Climatic controls on Antarctic ice regional accumulation variability

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Robust, SLR-related increase in future AIS snowfall observed across climate models (Frieler et al., 2015), including CESM (Lenaerts et al., 2016)
Recent observations show large spatial and temporal variability, often of opposite signs, in Antarctic snowfall.

Questions:
- How are counteracting regional variability patterns related?
- What are drivers of regional variability patterns?

Martín-Español et al. (2016), Memin et al. (2015)
Approach: basin-scale accumulation analysis

- Inputs
  - **Basin data (Zwally et al., 2012)**: 27 glaciologically distinct drainage basins
  - **Climate data**: CESM Large Ensemble control, 1800 yr of equilibrated preindustrial climate (Kay et al., 2015)
Approach: basin-scale accumulation analysis

- **Inputs**
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- **Processing**
  - For each basin:
    - Composite climatologies of low/high accumulation years (-/+ 2σ)

- **Analysis**
  - For each basin:
    - Analysis composite climatology differences
• Mean AIS PI climatological annual accumulation: **2167 Gt/yr** (>0.1% rain)
• AIS PI climatological annual accumulation σ: **98 Gt/yr**
• AIS-integrated coefficient of variation = **0.04**
• Average basin-integrated coefficient of variation = **0.17**
  ○ **AIS-wide variability dampened by regional signals**
• Accumulation mostly occurs in MAM and JJA
• Difference between low and high P years is large
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Multi-century ice core accumulation records (Banta et al., 2008)
Accumulation: 0.2-0.22 m/yr w.e.
CV: 0.18-0.21
- Local basins are correlated and anti-correlated, remote basins display scattered, weak correlation signal
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Regional dSIC shows strong low/high dipole relationship with high/low basin accumulation change.
Superimposing change in vertically integrated moisture transport explains basin-scale accumulation change, rules out dSIC as significant.
Moisture transport change geometrically aligned with dSLP and dynamically consistent with geostrophic transport
Phillips et al. (2014)

HadISST

PSA1:
$r = -0.47$ (p=0.00)

(reversed polarity)
Phillips et al. (2014)

Contours: 50 Pa

PSA1:
\[ r = -0.47 \quad (p=0.00) \]

SAM:
\[ r = -0.61 \quad (p=0.00) \]

(reversed polarity)

Contours: 50 Pa
- Accumulation mostly occurs in MAM
- Difference between low and high P years is large
Correlations suggest a wave-3 structure in basin-scale accumulation correlation.
- Offshore sea ice concentration change also reflects a wave-3 structure
- Moisture transport anomaly regionally focused on composited basin, but overall more zonally structured
Moisture transport change geometrically aligned with dSLP and dynamically consistent with geostrophic transport.
PSA1: \( r = -0.02 \) (\( p = 0.46 \))
Phillips et al. (2014), Raphael (2008), Holland et al. (2016)

**SAM:**
\[ r = -0.28 \quad (p = 0.00) \]

**PSA1:**
\[ r = -0.02 \quad (p = 0.46) \]

(reversed polarity)

Holland et al. (2016)
PSA1:  
\[ r = -0.02 \text{ (p=0.46)} \]

SAM:  
\[ r = -0.28 \text{ (p=0.00)} \]
Conclusions

1. Muted integrated Antarctic accumulation variability hides very large basin-scale variability

2. **Active** ‘variability dampening’ occurs via compensating onshore and offshore moisture transport patterns

3. Variability dampening appears linked to large-scale variability:
   a. **Basin 19: ENSO+SAM**
   b. **Basin 7: Non-annular wave-3 component of SAM**

Understanding causes of regional Antarctic surface accumulation variability will be important as system undergoes accelerating anthropogenically-forced change.

Comments welcome!