

# Analyzing the Effect of Climate Change on Atmospheric Rivers in North America

**Robert Filipiuk, Huancui Hu**

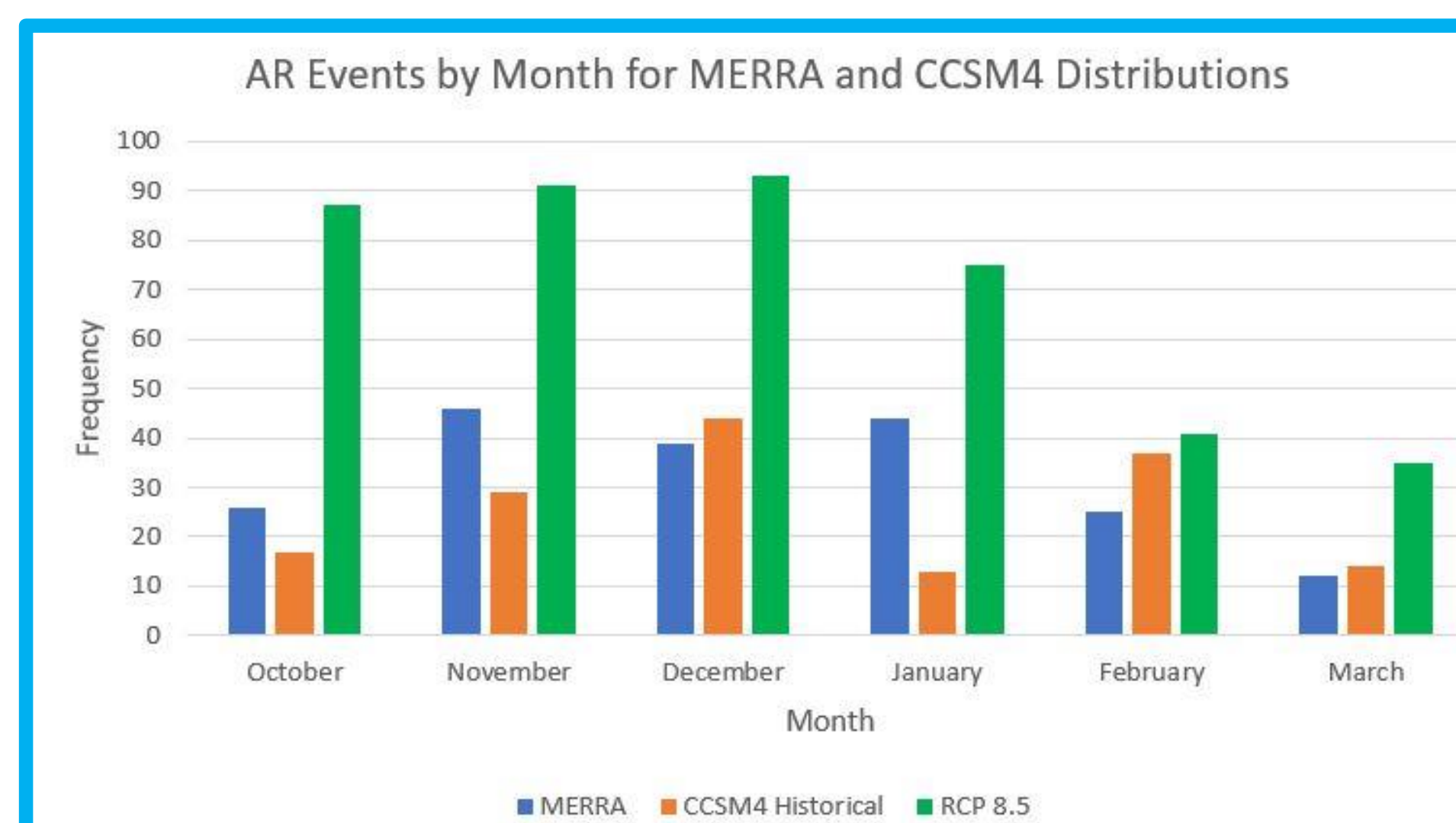
Department of Aerospace Engineering, College of Engineering, University of Illinois at Urbana-Champaign

