Projections and Physical Drivers of Extreme Precipitation in Greenland & Baffin Bay

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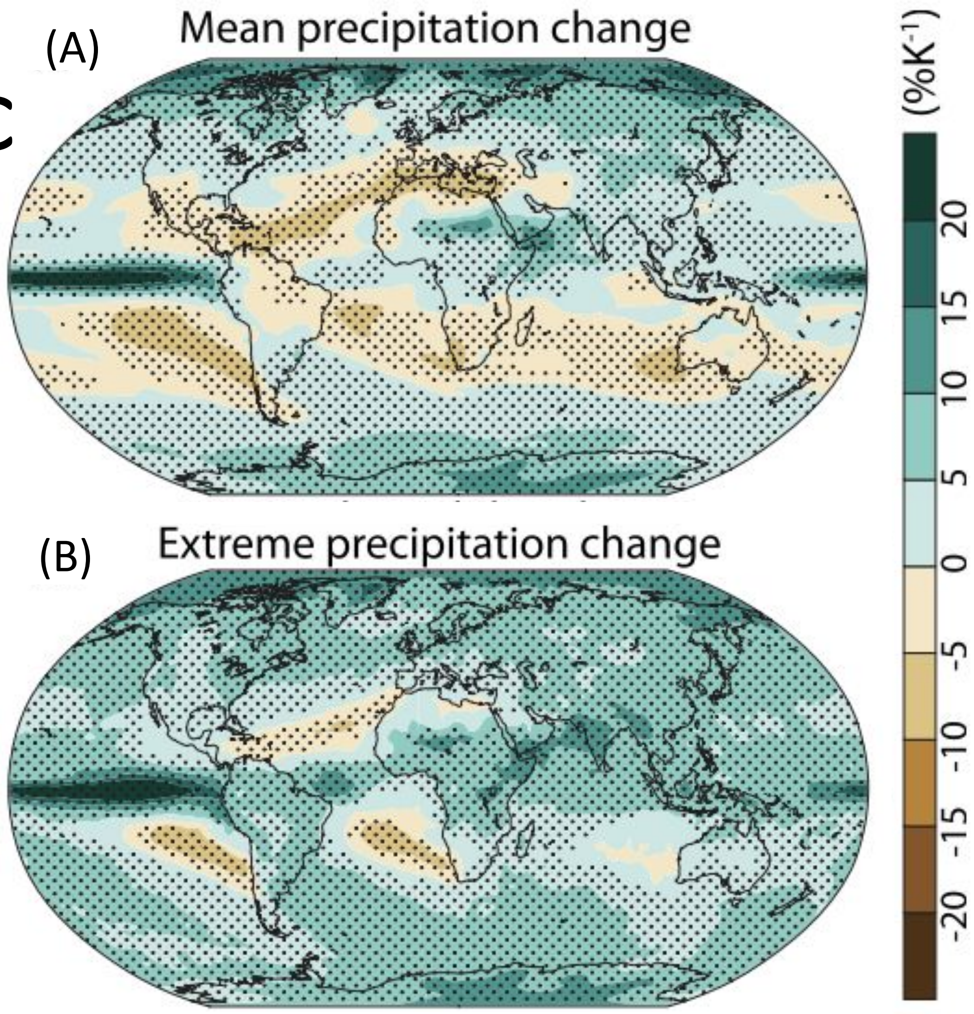
Precipitation in a Changing Arctic

- Slight changes in mean precipitation conditions □ larger shift in extremes

  (e.g., Pendergrass, 2018)

- Substantial impacts on Arctic communities and land ice

  (e.g., Doyle et al., 2015; Ford et al., 2010; Rinke et al., 2012)



(Pendergrass et al., 2017)

Research Questions

1. How does **extreme daily precipitation** change under SSP5-8.5 in the Greenland and Baffin Bay region?
2. Are there changes in **forcing factors**, particularly **extratropical cyclones** and **atmospheric rivers** (ARs) with extreme precipitation?

