A CONSOLIDATED CLIPER MODEL FOR IMPROVED AUGUST-SEPTEMBER ENSO PREDICTION SKILL 1950-2002

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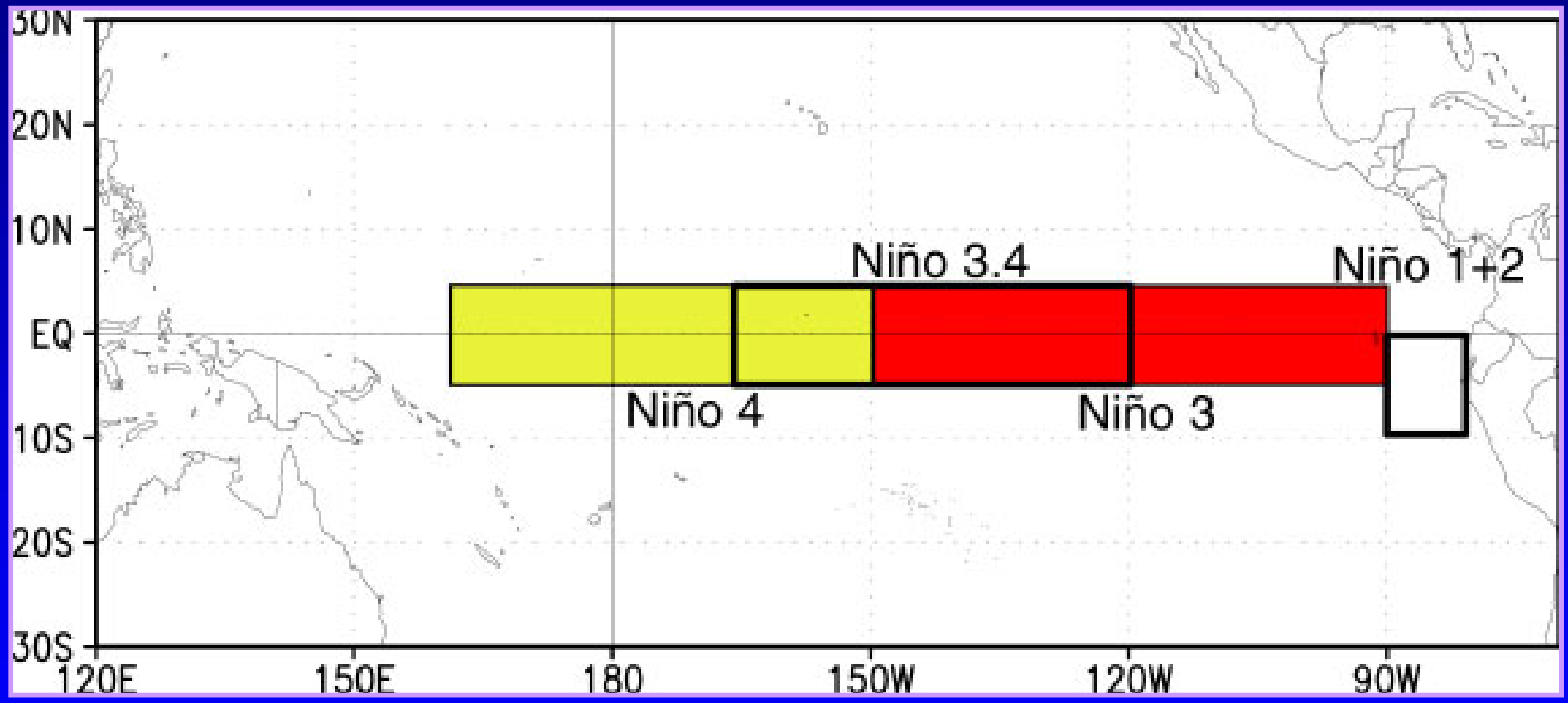
August-September ENSO Relevance

- A prime challenge for ENSO seasonal forecast models is to predict boreal summer ENSO conditions at lead.
- August-September ENSO has a strong influence on Atlantic hurricane activity, Northwest Pacific typhoon activity and tropical precipitation.
- However, summer ENSO skill is low due to the spring predictability barrier during March-May.

What Have We Done

- The **ENSO-CLIPER** statistical prediction model (*Knaff and Landsea, 1997*) is arguably one of the more successful ENSO seasonal forecast models to date.
- We have developed a **'Consolidated' CLIPER** model built from the mean of 18 CLIPER models each constructed with a different formulation.
- Rigorous hindcasts 1950-2002 show that the **'Consolidated' CLIPER outperforms the standard CLIPER by 10-20%** at all leads from 2 to 6 months for all the main ENSO indices.

