INVESTIGATING THE MILLIMETRE-SIZED ICE CRYSTALS THAT DRIVE THE GLOBAL OCEAN CIRCULATION

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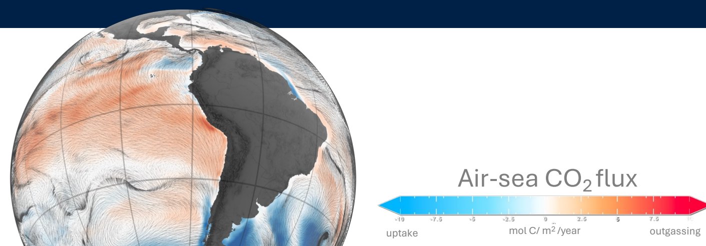
Introduction

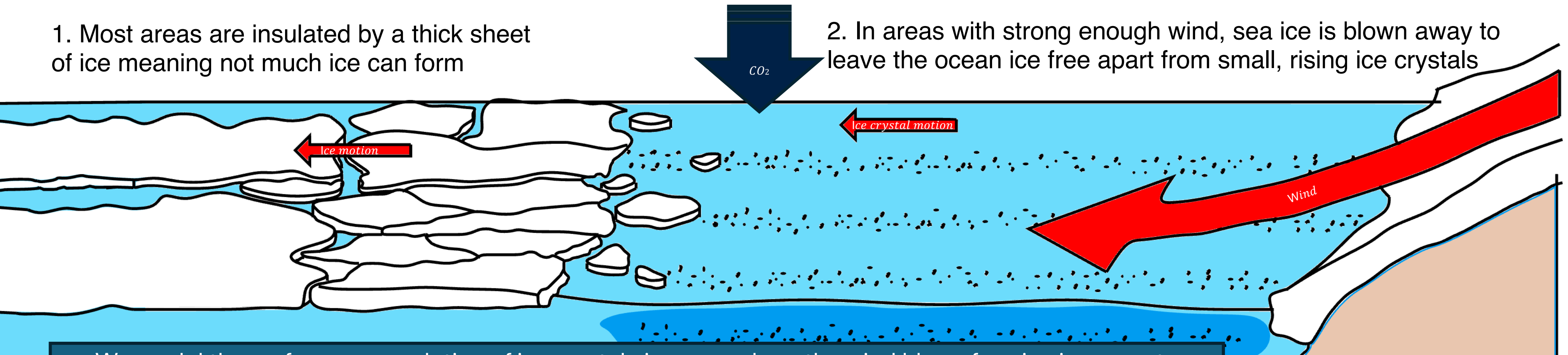
- The ocean is crucial to the **future climate** of our planet as it absorbs excess heat and acts as a CO_2 sink
- A key process responsible for storage of heat and CO_2 is the sinking of dense surface water caused by ice forming around the coast of Antarctica.
- The more ice that forms the more likely the ocean is to remove CO_2 and store excess heat
- We want to **estimate how much ice is forming** around the coast of Antarctica



Air-sea CO_2 fluxes, NASA's Scientific Visualization Studio [1]

1. Most areas are insulated by a thick sheet of ice meaning not much ice can form

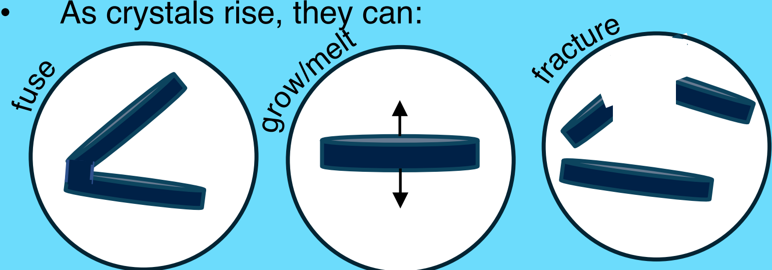
2. In areas with strong enough wind, sea ice is blown away to leave the ocean ice free apart from small, rising ice crystals



