Climate & Ecosystem Sciences
EARTH & ENVIRONMENTAL SCIENCES AREA

CASCADE

BERKELEY LAB
Lawrence Berkeley National Laboratory

# Probabilistic Detection of Atmospheric Rivers Across Climate Datasets with Neural Networks


Ankur Mahesh[1,2], Travis A. O'Brien[1,3], Burlen Loring[4], Abdelrahman Elbashandy[4], Karthik Kashinath[5], Bin Guan[6], L. Ruby Leung[7], Juan Lora[8], Mayur Mudigonda[5], Prabhat[5], William D. Collins[1,2]

[1]Climate and Ecosystem Sciences Division, Lawrence Berkeley Lab, Berkeley, CA, USA

[2]Dept. of Earth and Planetary Sciences, University of California, Berkeley, Berkeley, CA, USA

[3]Dept. of Earth and Atmospheric Sciences, Indiana University, Bloomington, IN, USA

[4]Computational Research Division, Lawrence Berkeley Lab, Berkeley, CA, USA

[5]National Energy Research Scientific Computing Center, Lawrence Berkeley Lab, Berkeley, CA, USA

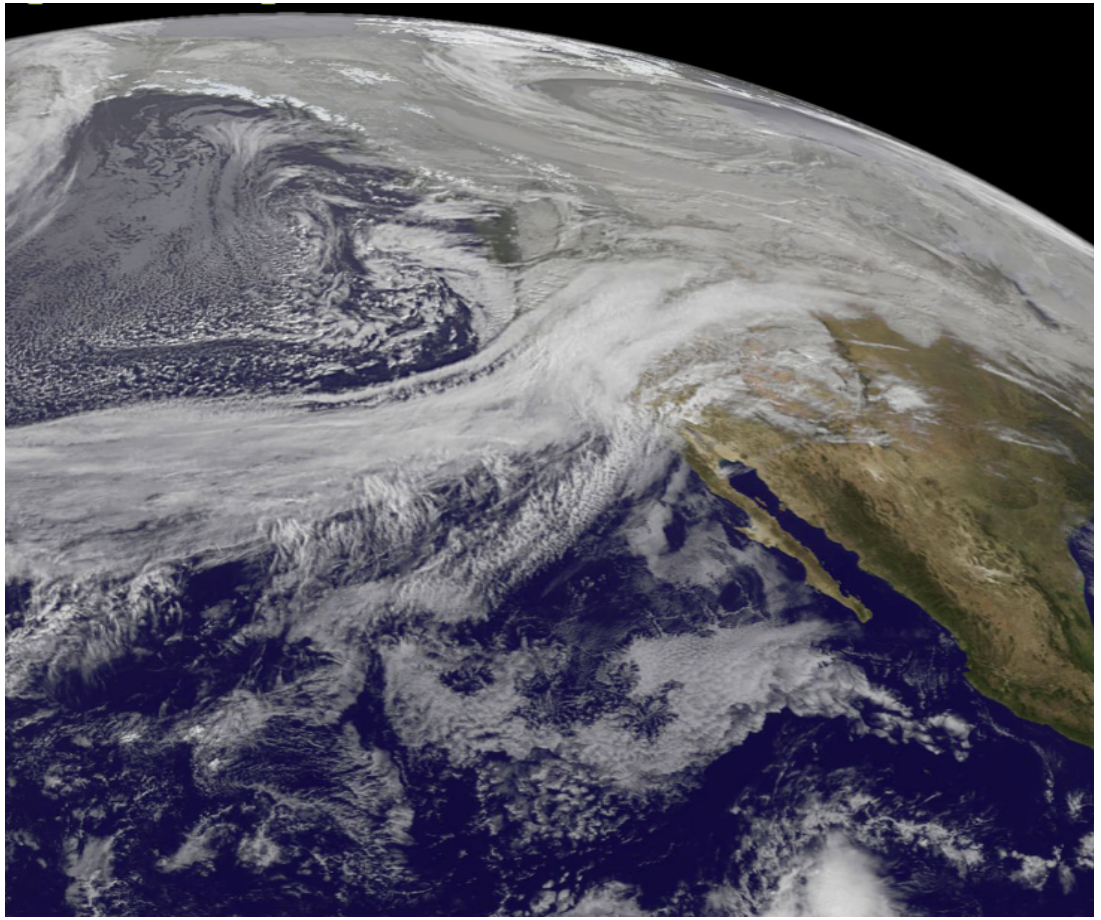
[6]Joint Institute for Regional Earth System Science and Engineering, University of California, Los Angeles, CA, USA

