A 35-Year perspective on seasonal climate prediction: Where we were, are, and should be going.

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Outline

- Introduction: Who asked you and what do you know?
- A brief history of making operational US seasonal forecasts: 1980 to 2015
- Has skill reflected major science innovations of 1995 and 2006?
- Retrospective on findings and recommendations of Livezey and Timofeyeva 2008 (LT08)
- Analysis and critique of JFM forecast. Repeating a mistake I made in 1997 and making one more? Two more opportunities left to fix this.
- Conclusions and Recommendations

Who asked you and what do you know?

- CPC invited me to give a candid perspective
- Homework:
  - Many hours on CPC's website
  - Many hours exercising LCAT (needs modification; why isn't this still funded?)
  - Many 2008-15 papers.

Making operational US seasonal forecasts: 1980 to 2015

- Refer to *Reflections on 25 Years of Analysis, Diagnosis & Prediction (1979-2004)* and O'Lenic et al. 2007 WAF (O07)
- New formats in 1982(probabilities) and 1995 (0.5- to 12.5 month leads)
- Linear/subjective in 1980s to linear/"objective" in the 1990s/2000s to non-linear/objective by 2020 (perhaps 15 years late)?

Making operational US seasonal forecasts: 1980 to 2015

- Seasonal forecasts in 1980:
  - Stacks of point to point 700-mb lag correlations, one-point teleconnection charts, subjective analog selection and synoptic T and P specification by hand
  - A poor man's subjective CCA.

Making operational US seasonal forecasts: 1980 to 2015

- After formation of CAC/CPC, innovation continuous: First by Livezey, then Barnston, Van den Dool, Unger, etc.

- But big discontinuities:

  - The procedure overhaul in 1995 (focus on CCA, OCN and CMP with skill masks)
  - The linear objective consolidation of CCA, OCN, SMLR, and CFSv1 in 2006 (O07)

Making operational US seasonal forecasts: 1980 to 2015

- After 1995 ENSO teleconnections have been used (apparently) inconsistently and sub optimally despite Higgins et al 2004 (H04), Livezey et al 2007, LT08, Wilks and Livezey 2013

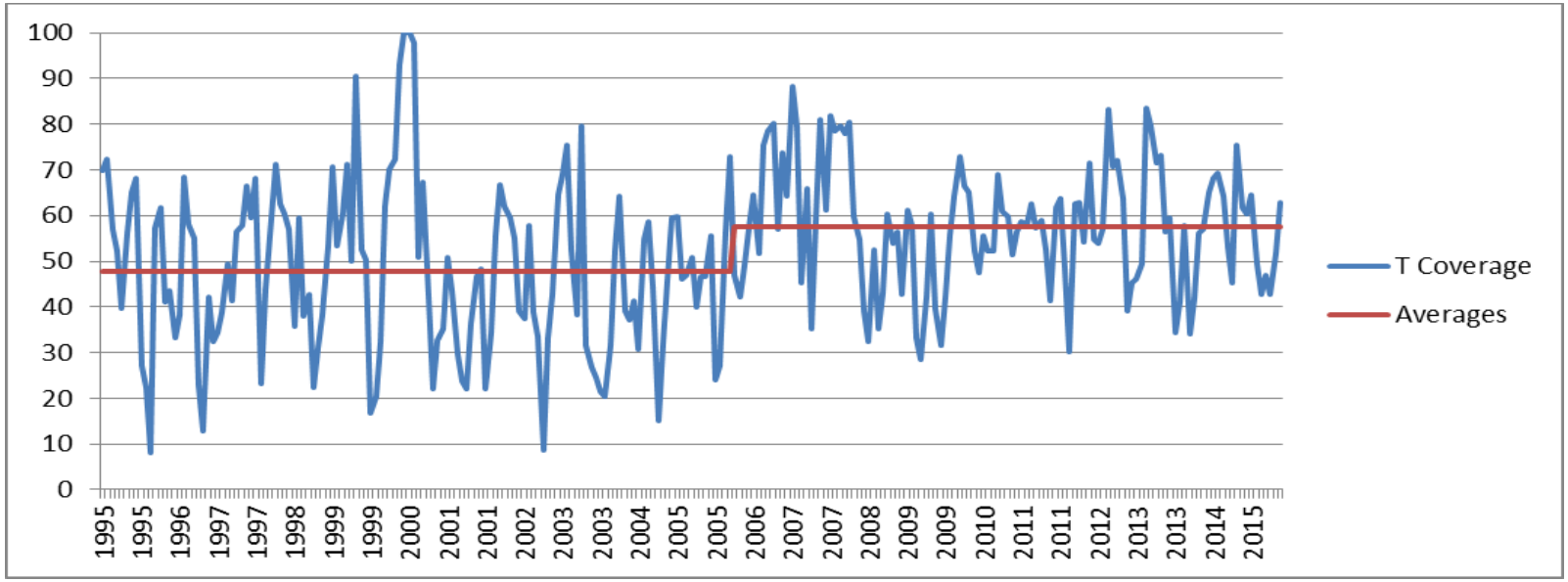
Has skill reflected science innovations of 1995 and 2006?

- Yes! Sources: Livezey 1990, O07, LT08, Peng et al 2012, CPC gridded verification database

"All" 3-Cat Seasonal Forecast Heidke Skill Scores		
	Temperature	Precipitation
0-Lead*	5	4
CPC Grid 0.5-Lead 1995-2005	11	2
CPC Grid 0.5-Lead 2006-2015	14	6

Has skill reflected science innovations of 1995 and 2006?

- Objective linear consolidation (O07) in 2006 increased coverage (non-EC) and reduced its variability, more for T than P.



