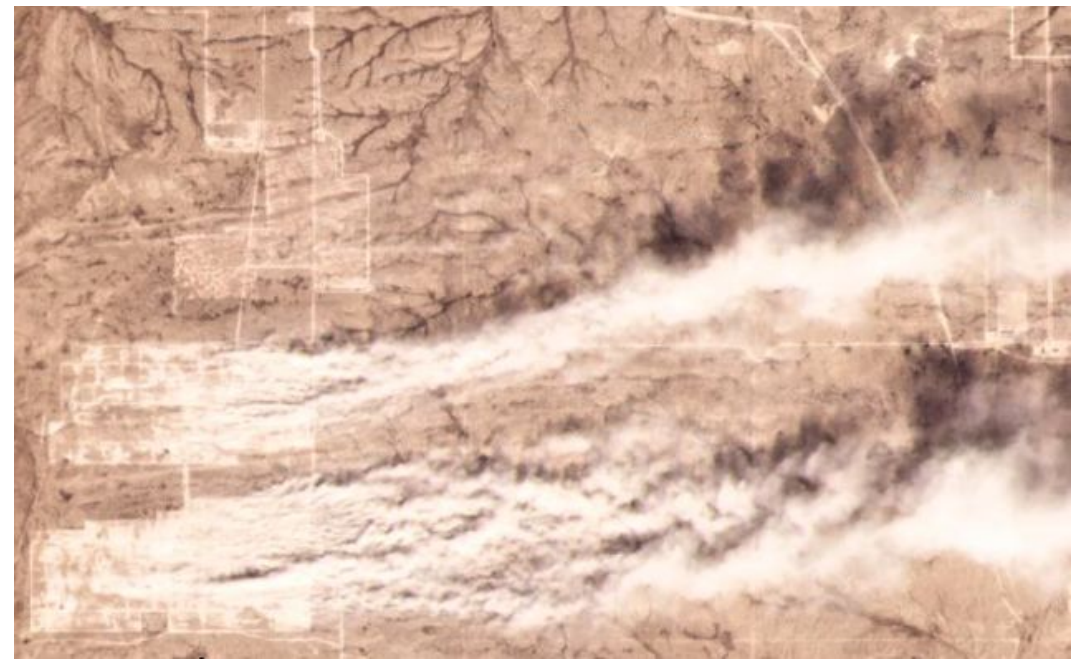


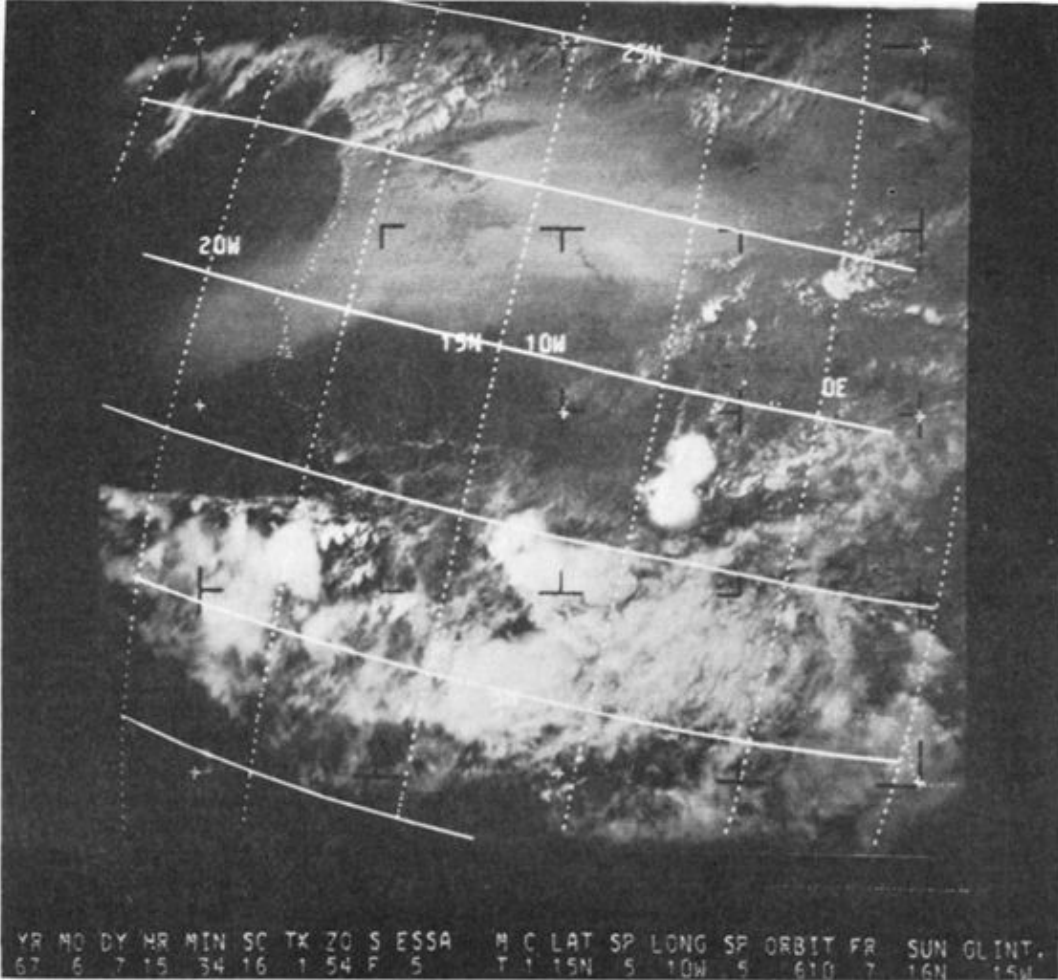
# CubeSats. A New Tool In The Dust Storm Detection Toolbox



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tegill@utep.edu and R.G.Bryant@Sheffield.ac.uk

