Atmospheric rivers in the CMIP3/5 historical and projection simulations

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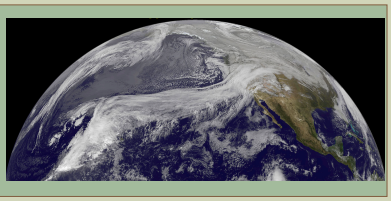


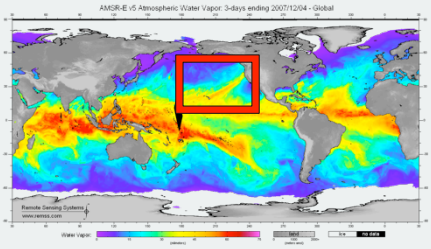
Atmospheric rivers

Extreme precipitation events on the western coast of North America are often traced to an unusual weather phenomenon known as atmospheric rivers (AR). These events refer to filamentary structures in atmosphere that transport significant amounts of water over a long distance in narrow bands.

We have developed an efficient atmospheric river detection algorithm based on image reconstruction techniques. Our detection algorithm is based on a thresholding condition on the total column integrated precipitable water vapor (prw) established by Ralph et al. (2004) followed by a connected component labeling procedure to group the mesh points into connected regions in space. We have applied this highly parallel technique both to satellite observations as well as climate model output.

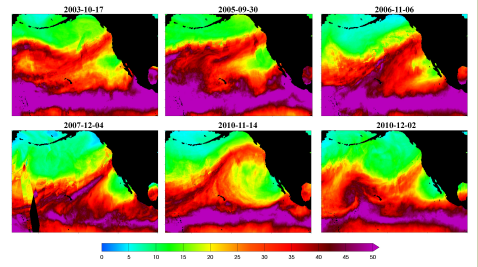
Detection of atmospheric rivers

•Threshold all the areas where prw> 2cm
•Find all the connected components
•Verify the origin and landing spots for all connected components
•If a connected component satisfies origin and landing criteria, measure length and width of the component
•If length and width criteria meet, then an AR is detected



Observed 3 day average precipitable water vapor from SSM/I satellite on December 4, 2004

Examples of observed AR



A selection of events in the SSM/I satellite record detected by our pattern recognition technique as atmospheric rivers. Note that they share a similar horseshoe-like pattern but vary greatly in their spatial extent. Events that pass over Hawaii, such as occurred on November 6, 2006, are often referred to as “The Pineapple Express”.

Counts of observed AR events reaching the western coast of North America. Summer events are generally farther north than in winter.

REFERENCES

F. M. Ralph, P. J. Neiman, G. N. Kiladis, K. Weickmann, and D. W.Reynolds. A multiscale observational case study of a pacific atmospheric river exhibiting tropical-extratropical connections and a mesoscale frontal wave. Monthly Weather Review, 139(4):1169–1189, 2011.

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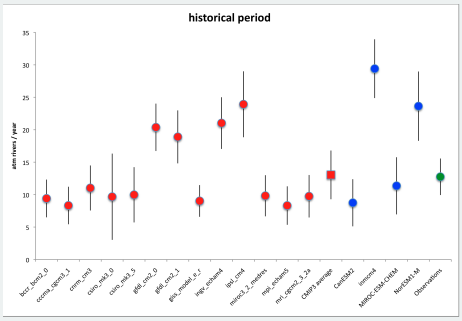
Observational data provided by Remote Sensing Systems, Inc. From www.ssmi.com

Performance of the CMIP models

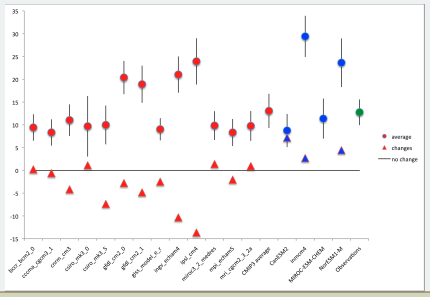
We have calculated three day average total column integrated precipitable water vapor from daily averaged specific humidity saved as part of the CMIP3/5 protocols. All CMIP3 models that provided data have been processed. Analysis of CMIP5 models are underway. Progress is limited by the size of whole atmosphere daily datasets. Also, despite the protocol specifications, missing data requires a workaround in certain models.



Comparison of the average annual number of detected AR in the CMIP3 and CMIP5 models with the SSM/I observations. Errors bars are the interannual standard deviations. Models can be grouped into two categories: Those that simulate the correct number (~10) and those that simulate about twice that. Red=CMIP3, Blue=CMIP5, Green=observations.

Future Changes

Consensus of future changes in the number is mixed. CMIP3 models project decreases in the total annual number of AR. CMIP5 model output is still too limited to draw a general conclusion but some show increases. There is no apparent relationship between future changes and model skill in the present.



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