Reviewer's report on the manuscript by S. Solomos et al. (2010) "An integrated modeling study on the effects of mineral dust and sea salt particles on clouds and precipitation", ACP-2010-638

This manuscript reports a study on aerosol (specifically, mineral dust and sea salt particles) feed back to cloud dynamics and microphysics using ICLAMS (an integrated community limited area modeling system). It is an area that is gathering a lot of interest in the atmospheric science community. Through numerous sensitivity studies the authors demonstrated the importance (or sensitivity) of the interaction between aerosol activation and cloud microphysics and dynamics on the model predicted precipitation. However there is a lack of clarity in the description of model representation of some of the key processes (particularly aerosol microphysics) and in the experiment design and setup which need to be addressed before the manuscript can be published. For example, it is not clear how aerosol particles are represented in the model: aerosol size - sectional (binned) or modal representation, aerosol mixing state - internally mixed or externally mixed (between mineral dust and sea salt, and other chemical components), processes - aerosol microphysics (condensation/evaporation, coagulation, other than the sedimentation and dry/wet deposition processes described) and secondary aerosol formation/production. It is not clear what aerosol properties are imposed and what are simulated for the various sensitivity tests. The following are some specific comments.

Specific comments:

2. Description of ICLAMS

Is this the first publication of ICLAMS? In Table 1 the authors have highlighted the model components added to RAMS, but not all of them are given description here. Are there references for those new components that are not described, e.g., on-line multi-phase chemistry and aerosol parameterizations?

P5, line 135: What do you mean by "cycle" here?

2.1 Mineral dust

P5, line 152-153: This seems to imply that a single landuse class is assigned to a given model grid (as opposed to multiple landuse classes with fractional coverage). Is this the case?

P6, line 166-167: What are the three modes, and what are the median diameters and geometric standard deviations for these modes? What is the "transport mode"? Is this the only model represented in the model?

2.2 Sea salt spray

P7, line 199 – 202: Is this bi-modal distribution of sea salt particles mapped onto the same 8-bin structure as in the case of dust particles? How is the particle mixing state represented in the model (e.g., externally mixed, internally mixed, or something else)?

2.4 Wet deposition

P8, line 234: Are you talking about in-cloud removal (rain-out) or below-cloud removal (wash-out)? The equations (8 – 10) are for below-cloud scavenging of particles by precipitation.

2.6 Cloud droplet nucleation parameterization

P10, line 297-299: What are the processes included in the calculation of aerosol properties, e.g., hygroscopic growth, uptake of condensable gases, coagulation?

P11, line 305-306: Is IN explicitly linked to modelled dust particle concentration in ICLAMS? This is not obvious from the reference given. It would be helpful to provide the actual formulation used as well as references.

3. Clouds and precipitation in an environment with natural particles

3.1 Idealized simulations

What kind of lateral boundary condition is used for these idealized tests?

For these tests only FNS parameterization is used for aerosol activation. It would be useful to include a run with the original droplet nucleation scheme in RAMS to look at the impact of the new scheme, or has this comparison been done elsewhere?

P12, 334: what is the soluble fraction assumed for these two cases?

P12, line 347: the maximum droplet number concentration 130 cm^{-3} is greater than the total number concentration of dust particles prescribed for this case (100 cm^{-3}), any explanation?

P12, line 358: similarly the maximum droplet number concentration 2133 cm^{-3} is greater than the total number concentration of dust particles prescribed for this case (1500 cm^{-3}), which again seems odd.

P12, line 359 – 360, and Table 3: the rain mixing ratio at hour 2 for the two cases are 0.47 g/kg for “pristine” and 0.37 g/kg for “hazy”. The difference is significant but not huge. In contrast, the difference in rain droplet concentration between the two cases is huge (27.65 L^{-1} vs. 2.2 L^{-1}). Does this make sense?

P13, line 367: figure 5 is redundant. It is simply a graphic presentation of column 3 of Table 3.

P13, line372 – 373: it is not clear how the role of melting hydrometeors is illustrated in Figure 4.

