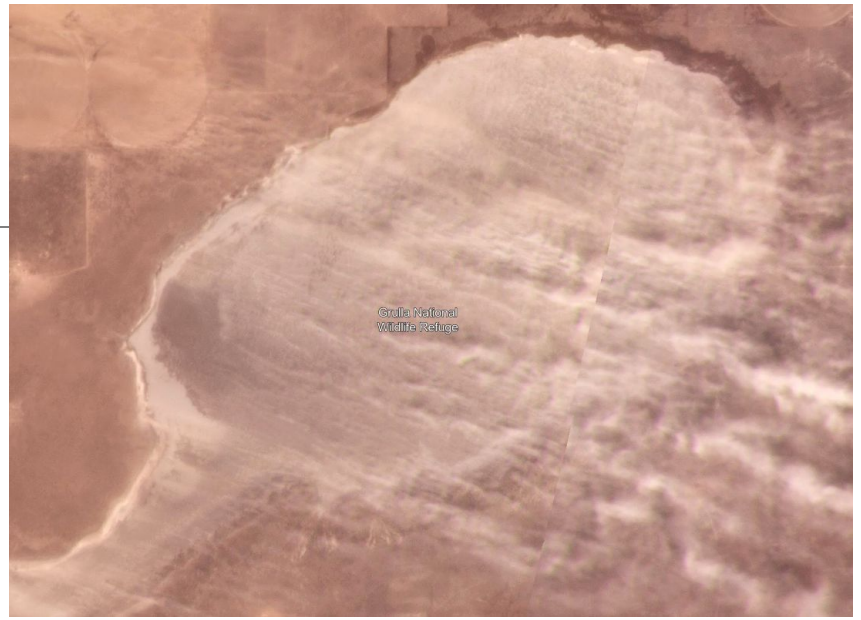
CubeSats: A New Tool In The Dust Storm Detection Toolbox



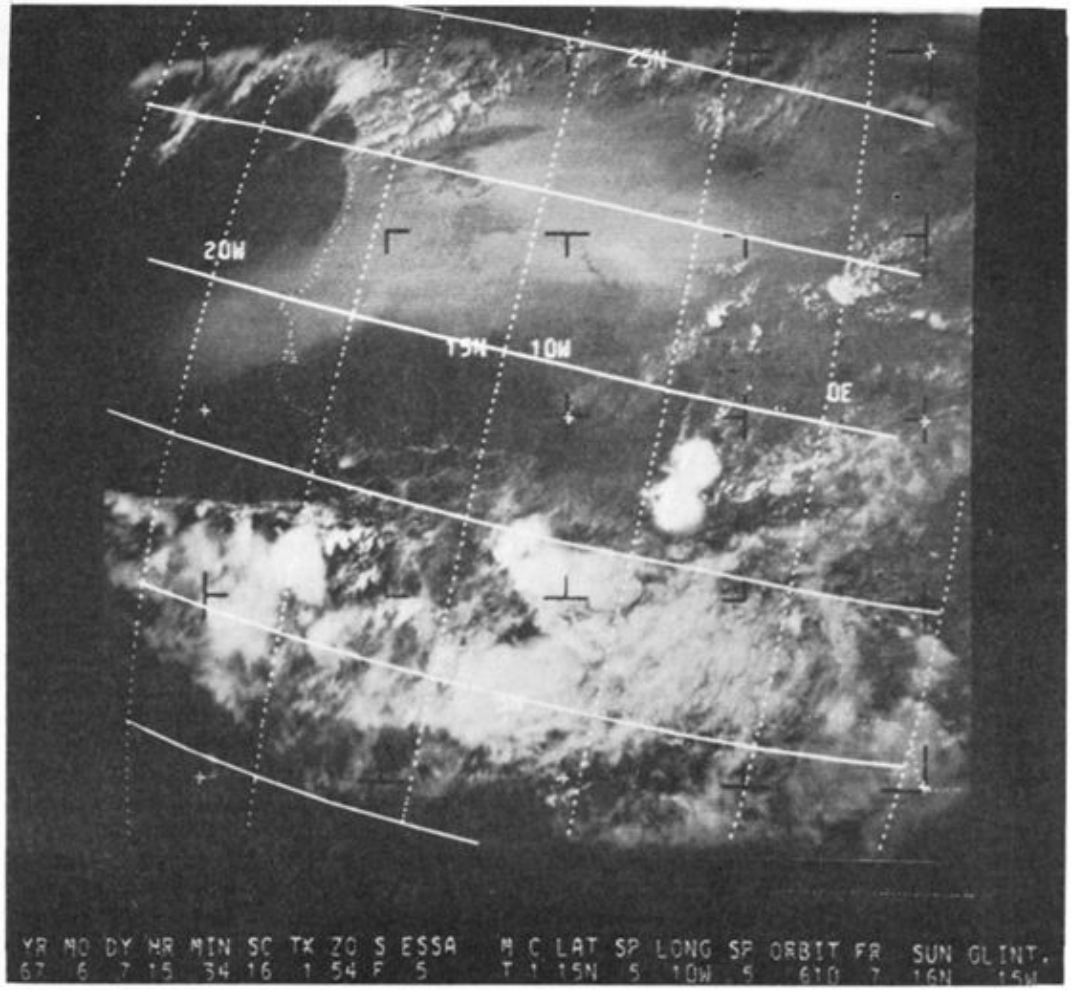
Tom Gill, The University of Texas at El Paso

Rob Bryant, The University of Sheffield (UK)

