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Interactive Comment

Interactive comment on "Online coupled regional meteorology-chemistry models in Europe: current status and prospects" *by* A. Baklanov et al.

Anonymous Referee #3

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General Comments:

This paper is a comprehensive overview of online and coupled meteorology-chemistry models that are currently in use in Europe. While the stated goal is to focus on integrated meteorology-chemistry models, the paper provides an extensive description of the chemical and physical processes involved in chemical transport modeling (section 4). Although it can be argued that this is important background for the paper's purpose, it seems disproportionate compared to the description of the processes and modeling techniques unique to online models such as aerosol direct and indirect radiative feedback effects. It seems like more than half of the paper is describing aspects of AQ modeling, including extensive discussion of meteorologically dependent emissions that are equally germane to offline models. Thus, I think these sections could be greatly

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reduced and instead have more in-depth description and discussion of processes that are only possible in online or coupled systems. While there is a complete survey of the techniques used for direct and indirect aerosol feedbacks there is not enough explanation of how these models work, especially the CCN activation algorithms. It would be more enlightening if the paper could give some judgement as to which techniques are most realistic and the trade-offs in terms of computational cost. As explained, evaluation of indirect effects is difficult but on theoretical basis some techniques must be more valid than others.

There would seem to be more opportunities for integration of meteorological and chemical processes than are discussed in this paper. In particular, the interactions between chemistry and clouds could go much beyond the effects of aerosols as CCN. For example, cloud droplet size spectra could be used in the aqueous chemistry calculations rather than a bulk cloud water approach that is typically used in offline models. Also, once a portion of the aerosol size spectra are activated the partitioning of the aerosol into cloud droplets and interstitial aerosol could be fed back to the chemical model where aerosol and aqueous process would be affected. In addition, aqueous chemical species could be advected through the model grid along with microphysical species. While some of these processes may not be worth the additional complexity and computational cost, they probably should be mentioned in the paper.

The terminology for coupled meteorology-chemistry models is confusing with inconsistencies throughout the paper. Section 3 attempts to define the distinctions between "online access models" and "online integrated models". However, in the same section the term "online coupled models" is used with no explanation of how this label relates to the other terms. Furthermore, in section 3.2 it is stated that online access models have meteorological and chemical data is available at each timestep but later this is contradicted (page 12616): "...some models (e.g. RACMO2/LOTOS-EUROS,COSMO-MUSCAT) follow the online access approach, with a data exchange between the chemistry and meteorology modules not on each model time step." It is important to make

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the terminology clear and consistent.

The quality of the English is rather uneven. Some parts are well written while others are poorly written. Also, some sections are composed of long paragraphs while others often have very brief paragraphs. A greater effort should be made to improve the writing and harmonize the style.

Overall, this paper is a valuable addition to the literature that provides a comprehensive description of all the major components of coupled meteorology-chemistry models with particular emphasis on integrated models and the chemistry to meteorology feedbacks that are only possible in such online systems. It is also quite interesting to see how the variety of models compare to each other and both the many similarities and differences in their approaches to the same processes. Once the general and specific issues mentioned here are dealt with, this should be acceptable for publication in ACP.

Specific comments:

P12545ln6: OCMC should be spelled out the first time it's used.

P12556ln5-6: This is one of the places where the interactions of aerosols and cloud droplets could be taken a step further. It is stated that aqueous chemistry is a function of liquid water content but in coupled models it could also take droplet size spectra into account.

P12556ln6-9: This sentence is poorly written. The statement that radiatively active gases are important for climate while aerosols are important for meteorology is incomplete since aerosols are also important for climate, especially at regional scales.

P12557ln23: There is also a CB6

P12561ln2-13: It is stated that a 3-moment modal approach could be problematic because of inconsistencies due to advection. But then it is stated that holding the standard deviation constant may lead to large errors. Examples of models using both approaches are mentioned but with no support or elaboration for either assertion. The

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reader is left with no insight into which approach is preferred or the tradeoffs involved.

