

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.

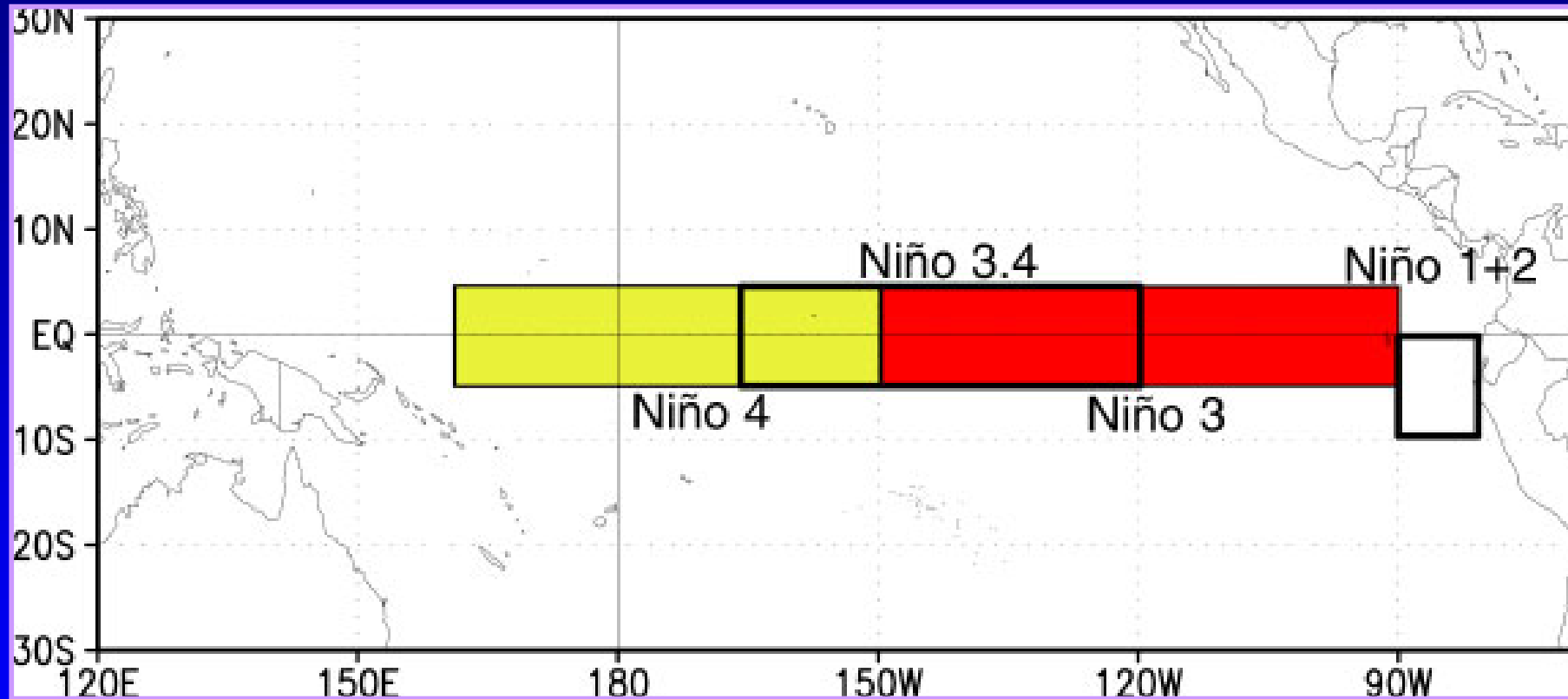


What Have We Done

- 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:

