ISDAC Modeling

Modeling of aerosol effects on Arctic stratiform clouds: Preliminary results from the ISDAC case study

(poster 13J)

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Indirect Semi-Direct Aerosol Campaign Science questions:

- How do properties of the arctic aerosol during April differ from those measured during the MPACE in October?
- To what extent do the different properties of the arctic aerosol during April produce differences in the microphysical and macrophysical properties of clouds and the surface energy balance?
- To what extent can cloud models and the cloud 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?
- How well can long-term surface-based measurements at the ACRF NSA locale provide retrievals of aerosol, cloud, precipitation, and radiative heating in the Arctic?

Modeling approach

Level of understanding of ice and mixed-phase clouds is low

Process oriented modeling

Simple, idealized cases

"Golden days"

8 April 2008, flight 16

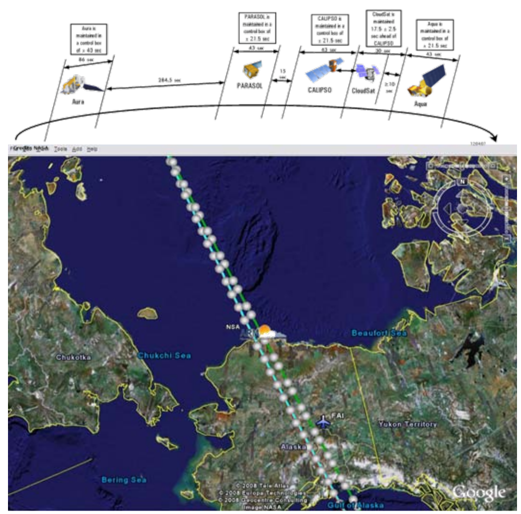
26 April 2008, flight 31

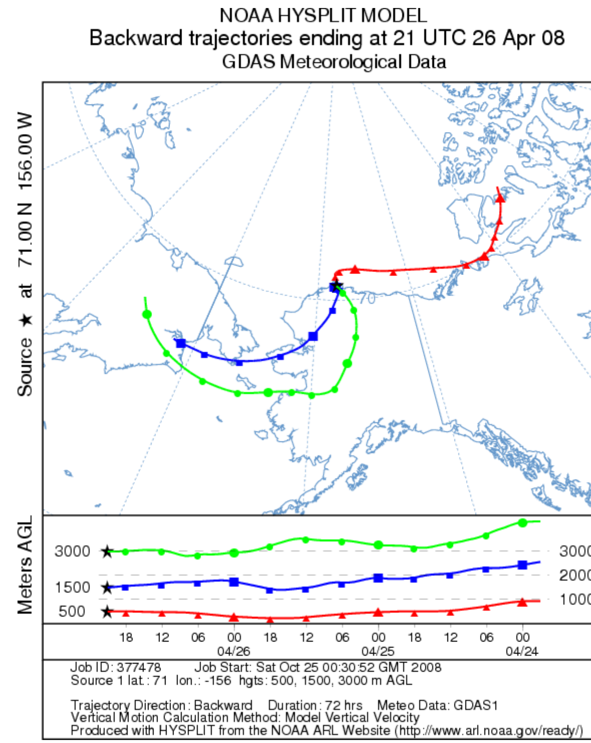
26 April 2008 – A "golden" day of ISDAC

Three flights: sampling below, above, and inside the cloud layer

Horizontal legs and profiles

A-train overpass





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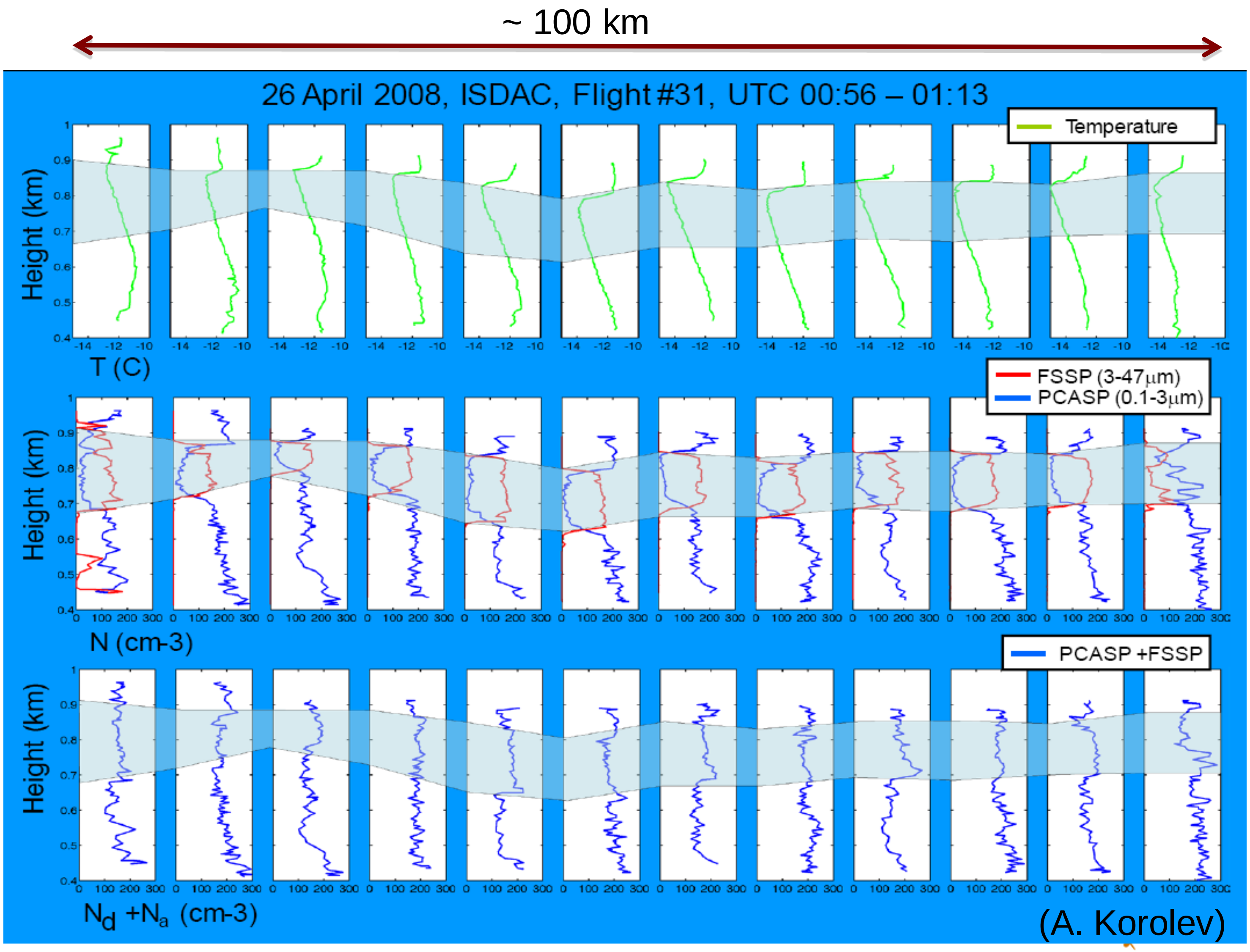
Observed cloud properties

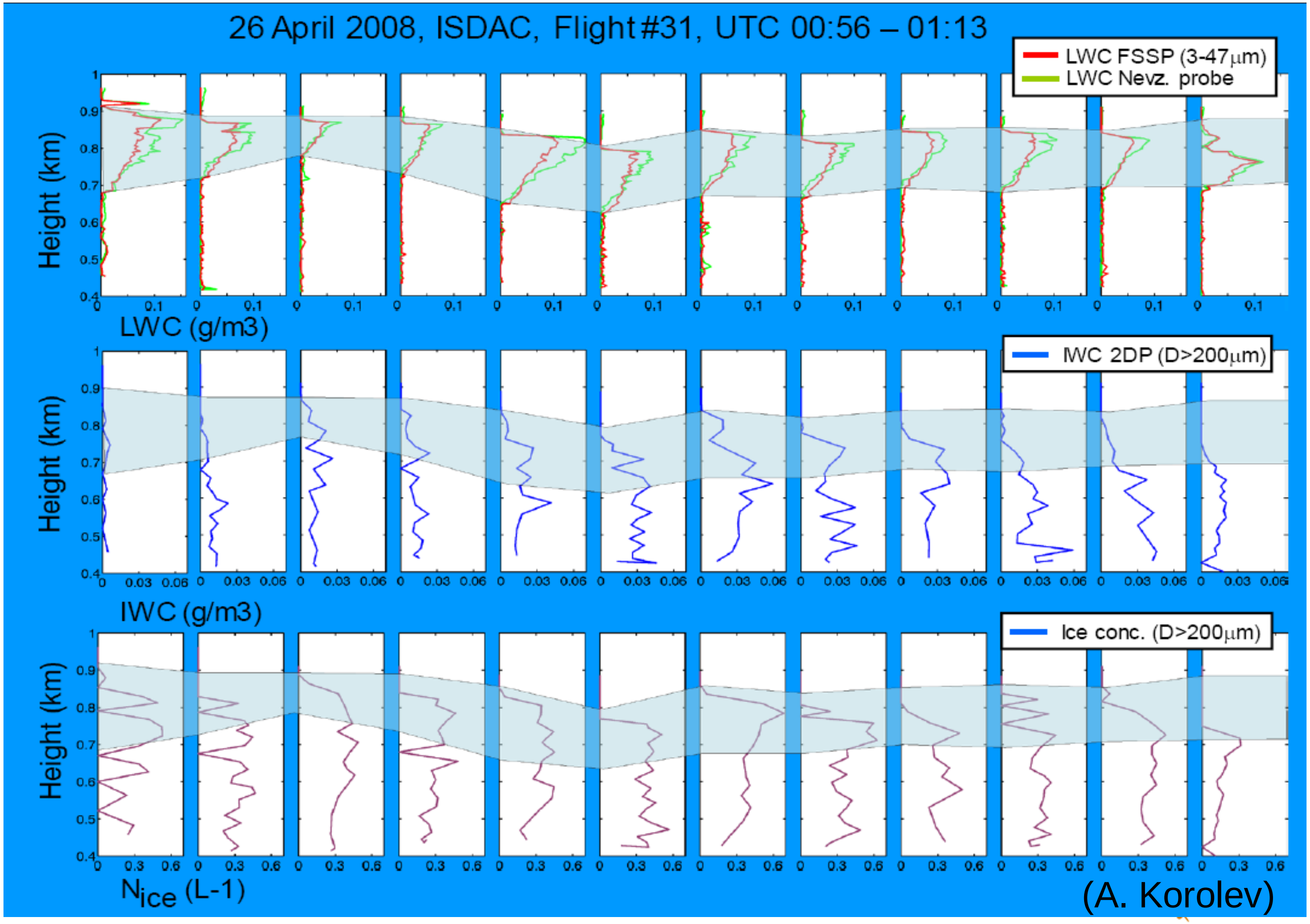
✓ Sharp inversion;
✓ Flat cloud boundaries

