Climatic controls on Antarctic ice regional accumulation variability

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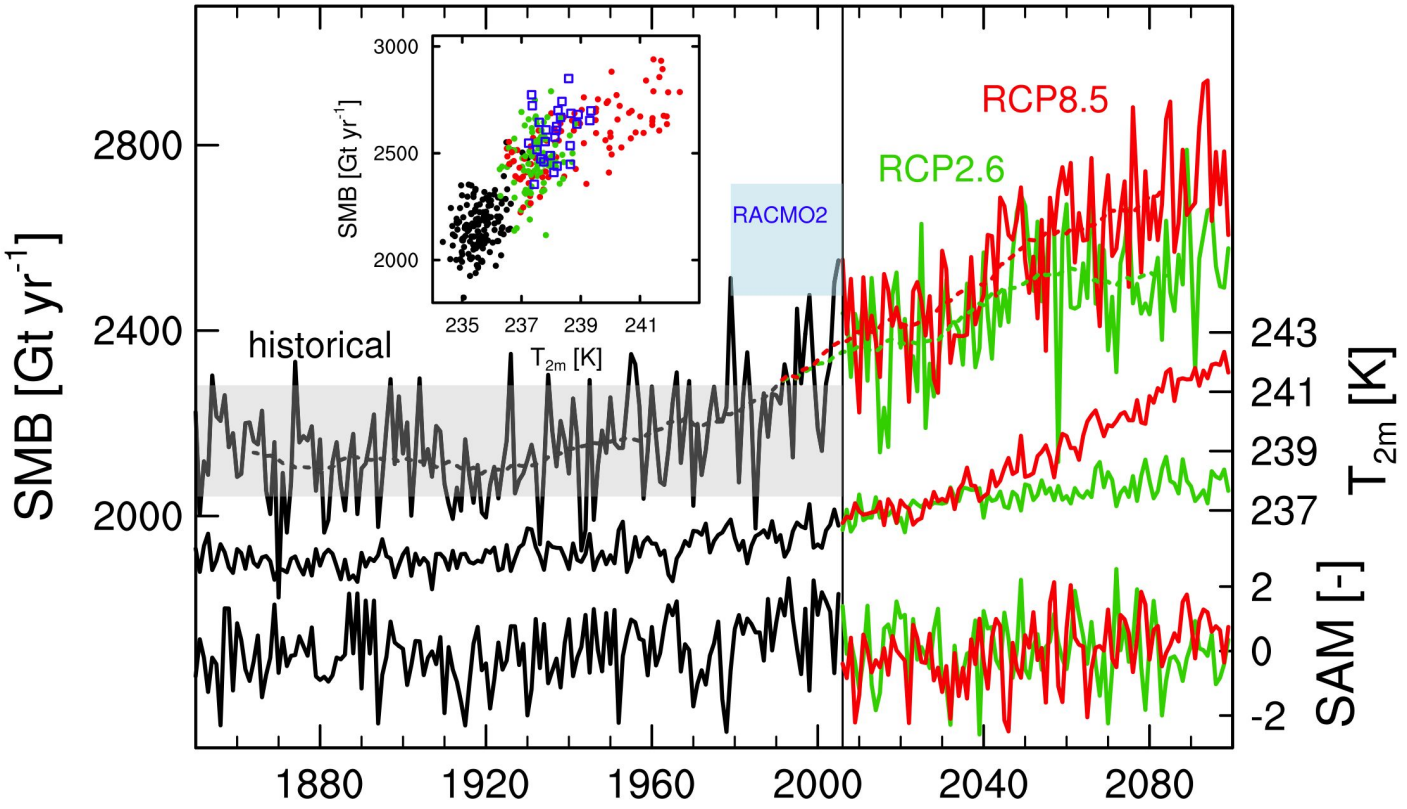
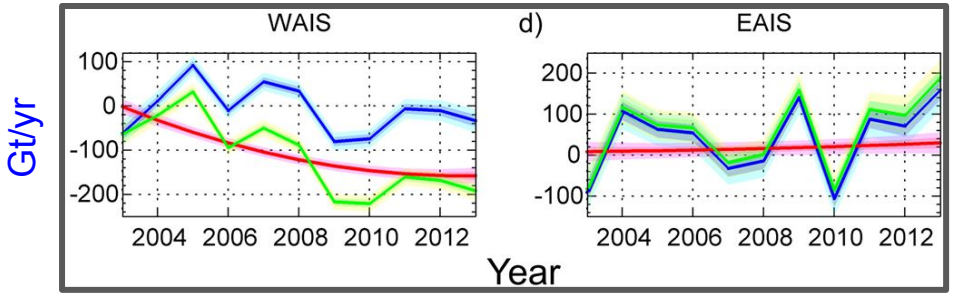
LA-UR-15-21974

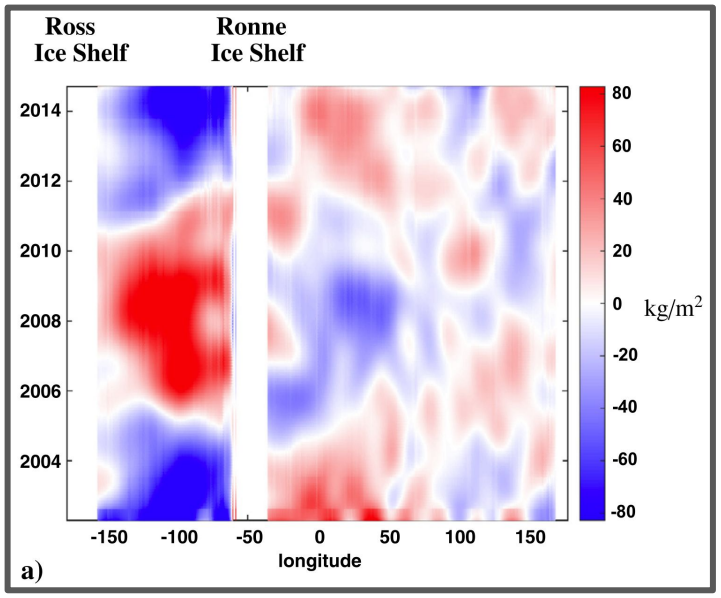
- Robust, -SLR-related increase in future AIS snowfall observed across climate models (*Frieler et al., 2015)*, including CESM (*Lenaerts et al., 2016)*



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?**

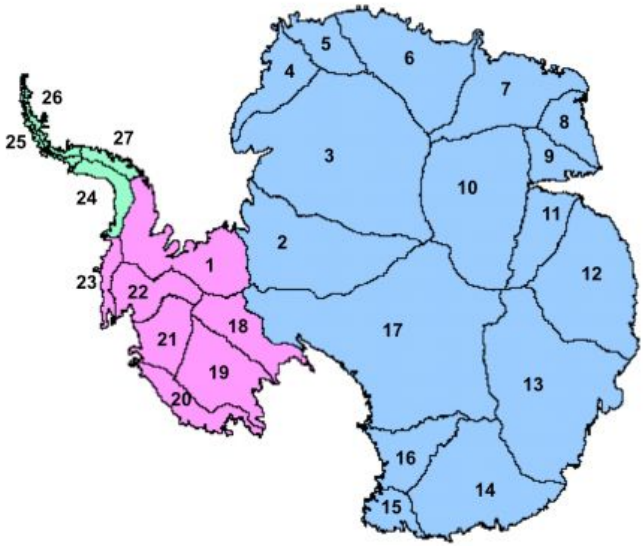




Martín-Español et al. (2016), Memin et al. (2015)

