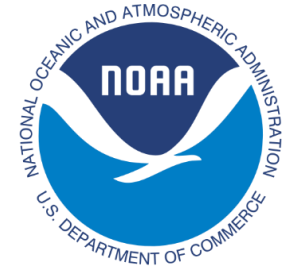


The Silent Sounds of Tornadoes and Their Potential Fluid Mechanism

EFPL EXPERIMENTAL FLOW
PHYSICS LAB

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Tornadoes are “small” coherent structures that rarely occur.

Photo courtesy of Kelly DeLay



However, tornadoes are also catastrophic.

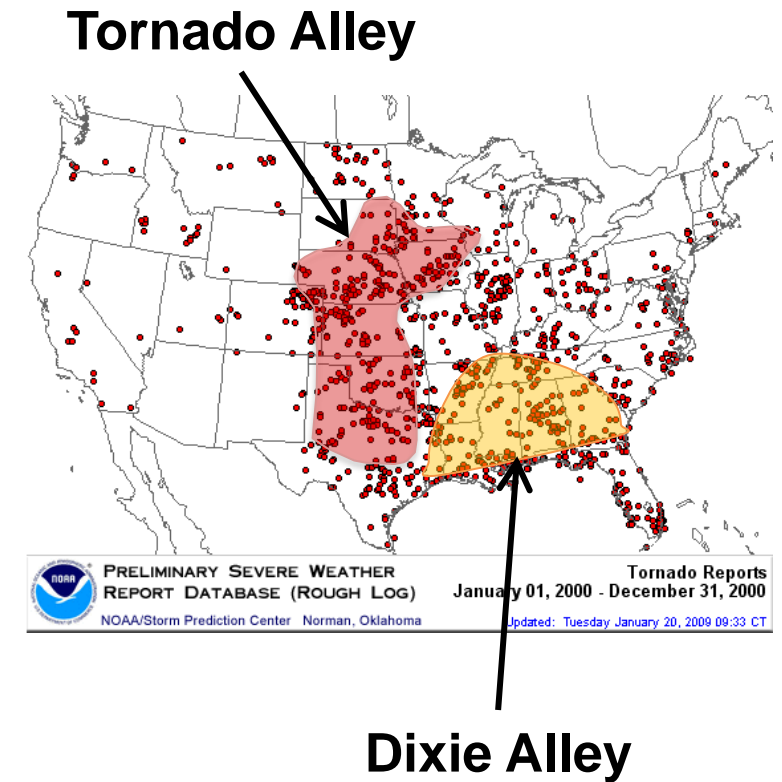
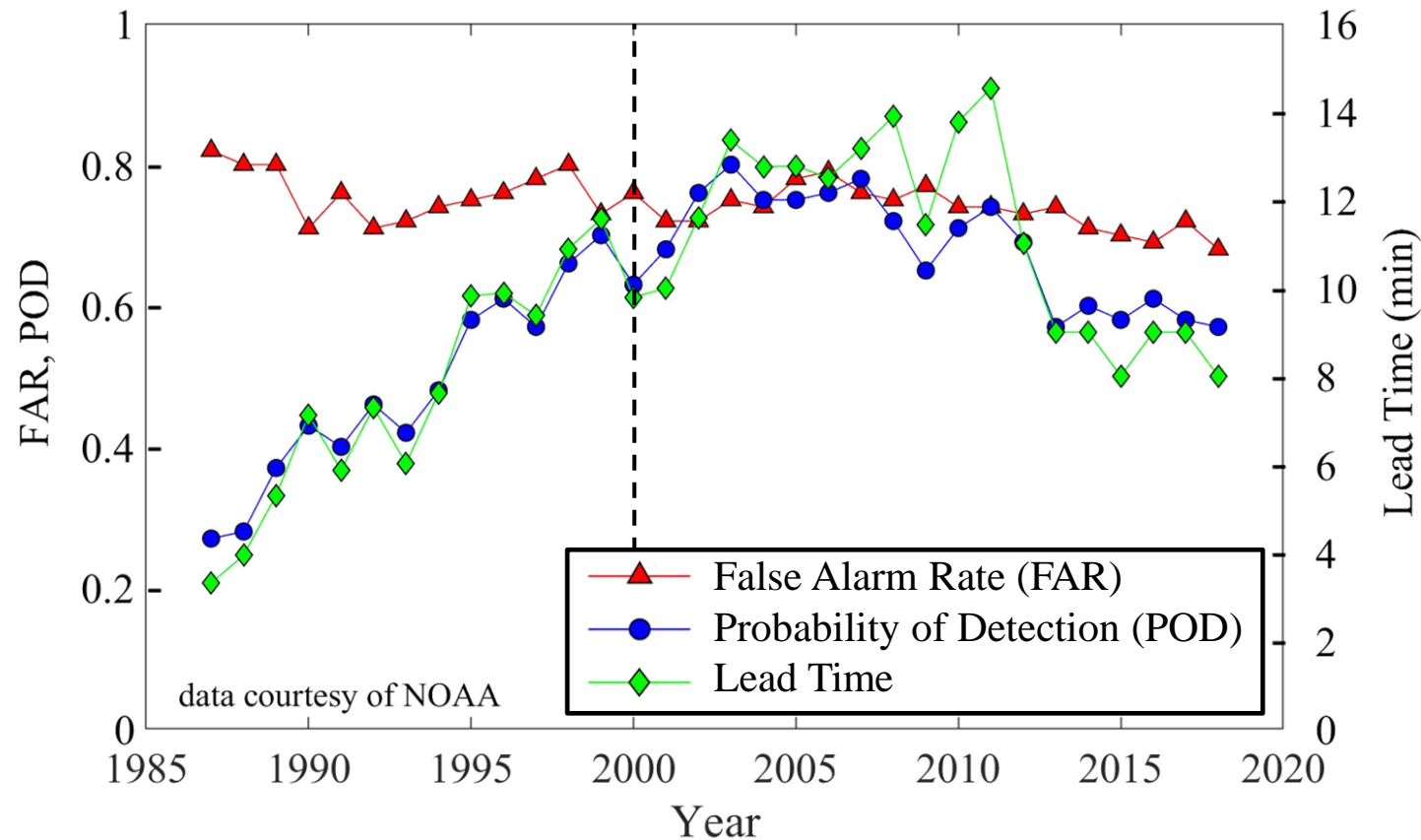
Vilonia, Arkansas
April 27, 2014 (16 killed)



