Regional model simulations of aerosol-cloud interactions in the SEP

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Introduction and motivation

Stratocumulus (Sc) clouds in the marine boundary layer (MBL) are crucial for the Earth's radiation balance and the global climate system. However, the radiative properties of Sc clouds are linked to their microphysical and macrophysical properties, which are not very well represented in current GCMs (e.g., Hannay et al., 2009).

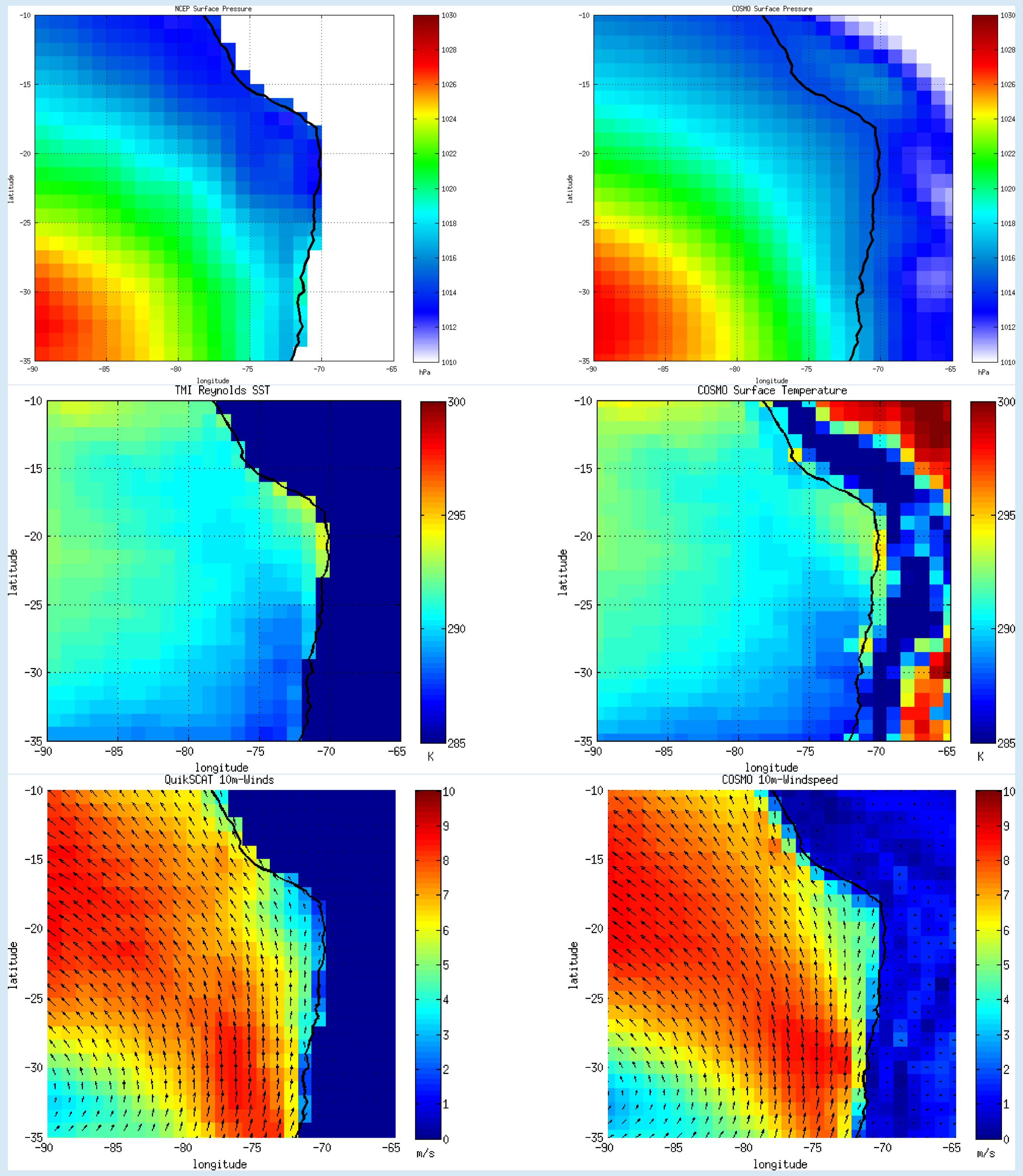
Goal and methods

The goal is to compare the microphysical and radiative properties of Sc clouds, simulated with a regional model, with observations from the VOCALS Regional Experiment (VOCALS-REx). The regional model simulations are driven by ECMWF initial and boundary conditions for the period Oct 15-Nov 15, 2008.
For the model evaluation we use microphysical observations collected by the NCAR/NSF C-130 aircraft and remotely sensed observations from QuikSCAT, MODIS, MISR and ISCCP. The MISR and ISCCP observations are simulated with the CFMIP Observational Simulator Package (COSP).

