DEPARTMENT OF ENVIRONMENTAL SCIENCE
AARHUS UNIVERSITY

The temporal model

Stakeholder workshop

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Dublin

Outline

- Introduction
- Model description
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    - Electricity production
    - Industrial production
    - Domestic heating
    - Road transport
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- Results
- Conclusions

Introduction

- Temporal distribution of emissions is an important input to quality modelling
- Very little work has been done internationally to improve the knowledge of the temporal aspects of emissions
- For air quality modelling in Europe, EMEP uses temporal profiles on monthly, daily and hourly basis
- The EMEP temporal profiles are very aggregated in terms of emission sectors
- The goal of the project was to develop more detailed sectoral temporal profiles

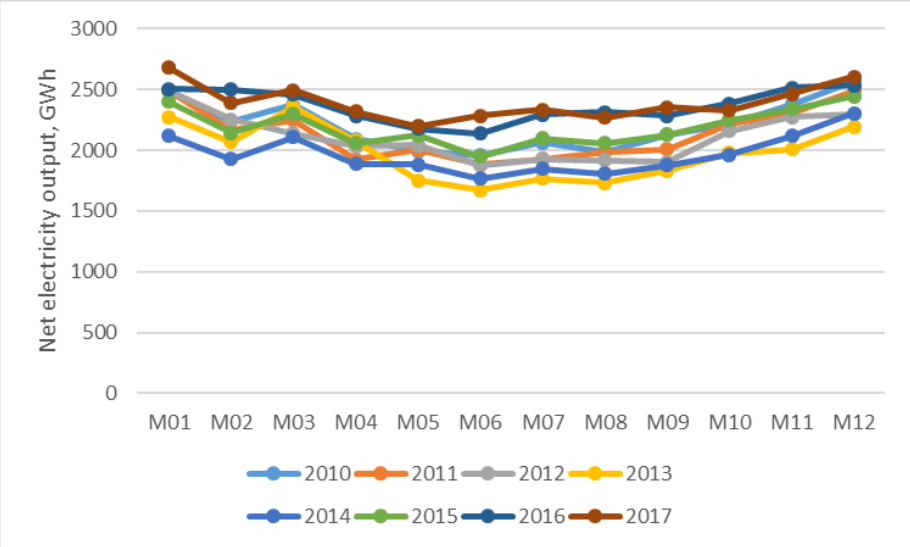
Model description

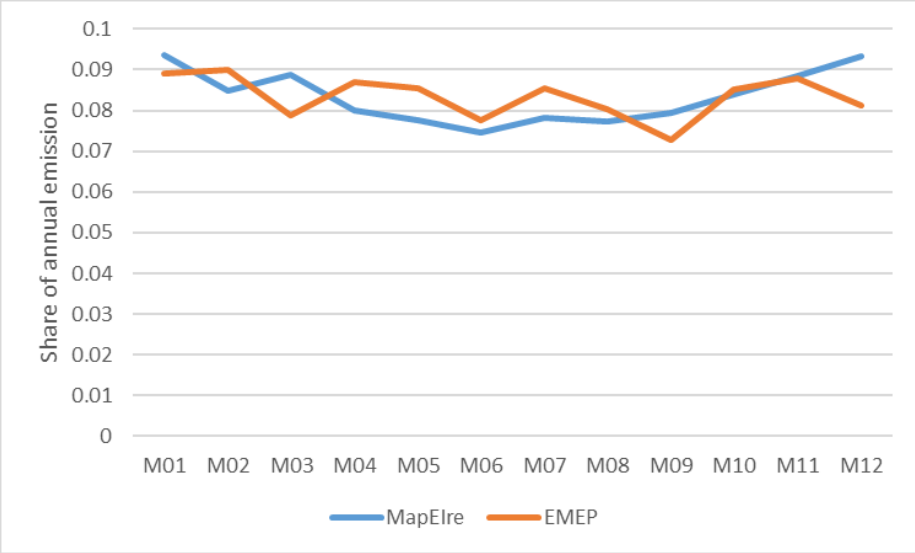
- The temporal component has been integrated in the MapEIre model using the same basic platform as the spatial distribution
- Temporal keys have been developed for all sectors with varying degree of detail based on data availability
- In some cases there are different temporal distributions for different pollutants from the same sector
- In all cases, the temporal profiles are developed showing monthly, daily and diurnal variations
- In some cases, the temporal profiles have been based on expert judgement as no better data were available

Electricity production

- Multiple datasets were considered and ultimately combined
- The monthly temporal profile is based on data from the CSO (MSM01 Electricity Output), while the daily and diurnal profiles are based on data downloaded from EirGrid
- For monthly electricity output an average for 2010-2017 has been used in the model
- Hourly values for thermal generation have been downloaded from EirGrid
- In total 4254 hours of data have been analysed in developing the temporal profiles

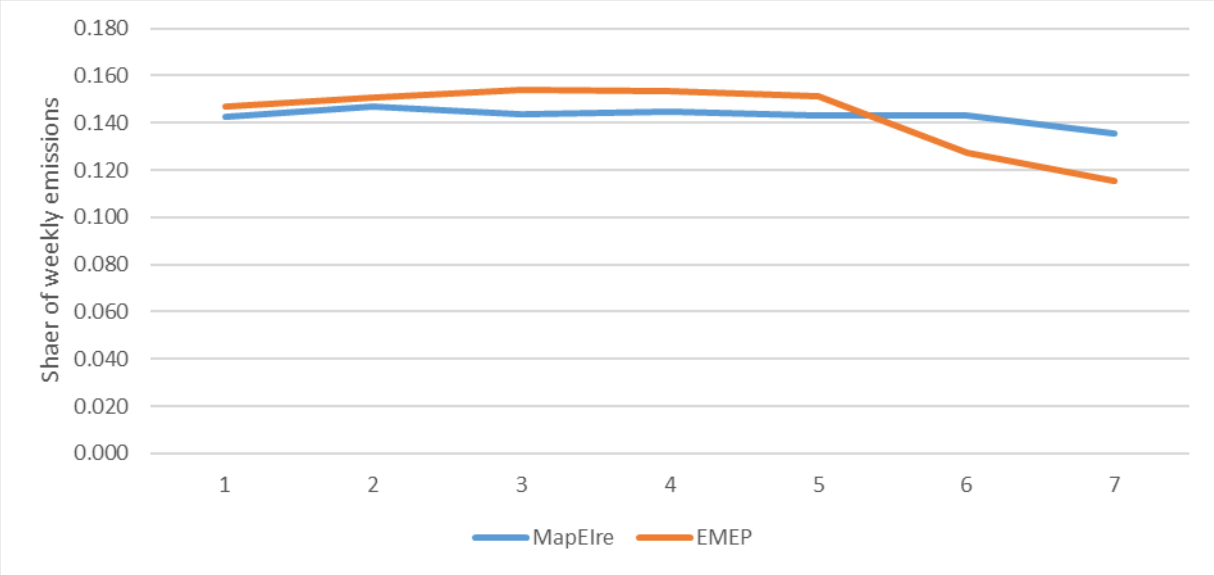
Electricity production – monthly





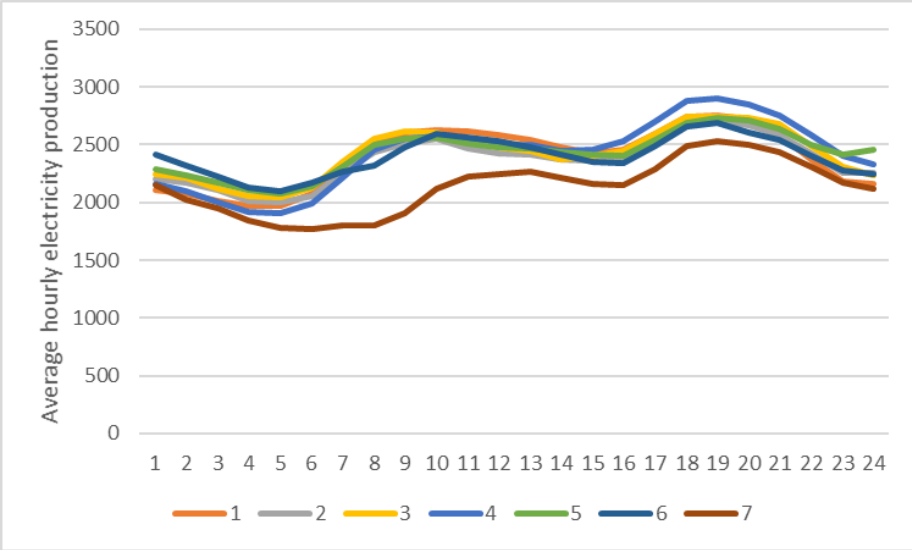
- Trends are broadly consistent between the eight years analysed
- The data matches expectations, e.g. that February is lower than January and March

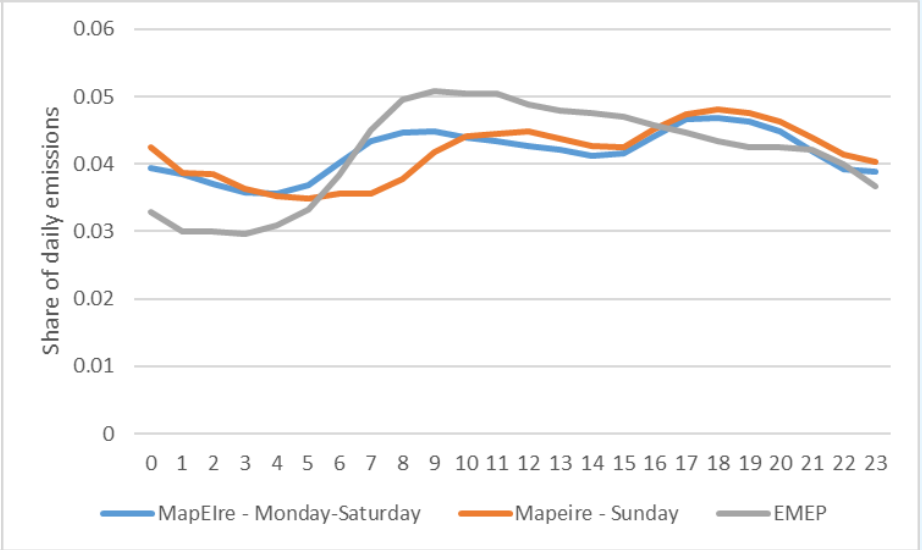
Electricity production – daily



- Very low variability across the week with only a slight decrease on Sunday
- EMEP has a more pronounced decrease during the weekend

