# Ensemble Forecasting with the NCEP coupled ocean-atmosphere model

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Thanks to: Zoltan Toth, Yuejian Zhu, Wanqiu Wang, Eugenia Kalnay, Shu-Chih Yang, Hua-Lu Pan, Suru Saha and many others
EMC/, ESRL/, CPC/ NOAA, UMD, NASA

# The NCEP coupled model: CFS

- Created to produce dynamical seasonal forecasts
- Couples the GFS (atmosphere & Land) with MOM (ocean)
- Several versions of the coupled model
- Routine ocean, land, and atmosphere forecasts out to 10 months

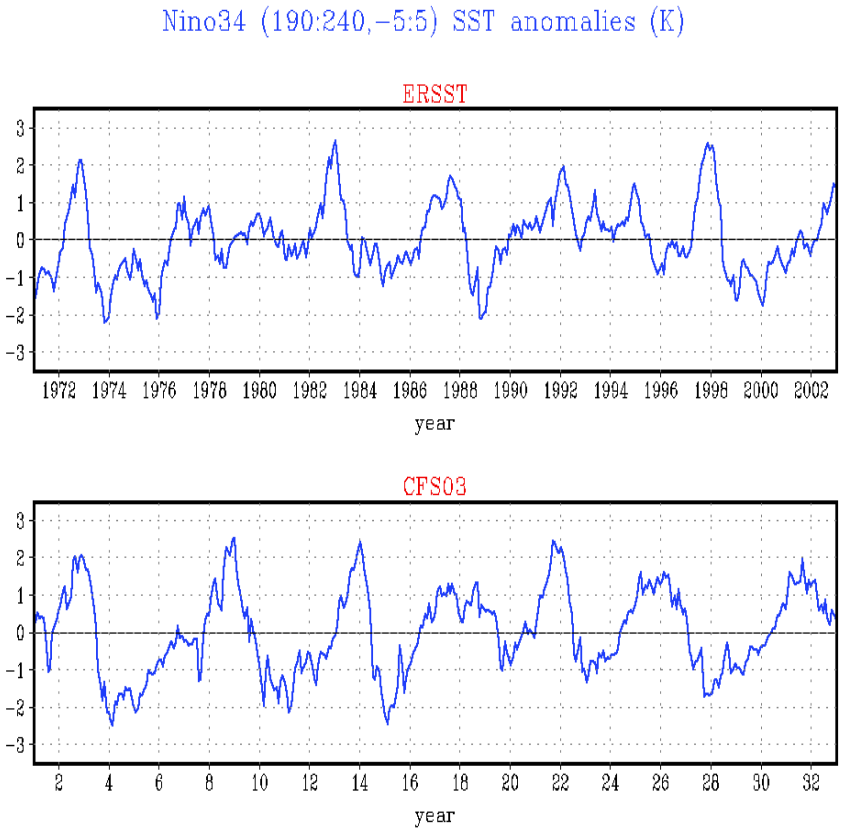
- Operational CFS: released in 2004
- GFS (T62L64) operational in 2003
- MOM v3 (40 levels, 0.5$^{o}$ in the equator and 1$^{o}$ poleward)
- Sea-Ice: climatology

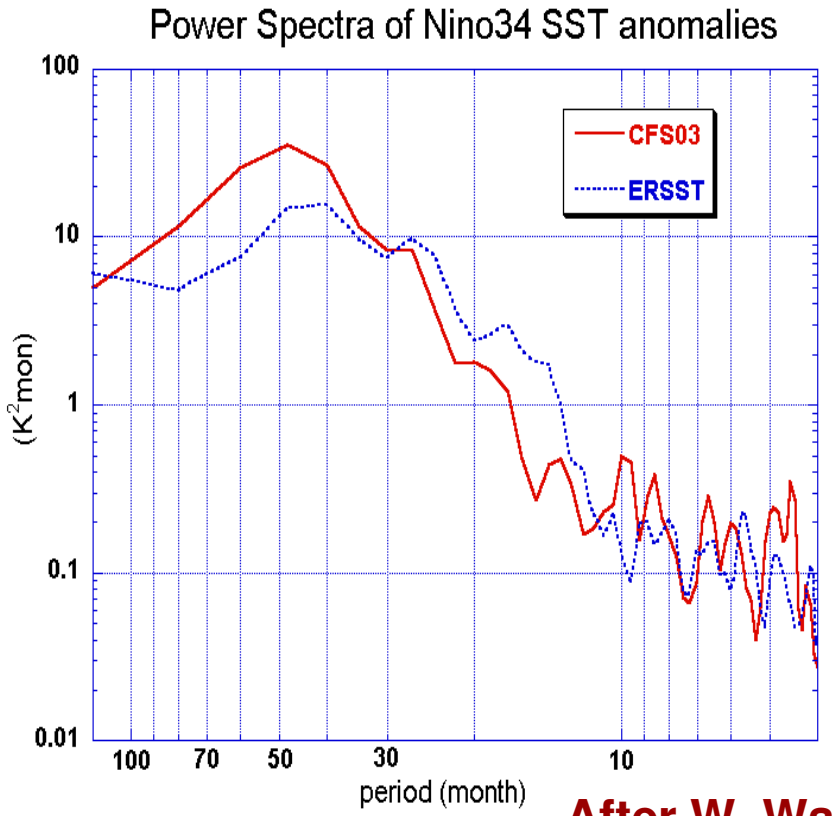
- New CFS: to be released in 2011
- GFS (T126L64)  v. 2009
- MOM v4 (40 levels, .25 in the equator and .5 poleward)
- Global Sea-Ice Model

