

# China testbed FMI-ENFUSER in Langfang

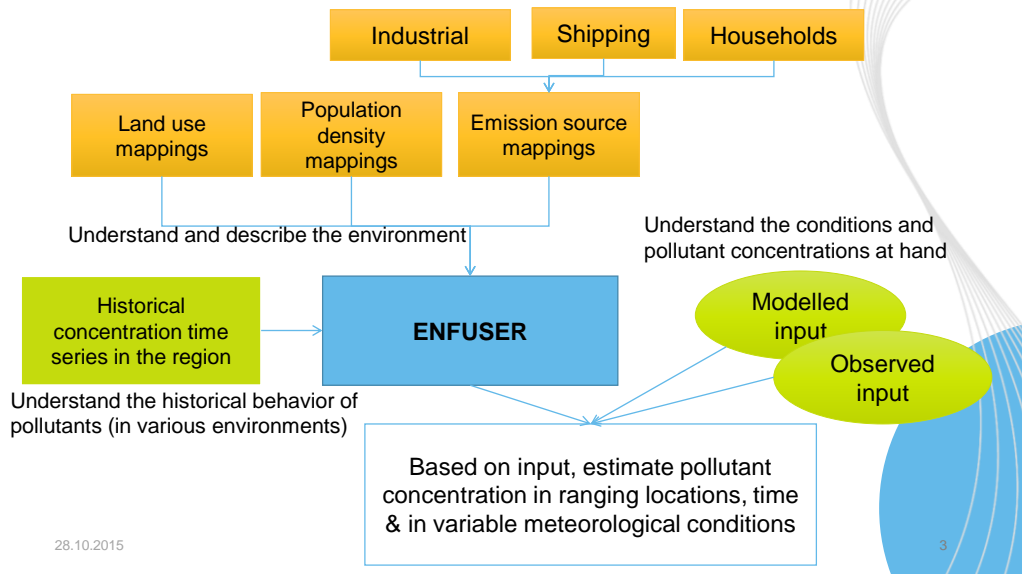
5.5.2015  
Lasse Johansson  
Ari Karppinen



## Outline

- **What is the FMI-ENFUSER model?**
  - A brief description
- **Setting up the system in China**
  - Main objective and the selected test region
  - Implementation of GIS-datasets for environment profiling
  - Gaining access to AQ measurements and meteorological data
- **Status and preliminary results**
  - What works and what needs more work
  - Observed seasonal average concentrations in Hebei province

## What is FMI-ENFUSER? (1/3)

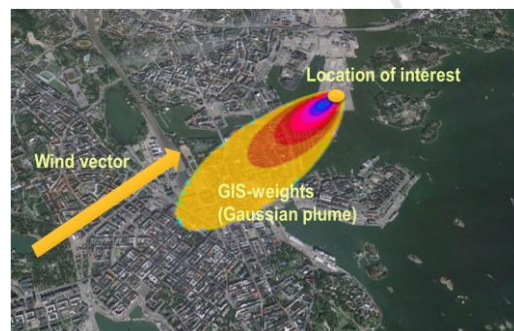


## What is FMI-ENFUSER? (2/3)

FMI-ENFUSER = (The Finnish Meteorological Institute's ENVironmental information FUsion SERVICE)

The **fusion of information** (a separate task for the model) has been described in (Johansson et al, 2014)

- Combines **land-use regression** (LUR) and **dispersion modelling** into a novel approach named as "**dynamic land-use regression**"
- Essentially, this is 3D land-use regression taking into account the meteorological conditions, especially the wind vector.



- There are several different layers of "land-use" for which the method is applied simultaneously.