✓Nd is constant with height



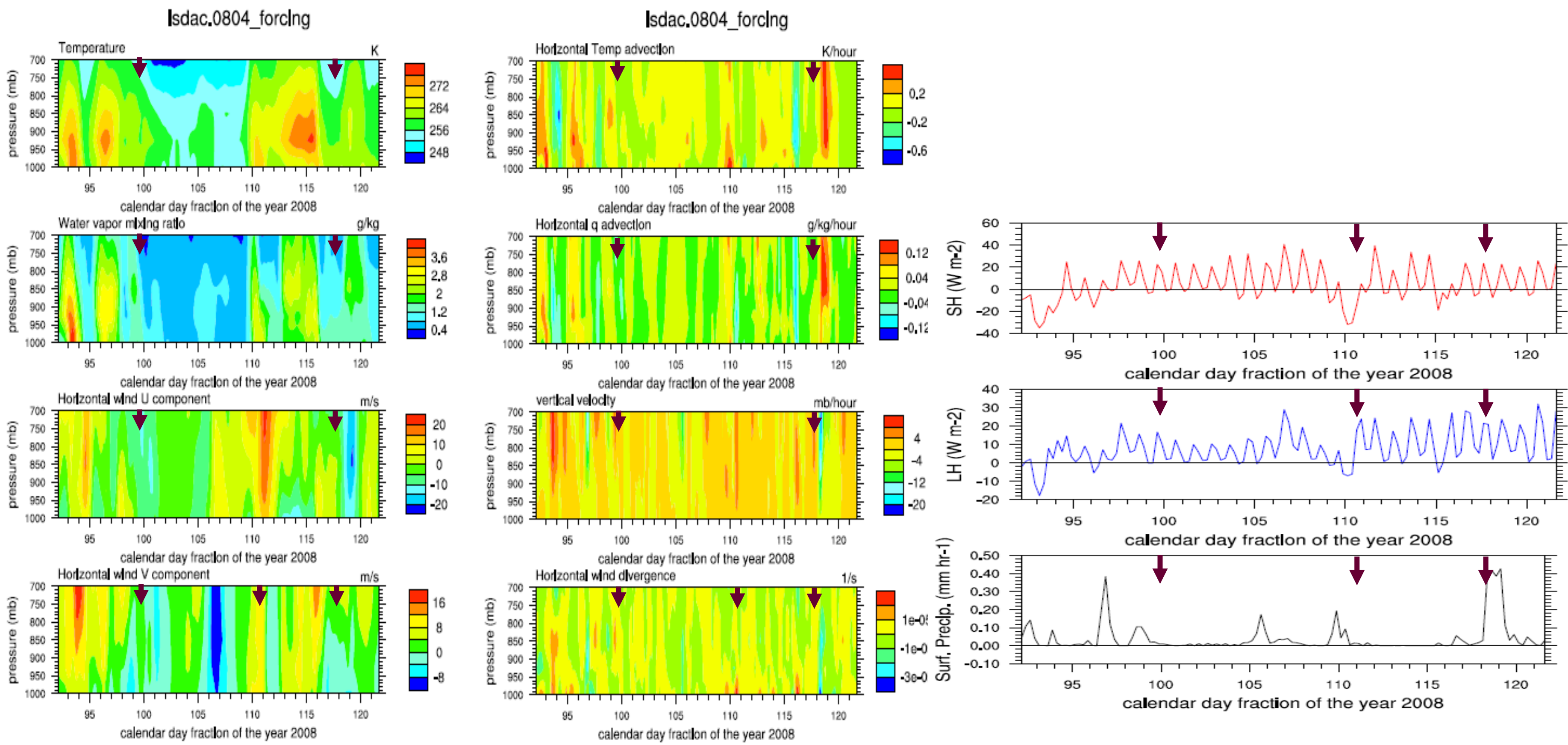
Observed cloud properties (continued)

