Atmospheric River during MOSAiC in Mid-November 2019: Impact on the Surface Energy Budget

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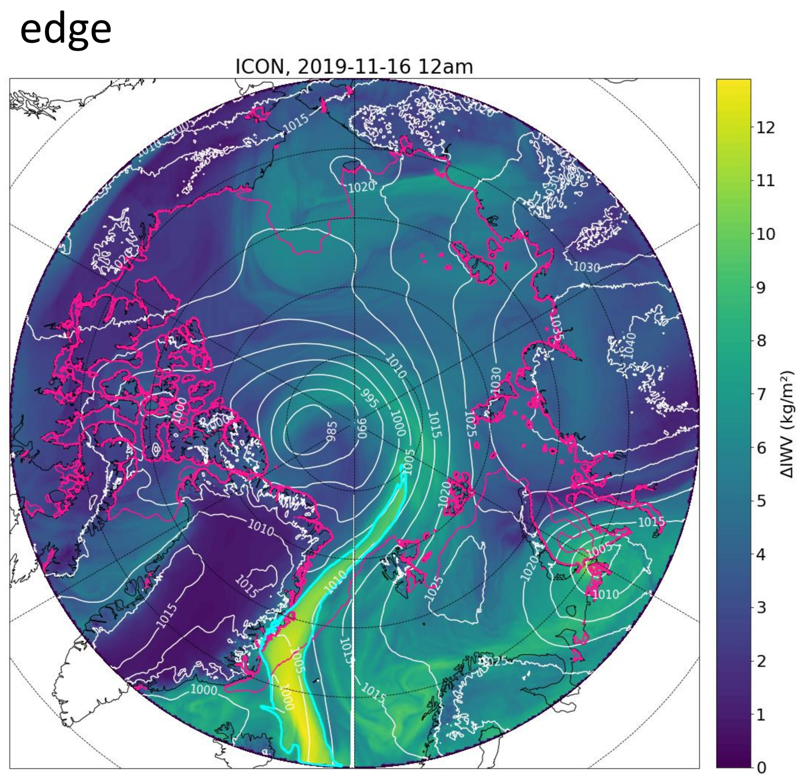
1. Introduction & Motivation

- Majority of poleward moisture transport occurs via Atmospheric Rivers (ARs)
- ARs are long, narrow structures that carry anomalously large amounts of water vapor and heat from the lower latitudes towards the polar regions
- Earlier studies show that ARs impact the surface energy budget (SEB) by increased sensible heat and downward longwave radiation [1,2] and can trigger melting events in the Greenland ice sheet interior [3] as well as tropospheric heating over Arctic sea ice [4]

3. AR in November 2019 – Characteristics & SEB

Synoptic Situation & Cross-Section of AR

- Moisture intrusion during the period from 2019-11-15, 00UTC to about 2019-11-16, 21UTC, driven by low pressure system north of Greenland, with extensive high-pressure blocking to the east
- The layer of moisture maximum stays shallow (<500m ASL) when AR flows over the sea ice edge



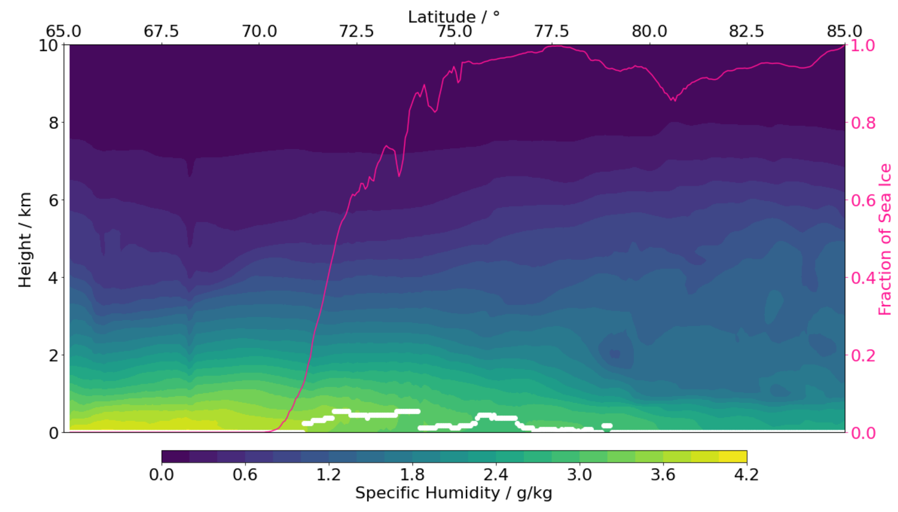


Fig 1: (left): IWV on 2019-11-16 at 12UTC. Pink: sea ice edge, cyan: detected shape of AR, white: mean sea level pressure (hPa). (top): vertical cross-section of mean specific humidity along the AR shape on 2019-11-16 at 12UTC. Pink: fraction of sea ice (average), white: height of maximum specific humidity.

