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NORTRIP emission model user guide

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Technical report

Preface

The NORTRIP emission model has been developed at NILU, in conjunction with other Nordic institutes, to model non-exhaust traffic induced emissions. This short summary document explains how to run the NORTRIP model from the MATLAB environment or by using the executable user interface version. It also provides brief information on input files and the model structure.

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NORTRIP emission model user guide

The NORTRIP model is a non-exhaust traffic emission model developed during the NORTRIP project (Johannson et al., 2012). A significant part of this project involved the development of the 'NORTRIP model'. The model is fully documented in Denby and Sundvor (2012).

The model has been programmed in the MATLAB scripting environment but an executable version of the model, with a user interface, is also available for windows platforms. In this users guide, installation and use of the model is described.

1 Downloading the required files

Folders and files for running the 'NORTRIP_model' are available on the NILU ftp site at:

ftp://ftp.nilu.no/pub/NILU/Bruce/NORTRIP/

log on as 'anonymous'

All the model scripts, example data and documentation are available in the zipped folder:

'\NORTRIP model.zip'

Within this folder the following sub-folders are available:

'\documentation\'
'\input data\'
'\model parameters\'
'\model run info\'
'\output data\'
'\output figures\'
'\Scripts\'

The MATLAB MCR library installer, needed to run the user interface executable version, is available in the folder:

'\Install MCR\'

Contact Bruce Rolstad Denby (bde@nilu.no) for more information or problems with downloading.

2 Running the executable version of the NORTRIP model in the Windows environment

An executable version of the NORTRIP emission model, with user interface, is available for windows. To run the executable version a set of MATLAB libraries must be installed. These are freely available and the installation is easily carried out. Note that this version only works on 64 bit machines, not 32.

2.1 Setting up the NORTRIP model user interface executable

1. Copy the folder '\NORTRIP model' (or zip file) to somewhere on your local PC. If the zip file is used then extract this folder.
2. If this is the first time you set up for the executable then some MATLAB libraries (dll's) must be installed for the executable to run. Copy the file 'MCRInstaller' in the '\Install MCR\' folder to somewhere on your local PC. Click on the 'MCRInstaller' file and follow the installer wizard instructions.
   Note: no password or user name is required. Just click further.
3. Open the 'modelrun_file' in the '\NORTRIP model\model run info' folder. Paste in and save the required default paths and filenames.

2.2 Running the NORTRIP model executable

1. Double click on the executable 'NORTRIP_model_v2.exe' in the '\NORTRIP model' folder. The first time it starts there can be a short delay.

3 Running the NORTRIP model from the MATLAB environment

3.1 Setting up the NORTRIP model MATLAB scripts

1. Copy the directory 'NORTRIP model' (or zip file) to somewhere on your local PC. If the zip file is used then extract this folder.
2. If you wish to set the default path for the model (useful but not necessary) then enter the MATLAB environment. Select 'File/Set path/' from the tool bar and add the position of the folder which contains the model and scripts e.g. 'C:\NORTRIP model\'. This sets the default path. Alternatively type `setpath('pathname')` in the MATLAB control window.
3. Open the 'modelrun_file.xlsx' in the '\NORTRIP model\model run info\' folder. Paste in and save the required default paths and filenames.

3.2 Running the NORTRIP model from MATLAB scripts

1. Start up MATLAB
2. Make sure that MATLAB can find the scripts by setting the path to the 'Script' folder. Select 'File' -> 'Set path' from the MATLAB tool bar.

Choose ‘Add with subfolders’ and browse to ‘\NORTRIP model\Scripts\’, wherever it has been placed on your PC. Select this path and save.

3. There are two control scripts for running the model. These are ‘Road_dust_uicontrol_v2’ and ‘Road_dust_control_v2’. The first of these is the user interface version (ui) of the model and the second is the script version. In the script version you must set the pathnames and other controls in the script (default path is manually set using the variable ‘root_path’). In the user interface version this is done using the interface. Run either of these scripts to start the model.

