



Atmospheric Response to the Weddell Polynya

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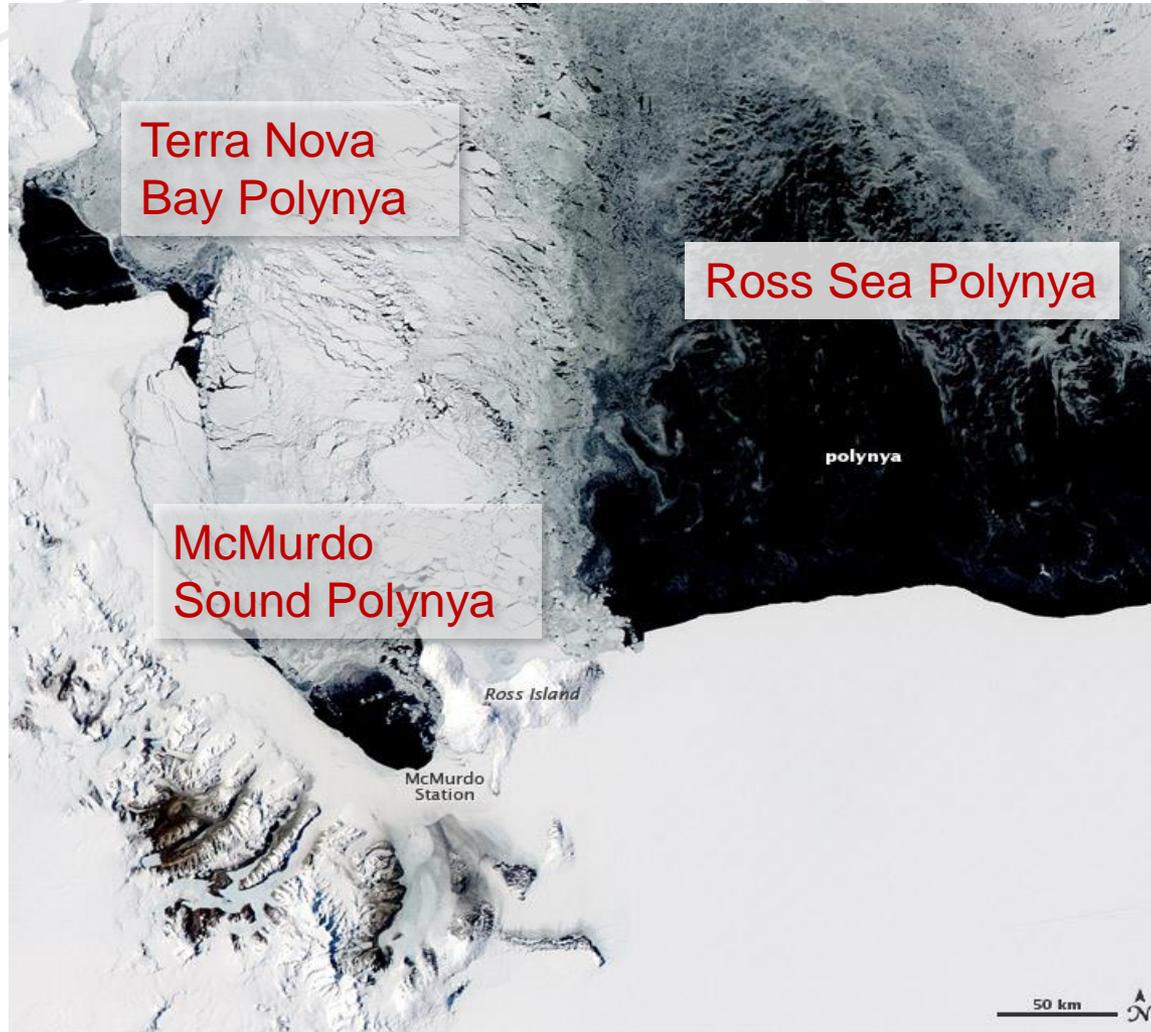
Polynyas

- Areas of open water amid ice pack
- Types
 - Coastal
 - Open ocean

Coastal Polynyas

- Mechanically driven
 - Kept ice-free by offshore winds
- Strong sea ice formation, brine rejection
 - Important for AABW formation