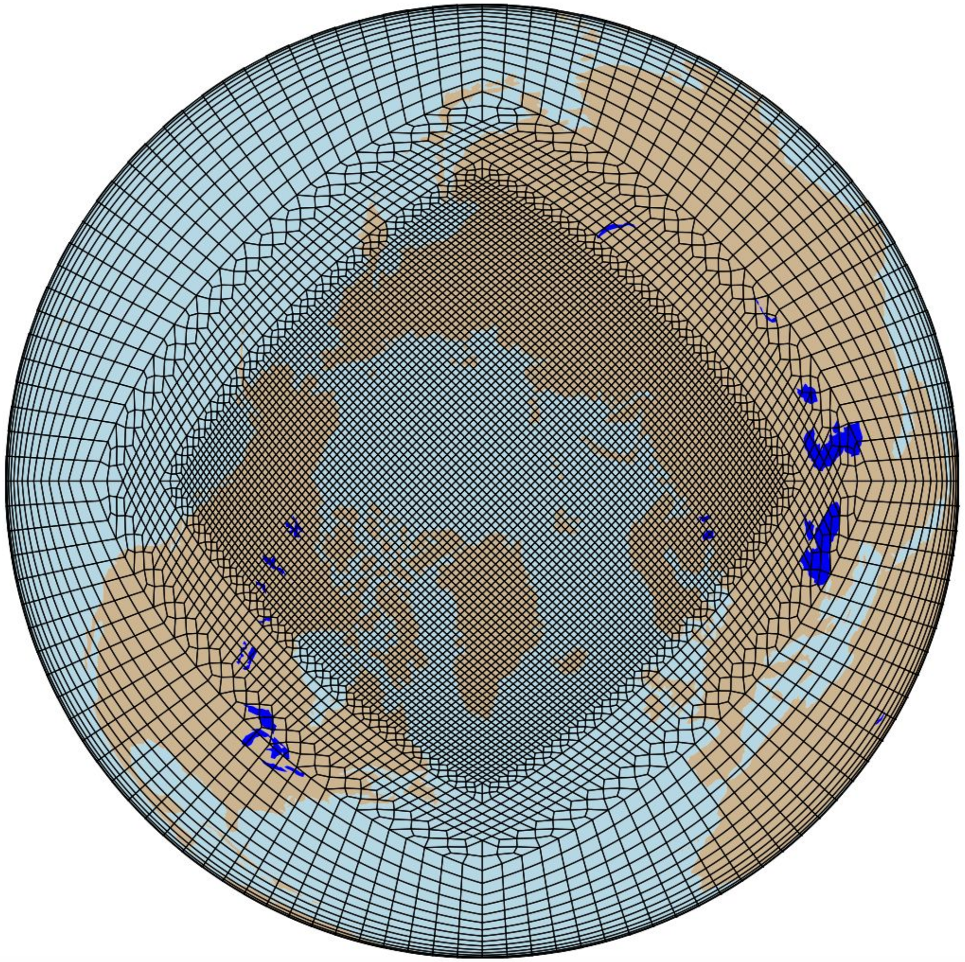
Defining Extreme Events

	Percent of Annual Precipitation	
DEFINITION	**SAN DIEGO, CA, US**	**TROMSØ, NORWAY**
1 day	16%	3.0%
99th percentile	42%	9.5%
98.6 percentile	50%	
95th percentile	89%	32%
90.5 percentile		50%
90th percentile	99%	52%
Wet day 95th (≥1 mm/d)	23%	17%

Extreme event = top 5% of daily accumulations where at least 1 mm was observed

(Pendergrass, 2018)

	Variable-resolution Community Earth System Model (VR-CESM)
Model type	Global earth system model
Spatial resolution	0.25° (~28 km)
Historical simulation	1980-1999 (Herrington et al., 2022)
Future simulation	2080-2100 following SSP5-8.5



