

# The Spatiotemporal Relationship between Climate and Valley Fever in the Southwestern United States

9/27/2016 - Phoenix, AZ, courtesy of KPHO/KTVK



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Charles Zender<sup>1</sup>, James Randerson<sup>1</sup>

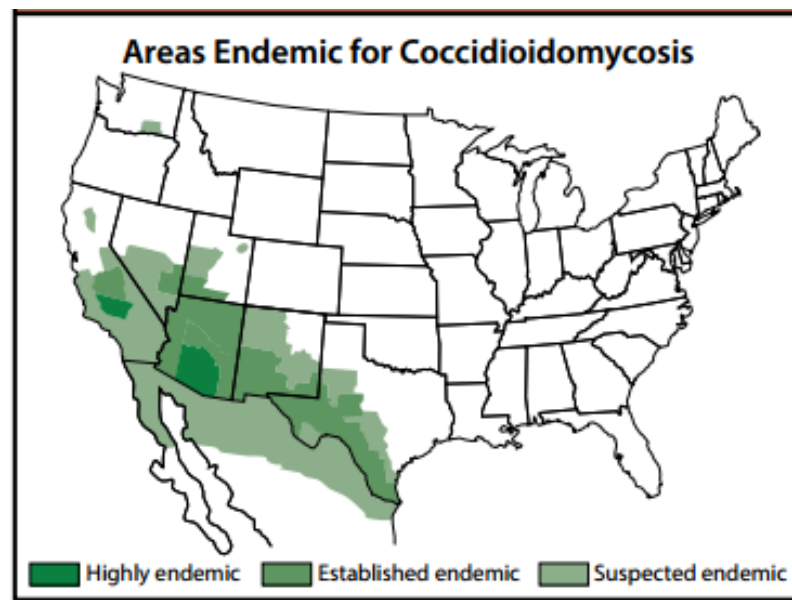
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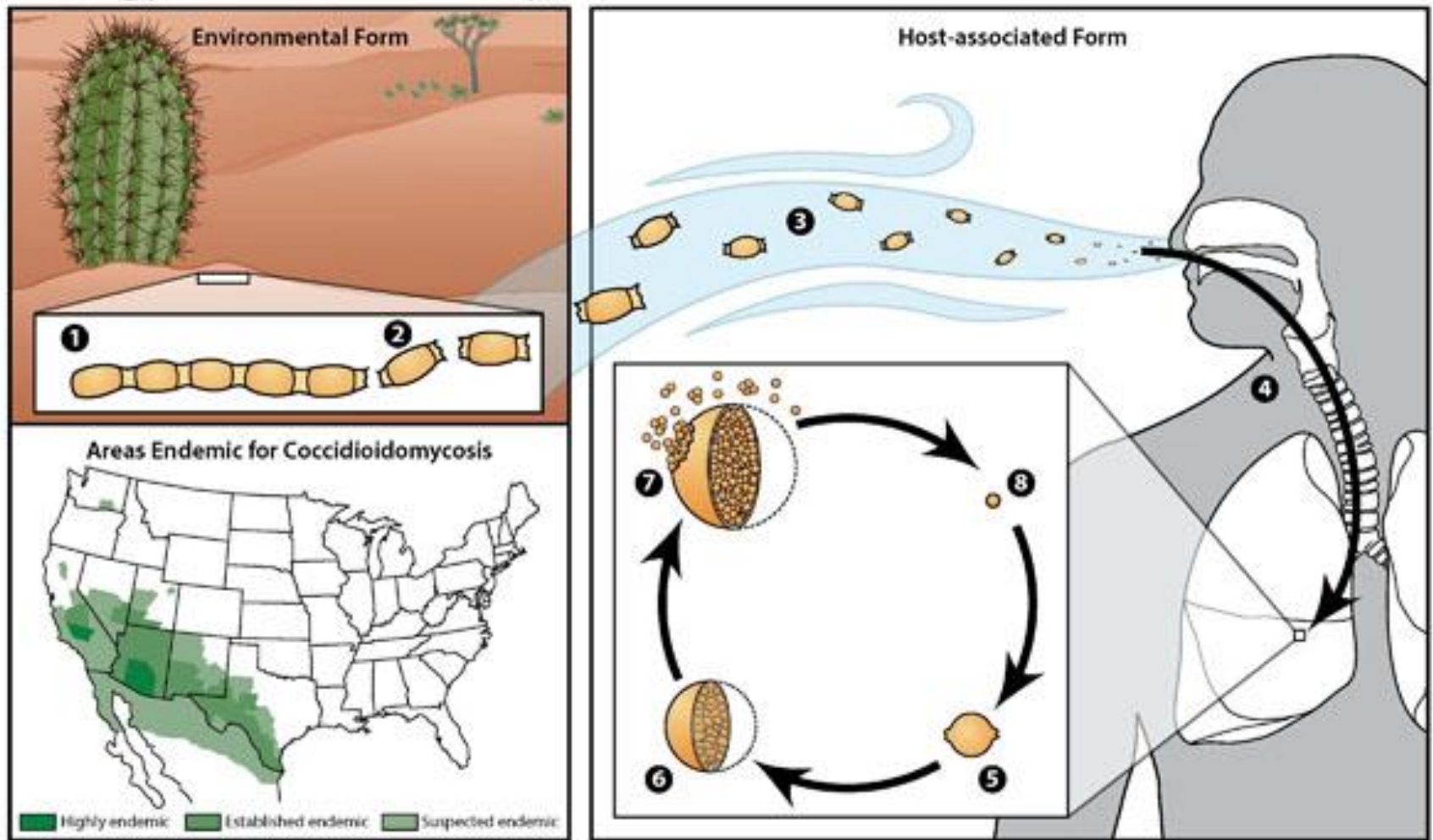
# Valley fever