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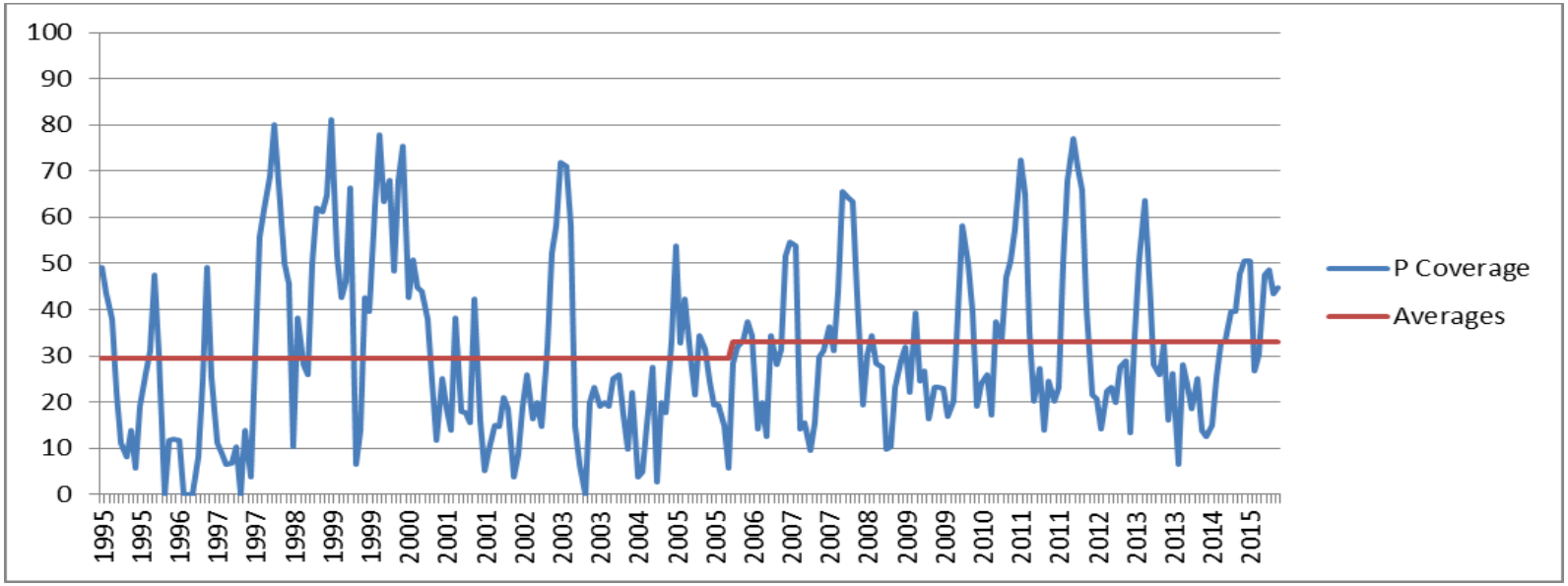


Has skill reflected science innovations of 1995 and 2006?

- Objective linear consolidation has far more effect on temperature forecast coverage than it does on non-EC skill, but the opposite for precipitation.

3-Cat 0.5-Month Lead Seasonal Forecast Heidke Skill Scores						
	Temperature			Precipitation		
	non-EC	All	Coverage	non-EC	All	Coverage
1995-2006	22.6	10.8	48	9.5	1.8	29.4
2006-2015	24.3	13.9	58	16.5	5.9	33.1

LT08 Retrospective: How have findings held up?

- "Post-1995 forecasts collectively represent a clear advance and new capability over the zero-lead forecasts issued prior to 1995"
  - Even more so now!
- Skill of these forecasts is entirely attributable (practically) to long-term trends dominantly associated with climate change and, for Winter only, **strong** predictable ENSO episodes
  - Confirmed at IRI and CPC with no evidence to counter.

LT08 Retrospective: Recommendations and CPC's Responses

- Forecasts should be based only on trends and confident **moderate to strong** ENSO episode forecasts, unless climate science and experimental prototypes demonstrate there is some other source of reliable, substantive skill.

  - Use of linear CCA and SMLR guarantees this is not the case.
  - Use of 0.5 ONI thresholds dilutes composite usefulness.
  - There is evidence that other considerations (PDO at least) still influence the forecasts, despite much work (by me and others, recently by Kumar et al 2013, Kumar and Wang 2015).

LT08 Retrospective: Recommendations and CPC's Responses

- The two signal sources need to be combined objectively and can be done in the frameworks of H04 and O07 but with important changes. Specifically,
  - H04:
    - Detrend temperature series to current climate with hinges or hybrid (rather than 10-year OCNs)
    - Use stronger thresholds for detrended composites (eg -0.8 and +1.0 ONI)
  - O07:
    - Scrap SMLR and CCA and replace with revised H04, because linear statistical techniques badly dilute U.S. ENSO signals
    - Replace 10-yr OCN with hinge or hybrid (15-yr/hinge).

LT08 Retrospective: Recommendations and CPC's Responses

- Issues in CPC's use of ENSO composites:
  - After implementation, CPC apparently has abandoned H04.
  - On-line composites:
    - Use -0.5 and +0.5 ONI thresholds, grossly underestimating probabilities for moderate to strong events and making them of little use for this Fall's forecasts.
    - Frequency maps are for 2 classes (+/-), not terciles, making them of even less use for forecasters.
    - Box plots are for terciles, but are **triply** useless to forecasters because the data is not only not detrended, but has obviously not been homogenized!

