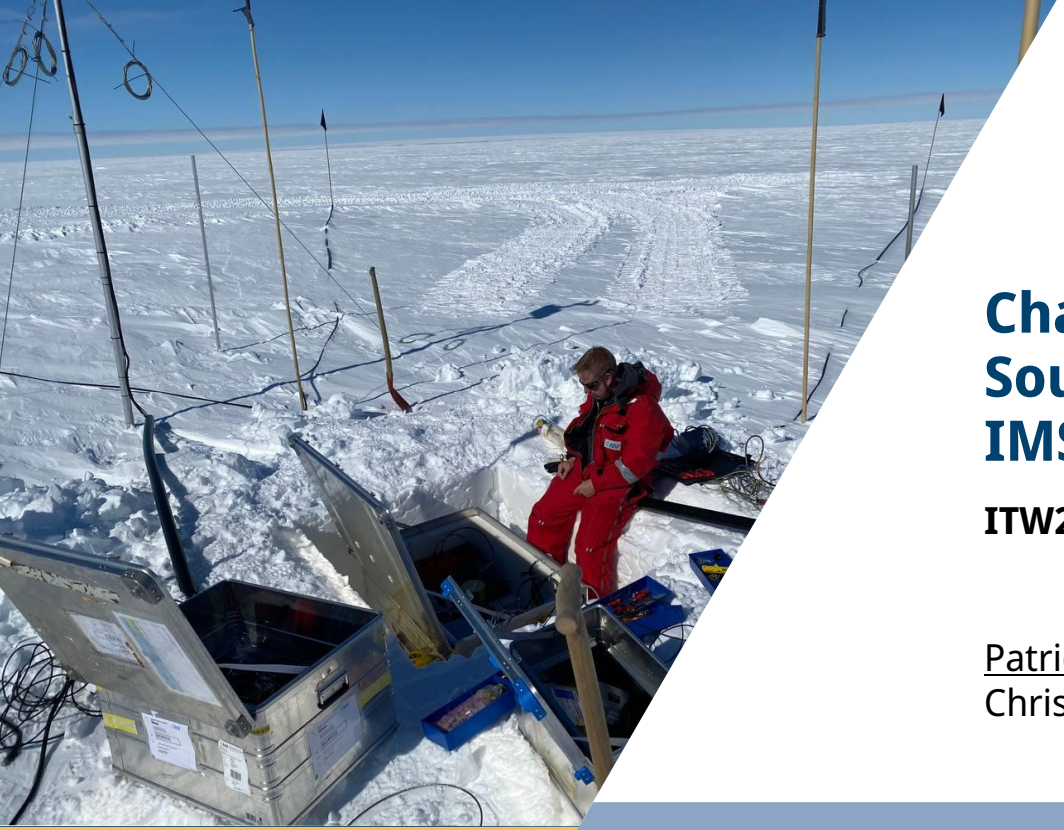


Characterization of the 2022 South Atlantic fireball using IMS infrasound recordings

ITW2024

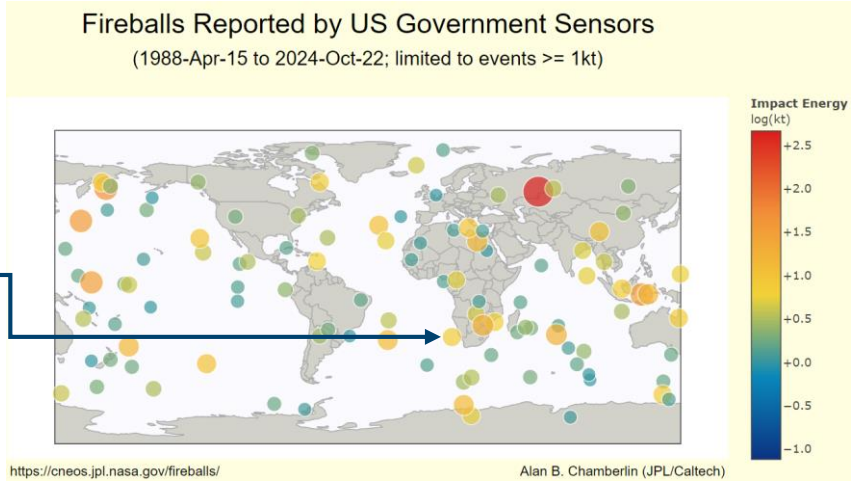
Patrick Hupe, Julien Vergoz, Benjamin Poste, Christoph Pilger, Alexis Le Pichon