- Caused by the fungus *Coccidioides* spp. (Cocci)
- Endemic to the SW U.S.
- Contracted by airborne inhalation
- Flu → Fatalities
  - Skin and bone lesions
  - Meningitis
  - Over 10 years, CA hospitalization cost over \$2 billion (Sondermeyer et al. 2011)



CDC Website

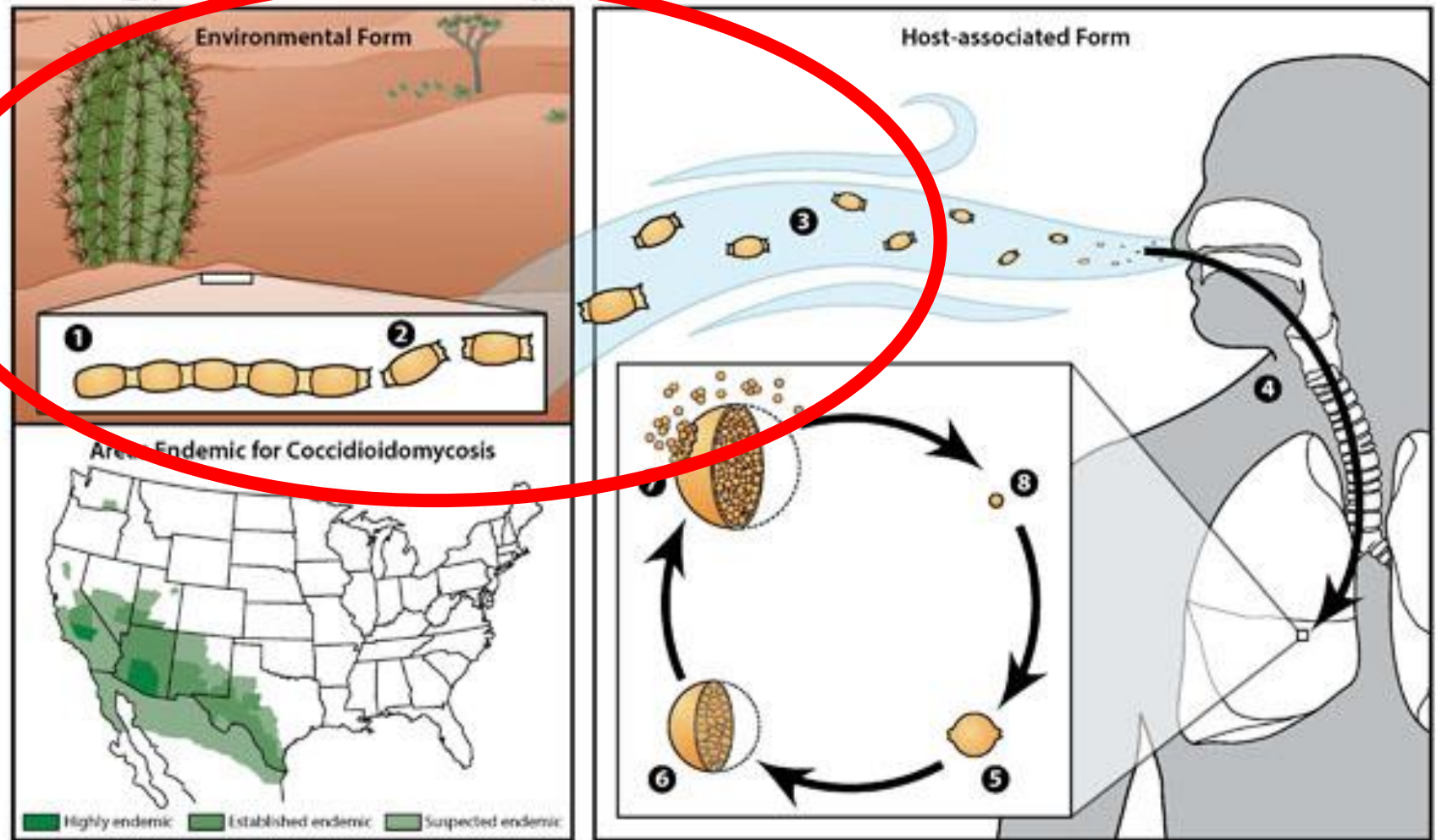
# Biology of Coccidioidomycosis



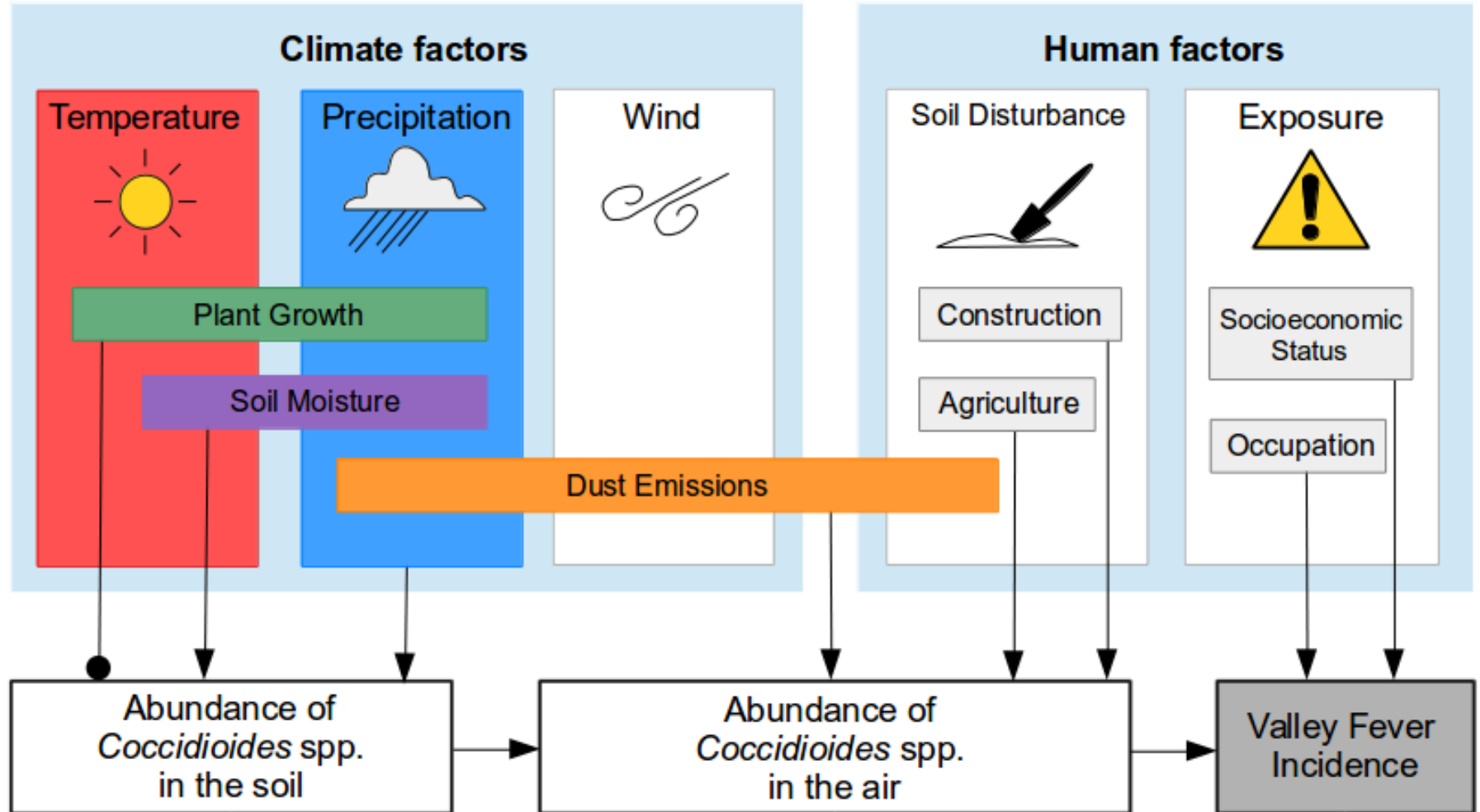
CDC Website



# Biology of Coccidioidomycosis



CDC Website



# Science Questions

1. How does climate determine the spatial structure of valley fever incidence?
2. What is the relationship between the seasonal climate and valley fever incidence?
