

NITROGEN OR US: TRACING THE SILENT KILLER FOR EFFECTIVE AIR POLICY

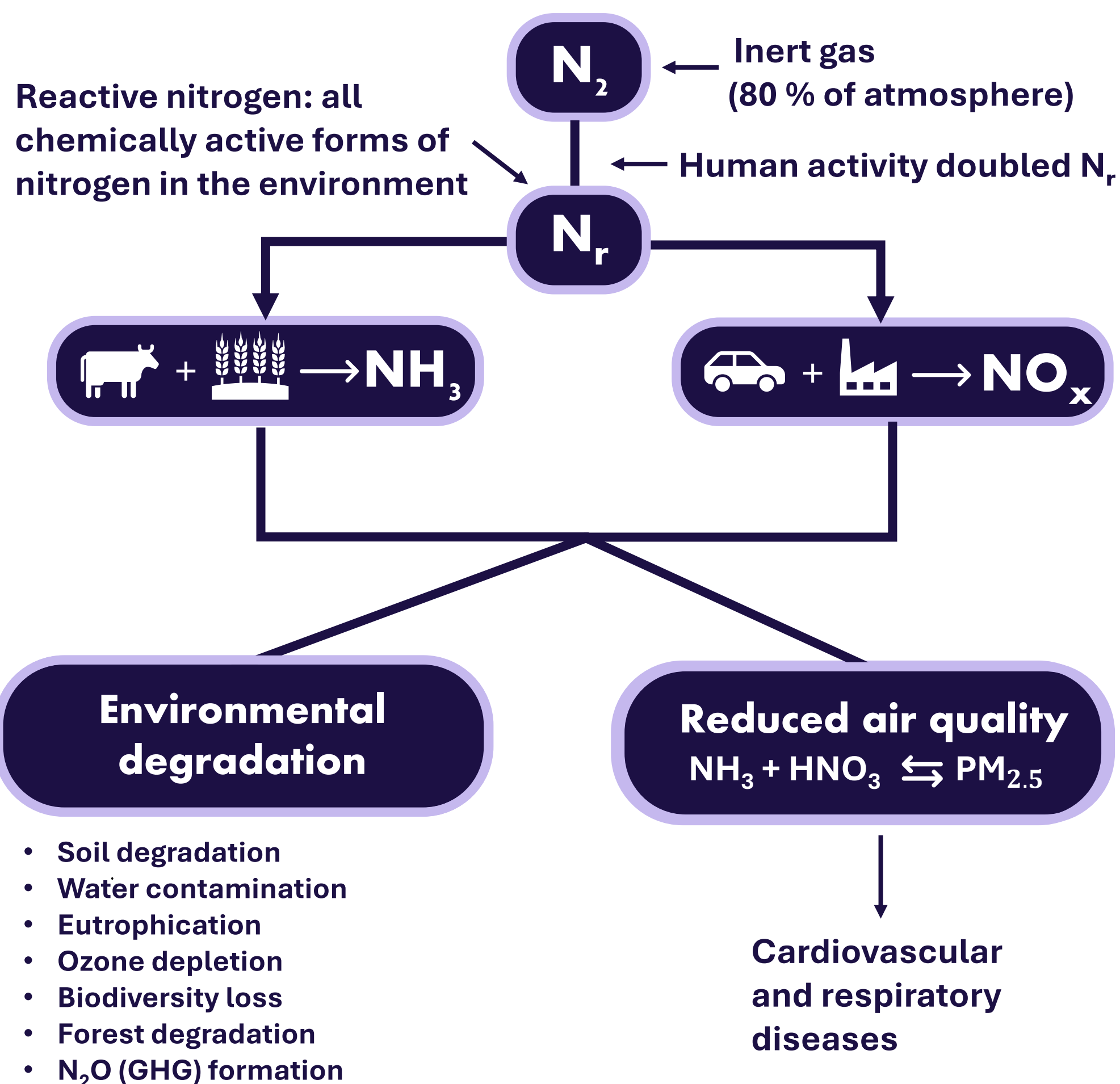
Laboratory of Atmospheric Processes and Impacts

Author: Beāte Anna Klepere Supervisors: Jun Zhang, Yanshun Li, Athanasios Nenes

Contact: beate.klepere@epfl.ch

MOTIVATION

WHY REACTIVE NITROGEN?



