

Today I Learned

An insight into the fun things I am learning and doing

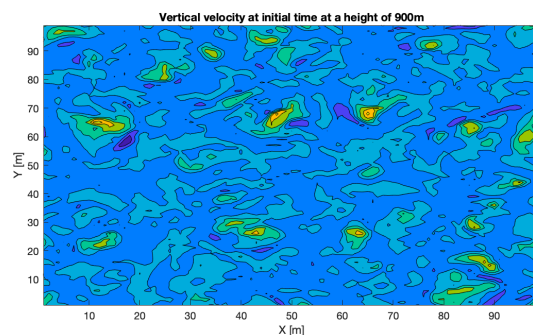
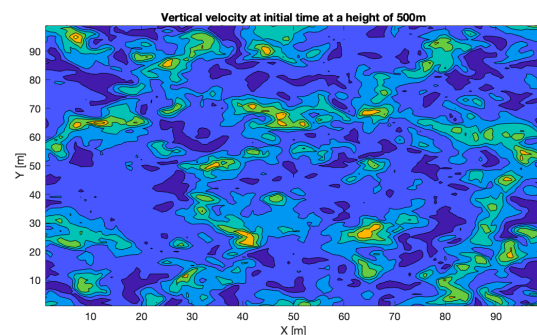
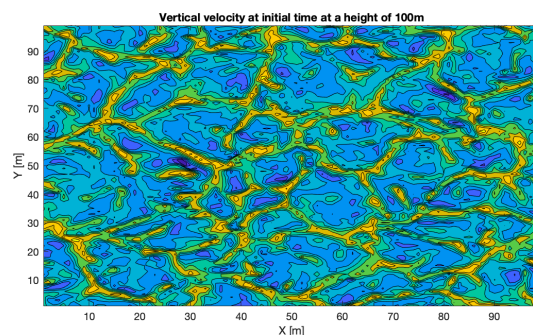
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Introduction

In an attempt to better document the things that I am learning and help things stick with me, I am hoping to create this running document so I can ramble about whatever cool things I learn each day.

