FFI Forsvarets forskningsinstitutt

# Comparison of some commercial dispersion models for heavy gas releases

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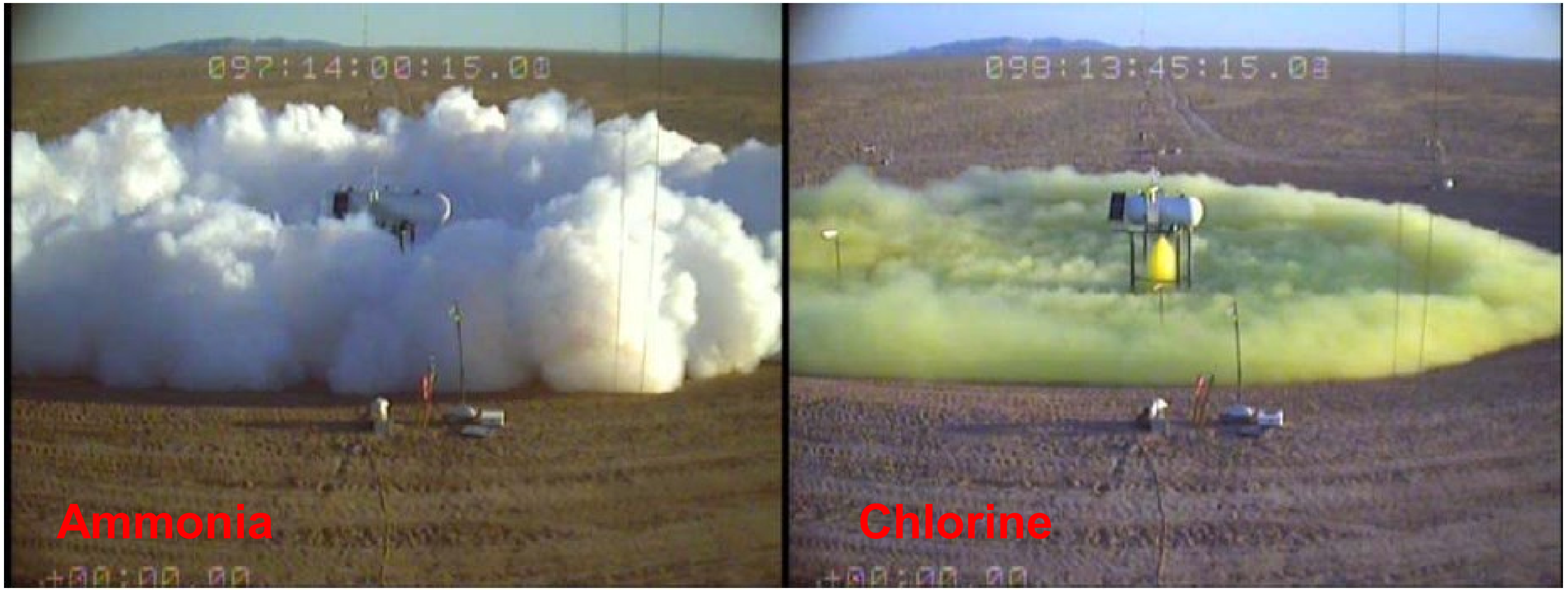
# Content of the presentation

- Motivation
  – We want to better understand the dispersion of heavy gases
- Tested models
  – ARGOS and SLAB and comparison with CFD-modelling
- Examples
  – Chlorine released in the Jack Rabbit field trials in 2010
  – Chlorine and ammonia released in an urban area



# Motivation

- Dispersion of heavy gases are complex to calculate, especially in urban areas
- Many of the most toxic gases used and transported are heavier than air – like chlorine and sulphur dioxide
- Recently, several field experiments and wind tunnel tests have been carried out to help understand the dispersion of heavy gases

