Atmospheric River Research in Alaska

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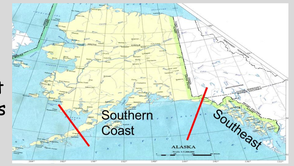
Abstract:

Atmospheric River (AR) events have been well documented and monitored for years along the West Coast of the continental United States. However, ARs impact the entire west coast of North America including British Columbia, the Alaska Panhandle, the southern mainland of Alaska (including Prince William Sound and the Cook Inlet region), as well as the west coast and interior portions of Alaska. There were a few impactful AR events over western and interior Alaska in June and July of 2016. While impactful ARs are most likely in the late summer, fall, and early winter seasons in Alaska, they can occur anytime of year and result in significant and impactful amounts of precipitation. These storms can impact communities with flooding, large debris flows, disruption to transportation, significant snowfall in winter events, and, in rare cases, casualties.

From a forecasting perspective, discerning significant AR events from a more typical strong synoptic storm is very difficult. Steep and complex coastal terrain, proximity to arctic air masses, and significant data sparsity can cause numerical models to struggle considerably with unexpected results in the short term, which affects the ability of the forecaster to provide accurate and timely impact-based decision support to communities and other core partners. Research in Alaska to aid in the decision making process through the development of meaningful thresholds of available AR-related parameters has commenced with the following methods:

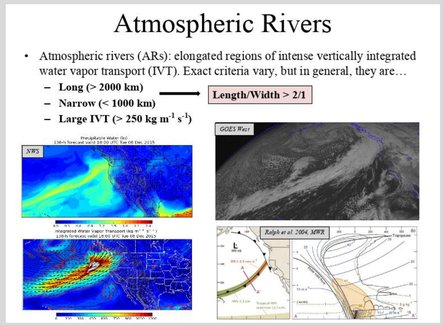
Southern coast including Southwest mainland: Will first look at impactful events, relate that to precipitation information, and then correlate that back to the historical AR detection schemes and datasets

Southeast Panhandle: Will look at all historical precipitation data and relate it back to AR detected dates from reanalysis IVT database (ERA,MERRA,NCEP), SSMI IWV AR detected algorithm and IVT algorithm for CFSR.



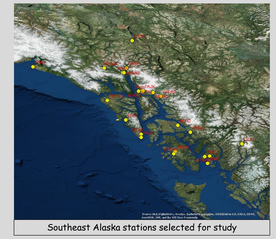
Question: Do the typical definitions of an Atmospheric River apply in Alaska???

Answer: Likely not. Coastal sections of southern and southeast Alaska are temperate rainforests, and so the associated river basins are used to repetitive (almost constant) amounts of light to moderate rainfall. It's only when rainfall is exceptionally heavy and/or lasts for an unusually long time (i.e. a "stalling" AR that affects the same locations for 24-48 continuous hours) that these coastal watersheds experience significant flooding from precipitation. This is why integrated vapor transport(IVT) values higher than 250kg/m/s and time integrated vapor transport (TIVT) may end up actually being the most useful metric in the diagnosis and prognostication of impactful AR's in Alaska.



Southeast Alaska Methods:

- Select a variety of WX stations(ASOS and COOP) across Southeast Alaska. With 24hr rainfall data.
- Link up rainfall data & IVT values from ESRL AR Auto-detection tool (ARDT) historical dates from CFSR data.
- Take top 30 events and compare to stream-flows and impacts
- Compute statistics & return intervals for impactful events



Southeast Alaska stations selected for study

Southern coast and Southwest mainland Methods:

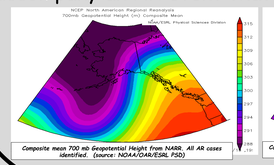
- Search through multiple historical datasets to identify known AR events based on various thresholds of IVT values and time-integrated vapor transport (TIVT).
- Dates and values will then be analyzed statistically and cross-referenced with the Alaska Floods Database.
- The objective of this study is to identify meaningful IVT and/or TIVT thresholds for both coastal and inland regions of Alaska that correlate to known flood impacts in the past and that can be used operationally in forecasting to anticipate elevated threats to life, property, and infrastructure.
- If time allows, a similar comparison will be performed using the parameter integrated water vapor (IWV)

The expected outcomes and research goals:

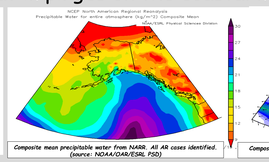
- Climatology of specific fields Integrated water transport (IVT), Precipitable water values (IWV), time integrated IWV with statistics (mean and standard deviation) from precipitation data and/or impact base analysis
- Derive a regional and seasonal classification scheme: non-AR, weak AR, moderate AR and Strong AR
- Assign different types of impacts (none, minor, moderate, major) to AR classification.
- Compute AR event analogs for pattern and strength of moisture transport
- Verification of reanalysis data to AR detection algorithms
- A tool for forecasters to provide increased situational awareness and impact-based decision support services to emergency management.
- Increase sustainable surface based observation network to improve atmospheric model output
- Promote remote sensing capabilities to produce a near real-time IVT data-set for better spatial detection of impactful IVT values

Synoptic AR set-up for Alaska:

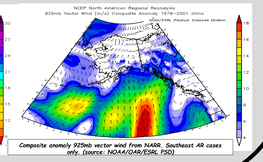
Over the years several atmospheric river events have been classified by individuals working at the National Weather Service in Alaska. In 2011, Papineau and Holloway described the necessary ingredients for heavy rain events in Alaska that ranged from coastal, interior and a "hybrid" of the coastal and interior. Within this report, coastal and coastal-interior events were associated with extended plumes of moisture originating in the lower latitudes, that may or may not meet the commonly accepted definitions of ARs. Looking at a simple average from the North American Regional Reanalysis (NARR) dataset of the 700mb geopotential heights of these events as well as more recent episodes, it is readily apparently that a high amplitude anomalous trough/ridge couplet is needed. Furthermore, a composite mean of the precipitable water for the entire atmosphere exposes the influx of moisture from the lower latitudes. Lastly, the presence of a dramatic coastal mountain range creates additional orographic lift that results from strong onshore winds that typically accompany an AR event that impinges on the coastal mountains.



Composite mean 700 mb Geopotential Height from NARR. All AR cases identified. (source: NOAA/OAR/ESRL PSD)



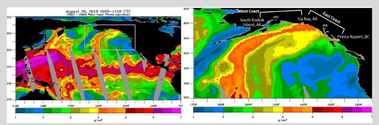
Composite mean precipitable water from NARR. All AR cases identified. (source: NOAA/OAR/ESRL PSD)

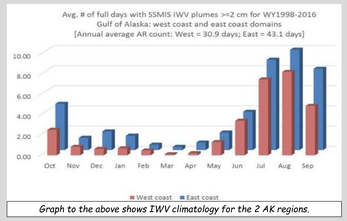


Composite anomaly 925mb vector wind from NARR. Southeast AR cases only. (source: NOAA/OAR/ESRL PSD)

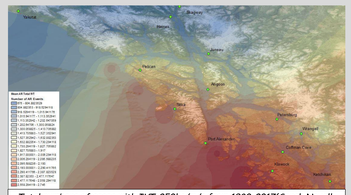
Preliminary Alaska-specific AR climatology:

- Collaborative project involving a number of forecasters within Alaska Region and researchers at Earth Sciences Research Laboratory (ESRL).
- Break the coast of Alaska into 2 regimes and evaluate the impacts using 2 different methods.
- Finding 1=Just having moist air Integrated Water Vapor may not be the best indicator for AK ARs. Most impactful AK AR's happen in the fall and winter months with relatively low IWV values but stronger atmospheric forcing and dynamics.
- Finding 2=Just using IVT values >250kg/m/s may place frequency of impacful AK Ar's too far south. (For example the map to the right shows a large amount over the southern half ofSEAK.)





Graph to the above shows IWV climatology for the 2 AK regions.



Total numbers of cases with IVT>250kg/m/s from 1980-2017(Sarah Novell-Lane map using Rutz MERRA AR dataset)

Acknowledgements/references

Rutz, Jonathan Ph.D, NWS/WRHQ/STI: "AR catalogs of IVT and presence of ARs from a variety of reanalysis data sets" http://journals.ametsoc.org/doi/abs/10.1175/MWR-D-13-00168.1

Papineau J., E. Holloway, 2011: The Nature of Heavy Rain and Flood Events in Alaska. Paper found at http://www.weather.gov/afc/

NCEP Reanalysis data provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their Web site at http://www.esrl.noaa.gov/psd/

Wick, Gary Ph.D, NOAA/ESRL/PSD: Provided dates of landfalling ARs over AK by using the AR Auto-detection tool (ARDT) for IVT values >250 kg/s/m and > 500 kg/m/s on CFSR data over Alaska

Neiman, Paul Ph.D, NOAA/ESRL/PSD: Provided a landfalling AR inventory from composite SSMIS IWV satellite imagery from 1998-2016 across Alaska

Sarah Novell-Lane, University of Southeast Alaska: compiled rainfall data for selected stations across Southeast Alaska from IVT data set