The Surface Warming Trend Over Antarctica

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Outline

• Signs of climate change
• Surface warming trend (Steig et al. 2009)
• Relationship between surface temperature and the SAM (Marshall 2006)
• Is the warming anthropogenic? (Gillett et al. 2008)
• Summary/Conclusions
Signs of Warming

2008: Wilkins Ice Shelf Breakup Events

2002: Collapse of Larsen Ice Shelf

Turner et al., 2005
Surface temps from thermal infrared (TIR) satellite and automatic weather stations (AWS) used as bases of near-surface temperature reconstructions from Jan 1957-Dec 2006

Temperature Trends

- West: $0.17 \pm 0.06 ^\circ C$/decade
- East: $0.10 \pm 0.07 ^\circ C$/decade
- Peninsula: $0.11 \pm 0.04 ^\circ C$/decade
- Continent: $0.12 \pm 0.07 ^\circ C$/decade
- Global Mean: $0.128 \pm 0.06 ^\circ C$/decade (1956-2005)
• Trends are from TIR reconstruction

• Individual stations show mean annual upward trends in West Antarctica

• Greatest warming in Austral spring (SON) and winter (JJA)
The Model
Steig et al. 2009

• NASA Goddard Institute for Space Studies (GISS) ModelE atmosphere-only model and coupled GCM

• Time Periods:
  • 1957-1981
  • 1979-2003

• Boundary Conditions:
  • 5-member ensemble w/ observed SST and sea ice
  • 4-member ensemble w/ observed SST, sea ice, and atmospheric forcings (changes in GHGs, decrease in stratospheric O₃)
  • Observed-climatological sea ice (same atmospheric forcings)
The Results
Steig et al. 2009

SST, sea ice generates weak cooling over East Antarctica

Sea ice decreases in west, increases elsewhere

Warming rate greatest over West Antarctica in spring and winter

SST, sea ice, forcings in general agreement w/obs

Sea ice obs unreliable before 1979

Coupled model (dynamic ocean) does not reproduce strong West Antarctic & Peninsula warming
The SAM Connection

- Southern Annular Mode (SAM) is first mode of atmospheric variability in SH
  - Positive phase characterized by anomalously strong circumpolar westerlies
  - MSLP is below normal over Antarctica and above normal over SH mid and high latitudes during positive phase
  - Explains ∼35% of SH climate variability
- Positive trend in SAM during past 50 years
- Consistent significant relationship between SAM and Antarctic surface temperature
Correlation Between SAM & Near-Surface Temperatures

Marshall 2006

Adiabatic cooling
Is Antarctic Warming Anthropogenic?  
(Gillett et al. 2008)

- 1950-1999 CRUTEM3 near-surface station temperature observations
- Ensemble of 4 CMIP-3 coupled climate models run from 1950-2008
  - NAT=natural forcings
  - ALL=natural + anthropogenic forcings
- Warming trend apparent in both obs & model output
Grid Cell Temperature Trends
(Gillett et al. 2008)

- Obs show warming over peninsula, cooling over South Pole
- Warming trend more widespread for obs extending thru Jul 2008
- NAT run does not reproduce warming trend
SAM Impacts on Temperature
Gillett et al. 2008

- Upward trend in SAM assoc. w/peninsula warming and cooling everywhere else
- Effect of obs SAM trend on temps seems weaker in this study than in others
- Simulated SAM-congruent temp trend is weaker than obs trend
The Verdict

Surface temperatures show a detectable response to anthropogenic warming
Summary & Conclusions

• There is a significant upward trend in surface air temperature over most of Antarctica

• The greatest warming has occurred in the western portion of the continent and the peninsula

• Anthropogenic forcing is detectable in the warming signal, and distinct from natural forcing

• Resultant circulation changes are responsible for the recent decrease in the rate of warming
References