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)*



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- Inputs
  - **Basin data (Zwally et al., 2012)**: 27 glaciologically distinct drainage basins
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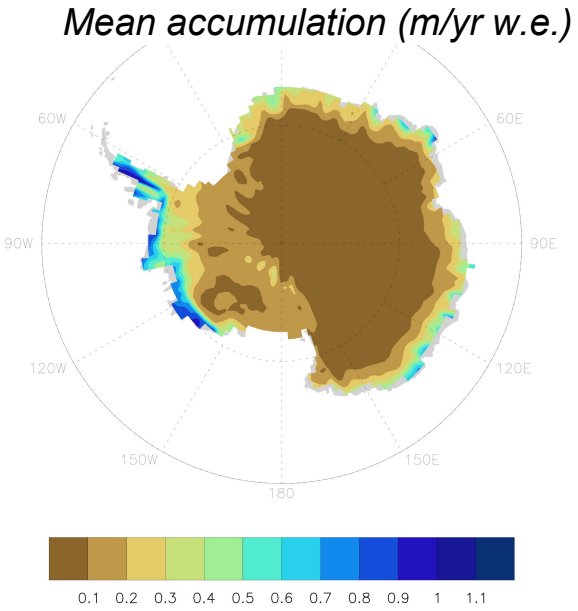
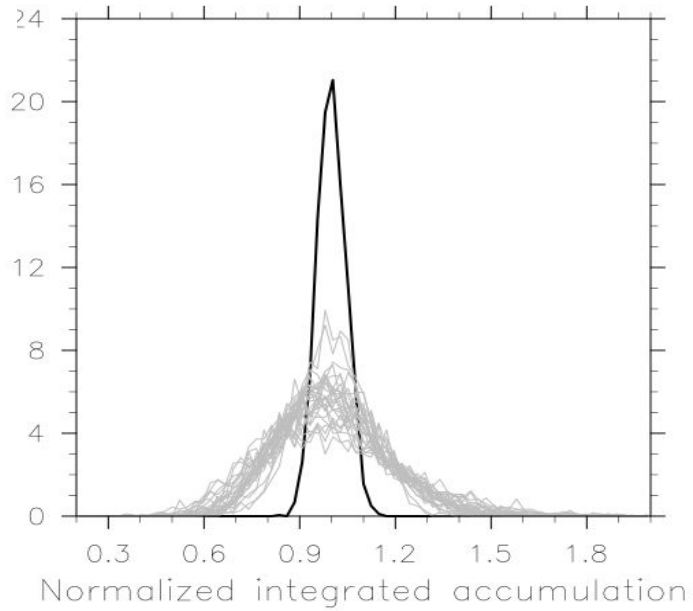
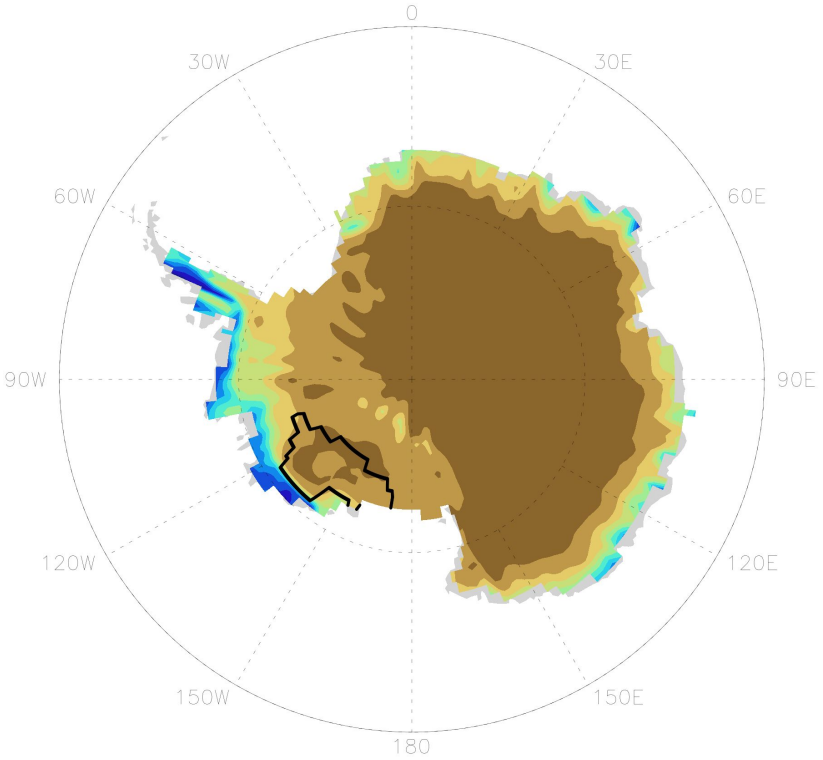
- Processing
  - **For each basin**:
    - **Composite climatologies** of low/high accumulation years (-/+ 2σ)
- Analysis
  - For each basin:
    - Analysis composite climatology differences

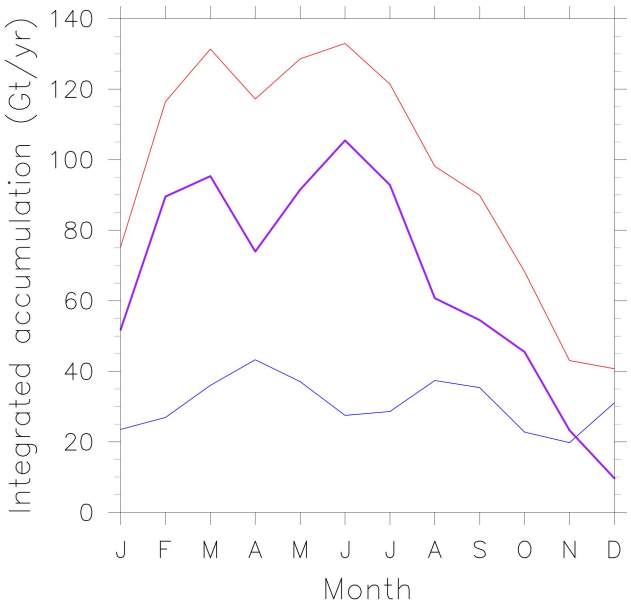
- Mean AIS PI climatological annual accumulation : **2167 Gt/yr** (*>0.1% rain*)
- AIS PI climatological annual accumulation σ: **98 Gt/yr**
- AIS-integrated coefficient of variation = **0.04**
- Average basin-integrated coefficient of variation = **0.17**
  - ***AIS-wide variability dampened by regional signals***





- Accumulation mostly occurs in MAM and JJA
- Difference between low and high P years is large





