Linking Inter-annual Variations in Atmospheric River Landfalls to Vegetation Responses in the Southwestern United States

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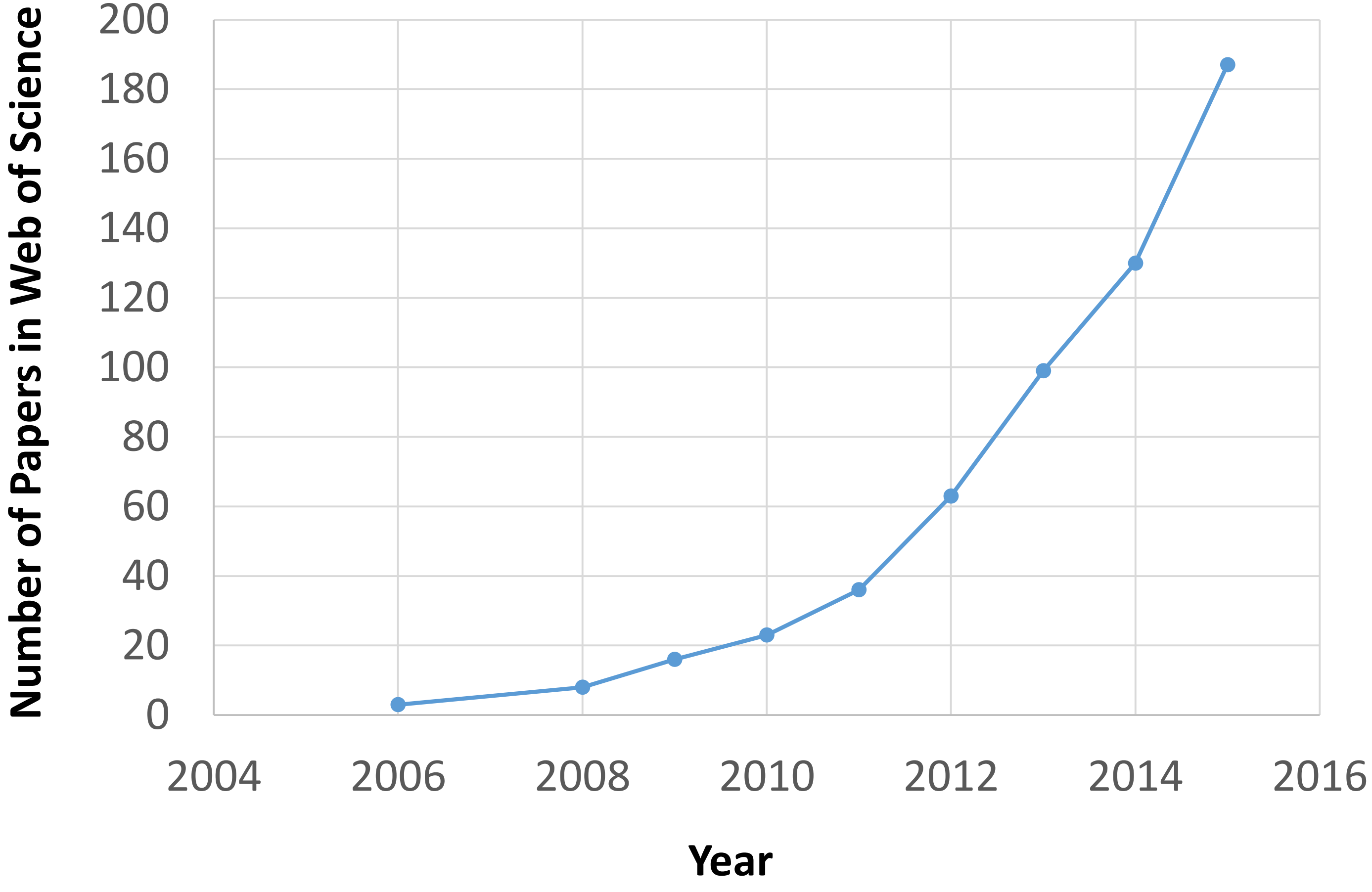
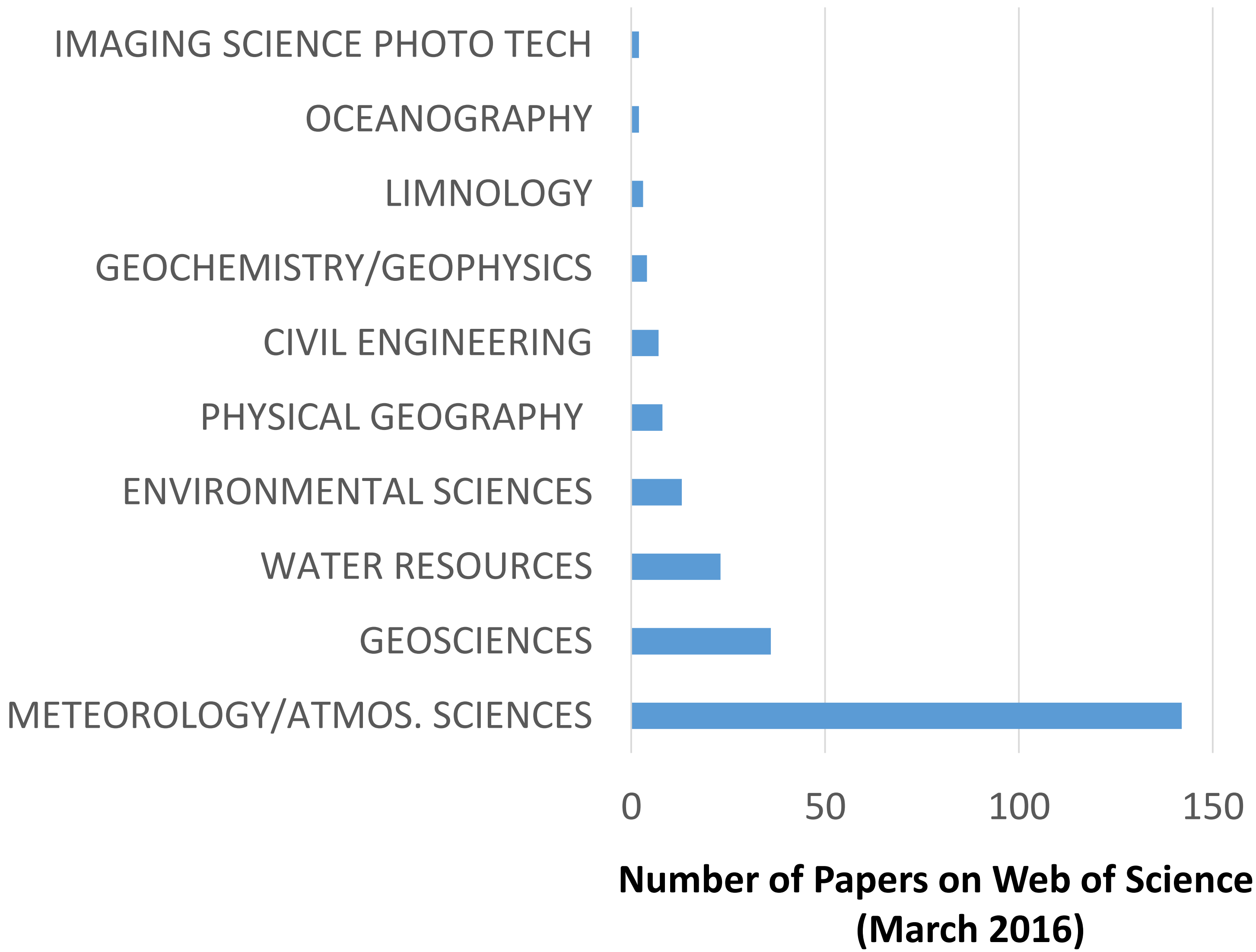
Knowledge of ARs is increasing rapidly