  - Does the “wet first, then dry” hypothesis hold? (Pappagianis 1994; Smith et al. 1946)
3. What processes regulate inter-annual variability and long term trends?

**Table 1. Valley Fever Incidence Database, Month-level data by County**

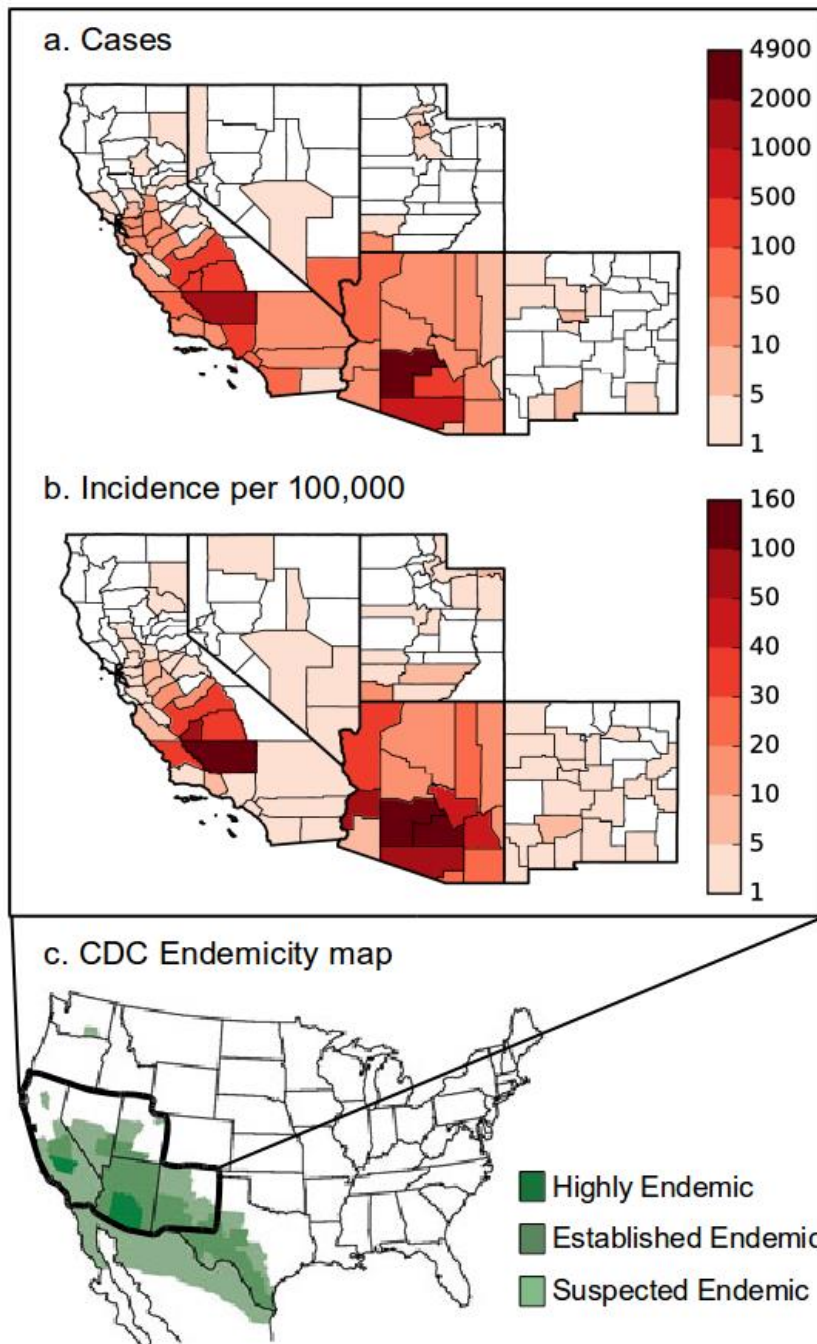
<b>State</b>	<b>Data availability</b>	<b>Reference</b>
Arizona	1990 – 2015	Arizona Department of Health Services Phoenix, AZ
California	2000 – 2015	California Department of Public Health Sacramento, CA
Nevada	1991 – 2015	Nevada Dept. of Health and Human Services Carson City, NV
New Mexico	1993 – 2015	New Mexico Department of Health Santa Fe, NM
Utah	1995 – 2015	Utah Department of Health Salt Lake City, UT