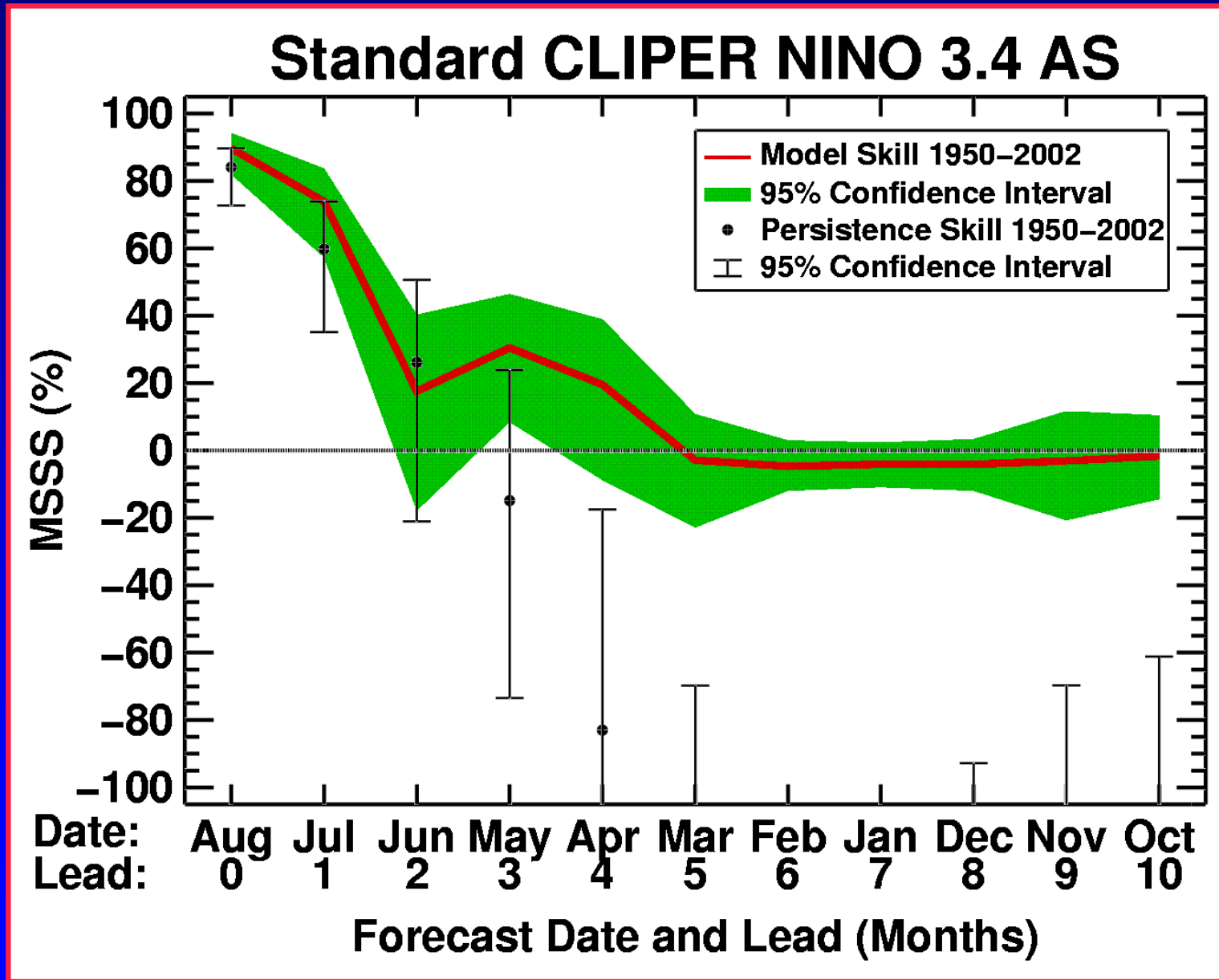
$$\text{MSSS (\%)} = (1 - \text{MSE}_{\text{Fore}}/\text{MSE}_{\text{Clim}}) \times 100$$

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.