## INTRODUCTION

Atmospheric rivers (ARs, for short) are exactly what their name suggests: immense streams of water vapor in the lower atmosphere, responsible for severe precipitation events at midlatitude regions in both hemispheres. In fact, atmospheric rivers carry more than 90% of the water vapor located between the tropics and the poles, and with usually no more than a dozen of these events occurring per year, each one is an extremely potent water source, hence they are responsible for flooding along coastlines around the world. Nonetheless, many regions, like the North American West Coast, depend on these gaseous streams to maintain their water supply. Thus, scientists are rushing to understand atmospheric rivers, and how they will evolve with Earth's changing climate.

## RESULTS

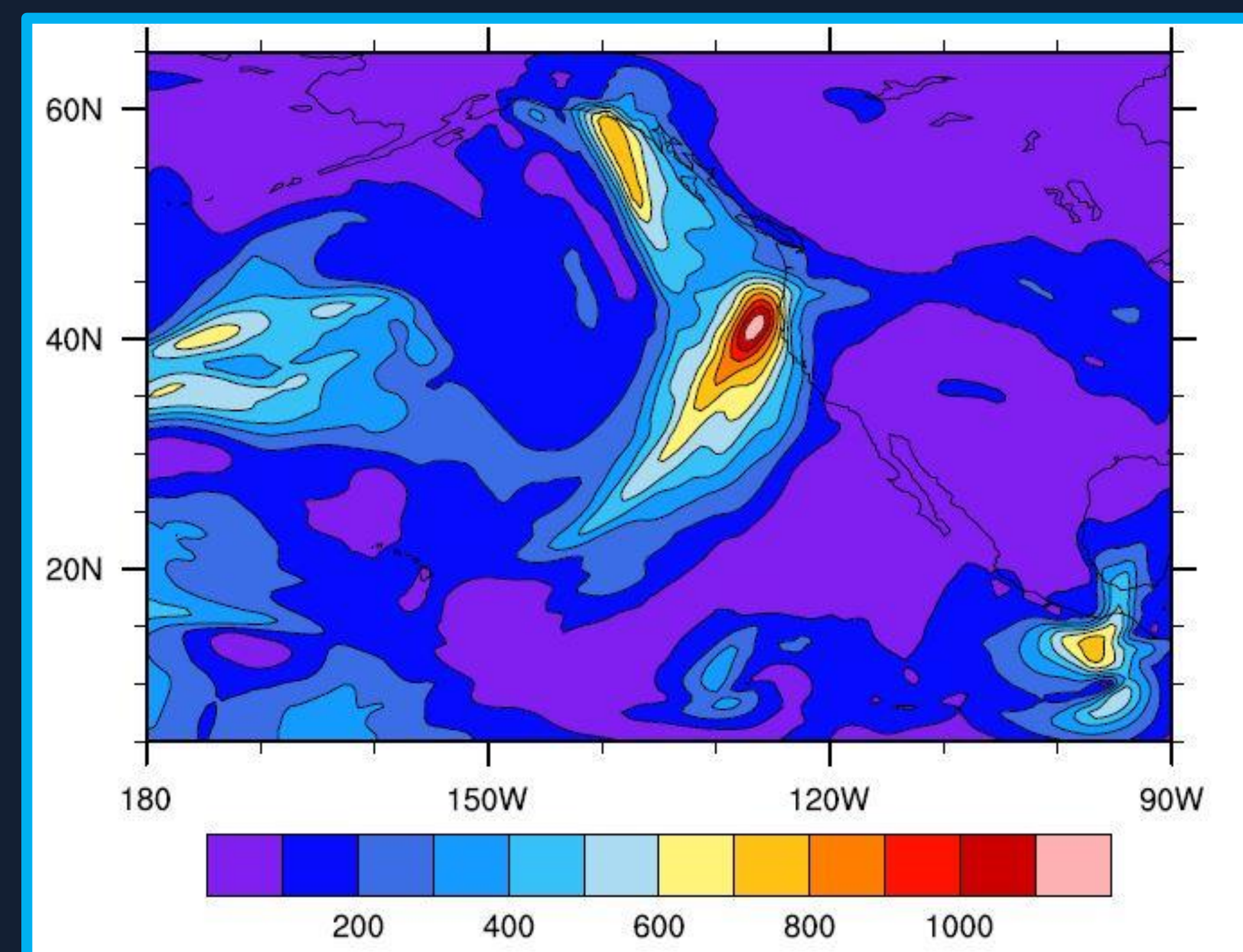
- We detected 422 AR events along the Washington-Oregon coast from the CCSM4 future simulation (which simulated global climate under the RCP 8.5 condition, the “worst case scenario” for climate change, from 2070 to 2100), which is much greater than the number of AR events detected in the historical simulation (154) or MERRA data (193).
- We ran Chi-square Tests of Homogeneity between both the historical and MERRA distributions, and the historical and future distributions. Both significance tests yielded positive results; that is, both pairs of distributions varied significantly from each other.