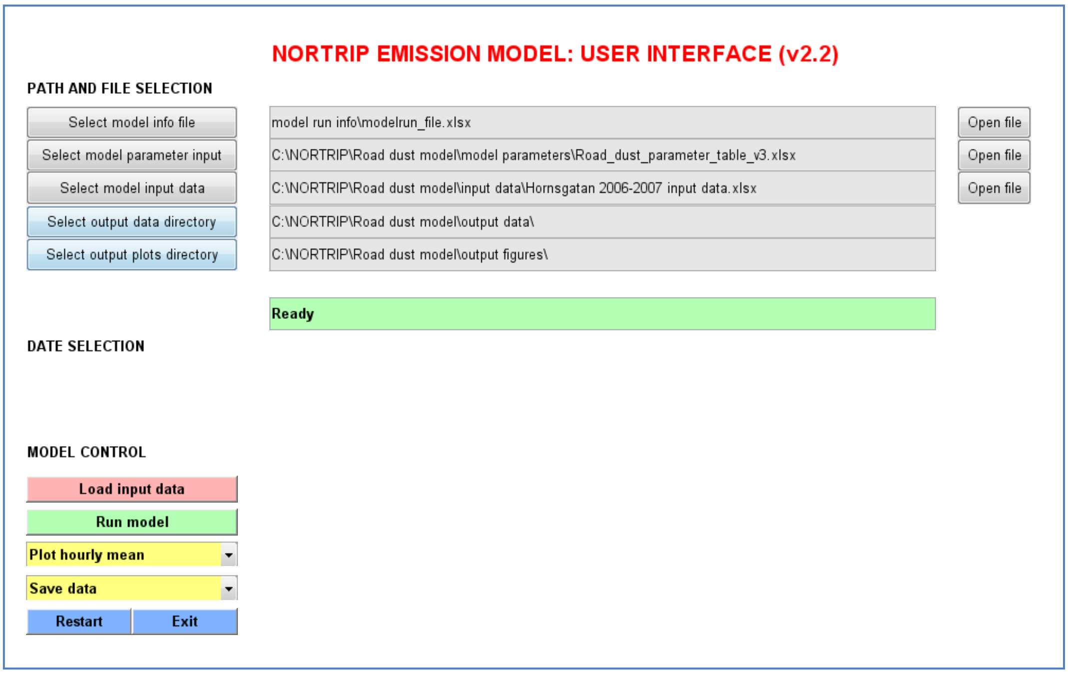
4 Overview of the model calculation

1. The model reads the excel file ‘\model run info\modelrun_file.xlsx’ (contained in ‘\NORTRIP model\model run info\’) to set the initial paths and filenames. This file name cannot be changed and should not be moved to another folder.
2. The model reads in one of the input data excel files contained in ‘\NORTRIP model\Input data\’, as specified by the user.
3. The model reads in the model parameter and flag file contained in ‘\Road dust model\model parameters\’, as specified by the user.
4. The model runs the calculation.
5. The model plots the results on a number of separate figures, dependent on the type of plot required. This is defined with the variable ‘plot_type_flag’ (= 1 for hourly means, = 2 for daily means, = 3 for daily cycle)
6. The model saves the plots (currently tiff format) and saves the data (excel sheet) according to the ‘save_type_flag’ variable (= 1 save data, = 2 save plots, = 3 save both, = 0 no save).

