

**Introduction and Motivation**

Aerosols serve as cloud condensation nuclei (CCN) and ice nuclei (IN), influence cloud-microphysical properties and are important for precipitation formation in mixed-phase orographic clouds

**Main goals**

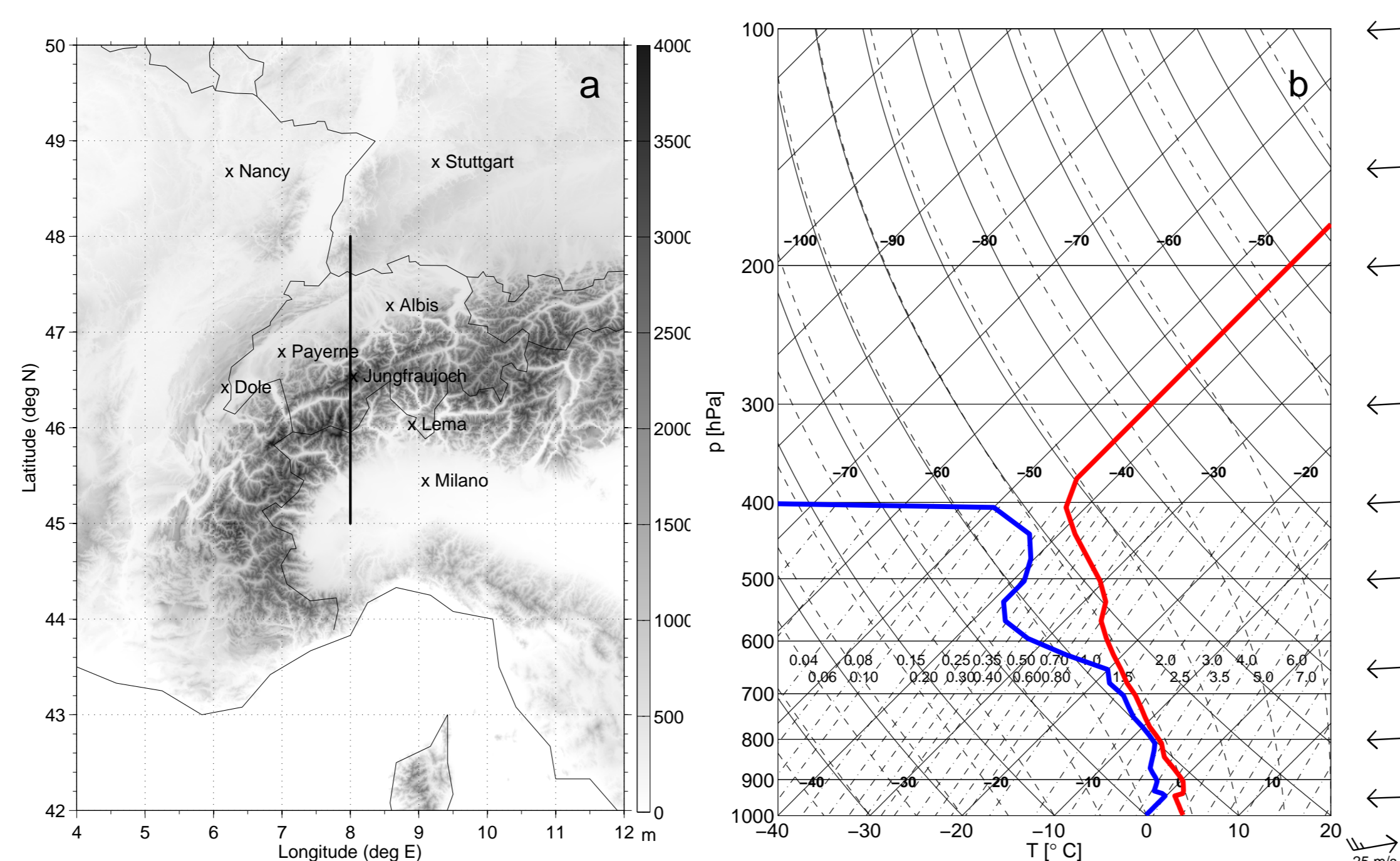
- Understanding the role of aerosols for initiating ice in mixed-phase orographic clouds via heterogeneous ice nucleation
- Modeling the co-existence of the liquid- and ice-phase in orographic clouds observed during the Cloud and Aerosol Characterization Experiment (CLACE 3)
- Estimating the mechanisms how aerosols may affect orographic precipitation

