# Recent Technological Advances in ANN Regression Modeling

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September 23, 2024

# X2 Modeling is an Economically Consequential Problem

- Wide variety of approaches over the years:
  - Simple empirical/algebraic/autoregressive equations
  - More complex empirical models (e.g. ANNs), beginning in ~2000
  - 1D physics-based numerical modelling of the estuary
  - Fully resolved 3D models
- Various tradeoffs among competing model approaches:
  - Accuracy / predictive power
  - Runtime (100-year runs take too long in 3D models)
  - Ease of understanding by public and regulators
- In 2015-16, we developed a hybrid mechanistic-feed-forward ANN application for this problem, published as Rath et al. 2017[1]
- Focus of presentation today: Have technologies evolved in the past 7 years to enhance the development of such ML tools?

[1]Rath, J.S., Hutton, P.H., Chen, L. and Roy, S.B., 2017. A hybrid empirical-Bayesian artificial neural network model of salinity in the San Francisco Bay-Delta estuary. *Environmental Modelling & Software*, *93*, pp.193-208.

| 2015-16 ANN Modeling Effort[1] | 2024 ANNs |
|---|---|
| MATLAB neural network toolbox was initially used; limited flexibility and didn't fully meet project needs | Entirely implemented in open source 3rd party libraries (Python, pytorch, raytune) |
| Programmed much of the math for a customized model from scratch (Stan MCMC language) over the course of multiple weeks | Reproduced results of comparable quality using pre-built pytorch functions |
| Ad hoc adjustment of antecedent flow moving averages, network size | More refined tools (e.g. raytune) for automated model hyperparameter optimization |
| Access to slower CPU based training; any given experiment took longer | GPU training: faster training time, easier iteration |
| | ~5-10X improvement in implementation time |
| | Note: More complex model is even more of a black box to explain results |

