Regional Experimental Seasonal Forecast Guidance: A 10-year Track Record in the Southwestern U.S.

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Motivation

1. Climate Prediction Center (CPC) forecast skill over the Interior West 'leaves room for improvement' for seasonal precipitation forecasts.

2. Recent severe drought conditions have made such forecasts more relevant - water managers are more motivated to utilize climate forecast information.

3. Is there anything reliably usable beyond ENSO for this region?

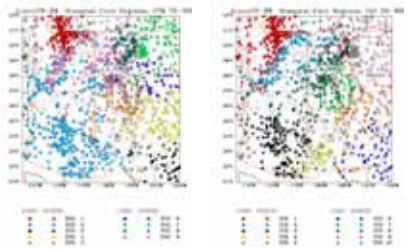
Can we get some of this 'climate puzzle' figured out before 'Global Change' alters everything?

The Trouble with Climate Divisions

Traditional Climate Divisions cover the U.S. unevenly, as one goes from east to west, and even from one state to another (Colorado vs. Wyoming!). Several statistical climate prediction schemes at CPC were originally based on climate divisions in the West.

January-March correlations between Climate Divisions and COOP (left)/ SNOTEL (right) precipitation values are lowest in the interior of the U.S., in particular along the spine of the Rockies (during one of the best seasons).
If we want to get away from looking at the predictive climate signal 'through coke-bottles', more coherent climate divisions can only help!

Can We Improve Upon Status Quo?

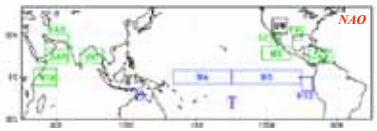


Improved seasonal **PREDICTANDS** based on COOP and SNOTEL station data were first developed in 2000-01, using multivariate techniques such as Cluster Analysis and Rotated Principal Components. The amount of color in each station symbol is proportional to locally explained variance via core index time series. Better predictands (higher signal-to-noise ratio) accomplish at least better down-scaled representation of ENSO associations.

Customized **PREDICTORS**: Regional SST in eastern Pacific and western Atlantic Ocean basins, preceding moisture history, and non-ENSO teleconnections (Indian Ocean!) - all had to have been established in previous analyses, or be 'intuitive'. Predictors were **not** optimized to **avoid overfitting**.

The prediction technique employed here is fairly old-fashioned: **stepwise linear regression** (SLR), with a 10% increase in explained variance requirement, and decadal cross-validation (poor man's ensembles; 6 sets of prediction equations).

Frequently Used (and Skillful) Predictor Regions



Robust PREDICTORS that show up repeatedly in these experimental seasonal precipitation forecast schemes (cross-validated WY'51-99 or verified WY'00-09 Heidke Skill Scores ≥30). Aside from '**flavors of ENSO**' (in blue), the **Indian Ocean** stands out with four important SST regions that show strong teleconnections with our predictands. **Nearby SST** may achieve skill by influencing regional moisture transports. The **NAO** plays a frequent role as well, possibly via altering North Atlantic SST.

A priori cross-validated skill

Bias-corrected ensemble (5 separate decades held out) Heidke skill scores (HSS) within the 1951-99 training period. Hindcasts are based on climate division predictands developed separately for four cardinal seasons (JFM - OND). Forecast equations frozen in 2003.

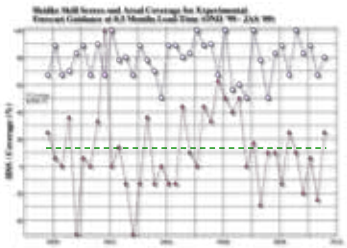
Season	<HSS>	Number of HSS ≥0.15/≥0.30	Highest HSS
JFM (9)	24	4 / 4	0.53 in NC CO
AMJ (9)	13	2 / 1	0.31 SE AZ-S NM
JAS(10)	16	5 / 0	0.28 in NE CO
OND (6)	17	4 / 0	0.28 in NM
All (34)	18	15 / 5	<Best / Worst>

One Decade of Seasonal Forecast Guidance

WY 2000-2009 verification skill

Heidke Skill Scores (HSS) calculated for ALL ensemble forecasts, and forecasts with ≥3% shifts at 0.5 month leads. Near-neutral forecasts had to have both extreme tercile probabilities suppressed to be counted.

