

Indirect and Semi-Direct Aerosol Campaign (ISDAC)

The Influence of Arctic Aerosol on Clouds

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Retrievals: Connor Flynn, Dan Lubin, David Mitchell, Rich Ferrare, Matthew Shupe, David Turner, Mengistu Wolde

Modeling: Mikhail Ovtchinnikov, Shaocheng Xie, Ann Fridlind, Xiaohong Liu

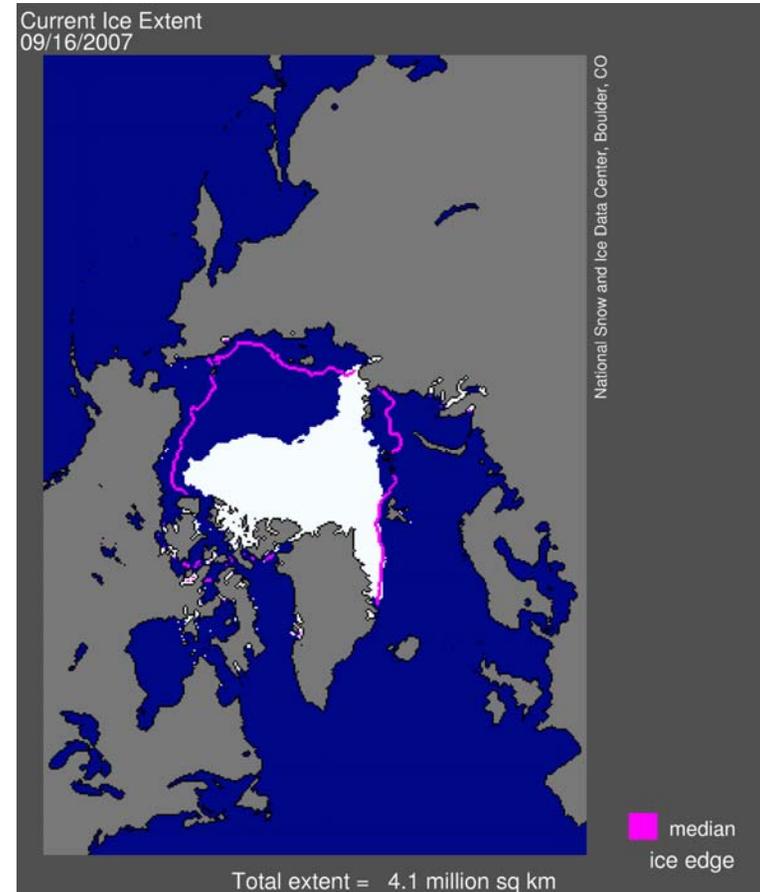
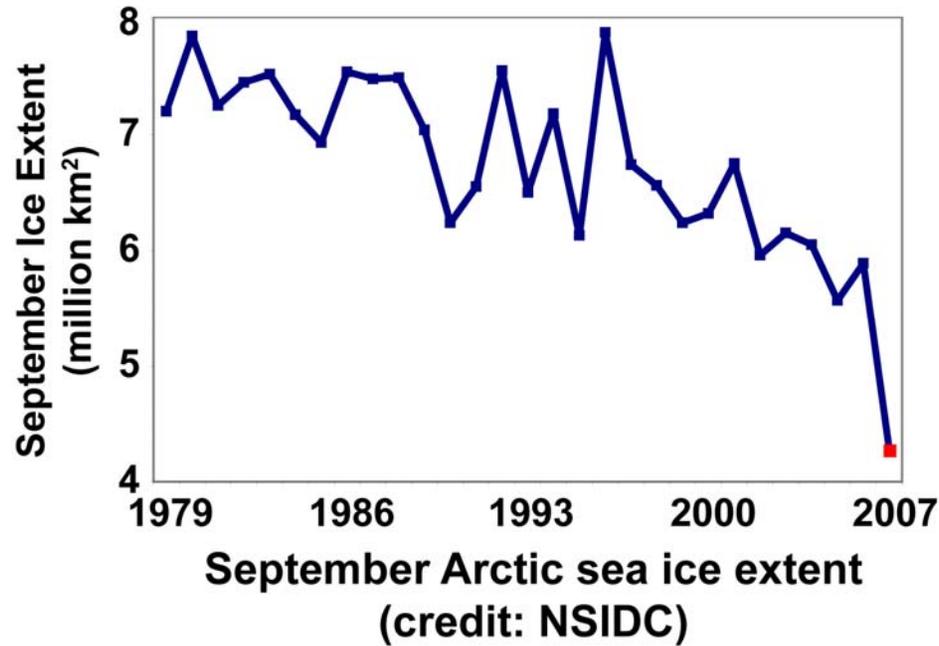
Barrow, Alaska April 2008



