Strål
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Swedish Radiation Safety Authority

Swedish investigations of dose calculation methods and the use of underlying geographical information in ARGOS

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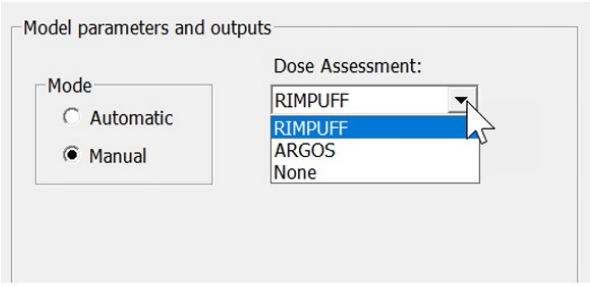
Adding dose calculation methods in RIMPUFF

Objective:

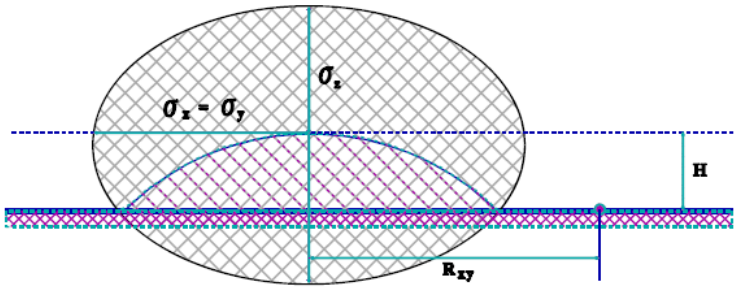
- A comparison between the built-in method and the semi-infinite method for external long range models when calculating the gamma dose from the radioactive plume (cloud dose) in RIMPUFF
  - New functionality in ARGOS



Why

- Opens up for the use of age-dependent external dose rate coefficients from ICRP 144
- When comparing RIMPUFF and MATCH results

RIMPUFF method



A1: Precalculated dose rates for 1 MeV/s. The volume integral in equation (2.12) is solved for different sets of parameters numerically

A2: Interpolation of A1 is made for a puff with a given set of parameters in 4 energy groups

A3: A nuclide library is tabulated with energy release rate per unit activity in 4 energy groups.

A4: The total energy released in 1 s in 4 energy groups: A3 times activity in the puff

A5: The dose rate for a nuclide is the sum of A2 times A4 for each energy group

The method for calculation of gamma dose rates in a given receptor point from a Gaussian puff for each gamma radiation energy is based on the solution of the equation below:

$$d(Q, E_\gamma, \sigma_{xy}, \sigma_z, H, R_{xy}) = 2\,K\,\sigma_{en}\,E_\gamma \int_{x=-\infty}^{\infty}\int_{y=0}^{\infty}\int_{z=-\infty}^{\infty} \frac{B(\mu r)}{4\pi r^2} e^{-\mu r}\,X(x,y,z)\,dxdydz \quad Gy/s \qquad (2.12)$$

where

Q	activity in one puff [Bq]
E_γ	energy of gamma radiation [MeV]
σ_{xy}	crosswind puff dispersion parameter [m] ($\sigma_x = \sigma_y$)
σ_z	vertical puff dispersion parameter [m]
H	height of the puff centre [m]
R_{xy}	distance of the puff centre base point (x = y = 0,z=-H) from the receptor point [m]
K	constant, 1.6 10^{-13} [Gy/s/MeV/kg]
σ_{en}	energy absorption coefficient for air [m^2/kg]
B	build up factor
μ	linear attenuation factor for air [m^{-1}]
r	distance of the volume dxdydz from the receptor point located at the distance R_{xy} from the puff centre base point
X(x,y,z)	the concentration in point x,y,z [Bq/m^3] due to the formula

$$X(x,y,z) = \frac{Q}{(2\pi)^{3/2}\,\sigma_{xy}^2\,\sigma_z}\, e^{-\frac{x^2}{2\sigma_{xy}^2}}\, e^{-\frac{y^2}{2\sigma_{xy}^2}}\, e^{-\frac{z^2}{2\sigma_z^2}}$$

