



Back to Basics L1.3: Gravity Waves

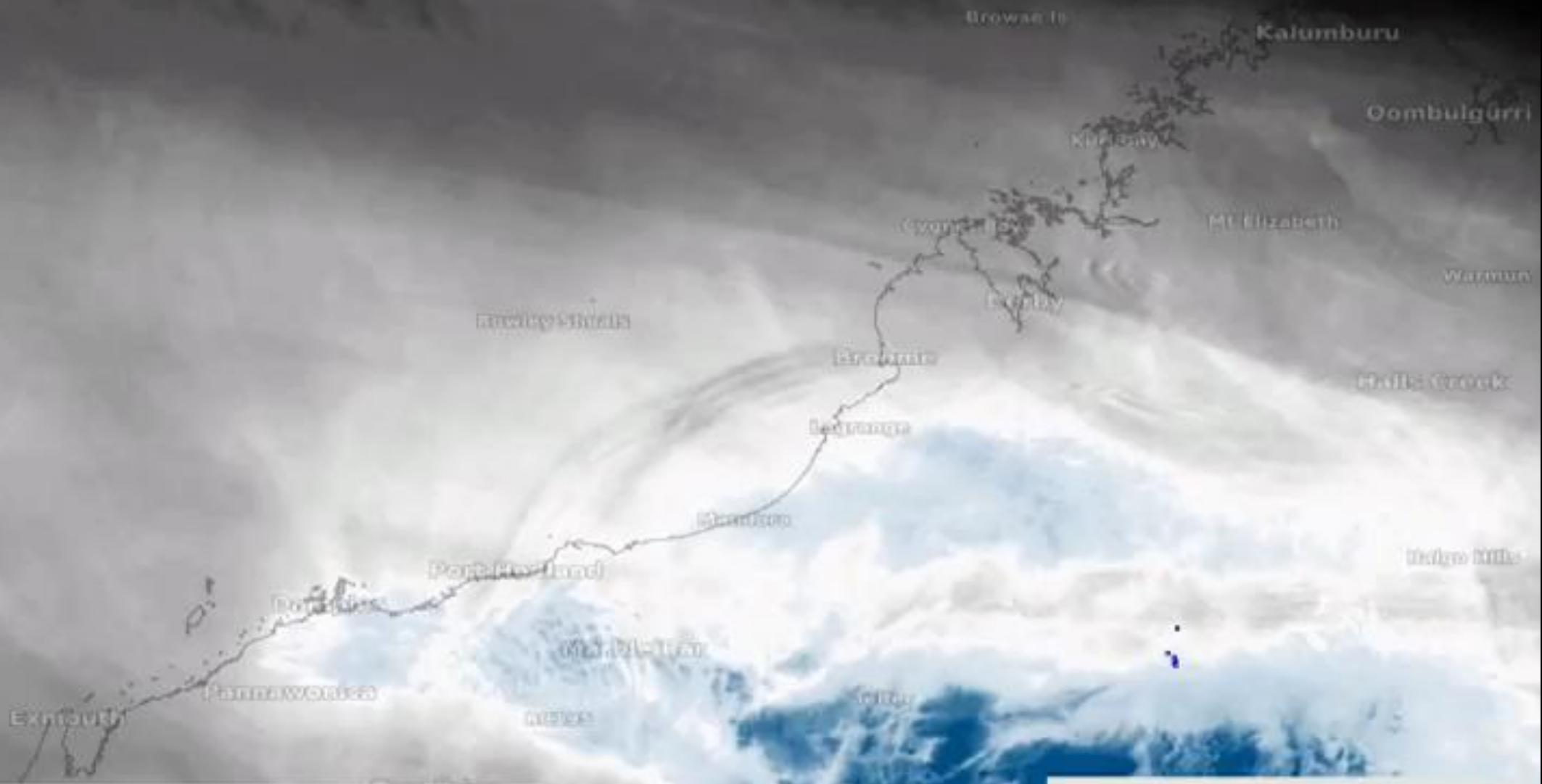
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University of Bath*