- We have used ARGOS and SLAB in the current work and compared some of the results with experiments and Large Eddy Simulations
- The programs require different input parameters. This comparison was therefore not designed to find the best, but to explore their capabilities

# Model descriptions

- ARGOS (PDC-ARGOS and Technical University of Denmark)
  - Uses a local scale puff model (Rimpuff)
  - Includes a source model for estimating the release rate from containers, pipes and spill on the ground
  - Has an urban wind field generator, URD, that allows for treatment of obstacles
  - Has a HeavyPuff box model for dense gases
- SLAB (Lawrence Livermore National Laboratory, USA)
  - Primarily a dense gas model
  - Both plume and/or puff dispersion model
  - Handles different sources: jet, liquid pool, instantaneous volume source
  - SLAB View Windows graphical user interface from Lakes Environmental Software has been used for the present work

# Chlorine release at Jack Rabbit field trials, 2010

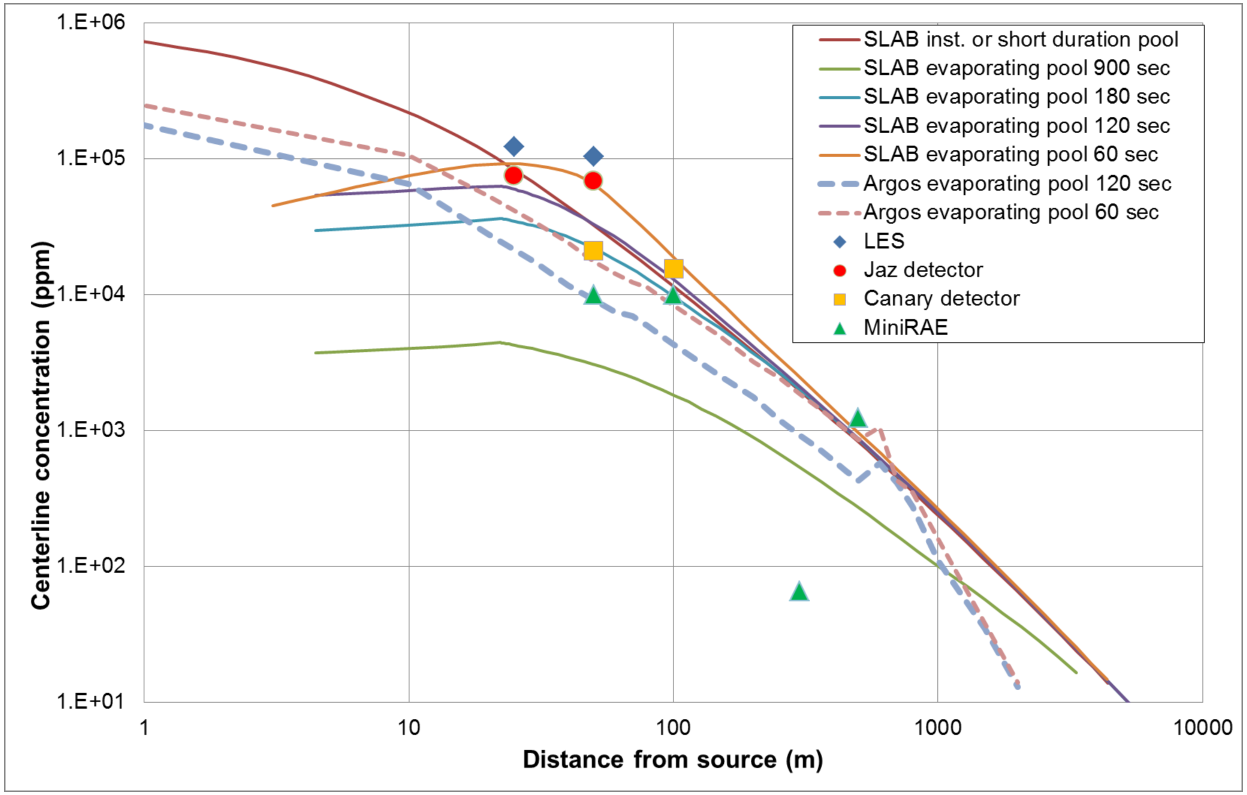

**Release no 05-RC**
Wind speed 1.5 m/s,
Temperature 3.5°C.
Several chemical detectors were placed downwind of the release site.