More information and data are posted at: **http://cfs.ncep.noaa.gov**

# CFS03 (old, operational) Model

Atmosphere: GFS03 T62L64, Ocean: GFDL's MOMv.3



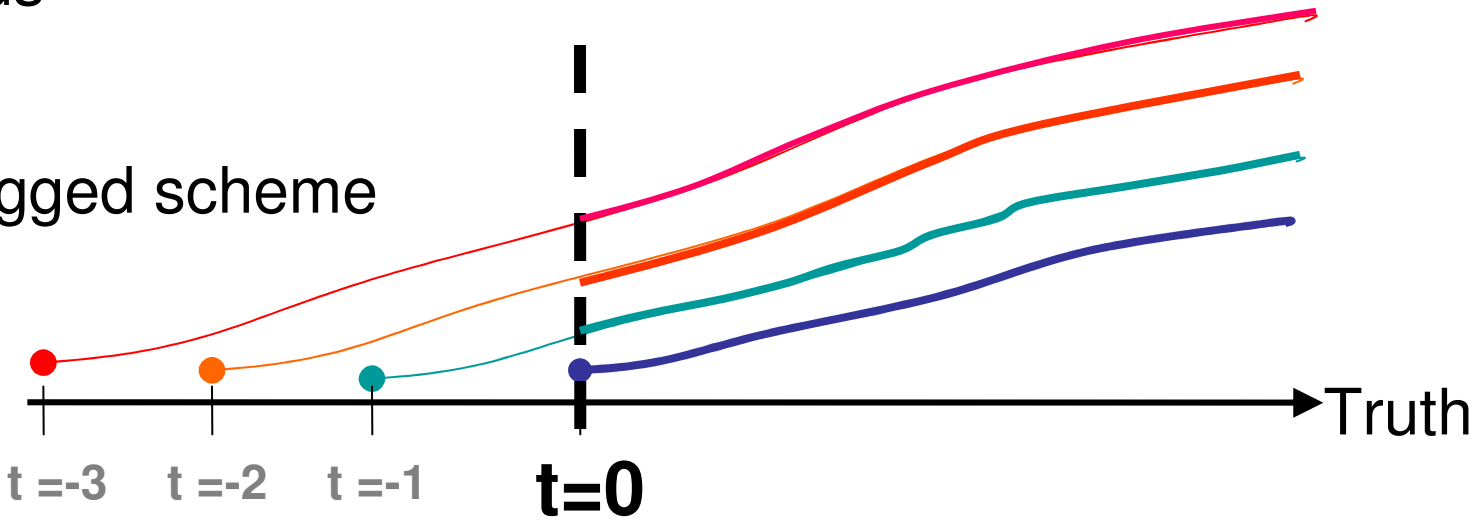

After W. Wang

**Adequate simulation of the intraseasonal-to-interannual SST variability to carry out successful seasonal ensemble forecasting**

# Operational Ensemble scheme

- Lagged ensemble
- Four forecasts per day
- Ensemble can be created by collecting the last 30-60 forecasts
- Ensemble forecasts are bias corrected via a long hindcast dataset
- Forecast quality is as good as or better than statistical methods