IMAGING SCIENCE PHOTO TECH
OCEANOGRAPHY
LIMNOLOGY
GEOCHEMISTRY/GEOPHYSICS
CIVIL ENGINEERING
PHYSICAL GEOGRAPHY
ENVIRONMENTAL SCIENCES
WATER RESOURCES
GEOSCIENCES
METEOROLOGY/ATMOS. SCIENCES
0
50
100
150
Number of Papers on Web of Science
(March 2016)

Acute to Aggregate Ecological Effects

Direct/Acute (hazard)

Windthrow

Avalanches

Debris Flows

Floods

Landslides

Fuel moisture

Soil moisture

Indirect/Aggregate (resource)

Streamflow

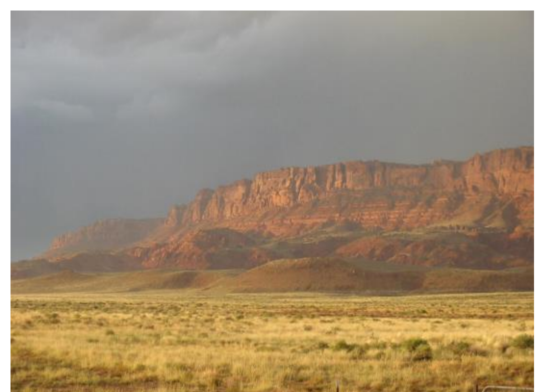
Veg. productivity

Fuel loading

Dispersal

Survival

Evolution



Life History

Phenology

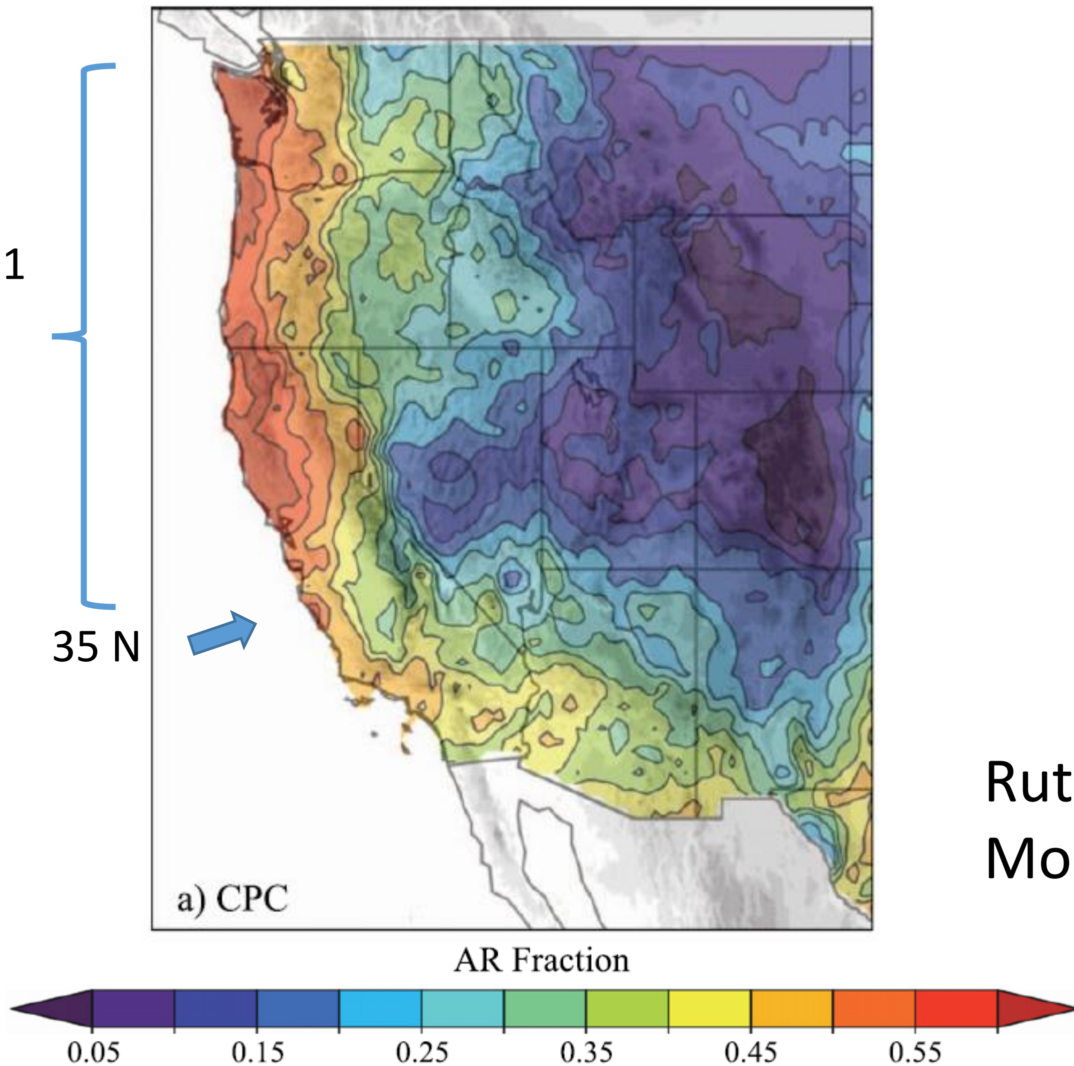
Morphology

Physiology

Most studies focused on higher latitude ARs

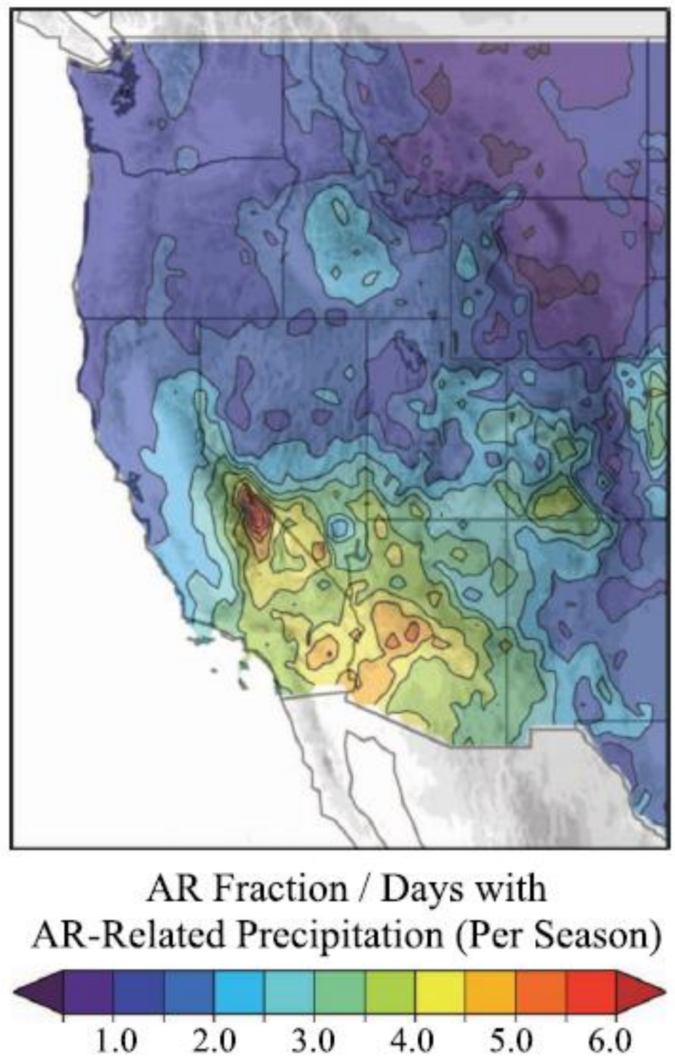
Neiman et al. 2011
Dettinger 2012
Guan et al. 2012
Hagos et al. 2016
Etc.