Gravity waves: an example

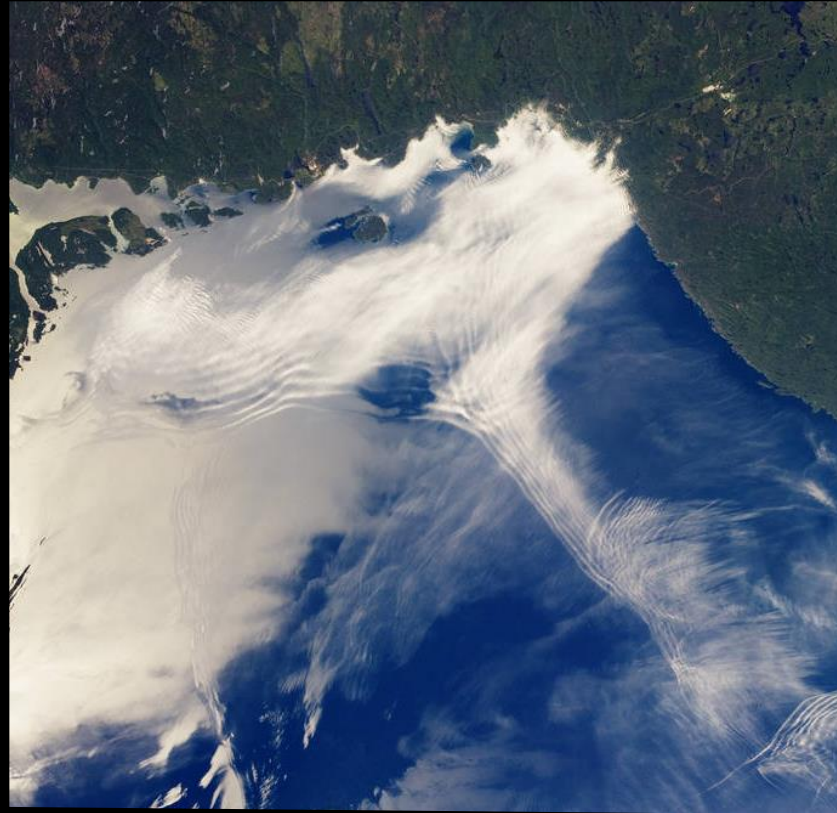
weatherzone^o



Himawari-8 Visible/Water Vapour, Lightning

Mon 21 Oct 00:30 AWST

Gravity waves, from small scales to large



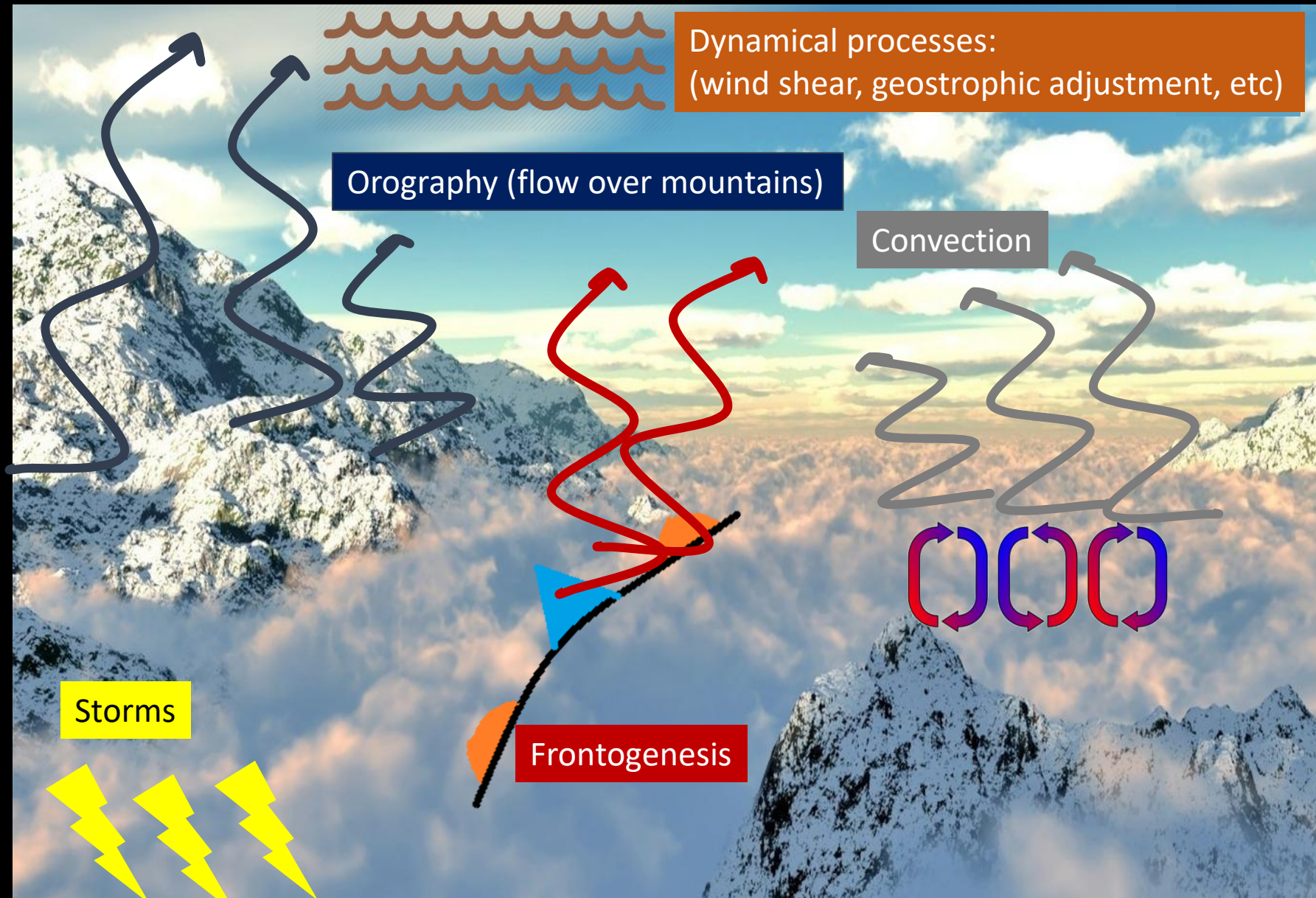
Not Einsteinian gravitational waves



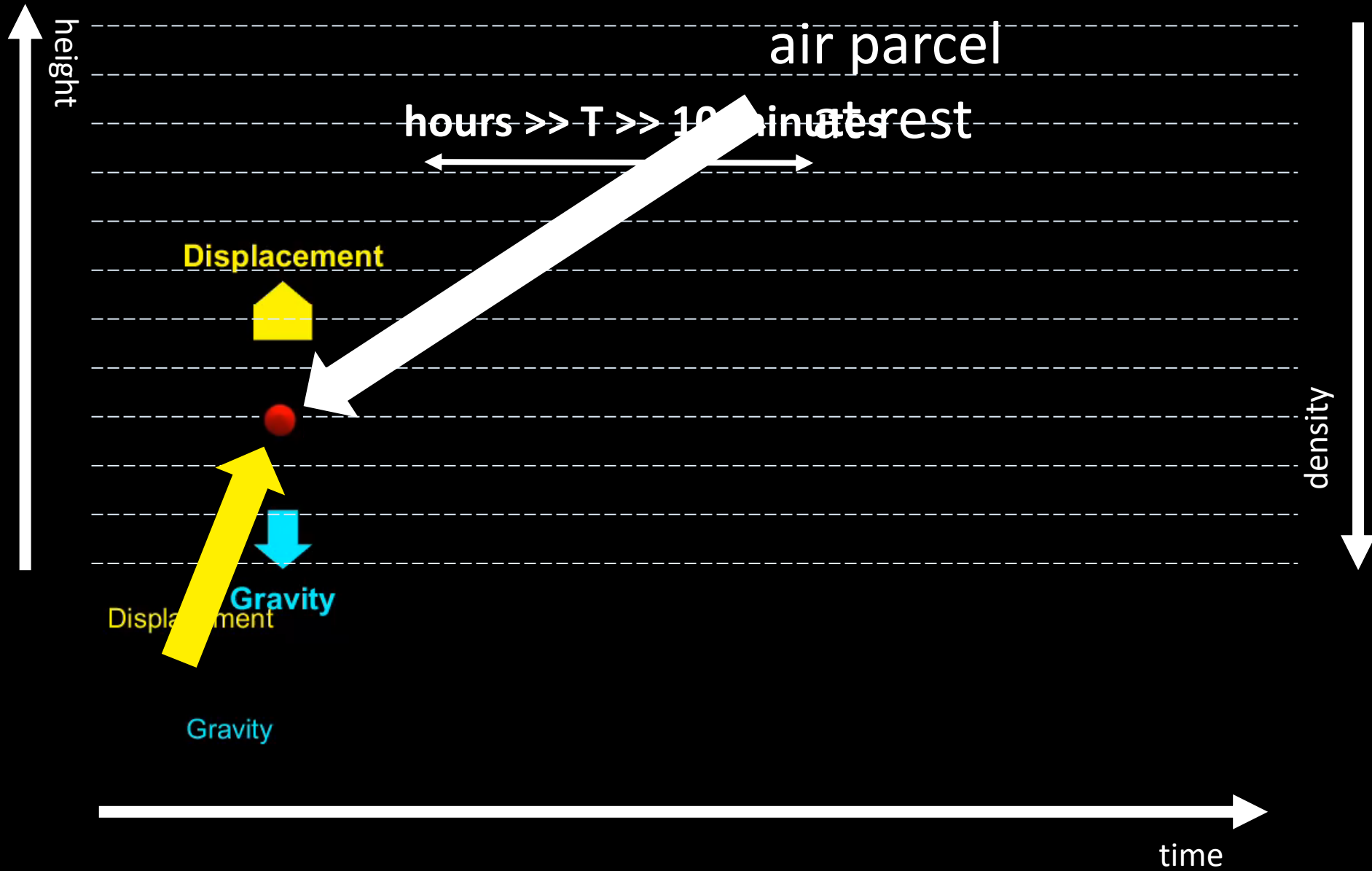
Not "Gravity Wave" at Funfields



What triggers gravity waves?



What is the underlying physical mechanism?



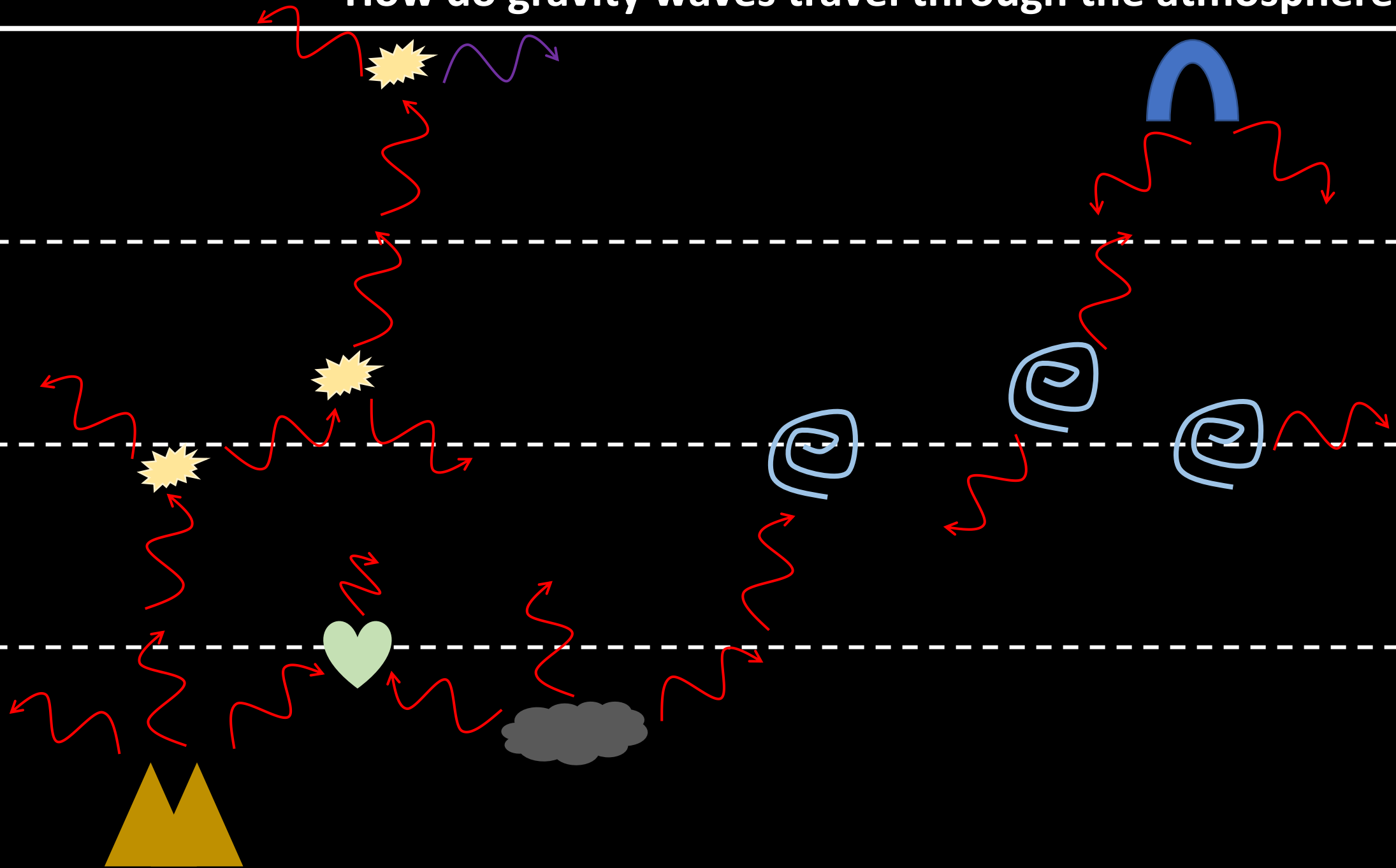
How do gravity waves travel through the atmosphere?

