HERMESv3

A **python-based, open source, parallel and stand-alone multiscale** atmospheric emission model that **processes and estimates gas and aerosol emissions** for use in chemistry transport models

| global-regional module (HERMESv3_GR)	bottom-up module (HERMESv3_BU)
A **processing system** to calculate emissions through an automatic **combination of existing inventories** and user defined vertical, temporal and speciation profiles	An **emission model** to estimate emissions at the source level (e.g. road link) combining state-of-the-art **bottom-up methods** with local activity and emission factors

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HERMESv3_GR

Existing emission inventories
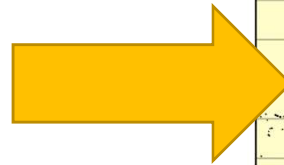
HERMESv3_GR output

Road transport - CO2 hourly emissions (2017/01/01)
Time: 2017-01-01 00:00 +0000

mol · h-1
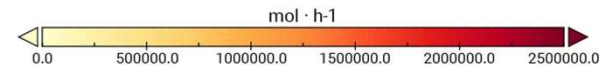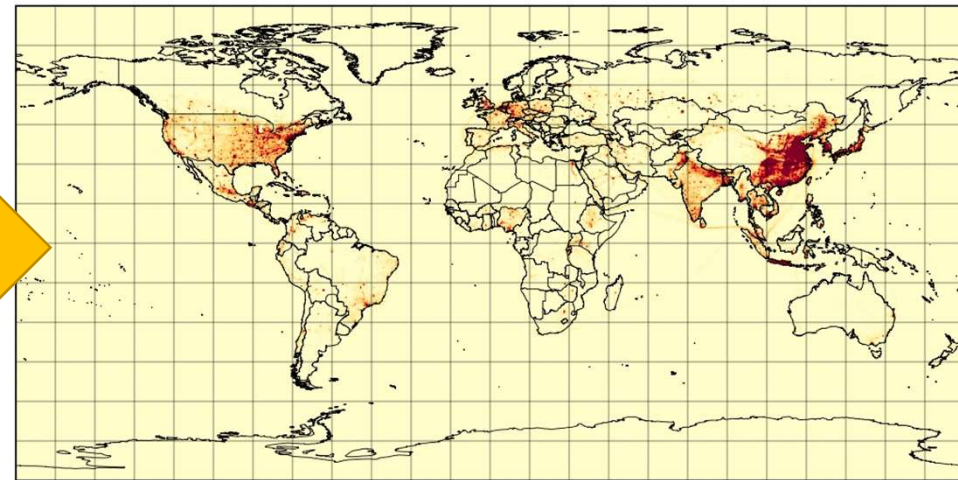
- Multiple up-to-date gridded emission inventories available to the user
- User defined destination working domain (conservative remapping)
- Combination of multiple emission inventories
- Application of country-specific scaling factors
- Monthly, weekly and diurnal profiles per sector and pollutant
- Speciation profiles for multiple chemical mechanisms (CB05, AERO5 and AERO6)

HERMESv3_GR: Emission data library

Multiple up-to-date gridded emission inventories available to the user

| Name	Sources	Spatial res/cov	Temporal res/cov	Reference
EDGARv4.3.2	Anthropogenic	Global (0.1x0.1)	Annual (1970 – 2012) Monthly (2010)	Cripa et al. (2018) Huang et al. (2017)
CEDS	Anthropogenic	Global (0.5x0.5)	Monthly (1851 – 2014)	Hoesly et al. (2018)
ECLIPSEv5.a	Anthropogenic	Global (0.5x0.5)	Monthly (1990 - 2050)	Klimont et al. (2017)
HTAPv2.2	Anthropogenic	Global (0.1x0.1)	Monthly (2008 and 2010)	Janssens-Maenhout et al. (2015)
GFASv1.2	Biomass burning	Global (0.1x0.1)	Daily (2012-present)	Kaiser et al. (2012)
CAMS-GLOB_ANTv2.1	Anthropogenic	Global (0.1x0.1)	Monthly (2000 - 2018)	Elguindi-Solmon et al. (under preparation)
CAMS-GLOB_SHIPv1.1	Anthropogenic	Global (0.25x0.25)	Daily (2000 - 2018)	Jalkanen et al. (2011)
CAMS-GLOB_OCEANv1.1	Ocean	Global (0.5x0.5)	Daily (2000 - 2015)	-
CAMS-GLOB_SOILv1.1	Soil	Global (0.5x0.5)	Monthly (2000 - 2015)	-
Carn	Volcanoes (degassing)	Point sources	Annual (2005 – 2015)	Carn et al. (2017)
Wiedinmyer	Open air trash burning	Global (0.1x0.1)	Annual (2010)	Wiedinmyer et al. (2014)
TNO_MACC-iii	Anthropogenic	Regional (0.0625*0.125)	Annual (2000 – 2011)	Kuenen et al. (2014)
EMEP	Anthropogenic	Regional (0.1x0.1)	Annual (2000 – 2016)	Mareckova et al. (2017)
CAMS-REG_APv2.2.1	Anthropogenic	Regional (0.1*0.05)	Annual (2000 – 2015)	Kuenen et al. (2014)

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Designing and adjusting the emission modelling experiment:

- Combination of multiple emission inventories
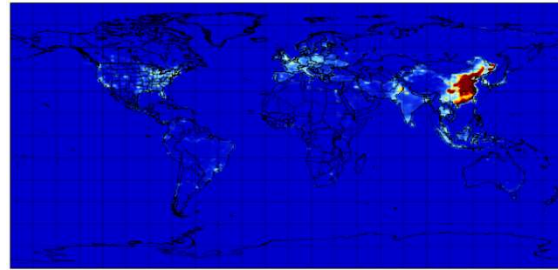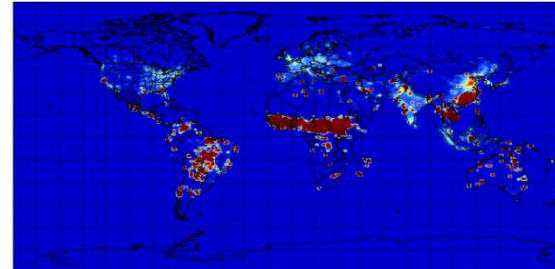- Country-specific scaling factors
- Country-specific masks
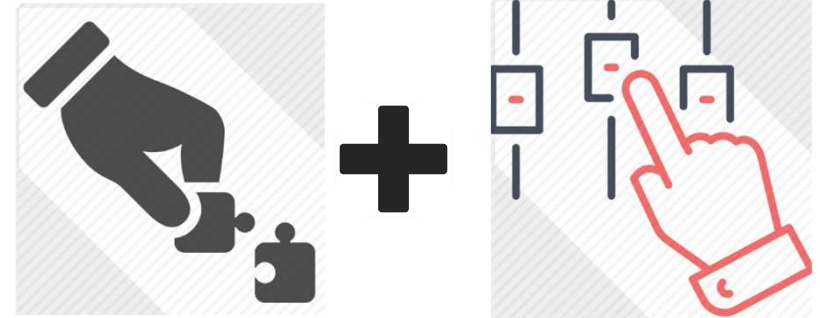
1 HTAPv2.2
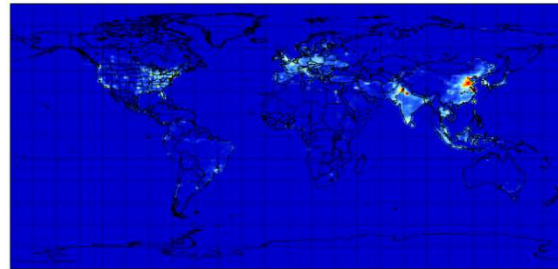
2 HTAPv2.2 + GFASv1.2

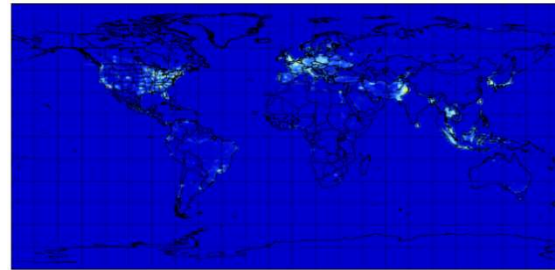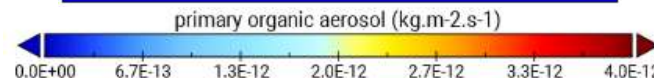**3** HTAPv2.2 (China x5, India x0.5)

4 HTAPv2.2 (China and India masked out)

5 ECLIPSEv5.a (China and India) HTAPv2.2 (other countries)

primary organic aerosol (kg.m-2.s-1)