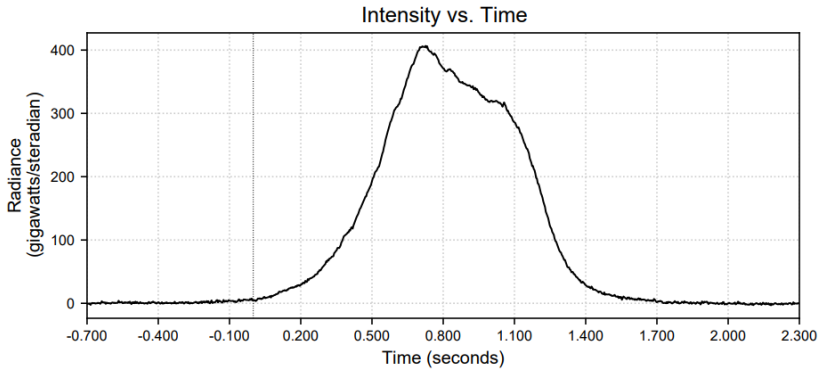
7 Nov 2024

Event details

Center for Near Earth Object Studies (CNEOS by NASA) based on peak brightness:

- 7 February 2022, 20:06:25 UTC
- ~500 km off the coast of South Africa and Namibia (28.7°S, 11.4°E)
- Altitude 26.5 km, velocity 13.1 km/s
- Impact energy of 7 kt TNT equivalent, initial estimates were larger

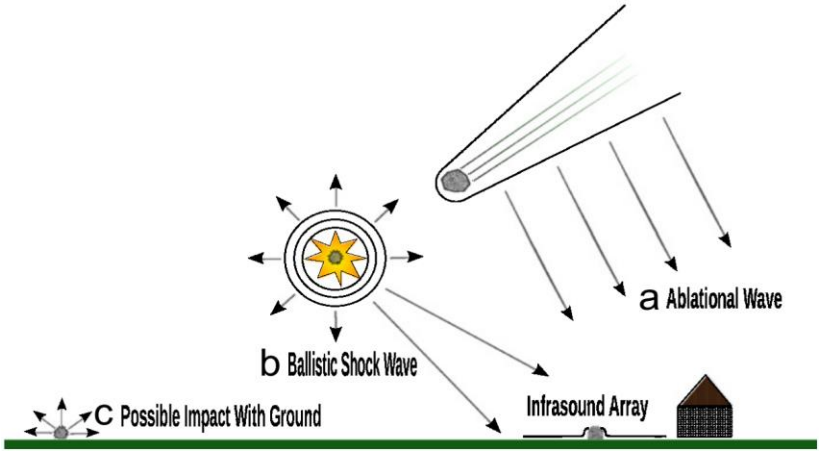




Motivation

More than 20 IMS infrasound stations detected it (more than the Chelyabinsk bolide)

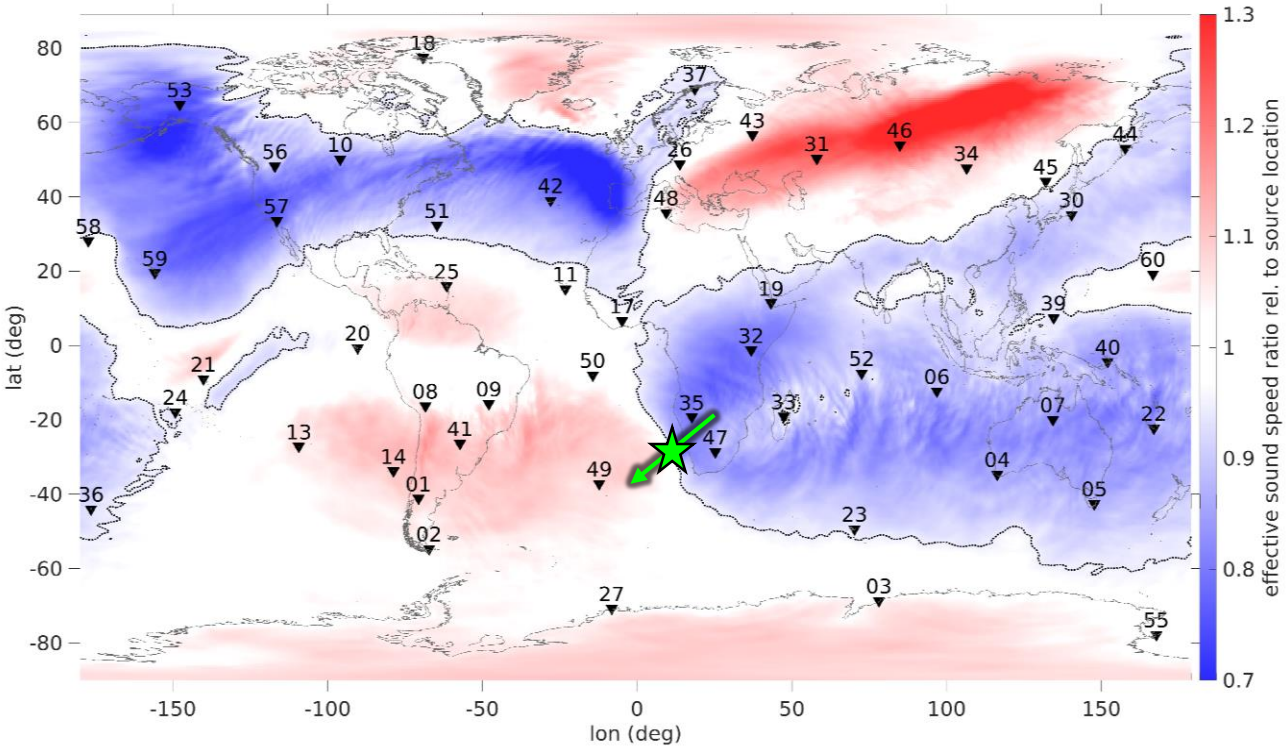
- Characterize the South Atlantic event
- Utilize new detection algorithm MCML
- Compare with and revisit past strong events (Chelyabinsk 2013, Bering Sea 2018)



Ens et al. (2012)

No reports in the media (nor social media).
Only 3 weeks after Hunga's explosive eruption.