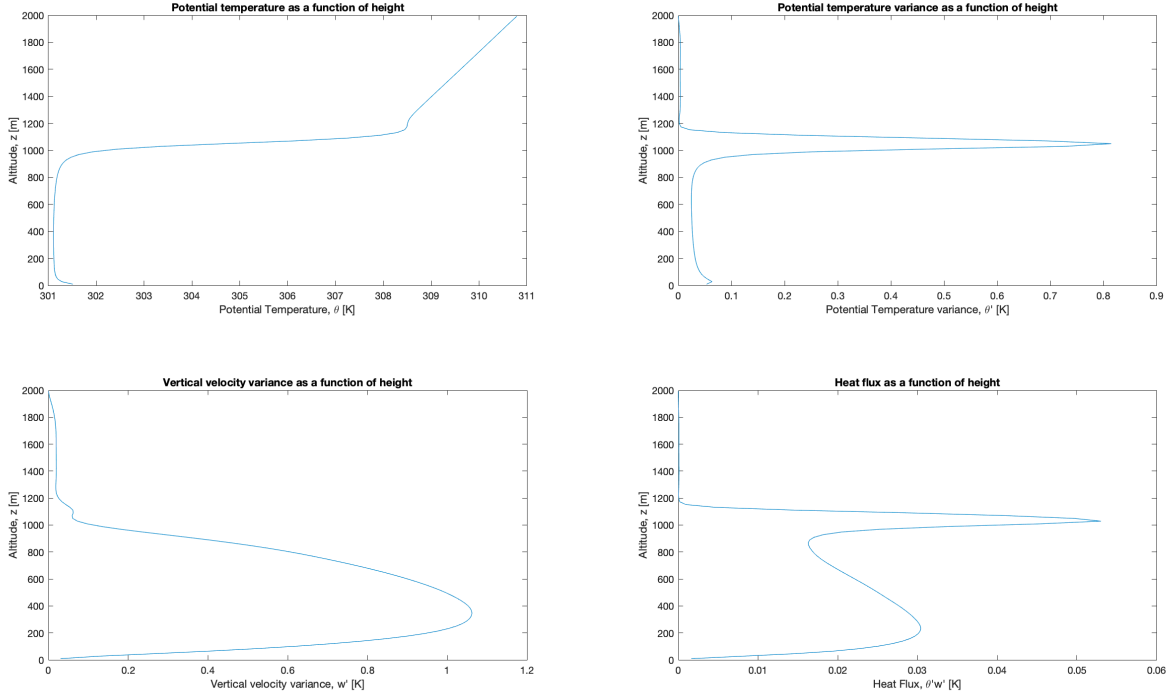
1 Wednesday, March 9, 2022

An interesting article on Nature titled *Flying with ionic wind* discussed how the ionocraft at MIT was developed. One of the big challenges with the ionocraft seems to be optimizing the weight so that the thrust from the corona is strong enough to create some lift. This is probably why the scalability of the ionocraft is uncertain. The original design was generated through some geometric parameter optimization algorithm to determine the optimal wing span and mass for the thrust generated. One of the big challenges seems to be that takeoff is very hard and inefficient but once in flight the efficiency of ionic wind significantly increases making it more feasible. In their experiments, they reported an energy efficiency of only 2%, but it is believed that at high speeds the energy efficiency can be as high as 50%. An interesting thing to note is that it can also be coupled with battery technologies to use electricity from batteries to possibly launch the plane and then use ionic wind propulsion as a secondary energy source.



In Physics of Wind I am still looking at the large eddy simulations of a "quasi-steady free-convection ABL" that we can allegedly assume is horizontally homogeneous and does not evolve

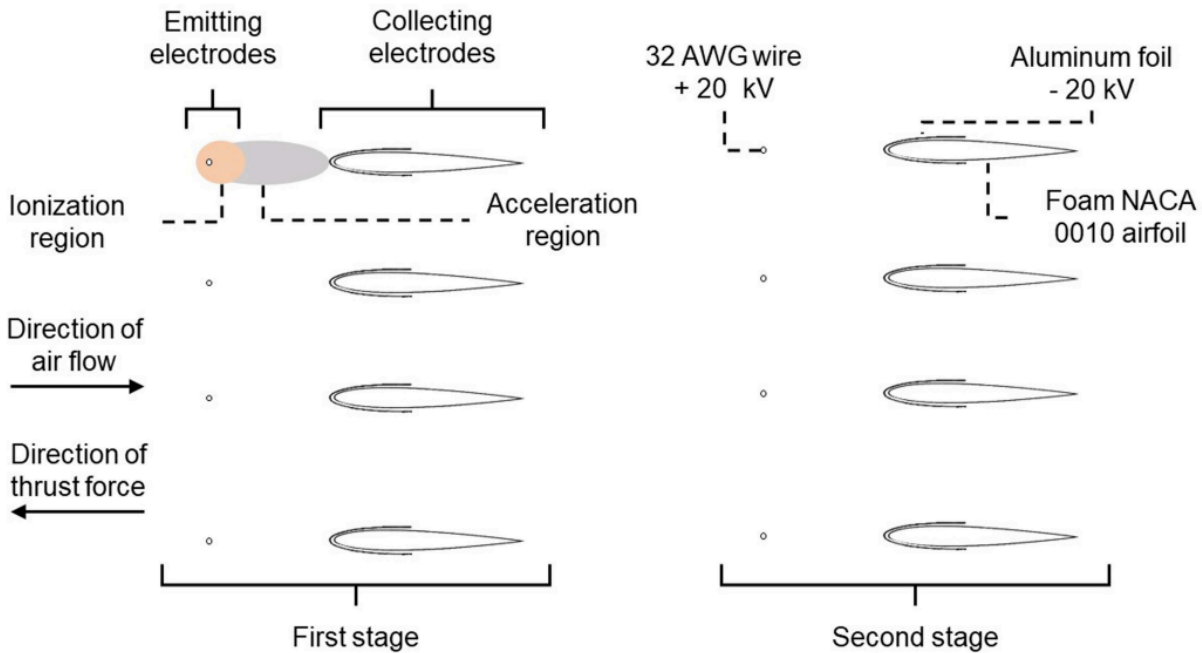
much temporally. Here is an interesting figure of how the vertical velocity profile changes (at the initial time) with height in the ABL.



2 Tuesday, March 8, 2022

To continue on yesterday's discussion about solid-state propulsion, Barrett's group used a corona discharge thruster to propel the aircraft. This works by applying a DC voltage across two asymmetric electrodes as shown, where the positive electrode is a wire that ionizes air molecules within some radius, referred to as the corona (is this related to the Debye length?) and the negative electrode is some sort of mesh material. Ionized materials then move along the induced electric field and collide with neutral air molecules to produce in the opposite direction of ion flow.

