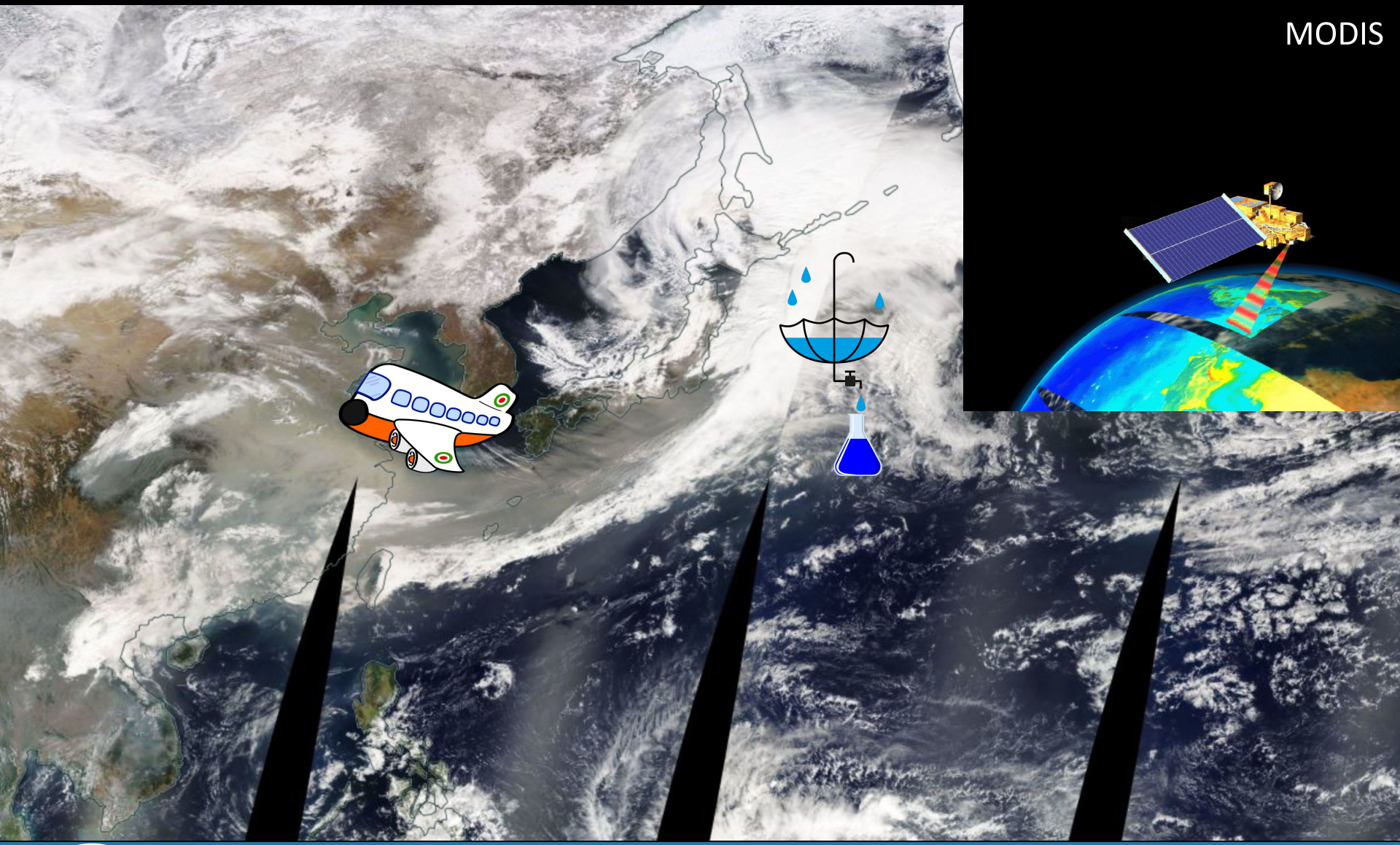
What makes an atmospheric river dusty?

