**Research Questions**

Do internal waves matter in the Arctic Ocean?

1. How does the Arctic internal wave field change seasonally and interannually?
2. Where does the wind energy entering the internal wave field end up? Is mixing important?

**Sea Ice and Near-Inertial Internal Waves from ITP Observations**

**Seasonal cycle**

Monthly-average near-inertial wave amplitude matches wind factor, which captures how easily wind forcing can move the sea ice.

**Wind factor**

- Ice speed
- Wind speed

**Interannual variations**

- Trend in wave amplitude: 5% increase over 9 years
- Variance in the wave amplitude distribution doubled due to an increase in the number of large waves

Since 2005, the energy in the internal wave field has increased slightly, and very energetic waves are now generated much more frequently.

**Model Predictions for Instability and Mixing**

Most near-inertial waves ($A_i < 1m$) are stable and won't cause mixing: $Ri \geq \frac{1}{2}$

However, many large amplitude waves ($A_i > 2m$) are unstable and will mix: $Ri < \frac{1}{2}$

At least 14% of observed near-inertial waves from ITPs are predicted to be unstable between ~200-400m depth, within the double-diffusive staircase and warm Atlantic Water, up from roughly 5% a decade ago.

**Modelling Internal Wave Propagation and Stability**

Analytic model for wave propagation: determines how internal wave amplitude and energy change with depth for a specified wave entering a measured stratification profile from the Western Arctic Ocean.

Solve 1-D ODE: $\frac{d^2 \eta}{dx^2} + \frac{2N^2}{\omega^2} \eta = 0$

for wave vertical displacement: $\eta = A_i \exp(ikx - i\omega t)$

The double-diffusive staircase, common in the Western Arctic, significantly affects internal wave propagation and stability.

Cartoon of internal wave propagation through a double-diffusive staircase' stratification, with 2 mixed layers separated by a stratified interface. Internal waves may reflect from a mixed layer or resonantly 'tunnel' through, depending on the vertical scale of the layers and the wave.


Internal waves may: reflect from the double-diffusive staircase, interact within it, and transmit through it.

**Summary**

Internal waves in the Western Arctic Ocean have become more energetic over the last decade.

1. Vertical displacement amplitude of near-inertial waves increased by 5% over the last decade due to changing sea-ice properties, variance doubled.

2. For typical Arctic internal waves, the double-diffusive staircase reflects up 50% of the energy back into the upper ocean, increasing wave interactions.

3. Waves energetic enough to cause mixing above the Atlantic Water temperature maximum now account for ~14% of the wave field, up from 5% in 2005.

Model predicts increased episodic mixing due to breaking internal waves, which may intermittently increase vertical heat flux or nutrient transport.

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Salinity, temperature, and pressure from 27 Ice-Tethered Profilers (ITPs) in the Canada Basin, year-round, from Fall 2005 to Fall 2014.