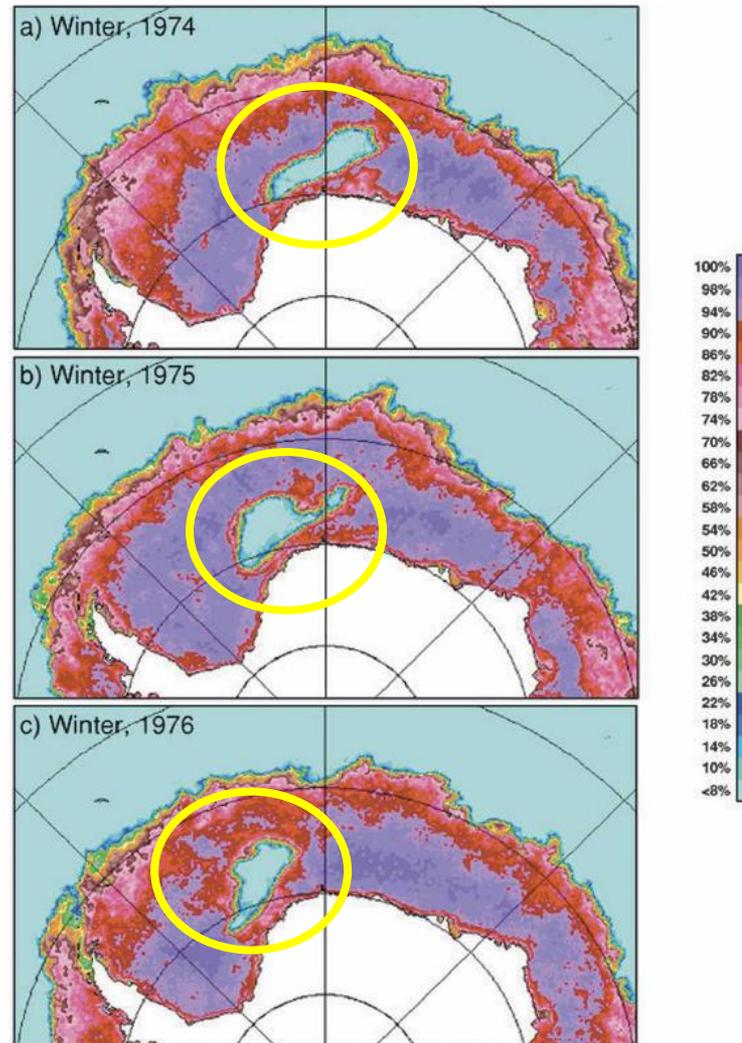
Coastal Polynyas: Ross Sea



Open Ocean Polynyas

- Thermally driven
 - Kept ice-free by ocean heat supply
- Mechanisms
 - Deep convection
 - Tap into warm Weddell Sea Deep Water
 - Weddell Polynya (e.g. Martinson et al. 1981)
 - Ekman suction
 - Passing low-pressure systems
 - Cosmonaut Polynya (e.g. Bailey et al. 2004)

Weddell Polynya



Gordon et al. 2007

Weddell Polynya: Relevance

- Weddell Polynya simulated in many models
 - Sensitive to **model** details
 - Sensitive to **configuration** details
 - How does this influence simulated climate state, biases?
- Is Weddell polynya gone for good?
 - Or is it part of multidecadal cycle?
 - What is its legacy?
- Will Arctic become an ocean with polynyas?
 - Can heat from Atlantic Water layer be tapped?