Electricity production – hourly



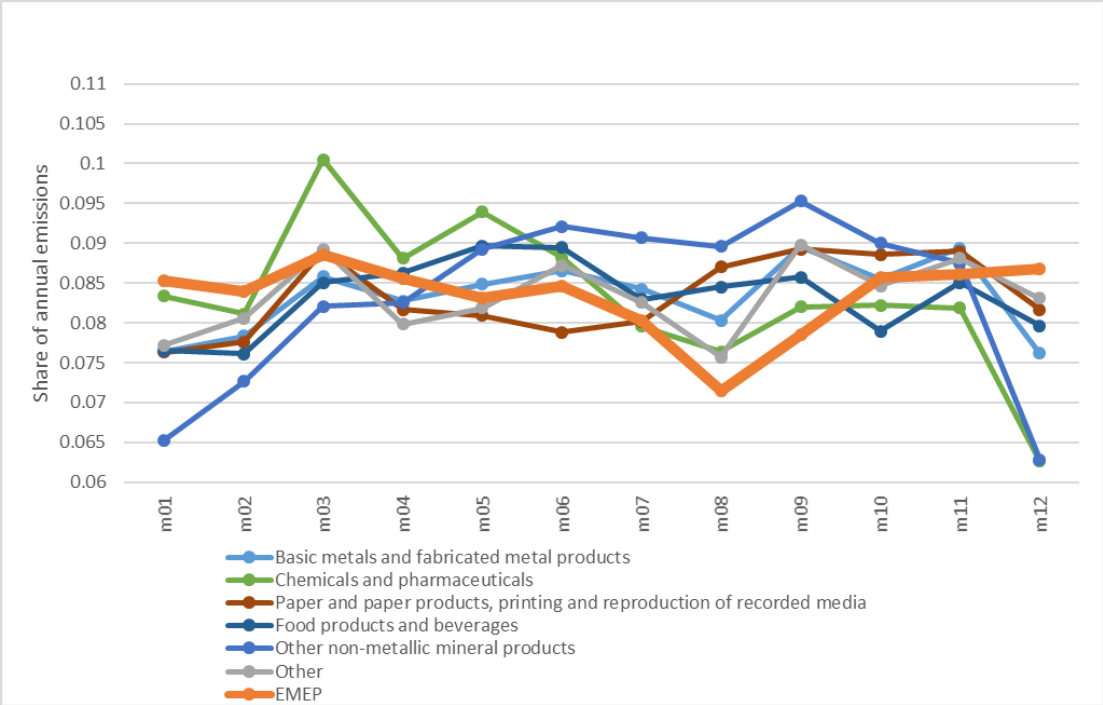


- Distinct difference between Sunday and Monday-Saturday
- Significant difference between the Irish data and the current data used by EMEP for Ireland

Industrial production

- The CSO publishes data for monthly production volume for various industries (MIM03 Industrial Production Volume and Turnover Indices)
- Based on data for 2010-2017, average monthly production for various industries has been compiled
- The industries defined by NACE (rev 2) have been mapped to emission sectors from the Irish emission inventory
- No data have been found for daily and diurnal variations. Assumptions have been made depending on industrial sector

Industrial production – monthly

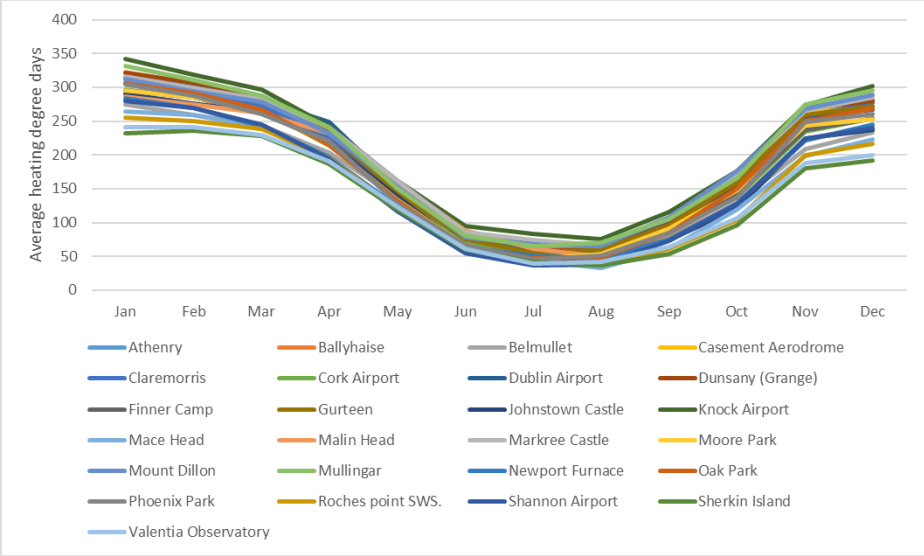


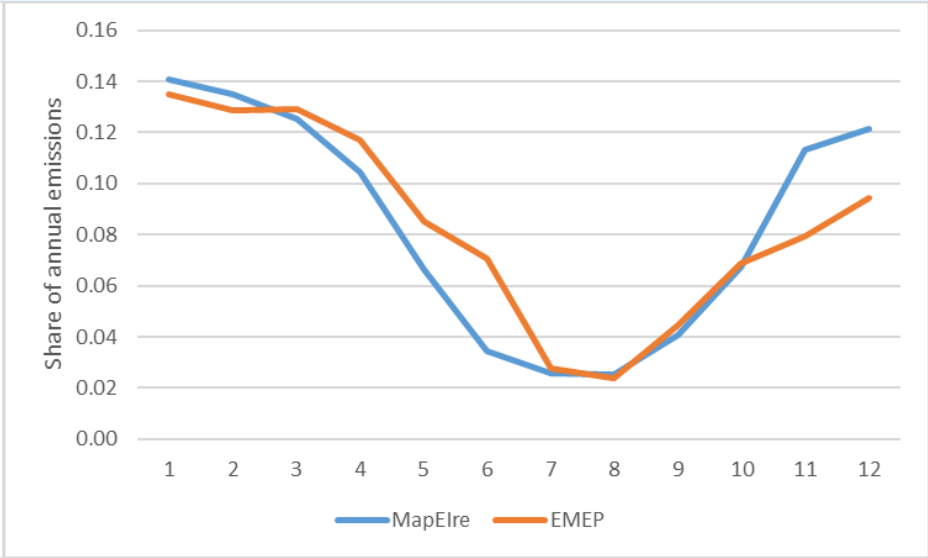
- Significant variations between months and between sectors
- For several key sectors the trend shows the same pattern as for Denmark

Domestic heating

- Monthly data for heating degree days have been collected from Met Éireann for 25 measurement stations for 2015-2017
- [Marlene skriver du lidt om uge og time profiler? Jeps – slides efter temperatur graf]

Heating degree days

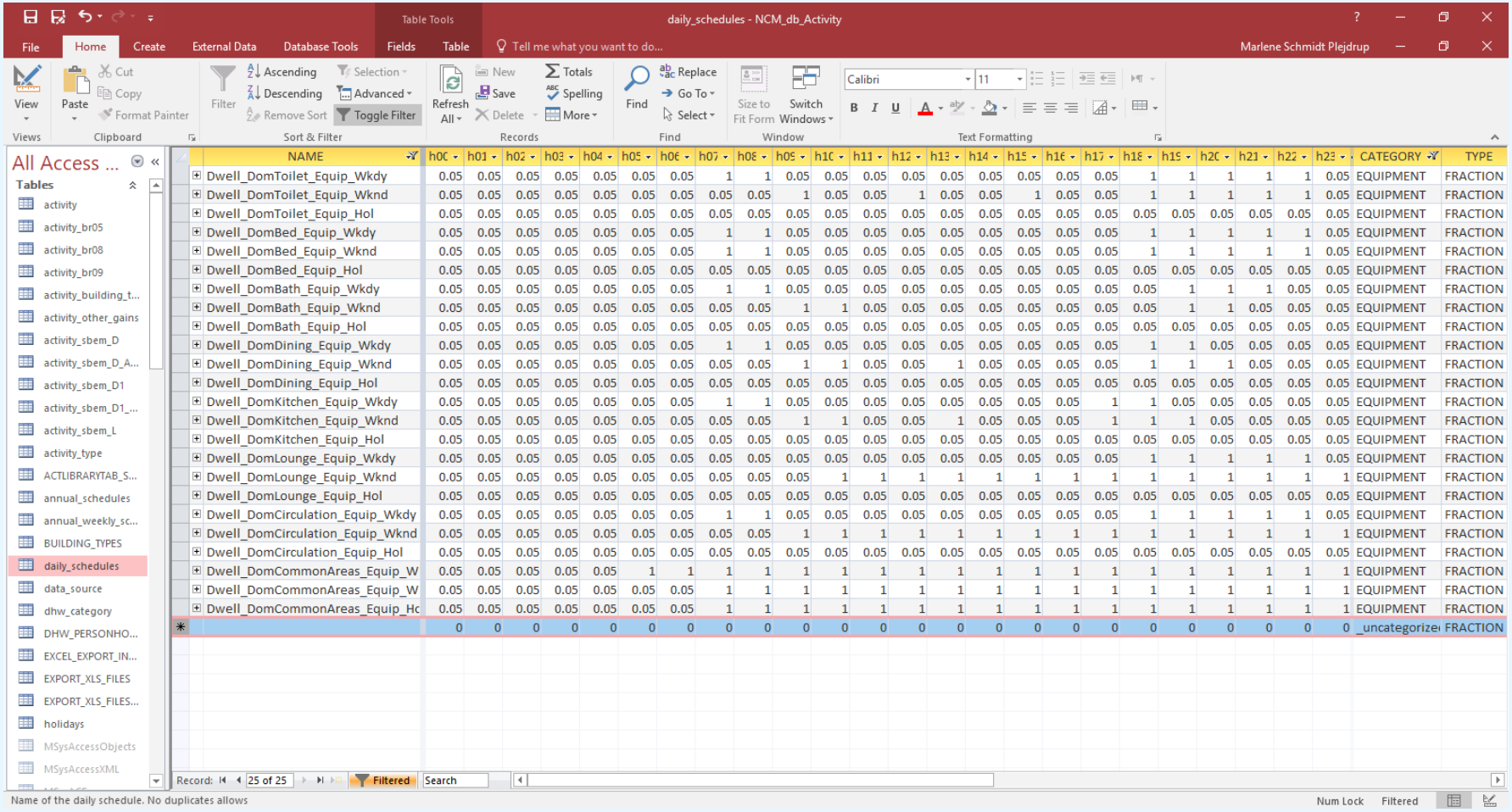




- Data analysed are very consistent
- The profile shows a trend roughly similar to EMEP
- EMEP has lower share for November and December and higher shares for April to July