Kara Voss

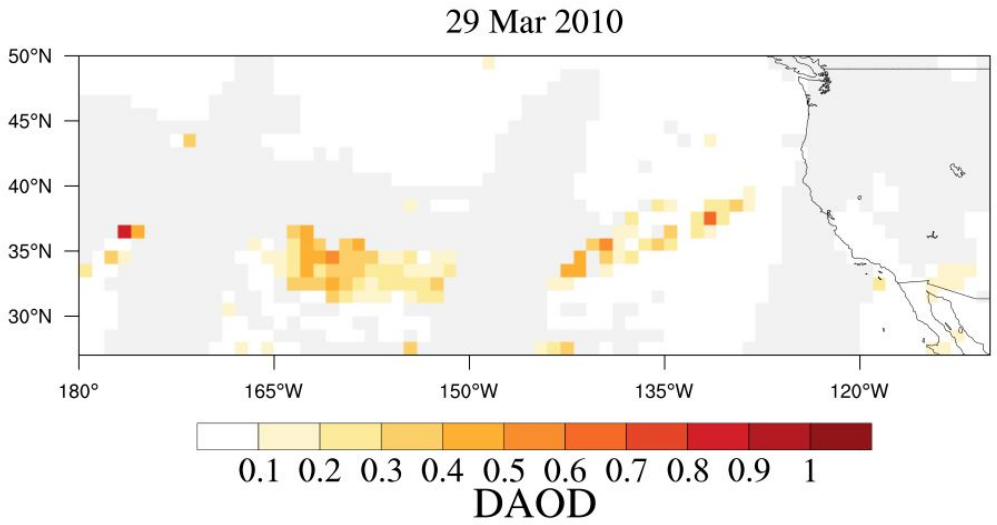
Dr. Leah Campbell

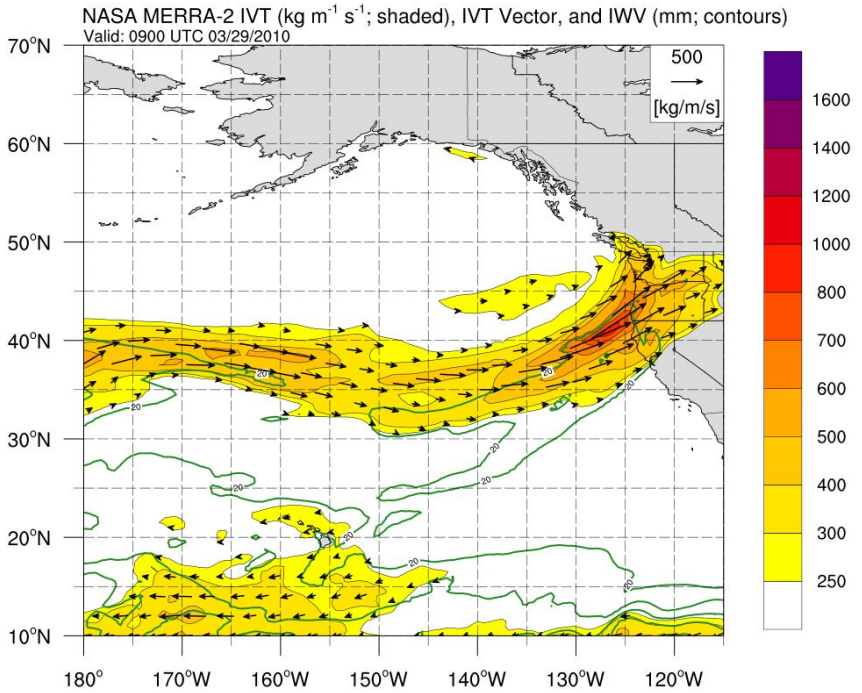
Dr. Amato Evan

Dr. Marty Ralph


MODIS

Case study of a dusty AR
March 29, 2010





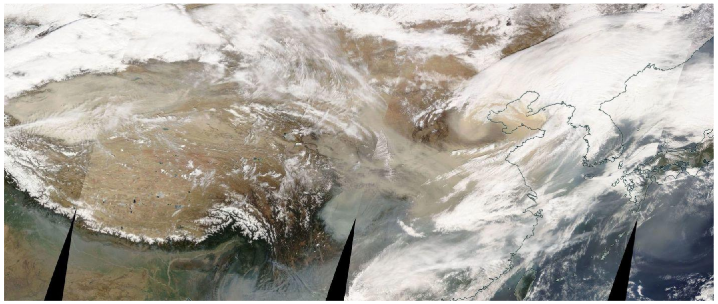
Provided by Brian Kawzenuk

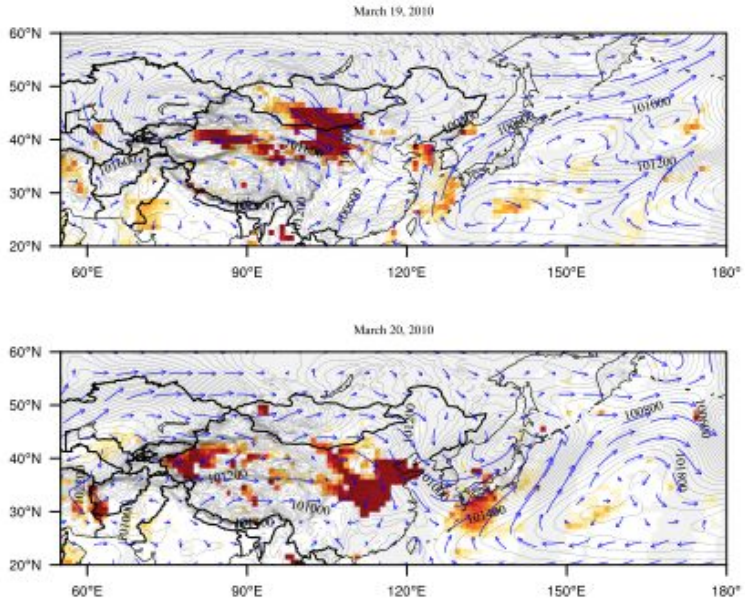
10 days earlier …

BBC NEWS

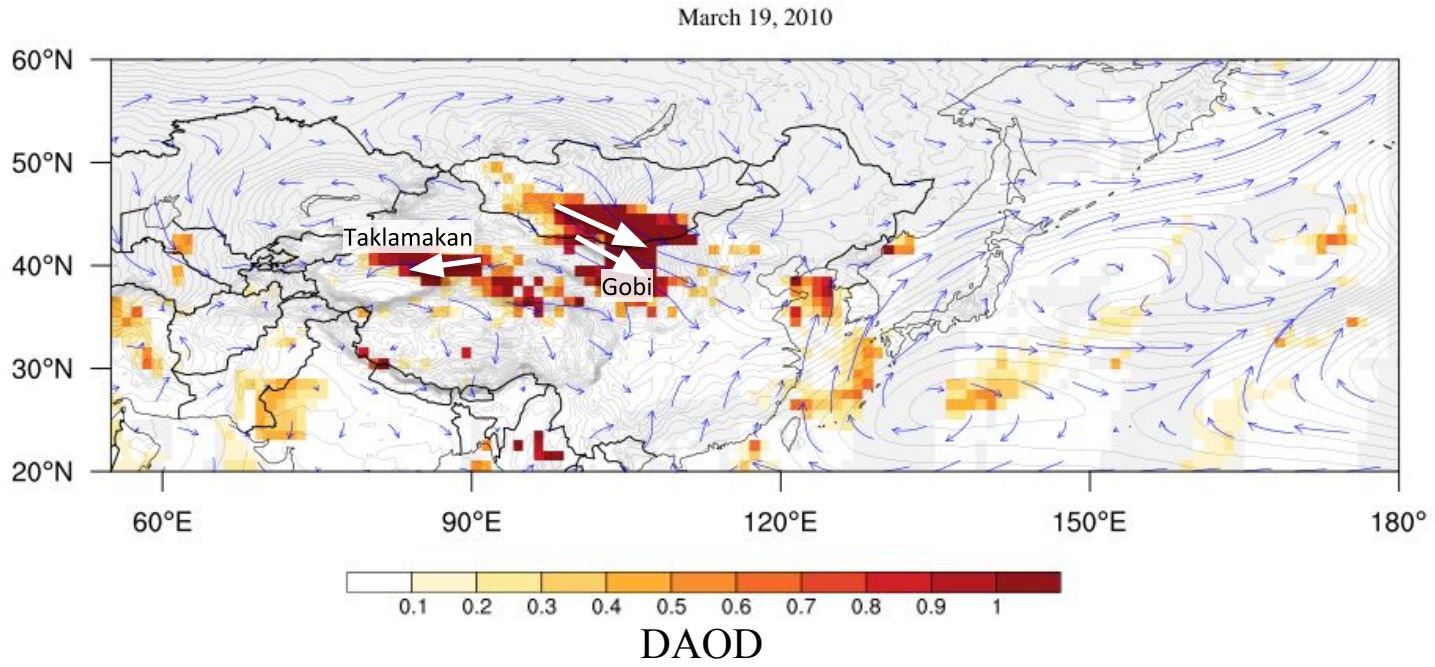
Sandstorm shrouds Beijing in dust

Beijing has been shrouded in orange dust as a strong sandstorm blew hundreds of miles from drought-struck northern China to the nation's capital.





Source region



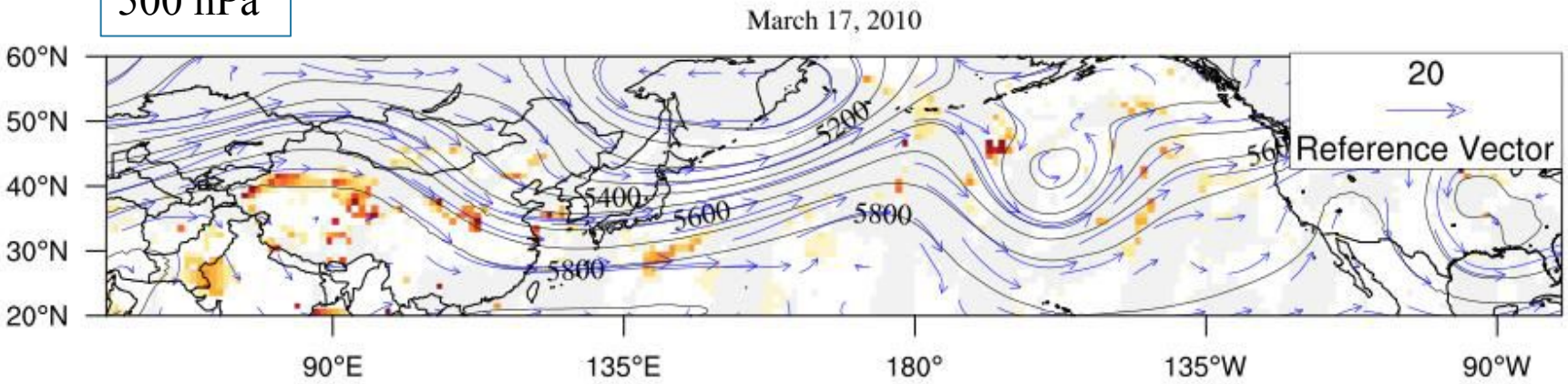
10m wind
and
Dust AOD

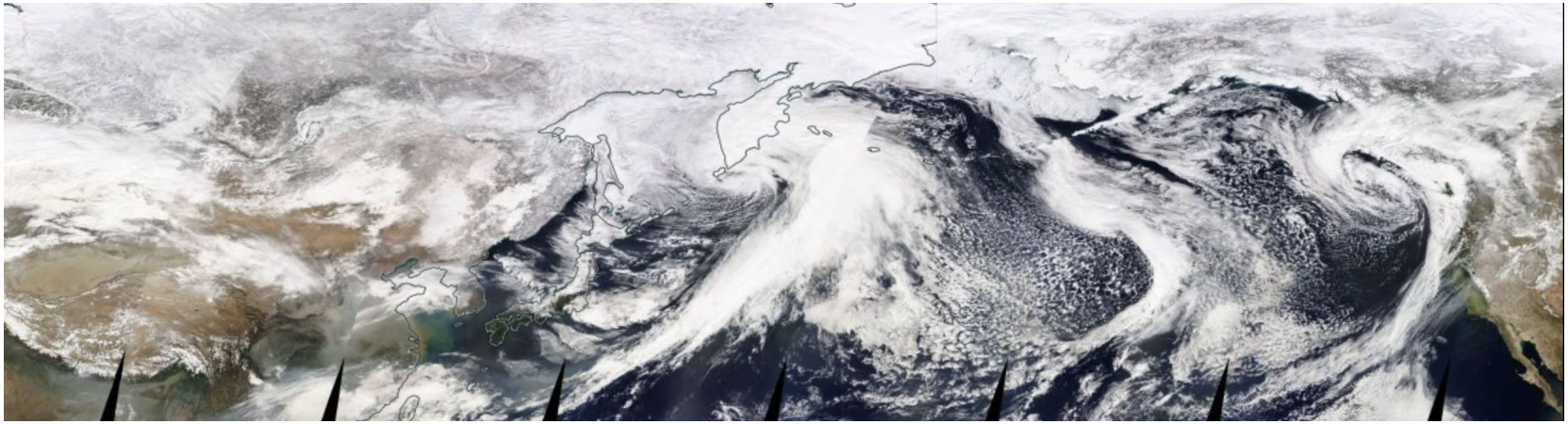
✓ Enhanced easterly winds over the Taklamakan

