



# **Modelling pollution in the urban environment using neural networks**

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# INTRODUCTION

## Topic

Air Pollution

Public Health Concern

## Question

Prediction Accuracy

Limitations of Traditional  
Methods

## Answer

Comprehensive  
Framework incorporating

- Neural Networks
- Computational Fluid Dynamic
- Data Assimilation

# LITERATURE REVIEW

1

## Neural Networks & Computational Fluid Dynamics

- NN-based Solver for PDEs
- Potential and Performance

Using ai libraries for incompressible computational fluid dynamics (Chen et al.)

2

## Traditional Modelling v.s. Convolutional VAE

- Generation of Predictions
- Computational Resources
- Reducing Dimensionality

Bridging observations, theory and numerical simulation of the ocean using machine learning (Sonnewald et al.)

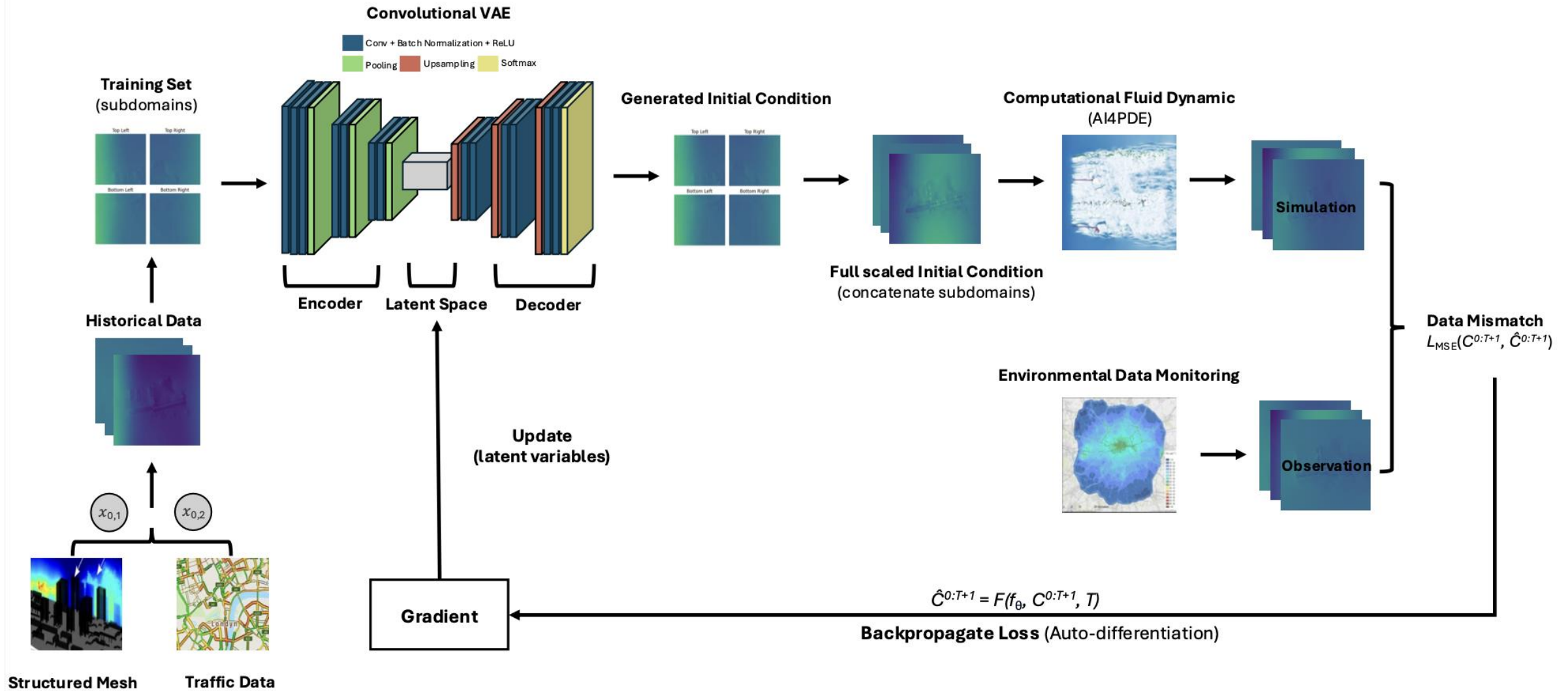
3

## Assimilation with Observational Data

- Refining the Model
- Adjusting to Realistic Environment
- Accuracy of Predictions

Data assimilation in the latent space of a neural network (Amendola et al.)

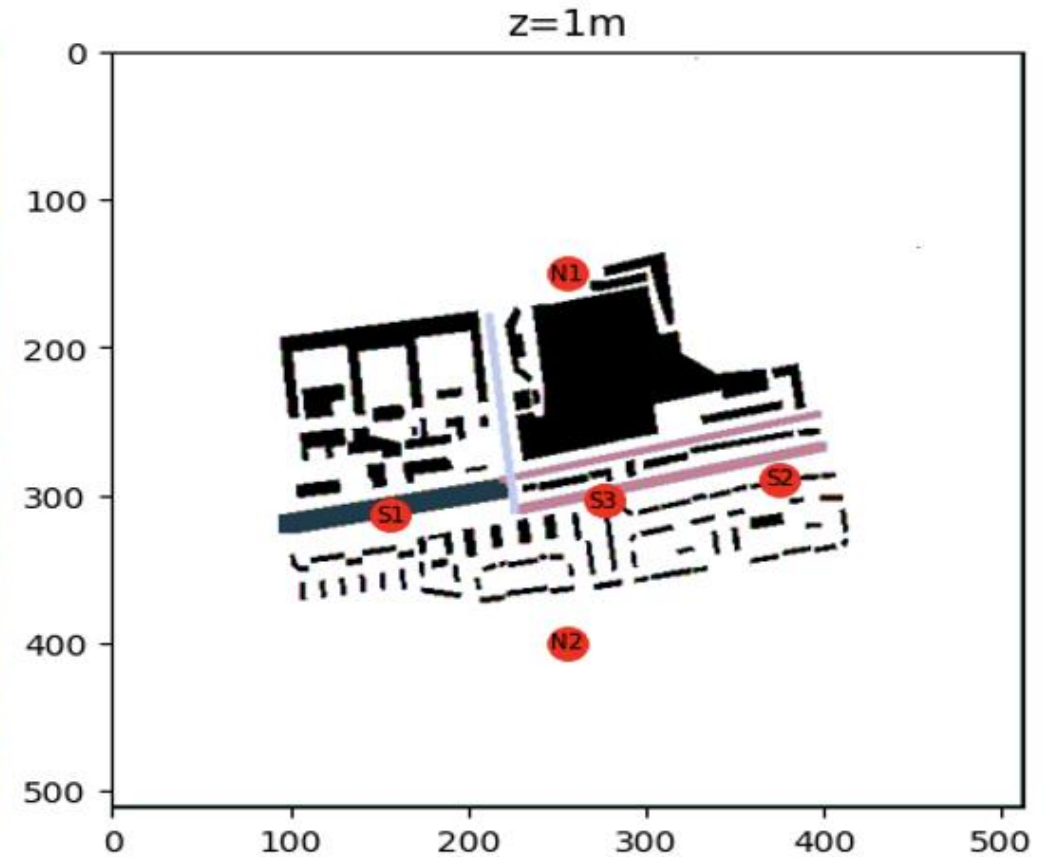
# METHODOLOGY – Overview of the Workflow