Data for daily and hourly energy use

- The Non-Domestic Energy Assessment Procedure (NEAP)
  - Ireland's official methodology for calculating a Building Energy Rating (BER) for non-domestic buildings
  - National Calculation Methodology (NCM) activity database
- Building types
  - Residential
    - Dwelling
  - Commercial/institutional
    - Culture, education, health, leisure, public, public transport, and retail
- Activity
    - Equipment


daily_schedules - NCM_db_Activity
Table Tools
File Home Create External Data Database Tools Fields Table
Tell me what you want to do...
Marlene Schmidt Plejdrup
All Access ...
Tables
activity
activity_br05
activity_br08
activity_br09
activity_building_t...
activity_other_gains
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activity_sbem_D1
activity_sbem_D1_...
activity_sbem_L
activity_type
ACTLIBRARYTAB_S...
annual_schedules
annual_weekly_sc...
BUILDING_TYPES
daily_schedules
data_source
dhw_category
DHW_PERSONHO...
EXCEL_EXPORT_IN...
EXPORT_XLS_FILES
EXPORT_XLS_FILES...
holidays
MSysAccessObjects
MSysAccessXML
NAME h00 h01 h02 h03 h04 h05 h06 h07 h08 h09 h10 h11 h12 h13 h14 h15 h16 h17 h18 h19 h20 h21 h22 h23 CATEGORY TYPE
Dwell_DomToilet_Equip_Wkdy EQUIPMENT FRACTION
Dwell_DomToilet_Equip_Wknd EQUIPMENT FRACTION
Dwell_DomToilet_Equip_Hol EQUIPMENT FRACTION
Dwell_DomBed_Equip_Wkdy EQUIPMENT FRACTION
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Dwell_DomCirculation_Equip_Wkdy EQUIPMENT FRACTION
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Dwell_DomCirculation_Equip_Hol EQUIPMENT FRACTION
Dwell_DomCommonAreas_Equip_W EQUIPMENT FRACTION
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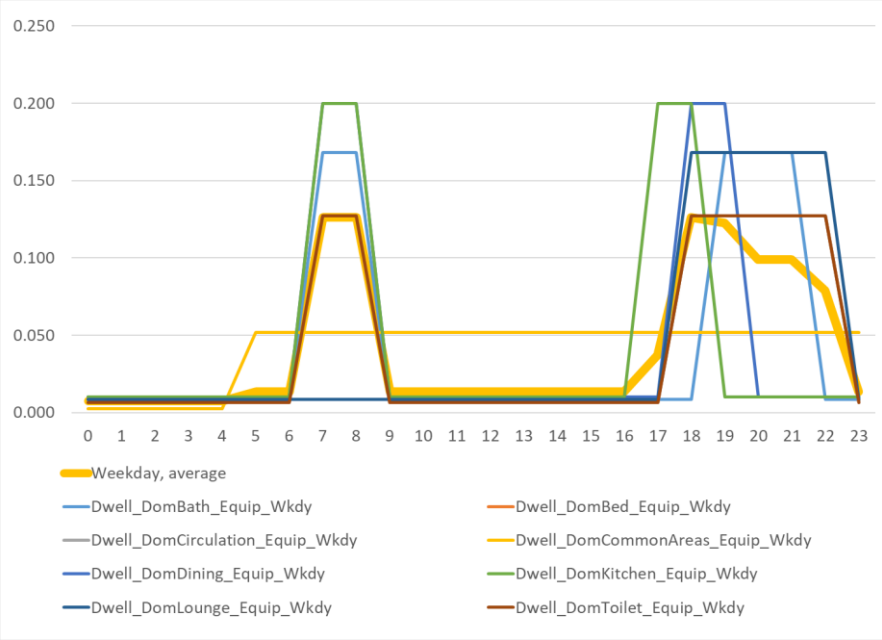
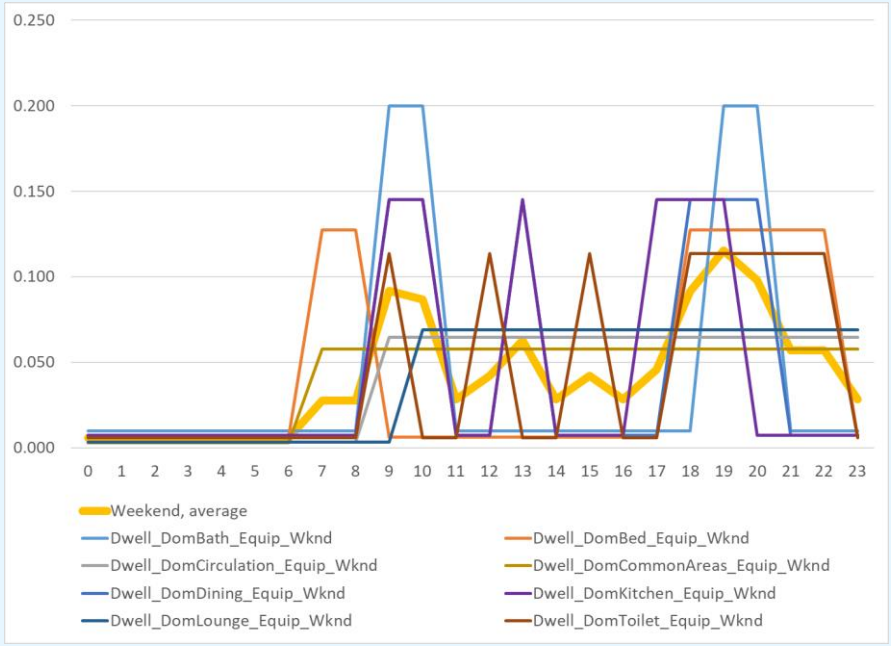
Dwell_DomCommonAreas_Equip_Hc EQUIPMENT FRACTION
_uncategorize FRACTION
Record: 25 of 25
Filtered
Search
Name of the daily schedule. No duplicates allows
Num Lock
Filtered

Residential

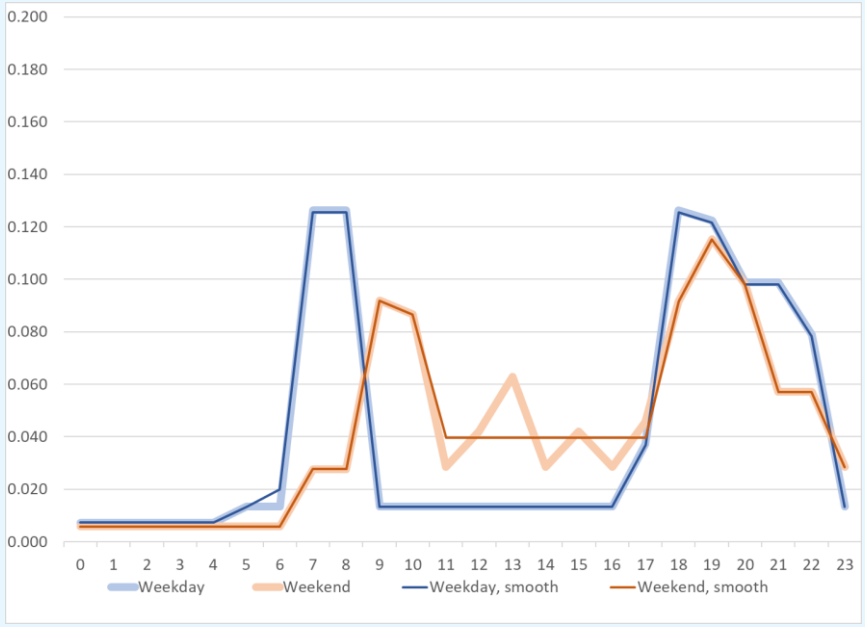


Weekday

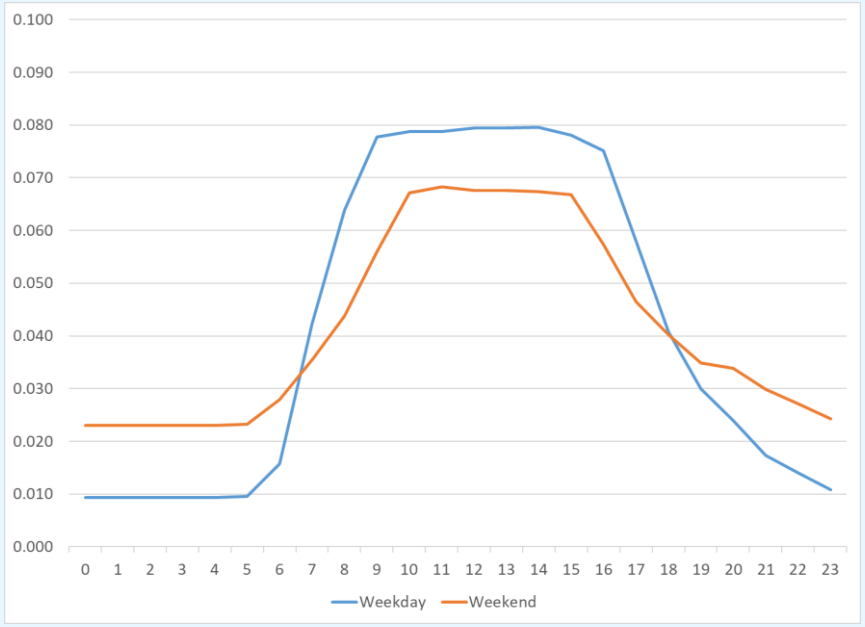


Weekend

Residential and commercial



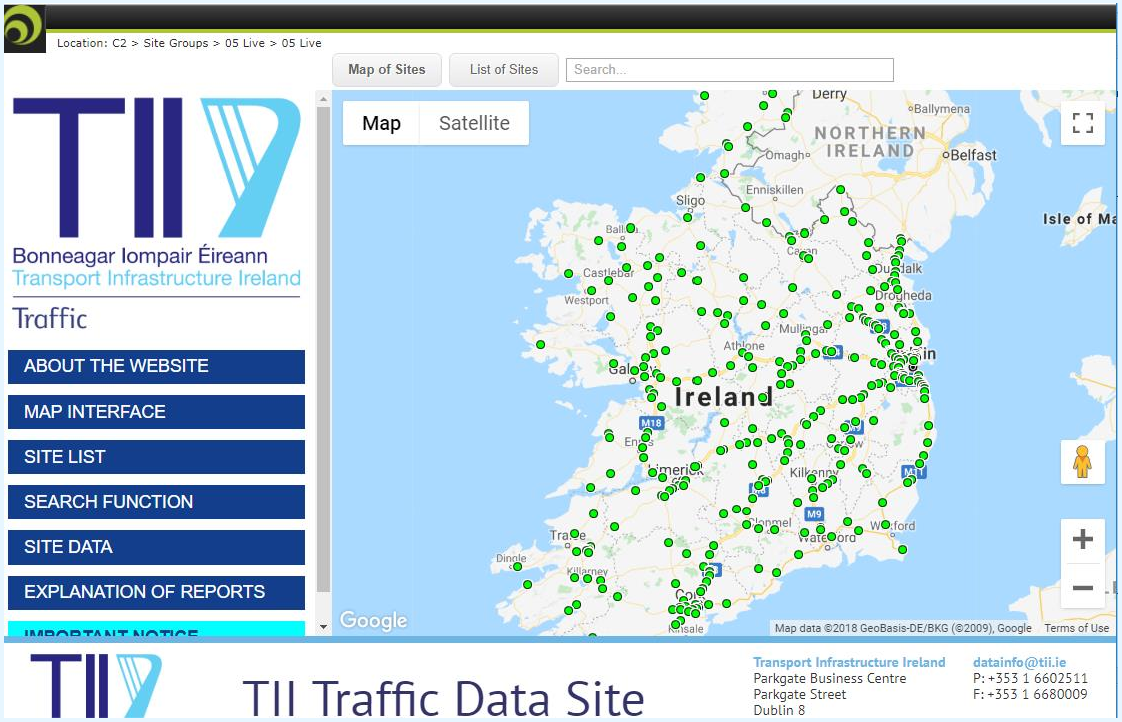
Residential



Commercial/institutional

Road transport

- TII traffic count data
  - Download from the web
- Hourly traffic counts by vehicle type
- Temporal profiles based on 2017 data
- > 300 sites
- Data grouped into two-wheelers, cars, LDV, HDV