## Table 2. Climate and Environmental Variables

Variable	Data Product	Resolution	Time Span
Surface temperature	PRISM Climate Group – AN81m	4 km <sup>2</sup>	01/2000 – 2015
Surface precipitation	PRISM Climate Group – AN81m	4 km <sup>2</sup>	01/2000 – 2015
Average soil moisture (0-10 cm)	NASA Global Land Data Assimilation System, Noah land surface model L4, Version 1	0.25 × 0.25°	03/2000 – 2015
Surface dust concentration	MERRA2 Monthly mean, Time averaged, Aerosol diagnostics, Version 6	0.5 × 0.625°	01/2000 – 2015
Normalized difference vegetation index (NDVI)	NASA Terra MODIS L3, Version 6, MOD13C2	0.05 × 0.05°	02/2000 – 2015



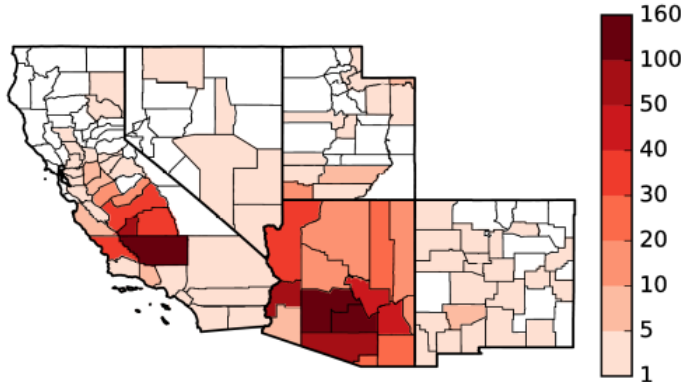
## Valley Fever Climatology (2000-2015)



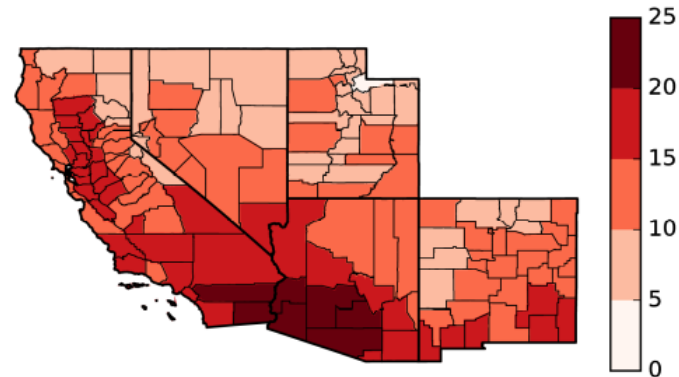
- Highly endemic region expands into San Joaquin Valley
- Established endemic region includes Central Coast of California
- Suspected endemic region expands north

# Climatological Maps of Valley Fever Incidence and Climate (2000-2015)

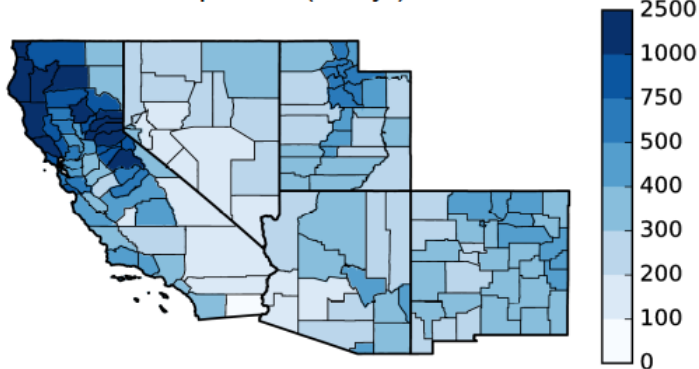
a. Valley Fever Incidence (per 100,000)



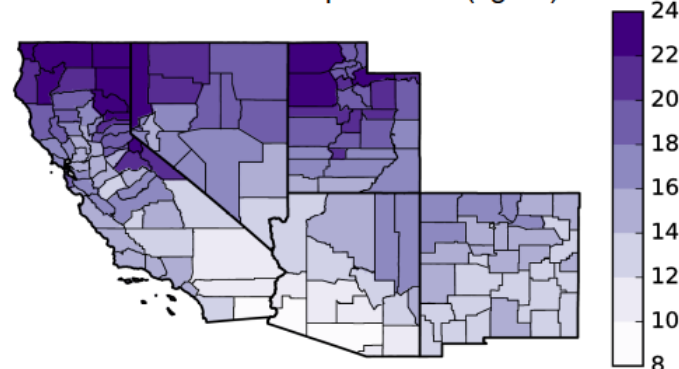
b. Surface Air Temperature (°C)



