THE FUKUSHIMA INVERSE PROBLEM

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

LCAV

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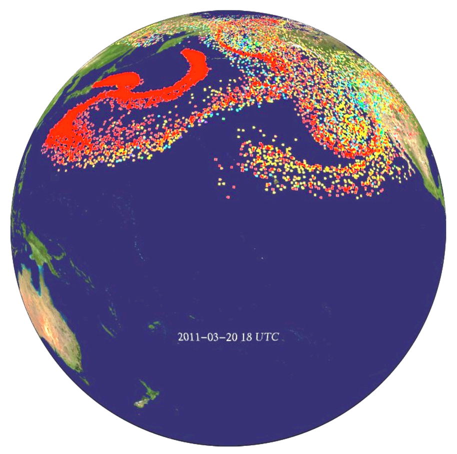
MOTIVATION

- March 11 2011, Japan
- Earthquake, tsunami, *nuclear accident*
- Estimate radioactivity dispersion
- Use atmospherical dispersion models

LAGRANGIAN DISPERSION MODELS (LDMs)



- Dispersion of particles by the atmosphere
- Approximated by a linear model
- Discretized into a *linear system*

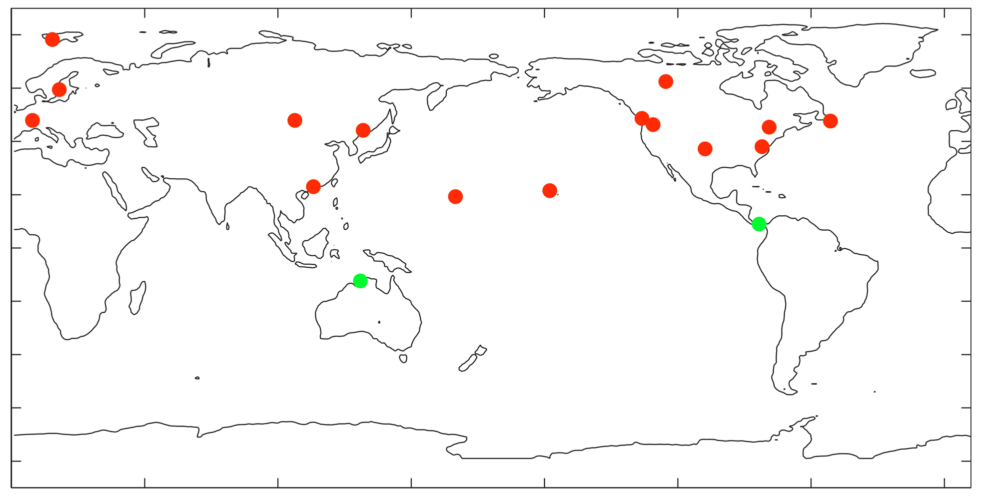
$$y(\xi, t) = \int_0^t A(\xi, \tau) x(\tau) d\tau$$