✓ Enhanced north-westerly winds over Mongolia/ Gobi desert

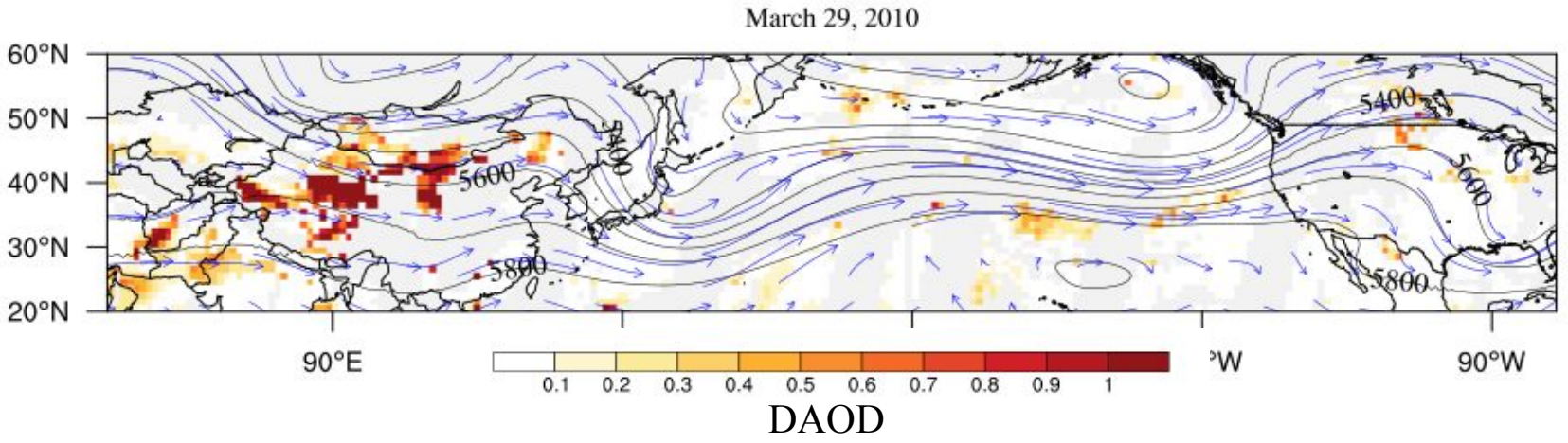
Prior to AR landfall at ARO

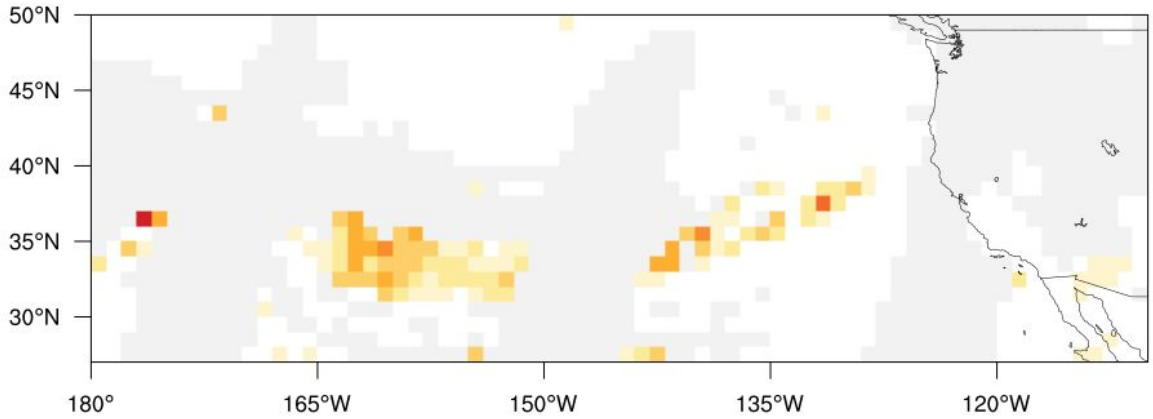
500 hPa





AR landfall at ARO





Can we see the dust?

Yes

!

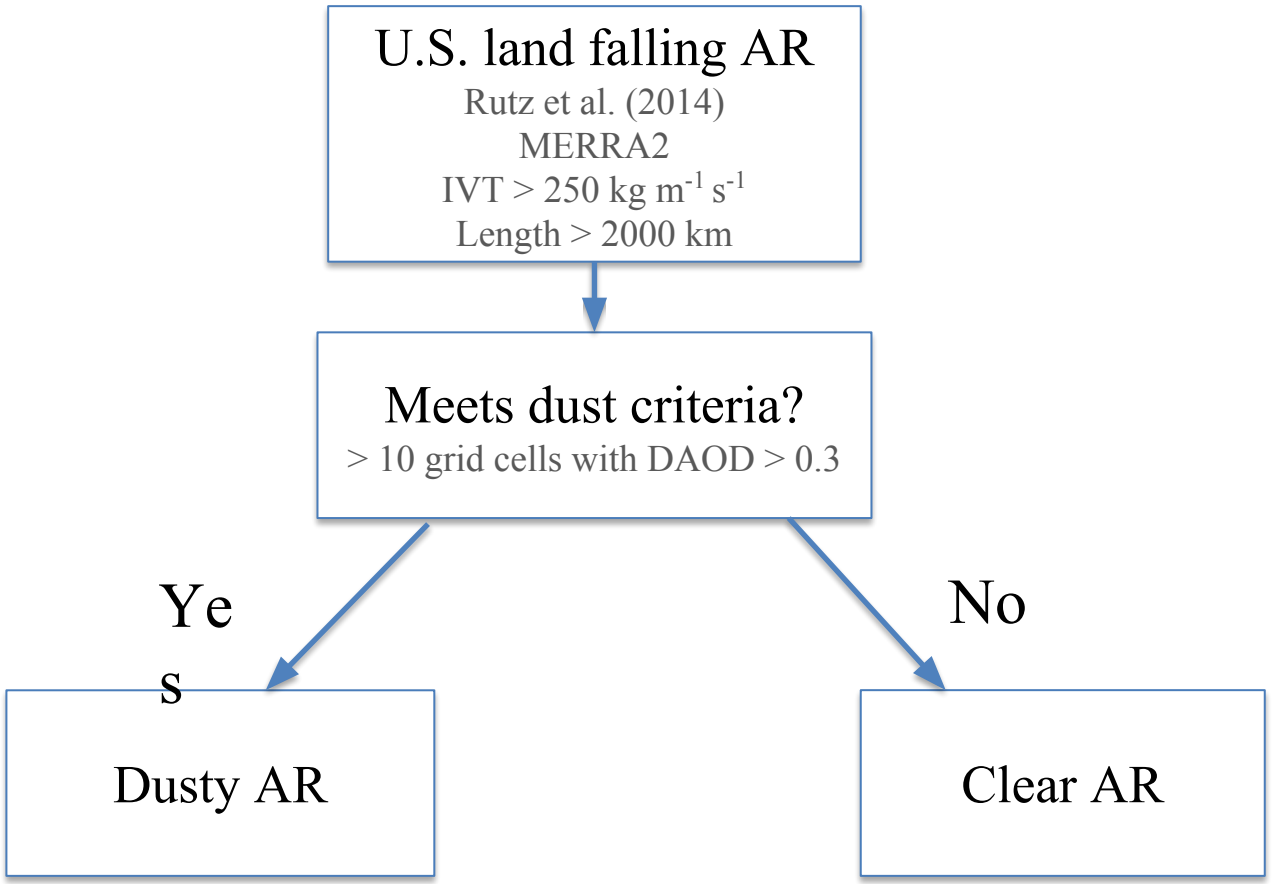
Now what can we learn from it?

