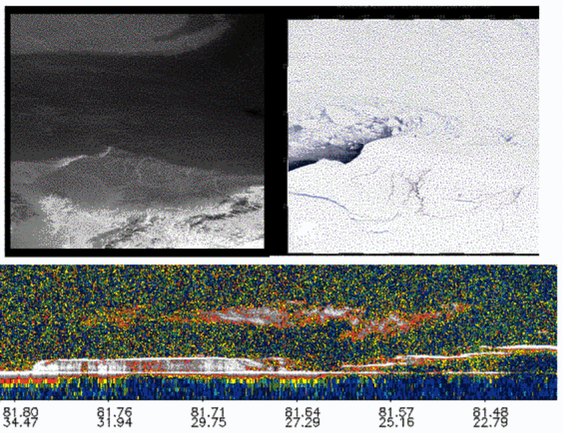

The Role of Radiative-dynamic Feedbacks in Amplifying Surface Warming by Arctic stratus under Polluted Conditions

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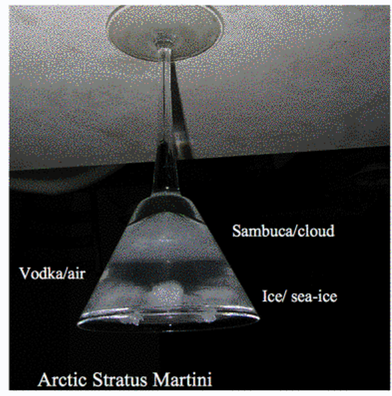
Chuanfeng Zhao, *Lawrence Berkeley Labs*



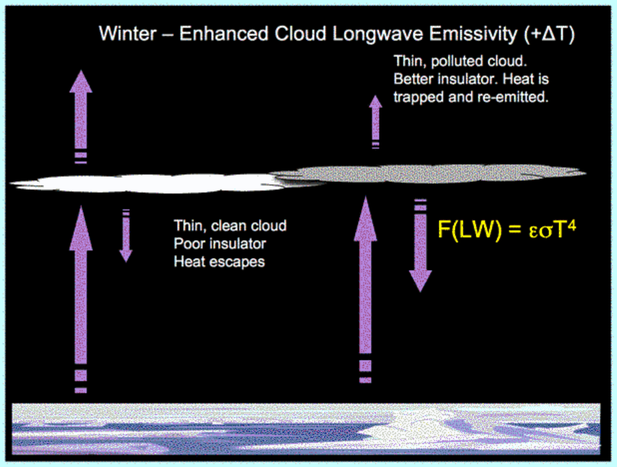
Goals

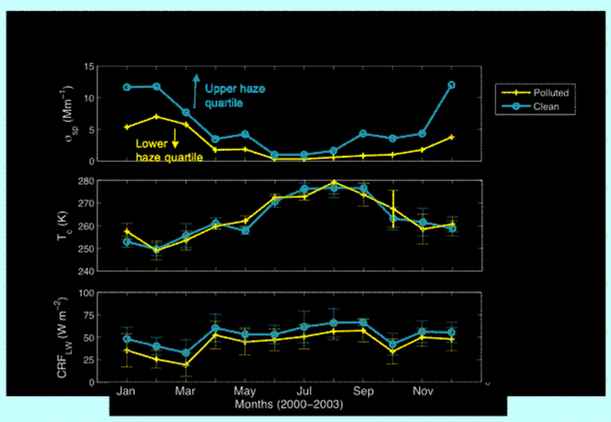
The aim of this project is to examine how pollution and Arctic Stratus interact to modify arctic sea-ice melting. Thermal radiative cooling is known to drive stratiform cloud dynamics. Pollution is argued to increase cloud thermal emission. We hypothesize that pollution should

- ***Increase the efficiency of cloud development***
- ***Contribute to arctic surface warming***

Introduction

Transport of pollution from mid-latitudes to the Arctic is proposed to increase arctic stratus droplet concentrations and decrease droplet radii. This is expected and observed to lead to greater cloud thermal emission, and possible accelerated sea-ice melting.