However, in their paper, *A dielectric barrier discharge ion source increases thrust and efficiency of electroaerodynamic propulsion*, they note that a corona discharge can be limited by two processes (1) a minimum electric field at the emitter for ionization and (2) a maximum space charge density arising from the self-limiting nature of electric-field driven charge flow. Thus, they pro-

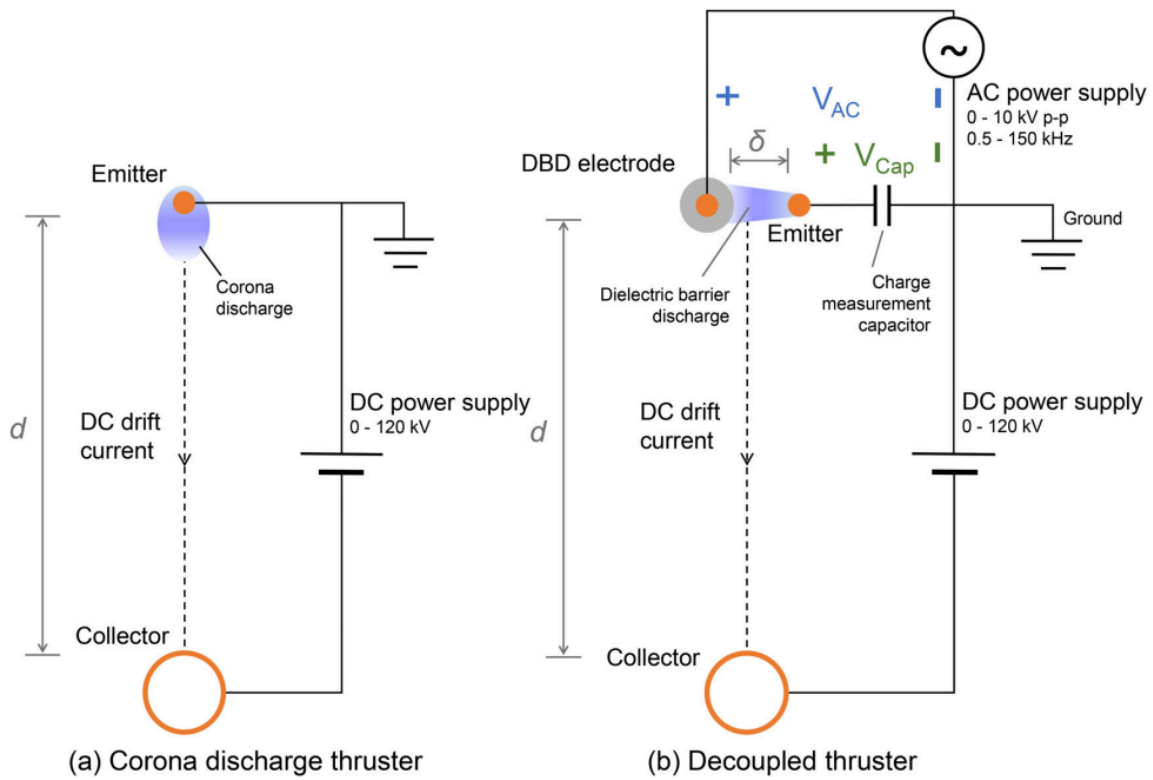


posed a decoupled system using a dielectric barrier discharge plasma where ions are produced by a separate "emitter." By using a decoupled thrust more current can be produced and, as a result, more thrust.

3 Monday, March 7, 2022

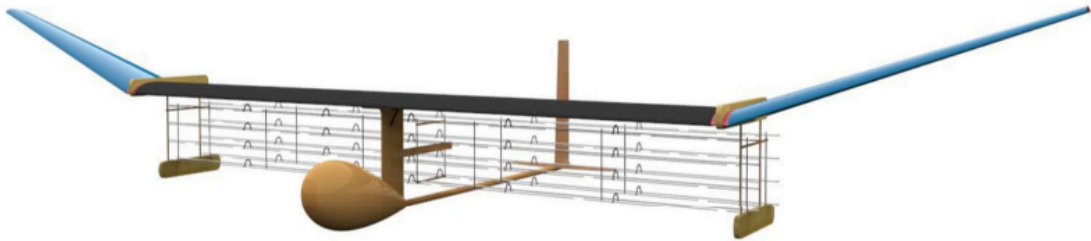
An interesting topic that I was reading about today is "ionocraft" which are airplanes propelled by ion propulsion systems that have no moving parts. This article by Steven Barrett's group shows a proof of concept on how a heavier than air craft can be propelled by ionic wind. From my understanding, it works by using high-voltage electrodes (20 kV+?) to ionize air (mostly N₂) and accelerate the ions across the electric field to the negative electrode. The thrust force is generated as a reaction to the motion of the ions. In their proof-of-concept tests, the craft traveled between 40-45 meters in 8-9s before turning the thruster off.

Today I also spent some time working on a computational fluid mechanics problem set for my Physics of Wind course. Given collected over a domain and assuming horizontally homogeneity I spatially averaged the data to study potential temperature and vertical velocity as a function of



altitude in the atmospheric boundary layer. One part of the assignment involves applying similarity relationships to estimate the convective velocity scale and the surface heat flux, but I am not exactly sure how to do that.

a



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