LT08 Retrospective: Recommendations and CPC's Responses

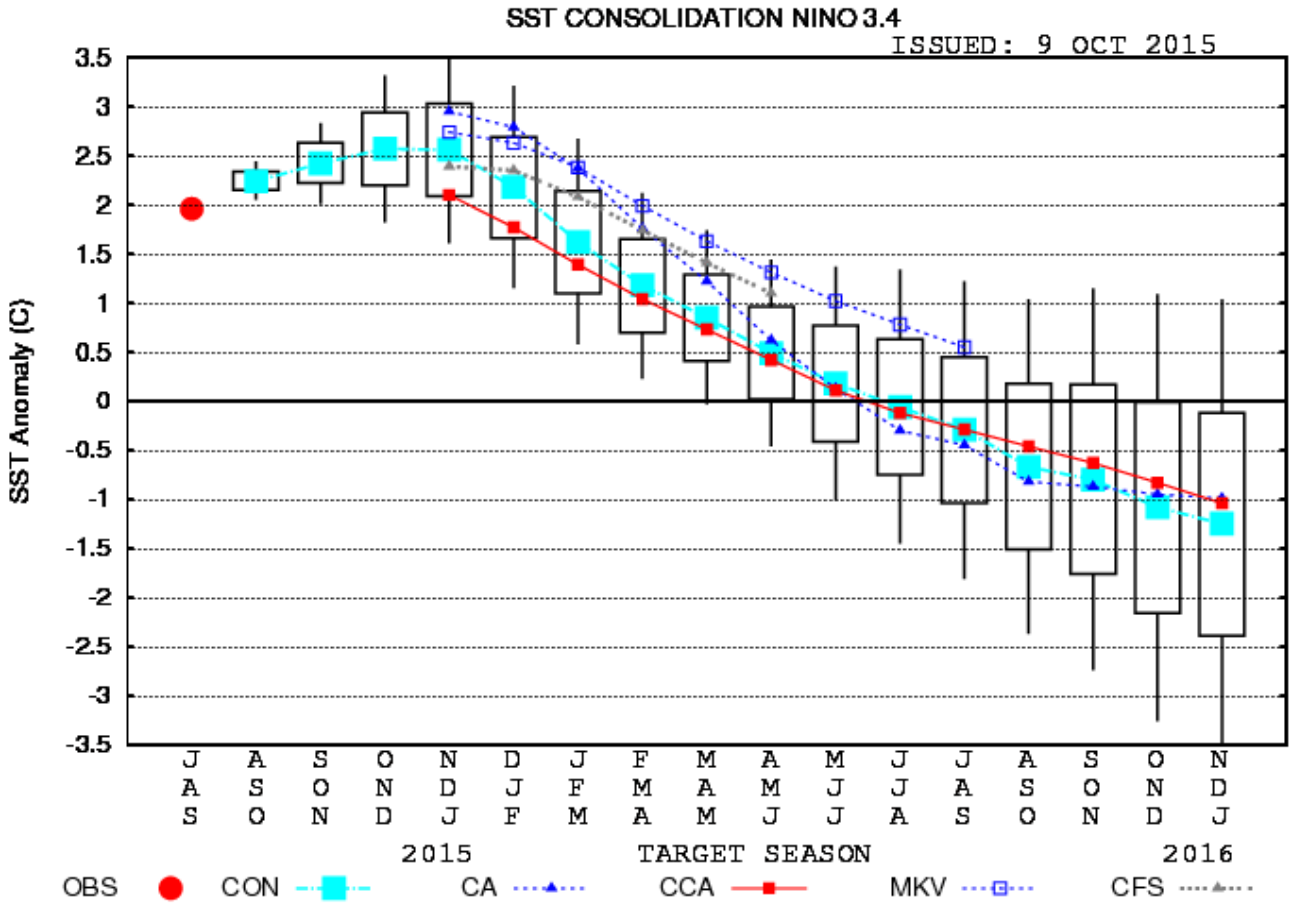
- Revised recommendation and challenge: Build, test (hindcasts), and implement a consolidation of a revised H04, hinge or hybrid trend, and CFSv2.

