Controls and consequences of rapid environmental change on the atmosphere–sea ice–ocean system in the Larsen Ice Shelf area

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Antarctic Peninsula – physical setting

Cook and Vaughan 2010
Larsen B collapse: system response

- Gradual retreat, rapid collapse 2002 (3250km²)
- Disintegration attributed to large regional warming, melt (Scambos et al. 2003, van den Broeke 2005)
- Cryosphere - ocean impacts
- Ecosystem implications
LARISSA: Marine ecosystem response

Open water area (SSM/I, AMSR-E) and net primary production (MODIS-A, SeaWiFS), Larsen B

- High rates of primary production
- Yearly rates reach 200 g C m\(^{-2}\) yr\(^{-1}\) – new hotspots
- High seasonal and inter-annual variability driven by sea ice (open water area)
Drivers of sea ice variability

- Open water periods linked to:
  - stronger SLP gradient
  - higher air temperature
  - enhanced cross-peninsula flow
Föhn mechanism

- Synoptic forcing leads to higher incidence of air flow over the peninsula
  - SAM+, stronger low-level westerlies
- Orographically induced ascent of westerlies -> advection of warm, dry air to the surface on the leeward side
- Föhn events persistent over days – weeks
Föhn detection

Following Speirs et al. 2010, others

- Warming $\geq 1 ^\circ C / \text{hour}$
- Decrease RH $\geq 5\% / \text{hour}$
- Wind speed $> 5 \text{ m/s}$
- Wind direction from W

- Föhn day recorded for events lasting 6 hours or more

Map of ground station locations

WAIS workshop, October 1, 2013
Föhn variability

Met observations from Robertson Island with föhn events highlighted (June 2010)

- Following Speirs et al. 2010, others
  - Warming $\geq 1 ^\circ C$ / hour
  - Decrease RH $\geq 5$ % / hour
  - Wind speed $> 5$ m/s
  - Wind direction from W

- Föhn day recorded for events lasting 6 hours or more
Föhn variability

- Föhn winds frequently seen in the Larsen B embayment
- Large seasonal and inter-annual variability in wind frequency and duration
Föhn effect on temperature regime

- Higher frequency of föhn winds impact mean regional temperature
- Weakest response in the summer
Larsen embayments as polynyas

- Opening of Larsen A, B tied to intensity, frequency of fohn winds
- Larsen B shows rapid response to wind dynamics
Larsen embayments as polynyas

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Föhn forcing and climate

- Positive SAM associated with:
  - Increased percentage of föhn days in the spring
  - Higher mean temperature in the summer

<table>
<thead>
<tr>
<th>Observation</th>
<th>Season</th>
<th>Nino3.4 (rho)</th>
<th>SAM (rho)</th>
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<tr>
<td>Föhn Days (%)</td>
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<td>DJF</td>
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<td>MAM</td>
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<td>JJA</td>
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<tr>
<td>SON</td>
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<td>Mean temp (°C)</td>
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</table>

- Spring: opening of the embayments
- Summer: persistence of open water conditions
Conclusions

- Larsen embayments are hotspots of production – sometimes
- Production constrained by sea ice dynamics
- Sea ice (open water) dynamics function of synoptic circulation, regional effects (föhn)
  - Links to climate (SAM) – spring and summer
- Atmospheric forcing on cryosphere impacts marine ecosystem
Thank you!