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PACIFIC CLIMATE IMPACTS CONSORTIUM

HUMAN INFLUENCE ON THE 2021 BC FLOODS

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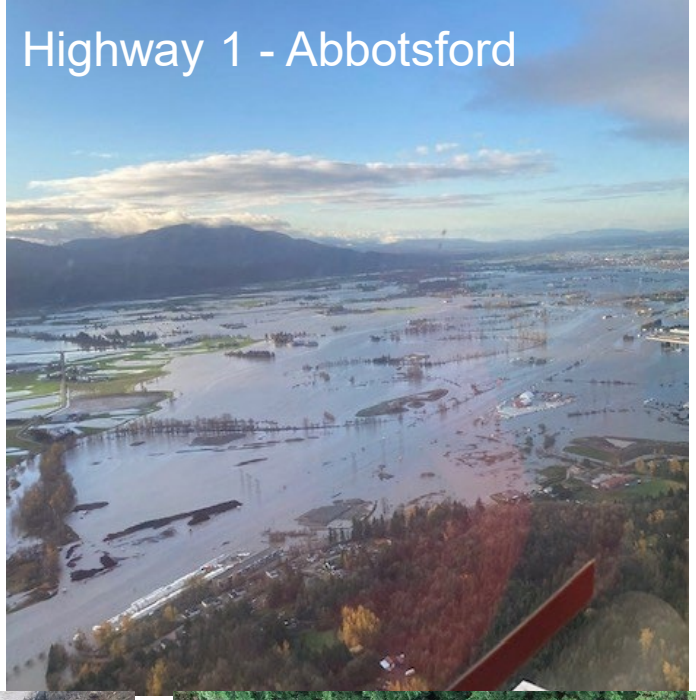
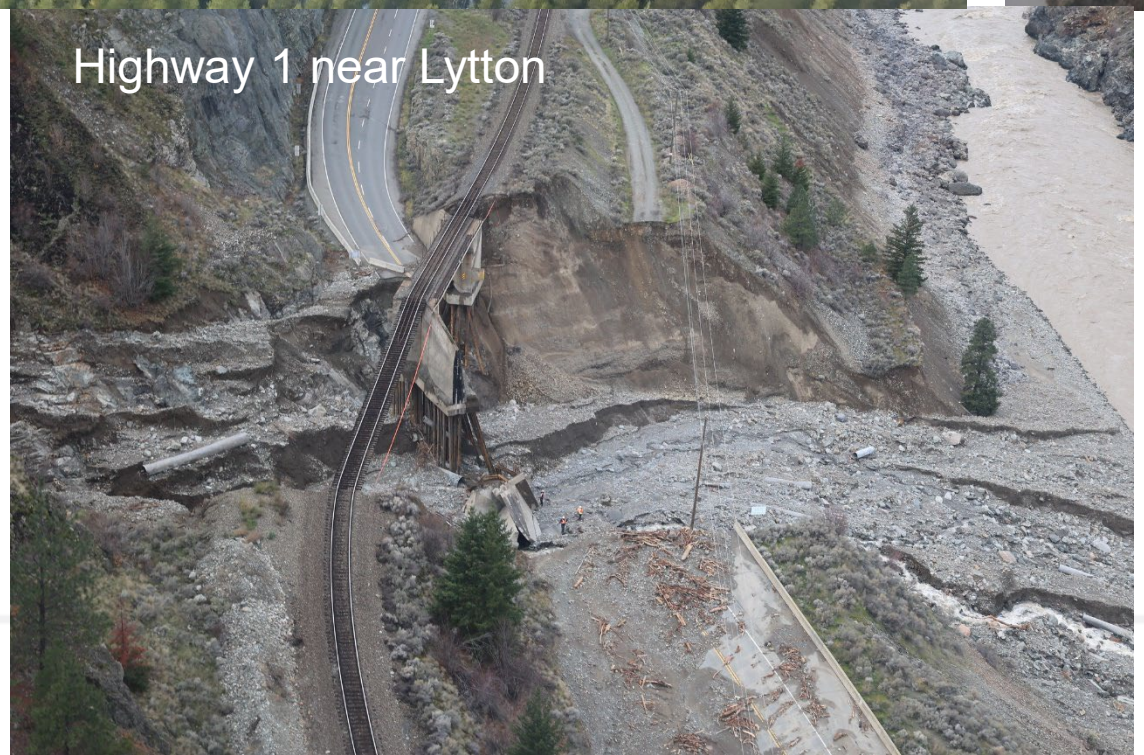
23rd February 2022