Where to expect infrasound arrivals at IMS stations on 7 February 2022?

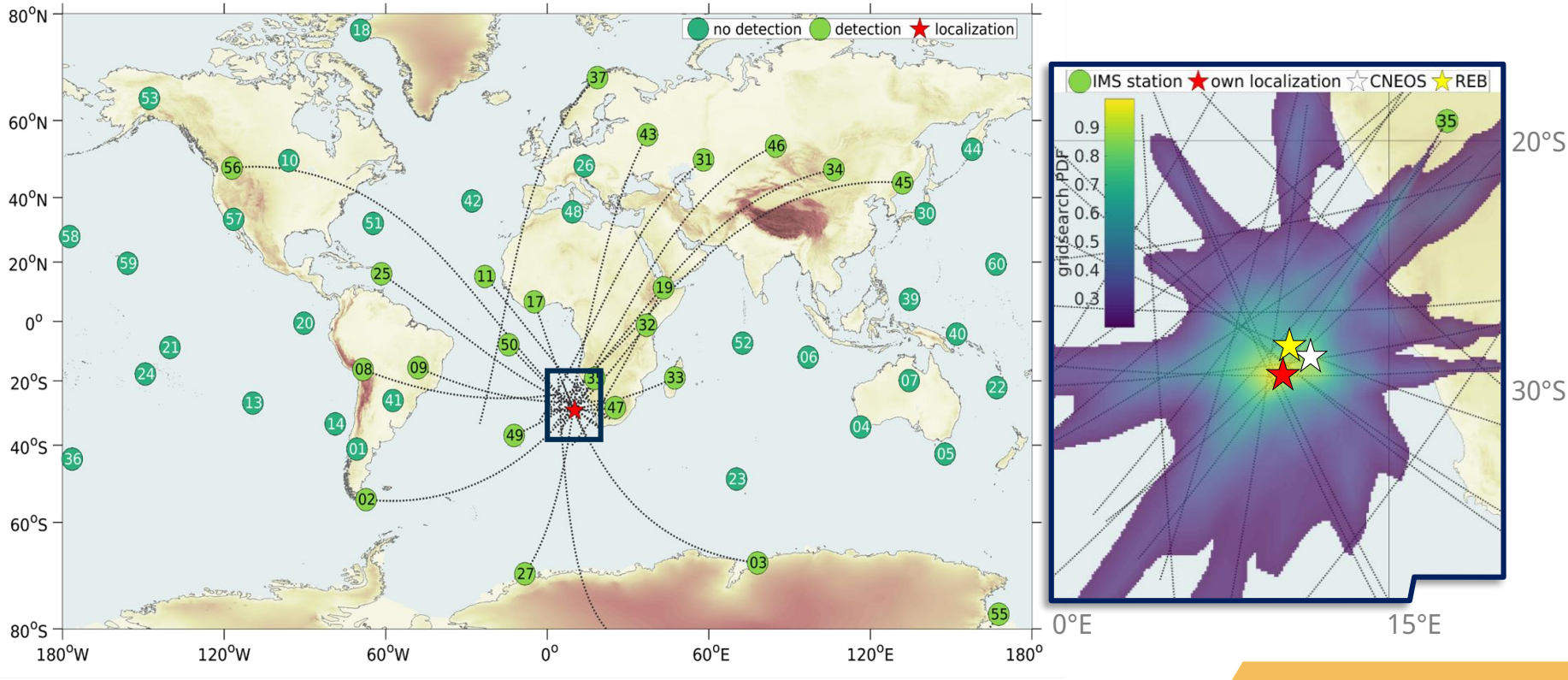


Hypersonic flight trajectory (direction) known from CNEOS data

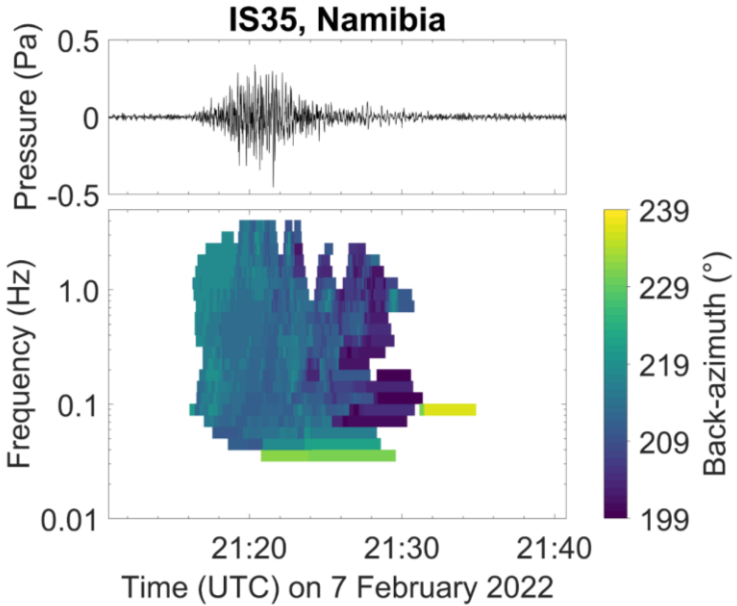
Peak brightness indicates location of most explosive fragmentation

