# A Web-based Uncertainty-enabled Information System for Urban Air Quality

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# Motivation

Estimate air quality on an urban scale

- – Relevant for health effect assessment

- – High spatial and temporal variability

- – Estimation includes uncertainties due to errors and simplifications

Use case: $PM_{10}$ in Münster

- – Estimating concentration for one GPS track for non-expert users (public)

**(i)** Regional background concentration: Interpolation of measurements

**(ii)** Local urban increment: AUSTAL2000 air pollution model
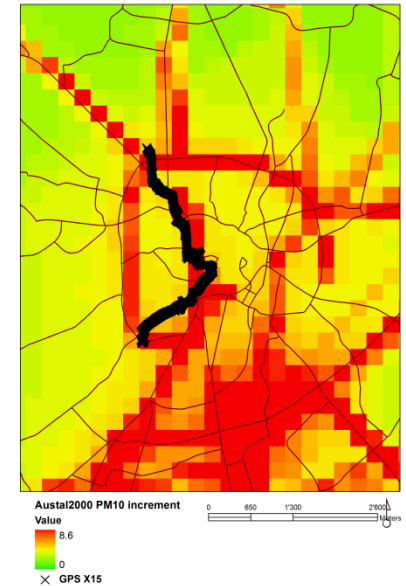
# The UncertWeb project

Uncertainty must be accounted for when chaining services if rational decisions are to be made



uncert|web

uncertainty-enabled model web

"UncertWeb develops mechanisms, standards, tools and test-beds for accountable uncertainty propagation in web service chains."