- ✓ Liquid dominated
- ✓ Precipitating ice



ECMWF derived forcing profiles and surface data

Available for NSA for April 2008



Shaocheng Xie

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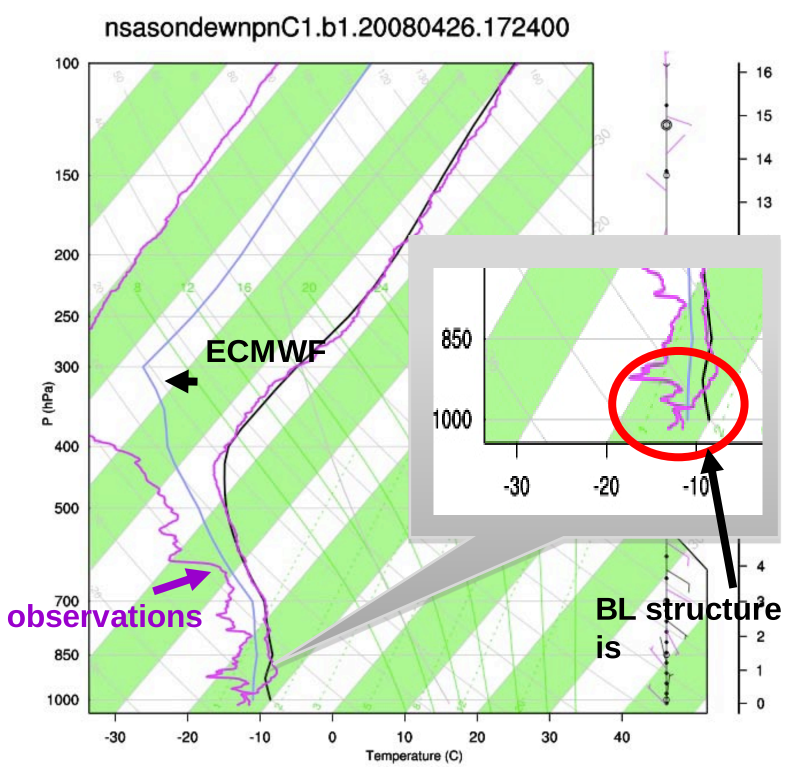
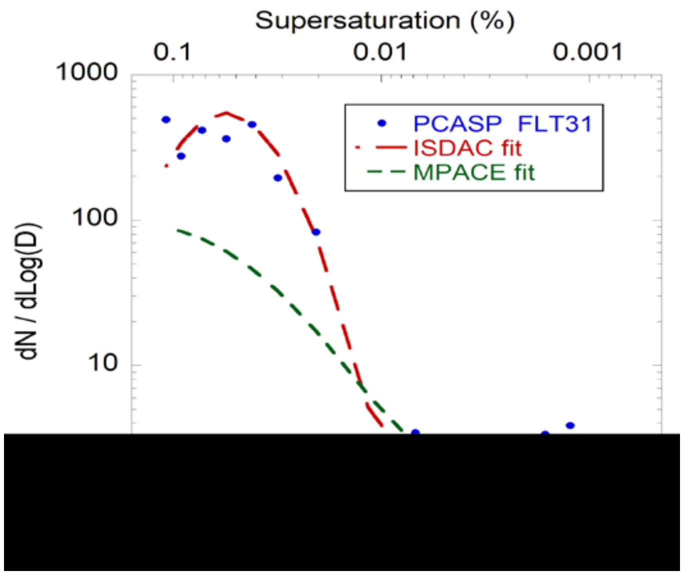
Modeling case setup, April 26, 2008

Model setup:

Cloud-resolving model: SAM v.6.7.4;
2D configuration;
full 2-moment liquid and ice microphysics (Morrison 2005)