Proxy for propagation conditions:
effective sound speed ratio from ECMWF HRES analysis (max. at 40-50 km resp. to the ground(!) at each grid point)

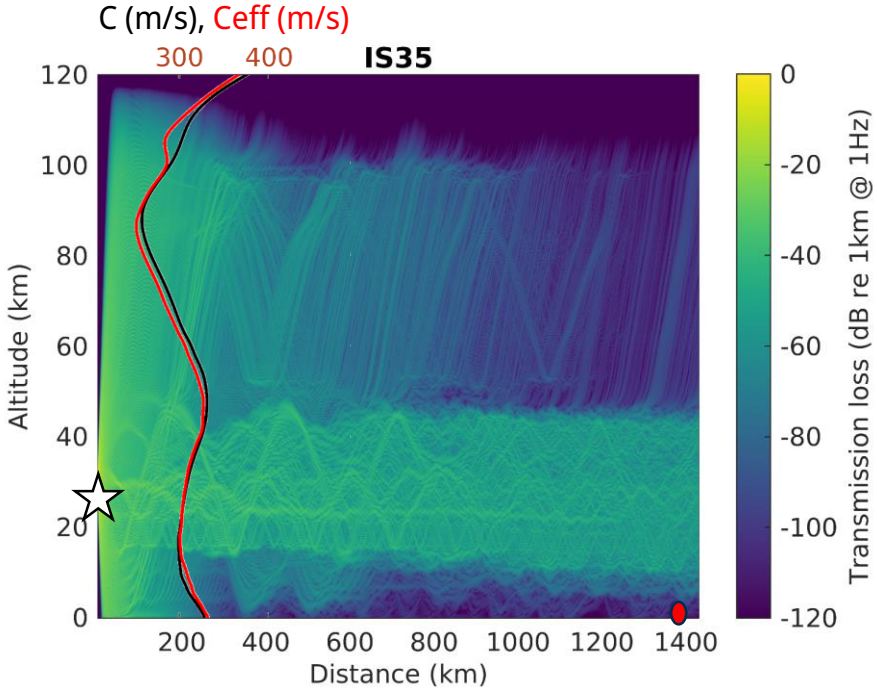
23 IMS infrasound stations detected the event - using PMCC