P13, line 388 – 389: the explanation given is not sound. The possible reason may be that the presence of giant CCNs in the "hazy" case drove down the maximum supersaturation reached in the updraft which prevented the activation of small particles. In the "pristine" case, because of the relative low number concentration of CCN, the maximum supersaturation may not be affected as significantly by the presence of a few giant CCNs. But of cause, this will all depend on parameterization used in the model.

P13 – p14: other than the visual illustration of Figure 7, can we look at domain total precipitation to see if the "hazy" cases always result in reduced precipitation in comparison to their respective "pristine" counterparts?

3.2 Case study

Some of the specifics for the simulation setup are missing, such as, the length of simulation (or simulation period), the chemical tracers (gaseous and particulate) carried in the simulation, the initial and lateral boundary conditions used for the chemical tracers. Again, it is not clear whether mineral dust and sea salt aerosols are treated as externally mixed aerosols and if the model allows internal mixing (through coagulation, for example).

P16, line 463 – 465: are any of these aging processes represented in the model simulation?

P16, line 468: Figure 10 is not a good illustration. It may be more effective using simple 2D plots to illustrate. Also, what model runs are shown in Figure 10 and 11 (15km, 3km, or 750m resolution runs)?

P16 bottom paragraph carrying over to p17: is particle number concentration a prognostic variable or diagnosed from mass concentration? Again, are dust and sea salt particles treated separately as externally mixed particles in ICLAMS?

P17, bottom paragraph: for EXP3 IN concentration was multiplied by 10 in presence of mineral dust – this implies that IN is not linked to modelled particles in ICLAMS (which is somewhat in conflict to the statement made at the end of section 2.6.

P17, line 517 – p18, line 527 (discussion on aerosol size spectrum): I am somewhat confused on how particles are modelled in ICLAMS. Is the particle size distribution simulated or imposed? Also, are sea salt particles included as CCNs in the droplet nucleation calculation? Is the soluble fraction of dust particles treated as sodium chloride or ammonium sulphate in these experiments?

P18, line 533: what does "less polluted cloud" mean here? The dust particles in EXP1 are less hygroscopic (or less) aged than those in EXP2. To clarify, by "5% of dust particles were hygroscopic" (referring to line 510 on p17) do you mean that all dust particles are composed of 5% soluble material and 95% insoluble material?

P18, line 555 – 557: does this translate to greater accumulated precipitation, which is in contrast to the idealized cases, i.e., more CCNs lead to reduced precipitation?

P19, line 565 – 566: "particle concentration was a prognostic variable" – number concentration or mass concentration, size-resolved or bulk?

P19, line 578 – 5580: can you indicate the number of observations available for each of these thresholds (somewhere in Figure 16 or 17)?

P19, 584 – 587: this statement is not well supported by Figure 16, e.g., case 7 and 9 overpredicted at the higher end. Again how many observations over these threshold ranges?

P20, line 601 – 603: the better average biases can be a result of compensating errors between over and under prediction as seen in Figure 16. What can be established here from these tests is sensitivity to the interaction between aerosol and cloud microphysics and dynamics. The improvement in the score may be fortuitous due to uncertainties in modelled/imposed aerosol properties and possible compensating errors.

4. Concluding remarks

P20, line 609 – 610: "Aerosol partitioning … such as aging particles" needs rephrasing.

P20, line 613 – 615: there is also significant uncertainty in modelled aerosol properties.

P21, line 640: what is the increase of 15% in soluble dust concentration referring to? Again, it is not clear if the soluble fraction refers to the fraction in number concentration or in particle composition. My understanding of the Fountoukis and Nenes scheme is that the soluble fraction is referring the latter (i.e., the fraction in composition assuming internally mixed aerosols).

P21, line 645 – 646: again the improved precipitation score may be fortuitous due to compensating errors.

P21, line 647 – 650: similar caveat to this statement as above, as well as uncertainties in the combination of simulated and imposed aerosol properties in this study.