Picture courtesy of U.S. DHS TSA and DPG

- Conducted at Dugway Proving Ground, Utah, by Department of Homeland Security (DHS) Science and Technology Directorate
- Two tons of chlorine was released downwards into a depression (depth 2 m, diameter 50 m) from a tank with the outlet 2 m above ground
- Downwind chlorine concentrations were predicted at FFI by SLAB, ARGOS and LES

# Results from a release of chlorine

- Two modelling approaches has been used:
  - Instantaneous release (SLAB only)
  - Evaporation from a pool with size of the ground depression using various evaporation times (ARGOS and SLAB)
- Comparison with LES and deployed detectors



# Experiences from the Jack Rabbit field trial

- It is difficult to specify the evaporation rate *a priori.* Several pool duration times have therefore been tested
- Instantaneous releases with SLAB give too high initial chlorine concentrations because chlorine was trapped inside the depression
- The differences between the runs get smaller with distance from the source
- ARGOS predicts lower concentrations than SLAB because the plume predicted by ARGOS is wider
- The discontinuity in the ARGOS results show where RIMPUFF (neutral gas) takes over from HeavyPuff (dense gas)
- Pool duration less than 180 s gives best fit with the observations

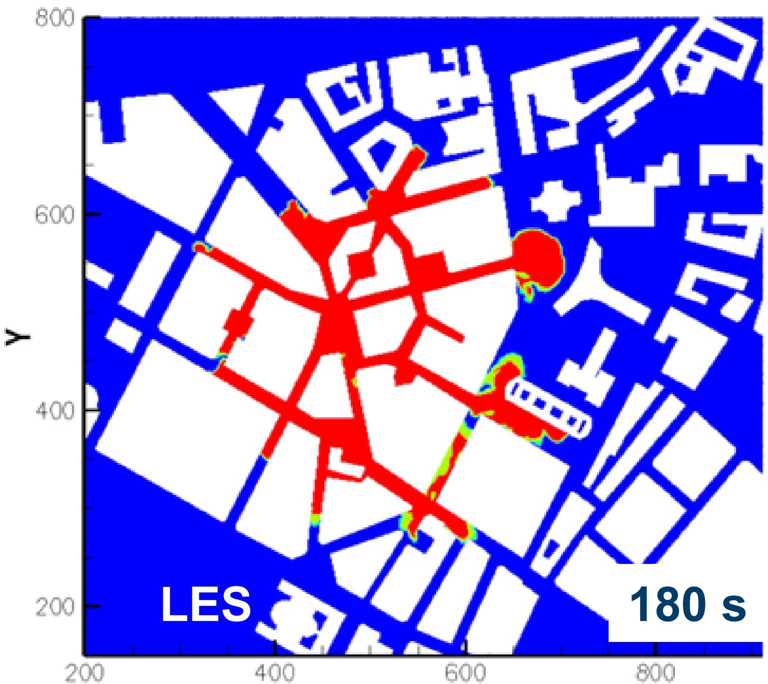
# Releases in an urban environment

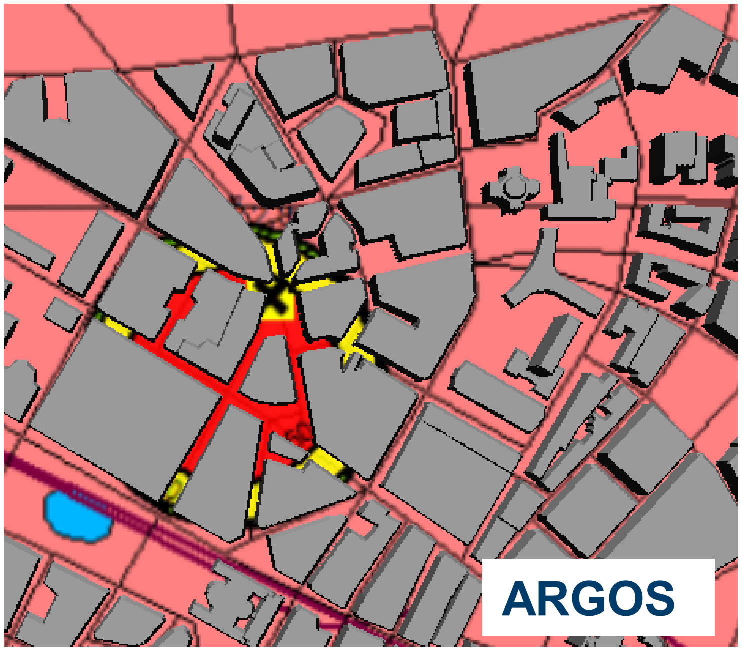
- The releases are simulated in an urban environment (Oslo)
- Two tonnes of chlorine or ammonia were released during one minute with a release rate of 33.3 kg/s
- Wind from west, 3 m/s at 2 m height
- Temperature 15 °C

- The source was positioned close to the ground
- Ammonia was released as two-phase jet consisting of 15 % gas and 85 % liquid or liquid aerosols

# Local dispersion of chlorine in an urban area

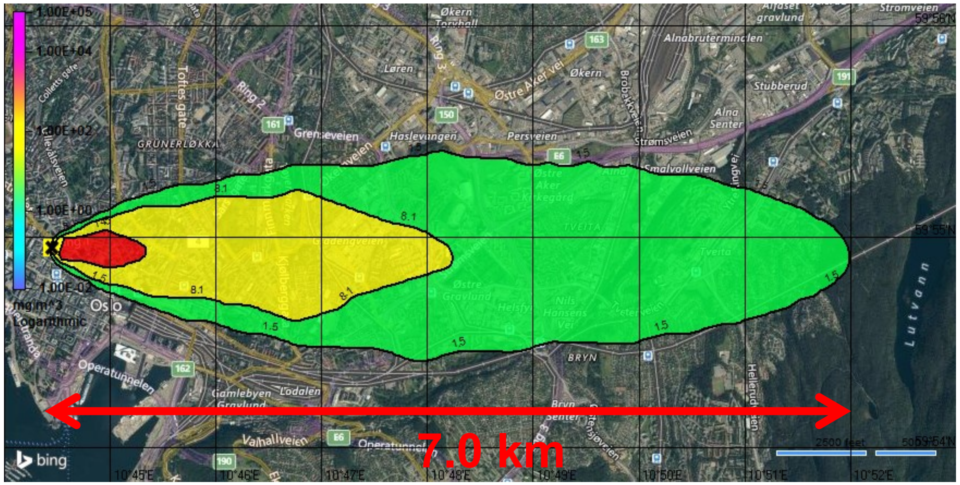
- ARGOS URD was compared with Large Eddy Simulations (LES) - measured 1 m above ground