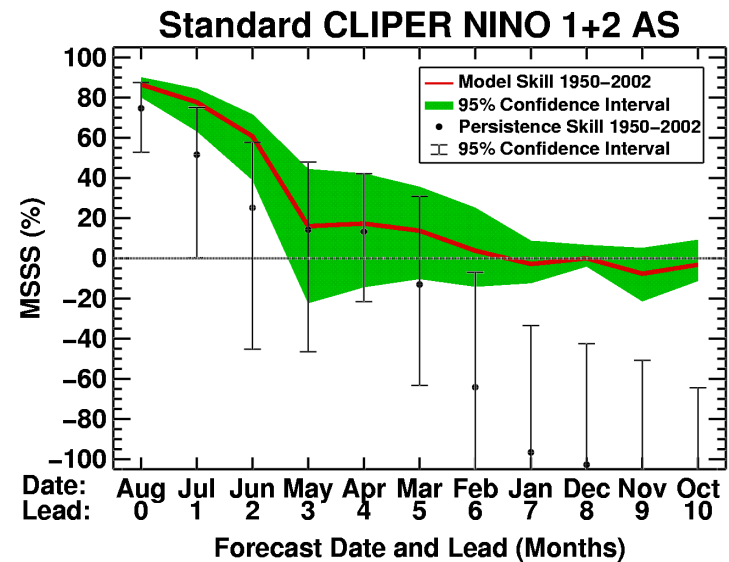
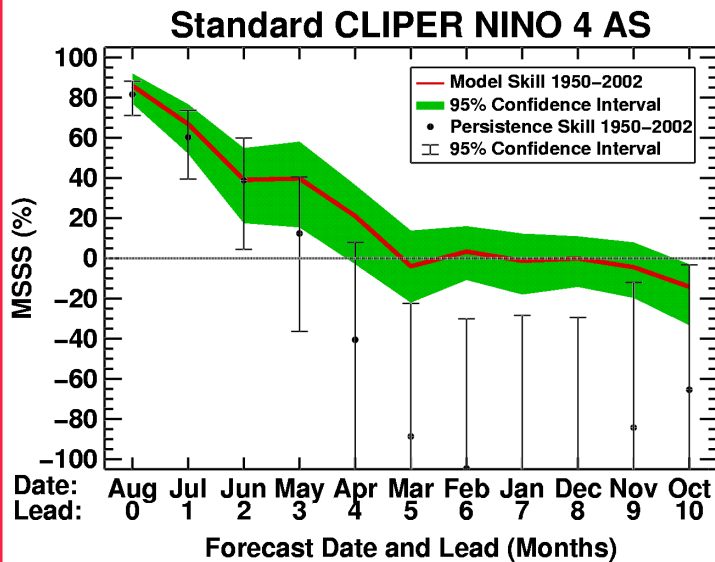