Canada

INTRODUCTION

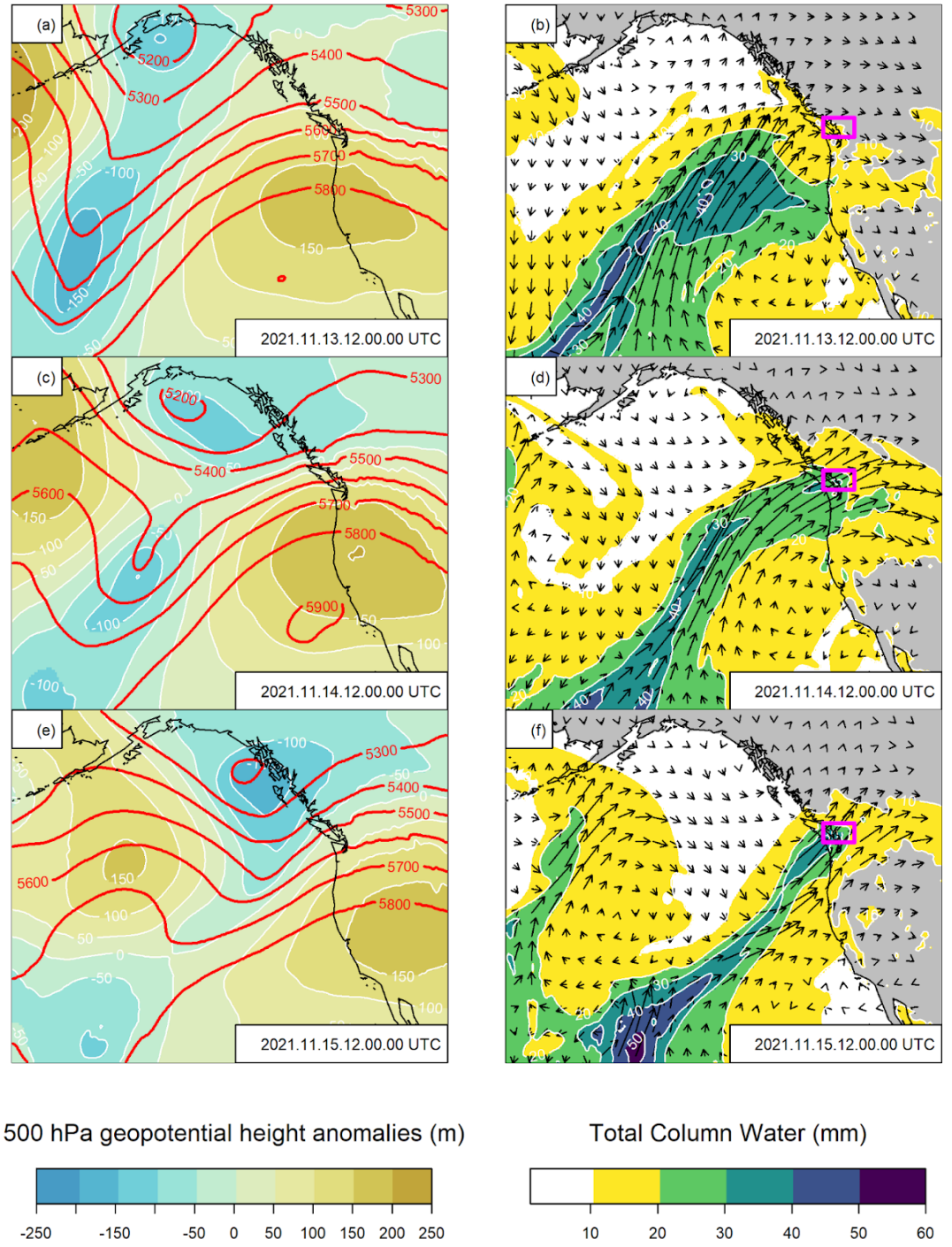
- A strong atmospheric river event on 14th and 15th November 2021 brought two days of intense precipitation to southwestern B.C..
- This caused the costliest natural disaster in B.C. history:
  - At least five people were killed.
  - Significant infrastructure damage: Tulameen and Sumas River dike failures; damage and closure of all major highways, railways, and pipelines linking south-west B.C. to the rest of Canada.
  - Extensive loss of property.
  - Loss of livestock in large agricultural region.
  - Insured losses estimated to be $450m, total cost likely much greater.
- Here we address the following questions:
  - What were the main mechanisms that produced the event?
  - How large and how unusual was this event?
  - How has human-caused climate change increased the likelihood and magnitude of such an event?