ECMWF derived initial and boundary conditions and forcing modified to capture the structure of the shallow boundary layer





CCN spectrum from PCASP size distribution

Ice nucleation is constrained by ice particle concentration but …

… aerosol composition and IN are or will be available

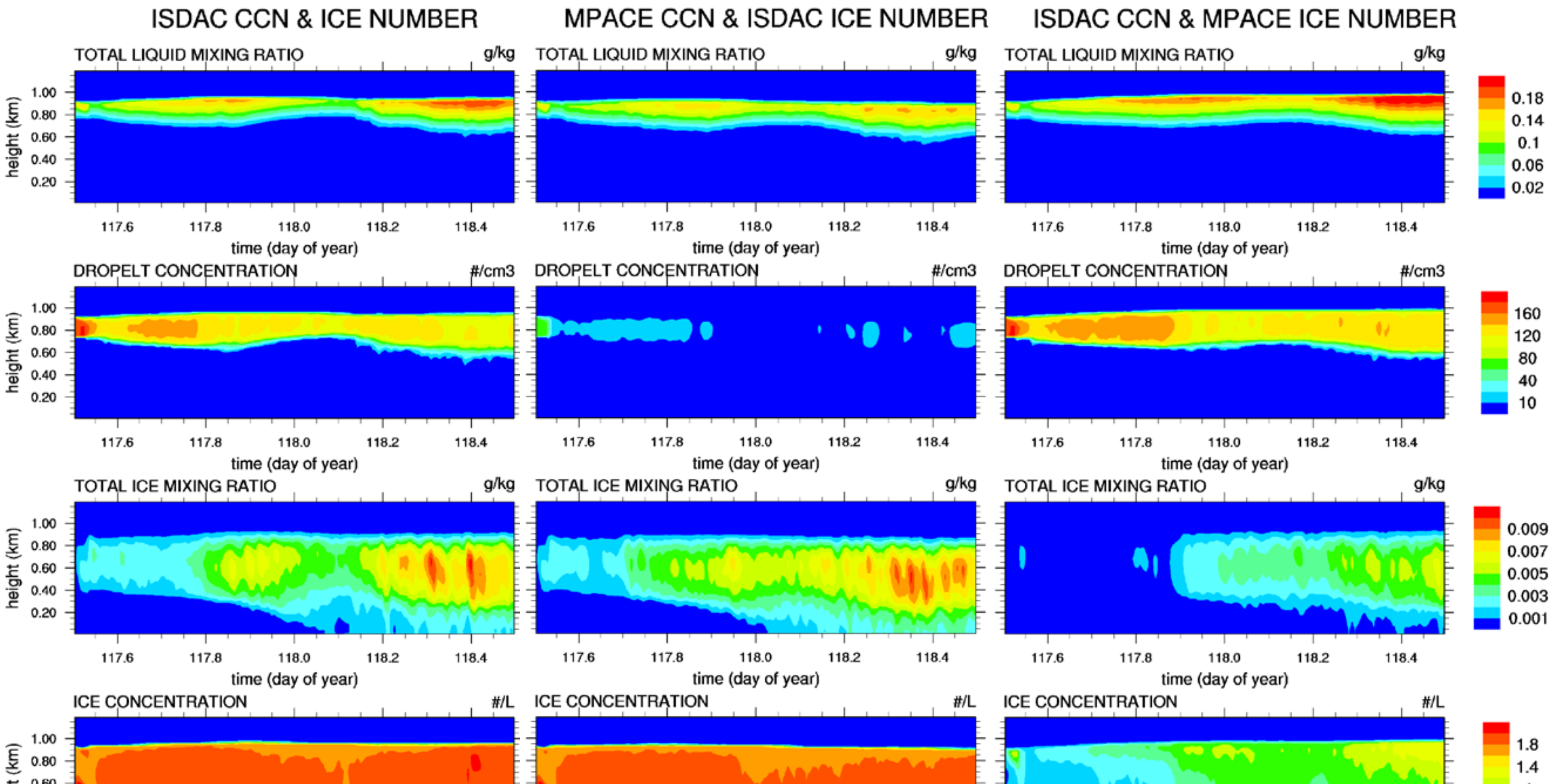
ISDAC versus M-PACE (spring vs fall)

- ✓ Polluted versus “clean”
- ✓ Radiatively driven versus surface-flux forced clouds (more open water during M-PACE => larger surface fluxes)

- ✓ Separate influence of different atmospheric and aerosol conditions by performing 4 sets of simulations:

		Aerosol: M-PACE	Aerosol: ISDAC
Atmospheric state	M-PACE	**X**	
	ISDAC	**X**	**X**

