

Atmospheric Rivers

Atmos 5210: Synoptic–Dynamic Meteorology II

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Learning Objectives

- After this class you should:
 - Be able to identify atmospheric rivers and their potential impacts using atmospheric analyses and numerical forecasts
 - Understand the processes that contribute to AR decay or maintenance during penetration into the interior western U.S.
 - Be able to forecast potentially high-impact AR events including comparisons with past events

Introduction

Key Moisture-Related Variables

- Integrated water vapor (IWV) – the amount of water vapor in an atmospheric column expressed as the depth of water if that vapor were condensed
 - a.k.a. precipitable water or total precipitable water

$$IWV = \frac{1}{g} \int_{p_{dc}}^{100 \text{ hPa}} q \, dp,$$

- Integrated water vapor transport (IVT) – the total amount of water vapor transport in an atmospheric column

$$IVT = \frac{1}{g} \int_{p_{dc}}^{100 \text{ hPa}} q \mathbf{V} \, dp,$$

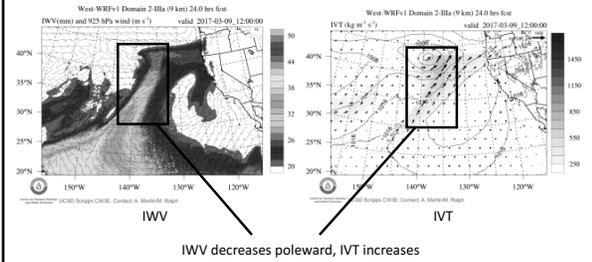
Key Moisture-Related Variables

IWV & IVT are not equivalent

Key Moisture-Related Variables

High IWV, Low IVT

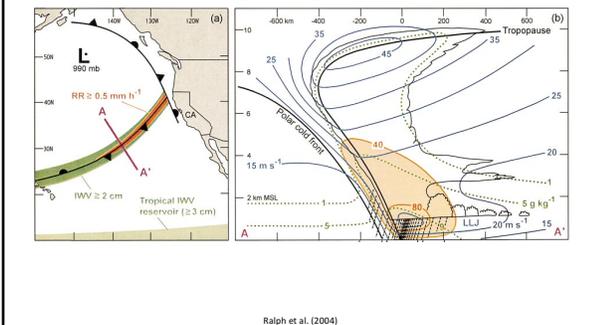
Key Moisture-Related Variables



Atmospheric Rivers (ARs)

- Narrow corridors (i.e., filaments) of strong vertically integrated water vapor transport (Newell et al. 1992; Newell and Zhu 1994; Zhu and Newell 1998)
- Often found along the pre-cold-frontal LLJ and may contribute to the moisture-rich portion of the broader, ascending warm conveyor belt (Ralph et al. 2004; Sodemann and Stohl 2013)
- Achieve their high water vapor content through transport from the tropics [i.e., tropical moisture exports (TMEs)] and/or moisture convergence (Knippertz et al. 2013; Cordeira et al. 2013)
- Associated with midlatitude hydrologic extremes