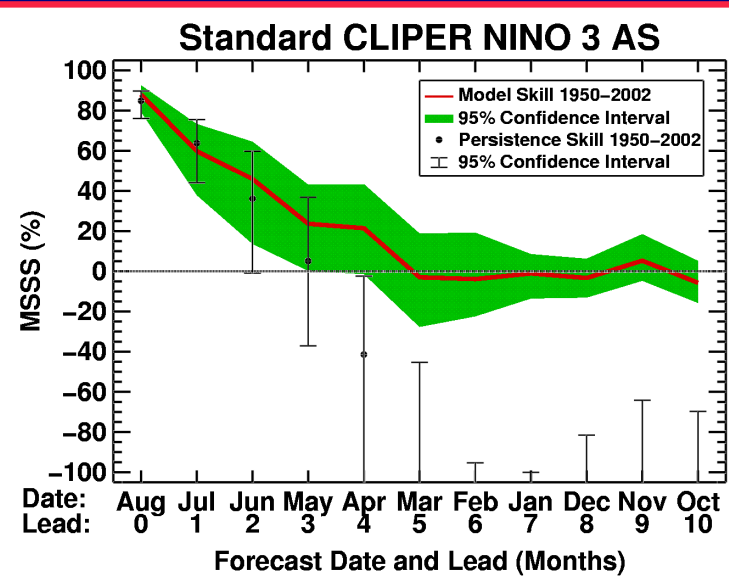
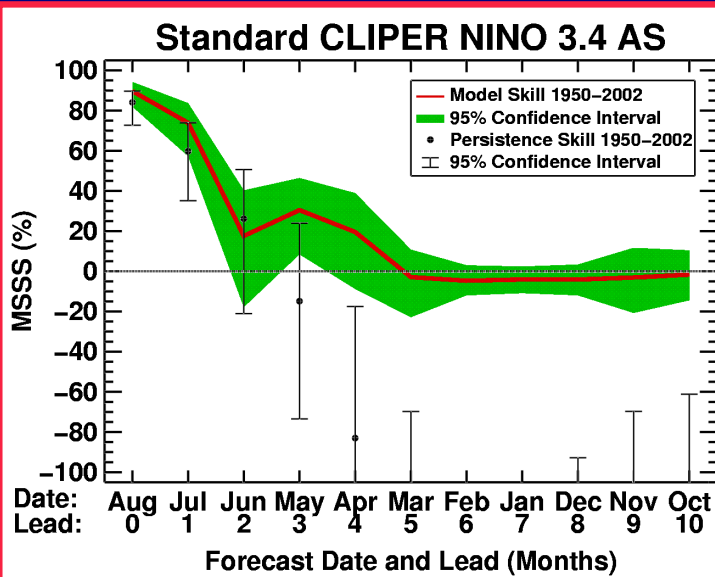