# We've been detecting dust storms from satellites for almost 55 years- and have come a long way!



Left: African dust cloud moving over the Atlantic, June 7, 1967, from ESSA-5 satellite (Prospero et al., 1970)

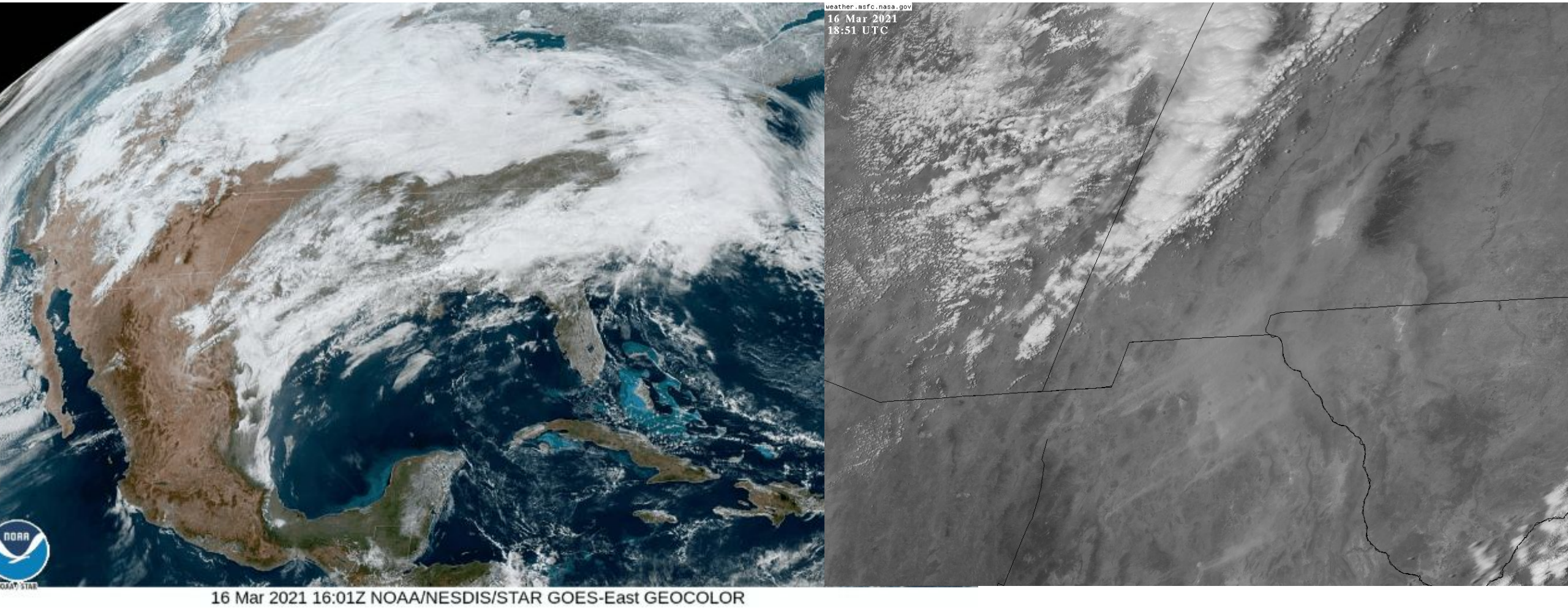


Right: LANDSAT-1 view of Southern California on January 1, 1973, showing dust plumes over the Mojave Desert.

J. Prospero et al., 1970, Earth & Planetary Sci. Letters 9:287-293

L.W. Bowden et al., 1974, Science 184:1077-1078.

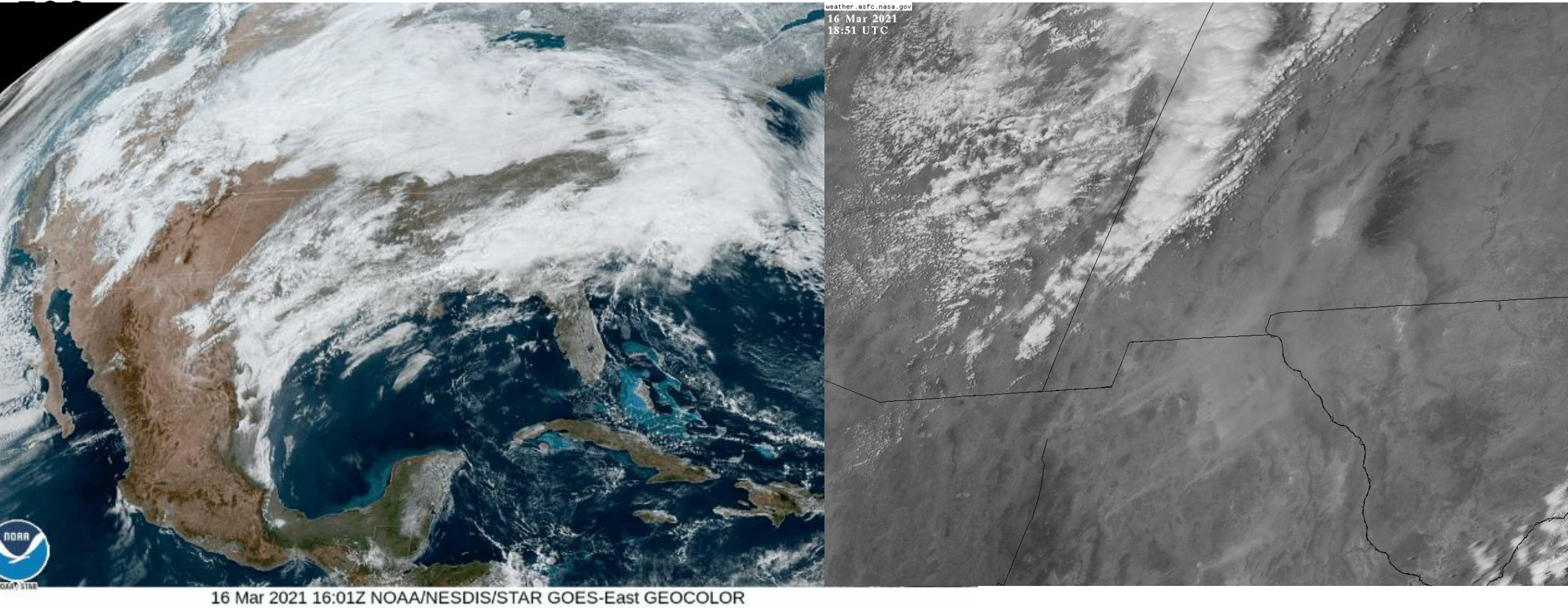
**The NOAA-GOES series, from its first satellite 45 years ago to the current GOES-17, provides a great tool for monitoring dust storms.**



