PIMS Workshop on Mathematics and Clean Energy Applications

May 22, 2019: Lunch and Learn:

Narratives in Mathematics and Clean Energy

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How I got involved in renewable energy

I started my undergraduate degree in Industrial Engineering. After my first year, I was hungry to learn more math so I started a double major in Mathematics. Soon, probability became my favorite topic, because it was right at the intersection of the two programs; Math taught me its theoretical foundation and Industrial engineering showed me how it is the applied to real world problems.

After finishing my undergraduate training, I started a Ph.D program in Operations Research. This way I could still keep one foot in applications and the other on theory. However, during my Ph.D and my postdoctoral training I focused more on the theory. I wanted to learn the hardest things in probability. My early years as a faculty member, I was working on a problem called the Martin Boundary theory of Super Brownian motion, which is a hard and esoteric problem in probability. Indeed, one of the referees reviewing my work commented that there are only a dozen people in the world who can make sense of my work. I became more and more isolated. Hard problems require teams, which I didn't have. I soon lost my motivation and felt the need to do something more fun and rewarding.

Why wind energy? Part of the reason is social responsibility. I believe working on renewable energy is something kind and wholesome. It makes me happy. But, the other part of the reason is that wind is a spatio-temporal process and offers a playground for a large spectrum of techniques from probability theory, and in particular, infinite dimensional stochastic processes which my training is on. The tools range from regression /machine learning type models to the most theoretical models such as stochastic partial differential equations, which is a very hot topic in probability theory nowadays.

How did I get started? I went and talked to a colleague (Hamidreza Zareipour) from electrical engineering. He told me about a problem related the estimation of the future aggregate wind power production. They were estimating the correlations between wind farms from historical data, but this was not possible for the future wind farms, since there was no data available. They used matrix completion techniques to extend the correlations to the future farms. After trying to understand their methods, soon I've realized what was missing, that is, the idea of modeling wind/wind power as a spatiotemporal process over a continuum and treat the data as discrete observations from it. I gave this as a project to my graduate student, Yilan Luo. We used a Gaussian spatio-temporal processes to model the wind power across Alberta, and used the data to infer its correlation function. Under the guidance of our engineering colleagues, David Wood and Hamid Zareipour , we wrote the work as an article and got it published in Energies. This successful collaboration gave rise to many exciting new projects and new collaborations, which are now the basis for a long term research program on the use of spatio-temporal processes for wind and solar energy.