<http://acrf-campaign.arm.gov/isdac/>

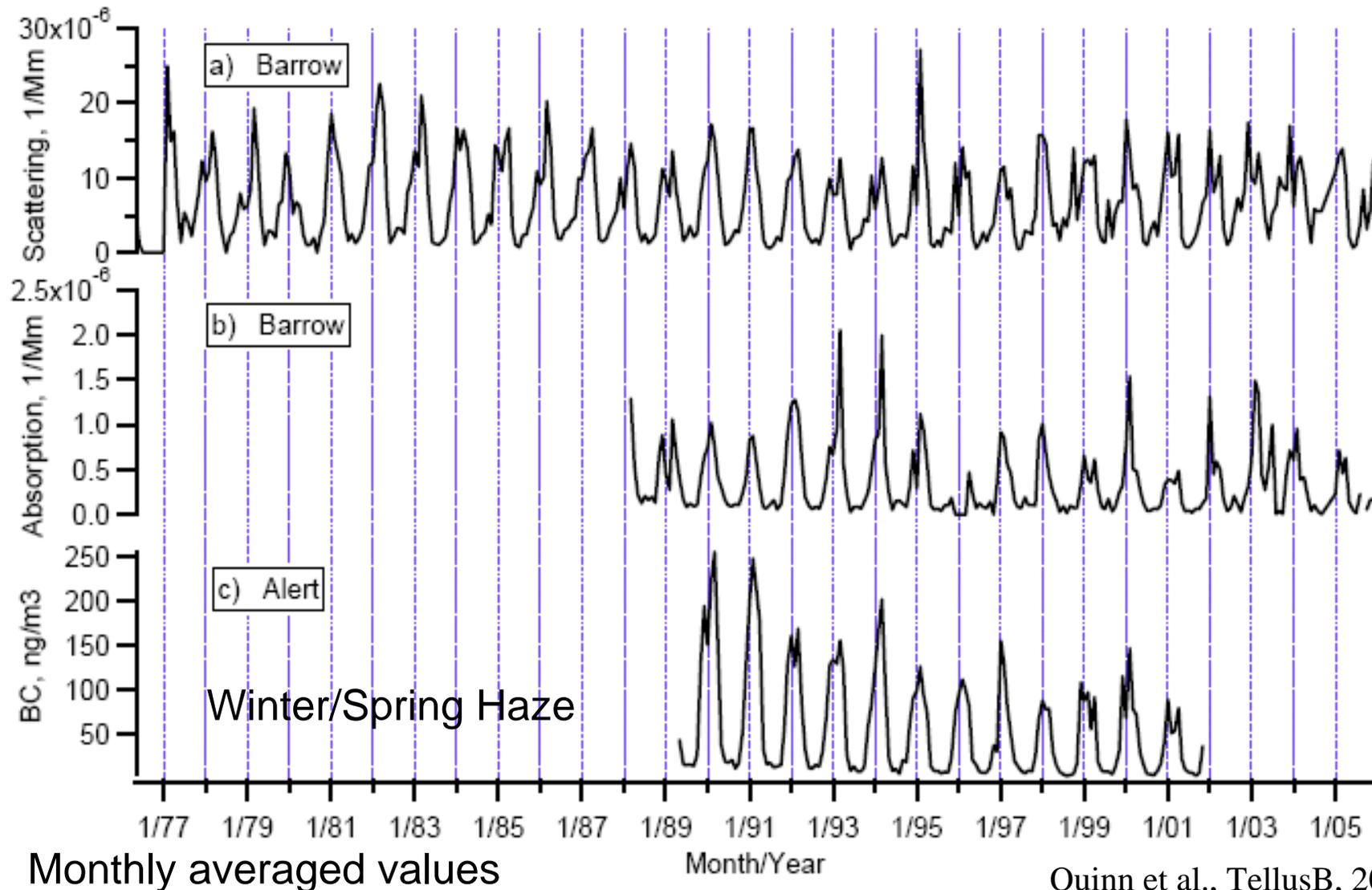


2007 Record Minimum Arctic Sea Ice Extent

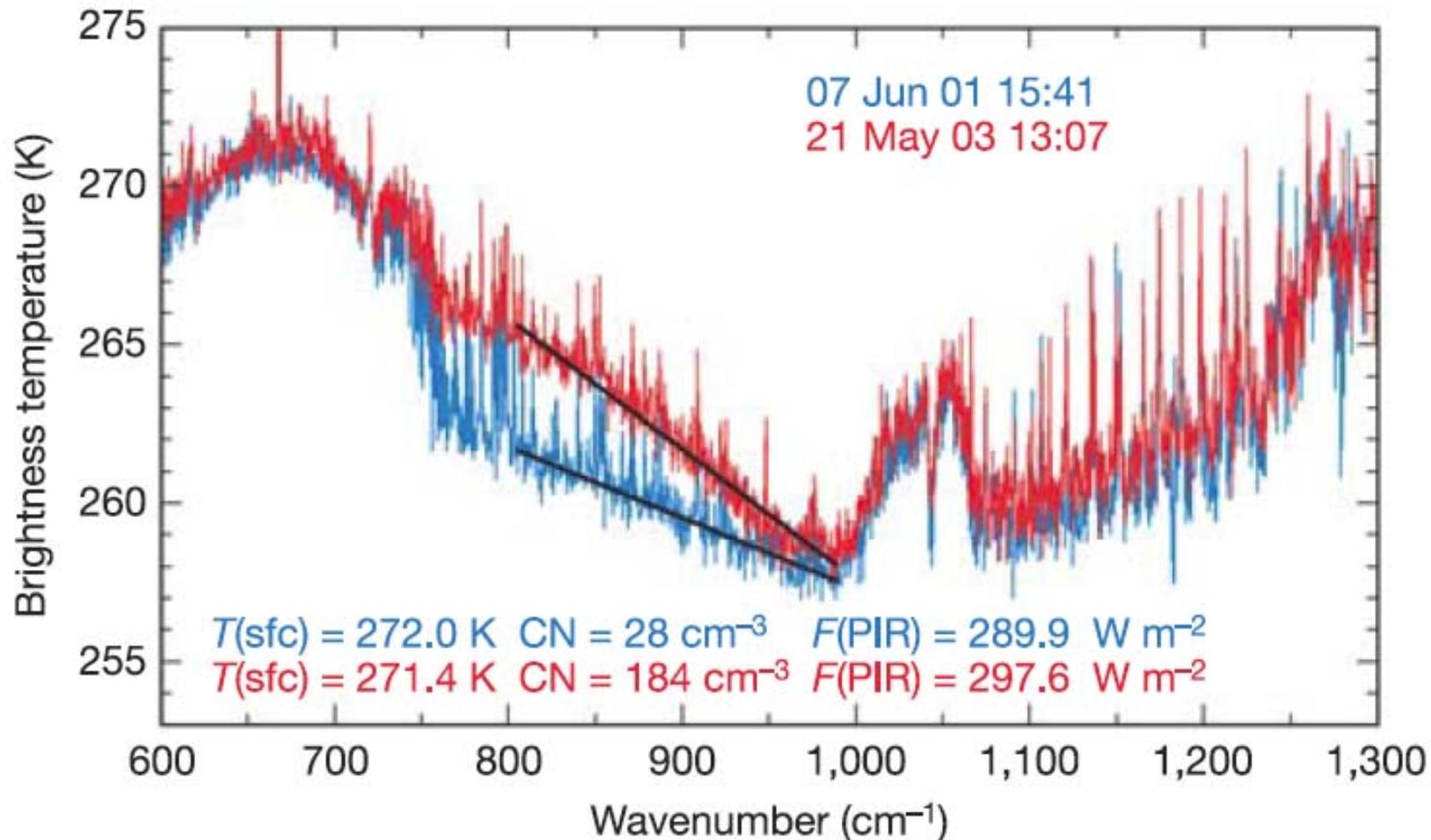


Credit:
NSIDC

Seasonality of Arctic Aerosol



Long-wave Aerosol Indirect Effect Observed at ARM NSA Barrow



Lubin & Vogelmann, Nature 2006

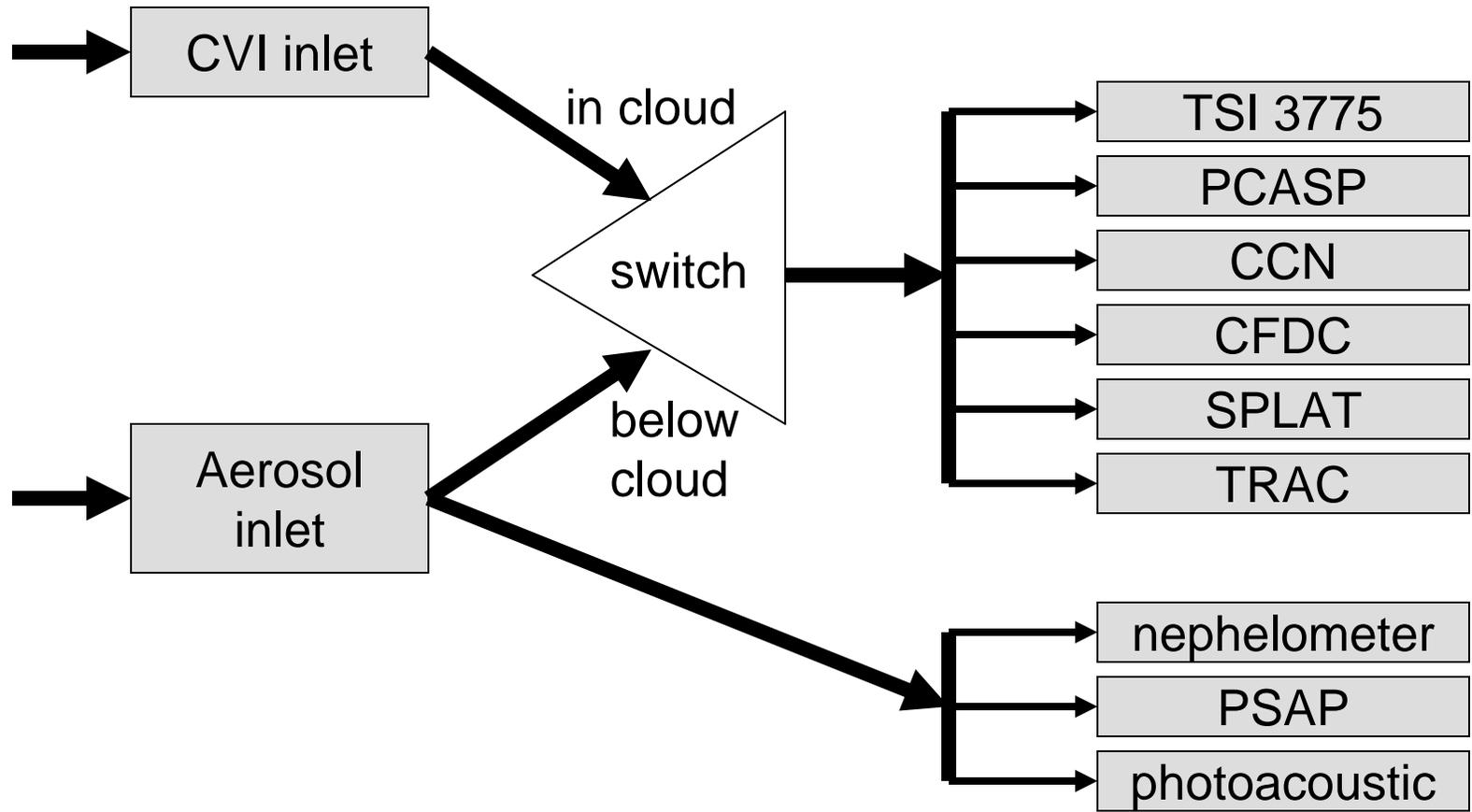
Key ISDAC Issues

1. How do properties of the Arctic aerosol during April differ from those measured by M-PACE during October?
2. To what extent do different properties of arctic aerosol during April produce differences in microphysical and macrophysical properties of clouds and the surface energy balance?
3. How well can cloud models and parameterizations used in climate models simulate the sensitivity of Arctic clouds and the surface energy budget to the differences in aerosol between April and October?
4. How well can long-term surface-based measurements at the ACRF Barrow site provide retrievals of aerosol, cloud, precipitation and radiative heating in the Arctic?

