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

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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

<table>
<thead>
<tr>
<th>Predictor Number</th>
<th>Niño 3.4</th>
<th>Niño 3</th>
<th>Niño 4</th>
<th>Niño 1+2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Niño 3.4 IC-1</td>
<td>Niño 3 IC-1</td>
<td>Niño 4 IC-1</td>
<td>Niño 1+2 IC-1</td>
</tr>
<tr>
<td>2</td>
<td>Niño 3.4 IC-3</td>
<td>Niño 3 IC-3</td>
<td>Niño 4 IC-3</td>
<td>Niño 1+2 IC-3</td>
</tr>
<tr>
<td>3</td>
<td>Niño 3.4 IC-5</td>
<td>Niño 3 IC-5</td>
<td>Niño 4 IC-5</td>
<td>Niño 1+2 IC-5</td>
</tr>
<tr>
<td>4</td>
<td>Niño 3.4 TR-1</td>
<td>Niño 3 TR-1</td>
<td>Niño 4 TR-1</td>
<td>Niño 1+2 TR-1</td>
</tr>
<tr>
<td>5</td>
<td>Niño 3.4 TR-3</td>
<td>Niño 3 TR-3</td>
<td>Niño 4 TR-3</td>
<td>Niño 1+2 TR-3</td>
</tr>
<tr>
<td>6</td>
<td>Niño 3.4 TR-5</td>
<td>Niño 3 TR-5</td>
<td>Niño 4 TR-5</td>
<td>Niño 1+2 TR-5</td>
</tr>
<tr>
<td>7</td>
<td>Niño 1+2 IC-3</td>
<td>Niño 1+2 IC-3</td>
<td>Niño 1+2 IC-3</td>
<td>Niño 3 IC-3</td>
</tr>
<tr>
<td>8</td>
<td>Niño 1+2 TR-3</td>
<td>Niño 1+2 TR-3</td>
<td>Niño 1+2 TR-3</td>
<td>Niño 3 TR-3</td>
</tr>
<tr>
<td>9</td>
<td>Niño 3 IC-3</td>
<td>Niño 3 IC-3</td>
<td>Niño 3 IC-3</td>
<td>Niño 4 IC-3</td>
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<td>10</td>
<td>Niño 3 TR-3</td>
<td>Niño 3 TR-3</td>
<td>Niño 3 TR-3</td>
<td>Niño 4 TR-3</td>
</tr>
<tr>
<td>11</td>
<td>Niño 4 IC-3</td>
<td>Niño 3.4 IC-3</td>
<td>Niño 3.4 IC-3</td>
<td>Niño 3.4 IC-3</td>
</tr>
<tr>
<td>12</td>
<td>Niño 4 TR-3</td>
<td>Niño 3.4 TR-3</td>
<td>Niño 3.4 TR-3</td>
<td>Niño 3.4 TR-3</td>
</tr>
<tr>
<td>13</td>
<td>SOI IC-3</td>
<td>SOI IC-3</td>
<td>SOI IC-3</td>
<td>SOI IC-3</td>
</tr>
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<td>14</td>
<td>SOI TR-3</td>
<td>SOI TR-3</td>
<td>SOI TR-3</td>
<td>SOI TR-3</td>
</tr>
</tbody>
</table>
Skill Score and Uncertainty

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

\[
\text{MSSS} (\%) = (1 - \frac{\text{MSE}_{\text{Fore}}}{\text{MSE}_{\text{Clim}}}) \times 100
\]

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

Standard CLIPER NINO 3.4 AS

- Red line: Model Skill 1950–2002
- Green area: 95% Confidence Interval
- Black dots: Persistence Skill 1950–2002
- Black dashed line: 95% Confidence Interval

MSSS (%) vs. Date (Aug-Oct) and Lead (0-10 months)

Forecast Date and Lead (Months)
Cross-Validated CLIPER Skill

Cross-Validated CLIPER Skill

Standard CLIPER NINO 3.4 AS

Date: Lead: Aug Jul Jun May Apr Mar Feb Jan Dec Nov Oct
Forecast Date and Lead (Months)

MSSS (%) 100 80 60 40 20 0 20 40 60 80 100

Model Skill 1950–2002
95% Confidence Interval
Persistence Skill 1950–2002
95% Confidence Interval

Standard CLIPER NINO 3 AS

Date: Lead: Aug Jul Jun May Apr Mar Feb Jan Dec Nov Oct
Forecast Date and Lead (Months)

MSSS (%) 100 80 60 40 20 0 20 40 60 80 100

Model Skill 1950–2002
95% Confidence Interval
Persistence Skill 1950–2002
95% Confidence Interval

Standard CLIPER NINO 4 AS

Date: Lead: Aug Jul Jun May Apr Mar Feb Jan Dec Nov Oct
Forecast Date and Lead (Months)

MSSS (%) 100 80 60 40 20 0 20 40 60 80 100

Model Skill 1950–2002
95% Confidence Interval
Persistence Skill 1950–2002
95% Confidence Interval

Standard CLIPER NINO 1+2 AS

Date: Lead: Aug Jul Jun May Apr Mar Feb Jan Dec Nov Oct
Forecast Date and Lead (Months)

MSSS (%) 100 80 60 40 20 0 20 40 60 80 100

Model Skill 1950–2002
95% Confidence Interval
Persistence Skill 1950–2002
95% Confidence Interval
Skill Sensitivity Factor 1

Avg Period Sensitivity NINO 3.4 AS

Avg Period Sensitivity NINO 3 AS

Avg Period Sensitivity NINO 4 AS

Avg Period Sensitivity NINO 1+2 AS
Skill Sensitivity Factor 2

L&B Sensitivity NINO 3.4 AS

L&B Sensitivity NINO 3 AS

L&B Sensitivity NINO 4 AS

L&B Sensitivity NINO 1+2 AS
Consolidated CLIPER Skill

Consolidated CLIPER NINO 3.4 AS

MSSS (%)

Date: Lead: Aug 0 Jul 1 Jun 2 May 3 Apr 4 Mar 5 Feb 6 Jan 7 Dec 8 Nov 9

Forecast Date and Lead (Months)

- Consolidated Model Skill 1950–2002
- 95% Confidence Interval
- Standard CLIPER Skill 1950–2002
- 95% Confidence Interval
### Improvement of Consolidated Model over the Standard CLIPER Model

#### 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.

<table>
<thead>
<tr>
<th>Niño Index</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>31 (19)</td>
<td>10 (6)</td>
<td>7 (4)</td>
<td>17 (8)</td>
<td>12 (6)</td>
</tr>
<tr>
<td>3</td>
<td>0 (0)</td>
<td>11 (9)</td>
<td>7 (5)</td>
<td>16 (10)</td>
<td>15 (9)</td>
<td>18 (9)</td>
<td>18 (9)</td>
</tr>
<tr>
<td>4</td>
<td>0 (0)</td>
<td>6 (5)</td>
<td>18 (12)</td>
<td>15 (10)</td>
<td>26 (16)</td>
<td>23 (12)</td>
<td>7 (4)</td>
</tr>
<tr>
<td>1+2</td>
<td>2 (3)</td>
<td>2 (3)</td>
<td>-5 (-4)</td>
<td>19 (11)</td>
<td>7 (4)</td>
<td>7 (4)</td>
<td>1 (1)</td>
</tr>
</tbody>
</table>
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.