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Science AMA Series: I'm Marty Ralph, research meteorologist at Scripps Institution of Oceanography. My research focuses on extreme weather events including atmospheric rivers. This winter, we're flying Hurricane Hunter aircraft through storms. AMA!

MARTY_RALPH R/SCIENCE

As director of the Center for Western Weather and Water Extremes at Scripps Institution of Oceanography at UC San Diego, I lead a team of researchers focused on understanding the physical processes that create extremes in precipitation, ranging from flood to drought. We are also focused on advancing extreme weather monitoring, predictions, climate projections, and decision support tools. The core of my research is to better understand atmospheric rivers, bands of moisture in the sky that can carry more water (as vapor) in them than any terrestrial river in the world (as liquid). These bands can deliver as much as half of California's water supply in a handful of precipitation events every year.
This winter, I'm leading a field effort with the National Weather Service using NOAA's Gulfstream IV and two Air Force WC-130J Super Hercules planes, manned by Air Force Hurricane Hunter crews, to study any atmospheric rivers that form over the Pacific Ocean and hit the West Coast. The planes will be stationed in Hawaii, Seattle, and Northern California, and when the conditions are right, we'll fly through atmospheric rivers, dropping instrument-laden, parachute-tethered dropsondes across the width of the storms to collect data. Our ultimate goal is to provide research and information to the National Weather Service and California Department of Water Resources to help improve atmospheric river forecasts. The effort is related to a study exploring the potential of using atmospheric river forecasts in reservoir operations on Lake Mendocino in northern California to support water supply management, flood mitigation and recovery of endangered salmon, supporting the U.S. Army Corps of Engineers.
Ask me anything about atmospheric rivers or other western US extreme weather and water events!

READ REVIEWS

WRITE A REVIEW

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Marty_Ralph , r/Science , Science AMA Series: I'm Marty Ralph, research meteorologist at Scripps Institution of Oceanography. My research focuses on extreme weather

Do weather forecasting / general circulation models already spontaneously generate features you would recognize as atmospheric rivers? It seems to me that these are such simultaneously large scale and narrow / intense features that they might not fit in a U.S. weather forecasting simulations and instead basically be prescribed by a boundary condition or something.

Do they show up in CMIP5 class models? What about these global cloud resolving simulations that people run for a day at a time?

aClimateScientist

Yes, every modern generation global weather forecasting model does spontaneously generate long narrow features of high integrated water vapor transport which are recognized as atmospheric rivers in different regions as seen in observations. The regional weather forecasting models (with limited domains such as just over the North American continent) currently get their boundary conditions from these global weather forecasting models. Hence even if the regional model may not capture the entire

events including atmospheric rivers. This winter, we're flying Hurricane Hunter aircraft through storms. AMA!, *The Winnower* 5:e151913.31062 , 2018 , DOI: 10.15200/winn.151913.31062

atmospheric river within its domain it does extend the atmospheric river from its boundary conditions into its interior (potentially capturing landfall of these ARs quite well).

Atmospheric rivers do show up in CMIP5 class models as well and there are some peer-reviewed scientific papers studying atmospheric rivers in CMIP5 class models (including some from our group). Here are some examples:

- *Lavers, D.A., Ralph, F.M., Waliser, D.E., Gershunov, A. and Dettinger, M.D., 2015. Climate change intensification of horizontal water vapor transport in CMIP5. Geophysical Research Letters, 42(13), pp.5617-5625.*
- *Warner, M.D., Mass, C.F. and Salathé Jr, E.P., 2015. Changes in winter atmospheric rivers along the North American west coast in CMIP5 climate models. Journal of Hydrometeorology, 16(1), pp.118-128.*
- *Lavers, D.A., Allan, R.P., Villarini, G., Lloyd-Hughes, B., Brayshaw, D.J. and Wade, A.J., 2013. Future changes in atmospheric rivers and their implications for winter flooding in Britain. Environmental Research Letters, 8(3), p.034010.*
- *Dettinger, M., 2011. Climate change, atmospheric rivers, and floods in California–a multimodel analysis of storm frequency and magnitude changes. JAWRA Journal of the American Water Resources Association, 47(3), pp.514-523.*

The global cloud resolving models also simulate atmospheric rivers but have not been tested sufficiently for their predictive capabilities.