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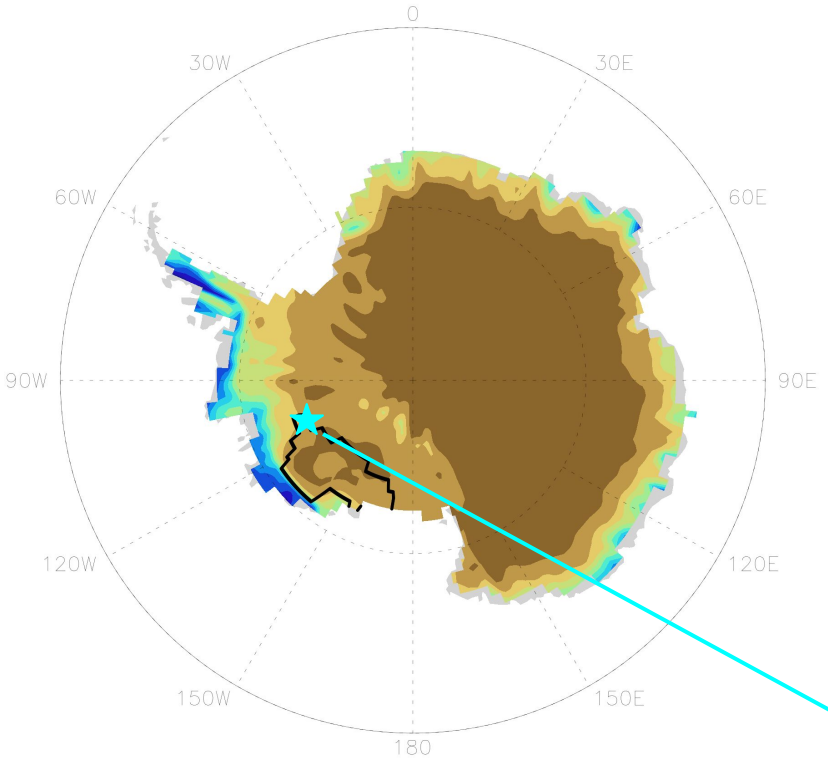
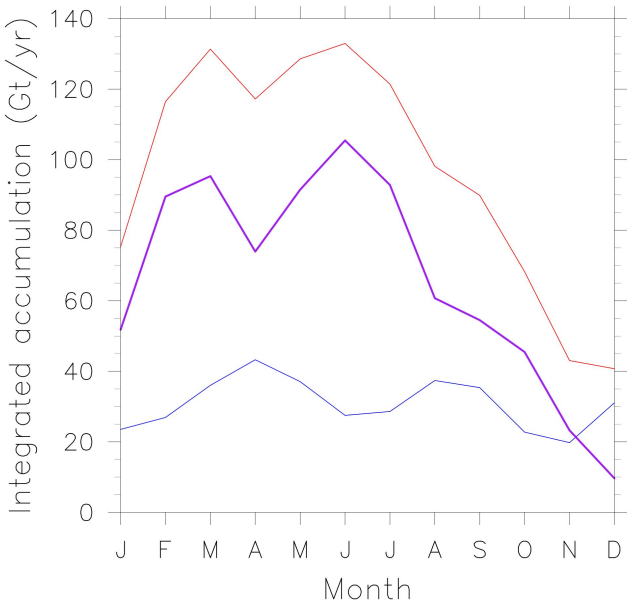
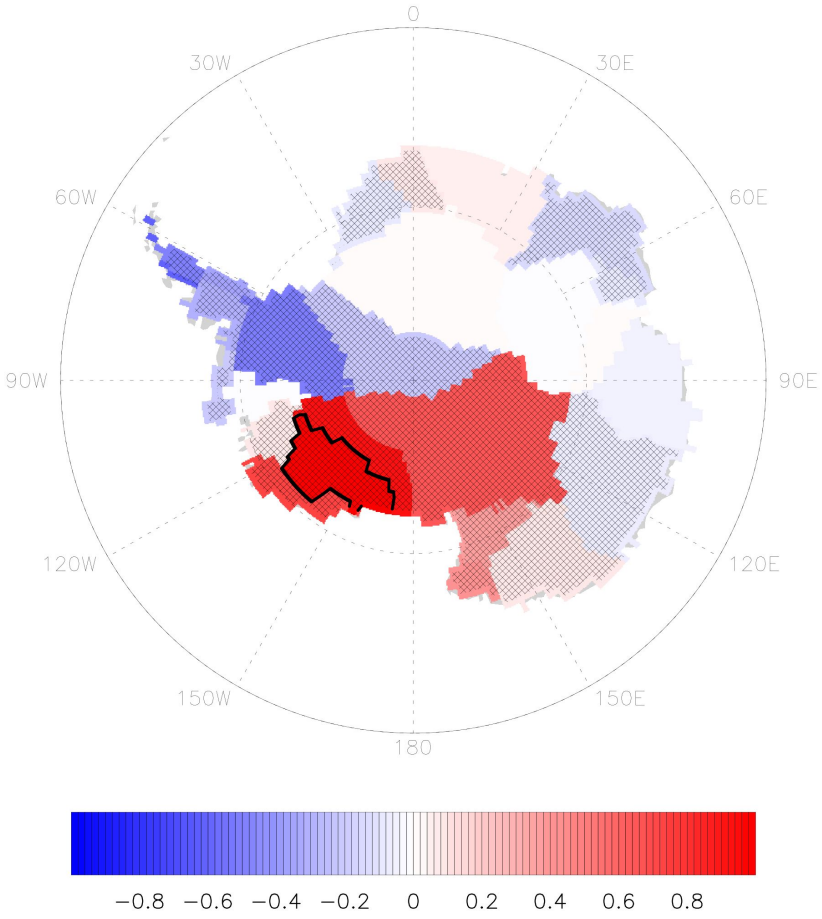




Multi-century ice core accumulation records (Banta et al., 2008)
Accumulation: 0.2-0.22 m/yr w.e.
CV: 0.18-0.21

- Local basins are correlated and anti-correlated, remote basins display scattered, weak correlation signal