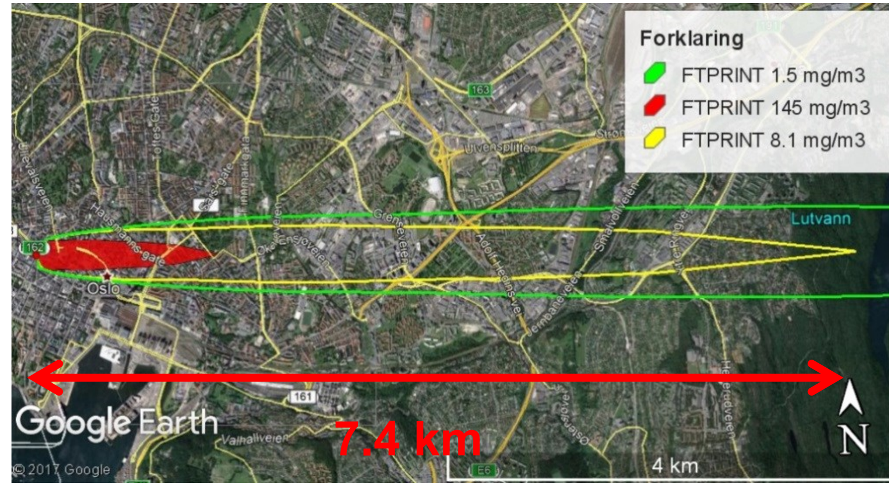



- The chlorine cloud is heavy and stays close to the ground in LES
- The extent of the AEGL-3 plume is therefore larger using LES compared to ARGOS, at least up to 180 s (end of LES-run)
- The LES cloud is spread symmetrically from the source (also upwind).