There are important differences in how atmospheric rivers are represented in these different global models and hence improved observations and understanding of processes that govern their evolution would help improve their representation in future weather and climate models.

How will better modeling of atmospheric rivers assist with reservoir operations on Lake Mendocino? What benefits will Californians derive from your work?

adenovato

How will better modeling of atmospheric rivers assist with reservoir operations on Lake Mendocino? What benefits will Californians derive from your work?

Lake Mendocino receives roughly 50% of its rainfall from about a dozen atmospheric rivers (ARs) each year, and when they are strong, ARs can cause flooding. Roughly 90% of floods on the Russian River come from AR storms, and the Russian River is a flood-prone watershed. Lake Mendocino was built largely to provide protection against floods, but also serves as a source of water supply. In the winter water level in the reservoir is kept low, so if a flood comes, the reservoir can hold back some of the flow to reduce the crest of the flood downstream. After the storm the extra water is released safely so the reservoir could help with a potential next storm. The idea of having better forecasts of ARs could enable reservoir operators to safely keep “extra” water behind the dam until an AR is predicted to hit. If a storm is not an AR, the chances of it producing flood risk are very small, so the forecast question really boils down to AR forecasts. Lessons from Lake Mendocino may be applicable to other reservoirs across the state, but this assessment requires in depth evaluation. By improving AR forecasts enough to support this proposed “Forecast-informed reservoir operations” (FIRO; http://cw3e-web.ucsd.edu/firo/) it could enhance water supply reliability, as well as improve flood mitigation, while also helping restore endangered salmon runs. Improved AR forecasts will also more broadly help in predicting heavy snow, landslides and debris flows, addressing transportation issues, emergency management…

What is the airspeed velocity of an unladen, flying swallow traveling eastward in an atmospheric river from Honolulu to San Diego?

grantacos

Excellent question! This of course would be highly dependent on the species of swallow. However, we can answer this question more generally based on a few simple assumptions. First, we'll assume an "unladen" (e.g. not carrying a coconut!) European swallow with an estimated airspeed velocity of 10 meters per second. Next we'll assume that our swallow is flying in the core of an easterly low level jet associated with water vapor transport within an atmospheric river. This region of intensified winds at approximately 1km above sea level typically features velocities in excess of 30 meters per second. So, very roughly, we could assume that with a 30m/s tailwind our swallow could achieve a ground speed of 40m/s, or almost 90mph!

On a more serious note, this is actually a very pertinent question for our flight planning during Atmospheric River Reconnaissance flights, since during mission planning we attempt to get the best observations possible, but need to negotiate tailwinds and headwinds along the flight track to optimize our sampling pattern. Granted, an Air Force C-130 isn't exactly an "unladen swallow", but environmental conditions can have a drastic impact on mission planning during Atmospheric River Reconnaissance. Here's a link to our latest updates on the aircraft observation campaign. http://cw3e.ucsd.edu/atmospheric-river-reconnaissance-2018-underway/

What is your advice for effectively communicating climate science to the public? How do you deal with people who have politically-motivated thinking?

jwaves11

A key approach that's been emphasized at the American Association for the Advancement of Science (AAAS) and other venues is to work to establish common ground with the people who you are communicating with. For example, we as individuals and as a society benefit from a better understanding of the systems that affect and govern the climate in which our civilization thrives. We all want to ensure that our children and their children inherit a healthy environment in which they can prosper.

We also know that people respond better to issues they can personally relate to, such as potential flooding during an El Niño year, or the potential sea-level rise along their local coastline, or the changes in seasonal cycles that plants and animals undergo in their region. When we communicate these changes, it's important to explain how we know things, such as the breadth and depth of evidence across various fields of study, and to be clear about what we don't know or what aspects we are uncertain about.

It's also important to reach out to communities and organizations that have different religious or political beliefs than you. Several of my Scripps colleagues have given talks to communities of faith including the Catholic Church and the Evangelical Church to communicate the facts about climate change and its impacts on the environment. Science and religion don't always mix, but the environment is an area in which common ground can be found.