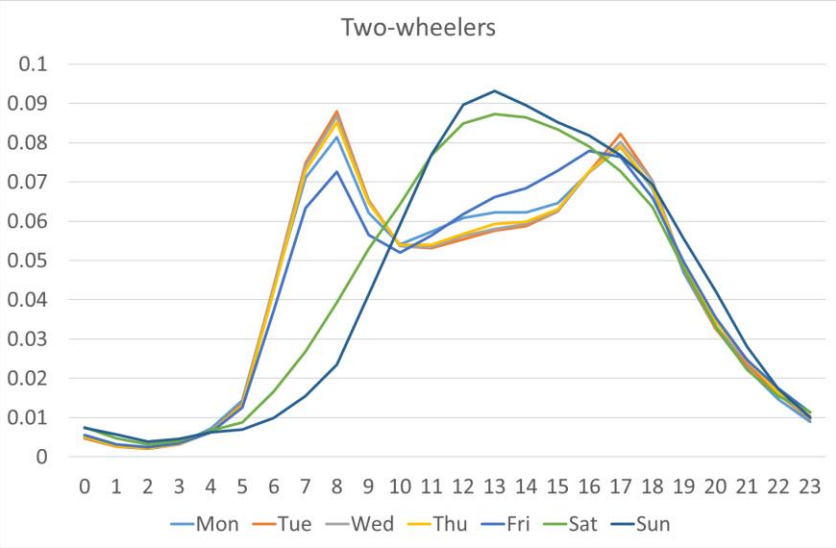
Site Name: TMU N01 040.0 S Site ID: 000000001013 Grid: 316991238959 Description: N01 South of M50 Jn02 Santry, Whitehall

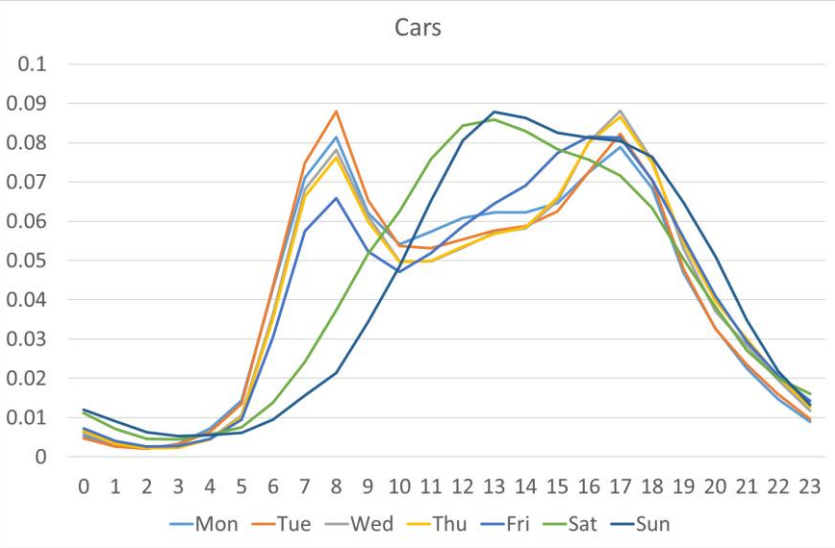
Setup: M1 1013 ▾ | Channel: All directions ▾ | Time Period: 1 hour ▾ | Class: Any ▾ | Precision: Normal ▾ | Exclude data: None ▾

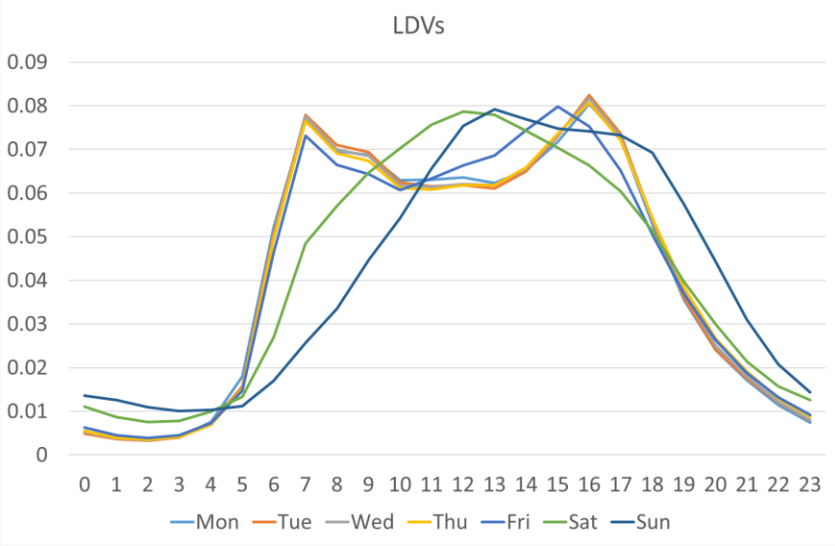
Any
MBIKE
CAR
LGV
BUS
HGV_RIG
HGV_ART
CARAVAN

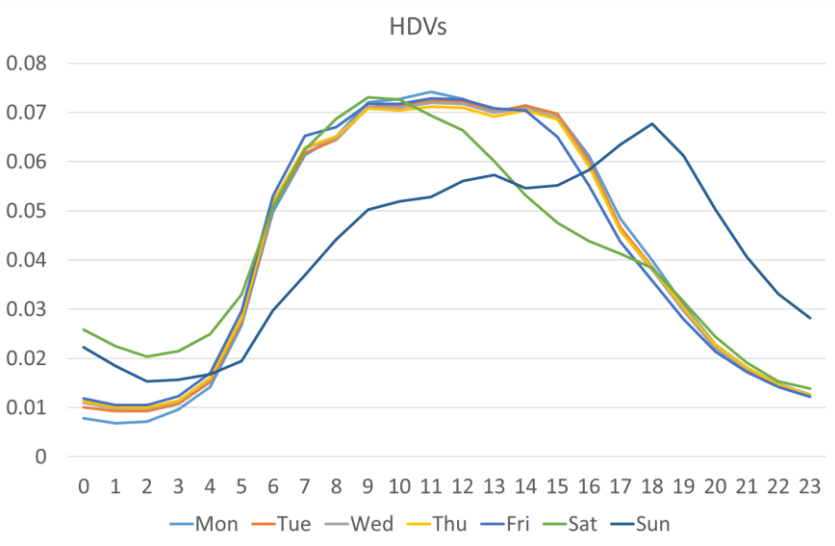
	Sun 1 Jan	Mon 2 Jan	Tue 3 Jan	Wed 4 Jan	Thu 5 Jan	Fri 6 Jan	Sat 7 Jan	Sun 8 Jan	Mon 9 Jan	Tue 10 Jan	W 11				Sun 15 Jan	Mon 16 Jan	Tue 17 Jan	Wed 18 Jan	Thu 19 Jan	Fri 20 Jan	2
00:00	669	705	724	594	611	780	760	698	755	520					668	608	434	425	537	714	
01:00	852	332	262	259	261	330	430	524	287	177					537	186	230	199	293	318	
02:00	714	214	148	155	141	219	311	428	123	130					429	141	139	157	201	217	
03:00	702	351	309	306	293	371	421	466	250	258					452	261	272	274	318	365	
04:00	680	853	777	708	665	789	793	729	694	552					603	706	590	635	727	893	
05:00	679	1084	1172	1077	950	991	863	666	1108	1026					717	1252	1010	1035	1044	1203	
06:00	565	953	1863	2172	2066	2017	880	733	2436	2403					712	2344	2501	2464	2511	2383	
07:00	862	1144	2277	2473	2474	2421	1183	1011	2861	2884					966	2894	2359	2857	2818	2808	
08:00	856	1179	2255	2505	2392	2452	1633	1031	2365	2505					1041	2483	2647	2647	2715	2744	
09:00	965	1218	1979	2143	2199	2238	1909	1377	2503	2529					1626	2551	2592	2640	2569	2694	
10:00	1156	1507	1984	2112	2229	2173	2104	1643	2282	2209					1898	2333	2337	2289	2381	2588	
11:00	1387	1955	2088	2244	2241	2324	2404	1996	2180	2253					2104	2305	2213	2339	2357	2407	
12:00	1820	2238	2165	2222	2259	2390	2459	2312	2223	2286	2264	2282	2430	2721	2544	2346	2218	2311	2438	2601	
13:00	2104	2526	2394	2336	2403	2443	2612	2670	2410	2237	2433	2496	2640	2617	2634	2594	2318	2463	2449	2771	
14:00	2174	2580	2338	2299	2456	2439	2667	2571	2388	2355	2429	2493	2778	2767	2678	2560	2419	2508	2537	2855	
15:00	2259	2539	2436	2347	2459	2547	2388	2670	2377	2513	2583	2620	2821	2443	2842	2604	2590	2714	2798	2979	
16:00	2102	2416	2570	2660	2711	2663	2413	2619	2501	2689	2705	2926	2965	2510	2572	2807	2700	2947	2944	2999	
17:00	1947	2263	2717	2645	2822	2658	2373	2475	2705	2834	3040	2960	3032	2445	2295	2894	2869	3073	3036	3063	
18:00	1872	2106	2462	2374	2573	2593	2134	2363	2596	2811	2761	2761	2664	2192	2408	2845	2760	2835	2799	2873	
19:00	1728	1908	1985	2109	2421	2553	1871	2031	2480	2508	2372	2397	2497	1884	2129	2401	2479	2579	2693	2751	
20:00	1240	1696	1604	1697	1868	1912	1454	1721	1683	1836	1838	1842	1953	1515	1911	1965	2002	1958	2173	2014	
21:00	1047	1286	1132	1378	1445	1495	1159	1315	1369	1579	1619	1414	1598	1170	1452	1577	1616	1742	1814	1664	
22:00	934	1057	1063	1039	1330	1323	1011	1119	1047	1208	1313	1209	1420	966	1226	1114	1133	1506	1672	1586	
23:00	822	932	864	702	967	940	1040	999	685	878	742	937	1074	933	1022	768	802	949	1095	1276	
07-19	19504	23671	27665	28360	29218	29341	26279	24738	29391	30105	30394	30678	31879	28068	25608	31216	30022	31623	31841	33382	
06-22	24084	29514	34249	35716	37018	37318	31643	30538	37359	38431	38734	38748	40072	33567	31812	39503	38620	40366	41032	42194	
06-24	25840	31503	36176	37457	39315	39581	33694	32656	39091	40517	40789	40894	42566	35466	34060	41385	40555	42821	43799	45056	
00-24	30136	35042	39568	40556	42236	43061	37272	36167	42308	43180	43471	43673	45749	39109	37466	44539	43230	45546	46919	48766	
am Peak	11:00	11:00	07:00	08:00	07:00	08:00	11:00	11:00	07:00	07:00	07:00	07:00	07:00	11:00	11:00	07:00	08:00	07:00	07:00	07:00	
Peak Volume	1387	1955	2277	2505	2474	2452	2404	1996	2861	2884	2855	2678	2788	2669	2104	2894	2647	2857	2818	2808	
pm Peak	15:00	14:00	17:00	16:00	17:00	16:00	14:00	13:00	17:00	17:00	17:00	17:00	17:00	14:00	15:00	17:00	17:00	17:00	17:00	17:00	