Distribution of AR events by month for the MERRA dataset and CCSM4 historical and future (RCP 8.5) simulations. MERRA data is from 1979-2009, the CCSM4 historical simulation is over the period 1975-2005, and the RCP 8.5 simulation is over the period 2070-2100.

## AIM

- To identify and characterize past atmospheric rivers along the western coast of the United States.
- To use climate models to project the frequency and intensity of future atmospheric rivers along the same coast, and compare these projections to historical data to determine the effects of climate change on these events.



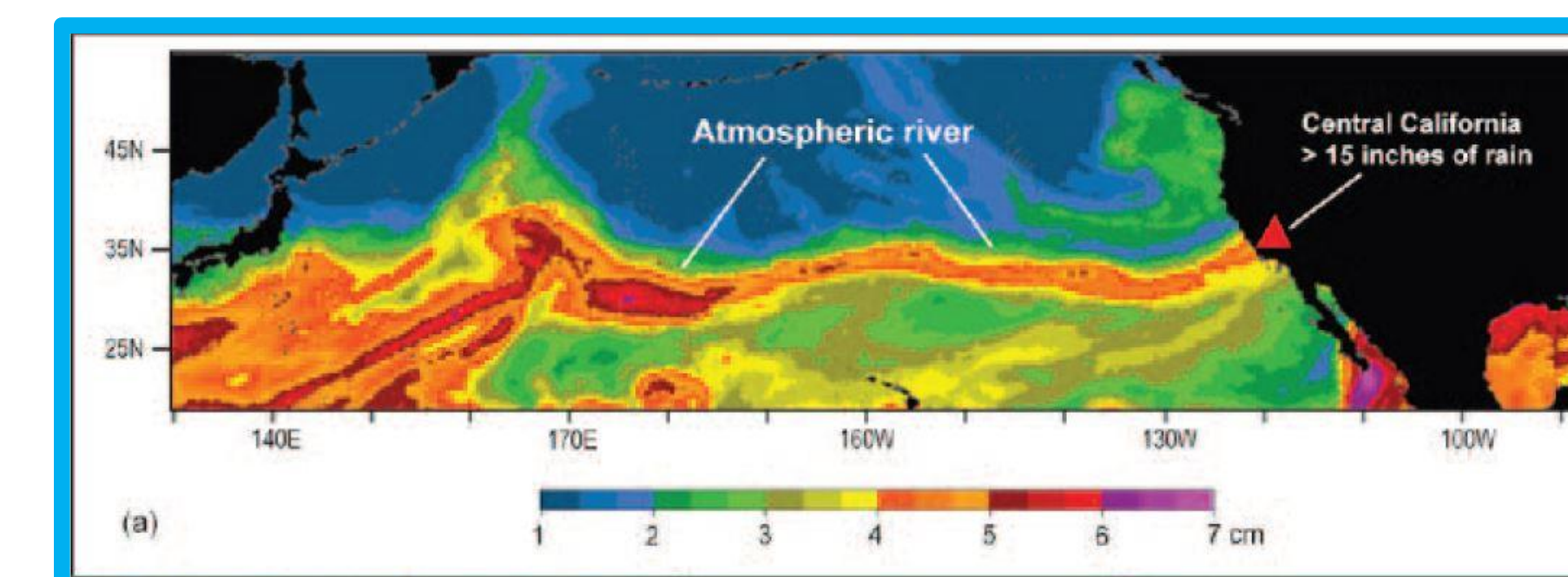
This visualization of IVT data from the MERRA database reveals an atmospheric river (central red feature) making landfall over the west coast of the United States on October 24, 1979.