35 N



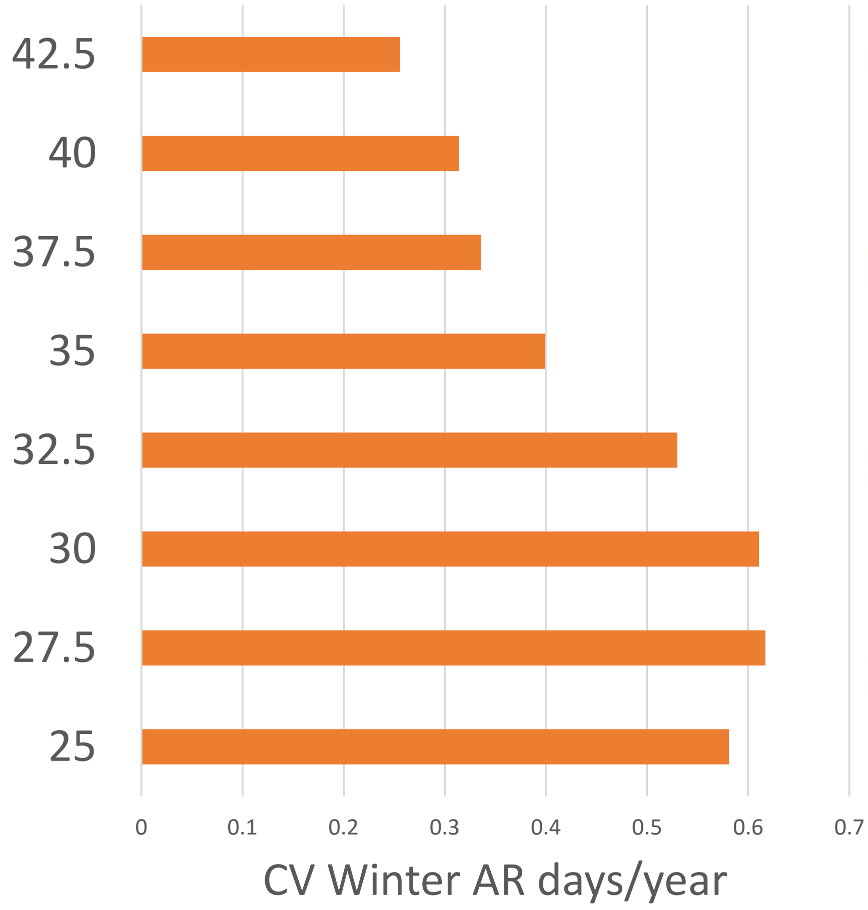
Rutz et al. 2014, Month Weath Rev

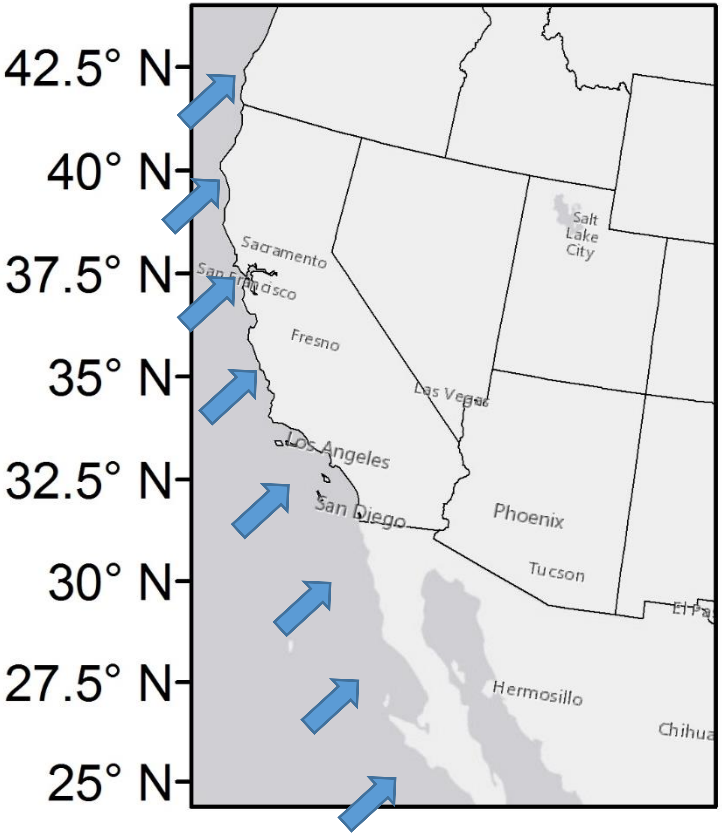
Cool-season precipitation in interior SW influenced by low-frequency, low-latitude ARs



Rutz et al. 2014, Month Weath Rev

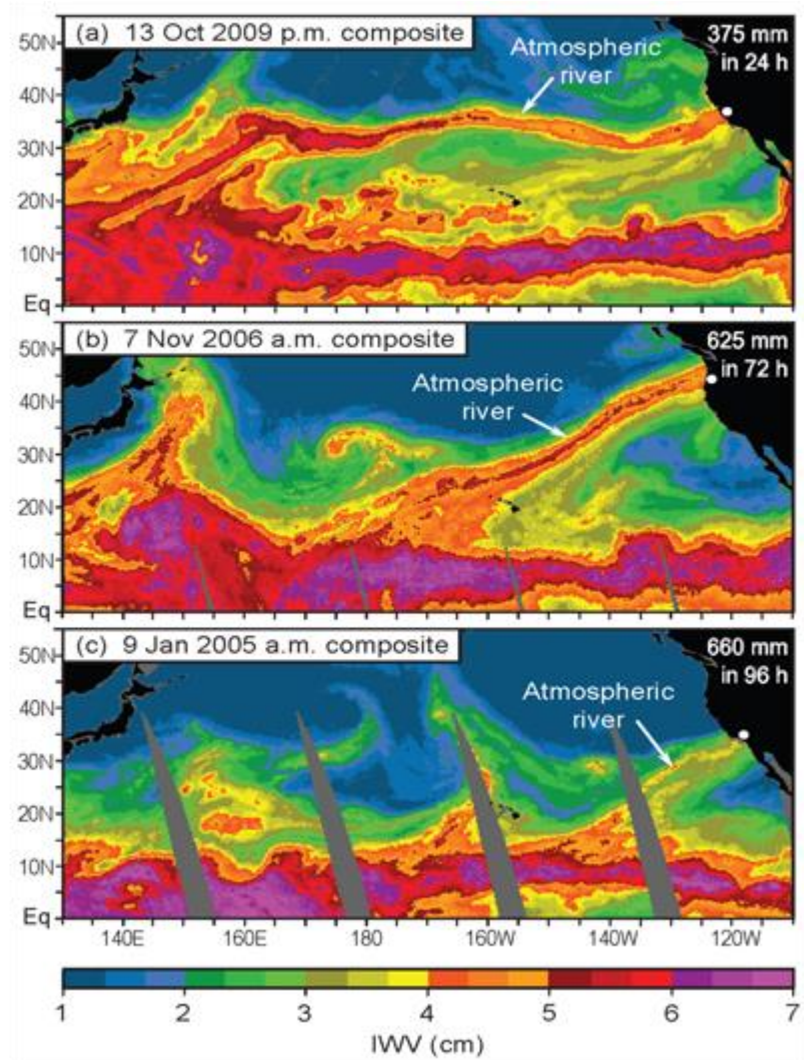
Interannual AR variability higher at low latitudes