Thermo

Meso

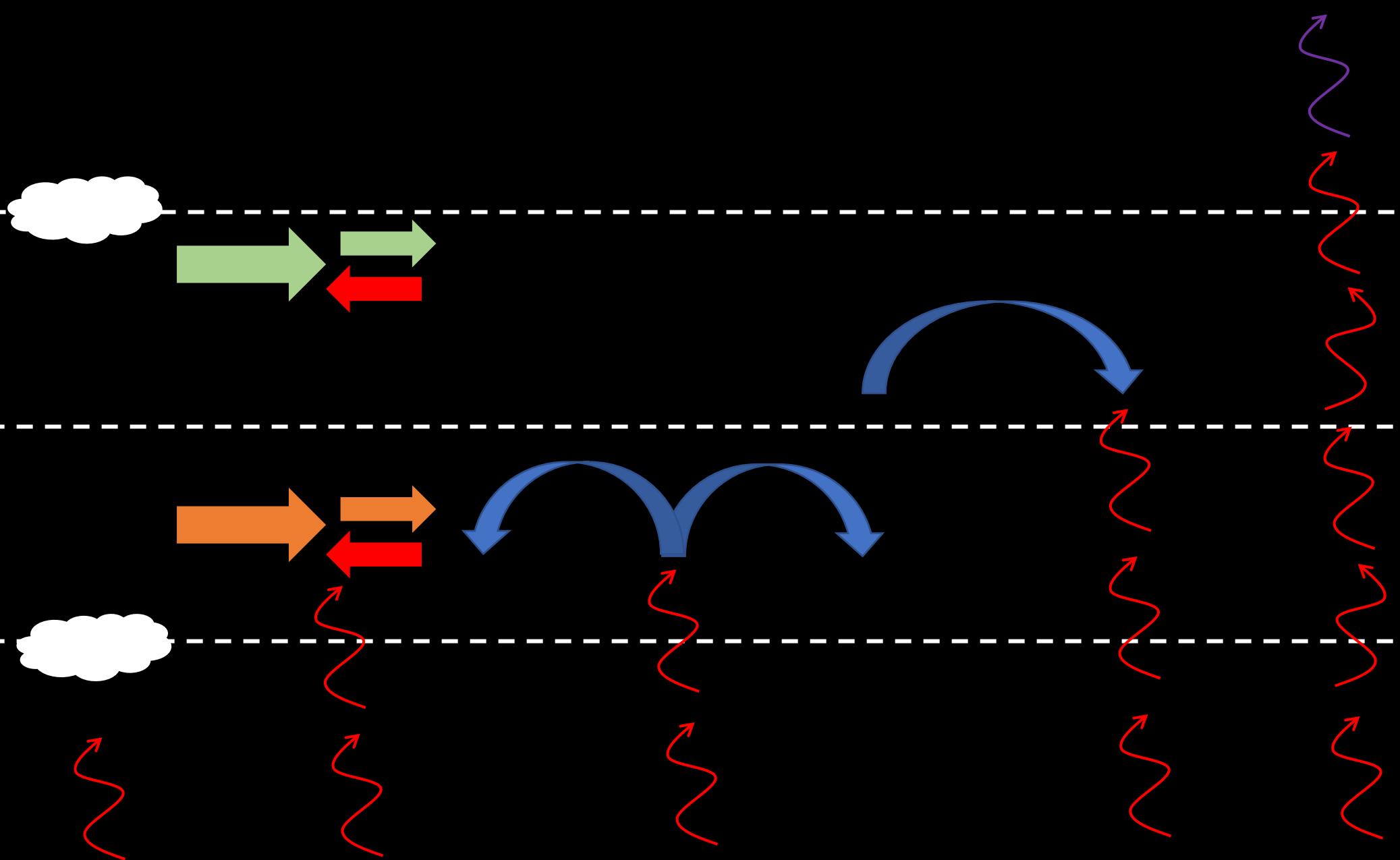
Strato

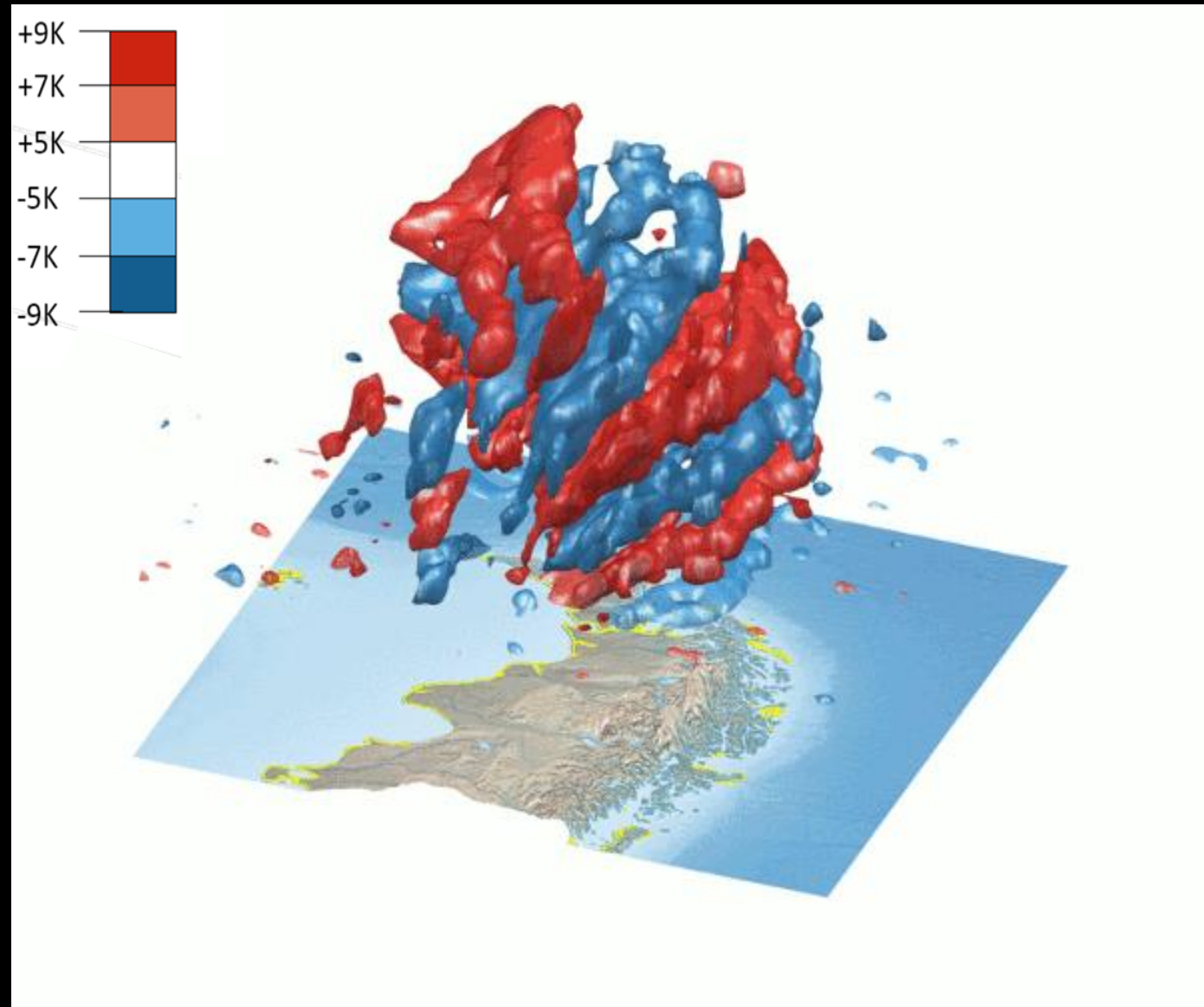
Tropo

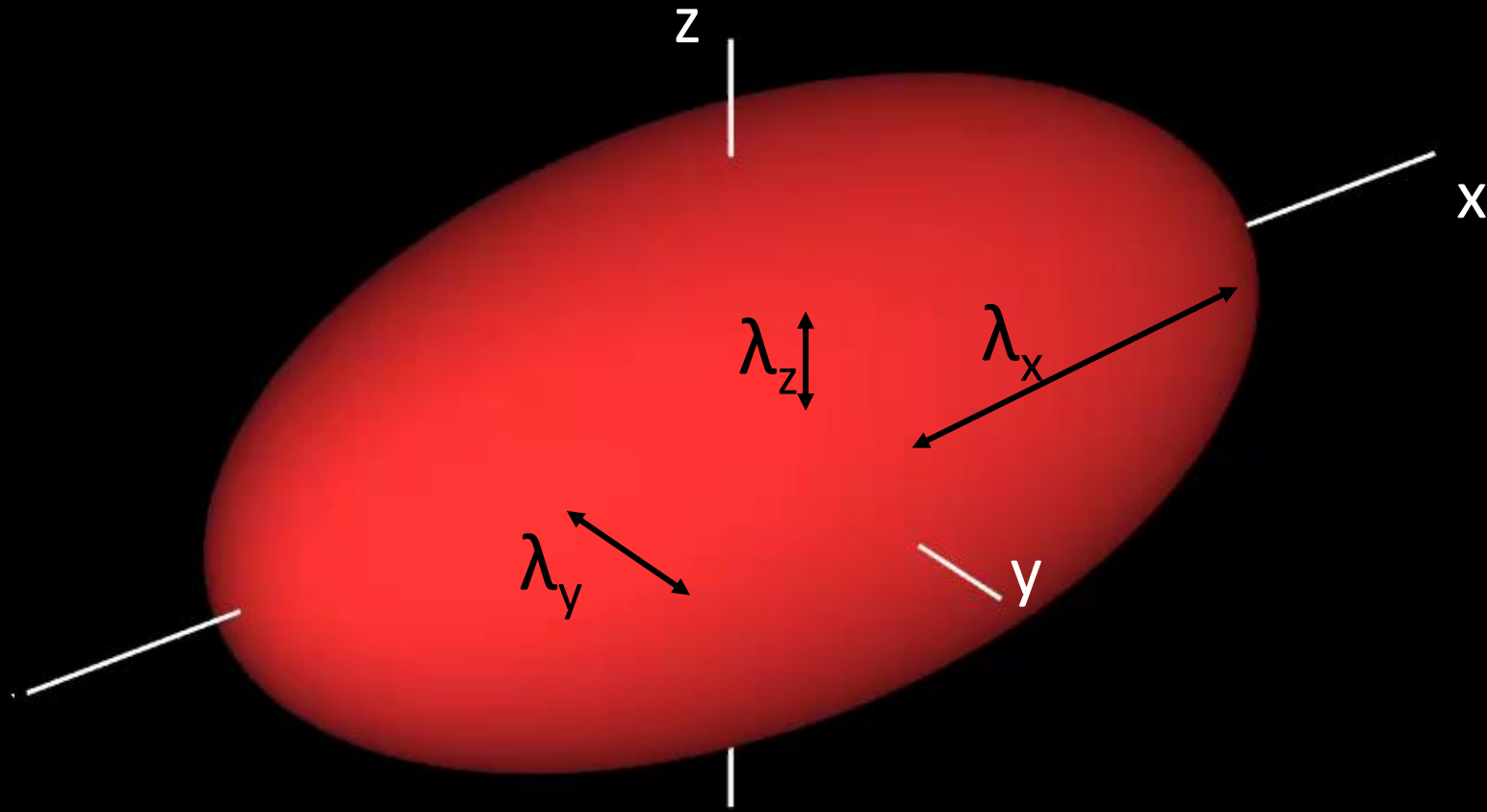


Why Do We Care?

Tropo
Strato
Meso
Thermo







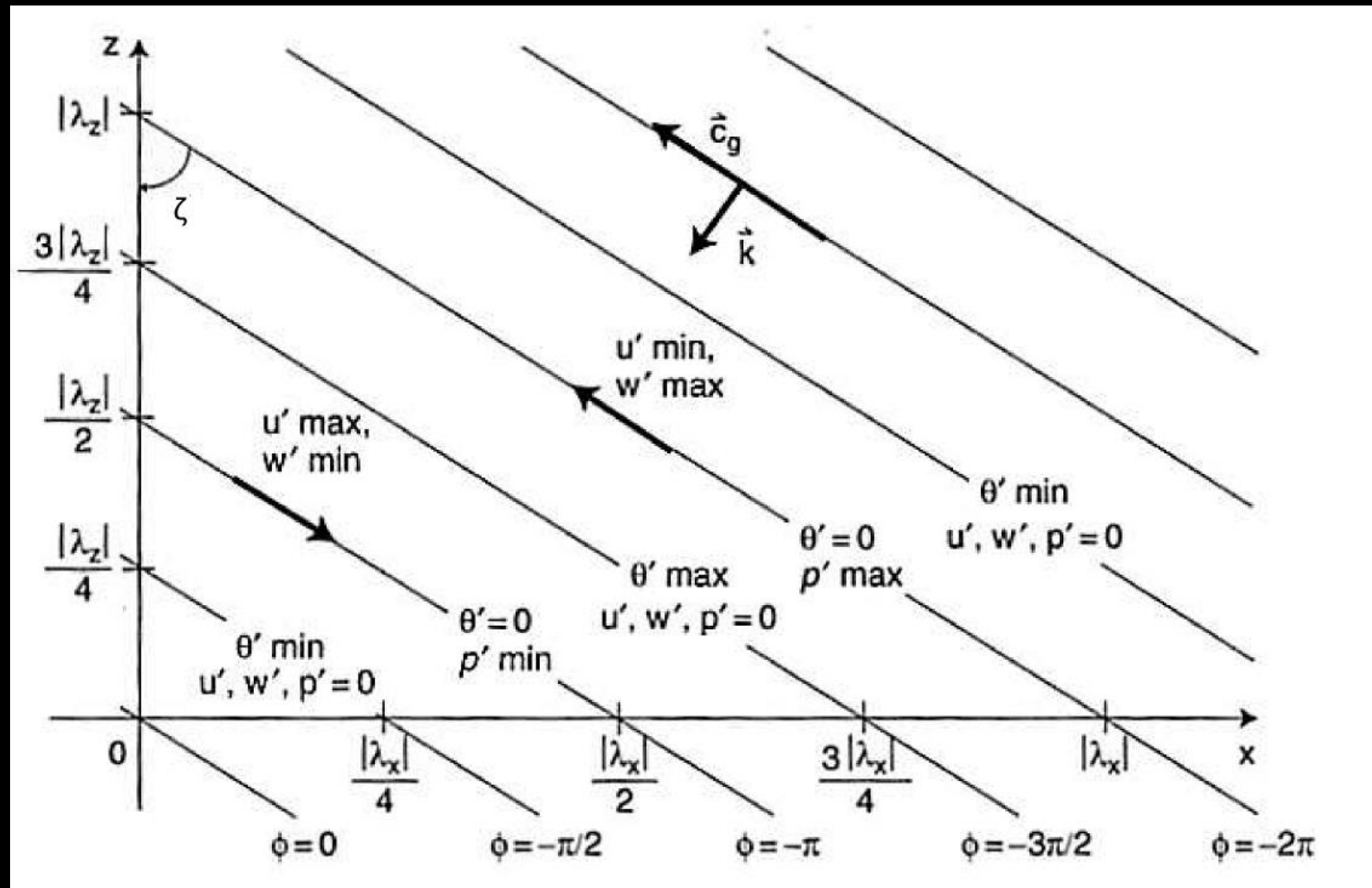
Wavelengths $\lambda_x, \lambda_y, \lambda_z$ (or wavenumbers k, l, m)