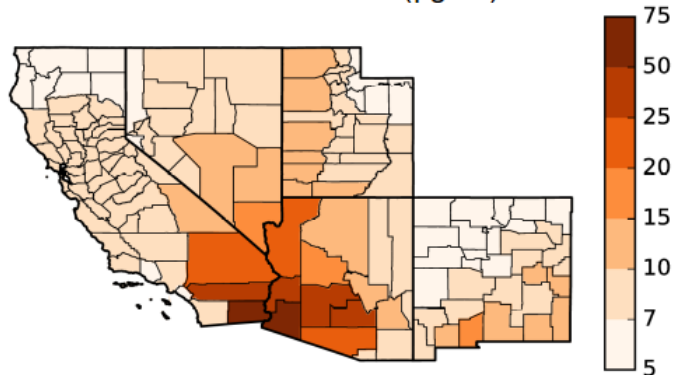
c. Annual Precipitation (mm/yr)



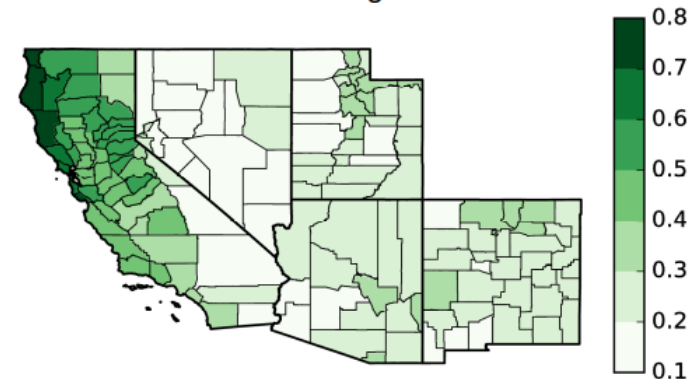
d. Soil Moisture in the top 0-10 cm (kg/m<sup>2</sup>)



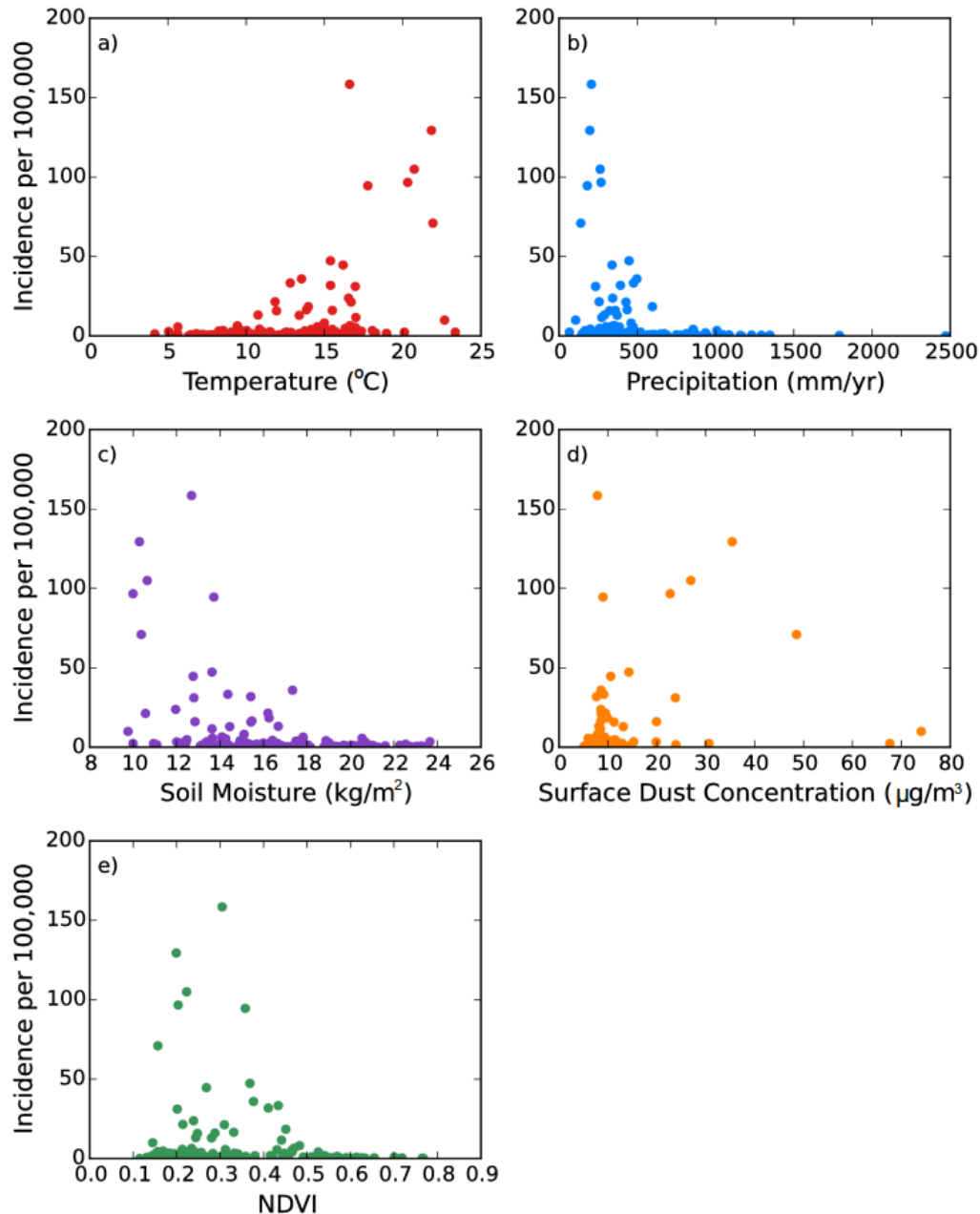
e. Surface Dust Concentration (µg/m<sup>3</sup>)