**GOES-East views of the dust storm affecting New Mexico, Texas and Chihuahua 3/16/21**

**National Weather Service 10<sup>th</sup> Dust Storm Workshop – March 24<sup>th</sup>, 2021**

**GOES now provides images minutes apart, great for watching evolution and progress of dust events, with spatial resolution to**



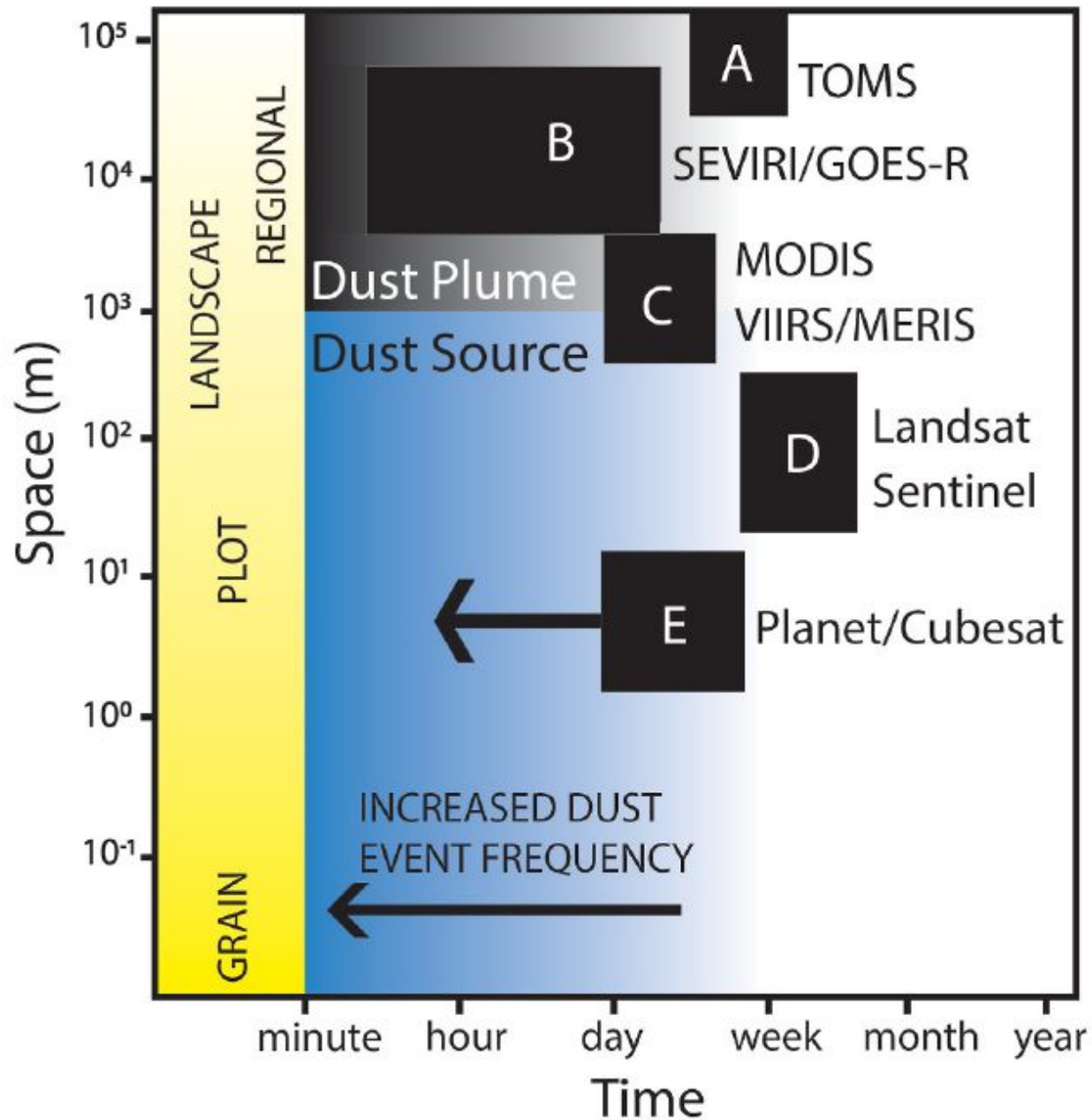
**GOES-East views of the dust storm affecting New Mexico, Texas and Chihuahua 3/16/21**

**National Weather Service 10<sup>th</sup> Dust Storm Workshop – March 24<sup>th</sup>, 2021**

**NASA'S MODIS sensor on board Terra and Aqua satellites has been a revolution in detecting dust source locations, with spatial resolution to 250m, but at most two images are available per day.**