Climatological Context of the Event

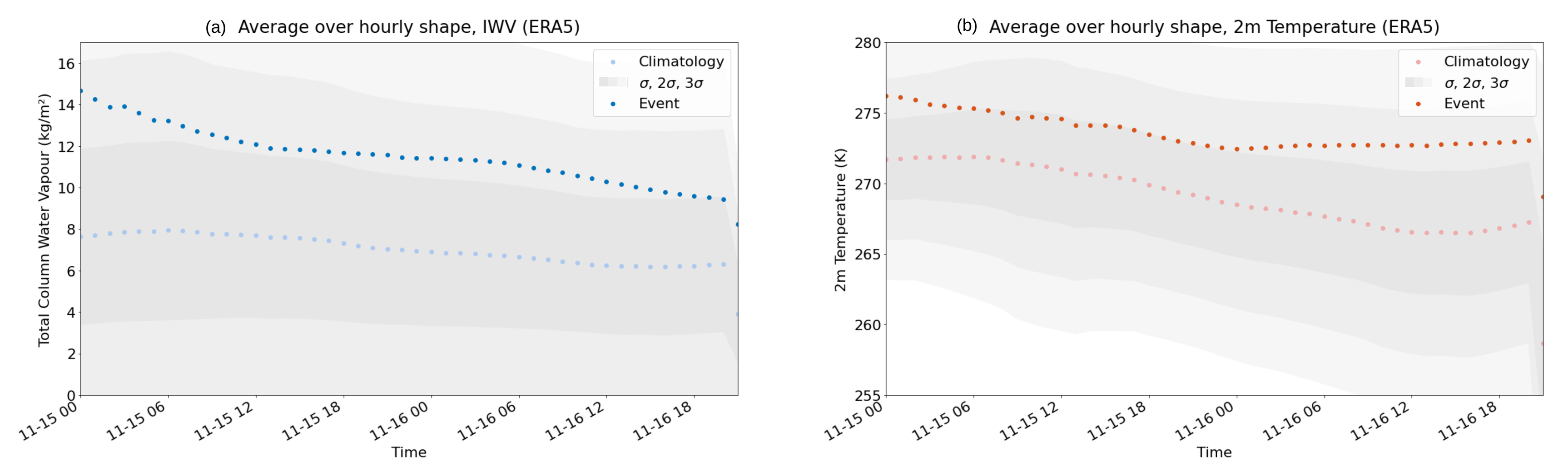


Fig 2: Climatological context of the events (a) integrated water vapor and (b) 2m temperature of the event. Values are averages over the hourly AR shape as detected by the algorithm using ICON data of the event. Darker color: event (ERA5), light color: climatology (ERA5). Grey ranges denote σ, 2σ and 3σ range.

