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Pest detection by inversion of a pheromone dispersion model

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► **To cite this version:**

Thibault Malou, Simon Labarthe, Béatrice Laroche, Elisabeta Vergu, François Deslandes. Pest detection by inversion of a pheromone dispersion model. ECMTB 2022 - 12th European Conference on Mathematical and Theoretical Biology, Sep 2022, Heidelberg, Germany. hal-03777604

HAL Id: hal-03777604

<https://hal.science/hal-03777604>

Submitted on 14 Sep 2022

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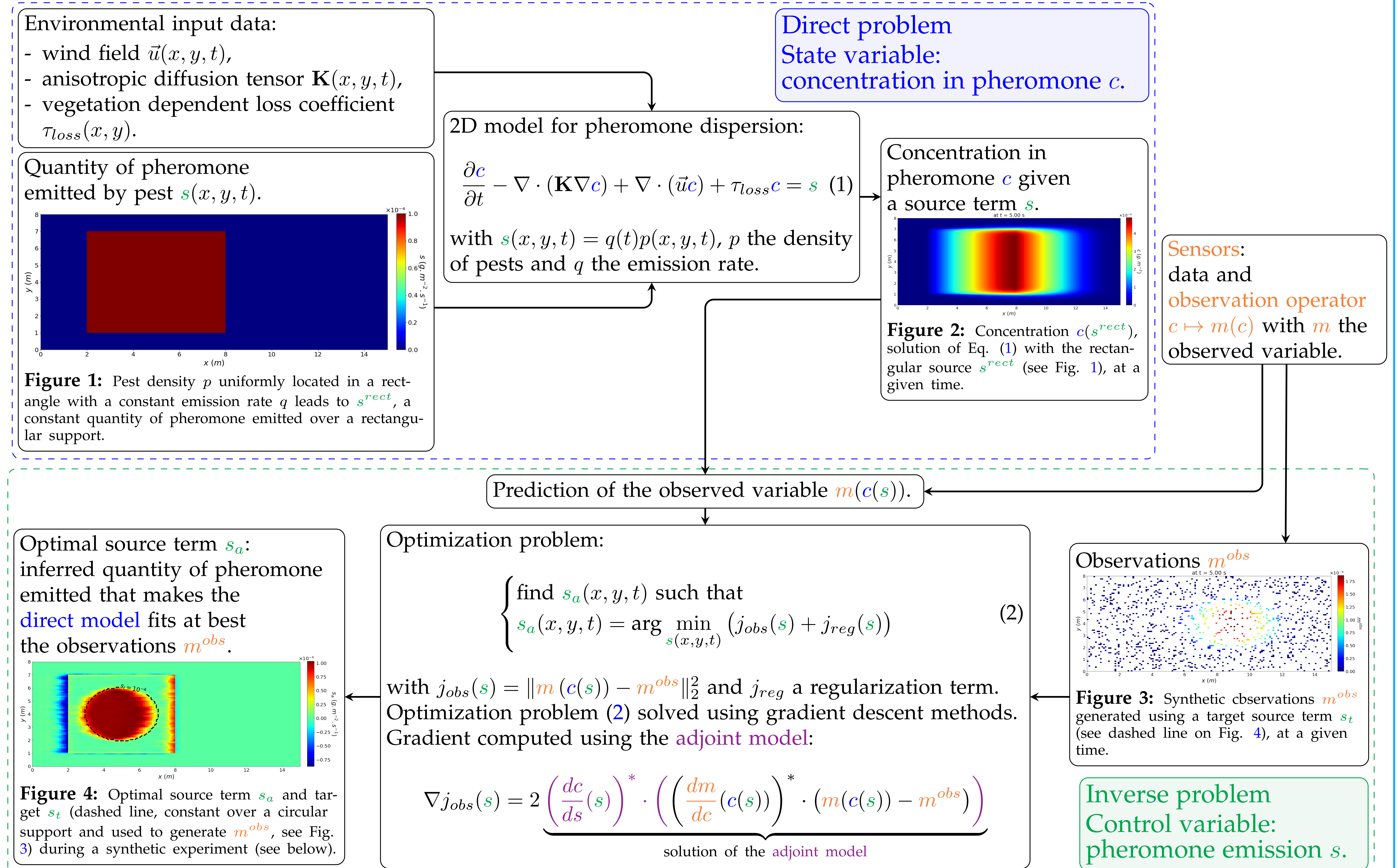
CONTEXT AND OBJECTIVES

Early detection of invasive insect pests is key for precise treatment of crops before infestation occurs. Promising new sensors are now available to detect pheromones produced by pests and dispersed in the environment. Knowing the rate of pheromone emission by the pest, **tracking the source of pheromone emission would allow to locate these pests** and to remove them with pesticide-free treatments.

In order to **model the dispersion of the pheromone in the environment** (direct problem), a 2D model (see Eq. (1)) is derived from a 3D diffusion-convection model (see e.g. [1]), and includes vegetation dependent loss coefficient.

The quantity of pheromone emitted by the pest is inferred from signals produced by sensors positioned in the landscape (inverse problem) in order to locate the pests. As classically done in the inverse problems theory and especially in data assimilation (see e.g. [2]), this problem is treated as an optimization problem (see Eq. (2)).

DIRECT AND INVERSE PROBLEMS FOR PESTS LOCATION



FIRST RESULTS

- Derivation of the direct model (1).
- Implementation of solvers for the direct and inverse problems.
- First experiments in a simple synthetic experiment:
 - stationary and uniform wind \vec{u} ,
 - observations generated (without noise) using a target source term s_t (see the dashed line in Fig. 4),
 - randomly chosen observations (see Fig. 3),
 - simple observation operator $m(c) = c$,
 - no regularization term considered ($j_{reg} = 0$ in (2)),
 - gradient descent algorithm with constant learning rate,
 - iterative process started from a rectangular source $s_0 = s^{rect}$ (see Fig. 1, $j(s^{rect}) \approx 6 \times 10^{-7}$).

Optimum s_a close to the target s_t on Fig. 4 ($j(s_a) \approx 7 \times 10^{-11}$).

REFERENCES

- [1] J. M. Stockie. The mathematics of atmospheric dispersion modeling. *Siam Review*, 2011.
- [2] F. Bouttier and P. Courtier. *Data assimilation concepts and methods*. Meteorological training course lecture series. ECMWF, 2002.

UPCOMING RESEARCHS AND CONTRIBUTIONS

- **Sensitivity analysis** of the dispersion model (1) with respect to the source term.
- **Inference of the source term in more realistic contexts:** sparse and noisy data, realistic observation operator and cases with field environmental input dataset.
- Introduction of **a priori biological knowledge** on pest behaviour (favourite habitat, insect clustering for reproduction...) in j_{reg} to constrain the inverse problem (2) towards biologically relevant solutions.
- Optimal experimental design for **optimal sensor placement**.
- Software optimization: **model reduction**, ...

CONTACT INFORMATION

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