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Interactive Comment

Interactive comment on "Glacial cycles and solar insolation: the role of orbital, seasonal, and spatial variations" *by* R. K. Kaufmann and K. Juselius

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We thank M. Crucifix for his review of our manuscript "Glacial cycles and solar insolation: the role of orbital,seasonal, and spatial variations." We are gratified to read that the reviewer supports statistical efforts to "disentangle the dynamics of the climate system."

Towards that end, the reviewer worries that strong collinearity between "most measures of insolation, whatever the latitude, season integrated or not, can be approximated to excellent accuracy as linear combinations of e sin, e cos and with e, eccentricity, heliocentric true solar longitude of the perihelion and obliquity" undermines our conclusion that "variations in solar insolation associated with changes in Earth's orbit have the greatest explanatory power and that obliquity, precession, and eccentricity are needed

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to generate an accurate simulation of glacial cycles. Seasonal variations in insolation play a lesser role, while cumulative summer-time insolation has little explanatory power." The collinearity described by the author has little effect because we base our conclusion on an experimental design that largely controls for the collinearity and results that explicitly demonstrate that the reviewer's concern is not warranted.

Our experimental design is specified to reduce the effect of collinearity. Model 2a includes only eccentricity, obliquity, and precession, Model 2b includes only seasonal measures of solar insolation at a given latitude, and Model 2c includes only cumulative measures of summer-time insolation. This individual grouping all but eliminates the collinearity described by the reviewer.

This separation is the basis for evaluating their explanatory power. Tests of forecast accuracy (Table 3) and visual examination of in sample-simulations (Figure 2) indicate the simulation of Temperature, CO2, and Ice generated by precession, obliquity, and eccentricity (Model 2a) is more accurate than the model that includes only the seasonal measures of solar insolation (Model 2b). Similarly, both Model 2a and Model 2b generate more accurate simulations than the model (Model 2c) which contains only cumulative measures of summer-time insolation. If collinearity is as important as argued by the reviewer, the accuracy of the simulations would not differ among the three groups.

The reviewer's argument about the importance of collinearity also is not supported by comparisons of Model 2a (precession, obliquity, and eccentricity) and Model 2b (seasonal measures of solar insolation) that are described in the first paragraph on page 2576. Results indicate that adding the seasonal measures of solar insolation to Model 2a (to create Model 2d) generates a more accurate simulation of CO2 and Ice than Model 2a, which includes precession, obliquity, and precession. Again, a statistically measurable improvement in forecast accuracy would not be possible if the collinearity is as important as described by the reviewer.

Finally, the results in Table 4 also suggest that concern about collinearity is not very relevant in this context. This table describes accuracy comparisons of models that specify seasonal and cumulative summer insolation at different latitudes in the Northern and Southern Hemisphere. For Temperature and Ice, comparisons indicate that solar insolation at 75oN and 60oS respectively, generate more accurate simulations than insolation measures at other latitudes. A statistically measurable improvement in forecast accuracy would not be possible if the collinearity is as important as described by the reviewer.

Although the experimental design and results diminish the collinearity in our results, we recognize that precession, obliquity, and eccentricity ultimately drive the climate system by causing realized levels of insolation to change over space and time. The point of our comparison is that the general measures of orbital parameters have more explanatory power than latitude and seasonal specific measures of insolation. We are happy to add this clarification.

The reviewer also writes "The lack of discussion about chronology is also worrying.. may challenge inferences on the effect of astronomical forcing." Uncertainty about chronology is unlikely to have a significant effect on our results. Our results are generated by comparing models that contain the same uncertainty about chronology. As such, the uncertainty is present in all models and so affects the accuracy of all models. But this shared effect would have little or no effect on comparisons among models. We are happy to add such a caveat to our results.

We are happy to read the papers referenced by reviewer and will use them, along with advice from colleagues to fix the "misprints and innocent inaccuracies." Finally, we will add Juselius (2006) to the references.

Literature Cited

Juselius, K. (2006), "The cointegrated VAR model: Econometric Methodology and Empirical Applications" Oxford University Press, Oxford. 457 pp.

Interactive comment on Clim. Past Discuss., 6, 2557, 2010.