Shaocheng Xie's input on cross-topic synergies/perspectives

- **Common challenges across various topic areas**
  - Lack of data for high-resolution modeling and human systems
  - Lack of model capability, resolution, output for the scales suitable for driving energy and other climate application models
  - Challenges in quantifying data and model uncertainties
  - Significant spatial and temporal gaps in models and observations for various applications
  - Challenges in downscaling, upscaling, and transferability
  - Challenges in data sharing, big data handling, and computational resources

Those challenges have provided a good opportunity for different federal/local agencies and BER programs to work together. The local/regional testbeds could serve as an effective tool to address many of the challenges and fill in data and model gaps.

- **Future research focuses**
  - Enhance interactions across different disciplinary areas and understand the gaps between different research areas
  - Develop integrated multi-scale/hierarchical modeling testbeds for process understanding, filling in the gaps across different modeling systems/between models and observations, and testing transferability, with the ultimate goal towards a digital Earth.
  - Data assimilation is critical to drive and constrain testbeds. It is a key component for a digital twin. It is also the key for sub-seasonal to seasonal forecasts and 1–5-year predictions, which are the scales that energy models care the most.
  - Build-up observational data library for various modeling testbeds through inter-agency/program collaborations
  - Ensemble data and model simulations to address uncertainties in the observations and models
  - Develop new metrics to measure the success
  - Develop simple models (one type of testbeds) to efficiently test new ideas and train undergraduate and graduate students.
  - Explore AI/ML to fill in scale and temporal gaps in the observations and streamline the processes
  - Enhance the connection with stakeholders