THE SYNOPTIC SITUATION

- Atmospheric river with axis determined by low pressure to the north and high pressure to the south, pumped a large amount of moisture into southwestern B.C..
- Circulation aligned with the Fraser Valley, funneling moisture into the region.

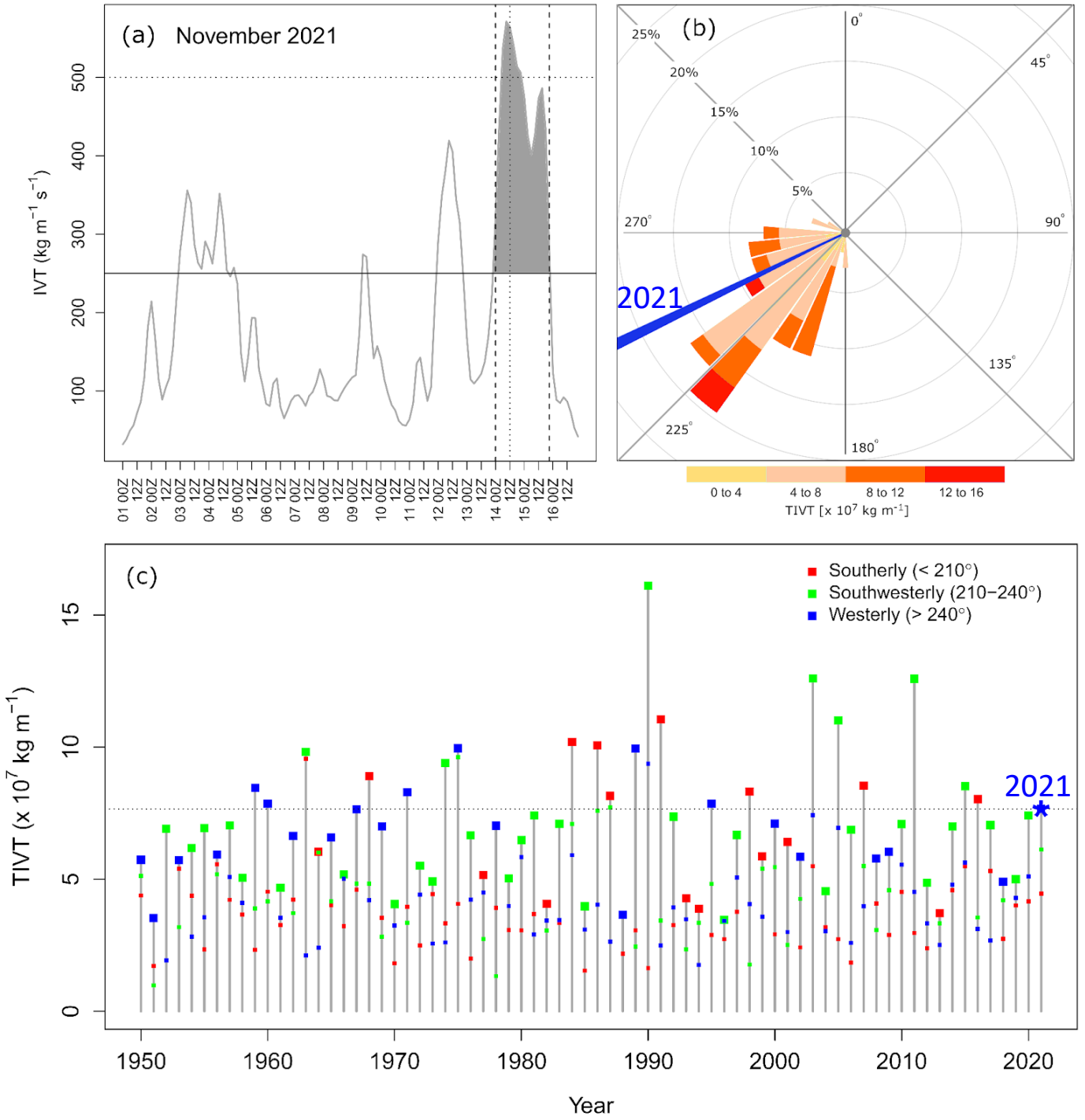


Synoptic evolution of the AR from November 13th to 15th, 2021, shown in terms of geopotential height anomalies (left column) and total column water (right column), from ERA5. Red-colored contours show geopotential height, while vectors depict the vertically integrated vapour transport.