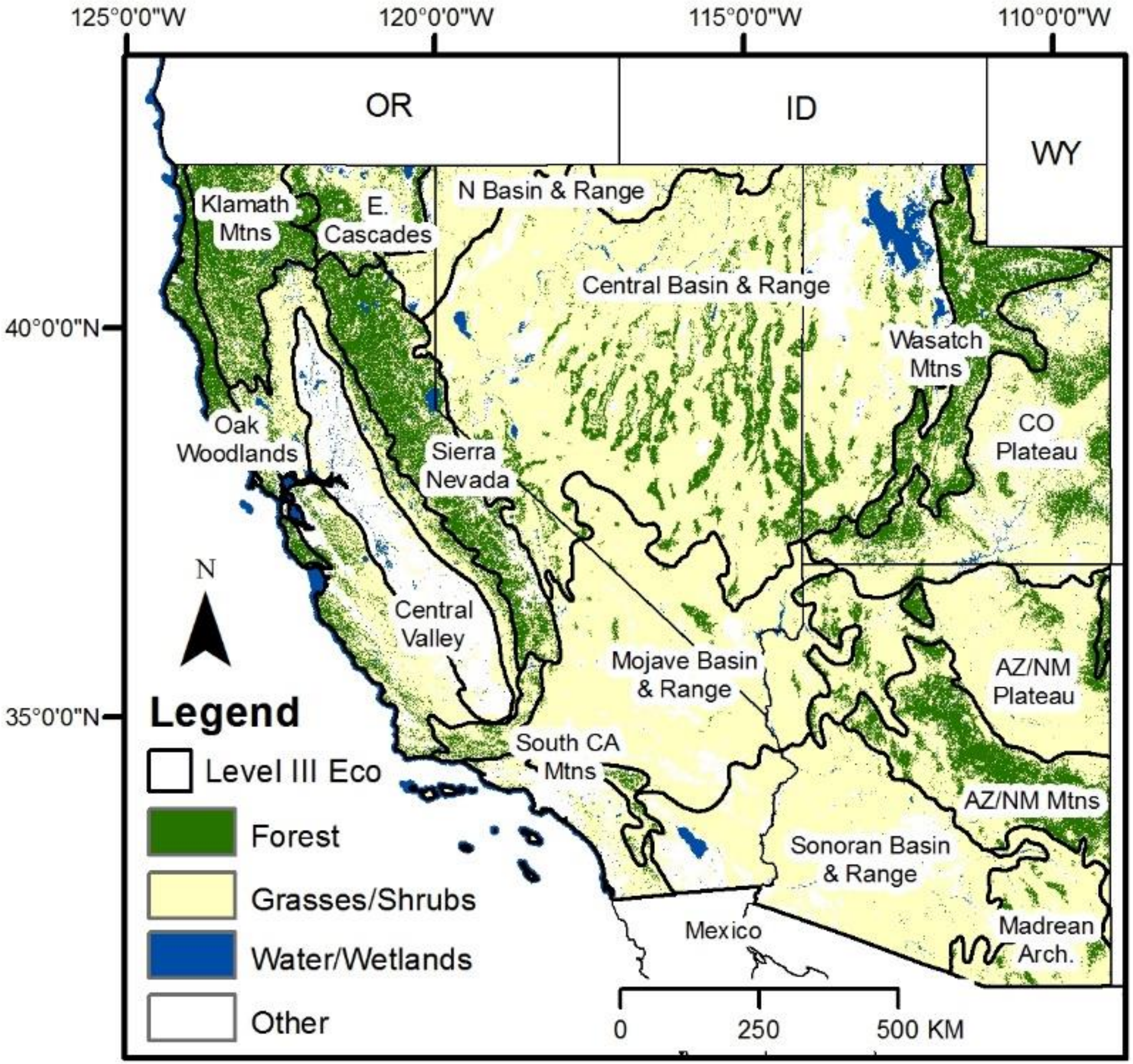




Hypotheses

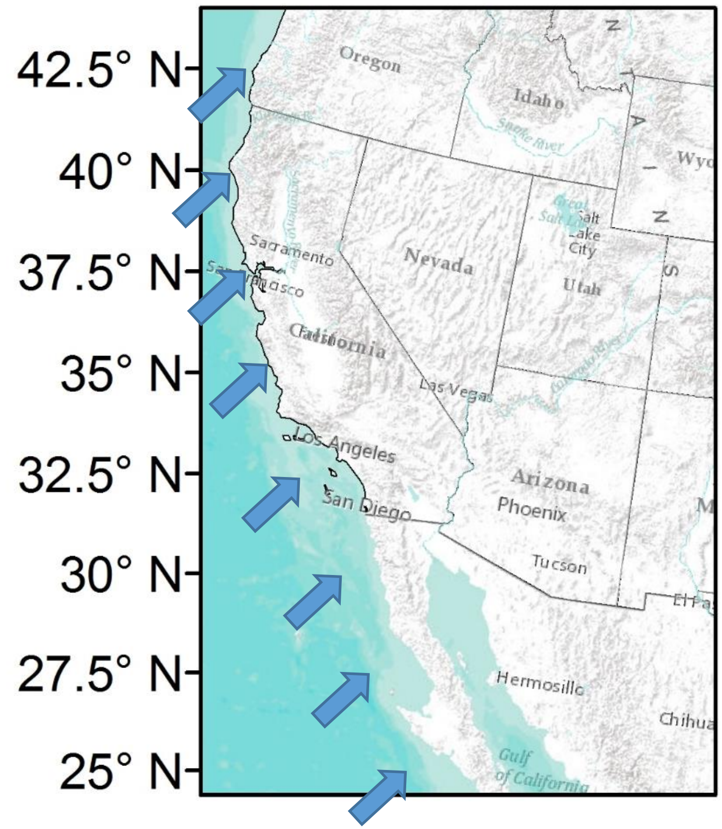
- ARs explain a large proportion of interannual variation in vegetation productivity in semi-arid systems in the SW
- Effects on vegetation productivity/fuel loading translates to patterns of fire occurrence/spread
- Effects dependent on landfall latitude




125°0'0"W
120°0'0"W
115°0'0"W
110°0'0"W
40°0'0"N
35°0'0"N
OR
ID
WY
Klamath Mtns
E. Cascades
N Basin & Range
Central Basin & Range
Wasatch Mtns
CO Plateau
Oak Woodlands
Sierra Nevada
Central Valley
Mojave Basin & Range
AZ/NM Plateau
South CA Mtns
AZ/NM Mtns
Sonoran Basin & Range
Madrean Arch.
Mexico
N
Legend
Level III Eco
Forest
Grasses/Shrubs
Water/Wetlands
Other
0
250
500 KM

Data and Methods

- AR chronology, 1989-2012
  - Rutz et al. 2014
  - landfall date
  - landfall latitude
    - 25N – 42.5N, every 2.5 deg
- Annual Cool-Season (Oct-Apr) Precip on AR landfall dates
  - daily 4km NLDAS-PRISM met data (Abatzoglou 2013)
  - summed winter AR precip in cell by water year (1989-2012)
  - by landfall latitude



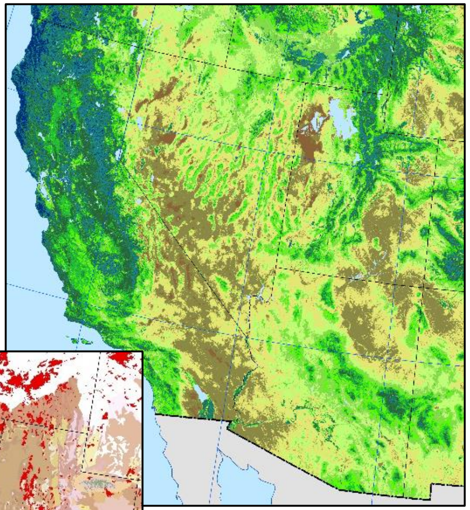
Data and Methods

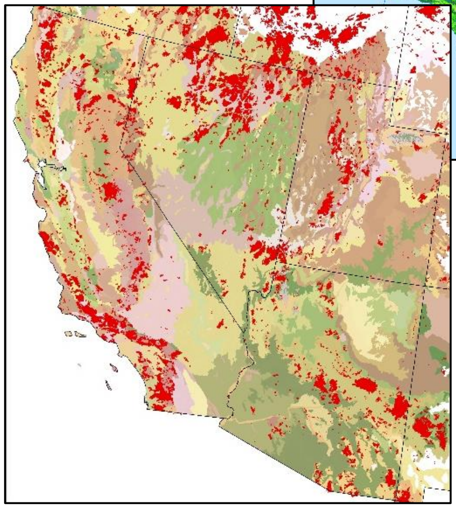
Vegetation Productivity

- Annual Maximum NDVI (1989-2012)
  - 1-km AVHRR (USGS EROS)

