Models we use

~~Adaptive Kalman filter (AR-KF hybrid)~~

~~from {"An adaptive kalman filtering approach to sensing & predicting AQI vals}~~

~~**How it works:**~~

~~(K)~~

The Kalman filter is a classic linear estimator that fuses autoregressive (AR) time-series modeling with recursive state update. In the reviewed study, an AR model of AQI was augmented by an adaptive Kalman filter (KF) to correct prediction errors. The KF runs iteratively on new data, making it inherently real-time: it is a recursive optimal estimator, providing "a real-time algorithm to estimate the unknown state vector … for each measurement"
web.cecs.pdx.edu
. In practice this hybrid AR–KF model modestly improves accuracy over a plain AR model (especially on monthly-averaged AQI) while remaining linear and interpretable. Because both AR and KF are linear, the combined model is straightforward to understand and tune. It has very low runtime cost per update, and can be deployed on simple hardware (even microcontrollers), making it highly suitable for on-the-fly AQI smoothing or short-term forecasting in resource-

constrained systems. Trade-offs: it captures only linear temporal patterns (no spatial or nonlinear effects), so accuracy lags more complex models.

Accuracy: Moderate (improves AR, good for smooth trends)
Interpretability: High (simple linear/regression-based model)
Real-time Performance: Excellent (recursive, low-latency update
web.cecs.pdx.edu
)
Ease of Deployment: Very easy (lightweight; minimal computational requirements)

Gaussian-mixture NV-VAE (Deep generative model)

from the paper {

predicting multivariate Air pollution: A Gaussian-Mixture Nested Variational Autoencoder Approach

This model uses a Nested Factorial Variational Autoencoder (NF-VAE) with a Gaussian mixture prior, tailored for multivariate air pollutant prediction. It jointly models multiple pollutants and sites via a probabilistic latent representation. In experiments, NF-VAE achieved the highest accuracy: it reduced RMSE by >31% and MAE by >22% versus standard RNNs (LSTM/GRU) across six pollutants
researchgate.net
. The key idea is that the VAE learns a low-dimensional factorization of the pollution dynamics, allowing it to generalize well even with noisy data. Technically, it consists of an encoder network mapping input pollutant readings to latent variables, a Gaussian-mixture latent prior, and a decoder reconstructing future pollutant values. Forecasting is done by sampling/decoding the latent. Like other deep models, NF-VAE is a “black box”: its latent factors are not easily interpretable as physical variables. Real-time performance is moderate to low: inference (forward pass) is feasible on modern hardware but heavier than trees or KF; training requires substantial GPU resources. Deployment demands the ML framework and careful calibration. NF-VAE is best used when multi-pollutant accuracy is critical (e.g. research or city-wide AQI systems) and offline batch forecasts are acceptable. Its trade-offs are excellent accuracy (quantified by the >30% error drop
researchgate.net
) versus higher complexity and lower explainability.

Accuracy: Highest (leverages deep latent modeling; 31% RMSE reduction vs RNNs
researchgate.net
)

Interpretability: Low (latent-space model; not human-readable)

Real-time Performance: Moderate (inference faster than training but still heavy)

Ease of Deployment: Hard (complex model, needs deep learning stack)

Model Comparison Summary

Model	Accuracy	Interpretability	Real-time Performance	Ease of Deployment
AR+Kalman	Moderate	High	Excellent	Very Easy
Decision Tree	Moderate	High	High	Easy
Graph NN	High	Low	Moderate	Moderate
PatchTST	Very High	Low	Low (slow)	Difficult
NF-VAE	Highest	Low	Moderate	Difficult

We use this model
for our project

How it works in
simple is :-

- deep generative model
used for predicting
multivariate air pollutants
like PM2.5, PM10,
NO_2, SO_2, CO, O_3
across location &
time zones

It has → Encoder

maps input time-series

into latent space

Latent Layer: structured as Gaussian mixture model (GMM) with factorial assumption

Decoder: future air quality

Why this model?

→ multivariate
→ Large error improvement