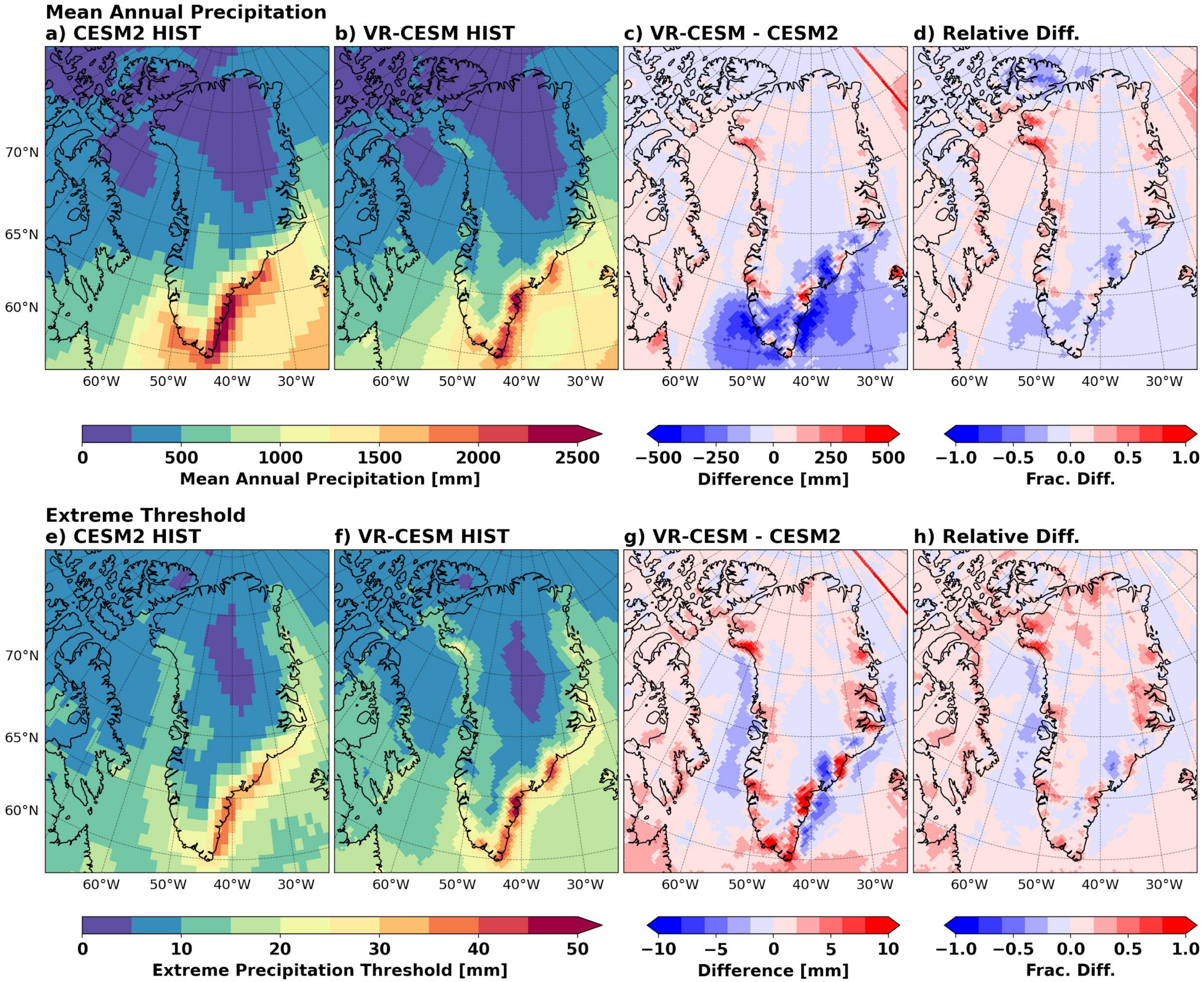
ARCTIC GRID
(Herrington et al., 2022)

