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eixport: An R package to export emissions to atmospheric models

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Software

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Summary

Emissions are the pollutant mass released into the atmosphere (Pulles and Heslinga 2010). The origin of the emissions can be human-made or anthropogenic or biogenic. The consequences of this pollution are complex affecting the atmosphere, human health, ecosystems, and infrastructure (Seinfeld and Pandis 2016). In fact, pollution caused 9 million premature deaths in 2015, 16% of all deaths worldwide (Landrigan et al. 2017).

An important tool for policy decision is air quality models. They have been used not only to study the impact of different emissions scenarios for policy making but also to understand the dynamics of air pollutants in various parts of the world (M. de F. Andrade et al. 2015). The inputs for an air quality models are meteorology and emissions. Currently, there are tools for developing emissions inventories such as the VEIN (S. Ibarra-Espinosa et al. 2017) and the EmissV models (Schuch 2017). However, the existing tools for inputting the emissions into the air quality models are not written in a user-friendly way, such as PREP-Chem written in Fortran and C (S. Freitas et al. 2011). Also, as the R language has a growing community, including statistical R packages for model evaluation and validation, such as openair [], air quality modelers already familiar with R would tend to use 'eixport' for inputing data into the appropiate format for each model without the need of deep knowledge in a specific model language. Therefore, we developed **eixport**, a tool for inputting data into atmospheric models using R (R Core Team 2017).

eixport imports functions form the R packages sf (E. Pebesma 2017) which provides functions for spatial vector data, providing bindings to the GDAL, GEOS, and Proj.4 C++ libraries. Also, eixport import functions from the package ncdf4 (Pierce 2017), which interface to Unidata netCDF Format Data Files, and from the raster package (Hijmans 2017), which provides functions to gridded data.

Functions and data

eixport count with the following functions:

Function	Description
emisco	Dataset of Emissions from VEIN demo
emis_opt	List of WRF emission species
rawprofile	A matrix to temporally distribute emissions
wrf_create	Create WRF-Chem inputs based on a WRFinput file
wrf_get	Reads variables from WRF-Chem inputs
wrf_grid	Creates spatial feature (sf) polygon grid from WRFinput file
wrf_plot	Simple plot from wrf emission file
wrf_profile	returns a traffic intensity profile (based on wrf file Times)

Function	Description
wrf_put	Function to write variables in WRF-Chem inputs
to_brams_spm	Produce inputs for BRAMS SPM (E. D. de Freitas et al. 2005)
to_rline	Produce inputs for R-Line (Snyder et al. 2013)
to_wrf	Distribution of emissions for WRF-Chem (G. A. Grell et al. 2005)
to_as4wrf	Produce data-frame to be used with NCL AS4WRF (Vara-Vela et al. 2016)

Examples

The following example creates a directory **EMISS** and then create a wrfchem input in that file. The package already counts with wrfinput files required to run eixport and create inputs for WRF-Chem. The line `data(Lights)` load a matrix of night light to spatially distribute the emissions. The perfil argument is used to temporally distribute the emissions. Lastly, the function `to_wrf` in one line reads the 1521983 $t \cdot y^{-1}$ of CO, spatially distribute it using nighttime traffic matrix Lights, temporally distribute it with the perfil, injecting the array of emissions directly into the wrfchemi file. The colour palette is "mpl_inferno" from the R package cptcity (Sergio Ibarra-Espinosa 2017).

```
library(eixport)
dir.create(file.path(tempdir(), "EMISS"))
wrf_create(wrfinput_dir = system.file("extdata", package = "eixport"),
          wrfchemi_dir = file.path(tempdir(), "EMISS"))

# get the name of created file
files <- list.files(path = file.path(tempdir(), "EMISS"),
                    pattern = "wrfchemi",
                    full.names = TRUE)

# load end write some data in this emission file
data(Lights)
to_wrf(Lights, files[1], total = 1521983, names = "E_CO")

wrf_plot(files[1], "E_CO")
# [1] "EMISS/wrfchemi_d01_2011-08-01_00:00:00"
# [1] "E_CO"
# [1] "Max value: 26.6966304779053, Min value: 0"
```

The resulting plot can be seen in the Fig. 1.

The R package eixport is available at the repository https://github.com/atmoschem/eixport. To ensure the usability of the package, in any commit to GitHub, eixport is installed in Ubuntu via Travis-CI (https://travis-ci.org/atmoschem/eixport) and Windows via Appveyor (https://ci.appveyor.com/project/Schuch666/eixport). Also, eixport is already on CRAN https://CRAN.R-project.org/package=eixport. Moreover, this packages tests functions with the suite CodeCov (https://codecov.io/) and the r package covr (Hester 2017), achieving 89% of coverage (https://codecov.io/github/atmoschem/eixport).

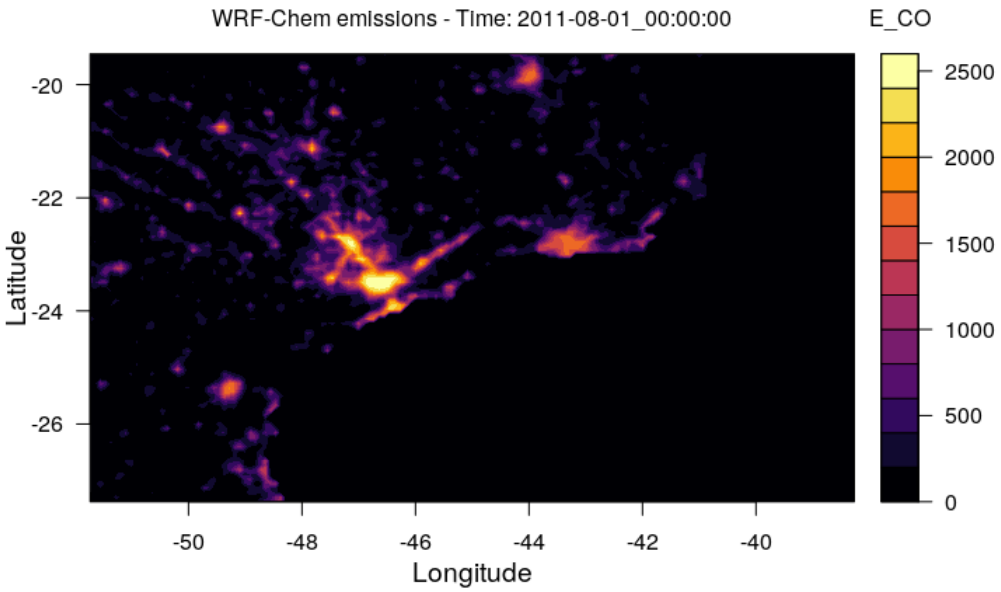

Figure 1: WRF-Chem emisisons of CO (t/y)

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