Road transport – hourly profiles

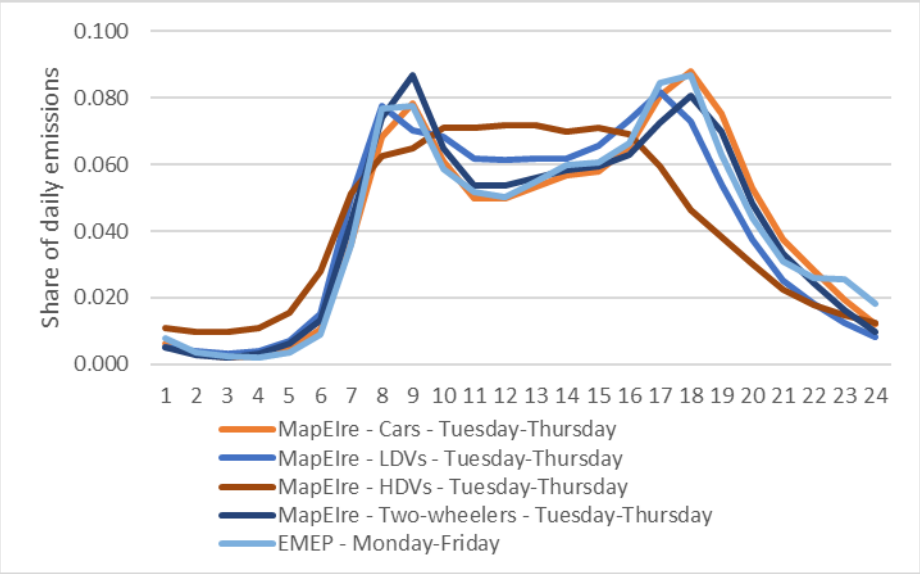






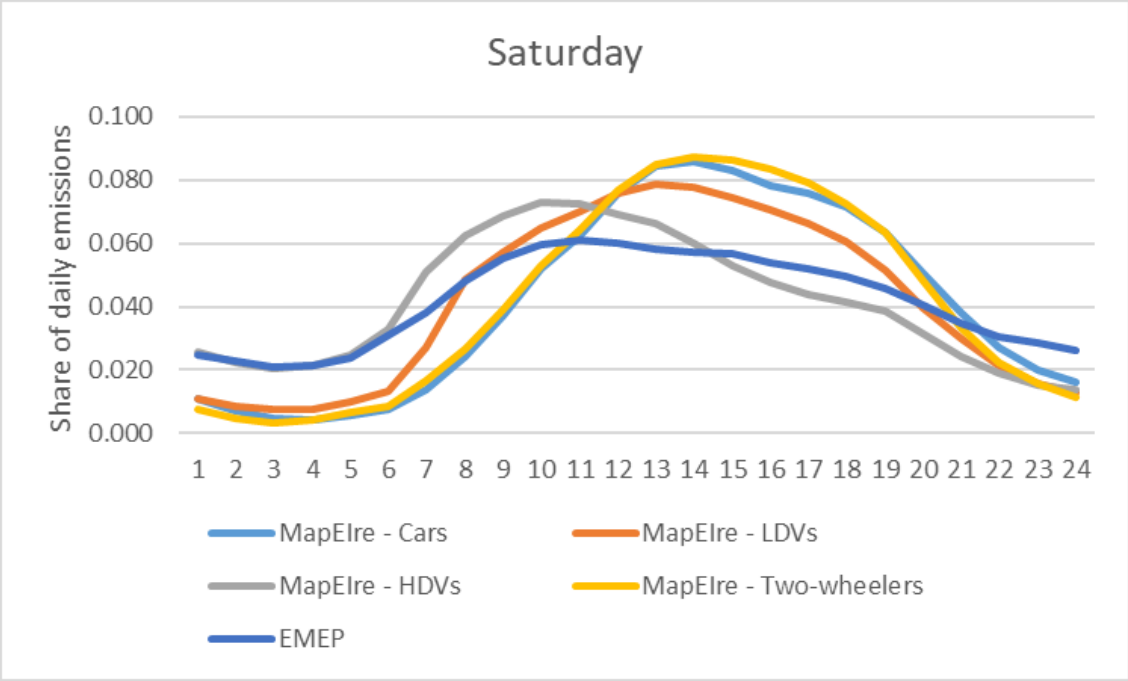


Road transport – hourly profiles (Tue-Thu)



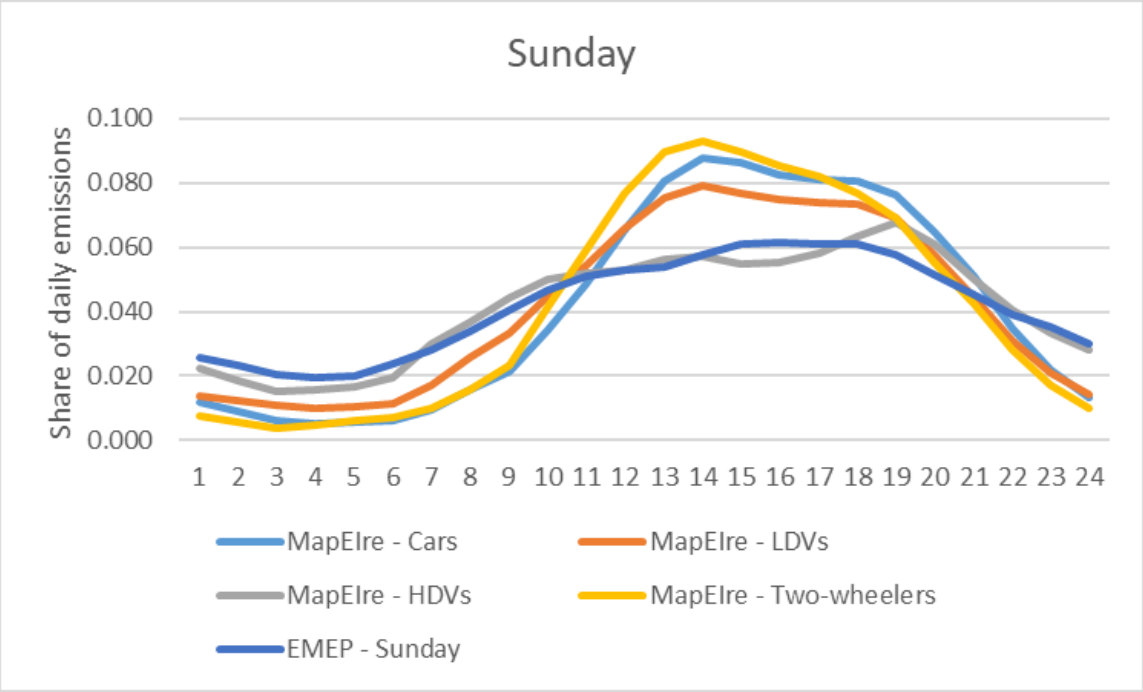
- Distinct difference between HDVs, LDVs and cars/two-wheelers
- Good agreement between EMEP profile and cars, while EMEP does not consider different vehicle categories

Road transport – hourly profile (Saturday)



- Again a significant difference between vehicle categories
- The EMEP profile for Ireland differs significantly from all Irish vehicle categories

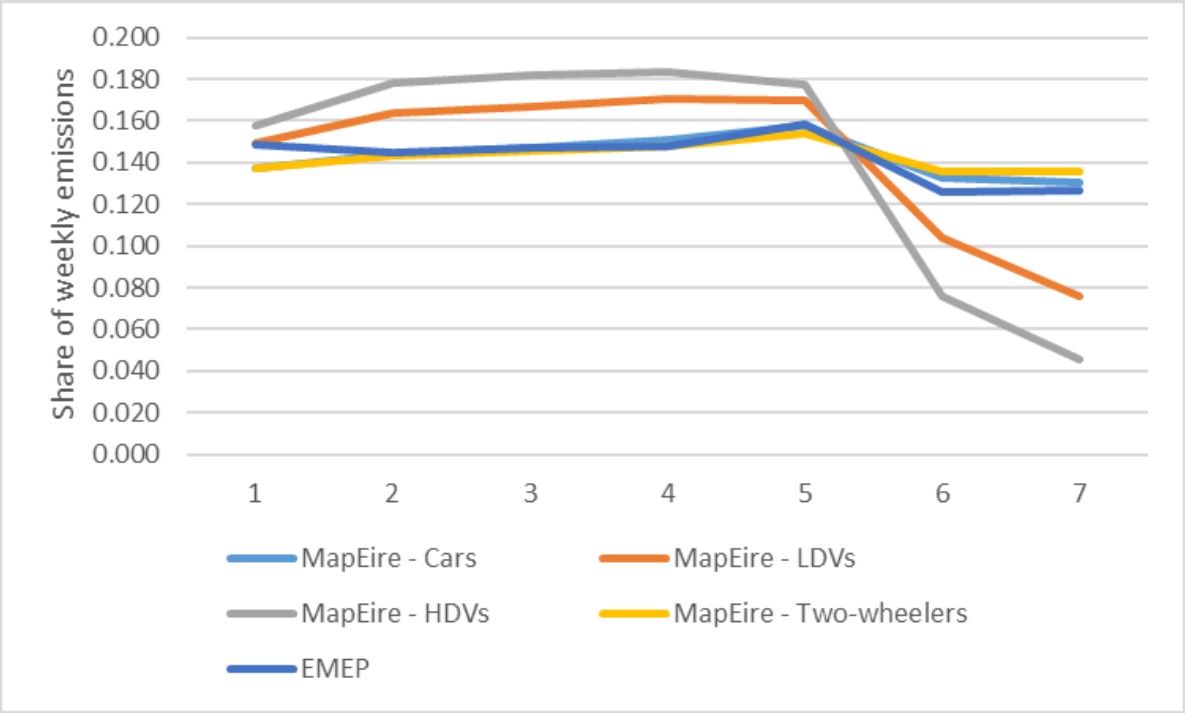
Road transport – hourly profile (Sunday)