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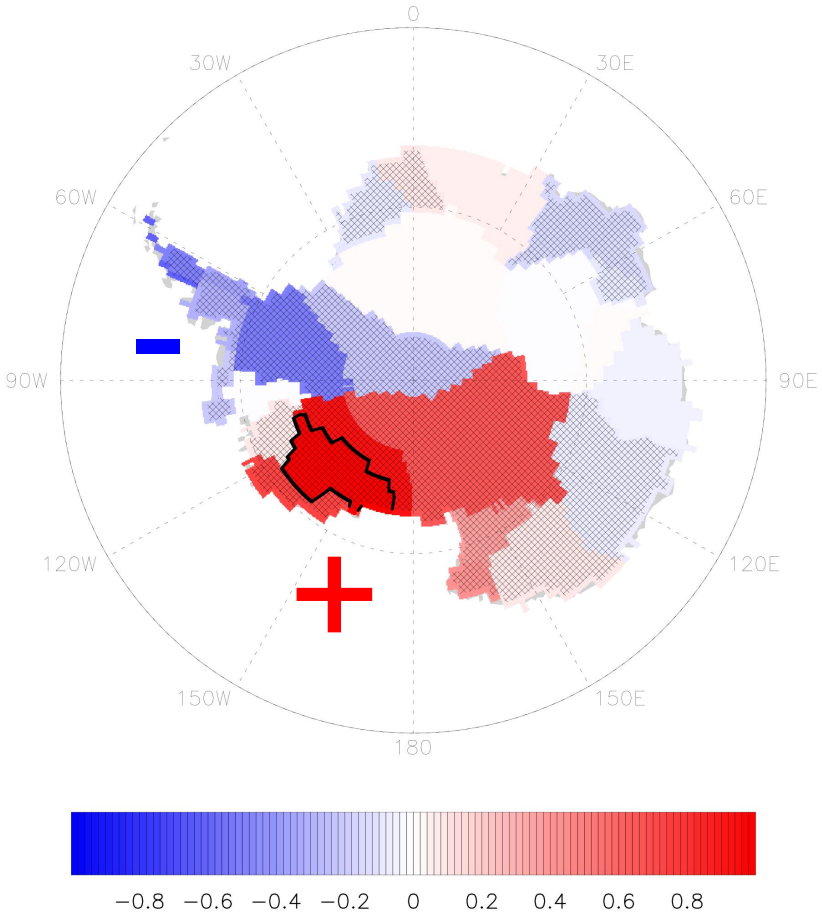
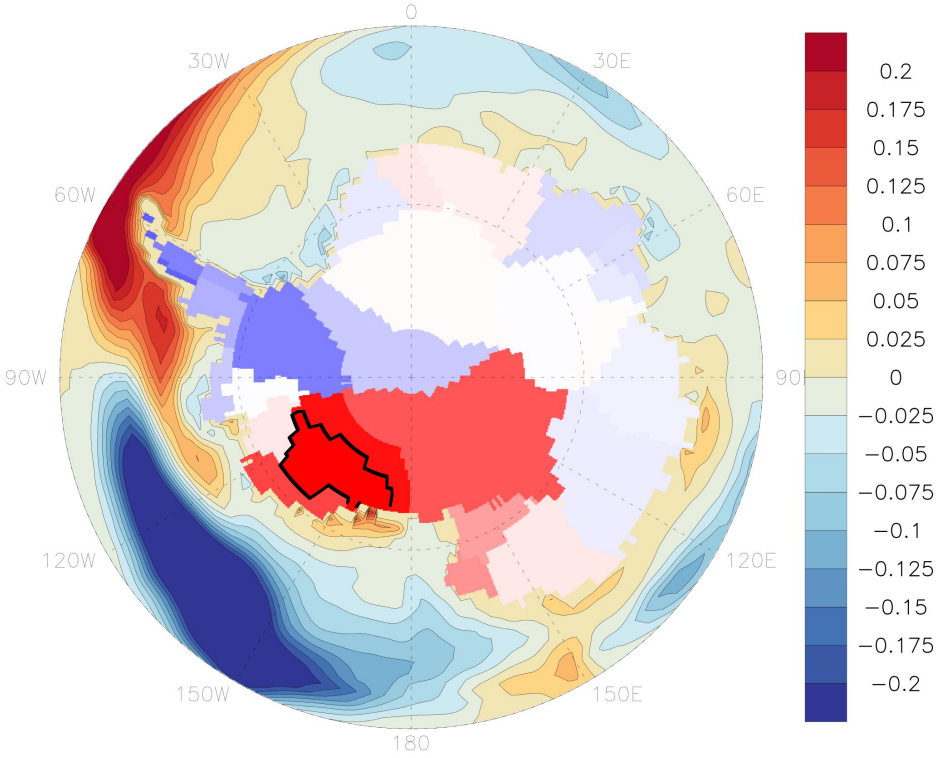
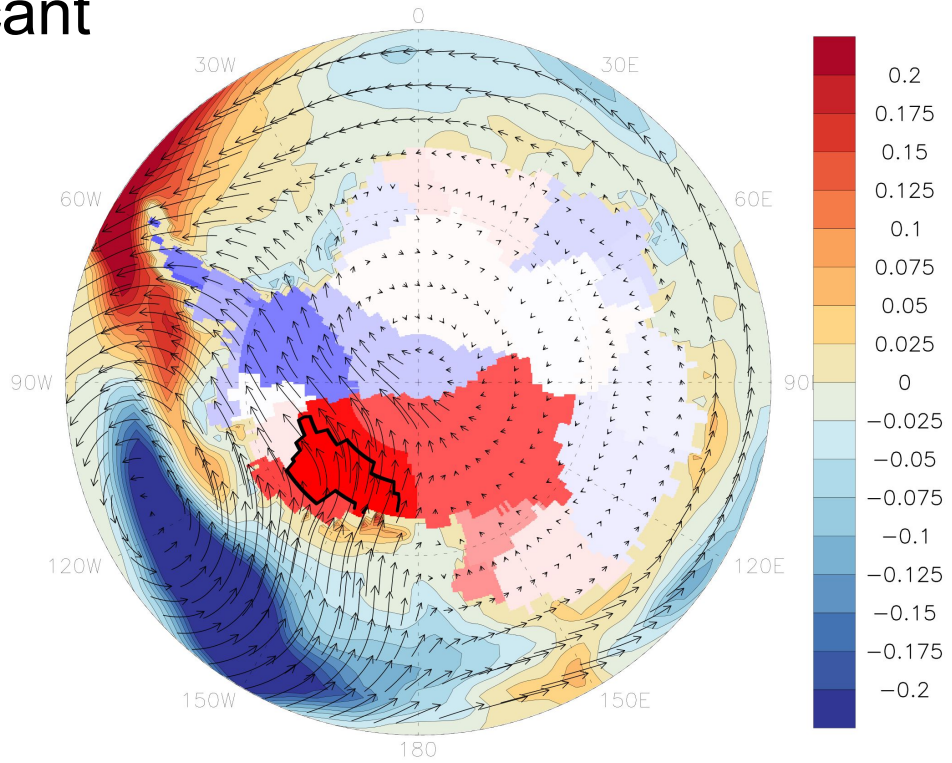


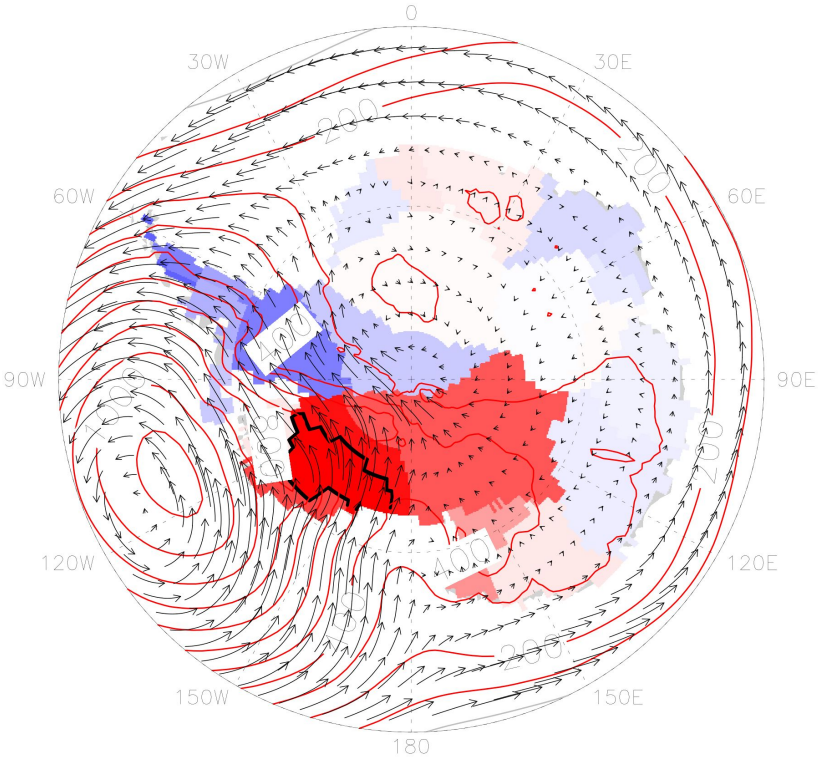
- Regional dSIC shows strong low/high dipole relationship with high/low basin accumulation change

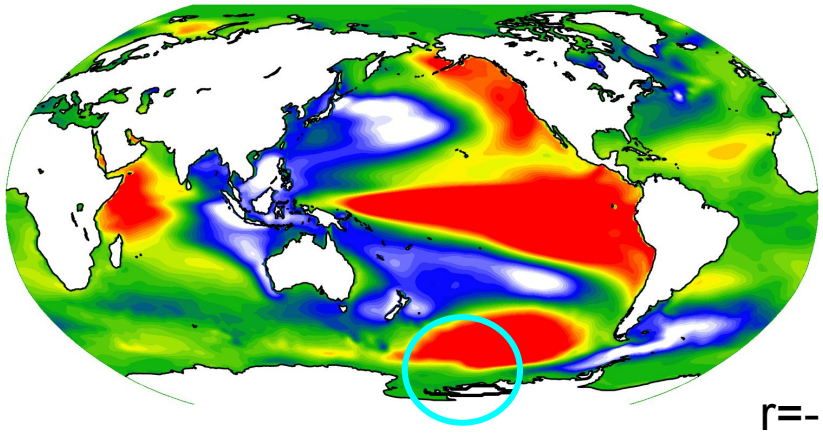


- Superimposing change in vertically integrated moisture transport explains basin-scale accumulation change, rules out dSIC as significant



