Analysis

Trend: Ensemble forecasting and data assimilation becomes one **unified system**
Through Ensemble Kalman Filter-like methods

Outlier: ECMWF remains 4-DVAR

Issues:
(1) All current work is in linear balance, none of them in nonlinear balance (???);
(2) How much SV or Bred vector projects on real analysis error?
(3) How much negative impact due to imperfect model?

NCEP: which way to go?

Ensemble Generation

1. SV vs Bred argument continues to be hot but with no answer to it
   (Tim listed 3 reasons of keeping SV – huge dimension, initial pdf unknown,
   underdispersive and focusing on future; geometric bred vectors by controlling
   spatial correlation)

The trend is for an **ETKF-like method** that will likely replace both SV and breeding.

2. How to consider model physics uncertainty is not clear. Seems **stochastic physics** is a possible way to explore; some mentioned Markov Chain to physics (Canada).

3. multi-model ensemble works very well in practice but lacks a theoretical basis (*ad hoc* system), more research is needed.

4. How to connect hi-res single forecast and low-res ensemble starts to draw attention from the community

Ensemble Forecasting in seasonal and climate prediction

1. Not an IC value problem but a boundary forcing (SST, CO_2 etc) and model physics problem. So, **multi-model or multi-version** of model is a way of doing business now.

2. Currently 2 or 3 tiers in ensembling but needs to be considered as **1-tier problem** (as a unified or coupled system).

3. Use ensemble info to modify a given prior fcst (from climatology).

NCEP?

Statistical post-processing and verification

1. Good news: many statisticians have been brought into the area.

2. Many methods: Bayesian model averaging-type, information theory, re-forecasting, …. For mean, spread and probability

3. Combination of multi-model and statistical method (such as IRI)

4. downscaling

Issues:
*We need to learn or **collaborate** with others.
*Find out the limitations of each methods and then improve them.