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

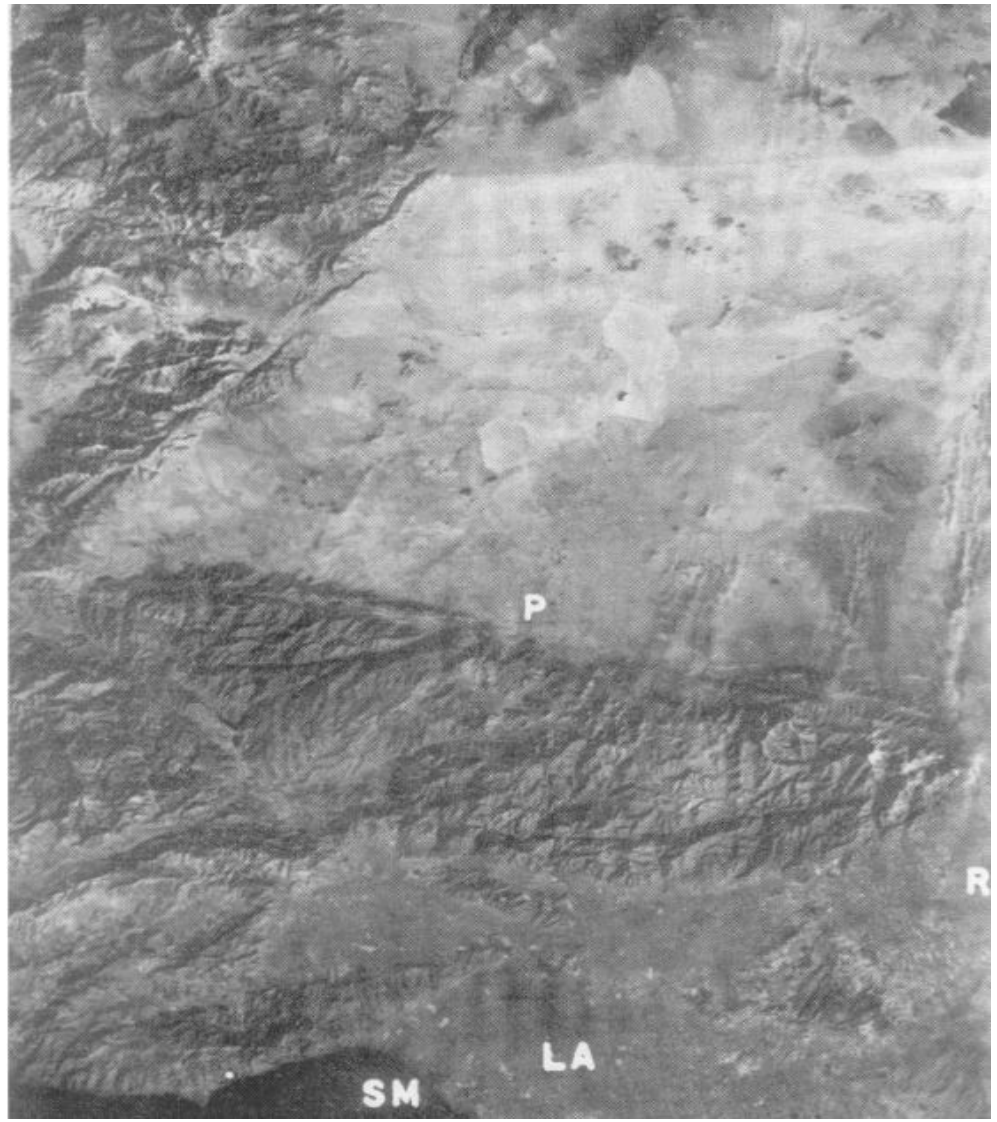
National Weather Service 10th Dust Storm Workshop – March 24th, 2021

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)

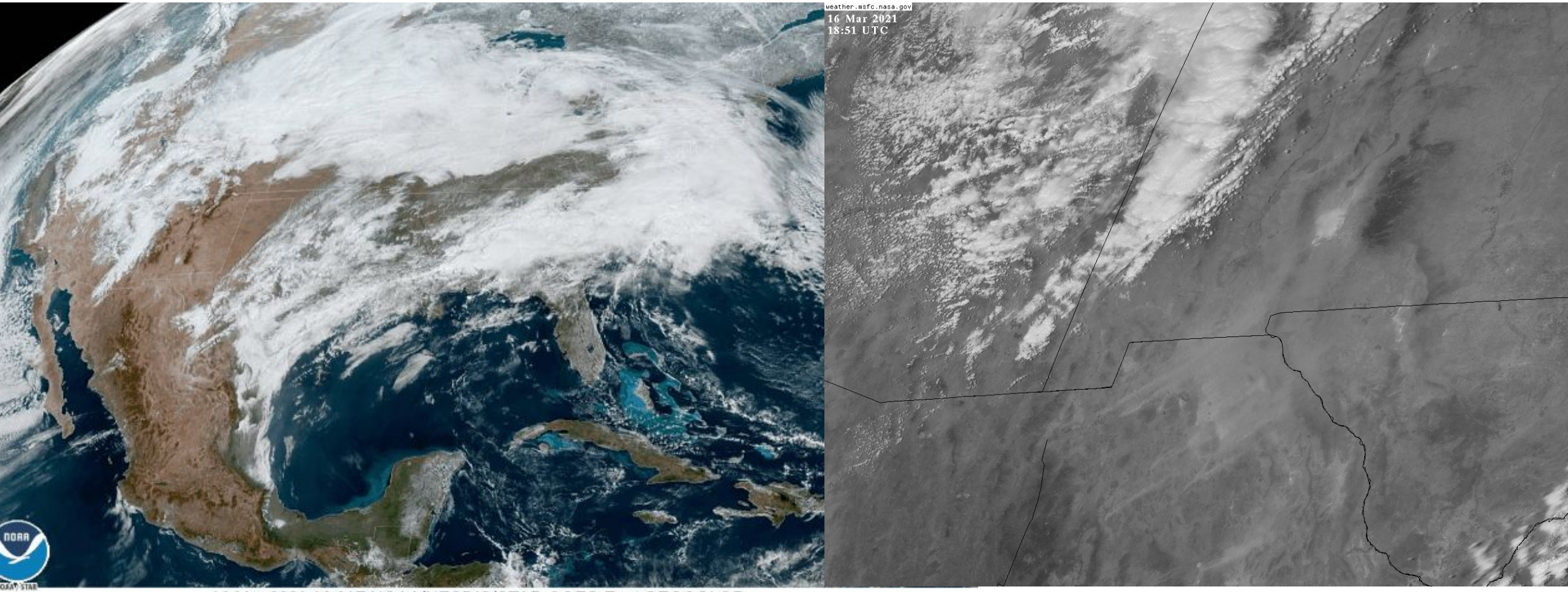
Right: LANDSAT-1 view of Southern California on January 1, 1973, showing dust plumes over the Mojave Desert.