[7]Atmospheric Sciences and Global Change Division, Pacific Northwest National Laboratory, Richland, WA, USA

[8]Department of Earth and Planetary Sciences, Yale University, New Haven, CT, USA

# Why Deep Learning for Detecting Atmospheric Rivers (ARs)?

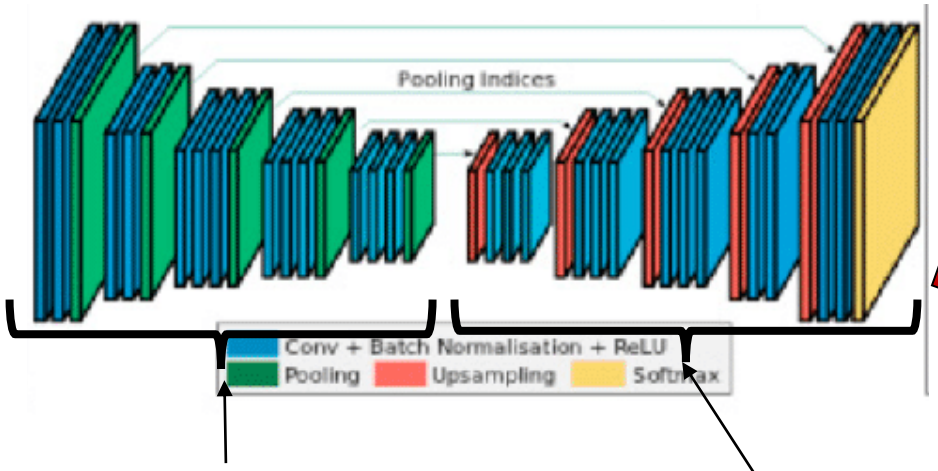
1. Current AR detection algorithms rely on expert-chosen thresholds. Neural networks can learn the **deeper patterns** of ARs, without requiring thresholds to be tuned for each dataset.
2. Neural networks can represent the **uncertainty** across AR detection algorithms
3. Neural networks can detect ARs **across datasets** and fields



An AR off the coast of California. Source: TheGuardian

# Probabilistic Segmentation with CNNs

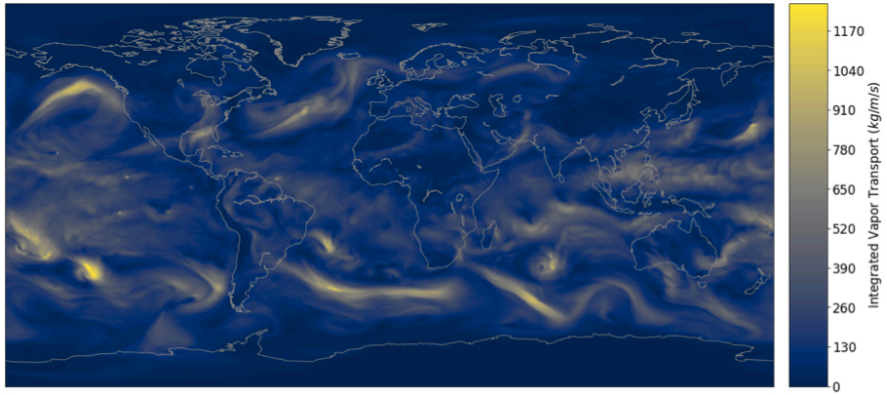
The CNN is trained on the mean of 14 ARTMIP algorithms.