JFM 2016 Forecast

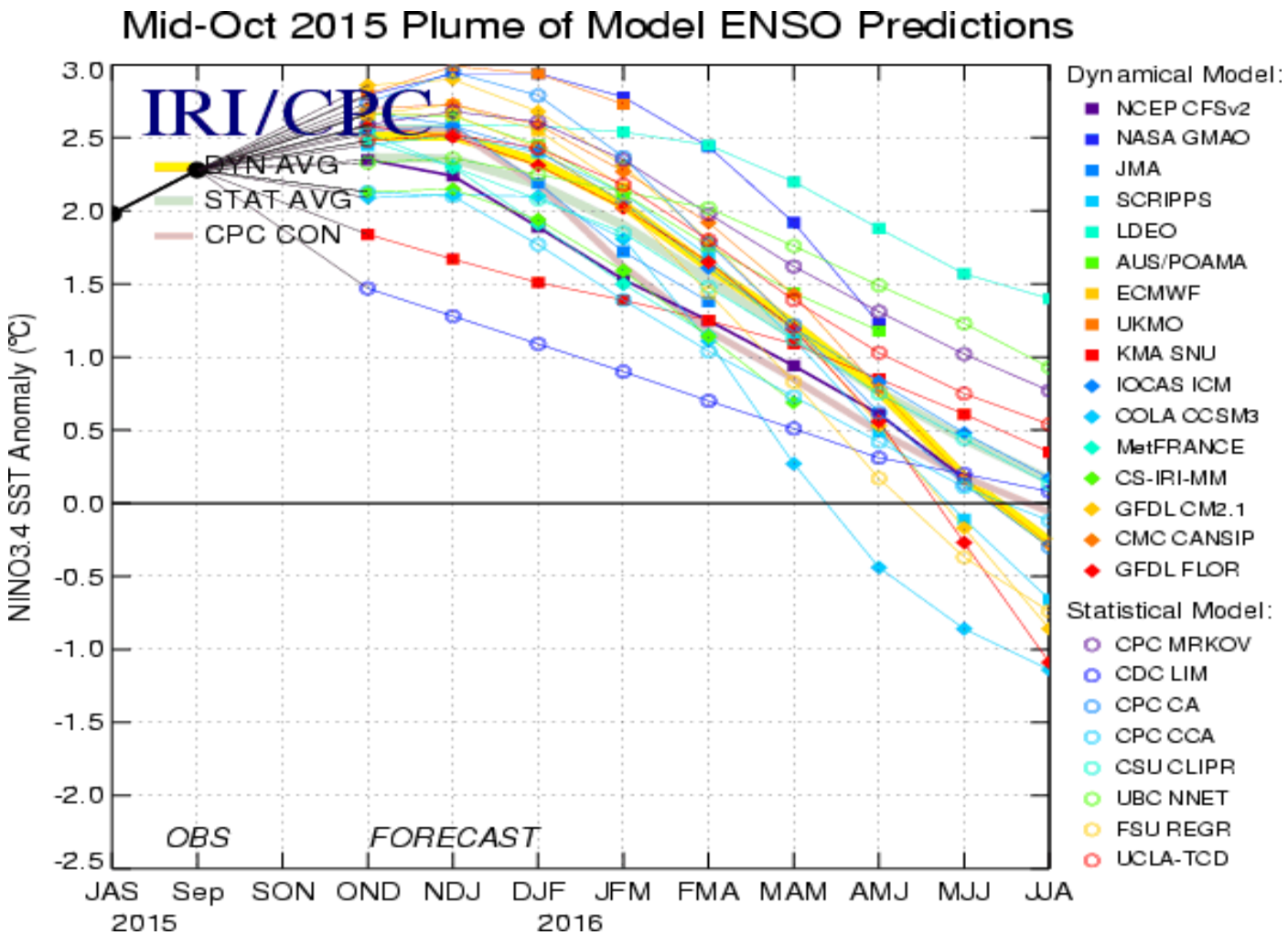
- Despite record skills*, ENSO temperature signals were not optimally exploited in Winter 1997-98 because composite cases were not detrended, Livezey et al 2007 (L07).
  - The temperature forecast was uniformly too cold and looked very much like the current forecast.
  - Are we repeating this mistake and compounding it in understating both T and P probabilities?

* Precipitation record still stands.

JFM 2016 ENSO Forecasts



JFM 2016 ENSO Forecasts

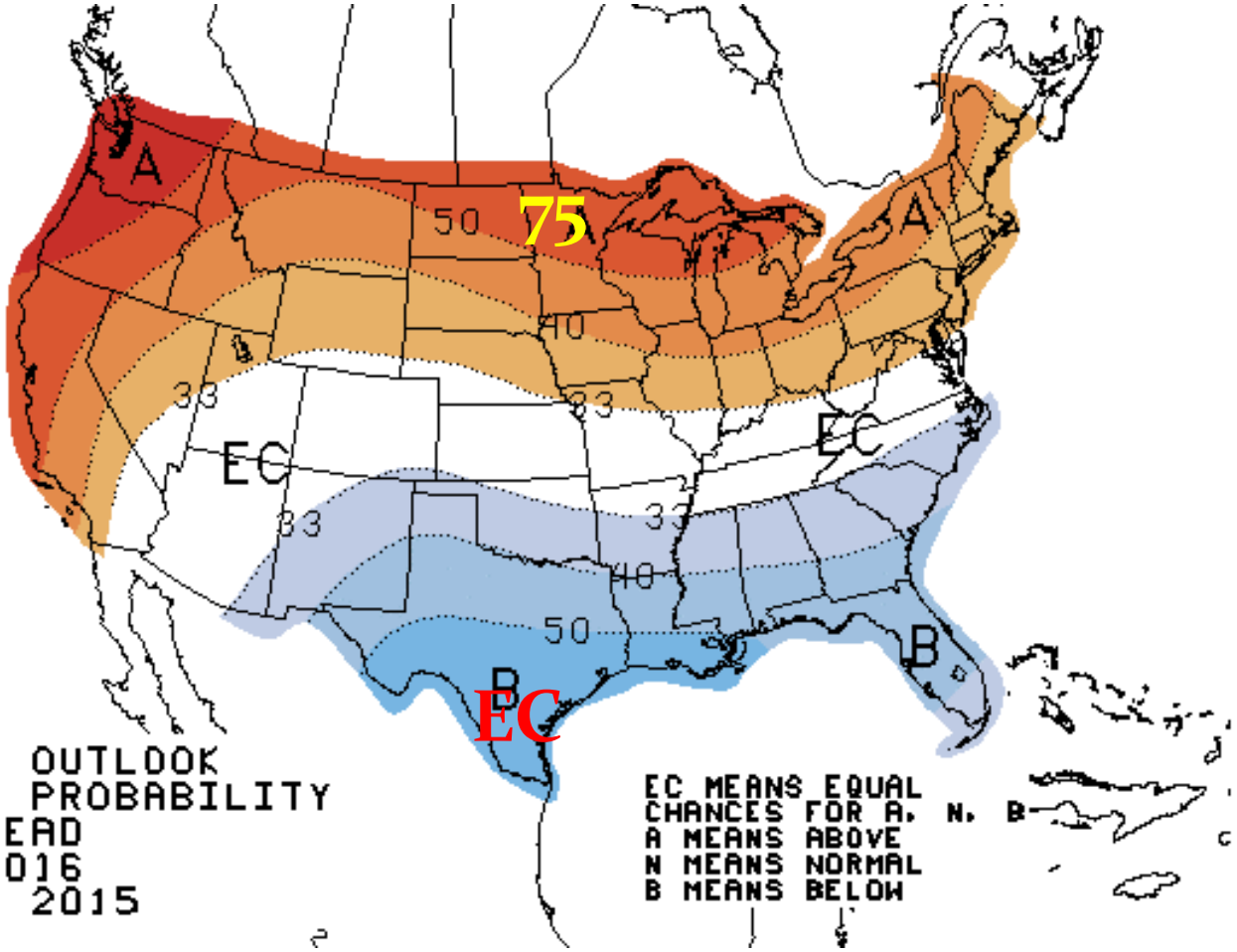


JFM 2016 ENSO Forecasts

- Based on these forecasts I use the following probabilities:
  - JFM ONI ≥ 0.5 : 100%
  - JFM ONI ≥ 1.0 : 95%
- A moderate El Nino is slam-dunk, a strong (top 5) probable, with a very good chance of a record.
- Special circumstances require special tools; CPC is missing those tools.