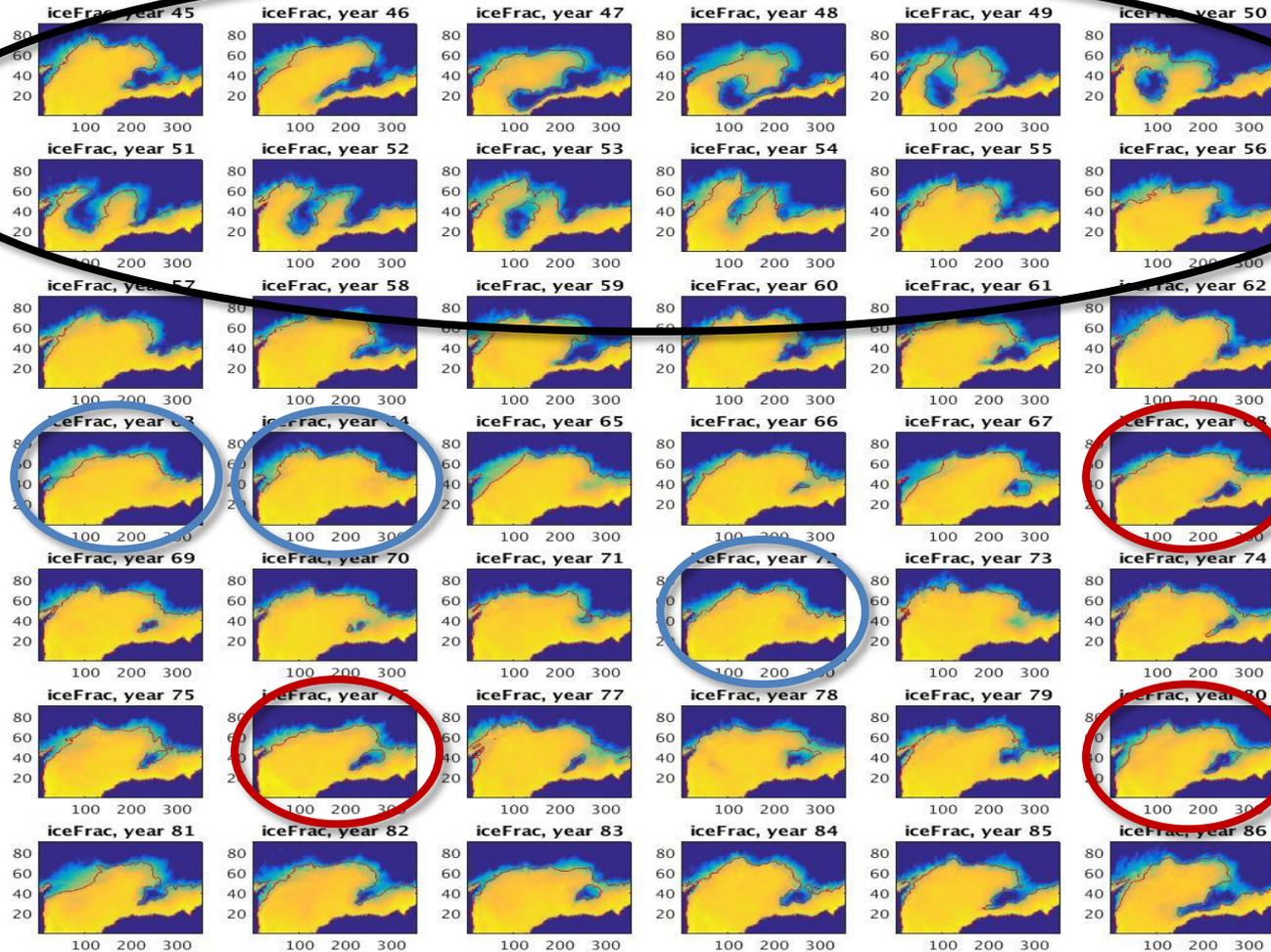
Weddell Polynya: Impacts

- Ocean
 - Heat exchange, brine release
 - Bottom water formation, ventilation of the abyss
 - Sequestration of CO₂, etc.
 - Upwelling of nutrients, biological productivity
- Atmosphere?
 - Heat budget?
 - Radiation balance?
 - Regional or large-scale circulation?

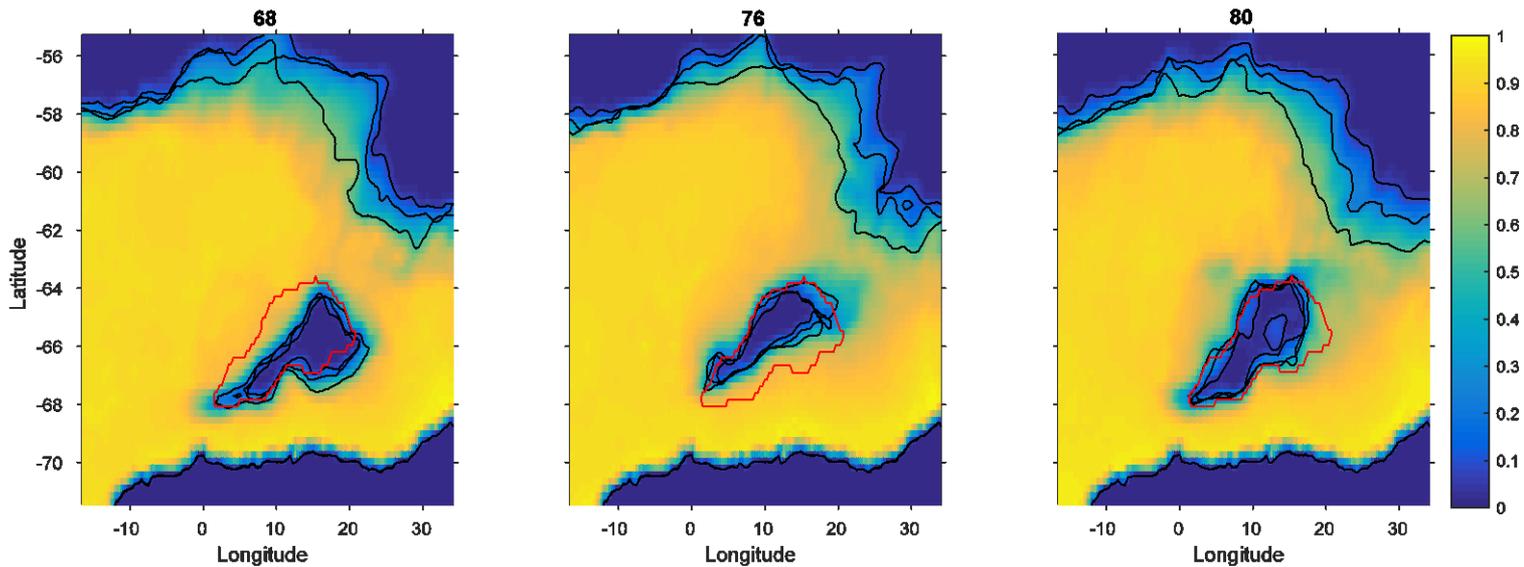
Weddell Polynya: This Study

- Uses NCAR's high-resolution CESM1 simulation
 - “ASD run”
 - Justin Small, Frank Bryan and colleagues (JAMES 2014)
 - CAM5: 0.25°
 - POP2 + CICE4: 0.1°