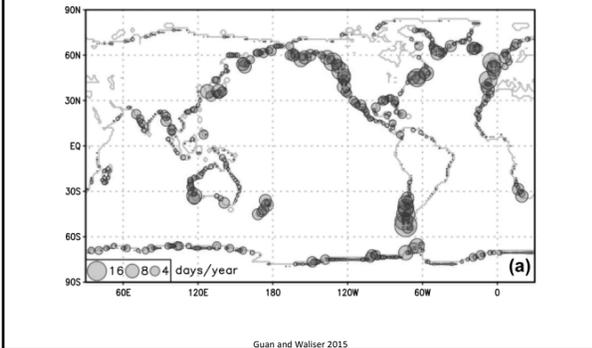
Importance of Pre-Frontal LLJ



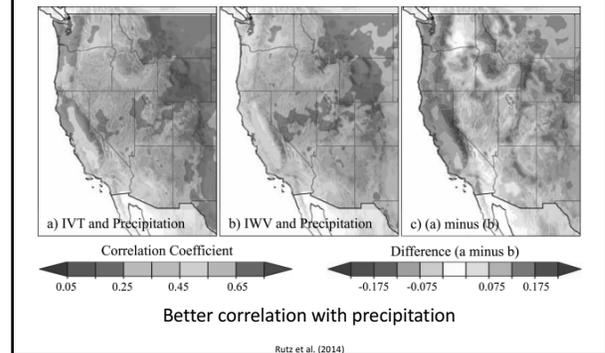
Identification

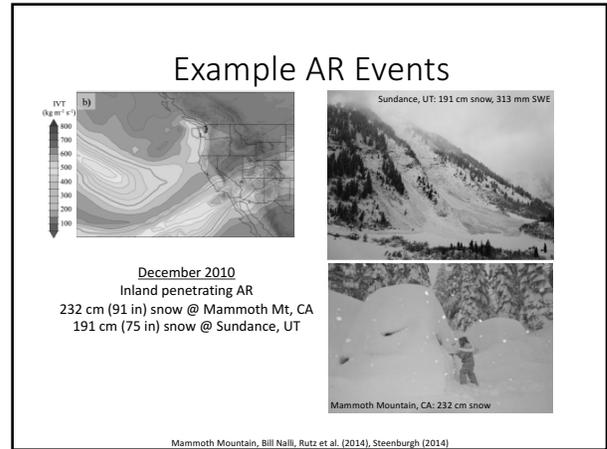
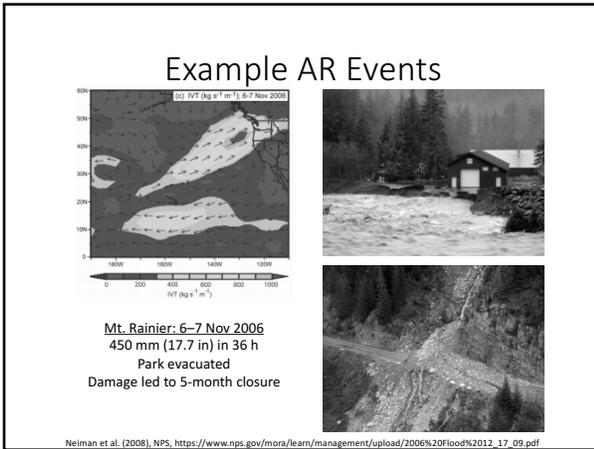
- Satellite based (Ralph et al. 2004)
 - IWV readily available; IVT not readily available
 - Use IWV as an IVT proxy (OK, but not great)
 - ARs identified as contiguous regions of IWV ≥ 20 mm that are ≥ 2000 km in length and ≤ 1000 km in width
- Analysis or NWP based
 - IVT magnitude
 - e.g., contiguous regions of IVT ≥ 250 kg m⁻¹ s⁻¹ ≥ 2000 km long (Rutz and Steenburgh 2012; Rutz et al. 2014)
 - Percentile IVT approaches
 - e.g., seasonally varying 85th percentile IVT (Guan and Waliser 2015)

Global Landfall Distribution



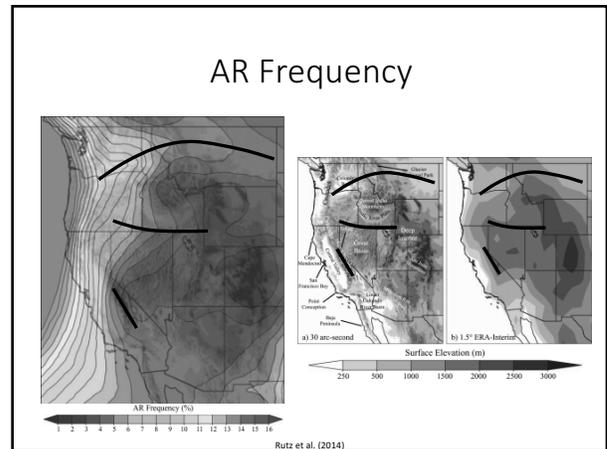
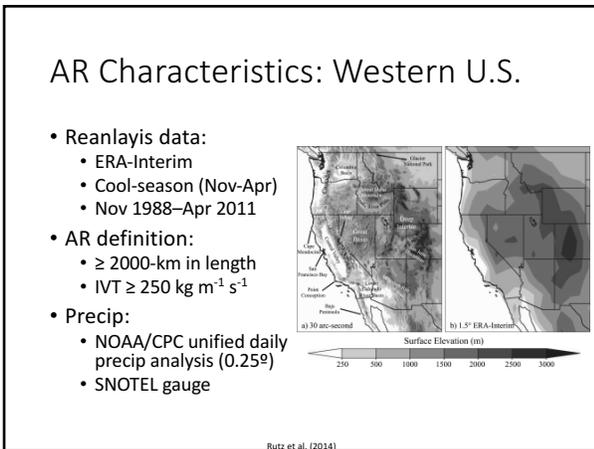
Importance of IVT