## CONCLUSIONS

- Under the RCP 8.5 condition, the number of AR events along the Northwest Coast of the United States is projected to more than double over the years 2070-2100, which suggests that if humans do not mitigate greenhouse gas emissions, then severe weather events will become several times more common along the Northwest Coast.
- The discrepancies in the AR event distributions suggest that the CCSM4 historical simulation was not able to capture the seasonal variation of AR frequencies very well, probably due to a slight shift in time of those events occurring in January.

## METHOD

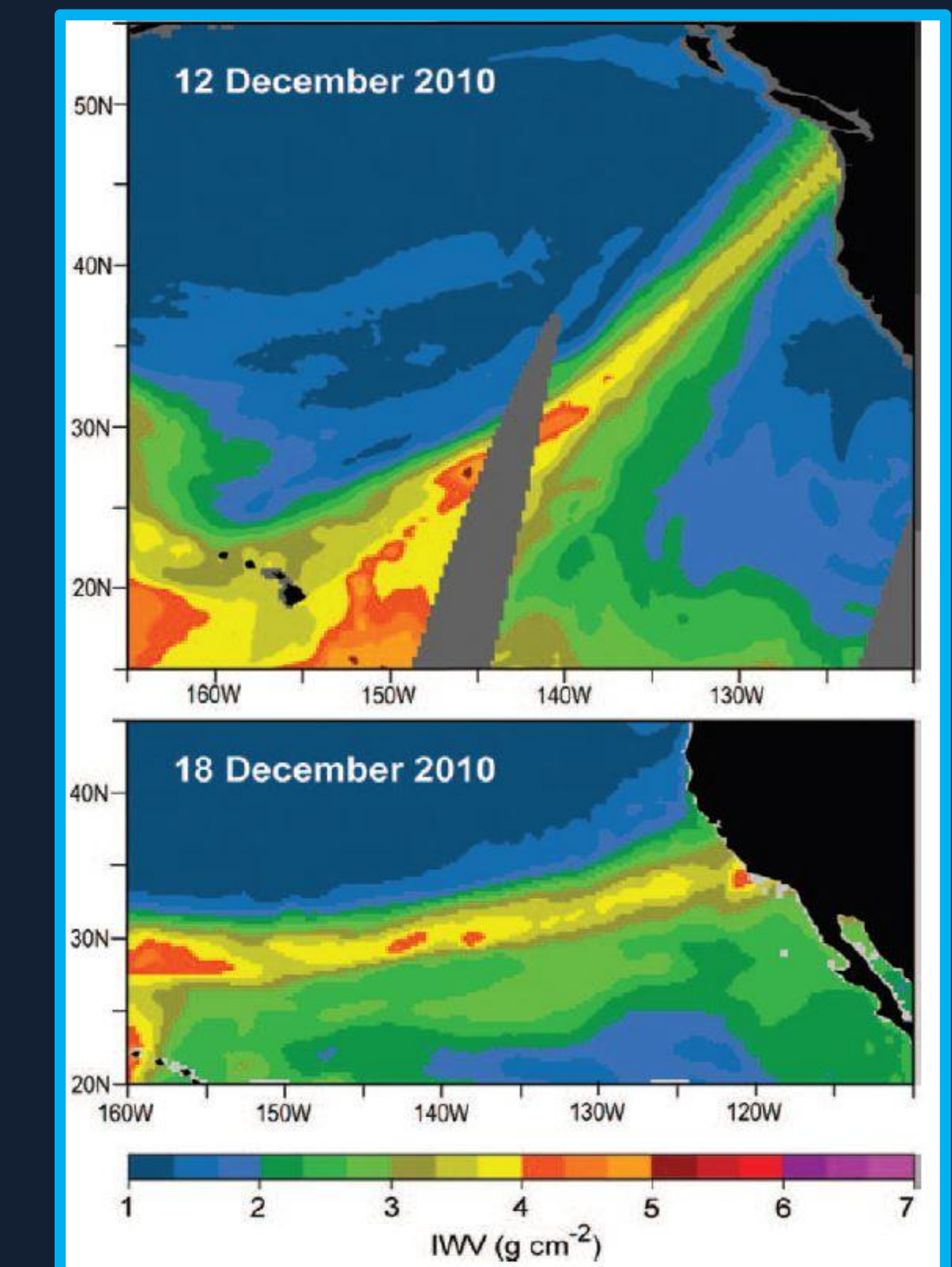
- We used a computer algorithm to detect atmospheric rivers along the Northwest coast of the United States using calculations of Integrated Vapor Transport (IVT), which measures the amount and speed of water vapor in a column of air.\*
- We used NASA's Modern Era Retrospective-Analysis for Research and Applications (MERRA), a database of global atmospheric measurements such as humidity and wind speed, to calculate IVT values globally. These data were then inputted into the algorithm to identify atmospheric rivers over the period 1979-2009.
- We then used the same algorithm to identify ARs from historical (1975-2005) and projected (2070-2100) climate simulations along the same region, provided by CCSM4 (Community Climate System Model 4), then compared the monthly distribution of events across the three datasets to identify any statistically significant differences.