Results

Historical Period

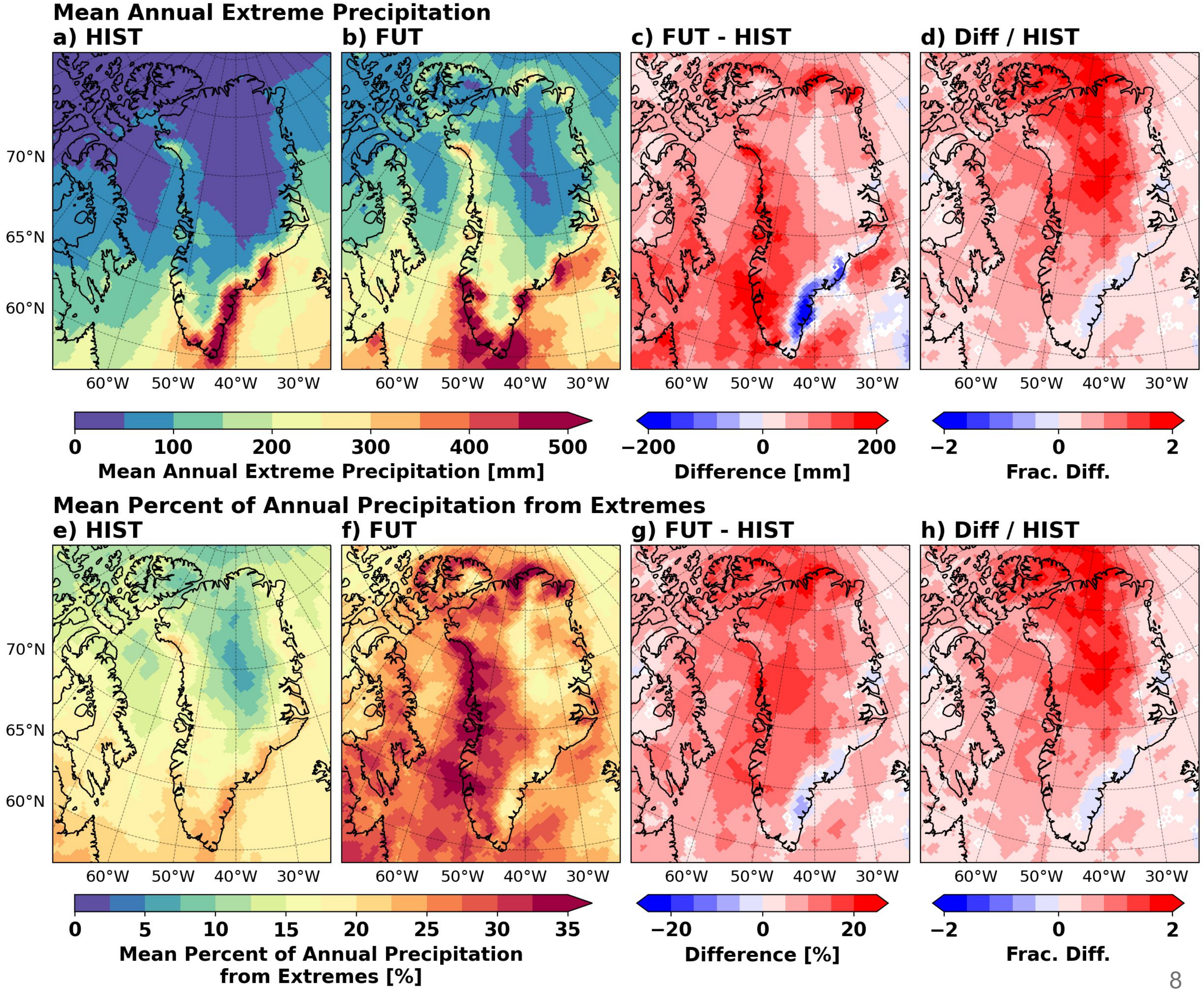
(1980-1999)

- Highest precipitation in SE Greenland
- VR-CESM **refines patterns** seen in CESM2
- Largest differences near **complex topography**
  - e.g., SE Greenland
- VR-CESM agrees more closely with ERA5

