Introduction to the r4moves Package

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Purpose

- To more easily:
  - Access and analyze data from the MOVES model using R
  - Manipulate MOVES inputs
  - Create and manipulate Runspecs and Batchfiles
  - Document the MOVES workflow
- Will be done “agilely” as is typical in open source

The end goal is to be able to complete all of your work in MOVES without ever leaving R

Problems r4moves Hope To Solve

1. Need to recreate and rewrite SQL queries to get MOVES data
2. Switching between analysis platforms
3. Allowing easier use of R data frames and R packages
4. Solid and replicable documentation

Accessing and Installing

- Locations:
  - Currently on Github - https://github.com/hlinak/R-for-MOVES
  - CRAN planned for future
    - Want to get a little bit more feedback and make sure the code works with MOVES3 before putting it up on CRAN

What DOEE Has Used It For

- Review of 2017 NEI Mobile Source Inventory Inputs
- Development of Emission Rates Based on Local Data
- DC Analysis of OTC Aftermarket Converter Model Rule Implementation
- 110(l) Demonstration for I/M Program Changes

Examples

- Over the next 6 Slides will be example code
- I picked some of the more interesting examples from the I/M 110(l) project
- I skipped many steps!
  - If you want to actually be able to run something like this I have more detailed slides and can send them along

Example: Accessing Input Table

We are going to look at the imcoverage table. Notice the additional, joined information.

```
#Get data in a MOVES input table
getMOVESInputTable(dbconn, movesdb_name, countydb_name, "imcoverage") %>%
  head(1)
```

```
##   yearID inspectFreq IMProgramID begModelYearID endModelYearID useIMyn
## 1   2025           2         111           1968           1983       Y
##   complianceFactor polProcessID processID pollutantID isAffectedByExhaustIM
## 1            93.12          101         1           1                      Y
##   isAffectedByEvapIM chainedto1 chainedto2 isAffectedByOnroad
## 1                  N         NA         NA                  1
##   isAffectedByNonroad nrChainedTo1 nrChainedTo2 stateID            stateName
## 1                   1           NA           NA      11 DISTRICT OF COLUMBIA
##   stateAbbr countyID           countyName altitude GPAFract barometricPressure
## 1        DC    11001 District of Columbia        L        0             29.739
##   barometricPressureCV sourceTypeID HPMSVtypeID sourceTypeName fuelTypeID
## 1                   NA           21          25  Passenger Car           1
##   defaultFormulationID fuelTypeDesc humidityCorrectionCoeff
## 1                   10     Gasoline                  0.0038
##   humidityCorrectionCoeffCV fuelDensity subjectToEvapCalculations
## 1                        NA        2839                         Y
##   testStandardsID  testStandardsDesc     shortName              pollutantName
## 1              11 Unloaded Idle Test Unloaded Idle Total Gaseous Hydrocarbons
##   energyOrMass globalWarmingPotential NEIPollutantCode pollutantDisplayGroupID
## 1         mass                     NA               HC                       30
##       processName SCCProcID occursOnRealRoads processDisplayGroupID
## 1 Running Exhaust         X                 Y                    NA
```

Example: Manipulating Input Table

Here we are going to increase the frequency of I/M tests in the inputs

```
#Get data in a MOVES input table
base_im_table <- getMOVESInputTable(dbconn, movesdb_name, countydb_name, "imcoverage")

#Get data in a MOVES input table
annual_inspections <- base_im_table %>%
  mutate(inspectFreq = 1)

annual_inspections %>%
  head(1)
```

```
##   yearID inspectFreq IMProgramID begModelYearID endModelYearID useIMyn
## 1   2025           1         111           1968           1983       Y
##   complianceFactor polProcessID processID pollutantID isAffectedByExhaustIM
## 1            93.12          101         1           1                      Y
##   isAffectedByEvapIM chainedto1 chainedto2 isAffectedByOnroad
## 1                  N         NA         NA                  1
##   isAffectedByNonroad nrChainedTo1 nrChainedTo2 stateID            stateName
## 1                   1           NA           NA      11 DISTRICT OF COLUMBIA
##   stateAbbr countyID           countyName altitude GPAFract barometricPressure
## 1        DC    11001 District of Columbia        L        0             29.739
##   barometricPressureCV sourceTypeID HPMSVtypeID sourceTypeName fuelTypeID
## 1                   NA           21          25  Passenger Car          1
##   defaultFormulationID fuelTypeDesc humidityCorrectionCoeff
## 1                   10     Gasoline                 0.0038
##   humidityCorrectionCoeffCV fuelDensity subjectToEvapCalculations
## 1                        NA        2839                        Y
##   testStandardsID  testStandardsDesc     shortName              pollutantName
## 1              11 Unloaded Idle Test Unloaded Idle Total Gaseous Hydrocarbons
##   energyOrMass globalWarmingPotential NEIPollutantCode pollutantDisplayGroupID
## 1         mass                    NA               HC                       30
##       processName SCCProcID occursOnRealRoads processDisplayGroupID
## 1 Running Exhaust         X                 Y                    NA
```

