Bayesian Inference, Evolutionary Methods (Non-Gradient Based Approaches)

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Current State:

- Bayesian inference
- Evolutionary Algorithms (Genetic Algorithms)
- Kalman Filter Approach
- Simulated Anealing
- Maximum Likelihood
- Plume Tracking

Requirements for STE:

- Effectiveness
- Efficiency
- Robustness
- Flexibility
- Quantifying uncertainty

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Sampling: MCMC, Sequential Monte Carlo, Particle Filters, Genetic Algorithm

Cost, likelihood function (there is a variety, not standardized):

- How to rigorously define likelihood and standardize terminology.
- Cost function: MAE, RMSE, difference of log of concentration, difference of concentrations, gradients?.

Gaps:

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- Accounting for sensitivity to wind direction (important to estimate wind direction and speed)
- Met data – NWP + observations, assimilation of concentration data for: Low level winds precipitation over long range
- The space of parameters can be very big for time dependent problems
- Adopt multi-model/multi-scale approach
- Probabilistic approach - how to make it useful for the user.

Suggest path forward:

- Combining methods (improving convergence)
- Framework approach: combining different forward (backward) methods, sampling, etc., mix and match
- Evolving field – eg. adopt new (more efficient) sampling methods
- Different types of cost function: cost of deployment of sensors, success of mission
- Communication of uncertainties

Suggested path forward (continued):

- STE methodologies could be used for optimal sensor network design and deployment
- Planning and preparedness where risk can be folded in the process (sampling over possible sources and climatologies)

How to present uncertainties to a user?

In the past some users suggested the following:

- Request is to have as simple presentation as “hurricane cone”
- How to quantify “Make them (ie. uncertainty bounds) narrower”

Unfortunately these are not viable solutions – more research in tight collaboration with users is needed to achieve effective communication of uncertainties.