ISDAC Observations (~42)

- **temperature**
- **dew-point temperature**
- **total particle concentration**
- **aerosol size distribution (0.01-3 μm)**
- **size-resolved aerosol hygroscopicity (0.02-0.6 μm)**
- **cloud condensation nuclei concentration**
- **ice nuclei concentration**
- **single particle composition**
- **optical scattering by aerosol (neph/3- λ PA)**
- **optical absorption by aerosol (PSAP/3- λ PA)**
- **vertical velocity**
- **cloud liquid water content**
- **total cloud water content**
- **cloud particle size distribution (0.5-2500 μm)**
- **cloud particle image (15-2500 μm)**
- **cloud extinction**

Aerosol Instrument Configuration



Applications

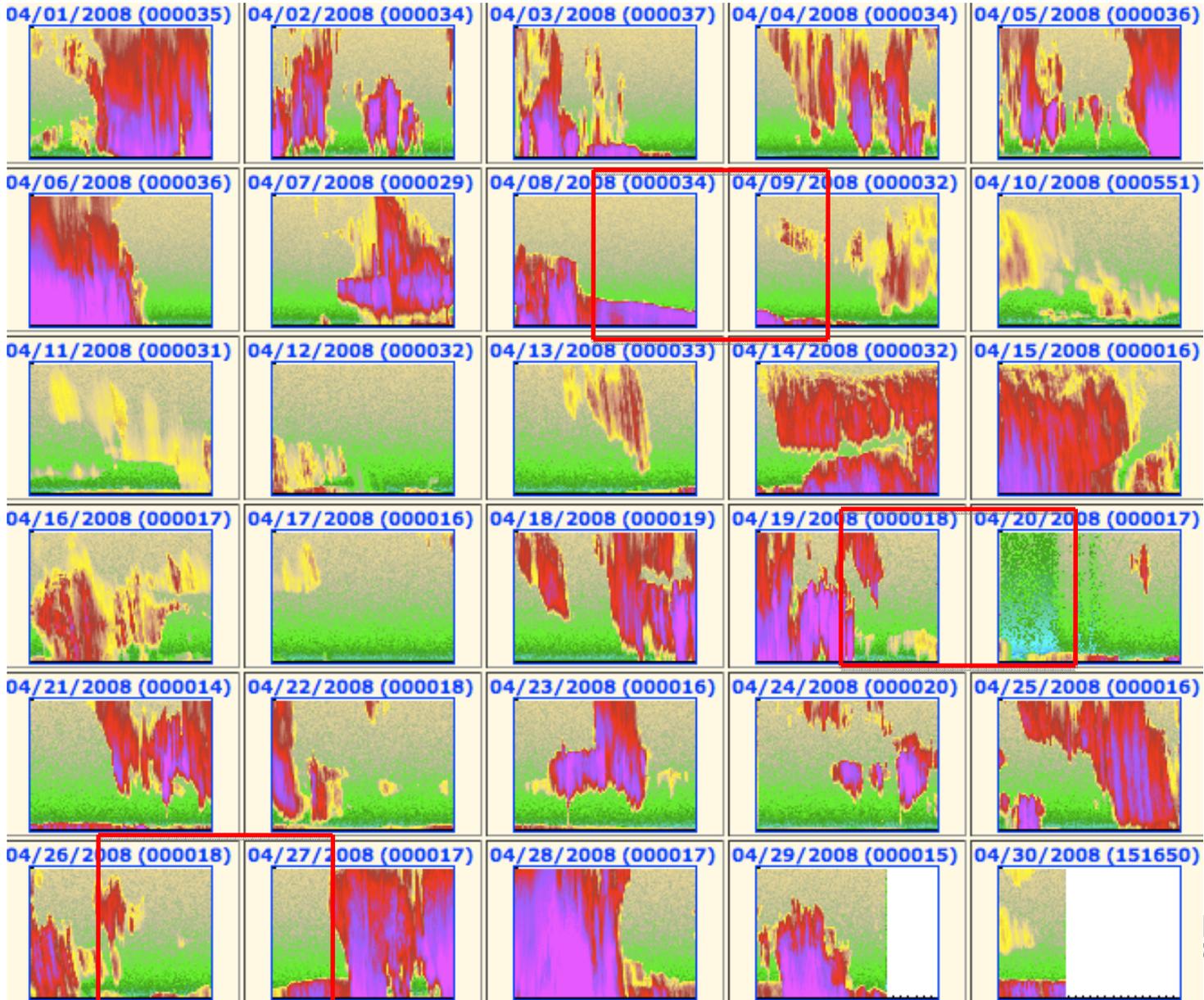
- ▶ CCN closure
- ▶ Droplet number closure
- ▶ Aerosol extinction closure
- ▶ Cloud extinction closure
- ▶ Cloud water closure
- ▶ **Cloud modeling**
- ▶ Semi-direct effect
- ▶ Crystal nucleation
- ▶ Aerosol extinction retrieval
- ▶ CCN retrieval
- ▶ MMCR retrievals
- ▶ MWR retrievals
- ▶ AERI retrievals
- ▶ ASD retrievals