Sea Ice Distribution

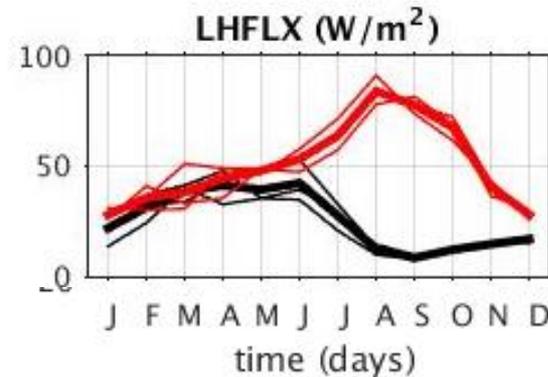
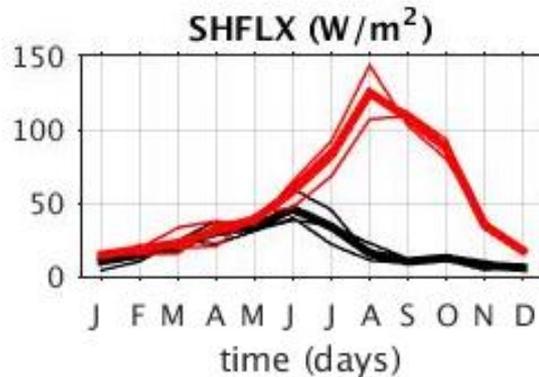
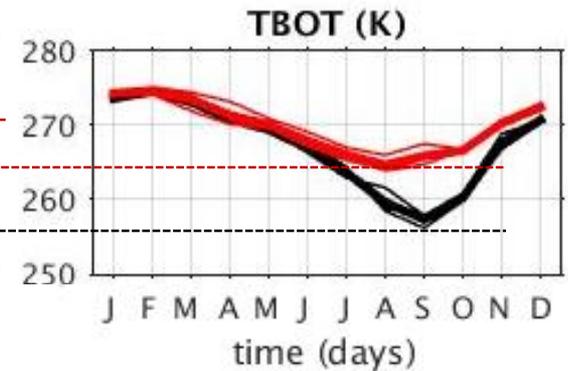
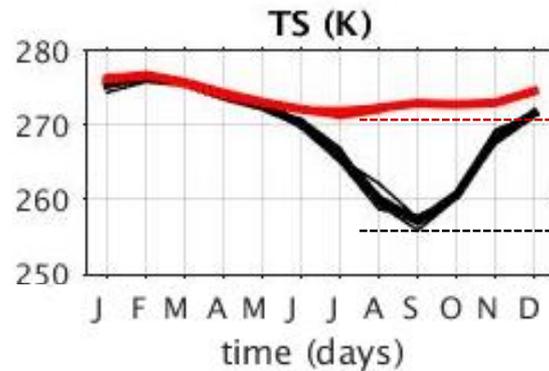
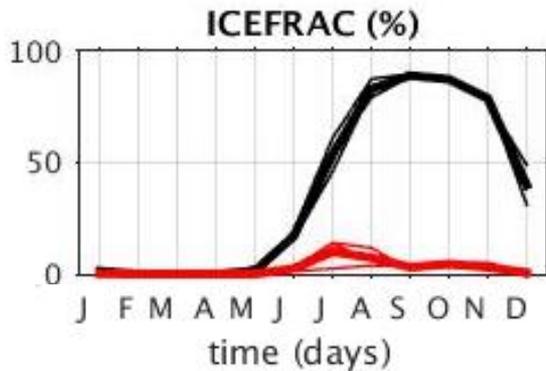


The Chosen Few



Black lines: ice edge (15%) for Aug, Sep, Oct
Red line: “polynya mask” for non-polynya years

Time Series: Turbulent Heat Fluxes

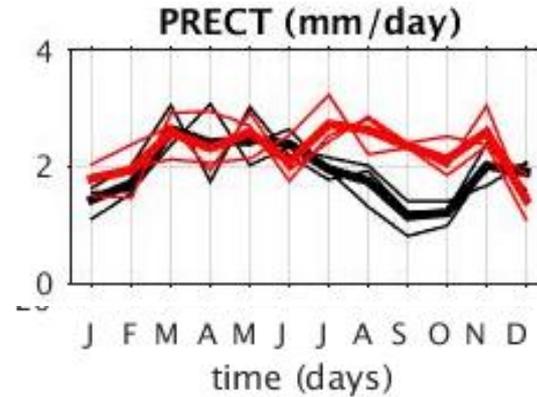
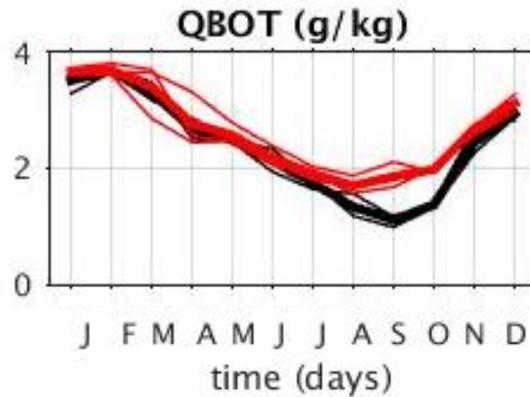