**Numerical model**

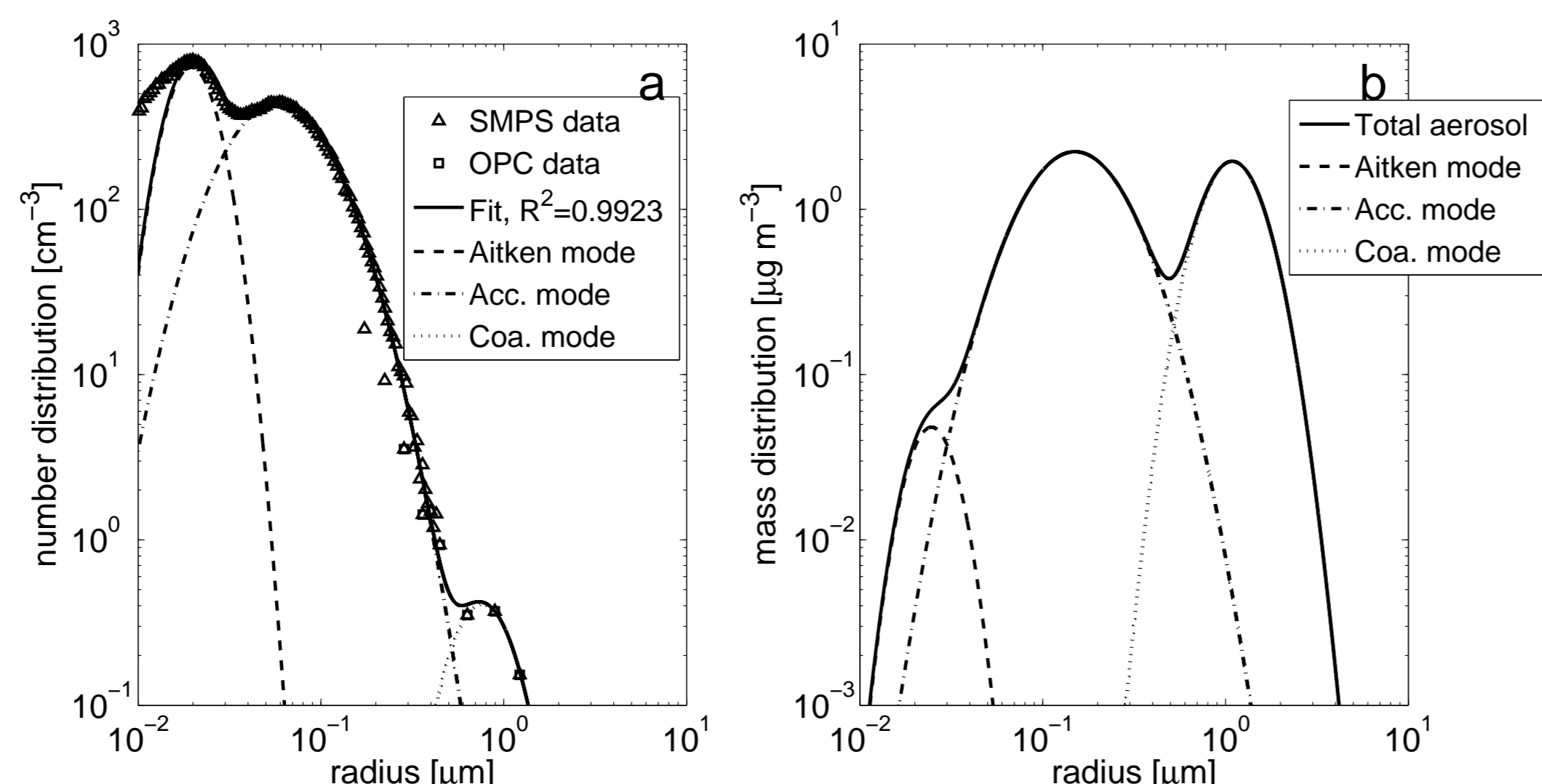
- Nonhydrostatic, fully compressible mesoscale weather prediction model COSMO (COnsortium for Small-scale Modeling, <http://www.cosmo-model.org>, Steppeler et al. 2003)
- 2D setup with 350 gridpoints and 60 vertical terrain-following levels
- 2 km horizontal model resolution, timestep of 10 s
- 3rd order Runge-Kutta scheme with 5th order advection scheme
- Positive definite 2nd order advection scheme for moisture variables and aerosols after Bott (1989)
- 2.5 level Mellor/Yamada turbulence scheme
- Coupled two-moment aerosol-cloud-microphysics parameterization (Seifert and Beheng 2006; Mühlbauer and Lohmann 2008a,b)
- Radiation-/convection param. switched off, no horizontal diffusion, no soil model