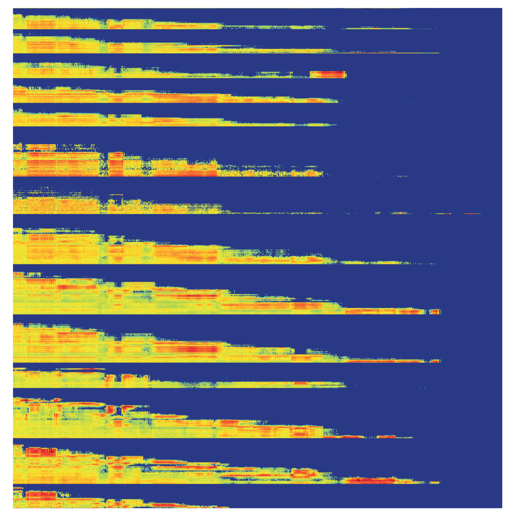
Measurements — Weather — Emissions

Known → $\mathbf{y} = \mathbf{A}\mathbf{x}$ ← Unknown

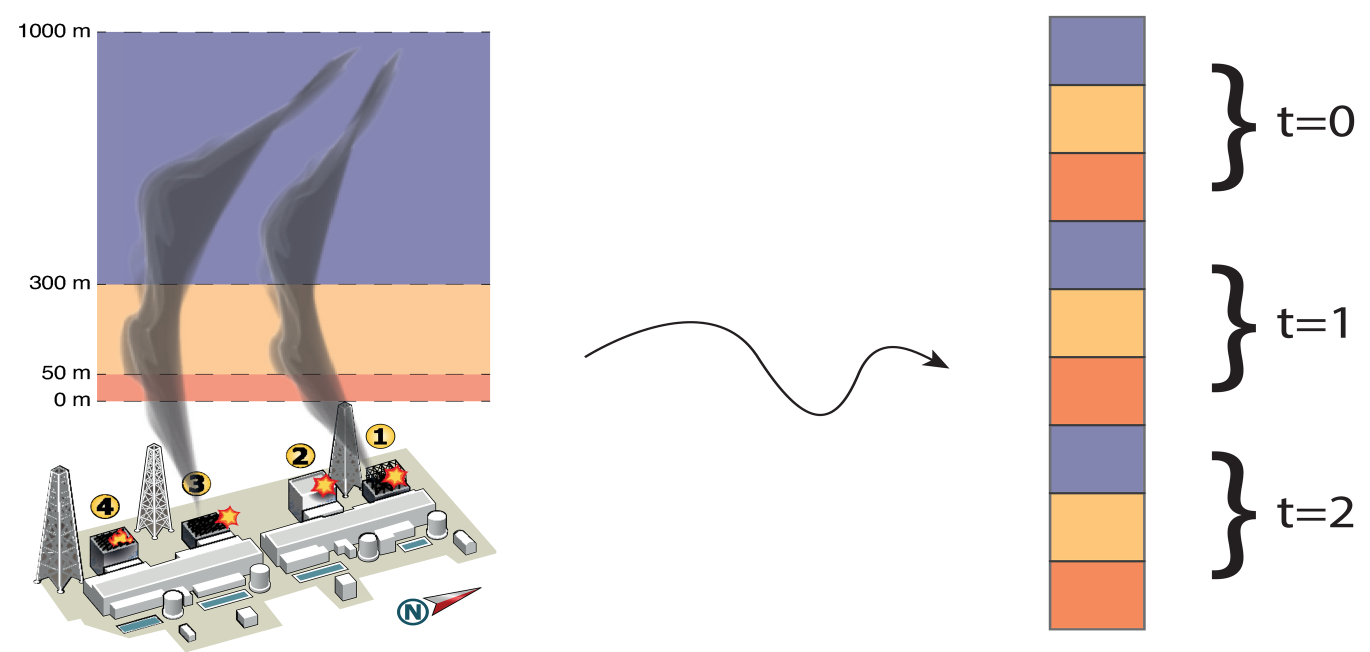
Estimated

MEASUREMENTS & MATRIX

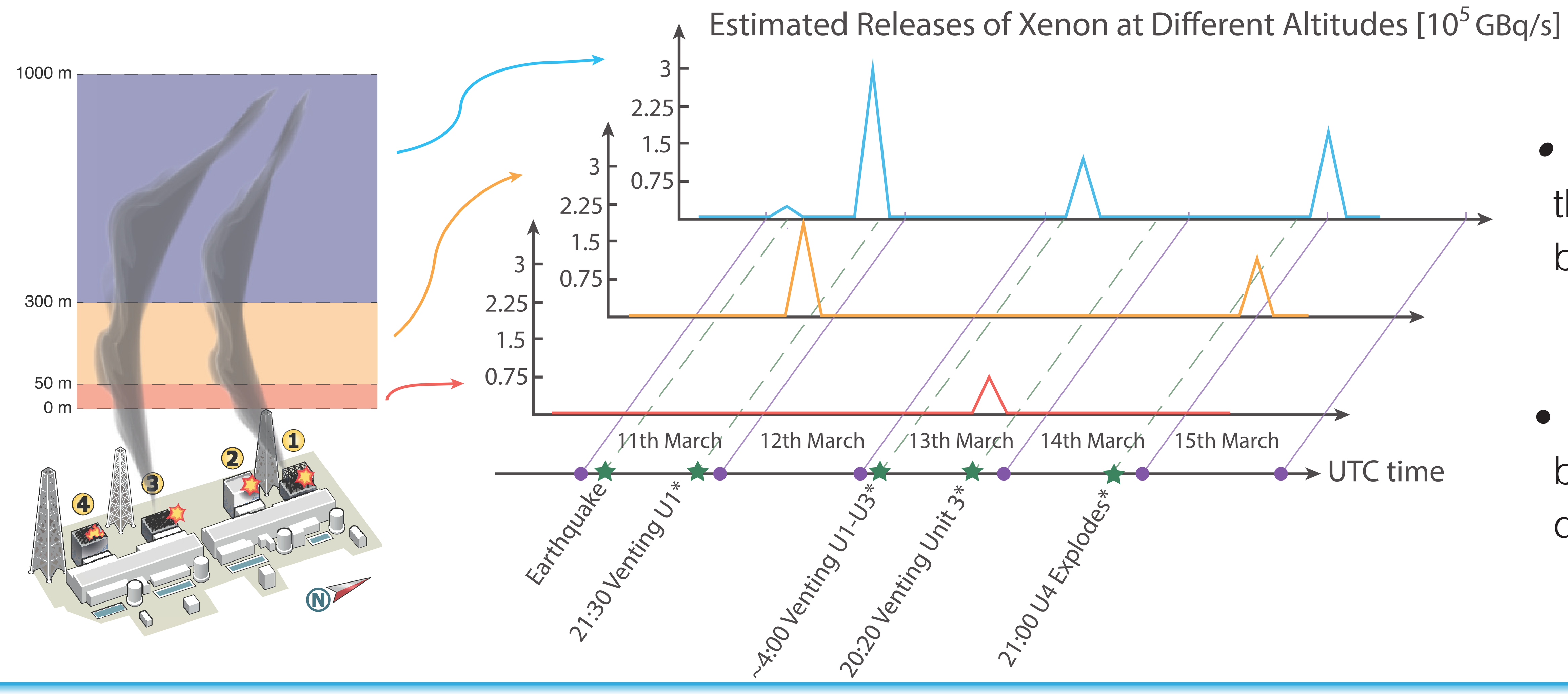




DIFFERENT ALTITUDES



ESTIMATION USING REAL MEASUREMENTS



- *Total emitted quantity* matches the Xe inventory in the plant before the accident.
- The estimated emissions can be related in time with the *events* during the accident.