www.uncertweb.org

# Uncertainty management
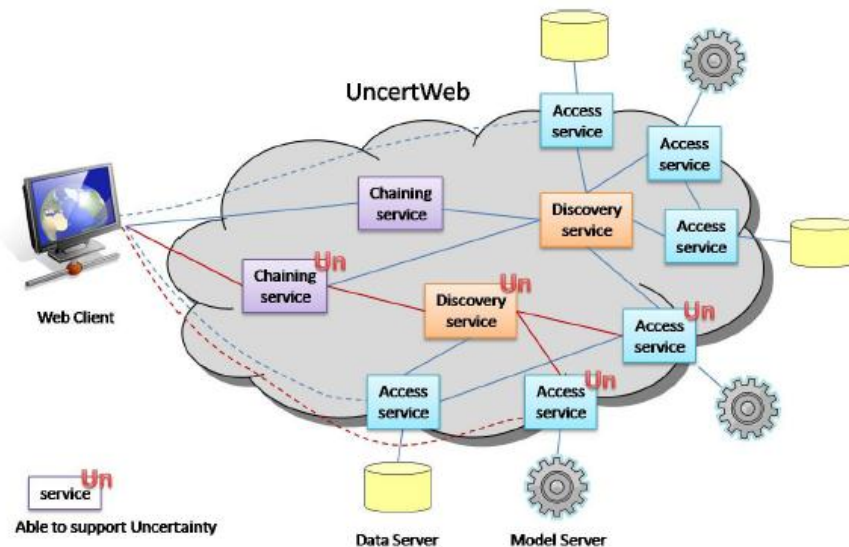
Monte Carlo simulation

  – Input uncertainty propagation

UncertML

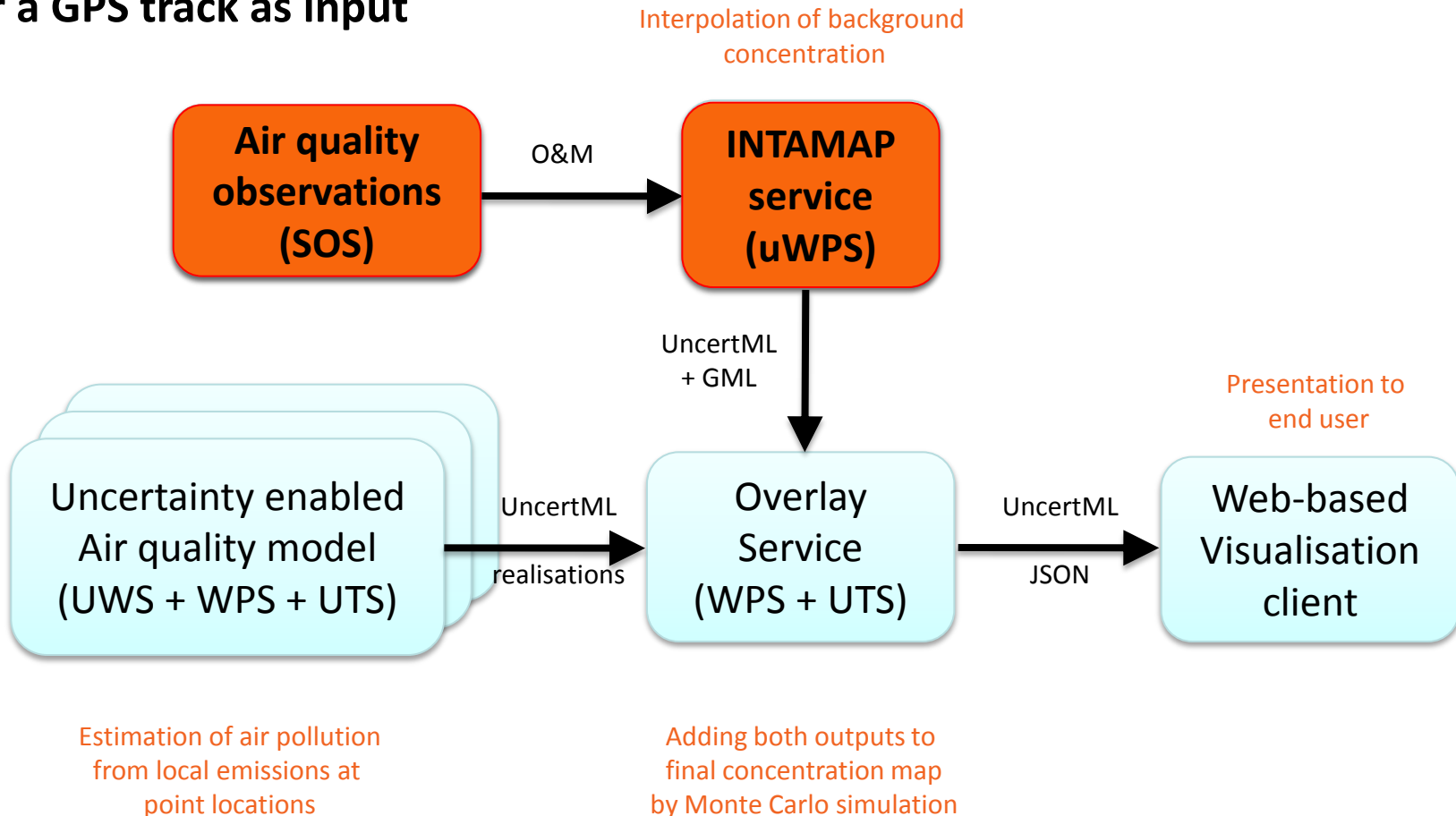  – Encoding of uncertain information

Web services

  – Data: OGC Sensor Observation Service (SOS)

  – Processes: OGC Web Processing Service (WPS)

    • Uncertainty-enabled WPS (uWPS)

    • Uncertainty Wrapper Service (UWS)

    • Uncertainty Transformation Service (UTS)

Uncertainty visualisation

  – Communication for decision making

# System architecture components
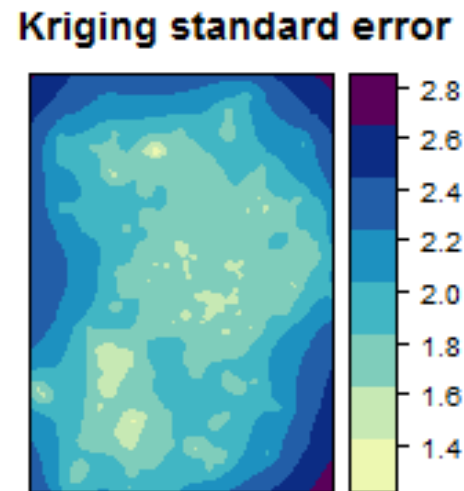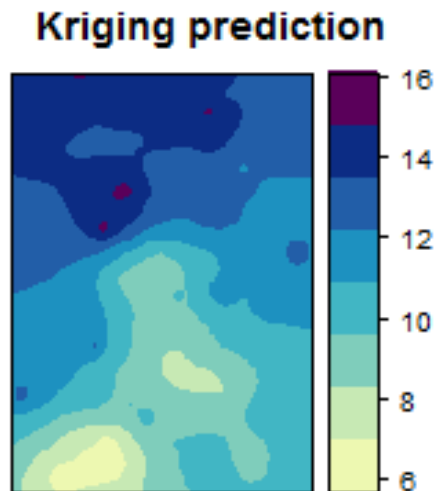
**Preconfigured workflow
for a GPS track as input**