Standard Niño Index Regions



Niño 3.4 region is linked to Atlantic Hurricane activity
Niño 4 region is linked to Northwest Pacific typhoon activity

Standard ENSO-CLIPER Predictor Pools

Predictor Number	Predictand			
	Niño 3.4	Niño 3	Niño 4	Niño 1+2
1	Niño 3.4 IC-1	Niño 3 IC-1	Niño 4 IC-1	Niño 1+2 IC-1
2	Niño 3.4 IC-3	Niño 3 IC-3	Niño 4 IC-3	Niño 1+2 IC-3
3	Niño 3.4 IC-5	Niño 3 IC-5	Niño 4 IC-5	Niño 1+2 IC-5
4	Niño 3.4 TR-1	Niño 3 TR-1	Niño 4 TR-1	Niño 1+2 TR-1
5	Niño 3.4 TR-3	Niño 3 TR-3	Niño 4 TR-3	Niño 1+2 TR-3
6	Niño 3.4 TR-5	Niño 3 TR-5	Niño 4 TR-5	Niño 1+2 TR-5
7	Niño 1+2 IC-3	Niño 1+2 IC-3	Niño 1+2 IC-3	Niño 3 IC-3
8	Niño 1+2 TR-3	Niño 1+2 TR-3	Niño 1+2 TR-3	Niño 3 TR-3
9	Niño 3 IC-3	Niño 3 IC-3	Niño 3 IC-3	Niño 4 IC-3
10	Niño 3 TR-3	Niño 3 TR-3	Niño 3 TR-3	Niño 4 TR-3
11	Niño 4 IC-3	Niño 3.4 IC-3	Niño 3.4 IC-3	Niño 3.4 IC-3
12	Niño 4 TR-3	Niño 3.4 TR-3	Niño 3.4 TR-3	Niño 3.4 TR-3
13	SOI IC-3	SOI IC-3	SOI IC-3	SOI IC-3
14	SOI TR-3	SOI TR-3	SOI TR-3	SOI TR-3

Skill Score and Uncertainty

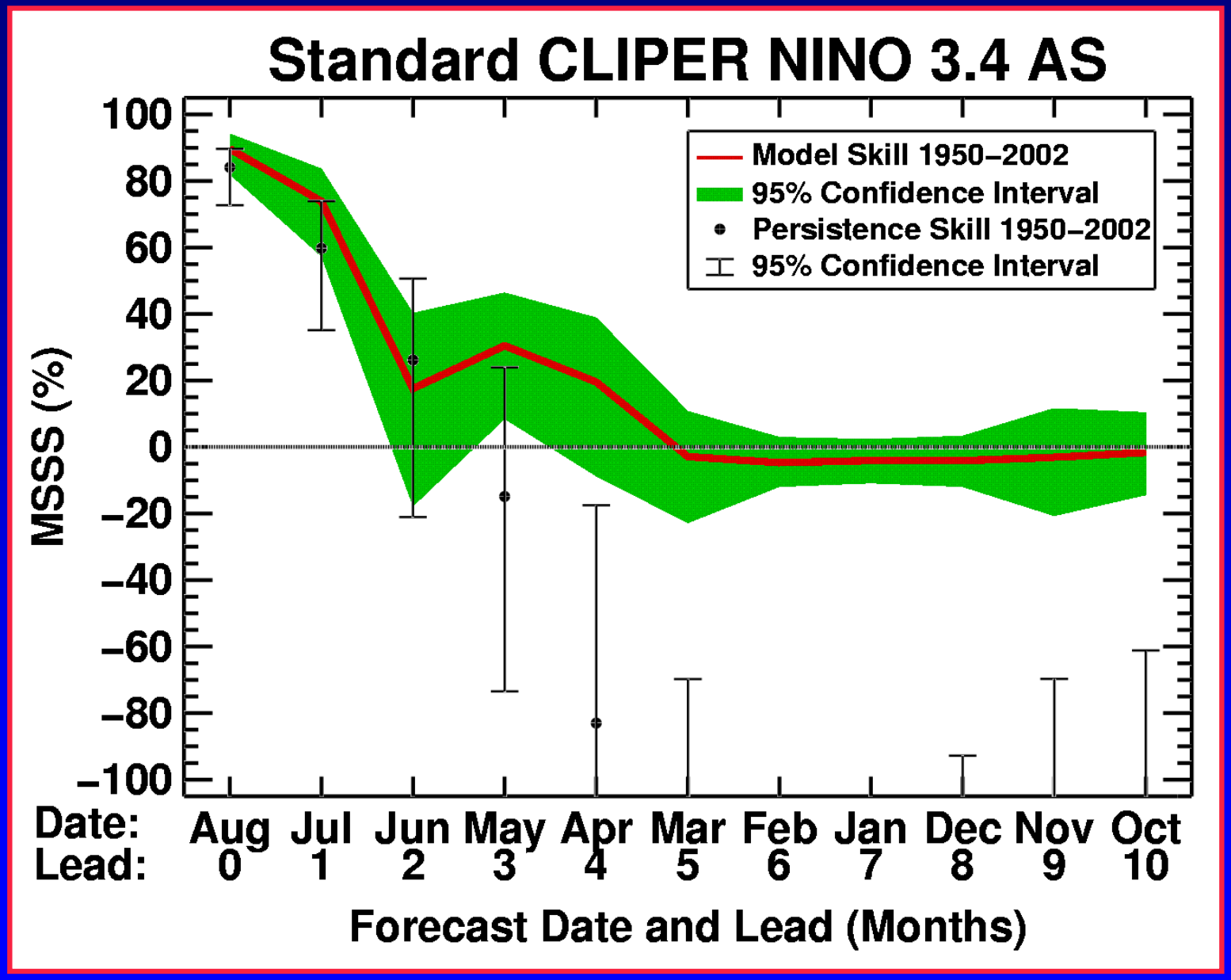
- Employ the mean square skill score (MSSS) defined as the percentage reduction in mean square error over a climatological forecast:

$$MSSS\ (\%) = (1 - MSE_{Fore}/MSE_{Clim}) \times 100$$

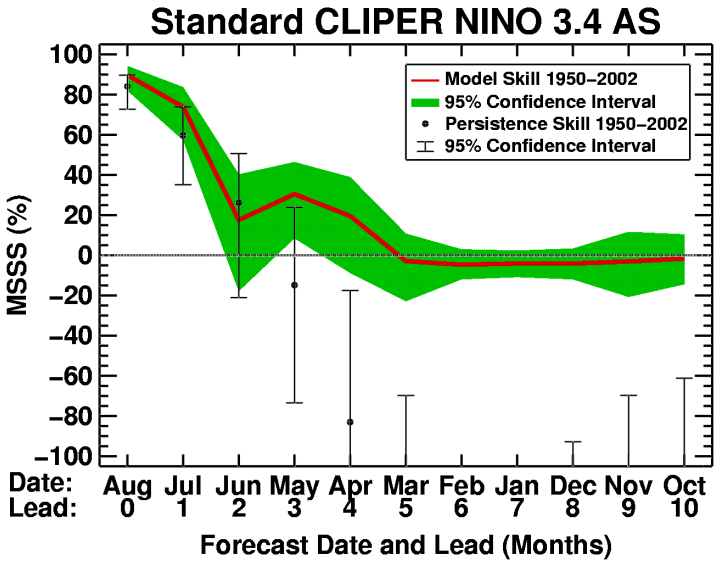
This is the standard skill score recommended by the World Meteorological Organisation (2002) for the verification of deterministic seasonal forecasts.

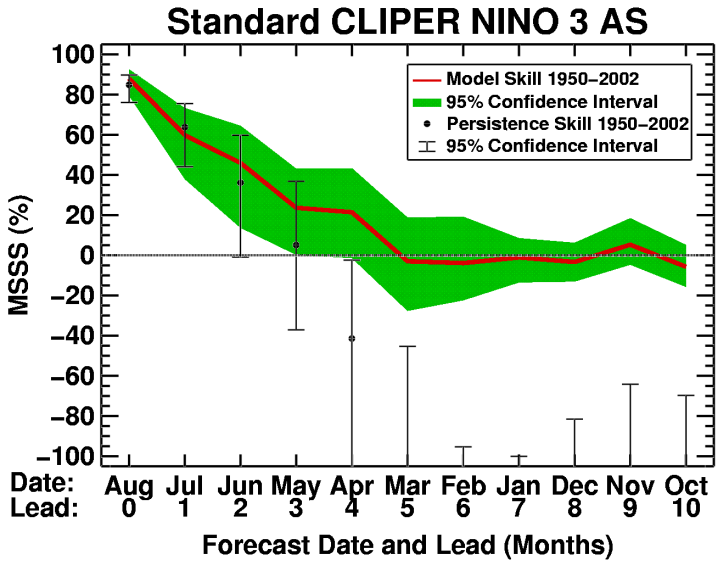
- Employ the standard bootstrap method with replacement to compute the 95% confidence interval on skill.

