NCEP's Climate Forecast System Version 2 (CFSv2) in the context of the US National Multi Model Ensemble (NMME) for Seasonal Prediction

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In March 2011, NCEP operationally implemented a 2nd version of its Climate Forecast System, CFSv2. The previous system CFSv1 was made operational from August 2004 onward. Significant resources had been applied to create initial conditions for the new system and to run retrospective forecasts over 30 years. In all, it took about 7 years. The assumption is that it may be that long to have version 3 on line.

In early 2011, there was a sudden decisiveness about organizing a National MME for seasonal prediction in the US. It had been a longstanding wish of some (especially funding agents) for this to happen. NCEP, at first, was a reluctant participant due to the sacrosanct characteristics of *operational* prediction. However, NCEP was prepared because EUROSIP (or IMME) was already being experimented with, in cooperation with the ECMWF, since late 2010. There was a willingness to go the extra mile on the part of other US modeling centers, especially NASA, GFDL, NCAR and IRI to get this done quickly. These were all US global coupled atmosphere-ocean models. NCEP organized the "rules of engagement" such as time table, common grid, reforecast periods, verification data sets, etc. The first experimental-operational release in real time was made in August 2011. (The first IMME real time operational forecast became available only in December 2011). NMME has played an increasing role in CPC's official seasonal predictions that are released to the public.

Table 1 provided basic information of each of the 7 models that participated in NMME in the first year, 12 monthly releases from August 2011 through July 2012. Among the 7 models that participated during the first year are both CFSv1 and CFSv2. Because so many customers had more or less automated applications running on the output of CFSv1 there were many objections to a speedy removal of CFSv1, even though CFSv2 had already been implemented. Ultimately, CFSv1 has been retired by NCEP in October 2012, although objections were raised even then.

Hindcasts situation Year 1						Model resident resolutions		
	Start months available	Period	Members	Arrangement of members	Lead (months)	Atmosphere	Ocean	Reference
NCEP CFSv1	12	1981-2009	15	1st 0Z+/-2days, 11th 0Z+/-2d 21st 0Z+/-2d	0-9	T62L64	MOM3L40 0.30 deq Eq.	Saha et al.2006
NCEP CFSv2	12	1982-2010	24(28)	4 members (0,6,12,18Z) Every 5th day	0-9	T126L64	MOM4L40 0.25 deq Eq.	Saha et al.2013
GFDL CM2.1	12	1982-2010	10	All 1st of the month 0Z	0-11	2x2.5° L24	MOM4L50 0.25 deq Eq.	Delworth et al.2006
IRI ECHAM4-f	12	1982-2010	12	All 1st of the month 0Z	0-7	T42L19	MOM3L25 0.5 deq Eq.	DeWitt MWR2005
IRI Echam4-a	12	1982-2010	12	All 1st of the month 0Z	0-7	T42L19	MOM3L25 0.5 deq Eq.	DeWitt MWR2005
NCAR CCSM3.0	12	1982-2010	6	All 1st of the month 0Z	0-11	T85L26	POP-L40 0.3 deq Eq.	Kirtman & Min 2009
NASA	12	1981-2010	6	1 member every 5th day as CFSv2	0-9	1x1.25° L72	MOM4L40 0.25 deq Eq.	Rienecker et al.2008

Table 1. Basic information about each of the 7 models participating in year-1 of NMME. From left to right, the name, number of start months (12 for all), period of hindcasts, the number of ensemble members, the organization of initial states, the leads (at a minimum through 7 month), resolution of atmospheric and oceanic components, and one pertinent reference.