Amplitude $A' - u, T, \rho, P, etc$

Phase speed and (temporal) frequency

Group velocity

Wave Properties Control Wave Propagation

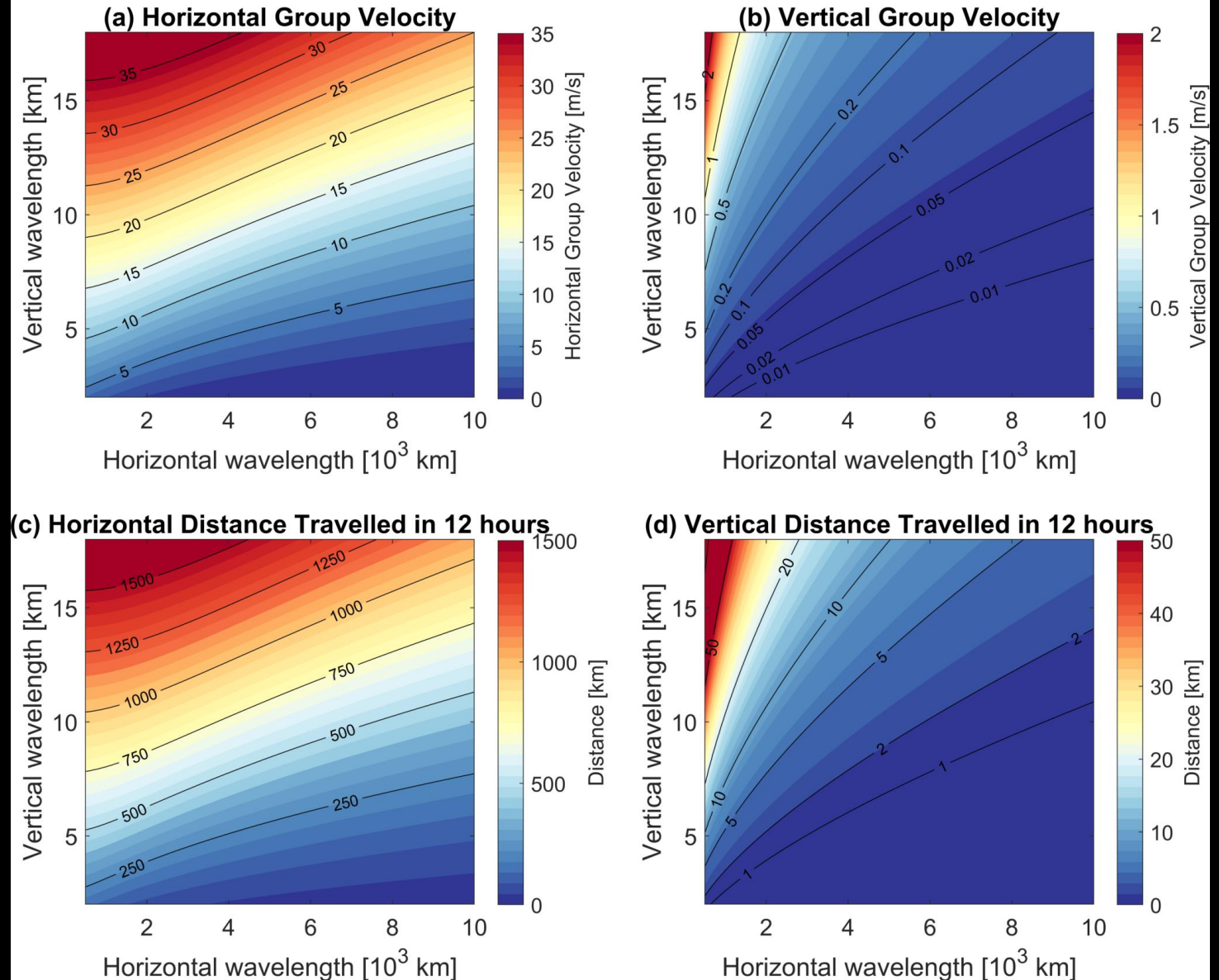


Wave Properties Control Wave Propagation

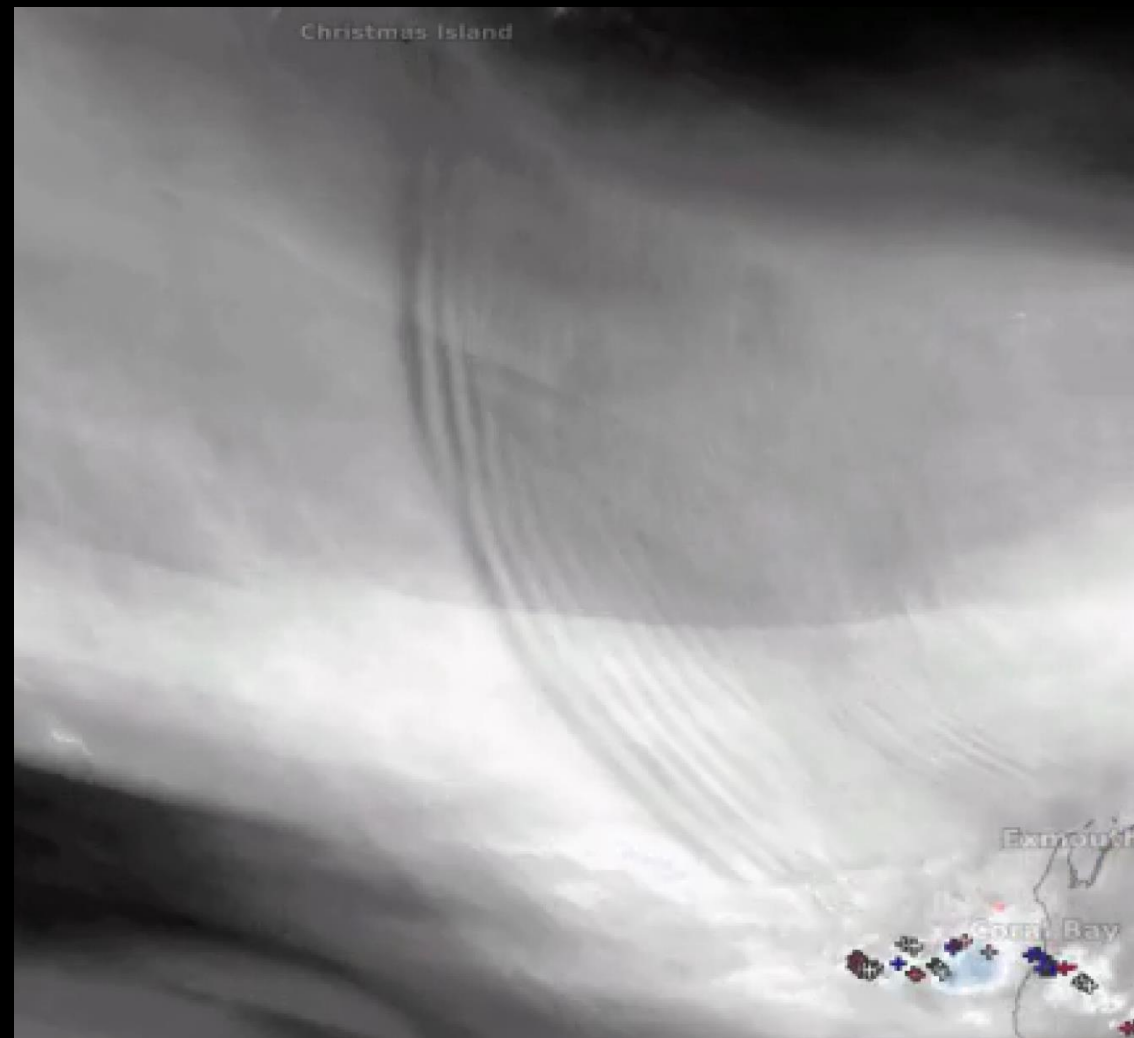
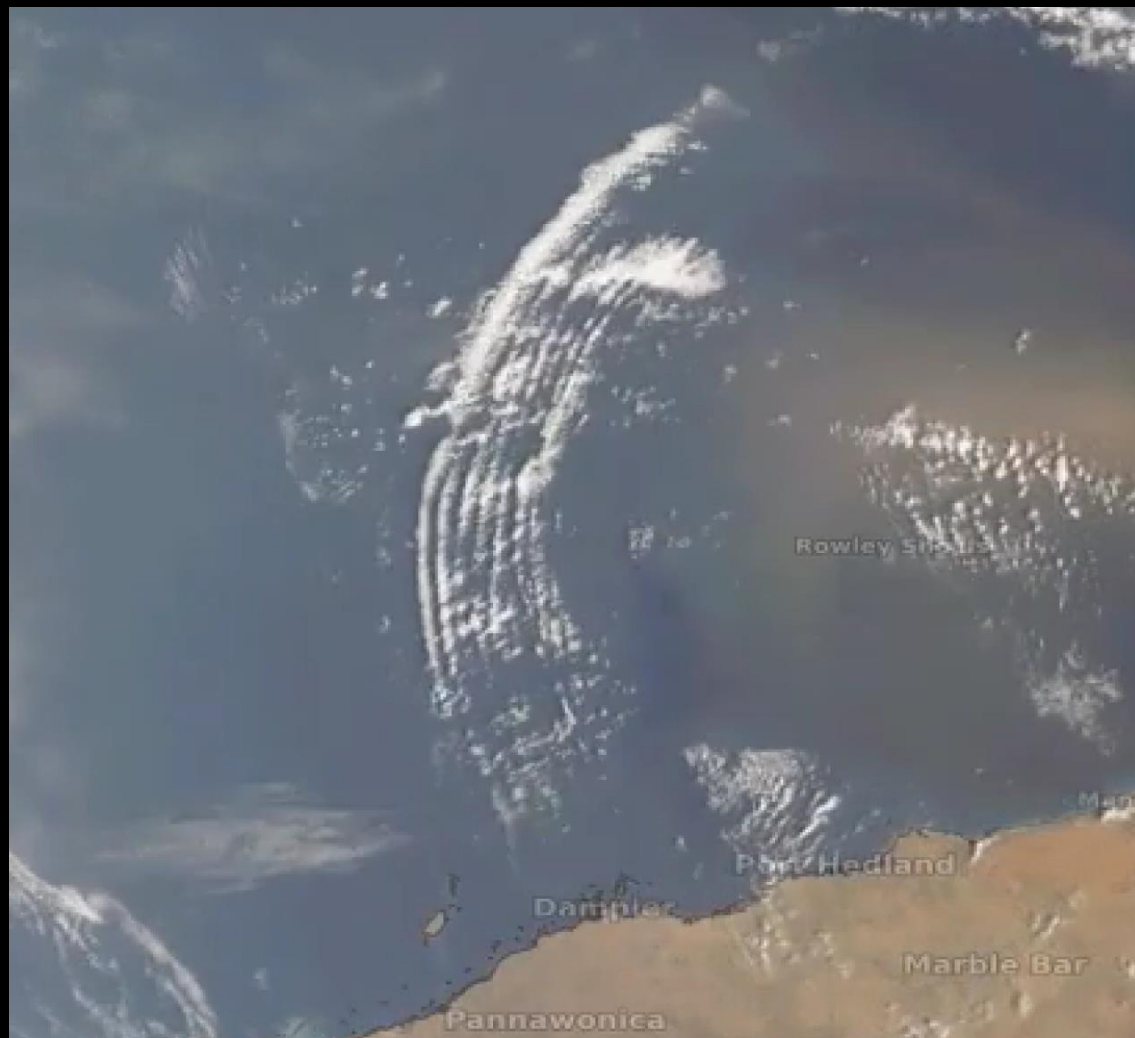
$$C_p = \omega/k$$