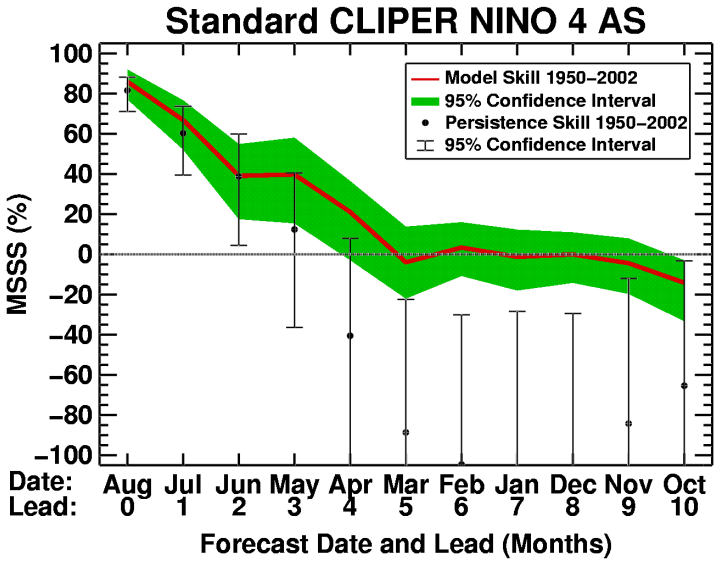
Cross-Validated CLIPER Skill

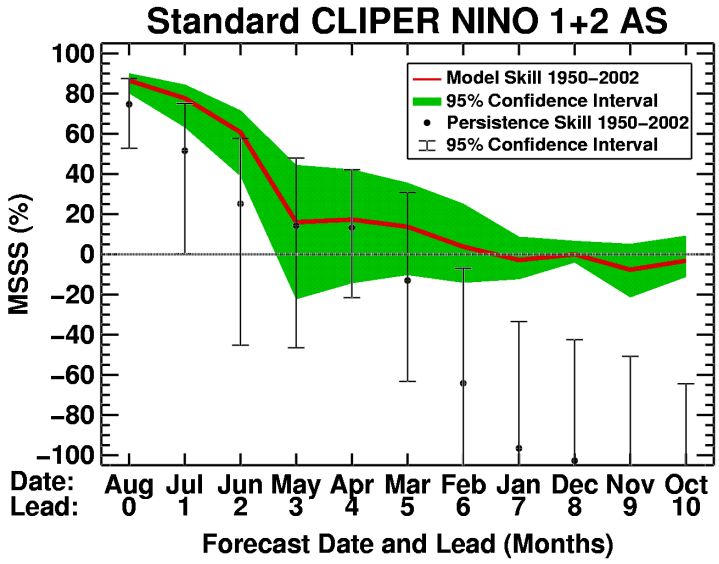


Cross-Validated CLIPER Skill

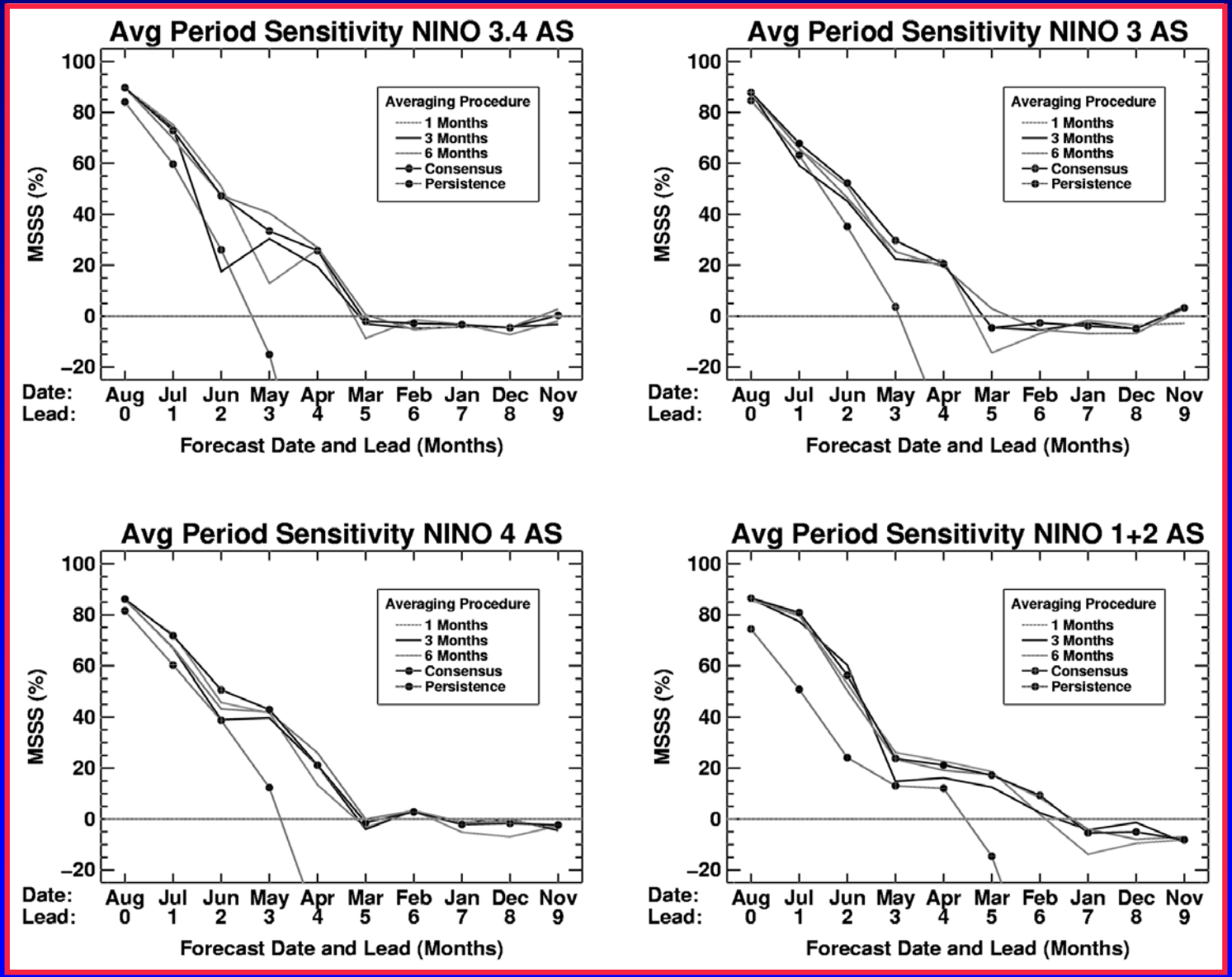




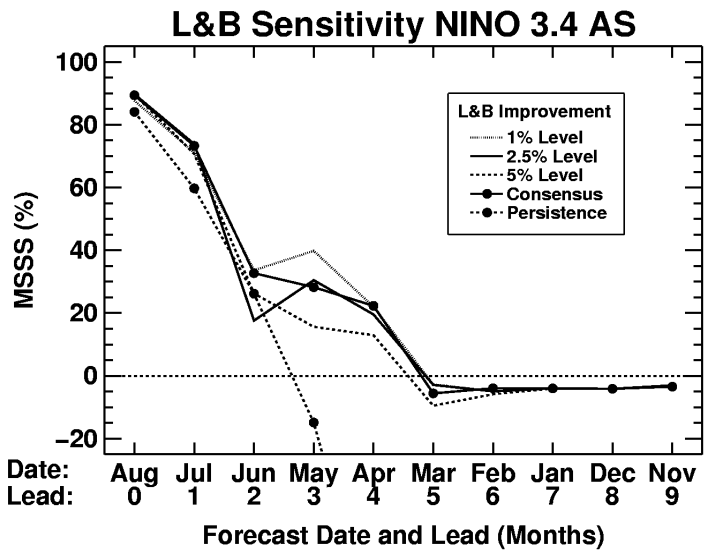


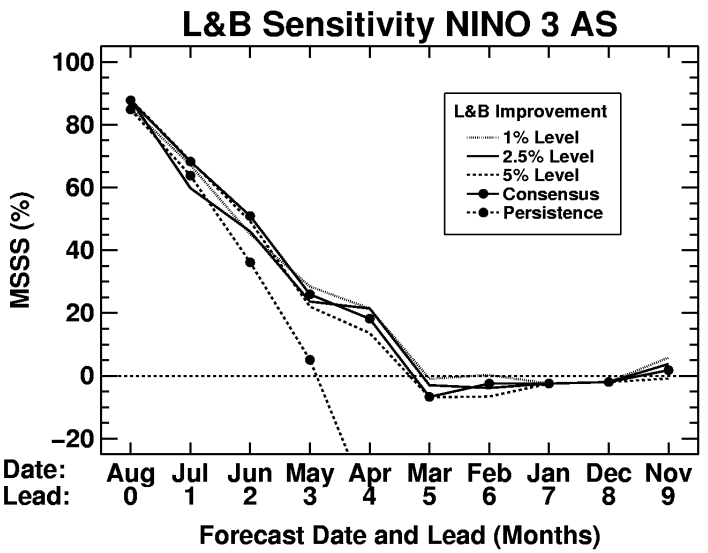


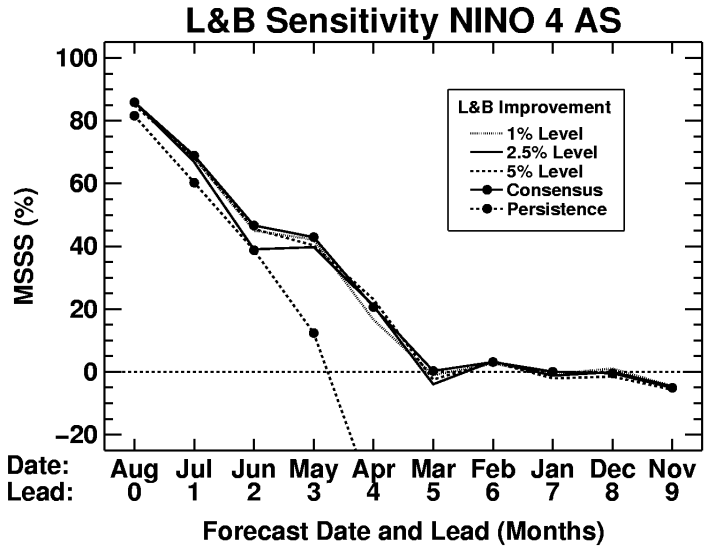
Skill Sensitivity Factor 1

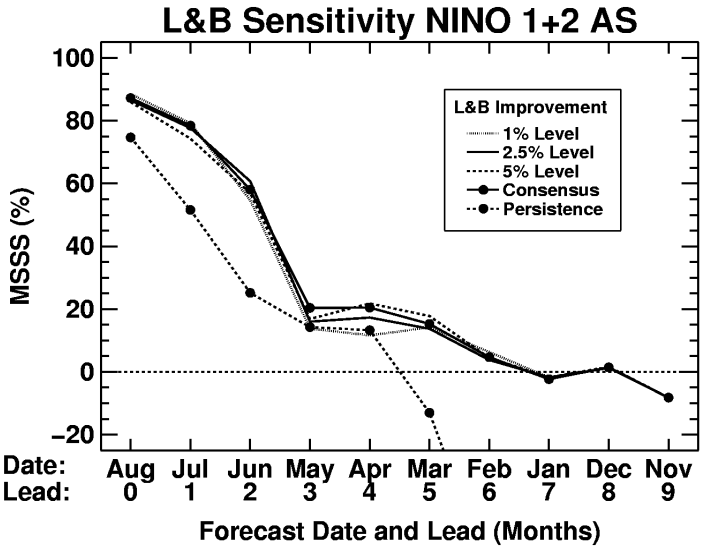


Skill Sensitivity Factor 2

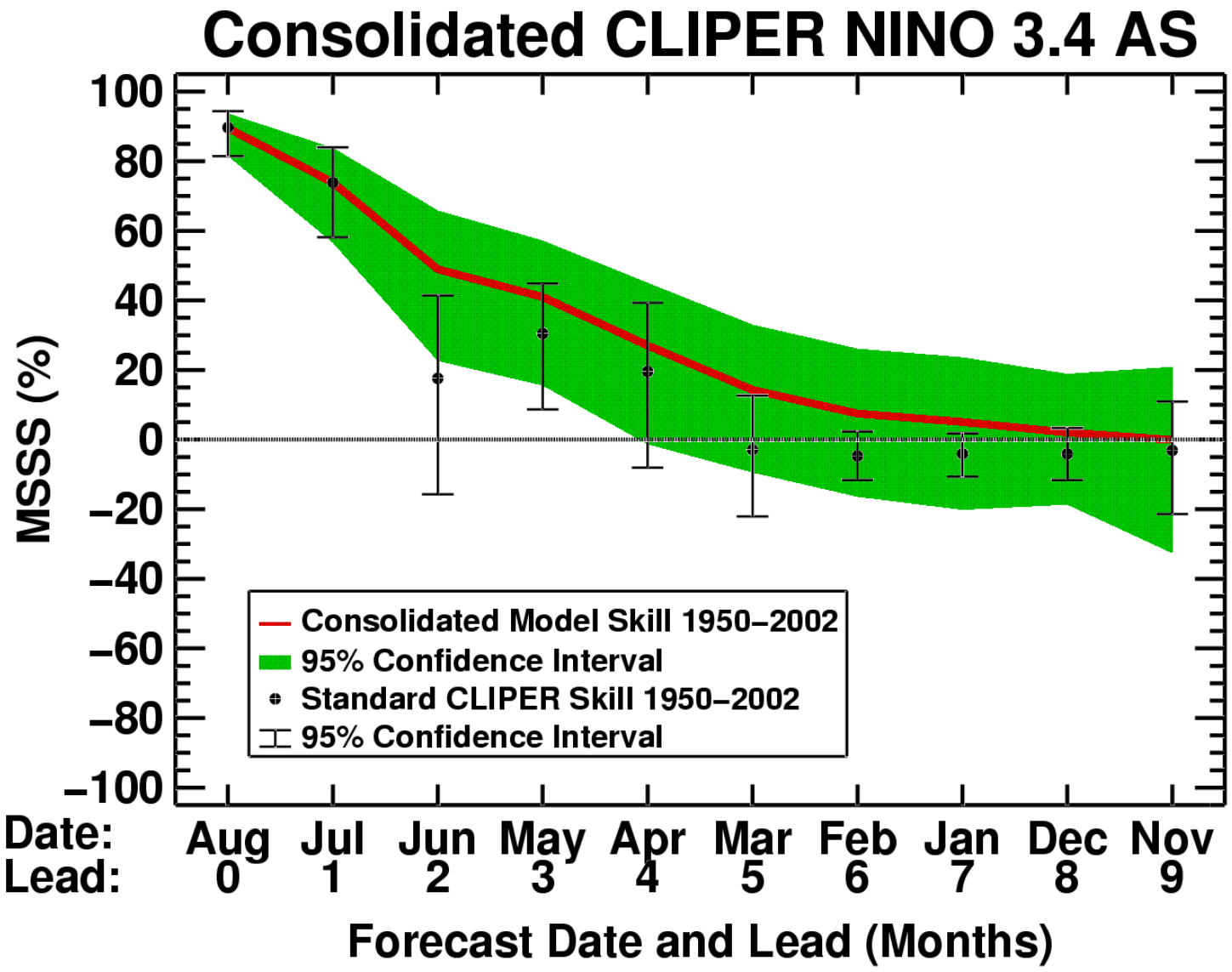