Cross-Validated CLIPER Skill



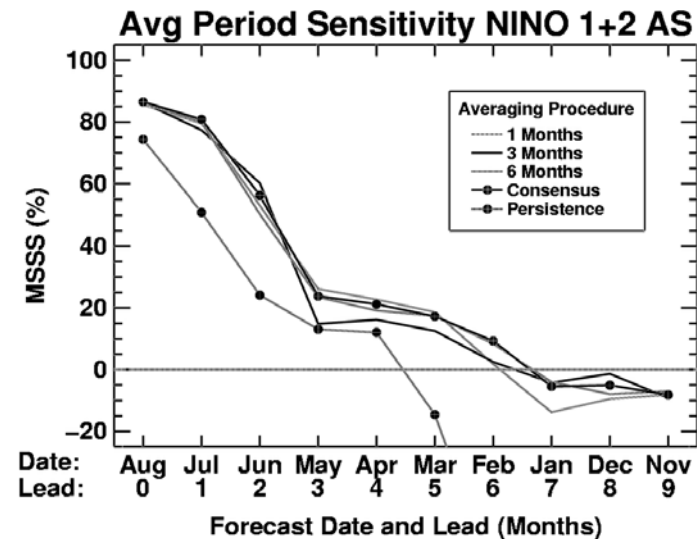
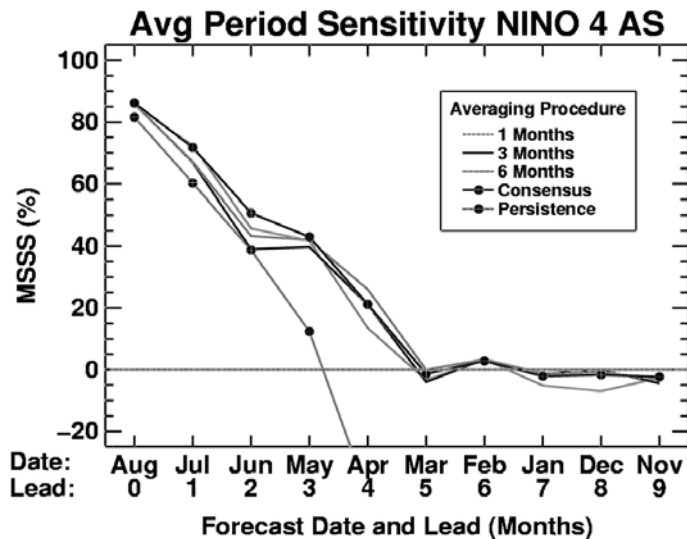
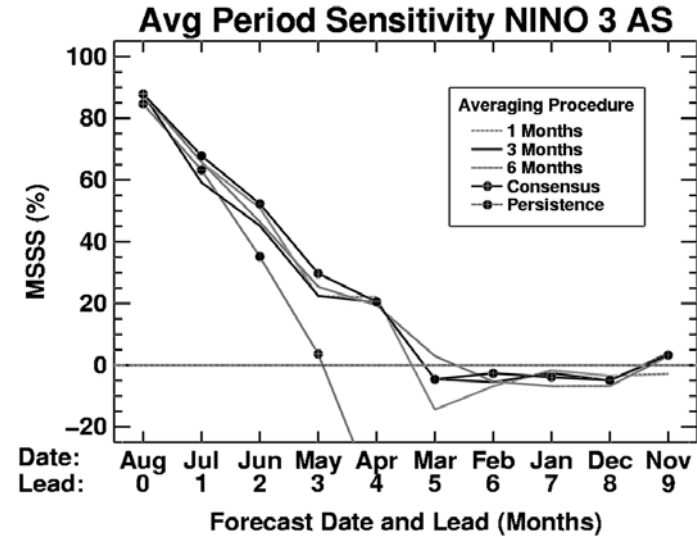
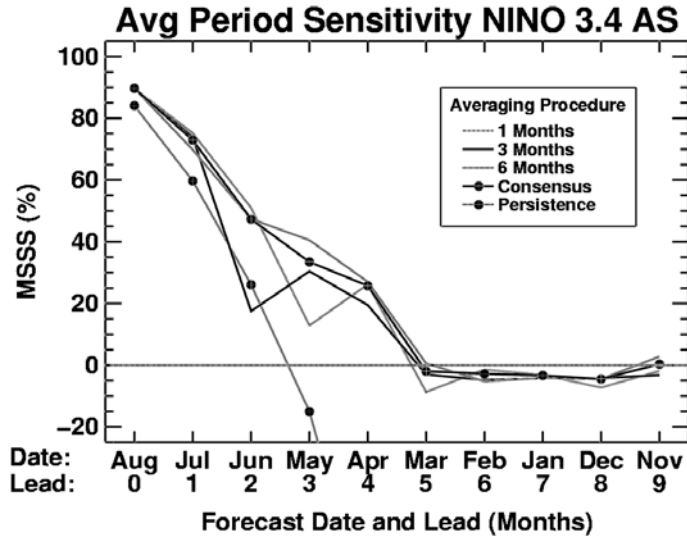


