The goal of this project was to compare observations of marine and arctic boundary layers with
(i) parameterization systems used in climate and weather forecast models, and (ii) two and three
dimensional eddy resolving (LES) models for turbulent fluid flow. Based on this comparison, we
hoped to better understand, predict, and parameterize the boundary layer structure and cloud
amount, type and thickness as functions of large scale conditions that are predicted by global cli-
mate models.

The principal achievements of the project were as follows

(1) Development of a novel boundary layer parameterization for large-scale models (Grenier
and Bretherton 2001) that better represents the physical processes in marine boundary
layer clouds. This parameterization has been implemented and validated in regional simu-
lations of the subtropical northeast and southeast Pacific Ocean stratocumulus regimes
using the MM5 mesoscale model. (McCaa et al. 2002 a,b), and sensitivities to horizontal
and vertical grid resolution as well as microphysical assumptions about the cloud droplet
concentration have been documented. It gave considerably better distributions of cloud
and cloud-radiative forcing than all four boundary layer schemes currently used in MM5. I
have also implemented this in NCAR’s Community Climate Model, where it also pro-
duces fairly realistic subtropical stratocumulus regimes, but do not yet have submitted
results since I need to improve the performance of the scheme in stable boundary layers
over high-latituude land masses.

(2) Comparison of column output from the ECMWF global forecast model with observations
from the SHEBA experiment. Overall the forecast model did predict most of the major
precipitation events and synoptic variability observed over the year of observation of the
SHEBA ice camp. Principal findings were (a) that the forecast model’s representation of
sea-ice thermodynamics was oversimplified, resulting in extreme damping of day-to-day
surface air temperature and humidity swings during the Arctic winter, and (b) that for tem-
peratures between -30 C and 0 C, the model clouds are often primarily ice-phase when the
observed clouds are often primarily composed of supercooled water droplets. The obser-
vational data used included mm-radar, lidar, soundings, surface turbulent and radiative-
fluxes, and surface precipitation (snow and rain) and led to the first attempt at producing
an integrated dataset for the atmospheric portion of the SHEBA column. The first finding
directly fed into the development of an improved land surface scheme called TESSEL now
used operationally by ECMWF, the second helped lead to changes in ECMWF’s ice
microphysics scheme although a good solution has not yet been found.
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