Introduction

The boundary layer wind and thermodynamic fields contain a great deal of information about convective cloud systems (see Figures 1 and 2). The existing observational systems at the ARM Southern Great Plains (SGP) Atmospheric Climate Research Facility (ACRF) can be used to provide an extensive statistical characterization of updrafts and downdrafts in convective cloud systems. We are producing several datasets that should be useful for quantifying the characteristics of precipitating convection over land and the effects of the convection on the boundary layer. Such datasets can be used for many purposes, including evaluating cumulus parameterizations in global and mesoscale models, and for evaluating cloud-system resolving models.

This poster shows our preliminary results about how to estimate the mesonet-averaged cloud-base updraft and downdraft mass fluxes from the surface divergence field and the evaluation of this method using a 3D CRM simulation of maritime-time convective cloud systems observed during KWAJEX and a 2D CRM simulation of convective systems observed during ARM July 1997 IOP.

Data Sources

We are using two observational datasets. One contains hourly accumulated precipitation amounts grided in the HRAP coordinates system with a grid size of approximately 4 km. The second is the Oklahoma Mesonet surface data. It includes standard surface meteorological measurements that are averaged over 5-minute intervals. At this time, we are analyzing two time periods: May-August 1997 and 2000. The averaged distance between stations is about 40 km.

Conclusions:

Both Oklahoma Mesonet observational data and results of two CRM simulations suggest that it is possible to estimate cloud-base mass fluxes from surface divergence field. The RMS errors of estimated $M_u$ and $M_d$ are 0.0097 m s$^{-1}$ and 0.0086 m s$^{-1}$ in the KWAJEX CRM simulation, and 0.0195 m s$^{-1}$ and 0.0197 m s$^{-1}$ in the 2D ARM case 3 simulation.

The observational data show that the maximum correlation of $M_u$ and precipitation occurs about 0.5 h before the precipitation peak while the maximum correlation of $M_d$ and precipitation occurs about an hour after the precipitation peak. The correlations of precipitation with $M_u$ and $M_d$ are larger than those with $M_u$ and $M_d$.

The maximum correlations between $P$ and $M_u$ and $M_d$ occurred at zero lag in KWAJEX. In ARM case 3 simulation, the maximum correlations between $M_u$ and $M_d$ with $M_u$, $M_d$, $M_u$, and $M_d$ occurred about an hour after the peak cloud mass fluxes. Surface divergence (convergence) correlated slightly better with $M_u$ than with $M_d$.

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References


Method of Analysis and Preliminary Results

Divergence Calculation

In Figures 2 and 3, each triangle is colored according to its divergence value. We define $M_u$ and $M_d$, where $d$ is the horizontal divergence of the $i$th triangle, which has area $A_i$ and $P(i)$ is the Heaviside step function, as

$$m_u = \sum A_i d_i (v - u)$$

$$m_d = \sum A_i d_i (v + u)$$

$M_u$ and $M_d$ are typically nonzero due to convective boundary layer circulations even when there is no precipitating convection (Figure 4). Therefore, we also define $M_u'$ and $M_d'$, the mesonet surface divergence averaged over regions of convergence $> 10^{-4} s^{-1}$, and $M_d'$, the mesonet surface divergence averaged over regions of divergence $> 10^{-4} s^{-1}$ (Figure 5).

Lagged Correlations of Precipitation Rate ($P$)

We are using two observational datasets. One contains hourly accumulated precipitation amounts grided in the HRAP coordinates system with a grid size of approximately 4 km. The second is the Oklahoma Mesonet surface data. It includes standard surface meteorological measurements that are averaged over 5-minute intervals. At this time, we are analyzing two time periods: May-August 1997 and 2000. The averaged distance between stations is about 40 km.

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Evaluation of the ‘Retrieval’ Method Using Model Simulation Data

3D KWAJEX CRM Simulation

The 3D simulation was performed with the UU LES with a horizontal grid size of 1 km and a horizontal domain size of 128 km by 128 km. Both cloud updraft ($M_u$) and downdraft ($M_d$) mass fluxes are calculated at 1050 m. Two different methods are used to calculate div $d$ for each 32-km square. In the first method, $u$ and $v$ at all the points on the boundary of the 32-km square are used to calculate the true value of div $d$ for the square. In the second method, only $u$ and $v$ at the four corners of the 32-km square (representing mesonet stations) are used to estimate div $d$.

$M_u$ and $M_d$ calculated using the first method are called true $M_u$ and $M_d$ ($M_u$ true and $M_d$ true). $M_u$ and $M_d$ calculated using the second method are called meso $M_u$ and $M_d$ ($M_u$ meso and $M_d$ meso).

Conclusions:

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2D ARM Case 3 CRM Simulation

The 2D ARM case 3 simulation was performed by Xu et al. (2002). The cloud mass fluxes are calculated at 3 km AGL.

Conclusions:

Both Oklahoma Mesonet observational data and results of two CRM simulations suggest that it is possible to estimate cloud-base mass fluxes from surface divergence field. The RMS errors of estimated $M_u$ and $M_d$ are 0.0097 m s$^{-1}$ and 0.0086 m s$^{-1}$ in the KWAJEX CRM simulation, and 0.0195 m s$^{-1}$ and 0.0197 m s$^{-1}$ in the 2D ARM case 3 simulation.

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