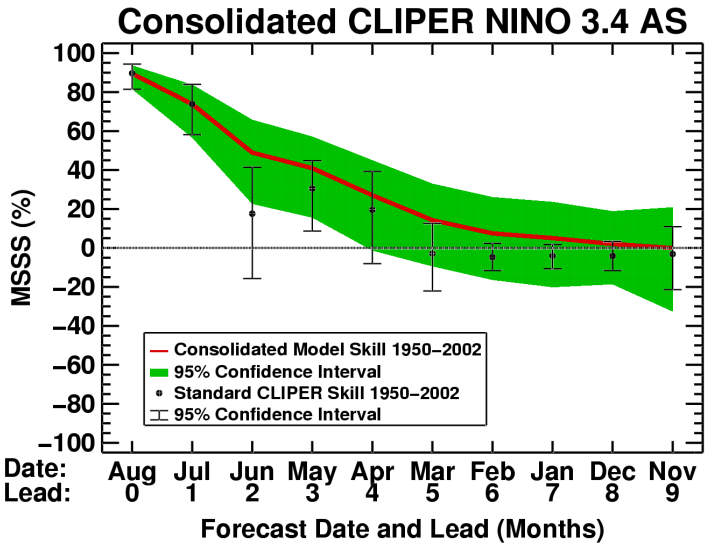


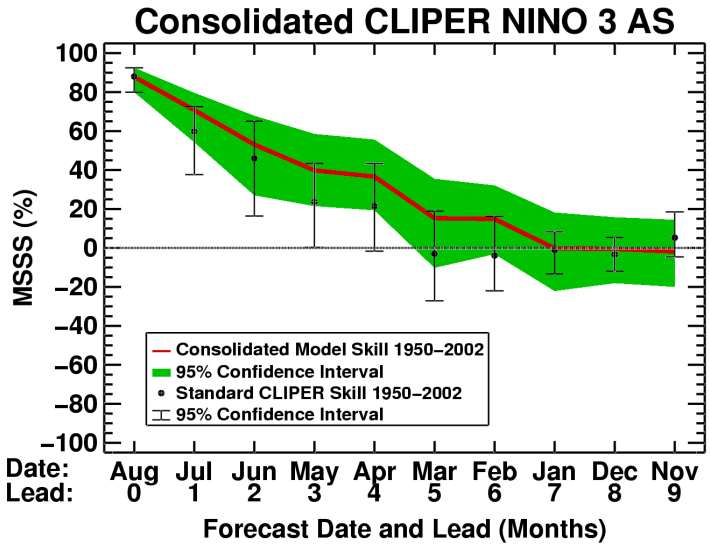


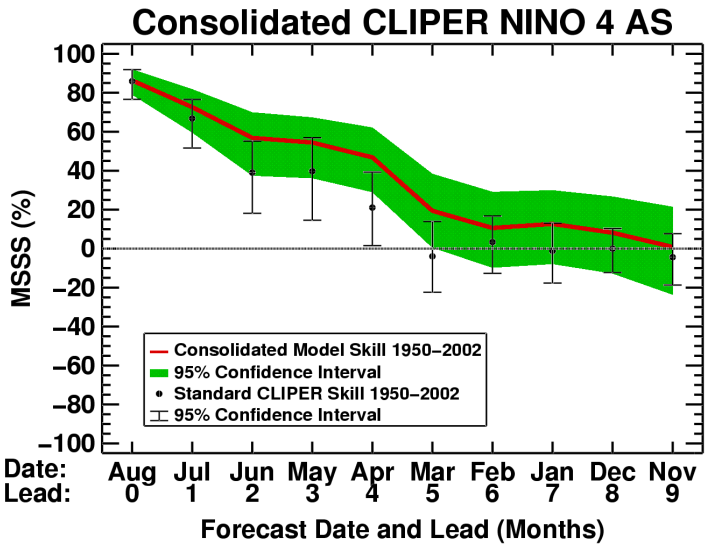
Consolidated CLIPER Skill

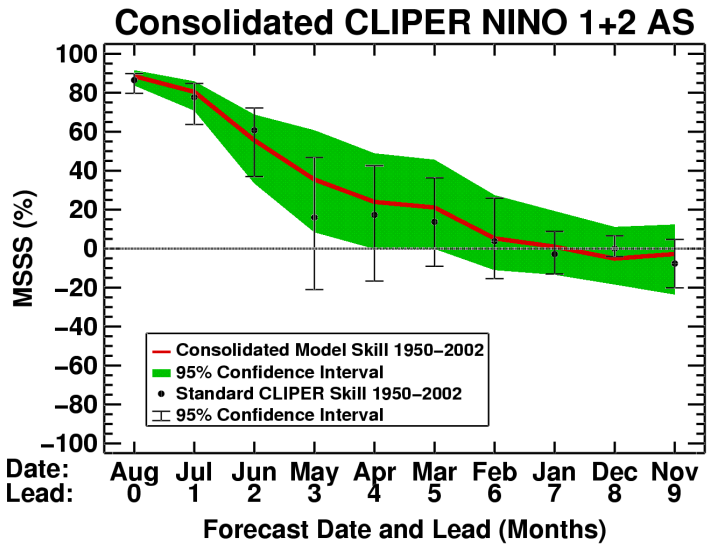


Consolidated CLIPER Skill









Improvement of Consolidated Model over the Standard CLIPER

Niño Index	Lead (months)						
	0	1	2	3	4	5	6
3.4	0 (0)	0 (0)	31 (19)	10 (6)	7 (4)	17 (8)	12 (6)
3	0 (0)	11 (9)	7 (5)	16 (10)	15 (9)	18 (9)	18 (9)