ISDAC Flights Summary

- ▶ 27 project sorties representing 103.6 hours of data on 12 different flight days
- ▶ Golden days with single-layer stratocumulus on 8 and 26 April when 3 sorties flown
- ▶ Heavily polluted day on 19 April
- ▶ Instrument performance for most part excellent

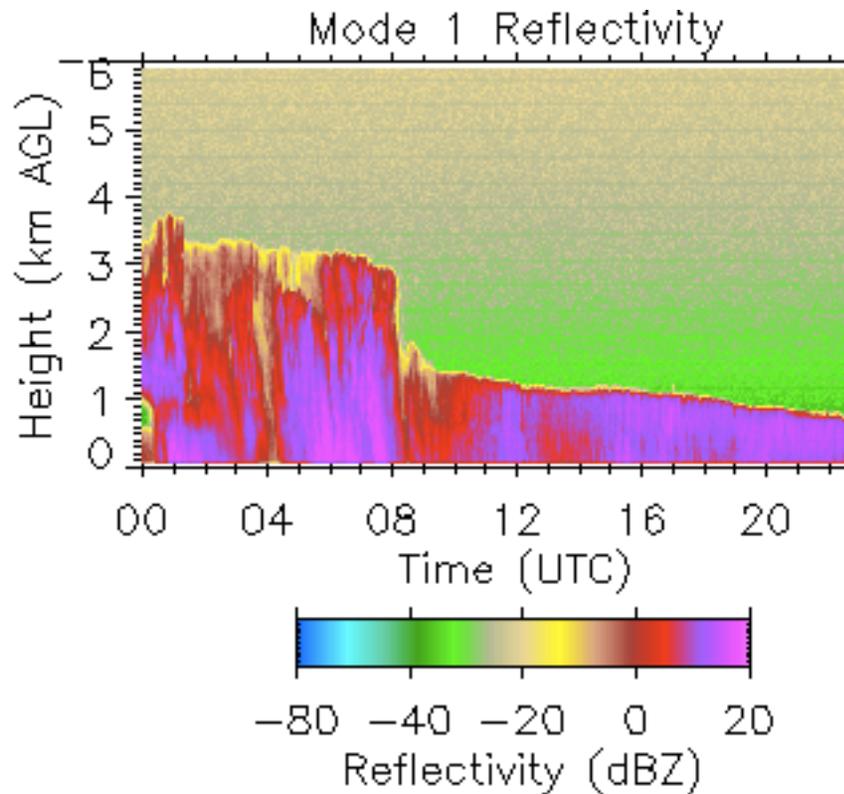


Cloud Radar Reflectivity

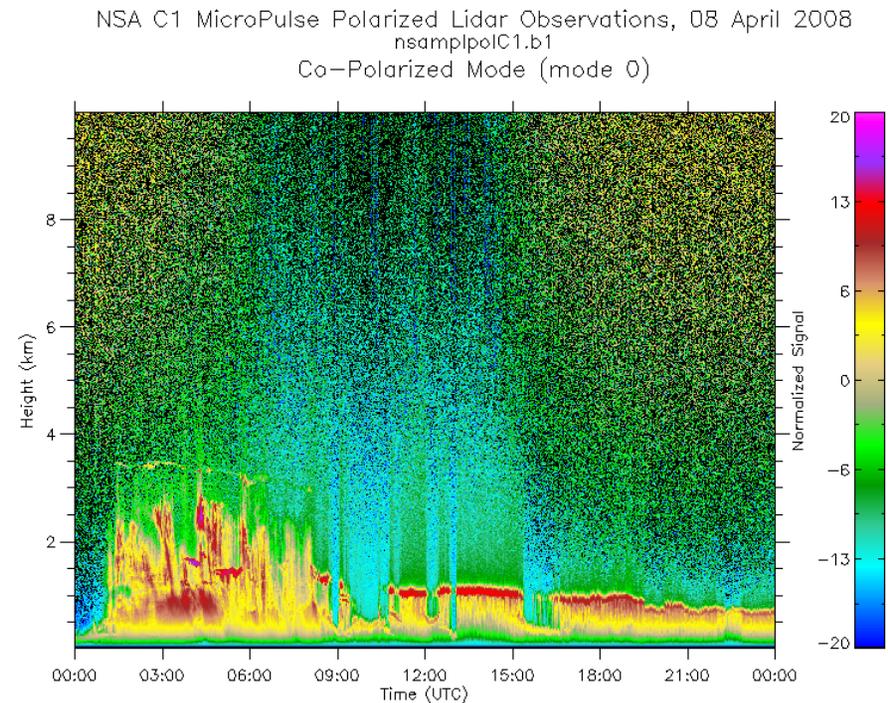


April 8

MMCR Reflectivity



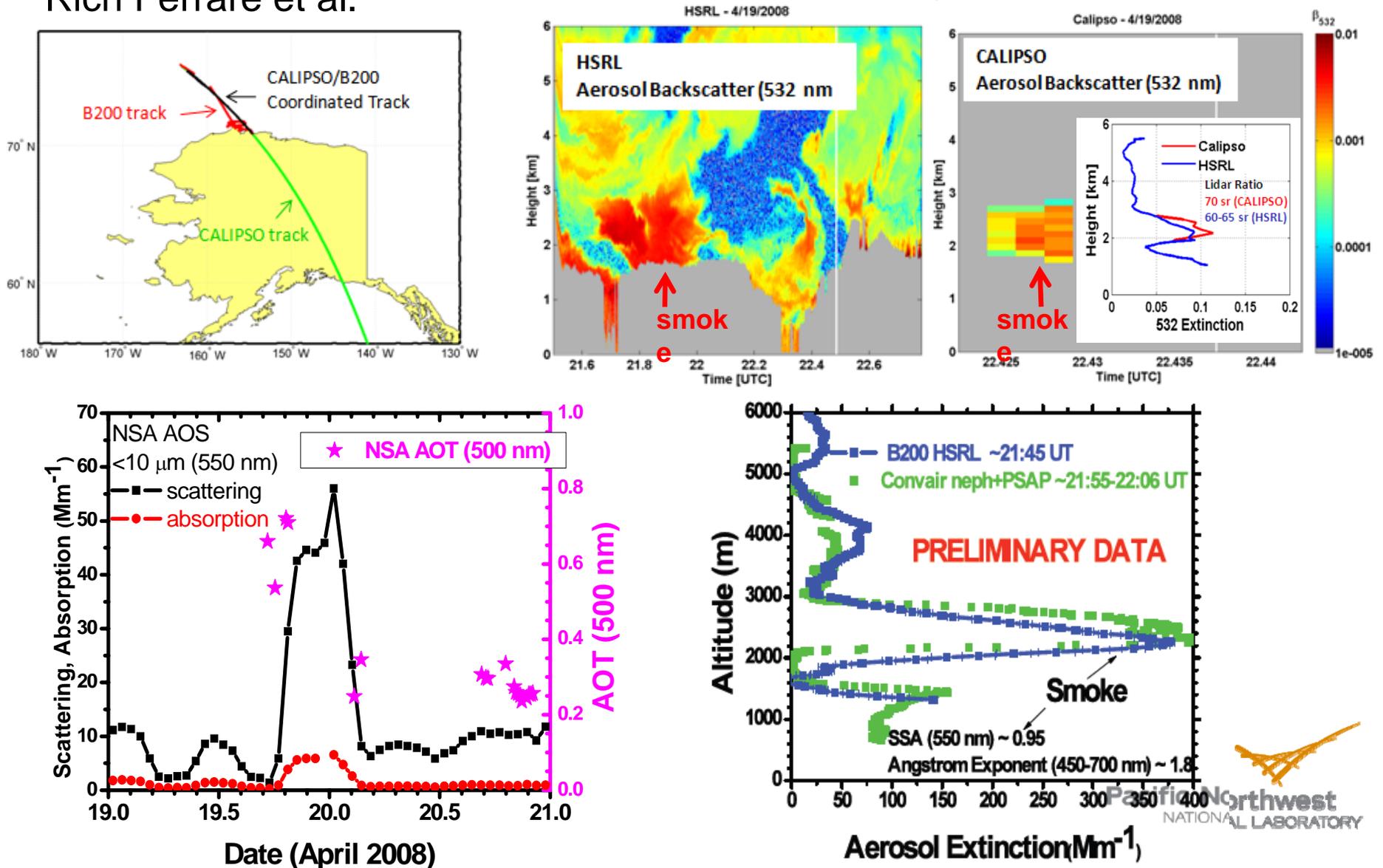
MPL Co-Polarized Mode



CALIPSO Validation During ARCTAS/ISDAC

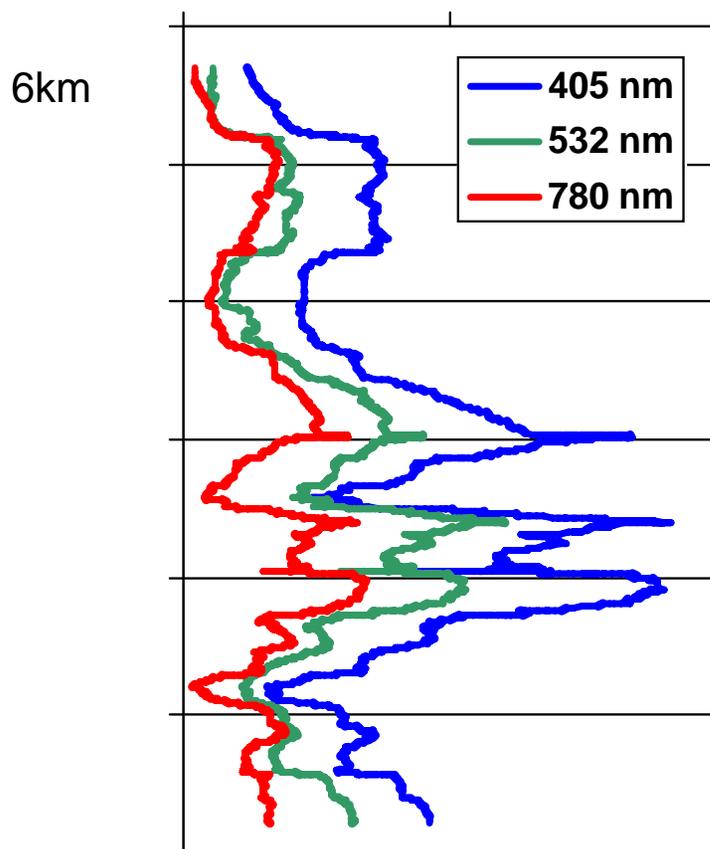
Example – April 19 – Siberian Forest Fire

Rich Ferrare et al.