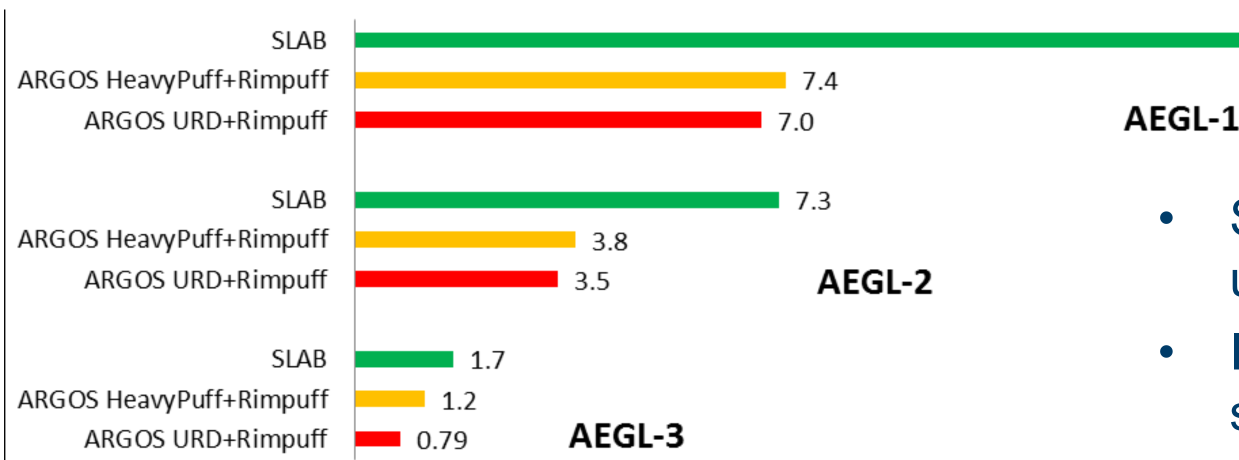
# Chlorine dispersion in an urban area




ARGOS URD+Rimpuff max instantaneous

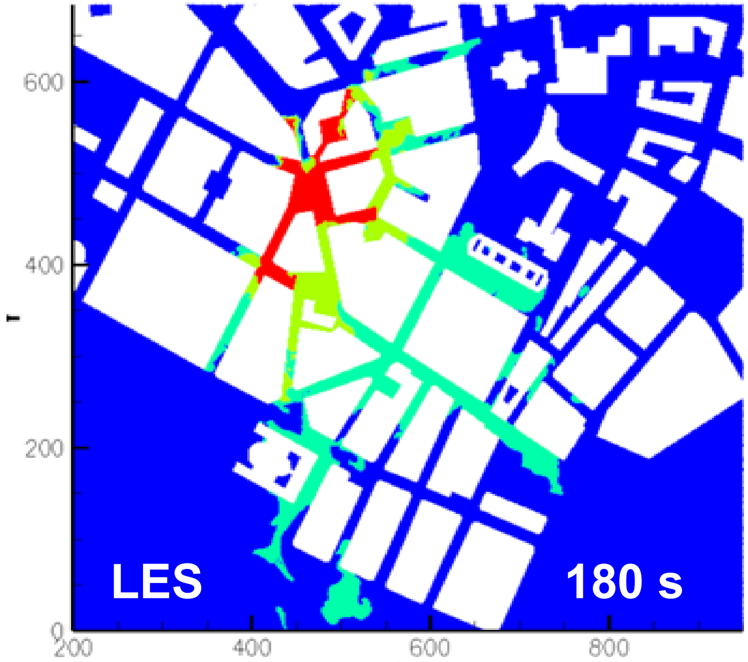
SLAB plume footprints

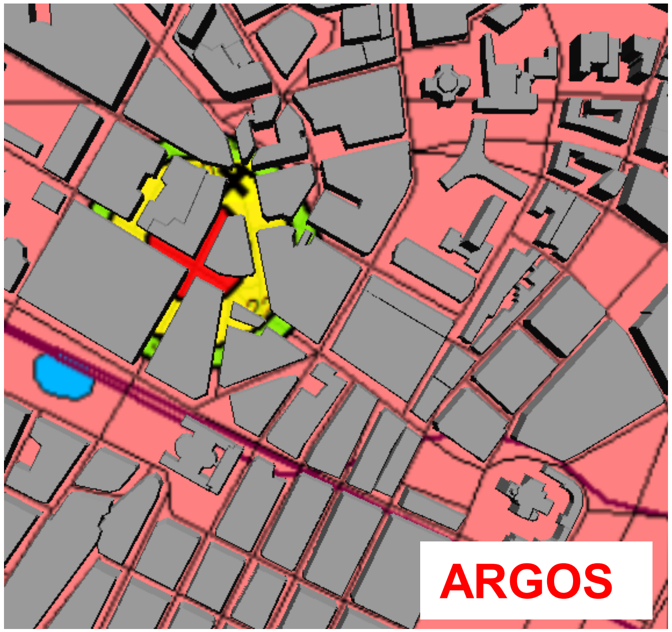



- SLAB does not account for urban topography