- Moisture transport change geometrically aligned with dSLP and dynamically consistent with geostrophic transport





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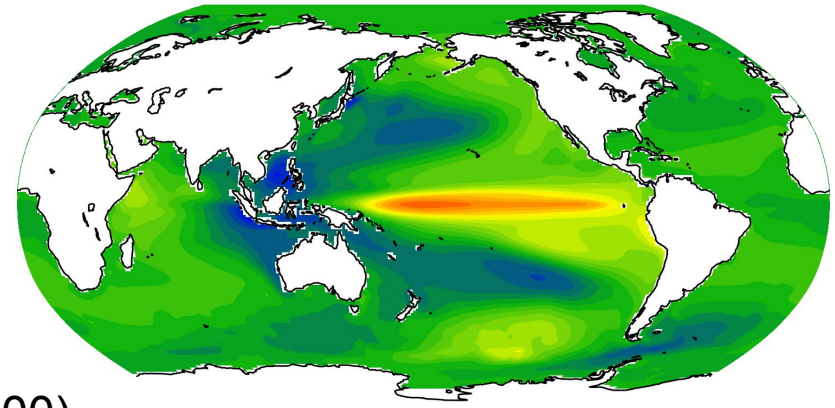

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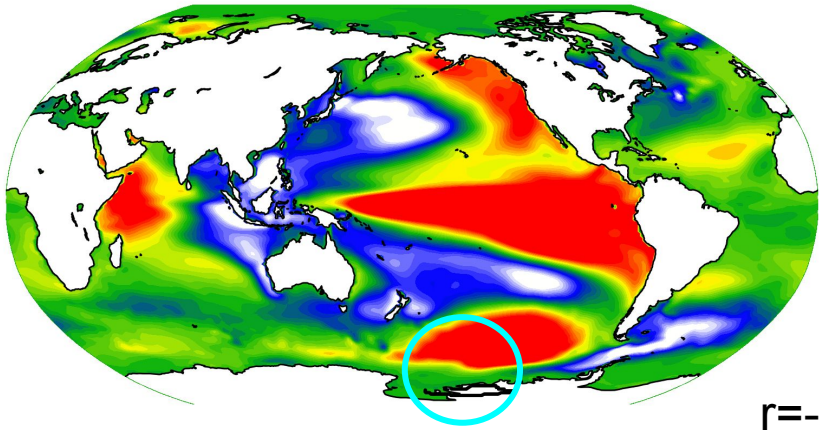
(reversed polarity)

Phillips et al. (2014)



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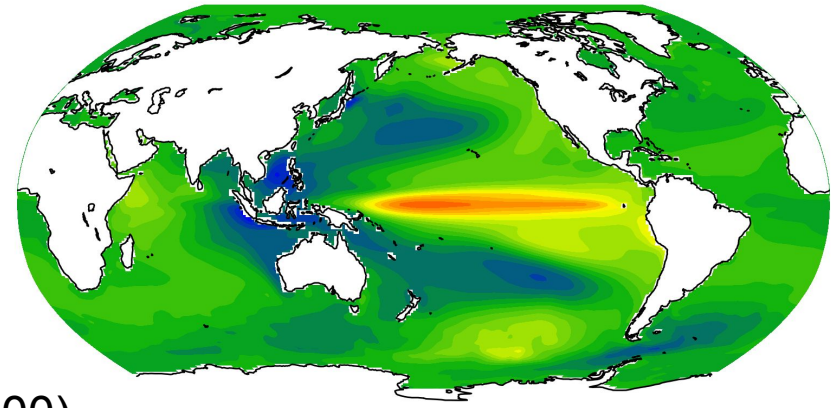

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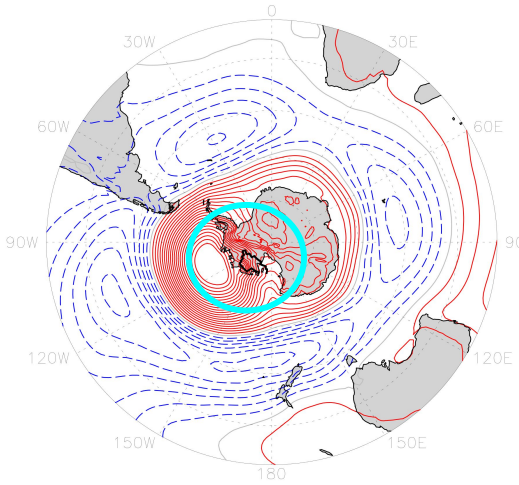

SAM:
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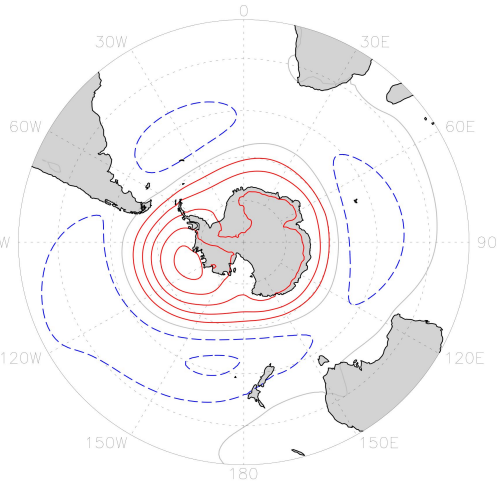

Contours: 50 Pa

Phillips et al. (2014)