Cross-Validated CLIPER Skill



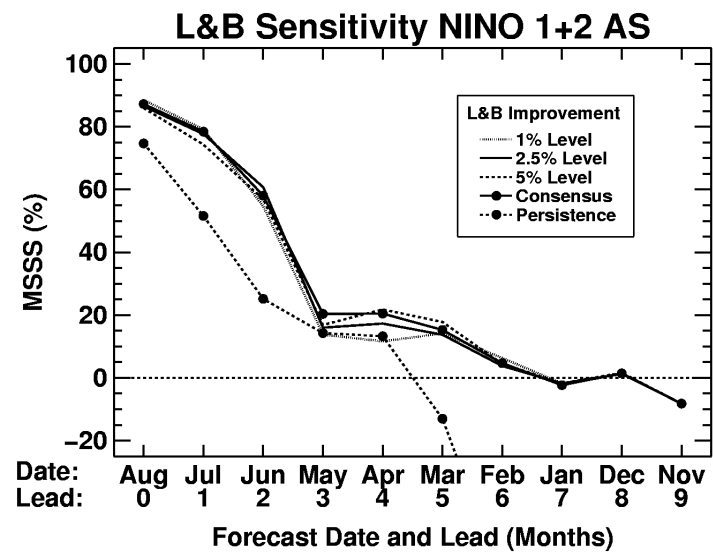
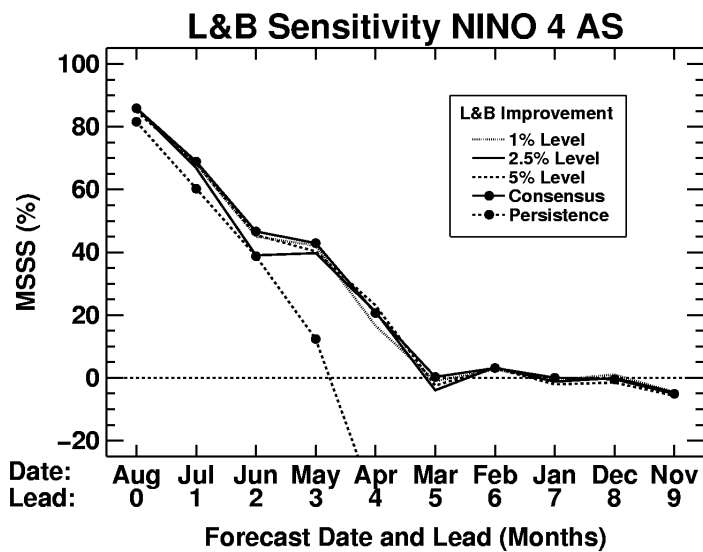
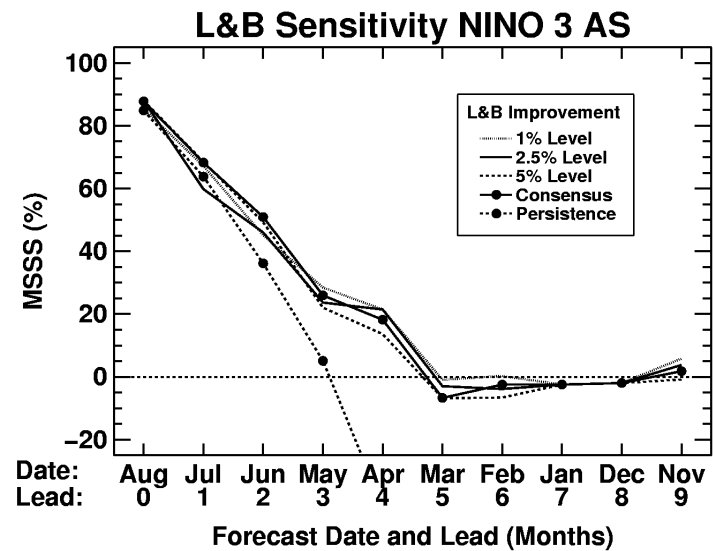
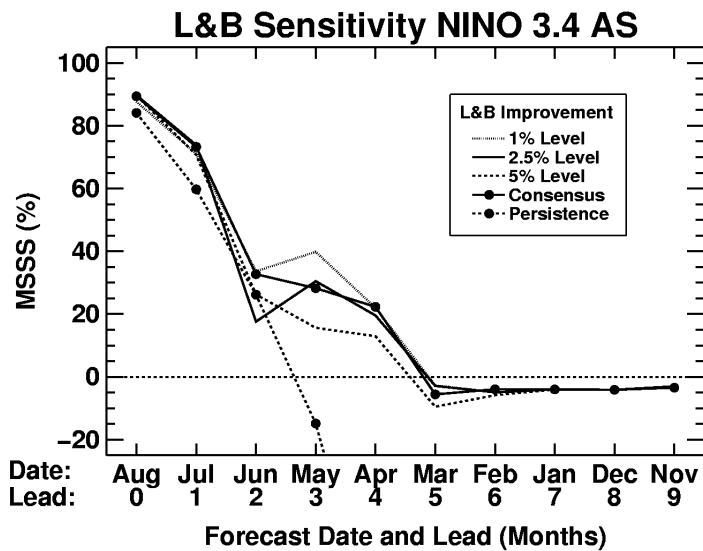