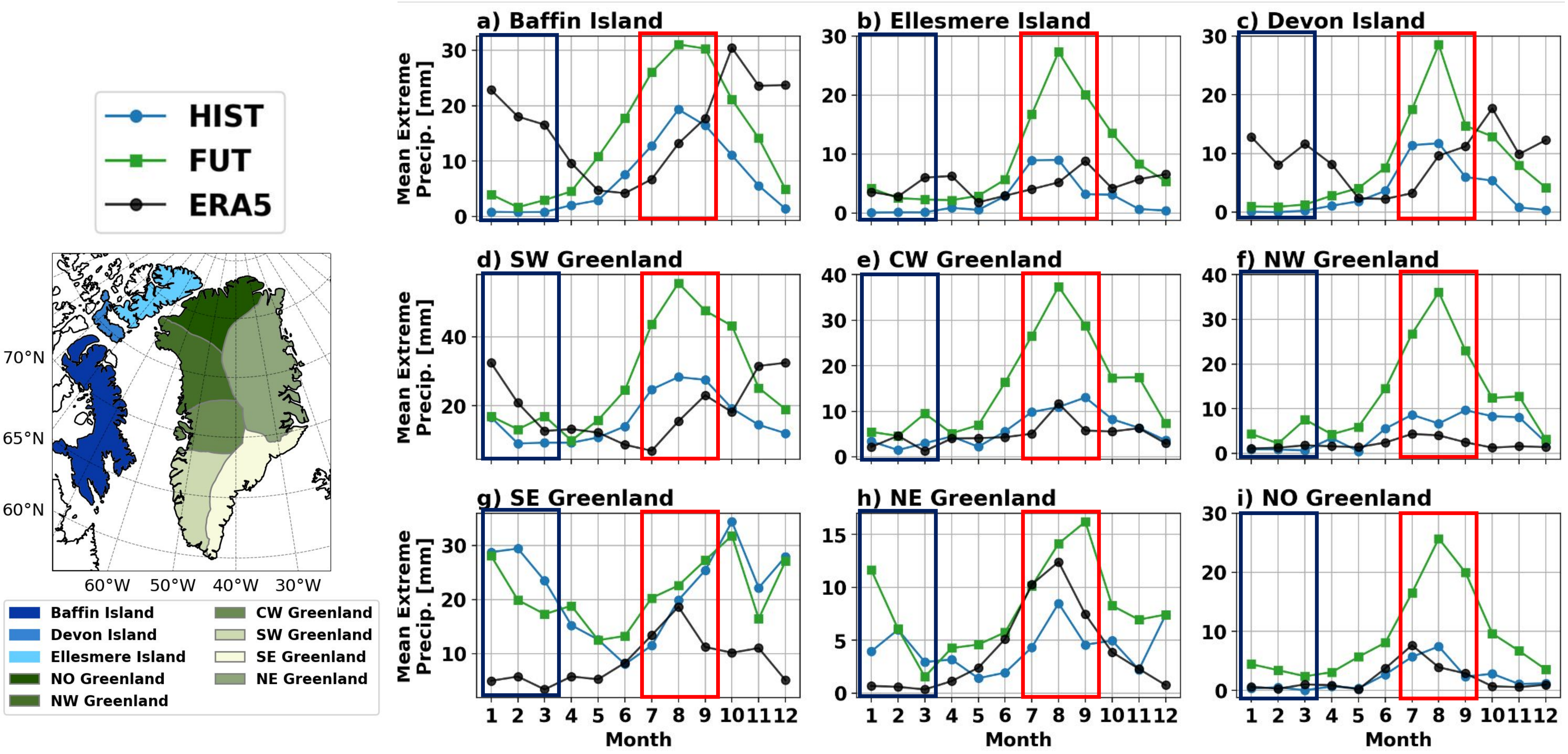


Changes in Extreme Precipitation in VR-CESM

- **Broad increases** in amount of extreme precipitation
  - Largest increases in SW Greenland & Baffin Island
  - Decrease in SE Greenland
- Extremes account for **higher portion of annual precipitation** (outside of SE Greenland)