Area burned

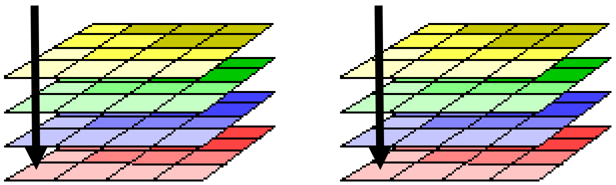
- Annual area burned by wildfire by EPA Level 4 ecoregion (MTBS)



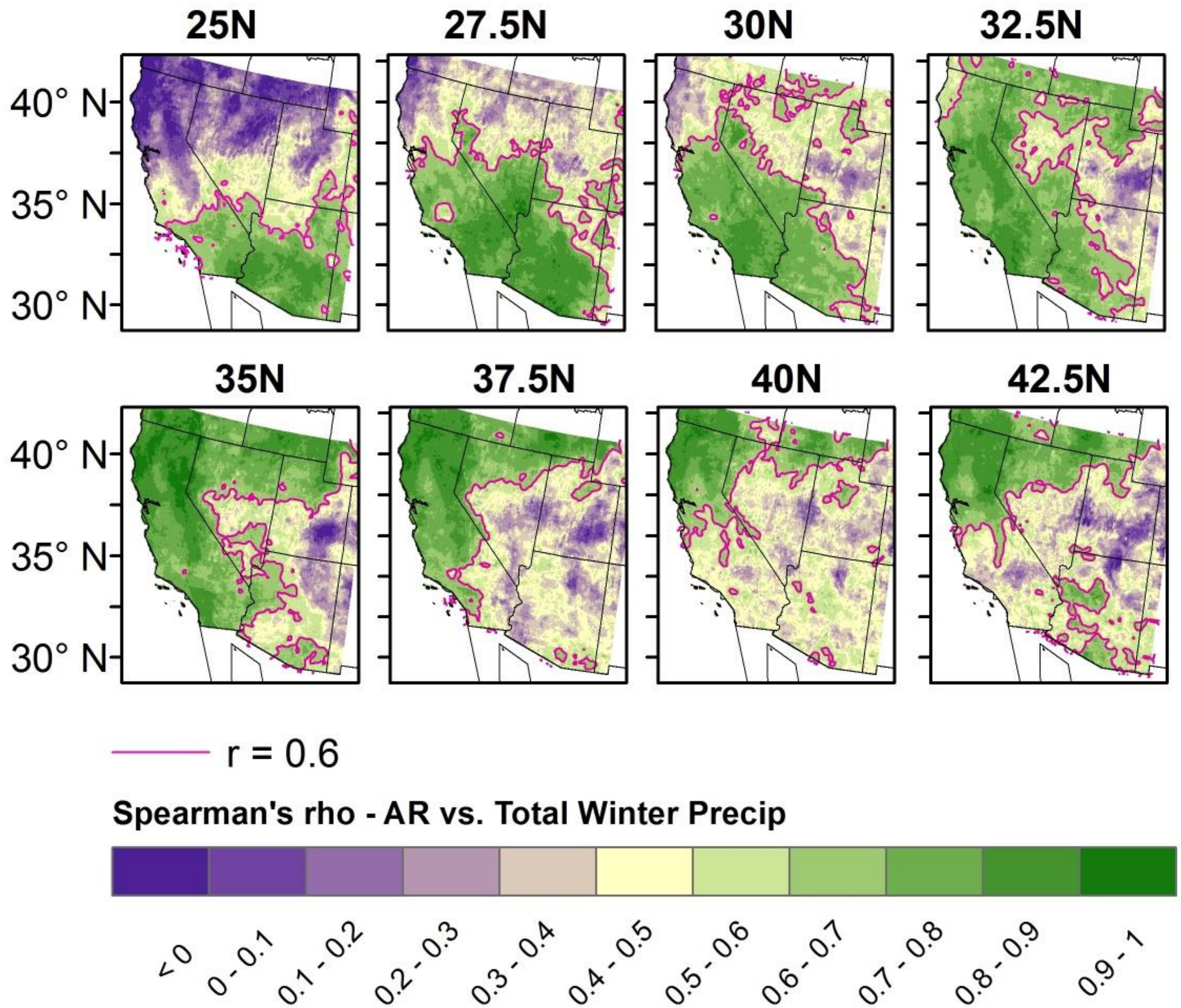


Analysis

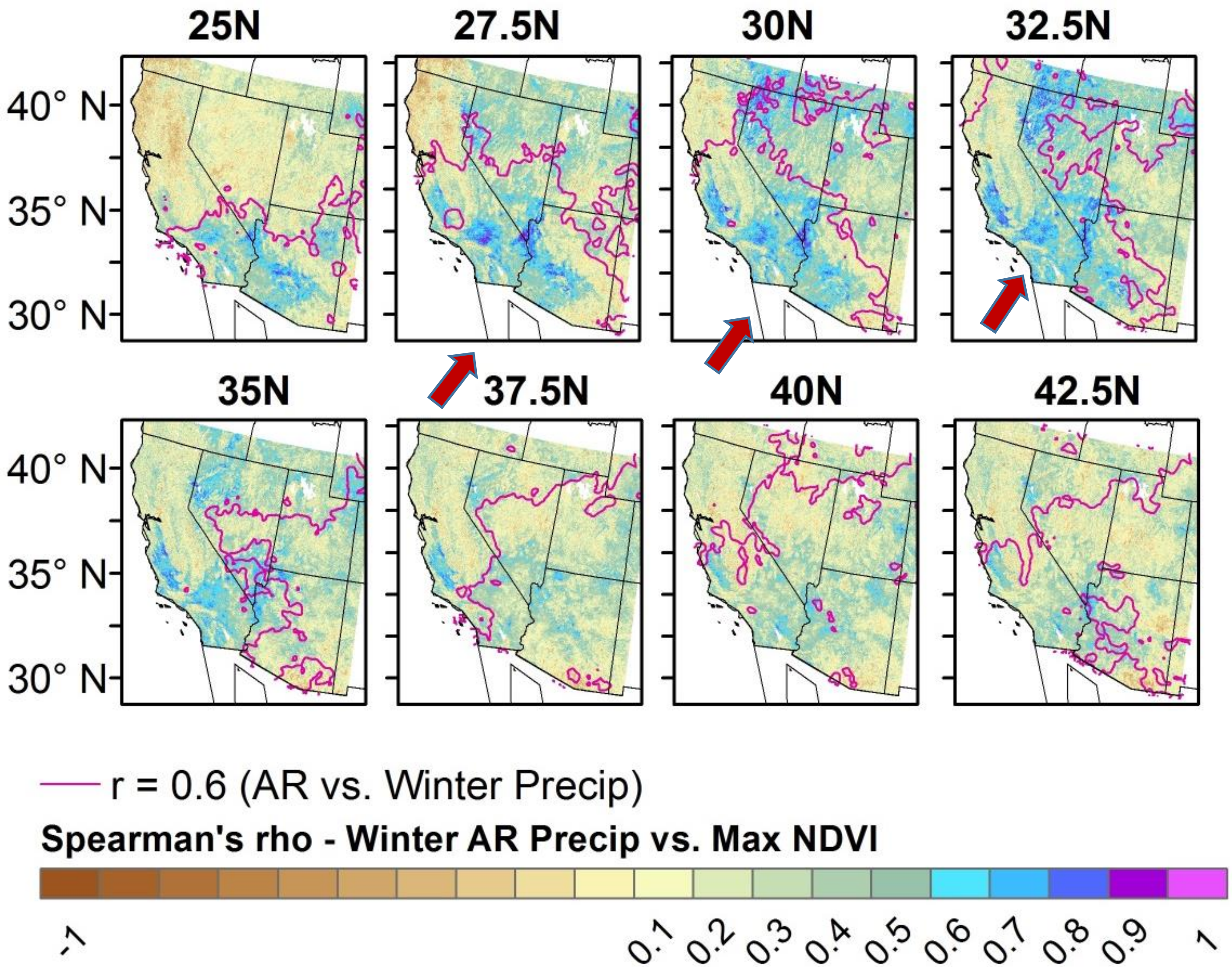
- Rank correlation
  - W. AR Precip x Total Winter Precip
  - W. AR Precip x Max NDVI
  - W. AR Precip x Area burned same year + 1-year lag (Westerling et al. 2003)
- Maps of correlation coefficients (rho)