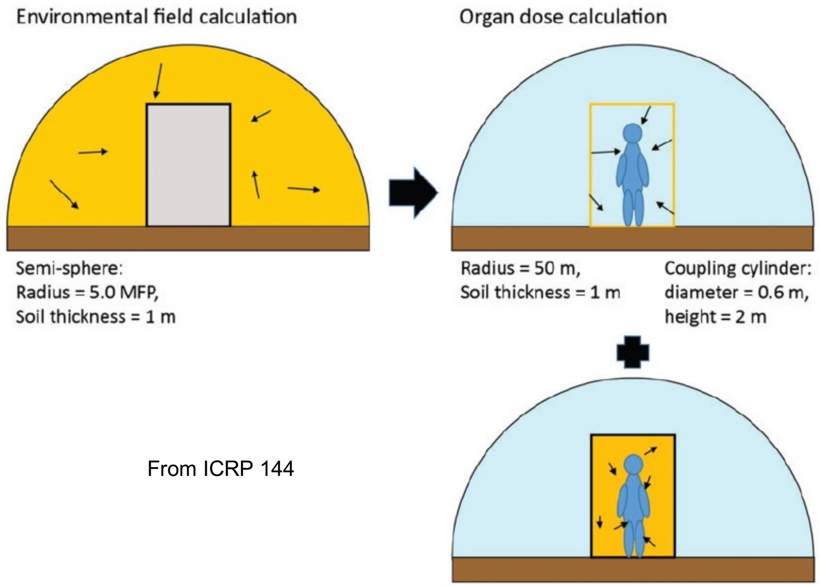
ARGOS method

- Apply nuclide-specific effective dose rates from air submersion in a semi-infinite source
- Tabulated values from ICRP 144:

  A1: Apply Monte Carlo method to simulate particle transport (monoenergetic photons and electrons) in a specified environment.

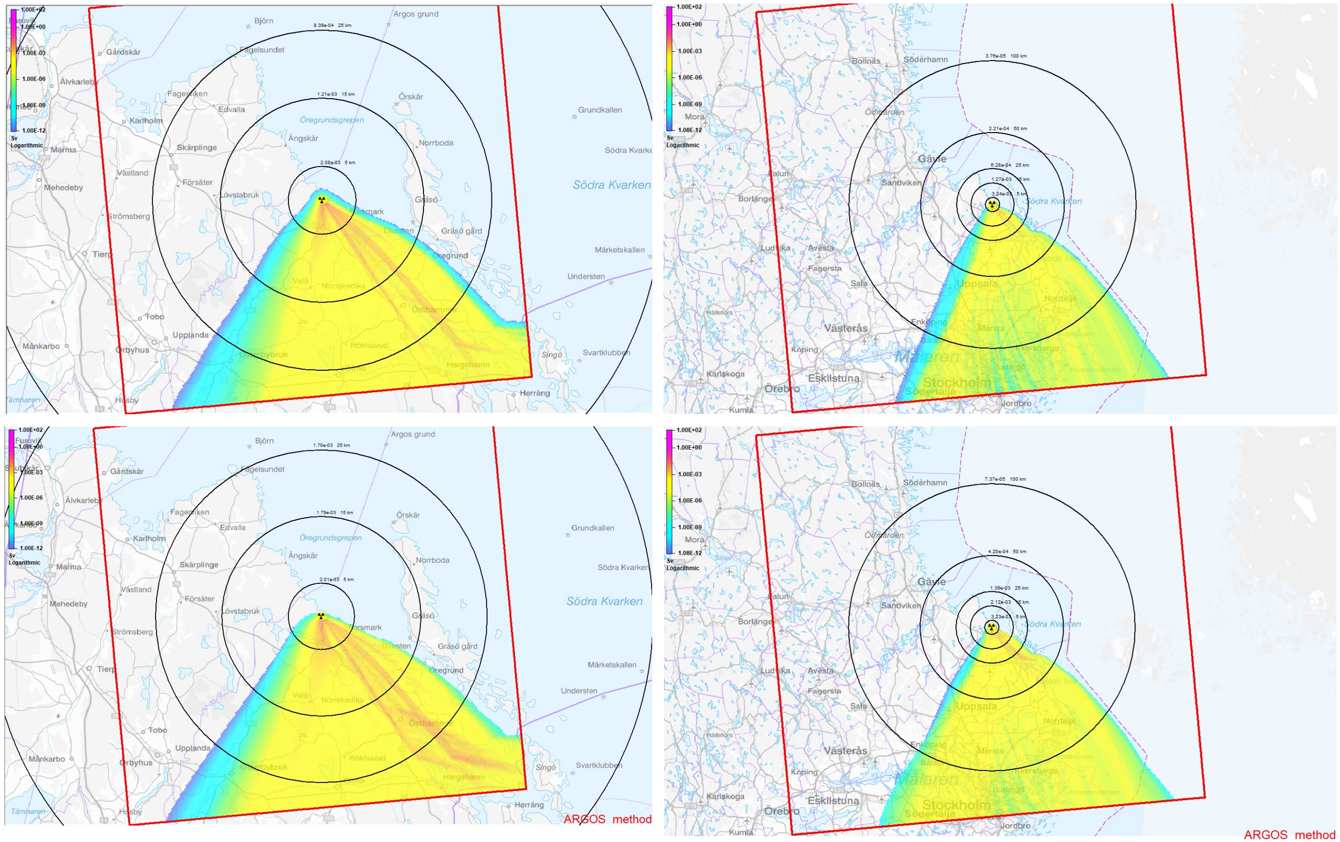
  A2: Computation of organ equivalent dose rate coefficients in each sex- and age-specific phantom resulting from the simulated radiation fields from A2.