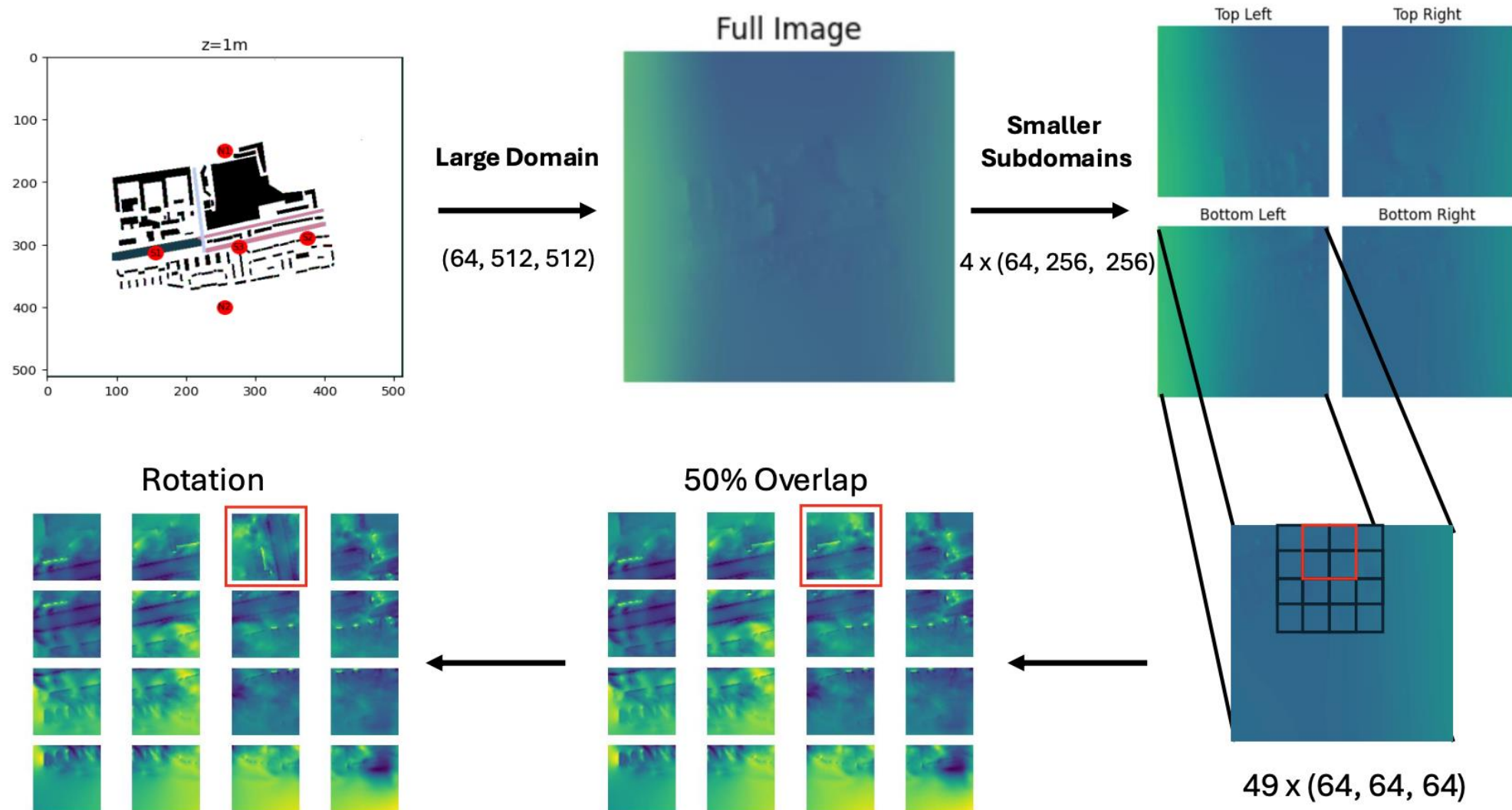
# METHODOLOGY - Setup of a Test Case

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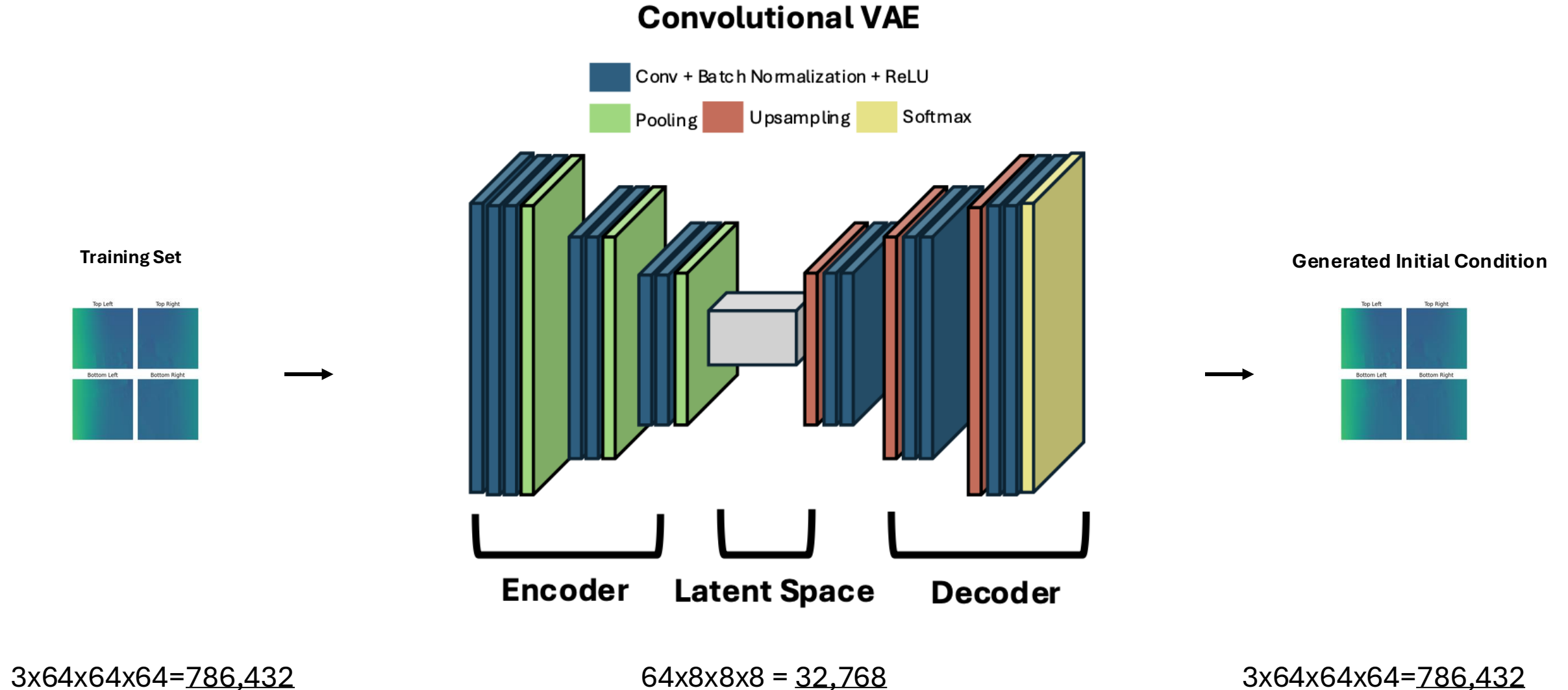