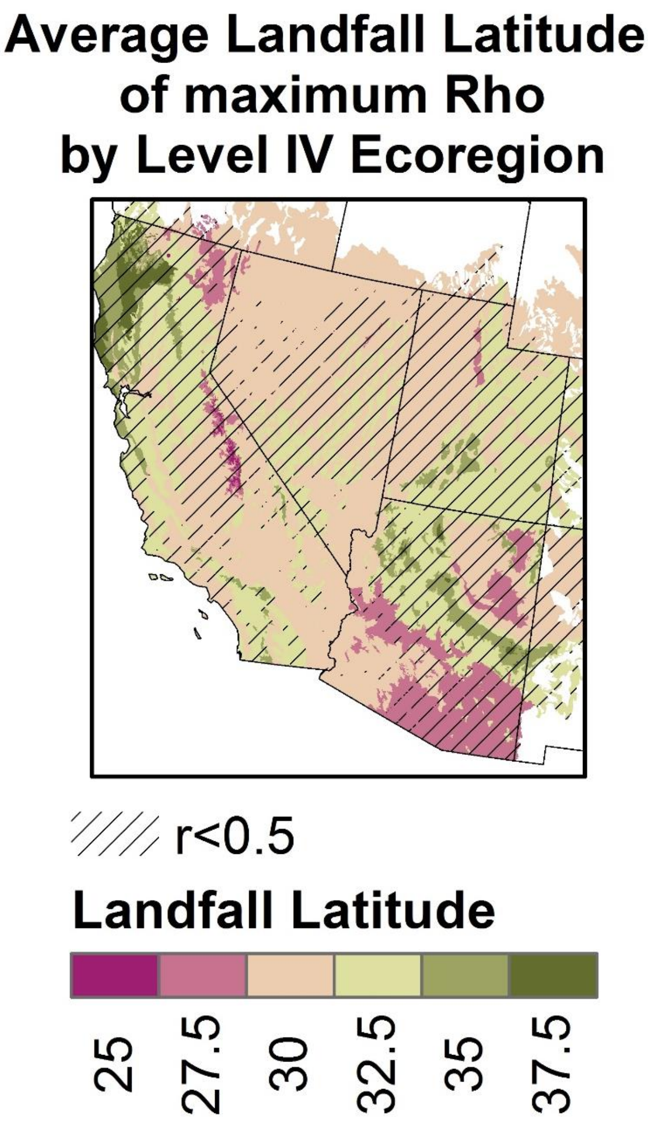
ARs influence variability in winter precipitation



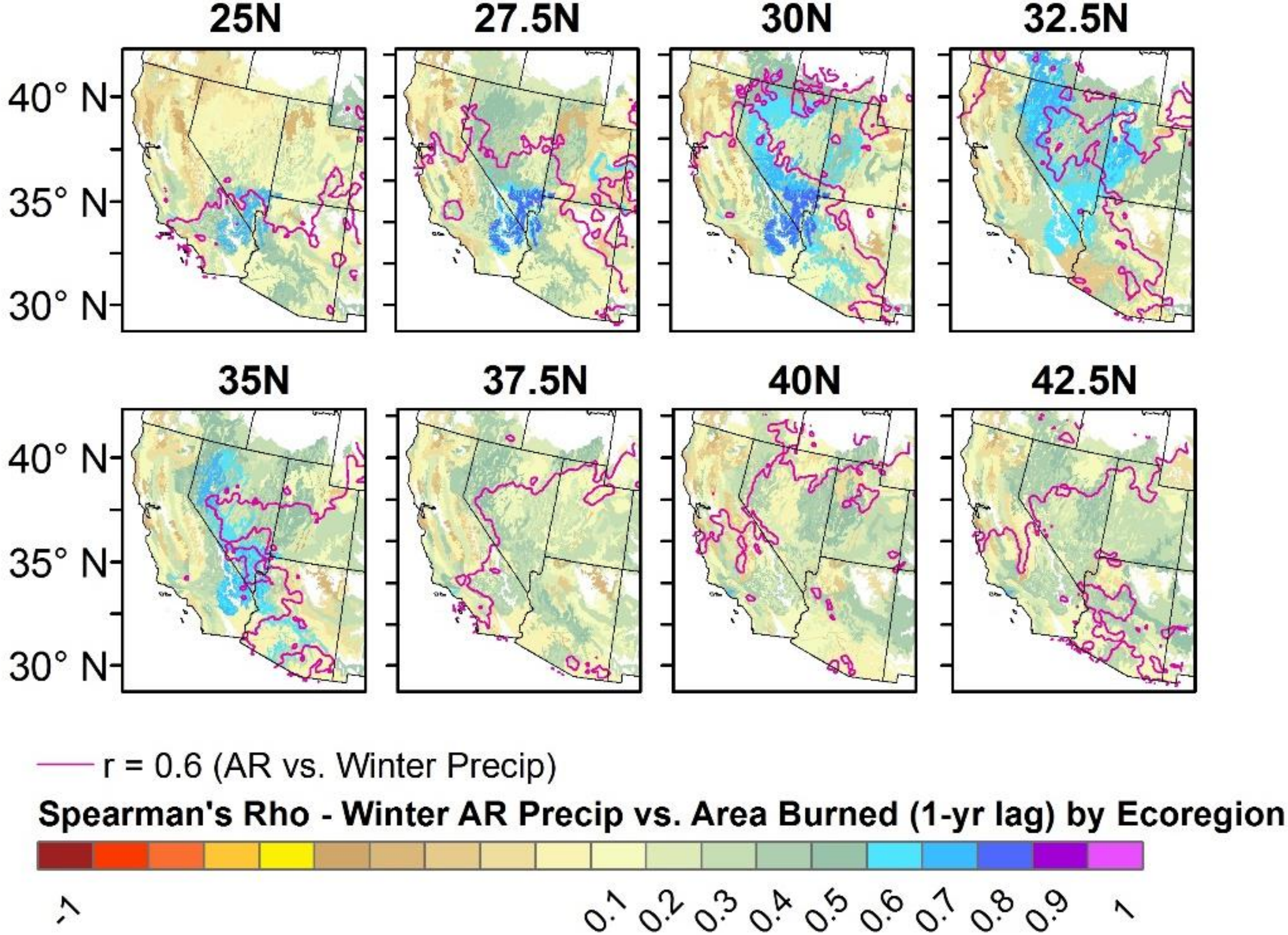
Low-latitude ARs influence vegetation productivity in interior SW