0.0E+00   6.7E-13   1.3E-12   2.0E-12   2.7E-12   3.3E-12   4.0E-12

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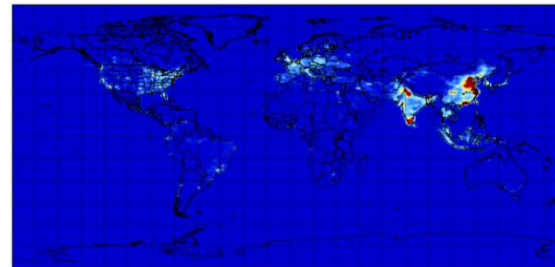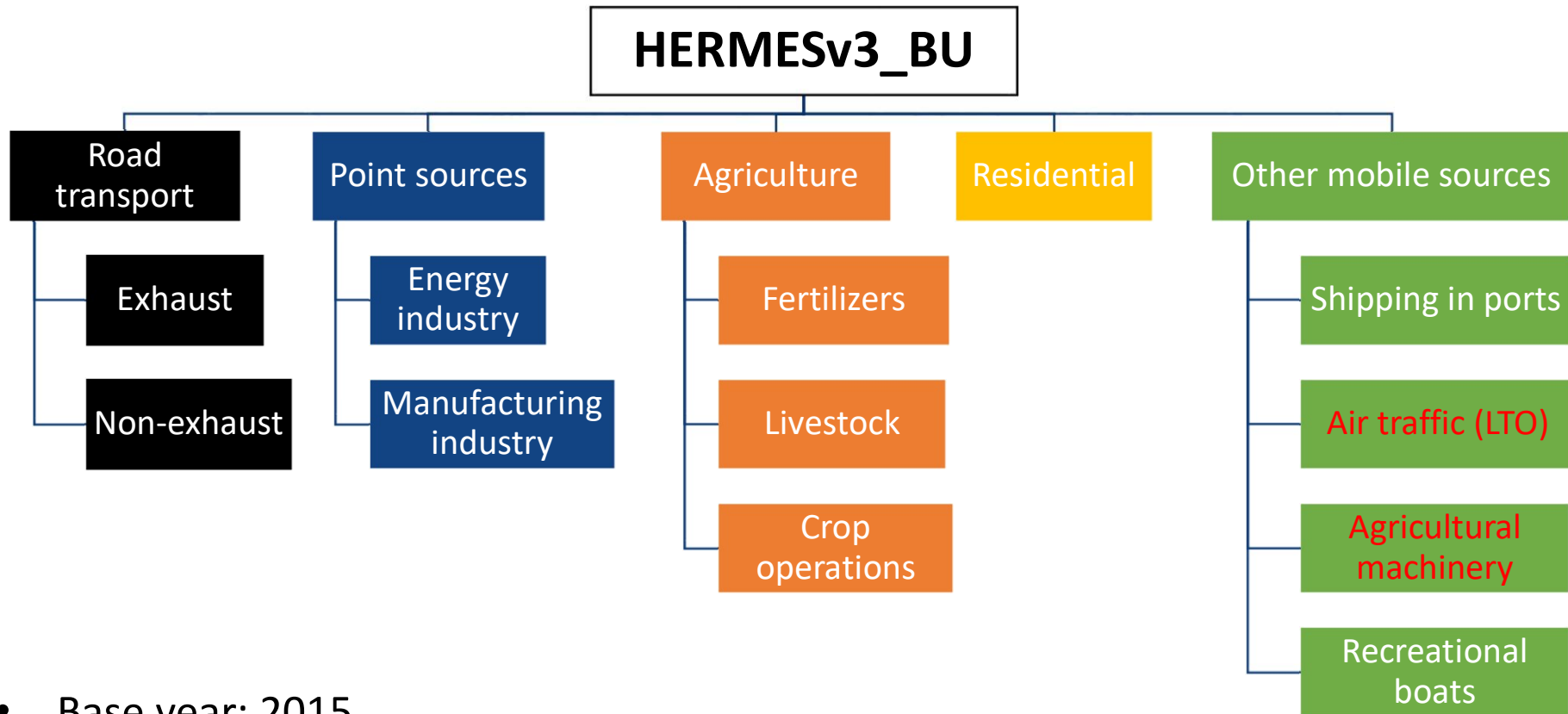
HERMESv3_BU

- Base year: 2015

- Pollutants included: NO_x, CO, SO_x, NMVOC, NH_3, PM_{10}, $PM_{2.5}$, CO_2, CH_4

- Speciation profiles: CB05 and AERO5

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HERMESv3_BU: Road transport

Traffic flow data (vehicle counts and speed)
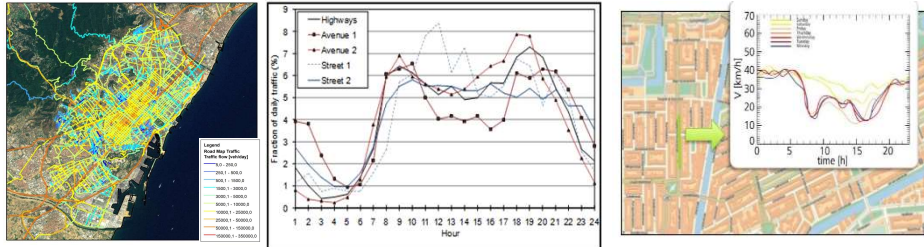
Vehicle fleet composition

Emission factors (speed dependent)

+ resuspension
(Amato et al., 2012)

Meteo parameters

Temperature to account for variation in
evaporative/cold-start emissions

NO2 traffic emissions
(20/01/2015)