$$C_g = \partial\omega/\partial k$$

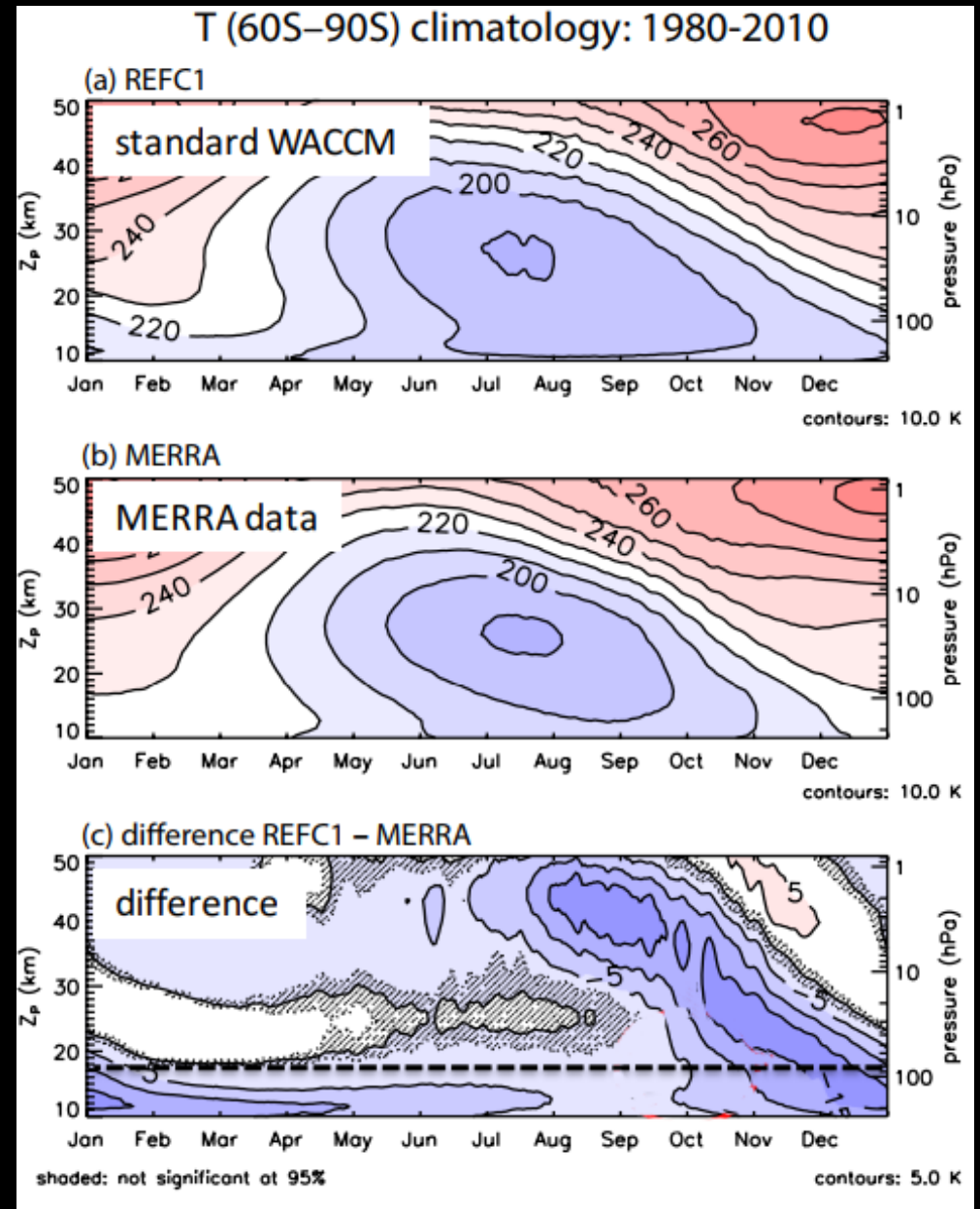
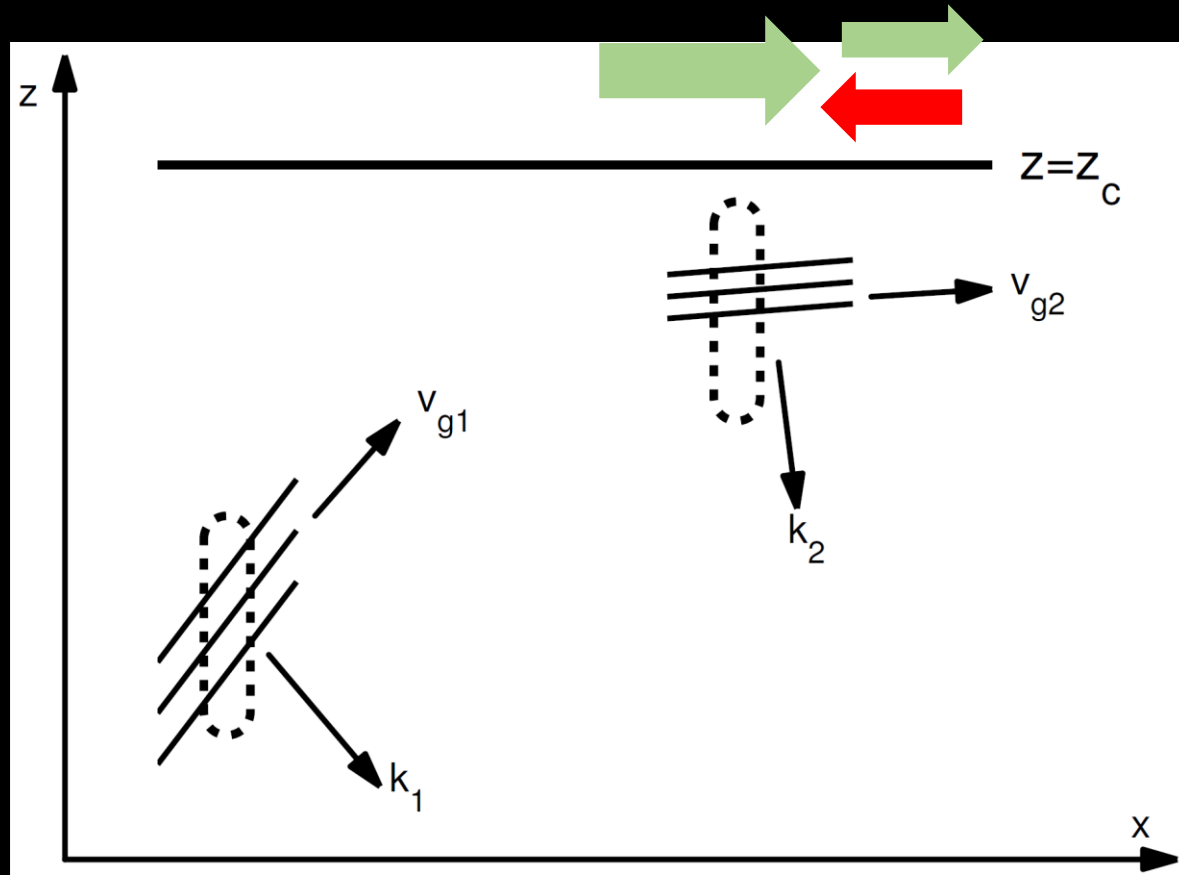
GW group travel in absence of background wind



