Linkages Between Atmospheric Rivers and Orographic Precipitation in the Western U.S.

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Atmospheric Rivers (ARs) are a dominant cause of flooding

Flooding on California’s Russian River: Role of atmospheric rivers

Ralph, F.M., P. J. Neiman, G. A. Wick, S. I. Gutman, M. D. Dettinger, D. R. Cayan, A. White


Russian River floods are associated with atmospheric rivers
- all 7 floods over 8 years.

Flooding in Western Washington: The Connection to Atmospheric Rivers


*J. Hydrometeorology* (2011)

46 of 48 annual peak daily flows on 4 watersheds were associated with atmospheric rivers.
Automated AR Detection Tool (ARDT)

- Automated tool developed for detection of AR events in observed and modeled IWV fields
- Based on thresholds for width, length, and IWV content of ARs
- Validated against manually identified landfalling events over 5 cool seasons
  - 92.8% critical success index
- Procedure returns core IWV, AR width, and orientation along length of AR

See poster by Darren Jackson tomorrow for more details on the ARDT.

Wick et al., TGRS, 2013
CA landfalling ARs as a function of time

Figure courtesy D. Jackson
Floods vs. duds: AR orientation

- Link between AR angle and flood risk: higher risk with west-southwesterly ARs, lower risk with southerly or westerly ARs.
Floods vs. duds: AR orientation

- Local aspect to this:
  Different basins respond differently to AR angle.
Landfalling Atmospheric River (AR) -> Extreme Precipitation amounts in Arizona

From Neiman et al. 2013
Smith and Evans (2007) Linear model (LM) of orographic precipitation

Spatial correlation coefficient = 0.83
Linear Model applied

LM precip for angle shifted by −40 degrees, mm
Linear Model applied

LM precip for angle shifted by −30 degrees, mm
Linear Model applied

LM precip for angle shifted by -20 degrees, mm
Linear Model applied

LM precip for angle shifted by -10 degrees, mm
Linear Model applied

LM precip for angle shifted by 0 degrees, mm
Linear Model applied

LM precip for angle shifted by 10 degrees, mm
Linear Model applied

LM precip for angle shifted by 20 degrees, mm
Linear Model applied

LM precip for angle shifted by 30 degrees, mm
Linear Model applied

LM precip for angle shifted by 40 degrees, mm
Mesoscale precipitation response to ARs

Southern AZ

6% difference region-wide

Water vapor flux angle
Mesoscale precipitation response to ARs

From Hughes et al. 2014

Water vapor flux angle
Summary and Conclusions

• ARs are a **dominant cause of, but not a sufficient condition for, extreme precipitation** – and often flooding – events on the US west coast.

• While ARs are themselves synoptic-scale features, **mesoscale orographic processes** control where and how much precipitation falls as a result of their landfall.

• Continued work in this area will help understand the **processes that control extreme precipitation at the basin scale** – fundamental for deducing flood risk.