

## **Workshop 4, SECURE Launch Event, 2015; led by Professor Richard Chandler**

### **Linking process and statistical models**

#### Summary of discussion

“Process models” were characterised as those built on a “first-principles” approach, that are particularly good for (a) understanding the mechanisms within a system (b) providing extrapolations / predictions that are based on mechanisms and understanding rather than just on a continuation of observed patterns. “Statistical” modelling was characterised as information-based, and can (a) provide guidance on what information (observations, model runs) is needed to answer a question of interest (b) ensure robust interpretation of results / outputs with uncertainty assessments.

Several science challenges and opportunities were discussed, as follows (in no particular order):

- Can we bring process-based thinking into statistical modelling? For example:
  - Can we embed process representations into statistical models? This would complement an alternative approach that is currently being explored in some areas, of developing “stochastic parameterisations” of process models.
  - Can we use process models to inform statistical techniques that are being used to develop monitoring frameworks?
- Conversely, to what extent can statistical thinking / techniques help to improve process models? For example:
  - How to characterise structural uncertainties in process models? How to determine which aspects / components of a model to target in terms of improving performance / reducing uncertainty? There may be a role for statistical emulation here.
  - How could we use comparisons between process model outputs and “unusual” features of observations, for example during extreme events, to better understand where model deficiencies are coming from?
- There are clear opportunities for bringing statistical design principles into both data collection and the design of model experiments; and, in some areas, for developing a “joined-up” approach to data collection and modelling. An example was given of grant proposals in which much of the effort is devoted to data collection, with “modelling” appended as a brief activity to be done afterwards.
- How should one interpret outputs from ensembles of models – for example when using ensemble-based forecasting / warning systems? A related question is how to verify / evaluate forecasts from process-based models.
- In some areas there is a tendency to think in terms of averages or “typical” scenarios, which can be problematic in situations where “risk” or “consequence” is a nonlinear function of system behaviour. There is potential here for improvement by adopting statistical thinking about how to characterise variability, including extremes. Downscaling is an example, where statistical techniques can be used to bridge the scale gap between the resolution of process model outputs and the resolution needed to evaluate their effects.

One barrier to progress at present is that different groups within SECURE (and more widely) are not aware of other people’s questions, or of the potential tools available for answering them. It was agreed, therefore, that one useful initiative would be to hold a two-day “matchmaking” workshop targeting the “linking statistical and process models” theme. Participants would be invited to share their questions, problems, potential solutions and existing tools with each other, as a way to help stimulate new collaborations.