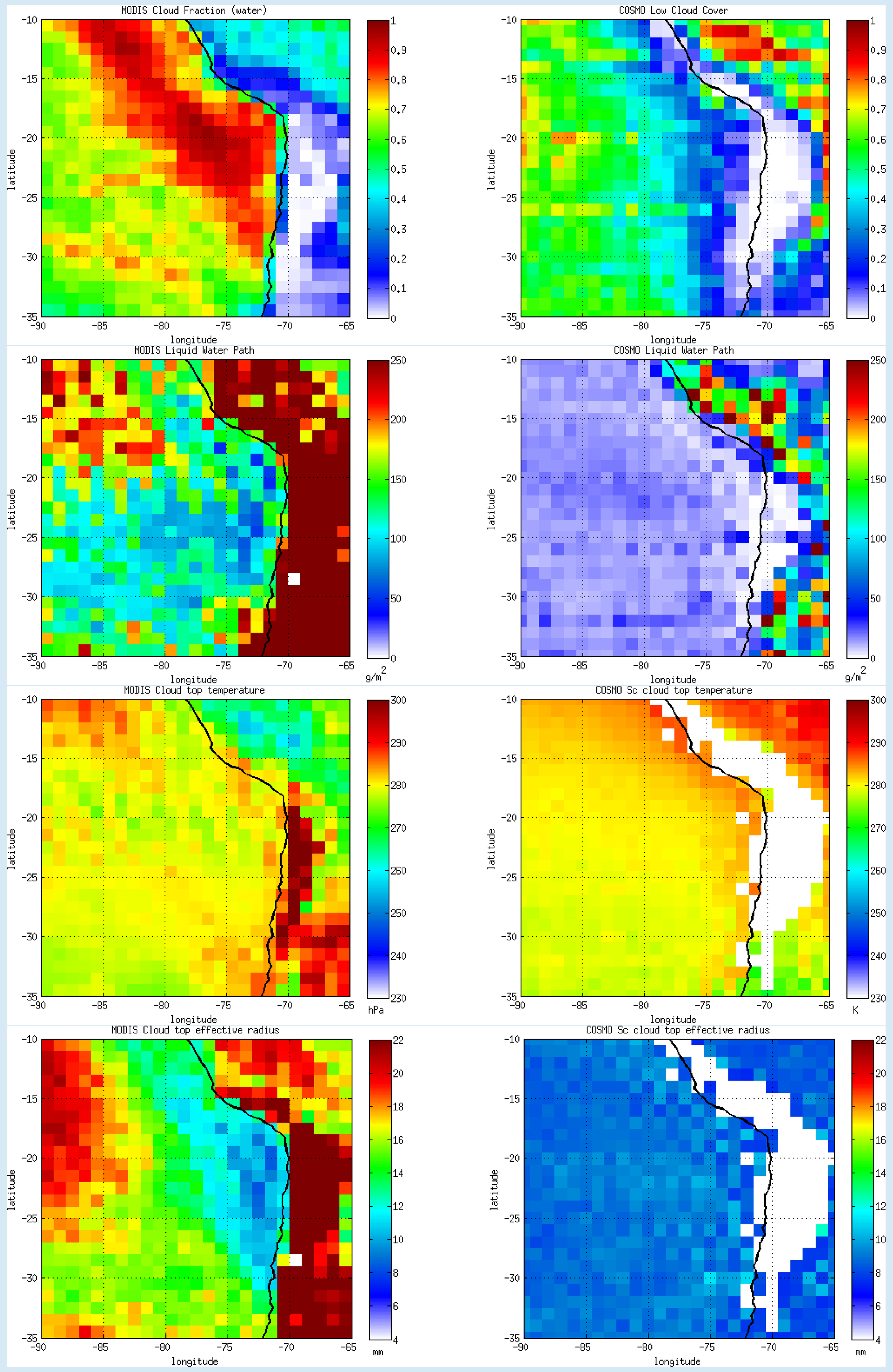
Setup of the numerical model

- Simulations are performed with the UW version of the COSMO model (COSMO-UW)
- The model domain spans the VOCALS-REx region (90W-65W and 35S-10S)
- Grid spacing: 1.0 degree with 60 vertical levels (SLEVE coordinates)
- Initial/boundary conditions provided by ECMWF analyses (1.0 degree, 6 h updates)
- Numerics: 3rd order Runge-Kutta, 4th order positive-definite advection, time step 40 s
- Parameterizations: Radiation (Ritter and Geleyn, 1992), convection (Park and Bretherton, 2009), turbulence, double-moment microphysics (Morrison et al., 2005)