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## What is FMI-ENFUSER? (3/3)

### • Benefits:

- **Very high resolution, especially suitable for urban areas (detects street canyons)**
- **A-priori information on emission sources not needed**
  - Automatic calibration
  - A-priori information on emission sources, if known, can still be included (e.g. shipping)
- **Fusion algorithm => latest sensor measurements & modelled data can be included in the pool of information**
  - Weather forecast + regional background forecast => ENFUSER
  - forecasting possible

### • Drawbacks:

- Statistical relationships between pollutant concentrations and special meteorological conditions is difficult to define and utilize
- Calibration is difficult with **incomplete/low quality GIS-dataset**

Main issue in China at the moment

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## Testbed setup

- **Main objective: Fuse PM2.5 measurements in Langfang**

### 1. Describe the environment in the surrounding region as accurately as possible

- Source and the nature of GIS data unknown

### 2. Gain access to AQ measurements in the surrounding region

- Pegasor + other unknown sources of information
- For calibration and operational use
  - Decent calibration: 20+ stations, full annual time series

### 3. Gain access to weather data

- For calibration and operational use
- Forecasts?

Optimal calibration: weather data for the same period as AQ measurements

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# Testbed region

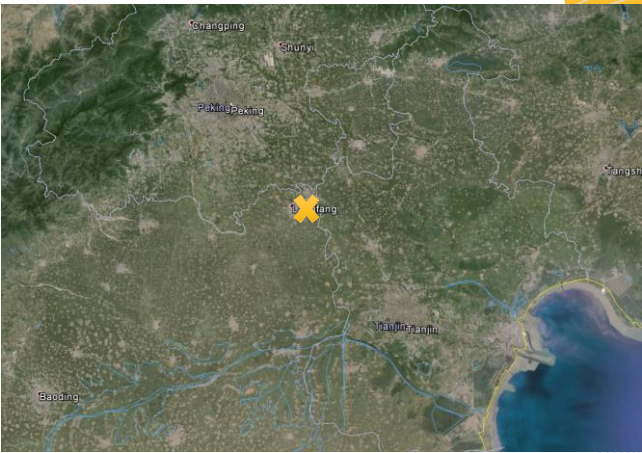
To obtain realistic behaviour in the model it is not enough to concentrate only on Langfang

The surrounding area is equally important for the calibration of the model.

The selected testbed region also includes **Beijing, Tianjin, Tangshan, Baoding** and several other cities.

For all of these other cities the environment has been mapped with the same detail as in Langfang.

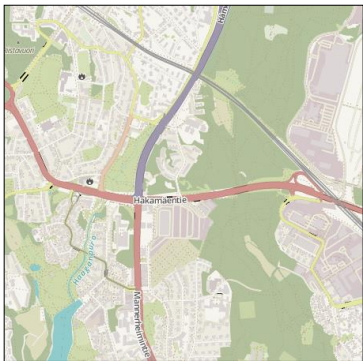
=> When calibrated and operational **ENFUSER should work all across the selected region.**



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# Open source Land-use

Finland/Europe



Forests, plains, parks, lakes, sea, roads (5), residential, industrial, buildings

Langfang/China



Lakes, sea, roads (5)

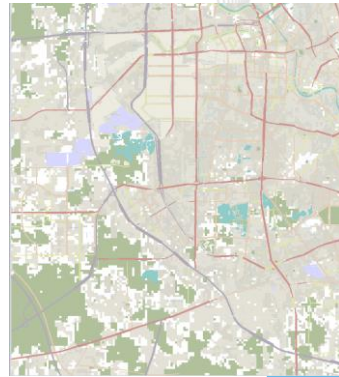
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## Enhancing Open source Land-use with satellite images

- **New approach: analyse rudimentary land use from satellite images => Fill in the gaps in OSM mapping**
  - Vegetation, Urban, Suburban
- **Simple image processing technique**
  - Deduction based on
    - Dominant color
    - Brightness
    - Saturation
- **Approach seems to work well in Hebei province when the "eye altitude" of satellite is approx. 100km**
  - 100 x 100m resolution achieved
  - Better resolution would require more sophisticated image processing and possibly shape/polygon detection