12:00AM

NO2 (kg/h)
- < 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1.1 - 5
- 5.1 - 10
- 10.1 - 20
- 20.1 - 50
- > 50.1
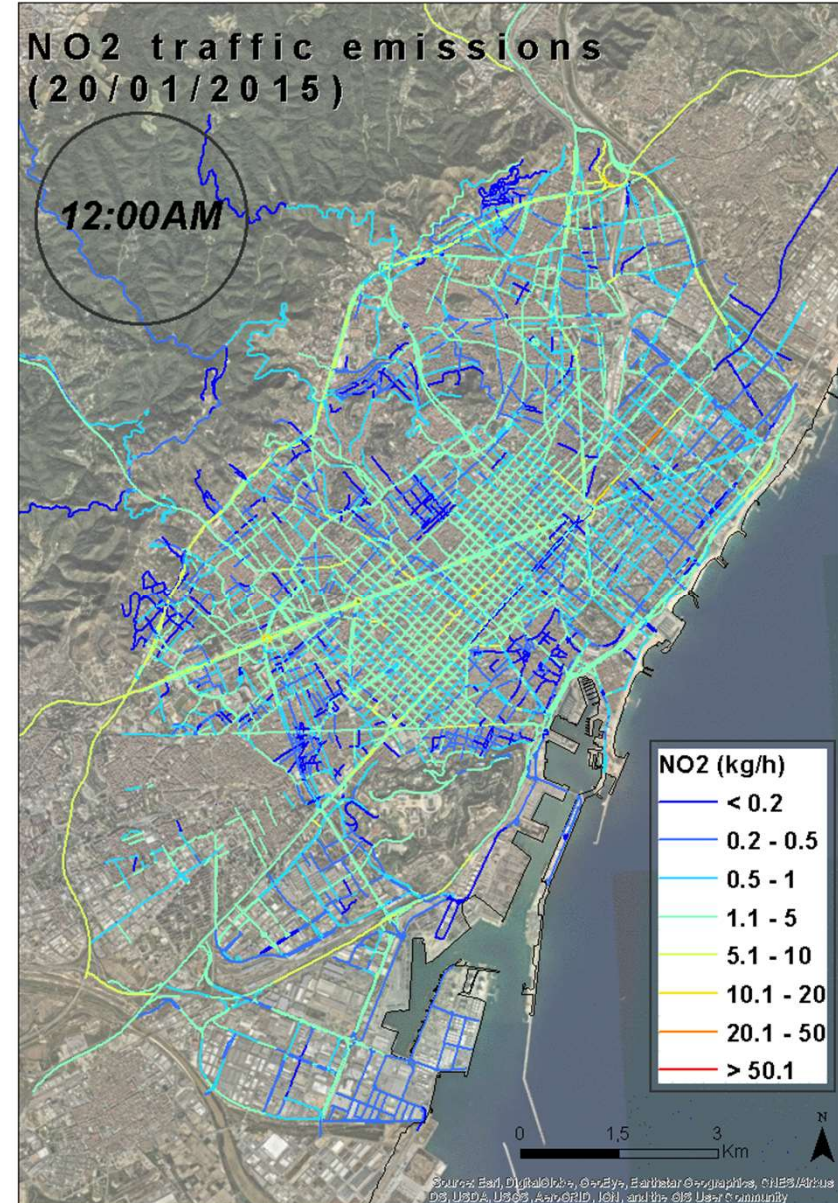
HERMESv3_BU: Road transport

Pollutants included: NO_x, CO, SO_x, NMVOC, NH_3, PM_{10}, $PM_{2.5}$, CO_2, CH_4

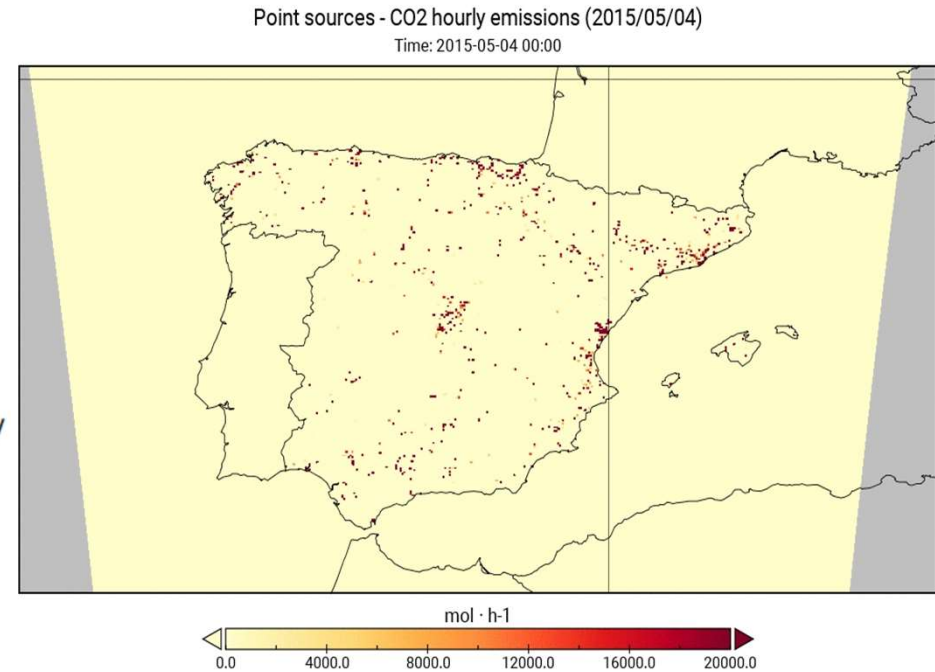Configuration options:

- Select type of source
    - ❖ do_hot = 1
    - ❖ do_cold = 1
    - ❖ do_tyre_wear = 1
    - ❖ do_brake_wear = 1
    - ❖ do_road_wear = 1
    - ❖ do_resuspension = 1
    - ❖ do_evaporative = 0
    - ❖ do_other_cities = 0

- Clip area of interest with a given shapefile or a defined square (lat lon points)

- Select type of vehicles

    - ❖ vehicle_types = BD_11 BD_12 (···)