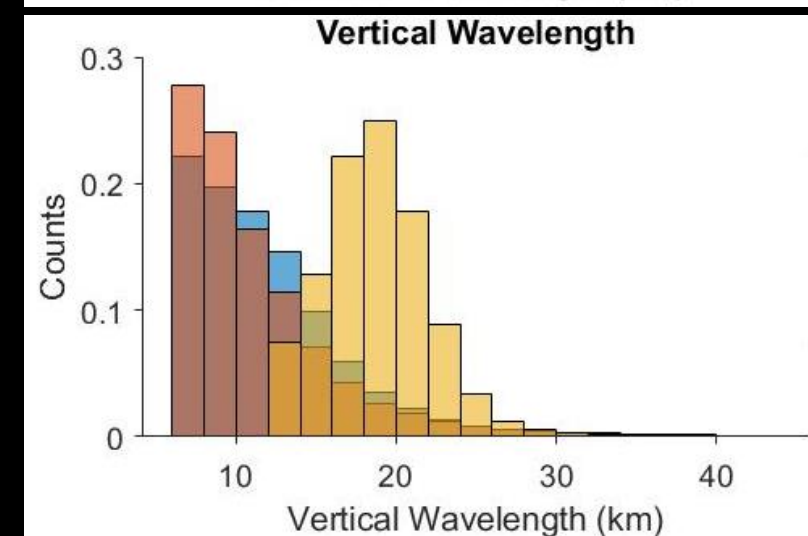
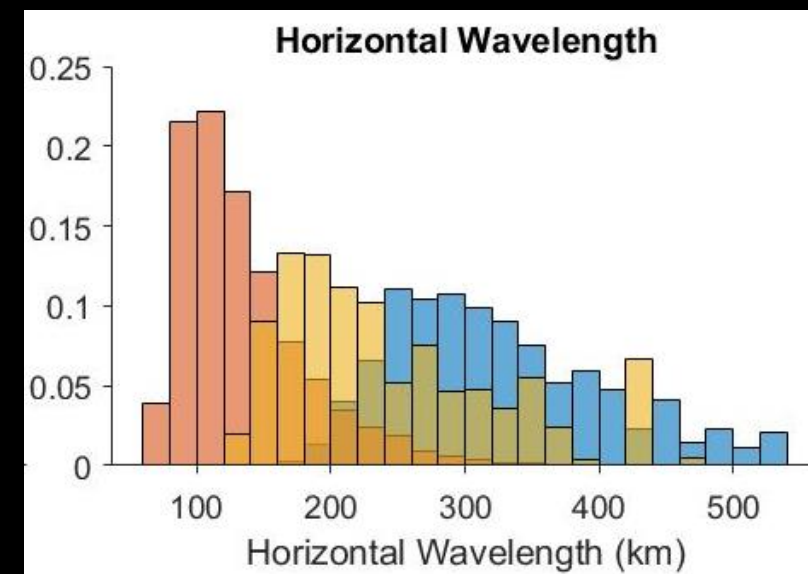
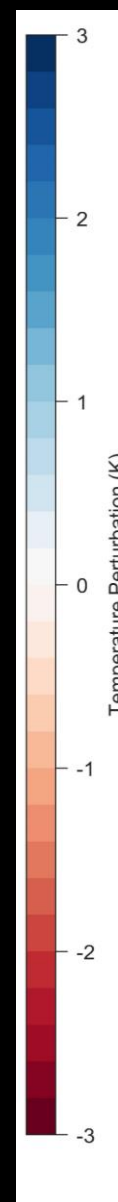
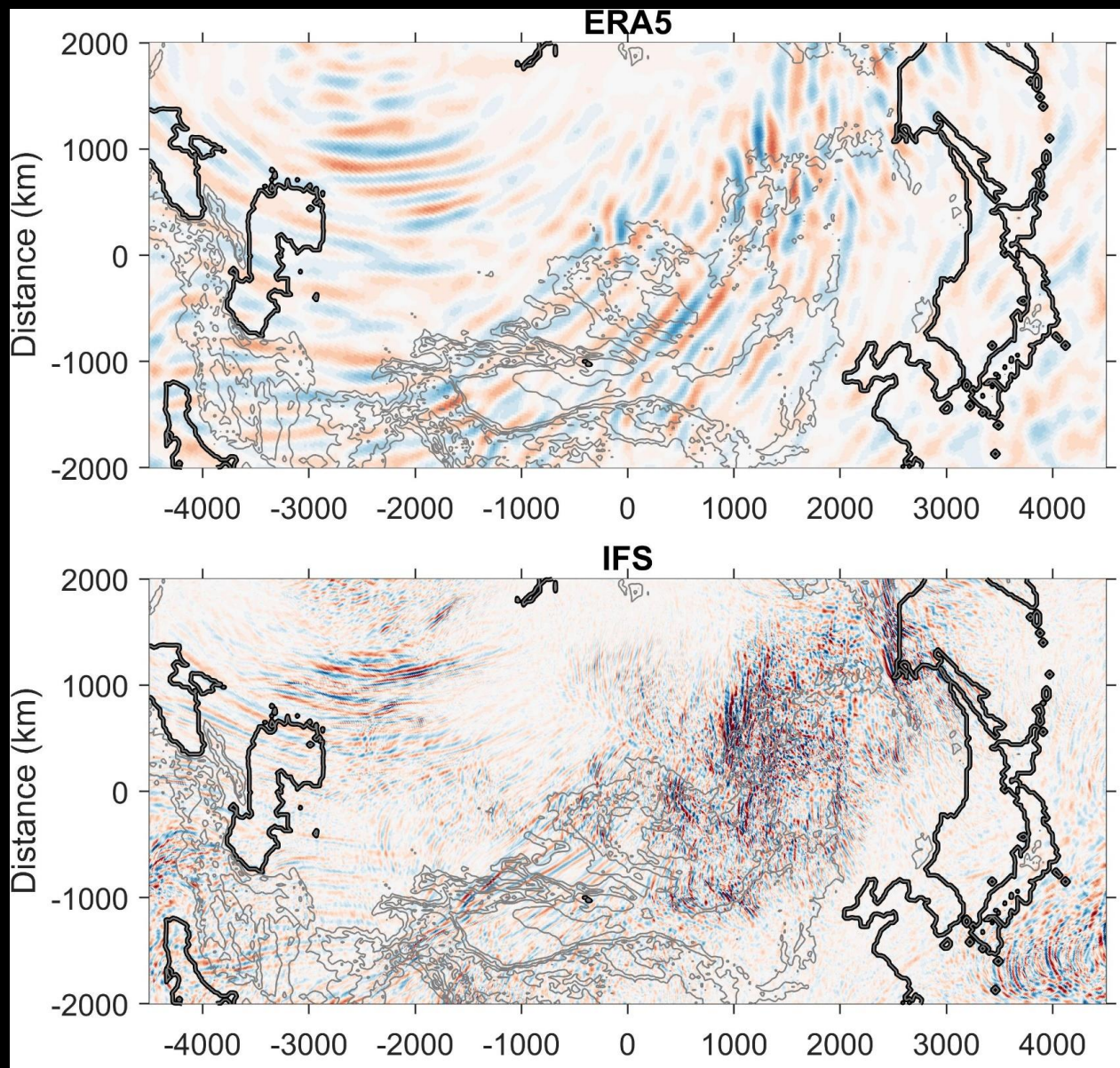
Wave Properties Control Atmospheric Interactions



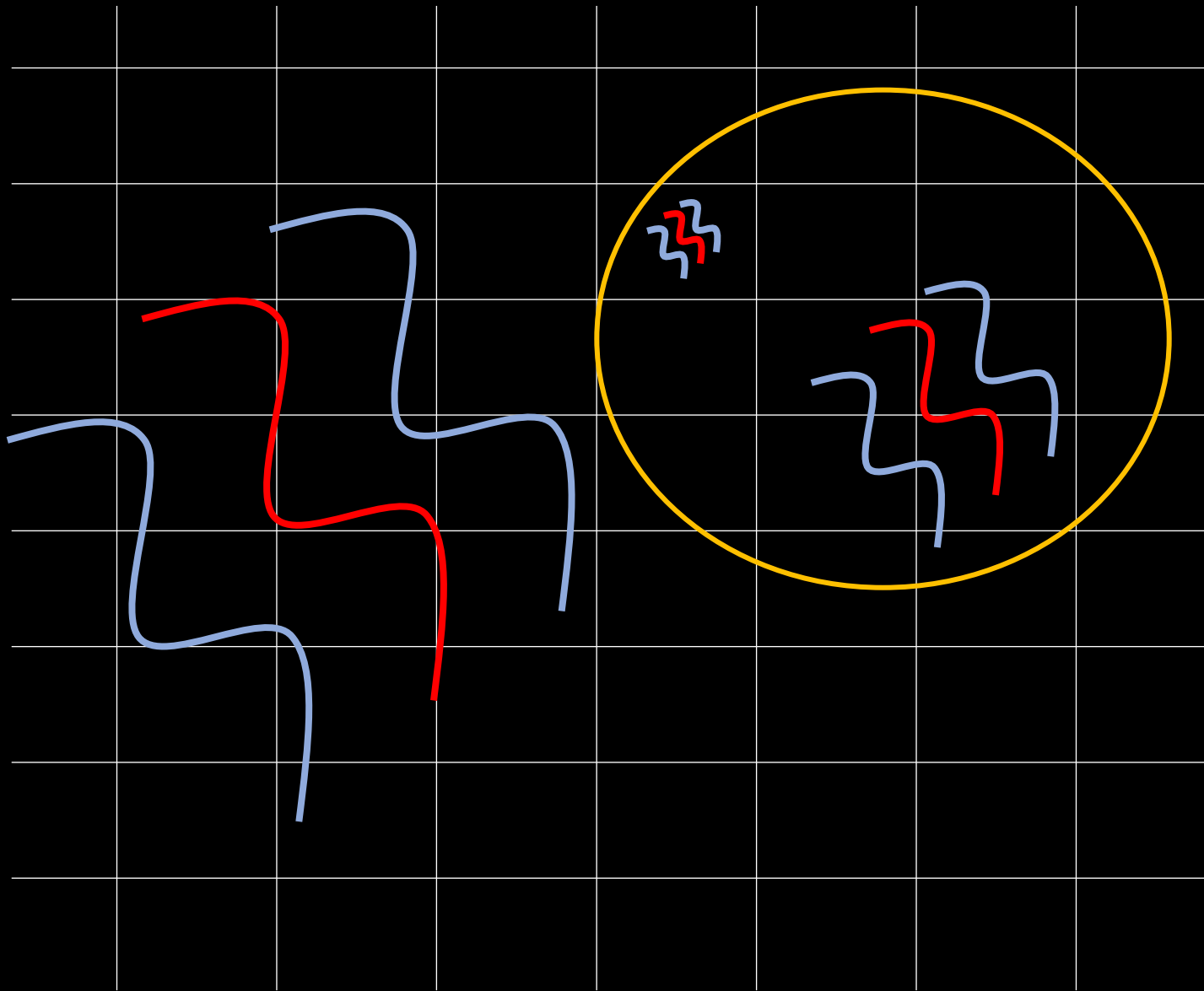
Wave Properties Control Atmospheric Interactions



Different high-resolution model resolutions “see” different wave fields



Many models cannot resolve GWs anyway - parameterisation



Big wave is resolved – fine!