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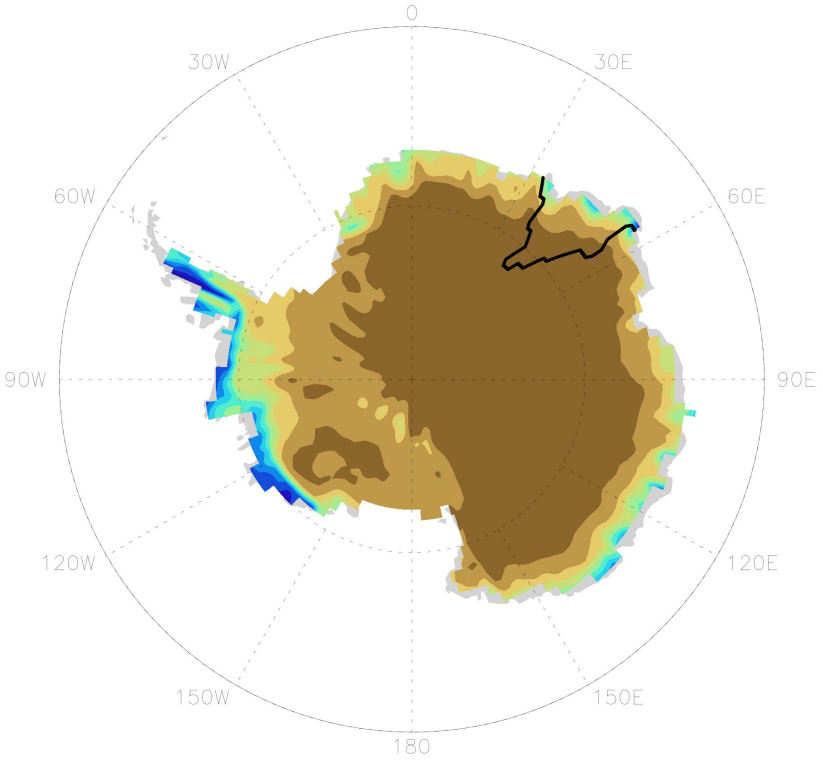
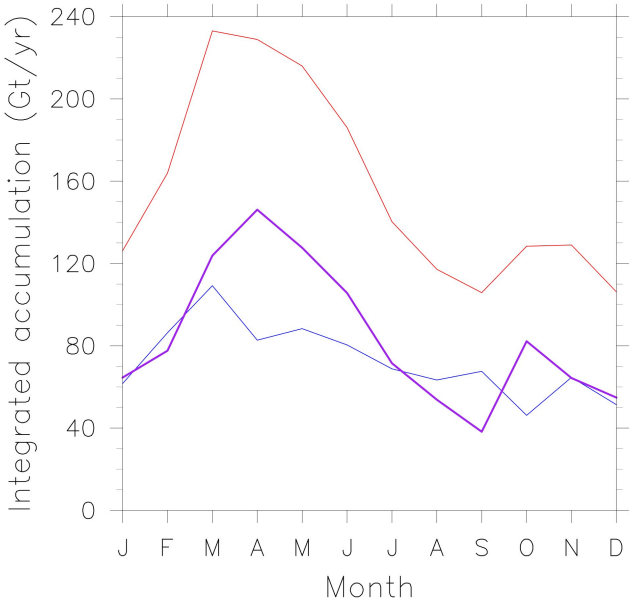
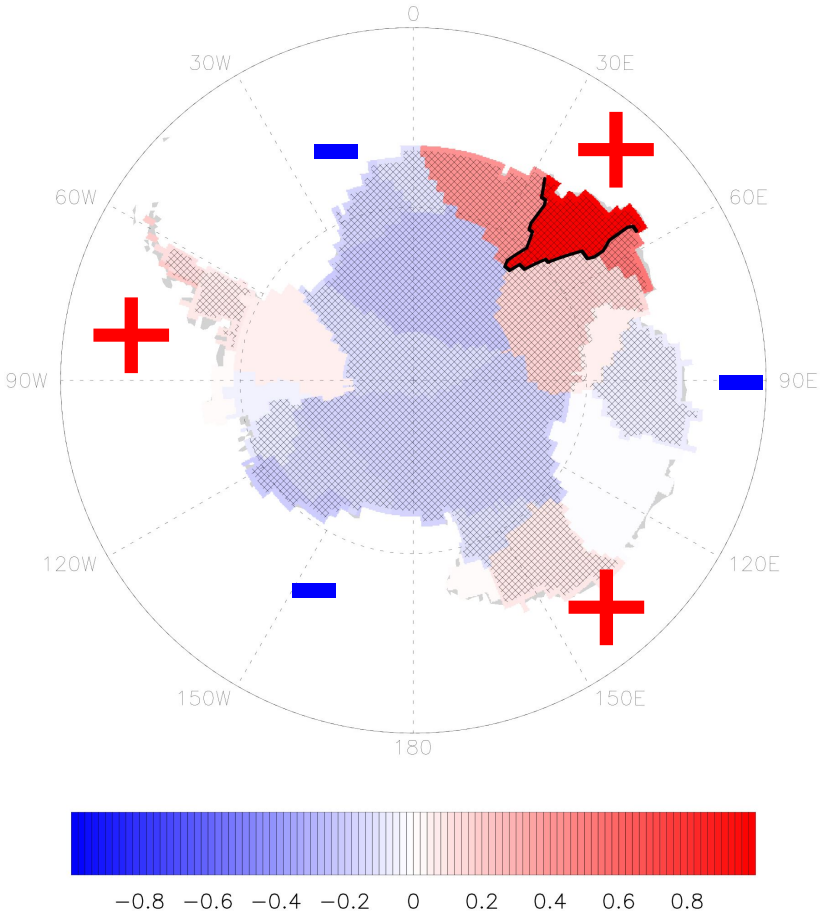
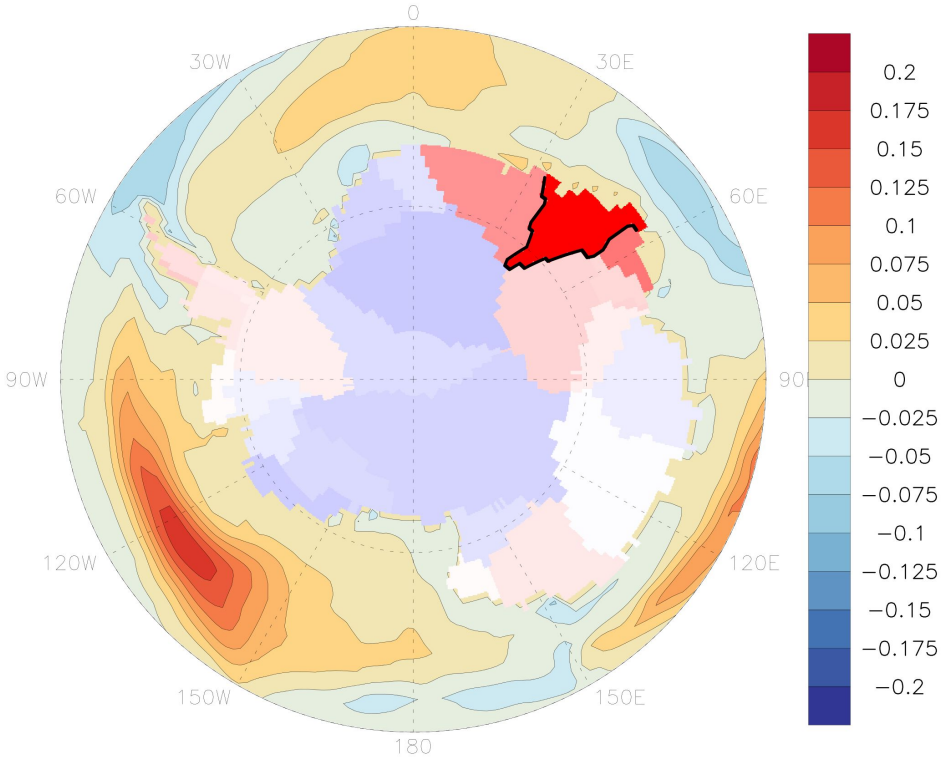




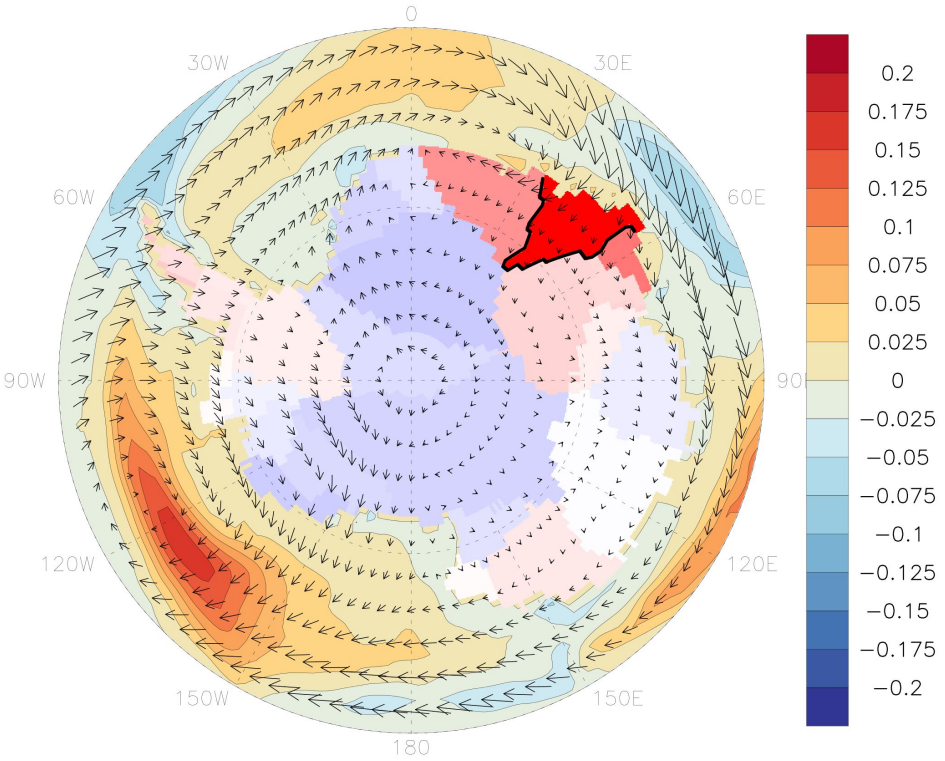
- Correlations suggest a wave-3 structure in basin-scale accumulation correlation



