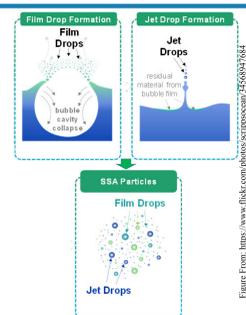


## Sea Spray Aerosols (SSA)

- Sea spray aerosols are a large source of key atmospheric aerosols (e.g., cloud condensation nuclei and ice nucleating particles)
- SSA occur when bubbles created by breaking waves burst at the ocean surface, by two different mechanisms:
  - Film drops- Dominant in larger bubble sizes (<1 micron SSA), produce smaller aerosols from the disintegration of the film covering the bubble
  - Jet drops- Created by 0.1 – 2 mm diameter bubble sizes (>1 micron SSA), produce larger aerosols from the jet that forms in the base of the cavity



## Ice Nucleating Particles (INPs) in SSA

- Water has two methods of forming ice crystals
  - Homogeneous Freezing- freezing of pure water ~ -38° C; rare in lower atmosphere
  - Heterogeneous Freezing- freezing with assistance of INPs; many different types of INPs, including organic and mineral species
- Oceans emit INPs in SSA, but their composition is unknown
- Birch pollen is a good source of INPs, so we used them as a proxy for SSA INPs
- This study investigated the difference between film and jet drop aerosol production, and how this controls the amount and size of INPs emitted



Birch pollen with sizing measurements  
Figure from: <http://www.microalgallery.com/BirchPollenFile.aspx>

## Bubbles Produced From Frits

**Frit A ~ 2.52 mm bubble diameter**  
Pore size: 145-174 µm  
Film Drops

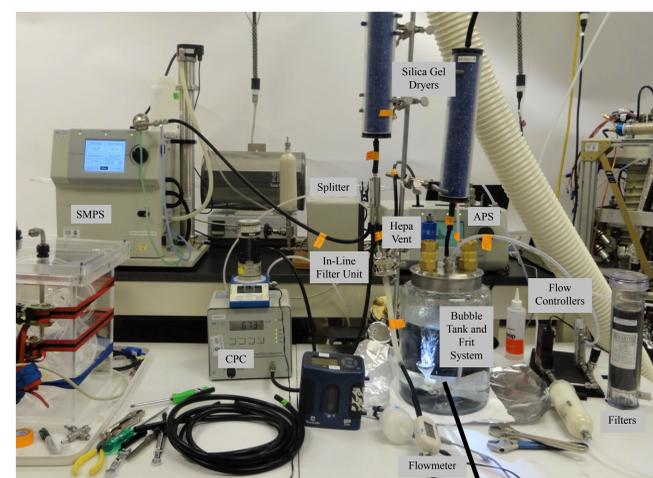
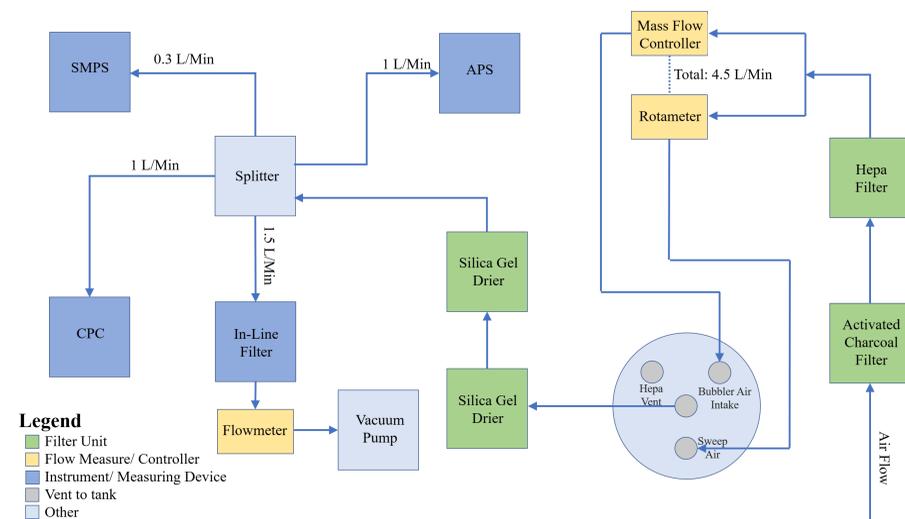
**Frit C ~ 0.635 mm bubble diameter**  
Pore size: 25-50 µm  
Jet and Film Drops

