Detection of a weakening Southern Ocean carbon sink

Nikki Lovenduski
University of Colorado Boulder

Thanks to
Galen McKinley and Amanda Fay
University of Wisconsin - Madison
Corroborating model results

<table>
<thead>
<tr>
<th>Model</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bern3D</td>
<td>Tschumi et al. 2008</td>
</tr>
<tr>
<td>CCSM/CESM</td>
<td>Lovenduski et al. 2007 Wang and Moore 2012 Lovenduski et al. 2013</td>
</tr>
<tr>
<td>CSIRO</td>
<td>Lenton et al. 2007</td>
</tr>
<tr>
<td>IPSL</td>
<td>LeQuéré et al. 2007 Lenton et al. 2009</td>
</tr>
<tr>
<td>LOVECLIM</td>
<td>Menviel et al. 2008</td>
</tr>
<tr>
<td>MITgcm</td>
<td>Lovenduski and Ito 2009 Hauck et al. 2013</td>
</tr>
<tr>
<td>NASA GISS</td>
<td>Romanou et al. 2013</td>
</tr>
<tr>
<td>UVic</td>
<td>Zickfeld et al. 2007 Swart et al. 2014</td>
</tr>
</tbody>
</table>

CO₂ outgassing  wind

ψᵋ  ψₑᵧᵧ

biological production

zonal-mean DIC concentration

ψₑᵧᵧ
Observed wintertime $pCO_2$ changes 1986-2010

Change in surface ocean $pCO_2$

Number of obs = '328,287'
Number of obs = '69,568''

Winter observations south of 50S
All SSTs 1981-2010

Change in atmospheric $pCO_2$

data from Takahashi et al. (2012)
Trend in $pCO_2^{oc}$ vs. $pCO_2^{atm}$ trend

Fay and McKinley (2013)
Research questions

1. Are CO$_2$ flux trends affected by the choice of start/end year or season?

2. Does the observational sampling introduce biases into the $\Delta p$CO$_2$ trends?

3. Do we have enough observational data to detect a weakening CO$_2$ sink?
Does the start/end year matter?

CO₂ flux trend, SO-SPSS

simulated period

observed period

Lovenduski et al. (in review)
Is the CO$_2$ flux trend larger in winter?

annual CO$_2$ flux trend

winter CO$_2$ flux trend

Lovenduski et al. (in review)
Do we have observational biases?

ΔpCO₂ trend, SO-SPSS

full model

model sampled as observed

observed

Lovenduski et al. (in review)
Do we have observational biases?

$\Delta pCO_2$ trend, SO-ICE

**full model**

**model sampled as observed**

**observed**

Lovenduski et al. (in review)
Do we have enough data?

Required length of time series

Years of data available

Lovenduski et al. (in review)
Conclusions

1. Are CO$_2$ flux trends affected by the choice of start/end year or season?
   - Start/end year: Yes.
   - Season: Not significantly.

2. Does the observational sampling introduce biases into the ΔpCO$_2$ trends?
   - In SO-SPSS: Only slightly.
   - In SO-ICE: Yes, but also model bias.

3. Do we have enough observational data to detect a weakening CO$_2$ sink?
   - No, but one promising route to detection is data from the Drake Passage time series.