› Big difference between HDVs and other vehicle categories

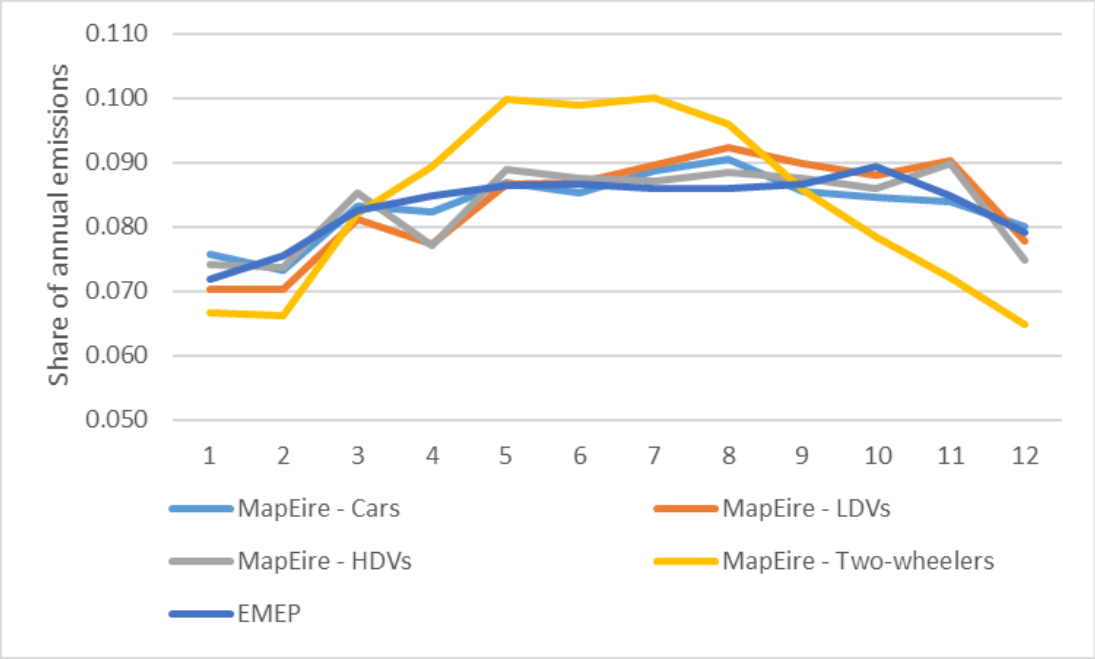
› EMEP profile for Ireland almost mirrors HDVs

Road transport – daily profile



- Big difference between vehicle categories, especially in weekends
- The EMEP profile for Ireland is almost identical to cars

Road transport – monthly profile

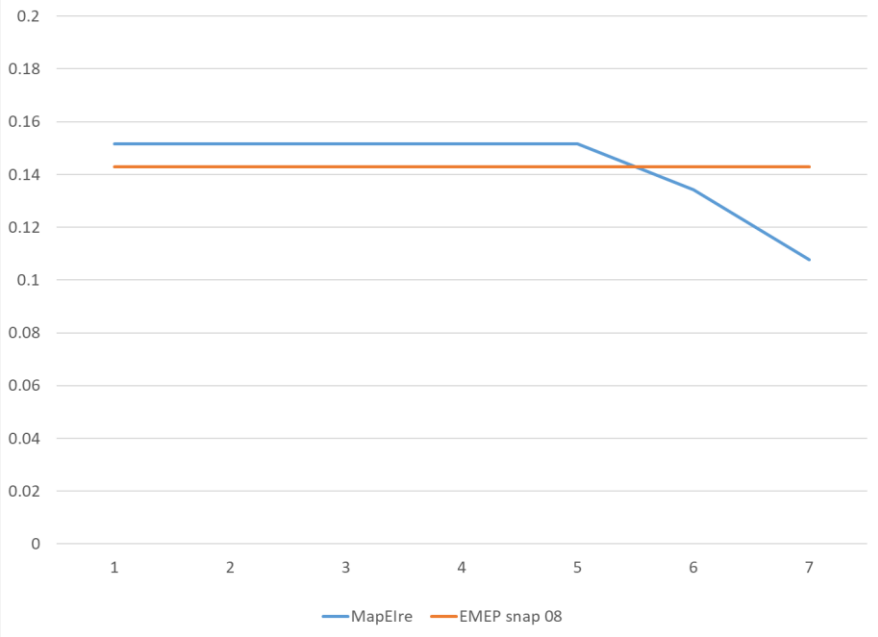


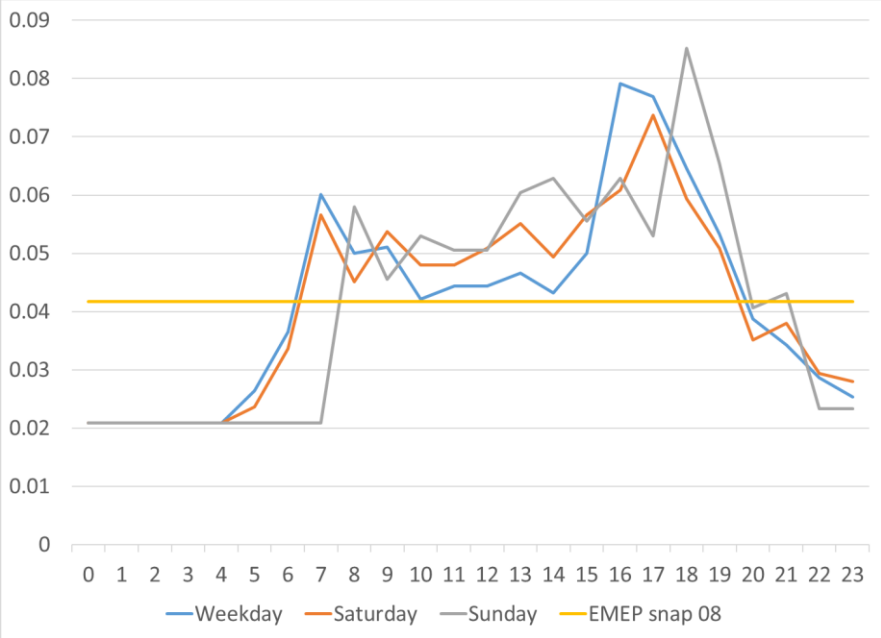
- Most significant difference is for two-wheelers with an emphasis on summer months
- The EMEP profile is reasonably consistent with Irish data

Railways

- Irish rail time tables
- Number of routes by start hour for weekdays, Saturday and Sunday
- Cargo assumed to contribute 50 % of the emission and being evenly distributed

Daily and hourly profiles for railways



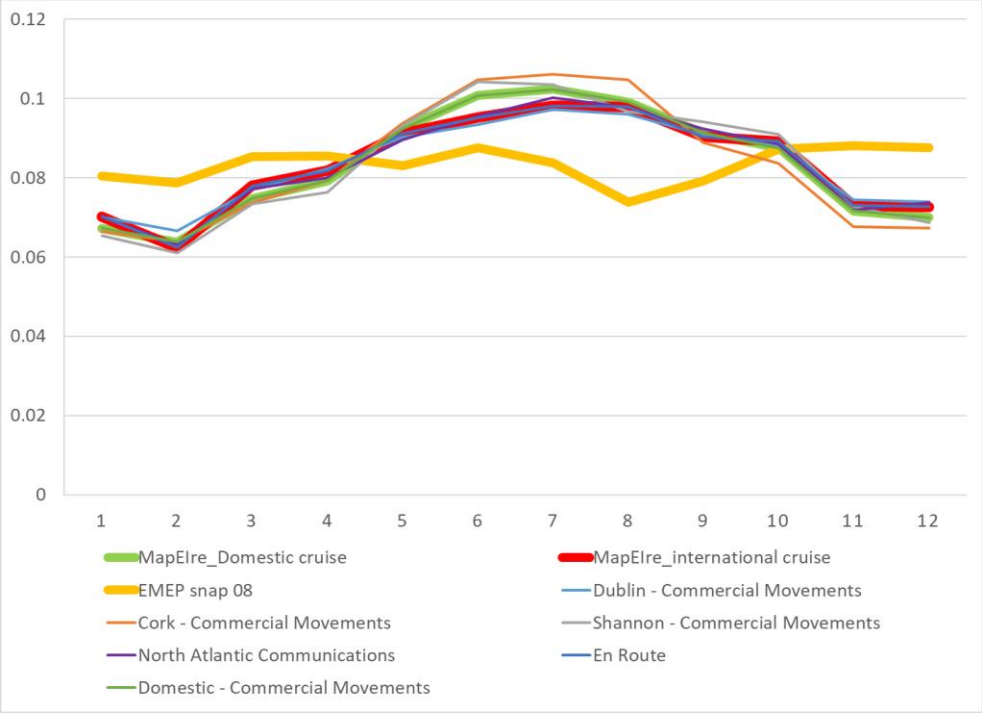


- Big difference between weekdays and weekends as well as during the days
- EMEP uses a constant profile for all non-road mobile sources

Aviation

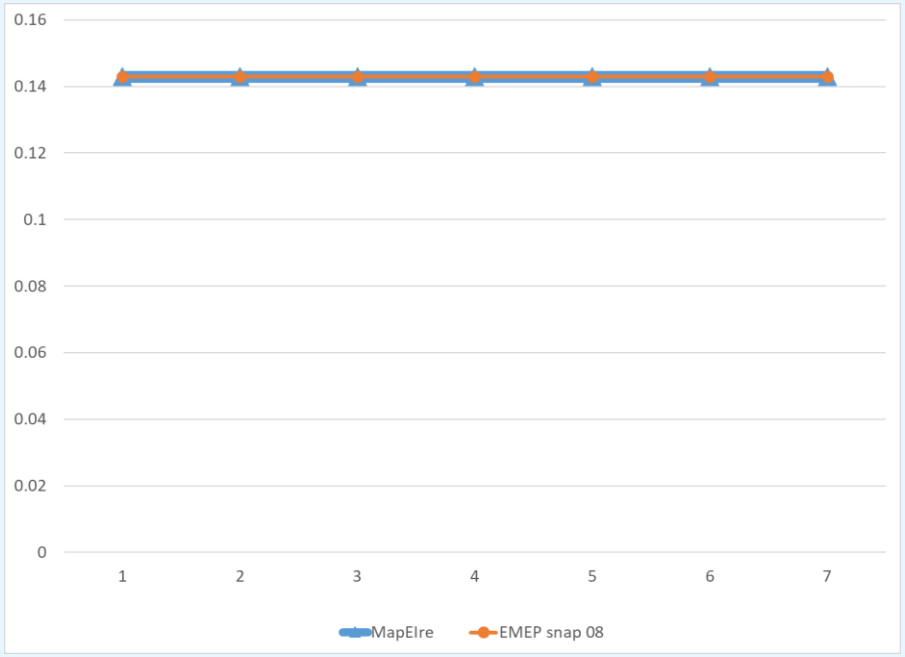
- For monthly profile the data are from the Irish Aviation Authority
- Monthly domestic and international commercial movements for Dublin, Cork and Shannon airport
- For the daily and hourly profiles, Dublin airport timetables for summer and winter 2017 have been analysed
- Number of domestic and international departures by start hour and by day of week

