AEA Energy & Environment
From the AEA group

Modelling resuspended heavy metal emissions

Keith Vincent and John Abbott

Outline

- ***Perceived view***→ Emissions from identified sources in the National Atmospheric Emission Inventory (NAEI) are not considered sufficient to explain the observed concentrations of the heavy metals lead, cadmium, nickel and arsenic
- The aim of this work was to assess whether
  - Resuspension from agricultural areas; and
  - Resuspension resulting from vehicle-generated turbulence

  make a significant contribution to measured concentrations
- Once emissions are generated a dispersion model is used to predict the contribution to concentrations of these metals in the air
- Modelled concentrations were compared with measured concentrations

Estimating emissions from agricultural areas (1)

- Used a sandblasting/saltation model similar to that used by EMEP and US Western Regional Air Partnership (WRAP)

- Emissions depend on:
  - Friction velocity (or surface shear stress)
  - Soil type – related to particle size distribution (data for 4 soil types)
  - Metal content of topsoil
  - Critical friction velocity
    - » Surface soil moisture content
    - » ON/OFF vegetative cover

- Modelling used:
  - Hourly sequential meteorological data from 10 sites
  - Bucket heat/mass transfer model of soil surface
  - Landcover 2000 data
  - Topsoil metal content data

Estimating emissions from agricultural areas (2)

- Friction velocity:

$$u_* = \frac{kU}{\ln\left(\frac{z_1}{z_0}\right)}$$

Threshold friction velocity, u_{*T}:

EMEP

0.2 m/s or 0.5 m/s dependent on particle size

WRAP

0.31 m/s (dependent on roughness length)

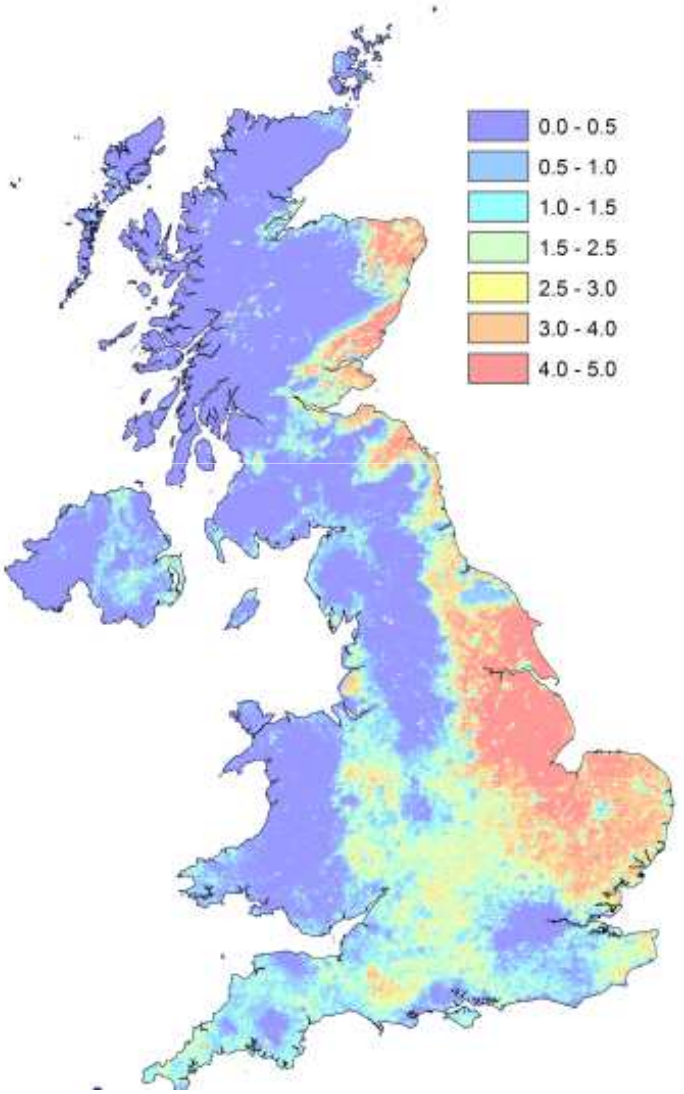
Similar schemes to account for soil moisture content