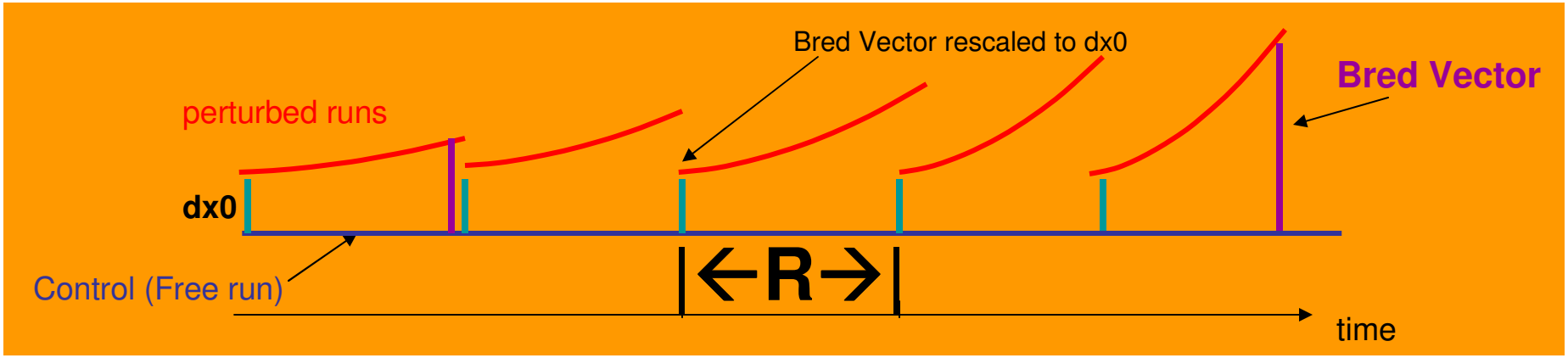
The lagged scheme



# Coupled ensemble schemes: what we know

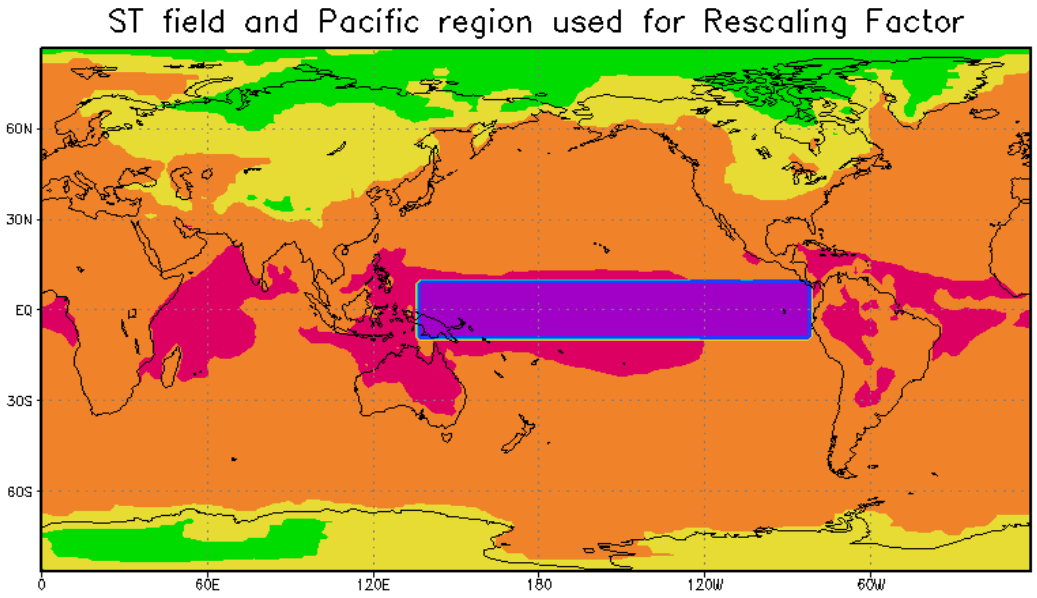
- The slow growing mode (associated with ocean) can be captured with the Breeding scheme when
  a) The rescaling time period is sufficiently long as to allow the fast mode to saturate and
  b) The rescaling factor is computed from a slow-evolving ocean variable (e.g. SST in the tropical Pacific)
- In both the ZC model (Cai et al 2002) and the NSIPP (Yang et al 2004) coupled models, the breeding method captures the ENSO mode
- Breeding scheme better than random perturbations for seasonal to intraseasonal forecasts (Yang et al. 2008) . NASA operational coupled model uses this scheme for its ensemble generation.