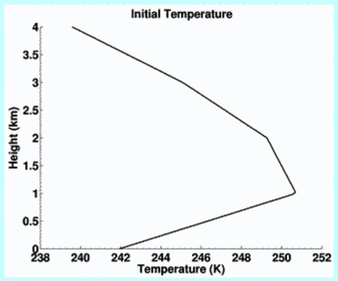


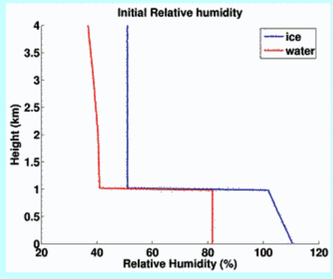


As seen in ground based measurements from Barrow AK, longwave cloud radiative forcing (CRF) is higher when clouds are in the presence of higher haze levels

Numerical experiment setup

- **Used a LES cloud-resolving-model at 30 m resolution (Zulauf, 2001)**
- **Allowed a 1 km deep moist arctic boundary layer to cool radiatively until cloud formed at 44 hours.**

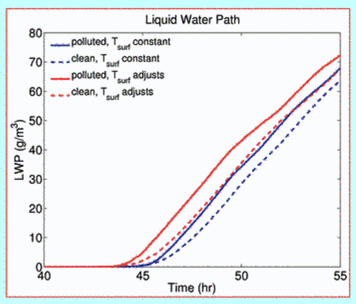


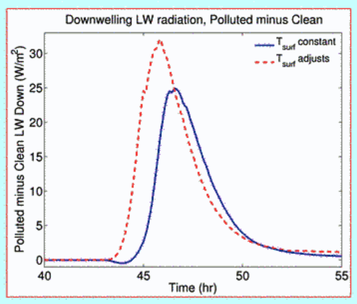


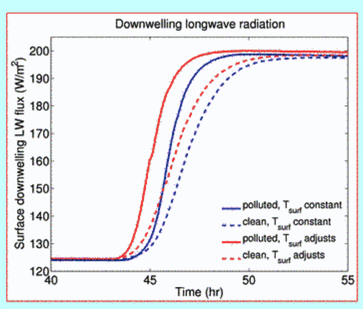
- **"Clean cloud" had 12 micron droplets; "Polluted" cloud had 6 micron droplets. No precipitation in model runs.**
- **Tracked cloud evolution for clean and polluted cases allowing for**
  - **no surface temperature adjustment to enhanced downwelling longwave fluxes (not realistic)**
  - **or, instantaneous temperature adjustment to enhanced downwelling longwave fluxes (more realistic)**

Results

- **Cloud forms after approximately 44 hours cooling of the moist boundary layer and from there on the cloud deepens**
- **Polluted cloud with smaller droplets develops sooner**
- **Allowing the surface temperature to more realistically adjust does not change the character of development, and only slightly changes its timing**
- **Downwelling surface IR fluxes are higher for polluted cases, but the difference is transient**



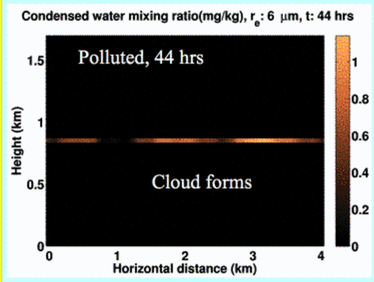


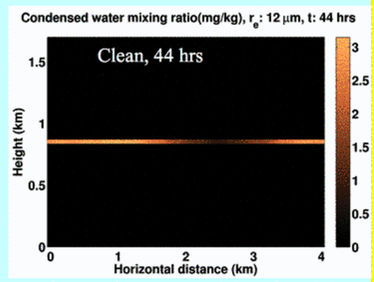


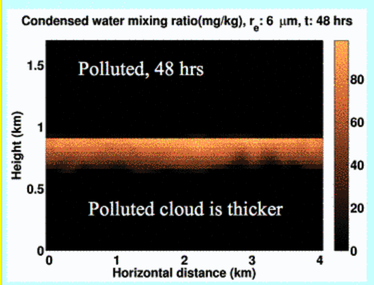
Summary

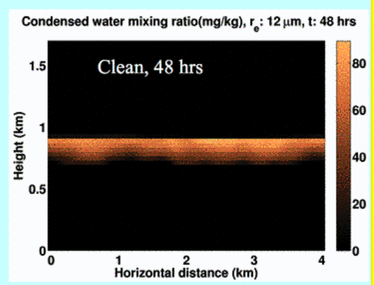
- **Observations suggest that pollution is associated with amplified longwave cloud radiative surface heating in the Arctic**
- **The radiative effect is reproduced in numerical experiments, independent of whether or not surface temperature is allowed to adjust to the increased flux.**
- **The effect is large, but transient - whether polluted or clean, the cloud eventually becomes a black-body**
- **Next step: allow for precipitation to permit thin, more realistic, equilibrium clouds**

Condensate cross-sections









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