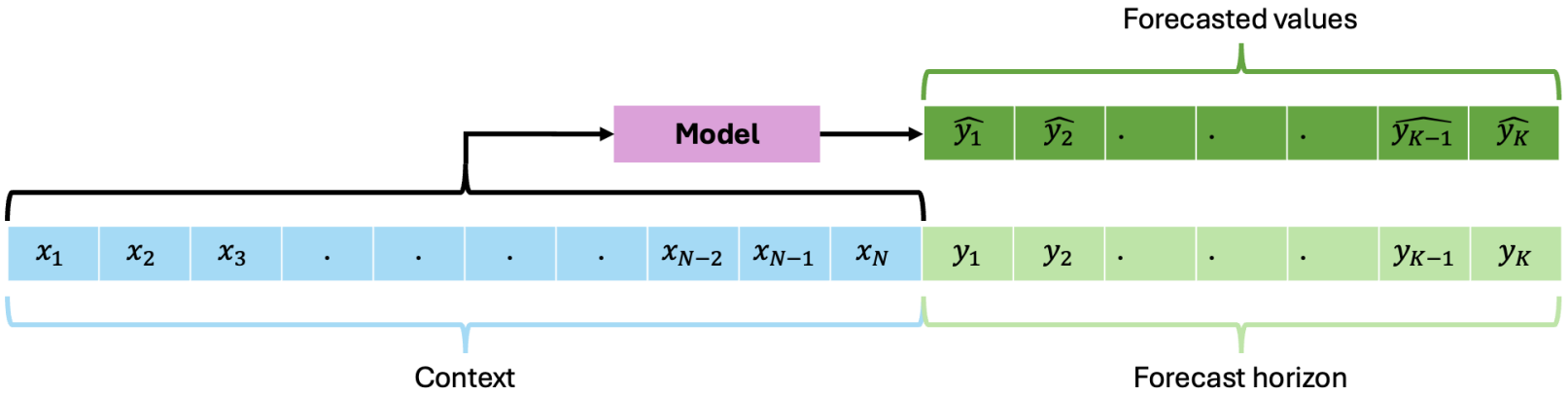
Using Time Series Foundation Models for Atmospheric CO_2 Concentration Forecasting

Kumar Saurav, Vinamra Baghel, Ayush Jain, Ranjini B Guruprasad
IBM Research Labs, Bangalore, India
kr.saurav.010@in.ibm.com, vinamra@ibm.com, ayush.jain@ibm.com, rangurup@in.ibm.com

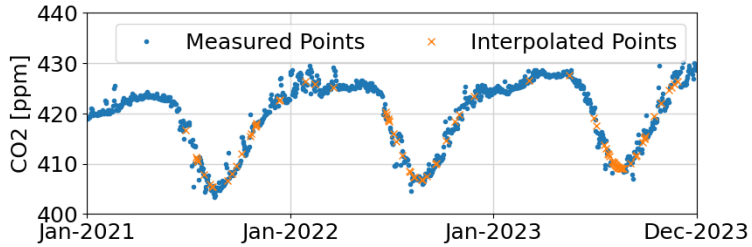
TSFM: Time Series Foundational Models

- TSFM: Foundation models pre-trained on public timeseries data
- Generalizability in forecasting across multiple domains.
- Rely on the strengths of architecture to learn generalized representations of time-series data.
- TSFMs can leverage transfer learning capabilities to forecast in diverse locations by fine-tuning on data from just one location, thus enabling scalable and accurate CO_2 forecasting.



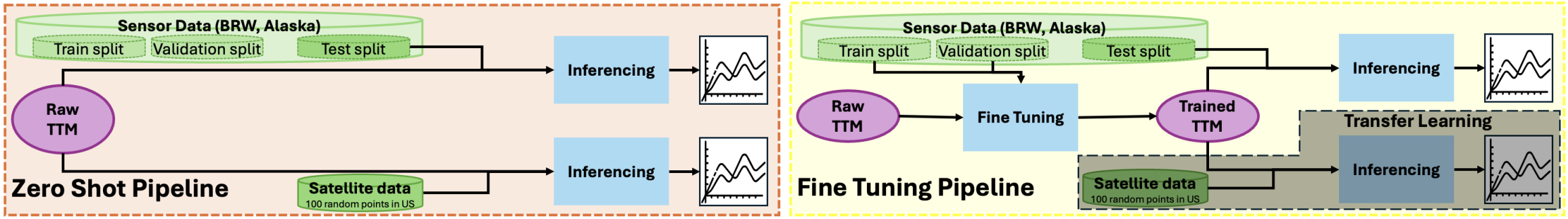
Key contribution of the paper

- Evaluating TSFMs to forecast CO2 data from NOAA sensor in zero-shot & fine-tuned settings.
- Comparing TSFMs with traditional models as baseline, namely: Prophet, Theta-Forecaster, & Seasonal Naive model
- Evaluating spatial transfer learning capability of TSFMs by using fine-tuned models to forecast X-CO2 concentrations from satellite-based timeseries (OCO-2 & OCO-3) across geographic regions (100 random locations in USA).



