Global Atmospheric Rivers Depicted from NWP Reanalysis, and Their Connection to Weather and Climate Phenomenon

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Introduction

We have developed an objective methodology for detecting atmospheric rivers (AR's) that can be applied to global field of total precipitable water (TPW). Tests have included application to TPW fields and have shown its utility in detecting global AR's contributing to recent flooding events across the U.S. and Europe. The importance of such a tool is that a global climatology of AR's can be developed on NWP reanalysis data sets to investigate changes in the characteristics over time in the AR's, and link them to meteorological and/or climate events. We have tried to connect the AR output with weather and climate phenomenon, and the results are promising. In our future work, we would build similar global AR climatology upon climate data record of satellite observations, such as SSM/I, or AMSU-A.

Methodology

The objective AR detection approach used here is adopted from drainage network extraction (DNE), a mature method in hydrology to delineate the drainage network of rivers on ground surface. Similar to the AR detection tool (ARDT) described in Wick et al. (2013), DNE relies heavily on gradient, yet it also strongly stresses for the contributing area and stream order.

To emphasize more for mid- and high- latitude AR's, and minimize the impact of Intertropical Convergence Zone (ITCZ) on the AR extraction, the latitude bands of -10° to 10° are excluded in this application which reduces false alarms and unrealistic AR's.

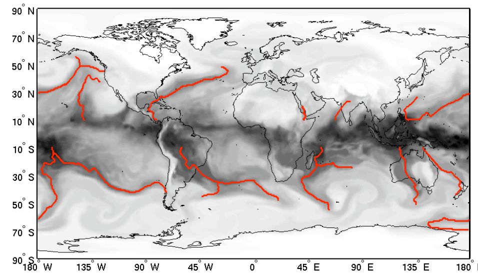
Basic Equations of Water Vapor Transport

$$\frac{\partial w}{\partial t} + \nabla \cdot \frac{1}{g}\int_{p_0}^{0} \vec{v} q \, dp = E - P$$

$$w = \frac{1}{g}\int_{p_0}^{0} q \, dp$$

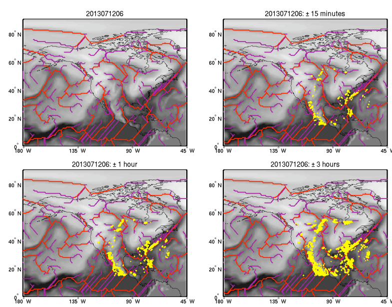
- w – total precipitable water
- t – time
- g – acceleration due to gravity
- p – pressure
- p_0 – surface pressure
- v – wind vector
- q – atmospheric humidity
- E – surface evaporation rate
- P – surface precipitation rate

Global AR's of Dec 31, 18:00 UTC, 2013



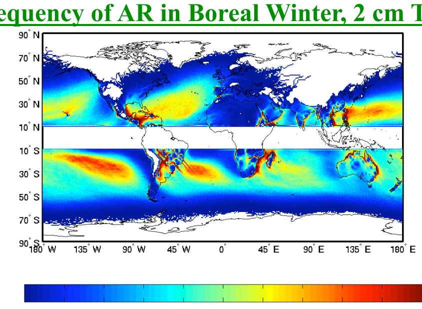
AR's in red are extracted from ERA-Interim TPW (≥2 cm), shown in background gray scale, with higher TPW darker. Note the connectivity of AR's at the 180° (W/E) boundary.

AR and Lightning on Jul 12, 6:00 UTC, 2013



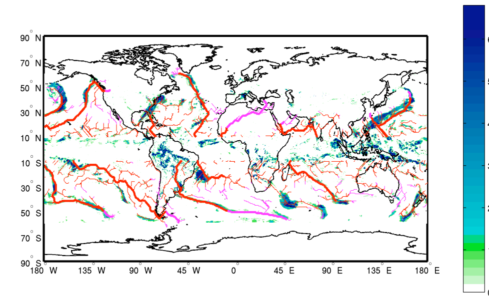
AR's with tributes are displayed using red lines, lightning data within 15 minutes, 1 hour, and 3 hours are displayed using yellow dots.

Frequency of AR in Boreal Winter, 2 cm TPW



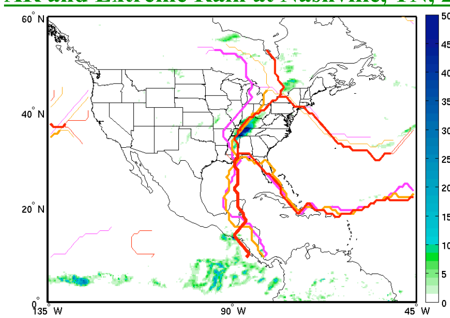
AR frequency climatology of 1979 to 2014, only boreal winter (NDJF) months are shown. The unit of the color bar is times per four months. The TPW threshold is 2 cm.

AR and Rain on Nov 30, 18:00 UTC, 2008



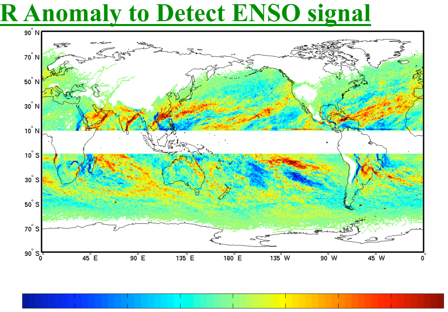
Rain information is from NOAA Climate Prediction Center (CPC) Morphing Technique (CMORPH) rain rate (mm/hr), in right color bar.

AR and Extreme Rain at Nashville, TN, 2010



Three consecutive 6-hourly AR's are shown in purple, brown, and red, with the last sharing the same time with rain rate (mm/hr), in right color bar.

AR Anomaly to Detect ENSO signal



AR frequency difference of El Nino years minus all years from 1979 to 2014, only boreal winter (NDJF) months are shown. The unit of the color bar is times per four months.