Propagation to nearest IMS station: IS35, Namibia

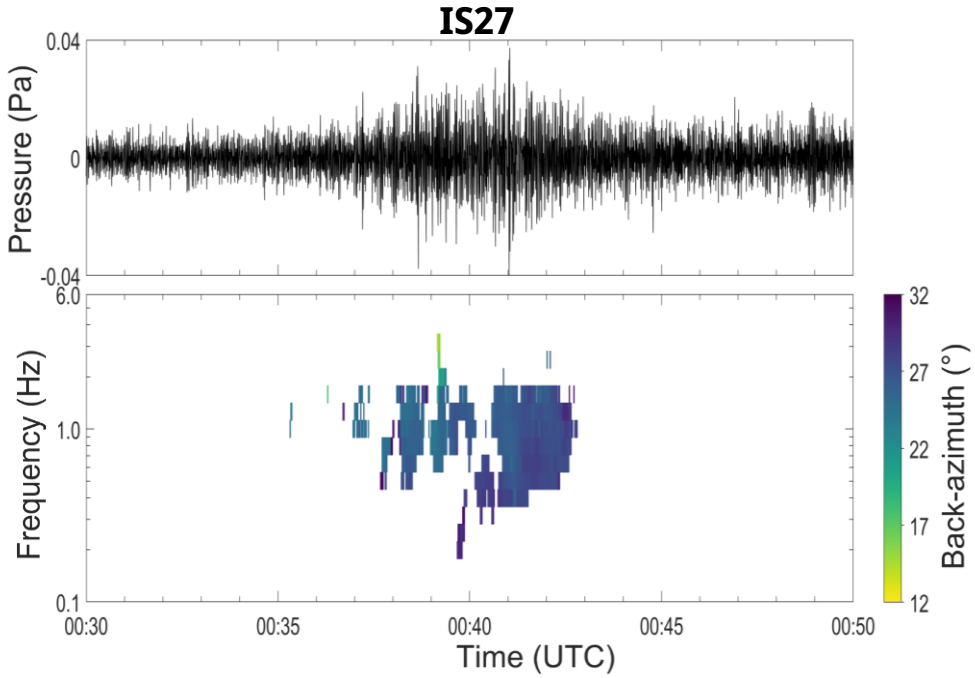


PMCC result

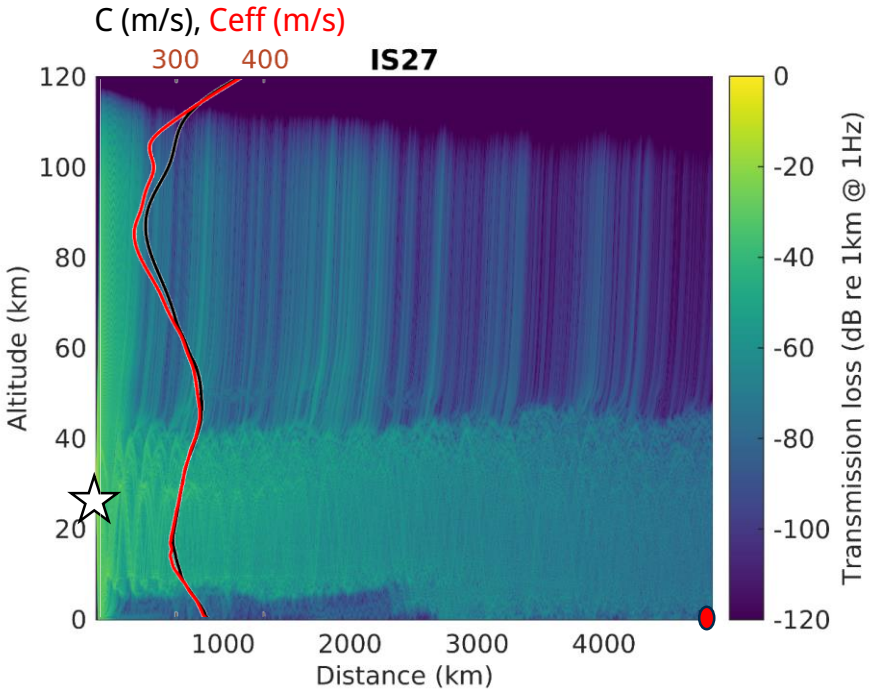


PE (NCPAprop ePape, ECMWF IFS + HWM/MSISE)

Propagation to IS27, Antarctica

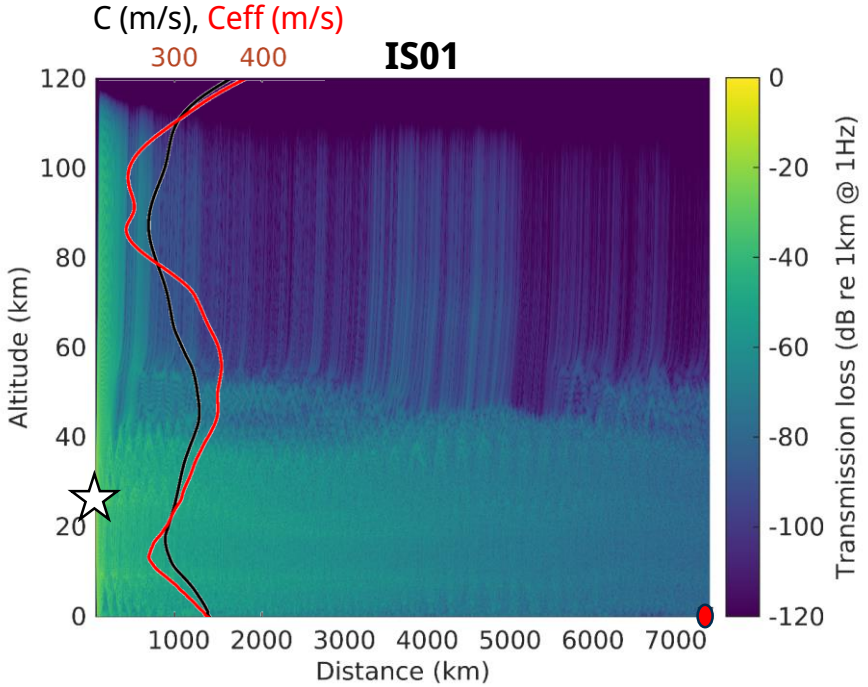


PMCC result



PE (NCPAprop ePape, ECMWF IFS + HWM/MSISE)