Polynya years
Non-polynya years

+100 W/m²

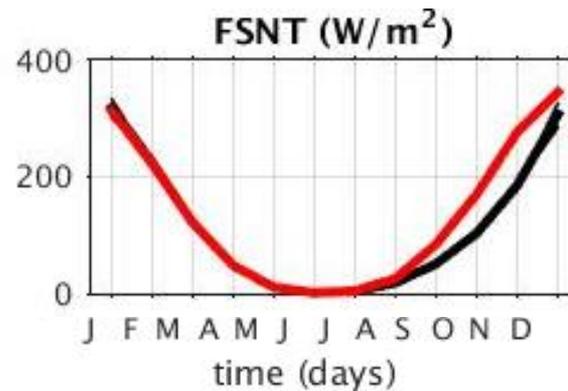
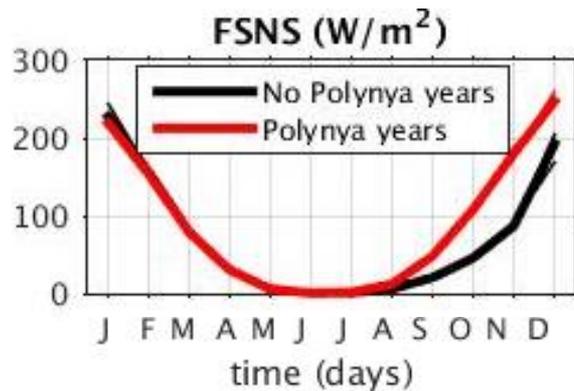
+70 W/m²

Time Series: Precipitation



Polynya years
Non-polynya years

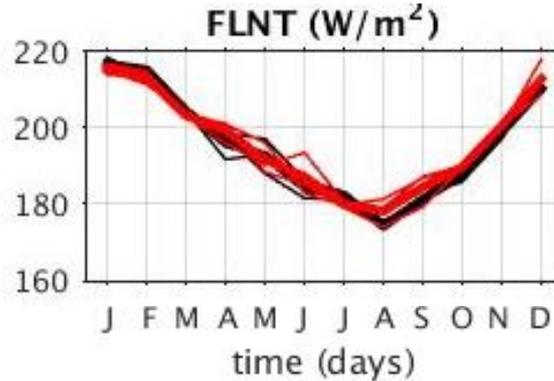
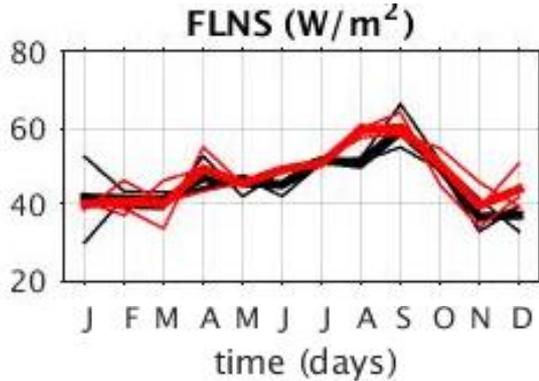
Time Series: Shortwave Radiation