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

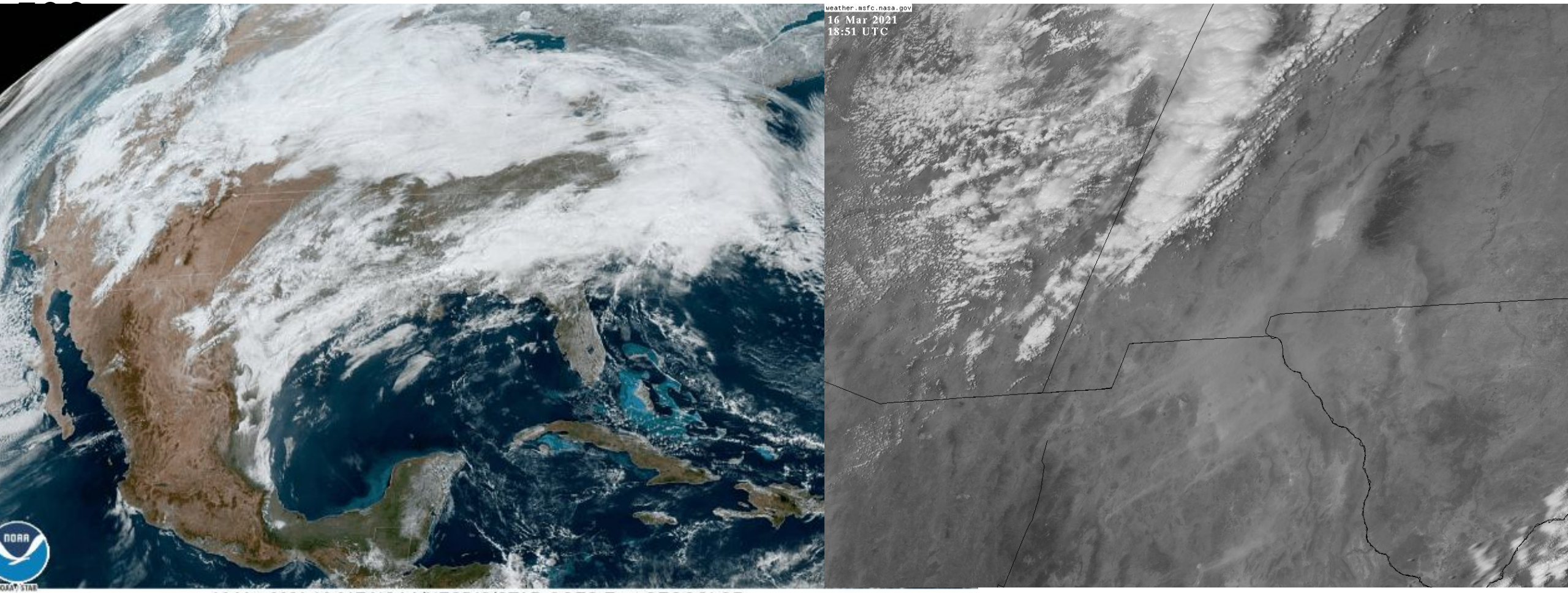
L.W. Bowden et al., 1974, Science 184:1077-1078.

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

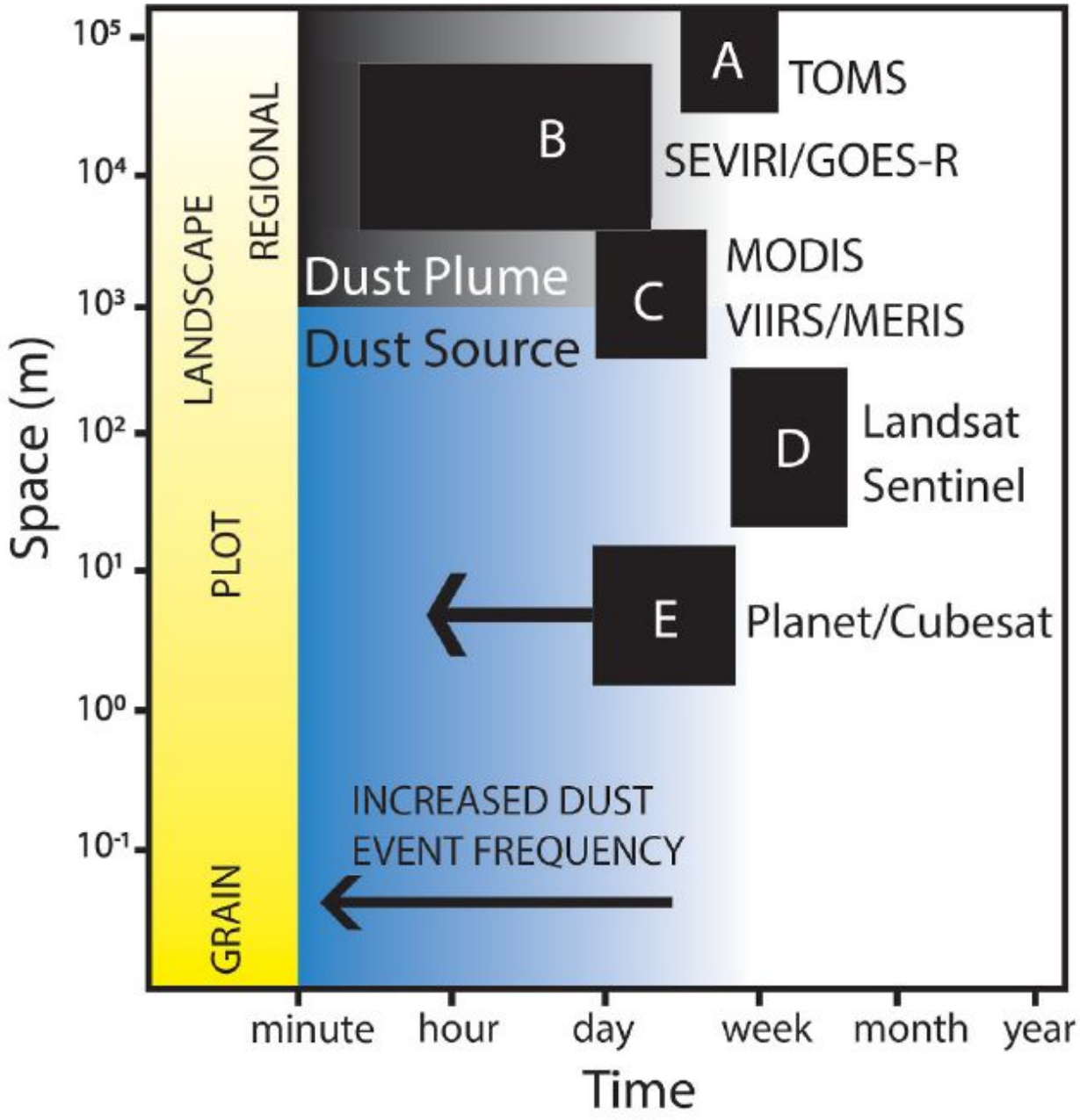
GOES now provides images minutes apart, great for watching evo-lution and progress of dust events, with spatial resolution to



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

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.