Propagation to IS01 (west) and IS26 (north) - no PMCC detections



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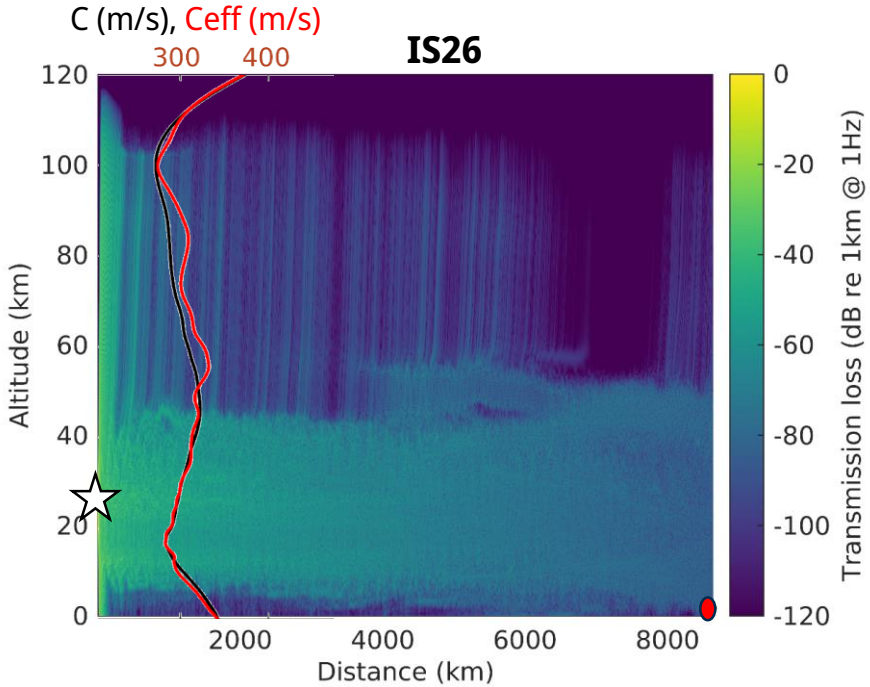
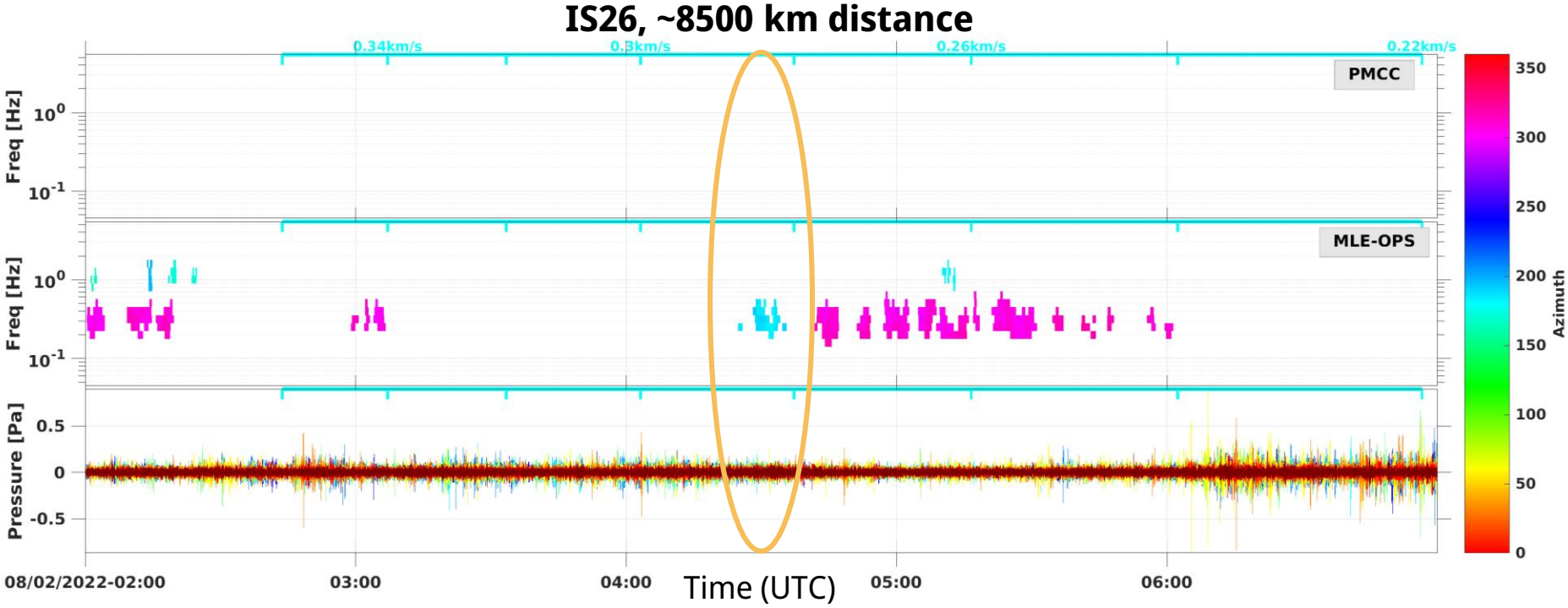


PE (NCPAprop ePape, ECMWF IFS + HWM/MSISE)