Sensor locations: Optimising sensor location using neural networks applied to air pollution (Zhan Xuan & Hong Xuan)

# METHODOLOGY – Data Preprocessing

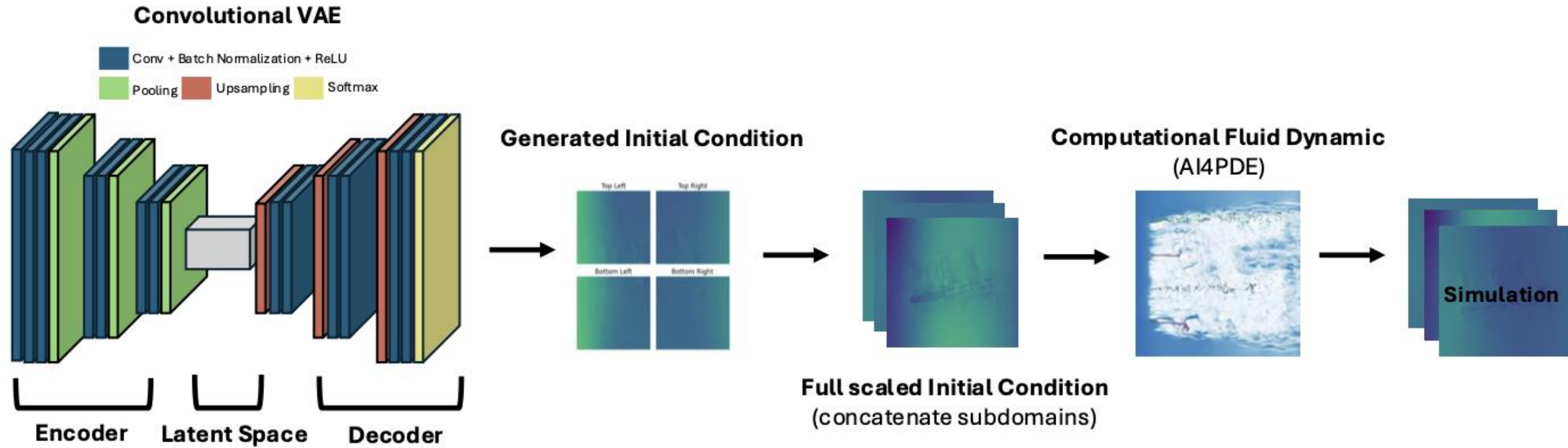


# METHODOLOGY – Convolutional VAE





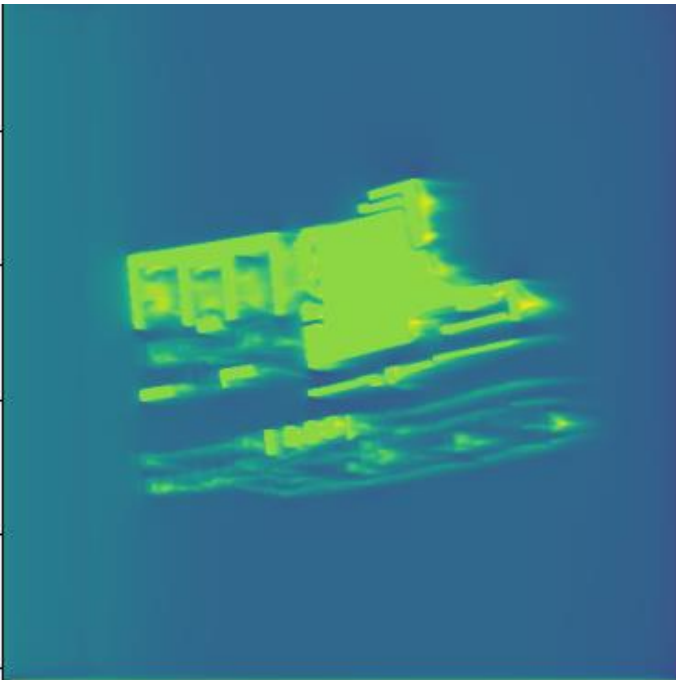
# METHODOLOGY – Convolutional VAE



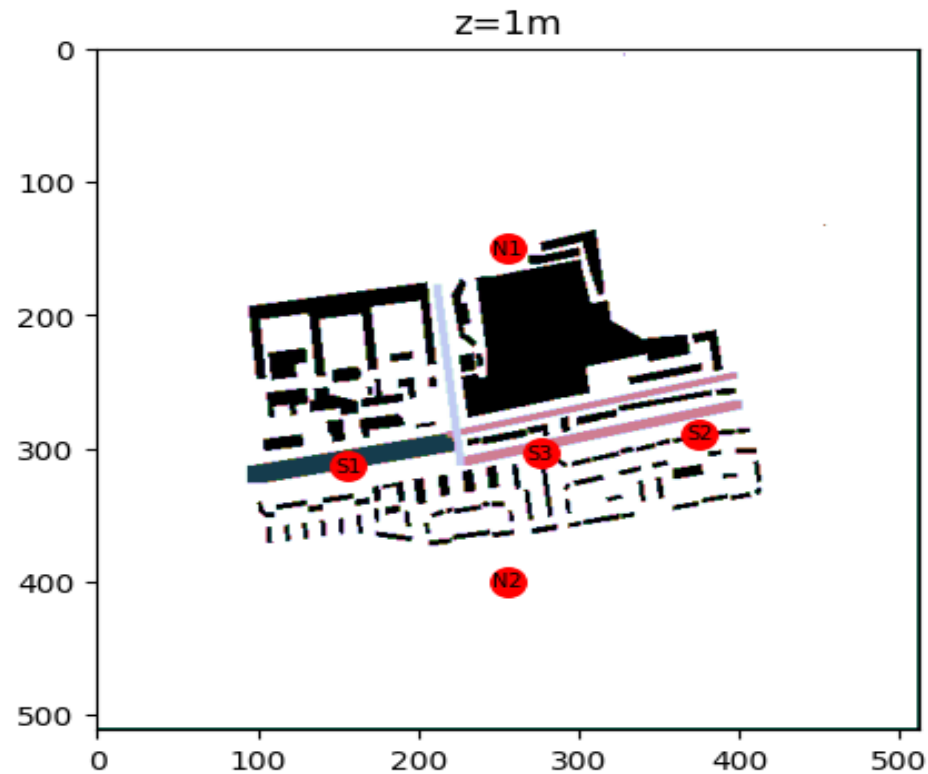
# METHODOLOGY – CFD Simulation

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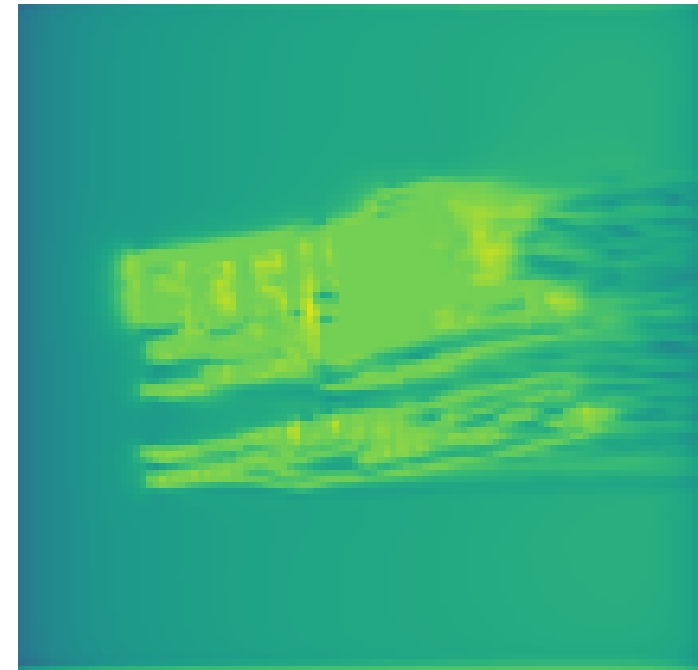