Seasonality?

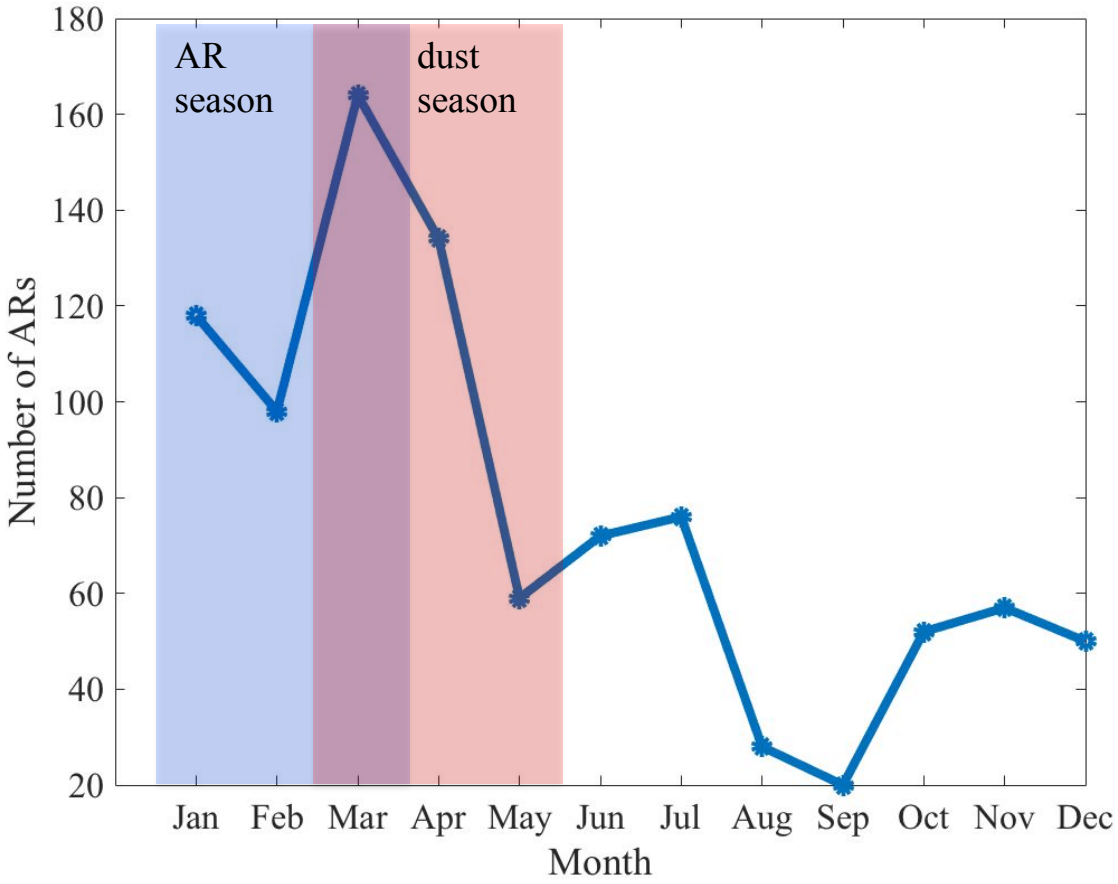
Long term trend?

Associated synoptic conditions?