THE ATMOSPHERIC RIVER

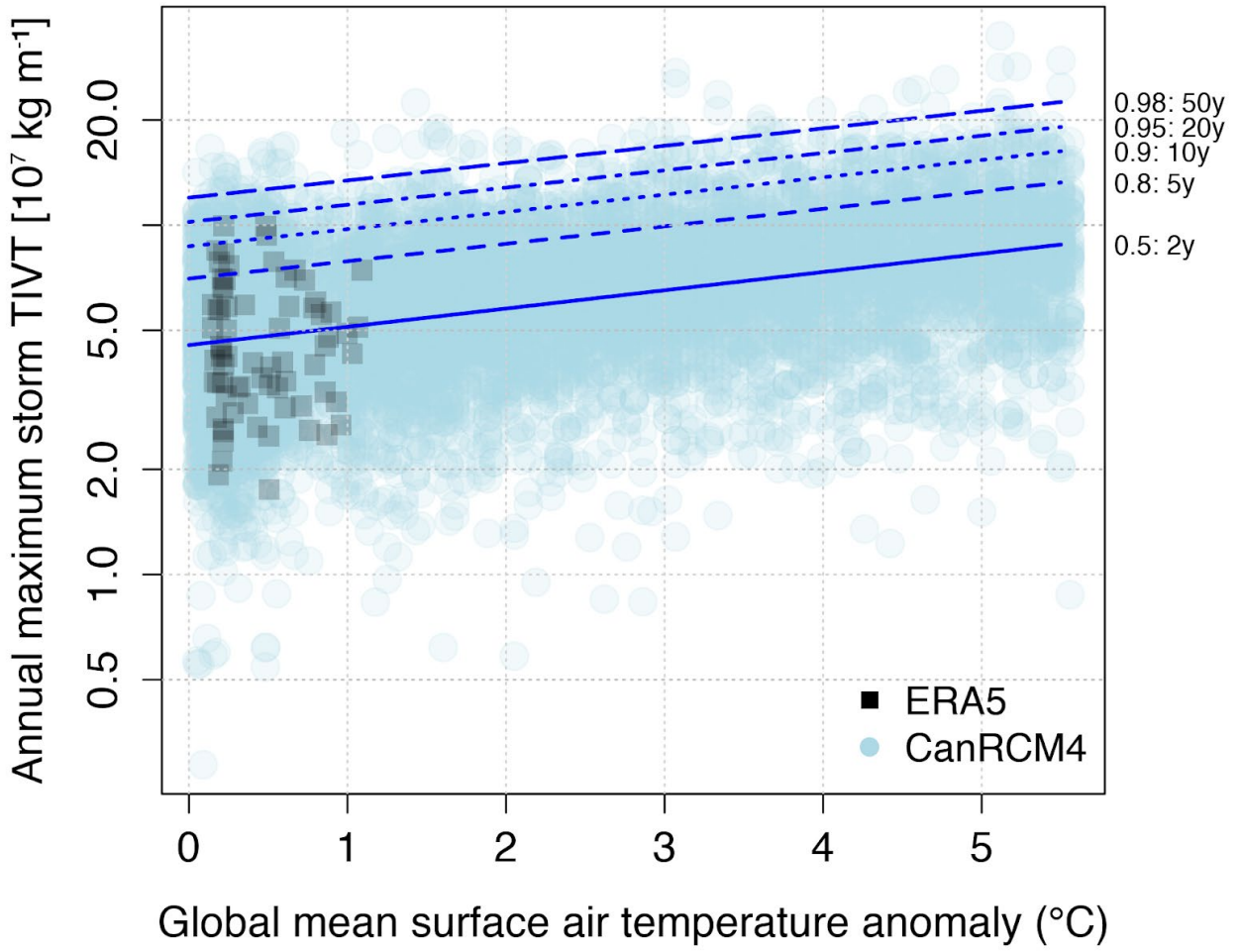
- Compared to all atmospheric rivers (ARs) in the region 2021 event was a 1 in 3.2 (2.5-4.1) year event.
- Compared to westerly ARs, which transport moisture further inland, 2021 was a 1 in 11.8 (7.8-17.9) year event.