**Generated Initial Condition**



**Computational Fluid Dynamic Model  
(10000 timesteps)**



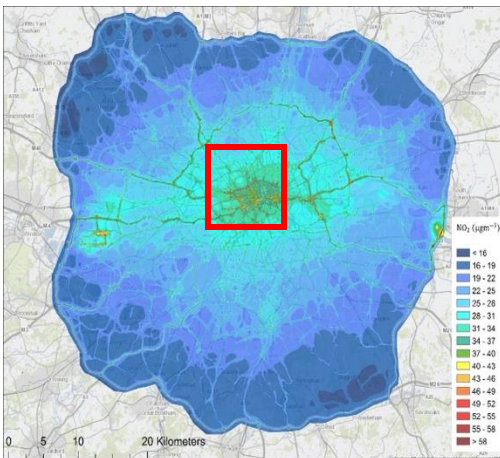
**Simulation Result**



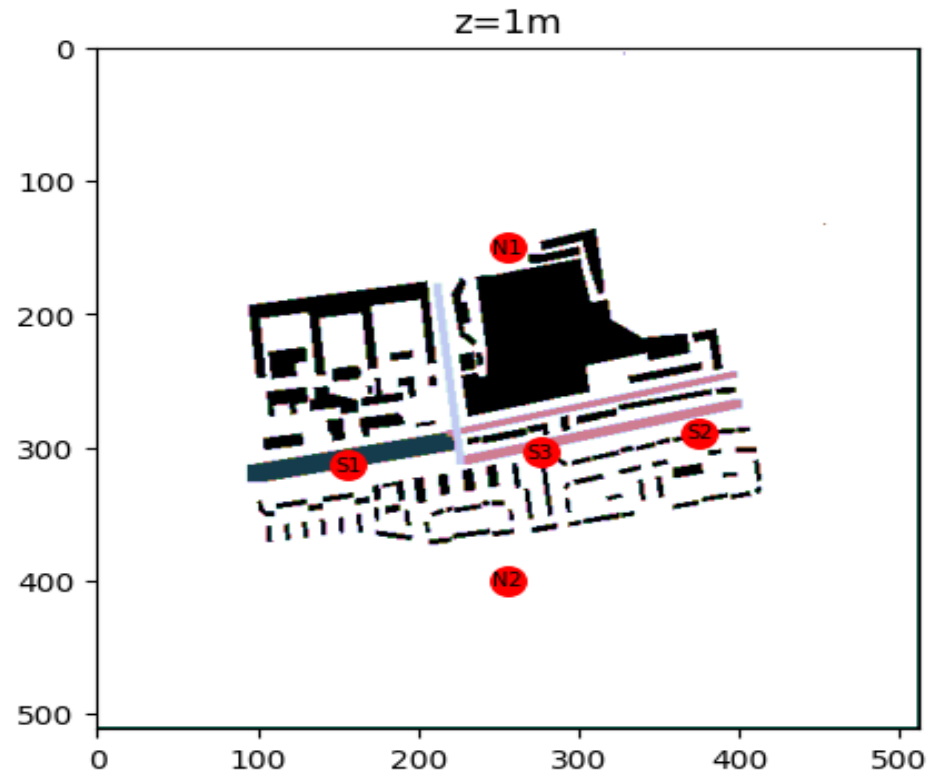
# METHODOLOGY – Observational Data

**Raw Data**  
(cleansing, missing values)

A4636	131	37	21	28		45
A2524	86	20	24	21	1	20
A3713	75	17	13	18		27
A4452	73	5	33	17		18
A4088	72	14	16	12	2	28
A2103	68	14	13	14	1	26
A2156	68	16	13	19	2	18
A3681	66	12	16	9	1	28
A1366	50	11	15	12		12
A2610	39	5	7	12		15