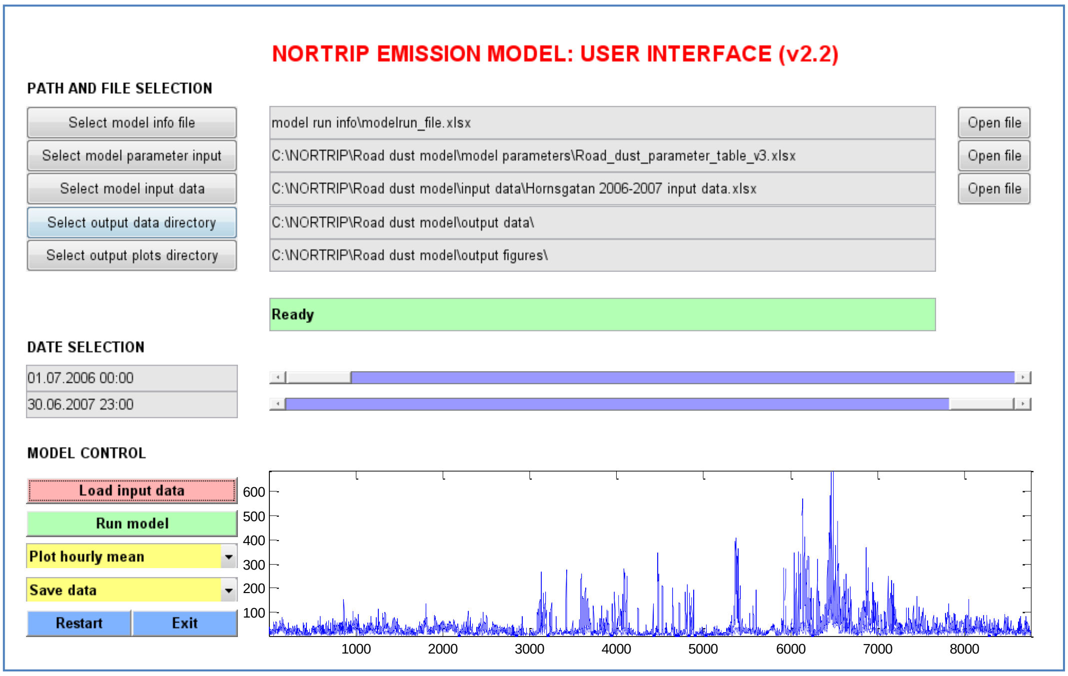
5 Using the user interface version

The user interface version is available as the MATLAB script ‘Road_dust_uicontrol_v2’ or as an executable ‘NORTRIP_model_v2.exe’.

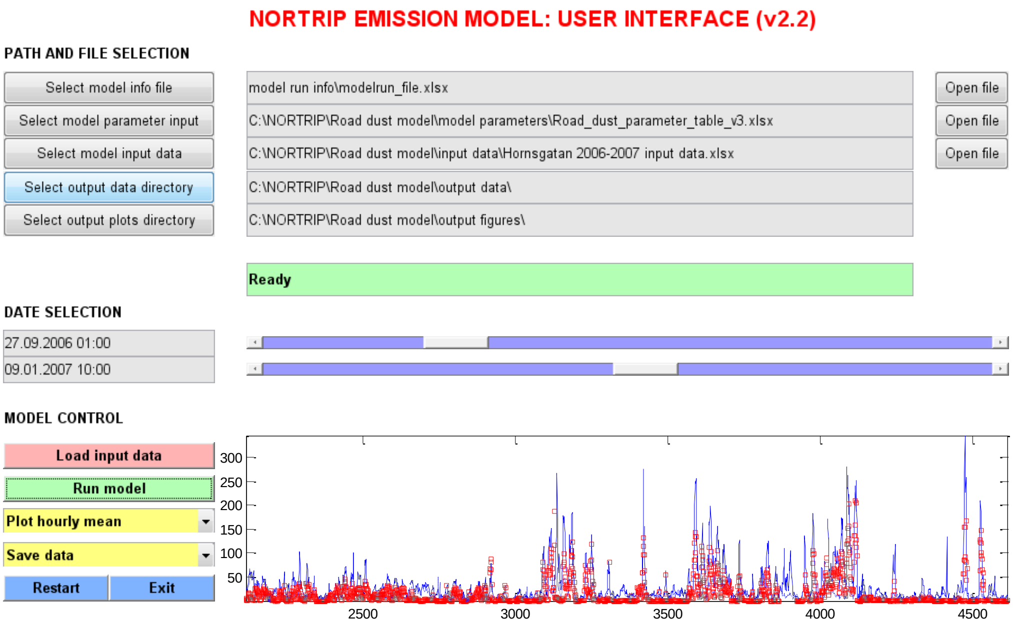
1. Run the ‘Road_dust_uicontrol_v2’ script from the MATLAB environment or double click on the executable file ‘\NORTRIP model\ NORTRIP_model _v2.exe’
2. If the default root directory has been properly set up then the interface displays the file names and paths contained in the ‘modelrun_file’ excel sheet, i.e. ‘\model run info\modelrun_file.xlsx’. The following figure should appear



3. You can change the paths and files for input and output files ('PATH AND FILE SELECTION') either by clicking on the buttons and browsing or by changing the text in the text box (press return when finished).
4. You can open the specific input files in EXCEL for editing by clicking on 'Open file'
5. Once having chosen the input data files press 'Load input data'. The input data file will be read and the measured concentrations (also background concentrations) for PM_{10} will be shown. Two sliders will also appear, along with dates in a text box, which can be moved to adjust the starting time (top slider) and the end time (bottom slider). The dates can also be changed directly in the text box (press return when finished typing).



6. Once times have been selected the model can be run by pressing the ‘Run model’ button. The calculated concentrations will appear as red squares in the plot during the model run.



7. Once the model is finished you can readjust the time sliders (or in the text box) to redefine the time period for plotting and saving data.
8. You can choose to plot the data as hourly mean, daily mean or mean daily cycle using the ‘Plot’ pull down selection. Nine figures will be produced showing a number of different variables.