WHY POLICY?

Although Europe **regulates combustion-derived NO_x** to decarbonize its energy and transport sectors, agricultural and biomass ammonia (NH_3) **remains largely unchanged**. To protect population and ecosystem health, effective policy requires **managing both pollutants through local chemistry**. High-resolution thermodynamic modeling provides the **continuous spatial mapping** of aerosol pH and sensitivity regimes needed for **targeted regional mitigation**.

METHODOLOGY

Chemical transport model, used to simulate the atmospheric concentrations of 2019 in Europe with 36 km resolution.

Thermodynamic equilibrium model, used to calculate atmospheric pH and LWC offline.

Model result validation by comparing with empirical data from 3 Swiss research stations (located in Payerne, Beromünster and Magadino).

Model reliability confirmation enables to **continuously map** the modelled data across all of Europe.

PMCAMx

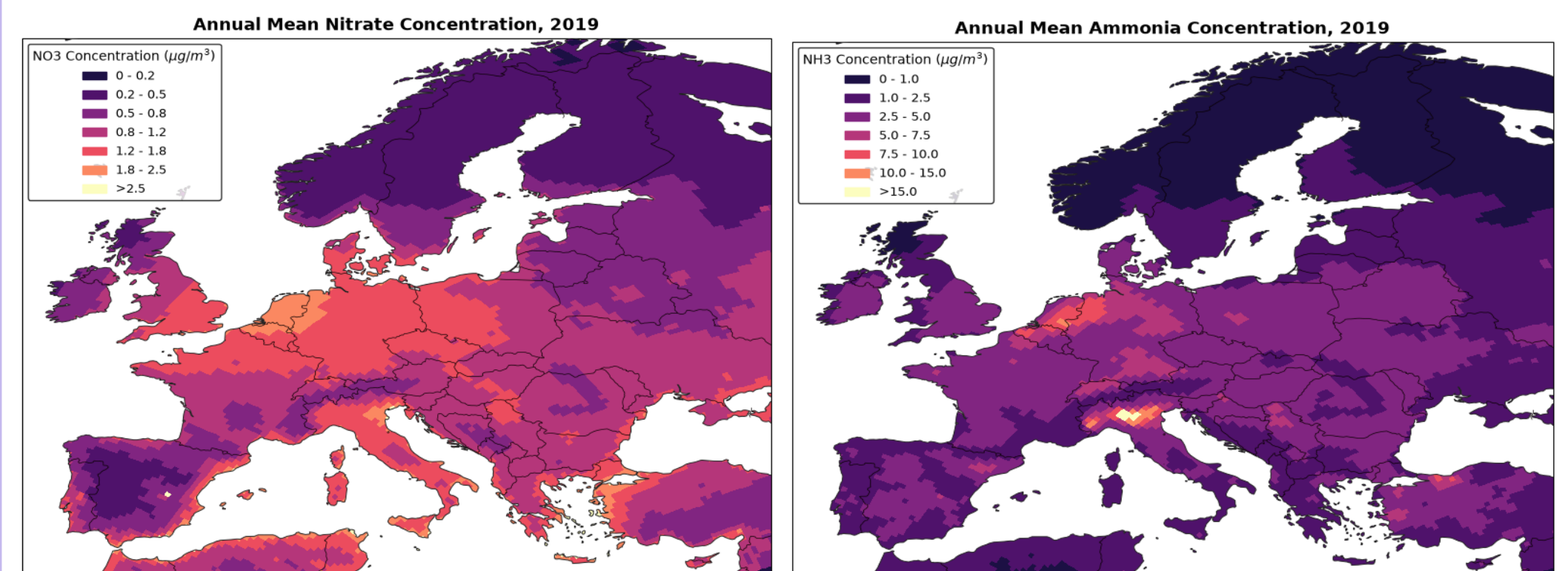
ISORROPIA-II

Comparison with observed data

Sensitivity and deposition regime mapping

RESULTS & CONCLUSIONS

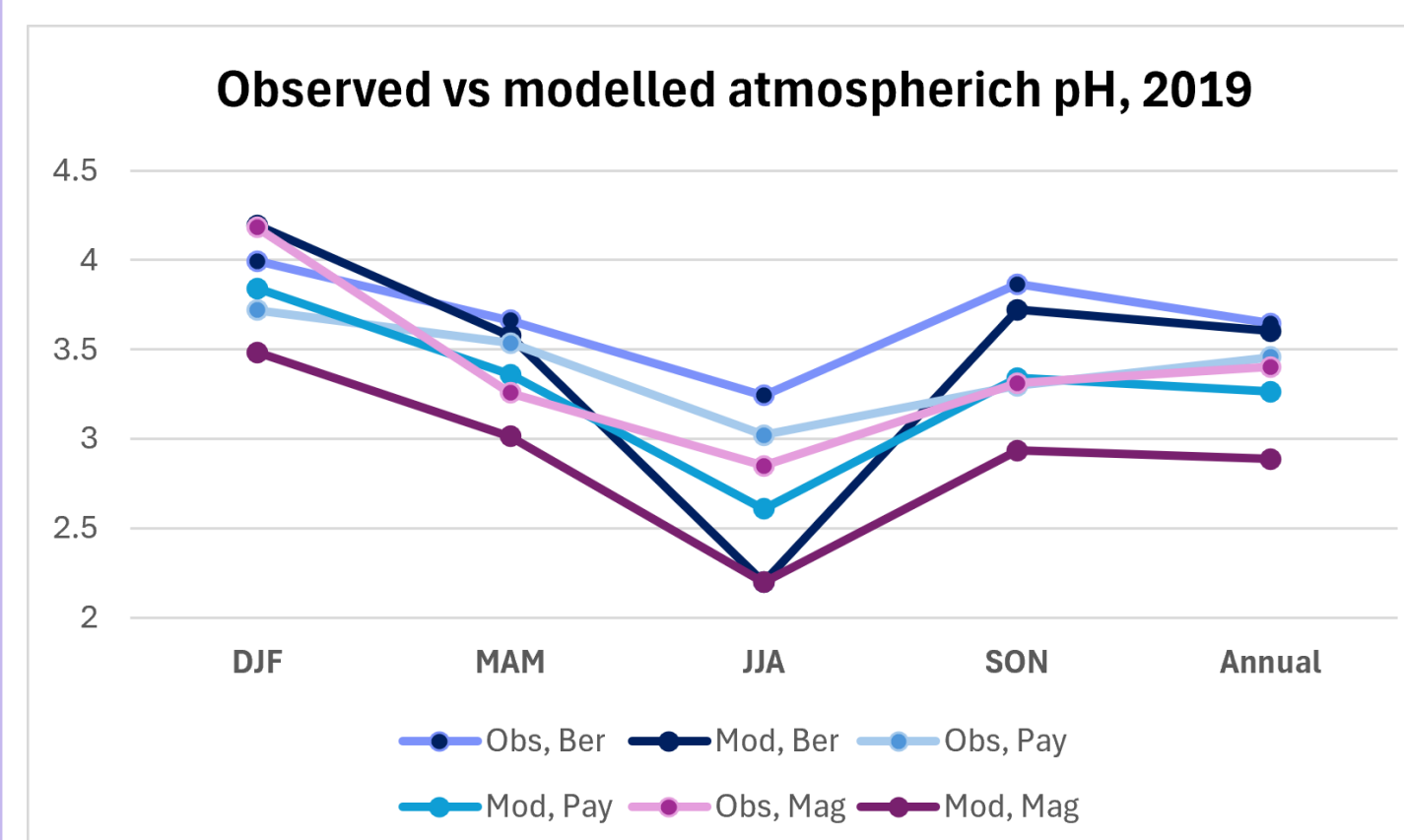
PREDICTED N_r SPECIES CONCENTRATIONS



Nitrate (NO_3^-): Peaks across Central Europe, the UK, and Northern Italy, reflecting widespread **combustion-derived NO_x** emissions.