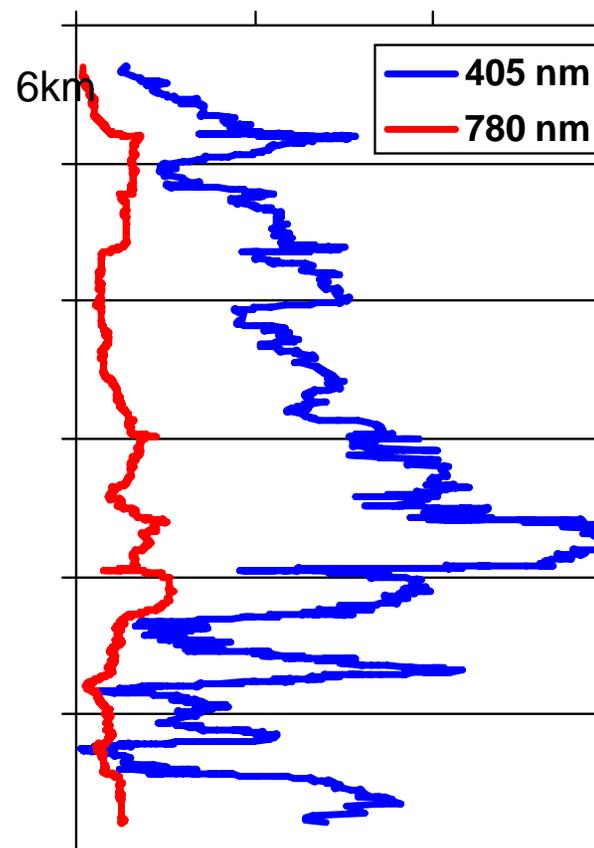


Los Alamos 3-Laser Photoacoustic Absorption and Scattering 405, 532, 781 nm

Scattering Mm^{-1}

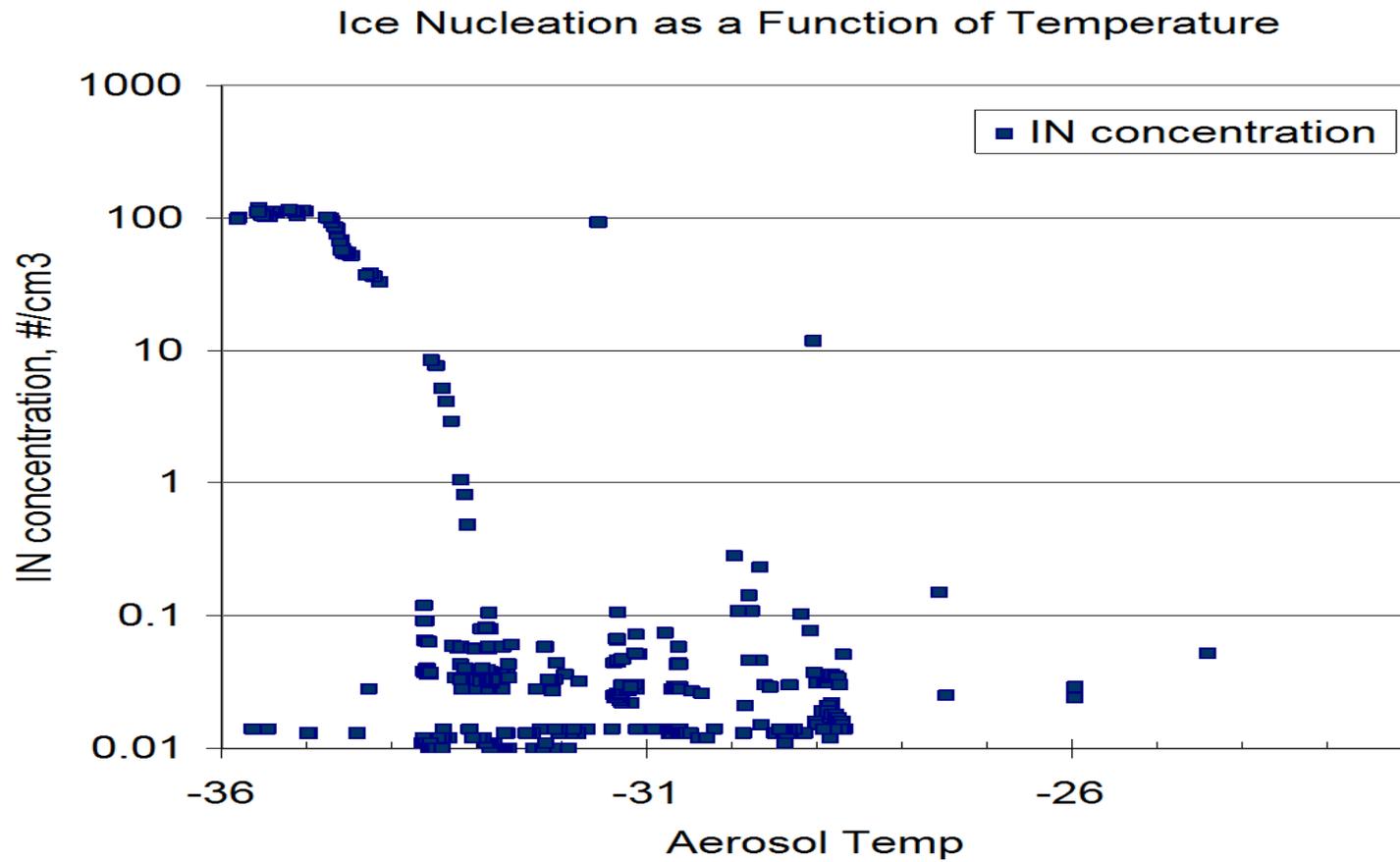


Absorption Mm^{-1}



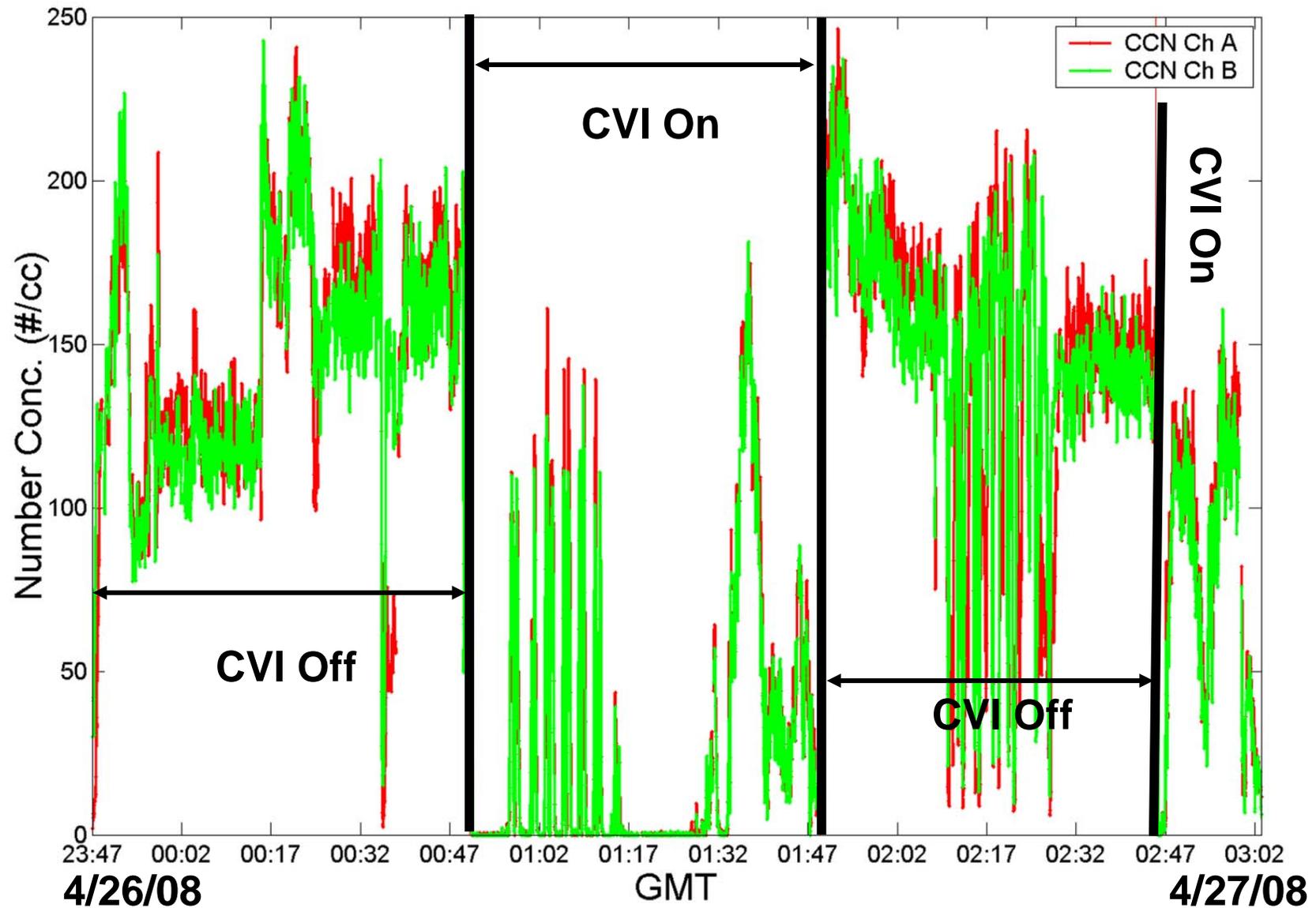
IN measurements

Sarah Brooks

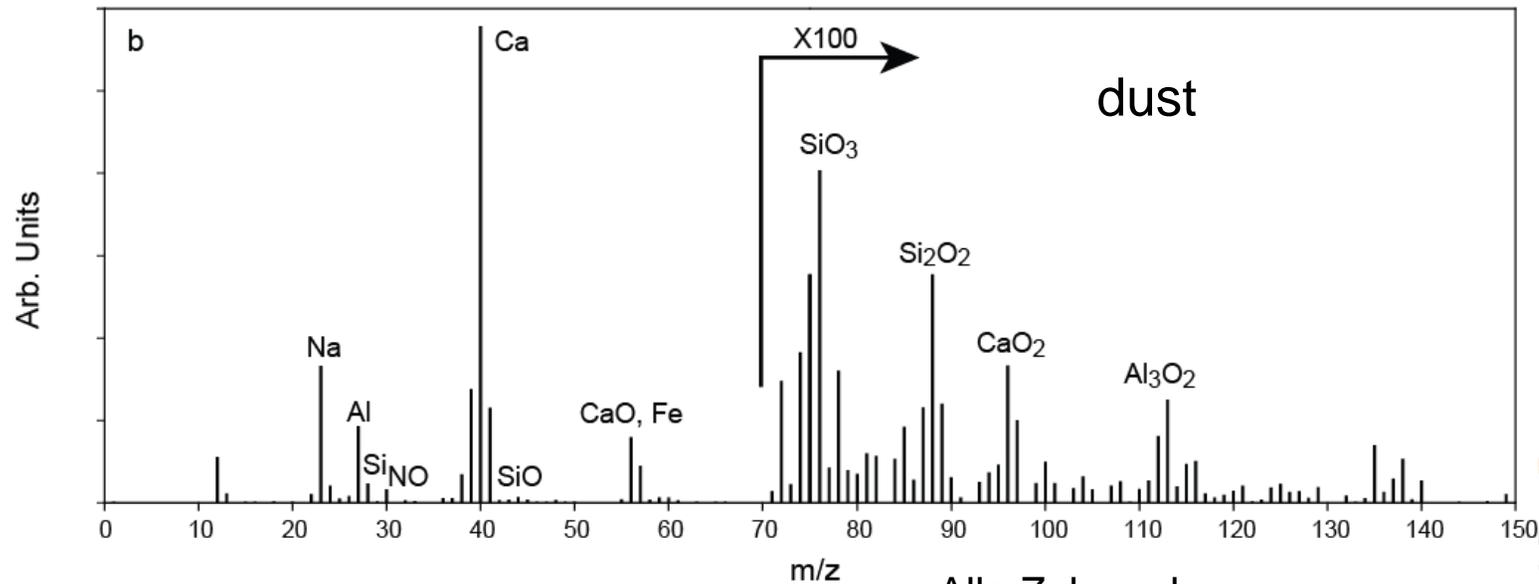
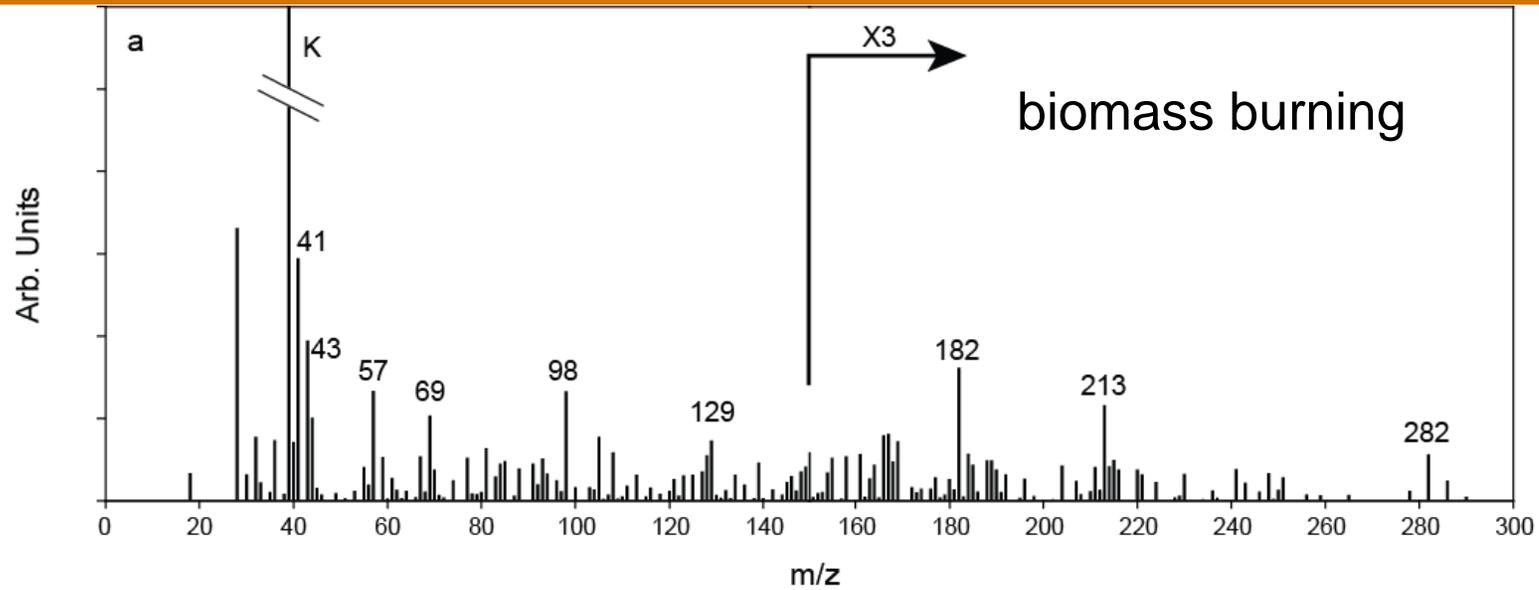


CCN Concentrations

Alex Laskin and Ryan Moffet



Aerosol composition from mass spectra



Alla Zelenyuk

Particle Composition Classification

Composition of 140,000 particles

We classify the mass spectral data and display the results in a circular dendrogram that is exploreable.

The data for flights 25 and 26 show that the vast majority of the particles fits into 5 major types:

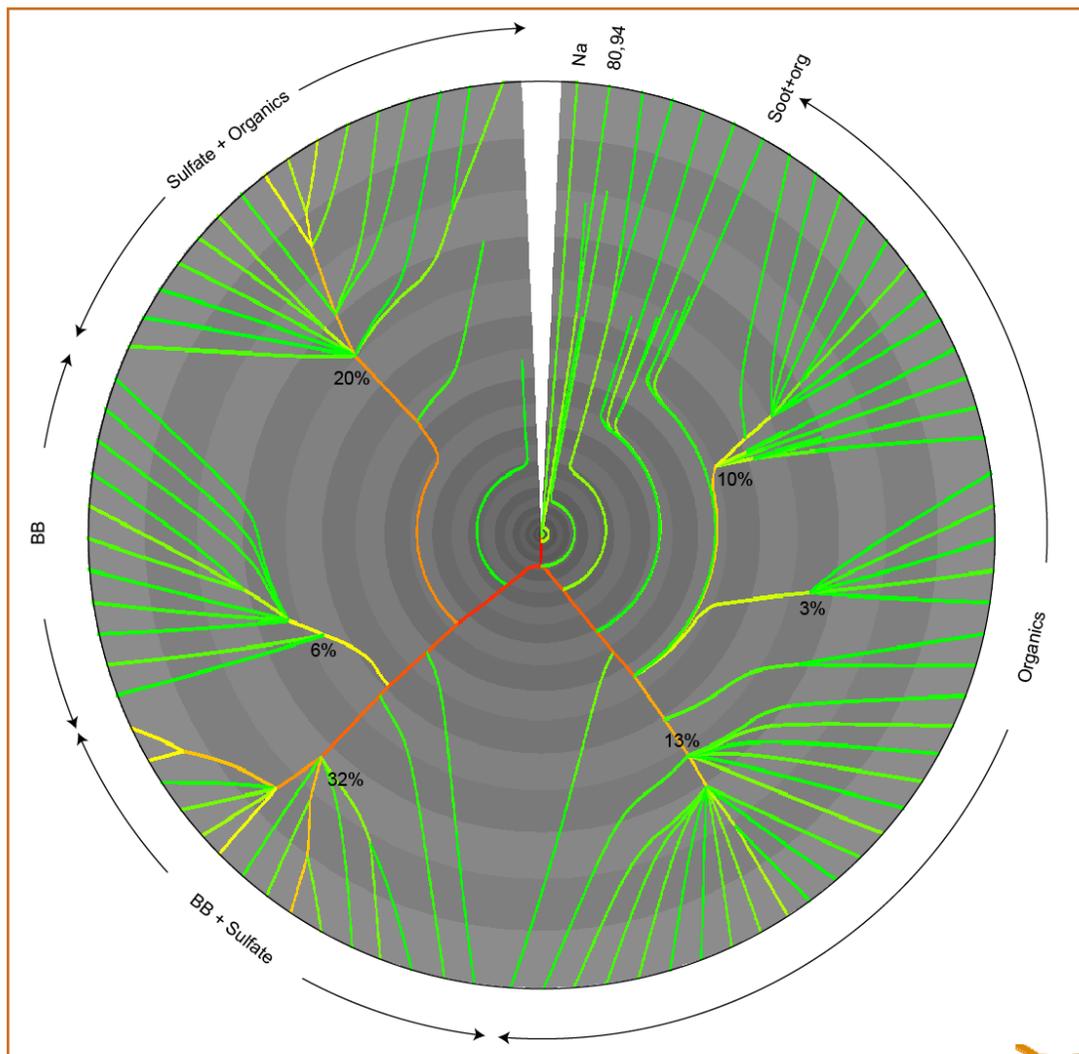
sulfate with some organics

BB

BB with sulfate

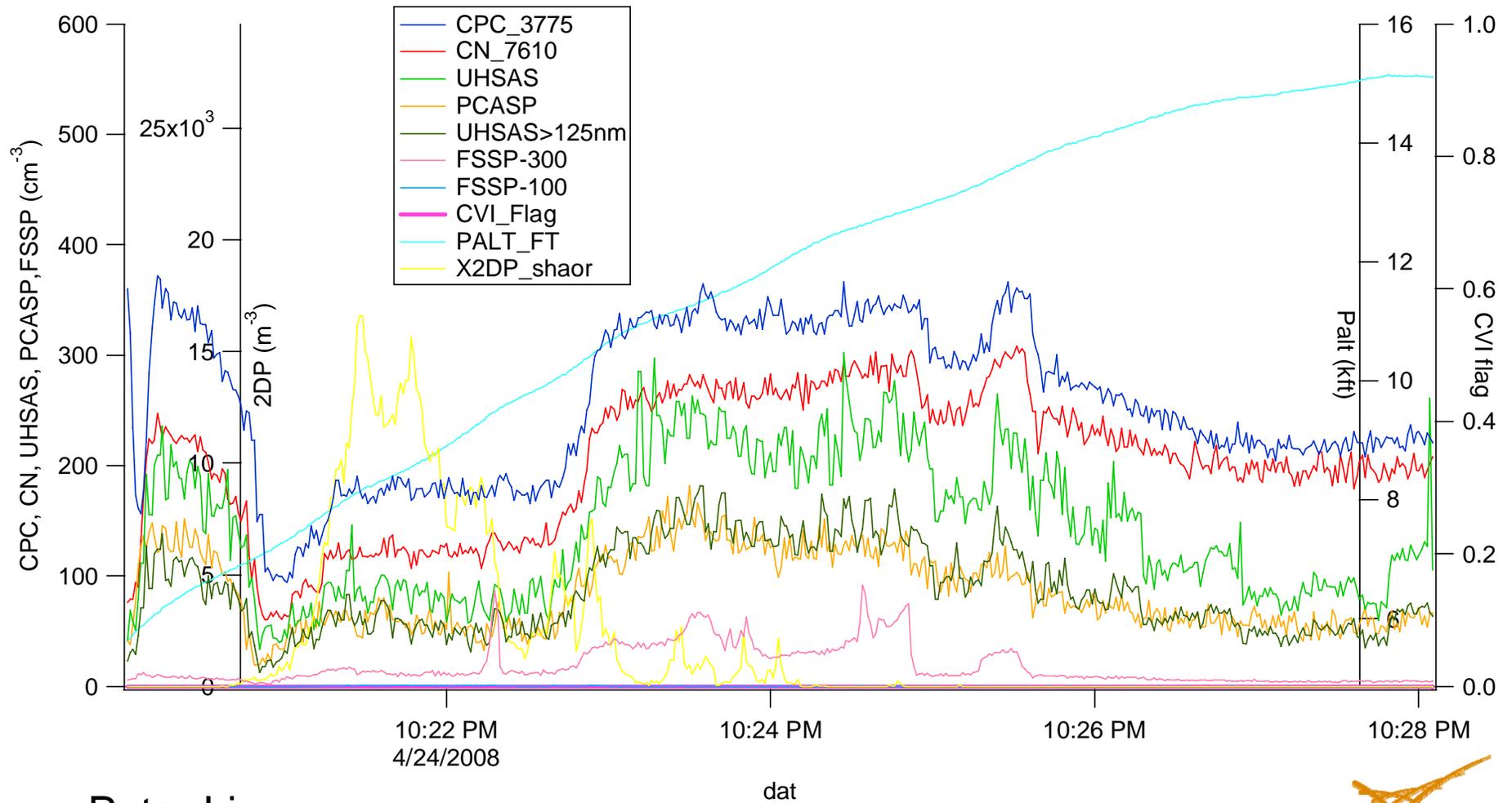
Organics

Others



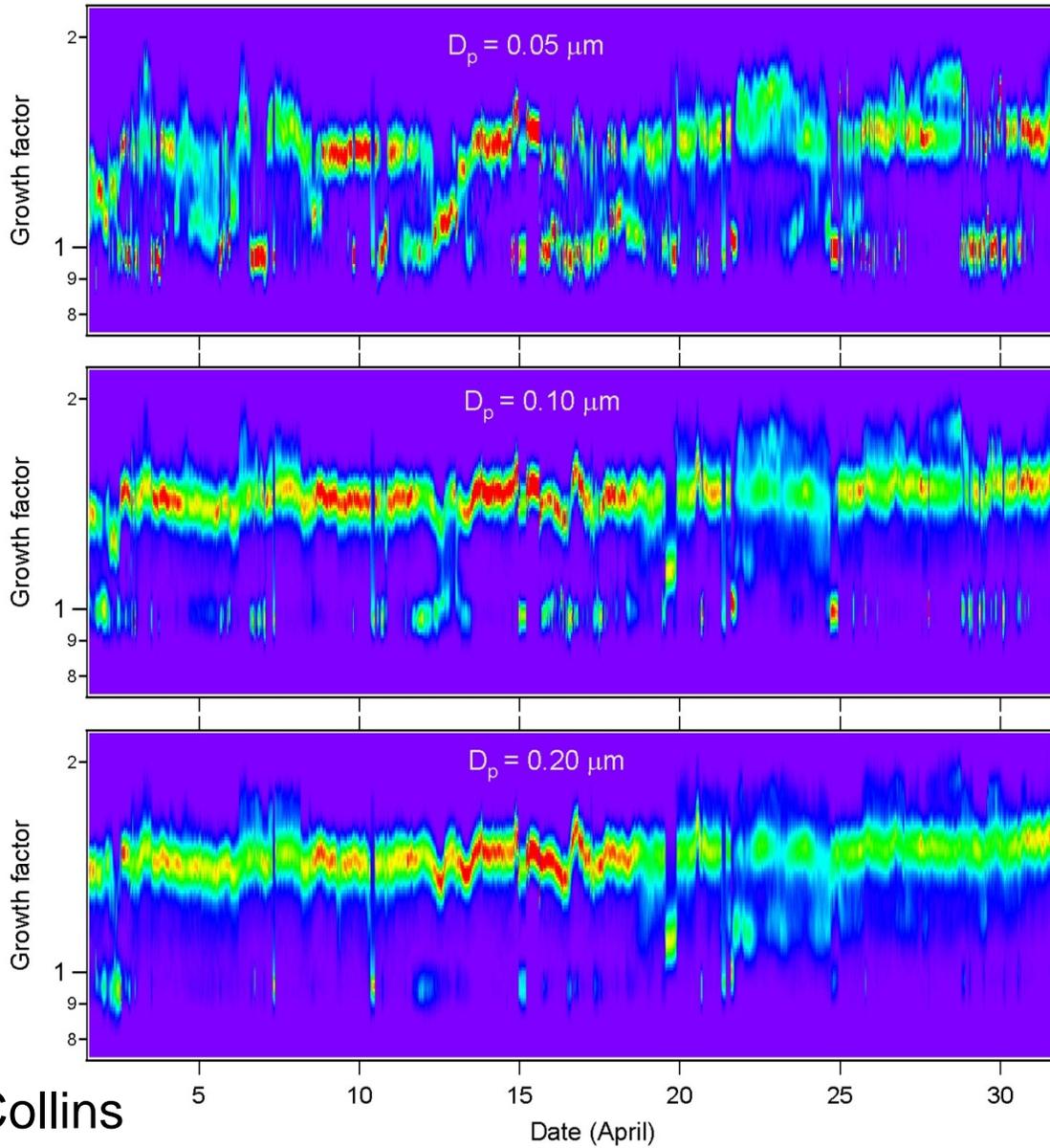
Alla Zelenyuk

Aerosol Number from Aircraft



Peter Liu

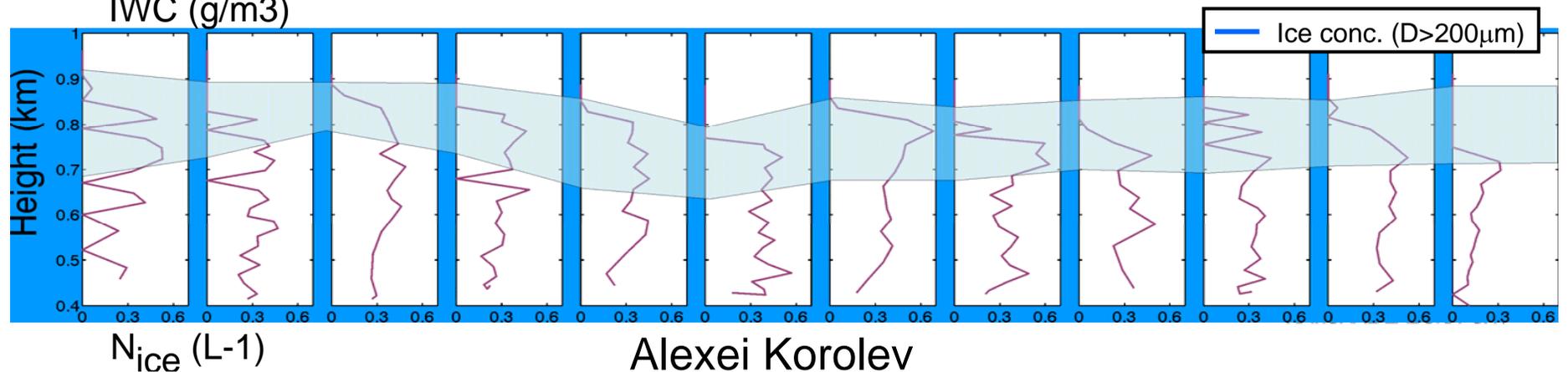