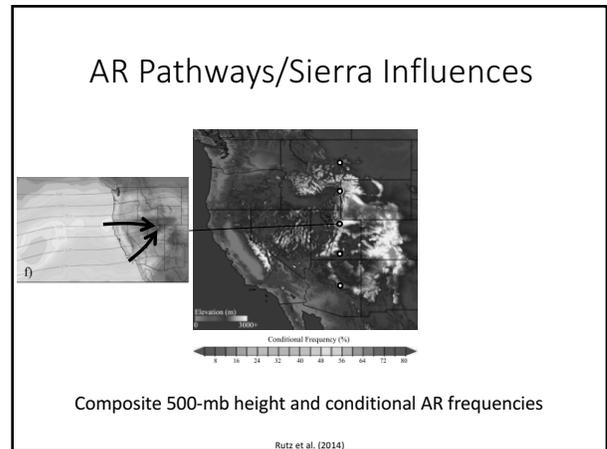
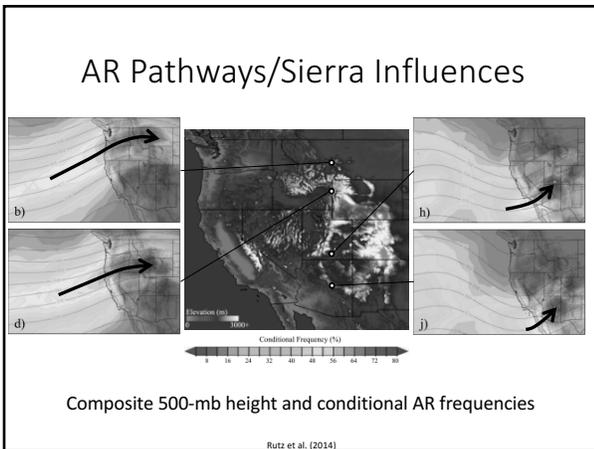
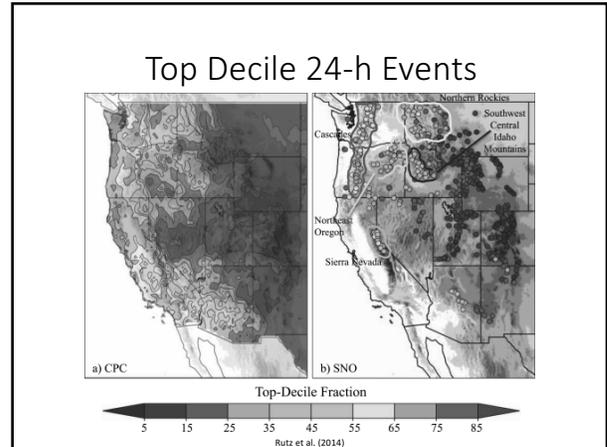
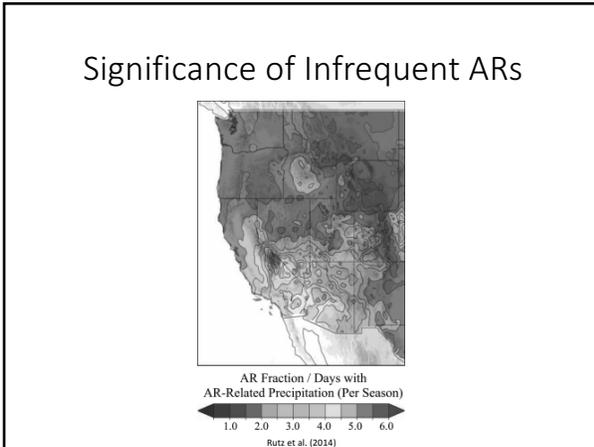
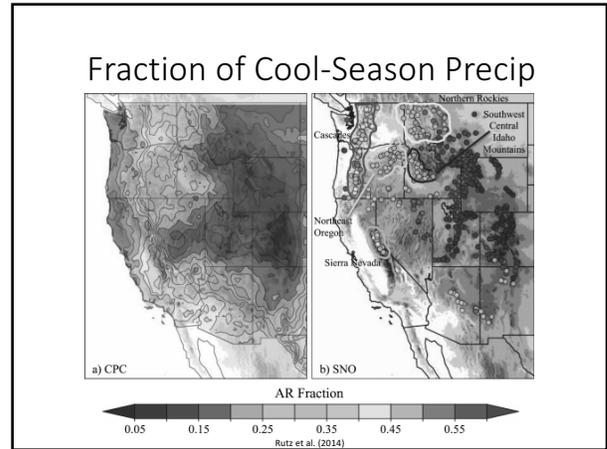
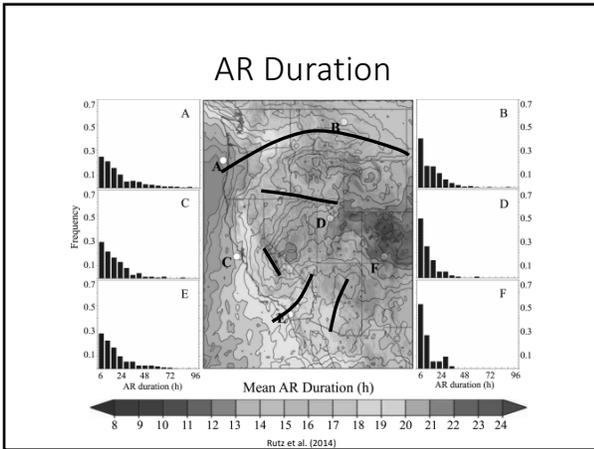