  A3: Weighting A2 with nuclide-specific energy spectra to yield nuclide-specific dose rate coefficients.
- Available for adults and children in five different age groups (newborn, 1-year-old, 5-year-old, 10-year-old and 15-year-old)
- Ambient dose rate coefficients also available



From ICRP 144

Qualitative results



- Next step is quantitative results:
  - Perform a well defined test using batch runs with different weather cases for the two methods
  - Use AI to define the test?

Updating the nuclear and radiological assessment report

Objective:

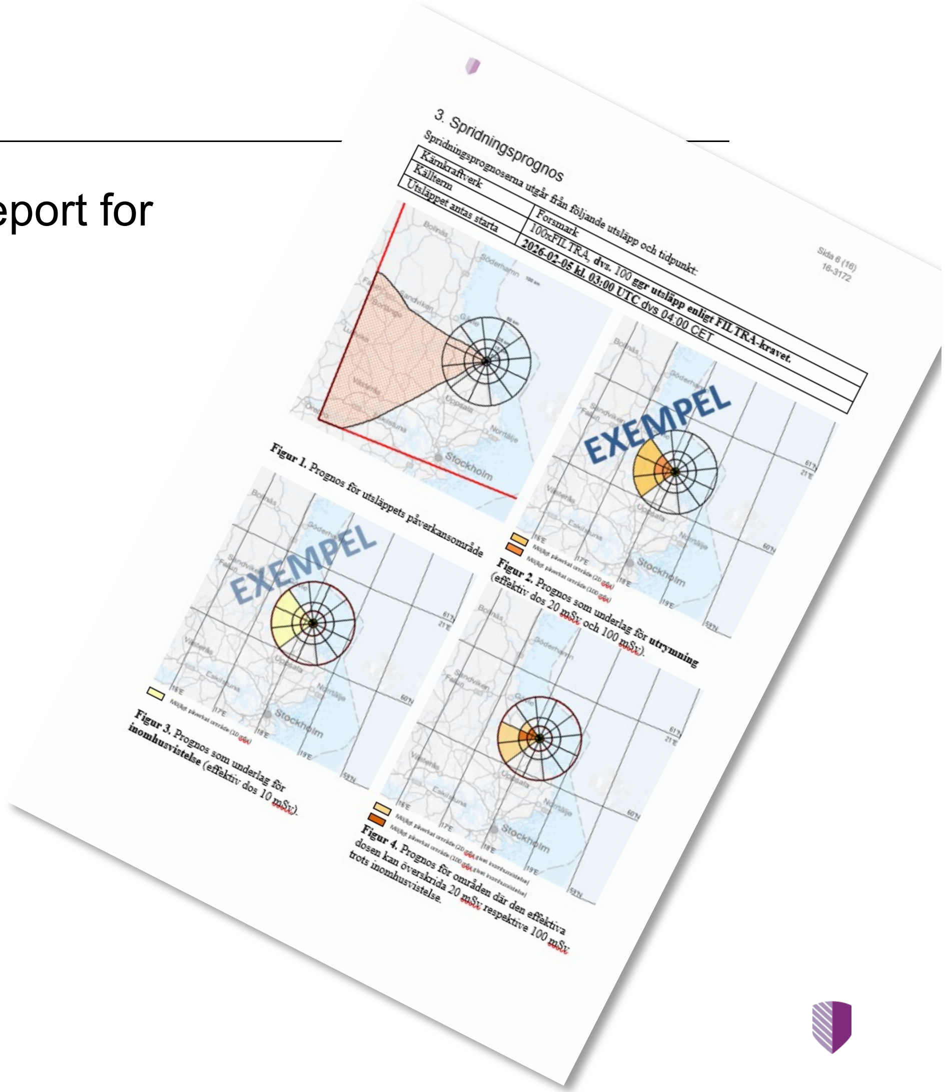
- Update of nuclear and radiological assessment report for Swedish nuclear power plant accidents