**Target area and model initial conditions**

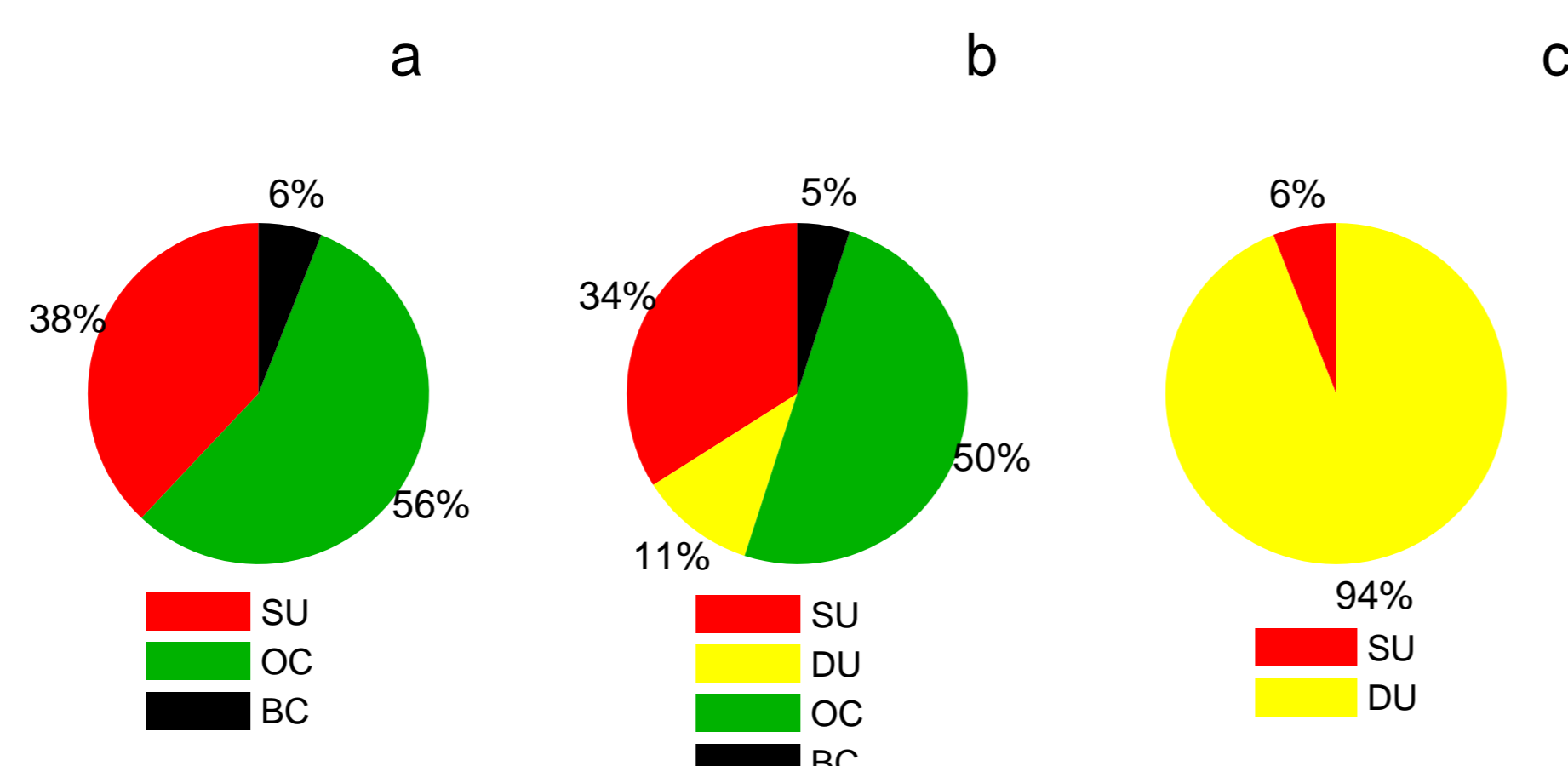
- 2D simulations of an mixed-phase orographic cloud at the Jungfrauoch (JFJ) during CLACE 3 (case 8 March 2004)
- 2D transect through the Alpine region (figure 1a)
- 00 UTC atmospheric sounding from Payerne used as initial condition (figure 1b)
- Aerosol number distribution from scanning mobility particle sizer (SMPS) and optical particle counter (OPC) prescribed internally mixed (see figure 2a)
- Aerosol mass distribution is calculated from aerosol number distribution by assuming an aerosol density of  $1.5 \text{ g cm}^{-3}$  (Cozic et al. 2007).
- Aerosol composition is based on averaged data from aerosol mass spectrometry (figure 3)



