Interannual climate variability in the Southern Ocean

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What are we talking about?
What do we know?

From reanalysis (NCEP-NCAR + ECMWF):

White & Peterson (1996)

T=8y and L=11000km

Zonal mode 2

Ocean and atmosphere phase locked
Sketch of the main pattern of interannual variability in the Southern Ocean

Figure 3
White & Peterson (1996)
Doing it with GCM:

Christoph (1998)
Bonekamp (1999)
Weisse (1999)
Haarsma (2000)

=> The atmosphere exhibit a standing zonal mode 3

=> SST travels advected by the ACC

And look data again:

Bonekamp et al (1999)
Carril and Navarra (2001)
Cai and Baines (2001)
Conoley (2002)
Venegas (2003)
Park (2004)

=> The atmosphere can exhibit a zonal mode 3

=> Eastward propagation not always occurs

Situation remains not clear!
Moreover:

Simple linear models show that resonance is possible in the *natural* channel of the Southern Ocean

Colin De Verdiere and Blanc (2001)
Motivations of my work:

=> GCM simulations and observations does not agree, what about an intermediate complexity model?

=> Can we re-find resonant conditions of linear models by adding transients
The model

Conservation of the quasi-geostrophic potential vorticity:

\[
\frac{Dq}{Dt} = \kappa (SHF) - Di + Si
\]


Surface Heat Flux:

\[
SHF = \rho \alpha_C \varphi \rho_s (1 + 1/B)|U_s|(SST - Ts)
\]

Mixed layer of constant depth:

\[
\frac{\partial SST}{\partial t} = -J(\psi, SST) - U_E \cdot \nabla SST - \frac{F}{C_{po}} - D + S_{SST}
\]

Spectral model (T21) on the sphere, perpetual winter time
The coupled simulation

Climatology:
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Amplitude: 0.3K

~ Zonal mode 2

~ Period 8 years

Band-pass 3-7y
PATTERNS ASSOCIATED WITH A 1ST / LEVEL POSITIVE SST ANOMALY

| SST| >0.097; 16.2% of occurrences
| Us |
| Vs |
| Tb |

Zonal mode: [0.0f]

-0.2  0  0.2  -0.5  0  0.5  -0.2  0  0.2  -1  -0.5  0  0.5  1

-0.2  0  0.2  -0.5  0  0.5  -0.2  0  0.2  -1  -0.5  0  0.5  1

-0.2  0  0.2  -0.5  0  0.5  -0.2  0  0.2  -1  -0.5  0  0.5  1

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RECAP:

SST of 0.3K with large zonal scale and period 8-10 years
Warm air and high pressure above warm SST
SST and SHF in quadrature
Atmosphere leads the ocean by few months
Atmosphere and ocean phase locked

What's the real importance of coupling?
PASSIVE OCEAN INTEGRATION

SST forced by the atmosphere

which in turn only feels a climatological SST
=> No change in spatial relation (same composites)

=> Downward SHF is now leading SST by 4-6 months
   No upward SHF lagging the SST
=> Decrease of SST anomalies persistence

Zonal mean of lagged SST autocorrelation (from doubled SHF simulations)

Coupled simulation
SST forced simulation
Coupled – Forced
Why does coupling increase SST anomalies life time?

=> Atmospheric response to SST anomalies:

PASSIVE ATMOSPHERE INTEGRATION
Difference between mean fields

Z500: 60deg eastward

T650: 40deg eastward
Baroclinic response?
Conclusion
How are SSTa created?
Hovmoller of SST for the coupled simulation with only a 2-20y time filtering