Why

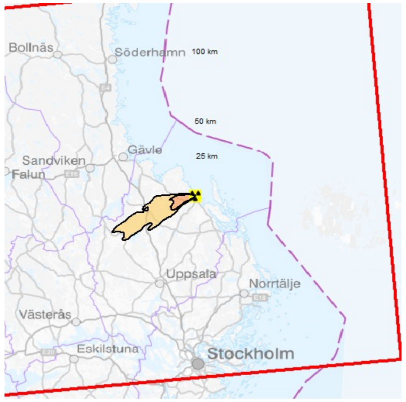
- Experience from large-scale NPP exercises
- Feedback from decision makers
- New recommendations

At the same time

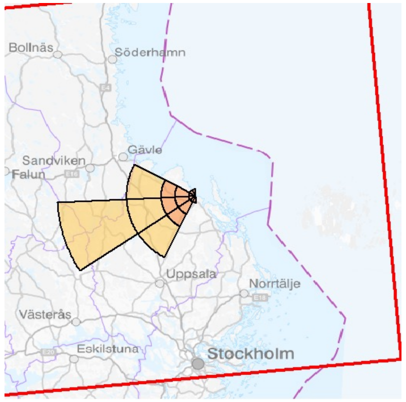
- New functionalities in ARGOS



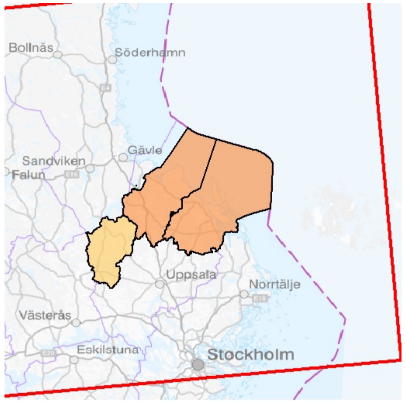
Examples of alternatives



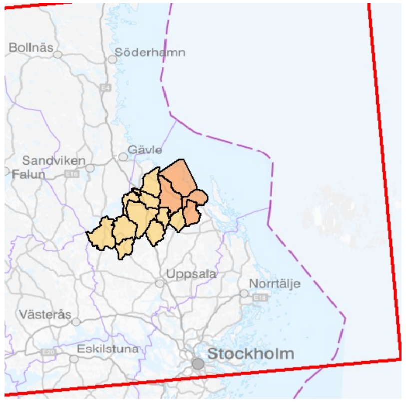
Plume isocurves



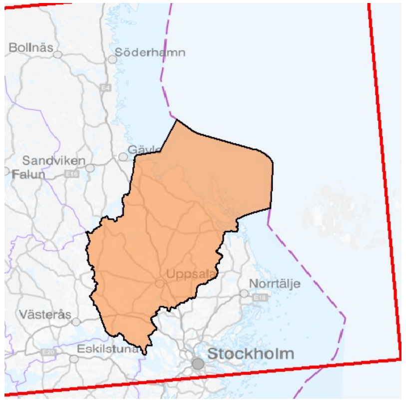
Sectors
(out to 5, 15, 25, 50 and 100 km)