Soil derived PM_{10}

- Apply saltation/sand blasting model to derive PM_{10} emission
- Apply crop cover correction factors
- PM_{10} re-suspension calculated for each hour of the year

  - Metal content in soils from Geochemical Atlas of Europe

  - Metal flux = mg kg^{-1} x PM_{10} flux



PM10 emissions from vehicle turbulence

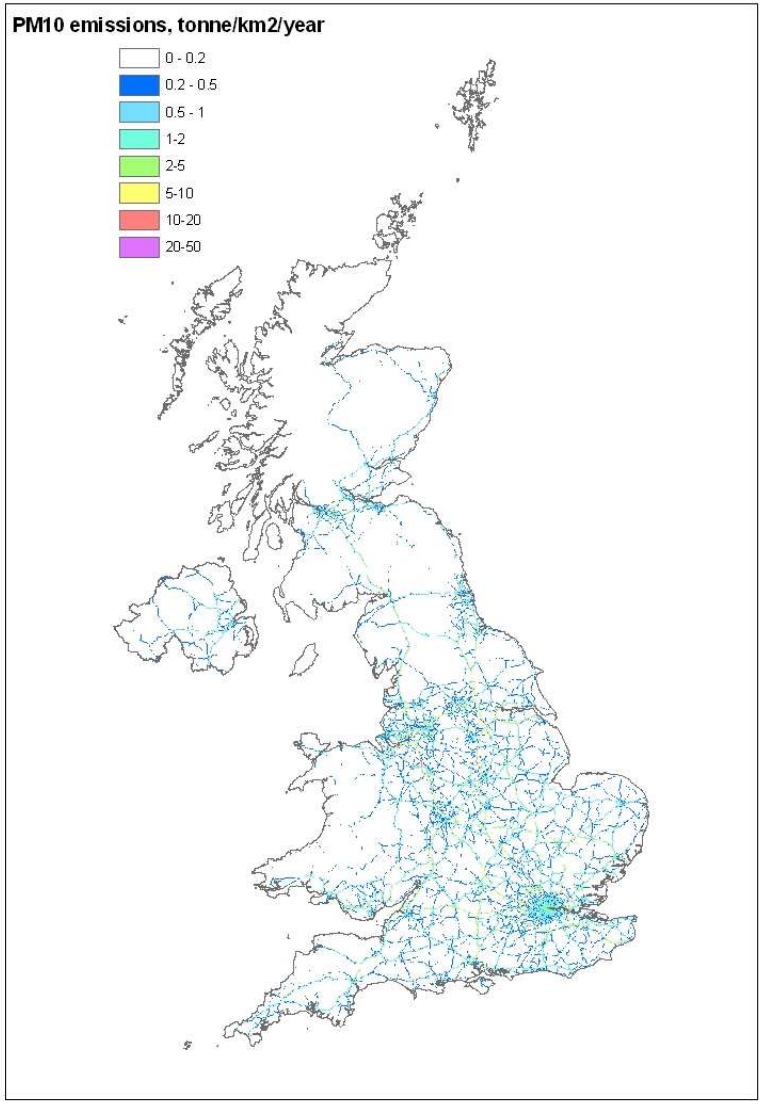
Large eddy simulation model used to predict
surface sheer stress resulting from vehicle turbulence

Model obtained from:
National Institute of Standards and Technology
http://fire.nist.gov/fds/

Derive emission factors (g vehicle^{-1} km^{-1})

Emission rate = Ef x total vehicle km in each 1 km x 1 km
(for lorries and buses; cars negligible)