Polynya years

Non-polynya years

Time Series: Longwave Radiation

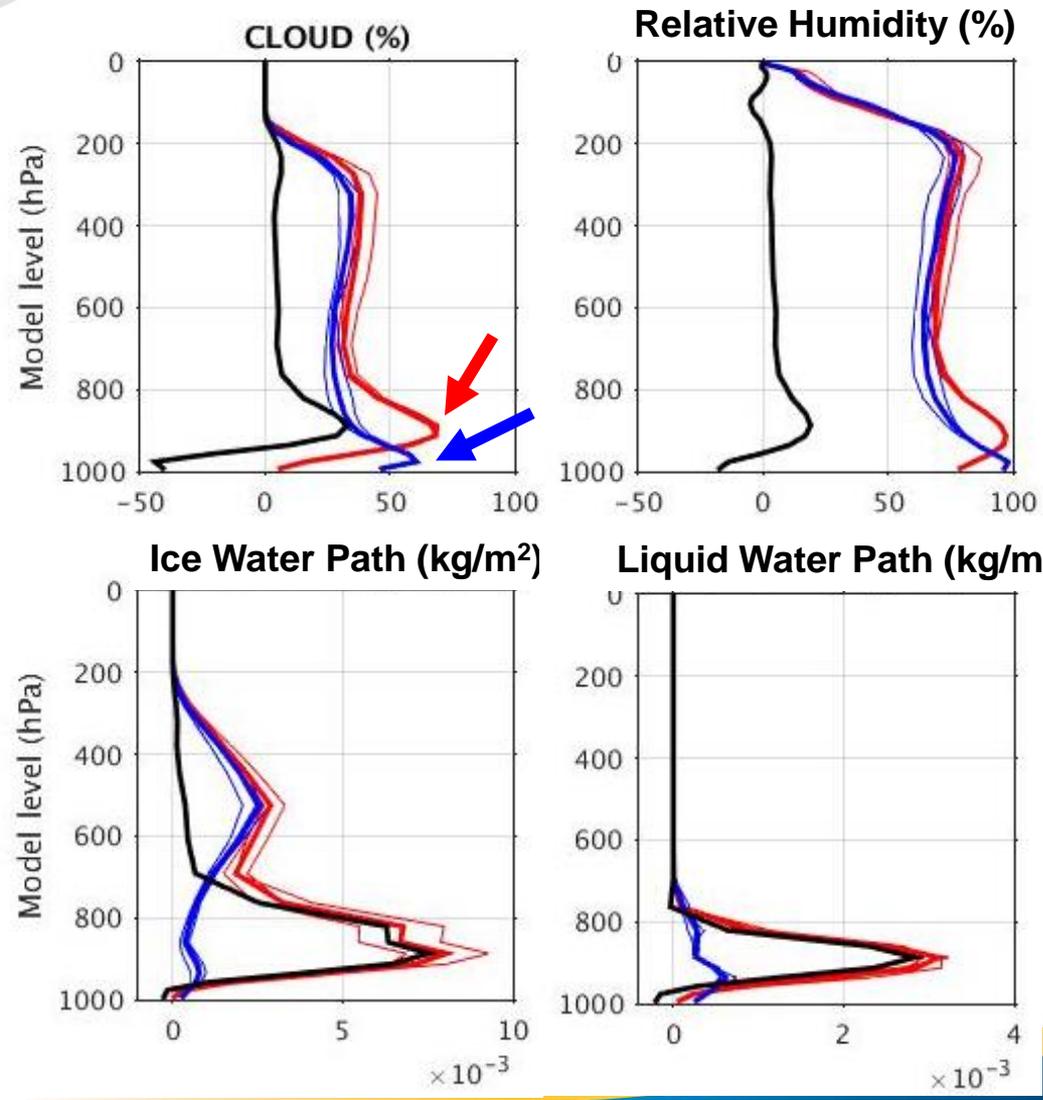


Polynya years

Non-polynya years