Model results: persistent cloud is there



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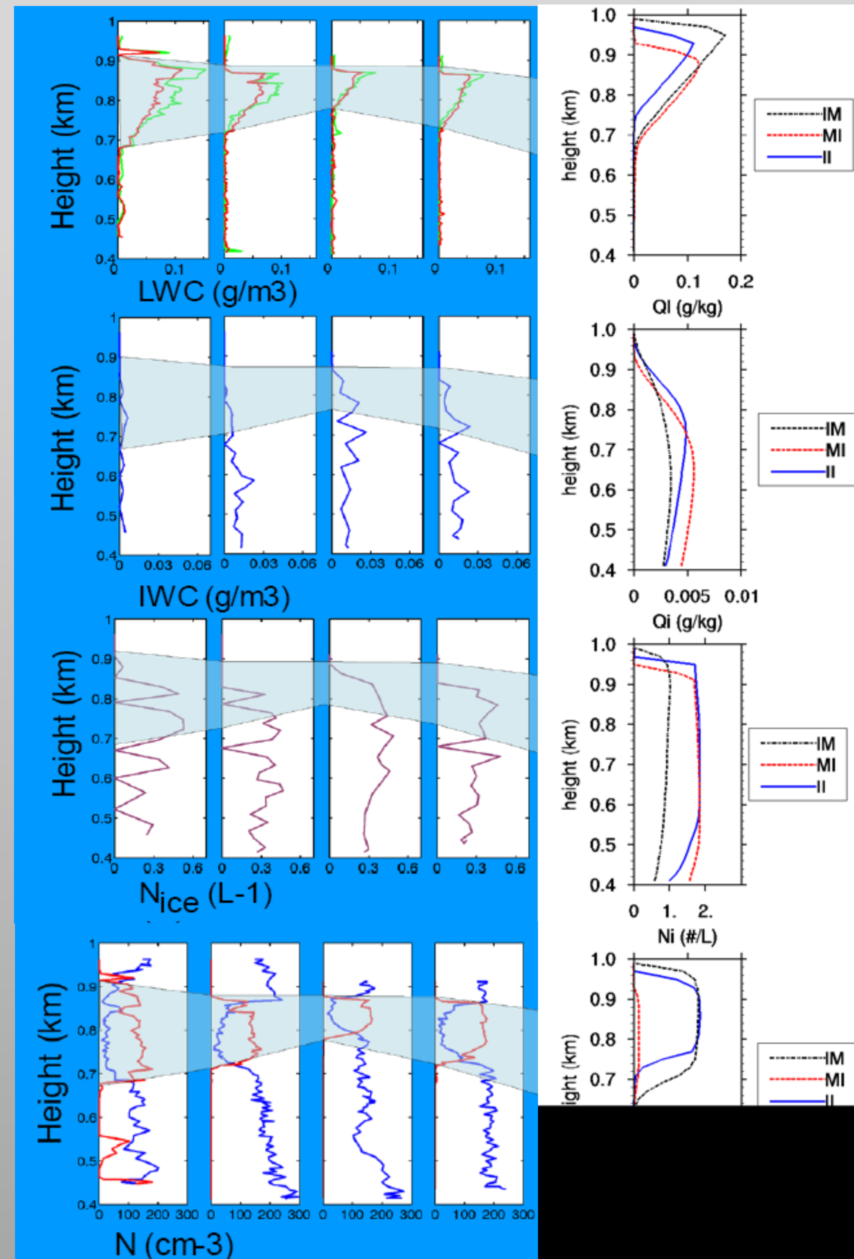
Reality check