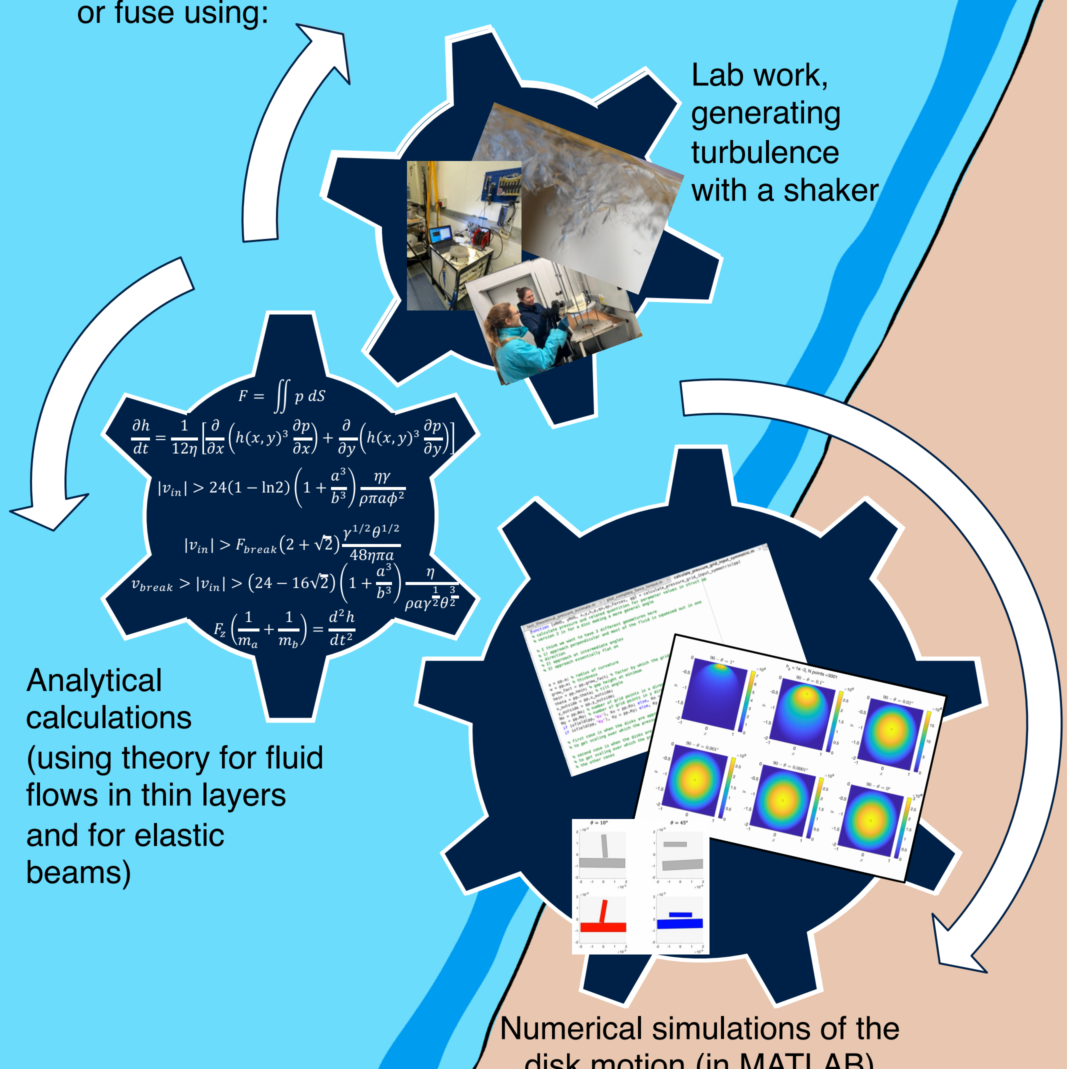
We model the surface accumulation of ice crystals in areas where the wind blows forming ice away to better understand ice formation rates

Methods

- As crystals rise, they can:



- We calculate the conditions required for crystals to break or fuse using:



$$F = \iint p\, dS$$

$$\frac{\partial h}{dt} = \frac{1}{12\eta}\left[\frac{\partial}{\partial x}\left(h(x,y)^3\frac{\partial p}{\partial x}\right) + \frac{\partial}{\partial y}\left(h(x,y)^3\frac{\partial p}{\partial y}\right)\right]$$

$$|v_{in}| > 24(1-\ln 2)\left(1+\frac{a^3}{b^3}\right)\frac{\eta\gamma}{\rho\pi a\phi^2}$$

$$|v_{in}| > F_{break}(2+\sqrt{2})\frac{\gamma^{1/2}\theta^{1/2}}{48\eta\pi a}$$

$$v_{break} > |v_{in}| > (24-16\sqrt{2})\left(1+\frac{a^3}{b^3}\right)\frac{\eta}{\rho a\gamma^{\frac{1}{2}}\theta^{\frac{3}{2}}}$$

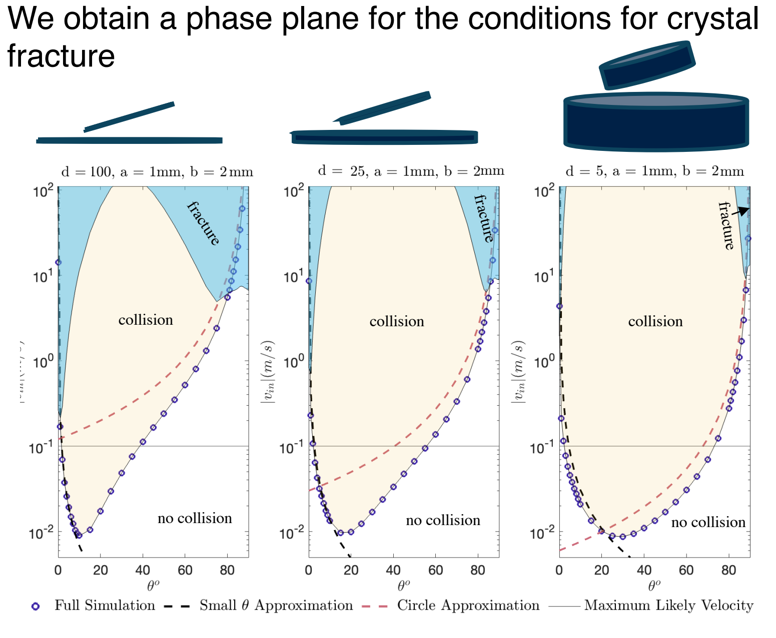
$$F_z\left(\frac{1}{m_a}+\frac{1}{m_b}\right) = \frac{d^2h}{dt^2}$$

Conclusions

1. When ice crystals rise to the surface, they are unlikely to break apart
2. Crystals approaching close to parallel or perpendicular are less likely to fuse than crystals approaching intermediate angles

Results

We obtain a phase plane for the conditions for crystal fracture



a = Top disk radius, b = Bottom disk radius, d = Ratio of disk diameter to thickness

Contact

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[1] Shirah, G. (2020) *Ocean Surface CO2 Flux with Surface Winds, https://svs.gsfc.nasa.gov/4873#section_credits*. Available at: https://svs.gsfc.nasa.gov/4873#section_credits.

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