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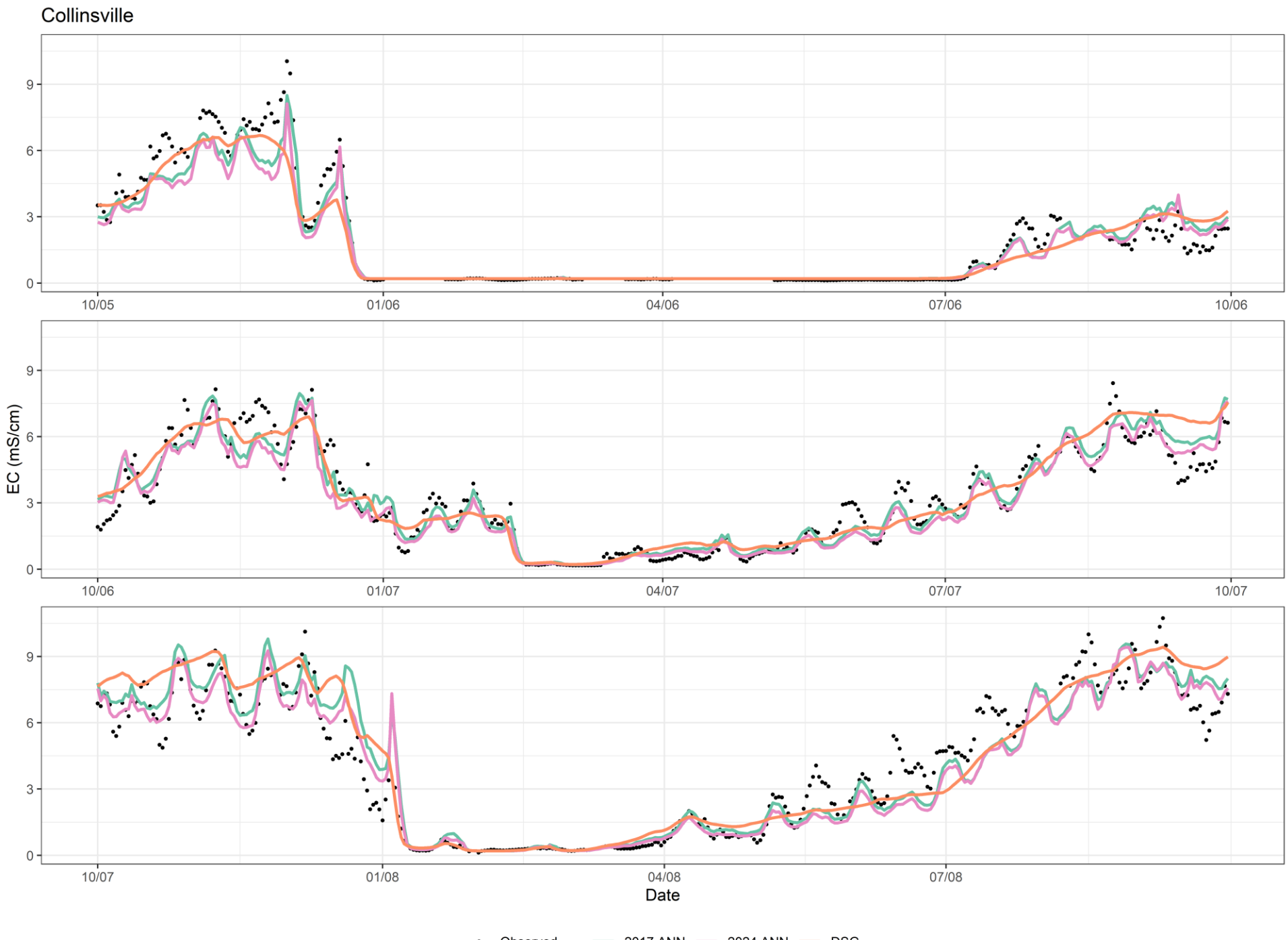
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2024 ANN
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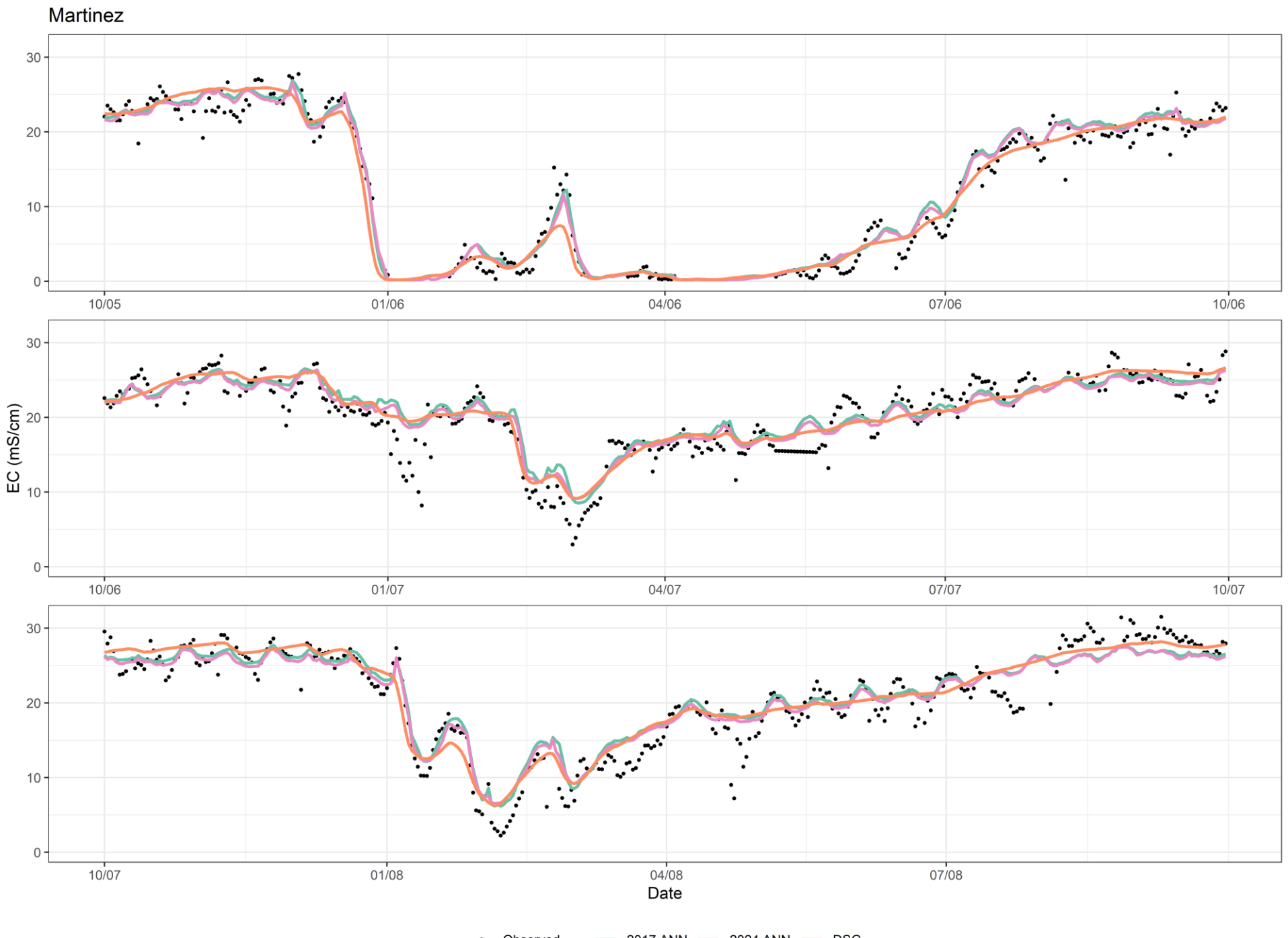
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