**Computational Fluid Dynamic Model**  
(1 timesteps to create structured mesh)

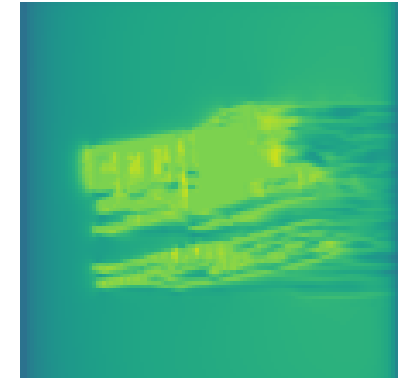
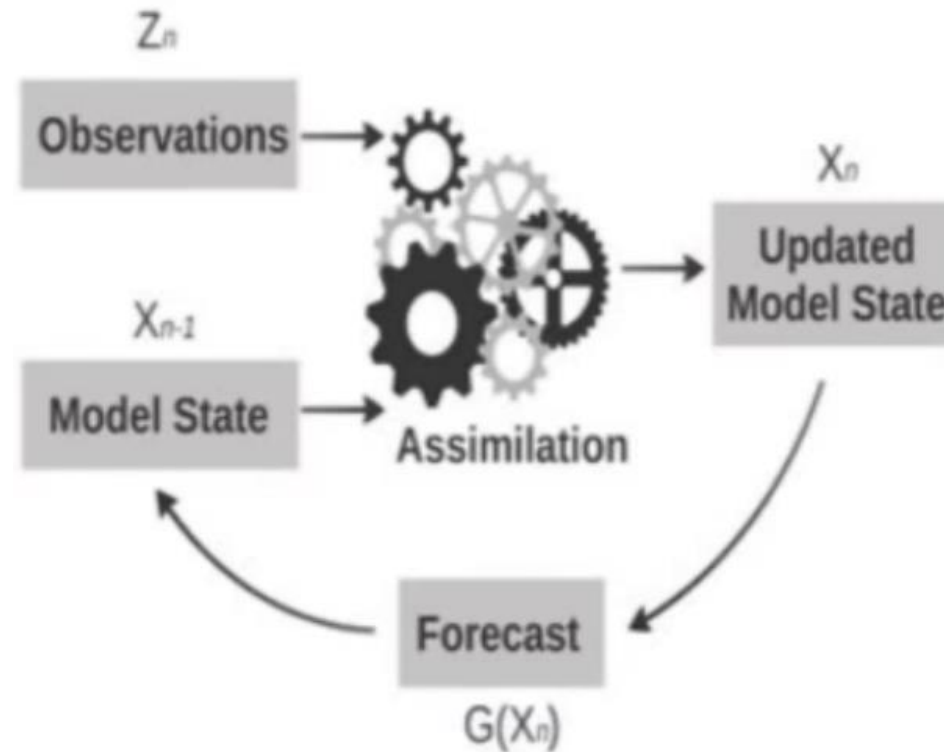


**Observational Data**

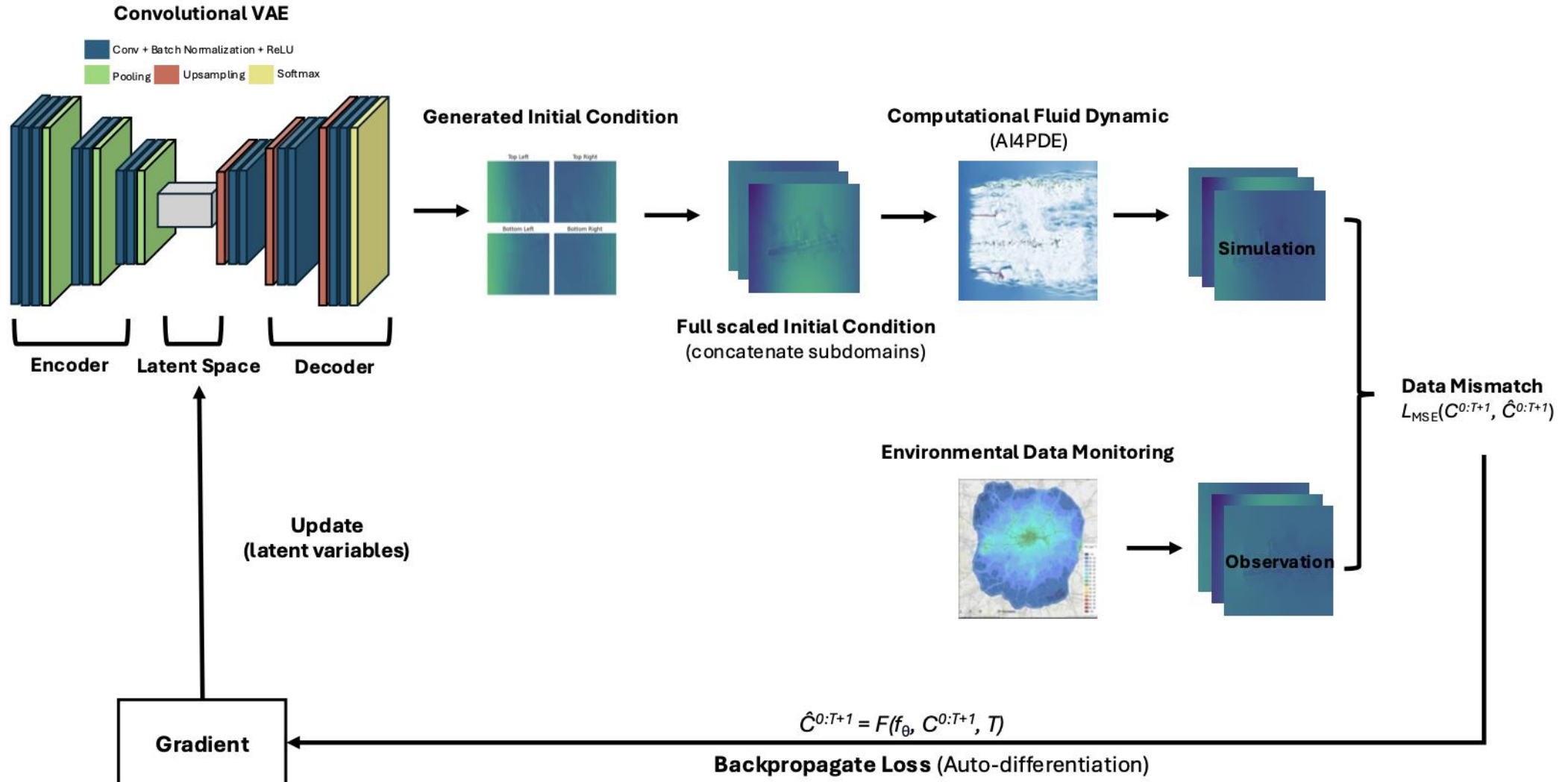


# METHODOLOGY – Data Assimilation

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# METHODOLOGY – Data Assimilation Loop