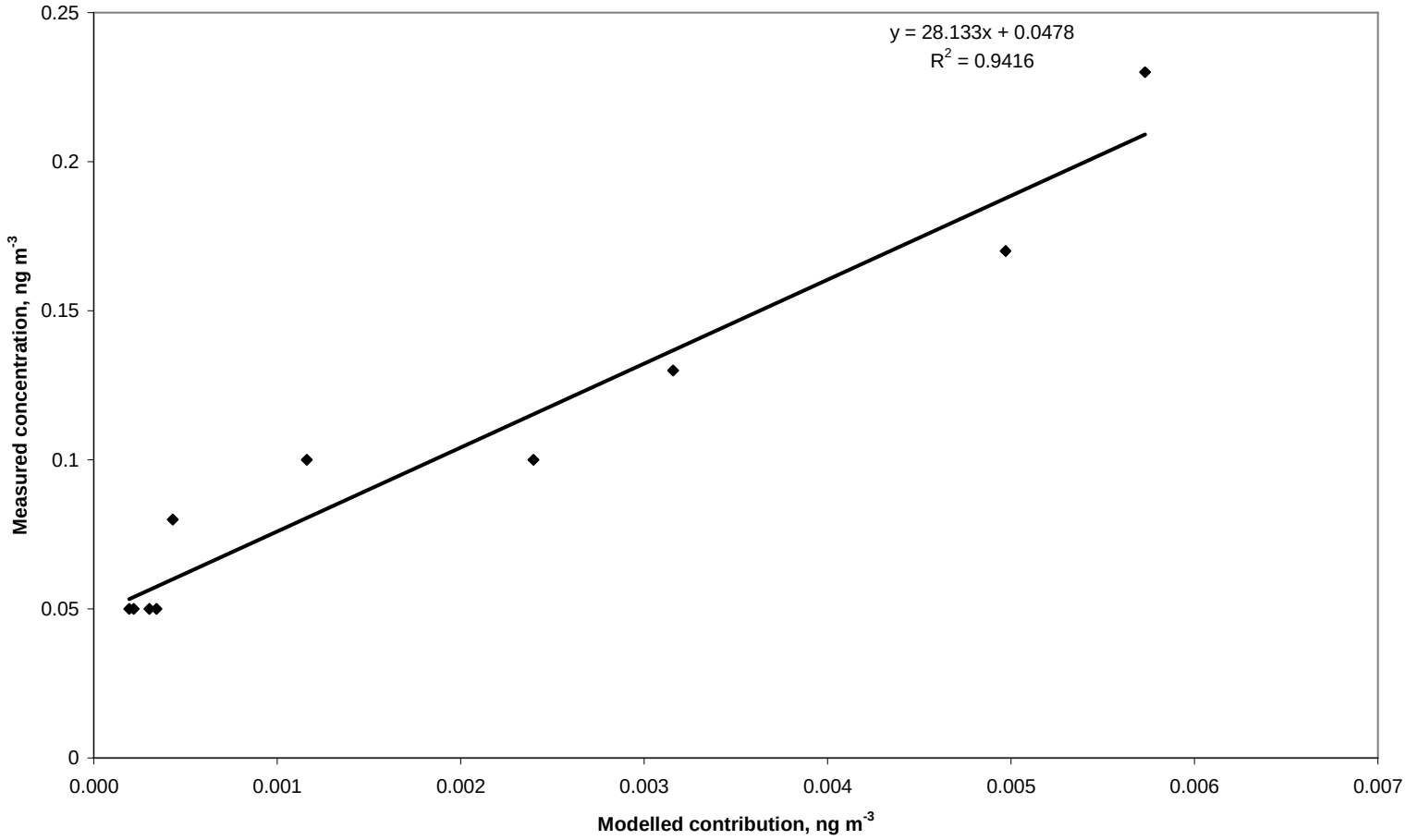
PM10 emissions from vehicle turbulence



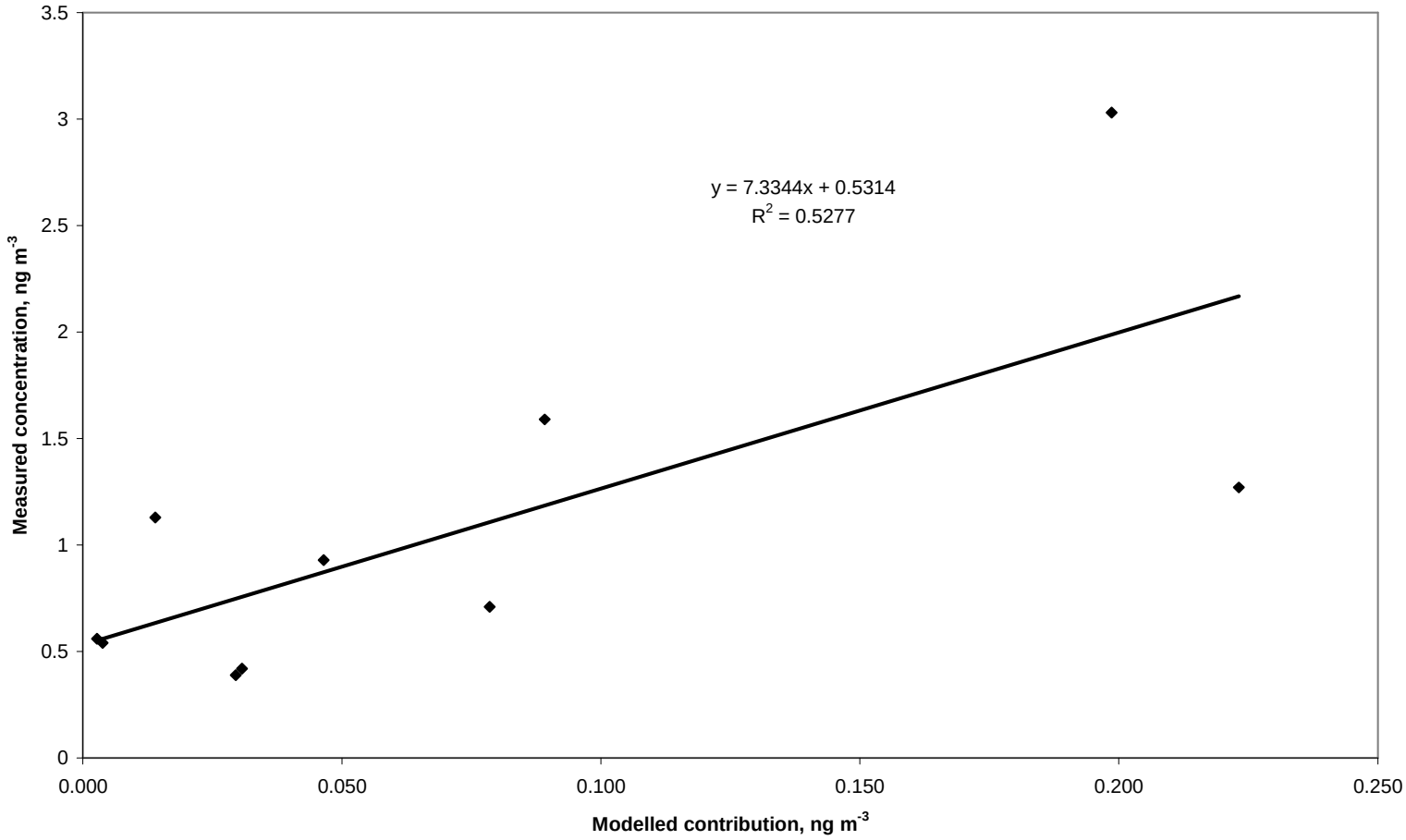
Dispersion modelling

- ADMS4
- Hourly sequential meteorological data from 10 sites
- Hourly sequential emissions from emissions models
- 1 km x 1 km resolution