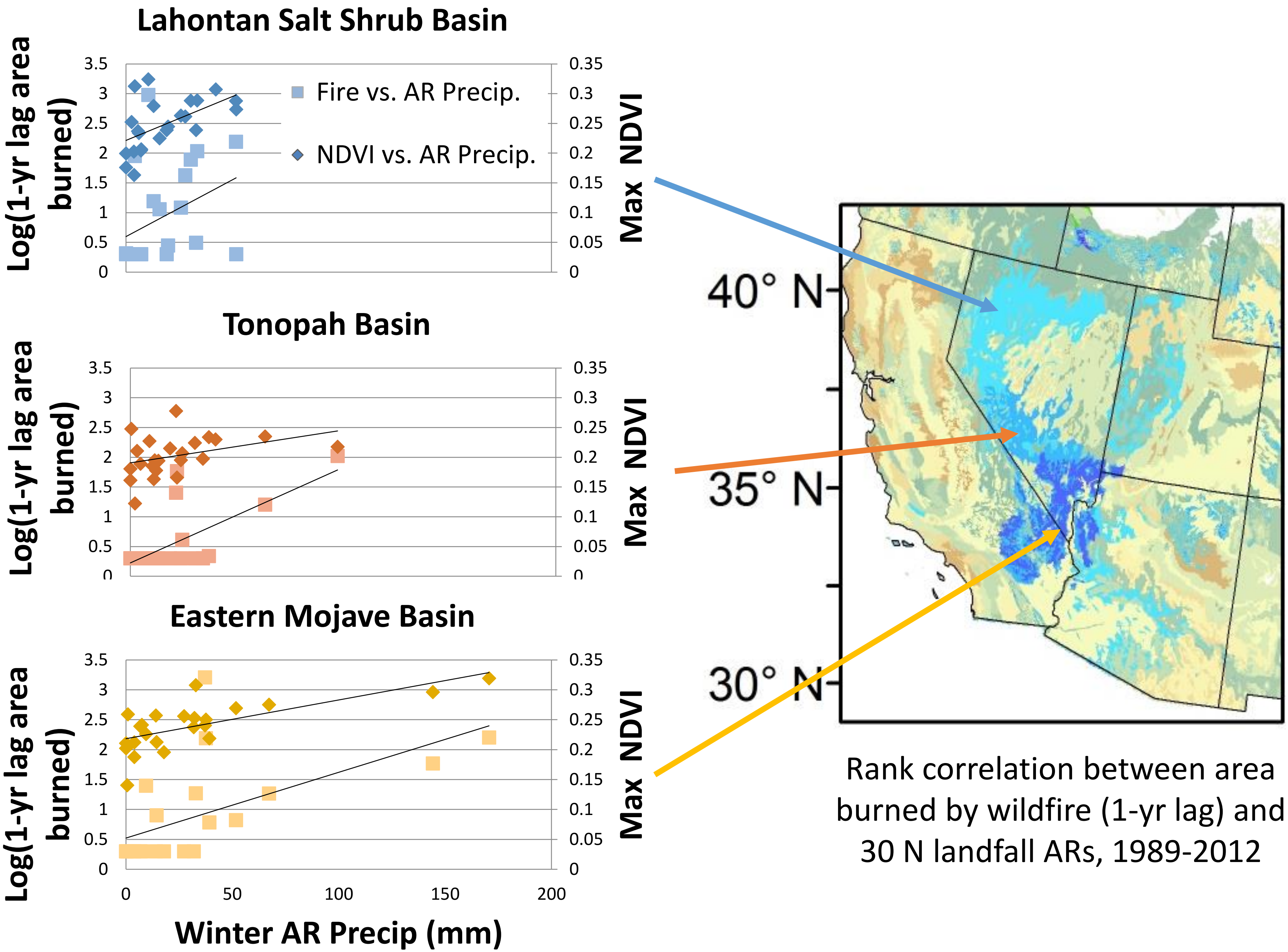


Low-latitude ARs influence vegetation productivity in interior SW



Low-latitude ARs influence fire patterns in interior SW





Rank correlation between area burned by wildfire (1-yr lag) and 30 N landfall ARs, 1989-2012

Summary

Interannual variation in ARs significantly influence vegetation growth, fuels availability, and fire patterns in some semi-arid ecoregions

landfall location–topography- ecosystem type

Implications

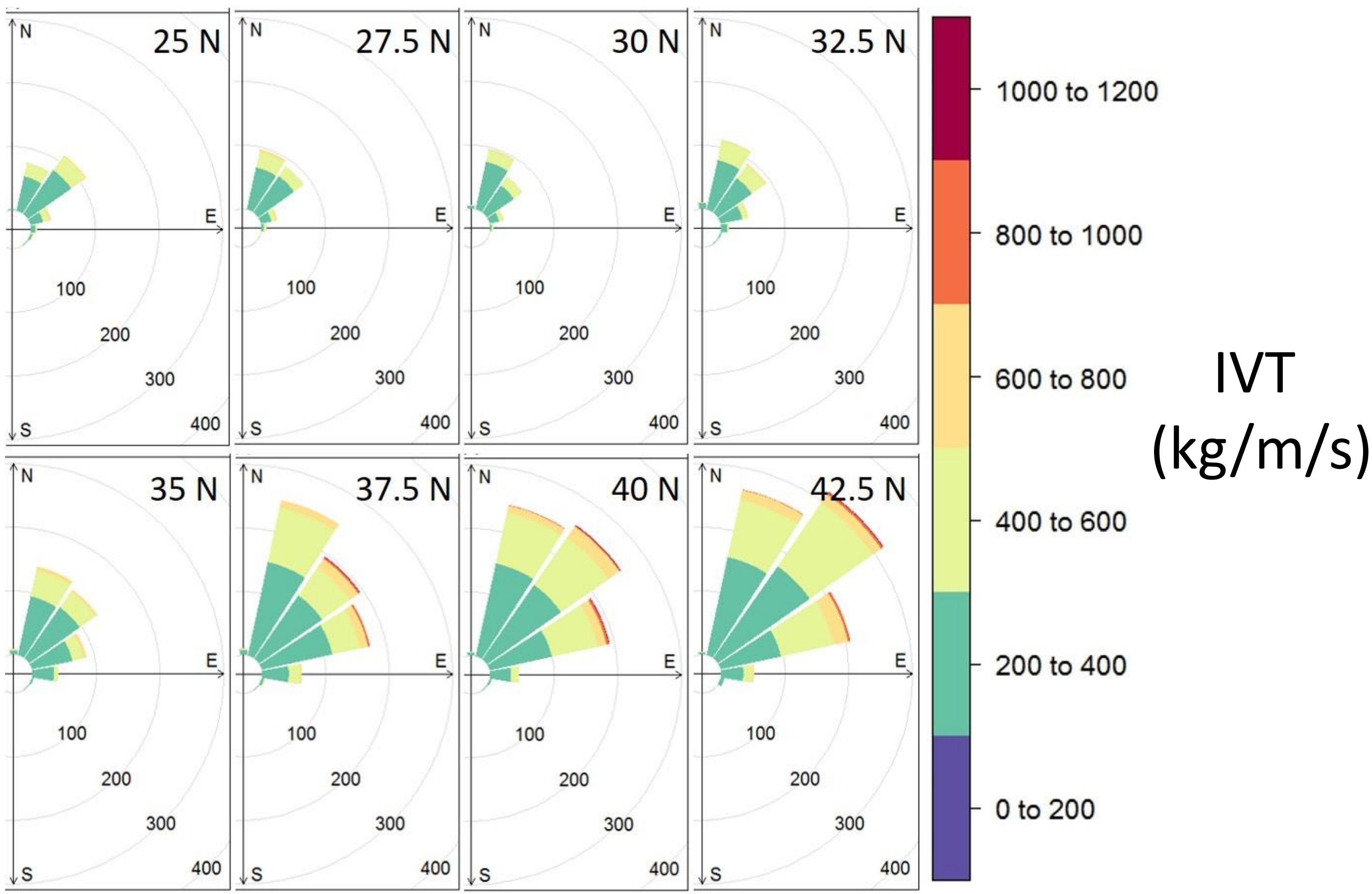
- AR occurrence provides an independent predictor of vegetation growth and associated fuels/fire activity in water-limited ecosystems in the SW
    - Alternative to ENSO/PDO
    - Northern NV
- Most studies of ARs focused on higher landfall latitudes (32.5+)
    - Better understanding patterns associated with lower-latitude landfalls may provide insights into ecosystem responses in interior SW
    - Effects are geographically distant from landfall location
- Implications of climate change for low-latitude ARs?
    - Changes in AR frequency/intensity/timing across narrow range of latitudes = important ecological changes

Acknowledgments

- Funding for this work was provided by the U.S. Department of Interior, Southwest Climate Science Center