**Figure 1:** 2D transect through the JFJ target area (a). 00 UTC sounding from Payerne (b) showing temperature (red) and dew-point temperature (blue) in a skewT-logp diagram



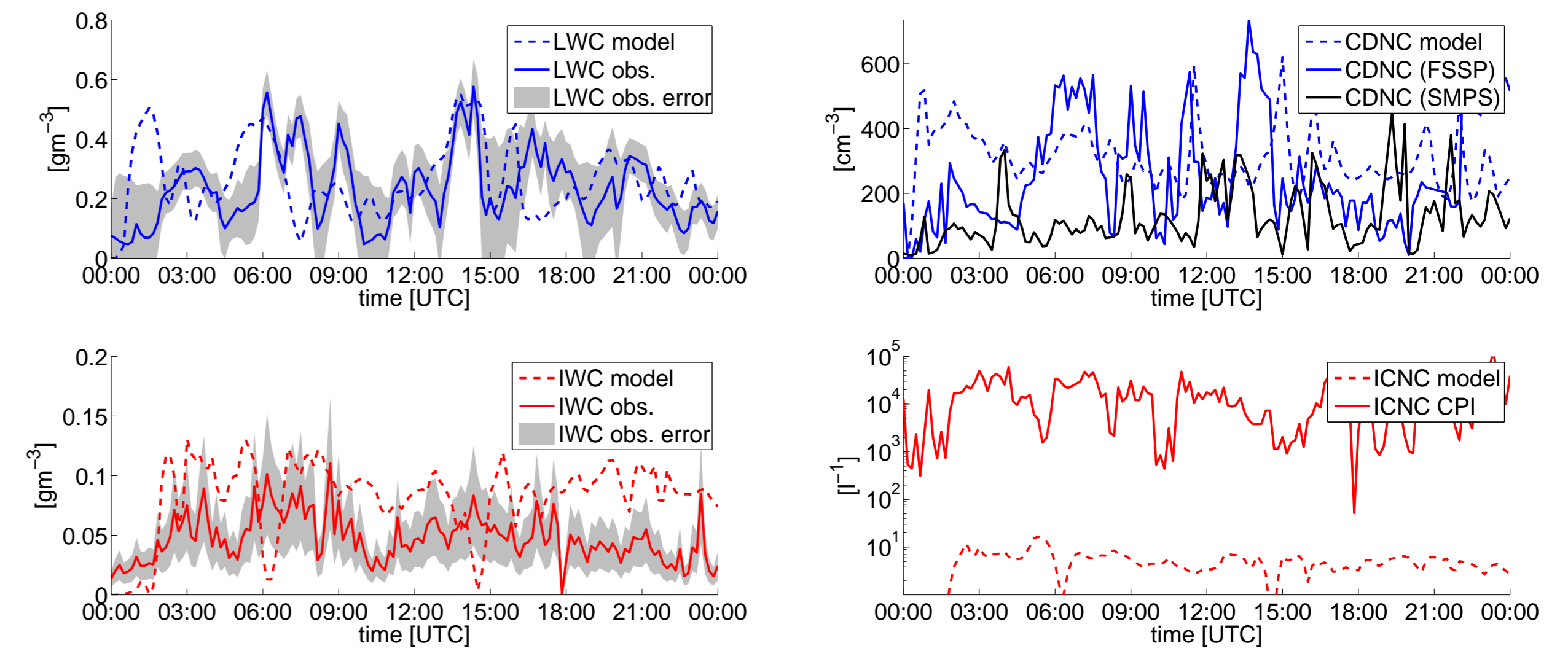
**Figure 2:** Aerosol number distribution (a) and mass distribution (b)