f. Normalized Difference Vegetation Index



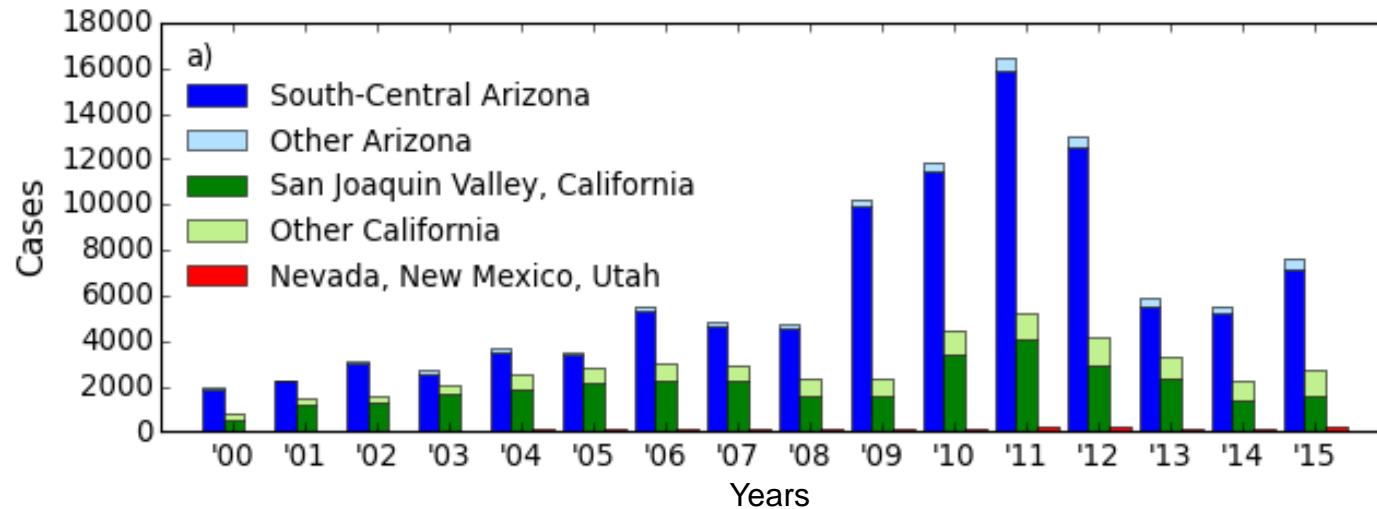
# Climatological Relationships of Climate Variables vs. Valley Fever Incidence (2000-2015)



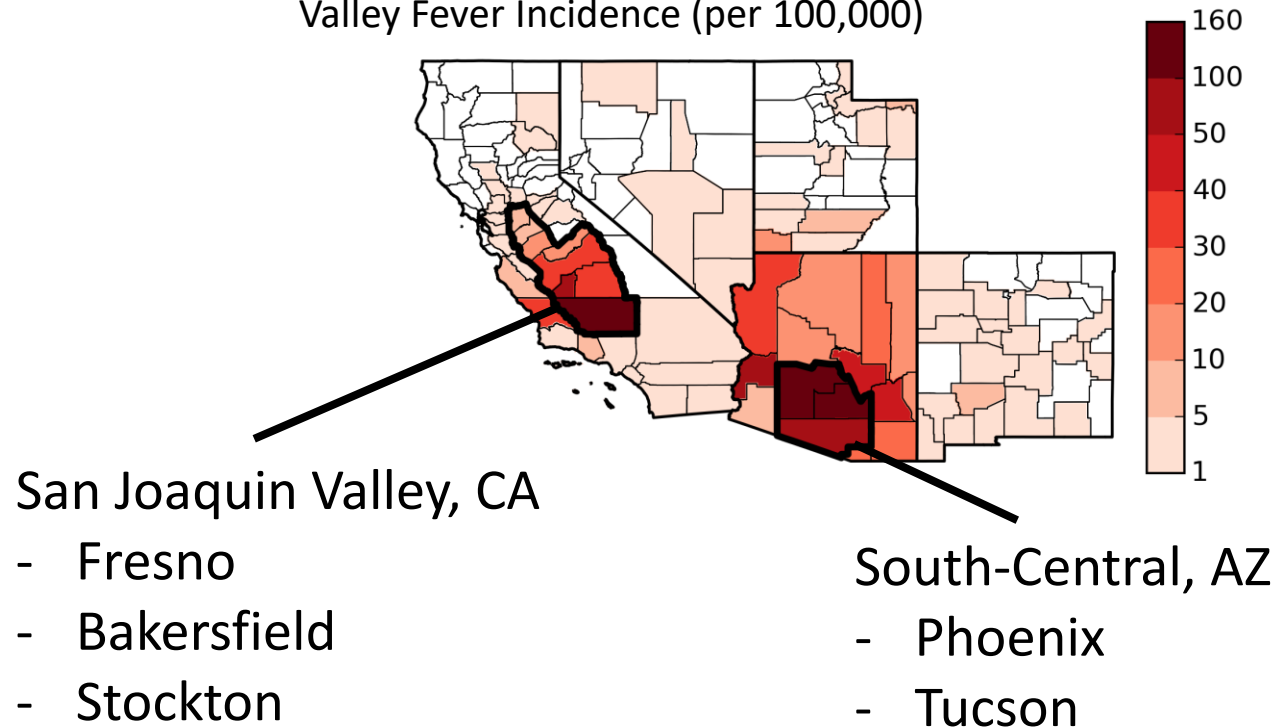
Recipe for increased valley fever incidence:

- Temperatures exceeding 10°C
- Precipitation below 750 mm/yr
- Soil moisture under 18 kg/m²
- Dust threshold above 8 µg/m³
- NDVI between 0.15 and 0.45