(a) Time series (November 1-16, 2021) of Integrated Vapour Transport (IVT) averaged over the event region. (b) Directional histogram showing the orientation and strength of the strongest ARs in each year from 1950-2021. (c). Time series of annual maximum storm total IVT for all ARs (vertical bars) and annual maximum total IVT for ARs with southerly (red), southwesterly (green), and westerly orientations (blue).



ATTRIBUTION OF THE ATMOSPHERIC RIVER

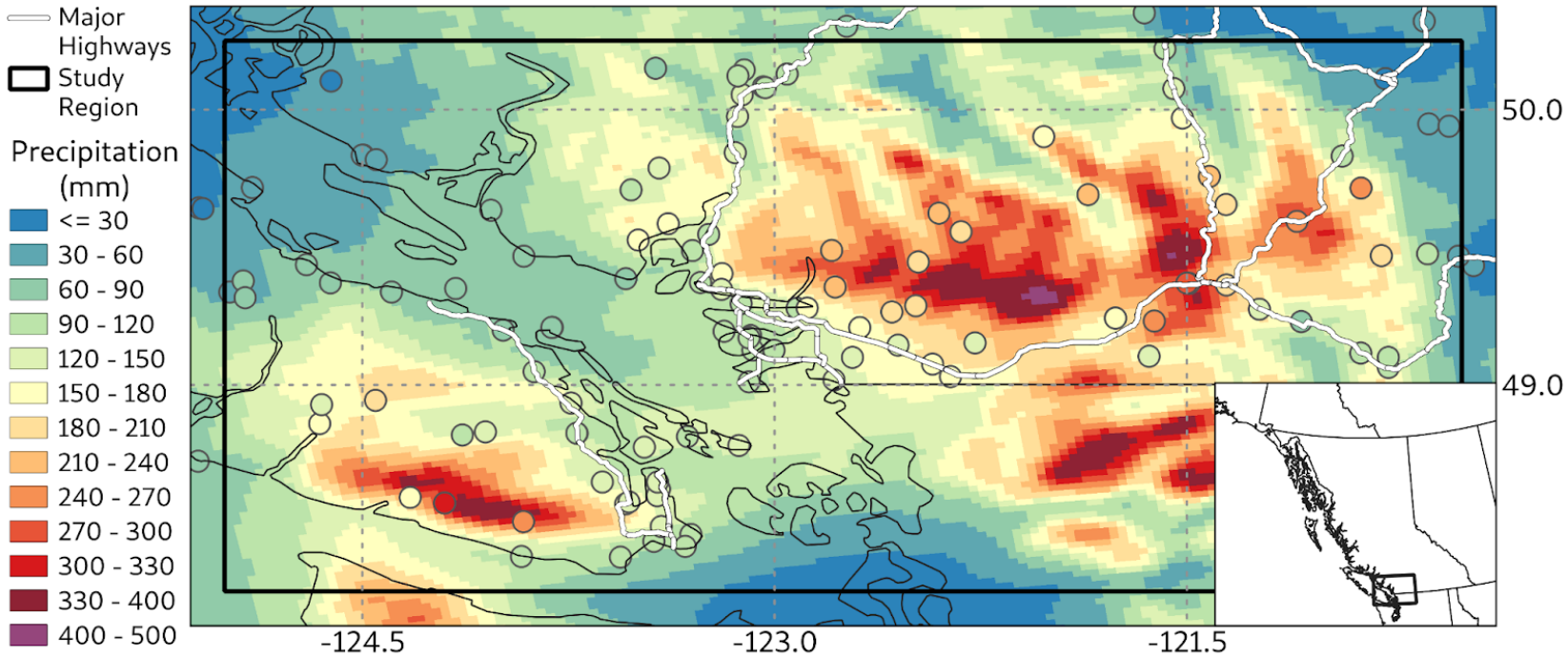
- A statistical model predicts annual maximum storm total integrated vapour transport well based on global mean surface air temperature, in CanRCM4 regional model large ensemble (right).
- Based on 1.09°C warming to date, human-induced climate change has increased the probability of westerly AR events like the 2021 event by 76% (64%-93%).
- At 3°C warming relative to preindustrial, the probably of such events is projected to increase by ~300%.