Little wave is clearly totally unresolved – parameterise

Medium wave is PARTLY resolved – this is harder

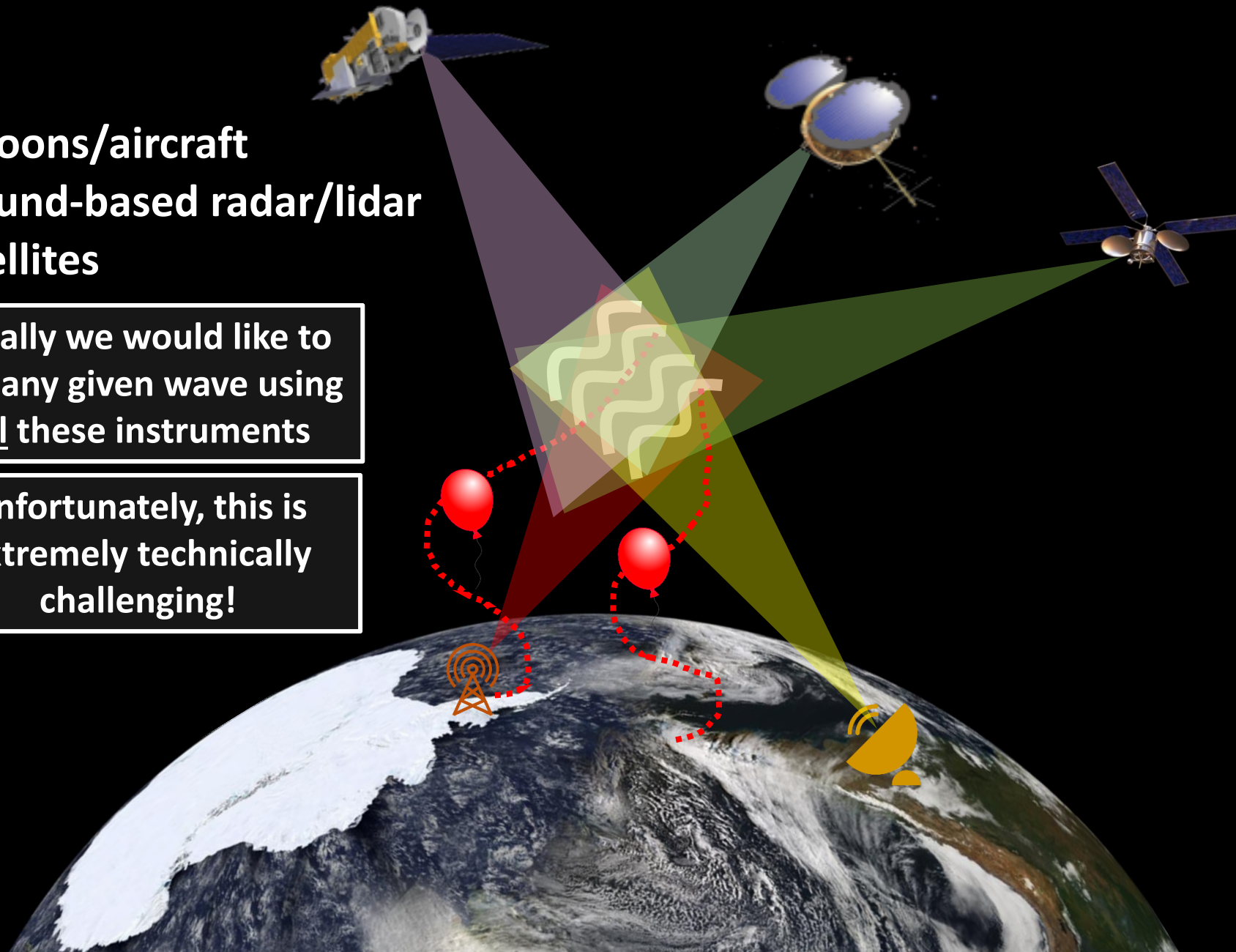
Parameterisations compensate for the effects of the little waves and the missing fraction of the medium waves

Can be observed from lots of platforms...

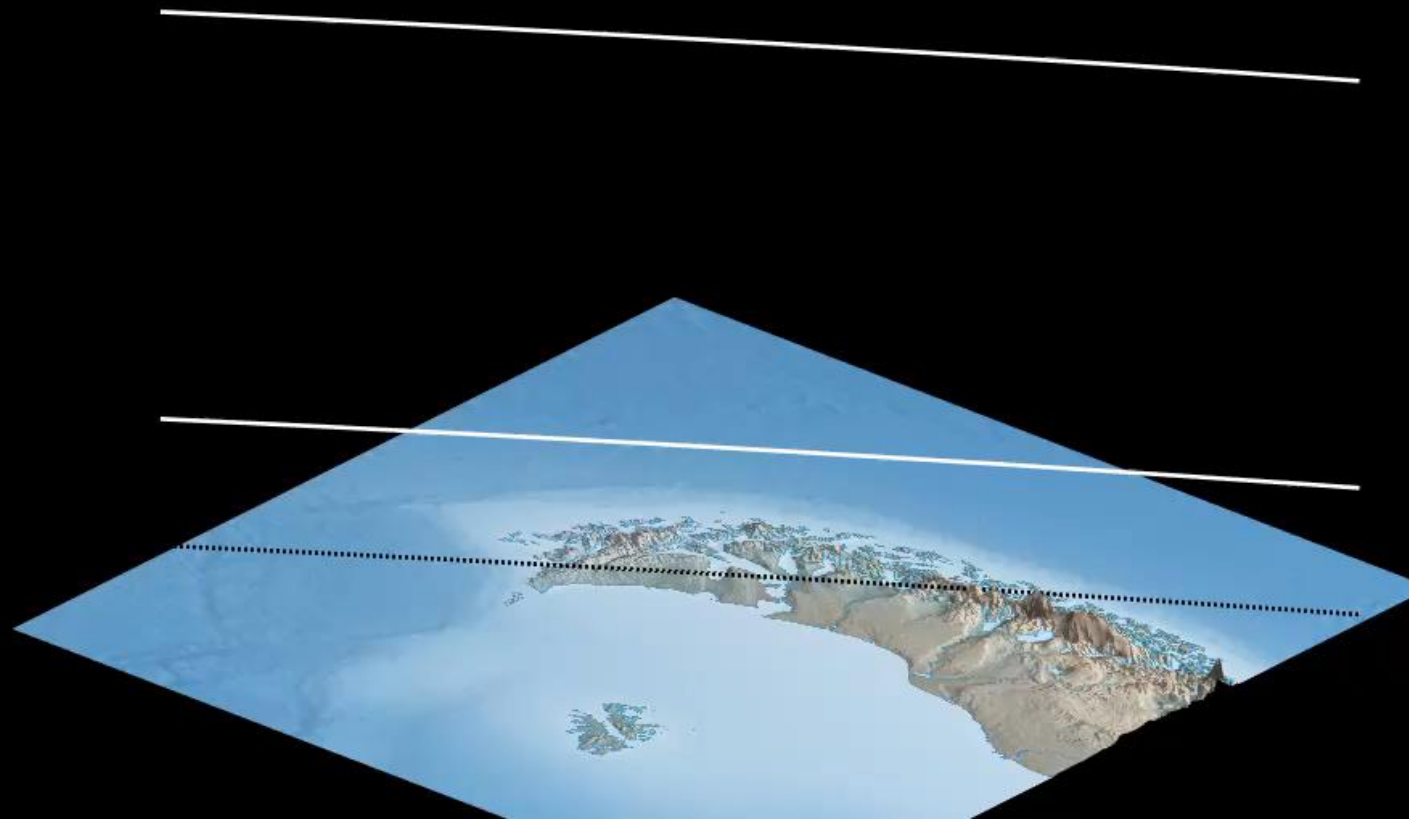
Balloons/aircraft
Ground-based radar/lidar
Satellites

Ideally we would like to
see any given wave using
all these instruments

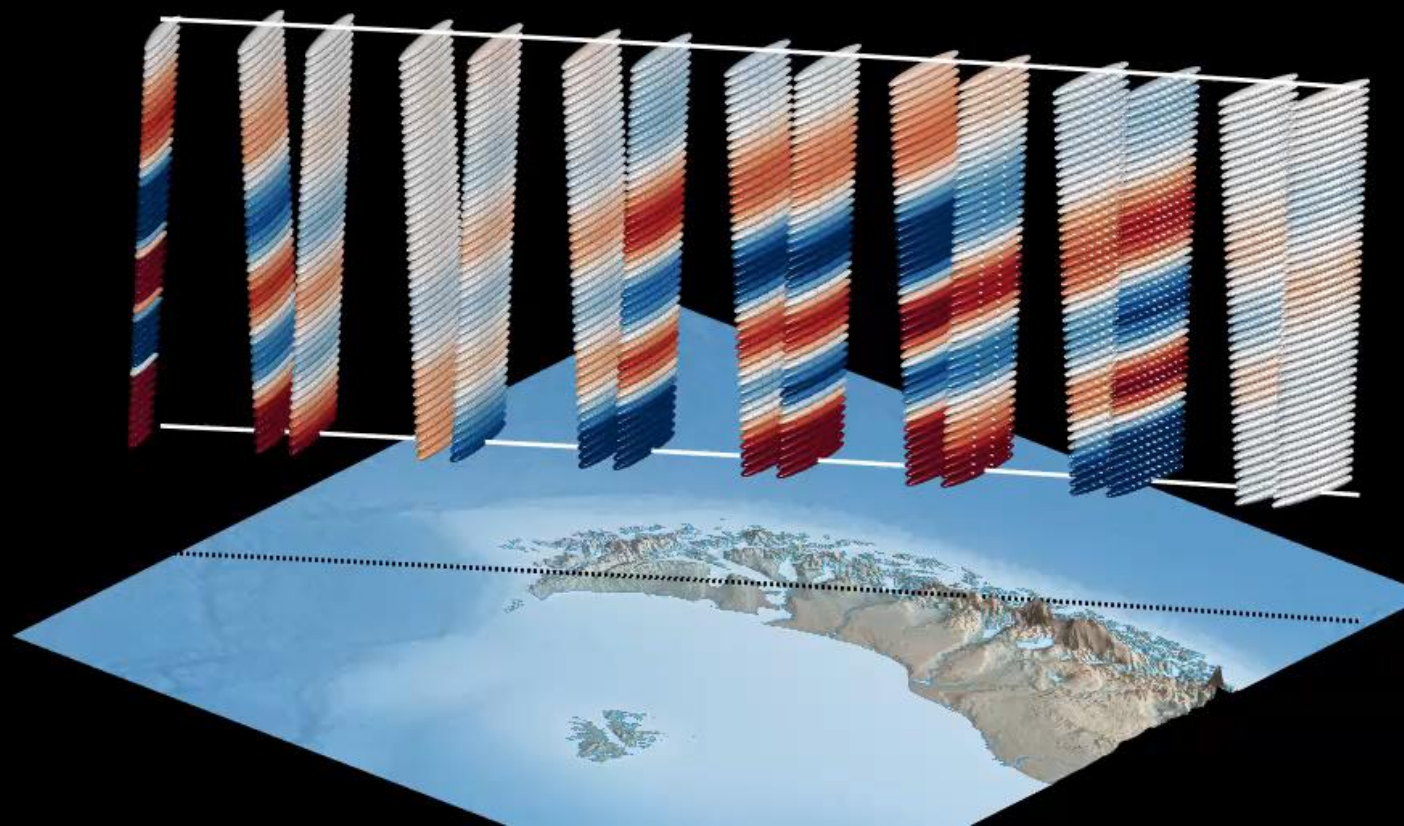
Unfortunately, this is
extremely technically
challenging!