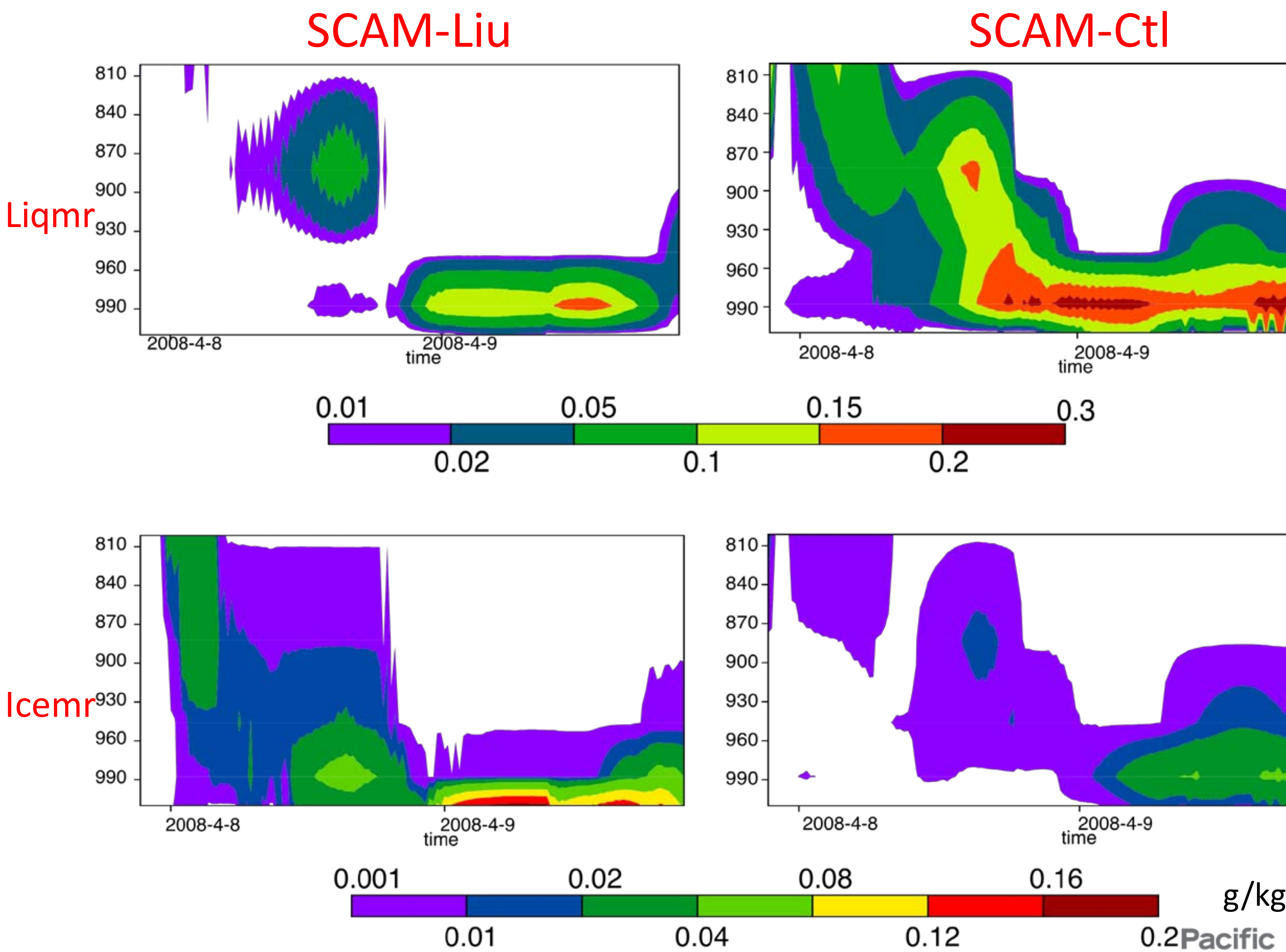
- ✓ Qualitatively similar structure
- ✓ Can we quantify the (dis)agreement ?

Look at

- ✓ spatial correlations
- ✓ other measurements (precipitation, remote sensing)
- ✓ aerosol effect on radiation and surface energy balances