JFM 2016 Forecast

NCDC MN2
NCDC TX9
1.0 ONI/Hinge



JFM 2016 Forecast

NCDC Texas 9 Temperature Tercile Probabilities			
ONI Threshold/ Detrending	Below	Near	Above
0.5/None	67	17	16
0.5/15-yr OCN	44	39	17
1.0/15-yr OCN	43	44	13
0.5/Hinge	28	39	33
1.0/Hinge	33	44	23
Official Forecast	55	33	12

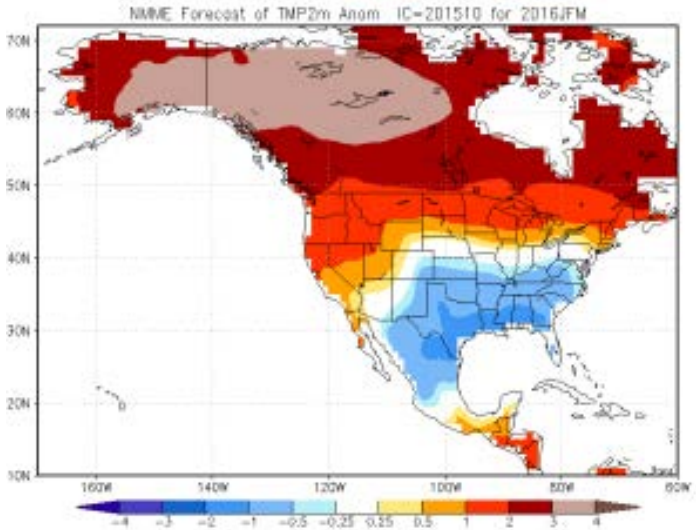
CPC 63 Temperature Tercile Probabilities			
ONI Threshold/ Detrending	Below	Near	Above
0.5/15-yr OCN	55	28	17
Official Forecast	55	33	12

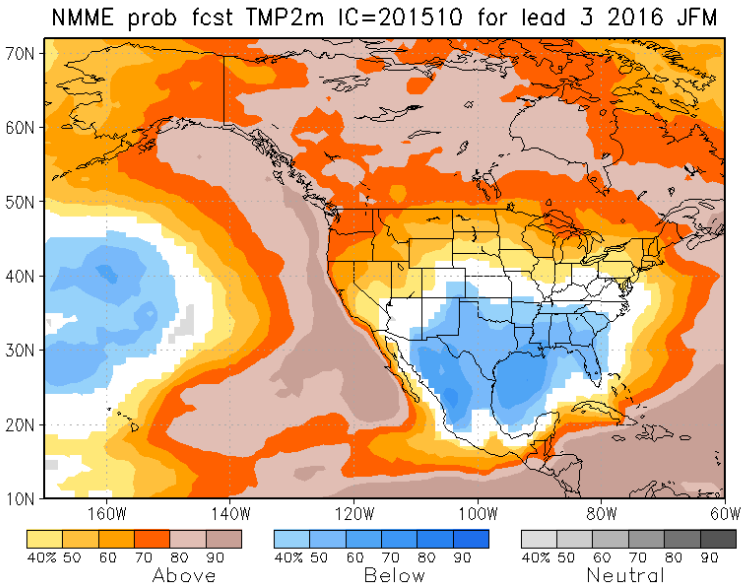
JFM 2016 Forecast

NCDC Minn 2 Temperature Tercile Probabilities			
ONI Threshold/ Detrending	Below	Near	Above
0.5/15-yr OCN	33	22	45
1.0/15-yr OCN	11	11	78
0.5/Hinge	11	33	56
1.0/Hinge	11	11	78
Official Forecast	12	33	55

- CFSv2 and IMME support a US Winter with very little below normal tercile temperatures, more in agreement with detrended composites.
- But official forecast follows NMME below tercile probabilities closely.