Observational Coverage – HIRDLS, sondes, and radar

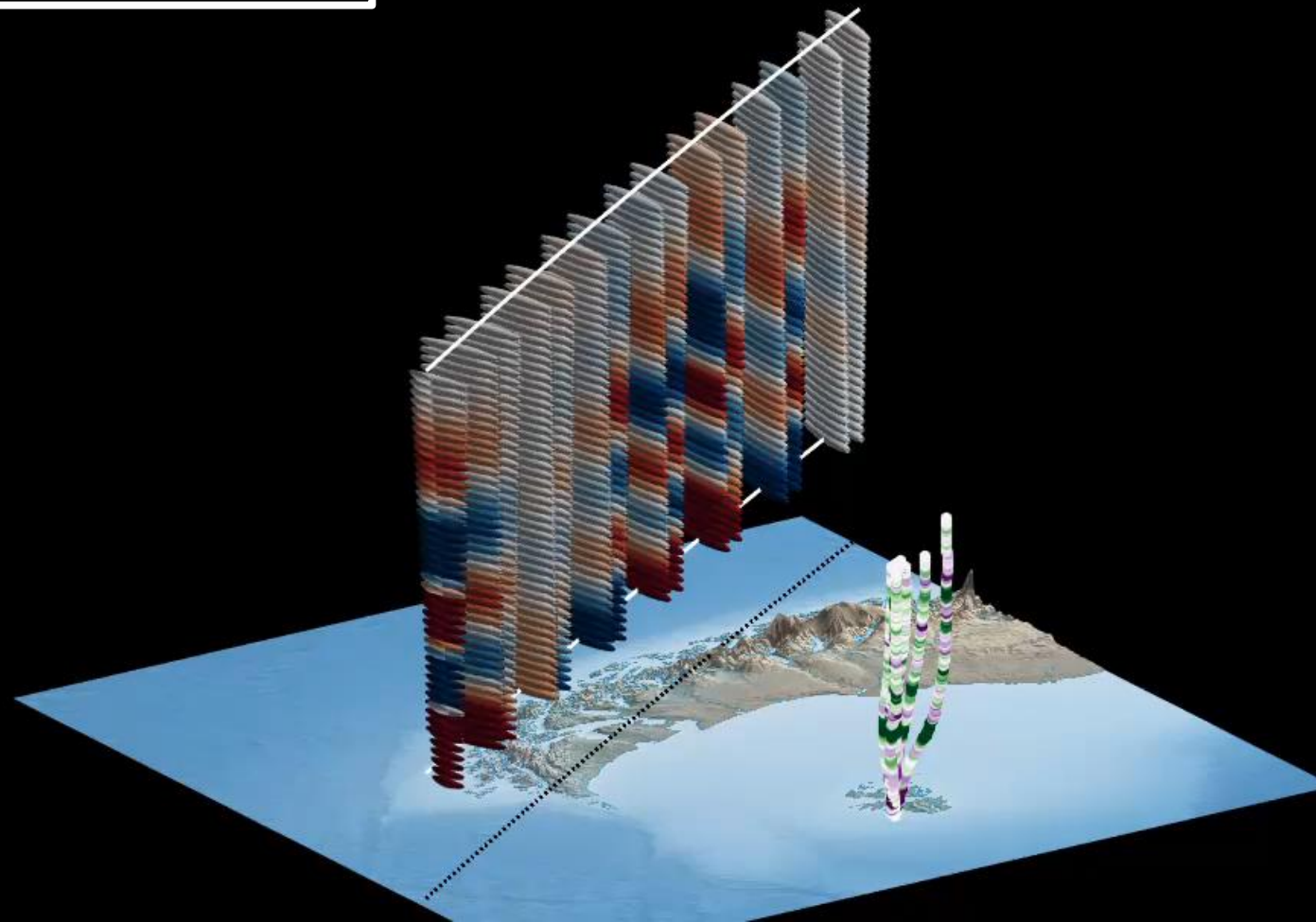


Observational Coverage – HIRDLS, sondes, and radar

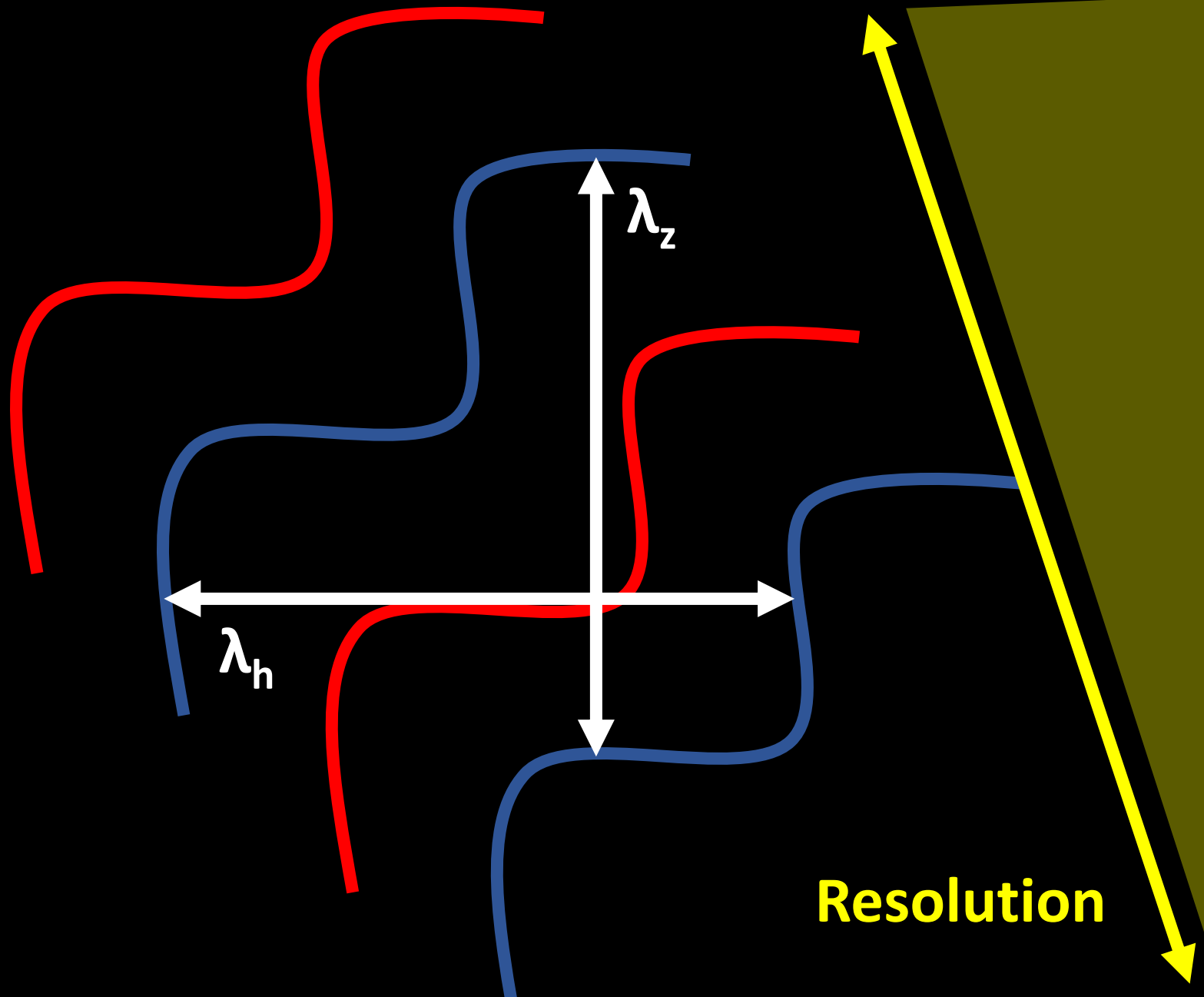


Observational Coverage – HIRDLS, sondes, and radar

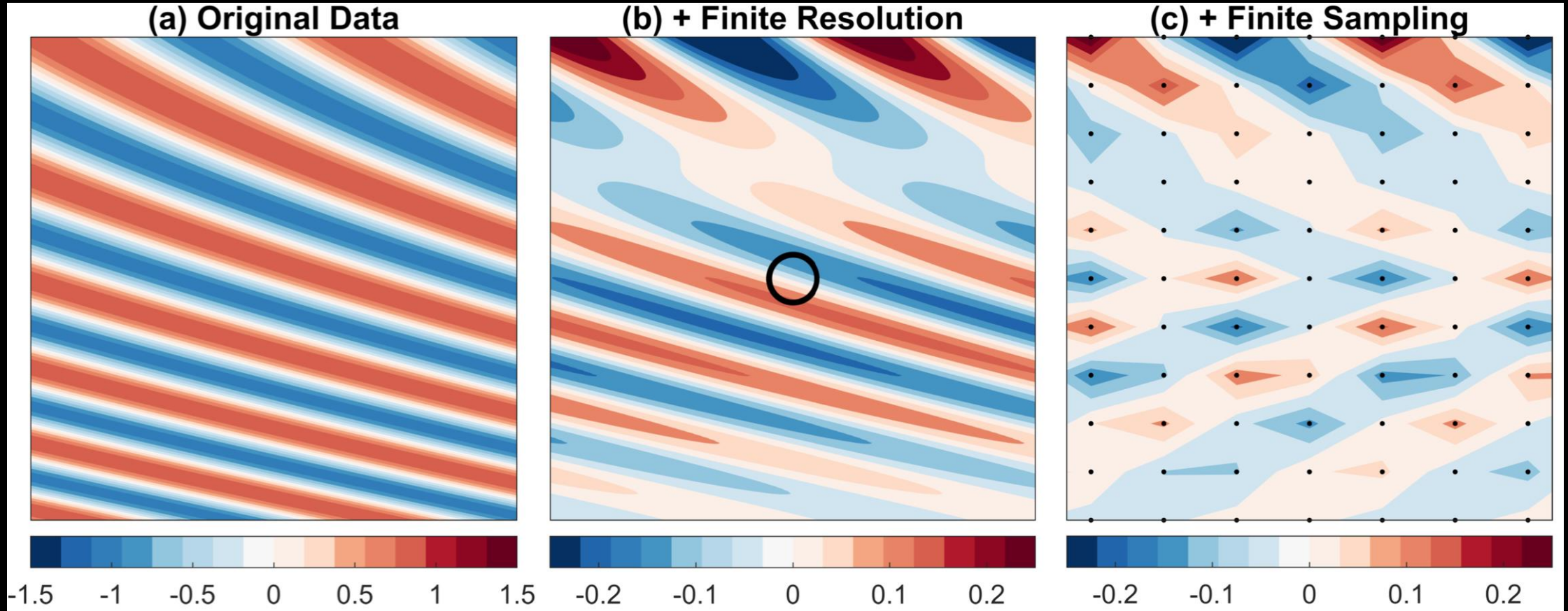
Since waves are **intermittent**, **localised** and **vary on short spatial scales**, we can almost never measure the same wave from two sources



Observational Filtering



Different sampling can even make GWs go backwards!



- **Gravity waves play a range of vital roles across the full depth of the atmosphere**
- **Their behaviour is a direct result of their physical structure**
- **Measuring/simulating this structure is hard – observations are getting better, but fundamental limitations apply**