Example: Manipulating Runspec

Now we are going to make a new runspec that calls a new County DB, created in a missing step to include the new I/M inputs

```
#Read in runspec
new_rs <- readRunspec(rs_file)

setRunspecValue(new_rs, "//description", paste("Presentation Test", sep=''),  TRUE)
```

```
## [[1]]
## <description><![CDATA[Presentation Test]]></description>
##
## attr(,"class")
## [1] "XMLNodeSet"
```

```
setRunspecAttr(new_rs, "//scaleinputdatabase", c(databasename =  new_countydb_name))
```

```
## [[1]]
##                       databasename
## "new_v45_2020_amnd_ozn_dc_2025_in"
```

```
createRunspec(new_rs, new_rs_file)
```

```
## [1] "C://Users//Joseph.Jakuta//Desktop//im-analysis//MOVES_Runspecs//2025_base_new"
```

Example: Output Data

Now let's look at some output data

```
#Get data in a MOVES runs
outputs %>%
  head(10)
```

```
##    MOVESRunID stateID countyID iterationID yearID hourID zoneID linkID
## 1           1      11    11001           1   2025     NA     NA     NA
## 2           1      11    11001           1   2025     NA     NA     NA
## 3           1      11    11001           1   2025     NA     NA     NA
## 4           1      11    11001           1   2025     NA     NA     NA
## 5           1      11    11001           1   2025     NA     NA     NA
## 6           1      11    11001           1   2025     NA     NA     NA
## 7           1      11    11001           1   2025     NA     NA     NA
## 8           1      11    11001           1   2025     NA     NA     NA
## 9           1      11    11001           1   2025     NA     NA     NA
## 10          1      11    11001           1   2025     NA     NA     NA
##    modelYearID  SCC hpID emissionQuant emissionQuantMean emissionQuantSigma
## 1         2025 <NA>   NA      1.027700                NA                 NA
## 2         2025 <NA>   NA      3.371250                NA                 NA
## 3         2025 <NA>   NA      1.116730                NA                 NA
## 4         2024 <NA>   NA      0.955054                NA                 NA
## 5         2024 <NA>   NA      3.148450                NA                 NA
## 6         2024 <NA>   NA      1.143670                NA                 NA
## 7         2023 <NA>   NA      0.894645                NA                 NA
## 8         2023 <NA>   NA      2.867400                NA                 NA
## 9         2023 <NA>   NA      1.099370                NA                 NA
## 10        2022 <NA>   NA      0.994352                NA                 NA
##    dayID dayName noOfRealDays monthID monthName noOfDays monthGroupID
## 1     NA    <NA>           NA      12  December       31           12
## 2     NA    <NA>           NA      12  December       31           12
## 3     NA    <NA>           NA      12  December       31           12
## 4     NA    <NA>           NA      12  December       31           12
## 5     NA    <NA>           NA      12  December       31           12
## 6     NA    <NA>           NA      12  December       31           12
## 7     NA    <NA>           NA      12  December       31           12
## 8     NA    <NA>           NA      12  December       31           12
## 9     NA    <NA>           NA      12  December       31           12
## 10    NA    <NA>           NA      12  December       31           12
```

Example: Making Summaries

Now we use our data frame containing to MOVES data with typical R functions to make summaries

```
#Summary by NOX by Source Use Type
outputs %>%
  filter(pollutantID %in% c(3)) %>%
  group_by(sourceTypeName)  %>%
  summarize(TotalEmissions = round(sum(emissionQuant)/2000,2)) %>%
  mutate(EmissionsPerDay = round(TotalEmissions/365, 2))
```

