Atmos. Chem. Phys. Discuss., 6, S1011–S1014, 2006
www.atmos-chem-phys-discuss.net/6/S1011/2006/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Comparing atmospheric transport models for future regional inversions over Europe. Part 1: Mapping the CO_2 atmospheric signals" *by* C. Geels et al.

Anonymous Referee #2

Received and published: 28 May 2006

This paper presents CO2 simulations (essentially over Europe) from 5 models of different construction and resolution. The simulations are compared with each other and to some extent with existing measurement data. The goal as stated in the title is to build knowledge about model behavior to serve as guidance for how inverse modeling techniques should be used to make quantitative estimates of regional European fluxes of carbon dioxide. The paper makes clear headway towards this goal but falls short of addressing issues like station representativity, model adequacy and measurement strategies thoroughly. Nevertheless, the paper is clear and well written and is a useful contribution which merits publication and attention.

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Interactive Discussion

Discussion Paper

My main concern is related to the logic utilized in arriving at the four main recommendations listed in the abstract. The authors appear to be attracted towards finding traits in the model simulations that are similar (and by their logic thus "robust"). That the model results are similar need not mean that the results are correct depictions of the real atmosphere. Secondly, the features of the model simulations that are similar are probably related to the least questionable of regional aspects of the system and will thus lead to minimal new knowledge when later de-convolved in an inverse study.

The authors also have a general attraction towards "higher resolution" as a solution to several problems. Higher resolution is only useful (for regional CO2 flux quantification) if we have ADEQUATE knowledge about the physics such that the increased resolution does not introduce more degrees of freedom in the model. We can actually end up knowing less despite acquiring better correspondence between data and simulation.

These general thoughts are developed further in the following more detailed page specific comments.

Page 3712 line 22 "Atmospheric transport integrated over all CO2 surface sources and sinks". This is the key statement. The real atmosphere "integrates" over all spatial and temporal scales. Our models are simplifications of reality with finite time steps, coarse grids and approximate (or incomplete) physics. Our source and sink functions are, likewise, approximate at best with yet other resolutions in time and space than the transport model. The instantaneous measured value at one sampling location is made up of all real effects "integrated". We are all attracted to a conceptual idea that the data are composed of a "background" signal with superimposed "local" effects. The real atmosphere is, however, full of idiosyncrasies with constantly changing mixing scales in space and time. We can here even discuss what we mean with "integrate". As argued above it is the sum of all effects prior to the occasion of measurement; as implicitly argued in the paper it may be more appropriate to consider "integration" as mixing. As sources and sinks influence a volume of air that air "parcel" acquires a new composition. Over time this air is mixed with other air and the mixtures composition is then

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a volume weighted average of the mixed air masses. When the mixture is completely homogeneous the information regarding the (idealized) two air masses different histories has been erased. It will then be impossible to arrive at anything but an average (or integrated?) CO_2 flux for the areas of exchange of the two air masses. But the surface exchange is continuous and the mixing is a continuous process. Sometimes the atmosphere is kind and we have some sort of physical boundary (like the ITCZ) that encloses or simplifies the problem at least for a limited time or area but most of the time we must utilize all our knowledge about the full history of the air being sampled.

Page 3713 line 13. Observation sitesĚ Based in preconceived ideas of what is "regional" and "local".

Page 3714 line 21. What do the authors mean with the words "transport variability" here? This sentence states the "ultimate purpose of the paper" but is unfortunately difficult to interpret.

Page 3716 section 2.1 A number of acronyms are introduced and well known to most of us in the field but an appendix with explanations may be appropriate. Some further details on the "zooming" and "nesting" methods used could also be considered.

Page 3721 line 3. The models are "referenced" to Mace Head. An explanation of how this is done would be helpful.

Page 3721 line 19. "qualitatively similar". It can be argued that this qualitative trait is there by design. Regardless of how "wrong" the models are in their physics anything but higher values over the continent and lower over the ocean given the fluxes as prescribed would have been shocking. This issue is profound since the choice of comparisons we make is rather arbitrary (for example page 3720 line 1, "occasional" high values are deemed unimportant).

Page 3725 The radiocarbon data are monthly mean values. How are the influenced by the "very local" contamination not included in the CO_2 concentration data? The

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Heidelberg station is clearly very special with numerous local effects but also the only calibration point utilized in this paper for the entire European continent. This raises representativity issues.

Page 3730 paragraph beginning on line 22 ECMWF and NCEP have evolved from needs to predict weather. Mid-latitude weather prediction is to a large extent comprised of predicting frontal passages. It is reassuring that the synoptic scale is captured well by both these tools.

But the CO_2 concentrations are influenced by annual cycles on hemispheric scales, long term trends, synoptic variability, finer scale circulation features and other local effects. The present study side-steps the first two, does well on the synoptic scale and then has mixed results on the finer scales with most discussion centered on PBL variations and a little on topography. There are many effects on local to regional scales that intermittently play important roles. To arrive at a conclusion that mid-afternoon values a few hundred meters above ground maximizes the information content in the data is not apparent to this reviewer. The "signal" is weaker so even if the values are less variable we must decipher more from the smaller variability. The "representative" altitude for the "region" will vary with season and weather. The afternoon values may be "representative" of something we wish to interpret as "background" but are for example the weakest data when it comes to quantifying the night time respiration flux. And finally; it is concluded that mountain stations should be used with care. I dare say that the CO_2 Mauna Loa data series has contributed more to our understanding of the global carbon cycle than all other stations combined. The series is comprised of hand picked afternoon (!) data from a mountain station.

Figure captions 12 & 13 "of the scale" should be "off the scale"

Interactive comment on Atmos. Chem. Phys. Discuss., 6, 3709, 2006.