4	0 (0)	6 (5)	18 (12)	15 (10)	26 (16)	23 (12)	7 (4)
1+2	2 (3)	2 (3)	-5 (-4)	19 (11)	7 (4)	7 (4)	1 (1)

Absolute percentage improvement in *MSSS* (*RMSSS*) of the consolidated ENSO-CLIPER model over the standard ENSO-CLIPER model for predicting August-September Niño 3.4, 3, 4 and 1+2 for the period 1950-2002 as a function of monthly lead.

Future Developments

1. **Consolidated Model Optimisation.**

   Optimisation of the consolidated model may lead to further skill improvements. The current consolidated model represents a small subset of possible CLIPER formulations.

2. **Extension to Other Seasons and DEMETER Comparison.**

   Ongoing research will extend the consolidated ENSO-CLIPER results to other seasons and will compare hindcast skill and model versatility to that achieved by leading dynamical ENSO prediction models.

Summary

- The 'Consolidated' CLIPER model offers a 10-20% absolute *MSSS* improvement over the standard CLIPER model for predicting August-September ENSO 1950-2002 at all leads from 2 to 6 months for all the main ENSO indices (3, 3.4 and 4).

- The 'Consolidated' CLIPER model Aug-Sept skill 1950-2002 is positive to 95% confidence at leads out to early April (early March for Niño 4).

- Optimisation of the Consolidated CLIPER model may lead to further skill improvements.