HERMESv3_BU: Point sources

Legend:
- Power Station
- Refinery
- Coke Oven
- Cement
- Cogeneration
- Fine Ceramics
- Glass
- Industrial Boiler
- Inorganic Chemistry
- Lime
- Non-ferrous Metallurgy
- Plaster
- Pulp and Paper
- Siderurgy
- Tyles and Bricks
- Incinerator

b

Point sources - CO2 hourly emissions (2015/05/04)
Time: 2015-05-04 00:00

mol · h-1
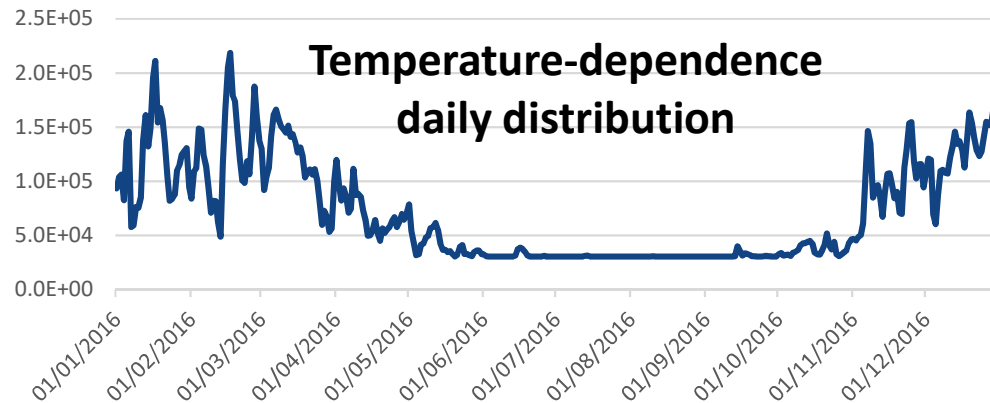
0.0   4000.0   8000.0   12000.0   16000.0   20000.0

- More than 1,800 stacks with specific information on:
  - ❖ Geographical location
  - ❖ Activity and emission factors (combustion and process)
  - ❖ Stack height, diameter, exhaust velocity and exhaust temperature
  - ❖ Temporal and speciation profiles
- Each source can be individually activated/deactivated
- Hourly measured emissions can be used if available
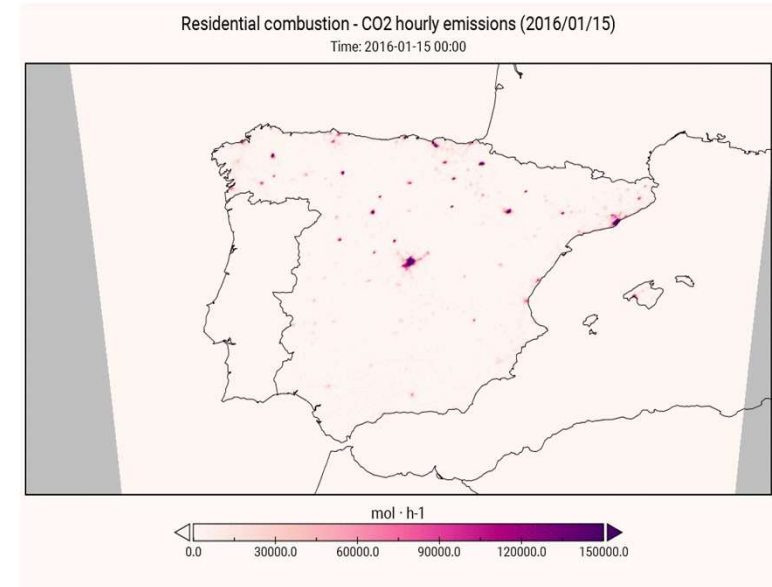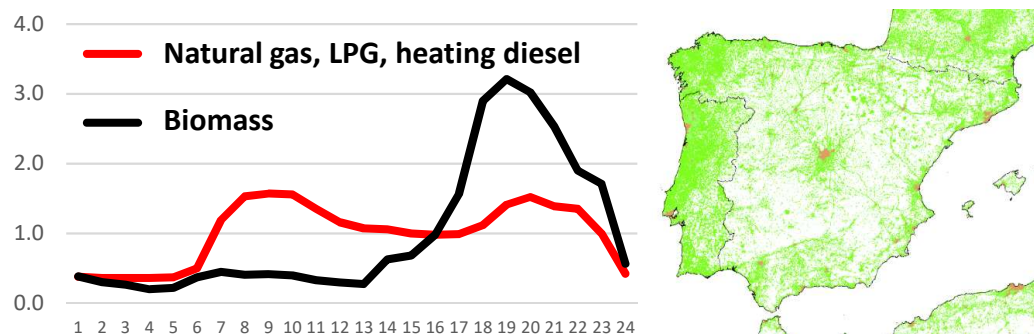- Pollutants included: NO_x, CO, SO_x, NMVOC, NH_3, PM_{10}, $PM_{2.5}$, CO_2, CH_4

HERMESv3_BU: Residential combustion

CO2 daily emissions

Temperature-dependence daily distribution

Fuel-dependence diurnal and spatial distribution

Diurnal profiles

- Natural gas, LPG, heating diesel
- Biomass

Residential combustion - CO2 hourly emissions (2016/01/15)
Time: 2016-01-15 00:00

mol · h-1

- Pollutants included: NO_x, CO, SO_x, NMVOC, NH_3, PM_{10}, $PM_{2.5}$, CO_2, CH_4
- **Select fuel type:**
  - ❖ fuel_list = HD_res, LPG_res, NG_res, B_res, HD_com, LPG_com, NG_com, B_com