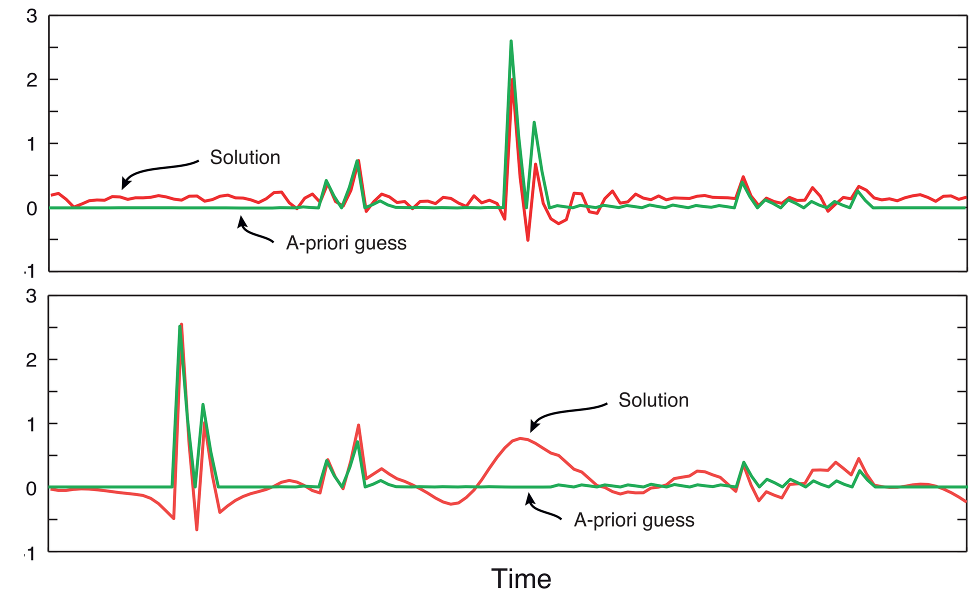
SOLVING THE INVERSE PROBLEM

- Large condition number, *ill-posed* problem
- Regularization needed

State of the art

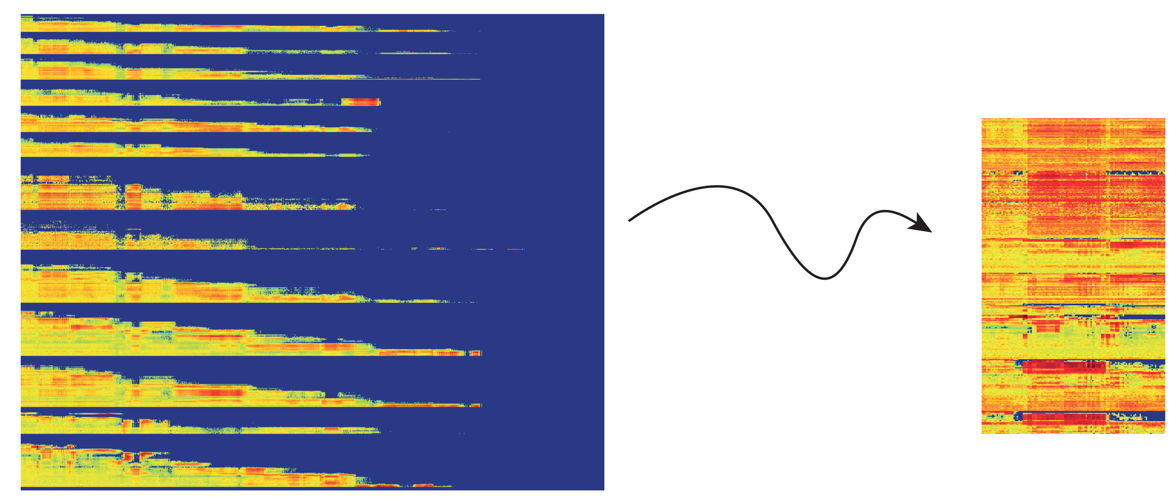
$$\min_{\mathbf{x}} ||\mathbf{A}\mathbf{x} - \mathbf{y}||_2 + \lambda ||\mathbf{x} - \mathbf{x}_a||_2$$

- [2] uses an *a priori* solution
- Hence, gives a biased result



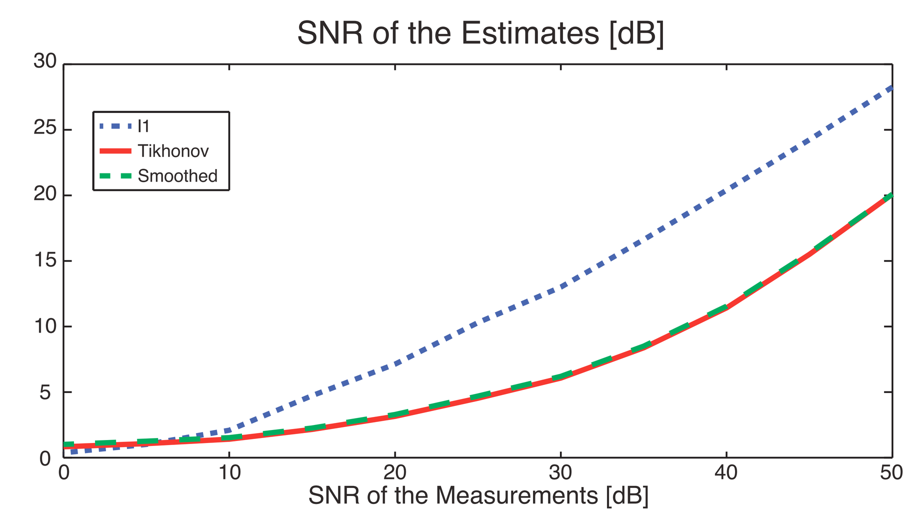
Our method

Step 1: Matrix cleaning



Step 2: Sparse regularization

$$\min_{\mathbf{x}} ||\mathbf{A}\mathbf{x} - \mathbf{y}||_2 + \lambda ||\mathbf{x}||_1$$
$$\text{s.t } \mathbf{x} \geq 0$$



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[1] A. Stohl, C. Foster, A. Frank, P. Seibert, and G. Wotawa, "Technical Note: The Lagrangian particle dispersion model FLEXPART version 6.2," Atmos. Chem. Phys. Discuss., vol. 5, no. 4, pp. 4739-4799, 2005.

[2] A. Stohl, P. Seibert, G. Wotawa, D. Arnold, J.F. Burkhart, S. Eckhardt, C. Tapia, A. Vargas, and T.J. Yasunari, "Xenon-133 abd caesium-137 releases into the atmosphere from the Fukushima Dai-ichi nuclear power plan: determination of the source term, atmospheric dispersion, and deposition", Atmos. Chem. Phys. Discuss., vol. 12, no. 5, pp. 2313-2343, 2012.

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