Interpolation of background
concentration

```
┌──────────────────┐              ┌──────────────────┐
│   Air quality    │     O&M      │    INTAMAP       │
│  observations    │ ──────────►  │    service       │
│     (SOS)        │              │    (uWPS)        │
└──────────────────┘              └──────────────────┘
                                           │
                                    UncertML
                                    + GML
                                           │
                                           ▼
                                                           Presentation to
                                                              end user
┌──────────────────┐              ┌──────────────────┐              ┌──────────────────┐
│ Uncertainty      │   UncertML   │    Overlay       │   UncertML   │   Web-based      │
│ enabled          │ ──────────►  │    Service       │ ──────────►  │  Visualisation   │
│ Air quality model│  realisations│   (WPS + UTS)    │    JSON      │     client       │
│ (UWS + WPS + UTS)│              │                  │              │                  │
└──────────────────┘              └──────────────────┘              └──────────────────┘
```

Estimation of air pollution
from local emissions at
point locations

Adding both outputs to
final concentration map
by Monte Carlo simulation

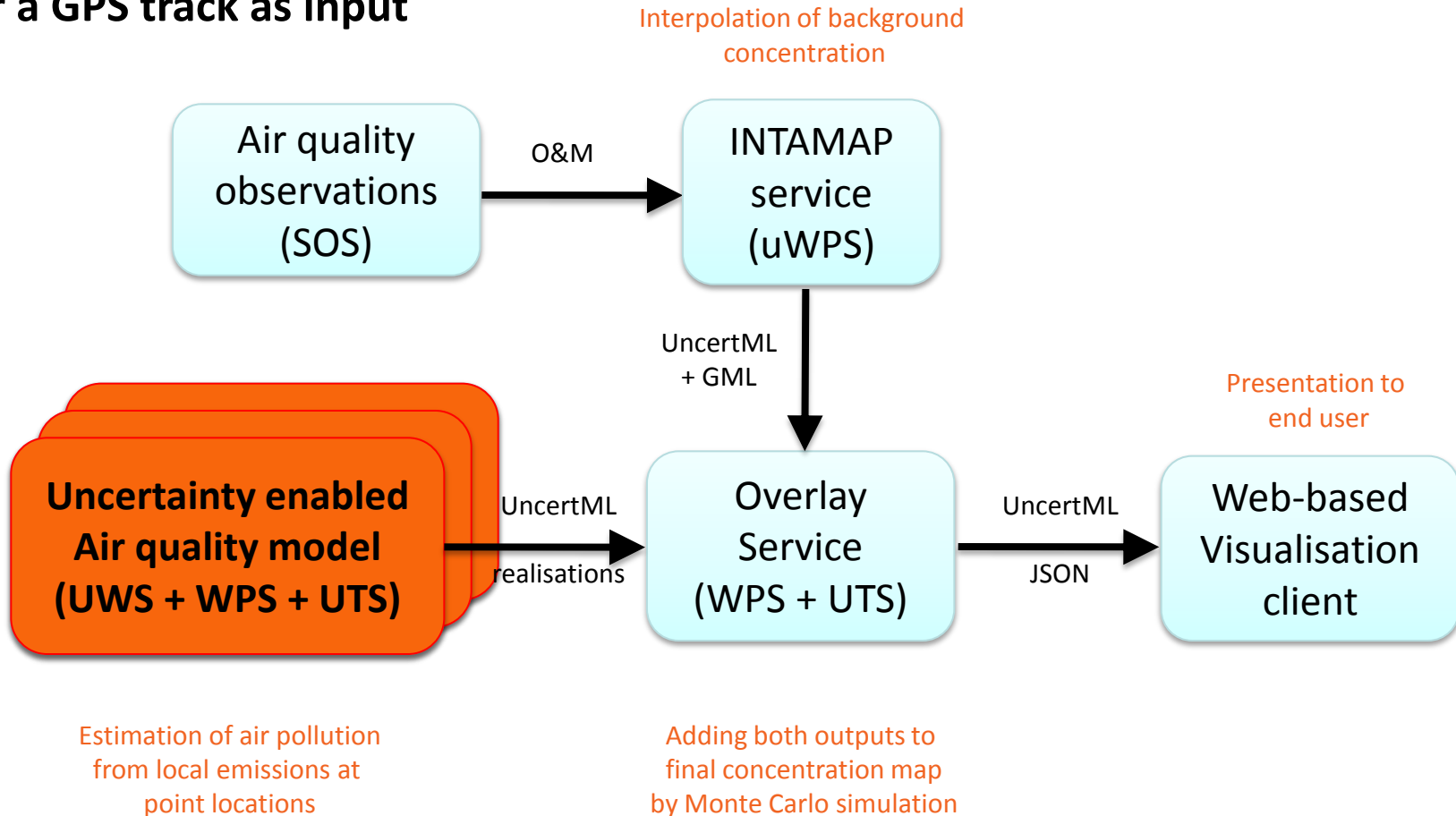# Regional background air quality

ifgi

Set-up developed in GEOSS AIP-3

→ SOS providing air quality data from the German Federal Environment Agency

→ INTAMAP WPS with R backend used for interpolation with estimation error (no observational errors)

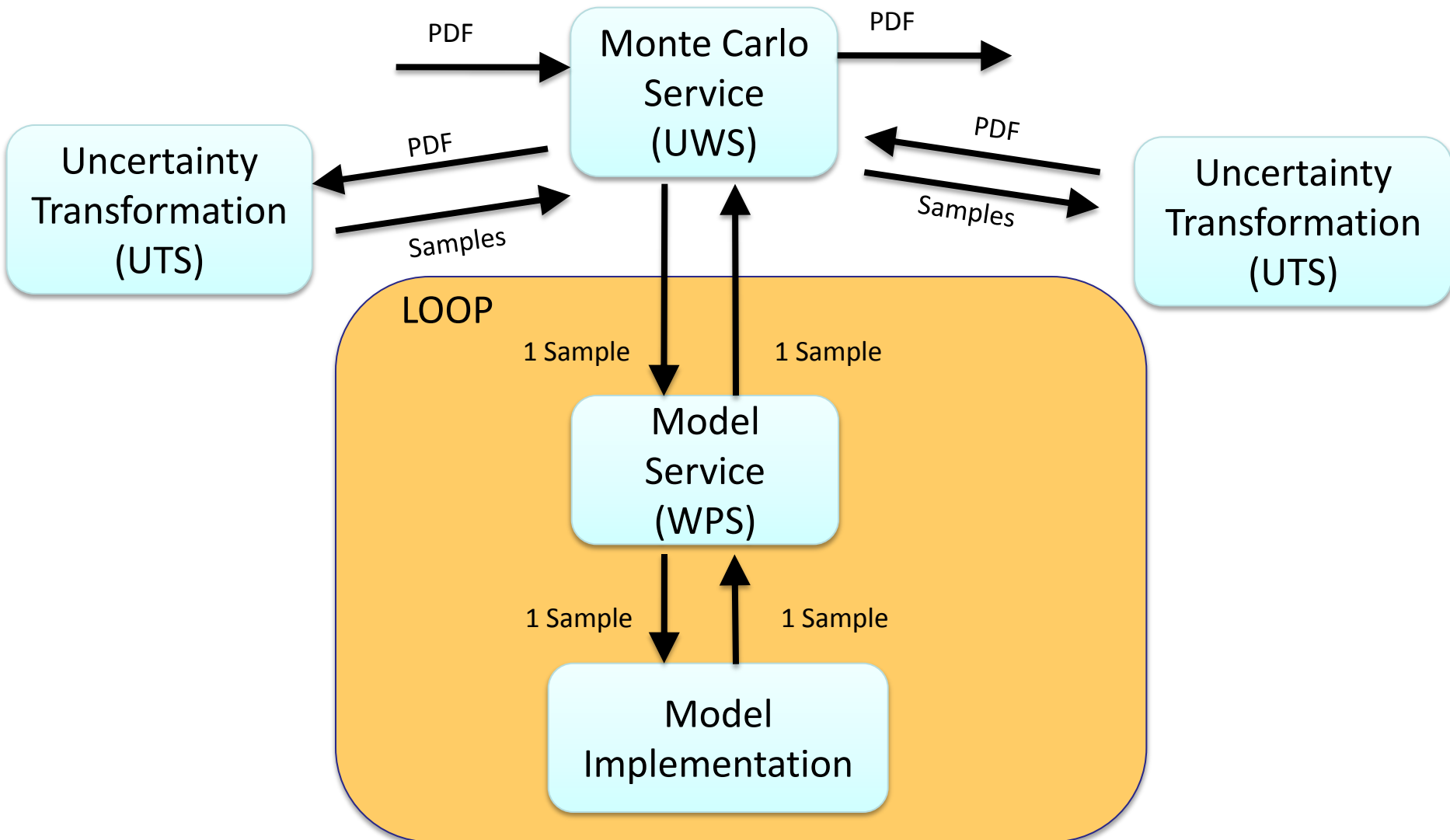Block Kriging (5x5 km²) for $PM_{10}$ background concentration