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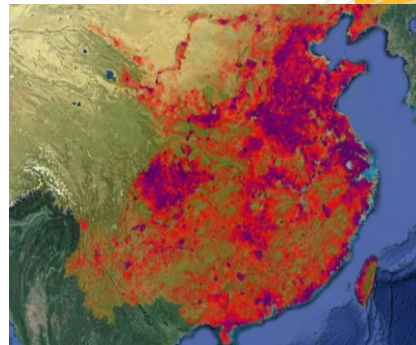
9



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## Population density mapping (1/3)

- **Important for ENFUSER**
  - Can be used to proxy traffic volumes (One of the subtasks considered in the calibration of the model)
  - Population => burning & heating
  - Desired resolution: 250 x 250m



- **Best "dataset" found for this purpose was an image describing the population in a 5 x 5km resolution**

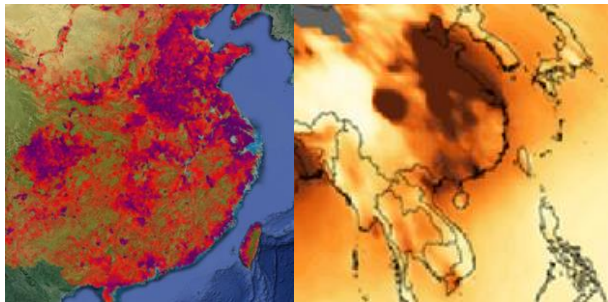
- This was converted into Google Earth layer file (kmz) and fitted to the area => coordinates for the data
- Gives only **indicative** information on the population

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10



# Population density mapping (2/3)



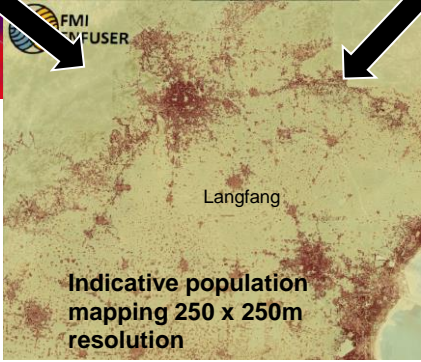
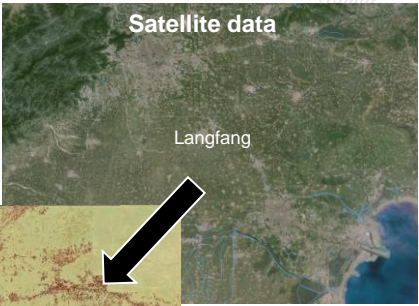
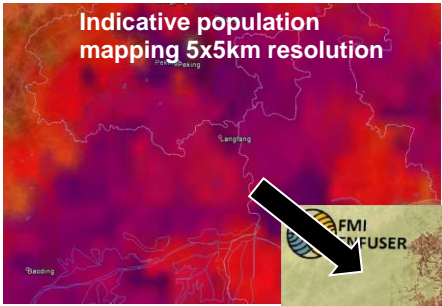
**Average aerosol optical depth, indicating the relative amount of particles that absorb sunlight. Based on satellite remote sensing during 2007-2011.**

Modis Terra (NASA), aerosol optical depth at 550nm 2007-01 to 2011-12 average. Data source: <http://daac.gsfc.nasa.gov/giovanni>

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11

# Population density mapping (3/3)



Original population data **redistributed** emphasizing urban and suburban areas

Satellite data enhances both land-use and population mapping

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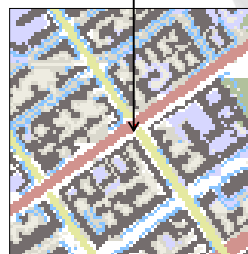
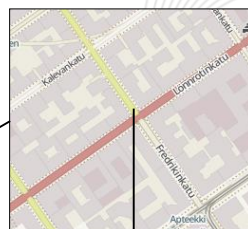
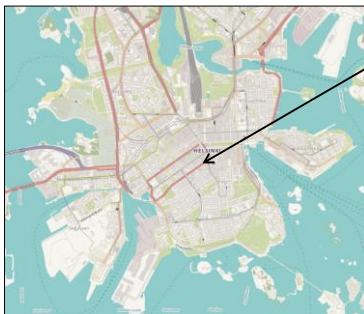
12

## OpenStreetMap & street canyons(1/2)

OpenStreetMap (OSM) is an open access map service provider that offers high resolution maps world wide.