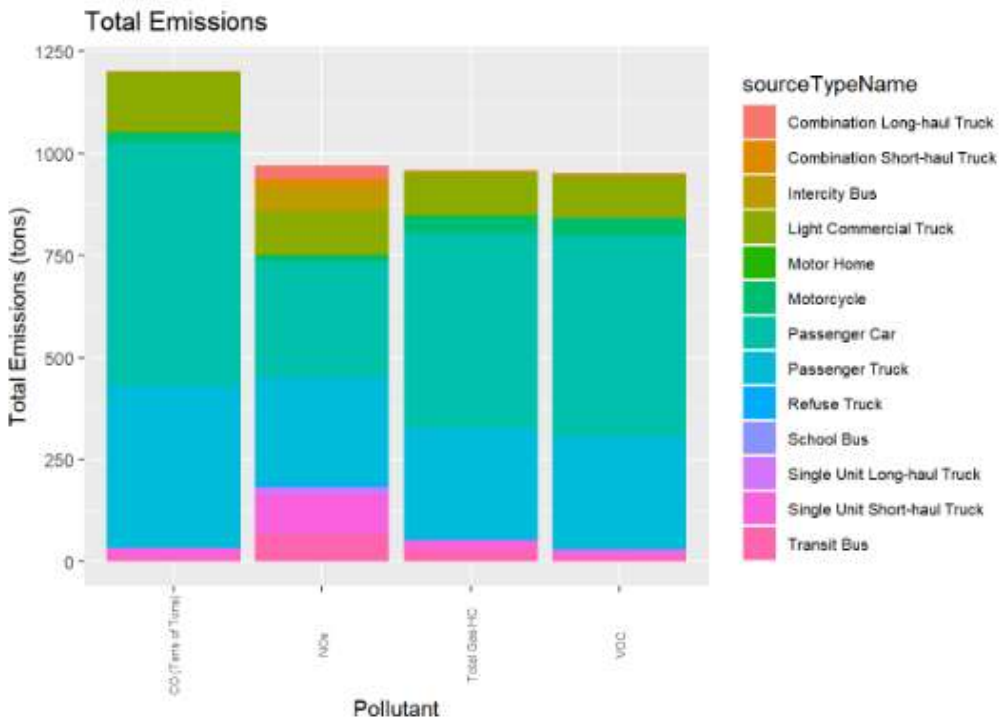
```
## `summarise()` ungrouping output (override with `.groups` argument)
```

```
## # A tibble: 13 x 3
##    sourceTypeName               TotalEmissions EmissionsPerDay
##    <chr>                                 <dbl>           <dbl>
##  1 Combination Long-haul Truck           35.2             0.1
##  2 Combination Short-haul Truck          16.5             0.05
##  3 Intercity Bus                         58.8             0.16
##  4 Light Commercial Truck               108.              0.3
##  5 Motor Home                             2.89            0.01
##  6 Motorcycle                            13.4             0.04
##  7 Passenger Car                        285.              0.78
##  8 Passenger Truck                      259.              0.71
##  9 Refuse Truck                           7.86            0.02
## 10 School Bus                             6.03            0.02
## 11 Single Unit Long-haul Truck           13.0             0.04
## 12 Single Unit Short-haul Truck          96.3             0.26
## 13 Transit Bus                           68.3             0.19
```

Example: Making Plots

Now we use our data frame containing to MOVES data with typical R functions to make plots

```
outputs %>%
  filter(pollutantID %in% c(87,1,2,3)) %>%
  group_by(shortName, sourceTypeName)  %>%
  summarize(TotalEmissions = round(sum(emissionQuant)/2000,2),
            pollutantID = max(pollutantID),
            sourceTypeID = max(sourceTypeID)) %>%
  mutate(TotalEmissions = ifelse(pollutantID == 2, TotalEmissions/10, TotalEmissions),
         shortName = ifelse(pollutantID == 2, paste(shortName, "(Tens of Tons)"), shortName)) %>%
  ggplot(aes(x = shortName, y = TotalEmissions , fill=sourceTypeName)) +
  geom_col() +
  labs(title = "Total Emissions",
       x = "Pollutant",
       y = "Total Emissions (tons)") +
  theme(axis.text.x = element_text(angle = 90, vjust = 0.5, size=6),
        legend.text = element_text(size=8) )
```



Next Steps (by priority)

- Get more people trying it out!
- Update to work with MOVES3
  - Work with MariaDB – Done!
  - Update new DB Structures
    - Input Tables Done!
    - Output Tables, Next
  - QA
  - Update to new CLI
- Put on CRAN
- Fix MOVES run bugs
- Add NONROAD output functions
- Possibly speed up getMOVESOutput on large runs
- Considering additional Runspec manipulation functions
- Update to work with older versions of MOVES

Questions?

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