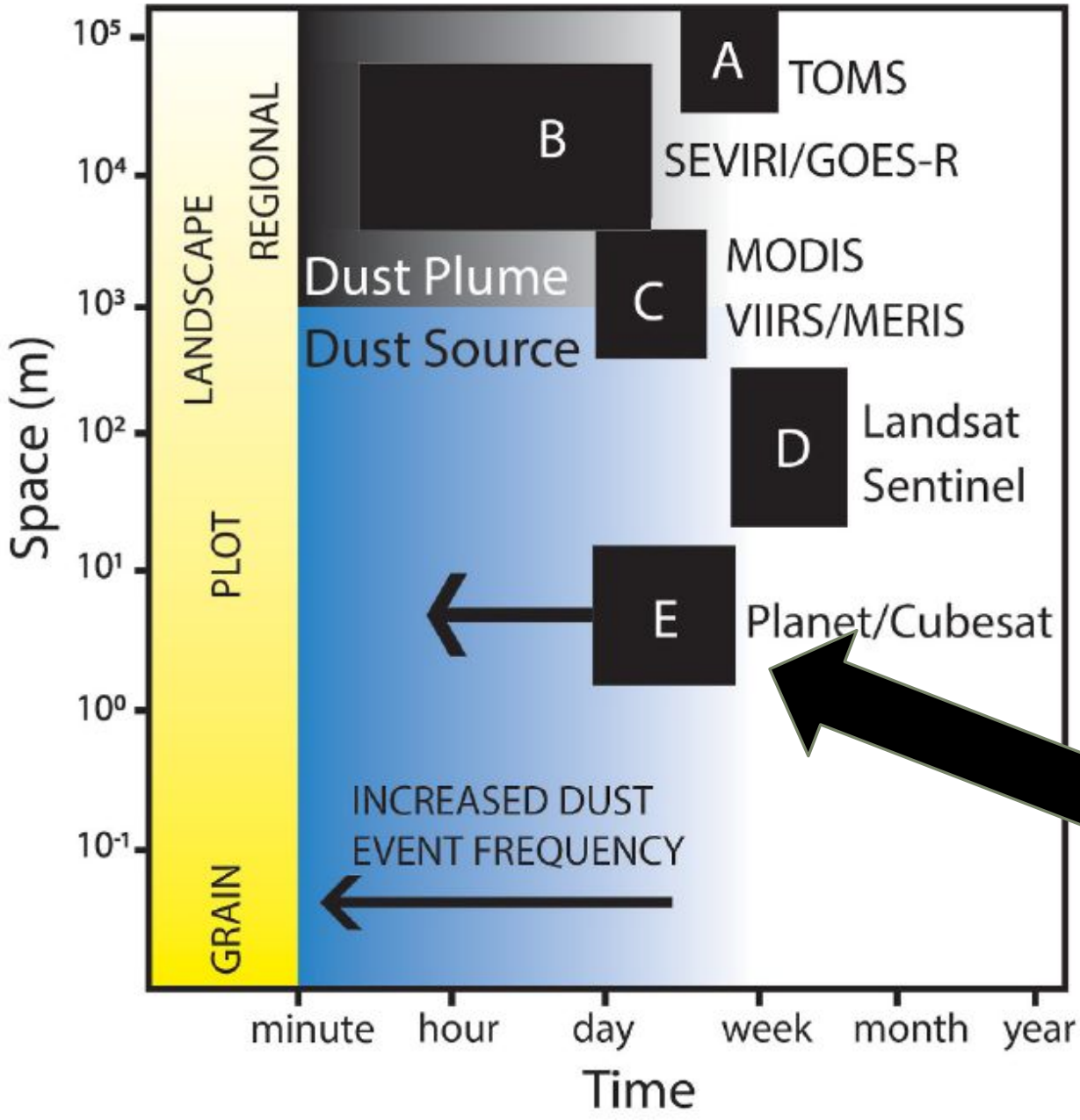
MODIS-Terra view of dust storm affecting New Mexico, Texas and Chihuahua 3/16/21



There is a trade-off between

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

when it comes to satellite imaging of dust storms.