- Offshore sea ice concentration change also reflects a wave-3 structure



- Moisture transport anomaly regionally focused on composited basin, but overall more zonally structured



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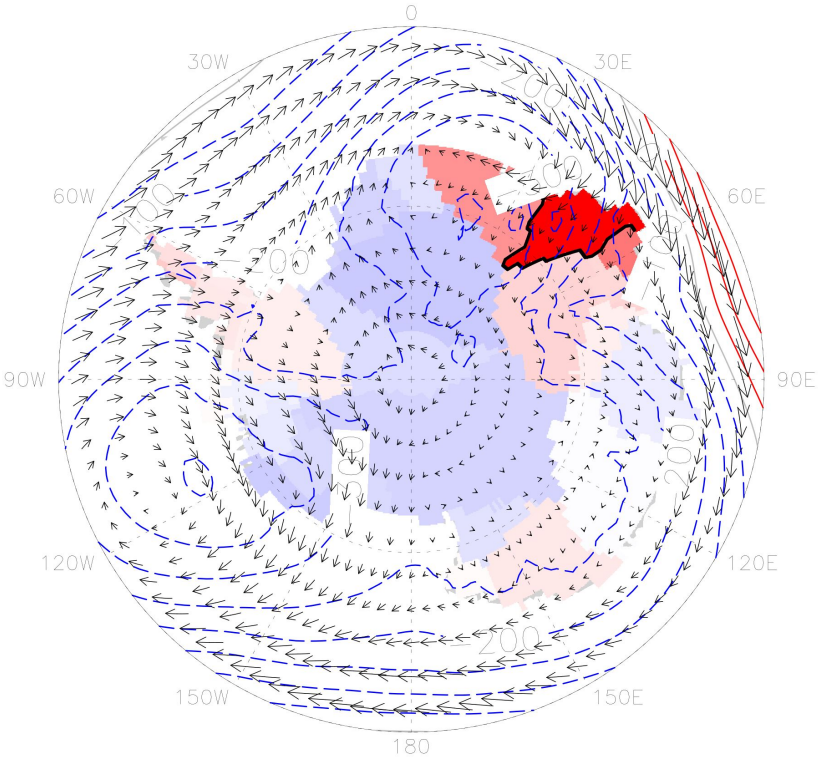

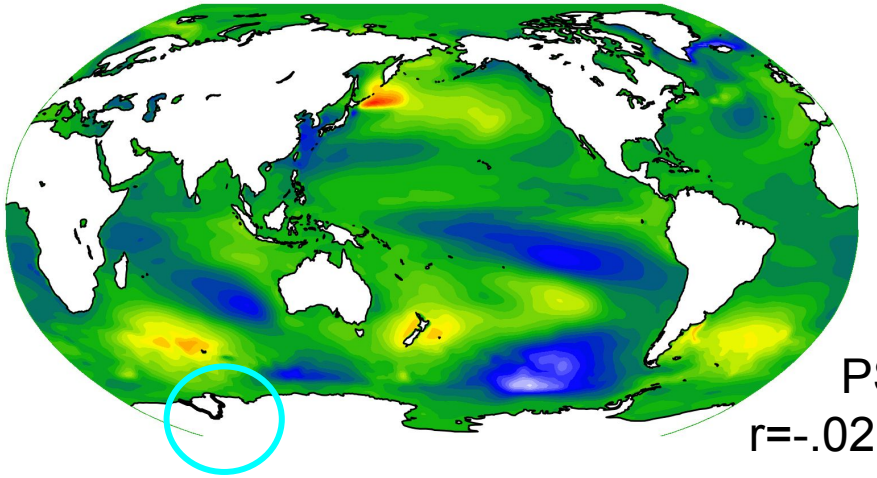

PSA1:
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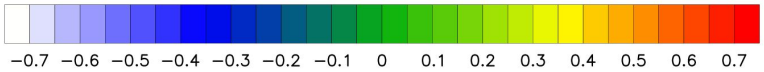
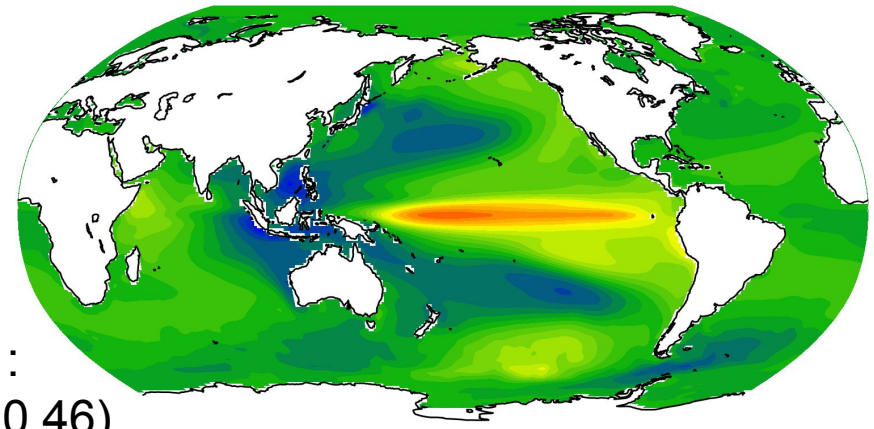
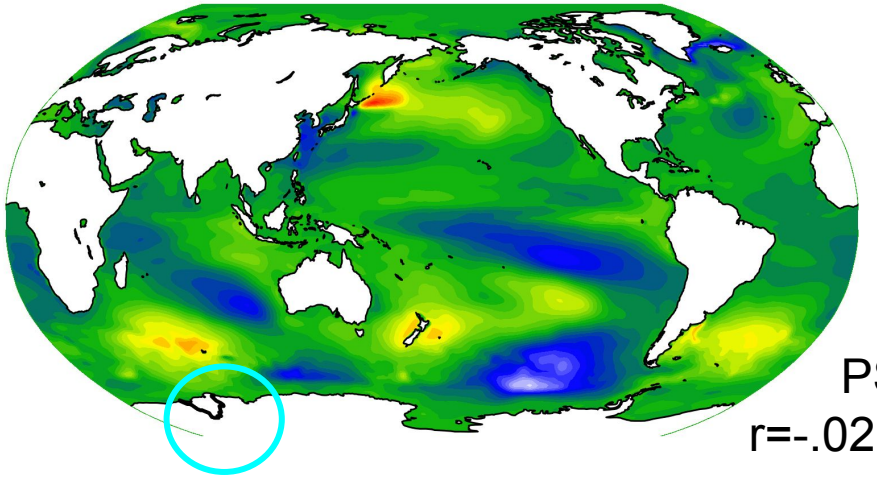




(reversed polarity)

Phillips et al. (2014), Raphael (2008), Holland et al. (2016)