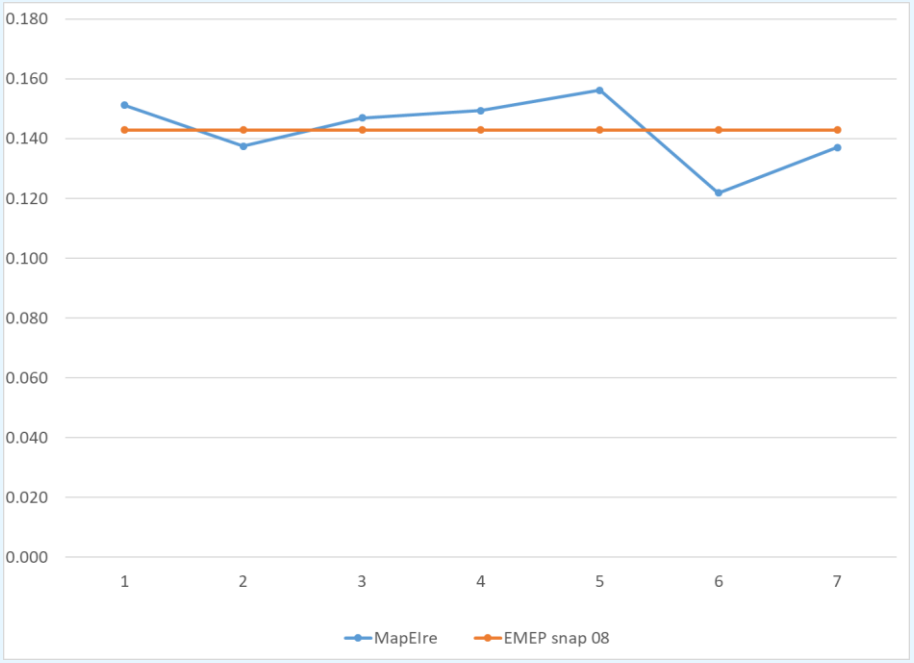
Monthly profile – aviation



- Similar profiles for the various airports with data
- Pronounced difference between summer and winter in the Irish data compared to the EMEP profile

Daily profiles for aviation





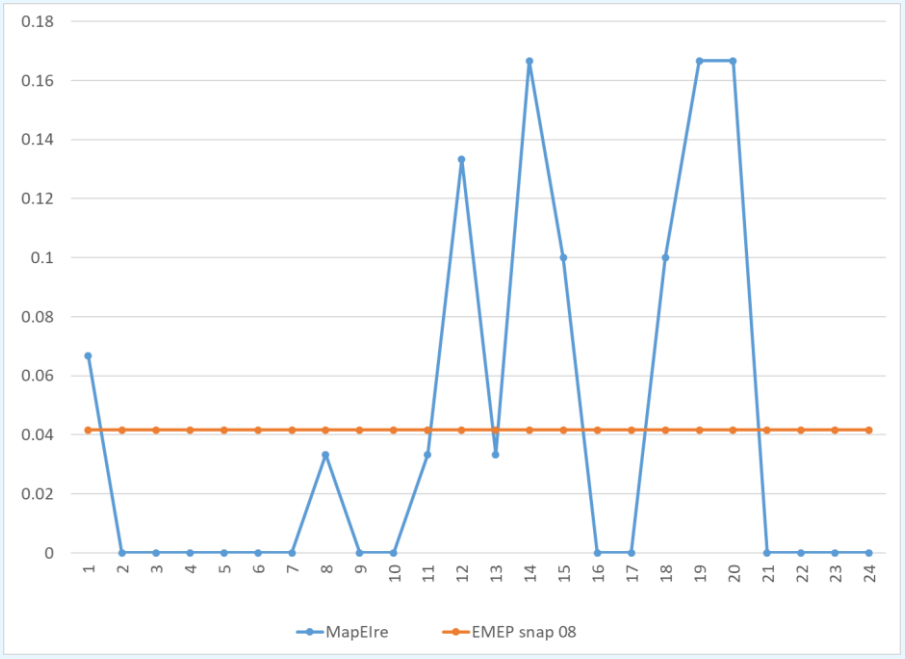
Domestic

Even profile

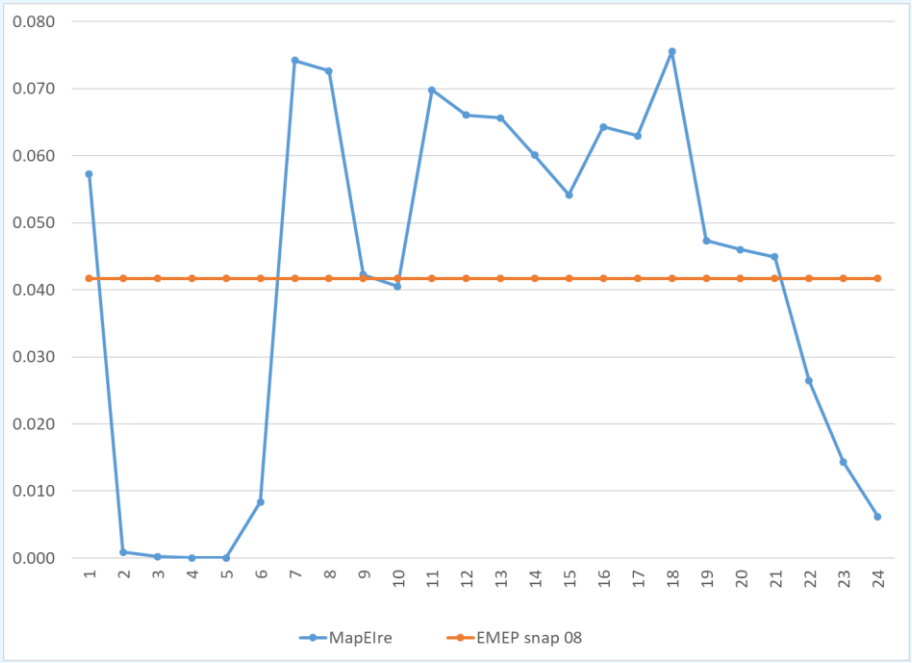
International

Difference between weekdays and weekend

Hourly profiles for aviation



Domestic



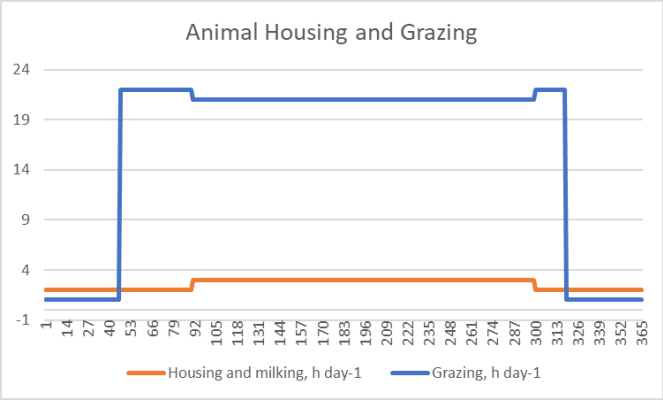
International

Agriculture

- Emissions from Agriculture and LULUCF are biological, chemical, physical and temperature dependent processes !
  - Not instant emissions
  - Give challenges on the temporal scale
  - If the temporal scale are becomes small, the uncertainty of the estimates becomes very large

Data sources

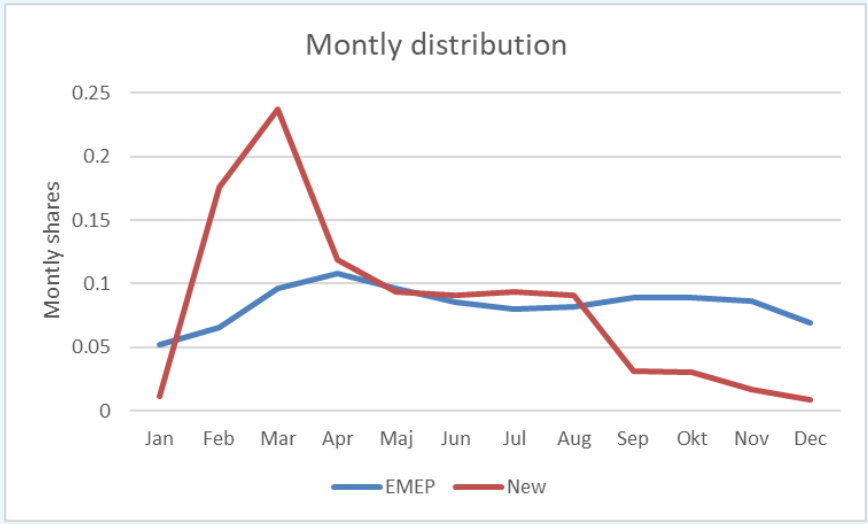
- Primary data sources
  - Recommended time for N application (Teagasc)
  - Housing days (Information from EPA)
  - Cultivation activities



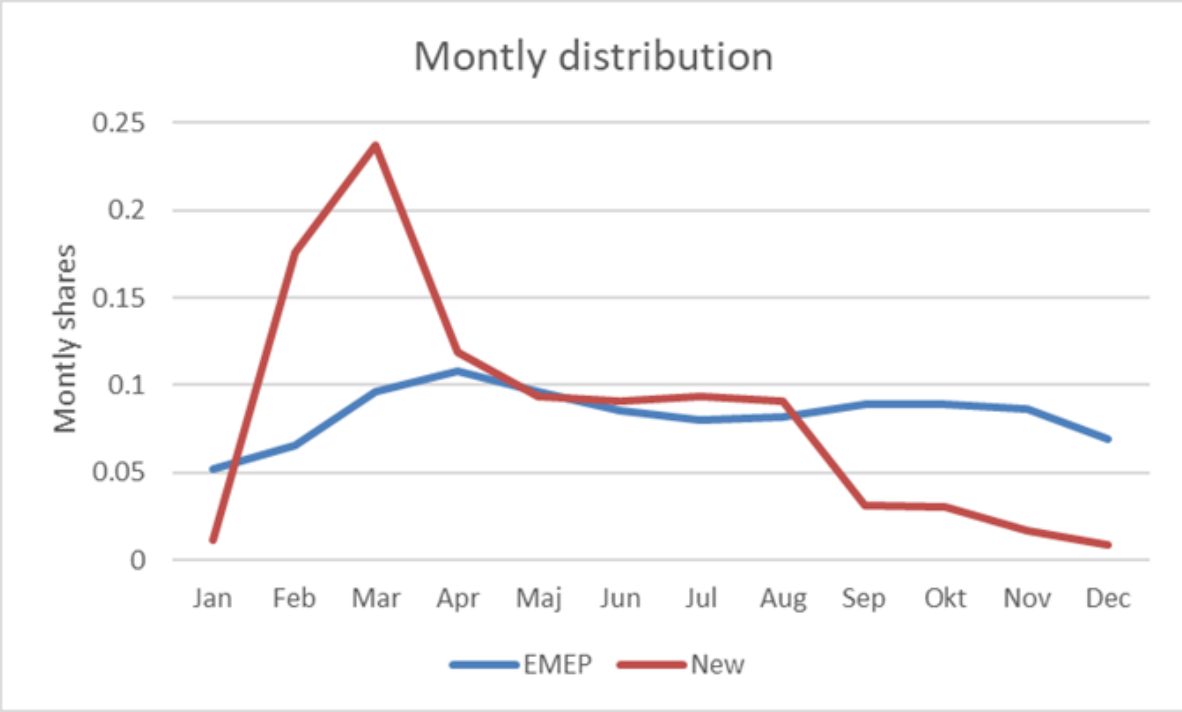
  - Currently no adjustments for differences in
    - temperature between winter and summer
    - Feed intake due to differences in milk production for dairy cows
      - Can be made with the IPCC model for feed intake
    - Daily patterns (temperature, solar radiation)

