<u>**Response to Reviewer's Comments**</u>

<u>**Reviewer #1**</u>

We thank the reviewer for careful evaluation of the manuscript. Below we give a detailed response to each of the concerns raised by the reviewer. Reviewer's comments are in regular font and our replies are in bold font characters.

The article is interesting, well written and the results are presentation is satisfactory; in particular, I appreciated the extensive comparison with all available observations.

Thank you for the encouraging words.

I only have some minor comments on the methodology:

- The authors apply nudging at all model levels while the common practice would be to nudge the variables only above the PBL in order let the dynamics evolve freely in the lower troposphere, which is especially important for the processes described in this paper, can the authors justify this choice and to discuss how this choice might affect dust production and transport.
  Since the production and transport of dust aerosols in the model depends crucially on the accuracy of simulated meteorology, we strive to get the best simulation of dust loading by constraining the meteorology throughout the model domain. The WRF model has been shown to perform better when meteorological fields (temperature, water vapor and winds) are nudged at all the levels as compared to with nudging only above the PBL (Deng et al., 2006). In this study, we also found that use of nudging at all model levels leads to better correlation between model and AERONET observed AOD (please see response to reviewer 2 for more details). Since dust emissions occur in the surface layer of the model and are driven by the near surface wind fields, we used nudging to mimimize errors in simulated near surface winds. The analysis nudging generally leads to slower winds and thus will decrease dust emissions and spatial extent of the dust plumes. In this study, we have tuned the dust emissions to achieve good agreement between model and AERONET AOD and Angstrom exponent. The role of nudging in tuning of dust emissions was already mentioned in the manuscript (Page 21844, Lines 10-17).

- It doesn't look nice that the statistics of the aerosol radiative forcing listed in the abstract are not significant, I would substitute with (or add) the results computed in an area significantly affected by the dust plume.
  Now, we have changed the domainwide radiative perturbation statistics with statistics over a subregion of (70^{o}-80^{o}E, 25^{o}-30^{o}N) as this region was affected significantly by the dust storm. Average radiative perturbation numbers for this subregion are -2.9±3.1 W m^{-2} at the top of the atmosphere, 5.1±3.3 W m^{-2} in the

atmosphere and -8.0±3.3 W m^{-2} at the surface. However, the assessment of radiation perturbation numbers as high/low is relative. These numbers are significantly higher than the global average (TOA: -0.5 W/m2) but are comparable to the regional mean values reported for the Arabian Peninsula and Red Sea (TOA: -2.3 W/m2 and SFC: -6.0 W/m) and East Asia (SFC: -8 to -12 W/m2), and significantly lower than the values reported for in situ observations (SFC: -50 to -100 W/m2) in India. We have also added information about the simulated maximum instantaneous cooling under the dust plume which reached reached 227 and 43 W m^{-2} at the surface and the top of the atmosphere respectively on 21 April 2010.

– The best way to compute the aerosol radiative forcing would be by invoking the radiation package twice during the simulation, one with and one without aerosols, and saving the second result in the output without feedbacks on the thermodynamics and dynamics of the model; computing the difference between two simulations with and without aerosols also include the effect of the different dynamics that can alter the state of the atmosphere and the result of the comparison; probably the difference is not so big since the run is nudged, but the authors should prove this.

We agree with the reviewer's opinion about aerosol radiative forcing calculation. To calculate the radiative effects of dust aerosols in a single model run, we first invoke the aerosol optical properties calculation subroutine twice to calculate aerosol optical properties (AOD, SSA and g) with and without dust aerosols, and then invoke the radiation subroutine twice with aerosol optical properties calculated for the two cases. The radiation fluxes provided by two calls to the radiation subroutines are saved to calculate dust aerosol induced radiative perturbation in a single model run.

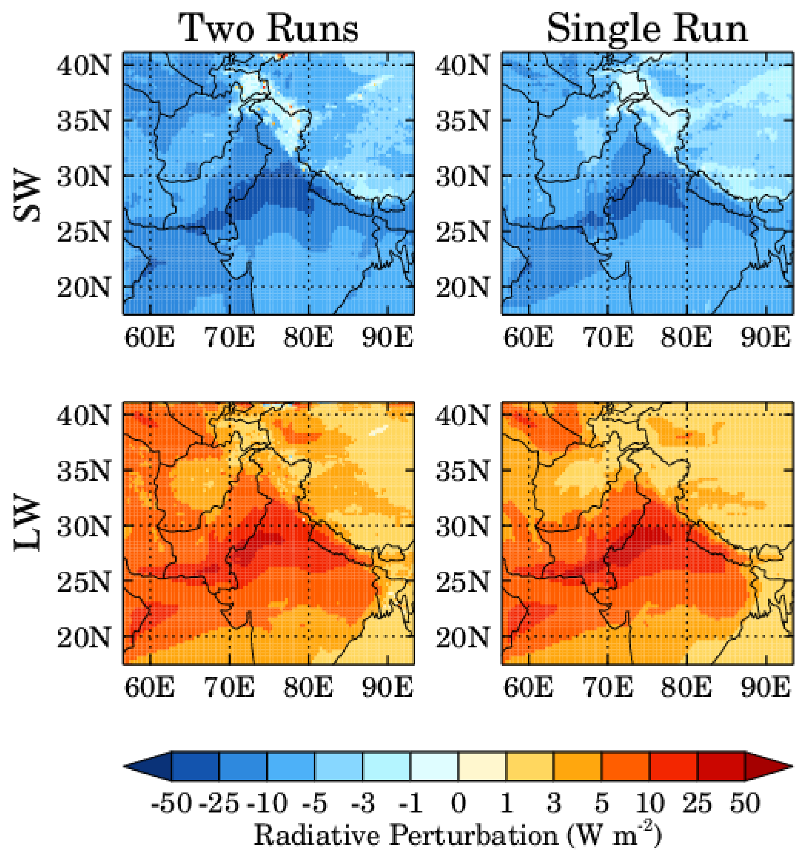

Figure : Spatial distributions of average shortwave (upper panel) and longwave (lower panel) radiative perturbation at the surface due to dust aerosols over the model domain during 17-22 April 2010 from single and two model runs.

The spatial distributions of average shortwave and longwave radiative perturbation at the surface due to dust aerosols over the model domain during 17-22 April 2010 from single and two model runs are compared in Figure above. Both the methods yield nearly similar distributions of radiative perturbations. However, the single model run case leads to somewhat smaller radiative perturbation in SW while larger in LW. Average SW radiative perturbation over the region of highest dust influence (70^o-80^oE; 25^o-30^oN) in the single and two model runs are estimated as -22±8 and -26±9 W m^{-2} respectively, and the corresponding LW values are estimated as 18±6 and 20±7 W m^{-2} respectively. Since there is not much difference between the two methods in this case, we chose to use the two model run approach in this paper. For future studies, we will make use of the single model run approach.