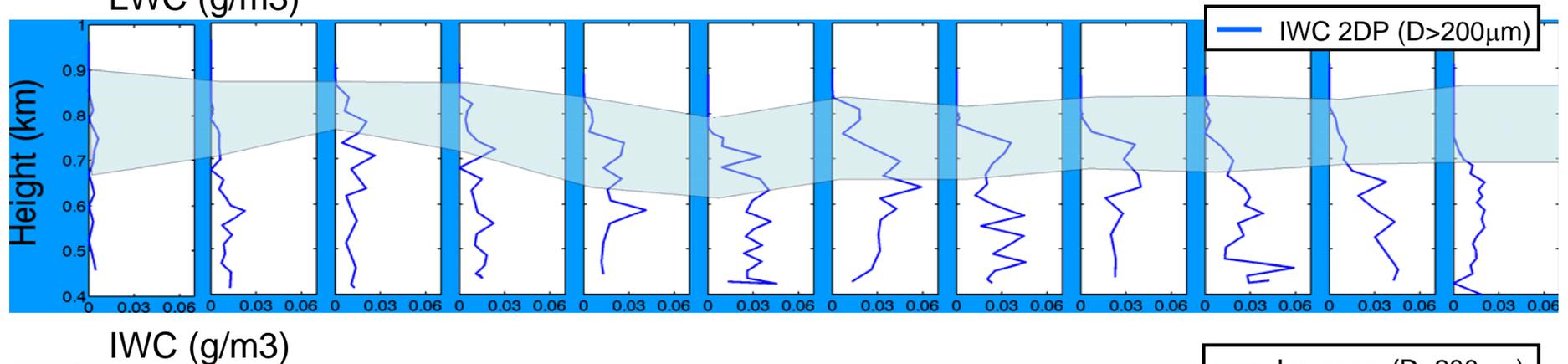
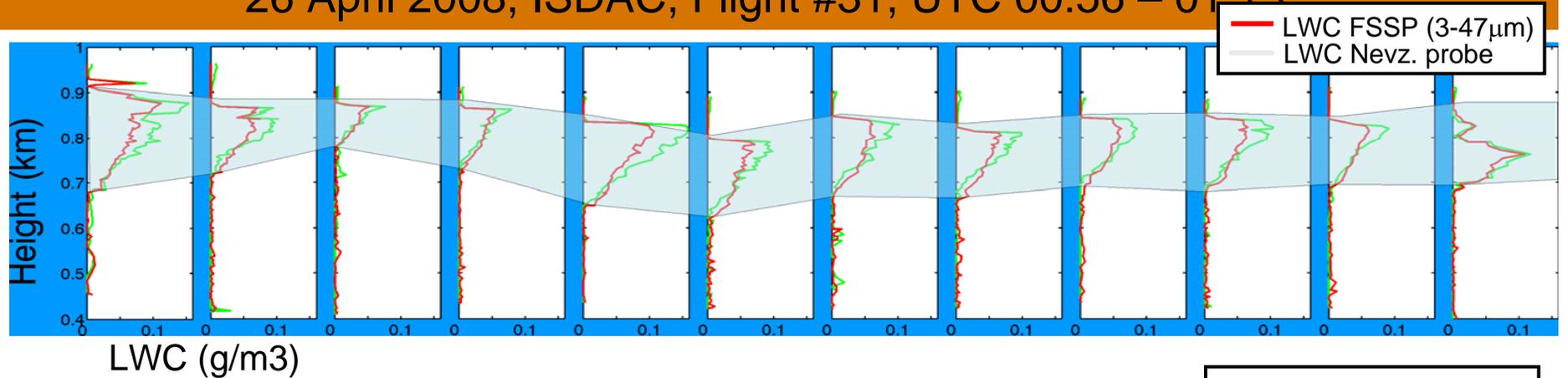
Aerosol Hygroscopicity



Don Collins

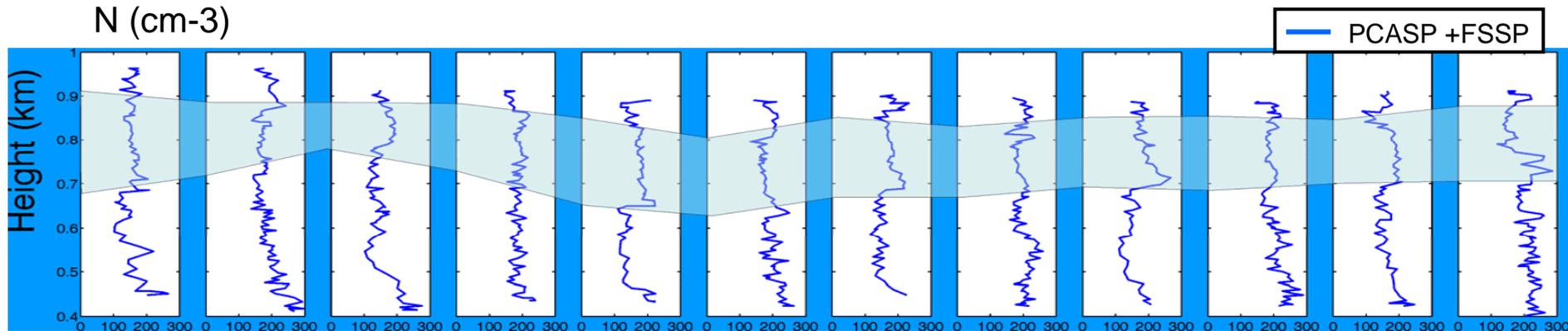
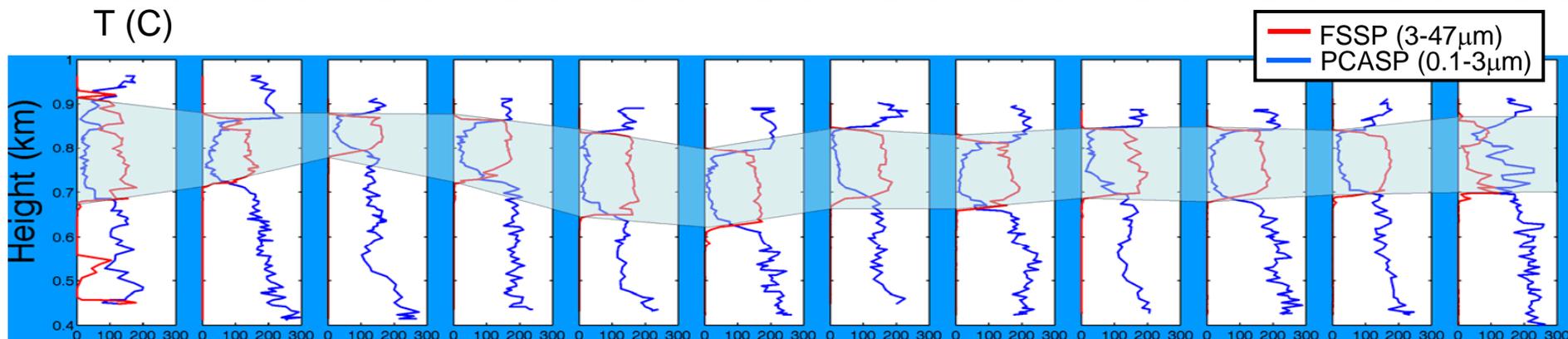
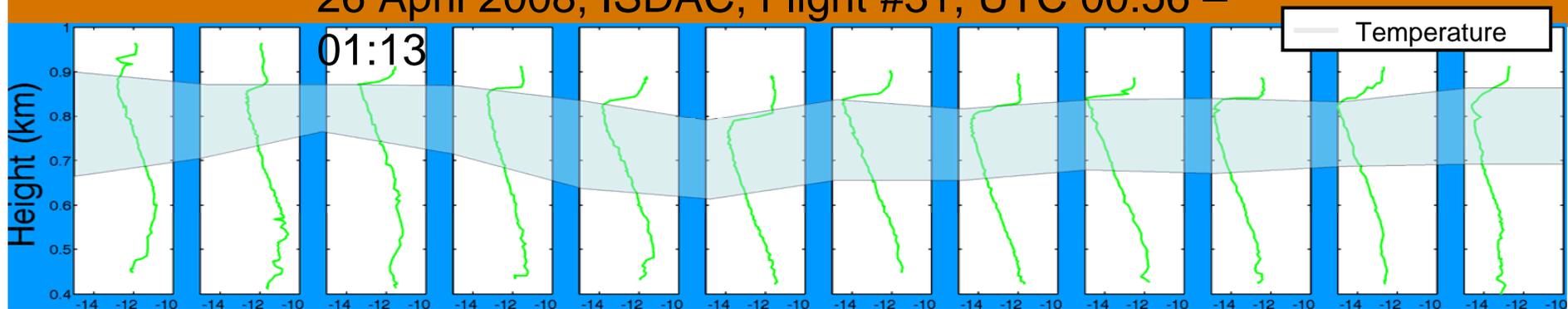
Bulk cloud properties