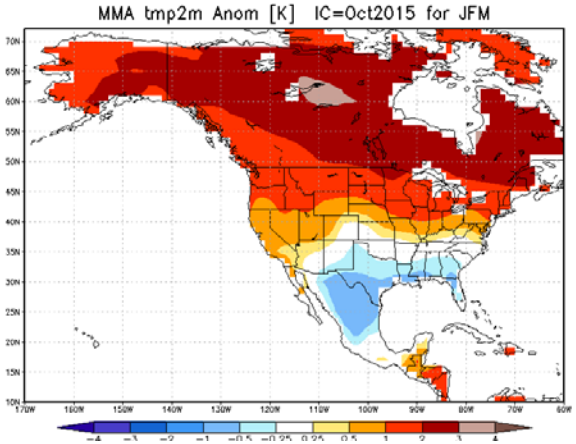
JFM 2016 Forecast

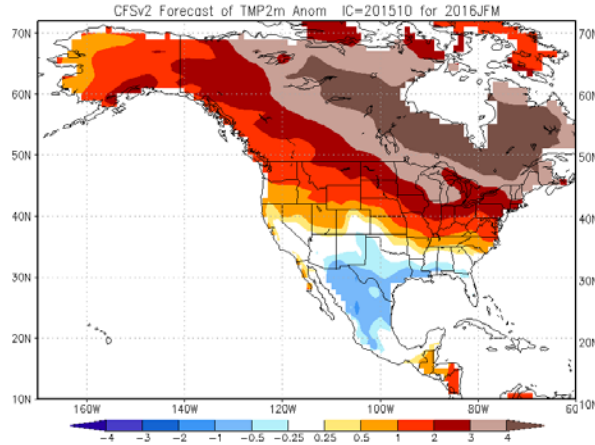


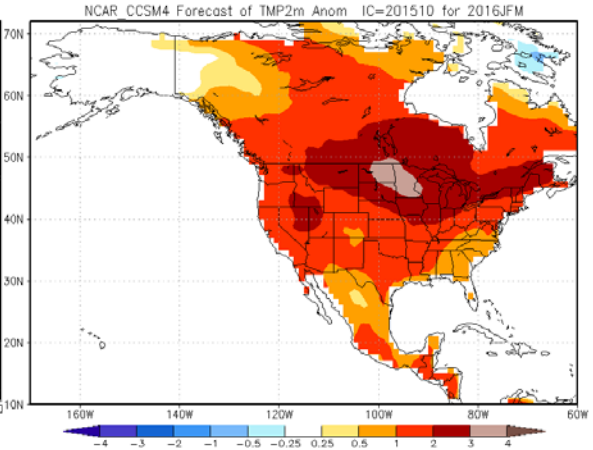


JFM 2016 Forecast

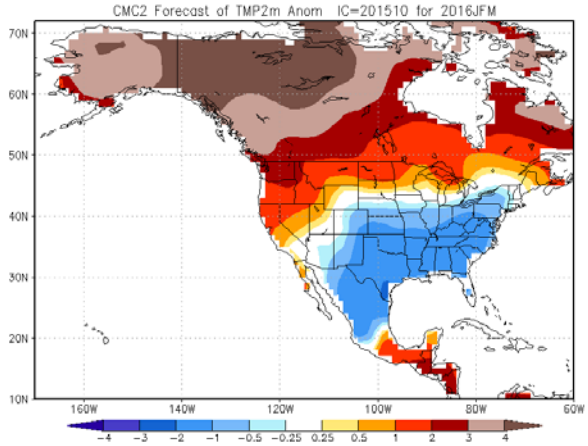
- Weak PNA signatures.

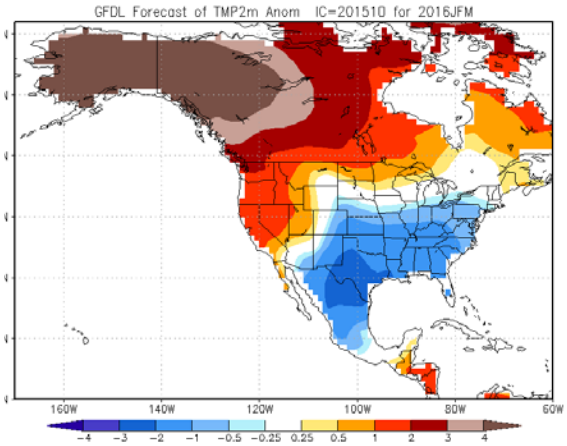


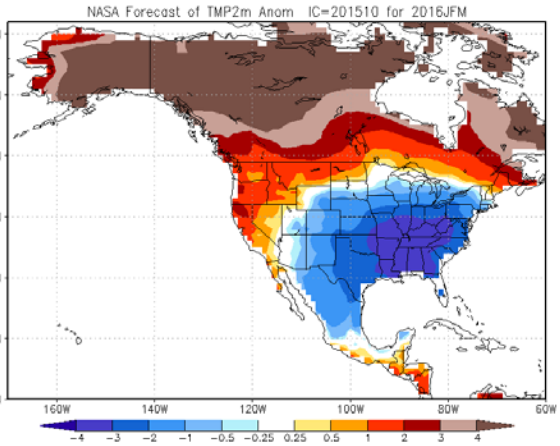




- Strong positive PNA signatures suggest warm SSTs west of dateline.