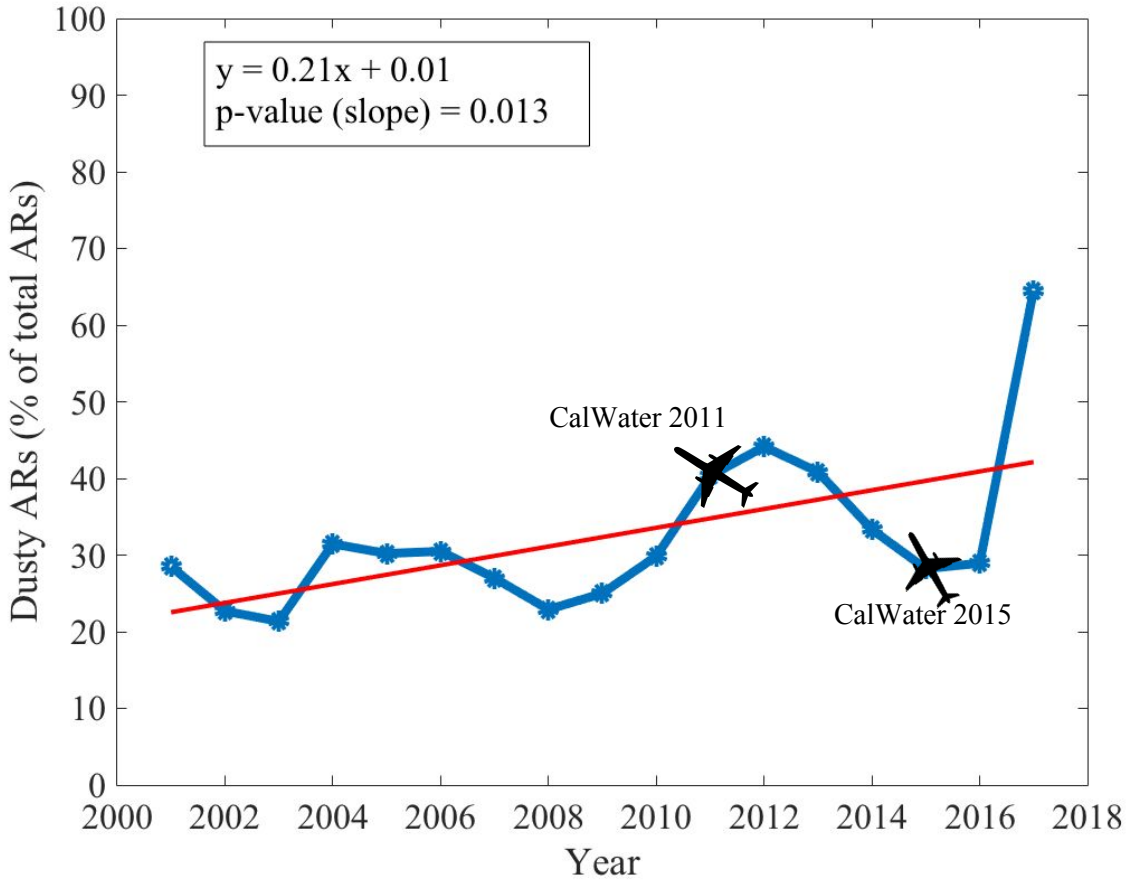
Initial study



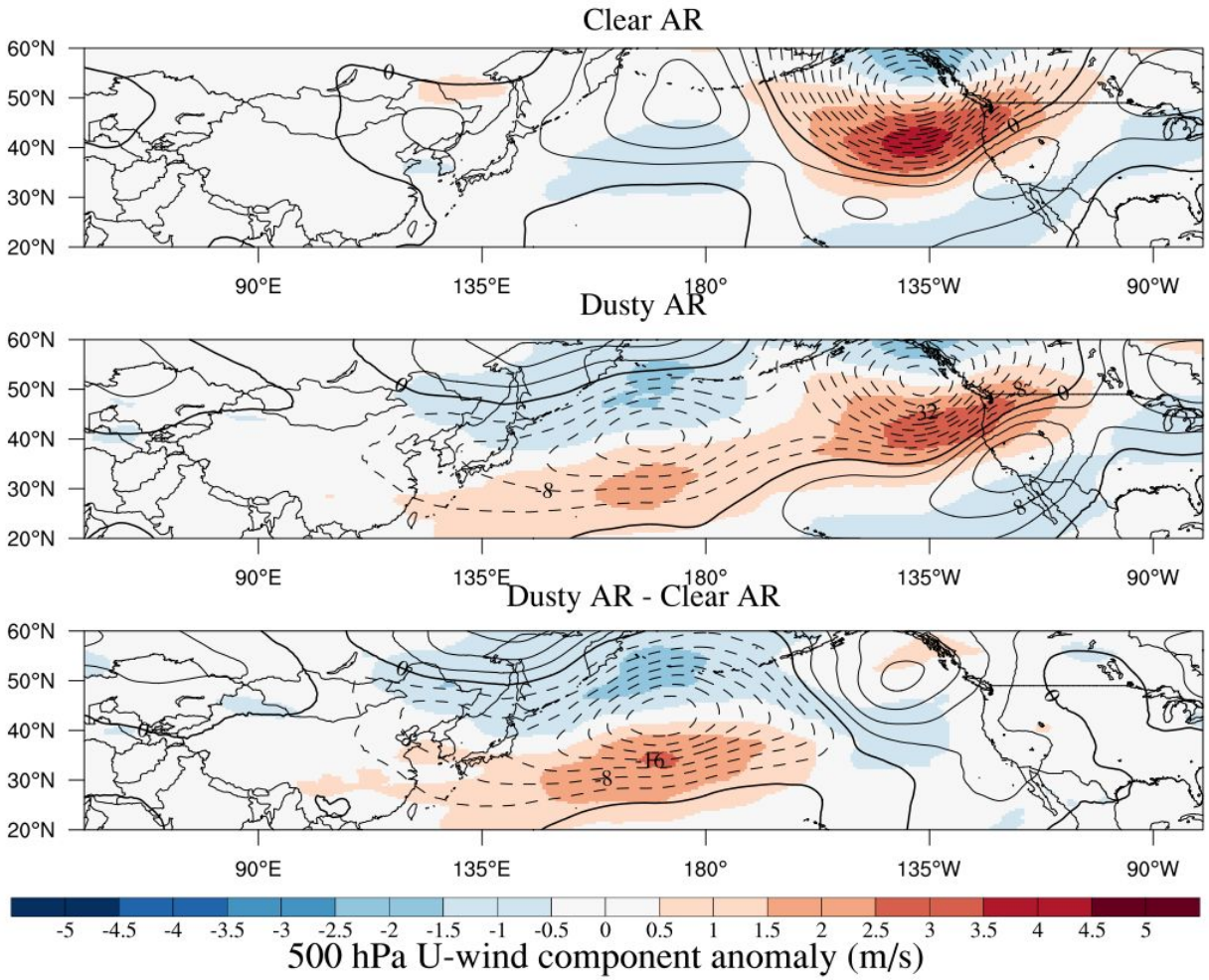
The number of dusty AR days peaks in March and April …



The frequency of dusty AR days has been increasing…

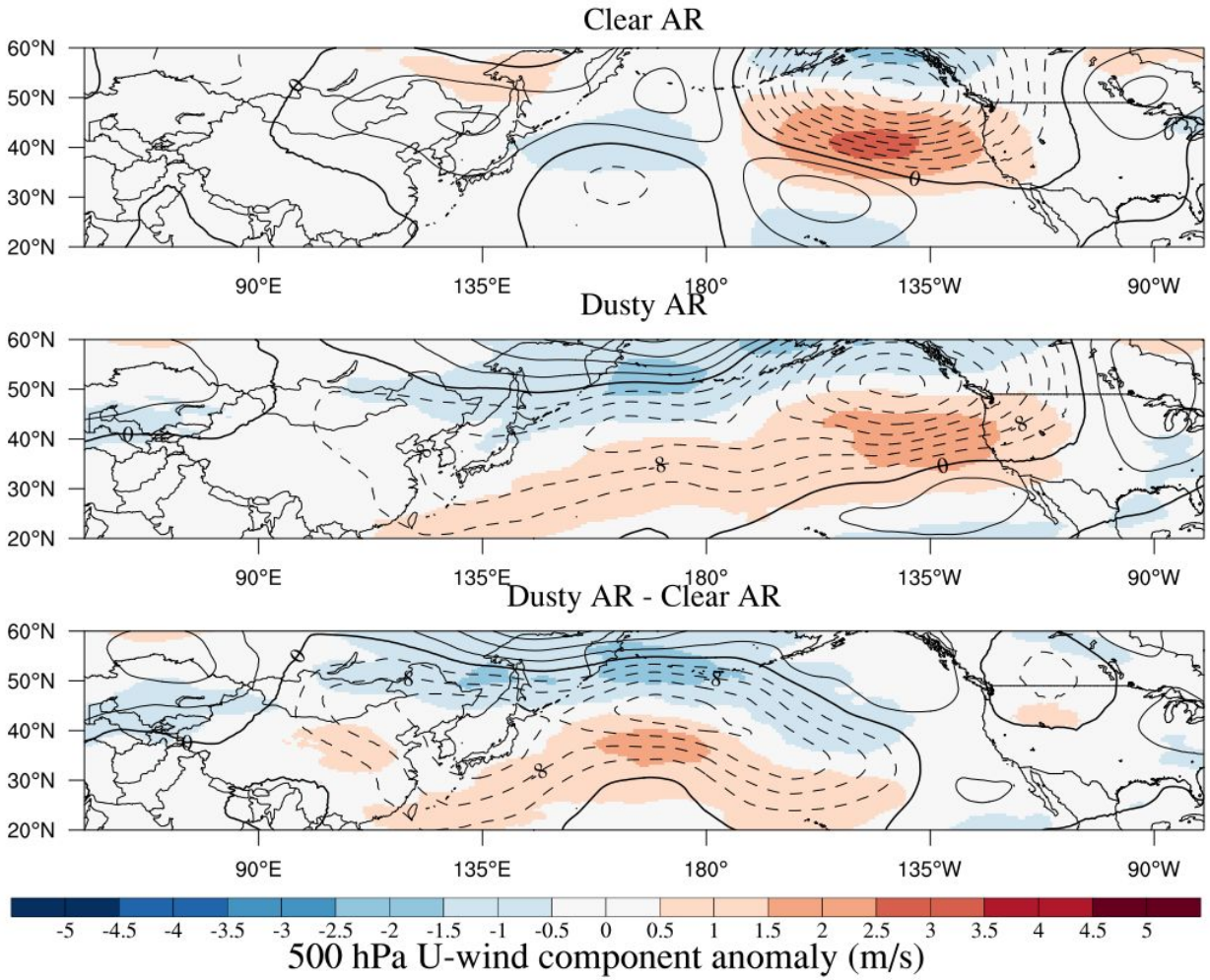


Day of AR landfall



Zonal wind anomaly (colored) and geopotential height anomaly (lines)