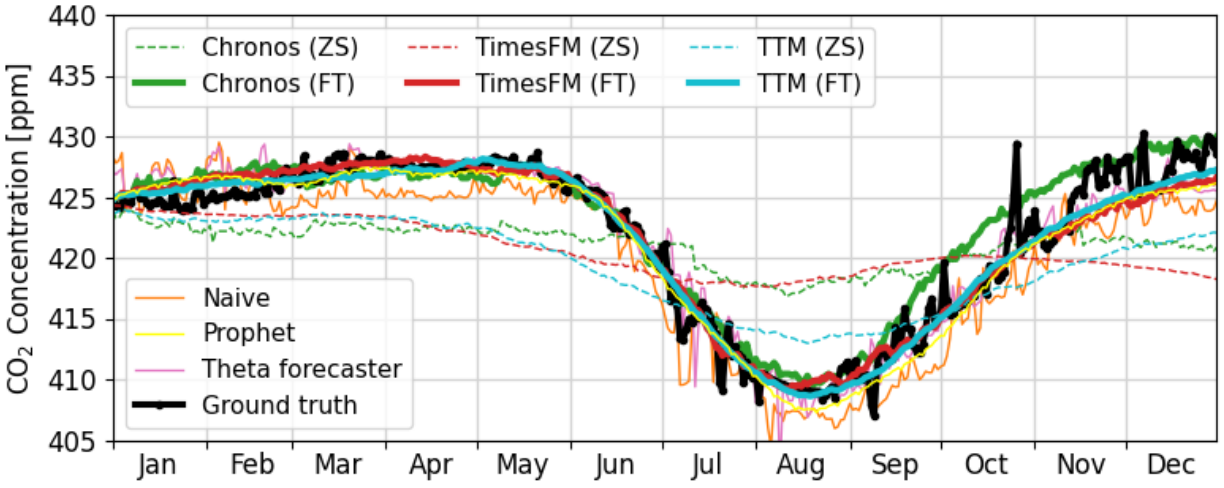
Experimental Setup

- Two evaluation pipelines for TSFMs:
  - Zero-shot &
  - Fine-tuning
- Zero-Shot(ZS): TSFMs are evaluated on NOAA sensor data to assess models' generalization capabilities to a new domain
- Fine-Tuning (FT): TSFMs are fine-tuned using train split of NOAA sensor data; performance is evaluated on test split to quantify improvements through fine-tuning on in-domain data.
- Transfer Learning: TSFMs fine-tuned on train split of NOAA sensor data is evaluated on OCO-2 & OCO-3 derived X-CO2 data for 100 locations in USA to assess transfer learning



Results (1/2): CO_2 forecasting on NOAA sensor data

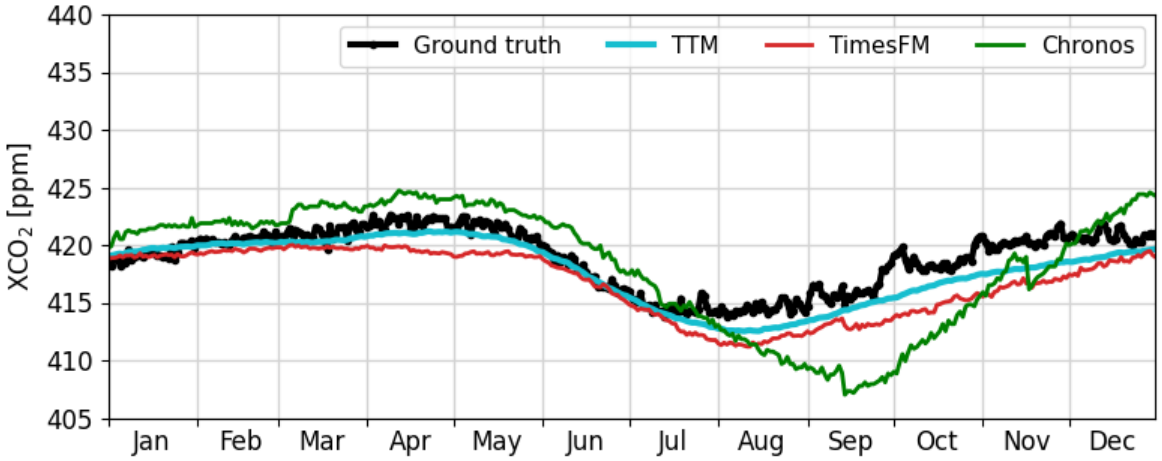
- Zero-Shot TSFMs are worse than traditional baselines
- Fine-Tuned TSFMs are better than traditional baselines
- TTM is the best performing model among TSFMs



	Baselines			Chronos		Times FM		TTM	
	Theta	Naive	Prophet	ZS	FT	ZS	FT	ZS	FT
RMSE	1.85	2.84	1.72	5.16	2.04	5.65	1.55	4.36	**1.37**
MAE	1.33	2.40	1.31	4.59	1.54	4.91	1.09	3.81	**0.95**
MASE	0.47	0.46	0.46	1.61	0.54	1.72	0.38	1.34	**0.34**

Results(2/2): Transfer learning for XCO_2 for OCO-2/3 derived data for 100 random locations in USA

- Transfer learning is slightly worse than finetuned TSFMs
- TTM performs best under transfer learning setting



	Transfer Learning		
	Chronos	**Times FM**	**TTM**
RMSE	3.63	2.49	**1.46**
MAE	2.93	2.13	**1.19**
MASE	1.20	0.87	**0.49**