Surface Winds along Eastern Boundary Upwelling Systems in Future Climate Scenarios

René D. Garreaud and Mark Falvey
Department of Geophysics
Universidad de Chile
EBUS: Subtropical anticyclones, equatorward flow and cold SST
Equatorward flow often exhibits a coastal jet structure.
EBUS also “under” cloudy skies (stratocumulus deck)
Year-to-year changes in subtropical equatorward flow forced by variations in **along-shore** pressure gradient

\[ \frac{\partial (WS)}{\partial (\Delta SLP)} \sim 1 \text{ ms}^{-1} / \text{hPa} \]
Future Climate Scenarios
GHG (CO2,...) emissions projections + GCMs

- Scenarios: A1B, A1T, A1FI, A2, B1, B2, IS92a
- Stabilisation at 550 ppm
- 20+ GCMs CMIP3/IPCC AR4
- Comparison of CO2 emissions and global surface warming
- Year range: 1900 to 2100
Multimodel average surface air warming A2-BL (future-present)

Warming everywhere but with different magnitude
Ocean warming less than land warming, especially on EBUS!

IPCC 2007
Multimodel average of difference in zonal mean air temperature between A2 and BL

Warming of the tropical upper troposphere ► Increased static stability at subtropics and midlatitudes ► Poleward expansion of the Hadley cell

Lu et al. 2007
Poleward expansion of the Hadley cell

Lu et al. 2007
Multimodel average SLP difference between A2 (2070-2100) and BL (1970-2000)

Strengthening of the poleward flank of subtropical anticyclones and poleward shift of the midlatitude storm track is very consistent among GCMs.

Annual mean
Multimodel average SLP and sfc wind difference between A2 (2070-2100) and BL (1970-2000)

Over open ocean $\Delta v$ in geostrophic balance with $\Delta$SLP. Near the coast $\Delta v$ more controlled by along-coast $\Delta$SLP
Multimodel average SLP and sfc wind difference between A2 (2070-2100) and BL (1970-2000)
Multimodel average SLP and sfc wind difference between A2 (2070-2100) and BL (1970-2000)
Multimodel average regional surface air warming A2-BL (Also shown dSLP)

Global mean: +3.3°

Stronger upwelling
Enhanced heat fluxes
More solar radiation
Multimodel average regional surface air warming A2-BL as a function of sfc. wind

Each dot a GCM
Multimodel average regional ocean warming A2-BL

5 m
+1.95°C
Multimodel average regional ocean warming A2-BL

100 m +1.52°C
Multimodel average regional ocean warming A2-BL

700 m
+0.78°C
Is the regional cooling of the Humboldt EBUS already taking place?

Over the Pacific SST trend looks very similar to the PDV pattern.
Is the regional cooling of the Humboldt EBUS already taking place?
Is the regional cooling of the Humboldt EBUS already taking place?

Temperature trends 1979-2006

- Radiosonde Air Temperature
- MSU (Mid-Troposphere)
- Surface Temperature
- Gridded SST
- WOD Water Temperature
- SST (Coastal Measurements)
Is the regional cooling of the Humboldt EBUS already taking place?

Global mean: +0.2º/dec

Multimodel mean Regional warming 1970-2000 (SST anomaly). Also shown in contours SLP trend.
Conclusions

- EBUS: complex interaction among atmospheric circulation (SLP, low-level winds), ocean processes (SST) and cloudiness.
- Interannual variations of upwelling favorable, equatorward flow driven by changes in the along-shore surface pressure gradient.
- Cooling off Chile (-0.25º/decade) due to (2/3) PDV variability and (1/3) Antropogenic climate change.

- GCMs consistently predict an expansion (and weakening) of the Hadley cell resulting in SLP increases at midlatitudes (largest @ SH).
- The increase in SLP results in a strengthening of the equatorward flow along the EBUS, most notable off Chile (subtropical Humboldt).
- Stronger flow leads to a regional cooling @ surface down to 200 m that superimpose to a global mean warming trend.


• Falvey, M. and R. Garreaud, 2008: Recent atmosphere and ocean temperature trends in Chile. Submitted to *JGR-Atmos.*

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