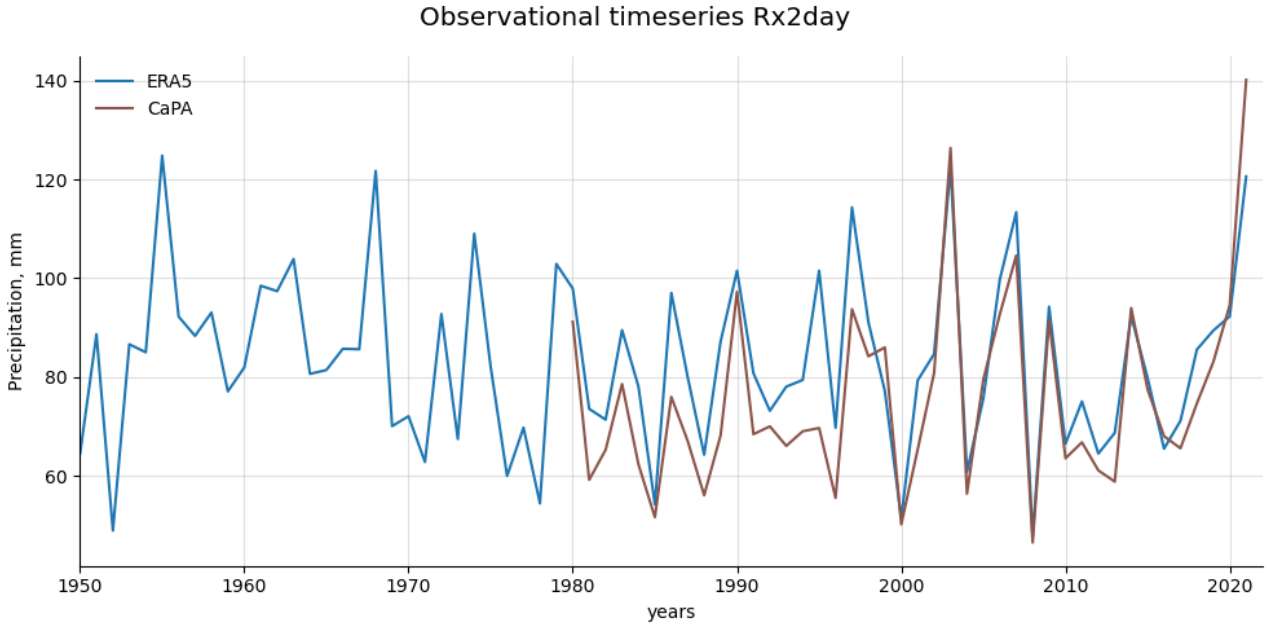


Annual maximum total IVT for westerly-oriented ARs over the southwestern B.C. event region in the 50-member CanRCM4 large ensemble is shown against decadal mean GSAT anomaly relative to pre-industrial climate (1850-1900) in the associated CanESM2 global driving simulations.

THE HEAVY PRECIPITATION EVENT

- Two-day precipitation exceeded 300mm in SW Vancouver Island and in the mountains around the Fraser Valley.
- Estimated return periods for the 2021 precipitation over the study are are 47 (29-98) years based on ERA5, and 99 (44-620) years based on CaPA.





Top: Two-day total precipitation for November 14th-15th, from the 2.5-km version of the CaPA analysis (colours) and from gauges (circles).
Bottom: Annual maximum 2-day precipitation averaged over the study area from ERA5 and 2.5-km CaPA.

HEAVY PRECIPITATION EVENT WAS MORE LIKELY BECAUSE OF CLIMATE CHANGE

- Human-induced climate change is estimated to have increased the probability of precipitation events at least as large as that observed in 2021 by 45% (1-84)%.
- Analysis based on 166 simulations from 22 CMIP6 climate models, including CanESM5.
- Under a scenario with 2.7°C global warming, this increase in probability is projected to be 216 (149-301)%.