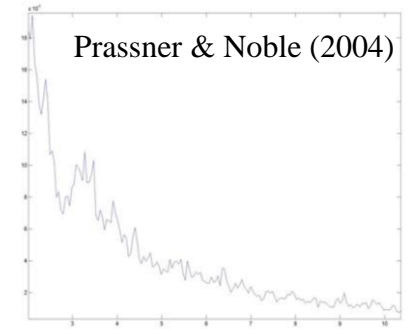
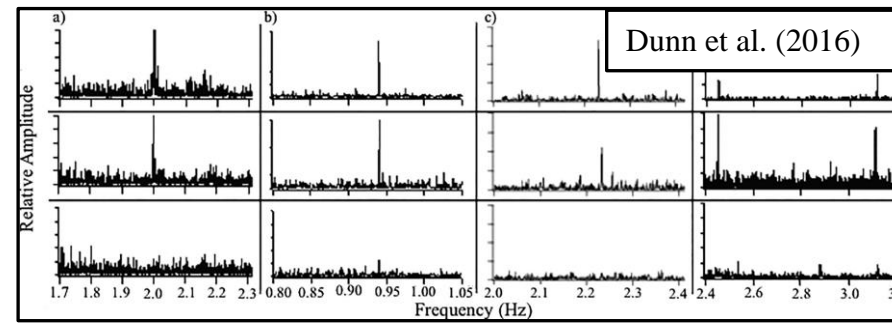
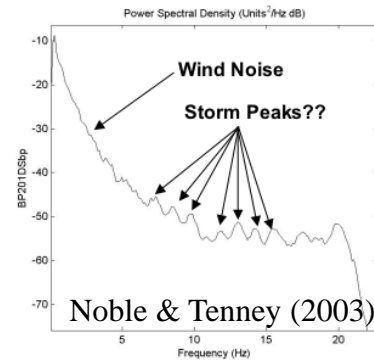
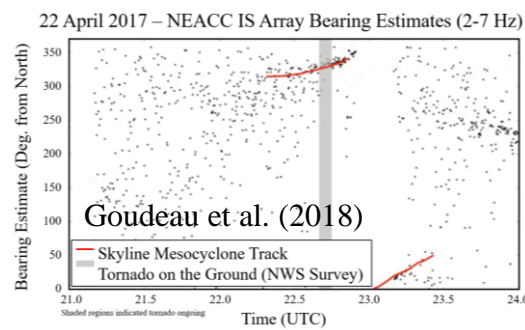
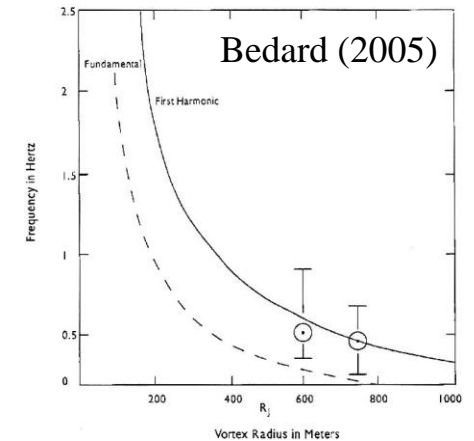
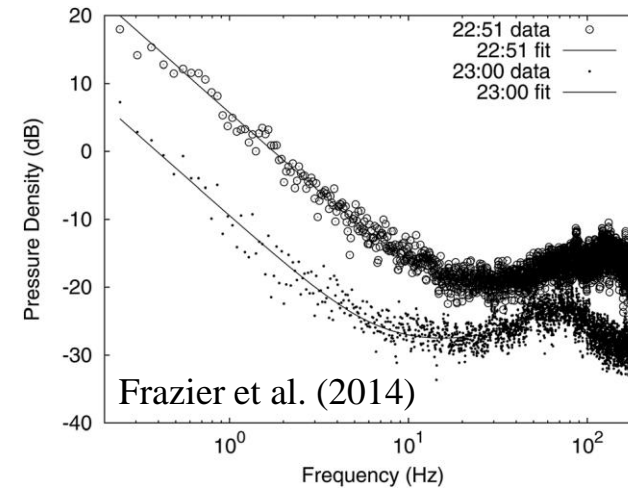
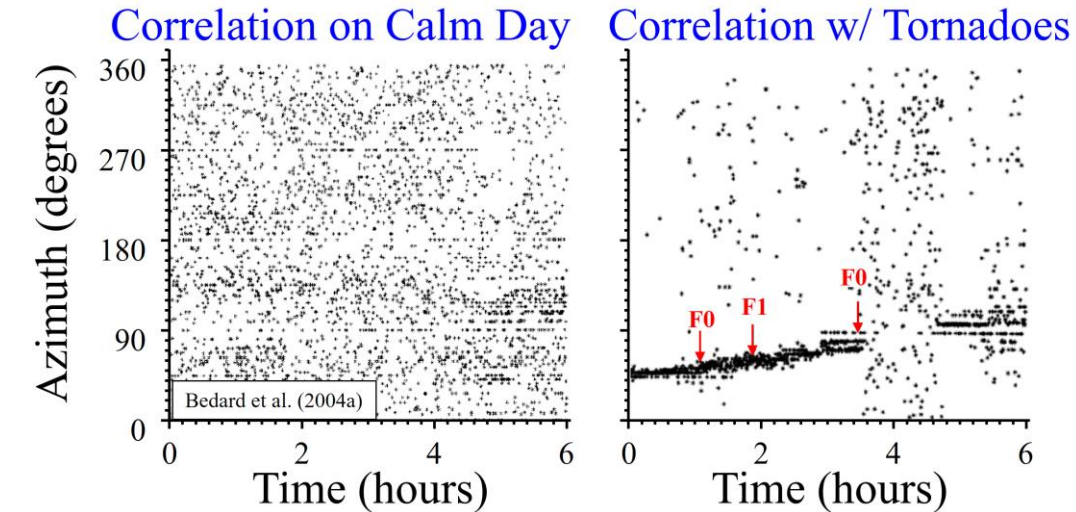
Joplin, Missouri
May 22, 2011 (158 killed)