Special Sensor Microwave Imager (SSM/I) satellite image of an atmospheric River that hit the California coast over October 13-14, 2009\*\*. The image is a visualization of vertically integrated water vapor (IWV), a measure of the amount of water vapor in the atmosphere.

## FURTHER RESEARCH

- To reduce uncertainty in our results, we would like to gather more historical and future simulations with slightly different initial conditions.
- Gather simulation data from parts of the world outside of the Northwest United States to make our results more generalizable.
- Gather simulation data from other RCP scenarios to obtain results for more realistic conditions.



SSM/I satellite image of two atmospheric rivers hitting the western United States over December 10-18, 2010. The image is a visualization of IWV.\*\*\*

## CITATIONS

- \*Lavers, David A., et al. "The Detection of Atmospheric Rivers in Atmospheric Reanalyses and Their Links to British Winter Floods and the Large-Scale Climatic Circulation." *Journal of Geophysical Research: Atmospheres*, vol. 117, no. D20, 19 Oct. 2012, doi:10.1029/2012jd018027.
- \*\* Ralph, F. M., and M. D. Dettinger. "Storms, Floods, and the Science of Atmospheric Rivers." *Eos, Transactions American Geophysical Union*, vol. 92, no. 32, 9 Aug. 2011, pp. 265-272., doi:10.1029/2011eo320001
- \*\*\* Ralph, F. M., and M. D. Dettinger. "Historical and National Perspectives on Extreme West Coast Precipitation Associated with Atmospheric Rivers during December 2010." *Bulletin of the American Meteorological Society*, vol. 93, no. 6, 2012, pp. 783-790., doi:10.1175/bams-d-11-00188.1.

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