## Valley Fever Cases over Time

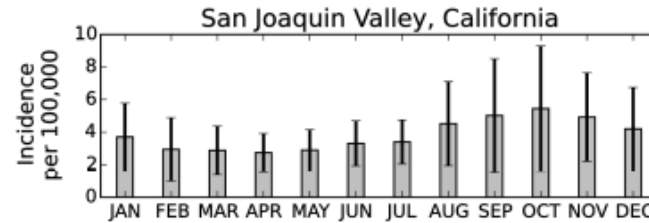


## Valley Fever Incidence (per 100,000)

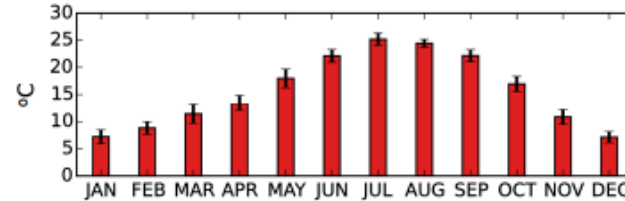


# Seasonal Cycle of Valley Fever Incidence and Climate Variables in the San Joaquin Valley, CA

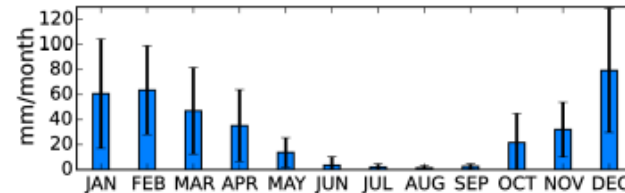
Valley Fever  
Incidence



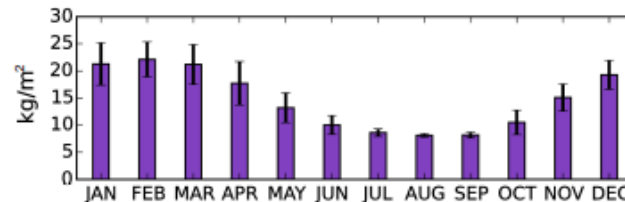
Temperature



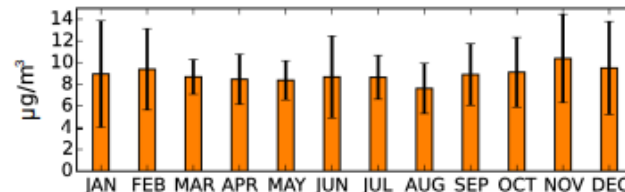
Precipitation



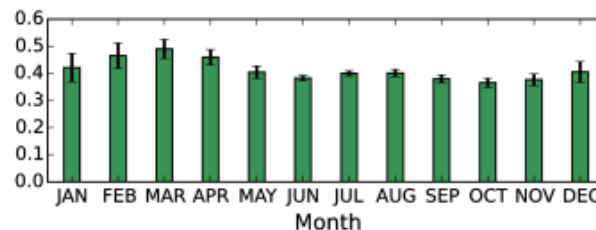
Soil Moisture



Surface Dust  
Concentration



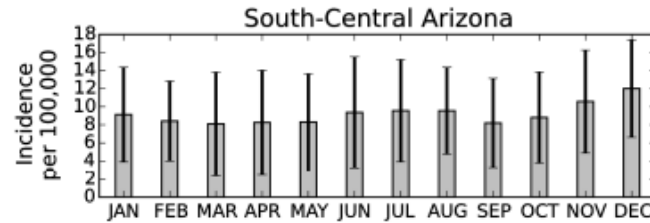
NDVI



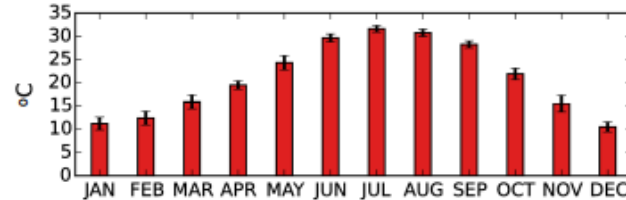
- High temperatures precede higher valley fever incidence by 3 months ( $r = 0.96$ )
- Valley fever incidence peaks 2-3 months after low moisture ( $r > 0.95$ )
- Lack of meaningful interpretation for dust and NDVI