When I get a weather forecast, how many days into the future is it reliable?

tigersharkwushen_

Assessing the skill of forecasting Atmospheric Rivers is extremely important given their impact on western US water resources and their potential for weather-related hazards. We rarely experience atmospheric river landfall that was not predicted at least 3 days ahead of time, although the location and strength may be in serious error. In some instances, model skill of Atmospheric River landfall even extends up to seven days, but with significant uncertainty in local precipitation impacts. An excellent example of this is the Oroville Dam event from last year (2017) where we saw that a “moderate strength” Atmospheric River would be making landfall 2 days later, but didn’t have much certainty in the details of the strength of duration of conditions over the Feather River watershed, or how that translated to precipitation quantity within the watershed. In fact, when the AR hit, its strength was “extreme” based on a scale developed by Marty Ralph/CW3E. Over 200,000 people were evacuated during this event due to concerns over the Dam’s spillway, and uncertainty in how much precipitation would fall and how fast the reservoir’s water level would rise.

Hello Marty. I couldn't decide between questions, so I've included my top 3.

*What do atmospheric rivers mean for water management operations and strategy in the West?

*Could better capture of atmospheric river precipitation create water security for drought-worn communities?

*Do you think that this recent understanding of atmospheric rivers could inform coastal habitat management strategies in addition to water supply management? I imagine the pulses of rain create a lot of polluted run-off into beaches and estuaries.

Aloha_Po-ouli

Hello Marty. I couldn't decide between questions, so I've included my top 3. answer is below

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*What do atmospheric rivers mean for water management operations and strategy in the West?

ARs provide the lion’s share of the precipitation, and most of the flooding on major rivers, in the western coastal states and they also impact states just inland from there. Science has started developing specialized tools to monitor and predict ARs (http://cw3e.ucsd.edu), and these are aiming partly to support water managers. Rules governing reservoir operations are meant to balance the often competing demands for a reservoir, e.g., flood control, water supply, recreation… Some reservoir operators, especially Sonoma County Water Agency and Orange County Water District are exploring these possibilities with the U.S. Army Corps of Engineers, and with scientists such as those here at UC San Diego/Scripps Institution of Oceanography’s Center for Western Weather and Water Extremes (CW3E). *Could better capture of atmospheric river precipitation create water security for drought-worn communities? The Forecast-informed reservoir operations (FIRO; http://cw3e-web.ucsd.edu/firo/) project on Lake Mendocino in northern California’s Russian River valley has produced a preliminary viability assessment that suggests FIRO (and the better AR forecasts it is pursuing) can lead to up to 20,000 acre feet of water supply reliability (that’s enough water for about 50,000 homes in the area for a year), at least in some years. Ideally, some of the lessons learned in the Lake Mendocino FIRO project will apply to at least a few other reservoirs. Early stages of exploration of this possibility are now being pursued with Orange County Water District, for example. It is plausible that FIRO and the forecasts of ARs could help make better use of existing reservoirs. *Do you think that this recent understanding of atmospheric rivers could inform coastal habitat management strategies in addition to water supply management? I imagine the pulses of rain create a lot of polluted run-off into beaches and estuaries. This seems plausible. Though the answer depends critically on how decisions are made in coastal management operations. If better runoff forecasts from AR storms could be used in decisions for coastal habitat, they likely could help.

How will a better understanding of the weather improve our forecast when related to tornados, High Winds, and other such phenomena in the Midwest?

Jsnookiii

A better understanding of atmospheric physics and how our extreme weather systems evolve can help improve their representation in our weather forecasting models. Also, better satellite and other observations of these extreme weather systems help improve our current estimate of the weather and hence improve weather forecasts. This will then help improve the predictions of atmospheric rivers, tornadoes, high winds and extreme weather in Midwest in the future weather forecasting models.

We have been advancing numerical weather prediction steadily over the past several decades with our collective scientific knowledge and technological advances. This has been primarily due to improved understanding of the physics of our atmosphere and improved supercomputing capabilities. The impact of numerical weather prediction is among the greatest of any area of physical science. To quote a recent paper by Dr. Peter Bauer (ECMWF): “As a computational problem, global weather prediction is comparable to the simulation of the human brain and of the evolution of the early Universe, and it is performed every day at major operational centers across the world.”

The following paper is a great read on how we have advanced numerical weather prediction over the past several years.

Bauer, P., Thorpe, A. and Brunet, G., 2015. The quiet revolution of numerical weather prediction. Nature, 525(7567), p.47.