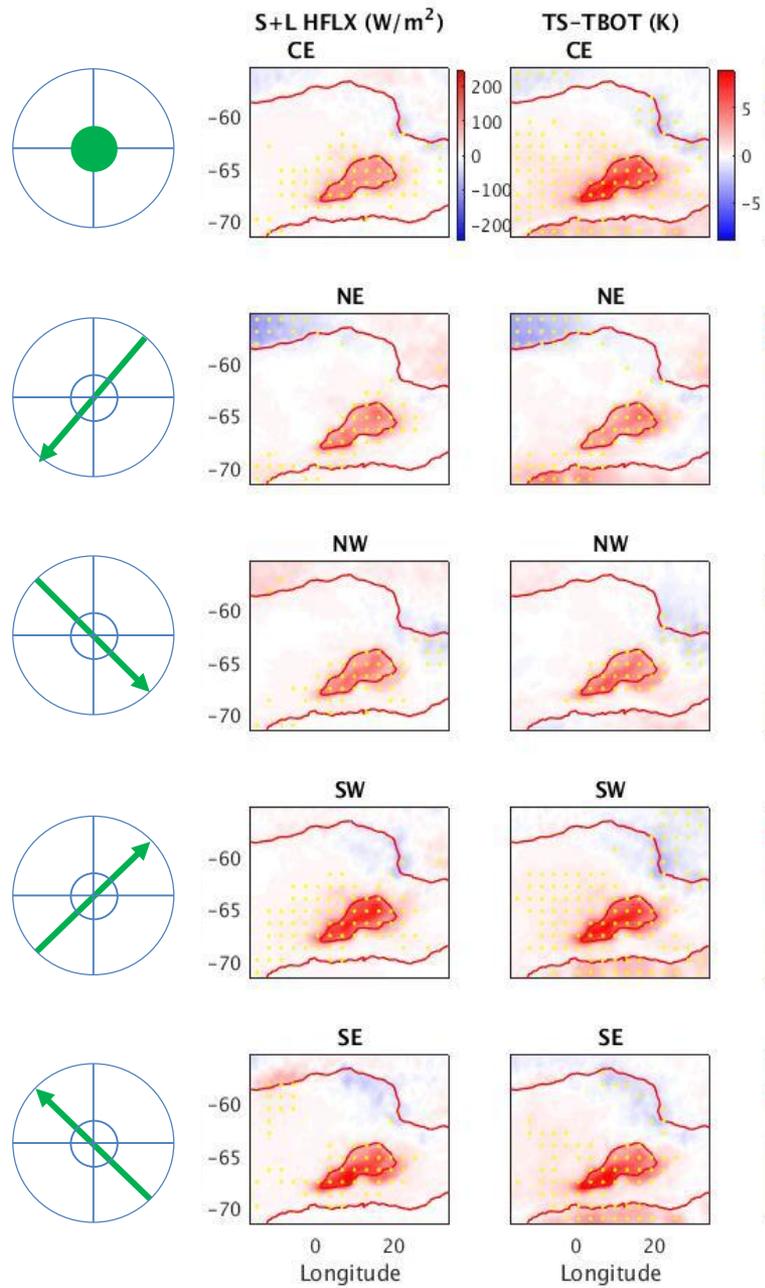
Vertical Profiles

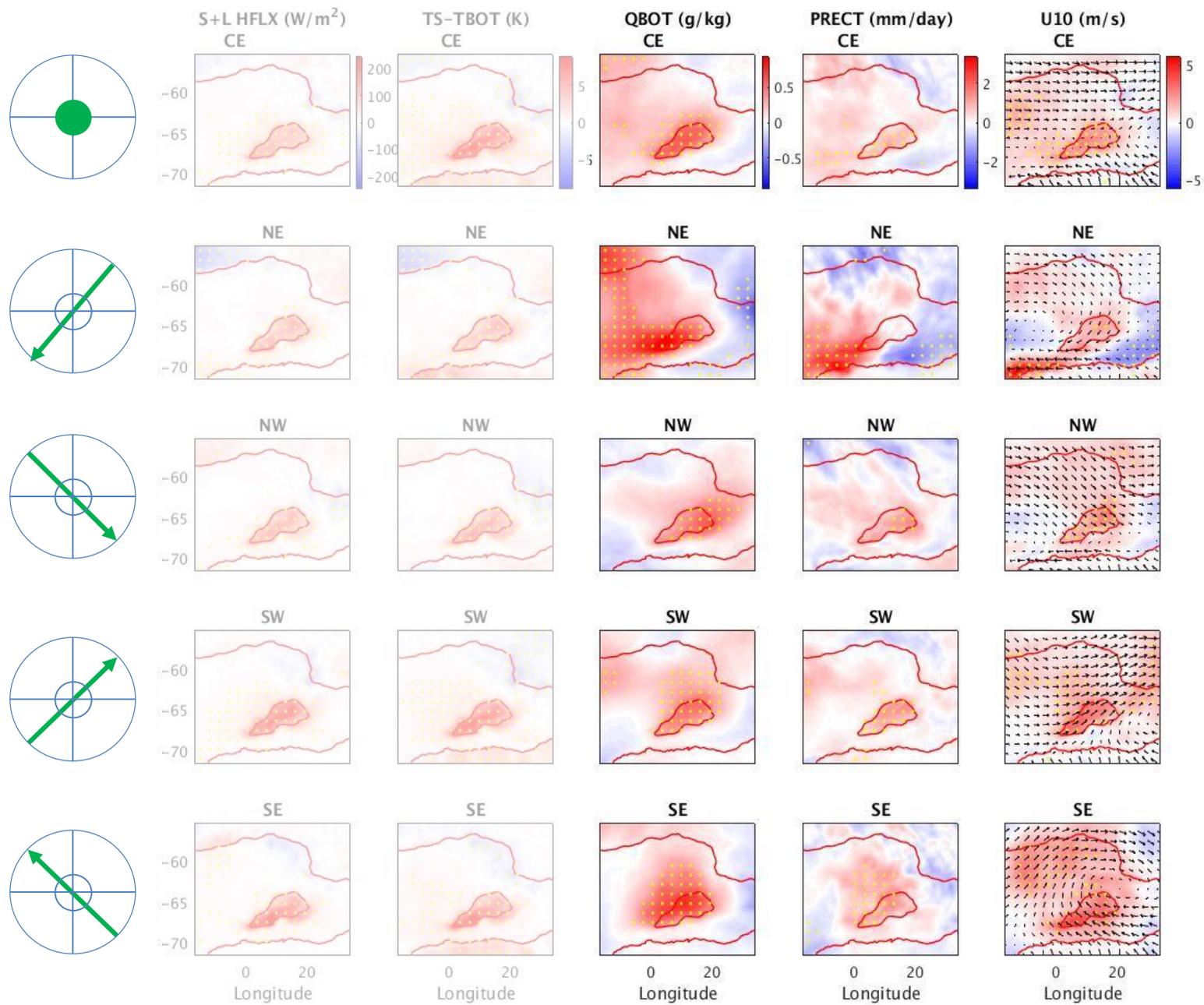
Polynya years
Non-polynya years
Pol – non-Pol

