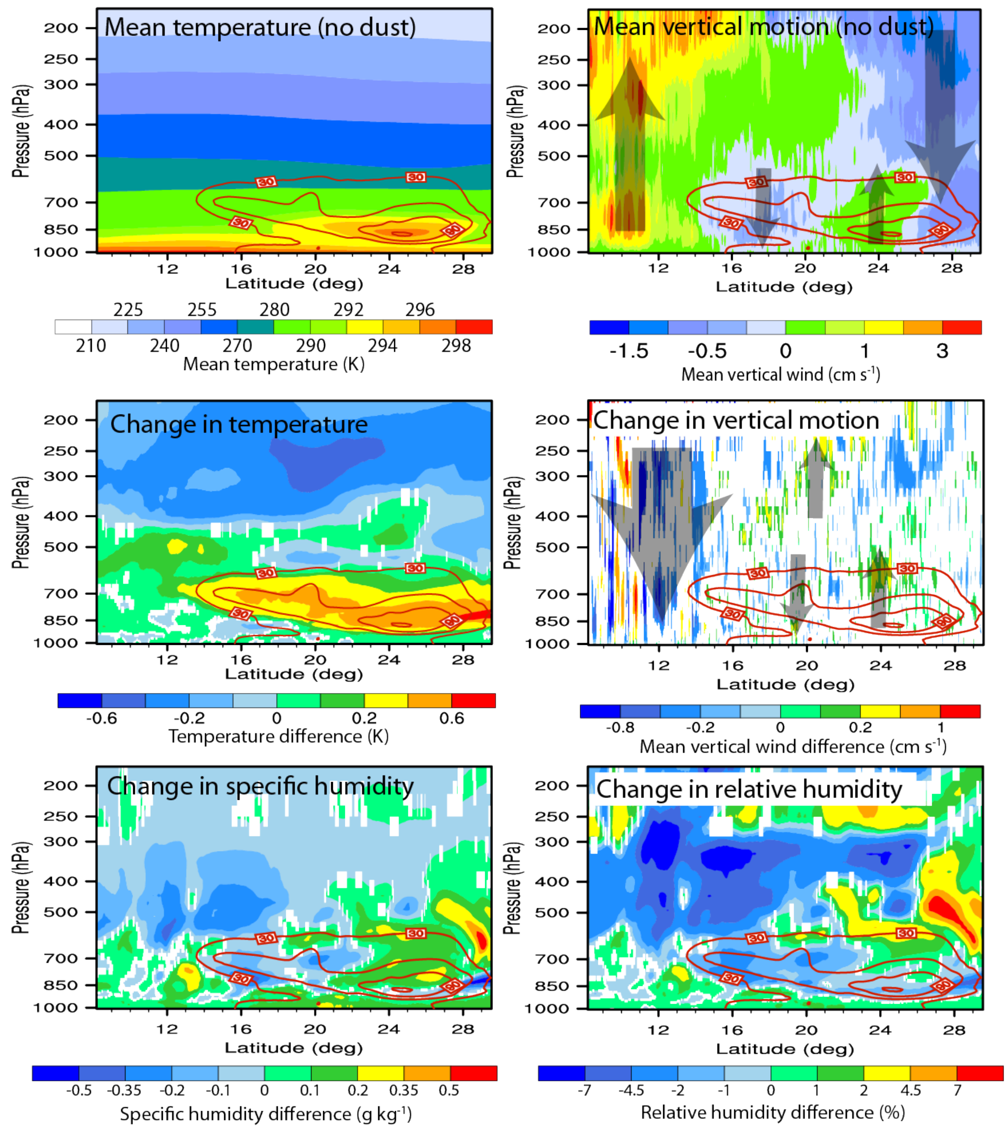
Microphysics and Radiation Effect of Dust on the Saharan Air Layer — An HS3 Case Study

- Study uses HS3 observations and simulations to examine SAL structure and the impact of dust on environmental structure
- Case: 24-25 August 2013 SAL flight
- Model: NASA Unified WRF

- SAL layer produces vertical motions with opposite sense of Hadley circulation (upper right)
- Dust reinforces dust-layer circulation, reduces rising motion in ITCZ (center right)
- Radiative impact of dust leads to warming within, cooling above dust layer (middle left)
- Drying near base and within and above the southern portion of dust layer, moistening near top and above northern part of dust layer (lower panels), consistent with changes in vertical motion
- Microphysical and radiative effects impact ITCZ convection, with net reduction of total hydrometeors

Impact of dust on zonal mean fields



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Publication: "**Microphysics and radiation effect of dust on Saharan Air Layer – A HS3 case study** " by Zhining Tao, S. A. Braun, J. J. Shi, M. Chin, D. Kim, T. Matsui, C. Peters-Lidard. *Monthly Weather Review*, **146**, 1813-1835.

Data sources: Data from the 24-25 August 2013 HS3 Saharan Air Layer (SAL) flight, including data from the AVAPS dropsonde system and Cloud Physics Lidar. MODIS and AERONET data also used. Simulations use the NASA Unified Weather Research and Forecasting (NUWRF) model, including simulations with fully interactive dust (designated AMR), no interactive dust (NoAMR), radiative effects of dust only (AR), and microphysical effects of dust only (AM).

Technical Description of Figures:
Figure: Vertical cross section of the zonal-mean temperature (top left) and and vertical motion (top right). Other panels show changes in temperature (middle left), vertical motion (middle right), specific humidity (lower left) and relative humidity (lower right) associated with the radiative and microphysical impacts of dust aerosols, with the impact measured as the difference between the simulation with radiative and microphysical effects (AMR) and the simulation without radiative and microphysical interactions (NoAMR). The figure shows how temperatures in the SAL (lower part of figure, middle right panel) are warmed by dust, primarily through the radiative interaction, while microphysical effects are small (not shown). Changes in vertical circulation are in the same sense as the mean flow within the dust layer, reinforcing the circulation, while to the south of the dust layer, the radiative and microphysical impacts of dust reduce upward motion in the Intertropical Convergence Zone (ITCZ). Changes in humidity are generally consistent with drying by reduced upward/increased downward motion and moistening by increased upward/decreased downward air motions. Red contours indicate zonal mean total dust mixing ratios at 30 $\mu g\ m^{-3}$ intervals from the NoAMR simulation. Transparent arrows indicate the sense of the vertical motions or changes in vertical motion. Data are only shown were differences between the AMR and NoAMR simulations are statistically significant.

Scientific significance, societal relevance, relation to future missions: The Global Hawk provides a valuable capability for mapping out large regions of the SAL and its environment. Observations of this SAL event are discussed in the paper and are used to validate the numerical simulation. While HS3 was focused on tropical cyclones, this study addresses one of its secondary objectives, to characterize the structure and impacts of the SAL. Using the NUWRF model with interactive dust, we assess the impact of Saharan dust on the thermodynamic and kinematic structure of the SAL and its environment. These effects can have implications for the interaction of the SAL with African Easterly Wave disturbances that are often the precursors for Atlantic hurricanes.