Monthly profile for mineral fertiliser

- The System:
  - Month: Sum = 1
  - Week: Sum = 1
  - Hour: Sum = 1
- Example: Mineral fertilizers
  - Cropland: Spring application
  - Grazing land: Spring and summer application
- Differences between every grid cell
  - Improvements can be made



Monthly profile for NH_3 – EMEP and new



- This is overall
  - More detailed as these are the sum of all SNAP 10 codes
  - Dominated by animal manure applied to soil

1A4cii: agricultural machinery

- Based on agricultural activies
- Model set up also used for PM and TSP

					Monthly distribution											
Annual Crops	Number/occasions	Capacity, ha/hour	Fuel consumption, l/ha/occasion	Fuel consumption, l/ha	1	2	3	4	5	6	7	8	9	10	11	12
Ploughing	1	0.52	19.6	19.6										1		
Fertilizer application	2	5.29	1.7	3.4		0.2	1	0.4	0.4							
Harrowing	3	6.17	10.9	32.7									1	2		
Sowing	1	4.27	4.6	4.6										1		
Rolling	1	3.83	1.8	1.8										1		
Pesticide application	5	4.12	1.5	7.5			1		1	2				1		
Harvesting	1		20.2	20.2								0.5	0.5			
Transport of harvest	0			0.0												
Bailing of straw	1		7.1	7.1								0.5	0.5			
Transport of straw	0															
Total				96.9												

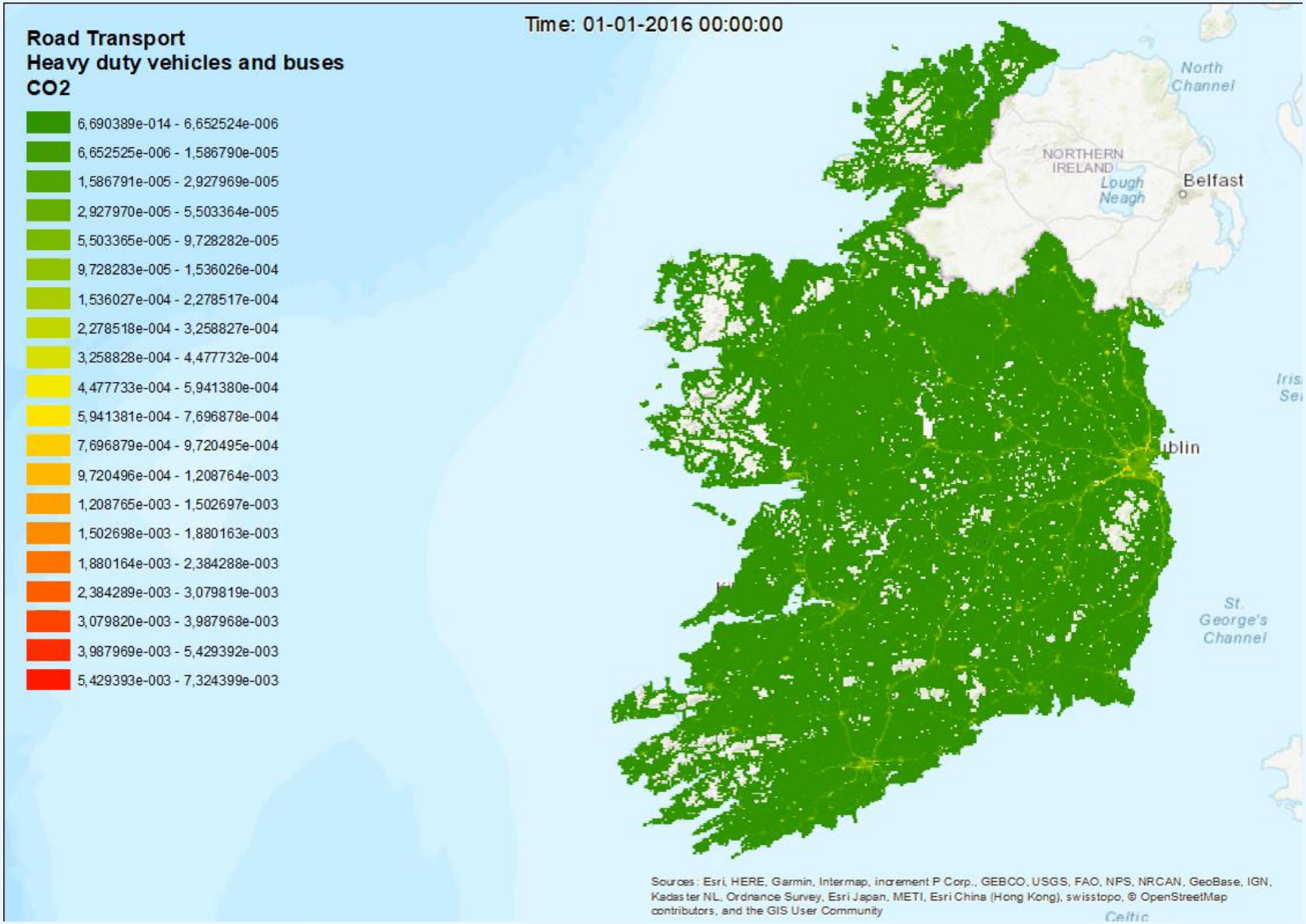
Source: Fuel consumption: Danish studies in 2004

GHG and LULUCF

- The temporal scale is very uncertain
- The model set with: Sum = 1
  - Does not allow a set up with sources and sinks
  - Sinks should then be negative values
- Emissions from organic soils could be shown/incorporated
  - It is our opinion that the map for organic soils should be improved
  - There is a likely mismatch between the inventory and current soil map
  - No data on peat excavation is available

Results

- Results are easiest visualised by creating videos showing the dynamics of the emissions
- In many cases, the variability in emissions is relatively small, which means that it is difficult to visualise the results
- Some good examples of emission sources with large temporal availability are road transport and residential combustion


Road Transport
Heavy duty vehicles and buses
CO2
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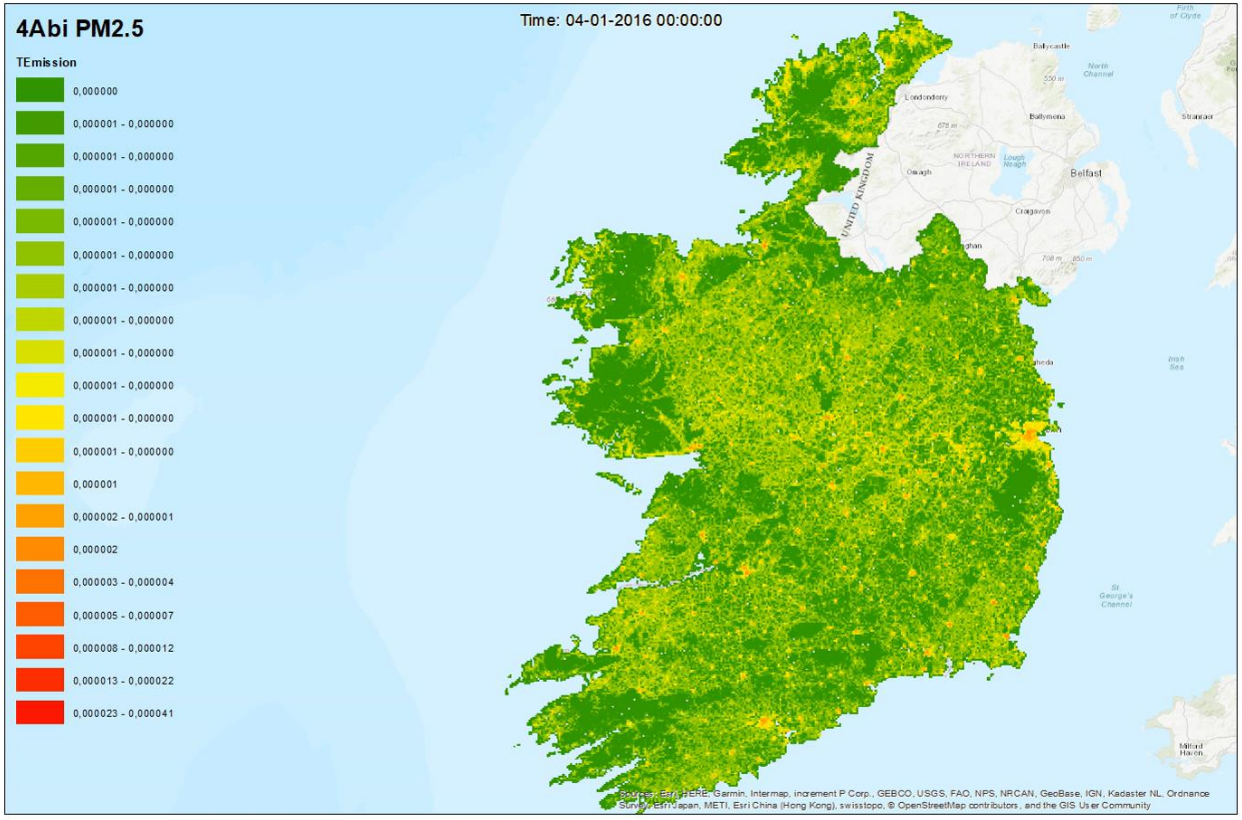
3,987969e-003 - 5,429392e-003
5,429393e-003 - 7,324399e-003
Time: 01-01-2016 00:00:00
North Channel
NORTHERN IRELAND
Lough Neagh
Belfast
St. George's Channel
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community

Residential combustion



Conclusions

- The work has improved the knowledge on the temporal distribution
  - The uncertainty on the temporal scale is large
- Taking into account the actual year, i.e. holidays
- Temporal scale can be improved by having different temporal models for different land use types, i.e.
  - one for cropland
  - one for grassland and grazing land

Thank you for your attention!