Effects of Meteorological Factors on PM2.5 Concentration

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- **Definition**: PM2.5 refers to particulate matters with diameters of 2.5 micrometers or less
- **Sources**: coal combustion, industrial activities, biomass burning, automobile emissions..
- **Harm**: Can easily penetrate deep into lung; jeopardize normal lung function; cause inflammation; promote cancer
- **Goal**:
  1. Understand the underlying dynamics of PM2.5
  2. Model association with meteorological factors concurrently
- **Dataset**:
- Hourly measure of Temperature (Celsius), Dew Point (Celsius), Pressure (hPa), PM2.5(mg/m^3)
- **1570** observations, **24** measurements per obs.

Model & Method

FPCA

Idea: Functional basis expansion that explains maximum amount of variation using K (functional) principal components

$$\check{X}_i^K(t) = \mu(t) + \sum_{k=1}^{K} A_{ik}\phi_k(t)$$

where $\phi_k(t)$ is the k-th eigenfunction, which we use to study the underlying dynamics of variation

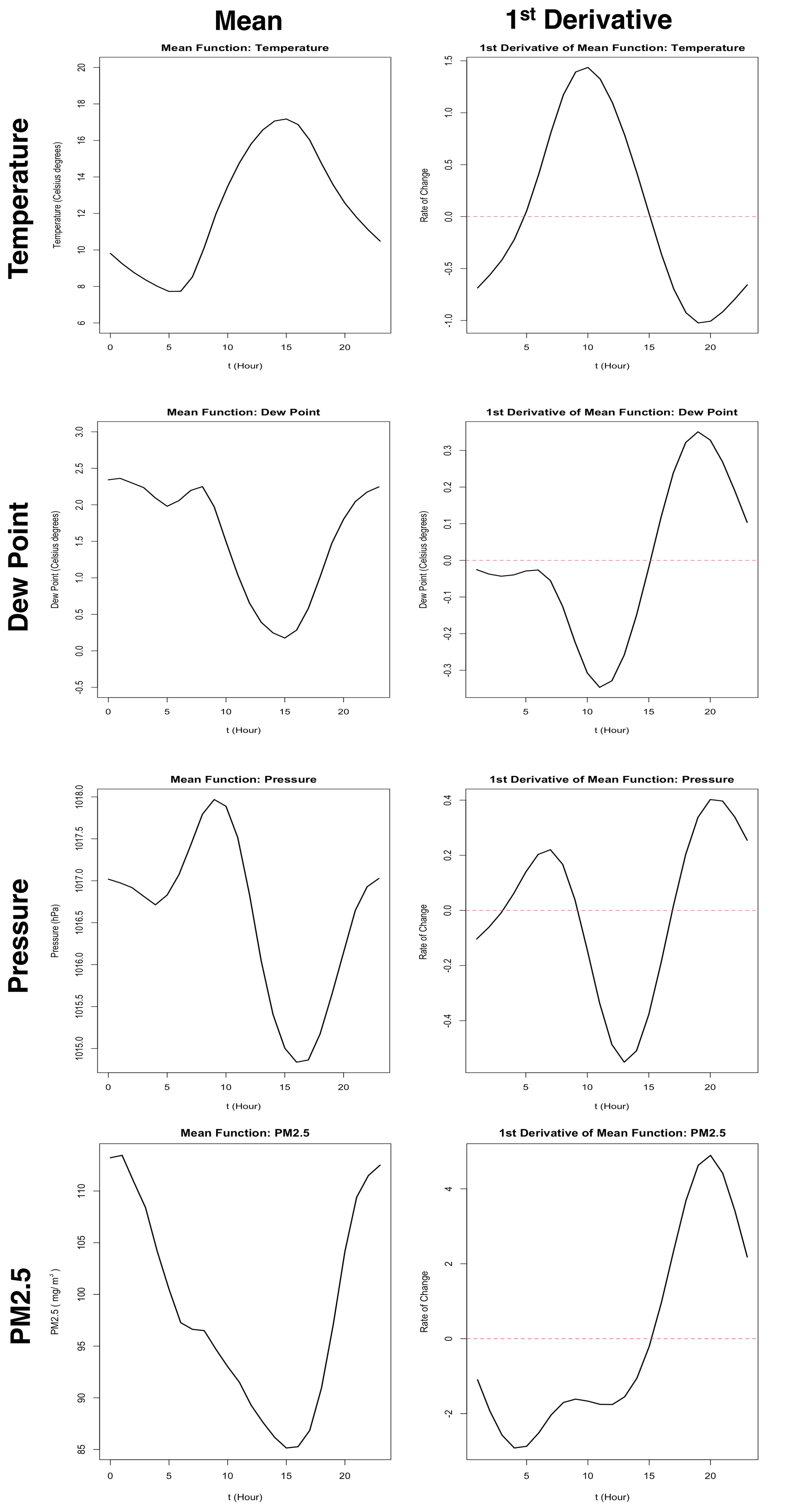
Mode of Variation:

$$\mu(t) \pm \alpha\sqrt{\lambda_k}\phi_k(t), t \in \mathbb{T}, \alpha \in [-A, A]$$

