Precipitation associated with Atmospheric Rivers, Cyclones and Fronts in the Arctic

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Introduction & Motivation

- Poleward moisture transport is often associated with **Atmospheric Rivers** (ARs) which are long, narrow structures
- ARs carry anomalous **huge amounts of water vapor and heat** from the lower latitudes, impact the surface energy budget [1] and produce significant **levels of rain and snow** [2]

- **What is the contribution of atmospheric rivers to total precipitation in the Arctic?**
- **How much precipitation can be attributed to other synoptical features, e.g. cyclones?**

→ Methodology is built by investigating two major field campaigns

Data & Method

- Application of **ERA5 reanalysis** to
  - detect **ARs** using the AR detection algorithm by Guan & Waliser [3]
  - detect **cyclones** [4]
  - identify **warm** and **cold fronts** using thermal front parameter

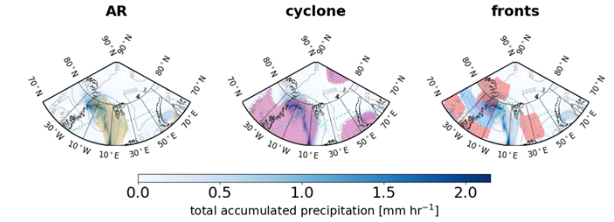

Fig. 1: Total precipitation on 20 March 2019 0 UTC from ERA5 with detected ARs, cyclones and cold (blue) and warm (red) fronts – frontal detection is challenging at high latitudes

Fiel Campaigns

ACLOUD May/June 2017

Total precipitation

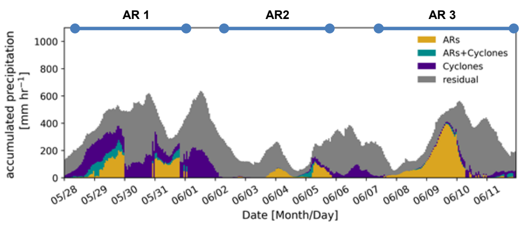

***Fig. 2a**: Time series of total area hourly precipitation rate for **ACLOUD (28 May – 11 June 2017)** for different synoptical features. AR detection periods are marked on top. Area is defined between 70 and 90 N and 50 W to 80 E.*

Snow and rain

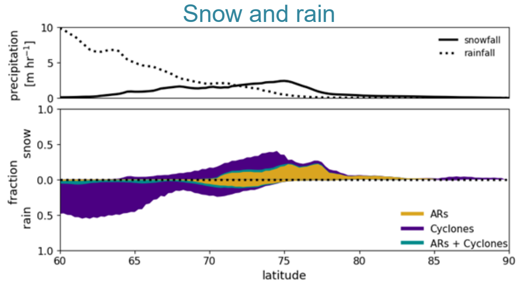

***Fig. 3a: ACLOUD** Top: Meridional dependence of total hourly precipitation rate for snow and rain. Bottom: Meridional distribution of snow and rain fraction by ARs and cyclones.*

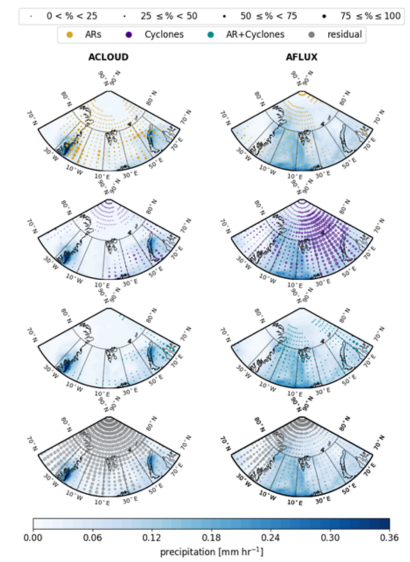

***Fig. 4**: Average hourly precipitation rate for ACLOUD (left) and AFLUX (right). Size of the dots represents the contribution to the total precipitation. From top to bottom ARs (yellow), cyclones (purple), ARs+cyclones (cyan) and residual (grey).*