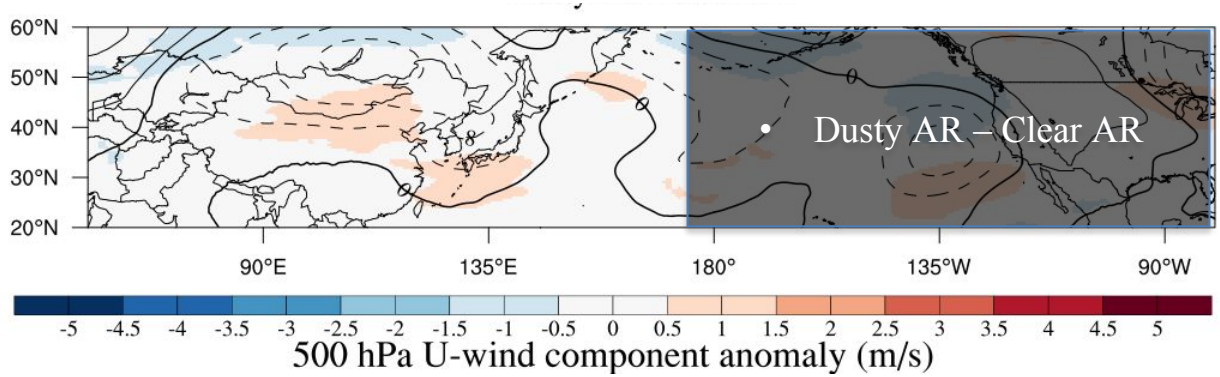
2 days prior to AR landfall



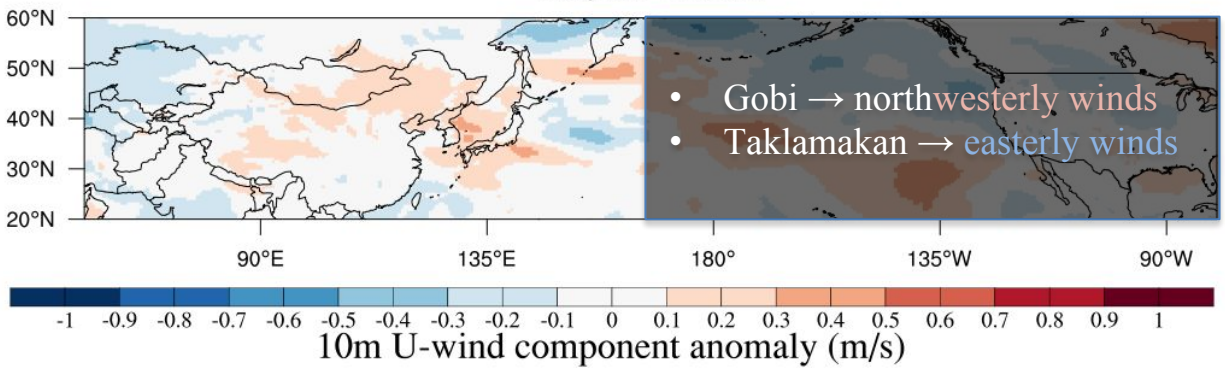
Zonal wind anomaly (colored) and geopotential height anomaly (lines)

8 days prior to AR landfall

500 hPa geopotential height and U-wind anomaly



10m U-wind anomaly

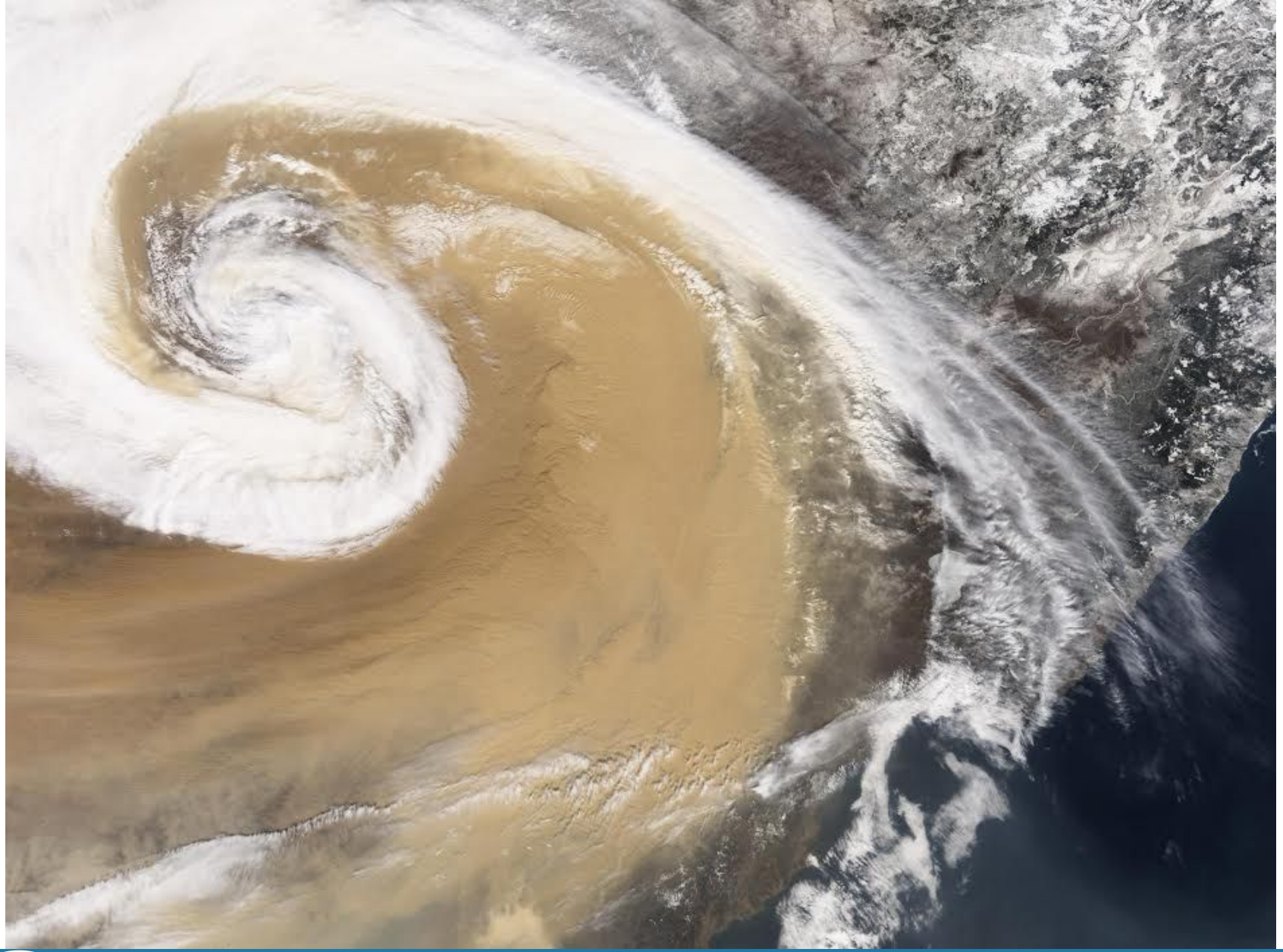


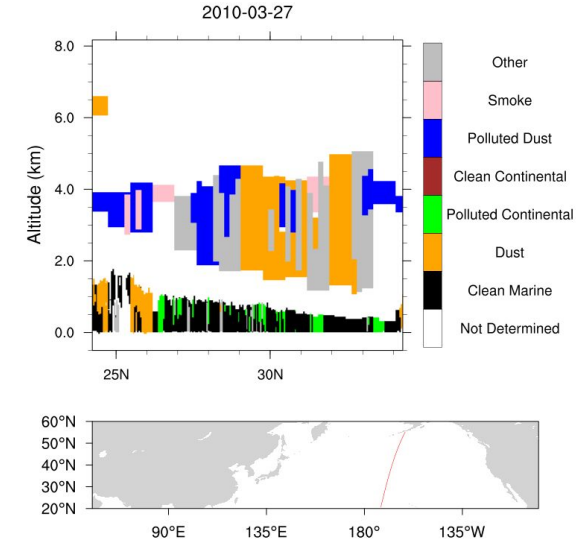
Dust AOD -- a new tool to track dusty ECs and ARs

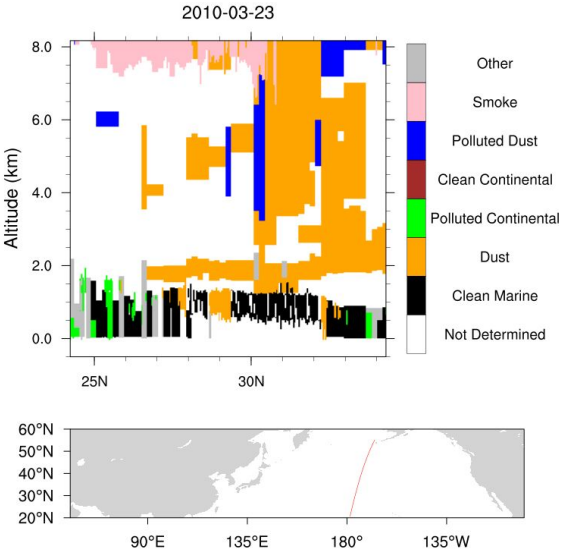
Dusty ARs **peak in March**

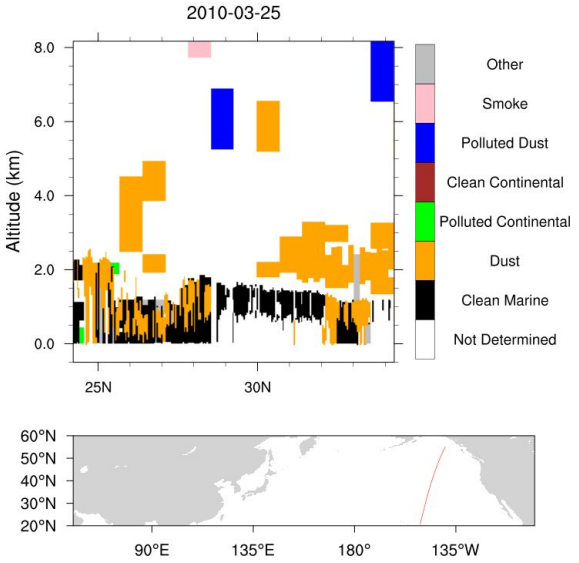
Dusty AR **frequency seems to be increasing** – mostly in March