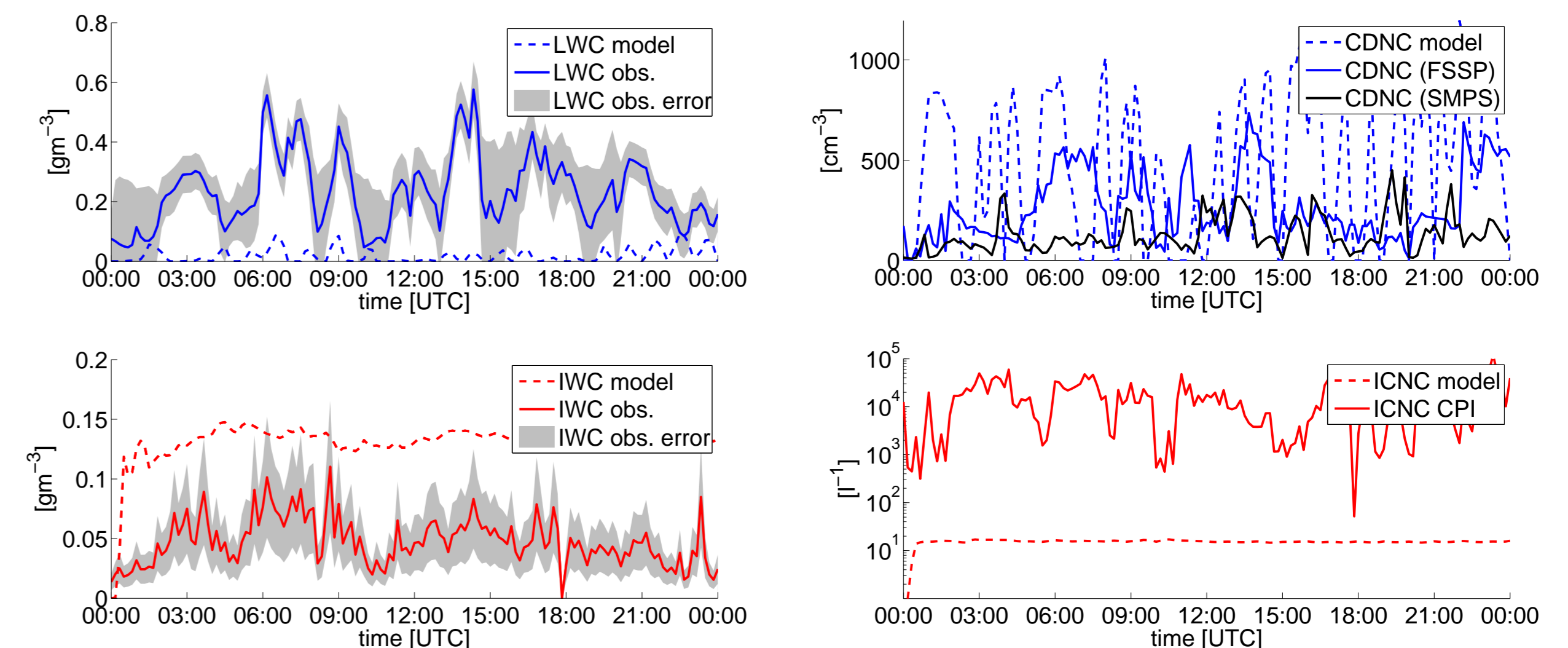
**Figure 3:** Average aerosol mass composition for Aitken (a), accumulation (b) and coarse mode (c) aerosols

