Atmos. Chem. Phys. Discuss., 13, C11852–C11854, 2014
www.atmos-chem-phys-discuss.net/13/C11852/2014/

Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Characteristic nature of vertical motions observed in Arctic mixed-phase stratocumulus" *by* J. Sedlar and M. D. Shupe

J. Sedlar and M. D. Shupe

josephs@misu.su.se

Received and published: 4 February 2014

We thank Reviewer 3 for the positive response to our paper. The reviewer raises two points that are relevant and important to the processes occurring within AMPS.

Response to Reviewer 3's comments:

1. With the the observational data we have, it is difficult, beyond speculation, to argue which processes are primarily responsible for cloud-surface layer decoupling. Such a study would be more suited toward an analysis of LES or cloud-resolving modeling results. The end of August in the high-latitude Arctic Ocean means solar radiation is present throughout the day, even though the solar zenith angles are large (low sun elevation). We do not find any relationship between time of day and coupling state.

However, since the sun is above the horizon always, it is possible that cloud layer heating through absorption of solar radiation may contribute to a reduction in TKE production within the cloud layer and cause cloud generated turbulence to be decoupled from surface generated turbulence.

Shupe et al. (2013) and Sotiropoulou et al. (2013), using the same ASCOS observations, conclude that changes in the turbulent fluxes near the surface have little to no connection with the coupling state of the surface and cloud layer. Both studies conclude that when the cloud base is sufficiently low in elevation above the ground (order of few hundred meters), these clouds tend to be coupled with the surface turbulence, and decoupled when the cloud layer is raised higher. Absorption of solar radiation within the cloud may be a cause for cloud base height changes. However, differential vertical advection appears to also be important. We show in case study 1 that the heat and moisture advection above the cloud layer in the morning, in conjunction with a mesoscale frontal passage, caused the cloud layer to rise. Mixing continued below cloud base, but now the cloud was displaced higher above the surface and cloud-generated mixing failed to connect with mixing driven by the surface.

The dominance of decoupling means the moisture source sustaining these clouds must be coming from aloft. If the vertical location of this source changes, the cloud geometric heights must also change in order for the cloud layer to survive. Thus vertical displacements of the cloud layer in response to heat and moisture advection aloft over the sea ice appear to play an important role in whether a coupled or decoupled state occurs. Furthermore, these AMPS are often observed as thin liquid layers with ice crystals falling into the sub-cloud layer. Diabatic effects within the sub-cloud layer may also play a role in stabilizing the cloud layer.

Additionally, in Fig. 13, we show that vertical wind speed shear is common during cases when cloud and surface are coupled. Additional mechanical mixing in the sub-cloud layer may also be contributing to the coupling nature of the system.

As the reviewer notes, we find radiative shielding, as well as mesoscale weather changes, to be an important factor modifying the timescales of cloud-generated w-variance and surface-cloud coupling state. Radiative shielding from additional cloud layers above, as well as mesoscale passages, are signatures of ongoing thermodynamic advection.

We have included a summary of these processes in bullet point one of the conclusions Section 7.

2. Following the reviewer's suggestion, we have highlighted some of the major differences between AMPS and lower-latitude stratocumulus and the concluding reasons we observe for such differences.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 31079, 2013.