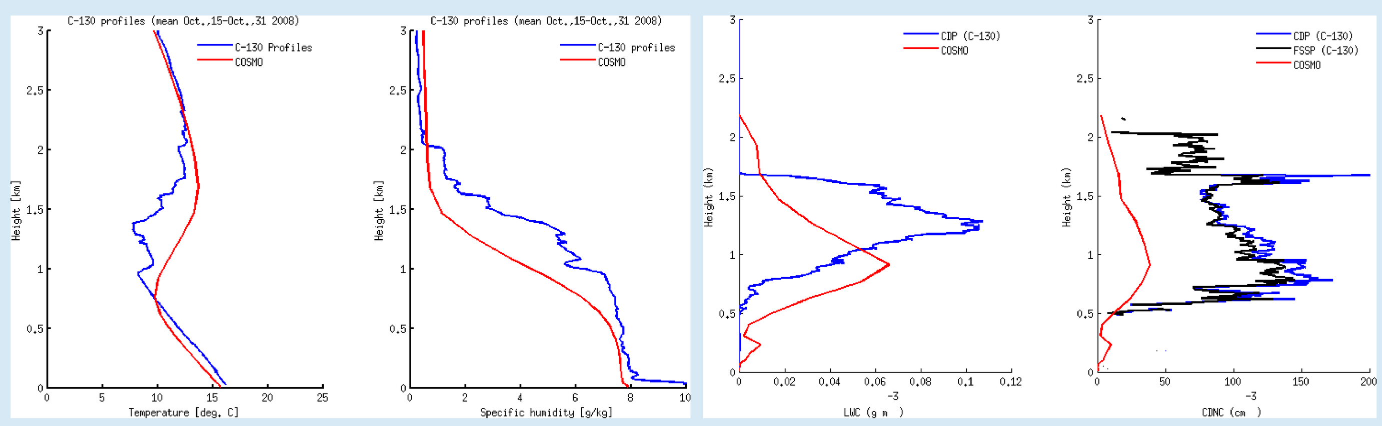
Large-scale Dynamics



Cloud Fields and Microphysics



Vertical Cloud and MBL Structure at 20S



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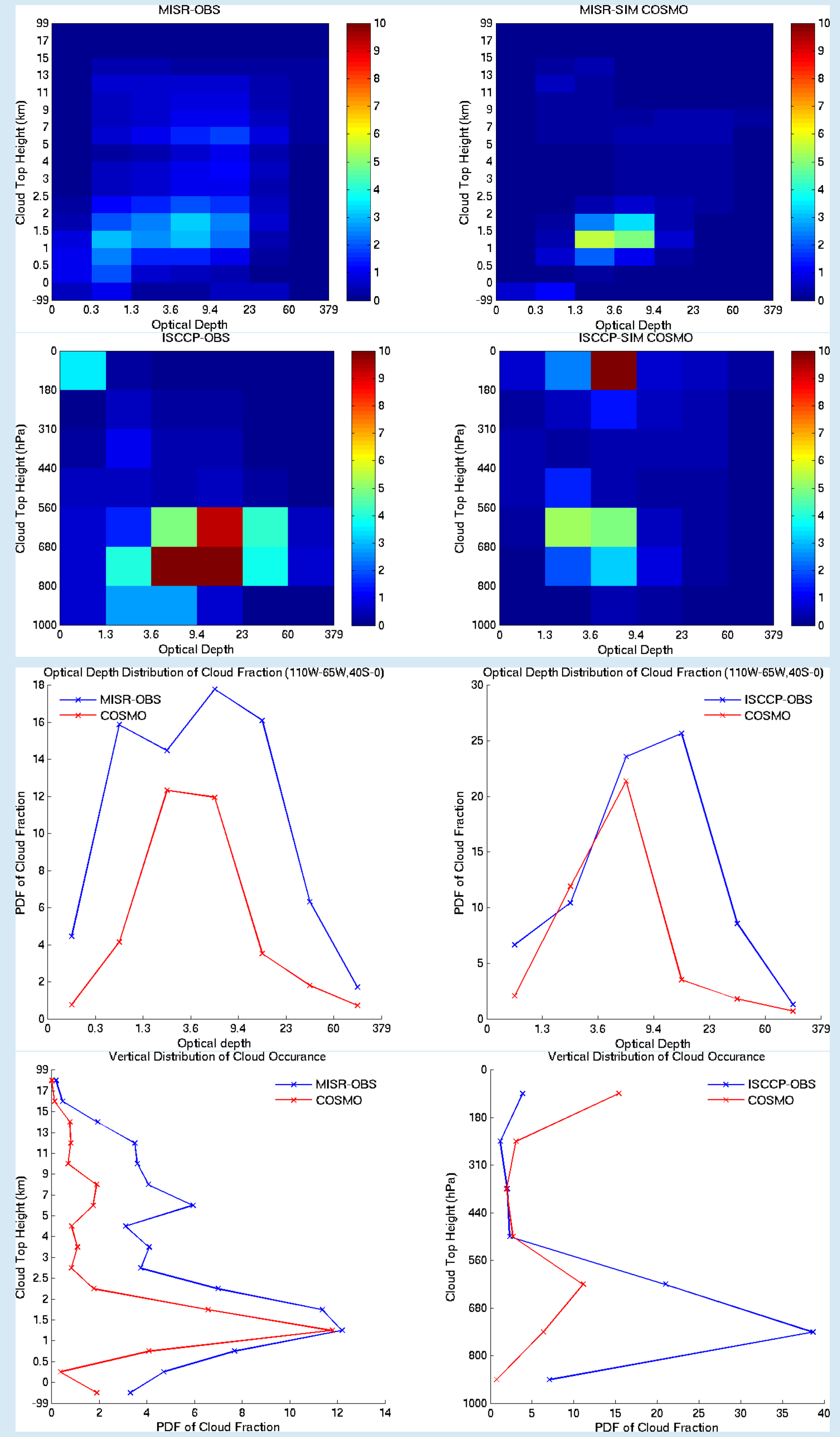
Observed Cloud Statistics Simulated with COSP



Results and Conclusions

- The subtropical high and SST structure is well captured. The 10m winds agree reasonably with QuikSCAT winds but simulated southerlies tend to be slightly stronger near the coast. This is in agreement with other models from the PreVOCA model intercomparison (Wyant et al., 2010).
- The simulated cloud cover is underestimated near the coast. Better agreement is found far offshore (e.g., southwest of 80W). The liquid water path (LWP) and cloud droplet number concentrations (CDNC) are significantly underestimated. However, due to both lower LWP and lower CDNC the cloud effective radius at Sc cloud tops is smaller than observed. Sc cloud top temperatures are lower than observed especially close to the coast.
- The vertical structure of the MBL and the inversion layer are not very well captured in the model. Hence, the depth of the mixed-layer is too shallow and the Sc cloud base is underestimated. Vertical profiles of LWC and CDNC are considerably lower than observed by the NCAR/NSF C-130 aircraft.
- In comparison to MISR and ISCCP observations, cloud occurrances in COSMO-UW are generally too low at almost all model levels. The observed distribution of cloud optical depth is broader in the observations than in the model.