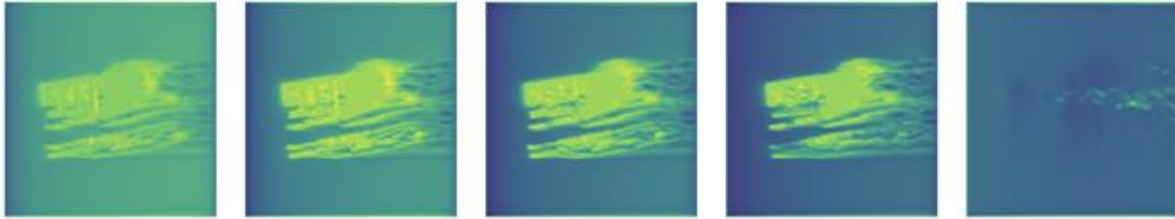


# RESULTS - Velocity and Pollution Field

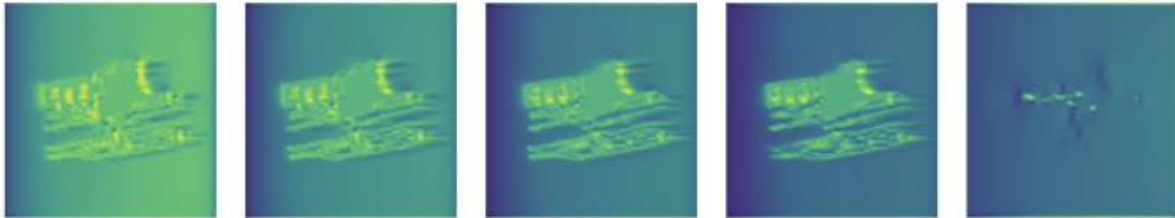
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Wind Velocity in X-Direction

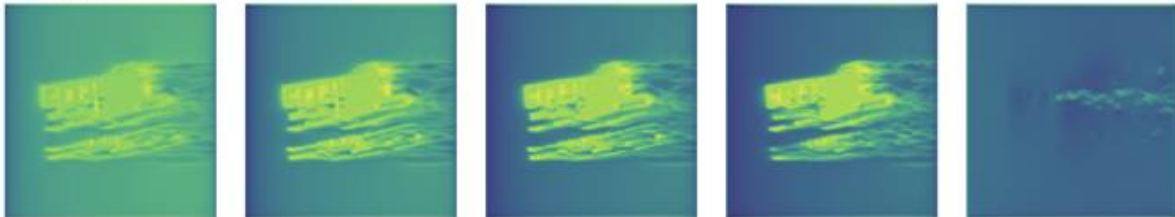
Simulation



Observation



Updated



Pollution Concentration Field

Simulation



Observation



Updated



# RESULTS - Velocity and Pollution Field

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Wind Velocity in Z-Direction