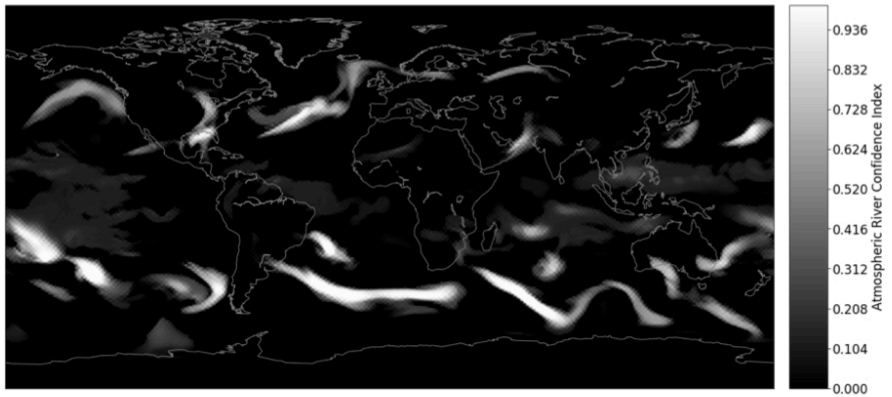

Neural network extracts lower-dimensional **features.**

These features are mapped to AR probabilities

**Input Field**: IVT



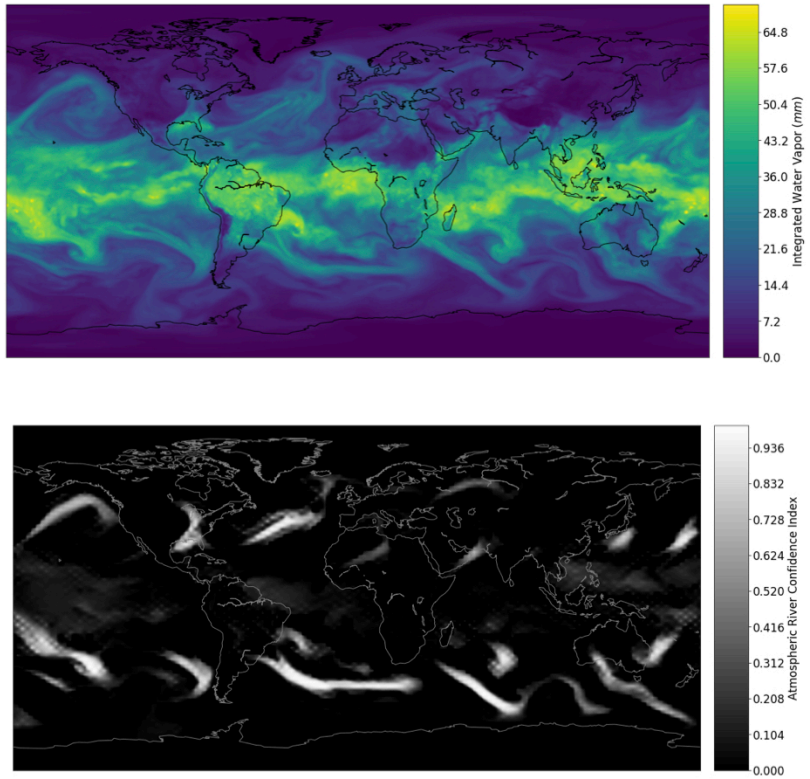