Municipalities

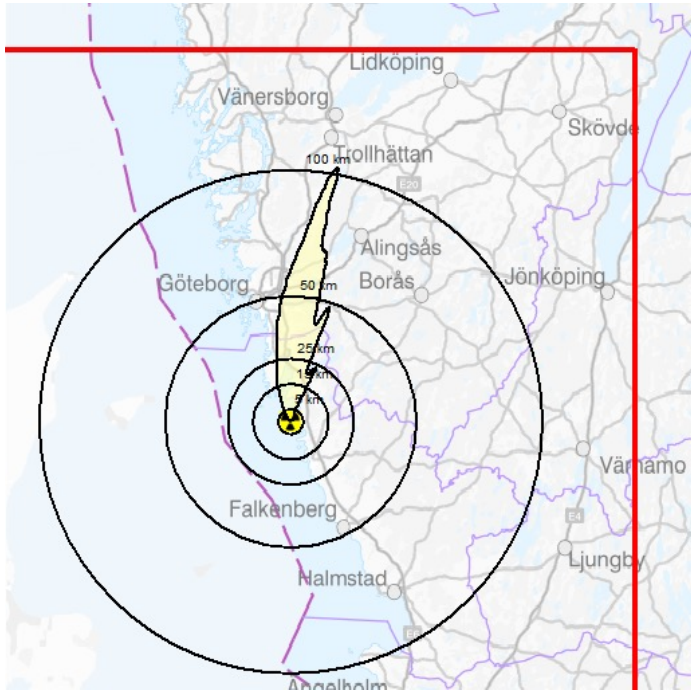


Parishes

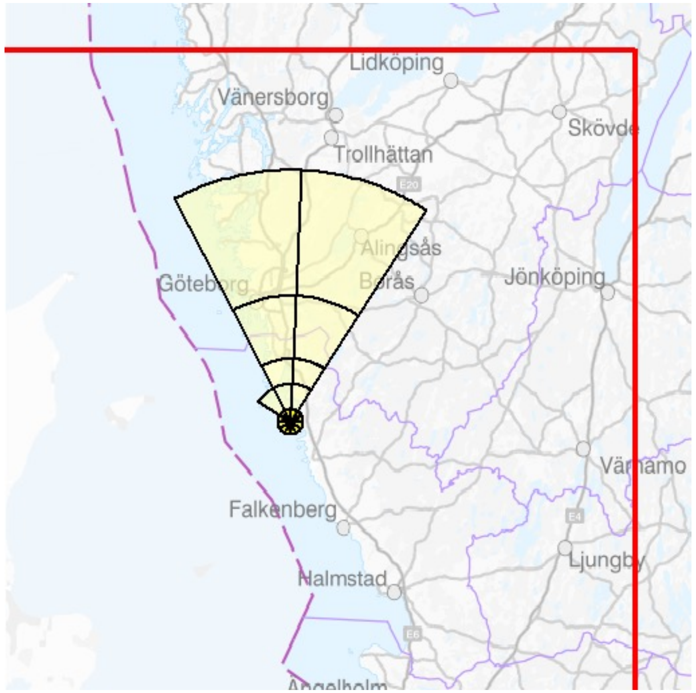


Counties

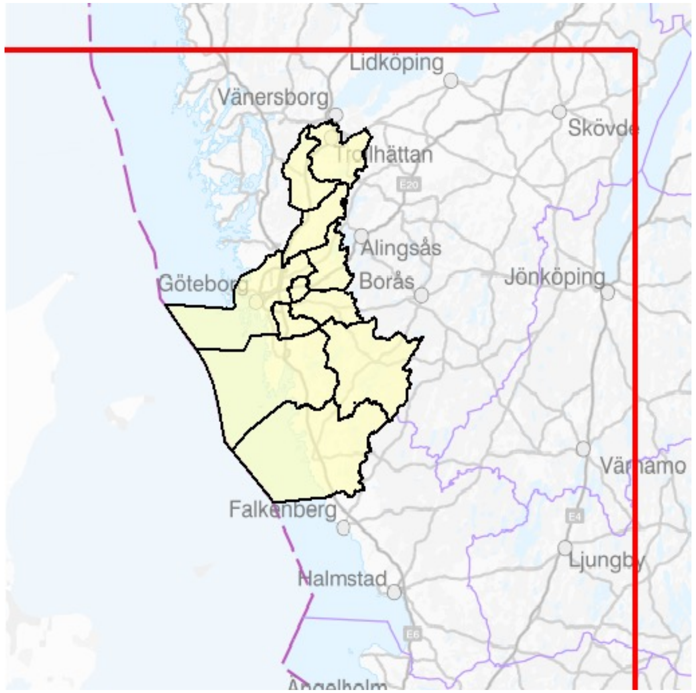
Which to choose?