9. Using the ‘Save’ pull down selection you can choose to save all these figures (tiff) to the defined ‘output figures directory’ or to save the data to the ‘output data directory’. When saving figures no browser is provided. These are saved given names, based on the name of the input data file, and placed directly in the ‘\output figures\’ directory, as defined in the ‘PATH AND FILE SELECTION’.
10. When saving the data, as excel sheets, a browser is provided so that paths and file names can be changed. Missing data values are given as blank cells in the excel sheets.
11. You can also choose “save both data and plots” to save data and figures at once, a browser is provided so that paths and file names can be changed.
12. You can choose a new input data file or output directory, etc., and then rerun the model
13. Whilst the user interface is open you can edit, and of course save, the input excel sheets. For convenience the ‘Open file’ buttons will open the currently selected file in EXCEL. This allows changes to be made, e.g. to the model parameters or the run time flags in the input data file. If you change the input data file you will need to reload that file by clicking ‘Load input data’. The script reads the model parameter file every time it runs the model.
14. You can exit or restart the user interface (restart if it seems to be running strangely)

6 Data files

In addition to the ‘modelrun_file’ the model reads a model parameter file and a model input data file. All three input files are excel files.

6.1 Input data excel file

Input data files contain the information for a particular road required by the model as well as monitoring data for comparison of the model with observations. The following input data files are currently available for demonstration:

- Hornsgatan 2006-2007 input data
- Hornsgatan 2007-2008 input data
- Hornsgatan 2008-2009 input data
- Hornsgatan 2009-2010 input data
- Hornsgatan 2010-2011 input data
- Essingeleden avBG 2008-2009 input data
- RV4 2004 input data
- RV4 2005 input data
- RV4 2005-2006 input data
- Mannerheimintie 2007-2008 input data new
- HCAB 2006-2007 input data newsalt

- HCAB 2007-2008 input data newsalt
- NB 2002 input data
- Runeberg 2004 input data measured speed

Currently the default is the Hornsgatan 2006-2007 file. If new data is to be used then use these as templates for the new data.

Within each of the excel files are a number of labelled worksheets. Do not change the names of the works sheets or the names of the variables listed, as MATLAB searches for key words when assigning the variables. Data in the worksheets may also be formulas, not just pure numbers, and other data and text can be placed in the worksheets (as well as figures) as long as the key words are not repeated. A complete description of the data can be found in the NORTRIP model documentation Appendix C.4 (Denby and Sundvor, 2012).

Most of the data is self explanatory but the following descriptions are given here in Table 1.

Table 1. Description of the input data files for the NORTRIP model.

Sheet name	**Comments**
Static data	
Metadata	Static data describing local street configuration and properties. Also given here is the missing data value that is applied in the rest of the sheets (if it is used)
Initialconditions	Initial values of the model prognostic variables. Also included is the long wave radiation offset. This is optional
Statictraffic	These are ratios to redistribute the total traffic into the different vehicle classes and tire types. If these are not used then these must be set to the defined missing data value. If a value is not a missing data value then it overrides the distribution in the 'Traffic' work sheet.
Time series data	
Traffic	Contains the traffic volume per vehicle class and tire type, as well as vehicle speed per class. Missing data are given either as a missing data value or as a blank cell
Meteorology	Input meteorological data and also road wetness and surface temperature values for model validation. Missing data are provided either as a missing data value or as a blank cell.
Activity	This indicates road maintenance activities. This is overridden if the 'auto_activity_flag' is set to 1 in the 'Flags' worksheet of the 'Input parameter file'. Activities include salting, sanding, ploughing and cleaning.
Airquality	Contains concentration data for comparison as well as emission data. Comparison of the model with observations can only be achieved if the NO_X concentrations are provided (traffic and background) which are used to convert PM emissions to concentrations. The same is true for the PM concentrations.

6.2 Model parameters excel file

The model parameter file consists of three worksheets. These are:

- the model parameters: "Parameters"
- the model control 'flags': "Flags"
- the road maintenance activity parameters: "Activities".

The current default file is 'Road_dust_parameter_table_v3'.

The parameters in this file are explained and listed in the model documentation (Denby and Sundvor , 2012; Appendix C.1-C.3). Do not change the labels in these files as they serve as key words for finding the data. This file can be altered to test sensitivity to the different model parameters. When model results are saved these three sheets are copied and saved in the same excel file.

7 Model routines

The MATLAB script version of the model is structured using scripts and functions, Table 2, and brief descriptions of these are given in Table 3. All these files must be in place for the model to run from the MATLAB environment. Indentation indicates the level in the programme. Bold type indicates scripts and normal type functions.