**Frit UF ~ 0.388 mm bubble diameter**  
Pore size: 0.9-1.4 µm  
Jet and Film Drops

- Frit constructed from funnel and in-line filter sealed together with epoxy
- Bubble diameter found using image analysis software

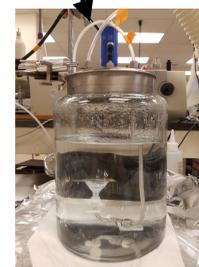
## Instrumental Setup

- Different size fractions of birch pollen were aerosolized in artificial seawater to test the efficiency of INP release as a function of bubble size
- SSA was generated using the 3 frit sizes, dried using diffusion driers, and then the size distribution and INP concentrations were measured
- The aerosols were split 4 ways:
  - The SMPS (Scanning mobility particle sizer) and APS (aerodynamic particle sizer) were used to size the particles; the SMPS is used from 20-600 nm and the APS is used from 600-15,000 nm
  - The CPC (Condensation particle counter) counted particles generated by frit
  - The in-line filter unit was used to SSA to measure INP number concentrations

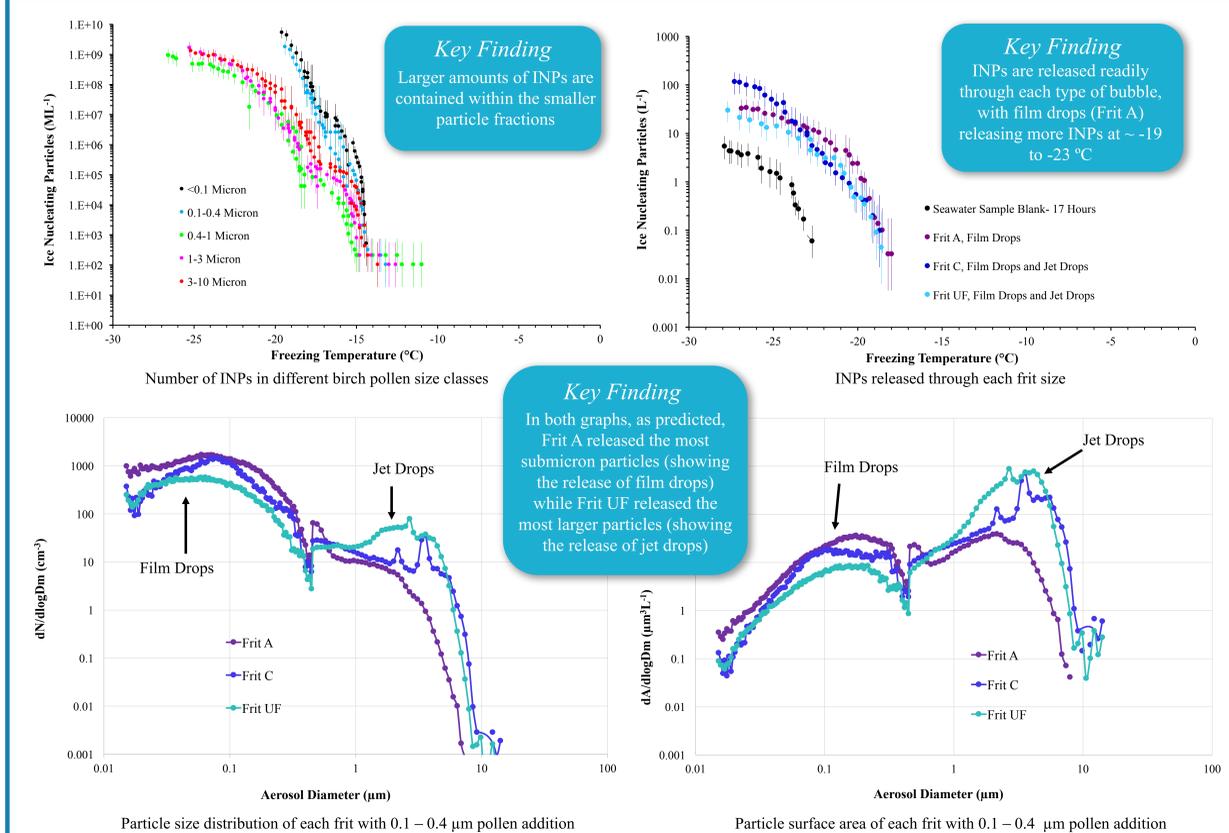


## Salt Water Preparation

- Salt water was mixed using Neomarine Seawater Salt Blend and distilled water (DI water)