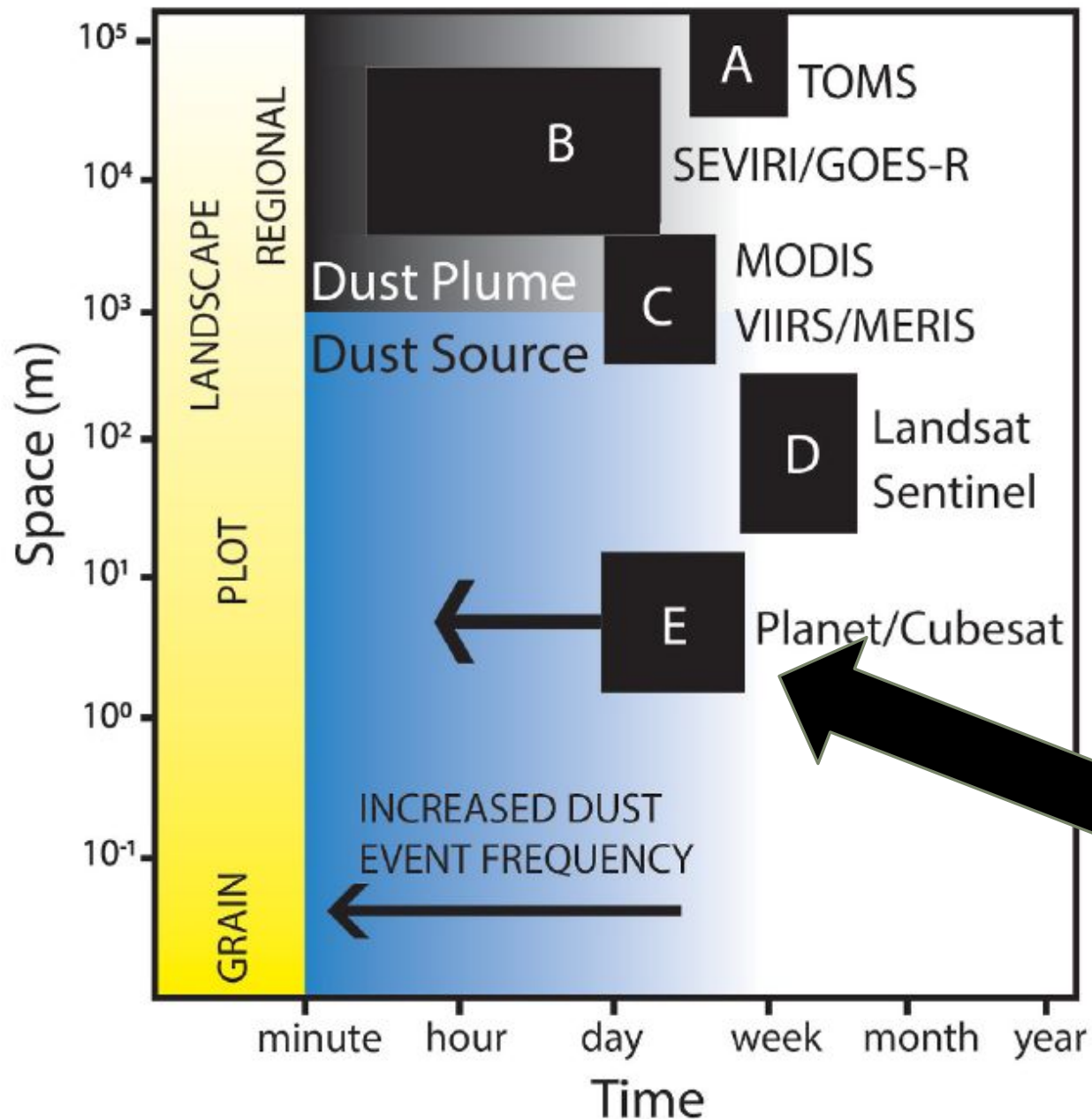
**MODIS-Terra view of dust storm affecting New Mexico, Texas and Chihuahua 3/16/21**



**There is a trade-off between**

- **Temporal frequency**
- **Spatial fidelity** and
- **Data availability**

**when it comes to satellite imaging of dust storms.**



**Now there's something new in the toolbox- Cubesats, especially PlanetScope from Planet Labs.**



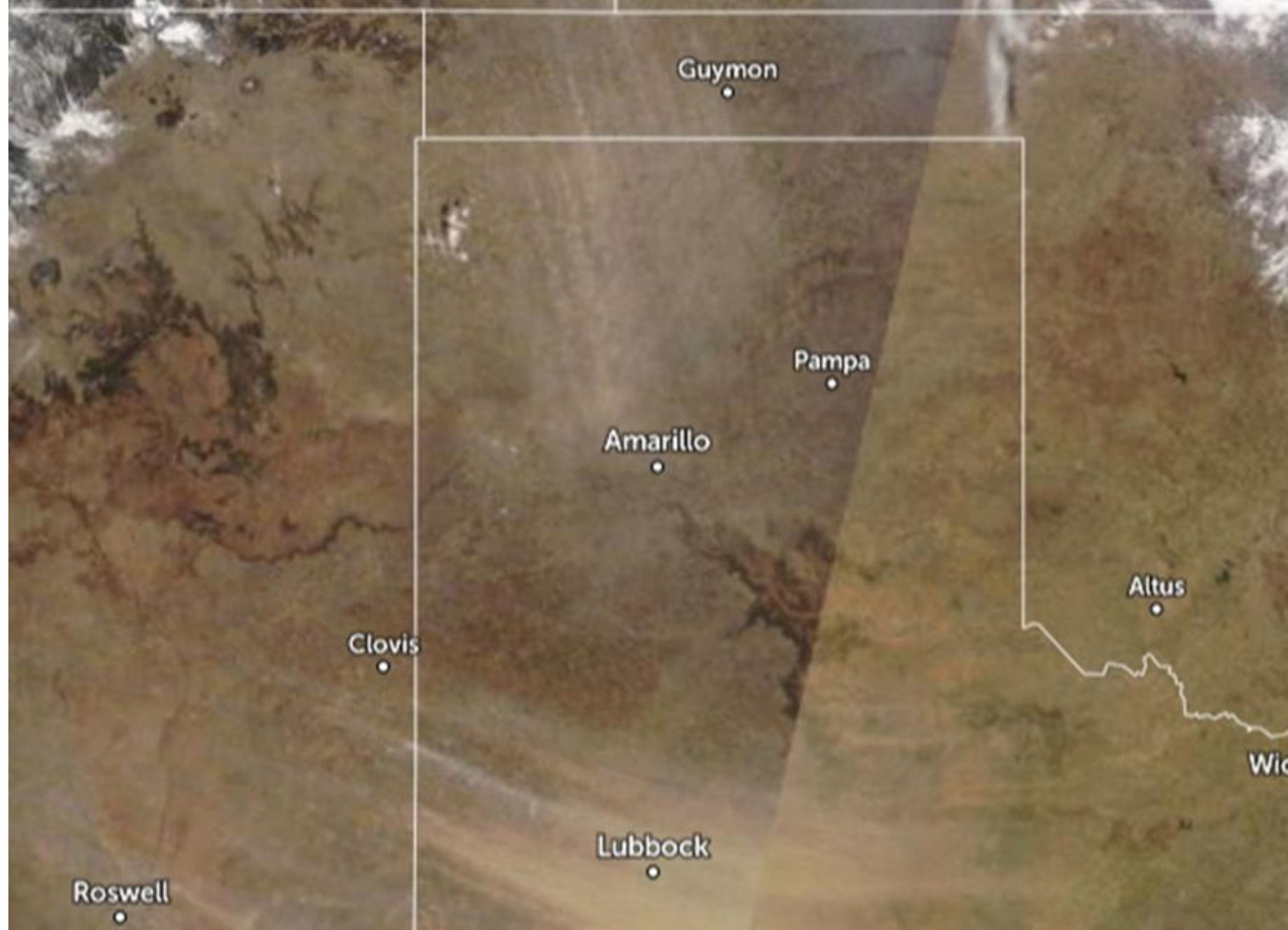
- Fleets or “flocks” of small, privately-launched miniature satellites (CubeSats) named “Doves” purposed for Earth imaging.
- More than 200 are currently in orbit.
- Various numbers cover the Earth at different times and frequencies.
- Spatial resolution is as good as 3 meters!
- Data is available in some quantity freely to university students and researchers, and NASA-supported researchers;  
and through license to others (governmental agencies, nonprofits, and businesses)