Surface Fluxes & Energy Budget

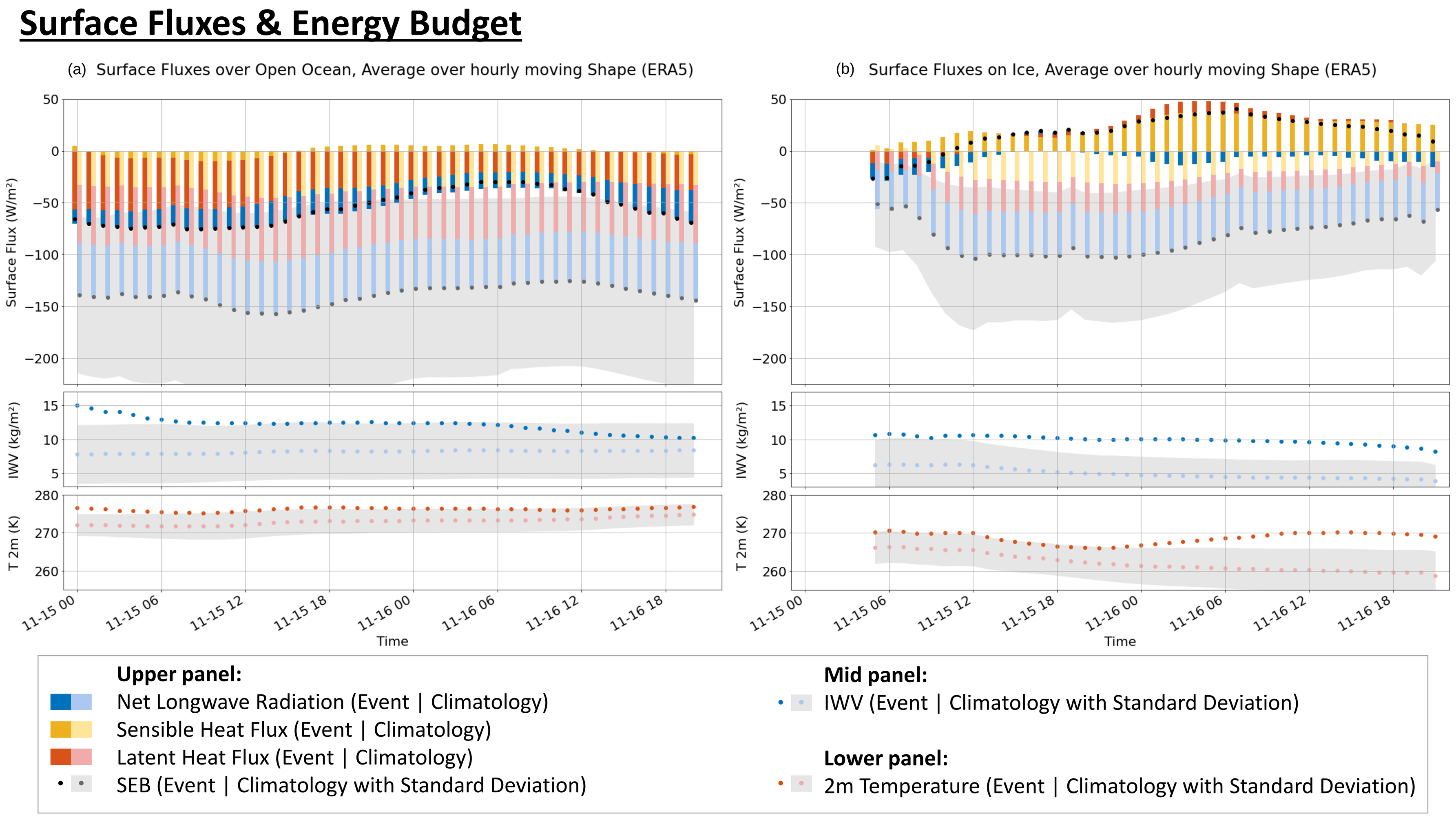


Fig 3: Surface fluxes (upper panels, positive downward), integrated water vapor (middle panels) and 2m temperature (lower panels), averaged over the hourly, moving shape of the AR; as detected by the algorithm. Shape is divided into (a) over open ocean and (b) on ice.
Darker colors: event (ERA5), light colors: climatology (ERA5). Gray range denotes the standard deviation of the parameters, respectively.

2. Methodology

Datasets:

- ERA5 reanalysis for comparison with climatology (1979-2021)
- ICON-LAM simulations (driven by ICON Global) for sensitivity studies with 6km horizontal resolution [5], applied over the circum-Arctic domain (>65°N)

Detection of AR:

Via algorithm presented by Gorodetskaya et al [6] using a threshold on the Integrated Water Vapor (IWV) amount and before the geometrical criteria application

4. Sensitivity Study: Reduced Moisture

- **Idea:** Simulate similar AR with reduced strength by decreasing moisture inflow at the lateral boundaries
- **Implementation - Experiments with ICON-LAM:** Multiply specific humidity at all vertical levels of lateral boundary data (3-hourly) with a constant factor (here: 0.7)

Integrated Water Vapor (IWV)