P12562 Sections 4.3.4 and 4.3.5: These sections seem ridiculously brief. I suggest combining them into one section perhaps entitled “Aerosol mixing state”. In addition to internal and external the core-shell and multiple inclusion models for BC should be discussed. However, since aerosol aging and the coating of BC particles is discussed in section 4.3.7, it may be better to move these sections to be part of that section. I think this whole larger section (4.3.x) should be reorganized and re-written for more logical progression and improved English and more uniform style (i.e. some sections are long and others are short.

P12562ln 14-15: This sentence seems to contradict the earlier sentence at lines 2-3.

P12564ln5-6: The VBS model is described as including “chemical aging within the particle” when I think the VBS concept is that chemical aging occurs via gas-phase reactions.

P12564 Section4.3.6: Another SOA process is the formation of non-volatile SOA via heterogeneous uptake and particle phase reaction.

P12565 Section4.3.9: This section is redundant and should be merged with section 4.3.6. More reason for reorganization of this whole section.

P12567ln20-22: This sentence seems to contradict the later discussion of CCN activation as function of supersaturation.

P12568ln24-25: This statement that “all online models have cloud schemes that to some extent represent the effects of aerosols on cloud” is clearly not correct.

P12570ln3: I think they meant to say: “In all such models. . .”

P12572ln27: What is meant by: “The opposite is true. . .”?

P12574lns15-20: This paragraph is confusing. Also, where are the effects of radiatively absorbing aerosols, such as BC, inside could droplets discussed? The heating caused

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by in-droplet BC radiation absorption can cause evaporation of the droplets.

P12580ln11-13: References for the ammonia bidirectional flux scheme in WRF-CMAQ should be included (Cooter et al 2012, Biogeosciences; Bash et al 2013, Biogeosciences; Pleim et al 2013, JGR)

P12582ln7-11: Dry deposition also depends on the land use and vegetation characteristics and the chemical and physical properties of gasses. The list of dry deposition references might also include Pleim and Ran Atmosphere 2011, 2, 271-302; doi:10.3390/atmos2030271.

P12583ln10-18: This is almost exactly repeated from Section 2. Why?

P12583ln21-27: This paragraph implies that only BC aerosols can cause the effects of lower PBL heights and higher concentrations. While BC is particularly able to warm upper levels of the PBL by radiation absorption, all aerosols reduce SW radiation at the ground thereby reducing surface temperatures leading to more stable and shallower PBLs.

P12584ln1-6: In addition to being poorly written, this paragraph overstates the inferiority of so-called online access models in simulating the chain effects.

P12584ln7-11: This is a badly written and useless paragraph. Section 5.1: Shouldn't positive definite and monotonicity also be mentioned as desirable properties for advection schemes?

Section 5.1.1: The terminology here is confusing. What is meant by volume density? It appears from the equations that this is plain density, i.e. mass per volume. Is mixing ratio mass mixing ratio?

Equation 2 seems to be incorrect. Shouldn't the RHS be –Vdel(qi)? P12590ln13-15: It should be mentioned that these statements are about horizontal turbulent mixing and not vertical turbulent mixing. Also, numerical diffusion may not always be much greater than turbulent diffusion, especially at finer horizontal grid resolution.

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P12591ln25-28: This sentence needs to be rewritten for more clarity. It mentions off-line models but then also says that information is exchanged through a coupler, which sounds more like an online access model. The next sentence says it's one-way. This is very confusing.

P12614ln26: “simulation” should be “assimilation”.

P12624ln 12-14: This statement is overstated. Not only online integrated models can include aerosol dynamics and feedbacks but also online access models.

P12625ln25-27: This sentence is poor grammar and incorrect. Online access models are not necessarily more expensive. In fact, they can be much more computationally efficient since the CTM can generally be integrated at a longer time timestep than the meteorology model.

P12627ln25: “base” should be “basis”

Table 5: The WRF model has far more convective, PBL, and radiation options than listed here. For PBL the YSU scheme is most commonly used for WRF-Chem and the ACM2 scheme is used for WRF-CMAQ. For radiation, the CAM, Goddard, and RRTMG schemes are the only ones capable of aerosol direct feedbacks using WRF-Chem and WRF-CMAQ.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 12541, 2013.