Plume isocurves

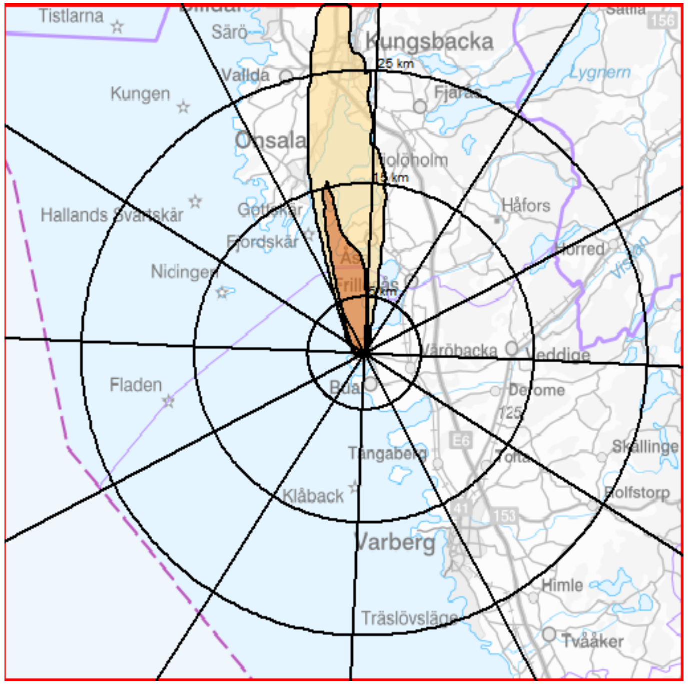


Sectors

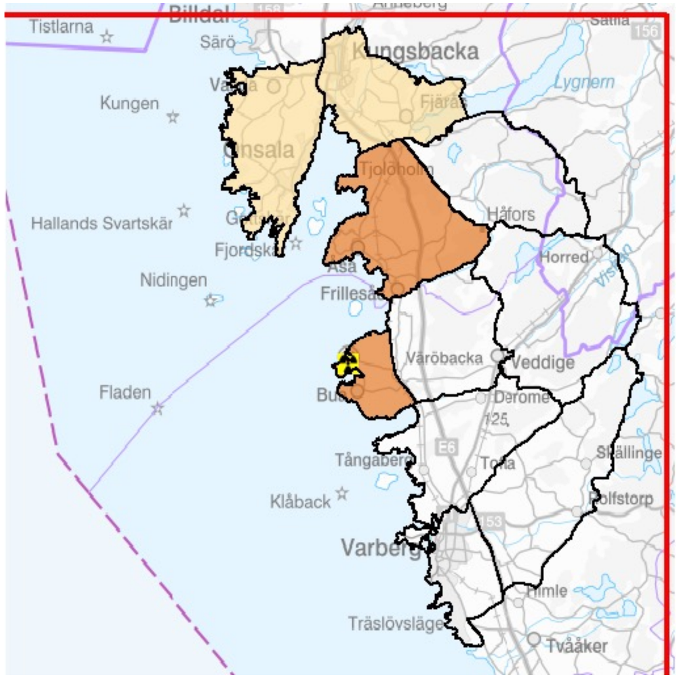


Municipalities

Next step



Plume isocurves with underlying sectors



Isocurves filled inside pre-planned action areas

Updating the land cover data in RIMPUFF