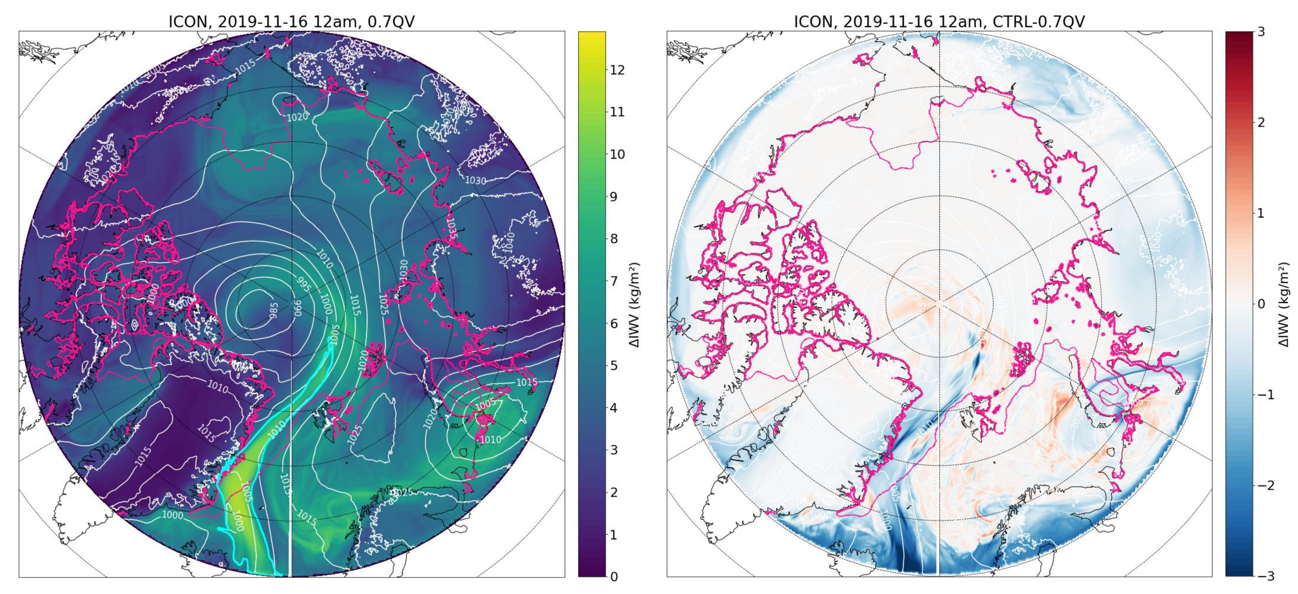


Fig 4: (left): integrated water vapor on 2019-11-16 at 12UTC with reduced humidity in lateral boundaries. Pink: sea ice edge, cyan: detected shape of AR, white: mean sea level pressure (hPa). (right): difference in IWV between control run (event) and experiment.

Surface Fluxes & Energy Budget

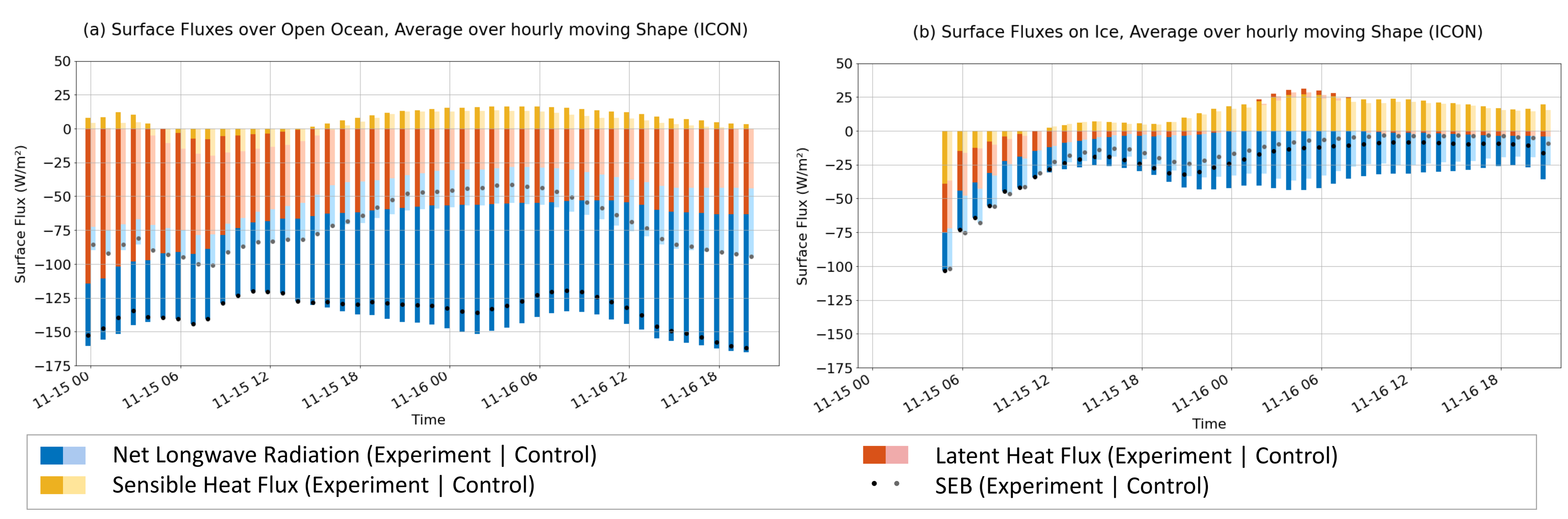


Fig 5: Surface fluxes averaged over the hourly, moving shape of the AR; as detected by the algorithm using ICON data of the event (control run). Shape is divided into (a) over open ocean and (b) on ice. Darker colors: experiment, light colors: control run.

5. Conclusions

- Event shows a **less negative SEB (i.e. less energy loss) over ocean** and even a change from negative to **positive SEB over sea ice**.
- The main contribution to the positive SEB over sea ice is a **positive downward surface sensible heat flux**
- **Reducing the AR strength (moisture) causes a reduced impact on SEB**, especially due to **less clouds** over open ocean and **less downward longwave radiation**

6. Outlook

- **Lagrangian Trajectories:** Calculate trajectories for both control run and experiment for enhanced process understanding
- **Further Experiments:**
  - Further experiments with reduced / enhanced humidity
  - Change cloud parameters
- **Climatological examination of ARs regarding their impact on SEB**

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