Model error – systematic and random

- Model error exists on all time and space scales but what is the balance between systematic model error and random error as a function of scale ? (planetary-scale errors are more likely to be systematic)
- Traditionally, one corrects systematic error by adjusting and reformulating deterministic parametrization. Why do we need stochastic physics?
  - many errors appear to be very difficult to correct
  - Necessary for more realistic parametrization by addressing the statistical nature of the physical processes
  - Nonlinear rectification effects driven my noise with zero mean may remove some systematic error
  - As a practical solution to the problem of deficient spread in ensemble forecast systems
- What are the options for making stochastic physics schemes?
  - Build them into existing parametrization schemes by:
    - Perturbing u,v,T,q etc inputs *without changing the model's state*
    - Perturbing 'critical parameters' internal to the parametrization schemes
    - Perturbing output tendencies (net tendency or independently for different schemes)
  - Additive versus multiplicative noise?
  - Stochastic parametrization that addresses dynamical error e.g. SKEB, convective vorticity forcing, stochastic gravity wave drag schemes
  - Avoid unnecessary complexity because tuning the whole system is expensive
  - Stochastic physics perturbations (at least in models with parametrized convection) need to have *mesoscale* temporal and spatial correlation scales or larger to generate EPS spread
  - You can use many different initial perturbations on the convective scale to get a similar response on the mesoscale (Hohenegger and Schar, 2007.)
  - Can observations play a greater role in the development stochastic physics schemes?

SPPT/SKEB and other stochastic parametrization

- SPPT is not only accounting for physics errors. What else?
- Is there a smooth transition between physical stochastic parameterizations, e.g. explicit convection and SPPT? Avoid double-counting!

- Remove tapering in boundary layer and middle atmosphere?
    - Introduced because of deficiencies in the Buizza et al implementation of SPPT
    - far too many high precipitation events; boundary layer wind noise at the edge of random number 'tiles'
    - less likely to be needed at convective-scale resolution ?
- Don't take SPPT, just take noise. If nothing different happens increase the amplitude of the noise (Tobias Selz)
- Triggering of convection from boundary layer turbulence or stochasticity in shallow convection.
- Blended nowcasting and convective-scale ensembles (Kober et al, 2012)
- What should be perturbed?
    - Perturb latent and sensible heat fluxes instead of tendencies.
    - Why not perturb condensate tendencies? Mass conservation is a problem.
    - Perturb sub-grid scale orographic drag associated with turbulence, wakes and gravity waves?
- You have to live dangerously to get the best forecast : model is likely to be most sensitive (and capable of generating EPS spread) when close to computational instability

Marco Arpagaus:

SPPT does not produce much spread in COSMO-E. Why?

- Should we increase the perturbation amplitude again (after having removed the Coriolis tendencies from the SPPT)?
- What about the spatial and temporal correlation scales?
- Individual perturbation of each parameterization scheme?
- If yes, which ones are most uncertain, and should hence be perturbed the most?
- Should some of the parameterization schemes not be perturbed at all?
- What about perturbing the soil / lower boundary condition (i.e., TERRA, FLake, …)?
- Why are qc, qi, qr, qs, and qg tendencies not perturbed?
- Do we need to re-visit the physics-dynamics coupling?