Improvements in tornado warnings is needed, especially for Dixie Alley.

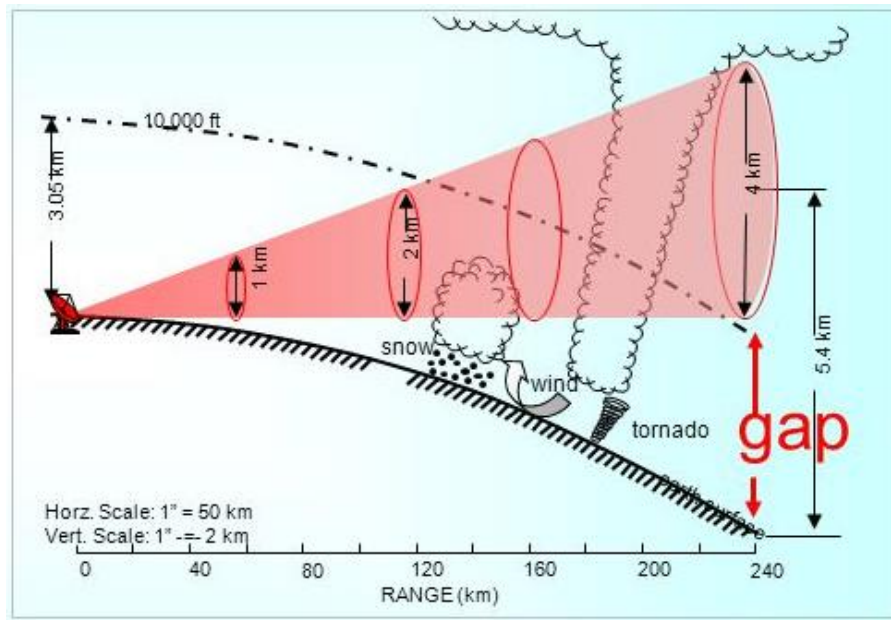


Low frequency sound from tornadoes has potential to provide a new data source.

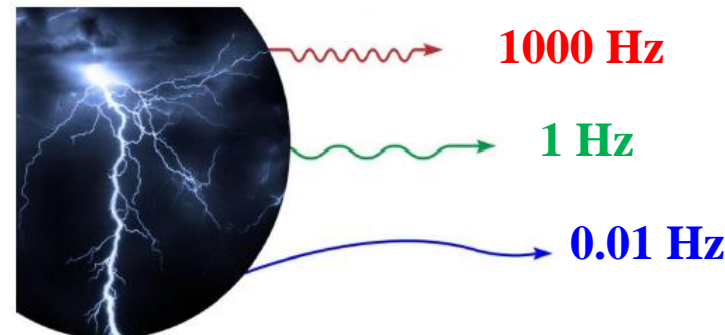
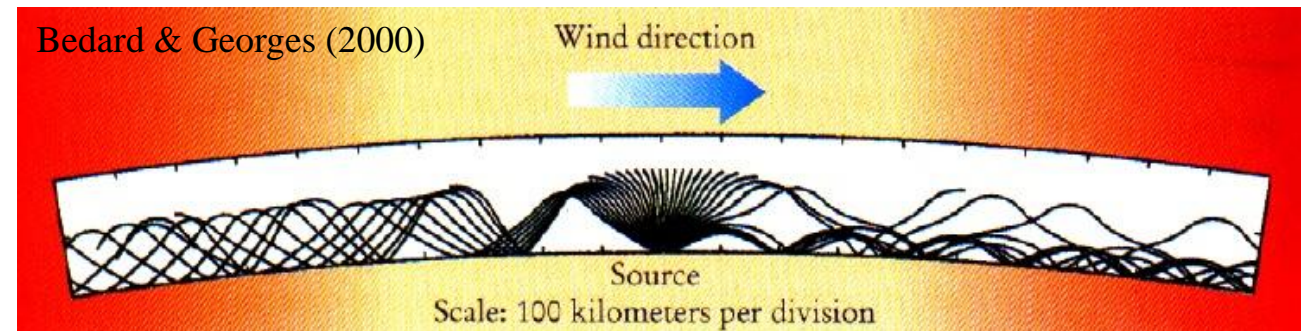


Infrasound is sound at frequencies below human hearing that has unique properties.