Modelled vs measured cadmium concentrations, rural network



Modelled vs measured nickel concentrations, rural network



Main issues

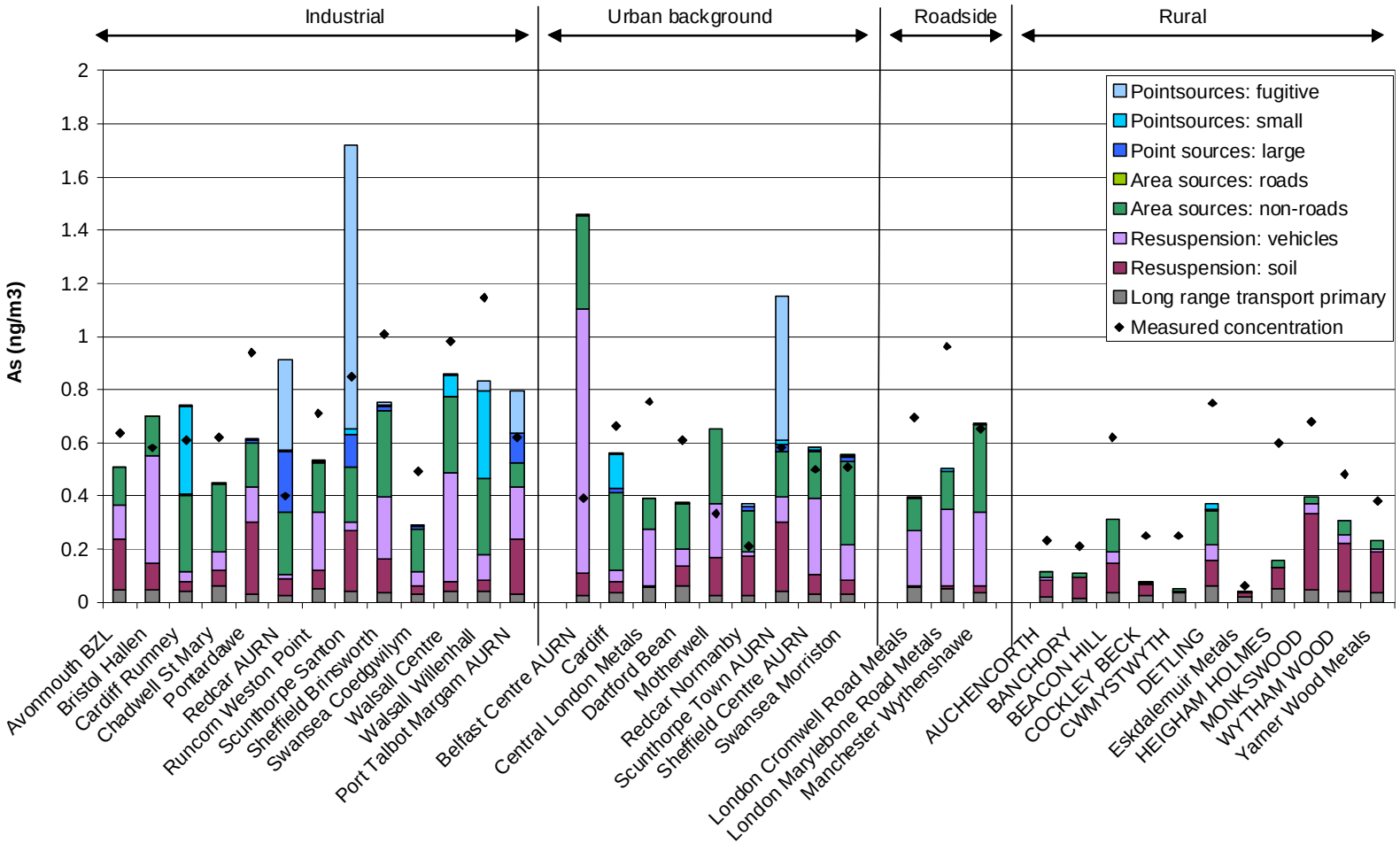
- Apparent correlation between measured and modelled contribution, but model underestimates by a factor of ~30.
  1: Fluke ???? Significant correlation for all four metals
  2: Coincidental correlation related to other factors????
  3: Enhancement of metal concentrations in small size fraction PM??

  - If there is enhancement then it might explain the observed correlation.
  - But little evidence
  - Suggest that useful studies could be done with BS EN 15051:2006 rolling drum dustability tester

Modelled emissions vs NAEI

Metal	NAEI total reported emissions, 2005, tonnes	Modelled emissions from resuspension, tonnes			Total as percentage of NAEI
		Agricultural soils	Vehicle turbulence	Total	
Lead	118	38.4	2.4	40.8	34.6%
Cadmium	3.8	0.5	0.024	0.524	13.8%
Arsenic	14.3	4.63	0.16	4.79	33.5%
Nickel	87	25.3	0.9	26.2	30.1%

Source apportionment plot



Conclusions

- Analysis of oil samples suggest that emission factors in NAEI are appropriate- provides confidence in anthropogenic inventory
- Nationally, re-suspension from agricultural soils is larger than vehicular induced re-suspension (but there is local variation)
- Relationship between measurement and modelled concentrations suggests an enrichment within soil
- Need for measurement - rolling drum dustability tester