**Output Field**: AR Prob.



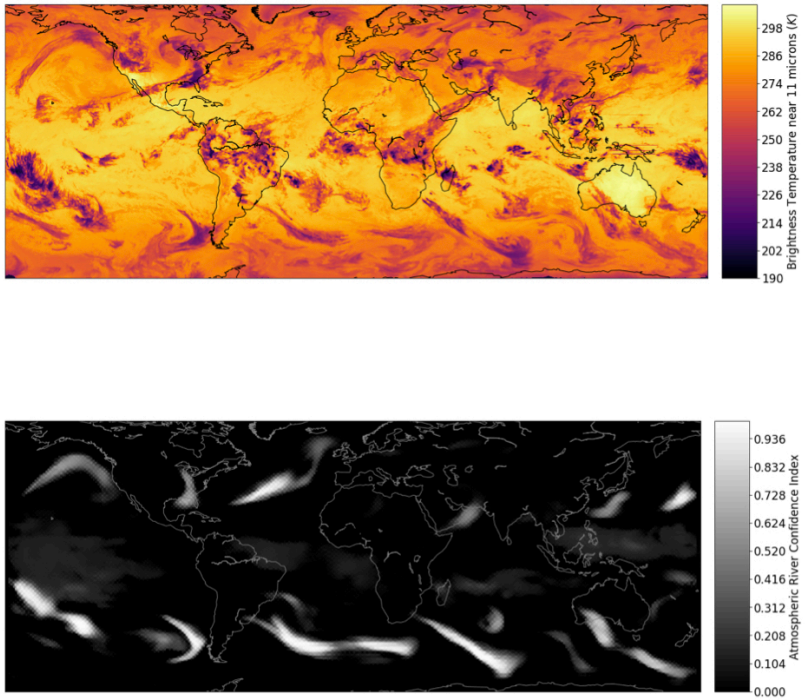

CNN Output (white shading)

# Applying the Network to Other Climate Datasets

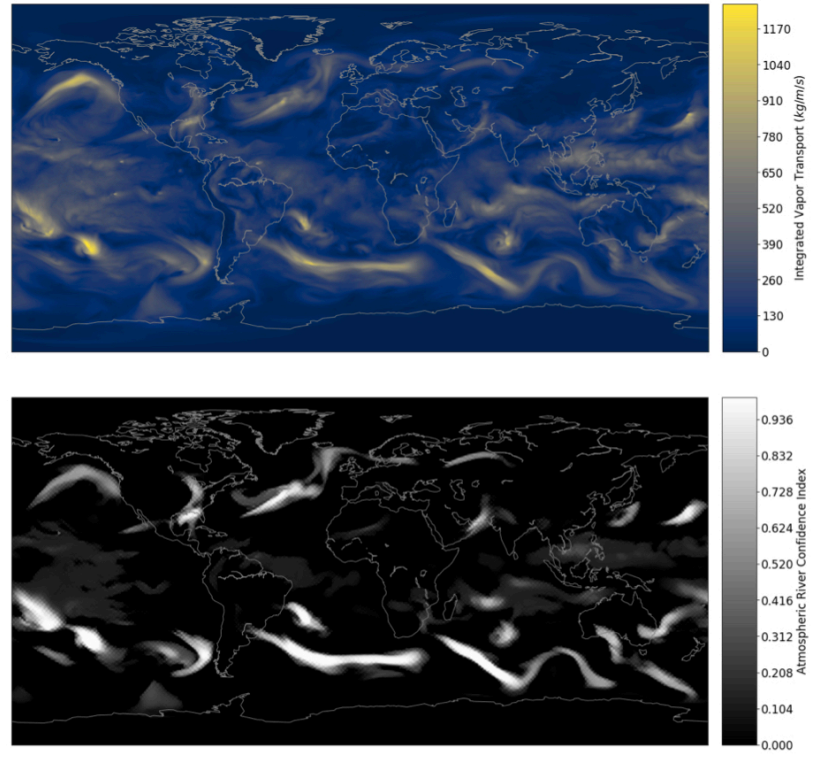
MERRA Integrated Water Vapor




GRIDSAT (infrared window, near 11 microns)