**Kriging prediction**

**Kriging standard error**

# System architecture components

**Preconfigured workflow
for a GPS track as input**

Interpolation of background
concentration

Air quality observations (SOS) → O&M → INTAMAP service (uWPS)

UncertML + GML

Uncertainty enabled Air quality model (UWS + WPS + UTS) → UncertML realisations → Overlay Service (WPS + UTS) → UncertML / JSON → Web-based Visualisation client

Presentation to end user

Estimation of air pollution
from local emissions at
point locations

Adding both outputs to
final concentration map
by Monte Carlo simulation

# Uncertainty enabled web services

# Local air quality model



## Austal2000

- Lagrangian dispersion model
- Open source implementation
- Uncertainty estimate of stochastic model component
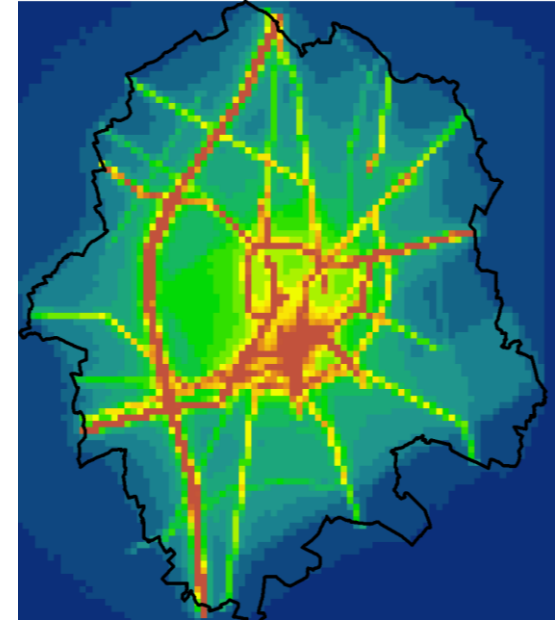
## Main inputs:

- Emissions
- Meteorology
- Landuse

## Output:

- $PM_{10}$ concentration
  - 250x250 m² cell size raster
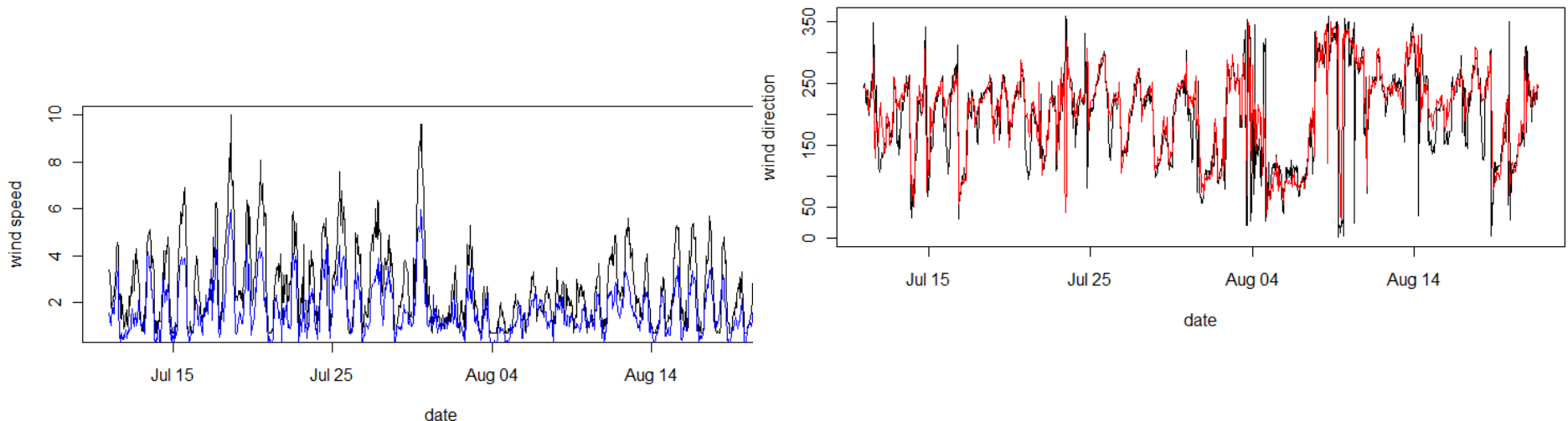  - 1 hour time series at max. 20 receptor points

# Input uncertainties – meteorology

Data:

- German Weather Service station near Münster
- Measurements of parameter subset within Münster

Uncertainties:

- High for low wind speeds
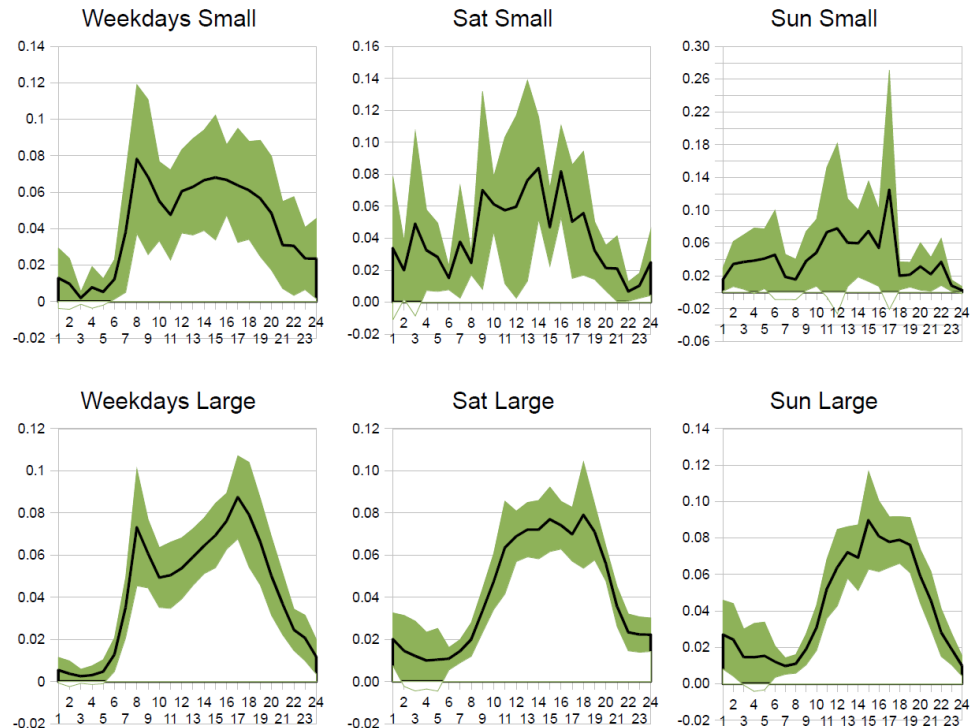- Medium for wind direction