# Example:

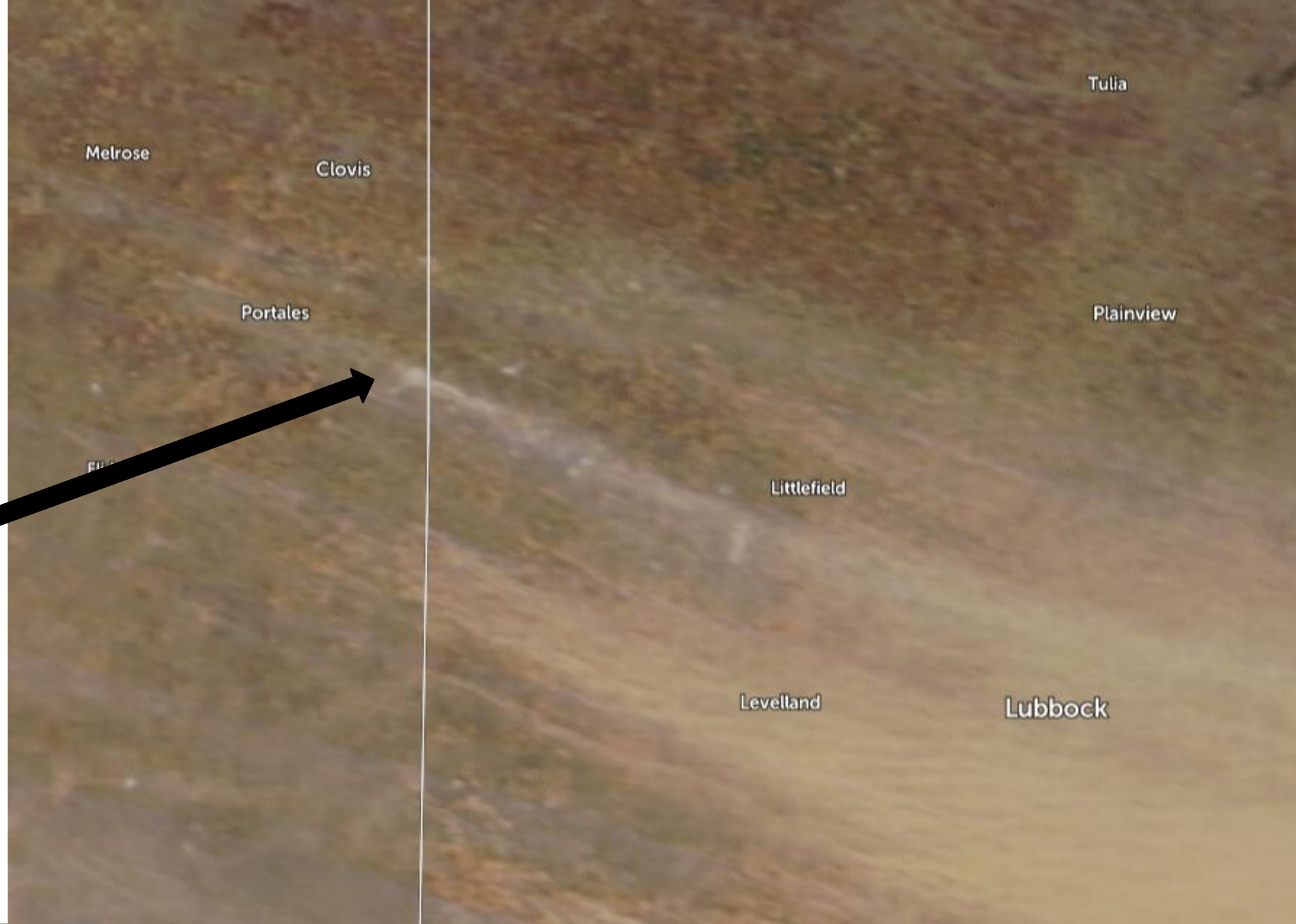
Dust storm of January 30, 2021 in the High Plains of the Texas Panhandle and extreme eastern New Mexico.