# Perfect model experiments




**dx0**: Amplitude of the initial perturbation ~10% of climatological s.d. over Pacific region

**R** = 5,15,30 days, rescaling time period

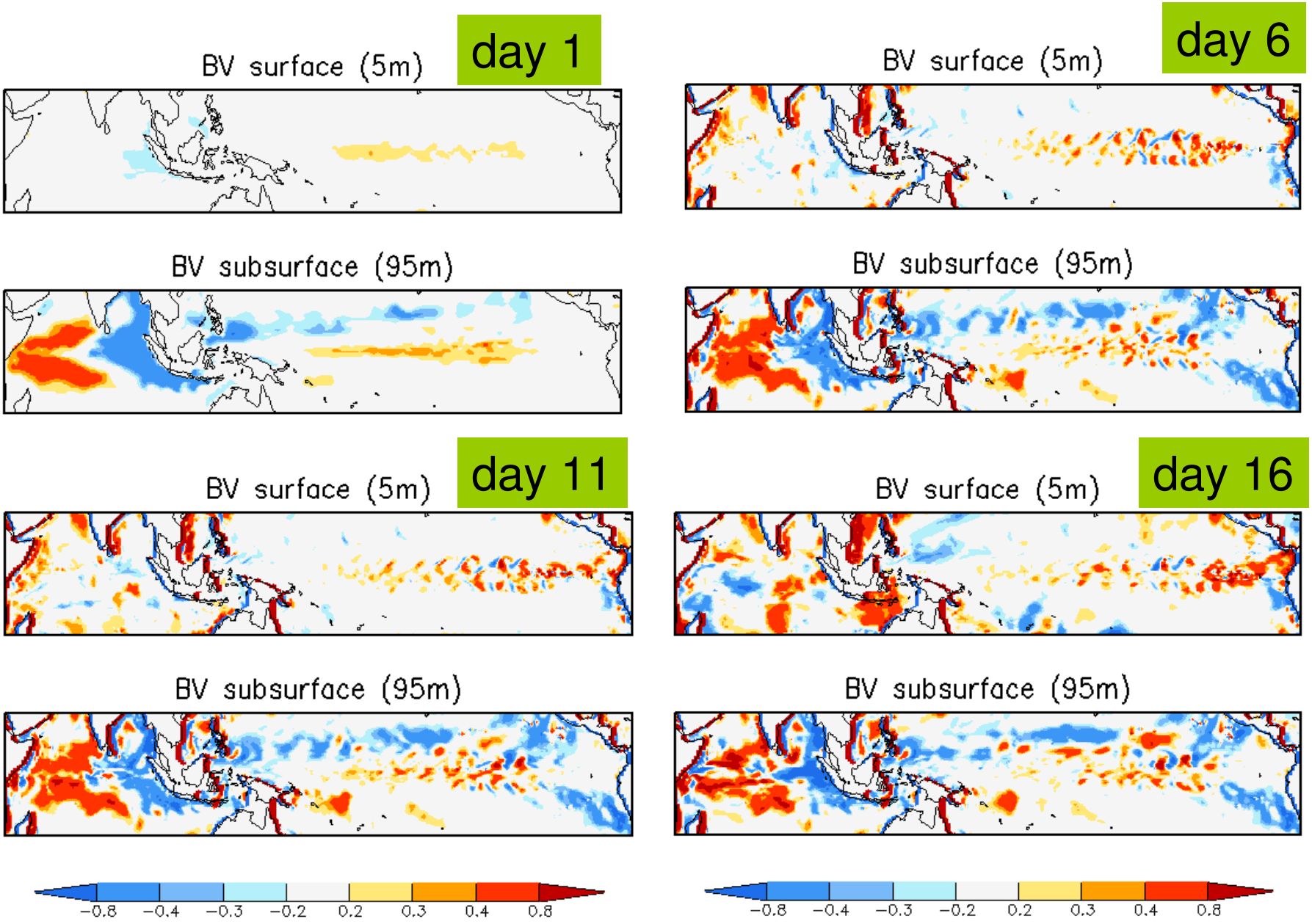



$$P_t = C_t + f * \left( F_{t-\tau \to t} - C_t \right)$$

Where C is the control field,
F is the forecast valid at t.