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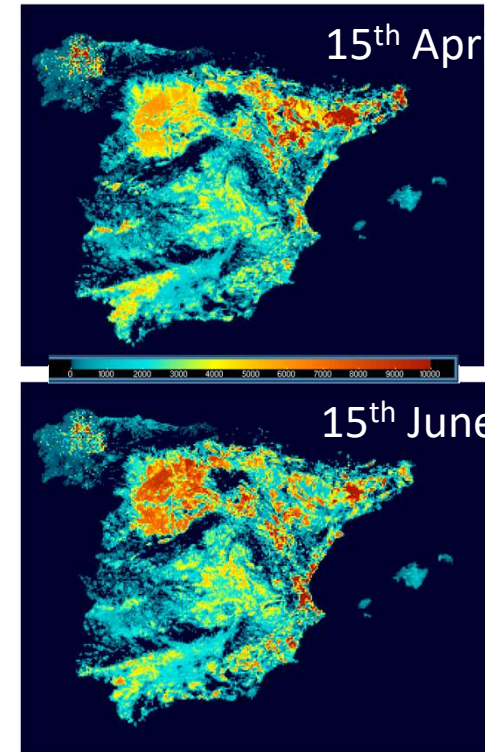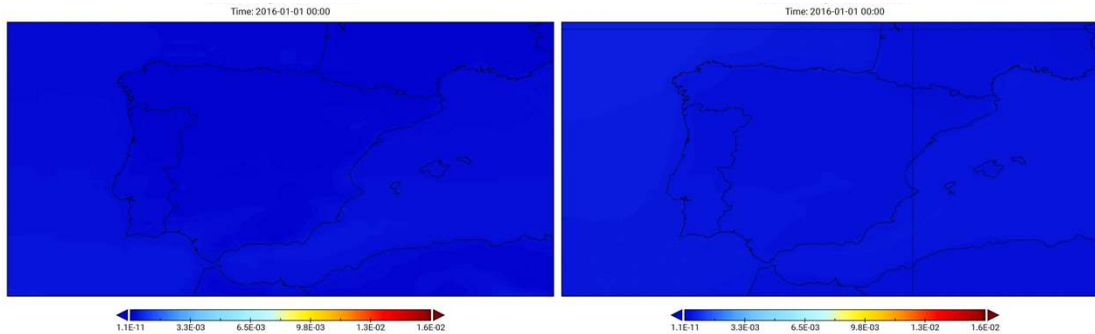Centro Nacional de Supercomputación

HERMESv3_BU: Fertilizers

Crop-dependence spatial and daily distribution using land use information, crop calendars and meteorological data (temperature and wind speed)

Wheat [ha/cell]
- 0,0 - 14,6
- 14,7 - 42,0
- 42,1 - 74,8
- 74,9 - 111,7
- 111,8 - 153,8
- 153,9 - 206,2
- 206,3 - 270,6
- 270,7 - 338,7
- 338,8 - 404,6
- 404,7 - 644,2

Olive [ha/cell]
- 0,0 - 40,9
- 41,0 - 131,1
- 131,2 - 248,9
- 249,0 - 392,8
- 392,9 - 550,9
- 551,0 - 728,6
- 728,7 - 928,9
- 929,0 - 1162,0
- 1162,1 - 1432,5
- 1432,6 - 2254,4

15th Apr

15th June

Daily factor wheat

Time: 2016-01-01 00:00
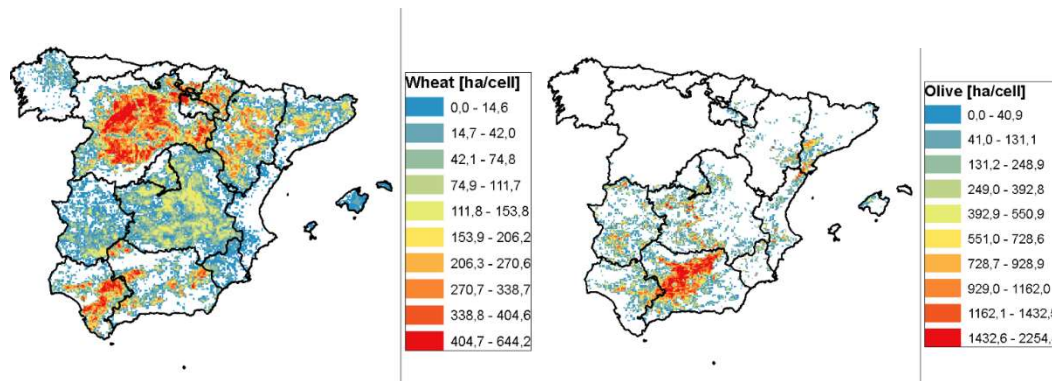
**Daily factor maize**