**MODIS Terra**



**Notice the one  
strong dust plume  
that's lighter in  
color,  
very close to the  
TX/NM state line  
SE of Portales,  
New Mexico.**

**MODIS Terra**



**PlanetScope shows  
the source in much  
more detail:  
a dry salt lake  
(playa) named  
Arch Lake.**



**PlanetScope shows  
the source in much  
more detail:  
a dry salt lake  
(playa) named  
Arch Lake.**



# Example:

Dust storm of  
March 16, 2021  
in the  
Chihuahuan  
Desert along  
the US-Mexico  
border.



**MODIS Terra**

# Example:

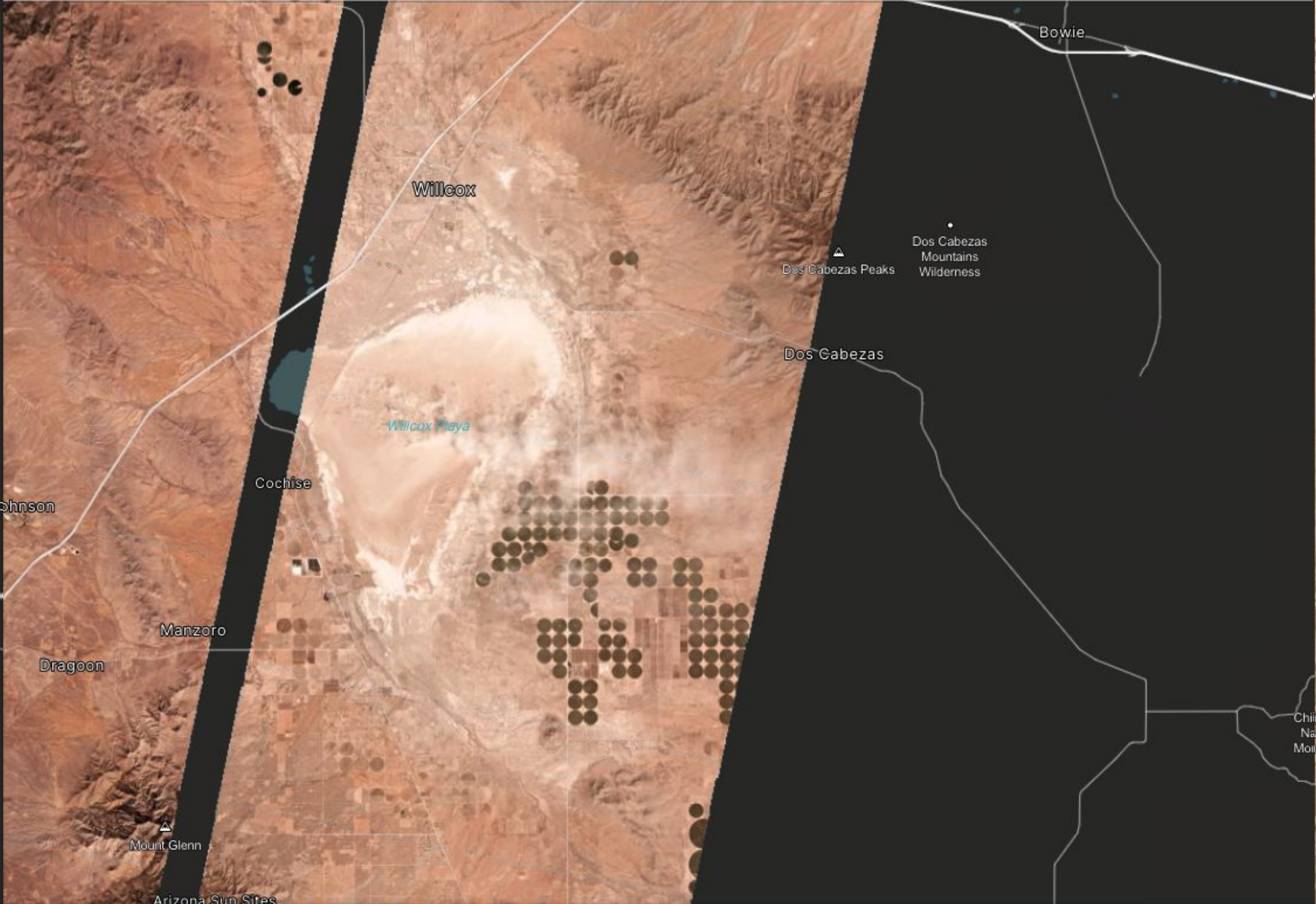
Dust storm of  
March 16, 2021  
in the  
Chihuahuan  
Desert along  
the US-Mexico  
border.



**MODIS Terra**



17:1  
2  
17:1  
4  
17:1  
8  
17:2  
1  
17:3  
8  
17:3  
9  
17:4  
7  
18:0  
3  
18:0  
5