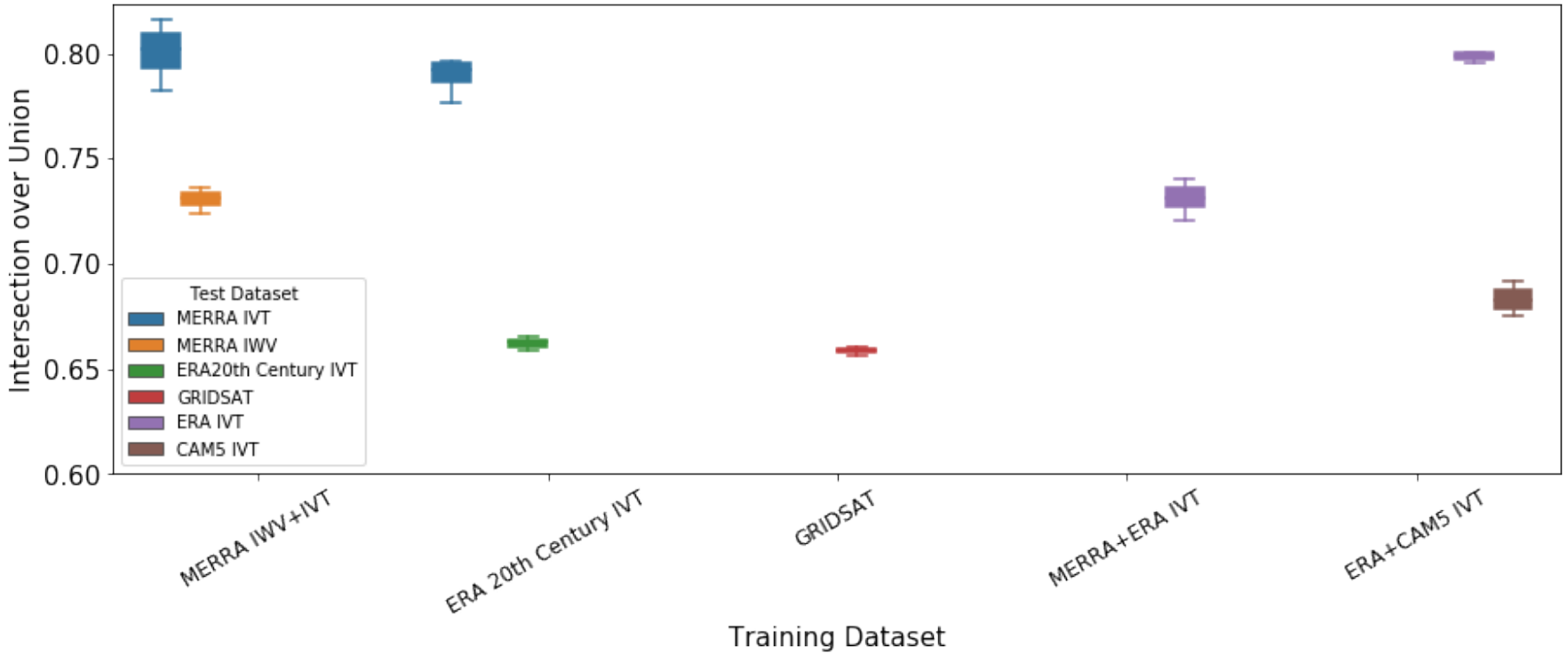



ERA-Interim: Integrated Vapor Transport



# White Paper Discussion: What are the Criteria for Documenting Observed and Simulated Extremes?

1. Neural networks should not replicate absolute thresholds
   - In the experiment below, we perturb the input field by factors from 0.92 to 1.08 and evaluate the neural network performance
2. (Future Goal) Neural networks should identify the same AR structure for different fields and datasets → their performance should be roughly constant for different datasets




Intersection over Union is a performance metric comparing ML predictions to ARTMIP labels. 0 is worst, 1 is best