**Model simulations vs. observations at the JFJ**

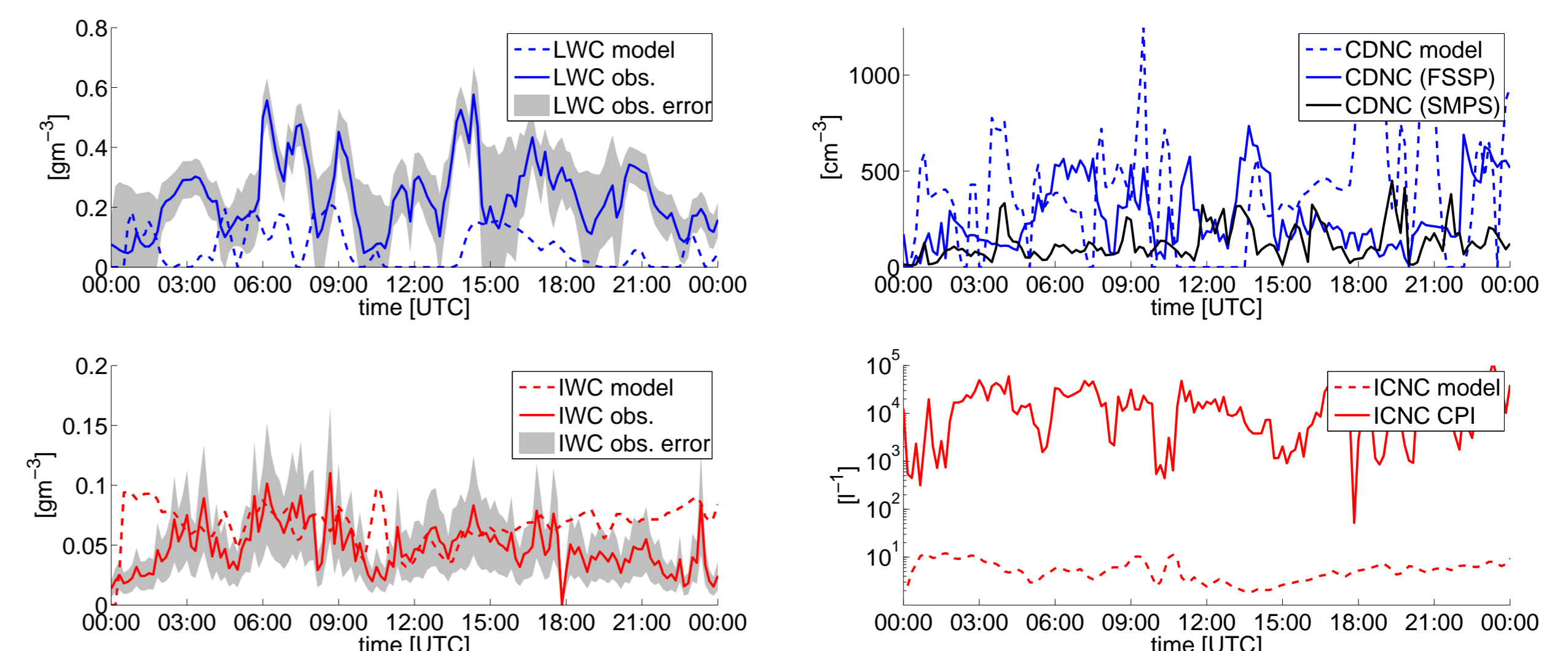
1. Simulation with prognostic ice nucleation (coupled to aerosols):



2. Simulation with diagnostic ice nucleation (Bigg 1953; Meyers et al. 1992):



3. Simulation with diagnostic ice nucleation (Bigg 1953; Fletcher 1962):



**Discussion**

- Prognostic treatment of cloud droplet nucleation and ice nucleation coupled to aerosols gives reasonable agreement with observations for the cloud liquid water content (LWC) and the cloud droplet number concentrations (CDNC). The ice water content (IWC) is slightly overestimated
- Diagnostic ice nucleation after Bigg (1953) and Meyers et al. (1992) underestimates LWC and overestimates CDNC and IWC
- Diag. ice nucleation after Bigg (1953) and Fletcher (1962) gives best results for IWC
- All schemes underestimate the ice crystal number (ICNC) by roughly a factor 10<sup>2</sup>-10<sup>3</sup>

**Outlook**

- 3D simulations with ECMWF initial and boundary conditions
- Sensitivity studies with different aerosol compositions to account for the different freezing properties of the aerosols

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**References**

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