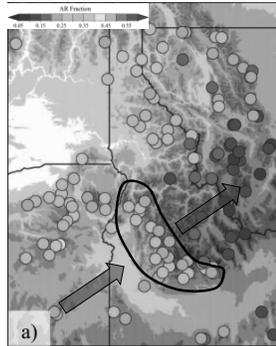
Characteristics of ARs over Western U.S.

- ## Discussion
- Where and why do you think atmospheric rivers are most common
 - Along the US west coast?
 - In the western US interior?
 - What processes favor AR decay during penetration into the western US?
 - What processes might contribute to AR maintenance or intensification?





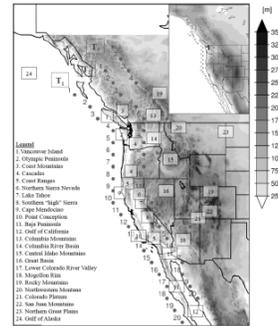
Aspect, Exposure, WV Depletion



Rutz et al. (2014)

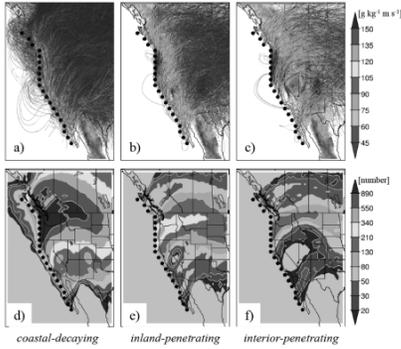
Lagrangian Perspective

- Launch 950-hPa trajectory from T_1 when AR is present
- Coastally Decaying: Reaches T_2 , but not in an AR
- Inland Penetrating: Reaches T_2 in an AR
- Interior Penetrating: Reaches T_2 in an AR