FMI-ENFUSER uses OSM-maps with 5 x 5m resolution, covering all main cities in Finland

**Street canyons and buildings** can be analyzed from the image.



This is how FMI-ENFUSER "sees" the crossing of Lönnrotinkatu and Fredrikinkatu after image processing. The vicinity of buildings can be taken into account when the concentration is being estimated in urban areas.

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13

## OpenStreetMap & street canyons(1/2)

An example of NO<sub>2</sub> fusion at the center of Helsinki based on local measurements.

Colorscale: [10,120] µgm-3.

With street canyon detection ENFUSER **understands the input data (measurements) better** and associates **higher concentrations** in all street canyons.

**OSM-data in China doesn't contain buildings!**



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## Testbed status (1/2)

### Describe the environment as accurately as possible

- 75% of work hours done, more difficult than predicted
- New approach: OSM layer implemented
  - Information content low in China
  - No buildings => no street canyon detection
- New approach: Satellite data implementation with image processing
  - Enhances the OSM-data some what
- A population density mapping implemented
  - Quality and reliability poor
  - Enhancement based on satellite data
- Road specific traffic flow mapping for Langfang received from Dr. Mao
  - Not yet implemented, but should prove useful
    - Road traffic should not be the key driver for observed PM2.5 concentrations however

5/10

Needs more work!

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15

## Testbed status (2/2)

### Gain access to AQ measurements in the surrounding region

- 5 Pegasor sensors installed in Langfang
- Hourly data from 900+ stations in China
  - Of which 45 were identified and utilized in study area
  - Several pollutant species
  - Since Feb 2015 => Calibration for Winter/Spring can be done

10/10

Exceeded expectations

### Gain access to weather data

- CMA agreed to provide weather data for the calibration period (pending)
- Open access weather (with forecasts) since Apr 2015

8/10

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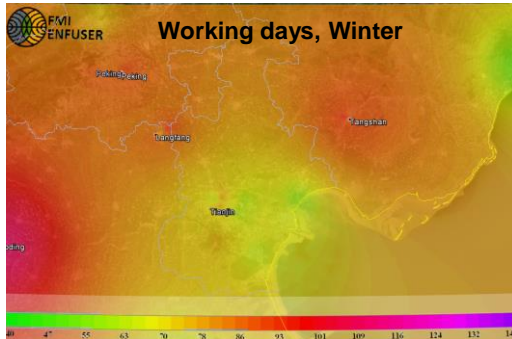
16



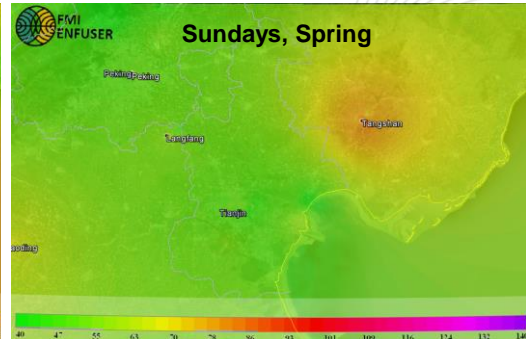


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## Seasonal PM2.5 averages (1/2)



Working days, Winter



Sundays, Spring

Based on the archived measurements from 45 stations.

Visualization: Simple Kriging extrapolation (with ENFUSER visualization toolbox).

No fusion of information, this kind of raw data would be used for the calibration of the model together with meteorological data.