# Input uncertainties – road traffic emissions

**Data:**

- Traffic counts per hour at point locations
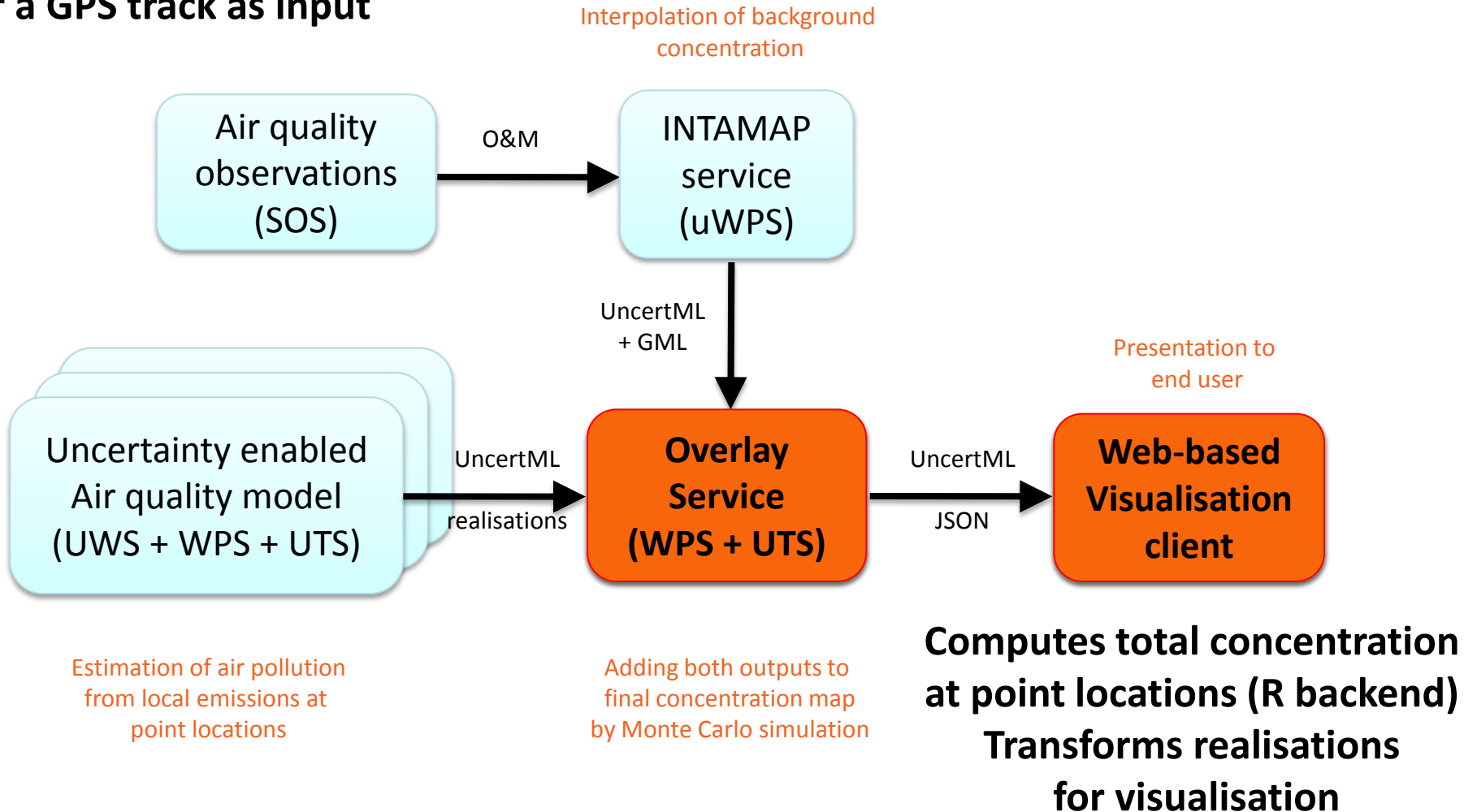- Daily traffic volume (DTV) available for street network

**Uncertainties:**

- DTV
- Hourly distributions
- Fleet composition
- Emission factors
- Simplification of network necessary

# System architecture components

**Preconfigured workflow
for a GPS track as input**

Interpolation of background
concentration

Air quality
observations
(SOS)

— O&M →

INTAMAP
service
(uWPS)

UncertML
+ GML

Presentation to
end user

Uncertainty enabled
Air quality model
(UWS + WPS + UTS)