**Willcox  
Playa,  
March  
22,  
2021**

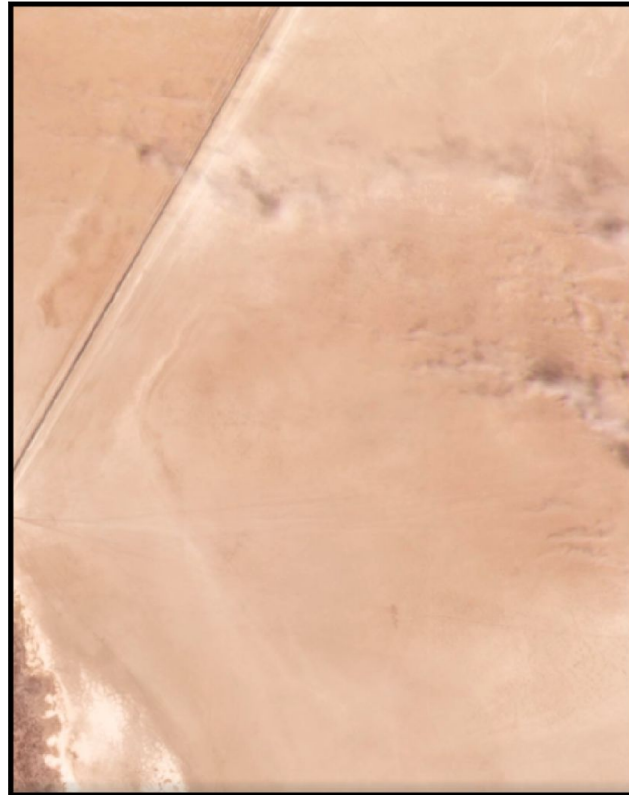
Chil  
Nac  
Mou



# Example:

March 22, 2021  
Willcox Playa,  
Arizona:  
Close-up along  
railroad trestle

17:14



17:39



17:42



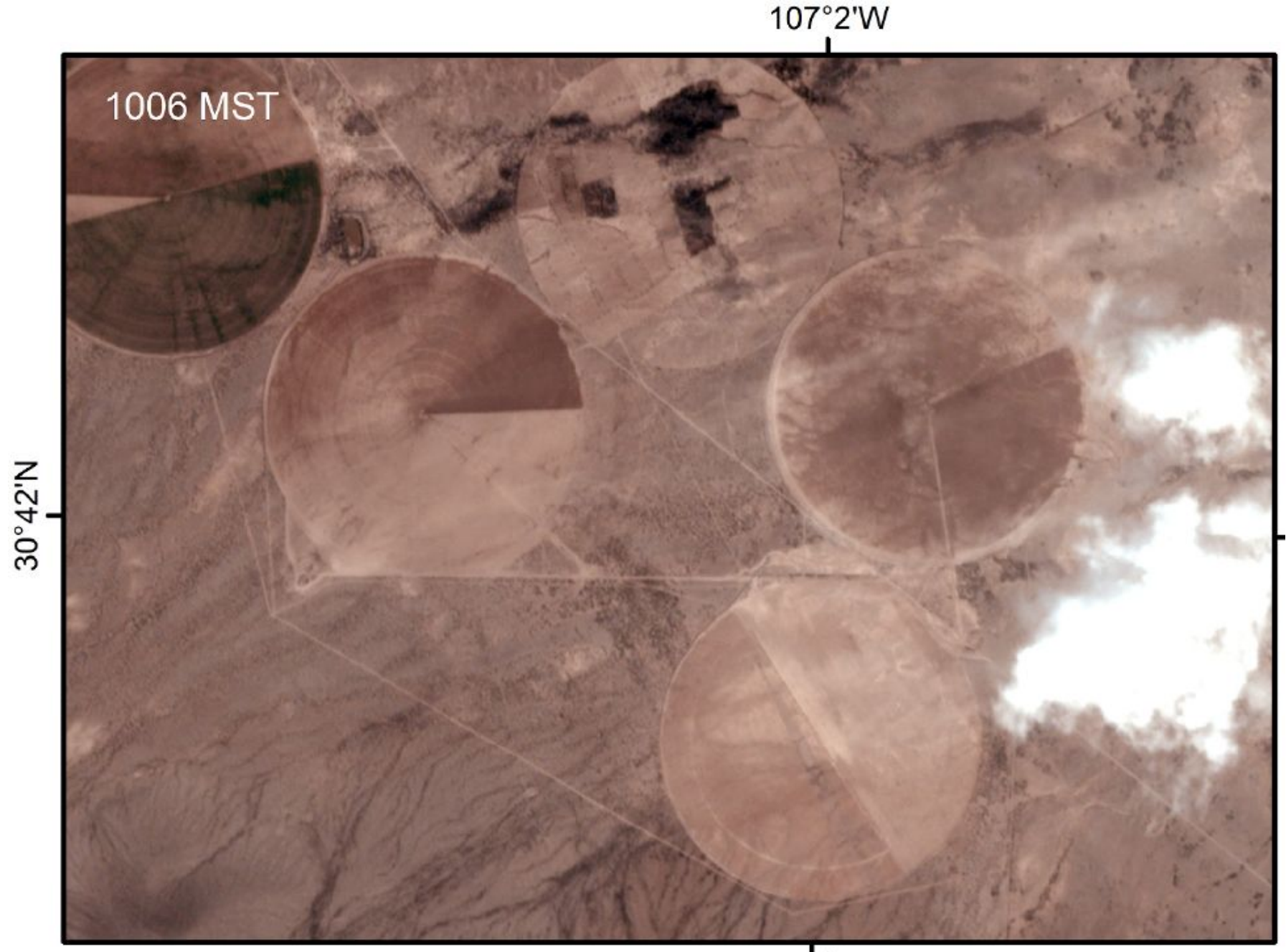
March 22 2021  
PlanetScope  
Overpass Times



# Example:

Dust storm of  
November 30,  
2018 in the  
Chihuahuan  
Desert south of  
Ciudad Juarez