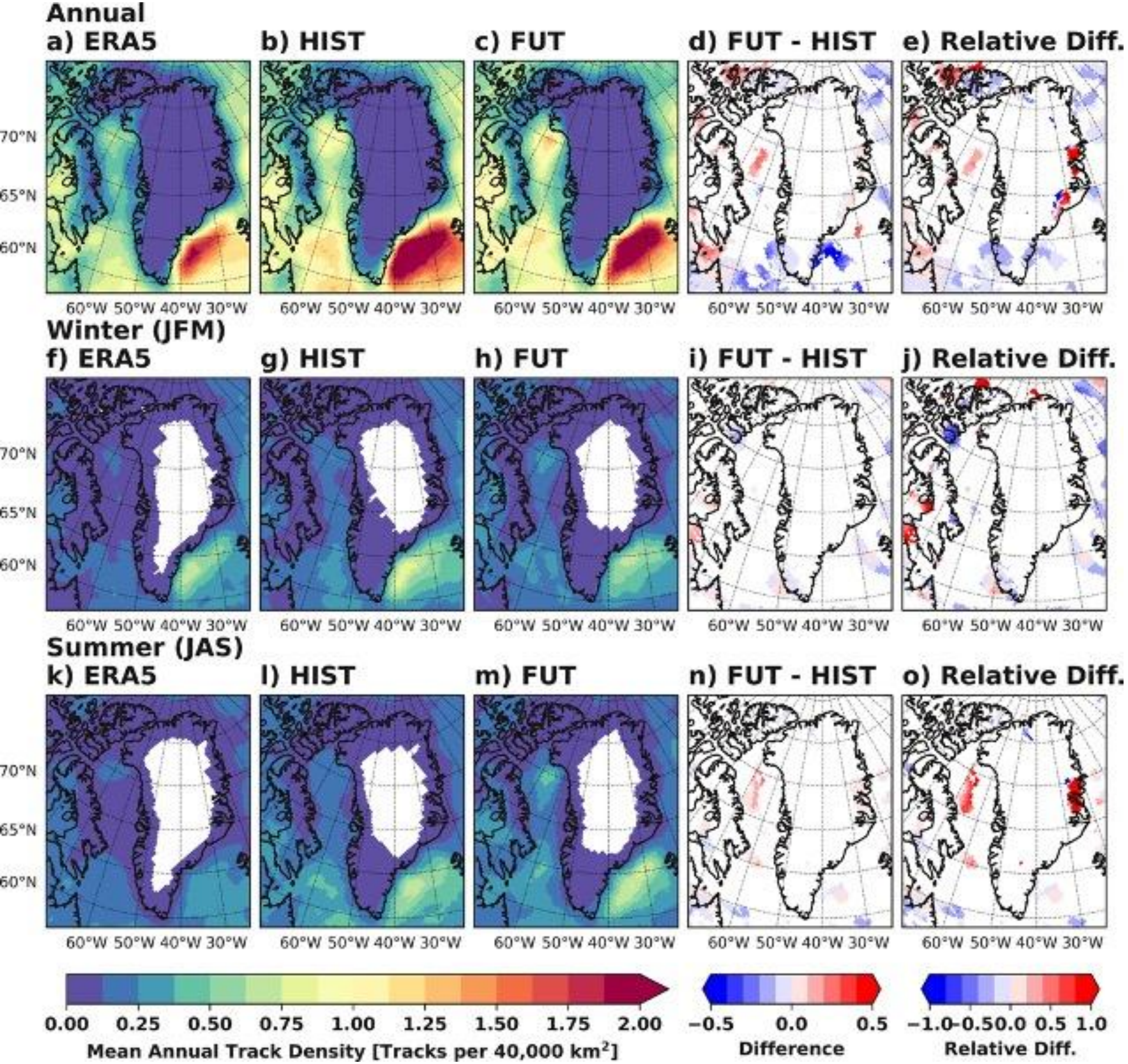


Seasonality and Event Occurrence



Winter vs. **Summer**

Drivers of Extreme Precipitation

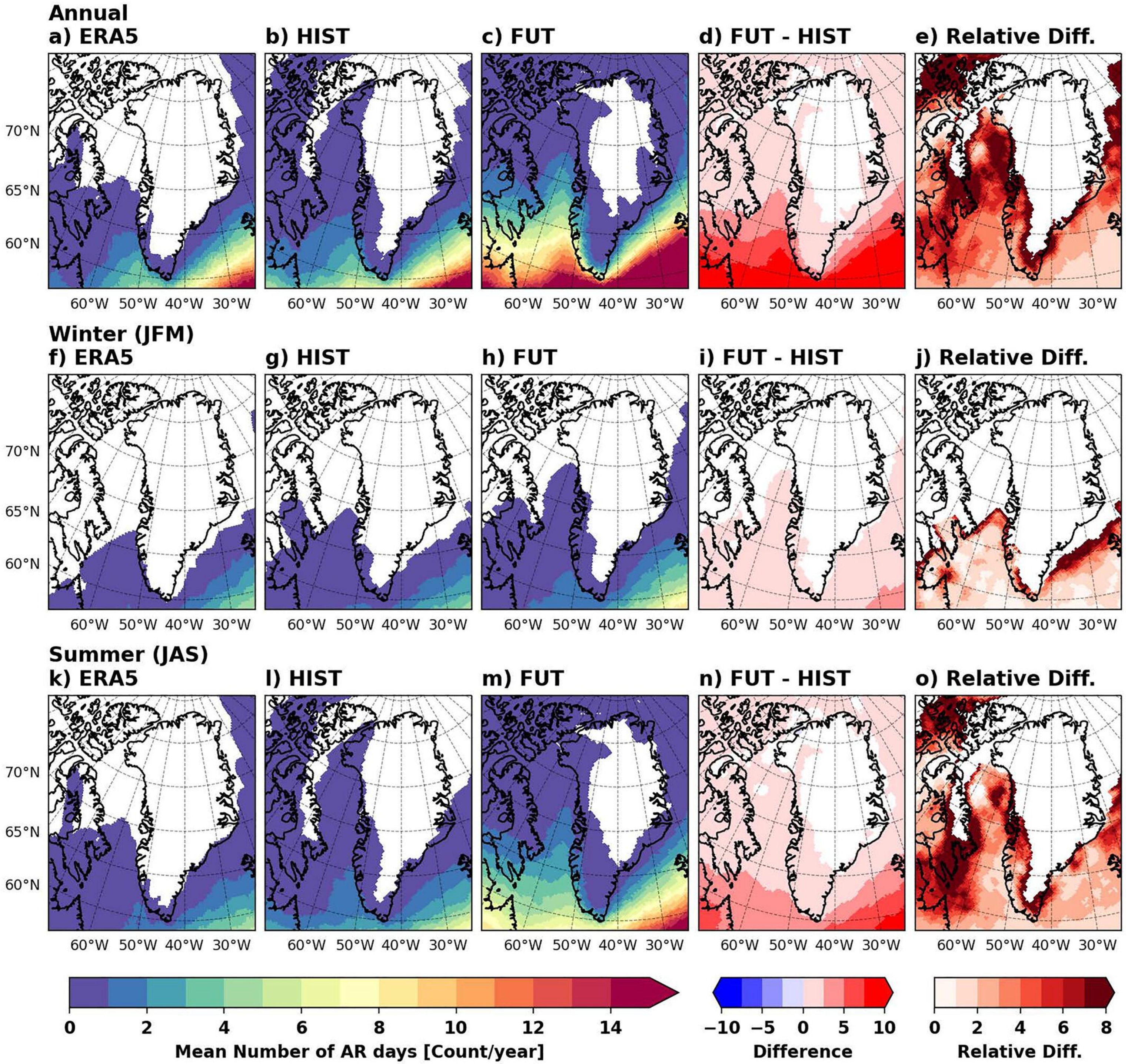


Cyclones

- **Small changes** across most of the domain
- Decreases **southeast of Greenland**
  - Agrees with previous studies

  (e.g., Priestley & Catto, 2022; Yettella & Kay, 2017)
- Summer increases in **northern Baffin Bay**

Detection Algorithm:
Crawford et al. (2021) Lagrangian sea-level pressure-based tracking algorithm



Atmospheric Rivers

- Historically, reach only ~65°N in Greenland/Baffin Bay
- **Northward expansion** in the future
  - Largest increases in summer
  - Largest relative increases in Baffin Island