Detections at up to 27 IMS infrasound stations - using MCML



Energy estimation

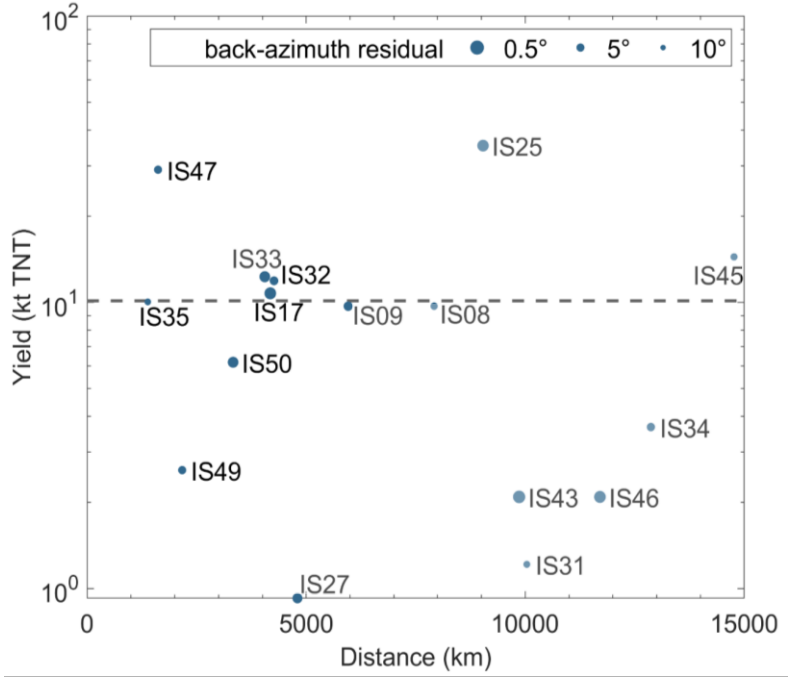
ReVelle's relation (1997) based on period (*P*) at maximum amplitude, energy (*E*) in kt TNT

$$\log_{10}\left(E/2\right) = 3.34 \times \log_{10}(P) - 2.58; \; E/2 \leq 100\,\text{kt},$$

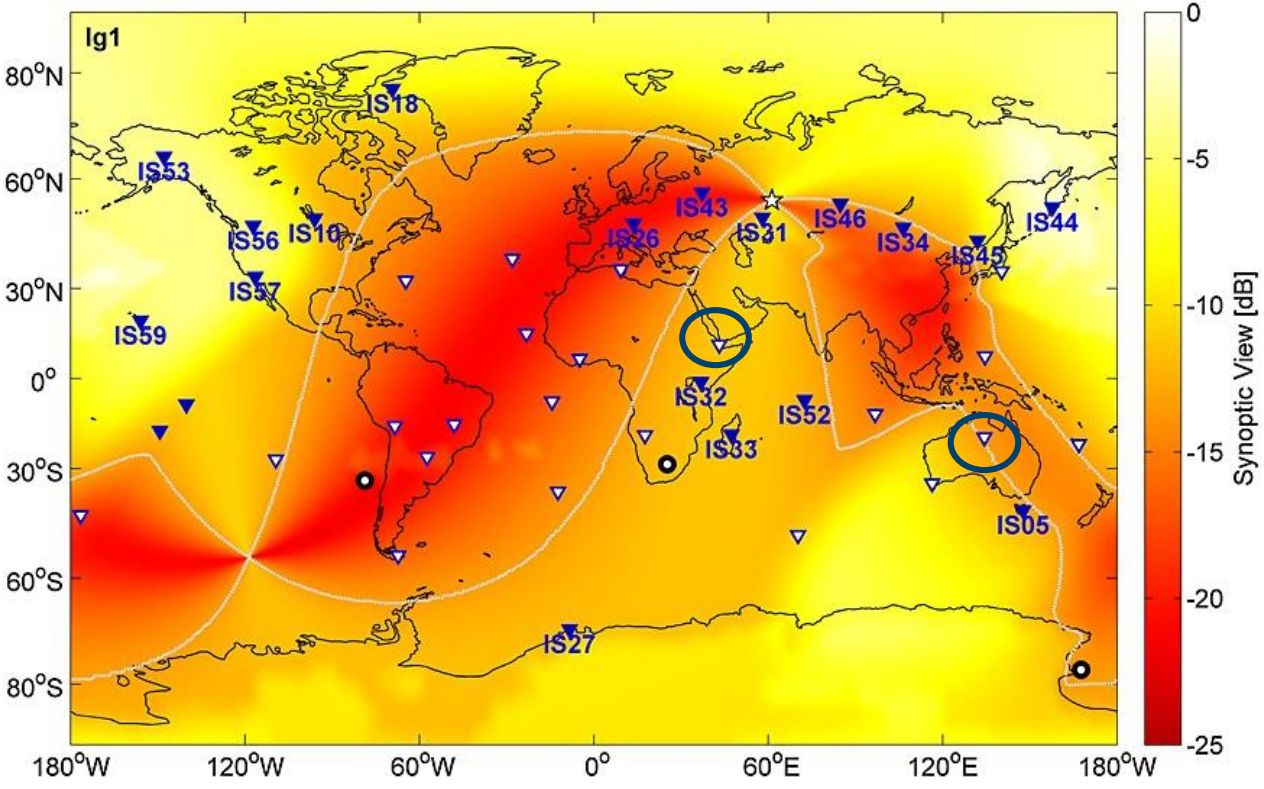
$$\log_{10}\left(E/2\right) = 4.14 \times \log_{10}(P) - 3.61; \; E/2 > 40\,\text{kt}.$$