$$f = \frac{0.1^o C}{\left\| SST - SST_c \right\|_{TropPacific}}$$

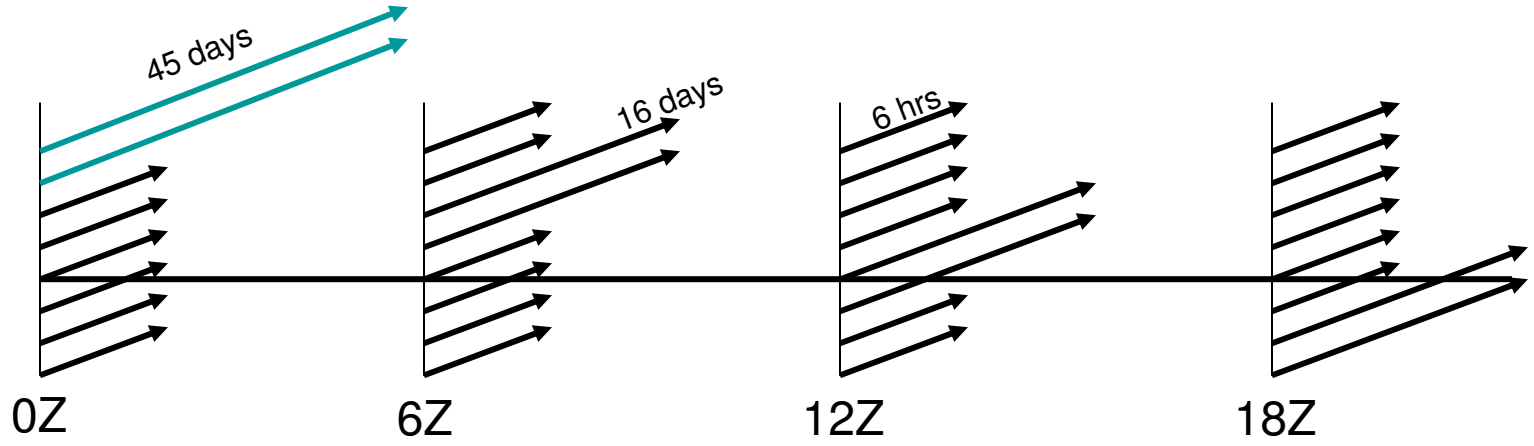
# Surface and subsurface error in T



# CTB funded project

- In collaboration with Schubert et al (NASA-GSFC) CPC and UMD (Kalnay).
- Objective: Create an operational ensemble forecast system for subseasonal time scales.

PROPOSED: Ensemble Transform (ET)




- Current GFS **coupled** with MOM4
- All variables are perturbed in each level
- 80 ET perturbations each 6 hrs
- Once a day 20 perturbations will be **integrated forward out to 45 days** and 60 out to 16 days

# CTB PROPOSAL WITH SCHUBERT ET AL

| | GEFS | CFS | Proposed |
|---|---|---|---|
| Model | Atmosphere forced by damped persistent SSTA | **Coupled OLA** | **Coupled OLA** |
| Initial Conditions | **GDAS** (Best available) | CDAS (sub-optimal) and **GODAS (best available)** | GDAS and GODAS Best available |
| Ensemble initialization | **Ensemble Transform** (State-of-the-art scheme; No information on uncertainty in lower boundary conditions) | Lagged (Not centered on the latest and best analysis; Initial variance not controlled) | **Ensemble Transform/Breeding** (State-of-the-art scheme. Incorporates uncertainty of lower boundary conditions) |
| Ensemble Size (per initial time) | **20 members** | 1 member (sub-optimal performance) | **20 members** |
| Length of Forecast | 16 days | 10 months | **Up to 45 days** |
| Generation of hindcasts | **Best DA/model/ensemble scheme** (Allows periodic DA/models/ensemble improvements) | *Frozen DA/model/ensemble scheme* (Sub-optimal performance) | **Real Time Hindcast** (Allows periodic DA/model/ensemble improvements) |
| Sample for bias correction | Most recent season (sub-optimal for longer led times) | **Large set of hindcasts** (Allows high quality bias correction for long leads) | **Large set of hindcasts** (Allows high quality bias correction for long leads) |
| DA/model/ensemble update frequency | ~ 1 per year | ~ 1 per 7 years | **~ 1 per year** |

*Blue colors indicate desirable features*

# Remarks

- Diagnostics of current operational ensemble (lagged) scheme deteriorates the skill of prediction at least for the short range forecasts
- Search for the best scheme suitable to the operational computer conditions.
- A research version of the CFS is being made available to assess ensemble schemes. The coupled model, however is not currently under the ESMF framework to easily incorporate to operations.
- Two teams have been formed. One to work on the numerical and another on the scientific issues.