Skill Sensitivity Factor 1



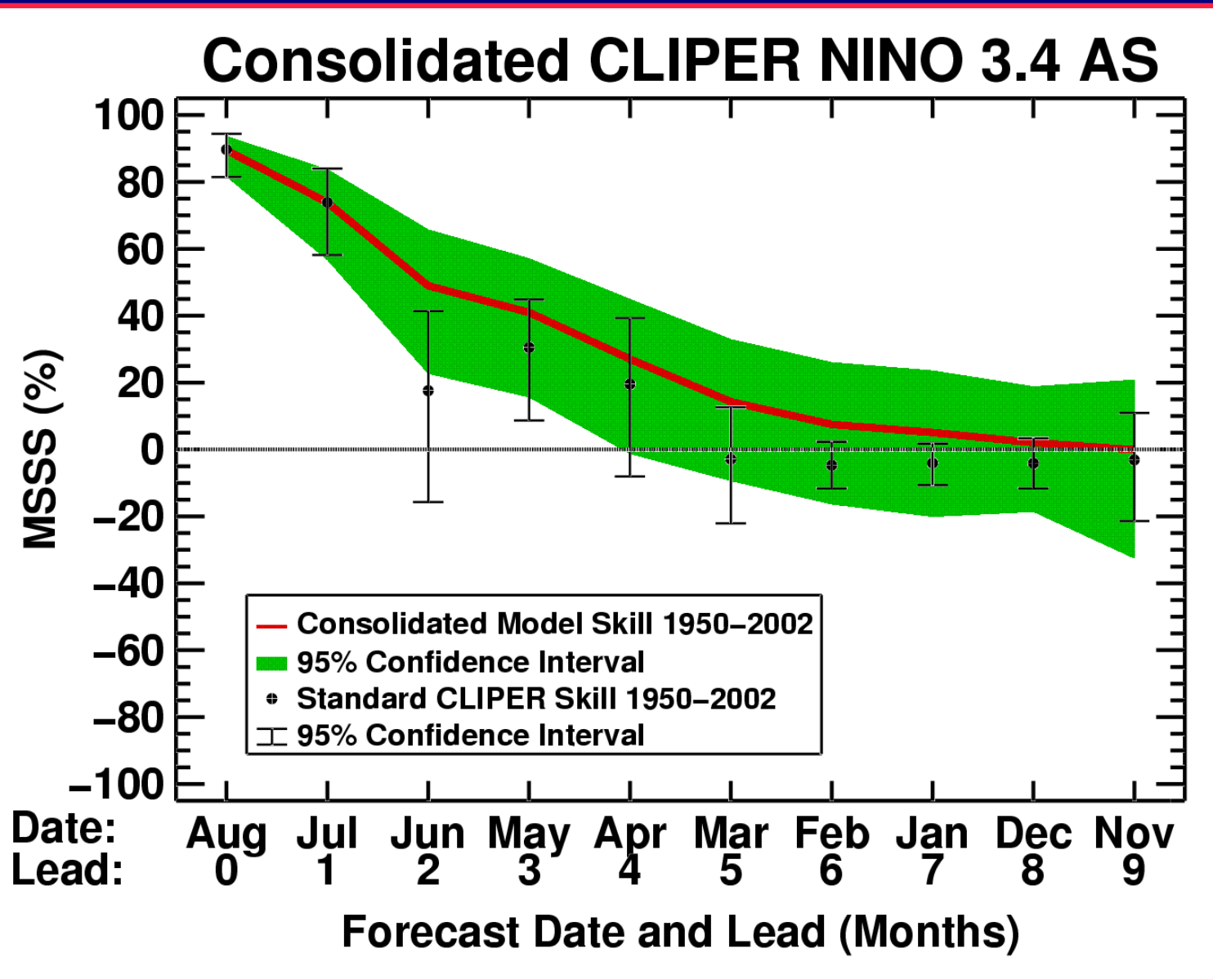


Skill Sensitivity Factor 2



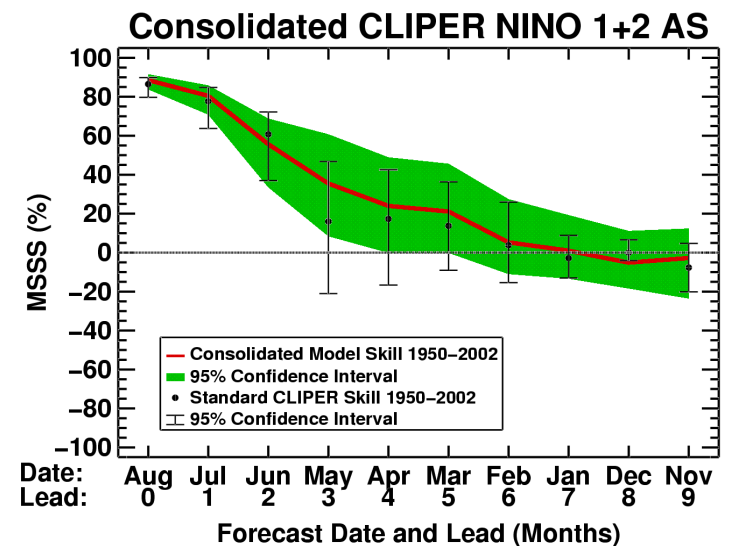
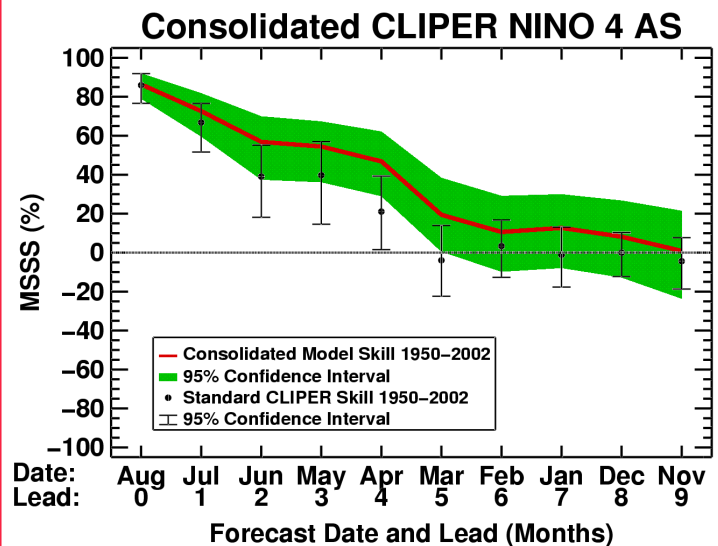