16 stations (*P* ~ 7.8-9.2 s)

- **E ~ 5-10 kt (CNEOS 7 kt)**



Revisiting the Chelyabinsk bolide event



From **Pilger et al.** (2015):

- Short orthodrome arrivals detected at **18 stations**
- **+2** additional stations (IS21, IS24) for long orthodrome Ig2

With MCML: 2 additional Ig1 arrivals (IS07, IS19)

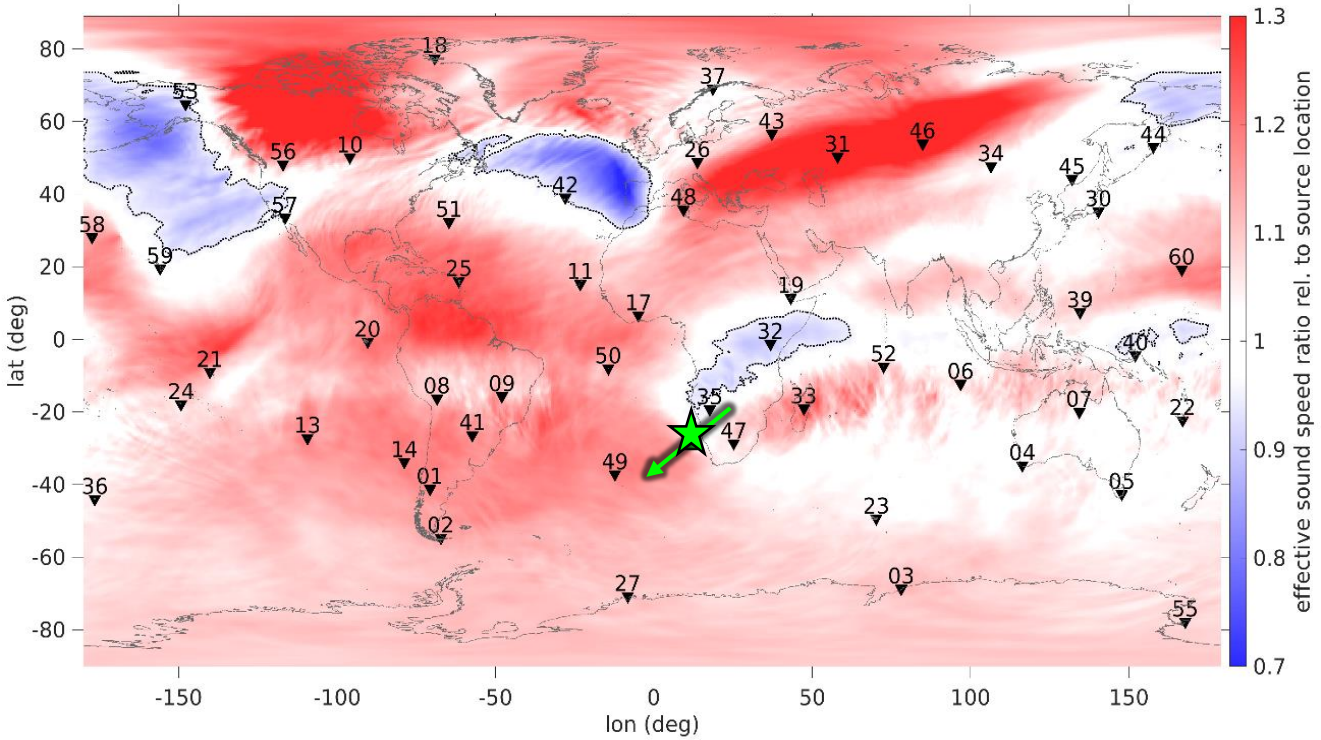
With today's network: ??
e.g. IS03, IS37, IS58, IS60

Summary & Conclusions

- Relatively large fireball event on 7-Feb-2022
- Hardly observed but **well captured by up to 27 remote IMS infrasound stations**
- Infrasound-based **energy estimate 5-10 kt TNT** (uncertainty range ~2-12 kt)
- Partly complex propagation paths for this elevated source – ongoing investigation
- State-of-the-art processing method MCML (single source mode) provides more signal characteristics during low signal-to-noise conditions
- Encouraging to revisit past events, e.g. Chelyabinsk benchmark event
- IMS network performs well for various fireball yields (and PMCC, too)

Thank you!

Where to expect infrasound arrivals at IMS stations on 7 February 2022?



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