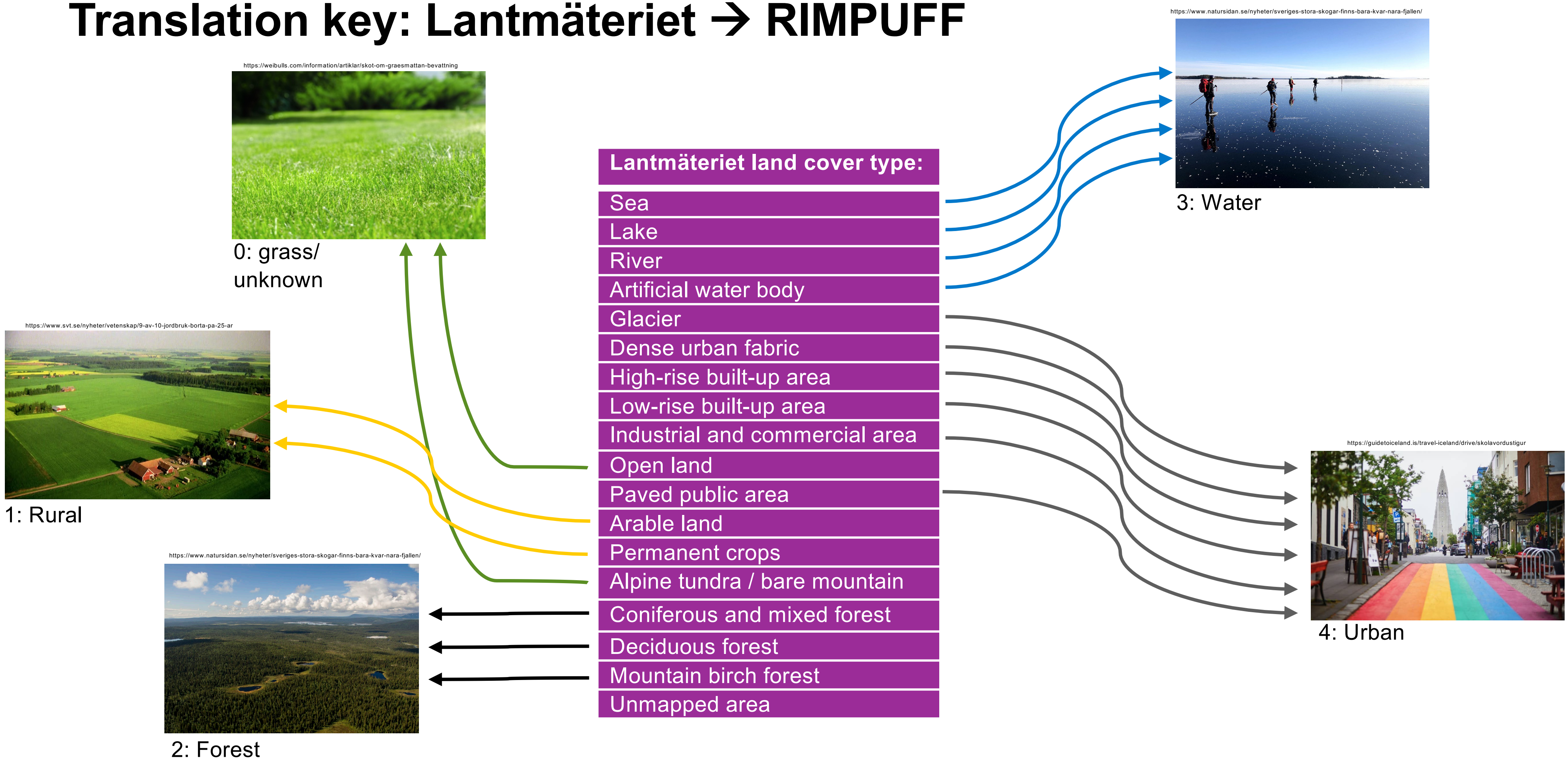
Objective:

- Update Sweden’s land cover dataset by replacing CORINE (2006–2010) with high-resolution land cover data from the Swedish Mapping, Cadastral and Land Registration Authority (Lantmäteriet)