Southwest Climate
Science Center

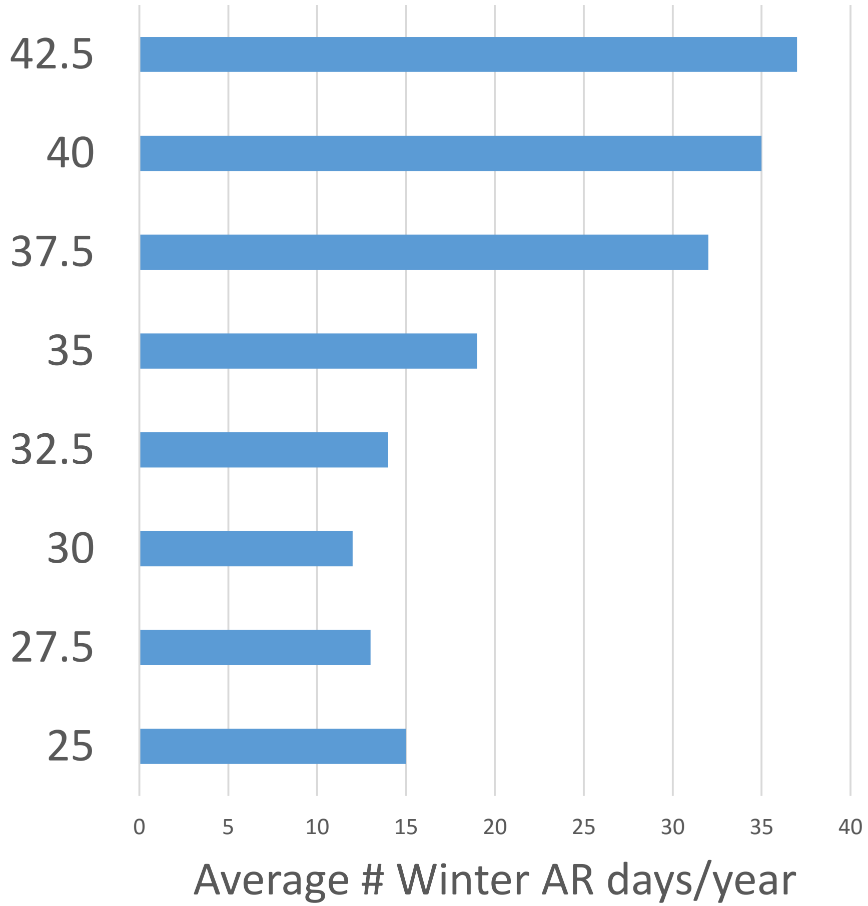
Winter AR Frequencies by Latitude and Trajectory Angle (1989-2012)

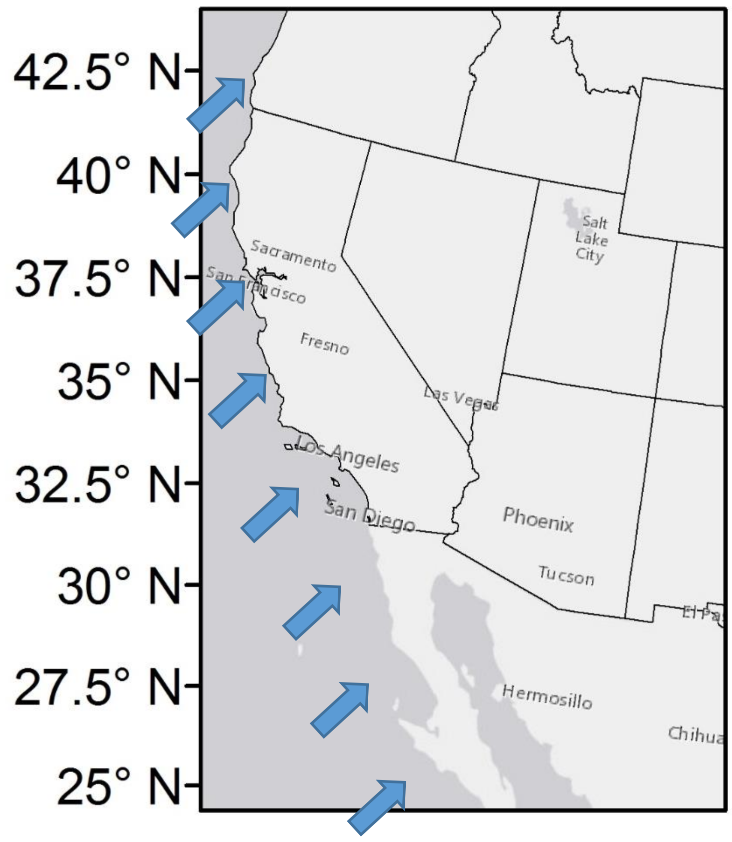


Co-occurrence of ARs making landfall at multiple latitudes on the same day

Landfall latitude (degrees North)	**25**	**27.5**	**30**	**32.5**	**35**	**37.5**	**40**	**42.5**
25	***1.00***	0.42	0.20	0.12	0.08	0.08	0.07	0.06
27.5	0.45	***1.00***	***0.60***	0.42	0.26	0.19	0.14	0.10
30	0.25	***0.67***	***1.00***	***0.69***	0.43	0.28	0.18	0.14
32.5	0.10	0.33	0.48	***1.00***	***0.69***	0.46	0.33	0.26
35	0.05	0.14	0.20	0.46	***1.00***	***0.74***	***0.57***	0.44
37.5	0.03	0.06	0.08	0.18	0.43	***1.00***	***0.78***	***0.63***
40	0.02	0.04	0.05	0.12	0.32	***0.73***	***1.00***	***0.84***
42.5	0.02	0.02	0.03	0.08	0.21	***0.52***	***0.72***	***1.00***

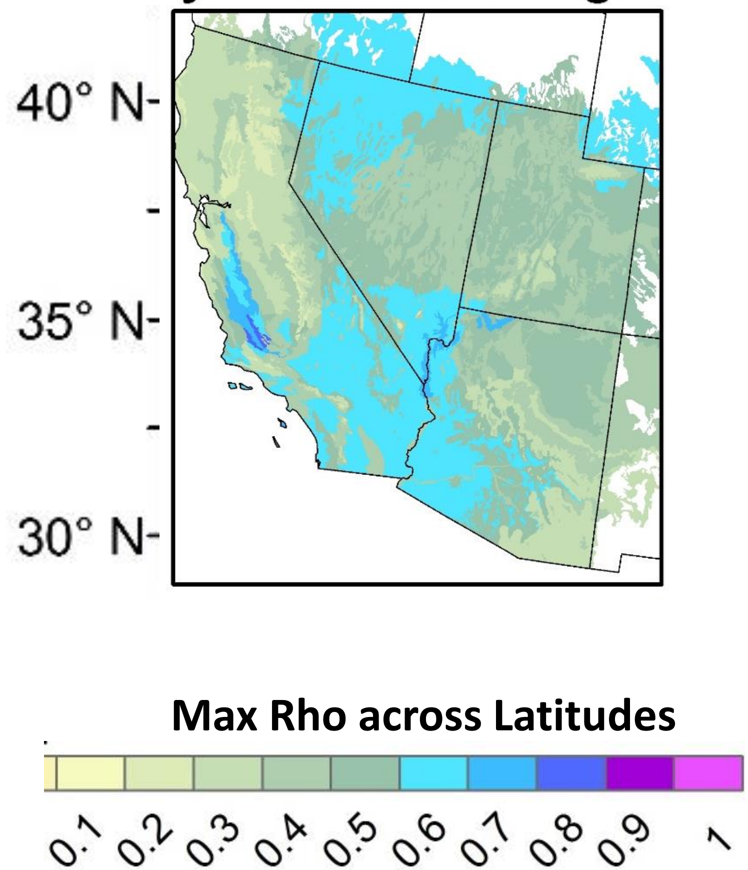
AR frequency increases with latitude





Low-latitude ARs influence vegetation productivity in interior SW

Average maximum Rho by Level IV Ecoregion



Average Landfall Latitude of maximum Rho by Level IV Ecoregion