UncertML

realisations →

**Overlay
Service
(WPS + UTS)**

UncertML

JSON →

**Web-based
Visualisation
client**

Estimation of air pollution
from local emissions at
point locations

Adding both outputs to
final concentration map
by Monte Carlo simulation

**Computes total concentration
at point locations (R backend)
Transforms realisations
for visualisation**

# Visualisation

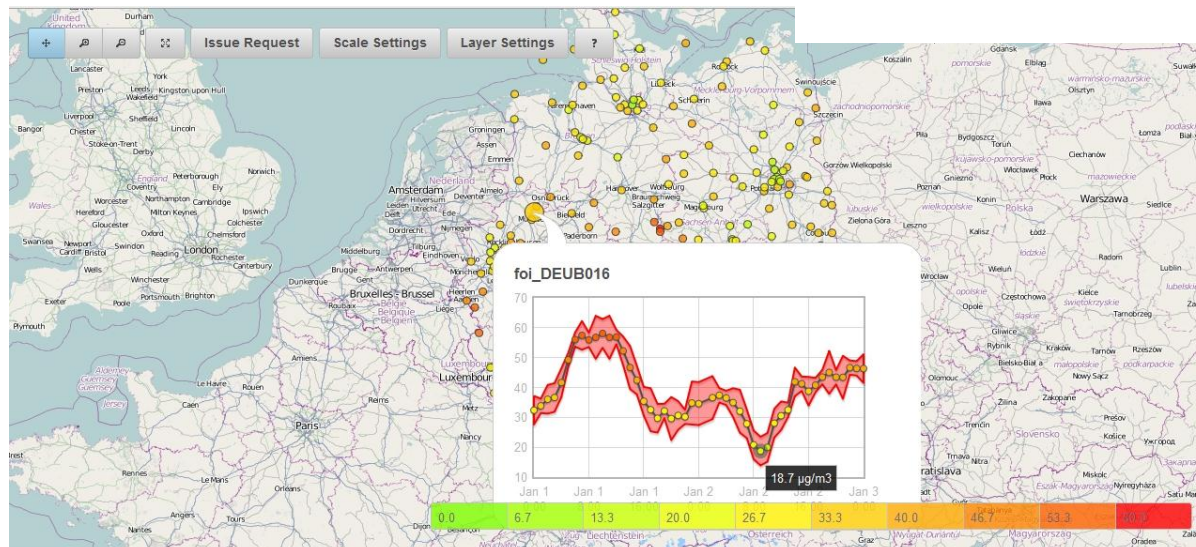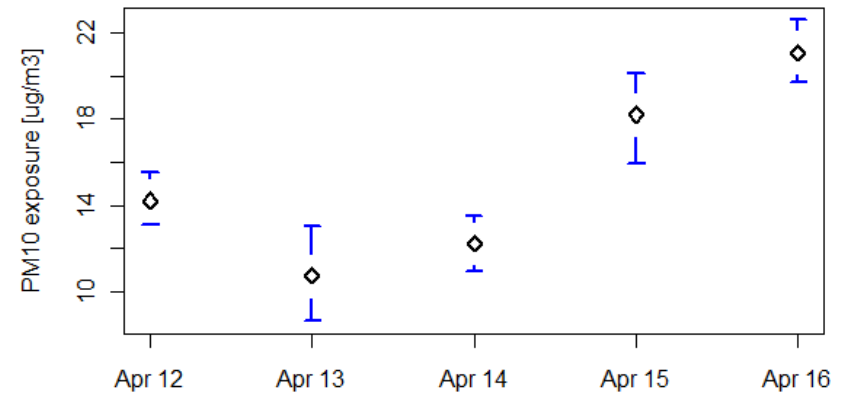## Results per GPS track

- Time series
- Track averages

## Web client

- On-going work



95 % confidence intervals per GPS track at different days

# Wrap-up

## Summary

- Uncertainty-enabled air quality estimation
- Web-based model system
  - Test-bed for UncertWeb concepts
- First prototype implementation available soon

## Open issues

- Local AQ model execution
  - Tradeoff uncertainty/run-time
  - # receptor points
- Future work: Create near real-time air quality maps

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# Thank you for your attention!
# Questions?!

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