# The Role of Atmospheric Jets in Ice Edge Dynamics

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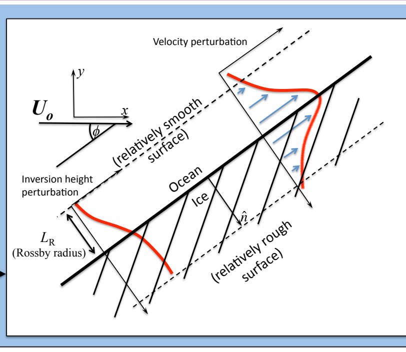
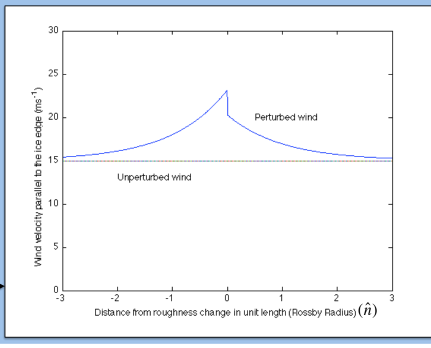
## 1. Background

- Current Global Climate models crudely parameterise sea ice dynamics. This leads to errors in the prediction of sea ice extent.
- The aim of this project is to apply atmospheric jets to the sea ice edge and investigate the effect this has upon the sea ice pack.
- Atmospheric jets are known to form over sharp changes in surface roughness, such as coastlines. The formation is well understood and documented in Hunt et al 2004.
- Winds blowing from smooth ocean to rough broken ice will become more turbulent. This will cause the atmospheric boundary layer to change thickness and due to the Coriolis effect, a jet will form.
- We have produced an idealised model using a Viscous Plastic sea ice rheology.
- We have introduced the jets to the Los Alamos Sea Ice Model (CICE) on an idealised domain.

## 2. Jet Formation

- We calculated the shape of the jet using a perturbation model.
- The jet width and intensity are dependent upon the wind velocity ($U_o$), the angle between the wind and ice edge ($\phi$), and the Froude number and Rossby Radius. see →
- The perturbation to the flow is parallel to the ice edge.
- A similar oceanic jet is expected to form underneath the ice. This jet is thinner than the atmospheric jet.
- The jets alter the atmospheric and oceanic forcing in the models.
- Perturbed wind parallel to an ice edge at angle $\phi \approx 20^{\circ}$ to the unperturbed win. →



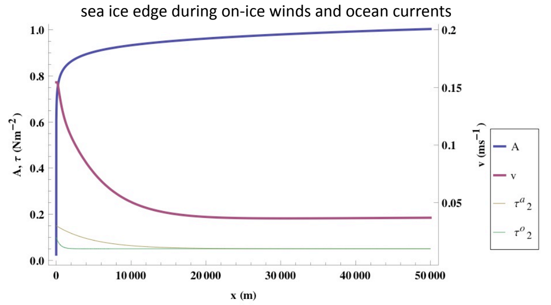

## 3. Idealised Modeling

Vertically integrated, two-dimensional momentum balance of the sea-ice-ocean mixture layer

$$m\left(\frac{\partial \mathbf{u}}{\partial t} + \mathbf{u}\cdot\nabla\mathbf{u}\right) = -mf_c\mathbf{k}\times\mathbf{u} + A\tilde{\tau}^a + A\tilde{\tau}^o + S + \nabla\cdot\sigma$$

- We solved the sea ice momentum balance using a Viscous - Plastic stress tensor. This stress regime is used in many sea ice models including the CICE model.
- The system of equations is simplified to be steady state and laterally invariant. , i.e. $\frac{\partial}{\partial t}=0 \quad \frac{\partial}{\partial y}=0 \quad u=\text{constant}$
- The atmospheric stress, $\tilde{\tau}^a$, is used to represent the atmospheric jet. The ice concentration is set to $A=0$ for $x=0$, to represent the ice edge.
- The graph below shows the solution for the ice concentration and velocity parallel to the edge (the $v$ component).
- The concentration increases rapidly as expected for on-ice winds bunching the ice together. The lateral velocity decays away from the ice edge. This follows the decay of the lateral wind stress.

Ice concentration, lateral velocity and lateral stresses at the sea ice edge during on-ice winds and ocean currents

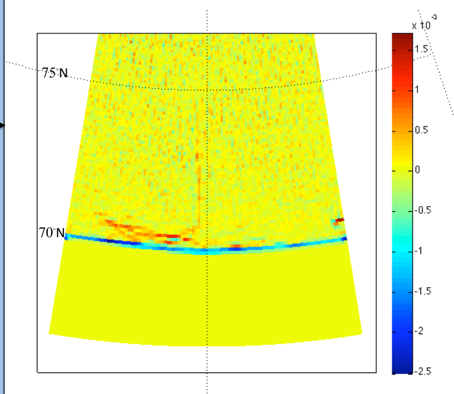



References: Hunt JCR et al, 2004, Coriolis effects in mesoscale flows with sharp changes in surface conditions, Q. J. R. Meteorol. Soc., 130, pp. 2703–2731

## 4. Large Scale Modeling

- We used a short CICE run on an idealised domain to produced a high resolution model of the sea ice edge. This domain is cyclic and land free to produce an undisturbed ice edge. see →
- Model runs are done in pairs using the same idealised forcing set with on-ice winds. One run has the jet and one is left unperturbed.
- From the pairs of model runs we were able to calculate the velocity anomaly due to the presence of an atmospheric jet. As with the idealised model, the ice velocity anomaly decays with the wind velocity anomaly.
- This increased ice velocity can have a significant effect upon the sea ice, such as increasing the compaction at the ice edge.
- Our aim is to parameterise CICE to apply the jets. This will enable us to study the role of the jets in a real world situation.

Sea ice concentration anomaly due to an atmospheric jet. Original winds at an angle of $\phi \approx 45^{\circ}$ to the ice edge.




Parallel velocity anomaly due to the presence of an atmospheric jet along the sea ice edge. The edge is located at 70°N and is at an angle of $\phi \approx 45^{\circ}$ to the ice edge. The sea ice anomaly is blue and wind speed anomaly green.