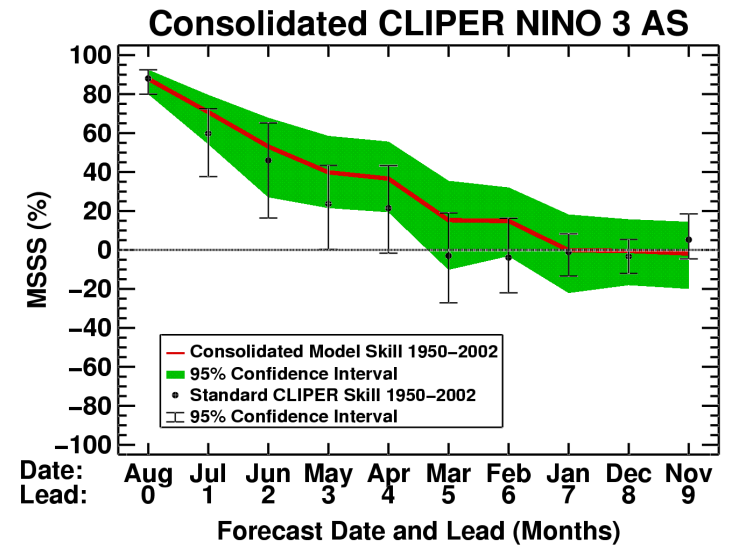
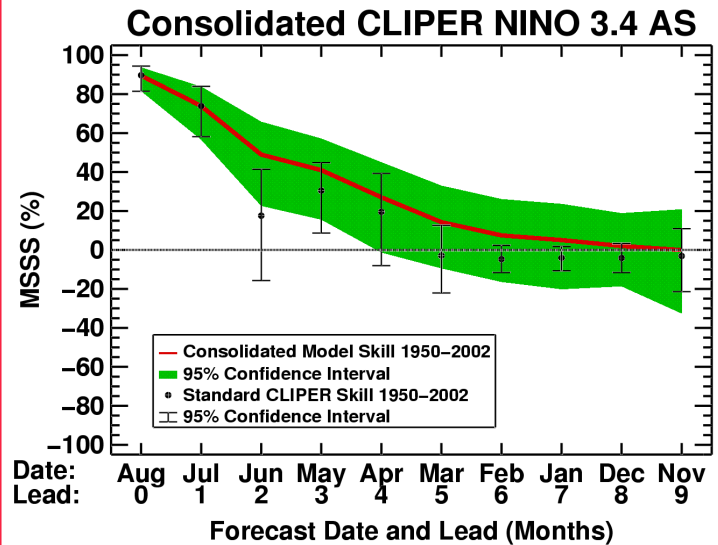


Consolidated CLIPER Skill





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.**