26 April 2008, ISDAC, Flight #31, UTC 00:56 – 01:13



Droplet and Aerosol Number

26 April 2008, ISDAC, Flight #31, UTC 00:56 –



NATIONAL LABORATORY

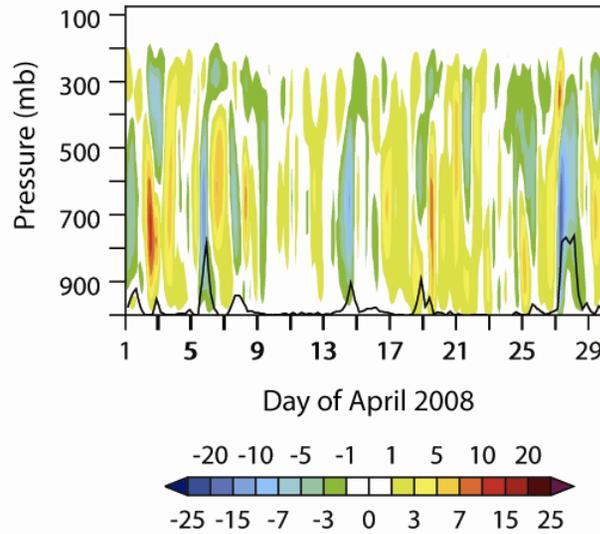
$N_d + N_a$ (cm⁻³)

Alexei Korolev

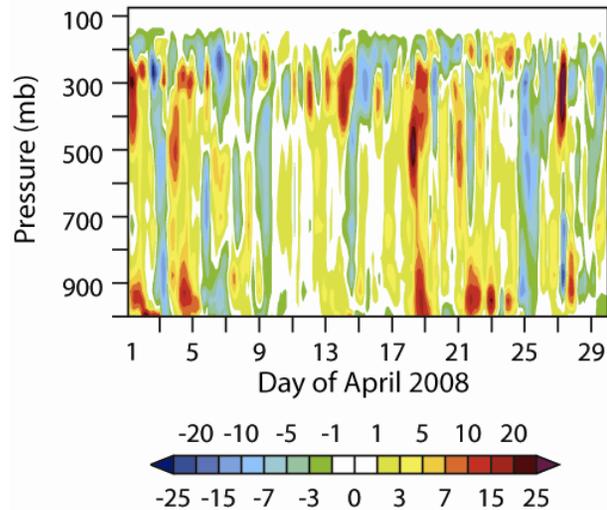
Forcing to Drive Cloud Models

Shaocheng Xie

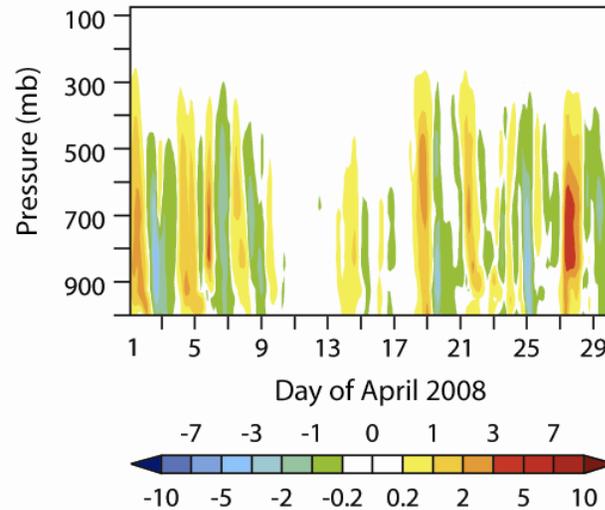
Omega (mb/hr)



Total Adv. Tend. of T (k/day)



Total Adv. Tend. of q (g/kg/day)

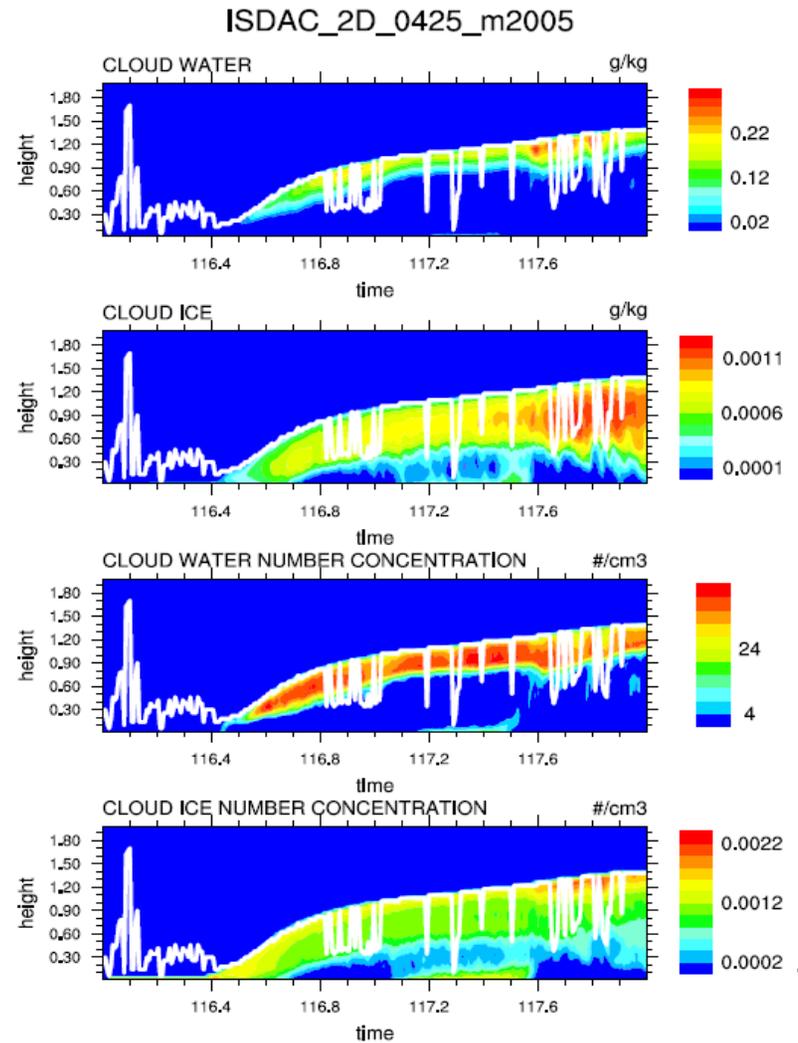
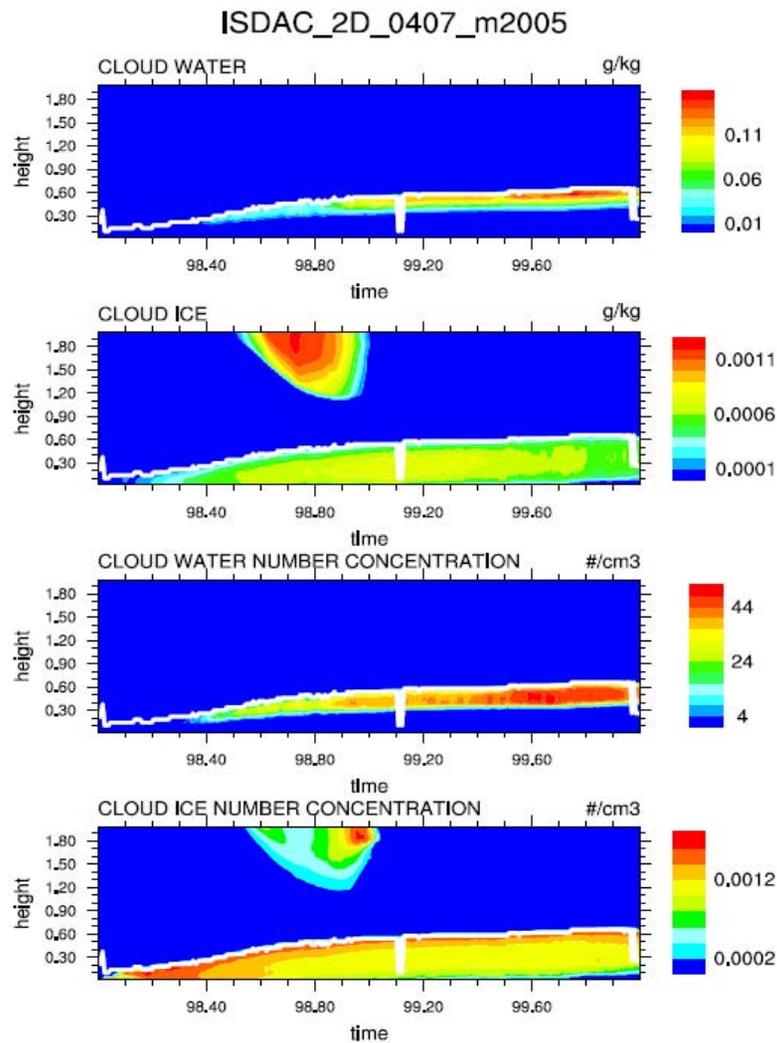


Simulation with Morrison microphysics

Mikhail Ovtchinnikov

April 8

April 26



M-PACE vs ISDAC

- ▶ ISDAC and M-PACE boundary conditions are very different because of the much more extensive ocean water during M-PACE.
- ▶ Separate influence of different boundary conditions from different aerosol by performing four simulations:
 - M-PACE aerosol and boundary conditions
 - M-PACE aerosol and ISDAC boundary conditions
 - ISDAC aerosol and M-PACE boundary conditions
 - ISDAC aerosol and boundary conditions.

ISDAC Summary

- ▶ Data from comprehensive (~42) state of the art instruments link aerosol composition, cloud microphysics and optical properties for process level model development of Arctic clouds.
- ▶ Very rich aerosol/cloud data set collected, including (but not limited to) golden cases of single-layer stratus.
- ▶ Data will be processed to provide both model input (aerosol) and model validation (cloud).
- ▶ An ISDAC modeling plan will be prepared for the next ARM Science Team meeting.