Radar is a Line-of-Sight Measurement



Infrasound can go beyond line-of-sight



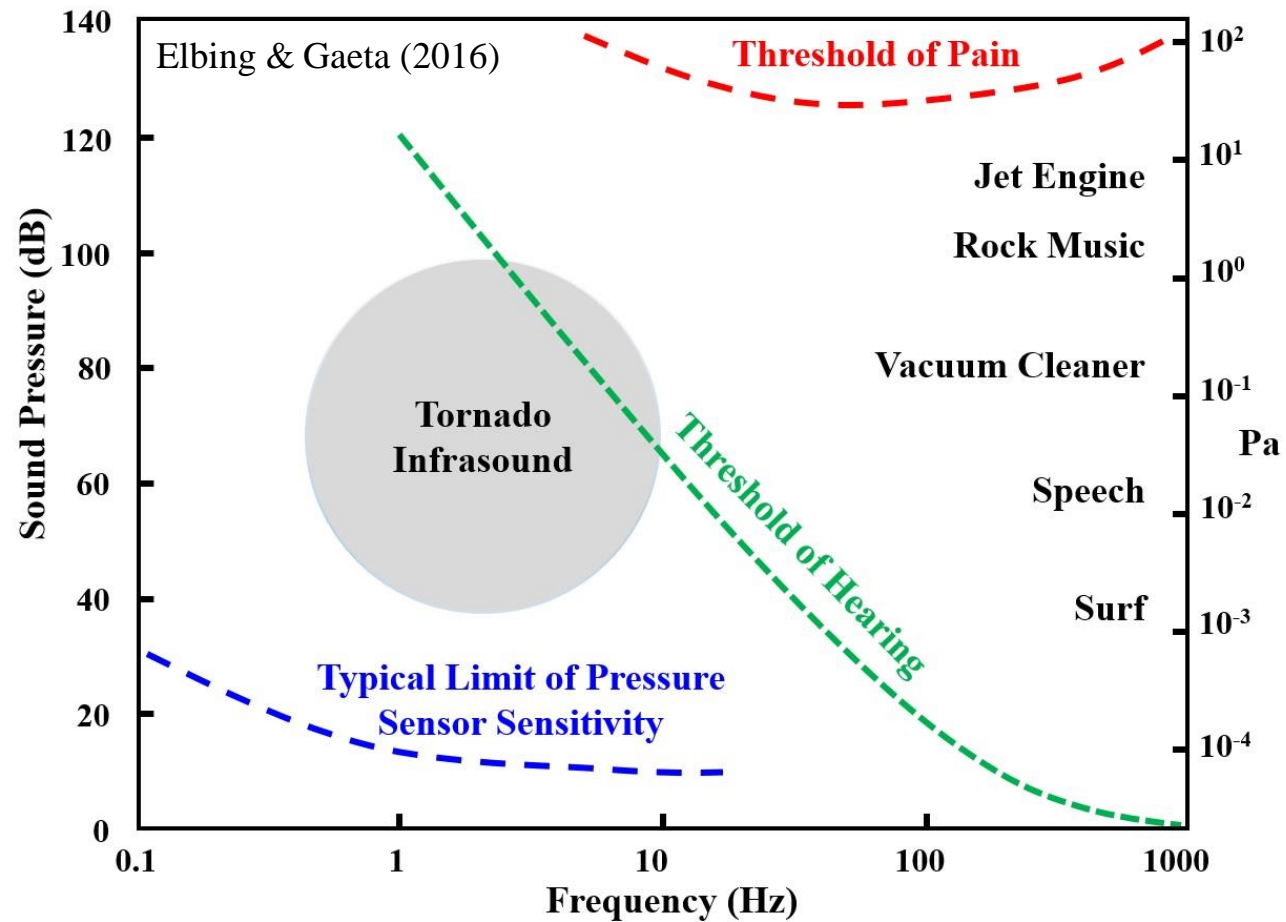
90% of energy absorbed

~7 km (4.3 miles)

3000 km (1,800 miles)

Earth's circumference

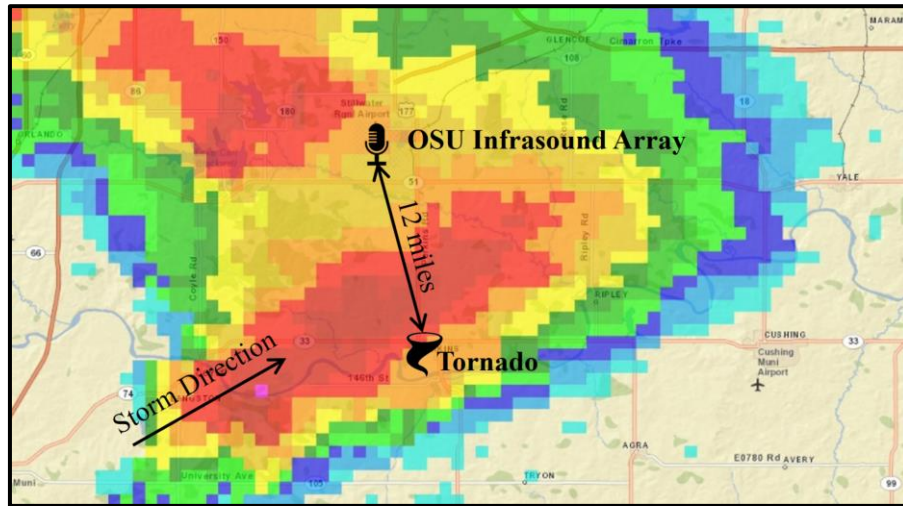
So tornadoes produce this sound...how do we make use of this fact?