Season	HSS ALL/3%	#0.15 (0.30)	Coverage (at 3%)
JFM (9)	5/ 7	3 (2)	93%
AMJ (9)	7/ 9	5 (3)	73%
JAS (10)	16/22	5 (5)	78%
OND (6)	5/ 9	3 (1)	70%
All (34)	8/12	16(11)	79%



Tercile verification HSS for tilts of at least 3% (red) as well as their areal coverage (purple) ensemble forecasts at 0.5 month lead-time for Water Years 2000-2009. Green stippled line indicates average skill score in last decade.

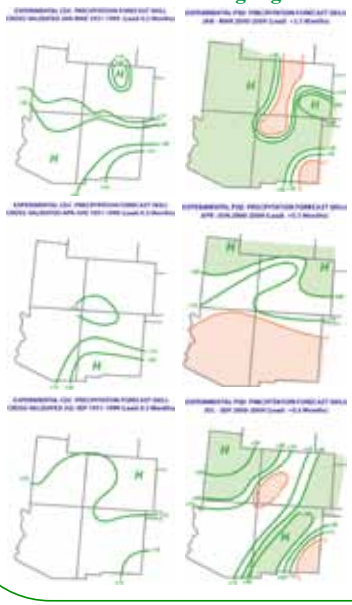
Full training period forecasts were inferior to **ensemble** forecasts in all seasons but Fall (OND).

Fall season has been the hardest season to predict, both in hindcast testing, as well as over last decade.

Increasing the probability shift requirement from 3% to 7% increases forecast skill only marginally, but drops almost half of the **areal coverage**, which is one of the main improvements over CPC forecast skill.

First year of public forecasting (**2002**) was literally a 'trial by fire' in Colorado, since forecast skills were so low in that record-wildfire year. Nevertheless, stakeholders understood that this was an experimental product, and were pleased that its low skill was transient.

Seasonal Highlights



Tercile cross-validated (left) and verification (right) skill in ensemble forecasts for **January-March**. This is the season with the clearest preference for a longer lead (**3.5 months**), with an average HSS=20. *Poor verification skill in NC Colorado!*

April-June: Highest *a priori* forecast skill region in southern NM has verified poorly since 2000, while a strip from northern UT into the NE panhandle stands out with HSS ≥ 30. This season is seasonably dry in AZ/NM compared to further north.

July-September: Most positive surprise: verification skill in UT and from southwestern NM to eastern CO has been much better than expected, while AZ, southeast NM, and southwest CO remain poorly predictable.

Conclusions

1. **Seasonal forecast skill for the interior southwestern U.S. appears to be linked not only to ENSO, but also to select other SST regions (Upstream + Indian Ocean). In fact, predictive skill in the ENSO context appears associated with 'flavors of ENSO' rather than mainstream ENSO indices such as Niño 3.4 ('ONI') SST.**

2. **Cross-validated hindcast skill is largest in winter, and lowest in spring, consistent with CPC's experience. However, fully independent verification for the last decade has revealed some surprises: low skill at 0.5 month lead-time for the winter, but much better at 3.5 months; best overall skill during the monsoon season. All seasons feature at least some regions with high verified skill (HSS≥30).**

3. **Except for fall, bias-corrected ensemble forecasts outperformed full training period regression forecasts. Filtering out forecast tilts under 7% increases overall skill only marginally, while dropping more than 40% of the coverage achieved with a 3% tilt requirement. Many, but not all 0.5 lead-time forecasts outperform forecasts issued earlier.**

4. **National new climate divisions have been developed, and could be tested in a much wider geographical range of prediction experiments, such as California and the Western U.S. in general. Meanwhile, current forecast guidance can be found at:** ***http://www.esrl.noaa.gov/people/klaus.wolter/SWcasts/***

   and new national climate divisions at: ***http://www. esrl.noaa.gov/people/klaus.wolter/ClimateDivisions/***