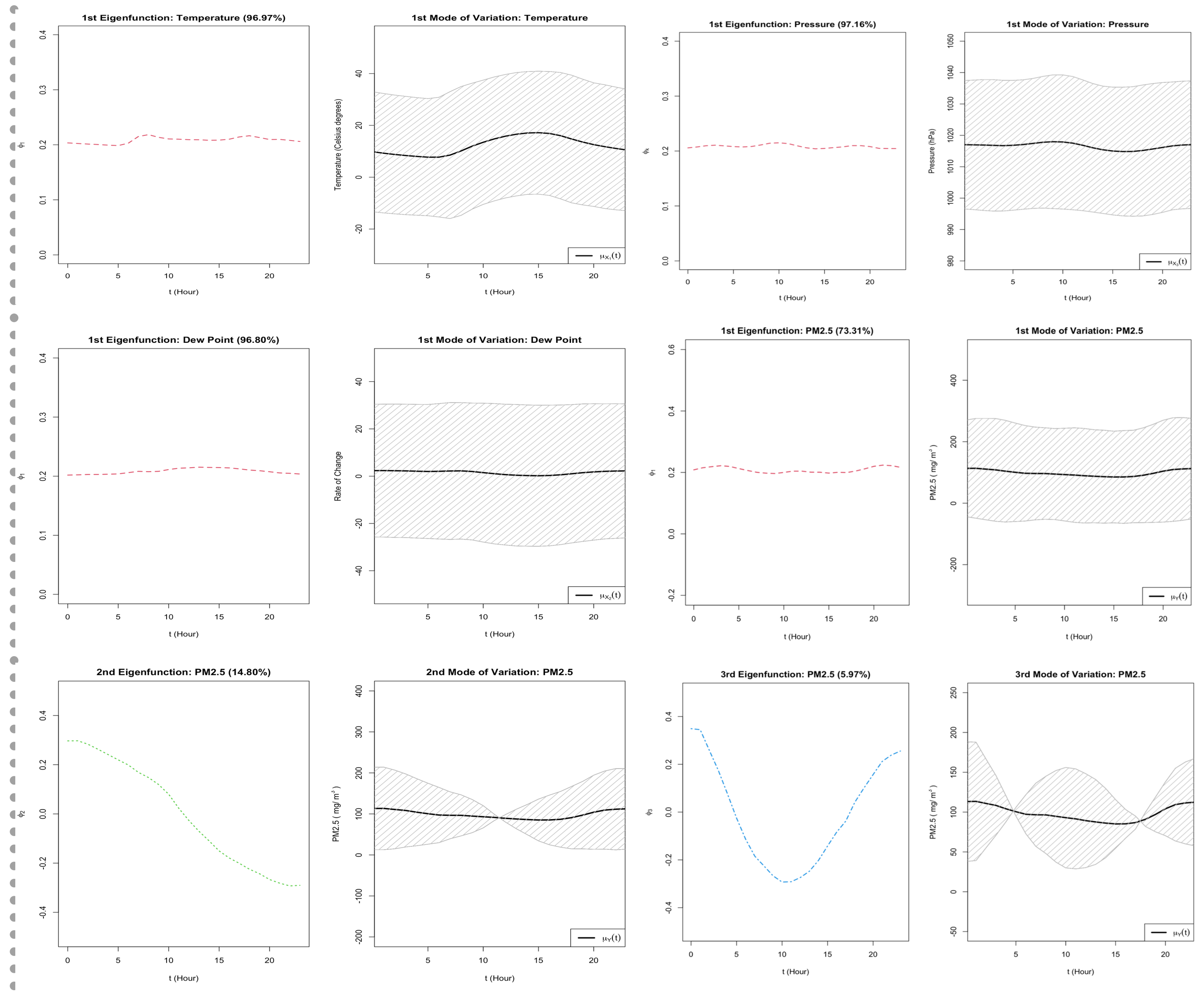
Functional Concurrent Regression

$$\mathbb{E}[Y(t)|X_1(t), X_2(t), X_3(t)] = \beta_0(t) + \sum_{r=1}^{3}\beta_r(t)X_r(t)$$