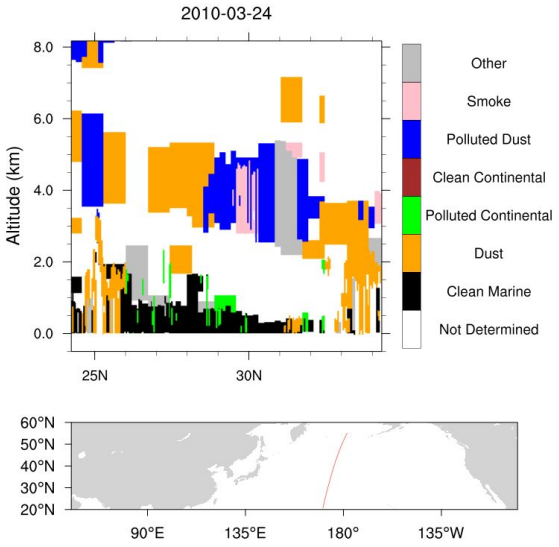
Dusty ARs have a **low anomaly in the western Pacific** and **enhanced westerly wind near 30°N**

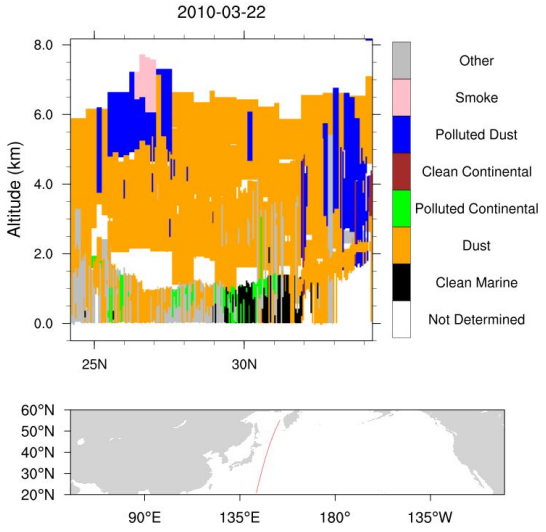



2010-03-27
Altitude (km)
8.0
6.0
4.0
2.0
0.0
25N
30N
Other
Smoke
Polluted Dust
Clean Continental
Polluted Continental
Dust
Clean Marine
Not Determined
60°N
50°N
40°N
30°N
20°N
90°E
135°E
180°
135°W


2010-03-23
Altitude (km)
8.0
6.0
4.0
2.0
0.0
25N
30N
Other
Smoke
Polluted Dust
Clean Continental
Polluted Continental
Dust
Clean Marine
Not Determined
60°N
50°N
40°N
30°N
20°N
90°E
135°E
180°
135°W

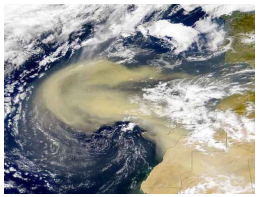

2010-03-25
Altitude (km)
8.0
6.0
4.0
2.0
0.0
25N
30N
Other
Smoke
Polluted Dust
Clean Continental
Polluted Continental
Dust
Clean Marine
Not Determined
60°N
50°N
40°N
30°N
20°N
90°E
135°E
180°
135°W


2010-03-24
Altitude (km)
8.0
6.0
4.0
2.0
0.0
25N
30N
Other
Smoke
Polluted Dust
Clean Continental
Polluted Continental
Dust
Clean Marine
Not Determined
60°N
50°N
40°N
30°N
20°N
90°E
135°E
180°
135°W


2010-03-22
Altitude (km)
8.0
6.0
4.0
2.0
0.0
25N
30N
Other
Smoke
Polluted Dust
Clean Continental
Polluted Continental
Dust
Clean Marine
Not Determined
60°N
50°N
40°N
30°N
20°N
90°E
135°E
180°
135°W

Dust AOD over ocean

$$f = f_{an}\tau_{an} + f_{ma}\tau_{ma} +$$



Terra MODIS

Climatological

$$\tau_{dust} = \frac{AOT(f_{an} - FMF) - (f_{an} - f_{mar})\tau_{mar}}{f_{an} - f_{dust}}$$