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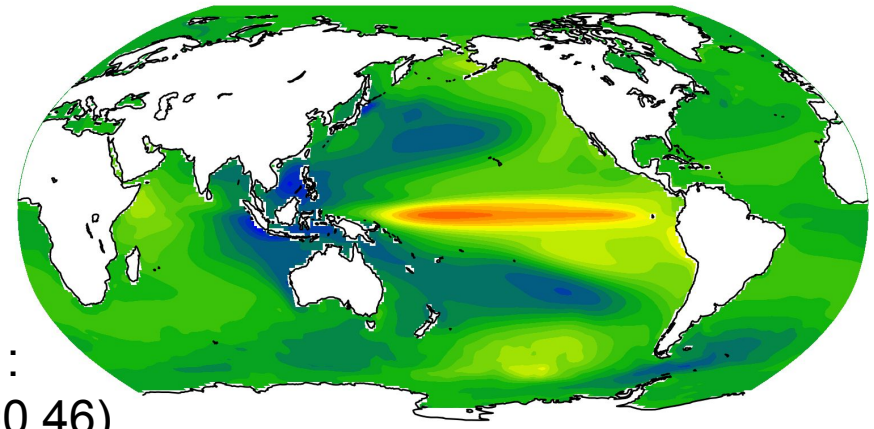

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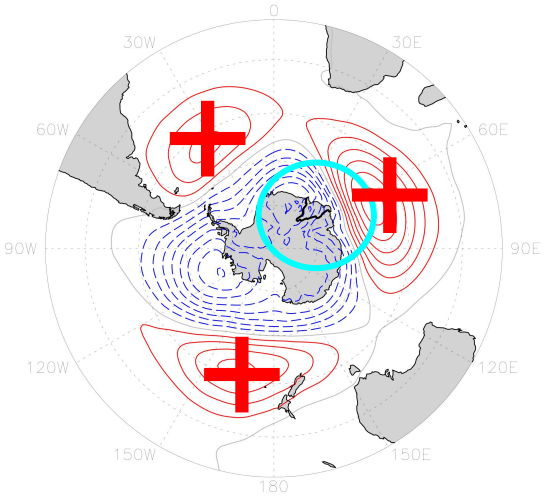

SAM:
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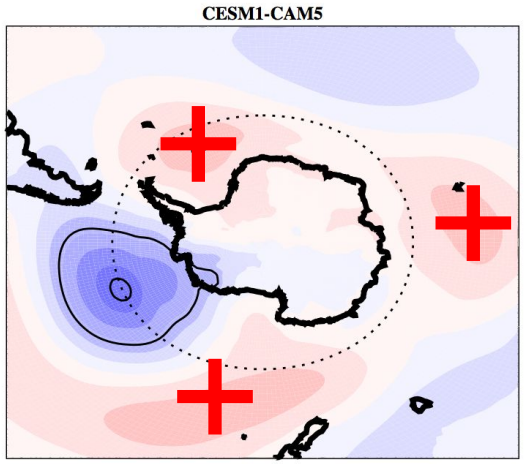
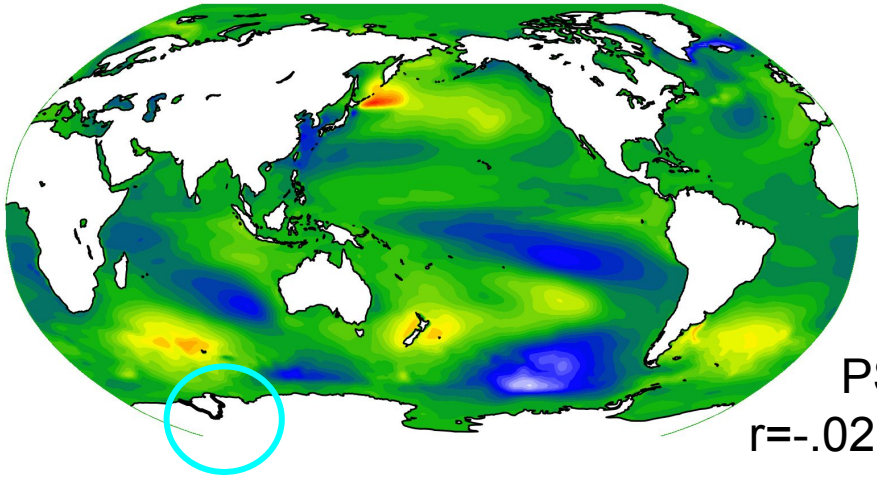


Holland et al. (2016)

Phillips et al. (2014), Raphael (2008), Holland et al. (2016)



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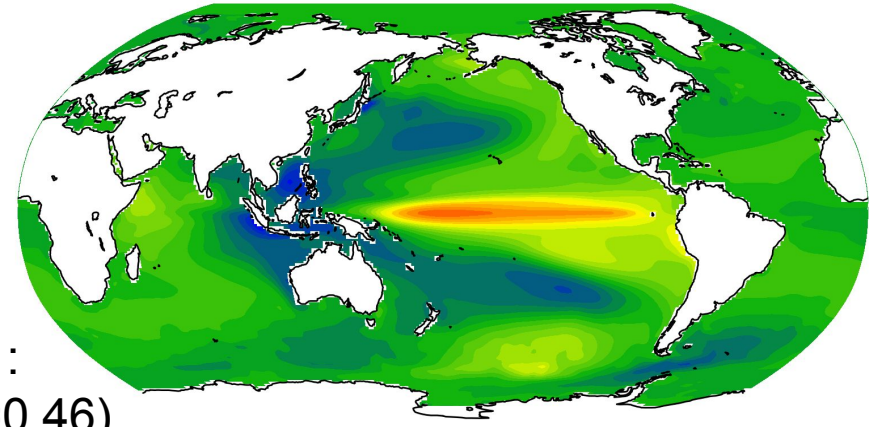

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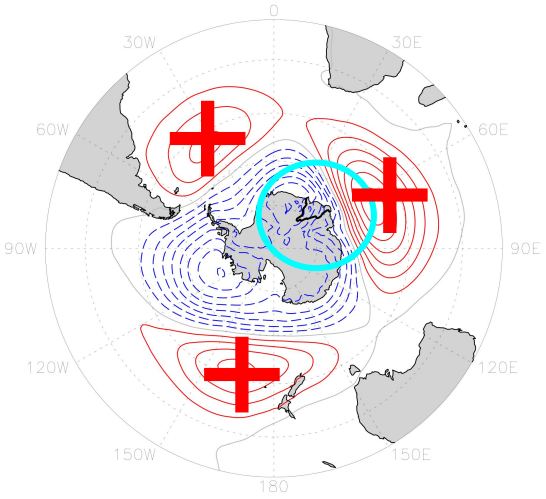

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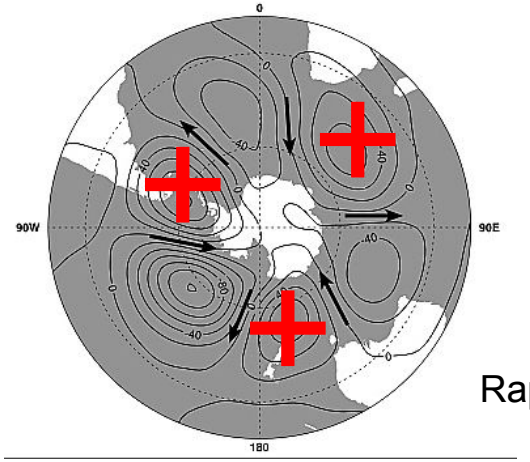

Raphael (2008)

Phillips et al. (2014), Raphael (2008), Holland et al. (2016)

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!