Trend



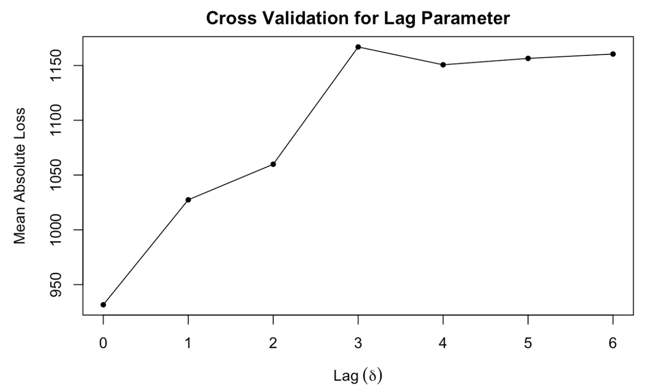
Variation



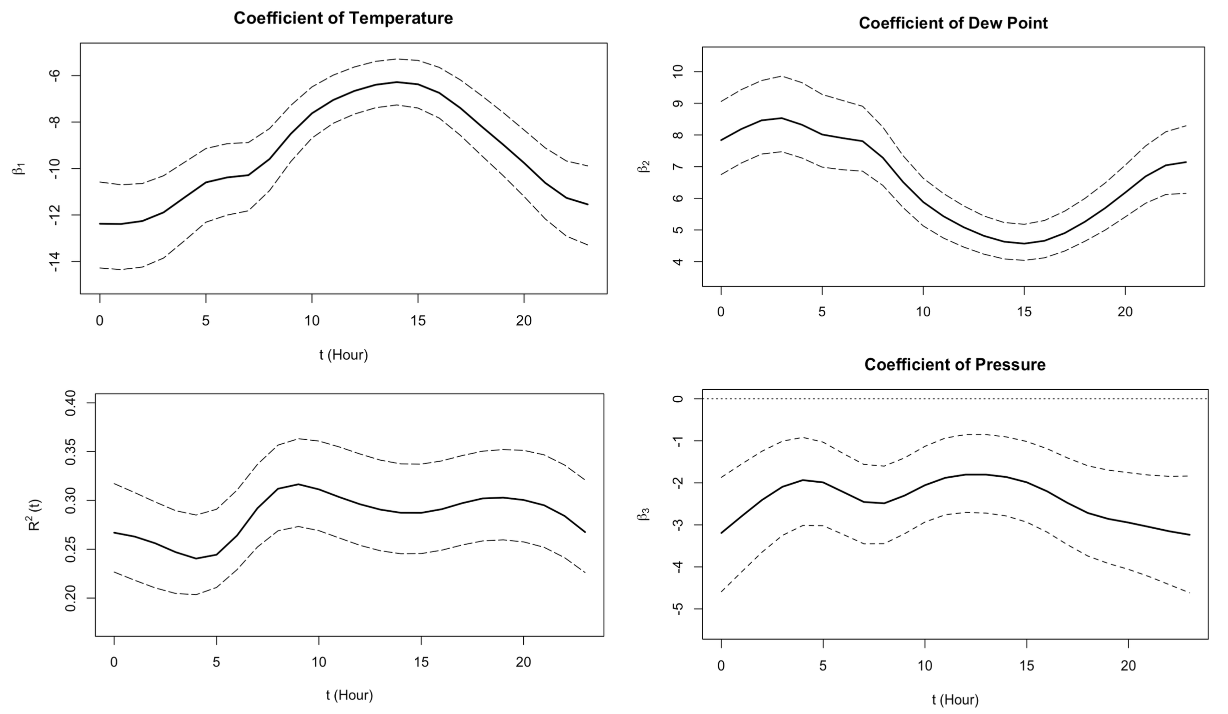
Findings:

1. Most of the variation in temperature, dew point, pressure and PM2.5 are explained by "time-invariant" eigenfunctions, which are due to difference in day-to-day averages instead of hourly fluctuations.
2. For PM2.5, more variability (more than twice as much) occurs in the early morning and late afternoon than during the day
3. (1) implies that the "curvature" of temperature, dew point and pressure varies very little

CV: Lag parameter



Modeling



- All effects significant & non-zero (avg. R^2=28%)
- Temperature & Dew Point tend to have weaker effect when avg. PM2.5 is low; vice versa

Conclusion and Discussion

- **Dew Point** vs. PM2.5: high dew points (moisture) facilitates formation of haze & fog, which traps tiny particles in the air and cause PM2.5 to accumulate
- **Temperature** vs. PM2.5: high relative temperature triggers vertical movement of air and creates convection currents that mix air at different altitudes, helping to "vertically" disperse PM2.5
- **Pressure** vs. PM2.5: low pressure leads to low height of atmospheric boundary layer (ABL), thus leads to increased dispersion of air pollutants
- **Hypothesis**: There may be a natural decline in the effect of temperature and dew point when PM2.5 concentration decreases

Reference & Acknowledgement

- Zhou, Y., Bhattacharjee, S., Carroll, C., Chen, Y., Dai, X., Fan, J., Gajardo, A., Hadjipantelis, P. Z., Han, K., Ji, H., Zhu, C., Müller, H.-G., & Wang, J.-L. (2022). **Fdapace**: Functional data analysis and empirical dynamics
- Liang, X., Zou, T., Guo, B., Li, S., Zhang, H., Zhang, S., Huang, H., & Chen, S. X. (2015). Assessing beijing's pm2.5 pollution: Severity, weather impact, apec and winter heating.
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