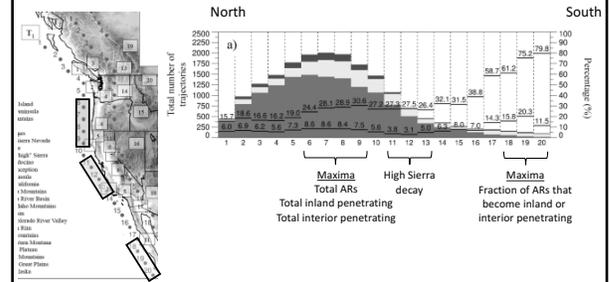
Rutz et al. (2015)

Overview



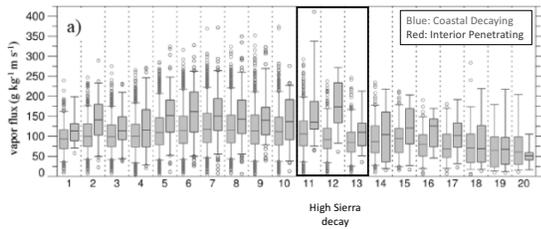
Rutz et al. (2015)

Overview



Rutz et al. (2015)

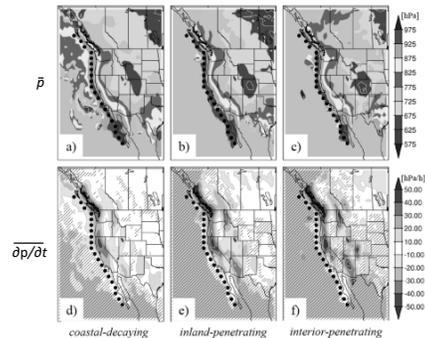
Characteristics @ Initiation



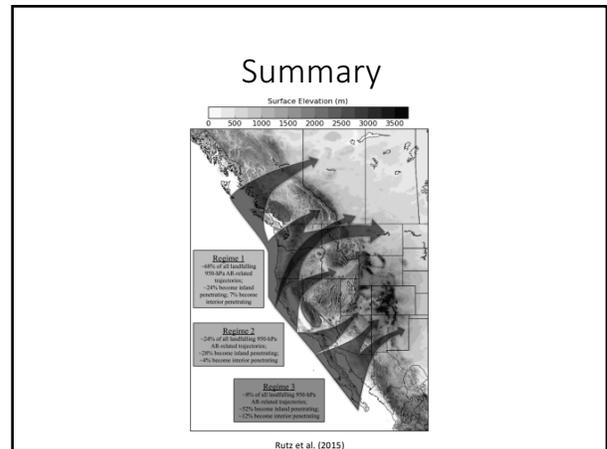
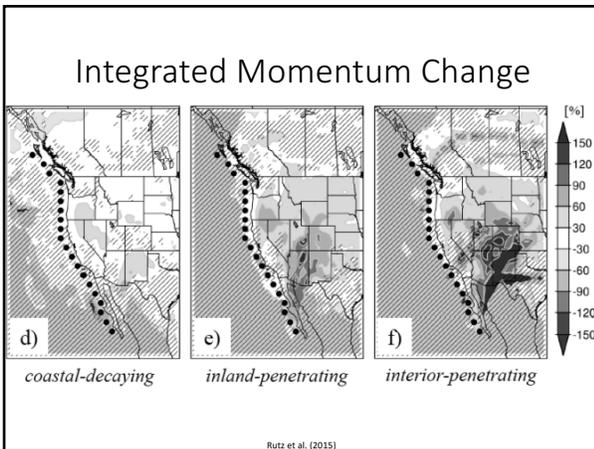
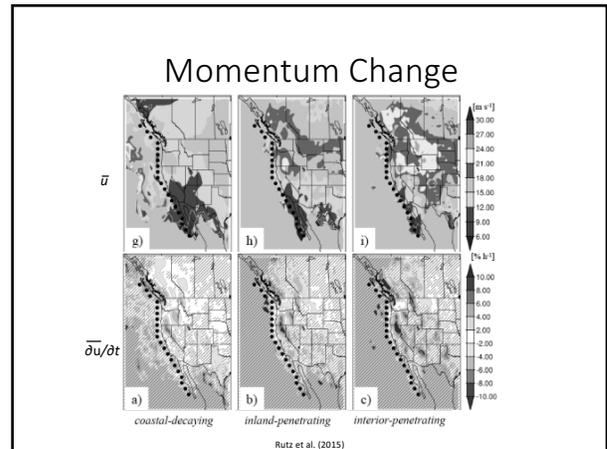
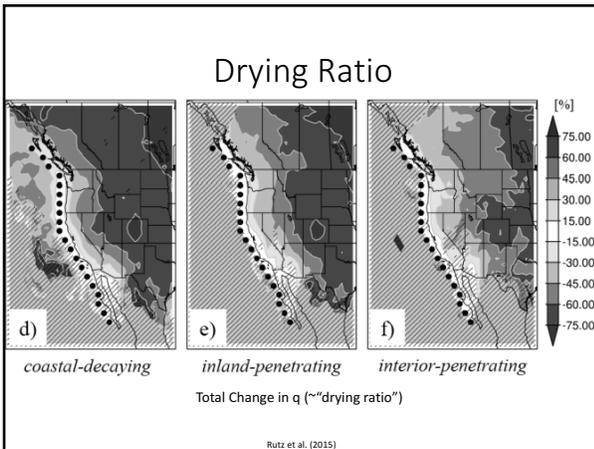
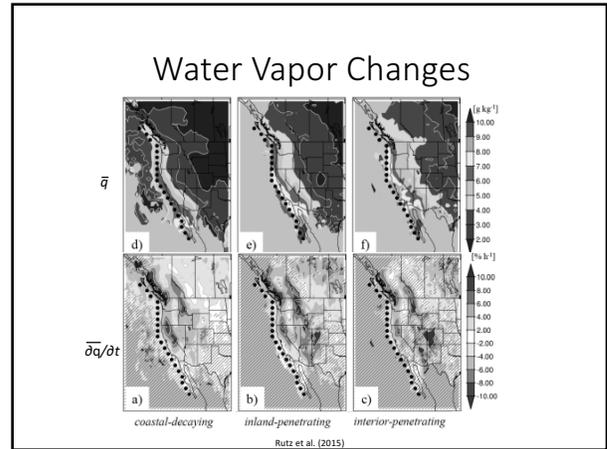
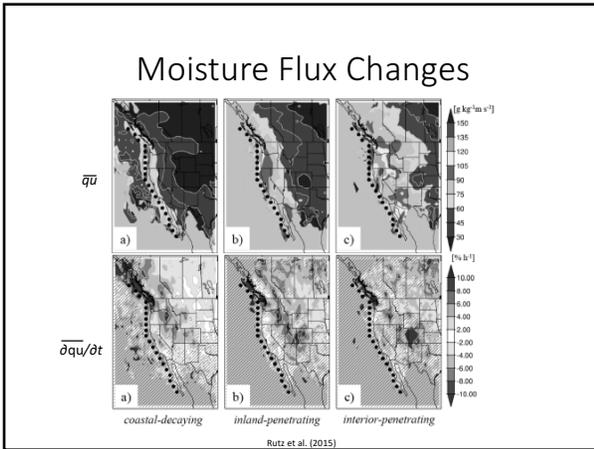
The best way to get an interior penetrating AR is to start with a "big" AR at the coast

Rutz et al. (2015)

Pressure Changes



Rutz et al. (2015)



AR Prediction

Useful Web Sites

- Atmospheric River Portal, Center for Western Weather and Water Extremes
 - <http://mead.ucsd.edu/>
 - Many many products – good for IVT identification, intensity, structure, probability, etc.
- NWS/WR Ensemble graphics
 - <http://ssd.wrh.noaa.gov/naefs/>
 - GEFS IVT
- NWS Situational Awareness Table
 - <http://ssd.wrh.noaa.gov/satable/>
 - IVT standardized anomalies and return periods

Real-Time Examples & Exploration

Group Activity

- Evaluate the characteristics of a future AR event along the west coast of North America over the next 10 days
 - What is the range of potential intensities and landfall locations?
 - How unusual are the lowest and highest intensities relative to past events?
 - How long might the event persist at a specific location?
 - What sort of forecast, watch, or warning action does the event warrant at the present time?