Simulation



Observation

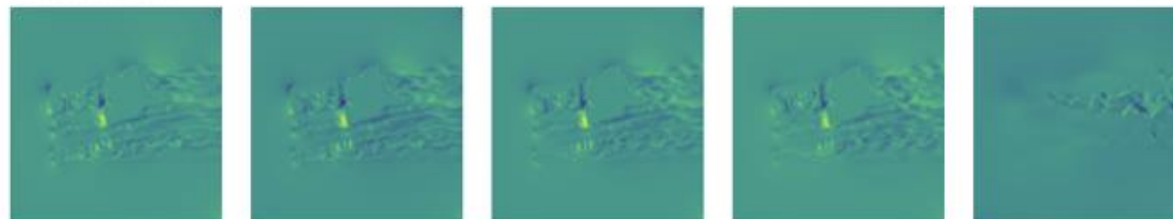


Updated

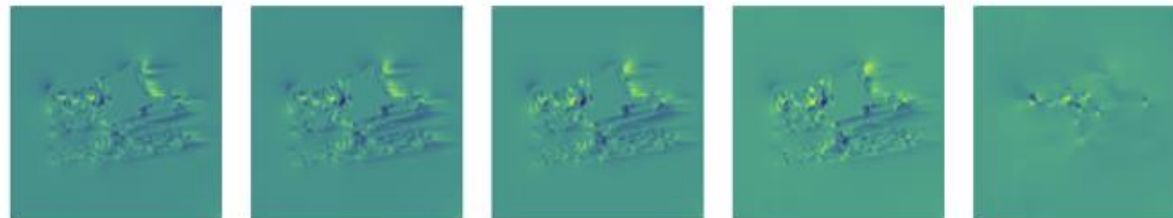


Wind Velocity in Y-Direction

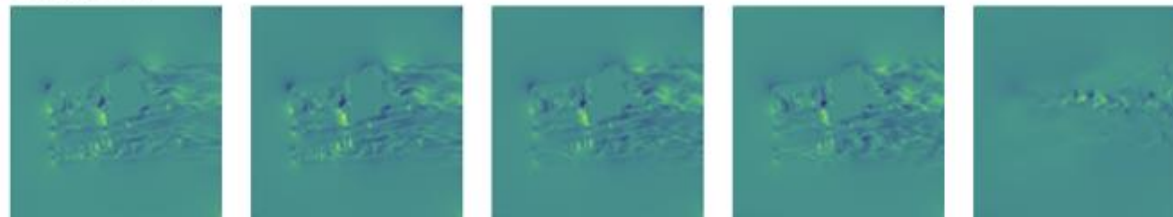
Simulation



Observation



Updated



# RESULTS - Detailed Analysis

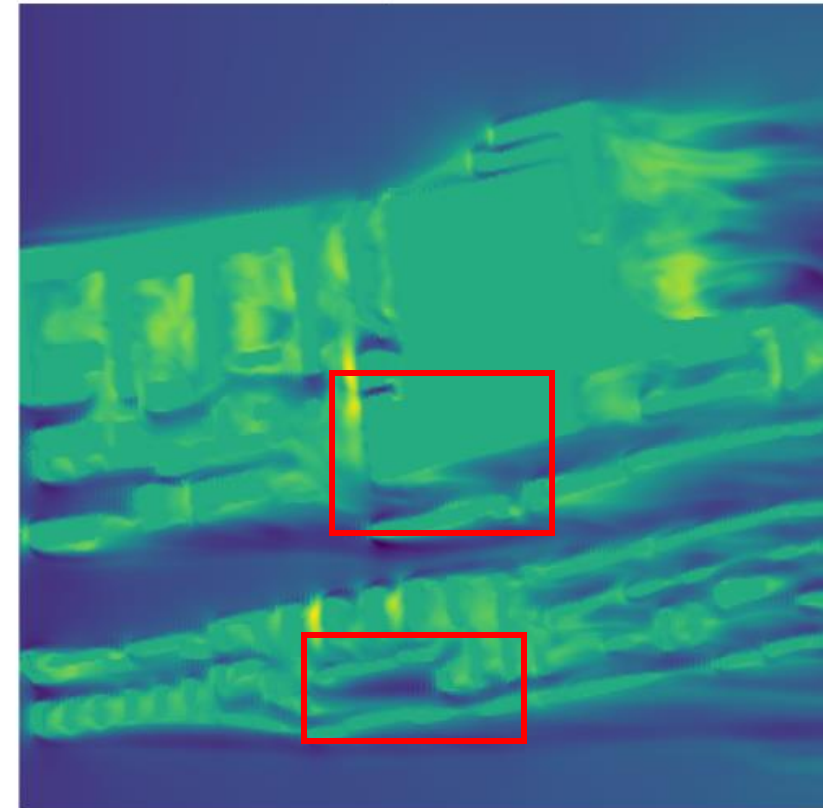
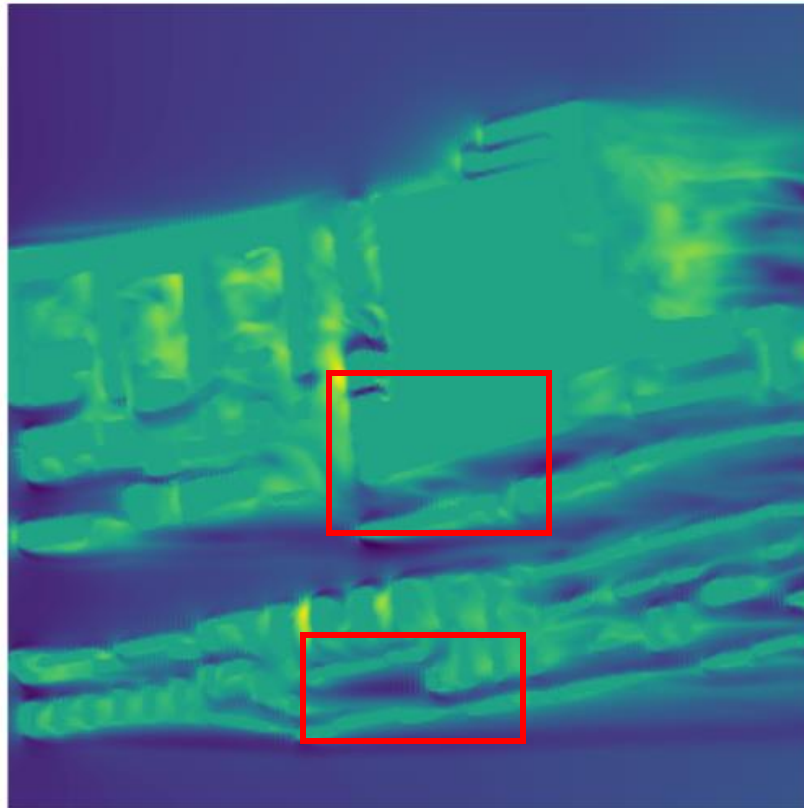
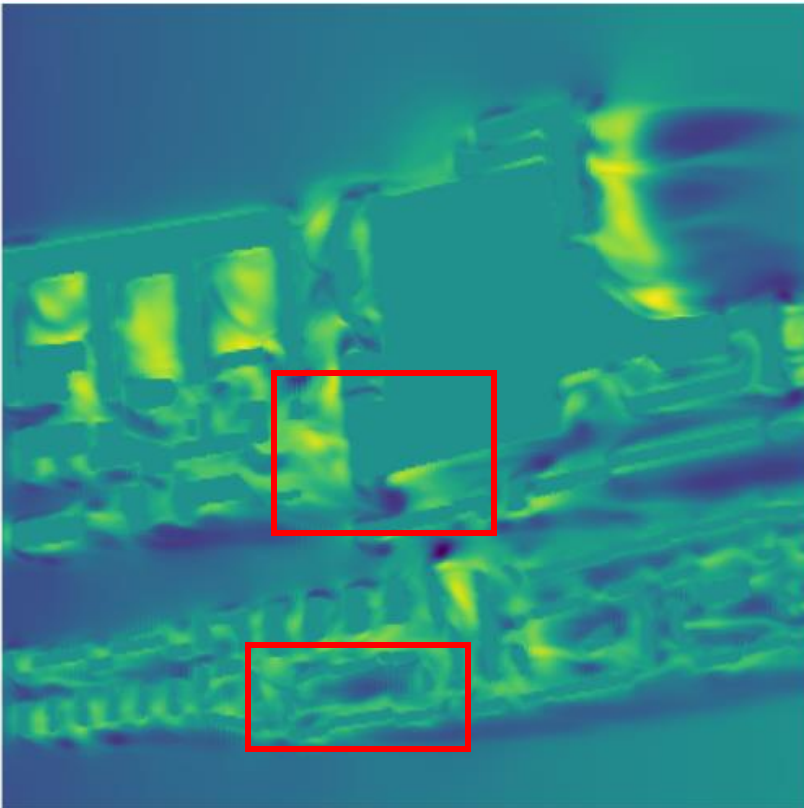
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(Velocity Field in x-direction at 1-Meter Height)