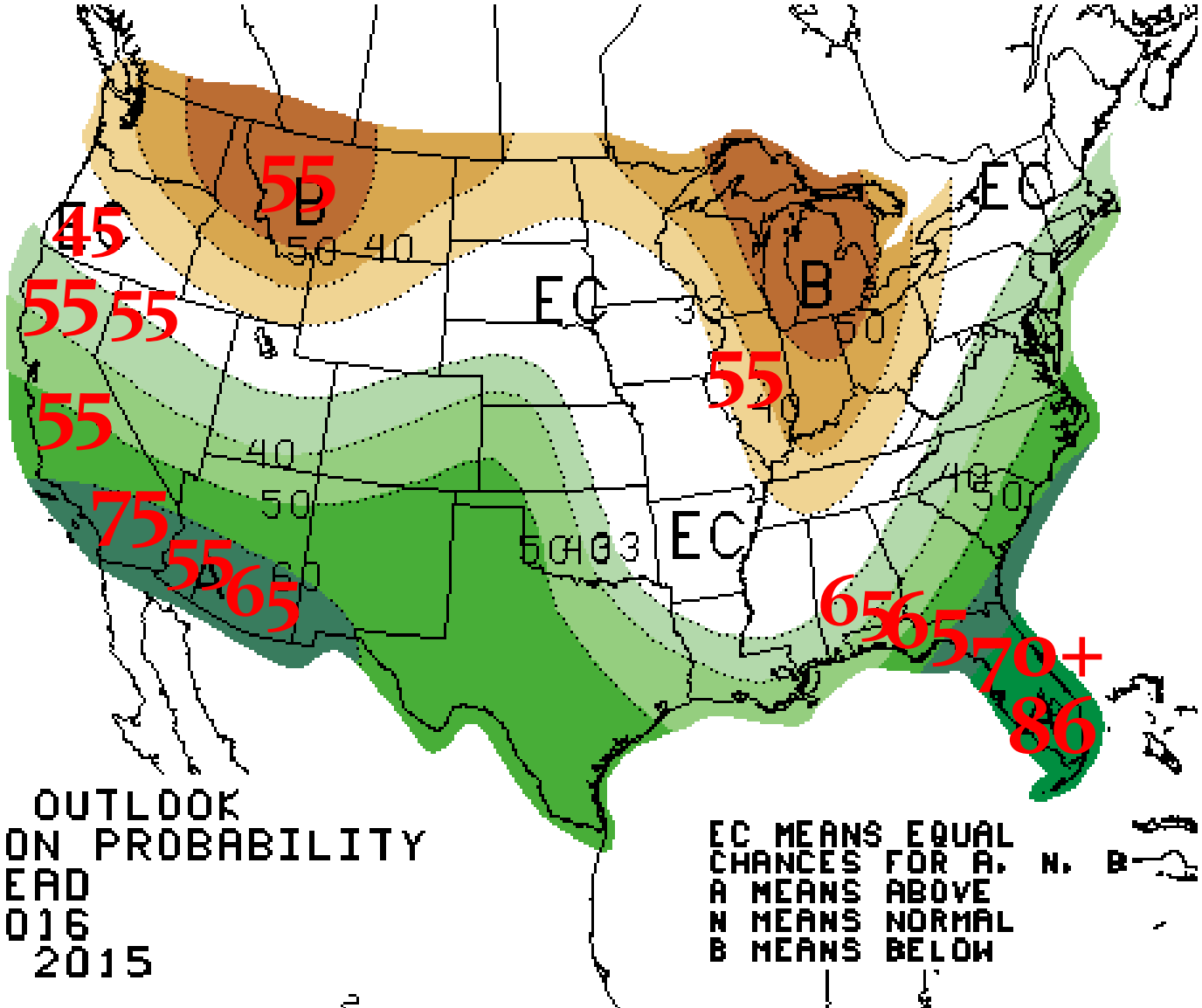


JFM 2016 Forecast

Model	JFM Forecast Rank	
	Cold anomaly at AL/TN Border	Western longitude of 1 deg C SST anomaly
NASA	1	1 *
GFDL CMD2.1	2	1 *
CMC2	2	3
CMC1	4	4
NMME	4	4
GFDL FLOR	4	6
IMME	7	7
CFSv2	8	8
NCAR	9	9 **
* Least SST skill west of dateline		
** Least skill for Nino 3.4		

JFM 2016 Forecast

5%<1.0 ONI
95%≥1.0 ONI



Recommendations

- By next forecast cycle compute probabilities of US temp and precip terciles based on probabilities of ONI above and below one, and corresponding composite tercile frequencies for precipitation and detrended (hinge or hybrid) temperature.
- Rely dominantly on this new guidance and CFSv2 to make official seasonal forecasts for the remainder of the major El Nino event.
- Build, test (hindcasts), and implement a consolidation of a revised H04, hinge or hybrid trend, and CFSv2.
- Monitor performance of the new consolidation and its components against operations and NMME and its components.
- Act on other unaddressed LT08 recommendations (in supplement).

Supplemental Slides

Homework References

- **Higgins et al 2004 JCli;** Kumar 2007 MWR; **O'Lenic et al 2007,2008 WAF**; Tippett and Barnston 2008 MWR; Unger et al 2008 MWR; Seo et al 2009 Jcli; Barnston et al 2010 JAMC; Barnston and Mason 2011 WAF; Tippett et al 2011 JAMC; Peng et al 2012 WAF; **Peng et al 2013 WAF**; Riddle et al 2013 Cdyn; Tippett et al 2013 JCli; **Kumar et al 2013 JCli**; Pegion and Kumar 2013 MWR; DelSole et al 2013 GRL; Kumar et al 2014 MWR; Kirtman et al 2014 BAMS; Johnson et al 2014 WAF; Barnston et al 2015 JAMC; **Kumar and Wang 2015 Cdyn.**

Making operational US seasonal forecasts: 1980 to 2015

TABLE 1. Evolution of operational LRFs.

Years	Variables (predictands)	Tools	Formulation, lead
1946–81	Surface temperature (T); precipitation (P); categorical: above (A), below (B), and normal (N)	Linear regression (with 700-hPa height as predictor), persistence of anomalies	Subjective, zero lead
1982–94	T, P, tropical Pacific SST, A, B, N, and probabilities (%)	Linear regression (with 700-hPa height as predictor), trend, analog–antianalog, ENSO	Mostly subjective, zero lead
1995–2004	T, P, SST, A, B, N, %, terciles, and POE	SMLR (with SST, 500-hPa height, surface T, P, most recent soil moisture, and trend as predictors), OCN, CCA (with SST, 700-hPa height, T, and P as predictors), ENSO, two-tier coupled model, skill mask (1995), SST, CON	Equal parts subjective/objective, ½–12½-month lead
2004–06	T, P, SST, A, B, N, %, terciles, and POE	SMLR, trend, CCA, ENSO, one-tier coupled model (CFS, in 2004), skill mask, T, P, CON	Mostly objective, ½–12½-month lead

LT08 Retrospective: How have findings held up?