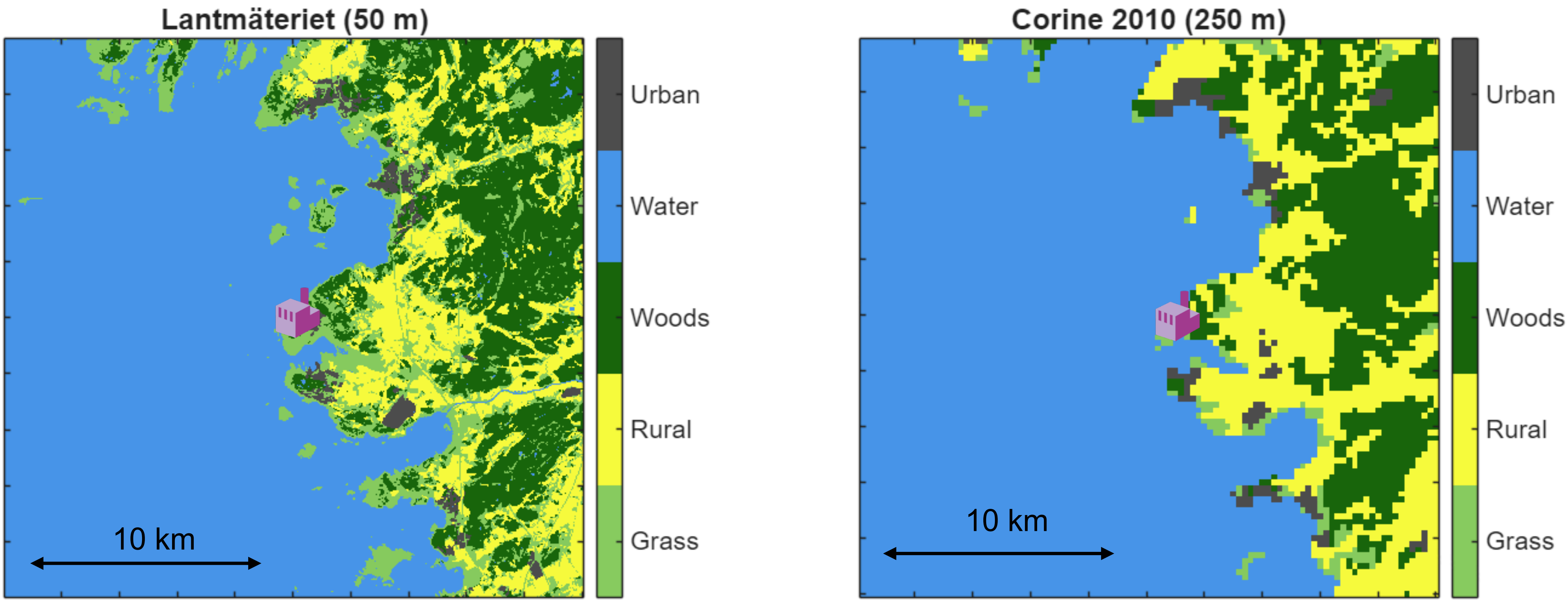
Why update the dataset?

- Landscape changes since 2010
- Higher spatial resolution should improve model accuracy
- Opportunity to evaluate model sensitivity to land cover data

Translation key: Lantmäteriet → RIMPUFF



Comparison between the datasets, the Ringhals area



Next step: apply seasonally dependent deposition?

https://www.freepik.com/premium-photo/winter-deciduous-forest-foggy-december-s-morning_12424946.htm

https://www.doktorn.com/artikel/bor-du-nara-en-lovskog-det-kan-minska-stress/

https://forskning.se/2025/11/17/insekter-ett-vaxande-hot-mot-europas-barrskogar/

- Why not use seasonally dependent deposition factors when ~ 70 % of Sweden is covered by forest?

  ~ 80 % of Swedish forests are coniferous

- Separate classes for deciduous and coniferous forest in RIMPUFF would be useful in this case
- Despite these refinements, considerable uncertainties in the deposition velocities persist

Conclusions and key learnings from the land cover update in RIMPUFF

- A small increase (10%) in dry deposition was found around Ringhals when using updated Lantmäteriet land cover data
- The higher resolution dataset contains more forested areas and islands, increasing land surface receptivity and deposition
- Educational process: providing insights into what aspects of the model are affected and what remains unchanged when replacing land cover dataset
- Using updated land cover data strengthens the credibility of future assessments
- Despite these refinements, there are still large uncertainties in the simulated depositions

Thank you!
Questions?