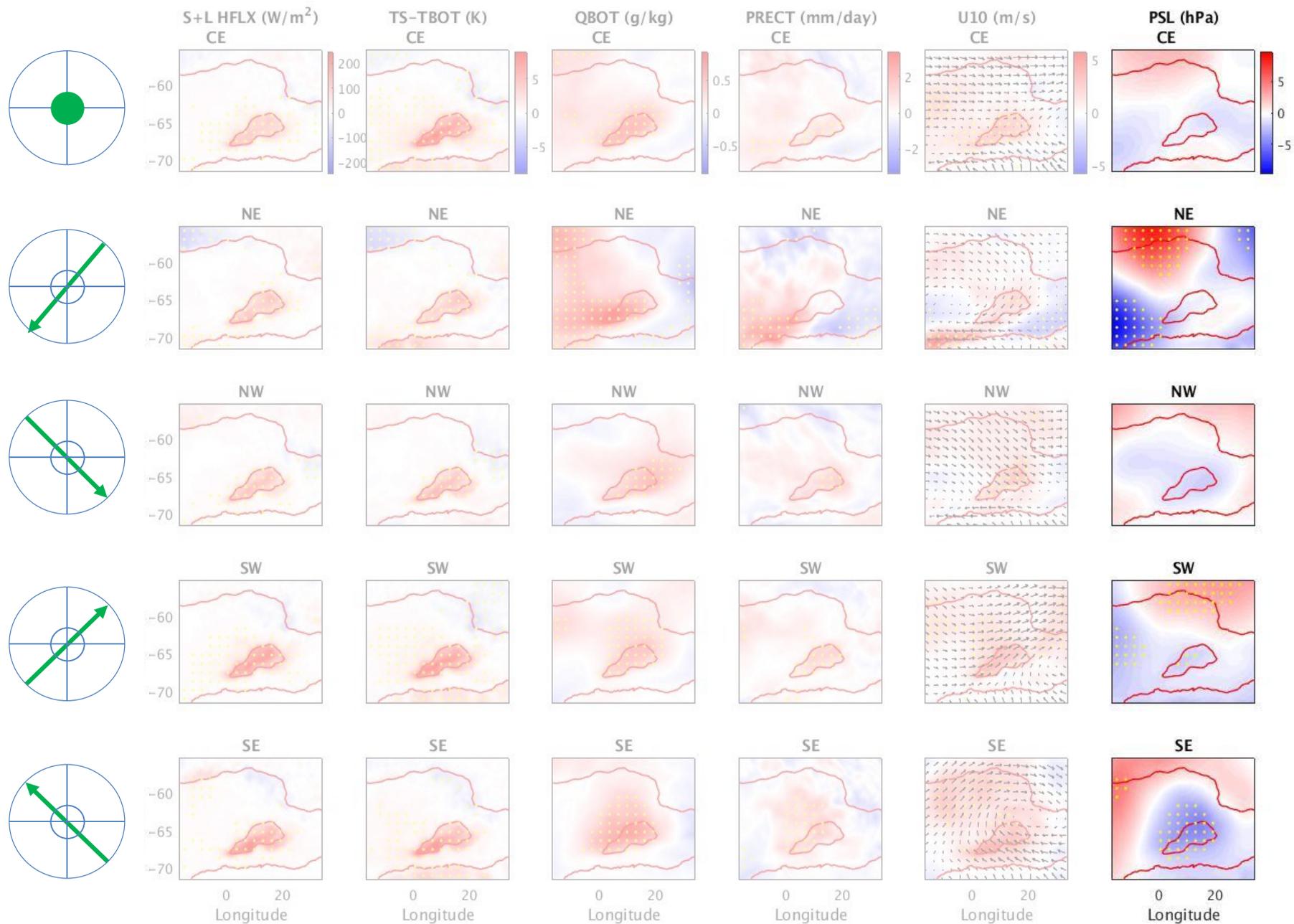


Directional Analysis

- Does atmospheric response depend on wind direction or strength?
 - Use available **daily-averaged** data
 - Stratify according to **wind direction**







Conclusions

- The Weddell Polynya has a **strong** impact on
 - Turbulent heat fluxes
 - Wind speed
 - Humidity and precipitation
 - Shortwave radiative balance
 - lower albedo
- The Weddell Polynya has a **weak** impact on
 - Sea level pressure
 - Dipole structure for NE
 - Thermal Low for SE & SW only
- The Weddell Polynya has **no** impact on
 - Net longwave balance
 - Increased upwelling counteracted by downwelling longwave fluxes
 - Moist cloud deck

Future Directions

- Analyze **generation** and **maintenance** of Weddell Polynya in ACMEv0
 - High resolution
 - 3 years' worth of daily data