- In ARGOS, the plume is somewhat affected by urban topography

# Local dispersion of ammonia in an urban area

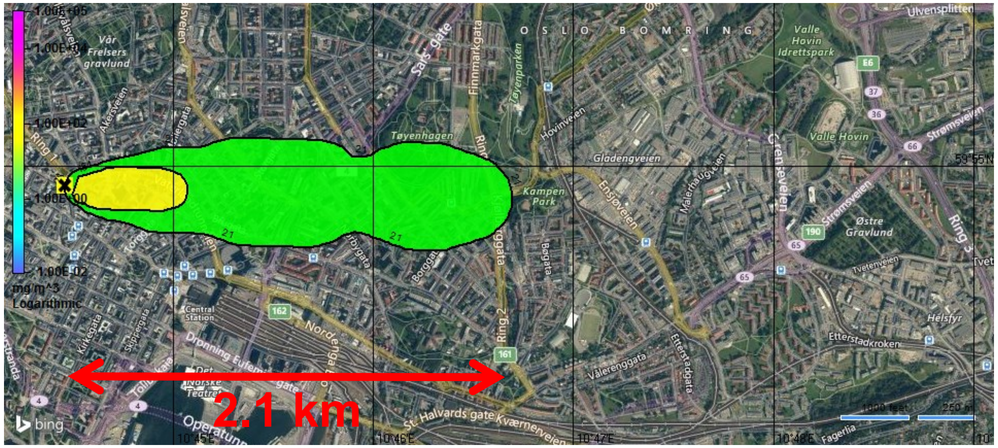
- ARGOS URD was compared with Large Eddy Simulations (LES)
  - measured 1 m above ground