Ammonia (NH_3): Concentrates heavily in **agricultural hotspots** like the Po Valley and the Netherlands, dropping sharply elsewhere.

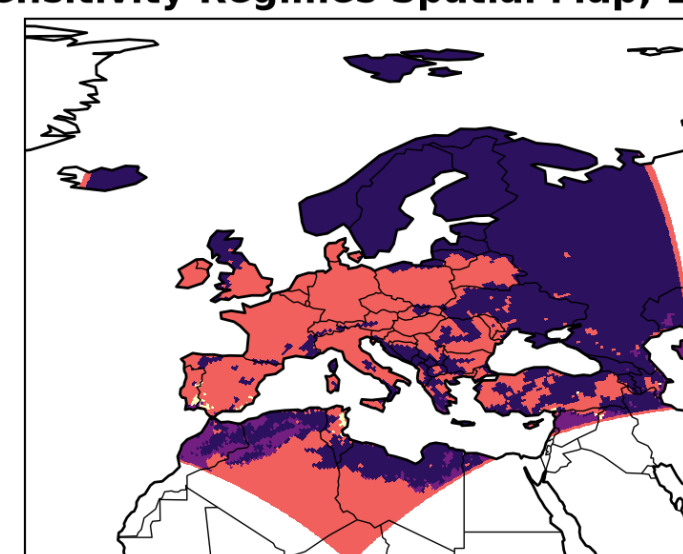
VALIDATION



Modeled annual pH and chemical regimes closely match observations across Swiss stations.

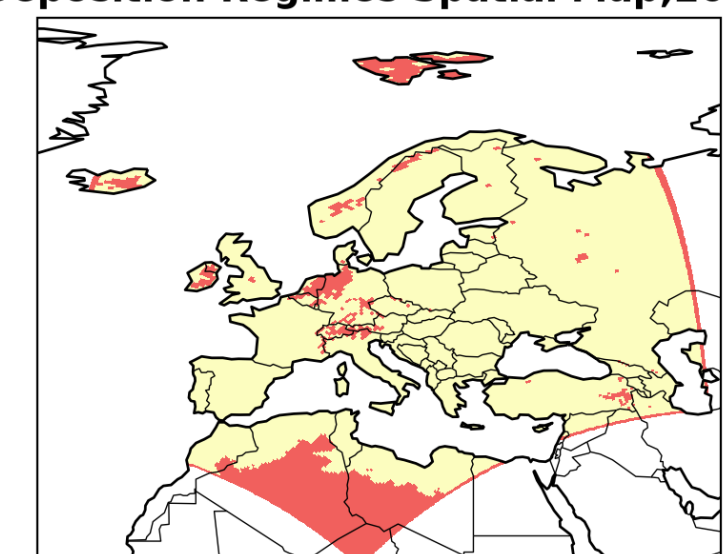
SENSITIVITY AND DEPOSITION REGIMES FOR POLICY

Sensitivity Regimes Spatial Map, 2019



Sensitivity Regimes: High- NH_3 regions fall strictly under HNO_3 sensitivity, making targeted NO_x controls essential for $PM_{2.5}$ mitigation.

Deposition Regimes Spatial Map, 2019



Deposition Regimes: " HNO_3 slow / NH_3 fast" areas highlight agricultural hotspots driving rapid local nitrogen deposition.

POLICY IMPLICATIONS

- **Target limiting reagents.**
- **Limit NO_x across urban corridors and NH_3 in agricultural hotspots.**
- **Integrate cross-sector policy.**
- **Impose and subsidize the adoption of more sustainable agriculture practices.**