17



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## Seasonal PM2.5 averages (2/2)

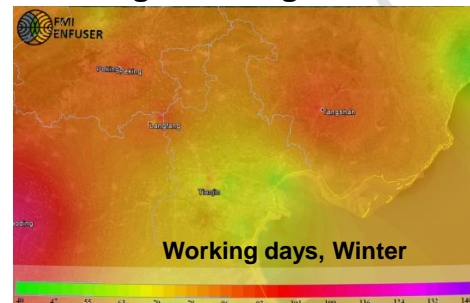
• Besides seasonal variation there's also a clear diurnal variation to be seen in average PM2.5 concentrations (not shown here)

• Highest concentrations during Winter (Monday-Friday)

• Current GIS-datasets cannot explain why the highest concentrations are observed near Baoding and Tangshan

• More explaining factors (layers of information, are needed)

- Demographics?
- Wealth?
- Industry?
- Other?
- Longrange transport?



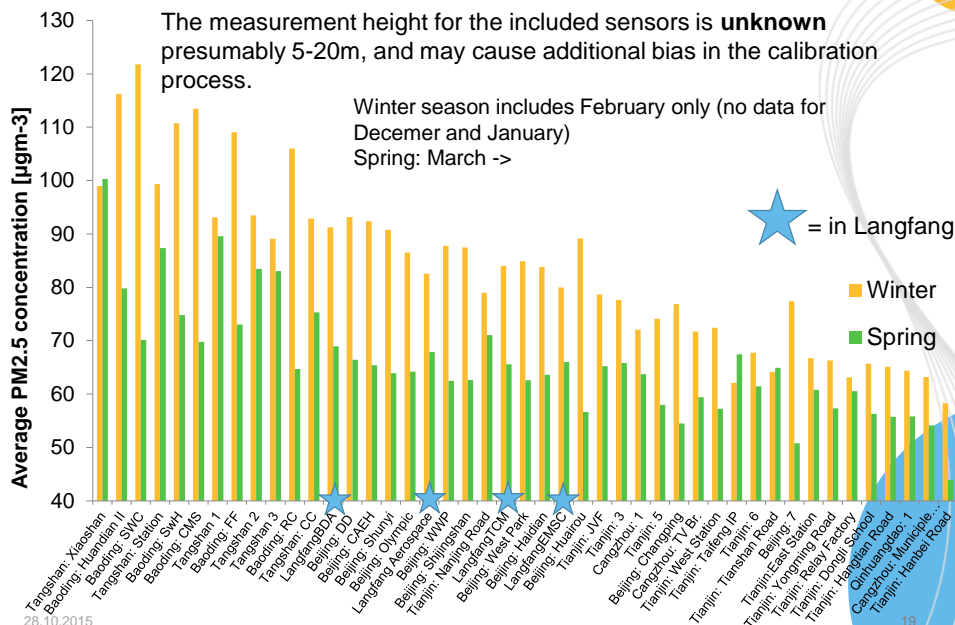
Working days, Winter

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18



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## Summary

- **Despite the difficulties in obtaining GIS-data a preliminary collection of information has been implemented for environment profiling**
- **A satisfactory amount of pollutant and weather data is available in China**
  - Quality will further improve after the addition of PEGASOR data
    - Denser sensor network will reveal better the "micro structure" of PM2-5 concentrations
- **Added benefit from using ENFUSER in China should increase after more research is being done**
  - A better and more complete collection of information for calibration is piling up hour after hour.
  - Real fusion output soon expected from the model

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20

Johansson, L., Epitropou, V., Karatzas, K., Karppinen, K., Wanner, L., Vrochidis, S., Bassoukos, A., Kukkonen, J. and Kompatsiaris I. *Fusion of meteorological and air quality data extracted from the web for personalized environmental information services*. Environmental Modelling & Software, Elsevier, [Volume 64](#), February 2015, Pages 143–155, 2014.



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