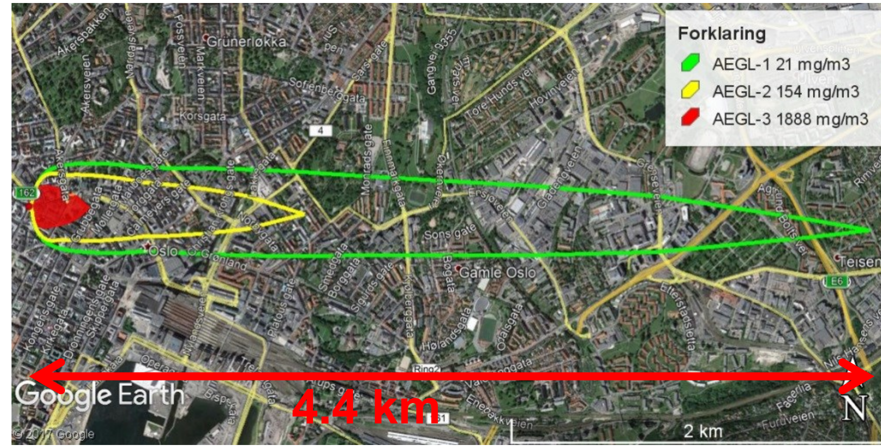



- The extent of the AEGL-3 (red) and AEGL-2 (yellow) plumes are similar, while the AEGL-1 (green) plume is larger using LES, compared to ARGOS, at least up to 180 s (end of LES-run)
- The plume follows the street pattern more closely in LES