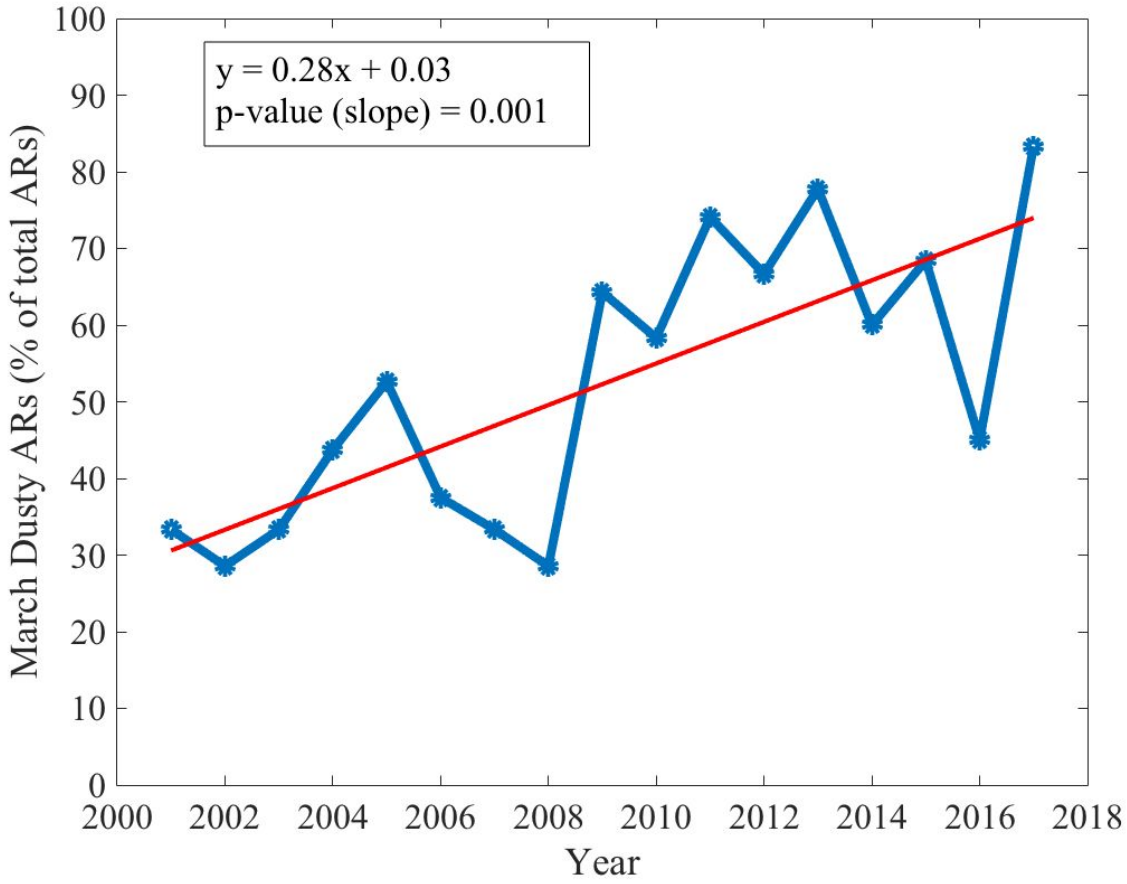
$$\tau_{mar} = 0.007U + 0.02$$

MERRA2 surface wind speed

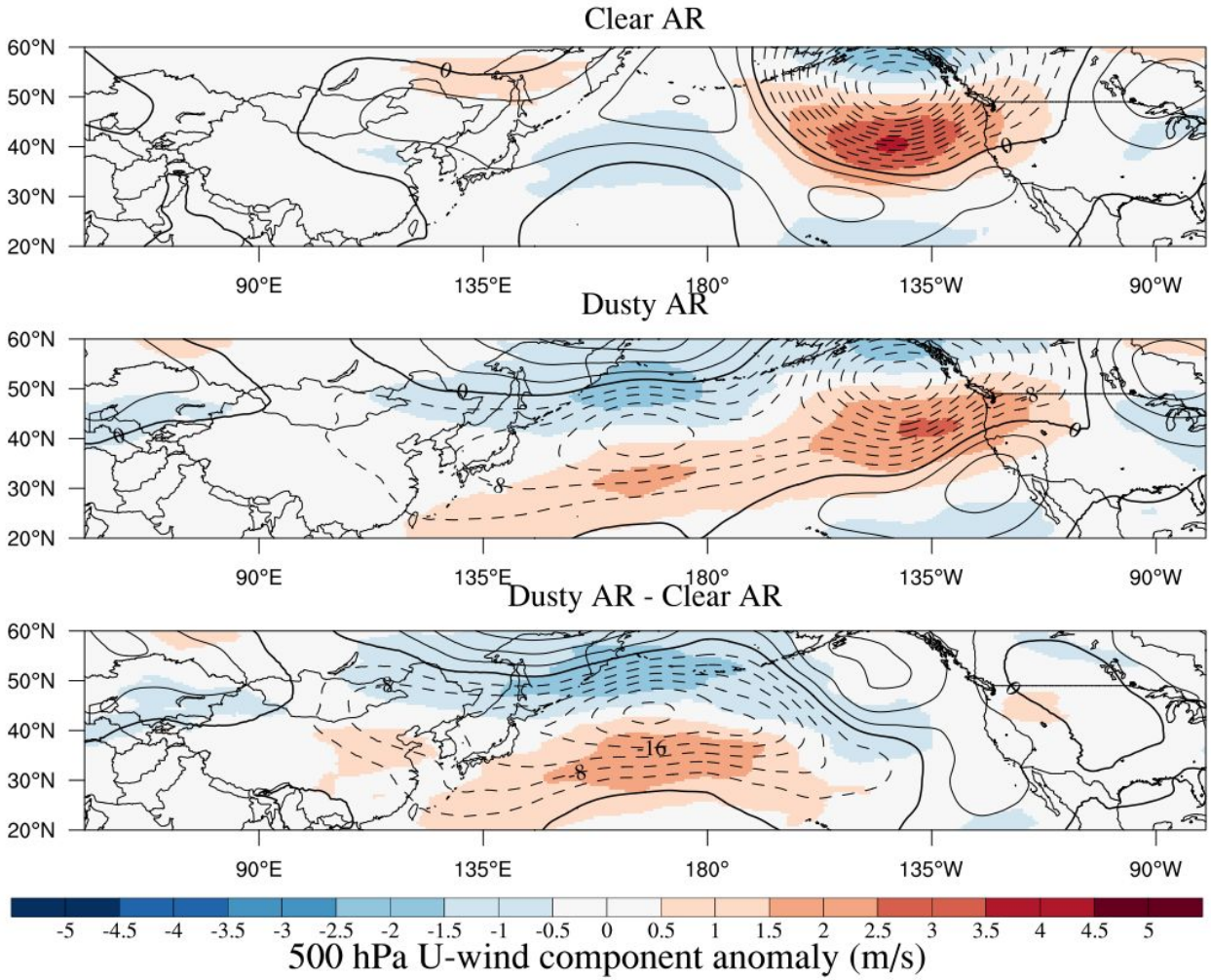
Kaufman et al. (2005)

AOD/τ: aerosol optical depth FMF/ f = fine mode fraction

Trend in dusty AR frequency is mostly due to increases in March …

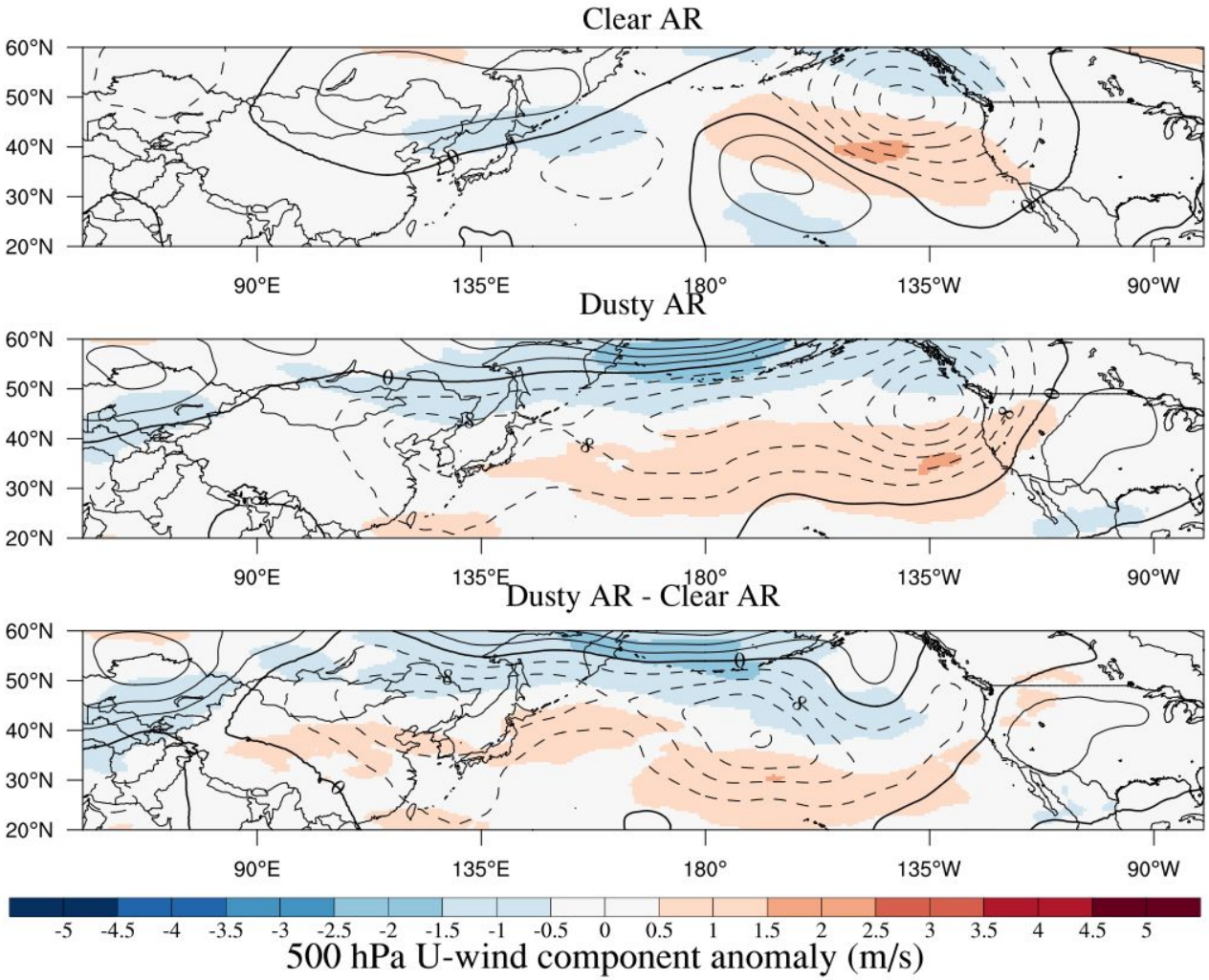


1 day prior to AR landfall



Zonal wind anomaly (colored) and geopotential height anomaly (lines)

4 days prior to AR landfall



Zonal wind anomaly (colored) and geopotential height anomaly (lines)

Datasets used

Dust AOD

- Resolution: 1° x 1°
- Based on MODIS AOD
- Dust detection over land based on optical properties
  - Single scattering albedo (SSA)
  - Angstrom exponent (AE)
- Dust detection over land = total AOD – marine AOD – anthropogenic & biomass burning
- No retrievals through clouds
- Probably will not detect heavily polluted dust

Meteorological

- MERRA2 reanalysis
- Resolution: 0.5° latitude x 0.625° longitude
- Geopotential height (500, 850hPa)
- Wind speed (10m, 500 hPa, 850 hPa)
- Integrated vapor transport (IVT) and Integrated water vapor (IWV)
- MODIS visible satellite imagery