# Seasonal Cycle of Valley Fever Incidence and Climate Variables in South-Central Arizona

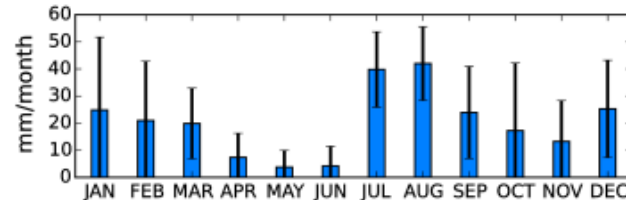
Valley Fever  
Incidence



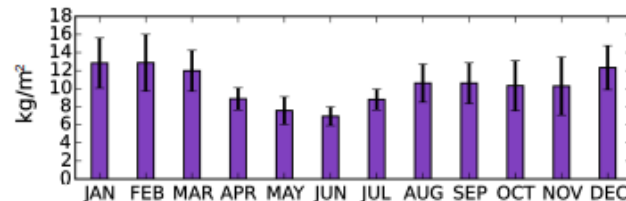
Temperature



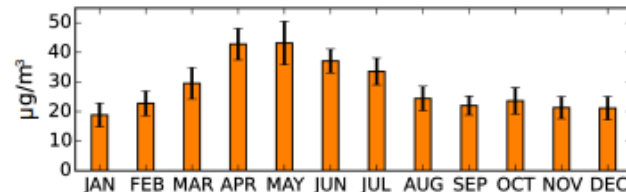
Precipitation



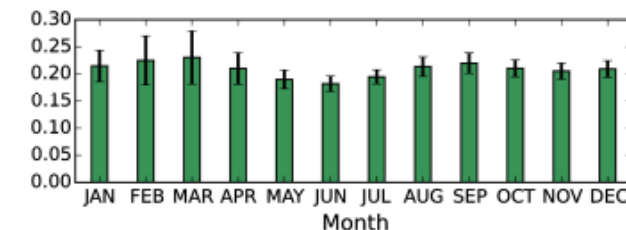
Soil Moisture



Surface Dust  
Concentration



NDVI

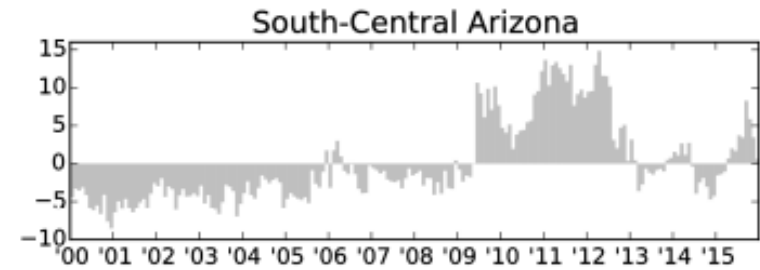
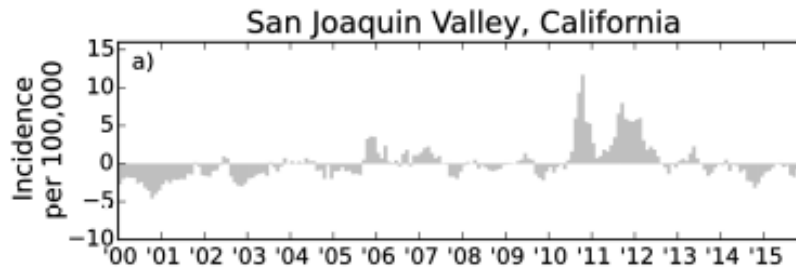


- High temperatures precede higher valley fever incidence by 4 months ( $r = 0.54$ )
- Bimodal precipitation drives changes of incidence 4 months later ( $r = 0.68$ )
- Lack of meaningful interpretation for soil moisture, dust, and NDVI

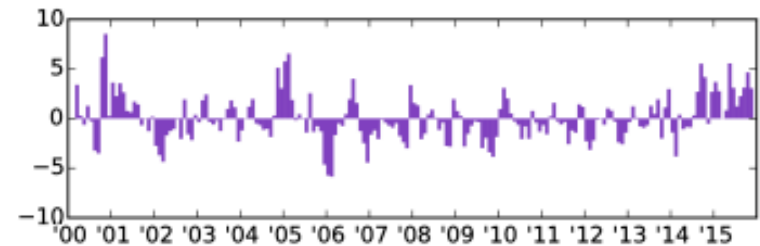
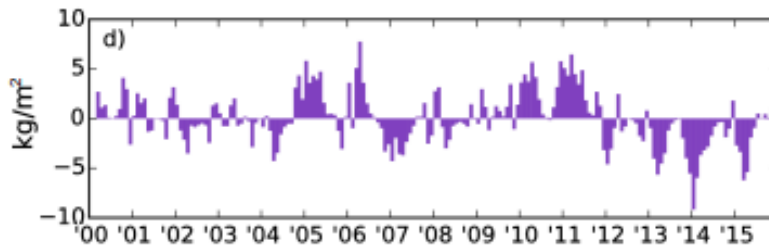


# Anomalies of Valley Fever Incidence and Climate Variables from 2000-2015

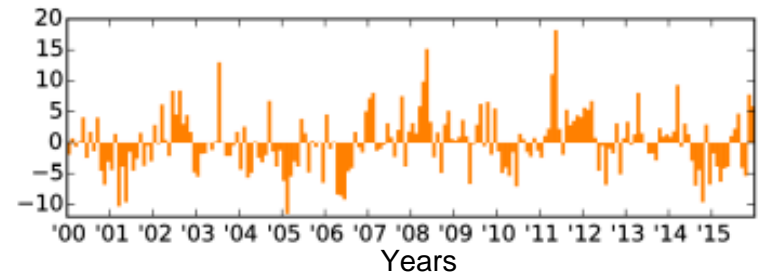
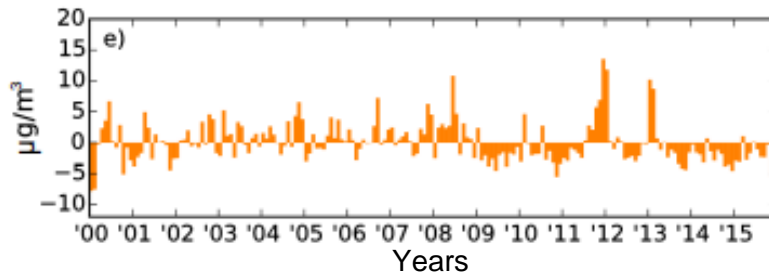
Valley Fever  
Incidence



Soil Moisture



Dust



- Soil moisture precedes valley fever incidence with a lead time of 8 months in SJV CA ( $r = 0.52$ )
- Soil moisture does not strongly correlate with incidence in S-C AZ
- Incidence positively correlates with dust in the previous month in both valley fever hotspots ( $r = 0.16, 0.23$  for SJV CA, S-C AZ)

# Conclusions

- Compared with CDC maps, endemic zones extend further north
- Moisture levels had a strong seasonal influence on valley fever
  - Both winter and monsoonal rain modulated the annual cycle of incidence
- Periods of high soil moisture precede valley fever outbreaks in CA with a lead time of 8 months
- AZ now exceeds CA in valley fever incidence

Next step: What new populations may be at risk due to climate change?

# Thank you:

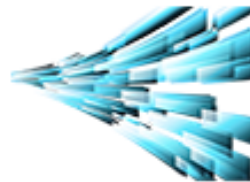


## NDSEG



Jenkins Family  
Fellowship

GORDON AND BETTY  
**MOORE**  
FOUNDATION



## UCI

Data Science  
Initiative



**B V E F**  
BORREGO VALLEY  
ENDOWMENT FUND

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