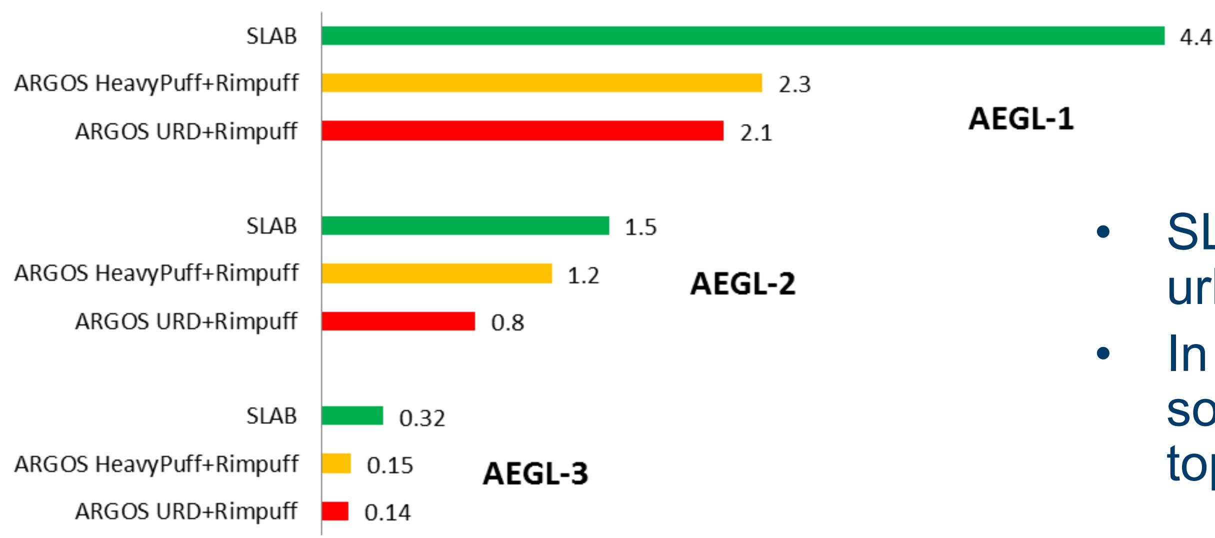
# Ammonia dispersion in an urban area




ARGOS URD+Rimpuff max instantaneous

SLAB plume footprints




- SLAB does not account for urban topography
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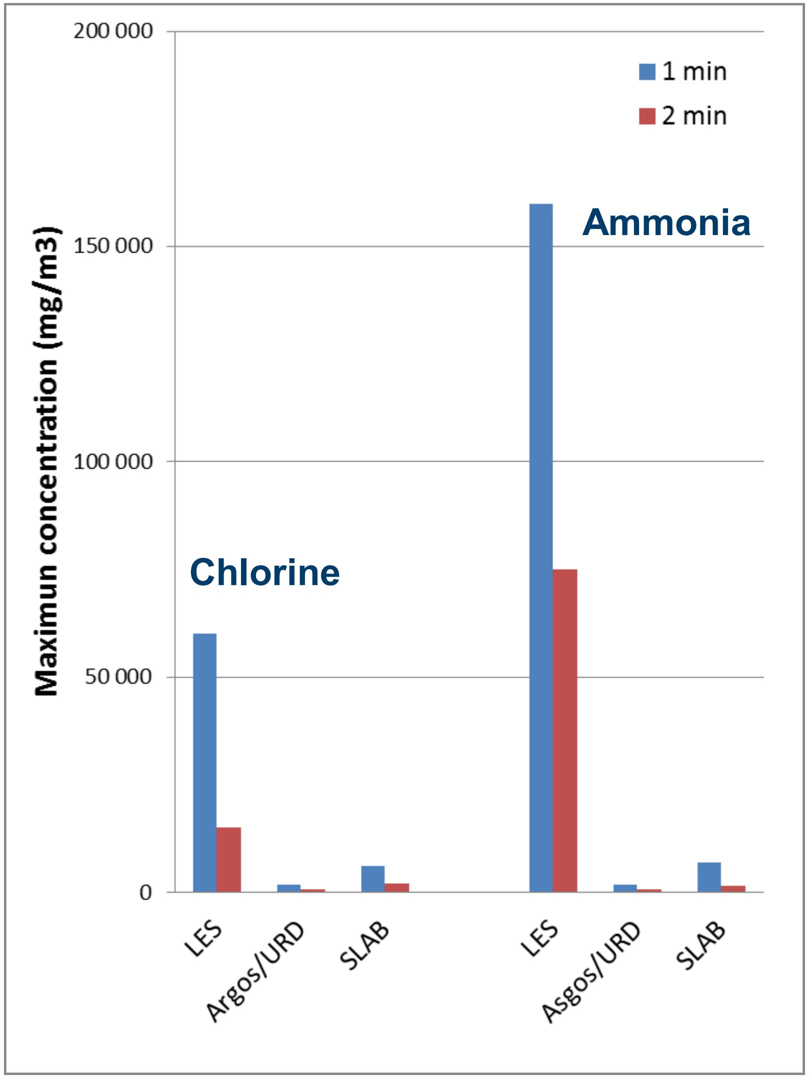
# Comparison of the maximum concentrations




- The peak concentrations one and two minutes after end of release were compared
- The turbulence in the urban area will give fluctuating concentration fields and velocity fields
- LES has much higher time resolution compared to ARGOS and SLAB and therefore predicts much higher maximum concentrations close to the release site

# Conclusions

- ARGOS, SLAB and LES gave results in good agreement with the experimental data from the Jack Rabbit field experiment
- ARGOS predicted a wider plume from the Jack Rabbit release compared to SLAB
- SLAB gave larger areas affected by the toxic chlorine or ammonia plumes compared to ARGOS in an urban release
- CFD produced much higher peak concentrations close to the release site compared with SLAB and ARGOS
- More research is needed to better understand the source term and the limitations of the operational models
- This will be studied during the upcoming EDA MODISAFE project with participation from France, Norway, Sweden and UK (tentative start primo 2018)

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# Thank you for your attention!

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