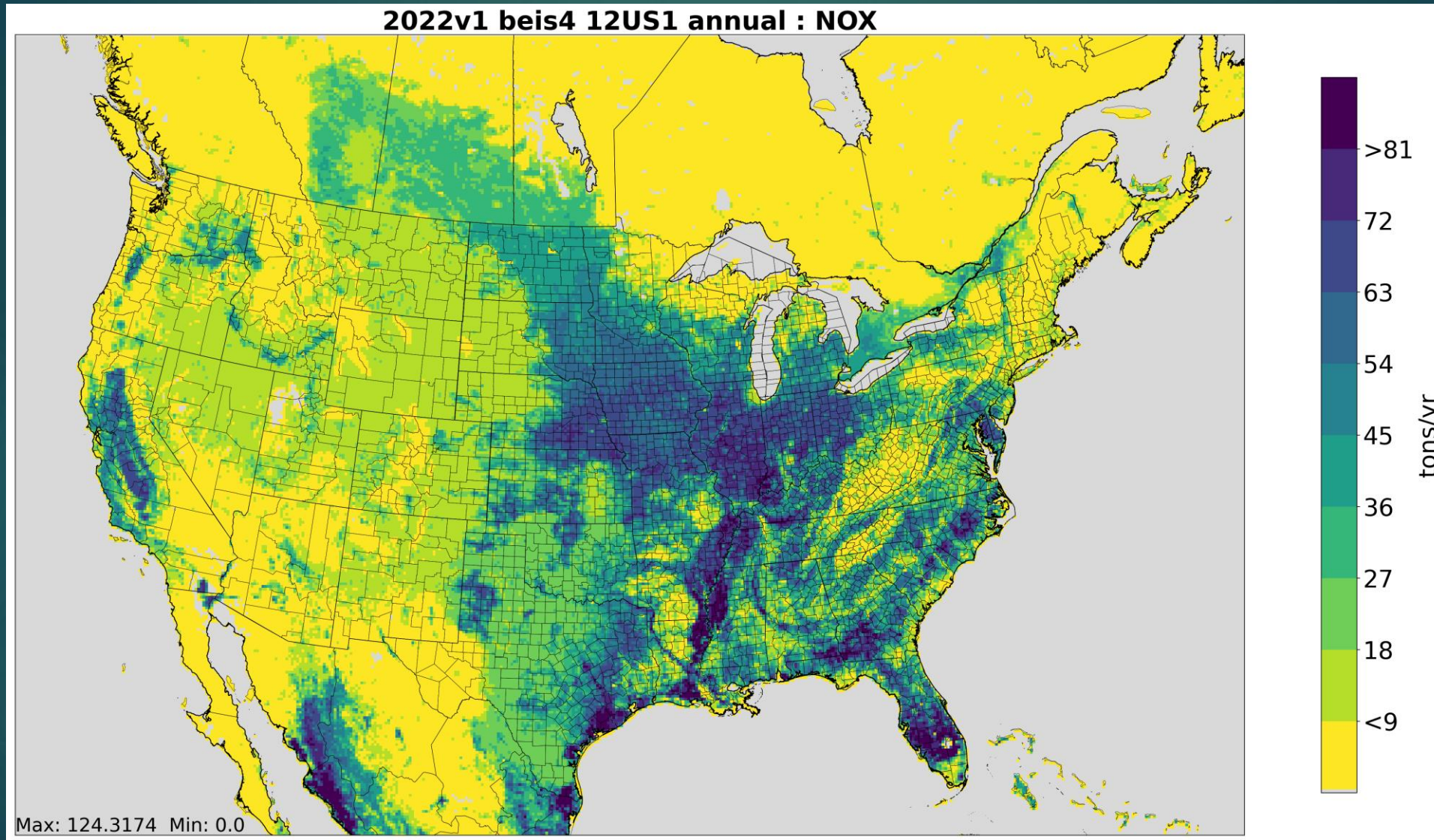
Annual biogenic VOC BEIS4 emissions for the 12US1 domain

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Annual biogenic NOX BEIS4 emissions for the 12US1 domain

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SCCs in National Emissions Inventory

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SCC	SCC Level Two	SCC Level Three	SCC Level Four	2023NEI
2701200000	Biogenic	Vegetation	Total	BEIS4 VOC
2701220000	Biogenic	Vegetation/Agriculture	Total	BEIS4 soil NO non-ag lands
2801700200	Agriculture Production - Crops	Fertilizer Application	Total: Biogenic	BEIS4 soil NO ag lands during growing season

Future Plans

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- The Soil-Atmosphere Gaseous Emissions (SAGE) module estimates soil NO approach
- Updating landuse
- Updating emissions factors

Questions?