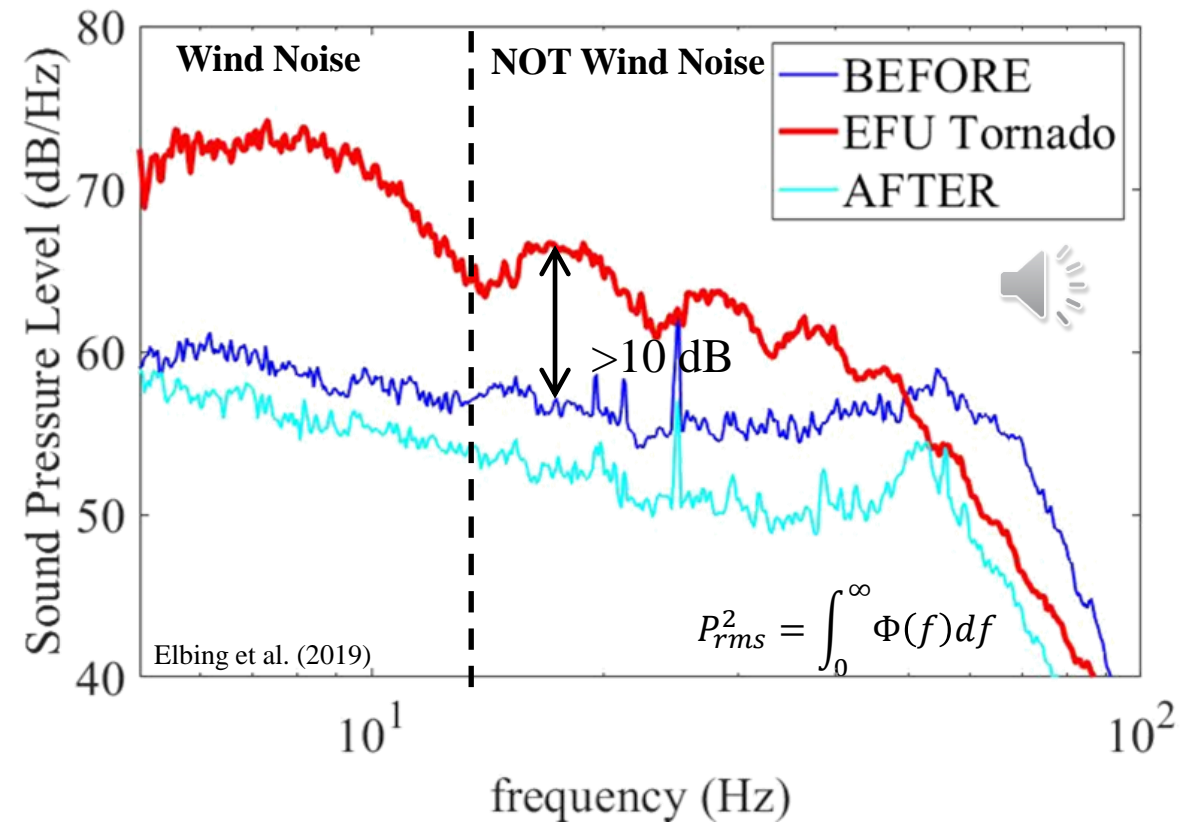
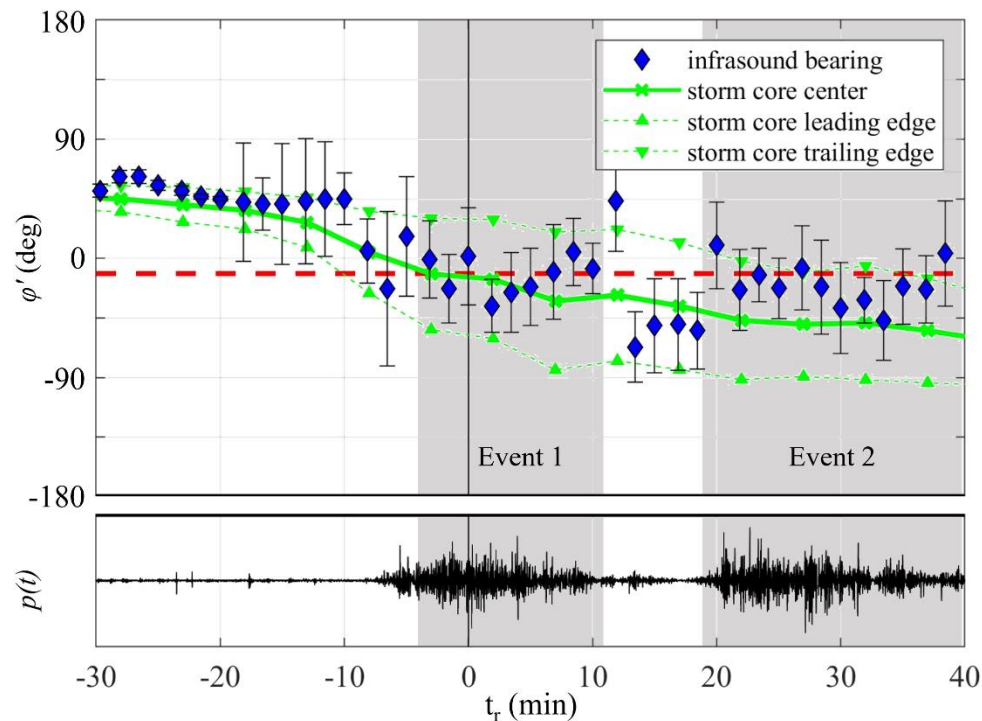
We have been monitoring for tornado infrasound since 2016.



Our first tornado with radar and infrasound observations was in May of 2017.



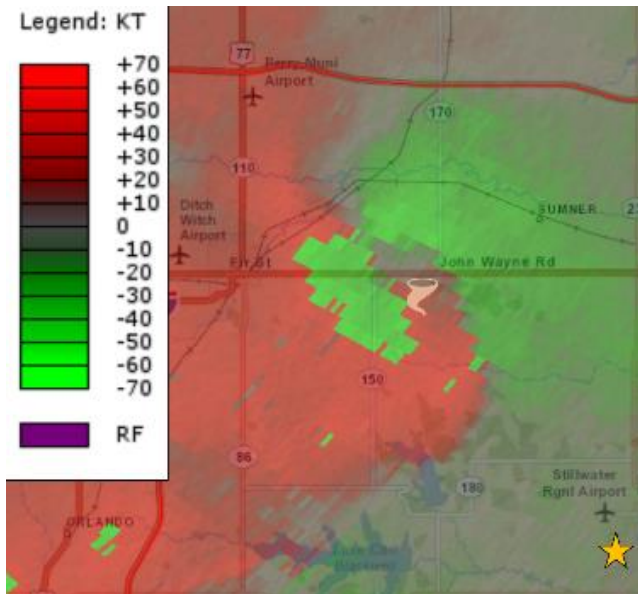
This EFU tornado produced a signal with a fundamental frequency of 8.3 Hz.