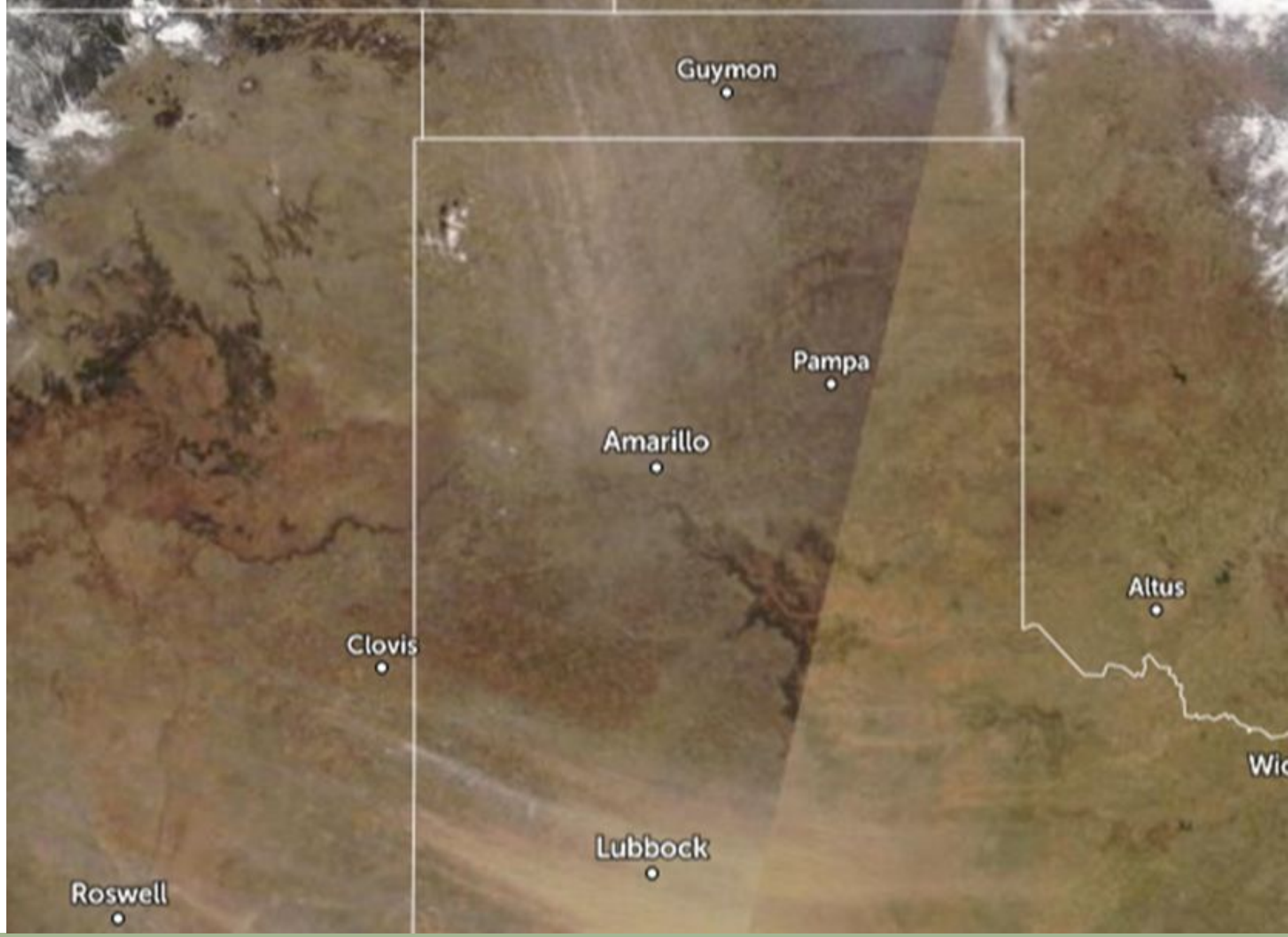
planet.

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)

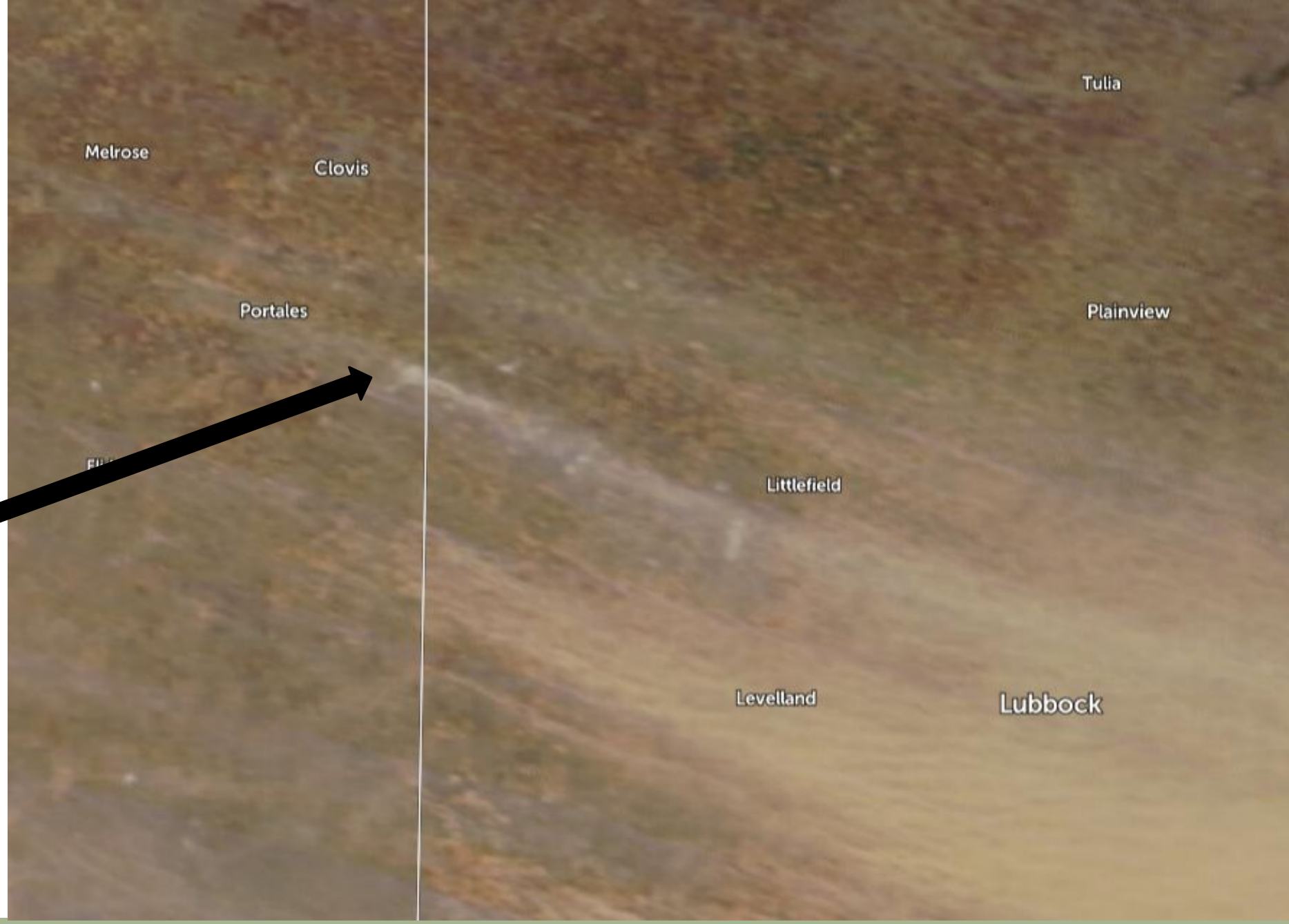
Example:

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

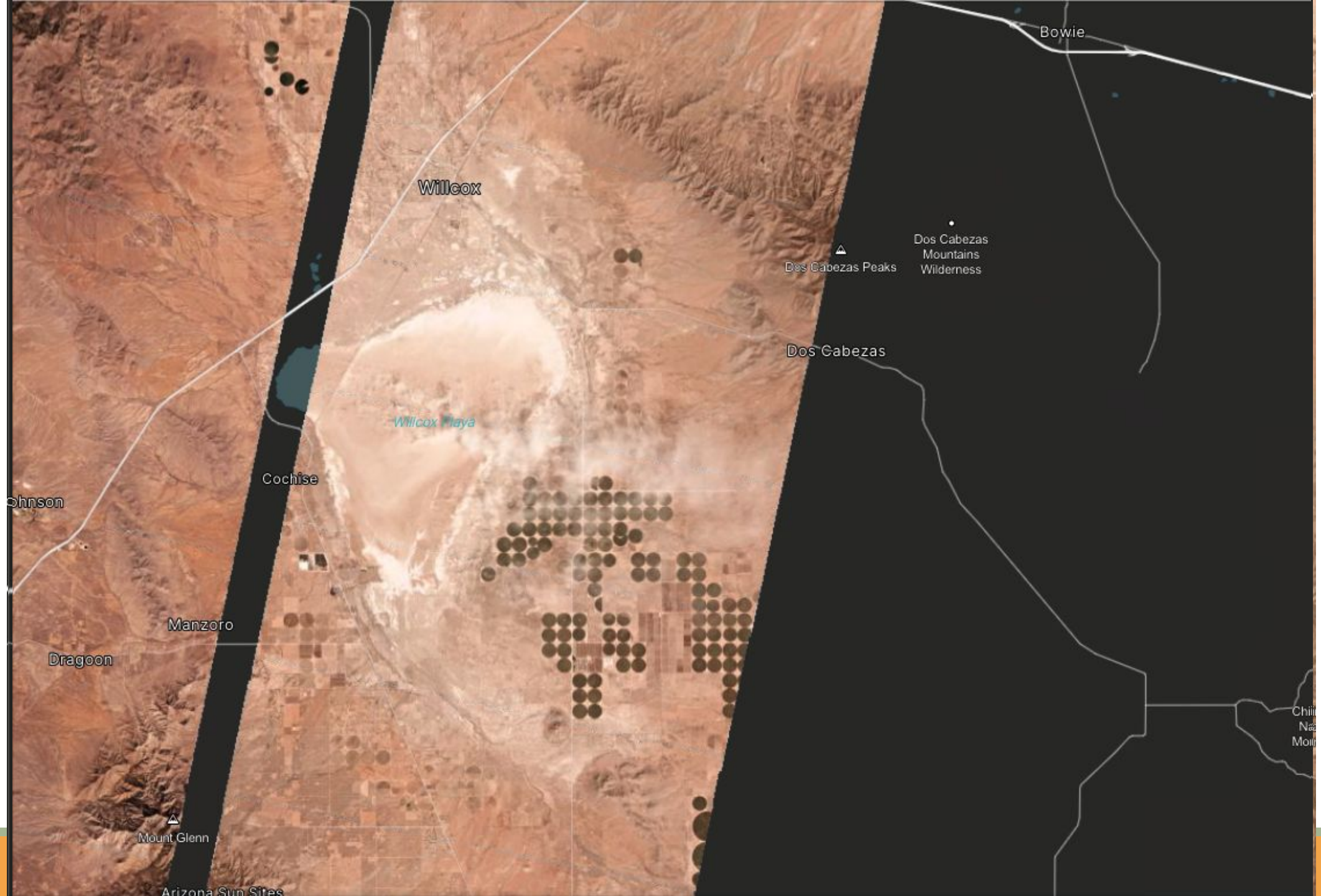
Example:

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

MODIS Terra

National Weather Service 10th Dust Storm Workshop – March 24th, 2021

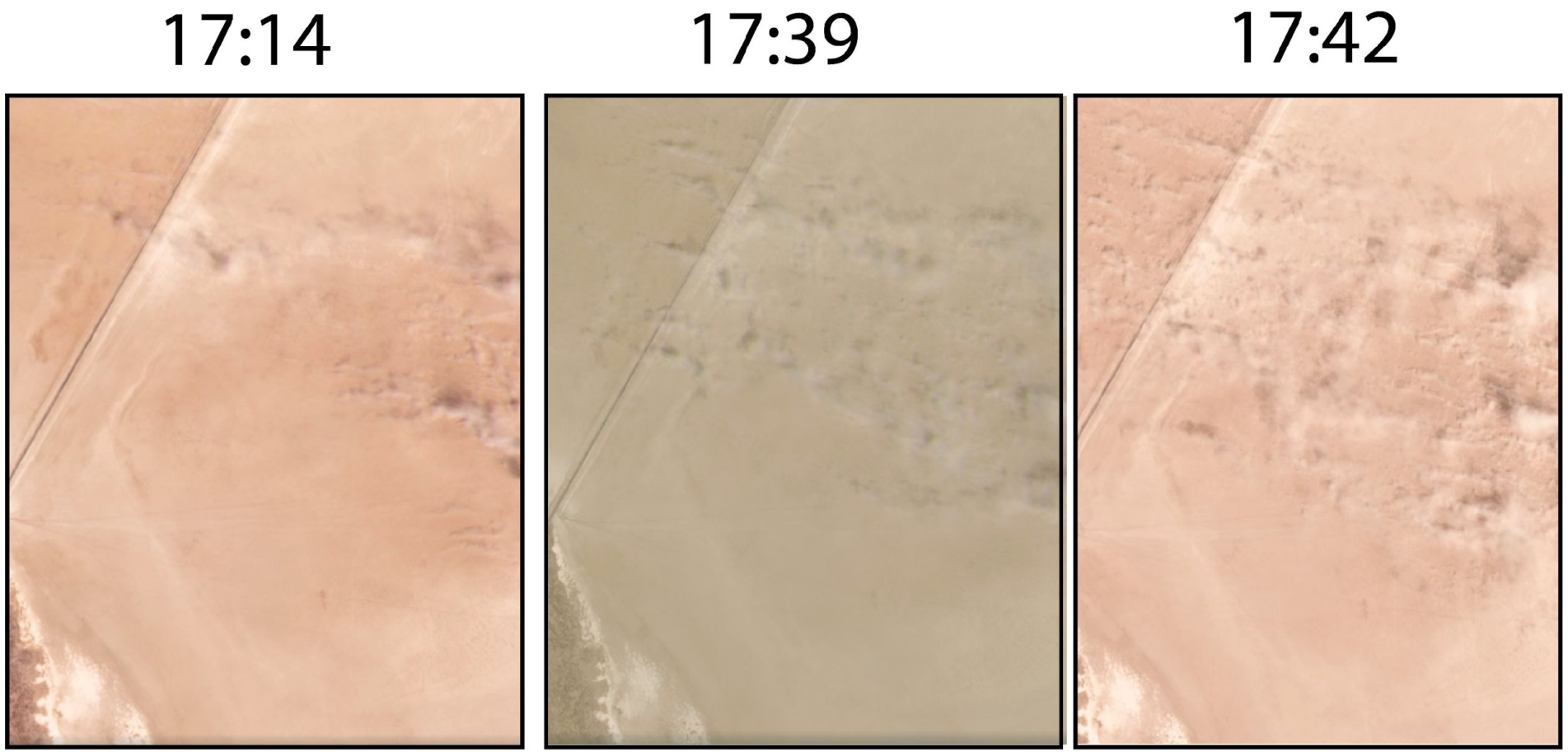
17:12
17:14
17:18
17:21
17:38
17:39
17:42
18:03
18:05