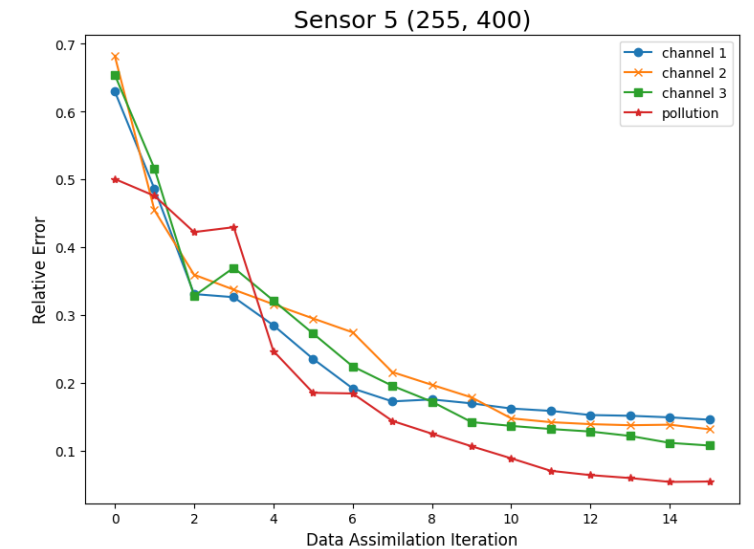
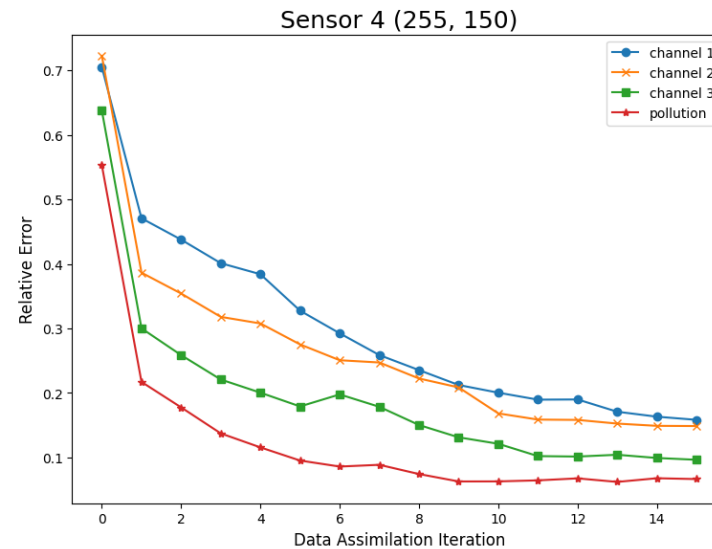
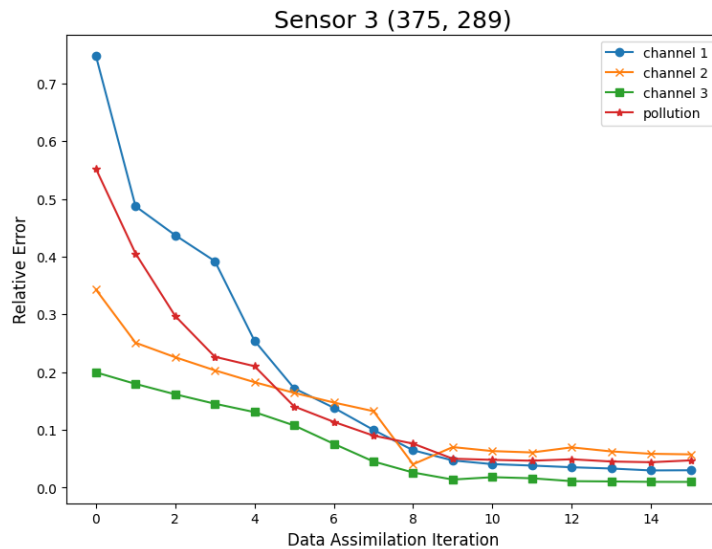
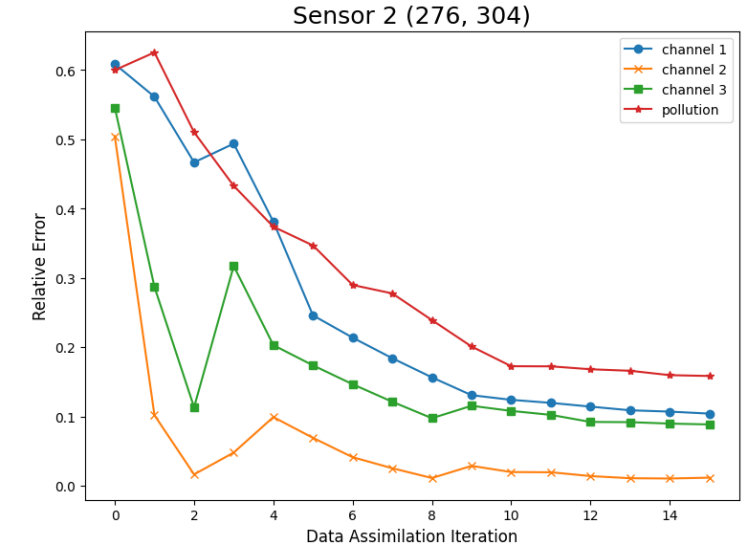
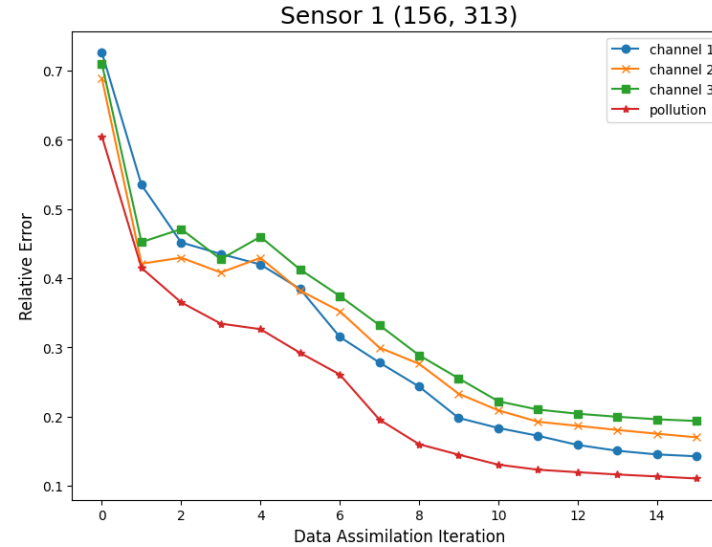
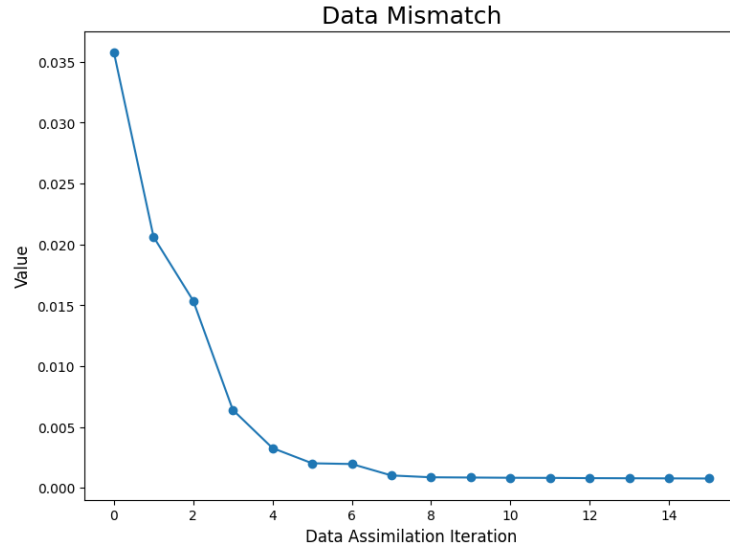
Simulation

Observation

Updated



# RESULTS – Data Mismatch & Sensor Performance



# CONCLUSION & DISCUSSION

1

## Novel Framework

- Neural Networks
- Computational Fluid Dynamic
- Data Assimilation

2

## Large-Scale Predictions

- Feasibility for a smaller domain
- Relative Error  $< 10\%$
- Environmental Policy

3

## Moving Window Strategy

- Memory Issue
- Stored and Reloaded





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