There were a lot of tornadoes in 2019...did not produce many observations.

EF1 Tornado

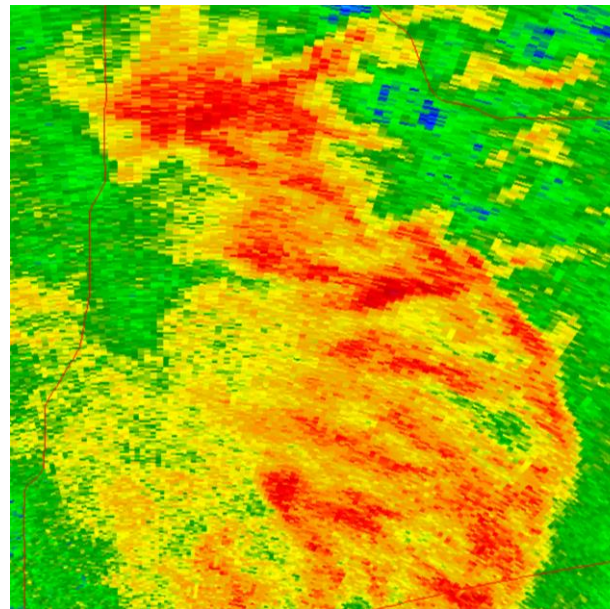
Sumner, OK (6 May 2019)



No radar available

EF0 QLCS Tornado

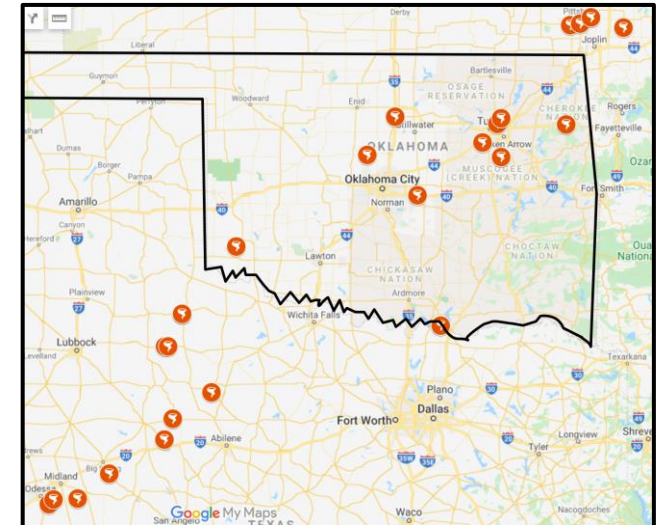
Stillwater, OK (18 May 2019)



No radar available

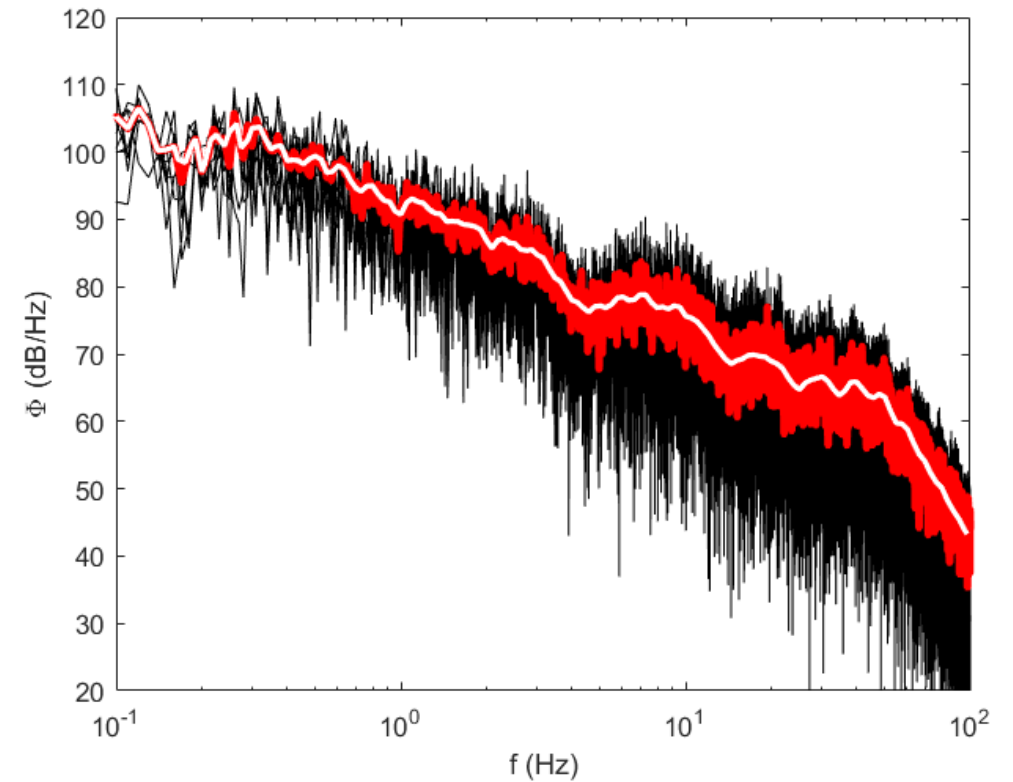
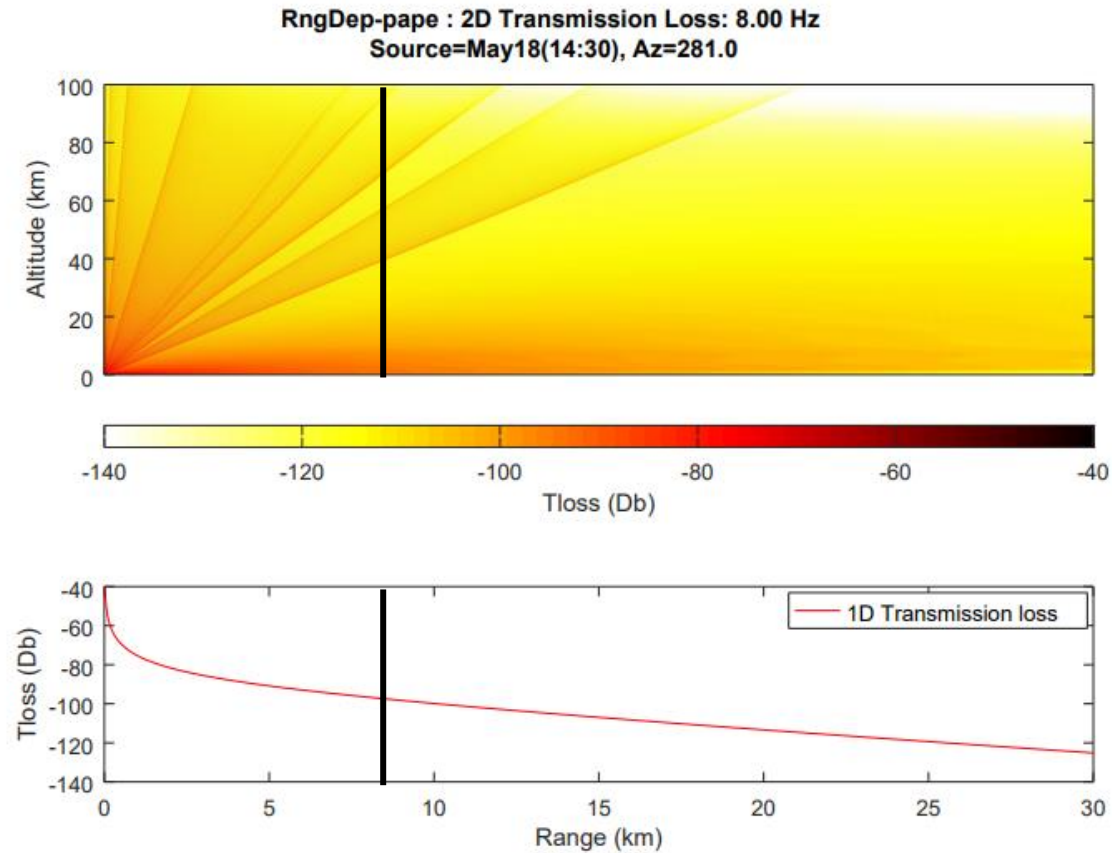
Tornado Outbreak