Willcox Playa, March 22, 2021

Example:

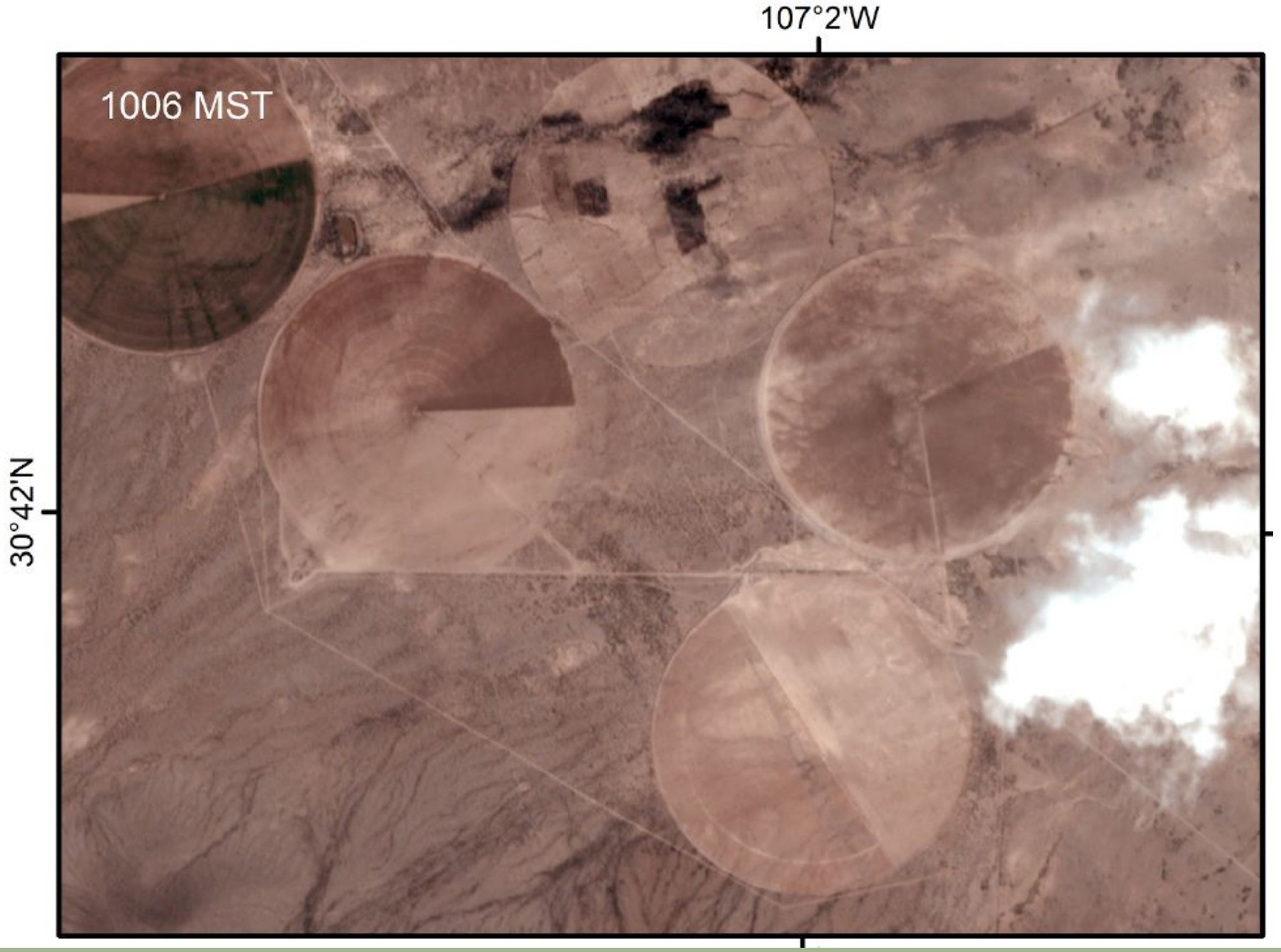
March 22, 2021
Willcox Playa, Arizona:
Close-up along railroad trestle



March 22 2021
PlanetScope
Overpass Times

Example:

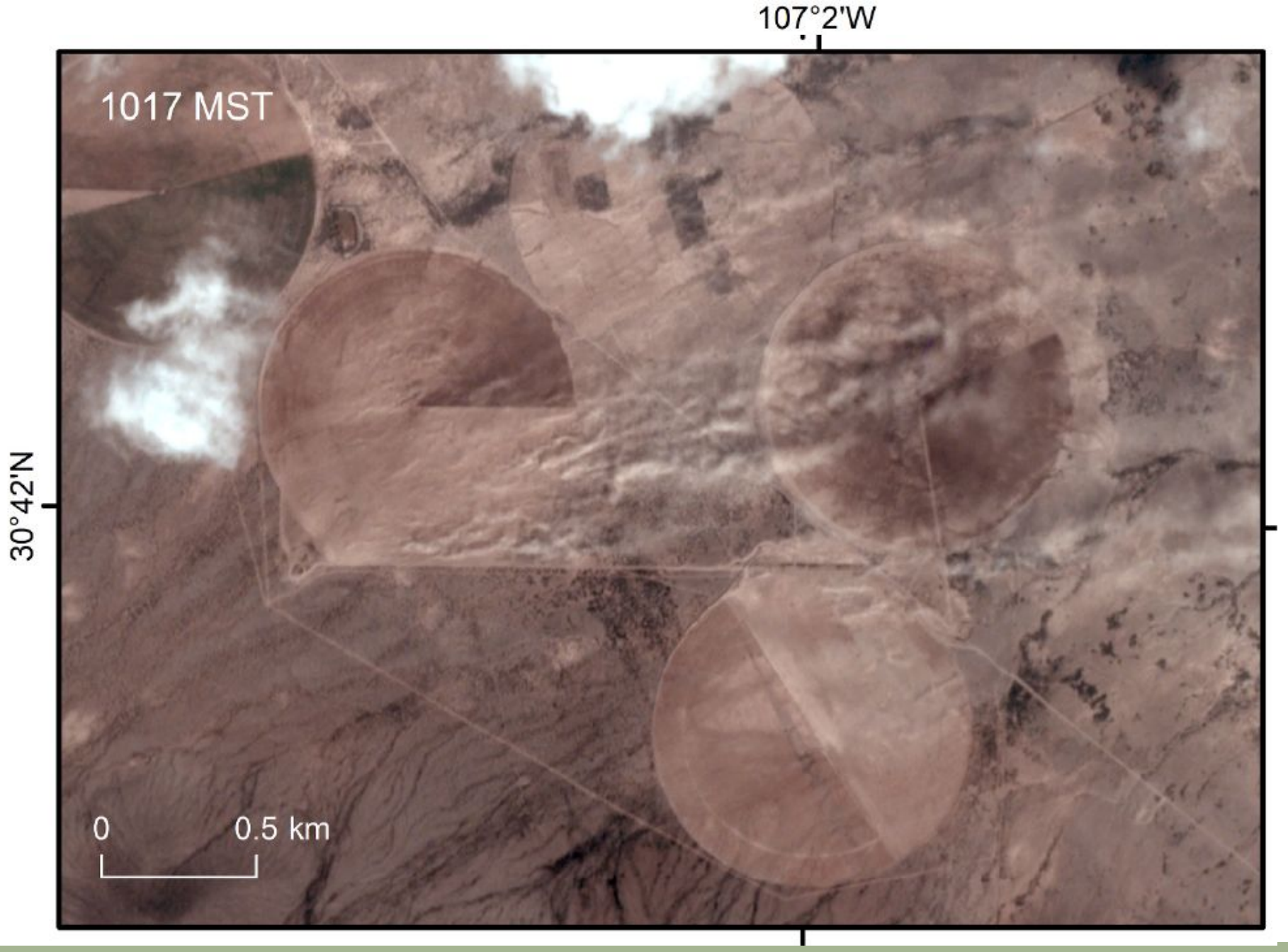
Dust storm of November 30, 2018 in the Chihuahuan Desert south of Ciudad Juarez



PlanetScope

Example:

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



PlanetScope

https://www.planet.com/markets/education-and-research/

GET ACCESS, MAKE DISCOVERIES

We're looking for university researchers, academics, and scientists to unlock the power of a one-of-a-kind dataset. Depending upon your affiliation and country of origin, there are three ways to apply for access:

UNIVERSITY-AFFILIATED STUDENT, FACULTY MEMBER OR RESEARCHER: Any university-affiliated student, faculty member or researcher may apply to the Education and Research Program for limited, non-commercial access to Planetscope Imagery and Rapid Eye Archive. A university email address is required, and nonprofit and government

GERMANY-BASED RESEARCHERS: Any German researcher, including nonprofit researchers and those at government institutions, may apply for access to Planetscope, RapidEye and SkySat imagery through RESA.

ANY OTHER RESEARCHER: Any researcher, including nonprofit researchers and those at government institutions or non-commercial early adopters, may apply for access to Planetscope, RapidEye and SkySat imagery through the European Space Agency Category 1 Portal.

GET STARTED TODAY

Level up your research and your classroom with flexible program offerings.

	BASIC	DEPARTMENTAL	CAMPUS
Users	Students and faculty	Grantees and research teams	Professors, administrators and your entire campus
Download Quota	5,000 km²/month	15 Tb / year	100 Tb / year
License	Personal research license	Administrative license	Administrative license
	APPLY NOW	CONTACT SALES	CONTACT SALES

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/

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

Journal of Arid Environments 184 (2021) 104335

Contents lists available at ScienceDirect

Journal of Arid Environments

journal homepage: www.elsevier.com/locate/jaridenv

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

Matthew C. Baddock [a,*], Robert G. Bryant [b], Miguel Domínguez Acosta [c], Thomas E. Gill [d]

[a] Geography and Environment, Loughborough University, Loughborough, LE11 3TU, UK
[b] Geography, University of Sheffield, Sheffield, S10 2TN, UK
[c] Ingenieria Civil y Ambiental, Universidad Autonoma de Ciudad Juarez, 450 N. Avenida del Charro, Ciudad Juarez, Chihuahua, 32315, Mexico
[d] Geological Sciences, University of Texas at El Paso, 500 W. University Avenue, El Paso, TX, 79968, USA

ARTICLE INFO

Keywords:
Mineral aerosol
PlanetScope
MODIS
Chihuahuan desert
Dust emission
Playa

ABSTRACT

Dust sources have been revealed through remote sensing, first regionally by ~1° 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 ~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 ~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:

tegill@utep.edu
r.g.bryant@sheffield.ac.uk

Acknowledgements to:

NASA 80NSSC19K0195

NOAA Educational Partnership Program Agreement No. NA16SEC4810006