Table 2. Structure and calling of MATLAB scripts and functions in the NORTRIP model.

```
road_dust_control_v2/road_dust_uicontrol_v2

  read_road_dust_paths
  road_dust_set_constants_v2
  read_road_dust_parameters_v3
  read_road_dust_input_v2
    check_data_func
  calc_radiation
    global_radiation_func
    longwave_in_radiation_func
    road_shading_func
  running_mean_temperature_func

  for t=min_time:max_time
    set_activity_data_v2
    road_dust_surface_wetness_v2
      calc_salt_solution
        antoine_func
        melt_func_antoine
      r_aero_func
      net_global_radiation_func
      Penman_modified_func
      Surface_energy_model_3_func
        q_sat_func
        q_sat_ice_func
      f_spray_func
      mass_balance_func
    road_dust_emission_model_v2
      W_func
      f_sandpaper_func
      f_crushing_func
      f_susroad_func
      R_0_wind_func
      mass_balance_func
    road_dust_concentrations
  end

  plot_road_dust_results_v2
    Average_data_func
    rmse
  save_plot_road_dust_results_2
  save_road_dust_results_v2
```

Table 3. List of MATLAB scripts and functions used in the NORTRIP model.

Script name	**Description**
road_dust_control_v2	Control script for running the model in the MATLAB environment
road_dust_uicontrol_v2	Control script for running the model from the user interface
read_road_dust_paths	Reads in the excel modelrun_info file that defines paths and filenames
road_dust_set_constants_v2	Sets constants used in the model, called in most functions
read_road_dust_parameters_v3	Reads in the model parameters from the excel parameter file
read_road_dust_input_v2	Reads in the site specific meta and temporal data excel file
calc_radiation	Pre-calculates all radiation parameters
set_activity_data_v2	Determines automatic road maintenance activities
road_dust_surface_wetness_v2	Moisture sub-model
calc_salt_solution	Determines the surface salt solution and related parameters
road_dust_emission_model_v2	Road dust sub-model, mass balance and emissions
road_dust_concentrations	Converts emissions to concentrations based on the tracer
plot_road_dust_results_v2	Routine for plotting standard plots
save_plot_road_dust_results_2	Saves plots as tiff files
save_road_dust_results_v2	Saves hourly values and input parameters as excel sheets
Function name	
check_data_func	Checks input data time series for data and determines if there is data available
global_radiation_func	Calculates the incoming global short wave radiation
longwave_in_radiation_func	Calculates the incoming long wave radiation
road_shading_func	Calculates the shortwave radiation shading by the street canyon
running_mean_temperature_func	Pre-calculates the running mean temperature
antoine_func	Calculates the partial vapour pressure of a saturated salt
melt_func_antoine	Calculates the melt/freezing temperature of a salt solution
r_aero_func	Calculates the aerodynamic resistance due to surface roughness and traffic induced turbulence
net_global_radiation_func	Calculates the net global radiation (only used for the Penman formulation)
Penman_modified_func	Penman formulation for the surface energy balance.
Surface_energy_model_3_func	Calculates the surface energy balance parameters and surface temperature and humidity
q_sat_func	Calculates the saturated partial vapour pressure and specific humidity for water
q_sat_ice_func	Calculates the saturated partial vapour pressure and specific humidity for ice
f_spray_func	Calculates the road spray rate
W_func	Calculates the road wear per vehicle
f_sandpaper_func	Calculates the sand paper abrasion rate
f_crushing_func	Calculates the sand crushing rate
f_susroad_func	Calculates the suspension rate
R_0_wind_func	Calculates the windblown dust suspension rate
mass_balance_func	Calculates the mass balance function given initial mass, production and sink terms

`Average_data_func`	Calculates averages from the hourly model output for plotting. Daily means, daily time profile, weekly daily means, half daily means
`rmse`	Calculates root mean square error (not a generic MATLAB function)

8 References

Denby, B. R., Sundvor, I. (2012) NORTRIP model development and documentation. Non-exhaust Road Traffic Induced Particle emission modeling. Kjeller, Norwegian Institute for Air Research (NILU OR 23/2012).

Johansson, C., Denby, B.R., Sundvor, I., Kauhaniemi, M., Härkönen, J., Kukkonen, J., Karppinen, A., Kangas, L., Omstedt, G., Ketzel, M., Massling, A., Pirjola, L., Norman, M., Gustafsson, M., Blomqvist, G., Bennet, C., Kupiainen, K., Karvosenoja, N. (2012) NORTRIP: NOn-exhaust Road TRaffic Induced Particle emissions. Development of a model for assessing the effect on air quality and exposure. Stockholm, Department of Applied Environmental Science, Stockholm university (ITM-report 212).

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ABSTRACT
The NORTRIP emission model has been developed at NILU, in conjunction with other Nordic institutes, to model non-exhaust traffic induced emissions. This short summary document explains how to run the NORTRIP model from the MATLAB environment or by using the executable user interface version. It also provides brief information on input files and the model architecture.

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