TX-OK-MO (20 May 2019)



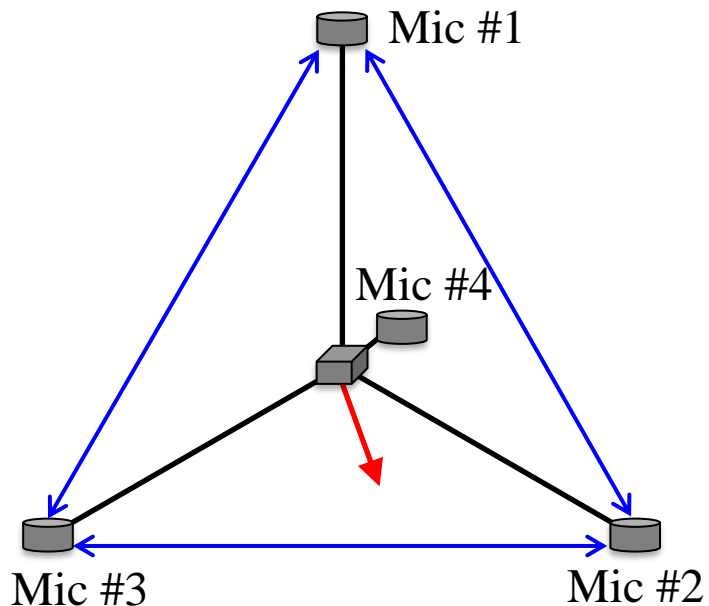
**No radar with
infrasound available**

Did capture tornado spectra on 18 May 2019 with similar spectra to first observation.



In 2020 we created mobile infrasound capabilities to increase likelihood of observations.