A rational approach to this issue is to ask whether a multi-model ensemble of CFSv1 and CFSv2 would be better than an individual model. As shown in Table 2 the answer depends on the variable. For 2-meter temperatures (T2m) over land, CFSv2 is so much better than CFSv1 that an equal weight ensemble mean actually drags down the skill of CFSv2. So the use of CFSv1 was no longer advisable for T2m. For precipitation rate (prate) and sea surface temperature (SST), the two model versions are closer in skill and their ensemble mean is a slight improvement over the better of the two models individually. Interestingly, these findings were a prelude to conclusions based on NMME. That is to say, CFSv2 frequently leads the pack (NMME) in terms of global monthly/seasonal T2m prediction over land. Trends are now modeled with some success in v2 and truth be told: verification over 1982-2010 depends crucially on the correct representation of the temperature trend. CFSv2 leads the pack (NMME) in terms of global monthly/seasonal SST prediction, but with caveats about Nino34 unfortunately. CFSv2 is just one of the models in the pack (NMME) in terms of global monthly/seasonal prate prediction over land. Very little skill for any of the models! CFSv2's leading role is more pronounced when probabilistic scores are considered, because it has many more members.

Table 3 shows that the models that have the highest skill for T2m also have higher predictability as measured by the anomaly correlation of one model member versus a model ensemble mean (not including that member)), and they are more correlated to each other than to models with lower skill.

In addition to the strict discussion of seasonal prediction we have had so far, we note that CFSv2 is far better than CFSv1 in terms of subseasonal prediction of the MJO. This may be attributed to the better initial states for CFSv2 (from CFSR) than for CFSv1 (from R2). And CFSv2 is run without delay in real time. Therefore, its short & medium range forecasts (16 members per day) should contribute to the 6-10 day, week2 and beyond (week3-week6) prediction. The other NMME models generally do not have the ambition to generate sub-seasonal forecasts in near real time to be useful. But a phase 2 NMME, as a matter of R&D, does address sub-seasonal prediction by each of the models.

In Year 2, Aug 2012-July 2013 release, CFSv1 has dropped out. The two IRI models could no longer be supported and were replaced by two Canadian models. So we carry on with 6 models, and NMME may now stand for North American Multi-Model Ensemble. Therefore, even when NMME has a future, it may be hard to predict who is in and who is out in 3 years. CFSv2 will be in, probably for another 4-5 years. Year 3, Aug 2013 has started. NMME is composed of GFSv2, GFDL, NASA, NCAR and two Canadian models.

2-meter Temps AC (All Leads, All Months)		**Sea Surface Temp AC** (All Leads, All Months)		**Precipitation AC** (All Leads, All Months)	
CFSv2	25.6	**CFSv2**	36.5	**CFSv2**	14.9
CFSv1	15.9	**CFSv1**	32.4	**CFSv1**	13.3
CFSv1v2	23.8	**CFSv1v2**	40.1	**CFSv1v2**	16.2

Table 2. Anomaly Correlation (AC) of CFSv1, CFSv2 and their equal weight mean CFSv1v2, for monthly mean prediction based on hindcasts over the period 1982-2010. All starts months and leads 1-7 are pooled. On the left is 2 meter air temperature over land, in the middle Sea Surface Temperature (global oceans), and on the right precipitation (land only).

	CFSV1	**CFSV2**	**ECHAMA**	**ECHAMF**	**GFDL**	**NASA**	**NCAR**	**OBS**
CFSV1 EM	0.19	0.08	0.05	0.06	0.07	0.09	0.04	**0.06**
CFSV2 EM	0.09	0.27	0.09	0.08	0.16	0.19	0.01	**0.19**
ECHAMA EM	0.04	0.08	0.15	0.16	0.08	0.08	0.05	**0.08**
ECHAMF EM	0.06	0.07	0.16	0.15	0.08	0.08	0.05	**0.07**
GFDL EM	0.06	0.14	0.07	0.06	0.25	0.15	0.01	**0.15**
NASA EM	0.07	0.14	0.07	0.05	0.15	0.27	0.00	**0.14**
NCAR EM	0.03	0.01	0.04	0.04	-0.01	0.00	0.12	**-0.01**

Table 3 A 7 by 7 matrix of cross anomaly correlations for T2m prediction between individual members of model i (i=1,7) with the ensemble mean (EM) of model j (j=1,7). Period is 1982-2010. All start months, leads 1-3, NH extra-tropical land and all 7 NMME models. The off-diagonal elements measure heterogeneous predictability. The underlined values on the main diagonal are estimates of homogeneous predictability, which should be compared to skill already achieved (against verification analysis) in the last column with bold numbers.

References

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