Time: 2016-01-01 00:00

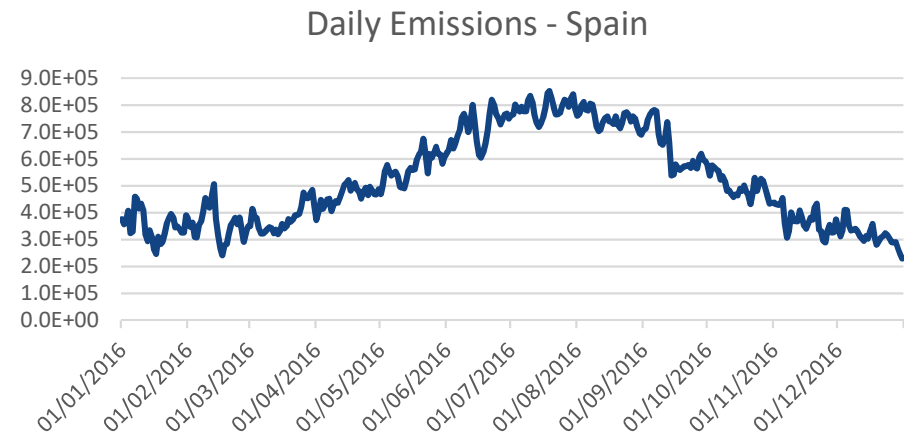Pollutants included: NH_3
Select crop type:
crop_fertilizer_list = alfalfa, almond, apple, apricot, barley, cherry, cotton, fig, grape, lemonlime, maize, melonetc, oats, olive, orange, pea, peachetc, pear, potato, rice, rye, sunflower, tangetc, tomato, triticale, vetch, watermelon, wheat

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HERMESv3_BU: Livestock

Animal-dependence spatial distribution
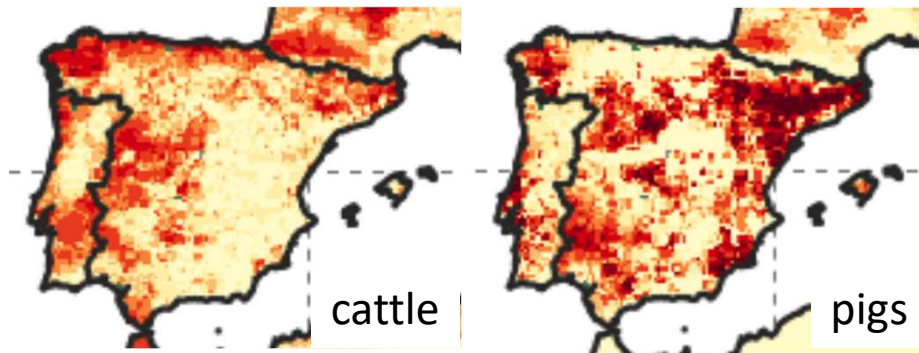
cattle

pigs

## Meteorological-dependence temporal distribution

Daily Emissions - Spain

Pollutants included: NO_x, NMVOC, NH_3, PM_{10}, $PM_{2.5}$,
Select animal type:
animal_list = cattle chicken goats pigs sheep

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HERMESv3_BU: Agricultural operations

Crop-dependence monthly distribution using land use information and crop calendars
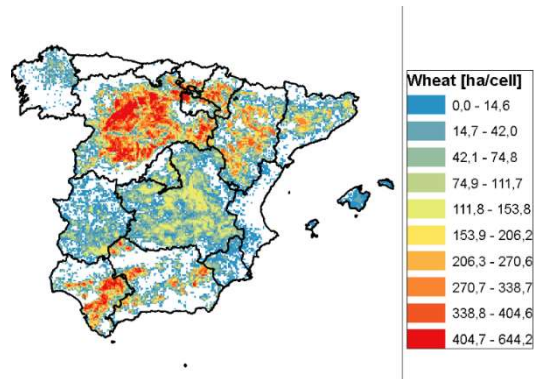
Crop type	Soil cultivation		Harvesting	
	Start_date	End_date	Start_date	End_date
Wheat	1st November	31st December	1st June	31st July
Rye	1st September	31st October	1st June	31st July
Barley	1st November	31st December	1st June	31st July
Oat	1st October	31st November	1st May	30th June

Pollutants included: PM_{10}, $PM_{2.5}$,
Select crop type:
crop_list = barley, oats, rye, wheat

HERMESv3_BU: Shipping in ports

Pollutants included: NO_x, CO, SO_x, NMVOC, NH_3, PM_{10}, $PM_{2.5}$, CO_2, CH_4

Select type of vessel:

vessel_list = LC,DC,GC,RO,FE,CR,CO,TU,OT

Select port:

port_list = ACO, ALC, ALI, ALM, ARI, ARR, AVI, ALG, BAR, BIL, CAB, CAD, CSA, CAR, CTG, CAS, CEU, HIE, FER, GAN, GIJ, HUE, IBI, LPM, LCR, MAH, MAL, MPO, MEL, MOT, PMA, PAS, PRO, PSM, SSG, SCP, SCT, SAG, SAL, SCI, SAN, SEV, TAR, TRG, VAL, VIG, VIL, ZFC
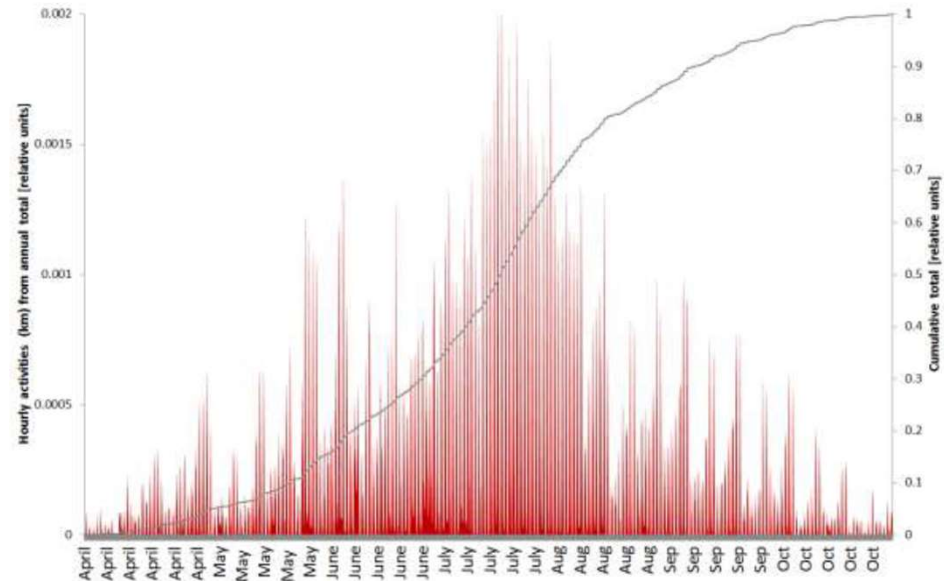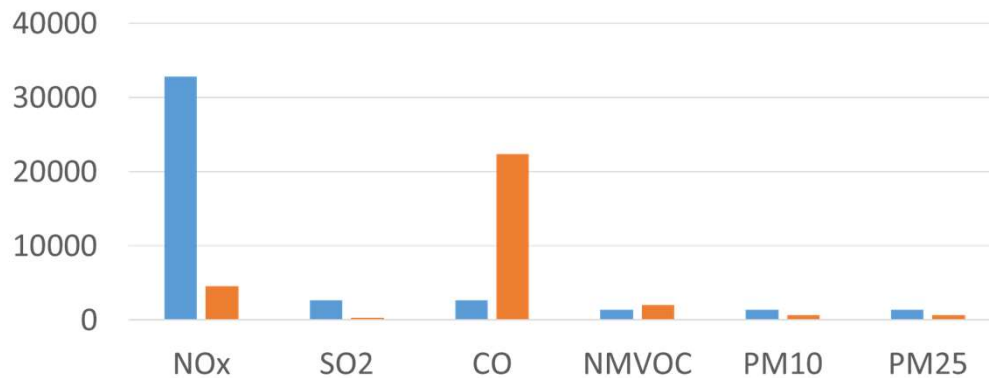
HERMESv3_BU: Recreational boats

Spatial distribution as a function of the location and capacity of Spanish marinas
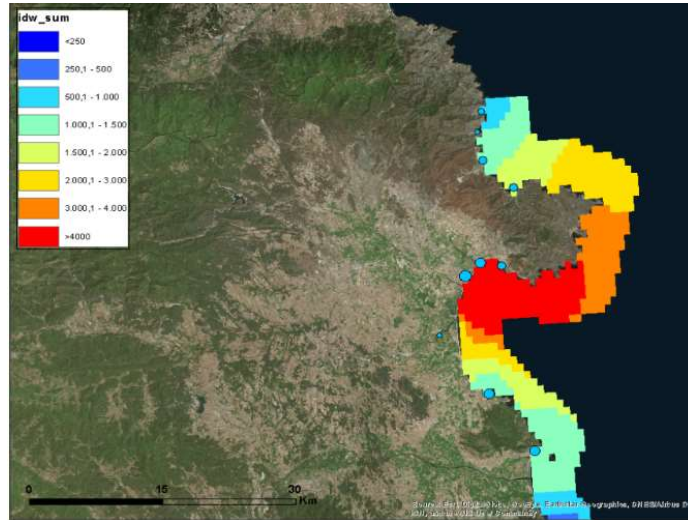
Estimated temporal profile based on AIS-data

TOTAL EMISSIONS (TON/Y)

Pollutants included: NO_x, CO, SO_x, NMVOC, NH_3, PM_{10}, $PM_{2.5}$, CO_2, CH_4

Select boat type:

recreational_boats_list = YB_001,YB_002,SB_001,SB_002,SP_001,SP_002,OB_001,OB_002,WS_001,WS_002,YB_003,SB_003,SP_004,SP_005,OB_002,WS_003,MB_001,MB_002,MB_003,MB_004,MB_005,MB_006,MS_001,MS_002,SB_004,SB_005

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Known issues

HERMESv3_GR:
- Add function to use daily, weekly and hourly gridded profiles (currently only monthly)
- Review parallel writing module

HERMESv3_BU:
- General:
  - Use NMMB-MONARCH/WRF meteo files (from reduced format) (now only ERA5)
- HERMESv3_BU_point_sources:
  - Implementation of plume rise algorithm in the point source module
- HERMESv3_BU_traffic:
  - Implementation of rain correction for traffic resuspension emissions
- HERMESv3_BU_agriculture:
  - Correct FAO's animal density raster files (contact with MITECO, mail)

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