AFLUX March/April 2019

Total precipitation

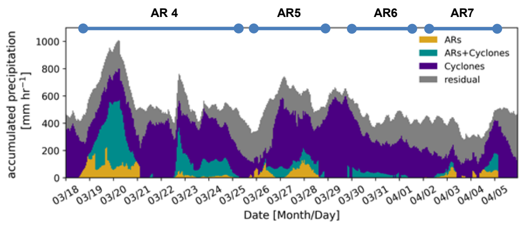

***Fig. 2b**: Time series of total area hourly precipitation rate for **AFLUX (18 March – 5 April 2019)** for different synoptical features. AR detection periods are marked on top. Area is defined between 70 and 90 N and 50 W to 80 E.*

Snow and rain

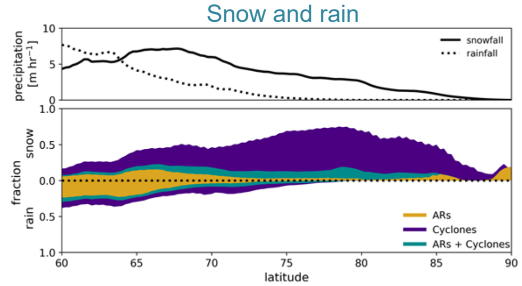

***Fig. 3b: AFLUX** Top: Meridional dependence of total hourly precipitation rate for snow and rain. Bottom: Meridional distribution of snow and rain fraction by ARs and cyclones.*

Differences between ARs

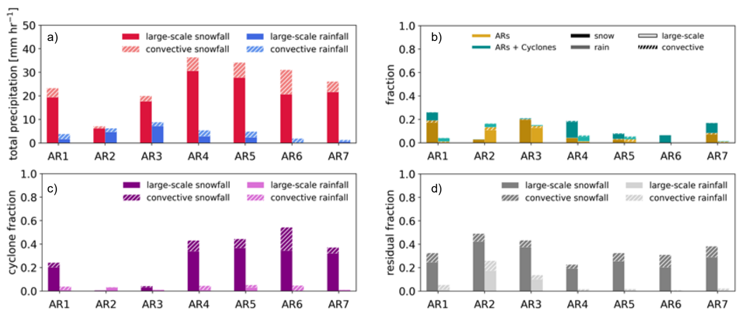

***Fig. 5**: Average hourly precipitation rate for each AR period as shown in Fig. 2. Precipitation is separated into snow and rain, large-scale and convective. a) Total area, b) only AR and AR+cyclone contribution, c) only cyclone contribution and d) residual precipitation not classified as cyclone or AR.*

References:

[1] Bresson, H., A. Rinke, M. Mech, D. Reinert, V. Schemann, K. Ebell, M. Maturilli, C. Viceto, I.V. Gorodetskaya, S. Crewell, *Atmospheric Chemistry and Physics,* (2021)

[2] Viceto, C., I.V. Gorodetskaya, A. Rinke, M. Maturilli, A. Rocha, S. Crewell, *Atmospheric Chemistry and Physics,* (2021)

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[4] Wernli, H., C. Schwierz, JAS, Vol. 63, 2486-2507, (2006)

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Conclusion & Outlook

- Atmospheric rivers (AR) can bring substantial precipitation into the Arctic and dominate total precipitation, e.g. 9 June 2017 (Fig. 2a)
- ARs contribute **19% to the total snowfall** above 70 N during early summer (ACLOUD)
- During early spring (AFLUX) AR contribution is lower (5% of total snowfall) and more effective when combined with cyclones (12% of total snowfall)
- During AFLUX cyclones are the most important source of precipitation (**44 % of total snowfall**)
- Convective precipitation has only a minor role though it slightly varies between cases (Fig.5)
- Large part of the precipitation (63% ACLOUD; 37% AFLUX) is not associated with ARs or cyclones (Fig.4)

- **Frontal detection techniques will be refined, e.g. to identify post-frontal cold air convection**
- **Findings shall be generalized by extending the analysis over entire ERA5 period and complete Arctic**

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