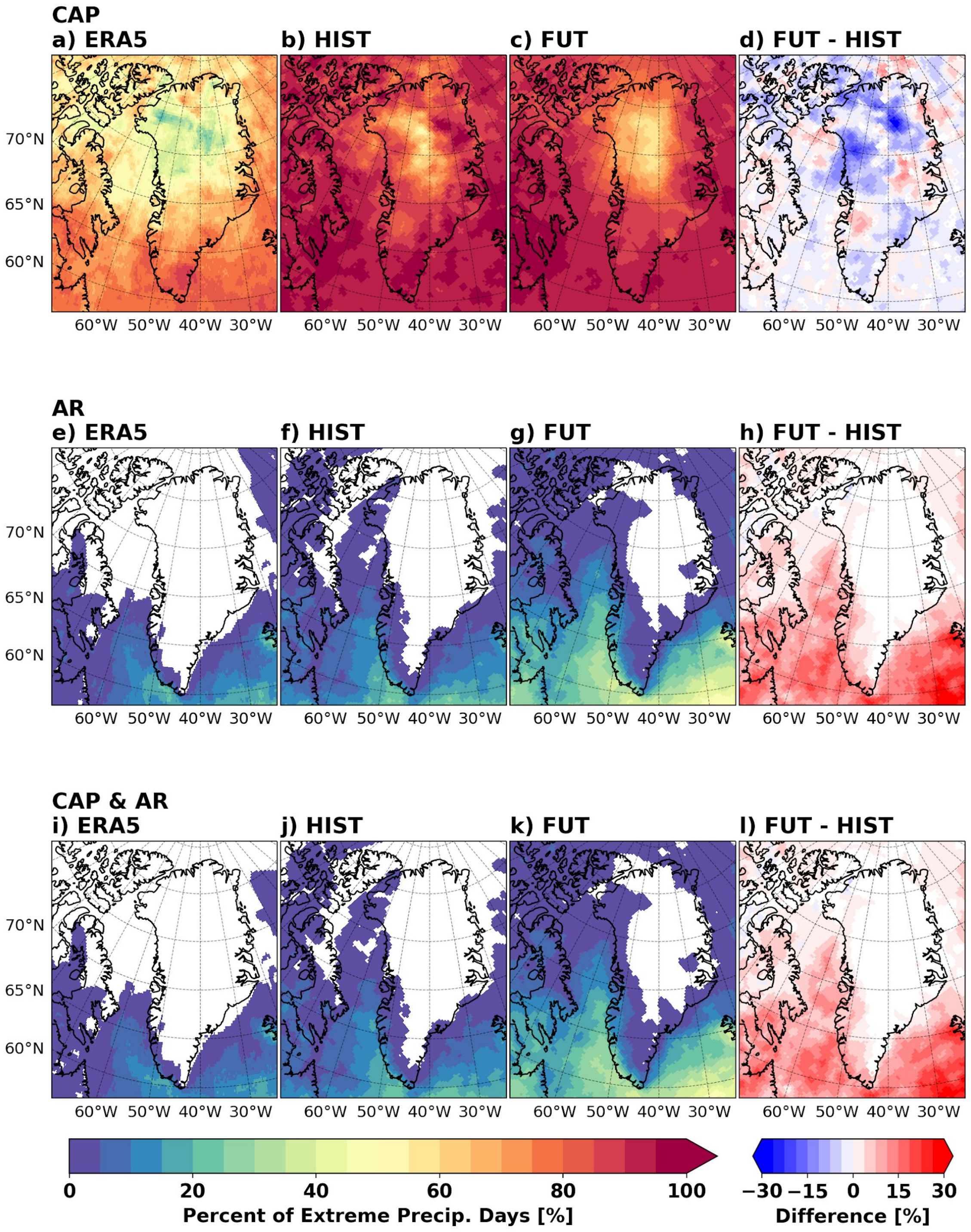
Detection Algorithm:

- TempestExtremes v2.1 *(Ullrich et al., 2021)*
- $\nabla^2 IVT \leq -50{,}000\ kg\ m^{-2}\ s^{-1}\ rad^{-1}$
- Areal extent $\geq$ 566,666 km^2
- Latitude $\geq 20°N$

Drivers of Extremes

Percent of extreme precipitation days associated with cyclones (CAP) and ARs

- Little change in influence of cyclones
  - Slight winter reduction in northern Baffin Bay
- ARs increase across south
  - Largest increase during the summer
- Almost all ARs associated with cyclones



Conclusions

Extreme precipitation rising across domain and accounting for higher portion of annual precipitation

- Decreases seen in Southeastern Greenland

Cyclones are dominant driver of extreme precipitation, but ARs become more important in the future

- ARs increase most in summer

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Thank you for your attention!

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