- Salt solution filtered through a 0.22 micron filter then run twice through a hepa-carbon filter to remove organic contaminants and any particulates



## Data and Results



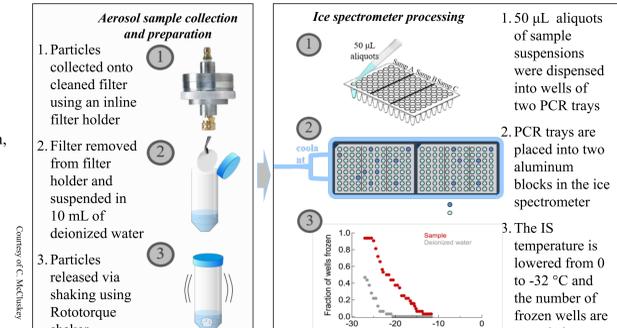
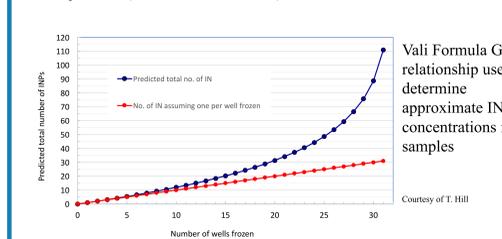
## Size-Fractioning Pollen

- 0.06 g of pollen was diluted with 50 mL of DI water
- Pollen sample run through filters of decreasing size: 10, 3, 1, 0.4, and 0.1 µm. The filtrate of <0.1 µm was also retained



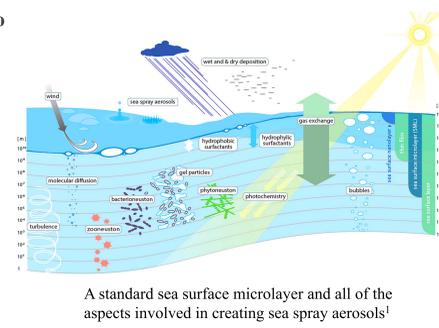
## The Ice Spectrometer

- Ice Spectrometer used to analyze INP concentrations in aerosol filters collected from frit system (in-line filter unit)



## Future Work

- Other pollen sizes measured to determine influence of bubble type
- Test other INPs with varying size and characteristics (e.g. Snomax)
- Simulated or real sea surface microlayers (SSML) added to determine effect on SSA formation and sizing



## References

- <sup>1</sup>Engel, A. et al. *Front. Mar. Sci.* **2017**, *4*(165), 1. Background: Deane, G. and Stokes, D. *Nat.* **2002**, *418*, 839. DeMott, P. et al. *PNAS.* **2009**, *107*(25), 11217. Wang, X. et al. *ACS Cent. Sci.* **2015**, *1*(3), 124.

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