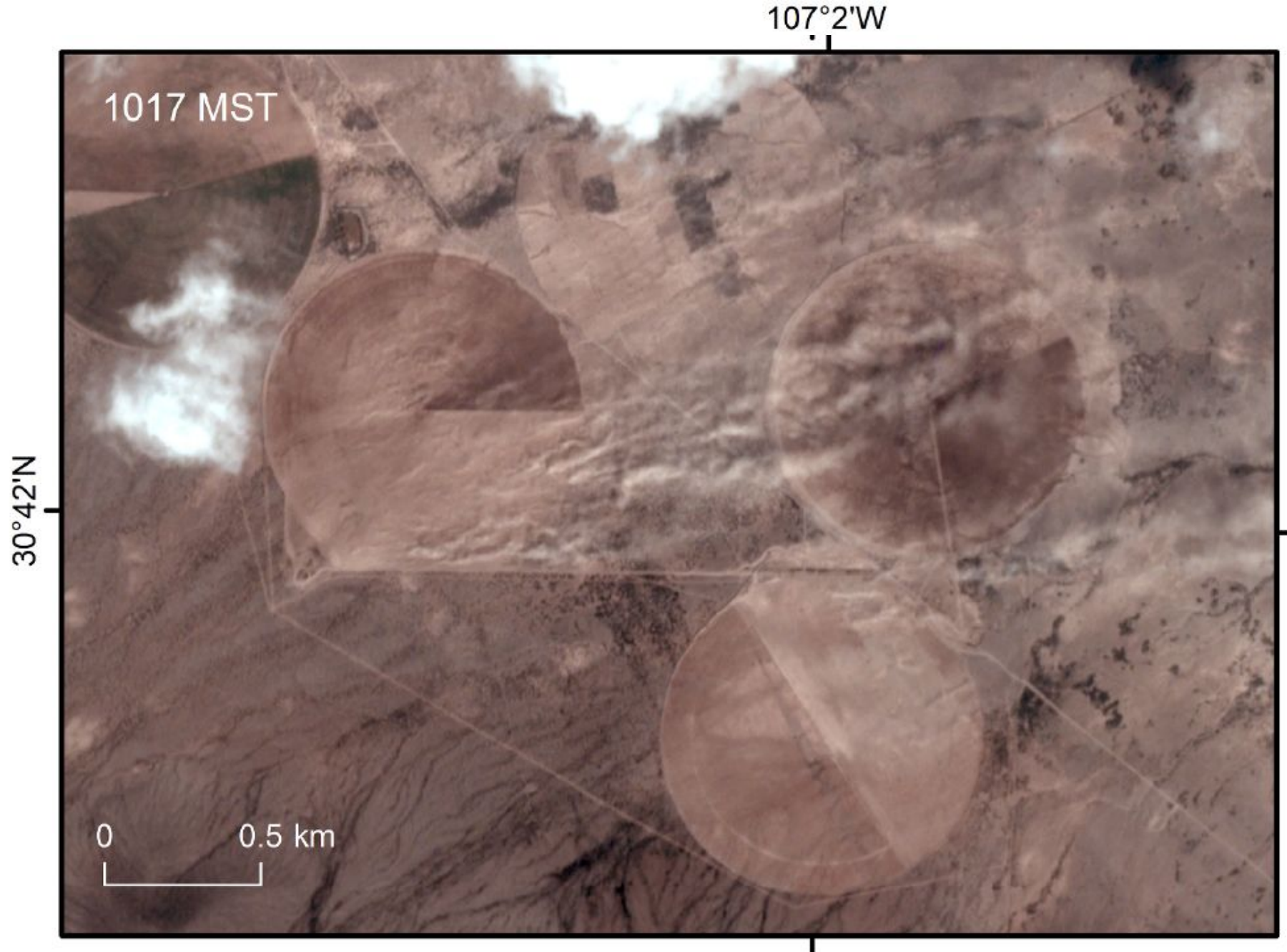
**PlanetScope**



# Example:

Dust storm of November 30, 2018 in the Chihuahuan Desert south of Ciudad Juarez

**PlanetScope**





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### GERMANY-BASED RESEARCHERS:

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### Planet Plugins for

- QGIS [this one works really well and is free]
- [ArcPro](#)

Cloud analysis available via Planet Explorer

Data delivery to Earth Engine:

[https://samapriya.github.io/projects/planet\\_gee\\_pipeline\\_gui/](https://samapriya.github.io/projects/planet_gee_pipeline_gui/)

**Note: Basic Users can have download access to up to 5,000 square kilometers of data/month**

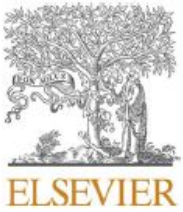
**Cite:** Planet Team (2017). Planet Application Program Interface: In Space for Life on Earth.

San Francisco, CA. <https://api.planet.com>



## **Downside of PlanetScope for dust monitoring in our region:**

- 2 to 3 “flock” overpasses per day
- Overpasses between approximately 1500- 1900 hours
- Earlier in the day than most dust storms occur in the Southwest.
- Does not have additional sensors/channels and enhancements available with GOES, MODIS, VIIRS



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## Understanding dust sources through remote sensing: Making a case for CubeSats

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MODIS  
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Dust emission  
Playa

### ABSTRACT

Dust sources have been revealed through remote sensing, first regionally by  $\sim 1^\circ$  resolution sensors (TOMS), then at sub-basin scale by moderate-resolution sensors (MODIS). Sensors with higher spatial resolution until recently were poorly temporally-resolved, precluding their use for systematic investigations of sources. Now, “CubeSat” constellations with high-temporal-and-spatial-resolution sensors such as PlanetScope offer  $\sim 3$  m resolution and daily (to sub-daily) temporal resolution. We illustrate the spatio-temporal dust plume observation capabilities of CubeSat data through a dust event case study, Bolson de los Muertos playa, Chihuahuan Desert, Mexico. For the event, PlanetScope showed numerous discrete point sources, revealing variability of surface erodibility and emission over  $\sim 8\%$  of a focus area at time of capture. The unprecedented detail of PlanetScope imagery revealed plume development where outer-playa sands and fluvial-deltaic inputs contact lacustrine silts/clays, consistent with field-studies. PlanetScope’s high fidelity improves spatial quantification and temporal constraint of source activity, and we assess the spatio-temporal capabilities of CubeSat in context with other dust observation remote sensing systems. Compared to previous satellite technologies, CubeSats bring better potential to link remote sensing to field observations of emission. This leap forward in the remote sensing of dust sources calls for the systematic analysis of CubeSat imagery in source areas.

**For questions or a copy of the scientific paper, email us at:**

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