Single-column model



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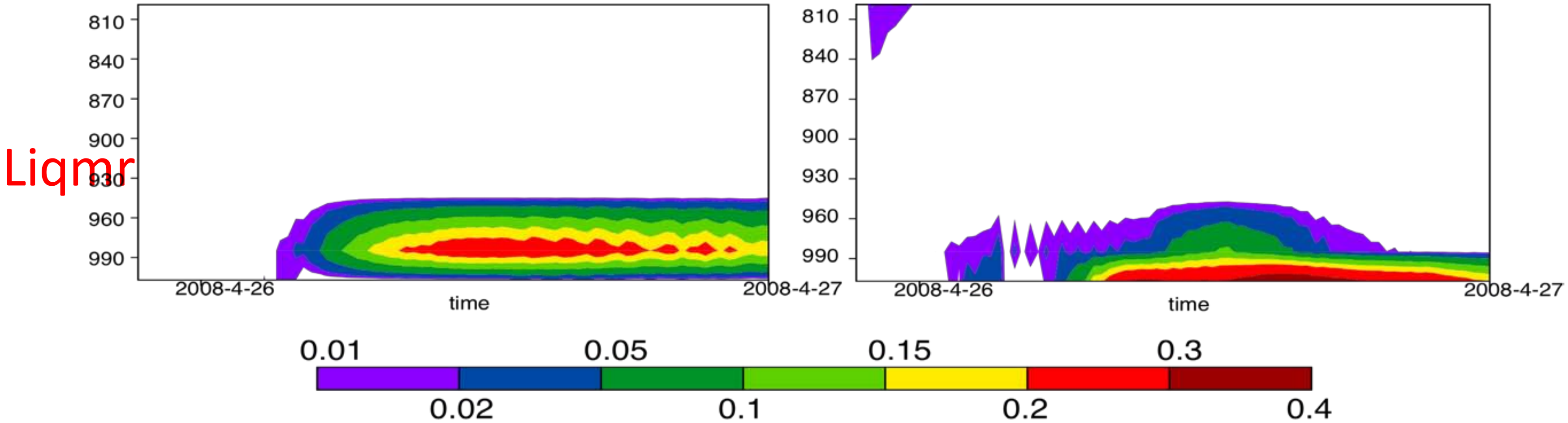
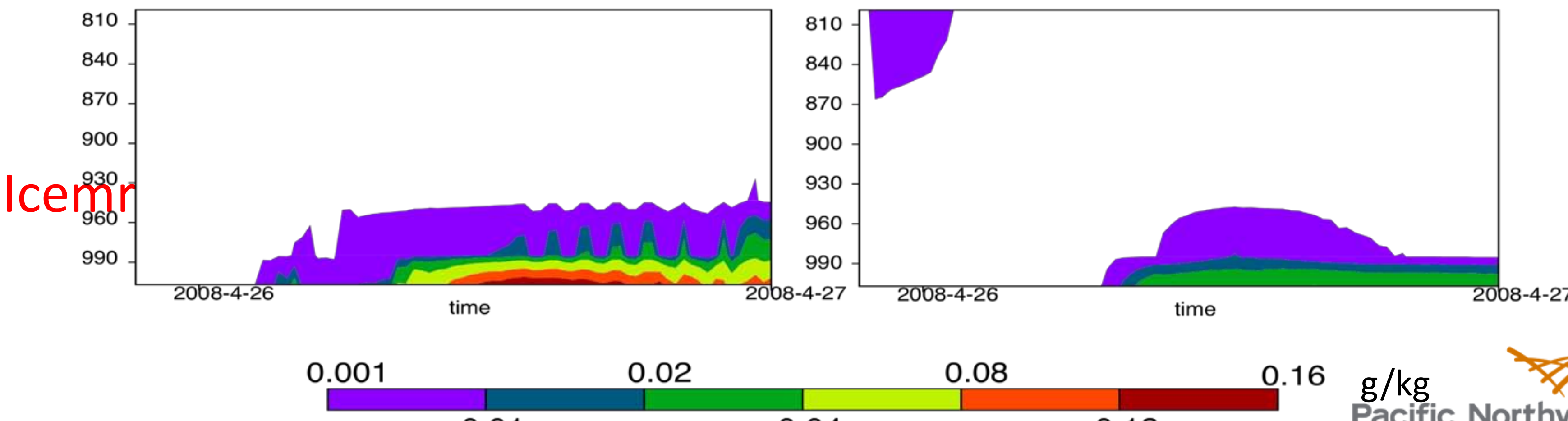
SCM: ice parameterization evaluation

April 26

SCAM-Liu SCAM-Ctl





Xiaohong Liu

Modeling plans and needs

Scale / model	Science focus	Critical data	Contact
Parcel / LES	Role of W in droplet nucleation	**W (gust probe)**, cloud-base aerosol size and chemistry distributions, profiles Nd, LWC, T	Richard Leaitch (Env. Canada)
LES, bin microphysics	Aerosol-IN-drop-ice-dynamics closure in idealized LES framework	**MMCR reflectivity and Doppler velocity**; aerosol, droplet, and ice size distributions, IN from CFDC	Ann Fridlind, Andrew Ackerman, Alex Avramov,(NASA GISS)
LES (SAM & WRF)	Development and testing IN parameterizations	Size and composition distributions for aerosol, IN, and CCN.	Mikhail Ovchinnikov, Jiwen Fan (PNNL)
Regional WRF	Sc formation, phase partitioning, the tke budget, and scale interactions	CCN, Nd, W, IN, Ql and Qi profiles	Amy Solomon and Matt Shupe (NOAA) and (CU/CIRES)
SCM	Testing ice microphysics parameterization	Liquid and ice number and mass mixing ratios, CCN, IN	Xiaohong Liu (PNNL), Shaocheng Xie (LLNL)
Regianal and SCM	Drop and ice nucleation, precipitation processes	Radar and precipitation data, volume radius	Surabi Menon, Igor Sednev (LBNL)
			Hugh Morrison, others

Next steps

- Finalize the setup for the April 26 and/or 8 case

  sounding, forcing, aerosol (CCN & IN)

- Compile an evaluation data set
- Define the level of coordination:
  - Run same cases using various models
  - Link models for different scales via input / output
  - Formal intercomparison / multiple model evaluation (wait for the completion of SHEBA case)

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