Mobile Infrasound Array



flowphysicslab.org

Storm Chaser

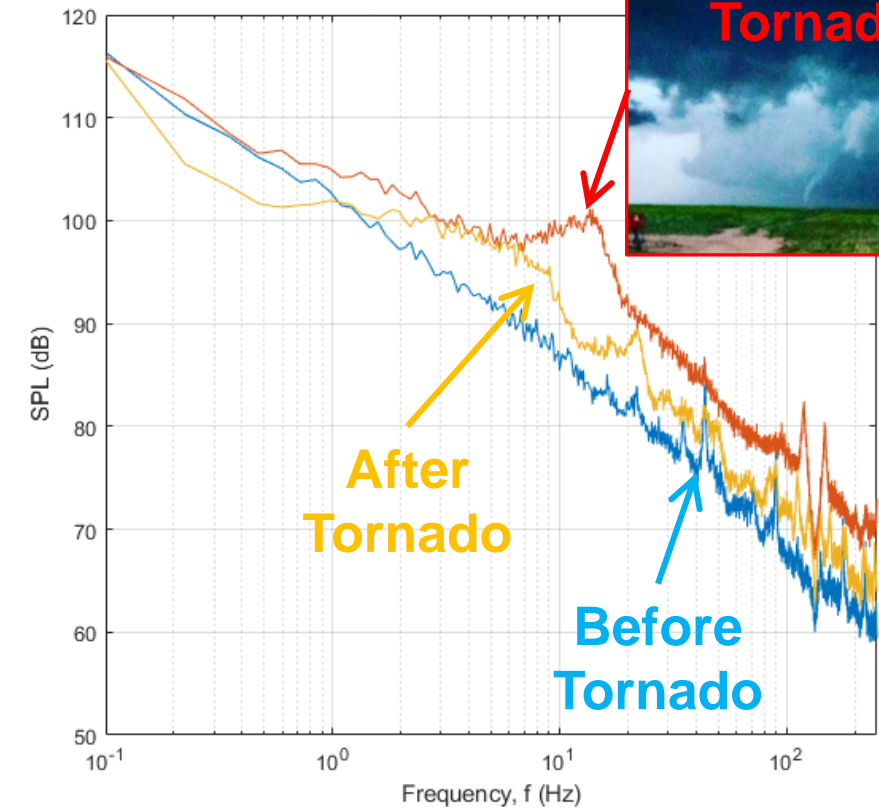


AGU Fall Meeting, Online Everywhere

Solar Balloons

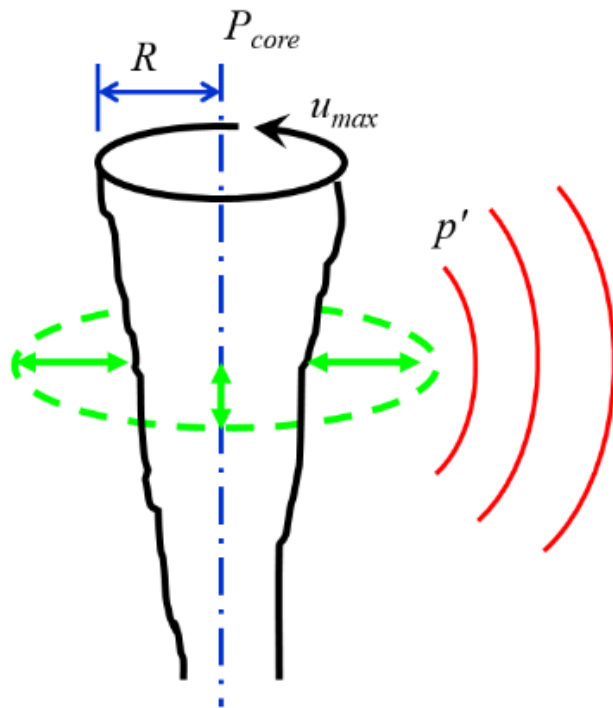


The storm chaser captured a small tornado in Lakin, Kansas on 22 May 2020.

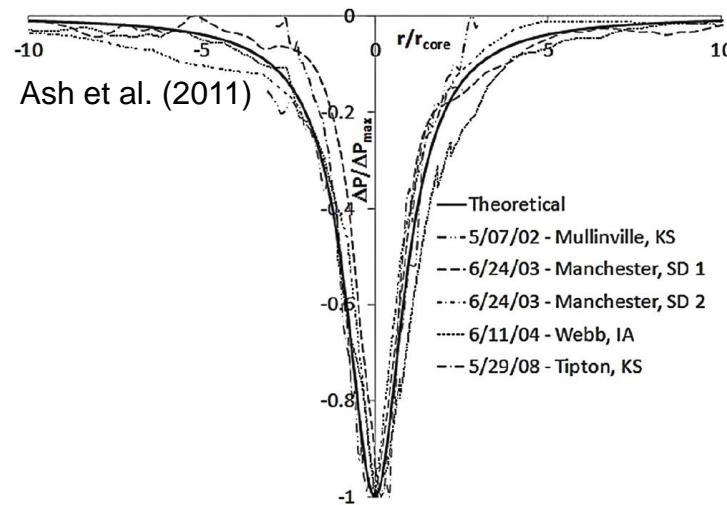


List of fluid mechanisms that could produce these observations has been narrowed down.

Radial Oscillations

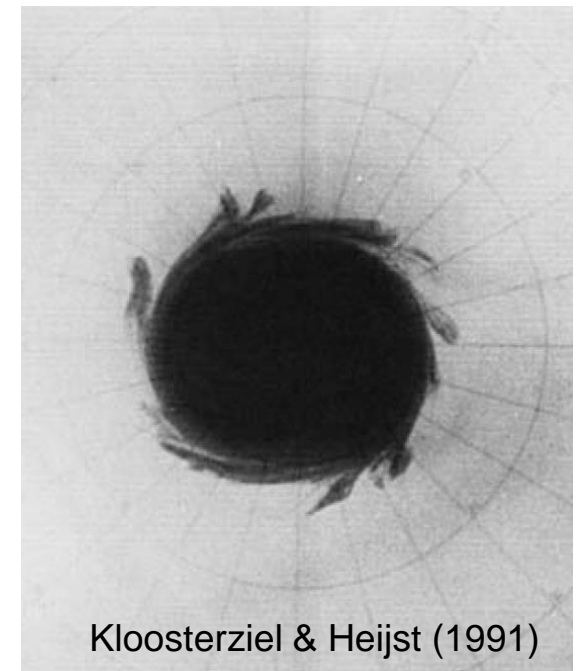


Non-equilibrium Pressure Relaxation



$$\rho \frac{Du_i}{Dt} = -\frac{\partial P}{\partial x_i} + \eta_p \frac{D}{Dt} \left(\frac{\partial P}{\partial x_i} \right) + \mu \frac{\partial^2 u_i}{\partial x_k^2} + \eta_p \left[\frac{\partial u_k}{\partial x_i} \frac{\partial P}{\partial x_k} - \frac{(\eta_v + \mu/3)}{\eta_p} \frac{\partial}{\partial x_i} \left(\frac{1}{\rho} \frac{D\rho}{Dt} \right) \right]$$

Shear Instability



We have narrowed our list of fluid mechanisms that could produce infrasound from tornadoes.



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