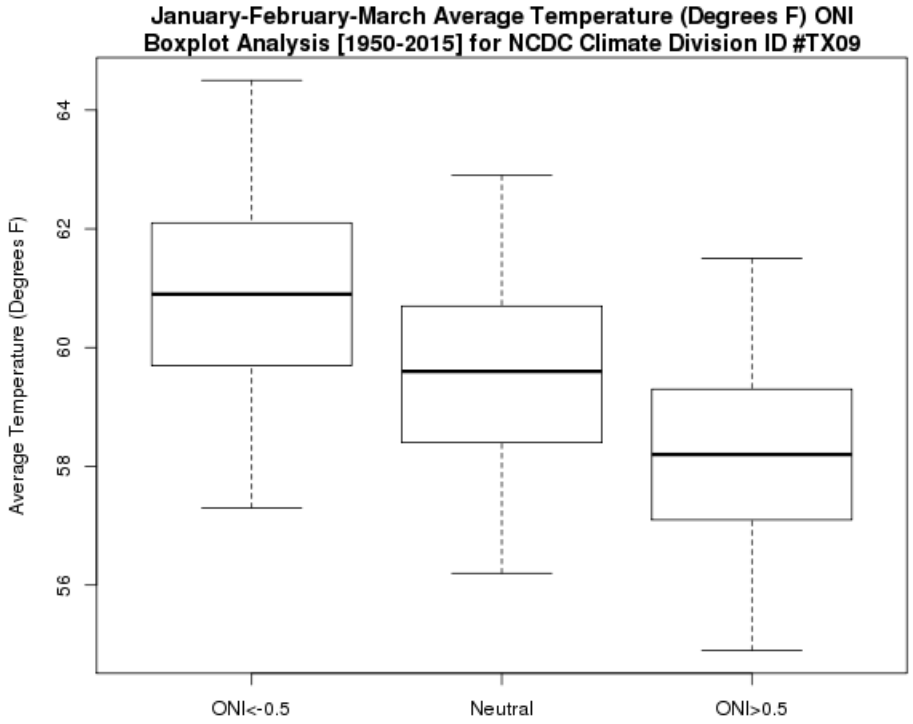
- Also evidence that:
  - Consideration of other factors during neutral and weak ENSO Winters degraded skill otherwise achievable from long-term trend.
  - Climate change signals were not being exploited fully in the forecasts.

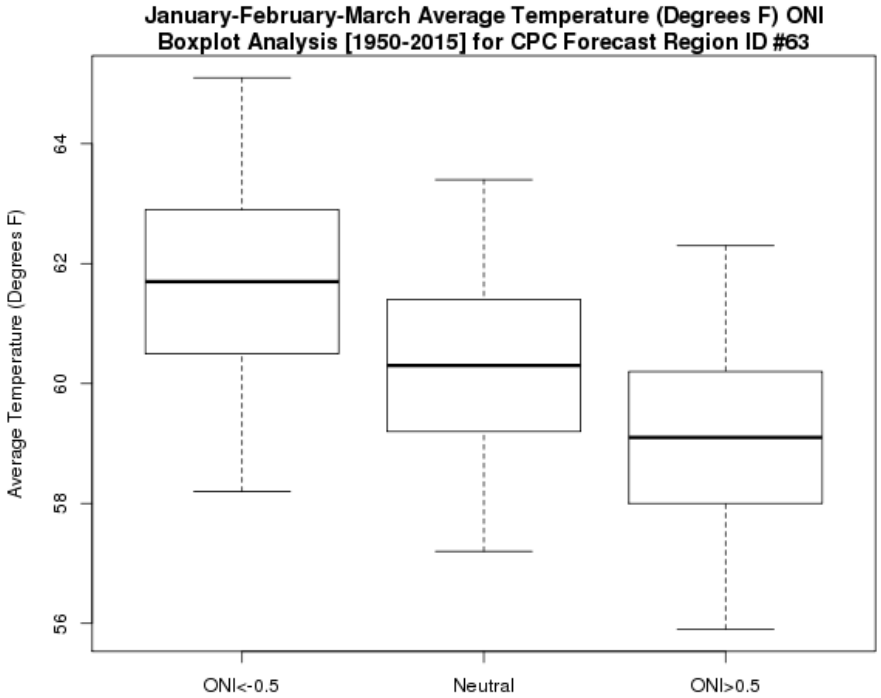
LT08 Retrospective: Recommendations and CPC's Responses

- Other recommendations involved:
  - Diagnosis and development of new prediction tools.
    - Apparently, CPC did not follow up on the promise of Thompson et al 2002.
    - Use of coupled models to explore feasibility of forecasts of opportunity via soil moisture anomalies. Perhaps CFSv2 is now adequate to this task, Peng et al 2013.
  - Skill transparency via interactive web tools.
    - I was excited to discover CPC's interactive Verification Web Tool, but couldn't make it work.

JFM 2016 Forecast

- CPC forecast region boxplots (right) are erroneously based on non-homogenized data.





JFM 2016 Forecast

Forecasts of Heavy Tercile Precipitation for California Based on ONI Forecasts and Composites							
Division	CA1	CA2	CA3	CA4	CA5	CA6/7	Mean
≥0.5 (100%}	44	39	39	44	44	55	46
≥1.0 (95%)	55	55	55	55	75	75	64

Forecasts of Heavy Tercile Precipitation for Florida Based on ONI Forecasts and Composites						
Division	FL1	FL2	FL3	FL4	FL5	Mean
≥0.5 (100%}	55	61	50	67	56	58
≥1.0 (95%)	65	75	55	86	86	73

Forecasts of Light Tercile Precipitation …		
Division	MT1	IL4
≥0.5 (100%}	33	33
≥1.0 (95%)	55	55

JFM 2016 Forecast

- Notes on JFM precipitation forecasts:
  - California:
    - 1966 (ONI=1) and 1987 (ONI=1.2) were non-wet for all divisions
    - 1966 was dry for divisions 2-7
      - AMO, AO, and PDO indices were all unexceptional
      - 1966 was also cold for Texas 9 and near normal temperature for Minnesota 2
  - Florida:
    - 2010 (ONI=1.1) had near normal for all divisions and 1992 (ONI=1.5) all but division 1.